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**CliMetLab**

***Release 0.17.1***

**ECMWF**

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# CONTENTS

|   |               |     |
|---|---------------|-----|
| 1 | Documentation | 3   |
| 2 | License       | 197 |



**Warning:** This documentation is work in progress. It is not yet ready.

*CliMetLab* is a Python package aiming at simplifying access to climate and meteorological datasets, allowing users to focus on science instead of technical issues such as data access and data formats. It is mostly intended to be used in [Jupyter](#) notebooks, and be interoperable with all popular data analytic packages, such as [NumPy](#), [Pandas](#), [Xarray](#), [SciPy](#), [Matplotlib](#), etc. as well as machine learning frameworks, such as [TensorFlow](#), [Keras](#) or [PyTorch](#). See [Overview](#) for more information.



## DOCUMENTATION

- *Overview*
- *Installing*
- *First Steps Tutorial*
- *Examples*

### 1.1 Overview

*CliMetLab* is a Python package which is intended to be used in [Jupyter](#) notebooks. Its main goal is to greatly reduce boilerplate code by providing high-level unified access to meteorological and climate datasets, allowing scientists to focus on their research instead of solving technical issues. Datasets are automatically downloaded, cached and transform into standard Python data structures such as [NumPy](#), [Pandas](#) or [Xarray](#), that can then be fed into scientific packages like [SciPy](#) and [TensorFlow](#). *CliMetLab* also aims at simplifying plotting of 2D maps, by automatically selecting the most appropriate styles and projections for any given data.

The goal of *CliMetLab* is to simplify access to climate and meteorological datasets, by hiding the access methods and data formats. The snippet of code below would download the dataset *dataset-name*, cache it locally and decodes its content as a NumPy array:

```
import climetlab as clm

data = clm.load_dataset("dataset-name")
a = data.to_numpy()
```

To achieve this, *CliMetLab* introduces two concepts: *Data source* and *Dataset*. Data sources represent various access methods, such as reading files, downloading from a web site or using APIs.

*CliMetLab* provides the interface between the left side and the right side of the figure below:

*CliMetLab* also provides very high-level map plotting facilities. By default *CliMetLab* will automatically select the most appropriate way to plot a dataset, choosing the best projection, colours and other graphical attributes. Users can then control how maps are drawn by overriding the automatic choices with their own.

```
import climetlab as clm

data = clm.load_dataset("some-dataset")
cml.plot_map(data)
```

## 1.2 Installing

### 1.2.1 Pip install

To install CliMetLab, just run the following command:

```
pip install climetlab
```

The CliMetLab pip package has been tested successfully with the latest versions of its dependencies ([build logs](#)).

### 1.2.2 Conda install

No conda package has been created yet. `pip install climetlab` can be used in a conda environment.

---

**Note:** Mixing pip and conda could create some dependencies issues, we recommend installing as many dependencies as possible with conda, then install CliMetLab with pip, as [recommended by the anaconda team](#).

---

### 1.2.3 Troubleshooting

#### Python 3.8 or above is required

CliMetLab requires Python 3.8 or above (mainly due the dependency *numpy*). Depending on your installation, you may need to substitute `pip` to `pip3` in the examples below. See the [build logs](#) to know on which version of Python CliMetLab is automatically tested.

#### No matching distribution found for ...

If the installation fails with the following error:

```
Collecting ecmwflibs>=x.x.x (from climetlab)
  Could not find a version that satisfies the requirement ecmwflibs>=0.0.90 (from
  climetlab) (from versions: )
No matching distribution found for ecmwflibs>=x.x.x (from climetlab)
```

you will need to make sure that you are using the latest version of pip (`>=21.0.0`):

```
% pip install --upgrade pip
% pip install climetlab
```



**WARNING: Retrying (Retry(total=4, connect=None, ...**

If you are installing CliMetLab (or any other package) without internet access. You can get a similar error. This happens for instance on Kaggle when you are not logged in or when your account has not been verified.

```
WARNING: Retrying (Retry(total=4, connect=None, read=None, redirect=None, status=None))
after connection broken by 'NewConnectionError(': Failed to establish a new connection:
[Errno -3] Temporary failure in name resolution')':....
```

**Module enum has no attribute 'IntFlag'**

If the installation fails with the following error:

```
AttributeError: module 'enum' has no attribute 'IntFlag'
```

This means that there is an old version of the `enum` package on your system that needs to be removed:

```
% pip uninstall -y enum34
% pip install climetlab
```

## 1.3 First Steps Tutorial

This is an easy to follow tutorial that gets you up to speed with *CliMetLab* to access scientific climate data. It assumes you have basic Python programming knowledge.

So, let's start with what *CliMetLab* does best:

### 1.3.1 Getting data

*CliMetLab* provides two main ways to access climate and meteorological data

1. Data Sources (*details*)
2. Datasets (*details*)

#### Data Sources

In *CliMetLab*, a *Data Source* refers to a local or remote storage server or data archive from where we can download or access files related to climate data.

To get started, let us first import *CliMetLab* at the top of our Python notebook:

```
import climetlab as cml
```

Now download `test.grib` (example GRIB file) to your project directory, or if you have `wget` command available, run following in your notebook:

```
!wget https://raw.githubusercontent.com/ecmwf/climetlab/main/docs/examples/test.grib
```

GRIB is a file format for storage and sharing of gridded meteorological data. You can think of gridded data as weather or some other data that is associated with specific locations using coordinates. For example, wind speed data for every longitude and latitude on a two dimensional grid.

The GRIB format (version 1 and 2) is [endorsed by WMO](#). GRIB (GRIdded Binary) is a binary file format so you cannot look at it using a text editor. But you sure can use *ClimetLab* to explore it:

```
grib_data = cml.load_source("file", "test.grib")
```

Here we used `load_source` method from *ClimetLab* to load our GRIB file into `grib_data` variable. The first argument "file" specifies the type of our data source. Which currently is indeed a local file that we downloaded. The second argument is the path to that file.

Let's plot this data using the `plot_map` convenience method:

```
cml.plot_map(grib_data, title=True, path="test-grib-plot.svg")
```

The `title` and `path` arguments supplied to `plot_map` are optional. When `title` is set to `True`, the plot will include the title of the data from our data file. If you specify the `path` ending with a supported format (`.svg`, `.png`, `.pdf`), the plot will be saved at the specified location.

You can also use `load_source` to directly download and load files from remote server, in one step. For example, let's download and plot a NetCDF file:

```
netcdf_url = "https://raw.githubusercontent.com/ecmwf/climetlab/main/docs/examples/test.
↪nc"
netcdf_data = cml.load_source("url", netcdf_url)
cml.plot_map(netcdf_data)
```

If you don't know already, [NetCDF](#) is another commonly used data format for transporting scientific data.

So, we have downloaded and plotted scientific weather data, can we convert this data to work with our favorite Data Science library? Pandas, Xarray or Numpy? Don't worry, *ClimetLab* has got you covered.

If your data is gridded data, like in our examples above, you can simply call `to_xarray()` method to convert it to an Xarray object:

```
grib_xr = grib_data.to_xarray()
# as well as:
netcdf_xr = netcdf_data.to_xarray()
```

*ClimetLab* will infer the type of data by probing the downloaded file. If the file contains gridded data, such as meteorological fields, they will be accessible as an Xarray dataset, using the `to_xarray()` method. If the file contains point data, such as observations, they can be converted to a Pandas data frame via the `to_pandas()` method. Other data may only be available as NumPy arrays using the `to_numpy()` method.

Observations are usually data points corresponding to time for a certain location unlike gridded data that contains data points that is usually for a range of locations. For example, monthly average temperature of Lahore for the past ten years.

The following example downloads a `.csv` file from NOAA's *International Best Track Archive for Climate Stewardship* (IBTrACS) using the `url` data source. The file is downloaded into the local cache. We then convert it to a Pandas frame. The rows corresponding to the severe tropical cyclone [Uma](#) are extracted and plotted.

```
import climetlab as cml

data = cml.load_source(
    "url",
    (
        "https://www.ncei.noaa.gov/data/international-best-track-archive-for-climate-
↪stewardship-ibtracs"
```

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```

        "/v04r00/access/csv/ibtracs.SP.list.v04r00.csv"
    ),
)

pd = data.to_pandas()
uma = pd[pd.NAME == "UMA:VELI"]
cml.plot_map(uma, style="cyclone-track")

```

The Data Sources implement various methods to access and decode data. When data are downloaded from a remote site, they are *cached* on the local computer.

The first argument to `load_source` can take the following values:

| Argument value | Description   |
|----------------|---|
| "file"         | A path to a local file name. <a href="#">Read more</a>  |
| "url"          | A URL to a remote file. <a href="#">Read more</a>   |
| "cds"          | A request to retrieve data from the <a href="#">Copernicus Climate Data Store</a> (CDS). Requires an account. <a href="#">Read more</a>                         |
| "mars"         | A request to retrieve data from ECMWF's meteorological archive (MARS), using the <a href="#">ECMWF web API</a> . Requires an account. <a href="#">Read more</a> |

To read more about Data Sources, head over to [Data Sources guide](#).

Now let's dive into the second way that you can access climate scientific data using *CliMetLab*:

## Datasets

Datasets are a higher-level concept compared to data sources.

---

**Todo:** metadata, hidden access to sources, control plotting, control conversion to pandas

---

The following Python code:

```

import climetlab as cml

data = cml.load_dataset("hurricane-database", bassin="atlantic")
print(data.home_page)

```

will print:

```
https://www.aoml.noaa.gov/hrd/hurdat/Data_Storm.html
```

then,

```

irma = data.to_pandas(name="irma", year=2017)
cml.plot_map(irma)

```

will plot:

Compare that with the [data source example](#).

### 1.3.2 Simple plotting

*CliMetLab* will try to select the best way to plot data.

```
cml.plot_map(data)
```

Below are the parameters you can pass to the plot function:

| Name            | Value       | Default | Description   |
|-----------------|-------------|---------|---|
| title           | str or bool | False   | The title of the plot. Use True for automatic.  |
| projec-<br>tion | str         | None    | The name of a map projection. Use None for automatic. See below for possible values.  |
| style           | str         | None    | The name of a plotting to apply. Use None for default. See below for possible values.                                       |
| fore-<br>ground | str         | None    | TODO. See below for possible values.  |
| back-<br>ground | str         | None    | TODO. See below for possible values.  |
| path            | str         | None    | Save the plot in a file instead of displaying it. The file type is inferred from the path extension (.png, .pdf, .svg, ...) |

You can find out what are the possible values for *projection*, *style*, *foreground* and *background* parameters using the code below:

```
import climetlab.plotting

# List of possible projections
for p in climetlab.plotting.projections():
    print(p)

# List of possible styles
for p in climetlab.plotting.styles():
    print(p)

# List of possible backgrounds/foregrounds
for p in climetlab.plotting.layers():
    print(p)
```

To get more information about a given projection, in a Jupyter Notebook:

```
from climetlab.plotting import projection

projection("global")
```

will output:

|             |  |
|-------------|--|
| Name:       | global   |
| Collection: | projections  |
| Path:       | /opt/venv/lib/python3.7/site-packages/climetlab/data/projections/global.yaml   |
| Definition: | <pre> magics:   mmap:     subpage_lower_left_latitude: -90.0     subpage_lower_left_longitude: -180.0     subpage_map_projection: cylindrical     subpage_upper_right_latitude: 90.0     subpage_upper_right_longitude: 180.0 </pre> |

### 1.3.3 Advanced plotting

**Todo:** Improve documentation.

There are two options to plot several datasets on the same map. If you do not need to specify data specific parameters (e.g. *style*), you can call `cml.plot_map()` with a list of data objects.

```
cml.plot_map((data1, data2), foreground=False)
```

or, if you want to specify a per-data custom *style*, you can use `cml.new_map()`:

```

p = cml.new_plot(projection="global")
p.plot_map(data1, style="style1")
p.plot_map(data2, style="style2")
p.show()

```

## 1.4 Examples

Here is a list of example notebooks to illustrate how to access data, create plots, and do machine learning using CliMetLab.

You can run this notebook in , in , in

```
[1]: !pip3 install --quiet climetlab
```

```

[2]: !test -f test.grib || wget https://github.com/ecmwf/climetlab/raw/main/docs/examples/
↪ test.grib

```

```

[3]: !test -f test.nc || wget https://github.com/ecmwf/climetlab/raw/main/docs/examples/test.
↪ nc

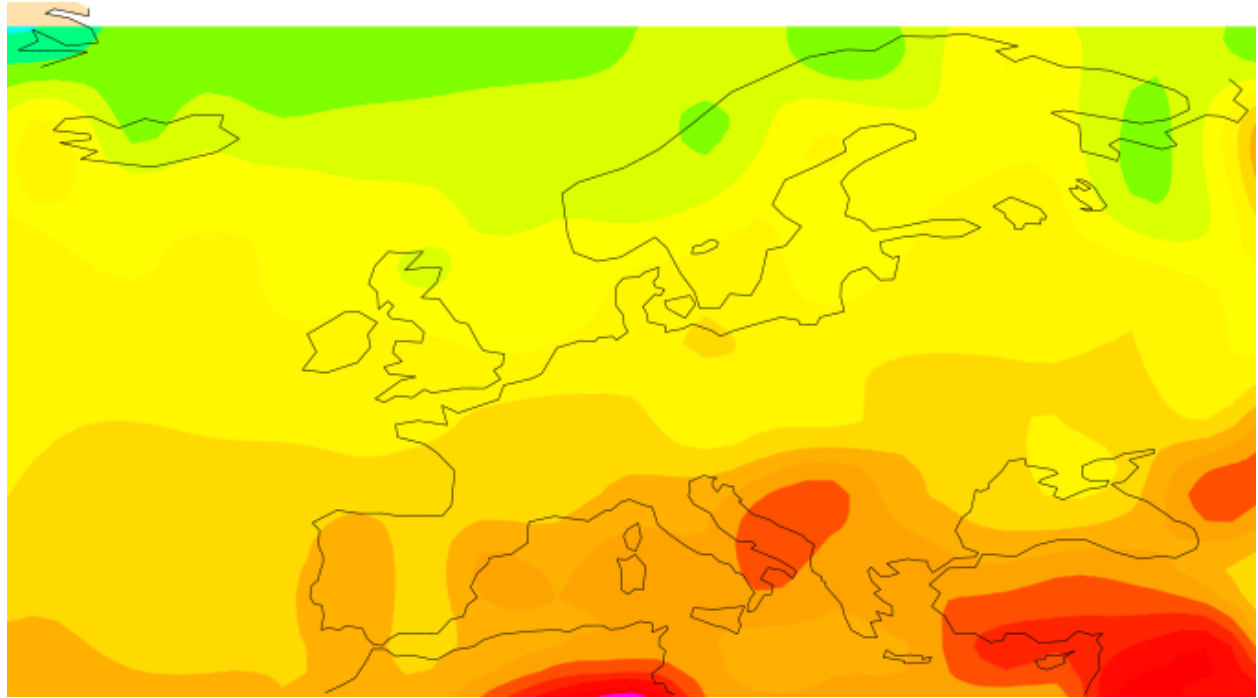
```

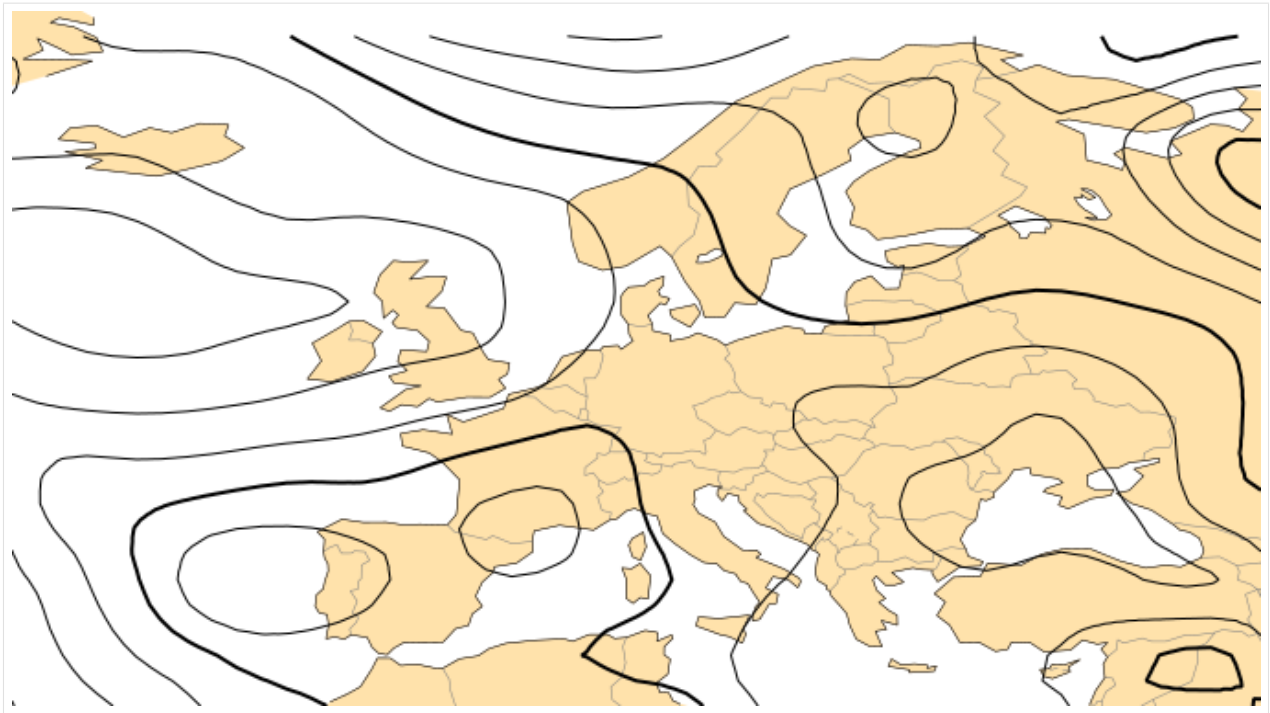
### 1.4.1 Reading data from a file

```
[4]: import climetlab as cml
```

#### Plot GRIB data

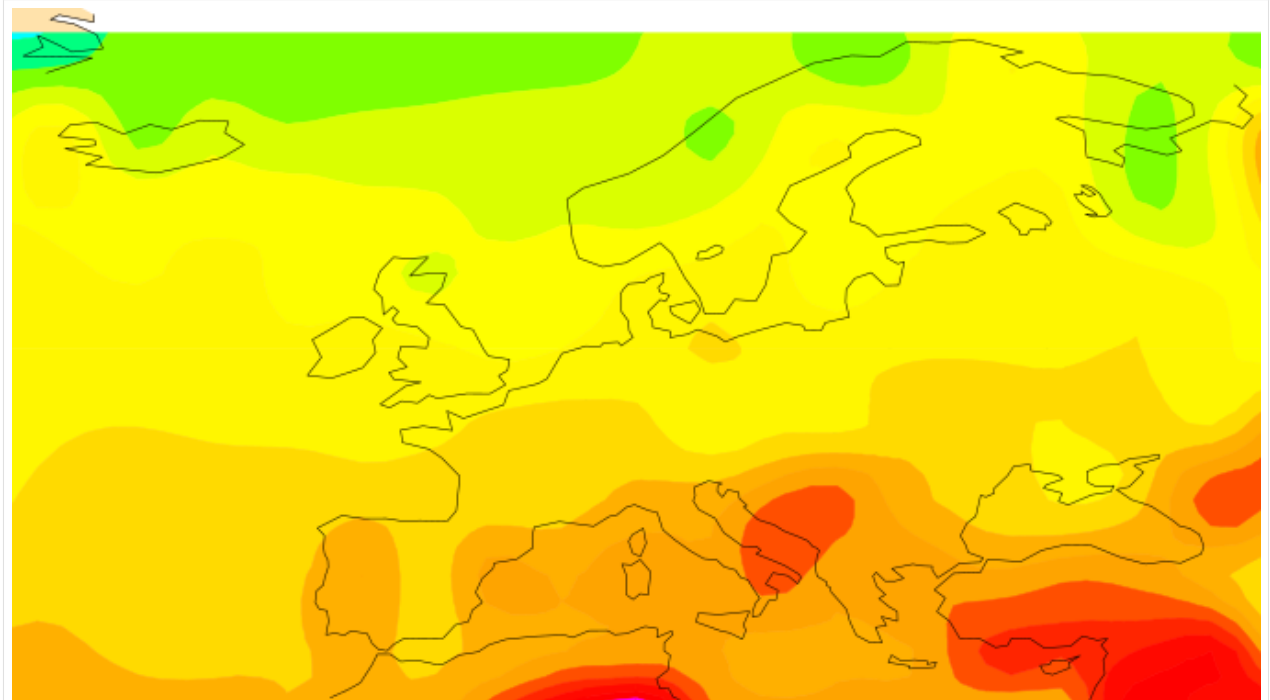
```
[5]: source = cml.load_source("file", "test.grib")
    for s in source:
        cml.plot_map(s)
```





#### Plot NetCDF data

```
[6]: source = cml.load_source("file", "test.nc")
    for s in source:
        cml.plot_map(s)
```





You can run this notebook in , in , in

```
[1]: !pip install --quiet climetlab
```

## 1.4.2 Downloading from an URL

```
[2]: import climetlab as cml
```

```
[3]: URL = "https://www.ncei.noaa.gov/data/international-best-track-archive-for-climate-
↳stewardship-ibtracs/v04r00/access/csv/ibtracs.SP.list.v04r00.csv"
```

```
[4]: data = cml.load_source("url", URL)
```

```
[5]: pd = data.to_pandas()
```

```
/usr/local/lib/python3.9/site-packages/IPython/core/interactiveshell.py:3418:
↳DtypeWarning: Columns (1,2,8,9,14,25,161,162) have mixed types.Specify dtype option on
↳import or set low_memory=False.
exec(code_obj, self.user_global_ns, self.user_ns)
```

```
[6]: uma = pd[pd.NAME == "UMA:VELI"]
```

```
[7]: cml.plot_map(uma, style="cyclone-track")
```





You can run this notebook in , in , in

```
[1]: !pip install --quiet climetlab
```

### 1.4.3 Retrieve ERA5 data from the CDS

```
[2]: import climetlab as cml
```

```
[6]: source = cml.load_source(
    "cds",
    "reanalysis-era5-single-levels",
    variable=["2t", "msl"],
    product_type="reanalysis",
    area=[50, -50, 20, 50],
    date="2012-12-12",
    time="12:00",
)
for s in source:
    cml.plot_map(s)
```



```
[8]: source = cml.load_source(  
    "cds",  
    "reanalysis-era5-single-levels",  
    variable=["2t", "msl"],  
    product_type="reanalysis",  
    area=[50, -50, 20, 50],  
    date="2012-12-12",  
    time="12:00",  
    format="netcdf",  
)  
for s in source:  
    cml.plot_map(s)
```

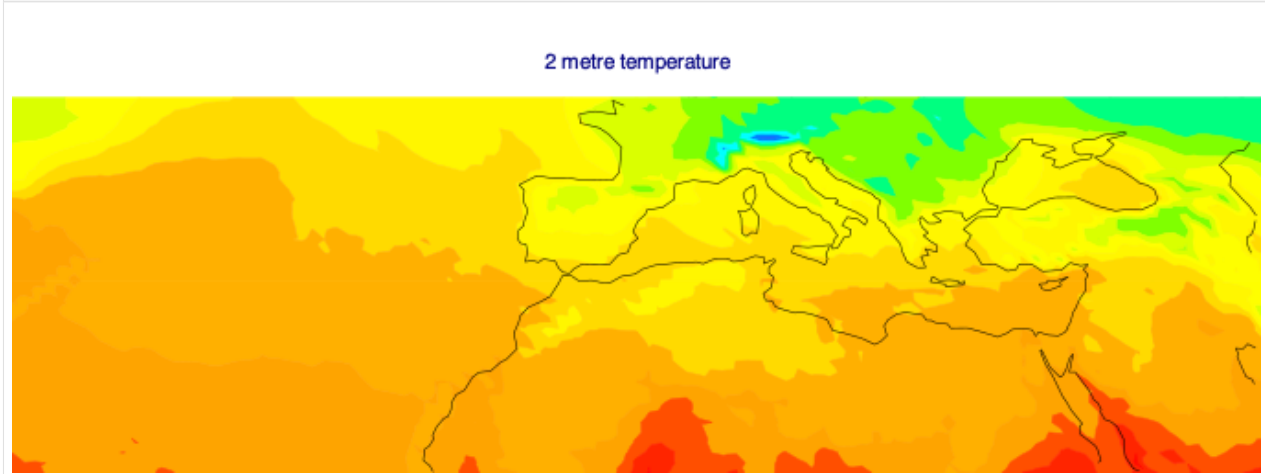




```
[10]: source.to_xarray()
```

```
[10]: <xarray.Dataset>
Dimensions:    (latitude: 121, longitude: 401, time: 1)
Coordinates:
  * longitude   (longitude) float32 -50.0 -49.75 -49.5 -49.25 ... 49.5 49.75 50.0
  * latitude    (latitude) float32 50.0 49.75 49.5 49.25 ... 20.5 20.25 20.0
  * time        (time) datetime64[ns] 2012-12-12T12:00:00
Data variables:
  t2m          (time, latitude, longitude) float32 ...
  msl          (time, latitude, longitude) float32 ...
Attributes:
  Conventions:  CF-1.6
  history:      2021-03-22 10:05:13 GMT by grib_to_netcdf-2.16.0: /opt/ecmw...
```

```
[12]: cml.plot_map(source.to_xarray(), title=True)
```



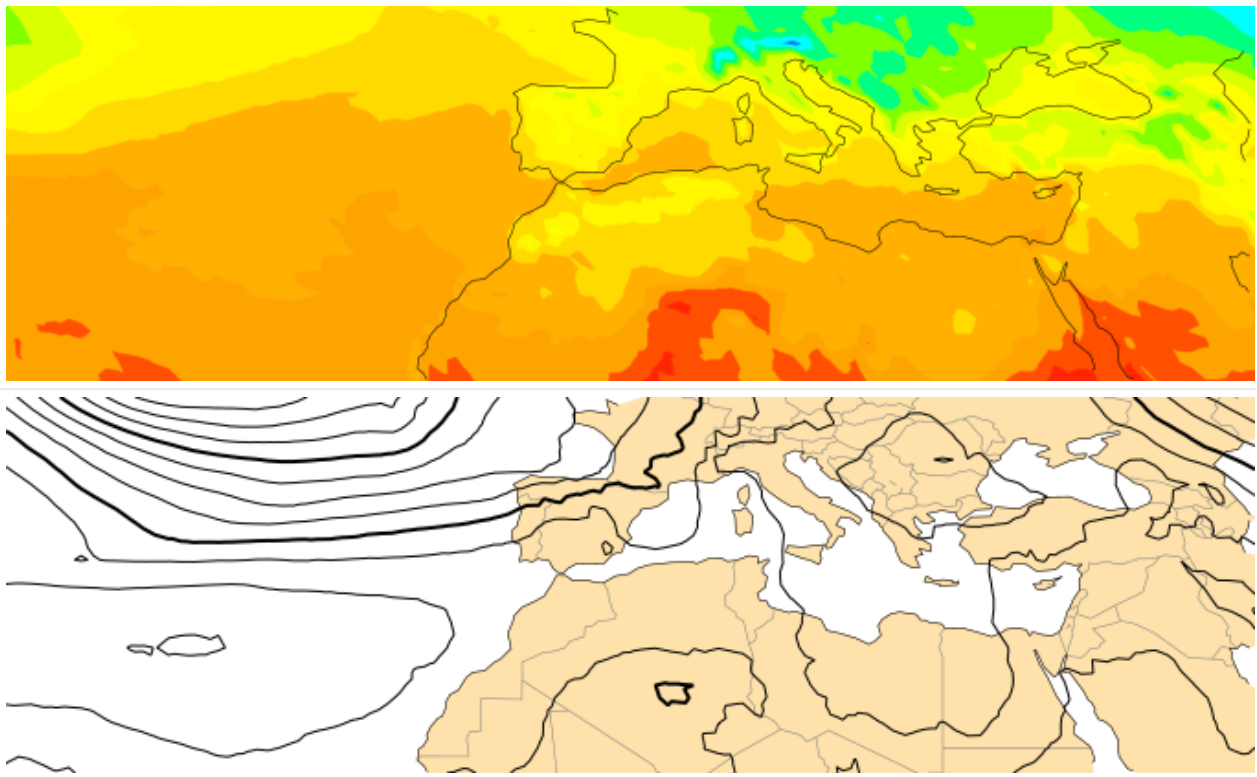
You can run this notebook in , in , in

```
[1]: !pip install --quiet climetlab
```

## 1.4.4 Retrieve data ECMWF MARS archive

```
[2]: import climetlab as cml
```

```
[3]: source = cml.load_source(
    "mars",
    param=["2t", "msl"],
    levtype="sfc",
    area=[50, -50, 20, 50],
    grid=[1, 1],
    date="2012-12-13",
)
for s in source:
    cml.plot_map(s)
```



```
[4]: source.to_xarray()
```

```
[4]: <xarray.Dataset>
Dimensions:      (latitude: 31, longitude: 101)
Coordinates:
  number         int64 ...
  time           datetime64[ns] ...
  step           timedelta64[ns] ...
  surface        int64 ...
  * latitude     (latitude) float64 50.0 49.0 48.0 47.0 ... 23.0 22.0 21.0 20.0
  * longitude    (longitude) float64 -50.0 -49.0 -48.0 -47.0 ... 48.0 49.0 50.0
  valid_time     datetime64[ns] ...
Data variables:
```

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```
t2m      (latitude, longitude) float32 ...
msl      (latitude, longitude) float32 ...
Attributes:
  GRIB_edition:      1
  GRIB_centre:       ecmf
  GRIB_centreDescription: European Centre for Medium-Range Weather Forecasts
  GRIB_subCentre:    0
  Conventions:       CF-1.7
  institution:       European Centre for Medium-Range Weather Forecasts
  history:            2021-03-24T13:23:13 GRIB to CDM+CF via cfgrib-0...
```

You can run this notebook in , in , in

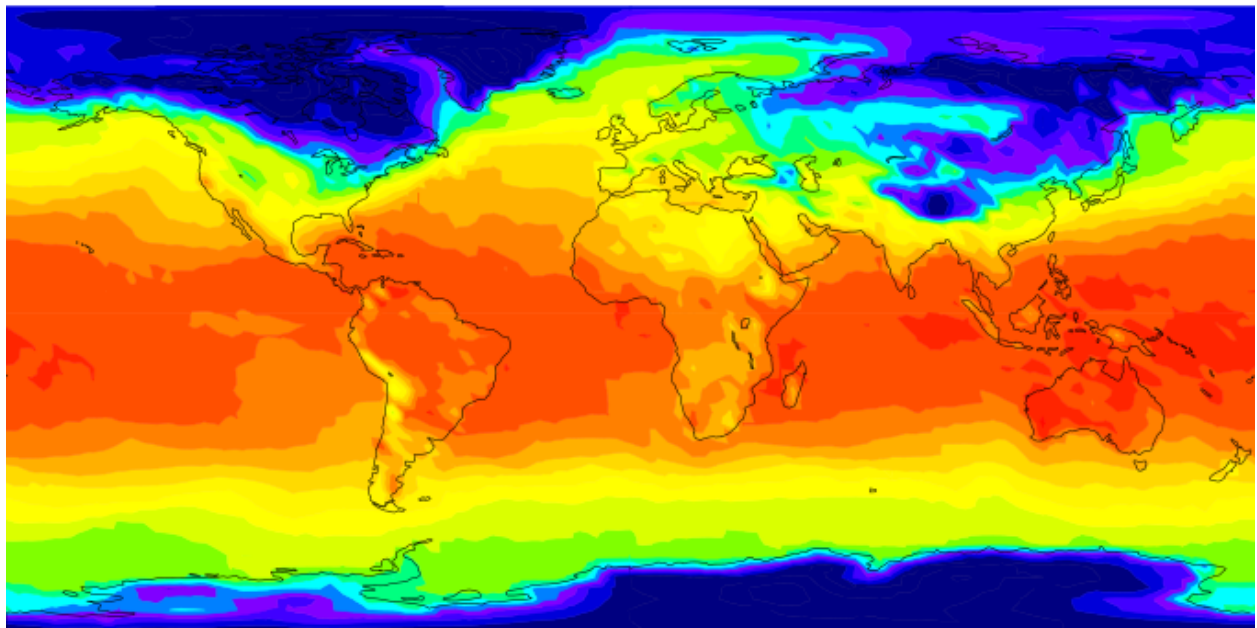
```
[20]: !pip install --quiet climetlab
```

### 1.4.5 Access ECMWF Open Data feed

```
[21]: import climetlab as cml
```

```
[22]: source = cml.load_source(
        "ecmwf-open-data",
        param=["2t", "msl"],
    )
    for s in source:
        cml.plot_map(s, title=True)
```

Sunday 06 February 2022 00 UTC ecmf t+0 VT: Sunday 06 February 2022 00 UTC 2 m 2 metre temperature





```
[23]: source.to_xarray()
```

```
[23]: <xarray.Dataset>
```

```
Dimensions:                (latitude: 451, longitude: 900)
```

```
Coordinates:
```

```
    time                    datetime64[ns] ...
```

```
    step                    timedelta64[ns] ...
```

```
    heightAboveGround       float64 ...
```

```
* latitude                  (latitude) float64 90.0 89.6 89.2 ... -89.2 -89.6 -90.0
```

```
* longitude                  (longitude) float64 -180.0 -179.6 -179.2 ... 179.2 179.6
```

```
    valid_time              datetime64[ns] ...
```

```
    meanSea                  float64 ...
```

```
Data variables:
```

```
    t2m                      (latitude, longitude) float32 ...
```

```
    msl                      (latitude, longitude) float32 ...
```

```
Attributes:
```

```
    GRIB_edition:            2
```

```
    GRIB_centre:             ecmf
```

```
    GRIB_centreDescription:  European Centre for Medium-Range Weather Forecasts
```

```
    GRIB_subCentre:          0
```

```
    Conventions:             CF-1.7
```

```
    institution:             European Centre for Medium-Range Weather Forecasts
```

```
    history:                  2022-02-06T12:42 GRIB to CDM+CF via cfgrib-0.9.1...
```

You can run this notebook in , in , in

```
[1]: !pip install --quiet climetlab matplotlib
```

### 1.4.6 ERA5-based datasets

```
[2]: import numpy as np
import matplotlib.pyplot as plt
```

```
[3]: import climetlab as cml
```

```
[4]: cml.plotting_options(width=400)
```

#### Surface temperature in France

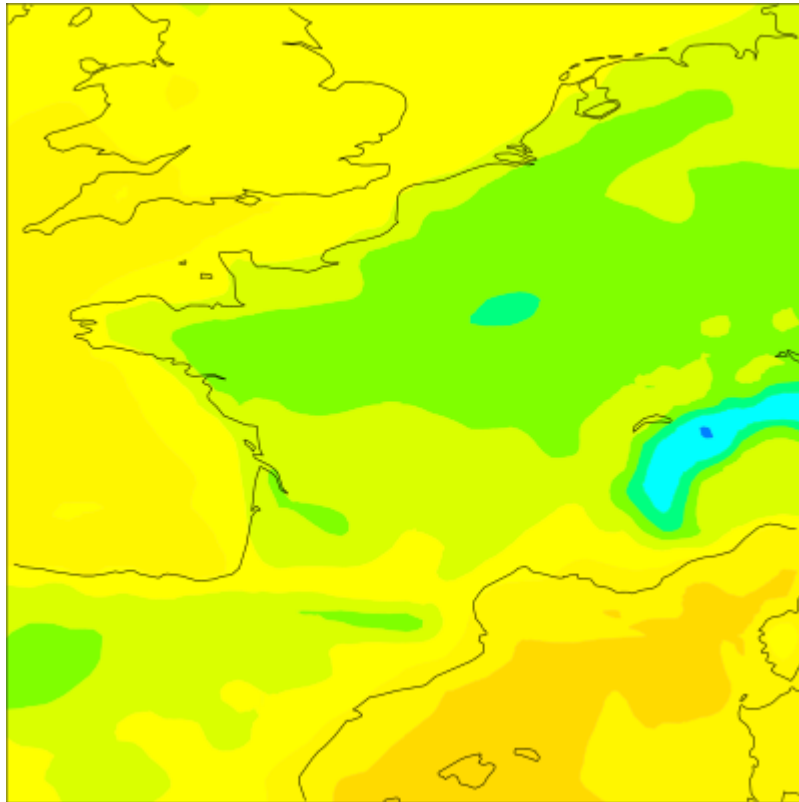
```
[5]: ds = cml.load_dataset("era5-temperature", period=(1979, 1982), domain="France", time=12)
```

```
[6]: %%time
len(ds)

CPU times: user 558 ms, sys: 94.9 ms, total: 653 ms
Wall time: 686 ms
```

```
[6]: 1461
```

```
[7]: cml.plot_map(ds[-1])
```



```
[8]: %%time
ds.to_numpy().shape
```



```
CPU times: user 603 ms, sys: 124 ms, total: 727 ms
Wall time: 739 ms
```

```
[8]: (1461, 63, 63)
```

```
[9]: average = np.mean(ds.to_numpy(), axis=0)
```

```
[10]: average
```

```
[10]: array([[283.75848794, 283.5668571 , 283.28540925, ..., 283.07590083,
          283.10228607, 283.10129547],
          [283.4987798 , 283.60046529, 283.65712864, ..., 283.17566394,
          283.24349259, 283.31315138],
          [283.27489098, 282.96305539, 283.02593639, ..., 283.29626172,
          283.42080452, 283.51664   ],
          ...,
          [291.8236389 , 291.01727633, 290.47778203, ..., 292.8580171 ,
          292.87150182, 293.54986986],
          [292.33919705, 292.04851029, 291.94756675, ..., 292.50002974,
          292.48287807, 294.12919668],
          [292.80611291, 292.51362676, 292.36608895, ..., 292.37801758,
          292.20149706, 292.06164609]])
```

```
[11]: cml.plot_map(average, metadata=ds[0])
```



```
[12]: x = ds.to_xarray()
```



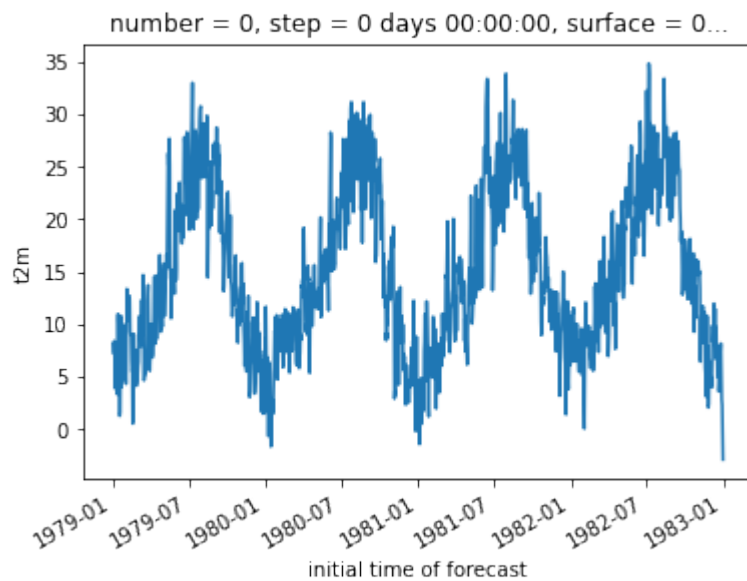
```
[13]: x
```

```
[13]: <xarray.Dataset>
Dimensions:      (latitude: 63, longitude: 63, time: 1461)
Coordinates:
  * time          (time) datetime64[ns] 1979-01-01T12:00:00 ... 1982-12-31T12:0...
    number        int64 0
    step          timedelta64[ns] 00:00:00
    surface       int64 0
  * latitude      (latitude) float64 54.5 54.25 54.0 53.75 ... 39.5 39.25 39.0
  * longitude     (longitude) float64 -6.0 -5.75 -5.5 -5.25 ... 8.75 9.0 9.25 9.5
    valid_time    (time) datetime64[ns] 1979-01-01T12:00:00 ... 1982-12-31T12:0...
Data variables:
    t2m           (time, latitude, longitude) float32 269.13837 ... 285.14648
```

```
[14]: point = x.t2m.isel(latitude=50, longitude=5) - 273.15
```

```
[15]: point.plot()
```

```
[15]: [<matplotlib.lines.Line2D at 0x10f788130>]
```



```
[16]: x.t2m.plot()
```

```
[16]: (array([6.200000e+01, 1.715000e+03, 2.437000e+04, 2.066870e+05,
        1.035682e+06, 2.078559e+06, 1.673685e+06, 6.841460e+05,
        9.120900e+04, 2.594000e+03]),
 array([247.29189, 254.00276, 260.71362, 267.4245 , 274.13538, 280.84625,
        287.55713, 294.268 , 300.97888, 307.68976, 314.40063],
      dtype=float32),
 <BarContainer object of 10 artists>)
```



[17]: `cml.plot_map(x)`



## Precipitations from Ireland

```
[18]: ds = cml.load_dataset(
      "era5-precipitations", period=(1979, 1982), domain="Ireland", time=12
    )
```

```
[19]: cml.plot_map(ds[0])
```



You can run this notebook in , in , in

```
[1]: !pip install --quiet climetlab tensorflow
```

## 1.4.7 Machine learning example

```
[2]: from tensorflow.keras.layers import Input, Dense, Flatten
      from tensorflow.keras.models import Sequential
```

```
[3]: import climetlab as cml
```

### Load the high-low data set and plot all the fields and their label

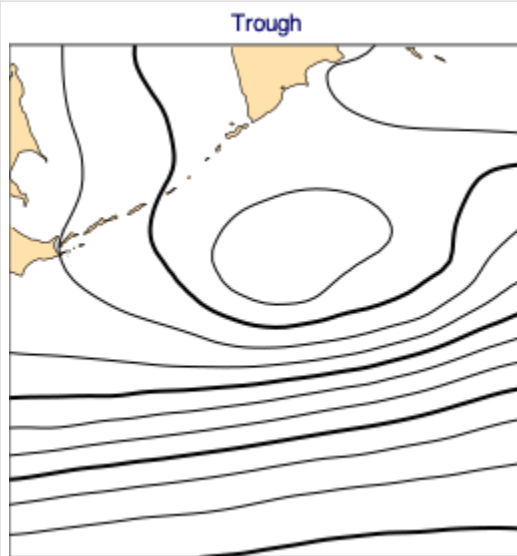
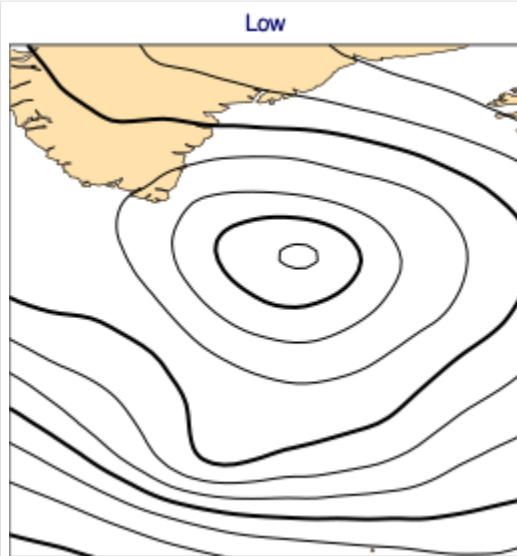
```
[4]: highlow = cml.load_dataset("high-low")
     for field, label in highlow.fields():
         cml.plot_map(field, width=256, title=highlow.title(label))
```

Trough

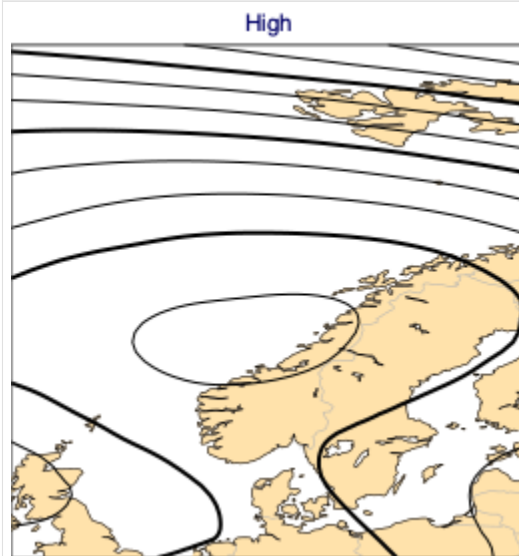
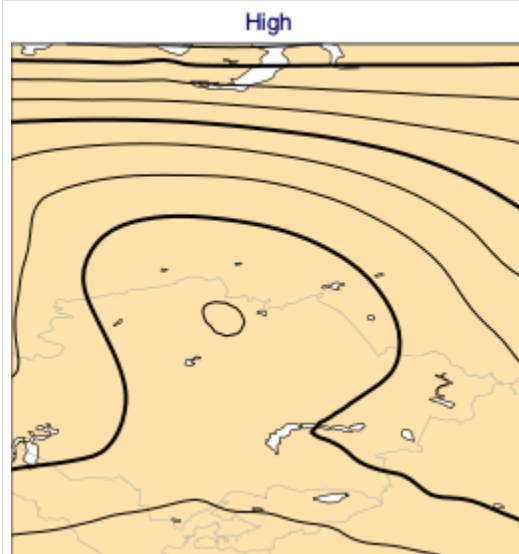
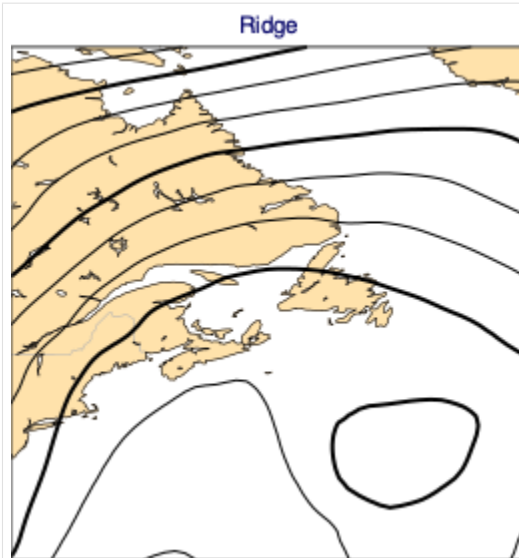


Ridge





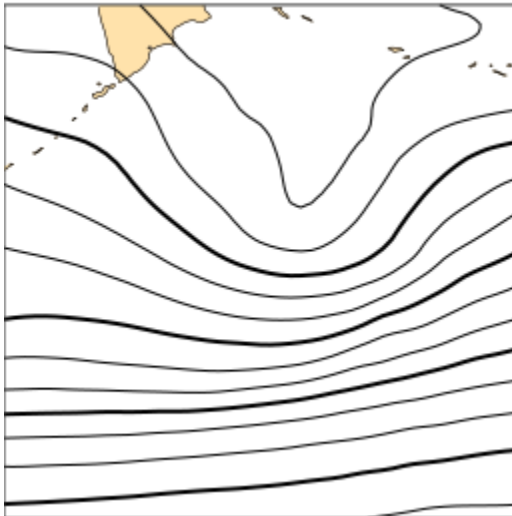




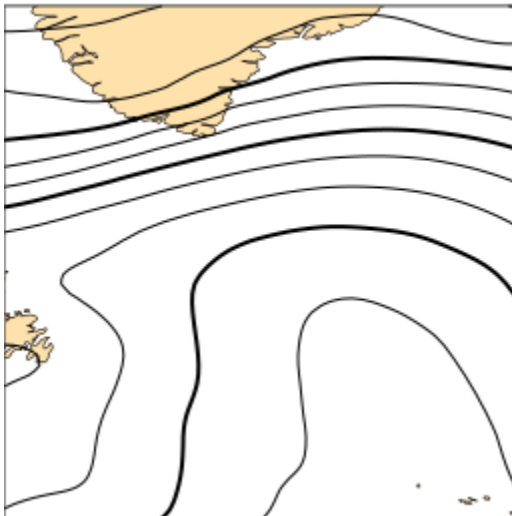




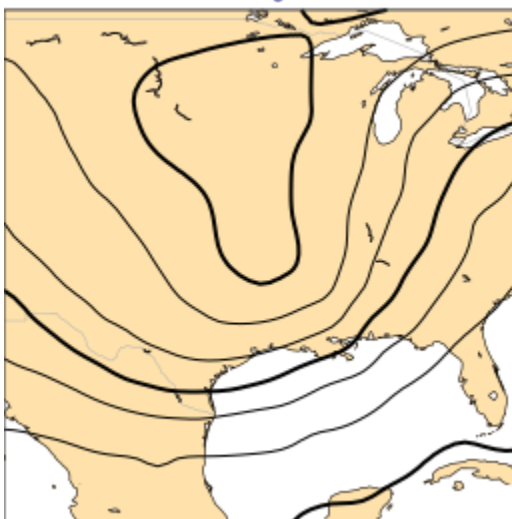
Trough



Ridge



Trough



Ridge



Low

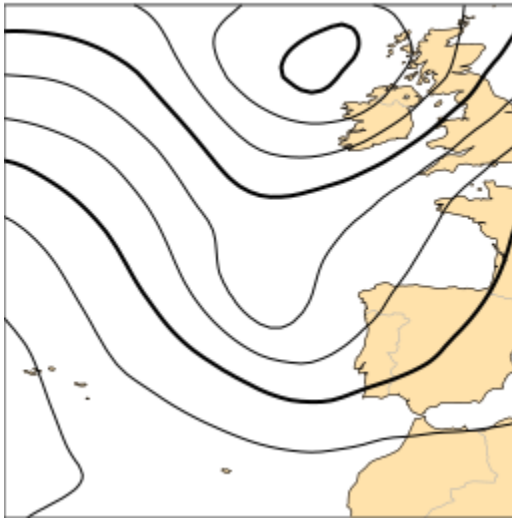


Trough





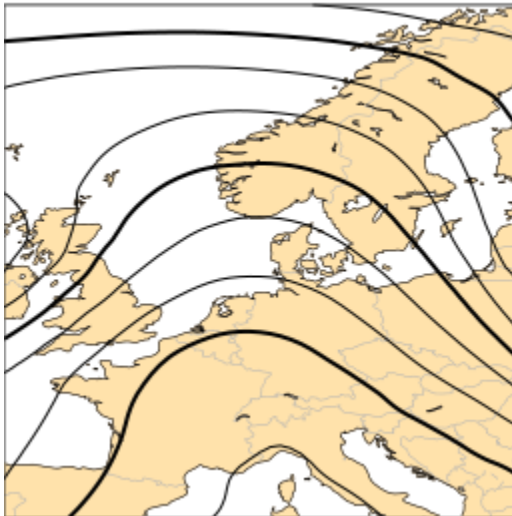
Trough



Ridge



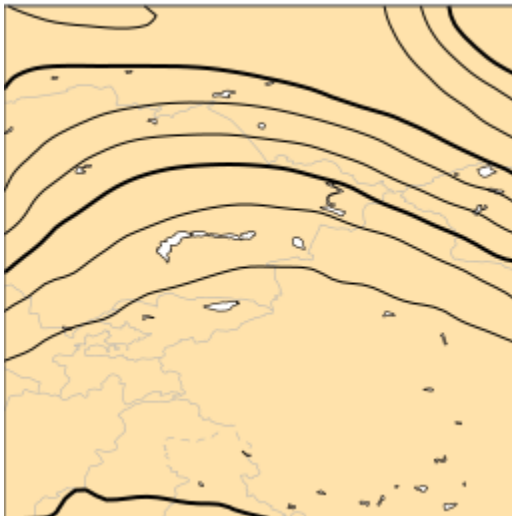
Ridge



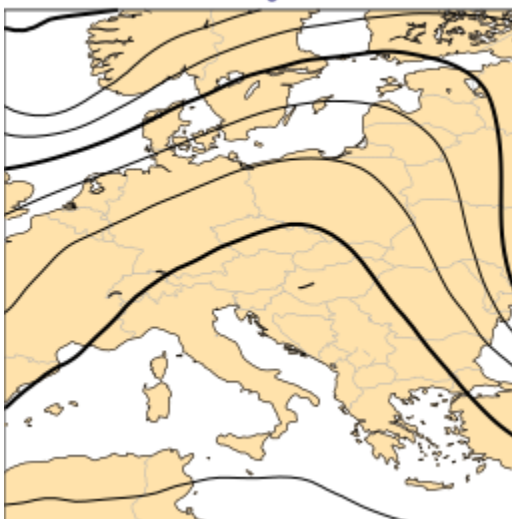
Trough

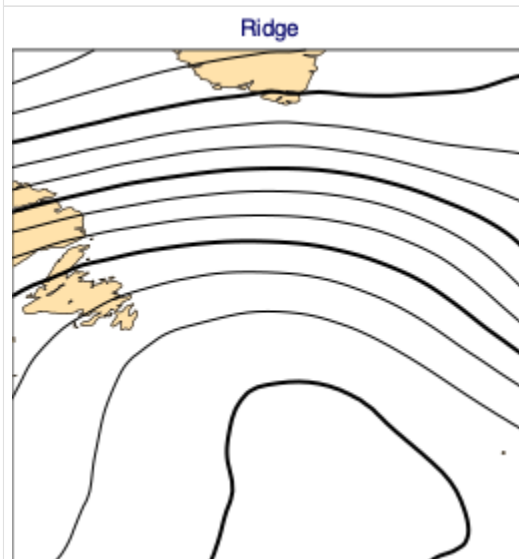
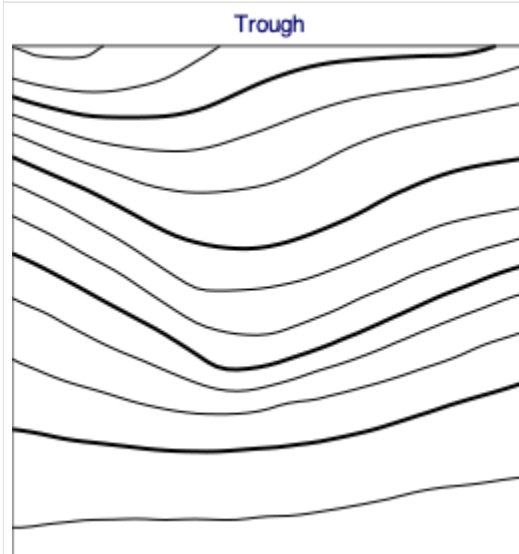
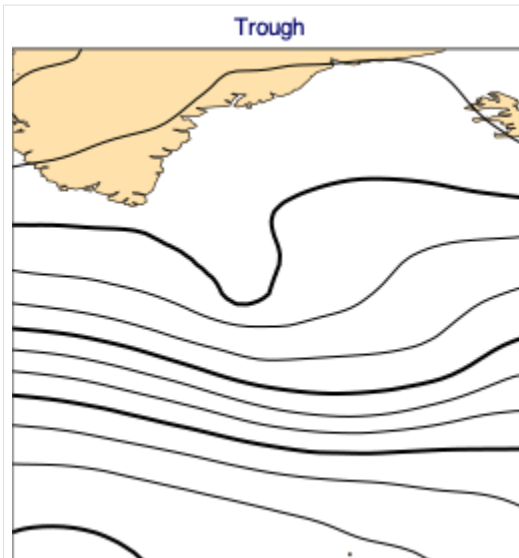


High



Ridge









### Get the train and test sets

```
[5]: (x_train, y_train, f_train), (x_test, y_test, f_test) = highlow.load_data(  
    test_size=0.3, fields=True  
)
```



## Build the model

```

[6]: model = Sequential()
      model.add(Input(shape=x_train[0].shape))
      model.add(Flatten())
      model.add(Dense(64, activation="sigmoid"))
      model.add(Dense(4, activation="softmax"))
  
```

```

[7]: model.compile(optimizer="adam", loss="categorical_crossentropy", metrics=["accuracy"])
      print(model.summary())
  
```

Model: "sequential"

| Layer (type)      | Output Shape | Param # |
|-------------------|--------------|---------|
| =====             |              |         |
| flatten (Flatten) | (None, 441)  | 0       |
| -----             |              |         |
| dense (Dense)     | (None, 64)   | 28288   |
| -----             |              |         |
| dense_1 (Dense)   | (None, 4)    | 260     |
| =====             |              |         |

Total params: 28,548

Trainable params: 28,548

Non-trainable params: 0

None

## Train the model

```

[8]: h = model.fit(x_train, y_train, epochs=100, verbose=0)
  
```

Evaluate the model on the test set

```

[9]: model.evaluate(x_test, y_test)
  
```

1/1 [=====] - 0s 1ms/step - loss: 0.2691 - accuracy: 0.9167

```

[9]: [0.26906612515449524, 0.9166666865348816]
  
```

## Plot the predictions

```

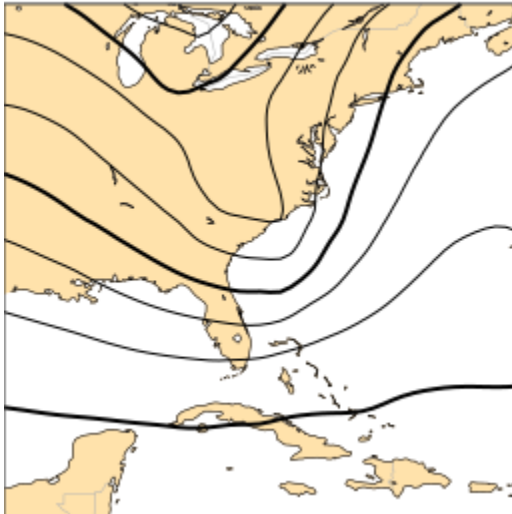
[10]: predicted = model.predict(x_test)

      for p, f in zip(predicted, f_test):
          cml.plot_map(f, width=256, title=highlow.title(p))
  
```

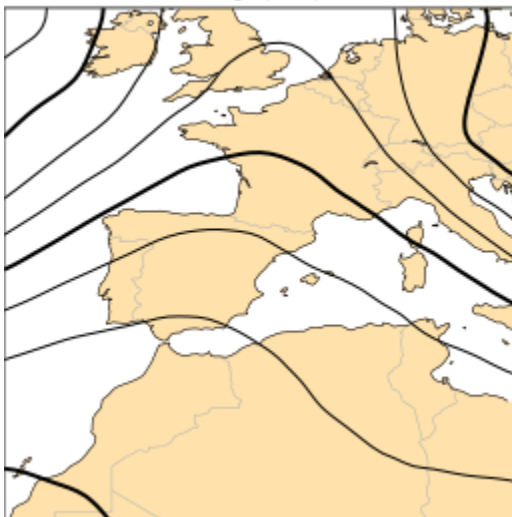
High (88%)



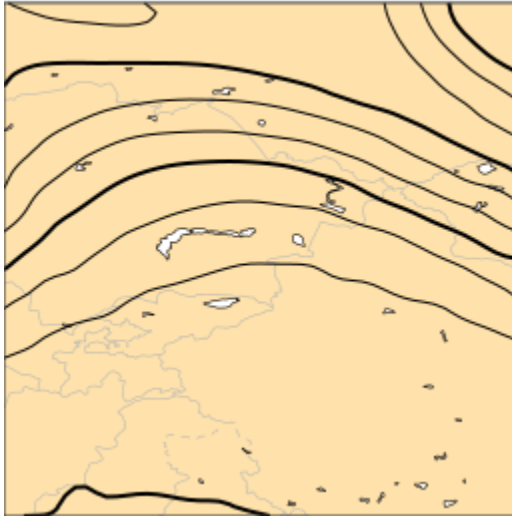
Trough (75%)



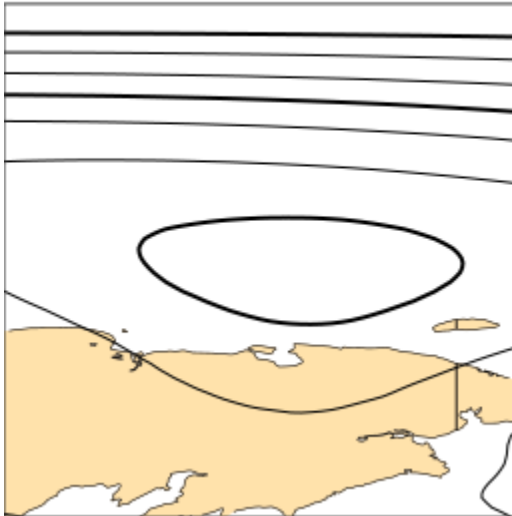
Ridge (90%)



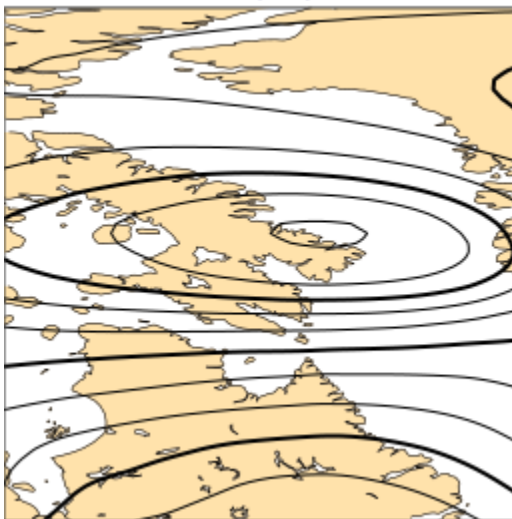
Ridge (67%)

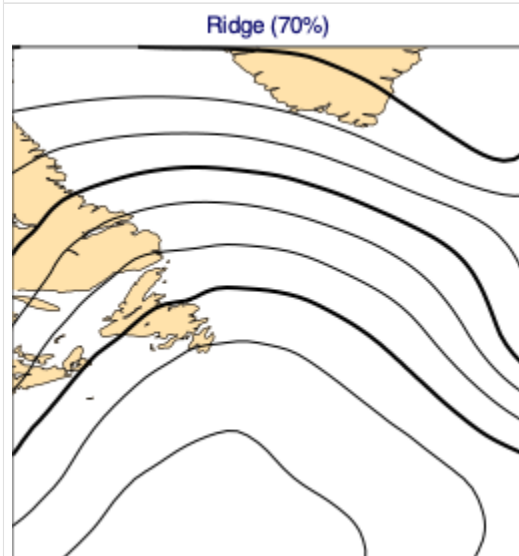
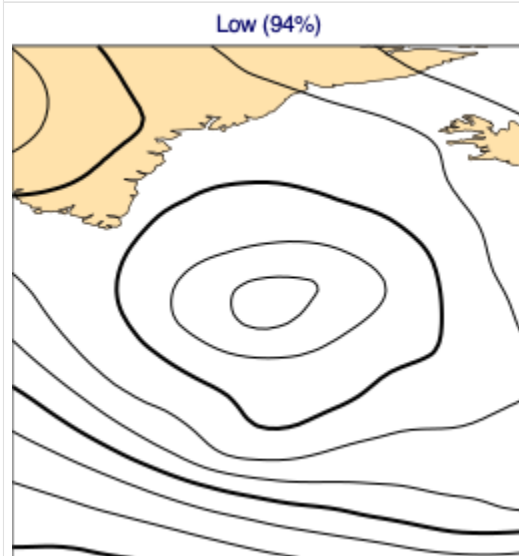


High (89%)



Low (94%)

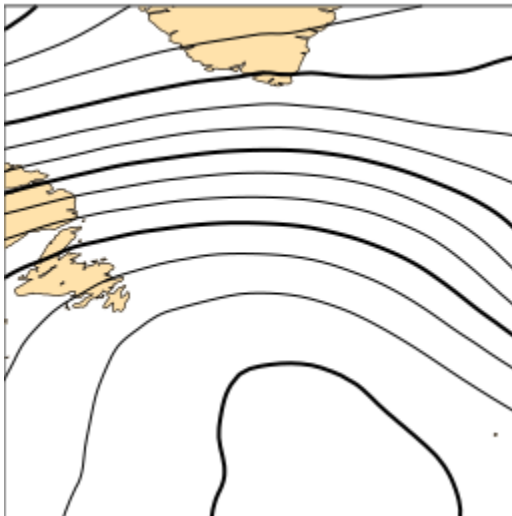




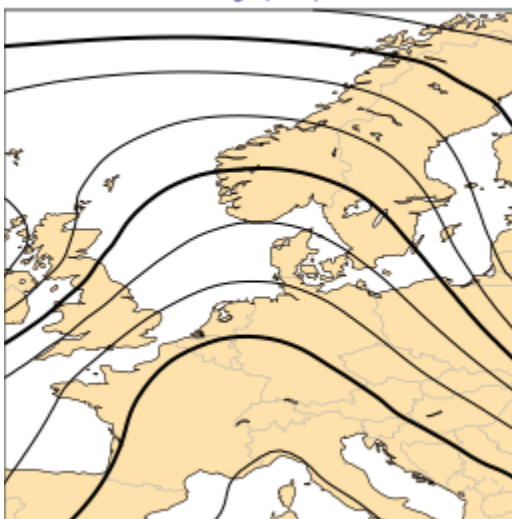
Trough (98%)



Ridge (80%)



Ridge (87%)



You can run this notebook in , in , in

```
[1]: !pip install --quiet climetlab
```

## 1.4.8 BUFR data

```
[2]: import climetlab as cml
```

```
[3]: source = cml.load_dataset("sample-bufr-data")
```

```
[4]: source
```

```
[4]: YAML[/Users/ baudouin/ git/ climetlab/ climetlab/ datasets/ sample-bufr-data. yaml]
```

See <https://github.com/ecmwf/pdbufr>

```
[5]: pd = source.to_pandas(
    columns=(
        "stationNumber",
        "latitude",
        "longitude",
        "data_datetime",
        "pressure",
        "airTemperature",
    ),
    filters={},
)
```

```
[6]: pd.head()
```

```
[6]:
```

|   | stationNumber | latitude | longitude | pressure | airTemperature | \ |
|---|---------------|----------|-----------|----------|----------------|---|
| 0 | 907           | 58.47    | -78.08    | 100300.0 | 258.3          |   |
| 1 | 907           | 58.47    | -78.08    | 100000.0 | 259.7          |   |
| 2 | 907           | 58.47    | -78.08    | 99800.0  | 261.1          |   |
| 3 | 907           | 58.47    | -78.08    | 99100.0  | 261.7          |   |
| 4 | 907           | 58.47    | -78.08    | 92500.0  | 258.1          |   |

```

    data_datetime
0 2008-12-08 12:00:00
1 2008-12-08 12:00:00
2 2008-12-08 12:00:00
3 2008-12-08 12:00:00
4 2008-12-08 12:00:00

```

```
[7]: pd.tail()
```

```
[7]:
```

|       | stationNumber | latitude | longitude | pressure | airTemperature | \ |
|-------|---------------|----------|-----------|----------|----------------|---|
| 26191 | 968           | 25.03    | 121.52    | 10000.0  | 197.9          |   |
| 26192 | 968           | 25.03    | 121.52    | 9520.0   | 196.3          |   |
| 26193 | 968           | 25.03    | 121.52    | 7000.0   | 201.5          |   |
| 26194 | 968           | 25.03    | 121.52    | 5000.0   | 209.1          |   |
| 26195 | 968           | 25.03    | 121.52    | 3000.0   | 217.3          |   |

(continues on next page)

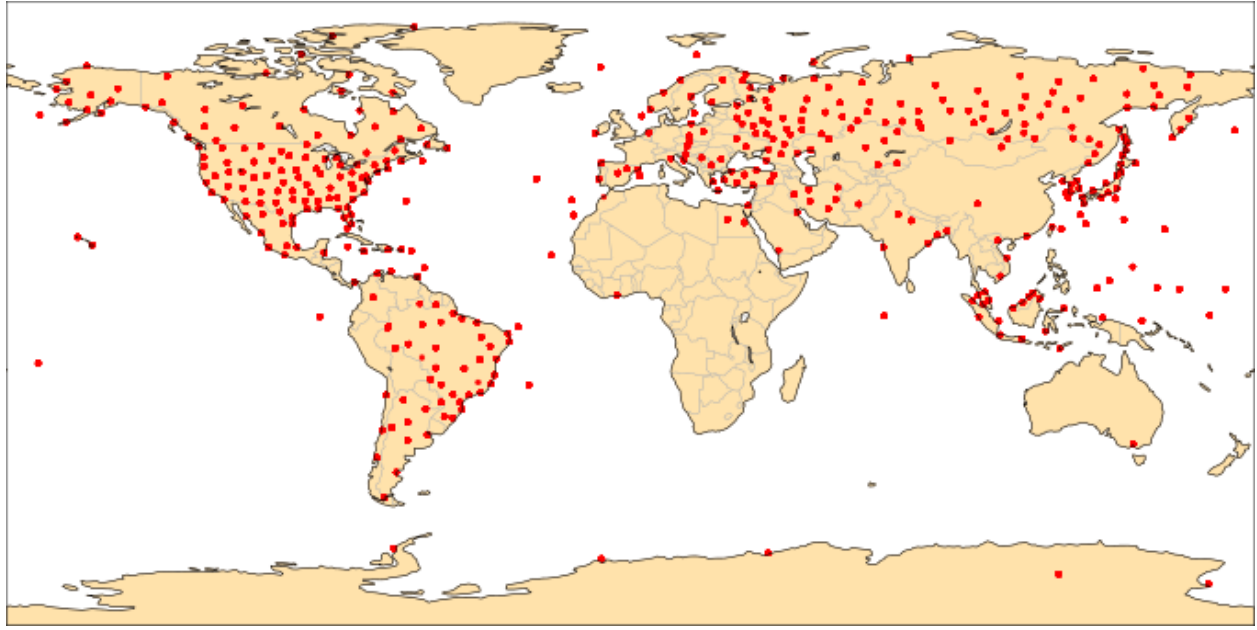
(continued from previous page)

```

data_datetime
26191 2008-12-08 12:00:00
26192 2008-12-08 12:00:00
26193 2008-12-08 12:00:00
26194 2008-12-08 12:00:00
26195 2008-12-08 12:00:00

```

```
[8]: cml.plot_map(pd, projection="global")
```



You can run this notebook in , in , in

```
[1]: !pip install --quiet climetlab[interactive]
```

## 1.4.9 ECMWF Observation bespoke format (ODB)

```
[2]: import climetlab as cml
```

```
[3]: source = cml.load_source(
    "mars",
    type="ofb",
    obsgroup="conv",
    time="12",
    format="odb",
    reporttype=16001,
    date="2020-05-18",
)
```

```
[4]: pd = source.to_pandas()
```

[5]: pd

```
[5]:
```

|        | type | expver | class | stream | andate   | antime | reportype | \ |
|--------|------|--------|-------|--------|----------|--------|-----------|---|
| 0      | 263  | 0001   | 1     | 1025   | 20200518 | 120000 | 16001     |   |
| 1      | 263  | 0001   | 1     | 1025   | 20200518 | 120000 | 16001     |   |
| 2      | 263  | 0001   | 1     | 1025   | 20200518 | 120000 | 16001     |   |
| 3      | 263  | 0001   | 1     | 1025   | 20200518 | 120000 | 16001     |   |
| 4      | 263  | 0001   | 1     | 1025   | 20200518 | 120000 | 16001     |   |
| ...    | ...  | ...    | ...   | ...    | ...      | ...    | ...       |   |
| 410015 | 263  | 0001   | 1     | 1025   | 20200518 | 120000 | 16001     |   |
| 410016 | 263  | 0001   | 1     | 1025   | 20200518 | 120000 | 16001     |   |
| 410017 | 263  | 0001   | 1     | 1025   | 20200518 | 120000 | 16001     |   |
| 410018 | 263  | 0001   | 1     | 1025   | 20200518 | 120000 | 16001     |   |
| 410019 | 263  | 0001   | 1     | 1025   | 20200518 | 120000 | 16001     |   |

|        | numtsl@desc | timeslot@timeslot_index | seqno@hdr | ...     | \   |
|--------|-------------|-------------------------|-----------|---------|-----|
| 0      | 17          |                         | 15        | 4443    | ... |
| 1      | 17          |                         | 15        | 4443    | ... |
| 2      | 17          |                         | 15        | 4443    | ... |
| 3      | 17          |                         | 15        | 4443    | ... |
| 4      | 17          |                         | 15        | 4443    | ... |
| ...    | ...         |                         | ...       | ...     | ... |
| 410015 | 17          |                         | 15        | 9133718 | ... |
| 410016 | 17          |                         | 15        | 9133718 | ... |
| 410017 | 17          |                         | 15        | 9133718 | ... |
| 410018 | 17          |                         | 15        | 9133718 | ... |
| 410019 | 17          |                         | 15        | 9133718 | ... |

|        | datum_rdbflag@body | biascorr@body | biascorr_fg@body | qc_pge@body | \   |
|--------|--------------------|---------------|------------------|-------------|-----|
| 0      |                    | 0             | NaN              | NaN         | NaN |
| 1      |                    | 0             | NaN              | NaN         | NaN |
| 2      |                    | 0             | 0.0              | 0.0         | NaN |
| 3      |                    | 0             | 0.0              | 0.0         | NaN |
| 4      |                    | 0             | 0.0              | 0.0         | NaN |
| ...    | ...                | ...           | ...              | ...         | ... |
| 410015 |                    | 0             | 0.0              | 0.0         | NaN |
| 410016 |                    | 0             | 0.0              | 0.0         | NaN |
| 410017 |                    | 0             | 0.0              | 0.0         | NaN |
| 410018 |                    | 0             | 0.0              | 0.0         | NaN |
| 410019 |                    | 0             | 0.0              | 0.0         | NaN |

|        | an_depar@body | fg_depar@body | obs_error@errstat | \ |
|--------|---------------|---------------|-------------------|---|
| 0      | -10.560810    | -14.283884    | 41.155659         |   |
| 1      | 36.250599     | 34.712360     | 41.155659         |   |
| 2      | -9.160848     | -12.384340    | 33.596455         |   |
| 3      | NaN           | NaN           | NaN               |   |
| 4      | 2.482570      | 2.683633      | 1.408449          |   |
| ...    | ...           | ...           | ...               |   |
| 410015 | NaN           | NaN           | NaN               |   |
| 410016 | NaN           | NaN           | NaN               |   |
| 410017 | NaN           | NaN           | NaN               |   |
| 410018 | NaN           | NaN           | NaN               |   |
| 410019 | NaN           | NaN           | NaN               |   |

(continues on next page)

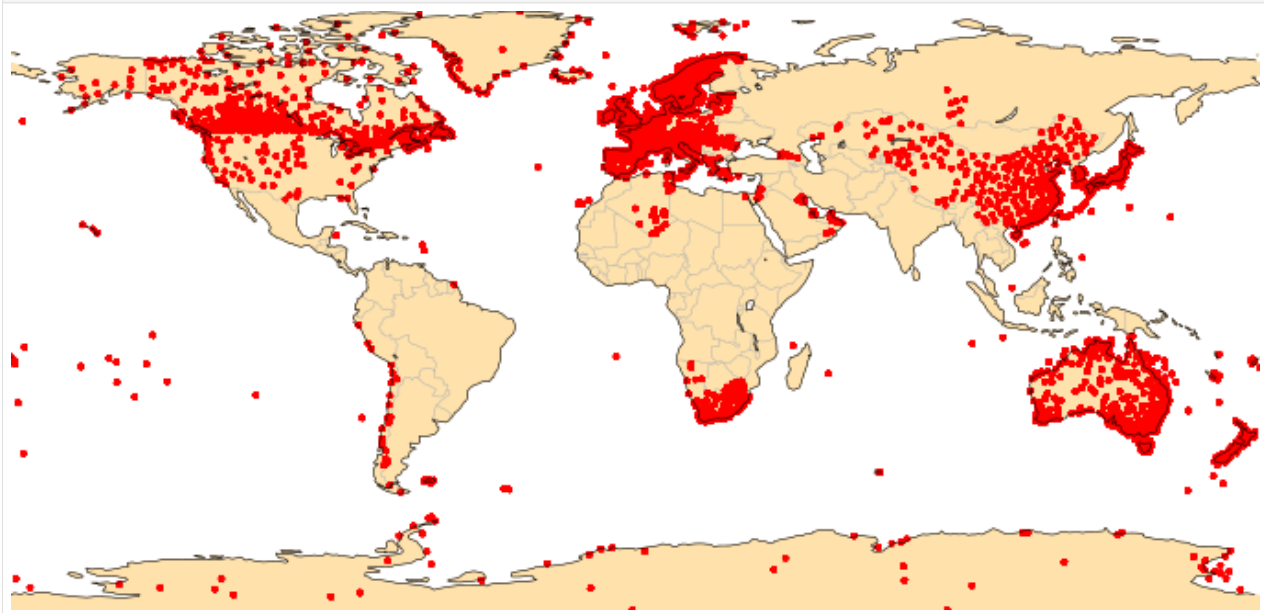


(continued from previous page)

|        | final_obs_error@errstat | fg_error@errstat | eda_spread@errstat |
|--------|-------------------------|------------------|--------------------|
| 0      | 41.155659               | 25.144444        | 13.044278          |
| 1      | 41.155659               | 25.144444        | 13.044278          |
| 2      | 33.596455               | 0.260278         | 0.011694           |
| 3      | NaN                     | NaN              | NaN                |
| 4      | 1.408449                | 0.502528         | 0.395115           |
| ...    | ...                     | ...              | ...                |
| 410015 | NaN                     | NaN              | NaN                |
| 410016 | NaN                     | NaN              | NaN                |
| 410017 | NaN                     | NaN              | NaN                |
| 410018 | NaN                     | NaN              | NaN                |
| 410019 | NaN                     | NaN              | NaN                |

[410020 rows x 51 columns]

[6]: `cml.plot_map(pd)`



You can run this notebook in , in , in

[1]: `# !pip install --quiet climetlab`

## 1.4.10 Meteonet

This is an retrieve an plot various data types from <https://github.com/meteofrance/meteonet>

[2]: `import climetlab as cml`

## Radar images

```
[3]: ds = cml.load_dataset("meteonet-samples-radar")
```

```
[4]: ds
```

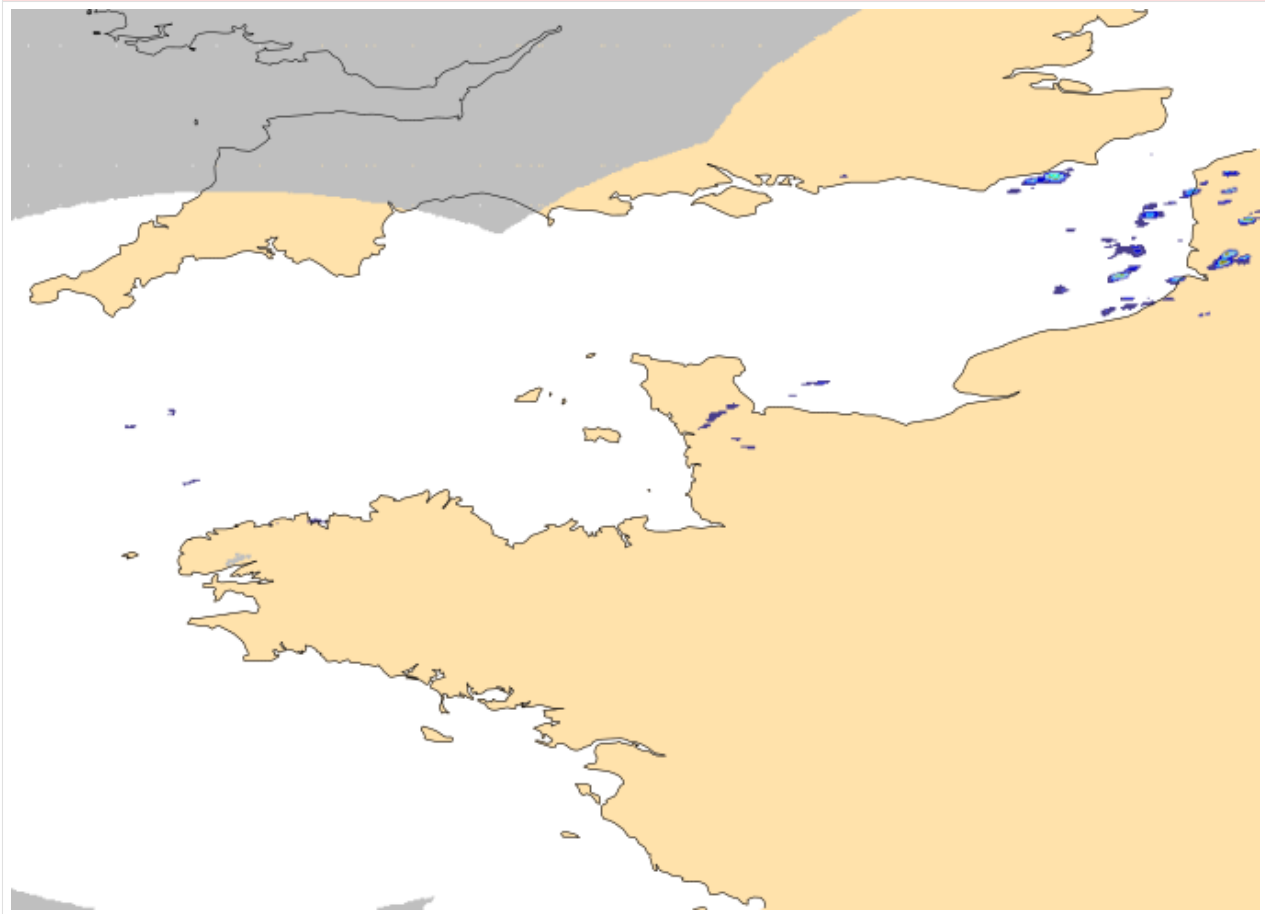
```
[4]: <climetlab.datasets.meteonet_samples.radar.MeteonetRadar at 0x104319b50>
```

```
[5]: ds.licence
```

```
[5]: 'https://meteonet.umr-cnrm.fr/dataset/LICENCE.md'
```

```
[6]: cml.plot_map(ds)
```

```
/Users/baudouin/git/climetlab/climetlab/normalize.py:17: UserWarning: Deprecated_
decorator @normalize_arg. Use @normalise on each argument instead.
warnings.warn(
```



```
[7]: ds.to_xarray()
```

```
[7]: <xarray.Dataset>
```

```
Dimensions: (time: 45, y: 565, x: 784)
```

```
Coordinates:
```

```
* x      (x) int64 0 1 2 3 4 5 6 7 8 ... 776 777 778 779 780 781 782 783
* y      (y) int64 0 1 2 3 4 5 6 7 8 ... 557 558 559 560 561 562 563 564
```

(continues on next page)

(continued from previous page)

```
lon      (y, x) float64 -5.832 -5.822 -5.812 -5.802 ... 1.978 1.988 1.998
lat      (y, x) float64 51.89 51.89 51.89 51.89 ... 46.25 46.25 46.25 46.25
* time   (time) datetime64[ns] 2016-08-21T00:10:00 ... 2016-08-31T00:30:00
Data variables:
rainfall (time, y, x) int16 -1 -1 -1 -1 -1 -1 -1 -1 -1 ... 0 0 0 0 0 0 0 0
```

## Ground station observations

```
[8]: ds = cml.load_dataset("meteonet-samples-ground-stations", domain="SE")
```

```
[9]: ds.to_pandas()
```

```
[9]:
```

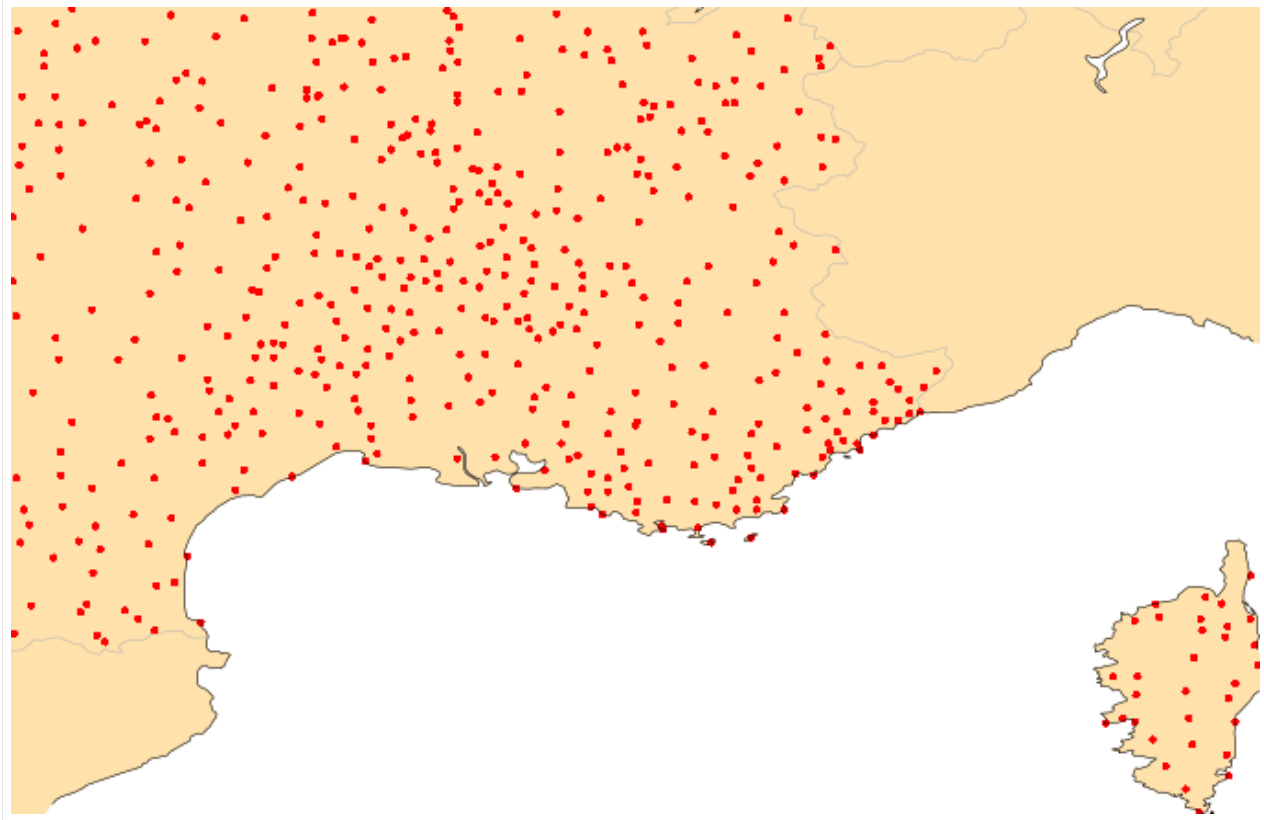
|        | number_sta | lat      | lon     | height_sta | date                | dd \  |
|--------|------------|----------|---------|------------|---------------------|-------|
| 0      | 1027003    | 45.83000 | 5.11000 | 196.0      | 2016-01-01 00:00:00 | NaN   |
| 1      | 1033002    | 46.09000 | 5.81000 | 350.0      | 2016-01-01 00:00:00 | 0.0   |
| 2      | 1034004    | 45.77000 | 5.69000 | 330.0      | 2016-01-01 00:00:00 | 0.0   |
| 3      | 1072001    | 46.20000 | 5.29000 | 260.0      | 2016-01-01 00:00:00 | NaN   |
| 4      | 1089001    | 45.98000 | 5.33000 | 252.0      | 2016-01-01 00:00:00 | 0.0   |
| ...    | ...        | ...      | ...     | ...        | ...                 | ...   |
| 111618 | 84085004   | 43.94000 | 5.23000 | 488.0      | 2016-01-01 23:54:00 | 100.0 |
| 111619 | 84086001   | 43.81000 | 5.15000 | 672.0      | 2016-01-01 23:54:00 | 140.0 |
| 111620 | 84087001   | 44.14000 | 4.86000 | 55.0       | 2016-01-01 23:54:00 | 130.0 |
| 111621 | 84107002   | 44.04067 | 5.49283 | 836.0      | 2016-01-01 23:54:00 | 120.0 |
| 111622 | 84150001   | 44.34000 | 4.91000 | 141.0      | 2016-01-01 23:54:00 | 110.0 |

|        | ff  | precip | hu    | td     | t      | psl      |
|--------|-----|--------|-------|--------|--------|----------|
| 0      | NaN | NaN    | 98.0  | 278.75 | 279.05 | NaN      |
| 1      | 0.0 | 0.0    | 99.0  | 278.25 | 278.35 | NaN      |
| 2      | 0.0 | 0.0    | 100.0 | 279.15 | 279.15 | NaN      |
| 3      | NaN | 0.0    | NaN   | NaN    | 276.55 | NaN      |
| 4      | 0.0 | 0.0    | 95.0  | 278.85 | 279.55 | 102720.0 |
| ...    | ... | ...    | ...   | ...    | ...    | ...      |
| 111618 | 2.0 | 0.0    | 94.0  | 280.05 | 280.95 | NaN      |
| 111619 | 7.6 | 0.0    | 93.0  | 279.65 | 280.75 | NaN      |
| 111620 | 5.0 | 0.0    | 76.0  | 281.25 | 285.35 | 101760.0 |
| 111621 | 3.8 | 0.2    | 99.0  | 278.55 | 278.65 | NaN      |
| 111622 | 3.1 | 0.0    | 82.0  | 281.85 | 284.85 | NaN      |

[111623 rows x 12 columns]

```
[10]: cml.plot_map(ds)
```



## Weather models

```
[11]: ds = cml.load_dataset("meteonet-samples-weather-models", model="arome")
```

```
[12]: ds.to_xarray()
```

```
[12]: <xarray.Dataset>
Dimensions:                (time: 1, step: 25, heightAboveGround: 1, latitude: 227,
    ↪ longitude: 315)
Coordinates:
  * time                    (time) datetime64[ns] 2018-05-01
  * step                    (step) timedelta64[ns] 00:00:00 ... 1 days 00:00:00
  * heightAboveGround      (heightAboveGround) int64 2
  * latitude                (latitude) float64 51.9 51.87 51.85 ... 46.3 46.27 46.25
  * longitude               (longitude) float64 -5.842 -5.817 -5.792 ... 1.983 2.008
    valid_time              (time, step) datetime64[ns] dask.array<chunksize=(1, 25), meta=np.
    ↪ ndarray>
Data variables:
  t2m                      (time, step, heightAboveGround, latitude, longitude) float32 dask.
    ↪ array<chunksize=(1, 25, 1, 227, 315), meta=np.ndarray>
  d2m                      (time, step, heightAboveGround, latitude, longitude) float32 dask.
    ↪ array<chunksize=(1, 25, 1, 227, 315), meta=np.ndarray>
  r                         (time, step, heightAboveGround, latitude, longitude) float32 dask.
    ↪ array<chunksize=(1, 25, 1, 227, 315), meta=np.ndarray>
Attributes:
```

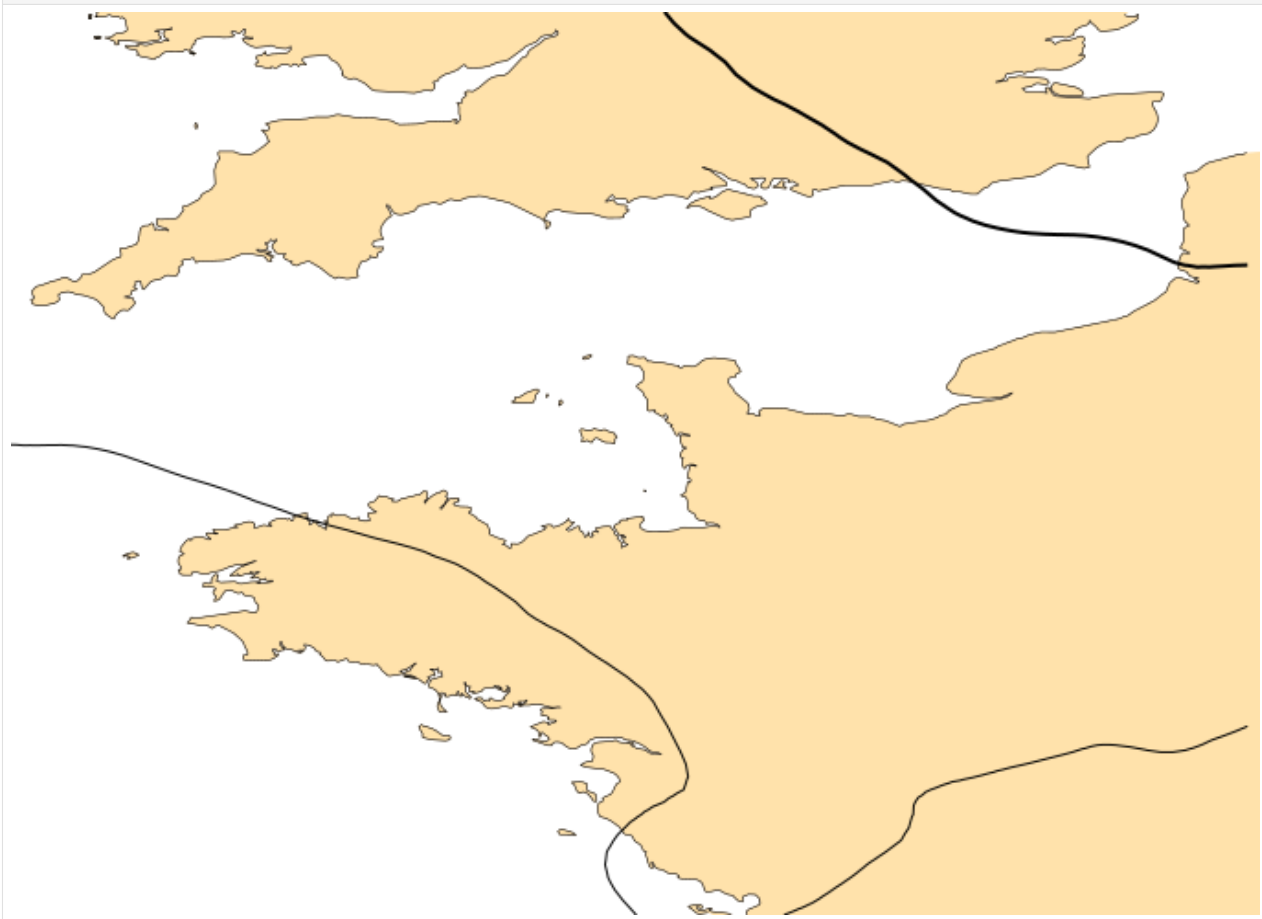
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```
GRIB_edition:      1
GRIB_centre:      lfpw
GRIB_centreDescription: French Weather Service - Toulouse
GRIB_subCentre:    0
Conventions:      CF-1.7
institution:      French Weather Service - Toulouse
history:          2021-11-13T18:08:50 GRIB to CDM+CF via cfgrib-0...
```

```
[13]: ds = cml.load_dataset(
      "meteonet-samples-weather-models", model="arpege", variable="P_sea_level"
    )
```

```
[14]: cml.plot_map(ds[0])
```



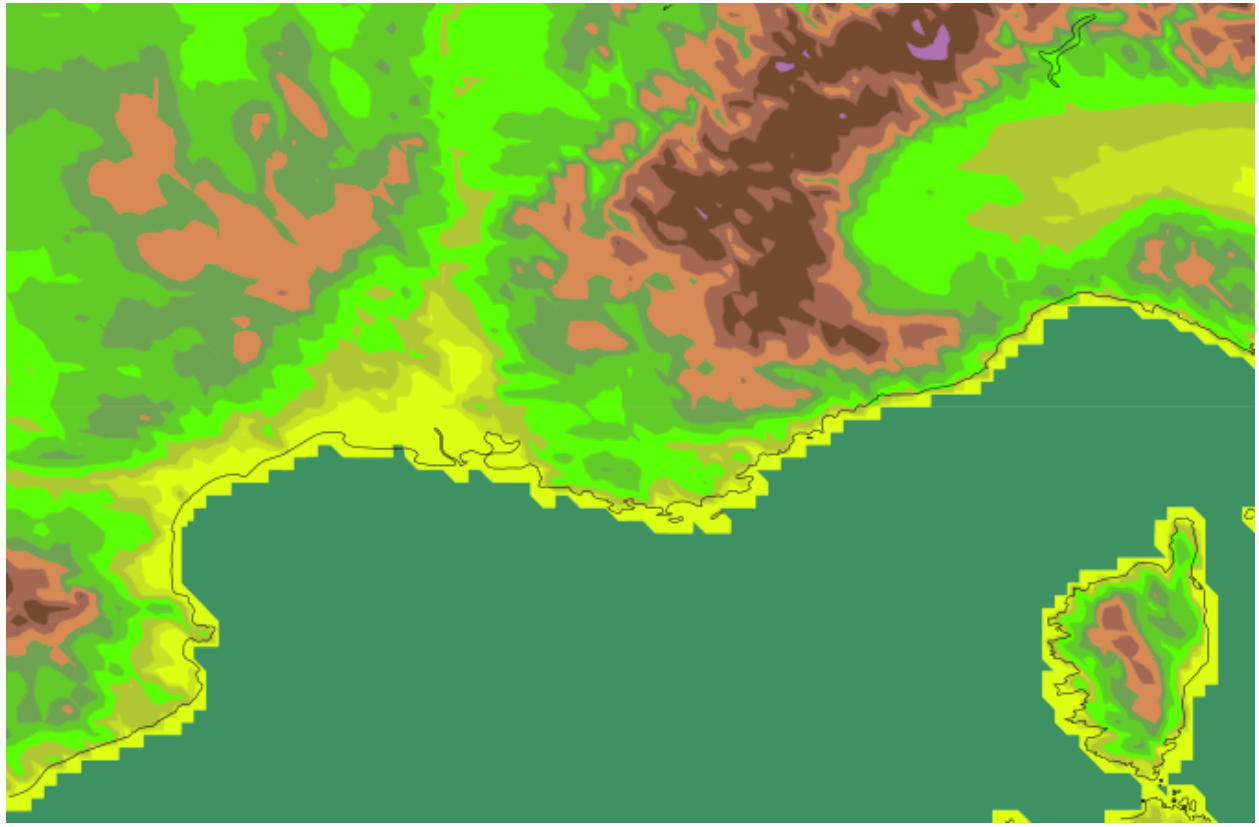
## Masks

```
[15]: ds = cml.load_dataset("meteonet-samples-masks", domain="SE")
```

```
[16]: cml.plot_map(ds[0])
```



```
[17]: cml.plot_map(ds[1])
```



You can run this notebook in , in , in

```
[1]: !pip install --quiet climetlab matplotlib
```

### 1.4.11 WeatherBench

This is an attempt to reproduce this research: <https://arxiv.org/abs/2002.00469>. There is a notebook available at: <https://binder.pangeo.io/v2/gh/pangeo-data/WeatherBench/master?filepath=quickstart.ipynb>

```
[2]: import matplotlib.pyplot as plt
```

```
[3]: import climetlab as cml
```

```
[ ]: ds = cml.load_dataset("weather-bench")
```

```
[5]: ds
```

```
[5]: <climetlab.datasets.weather_bench.WeatherBench at 0x7f621c0638b0>
```

```
[6]: print(ds.citation)
```

```
@article{rasp2020weatherbench,
  title={WeatherBench: A benchmark dataset for data-driven weather forecasting},
  author={Rasp, Stephan and Dueben, Peter D and Scher, Sebastian and Weyn,
    Jonathan A and Mouatadid, Soukayna and Thuerey, Nils},
```

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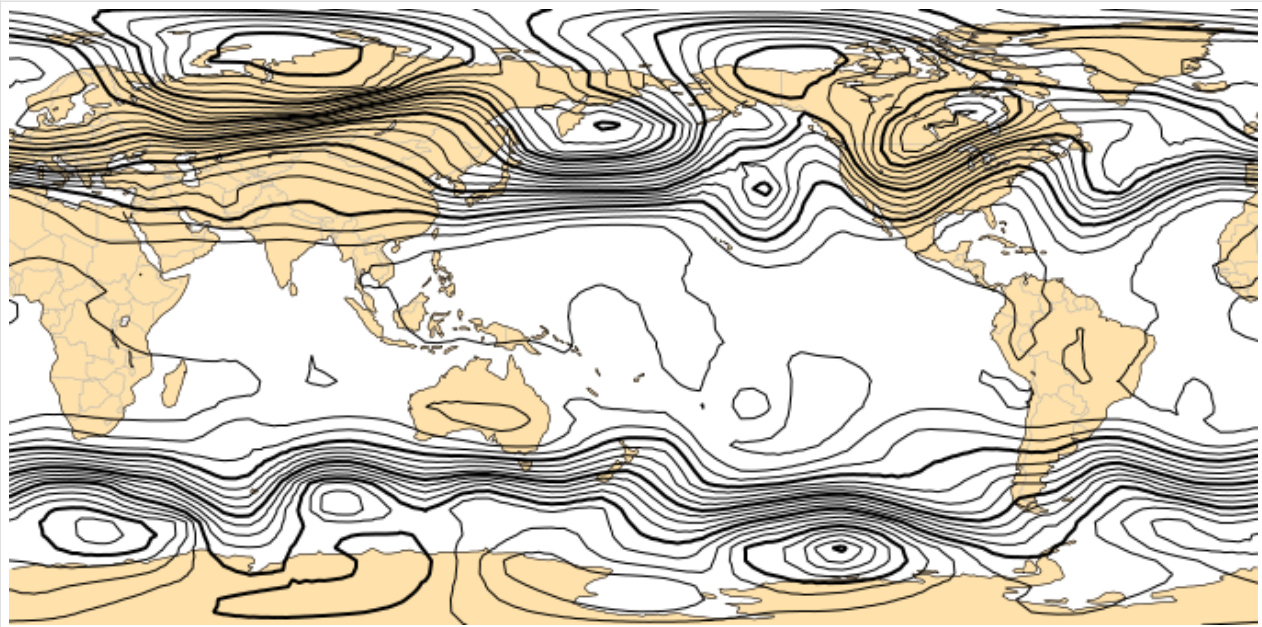
```
journal={arXiv preprint arXiv:2002.00469},
year={2020}
}
```

```
[7]: z500 = ds.to_xarray()
```

```
[8]: z500
```

```
[8]: <xarray.Dataset>
Dimensions: (lat: 32, lon: 64, time: 350640)
Coordinates:
  level      int32 500
  * lon      (lon) float64 0.0 5.625 11.25 16.88 ... 337.5 343.1 348.8 354.4
  * lat      (lat) float64 -87.19 -81.56 -75.94 -70.31 ... 75.94 81.56 87.19
  * time     (time) datetime64[ns] 1979-01-01 ... 2018-12-31T23:00:00
Data variables:
  z          (time, lat, lon) float32 dask.array<chunksize=(8760, 32, 64), meta=np.
    ndarray>
Attributes:
  Conventions: CF-1.6
  history:     2019-11-10 20:33:23 GMT by grib_to_netcdf-2.14.0: /opt/ecmw...
```

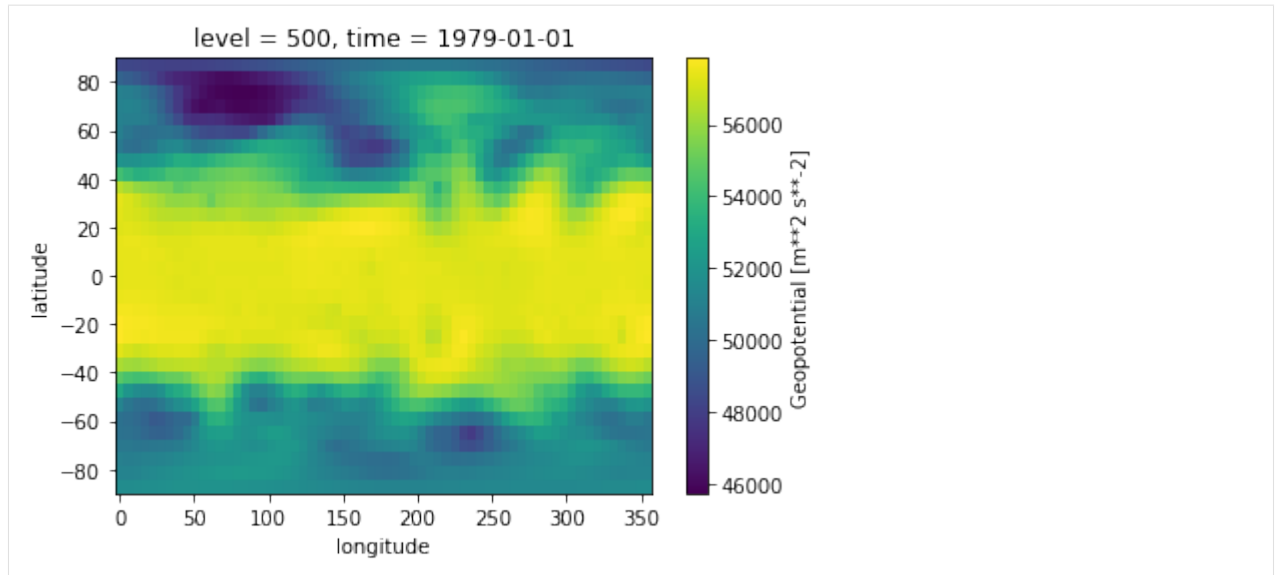
```
[9]: cml.plot_map(z500)
```



```
[10]: z500.z.isel(time=0).plot()
```

```
[10]: <matplotlib.collections.QuadMesh at 0x7f62146b2cd0>
```





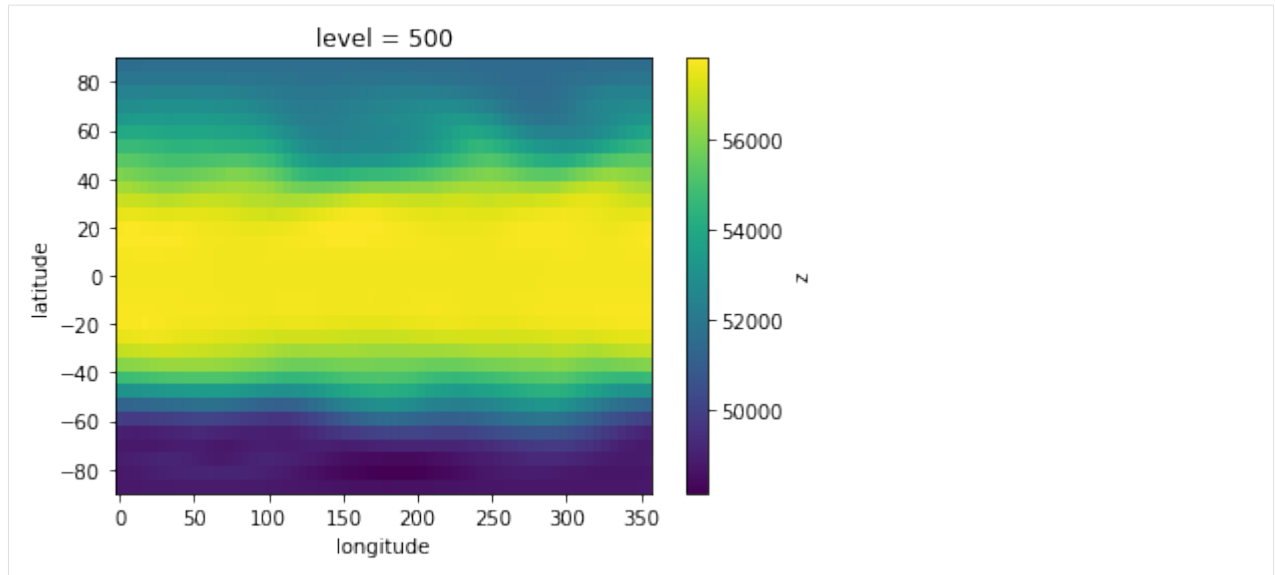
```
[11]: cml.plot_map(z500.z.isel(time=0))
```



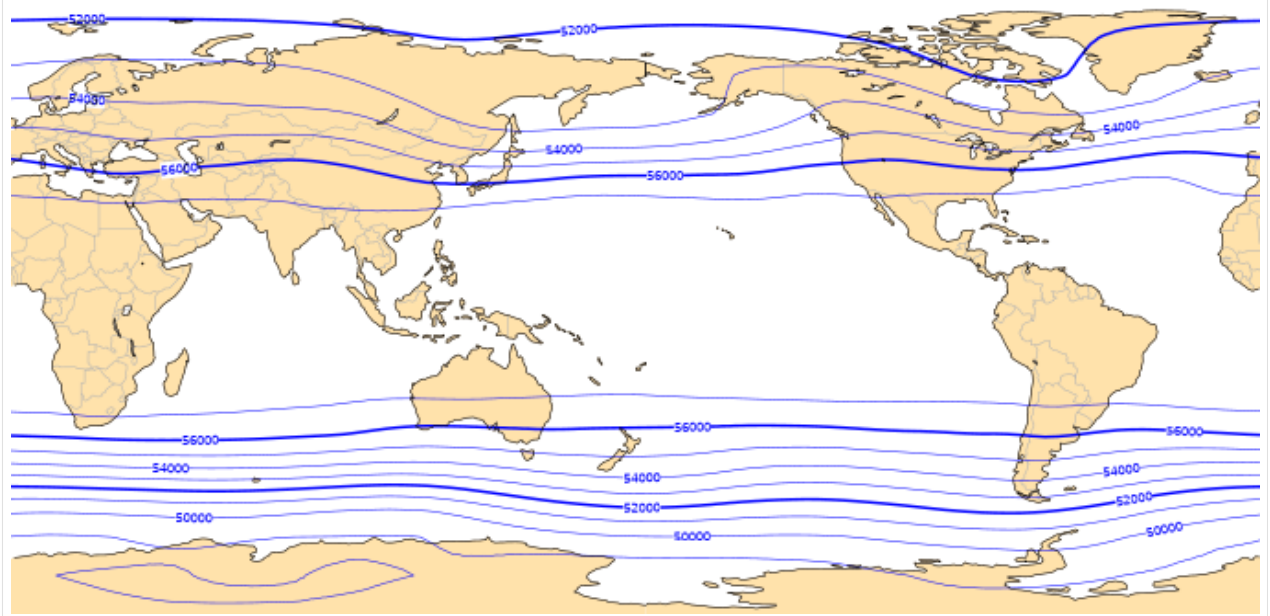
```
[12]: climatology = z500.sel(time=slice("2016", "2016")).mean("time").load()
```

```
[13]: climatology.z.plot()
```

```
[13]: <matplotlib.collections.QuadMesh at 0x7f62145059a0>
```



```
[14]: cml.plot_map(climatology.z)
```



```
[15]: climatology.z
```

```
[15]: <xarray.DataArray 'z' (lat: 32, lon: 64)>
array([[48765.18 , 48774.066, 48782.83 , ..., 48745.145, 48750.582,
        48757.645],
       [48755.164, 48798.348, 48845.02 , ..., 48690.23 , 48700.72 ,
        48721.727],
       [48890.742, 48941.703, 48997.42 , ..., 48815.234, 48822.87 ,
        48850.105],
       ...,
       [52378.613, 52398.484, 52420.074, ..., 52361.254, 52363.426,
        52366.344],
```

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```
[51937.207, 51943.78 , 51950.414, ..., 51906.508, 51919.223,
 51928.72 ],
[51565.38 , 51571.426, 51578.15 , ..., 51543.97 , 51551.11 ,
 51558.305]], dtype=float32)
Coordinates:
  level    int32 500
* lon      (lon) float64 0.0 5.625 11.25 16.88 ... 337.5 343.1 348.8 354.4
* lat      (lat) float64 -87.19 -81.56 -75.94 -70.31 ... 75.94 81.56 87.19
```

You can run this notebook in , in , in

```
[55]: !pip install --quiet climetlab matplotlib

DEPRECATION: Configuring installation scheme with distutils config files is deprecated.
↳ and will no longer work in the near future. If you are using a Homebrew or Linuxbrew
↳ Python, please see discussion at https://github.com/Homebrew/homebrew-core/issues/76621
DEPRECATION: Configuring installation scheme with distutils config files is deprecated.
↳ and will no longer work in the near future. If you are using a Homebrew or Linuxbrew
↳ Python, please see discussion at https://github.com/Homebrew/homebrew-core/issues/76621
```

## 1.4.12 NOAA's hurricane database

```
[56]: import climetlab as cml

[57]: atlantic = cml.load_dataset("hurricane-database", bassin="atlantic")

Get the Pandas frame

[58]: df = atlantic.to_pandas()

[59]: df.bassin.unique()

[59]: array(['AL'], dtype=object)
```

### Hurricanes making landfall at category 5

```
[60]: df[(df.category == 5) & (df.type == "L")]

[60]:
```

|       | bassin | number | year | name    | time                | type | status | lat  | \ |
|-------|--------|--------|------|---------|---------------------|------|--------|------|---|
| 17942 | AL     | 3      | 1935 | unnamed | 1935-09-03 02:00:00 | L    | HU     | 24.8 |   |
| 24300 | AL     | 10     | 1955 | janet   | 1955-09-27 17:00:00 | L    | HU     | 17.4 |   |
| 24303 | AL     | 10     | 1955 | janet   | 1955-09-28 05:00:00 | L    | HU     | 18.4 |   |
| 28888 | AL     | 9      | 1969 | camille | 1969-08-18 04:00:00 | L    | HU     | 30.3 |   |
| 36448 | AL     | 8      | 1988 | gilbert | 1988-09-14 15:00:00 | L    | HU     | 20.7 |   |
| 37967 | AL     | 4      | 1992 | andrew  | 1992-08-23 21:00:00 | L    | HU     | 25.4 |   |
| 37971 | AL     | 4      | 1992 | andrew  | 1992-08-24 08:40:00 | L    | HU     | 25.5 |   |
| 37972 | AL     | 4      | 1992 | andrew  | 1992-08-24 09:05:00 | L    | HU     | 25.5 |   |
| 45134 | AL     | 4      | 2007 | dean    | 2007-08-21 08:30:00 | L    | HU     | 18.7 |   |
| 45182 | AL     | 6      | 2007 | felix   | 2007-09-04 12:00:00 | L    | HU     | 14.3 |   |

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```

49925    AL      11  2017    irma 2017-09-06 05:45:00    L    HU   17.7
49927    AL      11  2017    irma 2017-09-06 11:15:00    L    HU   18.1
49929    AL      11  2017    irma 2017-09-06 16:30:00    L    HU   18.5
49941    AL      11  2017    irma 2017-09-09 03:00:00    L    HU   22.3
50139    AL      15  2017    maria 2017-09-19 01:15:00    L    HU   15.4
50835    AL      14  2018    michael 2018-10-10 17:30:00    L    HU   30.0

```

```

lon knots category pressure
17942 -80.8 160.0      5    892.0
24300 -83.9 140.0      5      NaN
24303 -87.8 150.0      5    914.0
28888 -89.4 150.0      5    900.0
36448 -87.0 140.0      5    900.0
37967 -76.6 140.0      5    923.0
37971 -80.2 145.0      5    926.0
37972 -80.3 145.0      5    922.0
45134 -87.7 150.0      5    905.0
45182 -83.2 140.0      5    934.0
49925 -61.8 155.0      5    914.0
49927 -63.1 155.0      5    914.0
49929 -64.4 155.0      5    915.0
49941 -77.9 145.0      5    924.0
50139 -61.3 145.0      5    922.0
50835 -85.5 140.0      5    919.0

```

## Get the track for Katrina

```
[61]: katrina = df[(df.name == "katrina") & (df.year == 2005)]
```

```
[62]: katrina
```

```

[62]:   bassin  number  year  name  time type status  lat  \
44065    AL      12  2005  katrina 2005-08-23 18:00:00    TD  23.1
44066    AL      12  2005  katrina 2005-08-24 00:00:00    TD  23.4
44067    AL      12  2005  katrina 2005-08-24 06:00:00    TD  23.8
44068    AL      12  2005  katrina 2005-08-24 12:00:00    TS  24.5
44069    AL      12  2005  katrina 2005-08-24 18:00:00    TS  25.4
44070    AL      12  2005  katrina 2005-08-25 00:00:00    TS  26.0
44071    AL      12  2005  katrina 2005-08-25 06:00:00    TS  26.1
44072    AL      12  2005  katrina 2005-08-25 12:00:00    TS  26.2
44073    AL      12  2005  katrina 2005-08-25 18:00:00    TS  26.2
44074    AL      12  2005  katrina 2005-08-25 22:30:00    L   HU  26.0
44075    AL      12  2005  katrina 2005-08-26 00:00:00    HU  25.9
44076    AL      12  2005  katrina 2005-08-26 06:00:00    HU  25.4
44077    AL      12  2005  katrina 2005-08-26 12:00:00    HU  25.1
44078    AL      12  2005  katrina 2005-08-26 18:00:00    HU  24.9
44079    AL      12  2005  katrina 2005-08-27 00:00:00    HU  24.6
44080    AL      12  2005  katrina 2005-08-27 06:00:00    HU  24.4
44081    AL      12  2005  katrina 2005-08-27 12:00:00    HU  24.4
44082    AL      12  2005  katrina 2005-08-27 18:00:00    HU  24.5
44083    AL      12  2005  katrina 2005-08-28 00:00:00    HU  24.8

```

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|       |       |       |          |          |            |          |      |      |
|-------|-------|-------|----------|----------|------------|----------|------|------|
| 44084 | AL    | 12    | 2005     | katrina  | 2005-08-28 | 06:00:00 | HU   | 25.2 |
| 44085 | AL    | 12    | 2005     | katrina  | 2005-08-28 | 12:00:00 | HU   | 25.7 |
| 44086 | AL    | 12    | 2005     | katrina  | 2005-08-28 | 18:00:00 | HU   | 26.3 |
| 44087 | AL    | 12    | 2005     | katrina  | 2005-08-29 | 00:00:00 | HU   | 27.2 |
| 44088 | AL    | 12    | 2005     | katrina  | 2005-08-29 | 06:00:00 | HU   | 28.2 |
| 44089 | AL    | 12    | 2005     | katrina  | 2005-08-29 | 11:10:00 | L HU | 29.3 |
| 44090 | AL    | 12    | 2005     | katrina  | 2005-08-29 | 12:00:00 | HU   | 29.5 |
| 44091 | AL    | 12    | 2005     | katrina  | 2005-08-29 | 14:45:00 | L HU | 30.2 |
| 44092 | AL    | 12    | 2005     | katrina  | 2005-08-29 | 18:00:00 | HU   | 31.1 |
| 44093 | AL    | 12    | 2005     | katrina  | 2005-08-30 | 00:00:00 | TS   | 32.6 |
| 44094 | AL    | 12    | 2005     | katrina  | 2005-08-30 | 06:00:00 | TS   | 34.1 |
| 44095 | AL    | 12    | 2005     | katrina  | 2005-08-30 | 12:00:00 | TD   | 35.6 |
| 44096 | AL    | 12    | 2005     | katrina  | 2005-08-30 | 18:00:00 | TD   | 37.0 |
| 44097 | AL    | 12    | 2005     | katrina  | 2005-08-31 | 00:00:00 | EX   | 38.6 |
| 44098 | AL    | 12    | 2005     | katrina  | 2005-08-31 | 06:00:00 | EX   | 40.1 |
|       |       |       |          |          |            |          |      |      |
|       | lon   | knots | category | pressure |            |          |      |      |
| 44065 | -75.1 | 30.0  | 1        | 1008.0   |            |          |      |      |
| 44066 | -75.7 | 30.0  | 1        | 1007.0   |            |          |      |      |
| 44067 | -76.2 | 30.0  | 1        | 1007.0   |            |          |      |      |
| 44068 | -76.5 | 35.0  | 1        | 1006.0   |            |          |      |      |
| 44069 | -76.9 | 40.0  | 1        | 1003.0   |            |          |      |      |
| 44070 | -77.7 | 45.0  | 1        | 1000.0   |            |          |      |      |
| 44071 | -78.4 | 50.0  | 1        | 997.0    |            |          |      |      |
| 44072 | -79.0 | 55.0  | 1        | 994.0    |            |          |      |      |
| 44073 | -79.6 | 60.0  | 1        | 988.0    |            |          |      |      |
| 44074 | -80.1 | 70.0  | 1        | 984.0    |            |          |      |      |
| 44075 | -80.3 | 70.0  | 1        | 983.0    |            |          |      |      |
| 44076 | -81.3 | 65.0  | 1        | 987.0    |            |          |      |      |
| 44077 | -82.0 | 75.0  | 1        | 979.0    |            |          |      |      |
| 44078 | -82.6 | 85.0  | 2        | 968.0    |            |          |      |      |
| 44079 | -83.3 | 90.0  | 2        | 959.0    |            |          |      |      |
| 44080 | -84.0 | 95.0  | 2        | 950.0    |            |          |      |      |
| 44081 | -84.7 | 100.0 | 3        | 942.0    |            |          |      |      |
| 44082 | -85.3 | 100.0 | 3        | 948.0    |            |          |      |      |
| 44083 | -85.9 | 100.0 | 3        | 941.0    |            |          |      |      |
| 44084 | -86.7 | 125.0 | 4        | 930.0    |            |          |      |      |
| 44085 | -87.7 | 145.0 | 5        | 909.0    |            |          |      |      |
| 44086 | -88.6 | 150.0 | 5        | 902.0    |            |          |      |      |
| 44087 | -89.2 | 140.0 | 5        | 905.0    |            |          |      |      |
| 44088 | -89.6 | 125.0 | 4        | 913.0    |            |          |      |      |
| 44089 | -89.6 | 110.0 | 3        | 920.0    |            |          |      |      |
| 44090 | -89.6 | 110.0 | 3        | 923.0    |            |          |      |      |
| 44091 | -89.6 | 105.0 | 3        | 928.0    |            |          |      |      |
| 44092 | -89.6 | 80.0  | 1        | 948.0    |            |          |      |      |
| 44093 | -89.1 | 50.0  | 1        | 961.0    |            |          |      |      |
| 44094 | -88.6 | 40.0  | 1        | 978.0    |            |          |      |      |
| 44095 | -88.0 | 30.0  | 1        | 985.0    |            |          |      |      |
| 44096 | -87.0 | 30.0  | 1        | 990.0    |            |          |      |      |
| 44097 | -85.3 | 30.0  | 1        | 994.0    |            |          |      |      |
| 44098 | -82.9 | 25.0  | 1        | 996.0    |            |          |      |      |

## Plot the track

```
[63]: cml.plot_map(katrina, margins=0.25)
```



## Retrieve matching fields from ERA5

```
[64]: hurricane = katrina[katrina.status == "HU"]
hurricane
```

```
[64]:
```

|       | bassin | number | year | name    | time                | type | status | lat  | \ |
|-------|--------|--------|------|---------|---------------------|------|--------|------|---|
| 44074 | AL     | 12     | 2005 | katrina | 2005-08-25 22:30:00 | L    | HU     | 26.0 |   |
| 44075 | AL     | 12     | 2005 | katrina | 2005-08-26 00:00:00 |      | HU     | 25.9 |   |
| 44076 | AL     | 12     | 2005 | katrina | 2005-08-26 06:00:00 |      | HU     | 25.4 |   |
| 44077 | AL     | 12     | 2005 | katrina | 2005-08-26 12:00:00 |      | HU     | 25.1 |   |
| 44078 | AL     | 12     | 2005 | katrina | 2005-08-26 18:00:00 |      | HU     | 24.9 |   |
| 44079 | AL     | 12     | 2005 | katrina | 2005-08-27 00:00:00 |      | HU     | 24.6 |   |
| 44080 | AL     | 12     | 2005 | katrina | 2005-08-27 06:00:00 |      | HU     | 24.4 |   |
| 44081 | AL     | 12     | 2005 | katrina | 2005-08-27 12:00:00 |      | HU     | 24.4 |   |
| 44082 | AL     | 12     | 2005 | katrina | 2005-08-27 18:00:00 |      | HU     | 24.5 |   |
| 44083 | AL     | 12     | 2005 | katrina | 2005-08-28 00:00:00 |      | HU     | 24.8 |   |
| 44084 | AL     | 12     | 2005 | katrina | 2005-08-28 06:00:00 |      | HU     | 25.2 |   |
| 44085 | AL     | 12     | 2005 | katrina | 2005-08-28 12:00:00 |      | HU     | 25.7 |   |
| 44086 | AL     | 12     | 2005 | katrina | 2005-08-28 18:00:00 |      | HU     | 26.3 |   |
| 44087 | AL     | 12     | 2005 | katrina | 2005-08-29 00:00:00 |      | HU     | 27.2 |   |
| 44088 | AL     | 12     | 2005 | katrina | 2005-08-29 06:00:00 |      | HU     | 28.2 |   |
| 44089 | AL     | 12     | 2005 | katrina | 2005-08-29 11:10:00 | L    | HU     | 29.3 |   |
| 44090 | AL     | 12     | 2005 | katrina | 2005-08-29 12:00:00 |      | HU     | 29.5 |   |
| 44091 | AL     | 12     | 2005 | katrina | 2005-08-29 14:45:00 | L    | HU     | 30.2 |   |
| 44092 | AL     | 12     | 2005 | katrina | 2005-08-29 18:00:00 |      | HU     | 31.1 |   |

|       | lon   | knots | category | pressure |
|-------|-------|-------|----------|----------|
| 44074 | -80.1 | 70.0  | 1        | 984.0    |
| 44075 | -80.3 | 70.0  | 1        | 983.0    |
| 44076 | -81.3 | 65.0  | 1        | 987.0    |
| 44077 | -82.0 | 75.0  | 1        | 979.0    |
| 44078 | -82.6 | 85.0  | 2        | 968.0    |
| 44079 | -83.3 | 90.0  | 2        | 959.0    |
| 44080 | -84.0 | 95.0  | 2        | 950.0    |
| 44081 | -84.7 | 100.0 | 3        | 942.0    |
| 44082 | -85.3 | 100.0 | 3        | 948.0    |
| 44083 | -85.9 | 100.0 | 3        | 941.0    |
| 44084 | -86.7 | 125.0 | 4        | 930.0    |
| 44085 | -87.7 | 145.0 | 5        | 909.0    |
| 44086 | -88.6 | 150.0 | 5        | 902.0    |
| 44087 | -89.2 | 140.0 | 5        | 905.0    |
| 44088 | -89.6 | 125.0 | 4        | 913.0    |
| 44089 | -89.6 | 110.0 | 3        | 920.0    |
| 44090 | -89.6 | 110.0 | 3        | 923.0    |
| 44091 | -89.6 | 105.0 | 3        | 928.0    |
| 44092 | -89.6 | 80.0  | 1        | 948.0    |

We can use the Pandas frame to specify the date and area of the request to the CDS.

```
[65]: source = cml.load_source(
        "cds",
        "reanalysis-era5-pressure-levels",
        variable="z",
        level=500,
```

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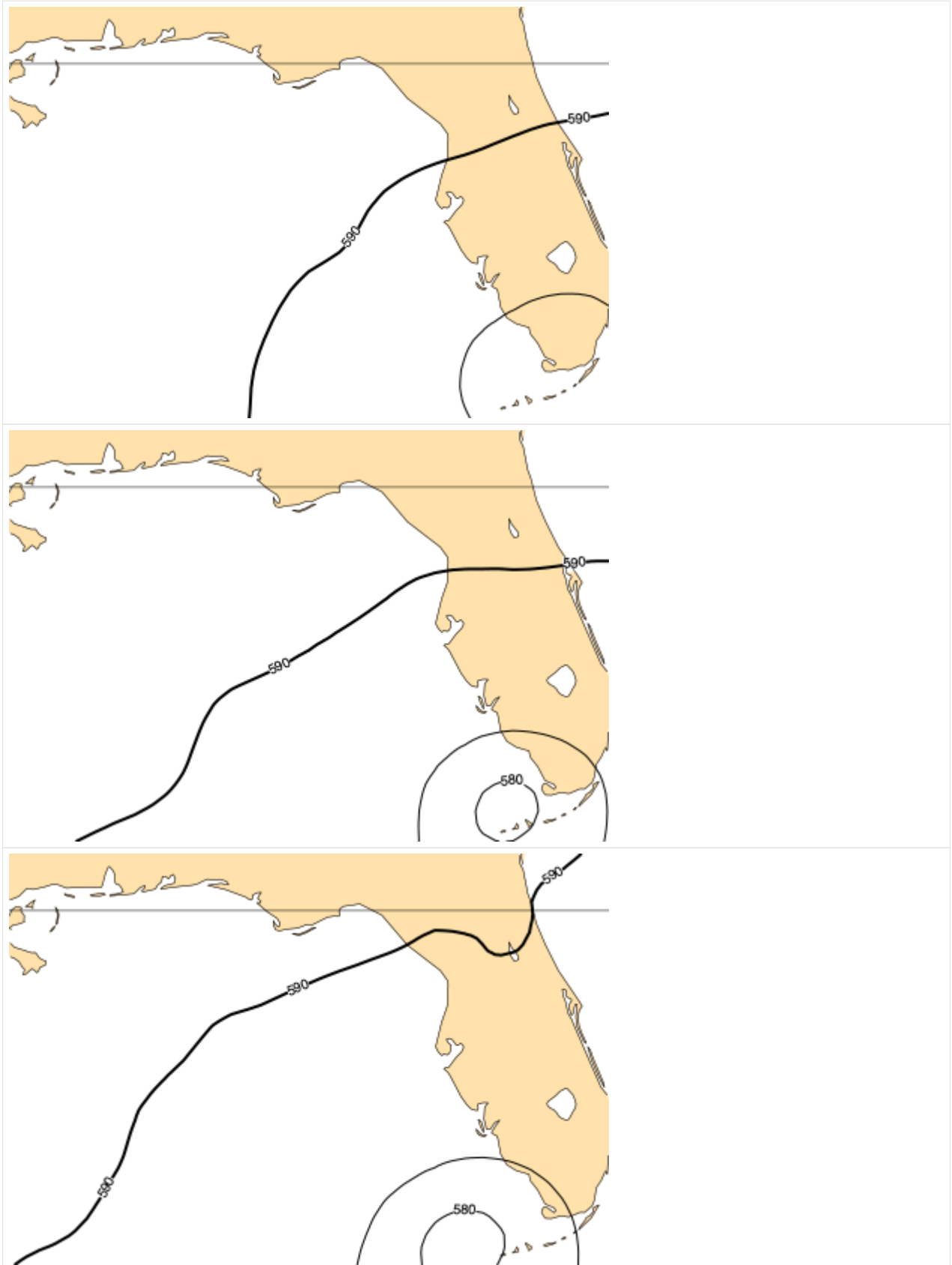
```
product_type="reanalysis",
time=[0, 6, 12, 18],
date=hurricane,
area=hurricane,
)

for s in source:
    cml.plot_map(s, width=400, grid=True)
```

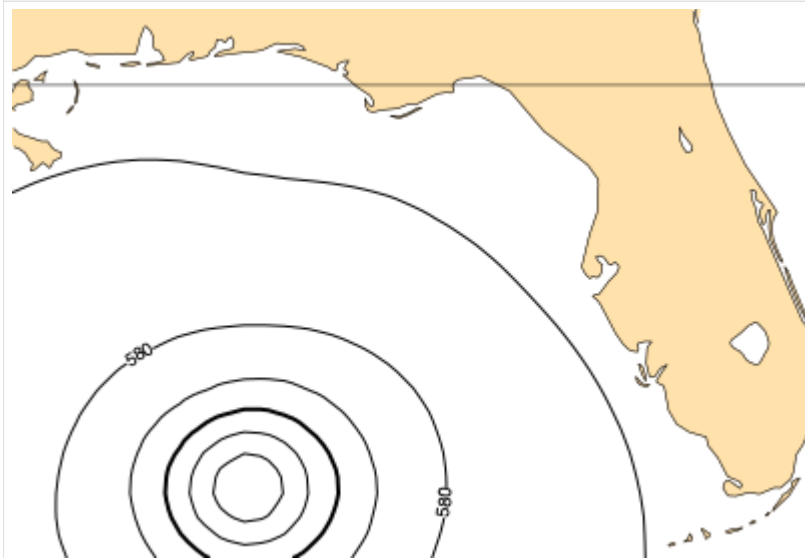
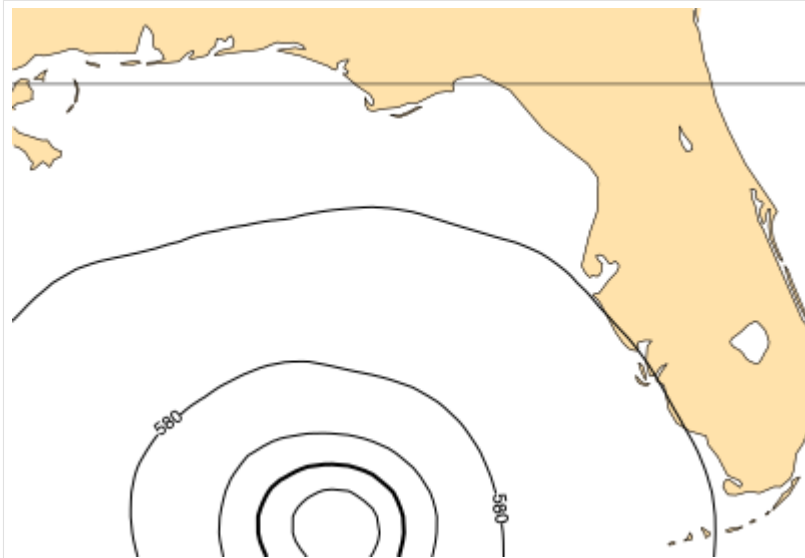
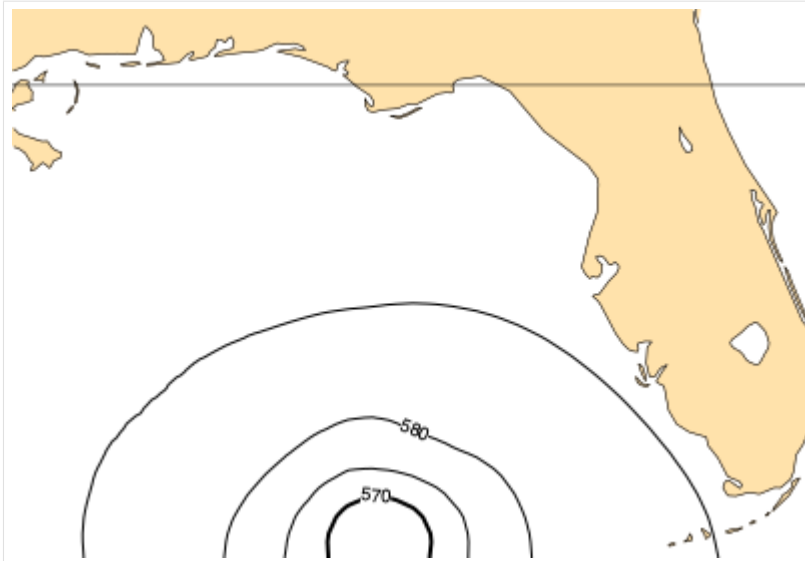
















## Pacific bassin

```
[66]: pacific = cml.load_dataset("hurricane-database", bassin="pacific")
```

Get the Pandas frame

```
[67]: df = pacific.to_pandas()
```

Plot a few years

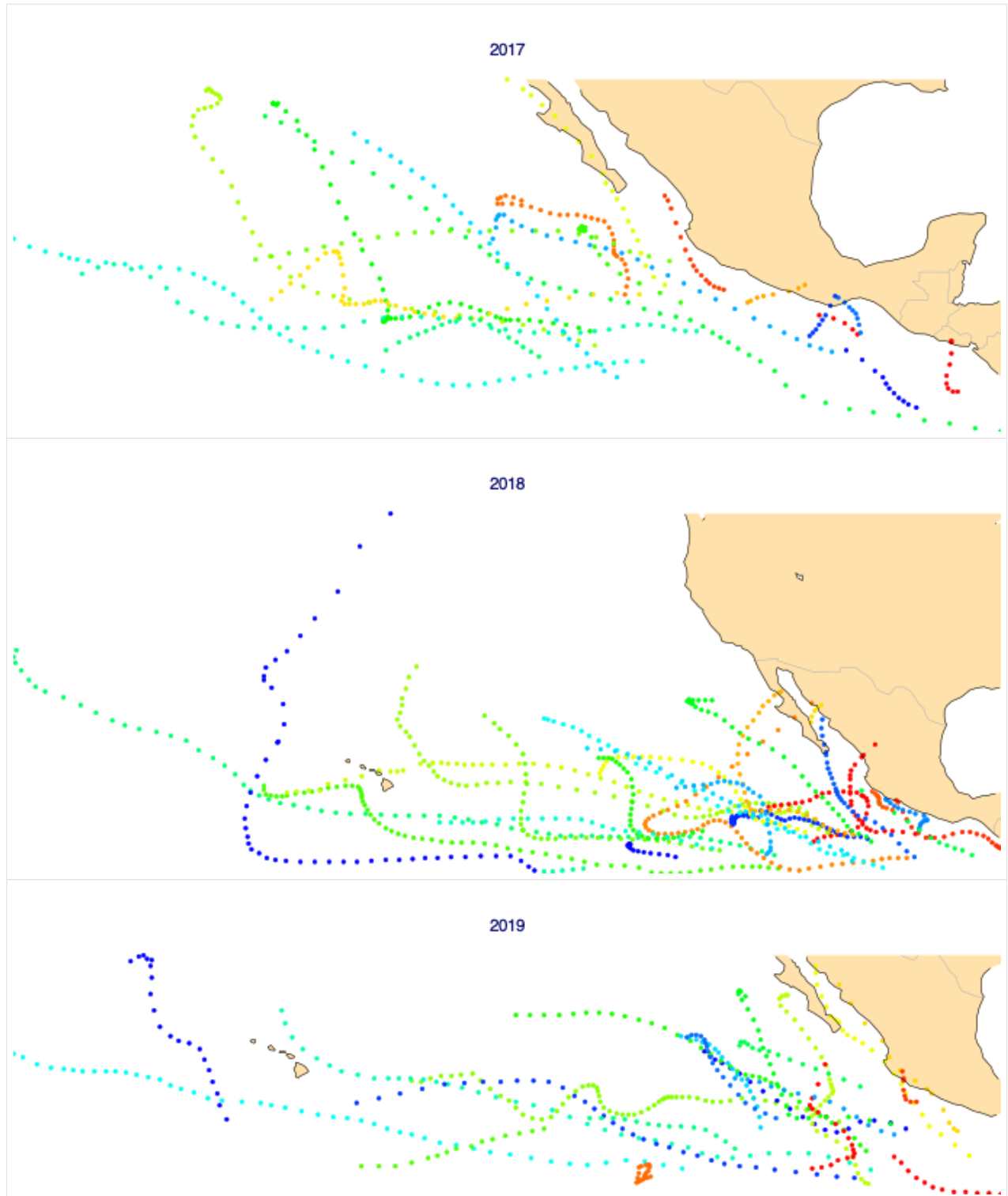
```
[68]: for year in range(2010, 2020):
        cml.plot_map(
            df[df.year == year], column="number", title=year, style="rainbow-markers"
        )
```









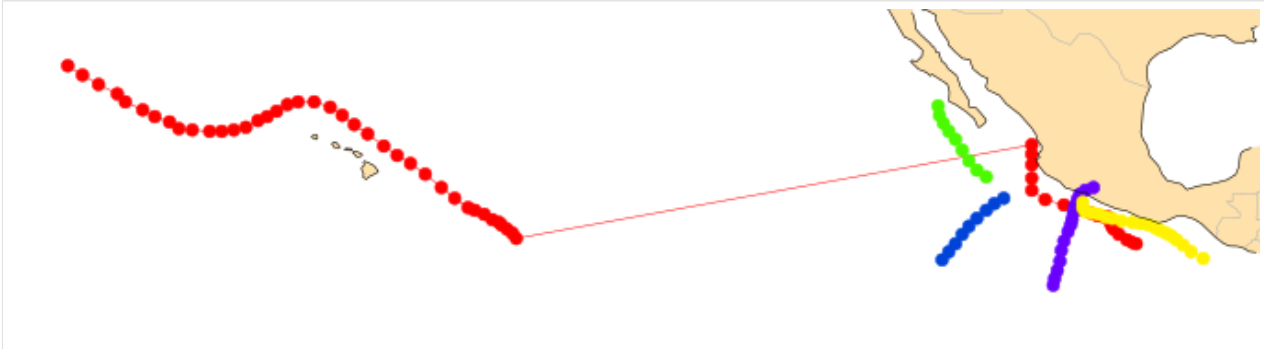


### Plot each track independently

```
[69]: import matplotlib.pyplot as plt
```

```
[70]: cmap = plt.get_cmap("prism")
```

```
[71]: p = cml.new_plot(margins="5%")
i = 0
for year in range(1950, 1955):
    cp = df[(df.year == year) & (df.number == 1)]
    if len(cp):
        p.plot_map(cp, style={"symbol_colour": cmap((i * 20) % cmap.N)})
        i += 1
p.show()
```



```
[ ]:
```

You can run this notebook in , in , in

```
[13]: !pip install --quiet climetlab
```

```
[14]: import climetlab as cml
```

```
[15]: r = {
    "class": "e2",
    "date": "1662-10-01/to/1663-12-31",
    "dataset": "icoads",
    "expver": "1608",
    "groupid": "17",
    "reporttype": "16008",
    "format": "ascii",
    "stream": "oper",
    "time": "all",
    "type": "ofb",
}

source = cml.load_source("mars", **r)
```

```
[16]: pd = source.to_pandas()
```

[17]: pd

```
[17]:      expver@desc  type@desc  class@desc  stream@desc  andate@desc  \
0      '1608'      263      22      1025      16621015
1      '1608'      263      22      1025      16621015
2      '1608'      263      22      1025      16621015
3      '1608'      263      22      1025      16621015
4      '1608'      263      22      1025      16621016
..      ...      ...      ...      ...      ...
673    '1608'      263      22      1025      16630425
674    '1608'      263      22      1025      16630426
675    '1608'      263      22      1025      16630426
676    '1608'      263      22      1025      16630426
677    '1608'      263      22      1025      16630426

      antime@desc  seqno@hdr  reporttype@hdr  bufrtype@hdr  subtype@hdr  ...  \
0      120000      1      16008      1      11      ...
1      120000      1      16008      1      11      ...
2      120000      1      16008      1      11      ...
3      120000      1      16008      1      11      ...
4      120000      2      16008      1      11      ...
..      ...      ...      ...      ...      ...
673      60000      25      16008      1      11      ...
674      60000      26      16008      1      11      ...
675      60000      26      16008      1      11      ...
676      60000      26      16008      1      11      ...
677      60000      26      16008      1      11      ...

      entryno@body  obsvalue@body  varno@body  vertco_type@body  \
0      1      158.000000      111      1
1      2      2.600000      112      1
2      3      -0.973977      41      1
3      4      2.410678      42      1
4      1      158.000000      111      1
..      ...      ...      ...      ...
673      4      2.155498      42      1
674      1      124.000000      111      1
675      2      6.700000      112      1
676      3      -5.554552      41      1
677      4      3.746593      42      1

      vertco_reference_1@body  datum_status@body  bias_volatility@body  \
0      0.0      1      NaN
1      0.0      1      NaN
2      0.0      1      NaN
3      0.0      1      NaN
4      0.0      1      NaN
..      ...      ...      ...
673      0.0      1      NaN
674      0.0      1      NaN
675      0.0      1      NaN
676      0.0      1      NaN
677      0.0      1      NaN
```

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|     | an_depar@body | fg_depar@body | ppcode@conv_body |
|-----|---------------|---------------|------------------|
| 0   | NaN           | NaN           | 0                |
| 1   | NaN           | NaN           | 0                |
| 2   | NaN           | NaN           | 0                |
| 3   | NaN           | NaN           | 0                |
| 4   | NaN           | NaN           | 0                |
| ..  | ...           | ...           | ...              |
| 673 | NaN           | NaN           | 0                |
| 674 | NaN           | NaN           | 0                |
| 675 | NaN           | NaN           | 0                |
| 676 | NaN           | NaN           | 0                |
| 677 | NaN           | NaN           | 0                |

[678 rows x 44 columns]

```
[12]: cml.plot_map(pd, margins=2)
```



You can run this notebook in , in , in

```
[1]: !pip install --quiet climetlab climetlab-demo-source climetlab-demo-dataset
```

### 1.4.13 External plugins

```
[2]: import climetlab as cml
```

Get the demo dataset:

```
[3]: ds = cml.load_dataset("demo-dataset")
```

Plot it:

```
[4]: cml.plot_map(ds)
```



#### External data source

```
[5]: !test -f test.db || wget https://github.com/ecmwf/climetlab/raw/main/docs/examples/test.  
↪db
```

```
[6]: s = cml.load_source(  
    "demo-source", "sqlite:///test.db", "select * from data;", parse_dates=["time"]  
)
```

```
[7]: df = s.to_pandas()
```

```
[8]: df
```

```
[8]:
```

|   | lat  | lon  | time       | value |
|---|------|------|------------|-------|
| 0 | 50.0 | 3.3  | 2001-01-01 | 4.9   |
| 1 | 51.0 | -3.0 | 2001-01-02 | 7.3   |
| 2 | 50.5 | -1.8 | 2001-01-03 | 5.5   |

```
[9]: cml.plot_map(df, margins=2)
```



You can run this notebook in , in , in

```
[1]: !pip install --quiet climetlab
```

```
[2]: %config Application.log_level="INFO"
```

### 1.4.14 More plotting examples

```
[3]: import climetlab as cml
```

Get some GRIB data

```
[4]: ds = cml.load_dataset("sample-grib-data")
```

Plot the first field

```
[5]: cml.plot_map(ds[0])
```



Plot the second field

```
[6]: cml.plot_map(ds[1])
```



Plot both fields on the same map

```
[7]: cml.plot_map((ds[0], ds[1]))
```





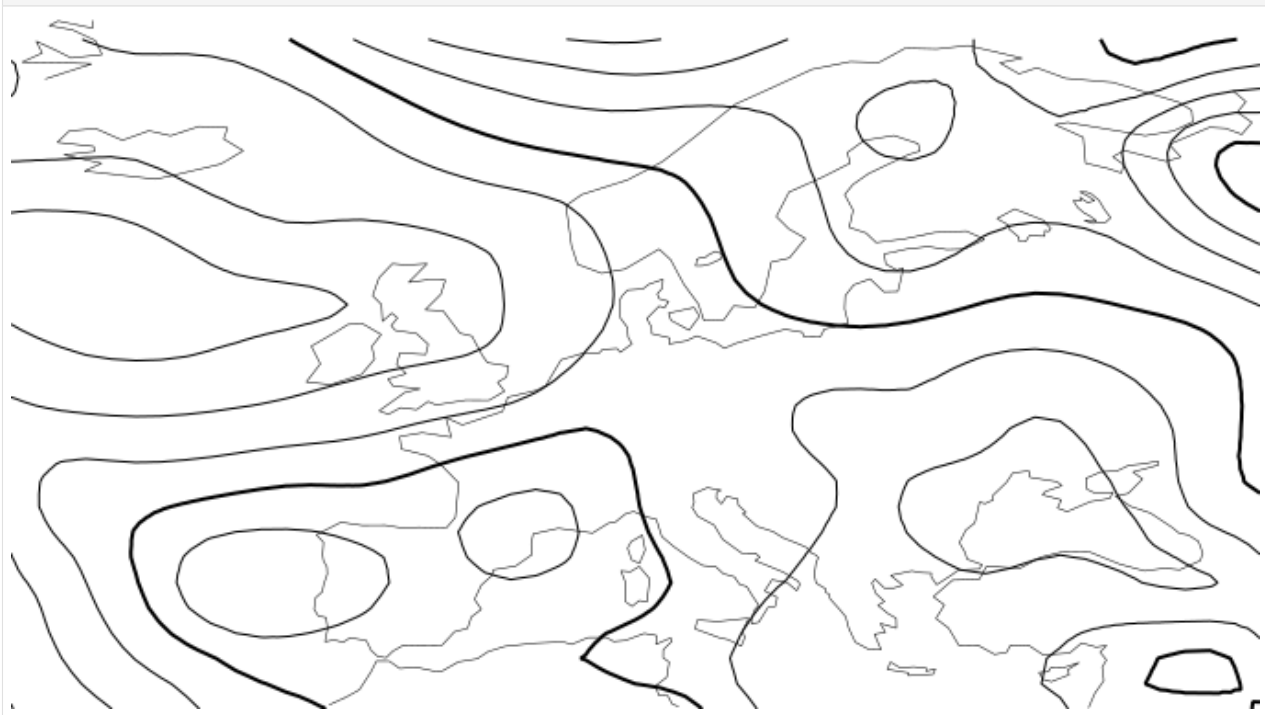
Alternative method:

```
[8]: p = cml.new_plot()
p.plot_map(ds[0])
p.plot_map(ds[1])
p.show()
```



Switch off background map

```
[9]: cml.plot_map(ds[1], background=False)
```



Switch off both foreground and background

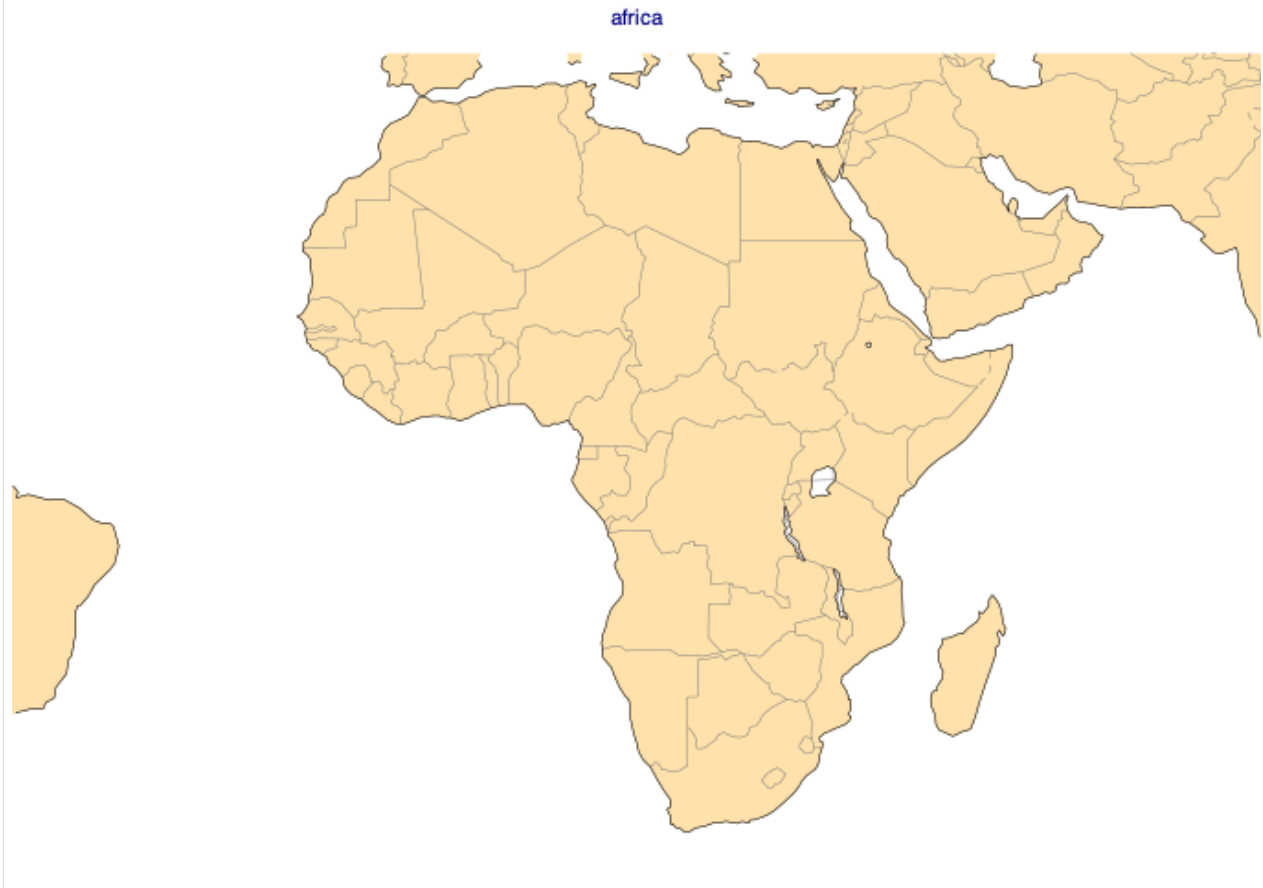
```
[10]: cml.plot_map(
    ds[1],
    foreground=False,
)
```



## Projections

```
[11]: from climetlab.plotting import projections
```

```
[12]: for projection in projections():
        cml.plot_map(projection=projection, title=projection)
```





collignon

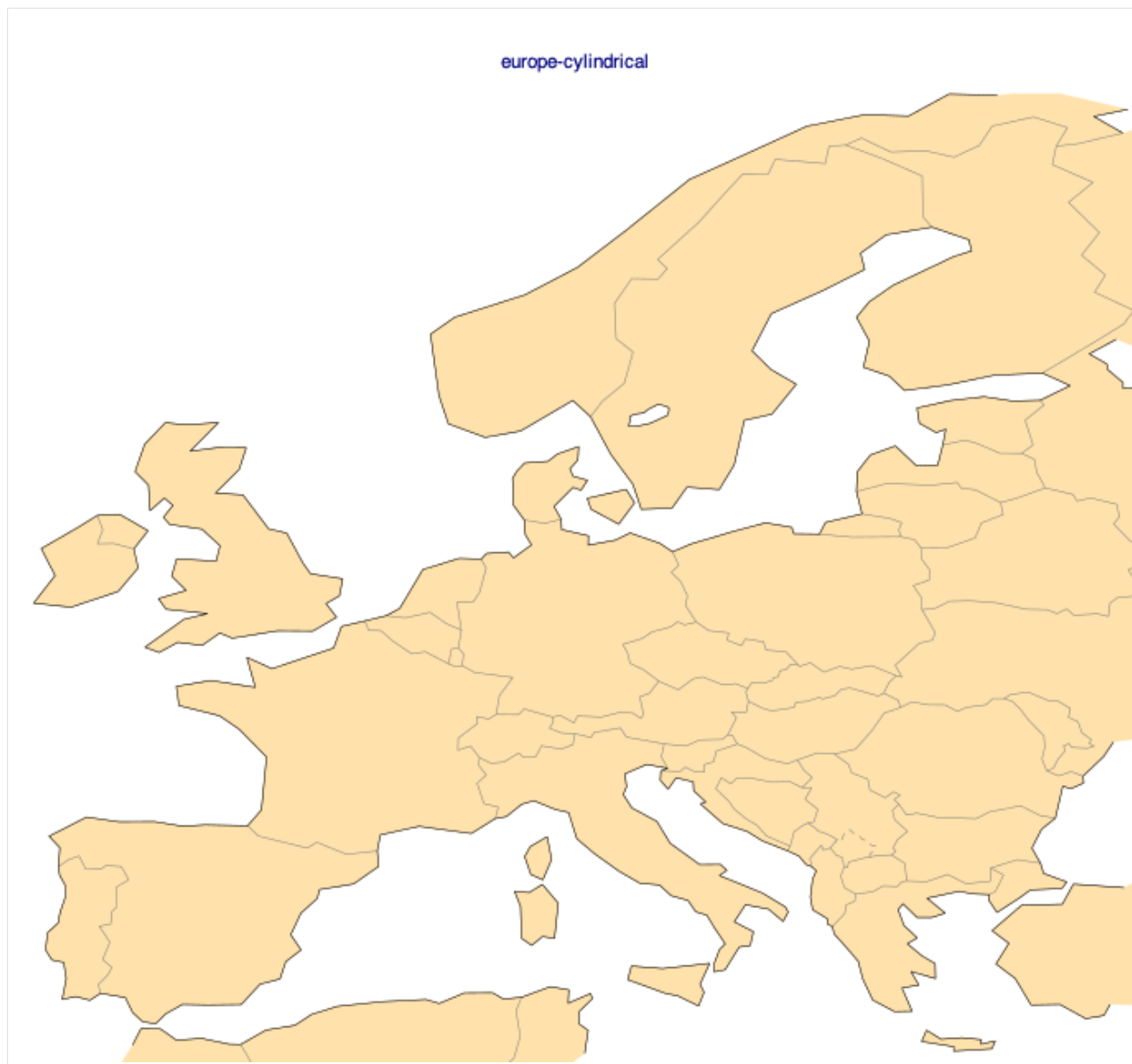


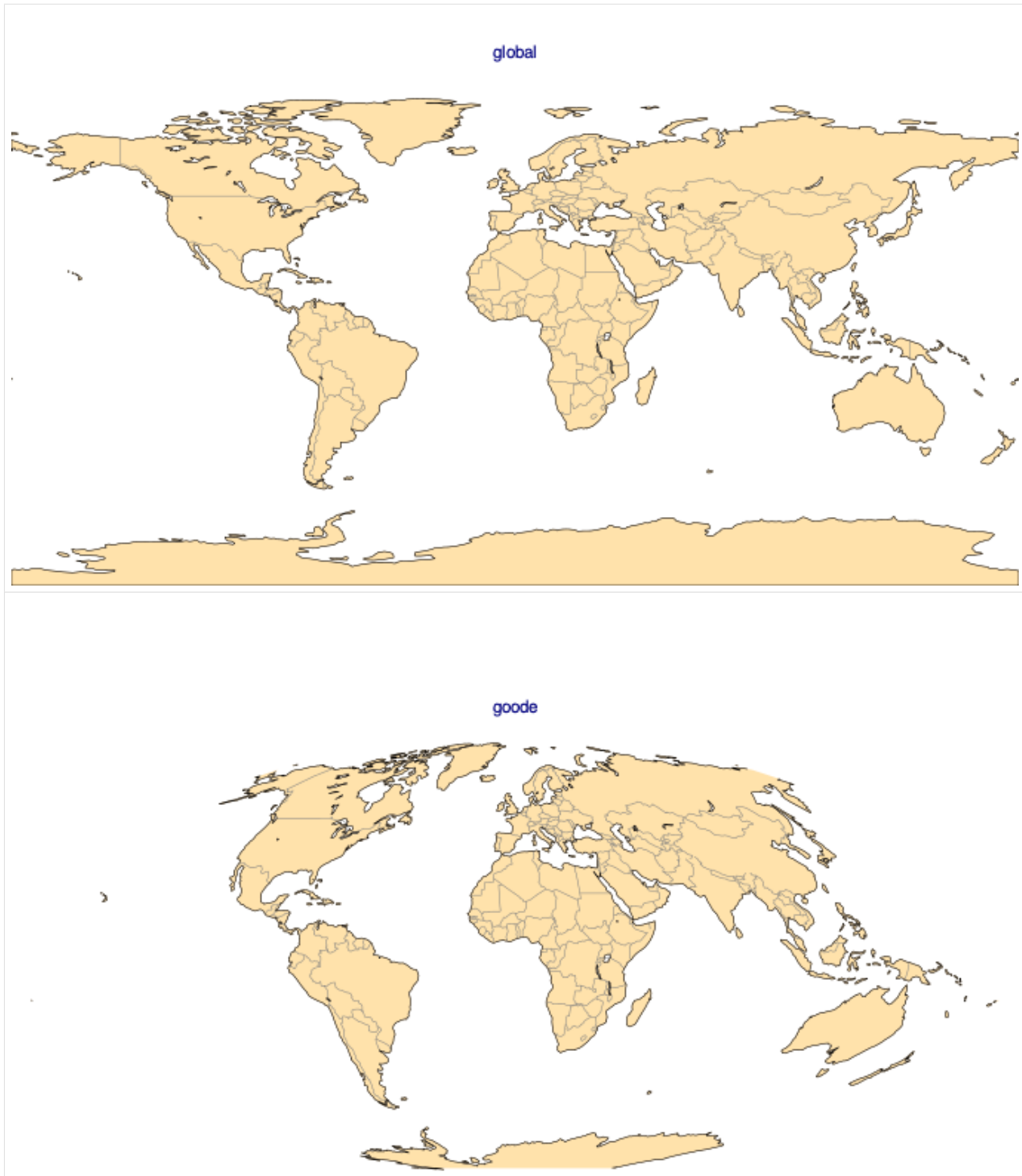
euro-atlantic



europe





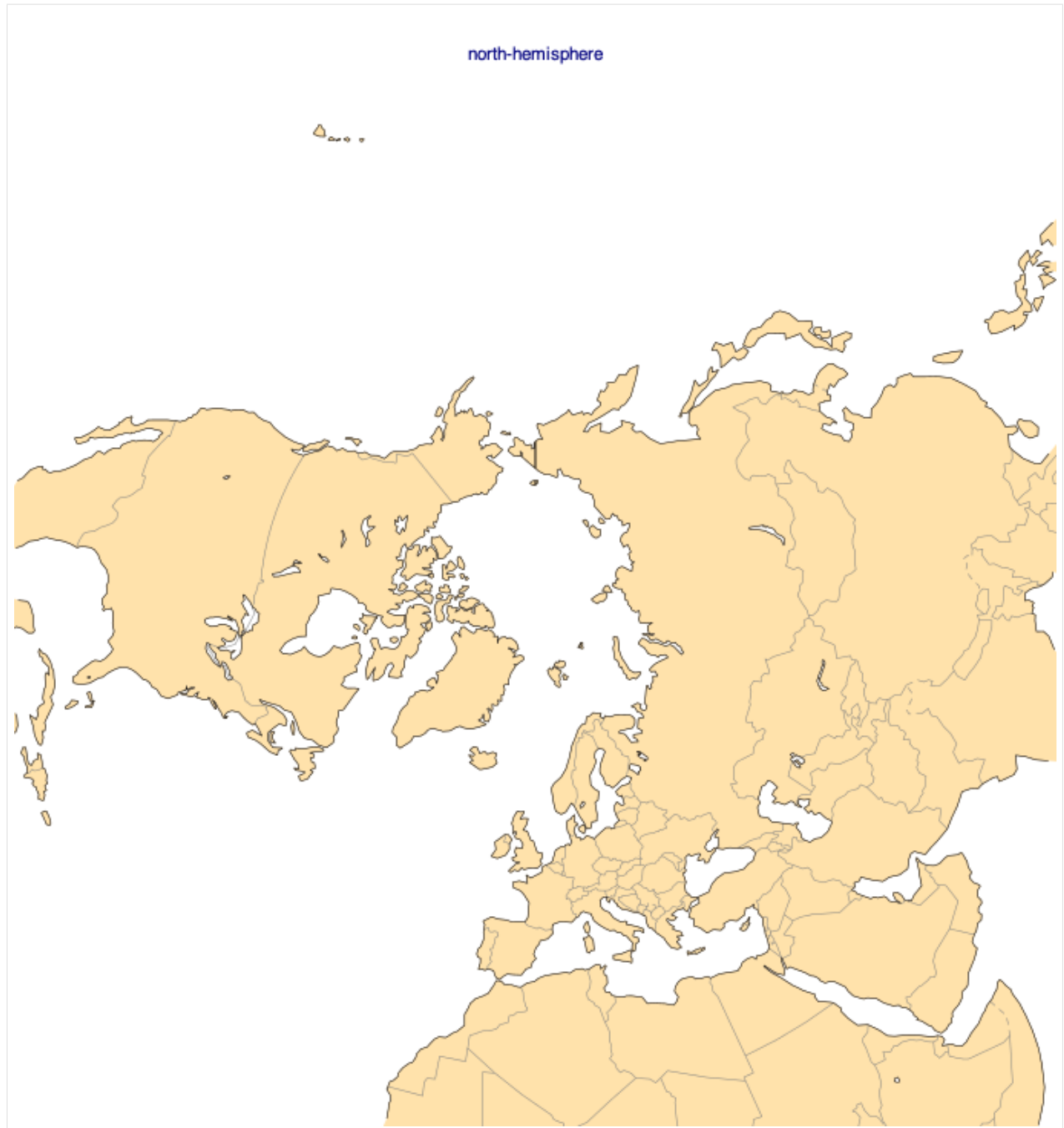


























### Low-level graphical attributes

```
[13]: cml.plotting_options(width=500)
```

```
[14]: atlantic = cml.load_dataset("hurricane-database", bassin="atlantic")
```

```
[15]: df = atlantic.to_pandas()
```

```
[16]: david = df[(df.name == "david")]
```

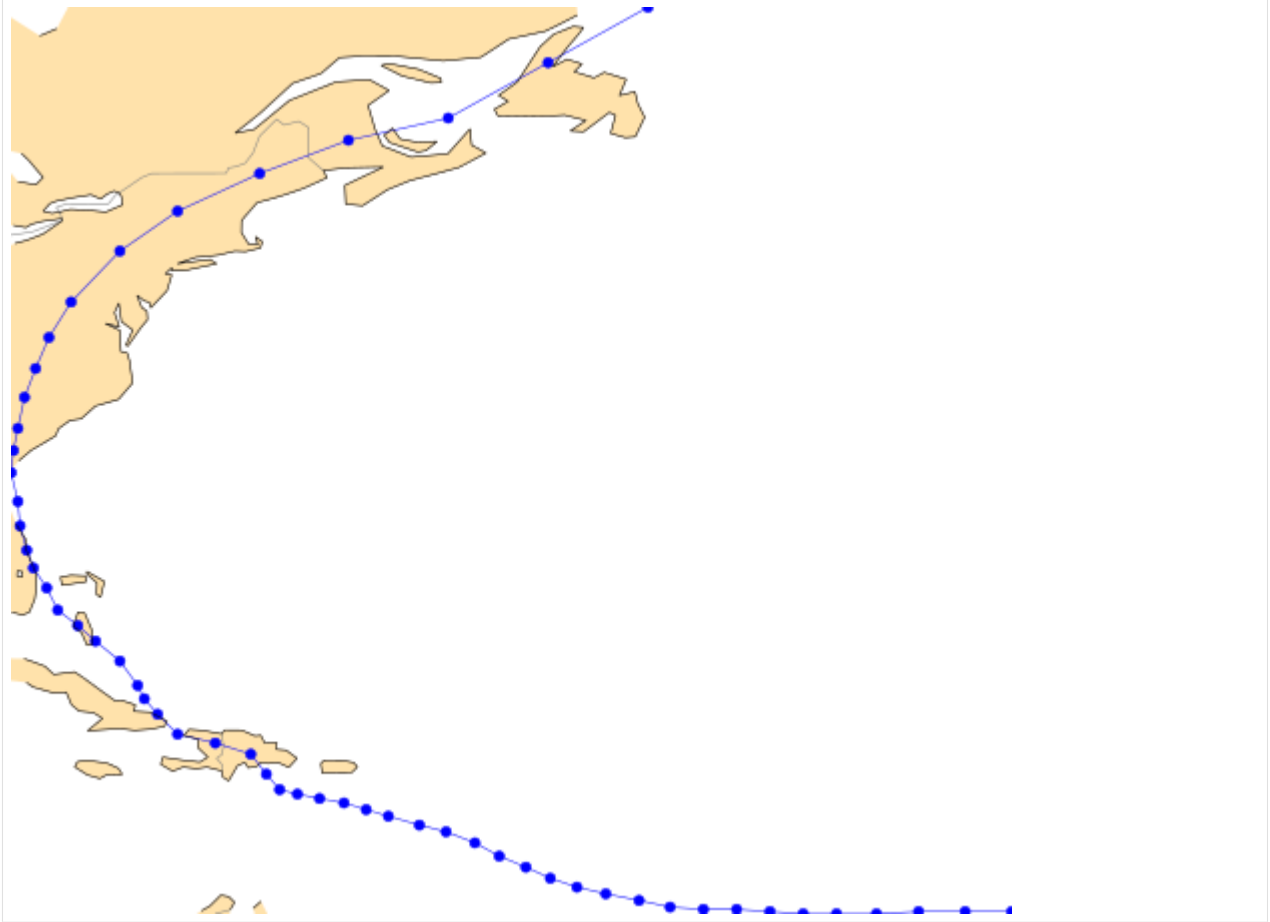
```
[17]: cml.plot_map(
    david, style=dict(symbol_colour="blue", symbol_type="marker", symbol_marker_index=3)
)
```



```
[18]: cml.plot_map(david)
```



```
[19]: cml.plot_map(david, style={"symbol_colour": "blue"})
```



```
[20]: cml.plot_map(  
    david,  
    background={  
        "map_coastline_land_shade": True,  
        "map_coastline_land_shade_colour": "green",  
    },  
)
```



```
[21]: cml.plot_map(david, background=False)
```



You can run this notebook in , in , in

```
[1]: !pip install --quiet climetlab
```

```
[2]: import climetlab as cml
```

```
[3]: source = cml.load_source(  
    "cds",  
    "insitu-observations-gruan-reference-network",  
    variable="air_temperature",  
    year="2017",  
    month="01",  
    day=[  
        "01",  
        "02",  
        "03",  
        "04",  
        "05",  
        "06",  
        "07",  
        "08",  
        "09",  
        "10",
```

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```

"11",
"12",
"13",
"14",
"15",
"16",
"17",
"18",
"19",
"20",
"21",
"22",
"23",
"24",
"25",
"26",
"27",
"28",
"29",
"30",
"31",
],
format="csv-lev.zip",
)

```

```
[4]: df = source.to_pandas()
```

```
[5]: df
```

```

[5]:      station_name      report_timestamp  time_since_launch  report_id \
0          LIN 2017-01-01 00:00:00+00:00          0.000000      242982
1          LIN 2017-01-01 00:00:00+00:00          1.000000      242982
2          LIN 2017-01-01 00:00:00+00:00          2.000000      242982
3          LIN 2017-01-01 00:00:00+00:00          3.00012      242982
4          LIN 2017-01-01 00:00:00+00:00          4.00012      242982
...          ...          ...          ...          ...
1645953      LIN 2017-01-31 18:00:00+00:00        5002.16000      246127
1645954      LIN 2017-01-31 18:00:00+00:00        5003.16000      246127
1645955      LIN 2017-01-31 18:00:00+00:00        5004.16000      246127
1645956      LIN 2017-01-31 18:00:00+00:00        5005.16000      246127
1645957      LIN 2017-01-31 18:00:00+00:00        5006.16000      246127

      longitude  latitude  height_of_station_above_sea_level  air_pressure \
0          14.1203    52.2094                103.8          101096.00
1          14.1203    52.2094                103.8          101019.00
2          14.1204    52.2094                103.8          100946.00
3          14.1204    52.2095                103.8          100879.00
4          14.1204    52.2095                103.8          100810.00
...          ...          ...          ...          ...
1645953      14.3240    51.9910                103.8           2354.49
1645954      14.3247    51.9909                103.8           2352.38
1645955      14.3253    51.9909                103.8           2350.24

```

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```
1645956    14.3260    51.9908                103.8    2347.39
1645957    14.3267    51.9907                103.8    2344.79
```

```
          air_pressure_total_uncertainty  air_temperature
0                                36.8895    274.357
1                                36.8886    274.321
2                                36.8878    274.282
3                                36.8870    274.255
4                                36.8861    274.257
...                                ...          ...
1645953                                37.2003    198.804
1645954                                37.1999    198.776
1645955                                37.1994    198.747
1645956                                37.1988    198.710
1645957                                37.1982    198.670
```

```
[1645958 rows x 10 columns]
```

```
[6]: cml.plot_map(df[(df.time_since_launch == 0)])
```



You can run this notebook in , in , in

```
[ ]: !pip install --quiet climetlab[interactive]
```

### 1.4.15 Interactive maps

```
[4]: import climetlab as cml
```

```
[5]: atlantic = cml.load_dataset("hurricane-database", bassin="atlantic")
df = atlantic.to_pandas()
katrina = df[(df.name == "katrina") & (df.year == 2005)]
cml.interactive_map(katrina)
```

```
[5]: <IPython.core.display.HTML object>
```



```
[ ]:
```

You can run this notebook in , in , in

```
[ ]: !pip install --quiet climetlab
```

## 1.4.16 Creating a shared dataset of GRIBs

```
[1]: import climetlab as cml
```

### Download data to the climetlab cache

```
[ ]: for month in range(1, 13): # This takes a few minutes.
    cml.load_source(
        "mars",
        param="2t",
        levtype="sfc",
        area=[50, -50, 20, 50],
        grid=[1, 1],
        date=f"2012-{month}",
    )
```

```
[ ]: cml.load_source(
    "mars",
    param="msl",
    levtype="sfc",
    area=[50, -50, 20, 50],
    grid=[1, 1],
    date="2012-12-01",
);
```

### Export the data to a shared directory

This is optional, you could keep working on the data from the cache if you are the only user of the data and you do not mind redownloading it later. Other people should not use your cache: - When using climetlab the cache will eventually fill up and the data may be deleted automatically, - You will need to deal with permissions issues. - It will make it difficult to share the data with other people.

Let us export the data to a shared directory `shared-data/temperature-for-analysis`

```
[4]: # Some housekeeping
!rm -rf shared-data/temperature-for-analysis
!mkdir -p shared-data/temperature-for-analysis
```

```
[5]: # export all data from my cache which is from mars and not older than 1 day
!climetlab export_cache shared-data/temperature-for-analysis --newer 1h --match mars
```

```
Copying cache entries matching 'mars' and newer than '2023-03-11 13:29:29' to shared-
↳data/temperature-for-analysis.
100%| 13/13 [00:00<00:00, 367.98it/s]
Copied 13 cache entries to shared-data/temperature-for-analysis.
```

### Create indexes to speed up data access when using it. (Optional)

```
[ ]: !climetlab index_directory shared-data/temperature-for-analysis
```

```
[ ]: !climetlab availability shared-data/temperature-for-analysis
```

### Using the data

```
[18]: DATA = "shared-data/temperature-for-analysis"
```

```
[19]: source = cml.load_source("indexed-directory", DATA)
```

```
[20]: source.availability
```

```
[20]: class=od, domain=g, expver=0001, levtype=sfc, md5_grid_
↳section=celbd075c48ae7a5bf34f4e47166e942, step=0, stream=oper, time=1200, type=an
    date=20120101/to/20121231, param=2t
    date=20121201, param=msl
```

This is a good time to check the data, is all the data here? Are they missing dates? Parameters?

The data is ready to be used as numpy, tensorflow or xarray object.

```
[11]: source.sel(param="msl").to_numpy().mean()
```

```
[11]: 101725.47522756307
```

```
[22]: cml.load_source("indexed-directory", DATA, param="msl").to_numpy().mean()
```

```
[22]: 101725.47522756307
```

```
[23]: temp = source.sel(param="2t").order_by("date")
temp.to_tfdataset()
```

```
[23]: <PrefetchDataset element_spec=TensorSpec(shape=<unknown>, dtype=tf.float32, name=None)>
```

```
[24]: temp.to_xarray()
```

```
[24]: <xarray.Dataset>
Dimensions:      (number: 1, time: 366, step: 1, surface: 1, latitude: 31,
                  longitude: 101)
Coordinates:
  * number        (number) int64 0
  * time          (time) datetime64[ns] 2012-01-01T12:00:00 ... 2012-12-31T12:0...
  * step          (step) timedelta64[ns] 00:00:00
  * surface       (surface) float64 0.0
```

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```
* latitude      (latitude) float64 50.0 49.0 48.0 47.0 ... 23.0 22.0 21.0 20.0
* longitude     (longitude) float64 -50.0 -49.0 -48.0 -47.0 ... 48.0 49.0 50.0
  valid_time    (time, step) datetime64[ns] ...
Data variables:
  t2m           (number, time, step, surface, latitude, longitude) float32 ...
Attributes:
  GRIB_edition:      1
  GRIB_centre:       ecmf
  GRIB_centreDescription: European Centre for Medium-Range Weather Forecasts
  GRIB_subCentre:    0
  Conventions:       CF-1.7
  institution:       European Centre for Medium-Range Weather Forecasts
  history:           2023-03-11T14:35 GRIB to CDM+CF via cfgrib-0.9.1...
```

```
[25]: # Note that this is wrong (not implemented yet)
temp.availability
```

```
[25]: class=od, domain=g, expver=0001, levtype=sfc, md5_grid_
      ↪ section=celbd075c48ae7a5bf34f4e47166e942, step=0, stream=oper, time=1200, type=an
      date=20120101/to/20121231, param=2t
      date=20121201, param=msl
```

```
[ ]:
```

```
[ ]:
```

You can run this notebook in , in , in

### 1.4.17 Save data to GRIB

Here is an example of generating custom GRIB using climetlab.

To generate a GRIB, CliMetLab provides the function `cml.new_grib_output()`, requiring the following arguments:

- A numpy array containing the data to save.
- An object containing a template for the GRIB metadata, such as a CliMetLab source
- (Optional) A dictionary of metadata to override the template metadata.

Using this function is similar to `open(path)` in python, as shown below:

#### A template for the GRIB metadata

```
[1]: import climetlab as cml

s = cml.load_source(
    "cds",
    "reanalysis-era5-single-levels",
    variable=["2t", "msl"],
    product_type="reanalysis",
    area=[50, -50, 20, 50],
```

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```

    date="2012-12-12",
    time="12",
)

template = s[0] # temperature template

```

An numpy array with the data:

```

[2]: import numpy as np
import math

def generate_numpy_field(shape, ref=273.15, offset1=0, offset2=0):
    f = np.zeros(shape=shape, dtype=np.float64)
    for i in range(f.shape[0]):
        for j in range(f.shape[1]):
            f[i, j] = (
                ref
                + (math.sin((i + offset1) / 45.0) + math.sin((j + offset2) / 90.0)) * 15
            )
    return f

arr = generate_numpy_field(template.shape)

```

Let us plot the generated field for inspection. Notice how `cml.plot_map()` also uses the template to find the metadata required to plot the field as a temperature field.

```

[3]: cml.plot_map(arr, metadata=template)

```



## Write to GRIB

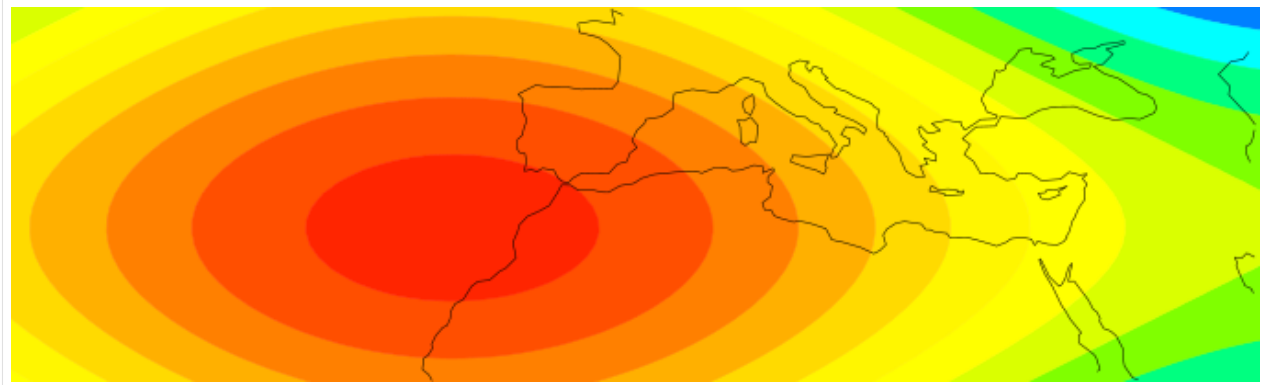
### Method 1

Compare to the usual python code:

```
f = open(path)
f.write(data)
f.close()
```

```
[4]: output = cml.new_grib_output("test1.grib", template=template)
      output.write(arr)
      output.close()
```

```
[5]: cml.plot_map(cml.load_source("file", "test1.grib"))
```



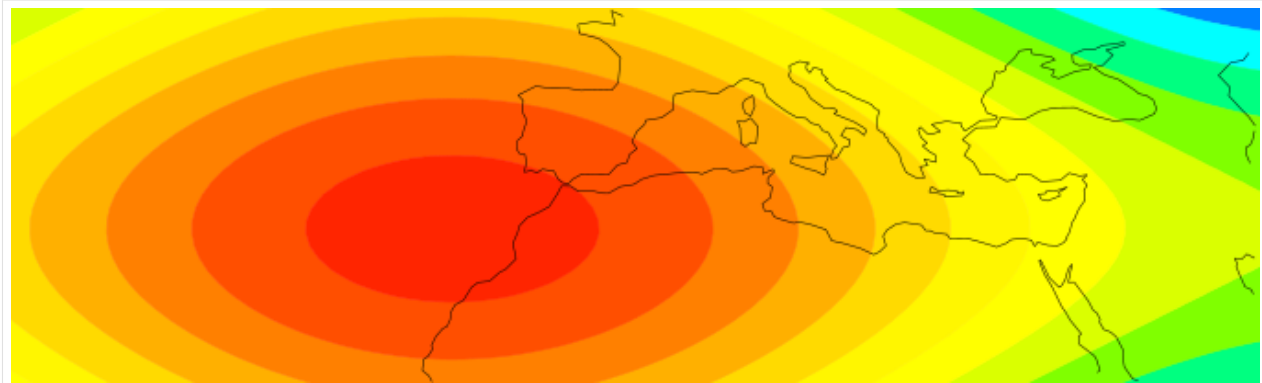
## Write to GRIB

### Method 2

The template can also be added in the `.write()` method instead of the `cml.new_grib_output()` function:

```
[6]: output = cml.new_grib_output("test2.grib")
      output.write(arr, template=template)
      output.close()
```

```
[7]: cml.plot_map(cml.load_source("file", "test2.grib"))
```



### Method 3

Compare to the usual python code:

```
with open(path) as f:
    f.write(data)
```

```
[8]: with cml.new_grib_output("test3.grib", template=template) as output:
      output.write(arr)
```

```
[9]: cml.plot_map(cml.load_source("file", "test3.grib"))
```



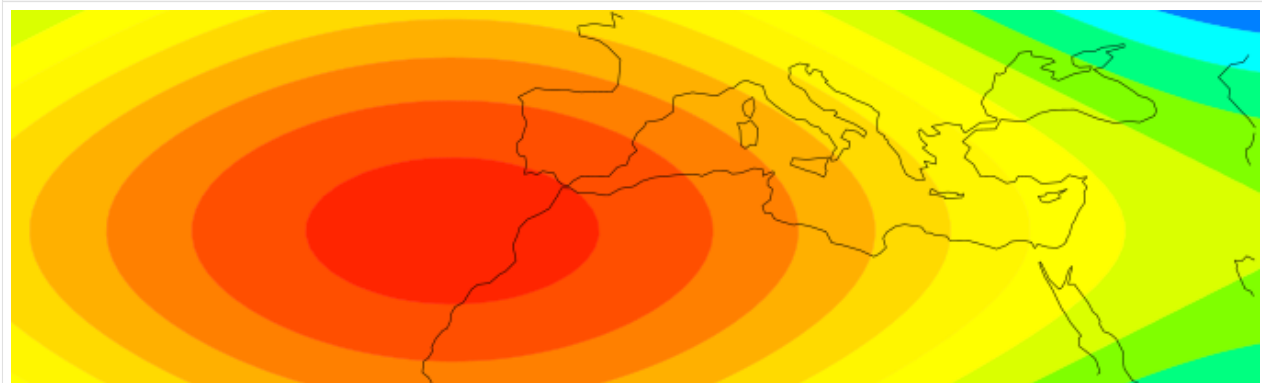
Once a GRIB output has been open, several fields can be written to it, as follows:

```
[10]: with cml.new_grib_output("test4.grib", template=template) as output:
      for i in range(24):
          f = generate_numpy_field(template.shape, offset1=i, offset2=i)
          output.write(f, metadata={"time": i})
```

```
[11]: test4 = cml.load_source("file", "test4.grib")
```

```
assert len(test4) == 24
```

```
cml.plot_map(test4[0])
cml.plot_map(test4[10])
cml.plot_map(test4[-1])
```





You can run this notebook in , in , in

```
[1]: !pip install --quiet climetlab
```

## 1.4.18 Dataset availability

(Work in progress)

```
[2]: from climetlab.utils.availability import Availability
      from climetlab.decorators import availability
```

```
[3]: C0 = [
      {"level": "500", "param": "Z", "step": "24"},
      {"level": "500", "param": "Z", "step": "36"},
      {"level": "500", "param": "Z", "step": "48"},
      {"level": "500", "param": "T", "step": "24"},
      {"level": "500", "param": "T", "step": "36"},
      {"level": "500", "param": "T", "step": "48"},
      {"level": "850", "param": "T", "step": "36"},
      {"level": "850", "param": "T", "step": "48"},
      {"level": "1000", "param": "Z", "step": "24"},
      {"level": "1000", "param": "Z", "step": "48"},
      ]
```

```
[4]: a0 = Availability(C0)
```

```
[5]: a0
```

```
[5]: <climetlab.utils.availability.Availability at 0x114a0ad60>
```

```
[6]: C1 = [
    {"level": "500", "param": "Z", "step": "24"},
    {"level": "500", "param": "Z", "step": "36"},
    {"level": "500", "param": "Z", "step": "48"},
    {"level": "500", "param": "T", "step": "24"},
    {"level": "500", "param": "T", "step": "36"},
    {"level": "500", "param": "T", "step": "48"},
    {"level": "850", "param": "T", "step": "36"},
    {"level": "850", "param": "T", "step": "48"},
    {"level": "1000", "param": "Z", "step": "24"},
    {"level": "1000", "param": "Z", "step": "48"},
    {"level": "850", "param": "Z", "step": "36"},
    {"level": "850", "param": "Z", "step": "48"},
]
```

```
[7]: a1 = Availability(C1)
```

```
[8]: a1
```

```
[8]: <climetlab.utils.availability.Availability at 0x10341e430>
```

```
[9]: a1.select(param="Z")
```

```
[9]: <climetlab.utils.availability.Availability at 0x114a0a790>
```

```
[10]: a1.select(param="T")
```

```
[10]: <climetlab.utils.availability.Availability at 0x114a2d0d0>
```

```
[11]: for r in a1.select(param="T").iterate():
    print(r)

{'param': ('T',), 'level': ('500',), 'step': ('24', '36', '48')}
{'param': ('T',), 'level': ('850',), 'step': ('36', '48')}
```

```
[12]: for r in a1.select(param="T").iterate(True):
    print(r)
```

```
{'param': 'T', 'level': '500', 'step': '24'}
{'param': 'T', 'level': '500', 'step': '36'}
{'param': 'T', 'level': '500', 'step': '48'}
{'param': 'T', 'level': '850', 'step': '36'}
{'param': 'T', 'level': '850', 'step': '48'}
```

```
[13]: a1.select(step="36")
```

```
[13]: <climetlab.utils.availability.Availability at 0x114a2daf0>
```

```
[14]: a1.select(step="36", param="T")
```



```
[14]: <climetlab.utils.availability.Availability at 0x114a2db20>
```

```
[15]: a1.count(step="36", param="T")
```

```
[15]: 2
```

```
[16]: a1.count()
```

```
[16]: 12
```

```
[17]: a1.select(step="22")
```

```
[17]: <climetlab.utils.availability.Availability at 0x114a2d7c0>
```

```
[18]: a1.select(param="Z", step="99").count()
```

```
[18]: 0
```

```
[19]: a3 = Availability(
    [
        {"date": ["1990-01-01/1990-01-02"], "param": ["Z", "T"]},
        {"date": ["1990-01-02/1990-01-05"], "param": ["Z"]},
        {"date": ["1990-01-04/1990-01-15"], "param": ["Z", "T"]},
    ],
    intervals=["date"],
)
```

```
[20]: a3
```

```
[20]: <climetlab.utils.availability.Availability at 0x114a2d460>
```

```
[21]: a3.count()
```

```
[21]: 29
```

```
[22]: a3.select(date="1990-01-02/1990-01-04")
```

```
[22]: <climetlab.utils.availability.Availability at 0x114a2d610>
```

```
[23]: for r in a3.select(date="1990-01-02/1990-01-04").iterate(True):
    print(r)
```

```
{'date': datetime.date(1990, 1, 2), 'param': 'T'}
{'date': datetime.date(1990, 1, 4), 'param': 'T'}
{'date': datetime.date(1990, 1, 2), 'param': 'Z'}
{'date': datetime.date(1990, 1, 3), 'param': 'Z'}
{'date': datetime.date(1990, 1, 4), 'param': 'Z'}
```

```
[24]: a3.missing(param="T", date="1990-01-01/1990-01-15")
```

```
[24]: <climetlab.utils.availability.Availability at 0x114a2dc10>
```

```
[ ]:
```

User Guide (TODO)

- *Howtos*
- *Datasets*
- *Data sources*
- *Data Manipulation*
- *Machine learning tools*
- *Plotting*
- *Caching*
- *Settings*
- *Using dask*
- *List of CliMetLab plugins*
- *Command line tool*

## 1.5 Howtos

### 1.5.1 How to install CliMetLab?

```
pip install climetlab
```

See the *installing instructions* for more details.

### 1.5.2 How to access data?

There are two ways to access data using CliMetLab:

- *Using a Dataset*: CliMetLab provides a few demo datasets. In order to access other datasets with `cml.load_dataset()`, the relevant plugin must be installed.
- *Using a data Source*: A data Source allows loading various kinds of data format and location through `cml.load_source()`. Data sources should be used when there is no dataset plugin for the data you are interested in.

### 1.5.3 How do I access data from this BUFR/GRIB/... file?

Use the *file* source.

### 1.5.4 How do I access data from this file on this unsupported format?

Write your own python code to open the file.

---

**Todo:** Add plugins and doc for readers.

---

### 1.5.5 How to help others to use my data ?

Creating a CliMetLab plugin can be a solution to share some code along with the dataset that you are publishing/using. See the *plugin documentation*.

### 1.5.6 How to set up my CliMetLab cache directory ?

See *Caching*.

### 1.5.7 How to share my cache directory with another user ?

It is not recommended to share your cache with others. What you are looking for may be a mirror. And this feature is not implemented yet.

A more robust approach is to put the data to a shared location, and define a *CliMetLab dataset* plugin to use it.

### 1.5.8 Can CliMetLab help using dask ?

See *Using dask*.

## 1.6 Datasets

A **Dataset** is an object created using `cml.load_dataset(name, arg1, arg2=..., ...)` with the appropriate **name** and **arguments**, which provides access to a clearly well-defined **dataset**: these data have been defined and curated by somebody providing code along with the data. It also provides **metadata** and **additional functionalities**.

- The **name** is a string that uniquely identifies the dataset.
- The **argument(s)** `arg1` and keyword argument(s) `arg2` can be used to specify a subset of the dataset.
- The **data** can be accessed using methods such as `to_xarray()` or `to_pandas()` or other.
- Relevant **metadata** are attached directly to the dataset to provides additional information such as *an URL, a citation, licence, etc.*
- **Additional functionalities**: When working on data, we are often writing code to transform, preprocess, adapt the data to our needs. While it may be very nice to understand deeply to deep magic under the hood, this process could be very time-consuming. Once somebody else did the hard work of preparing the data for a given purpose and designing relevant functions to process it, their code can be integrated and made available to others through a CliMetLab dataset plugin. The Dataset object is an instance of a Python class in which the plugin maintainers/users can share additional code.

---

**Note:** *Dataset* objects differ from data *Source* objects, as Datasets refer to a given set of data (such as “the 2m temperature on Europe in 2015”, while Sources are more generic such as “url”).

---

CliMetLab has build-in datasets (as examples) and most of the datasets are available as plugins (non-exhaustive *list of CliMetLab plugins*).

### 1.6.1 How to load a dataset?

The relevant plugin must be installed first, using pip.

```
pip install climetlab-demo-dataset
```

This ensures that the dataset can be loaded with `climetlab.load_dataset()`.

```
>>> import climetlab as cml
>>> ds = cml.load_dataset("demo-dataset")
```

The first argument is the name of the dataset. It is used to find the relevant plugin and class to use. Other arguments are defined by the plugin maintainer and are documented in the plugin documentation (see [List of CliMetLab plugins](#)).

The Dataset object provides methods to access and use its data such as `to_xarray()` or `to_pandas()` or `to_numpy()` (there are other *methods that can be used to access data* from a Dataset).

```
>>> ds.to_xarray() # for gridded data
>>> ds.to_pandas() # for non-gridded data
>>> ds.to_numpy() # When the data is a n-dimensional array.
>>> ds.to_tfrecored() # Experimental
```

---

**Note:** The name of the python package for a CliMetLab plugin usually starts with “climetlab-“.

---



---

**Note:** The plugin name does not necessarily match the dataset name, and one plugin can provide several datasets. As an example, the plugin `climetlab-s2s-ai-challenge` provides the datasets `s2s-ai-challenge-training-input` and `s2s-ai-challenge-training-output`:

---

```
>>> !pip install climetlab-s2s-ai-challenge
>>> climetlab.load_dataset("s2s-ai-challenge-training-input", ...)
>>> climetlab.load_dataset("s2s-ai-challenge-training-output", ...)
```

---

### 1.6.2 Xarray for gridded data

Gridded data typically are field data such as temperature or wind from climate or weather models or satellite images.

```
>>> import climetlab as cml
>>> ds = cml.load_dataset("demo-dataset")
>>> ds.to_xarray()
<xarray.Dataset>
Dimensions:      (latitude: 181, longitude: 360)
Coordinates:
  * longitude    (longitude) float64 -180.0 -179.0 -178.0 ... 177.0 178.0 179.0
  * latitude     (latitude) float64 90.0 89.0 88.0 87.0 ... -88.0 -89.0 -90.0
Data variables:
  t2m           (latitude, longitude) float64 273.1 273.3 273.5 ... 250.7 250.6
```

### 1.6.3 Pandas for non-gridded data

None-gridded data typically is tabular non-structured data such as observations. It often includes a column for the latitude and longitude of the data.

```
>>> import climetlab as cml
>>> ds = cml.load_dataset("dataset-name", **options)
>>> ds.to_pandas()
```

### 1.6.4 Metadata attached to a dataset

Metadata attached to a dataset include the following.

**home\_page:** A link to the home page related to the dataset.

**licence:** A link to the licence of the dataset.

**documentation:** A link to the documentation related to the dataset.

**citation:** A citation related to the dataset.

**terms\_of\_use:** A text or link to the terms of use of the data.

```
>>> import climetlab as cml
>>> ds = cml.load_dataset("demo-dataset")
>>> ds.home_page
'https://github.com/ecmwf/climetlab-demo-dataset'
>>> ds.documentation
'Generates a dummy temperature field'
```

### 1.6.5 Best practices

**Note:** When sharing a python notebook, it is a good practice to add `!pip install climetlab-...` at the top of the notebook. If the package is not installed, CliMetLab fails with a `NameError` exception.

```
>>> # if the package climetlab-demo-dataset is not installed
>>> import climetlab as cml
>>> ds = cml.load_dataset("demo-dataset")
NameError: Cannot find dataset 'demo-dataset' (values are: ...),
```

```
>>> !pip install climetlab_demo_dataset --quiet
>>> import climetlab as cml
>>> ds = cml.load_dataset("demo-dataset")
>>>
```

There is no need to import the plugin package to enable loading the dataset:

```
>>> import climetlab_demo_dataset # Not needed
```

## 1.7 Data sources

### 1.7.1 What is a data Source?

A data **Source** is an object created using `cml.load_source(name, *args, **kwargs)` with the appropriate name and arguments, which provides access to the data.

A Source also provides metadata and additional functionalities:

- The source **name** is a string that uniquely identifies the source type.
- The **arguments** (args and kwargs) are used to specify the data location to access the data. They can include additional parameters to access the data.
- The **additional functionalities** include python code related to caching, plotting and interacting with other data.

```
>>> import climetlab as cml
>>> source = cml.load_source(name, *args, **kwargs)
```

The Source object provides methods to access and use its data such as `to_xarray()` or `to_pandas()` or `to_numpy()` (there are other *methods that can be used to access data* from a data Source).

```
>>> source.to_xarray() # for gridded data
>>> source.to_pandas() # for non-gridded data
>>> source.to_numpy() # When the data is a n-dimensional array.
>>> source.to_tfreord() # Experimental
```

---

**Note:** *Source* objects differ from data *Dataset* objects, as Datasets refer to a given set of data (such as “the 2m temperature on Europe in 2015”, while Sources are more generic such as “url”).

---

### 1.7.2 Which data Sources are available?

CliMetLab has built-in sources and additional sources can be made available *as plugins*.

Built-in data sources:

- *file* source: Load data from a file.
- *url* source: Load data from a URL.
- *url-pattern* source: Load data from list of URL created from a pattern.
- *cds* source: Load data from the Copernicus Data Store (CDS).
- *mars* source: Load data from the Meteorological Archival and Retrieval System at ECMWF (MARS).
- *multi (advanced usage)* source: Aggregate multiple sources.
- *zenodo* source (experimental): Load data from Zenodo.
- *indexed\_urls* source (experimental): Load data from GRIB urls with partial download.

### 1.7.3 file

The simplest data source is the "file" source that accesses a local file.

```
>>> import climetlab as cml
>>> data = cml.load_source("file", "path/to/file")
>>> data.to_xarray() # for gridded data fields
>>> data.to_pandas() # for non-gridded data
```

*CliMetLab* will inspect the content of the file to check for any of the supported data formats listed below:

- **Fields:**
  - NetCDF
  - GRIB (see *GRIB support*)
- **Observations:**
  - CSV (comma-separated values)
  - BUFR (<https://en.wikipedia.org/wiki/BUFR>)
  - ODB (a bespoke binary format for observations)
- **Archive formats:** When given an archive format such as .zip, .tar, .tar.gz, etc, *CliMetLab* will attempt to open it and (recursively) extract any usable file.

```
>>> import climetlab as cml
>>> data = cml.load_source("url",
                           "https://www.example.com/data.tgz",
                           unpack=False)
```

---

**Todo:** Support for additionnal formats could be implemented as plugins.

---

### GRIB file example

```
>>> import climetlab as cml
>>> data = cml.load_source("file", "examples/test.grib")
>>> data.to_xarray()
<xarray.Dataset>
Dimensions:      (number: 1, time: 1, step: 1, surface: 1, latitude: 11,
↳ longitude: 19)
Coordinates:
  * number        (number) int64 0
  * time          (time) datetime64[ns] 2020-05-13T12:00:00
  * step          (step) timedelta64[ns] 00:00:00
  * surface       (surface) float64 0.0
  * latitude      (latitude) float64 73.0 69.0 65.0 61.0 ... 45.0 41.0 37.0 33.0
  * longitude     (longitude) float64 -27.0 -23.0 -19.0 -15.0 ... 37.0 41.0 45.0
    valid_time    (time, step) datetime64[ns] ...
Data variables:
  t2m             (number, time, step, surface, latitude, longitude) float32 ...
  msl             (number, time, step, surface, latitude, longitude) float32 ...
```

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```

Attributes:
  GRIB_edition:      1
  GRIB_centre:       ecmf
  GRIB_centreDescription: European Centre for Medium-Range Weather Forecasts
  GRIB_subCentre:    0
  Conventions:       CF-1.7
  institution:       European Centre for Medium-Range Weather Forecasts
  history:           2022-02-08T10:50 GRIB to CDM+CF via cfgrib-0.9.1..
→ .

```

## NetCDF file example

```

>>> import climetlab as cml
>>> data = cml.load_source("file", "examples/test.nc")
>>> data.to_xarray()
<xarray.Dataset>
Dimensions:      (number: 1, time: 1, step: 1, surface: 1, latitude: 11,
→ longitude: 19)
Coordinates:
  * number        (number) int64 0
  * time          (time) datetime64[ns] 2020-05-13T12:00:00
  * step          (step) timedelta64[ns] 00:00:00
  * surface       (surface) float64 0.0
  * latitude      (latitude) float64 73.0 69.0 65.0 61.0 ... 45.0 41.0 37.0 33.0
  * longitude     (longitude) float64 -27.0 -23.0 -19.0 -15.0 ... 37.0 41.0 45.0
  valid_time     (time, step) datetime64[ns] ...
Data variables:
  t2m            (number, time, step, surface, latitude, longitude) float32 ...
  msl            (number, time, step, surface, latitude, longitude) float32 ...
Attributes:
  GRIB_edition:      1
  GRIB_centre:       ecmf
  GRIB_centreDescription: European Centre for Medium-Range Weather Forecasts
  GRIB_subCentre:    0
  Conventions:       CF-1.7
  institution:       European Centre for Medium-Range Weather Forecasts
  history:           2022-02-08T10:50 GRIB to CDM+CF via cfgrib-0.9.1..
→ .

```

## Other format file example

If the format is supported, see the [Examples](#) notebooks for a working example.

If the format is not supported, additional code can be included in CliMetLab to support it.

---

**Todo:** Support for additional formats could be implemented as plugins.

---



### 1.7.4 url

The "url" data source is very similar to the "file" source.

This source downloads the data from the specified address and stores it in the *cache*, then it operates similarly to the "file" source above. The supported data formats are the same as for the "file" source.

```
>>> import climetlab as cml
>>> data = cml.load_source("url", "https://www.example.com/data.csv")
```

When given an archive format such as .zip, .tar, .tar.gz, etc, *CliMetLab* will attempt to open it and extract any usable file. If you want to keep the downloaded file as is, pass `unpack=False` to the method.

```
>>> import climetlab as cml
>>> data = cml.load_source("url",
                           "https://www.example.com/data.tgz",
                           unpack=False)
```

### 1.7.5 url-pattern

The "url-pattern" data source will build urls from the pattern specified, using the other arguments to fill the pattern. Each argument can be a list to iterate and create the cartesian product of all lists. Then each url is downloaded and stored in the *cache*. The supported download the data from the address data formats are the same as for the *file* and *url* data sources above.

```
import climetlab as cml

data = cml.load_source("url-pattern",
                       "https://www.example.com/data-{{foo}}-{{bar}}-{{qux}}.csv",
                       foo = [1,2,3],
                       bar = ["a", "b"],
                       qux = "unique"
                       )
```

The code above will download and process the data from the six following urls:

1. <https://www.example.com/data-1-a-unique.csv>
2. <https://www.example.com/data-2-a-unique.csv>
3. <https://www.example.com/data-3-a-unique.csv>
4. <https://www.example.com/data-1-b-unique.csv>
5. <https://www.example.com/data-2-b-unique.csv>
6. <https://www.example.com/data-3-b-unique.csv>

If the urls are pointing to archive format, the data will be unpacked by `url-pattern` according to the **unpack** argument, similarly to what the source `url` does (see above the *url* source).

Once the data have been properly downloaded [and unpacked] and cached. It can be accessed using `to_xarray()` or `to_pandas()`.

To provide a unique `xarray.Dataset` (or `pandas.DataFrame`), the different datasets are merged. The default merger strategy for field data is to use `xarray.open_mfdataset` from *xarray*. This can be changed by providing a custom merger to the `url-pattern` source. See *merging sources*

### 1.7.6 cds

The "cds" data source accesses the [Copernicus Climate Data Store \(CDS\)](#), using the `cdsapi` package. A typical `cdsapi` request has the following format:

```
import cdsapi

client = cdsapi.Client()

client.retrieve("dataset-name",
                {"parameter1": "value1",
                 "parameter2": "value2",
                 ...})
```

to perform the same operation with *CliMetLab*, use the following code:

```
import climetlab as cml

data = cml.load_source("cds",
                       "dataset-name",
                       {"parameter1": "value1",
                        "parameter2": "value2",
                        ...})
```

Data downloaded from the CDS is stored in the the *cache*.

To access data from the CDS, you will need to register and retrieve an access token. The process is described [here](#).

For more information, see the CDS [knowledge base](#).

### 1.7.7 mars

The "mars" source allows handling data from the Meteorological Archival and Retrieval System (MARS).

To figure out which data you need, or discover relevant data available on MARS, see the publicly accessible [MARS catalog](#) (or this [access restricted catalog](#)). Notice that various [datasets of interests](#) are also publicly available. To access data from the MARS, you will need to register and retrieve an access token. For a more extensive documentation about MARS, please refer to the [MARS documentation](#) (or its [access from the internet](#) through its [web API](#)).

```
from ecmwfapi import ECMWFDataServer

server = ECMWFDataServer()

client.retrieve(
    { "parameter1": "value1",
      "parameter2": "value2",
      ...
    })
```

to perform the same operation with *CliMetLab*, use the following code:

```
import climetlab as cml

data = cml.load_source("mars",
                       { "parameter1": "value1",
```

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```
"parameter2": "value2",
...
})
```

Data downloaded from MARS is stored in the the *cache*.

## Examples

See the *Examples* notebooks for a working example.

### 1.7.8 zenodo

*Zenodo* is a general-purpose open repository developed and operated by CERN. It allows researchers to deposit research papers, datasets, etc. For each submission, a persistent digital object identifier (DOI) is minted, which makes the stored items easily citeable.

The "zenodo" source provides access data from [zenodo.org](https://zenodo.org), including downloading, caching, etc.

```
>>> ds = load_source("zenodo", record_id=...)
```

## Example

```
>>> import climetlab as cml
>>> def only_csv(path):
    return path.endswith(".csv")
>>> source = cml.load_source("zenodo", record_id=5020468, filter=only_csv)
>>> source.to_pandas()
```

---

**Note:** Support for zenodo access is experimental.

---

### 1.7.9 indexed\_urls

```
>>> ds = load_source("indexed_urls", index, request)
```

Experimental. See *GRIB support*.

### 1.7.10 multi (advanced usage)

```
>>> ds = load_source("multi", source1, source2, ...)
```

---

**Todo:** add documentation on multi-source.

---

## 1.8 Data Manipulation

---

**Todo:** This section is a draft.

---

### 1.8.1 Methods provided by CliMetLab data objects

Methods provided by CliMetLab data objects (such as a Dataset, a data Source or a Reader): Depending on the data, some of these methods are or are not available.

A CliMetLab data object provides methods to access and use its data.

```
>>> source.to_xarray() # for gridded data
>>> source.to_pandas() # for non-gridded data
>>> source.to_numpy() # When the data is a n-dimensional array.
>>> source.to_tfrecord() # Experimental
```

---

**Todo:** Explain fields.to\_xarray() and obs.to\_pandas().

Explain data[0]

Add here more details about the .to... methods.

---

### 1.8.2 Iterating

When a CliMetLab data *source* or dataset provides a list of fields, it can be iterated over to access each field (in a given order see [below](#)).

Let us get a source of fields from the Climate Data Store (CDS) and iterate through the list, each element is a field.

```
>>> import climetlab as cml
>>> ds = cml.load_source(
    "cds",
    "reanalysis-era5-single-levels",
    param=["2t", "msl"],
    product_type="reanalysis",
    grid='5/5',
    date=["2012-12-12", "2012-12-13"],
    time=[600, 1200, 1800],
)

>>> len(ds)
10

>>> for f in ds: print(f)
GribField(2t,None,20121212,600,0,0)
GribField(msl,None,20121212,600,0,0)
GribField(2t,None,20121212,1200,0,0)
GribField(msl,None,20121212,1200,0,0)
GribField(2t,None,20121212,1800,0,0)
```

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```
GribField(msl,None,20121212,1800,0,0)
GribField(2t,None,20121213,600,0,0)
GribField(msl,None,20121213,600,0,0)
GribField(2t,None,20121213,1200,0,0)
GribField(msl,None,20121213,1200,0,0)
GribField(2t,None,20121213,1800,0,0)
GribField(msl,None,20121213,1800,0,0)
```

### 1.8.3 Selection with [...]

When a CliMetLab data *source* or dataset provides a list of fields, it can be *iterated* over to access each field (in a given order see *below*).

A subset of the list can be created using the standard python list interface relying on brackets and slices.

```
>>> import climetlab as cml
>>> ds = cml.load_source(
    "cds",
    "reanalysis-era5-single-levels",
    param=["2t", "msl"],
    product_type="reanalysis",
    grid='5/5',
    date=["2012-12-12", "2012-12-13"],
    time=[600, 1200, 1800],
)

>>> len(ds)
10

>>> print(f[0])
GribField(2t,None,20121212,600,0,0)

>>> for f in ds[0:3]: print(f)
GribField(2t,None,20121212,600,0,0)
GribField(msl,None,20121212,600,0,0)
GribField(2t,None,20121212,1200,0,0)

>>> for f in ds[0:5:2]: print(f)
GribField(2t,None,20121212,600,0,0)
GribField(2t,None,20121212,1200,0,0)
GribField(2t,None,20121212,1800,0,0)
```

### 1.8.4 Selection with `.sel()`

When a CliMetLab data *source* or dataset provides a list of fields, it can be *iterated* over to access each field (in a given order see *below*).

The method `.sel()` allows filtering this list to **select a subset** of the list of fields.

For instance, the following examples shows how to select various subsets of fields from a list of fields. After selection the required list of fields, the selected data from this subset is available with the methods `.to_numpy()`, `.to_pytorch()`, `.to_xarray()`, etc...

This list of fields can be filtered to extract on the fields corresponding to the 2m-temperature parameter with `.sel(param="2t")`:

```
>>> import climetlab as cml
>>> ds = cml.load_source(
    "cds",
    "reanalysis-era5-single-levels",
    param=["2t", "msl"],
    product_type="reanalysis",
    grid='5/5',
    date=["2012-12-12", "2012-12-13"],
    time=[600, 1200, 1800],
)

>>> len(ds)
10

>>> subset = ds.sel(param="2t")
>>> len(subset)
6
>>> for f in subset:
GribField(2t, None, 20121212, 600, 0, 0)
GribField(2t, None, 20121212, 1200, 0, 0)
GribField(2t, None, 20121212, 1800, 0, 0)
GribField(2t, None, 20121213, 600, 0, 0)
GribField(2t, None, 20121213, 1200, 0, 0)
GribField(2t, None, 20121213, 1800, 0, 0)
```

This list of fields can be filtered to extract on the fields corresponding to 12h time with `.sel(time=1200)`:

```
>>> import climetlab as cml
>>> ds = cml.load_source(
    "cds",
    "reanalysis-era5-single-levels",
    param=["2t", "msl"],
    product_type="reanalysis",
    grid='5/5',
    date=["2012-12-12", "2012-12-13"],
    time=[600, 1200, 1800],
)

>>> len(ds)
10
>>> subset = ds.sel(time=1200)
```

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```
>>> len(subset)
4
>>> for f in subset:
GribField(2t, None, 20121212, 1200, 0, 0)
GribField(msl, None, 20121212, 1200, 0, 0)
GribField(2t, None, 20121213, 1200, 0, 0)
GribField(msl, None, 20121213, 1200, 0, 0)
```

Or both filters can be applied simultaneously with `.sel(param="2t", time=1200)`.

```
>>> import climetlab as cml
>>> ds = cml.load_source(
    "cds",
    "reanalysis-era5-single-levels",
    param=["2t", "msl"],
    product_type="reanalysis",
    grid='5/5',
    date=["2012-12-12", "2012-12-13"],
    time=[600, 1200, 1800],
)

>>> len(ds)
10
>>> subset = ds.sel(param="2t", time=1200)
>>> len(subset)
2
>>> for f in subset:
GribField(2t, None, 20121212, 1200, 0, 0)
GribField(2t, None, 20121213, 1200, 0, 0)
```

Filtering on multiple values is also possible by providing a list of values `.sel(param="2t", time=[600, 1200])`.

```
>>> import climetlab as cml
>>> ds = cml.load_source(
    "cds",
    "reanalysis-era5-single-levels",
    param=["2t", "msl"],
    product_type="reanalysis",
    grid='5/5',
    date=["2012-12-12", "2012-12-13"],
    time=[600, 1200, 1800],
)

>>> len(ds)
10
>>> subset = ds.sel(param="2t", time=[600, 1200])
>>> len(subset)
4
>>> for f in subset:
GribField(2t, None, 20121212, 600, 0, 0)
GribField(2t, None, 20121212, 1200, 0, 0)
GribField(2t, None, 20121213, 600, 0, 0)
GribField(2t, None, 20121213, 1200, 0, 0)
```

## 1.8.5 Ordering with .order\_by()

## 1.9 Merging Data sources

**Warning:** The merger functionality is experimental, the API may change.

---

**Todo:** add documentation on merging. merge=concat(). merge=merge().

---

```
import climetlab as cml
import xarray as xr

class MyMerger():
    def __init__(self, *args, **kwargs):
        pass
    def merge(self, paths, **kwargs):
        return xr.open_mfdataset(paths)

data = cml.load_source("url-pattern",
    "https://www.example.com/data-{foo}-{bar}-{qux}.csv",
    foo = [1,2,3],
    bar = ["a", "b"],
    qux = "unique"
    merger = MyMerger()
)
```

## 1.10 Machine learning tools

**Warning:** This part of CliMetLab is still a work in progress. Documentation and code behaviour will change.

---

**Todo:** TODO: Develop and document machine learning related tools

---

### 1.10.1 to\_tfdataset()

To use a CliMetLab dataset with tensorflow, use the `_to_tfdataset()` method.

```
>>> import climetlab as cml
>>> ds = cml.load_dataset(x)
>>> x = ds.to_tfdataset(options)
>>> model.fit(x, ....)
```

The discussion is still open to decide whether `to_dataset()` returns:

- `tf.keras.utils.experimental.DatasetCreator`



- `tf.data.Dataset`
- `tf.keras.utils.Sequence`
- A custom CliMetLab class

### 1.10.2 PyTorch support

**Todo:** A long-term goal of CliMetLab is to provide a easy way to use a dataset with Pytorch. A merge request within this respect would be welcome. The CliMetLab API (exposed to the end-user) should be mostly identical for Tensorflow or Pytorch.

## 1.11 Plotting

See also : <https://confluence.ecmwf.int/display/MAGP/Reference+guide>

**Todo:** Introduce advance plotting options

```
import climetlab as cml

# cml.settings.set("plotting-options", {'dump_yaml': True})

dataset = cml.load_dataset("example-dataset")
data = dataset[0]

cml.plot_map(data, foreground=False)

cml.plot_map(data, foreground=True)

cml.plot_map(data, foreground="example-foreground")

cml.plot_map(
    data,
    foreground=dict(
        map_grid=False,
        map_label=False,
        map_grid_frame=True,
        map_grid_frame_thickness=5,
        map_boundaries=True,
    ),
)

# Partial update of the current `foreground`
# How to do is still to be decided

# Option 1
cml.plot_map(
```

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```

data,
foreground={
    "+map_rivers": True,
    "+map_cities": True,
    "+map_label": True,
    "-map_boundaries": None,
},
)

# Option 2
cml.plot_map(
    data,
    foreground={
        "set": {"map_rivers": True, "map_cities": True, "map_label": True},
        "clear": ["map_boundaries"],
    },
)

# Option 3
cml.plot_map(
    data,
    foreground={
        "+": {"map_rivers": True, "map_cities": True, "map_label": True},
        "-": ["map_boundaries"],
    },
)

# Option 4
cml.plot_map(
    data,
    update_foreground={
        "map_rivers": True,
        "map_cities": True,
        "map_label": True,
        "map_boundaries": None,
    },
)

# Option 5
cml.plot_map(
    data,
    update={
        "foreground": {
            "map_rivers": True,
            "map_cities": True,
            "map_label": True,
            "map_boundaries": None,
        },
    },
)

```

```
import climetlab as cml
```

```
cml.plotting_options(width=400, foreground=False)
```

### 1.11.1 Projections

file\_content Traceback (most recent call last):

```
File "/home/docs/checkouts/readthedocs.org/user_builds/climetlab/checkouts/0.17.1/climetlab/sphinxext/module_output.py", line 10, in module.execute(*args)
```

```
File "/home/docs/checkouts/readthedocs.org/user_builds/climetlab/checkouts/0.17.1/climetlab/sphinxext/file_content.py", line 10, in print(".. code-block::", LANGUAGES[ext])
```

KeyError: 'YAML'

See [mmap](#).

### 1.11.2 Styles

TODO

See [mcont](#) and [msymb](#).

### 1.11.3 Layers

See [mcoast](#).

TODO

## 1.12 Caching

**Warning:** This part of CliMetLab is still a work in progress. Documentation and code behaviour will change.

### 1.12.1 Purpose

CliMetLab caches most of the remote data access on a local cache. Running again `cml.load_dataset` or `cml.load_source` will use the cached data instead of downloading it again. When the cache is full, cached data is deleted according to its cache policy (i.e. oldest data is deleted first). CliMetLab cache configuration is managed through the CliMetLab [Settings](#).

**Warning:** The CliMetLab cache is intended to be used by a single user. Sharing cache with **multiple users is not recommended**. Downloading a local copy of data on a shared disk to have multiple users working is a different use case and should be supported through using mirrors. [Feedback and feature requests are welcome](#).

### 1.12.2 Cache location

The cache location is defined by the `cache-directory` setting. Its default value depends on your system:

- `/tmp/climetlab-$USER` for Linux,
- `C:\Users\\$USER\AppData\Local\Temp\climetlab-$USER` for Windows
- `/tmp/.../climetlab-$USER` for MacOS

The cache location can be read and modified either with shell command or within python.

---

**Note:** It is recommended to restart your Jupyter kernels after changing the cache location.

---

From a shell with the `climetlab` command:

```
# Find the current cache directory
$ climatlab settings cache-directory
/tmp/climetlab-$USER

# Change the value of the setting
$ climatlab settings cache-directory /big-disk/climetlab-cache

# Cache directory has been modified
$ climatlab settings cache-directory
/big-disk/climetlab-cache
```

From a python notebook or python script:

```
>>> import climatlab as cml
>>> cml.settings.get("cache-directory") # Find the current cache directory
/tmp/climetlab-$USER
>>> # Change the value of the setting
>>> cml.settings.set("cache-directory", "/big-disk/climetlab-cache")

# Python kernel restarted

>>> import climatlab as cml
>>> cml.settings.get("cache-directory") # Cache directory has been modified
/big-disk/climetlab-cache
```

More generally, the CliMetLab settings can be read, modified, reset to their default values using the `climetlab` command or from python, see the [Settings documentation](#).

### 1.12.3 Cache limits

**Maximum-cache-size** The `maximum-cache-size` setting ensures that CliMetLab does not use too much disk space. Its value sets the maximum disk space used by CliMetLab cache. When CliMetLab cache disk usage goes above this limit, CliMetLab triggers its cache cleaning mechanism before downloading additional data. The value of `cache-maximum-size` is absolute (such as “10G”, “10M”, “1K”).

**Maximum-cache-disk-usage** The `maximum-cache-disk-usage` setting ensures that CliMetLab leaves does not fill your disk. Its values sets the maximum disk usage of the filesystem containing the cache directory. When the disk space goes below this limit, CliMetLab triggers its cache cleaning mechanism before downloading additional data. The value of `maximum-cache-disk-usage` is relative (such as “90%” or “100%”).

**Warning:** If your disk is filled by another application, CliMetLab will happily delete its cached data to make room for the other application as soon as it has a chance.

**Note:** When tweaking the cache settings, it is recommended to set the `maximum-cache-size` to a value below the user disk quota (if applicable) and `maximum-cache-disk-usage` to `None`.

### 1.12.4 Caching settings default values

| Name                                  | Default                            | Description  |
|---------------------------------------|------------------------------------|--|
| <code>cache-directory</code>          | <code>~/.tmp/climetlab-docs</code> | Directory of where the downloaded files are cached, with <code>\${USER}</code> is the user id. See <a href="#">Caching</a> for more information.         |
| <code>maximum-cache-disk-usage</code> | <code>'90%'</code>                 | Disk usage threshold after which CliMetLab expires older cached entries (% of the full disk capacity). See <a href="#">Caching</a> for more information. |
| <code>maximum-cache-size</code>       | <code>None</code>                  | Maximum disk space used by the CliMetLab cache (ex: 100G or 2T).   |

Other CliMetLab settings can be found [here](#).

## 1.13 Settings

*CliMetLab* is maintaining a set of global settings which control its behaviour.

The settings are saved in `~/.climetlab/settings.yaml`. They can be accessed from Python or using the `climetlab` command line.

### 1.13.1 Accessing settings

CliMetLab settings can be accessed using the python API:

```
import climetlab as cml

# Access one of the settings
cache_path = cml.settings.get("cache-directory")
print(cache_path)

# If this is the last line of a Notebook cell, this
```

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```
# will display a table with all the current settings
cml.settings
```

Or through the command line interface.

```
$ climetlab settings cache-directory
```

Or using the climetlab interactive prompt:

```
$ climetlab
(climetlab) settings cache-directory
```

## 1.13.2 Changing settings

---

**Note:** It is recommended to restart your Jupyter kernels after changing or resetting settings.

---

CliMetLab settings can be modified using the python API:

```
import climetlab as cml

# Change the location of the cache:
cml.settings.set("cache-directory", "/big-disk/climetlab-cache")

# Set some default plotting options (e.g. all maps will
# be 400 pixels wide by default):
cml.settings.set("plotting-options", width=400)
```

Or through the command line interface (CLI). Note that changing settings containing dictionary values is not possible with the CLI.

```
$ climetlab settings cache-directory /big-disk/climetlab-cache
```

Or using the climetlab interactive prompt:

```
$ climetlab
(climetlab) settings cache-directory /big-disk/climetlab-cache
```

## 1.13.3 Resetting settings

---

**Note:** It is recommended to restart your Jupyter kernels after changing or resetting settings.

---

CliMetLab settings can be reset using the python API:

```
import climetlab as cml

# Reset a named setting to its default value
cml.settings.reset("cache-directory")
```

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```
# Reset all settings to their default values  
cml.settings.reset()
```

Or through the command line interface (CLI):

```
$ climetlab settings_reset cache-directory  
$ climetlab settings_reset --all
```

Or using the climetlab interactive prompt:

```
$ climetlab  
(climetlab) settings_reset  
To wipe the cache completely, please use the --all flag. Use --help for more information.  
(climetlab) settings_reset --all  
(climetlab) Ctrl^D
```





### 1.13.4 Default values

| Name                       | Default  | Description  |
|----------------------------|--|--|
| cache-directory            | <code>~/.cache/limetlab/docs</code>  | Directory of where the downloaded files are cached, with <code>\${USER}</code> is the user id. See <a href="#">Caching</a> for more information.         |
| check-out-of-date-urls     | True   | Perform a HTTP request to check if the remote version of a cache file has changed  |
| dask-directories           | <code>['~/home/docs/.climetlab/dask']</code>                                       | List of directories where to search for dask cluster definitions. See <a href="#">dask</a> for more information.   |
| datasets-catalogs-urls     | <code>['https://github.com/ecmwf-lab/climetlab-datasets/raw/main/datasets']</code> | List of url where to search for catalogues of datasets definitions. See <a href="#">Datasets</a> for more information.                                   |
| datasets-directories       | <code>['~/home/docs/.climetlab/datasets']</code>                                   | List of directories where to search for datasets definitions. See <a href="#">Datasets</a> for more information.   |
| download-out-of-date-urls  | False  | Re-download URLs when the remote version of a cached file as been changed  |
| layers-directories         | <code>['~/home/docs/.climetlab/layers']</code>                                     | List of directories where to search for layers definitions. See <a href="#">Layers</a> for more information.   |
| maximum-cache-disk-usage   | '90%'  | Disk usage threshold after which ClimetLab expires older cached entries (% of the full disk capacity). See <a href="#">Caching</a> for more information. |
| maximum-cache-size         | None   | Maximum disk space used by the ClimetLab cache (ex: 100G or 2T).   |
| number-of-download-threads | 5  | Number of threads used to download data.   |
| plotting-options           | <code>{}</code>  | Dictionary of default plotting options. See <a href="#">Plotting</a> for more information.   |
| <b>1.13. Settings</b>      |  | <b>133</b>   |
| projections-directories    | <code>['~/home/docs/.climetlab/projections']</code>                                | List of directories where to search for projections definitions. See <a href="#">Projections</a> for more information.                                   |

## 1.14 Using dask

### 1.14.1 Climetlab dask tools

You do not need CliMetLab to use *dask*. Dask is an independent python package often use with. to *xarray* and *pandas*. As CliMetLab seeks a strong integration to *dask*, some high-level functions may be useful to ease the interaction with *dask*.

---

**Todo:** This whole part about *dask* is EXPERIMENTAL, it will change in the future, may be removed or (very likely) moved to another package.

---

#### Start an local cluster and client

```
from climetlab.utils.dask import start
start('local')
# or $ climetlab dask start local
# or $ climetlab dask local --start
```

#### Start an ssh cluster and client

```
from climetlab.utils.dask import start
start('ssh')
```

#### Start a SLURM dask cluster and client

```
from climetlab.utils.dask import start
start('slurm')
```

#### Start a slurm dask cluster on HPC

This is assumes that your HPC admin set up the `hpc-name-config-1.yaml` file on the appropriate location.

```
from climetlab.utils.dask import start
start('hpc-name-config-1')
```

#### Access the dask dashboard

---

**Todo:** Not implemented yet.

---

## Access the dask logs

---

**Todo:** Not implemented yet.

---

## Stop the dask cluster

The dask cluster and client will usually stop automatically when the python process ends. Nevertheless, it is possible to stop dask if it has been started from climetlab.

```
from climetlab.utils.dask import stop
stop()
```

### 1.14.2 Advanced dask usages

Note: In this section a “dask deployment” refers to a client and a cluster. It does not refers to a Cloud deployment using Kubernetes, etc.

#### Create a custom dask deployment specifications

Create the yaml file \$HOME/.climetlab/dask/hpc-name-config-1.yaml. Then use it with:

```
from climetlab.utils.dask import start
start('hpc-name-config-1')
```

---

**Todo:** This is EXPERIMENTAL.

---



---

**Note:** For HPC system admin: Adding yaml files in /opt/climetlab/dask/\*.yaml will give global access to all users.

---

#### Reuse the dask client

```
from climetlab.utils.dask import start
client = start('local').client
```

#### Scale the dask cluster

---

**Todo:** Define what “scale” mean in this context.

---

```
from climetlab.utils.dask import start
deploy = start('slurm')
deploy.scale(..)
```

## 1.15 List of CliMetLab plugins

**Note:** This list is **not exhaustive**. Some plugins are not listed here because we are not aware of them or because they are for internal use only, or not ready to be shared.

If you would like a plugin to be added in this list, please submit a pull request to CliMetLab or [open an issue on github](#).

---

### 1.15.1 Dataset plugins

Installing a *dataset* plugin, allows using an additional dataset in `cml.load_dataset`.

- **climetlab-s2s-ai-challenge:** Providing data for the Sub-seasonal to Seasonal (S2S) Artificial Intelligence Challenge (<https://s2s-ai-challenge.github.io>)  
 Datasets provided: `s2s-ai-challenge-*`
- **climetlab-demo-dataset:** Demo plugin to illustrate to dataset plugin mechanism.  
 Dataset provided: `demo-dataset`
- **climetlab-tropical-cyclone-dataset:** Tropical cyclones. In progress.  
 Datasets provided: `tc-*`
- **climetlab-maelstrom-yr:** Alpha. Gridded weather data for the Nordics, designed for ML postprocessing. Part of the MAELSTROM project.  
 Dataset provided: `maelstrom-yr`
- **climetlab-maelstrom-nogwd:** Alpha. Dataset for learning non-orographic gravity wave parametrization. Part of the MAELSTROM project.  
 Dataset provided: `maelstrom-nogwd`
- **climetlab-maelstrom-radiation:** Alpha. Dataset for learning radiative heating parametrization. Part of the MAELSTROM project.  
 Datasets provided: `maelstrom-radiation`, `maelstrom-radiation-tf`
- **climetlab-maelstrom-ens10:** Alpha. Dataset for testing ensemble postprocessing techniques. Part of the MAELSTROM project.  
 Datasets provided: `maelstrom-ens5mini`, `maelstrom-ens10`
- **climetlab-maelstrom-downscaling:** Alpha. Dataset for testing downscaling techniques. Part of the MAELSTROM project.  
 Dataset provided: `maelstrom-downscaling`
- **climetlab-maelstrom-power-production:** Alpha. Dataset for predicting wind farm power production from weather data. Part of the MAELSTROM project.  
 Datasets provided: `maelstrom-power-production`, `maelstrom-weather-model-level`,  
`maelstrom-weather-pressure-level`, `maelstrom-weather-surface-level`,  
`maelstrom-constants-a-b`

## Drafts Dataset Plugins

- `climetlab-cems-flood`: Glofas data. In progress.  
Dataset provided: `glofas`
- `climetlab-eumetnet-postprocessing-benchmark`:  
Eumetnet postprocessing benchmark dataset.
- `climetlab-meteonet`: Meteonet dataset developed by Météo-France.

## 1.15.2 Source plugins

Installing a *source* plugin, allows using an additional source in `cml.load_source`.

- `google-drive`  
Access public files in Google Drive with `cml.load_source("google-drive", file_id="...")`
- `climetlab-demo-source`  
Demo plugin to illustrate to source plugin mechanism.

## Drafts Source Plugins

- `stvl`  
Access data the STVL database with `cml.load_source("stvl", ...)`

## 1.16 Command line tool

Installing `climetlab` also make available the `climetlab` utility command line interface.

### 1.16.1 Usage

```
$ climetlab <command> [options]
```

```
$ climetlab
(climetlab) <command> [options]
```

### 1.16.2 Interactive prompt

`climetlab`

Running the `climetlab` command with no argument starts the interactive prompt. Autocompletion is enabled on the interactive prompt. To exit the interactive prompt use Control+D.

```
$ climetlab
(climetlab) <command> [options]
(climetlab)
```

### 1.16.3 availability

#### Usage

```
climetlab availability [-h] [--stdout] [--yaml] [--keys KEYS [KEYS ...]] source
```

Create json availability file.

#### Positional arguments

|           |   |
|-----------|---|
| source    | File or directory for describing a dataset or source. |
| ↪ of data | with GRIB data.                                       |

#### options:

|                              |   |
|------------------------------|---|
| <b>-h, --help</b>            | show this help message and exit   |
| <b>--stdout</b>              | Output to stdout (no file).   |
| <b>--yaml</b>                | Output yaml format.   |
| <b>-keys KEYS [KEYS ...]</b> | Keys to use in availability default is (param,time,date,step,levelist). |

---

### 1.16.4 benchmark (experimental)

#### Usage

```
climetlab benchmark [-h] [--indexedurl] [--dataloading] [--nargs [NARGS ...]]  
↪ [--all]
```

Run predefined benchmarks, for CliMetLab development purposes.

#### options:

|                                 |  |
|---------------------------------|--|
| <b>-h, --help</b>               | show this help message and exit                                  |
| <b>--indexedurl</b>             | Benchmark on using indexed URL (byte-range) and various servers. |
| <b>--dataloading</b>            | Test loading some data.  |
| <b>-nargs [NARGS ...] --all</b> | Run all benchmarks.  |

## 1.16.5 cache

### Usage

```
climetlab cache [-h] [--json] [--all] [--path] [--sort KEY] [--reverse] [--
↪match STRING]
                [--newer DATE] [--older DATE] [--accessed] [--larger SIZE] [--
↪smaller SIZE]
```

Cache command to inspect the ClimetLab cache. The selection arguments are the same as for the `climetlab decache` deletion command.

### Examples

```
climetlab cache --all
```

#### options:

**-h, --help** show this help message and exit

**--json** produce a JSON output

**-all** **-path** print the path of cache directory and exit **-sort KEY** sort output according to increasing values of KEY. **-reverse** reverse the order of the sort, from larger to smaller **-match STRING** **TODO** **-newer DATE** **TODO** **-older DATE** **TODO** **-accessed** use the date of last access instead of the creation date **-larger SIZE** consider only cache entries that are larger than SIZE bytes **-smaller SIZE** consider only cache entries that are smaller than SIZE bytes

SIZE can be expressed using suffixes such as K, M, G, etc. For example **--larger 1G** will match all cache entries larger than 1 GiB.

DATE can be expressed as absolute time like `2021-10-10T22:59:00`` or relative such as `1h` (one hour ago) or `2d` (two days ago).

The **--older** and **--newer** consider the *creation date* of cache entries, unless **--accessed** is specified. In this case the time of *last access* is used.

Example, to remove large files not accessed for one week:

```
decache --accessed --older 1w --larger 1G
```

---

## 1.16.6 check (experimental)

### Usage

```
climetlab check [-h]
```

Experimental script to help debugging.

#### options:

**-h, --help** show this help message and exit

## 1.16.7 completion

### Usage

```
climetlab completion [-h] [SHELL]
```

Enable autocompletion for the “climetlab” shell command.

Supported shells are : zsh bash.

**Usage:** climetlab completion

### Positional arguments

|       |   |
|-------|---|
| SHELL | Shell to use for autocompletion. Must be zsh or bash. |
|-------|---|

#### options:

|                   |                                 |
|-------------------|---------------------------------|
| <b>-h, --help</b> | show this help message and exit |
|-------------------|---------------------------------|

---

## 1.16.8 create

### Usage

```
climetlab create [-h] [--path PATH] [--init] [--load] [--statistics] [--config↵
↵CONFIG]
                [--parts PARTS [PARTS ...]] [--cache-dir CACHE_DIR] [--format↵
↵FORMAT]
```

#### options:

|                                   |  |
|-----------------------------------|--|
| <b>-h, --help</b>                 | show this help message and exit  |
| <b>--path PATH, --target PATH</b> | Where to store the final data. Currently only a path to a new ZARR is supported.   |
| <b>--init</b>                     | Initialise zarr.   |
| <b>--load</b>                     | Load data into zarr.   |
| <b>--statistics</b>               | Compute statistics.  |
| <b>--config CONFIG</b>            | Use with --init. A yaml file that describes which data to use as input and how to organise them in the target.                                   |
| <b>-parts PARTS [PARTS ...]</b>   | Use with --load. Part(s) of the data to process.   |
| <b>--cache-dir CACHE_DIR</b>      | Use with --load. Location of cache directory for temporary data.   |
| <b>--format FORMAT</b>            | The format of the target storage into which to load the data (default is inferred from target path extension) only .zarr is currently supported. |

---



## 1.16.9 decache

### Usage

```
climetlab decache [-h] [--all] [--match STRING] [--newer DATE] [--older DATE]
↳[--accessed]
    [--larger SIZE] [--smaller SIZE]
```

Cache deletion command (decache) to clean the cache from selected files. The selection arguments are the same as for the `climetlab cache query` command.

#### options:

**-h, --help** show this help message and exit

**--all** **--match STRING** **TODO** **--newer DATE** **TODO** **--older DATE** **TODO** **--accessed** use the date of last access instead of the creation date **--larger SIZE** consider only cache entries that are larger than **SIZE** bytes **--smaller SIZE** consider only cache entries that are smaller than **SIZE** bytes

**SIZE** can be expressed using suffixes such as K, M, G, etc. For example **--larger 1G** will match all cache entries larger than 1 GiB.

**DATE** can be expressed as absolute time like `2021-10-10T22:59:00`` or relative such as `1h` (one hour ago) or `2d` (two days ago).

The **--older** and **--newer** consider the *creation date* of cache entries, unless **--accessed** is specified. In this case the time of *last access* is used.

Example, to remove large files not accessed for one week:

```
decache --accessed --older 1w --larger 1G
```

---

## 1.16.10 dump\_index

### Usage

```
climetlab dump_index [-h] filename
```

#### Positional arguments

```
filename    Database filename.
```

#### options:

**-h, --help** show this help message and exit

---

### 1.16.11 export\_cache

#### Usage

```
climetlab export_cache [-h] [--match STRING] [--newer DATE] [--older DATE] [--
↪accessed]
                        [--larger SIZE] [--smaller SIZE] [--permissions [PERMISSIONS_
↪...]]
                        DIRECTORY
```

Copy part of the cache content to a directory.

#### Positional arguments

|           |   |
|-----------|---|
| DIRECTORY | Output directory where to copy the cache_ |
| ↪content. |   |

#### options:

|                       |  |
|-----------------------|--|
| <b>-h, --help</b>     | show this help message and exit                              |
| <b>--match STRING</b> | TODO   |
| <b>--newer DATE</b>   | TODO   |
| <b>--older DATE</b>   | TODO   |
| <b>--accessed</b>     | use the date of last access instead of the creation date     |
| <b>--larger SIZE</b>  | consider only cache entries that are larger than SIZE bytes  |
| <b>--smaller SIZE</b> | consider only cache entries that are smaller than SIZE bytes |

**-permissions [PERMISSIONS ...]** By default, the exported data is public and writable by its owner. -permissions read-only : Make the data public and read only. -permissions disabled : Do not tweak the files or directories permissions.

SIZE can be expressed using suffixes such as K, M, G, etc. For example **--larger 1G** will match all cache entries larger than 1 GiB.

DATE can be expressed as absolute time like `2021-10-10T22:59:00`` or relative such as `1h` (one hour ago) or `2d` (two days ago).

The **--older** and **--newer** consider the *creation date* of cache entries, unless **--accessed** is specified. In this case the time of *last access* is used.

Example, to remove large files not accessed for one week:

```
decache --accessed --older 1w --larger 1G
```

### 1.16.12 grib\_info

#### Usage

```
climetlab grib_info [-h] [--param PARAM] [--json] [--stdin]
```

Display information about grib parameters.

#### options:

|                      |   |
|----------------------|---|
| <b>-h, --help</b>    | show this help message and exit         |
| <b>--param PARAM</b> | Comma separated list of parameters.     |
| <b>--json</b>        | Long json output format.                |
| <b>--stdin</b>       | Using stdin as input (for bash piping). |

### 1.16.13 index\_directory

#### Usage

```
climetlab index_directory [-h] [--no-follow-links] [--relative-paths] [--  
↪output OUTPUT]  
                        directory
```

Index a directory containing GRIB files.

#### Positional arguments

|           |   |
|-----------|---|
| directory | Directory containing the GRIB files to index. |
|-----------|---|

#### options:

|                          |  |
|--------------------------|--|
| <b>-h, --help</b>        | show this help message and exit  |
| <b>--no-follow-links</b> | Do not follow symlinks.  |
| <b>--relative-paths</b>  | Use relative paths. Default is to use relative paths, except when a custom location is provided for the index location. (when the argument <code>--output</code> is used, default for <code>--relative-path</code> is False) |
| <b>--output OUTPUT</b>   | Custom location of the database file, will write absolute file-names in the database.  |

### 1.16.14 index\_url

#### Usage

```
climetlab index_url [-h] URL
```

Create json index files for remote Grib url.

#### Positional arguments

| URL               | url to index                    |
|-------------------|---------------------------------|
| <b>options:</b>   |                                 |
| <b>-h, --help</b> | show this help message and exit |

---

### 1.16.15 index\_urls

#### Usage

```
climetlab index_urls [-h] [--baseurl BASEURL] URLS [URLS ...]
```

**Create json index files for remote Grib urls.** If the option `--baseurl` is provided, the given url are relative to the BASEURL. This allows creating an index for multiple grib.

#### Positional arguments

| URLS                     | List of urls to index.   |
|--------------------------|--|
| <b>options:</b>          |  |
| <b>-h, --help</b>        | show this help message and exit  |
| <b>--baseurl BASEURL</b> | Base url to use as a prefix to happen on each URLS to build actual urls. |

---

### 1.16.16 libraries

#### Usage

```
climetlab libraries [-h] [--json]
```

**options:**

**-h, --help** show this help message and exit

**--json** produce a JSON output

### 1.16.17 plugins

#### Usage

```
climetlab plugins [-h] [--json]
```

List the available plugins

#### options:

|                   |                                 |
|-------------------|---------------------------------|
| <b>-h, --help</b> | show this help message and exit |
| <b>--json</b>     | produce a JSON output           |

### 1.16.18 settings

#### Usage

```
climetlab settings [-h] [--json] [SETTING ...]
```

Display or change CliMetLab settings. See <https://climetlab.readthedocs.io/guide/settings.html> for more details.

#### Examples

```
climetlab settings cache-directory /big-disk/climetlab-cache
```

#### Positional arguments

```
SETTING
```

#### options:

|                   |                                 |
|-------------------|---------------------------------|
| <b>-h, --help</b> | show this help message and exit |
| <b>--json</b>     | produce a JSON output           |

### 1.16.19 settings\_reset

#### Usage

```
climetlab settings_reset [-h] [--all] [SETTING ...]
```

Display or change CliMetLab settings. See <https://climetlab.readthedocs.io/guide/settings.html> for more details.

## Examples

```
climetlab settings cache-directory /big-disk/climetlab-cache
```

## Positional arguments

SETTING

### options:

|                   |                                 |
|-------------------|---------------------------------|
| <b>-h, --help</b> | show this help message and exit |
| <b>--all</b>      | All settings                    |

---

## 1.16.20 test\_data

### Usage

```
climetlab test_data [-h] [DIRECTORY]
```

Create a directory with data used to test climetlab.

## Positional arguments

DIRECTORY Shell to use for autocompletion. Must be zsh or bash.

### options:

|                   |                                 |
|-------------------|---------------------------------|
| <b>-h, --help</b> | show this help message and exit |
|-------------------|---------------------------------|

---

## 1.16.21 versions

### Usage

```
climetlab versions [-h] [--json] [--all] [PACKAGE ...]
```

List the versions of important Python packages.

## Positional arguments

|         |                                  |
|---------|----------------------------------|
| PACKAGE | optional list of Python packages |
|---------|----------------------------------|

### options:

|                   |                                 |
|-------------------|---------------------------------|
| <b>-h, --help</b> | show this help message and exit |
| <b>--json</b>     | produce a JSON output           |
| <b>-all</b>       |                                 |

## Plugin Developer Guide

- [Overview](#)
- [How to create a dataset plugin \(pip\)](#)
- [How to create a dataset plugin \(YAML\)](#)
- [How to create a source plugin](#)
- [Normalize decorator](#)
- [Availability decorator](#)
- [Alias argument decorator](#)
- [GRIB support](#)
- [Plotting](#)

## 1.17 Overview

*“CliMetLab provides a common place to share code used in the Weather and Climate community to pre-process data, plot it, and include additional tools, especially for machine learning purposes.”*

**Warning:** CliMetLab is still a work in progress: Backward compatibility is not ensured as long a version 1.0 is not released (see [todo list](#)). Nevertheless, the API and functionalities provided for the dataset and source plugins are **mostly** stable and already usable.

The **plugins developer guide** part of the CliMetLab documentation describes how to create plugins (or YAML files) to add data and functionalities to CliMetLab, to make it available to the end-users.

### 1.17.1 Sharing code using plugins

In order to avoid rewriting the same code over and over, consider distributing it, the design of CliMetLab allows this through plugins developed by data providers and data users and other stakeholders.

CliMetLab has several types of plugins.

- [Dataset plugin](#)
- [Sources plugin](#)
- Reader plugin (draft)
- Helper plugin (draft)

- Machine learning plugin (not yet implemented)

Depending on the functionalities provided by your code, it can be integrated in CliMetLab differently either as a dataset or a source or a reader or a helper plugin (please refer to the table below.) If you are distributing or referring to a dataset, the right plugin type for you is likely to be a *dataset plugin*.

For more details, here is also a general description of the *CliMetLab plugin mechanism*.

| Plugin type             | Use case  | End-User API  |
|-------------------------|---|---|
| <i>Dataset</i>          | Sharing code to access a curated dataset optionally with additional functionalities.  | <code>climetlab.load_dataset()</code>                             |
| <i>Source</i>           | Sharing code to access a new type of location where there are data.   | <code>climetlab.load_source()</code>                              |
| Reader (DRAFT)          | Sharing code to read data on a given format, using specific conventions, or requiring conversions. Readers will be available to the code written for the sources. | <code>climetlab.load_source()</code>                              |
| Helper (DRAFT)          | Sharing code related to plotting data, enhancing data with additional functionalities.  | <code>climetlab.plot_map()</code>                                 |
| Machine Learning (TODO) | Sharing weather and climate specific code related to machine learning.  | <code>climetlab.Dataset</code> ,<br><code>climetlab.Source</code> |

## 1.17.2 How else can I contribute?

See the *todo list*.

## 1.18 How to create a dataset plugin (pip)

*From the end-user's perspective*, a **Dataset** is a object created using `cml.load_dataset(name, *args)` with the appropriate name and arguments, which provides data.

From the plugin's developer perspective, a **Dataset** is a Python class that inherits from the CliMetLab class `climetlab.Dataset`. This class contains the Python code providing specific helper functions and curated access to the data. Dataset can also be defined from *yaml files* if they have no specific Python code and rely on (yet to defined) standard conventions.

CliMetLab has build-in example datasets for demo purposes. And more examples can be found in the non-exhaustive *list of CliMetLab plugins*.

---

### Note: Naming convention

- A plugin package name (pip) should preferably start with `climetlab-` and use dashes “-”.
  - The Python package to import should start with `climetlab_` and must use underscores “\_”.
  - A CliMetLab dataset defined by a plugin should start with the plugin name and must use dashes “-”.
-



## 1.18.1 Blueprint

### Automatic creation script

While creating the package manually from the documentation and from the example above is possible, there is also a semi-automated way to generate a pip package from a template. The generated package has a predefined dataset and is ready to be shared on Github and distributed with pip.

```
$ pip install climetlab-plugin-tools
$ climetlab plugin_create_dataset
# Answer the questions
# Only the first question (plugin name) and the latest (licence) are required.
# Other have sensible default values.
```

Here is a verbose output of running the plugin creation script.

**Note:** “Unknown command plugin\_create\_dataset” This error happens if you have not installed the package *climetlab-plugin-tools*.

```
$ climetlab plugin_create_dataset
Unknown command plugin_create_dataset. Type help for the list of known command
↪ names.
```

### Dataset names

The plugin mechanism relies on using *entry\_points*. The three lines highlighted below are registering the class *climetlab\_dataset\_plugin.rain\_observations:RainObservations* with *entry\_points* to a CliMetLab dataset called *dataset-plugin-rain-observations*. The python plugin mechanism is exhaustively described in the [Python reference documentation](#) and here are more details about *how on CliMetLab uses it*.

```
setuptools.setup(
    name="climetlab-dataset-plugin",
    version="0.0.1",
    description="Example climetlab external dataset plugin",

    entry_points={"climetlab.datasets":
        ["dataset-plugin-rain-observations=climetlab_dataset_plugin.rain_observations:
↪ RainObservations"]
    },
)
```

Once *entry\_point* has registered the class, the end-user can use this external plugin to access it

```
import climetlab as cml
cml.load_dataset("dataset-plugin-rain-observations")
```

## Automatic testing of the plugin

In the folder `tests` are set up automatic tests of the plugin using `pytest`. If the repository is hosted on github, the tests triggers automatically when pushing to the repository. Additionally, code quality is enabled using `black`, `isort` and `flake`.

All tests could be disabled or adapted in the `.github/workflows/` folder.

## Notebooks as documentation

The folder `notebooks` in each plugin can be used to store usage example or demo on how to use the data, such as this [notebook](#), Notebook are automatically tested if the repository is on github.

Links on the README file are pointing to binder, colab, etc. to run the automatically created notebook.

## Manually creating the Python package

Here is a minimal example of pip package defining a dataset plugin : <https://github.com/ecmwf/climetlab-demo-dataset>

### 1.18.2 Adapting plugin code

#### Renaming a dataset

The dataset name can be changed by changing the `setup.py` file.

```
- ["dataset-plugin-rain-observations=climetlab_dataset_plugin.rain_observations:
↪RainObservations"]
+ ["dataset-plugin-new-name           =climetlab_dataset_plugin.rain_observations:
↪RainObservations"]
```

A good practice is to change keep the class name in sync with the dataset name.

#### Adding a dataset to a plugin

New datasets can be added to the plugin, as long as the corresponding class is created:

```
- ["dataset-plugin-rain-observations=climetlab_dataset_plugin.rain_observations:
↪RainObservations"]
+ ["dataset-plugin-rain-observations=climetlab_dataset_plugin.rain_observations:
↪RainObservations",
+   "dataset-plugin-rain-forecast    =climetlab_dataset_plugin.rain_observations:
↪RainForecast"]
```

---

## CliMetLab hooks

---

**Todo:** Document `.source` attribute, `to_xarray()`, `to_pandas()`, `to_etc()` Point to decorator

---

## 1.19 How to create a dataset plugin (YAML)

YAML file definitions can be used for simple datasets which rely on existing built-in *data source*, and cannot be as flexible to end-users. The following example shows how to use a source when the data consists of a single file downloadable from a URL.

```
---
dataset:
  source: url
  args:
    url: http://get.ecmwf.int/test-data/metview/gallery/temp.bufr

metadata:
  documentation: Sample BUFR file containing TEMP messages
```

---

**Todo:**

Document the YAML file way to create a dataset. Choose a good way to implement the workflow.

- Create a dataset YAML file.
  - Distribute it.
- 

## 1.20 How to create a source plugin

A *Data source* is a Python class that accesses data from a given location. CliMetLab has build-in sources (the most common being the “url” source) and a plugin can add more sources capabilities. A Source provides access to data, the code performing the actual reading can either be located in the Source itself or delegated to a Reader class. .. See details in Source class.

---

**Note: Naming convention:** A plugin package name should preferably starts with `climetlab-` and use “-”. The Python package to import should starts with `climetlab_` and use “\_”.

---

### 1.20.1 Adding a new source as a pip plugin

The plugin mechanism for data sources relies on `entry_points`. In the `setup.py` file of the package, we should have the `entry_points` integration as follow:

```
setuptools.setup(
    entry_points={"climetlab.sources": [
        "source-name = package_name:ClassName"
    ]
},
)
```

The package name and the class name should match the class defined in the code of the plugin:

- **source-name**: is the string that will be used in `cml.load_source("source-name", ...)` in order to trigger the source plugin code.
- **package\_name**: is the python package, as it would be used in `import package_name`
- **ClassName**: is the source class which inherits from `climetlab.Source`, it must be importable from the package\_name as `from package_name import ClassName`.

### 1.20.2 Example

As an example, the code located at <https://github.com/ecmwf/climetlab-demo-source> creates build a pip package named `climetlab-demo-source`.

This data source plugin allows accessing data from a SQL database using CliMetLab.

Once the plugin is installed (with `pip`), tabular data can be read from as follow:

```
>>> import climetlab as cml
>>> s = cml.load_source(
    "climetlab-demo-source",
    "sqlite:///test.db",
    "select * from data;",
    parse_dates=["time"],
)
df = s.to_pandas()
```

The integration is performed by `entry_points` called from `setup.py`.

```
setuptools.setup(
    entry_points={"climetlab.sources": [
        "demo-source = climetlab_demo_source:DemoSource"
    ]
},
)
```

## 1.21 Normalize decorator

This section discusses *the purpose* of the `@normalize` decorator, shows *how to use it* and provides the *reference documentation*.

### 1.21.1 Purpose (discussion)

When sharing code, a large amount of code is usually dedicated to processing the arguments of the functions or methods to check their value and normalize it to a standard format.

The Python language offers the ability to accept a large range of input type on a unique function through *duck typing*. This leads to better integration of the different objects at stake, for instance using an object such as `xarray.Dataset` or a `pandas.DataFrame` or `pandas.Series` as input to provide a list of dates.

CliMetLab offers predefined shortcuts to implement this. The short API aims to address 80% of the use cases using the `@normalize` decorator. The longer form aims to tackle specific needs.

Compare the following codes snippets:

Boilerplate code

Tedious and error-prone Python code is needed to check and normalize the values of the function arguments given by the user.

```
def __init__(self, date, option):
    if date is None:
        date = DEFAULT_DATE_LIST
    if isinstance(date, tuple):
        date = list(date)
    if not isinstance(date, list):
        date = [date]
    for d in date:
        check_date_is_sunday(d)
    if not option in VALID_OPTIONS:
        raise ValueError(f"option={option} invalid")
    (...)
    (more checks and transformations)
    (...)
    do_stuff(date, option)
```

Using CliMetLab short form API

The decorator `@normalize` provides generic default behaviour to handle domain-specific arguments (for dates, meteorological and climate parameters, bounding boxes, etc.)

```
from climetlab.decorators import normalize
@normalize("date", "date(%Y%m%d)")
@normalize("option", ["foo", "bar"])
def __init__(self, date, option):
    do_suff(date, option)
```

### 1.21.2 How to use

- How to ensure that the value in the function belongs to a list?

```
from climetlab.decorators import normalize

@normalize("param", ["tp", "gh"])
def f(self, param):
    print(param)
```

- How to ensure that the value in the function is a date with this format “YYYY-MM-DD”?

```
from climetlab.decorators import normalize

@normalize("option", "date(%Y-%m-%d)")
def f(option):
    return option

assert f(option="2022-12-31") == "2022-12-31"
assert f(option="20221231") == "2022-12-31"
assert f(option=20221231) == "2022-12-31"
```

- How to ensure that the value in the function is a list?

Add the keyword argument `multiple=True`. Not available for bounding-box.

- How to ensure that the value in the function is a list of int?

```
from climetlab.decorators import normalize

@normalize("option", "int", multiple=True)
def f(option):
    return option

# Alternative shorter version
@normalize("option", "int-list")
def g(option):
    return option

assert f(option="2022") == [2022]
assert g(option="2022") == [2022]
assert f(option=[48, 72.0, "96"]) == [48, 72, 96]
assert g(option=[48, 72.0, "96"]) == [48, 72, 96]
```

- How to ensure that the value in the function is not a list?

Add the keyword argument `multiple=False`.

- How to accept list or non-list as input?

Add the keyword argument `multiple=None`. Not available for bounding-box.

- How to add alias/shortcuts/special values to be replaced by actual predefined values?

Use the keyword argument `alias` and provide a dictionary.

```
from climetlab.decorators import normalize
```

```
@normalize("param", ["tp", "gh"])
def f(param):
    return param
```

```
assert f(param="tp") == "tp"
# f(param="t2m") # fails
```

```
from climetlab.decorators import normalize
```

```
DATES = dict(
    april=["20210401", "20210402", "20210403"],
    june=["20210610", "20210611"],
)
```

```
@normalize("x", "date-list(%Y%m%d)", aliases=DATES)
def f(x):
    return x
```

```
assert f("2021-06-10") == ["20210610"]
assert f("june") == ["20210610", "20210611"]
assert f("1999-01-01") == ["19990101"]
```

### 1.21.3 Reference

**Warning:** This API is experimental, things may change.

`@normalize(name, values, aliases={}, multiple=None, **kwargs)`

The `@normalize` decorator transforms the arguments provided when calling the decorated function, modifies it if needed, and provides a normalised value to the function. It ensures that the value of the argument is what is expected to be processed by the function.

**values** If *values* is a list, the list provides allowed values for the parameter. If *values* is a string, it is expected to be a shortcut similar to “*type(options)*” where *type* is one of the following: “date”, “date-list”, “bounding-box”. These shortcuts aim at providing an easy way to define many options in a more concise manner.

Example: “date-list(%Y%m%d)”

**type** Type of value expected by the function. The type should be one of the following: “str”, “int”, “float”, “date”, “date-list”, “str-list”, “int-list”, “float-list”.

**format** The keyword argument *format* is available for *type* = ‘date’ and ‘date-list’. It provides the expected format according to *datetime.strptime*. Example: `format='%Y%m%d'`

**convention** Experimental. To be documented.

**aliases** Replace a value with another using a dictionary of aliases.

**multiple** The keyword argument *multiple* is not available for **bounding-box**.

*True*: Ensure a list value. Turn input into a list if needed.

*False*: Ensure a non-list value. Turn a list input as non-list if the list has only one element. Fails with `ValueError` if the list has more than one element.

*None*: Accept list and non-list values without transformations.

## 1.22 Availability decorator

---

**Todo:** Not implemented yet

---

### 1.22.1 Purpose

When sharing code, a large amount of code is usually dedicated to processing the arguments of the functions or methods where users are requesting data. This boilerplate code needs to check their values and ensure that data is actually available. In case of failure, it would be helpful to generate an appropriate error message to the user, in order to help them understand why the call to the function was not successful.

CliMetLab offers predefined shortcuts to implement this. The short API aims to address the most common use cases using the `@availability` decorator.

Example:

```
@availability("availability.json")
def func(date, option):
    do_stuff(date, option)
```

### 1.22.2 Usage

### 1.22.3 Reference

## 1.23 Alias argument decorator

This section discusses the purpose of the `@alias_argument` decorator, shows how to use it and provides reference documentation.



### 1.23.1 Purpose

This decorator allows a function to accept a range of parameters names, to make the interface easier to use for the end-user.

```
from climetlab.decorators import alias_argument

@alias_argument(param="parameter")
def func(param, other=1):
    return "param=" + param

func(param="tp", other=1)
# -> param=tp

func(parameter="tp", other=1)
# -> param=tp
```

The decorator also accept a list of alias values.

```
from climetlab.decorators import alias_argument

@alias_argument(param=["parameter", "variable"])
def func(param, other=1):
    return "param=" + param

func(param="tp")
# -> param=tp

func(parameter="tp")
# -> param=tp

func(variable="tp")
# -> param=tp
```

## 1.24 GRIB support

CliMetLab provides built-in functionalities regarding GRIB format handling.

### 1.24.1 Reading GRIB files

- CliMetLab can read *gridded* GRIB files (or urls) and provide data as `xarray.Dataset` objects. This can be performed using `cml.load_source("file", "myfile.grib")`.
- In addition to reading GRIB from local or remote sources, CliMetLab can also use a precomputed index, avoiding the need to parse the GRIB file to know its content. Using this index allows partial read of local files, and merging of multiple GRIB sources.

This can be performed using `cml.load_source("indexed-directory", "my/dir")`. To allow fast access to the data in the directory, CliMetLab relies on an index. Note that the index must have been created on this directory, CliMetLab will create one (see GRIB indexing below).

### 1.24.2 Writing GRIB files

There are two ways to write GRIB files:

- To save data from MARS, CDS or other, when GRIB is already the native format of the data,

use the `source.save(filename)` method. This method is implemented only on a sources relying on GRIB.

- CliMetLab also supports writing custom GRIB files, with **modified values or custom attributes**

through the function `cml.new_grib_output()`. See usage example in the example notebook ([Examples](#)).

### 1.24.3 Building indexes

CliMetLab can create GRIB index files through its command line interface.

#### How to build a index for a directory containing GRIB files ?

```
climetlab index_directory my/dir
```

This will create a CliMetLab index file in *my/local/dir*, allowing other to access the data with `cml.load_source("indexed-directory", "my/dir")`.

#### How to build a index for one given URL containing a GRIB file ?

```
climetlab index_url "https://get.ecmwf.int/repository/test-data/climetlab/test-data/  
↪input/indexed-urls/large_grib_1.grb" > large_grib_1.index
```

Then upload the file *large\_grib\_1.index* and make sure it is available at: “[https://get.ecmwf.int/repository/test-data/climetlab/test-data/input/indexed-urls/large\\_grib\\_1.index](https://get.ecmwf.int/repository/test-data/climetlab/test-data/input/indexed-urls/large_grib_1.index)”

This allows accessing the data with

```
cml.load_source("indexed-url",  
               "https://get.ecmwf.int/repository/test-data/climetlab/test-data/input/  
↪indexed-urls/large_grib_1.grb"  
)
```

## How to build indexes for a set of URLs containing GRIB files ?

Or, if you do the same for another URL “https://get.ecmwf.int/repository/test-data/climetlab/test-data/input/indexed-urls/large\_grib\_2.grb”.

```
climetlab index_url "https://get.ecmwf.int/repository/test-data/climetlab/test-data/
↪input/indexed-urls/large_grib_1.grb" > large_grib_1.index
climetlab index_url "https://get.ecmwf.int/repository/test-data/climetlab/test-data/
↪input/indexed-urls/large_grib_2.grb" > large_grib_2.index
```

Then upload the files *large\_grib\_1.index* and *large\_grib\_2.index* and make sure they are available on the server at: “https://get.ecmwf.int/repository/test-data/climetlab/test-data/input/indexed-urls/large\_grib\_1.index” “https://get.ecmwf.int/repository/test-data/climetlab/test-data/input/indexed-urls/large\_grib\_2.index”

This allows accessing the data with

```
cml.load_source("indexed-urls",
                "https://get.ecmwf.int/repository/test-data/climetlab/test-data/input/
↪indexed-urls/large_grib_{n}.grb",
                {"n": [1, 2]},
            )
```

## How to build a index for a set of URLs containing GRIB files ?

**Todo:** Not implemented yet.

```
climetlab index_urls --base-url "https://get.ecmwf.int/repository/test-data/climetlab/
↪test-data/input/indexed-urls" large_grib_1.grb large_grib_2.grb > global_index.index
```

Then upload the file *global\_index.index* and make sure it is available at: “https://get.ecmwf.int/repository/test-data/climetlab/test-data/input/indexed-urls/global\_index.index”

This allows others to access the data with :

### 1.24.4 How to export files from the CliMetLab cache to another directory ?

When using CliMetLab to access MARS, CDS or other source, data is cached into the CliMetLab cache directory (the cache folder is `climetlab settings cache-directory`).

To prevent the cache from growing forever, old data in the cache directory are deleted automatically by CliMetLab when new data is downloaded. CliMetLab can create a shareable directory with some of the data from the cache through its command line interface.

```
climetlab export_cache DIRECTORY --help
```

**Todo:** Update this when mirror implementation changes.

**Warning:** This part of CliMetLab is still a work in progress. Documentation and code behaviour will change.

## 1.25 Plotting

---

**Todo:** Explain how to contribute layers, projections and styles

---

### CliMetLab Developer Guide

- *Overview*
- *Help wanted*
- *Architecture*
- *Plotting*
- *Gallery*
- *Climetlab Plugin mechanism*

## 1.26 Overview

The is the **CliMetLab** developer guide part of the CliMetLab documentation.

The CliMetLab documentation is split as follow:

- *Getting started:* General introduction with the main idea described there.
- *User guide:* This is the part you should read if you are using CliMetLab and plugins developed by others.
- *Plugin Developer guide:* describes how to create plugins (or YAML files) to add data and functionalities to CliMetLab, to make it available to the users above. In order to avoid rewriting the same code over and over, consider distributing it, the design of CliMetLab allows to do this with plugins.
- **CliMetLab Developers guide:** Please refer to this part either if you are willing to develop further CliMetLab or if you want to achieve something that is not possible with the current plugin framework.

## 1.27 Help wanted

CliMetLab is still experimental and its development status is still Alpha. Here are the parts that would need work and/or benefit from a community contribution.

Backward compatibility is not ensured as long a version 1.0 is not released. Nevertheless the functionalities are expected to be usable and stable, please submit a issue if needed (pull request welcome).

### 1.27.1 How can I to contribute ?

- Submit bug reports, propose enhancements, on github.
- You can also contribute to the core code by forking and submitting a pull request.
- TODO: fill this todo list.

## 1.28 Architecture

Message dispatch

With:

## 1.29 Plotting

### 1.29.1 mcoast

This action controls the plotting of coastlines, rivers, cities and country boundaries, as well as the latitude/longitude grid lines.

| Name   | Type                                    | Default     |
|--|---|-------------|
| <b>map_coastline_general_style</b><br>Use a predefined style depending on the general theme  | str                                     | ""          |
| <b>map_coastline</b><br>Plot coastlines on map (ON/OFF)  | bool                                    | True        |
| <b>map_grid</b><br>Plot grid lines on map (On/OFF)   | bool                                    | True        |
| <b>map_label</b><br>Plot label on map grid lines (On/OFF)  | bool                                    | True        |
| <b>map_coastline_resolution</b><br>Select one of the pre-defined resolutions: automatic, low, medium, and high.<br>When set to AUTOMATIC, a resolution appropriate to the scale of the map is chosen in order to balance quality with speed. | "automatic", "low",<br>"medium", "high" | "automatic" |
| <b>map_coastline_land_shade</b><br>Sets if land areas are shaded   | bool                                    | False       |
| <b>map_coastline_land_shade_colour</b><br>Colour of Shading of land areas  | str                                     | "green"     |

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Table 1 – continued from previous page

| Name  | Type   | Default |
|---|--|---------|
| <b>map_coastline_sea_shade</b><br>Shade the sea areas                   | bool   | False   |
| <b>map_coastline_sea_shade_colour</b><br>Colour of Shading of sea areas | str  | “blue”  |
| <b>map_boundaries</b><br>Add the political boundaries                   | bool   | False   |
| <b>map_cities</b><br>Add the cities (capitals)                          | bool   | False   |
| <b>map_rivers</b><br>Display rivers (on/off)                            | bool   | False   |
| <b>map_rivers_style</b><br>Line style for rivers                        | “solid”, “dash”,<br>“dot”,<br>“chain_dash”,<br>“chain_dot” | “solid” |
| <b>map_rivers_colour</b><br>Colour of the rivers                        | str  | “blue”  |
| <b>map_rivers_thickness</b><br>Line thickness of rivers                 | int  | 1       |
| <b>map_user_layer</b><br>Display user shape file layer                  | bool   | False   |
| <b>map_user_layer_name</b><br>Path + name of the shape file to use      | str  | “”      |
| <b>map_user_layer_projection</b><br>Projection used in the shape file   | str  | “”      |

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Table 1 – continued from previous page

| Name  | Type   | Default |
|---|--|---------|
| <b>map_user_layer_style</b><br>Line style for User Layer  | “solid”, “dash”,<br>“dot”,<br>“chain_dash”,<br>“chain_dot” | “solid” |
| <b>map_user_layer_colour</b><br>Colour of the User Layer  | str  | “blue”  |
| <b>map_user_layer_thickness</b><br>Line thickness of User Layer                                     | int  | 1       |
| <b>map_coastline_colour</b><br>Colour of coastlines   | str  | “black” |
| <b>map_coastline_style</b><br>Line style of coastlines  | “solid”, “dash”,<br>“dot”,<br>“chain_dash”,<br>“chain_dot” | “solid” |
| <b>map_coastline_thickness</b><br>Line thickness of coastlines                                      | int  | 1       |
| <b>map_grid_latitude_reference</b><br>Reference Latitude from which all latitude lines are drawn    | float  | 0.0     |
| <b>map_grid_latitude_increment</b><br>Interval between latitude grid lines                          | float  | 10.0    |
| <b>map_grid_longitude_reference</b><br>Reference Longitude from which all longitude lines are drawn | float  | 0.0     |
| <b>map_grid_longitude_increment</b><br>Interval between longitude grid lines                        | float  | 20.0    |

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Table 1 – continued from previous page

| Name   | Type   | Default     |
|--|--|-------------|
| <b>map_grid_line_style</b><br>Line style of map grid lines       | “solid”, “dash”,<br>“dot”,<br>“chain_dash”,<br>“chain_dot” | “solid”     |
| <b>map_grid_thickness</b><br>Thickness of map grid lines         | int  | 1           |
| <b>map_grid_colour</b><br>Colour of map grid lines               | str  | “black”     |
| <b>map_grid_frame</b><br>Add a frame around the projection       | bool   | False       |
| <b>map_grid_frame_line_style</b><br>Line style of map grid lines | “solid”, “dash”,<br>“dot”,<br>“chain_dash”,<br>“chain_dot” | “solid”     |
| <b>map_grid_frame_thickness</b><br>Thickness of map grid lines   | int  | 1           |
| <b>map_grid_frame_colour</b><br>Colour of map grid lines         | str  | “black”     |
| <b>map_label_font</b><br>Font of grid labels                     | str  | “sansserif” |
| <b>map_label_font_style</b><br>Font of grid labels               | str  | “normal”    |
| <b>map_label_colour</b><br>Colour of map labels                  | str  | “black”     |

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Table 1 – continued from previous page

| Name   | Type  | Default |
|--|-------|---------|
| <b>map_label_height</b><br>Height of grid labels                             | float | 0.25    |
| <b>map_label_blanking</b><br>Blanking of the grid labels                     | bool  | True    |
| <b>map_label_latitude_frequency</b><br>Every Nth latitude grid is labelled   | float | 1.0     |
| <b>map_label_longitude_frequency</b><br>Every Nth longitude grid is labelled | float | 1.0     |
| <b>map_label_left</b><br>Enable the labels on the left of the map            | bool  | True    |
| <b>map_label_right</b><br>Enable the labels on the right of the map          | bool  | True    |
| <b>map_label_top</b><br>Enable the labels on the top of the map              | bool  | True    |
| <b>map_label_bottom</b><br>Enable the labels on the bottom of the map        | bool  | True    |

## 1.29.2 mcont

This action controls the plotting of isolines, contour bands and grid points. It is used to plot gridded data, such as fields.

| Name                                   | Type | Default |
|--|------|---------|
| <b>legend</b><br>Turn legend on or off | bool | False   |

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Table 2 – continued from previous page

| Name   | Type   | Default           |
|--|--|-------------------|
| <b>contour</b><br>Turn contouring on or off  | bool   | True              |
| <b>contour_method</b><br>Contouring method   | “automatic”,<br>“linear”,<br>“akima760”,<br>“akima474” | “automatic”       |
| <b>contour_interpolation_floor</b><br>Any value below this floor will be forced to the floor value. avoid the bubbles artificially created by the interpolation method       | float  | -<br>2147483647.0 |
| <b>contour_interpolation_ceiling</b><br>any value above this ceiling will be forced to the ceiling value. avoid the bubbles artificially created by the interpolation method | float  | 2147483647.0      |
| <b>contour_automatic_setting</b><br>Turn the automatic setting of contouring attributes  | False,<br>“style_name”,<br>“ecmwf”                     | False             |
| <b>contour_style_name</b><br>Use of a predefined setting   | str  | “”                |
| <b>contour_metadata_only</b><br>Only get the metadata  | bool   | False             |
| <b>contour_hilo</b><br>Plot local maxima/minima  | 1, 0, “hi”, “lo”                                       | False             |
| <b>contour_grid_value_plot</b><br>Plot Grid point values   | bool   | False             |
| <b>contour_akima_x_resolution</b><br>X resolution of Akima interpolation.  | float  | 1.5               |

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Table 2 – continued from previous page

| Name   | Type                       | Default       |
|--|----------------------------|---------------|
| <b>contour_akima_y_resolution</b><br>Y resolution of Akima interpolation.                                  | float                      | 1.5           |
| <b>contour_grid_value_min</b><br>The minimum value for which grid point values are to be plotted           | float                      | -1e+21        |
| <b>contour_grid_value_max</b><br>The maximum value for which grid point values are to be plotted           | float                      | 1e+21         |
| <b>contour_grid_value_lat_frequency</b><br>The grid point values in every Nth latitude row are plotted     | int                        | 1             |
| <b>contour_grid_value_lon_frequency</b><br>The grid point values in every Nth longitude column are plotted | int                        | 1             |
| <b>contour_grid_value_height</b><br>Height of grid point values  | float                      | 0.25          |
| <b>contour_grid_value_colour</b><br>Colour of grid point values  | str                        | “blue”        |
| <b>contour_grid_value_format</b><br>Format of grid point values  | str                        | “(automatic)” |
| <b>contour_grid_value_marker_height</b><br>Height of grid point markers                                    | float                      | 0.25          |
| <b>contour_grid_value_marker_colour</b><br>Colour of grid point markers                                    | str                        | “red”         |
| <b>contour_grid_value_marker_qual</b><br>Quality of the grid point marker                                  | “high”, “medium”,<br>“low” | “low”         |

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Table 2 – continued from previous page

| Name   | Type                                | Default          |
|--|-------------------------------------|------------------|
| <b>contour_grid_value_marker_index</b><br>Table number of marker index. See Appendix for Plotting Attributes   | int                                 | 3                |
| <b>contour_grid_value_position</b><br>Position of the value  | “right”, “left”,<br>“bottom”, “top” | “top”            |
| <b>contour_shade_max_level_colour</b><br>Highest shading band colour   | str                                 | “blue”           |
| <b>contour_shade_min_level_colour</b><br>Lowest shading band colour  | str                                 | “red”            |
| <b>contour_shade_colour_direction</b><br>Direction of colour sequencing for shading  | “clockwise”,<br>“anti_clockwise”    | “anti_clockwise” |
| <b>contour_shade_cell_resolution</b><br>Number of cells per cm for CELL shading  | float                               | 10.0             |
| <b>contour_shade_cell_method</b><br>NMethod of determining the colour of a cell  | “nearest”,<br>“interpolate”         | “nearest”        |
| <b>contour_shade_cell_resolution_method</b><br>if adaptive, magics will switch to grid_shading when the data resolution is greater than the requested resolution | “classic”,<br>“adaptive”            | “classic”        |
| <b>contour_max_level</b><br>Highest level for contours to be drawn   | float                               | 1e+21            |
| <b>contour_min_level</b><br>Lowest level for contours to be drawn  | float                               | -1e+21           |
| <b>contour_shade_max_level</b><br>Highest level for contours to be shaded  | float                               | 1e+21            |

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Table 2 – continued from previous page

| Name   | Type                                 | Default |
|--|--------------------------------------|---------|
| <b>contour_shade_min_level</b><br>Lowest level for contours to be shaded   | float                                | -1e+21  |
| <b>contour_level_count</b><br>Count or number of levels to be plotted. Magics will try to find “nice levels”, this means that the number of levels could be slightly different from the asked number of levels | int                                  | 10      |
| <b>contour_level_tolerance</b><br>Tolerance: Do not use nice levels if the number of levels is really to different [count +/- tolerance]   | int                                  | 2       |
| <b>contour_reference_level</b><br>Contour level from which contour interval is calculated  | float                                | 0.0     |
| <b>contour_shade_dot_size</b><br>Size of dot in shading pattern  | float                                | 0.02    |
| <b>contour_shade_max_level_density</b><br>Dots/square centimetre in highest shading band   | float                                | 50.0    |
| <b>contour_shade_min_level_density</b><br>Dots/square centimetre in lowest shading band  | float                                | 1.0     |
| <b>contour_gradients_colour_list</b><br>Colour used at the stops : the gradient will be calculated between 2 consecutive ones.   | List[str]                            | []      |
| <b>contour_gradients_waypoint_method</b><br>waypoints at the left, right, middle of the interval.  | “both”, “ignore”,<br>“left”, “right” | “both”  |
| <b>contour_gradients_technique</b><br>Technique to apply to compute the gradients rgb/hcl/hsl  | “rgb”, “hcl”, “hsl”                  | “rgb”   |

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Table 2 – continued from previous page

| Name  | Type  | Default     |
|---|---|-------------|
| <b>contour_gradients_technique_direction</b><br>Technique to apply to compute the gradients clockwise/anticlockwise   | “clockwise”,<br>“anti_clockwise”,<br>“shortest”,<br>“longest” | “clockwise” |
| <b>contour_gradients_step_list</b><br>Number of steps to compute for each interval  | List[int]   | []          |
| <b>contour_shade_method</b><br>Method used for shading  | “area_fill”, “solid”,<br>“dot”, “hatch”                       | “dot”       |
| <b>contour_grid_shading_position</b><br>Middle : the point is in the middle of the cell, bottom_left : the point is in the bottom left corner                                   | “middle”,<br>“bottom_left”                                    | “middle”    |
| <b>contour_shade_hatch_index</b><br>The hatching pattern(s) to use. 0 Provides an automatic sequence of patterns, other values set a constant pattern across all contour bands. | int   | 0           |
| <b>contour_shade_hatch_thickness</b><br>Thickness of hatch lines  | int   | 1           |
| <b>contour_shade_hatch_density</b><br>Number of hatch lines per cm.   | float   | 18.0        |
| <b>contour_hilo_height</b><br>Height of local maxima/minima text or numbers   | float   | 0.4         |
| <b>contour_hi_colour</b><br>Colour of local maxima text or number   | str   | “blue”      |
| <b>contour_lo_colour</b><br>Colour of local minima text or number   | str   | “blue”      |

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Table 2 – continued from previous page

| Name  | Type                        | Default       |
|---|-----------------------------|---------------|
| <b>contour_hilo_format</b><br>Format of HILO numbers (MAGICS Format/(AUTOMATIC))  | str                         | “(automatic)” |
| <b>contour_hilo_marker_height</b><br>Height of HighLow marker symbol              | float                       | 0.1           |
| <b>contour_hilo_marker_index</b><br>Index of marker symbol                        | int                         | 3             |
| <b>contour_hilo_marker_colour</b><br>Colour of grid point markers                 | str                         | “red”         |
| <b>contour_hi_text</b><br>Text to represent local maxima                          | str                         | “H”           |
| <b>contour_lo_text</b><br>Text to represent local minima                          | str                         | “L”           |
| <b>contour_hilo_blanking</b><br>Blank around highs and lows                       | bool                        | False         |
| <b>contour_hilo_type</b><br>Type of high/low (TEXT/NUMBER/BOTH)                   | “text”, “number”,<br>“both” | “text”        |
| <b>contour_hilo_window_size</b><br>Size of the window used to calculate the Hi/Lo | int                         | 3             |
| <b>contour_hilo_max_value</b><br>Local HiLo above specified value are not drawn   | float                       | 1e+21         |
| <b>contour_hilo_min_value</b><br>Local HiLo below specified value are not drawn   | float                       | -1e+21        |

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Table 2 – continued from previous page

| Name  | Type   | Default  |
|---|--|----------|
| <b>contour_hi_max_value</b><br>Local HI above specified value are not drawn                       | float  | 1e+21    |
| <b>contour_hi_min_value</b><br>Local HI below specified value are not drawn                       | float  | -1e+21   |
| <b>contour_lo_max_value</b><br>Local Lo above specified value are not drawn                       | float  | 1e+21    |
| <b>contour_lo_min_value</b><br>Local Lo below specified value are not drawn                       | float  | -1e+21   |
| <b>contour_hilo_marker</b><br>Plot hilo marker (ON/OFF)   | bool   | False    |
| <b>contour_interval</b><br>Interval in data units between two contour lines                       | float  | 8.0      |
| <b>contour_highlight_style</b><br>Style of highlighting (SOLID/ DASH/ DOT/ CHAIN_DASH/ CHAIN_DOT) | “solid”, “dash”,<br>“dot”,<br>“chain_dash”,<br>“chain_dot” | “solid”  |
| <b>contour_highlight_colour</b><br>Colour of highlight line                                       | str  | “blue”   |
| <b>contour_highlight_thickness</b><br>Thickness of highlight line                                 | int  | 3        |
| <b>contour_highlight_frequency</b><br>Frequency of highlight line                                 | int  | 4        |
| <b>contour_label_type</b><br>Type of label (text/number/both)                                     | “text”, “number”,<br>“both”                                | “number” |

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Table 2 – continued from previous page

| Name   | Type  | Default               |
|--|---|-----------------------|
| <b>contour_label_text</b><br>Text for labels   | str   | “”                    |
| <b>contour_label_height</b><br>Height of contour labels  | float   | 0.3                   |
| <b>contour_label_format</b><br>Format of contour labels (MAGICS Format/(AUTOMATIC))  | str   | “(automatic)”         |
| <b>contour_label_blanking</b><br>Label Blanking  | bool  | True                  |
| <b>contour_label_font</b><br>Name of the font  | str   | “sansserif”           |
| <b>contour_label_font_style</b><br>Style of the font normal/bold/italic  | “normal”, “bold”,<br>“italic”   | “normal”              |
| <b>contour_label_colour</b><br>Colour of contour labels  | str   | “contour_line_colour” |
| <b>contour_label_frequency</b><br>Every Nth contour line is labelled   | int   | 2                     |
| <b>contour_shade_technique</b><br>Technique used for shading (POLYGON_SHADING/ CELL_SHADING/ MARKER)                             | “polygon_shading”,<br>“grid_shading”,<br>“cell_shading”,<br>“dump_shading”,<br>“marker” | “polygon_shading”     |
| <b>contour_shade_colour_method</b><br>Method of generating the colours of the bands in contour shading (list/calculate/advanced) | “calculate”, “list”,<br>“gradients”,<br>“palette”                                       | “calculate”           |

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Table 2 – continued from previous page

| Name   | Type   | Default |
|--|--|---------|
| <b>contour_level_list</b><br>List of contour levels to be plotted  | List[float]  | []      |
| <b>contour_shade_colour_list</b><br>List of colours to be used in contour shading.   | List[str]  | []      |
| <b>contour_shade_colour_table</b><br>Colour table to be used with marker shading technique   | List[str]  | []      |
| <b>contour_shade_height_table</b><br>Height table to be used with marker shading technique   | List[float]  | []      |
| <b>contour_shade_marker_table_type</b><br>index: using contour_shade_marker_table and defining the markers by index,<br>name: using contour_shade_marker_name_table and defining the symbols by<br>their names | “index”, “name”  | “index” |
| <b>contour_shade_marker_table</b><br>Marker table to be used with marker shading technique   | List[int]  | []      |
| <b>contour_shade_marker_name_table</b><br>Marker name table to be used with marker shading technique   | List[str]  | []      |
| <b>contour_line_style</b><br>Style of contour line   | “solid”, “dash”,<br>“dot”,<br>“chain_dash”,<br>“chain_dot” | “solid” |
| <b>contour_line_thickness</b><br>Thickness of contour line   | int  | 1       |
| <b>contour_line_colour_rainbow</b><br>if On, rainbow colouring method will be used.  | bool   | False   |

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Table 2 – continued from previous page

| Name   | Type                             | Default          |
|--|----------------------------------|------------------|
| <b>contour_line_colour</b><br>Colour of contour line   | str                              | “blue”           |
| <b>contour_line_colour_rainbow_method</b><br>Method of generating the colours for isoline  | “calculate”, “list”              | “calculate”      |
| <b>contour_line_colour_rainbow_max_level_colour</b><br>Colour to be used for the max level   | str                              | “blue”           |
| <b>contour_line_colour_rainbow_min_level_colour</b><br>Colour to be used for the mainlevel   | str                              | “red”            |
| <b>contour_line_colour_rainbow_direction</b><br>Direction of colour sequencing for colouring   | “clockwise”,<br>“anti_clockwise” | “anti_clockwise” |
| <b>contour_line_colour_rainbow_colour_list</b><br>List of colours to be used in rainbow isolines   | List[str]                        | []               |
| <b>contour_line_colour_rainbow_colour_list_policy</b><br>What to do if the list of colours is smaller that the list of contour: lastone/cycle  | “lastone”, “cycle”               | “lastone”        |
| <b>contour_line_thickness_rainbow_list</b><br>List of thickness to used when rainbow method is on  | List[int]                        | []               |
| <b>contour_line_thickness_rainbow_list_policy</b><br>What to do if the list of thickness is smaller that the list of contour:<br>lastone/cycle | “lastone”, “cycle”               | “lastone”        |
| <b>contour_line_style_rainbow_list</b><br>List of line style to used when rainbow method is on   | List[str]                        | []               |
| <b>contour_line_style_rainbow_list_policy</b><br>What to do if the list of line styles is smaller that the list of contour:<br>lastone/cycle   | “lastone”, “cycle”               | “lastone”        |

continues on next page

Table 2 – continued from previous page

| Name   | Type                                 | Default   |
|--|--------------------------------------|-----------|
| <b>contour_highlight</b><br>Plot contour highlights (ON/OFF)   | bool                                 | True      |
| <b>contour_level_selection_type</b><br>count: calculate a reasonable contour interval taking into account the min/max and the requested number of isolines. interval: regularly spaced intervals using the reference_level as base. level_list: uses the given list of levels. | “count”, “interval”,<br>“level_list” | “count”   |
| <b>contour_label</b><br>Plot labels on contour lines   | bool                                 | True      |
| <b>contour_shade</b><br>Turn shading on  | bool                                 | False     |
| <b>contour_legend_only</b><br>Inform the contour object do generate only the legend and not the plot!  | bool                                 | False     |
| <b>contour_shade_palette_name</b><br>Colour used at the stops : the gradient will be calculated between 2 consecutive ones.  | str                                  | “”        |
| <b>contour_shade_palette_policy</b><br>What to do if the list of colours is smaller that the list of levels: lastone/cycle   | “lastone”, “cycle”                   | “lastone” |
| <b>contour_grid_value_type</b><br>For Gaussian fields, plot normal (regular) values or reduced grid values. (NORMAL/REDUCED/akima). If akima, the akima grid values will be plotted  | “normal”,<br>“reduced”, “akima”      | “normal”  |
| <b>contour_grid_value_plot_type</b><br>(VALUE/MARKER/BOTH)   | “value”, “marker”,<br>“both”         | “value”   |

### 1.29.3 mmap

| Name  | Type  | Default   |
|---|---|-----------|
| <b>subpage_x_axis_type</b>  | “regular”, “date”,<br>“geoline”,<br>“logarithmic” | “regular” |
| <b>subpage_y_axis_type</b>  | “regular”, “date”,<br>“geoline”,<br>“logarithmic” | “regular” |
| <b>x_min</b>  | float   | 0.0       |
| <b>subpage_x_automatic</b>  | bool  | False     |
| <b>subpage_y_automatic</b>  | bool  | False     |
| <b>x_max</b>  | float   | 100.0     |
| <b>y_min</b>  | float   | 0.0       |
| <b>y_max</b>  | float   | 100.0     |
| <b>thermo_annotation_width</b><br>Percentage of the width used to display the annotation on the right side .                        | float   | 25.0      |
| <b>subpage_x_position</b><br>Y-Coordinate of lower left hand corner of subpage in cm. -1 is the default:<br>7.5% of the parent page | float   | -1.0      |

continues on next page

Table 3 – continued from previous page

| Name   | Type  | Default |
|--|-------|---------|
| <b>subpage_y_position</b><br>X-Coordinate of lower left hand corner of subpage in cm. -1 is the default: 5% of the parent page | float | -1.0    |
| <b>subpage_x_length</b><br>Length of subpage in horizontal direction in cm. -1 is the default: 85% of the parent page          | float | -1.0    |
| <b>subpage_y_length</b><br>Length of subpage in vertical direction in cm. -1 is the default: 85% of the parent page            | float | -1.0    |
| <b>subpage_map_library_area</b><br>if On, pickup a predefined geographical area  | bool  | False   |
| <b>subpage_map_area_name</b><br>Name of the predefined area  | str   | False   |

continues on next page

Table 3 – continued from previous page

| Name   | Type  | Default       |
|--|---|---------------|
| <b>subpage_map_projection</b><br>Projection to set in the drawing area   | “cylindrical”, “polar_stereographic”, “polar_north”, “polar_south”, “geos”, “meteosat”, “meteosat_57E”, “goes_east”, “lambert”, “EPSG:3857”, “EPSG:900913”, “EPSG:32661”, “EPSG:32761”, “EPSG:4326”, “goode”, “collignon”, “mollweide”, “robinson”, “bonne”, “google”, “efas”, “tpers”, “automatic”, “lambert_north_atlantic”, “mercator”, “cartesian”, “taylor”, “tephigram”, “skewt”, “emagram” | “cylindrical” |
| <b>subpage_clipping</b><br>Apply a clipping to the subpage to avoid any symbol, flag or arrow to go outside of the plotting area | bool  | False         |
| <b>subpage_background_colour</b><br>Colour of the subpage background   | str   | “none”        |
| <b>subpage_frame</b><br>Plot frame around subpage (ON/OFF)   | bool  | True          |
| <b>subpage_frame_colour</b><br>Colour of subpage frame (Full choice of colours)  | str   | “charcoal”    |

continues on next page

Table 3 – continued from previous page

| Name   | Type   | Default  |
|--|--|----------|
| <b>subpage_frame_line_style</b><br>Style of subpage frame (SOLID/DASH/DOT/CHAIN_DASH/CHAIN_DOT)                                  | “solid”, “dash”,<br>“dot”,<br>“chain_dash”,<br>“chain_dot” | “solid”  |
| <b>subpage_frame_thickness</b><br>Thickness of subpage frame   | int  | 2        |
| <b>subpage_vertical_axis_width</b><br>width of the vertical axis in cm   | float  | 1.0      |
| <b>subpage_horizontal_axis_height</b><br>height of the horizontal axis in cm   | float  | 0.5      |
| <b>subpage_align_horizontal</b><br>Used in automatic layout to setup the horizontal alignment of the drawing area in the subpage | “left”, “right”  | “left”   |
| <b>subpage_align_vertical</b><br>Used in automatic layout to setup the vertical alignment of the drawing area in the subpage     | “bottom”, “top”  | “bottom” |
| <b>subpage_lower_left_latitude</b><br>Latitude of lower left corner of map.  | float  | -90.0    |
| <b>subpage_lower_left_longitude</b><br>Longitude of lower left corner of map   | float  | -180.0   |
| <b>subpage_upper_right_latitude</b><br>Latitude of upper right corner of map   | float  | 90.0     |
| <b>subpage_upper_right_longitude</b><br>Longitude of upper right corner of map   | float  | 180.0    |

continues on next page



Table 3 – continued from previous page

| Name   | Type                           | Default    |
|--|--------------------------------|------------|
| <b>subpage_map_area_definition_polar</b><br>Method of defining a polar stereographic map   | “full”, “corners”,<br>“centre” | “corners”  |
| <b>subpage_map_hemisphere</b><br>Hemisphere required for polar stereographic map(NORTH/SOUTH)  | str                            | “north”    |
| <b>subpage_map_vertical_longitude</b><br>Vertical longitude of polar stereographic or Aitoff map   | float                          | 0.0        |
| <b>subpage_map_centre_latitude</b><br>Latitude of centre of polar stereographic map defined by ‘CENTRE’ or centre latitude of Lambert/satellite subarea projections    | float                          | 90.0       |
| <b>subpage_map_centre_longitude</b><br>Longitude of centre of polar stereographic map defined by ‘CENTRE’ or centre longitude of Lambert/satellite subarea projections | float                          | 0.0        |
| <b>subpage_map_scale</b><br>Scale of polar stereographic or Aitoff map   | float                          | 50000000.0 |
| <b>subpage_map_area_definition</b><br>method used to define the geographical area.   | “corners”, “full”              | “full”     |
| <b>subpage_map_true_scale_north</b><br>Developement in progress  | float                          | 6.0        |
| <b>subpage_map_true_scale_south</b><br>Developement in progress  | float                          | -60.0      |
| <b>subpage_map_projection_height</b><br>height (in meters) above the surface   | float                          | 42164000.0 |
| <b>subpage_map_projection_tilt</b><br>angle (in degrees) away from nadir   | float                          | 0.0        |

continues on next page

Table 3 – continued from previous page

| Name  | Type  | Default |
|---|-------|---------|
| <b>subpage_map_projection_azimuth</b><br>bearing (in degrees) from due north                | float | 20.0    |
| <b>subpage_map_projection_view_latitude</b><br>latitude (in degrees) of the view position   | float | 20.0    |
| <b>subpage_map_projection_view_longitude</b><br>longitude (in degrees) of the view position | float | -60.0   |
| <b>subpage_map_geos_sweep</b><br>the sweep angle axis of the viewing instrument             | float | 0.0     |
| <b>taylor_standard_deviation_min</b><br>Min of the Standard deviation axis.                 | float | 0.0     |
| <b>taylor_standard_deviation_max</b><br>Max of the Standard deviation axis.                 | float | 1.0     |

### 1.29.4 msymb

This action controls the plotting of meteorological and marker symbols. It is used to plot point data, such as observations.

| Name  | Type                           | Default |
|---|--------------------------------|---------|
| <b>symbol_advanced_table_selection_type</b><br>Technique to use to calculate the shading band levels. | “count”, “interval”,<br>“list” | “count” |
| <b>symbol_advanced_table_min_value</b><br>Min value to plot   | float                          | -1e+21  |
| <b>symbol_advanced_table_max_value</b><br>Max value to plot   | float                          | 1e+21   |

continues on next page

Table 4 – continued from previous page

| Name   | Type                             | Default          |
|--|----------------------------------|------------------|
| <b>symbol_advanced_table_level_count</b><br>Count or number of levels to be plotted. Magics will try to find “nice levels”, this means that the number of levels could be slightly different from the requested number of levels | int                              | 10               |
| <b>symbol_advanced_table_level_tolerance</b><br>Tolerance: Do not use “nice levels” if the number of levels is really to different [count +/- tolerance]   | int                              | 2                |
| <b>symbol_advanced_table_interval</b><br>Interval in data units between different bands of shading   | float                            | 8.0              |
| <b>symbol_advanced_table_reference_level</b><br>Level from which the level interval is calculated  | float                            | 0.0              |
| <b>symbol_advanced_table_level_list</b><br>List of shading band levels to be plotted   | List[float]                      | []               |
| <b>symbol_advanced_table_colour_method</b><br>Method of generating the colours of the bands in polygon shading   | “calculate”, “list”              | “calculate”      |
| <b>symbol_advanced_table_max_level_colour</b><br>Highest shading band colour   | str                              | “blue”           |
| <b>symbol_advanced_table_min_level_colour</b><br>Lowest shading band colour  | str                              | “red”            |
| <b>symbol_advanced_table_colour_direction</b><br>Direction of colour sequencing for plotting (CLOCKWISE/<br>ANTI_CLOCKWISE)  | “clockwise”,<br>“anti-clockwise” | “anti_clockwise” |
| <b>symbol_advanced_table_colour_list</b><br>List of colours to be used in symbol plotting  | List[str]                        | []               |

continues on next page

Table 4 – continued from previous page

| Name  | Type                | Default   |
|---|---------------------|-----------|
| <b>symbol_advanced_table_colour_list_policy</b><br>What to do if the list of colours is smaller than the list of intervals:<br>lastone/cycle                                      | “lastone”, “cycle”  | “lastone” |
| <b>symbol_advanced_table_marker_list</b><br>List of markers to be used in symbol plotting   | List[int]           | []        |
| <b>symbol_advanced_table_marker_name_list</b><br>List of markers to be used in symbol plotting symbol   | List[str]           | []        |
| <b>symbol_advanced_table_marker_list_policy</b><br>What to do if the list of markers is smaller than the list of intervals:<br>lastone/cycle                                      | “lastone”, “cycle”  | “lastone” |
| <b>symbol_advanced_table_height_method</b><br>Method of generating the height   | “calculate”, “list” | “list”    |
| <b>symbol_advanced_table_height_max_value</b><br>Maximum height to use  | float               | 0.2       |
| <b>symbol_advanced_table_height_min_value</b><br>Minimum height to use  | float               | 0.1       |
| <b>symbol_advanced_table_height_list</b><br>List of heights to be used  | List[float]         | []        |
| <b>symbol_advanced_table_height_list_policy</b><br>What to do if the list of heights is smaller than the list of intervals: lastone/cycle   | “lastone”, “cycle”  | “lastone” |
| <b>symbol_advanced_table_text_list</b><br>Text to display   | List[str]           | []        |
| <b>symbol_advanced_table_text_list_policy</b><br>What to do if the list of text is smaller than the list of intervals lastone: reuse the last one, cycle: return to the first one | “lastone”, “cycle”  | “cycle”   |

continues on next page

Table 4 – continued from previous page

| Name   | Type   | Default     |
|--|--|-------------|
| <b>symbol_advanced_table_text_font</b><br>Font to use for text plotting.   | str  | “sansserif” |
| <b>symbol_advanced_table_text_font_size</b><br>Font size   | float  | 0.25        |
| <b>symbol_advanced_table_text_font_style</b><br>Font Style   | str  | “normal”    |
| <b>symbol_advanced_table_text_font_colour</b><br>Symbol Colour   | str  | “automatic” |
| <b>symbol_advanced_table_text_display_type</b><br>How to display text none:do not display it centre : display it instead of the symbol, right : attached it to the right of the symbol, top : attached it to the top of the symbol, bottom: attached it to the bottom of the symbol, | “centre”, “none”,<br>“right”, “left”,<br>“top”, “bottom” | “none”      |
| <b>symbol_advanced_table_outlayer_method</b><br>outlayer method  | “none”, “simple”   | “none”      |
| <b>legend_user_text</b><br>if set, the text to be shown for the symbol group in the legend   | str  | “”          |
| <b>symbol_colour</b><br>Colour of symbols.   | str  | “blue”      |
| <b>symbol_height</b><br>Height of symbols.   | float  | 0.2         |
| <b>symbol_marker_mode</b><br>Method to select a marker : by name, by index, by image : in that case, Magics will use an external image as marker.  | str  | “index”     |
| <b>symbol_marker_index</b><br>Marker indice: An integer between 1 and 28   | int  | 1           |

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Table 4 – continued from previous page

| Name   | Type                             | Default     |
|--|----------------------------------|-------------|
| <b>symbol_marker_name</b><br>Symbol name. Choose in a list of available markers dot/circle/ww_00 ...                                     | str                              | “dot”       |
| <b>symbol_image_path</b><br>Path to the image  | str                              | “”          |
| <b>symbol_image_format</b><br>Format of the image file. If set to AUTOMATIC, the file extension will be used to determine the file type. | “automatic”, “png”, “svg”        | “automatic” |
| <b>symbol_image_width</b><br>width of the image  | float                            | -1.0        |
| <b>symbol_image_height</b><br>height of the image  | float                            | -1.0        |
| <b>symbol_text_list</b><br>list of texts to plot   | List[str]                        | []          |
| <b>symbol_text_position</b><br>Position of the text  | “right”, “left”, “bottom”, “top” | “right”     |
| <b>symbol_text_font</b><br>Font to use   | str                              | “sansserif” |
| <b>symbol_text_font_size</b><br>Font size  | float                            | 0.25        |
| <b>symbol_text_font_style</b><br>Font style  | str                              | “normal”    |
| <b>symbol_text_font_colour</b><br>Font colour.   | str                              | “automatic” |

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Table 4 – continued from previous page

| Name   | Type                                  | Default       |
|--|---------------------------------------|---------------|
| <b>symbol_legend_height</b><br>If set, the height will be used to plot the symbols in the legend   | float                                 | -1.0          |
| <b>legend</b><br>Turn legend on or off (ON/OFF) : New Parameter!   | bool                                  | False         |
| <b>symbol_scaling_method</b><br>Turn legend on or off (ON/OFF) : New Parameter!  | bool                                  | False         |
| <b>symbol_scaling_level_0_height</b><br>Turn legend on or off (ON/OFF) : New Parameter!  | float                                 | 0.1           |
| <b>symbol_scaling_factor</b><br>Turn legend on or off (ON/OFF) : New Parameter!  | float                                 | 4.0           |
| <b>symbol_type</b><br>Defines the type of symbol plotting required   | “number”, “text”,<br>“marker”, “wind” | “number”      |
| <b>symbol_table_mode</b><br>Specifies if plotting is to be in advanced, table (on) or individual mode (off).<br>Note: The simple table mode is not recommended anymore, try to use the advanced mode instead, this should give you easier control of the plot. | 0, “advanced”, 1                      | “OFF”         |
| <b>symbol_format</b><br>Format used to plot values (MAGICS Format/(AUTOMATIC))   | str                                   | “(automatic)” |
| <b>symbol_text_blanking</b><br>blanking of the text  | bool                                  | False         |
| <b>symbol_outline</b><br>Add an outline to each symbol   | bool                                  | False         |
| <b>symbol_outline_colour</b><br>Colour of the outline  | str                                   | “black”       |

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Table 4 – continued from previous page

| Name  | Type   | Default |
|---|--|---------|
| <b>symbol_outline_thickness</b><br>thickness of the outline   | int  | 1       |
| <b>symbol_outline_style</b><br>Line Style of outline  | “solid”, “dash”,<br>“dot”,<br>“chain_dash”,<br>“chain_dot” | “solid” |
| <b>symbol_connect_line</b><br>Connect all the symbols with a line   | bool   | False   |
| <b>symbol_connect_automatic_line_colour</b><br>if on, will use the colour of the symbol   | bool   | True    |
| <b>symbol_connect_line_colour</b><br>Colour of the connecting line  | str  | “black” |
| <b>symbol_connect_line_thickness</b><br>thickness of the connecting line  | int  | 1       |
| <b>symbol_connect_line_style</b><br>Line Style of connecting line   | “solid”, “dash”,<br>“dot”,<br>“chain_dash”,<br>“chain_dot” | “solid” |
| <b>symbol_min_table</b><br>Table of minimum values. The table is used in conjunction with<br>SYMBOL_MAX_TABLE                               | List[float]  | []      |
| <b>symbol_max_table</b><br>Table of maximum values. The table is used in conjunction with<br>SYMBOL_MIN_TABLE                               | List[float]  | []      |
| <b>symbol_marker_table</b><br>Table of MARKER indices. The table is to be used in conjunction with<br>SYMBOL_MIN_TABLE and SYMBOL_MAX_TABLE | List[int]  | []      |

continues on next page



Table 4 – continued from previous page

| Name   | Type        | Default |
|--|-------------|---------|
| <b>symbol_name_table</b><br>Table of Symbol names. The table is to be used in conjunction with SYMBOL_MIN_TABLE and SYMBOL_MAX_TABLE       | List[str]   | []      |
| <b>symbol_colour_table</b><br>Table of SYMBOL colours. T The table is to be used in conjunction with SYMBOL_MIN_TABLE and SYMBOL_MAX_TABLE | List[str]   | []      |
| <b>symbol_height_table</b><br>Table of SYMBOL heights. The table is to be used in conjunction with SYMBOL_MIN_TABLE and SYMBOL_MAX_TABLE   | List[float] | []      |



## 1.29.5 mtable

| Name  | Type             | Default  |
|---|------------------|----------|
| <b>table_filename</b><br>Path to the table data   | str              | ""       |
| <b>table_delimiter</b><br>Used delimiter  | str              | ","      |
| <b>table_combine_delimiters</b><br>Consecutive delimiters will be considered as one                         | bool             | False    |
| <b>table_header_row</b><br>Which row (first is 1) is the header line on?                                    | int              | 1        |
| <b>table_data_row_offset</b><br>How many rows after the header row does the data start? 1 if no header row. | int              | 1        |
| <b>table_meta_data_rows</b><br>List of row indexes containing meta-data of the form P1=V1 P2=V2.            | List[int]        | []       |
| <b>table_x_type</b><br>Type used for X variable_index: number or date                                       | "number", "date" | "number" |
| <b>table_y_type</b><br>Type used for Y variable_index: number or date                                       | "number", "date" | "number" |
| <b>table_variable_identifier_type</b><br>are we refering to the columns by names or index (index/name)      | str              | "index"  |
| <b>table_x_variable</b><br>X variable_index or name   | str              | 1        |
| <b>table_y_variable</b><br>Y variable_index or name   | str              | 2        |

## 1.30 Gallery

### 1.30.1 Layers

default-background

default-foreground

land-sea

### 1.30.2 Styles

cyclone-track

default-style-fields

default-style-observations

land-sea-mask

no-style

orography

rainbow-markers

### 1.30.3 Projections

africa

asia

bonne

collignon

euro-atlantic

europe

europe-cylindrical

global

goode

mercator

mollweide

north-america

north-america1

north-atlantic

north-hemisphere

polar-north

robinson

south-america

south-atlantic

south-hemisphere

south-pacific

tropics-east

tropics-west

web-mercator

## 1.31 Climetlab Plugin mechanism

This document discuss how plugins are integrated into CliMetLab. There are two ways to add a plugin into CliMetLab:

- A Python package using the standard [Python plugin](#) mechanism based on `entry_points`. This is the generic CliMetLab plugin mechanism.
- A YAML file can be also be used to create plugins, when the plugin is simple enough and used only generic predefined code. (currently only for *dataset plugins*).

### 1.31.1 Plugin as python packages using entry\_points

During the installation of the pip package, the plugin registers itself thanks to the entry points in its setup.py file, making CliMetLab aware of the new capabilities. Then, the user can take advantage of the shared code through the enhanced `climetlab.load_dataset()`, `climetlab.load_source()` and `climetlab.plot_map()`, etc.

For pip packages using `setuptools`, creating a plugin consists in adding an entry in `setup.py`:

```
setuptools.setup(
    name = 'climetlab-package-name',
    ...
    entry_points={"climetlab.<plugintype>":
        ["foo = climetlab_package_name:FooClass",
         "bar = climetlab_package_name:BarClass"]
    },
)
```

In this package called **climetlab-package-name**, the class `climetlab_package_name.FooClass` provides Python code related to "foo". Additional code related to "bar" is located in the class `climetlab_package_name.BarClass`. The **<plugintype>** is one of the plugin type in the table above: *dataset*, *sources*, *readers*, etc. See the individual documentation for each plugin type for detailed examples and the standard **Python plugin documentation** <https://packaging.python.org/guides/creating-and-discovering-plugins>`.

### 1.31.2 Plugin as YAML files

---

**Todo:** This is still a work-in-progress.

---

Additionally, for *dataset plugins* only, CliMetLab search for known locations to find a YAML file with a name matching the requested dataset. The YAML files are used to create an appropriate class.





## LICENSE

*CliMetLab* is available under the open source [Apache License](#).