xarray architecture

Overview

Teaching: 5 min
Exercises: 5 min
Questions
- What functionality does the xarray library offer?
- What are the benefits and limitations of this library?
- What is the fundamental architecture of xarray data objects?

Objectives
- learning the xarray data model
- selection and subsetting of array datasets using labeled indexing

What is xarray?

- originally developed by employees (Stephan Hoyer, Alex Kleeman and Eugene Brevdo) at The Climate Corporation (https://climate.com/)
- xaray extends some of the core functionality of the Pandas library:
  - operations over *named* dimensions
  - selection by label instead of integer location
  - powerful *groupby* functionality
  - database-like joins

When to use xarray:

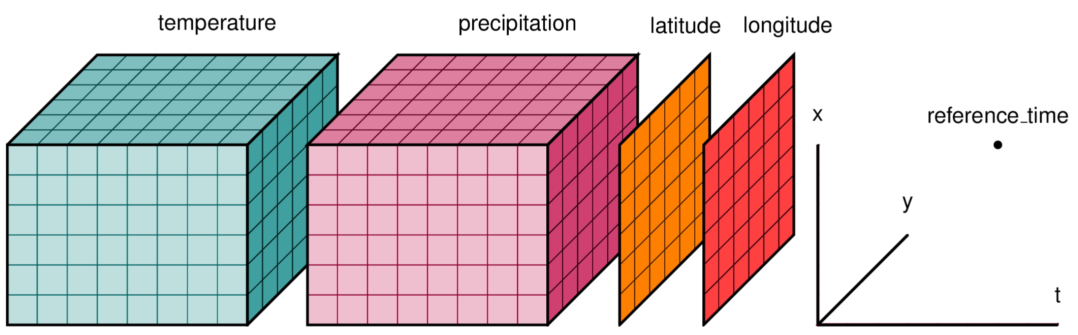
- if your data are multidimensional (e.g. climate data: x, y, z, time)
- if your data are structured on a regular grid
- if you can represent your data in netCDF format

Basic xarray data structures:

- NetCDF forms the basis of the xarray data structure
- two main data structures are the `DataArray` and the `Dataset`

`DataArray`

- the `DataArray` is xarray's implementation of a labeled, multi-dimensional array
- the `DataArray` has these key properties:
  - `data`: N-dimensional array (NumPy or dask) holding the array's values,
  - `dims`: dimension names for each axis,
  - `coords`: dictionary-like container of arrays that label each point, and
  - `attrs`: ordered dictionary holding metadata



* dimensions (x, y, time); variables (temp, precip); coords (lat, long); attributes

`Dataset`

- xarray's multi-dimensional equivalent of a Pandas `DataFrame`
- dict-like container of DataArray objects with aligned dimensions

- Datasets have these key properties:
  - `dims`: dictionary mapping from dimension names to the fixed length of each dimension,
  - `data_vars`: dict-like container of `DataArrays` corresponding to data variables,
  - `coords`: dictionary-like container of `DataArrays` intended to label points used in data_vars
  - `attrs`: ordered dictionary holding metadata

begin by importing the xarray library

```
import xarray as xr
```

Open the dataset

First we open (http://xarray.pydata.org/en/stable/generated/xarray.open_dataset.html) the data and load it into a `Dataset`. (Note: the choice of engine depends on the format of the netCDF file. See our dataset description (../00-datasets) lesson).

```
ds = xr.open_dataset('../data/airtemp_global.nc')
```

(**NOTE**: here and elsewhere, replace `<rootDir>` with the full path to your own data directory)

You'll notice this seemed to go very fast. That is because this step does not actually ask Python to read the data into memory. Rather, Python is just scanning the contents of the file. This is called *lazy loading*.

`Dataset` Properties

Next we will ask xarray to display some of the parameters (http://xarray.pydata.org/en/stable/generated/xarray.Dataset.html) of the `Dataset`. To do this simply return the contents of the `Dataset` variable name:

```
ds
```

```
<xarray.Dataset>
Dimensions:    (latitude: 241, longitude: 480, time: 13361)
Coordinates:
  * latitude   (latitude) float32 90.0 89.25 88.5 87.75 87.0 86.25 85.5 ...
  * longitude  (longitude) float32 0.0 0.75 1.5 2.25 3.0 3.75 4.5 5.25 6.0 ...
  * time       (time) datetime64[ns] 1979-01-01T06:00:00 1979-01-02T06:00:00 ...
Data variables:
    t2m        (time, latitude, longitude) float64 242.0 242.0 242.0 242.0 ...
Attributes:
    Conventions: CF-1.0
    history: 2015-10-19 21:11:12 GMT by grib_to_netcdf-1.13.1: grib_to_netcdf /data/data04/scratch/netcdf-atls05-a562
cefde8a29a7288fa0b8b7f9413f7-1hbxws.target -o /data/data04/scratch/netcdf-atls05-a562cefde8a29a7288fa0b8b7f9413f7-y_O
M5J.nc -utime
```

Displaying `Dataset` properties

Extracting `DataArrays` from a `Dataset`

We have queried the dataset details about our `Datset` dimensions, coordinates and attributes. Next we will look at the variable data contained within the dataset. In the graphic above, there are two variables (temperature and precipitation). As described above, xarray stores these observations as a `DataArray`, which is similar to a conventional array you would find in numpy or matlab.

Extracting a `DataArray` for processing is simple. From the `Dataset` metadata shown above, notice that the name of the climate variable is 't2m' (2 meter air temperature). Suppose we want to extract that array for processing and store it to a new variable called `temperature`:

```
temperature = ds['t2m']
```

Now, take a look at the contents of the `temperature` variable. Note that the associated coordinates and attributes get carried along for the ride. Also note that we are still not reading any data into memory.

Key Points

- xarray is build on the netCDF data model
- xarray has two main data structures: DataArray and Dataset
- DataArrays store the multi-dimensional arrays
- Datasets are the multi-dimensional equivalent of a Pandas dataframe