xarray: multi-dimensional data analysis in Python

Stephan Hoyer (1), Joe Hamman (2), Fabien Maussion (3) and Benoît Bovy (4)

(1) Google Research, Mountain View, CA, USA (2) NCAR, Boulder, CO, USA (3) University of Innsbruck, Austria (4) GFZ Potsdam, Germany

What is xarray?

For Python / Numpy users

- xarray handles N-dimensional arrays with labels (dimension names & coordinates) and metadata.

For Python / Pandas users

- xarray is a powerful, pandas-like toolkit for analytics on multi-dimensional arrays.

For scientists familar with the netCDF format

- xarray implements the netCDF data model with a high level Python API.

For scientists working with big datasets

- xarray (with dask) supports efficient, out-of-core computing for datasets that don't fit in memory.

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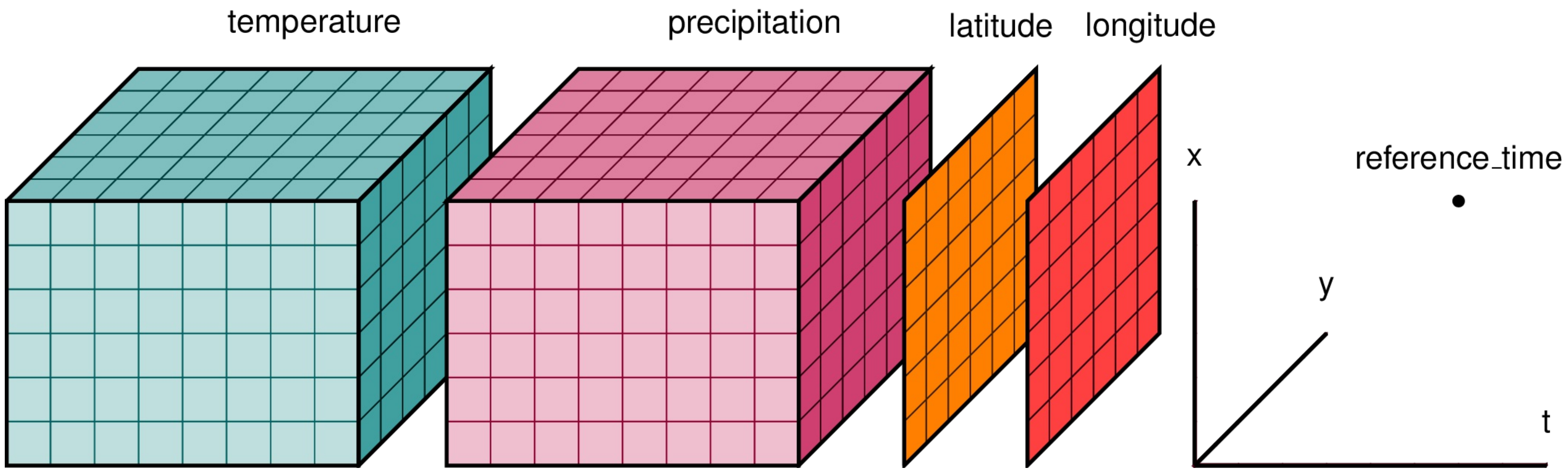
What is xarray?

If you are dealing with data that...

- is multi-dimensional ;
- is labelled ;
- has (lots of) metadata ;
- is sometimes (very) large ;



...then you may find xarray very useful!

xarray

- Open source
- Very good integration with other Python libraries for scientific computing (SciPy / PyData Stack)
- Documentation: http://xarray.pydata.org
- Repository: https://github.com/pydata/xarray
- 60 contributors (still growing)
- Latest release: v0.9.2 (02.04.2017)
- Umbrellas (no funding): Python for Data & NumFOCUS

numpy.array

```
>>> import numpy as np
>>> a = np.array([[1, 3, 9], [2, 8, 4]])
>>> a
```

```
array([[1, 3, 9],
       [2, 8, 4]])
```

```
>>> a[1, 2]   # get the value at 2nd row and 3rd column
```

```
4
```

```
>>> a.mean(axis=0)   # compute the mean column-wise
```

```
array([1.5,  5.5,  6.5])
```

Not well supported by numpy:

- array dimensions and indexes often have a meaning, e.g., latitude / longitude and their coordinates.

xarray.DataArray

```
>>> import xarray as xr
>>> da = xr.DataArray(a, dims=['latitude', 'longitude'],
                      coords={'longitude':[11, 12, 13], 'latitude':[1, 2]})
>>> da
```

```
<xarray.DataArray (latitude: 2, longitude: 3)>
array([[1, 3, 9],
       [2, 8, 4]])
Coordinates:
  * longitude    (longitude) int64 11 12 13
  * latitude     (latitude) int64 1 2
```

```
>>> da.sel(longitude=13, latitude=2)   # easier to work with coordinate values!
```

```
<xarray.DataArray ()>
array(4)
Coordinates:
    longitude    int64 13
    latitude     int64 2
```

```
>>> da.mean(dim='latitude')    # easier to remember dimension names!
```

```
<xarray.DataArray (longitude: 3)>
array([ 1.5,  5.5,  6.5])
Coordinates:
  * longitude    (longitude) int64 11 12 13
```

xarray.Dataset

A collection of `xarray.DataArray`, a netCDF file...

```
>>> ds = xr.open_dataset('ERA-Int-MonthlyAvg-4D-TUVWZ.nc')
>>> ds
```

```
<xarray.Dataset>
Dimensions:    (latitude: 241, level: 15, longitude: 480, month: 12)
Coordinates:
  * latitude   (latitude) float32 90.0 89.25 88.5 87.75 87.0 ...
  * level      (level) int32 50 100 150 200 300 400 500 600 ...
  * longitude  (longitude) float32 -180.0 -179.25 -178.5 ...
  * month      (month) int64 1 2 3 4 5 6 7 8 9 10 11 12
Data variables:
    u          (month, level, latitude, longitude) float64 10.38 ...
    v          (month, level, latitude, longitude) float64 5.594 ...
    w          (month, level, latitude, longitude) float64 -0.0003052 ...
    z          (month, level, latitude, longitude) float64 1.888e+05 ...
    t          (month, level, latitude, longitude) float64 201.1 ...
Attributes:
    Conventions: CF-1.0
    Info: Monthly ERA-Interim data.
```

Powerful analytics

- Advanced selection

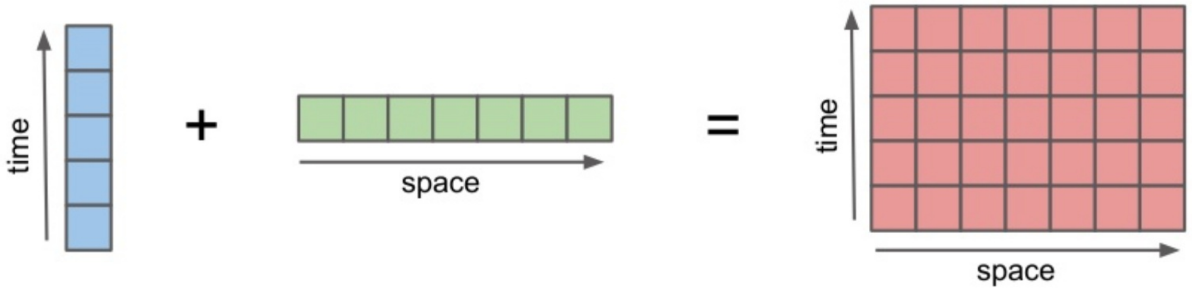
```
ds.sel(latitude=47.26, method='nearest')  # no need to provide exact coordinate values
```

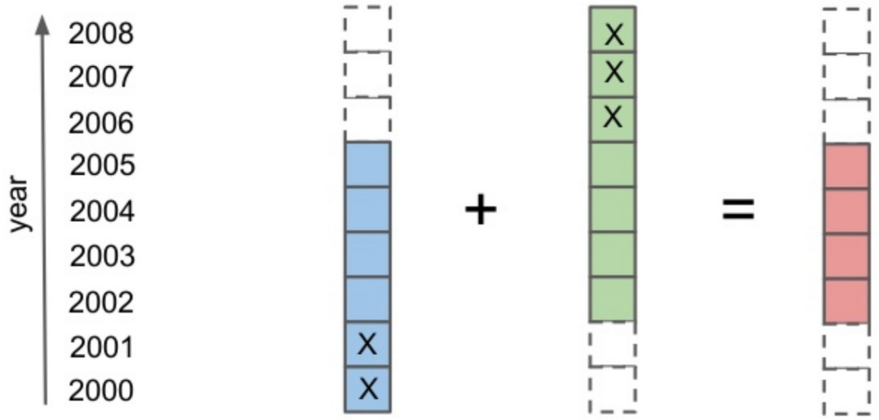
- Aggregation

```
ds.mean(dim=['month', 'longitude'])
```

- Arithmetics

```
ds1 + ds2   # supports automatic broadcasting and alignment!
```

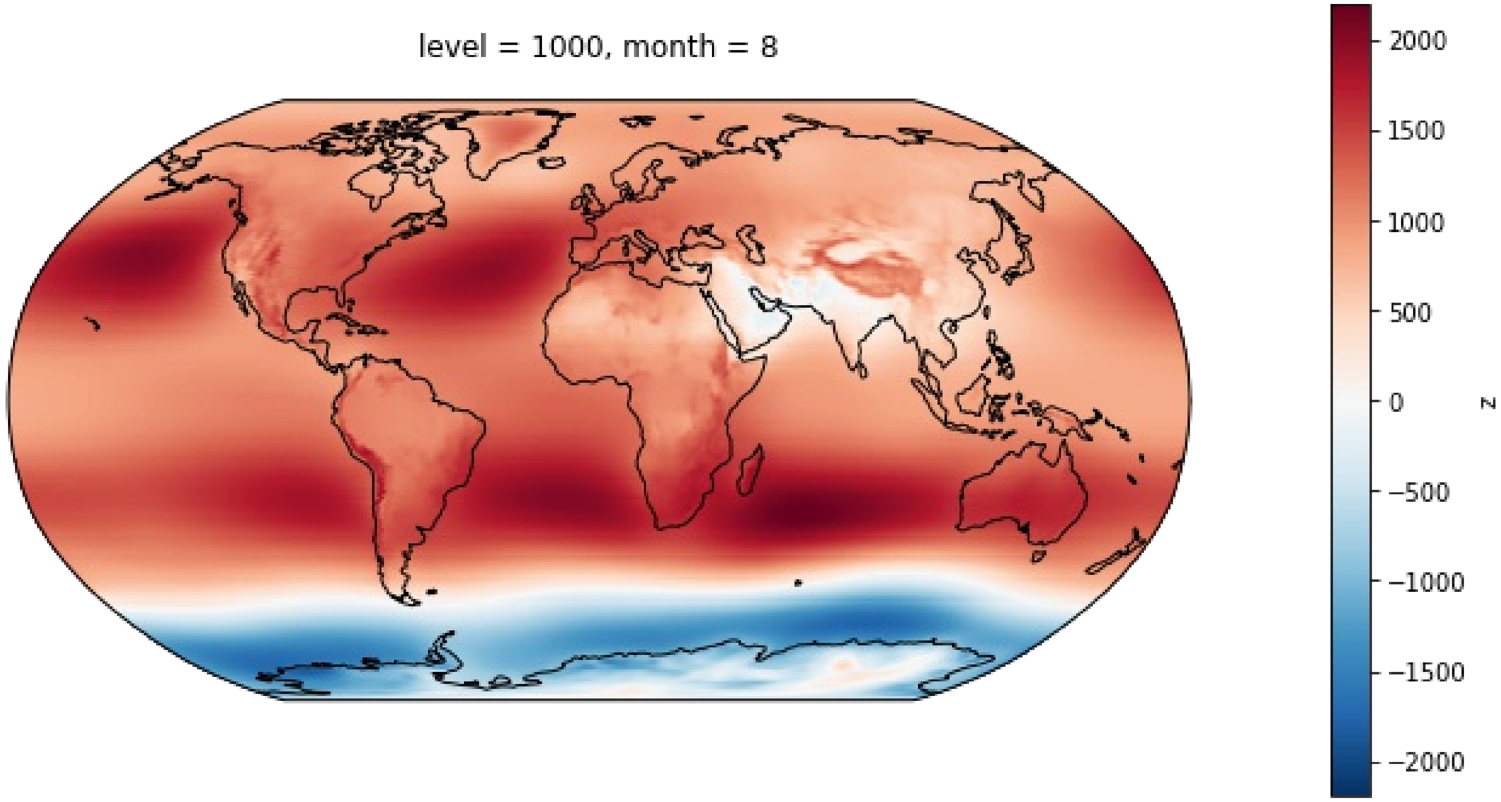




Powerful analytics (2)

- Plotting

```
import cartopy.crs as ccrs
ax = plt.axes(projection=ccrs.Robinson())
ds.z.sel(level=1000, month=8).plot(ax=ax, transform=ccrs.PlateCarree());
ax.coastlines();
```



Powerful analytics (3)

- Out-of-core computing

```
big_ds = xr.open_mfdataset('data*.nc') # lazy loading of many netCDF files
                                       # (>1GB) into a single xarray.Dataset

big_ds.mean(dim=['longitude', 'latitude'])  # lazy computation

big_ds.load()   # triggers efficient, multi-core computation (using dask)
```

- ... and more!