UXarray: Python package for the analysis and visualization of model output on unstructured climate grids

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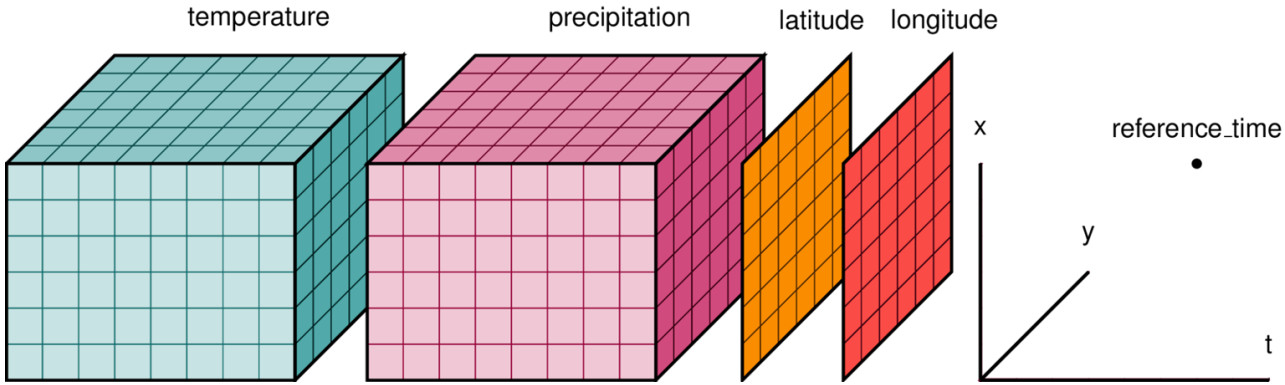
Xarray: The Structured Scientific Data Model
What makes it so popular with geoscientists?



- **Convenience**: Select values by label, not integer location
- **Popular geoscience I/O backends**: NetCDF, GRIB, OpenDap, HDF, Zarr
- **Interoperability**: works with the scientific Python ecosystem including NumPy, Dask, Pandas, and Matplotlib
- **Performant**: Operators are vectorized, implemented in compiled code, and easily parallelized (usually) with Dask
- **Ease of use**: E.g. overloaded operators, such as `plot()`, that just “do the right thing”

image source: https://doi.org/10.5334/jors.148

UGRID Conventions

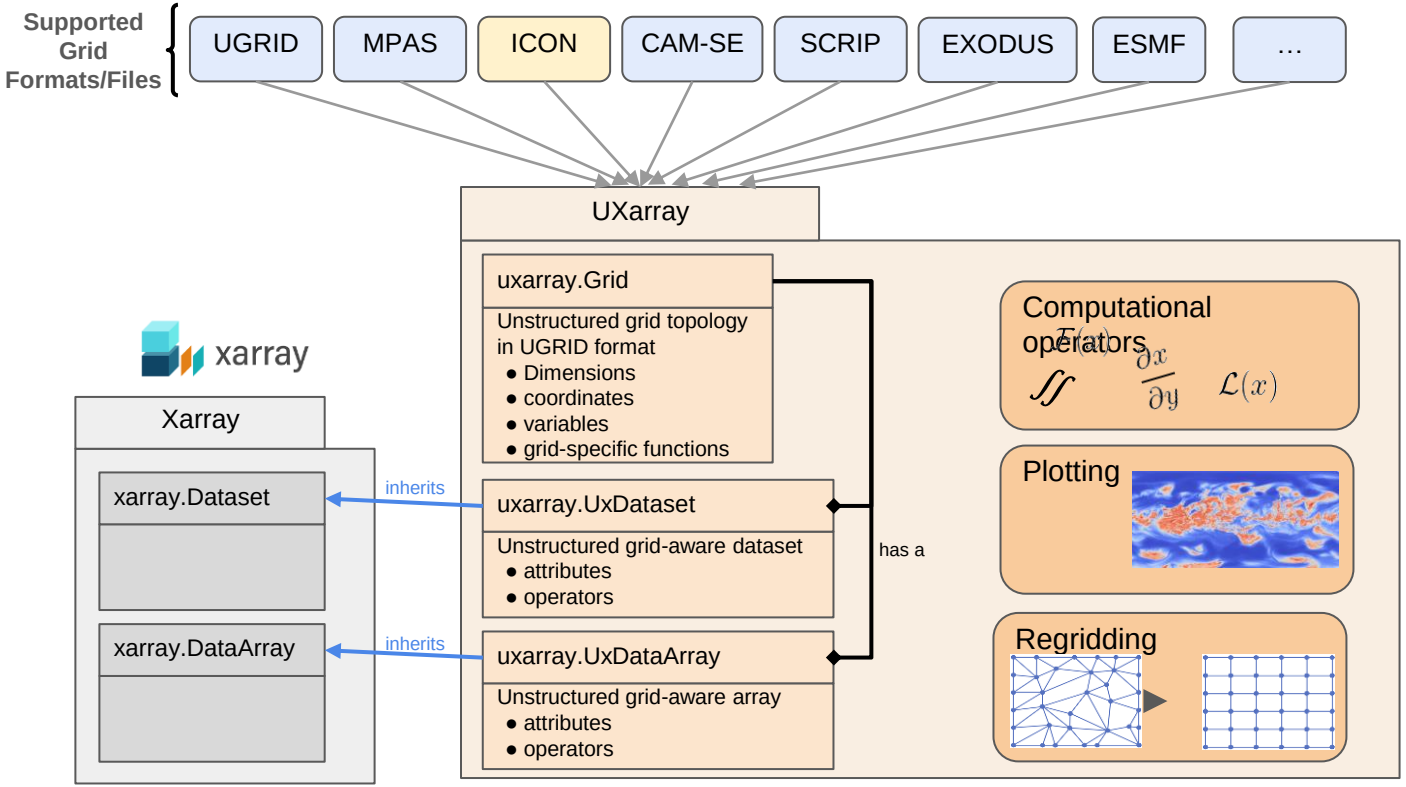
- UGRID is a convention for describing unstructured meshes in the Unidata Network Common Data Form (NetCDF) file format
- UGRID conventions are consistent, portable and extensible [1]
- Key features in the UGRID conventions include: Topology, Node attributes, Edge attributes, Face attributes, Data variables, Metadata

Required topology attributes	**Value**
cf_role	mesh_topology
topology_dimension	2
node_coordinates	
face_node_connectivity	
Optionally required attributes*	
face_dimension	
edge_node_connectivity	
edge_dimension	
Optional attributes	
face_edge_connectivity	
face_face_connectivity	
edge_face_connectivity	
boundary_node_connectivity	
face_coordinates	
edge_coordinates	

[1]http://ugrid-conventions.github.io/ugrid-conventions/#2d-flexible-mesh-mixed-triangles-quadrilaterals-etc-topology

UXarray: Xarray + unstructured grid support

UXarray operates directly on Unstructured Grids (without regridding needed)



Key Features

- Support for reading a variety of grid formats
- Integration and other Derivative Support
- Regridding/Remapping and Subsetting
- Tree Representation and Dual Mesh Construction
- Topological Aggregation
- Lat/lon Bounding Box Calculations
- Visualization and rendering capabilities

A sampling of UXarray public class methods

```
# Open a dataset and analyze sea surface temperature
import uxarray as ux
uxds = ux.open_dataset(grid_file, data_file…)
grid = ux.open_grid(grid_file)
sst = uxds[`sst`]
```

Operators inherited as is from Xarray (grid info not needed!)

```
sst.argmin()

sst.mean()

sst.where()
```

Operators overridden from Xarray

```
sst.integrate()

sst.to_netcdf()

sst.plot()
```

New operators added by UXarray

```
grid.plot()

sst.plot.points()

grid.compute_face_areas()
```

Already using Xarray? UXarray should look pretty familiar!

Future work

Work in progress

- Derivatives (advanced capabilities)
- Zonal means (conservative and non-conservative)
- Topological aggregations
- Rendering performance optimizations

Longer term

- New computational operators
- Support for more unstructured grid formats
- Address performance and scalability issues
- More: tutorials and demonstrations

Documentation and Jupyter Notebooks