U.S. DEPARTMENT OF ENERGY | Office of Science

BER/EESM/RGMA

#117

New Tools for Analysis of Data on Unstructured Grids

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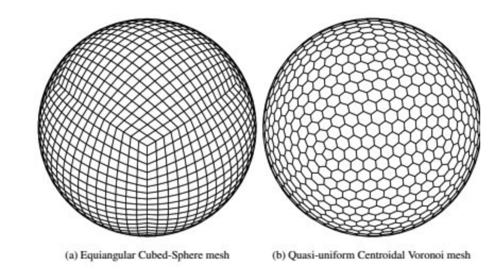
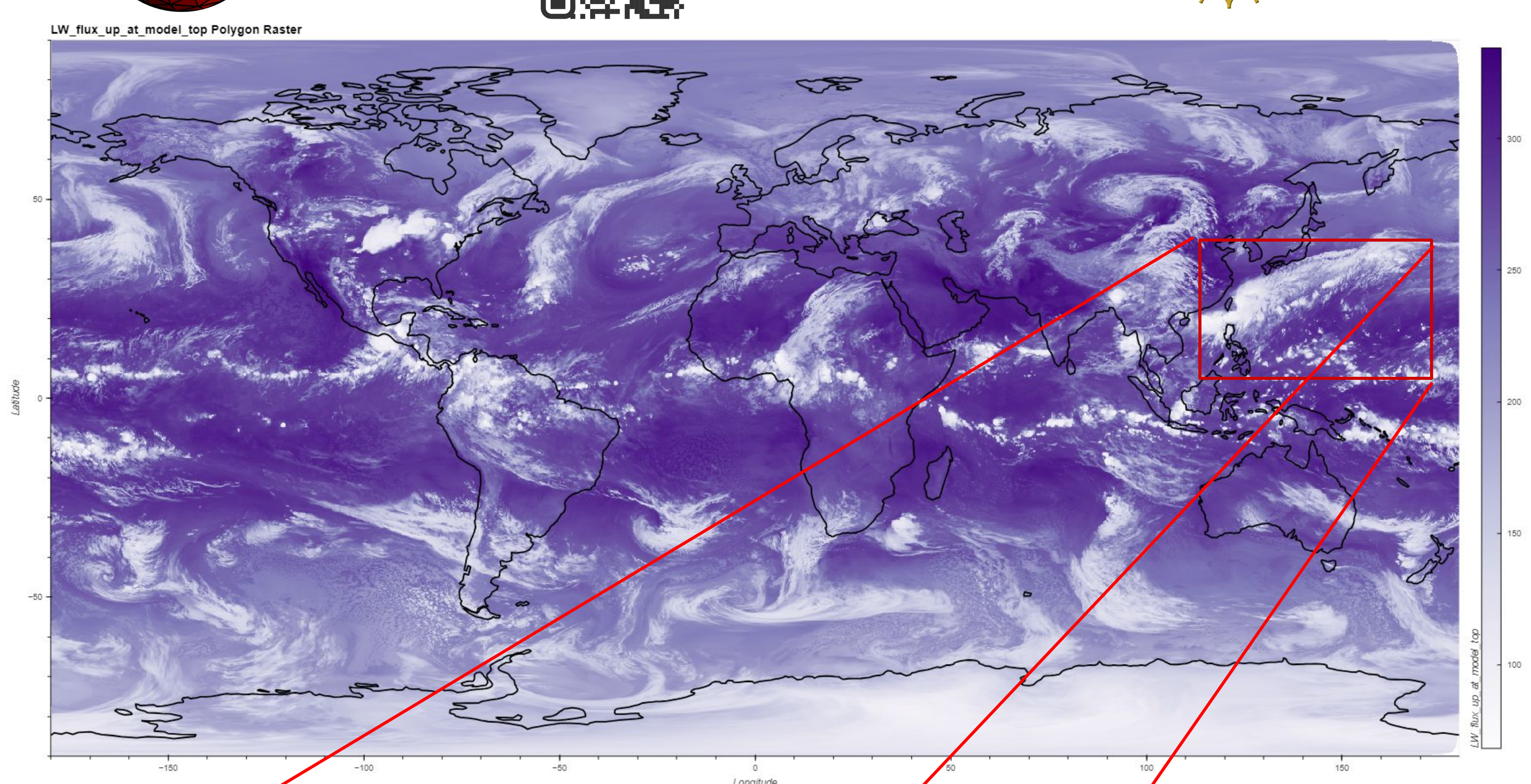
SEATS seatstandards.org

- Climate models such as E3SM increasingly have components that use unstructured grids for their numerical methods.
- Because many of the current analysis tools assume data is on structured grids, additional steps such as interpolation are required before analysis can be done.
- One goal of the **SEATS** (Simplifying ESM Analysis Through Standards) project is to create new tools that can be used to analyze unstructured data directly.
- Some of the new standard tools SEATS is developing are described below.

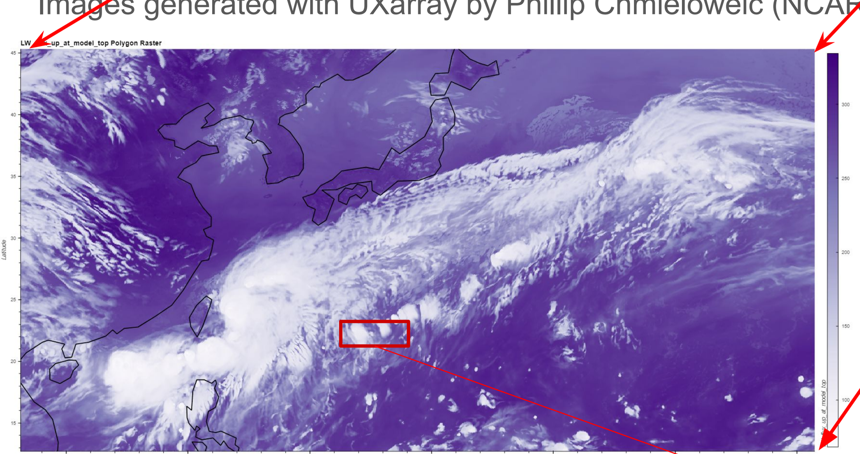


More ESMs are using unstructured meshes

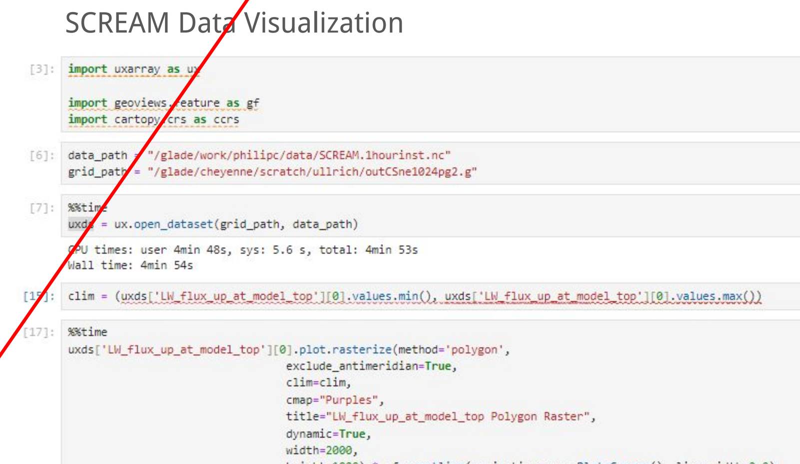
Uxarray

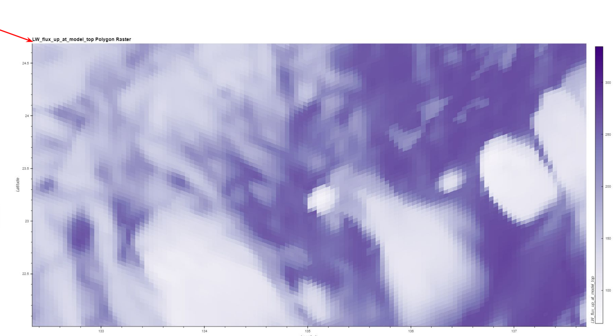


Images generated with UXarray by Phillip Chmieloweic (NCAR)



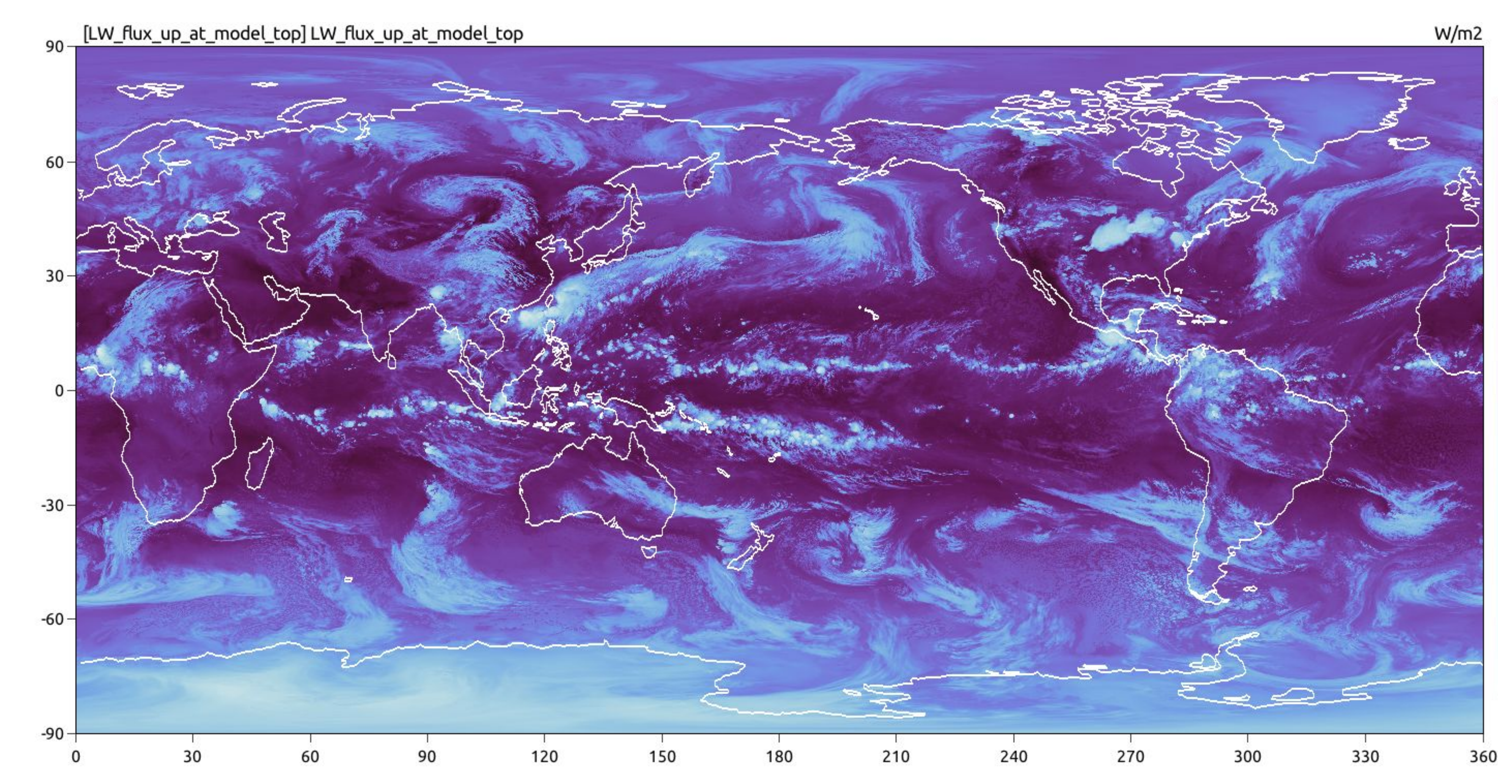
SCREAM Data Visualization



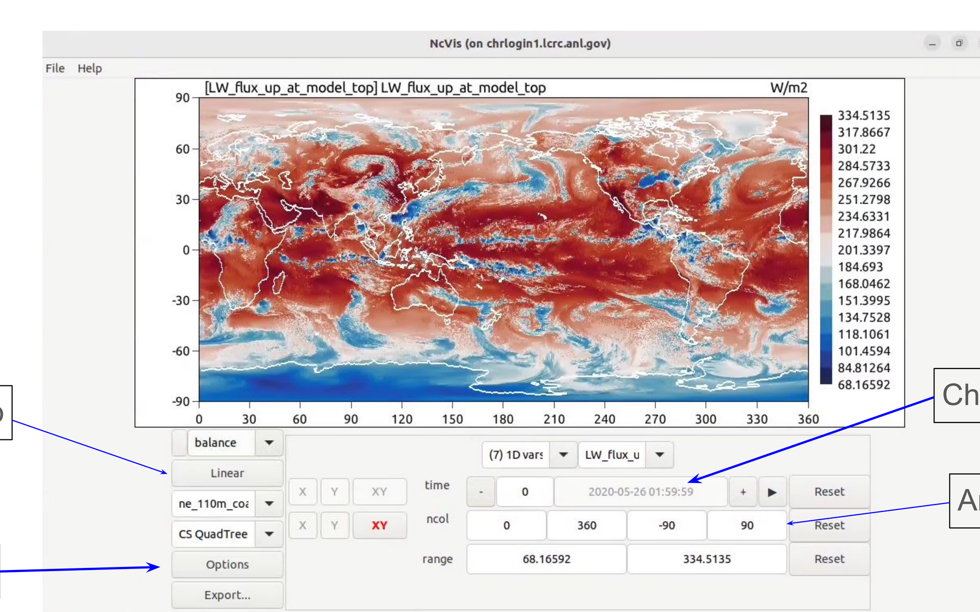


- UXarray is new python library that provides xarray-styled functions to operate on data stored in NetCDF files on unstructured grids
- User opens two files to instantiate UXarray: a NetCDF file with output fields and second NetCDF file with the mesh description.
- UXarray can read mesh descriptions in several formats (SCRIP, ESMF, MPAS, Exodus) but internally stores it following **UGRID**. (UGRID has been added to CF to provide a standard for describing unstructured climate and weather grids in NetCDF).
- Supports operations on unstructured grids
- See poster #115 in this session for more info
- **UXarray is developed in collaboration with NSF Project Raijin (NCAR)**

NCVIS



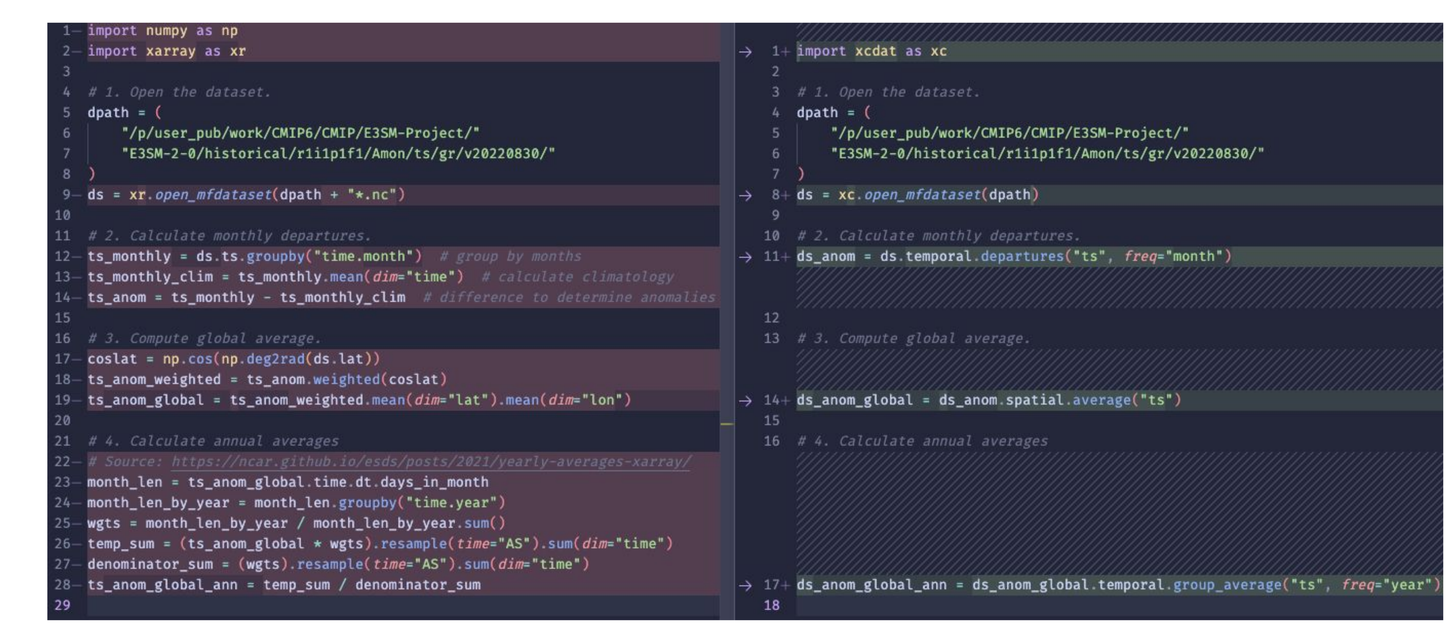
Data from E3SM EAMxx (SCREAM) 3km global simulation.



- NCVIS is a new standalone GUI application for quickly viewing fields stored in CF-compliant NetCDF files.
- Inspired by *Ncview* (by David Pierce) but allows viewing of model data on unstructured grids.
- Only requires that latitude and longitude arrays be included in the file, not a full mesh description.
- Simple point-and-click interface
- Written in C++ with the WxWidgets GUI library

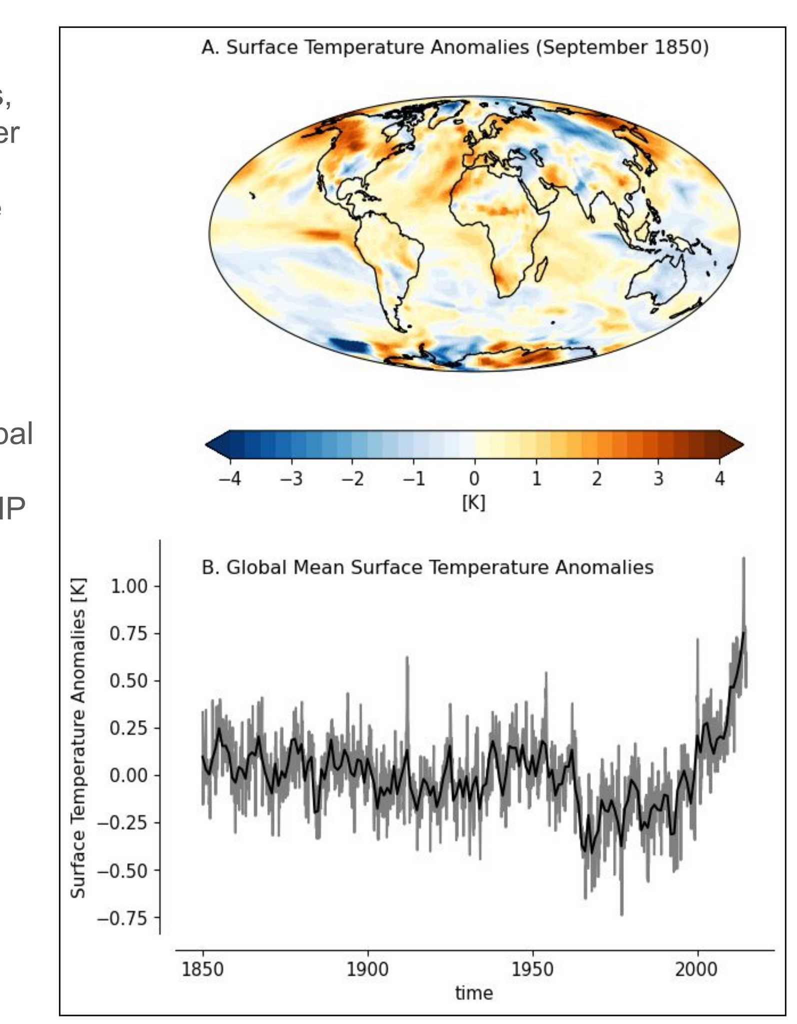
All tools available in e3sm-unified and individually from conda-forge

xCDAT



Above: Code comparison for calculating monthly departures, global mean time series, and annual averages with plain Xarray (upper left) and with xCDAT (upper right). Plots showing the results of these calculations are shown on the right.

Right: A) Map showing the monthly surface temperature departures departures (September 1850) and B) the corresponding monthly (gray) and annual mean (black) global mean surface temperature time series. Data from E3SM v2 historical simulation from CMIP archive.



- xCDAT is a successor to CDAT and is designed to perform routine geospatial analysis operations in python.
- xCDAT extends Xarray, is interoperable with dask (parallelism) and matplotlib (plotting) and leverages other packages for key functionality/interoperability (e.g., xESMF, xGCM, cf_xarray)
- Key features include: spatial averaging, temporal averaging, and regridding.
- Can operate on UXarray objects. Further integration TBD.
- See talk by Tom Vo in Metrics session, 2:45pm, Thursday.
- **xCDAT is developed in collaboration with the E3SM and PCMDI projects**