

PROJECT



Community Geoscience
Analysis Tools
for
Unstructured Grids

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NCAR/UCAR

Joint WRF/MPAS Users Workshop 2023

Boulder, CO

June 20, 2023



EarthCube
Transforming Geosciences Research

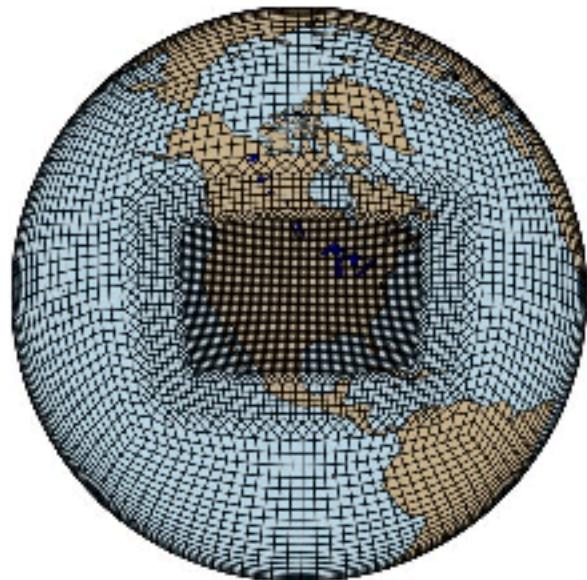
This presentation is based upon work supported by the National Science Foundation under Grant No. 2126458



"Lat-lon" structured grid



Icosahedral grid
(MPAS-A)



Variable resolution, cube sphere grid
(CAM-SE)

After nearly two decades of development and evaluation, the climate and global weather modeling communities are transitioning from more simple structured grids to more complex, but scalable unstructured grids upon which governing equations of state are solved.

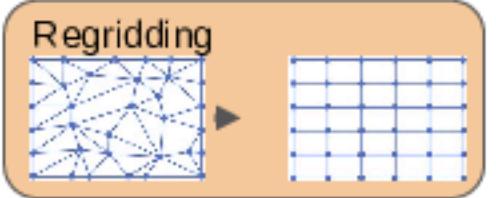
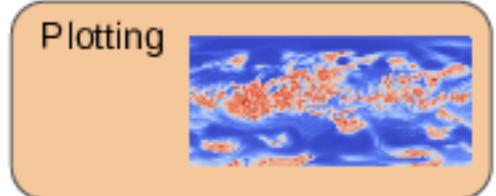
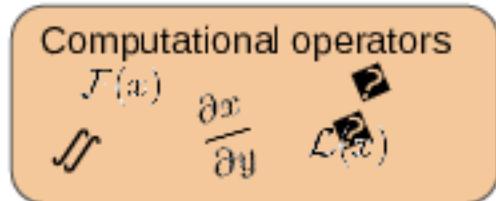
Challenges?

1. No widely used convention for the storage of unstructured grid data
 - UGRID conventions: <https://ugrid-conventions.github.io>
2. Few analysis tools capable of working directly with unstructured data
 - Resampling to structured grids has numerous pitfalls
3. Global storm resolving resolution models generating LOTS of data
 - Further exacerbating problems with limited set of tools that operate directly on unstructured meshes
4. Trivial and efficient analysis operators on structured data can become complex and computationally expensive on unstructured meshes
 - E.g. Efficiently finding the cell containing a point in an unstructured mesh requires an acceleration data structure such as a kd-tree

Project Raijin Goals



Extensible, scalable, open
source software for analysis on
unstructured grids



Community owned & developed



Driving use cases

1. Dynamical core evaluation

- Comparison and determination of suitability of new dynamical cores

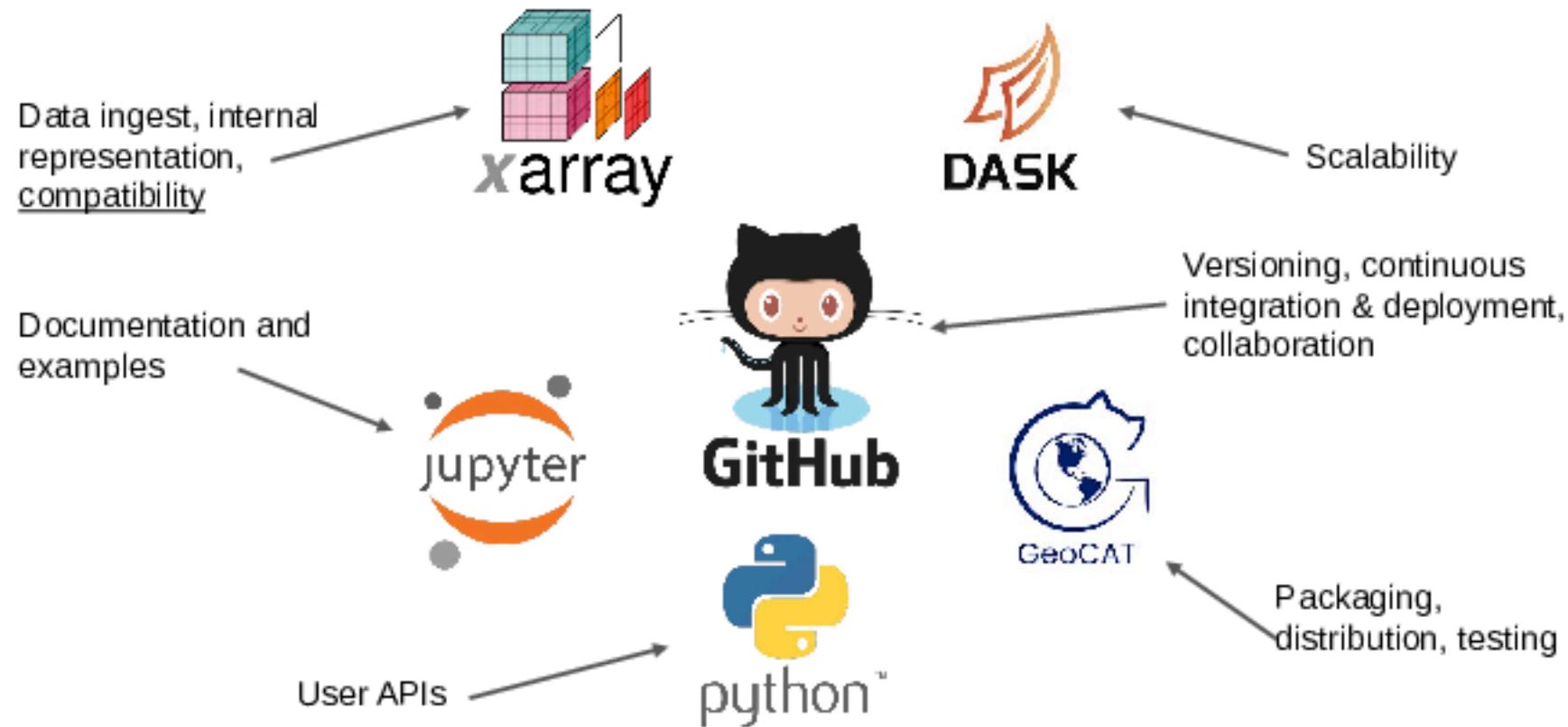
1. Atmospheric blocking frequency

- An important atmospheric phenomenon that emerges within chaotic atmospheric flow

1. Cyclonic storm analysis

- Lagrangian evaluation of extreme weather features

Core technologies



Deliverables

- **Continuous Delivery**
 - New releases on approx. monthly basis
- **Draft API of the eventual functionality**
- **Community-involved prioritization**
 - Global means (conservative and non-conservative)
 - Zonal means
 - Gradients
 - Cross sections
 - Integration - DONE

Draft API



Get involved in
prioritization convo!



Deliverables

UXarray 2023 Roadmap #196

English version announced in Announcements



rajinchen

on Dec 26, 2022

• Maintenance

View topic

... more

This discussion can be closed.

1. Announcement of what we are planning to do overall in the 2023 calendar year for UXarray
2. Feedback open until the end of day on our roadmap

UXarray 2023 roadmap

1. UXarray development

- ✓ We started API redesign to unify both the array requirements & specifications to comply with the Xarray codebase standard.
 - See the UXarray Redesign Thought and Options discussion for detailed information and your input.
- ✓ Analysis iteration development
 - See the Preliminary UXarray analysis iteration discussion for detailed information and your input.
- ✓ Backend migration to Microservices development.

2. Open development & community engagement

- ✓ Continue RAIjin & SCATS collaboration on UXarray development
- ✓ Collaboration with NCAR's SPRINT (System for Research and Modelling of the Atmosphere)
 - Take the documents to update to new version
- ✓ Backtrace collaboration

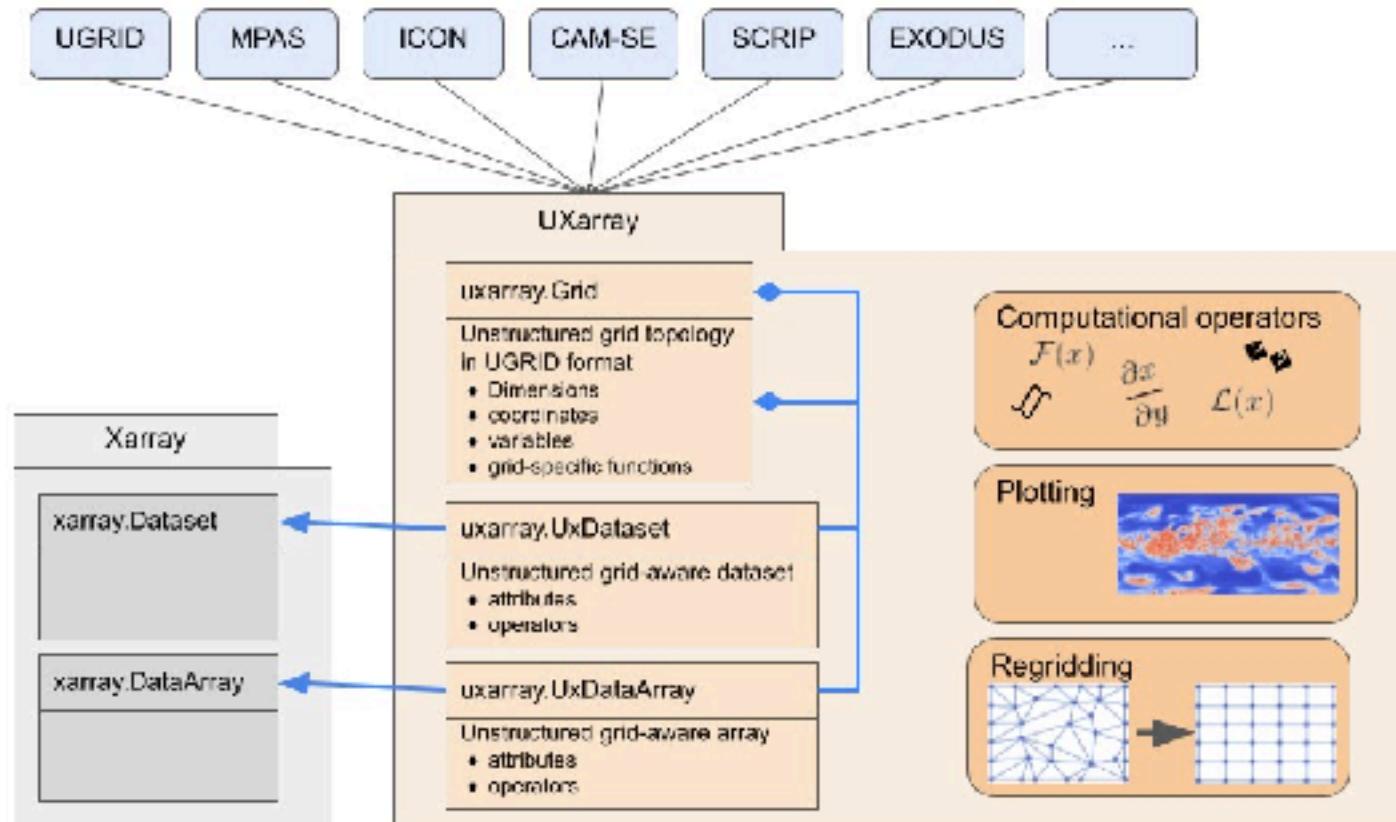
3. Scalability

- ✓ Backtrace
 - Ensure compatibility & apply best practices
 - Investigation on reimplementation in backtrace own implementation with Backtrace provider
 - Ensure 100% new implementation
- ✓ Performance analysis
 - Investigation on performance of the existing functioning implementations with Backtrace
- ✓ Q4 project meeting (01/04/2023) complete discussion
 - Backtrace

Roadmap 2023 for
community input!



New design just released (v2023.6.0)!



New design
announcement



Release notes



New design just released (v2023.6.0)!

```
import uxarray as ux

# Open an unstructured grid dataset
uxds = ux.open_dataset("grid_file", "dataset_file")

# Call dataset, data array, and grid functions
result_ds = uxds.<UxDataset-specific-func>()
result_var = uxds.<variable>.<UxDataArray-specific-func>()
result_grid = uxds.uxgrid.<Grid-specific-func>()

# Or, explore only the unstructured grid
ux_grid = ux.open_grid("grid_file")

result_grid = ux_grid.<Grid-specific-func>()
```

Redesign
announcement



Release notes



MPAS recognition

- Most recent addition
 - Both Primal and Dual Meshes supported

UXarray MPAS Usage Example



Future work

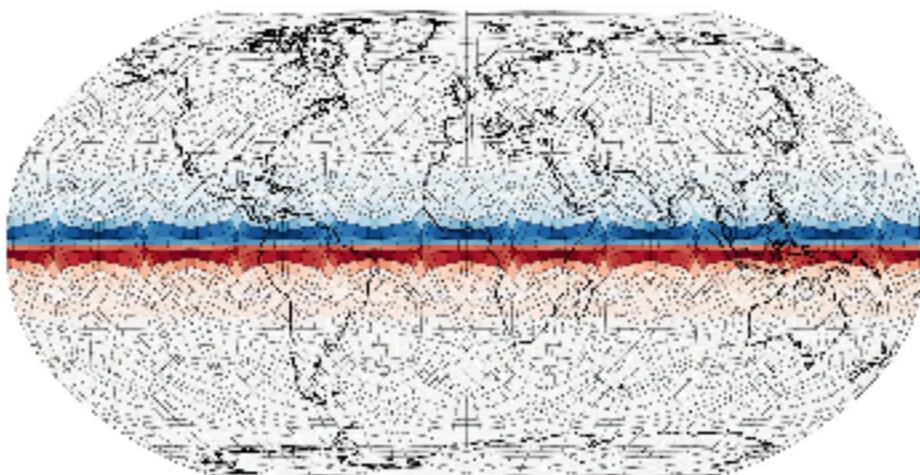
- **New computational functions**
 - Motivated by the needs of driving use cases
- **Basic plotting integrated to UxDataset/UxdataArray**
 - e.g. `uxarray.UxDataSet.uxplot()`?
- **Interactive plotting (with UXarray)**
 - Encouraging proof-of-concept already done!
 - Native grid connectivity information is used
 - Native grid directly rendered (without re-gridding)
 - 3.75 km (~43M data points) rendered
 - Pan & zoom interactivity on a commodity laptop

MPAS vis. Notebook



Community Geoscience Analysis Tools for Unstructured Grids

UXarray for visualization



Get involved!

Send us email

projectrajin@googlegroups.com

Start or contribute to a UXarray discussion

<https://github.com/UXARRAY/uxarray/discussions>

Find out more

<https://rajin.ucar.edu>



Acknowledgements



NSF Earth Cube program (award #2126458)



Collaborators: Ryan Abernathy, Falko Judt, David Randall, Niklas Röber, and Bjorn Stevens

Pangeo community

Our growing list of contributors on GitHub!