PROJECT raijin

Community Geoscience Analysis Tools for Unstructured Grids

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NCAR/UCAR
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EarthCube
Transforming Geosciences Research

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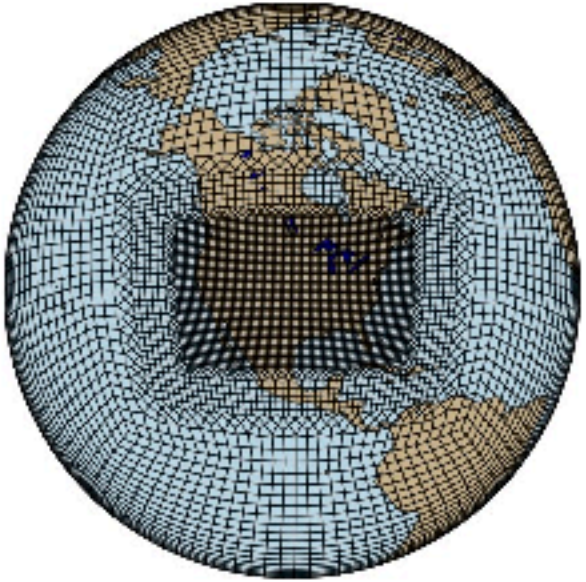
"Lat-lon" structured grid

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

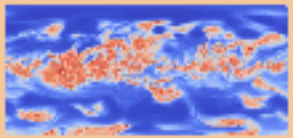
Project Raijin Goals

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

Computational operators

$\mathcal{F}(x)$ $\frac{\partial x}{\partial y}$ $\mathcal{L}(x)$

Plotting



Regridding

Community owned & developed

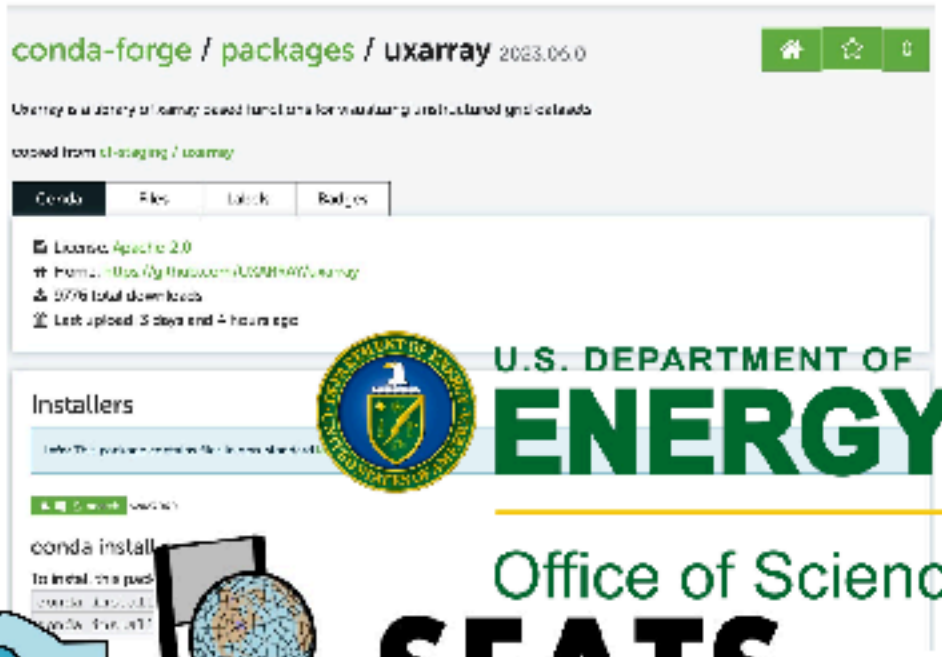
Driving use cases

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

UXarray



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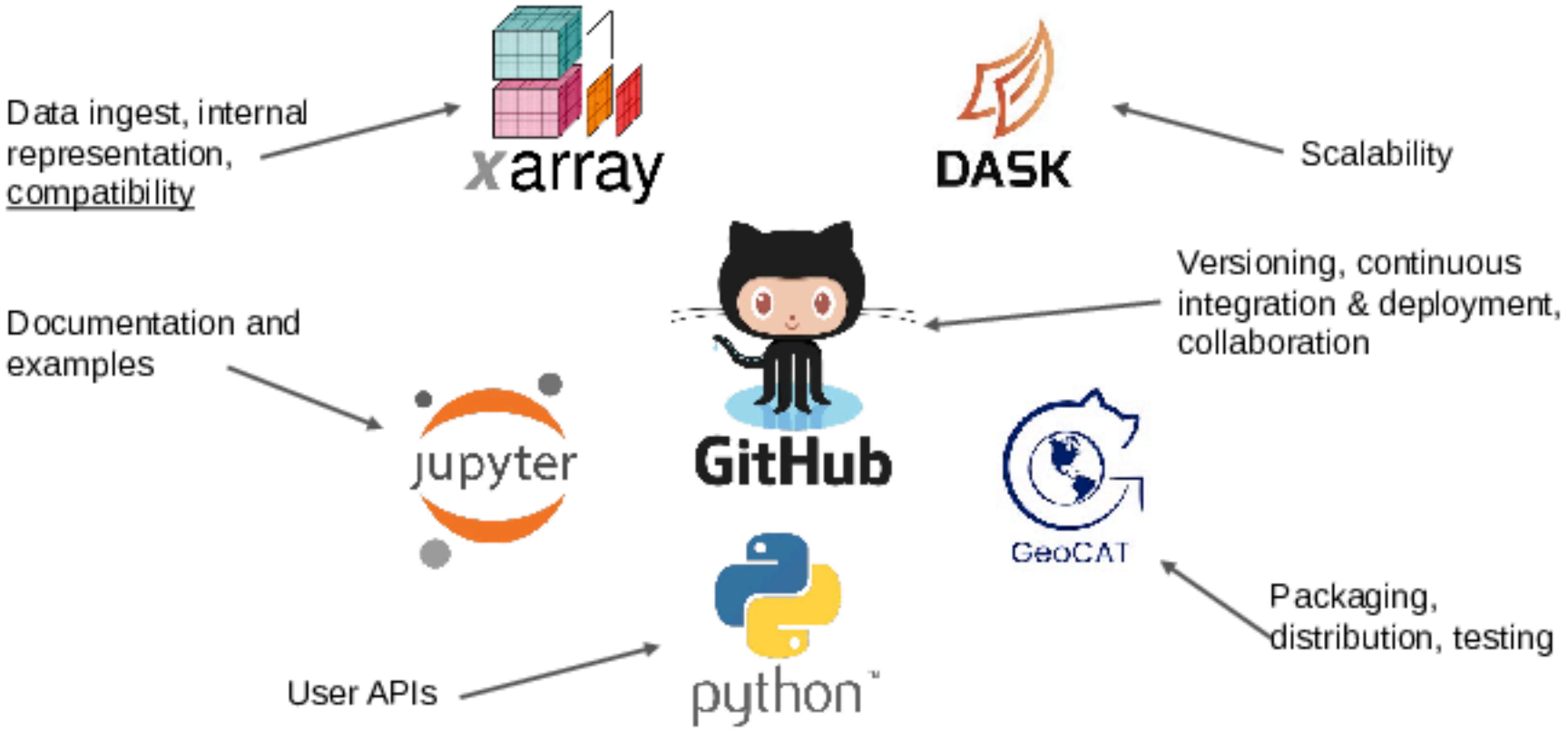
Core technologies



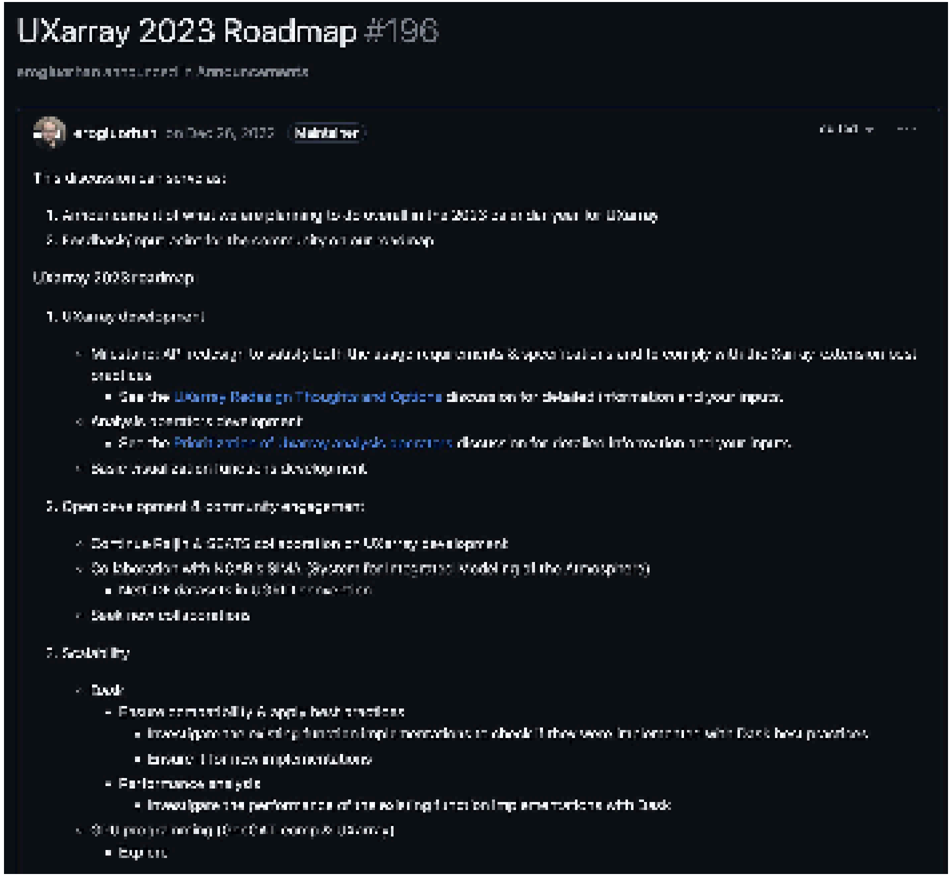
Deliverables

- **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

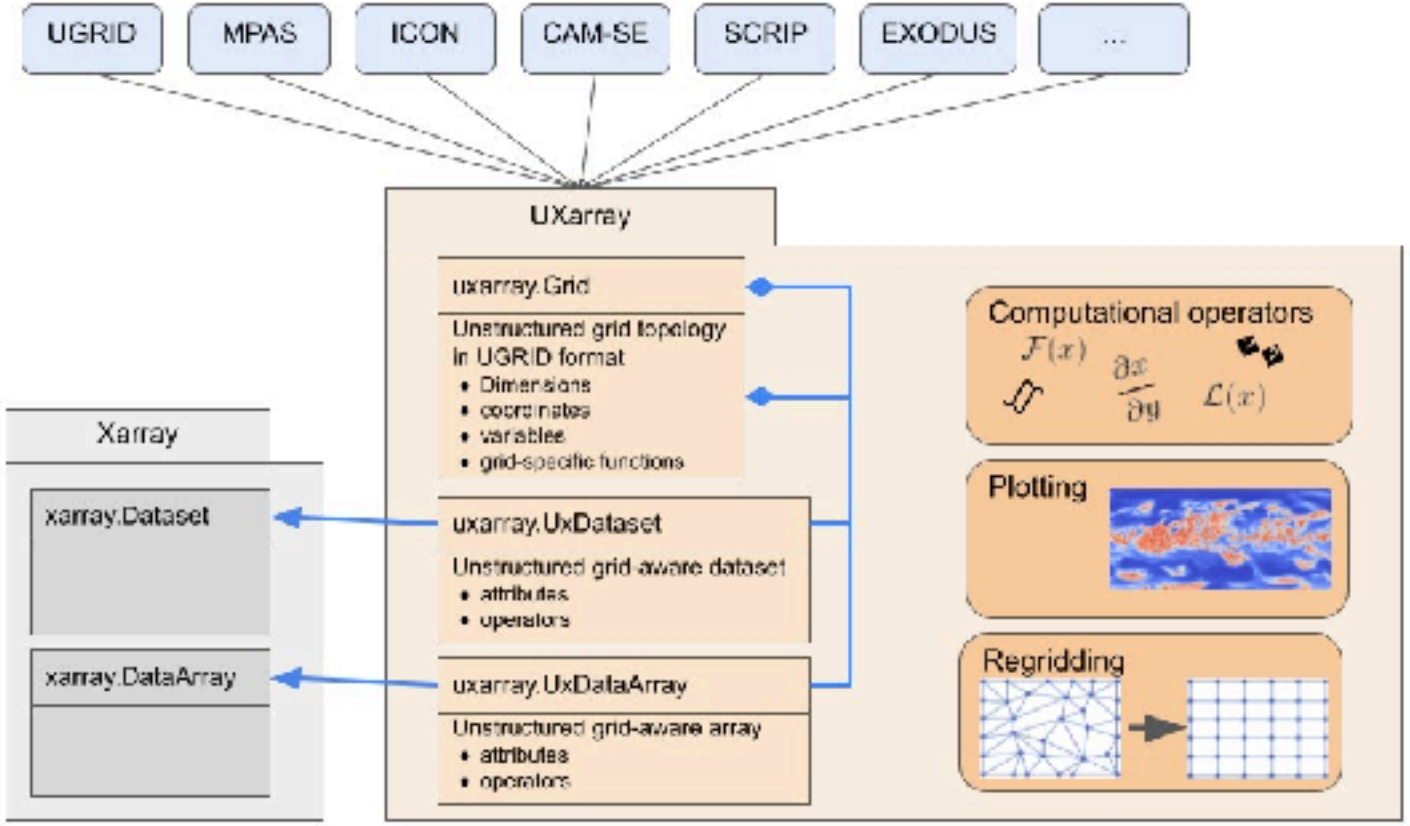
Get involved in prioritization convo!

Deliverables



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

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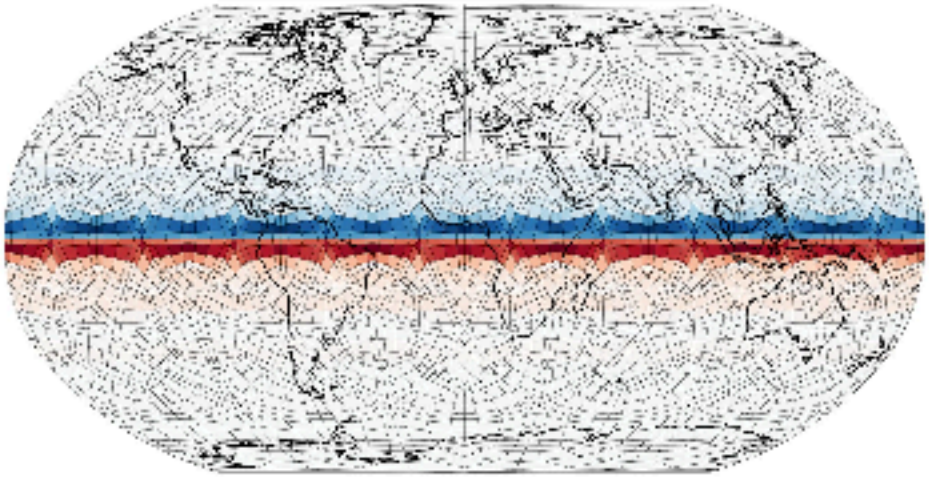
UXarray for visualization



Get involved!

Send us email
projectraijin@googlegroups.com

Start or contribute to a UXarray discussion
https://github.com/UXARRAY/uxarray/discussions

Find out more
https://raijin.ucar.edu

Acknowledgements

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Pangeo community

Our growing list of contributors on GitHub!