yt-xarray, Facilitating Software Reuse Between Space and Earth Sciences

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Abstract

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CHAPTER

ONE

INTRODUCTION

Overview of the project.

Overview of the primary software pieces:

1.1 xarray

xarray: words: geo, NASA, cloud-native formats (zarr)

1.2 yt

more words

1.3 yt_xarray

more words

CHAPTER

TWO

RECENT IMPROVEMENTS TO YT, YT_XARRAY

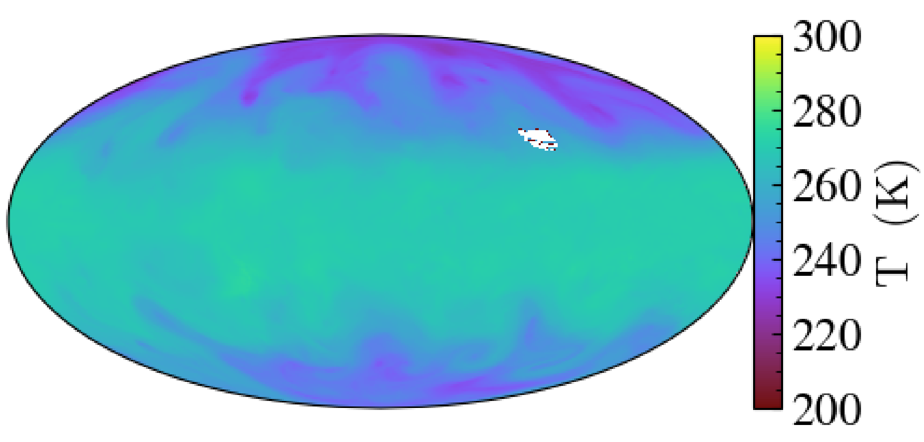
yt_xarray: yt api access:

initial setup: silencing unrelated warnings and logs for brevity here.

```
import yt_xarray
import yt
import warnings
warnings.filterwarnings("ignore") # silence the cartopy bounds warning

yt.set_log_level(50)
yt_xarray.utilities.logging.ytxr_log.setLevel(50)
```

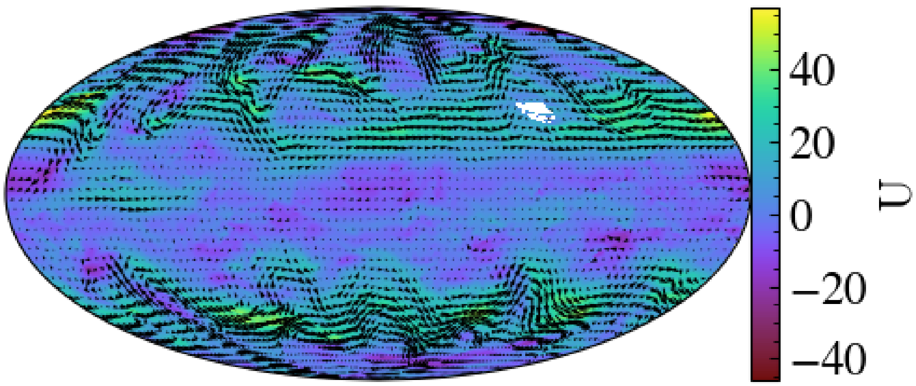
load the data. data is local file, data is from the MERRA-2 reanalysis dataset (hosted at GES DISC, NASA EarthData)

```
dsx = yt_xarray.open_dataset("sample_nc/MERRA2_100.inst3_3d_asm_Np.19800120.nc4")

dsx0 = dsx.isel({'time':0})
slc = dsx0.yt.SlicePlot('altitude', 'T', window_size=(4,2))
slc.set_log('T', False)
slc.set_zlim('T', 200, 300)
_ = slc.save()
```



yt: geoquiver:

```
ds = dsx.yt.load_grid(fields=['U', 'V'], sel_dict={'time':0}, use_callable=False)

slc = yt.SlicePlot(ds, 'altitude', 'U', window_size=(4,2))
slc.set_log('U', False)
slc.annotate_quiver('U', 'V')
_ = slc.save()
```



yt: cartesian cutting plane:

CHAPTER

THREE

EMBEDDED TRANSFORMATIONS WITHIN YT_XARRAY

data commonly in geographic coordinates.

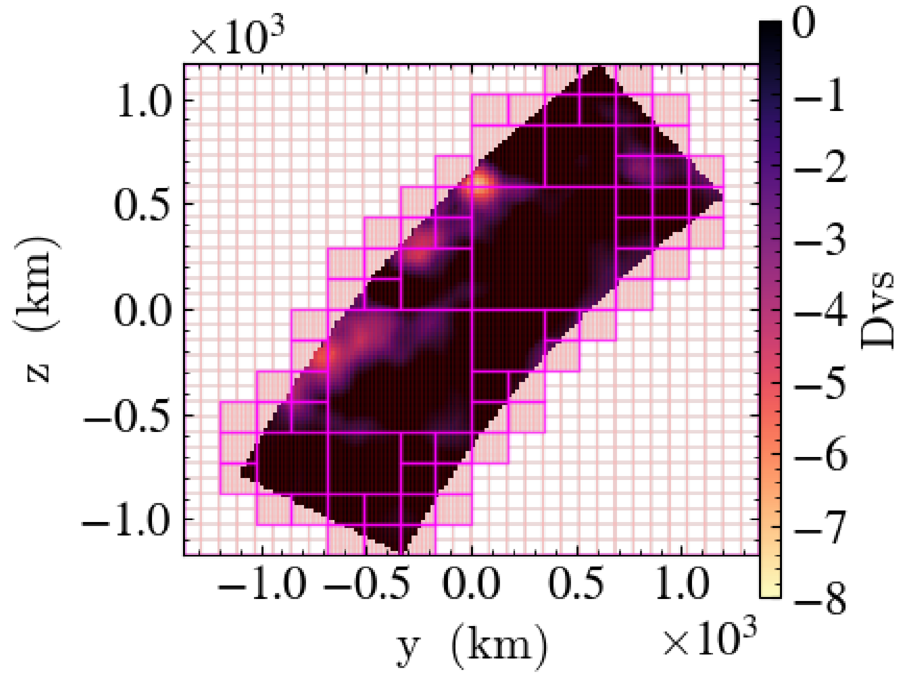
3.1 An example with 3D geographic data

```
import xarray as xr
import yt_xarray
import yt
from yt_xarray import transformations as tf
from yt_xarray.utilities.logging import ytxr_log
import numpy as np
import cartopy
from yt.visualization.volume_rendering.render_source import LineSource
from dask import delayed, compute
import shapely
```

```
yt.set_log_level(50)
ytxr_log.setLevel(50)

ds = yt_xarray.open_dataset("IRIS/wUS-SH-2010_percent.nc")
grid_resolution = (32, 32, 32)
gc = tf.GeocentricCartesian(radial_type='depth', r_o=6371., use_neg_lons=True)
ds_yt = tf.build_interpolated_cartesian_ds(
    ds,
    gc,
    fields = 'dvs' ,
    grid_resolution = grid_resolution,
    refine_grid=True,
    refine_max_iters=2000,
    refine_min_grid_size=4,
    refine_by=4,
    interp_method='interpolate',
)
```

```
slc = yt.SlicePlot(ds_yt, 'x', ('stream', 'dvs'), window_size=(3,3))
slc.set_log(("stream", "dvs"), False)
slc.set_cmap(("stream", "dvs"), "magma_r")
slc.set_zlim(("stream", "dvs"), -8, 0)
slc.annotate_cell_edges(color=(1,0,0), alpha=0.3)
slc.annotate_grids(edgecolors=(1,0,1,1))
slc.save()
```

```
['AMRGridData_Slice_x_dvs.png']
```



add a field to return abs(dvs<0)

```
def _slow_vels(field, data):
    dvs = data['dvs'].copy()
    dvs[np.isnan(dvs)] = 0.0
    dvs[dvs>0] = 0.0
    return np.abs(dvs)

ds_yt.add_field(
    name=("stream", "slow_dvs"),
    function=_slow_vels,
    sampling_type="local",
)
```

volume render: use the yt_xarray transformer to easily create a yt `LineSource` in the correct cartesian coordinates. Using dask here to process NaturalEarth state boundaries accessed via cartopy

```
def process_state(state):
    linesegs = []
    if isinstance(state, shapely.geometry.polygon.Polygon):
        geoms_iter = [state,]
    elif isinstance(state, shapely.geometry.multipolygon.MultiPolygon):
        geoms_iter = state.geoms
    else:
        msg = f"Unexpected geometry type: {type(state)}"
        raise TypeError(msg)
```

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```
    for geom in geoms_iter:
         linesegs = transform_geom_bounds(linesegs, geom.boundary.xy)
    return linesegs
```

```
def transform_geom_bounds(linesegs, xy):
    lons = np.array(xy[0])
    lats = np.array(xy[1])

    x, y, z = gc.to_transformed(latitude=lats,
                                longitude=lons,
                                depth=0.0)

    for iseg in range(len(x)-1):
        lineseg = [[x[iseg], y[iseg], z[iseg]], [x[iseg+1], y[iseg+1], z[iseg+1]]]
        linesegs.append(lineseg)
    return linesegs
```

```
state_segs = []
for s in cartopy.feature.STATES.geometries():
    state_segs.append(delayed(process_state)(s))

state_segs = np.concatenate(compute(*state_segs))
colors = np.ones((state_segs.shape[0], 4))
colors[:,3] = 0.1
lsrc = LineSource(state_segs,colors=colors)
```

now ready for the volume rendering

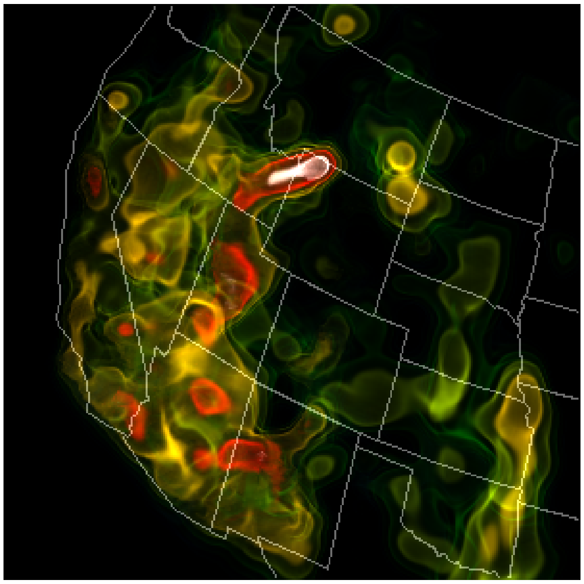
```
reg = ds_yt.region(ds_yt.domain_center,
                   ds_yt.domain_left_edge,
                   ds_yt.domain_right_edge)
sc = yt.create_scene(reg, field=('stream', 'slow_dvs'))
cam = sc.add_camera(ds_yt)

# transfer function
source = sc[0]
source.tfh.set_bounds((0.1, 8))
source.tfh.set_log(True)

# add state outlines
sc.add_source(lsrc)

# adjust camera
cam.zoom(2)
cam.yaw(100*np.pi/180)
cam.roll(220*np.pi/180)
cam.rotate(30*np.pi/180)
cam.set_resolution((300,300))

sc.show(sigma_clip=5.)
```



CHAPTER

FOUR

UTILIZING CLOUD NATIVE DATA FORMATS WITH YT_XARRAY

4.1 zarr via xr

xr backend allows zarr access: simple demo?

4.2 zarr with yt

zarr with yt paragraph or two

CHAPTER FIVE

SUMMARY

In summary

CHAPTER SIX

TECHNICAL APPENDIX

notebook requirements, notes on use of development branches, etc.

6.1

development branches:

yt: need dev (until yt4.4, geoquiver) yt_xrarray: need PR branch

6.2 building this book

Recommended that you use `pdflatex` directive to build the pdf, which requires that you first install a texlive distribution, see

https://jupyterbook.org/en/stable/advanced/pdf.html

```
$ pyenv virtualenv 3.10.11 yt_NASA_SMD
$ pyenv activate yt_NASA_SMD
```

from top level

```
$ pip install -r requirements.txt
$ jupyter-book build yt_xr_2024/ --builder pdflatex
$ cp yt_xr_2024/_build/pdf/book.pdf ./yt_xr_2024.pdf
```

6.3 all the data