yt_xarray: Facilitating Software Reuse Between Space and Earth Sciences

Contents

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Abstract

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Introduction

Overview of the project.

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Overview of the primary software pieces:

`xarray`

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

`yt`

more words

`yt_xarray`

more words

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)
```

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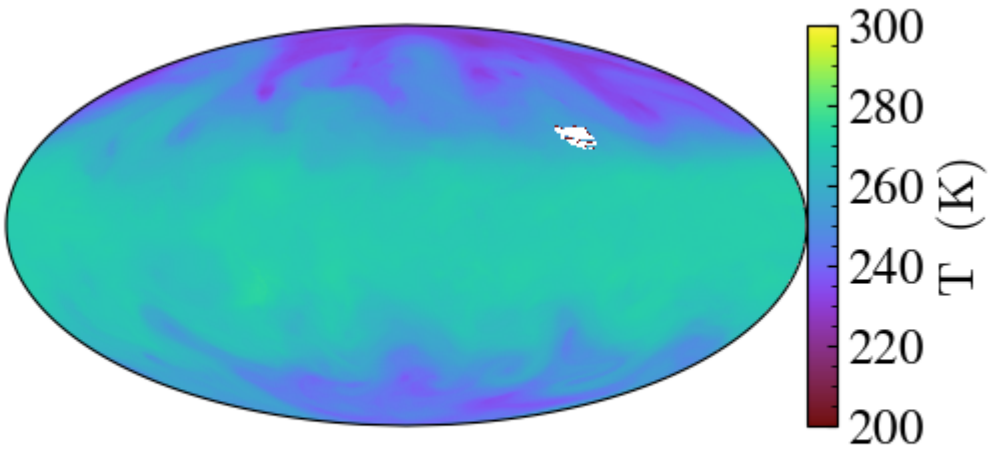
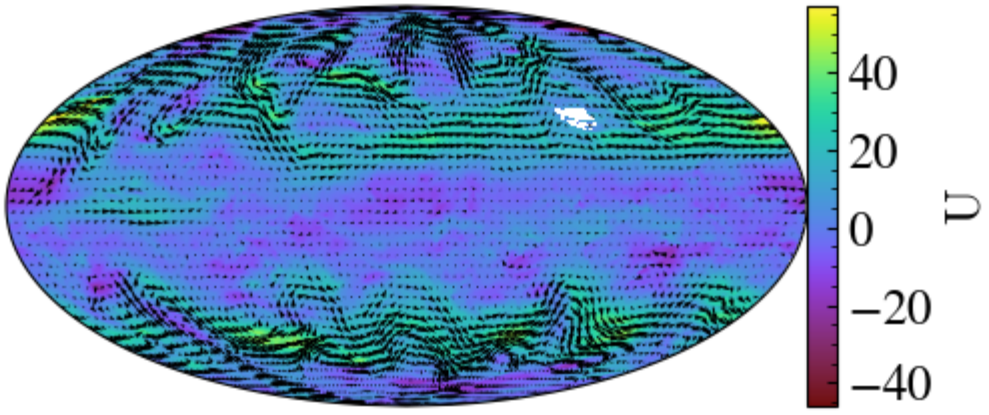


yt: geoquiver:

```
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.show()
```



yt: cartesian cutting plane:

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Embedded Transformations within yt_xarray

data commonly in geographic coordinates.

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.show()
```

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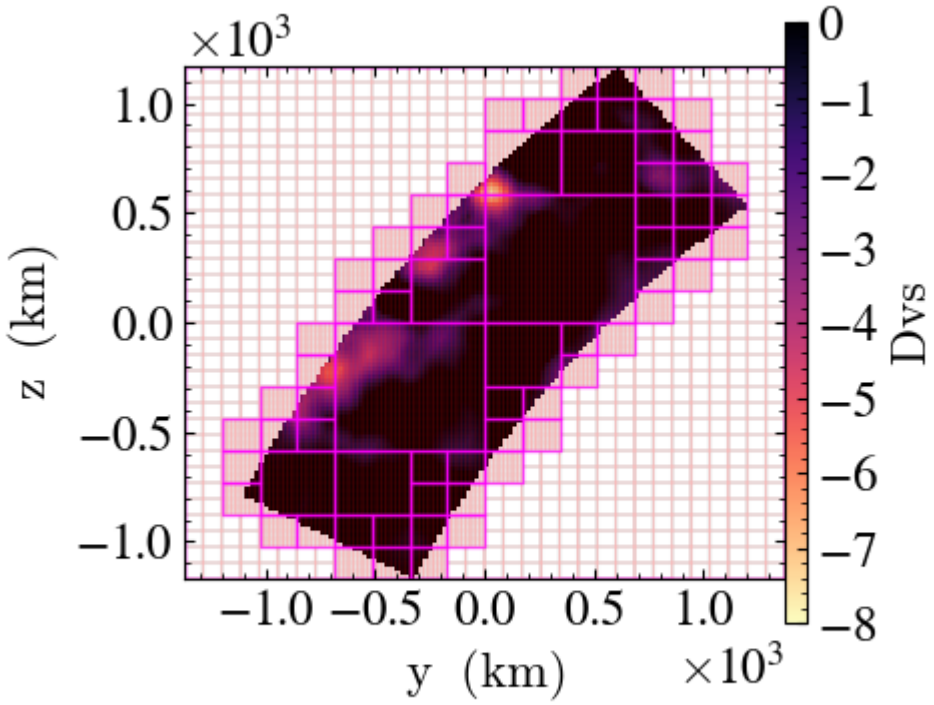

add a field to return abs(dvs<0)

```
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

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```
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)

    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

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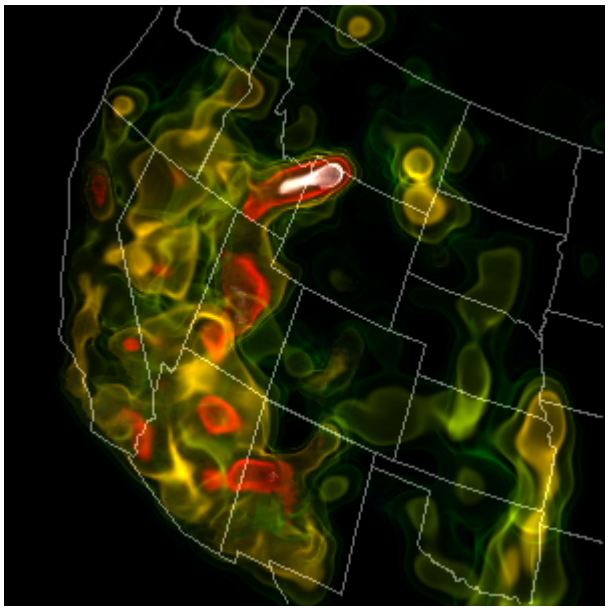
```
reg = ds_yt.region(ds_yt.domain_center,
                   ds_yt.domain_left_edge,
                   ds_yt.domain_right_edge)
sc = yt.create_scene(reg, field=('stream', 'slow_dvs'))
cam = sc.add_camera(ds_yt)

# 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.)
```



Utilizing Cloud Native data formats with yt_xarray

zarr via xr

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zarr with yt

zarr with yt paragraph or two

Summary

In summary

Technical Appendix

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

development branches:

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

building this book

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 pdfhtml
$ cp yt_xr_2024/_build/pdf/book.pdf ./yt_xr_2024.pdf
```

all the data