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Analyzing large radar datasets using Python

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Motivation

- Ground based scanning radars collects years of data:
  - Datasets useful for statistical analysis of convection, GCM validation
- Datasets are on order of >100,000 files, >10 TB of data:
  - Need to map radar processing onto supercomputing cluster
- Tools exist in Python to map problem to supercomputing cluster.

Which tools do we use?

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The Python ARM Radar Toolkit: Py-ART

- The Python ARM Radar Toolkit, Py-ART, is an open source Python module containing a growing collection of weather radar algorithms and utilities build on top of the Scientific Python stack and distributed under the 3-Clause BSD license.

- Py-ART is used by the Atmospheric Radiation Measurement (ARM) Climate Research Facility and by others in the scientific community for working with data from a number of weather radars and instruments.

- Py-ART is open source and hosted on GitHub at http://arm-doe.github.io/pyart/

The Python ARM Radar Toolkit: Py-ART

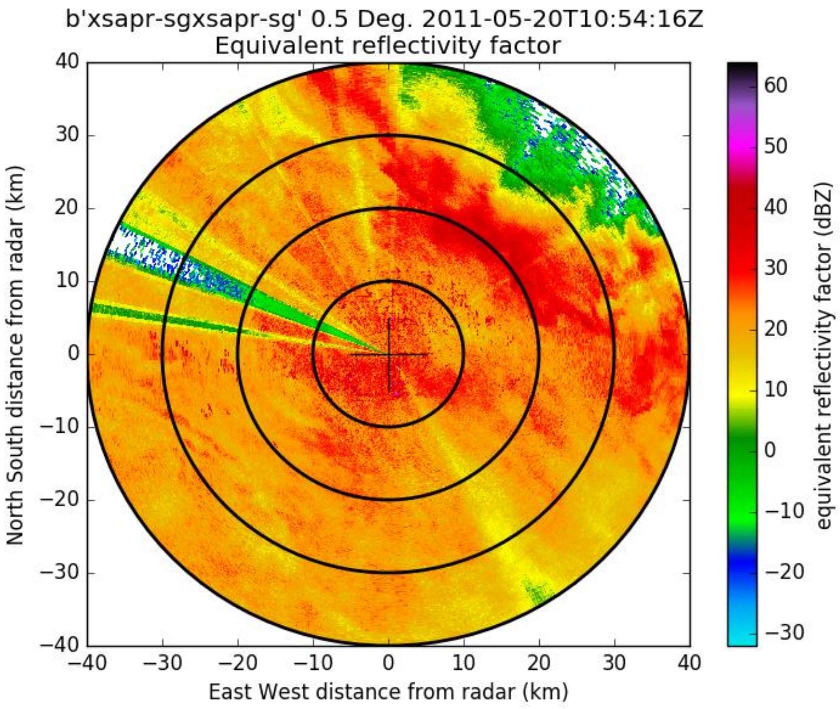
```
print(__doc__)

# Author: Jonathan J. Helmus (jhelmus@anl.gov)
# License: BSD 3 clause

import matplotlib.pyplot as plt
import pyart

filename = 'XSW110520105408.RAW7HHF'

# create the plot using RadarDisplay (recommended method)
radar = pyart.io.read_rsl(filename)
display = pyart.graph.RadarDisplay(radar)
fig = plt.figure()
ax = fig.add_subplot(111)
display.plot('reflectivity', 0, vmin=-32, vmax=64.)
display.plot_range_rings([10, 20, 30, 40])
display.plot_cross_hair(5.)
plt.show()
```



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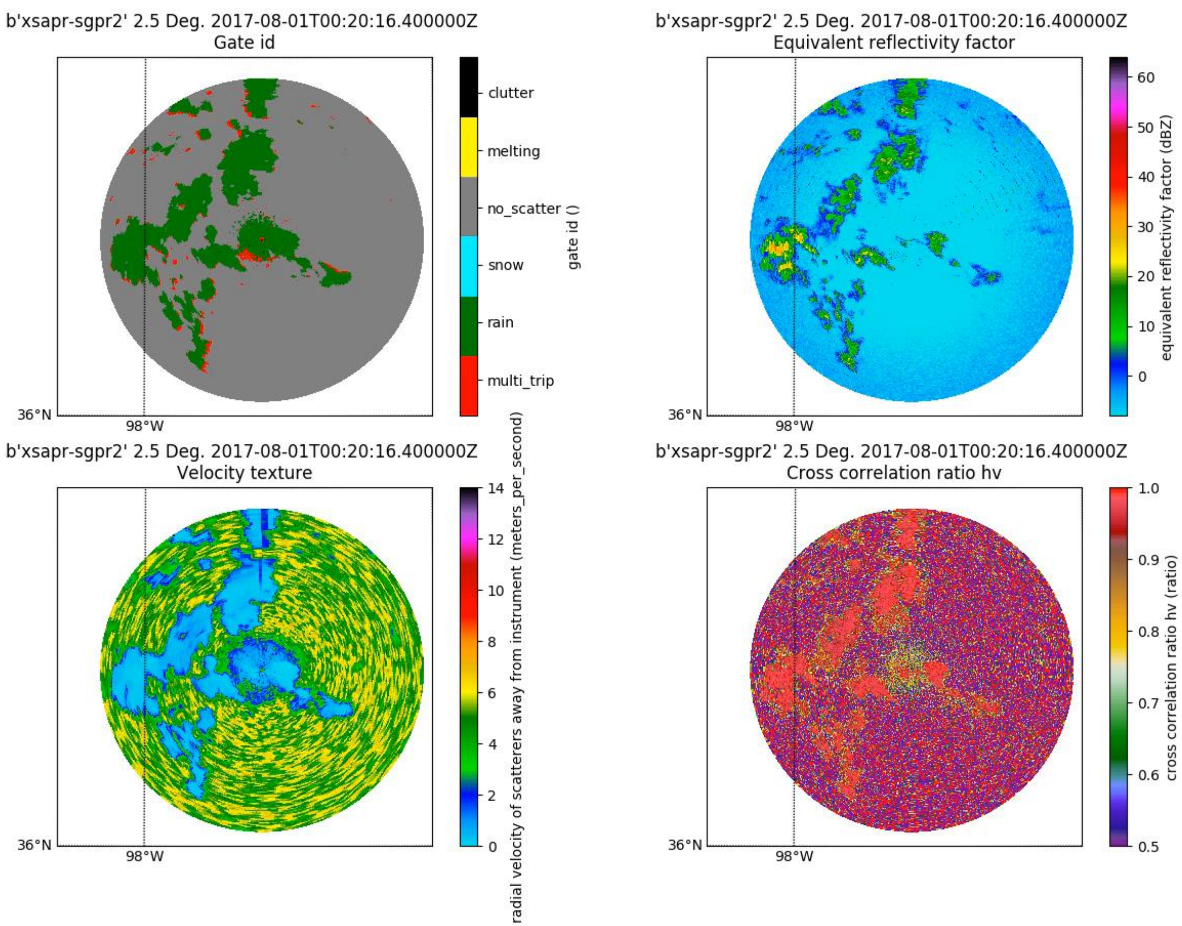
Corrected Moments in Antenna Coordinates 2.0

- Python ARM Radar Toolkit/CSU Radar Tools used for visualization, processing

CMAC2.0 processes data + provides quicklooks from XSAPR @ ARM SGP:

Operation	Methodology
Hydrometeor ID	CSU fuzzy logic
Clutter filter	Texture + reflectivity stats
Phase processing	Giangrande et al. (2014)
Dealiasing	Region based from Py-ART
Attenuation correction	Gu et al (2011) Z-phi
Rainfall rate retrieval	Ryzhkov et al. (2014)

CMAC2.0 quicklooks



CMAC2.0 available at: https://github.com/EVS-ATMOS/cmac2.0

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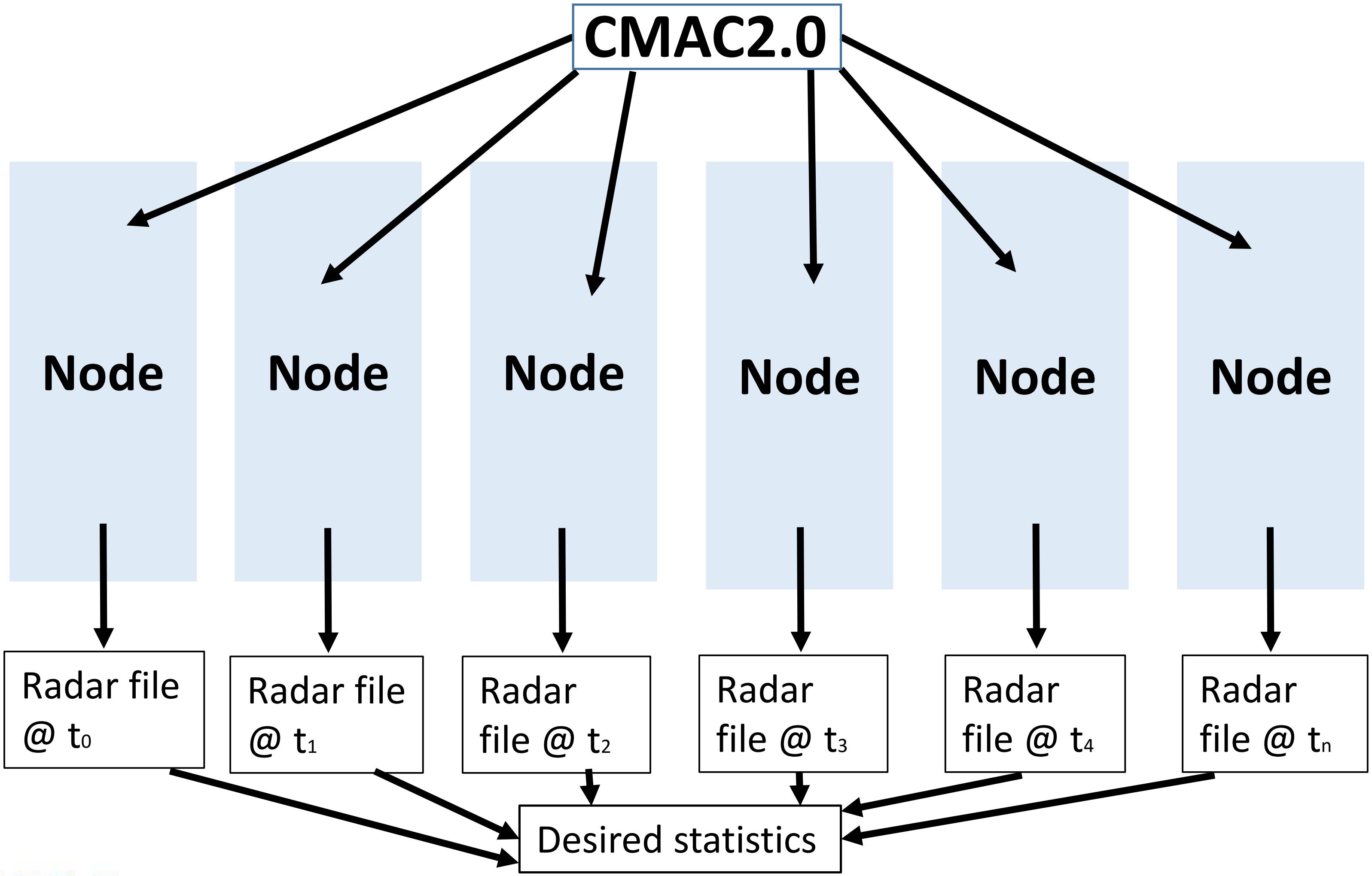
Stratus cluster

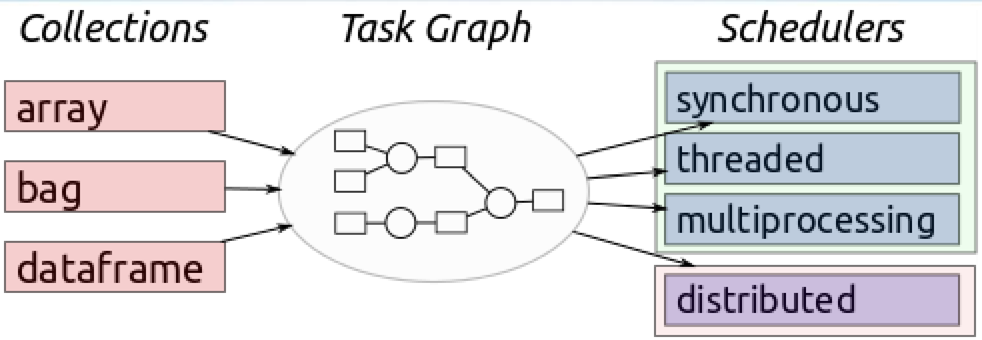
Cluster hosted at Oak Ridge National Laboratory

- 1080-core computing cluster for ARM investigators and users of ARM data
- 241-node Cray cluster w/7.68 GB DDR4 memory per core.
- Two Intel Xeon E5-2697V4 processors/core (18 cores per processor, 36 cores per node).
- 57.6 TB fast Solid State Drive (SSD) storage
- 100 TB parallel Lustre filesystem storage.

MapReduce


CMAC2.0
Node
Node
Node
Node
Node
Node
Radar file @ t_0
Radar file @ t_1
Radar file @ t_2
Radar file @ t_3
Radar file @ t_4
Radar file @ t_n
Desired statistics

DASK



Source: dask documentation

Designed to interact with NumPy/SciPy/Pandas.

Advantages:

- Easy integration w/CMAC2.0 using a `bag` to do MapReduce.
- Low overhead/latency

Disadvantages:

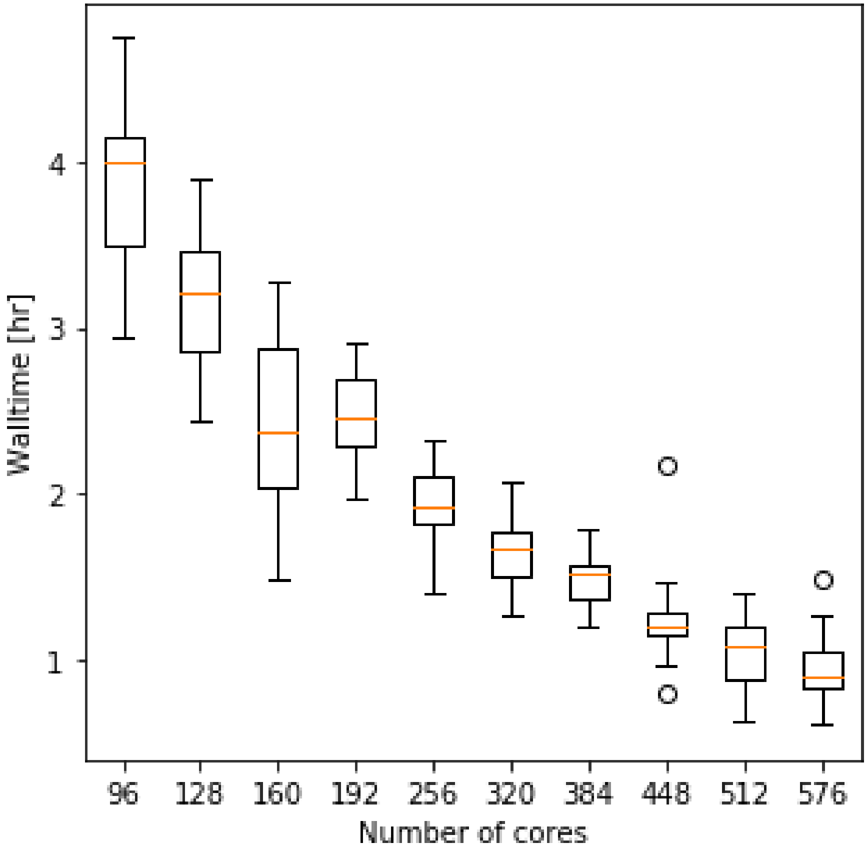
- Limited to Python, no high level optimization

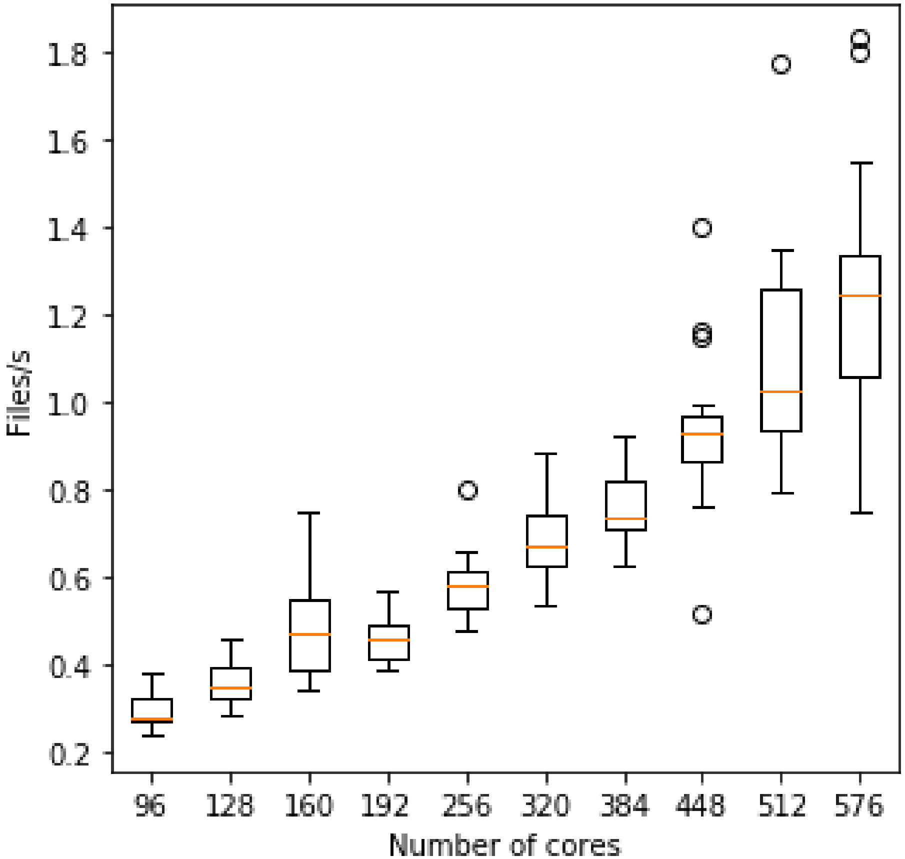
Dask code example (go to notebook)

```
import dask.bag as db

from distributed import Client

client = Client(scheduler_file='myfile.json')

the_bag = db.from_sequence(radar_files)

run_cmac = lambda file_name:
run_cmac_and_plotting(file_name,sounding_time,args)

result = the_bag.map(run_cmac).compute()
```

CMAC2.0 performance (go to dask profiler)

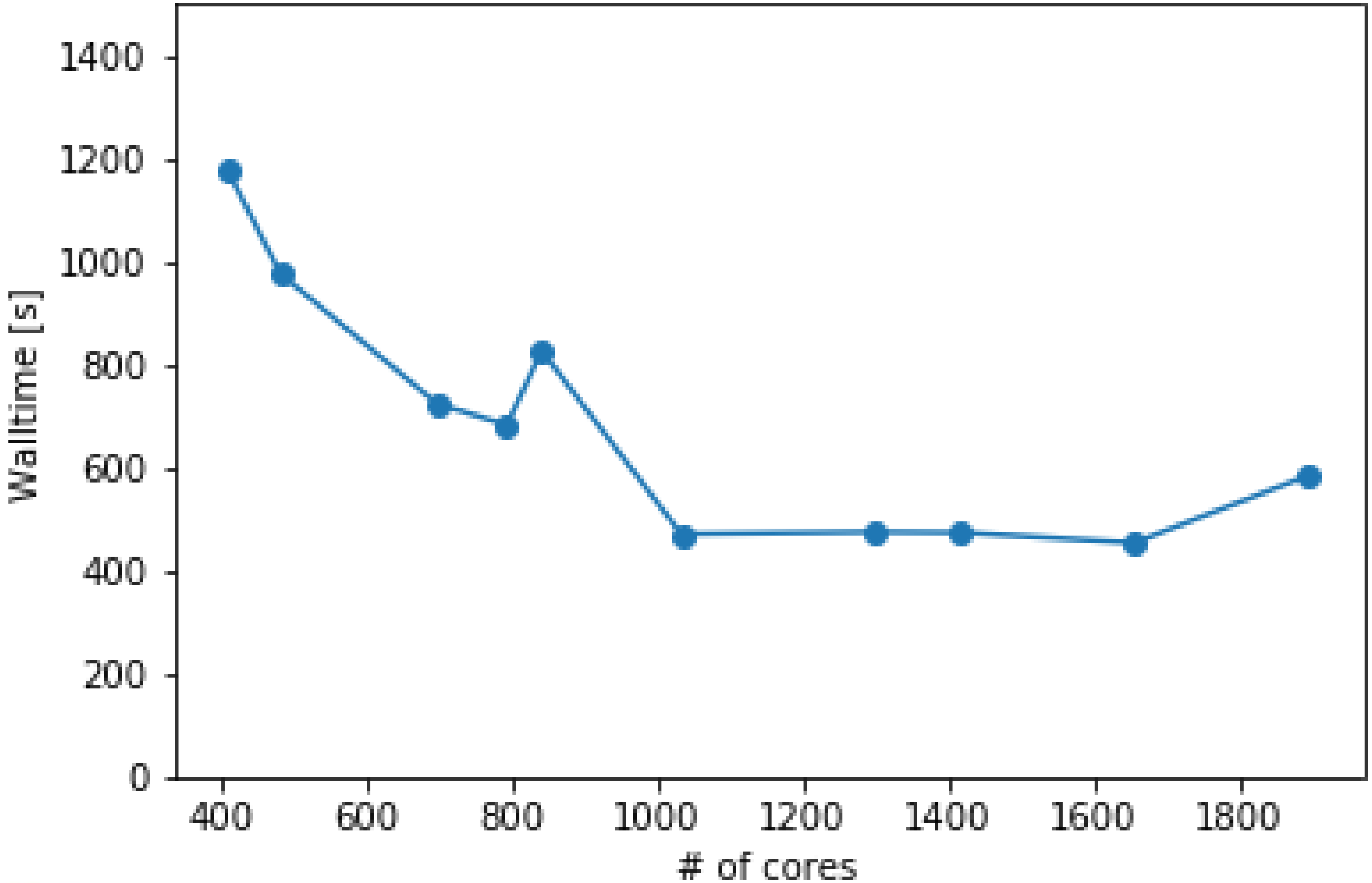
CMAC2.0 run on 1 month (~4200 files) of PPIs of XSAPR i5 data





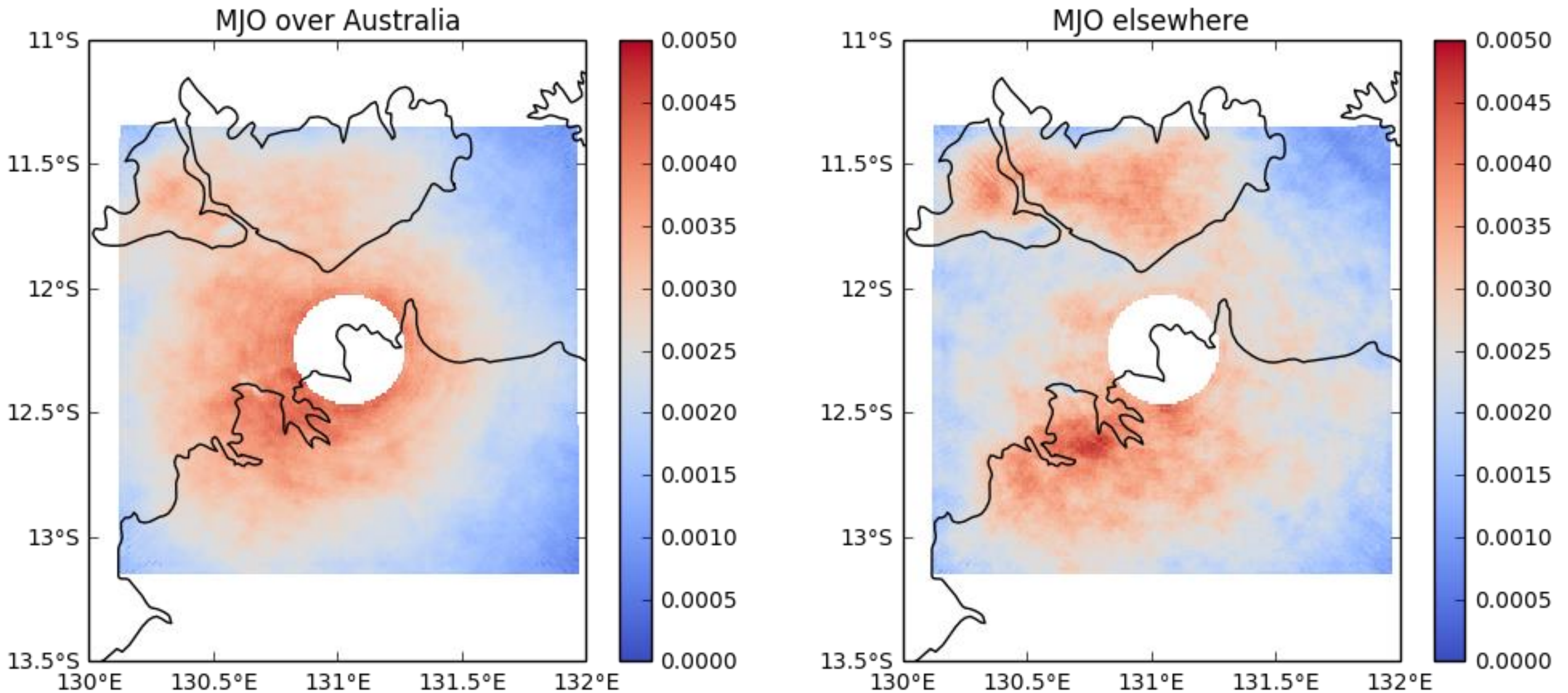
Gridding performance - NEXRAD

Gridding run on 4,000 files from KHGX NEXRAD radar using Bebop (36 cores/node – 4 GB ram/node). Dask used.



Example of a reduction!

18 years of CPOL data! ETHs > 7 km in convection (~250,000 radar files, 4 yrs 9 mos)



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Conclusions/Future work

Python can be used to easily processes thousands of radar files within hours!

250,000 radar files analyzed using Python and Dask!

Evaluate performance with quasi-vertical profiles

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