Statistical evaluation of three distinct automated Doppler dealiasing algorithms using a hand-dealiased shipborne radar dataset

Timothy Lang, Paul Hein, Themis Chronis, Tyler Castillo, Kacie Hoover, Scott Collis, Jonathan Helmus

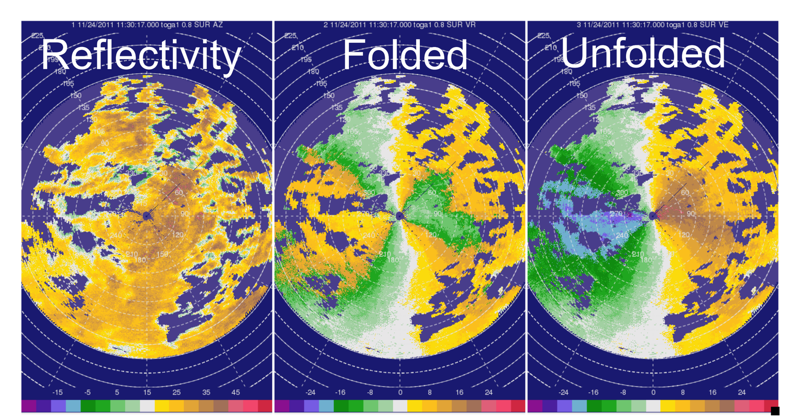
Colorado State University; The University of Alabama in Huntsville; Argonne National Laboratory

1. Introduction

We seek an effective, open-source, automated Doppler dealiasing tool for processing a large number of radar volumes, in order to ingest these data into single- or multi-Doppler retrieval algorithms, as well as into model data assimilation schemes.

The Python Atmospheric Radiation Measurement (ARM) Radar Toolkit (Py-ART) provides three automated dealiasing methods. Evaluation of their performance is required. For this we use the hand-dealiased NASA TOGA C-band radar dataset from the Dynamics of the Madden-Julian Oscillation campaign (DYNAMO).

2. Methodology



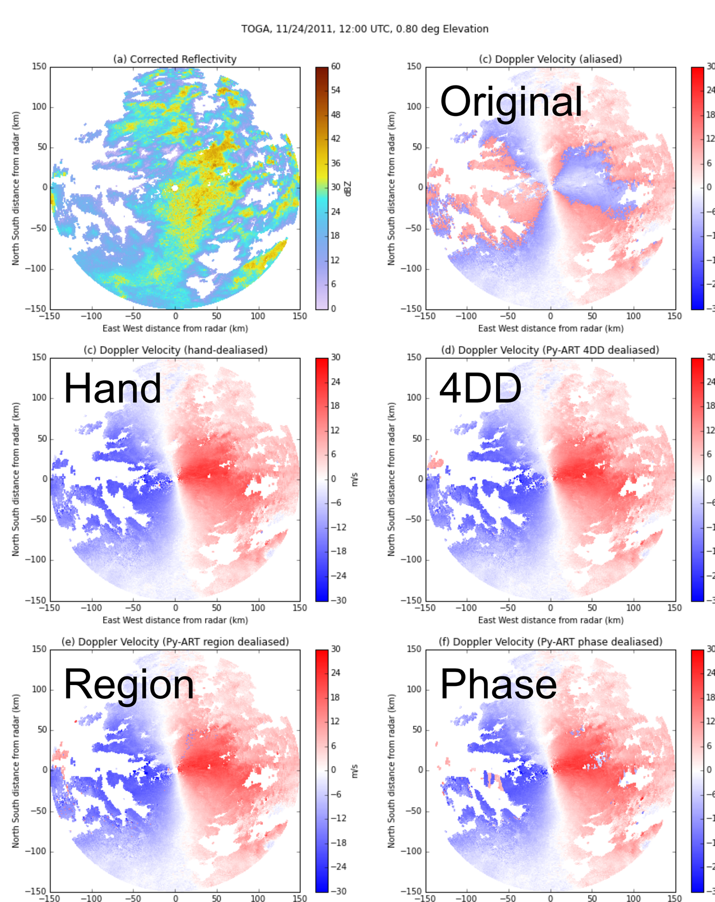
Example of Manual Dealiasing in Solo3

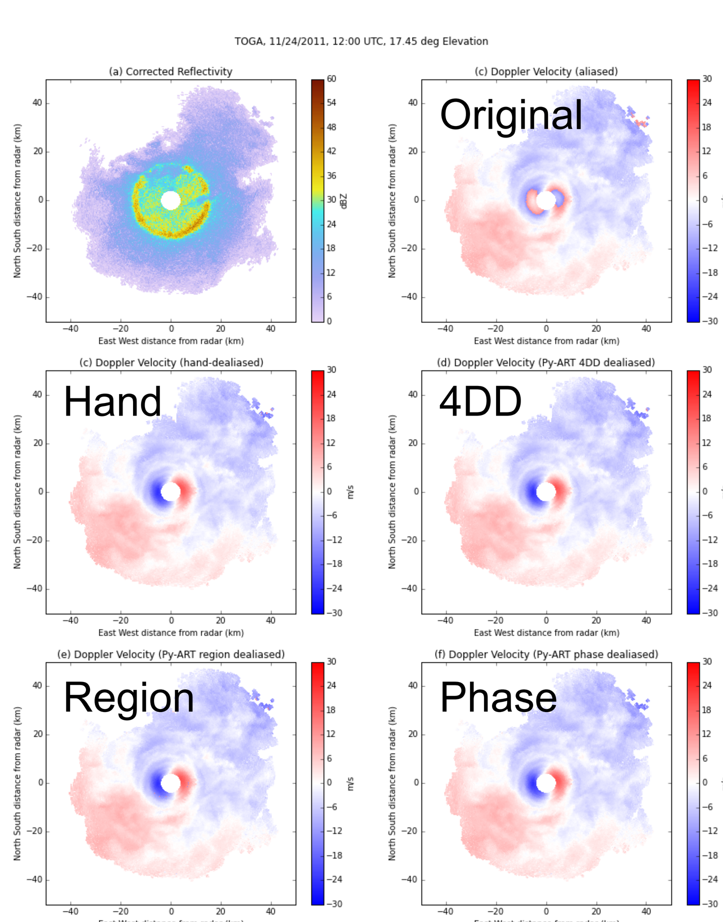
TOGA Doppler velocity data

- Hand-dealiased using NCAR Solo3
- One volume every 30 minutes over Cruises 2-4
- 360-deg PPI volumes, normally 22 tilts apiece
- Exclude INU failures, other major radar problems

Py-ART Version 1.5 *(Helmus et al., Poster Session 1)*

- *pyart.correct.dealias_region_based* (**REGION**)
  - Regions of similar velocities identified and unfolded against each other by modeling system as a dynamic weighted graph
  - interval_splits=3, skip_between_rays=100
- *pyart.correct.dealias_unwrap_phase* (**PHASE**)
  - Multi-dimensional phase unfolding method originally designed to analyze optical fringe-patterns
  - unwrap_unit='volume', keep_original=False
- *pyart.correct.dealias_fourdd* (**4DD**)
  - James and Houze (2001), six-step process that uses sounding and previous scan info to correct
  - In present study, previous unfolded radar volume used as sounding, not radiosonde





Example from 11/24/11, CSI = 0.995 (4DD), 0.981 (Region), 0.944 (Phase)

Statistical Analysis

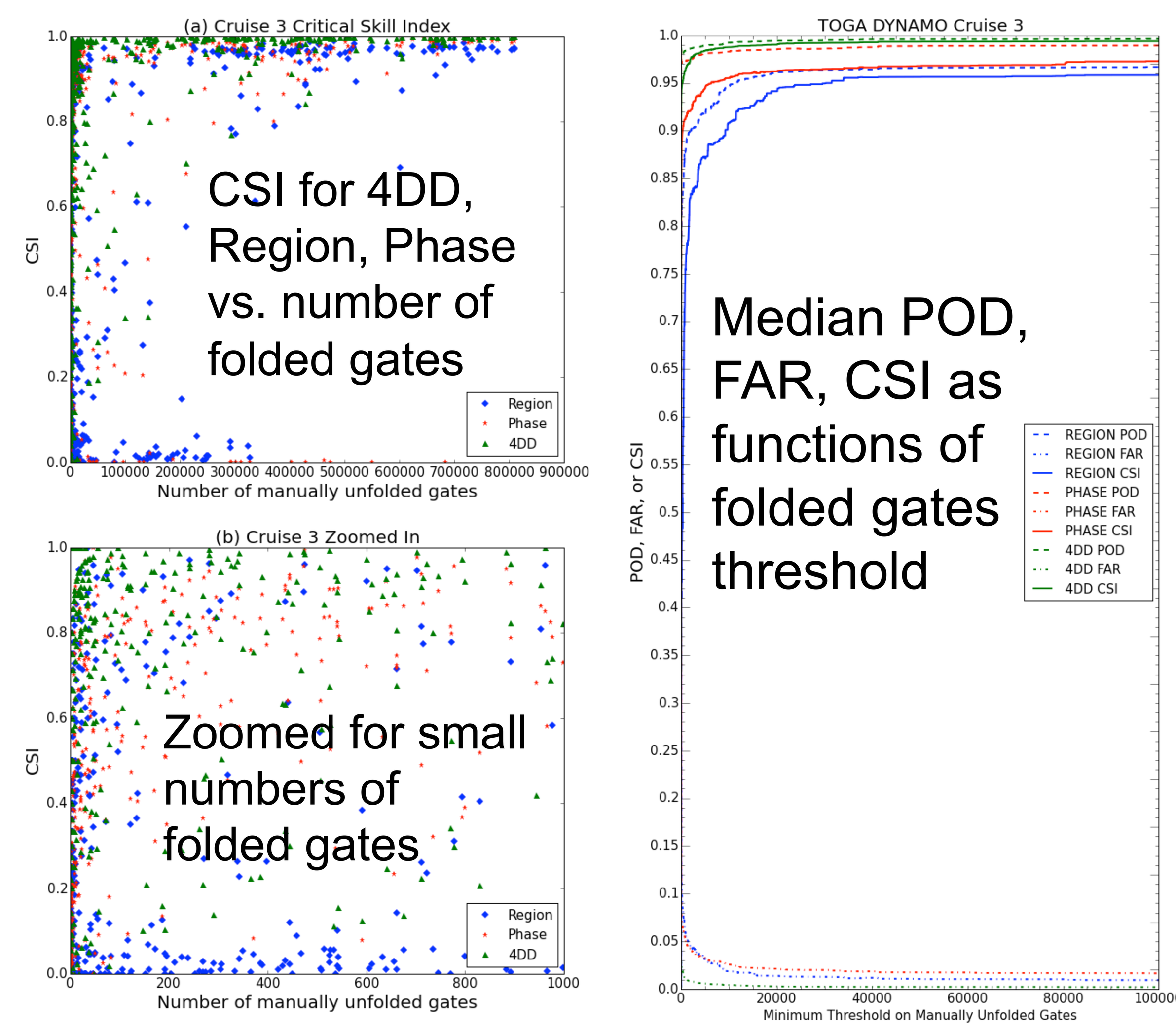
- Performance evaluated against manually dealiased field (assumed 99% accuracy)
- Python simplifies analysis via dicts and logical masks
- Hit = Correctly dealiased, Miss = Not, False Alarm = Unnecessary dealiasing
- Probability of Detection (POD), False Alarm Rate (FAR), Critical Skill Index (CSI)

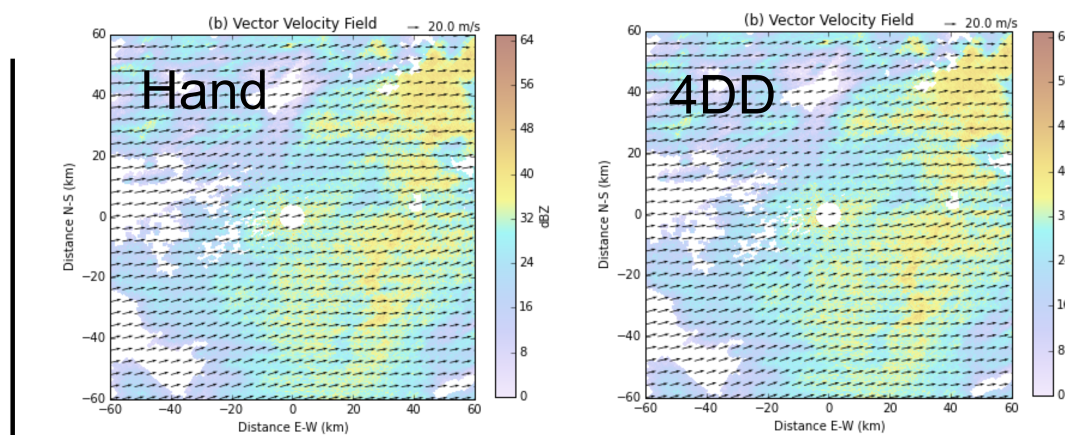
Contact Info: Timothy Lang, NASA MSFC (ZP11), Huntsville, AL 35812; (256) 961-7861, timothy.j.lang@nasa.gov
Funding for this work has come from NASA CYGNSS and OVWST

3. Results

- Cruise 3 results shown here – Increasing CSI with increasing number of folds
- Cruise 4 results (not shown) similar to Cruise 3
- Cruise 2 results still being analyzed and debugged – Region-Based failed A LOT.

Cruise 3





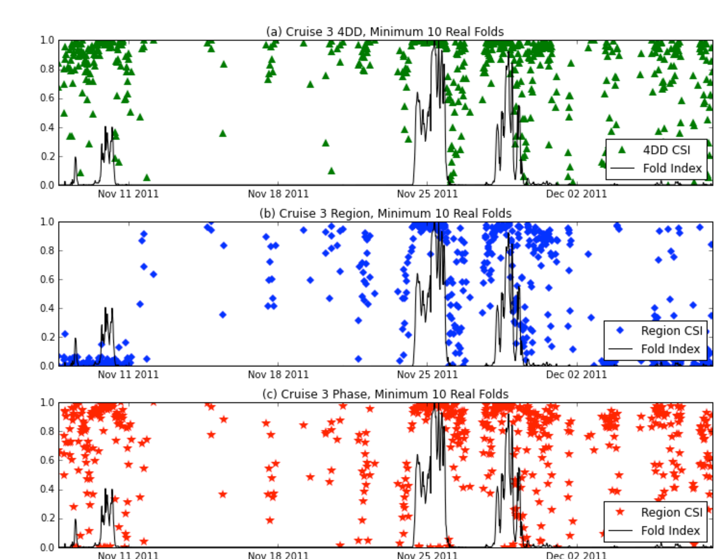
Effects on Single-Doppler Retrievals (*See Talk 12B.2, 4:45p, 11/17*)

Results for 11/24/11, 1200 UTC

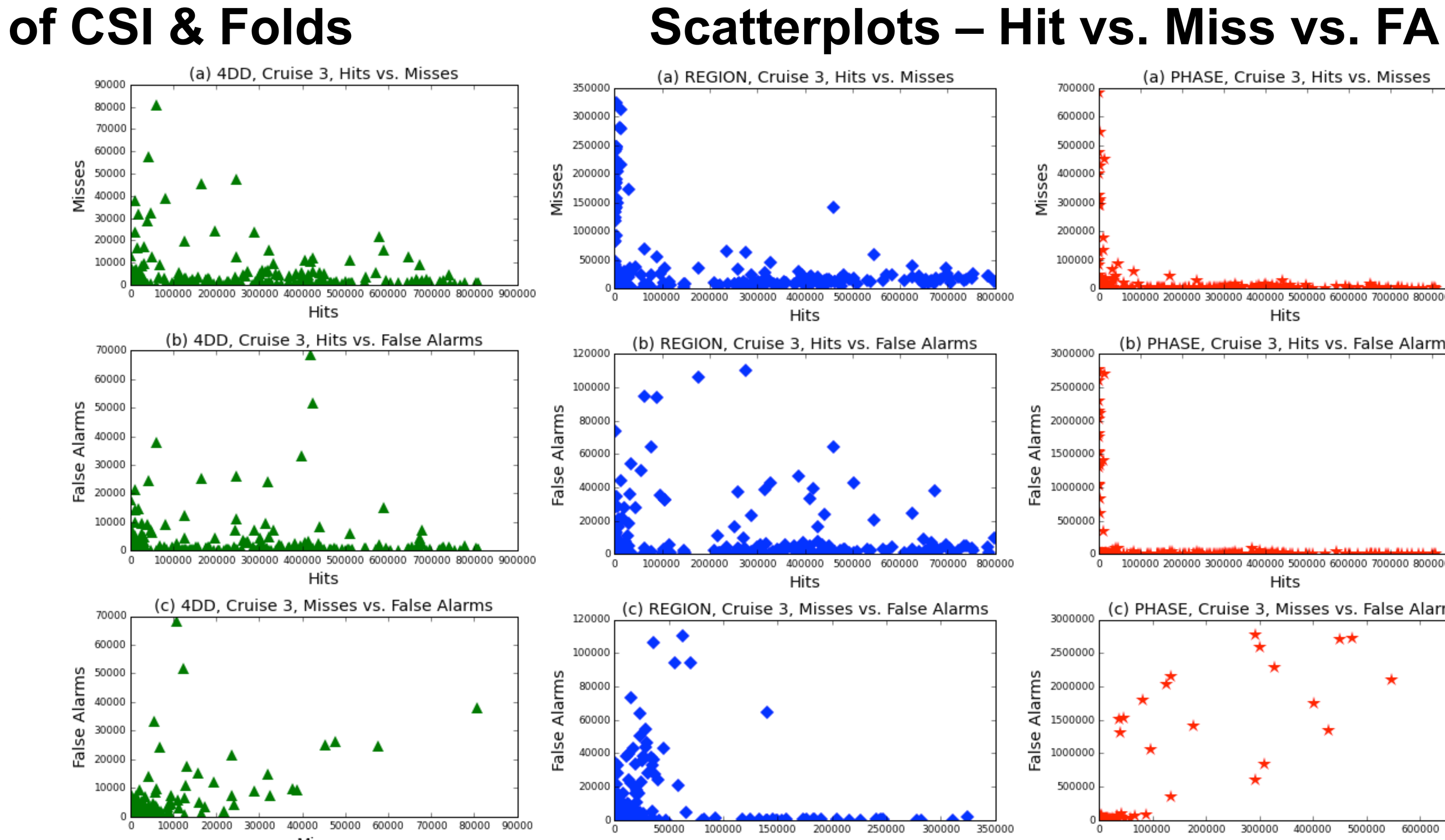
Method	Velocity	Median Absolute Error ($m\ s^{-1}$)	Mean Square Error ($m^2\ s^{-2}$)
4DD	Radial	0.22	0.42
	Tangential	0.23	0.73
Region	Radial	0.28	0.71
	Tangential	0.33	0.82
Phase	Radial	0.29	3.39
	Tangential	0.56	1.51
None	Radial	12.6	293
	Tangential	13.3	269

Cruise 3

Time Series of CSI & Folds



Scatterplots – Hit vs. Miss vs. FA



- Binary behavior (esp. Phase); algorithms did extremely well or bombed.
- Failures common when few folds, Phase and Region sometimes w/ many folds

4. Summary and Conclusions

- Performance of all three algorithms is very high when volumes are significantly aliased (~1000s of folded gates)
- Algorithms may not be worth running if few folds – "Critical mass" of folds needed?
- On average, 4DD performs very similarly to hand-dealiasing, but failures during individual radar volumes can and do occur
- Region-Based and Phase-Unwrap methods perform worse than 4DD, but are good options if 4DD fails. Phase has higher POD and CSI but also higher FAR than Region.
- Region and Phase methods prone to occasional massive failures (CSI ~0)