Effect of sampling difference on satellite-buoy wind consistency: an assessment based on WRF models

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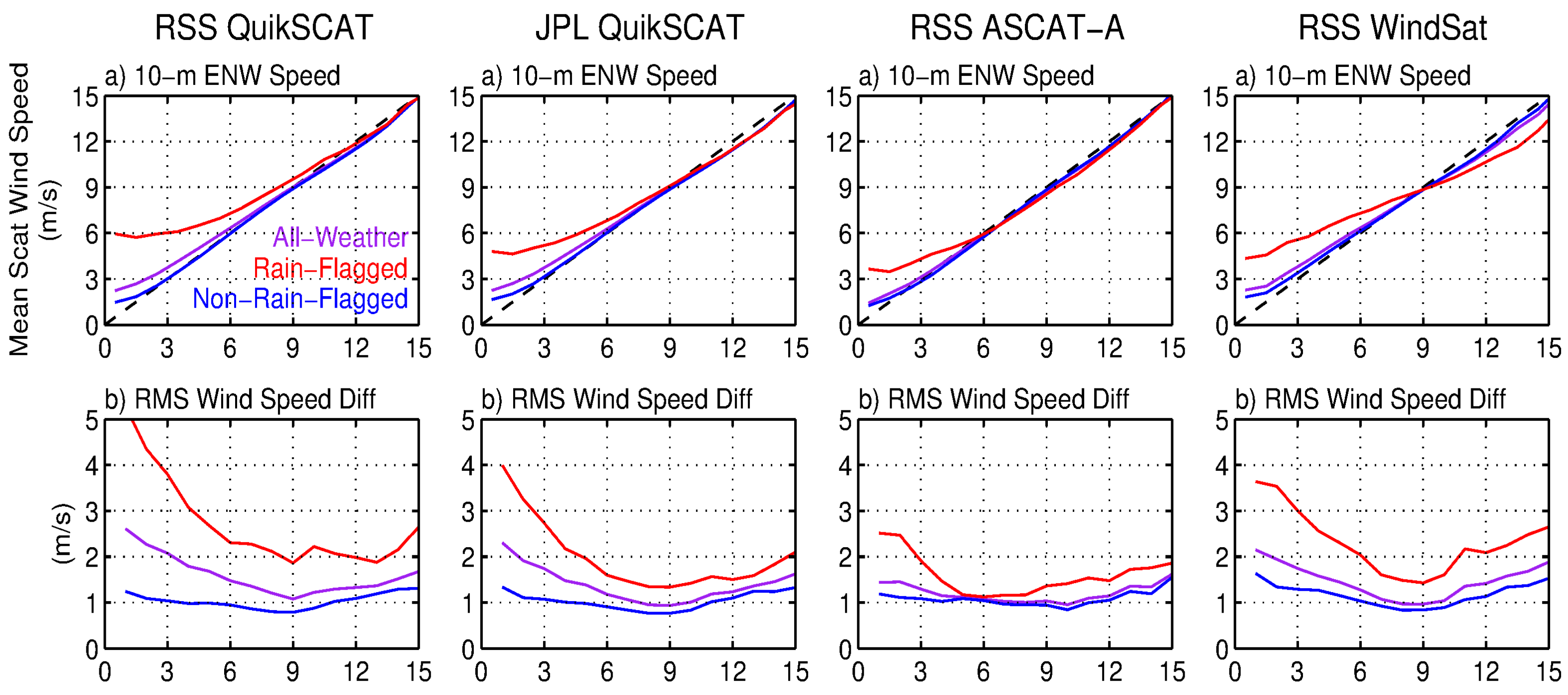
Special thanks to Dr. Claire Vincent of University of Melbourne for providing data link for output from one of the WRF models

Background

- Understanding the consistency of satellite & buoy winds is important to satellite wind cal/val, observing system design (e.g., TPOS2020), and wind synthesis (e.g., CCMP)
- Satellite & buoy winds have good consistency (~1 m/s) for rain-free conditions, but have significantly larger differences under rainy conditions.

- Possible reasons:
  - Rain contamination of satellite winds
  - Buoy wind measurement issues
  - Spatial/temporal sampling differences (e.g., satellite footprint averages vs point-wise buoy winds)



Courtesy of Larry O'Neill, OSU

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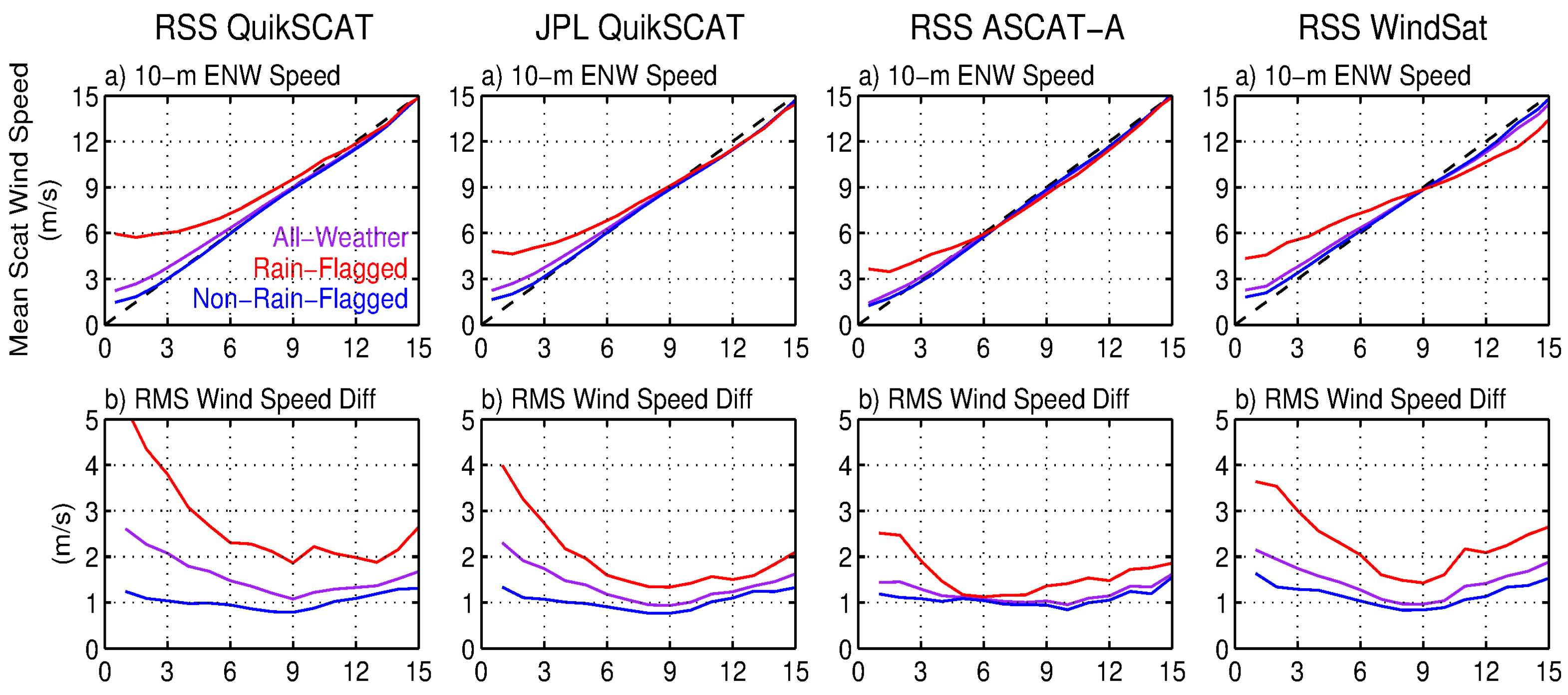

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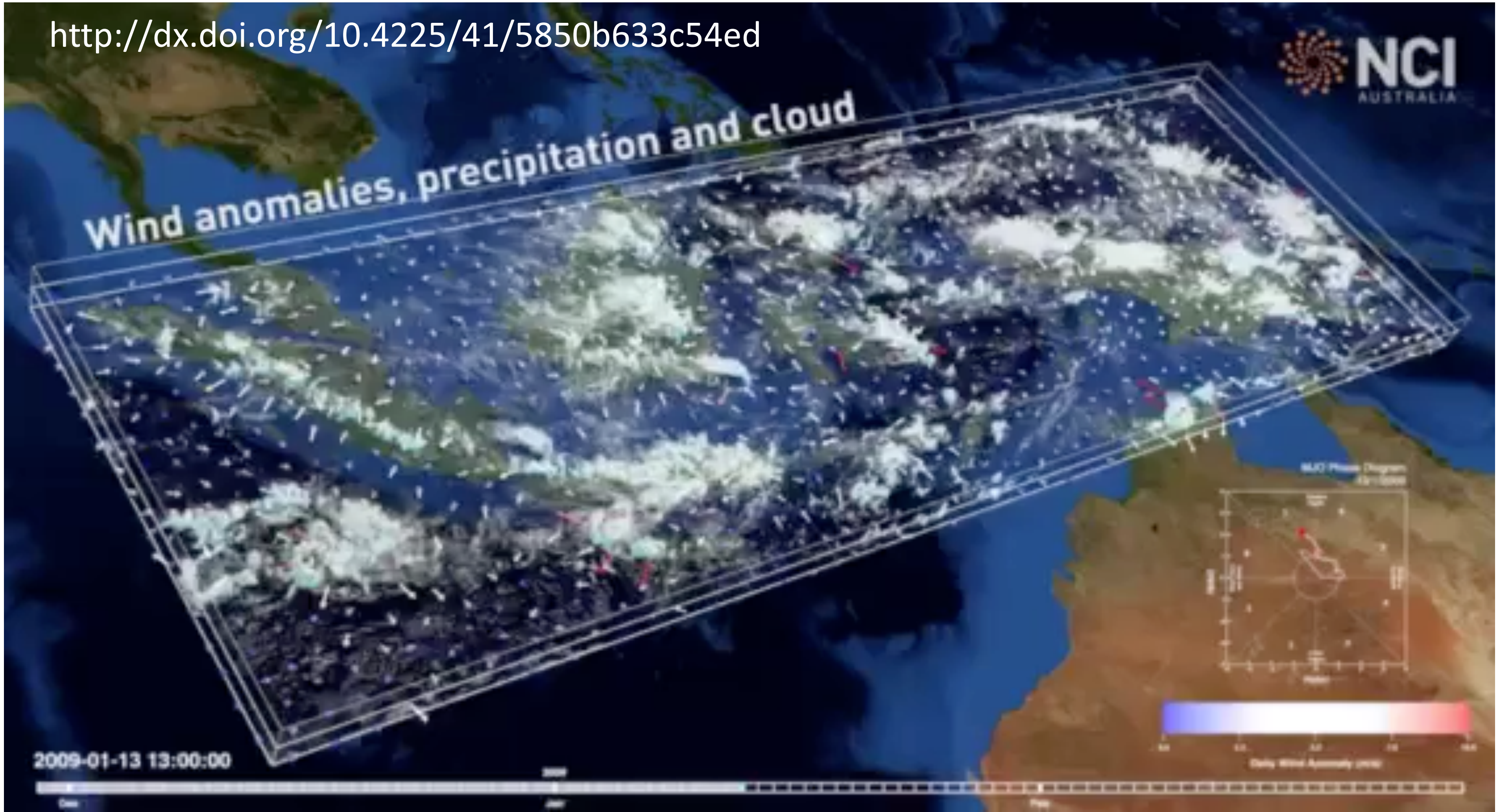
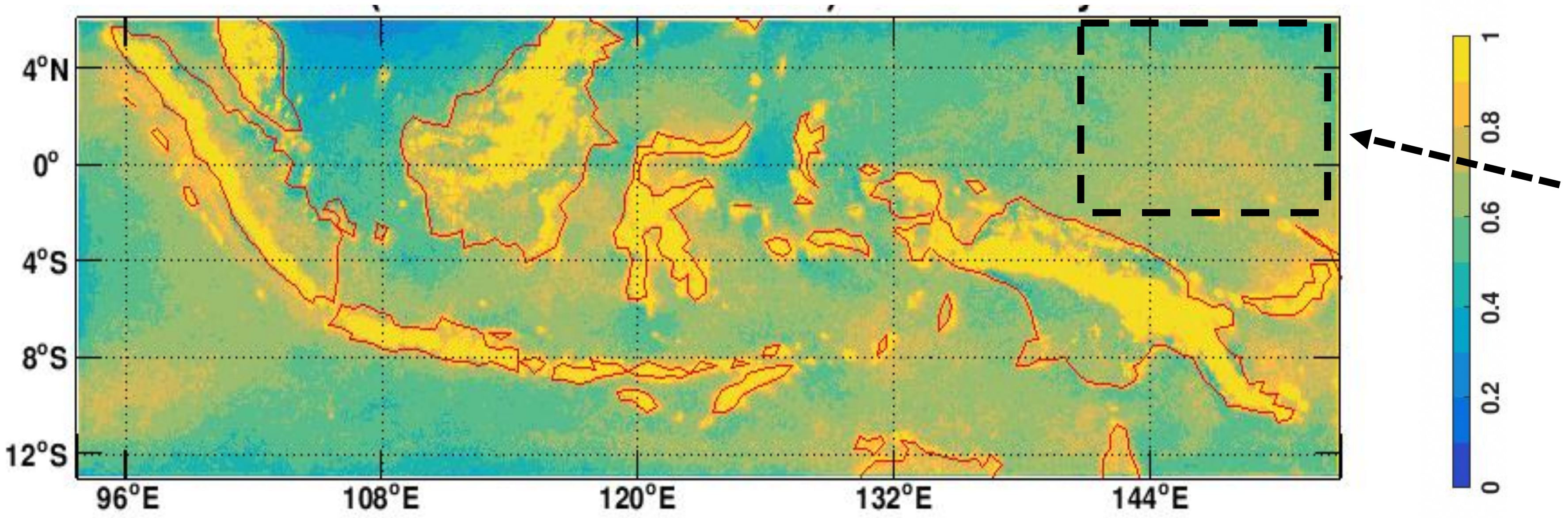
Method: assessment based on WRF models

- Analysis of output from two WRF models for the maritime-continent region
  - Produced by Dr. Claire Vincent (Univ. of Melbourne) & Dr. Longtao Wu (JPL), respectively
- WRF models have 4-km resolution, hourly output; large-scale field constrained by ERA-Interim for UM WRF
- Examine wind variability within 25x25 km (typical scatterometer footprint)



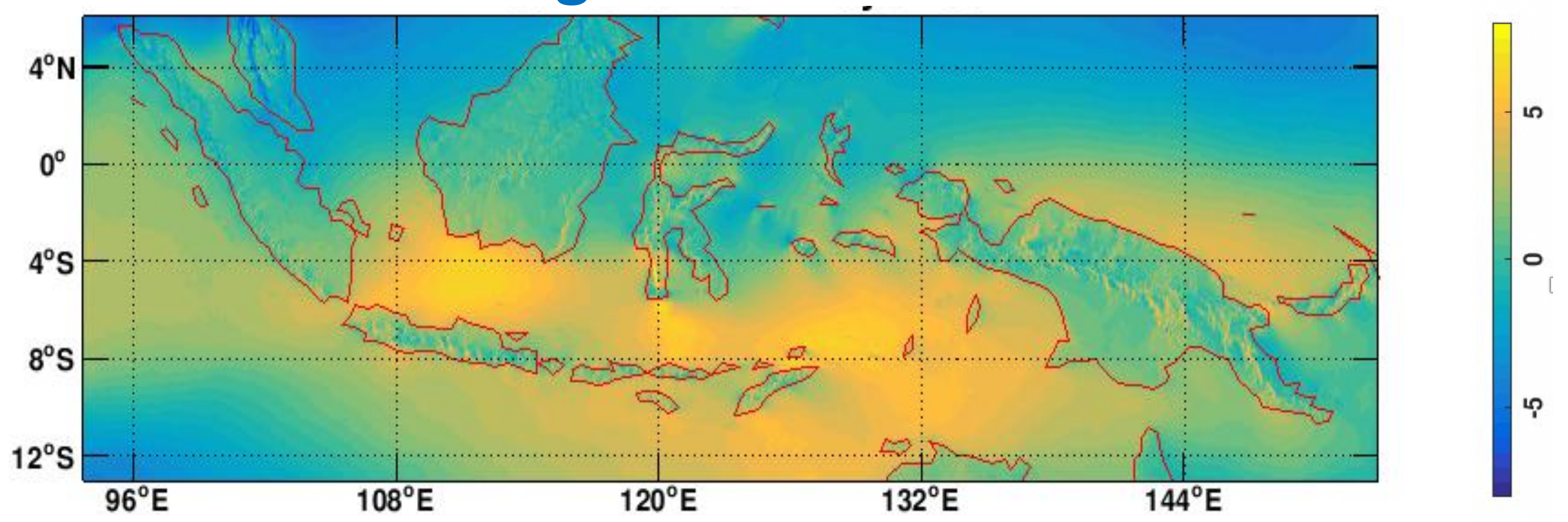
WRF's sub-25 km wind speed variability averaged over 2014 boreal winter



~ 0.7 m/s

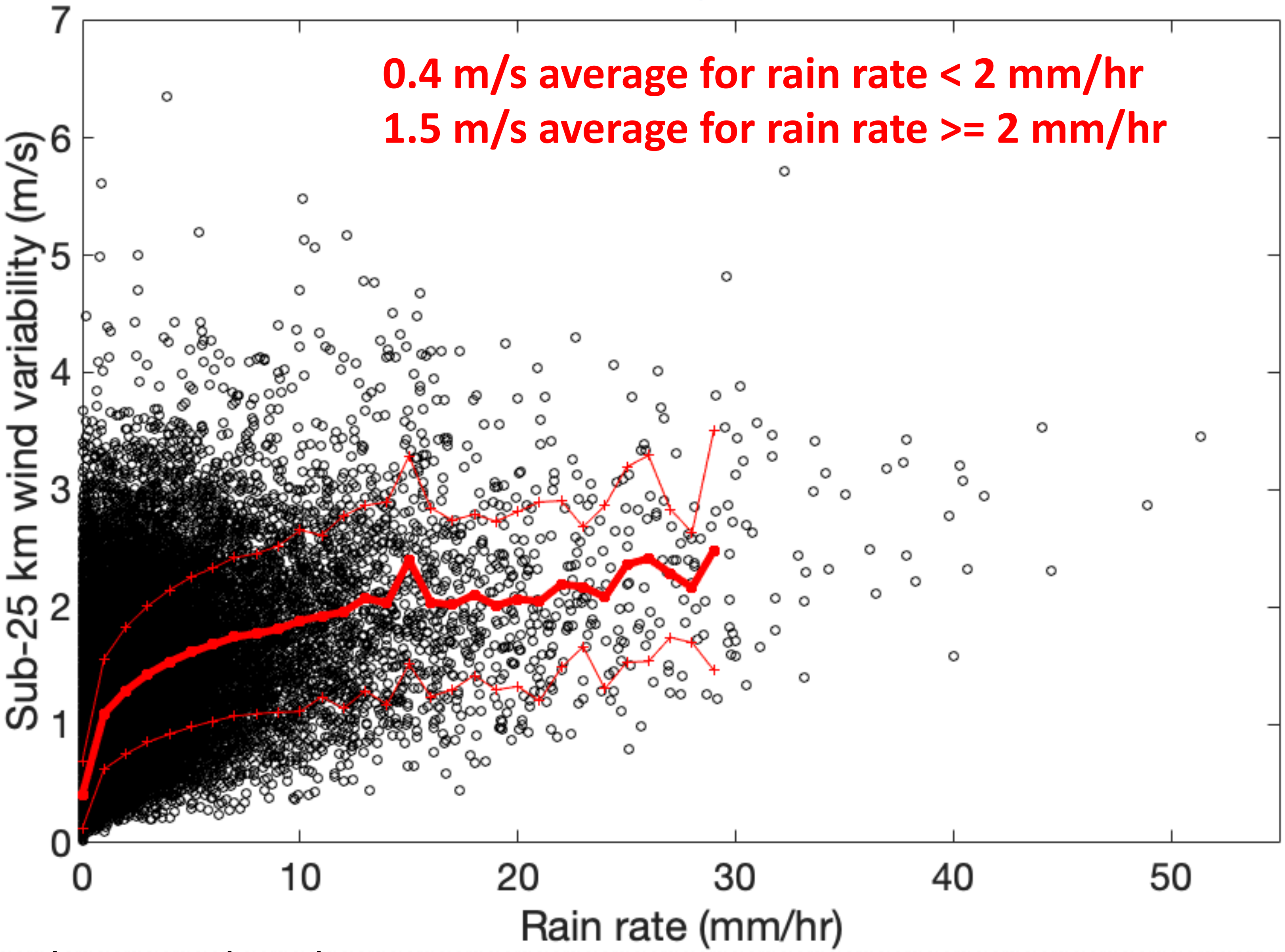
Similar results from outputs of the two WRF models.

Zonal wind averaged over 2014 boreal winter



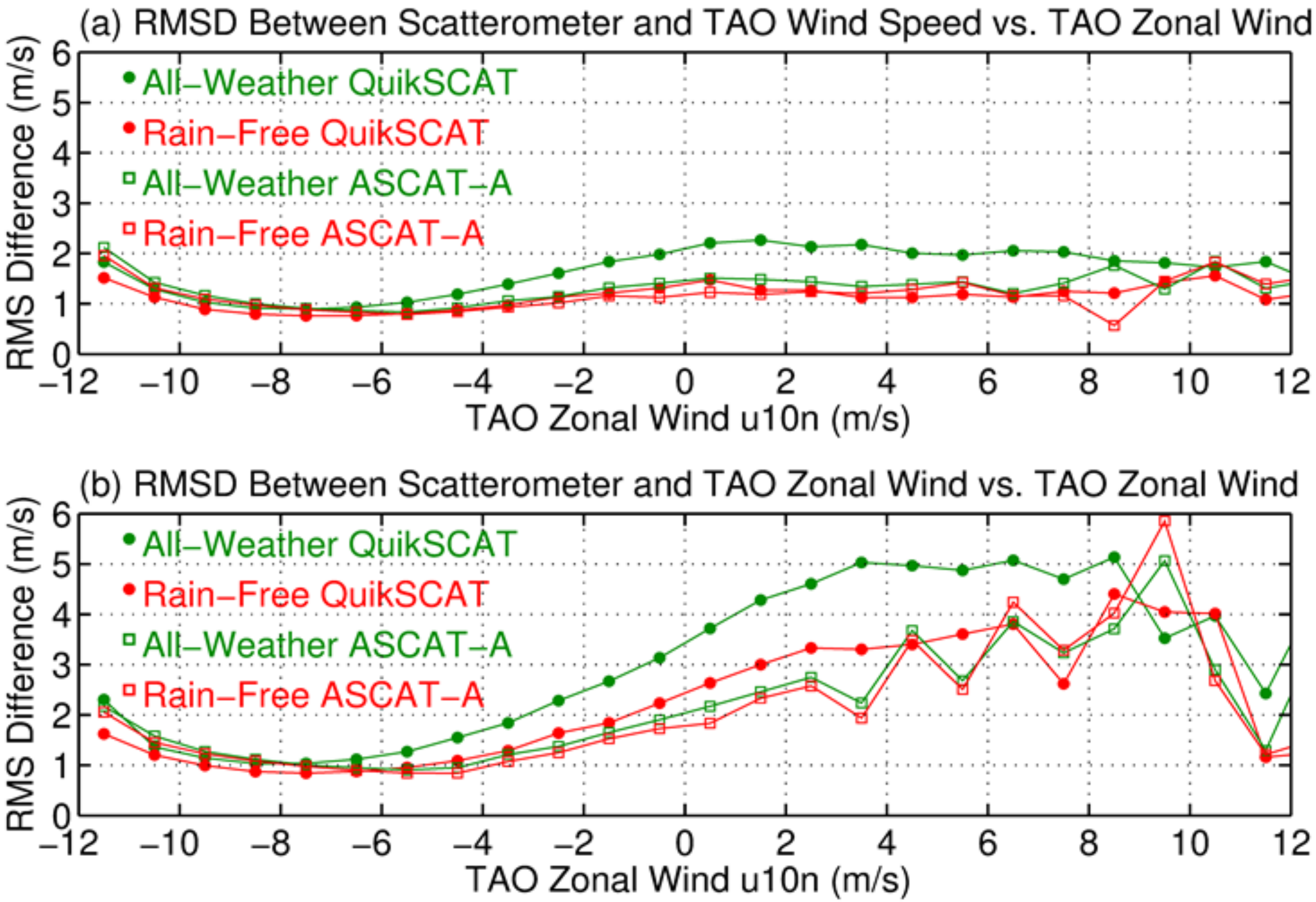
Likely underestimated "sub-footprint" variability due to 4-km resolution & hourly outputs.

WRF sub-25 km wind variability as a function of rain rate



- This is based on 4-km WRF, hourly output.
- Finer-resolution WRF model with more frequent output may result in larger differences.

Satellite-buoy winds more consistent for wind speed than for zonal wind



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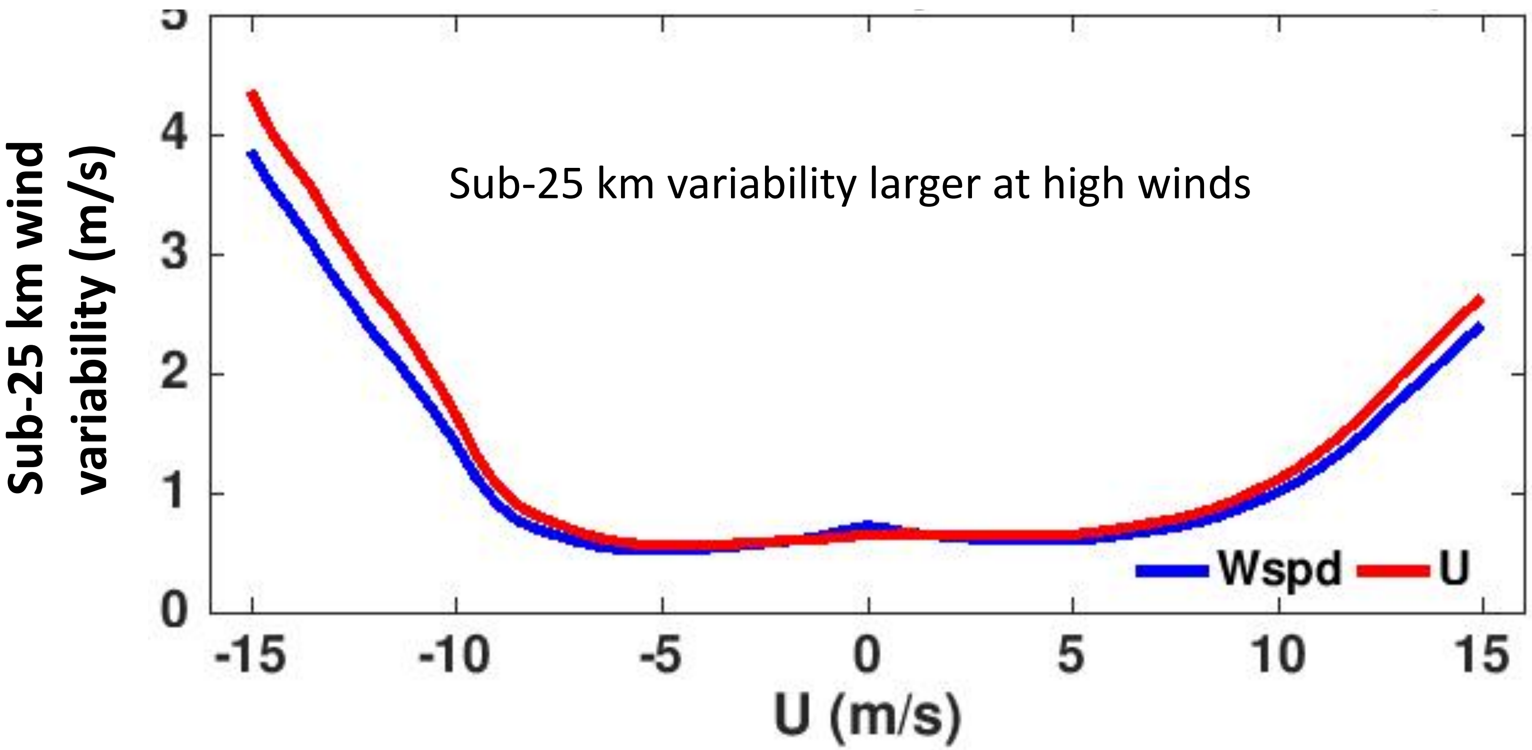
Larger differences between satellite & buoy winds, esp. during westerly winds. Likely cause:

- Sampling differences cause increased directional discrepancy
- Buoy compass error?

Sub-25 km variability for wind speed and zonal wind in WRF models as a function of zonal wind



- Zonal wind sub-25 km variability is indeed larger than that of wind speed, but the differences are much less than those between scatterometer and buoy winds.
- This difference from observations may be caused by the domain of the WRF models not encompassing enough tropical Pacific domain.

Summary

- Analysis of WRF model outputs (4-km, hourly) suggest an average ~0.7 m/s sub-25 km variability for ocean surface winds: increasing with rain rate, larger at high winds.

- Such ”sub-footprint variability” can contribute to satellite-buoy wind RMSD significantly.

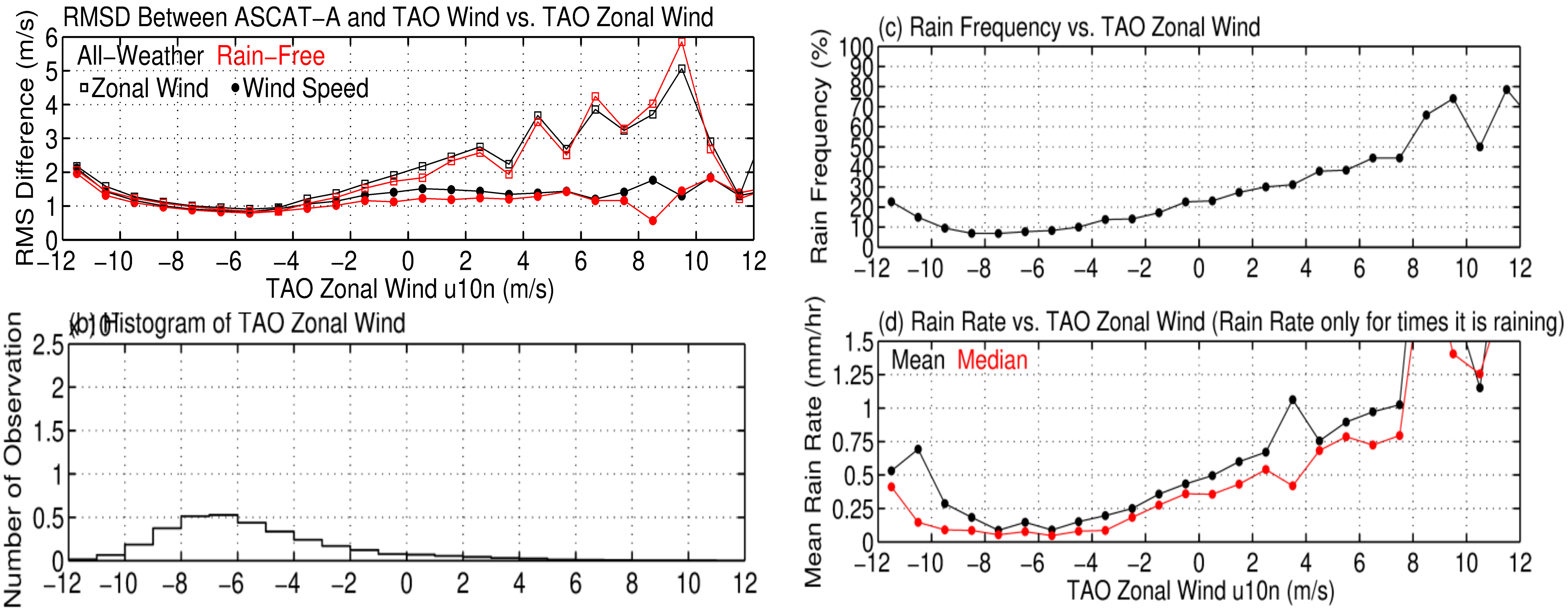
- The small-scale variability is likely underestimated due to the limited spatial resolution (4 km) and hourly output of the WRF models because individual convective rain cells can have spatial scale of ~10 km & time scale of minutes.

- The cause for the larger differences between satellite & buoy winds during westerly wind bursts need to be understood.

Future strategy to improve understanding of sub-footprint wind variability

- Examine finer-resolution WRF model with more frequent output (e.g., 1.5-km, 1-minute).
- Analyze Sentinel SAR winds
- Innovative ideas for in-situ process studies: important for wind, precipitation, and SSS cal/val.
- Examine vertical coherence of winds associated with convective rain cells: have implications to using ship-based radar measurements to understand satellite sub-footprint surface wind variability.
- Triple co-location analysis for convective regions.

Comparison of ASCAT zonal wind & wind speed vs TAO equivalents as a function of (a) TAO zonal wind, (b) # of obs, (c) rain probability, and (d) mean rain rate



- Excellent consistency for wind speed (~ 1 m/s)
- Larger discrepancies for zonal wind associated w/ westerly winds (infrequent & rainy events); potential causes:
  - Small-scale variability sampled differently by satellites & buoys causing directional discrepancies
  - Rain contamination in satellite winds
  - Buoy compass error

Courtesy of Larry O’Neill