Examining convective signatures in scatterometer data

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Background

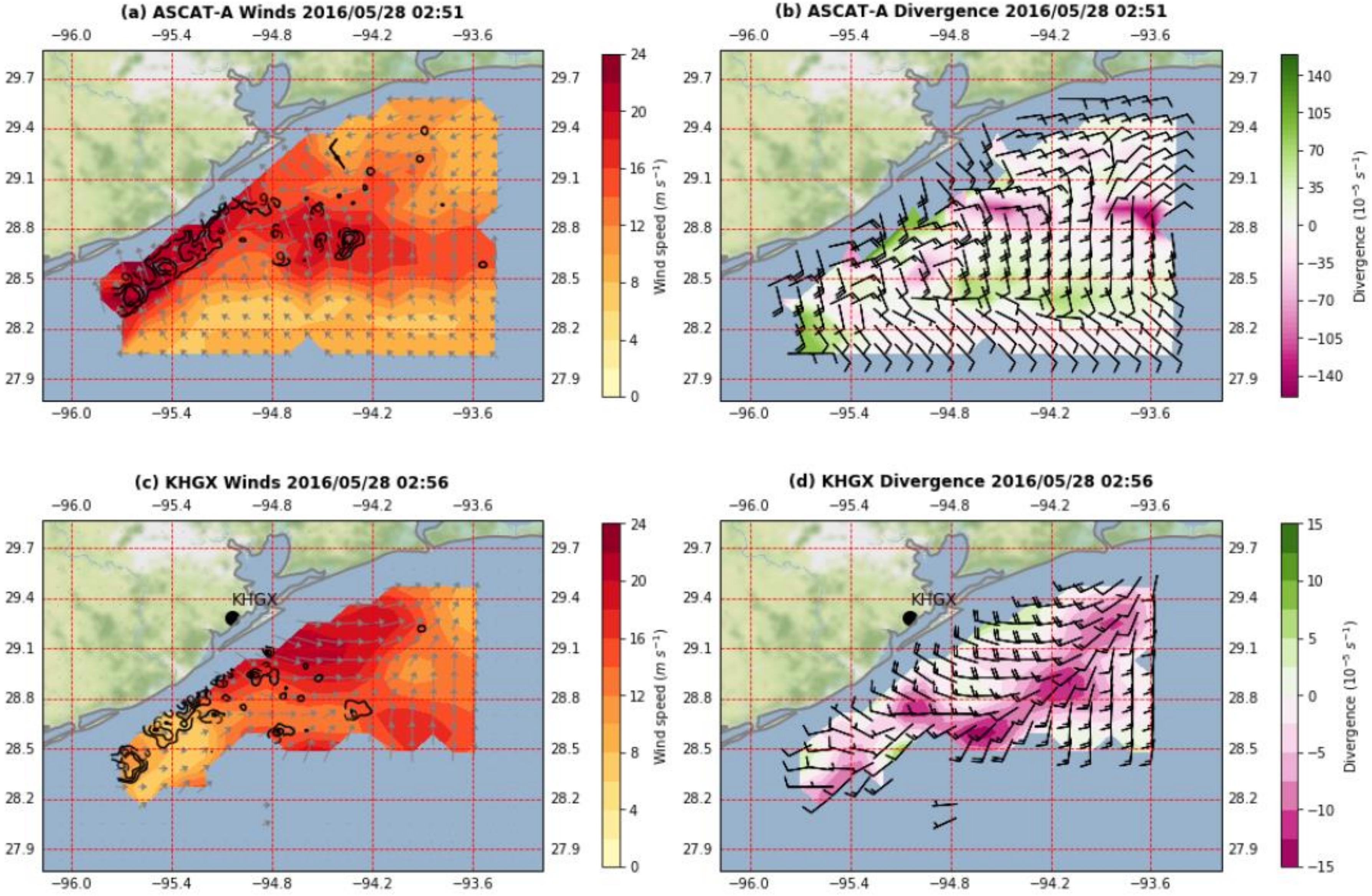
- Scatterometers have been used repeatedly to examine convectively driven winds near precipitation

- Recent work (e.g., Portabella et al. 2012, Elsaesser and Kummerow 2013, Kilpatrick and Xie 2015) has indicated that real signatures are observed despite confounding issue of rain contamination

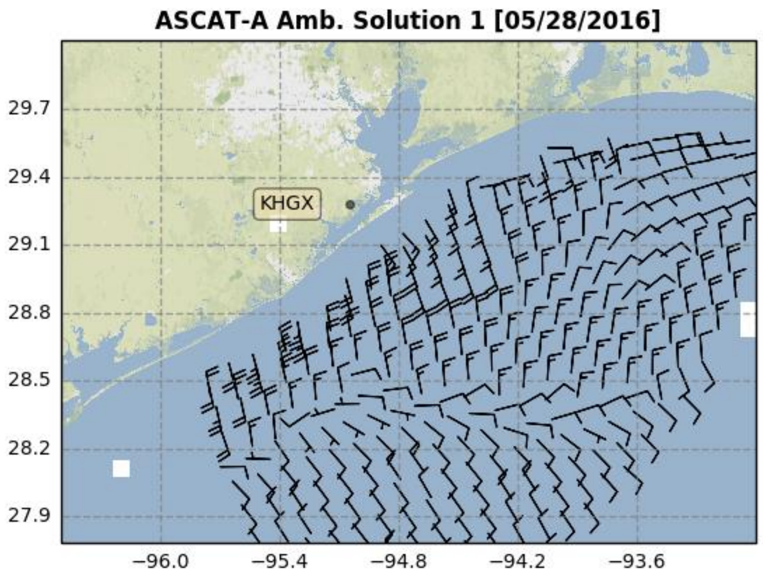
- OVWST-funded work culminating in Priftis et al. (2018) demonstrated value of using ground-based polarimetric Doppler radar in concert with scatterometers to understand low-level winds near mesoscale convection

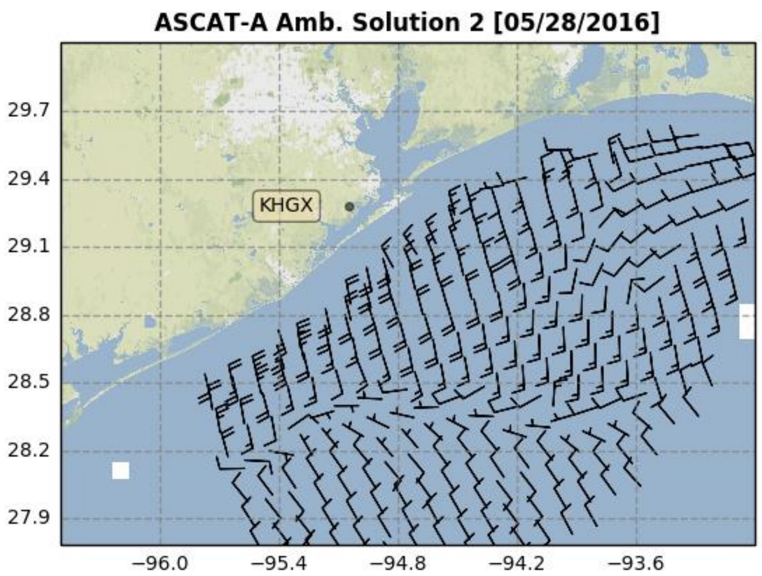
- OVWST-funded work culminating in Garg et al. (2018) introduced a novel technique for identifying cold pools with scatterometers

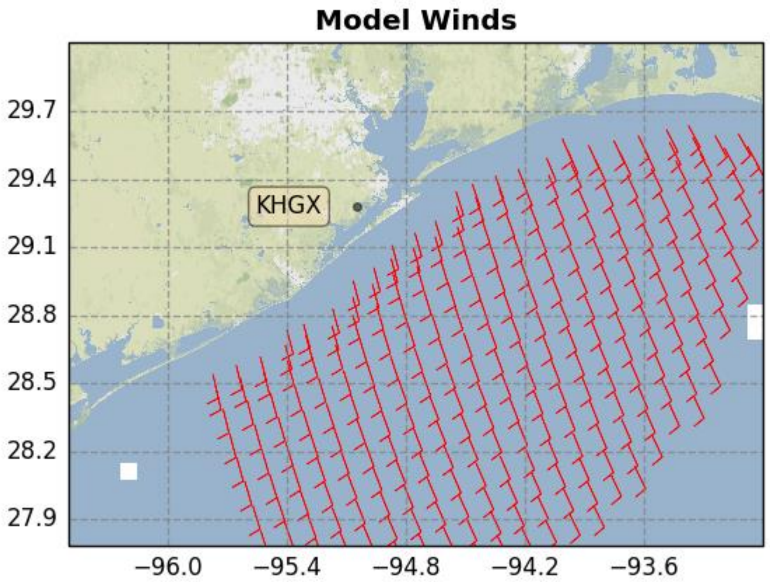
Doppler comparison

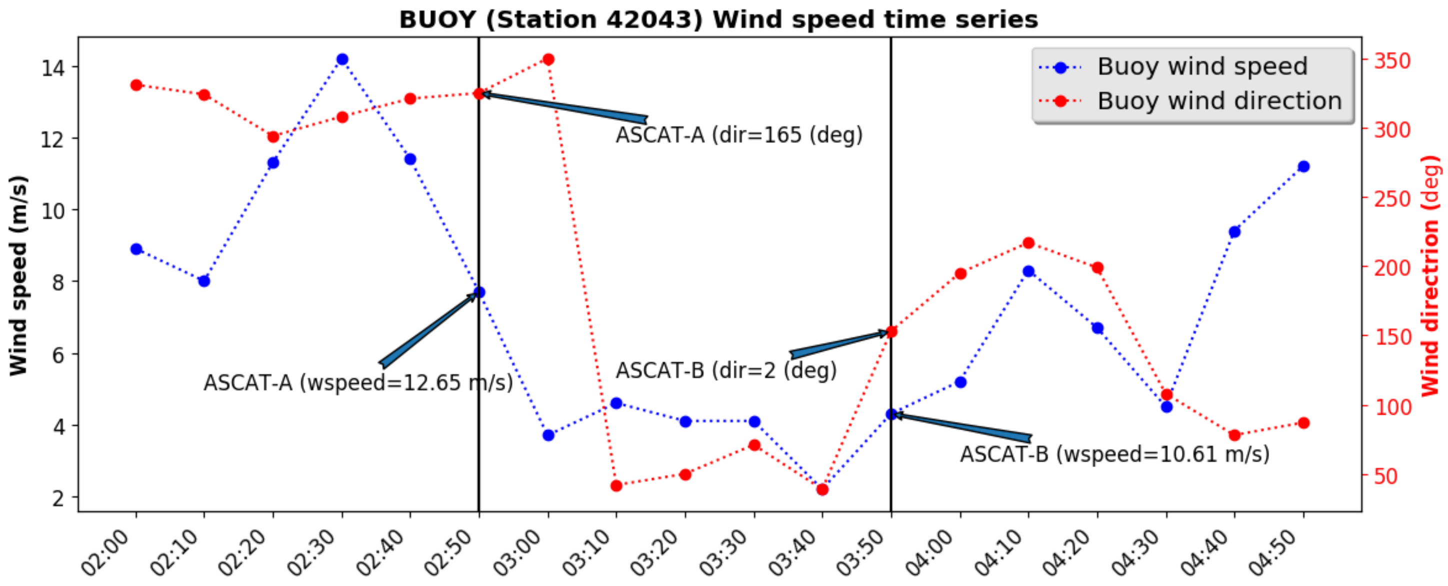


- Resample NEXRAD 2D winds to ASCAT 12.5-km resolution
- ASCAT low-level divergence associated with leading edge of precipitation system
- Doppler radar shows low-level convergence and turning of winds out in front of storm

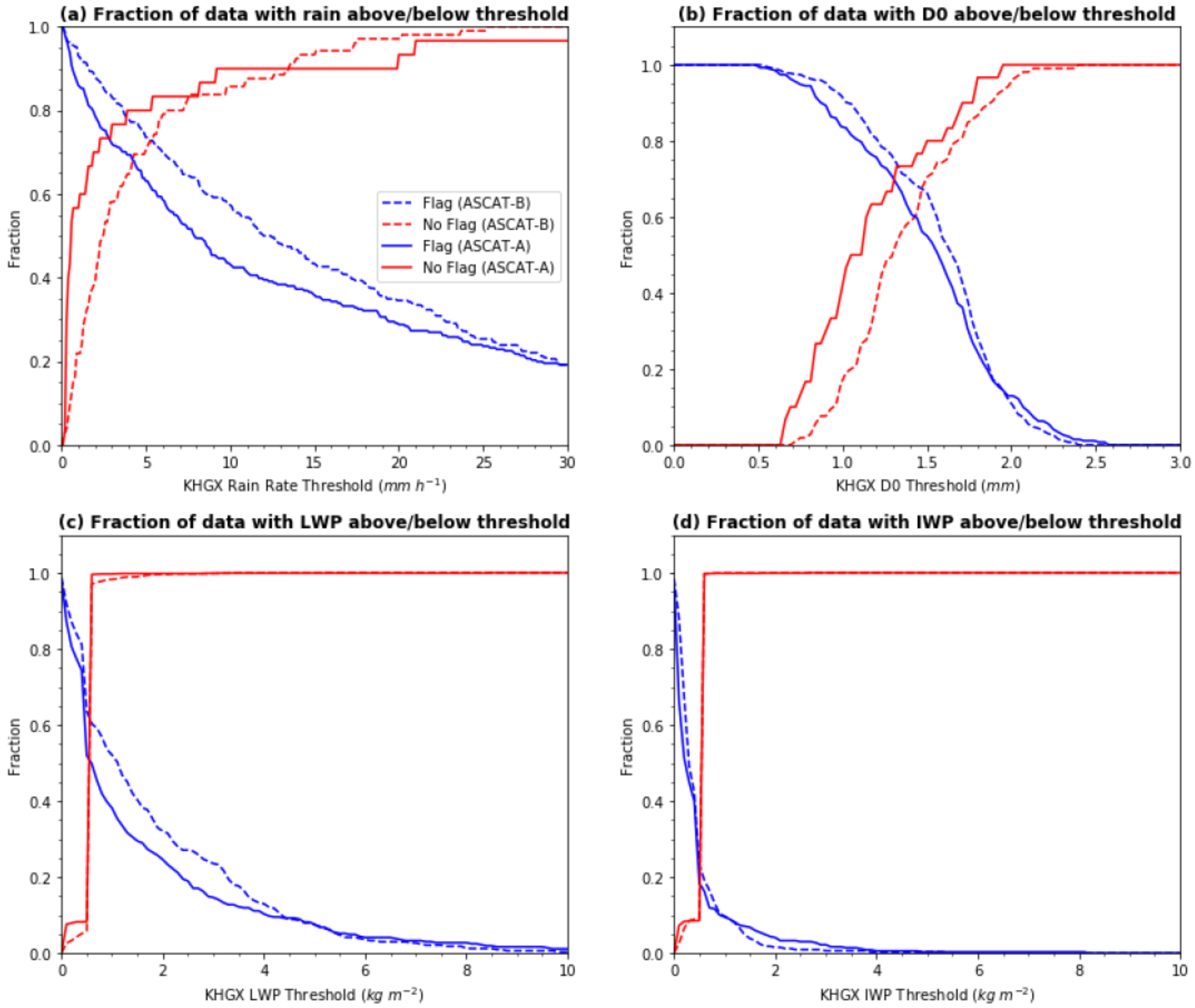








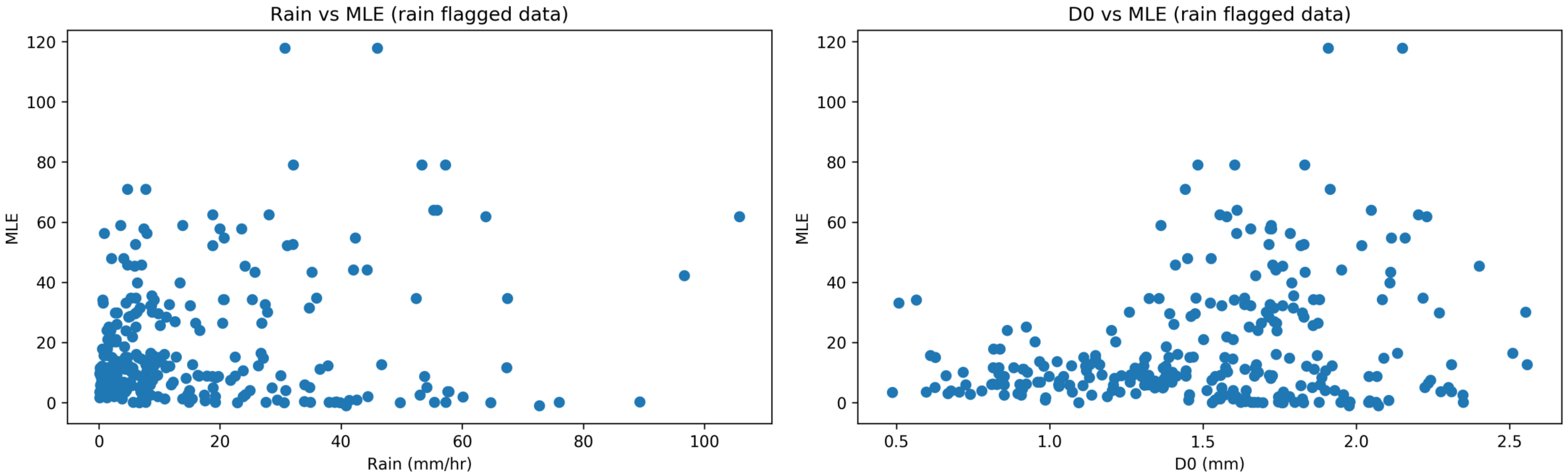
- ASCAT primary solution is SE flow even behind the gust front, which agrees with ECMWF model winds
- However, offshore buoy, Doppler radar, and typical MCS kinematics suggest NW flow behind the front
- Some ASCAT ambiguity select options offer more realistic NW flow in WVCs



Polarimetric radar comparison

- Resample NEXRAD to ASCAT 12.5-km resolution
- Rain rate and median volume diameter thresholds that lead to triggering of ASCAT QC flags vary by case/overpass
- However, ice and liquid water paths for unflagged ASCAT obs are nearly always < 0.5 kg m^{-2}.

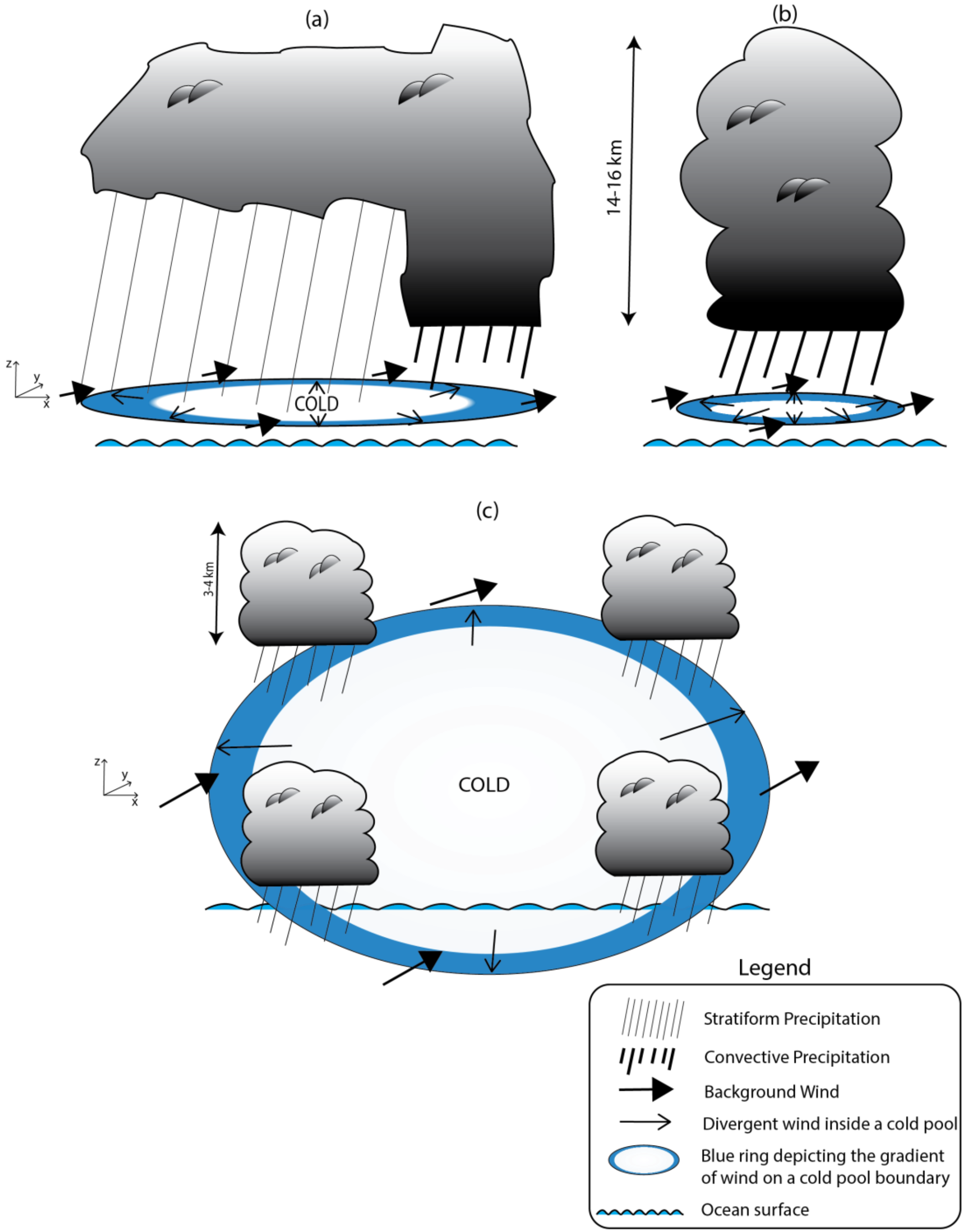
ASCAT-A Overpass 0251 UTC on 5/28/2016

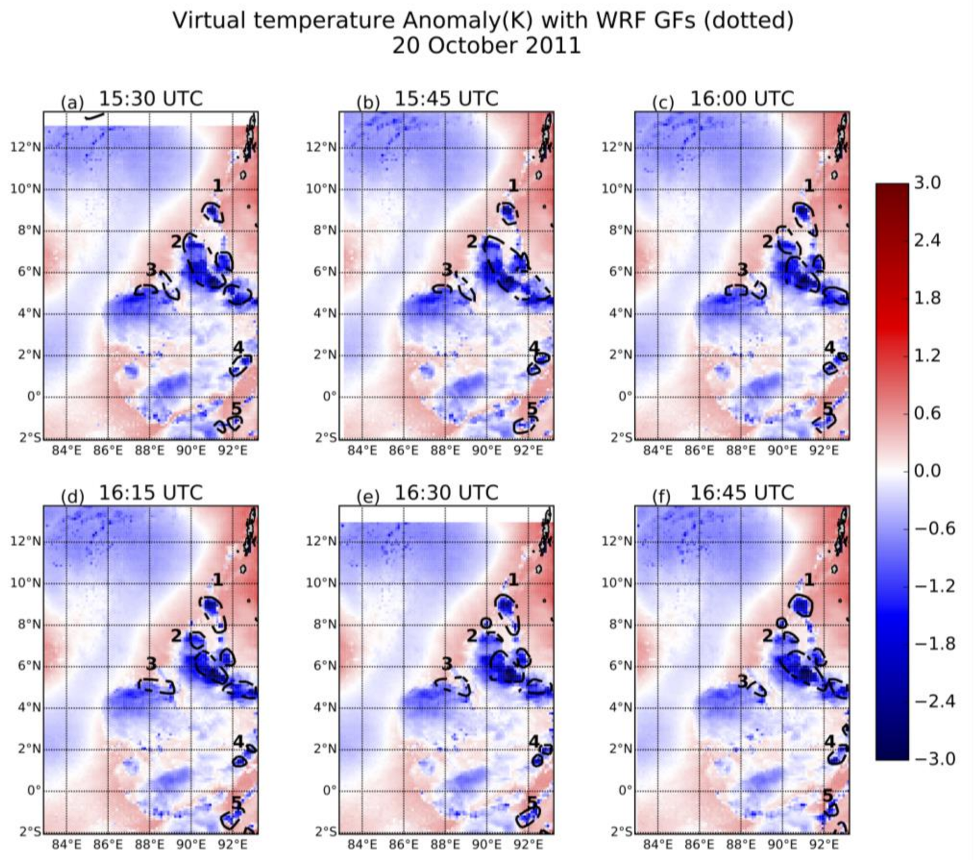


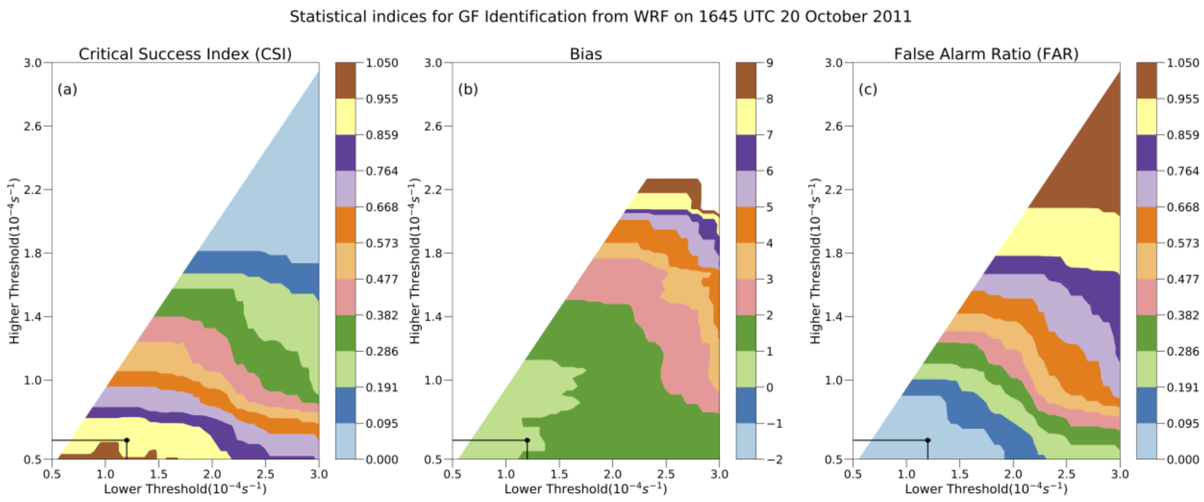
- MLE shows a tendency to increase as polarimetric rain rate and D_0 increase, but signal is noisy and correlations are low ($R^2 < 0.1$)
- D_0 relationship suggests larger surface features, caused by larger drops striking on the sea surface, alter the backscatter and increase occurrence of anisotropy of the signal

- Hypothesis: Closed areas of wind gradients will surround tropical cold pools
- Cold pool size related to parent storm size and organization
- Ostensibly detectable via scatterometer
- Identify areas of increased scalar gradients using:

$$|\nabla\vec{V}| = \begin{bmatrix} \frac{\partial u}{\partial x} + \frac{\partial v}{\partial x} \\ \frac{\partial u}{\partial y} + \frac{\partial v}{\partial y} \end{bmatrix}$$

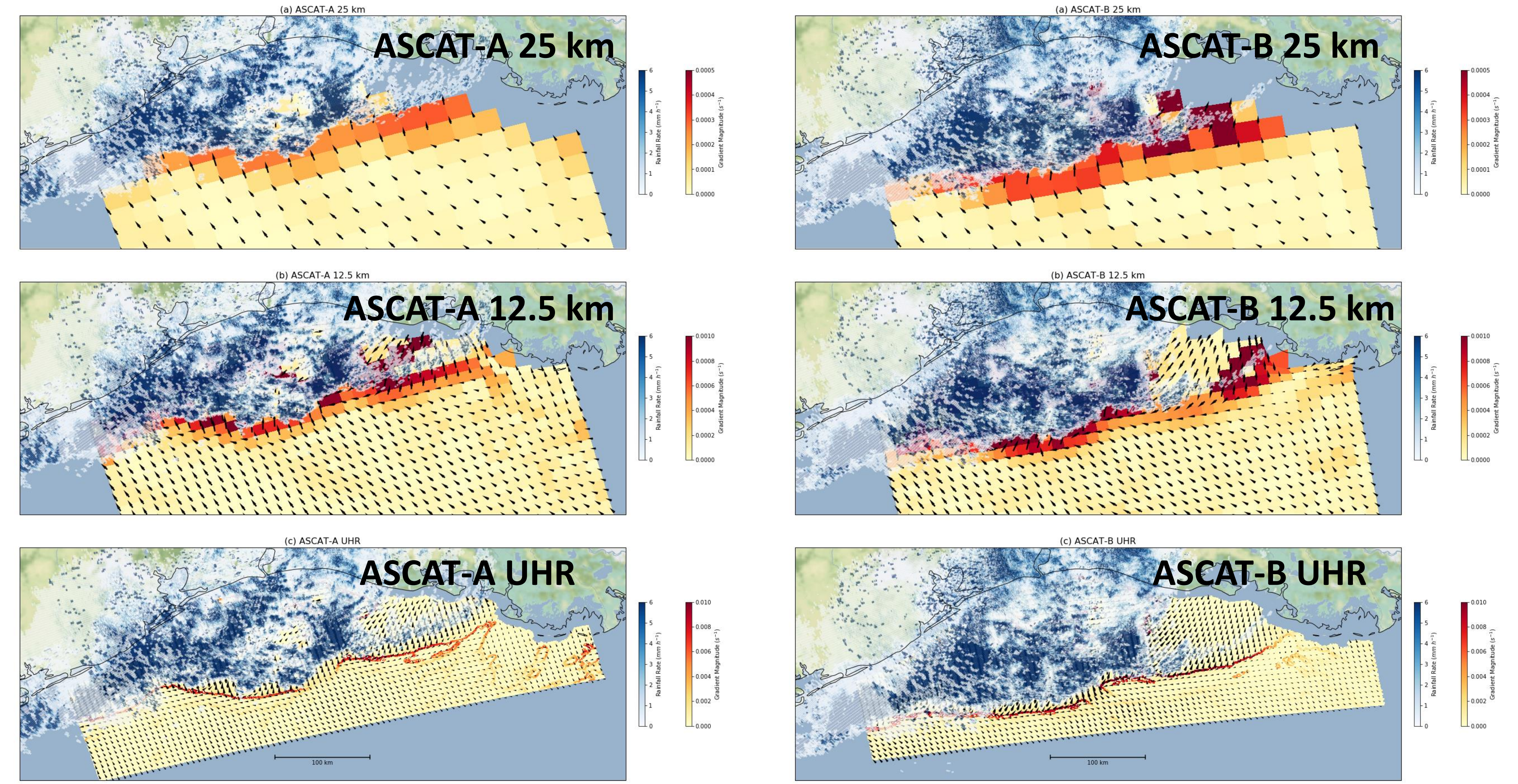




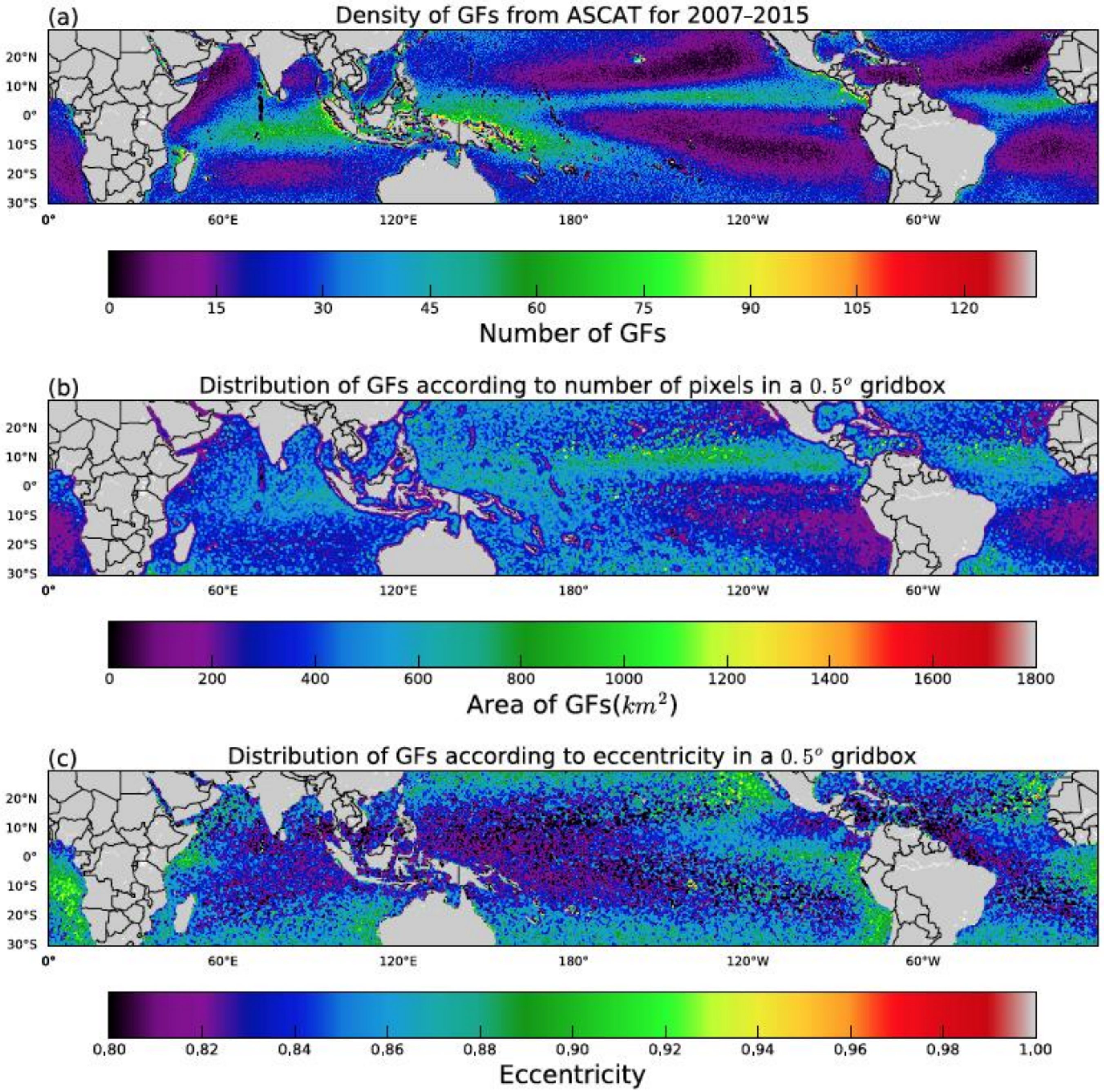


Examples from WRF simulation

- Calculate gradient wind magnitude in resampled output from WRF simulation of DYNAMO convection
- Identify gradient features (GFs) using standard image processing and edge detection analysis
- GFs correspond well to simulated T_v depressions (i.e., cold pools); High CSI, low FAR

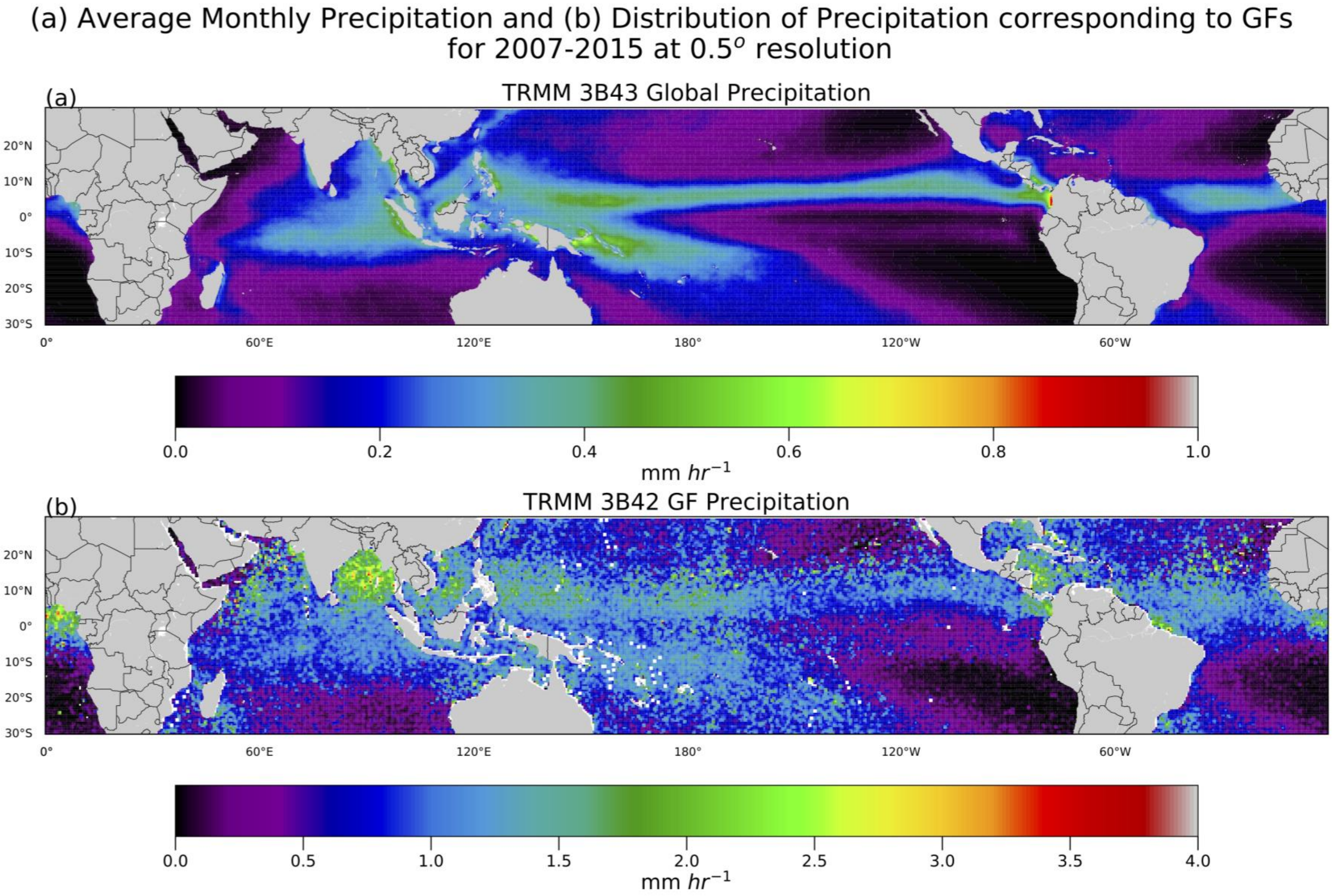


Wind gradients become more sharply defined as product resolution improves

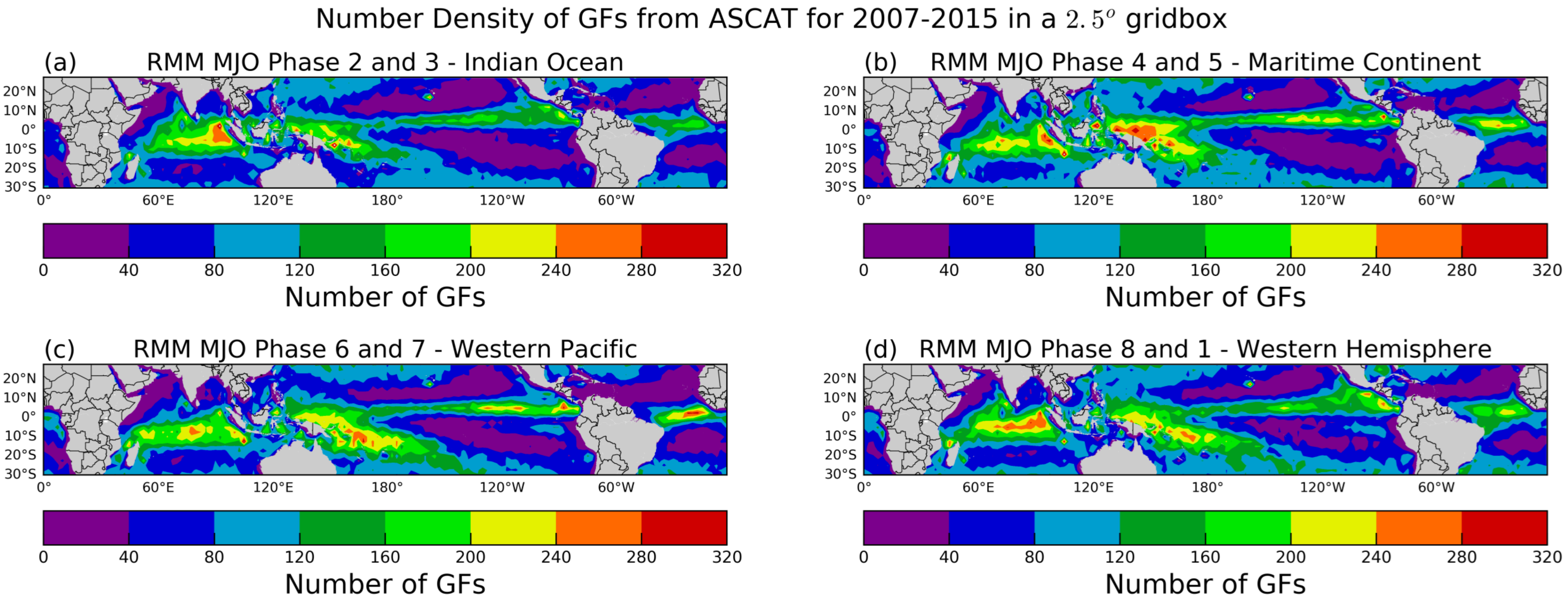


Gradient Feature Global Analysis

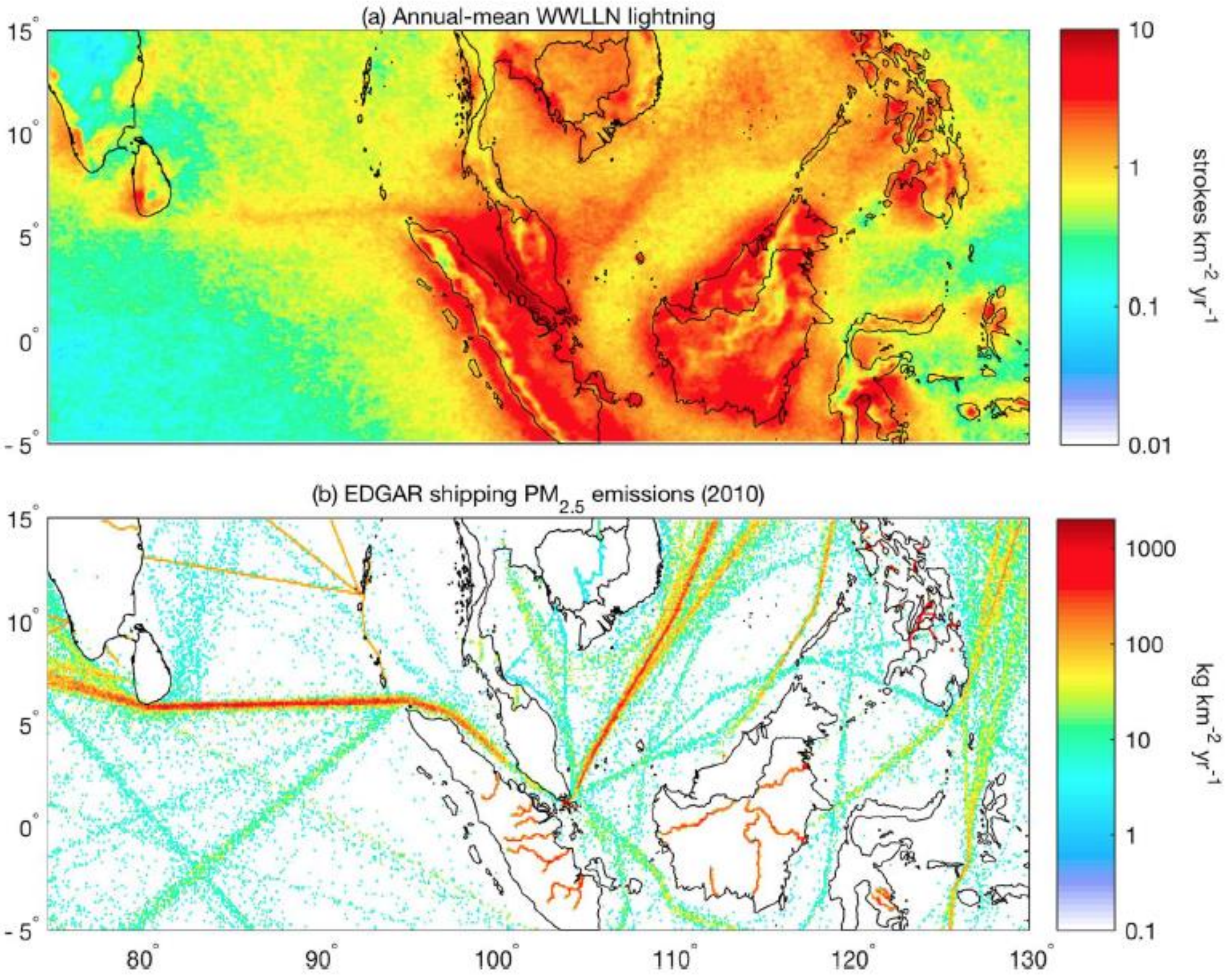
- ASCAT 12.5-km rain-flagged data removed from consideration
- Density corresponds well to known global distribution of tropical rainfall
- Largest GFs in/near ITCZ
- Increased eccentricity (i.e., more linear) in higher latitudes, eastern Pacific, and near coastlines



- GFs associated with heavier precipitation than average
- Broader latitudinal distribution of GF-related precip
- Bay of Bengal associated with most GF-related precip

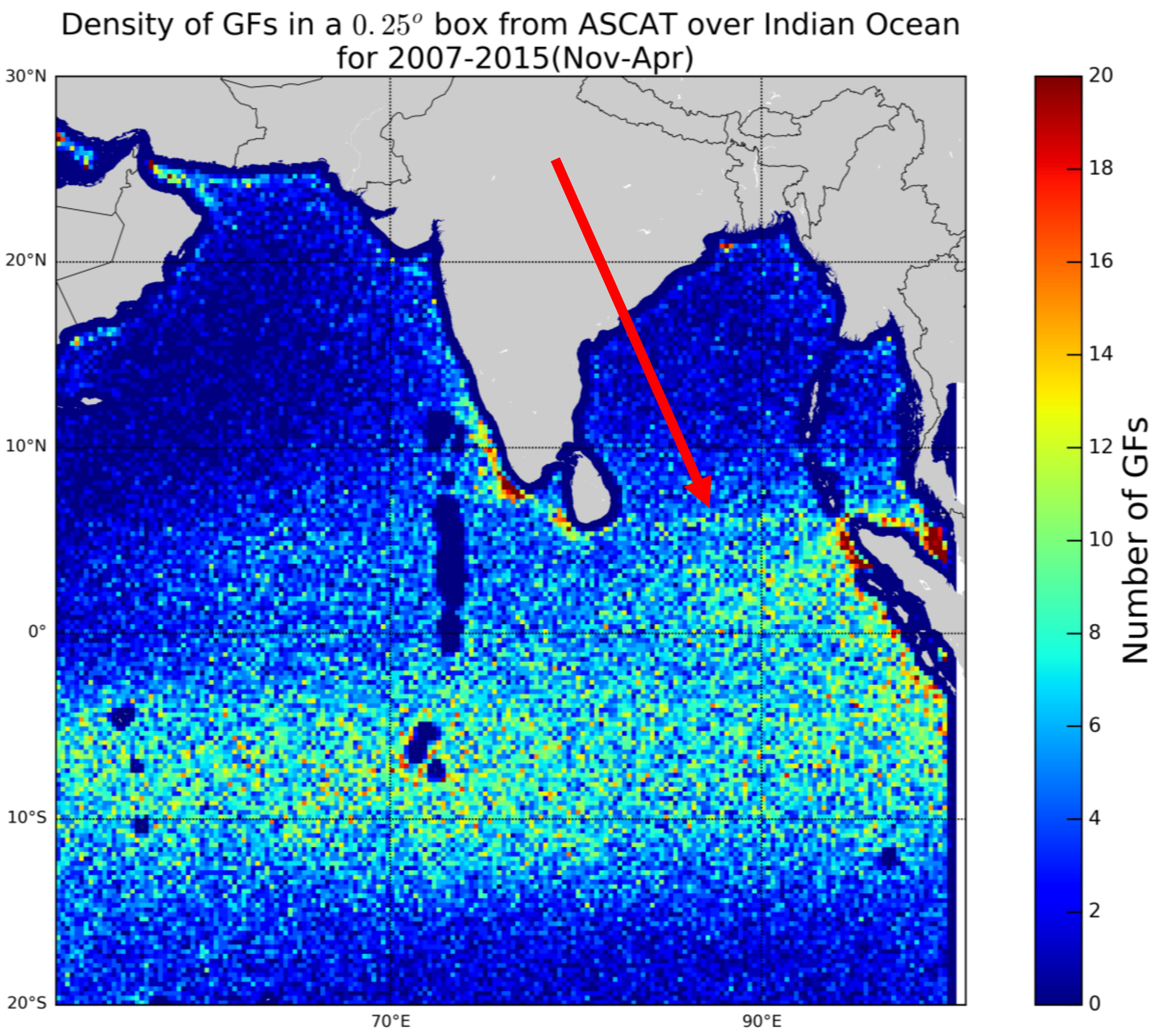


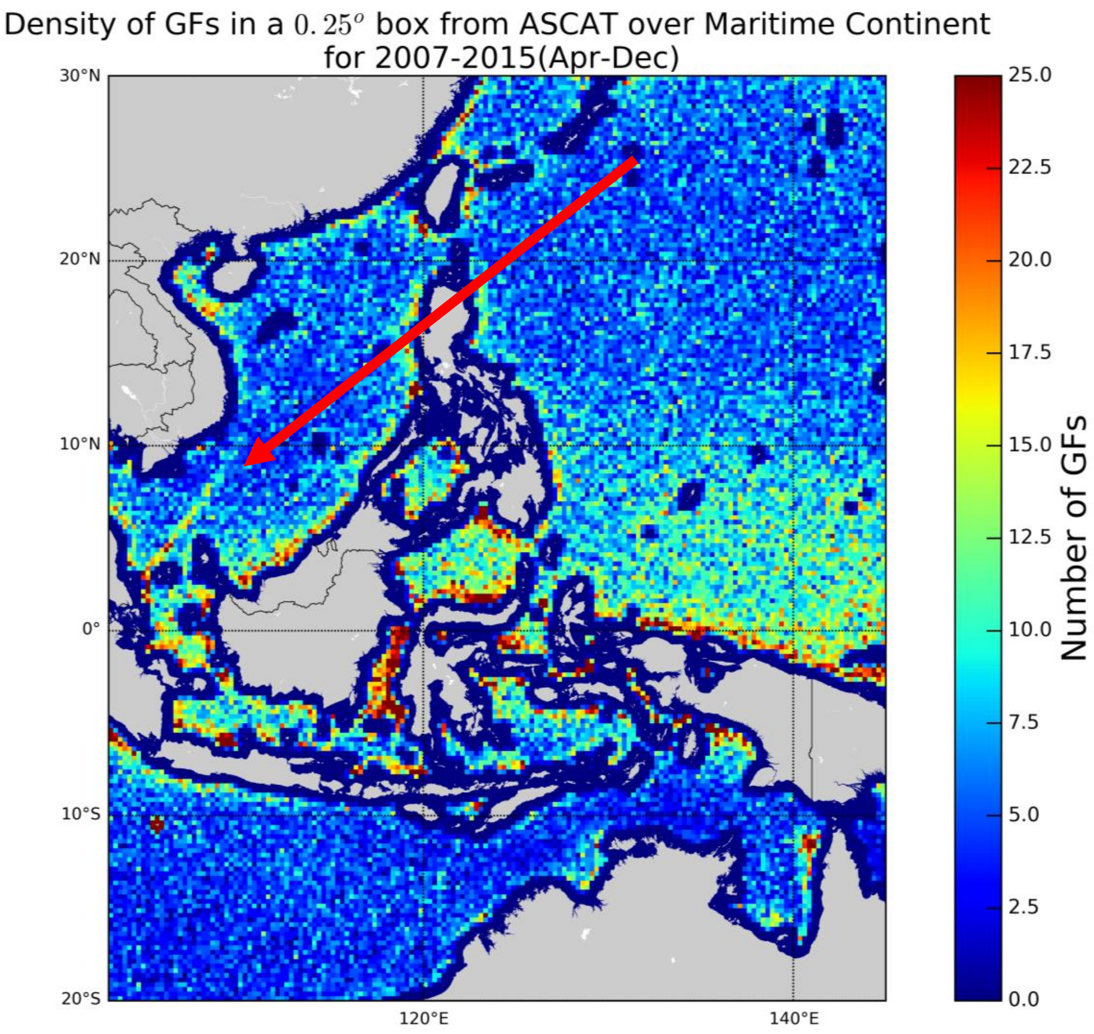
Variability of GF number density with MJO index



Thornton et al. (2017; GRL)

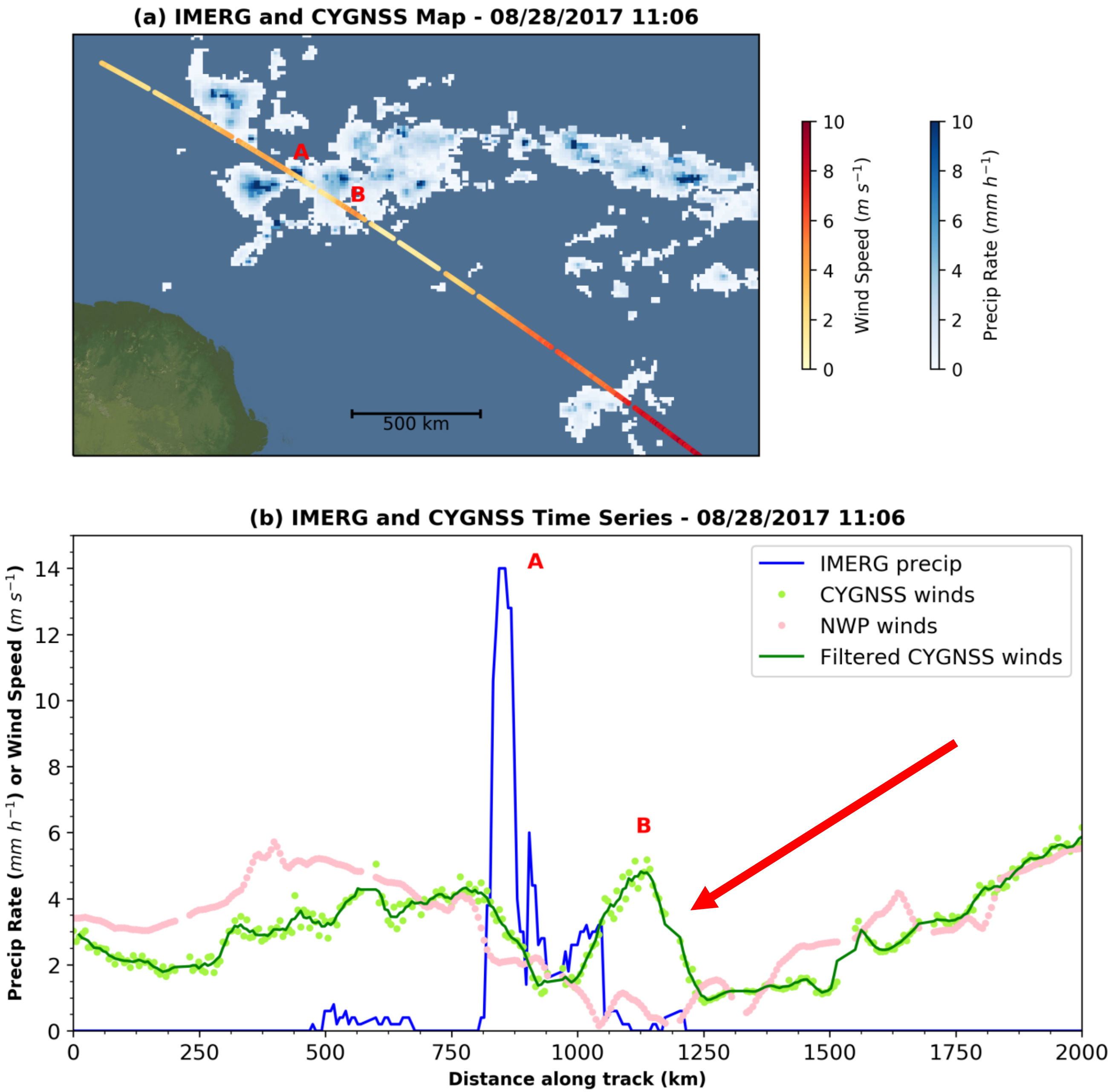
- Lightning enhanced by about a factor of ~2 directly over two of the busiest shipping lanes in the Indian Ocean and South China Sea
- Environmental factors do not explain the enhancement
- Study hypothesizes that ship exhaust particles change storm cloud microphysics, causing enhanced condensate in mixed-phase region and thus lightning





Ship track signatures also observed in ASCAT GF dataset

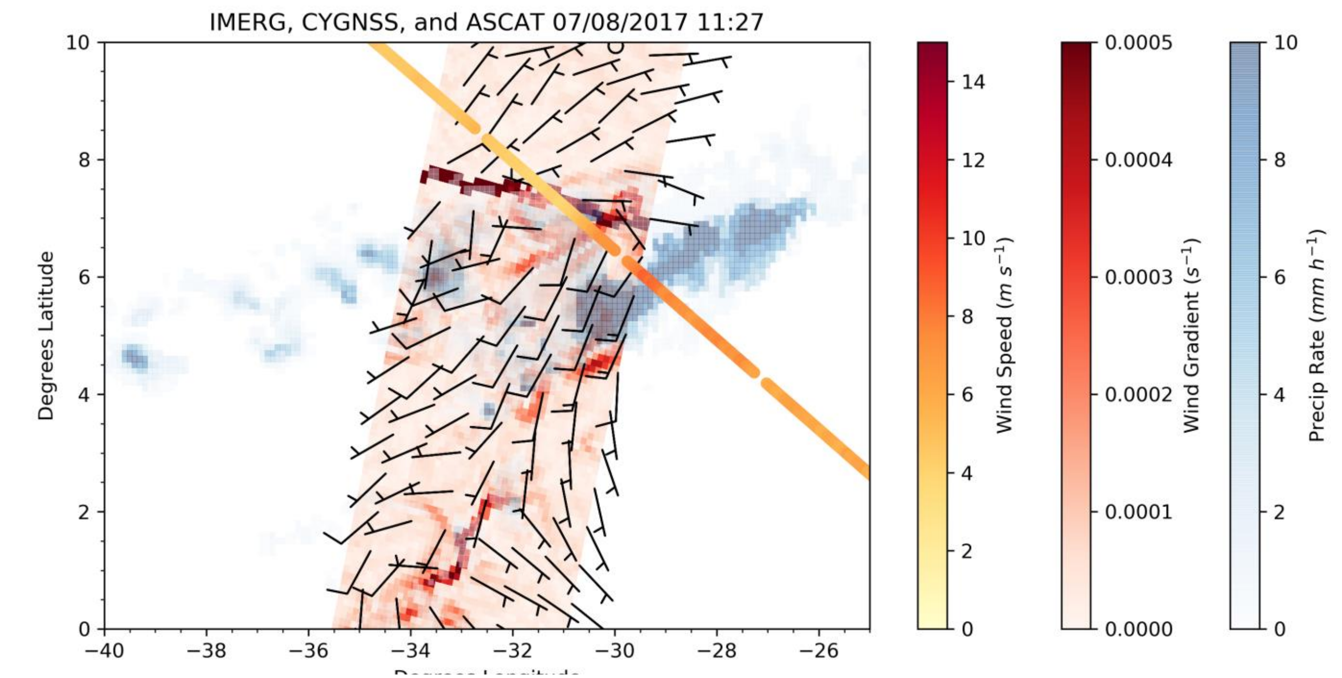
- Consistent with presence of more intense convection – more gust fronts expected!
- Or related to ship reflections from busy shipping lanes?

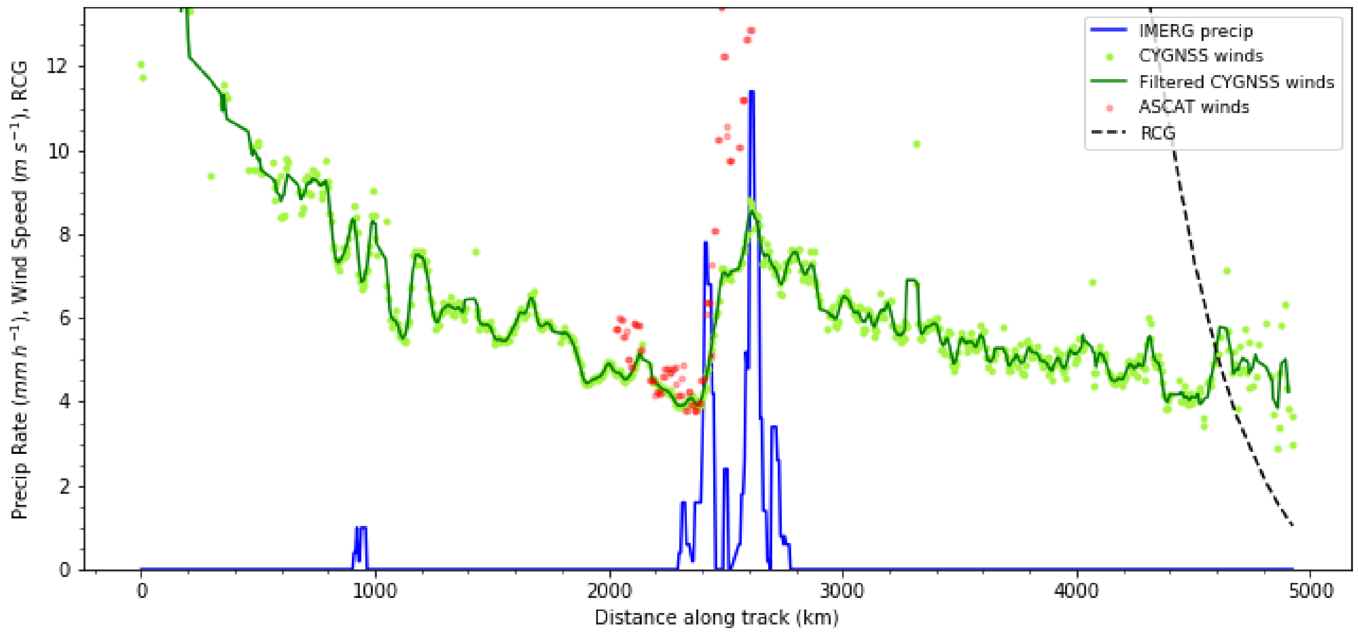


Ruf et al. (2018)

Convective Signatures in CYGNSS Data

- Combine CYGNSS specular point tracks with IMERG precipitation
- Have found numerous examples of wind gradients (B) in/near significant convective precipitation (A)
- Gradients not always observed in NWP analyses





- May 2017 thru January 2018, v2 CYGNSS vs. PO.DAAC 12.5-km coastal ASCAT A/B
- Search for CYGNSS wind gradients – require > 10 mm h^{-1} and > 3 m s^{-1} change over 100 km
- ASCAT GFs commonly found in vicinity of CYGNSS wind gradients
- CYGNSS demonstrates relative insensitivity to rainfall

CYGNSS - ASCAT	Samples	Bias (m s^{-1})	RMSE (m s^{-1})
All	160367	+0.2	2.2
Rain	54552	-0.1	2.7
No Rain	105815	+0.3	1.9

Conclusions

- Convective signatures are evident in scatterometer data
- Polarimetric and Doppler radar is useful to help cross-check winds and rain flags and thus help distinguish between good/corrupted patterns
- GF technique shows excellent promise, particularly when applied to higher-resolution data
- Potential corroboration of enhanced convection in busy shipping lanes (or evidence that ships/wakes do provide significant scatterometer signature)
- CYGNSS provides a new avenue for cross-checking scatterometer-detected convective signatures