Tropical Processes Applications for CYGNSS

CYGNSS Applications Workshop
31 October to 2 November 2017
Monterey, CA

Motivation

The Cyclone Global Navigation Satellite System (CYGNSS) is focused primarily on observing extreme winds in the inner core of tropical cyclones

But …

- Named storms will occur in view of CYGNSS constellation for only a small percentage of the time on orbit

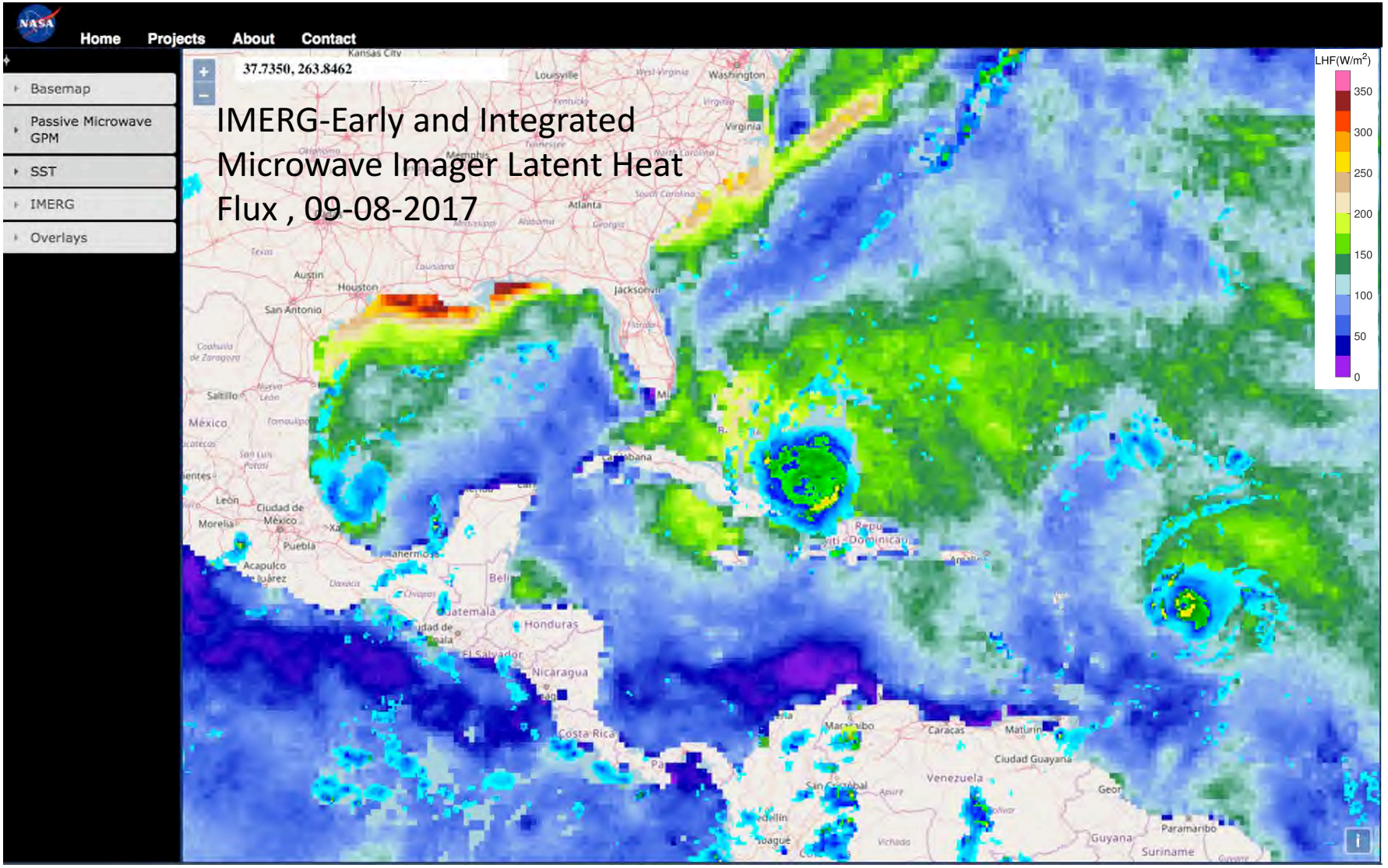
And …

- Rapid-update, all-weather sampling of wind speeds has many other applications in Tropical Meteorology

So …

- Many potential tropical processes applications for CYGNSS were identified in previous Workshop – Let's revisit some of these possibilities now that the mission is up

CYGNSS Value Added



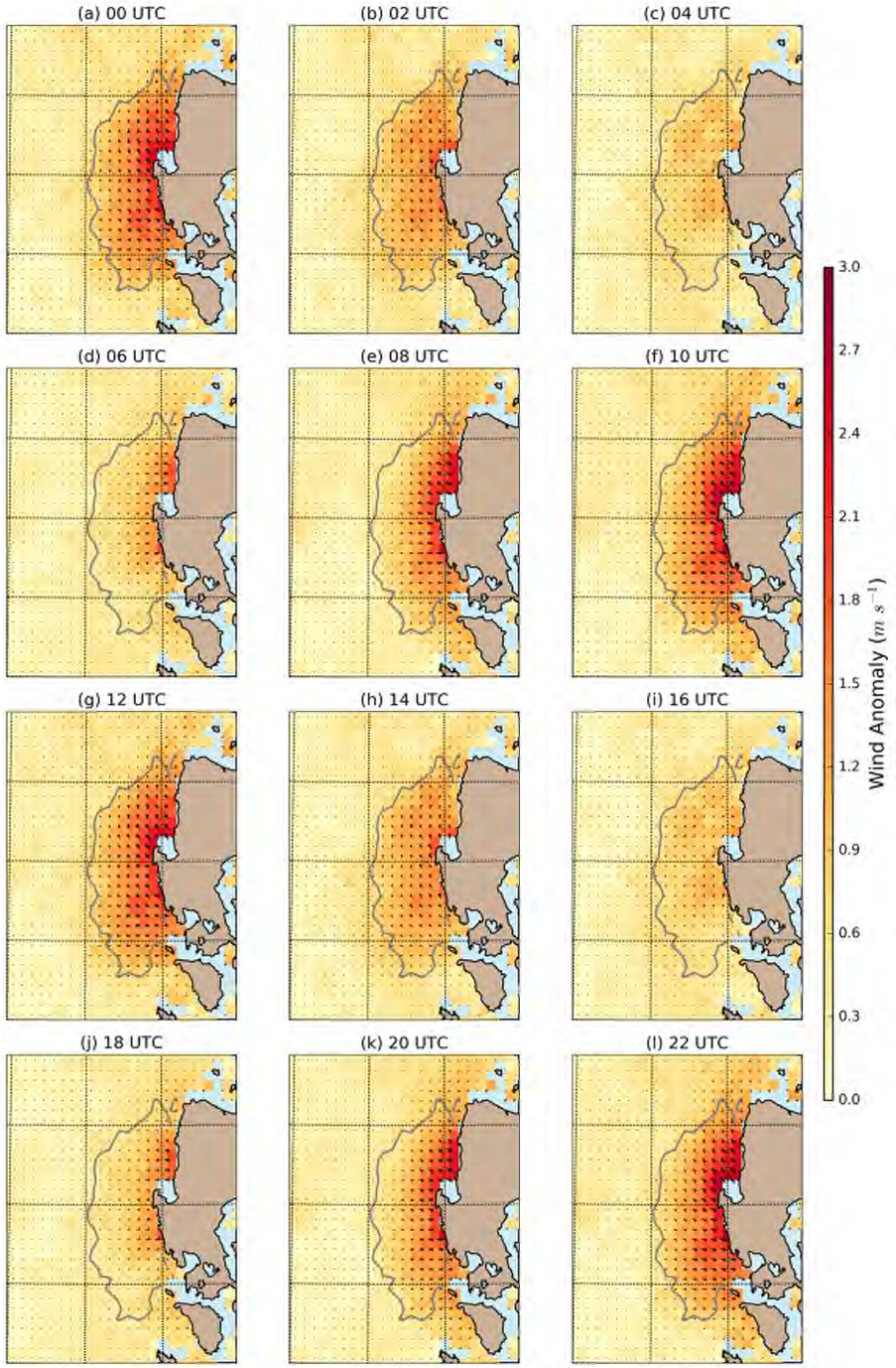
Brent Roberts, NASA MSFC

CYGNSS Value Added - Filling in wind and even heat flux measurement gaps in rainy regions

CYGNSS Value Added

Sub-diurnal sampling due to 2-3 hour revisit cycle

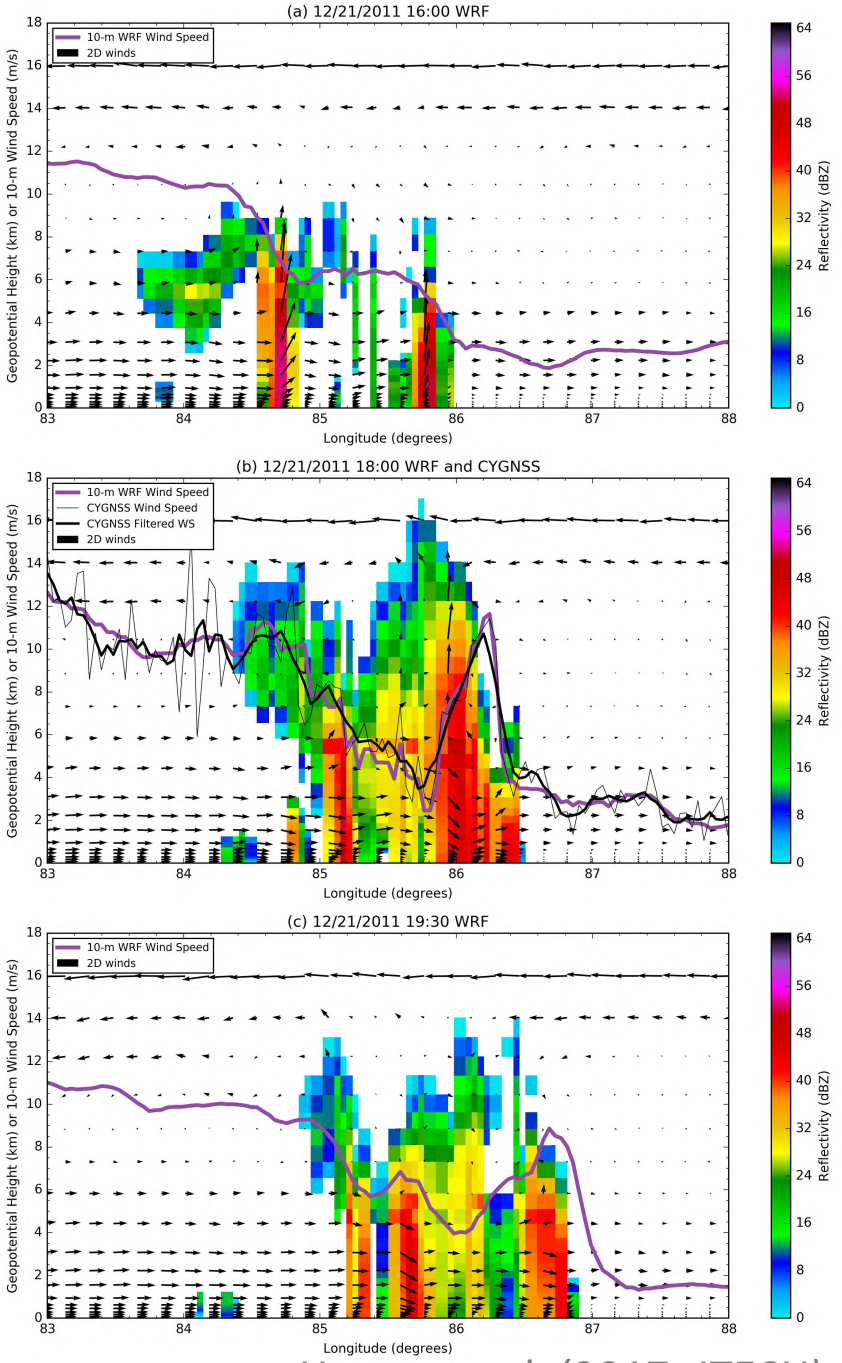
Partially returns wind diurnal cycle resolution lost when RapidScat mission ended



Lang (2017; JGR)

CYGNSS Value Added - Mesoscale Convective Systems

- Fundamental building block of tropical convection, key source of marine hazards and impacts
- Near-surface inflow winds feed with moisture
- Outflows trigger additional convection
- Size and longevity consistent with CYGNSS capabilities (About 25-km spatial, 3-h temporal sampling)
- CYGNSS capable of observing gust fronts, etc.



Hoover et al. (2017; JTECH)

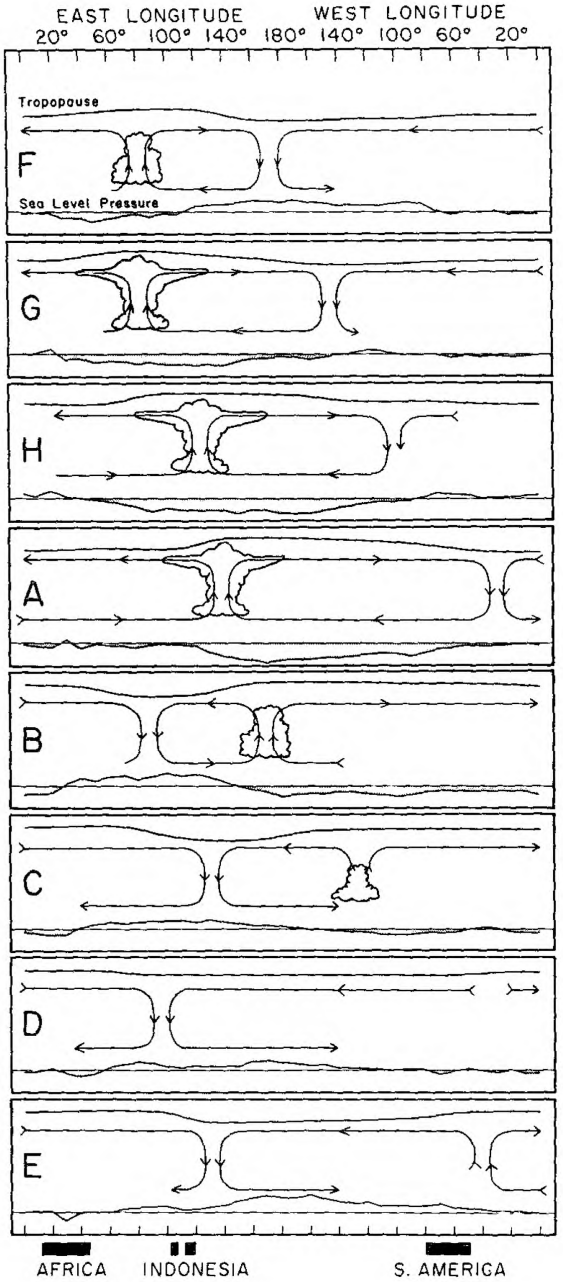
Sample Topics

- Madden-Julian Oscillation
- Monsoons
- Extratropical transitions and storms
- Atmospheric rivers, heavy rain, and flooding

MJO

Monitoring and Forecasting the Madden Julian Oscillation (MJO)

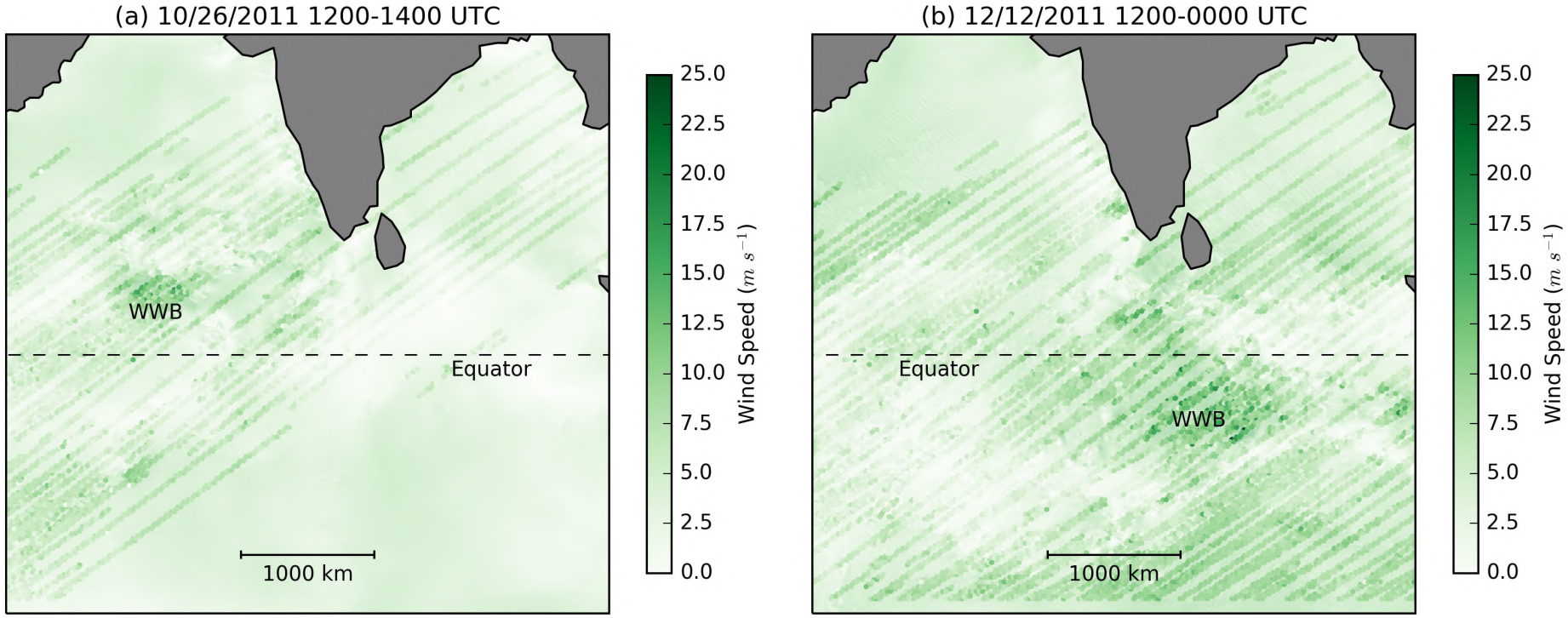
- Fundamental mode in the tropical atmosphere, 30-90 day cycle
- Upscale development of convection during active phase (convection-related convergence & outflows)
- Strong westerly winds common during suppressed phase
- Predictability issues near Maritime Continent, possibly related to interaction with diurnal cycle there
- CYGNSS thus has applications to improving monitoring and forecasting of MJO development and evolution



Madden and Julian (1972)
Zhang (2005)

MJO Onset and Westerly Wind Bursts (WWBs)

- CYGNSS capable of observing enhanced wind speeds in WWBs that are often associated with enhanced rainfall and convection
- Note spatial sparseness – tradeoff with increased temporal revisit, applications need to account for this



Hoover et al. (2017; JTECH)

MJO Applications Thoughts

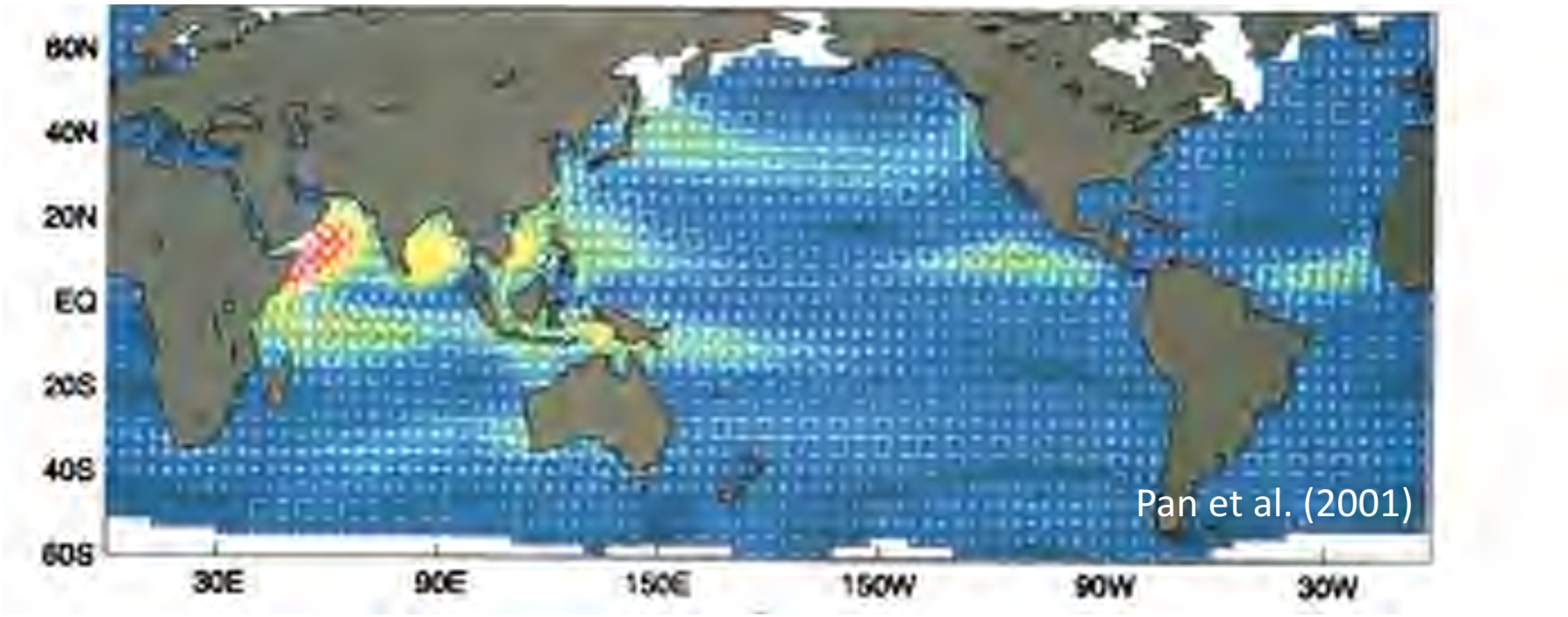
- First Applications Workshop found MJO monitoring and forecasting to be a promising role for CYGNSS – Does not necessarily require reduced data latency for sub-seasonal forecasting

- R&D Needed - Model and data assimilation enhancements to preserve CYGNSS winds, CYGNSS reprocessing to improve spatial resolution near coasts, Investigation of viability of wind direction retrievals from CYGNSS

- Potential End Users - Global and regional forecasting agencies, Water resources agencies, Militaries, Agricultural industry

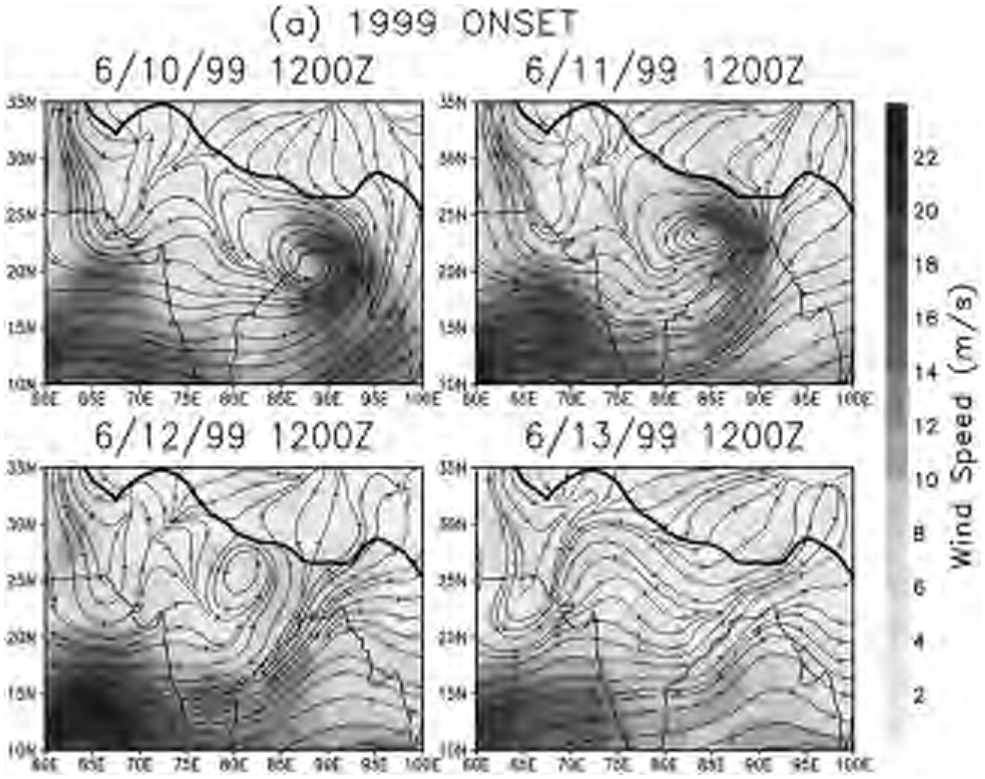
Monsoons

Monitoring and Forecasting Monsoons



- Scatterometer composites reveal seasonal variability of winds associated with Asian/Indian monsoons
- Resolution and coverage of CYGNSS can extend this to short time scales, where variability is driven by the diurnal cycle and the passage of individual convective weather systems
- These individual events (e.g., monsoon depressions) are the ones that impact society the most

Monsoon Depressions

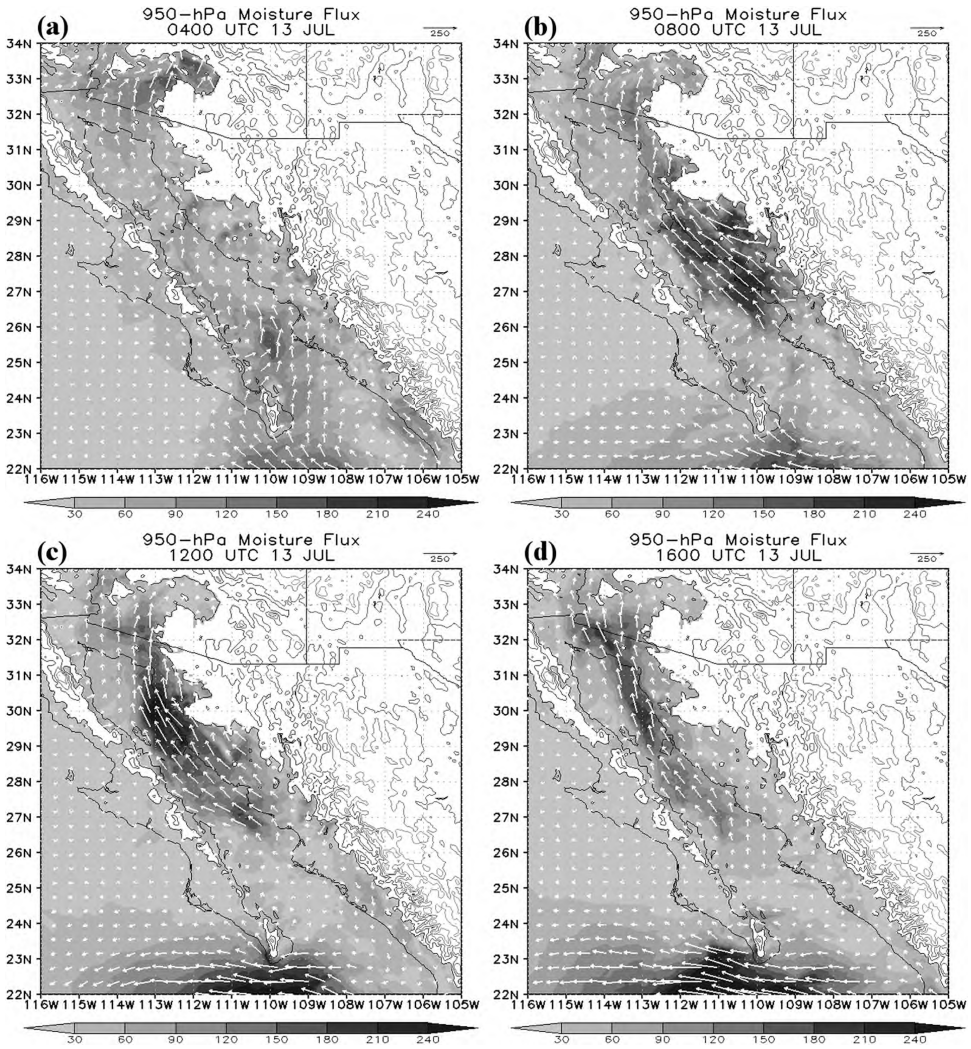


Lang and Barros (2002; MWR)

- Monsoon depressions often don't reach tropical storm intensity, but are significant during active periods of the Indian Summer Monsoon, bringing needed rainfall.

- CYGNSS can provide additional wind observations in rainy, over-ocean quadrants of the depression, potentially providing forecast value.

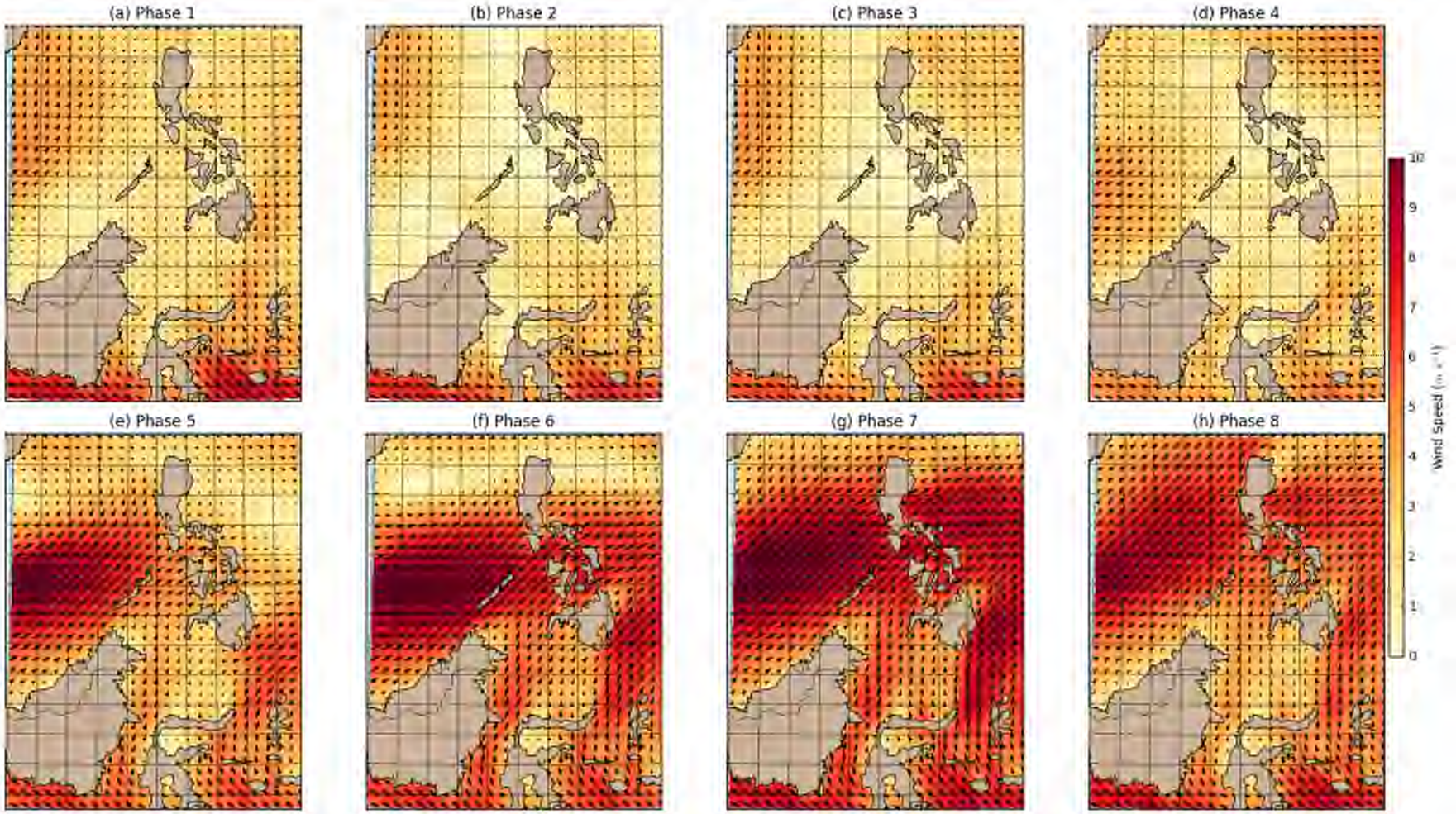
Gulf of California Moisture Surges



Newman and Johnson (2012; MWR)

- Important characteristic of North American Monsoon and major source of its impacts
- Can be initiated by strong convection or tropical cyclone
- Brings enhanced winds, moisture, and rainfall to the southwest USA
- Rapid process that can complete in < 1 day – CYGNSS can be useful here

CCMP Winds by BSISO Phase – July-September 1997-2013, Magnitude > 1



Lang et al. (2017; IOVWST Meeting)

Boreal Summer Intraseasonal Oscillation (BSISO) modulates Asian Monsoon, CYGNSS can provide additional sampling during heavily raining active phases - PISTON, CAMP^{2}Ex

Monsoon Applications Thoughts

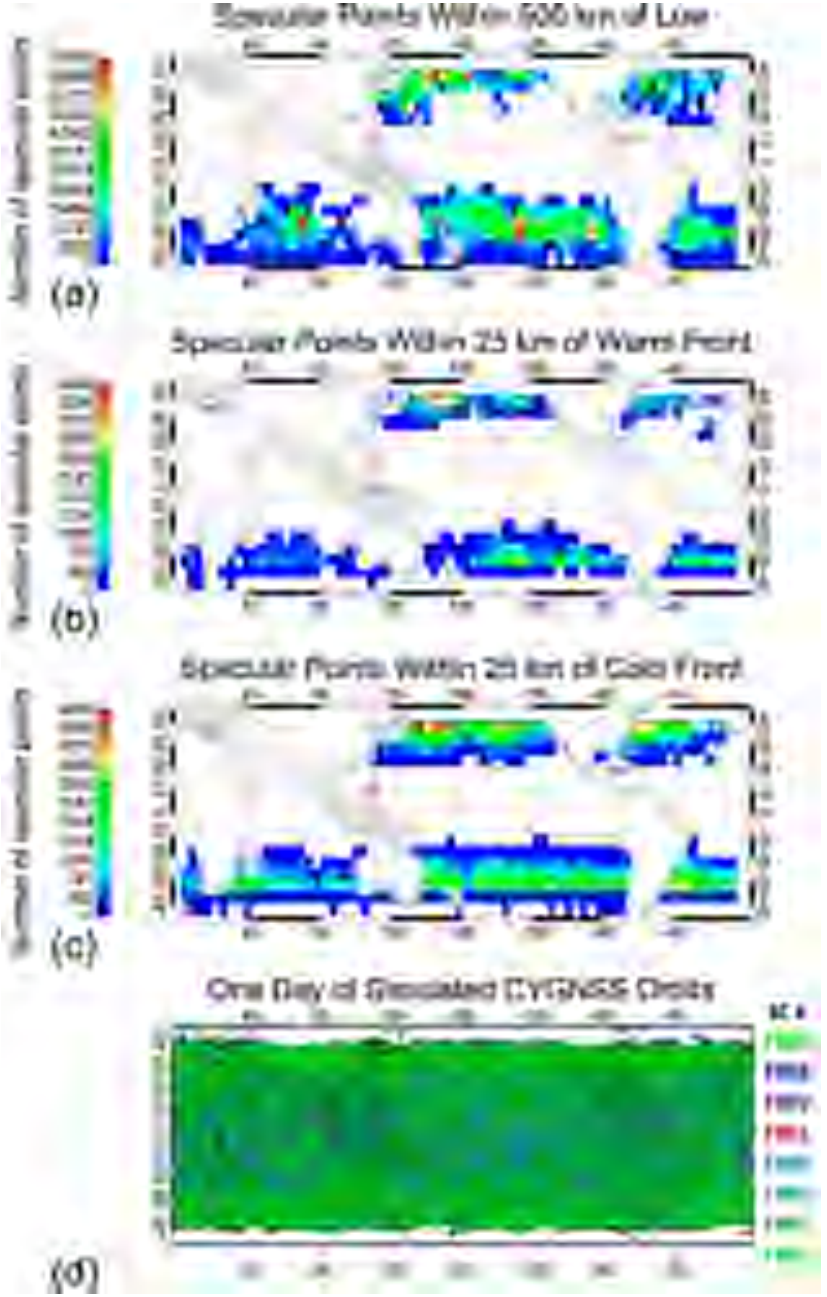
- CYGNSS monsoon applications can range from monitoring/forecasting individual events like depressions and Gulf surges (requiring latency < 1 day) to sub-seasonal active/break variability like the BSISO (allowing longer latency)

- R&D and End Users similar to MJO applications, but we should take advantage of near-term field campaigns like PISTON, CAMP^{2}Ex, YMC, etc. which have significant data assimilation, modeling, and forecasting components as well as NASA support

ET Cyclones

Extratropical Cyclones
(incl. ET transitions)

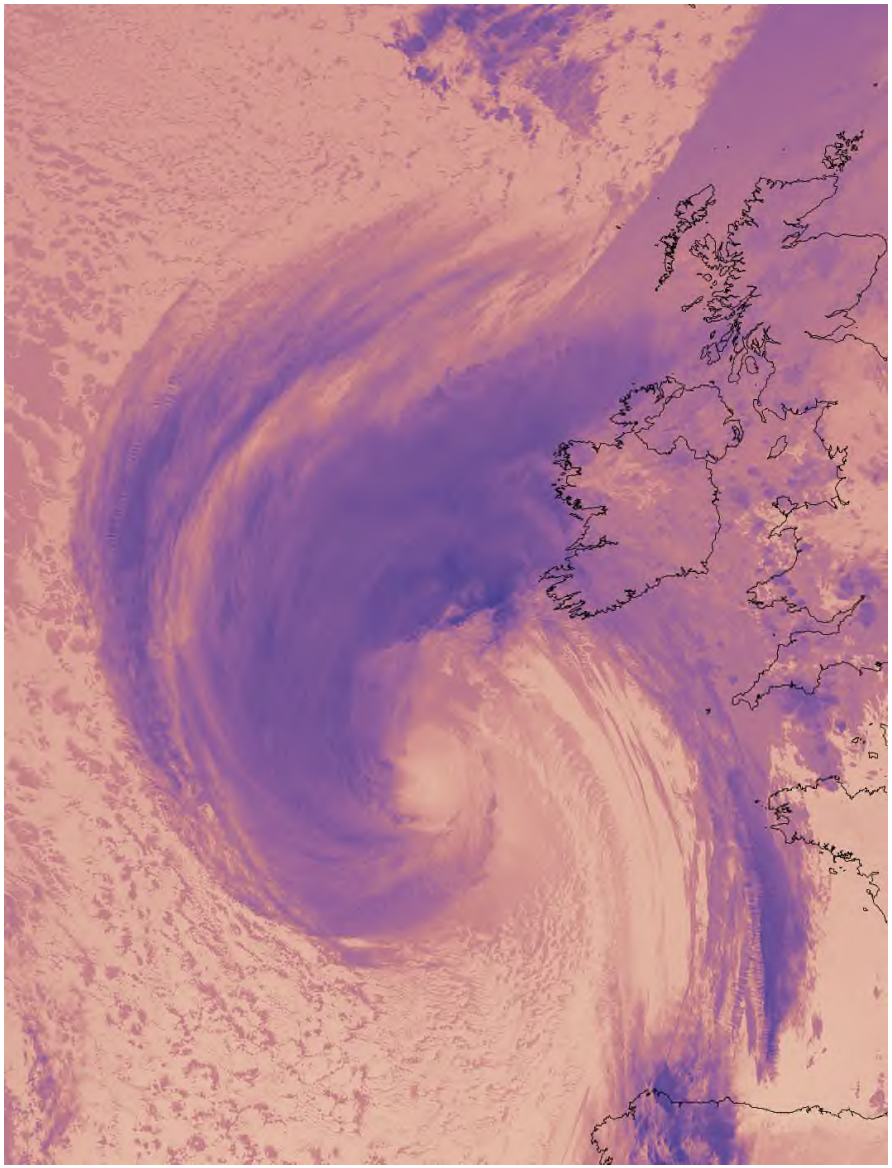
- ET cyclones often feature strong winds near cores and significant wind shifts across frontal zones
- ET transitions of TCs lead to unique hybrid storms that can retain severe weather potential
- Pre-launch simulations suggest CYGNSS will provide useful sampling of extratropical cyclones themselves, not just TC transitions



Crespo et al. (2017; JAMC)

ET Applications Thoughts

- CYGNSS roles include filling scatterometer gaps and enhancing temporal continuity of wind obs
- ET transitions can be rapid, requiring low-latency data (< 1 day)
- Canada and Europe often affected by storms that underwent ET transition
- Potential applications will need to account for limited viewing region of CYGNSS

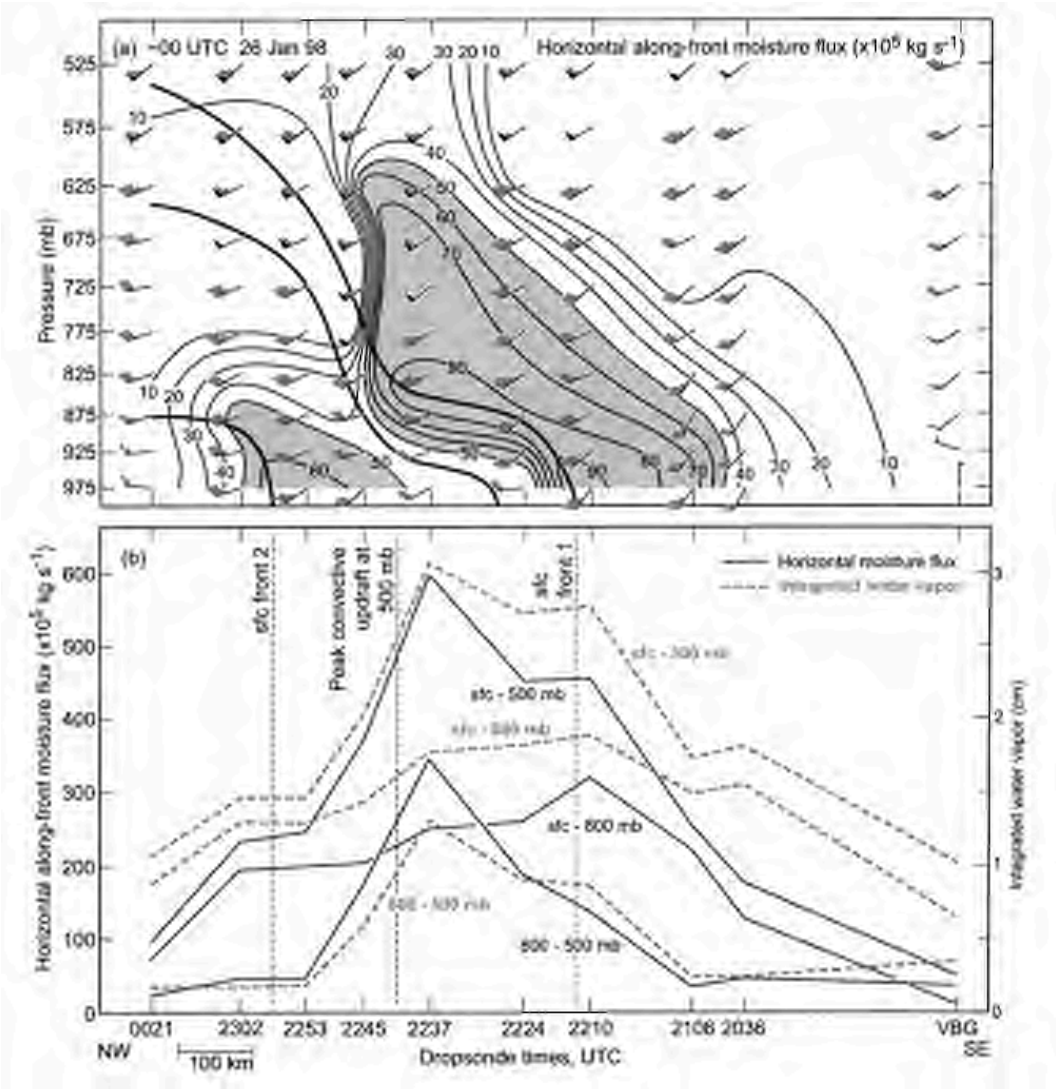


NASA

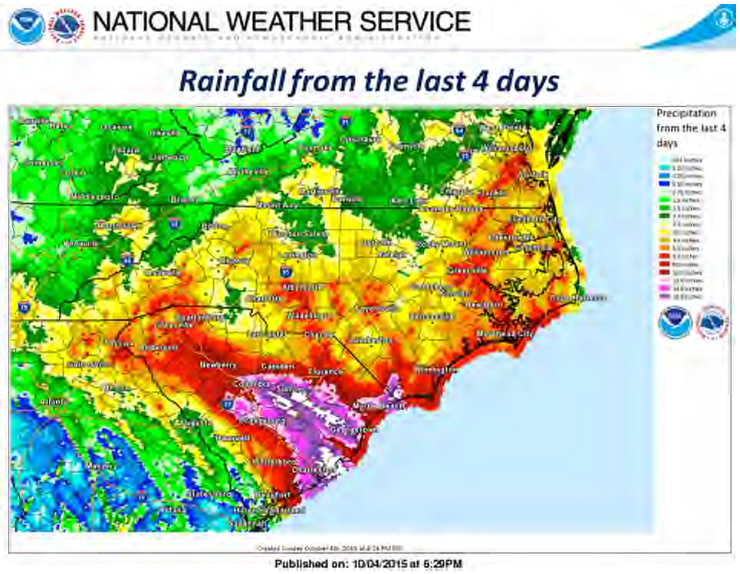
ARs, Flooding

Atmospheric Rivers

- Narrow (< 1000 km width), long (> 2000 km) plumes of water vapor connecting tropics to the mid-latitudes
- Often described using integrated water vapor (IWV) or Integrated vapor transport (IVT)
- Associated with significant precipitation/flooding events when they reach land
- CYGNSS able to view near-sfc winds even when heavily raining



Ralph et al. (2004; MWR)



- ARs and AR-like events often associated with TC landfall or passage (e.g., Joaquin & SC floods, 2015)
- Significant offshore mesoscale variability in winds associated with precip maxima

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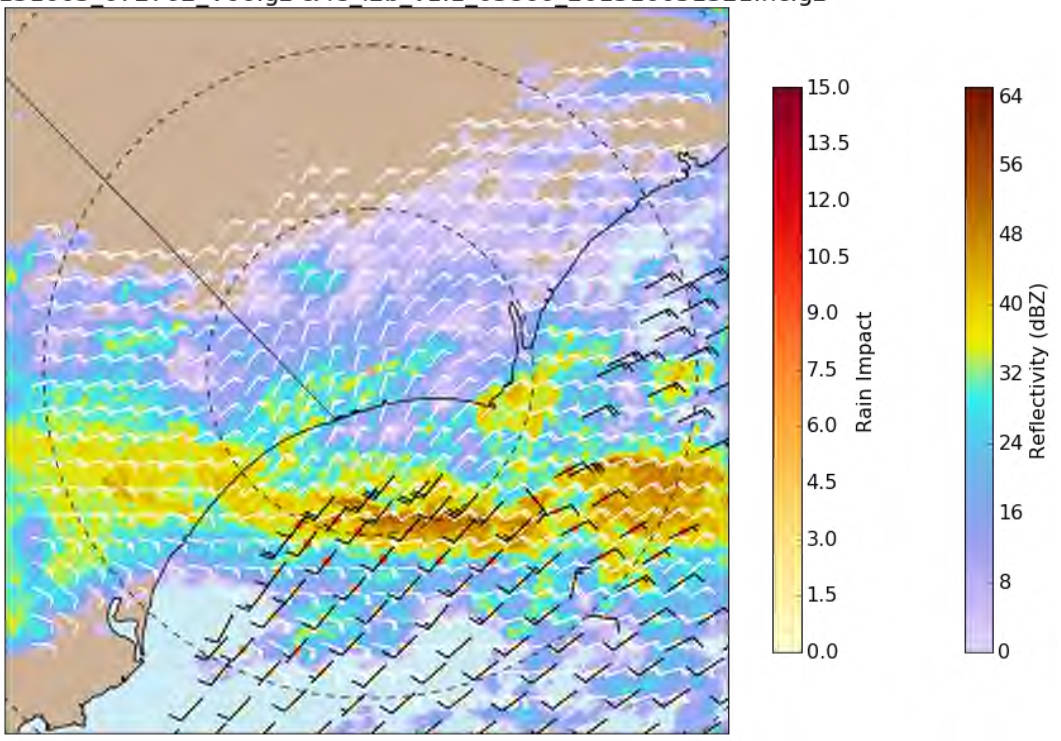
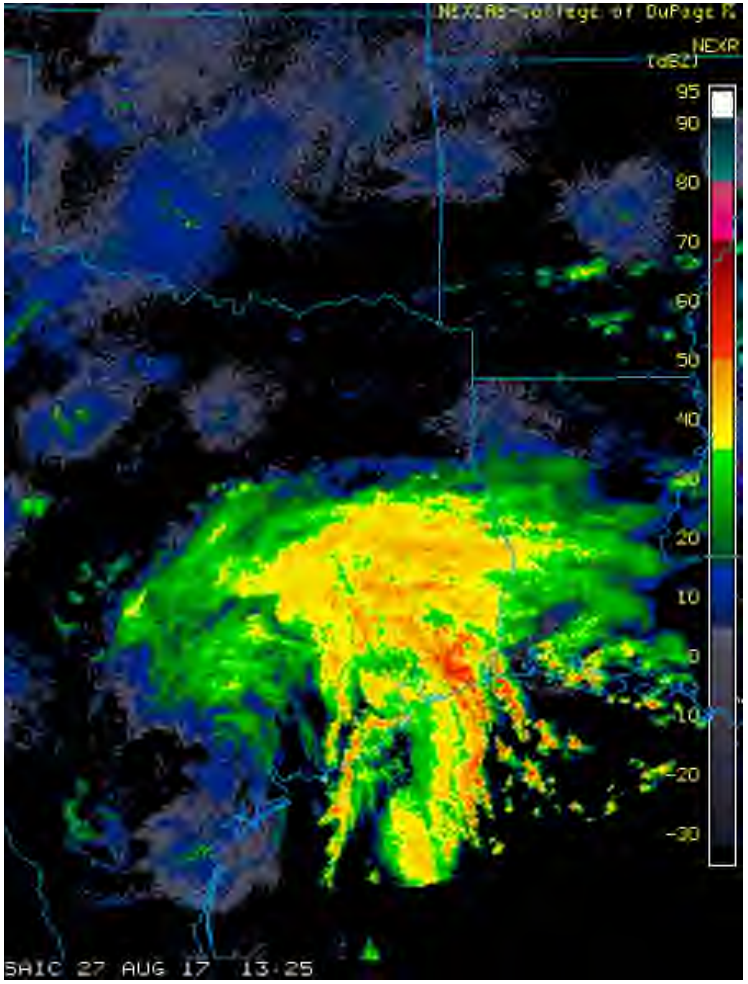


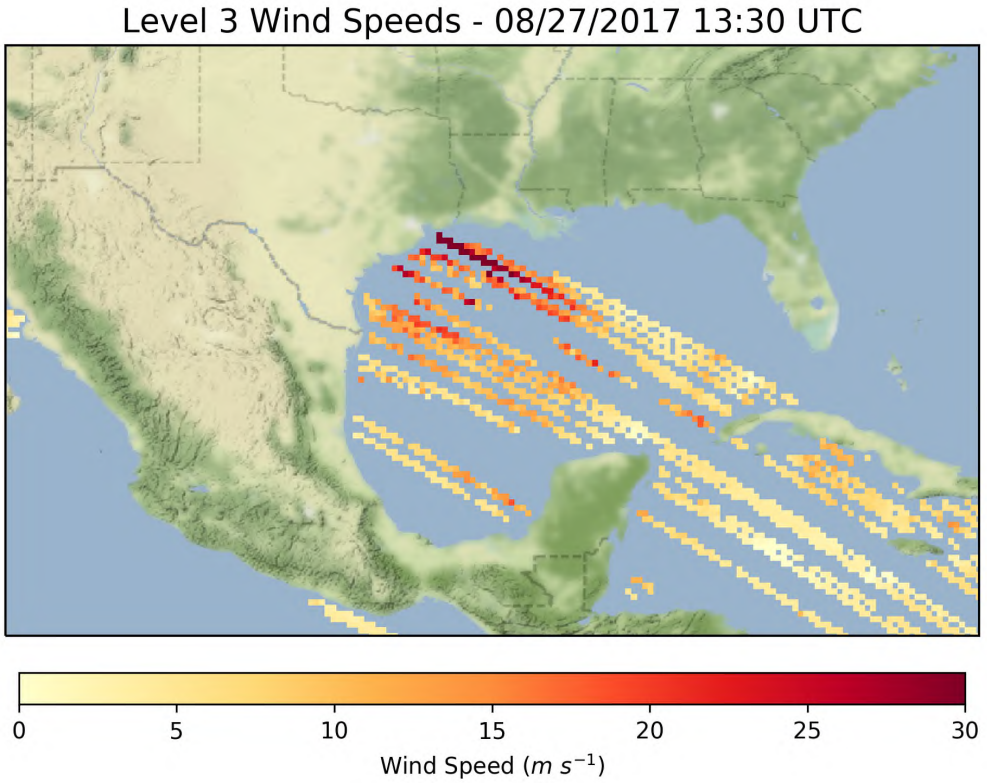
RapidScat + NEXRAD Reflectivity & Single-Doppler winds

Lang et al. (2016; IOVWST Meeting)

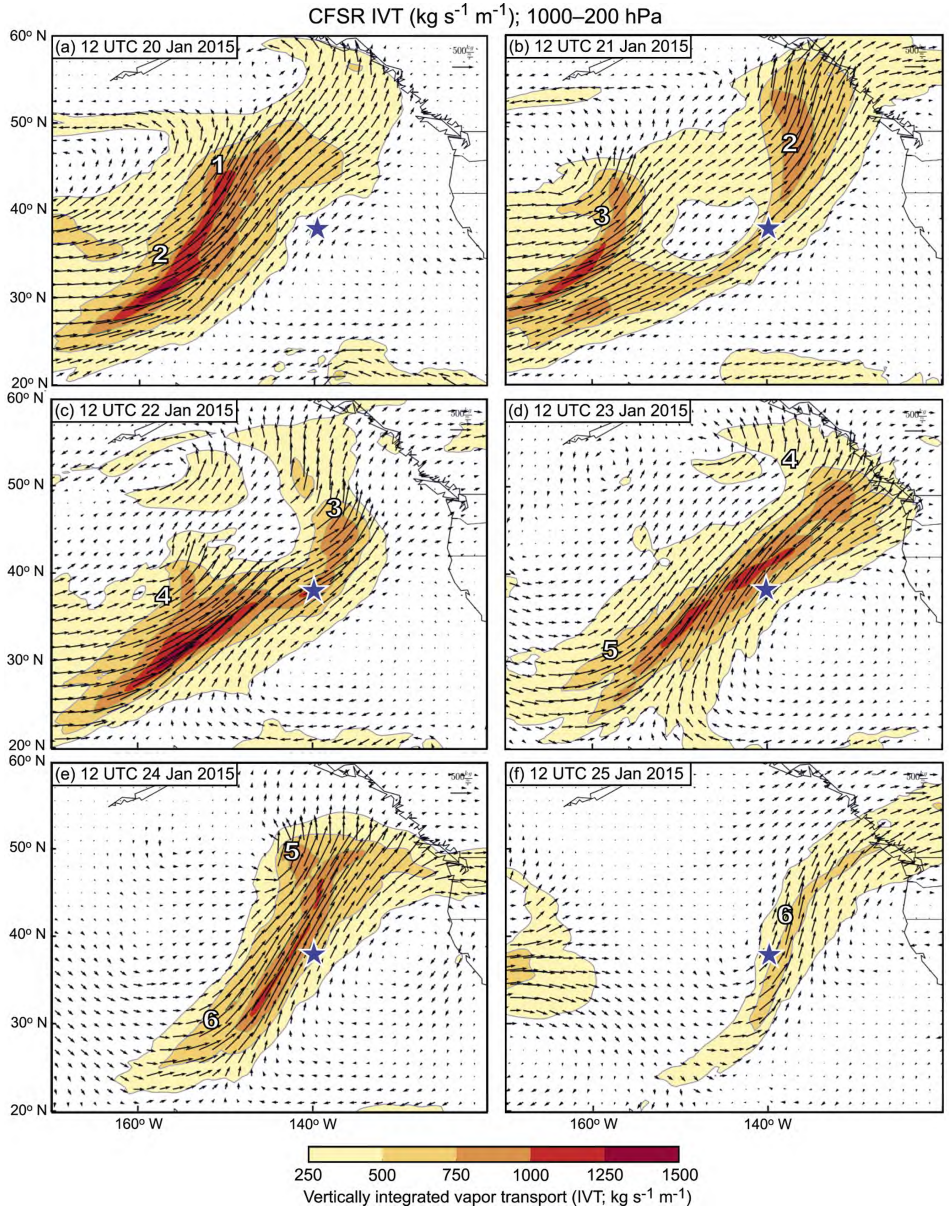
Harvey – Extreme Rainfall Post-Landfall



NCAR Image Archive



- Preliminary CYGNSS L3 indicates increased winds offshore during event, potential mesoscale variability



Neiman et al. (2017; MWR)

AR/Flooding Applications Thoughts

- Impacts of improved forecasting could include better flood warnings and reservoir management
- ARs have complex 3D structures, surface only part of story
- Likely need low-latency CYGNSS data
- Applications will need to account for spatial sparseness of CYGNSS

Parting Thoughts

- Tropical process applications involving CYGNSS will work best when they leverage its more frequent updates and ability to sample in rainy regions
- Possible CYGNSS may observe mesoscale variability masked from traditional wind methods
- To fully take advantage, NWP must incorporate improved model physics, esp. momentum, heat, and moisture fluxes near ocean surface – how to get better T_a/Q_a obs?
- CYGNSS best when supplementing global observations of winds, humidity, pressure, temperature, precipitation, etc. Need to blend diverse wind products into a coherent 3D wind product.
- Low-latency data important, but some applications can do w/out