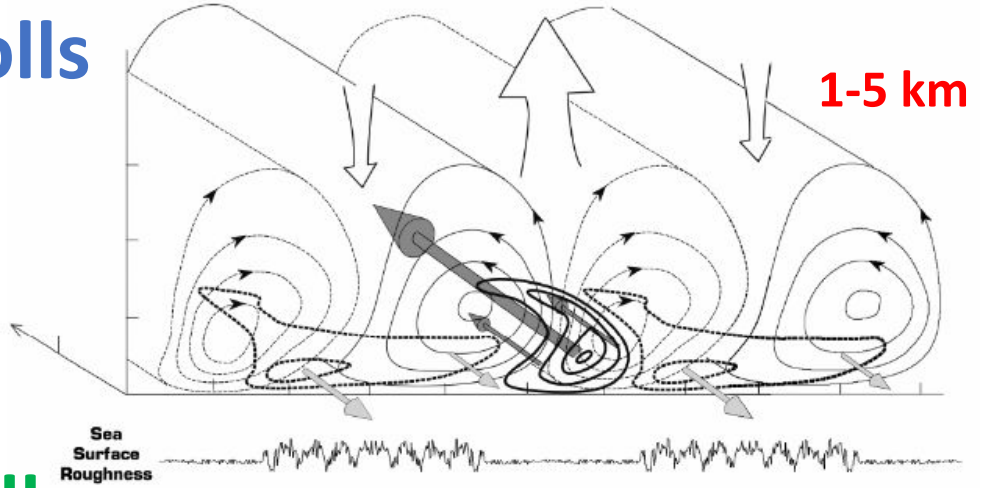


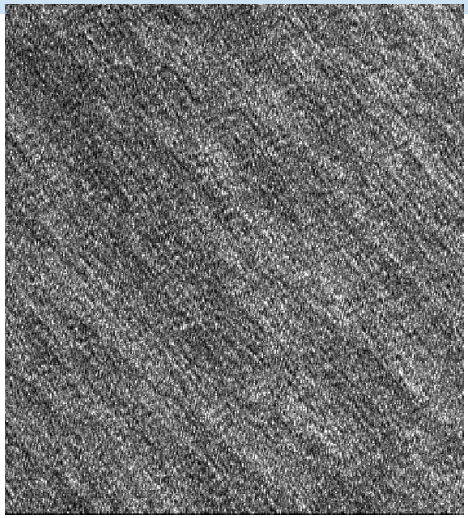
Modulation of Trade Wind Precipitation by Sub-Kilometer Boundary Layer Rolls and Convective Cells

Justin Stopa *The University of Hawai'i at Mānoa*
Ryan Eastman, Ralph Foster *The University of Washington*
Doug Vandemark, The University of New Hampshire
Alexis Mouche & Bertrand Chapron, *IFREMER*
Yannik Glaser & Peter Sadowski, *The University of Hawai'i at Mānoa*

SAR - sea surface roughness

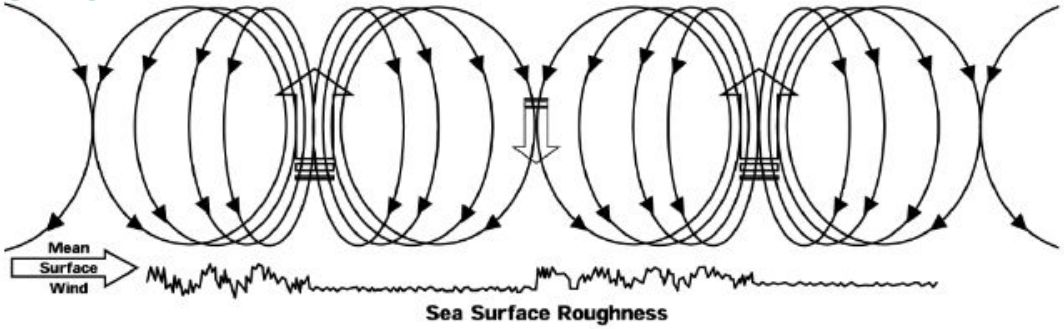
Rolls

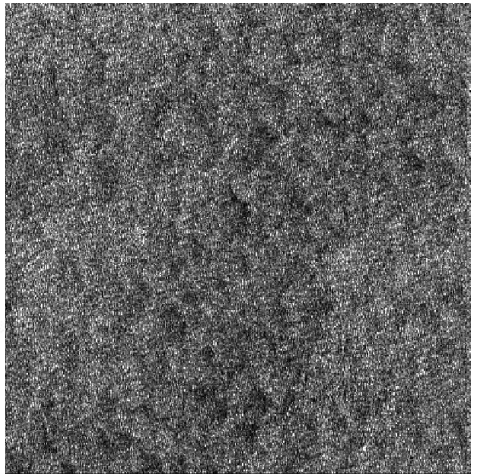




Wind Streaks - WS

Cells





Micro-scale convection MC

Methods: Textures→*Ri*

$$Ri = \frac{g}{T_{10v}} \frac{z_{10}\left(T_{10v} - SST_v\right)}{U_{10N}^2}$$

CS=coherent structure ~ cells or rolls

SAR detection using the sea-surface roughness
1) Microscale Convection (MC) - unstable (UBL)
2) Wind Streaks (WS) - near neutral (NNBL)
3) Negligible Variability (NV) - stable (SBL)
maps to *Ri* from ERA5

Method

- ML model detects phenomena
- Detection of multiple classes
- Using Sentinel-1 wave mode ~ 20 km frames, global coverage

Stopa et al., GRL 2022

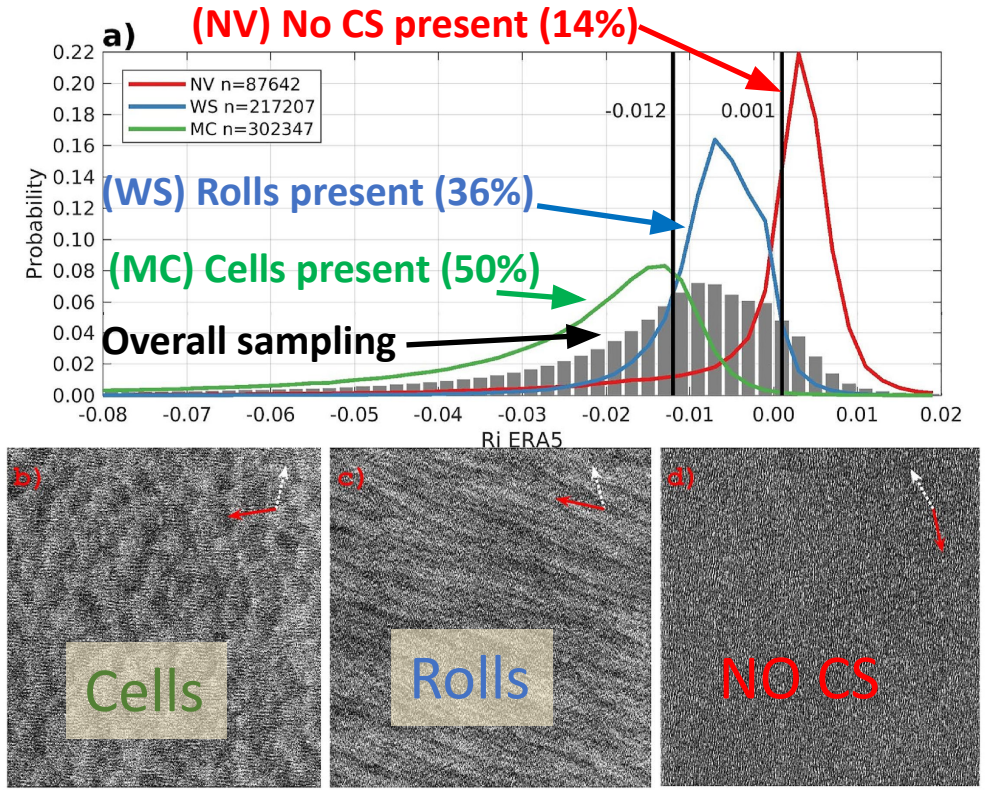
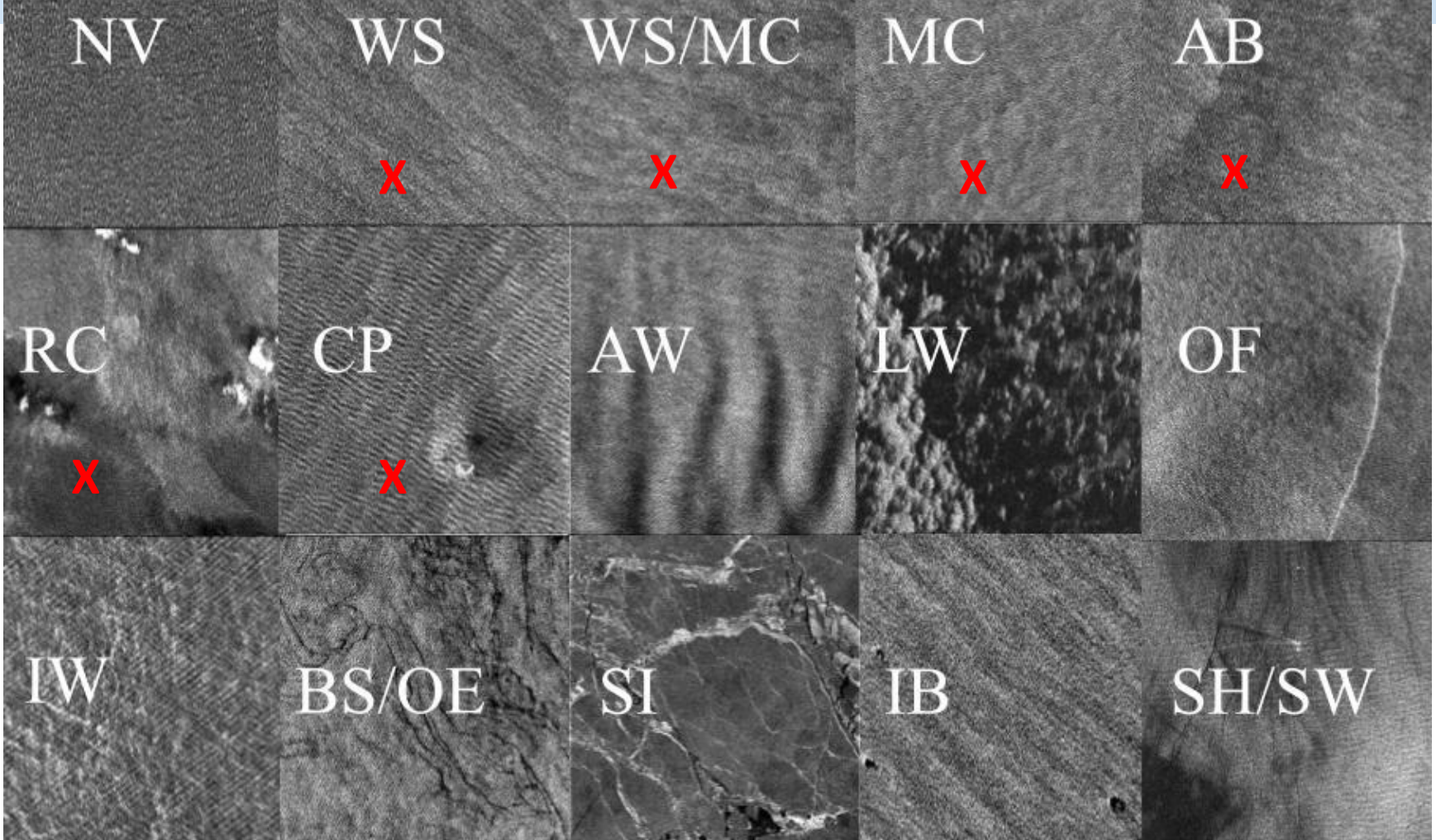


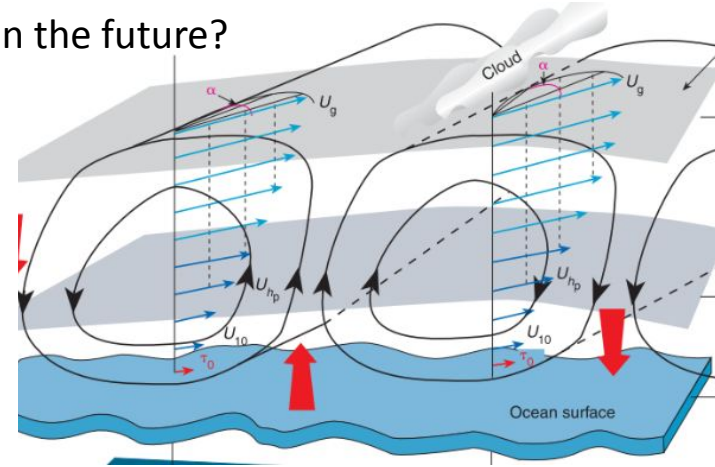
Figure 1. (a) PDFs of MABL *Ri* estimated from ERA5 for cells (unstable), streaks (near stable), and negligible atmospheric variability (stable) detection from SAR. The shaded gray PDF denotes the entire WV2 population. Representative SAR images for (b) unstable $Ri = -0.032$, $U_{10}^N = 5.3$ ms^{-1}, $\Delta T_v = -2.81°$, (c) near-neutral $Ri = -0.006$, $U_{10}^N = 9.8$ ms^{-1}, $\Delta T_v = -1.74°$, and (d) stable $Ri = 0.005$, $U_{10}^N = 7.6$ ms^{-1}, $\Delta T_v = 0.84°$ MABL states. The white dashed arrow points north and the red solid arrow is the ERA5 wind direction.

GOALI = Global Oceanic & Atmospheric multi-Labeled Imagery



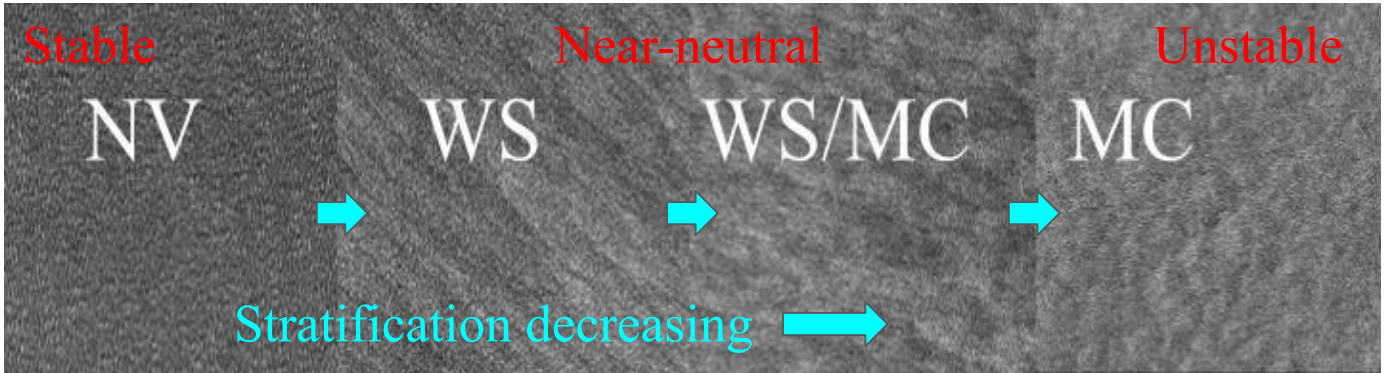
Science Questions

1. Is there coupling between the distribution of coherent structures (rolls→cells) within the sub-cloud MABL and the precipitation?
   1.1. Are rolls or cells more likely to be associated with precipitation?
   1.2. Is a region dominated by rolls or cells more likely to rain in the future?

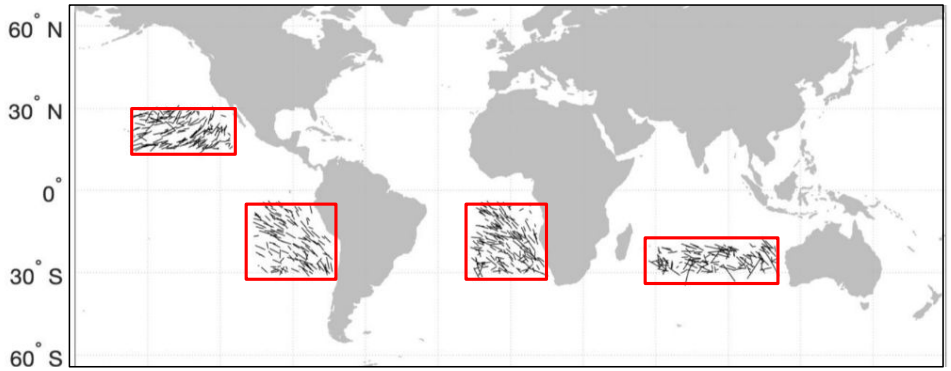


Results

1) Radiometers (GMI, COWVR, WINDSAT) agree
2) Convective events - more CLW and vapor
3) WS - low CLW, vapor increases with increasing U10
4) WS/MC - low CLW & vapor
5) MC - as U10 increases: CLW increases, vapor decreases



Domain and Datasets



Datasets

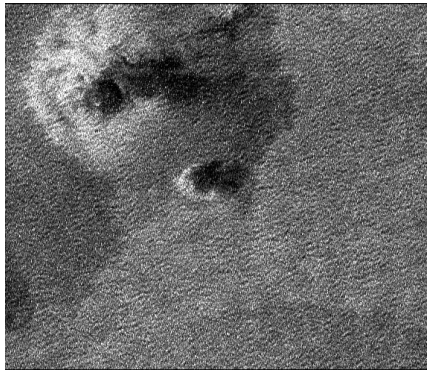
- MABL state - estimated from SAR textures
  - S-1A/B/C/D – 2014, 2016, 2024, 2025
  - Probabilities of rolls, cells, rain, etc.
  - 06/18 daily EQ crossing

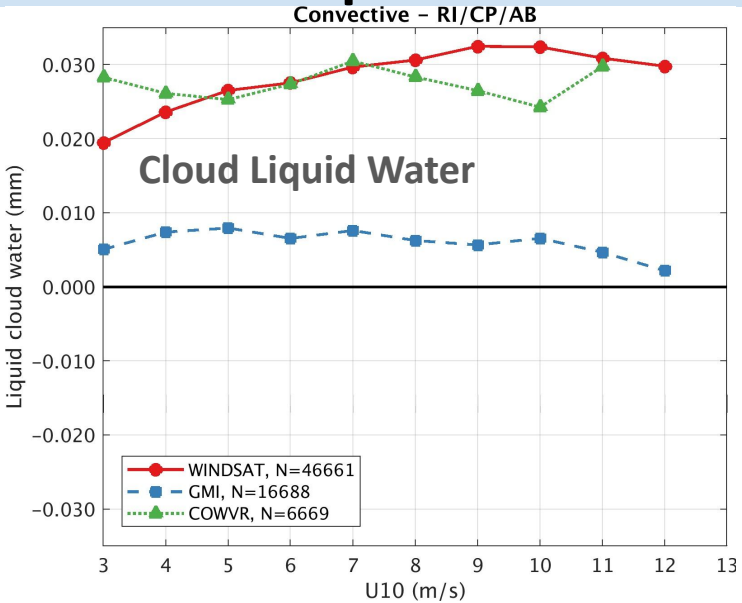
- Precipitation: Cloud Liquid H20, vapor, (rain rate)
  - **WINDSAT** - 06/18 crossing ~ 0.4° no 89 GHz
  - **COWVR** - non-sun syn.~0.25°
  - **GMI** - non-sun syn. ~0.25°
  - **AMSR2** - 01/13 crossing ~0.1°

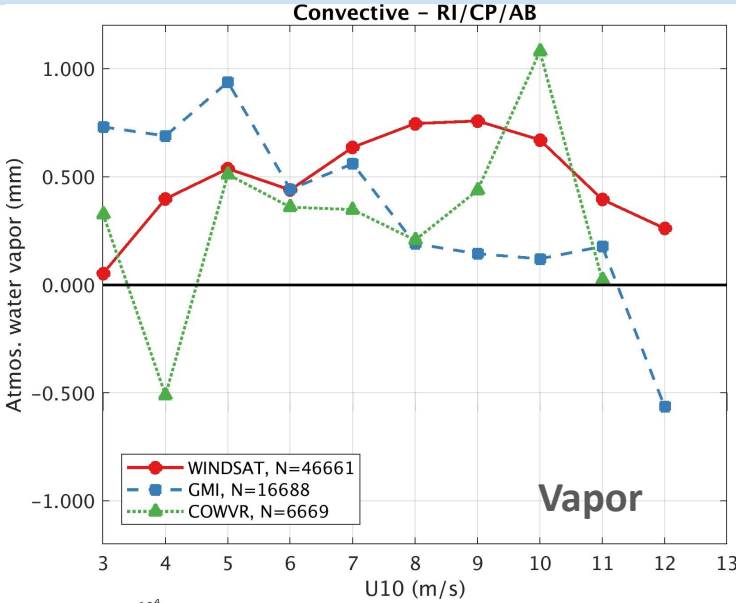
Domain

- Subtropical Ocean
- Regions analyzed together

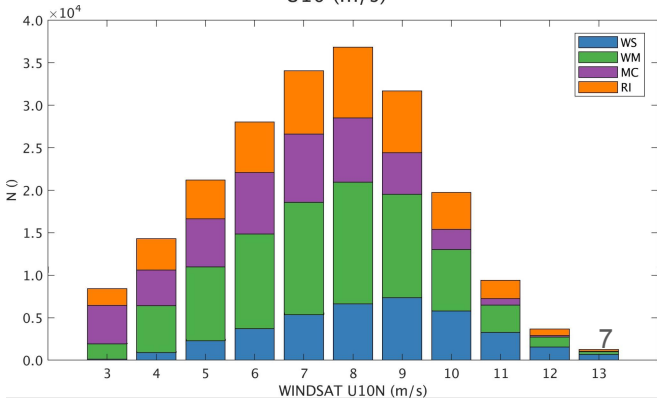
Convective Events vs Precipitation





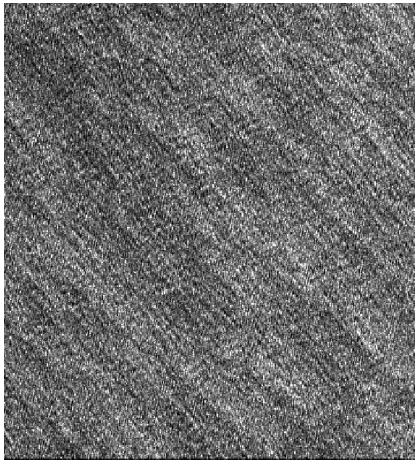


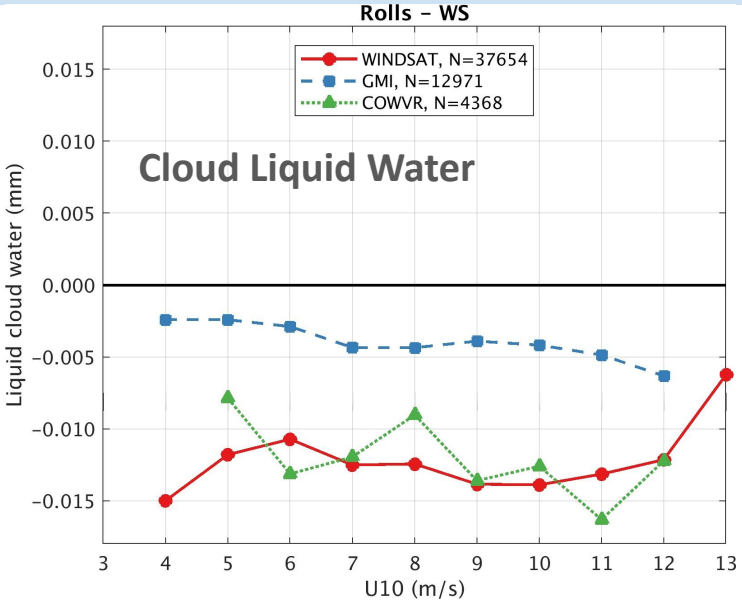
- Anomalies - removed the mean of each U10 bin
- ‘Pure’ WS - nothing else… high confidence in model output (low false positives)
- N~300K, 100K, 35K, →WINDSAT, GMI, COWVR

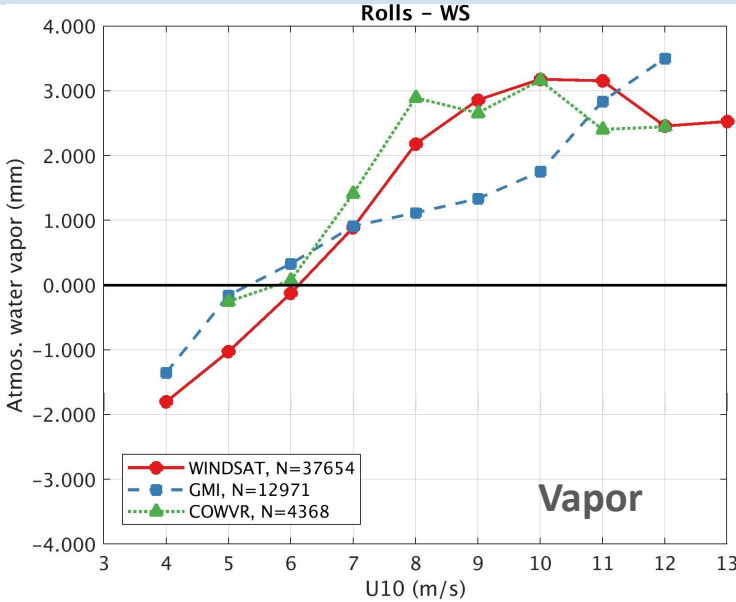


- High CLW and vapor - No surprise!

Rolls vs Precipitation



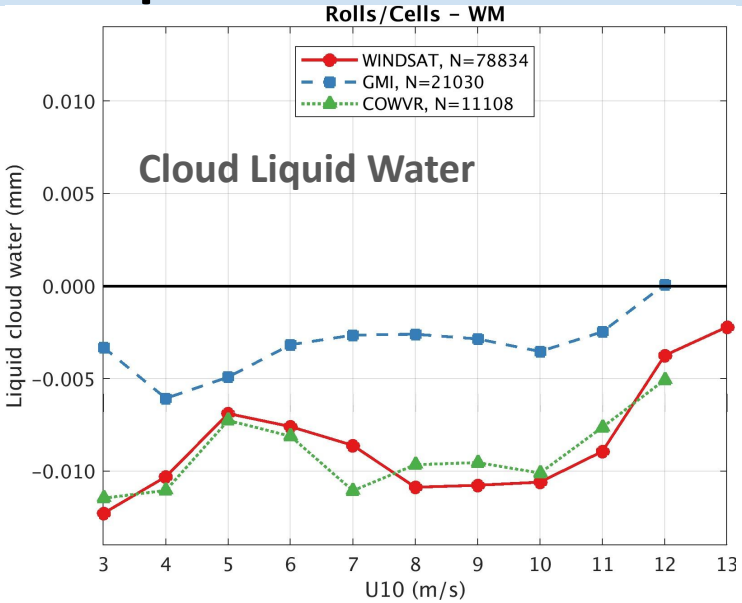


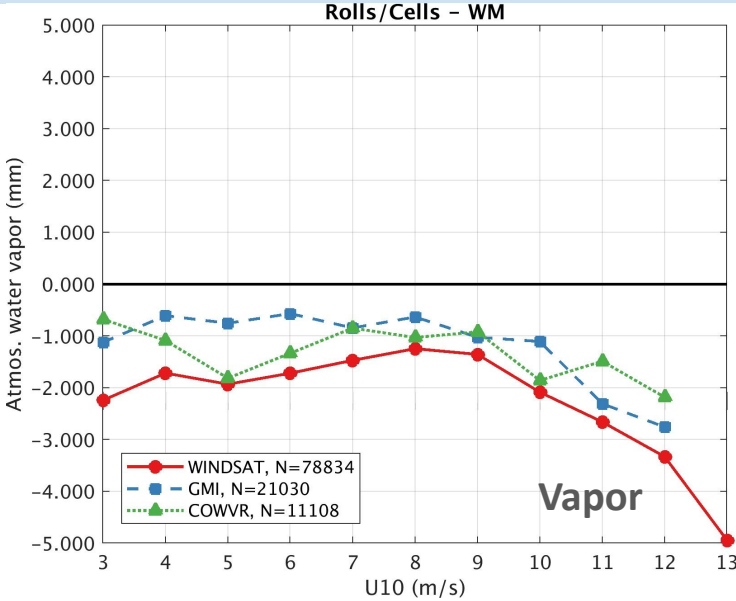


- Low liquid cloud water
- Low vapor when U10N<6 m/s, high vapor when U10>7 m/s

Rolls/Cells vs Precipitation



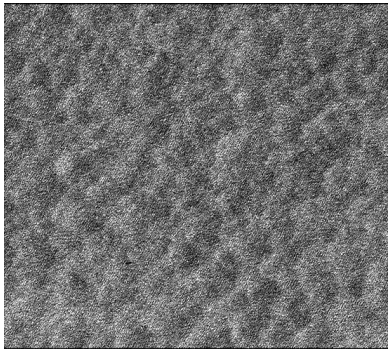


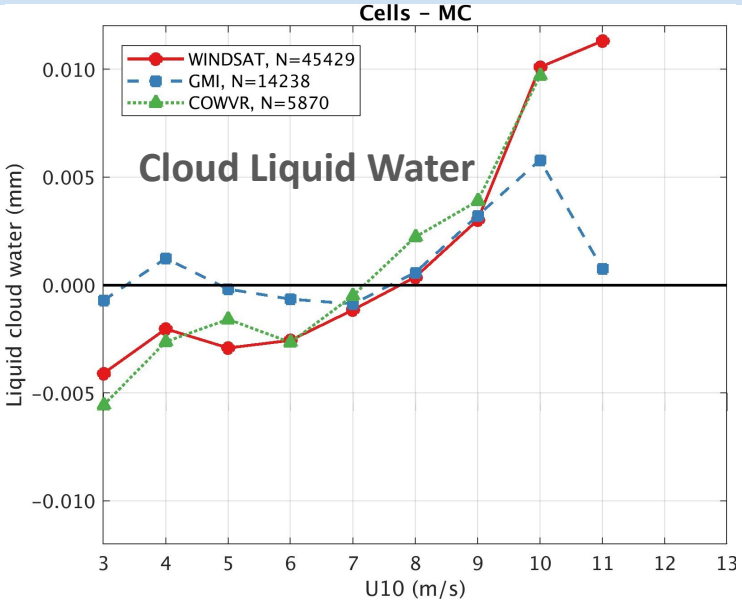


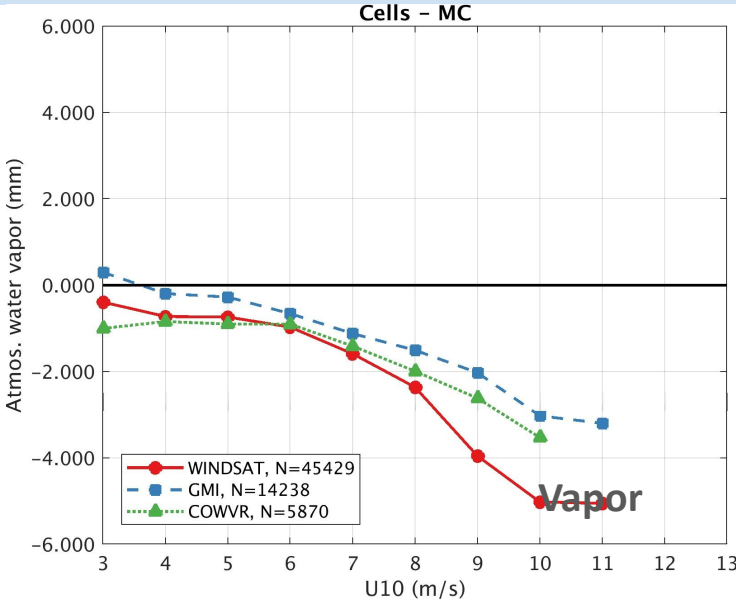
- Agreement between radiometers

- Low liquid cloud water
- Low vapor

Cells vs Precipitation

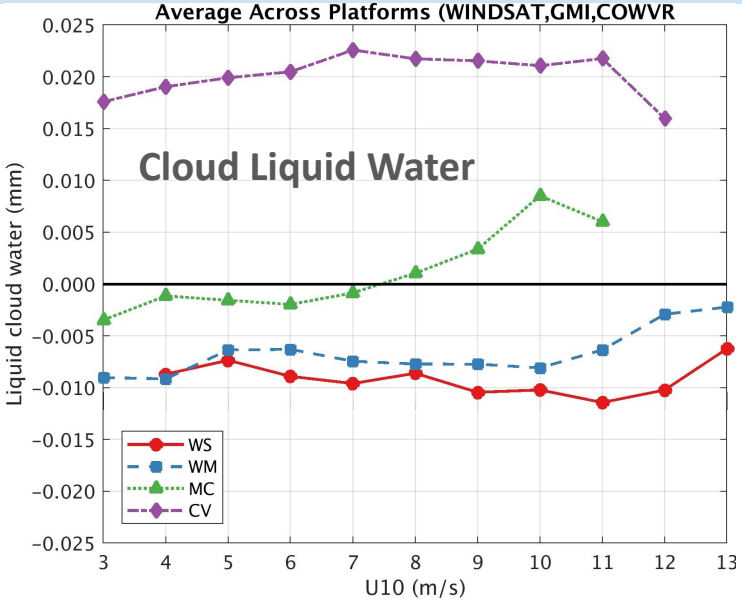


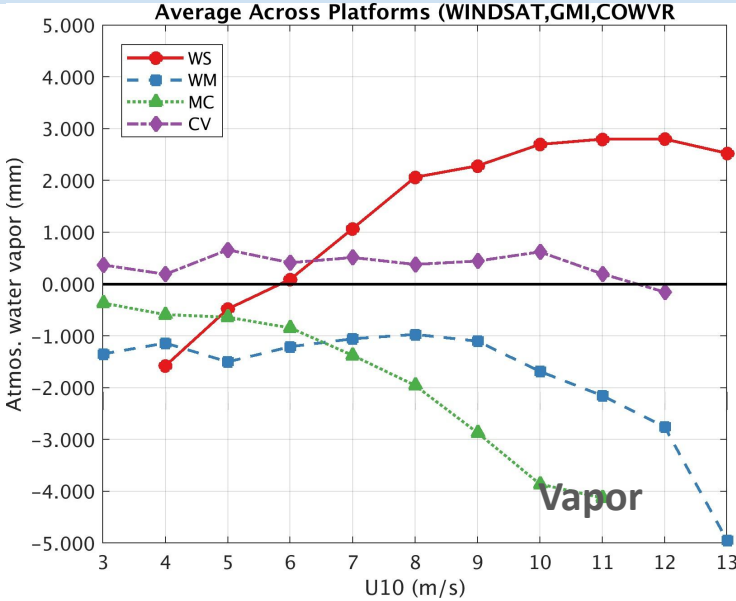




- Low CLW when U10<7 m/s, high CLW when U10>7 m/s
- Low vapor decreases with increasing U10

Summary





- RC/CP/AB - more CLW and vapor

- WS - low CLW, vapor increases with increasing U10
- WS/MC - low CLW & vapor
- MC - as U10 increases: CLW increases, vapor decreases

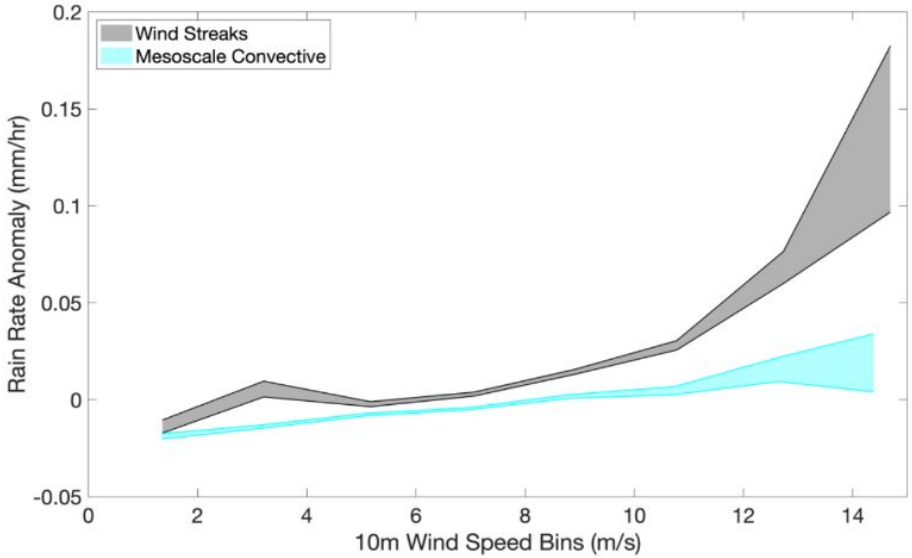
Rolls and Cells vs AMSR/2

- AMSR/2 has 1:30 AM/PM passes
- forward/backward Lagrangian trajectories to match the datasets
- Rain rate ∝ CLW

- WS - high rain rate
- MC - low rain rate
- Convective cases agree (not shown)

- Are these results conflicting?
- Are WS more likely to rain ~6 hrs later?
- Did the boundary layer change too much (diurnal signal)?

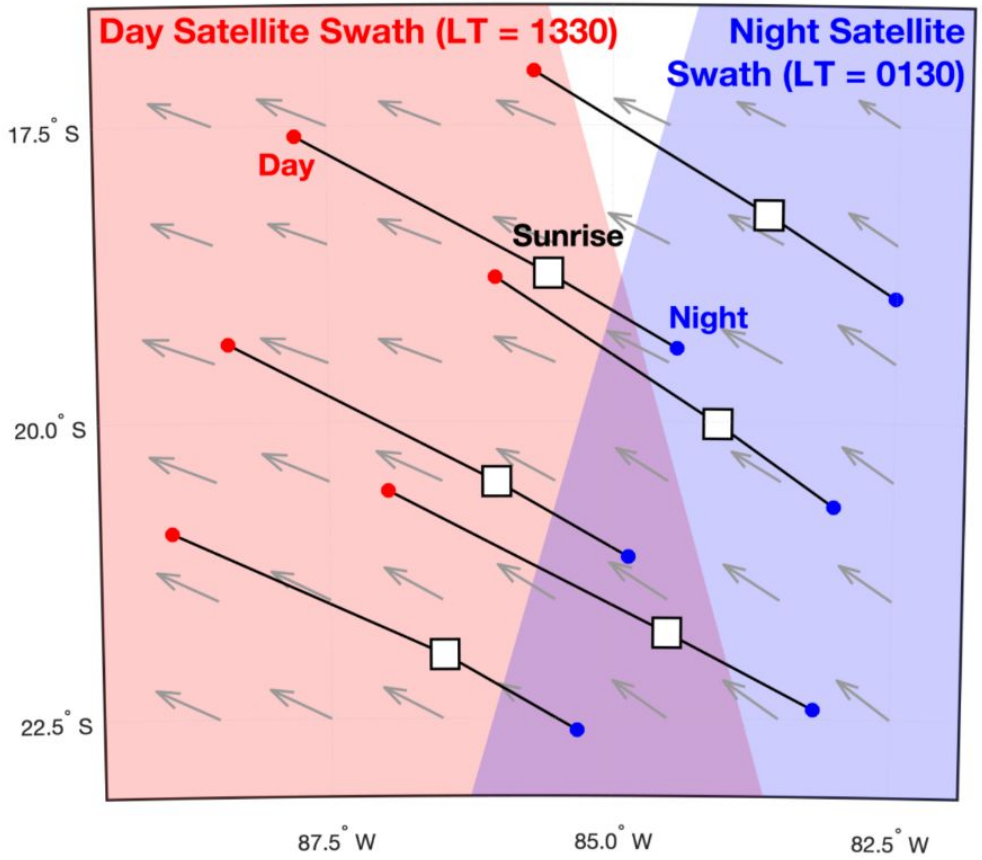
- **Outlook** - will address using IMERG rain rates (GPM) available every 30 minutes



Thank you!

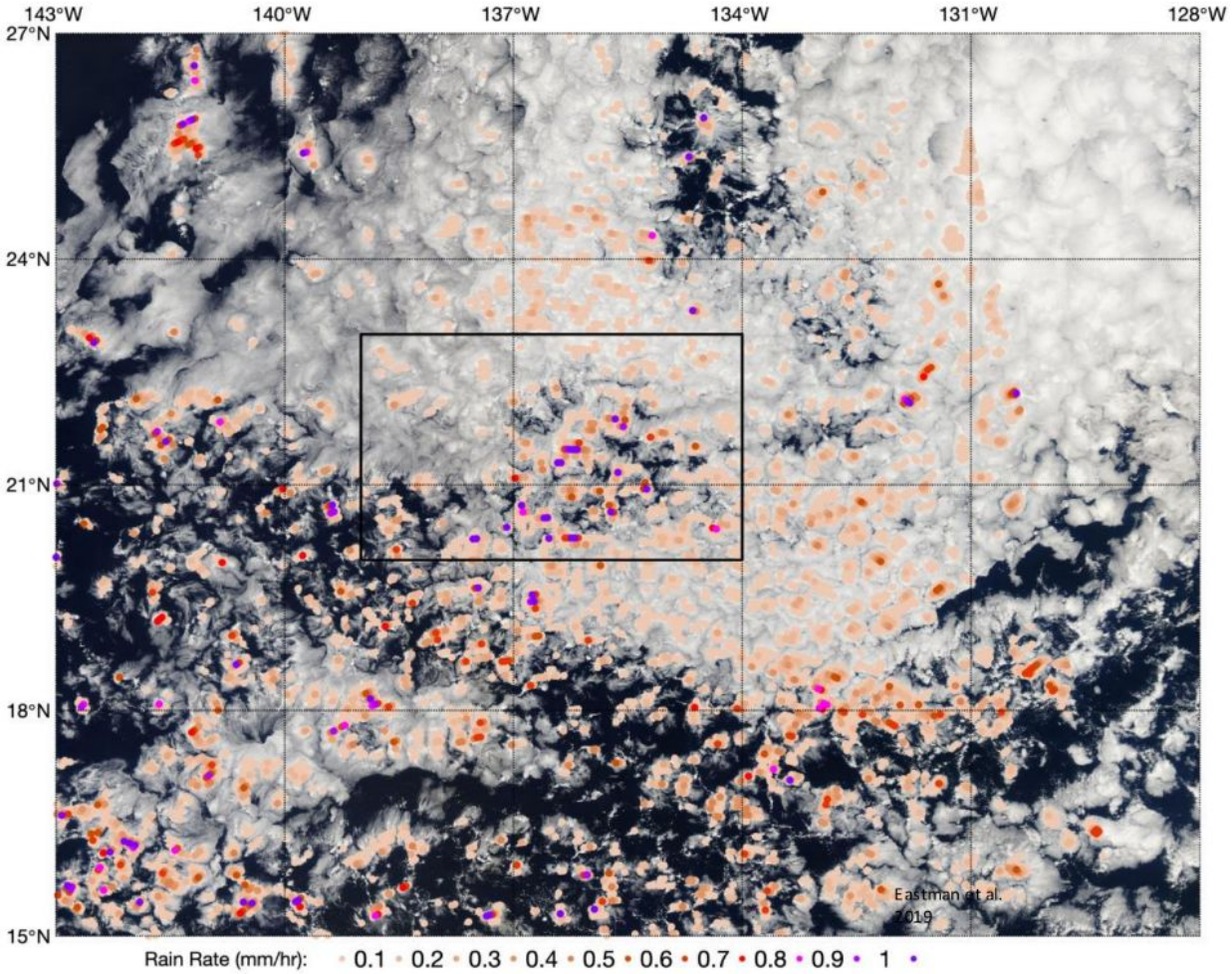
Tying SAR Observations to Rain Observations

- PBL Trajectories link SAR obs to rain obs, both before and after.
- SAR obs are ‘bracketed’ by rain information, ~5-7 hours removed.
- Trajectories built using ERA5 winds at 925 hPa.

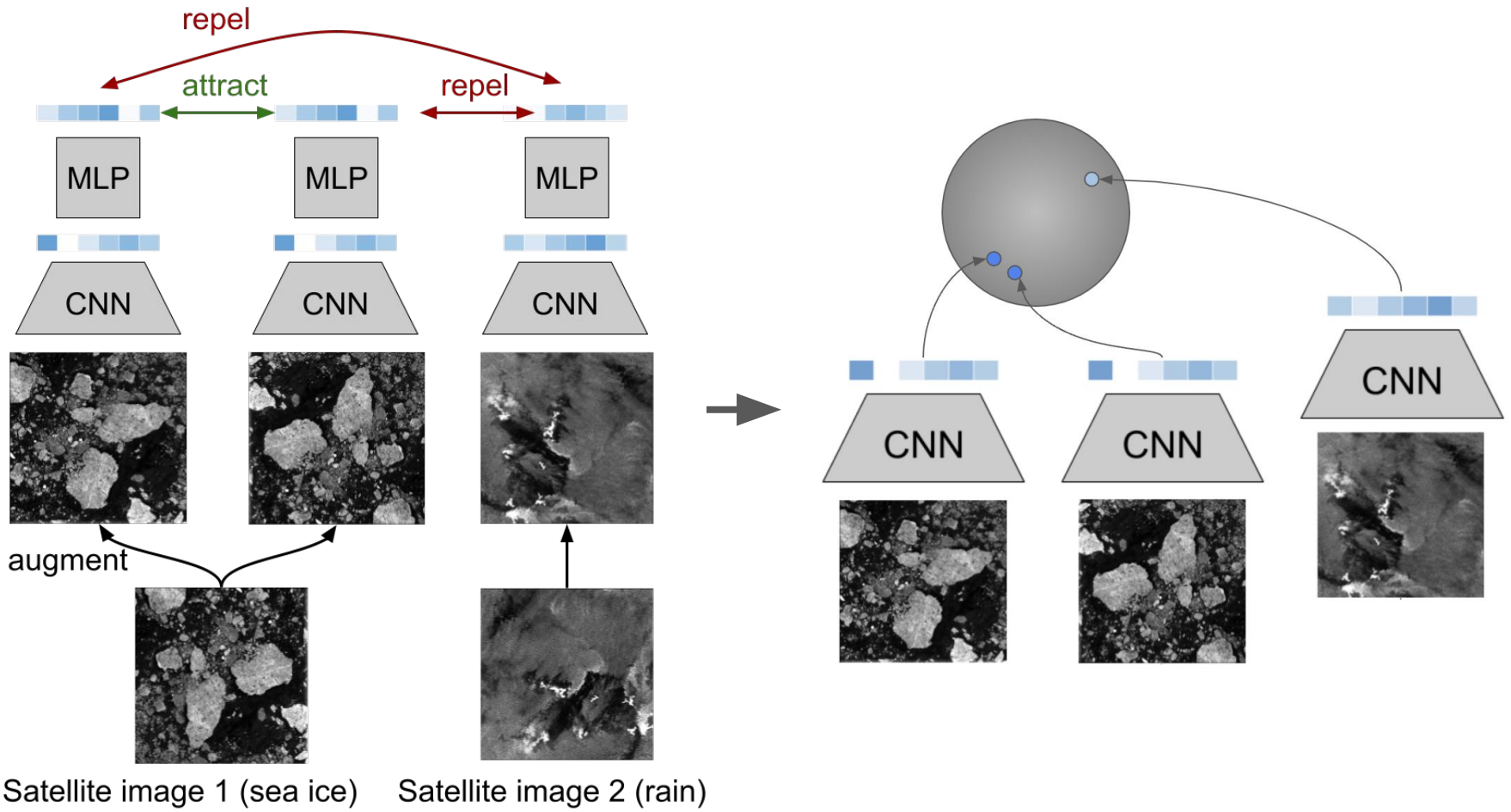


S-1/AMSR2

- AMSR/2 - 89GHz channel can estimate light warm rain in shallow clouds
- High spatial variability!



1) Methods - WVNet contrastive model



1) Methods - WVNet - a foundational SAR model

