Studying Atmospheric Dynamics at the top of the PBL with LEO-GEO Stereo Imaging

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Topics

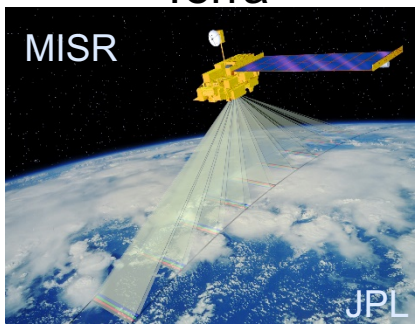
- New Results with Stereo Imaging* (Carr)
  - MISR and GOES 3D-Wind Retrievals
  - Good accuracy and coverage for PBL studies
  - Future LEO-GEO Systems (see: “A New Approach to Passive Wind Estimation Using Stereo Methods”, Michael Kelly et. al. tomorrow)
- PBL Sciences with LEO-GEO Stereo Imaging (Wu/GSFC)

*Submitted to *Remote Sensing*
Special Issue: MISR
Authors: Carr, J., D. Wu, M. Kelly (APL), J. Gong (GSFC)

LEO-GEO 3D-Winds

Terra

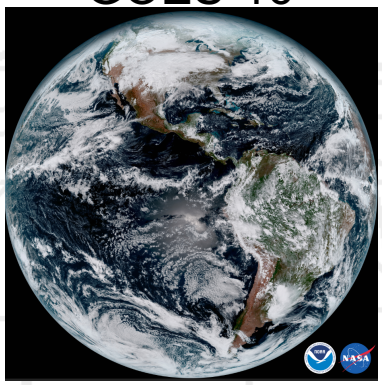
Multi-Angle



- LEO on NASA Terra S/C
- Fore & Aft-looking Cameras
  - An: nadir looking
  - Af, Aa: ±26.1°
  - B, C, D: oblique viewing
- Red Band
  - 275 m resolution
  - 360 km swaths

GOES-16

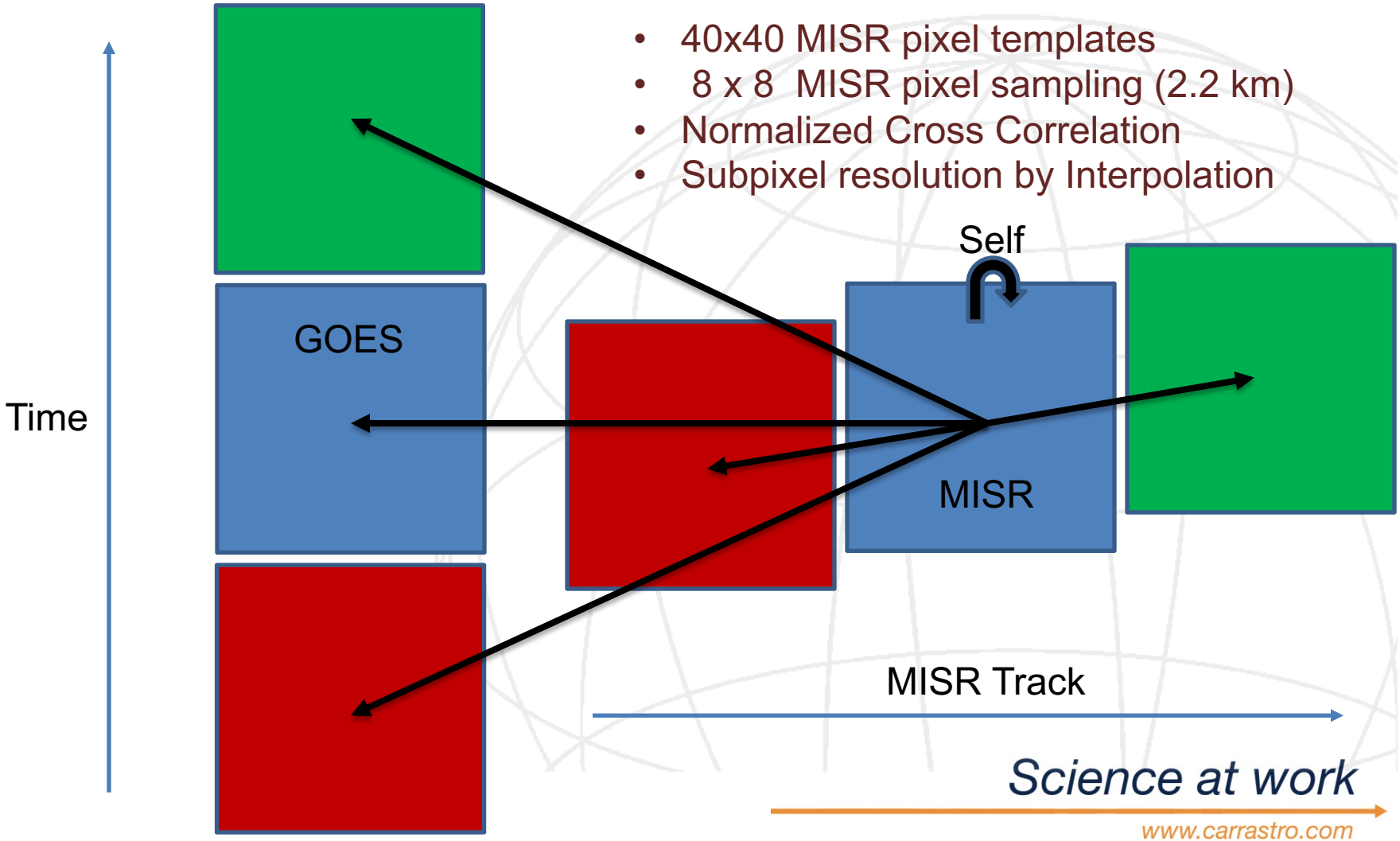
Multi-Temporal



- GEO stationed at -75°
- Advanced Baseline Imager
  - Full-Disk (5, 10, 15-min. refresh)
  - CONUS (5-minute refresh)
  - MESO (30, 60-sec. refresh)
- Red Band
  - 500 m resolution
- Very accurate geo-registration

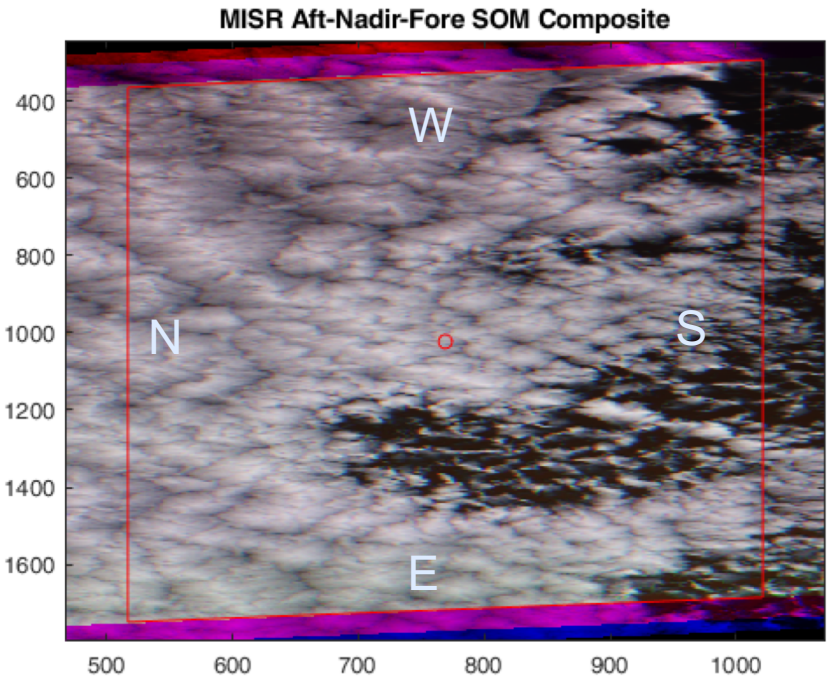
Disparity Measurements

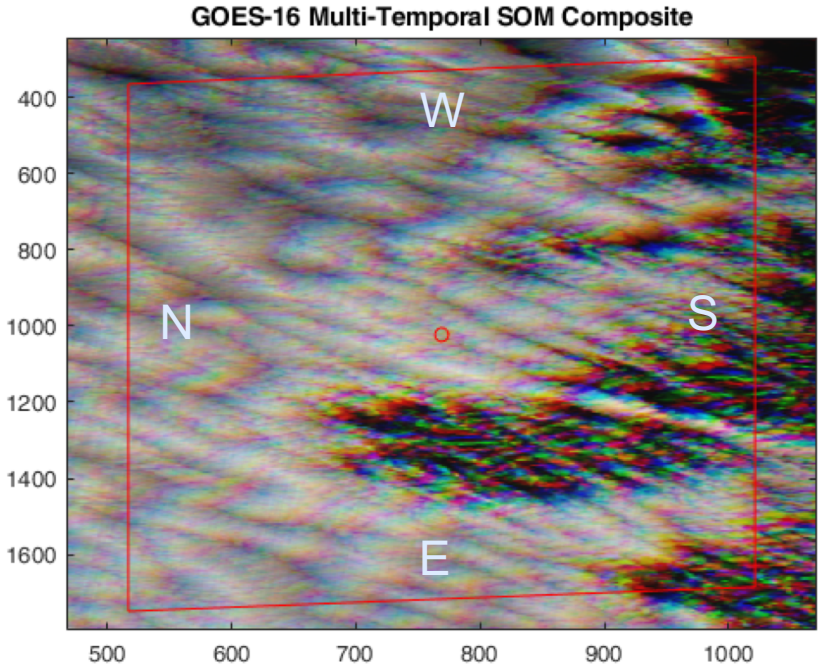
- 40x40 MISR pixel templates
- 8 x 8 MISR pixel sampling (2.2 km)
- Normalized Cross Correlation
- Subpixel resolution by Interpolation



Multi-Angle/Temporal Composites

GOES Remapped to MISR Projection





Disparity = Height Parallax + Wind

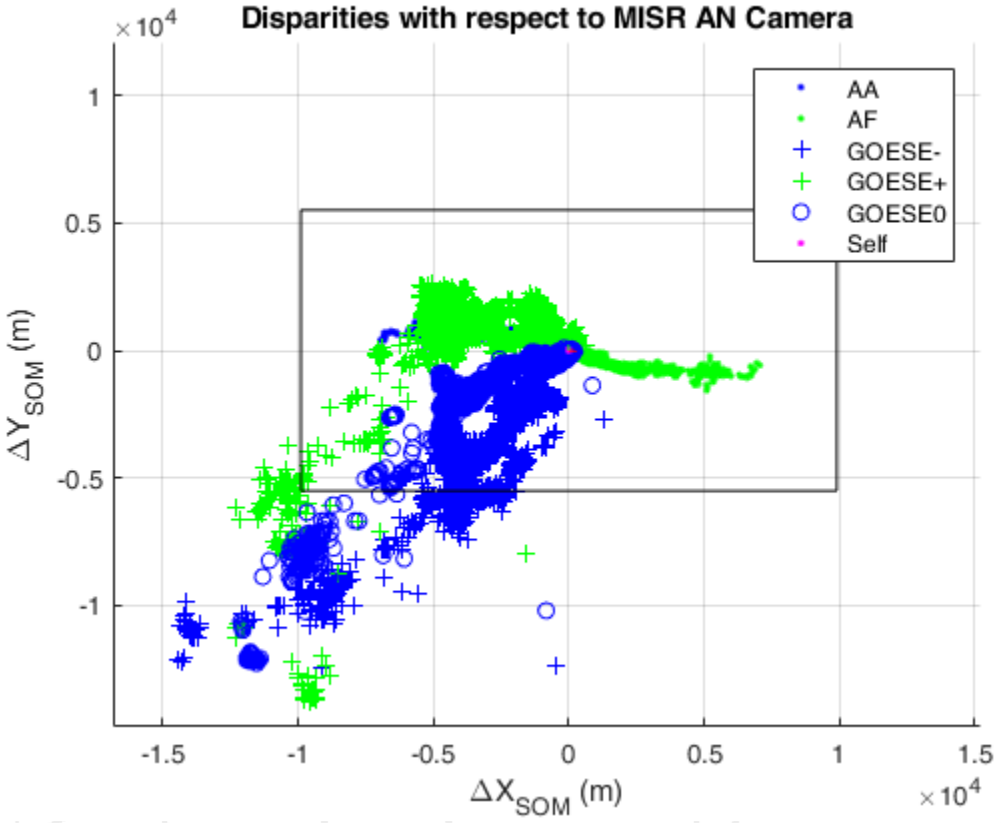
MISR alone: Challenged to separate Along-track wind from height

Disparity = Wind + MISR-to-GOES Parallax

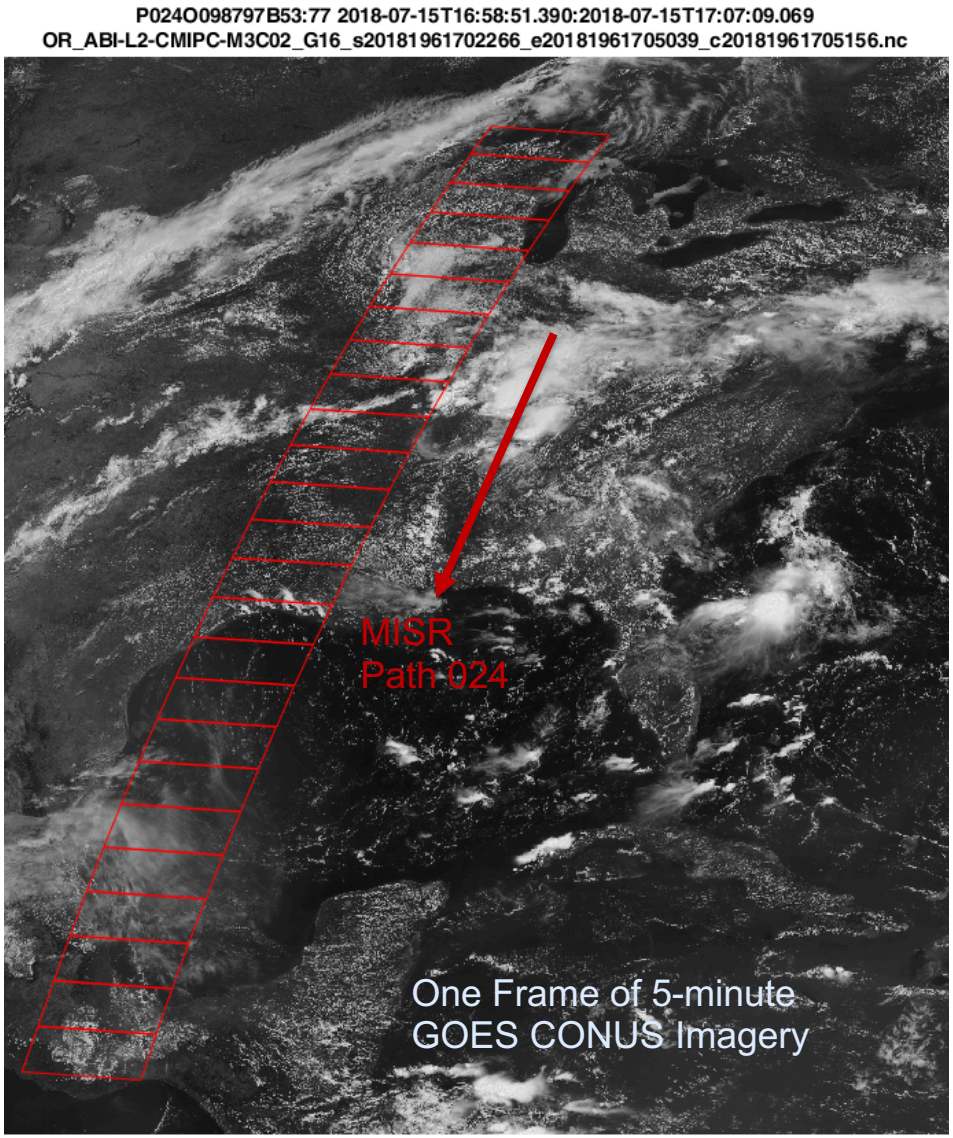
GOES alone: IR height assignment

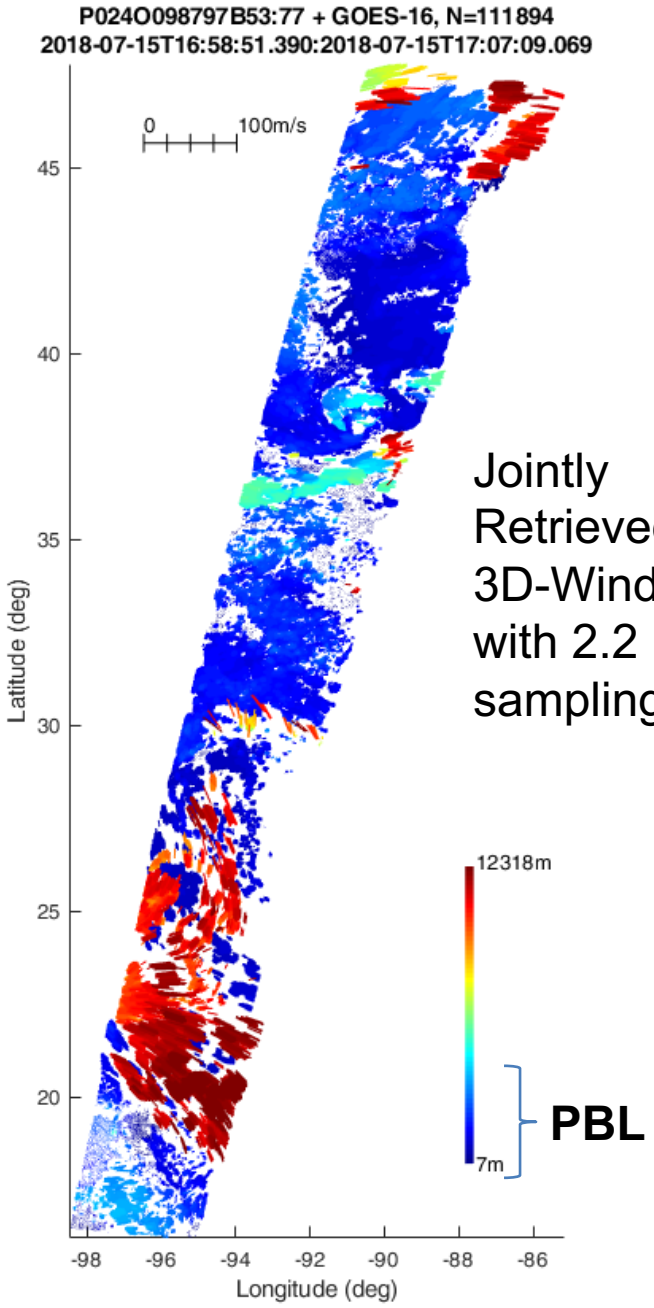
Interpreting Disparities An-to-X

- Process in MISR blocks
- Model MISR and GOES pixel times – No LEO-GEO Synchronization Needed!
- Retrieval Model States
  - 1 pattern height/site
  - 2 horizontal position adjustments/site
  - 2 horizontal velocities/site
  - 2 global bundle adjustment states
- Nonlinear, sparse-matrix solution of order $5N+2 \sim 10^4$



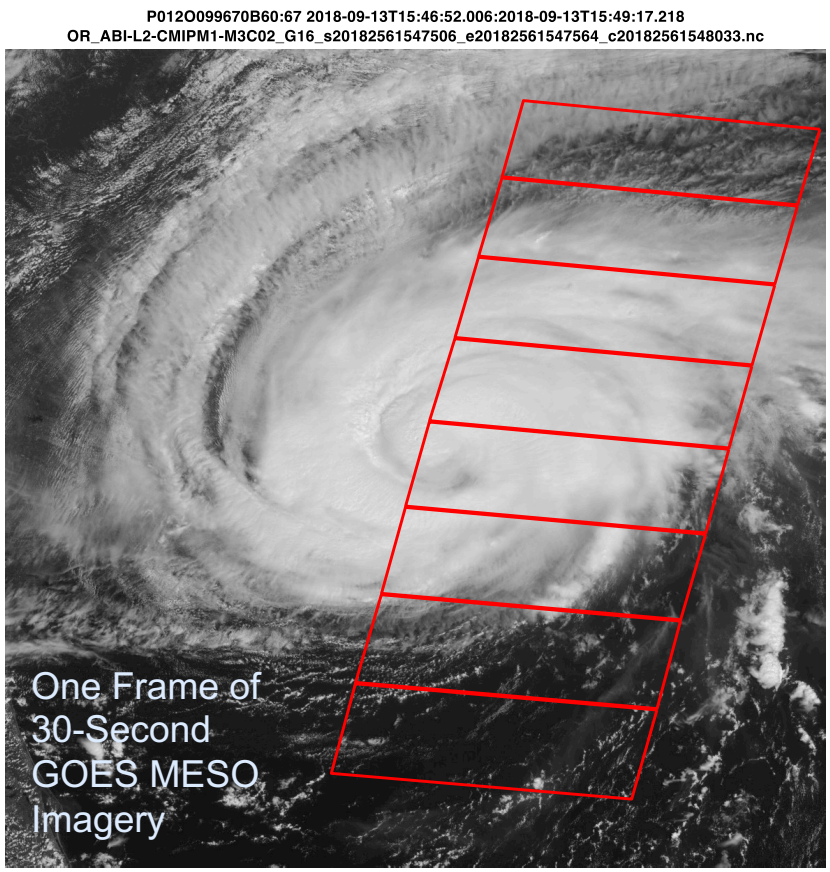
MISR+GOES over CONUS 2018

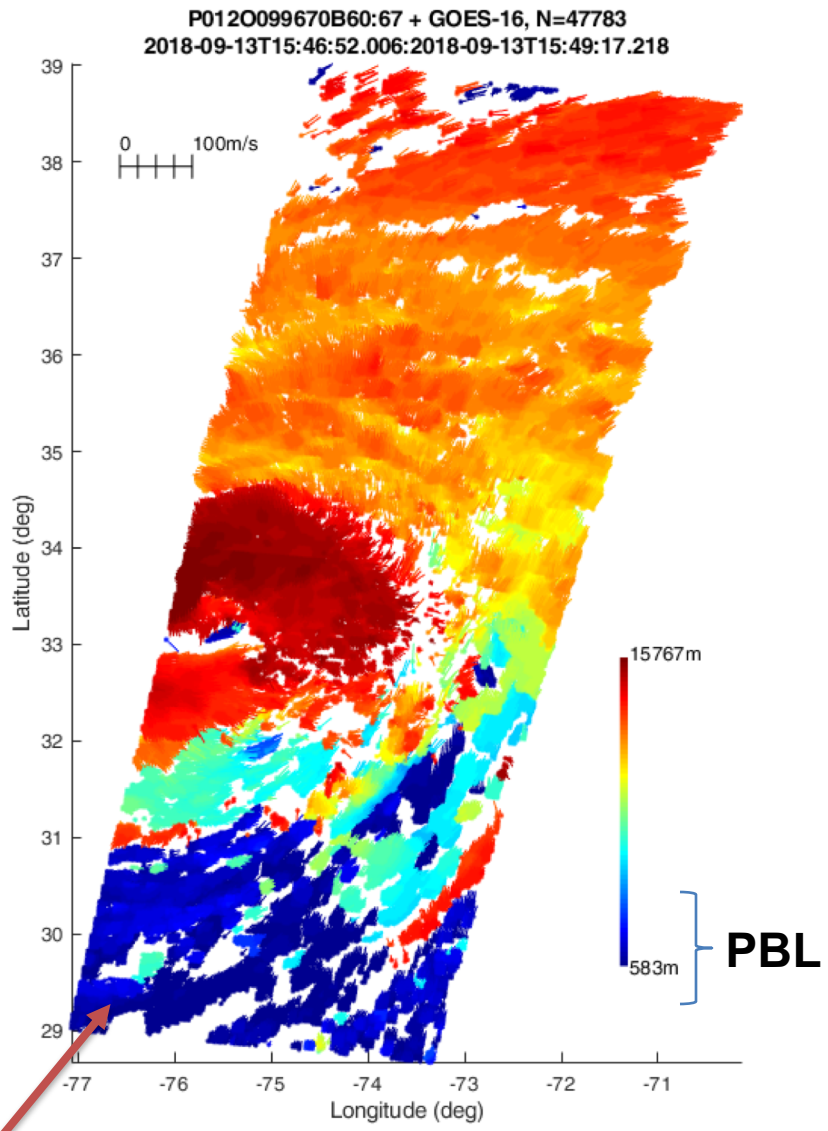




Jointly Retrieved 3D-Winds with 2.2 km sampling

Florence MESO 2018

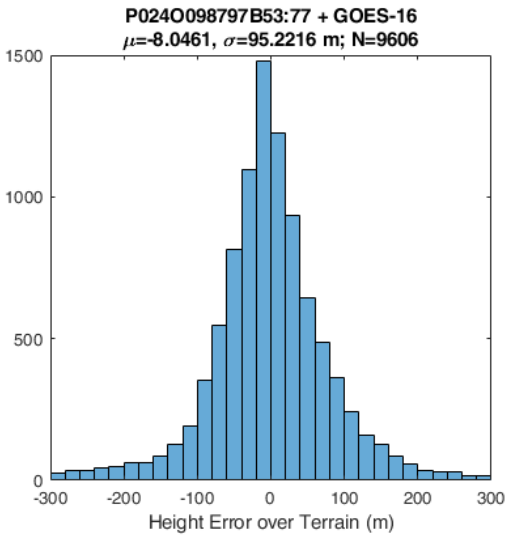


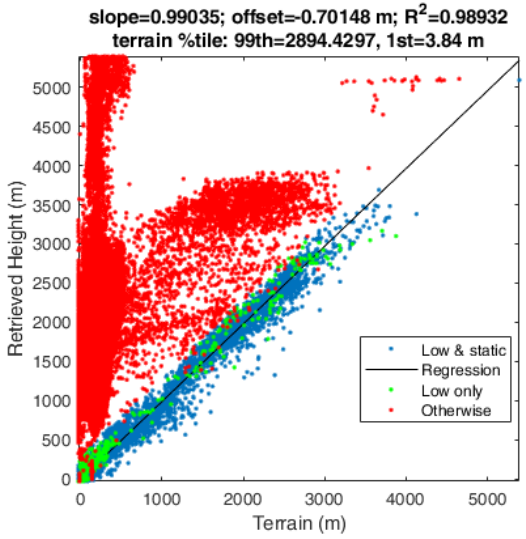


Low-altitude winds
feeding in warm, moist air

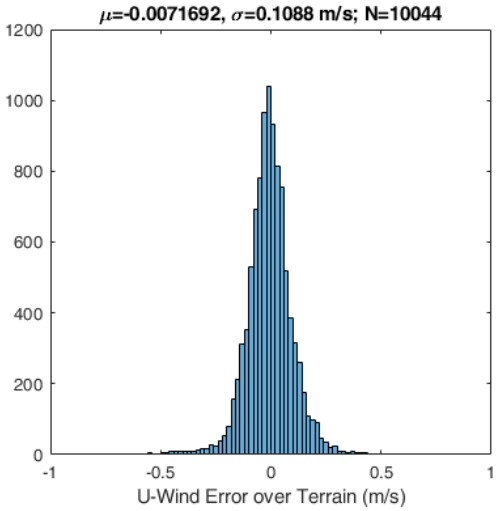
Validation over Clear-Sky Terrain

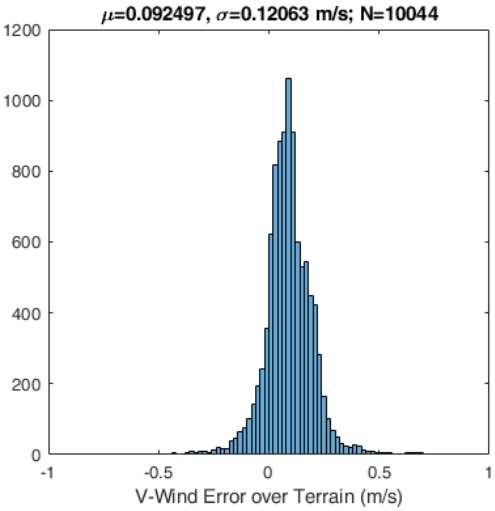
Estimated Uncertainty<200m



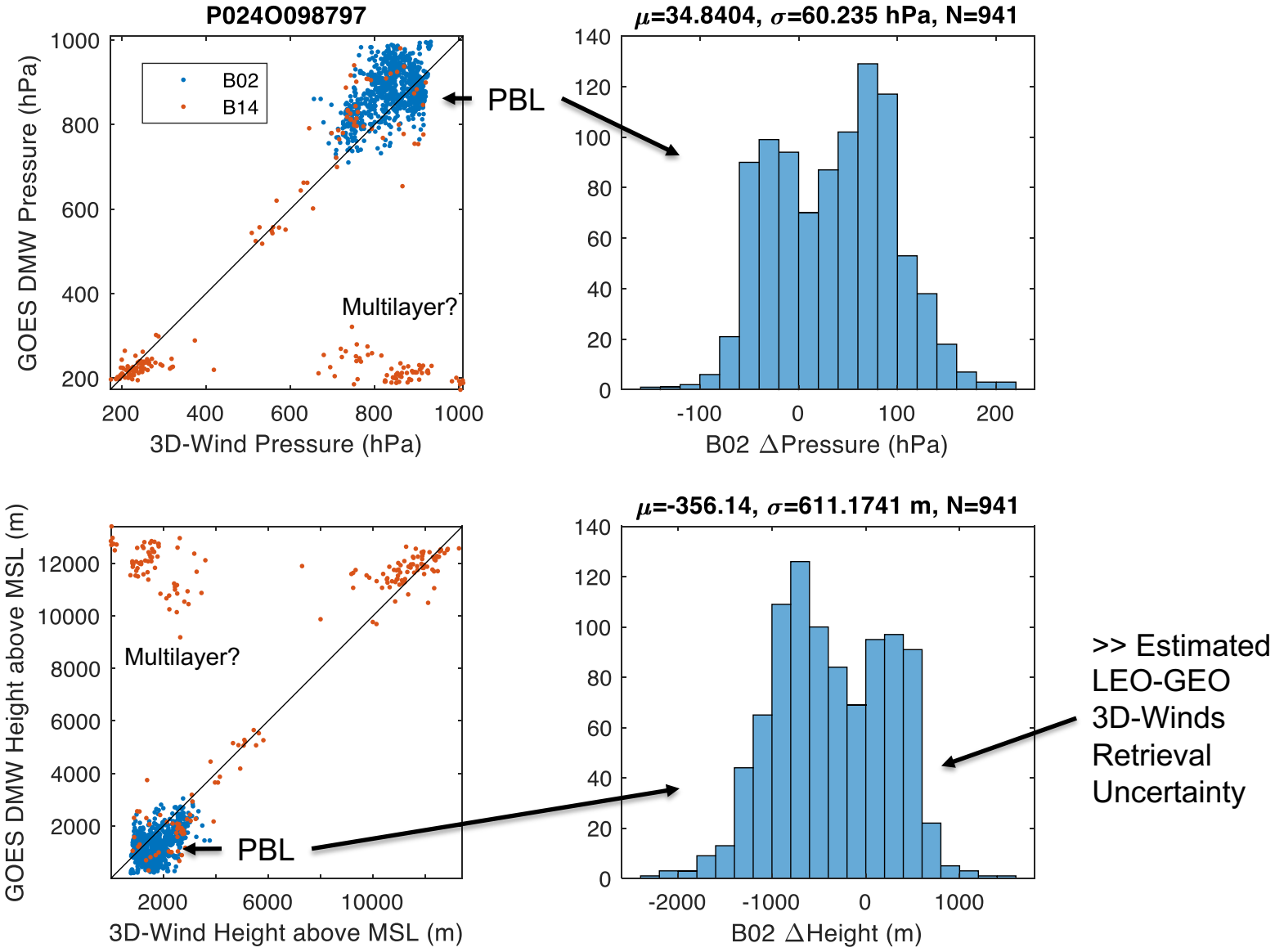


Estimated Uncertainty<0.5m/s

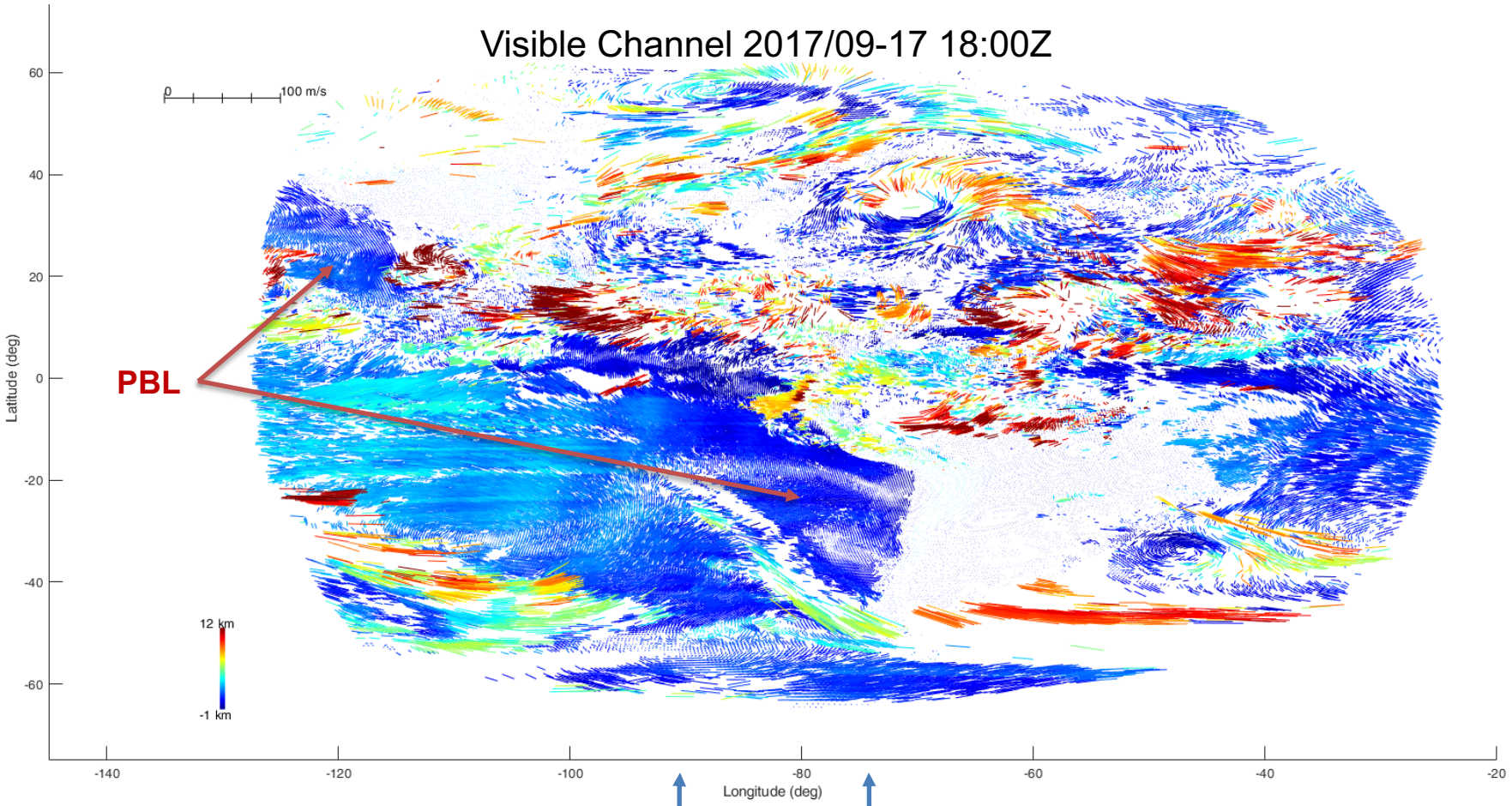




Comparison with IR Height Assignments

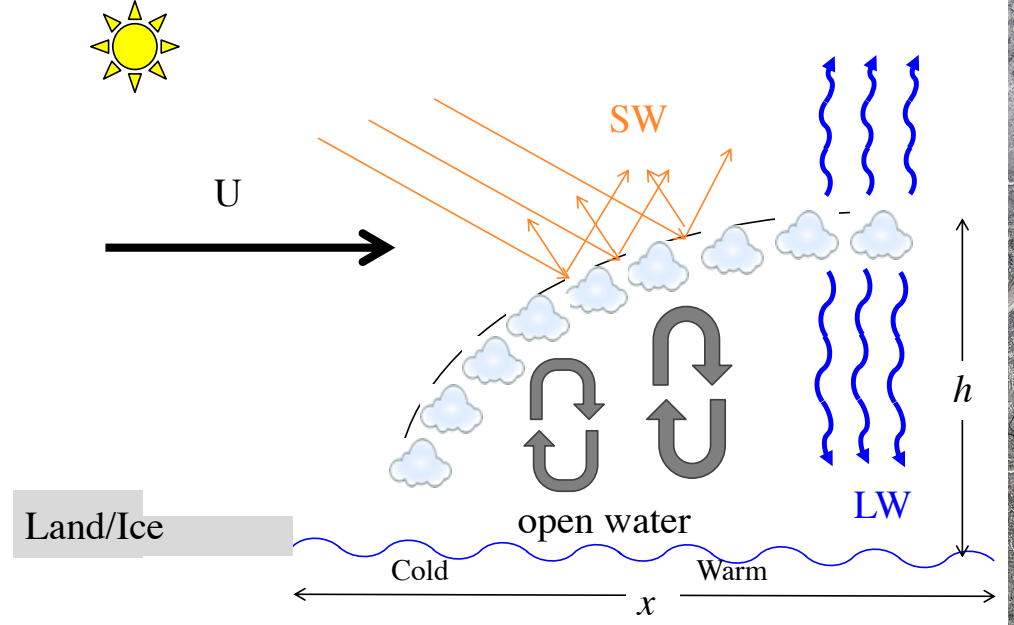


GEO-GEO 3D-Winds



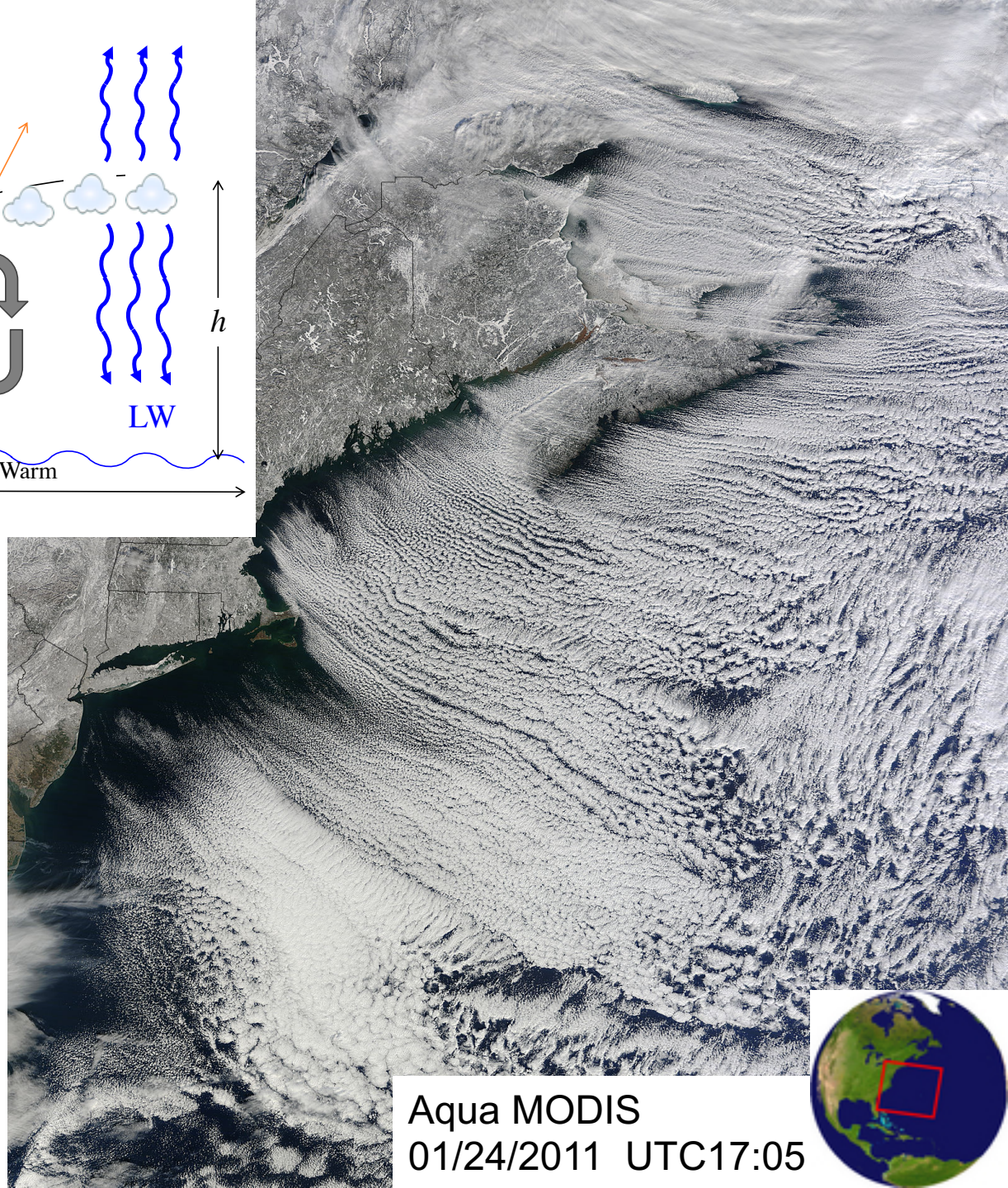
GOES-16
(Test Slot)

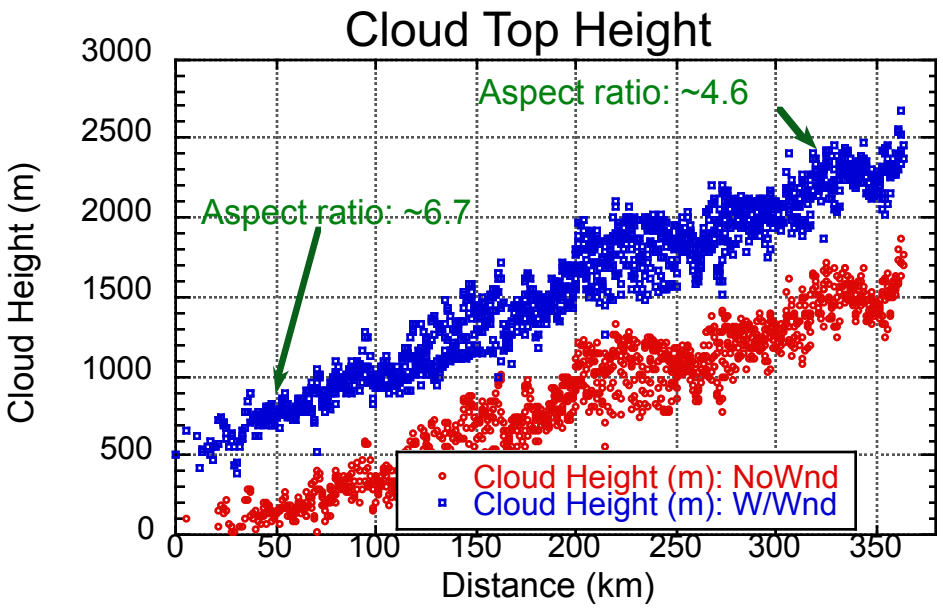
GOES-13
(East Slot)

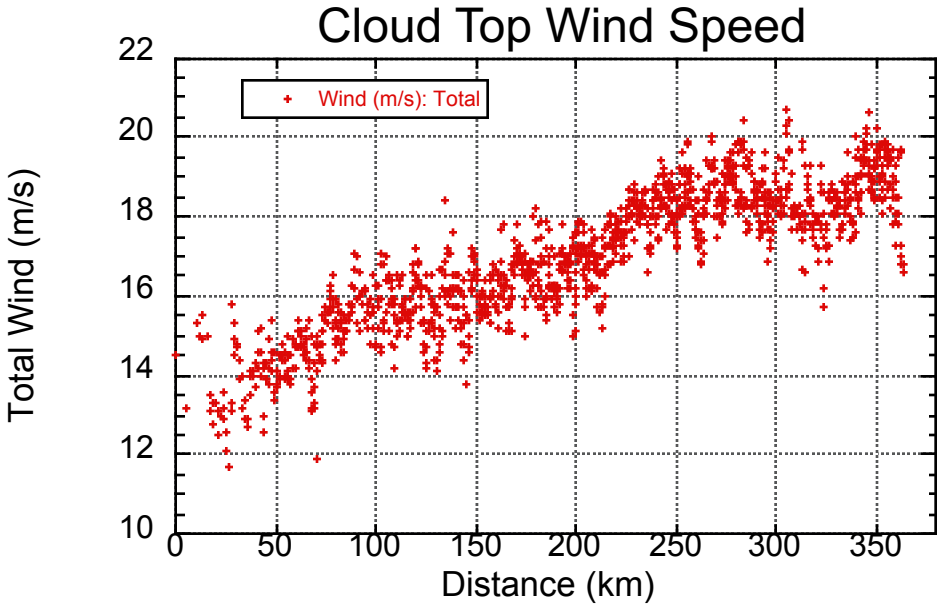


Cold Air Outbreak Processes

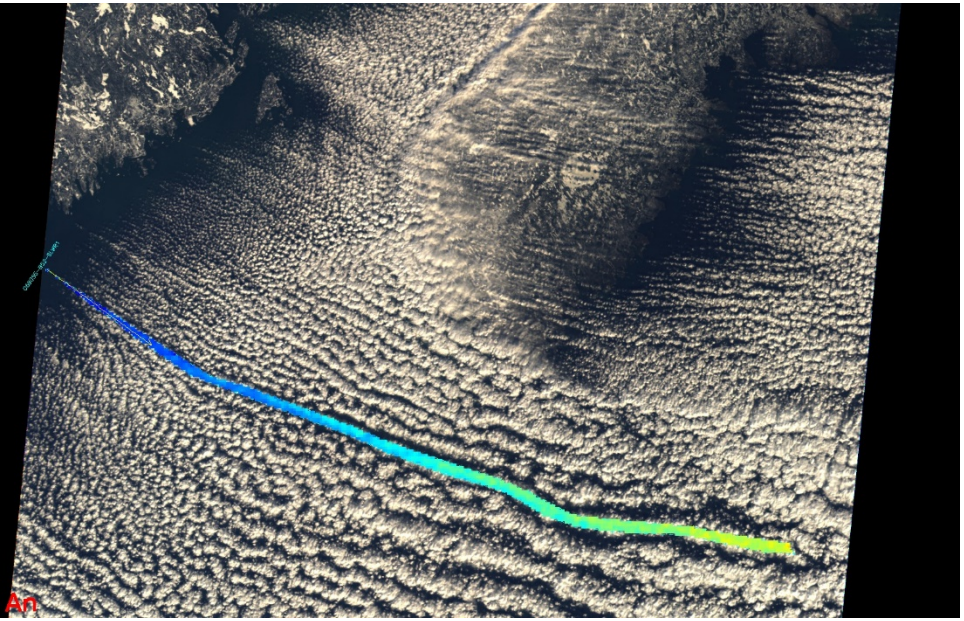
- Surface heat and moisture fluxes
- PBL structural evolution
- Cloud and precipitation microphysics

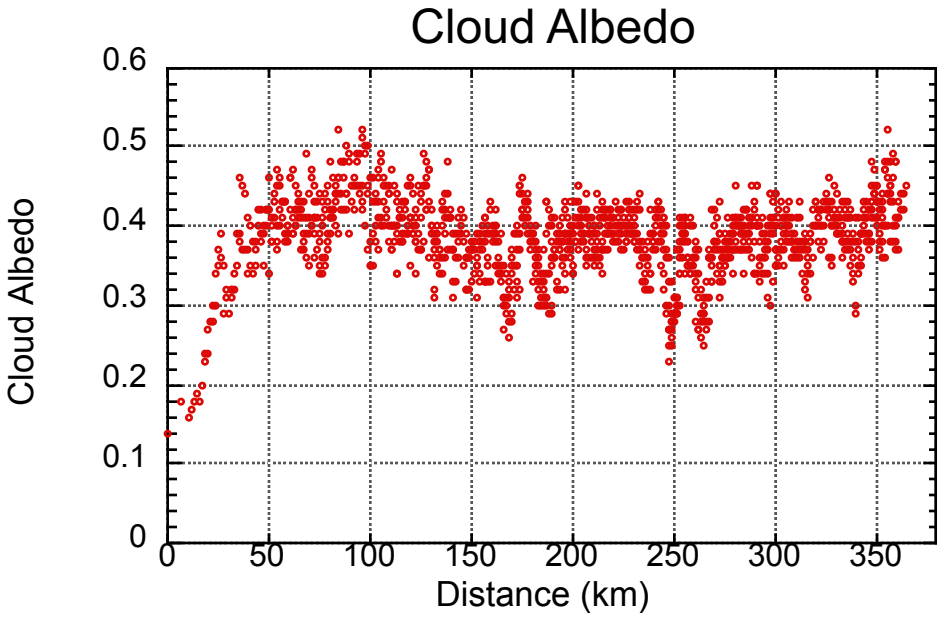




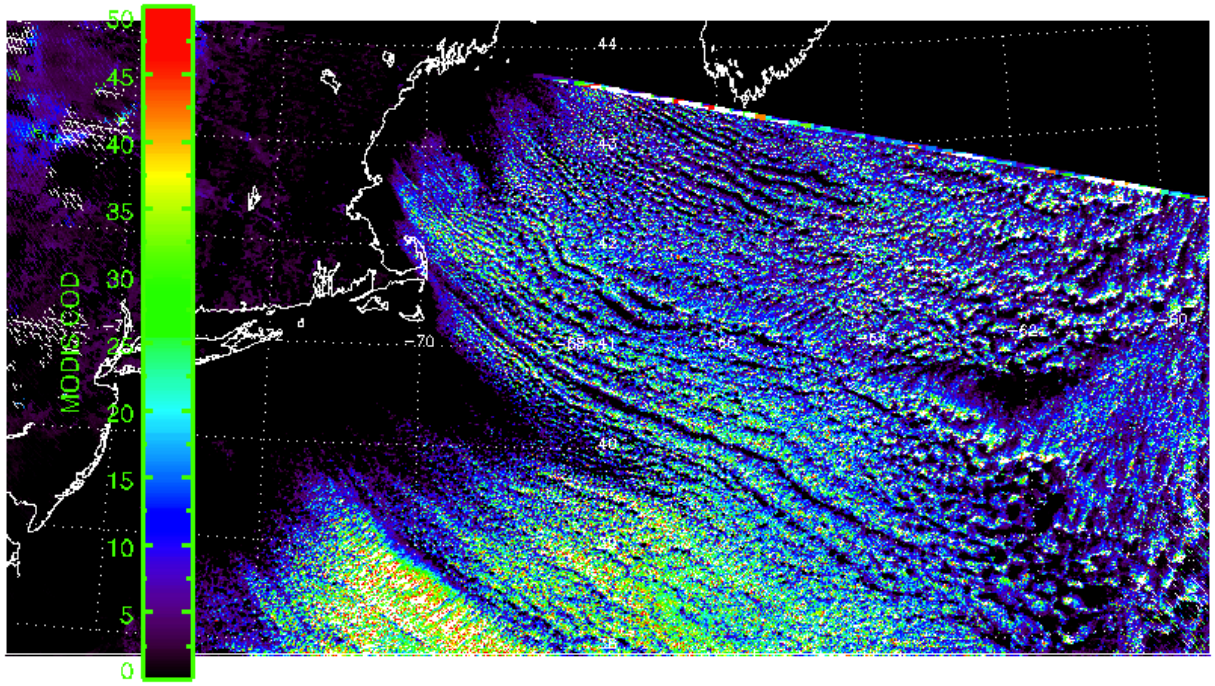


MINX outputs

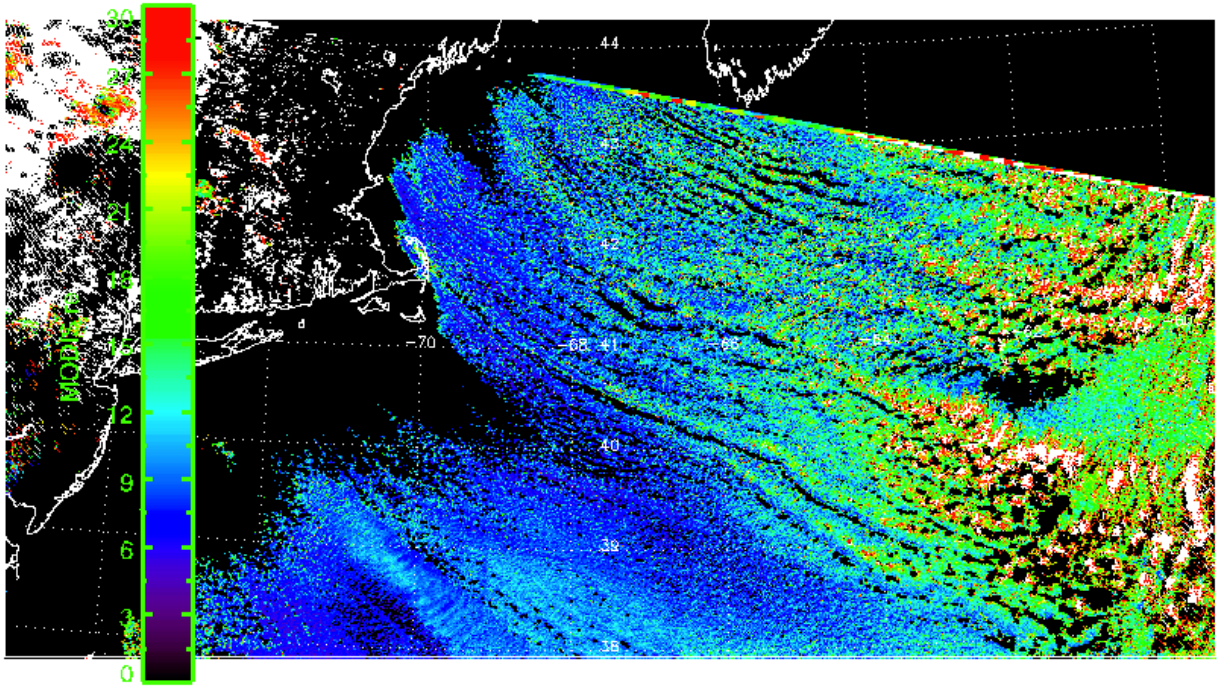




MODIS
Cloud Optical Depth (COD)



MODIS
Cloud Eff Radius (Reff)



(Courtesy of Y. Yang)

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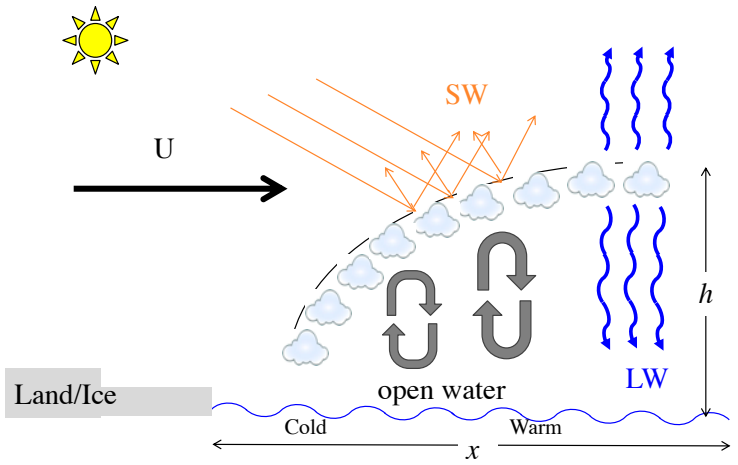
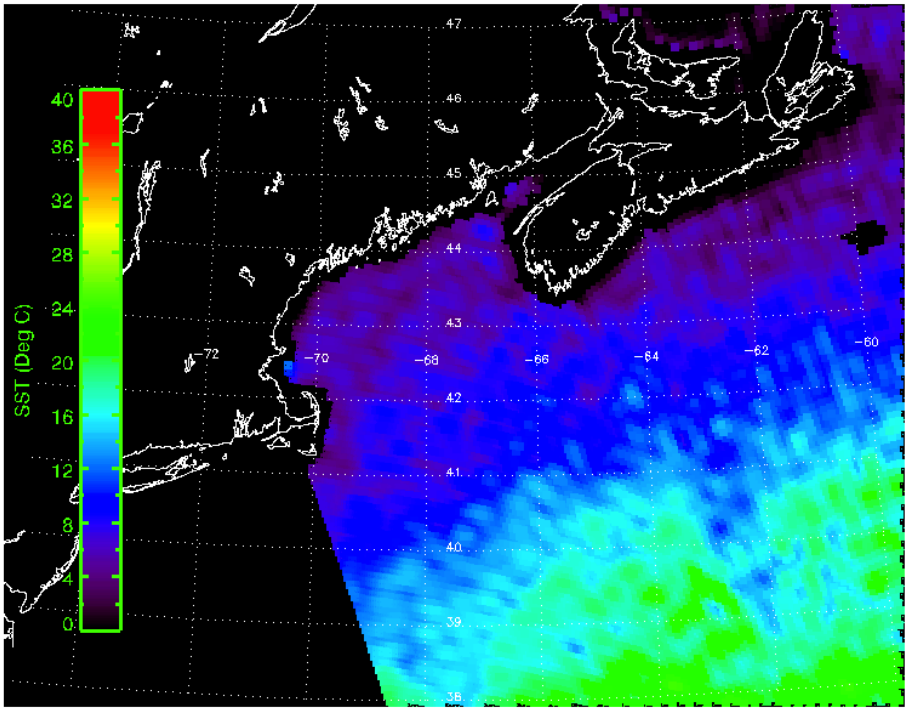
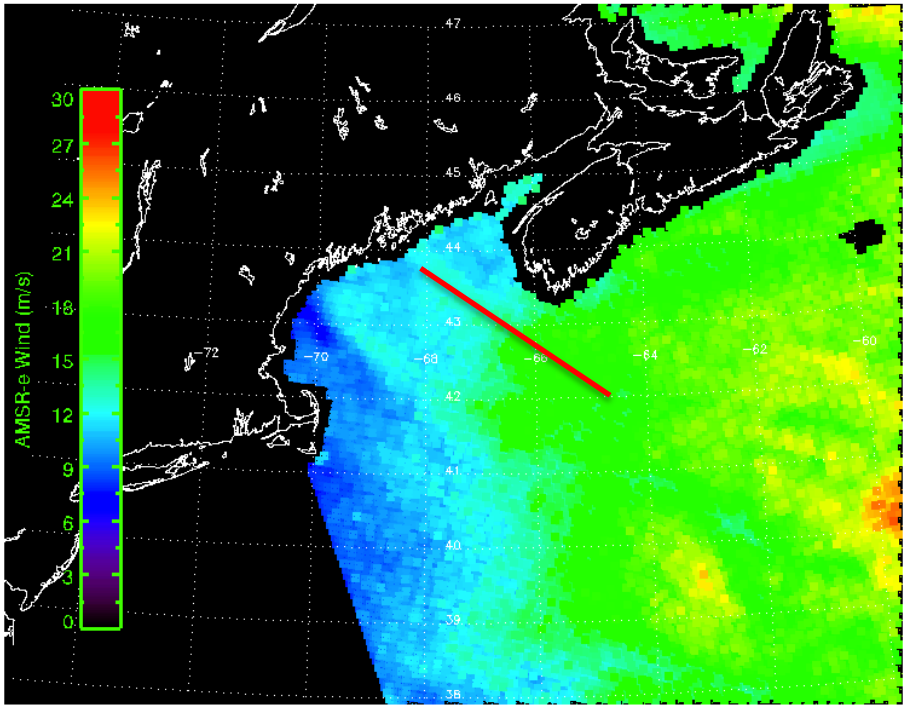
Aqua AMSR-E SST

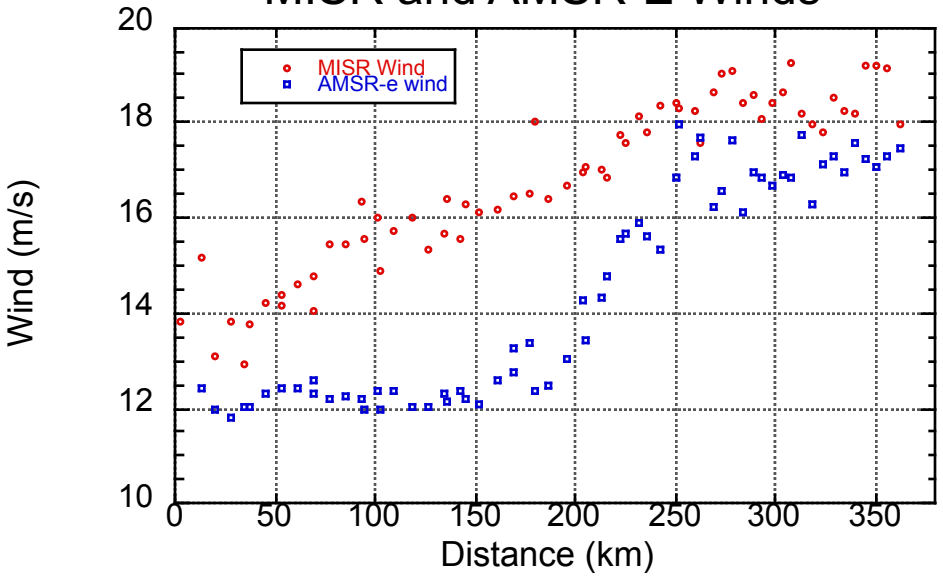




Aqua AMSR-E 10m Wind Speed

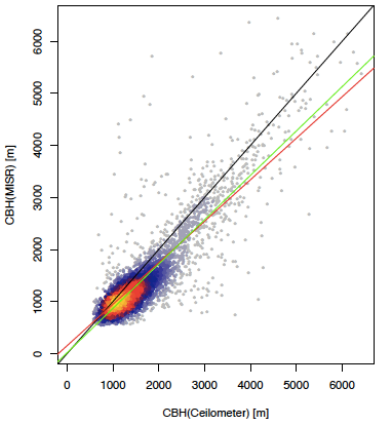


MISR and AMSR-E Winds

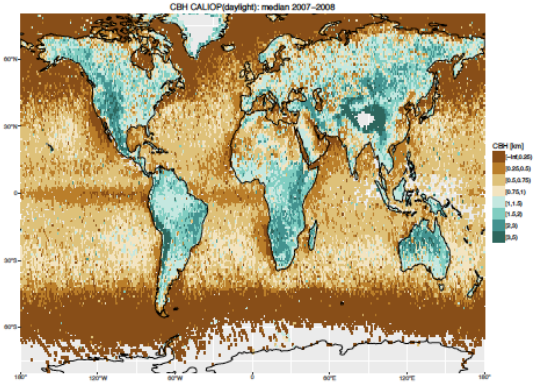


PBL Cloud Top (CTH) and Base (CBH) Heights

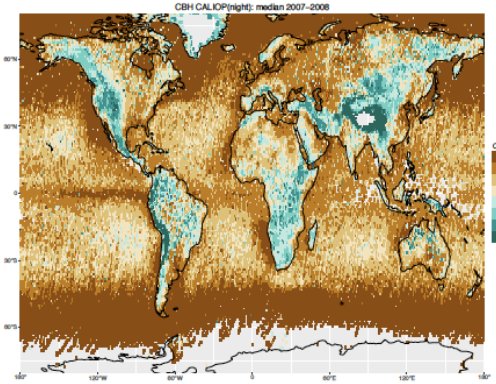
- Broken clouds from high-res stereo imaging
- Parallaxes for both cloud top and base



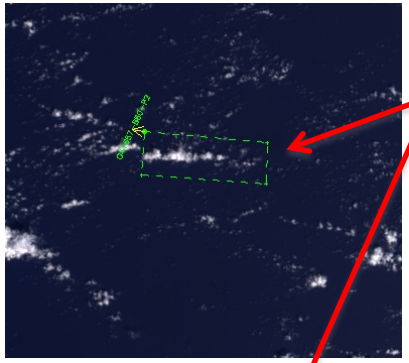
CALIPSO CBH

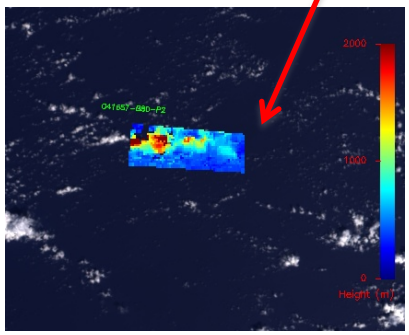


MISR CBH

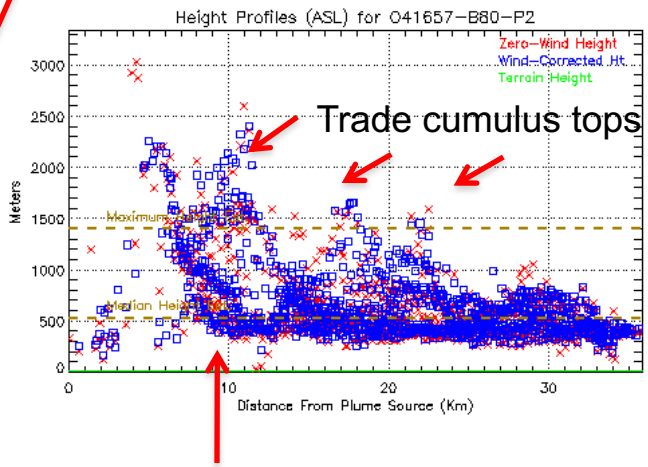


Böhm (2017)

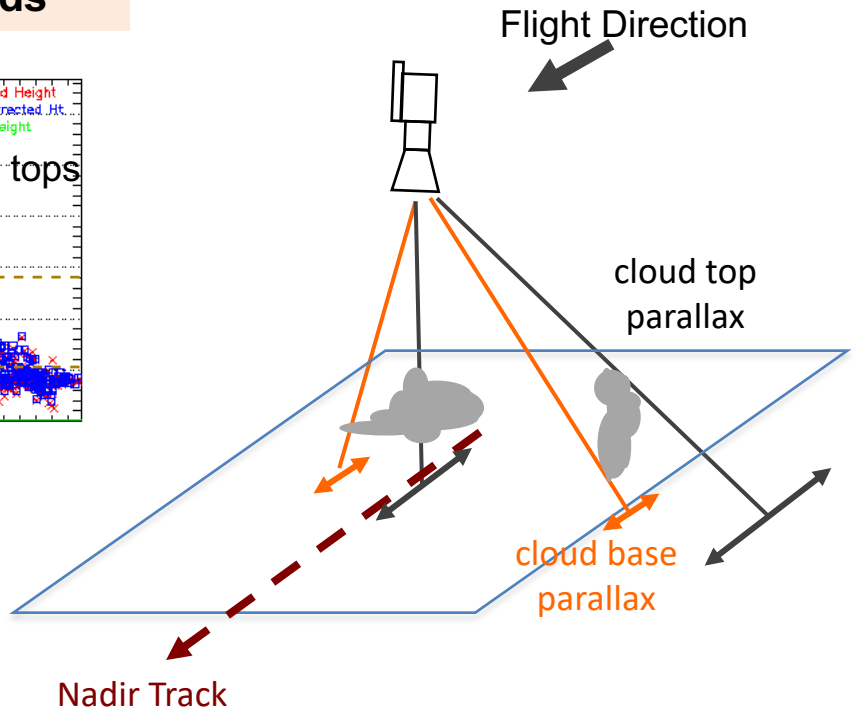




MISR view of broken clouds



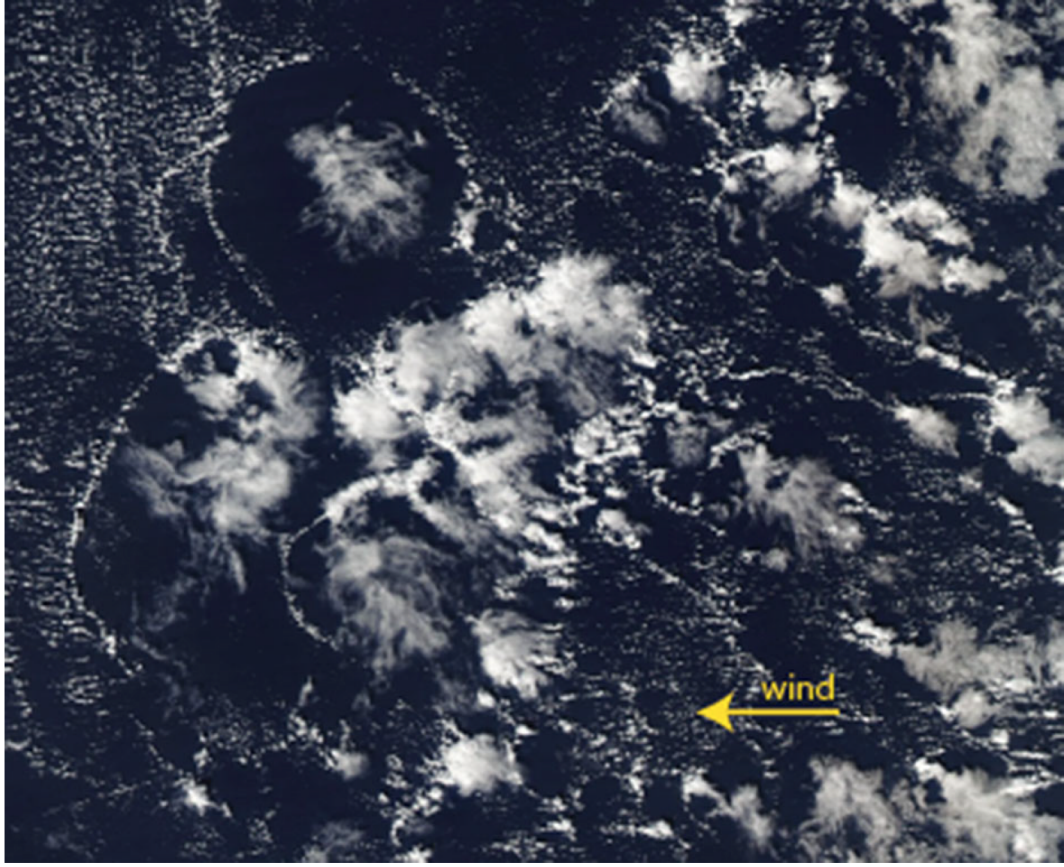
Cloud bases: 300-400 m



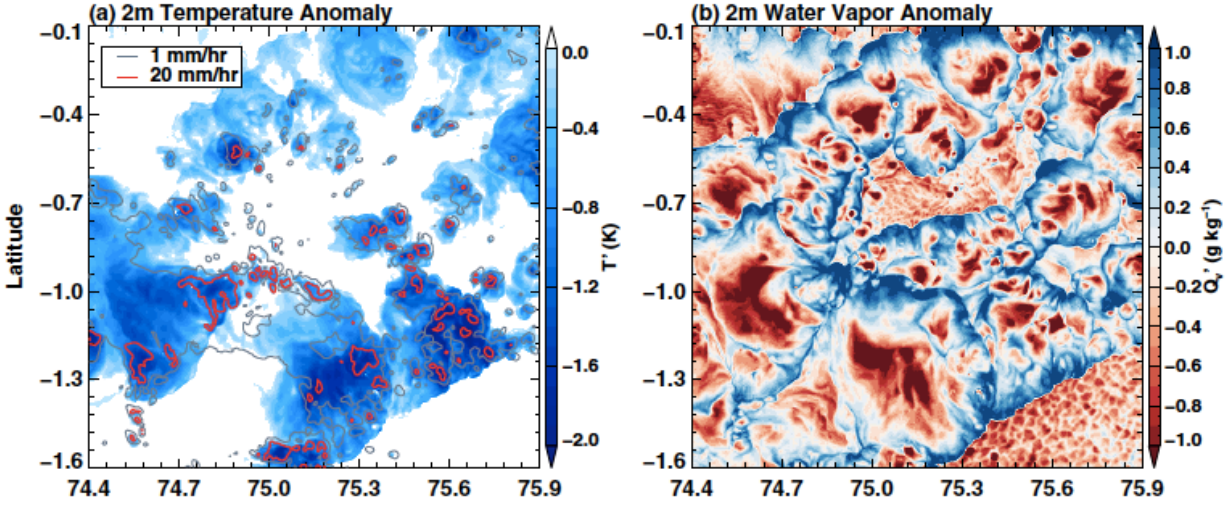
Oceanic Cold Pool Processes

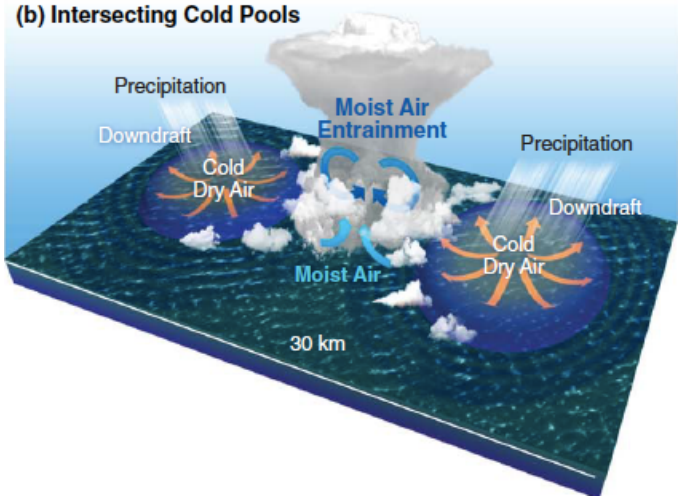
- Lifetime < 1 day
- Shallow convection and precipitation-induced downdrafts
- Reorganization of cloud distributions: albedo and moisture transition

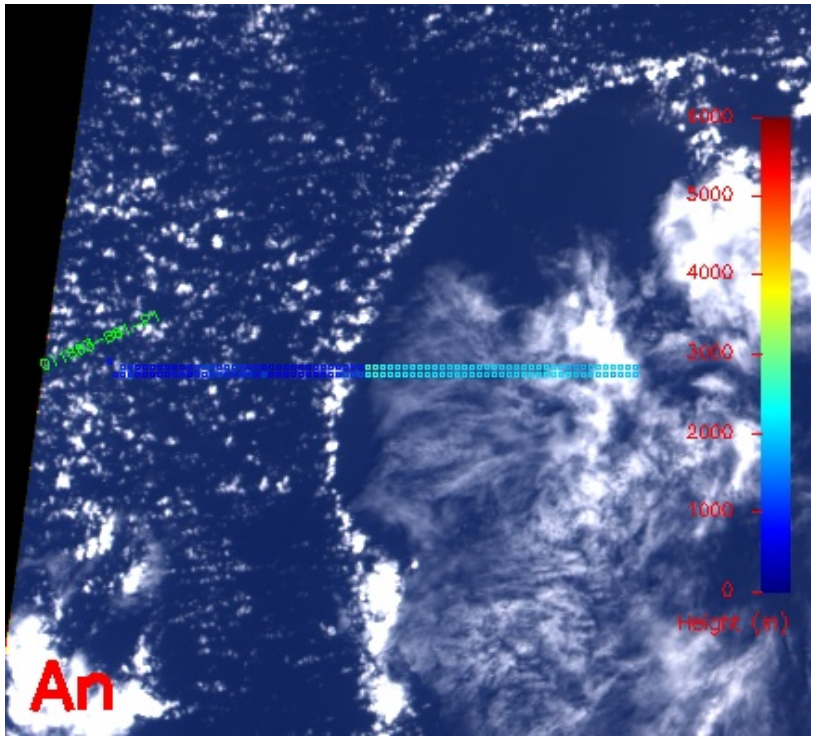
Zuidema et al. (2017)



Model Simulation (Feng et al, 2015)





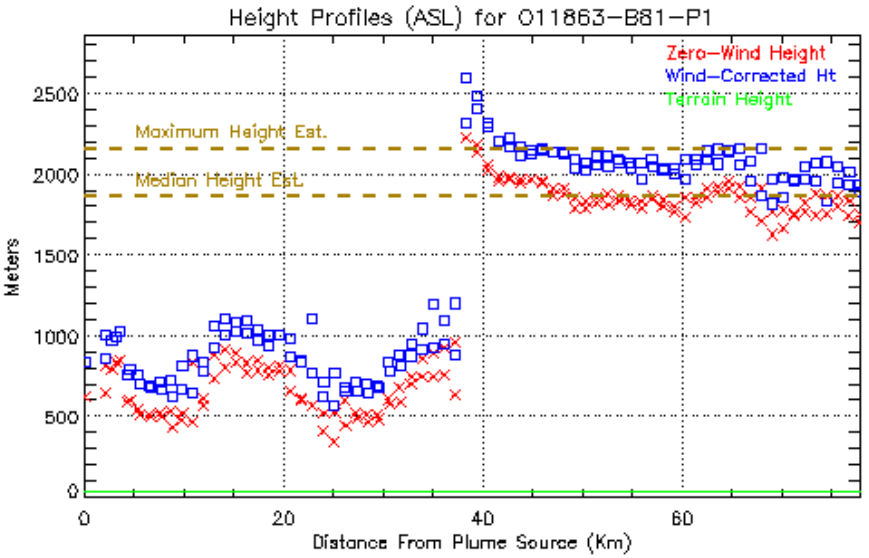


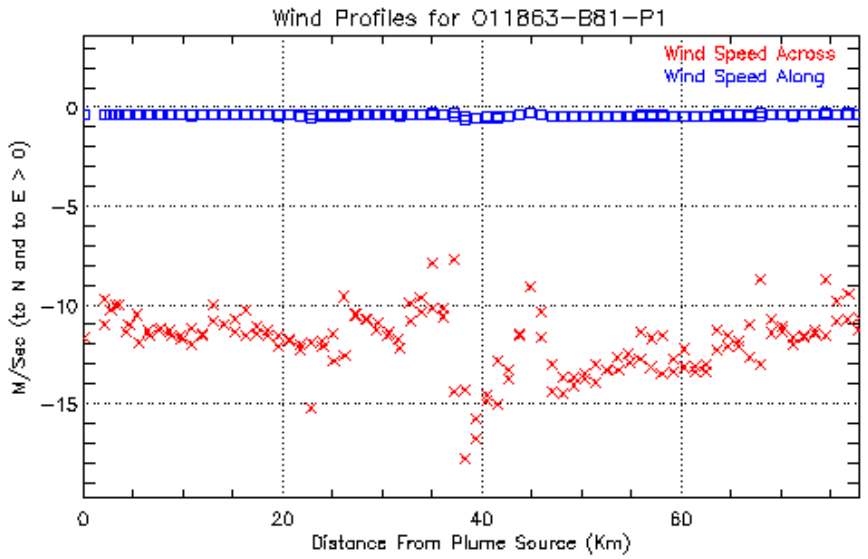
Resolution: 1.1 km

Precision:

height: ~100 m

wind: ~0.3-1 m/s

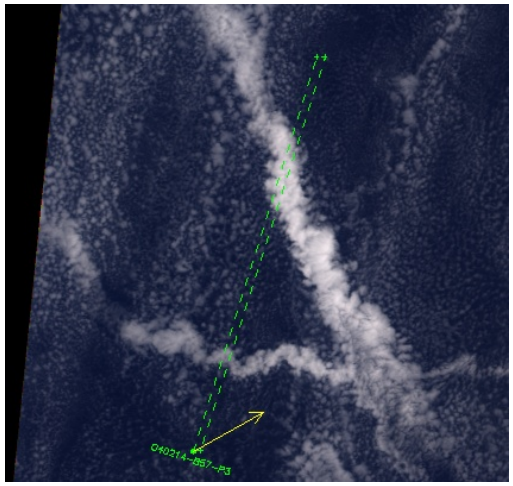


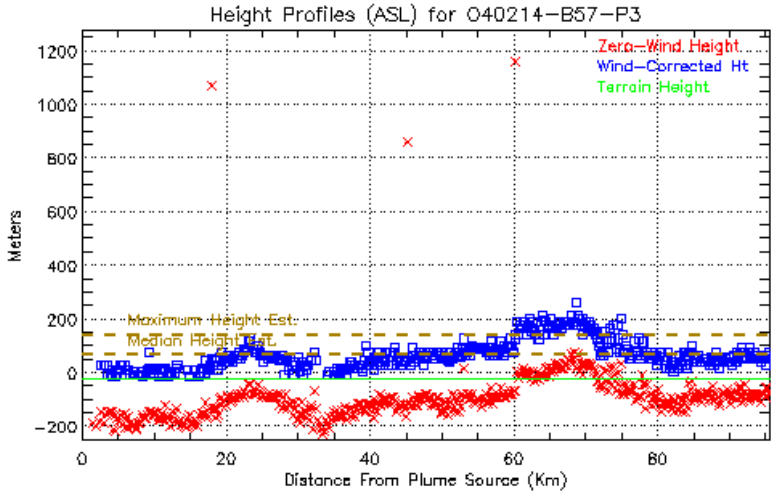


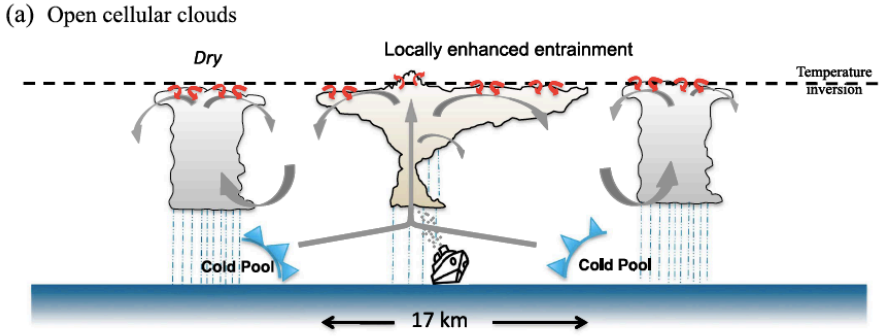
Ship Track Clouds from MISR
(Aerosol-Cloud Interactions)

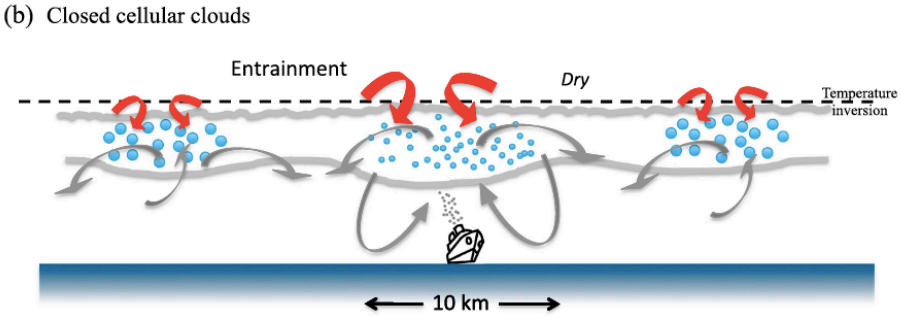
Height Precision:

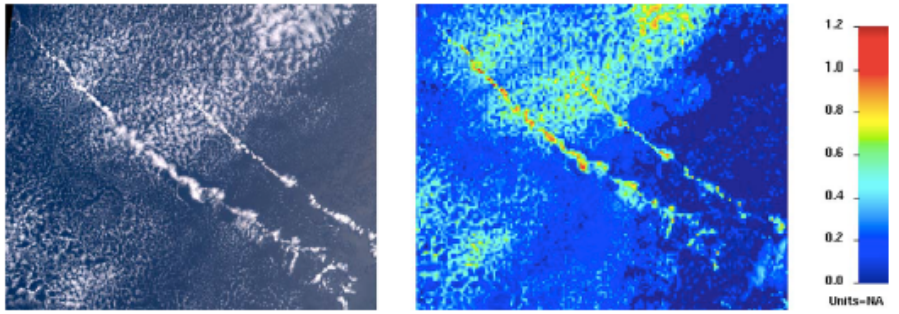
< 50 m





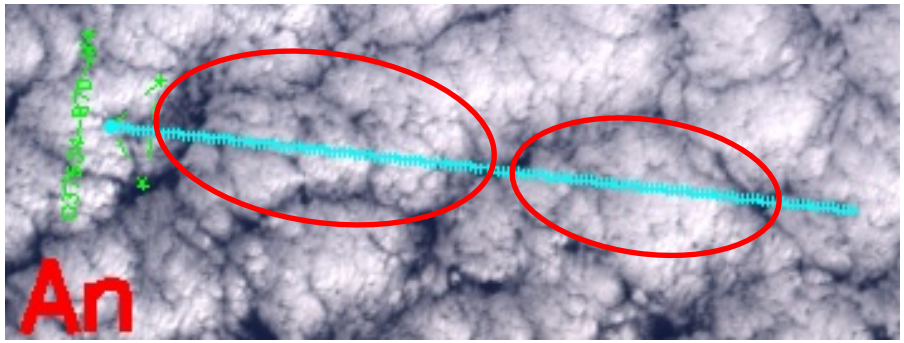


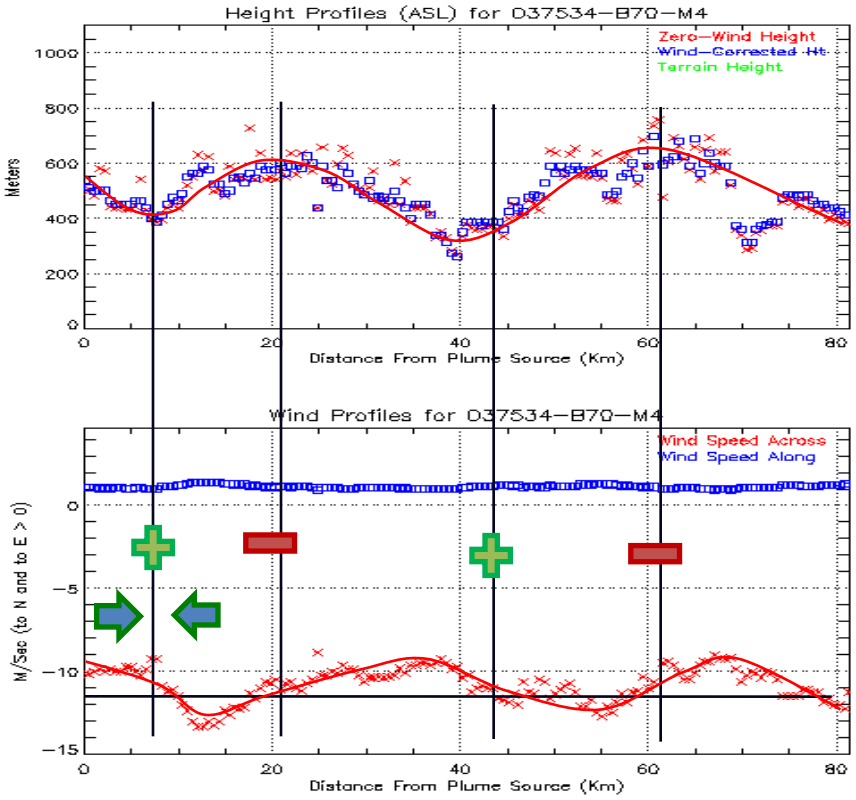




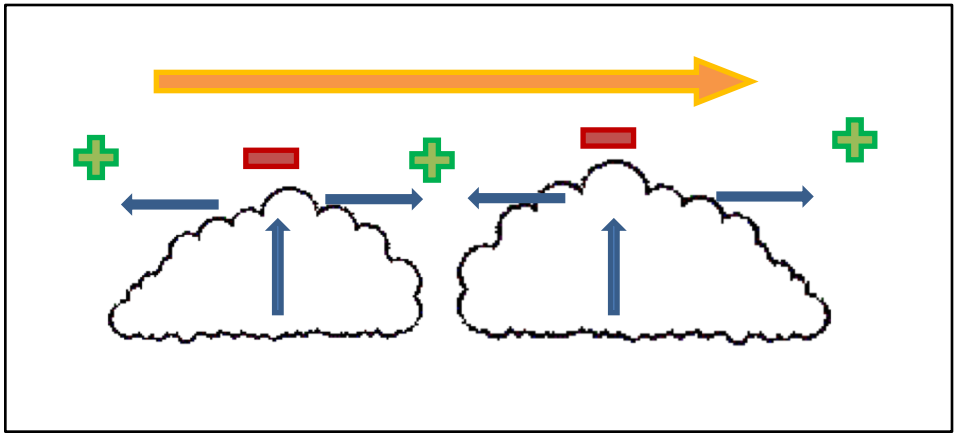
Chen et al. (2015)

Maritime PBL Closed and Open Cells





- What is the correlation between cloud top height and the wind divergence?
- How are cellular structures related to wind convergence/divergence?
- What determine cloud height variations?



Wind Con/Divergence

Background wind

Relative motion

Summary

- Stereo imaging has sufficient vertical resolution and good coverage for PBL studies
- Needs for constraining PBL dynamics at top and bottom:
  - Winds from cloud imager (top) and from scatterometer (bottom)
  - Cloud microphysics from imager (top) and SST from microwave (bottom)
- Needs for sufficient PBL spatial and temporal sampling:
  - LEO for global high vertical resolution
  - GEO for temporal evolution
  - LEO-GEO for comprehensive understanding