Estimating Boundary Layer Eddy Viscosity in Tropical Cyclones from Synthetic Aperture Radar Images

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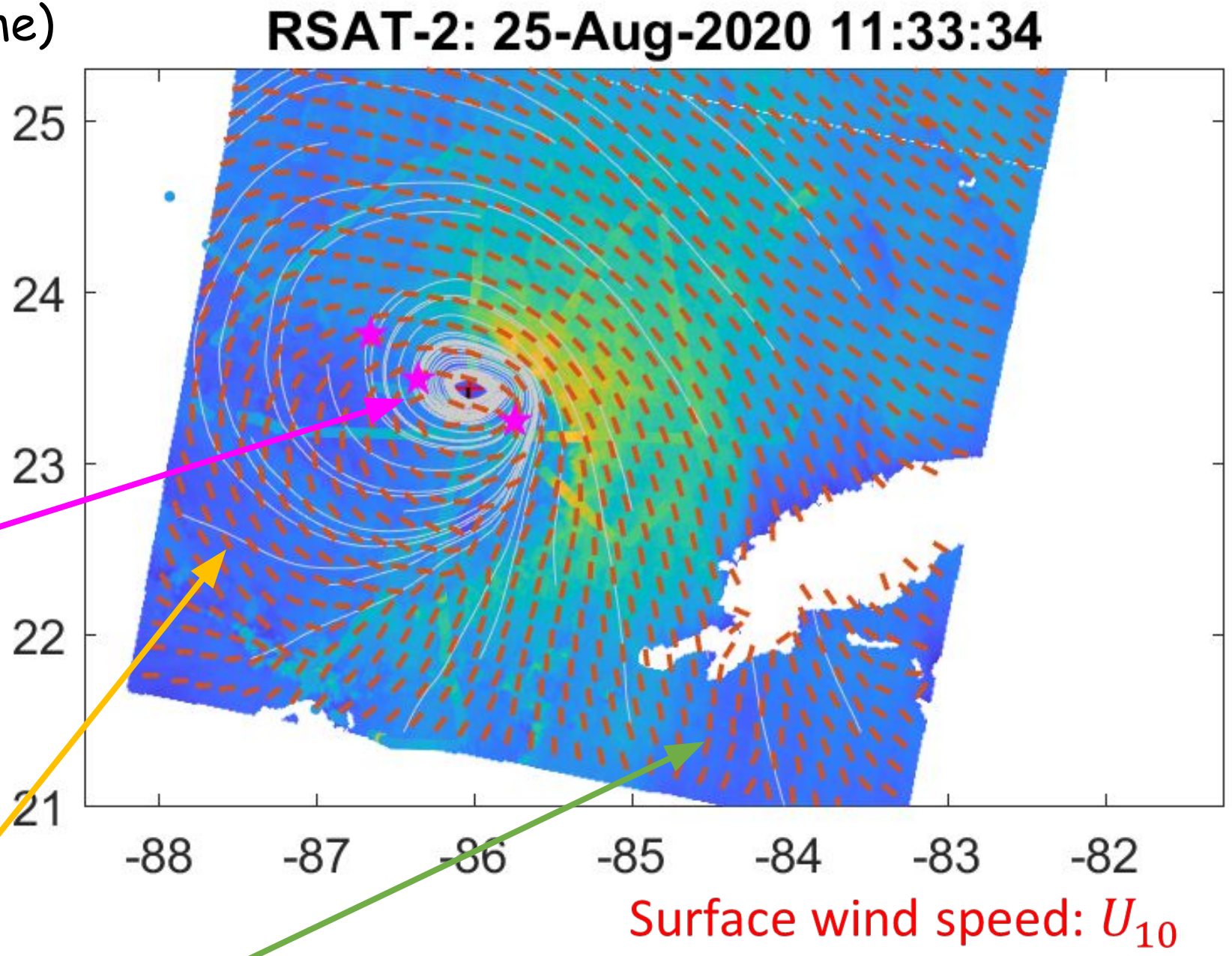
Laura 2020: Cat-1 (at this time)

P-3 (N42) flight: 10:20 to 15:00
SAR overpass: 11:30



Magenta stars: P3 Center fixes
Red +: SAR circ. Ctr.

Gray streaklines: Wind Direction
Red Dashes: Wind streak (PBL roll) directions

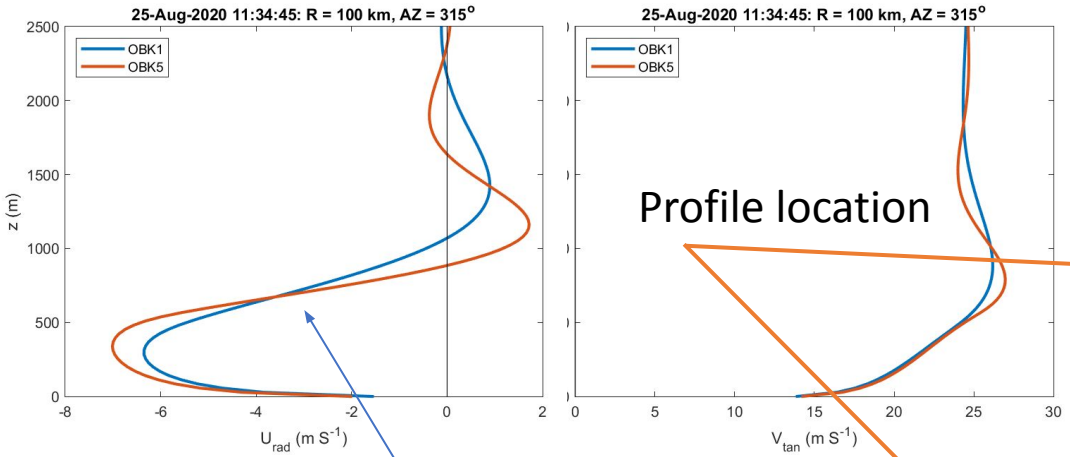
Derive TCBL U(z), V(z) from SAR

- SAR (VV and VH) NRCS → U_N vectors (~1 km footprint)
  - (kinematic) Surface stress: $u_*^2 = C_D U_N^2$
  - $\frac{\partial U_{10}}{\partial z} \sim \frac{1}{\kappa z_{sfc}} C_D^{1/2} U_{10}$ (near-neutral stratification)
- Sea-level Pressure pattern from U_{10} (FOSTER,2017)
  - Estimate radial pressure gradient ($\frac{\partial P}{\partial r}$)
- Diagnostic similarity TCBL model (BVP) (FOSTER, 2009)
  - Upper and lower BCs from SAR images
    - Lower BC: Surface stress
    - Upper BC: $\frac{\partial P}{\partial r}$
- Wind profiles are sensitive to assumed K(z) <u>for the same BCs</u>
- PBL roll characteristics are sensitive to U(z), V(z)

Hypothesis

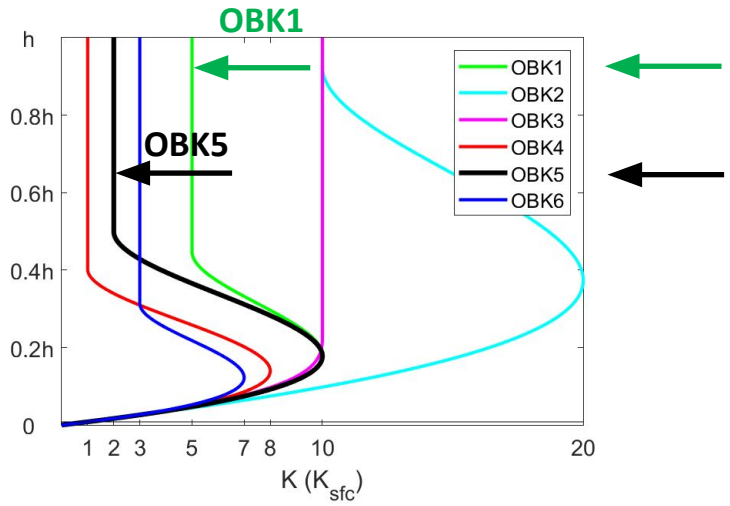
- **Given: Independent** retrievals of
  - Surface Wind Direction:
    - Minimize misfit between observed/derived NRCS
    - ECMWF first-guess
  - TCBL roll orientation:
    - Local NRCS gradient
    - ~25 km patches
- "Optimal" K(z) best predicts the TCBL roll orientations
  - This will hopefully provide insight into TCBL parameterizations

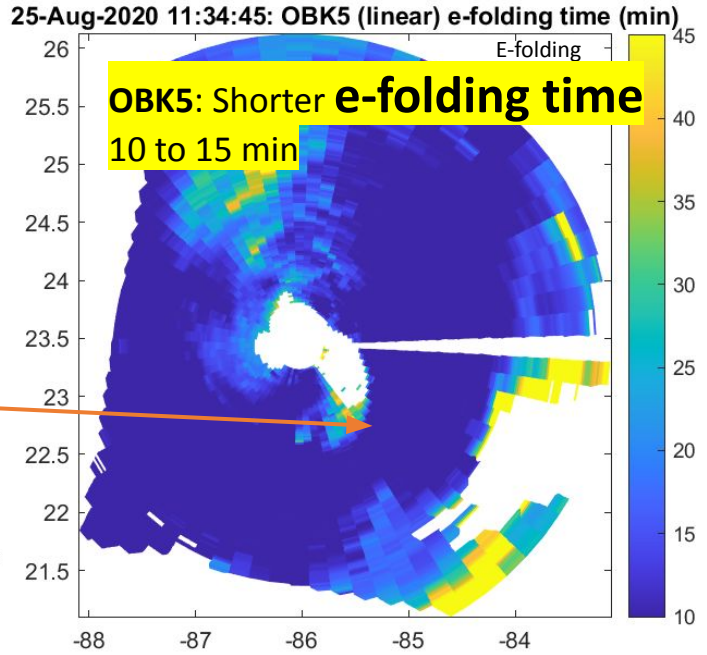
TCBL roll Characteristics are sensitive to U(z), V(z), K(z)

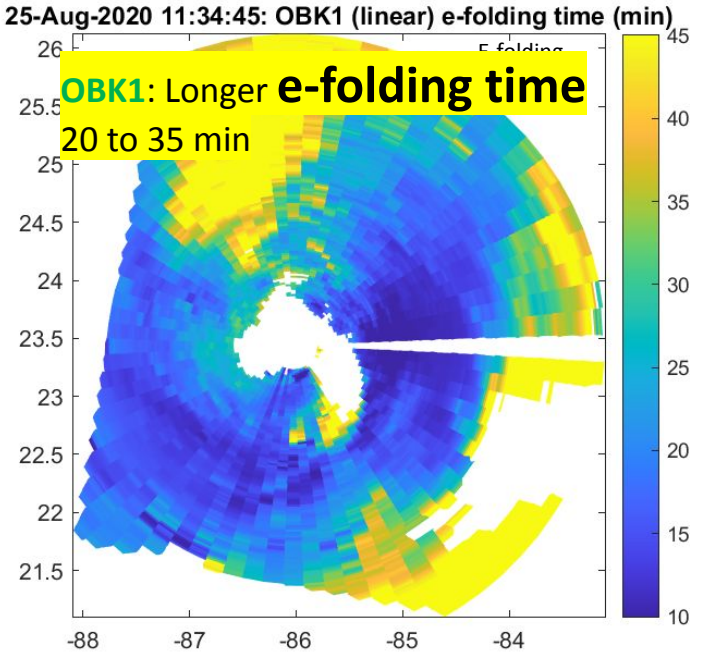


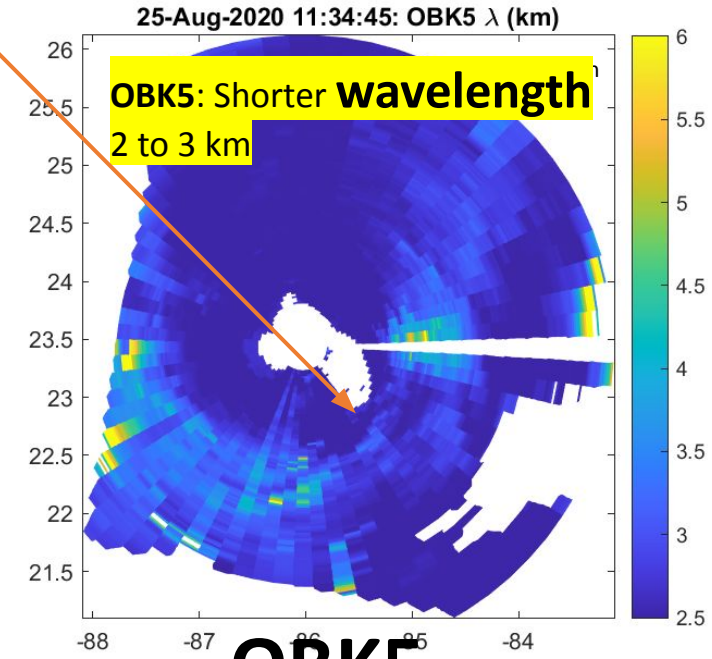
Profile location

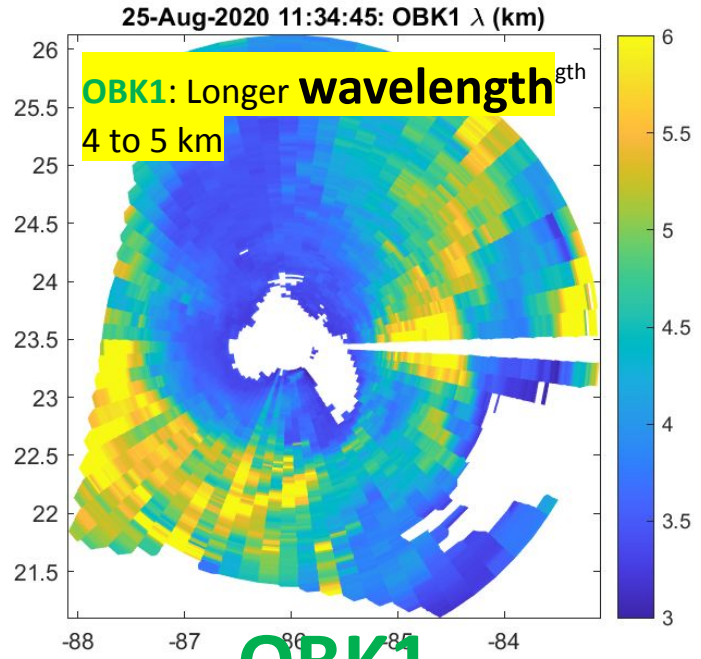
OBK5: Higher shear in cross-wind inflection point
 Faster growth, shorter wavelength





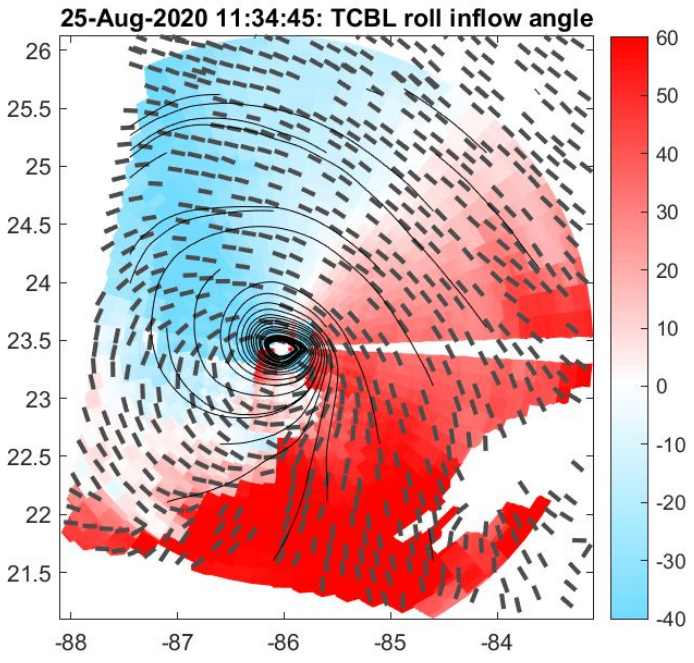


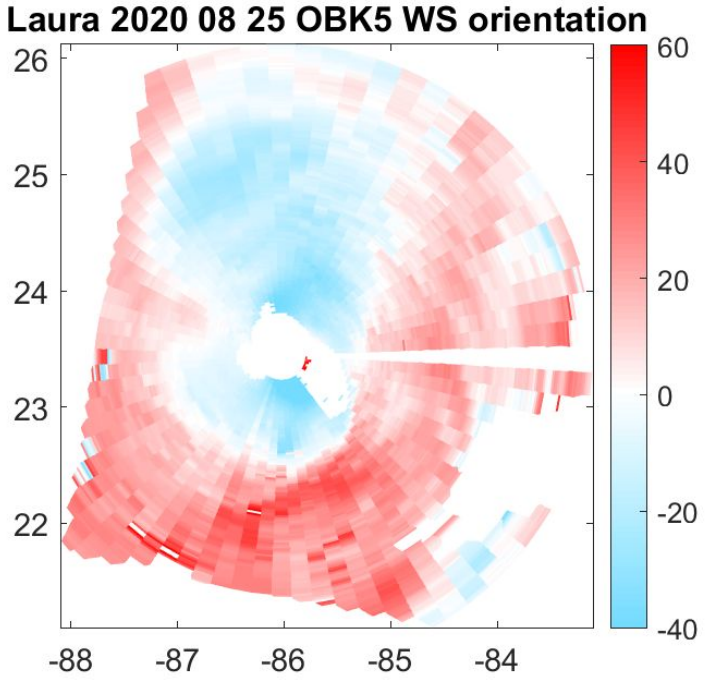


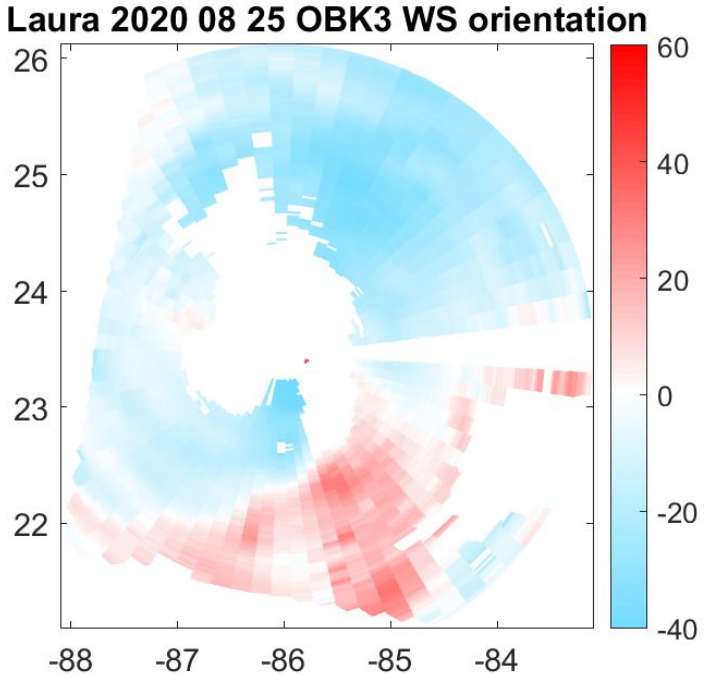


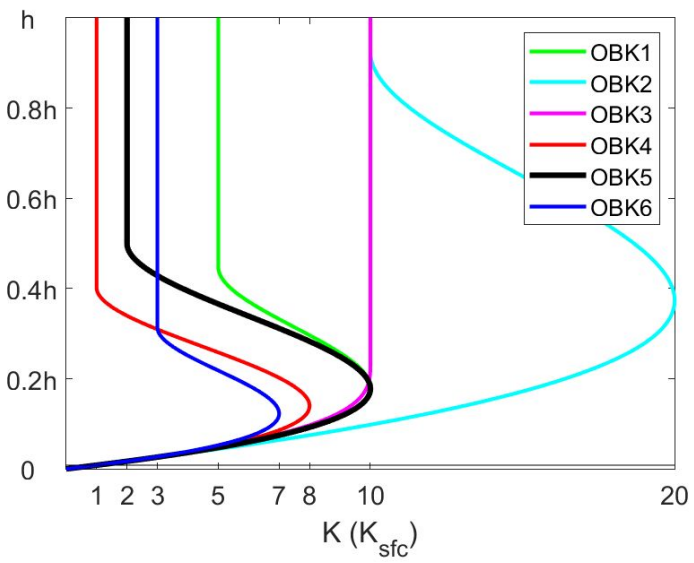
OBK5

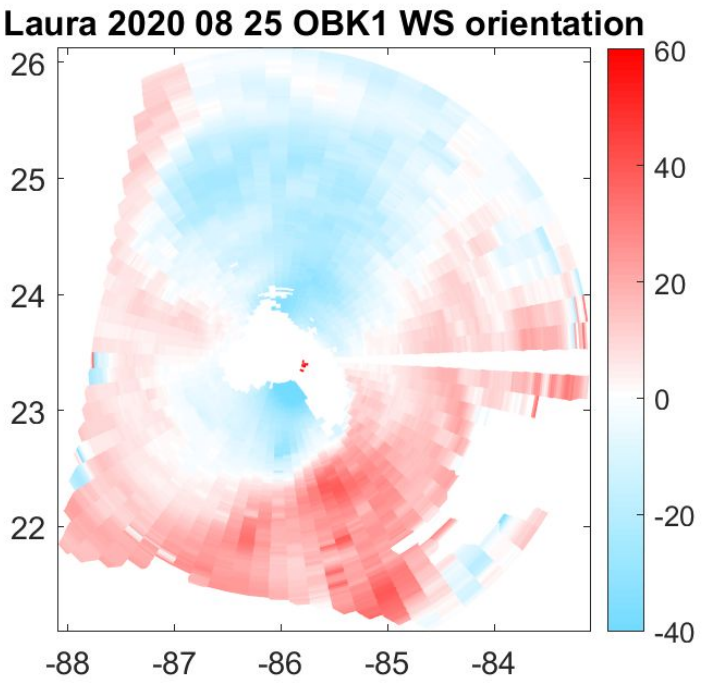
OBK1











Caveat: Symmetric Cd

- Key parameters seem to be
  - $K_{max}(K_{sfc})$
  - Z_{max}
  - $K_{top}(K_{sfc})$
  - Z_{top}
- Simple K(z) varies these independently

Summary

- SAR provides unique, high resolution data in TCs
  - Move beyond surface wind fields to
    - Sea-level pressure
    - Flow partitioning (irrotational, non-divergent and synoptic-scale steering)
    - TCBL roll characteristics
    - Mean U(z), V(z) in TCBL
  - Seek typical K(z) characteristics, compare to common parameterizations
    - Evident skill in predicting TCBL roll orientation
  - Could method be applied to future WACM-like data?
    - Rain gaps? High Winds? Current effects on stress?
    - Test with SAR (degrade resolution, add rain-missing vectors)
- Compare SAR-estimated TCBL roll characteristics with any Obs (IWRAP?)
    - Roll orientation is easily measured by SAR and quite sensitive to mean mean U(z), V(z)
    - TCBL parameterization: non-local fluxes
- Validate SAR-estimated U(z), V(z)
    - SAR estimates are mean winds
    - Sondes are slant-wise profiles across several minutes
      - Single realization in turbulent flow
    - Working on comparisons with IWRAP (spatial mean)
    - Numerical models?
      - mesoscale tied to parameterizations
      - LES often has domain size issues (not so bad these days …)