Combined polarimetric Doppler radar and satellite scatterometer observations of organized convection near coastal regions

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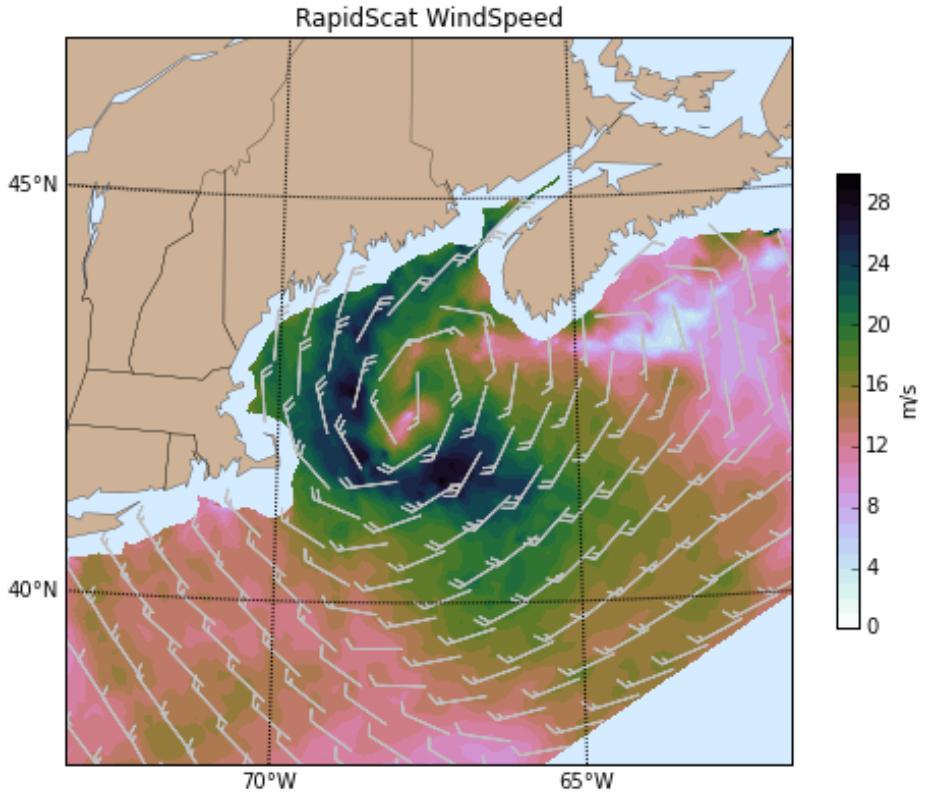
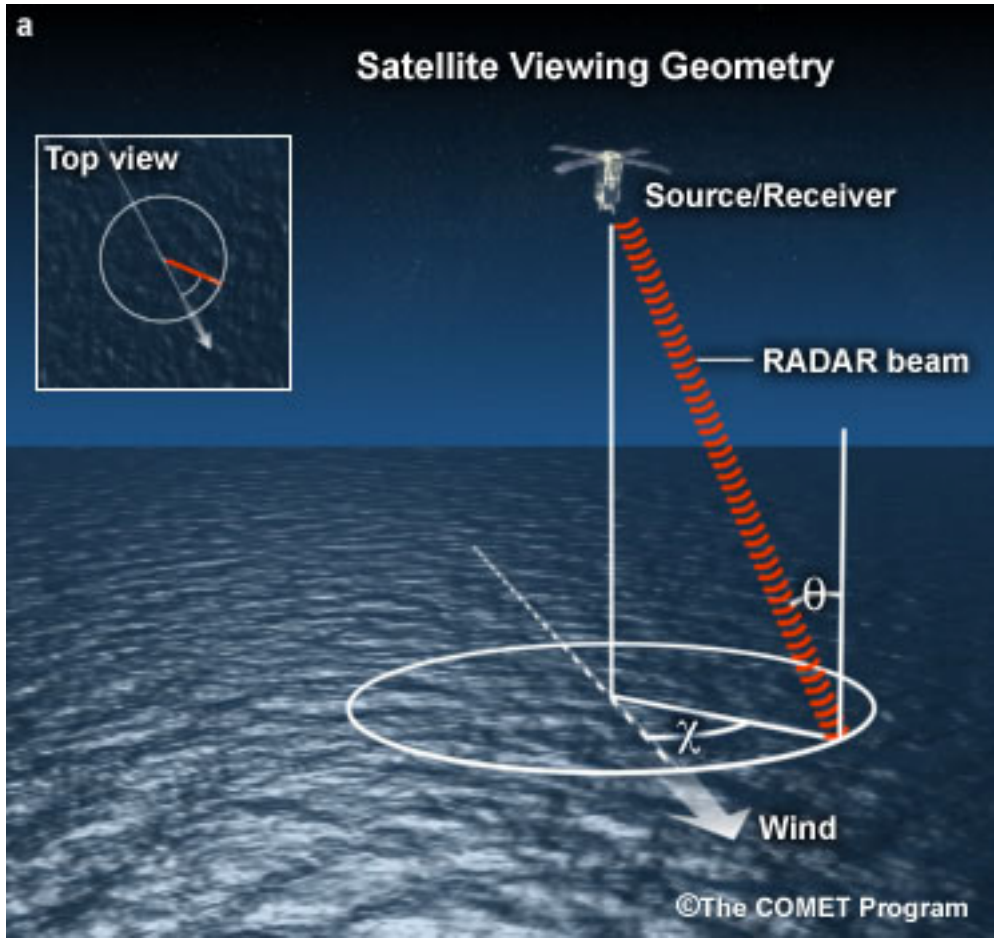


Background

- Scatterometers are radars on satellites that scan the ocean surface at multiple look angles
- Retrieve wind speed and direction via empirical relationships (geophysical model functions) linked to ocean surface state (mean square slope)
- Typically Ku- (e.g., QuikSCAT, RapidScat) or C-band (e.g., ASCAT) - subject to attenuation by rainfall, or spoofing by raindrop-induced surface capillary waves

Our Scientific Questions

- Given limitations of scatterometers in raining areas, how can we best use them to understand near-surface winds in and near organized convective systems?
- What is the value added by combining scatterometry with polarimetric Doppler radars near coastlines/islands?
- Can we identify significant surface wind features (e.g., in/outflow, boundaries, jets, etc.) that may be responsible for organizing convective systems?

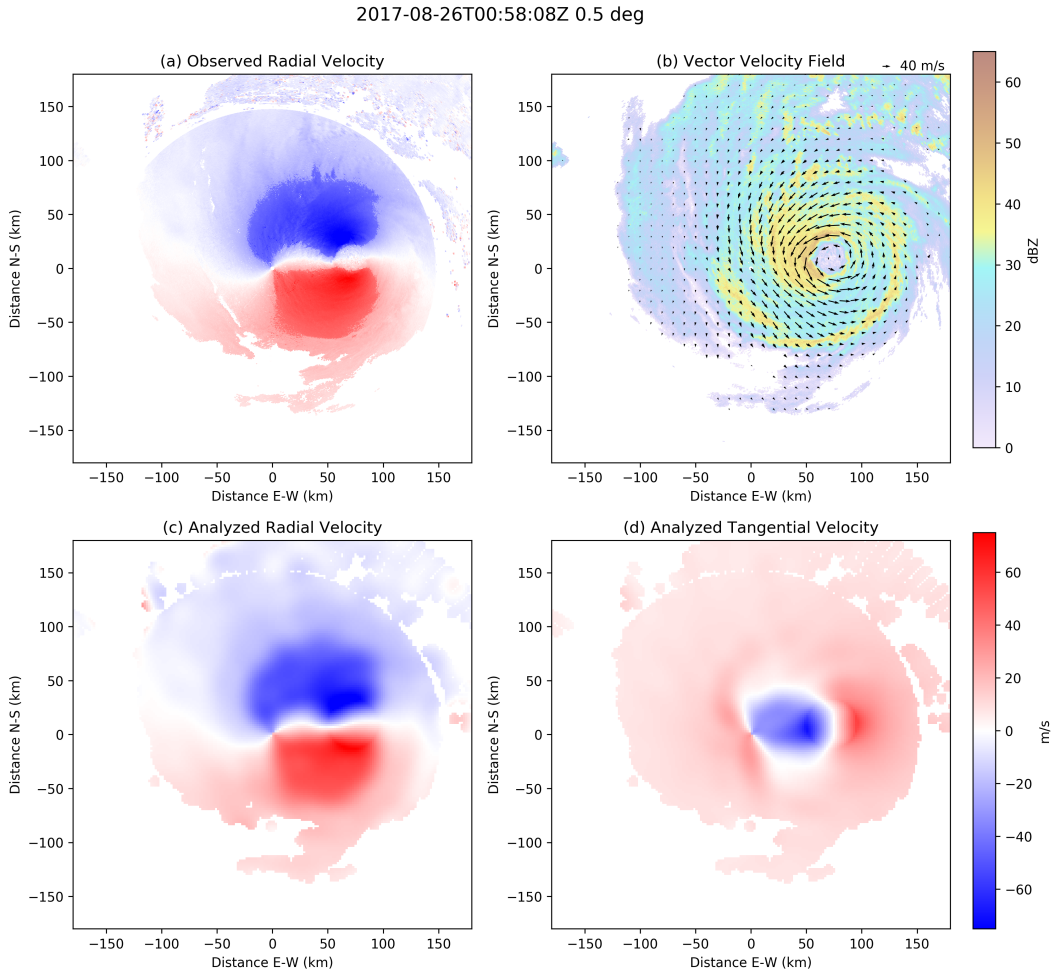


www.goes-r.gov (COMET module)

SingleDop

https://github.com/nasa/SingleDop

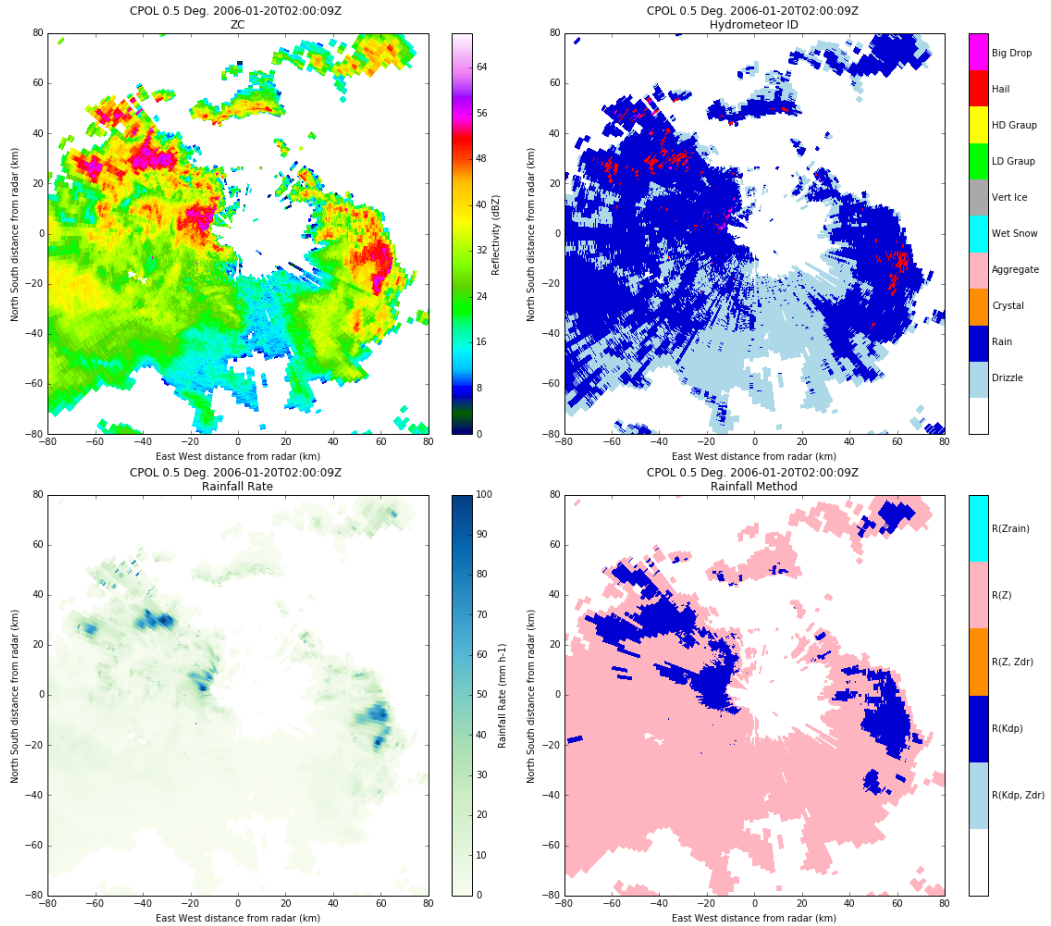
- Single-Doppler retrievals of low-level 2D winds on conical PPI sweep
- Based on Xu et al. (2006) 2DVAR algorithm



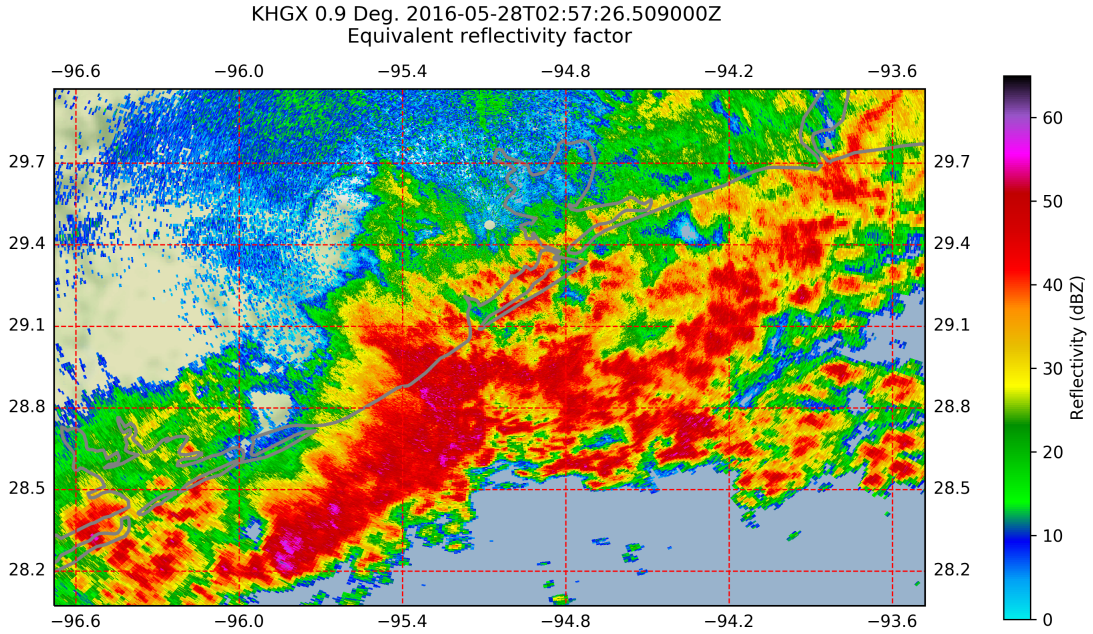
DualPol

https://github.com/nasa/DualPol

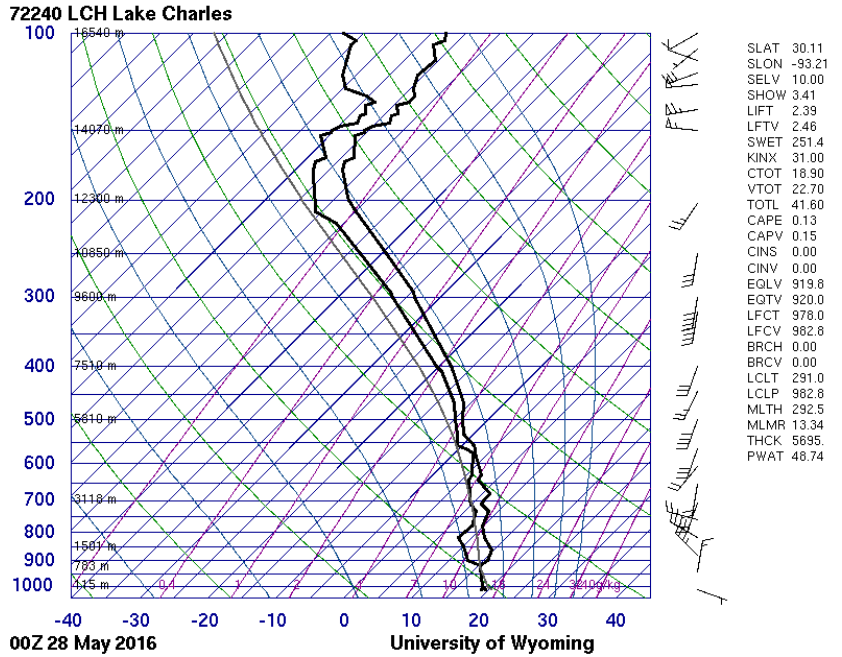
- Dual-pol retrievals from arbitrary radar, including rain, DSD, LWC/IWC, HID, etc.
- Based on CSU algorithm heritage (e.g., Bringi, Chandra, Carey, Cifelli, Dolan, Lang)

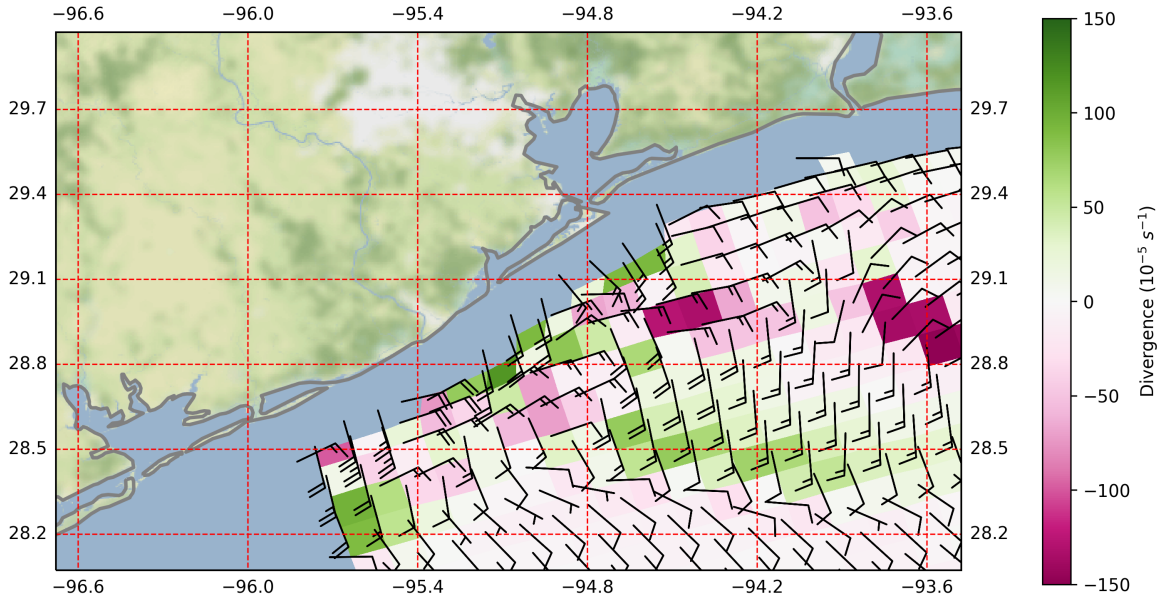


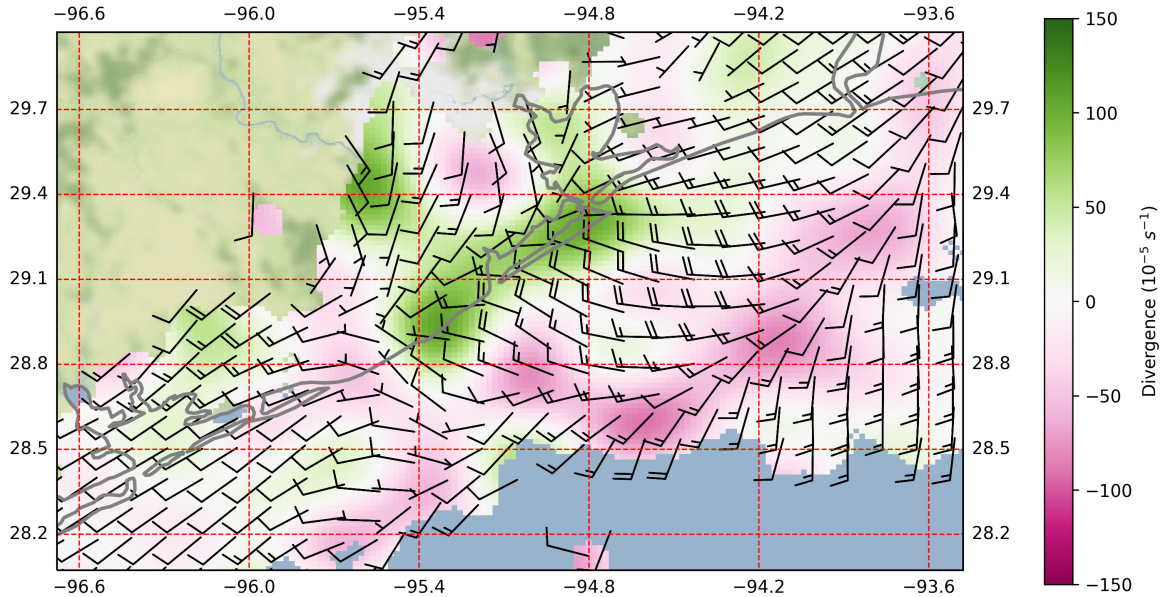
Also – Py-ART, CSU_RadarTools, pyresample, etc.



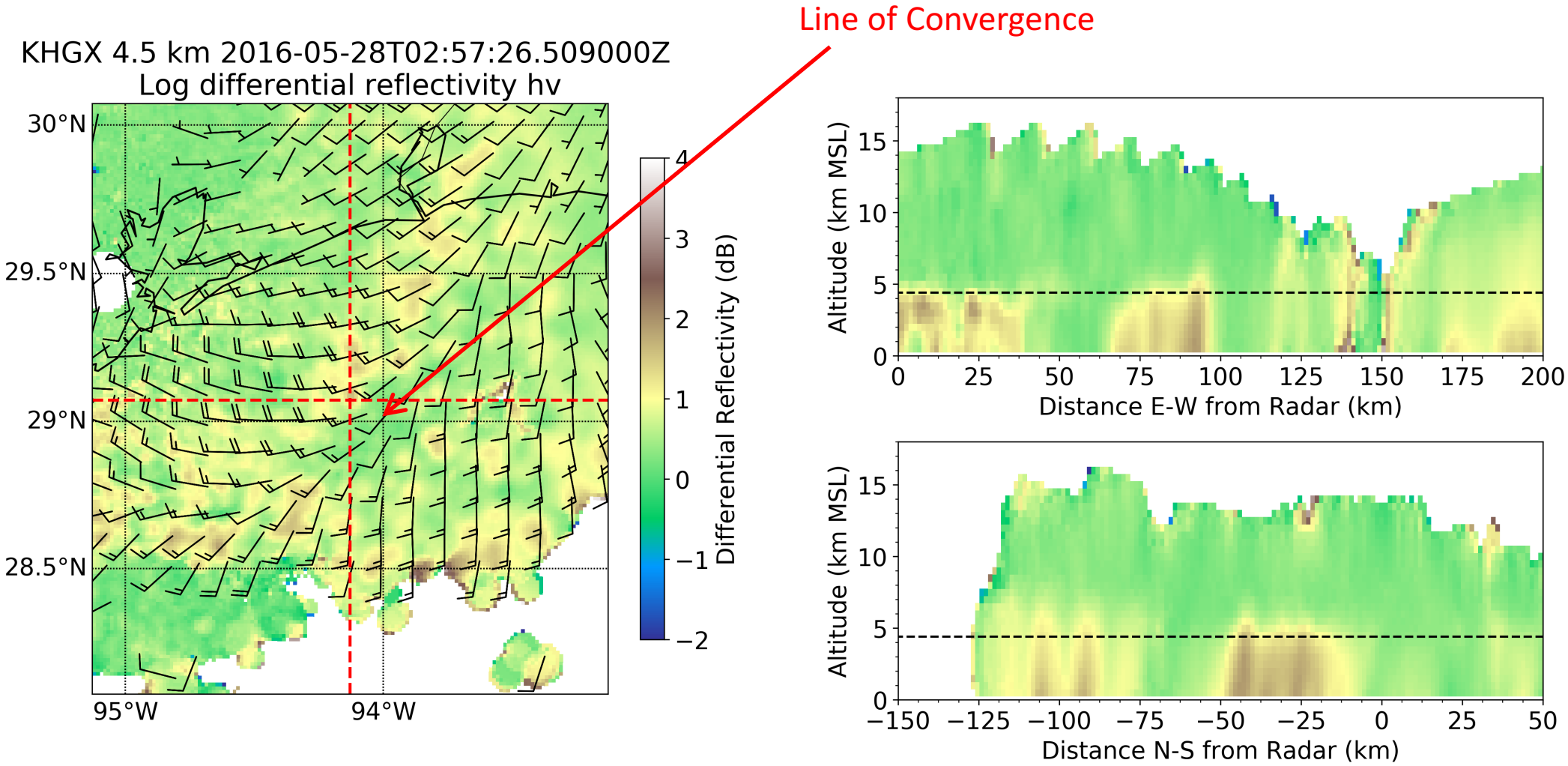
5/28/2016
Houston





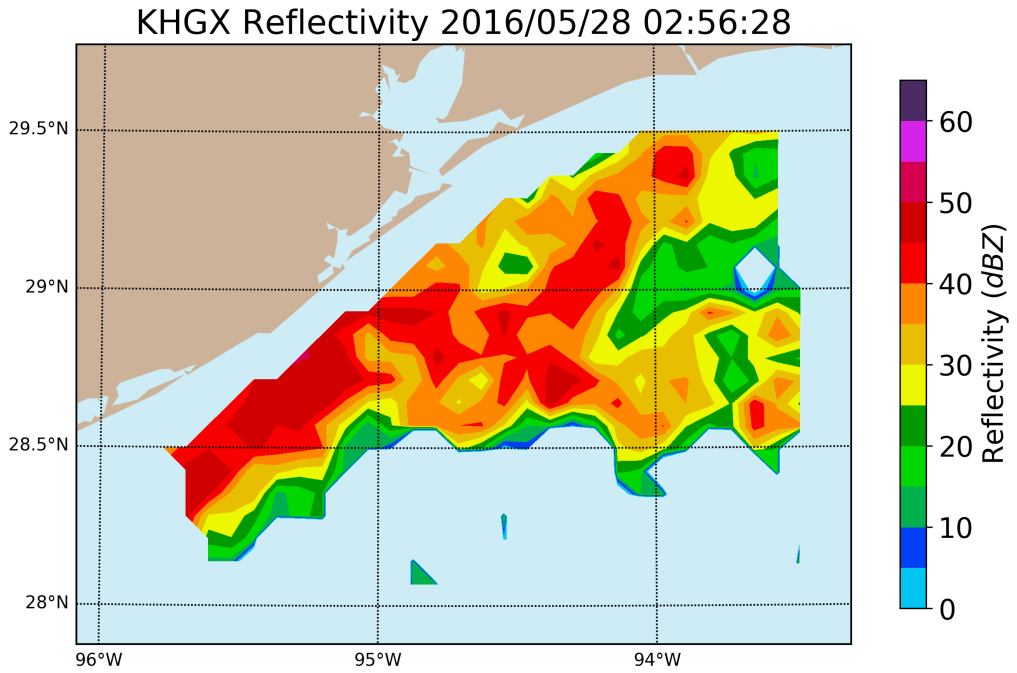


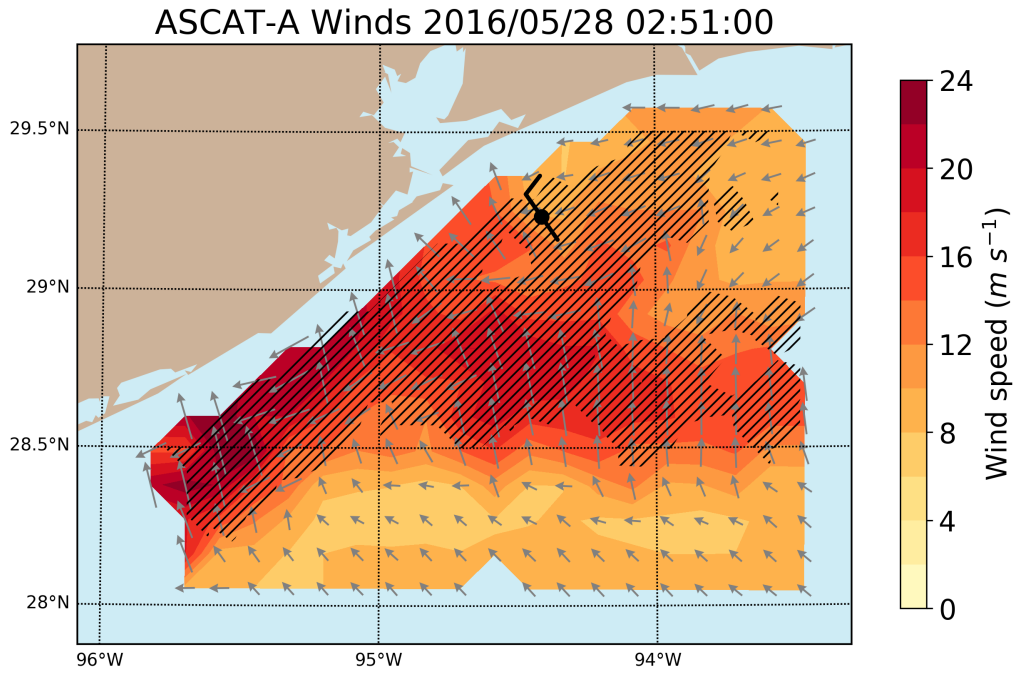
ZDR and SingleDop Winds

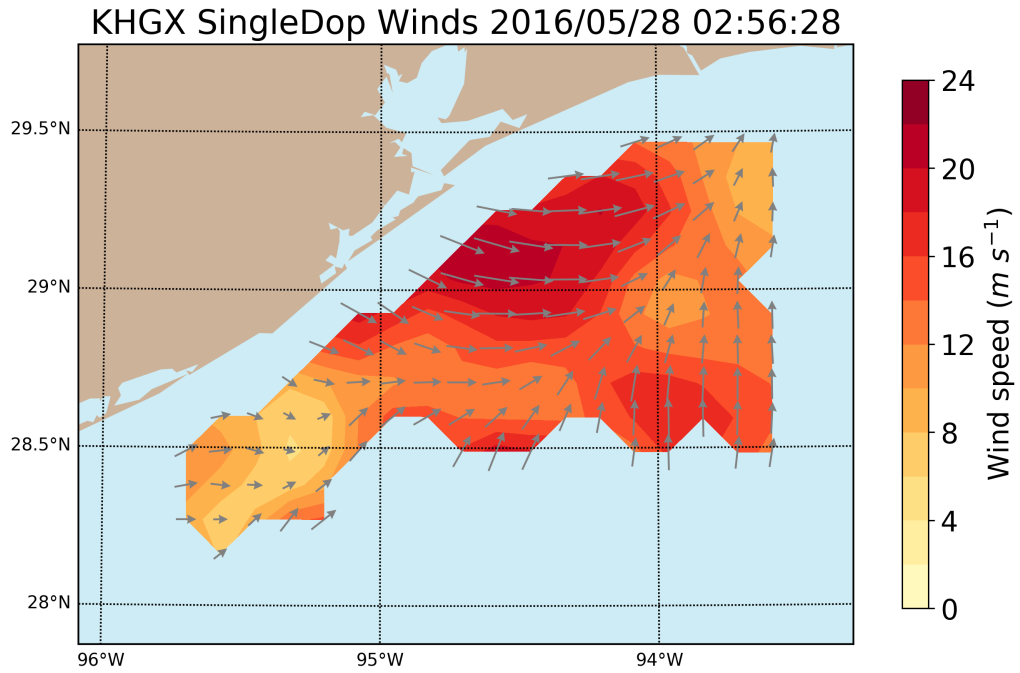


ZDR columns reside just rearward of low-level convergence

Radar resampled to 12.5-km ASCAT resolution

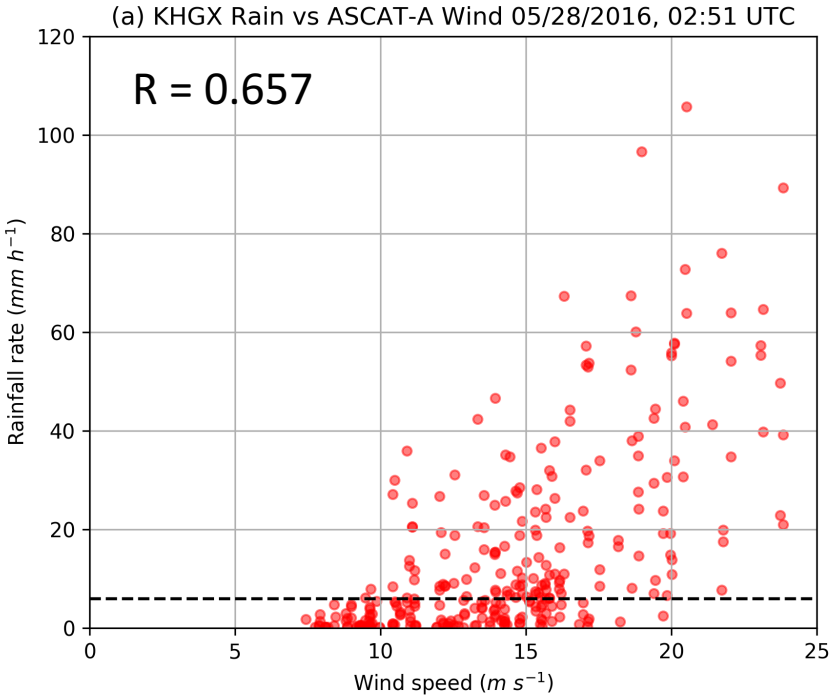


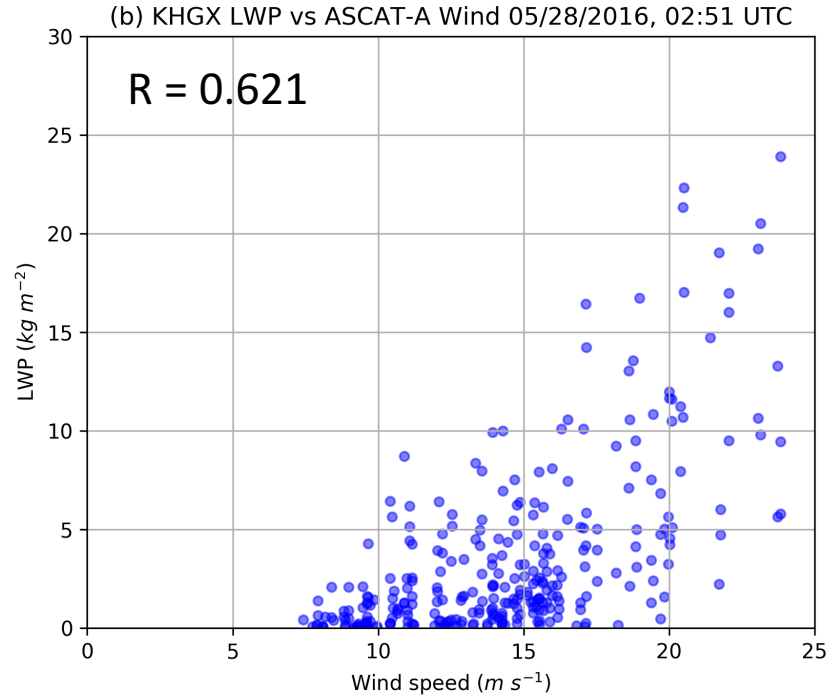




Resampled to 12.5-km

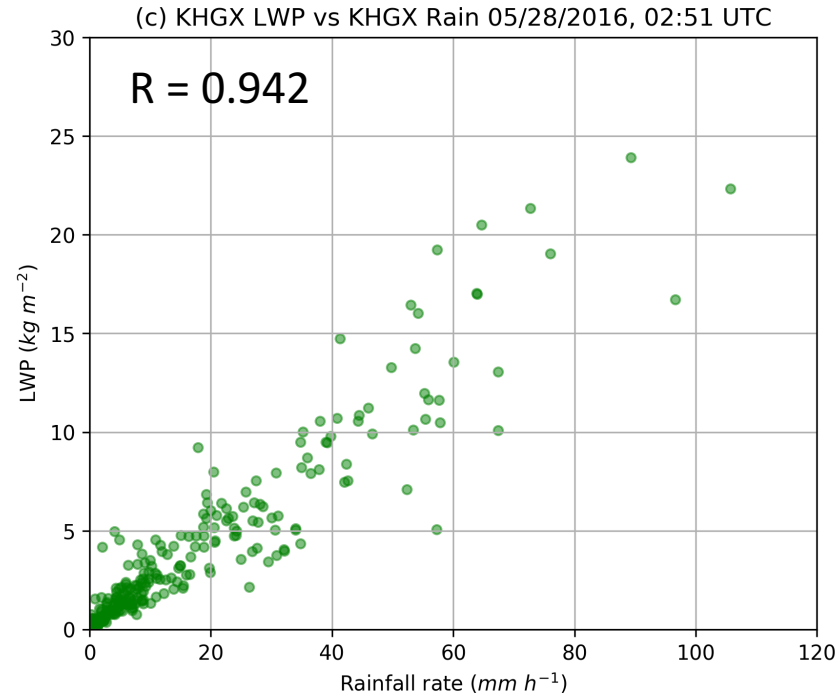
KHGX Rain vs. ASCAT-A Wind

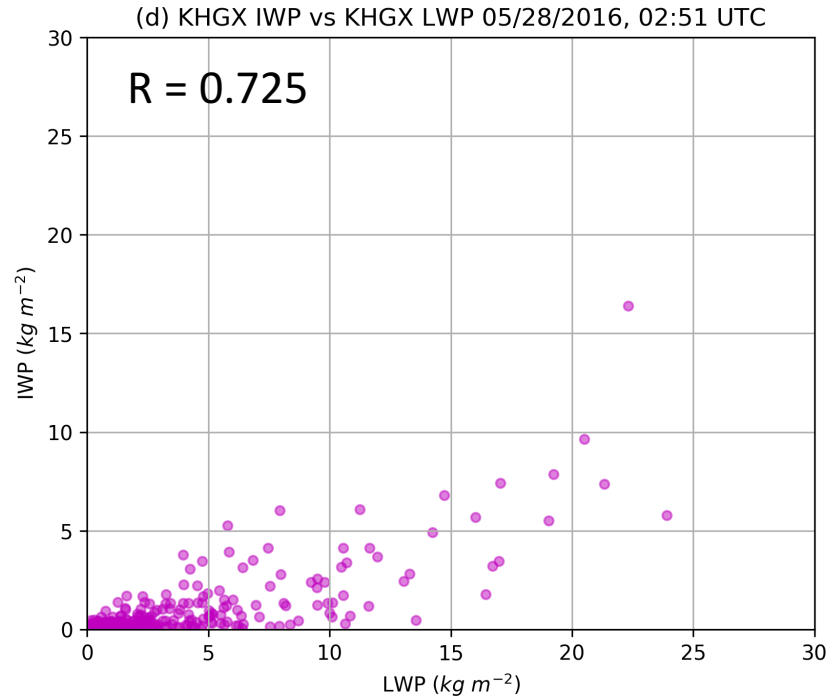




KHGX LWP vs. ASCAT-A Wind

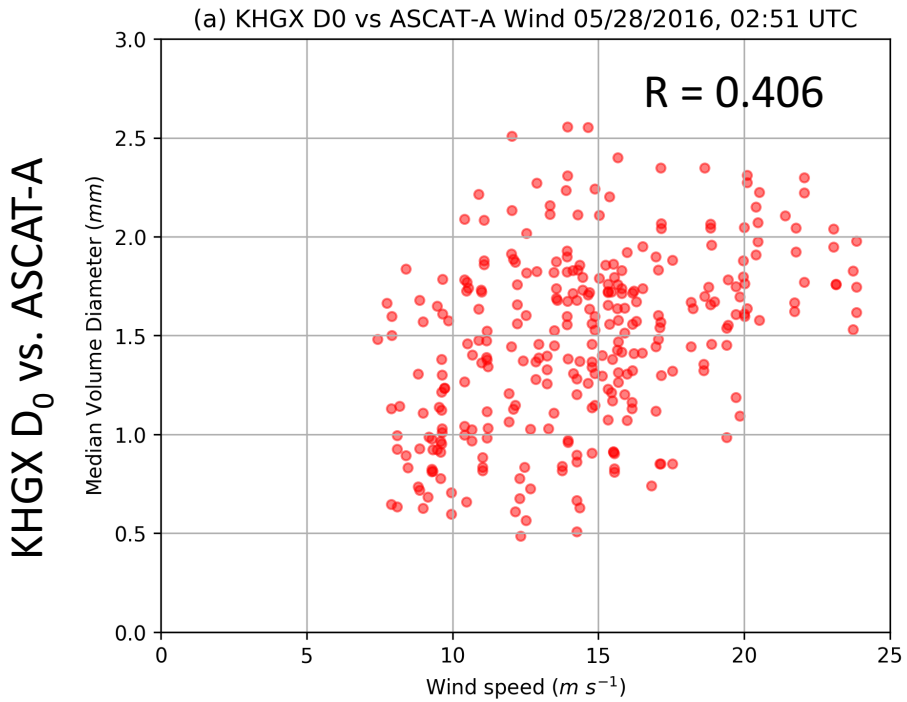
KHGX LWP vs. KHGX Rain



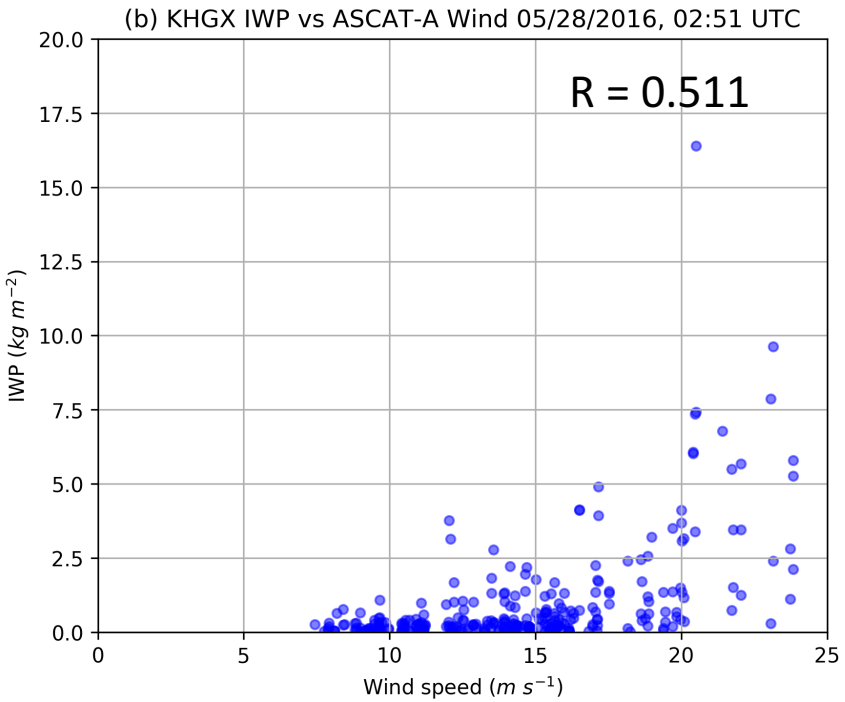


KHGX IWP vs. KHGX LWP

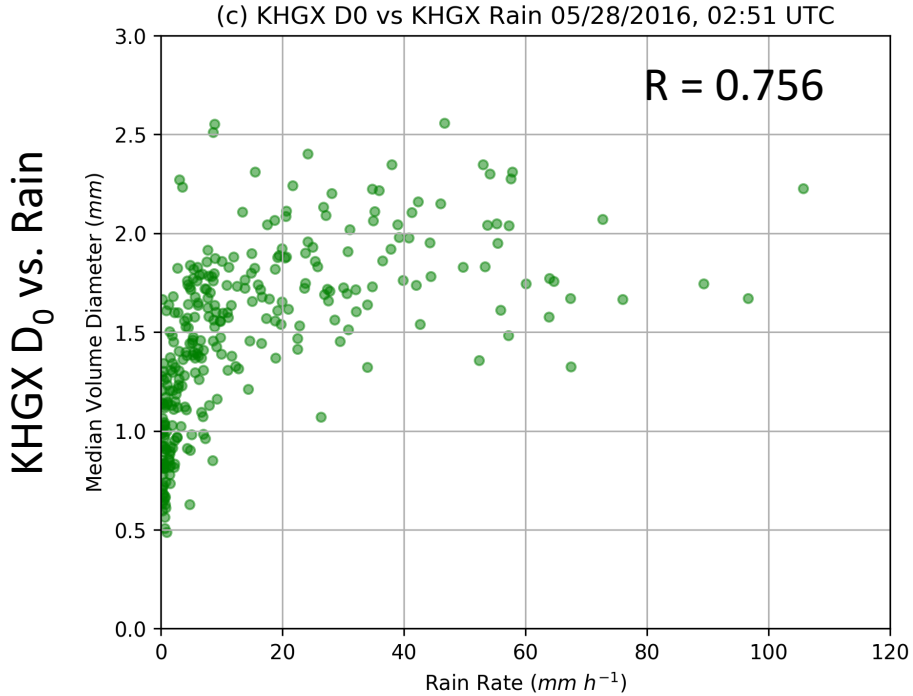
Resampled to 12.5-km



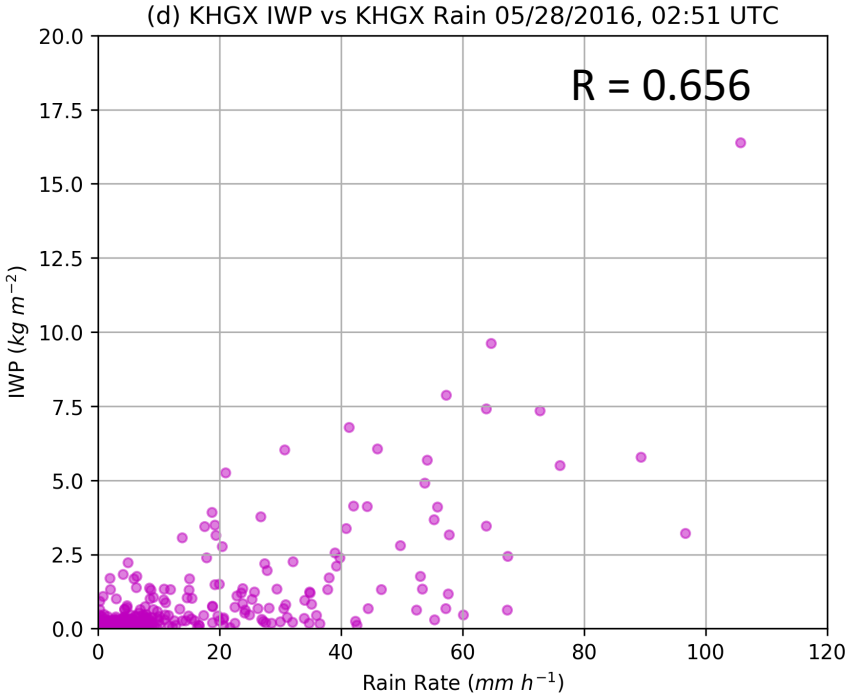
KHGX D_0 vs. ASCAT-A



KHGX IWP vs. ASCAT-A



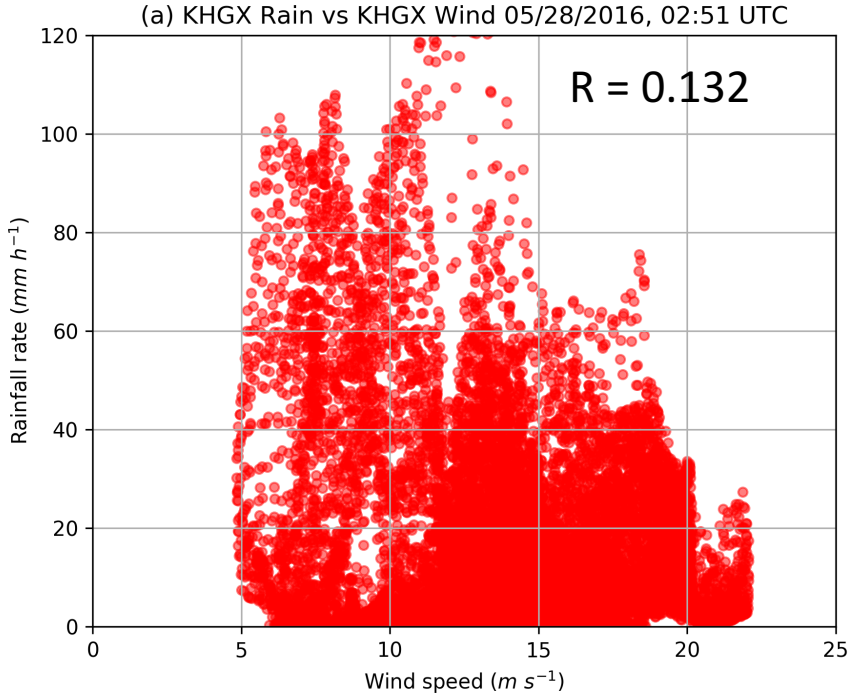
KHGX D_0 vs. Rain

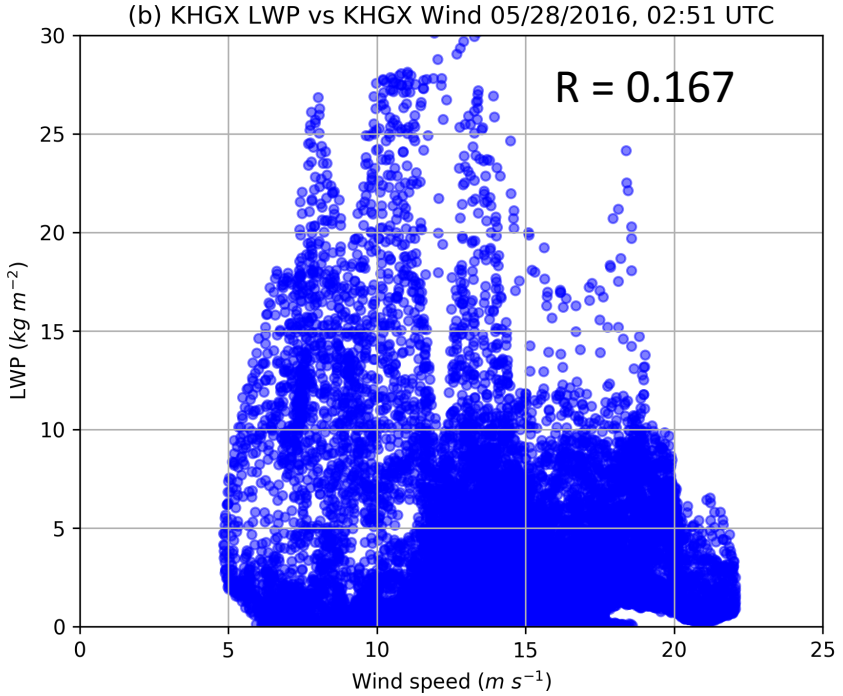


KHGX IWP vs. Rain

Resampled to 2-km

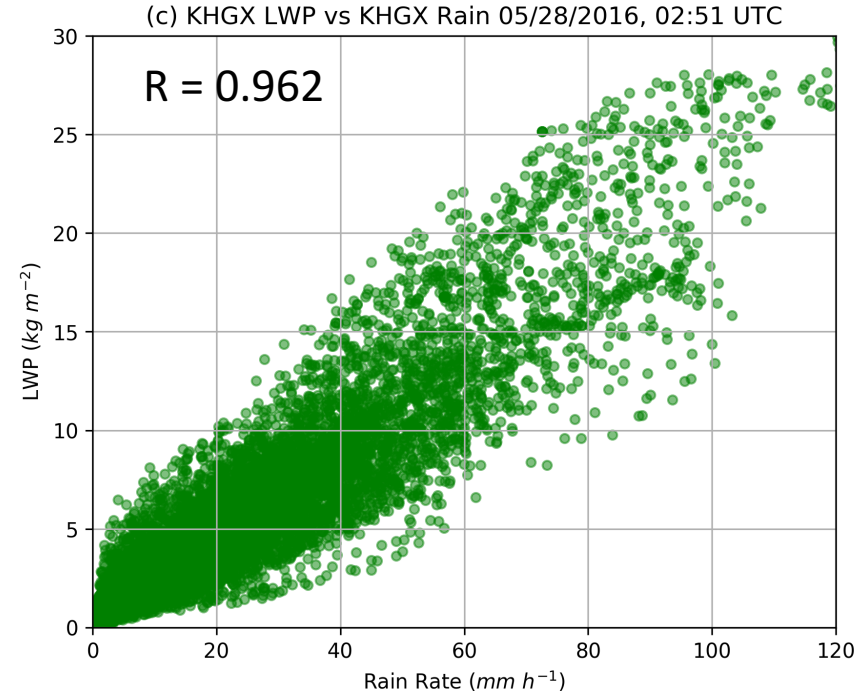
KHGX Rain vs. KHGX Wind

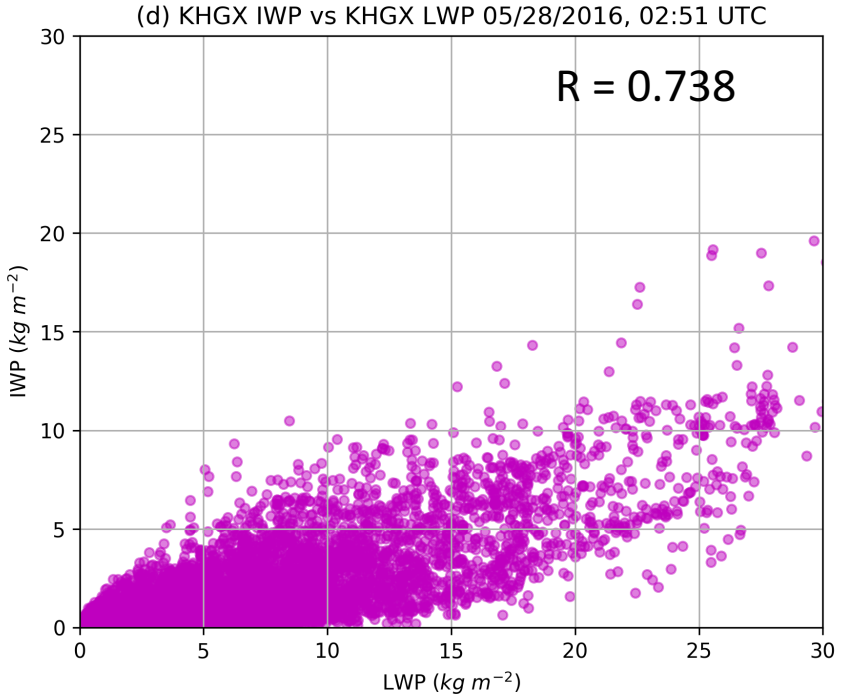




KHGX LWP vs. KHGX Wind

KHGX LWP vs. KHGX Rain

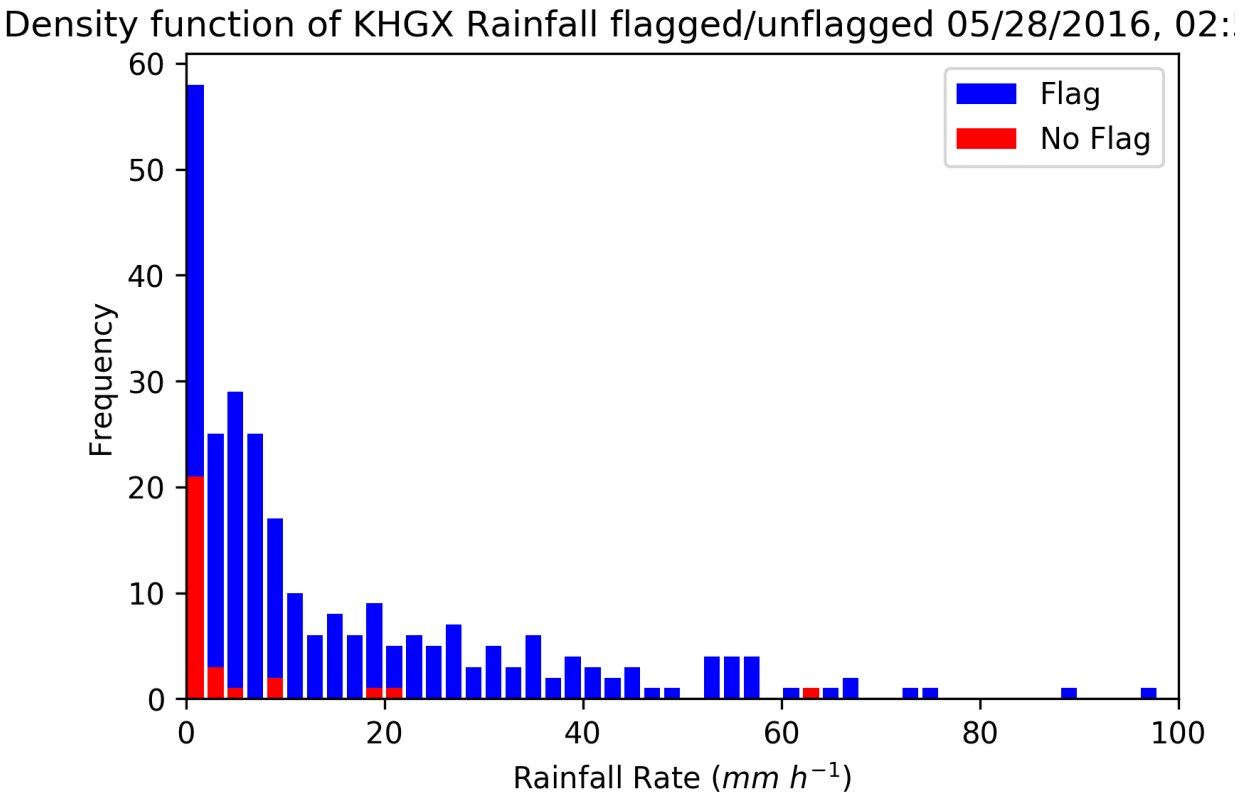


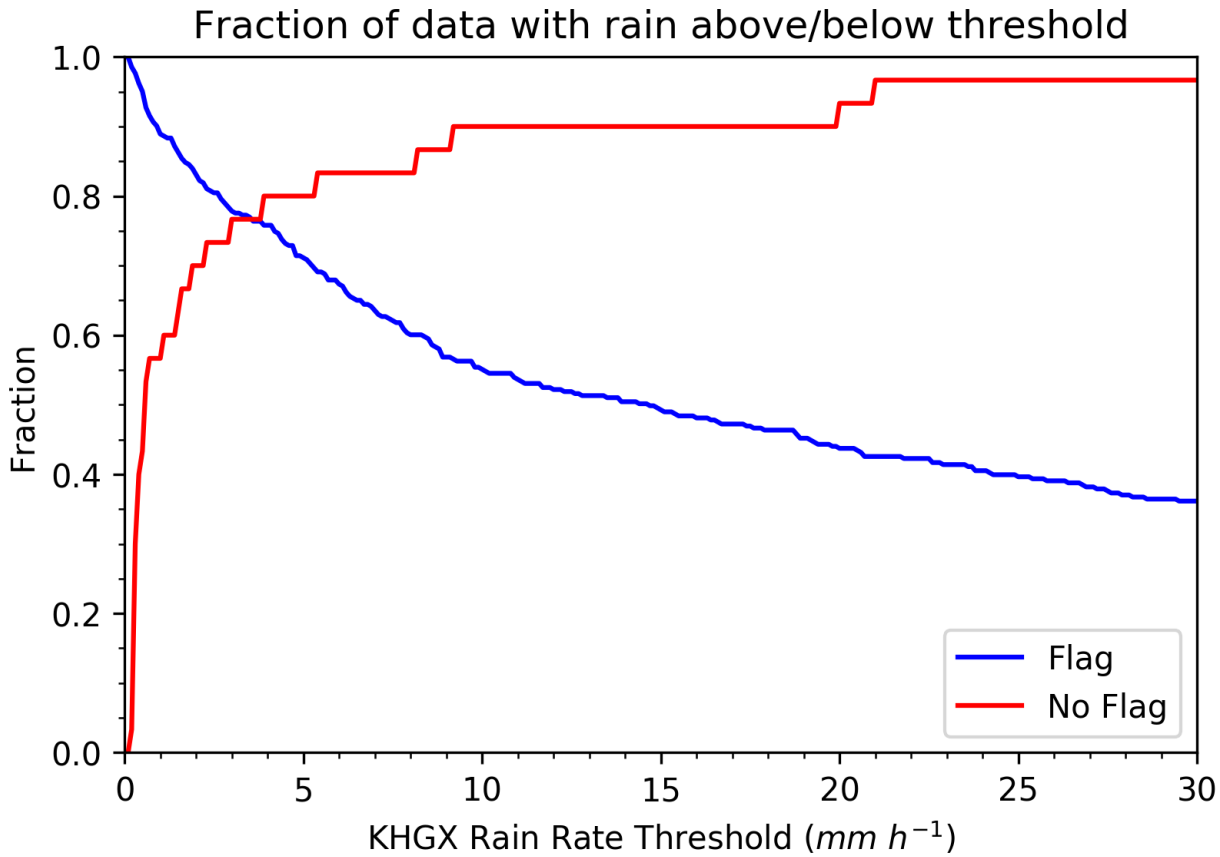


KHGX IWP vs. KHGX LWP

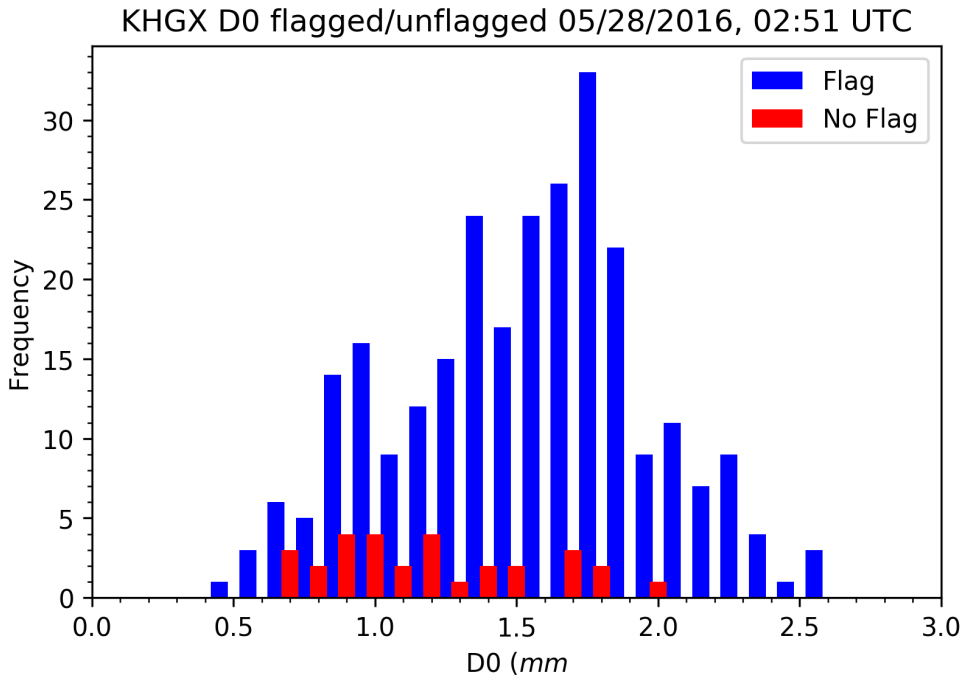
At a threshold of 3 mm h^{-1}:

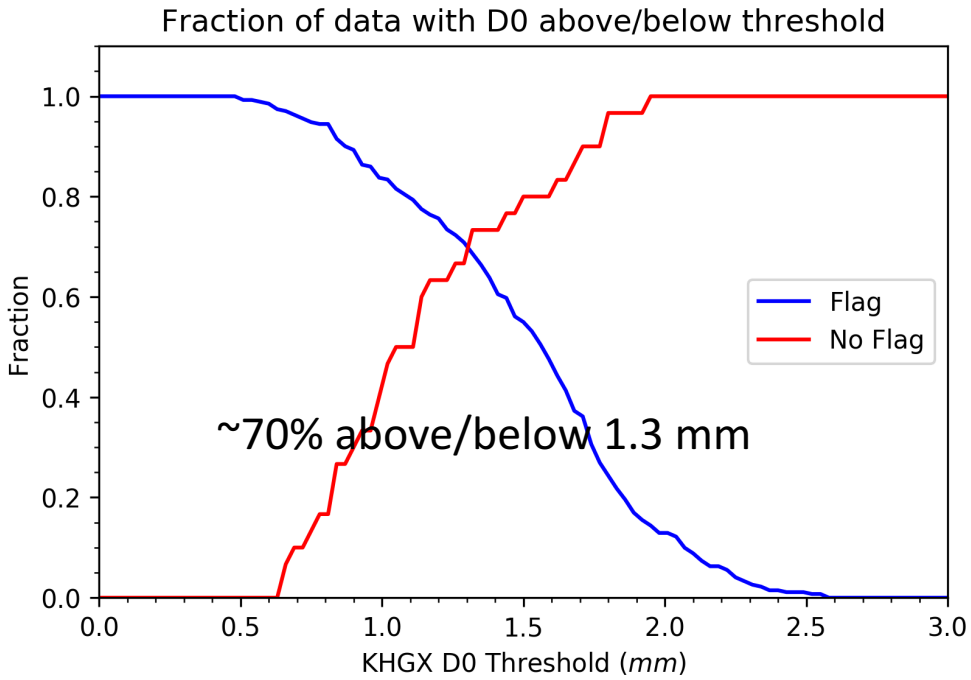
- ~75% of flagged ASCAT data are above
- ~75% of unflagged ASCAT data are below



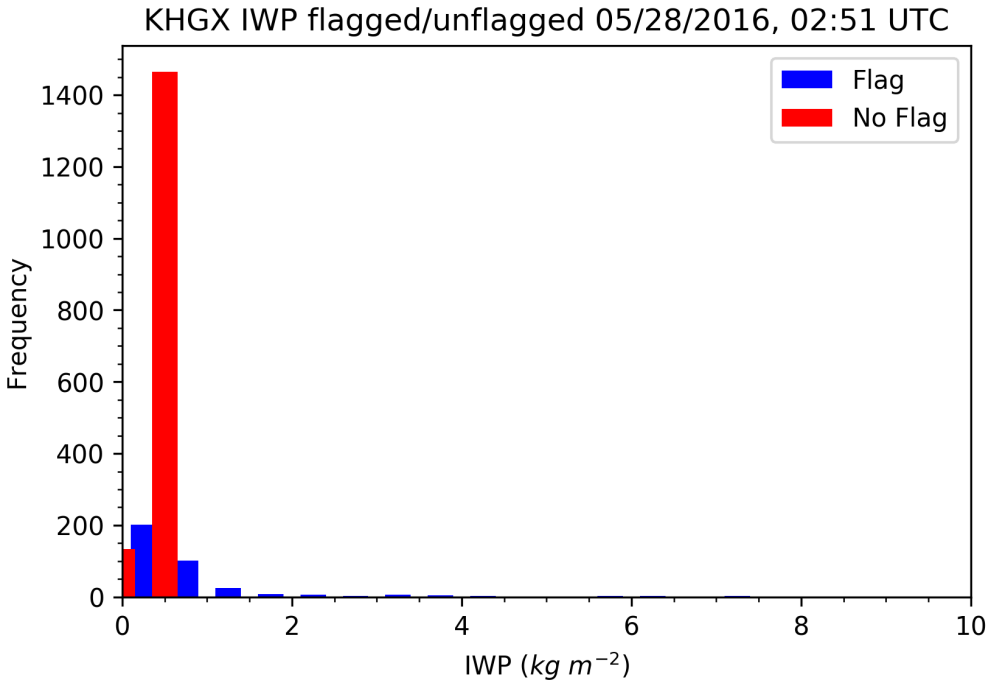


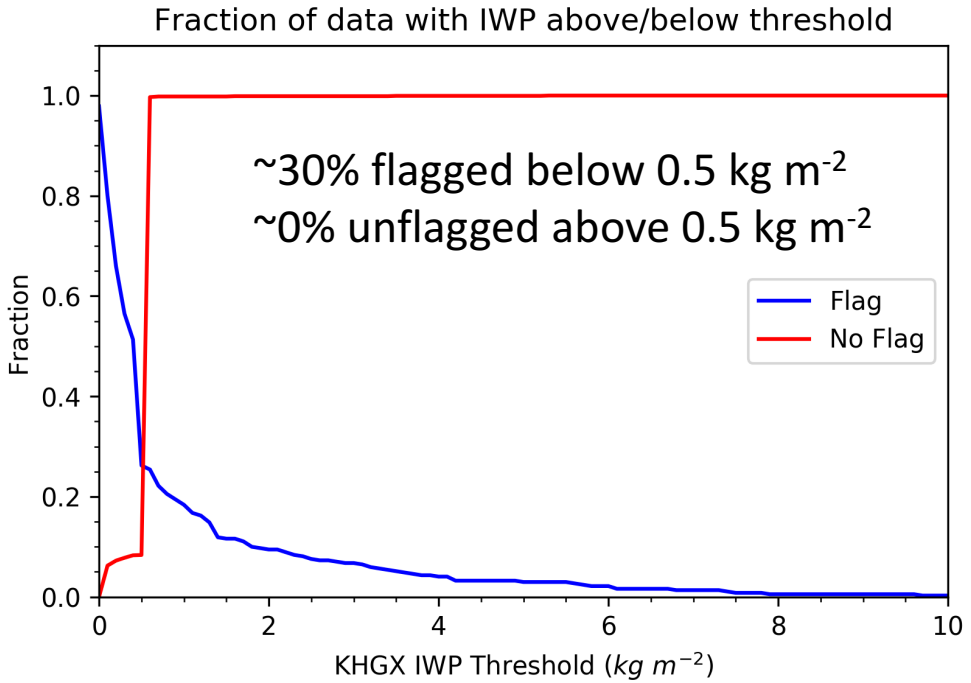
D_0


KHGX D0 flagged/unflagged 05/28/2016, 02:51 UTC
Flag
No Flag
Frequency
D0 (mm)

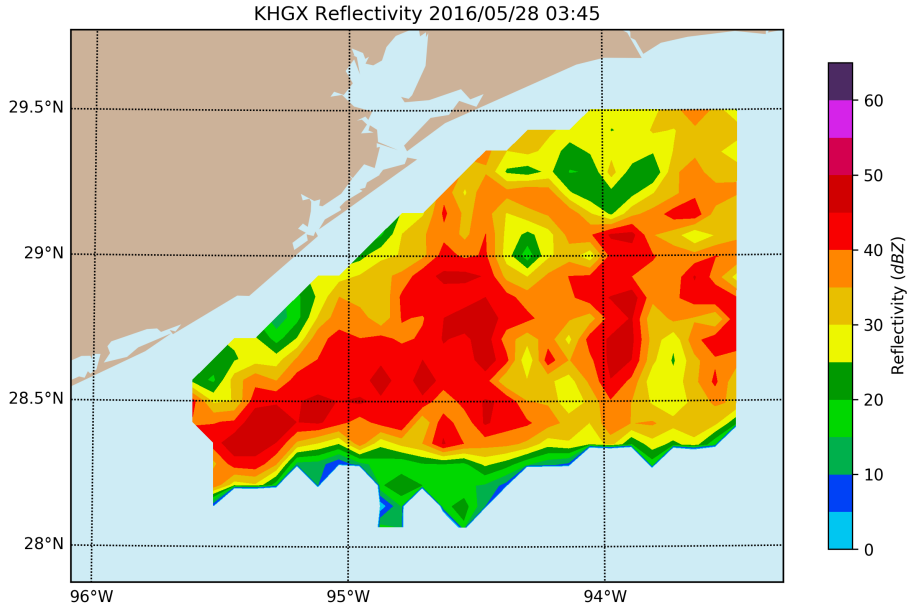

Fraction of data with D0 above/below threshold
Flag
No Flag
~70% above/below 1.3 mm
Fraction
KHGX D0 Threshold (mm)

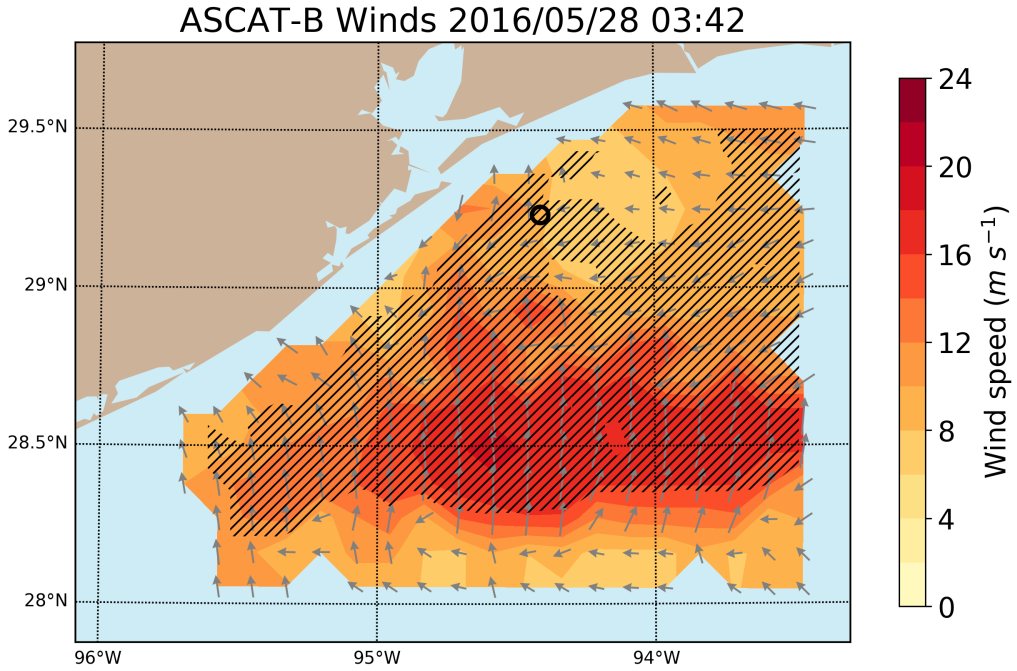
IWP

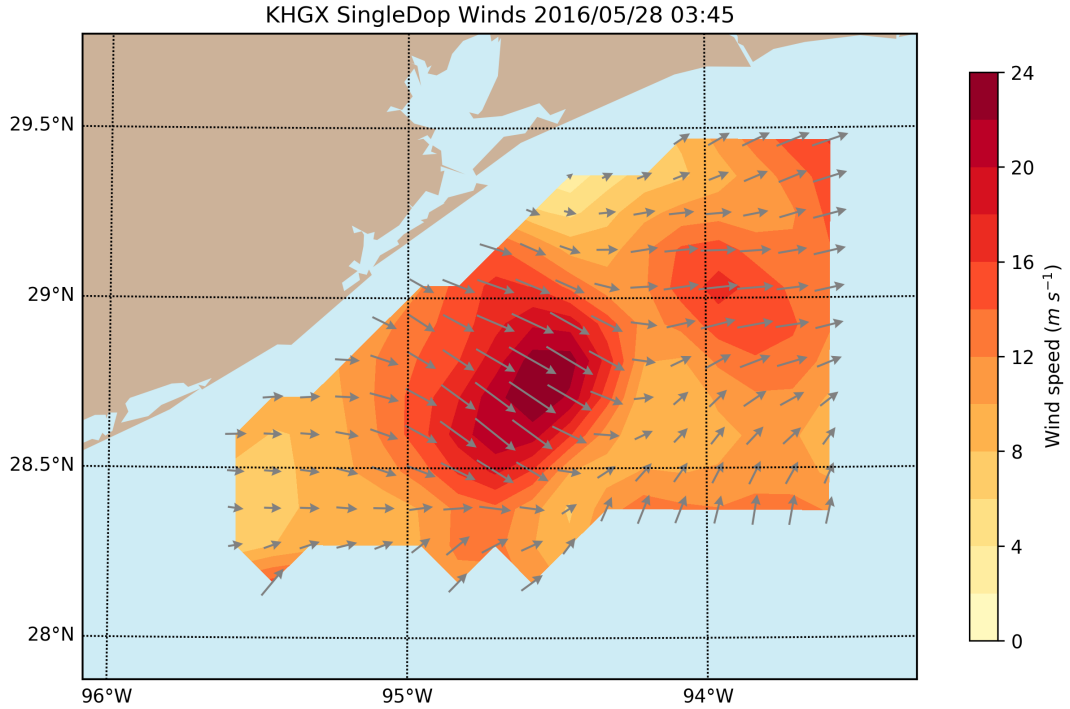

KHGX IWP flagged/unflagged 05/28/2016, 02:51 UTC
Flag
No Flag
Frequency
IWP (kg m⁻²)

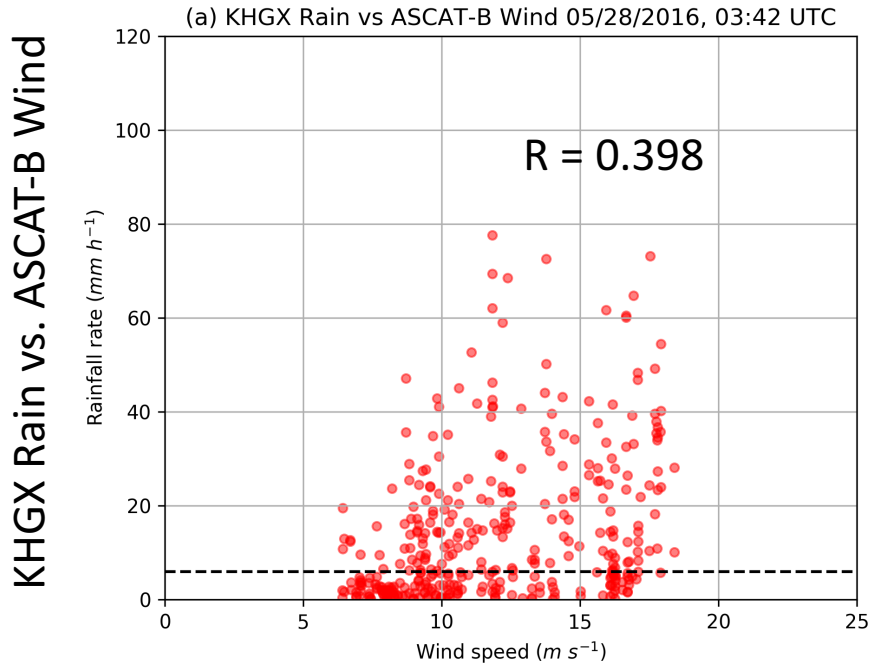

Fraction of data with IWP above/below threshold
~30% flagged below 0.5 kg m-2
~0% unflagged above 0.5 kg m-2
Flag
No Flag
Fraction
KHGX IWP Threshold (kg m⁻²)

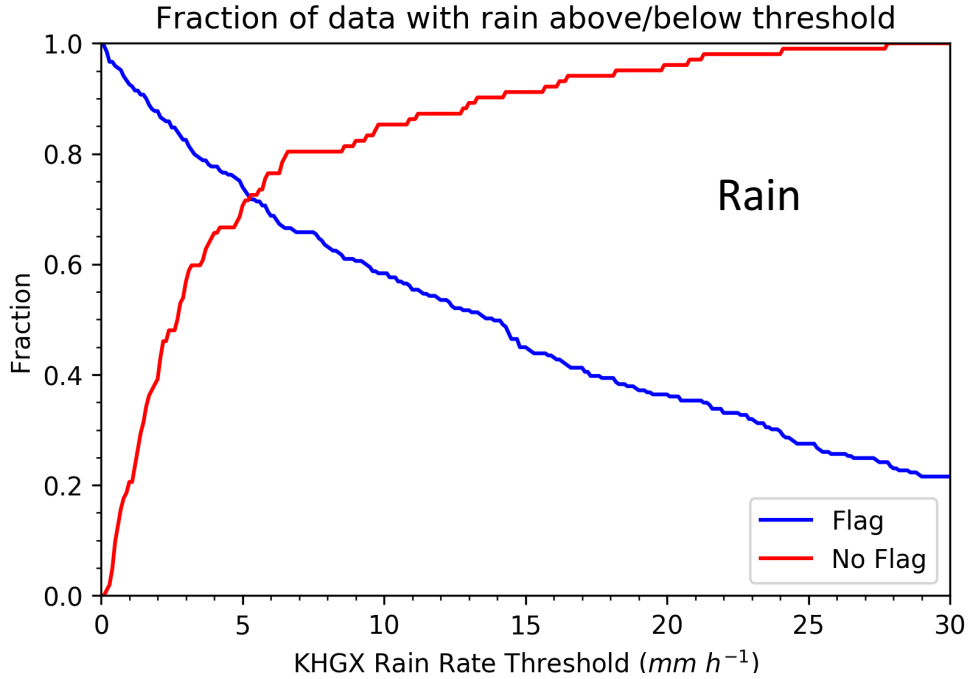
ASCAT-B Overpass
0342 UTC



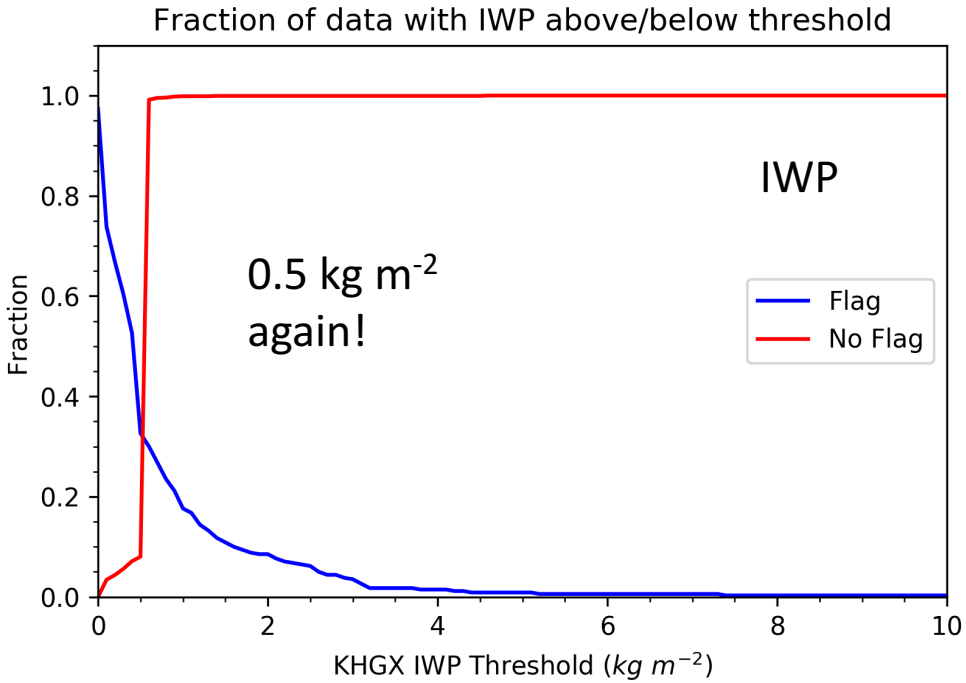


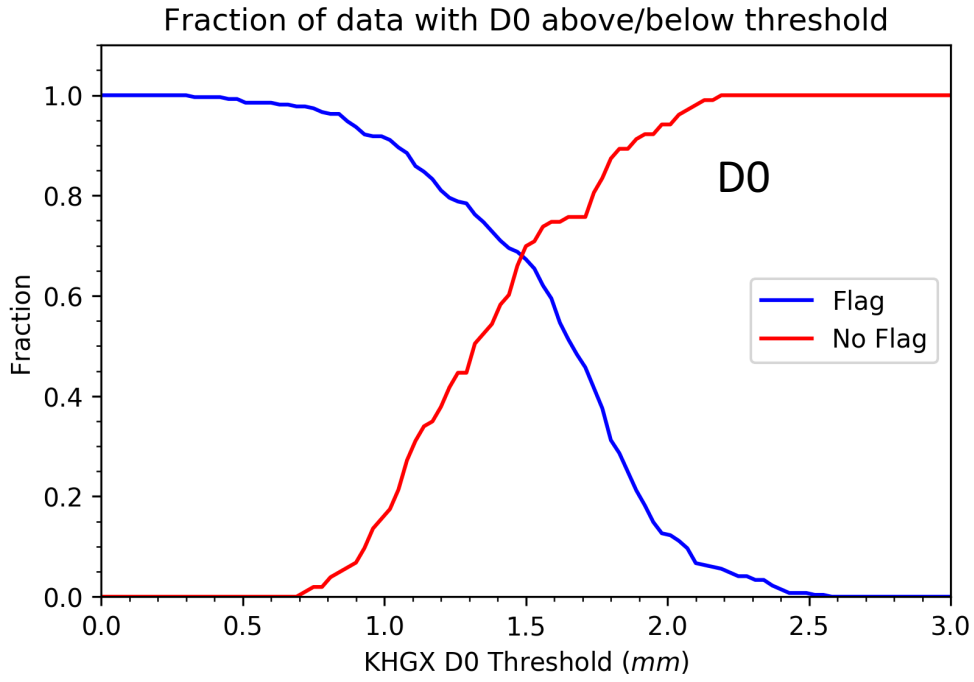






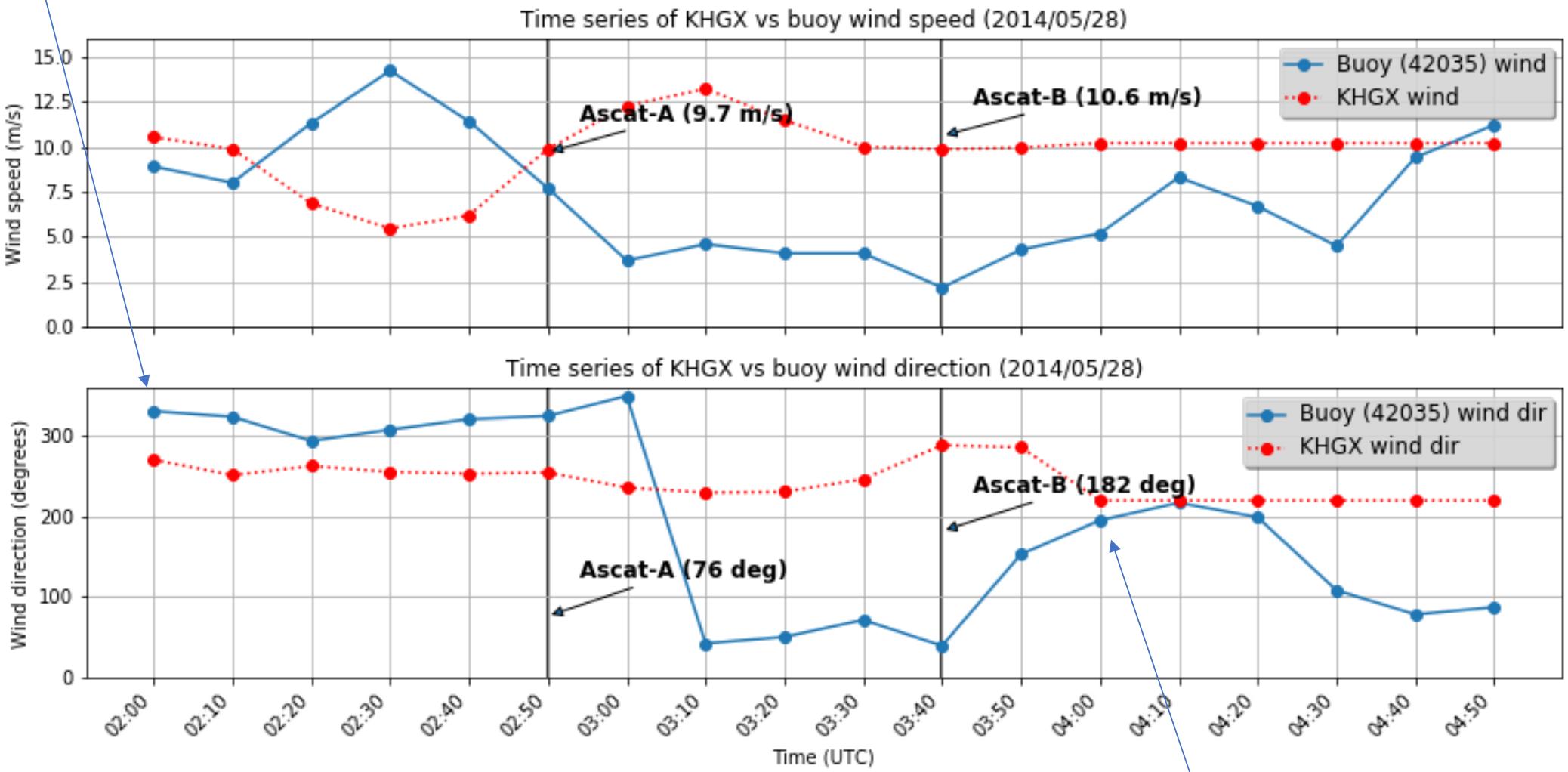
~70% above/below 5 mm h^{-1}





~70% above/below 1.5 mm

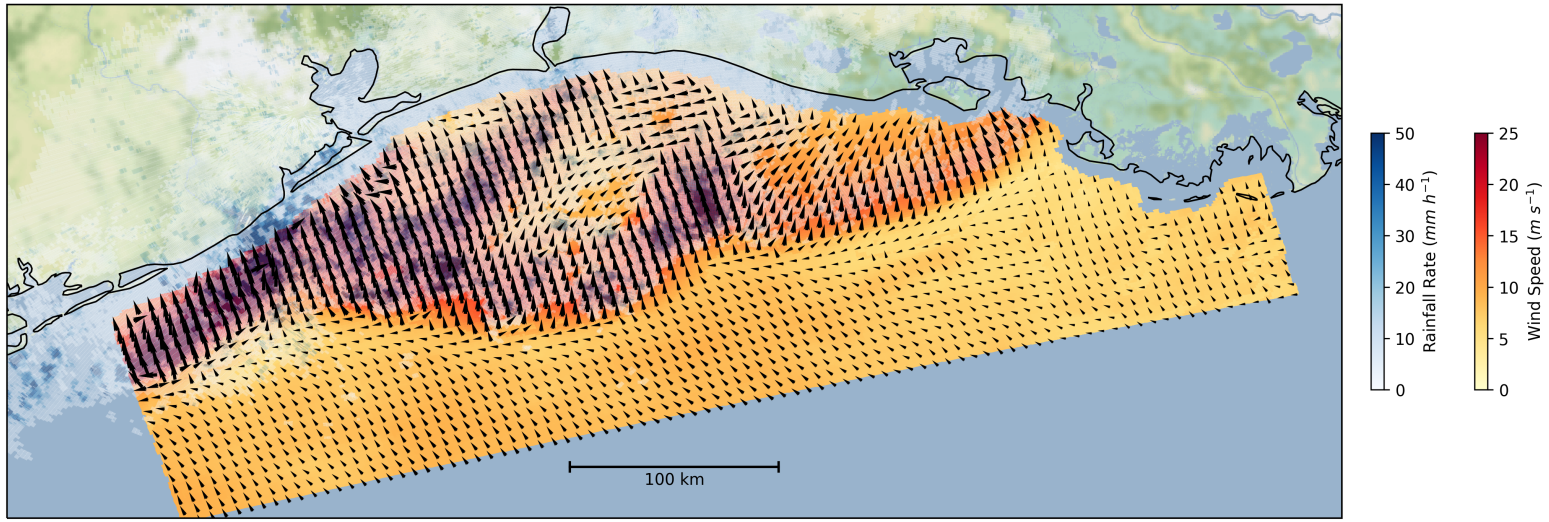
Gust front has already hit buoy



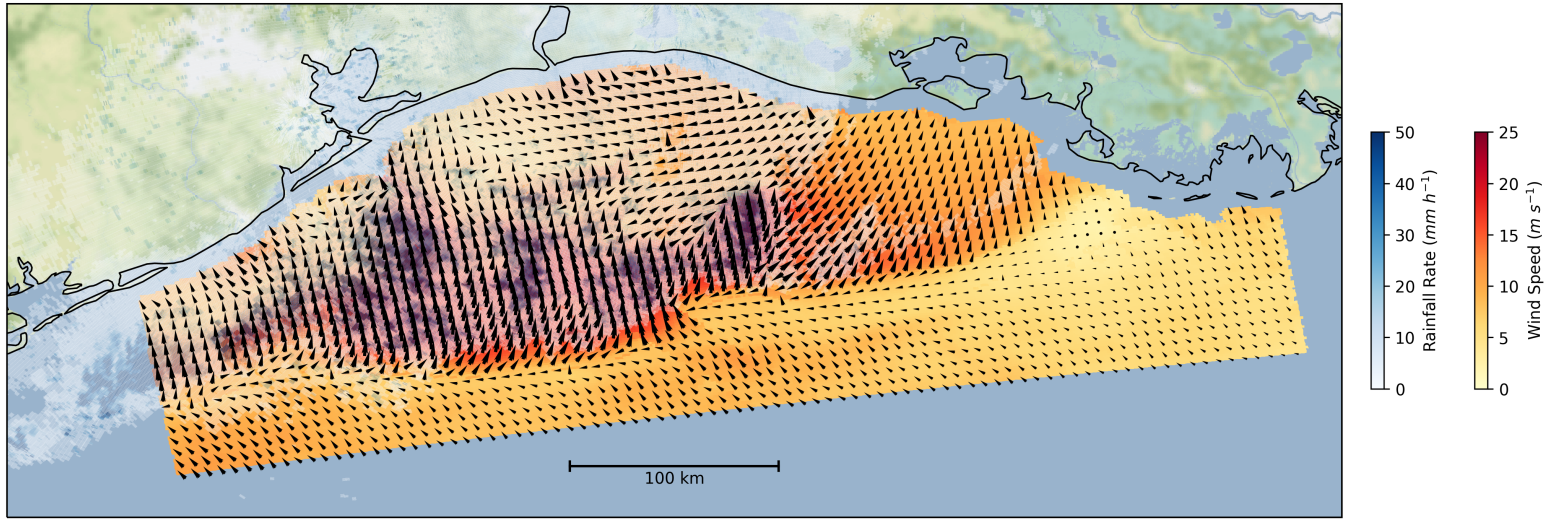
Storm moving away from buoy

ASCAT Ultra-High Resolution Data

(a) ASCAT-A UHR Winds + KHGX/KLCH Rain Rate



(b) ASCAT-B UHR Winds + KHGX/KLCH Rain Rate



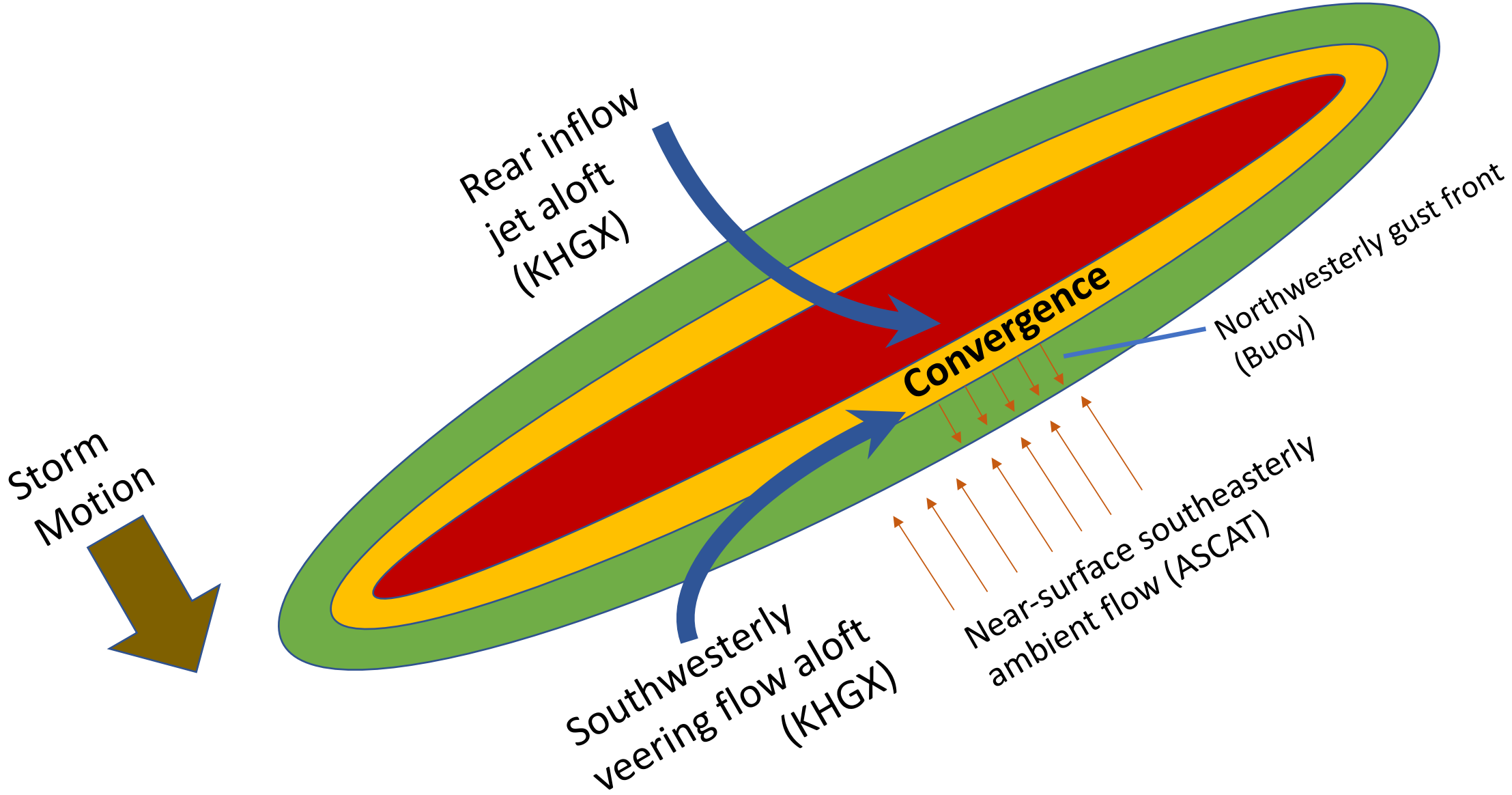
- Lindsley et al. (2016)
- L1 sigma-0 reprocessed to 1.25-km grid
- Effective resolution ~4-10 km

- Wind speed maxima and direction anomalies correspond well to NEXRAD rainfall

- Concern about directionality of gust front winds (should be northerly based on buoy/radar)

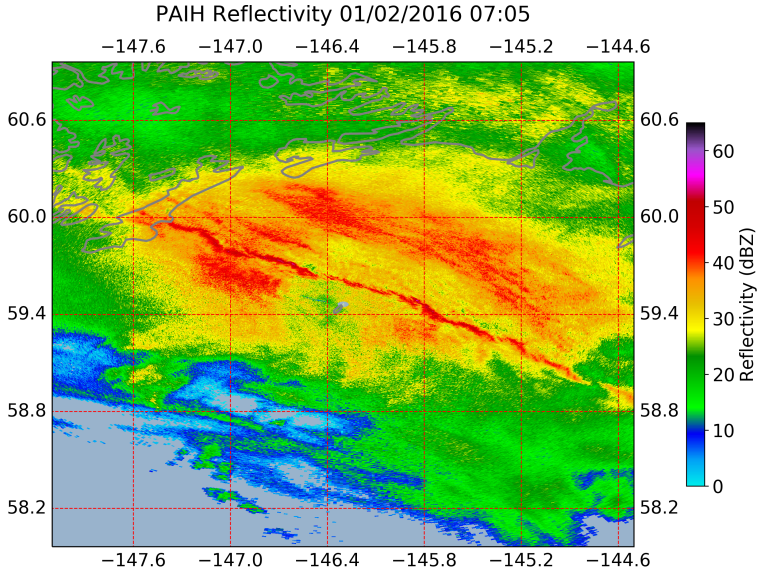
Data Courtesy of Richard Lindsley, Remote Sensing Systems

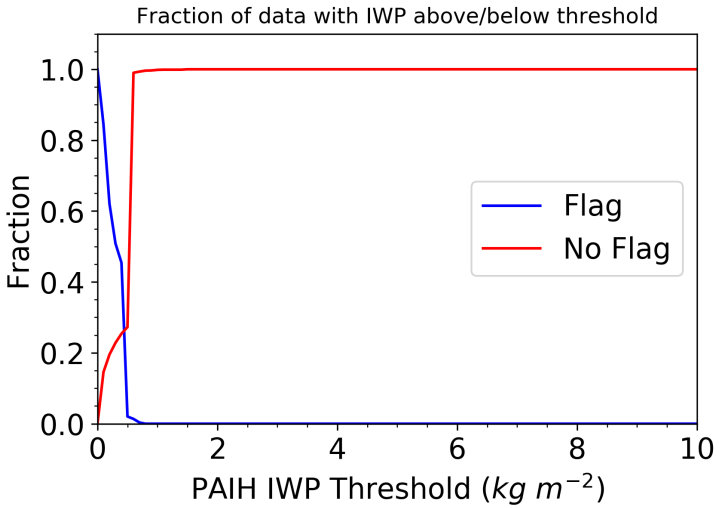
Schematic View of Case

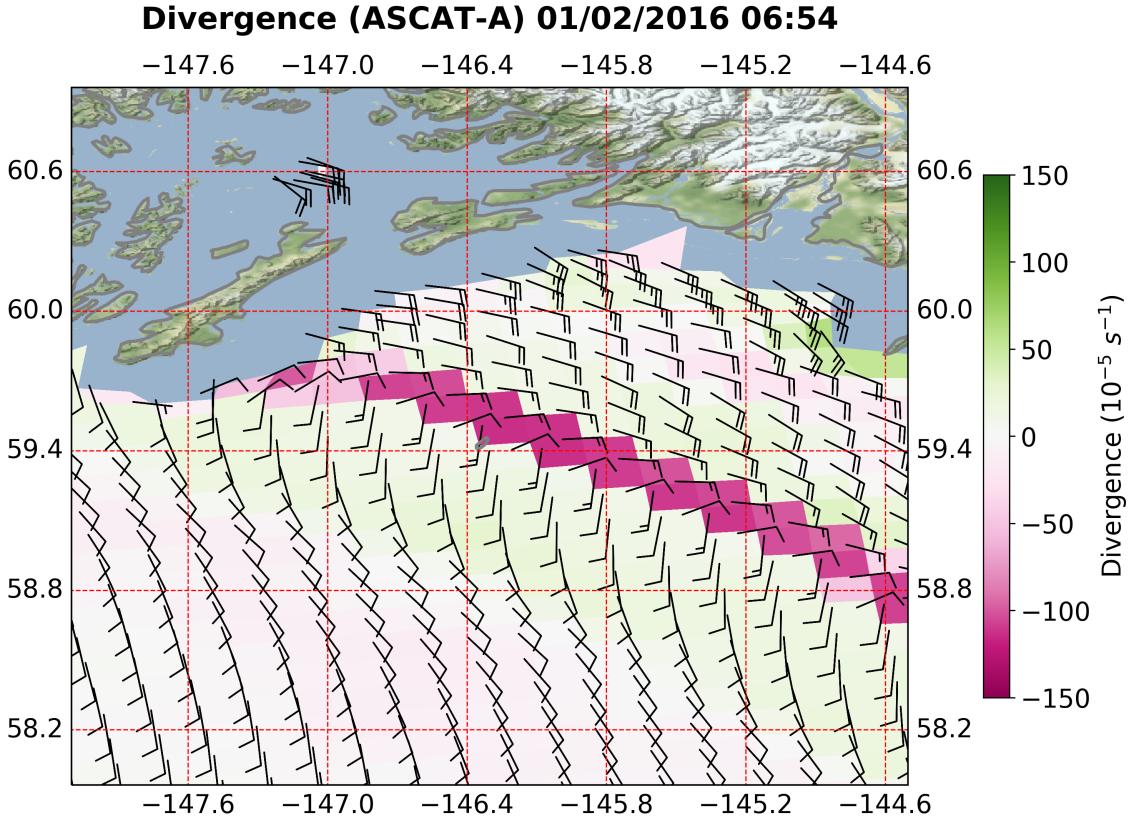


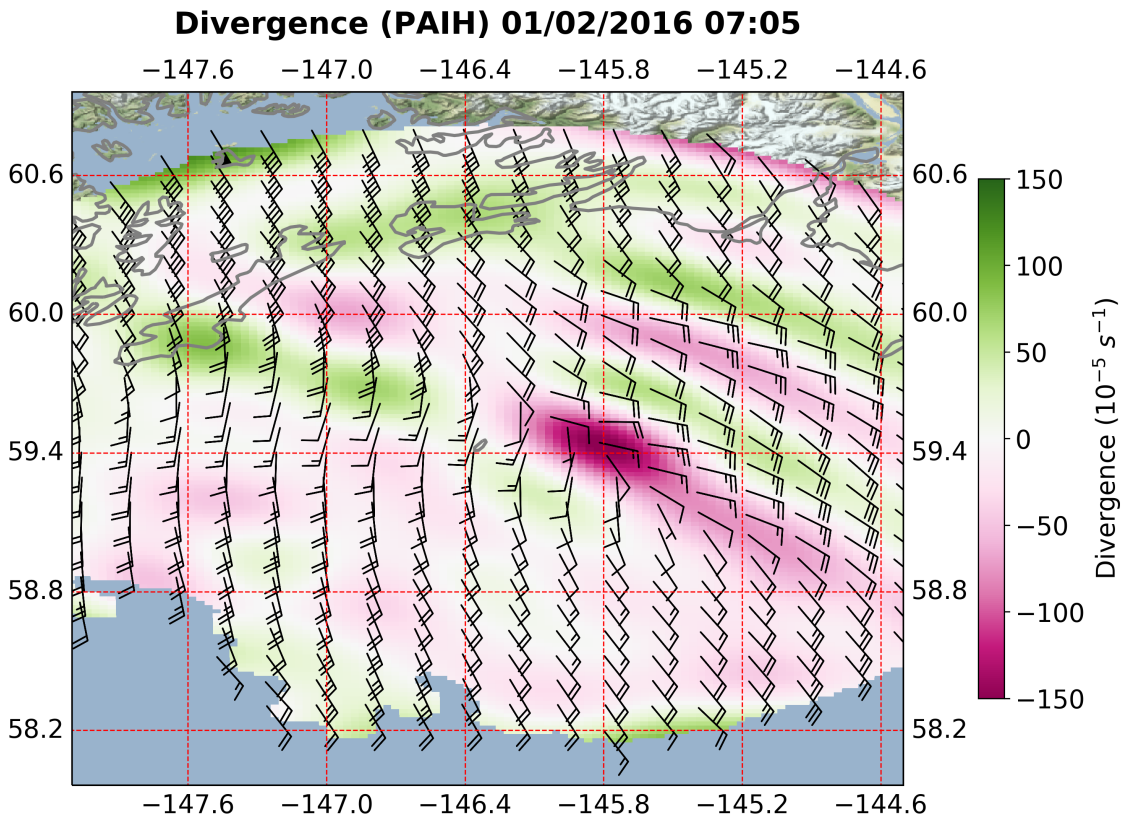
Quick look at another case (we have many!)

1/2/2016 near Alaska









Summary

- Significant care must be taken when interpreting scatterometer data near organized convective systems
- However, ground radar and scatterometer together can provide an understanding of near-surface to low-level flow structures near organized convective systems
- ASCAT quality flags do not appear to correspond to consistent rain properties (e.g., rain rate, D_0, LWP) – case/overpass dependent!
- However, if ASCAT quality flags are not set, that suggests low IWP (< 0.5 kg m^{-2}) overhead

Questions? timothy.j.lang@nasa.gov

Putting it all together

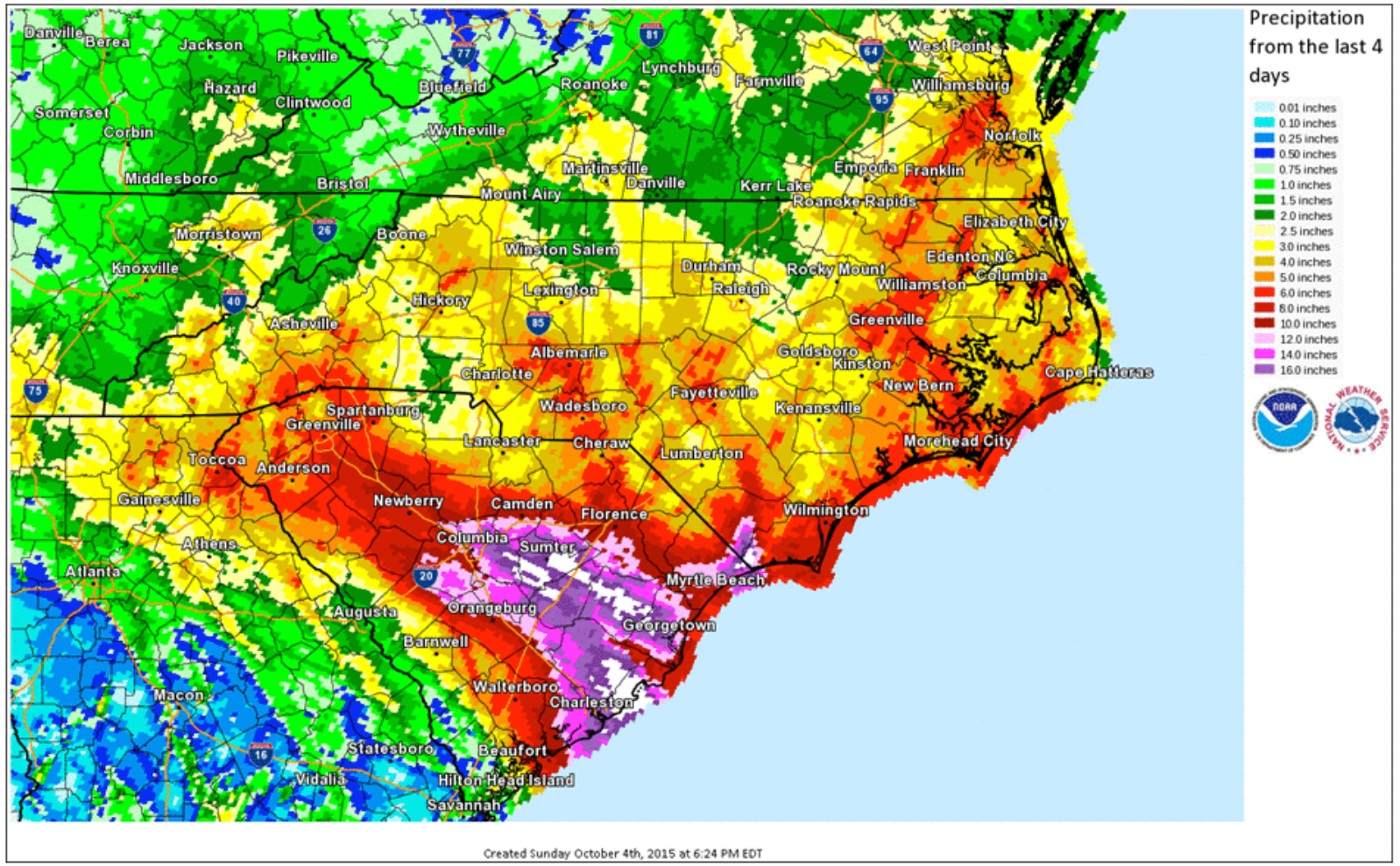
Let's take a brief look at last fall's South Carolina flood, from the offshore perspective.

<u>Radars</u>
KLTX (Wilmington) and KCLX (Charleston)

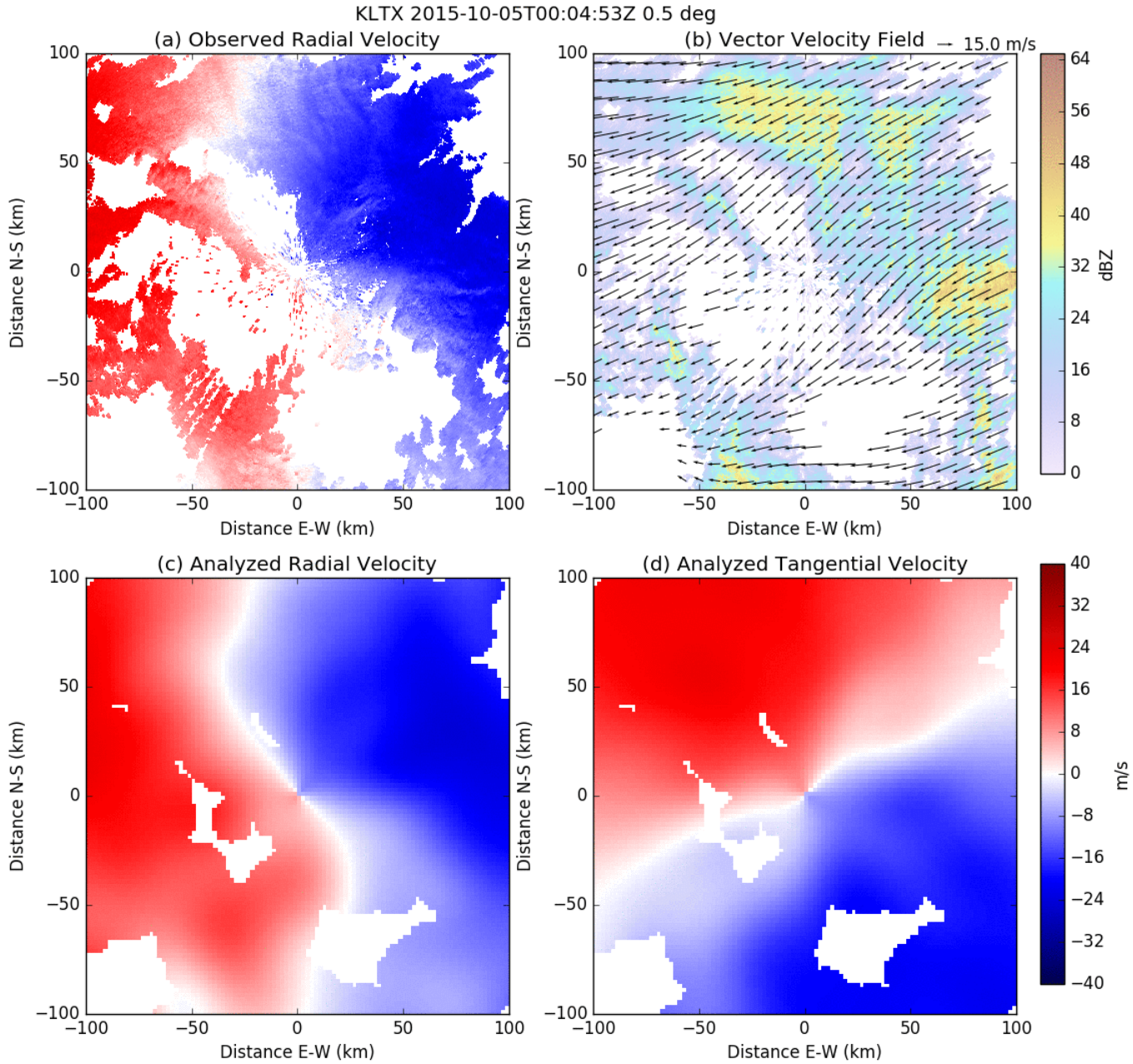
<u>Scatterometers</u>
RapidScat, ASCAT-A, and ASCAT-B

NATIONAL WEATHER SERVICE
NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION

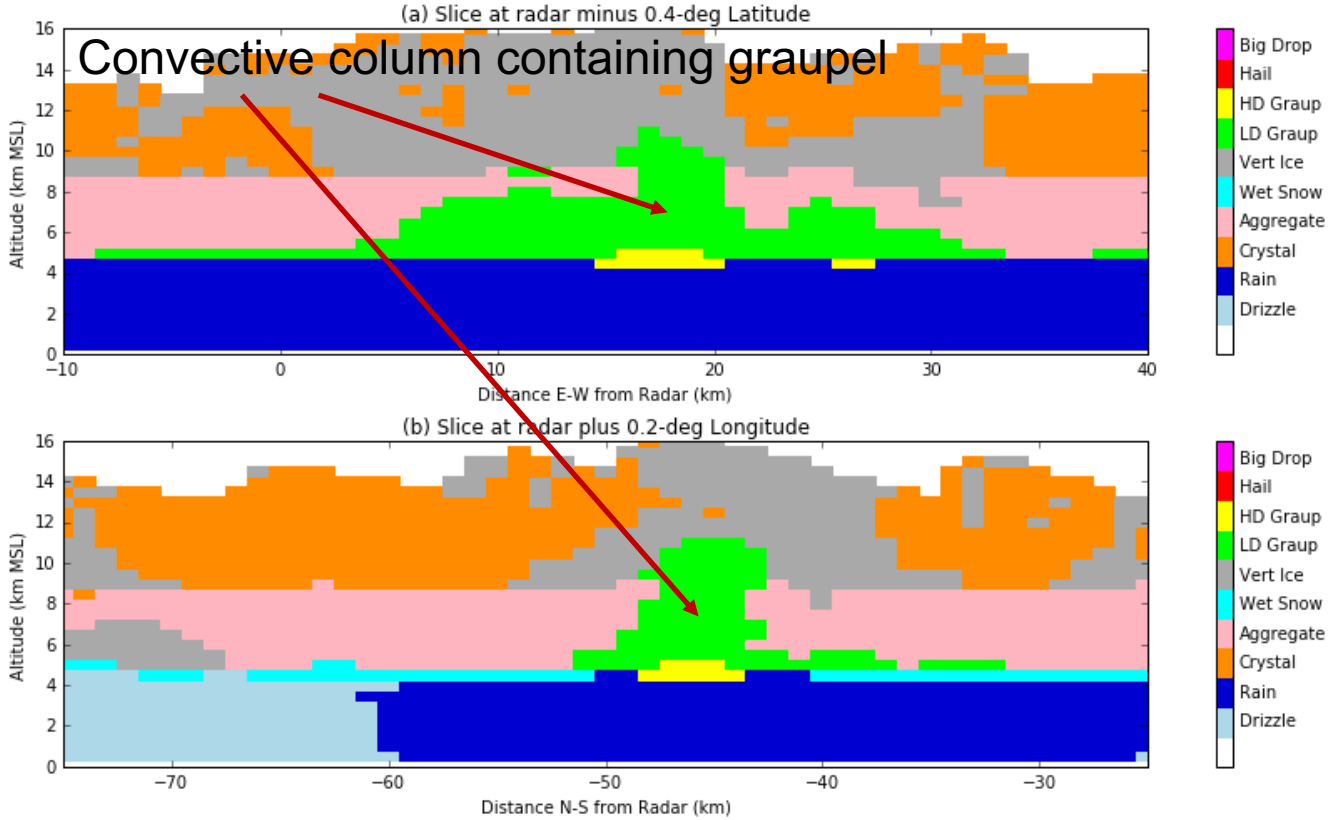
Rainfall from the last 4 days

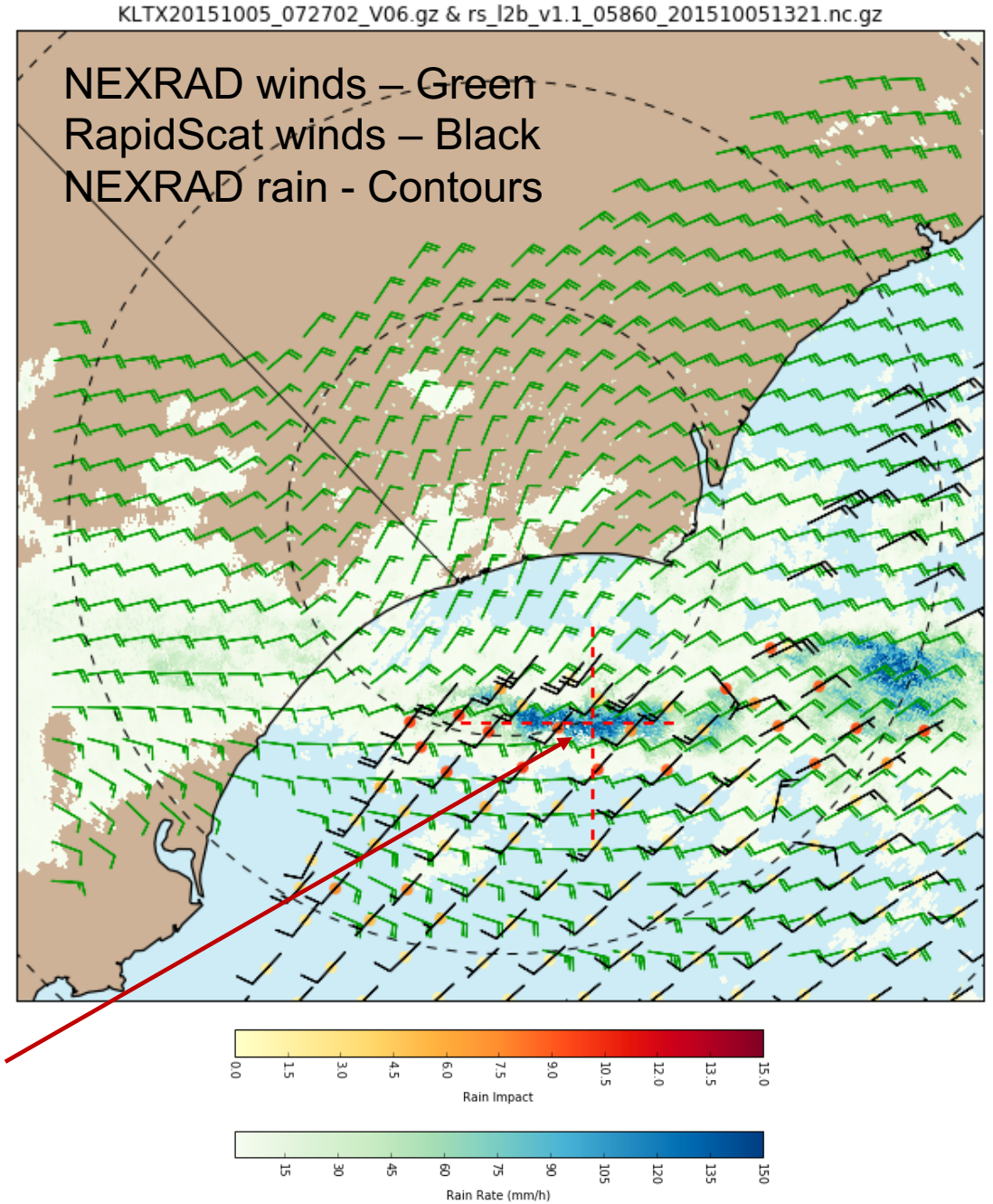


Published on: 10/04/2015 at 6:29PM


KLTX 2015-10-05T00:04:53Z 0.5 deg
(a) Observed Radial Velocity
(b) Vector Velocity Field
15.0 m/s
(c) Analyzed Radial Velocity
(d) Analyzed Tangential Velocity
Distance N-S (km)
Distance E-W (km)
dBZ
m/s
100
50
0
−50
−100
64
56
48
40
32
24
16
8
0
−8
−16
−24
−32
−40

Doppler wind, rainfall, and microphysical observations from polarimetric radar fill in low-level wind information where RapidScat is sparse (heavy rain and coastal regions). Together they show convergence line fueling heavy rain.





Simulating CYGNSS sampling organized convection with gust front in Westerly Wind Burst during MJO