

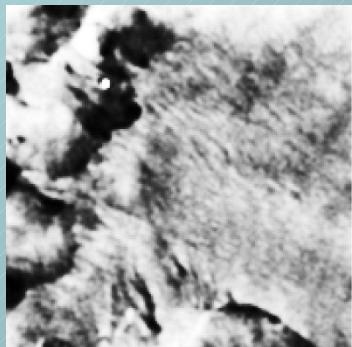
Using Sea-level Pressure to Improve Surface Wind Retrievals Derived From Satellite Synthetic Aperture Radar Images of Tropical Cyclones

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(with significant input from Chris Wackerman (GD);
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(CSTARS))

Science Question

- *How can we best use surface pressure data to improve SAR winds in TC conditions?*
 - Pressure data usually reliable even in severe storms
 - Bulk pressure gradients dynamically relevant
- Pixel-by-pixel wind retrieval may not always be possible in high winds
 - Cross-beam & Up-beam in high wind conditions?
 - Wind direction uncertainty
 - OLE direction Vs. Wind direction
 - Choice of OLE spatial scale
 - High sensitivity at low incidence angles
 - Sigma0 uncertainty (especially low incidence angle)
- SLP allows scene-wide wind retrievals
 - Use Pixel-by-pixel as initial guess
 - Integrating/smoothing operation
 - Fill small to moderate sized gaps
 - Dynamic constraint on wind directions
 - Tends to increase inner core inflow
- SLP is a useful measure of storm intensity
 - Pressure-Wind relationships

Estimate direction
OLE, streaks, etc.
interpolate



GMF

U_{10}

U_{interior}

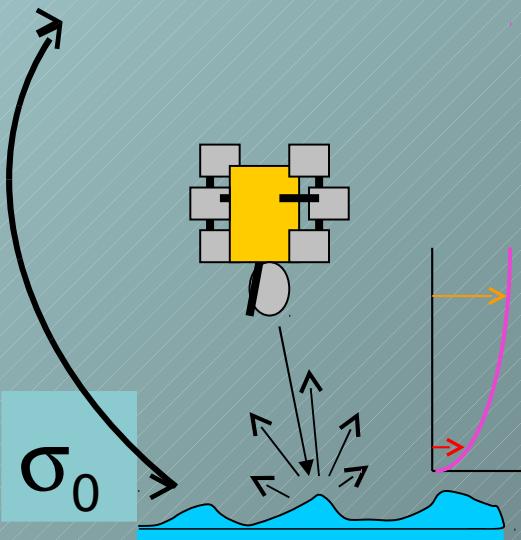
TCBL
model
(Foster,
2005,
2009)

$\text{div}(U_{\text{geo}}) =$
0

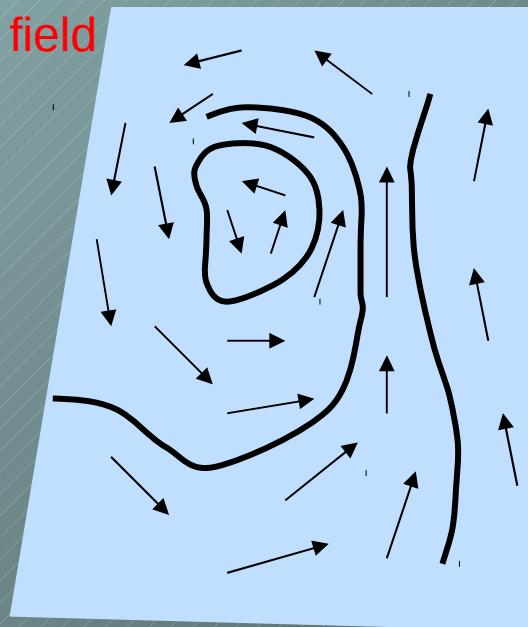
Iterate

(Spurious & missing
Vectors tolerated)

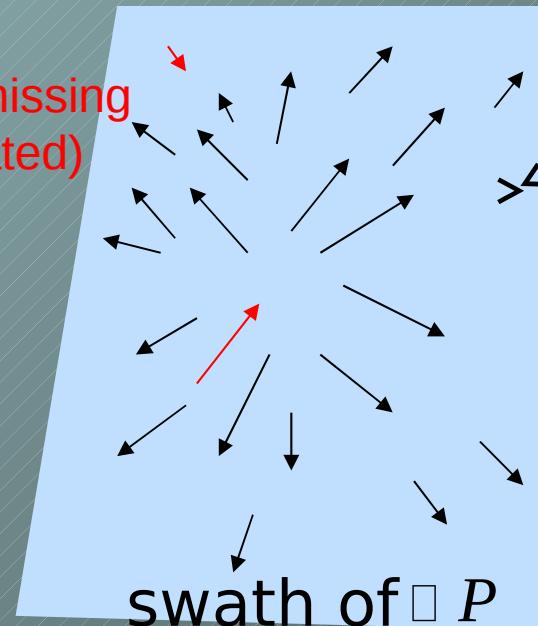
Derive new surface
wind field



σ_0



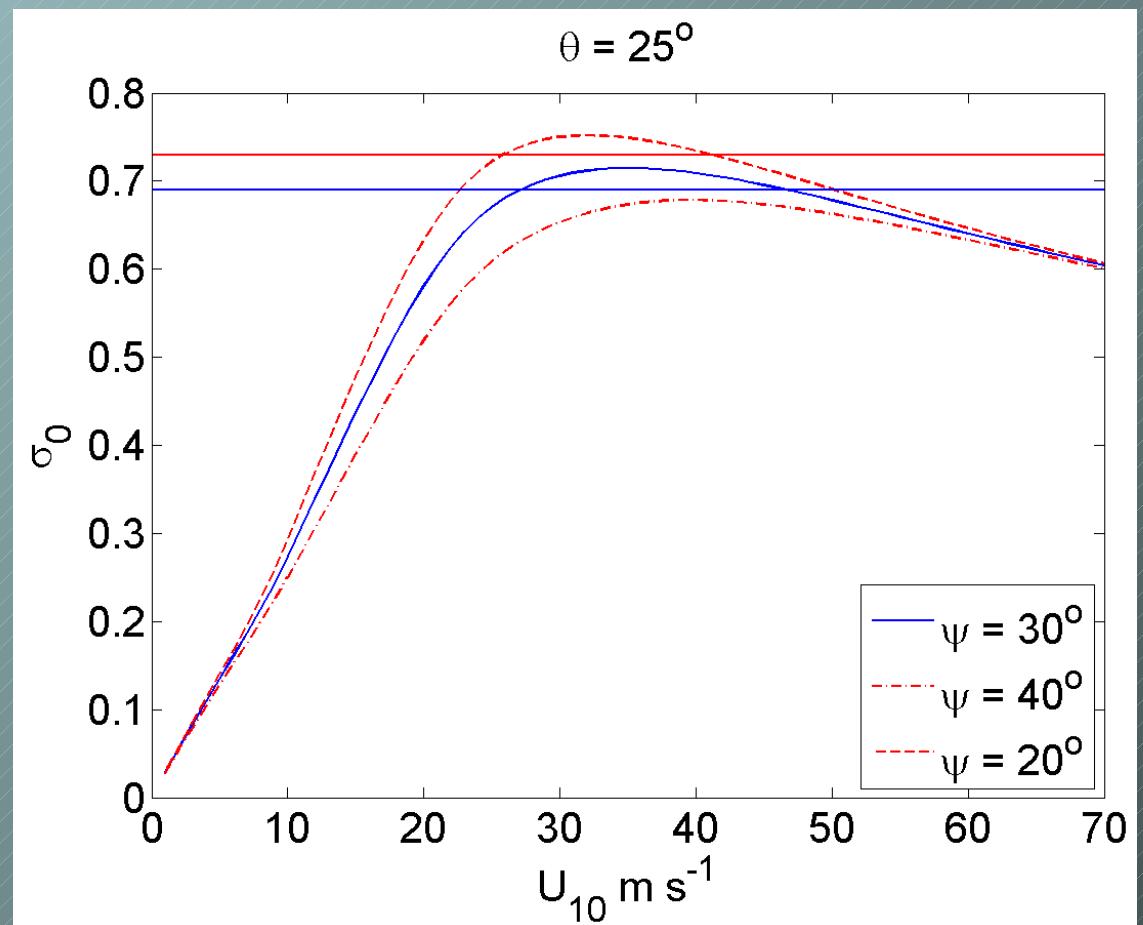
Fit a
surface
pressure
field



swath of P

CMOD5 Geophysical Model Function (GMF) Ambiguity Problem in High Winds, Low Incidence Angles (θ)

Slice through CMOD5
for particular viewing geometry

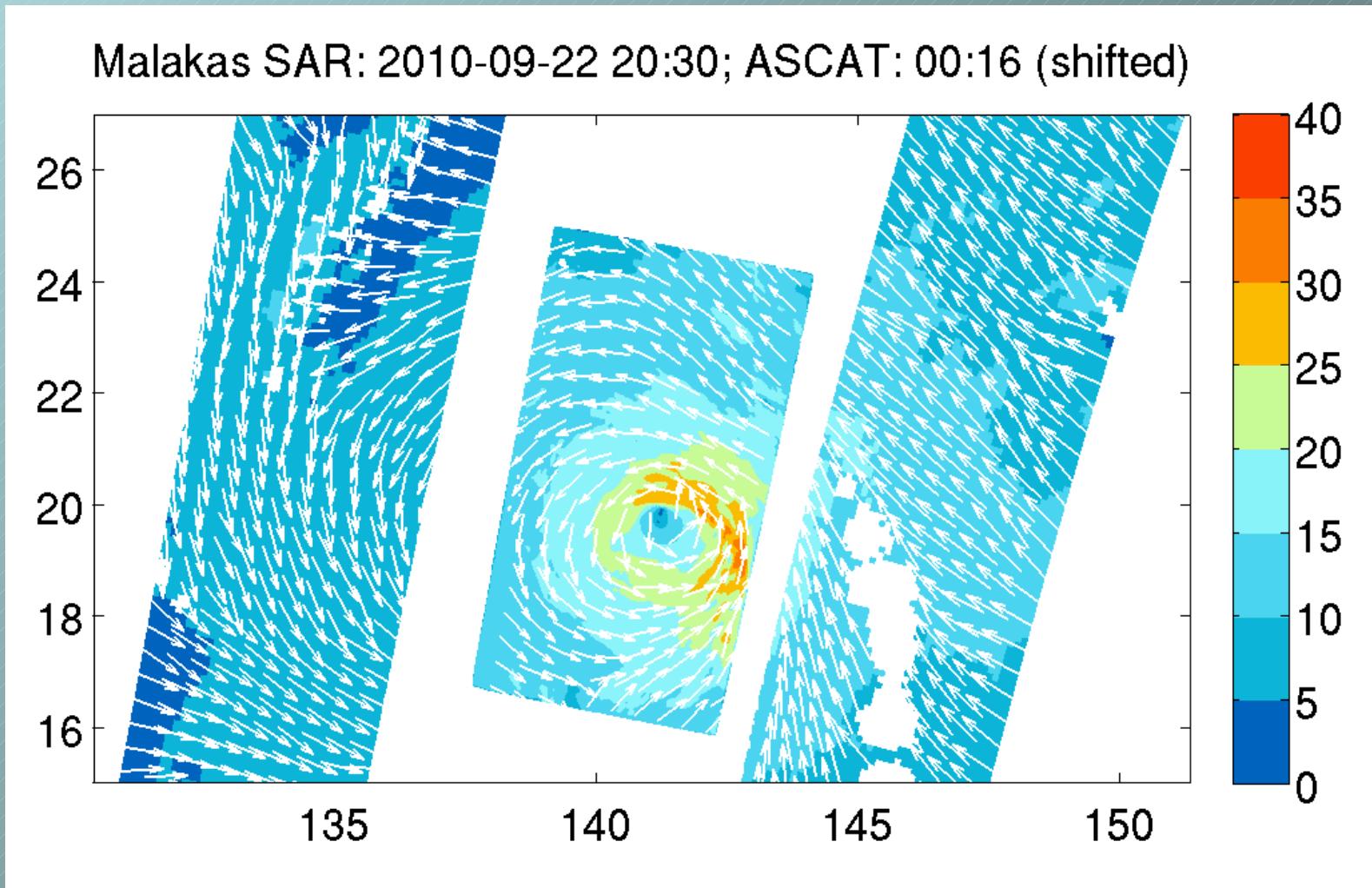


Note sensitivity to small direction (ψ) changes

ITOP: Typhoon (Cat 1) Malakas

- Malakas 22 Sep, 2010 (Great test case)
 - C130 arrived on scene within 15 minutes of SAR overpass (15 min to 8 hour time difference overall)
 - 28 Drop Sondes; corrected for storm translation
 - SFMR/Flight level data analysis in progress
- Malakas 24 Sep, 2010
 - C130 Bracketed SAR overpass (8 hours before or 8 hours after)
 - SAR near-miss on eye

XOVM-lite?

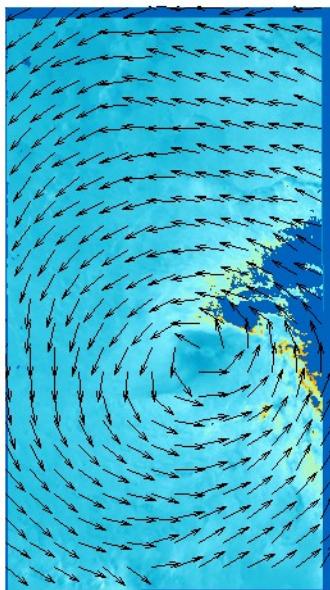


ASCAT

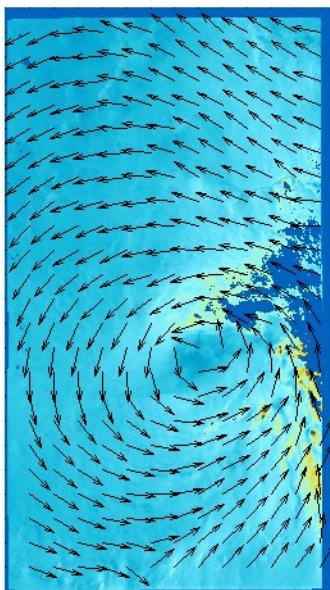
RSAT-2

ASCAT

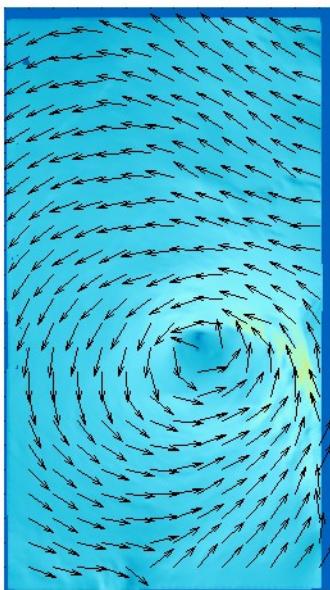
CMOD5: WiSAR



CMOD5: SLP AZ1



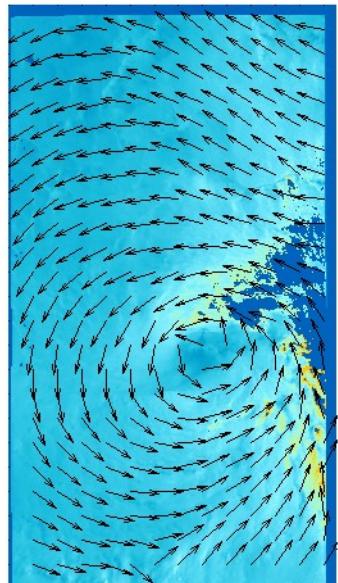
SLP-Filtered 1



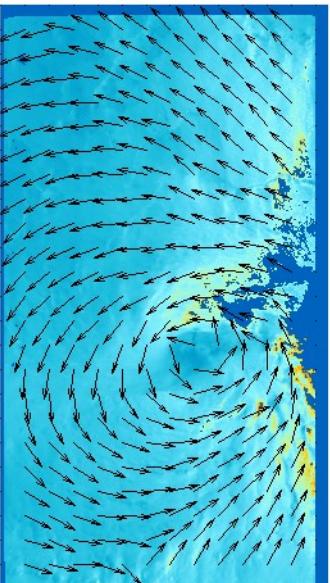
RSAT-2 (HH)

960 km

CMOD5: SLP AZ1



CMOD5: SLP AZ2



SLP-Filtered 2



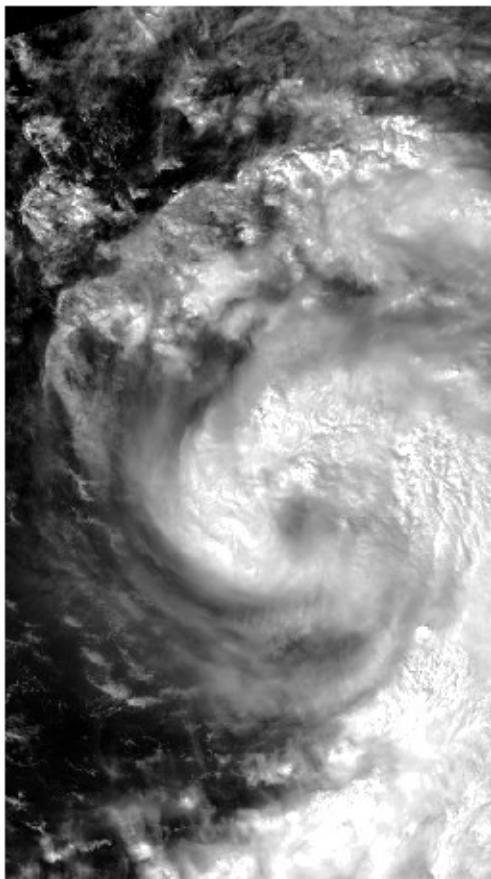
540 km

Malakas
2010-09-22
20:30

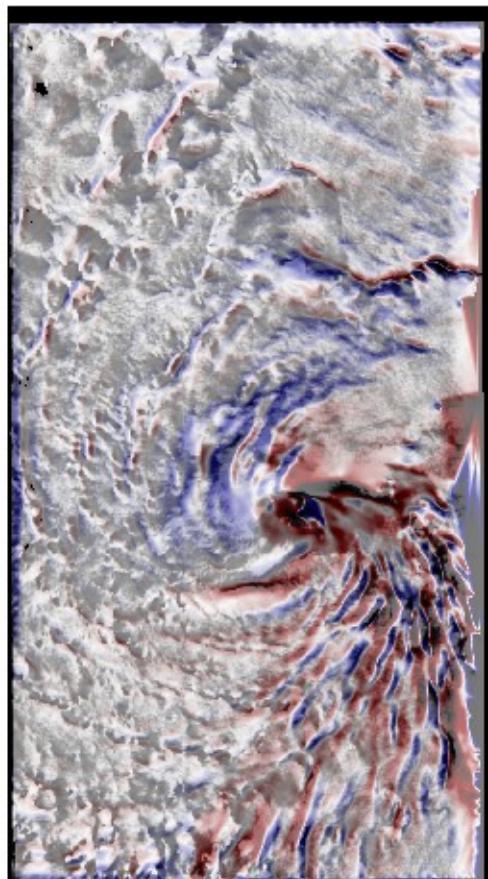
Note: SLP-refinement
of wind directions
reduces extent of
no-solution at low
incidence angles

Surface Wind Divergence

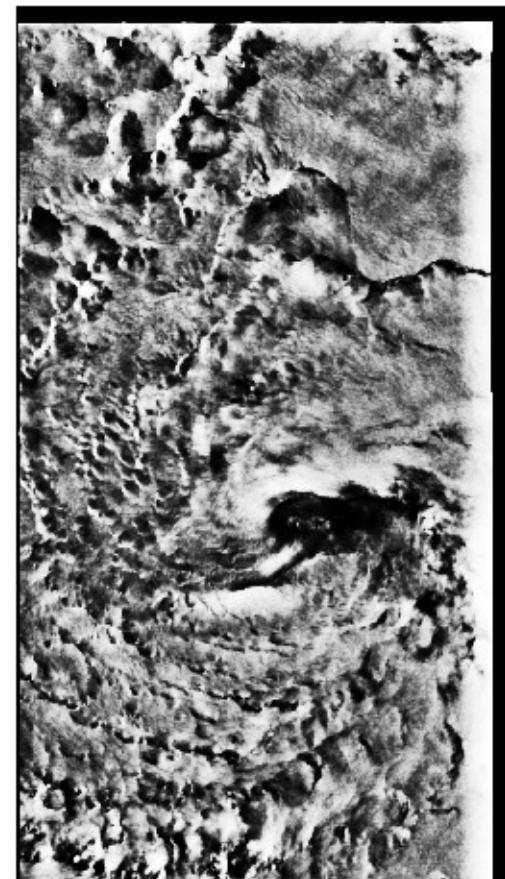
Shifted IR Radiance
20100923T04:05
MODIS + 8 hr



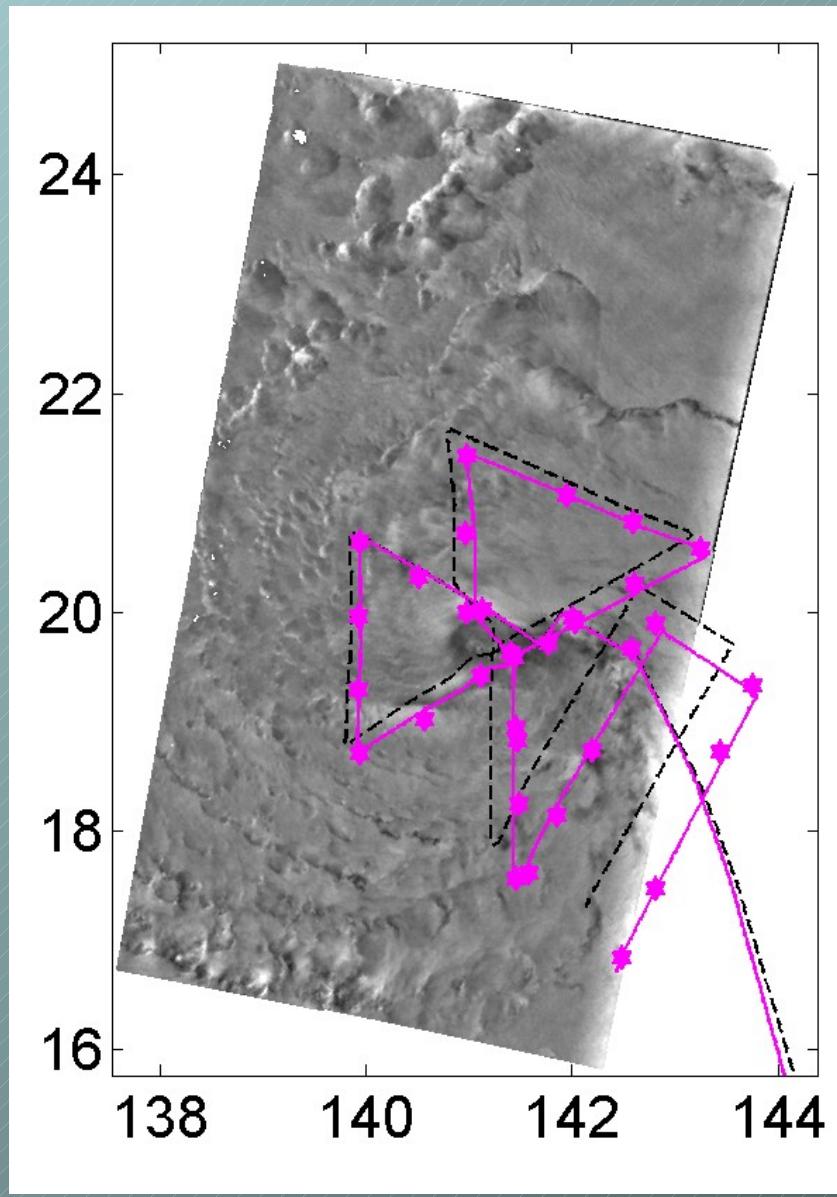
Sea Surface & Sfc. Conv.
20100922T20:30



Sea Surface
20100922T20:30



Adjusted 22 Sep 2010 C-130 flight to SAR Overpass



C130: 14:42 to 02:34

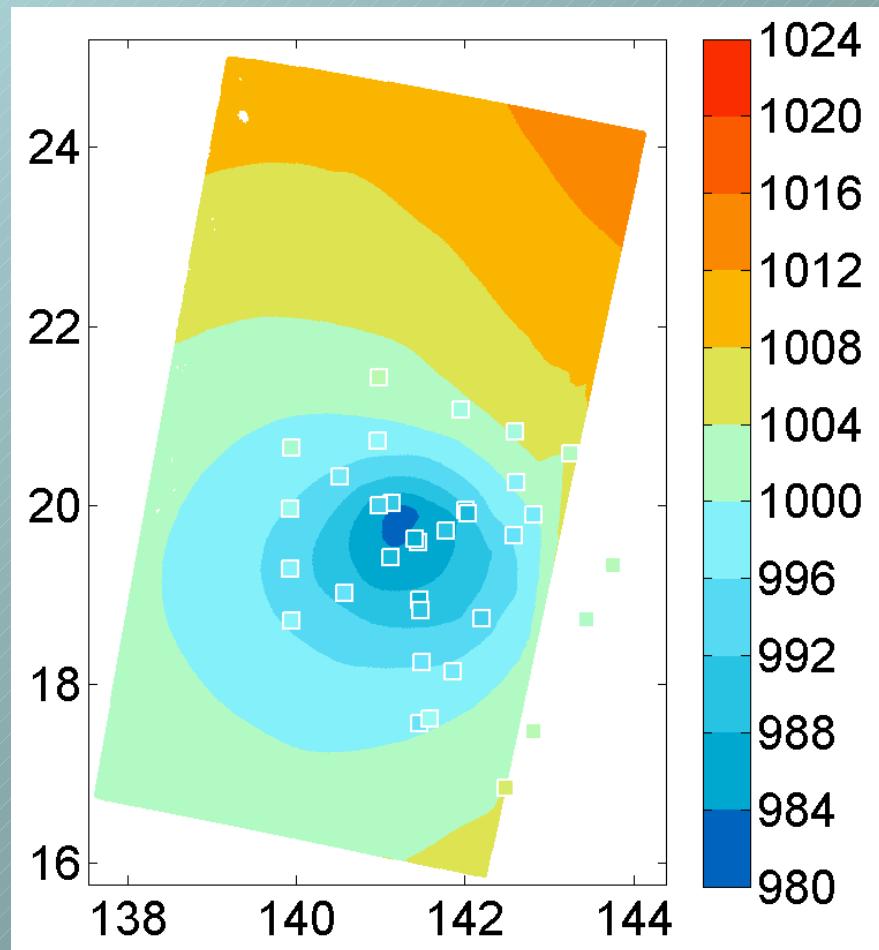
SAR: 20:30

(to Guam)

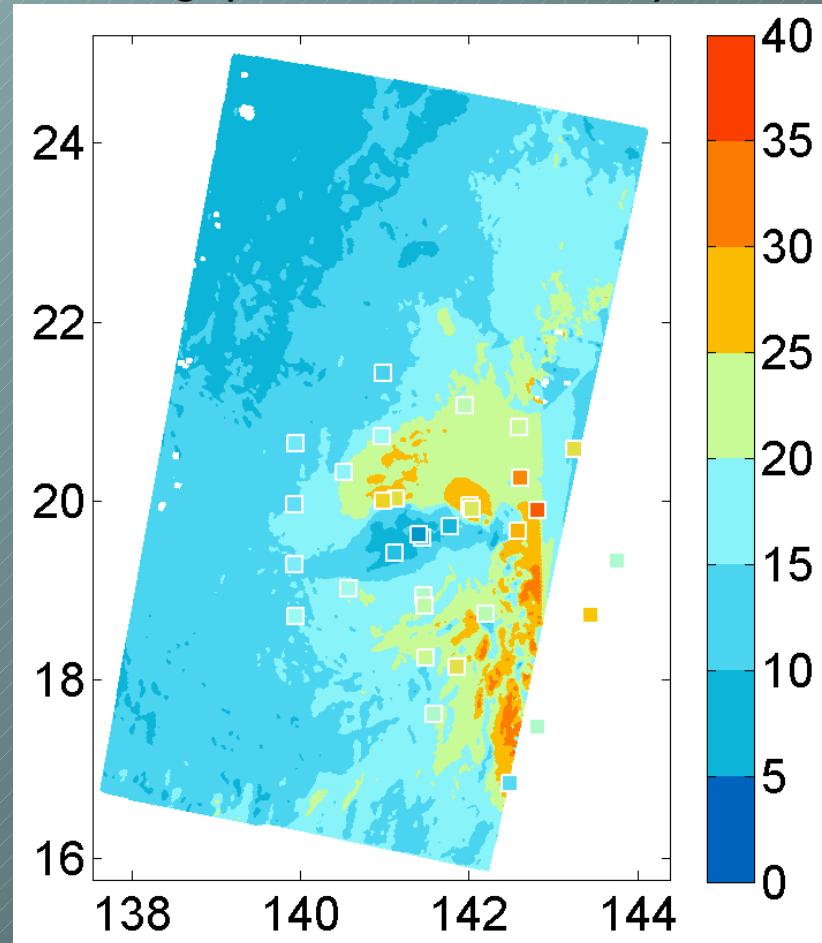
Malakas 22Sep2010 20:30

One Iteration

Comparison with Drop Sondes

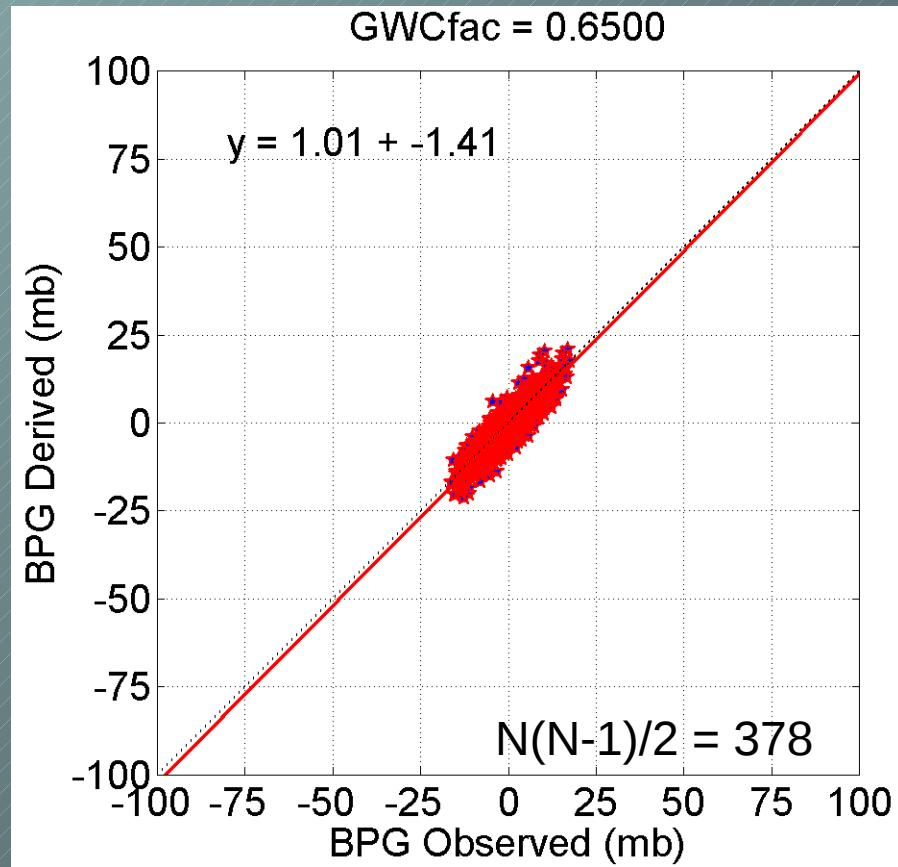
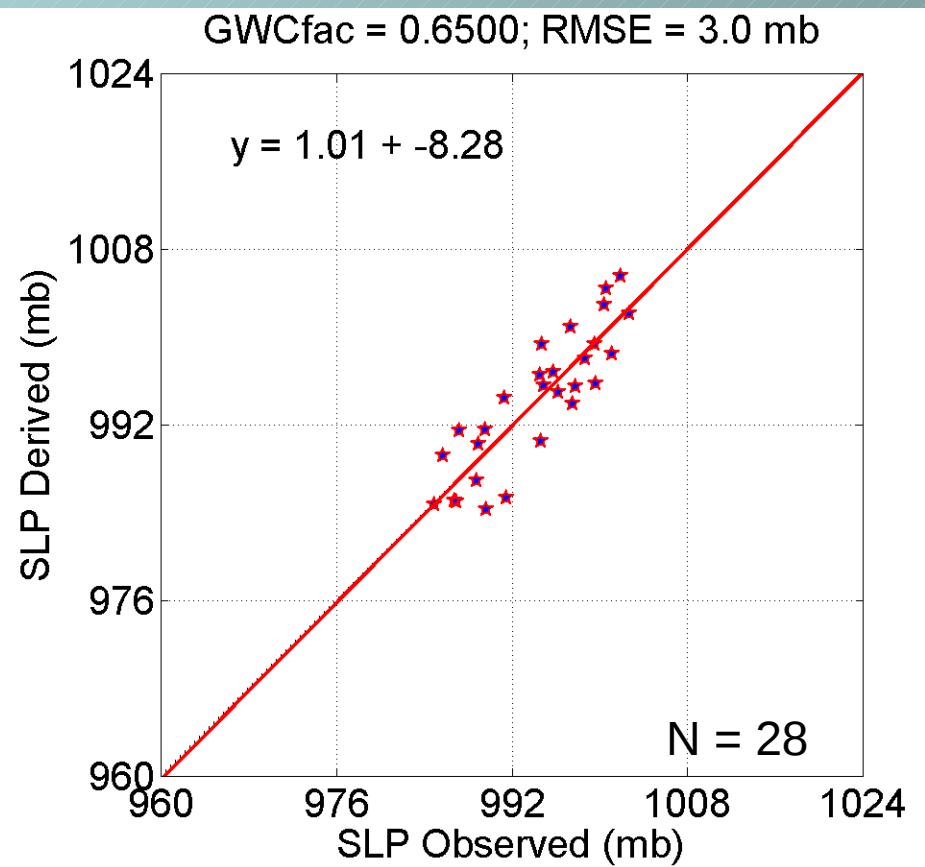


(CMOD5 with SLP-Azimuths
gap-fill with SLP-winds)



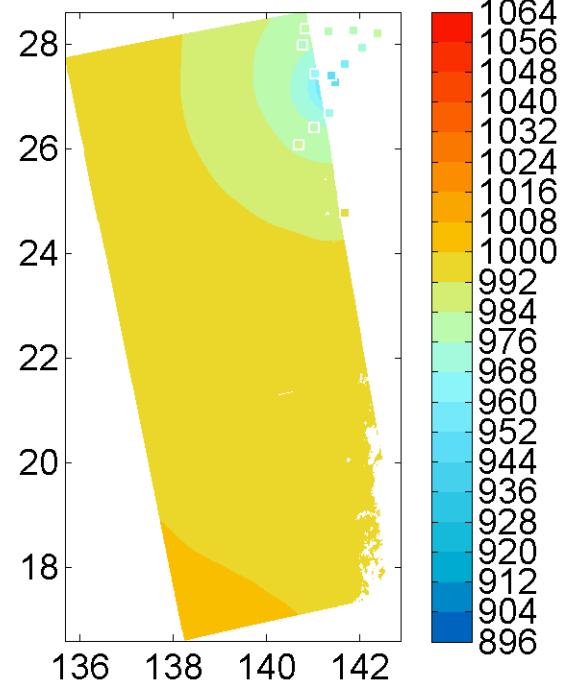
Malakas 22 Sep 2010 20:03 UTC

$N(N-1)/2$ Pairs of sondes



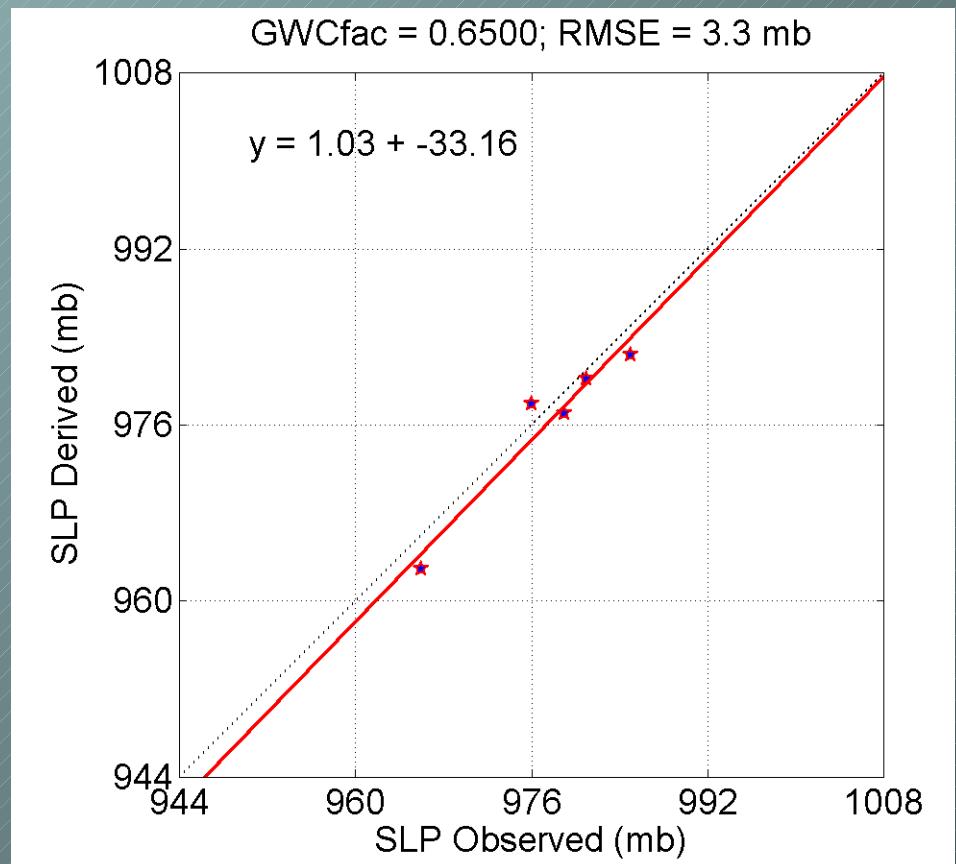
SAR-derived SLP

malization; Min: 955.72 mb at (141.152, 27.14)
100924084738.20km_NURCPROD_1000_sn



Malakas 24 Sep, 2010 08:47 UTC

Larger adjustment of C-130: 13:29 to 22:02

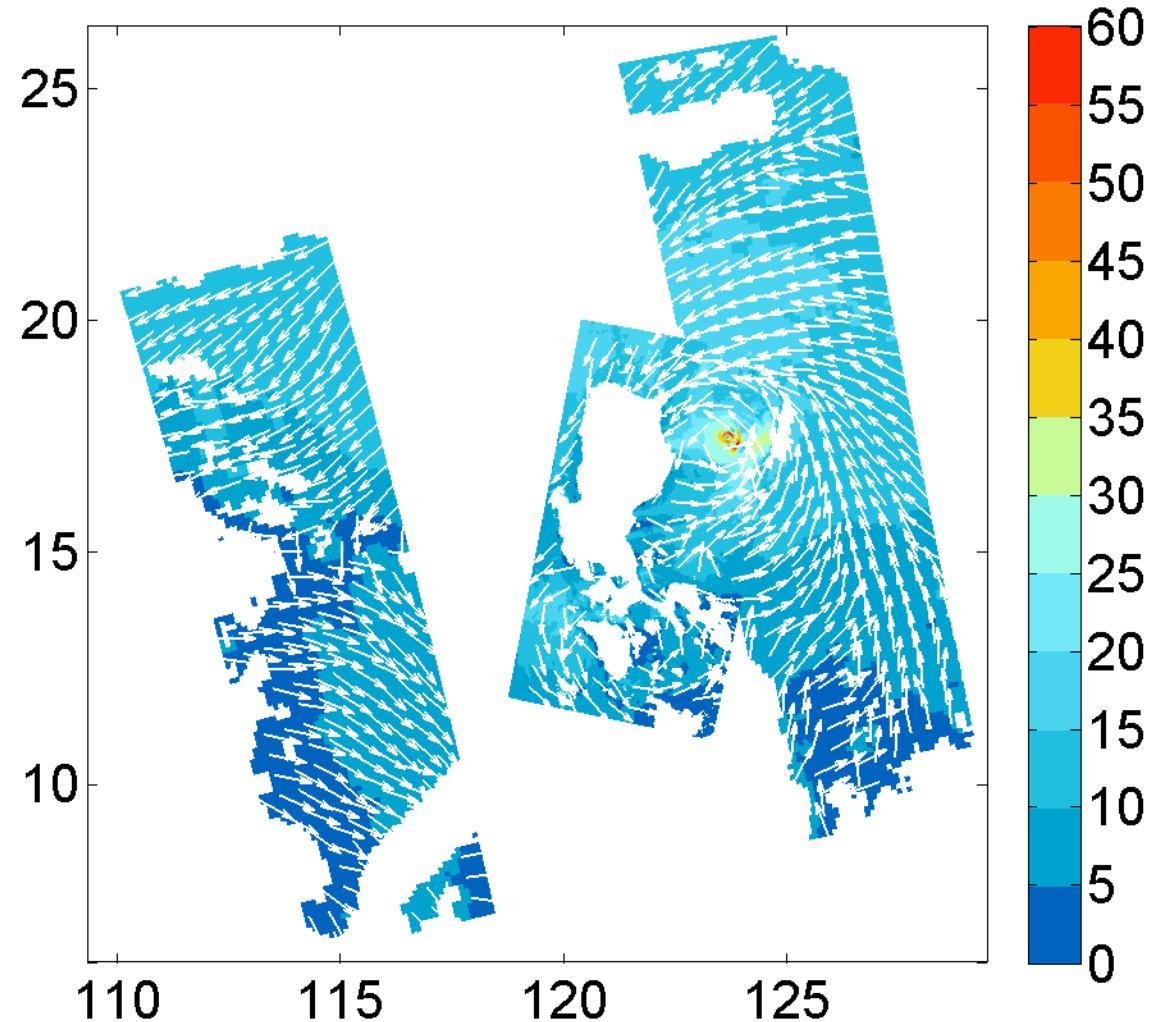


Super-Typhoon Megi 17 Oct, 2010

- Reached Cat-5
 - MSLP = 885 mb (JMA)
- Devastating landfall on Luzon
 - 19 killed
 - 200,000 homeless

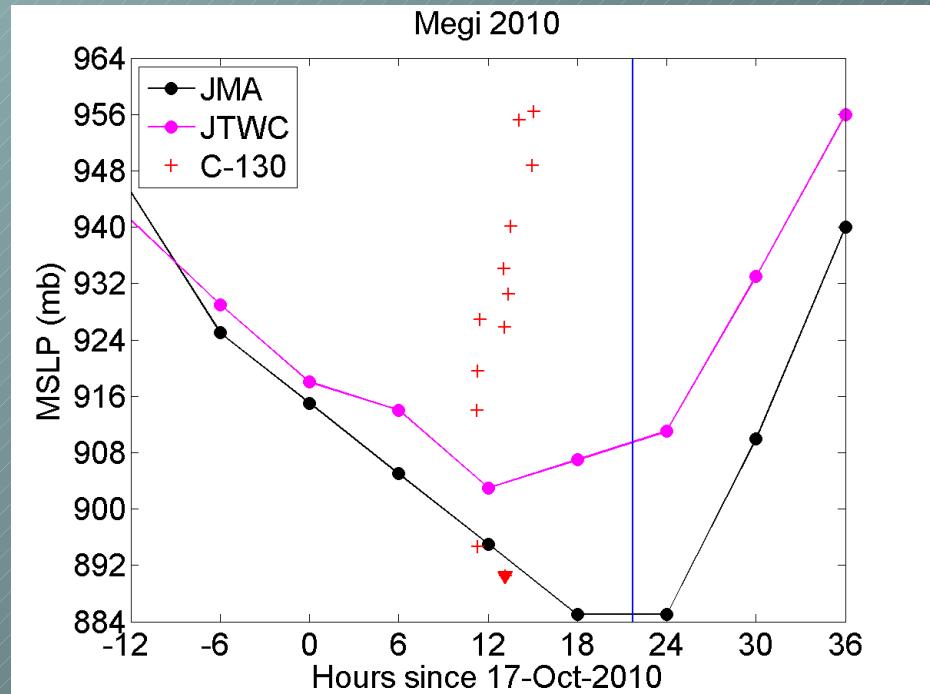


Megi SAR: 2010-10-17 21:44; ASCAT: 13:11 (shifted)

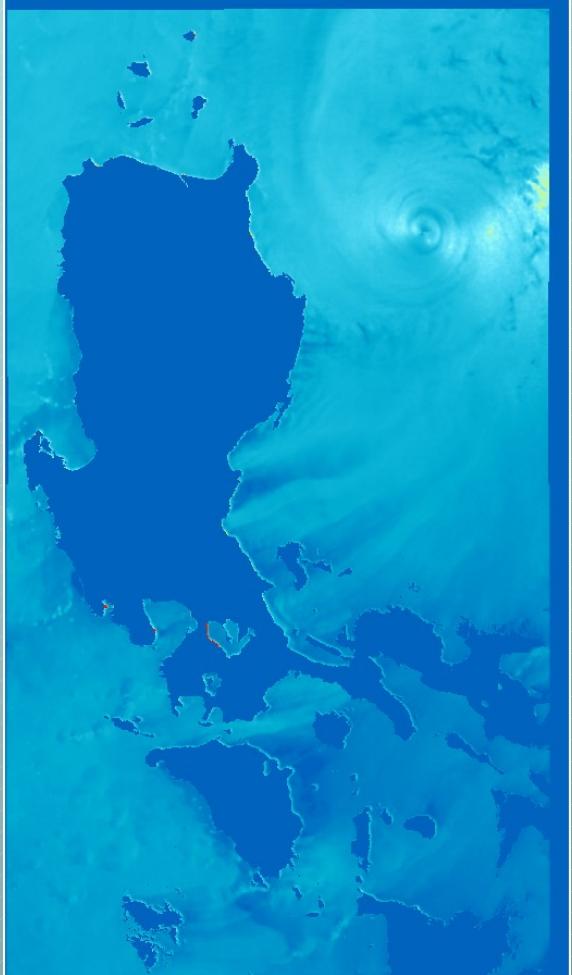


Major Challenge

- RSAT-2 VV 21:41
 - Near Cat 5 Strength
 - ~weakening phase
 - Eye in low incidence angles
 - Extreme conditions for GMF
- C-130
 - 06:50 to 18:44
 - ~6 hour shift to SAR
 - Deepening Phase



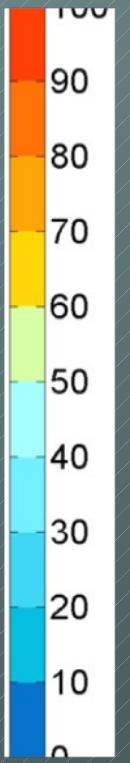
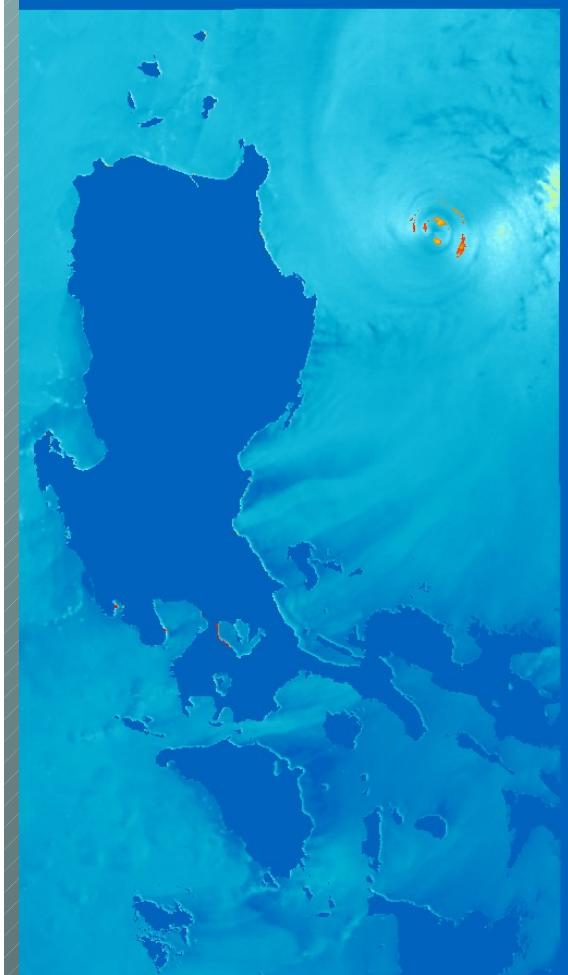
Lower Ambiguity



Higher Ambiguity
inner core only:
 $R < 35 \text{ km} (<200 \text{ pix})$

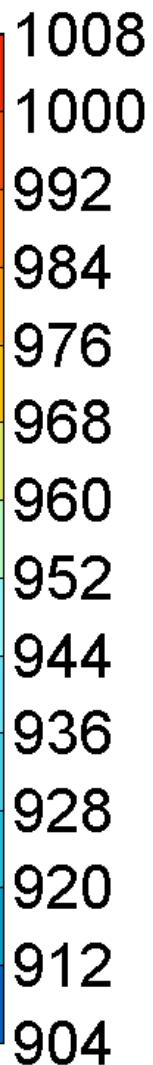
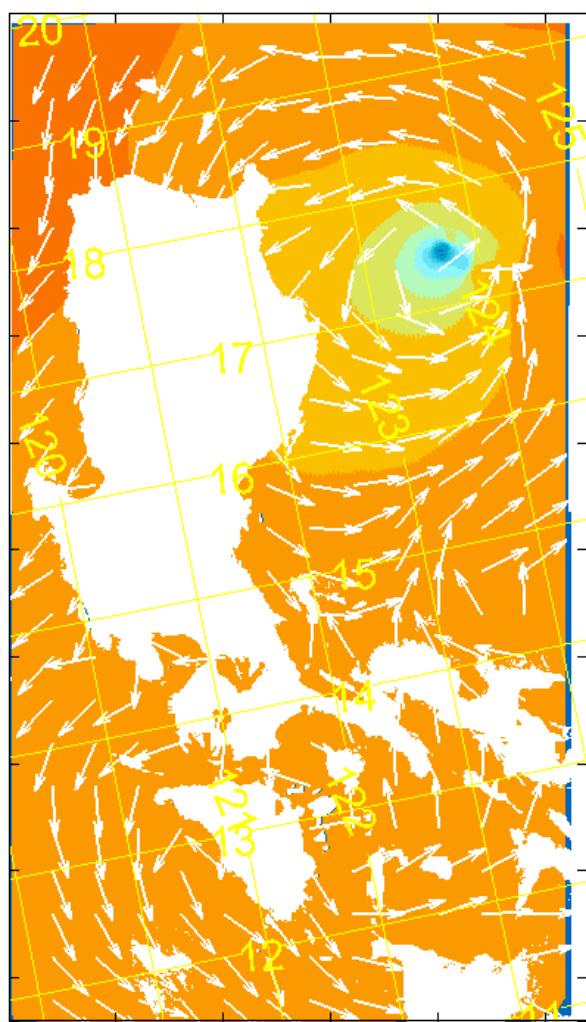


Input winds



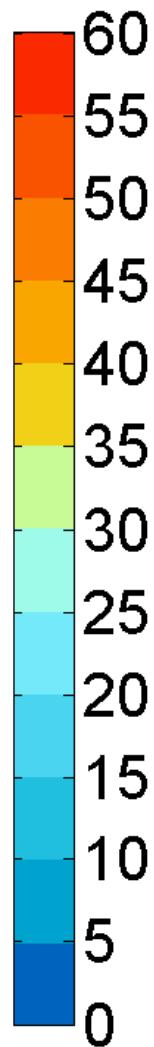
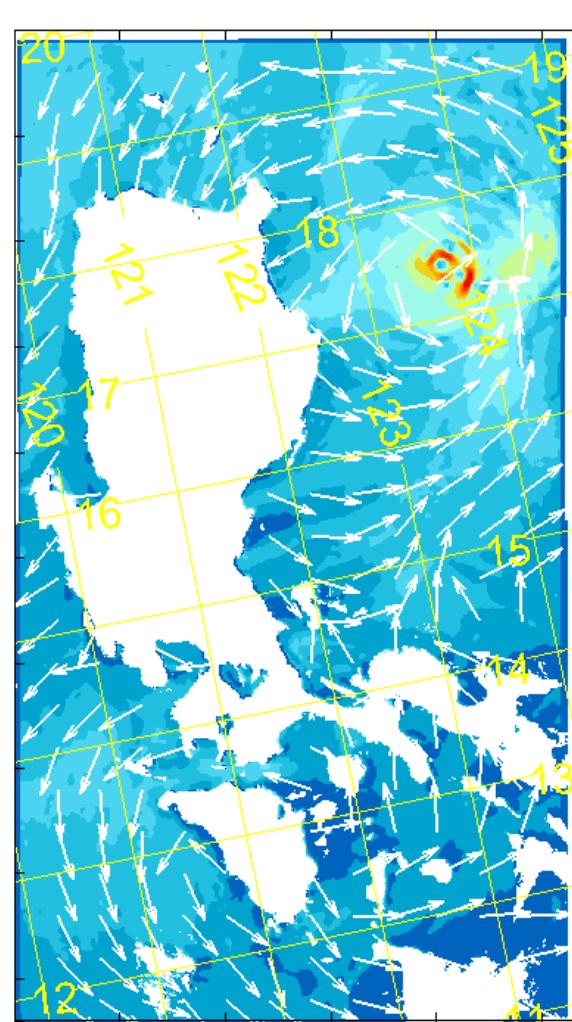
2010-10-17 21:44:04

Sea-Level Pressure (mb)

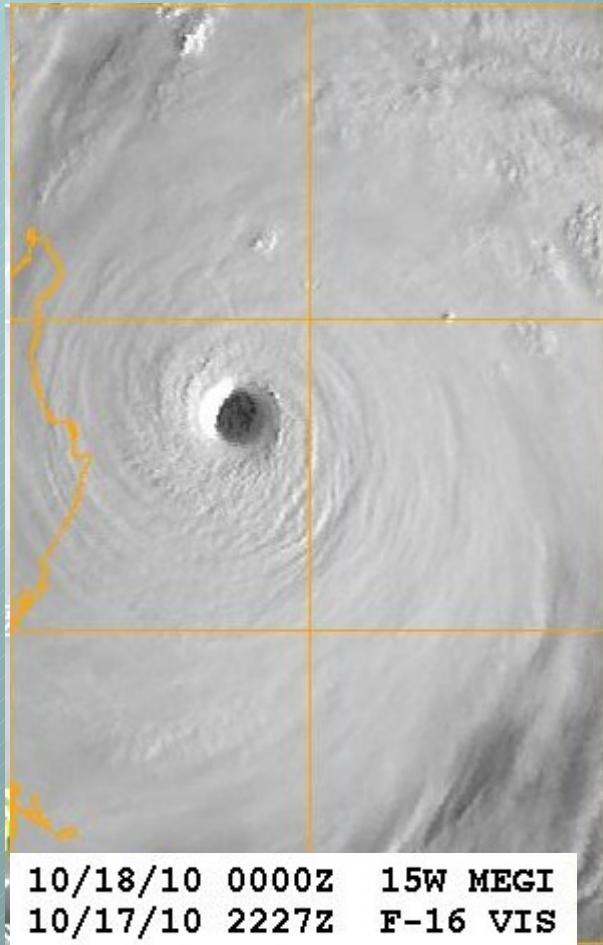


2010-10-17 21:44:04

Blended U_{10} (m s^{-1})

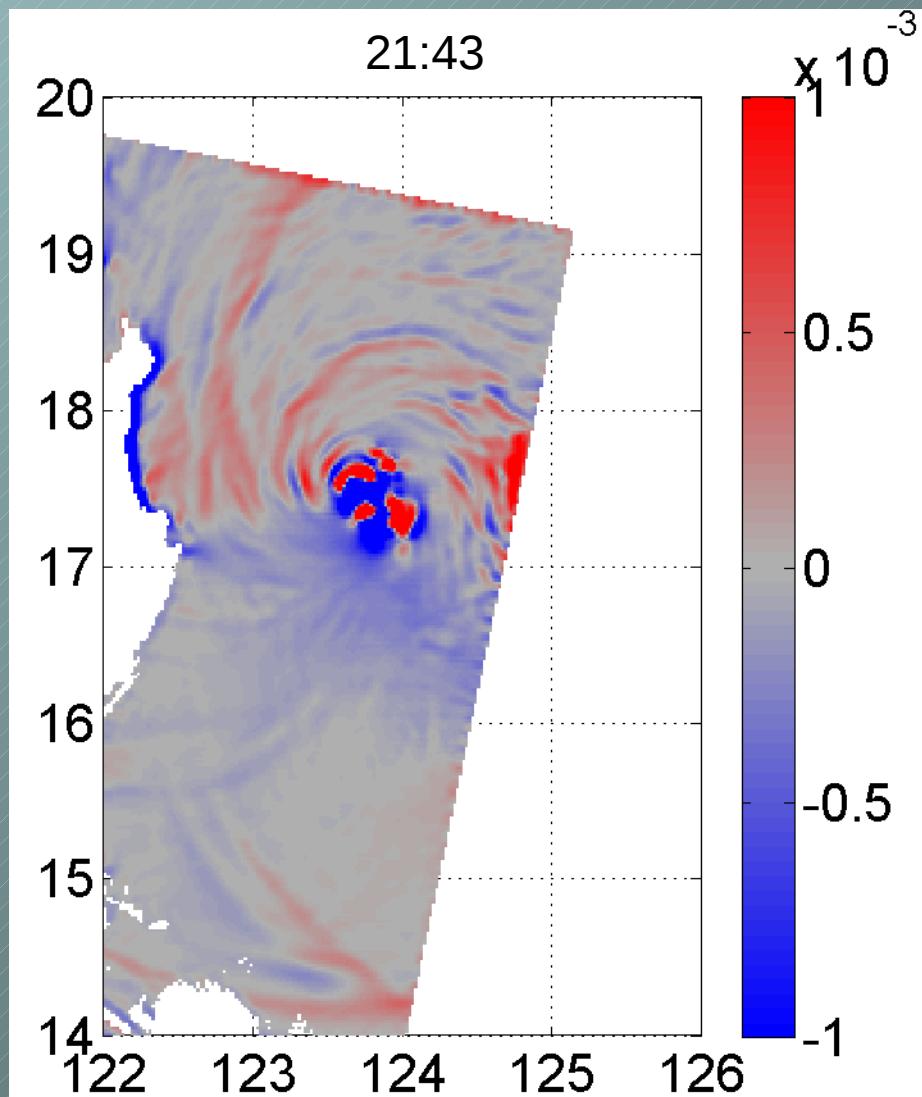


Megi 17-Oct-2010 21:43



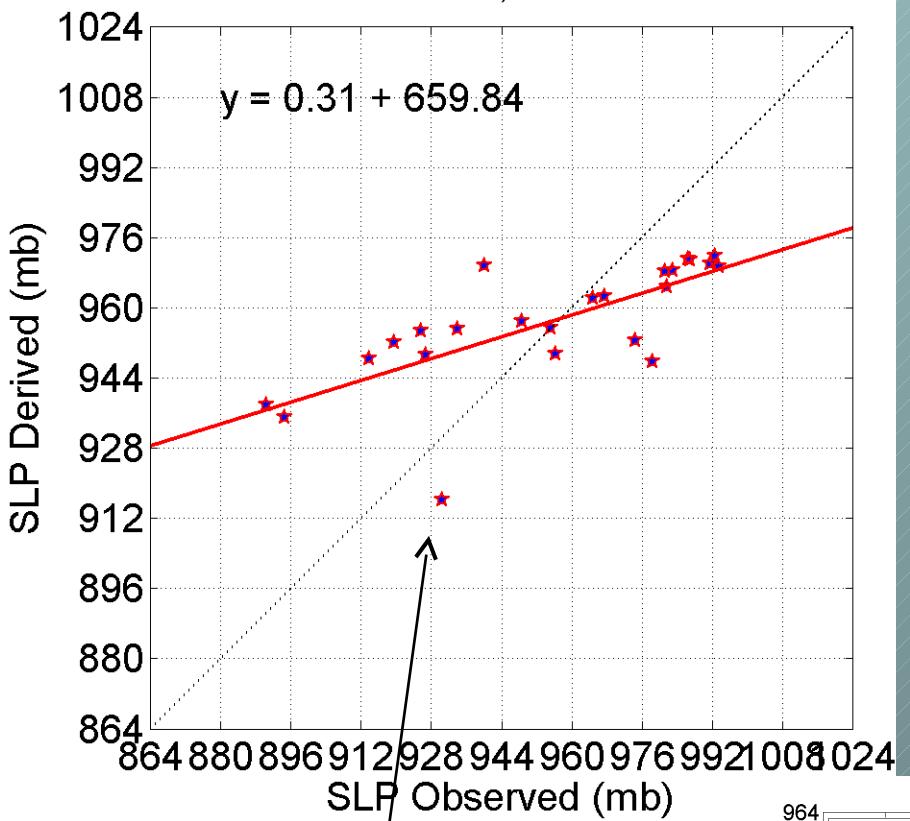
10/17/10 1800Z 15W MEGI
10/17/10 1707Z AQUA-1 RAIN
10/17/10 1657Z MTSAT IR

Surface wind divergence



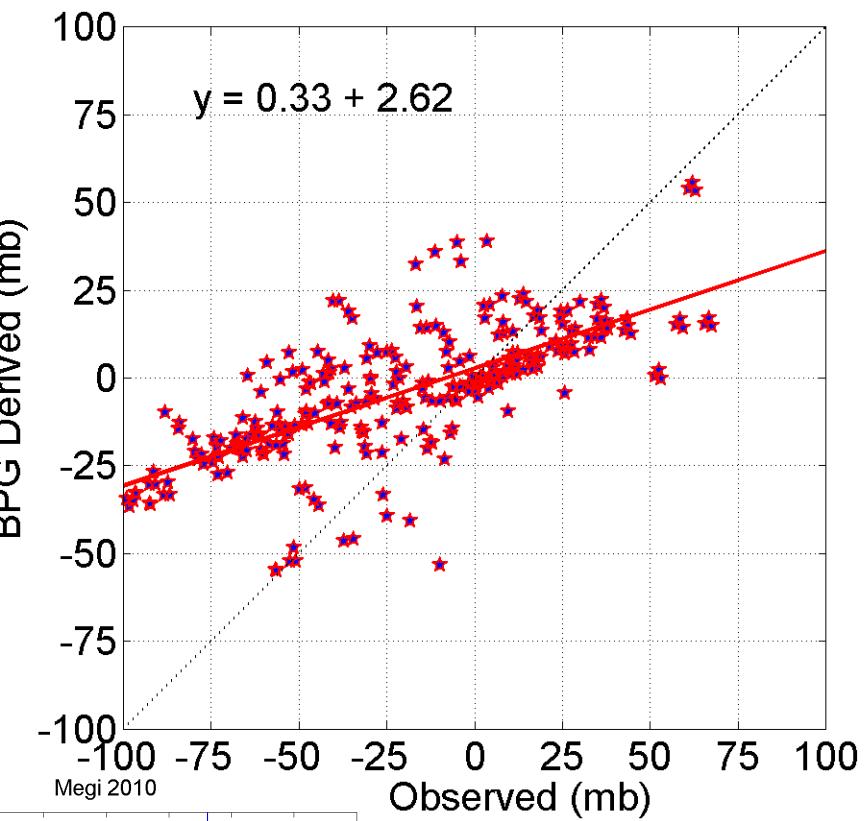
Megi 17-October-2010 21:43

GWCFac = 0.6500; RMSE = 28.4 mb

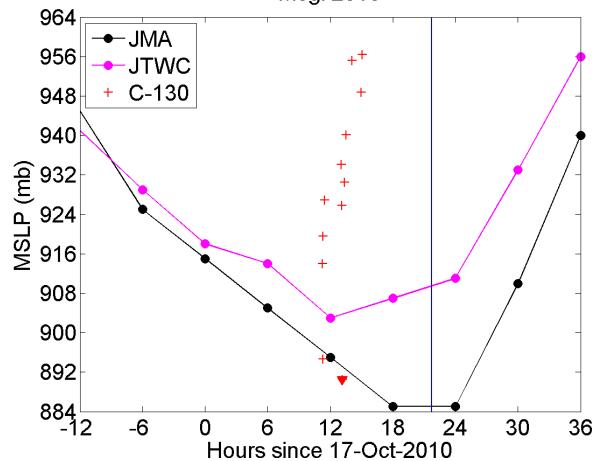


C-130 shift error?

GWCFac = 0.6500



No more than half
of error due to
Time difference



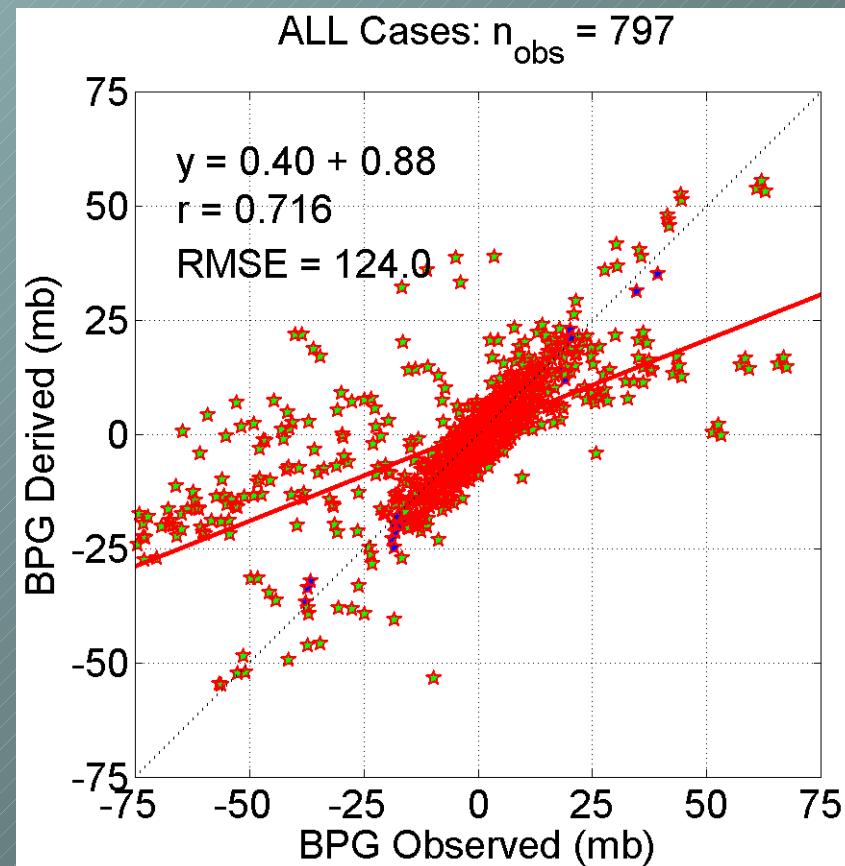
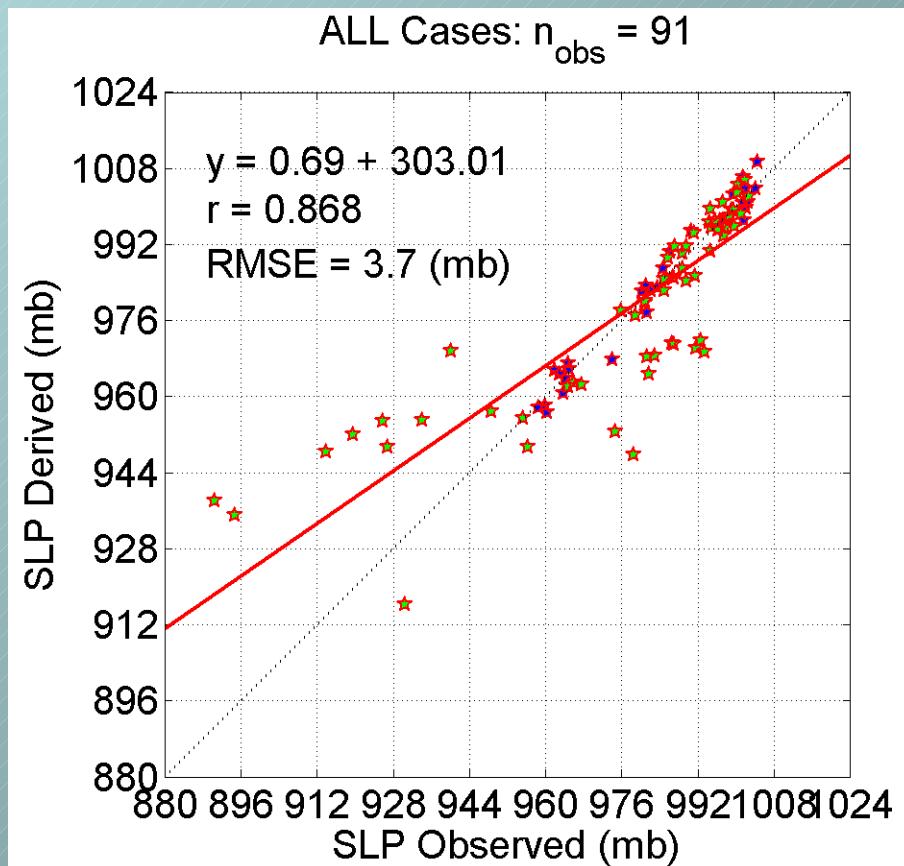
Drop Sonde SLP Summary

ATL (Blue):

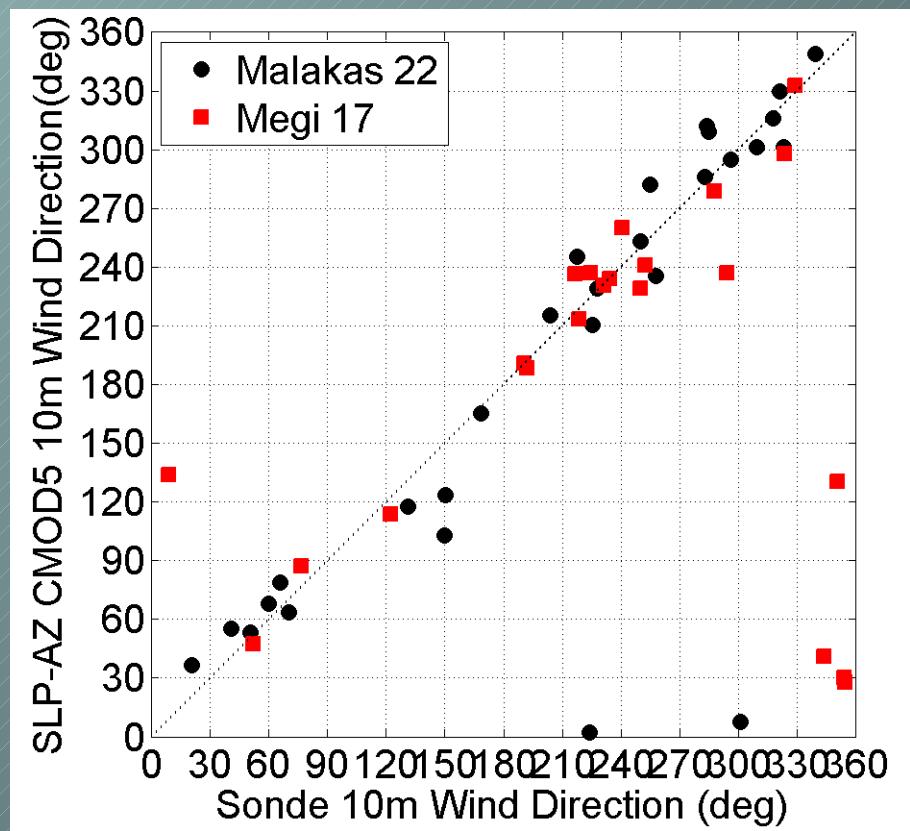
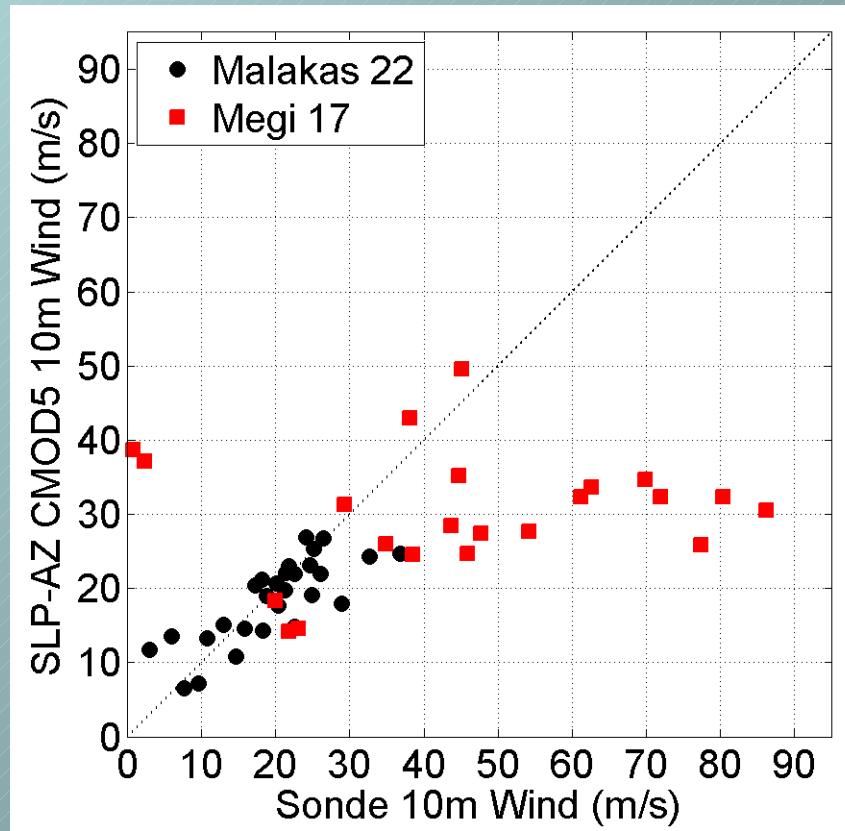
2005-08-27 Katrina
2008-09-13 Ike
2006-09-20 Helene
2002-09-30 Lili

WPAC (Green):

2010-09-22 Malakas
2010-09-24 Malakas
2010-10-17 Megi



ITOP-only Drop Sonde 10m Wind Vector Summary



Progress so far

- Successfully adapted Sea-Level Pressure retrievals to **1-km-scale** SAR winds in **Tropical Cyclones**
- Major improvements to Tropical Cyclone Boundary Layer (TCBL) model
- Available SAR-derived sea-level pressure patterns agree well with near-in-time drop sondes (4 ATL cases plus 2 of the ITOP scenes)
 - ~1 mb RMS between SAR and drop Sondes
 - ~3 mb RMS storm by storm (fairest score)
 - Including *extreme* case (Megi17) significantly *degrades* this score
- SLP-derived surface wind patterns remove much of the most egregious GMF-induced and/or direction error induced surface wind artifacts
 - Iterating directions with TCBL model seems to improve wind retrievals
- SLP errors scale with wind speed errors (clearly seen in Megi17)

Near-Future

- SFMR wind comparisons
- CMOD5N & IWRAP GMFs
- Implement optimization scheme to produce optimal surface wind field consistent with SAR, drop sondes, SFMR and in situ data from ITOP
- Examine all remaining ITOP imagery (C-band and X-band)
- Use these data to evaluate GMFs (X-band, C-band)

