HRD's Science Meeting

March 10, 2011 @NHC

Next meeting: April 14, 2011

Achieving Superior Tropical Cyclone Intensity Forecasts by Improving the Assimilation of High-Resolution Satellite Data into Mesoscale Prediction Models

PIs: Chris Velden (CIMSS/U. Wisconsin)

Sharan Majumdar (RSMAS/U. Miami)

Co-PIs: Jim Doyle and Jeff Hawkins (NRL-Monterey)

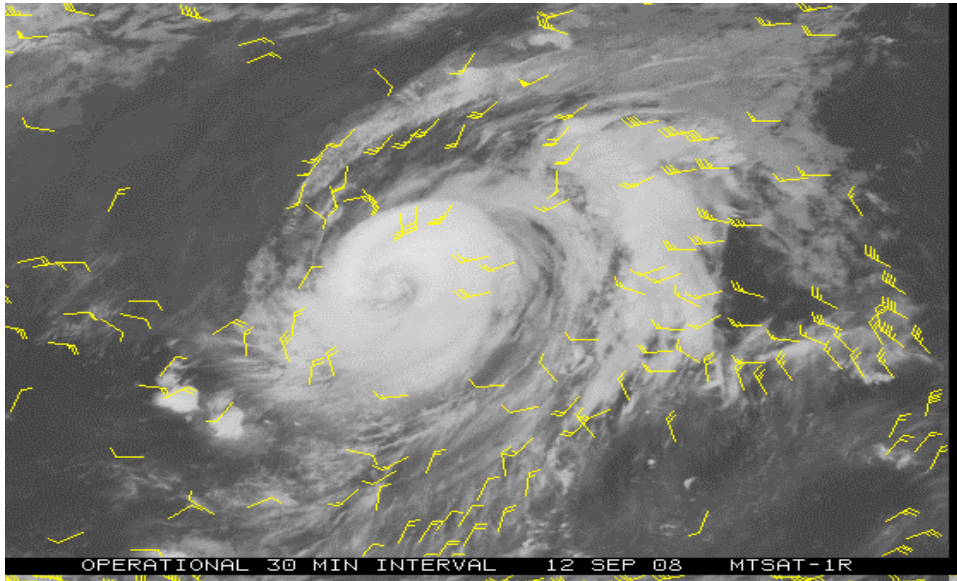
Jeff Anderson and Hui Liu (NCAR), Jun Li (CIMSS/U. Wisconsin)

Collaborators: Bob Atlas (NOAA/AOML), John Knaff (NOAA/NESDIS), Song Yang (NRL-Monterey), William Lewis (CIMSS/U. Wisconsin)

Ph.D. Student: Ting-Chi Wu (RSMAS/U. Miami)

HRD Group Meeting @ NHC, 3/10/11

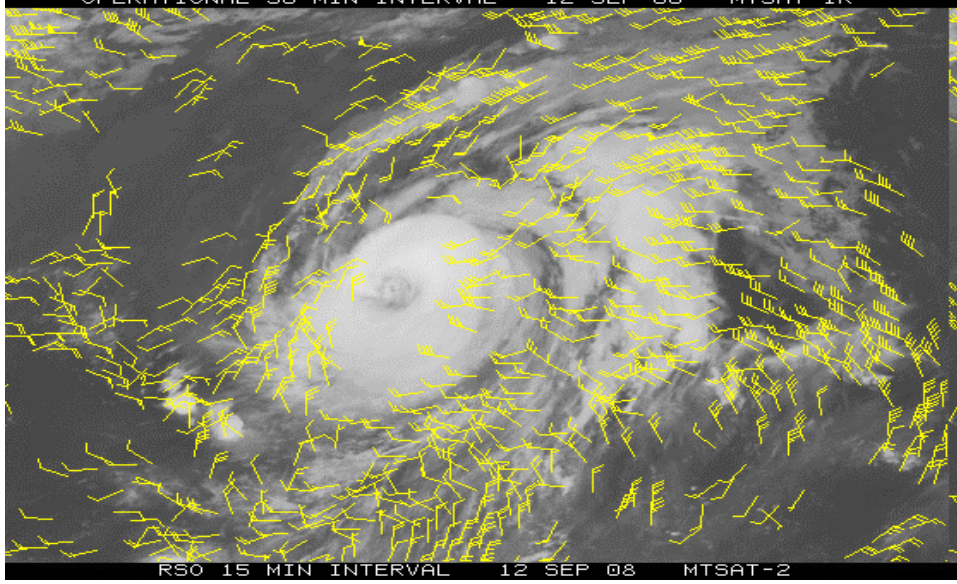
Example of AMVs from MTSAT

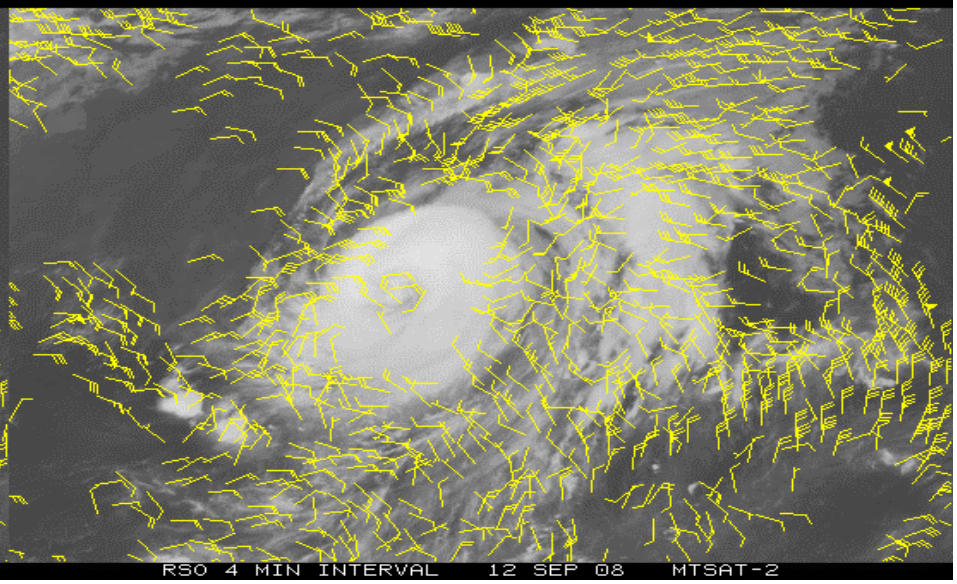


Left: AMV (IR-only) field produced from routinely available hourly sequence of MTSAT-1 images during Typhoon Sinlaku

Bottom Left: Same as above, but using a 15-min rapid scan sequence from MTSAT-2 (better AMV coverage and coherence)

Bottom Right: Same as above, but using a 4-min rapid scan sequence (improved coverage/detail of typhoon flow fields)





S. Majumdar

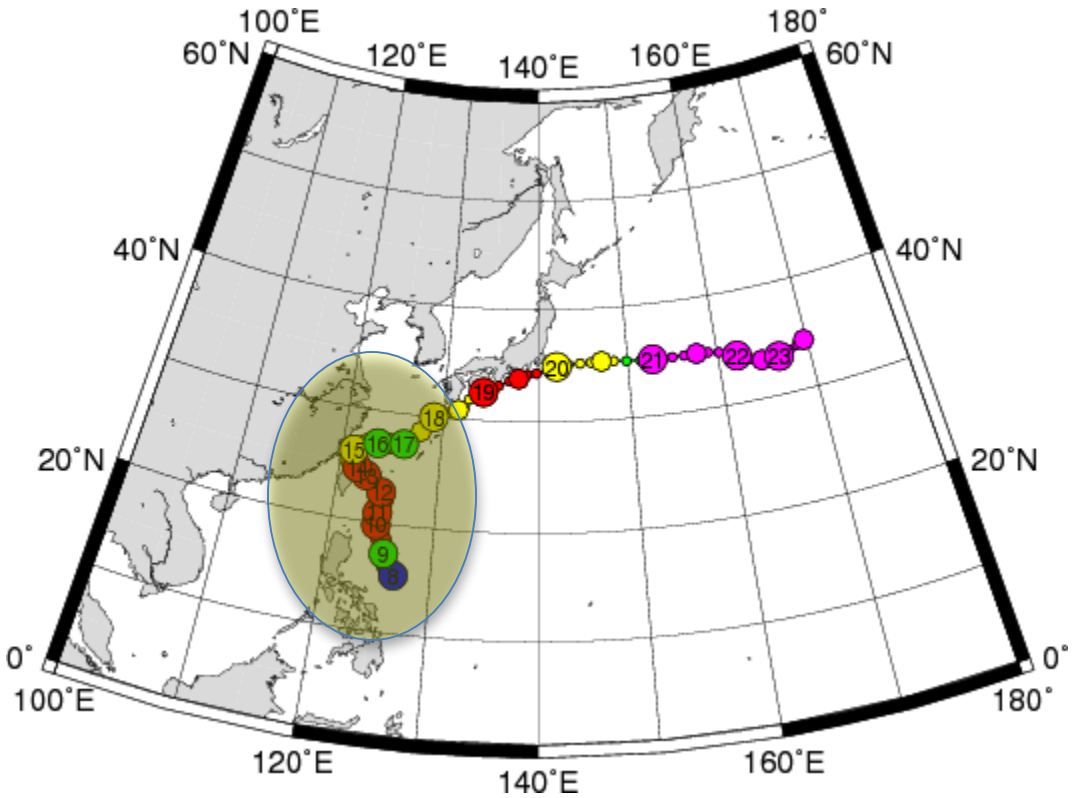
Analysis Experiments of Typhoon Sinlaku (2008)

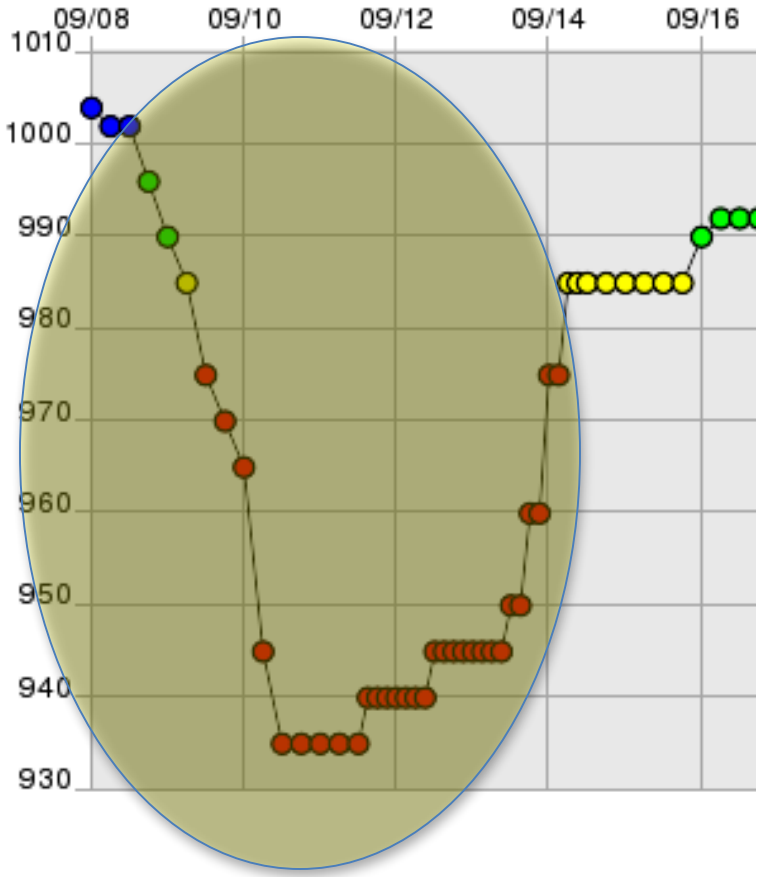
- **CTL**: Radiosondes, operational cloud winds from NCEP BUFR files (original source: JMA), aircraft, JTWC advisory TC position. 6-hourly cycle.
- **CIMSS**: CIMSS hourly AMVs and rapid-scan AMVs (after 12 UTC Sep 10 2008) replace operational cloud winds. 3-hourly cycle.

- Assimilation cycle started September 1 2008.
- 9km moving nest grid with feedback to 27km grid in the forecasts when TC is present.
- Only the cloud winds at exact analysis times are used.

S. Majumdar

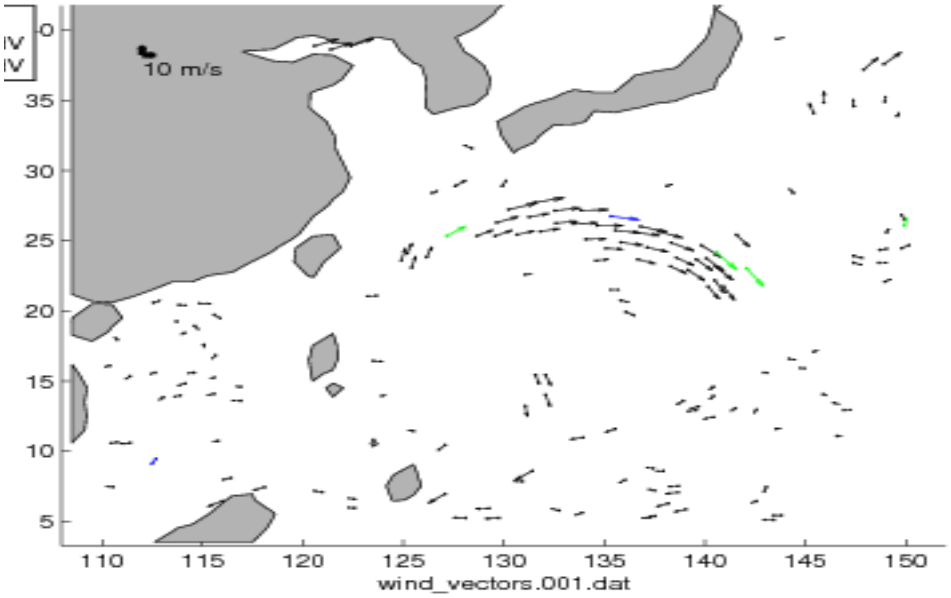
Typhoon Sinlaku (2008)



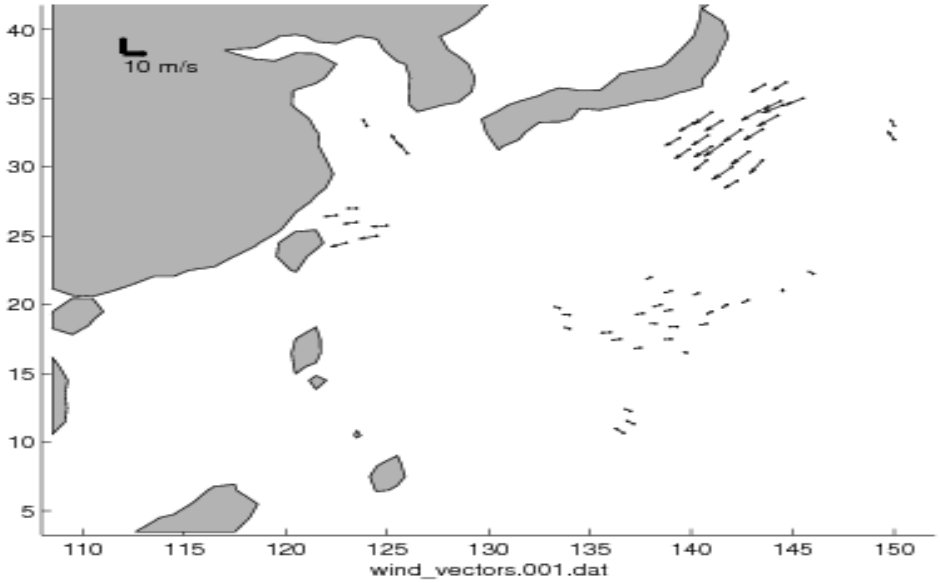


S. Majumdar

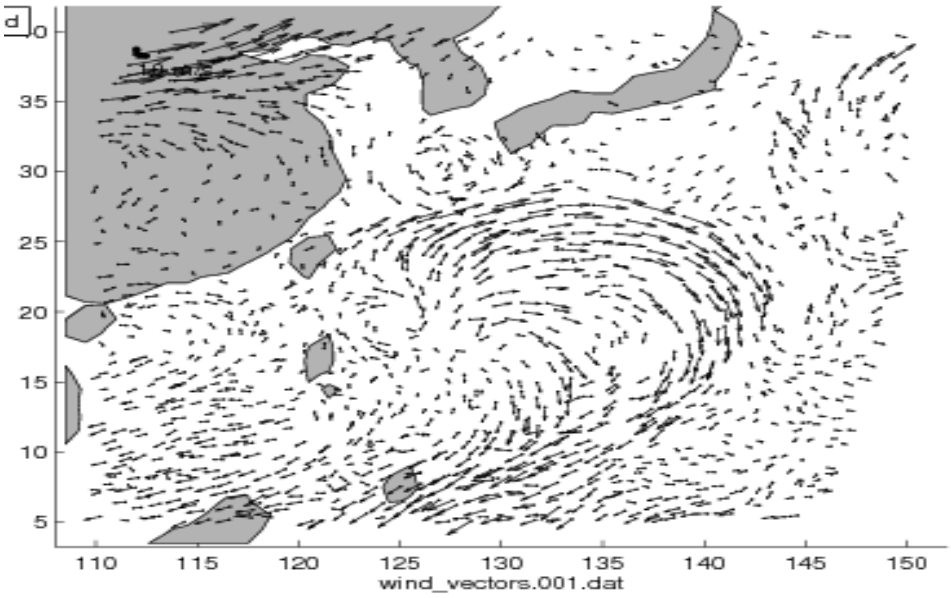
Operational AMVs: Above 500 hPa



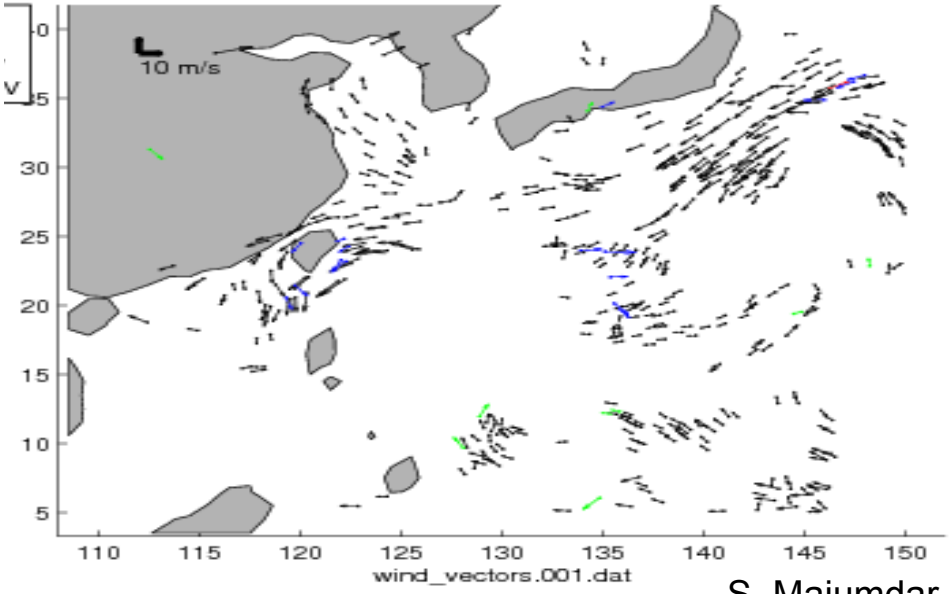
Operational AMVs: Below 500 hPa



CIMSS AMVs: Above 500 hPa



CIMSS AMVs: Below 500 hPa



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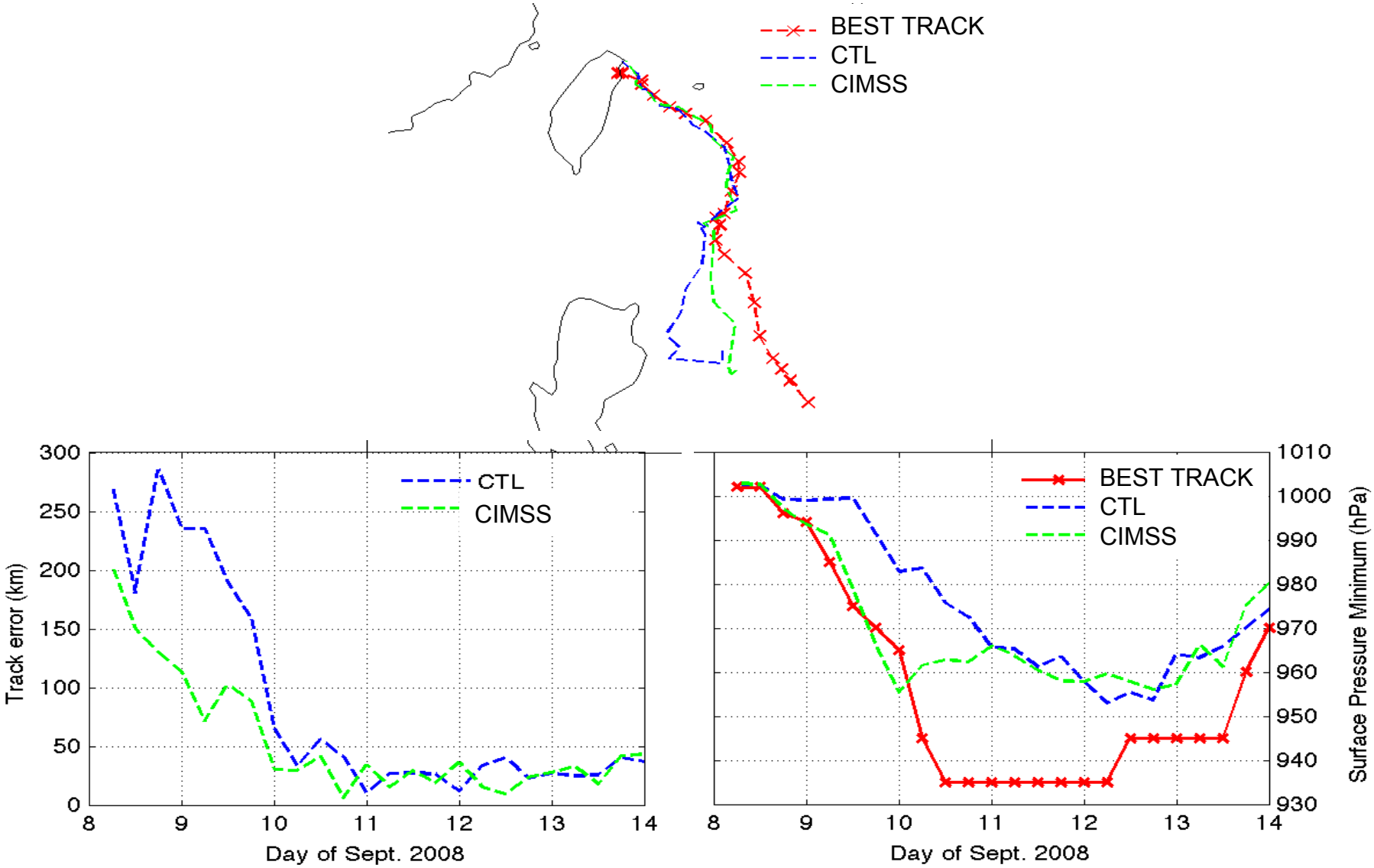
WRF/EnKF Analyses: Track & Minimum SLP



S. Majumdar

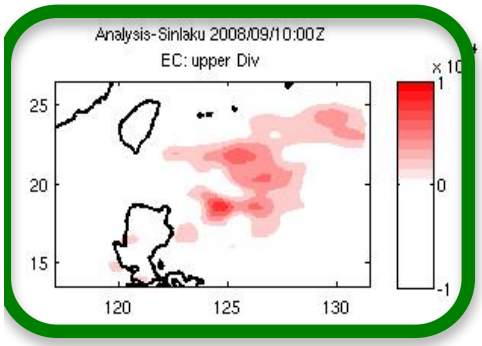
EnKF Analysis Diagnostics

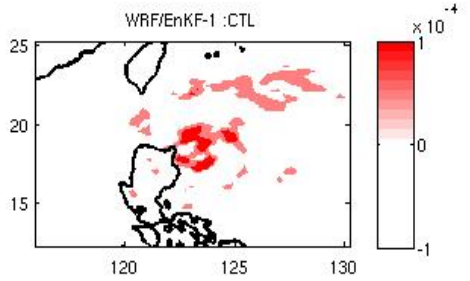
- Vertical X-section of divergence through TC.
- 150-300 hPa layer mean divergence.
- Vertical X-section of azimuthally-averaged relative vorticity.

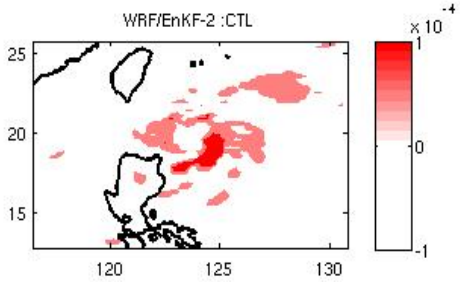
- 25-km resolution ECMWF deterministic analyses are used as a benchmark.

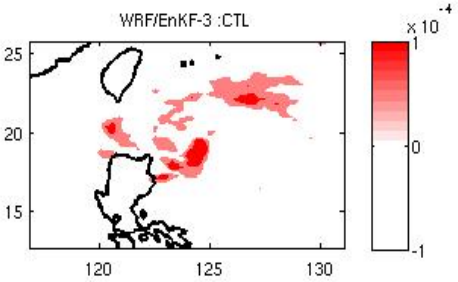
S. Majumdar

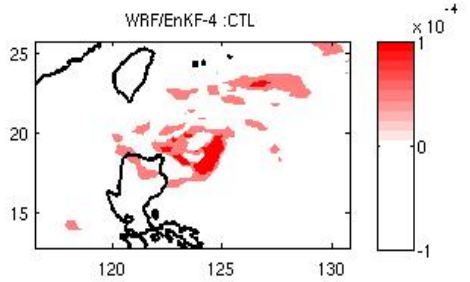
150-300 hPa Divergence: CTL

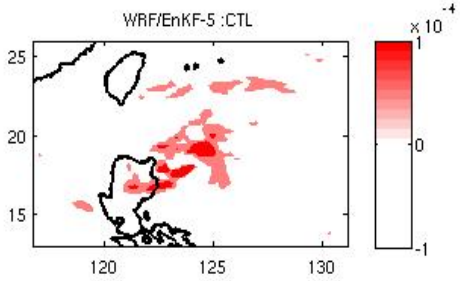


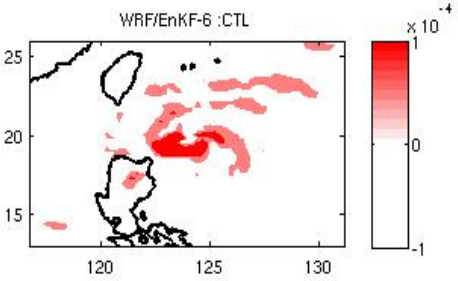


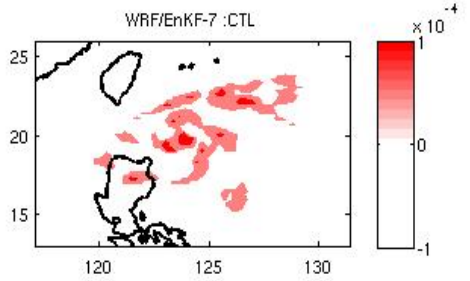


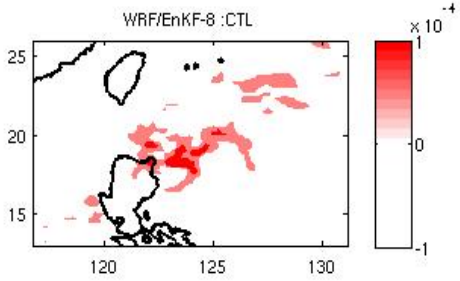


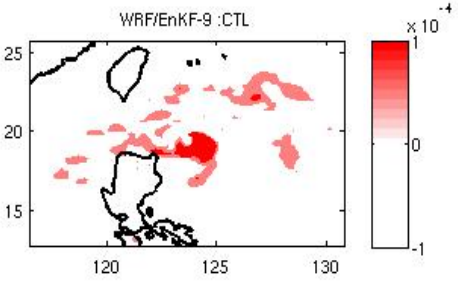


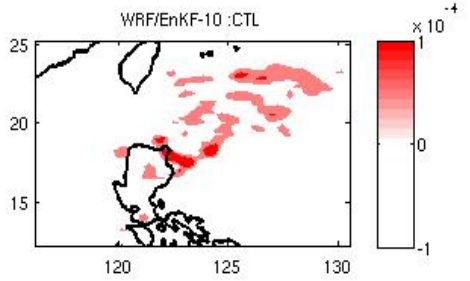




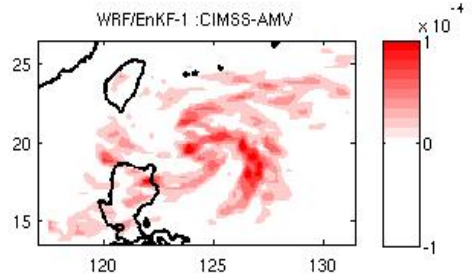


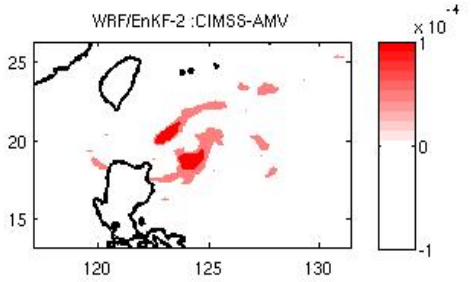


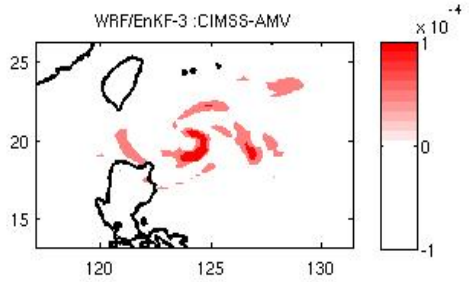


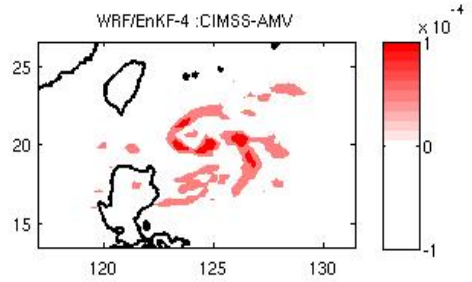


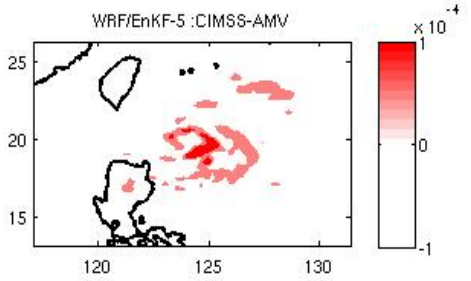
150-300 hPa Divergence: CIMSS

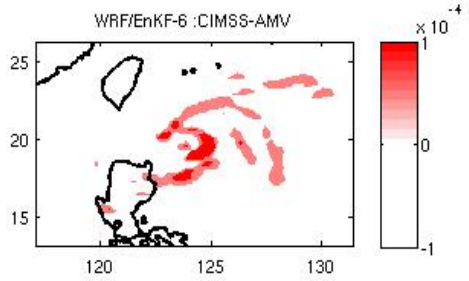


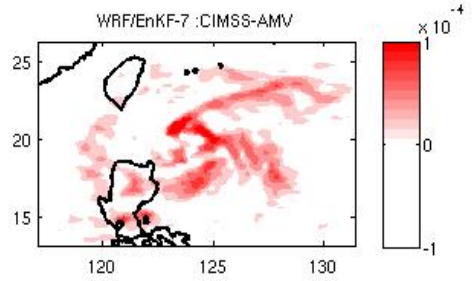


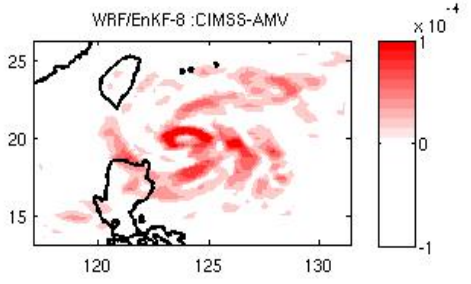


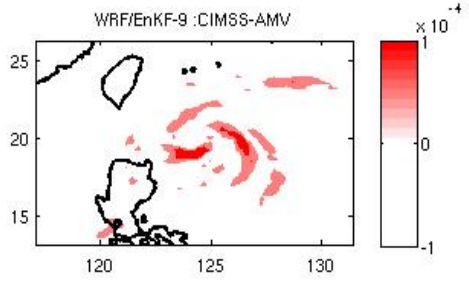


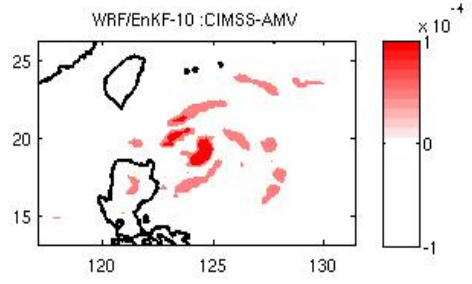










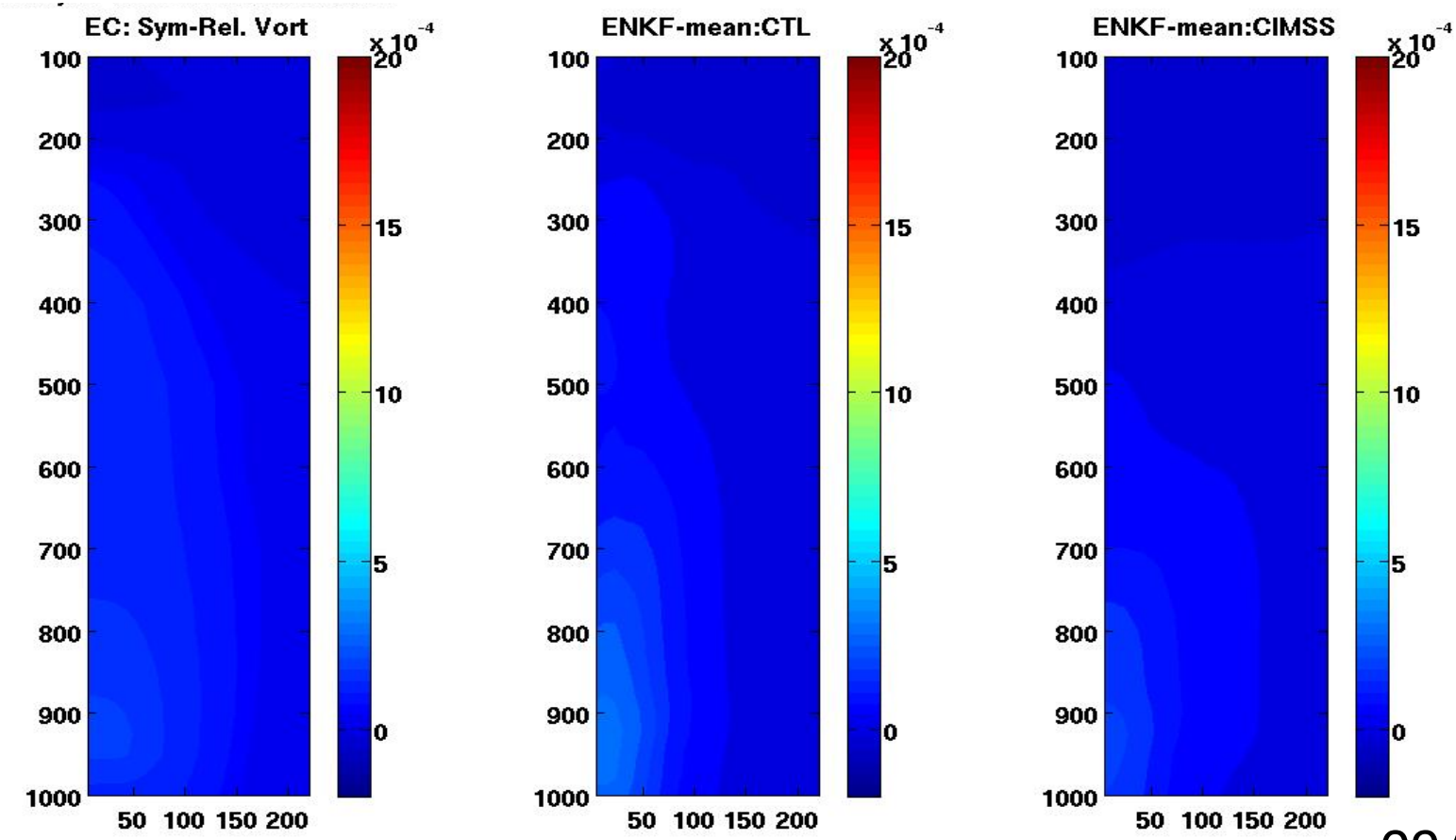


X-section of relative vorticity

WRF-EC

WRF-EnKF CTL

WRF-EnKF CIMSS



S. Majumdar

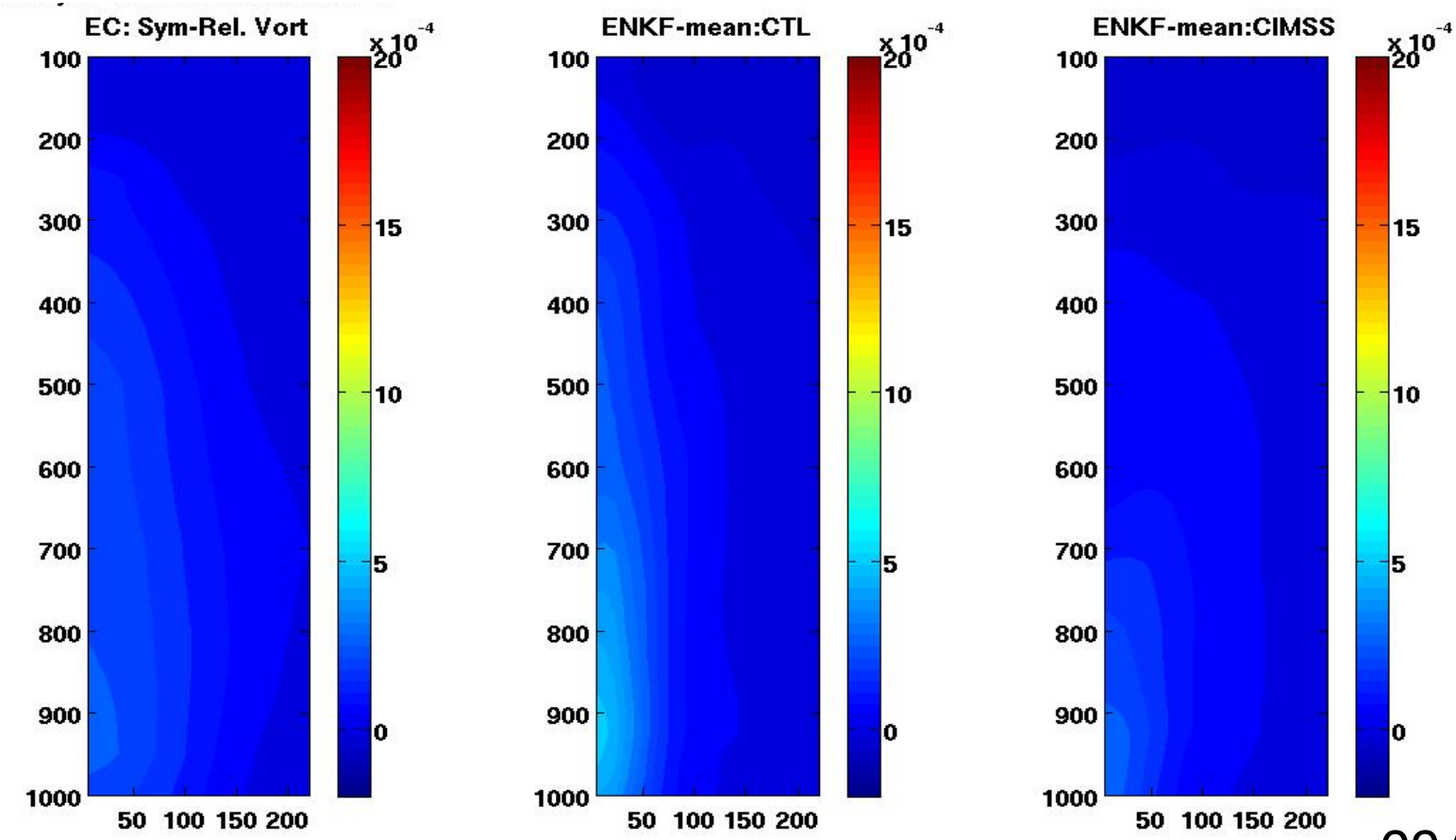
09/08:00Z

X-section of relative vorticity

WRF-EC

WRF-EnKF CTL

WRF-EnKF CIMSS



S. Majumdar

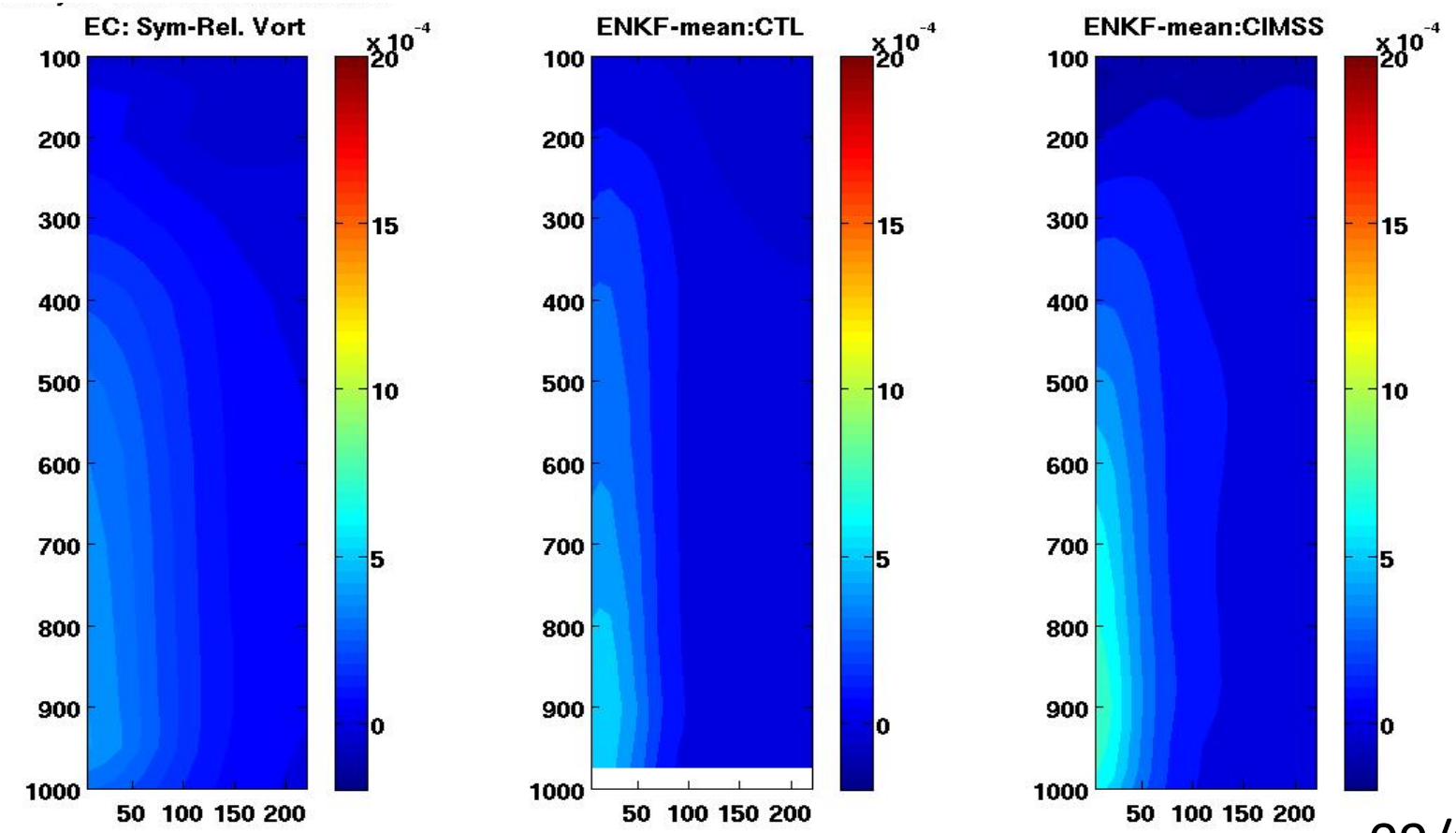
09/08:12Z

X-section of relative vorticity

WRF-EC

WRF-EnKF CTL

WRF-EnKF CIMSS



S. Majumdar

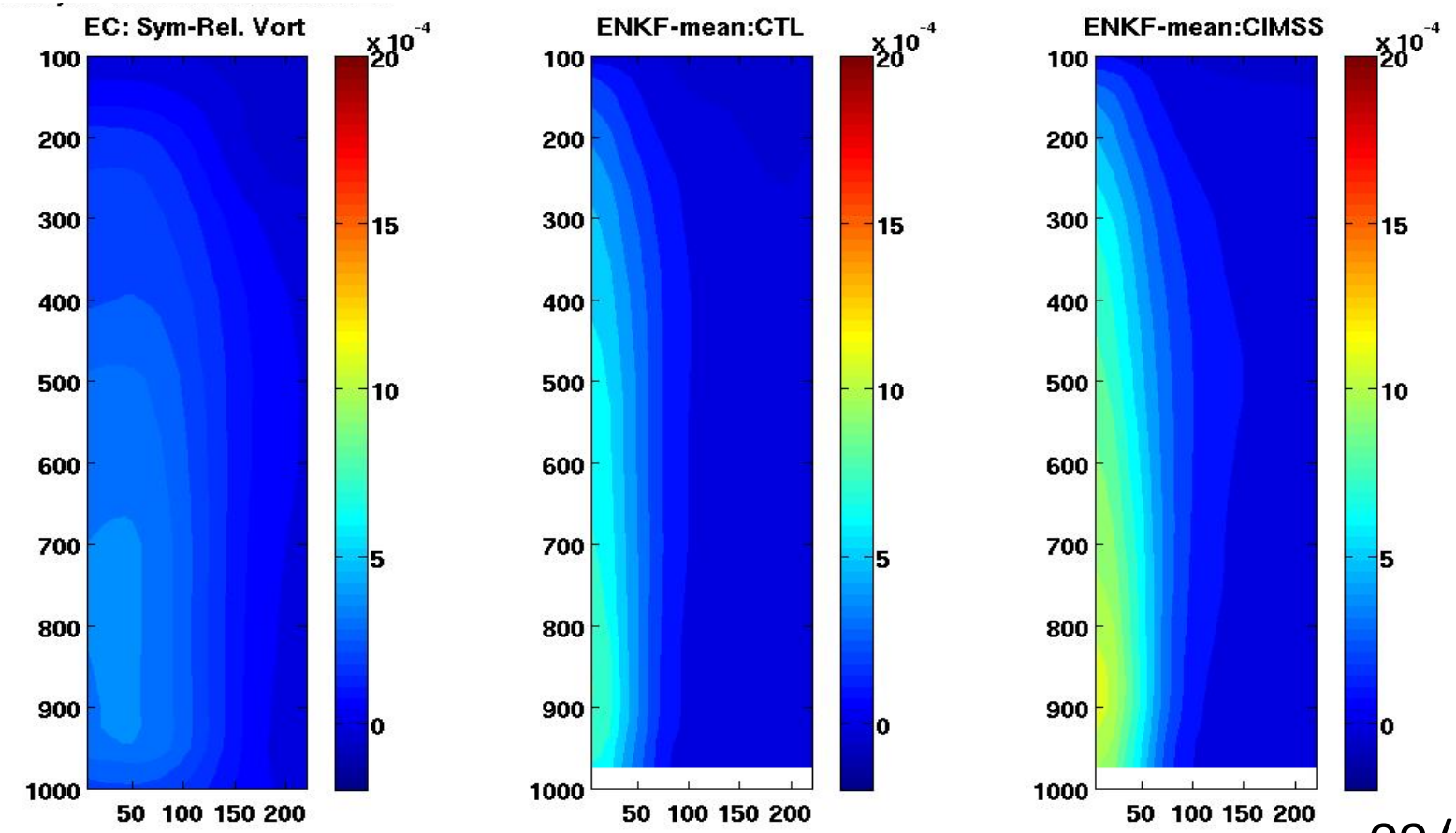
09/09:00Z

X-section of relative vorticity

WRF-EC

WRF-EnKF CTL

WRF-EnKF CIMSS



S. Majumdar

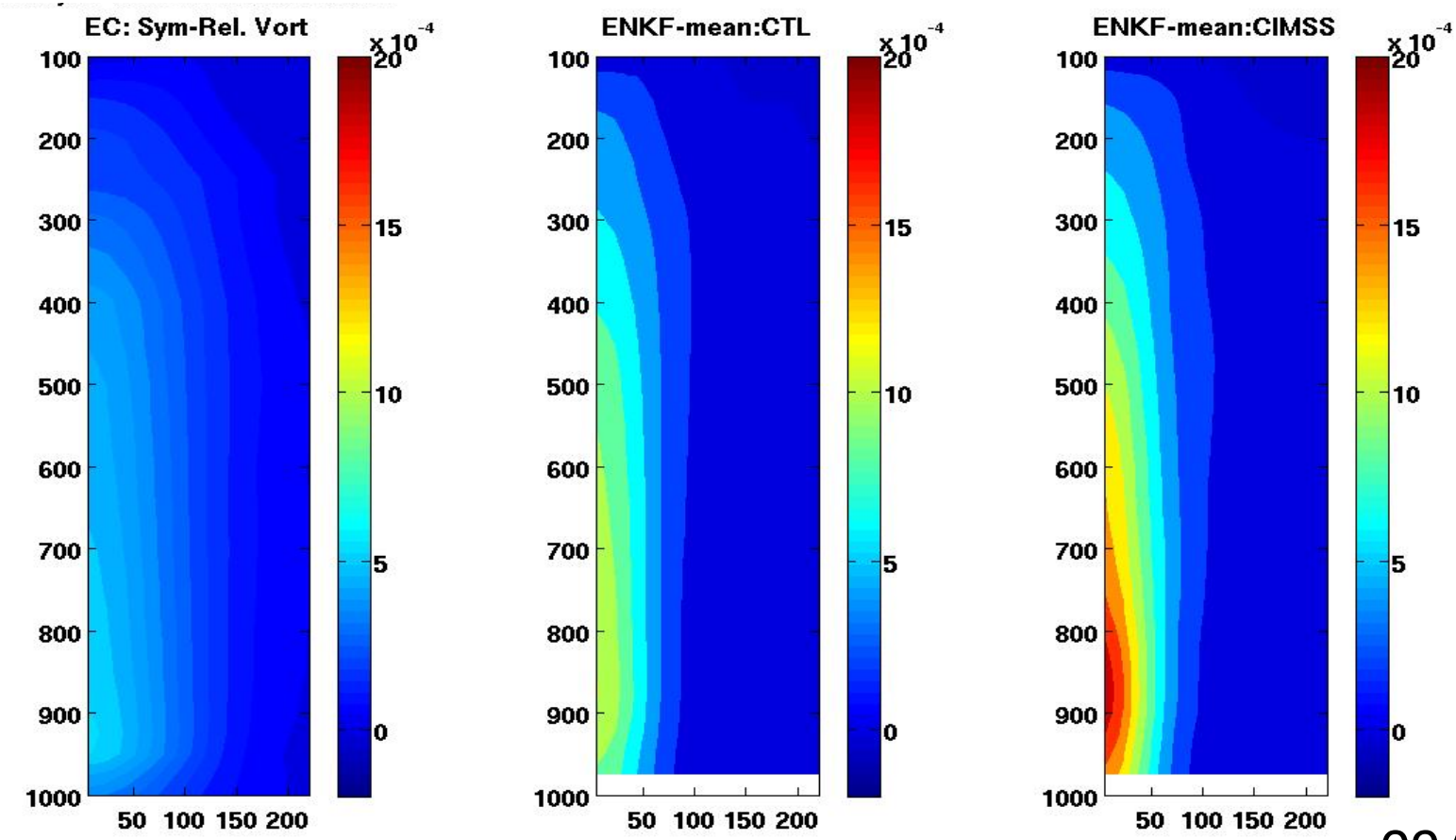
09/09:12Z

X-section of relative vorticity

WRF-EC

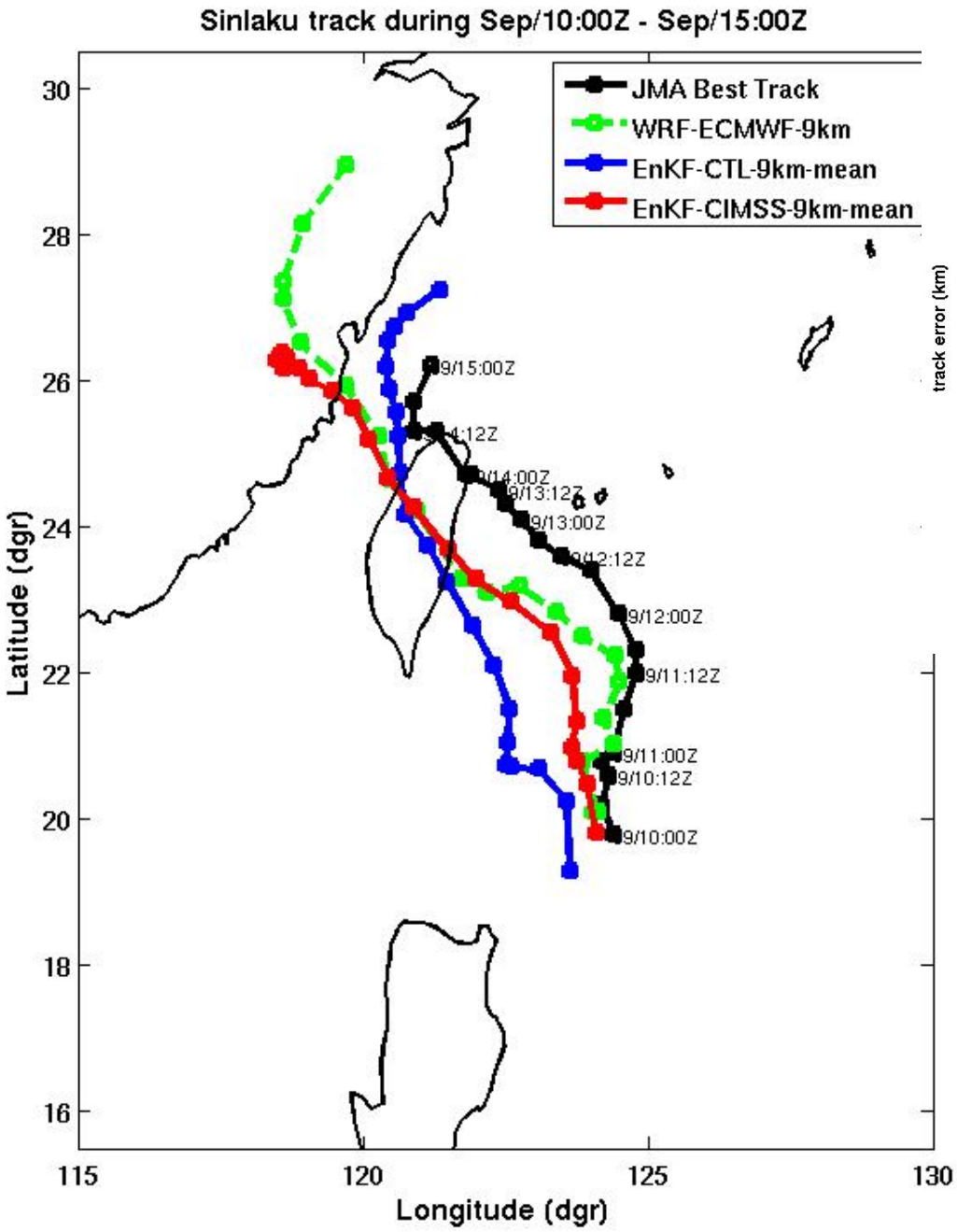
WRF-EnKF CTL

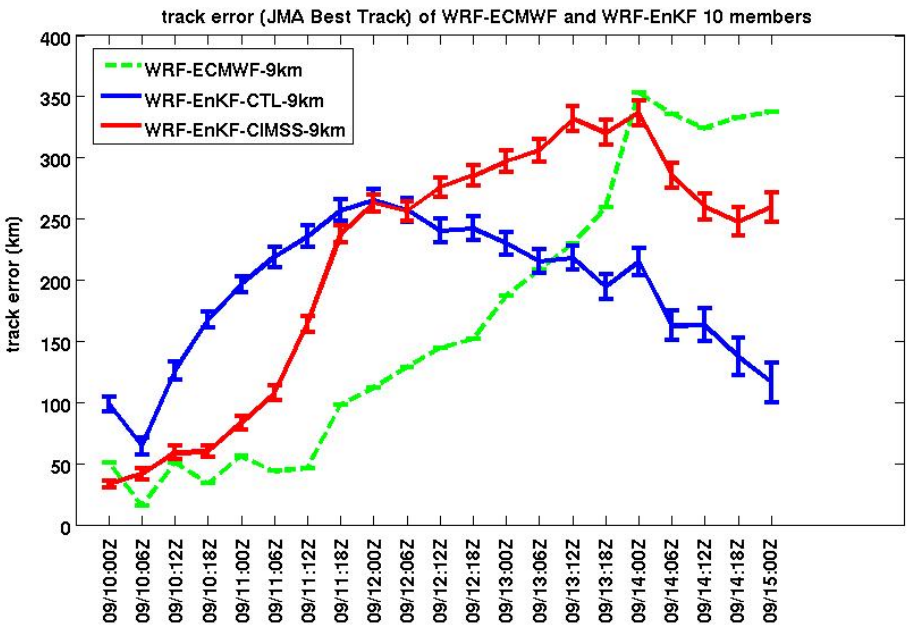
WRF-EnKF CIMSS



S. Majumdar

09/10:00Z

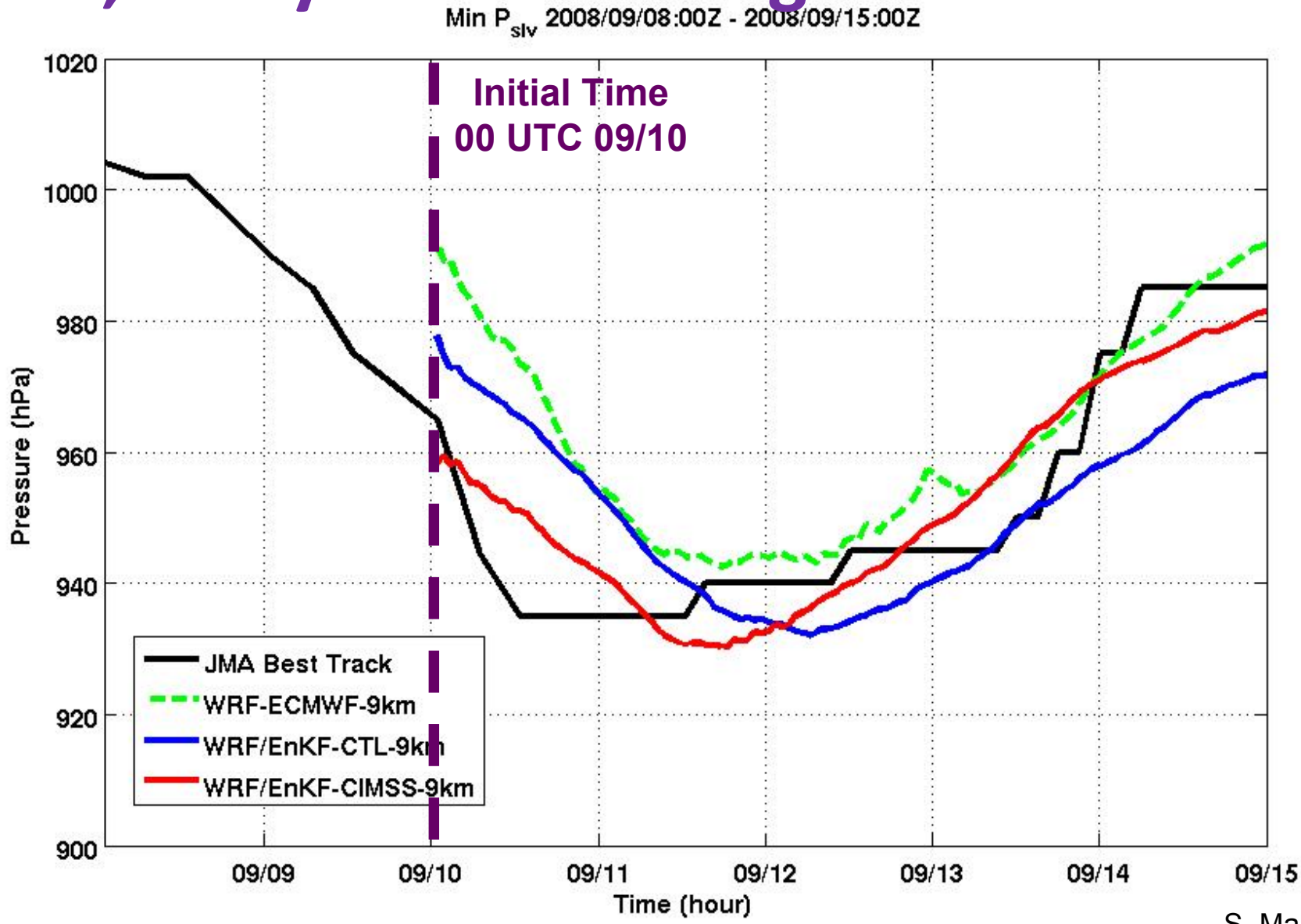




CIMSS mean track forecast superior to CTL prior to landfall. Narrow spread.

S. Majumdar

1-day CIMSS intensity forecast superior to CTL, likely due to stronger initial vortex



S. Majumdar

Brad Klotz

10 March, 2011

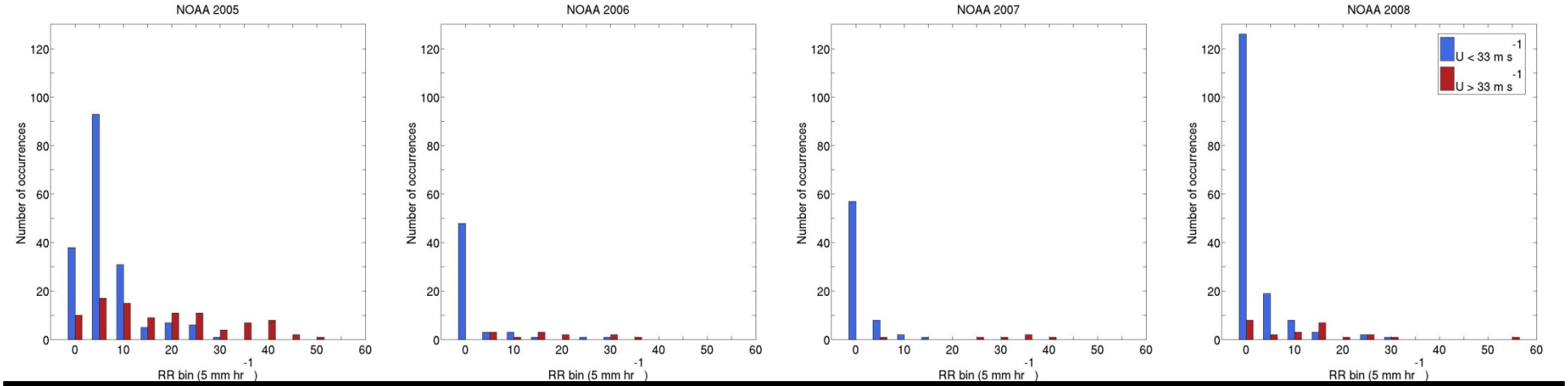
National Hurricane Center

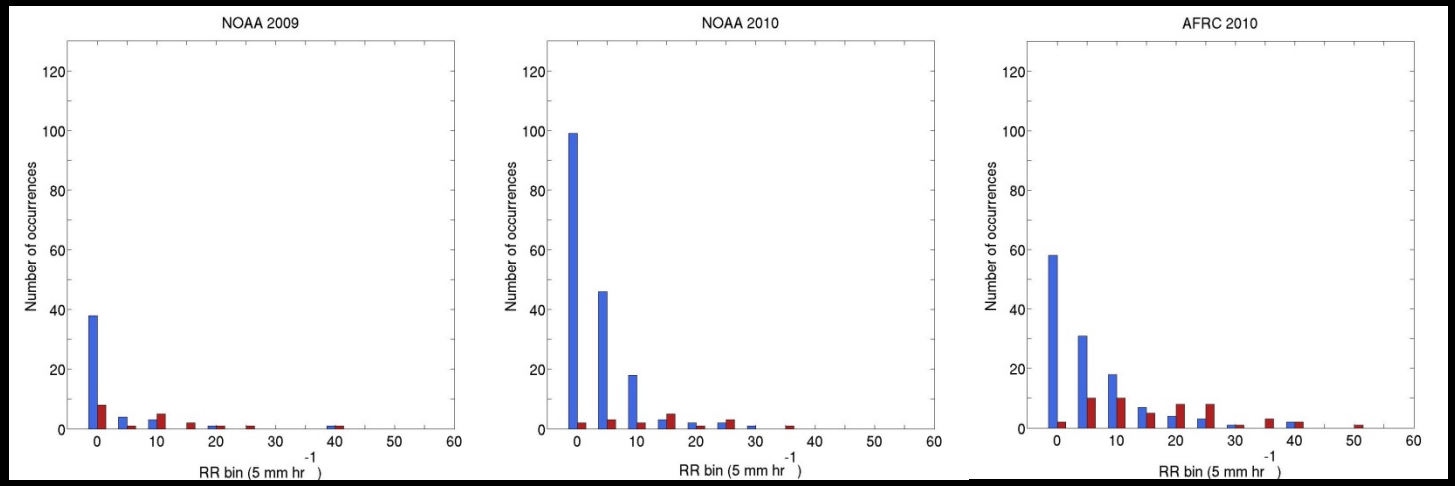
SFMR – GPS sonde database

- Collection of paired NOAA or AFRC SFMR and GPS data
  - NOAA data: 2005 – present
  - AFRC data: 2010
  - Key components: SFMR surface wind speeds, rain rates, altitudes, brightness temperatures, and GPS sonde surface-adjusted wind speeds
- Seasonal comparison shows some large differences in data coverage

B. Klotz

Seasonal Histograms

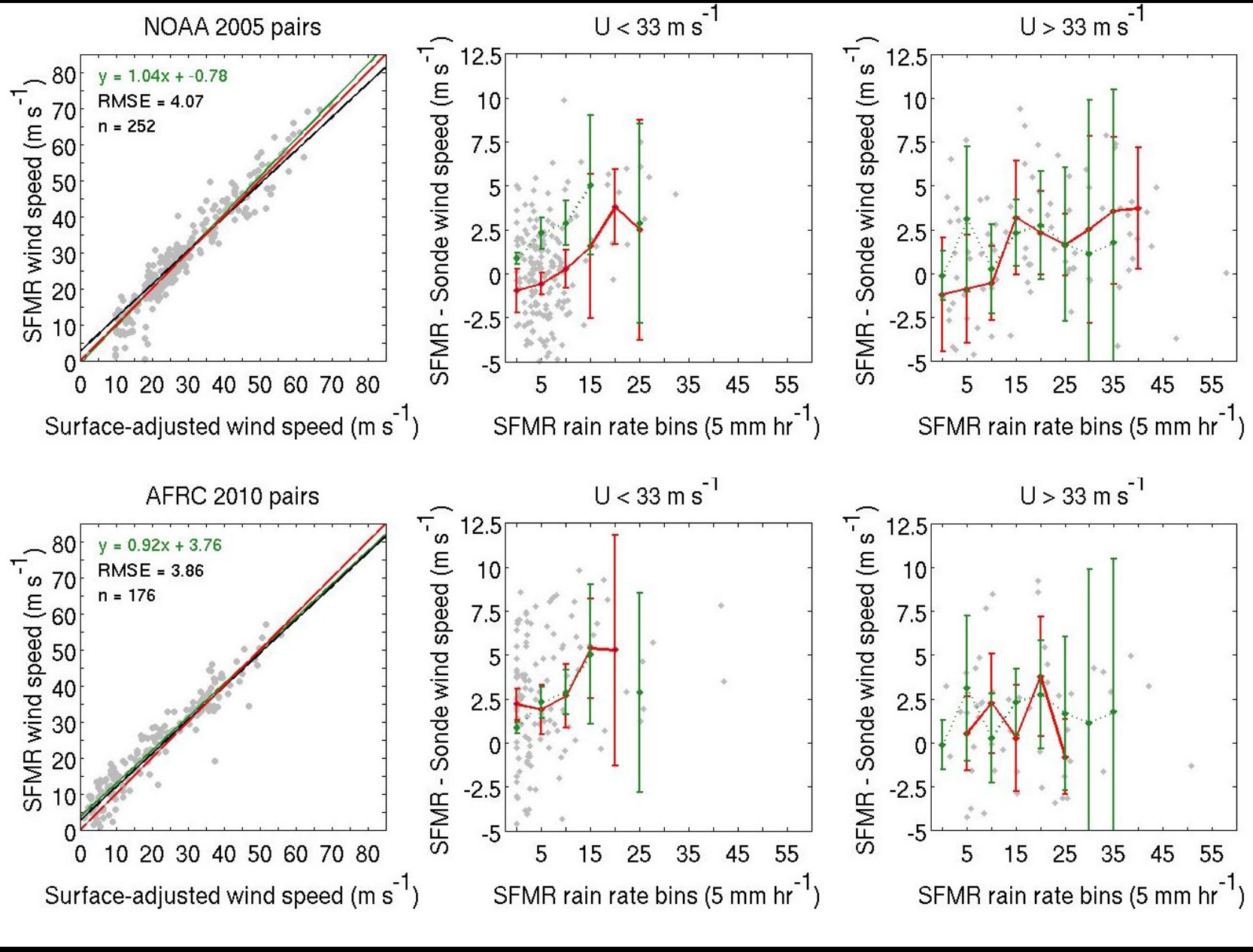




- 2005 has best overall data coverage
- Lack of data at higher rain rates for depression, storm, and hurricane strength winds

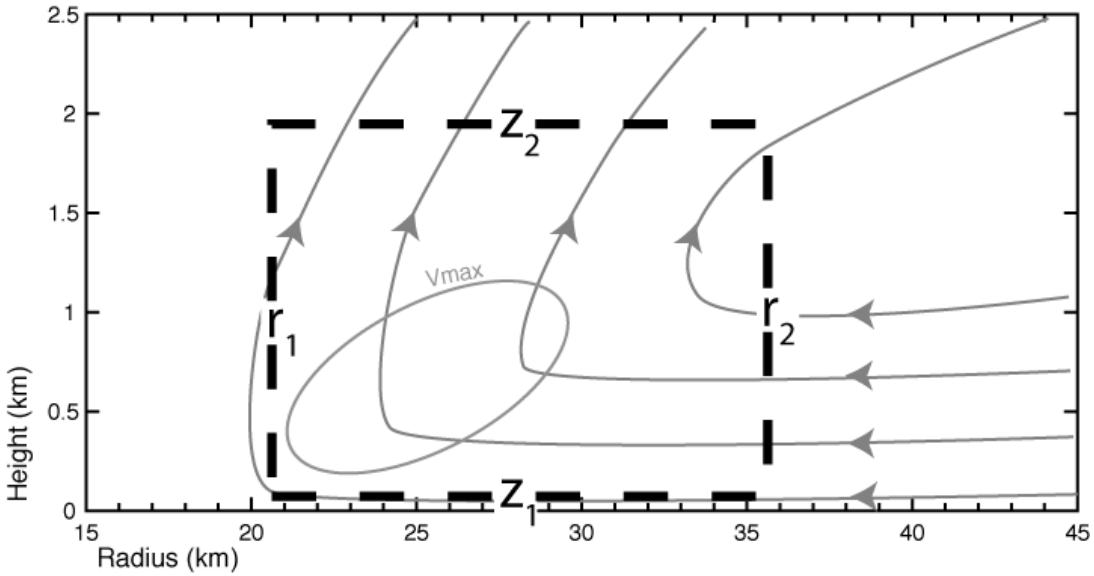
B. Klotz

Independent Comparisons



B. Klotz

Mike Montgomery
Naval Postgraduate School



Courtesy Michael Bell
NPS

$$C_D = \left(-r_2 \int_{z_1}^{z_2} [\rho u M]\Big|_{r_2}\, dz + r_1 \int_{z_1}^{z_2} [\rho u M]\Big|_{r_1}\, dz \right.$$

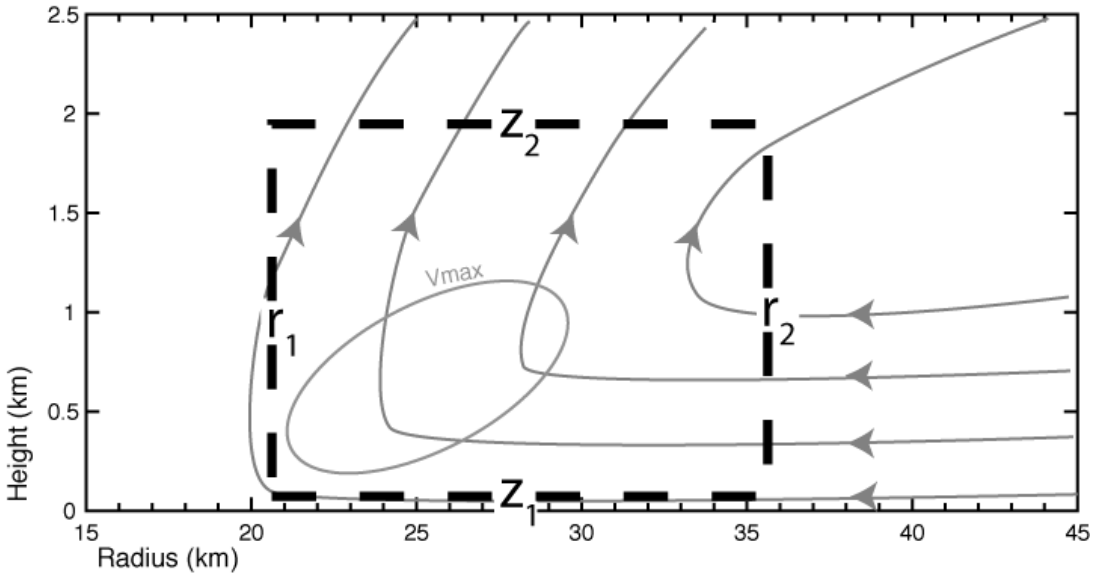
$$\left. - \int_{r_1}^{r_2} [\rho w M]\Big|_{z_2}\, r dr + \int_{r_1}^{r_2} [\rho w M]\Big|_{z_1}\, r dr \right) \Big/ \left(\int_{r_1}^{r_2} [\rho\, |\vec{u}_h|\, v]\Big|_{z_1}\, r^2 dr \right) + \mathbf{R}$$

$$M = rv + \frac{1}{2} f r^2$$

$$\mathbf{R} = \left(r_2 \int_{z_1}^{z_2} [r\tau_{r\theta}]\Big|_{r_2}\, dz - r_1 \int_{z_1}^{z_2} [r\tau_{r\theta}]\Big|_{r_1}\, dz + \int_{r_1}^{r_2} [r\tau_{z\theta}]\Big|_{z_2}\, r dr - \int_{z_1}^{z_2} \int_{r_1}^{r_2} \frac{\partial(\rho M)}{\partial t} r dr dz \right) /$$

$$\int_{r_1}^{r_2} [\rho\, |\vec{u}_h|\, v]\Big|_{z_1}\, r^2 dr$$

M. Montgomery



Courtesy Michael Bell
NPS

$$C_K = \left(\int_{z_1}^{z_2} r_2 \left[\rho u E \right] \Big|_{r_2} dz - \int_{z_1}^{z_2} r_1 \left[\rho u E \right] \Big|_{r_1} dz + \int_{r_1}^{r_2} \left[\rho w E \right] \Big|_{z_2} r dr - \int_{r_1}^{r_2} \left[\rho w E \right] \Big|_{z_1} r dr + F_{SHEAR} \right) /$$

$$\int_{r_1}^{r_2} \left[\rho \left| \vec{u}_h \right| (k^* - k) \right] \Big|_{z_1} r dr + \mathbf{R}$$

$$\mathbf{R} = \left(\int_{z_1}^{z_2} r_2 \left[F_{rk} + ue + \overline{u'e} - w\tau_{rz} - v\tau_{r\theta} \right] \Big|_{r_2} dz \right.$$

$$- \int_{z_1}^{z_2} r_1 \left[F_{rk} + ue + \overline{u'e} - w\tau_{rz} - v\tau_{r\theta} \right] \Big|_{r_1} dz$$

$$+ \int_{r_1}^{r_2} \left[F_{zk} + we + \overline{w'e} - u\tau_{rz} - v\tau_{z\theta} \right] \Big|_{z_2} r dr$$

$$\left. - \int_{r_1}^{r_2} \left[we + \overline{w'e} \right] \Big|_{z_1} r dr + \int_{z_1}^{z_2} \int_{r_1}^{r_2} \left[\frac{\partial(\rho E + e)}{\partial t} \right] r dr dz \right) /$$

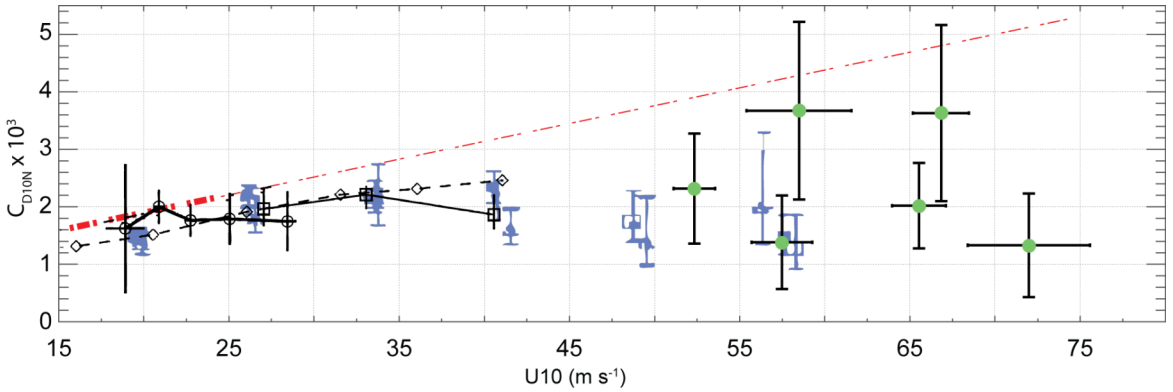
$$\int_{r_1}^{r_2} \left[\rho \left| \vec{u}_h \right| (k^* - k) \right] \Big|_{z_1} r dr$$

$$E = c_p T + Lq + \frac{1}{2}(u^2 + v^2 + w^2) + gz$$

$$F_{SHEAR} = \int_{r_1}^{r_2} \left[u\tau_{rz} + v\tau_{z\theta} \right] \Big|_{z_1} r dr$$

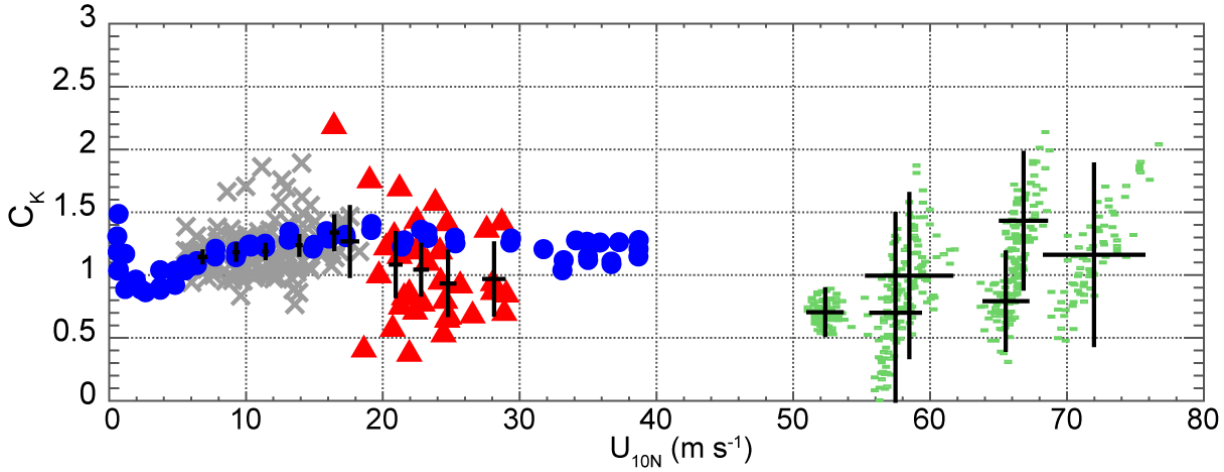
M. Montgomery

C_D



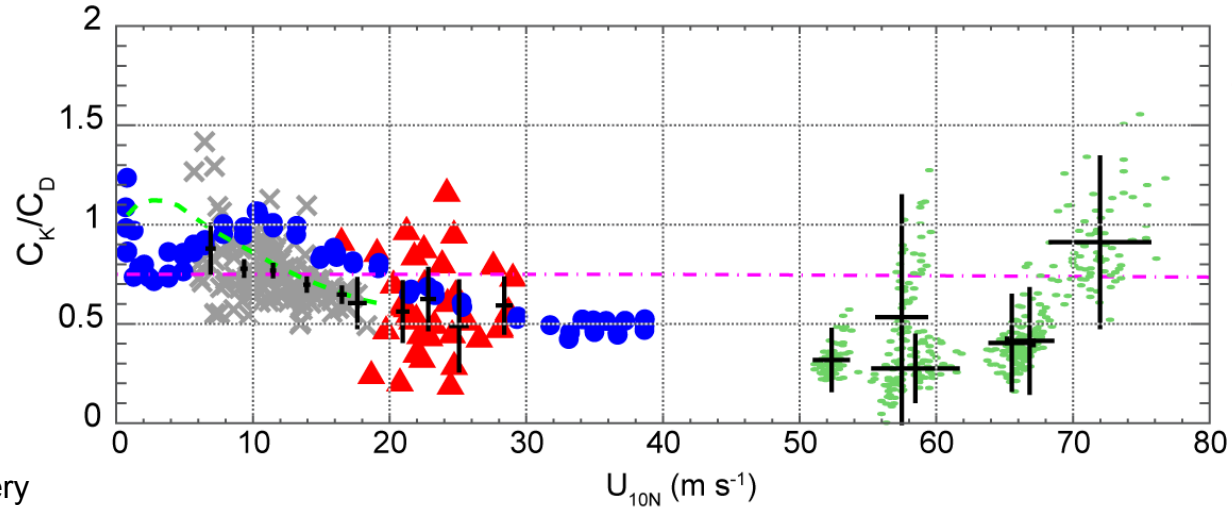
Large and Pond 1981
Donelan et al. 2004
Black et al. 2007
French et al. 2008
Powell et al. 2003
Vickery et al. 2009
Bell 2010

C_K



Large and Pond 1982
DeCosmo et al. 1996
Black et al. 2007
Drennan et al. 2007
French et al. 2008
Zhang et al. 2008
Haus et al. 2010
Bell 2010

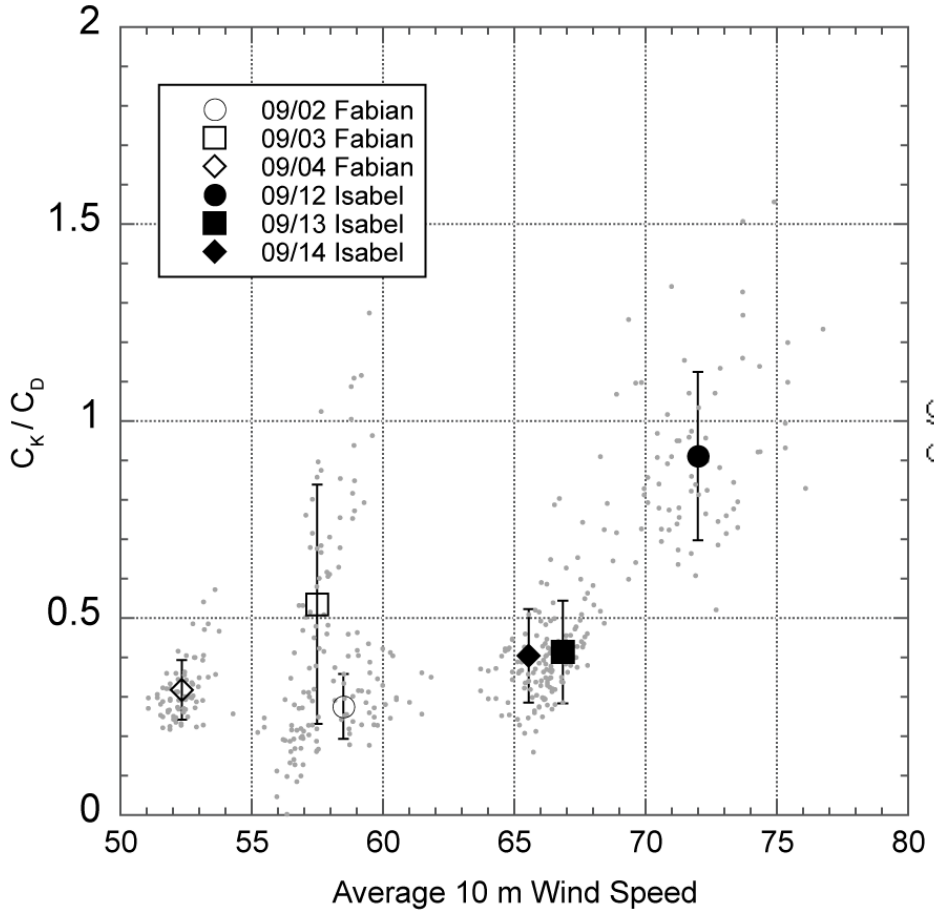
$\frac{C_K}{C_D}$

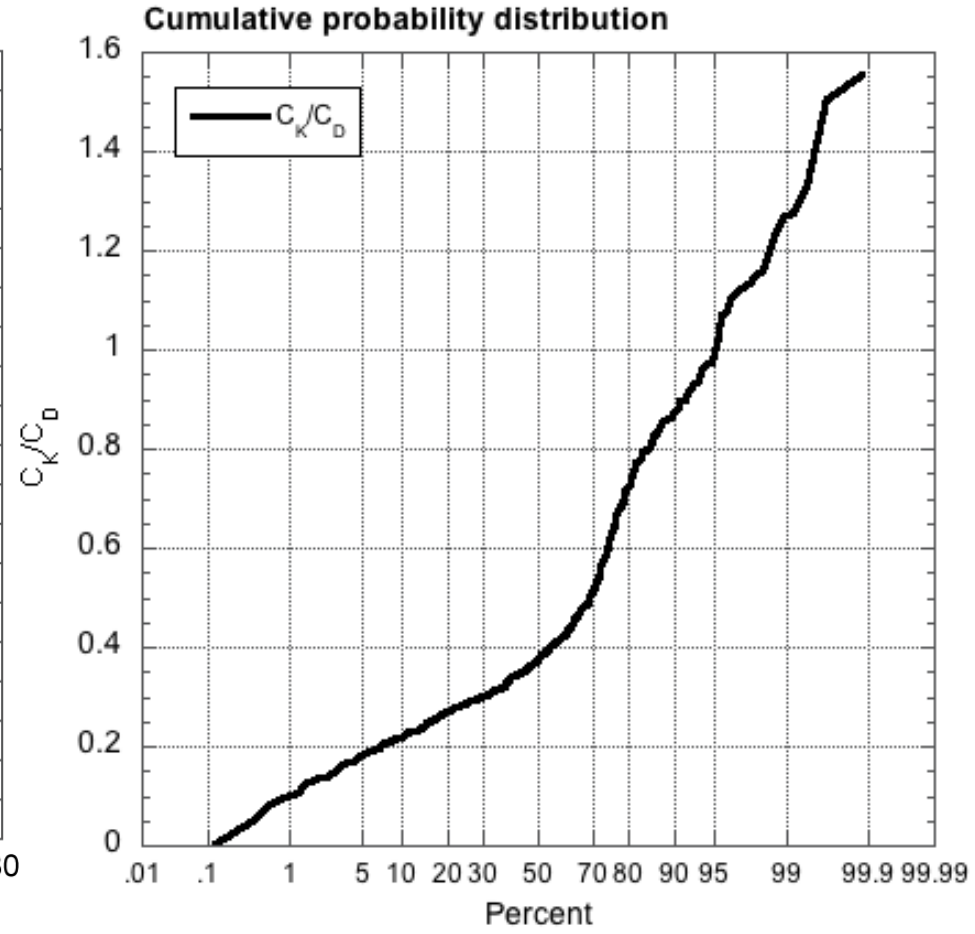


Courtesy Michael Bell
NPS

Courtesy Michael Bell
NPS

C_K / C_D





M. Montgomery

Thank you
Joins us for our next science meeting
on April 14, 2011