Assimilation of TROPICS data to improve prediction and understanding of tropical cyclones with data assimilation: Potential applications and data quality requirements

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Outline -- About this talk

- **Potential benefits of TROPICS data on tropical cyclone research and applications**

  - Temperature and moisture profiles
  - Precipitation
  - Satellite radiances

- **Outstanding issues in data assimilation**

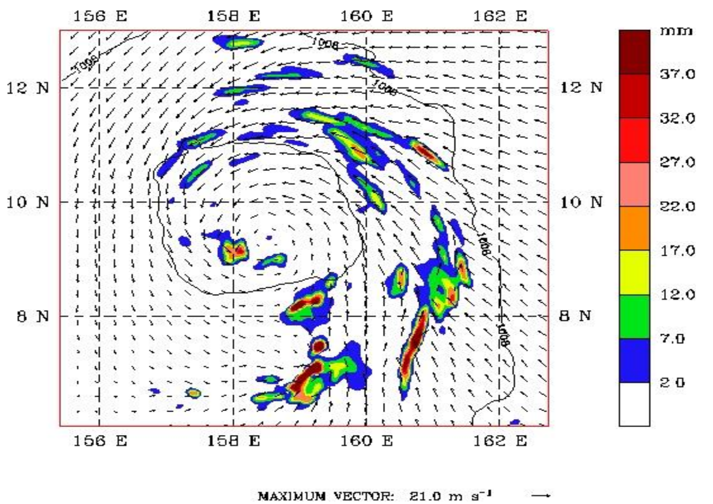
  - Data quality
  - Bias correction
  - Spatial and temporal distribution: Thinning vs. Super-obs
  - Data assimilation strategies

- **Some practical recommendations**

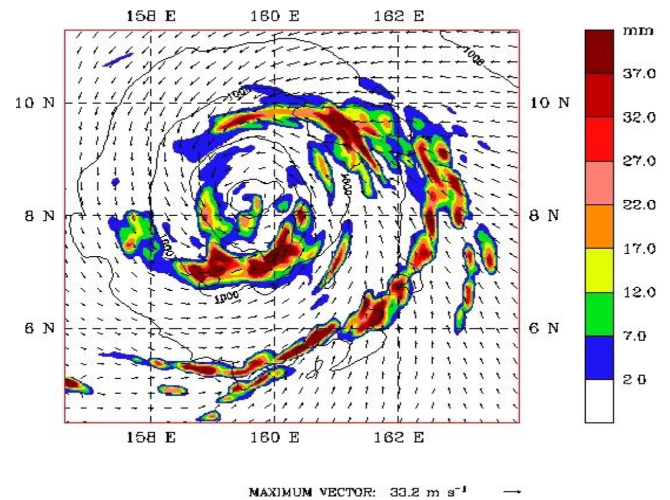
Impact of assimilation of TRMM rainfall rate on Numerical Forecast of Super Typhoon Paka

33 h forecasts vs. observations   0900 UTC 13 December 1997

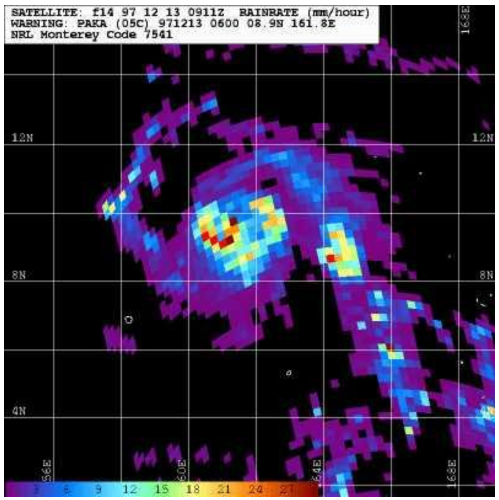
Without TRMM



With TRMM



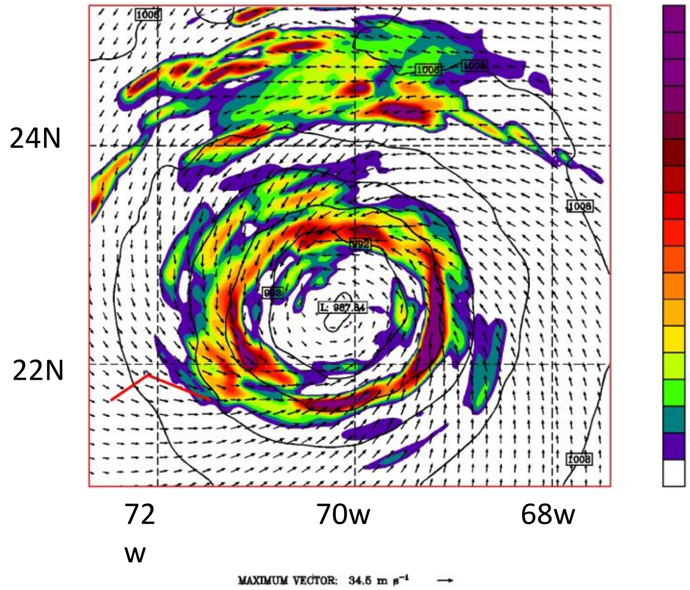
SSM/I derived rainfall rates at 0911 UTC 13 December 1997



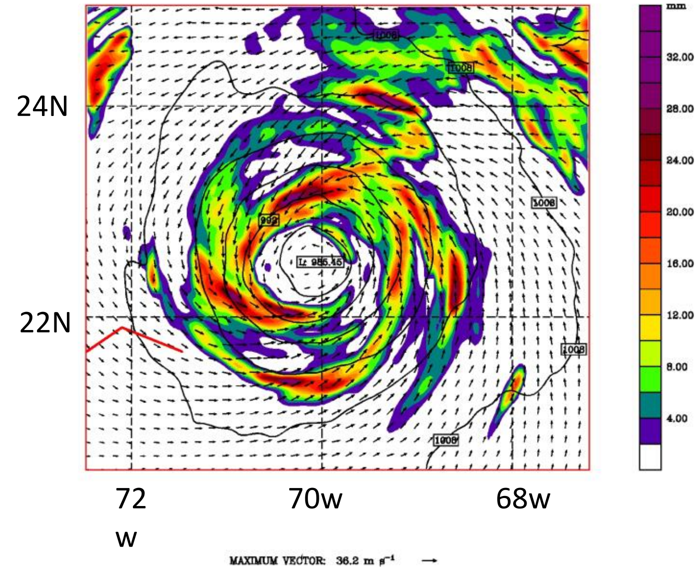
Pu et al. 2002 MWR

Assimilation of TMI rainfall rates with 4DVAR

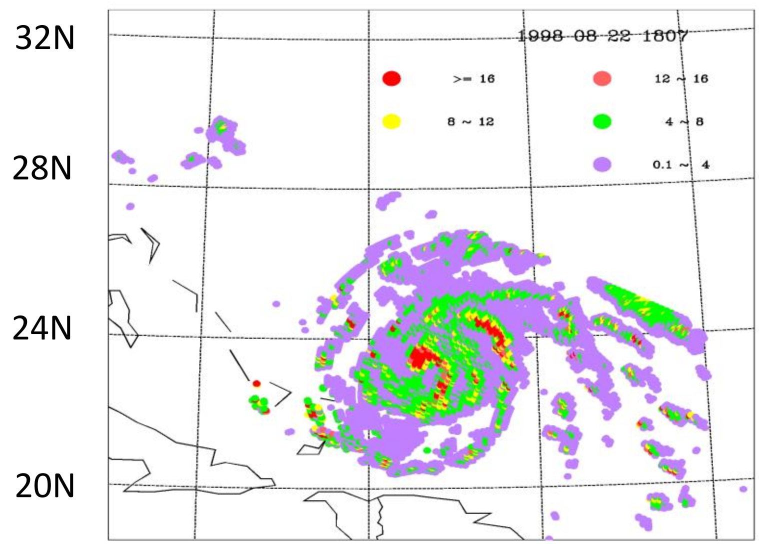
Without TMI rainfall ass.



With TMI rainfall ass.



TMI observed



Hurricane Bonnie (1998)

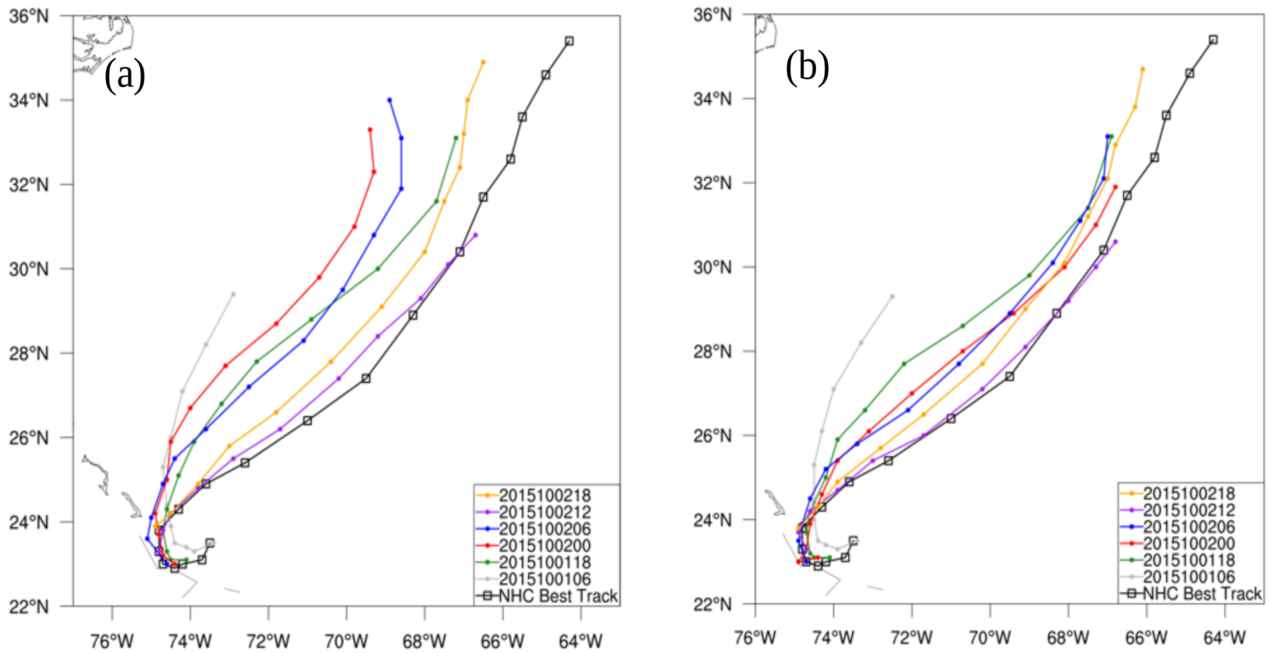
1800 UTC 22 Aug.

Pu and Tao 2004 JMSJ

Impact of GPM Microwave Imager (GMI) clear-sky radiances on hurricane forecasts

Without GMI

With GMI

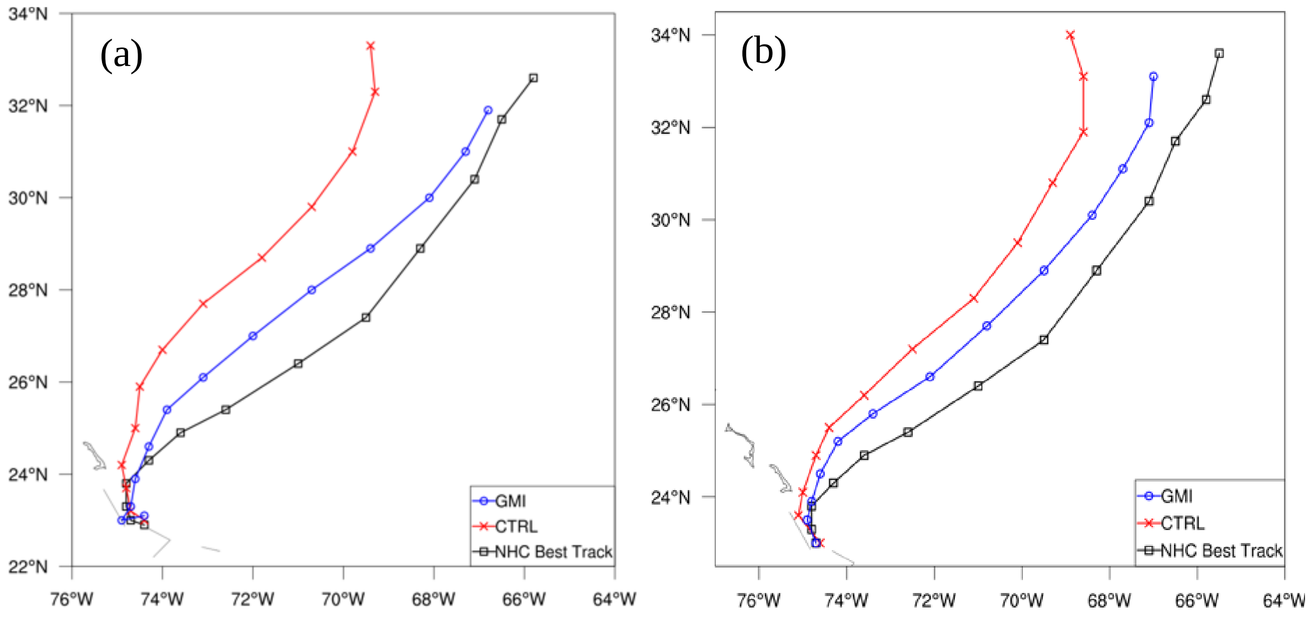


Hurricane Joaquin (2015)

Pu et al. 2019 MWR

Impact of GPM Microwave Imager (GMI) clear-sky radiances on hurricane forecasts

(a) 0000 UTC, and (b) 0600 UTC 2 October.



Hurricane Joaquin (2015)

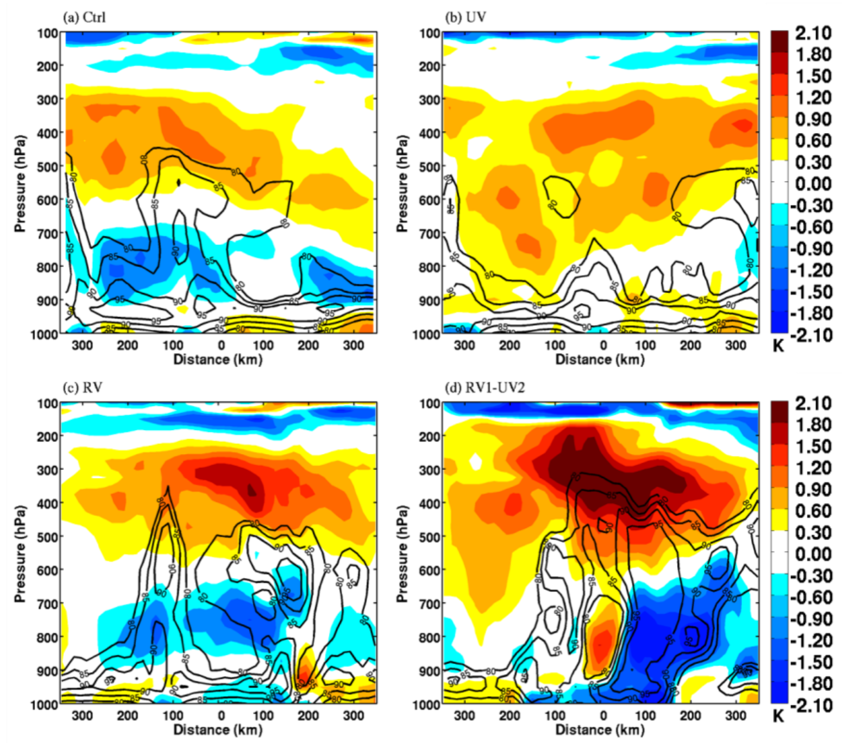
Temperature and moisture profiles

Studying the formation of Typhoon Nuri (2008)

- Upper level warming

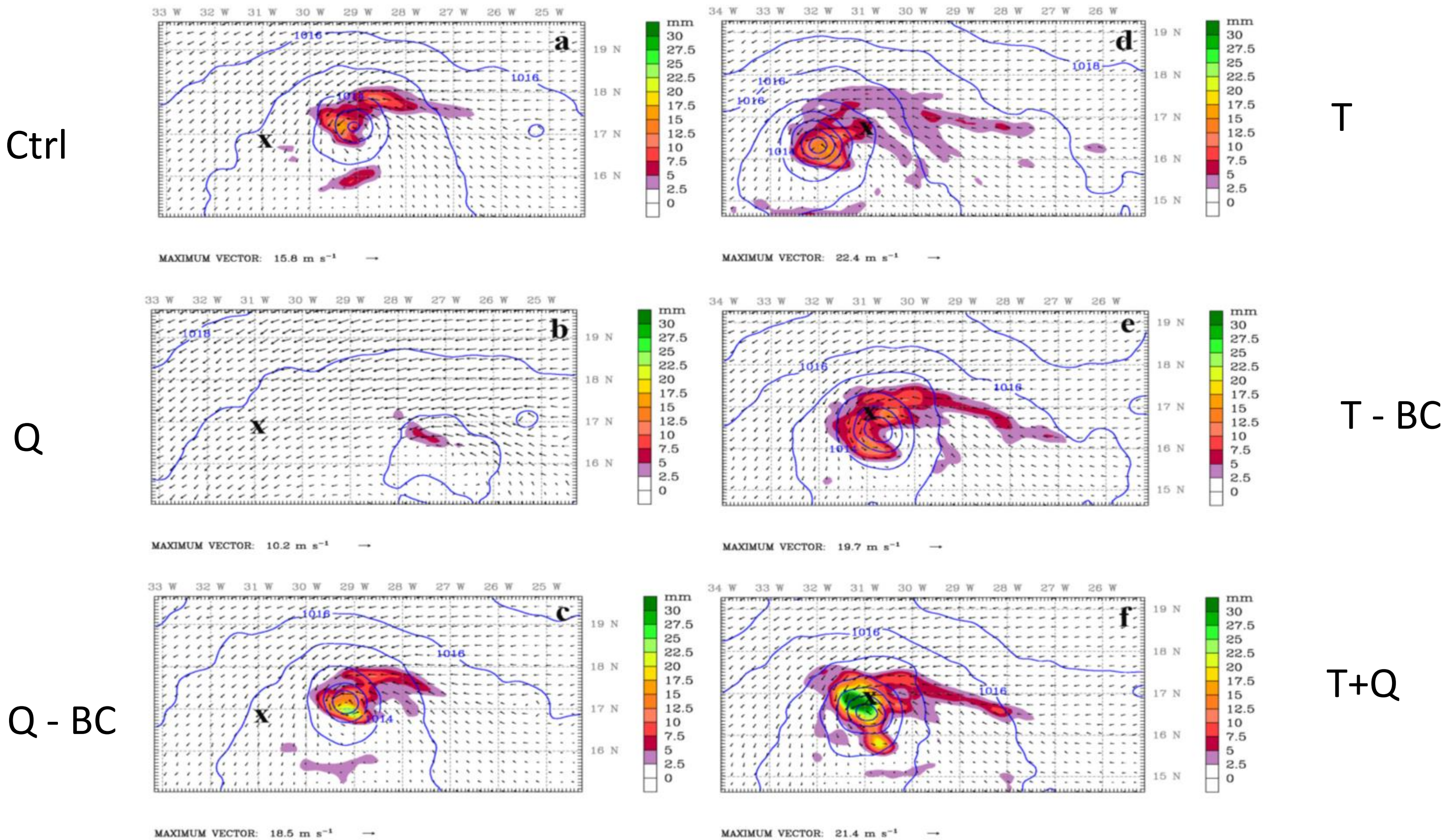
➢ Assimilation of airborne Doppler radar and satellite (e.g., AIRS temperature and moisture profiles) data enhances the representation of TC structure and environmental conditions , especially the upper-level atmospheric conditions in the numerical simulations of Typhoon Nuri, resulting in significant understanding of the role of upper-level warming in TC rapid intensification.

Enhanced upper level warming with data assimilation



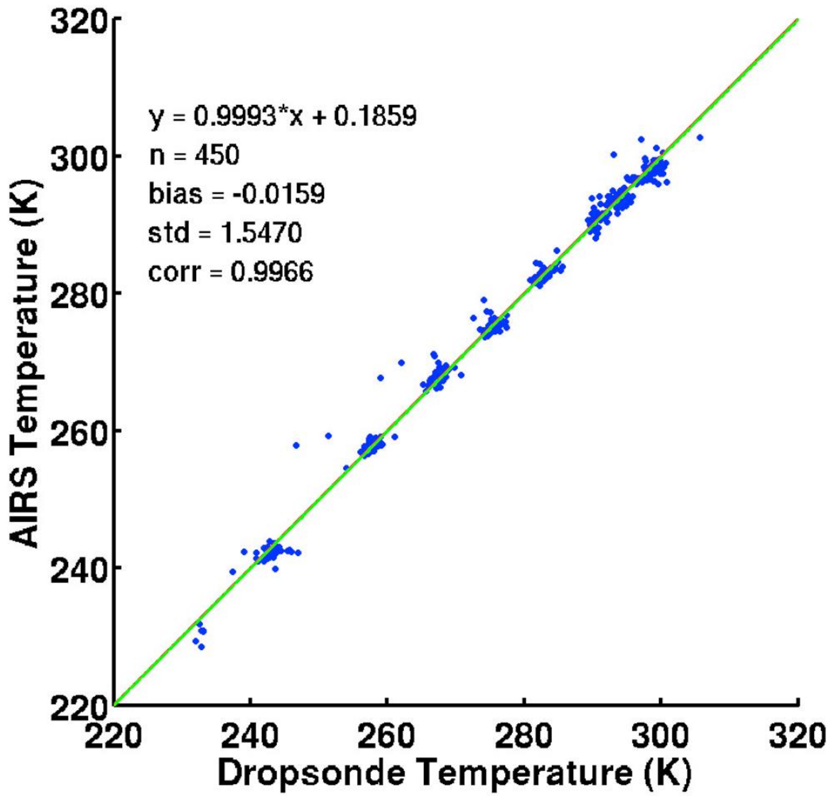
E-W cross section of the temperature anomaly (shaded) and the relative humidity (black contours) through the Nuri's center 1800 UTC 16 Aug 2008

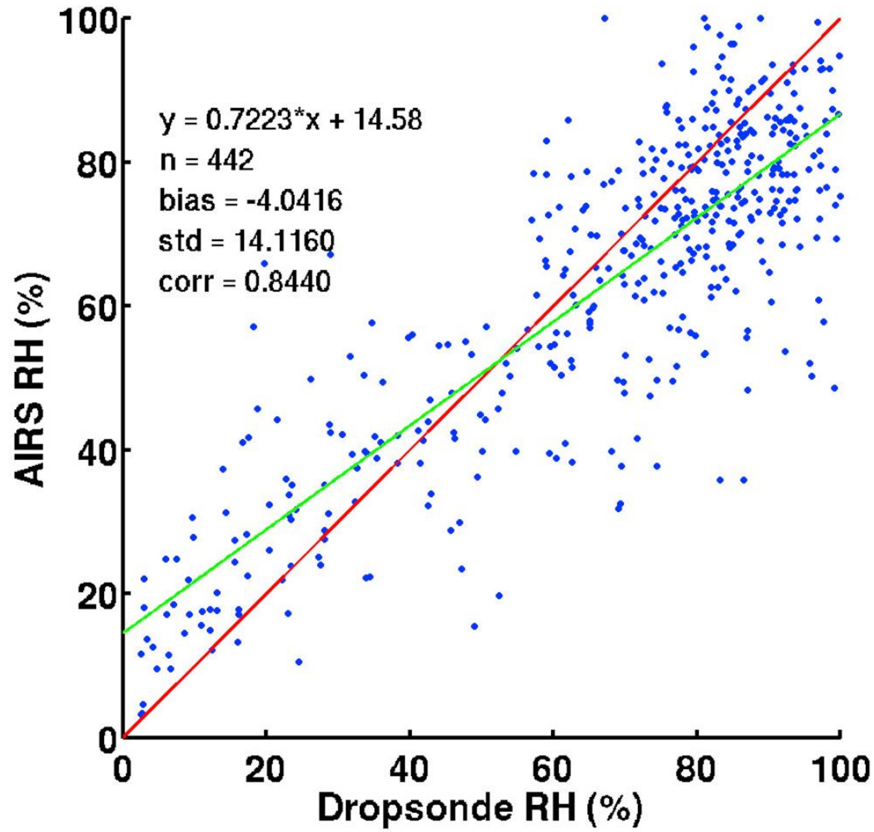
Impacts of data quality control and bias correction -- assimilation of retrieved data products - (with early AIRS T and Q profiles)



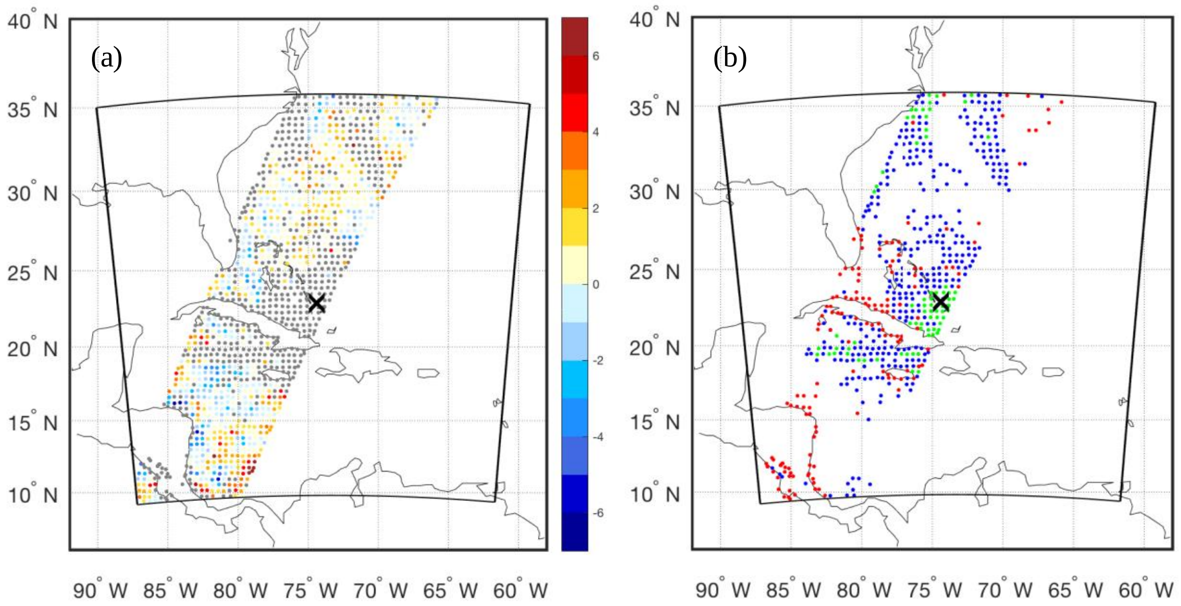
Tropical Storm Debby (2006)

Pu and Zhang 2010 JGR

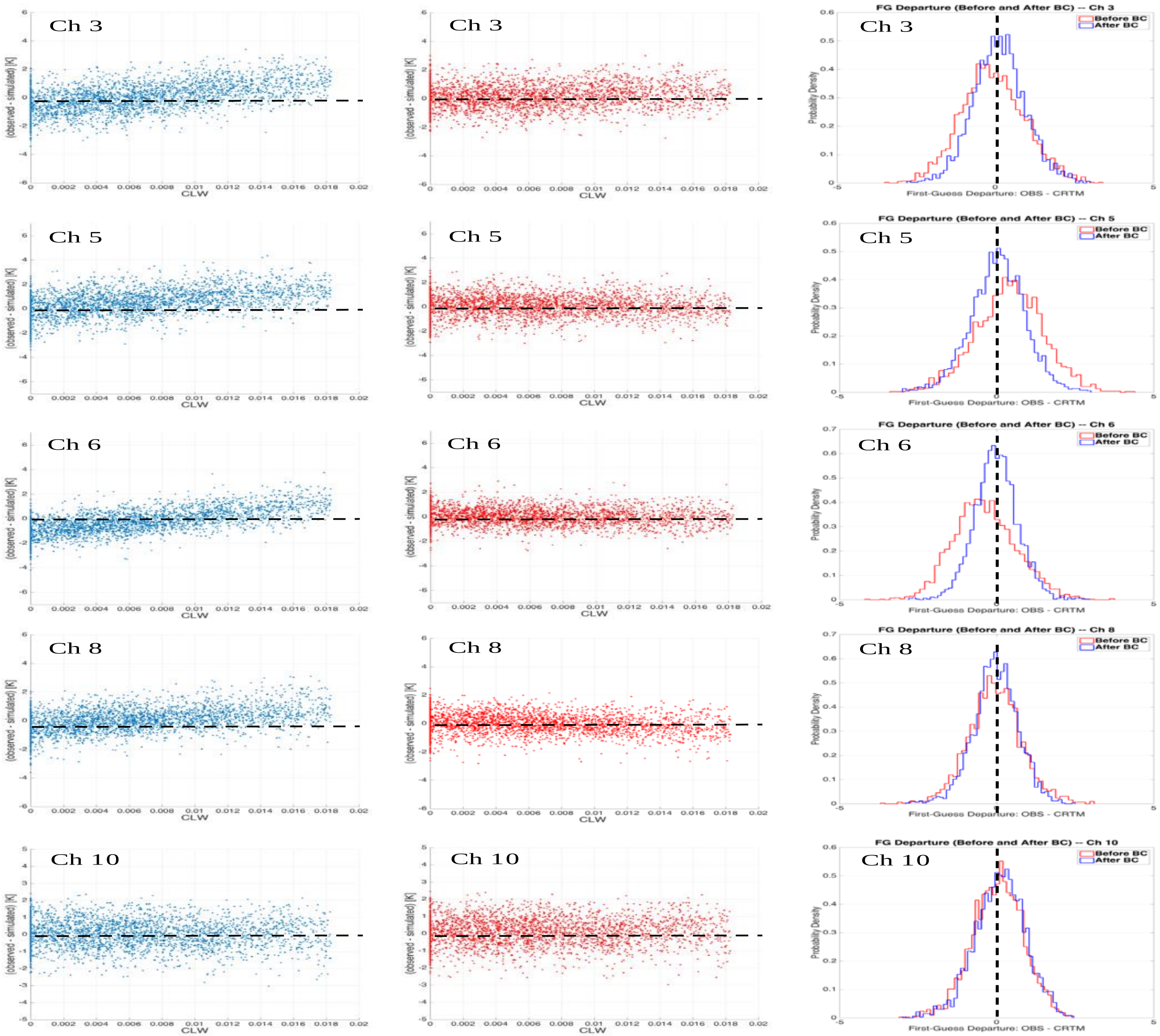

y = 0.9993*x + 0.1859
n = 450
bias = -0.0159
std = 1.5470
corr = 0.9966
AIRS Temperature (K)
Dropsonde Temperature (K)
220
240
260
280
300
320


y = 0.7223*x + 14.58
n = 442
bias = -4.0416
std = 14.1160
corr = 0.8440
AIRS RH (%)
Dropsonde RH (%)
0
20
40
60
80
100

Quality Control and Bias Correction. -- Satellite radiances. (GMI)



Quality Control and Bias Correction. -- Satellite radiances (GMI)



Direct Assimilation of Radiances vs. Assimilation of Retrievals

- Operational centers mostly assimilate satellite radiances, although a few satellite derived products (AMVs) are assimilated at the same time.

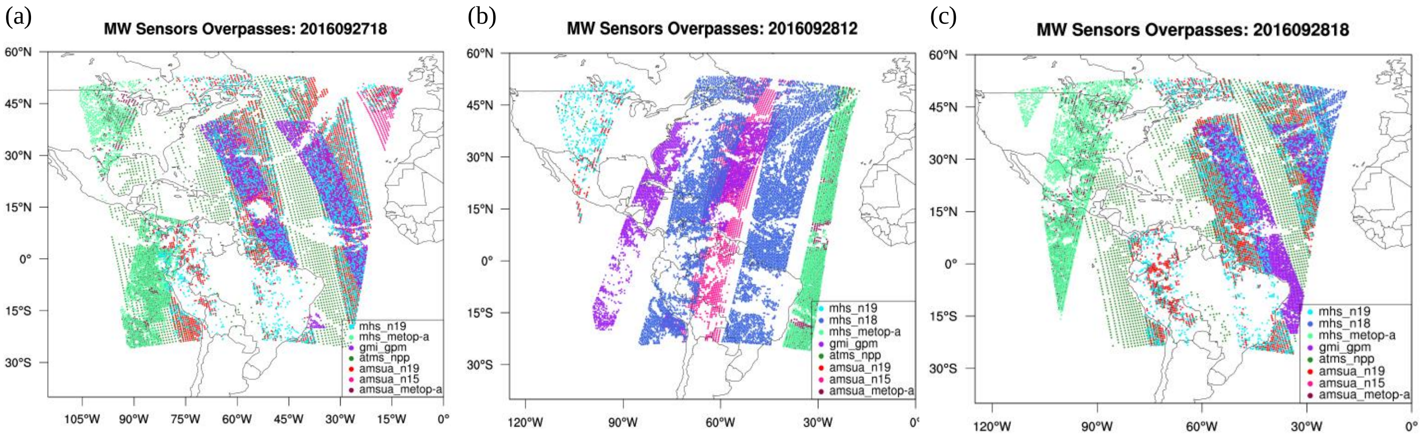
- Research community assimilates both satellite radiances and retrievals for applications

- Retrieved products provide direct quantities for needed variables to understand hurricane intensity and structure changes

- Provide direct quantities for data assimilation – perhaps with more information contents regarding the targeted research objectives

- Avoid to dealing with the cloud and precipitation contamination, although the quality of the retrieved products need to be treated properly

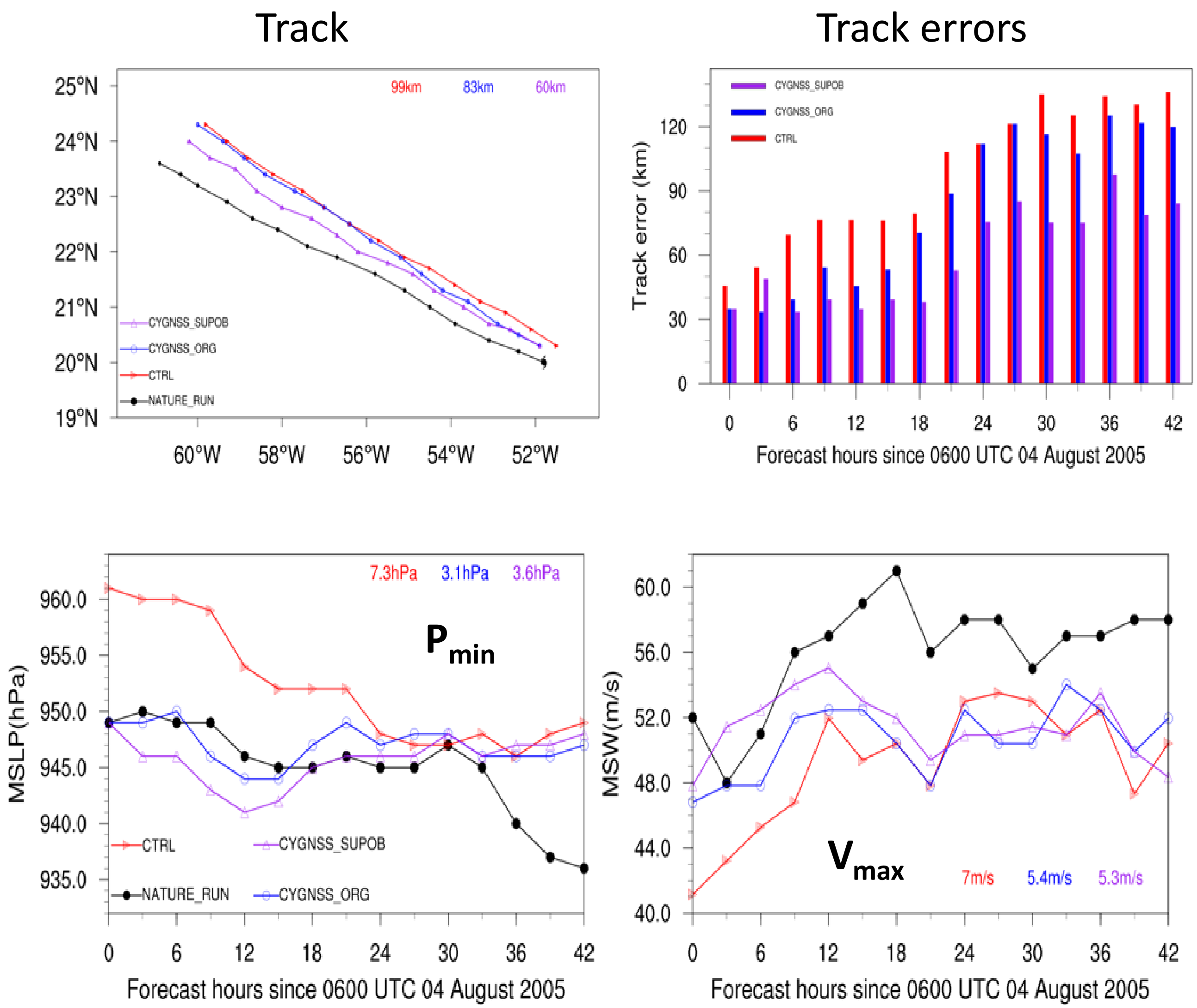
Data thinning vs. superobs.



Satellite overpass for all microwave sensors within analysis cycles at (a) 18 UTC 27 September, (b) 12 UTC 28 September and (c) 18 UTC 28 September, 2017.

- Resolution, spatial and temporal distribution of existing and planned data should be considered

Forecast impact of CYGNSS data: thinning vs. superobs



Zhang et al. 2017 JTECH

Some practical considerations/recommendations

- Radiances data will be the primary source for operational data assimilation. An efficient forward model should be available to facilitate the effort.
- Retrieved data products (temperature/moisture profiles, precipitation, etc.) provide the useful source for studying hurricane structure and intensity changes, as well as model validation and data assimilation. Therefore, data quality flags, error ranges, and biases should be well specified during the Cal/Val.
- The representativeness is of particular importance for spatially coarse-resolution data; High temporal frequency add values for all applications.
- Proper data assimilation methods/strategies should be developed for best utilizing the data.