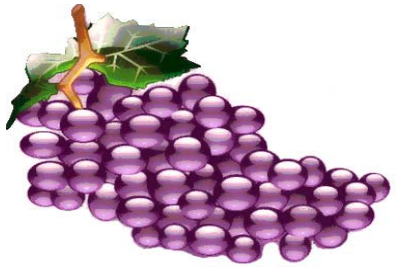


CMA

Use and Impact of GPS Radio Occultation Messurements at GRAPES

1）Liu Yan and 2）Jishan Xue

1）Numerical Weather Prediction Center,

2）Chinese Academy of Meteorological Sciences,

China Meteorology Administration

5th WMO Workshop on the Impact of Various Observing Systems on NWP
Sedona, Arizona, May 22-25, 2012

Outline

- GRAPES_GFS (Global Forecast System) overview
- Status of GPSRO assimilation at GRAPES
- Future work
- Summary

Global GRAPES Analysis and Forecast System

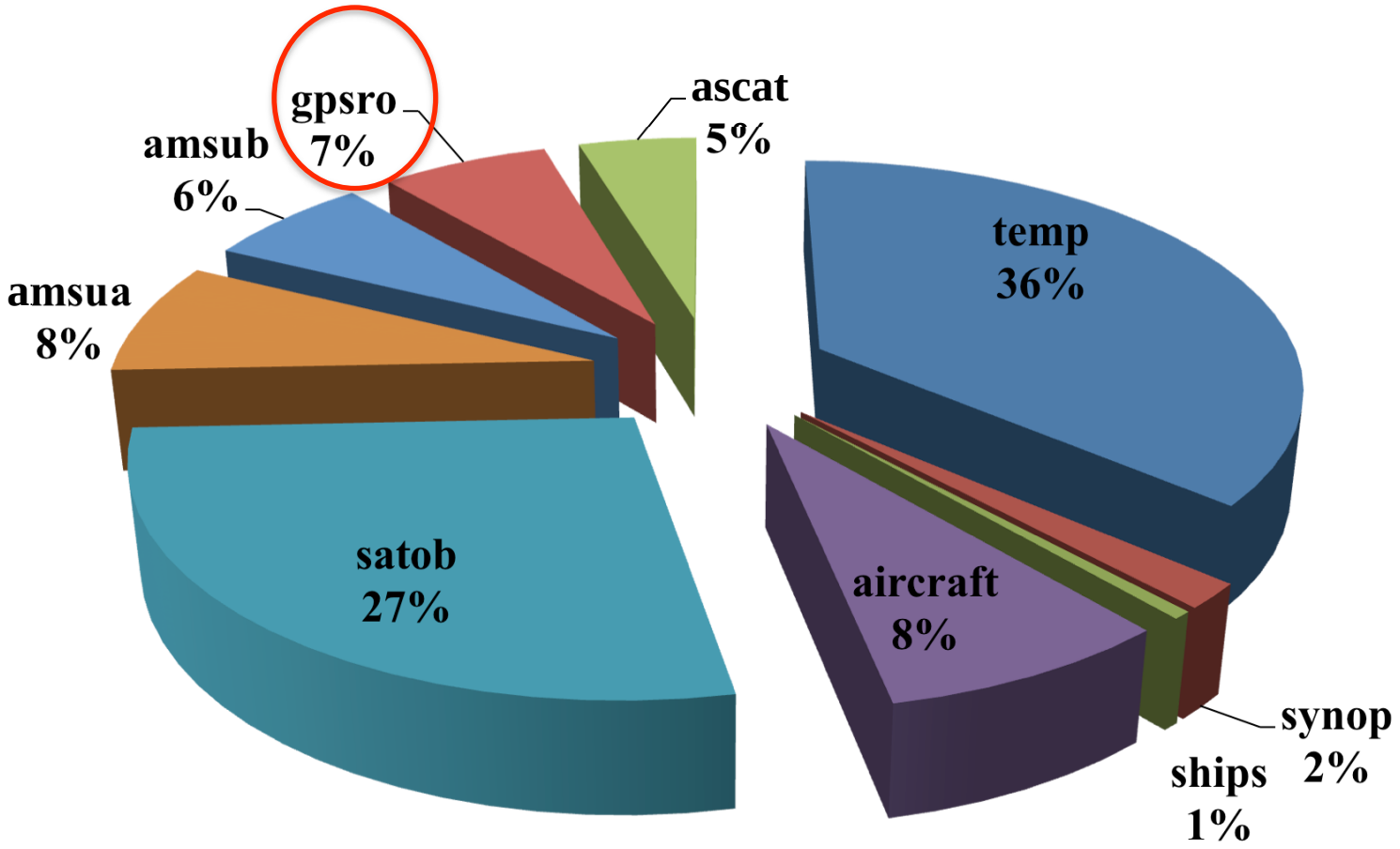
GRAPES forecast model

- Non-hydrostatic equations
- Terrain-following coordinate
- Arakawa-C(horizontal) and Charney-Phillips(vertical) grid
- Model top at 32.5km
- Resolution 0.5°x 0.5 °.

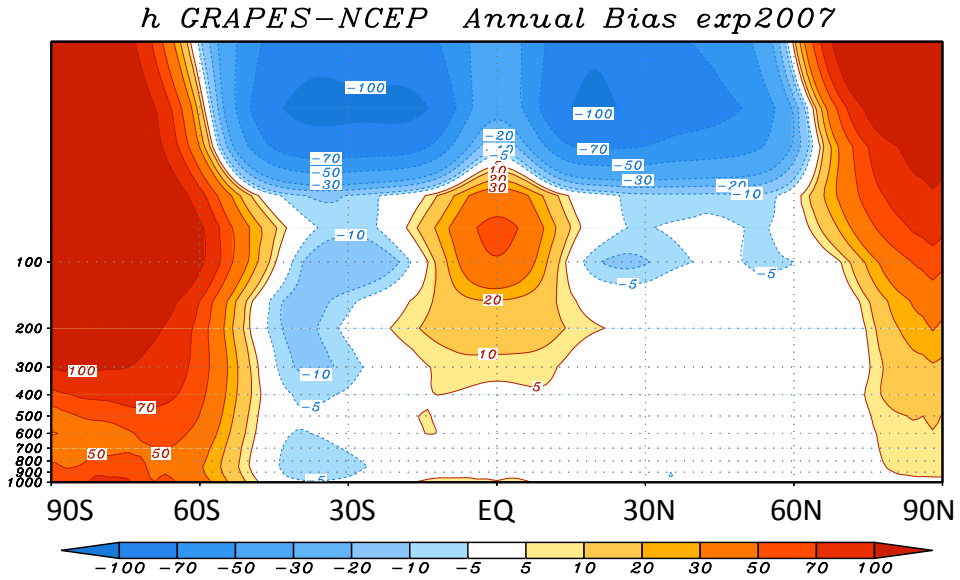
GRAPES-3DVar

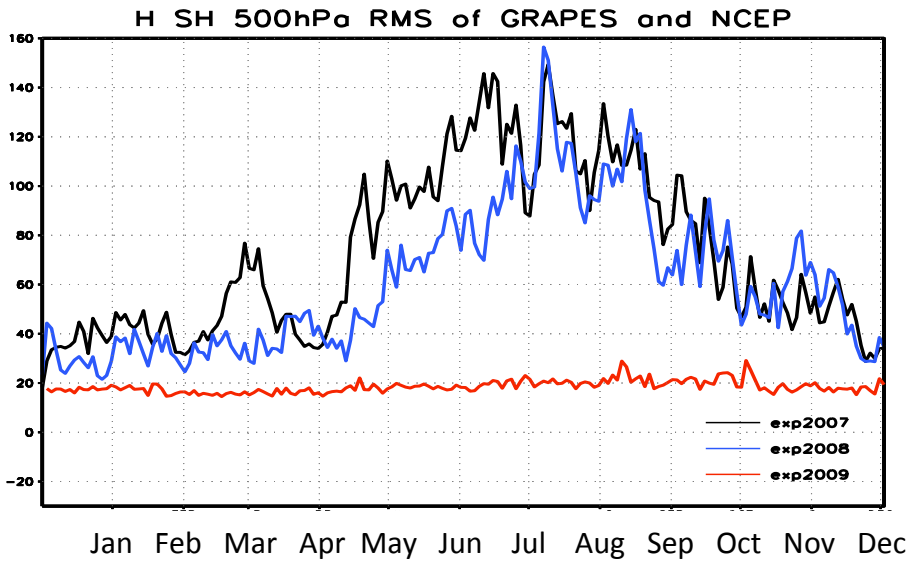
- Pressure (17 standard levels) or Terrain-following coordinate(consistent with forecast model)
- Resolution 1.125°x 1.125 °.
- Observations assimilated : conventional data (radiosondes, synops, ships, AMV and aircraft), GPSRO, MODIS wind, ASCAT wind, atovs (NOAA15,16,17,18,19,METOP and FY3)
- Incremental digital filter initialization

Percentage of Observations Assimilated at GRAPES-VAR



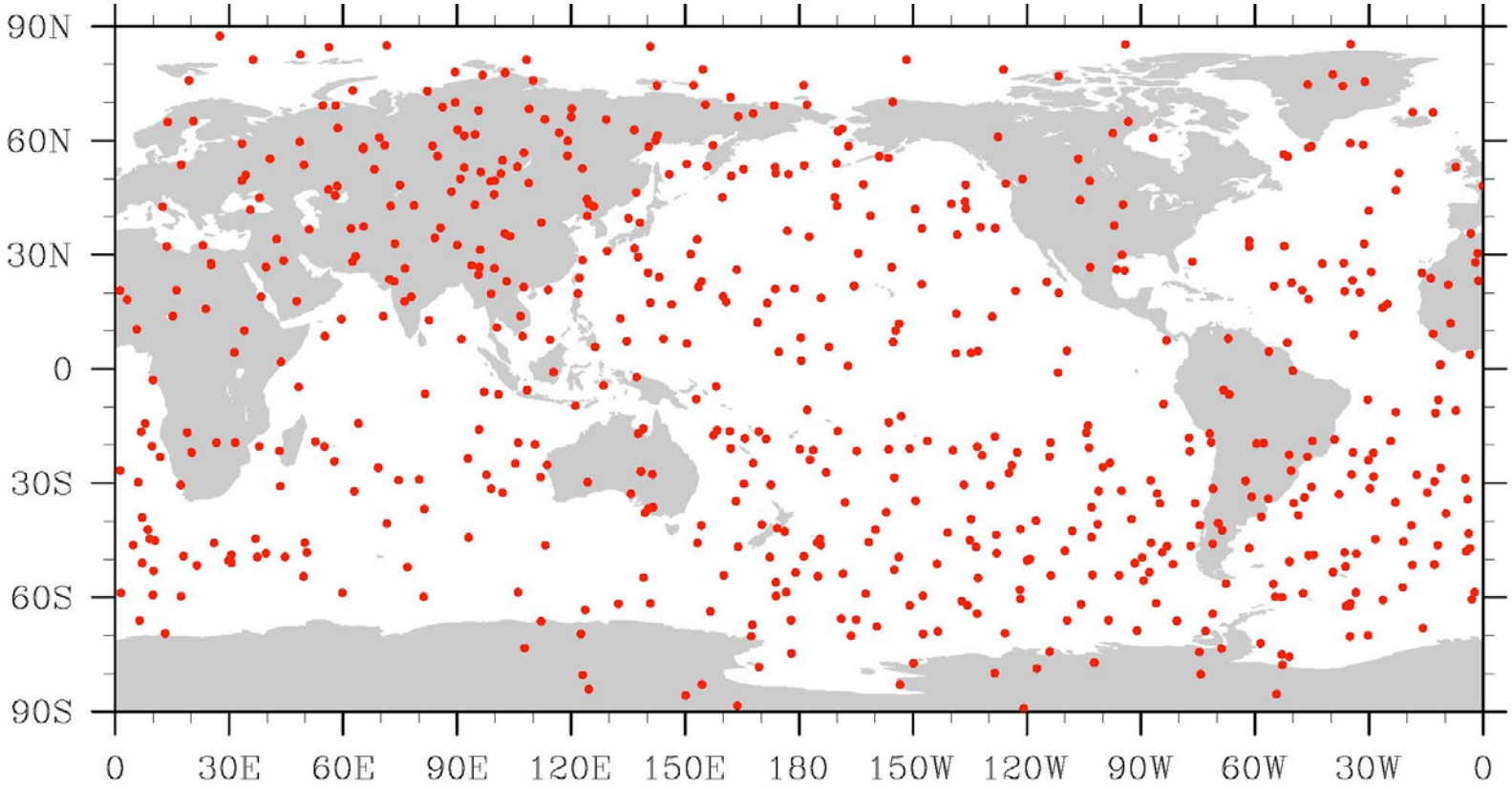
Major Problems in Early GRAPES_GFS
(1-year trail and geo. heights compared to NCEP analysis)





- **Big differences in the polar, equatorial and upper regions(left fig.)**
- **Bias grow up quickly in the southern hemisphere in winter(right fig.)**
- **Need to look for good observations to reduce these bias**

Characteristics of GPS RO Data



- **Global distribution**
- **Near real time**
- **No satellite-to-satellite bias**
- **High accuracy (equivalent to <1 K; average accuracy <0.1 K)**
- **All weather-minimally affected by aerosols, clouds or precipitation**
- **Complements IR and microwave sounders**

Data Received and Preprocessing

- ✓ **COSMIC via GTS or Internet**
- ✓ **GRAS via GTS or Internet**
- **GRACE-A from GFZ via GTS**

- **Use both rising and setting occultations**
- **Use data from surface to model top (10mb) in most regions, but down to 850mb in the polar regions**
- **QC (refer to Mete. France):**
  - $\frac{dN}{dz} < -50 km^{-1}$ **at all levels**
  - $abs(\frac{d^2N}{d^2z}) > 100 km^{-2}$ **at all levels**
- **Vertical thinning: 1 datum per analysis vertical layer**
- **Background check:** $\frac{o-b}{b} > 4 * \sigma_o$

Assimilation of GPS/RO data at GRAPES

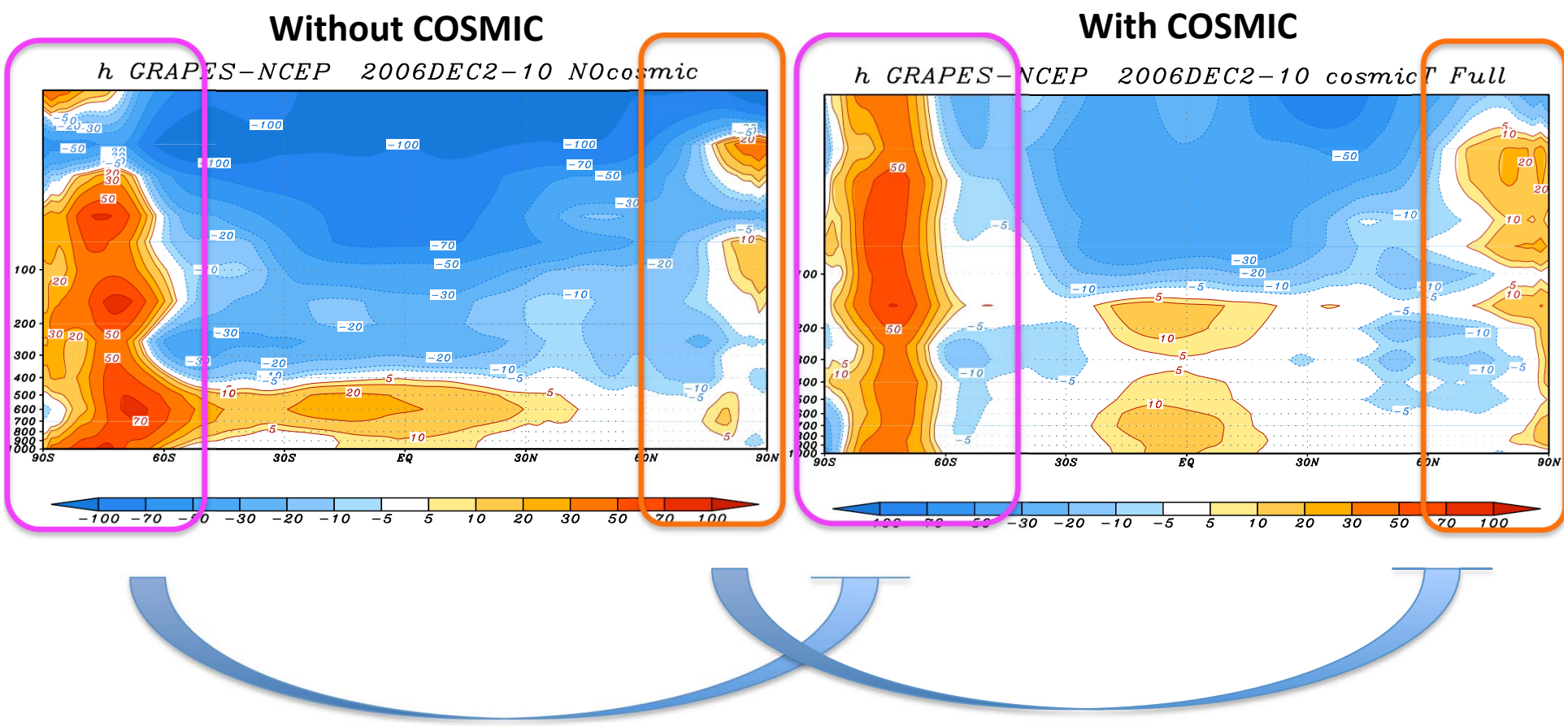
- **Assimilate retrieved profile of T and Q in 2008**
- **Assimilate retrieved refractivity since 2009**
  - **Obs. Error: vary with latitudes(low, high and mid) and height**
- **Assimilate bending angles (in developing)**

$$N = 77.6 * \frac{P}{T} + 3.73 * 10^5 * \frac{e}{T^2}$$

$$N = 77.6 * \frac{P}{T} + 3.73 * 10^5 * \frac{Pq}{T^2 * (0.622 + 0.378q)}$$

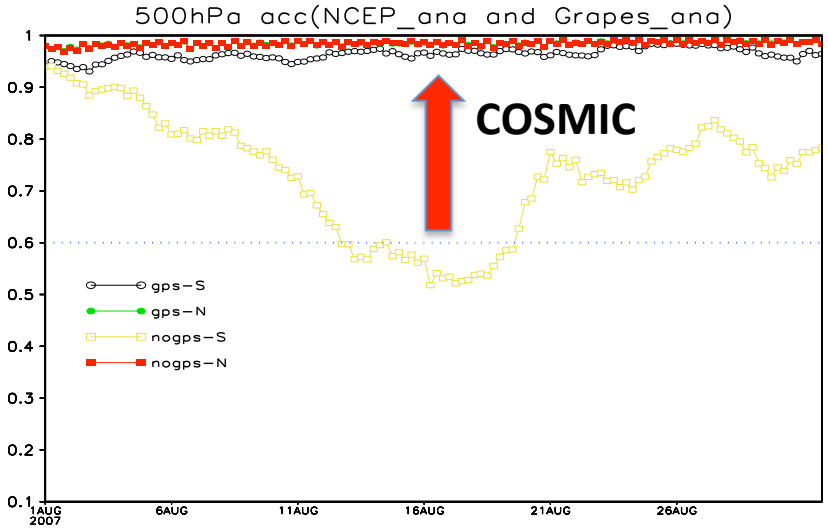
$$dN = \left(\frac{77.6}{T} + \frac{3.73 * 10^5 * q}{T^2 (0.622 + 0.378q)} \right) dP - \left(\frac{77.6P}{T^2} + \frac{2 * 3.73 * 10^5 * Pq}{(0.622 + 0.378q) T^3} \right) dT + \frac{3.73 * 10^5 * 0.622 * P}{(0.622 + 0.378q)^2 T^2} dq$$

Impact of assimilate COSMIC retrieved T and q on GRAPES analysis

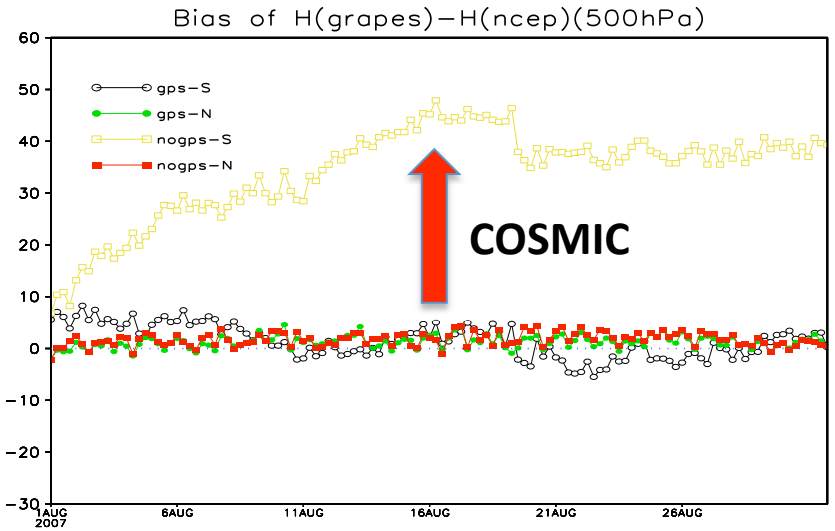


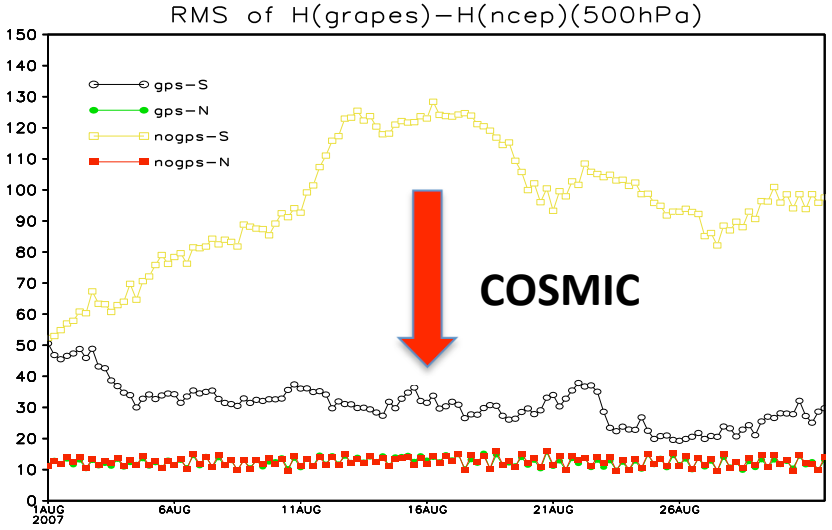
Analysis are improved in most regions expect for the polars.

Impact of assimilate COSMIC refractivity on GRAPES analysis

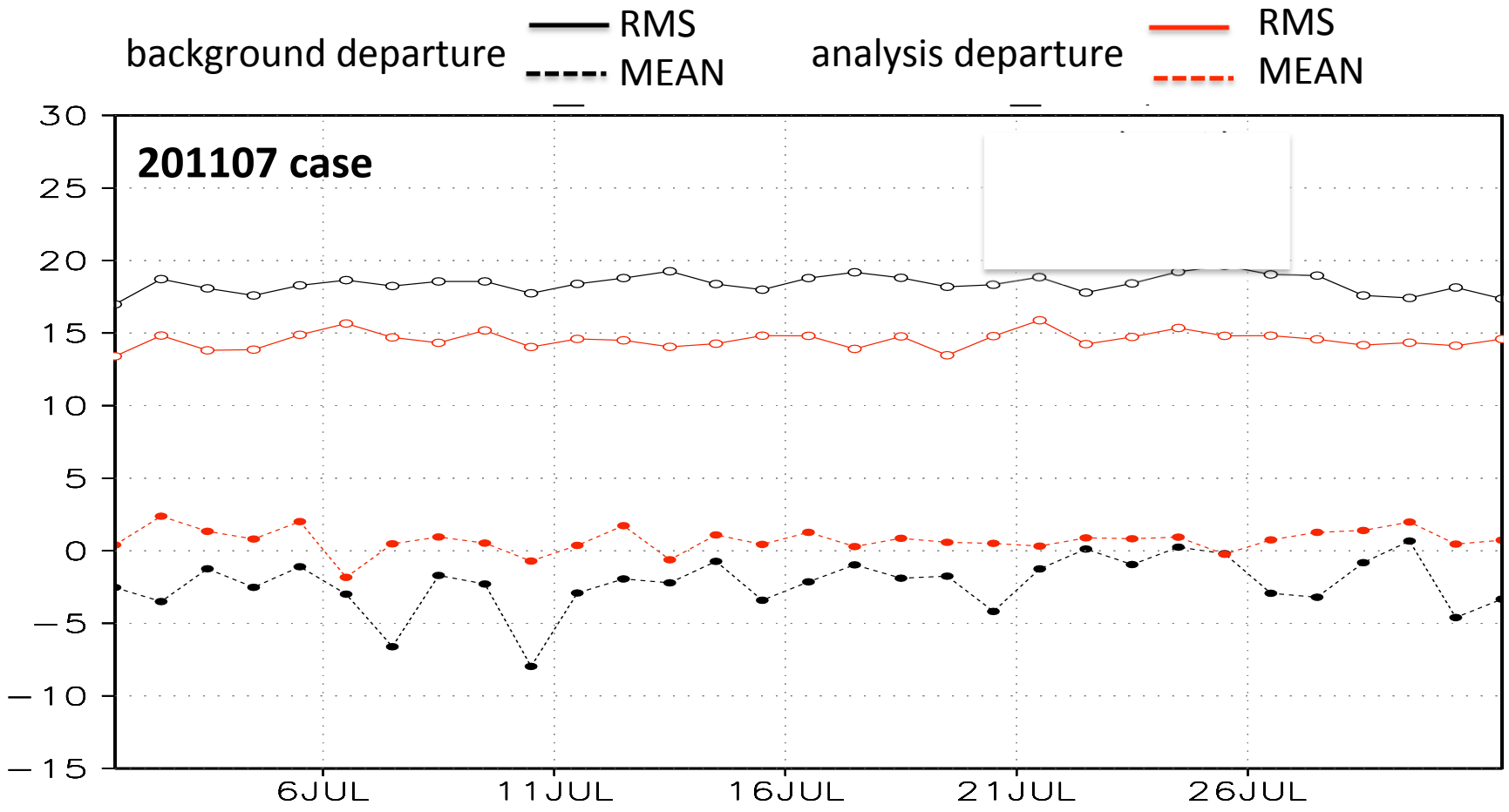


200708 case
(one month running)



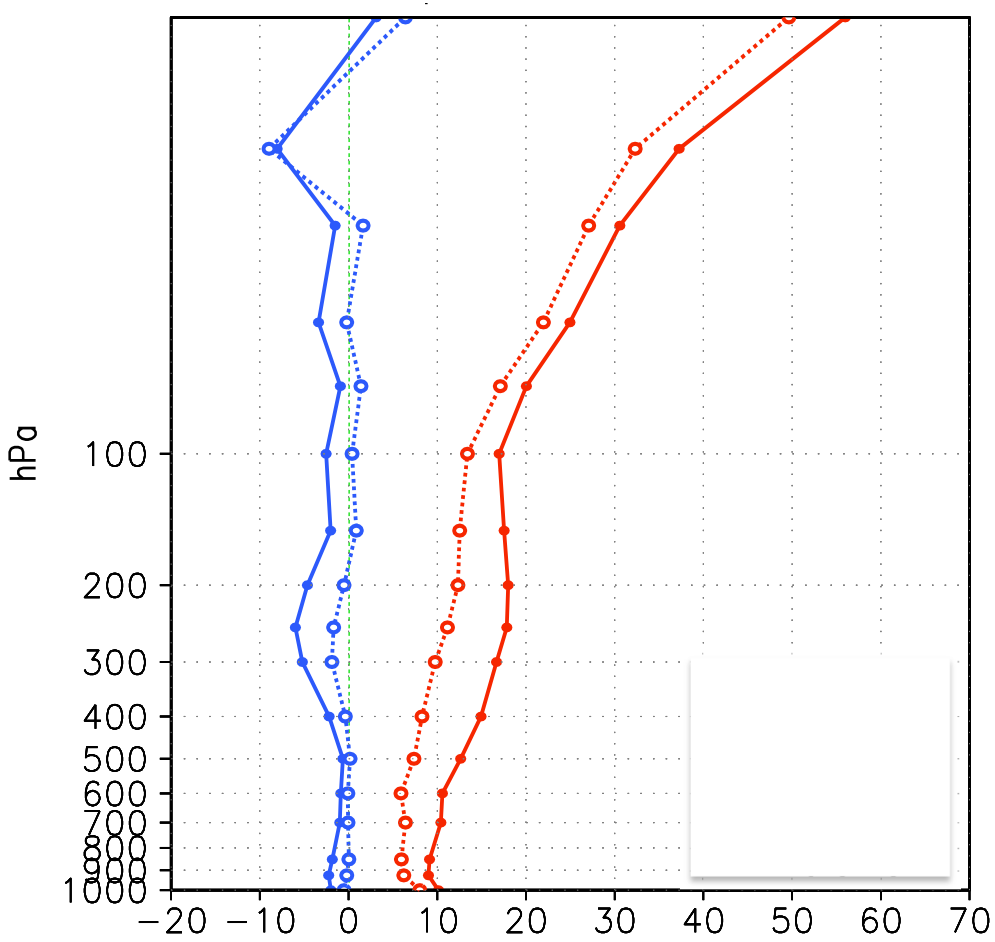


Short-range Forecast Fit to Radiosonde Geo*geopotential Heights* Measurements (100mb, Global)



Improvement in the bias **after assimilating refractivity.**

Short-range Forecast Fit to Radiosonde Geo*geopotential Heights* Measurements (Global)



background departure

RMS

MEAN

analysis departure

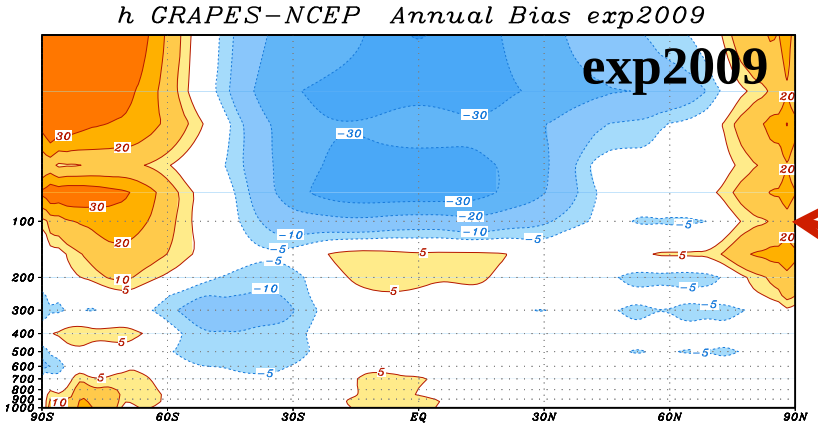
RMS

MEAN

201107 case
(one month running)

Improvement in the bias after assimilating refractivity.

COSMIC Impact on GRAPES Analysis

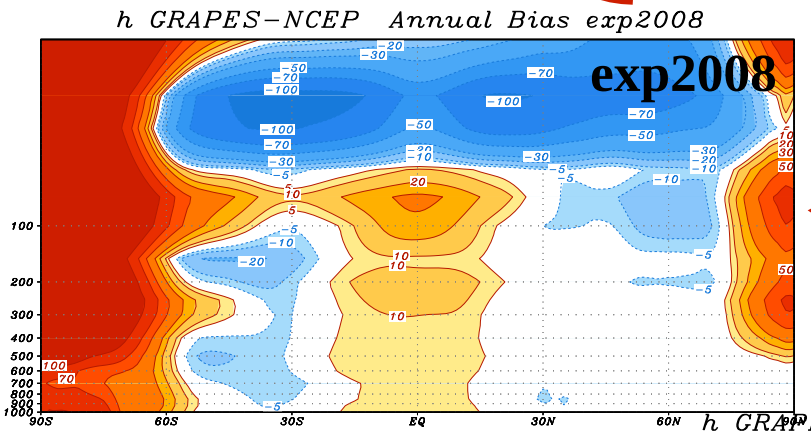


SOAR horizontal correlation

Observation QC（blacklist）

Cosmic refractivity data - determine where the improvement in analysis and forecast skill as the number of GPSRO available

Model …



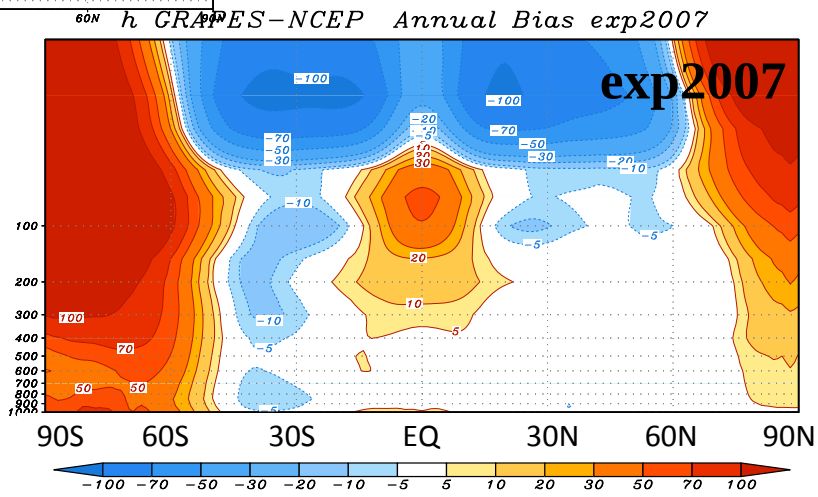
1-year trail

Model BC

Satellite BC

NMC statistical

Model …

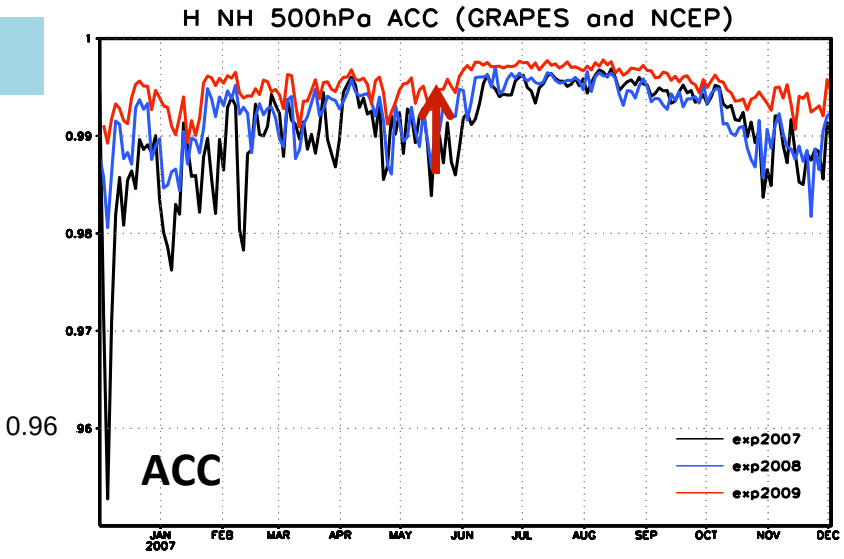


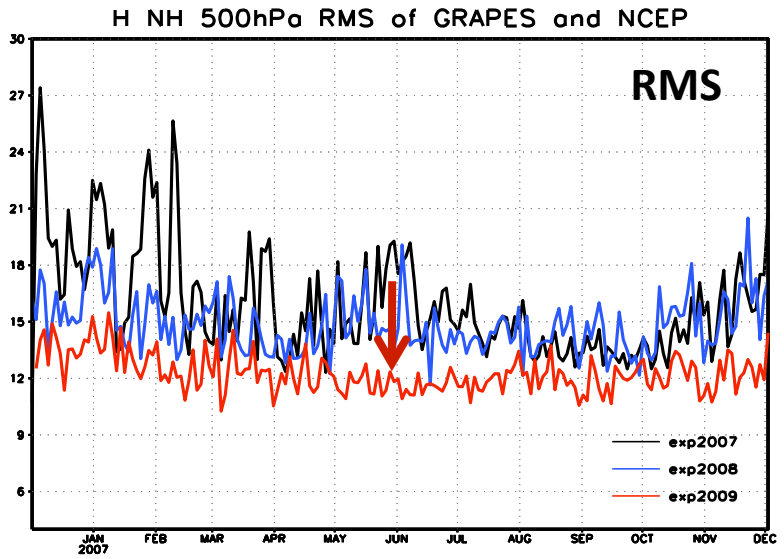
Annual average geopotential heights difference between GRAPES and NCEP analysis

COSMIC Impact on GRAPES Analysis

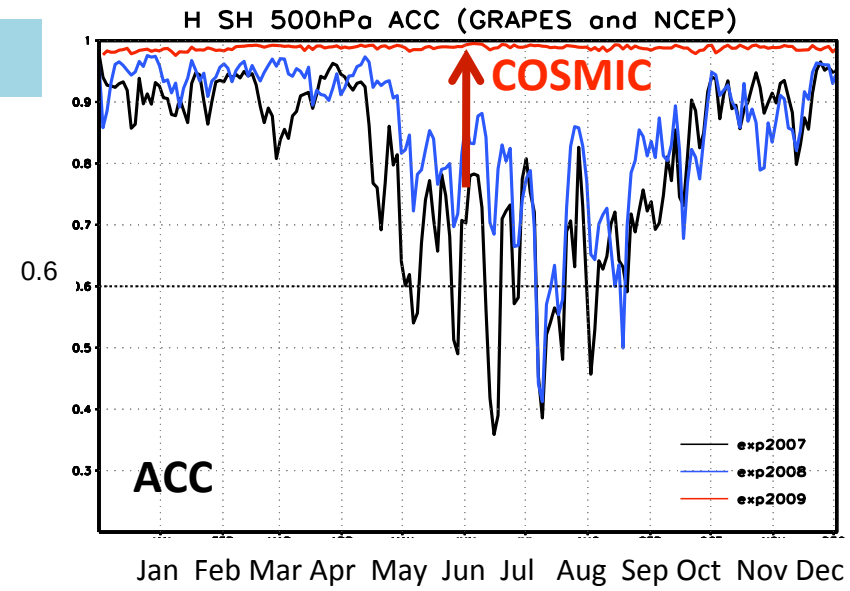
(500mb geopotential Height analysis, exp2009)

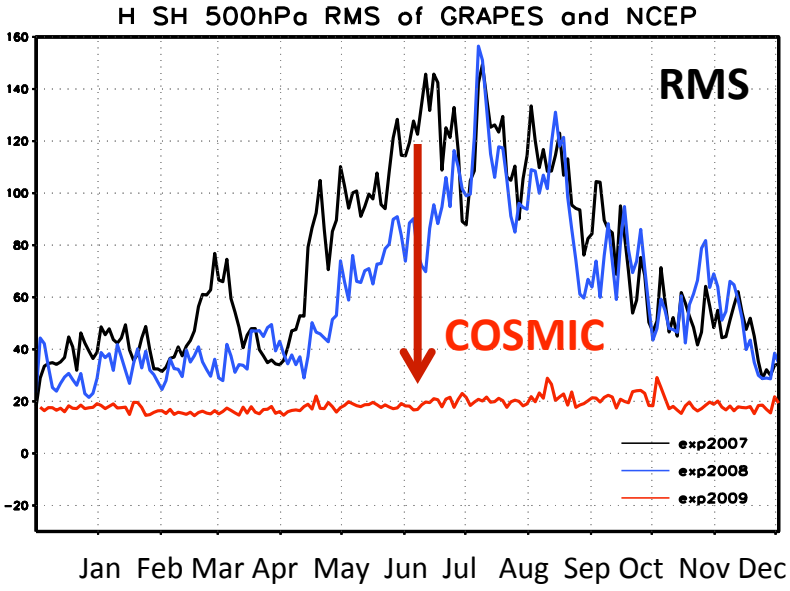
N.H.



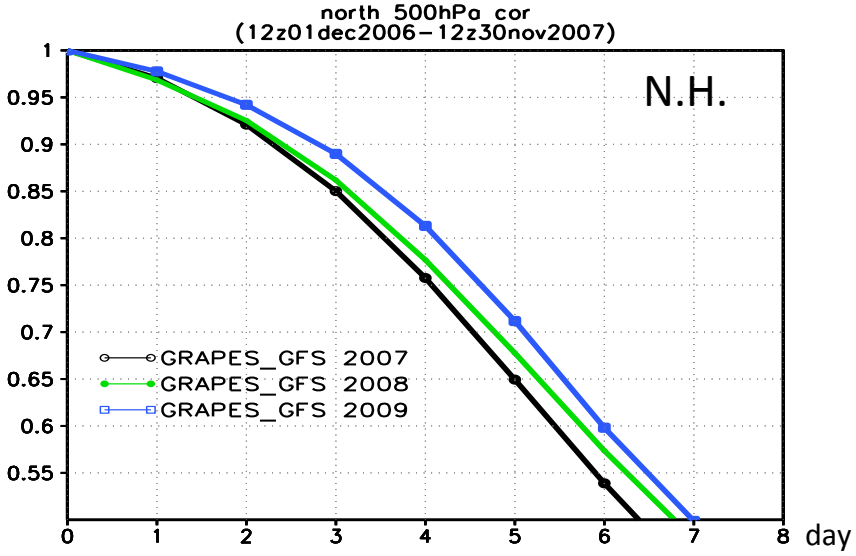


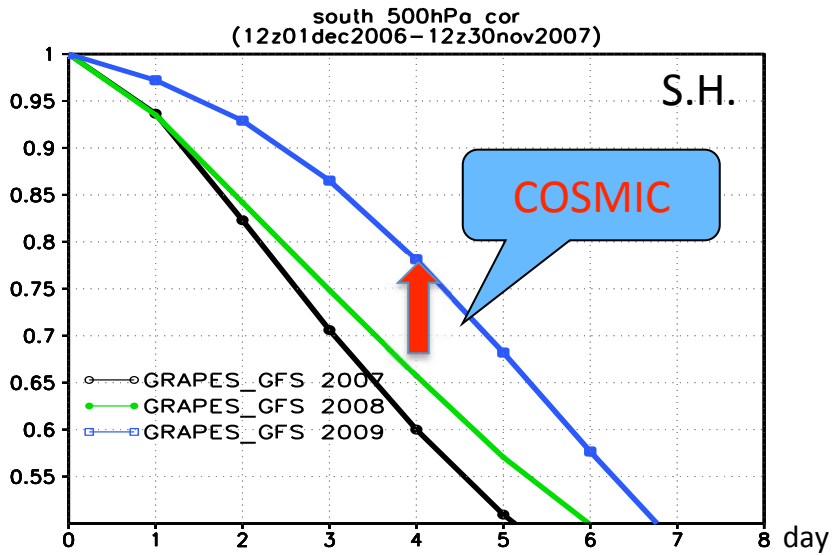
S.H.



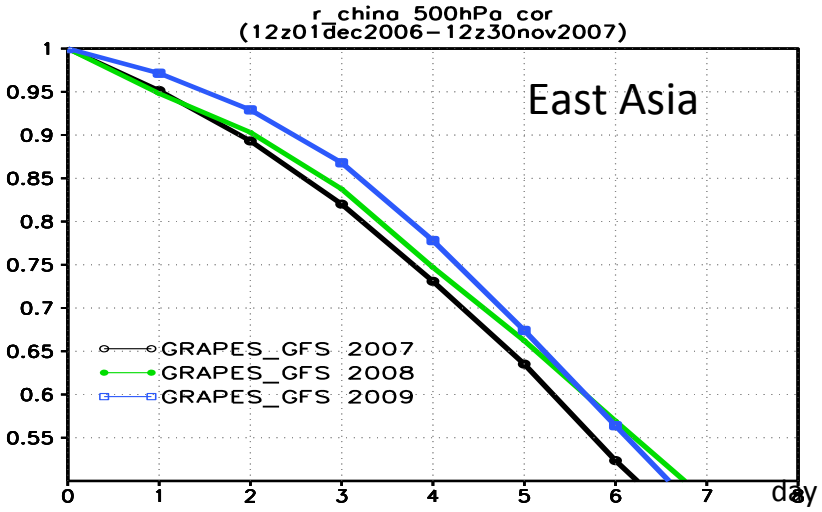


COSMIC Impact on GRAPES Forecast Accuracy





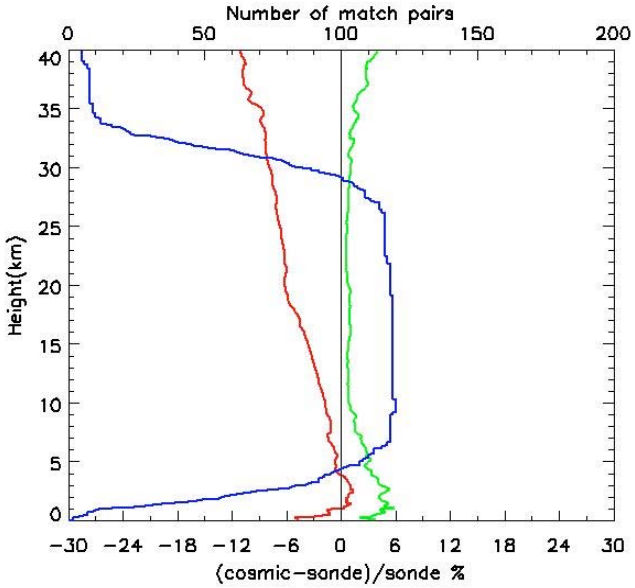
ACC scores (the higher the better) for forecast days 1-8.

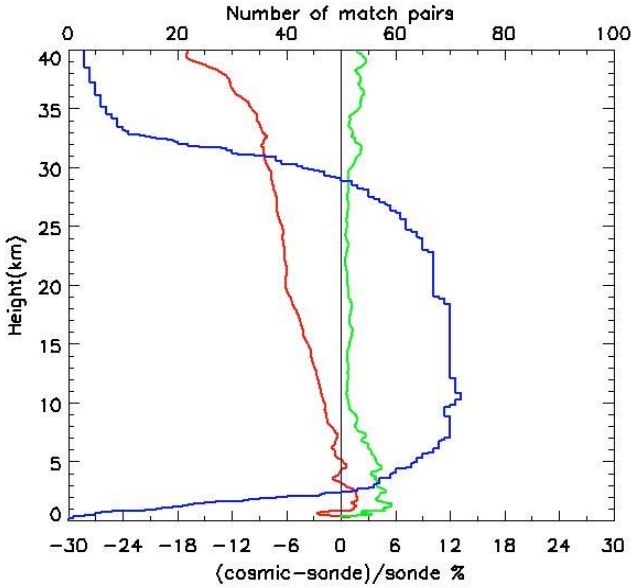


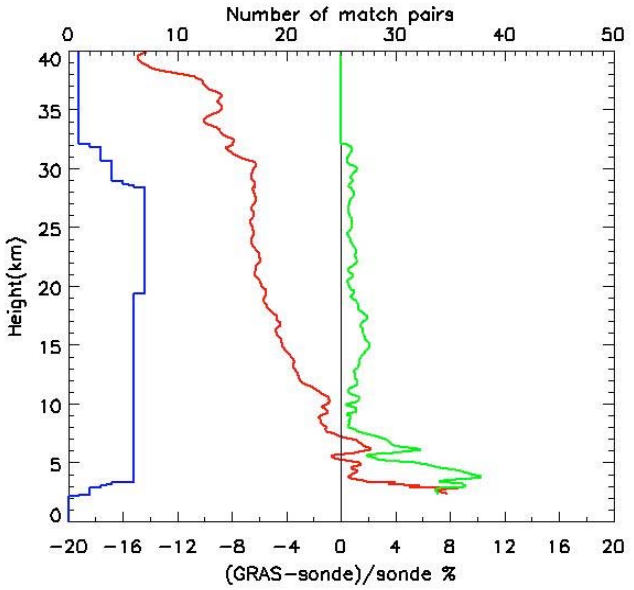
Monitoring GPS RO against Radiosondes

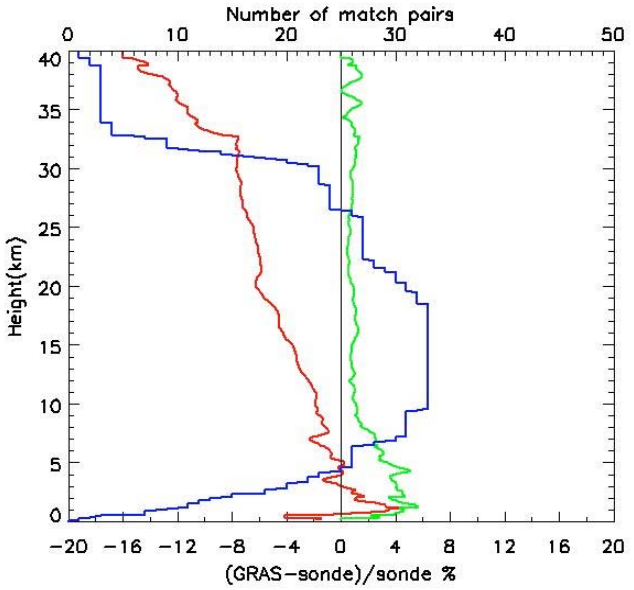
- **GPS RO refractivity against co-located radiosonde-derived refractivity (within 300 km and ±3 hours).**
- **Radiosonde temperature and dew-point as a function of pressure, then converted to refractivity as a function of geopotential height using hypsometric equation.**
- **Plot (RO - sonde)/sonde % for low, middle and high latitudes.**
- **Split by night and day**.

Monitoring GPS RO against Radiosondes









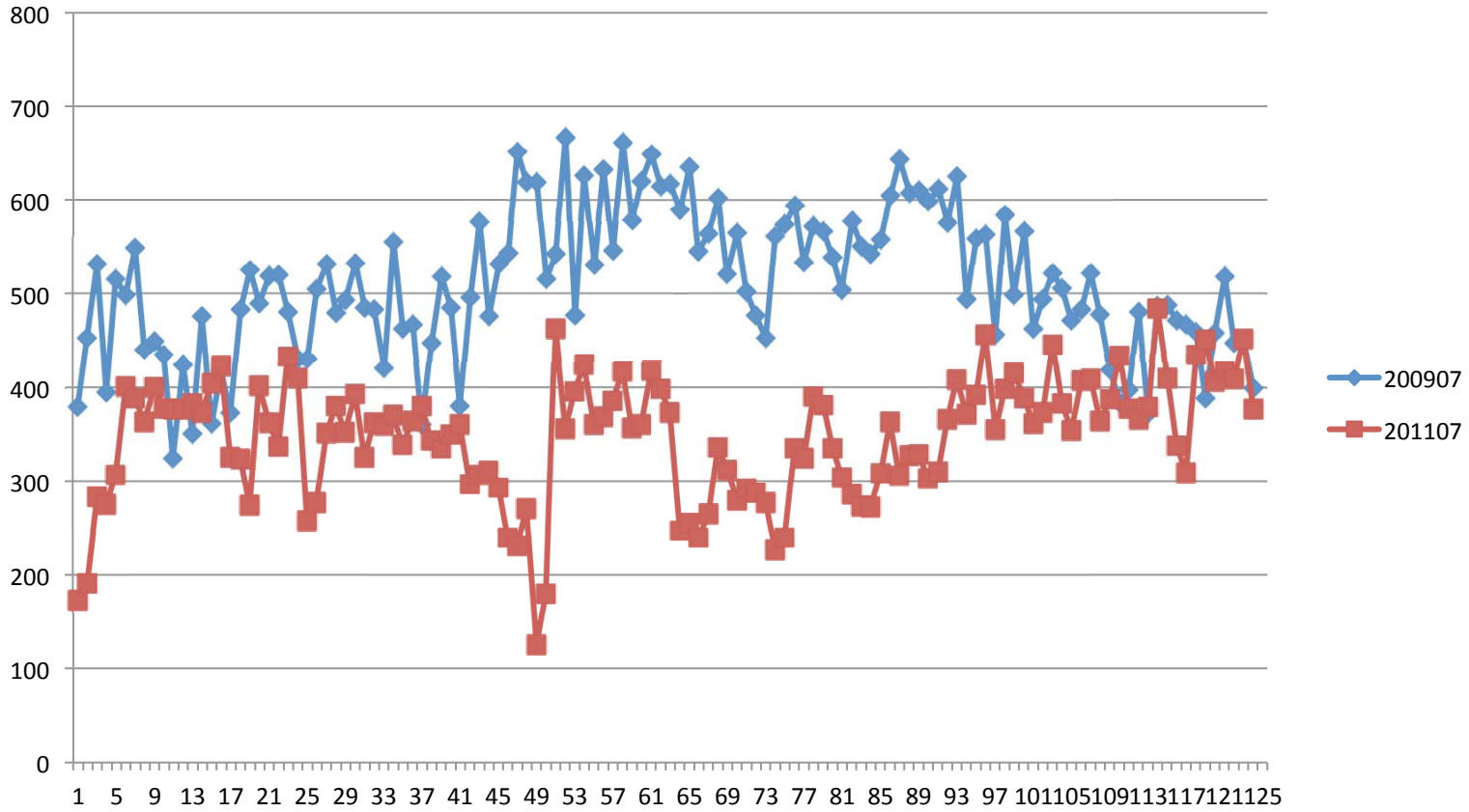
Num of match pairs
Mean of fractional bias
RMS of fractional bias

Data(200907):

- COSMIC
- GRAS
- Chinese high vertical resolution radiasonde collected in one second

Do Chinese radiosonde temperature instrument have system bias? –not sure yet!

Number of COSMIC/GPS RO data Assimilated per 6 hours in July 2009 and 2011: reduce year by year



Present:

- **COSMIC: in April 2006**
- **GRAS: in October 2006**

Future: ???

- **COSMIC-2:** Expected first launch in **mid-2015**, second in **mid-2017 (from Bill Kuo)**
- **FY3: carry one GPS receiver to be launched in 2013**

Next work

- Update and optimize the refractivity operator at the new GRAPES-Var version
- Implementation of BA operator

Summary

- GPSRO data have an significant impacts on GRAPES analysis and forecast skill, especially in the southern hemisphere, ocean and upper regions where there are lack of observations .
- How will we ensure GRAPES analysis and forecast quality with the reduction of GPSRO data?