Satellite data use in Chinese new GFS(GRAPES)

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ABSTRACT

The brief description and results of pre-operational trials of Chinese new generation global forecast system (GFS) are presented with stress on the use of satellite data. The new GFS is based on the global version of the unified NWP system GRAPES developed recently. The prediction model of GRAPES is non-hydrostatic in grid mesh and height based terrain following vertical coordinate with semi-implicit and semi-Lagrangian time integration scheme. The 3D variational data assimilation in GRAPES is designed to match the prediction model of GRAPES defining the same state variables in the same spatial coordinates as in the model. The observational data assimilated include conventional rawinsondes and surface synoptic reports, and a variety of unconventional data such as ATOVS from NOAA series satellites and AMVs from geostationary satellites and polar satellites. One year pre-operational experiments of cyclic assimilation with 6 hour time window and 10 day forecasts initiating at 12 UTC every day have been conducted by use of archived data from Dec 1st 2006 through Nov 30th 2007. The predictions are verified not only with GRAPES analyses but with NCEP analyses as well to assess the performance of the whole GFS system. Improvements of analyses and forecasts are evident comparing with the old system, especially in the southern hemisphere. The impact tests of different observational systems on the analysis and forecast show that the assimilation of satellite data plays the main role in the improvement of assimilation and forecasts. However there are still obvious differences between current GFS and NCEP analyses resulting in the degradation of forecasts of the former. Further studies show that the difference in the usage of the observational data in some specific regions is a main factor responsible to the difference in the assimilations of the two systems, implying the necessity of optimization of the data screening and quality control algorithms.

Some preliminary results from assimilation of FY3A microwave radiances in GRAPES GFS are presented.

1. Satellite Data used in GRAPES

- -Radiances(AMSU onboard NOAA15,16,17,18 and METOP)
- -AMVs (Geo, and Modis polar winds)
- -Reflectivity(COSMIC)
- - Quasi operational since Maech 2009

2. Radiance Observation Operator in GRAPES

- -RTTOV: RTTOV6->RTTOV7->RTTOV9
- -CRTM: CRTM2.0->CRTM2.1

3. Bias Correction of Satellite Data

- -Harris and Kelly(2001) Scheme
- -Scan bias correction based on mode
- *-Constrained observation bias correction (Under development)*
- -Height adjustment of FY2C and FY2D AMVs *(Han et al 2006)*

4. Observation Error Tuning(Han and Xue 2007)

- - Optimal: necessary condition (Bennet 1992;Talagrand,1999)
- - Desrosies et al.,2005

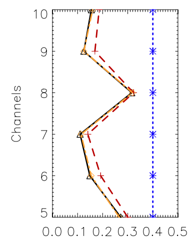
5. FY3 data assimilation

- - MWTS and MWHS
- - Trials and quasi-operational run (Since Feb. 2010)

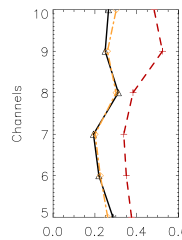
6. Ongoing Research

- - IASI and AIRS
- - Use of radiances over land

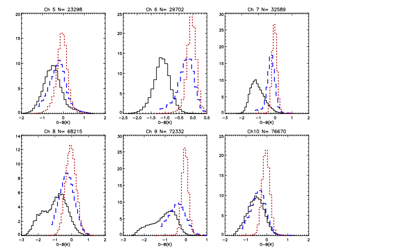
7. Conclusions



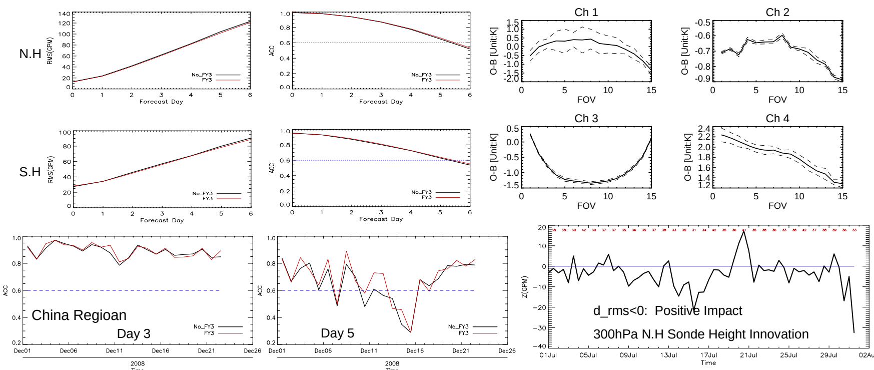
Obs error of NOAA16 AMSUA



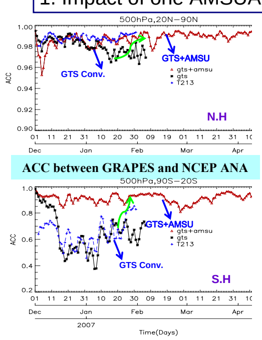
AMSUA HBHᵗ

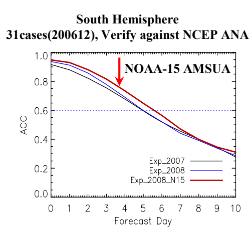


3. FY3 data assimilation: MWTS

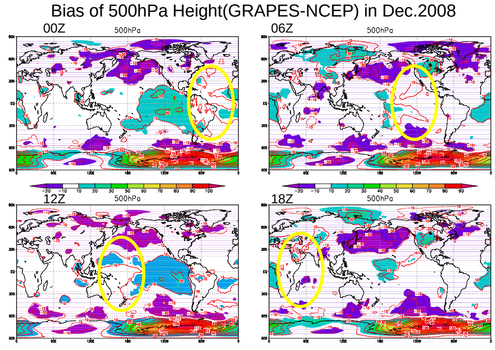


1. Impact of one AMSUA

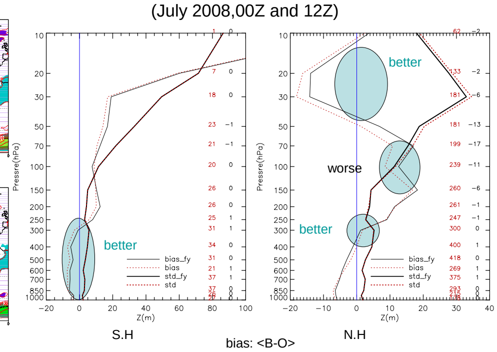




Bias of 500hPa Height(GRAPES-NCEP) in Dec.2008



Impact on innovations statistics of sonde data (July 2008,00Z and 12Z)



2. Bias Correction and Observation Error Tuning

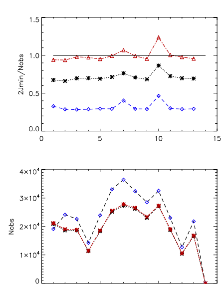
$E(\varepsilon^b)=0$	$E(\varepsilon^o)=0$
$\mathbf{B}=E(\varepsilon^b\varepsilon^{b^T})$	$\mathbf{R}=E(\varepsilon^o\varepsilon^{o^T})$
$E(\mathbf{d}_b^o\mathbf{d}_b^{o^T})=\mathbf{R}+\mathbf{HBH}^T$	$E(J\min)=p/2$

$$E(J_{\min})=\frac{1}{2}E(\chi^2)=\frac{1}{2}E(\mathbf{d}^T\mathbf{D}^{-1}\mathbf{d})=\frac{1}{2}Tr(\mathbf{D}^{-1}\bar{\mathbf{D}})=\frac{1}{2}p$$

$$E(\mathbf{d}_b^o\mathbf{d}_b^{oT})=\mathbf{R}+\mathbf{HBH}^T$$

$$E(\mathbf{d}_a^o\mathbf{d}_b^{oT})=\mathbf{R}(\mathbf{R}+\mathbf{HBH}^T)^{-1}E(\mathbf{d}_b^o\mathbf{d}_b^{oT})=\mathbf{RD}^{-1}\bar{\mathbf{D}}$$

$$E(\mathbf{d}_b^a\mathbf{d}_b^{oT})=\mathbf{HBH}^T(\mathbf{R}+\mathbf{HBH}^T)^{-1}E(\mathbf{d}_b^o\mathbf{d}_b^{oT})=\mathbf{HBH}^T\mathbf{D}^{-1}\bar{\mathbf{D}}$$



Reference

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(http://people.sca.uqam.ca/~gauthier/WGNE24-montreal/WGNE-BiospherePDF/19_Shen.pdf)