ITSC-16, Brazil
7-13 May 2008

Radiance Data Assimilation for WRF model : Overview and Results

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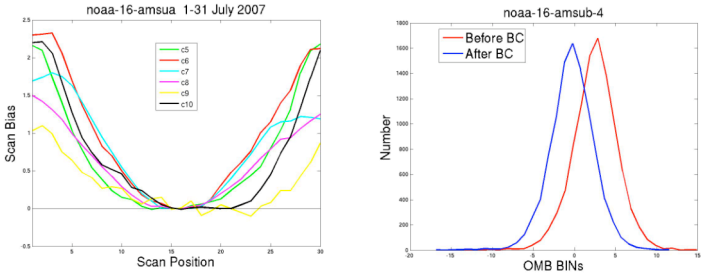
Introduction

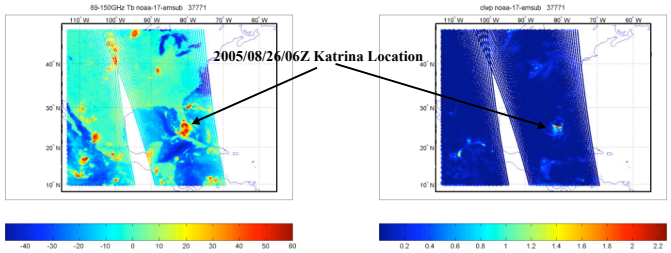
A general framework of satellite radiance assimilation in Weather and Research Forecast Variational Assimilation (WRF-Var) system was implemented in the past three years (Liu and Barker, 2006). The system incorporates both CRTM and RTTOV into WRF-Var system. This poster summarizes current status of radiance assimilation in WRF-Var with some demonstrations for basic components. The results from some case study and extended tests are also shown.

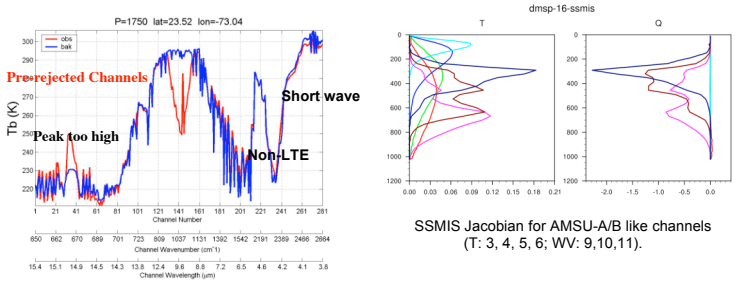
Radiance Assimilation Status

- Data Ingestion
  - –NCEP radiance BUFR data, including AMSU-A/B, MHS, HIRS, AIRS
  - –SSMIS from AFWA/NRL, UPP produced
- Radiative Transfer Model
  - – Both CRTM_1.1 and RTTOV8_7 are incorporated into WRF-Var
- Bias Correction
  - –Scan bias and air-mass bias (Harris and Kelly, 2001)
  - –Variational Bias Correction (Derber and Wu, 1998)
- Quality Control:
  - AMSU, MHS, SSMIS: Scatter Index and Background CLWP for precipitation check
  - AIRS: Multivariate Minimum Residual (MMR) scheme for cloud detection
- Thinning
  - Pick one pixel closest to the center of the box for AMSU, MHS, SSMIS
  - Pick the warmest pixel for AIRS
- Load Balancing (only for RTTOV currently)
- Observation error tuning (Desroziers & Ivanov, 2001)
- Monitoring tool: useful for research and operational implementation
- Work for 3DVAR/FGAT/4DVAR
- Initial Cloudy Radiance Assimilation Capability with CRTM
  - CRTM Forward, TL and AD modules for cloudy radiance implemented in WRF-Var.



Scan bias statistics and bias correction verification over East Asia (over sea)



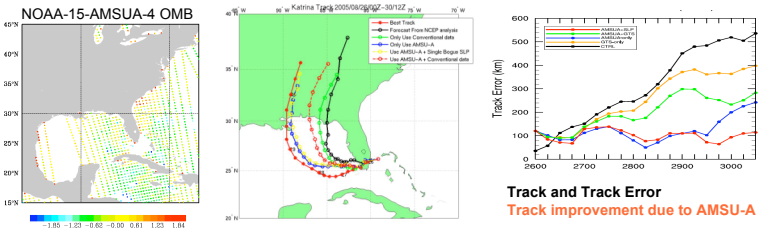


SSMIS Jacobian for AMSU-A/B like channels (T: 3, 4, 5, 6; WV: 9,10,11).

Observed and CRTM computed AIRS spectrum over clear sky

Katrina Case at 00Z 26th Aug. 2005

Model: WRF-ARW with 12km*51L, (not nested), model top at 10hPa, WSM3
Assimilation Experiments: WRF 6h forecast as the background, 4 exps.
(1) **GTS** (only conventional data); (2) **AMSU** (only AMSU-A data, channels 1~4 over sea, channels 5~10 over land and sea); (3) **GTS+AMSU** (4) **AMSU+SLP** (AMSU-A plus a single sea level pressure obs)



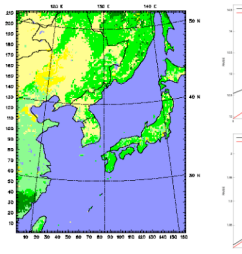
Track and Track Error
Track improvement due to AMSU-A

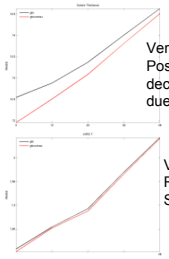
DATC Extended Testbeds

DATC: Data Assimilation Testbed centers, extended tests for pre-operational implementation
Testbeds: East Asia, Atlantic, Antarctic etc., full cycling experiments for radiance impact evaluation

East Asia Testbed:

- 162*212*42L, 15km
- model top: 50mb
- Full cycling exp. for a month
  - 1 ~ 30 July 2007
- GTS+AMSU
  - NOAA-15/16, AMSU-A/B from AFWA
  - AMSU-A: channels 5~9 (T sensitive)
  - AMSU-B: channels 3~5 (Q sensitive)
  - Radiance used only over water
  - thinned to 120km
  - +-2h time window
  - Bias Correction (H&K, 2001)
- Compare to GTS exp.
  - Only use GTS data from AFWA
- 48h forecast, 4 times each day
  - 00Z, 006, 12Z, 18Z



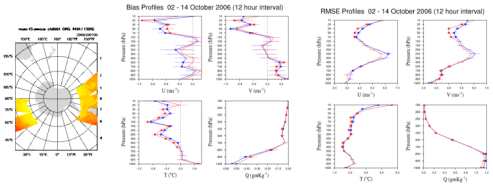


Verification Vs. SATEM
Positive impact, but impact decrease with longer forecast due to LBC effect.

Verification Vs. AIRS Retrieval.
Slightly positive impact

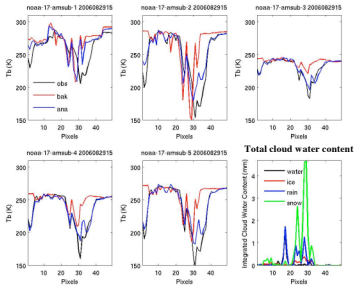
Antartic Testbed:

- 57L, 60km
- model top: 10mb
- Full cycling exp. for 14 days
  - 1 ~ 14 October 2006
- GTS: assimilate NCAR conventional
- GTS+AMSU-A (NCEP BUFR rad.)
  - NOAA-15/16/18, AMSU-A, ch. 4~9
  - Radiance used only over water
  - +-2h time window
  - Bias Correction (H&K, 2001)



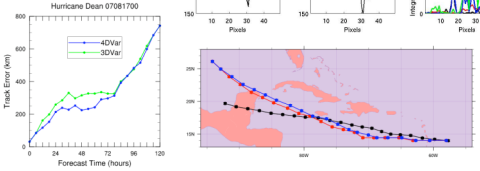
Initial Cloudy Radiance Capability

- CRTM cloudy radiance Forward/TL/AD calculation interface implemented
- Particle size is diagnosed from cloud water content
- No hydrometeor control variables available in WRF-3DVAR, instead Total Water (Qt) as control variable, and a warm-rain process' TL/AD is used to partition Qt into cloud water and rain (Xiao et al., 2007) in 3DVA (Warm-rain process limits the application)
- Initial test with WSM3 microphysics scheme for hydrometeors forecast with a 4km resolution
  - –Include cloud water/ice, rain/snow, no mixture phase



4DVAR Vs. 3DVAR

- 45km resolution
  - 4DVAR is still very slow
- 57Levels, model top = 10mb
- Only assimilate radiance data (AMSU/MHS), 6h time window
- Use CRTM and a static bias correction



Future Plans

- Add more instruments, IASI, GOES platforms etc.
- Tune the system for various testbeds
- Further developments for cloudy radiance assimilation and 4DVAR+radiance
- Explore ensemble-based radiance assimilation

Reference

Liu, Z.-Q. and Barker, D. M., 2006. Radiance Assimilation in WRF-Var: Implementation and Initial Results. 7th WRF users' workshop, Boulder, Colorado, 19-22 June 2006.
http://www.mmm.ucar.edu/wrf/users/workshops/WS2006/abstracts/Session04/4_2_Liu.pdf