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 Forecasts 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 radiation 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 (Dreizler & Ivanov, 2001)
- Monitoring tool: useful for research and operational implementation
- Work for 3DVAR/4DVAR
- Initial Cloudy Radiance Assimilation Capability with CRTM
- CRTM Forward, TL and AD modules for cloudy radiance implemented in WRF-Var.

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 (AMSU+SLP (AMSU-A plus a single sea level pressure obs)

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:

- 57L, 40km
- Full cycling exp. for a month
- 82 levels
- NOAA-15/16, AMSU-A/B from AFWA
- AMSU-A channel 5-9 (T sensitive)
- AMSU-B channel 3-4 (Q sensitive)
- Radiance used over land except China
- AMSU-A
data obtained from 120km
- +2h time window
- Bias Correction (H&K, 2001)

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

Verification Vs. AIRS
- Retrieval
- Slightly positive impact

Antarctic Testbed:

- 57L, 41km
- Full cycling exp. for 10 days
- 1-14 October 2006
- GTS: assimilate NCEP conventional
- GTS+AMSU-A (AMSU-A
- SSMIS-360, AMSU-A, 4-9
- AMSU-B
- AMSU-A/B
- AMSU-A
- +2h time window
- Bias Correction (H&K, 2001)

Initial Cloudy Radiance Capability

CRTM cloudy radiance forward/TL/AD calculation interfaced implemented
- Particle size is determined 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 (wet-rain process for the application)
- Initial test with WSM3 microphysics scheme for hydrometers forecast with a 4km resolution
- Include cloud water, rain, snow, no mixture phase

4DVAR vs. 3DVAR

- 4km resolution
- ARW-FVAR is still very slow
- TL/AD, model top 10hPa
- Only assimilate radiance data (AMSU/MHS), 6h time window
- Use CRTM 1.1 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


Observed and CRTM computed AIRS spectrum over clear sky