# Recent development of satellite data assimilation at JMA

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## 1.Outline of NWP systems at JMA

Specification of JMA's forecast model and data assimilation system

| Model | Global Model & Analysis (GSM,GA) | Meso-scale Model & Analysis (MSM,MA) |
|---|---|---|
| Horizontal /vertical res. | TL959/60 (0.1hPa) | 5km / 50(21.8km) |
| Forecast range (Initial time) | 84h (00,06,18UTC)<br>216h (12UTC) | 15h (00,06,12,18UTC)<br>33h (03,09,15,21UTC) |
| Data Assimilation (inner loop res.) | 4D-Var (TL319) | 4D-Var (15km) |
| Assimilation window | 6h (-3 ~ +3 hours) | 3h (-3 ~ 0 hours) |
| Radiance assimilation | RTTOV9.3 | |
| Cut off time | Early Analysis : 2h25m<br>Cycle Analysis:<br>11h15m(00,12UTC), 5h15m(06,18UTC) | 50m |

Satellite (to be) used in the operational global and meso-scale NWP system
Items in red were implemented in the operational system since ITSC17

| | Satellite/Instrument | GA | MA |
|---|---|---|---|
| 1. Sounder | NOAA15,16,18,19, Aqua, Metop / AMSU-A | Radiance | Radiance |
| | NOAA18,19, Metop / MHS | Radiance | Radiance |
| | (Aqua/AIRS, Metop/IASI) | Under development | Under development |
| 2. MW Imager | TRMM/TMI | Radiance | Radiance, Rain Rate |
| | DMSP16,17,18 / SSMIS | Radiance | Radiance, Rain Rate |
| 3. VIS/IR Imager | MTSAT-2, Meteosat-7,9, GOES-13,15 | Radiance | Radiance |
| | | AMV | AMV |
| | Aqua,Terra/MODIS | AMV | X |
| 4. Scatterometer | Metop/ASCAT | Ocean surface wind | Under development |
| 5. GPS-RO | COSMIC | Refractivity | Under development |
| | Metop/GRAS | Refractivity | Under development |

## 2.1 Exploit AMSU-A channels of 6,7,8 in the operational Global analysis (GA)

- AMSU-A channels of 6-8 have been assimilated additionally in coastal area since Nov 2010.
  - Their qualities in coastal area, with surface emissivities fixed (0.9) in RTM calculations, were found to be similar to those in land area.
- The experiment in advance of the operation showed ;
  - available data increased by 20-30% (Fig2.1.1)
  - analyses field got closer to other centers' ones (Fig 2.1.2)
  - forecast was improved especially in about 100-700hPa vertical layers

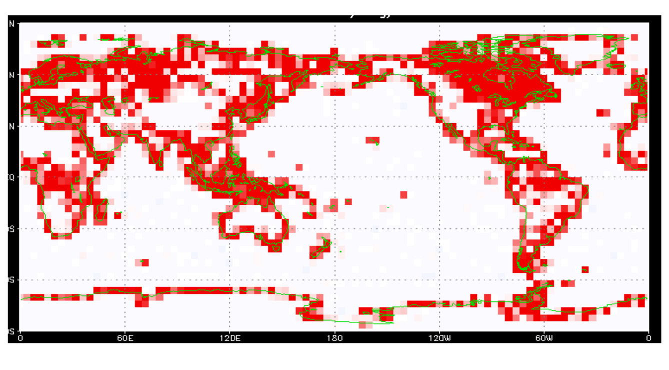

Fig 2.1.1: Difference of assimilated data number of channel 6. Red shows increments.

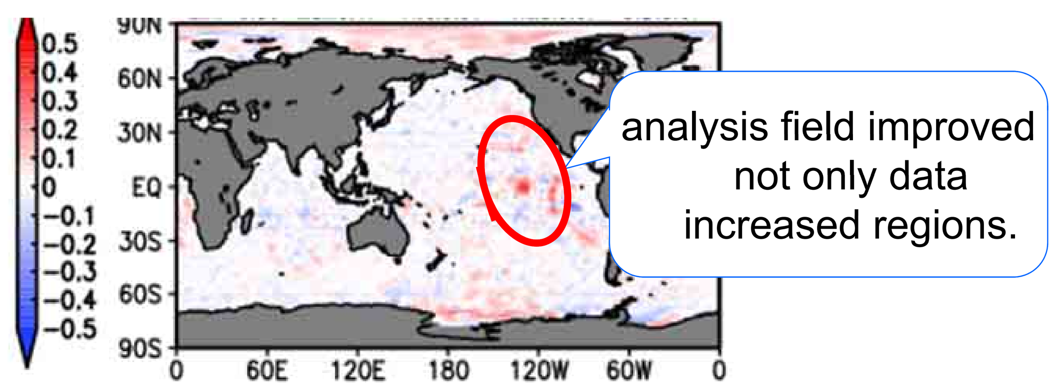


Fig 2.1.2: T850 analysis field verification against independent analysis. Red color shows analysis fields get closer to ECMWF's ones in the assimilation experiment.

## 2.2 Radiance assimilation in the operational Meso-scale analysis (MA)

- Radiance data have been assimilated instead of retrievals since Dec 2010.
- A quality control used in GA was applied for the MA with several modifications ;
  - 45km thinning distance while 180~250km in GA
  - extrapolating atmospheric profiles with U.S. standard atmosphere's lapse rate above MSM top height (~40hPa)
  - employ VarBC coefficients estimated in the latest GA
- Considerable improvements in the tropospheric analyses and short range forecasts (Fig 2.2.2)

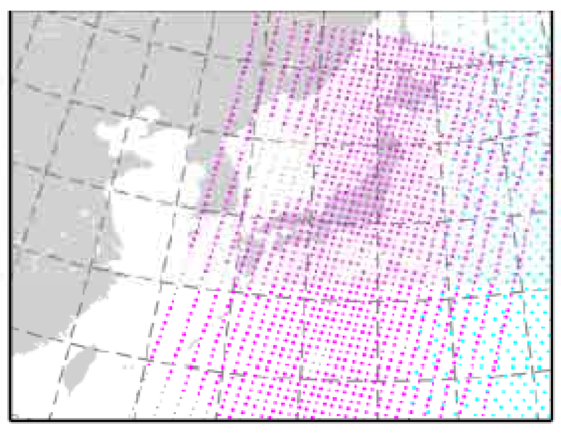

Fig 2.2.1: MSM domain and example of AMSU-A observation coverage(NOAA18, Aqua).

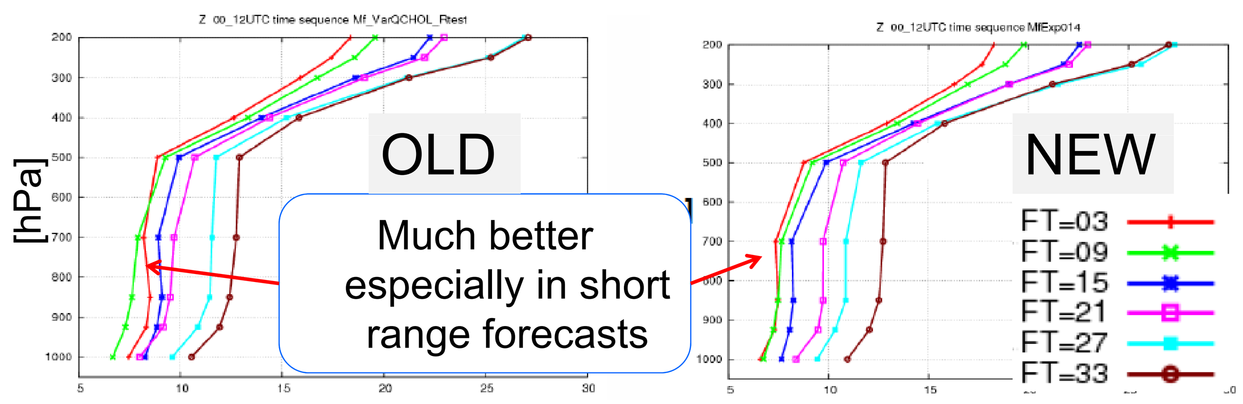


Fig 2.2.2: RMSE[m] of geopotential height forecast of MSM against radiosonde observations from July 16 to 26, 2009. The color indicate the difference of Forecast Time. The left panel corresponds to old system, before Dec 2010, and the right one corresponds to new system.

## 3.1 Assimilation experiment of surface-sensitive microwave radiances with RTTOV-10 in the GA

- TEST run uses RTTOV-10.1, while CNTL run uses RTTOV-9.3. TEST employs also ;
  - FASTEM-4 and climatological land surface emissivity, both supplied in RTTOV-10
  - Active assimilation of MHS channel 3-5 over land
  - Reduction of observation error inflation for AMSU-A ch6 over land
  - Use of hourly surface temperature from GSM as the first guess in RTM calc
- Increase TCWV over land, especially desert areas. It got closer to ground-based GPS observation than CNTL (Fig 3.1.1)
- Forecasts were improved not only in the troposphere, but also in the stratosphere (Fig 3.1.2)

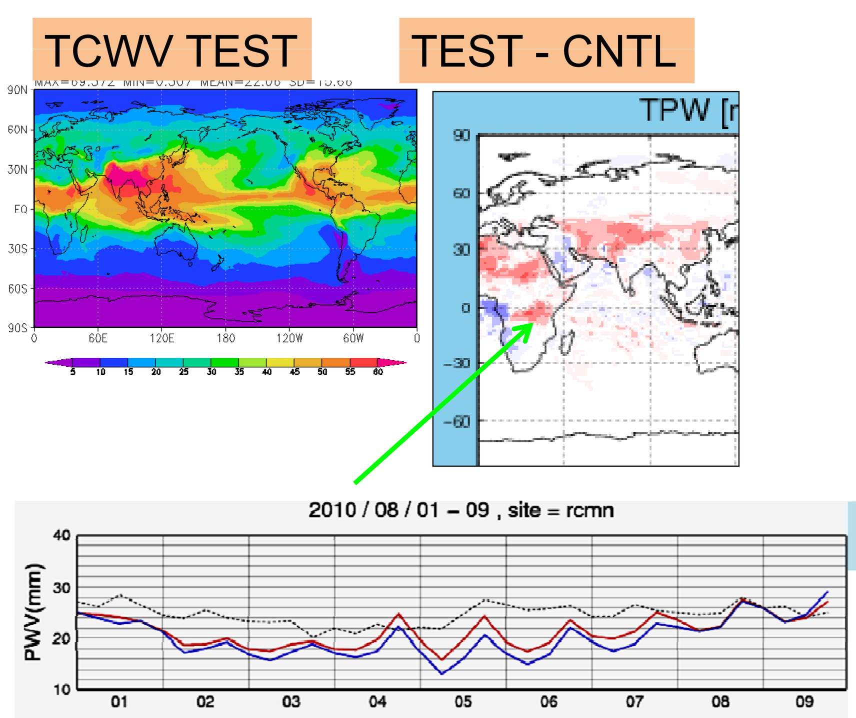


Fig 3.1.1: (Upper left) Mean TCWV field for TEST; (Upper right) Mean TCWV field TEST – CNTL; (Botttom) Time sequence of analyzed TCWV at Ground-based GPS observation.TEST, CNTL, OBS

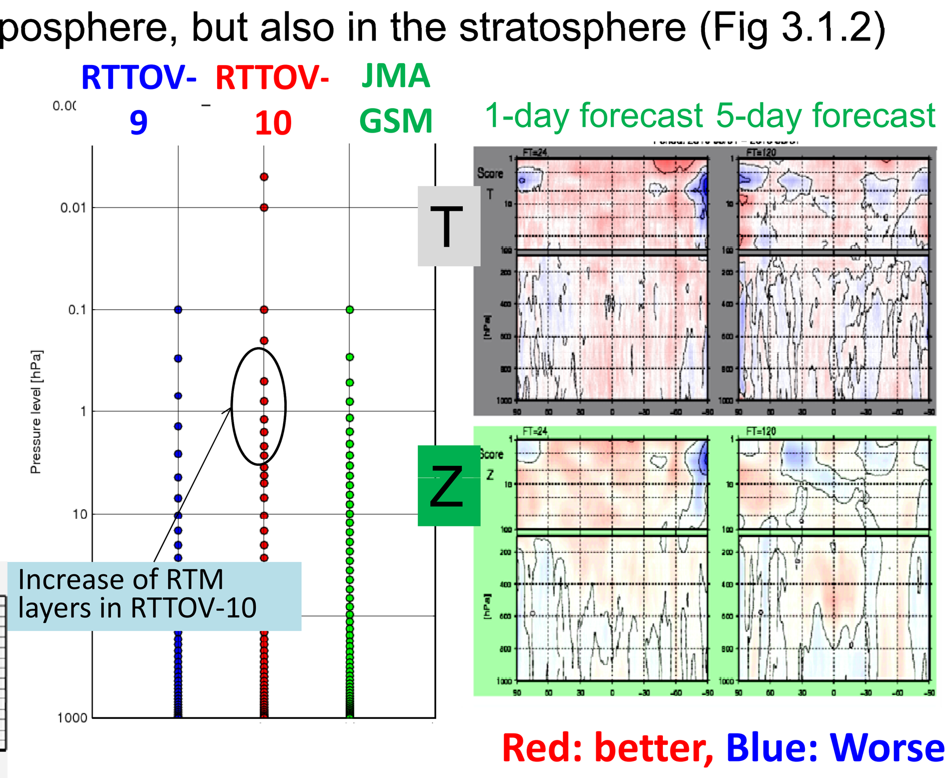


Fig 3.1.2: (Left) Comparison of vertical layers of RTTOV-9, RTTOV-10 and GSM. (Right) Improvement ratio of zonal mean forecast RMSE against the initials [%]

## 3.2 Initial assessment of FY-3A/MWTS

- According to departure (Observed minus Background) statistics, its quality is almost equivalent or slightly better than AMSU-A (Fig 3.2.1).
- In data assimilation experiment, channel 2 and 3 were newly assimilated. Channel 1 was used to screen out cloud contaminated data. Improvements of temperature forecast for Southern Hemisphere were confirmed when compared to runs without FY-3A/MWTS (Fig 3.2.2).

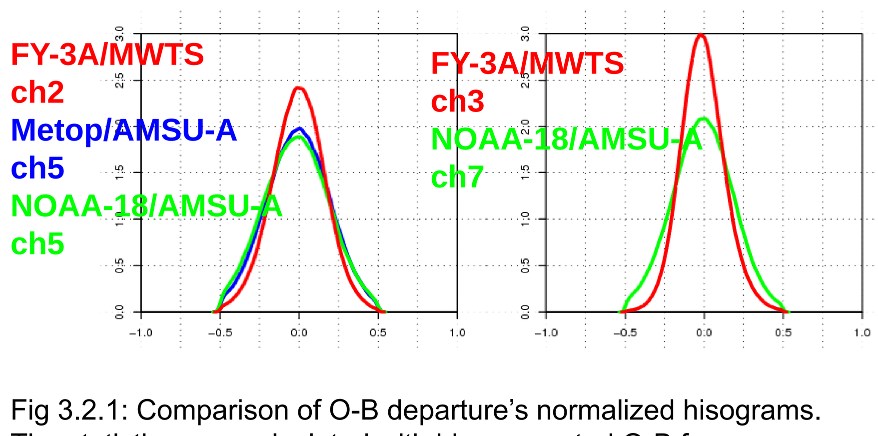


Fig 3.2.1: Comparison of O-B departure's normalized hisograms. The statistics was calculated with bias corrected O-B from one month (August 2011) data set.

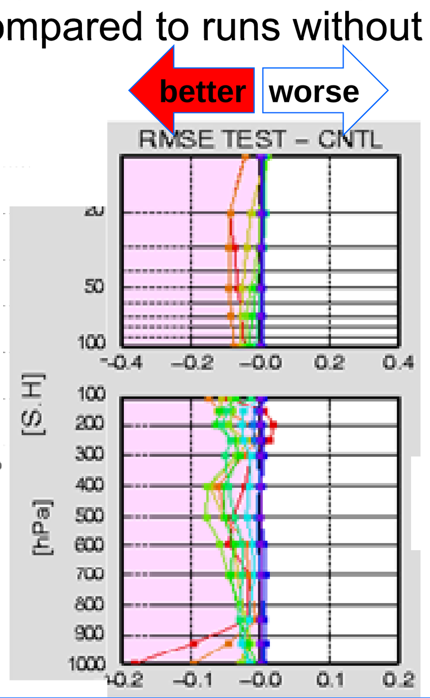


Fig 3.2.2: Difference of RMSE of temperature forecast against the initials in the southern hemisphere.
Colors represent forecast time.

## 3.3 AIRS & IASI clear radiance assimilation

- Cloud detection and Cloud top height estimation
  - 1. Window channel (AIRS ch950, 10.2µm) O-B threshold
  - 2. Difference of observed radiances (AIRS 10.2µm – 11.8µm) threshold
  - 3. The cloud top heights are estimated by Minimum Residual Method (Eyre and Menzel 1989) with two AIRS channels (13.4µm, 10.8µm)

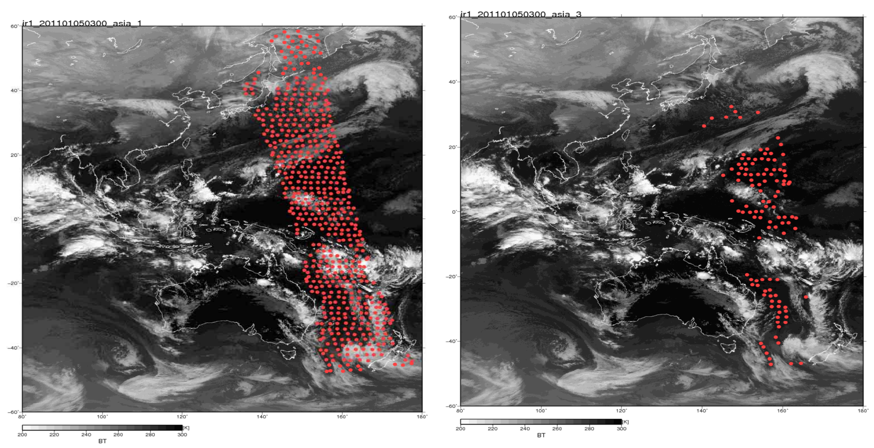

Fig 3.3.1: (Left)AIRS one granule and MTSAT image at the same time; (Right) Clear flagged data

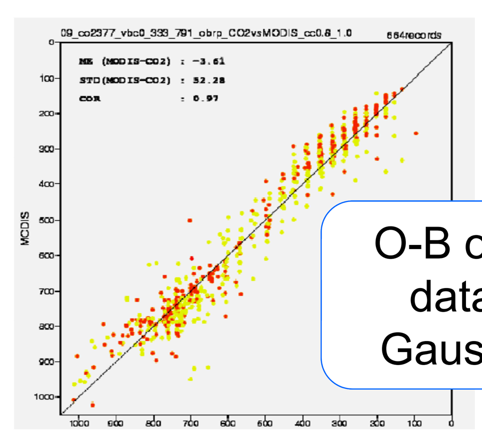

Fig 3.3.2: Comparison of cloud top pressure estimated in 3. and co-located MODIS products.

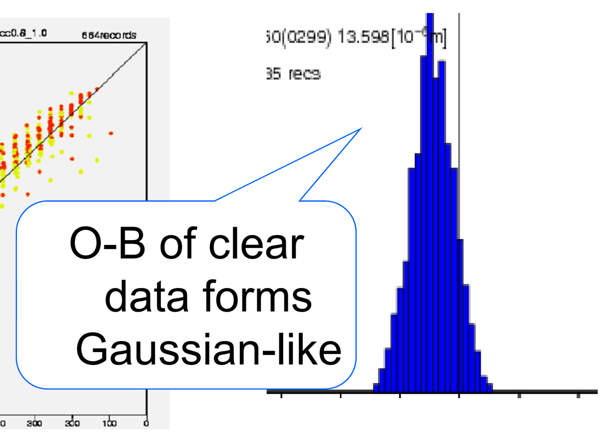


Fig 3.3.3: O-B histogram of AIRS 299 (~800hPa) for clear data.

- Use of daily ozone product instead of climatological values for RTM calculation

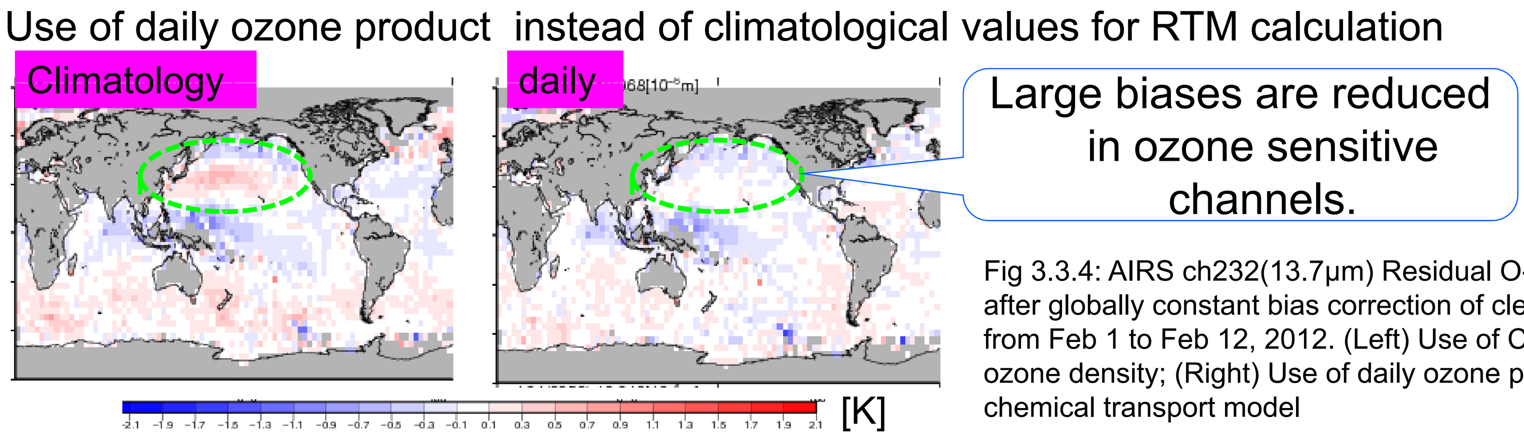


Fig 3.3.4: AIRS ch232(13.7µm) Residual O-B distribution after globally constant bias correction of clear data, averaged from Feb 1 to Feb 12, 2012. (Left) Use of Climatological ozone density; (Right) Use of daily ozone product of JMA's chemical transport model

- AIRS assimilation experiment with these configurations performed well (Fig 3.3.5)

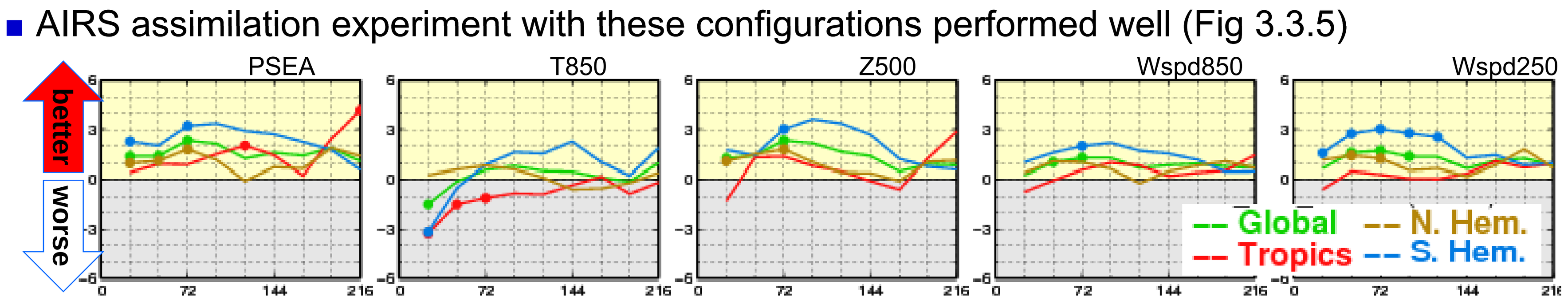


Fig 3.3.5: RMSE improvement ratio [%] for AIRS assimilation experiment in Jan.2011. Solid circles indicate statistically significant difference.

- Assimilating IASI almost equal configuration did not show improvement. Under investigation.

## 4. Future Plans

- Assimilate clear radiances of AIRS and IASI
- Implement RTTOV-10 into GA and MA, and exploit more land sensitive channels
- Further investigation of FY-3A/MWTS toward operational use. Also FY-3B
- Assimilate radiances affected by clouds and rain

## <References>


- M.Kazumori 2011. Impacts of radiance assimilation in the JMA operational meso-scale analyses and forecasts. Proceeding s of 2011 EUMETSAT Meteorological Satellite Conference, 5-9 September 2011, Oslo,Norway
- M.Kazumori 2012. Assimilation experiments involving surface-sensitivity microwave radiances in JMA's global data assimilation system. CAS/JSC WGNE Res. Activ. Atmos. Oceanic Model. *Submitted*
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