Assimilation of radiance data at JMA: recent developments and prospective plans
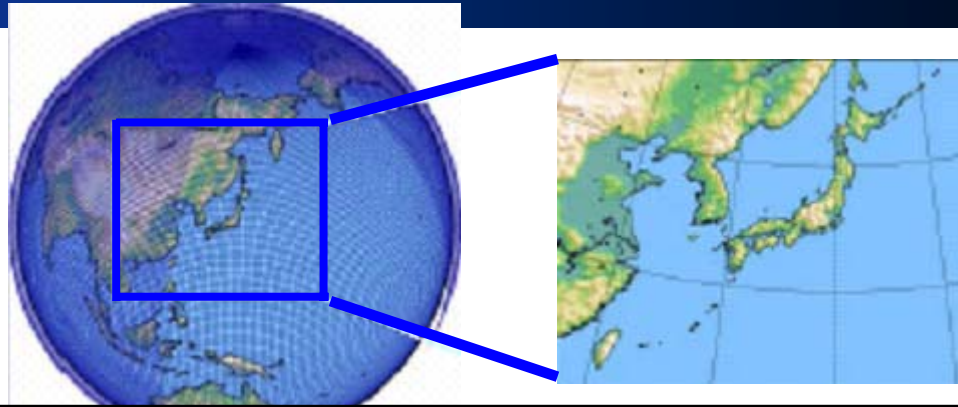
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ITSC16, Angra dos Reis, Brazil, 7-13 May 2008

NWP models of JMA (Nov.2007~)

Model	Global Model (GSM)	Meso-scale Model (MSM)
Resolution H/V(top height)	TL959 (20km)/60(0.1hPa) *Before Nov.2007: TL319(60km)/40(0.4hPa)	5km/50 (21.8km)
Forecast range (Initial time)	84h (00,06,18UTC) 216h (12UTC)	15h (00,06,12,18UTC) 33h (03,09,15,21UTC
Target	1~7 day forecast Aeronautical forecast	Disaster prevention information
Data Assimilation (outer/inner loop)	4D-Var (TL959/T159 or 20km/80km)	4D-Var (10/20km)
Window Length	6h	6h
Radiance Assimilation	RTTOV7, VarBC	X (T/TCWV/rain retrieval)

Satellite data assimilated

- **Sounders**
  - Radiance from NOAA15~18/AMSU-A,-B,MHS, Aqua/AMSU-A, Metop/AMSU-A,MHS in GDAS
    - □ Including AP-RARS and EARS
  - Temperature retrieval from NOAA15-18 and Metop/ATOVS in MDAS
- **Microwave Radiometers (MWRs)**
  - Radiance from DMSP/SSMI, TRMM/TMI and Aqua/AMSR-E in GDAS
  - Total Column Water Vapor (TCWV) and Rain Rate retrieval in MDAS
- **Scatterometer**
  - Ocean surface wind vector from QuikSCAT/SeaWinds in GDAS & MDAS
- **GPS-RO (Radio Occultation)**
  - Refractivity from CHAMP in GDAS
- **AMV (Atmospheric Motion Vector) from Aqua+Terra/MODIS in GDAS**
- **Geostationary satellites**
  - AMV from MTSAT-1R, Meteosat7,9, GOES11,12 in GDAS & MDAS
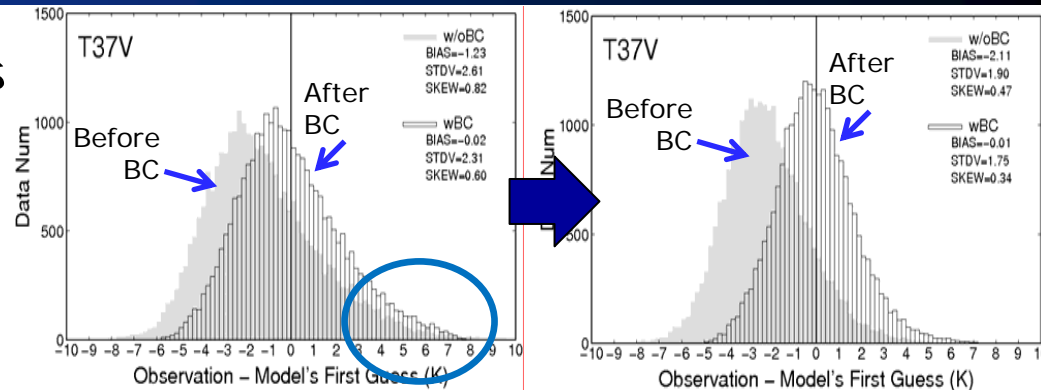 - CSR (clear sky radiance) from MTSAT-1R in GDAS

GDAS : Global Data Assimilation System
MDAS : Meso-scale Data Assimilation System

MW window channel assimilation

- Operationally assimilate less cloud affected radiances of SSM/I, TMI and AMSR-E in GDAS since May 2006
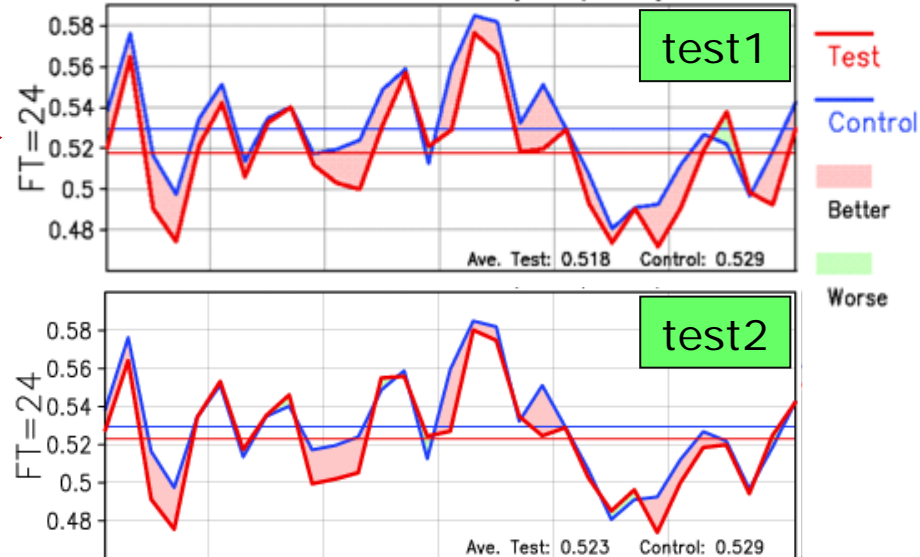   - V.Pol only
    - VarBC

- test1: Improve QC and BC
    - Stricter cloud screening & addition of total column cloud liquid water predictor in VarBC
    - Small but consistent positive impact on the forecast of T850

- test2: Add SSMIS+test1
    - 19V, 22V, 37V, 92V
    - Neutral impact from SSMIS window ch

Time sequence of RMSE of day 1 forecast

AIRS assimilation (ongoing development)

Biases of Analysis/first-guess verified against radiosondes, Aug2007

- **Assimilate radiances 54ch/324ch over the sea**
  - Channel selection using Entropy Reduction (Rodgers 2000)
  - Detect cloud-affected radiances based on McNally and Watts (2003)
    - Comparison with CloudSat showed performance enough for QC (in poster)
  - Bias correction scheme is the same as ATOVS except predictors in VarBC
    - Tbobs, $1/\cos\theta$, const
- **Positive impact on analysis but neutral or negative on forecast**
  - reduces model biases of temperature and moisture.

T [K] (SH)

Rh [%] (TRP)

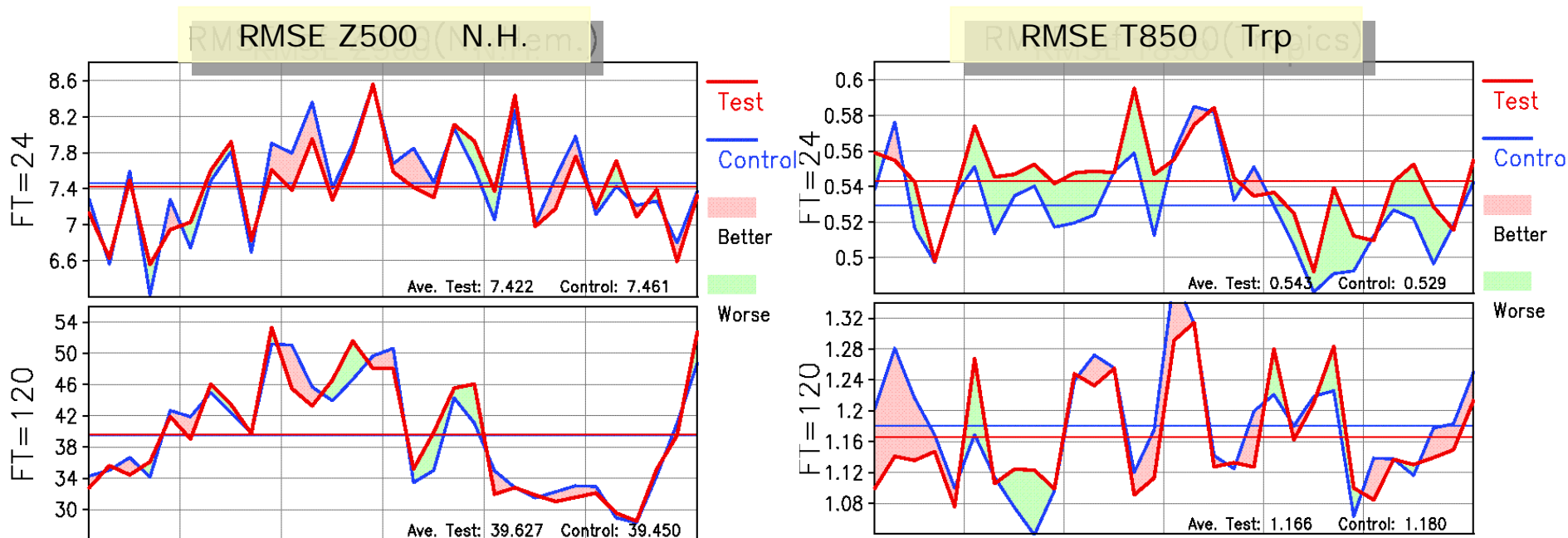|	
—	**Anal (use AIRS)**
—	**Anal (no AIRS)**
—	**Guess (use AIRS)**
—	**Guess (no AIRS)**

AIRS radiance assimilation

- Degrades forecast skills of the lower tropospheric temperature
  - Possibely caused by the conflict of analysis increment with model trend

Time sequence of RMSE of 1- & 5-day forecasts verified against the initials

RMSE Z500 (N.H.)

Ave. Test: 7.422   Control: 7.461

Ave. Test: 39.627   Control: 39.450

RMSE T850 (Trp)

Ave. Test: 0.543   Control: 0.529

Ave. Test: 1.166   Control: 1.180

Test
Control
Better
Worse

Other topics on Poster 6.9

- Metop/ATOVS impact
- AP-RARS & EARS impact
- Clear Sky Radiances (CSRs) of WV-ch from geostationary satellites
  - 1 geo vs. 5 geo
- AIRS radiance assimilation
 - CloudSat comparison
- Plans

End

Metop/AMSU-A & MHS assimilation

- **Assimilate radiances in GDAS**
  - Less cloud-affected, less land-surface-dependent radiances
  - Implement a static scan-dependent Bias Correction (BC) and adaptive air-mass dependent BC
    - Variational BC (VarBC) applied to air-mass BC

- **Significantly positive impacts on forecasts, especially, of the geopotential height**

- **Moreover, great benefits of early and stable data dissemination**

Forecast Improvement Rate wrt RMSE for 1-9 day forecasts (cntl-test)/cntl   test : using Metop, cntl : no Metop
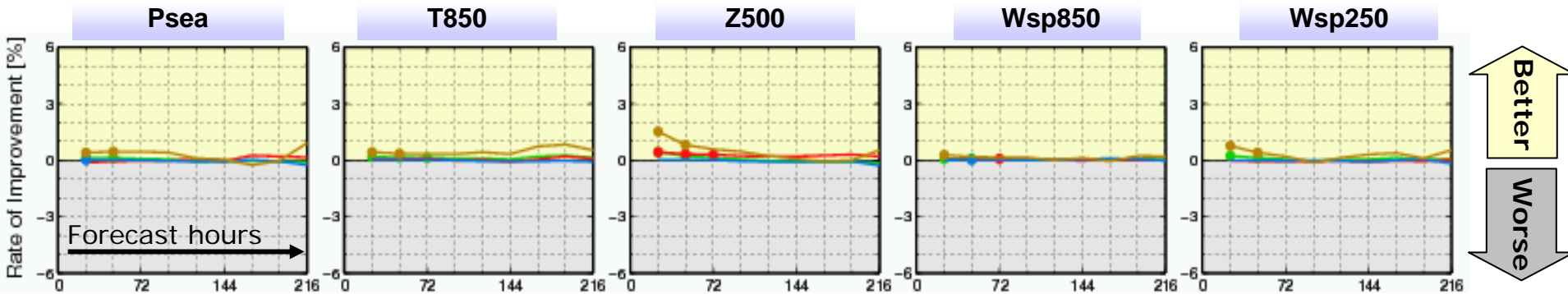
-- Global -- N. Hem.
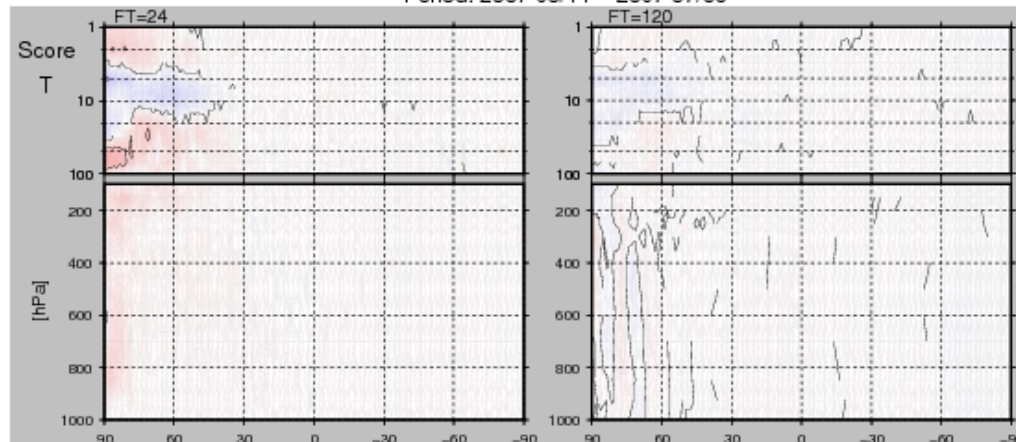-- Tropics -- S. Hem.
—●— Statistically significant

Rate of Improvement [%]

| Psea | T850 | Z500 | Wsp850 | Wsp250 |

Forecast hours

Better / Worse
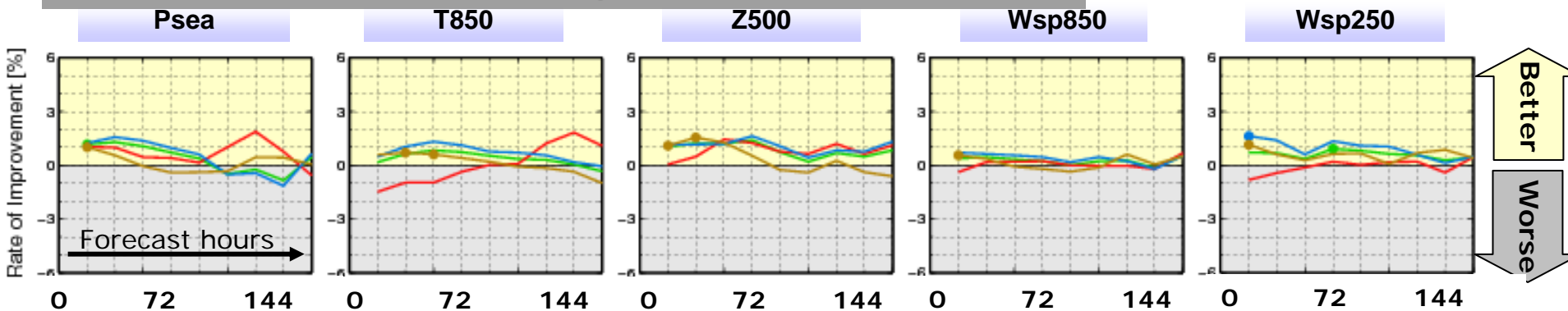
EARS impacts on forecasts

Forecast Improvement Rate average over 6/11-7/6 2007

Psea   T850   Z500   Wsp850   Wsp250

Rate of Improvement [%]

Forecast hours

Better
Worse

Temperature improvement rate FT=24 (left) and 120 (right)

Modified Rate (Vertical Zonalmean) $R(x) = \dfrac{E(Cntl) - E(test)}{\{E(Cntl)+E(Test)\}\times 0.5}$ [%] Test:EARS
Compare EARS(TEST) to CNTL_for_EARS(CNTL) Cntl:CNTL_for_EARS
Period: 2007 06/11 – 2007 07/08

FT=24   FT=120

Score T

[hPa]

Geo. Sat. WVch CSR assimilation
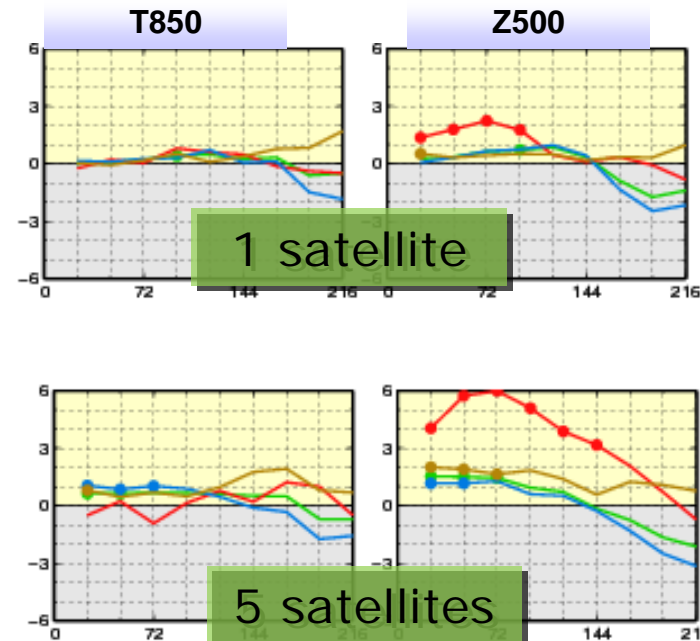
- ## 5 Geo.Sat. WVch CSRs added
  - Increase humidity in the mid- to upper troposphere, and even in the lower troposphere in dry areas
  - Make analysis/guess closer to RAOB around 500hPa in RH and to AMSU-B&MHS channel 3 in TB
  - Positive impact on forecast, especially at day 1 to 3
  - 5 geo.sat. CSR assimilation has greater positive impact than one (MTSAT-1R)
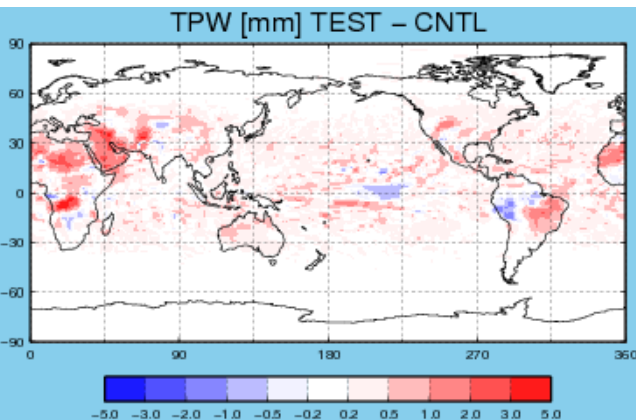
Monthly averaged TCWV diff. by WV-CSR assimilation
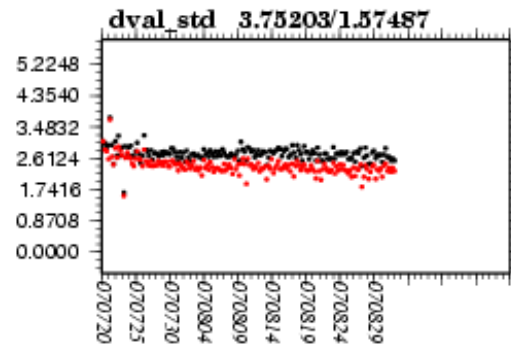
Time sequence of TB O-B STD

T850 Z500

1 satellite

5 satellites