Assimilation of Suomi-NPP/CrIS radiances into the JMA's global NWP system

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[SESSION 9a] 9.02:Hyperspectral IR assimilation

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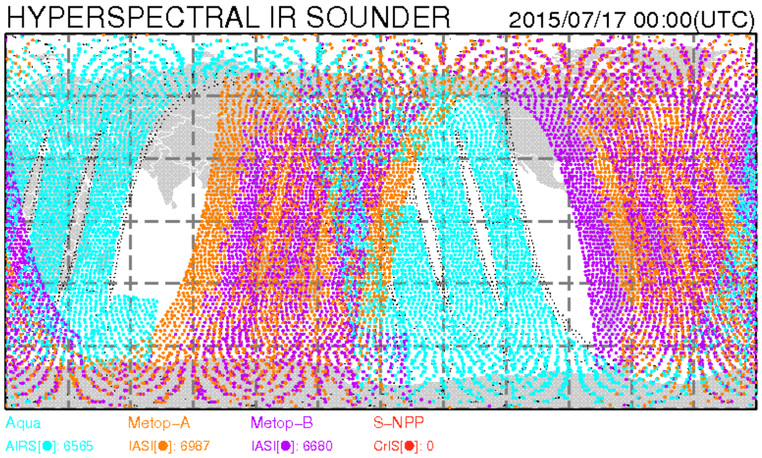
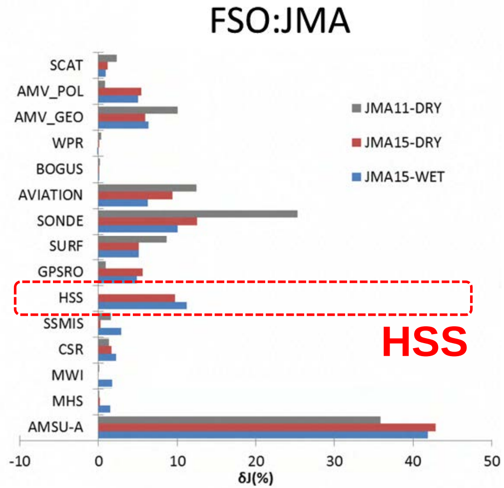
Current usage of HSS in JMA

IASI and AIRS (hereafter, refer to as HSS) radiance data have been operationally assimilated into JMA's global Numerical Weather Prediction (NWP) system since September 2014. HSS data contribute to the accuracy of NWP forecasts.

Before using S-NPP/CrIS



Aqua/AIRS Metop-A/IASI Metop-B/IASI



Forecast Sensitivity to Observations (%) (Ishibashi:2016)

We got positive results from CrIS data assimilation experiments in JMA NWP system. We have operationally used CrIS data since this March.

Usage status of other NWP centers

ITSC-21(2017.11) HSS NWP Survey

As of 2017.11.21 online

CrIS

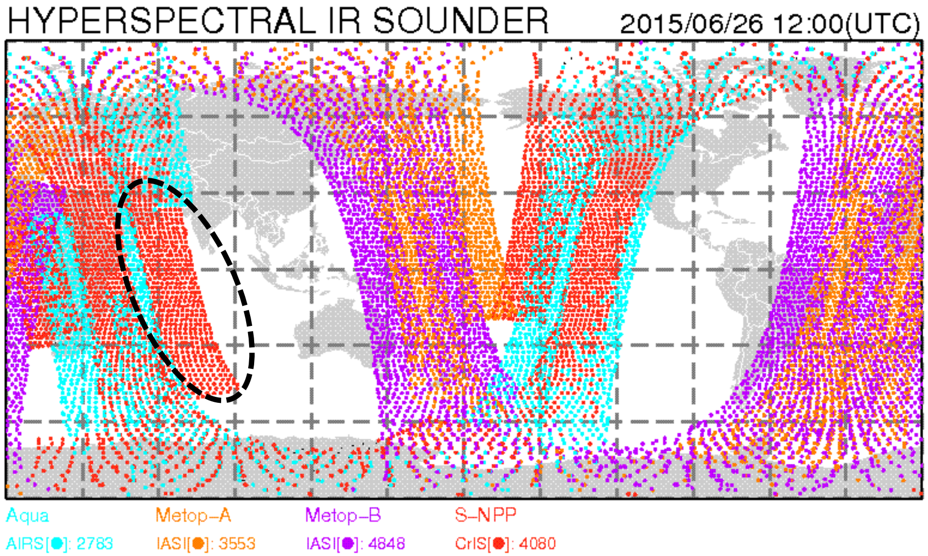
Centre	CrIS							
	15 microns (1)		Window + O3 (2)		H2O (3)		Short Wave (4)	
	Land	Ocean	Land	Ocean	Land	Ocean	Land	Ocean
ECCC(Canada)	41	41	0	20	29	29	6 (6)	13 (6)
ECMWF(Europe)	88	88	23	23	7	7	0	0
MET Norway(Norway)								
US-FNMOC/NRL(USA)	27	45	0	34	0	41	0	0
DWD(Germany)	0	0	0	0	0	0	0	0
Met Office(UK)	75 (5)	75	15 (5)	27	32 (5)	32	0	0
DMI(Denmark)								
JMA(Japan)	25	27	0	0	0	0	0	0
Meteo France(France)	42	55	0	8	0	5	0	0
NCEP(USA)	69	69	15	15	□	□	□	□
BoM(Australia)	34	75	12	27	31	32	0	0

Introduction of CrIS on March 2017

JMA started the use of CrIS radiance data from CO_2 band.
Increase of channel for assimilation is our future work.

Merit of CrIS use in Early analysis

Early Analysis



Aqua/AIRS

Metop-A/IASI

Metop-B/IASI

S-NPP/CrIS

Data cut off time
2h20m

Direct broadcast CrIS data received at MSC/JMA are used.

Early analysis: analysis for long range forecasts (11 day)

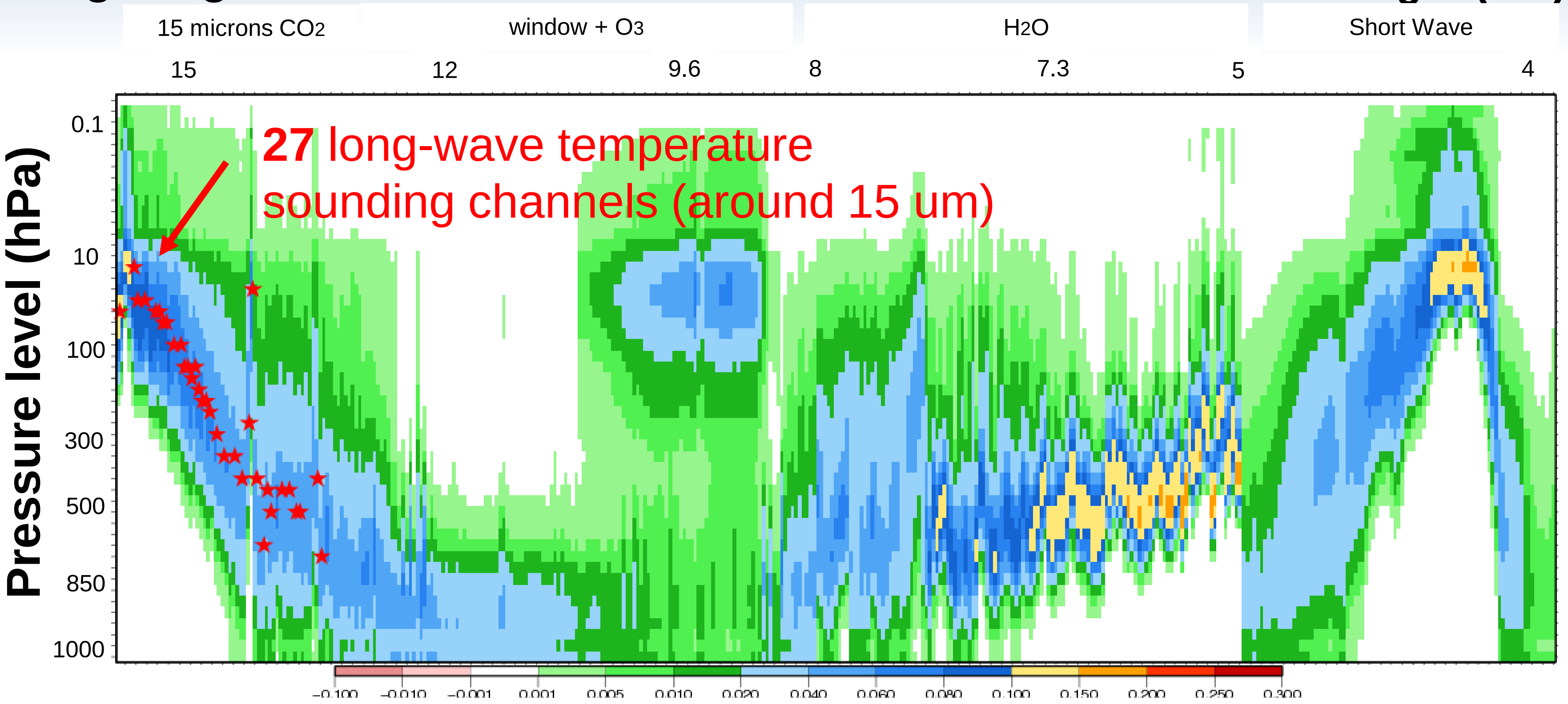
ECTL(Equator-Crossing Times Local) of both AIRS and CrIS are 13:30.

- Backup of AIRS(High priority in the data thinning for CrIS)
- Expansion of coverage(Wider Swath AIRS:1650km < CrIS:2230km)

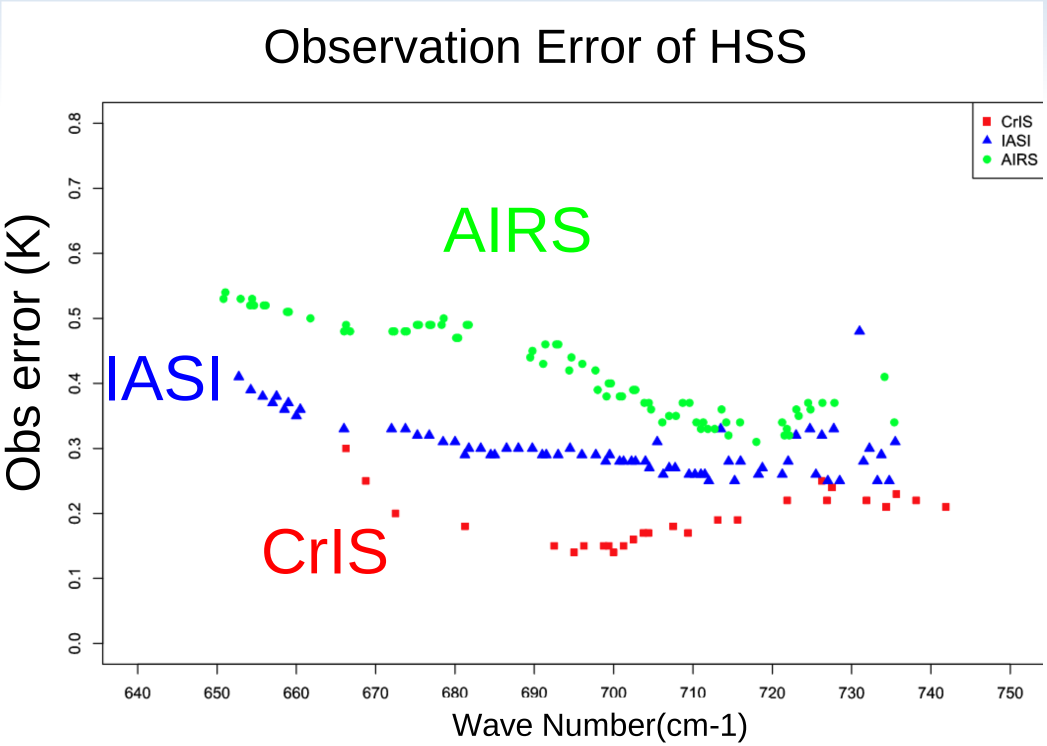
Used channels

Weighting Function of CrIS

Wave length (um)



Observation Error setting of HSS



The observation error was estimated from FG departure statistics.
Smaller observation errors are assigned for CrIS compared to other HSS (IASI, AIRS).

Statistic period
Jun. 2015 - Aug. 2015 summer
Dec. 2015 – Feb. 2016 winter

Setup of assimilation experiments

Experiments to investigate the impacts of utilizing CrIS in the latest global NWP system

Control : current operational system

Test : Control + Suomi-NPP/CrIS

Assimilation Period: From 10 July to 11 September 2015

From 10 December 2015 to 11 February 2016

Forecast from 12UTC initial every day

GSM: Global Spectral Model

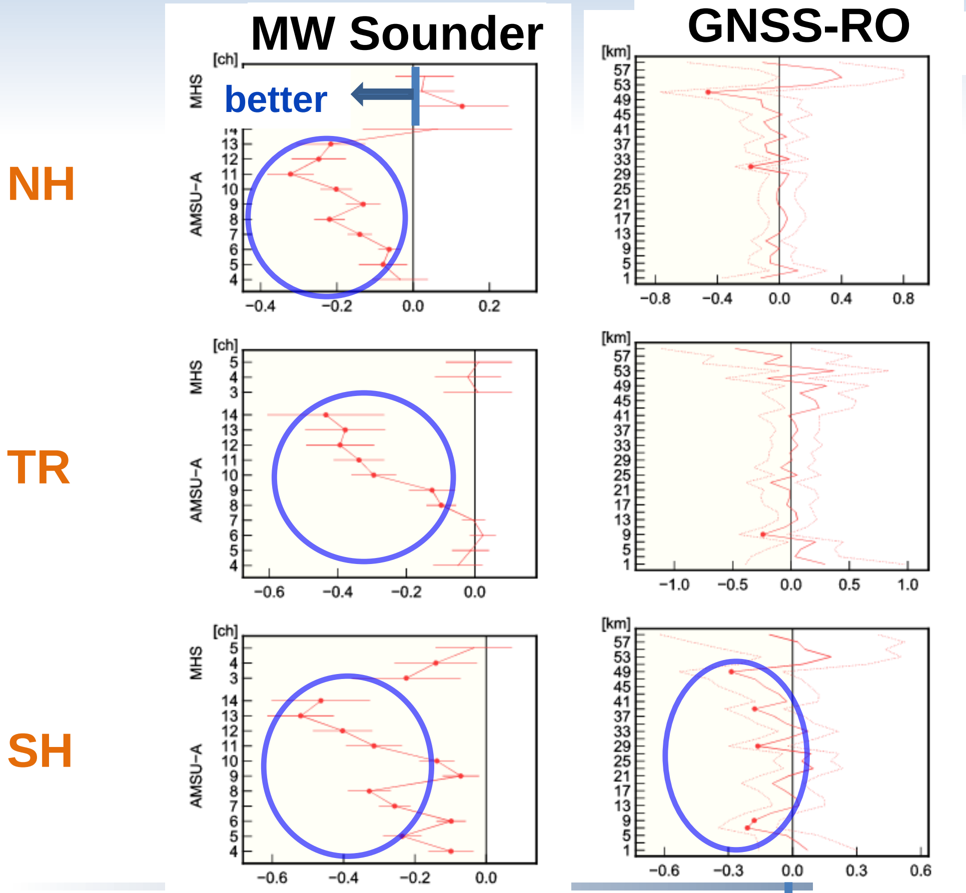
TL959(0.1875deg.) / 100 Layers up to 0.01hPa

4D-Var (inner loop: TL319)

Assimilation window: 6 hr (-3~+3 hours)

RTM for assimilation: RTTOV 10.2

FG fit to observations



START:20150710_END:20160211,
Total 128 day samples

Changes of standard deviation of FG departure .

Improvement of temperature sensitive channels of AMSU-A (stratosphere and upper troposphere).

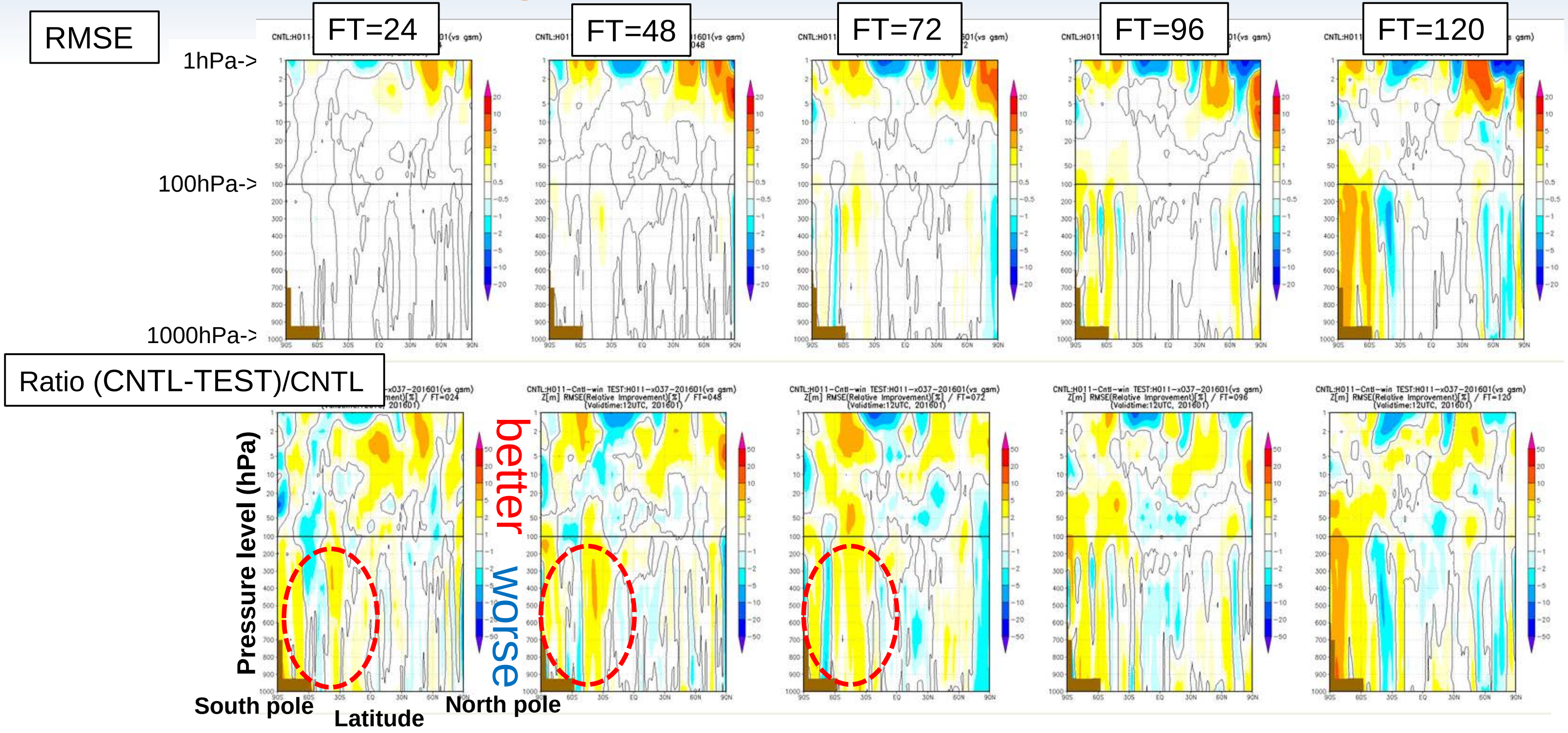
Large improvements of GNSS RO in the Southern Hemisphere.

AMSU-A and GNSS RO showed consistent positive results.

Negative value indicates improvements

Change in RMSE of geopotential height forecast

Warm color indicates improvement



Improvements in geopotential height forecast in the Southern Hemisphere

RMSE is against own analysis

Recent development

1. Usage status of Hyperspectral IR sounder data
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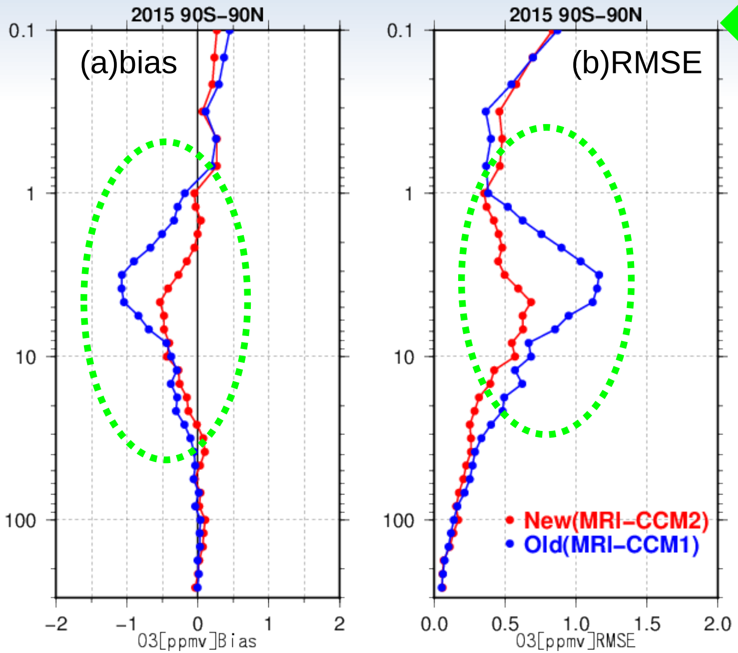
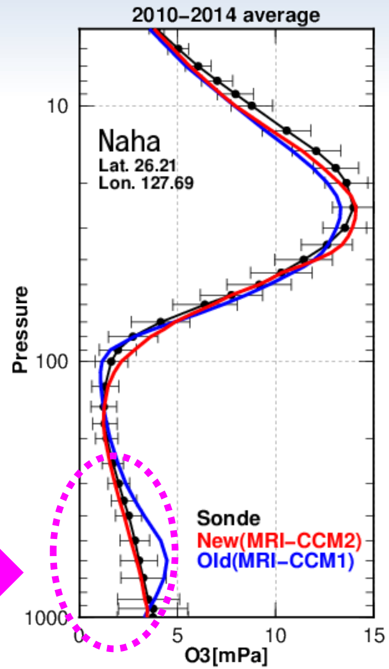
Improvement of Ozone Profile



Comparison of vertical ozone profiles from MLS observation, old model (blue) and new model (red).
(a) Bias and (b) RMSE against MLS observations are shown in the partial volume of ozone.

Comparison of vertical ozone partial pressure profiles from ozonesonde (black) at Naha.
Error bars shows the standard deviations of the observations.



●New Model(MRI-CCM2)
●Old Model(MRI-CCM1)

Improvements of New Model

Stratosphere: Adding the gas-phase reaction [ClO + OH → HCl + O2] and updating the photolysis rate table significantly reduces the negative model bias of ozone in the upper stratosphere.
Troposphere: By adding detailed tropospheric chemistry, vertical distributions of tropospheric ozone agree better with the observations.

Setup of assimilation experiments

Experiments to investigate the impacts of utilizing new ozone profile in the latest global NWP system

Control : current operational system

Test : Control + new ozone profiles

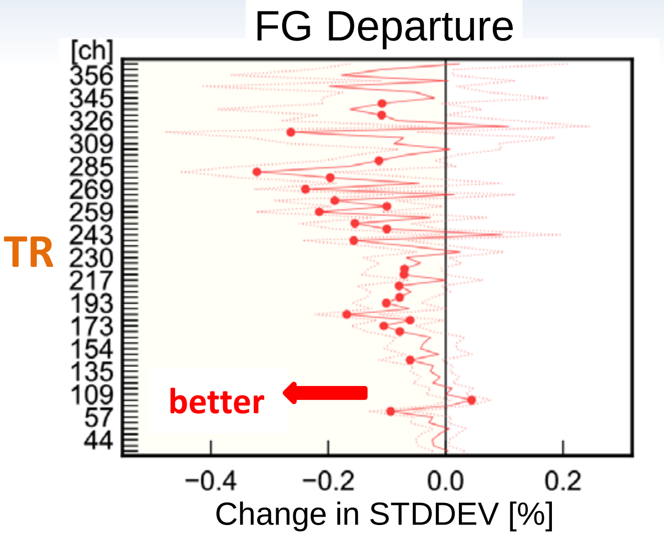
Assimilation Period: From 10 July to 11 September 2015

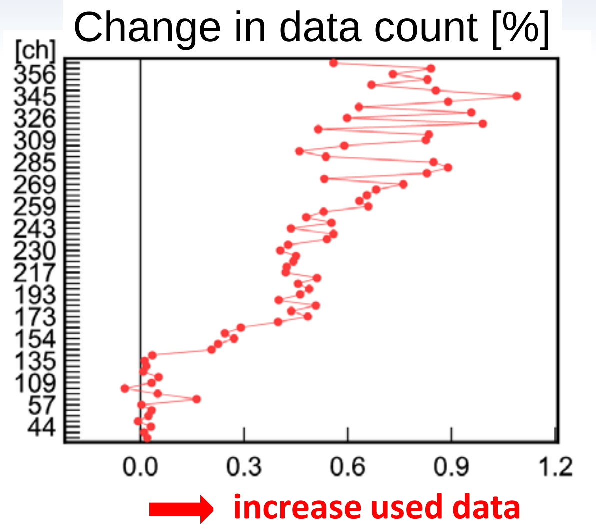
From 10 December 2015 to 11 February 2016

Forecast from 12UTC initial every day

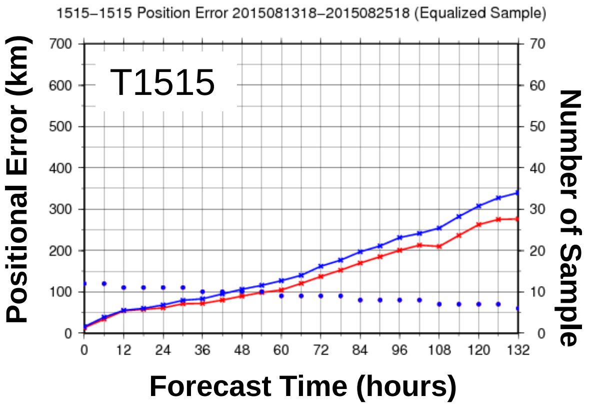
Impact of new ozone on analysis

IASI





Typhoon case



FG fit to IASI are improved in tropics area.
The number of the lower layer of HSS is increased.
A case of typhoon track prediction improved was confirmed.

Summary

- CrIS radiance data are assimilated operational at JMA global NWP system.
- Improved temperature analysis and FG in the upper troposphere and stratosphere.
- Large improvement of geopotential height forecast especially in the southern hemisphere.

- Use of new ozone profile of JMA for HSS produced better temperature analysis. An improved TY prediction was found.
- Better ozone profiles contribute to the accuracy of NWP.

Thank you for your attention.

reference

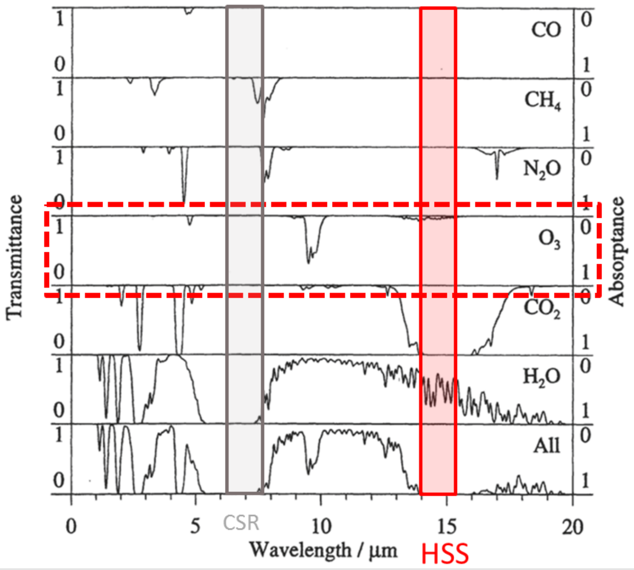
Shibata, K., M. Deushi, T. T. Sekiyama, and H. Yoshimura: Development of an MRI Chemical Transport Model for the Study of Stratospheric Chemistry, Papers in Meteorology and Geophysics, 55, 75-119, 2005.

Deushi, M., and K. Shibata: Development of a Meteorological Research Institute Chemistry-Climate Model version 2 for the Study of Tropospheric and Stratospheric Chemistry, Papers in Meteorology and Geophysics, 62, 1–46, 2011.

Backup slide

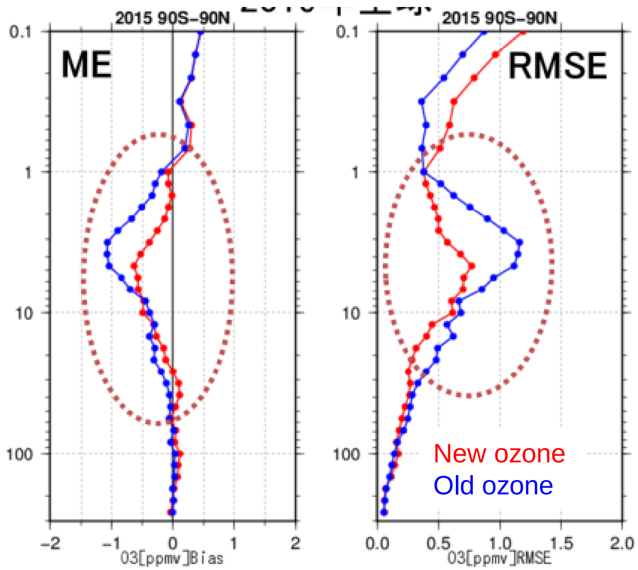
Improvement of Ozone Profile

Ozone Profile for RTTOV10.2 in GA is given by the JMA products .

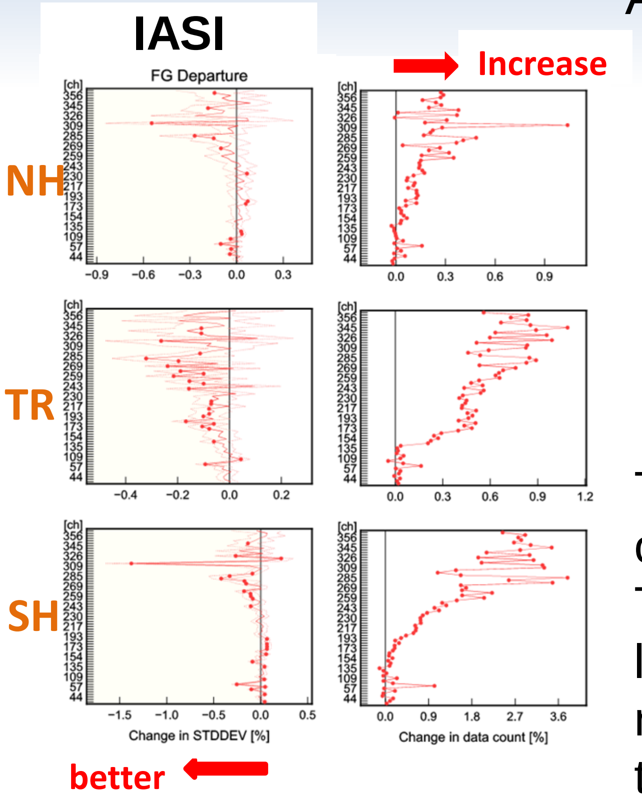


Andrews, An Introduction to Atmospheric Physics (2000)

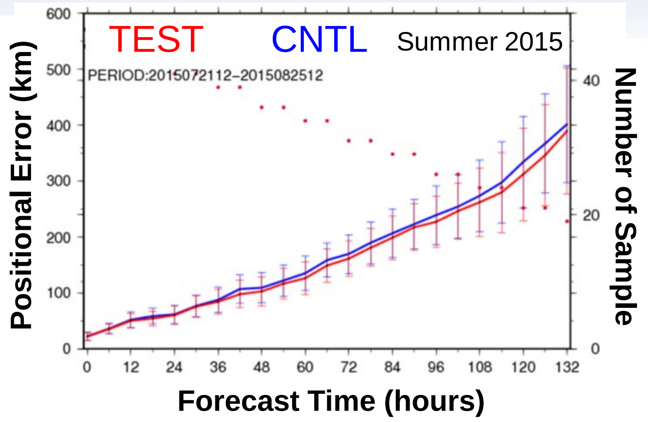
Comparison of New Ozone and Old Ozone
reference to ozone profile of Aura/MLS



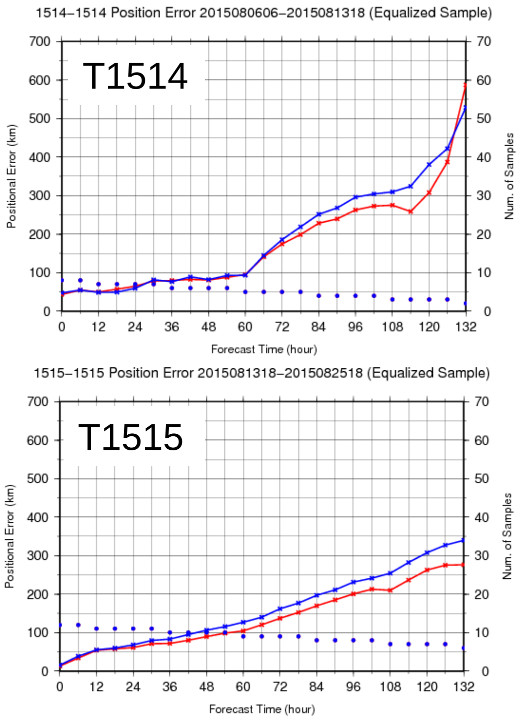
Impact of new ozone on analysis



Average typhoon track forecast



Typhoon case



The number of the lower layer of HSS is increased.
The significant improvement of lower layer temperature field may have reduced errors of typhoon track forecast.