IRFS-2 instrument onboard Meteor-M N2 satellite: measurements analysis

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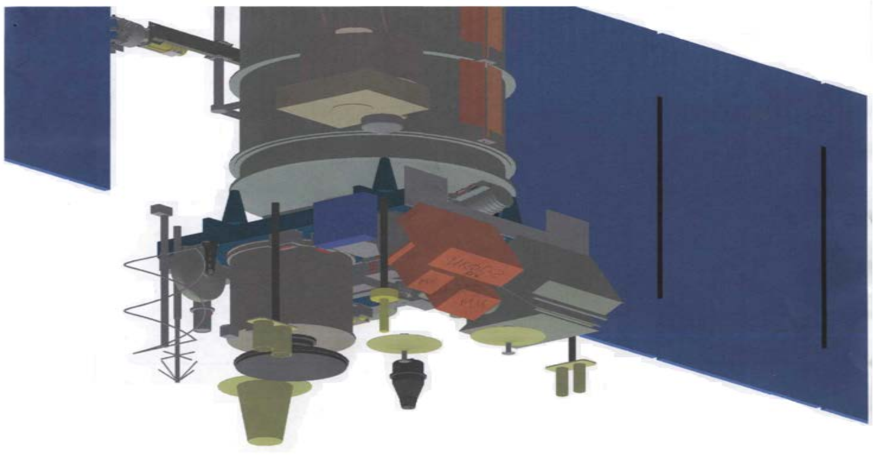
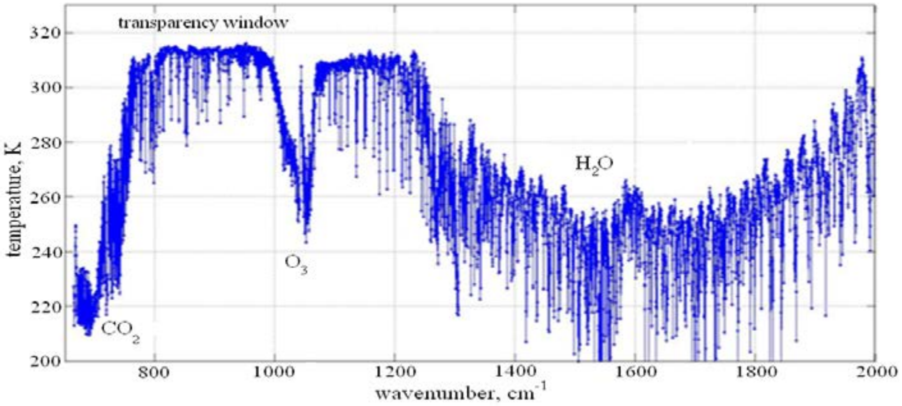
OVERVIEW

- IRFS-2 instrument specifications
- IRFS-2 spectra intercomparisons with SEVIRI and IASI
- Retrieval algorithms
- Temperature and humidity profiles, ozone retrievals
- Conclusions

Space borne Infrared Fourier-Transform Spectrometer IRFS-2

Space borne infrared Fourier-transform spectrometer IRFS-2 measures outgoing infrared radiance and provides data on the atmosphere for numerical weather prediction and other various applications. IRFS-2 is one of the key instruments of the Meteor-M2 satellite. The instrument was developed by Keldysh Research Center together with Krasnogorsky zavod and Bauman State Technical University (Moscow).

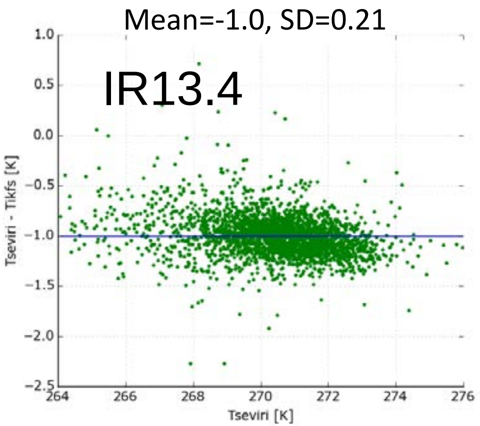


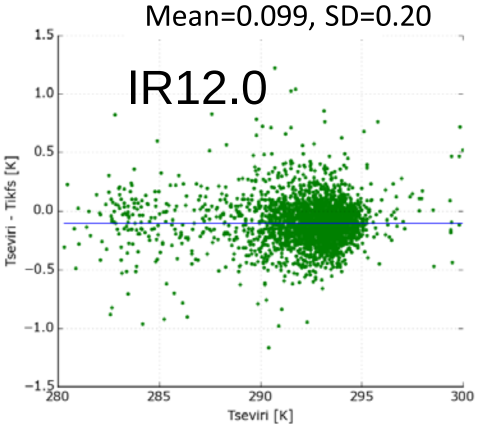


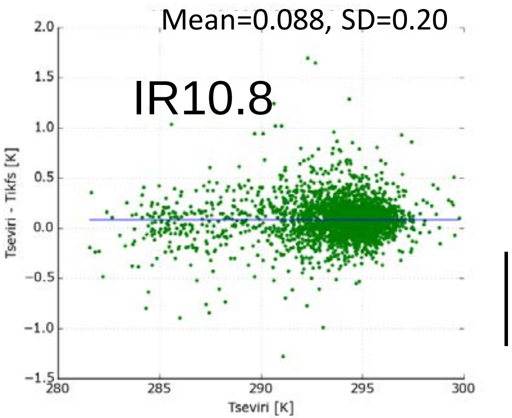
2. Main instrument characteristics

parameter	requirement
spectral range	5-15 μm (660-2000 cm^{-1})
non-apodized spectral resolution	0.4 cm^{-1}
radiometric calibration error (λ=11…12 μm, T=280…300 K), no more than	0.5 K
noise equivalent spectral radiance NESR, [$W \cdot m^{-2}\ sr^{-1} cm$]	$3.5 \cdot 10^{-4}$, λ = 6 μm $1.5 \cdot 10^{-4}$, λ = 13 μm $4.5 \cdot 10^{-4}$, λ = 15 μm
instantaneous field of view (IFOV) spatial resolution at sub-satellite point	40 mrad 30 km
swath width spatial step	1000…2500 km 60…110 km
sampling period	0.6 s
data rate	580 kb/s
mass	50 kg
power consumption (orbit average)	50 W

Intercomparison of IRFS-2 and SEVIRI (Meteosat-10)

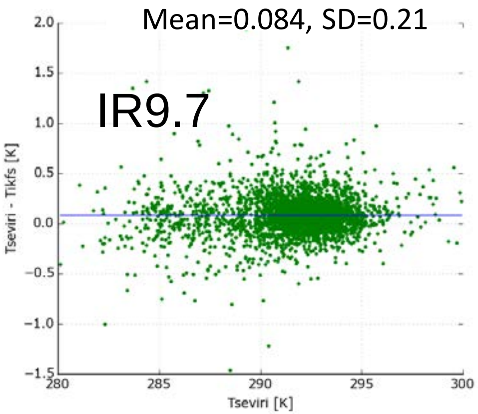


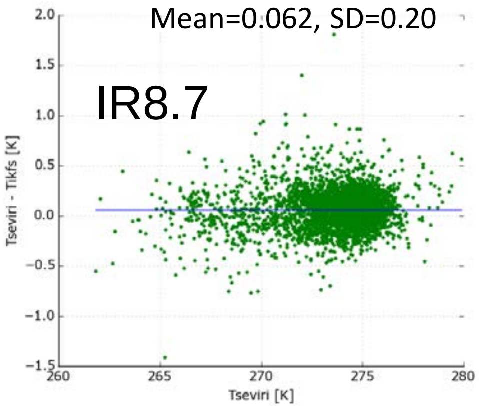


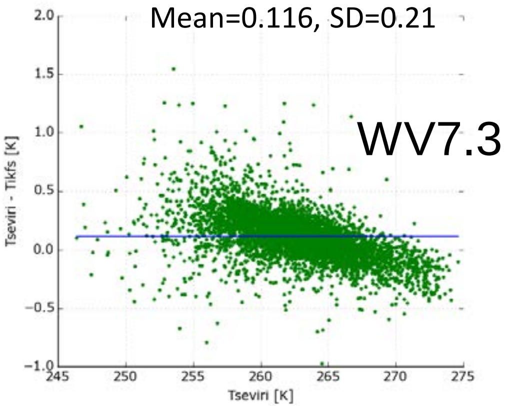


Time difference between observations less than 15 min;

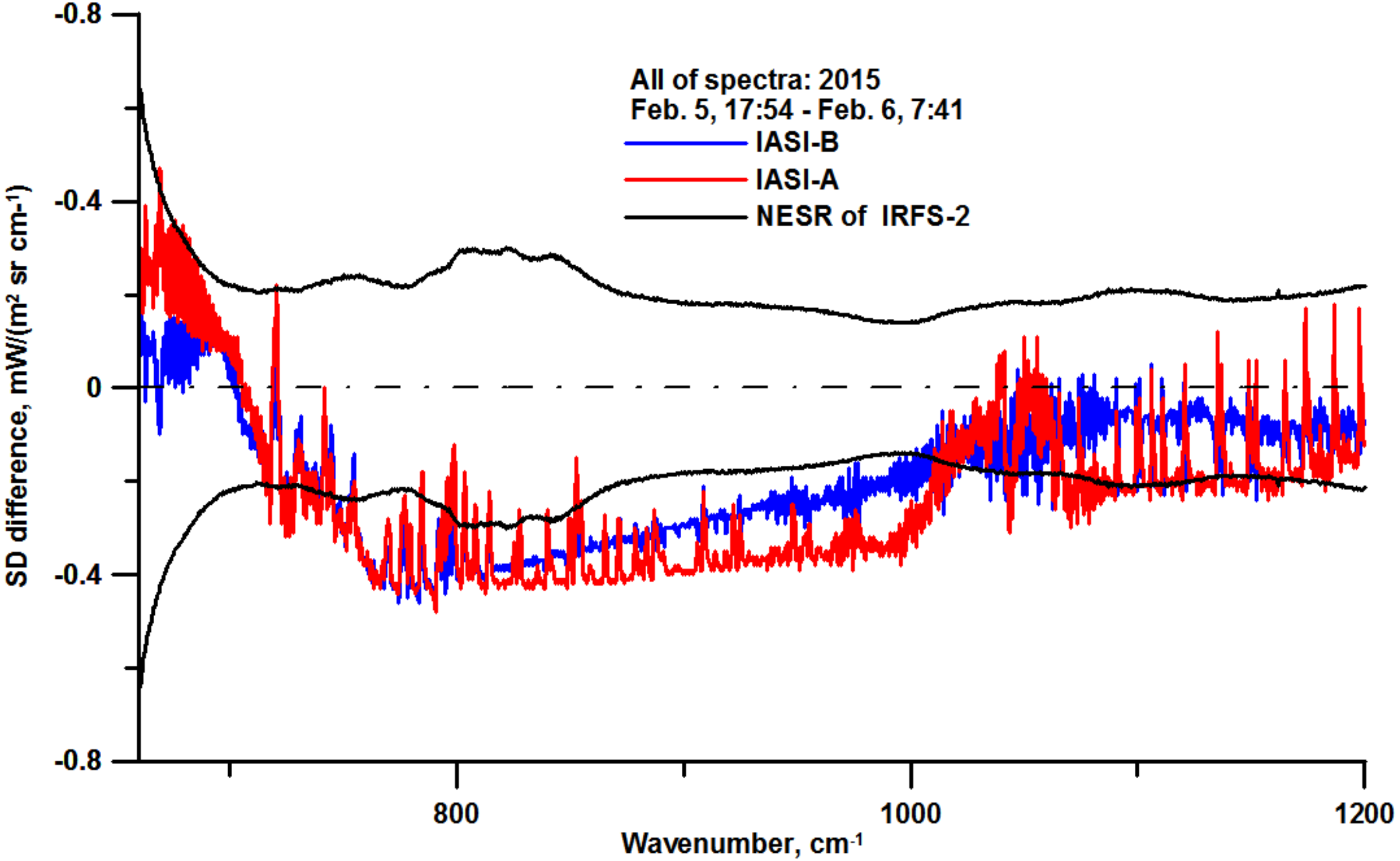
$$\left|\frac{\cos(ZA_{leo})}{\cos(ZA_{geo})} - 1\right| < 0.01$$



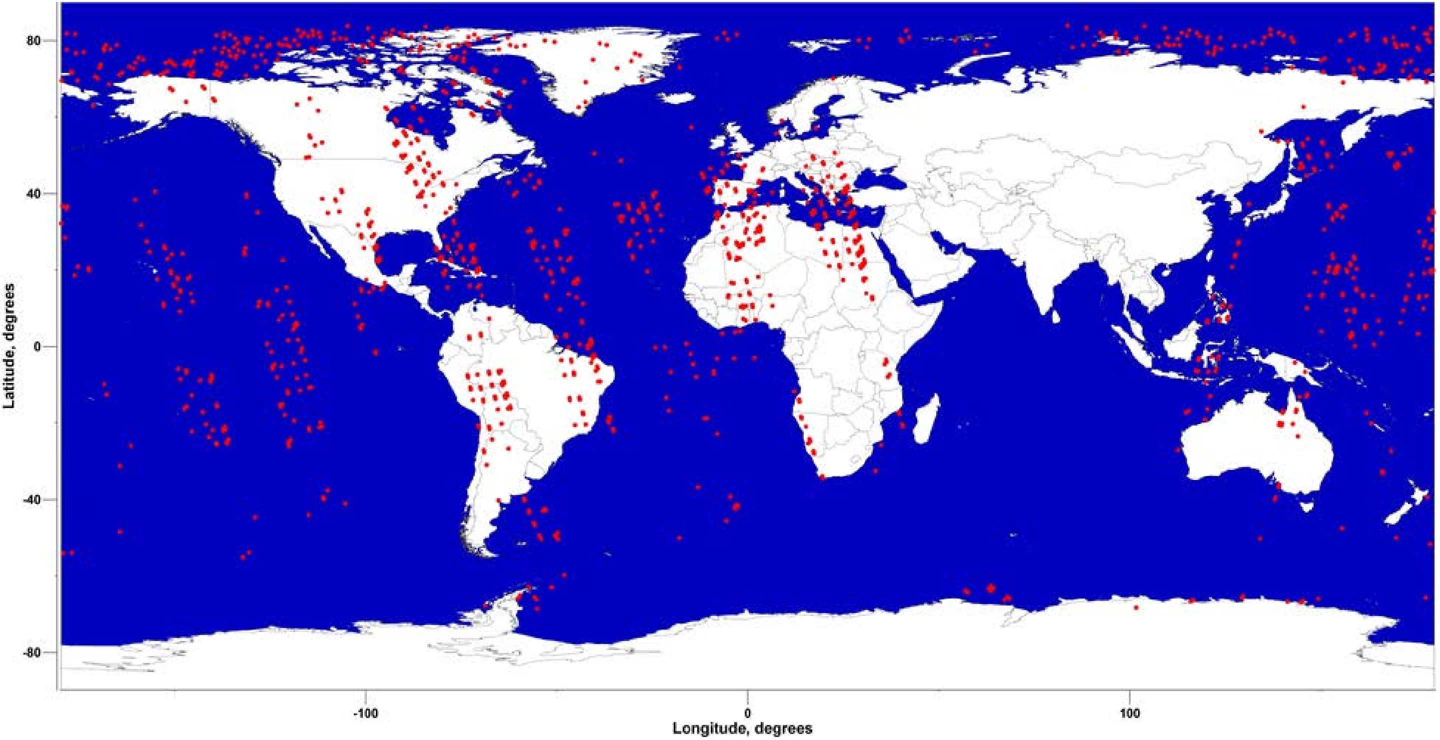




Statistical comparison of outgoing radiation measurements by 3 instruments: IRFS-2 and IASI-A, -B : Difference between SD of radiances: IRFS-2 minus IASI



IRFS-2 and IASI-B **selected measurements pairs**, July 22-23, 2015, Land and Sea



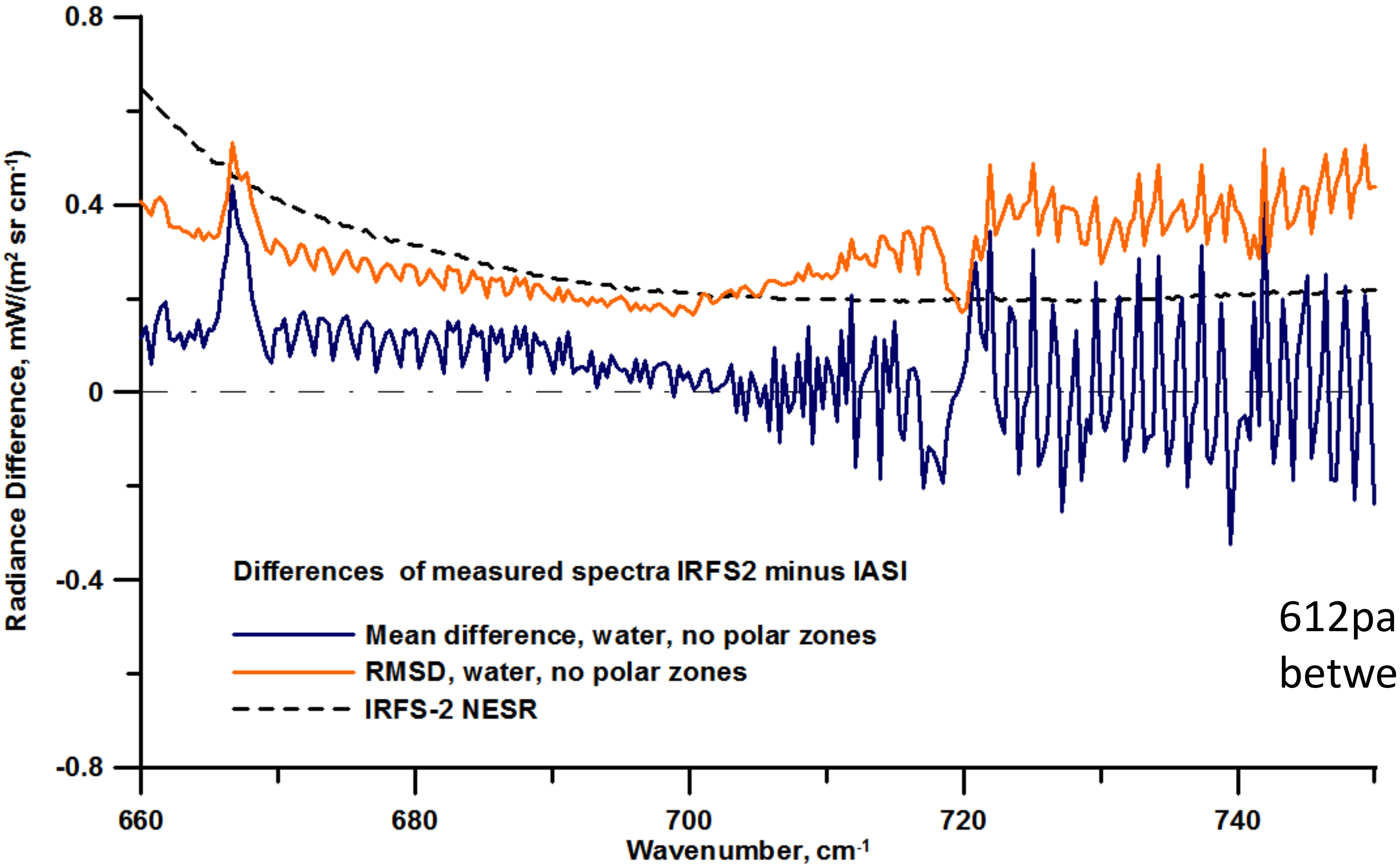
Selection : Clear sky,
Time difference~20min,
Pixels centers distance < 10km,
Satellite zenith angles difference < 2°

368 pairs over the land

874 pairs over the water

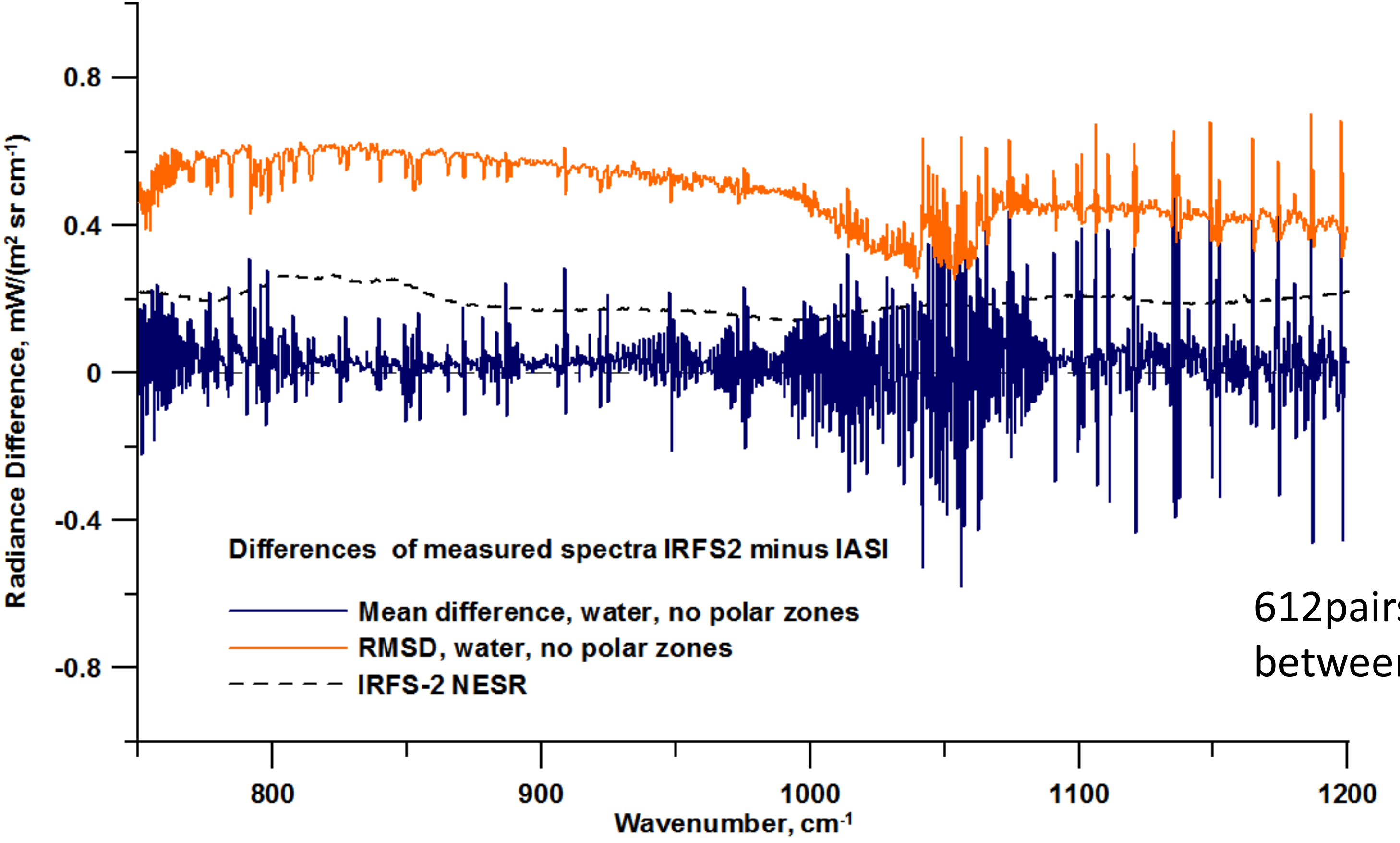
612pairs over the water between 65S and 65N

IRFS-2 and IASI-B measurements pairs, July 22-23, 2015, water surface, 65S – 65N



612pairs over the water between 65S and 65N

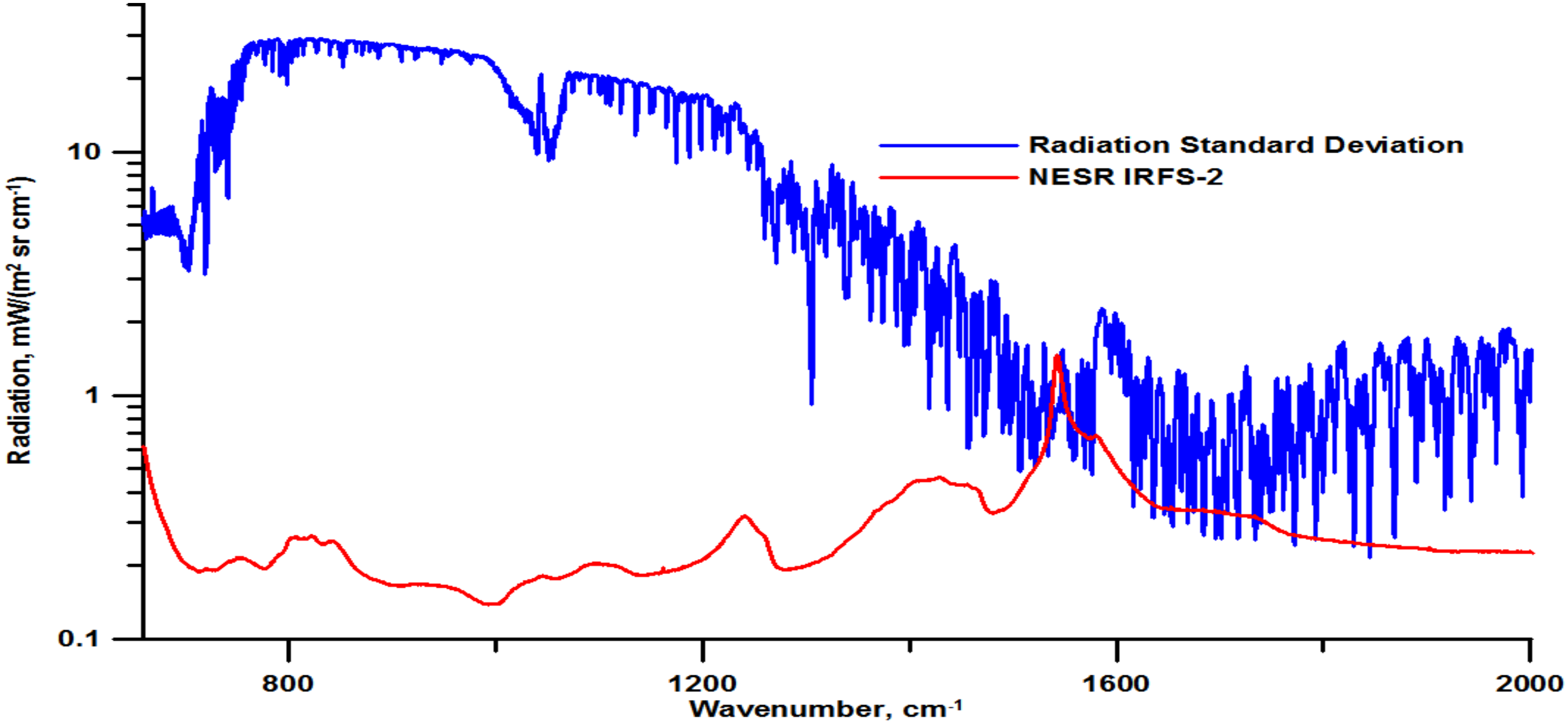
IRFS-2 and IASI-B measurements pairs, July 22-23, 2015, water surface, 65S – 65N



612pairs over the water between 65S and 65N

IRFS-2: SD spectral radiance and measurement NESR

spectra set: 2015 Feb 05 – Apr 04, total number of the spectra is 1041735



Algorithms for retrieval of the atmospheric and surface parameters from IRFS-2 measurements:

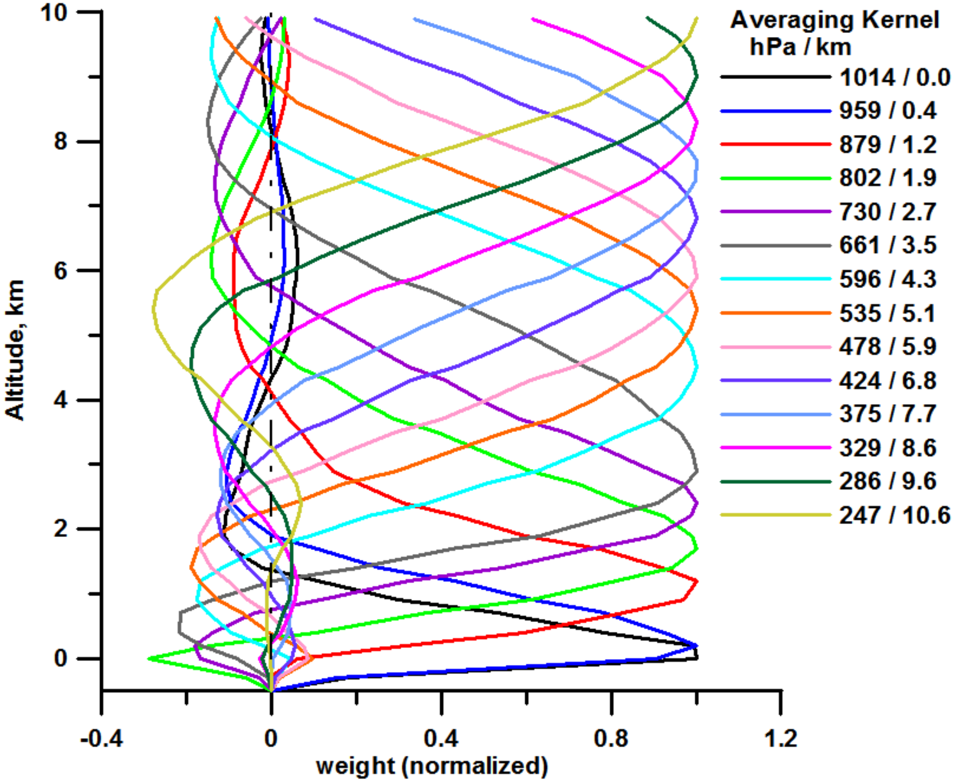
Multiple Linear Regression **(MLR)** for deriving the first guess,

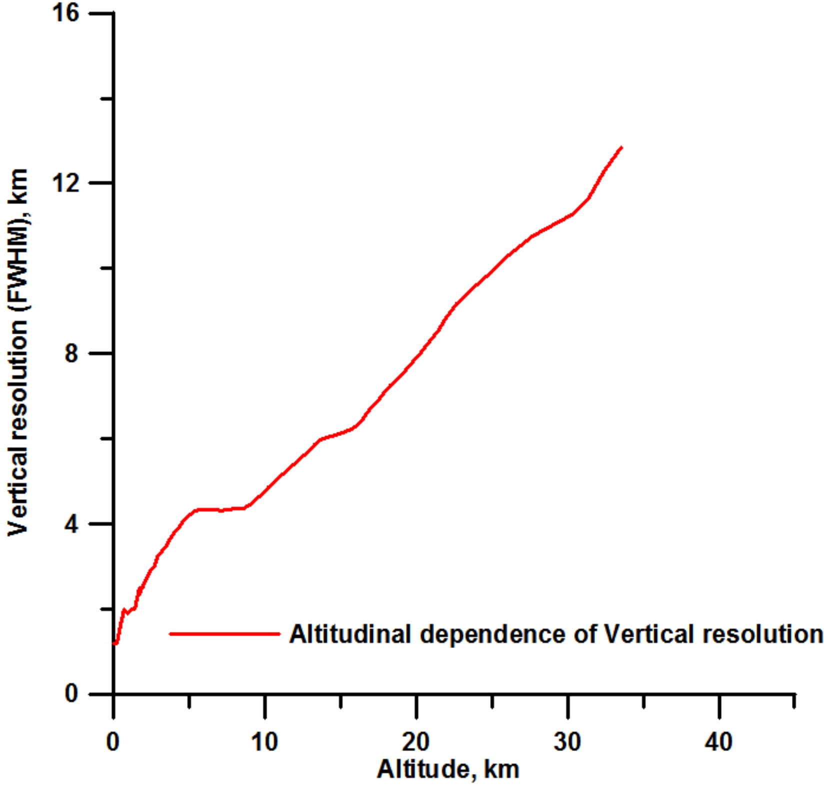
Artificial Neural Networks **(ANN),**

Optimal Estimation **(OE) method**

Radiometric correction of the radiation measurements is preliminary performed

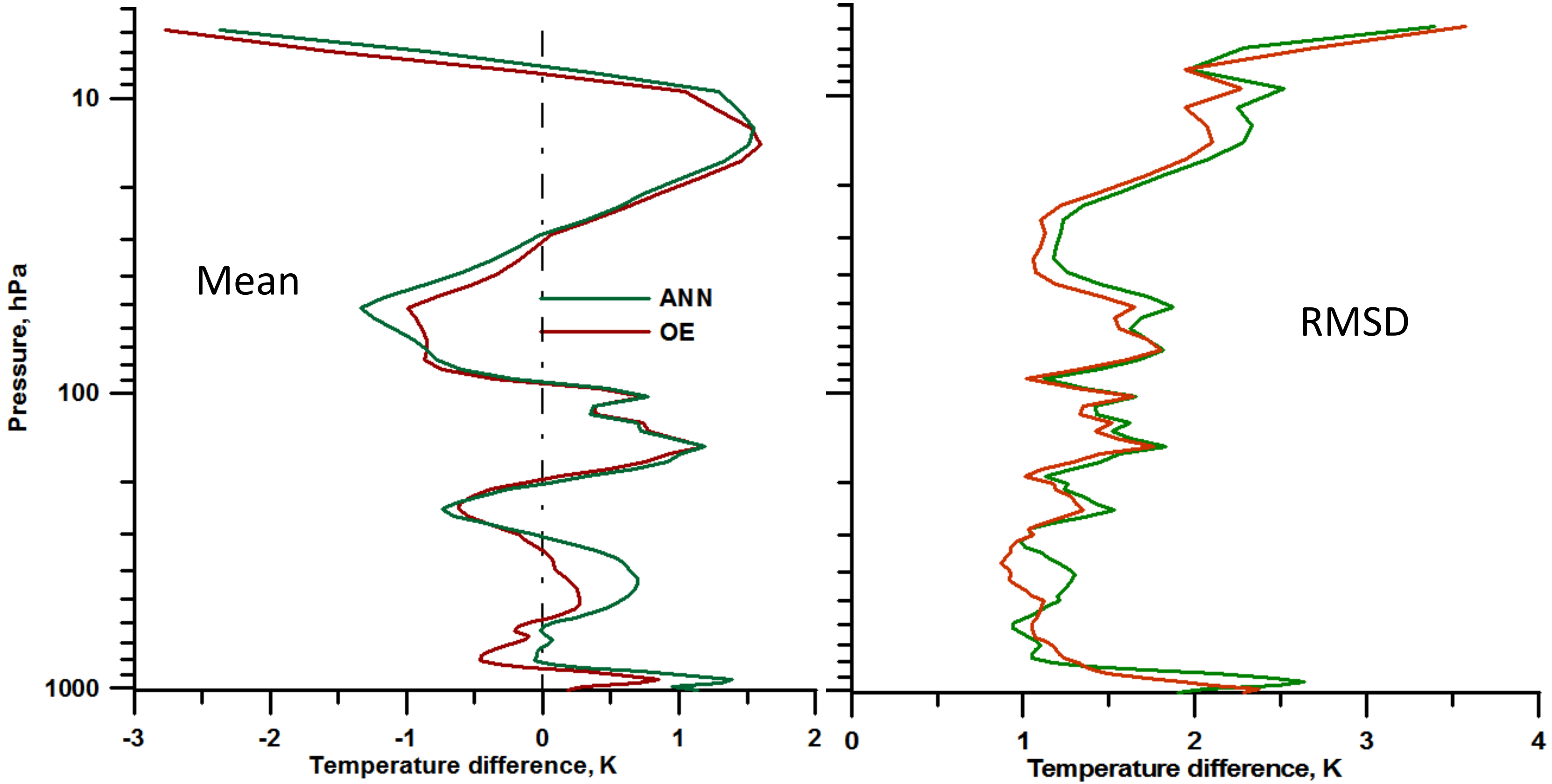
Averaging kernels and vertical resolution of our method in the troposphere temperature profile retrieval





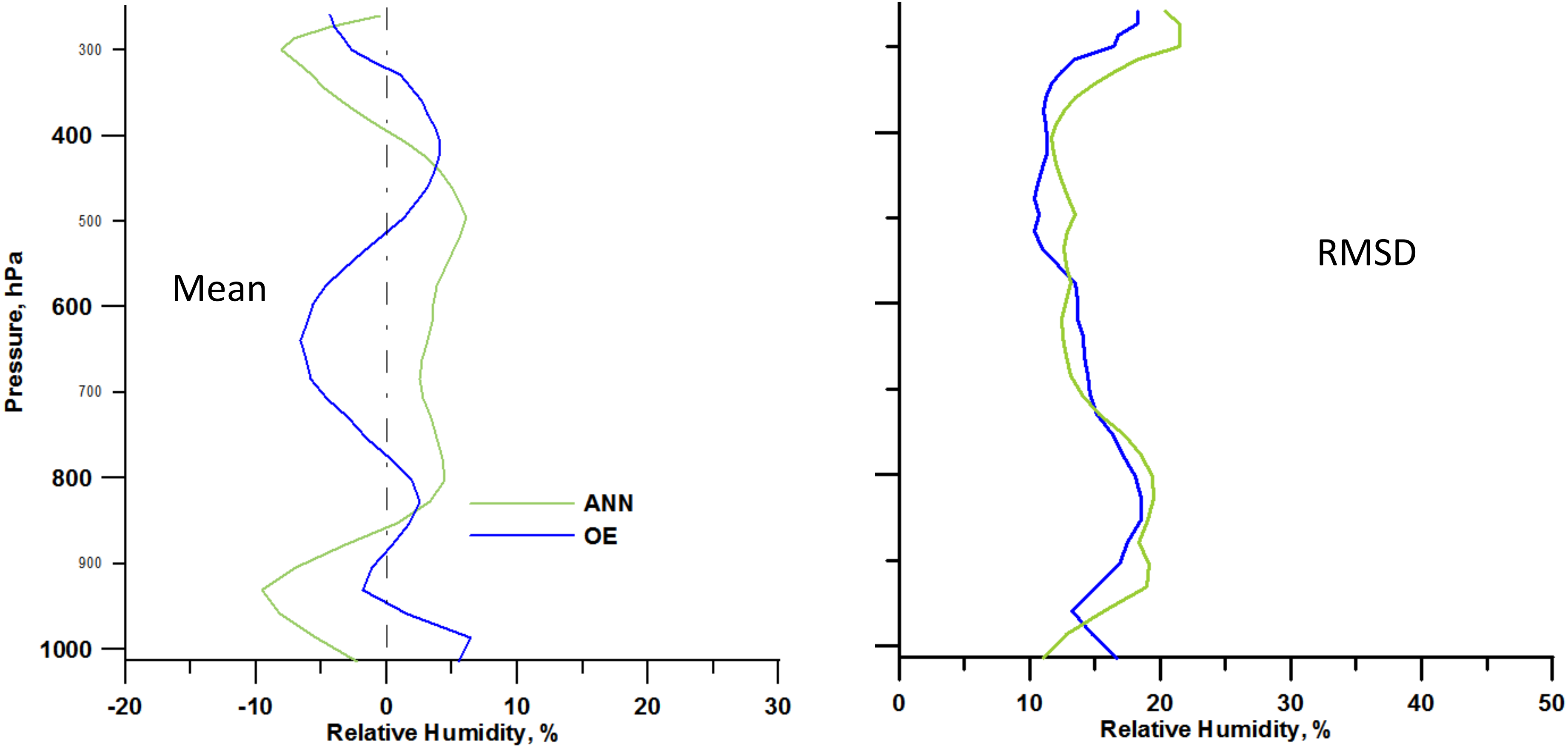
Bias and RMS of temperature profiles : retrieved minus NCEP GFS.

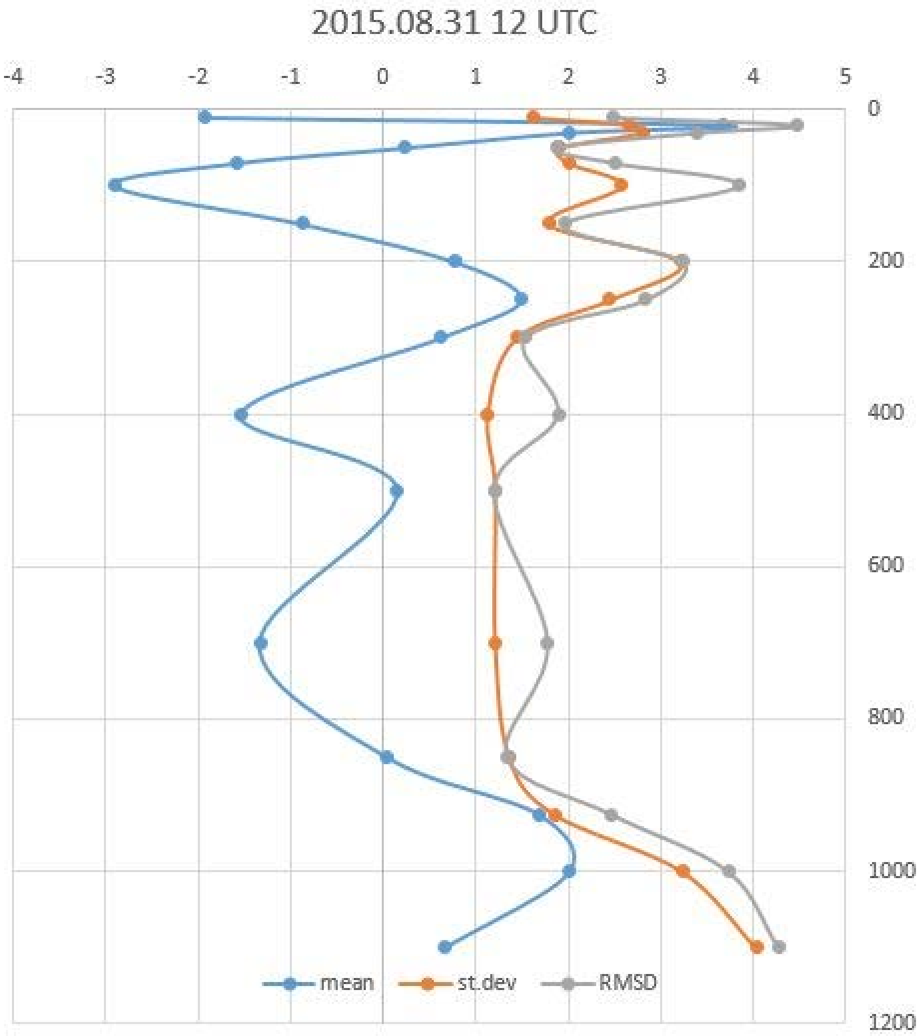
August 20-22, 2015, water surface, latitudes 60S – 60 N, clear sky



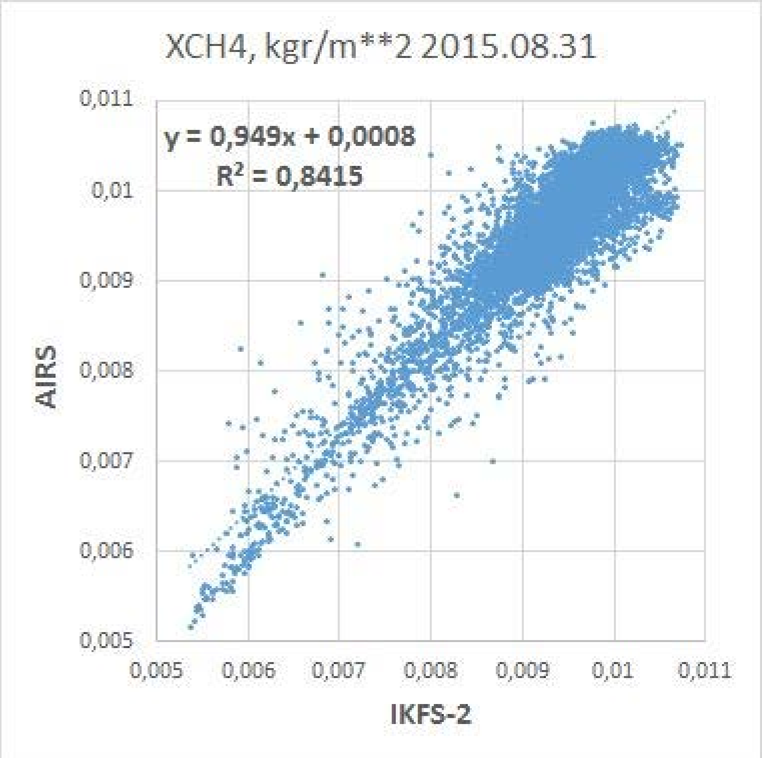
Bias and RMS of Relative Humidity profiles : retrieved minus NCEP GFS.

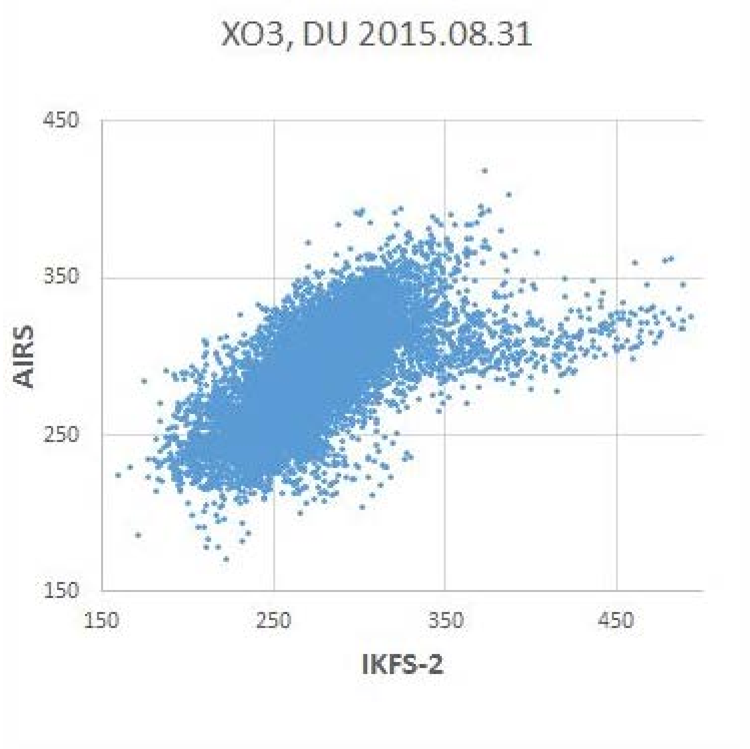
August 20-22, 2015, water surface, latitudes 60S – 60 N, clear sky



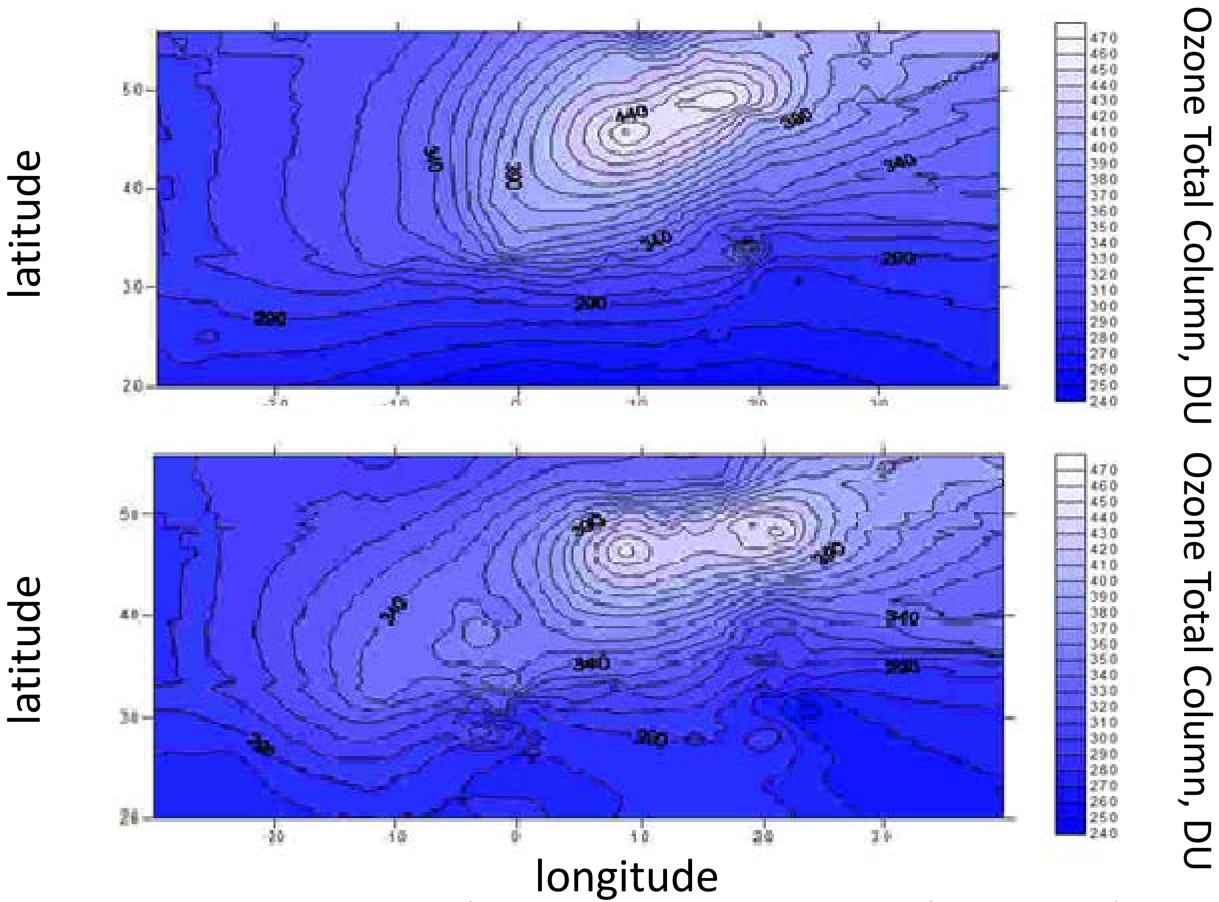


Comparison Temperature profiles vs radiosondes


XCH4, kgr/m**2 2015.08.31
y = 0,949x + 0,0008
R² = 0,8415
0,011
0,01
0,009
0,008
0,007
0,006
0,005
AIRS
0,005
0,006
0,007
0,008
0,009
0,01
0,011
IKFS-2


XO3, DU 2015.08.31
450
350
250
150
AIRS
150
250
350
450
IKFS-2

Ozone Total Column. IRFS-2 data (top figure) and OMI data (bottom figure)



Summary

1. IRFS-2 Fourier spectrometer onboard Meteor-M N2 is healthy.
2. Comparisons of IRFS-2 measurements with SEVIRI and IASI data show:
   - Variability of IRFS-2 spectrum vs. IASI spectrum variability is relatively close
   - Mean difference of IRFS-2 and IASI spectrum in selected measurement pairs is close to zero
   - SD difference of IRFS-2 and IASI spectrum in selected measurement pairs is less than NESR in 15um band and less than 0.6 mW/(sr m^2 cm^{-1}) in transparent windows
3. According to the preliminary estimates, temperature and humidity vertical profiles retrieved by MLR, ANN and physical algorithms give us the RMSE of 1-3K and 10-15% in comparison with the NCEP GFS data.

Acknowledgements

We thank

- NCEP for possibility of using GFS data
- Eva Borbas and other colleagues from CIMSS/SSEC WU for possibility of using data of atmospheric model SeeBor and the global IR land surface emissivity database
- International TOVS Working Group and personally Dr. Mitch Goldberg and Dr. Niels Bormann for the support of my trip to ITSC-20

THANK YOU
FOR YOUR ATTENTION