RUSSIAN FTIR SPECTROMETER (IKFS-2) FOR METEOROLOGICAL SATELLITES: FLIGHT EXPERIENCE AND FURTHER DEVELOPMENT

Presented to CGMS-48 Plenary Session, HSIR Observations, Agenda 4.2

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Report prepared based on inputs from colleagues at Roscosmos & Roshydromet

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Outline of Presentation

IKFS-2 characteristics and performances

Atmospheric sounding products:

- ***atmospheric temperature and humidity profiles***
- ***total ozone column (TOC)***
- ***CO_2 column-averaged dry-air mixing ratio (XCO2)***

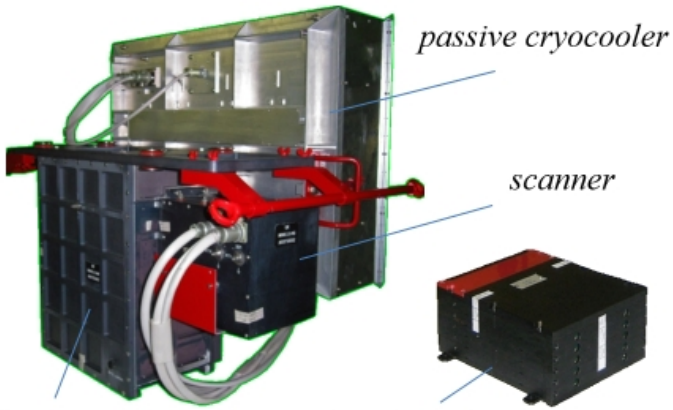
Assimilation trials

Technical characteristics of Russian promising FTIR spectrometers

Advanced IR Sounder IRFS-2

Parameter	*Units*	*Value*
Spectral range: wavelength wave number	μm cm^{-1}	5-15 2000-665
Reference channel wavelength	μm	1.06
Maximum optical path difference (OPD)	mm	17
Radiometric noise (NESR)	mW·cm/m2·sr	0.15-0.3
Spatial resolution (at sub-satellite point)	km	30
Swath width and spatial sampling	km	2500, 110 2000, 100
Duration of the interferogram measurement	s	0.6
Mass	kg	45-50
Power	W	50

Spectral range	*Absorption band*	*Application*
665 to 780 cm^{-1}	CO_2	Temperature profile
790 to 980 cm^{-1}	Atmospheric window	Surface parameters (T_s, ε_ν), cloud properties
1000 to 1070 cm^{-1}	O_3	Ozone sounding
1080 to 1150 cm^{-1}	Atmospheric window	T_s, ε_ν,; cloud properties
1210 to 1650 cm^{-1}	H_2O, N_2O, CH_4	Moisture profile, CH_4, N_2O, column amounts



It was launched on board of the Russian Meteor-M No.2 polar-orbiting (or LEO) meteorological satellite on **July 8, 2014,** Equatorial Crossing Time 09:00 desc

The launches of the next4 instruments are scheduled for the LEO (inclination ~98.6°) satellites of Meteor-M series:

2021: No.2-3, ECT 09:00 desc
No.2-4, ECT 15:00 asc
2025: No.2-5, ECT TBD
No.2-6, ECT TBD

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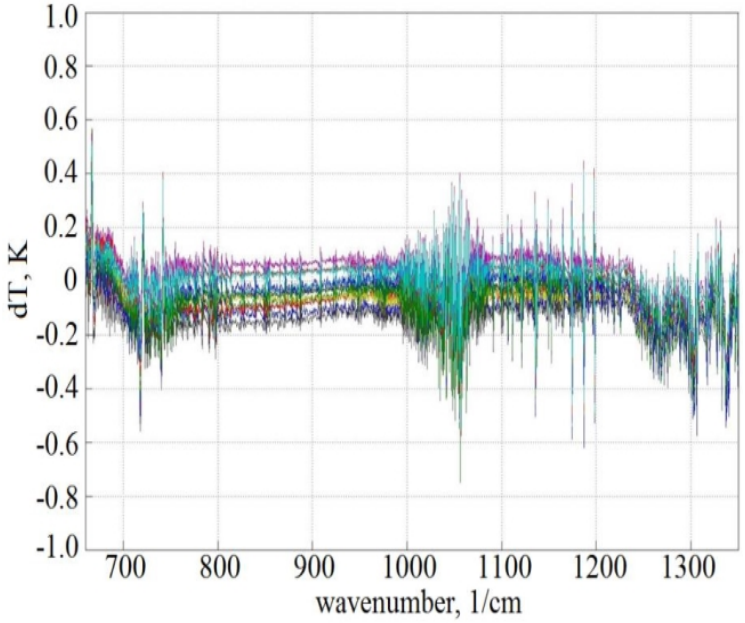
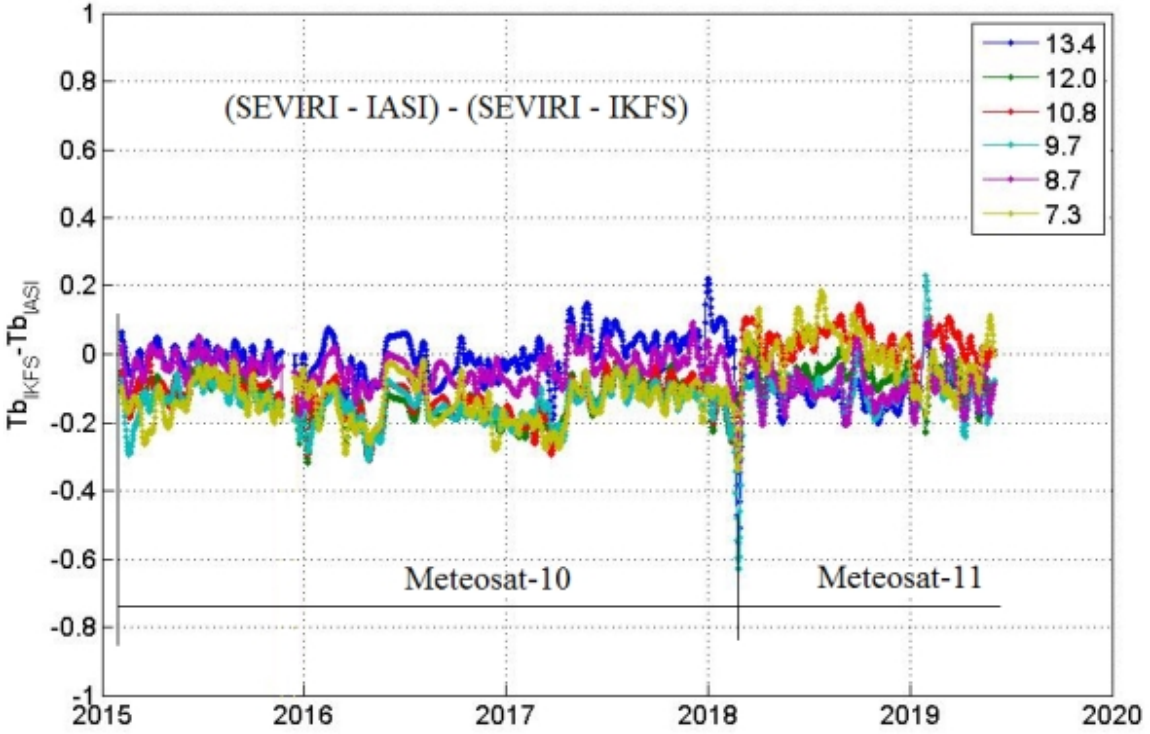
IKFS-2 characteristics and performances

Daily averaged (IKFS-IASI) BT differences from July 2015 to June 2017 (once per 2 months)



IKFS and IASI intercomparison results in different SEVIRI spectral channels by double differences method



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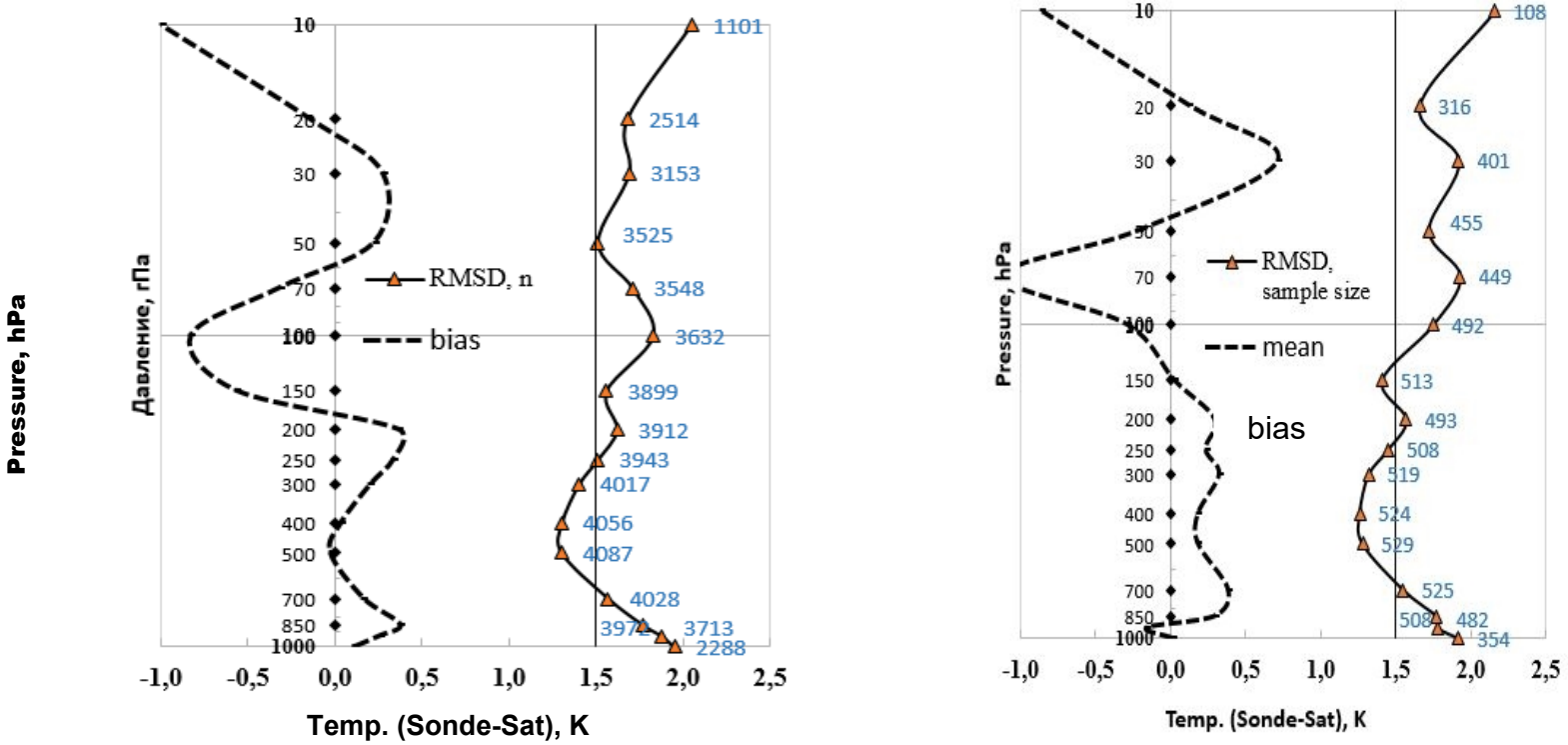
Atmospheric sounding products

Temperature Profile Error Statistics (retrievals vs radiosonde data)



The averaging period January-November 2018 (left side) and of March 2019 (right side)

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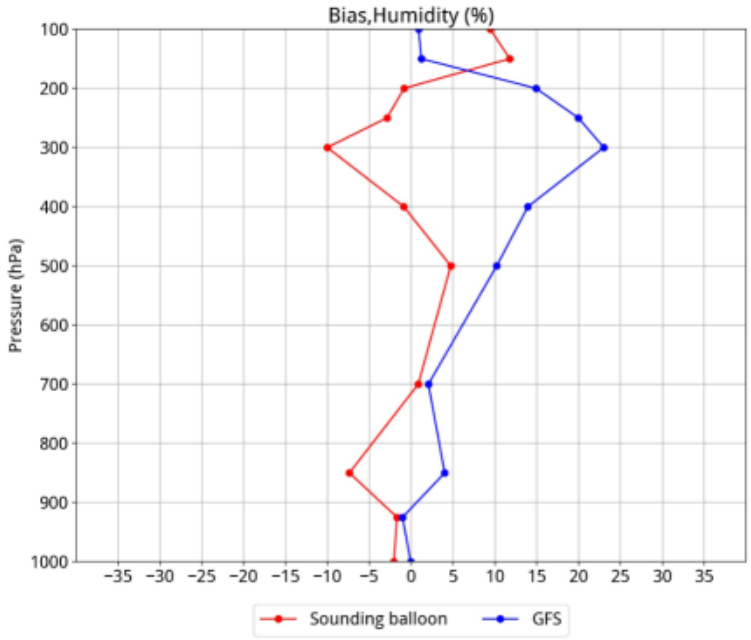
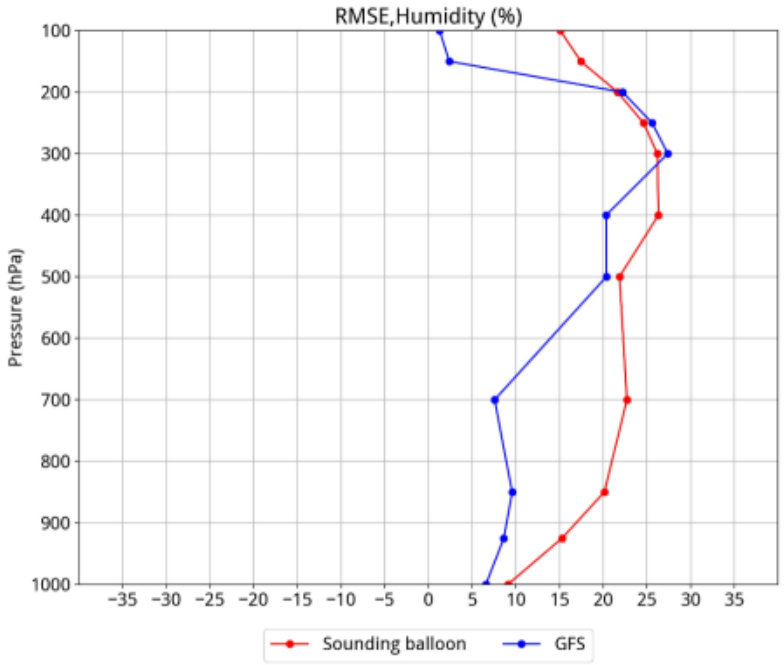
Atmospheric sounding products

Relative Humidity Profile Error Statistics





At least 1000 pairs of comparisons with Global Forecast System data

At least 300 pairs of comparisons with radiosondes

Russian Far-Eastern region
July, 2020

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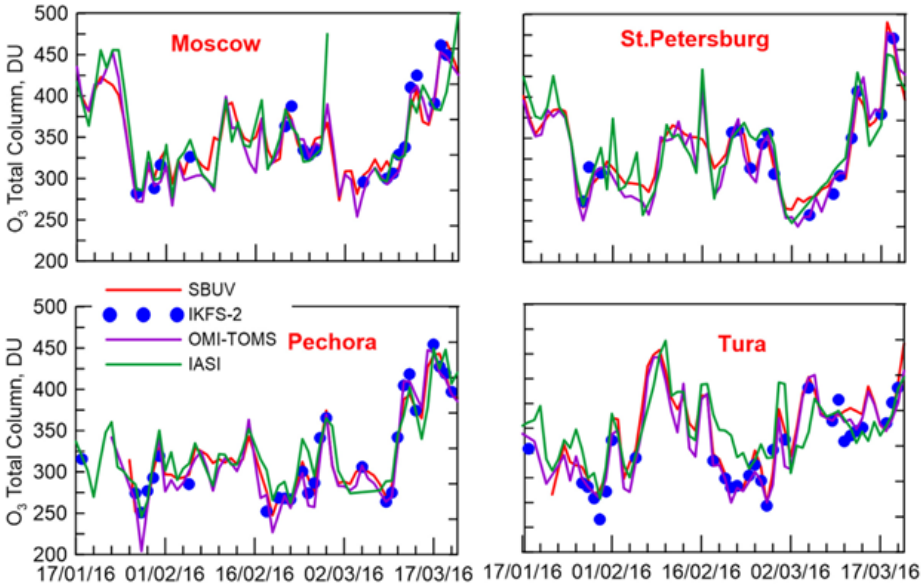
Atmospheric sounding products

Total ozone column (TOC)

Comparison of TOCs estimates derived from different spectrometers data

Sensors	March–May			June–August			September–November		
	R	Bias (%)	SD	R	Bias (%)	SD	R	Bias (%)	SD
IKFS-2-OMI	0,99	–0,1	2,7	0,98	–0,1	2,1	0,99	–0,1	3,1
IKFS-2-GOME-2	0,98	0,7	4,0	0,97	–1,9	2,3	0,99	–1,2	3,9



TOC evolution

estimated from different satellite data (IKFS-2, OMI, SBUV, and IASI) at several Russian ground- based stations. Winter 2016

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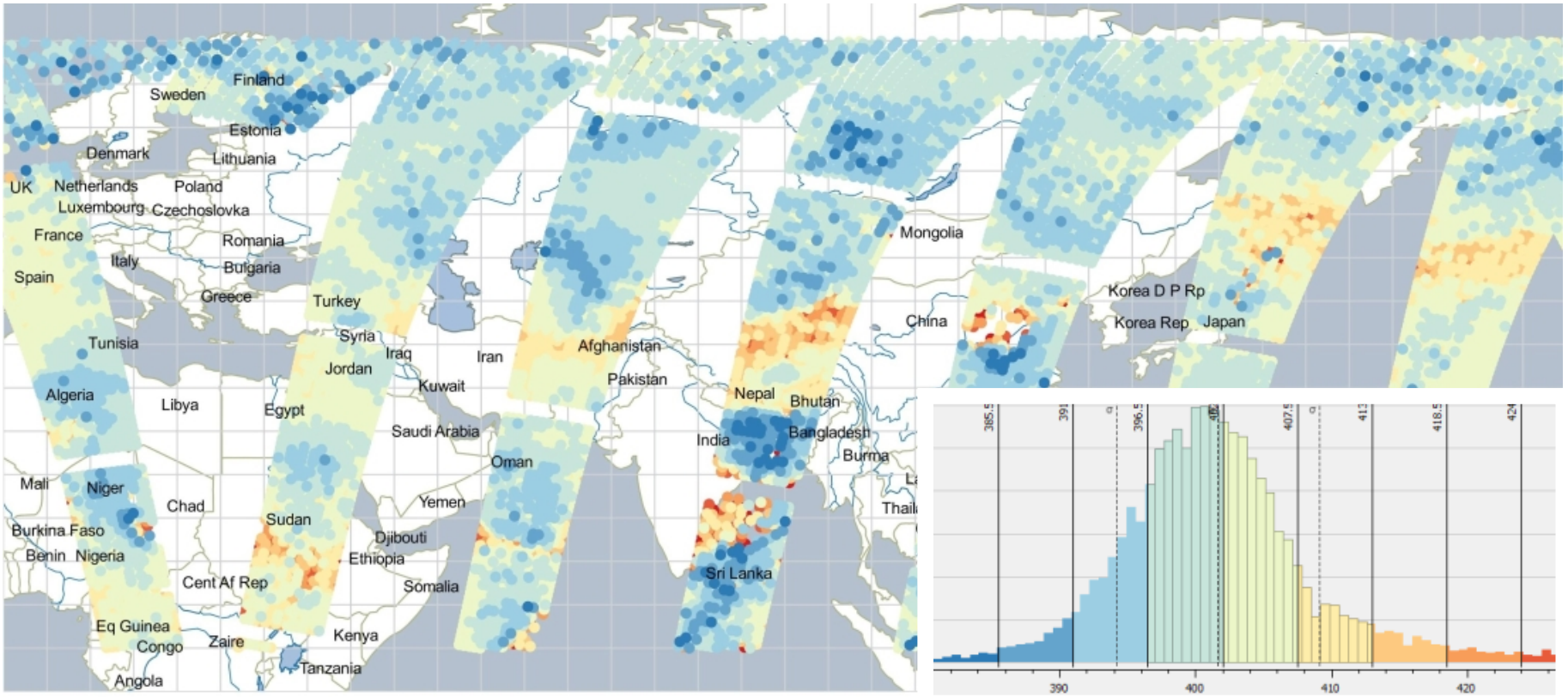
Atmospheric sounding products

Carbon dioxide mixing ratio (XCO2) distribution, ppm



5 August 2020

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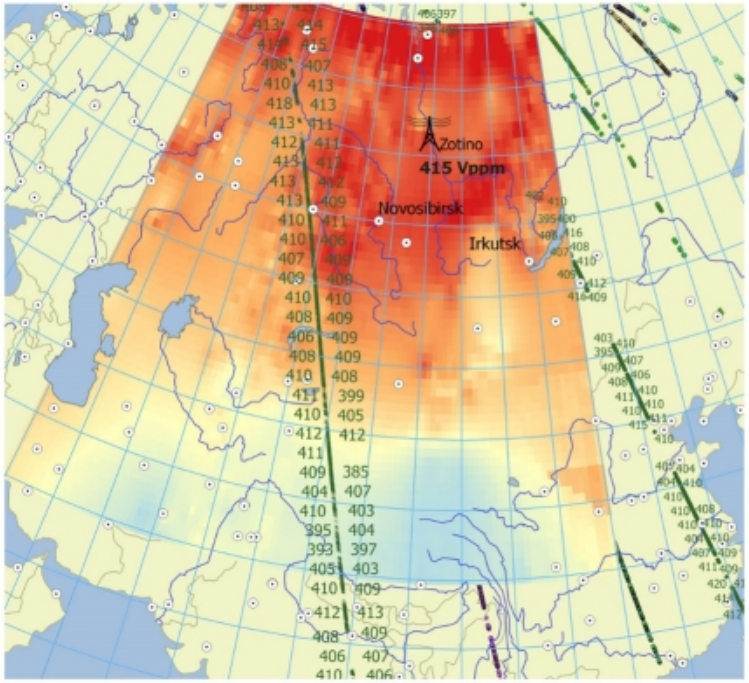
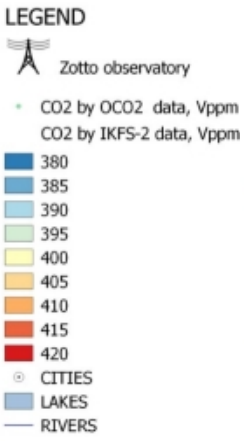
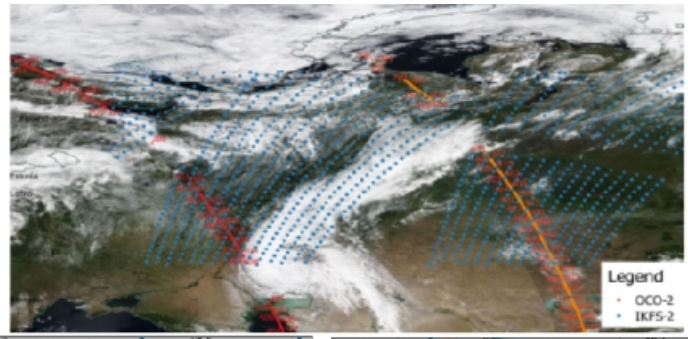
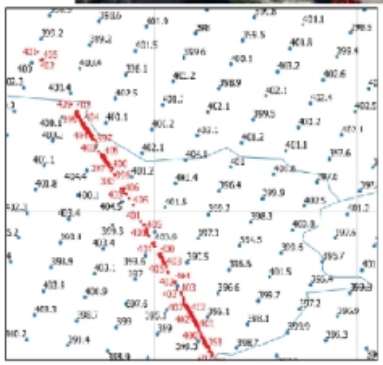
Atmospheric sounding products

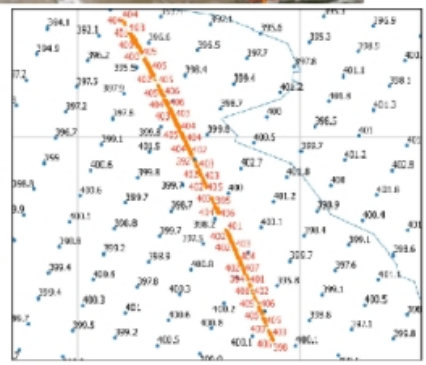
CO_2 product validation: comparison of IKFS- 2 and OCO2-based XCO2 estimates (ppm)











8 April 2019

5 August 2020

Discrepancy between two estimates in average are less than 5 ppm

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Assimilation trials

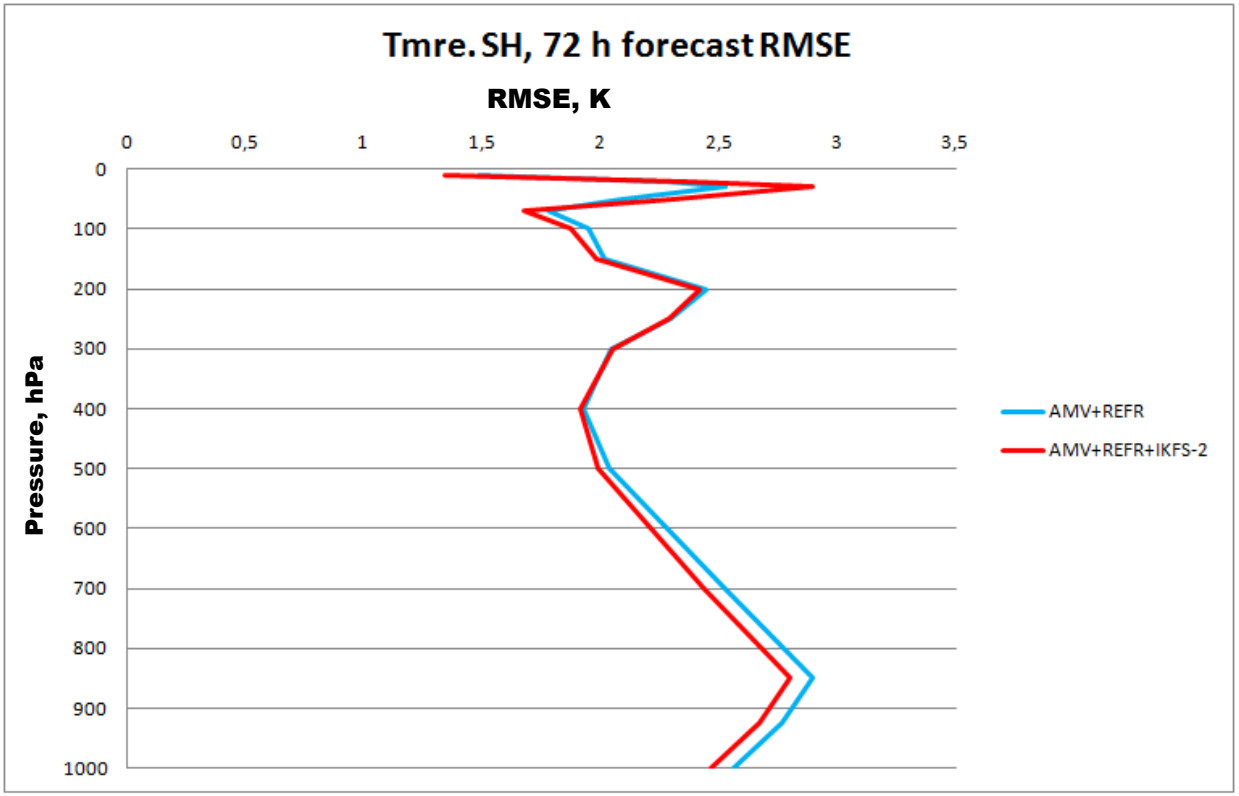
Assimilation of infrared radiances (IKFS-2/Meteor-M No.2) in the Hydrometcenter of Russia

The following procedures were implemented:

1. The analysis of the IKFS-2 measurements accuracy, assessment of the biases (comparison with reference spectra)
2. A cloud filtering scheme (McNally and Watts, 2003)
3. A bias correction procedure (Gayfulin et al., 2017; Harris and Kelly, 2002)
4. Selection of channels subset (20 channels in the 15-μm CO2 absorption band)
5. Numerical experiments on assimilation of IKFS-2 data (the 3D-Var system + SLAV global atmosphere model, Hydrometcenter of Russia):
   - forecasts, computed with the SLAV model and baseline data configuration (conventional data + AMV+REFR);
   - forecasts, computed with the baseline + IKFS-2 data.

Assimilation trials

Numerical experiments on assimilation of IKFS-2 data



RMSEs (K) of three-day temperature forecast in the Southern Hemisphere: without IKFS-2 data (blue) and with IKFS-2 data (red)

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Planned/future hyperspectral infrared sounding

FTIR spectrometer	**IKFS-3** **2029 year**	**IKFS-GS** **2030 year**
Satellite platform	**LEO Meteor-MP (SSO, 820 km, ECT TBD)**	**GEO Electro-M (GSO)**
Spectral range	3.6-15.5 μm (645-2760 cm^{-1}) LW: 645-1200 cm^{-1} MW: 1200-2000 cm^{-1} SW: 2000-2760 cm^{-1}	LWIR: 700-1210 cm^{-1} MWIR: 1600-2250 cm^{-1}
Spectral resolution	0.25 cm^{-1} (nominal) (MPD = 2 cm)	0,5 cm^{-1} (MPD = 1 cm)
Radiometric noise (NEdT@280K)	LW: 0.2…0.3 K MW: 0.2…0.5 K SW: 0.5…2.0 K	LWIR: 0.3…1.0 K MWIR: 0.3…1.8 K SW: 0.5…2.0 K
Radiometric calibration uncertainty	0.3 K	0.5 K
Field of view (at nadir)	IFOV: 14 km (17 mrad) FOV: 50x50 km2 (5 pixels)	8 km
Swath width & spatial sampling	2200 km 30 km	global coverage (60 min) regional coverage
IFG scan period	-	(10-11) s
Mass	120 kg	250-300 kg
Power consumption	120 W	300-400 W
Data rate	3 Mbit/s	150 Mbit/s

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Thanks for attention!

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