

Validation of temperature sounding of the atmosphere from a board of «Meteor-M» No 2 satellite (IKFS-2 device)

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The vertical temperature profiles retrieved from spectral satellite measurements of outgoing thermal radiation by the IRFS-2 instrument ("Meteor M" No 2 satellite) in cloudless conditions are compared with radiosonde data and results of the NCEP GFS analysis. For comparisons, the measurements of IKFS-2 were used for 2 days in each month from November 2015 to November 2016.

Instrument: IKFS-2 is Russian Fourier –interferometer onboard satellite "Meteor M No2". Measurement spectral region of the instrument is 660-2000cm⁻¹, spectral resolution after apodization is equal 0.7cm⁻¹

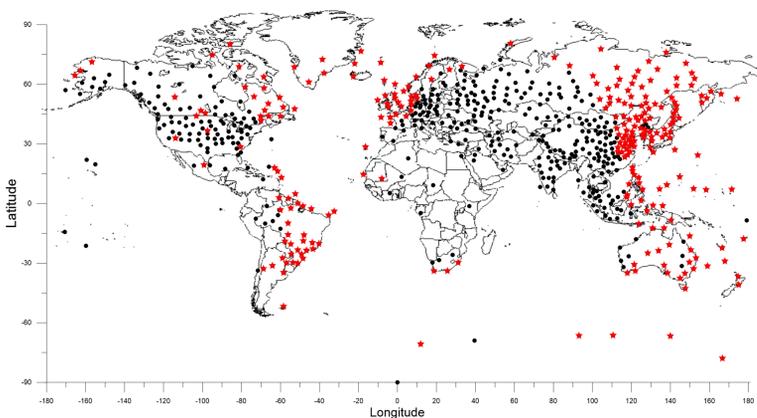


Fig 1. Position of Radiosonde stations. Black rounds – all of stations, red stars – stations, selected in pairs for comparisons. Station positions and radiosonde data have been obtained from Wyoming University internet pages (<http://weather.uwyo.edu/upperair/sounding.html>)

Elimination of maximal temporal and spatial distance between two compared measurement.

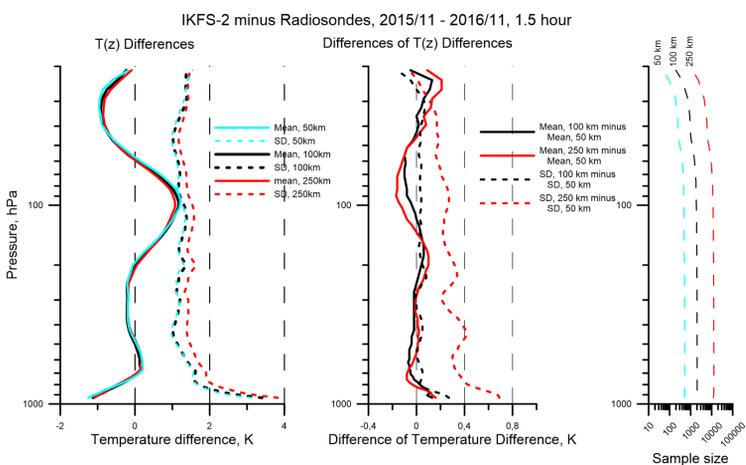


Fig.2. Mean and SD difference between satellite and radiosonde temperature profiles for three values of maximal distance (left figure), differences between these differences (in the middle), number of considered pairs (right figure).

Figure 2 shows, differences between SDs for 250 and 50 km are 0.2 – 0.4 K in the troposphere. But the differences of SDs for 100 and 50km are close to zero. Thus, we selected for the comparison measurements performed at no more than 100 km distance.

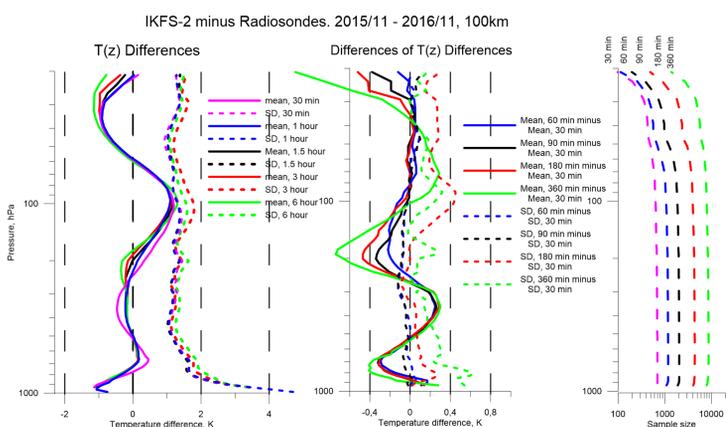


Fig. 3. Mean and SD difference between satellite and radiosonde temperature profiles for five values of maximal discrepancies in time (left figure), differences between these differences (in the middle), number of considered pairs (right figure).

Figure 3 shows, difference between SDs and mean differences for 360, 180 and 30 min are greater 0.3 – 0.4K. But the differences of SDs for 90 and 60 min are close to zero. Thus, we selected for the comparison measurements with no more than 90 min mismatch.

Criterion of quality of measurements S.

$$S = \sqrt{\frac{\sum_{i=1, N_T} (J_i^C - J_i^M)^2 / \sigma_i^2}{N_T}}$$

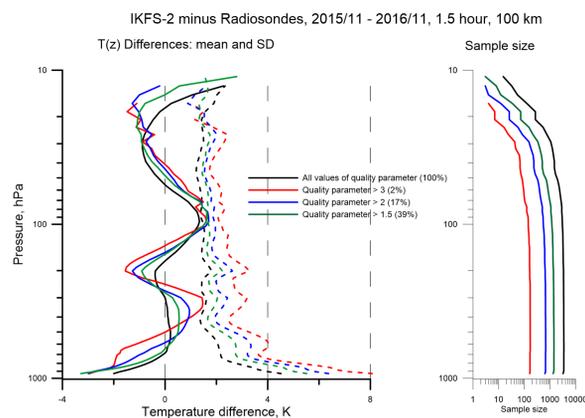


Fig4. Rejected results. Total 3485 measurements
S < 3, rejected 171 (5%)
S < 2, rejected 685 (20%)
S < 1.5, rejected 1442 (40%)

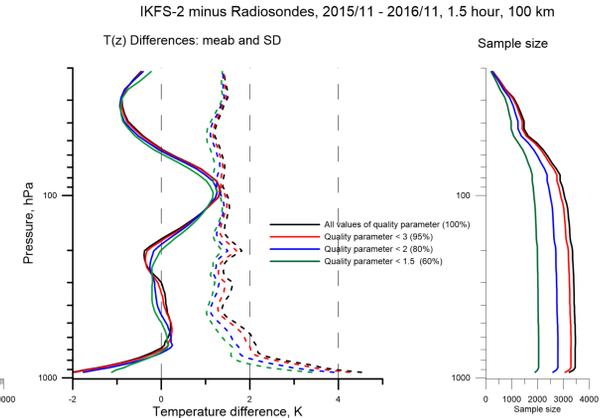


Fig. 5. Accepted results
S < 3, remained 95%
S < 2, remained 80%
S < 1.5, remained 60%

Effect of vertical resolution and results

IKFS-2 minus Radiosondes, 2015/11 - 2016/11, 1.5 hour, 100 km, S < 1.5

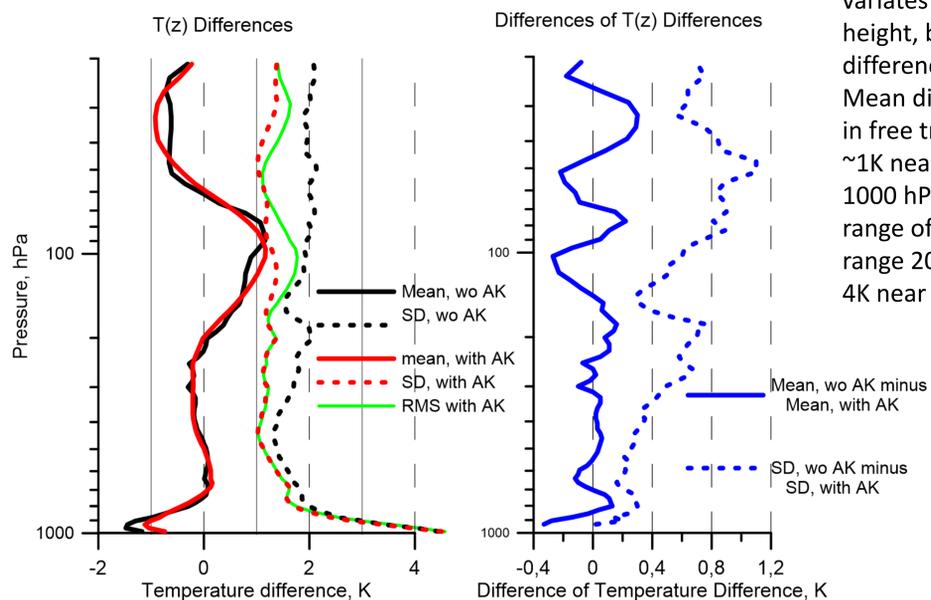


Fig. 6. Effect of vertical resolution fitting on the temperature profiles differences.

We can see, the effect of vertical averaging satellite data on SD variates up to about 1K with height, but is small on mean difference. Mean difference is close to zero in free troposphere but rise up to ~1K near 100 hPa and ~-1 near 1000 hPa. SD changes in the range of 1-1.4 K in the pressure range 20-600 hPa and rise up to 4K near 1000 hPa.

IKFS-2 minus NCEP GFS, 2015/11 - 2016/11, 1.5 hour, interpolation, S < 1.5

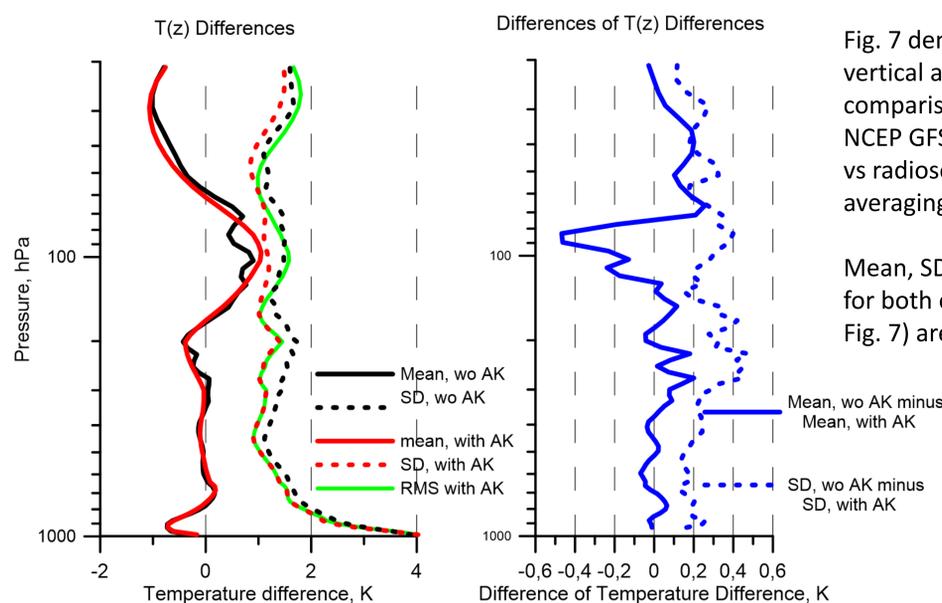


Fig. 7. Comparison of IKFS-2 temperature profiles vs NCEP GFS analysis results with and without taking into account the vertical averaging of the temperature profile

Fig. 7 demonstrates, effect of vertical averaging on the results of comparison of satellite data vs NCEP GFS analyze data is less, than vs radiosondes due to the vertical averaging of NCEP GFS data.

Mean, SD and RMS of differences for both comparisons (Fig. 6 and Fig. 7) are close to each other.

Conclusion: It is shown that the adjustment of vertical resolutions of various measurements leads to the decrease of a mean square difference between results by 0.2–1 K depending on the atmospheric altitude. In the case of the consistent vertical resolution, average differences between satellite and radiosonde measurements do not exceed about 1 K in an absolute value, SDs change from 1 to 1.4 K and RMS differences change from 1.0 to 1.8 K in pressure region 20-600 hPa. In near-surface layer, SD and RMS differences increase up to 4 K. Differences between satellite measurements and NCEP GFS data show the same consent, RMS of the difference changes from 1 to 1.8 in pressure 20-600 hPa. We note that both the radiosonde data and the analysis data have an errors, so the errors of the data of the IRFS-2 are less than the obtained differences.

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