Technique and results of retrieving the total ozone content using satellite IR measurements from «Meteor-M» No 2

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Technique for retrieving the total ozone content (TOC) from spectra of outgoing thermal radiation measured by IKFS-2 from aboard the meteorological «Meteor-M» No 2 satellite not depending on the presence of clouds is developed. Comparison of TOCs retrieved using the developed technique with independent data is performed.

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

TOC retrieval method

Artificial neural network - three-layer perceptron. Activation function - Hyperbolic tangent for hidden layer, linear for output layer. The input parameters are the spectral measurements of the IKFS-2 device: 25 Principle Components (PC) of the whole spectrum, 50 PCs of the ozone band and satellite zenith angle, 50 neurons in the hidden layer. One outgoing parameter – TOC. Made with MATLAB.

1. Cloudless atmosphere

Training set was based on OMI level 3 data, ~ 180000 pairs OMI and IKFS-2 measurements. Selection conditions: the same day, distance less than 35 km. Results are below:

Comparison vs. GOME-2 data

GOME-2: level 3 data - TOC defined on a regular grid 10 x 10. IKFS-2: day measurements (zenith angle of the Sun < 90°). Sample size: 11084

TOC comparison: IKFS-2 vs. GOME-2

2. Cloudy atmosphere

The same method, but training data set contains all the measurements, cloudless and cloudy. Sample (2015) size was ~600000.

3. Implementation of the method in the style of an operational code

Artificial neural network - three-layer perceptron. Activation function - Hyperbolic tangent for both layers.

The input parameters are the spectral measurements of the IKFS-2 device: 25 PCs of the whole spectrum, 50 PCs of the ozone band (980 - 1080 cm\(^{-1}\)) and satellite zenith angle, 35 neurons in the hidden layer.

One outgoing parameter – TOC

A special sample of measurements of improved quality was prepared (special qualitative measurements of IKFS-2 were selected, and algorithms for spectrometric calibration were improved) for 2 years (to include IBD in its entirety). This sample contains 12 hour measurement periods per month. Overlaps the period August 2015 - July 2017. Training set was based on OMI level 2 data. For every IKFS-2 spectra, one OMI measurement was selected by criterion:

\[
\left(\frac{\partial R}{\partial \tau}\right)^2 + (\langle \tau \rangle - \langle \tau \rangle )^2 \rightarrow \min
\]

r < 1 and |\langle \tau \rangle - \langle \tau \rangle | < 1, \quad \Delta \tau = 300 km, \Delta t = 12 hours

~ 290000 pairs OMI and IKFS-2 measurements were selected.

Another sample was used for a validation of the retrieval code and for investigations in future. We took all available IKFS-2 measurements from October 2015 to April 2016. There were 334 half-day data files, ~ 200000 spectra.

The validation was based on comparison with independent ground-based measurements of WOUDC network and OMI level 3 data.

TOC comparison: IRFS-2 vs. ground-based measurements of WOUDC network

Conclusions: It is shown that differences between TOCs retrieved from IKFS-2 spectral measurements and satellite (OMI device) and ground-based (Dobson, Brewer, M-124) device made with FORTAN, are ~ 3.5%. The greatest differences (up to 10 %) are observed over Antarctica in the presence of an ozone hole in the southern polar latitudes. Using the developed technique and IKFS-2 measurements, ozone anomalies over Russia detected earlier by other methods in the first quarter 2016 were registered. In separate days during this period almost 2 times reduction of TOC was observed.

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