Exploitation of SI-1 data from Meteor-28 and 29 spacecraft for climate purposes

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EUMETSAT

Main Goal

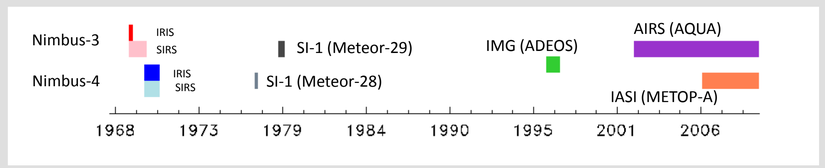
Why is rescuing Historical Satellite Measurements important ? The answer addresses two issues:

1. Atmospheric reanalyses allow looking back at the evolution of the weather in the past decades
2. Observations bring valuable information to constrain the reanalyses.

Hyperspectral measurements are operationally possible only since the '90s. There have been however earlier attempts:

- IRIS/SIRS on Nimbus-3 and 4
- SI-1 on Meteor-25, 28 and 29.

→ These satellite data are essential and can thus provide critical information on the evolution of the climate



A bit of history: 1976-1979

The series of Meteor spacecraft was developed in the '60s by the Soviet Union to set up a network of meteorological satellites on a sun-synchronous polar orbit. An infrared Fourier Transform spectrometer, SI-1 (Spectrometer-Interferometer 1), build by the German Democratic Republic (GDR) was part of the payload on 3 flights between 1976 and 1979 in the frame of the "Intercosmos Cooperation":

- The Acadamy of Sciences of the GDR was responsible for the development of the instrument, as well as the data reception in East-Germany.
- The Hydrometeorolocical Service of the USSR was responsible for the integration of SI-1 on Meteor satellites, the launch and the SI-1 mission operations.
- Three spacecraft have been launched:

Spacecraft	Launch date
Meteor-25	15th of May 1976
Meteor-28	29th of June 1977
Meteor-29	25th of January 1979

→ Measurements made available to EUMETSAT:

- No data from Meteor-25
- 22 orbits from Meteor-28 from July 5th to Sept 23rd, 1977: 1087 spectra
- 68 orbits from Meteor-29 from January 26th to June 19th, 1979: 1949 spectra

Data description

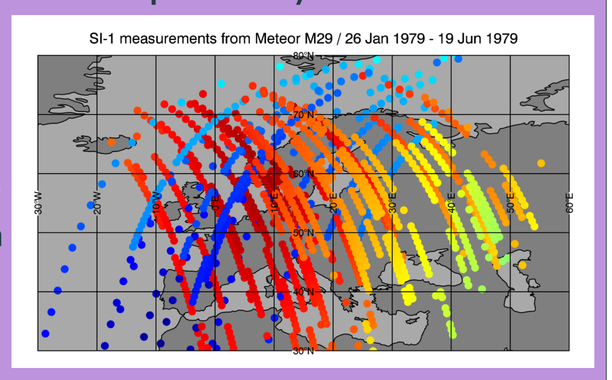
- Each of the 3000 Spectra:
  - Spectral band: 400 – 1600 cm^{-1} (6.25 – 25 mm)
  - Spectral resolution (with apodisation) of 5 cm^{-1}
  - Spectral sampling of 2.08 cm^{-1}
  - FoV: rectangle of 2°x2° - 23km x 23km

Two types of measurements:

- Real-time: limited to measurements performed around receiving stations near Berlin (data available at EUMETSAT) and Moscow (data not available):
  - A measurement every 15 seconds (i.e. every 100 km)
  - with a calibration every 4 minutes
- Non real-time: stored onboard:
  - A measurement every minute (i.e. every 400 km)
  - with a calibration every 16 minutes

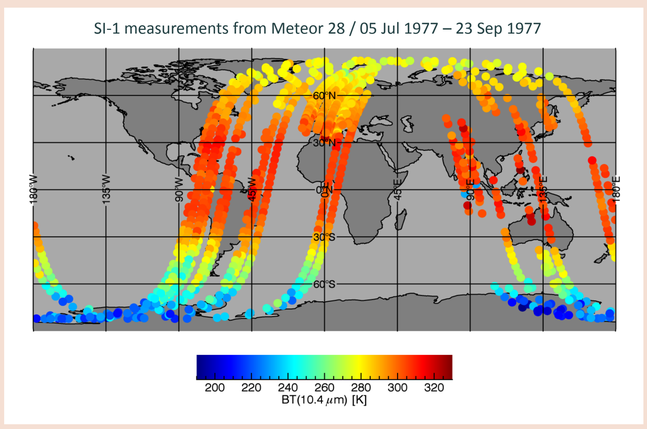
Data inspection, completion and reformatting

The 3000 spectra have been inspected one by one due to a lack of information and documentation. 5% of the spectra turned out to be of low quality and have been removed from the database. The estimated cloud coverage (in octas) based on visual inspection of each individual spectrum has not been changed. Efforts have been put on the completion by orbit information (angles,…). The orbit determination had to be performed without the NORAD TLEs because those do not match the time-positions pairs from The instrument data packets. Another methodology has been used, based on the timeseries of geolocations of the measurements. The method was successful. The figure is showing the example of the sun zenith angles that have been added to the products. Finally, the data (header+spectra) have been re-ordered, concatenated and reformatted into netCDF-4.



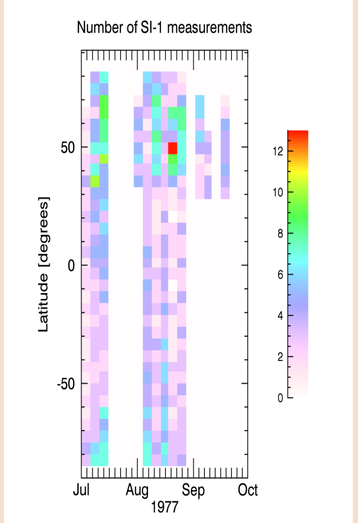
Meteor – 28 datasets

The meteor 28 data has been acquired during three months in summer. The high density of measurements over Europe corresponds to real-time data, directly dumped to the Berlin ground-station.



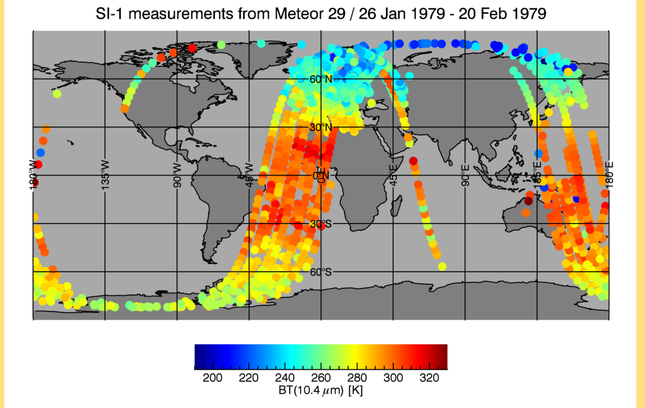
Map of the SI-1 measurements.
Brightness temperature at 10.4 microns

Hovmoeller diagram of the number of SI-1 measurements



Meteor-29 datasets

After a month of measurements performed by SI-1 on Meteor-29, the satellite stopped working properly . It took 3 months to fix the on-board processing but the internal memory did not recover. Only real time measurements were then acquired.



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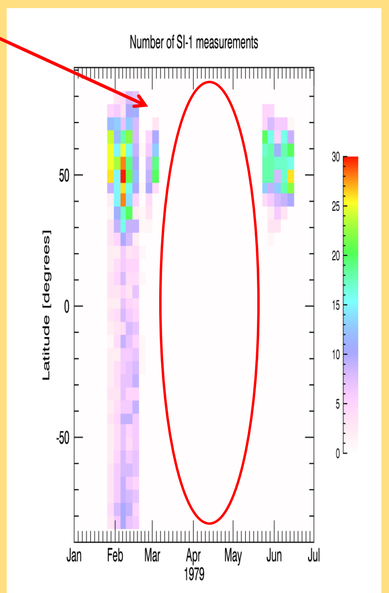
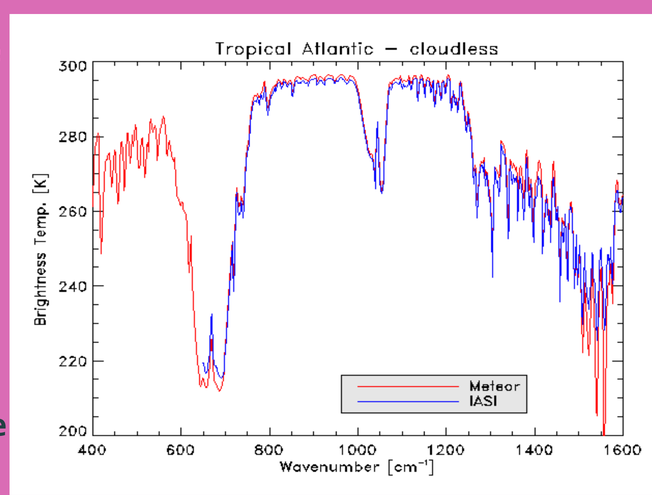


Comparisons with IASI

Comparisons with IASI have been performed and are illustrated here with the case of a cloud-free, ocean scene, observed at night. The plot shows an average of 3 Meteor and 300 IASI spectra. IASI has been resampled to the spectral resolution of SI-1. The figure shows a very good agreement between the two instruments in spite of a difference of 35 years. Further investigations on specific spectral ranges or using an RTM fed with reanalysis could provide information on the climate change.



Conclusion

Rescuing SI-1 data from meteor-28 and -29 has been a real success despite the fact that not a lot of documentation was available, neither auxiliary information nor raw data. All spectra have been checked one by one. The data have been cleaned, completed with additional information as much as possible without large post-processing, reformatted and sent to ECMWF to be used into their reanalyses efforts. First comparison with IASI measurements have turnes out to be very promising.

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