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# IRS – an infrared sounder designed to improve weather forecasts

***by Laetitia Theunis***

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Meteosat Third Generation (MTG) is the third generation of European weather satellites that will operate from geostationary orbit. The first of these could be launched this year, with the second one in 2024. The second MTG will carry an Infrared Sounder (IRS), which is expected to improve the accuracy of weather forecasts.

**Temperature and humidity at different altitudes**

For the first time, Meteosat satellites will carry out a continuous layer-by-layer analysis of the atmosphere. "The aim is to obtain vertical profiles of temperature and humidity.  This involves the IRS taking measurements in the absorption bands of water vapour and CO2, and doing so with very high resolution and spectral accuracy," explains Dr Nicolas Clerbaux, a specialist in satellite meteorological data at the RMI (Royal Meteorological Institute).

"Atmospheric soundings are usually made by sounding balloons or sensor-equipped aircraft that take off from local airports. Twice a day, however, measurements are also taken by the IASI instrument. This sounder, which is carried on the European Metop weather satellites, is placed in polar orbit and therefore flies over Belgium twice a day. This is the key difference between the Metop satellites and the IRS, the latter being in geostationary orbit, which enables it to observe the European atmosphere on a permanent basis. The IRS will therefore provide hourly updates of meteorological information, which is a significant improvement on the frequency of current data.

"This data is very important in order to align the global weather models. These vertical profiles also tell us about the stability of the atmosphere, which enables us to analyse and predict the convective development of thunderstorms. With this in mind, it will be very useful to have measurements every hour instead of every 12 hours, which is currently the case with the IASI."

**The Earth is divided into zones**

The IRS will be placed in an orbit around 36,000 kilometres above the Earth's surface. This orbit rotates at exactly the same speed as our planet and is otherwise known as a geostationary orbit. This type of orbit enables a satellite to permanently monitor the same point on the globe. For technical reasons, the IRS will be positioned above the equator and its sensors will be permanently focused on Europe and Africa.

The Earth's disc observed by the IRS is divided into four zones, called LACs. LAC4 comprises the whole of Europe, as well as North Africa and the North Atlantic (two regions that have a significant impact on European weather). The whole LAC zone will be scanned every 30 minutes. The other three LACs, which are numbered southwards in descending order, will be observed less frequently.

Each LAC will be scanned sequentially along sounding lines in an east-west direction, resulting in a series of square dwells. Each of these spectral soundings will be recorded as a 160 x 160 pixel image, where each pixel represents a 4 km square. One LAC is acquired within 15 minutes. “This will be the highest degree of accuracy that we’ve ever achieved,” says Professor Serge Habraken, Director of the Liège Space Centre.

**Chemical components in the collimator**

The instrument will take measurements in two spectral bands: long-wave infrared (LWIR), from 680 to 1210 cm-1 and mid-wave infrared (MWIR), from 1600 to 2250 cm-1.

“These are the two infrared transparency bands of the atmosphere. The purpose of the IRS is not to observe the light reflected by the Earth in the infrared range, but to measure the infrared radiation that our planet produces as a result of its own temperature,” explains Christophe Grodent, Commercial Director at the Liège Space Centre. “In other words, these images can be taken either during the day or at night. The warmer the atmosphere, the stronger the signal will be.”

“The instrument will analyse the spectrum in these wavelengths and split it into very narrow bands. The purpose of this is to detect any atmospheric absorption linked to the presence of certain components – particularly $O_3$ in the LWIR band and CO in the MWIR band. Once these have been detected, the IRS will ascertain their concentration. The instrument will provide an image of the atmospheric concentration of these two components at 30-minute intervals,” explains Habraken.

**Cooling is critical**

Before it is launched, the IRS will have to undergo testing at the Liège Space Centre. “It will be tested in FOCAL 5, a five-metre wide vacuum tank that simulates conditions in space,” explains Habraken. “Black bodies, which were developed in England and tested by the Liège Space Centre, will inject a defined level of energy. These bodies will be supplied with nitrogen from a tank at the top of the FOCAL 5.

The IRS is an infrared instrument, which means that cooling it down drastically is critical.

“You can only see a dog when its coat reflects white light, composed of visible wavelengths, emitted by a source of light – in this case, the Sun. But with a body temperature of 38.5°C, the dog is also a source of heat and emits infrared radiation,” explains Grodent.

“This is similar to how the IRS works. The instrument has been designed to observed the Earth and measure infrared radiation. However, if the instrument itself is hot, it’s going to detect its own radiation, as well as the radiation from the Earth. This will lead to two signals being superposed, which makes them impossible to tell apart.”

“To avoid this internal radiation, the instrument needs to be cooled down. This will lengthen the wavelength of its radiation, which will be reduce its energy. As a result, we will end up only seeing what we are interested in – infrared radiation emanating from the Earth. This is referred to as the signal-to-noise ratio.”

When the IRS is tested at the Liège Space Centre, therefore, it will need to be cooled down drastically – to around -250°C. “By way of comparison, the temperature of instruments used to observe the Universe is lower still. This was the case with the Planck space telescope, which was launched in 2009. Although the Liège Space Centre was not involved in its calibration, the centre was tasked with providing a simulated space environment. The centre provided a cold shell with a temperature of 20 Kelvin (-253°C) – which even dropped to 4 Kelvin (-269°C) in places. The customer, Thales, then activated its serial cooling loops, which enabled an absolute temperature of 0.1 Kelvin (-273.05°C) to be reached at the end of the last loop, maintained over a period of 15 days. It was the coldest point in the Universe – absolutely unique,” concludes Grodent.

**4 imagers, 2 sounders**

Between 2002 and 2015, the four Second Generation Meteosat (MSG) satellites, developed jointly by the European Space Agency ESA and the European Meteorological Organisation EUMETSAT, were put into orbit. Since they are reaching the end of their service life, they will gradually be replaced by MTG satellites, starting this year.

There will be six MTG satellites in total. Four of these will be imagers (MTG-I) and two will be sounders (MTG-S), carrying different instruments on board. Both sounders will be equipped with an IRS and a Sentinel-4. This latter instrument, part of the European programme Copernicus, will measure the concentrations of trace gases and aerosols in the Earth’s atmosphere.

“Compared to previous Meteosats, the advantage of these satellites is their excellent stability, thanks to their three stabilisation axes. We are expecting a very good quality of image from now on,” explains Habraken.

EUMETSAT, who operates these meteorological satellites, has designed each constellation to permanently include two imagers and one sounder. The first imager and sounder are expected to be launched in 2022 and 2023, respectively. The second imager will be put into orbit in 2024. As the service life of each satellite is 7 years, the second sounder and the other imagers will be launched at some point after 2030.