DAILY SCIENCE
DÉCOUVREZ LA SCIENCE, LA RECHERCHE ET L'INNOVATION "MADE IN BELGIUM"

Weather forecasts are set to focus more on the immediate future

by Laetitia Theunis

Part of the "Climate as seen by satellites" series (5/5)

Over the next few years, the Royal Meteorological Institute (RMI) will have access to data from a new generation of satellites – MTGs – for its weather forecasts. The revolutionary instruments on board some of these satellites will allow us to monitor the development of thunderstorms in specific areas and produce real-time images of lightning strikes. This will improve the system by which people are warned of extreme weather incidents.

Major replacement project

Between 2002 and 2015, four second-generation Meteosat satellites (MSGs) were put into orbit. Developed under the responsibility of the European Space Agency (ESA) on behalf of the European meteorological organisation EUMETSAT, these satellites are reaching the end of their service life.

This year, they will begin to be replaced gradually by two sets of three MTG satellites (Meteosat third generation) in geostationary orbit. At a distance of 36,000 km from the Earth's surface, these will rotate at the same speed as our planet, enabling them to observe the same place constantly – which, in this case, will be Europe.

Each set of three satellites will comprise one MTG-S satellite (carrying the IRS instrument, an infrared sounder, to be launched in 2023), and two satellites carrying MTG-I imagers (one sent into orbit at the end of 2022 and the other to be launched in 2024). As the service life of each satellite is 7 years, the second sounder and the other two imagers will be launched at some point after 2030.

More spectral bands

The first imager of each satellite group, the MTG-I1, will be used exclusively for multispectral imaging. This will require it to carry the FCI (Advanced Flexible Combined Imager), a 16-channel imaging radiometer. "In other words, it will see in 16 'colours' – those in the visible spectrum (blue, yellow, green, etc.) as well as those in the infrared. This will enable it to observe the Earth at night," explains Dr Nicolas Clerbaux, a specialist in satellite meteorological data at the MRI. The FCI will take images at 10-minute intervals.

"This latest version of the radiometer is a newer version of an instrument that we've been using for about 50 years. It has considerably more spectral bands, which are much finer than on its predecessors."

A lightning chaser

The MTG-I1, a large four-tonne cube powered by solar panels, will also be equipped with a lightning imager (LI) to detect the optical radiation emitted by lightning. This revolutionary instrument will be able to observe lightning between clouds, as well as lightning that will strike the ground.

“This is the first time that EUMETSAT is launching this kind of optical instrument. It will simultaneously be able to see lightning in Europe, over the Mediterranean, throughout Africa, over much of the Atlantic Ocean, and in parts of Brazil. This will enable us to monitor both electric activity and convective activity (*sometimes, lightning develops before thunderstorms – Ed.*),” continues Clerbaux.

The LI will take a picture of the Earth every 2 milliseconds. The illuminated pixels will then be identified and analysed in real time, both on board the satellite and in centres of expertise on the ground so that users have access to the data no more than 30 seconds later. As a result, storm observation from space will enter a new era, which is bound to have a significant impact on the fields of air travel and shipping.

Forecasts versus reality

“These two instruments, the FCI and LI, will be used for nowcasting [*provision of imminent forecasts – Ed.*]. Firstly, they will enable extremely short-term forecasts to be established, i.e. for the next 1–2 hours. Secondly, since meteorological models deviate somewhat from reality, these two instruments will enable a comparison between the actual weather and the forecast, i.e. did the expected storm arrive?” explains Clerbaux.

“This will enable us to pinpoint weather events that the models didn’t predict. Currently, models are unable to specify the exact time and place where a storm will develop. In fact, the information is relatively vague, citing, for example, that “there is a significant risk of thunderstorms in this fairly large region this afternoon”.

“Nowcasting is a complementary concept to existing models, providing information about what is actually happening at a more specific location. And this helps provide more specific warnings.”

An informed response

On 18 August 2011, the Pukkelpop festival in Hasselt, Belgium, took a disastrous turn, causing five people aged between 15 and 59 to lose their lives. Ten festival-goers also ended up seriously injured and 140 people suffered minor injuries as a result of stages and tents collapsing, with a whole host of other equipment flying around. The cause of the incident was an extremely localised, intense and fast-moving storm, which brought with it extremely strong winds.

The day before the storm, the MRI had issued a general ‘orange’ alert, warning people that storms were on their way with a risk of “severe damage to buildings, uprooted trees, electric discharges due to lightening and, in certain areas, water-related damage”. However, back in 2011, weather forecasters couldn’t provide more accurate information about where exactly the storm would hit. This will be possible in the future, thanks to the new geostationary imagers and the emergence of nowcasting.

“These instruments will enable forecasters to confirm the significance of an atmospheric instability. They should also be able to predict the imminent arrival of a thunderstorm or tornado – within the next half hour, for example – and track the development of these events. This not only ensures that sites can be evacuated if necessary, but also provides precise information for deciding exactly when to cease airport operations if weather conditions are considered too dangerous,” adds Clerbaux.

Rapid scanning

The FCI imager, which loaded on board the MTG-I1 in 2022, will refresh the images every 10 minutes, as opposed to every 30 minutes on the first generation of Meteosat satellites and every 15 minutes on the second generation. Furthermore, the imager on board MTG-I2 (the second imager of the first satellite group), which will be launched in 2024, will be a rapid-scan imager, i.e. it will take images every two and a half minutes.

"The MTG-I2 is identical to the MTG-I1 satellite and will save the data it gathers. However, the MTG-I1 will scan the entire Meteosat circle, from the South Pole to the North Pole, albeit centring on Europe, whereas the MTG-I2's imager will focus on a lower latitude window, comprising the whole of Europe, as well as the neighbouring Atlantic. This is an area four times smaller than the one observed by the MTG-I1. As a result, the frequency of the images will be four times higher." What we can expect, therefore, are highly accurate weather forecasts for a more specific area.

CubeSats and radio occultation

Alongside these colossal satellites in geostationary orbit, there are also a number of much smaller satellites in low orbit, i.e. at an altitude of up to 2,000 km. Developed and launched by private companies, these smaller satellites are dedicated to radio occultation (RO) and deliver valuable data on atmospheric temperature and humidity. The pioneering company in this field is Spire.

Spire has launched a constellation of about 100 CubeSats into low orbit. These are small, standardised satellites that are cube-shaped, measuring no more than 10 cm across, and equipped with a GPS wave receiver – a very simple, low-cost instrument.

"The American, European (Galileo) and Chinese (Beidu) GPS satellites constantly emit various positioning waves. These signals can be picked up by a receiver on a CubeSat on the other side of the Earth," explains Clerbaux. "Since the path between the transmitter and receiver is tangential to the Earth's surface, the signals travel through this thin layer of tangential atmosphere. This is what a RO CubeSat looks at. It sounds the atmosphere along the tangent between the transmitter and the receiver so that is can produce temperature and humidity profiles." We end up with two pieces of essential data (alongside wind) that we input into weather forecasting models.

Complementary data from the private sector

EUMETSAT has commissioned Spire to provide accurate data for distribution to its partner countries. But why is this necessary when high-performance European satellites are going to be put into geostationary orbit? "The large number of small satellites gives us a huge volume of data. 100 CubeSats take 100 atmospheric soundings while a geostationary satellite only takes one. This is the equivalent of having 100 times as many observation stations in orbit with a combined weight of just 100 kg [*compared to a single MTG at 4000 kg – Ed.*]," adds Clerbaux.

Spire currently collects approximately 10,000 radio occultation measurements around the world per day. Its aim is to collect 100,000.

Another interesting point to note is the potential launch of special CubeSats to monitor forest fires, from a lower orbit than the future geostationary FCI instrument. These satellites would deliver additional information to help in the fight against fires, which are expected to become increasingly common as a result of climate change.