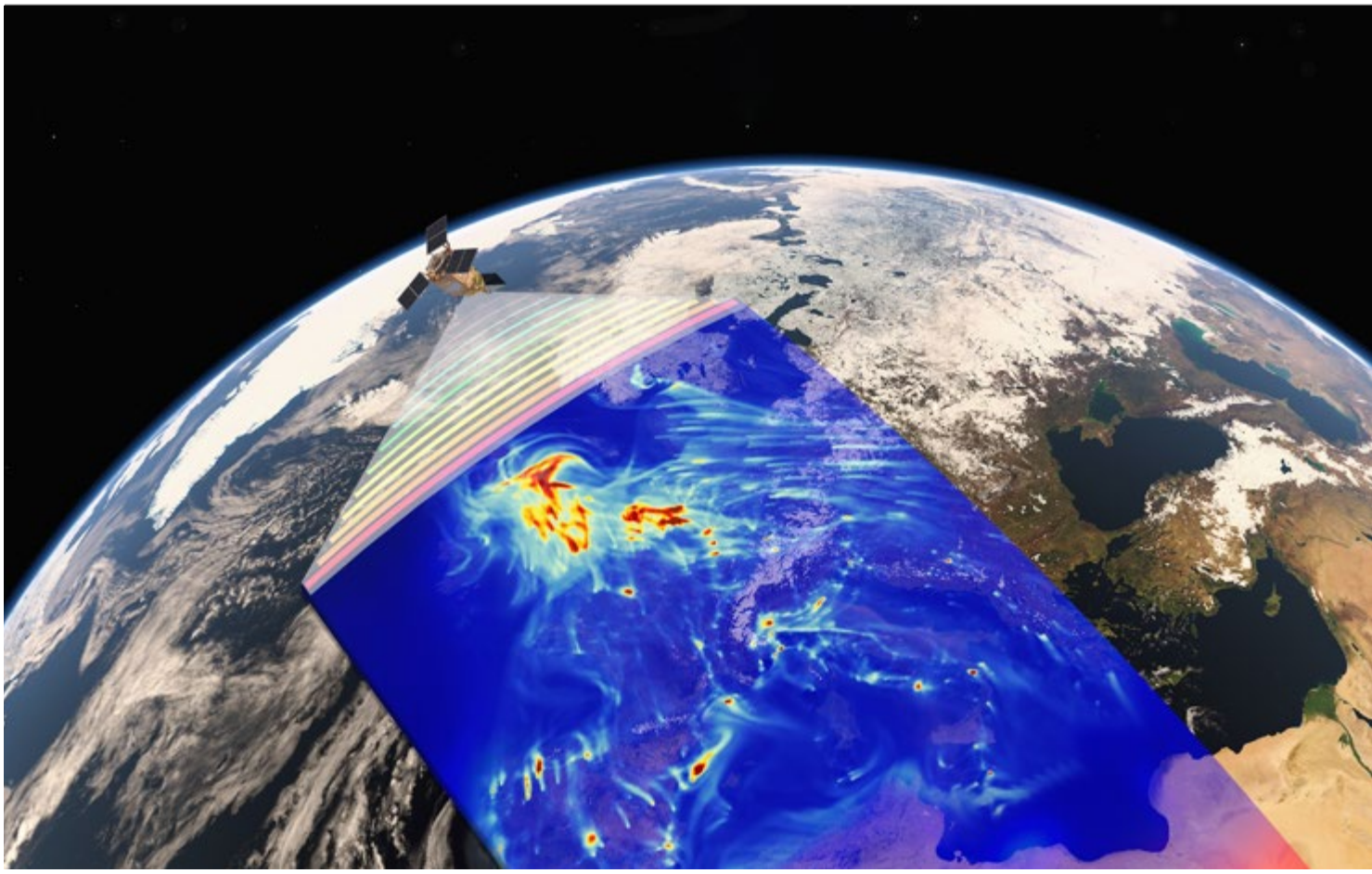


It takes an ESA satellite with a spectrometer one day to give a complete picture of air pollution all around the world.

Space watchdog for Earth's atmosphere

Tropomi, a Dutch-built measuring instrument that was mounted onto a satellite at the end of 2017, measures air quality better than has ever been done before. This reveals new sources of nitrogen dioxide. Authorities can use these data to check whether a sector is sticking to emission reduction agreements.

TEXT RENÉ DIDDE **PHOTO'S** ESA/ATG MEDIALAB

Since the end of 2017, a satellite with the Tropomi measuring instrument has been orbiting the earth on a different path every 100 minutes. In one day with 14 orbits, it gives a complete picture of all the air pollution in the world. 'Our Tropomi spectrometer measures sunlight reflected by Earth, from which we can deduce the type and the concentration of gases such as nitrogen dioxide,' says Folkert Boersma, associate professor of Meteorology and Air Quality in Wageningen, who works for the Royal Dutch Meteorological Institute (KNMI) as well. The images of the concentrations the instrument sends to Earth are not only light-

ning fast but also crystal clear. 'We have millions of images at our fingertips within three hours, of cities from Jakarta to Paris, and from Vancouver to Sydney. They enable us to see the concentration of polluting nitrogen dioxide at the urban district level.'

BOULEVARD PERIPHERIQUE

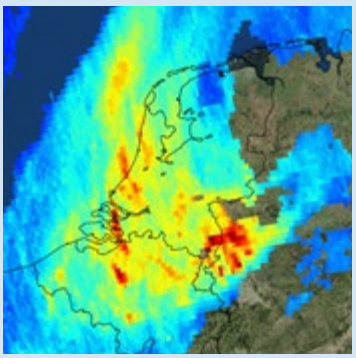
Nitrogen dioxide contributes to smog, especially in the summer months. It can sometimes be seen with the naked eye as a reddish-brown haze over cities. With Tropomi's predecessors, researchers could already see patches of air pollution above areas such as Rijnmond, the Ruhr and the Po valley. Nowadays the spectrometer measures with an improved pixel resolution of 5 by 3.5 kilometres. 'Now we can see the *Boulevard Peripherique* around Paris, the *Autoroute du Soleil* and the main shipping lanes,' says Boersma.

By factoring in the impact of the wind and chemical reactions, he explains, emissions from the source can be deduced from the concentrations indicated by the spectrometer. This brings to light hitherto undiscovered sources of nitrogen dioxide. On satellite images above China, Boersma discovered patches of pollution that turned out to come from new coal-fired power stations that the authorities had not yet registered for emissions reporting. He also saw the opposite. 'In north-west Spain less nitrogen dioxide was picked up because, it turned out later, air filtering techniques had been introduced in the power stations.'

DETECTIVE WORK

The basis for the environmental detective work is that the spectrometer measures sunlight reflected by Earth's atmosphere in many different colours of the spectrum. Take the nitrogen dioxide in smog. 'The NO_2 molecule absorbs sunlight of one colour a little bit more than that of another colour, so NO_2 leaves a unique barcode behind in the spectrum measured. The more NO_2 there is in the atmosphere, the more clearly it is recorded,' explains Boersma. And it is not just nitrogen dioxide that Tropomi can detect, but also other pollutants such as carbon monoxide, ozone, fine particles and methane. Methane contributes significantly to climate change.

The research using Tropomi makes it possible to monitor the emissions of a city from day to day. Boersma: 'We see that there is less nitrogen dioxide on Sundays because there is less traffic and industrial activity, and we see the smoke from ships in busy shipping lanes.' The Wageningen analysis also revealed that last year in a cold week in February in Paris, much more fuel was burned than had been assumed on the basis of existing databases on fuel use and consumption patterns in power stations and urban heating systems.



TROPOMI

The Tropomi spectrometer was launched with the ESA satellite Sentinel-5 Precursor in 2017. It took six years to develop and cost 80 million euros. Besides WUR, other Dutch institutes that are involved are the Royal Netherlands Meteorological Institute (KNMI), the Netherlands Institute for Space Research (SRON), research organization TNO and the Technical University of Delft. The Belgian Institute for Space Aeronomy BIRA is involved, and from Germany, the University of Bremen, the aerospace centre DLR and the Max Planck Institute.

www.tropomi.eu

WATCHDOG

With this information, Tropomi, which has been worked on by several European research institutions and universities (see inset) alongside Wageningen University & Research, can be an important watchdog for Planet Earth, says Boersma. 'We provide data with which the authorities can ascertain whether a sector such as road transport is keeping its word on emissions reductions. In future we can also see whether such measures as car-free inner cities really work, or whether there is much point in systems like letting cars with even and odd registration numbers be on the road on different days.'

A genuine Sherlock Holmes case is the mystery of the stagnating reduction in nitrogen dioxide emissions in the European Union. 'In the period 2004-2010, the concentration plummeted due to the introduction of the European emissions norms for road traffic, but after that nitrogen dioxide emissions did not go down any further. Economic growth is not an adequate explanation for that. We are currently researching whether "dieselgate" could explain it.' Car manufacturers manipulated the statistics on nitrogen oxide emissions from cars using software fixed to falsify emissions figures; the real emissions were much higher. 'We are also looking at the impact of natural sources such as lightning.'

TYPICAL OF WAGENINGEN

A typical example of Wageningen research that Folkert Boersma is doing with Tropomi is a study of fluorescence in plants, as a contribution to solving the climate puzzle. 'Plants emit a bit of light when they absorb CO_2 for their photosynthesis. From the satellite images, we can see where the amount of photosynthesis is going down, due to drought or felling in the Amazon, for example. We can also find out whether reforestation projects are working.' ■

www.wur.eu/maq