Earth observation in times of COVID

Earth observation is one of the oldest applications of satellite technology, and one that provides a huge amount of value to everyday life without the general population being particularly aware of it. In times like these, with pandemic upon us, satellite-enabled Earth observation is more important than ever before for continued remote environmental monitoring, and to track staple utility, energy and agricultural patterns.

Sentinel 1. Photo courtesy of ESA

Dr Amy Saunders, Editor, Satellite Evolution Group

With so much chaos in the world right now, the importance of Earth observation has not been overlooked; in fact, the vital information it provides has never been more valuable.

A technology typically utilised for more widely applicable meteorology, environmental monitoring, remote sensing, mapping and military applications has proven itself immeasurably invaluable during times of COVID-19. Indeed, with the right pollution monitoring equipment, Earth observation satellites have shown the reductions in air pollution brought about by reduced industrial activities, while those monitoring agricultural processes from space have been able to gain a better understanding in how production shortfalls and delays as a result of COVID-19 will impact the food supplies of the entire world.

Pollution monitoring – An unusual year

The impact of COVID-19 on air pollution this year has been astounding. Pollution, of course, is one of the biggest environmental challenges faced today, with one recent report from the European Environment Agency (EEA) proportion that air pollution now contributed to one in every eight deaths across Europe. Earth observation satellites have proven invaluable for studying the fluctuations in air quality as a direct result of restrictive COVID-19 measures.

Scientists from the Royal Netherlands Meteorological Institute (KNMI) and the Royal Belgian Institute for Space Aeronomy (BIRA-IASB) have used satellite data from Sentinel-5P and ground-based data in order to pinpoint the correlation between COVID-19 and the effects of air pollution across Europe. The data shows that the strongest reductions of 40–50 percent were seen in the first stage of the lockdown in southern Europe, specifically Spain, Italy and France. In July and August 2020, the data suggests that the concentrations are still 10-20 percent lower than pre-COVID levels.

"Quarantine measures implemented in Berlin led to a drop of about 20 percent with small variations seen until August 2020," said Bas Mijling, atmospheric scientist at KNMI. "In eastern Europe, the impact of the measures has been generally less dramatic than in southern Europe, and in France, where reductions of approximately 40–50 percent were observed during the strict lockdowns of March and April. More research is currently taking place as part of ESA's ICOVAC project, or impact study of COVID-19 lockdown measures on air quality and climate."

The decreases in air pollution were attributed to reduced emissions from traffic, industrial and energy sectors. The concentrations appear to return to near-normal levels in July and August, except over large cities where human activities have not yet fully resumed.

A similar study in India yielded comparable results. India is the world's largest emitter of anthropogenic sulphur dioxide, a major air pollutant causing many health-related problems and also a precursor to acid rain, according to a 2019 study by Greenpeace.

While some atmospheric sulphur dioxide is produced from natural processes, such as volcanoes, a substantial amount is produced by human activities – predominantly from power plants burning fossil fuels. A recent algorithm improvement, completed by the Royal Belgian Institute for Space Aeronomy (BIRA-IASB), allowed the team to better picture the evolution of anthropogenic sulphur dioxide emissions over the country.

Atmospheric analysis from the Tropomi instrument on board Copernicus Sentinel-5P showed a significant reduction (40 percent year-on-year) in sulphur dioxide emissions in April 2020 as a result of the sudden slowdown in human and industrial activity in the wake of COVID-19. The study showed that concentrations of the pollutant had dropped significantly compared to 2019, notably over New Delhi, over many large coal-fired power plants as well as other industrial areas. Some large plants in the northeast states of Odisha, Jharkhand, and Chhattisgarh have maintained a substantial level of activity, while others appear to have ceased entirely.

"With our operational product, we can reliably measure strong sulphur dioxide concentrations emitted by volcanoes, but we have problems in detecting anthropogenic sulphur dioxide emissions," said ESA's Copernicus Sentinel-5P mission manager, Claus Zehner. "This new algorithm will enable new applications, for example in verifying existing sulphur dioxide emission inventories, after it has been implemented into the operational Sentinel-5P processing chain at the German Aerospace Center."

The great food shortages of 2020

With COVID-19, the first pandemic is modern memory, came panic buying. In the UK, the shelves were stripped of toilet paper, kitchen towel, pasta, rice, canned goods and baby formula (apparently some people were stockpiling to make milk for tea in case milk became inaccessible… clearly such people have never tasted baby formula or they wouldn't have bothered). When supplies and supply chains of such essential goods becoming severely impacted, Earth observation satellite technology again came into play to ensure that people would continue to have access to food through 2020 and beyond.

A recent study from the World Food Programme has forecast that COVID-19 might push more than 130 million extra people into chronic hunger by year end. As we already saw earlier this year, COVID-19 has caused numerous problems and uncertainties along the food supply chain such as limited labour, transport, cross-border trade and the availability of produce.

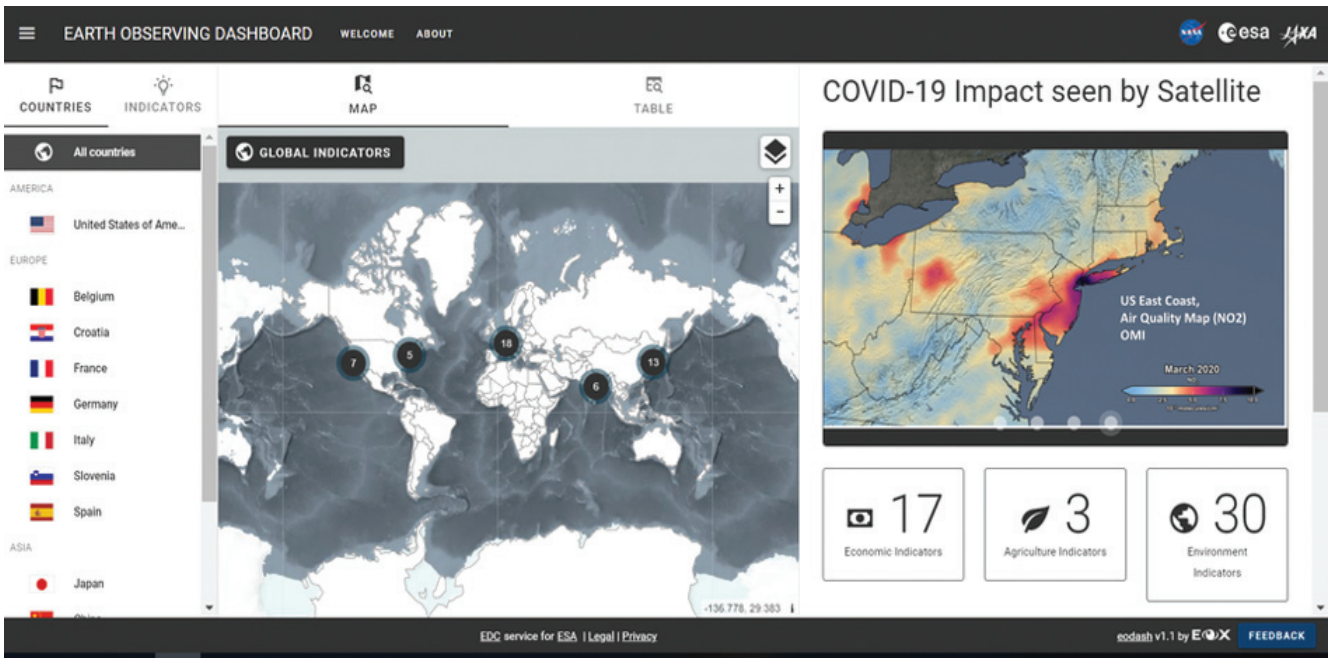
NASA, ESA and the Japanese Aerospace Exploration Agency (JAXA) recently worked together to create the COVID-19 Earth Observation Dashboard, a platform that combines a wide variety of satellite data to monitor the impacts of COVID-19 worldwide – including agricultural production.

One recent study featured on the dashboard analysed the harvests of winter cereals over Spain. In Spain, winter cereals are cultivated over almost two million hectares. Thanks to satellite data, the harvests can be monitored in near-real time, at parcel-level over the entire country. Scientists from the Université catholique de Louvain in Belgium used data from the Copernicus Sentinent-1 and Sentinel-2 mission and the US Landsat-8 mission together with machine learning to monitor crops on a weekly basis. Comparing the data with 2019, they found that the 2020 harvesting season started in mid-June, which is later than the average crop calendar for winter cereals in Spain. Experts from the National Spanish Agrarian Guarantee Fund (FEGA) supported the monitoring and worked with Université catholique de Louvain (UCL) to analyse the results, which concluded that while COVID-19 may have contributed to the delayed harvest, the weather may have also played a role.

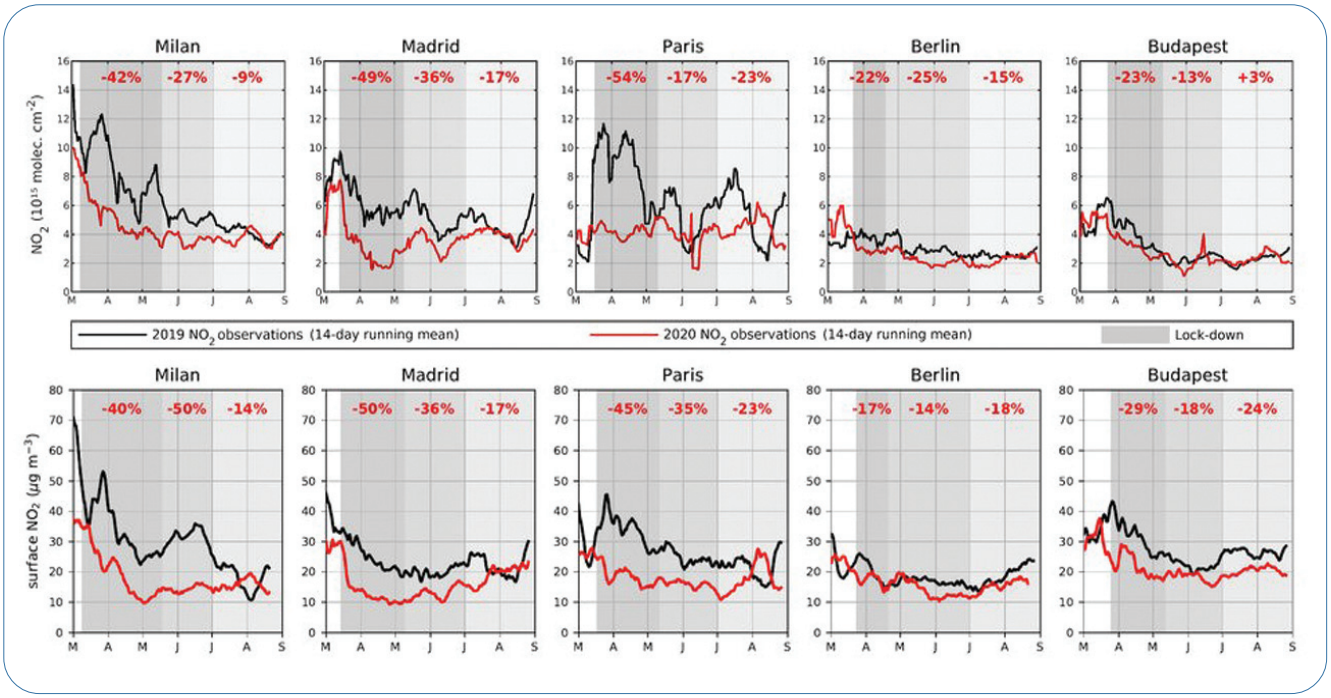
"After consulting our colleagues at FEGA, the time lag in harvesting can be explained partially by the drought that affected Europe in 2019, which led to an unusually early harvest last year," said Sophie Bontemps, scientist at UCL. "Therefore, the assessment of COVID-19 impacts on the 2020 harvest must consider the interannual variability caused by specific climate conditions in 2019."

In another example featured on the dashboard, data from JAXA's ALOS-2 and GCOM-C satellites, combined with information from the Landsat and Copernicus Sentinel-2 missions, were used to assess rice fields near Sacramento, California. These satellites can provide key information on rice phenology such as when rice is planted, when it matures and when it is harvested. Here, satellite observations showed that in many regions, the rice was planted earlier than the last two years. These early assessments allow agriculture markets to respond more efficiently to disruptions owing to natural events such as the weather and to human-caused events such as changes in trade policy and consumer demand triggered, for example, by the COVID-19 pandemic.

"Satellite indicators demonstrate the capabilities of monitoring the planting, growth and harvest of staple crops such as cereals and rice at national scales. These data are vital in providing timely and transparent information on agricultural production during the COVID-19 outbreak and recovery," said ESA's Benjamin Koetz. "ESA, NASA and JAXA continue to work with organisations such as the UN Food and Agriculture Organization and the Group on Earth Observations Global Agricultural Monitoring Initiative to



Dashboard image courtesy of ESA, NASA, and JAXA



Nitrogen dioxide concentrations observed over major European cities. Image courtesy of ESA

ensure the best use of satellites to monitor agricultural production from national to global scales."

Observing the Earth in 2021 (and beyond)

Earth observation via satellite has once again proven itself a key enabler for monitoring and understanding the present, as well as planning for the future. Copernicus is the biggest provider of Earth observation data in the world – and while the EU is at the helm of this environmental monitoring programme, ESA develops, builds and launches the dedicated satellites. It also operates some of the missions and ensures the availability of data from third party missions. The current suite of Sentinel missions are at the heart of the programme, feeding data into the Copernicus Services, which help address challenges such as food security, air pollution, rising sea levels, diminishing polar ice, natural disasters and, importantly, climate change.

ESA is so pleased with the success of recent Earth observation missions that it's industrial policy committee has approved contracts totalling Euro2.55 billion to forward the development of six new Copernicus satellite missions, each mission comprising two satellites, a development and a recurrent unit. The overall package is co-funded by the EU and ESA Member States and relies on future funding from the EU Multiannual financial framework. The six new upcoming missions will expand the current capabilities of the Sentinels and address EU policy priorities and gaps in Copernicus user needs:.

- The Copernicus Anthropogenic Carbon Dioxide Monitoring (CO2M) mission will carry a near-infrared and shortwave-infrared spectrometer to measure atmospheric carbon dioxide produced by human activity. OHB-System Germany will lead the development with a contract value of Euro445 million.
- The Copernicus Hyperspectral Imaging Mission (CHIME) will carry a hyperspectral imager to return detailed information for sustainable agricultural and biodiversity management. Thales Alenia Space France will lead the development with a contract value of Euro455 million.
- The Copernicus Imaging Microwave Radiometer (CIMR) mission will carry a microwave radiometer to provide observations of sea-surface temperature, sea-ice concentration and sea-surface salinity. Thales Alenia Space Italy will lead the development with a contract value of Euro495 million.
- The Copernicus Polar Ice and Snow Topography Altimeter (CRISTAL) mission will carry a multi-frequency radar altimeter and microwave radiometer to measure and monitor sea-ice thickness and overlying snow depth. Airbus Defence and Space Germany will lead the development with a contract value of Euro300 million.
- The Copernicus Land Surface Temperature Monitoring (LSTM) mission will carry a high spatial-temporal resolution thermal infrared sensor to provide observations of land-surface temperature for sustainable agriculture and to predict drought. Airbus Defence and Space Spain will lead the development with a contract value of Euro375 million.
- The L-band Synthetic Aperture Radar (ROSE-L) mission will carry an L-band synthetic radar altimeter that penetrates through materials such as vegetation, to support forest management and to monitor subsidence and soil moisture. Thales Alenia Space Italy will lead the development with a contract value of Euro482 million.

"With us concerned about issues such as climate change, Europe's Copernicus programme and the Sentinel missions play a pivotal role in providing free and open data to manage the environment," said ESA's Director General, Jan Wörner. "These new contracts are the next step in ensuring the family of Copernicus satellites expands to deliver vital information that will ultimately help protect the environment and citizens alike."

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