

Earth From Space

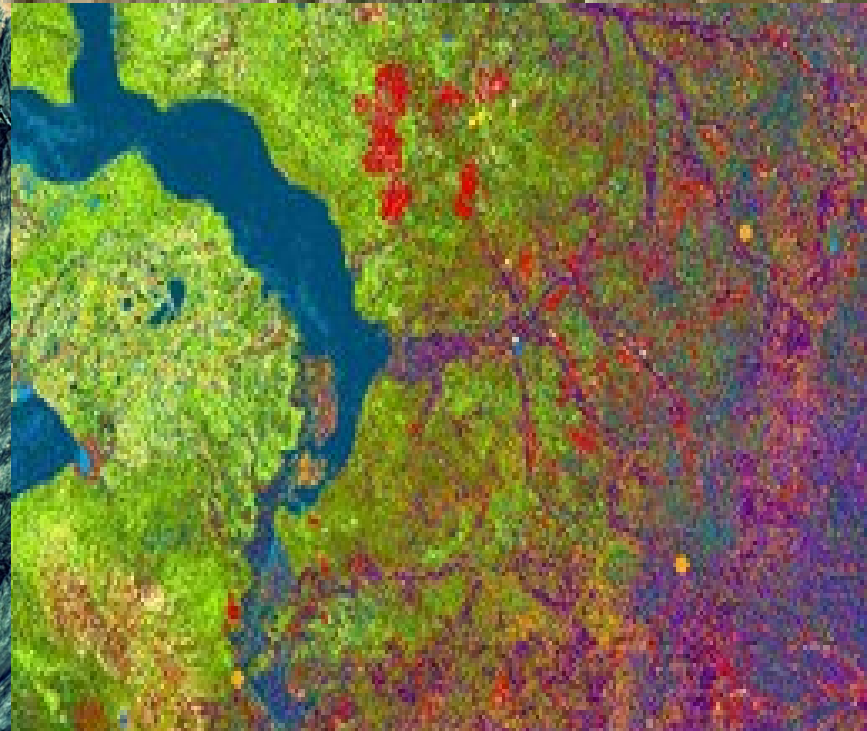
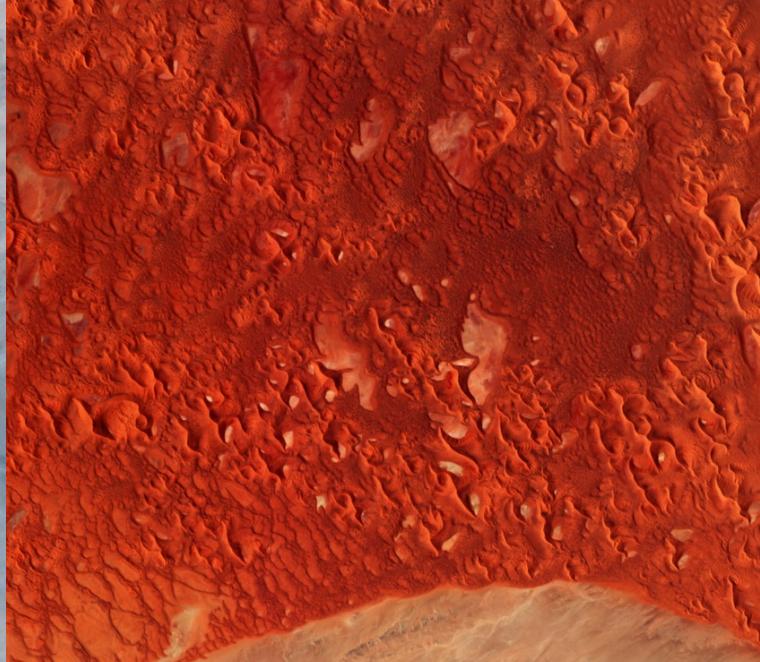
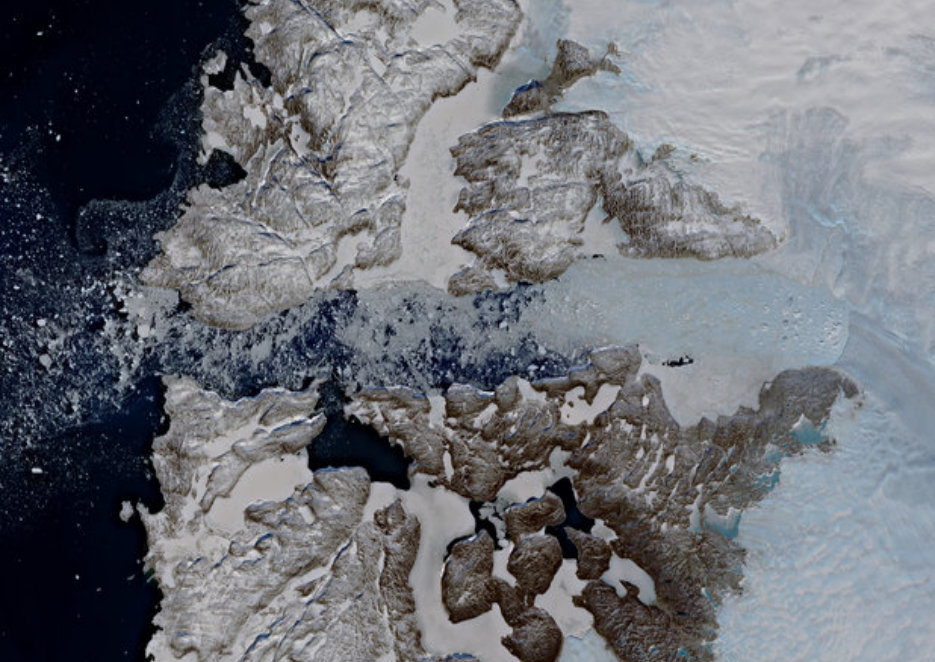
Professor Jacqueline McGlade
Frank Jackson Gresham Professor of
Environment



Maasai Mara University
eng'eno e puaan



UCL



Earth Explorers



GOCE **2009 – 2013**

SMOS **2009 – Present**

Cryosat **2010 – Present**

SWARM **2013 – Present**

Aeolus **launched 2018**

EarthCARE **2020**

Biomass **2021**

FLEX **2022**



Atmospheric Dynamics Mission

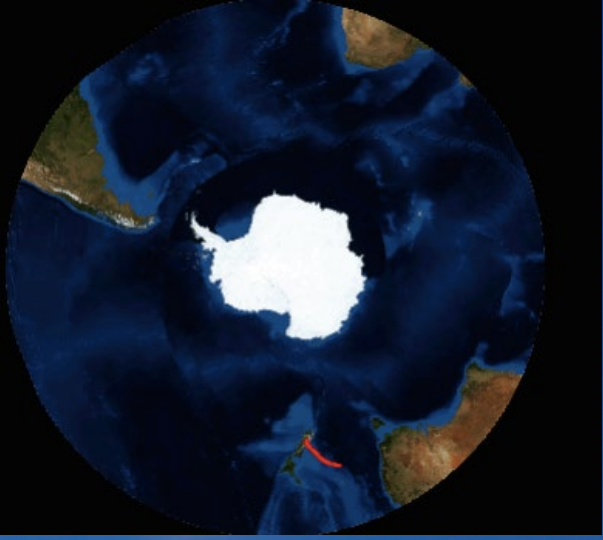
timely and accurate profiles of the world's winds to improve weather forecasts and climate research, predictions about extreme events such as hurricanes and information on aerosols and clouds

carries the ground-breaking instrument - ALADIN – the first wind lidar in space

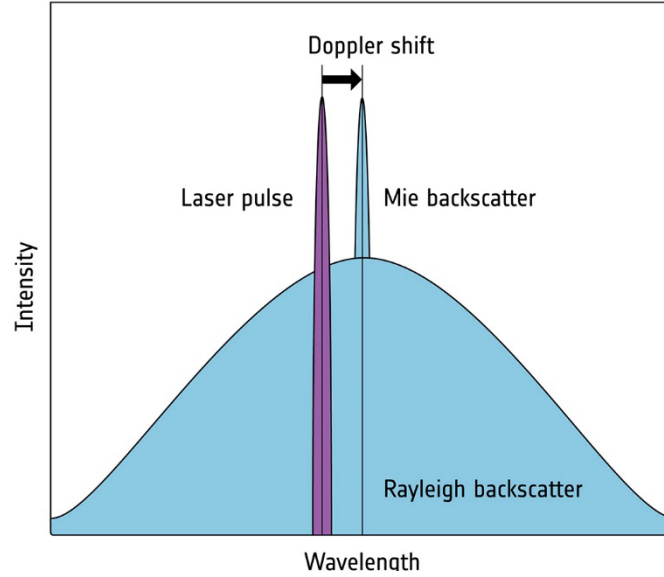
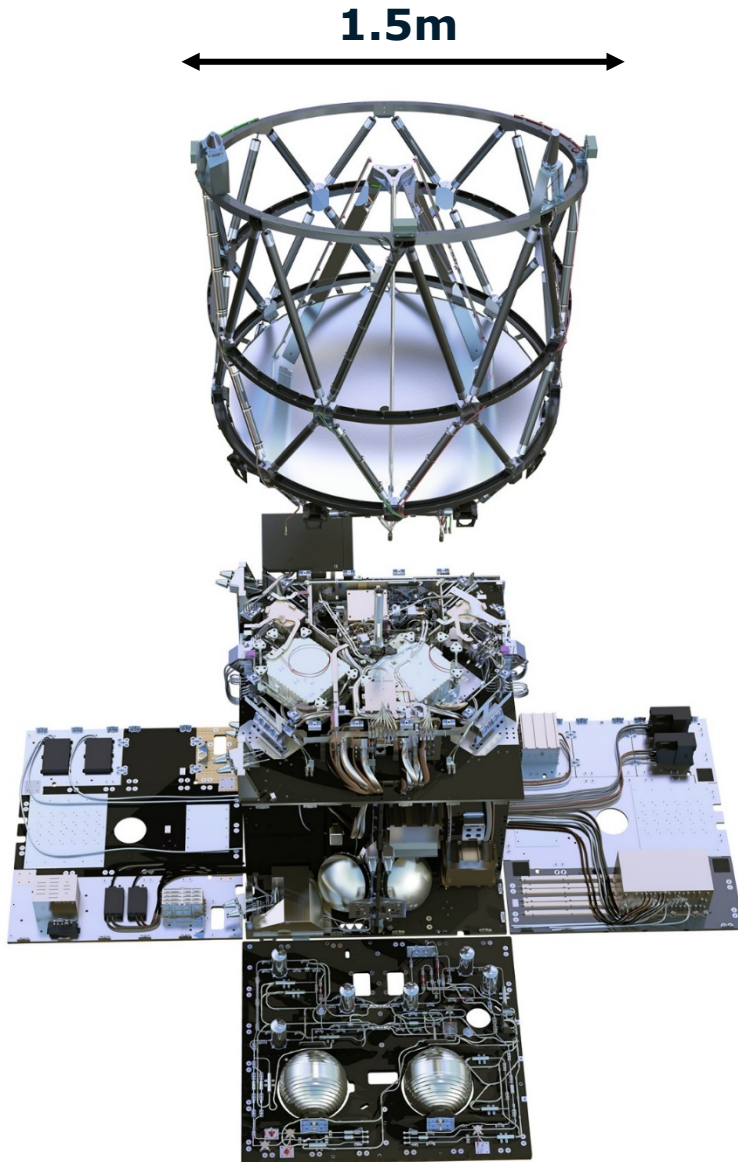
has a powerful laser, large telescope and a very sensitive receiver

works by emitting short, powerful pulses of ultraviolet light from a laser to deliver vertical profiles that show the speed of the world's winds in the lowermost 30 km of the atmosphere

ESA ADM-AEOLUS WIND MISSION



AEOLUS ALADIN DOPPLER WIND LIDAR



Rayleigh scattering is from molecules such as oxygen and nitrogen and is most efficient at scattering light at shorter wavelengths, i.e. blue and violet – **which is why the sky looks blue**

The lidar emits a **short, powerful light pulse from a laser** through the atmosphere and then collects the light that is backscattered from particles of gas and dust and droplets of water

The time between sending the light pulse and receiving the signal back determines the **distance to the 'scatterers'** and so the **altitude above Earth**

As the scattering particles are moving in the wind, **the wavelength of the scattered light is shifted by a small amount as a function of speed**

The Doppler wind lidar **measures this change so that the velocity of the wind can be determined**

LAUNCH OF AEOLUS ON A VEGA ROCKET

Europe's Spaceport in Kourou, French Guiana 22 August 2018



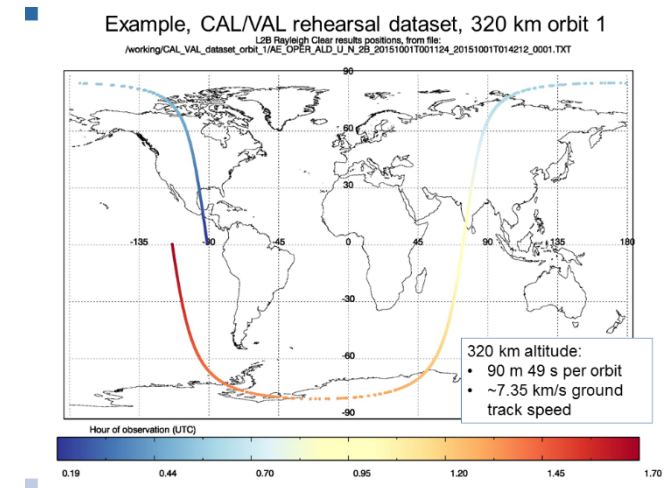
AEOLUS CALIBRATION AND VALIDATION

Field campaigns all over the world to calibrate and validate the Aeolus data with measurements from the ground, balloons and aircraft to compare with Aeolus data from space

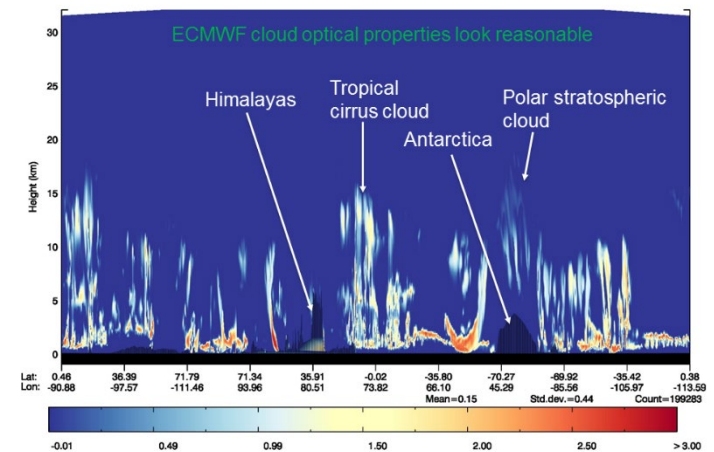
Flying an aircraft directly under Aeolus' orbital path and taking more or less simultaneous measurements with an airborne version of the satellite instrument

The largest improvement is in the tropics, over the oceans and in polar areas, where the atmosphere is currently not well sampled on small scales.

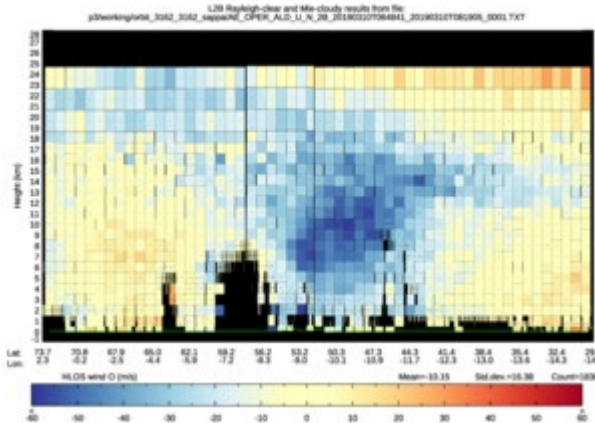
Also providing valuable profile information of aerosol and cloud layer optical properties.



Simulator input scattering ratio $(1 + \beta_p / \beta_m)$ from ECMWF model



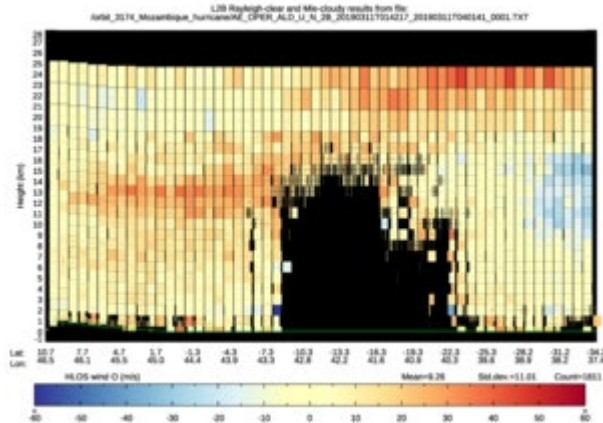
AEOLUS IN ACTION



Western Europe on 10 March 2019
Red wind blowing from east to west (**easterlies**), blue indicates wind blowing from west to east (**westerlies**), black no measurements due to thick cloud

Strong westerly wind in the jet stream, with **speeds of >200 km per hour at 10 km**

Very strong winds extended from the jet stream all the way down to the surface and **caused problems for traffic and construction**



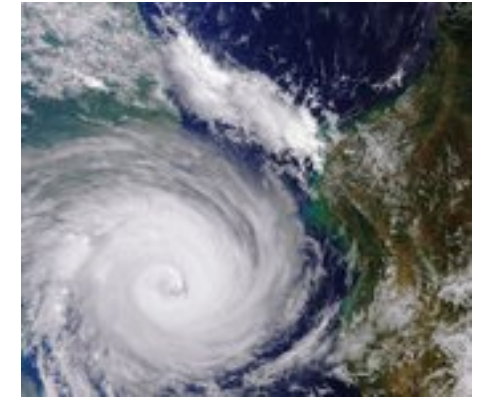
Cyclone Idai west of Madagascar, 11 March 2019

Red easterlies, blue westerlies, black thick cloud

Aeolus measures winds surrounding Idai

Strong easterly winds north of the hurricane with wind speeds up to 150 km per hour (above 40 m/s).

Upper right (altitude of 22–25 km) **tropical stratospheric easterly jet**
lower right (altitude of 10–16 km) the **sub-tropical westerly jet in the southern hemisphere**



Cyclone Idai from Copernicus Sentinel-3
Aeolus data Aeolus is adding **complementary information** to satellites carrying **optical instruments such as the Copernicus Sentinel-3** and the satellites carrying **radar such as the Copernicus Sentinel-1**

By end of 2019 the data will be ready for scientific research and for weather forecasting

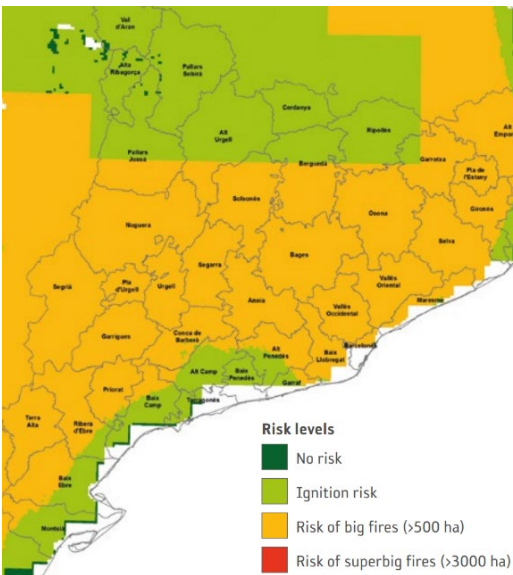
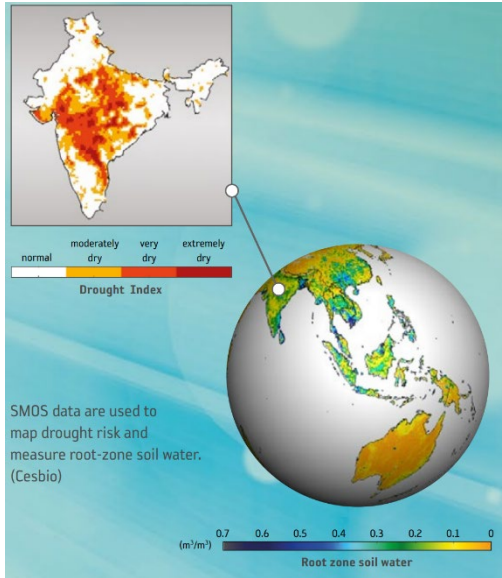
SOIL MOISTURE AND OCEAN SALINITY MISSION

smos

→ ESA'S WATER MISSION



SMOS MISSION TODAY



low-frequency passive L-band microwave
to capture images of **brightness
temperature**

measures **soil moisture and ocean
salinity**

New information on

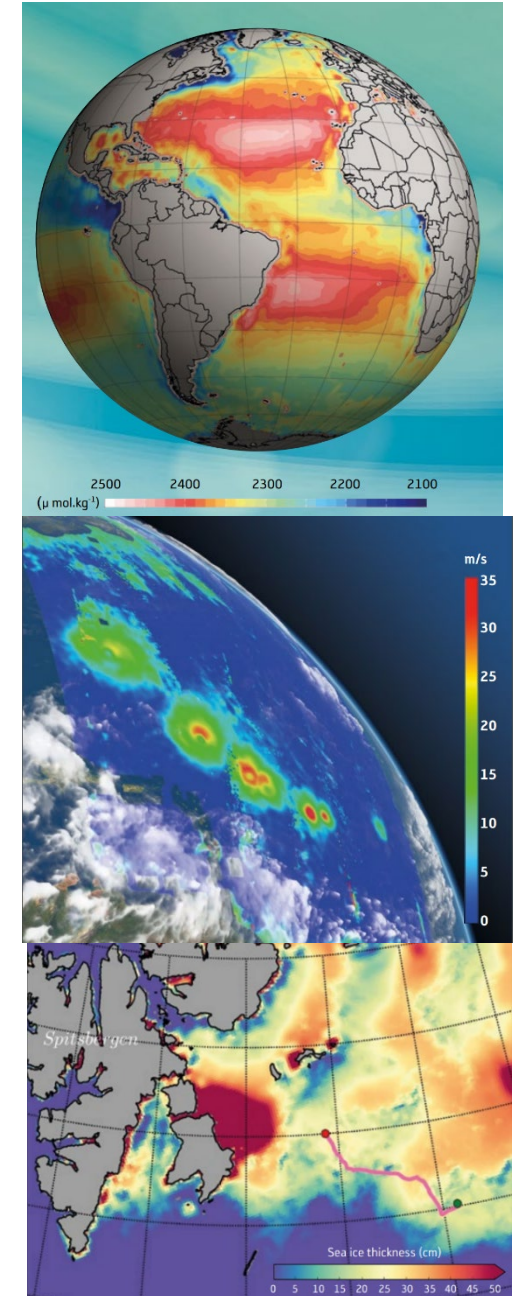
ocean circulation and salinity

tracking storms and hurricanes

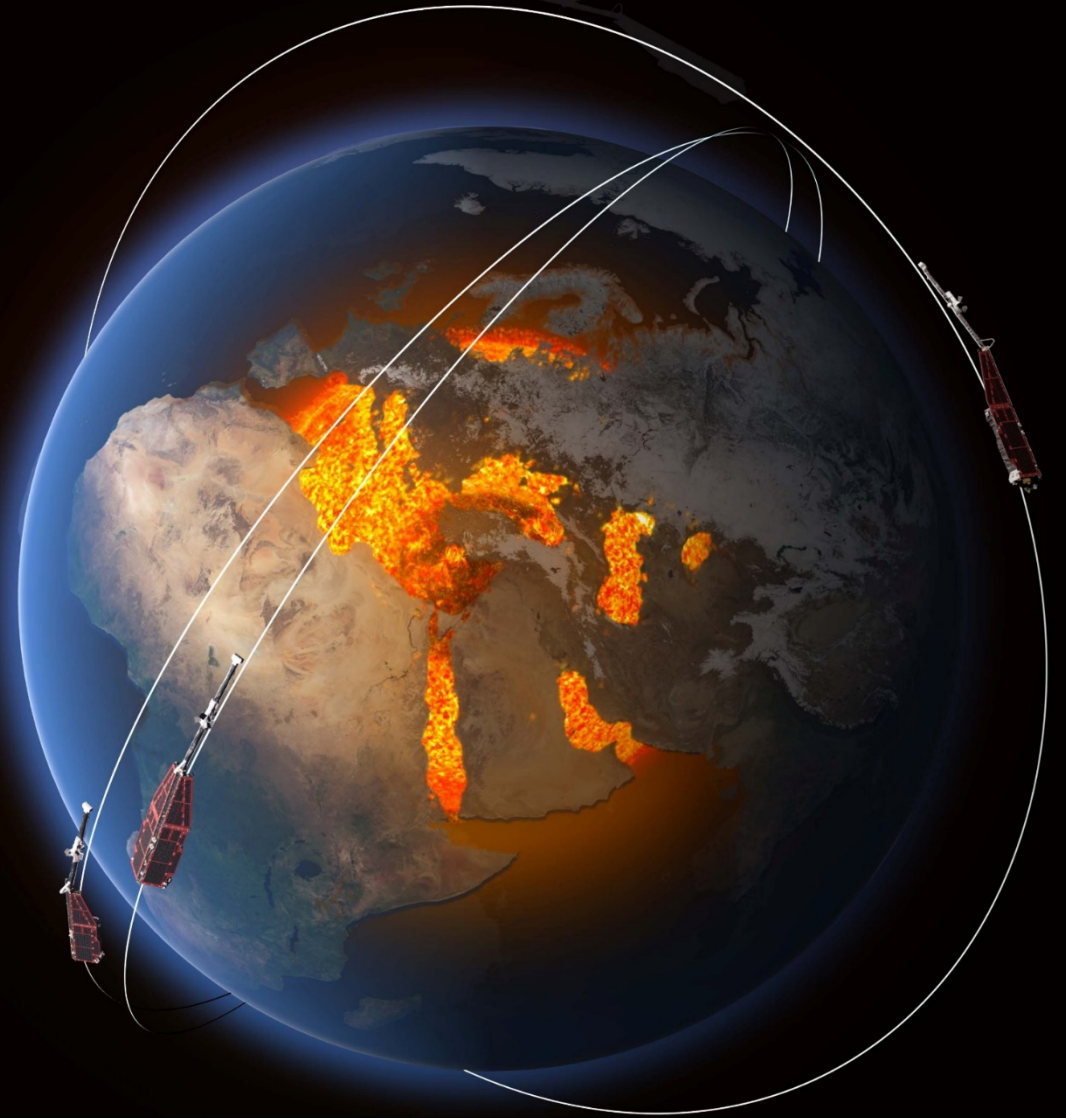
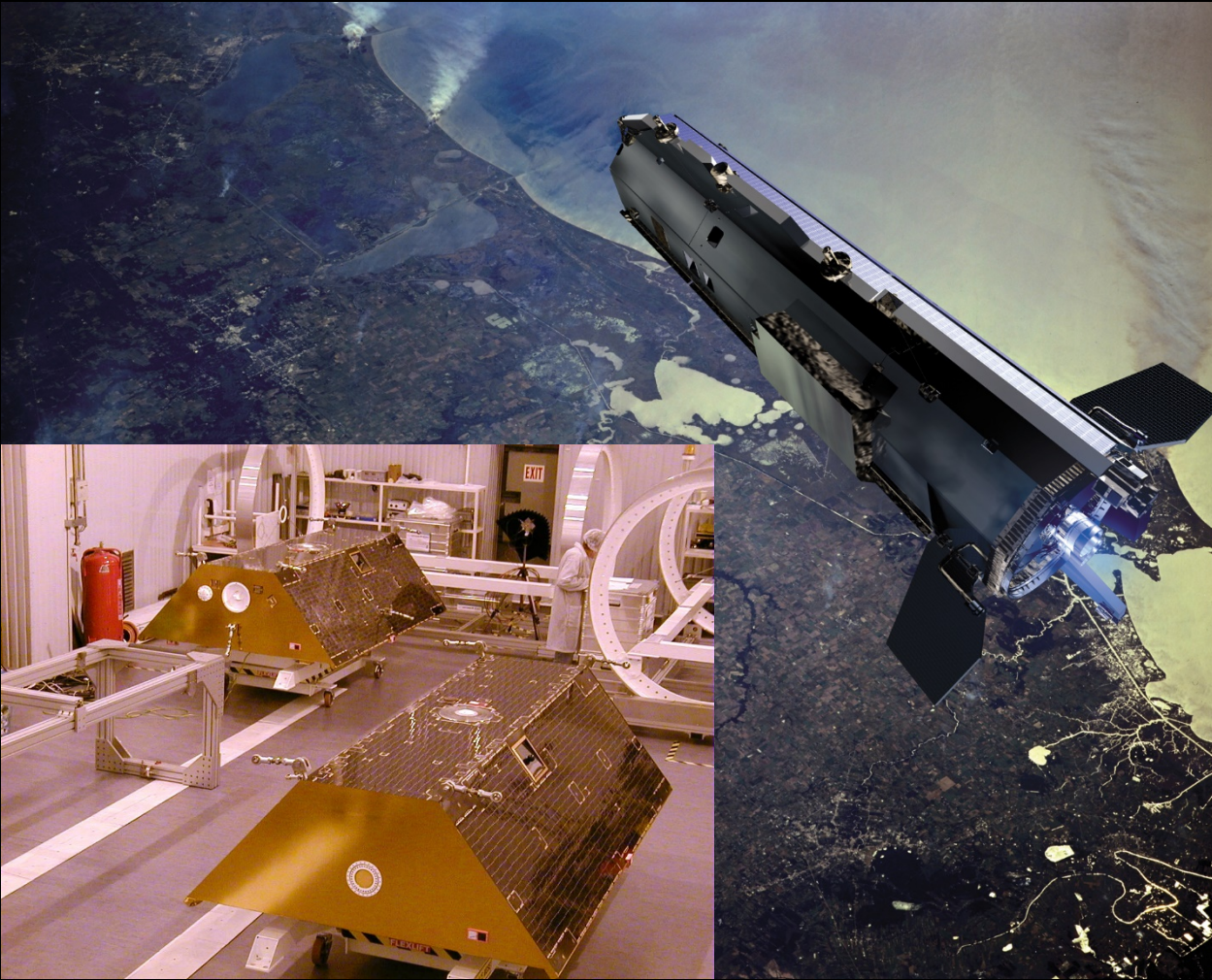
polar thin ice for shipping

**mapping droughts and crop-yield
forecasts risk of forest fires**

thawing soils and carbon storage



3D EARTH GOCE GRACE AND SWARM



GRACE, GOCE and SWARM A and SWARM B in near-polar orbit

GOCE AND GRACE GRAVITY AND SOLID EARTH

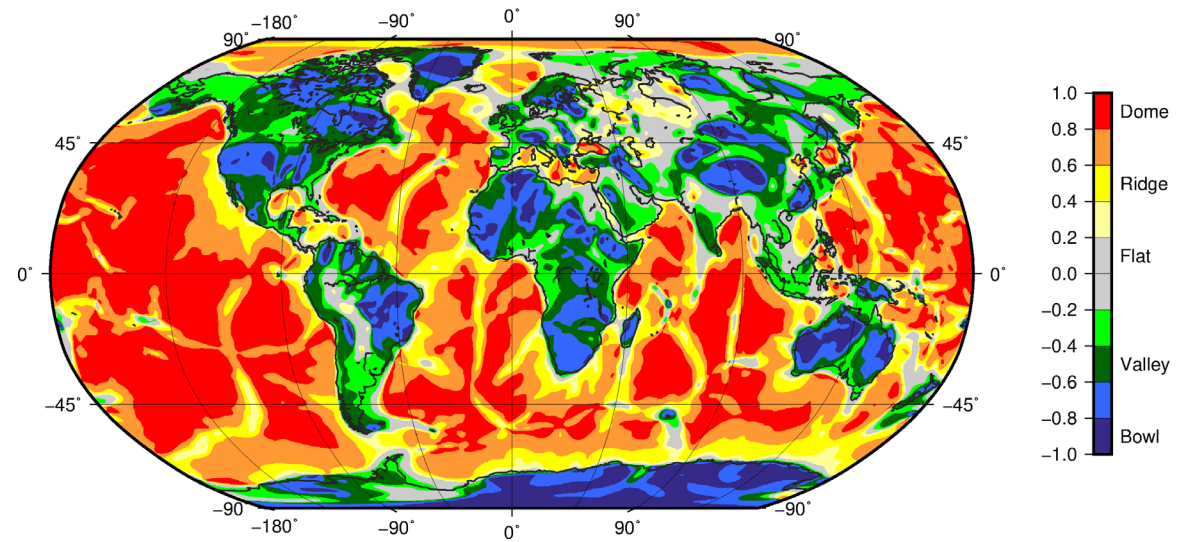
GOCE Gravity field & steady-state Ocean Circulation Explorer state-of-the-art gradiometer mapped Earth's geoid to an unprecedented level of accuracy

Explored core dynamics, geodynamo processes and core-mantle interaction

Tectonic map and determination of the 3D electrical conductivity of the mantle

GRACE Gravity Recovery and Climate Experiment

Measuring mass balance changes in water

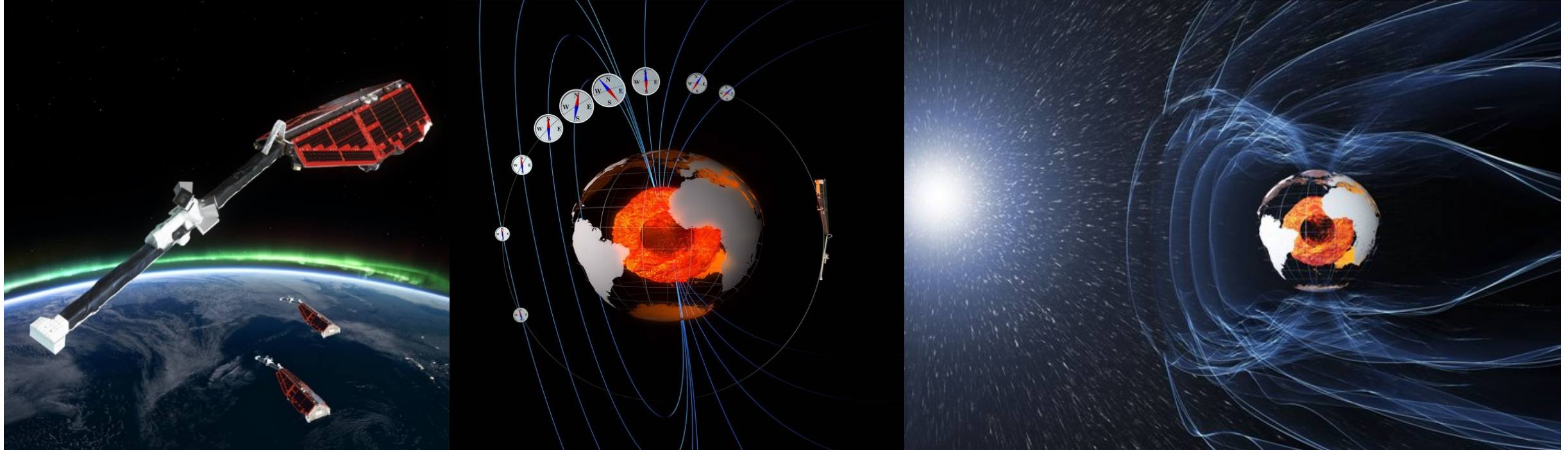


SWARM MONITORING THE MAGNETOSPHERE

SWARM provides the best-ever survey of the **geomagnetic field and its temporal evolution and the electric field** in the atmosphere

SWARM is a constellation of 3 identical satellites carrying sophisticated magnetometers and electric field instruments

SWARM pinpointing the position and movement of magnetic north for smartphones



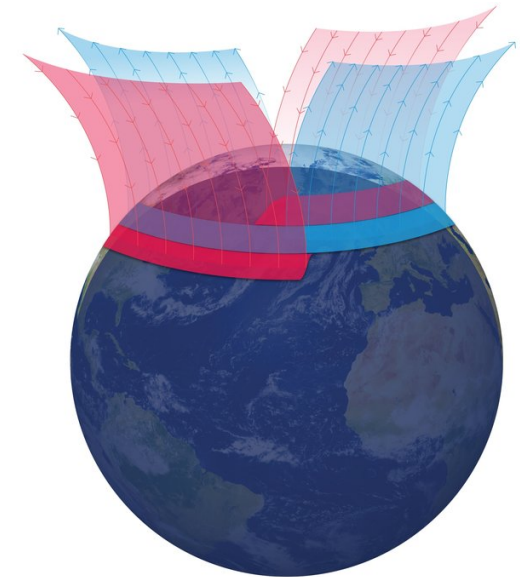
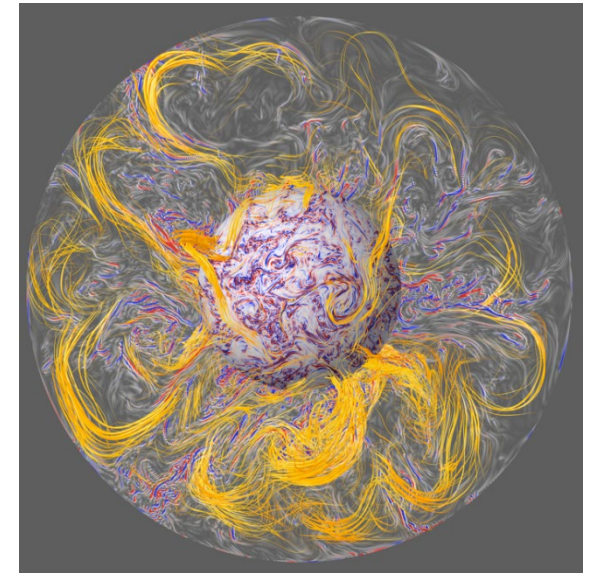
UNDERSTANDING OUR PROTECTIVE SHIELD

The magnetic field is thought to be generated by an **ocean of superheated, swirling liquid iron** that makes up Earth's outer core **3000 km under our feet**

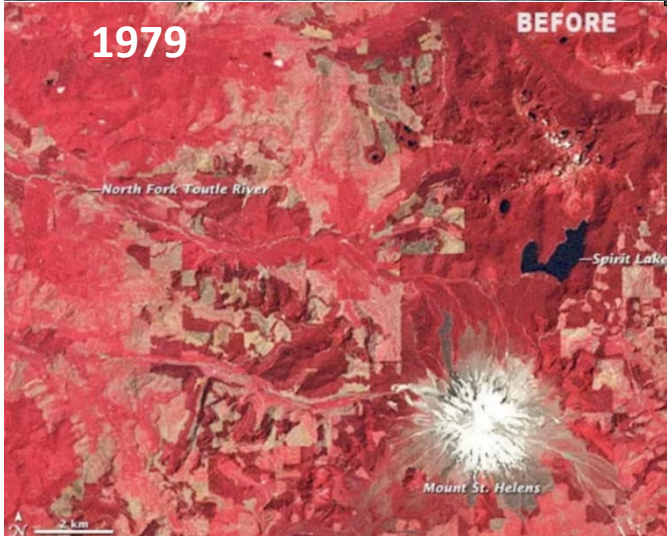
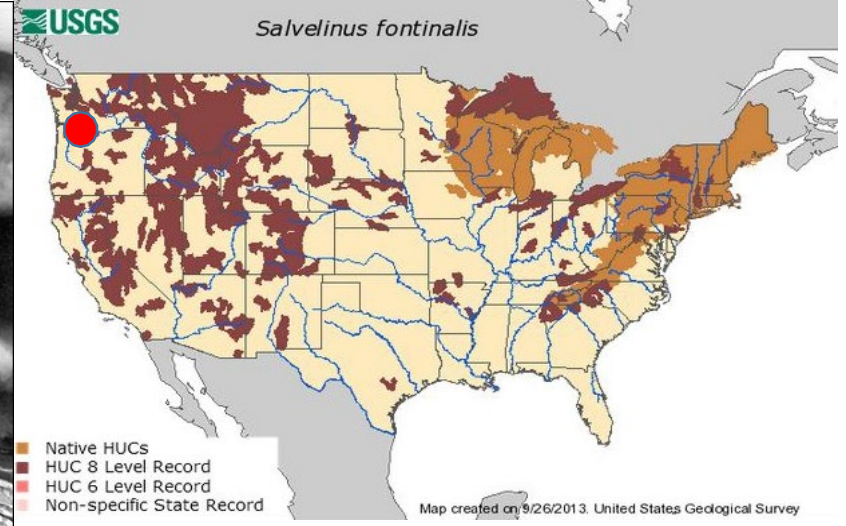
Acting like the spinning conductor in a bicycle dynamo, it generates **electrical currents** and the **continuously changing electromagnetic field**

Magnetism also come from minerals in Earth's mantle and crust, magnetosphere and oceans and solar weathrt

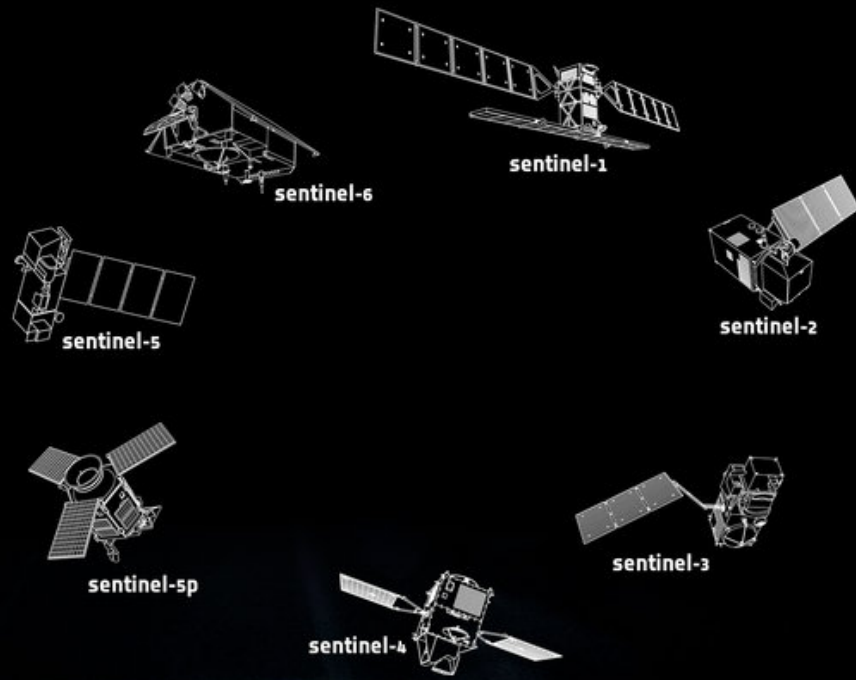
Swarm identifies and measures precisely these different magnetic signals and helps to explain phenomena such as **magnetic jerks and plasma jets**



FORECASTING VOLCANIC ACTIVITY



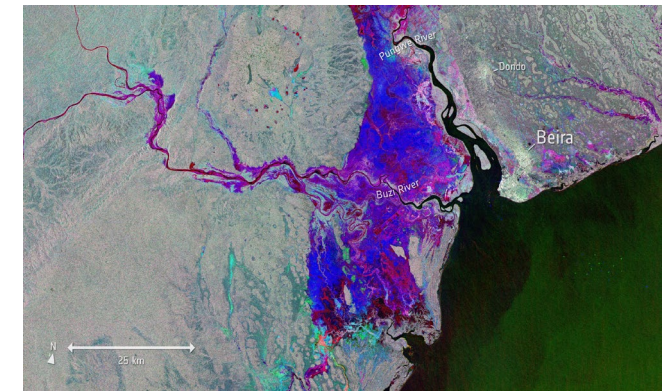
COPERNICUS - SENTINEL MISSIONS



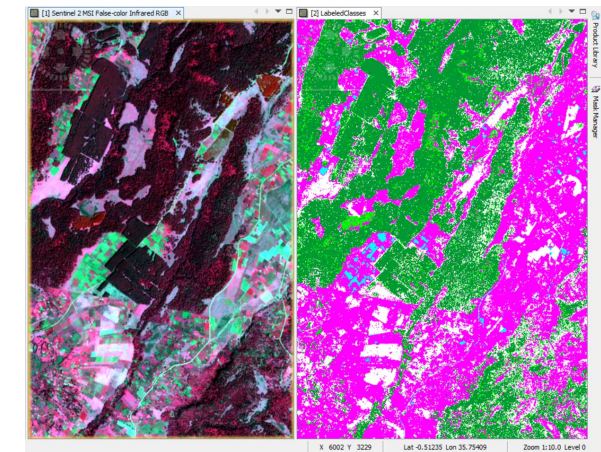
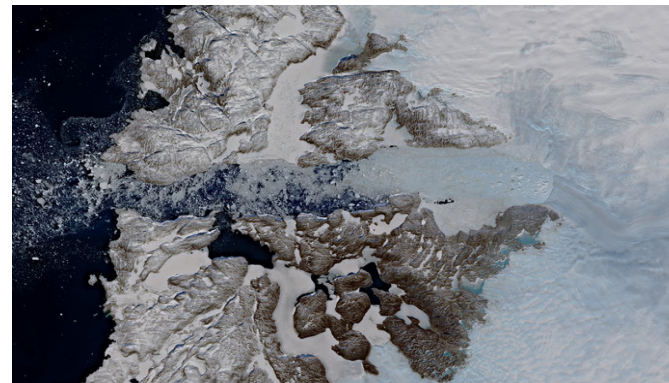
The largest constellation of earth observing satellites carrying a range of technologies for land, atmospheric and ocean monitoring

SENTINEL OPERATIONAL SERVICES

Sentinel-1 polar-orbiting, all-weather, day-and-night **radar imaging mission for land and ocean services**. Launched 2014 and 2016
Maritime traffic and flooding after Cyclone Idai



Sentinel-2 polar-orbiting, **multispectral high-resolution imaging mission for monitoring land, vegetation, soil and water cover, inland waterways and coastal areas**. Sentinel-2 also delivers information for **emergency services**. Launched 2015 and 2017

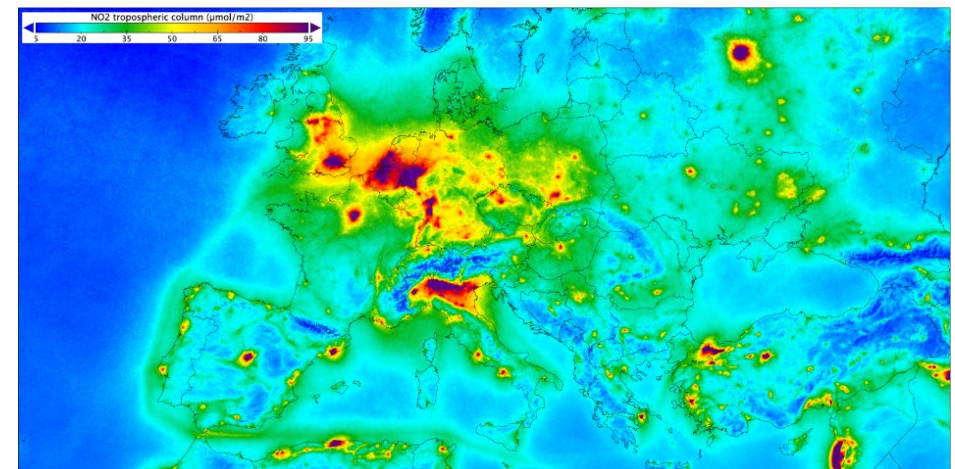
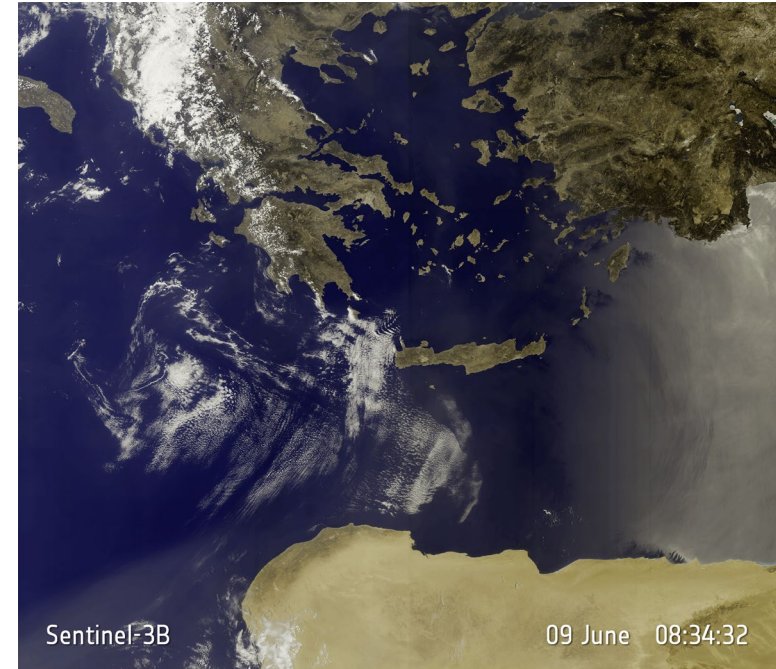


SENTINEL OPERATIONAL SERVICES

Sentinel-3 multi-instrument mission to measure sea-surface topography, sea- and land-surface temperature, ocean colour and land colour with high-end accuracy and reliability to support **ocean forecasting systems, environmental and climate monitoring**. Flying in tandem, travelling at 7.4 km per second and separated by 30 seconds ie a distance of 223 km. Launched 2016 and 2018.

Sentinel-5 Precursor provide timely data on a multitude of trace gases and aerosols **affecting air quality and climate**. Launched 2017

Image shows nitrogen dioxide over Europe. Nitrogen dioxide pollutes the air mainly as a result of traffic and the combustion of fossil fuel in industrial processes. It has a significant impact on human health, contributing particularly to respiratory problems.



LEAVING EARTH ... WE'RE GOING TO MARS....



OR MAYBE NOT