Protection against extreme weather events

Earth observation satellites were originally mainly used by the scientific community in order to improve their understanding of the natural world. How times have changed. Today, Earth observation satellites are used for a range of applications, including environmental monitoring, defence, resource monitoring, meteorology and navigation, by businesses and governments as well as scientists. Here Satellite Evolution takes a look at the use of Earth observation satellites for protection against extreme weather events like hurricanes and the El Niño phenomenon.

One of the first Earth observation satellites, SPOT 1, started operations in 1986 and is now celebrating three decades of experience in the Earth observation field. SPOT 1 was equipped with steerable mirrors, ground-breaking technology at the time, to enable it to observe a given site every five days with a 10m resolution. Each of the SPOT satellites that came since, all built by Airbus Defence and Space, have had improved performance thanks to design and technology developments. SPOT 5, for example, was able to take 2.5m resolution images and opened the door for the commercial use of satellite images. SPOT 6 and 7, meanwhile, weigh just 720kg each compared to the three tonne SPOT 5, and allow daily revisits of anywhere on Earth with 1.5m resolution.

Technology has advanced a lot since 1986, meaning that more detailed and accurate images can be taken of Earth from space than ever before. Scientists are now able to make forecasts accurate enough to protect the population from unusual and extreme weather patterns, a skill that continues to improve as technology and understanding advances.

Monitoring El Niño

The El Niño phenomenon, which takes place every 2-7 years and lasts for nine months to two years, is one of the major weather events to be monitored closely by Earth observation satellites. During El Niño, the temperature of part of the Pacific Ocean rises by at least 0.5°C (usually 2-3°C), while air pressures rise in the western Pacific and fall in the eastern Pacific. This results in unusual rainfall patterns in much of the world, with droughts in some regions and floods in others.

El Niño has an unfortunate effect on many areas that rely on the agriculture and fishing industries. Australia, Chile, Indonesia, India, Japan, New Zealand and South Africa are all negatively affected by El Niño. Warm, nutrient-sparse water replaces cold, nutrient-dense water, reducing crop yields and displacing fish from their usual locations. The warmer temperatures are also linked to an increase in mosquito-transmitted diseases like Dengue fever and the Zika virus and, in Japan and the USA, Kawasaki disease due to the tropospheric winds over the north Pacific Ocean.

The most recent 2014-2016 El Niño has been compared in severity to that of 1997-1998, the worst on record. In 2015, the drier atmosphere in Australia resulted in raging bushfires that destroyed significant parts of the Tasmanian UNESCO World Heritage Centre. Drought in New Zealand and the Philippines is expected to have a major economic impact.
Earth Observation

due to crop loss, while in South Africa it has resulted in major livestock deaths.

Earth observation satellites have played a major part in monitoring recent El Niño and predicting the severity and likely outcomes. To monitor the 2014-2016 El Niño, NASA’s Jason-2 satellite measured the sea surface height and ocean temperatures around the globe. Meanwhile, its Global Precipitation and Measurement Mission and the Soil Active Passive Mission satellites tracked precipitation and surface level moisture all over the world. The measurements enable scientists to improve their understanding, for instance, on the connectivity between El Niño and the variability in fire seasons in the USA, Amazon and Indonesia, or droughts in California.

“We still have a lot to learn about these connections, and NASA’s suite of satellites will help us understand these processes in a new and deeper way,” said Lesley Ott, Research Meteorologist at NASA’s Goddard Space Flight Center, Greenbelt, Maryland.

There’s also been suggestions from the scientific community, based on recent satellite imagery, that El Niño may be affected by climate change. In the last twenty years, several unusual El Niño phenomenon have taken place, in which the temperature is raised in the Central rather than the Eastern Pacific Ocean. Different weather patterns are experienced during these unusual El Niño, including hurricanes in the Atlantic. However, as historic satellite imagery only dates back to 1979, no consensus has yet been reached.

**Protection against extreme weather**

Hurricanes, typhoons and other extreme weather incidents cause widespread devastation to the areas where they occur. In 2005, Hurricane Katrina caused around US$108 billion of property damage and the deaths of 1,245 people in the USA. Meanwhile, in 2013, Southeast Asia was hit by Typhoon Haiyan, which caused some US$2.86 billion of damage, and killed 6,300 people in the Philippines alone. The ability to better monitor the rapid changes in extreme weather conditions is critical to forecasters in order to make earlier and more accurate predictions, to save lives and protect livelihoods. Satellites have a major part to play in this field.

August 2015 saw the start of construction of NASA’s Cyclone Global Navigation Satellite System (CYGNSS) mission in Texas. The project will see a constellation of eight, 64lb micro-satellites launched into 500km orbit, with 35° inclinations. CYGNSS will allow scientists to probe the inner core of hurricanes frequently for the first time, using both direct and reflected signals from existing GPS satellites to obtain estimates of surface wind speeds over the ocean. The existing and new LEO satellites will be able to collect data every 1.5 hours. Measurements of ocean surface winds in and near the eye of tropical cyclones, typhoons and hurricanes will improve forecasting methods.
“The rapid refresh CYGNSS will offer is a key element of how we’ll be able to improve hurricane forecasts,” said Christopher Ruf, Director of the U-M Space Physics Research Lab, Professor of Atmospheric, Oceanic and Space Sciences and CYGNSS Lead Investigator. “CYGNSS gets us the ability to measure things that change fast, like extreme weather. Those are the hardest systems to measure with today’s satellites. And because the world is warmer and there’s more energy to feed storm systems, there’s more likelihood of extreme weather.”

As the satellites do not have propulsion systems on board, they will all travel at different speeds, dictated by their deployment from the Orbital ATK Pegasus XL expendable rocket. If left unaided, the fastest satellite would take six months to lap the slowest. To minimize the poor exposure that would result from the satellites bunching in one region during some of their lifetime, the satellites will be ‘tipped’ for short periods as required so that, using drag, their position and speeds can be altered. This will ultimately allow the satellites to be evenly spread throughout a circular orbit.

Simulations have shown that the current average error from wind speed forecast of 33 knots (38mph) could be reduced by 9 knots (10mph) using the new constellation. “I’d describe the feeling about it as guarded excitement,” said Ruf on the simulations. “It’s preliminary and it’s all based on models. People will be really excited when we get up there and it works.”

Construction of the first satellite was completed in February 2016. The remaining seven will be completed in the Spring of 2016, after which they will undergo environmental testing and calibration. The mission is scheduled to launch in late 2016 from Cape Canaveral in Florida, with operations beginning in the 2017 Atlantic hurricane season.

Looking ahead
The use of Earth observation satellites to monitor El Niño, extreme weather events and other environmental patterns are of vital importance in furthering mankind’s understanding of the world. With improved understanding, scientists are better able to separate cause and effect, make predictions for the future, and thus protect our people, economy and environment.

According to analysts at Research and Markets, the satellite-based Earth observation sector will have a CAGR of 13.23 percent in 2014-2019, which suggests that businesses and governments around the world understand the important part that Earth observation satellites must play in the future. Indeed, many established and start-up companies like Planet Labs, Skybox Imaging, Satellogic and OmniGlobe have announced recent plans for investment in the sector.

BlackSky is just one of the companies expanding its Earth observation capabilities. In June 2015, it announced plans to deploy a 60-satellite constellation by 2019, to be built and launched by Spaceflight, in order to provide ‘high-resolution images of the globe at an unparalleled cost and frequency.’

Rakesh Narasimhan, BlackSky’s Executive Vice President/General Manager, informed Satellite Evolution that the first two satellites, known as Pathfinder, will be launched in the Summer of 2016. The next four satellites will be launched in 2017, with launches continuing until 2020 to populate the constellation. After that, the launch cadence will continue in order to replenish older satellites, which have an expected lifetime of three years.

The constellation will supply 1m resolution images and 1fps video within two hours via BlackSky’s software platform on a pay-per-picture basis. The services are intended for use by both government and commercial entities, with end-use anticipated in the agriculture, oil and gas, defence, energy and civil government sectors, among others.

“By operating the infrastructure to view our planet in near real-time, we envision an open future where enhanced Earth observation leads to positive change and a better understanding of our world,” said Peter Wegner, BlackSky’s Chief Technology Officer.