proposals to cut back Earth-science research at NASA or otherwise restrict studies of global warming. One rescue effort had archived 11 of 91 data sets on its list for preservation as of 16 December; these include a global temperature record maintained by NASA and palaeoclimate archives held by the National Oceanic and Atmospheric Administration (NOAA).

Marcia McNutt, president of the US National Academy of Sciences, says that private foundations have expressed interest in "funding up to the order of billions of dollars" for climate-change research if the Trump administration reduces support for such work. But McNutt — who directed the US Geological Survey (USGS) from 2009 to 2013 — is not ready to give up on government science. "I don't want that to be an excuse for the government to pull away — to say private philanthropy can do this, the government doesn't need to fund it," she told journalists at the AGU meeting.

The road ahead for scientists looks tough. Perry dealt with energy issues as governor of Texas, but he lacks experience with key areas of the DOE portfolio, says John Deutch, a chemist at the Massachusetts Institute of Technology in Cambridge. Deutch, who leads the department's advisory board, says that Trump should identify a deputy energy secretary who understands the agency's programmes on basic science, nuclear weapons and national security.

And Perry is not the only climate sceptic poised to join Trump's inner circle. Trump's pick to lead the US Environmental Protection Agency is Oklahoma attorney-general Scott Pruitt, who has sued the federal government to overturn greenhouse-gas and air-quality rules.

The president-elect has not announced whom he would like to run NASA, NOAA or the USGS, among other science agencies. McNutt says that the National Academies of Science, Engineering, and Medicine have provided his transition team with a list of potential candidates, but none of those people has been contacted by Trump staff.

Some scientists argue that even if policies to fight climate change are weakened or struck down under Trump, his latest nominations hint that there may be ways to promote clean energy. Tillerson has said that a carbon tax is the best way to address global warming. And although Perry is a strong proponent of fossil fuels, Texas's wind-power production grew significantly during his governorship.

"Those are places to insert a progressive agenda into an otherwise kind of ugly and cloudy landscape," says Daniel Kammen, an energy researcher at the University of California, Berkeley.

McNutt advises scientists to stay clear-eyed as they confront whatever challenges the Trump administration brings. "I see so many people in this country freaked out," she says. "That is exactly what those who want to disrupt science are hoping to achieve." ■

NAVIGATION SATELLITES

Galileo satellites herald new era for Earth sciences

Europe and Asia will set the atmosphere abuzz with more radio-wave navigation signals.

BY DECLAN BUTLER

After soaring costs and years of delays, Europe's global satellite-navigation system, Galileo, finally began beaming its first signals to receivers in smartphones and cars on 15 December.

The 18-strong fleet of satellites promises travellers another way to accurately locate their position on Earth, ending Europe's dependence on the US Global Positioning System (GPS) and Russia's GLONASS. But Galileo, which was first proposed in 1999, is a big deal for science, too, says Richard Langley, an expert in navigation-satellite systems at the University of New Brunswick in Fredericton, Canada. What most excites scientists is the prospect of combining signals from multiple satellite networks, enabling new kinds of atmospheric and Earth-sciences research.

Galileo's constellation of satellites should reach its full complement of 30 in 2020, by which time China's BeiDou system, comprising 35 satellites, is scheduled to enter service. Japan and India are also building regional systems. Altogether, the number of global navigation satellites encircling Earth is set to rise from around 90 today to at least 130 over the next decade, estimates Oliver Montenbruck, a physicist at the German Aerospace Center in Oberpfaffenhofen, Germany. At the same time, existing satellite fleets will be modernized.

Earth's atmosphere will then be streaming with many more kinds of radio-wave signal at a greater variety of frequencies — each carrying information about the time and the position of the satellite that sent it. Sat-nav receivers use data from multiple satellites to pinpoint their own position. So simply having more satellites overhead will help stop signal loss and provide more accurate position fixes, says Langley. "The more satellites you have, the greater the precision," adds Tonie Van Dam, an Earth scientist at the University of Luxembourg who uses receivers to monitor how Earth's crust deforms in response to shifting water or ice.

"The more satellites you have, the greater the precision."

Skies increasingly crowded with radio waves will also benefit weather forecasting and climate research. Scientists use the refraction of navigation-satellite signals in the Earth's atmosphere to make measurements of atmospheric temperature, pressure, density and water-vapour content. And the signals can similarly be exploited to measure electron density in the ionosphere, an electrically charged layer in the upper atmosphere. These data are used to track space weather and to monitor tsunamis and earthquakes, says Philippe Lognonné, a geophysicist at the Institute of Earth Physics of Paris. These events disturb air so violently that they send acoustic and gravity waves up to the ionosphere where they perturb electrons. With fully operational Galileo and BeiDou systems, researchers should be better able to estimate tsunami heights, Lognonné says.

Scientists also plan to use multiple navigation-satellite constellations to improve measurements of ocean wind speeds and sea surface roughness, says Jens Wickert, a scientist at the GFZ German Research Centre for Geosciences in Potsdam. Today's remote-observation ocean maps are built largely by bouncing radar waves off the sea from aircraft or spacecraft, and combining those data with information from other satellite instruments. The best current maps have a spatial resolution of around 80 kilometres and are updated every 10 days. Wickert aims to improve on that using orbiting receivers ▶

STEPHANE CORVAJA – ESA

Over the past five years, 18 Galileo satellites have been launched into orbit.

for navigation-satellite signals. A European experiment called GEROS-ISS, which Wickert is leading, aims to fly a receiver on the International Space Station in 2019. The experiment would measure navigation-satellite signals as they reflect off the sea. By combining data from Galileo, BeiDou, GPS and GLONASS, it could map the oceans at spatial scales down to a few kilometres every four days or less. Many ocean phenomena, such as eddies, occur at these scales, so better maps would help to improve weather and climate-change models.

A fleet of receivers in space could provide even finer resolution. In a step in that direction, on 15 December NASA launched its own ocean-reflection research mission, the Cyclone Global Navigation Satellite System. A fleet of eight microsatellites, each carrying four navigation-satellite receivers, will measure wind speeds and ocean roughness in the eyes of storms at unprecedented resolutions of a few kilometres every few hours. Chris Ruf, Cyclone's principal investigator and a remote-sensing scientist at the University of Michigan in Ann Arbor, says that the first mission will use GPS only, but he is keen to integrate data from Galileo and BeiDou in follow-ups.

Much research on fusing signals from navigation-satellite systems is taking place under a federation of more than 200 agencies, universities and research centres. Montenbruck, who heads this effort, cautions that it may take more than five years after Galileo and BeiDou enter full service before scientists can exploit their possibilities completely. "Today's use of GPS benefits from 30 years of experience and an excellent understanding and characterization of all the dirty details," he says. "All that still needs to be carried out for Galileo and BeiDou." ■

POLICY

Major rethink for outbreak response

World Health Organization aims to prevent crises similar to the West African Ebola epidemic.

BY ERIKA CHECK HAYDEN

Three years after the start of the world's worst Ebola epidemic, the World Health Organization (WHO) has created a programme to improve its response to disease outbreaks and to prevent another such calamity.

In June, WHO director-general Margaret Chan named medical epidemiologist Peter Salama to lead a new health-emergencies programme intended to streamline the agency's response to crises. As part of that programme, the WHO has launched the Emerging Diseases Clinical Assessment and Response Network (EDCARN) to provide guidance on how to care for people during disease outbreaks.

Global-health experts say that the changes are a step in the right direction, but both developing and wealthy nations must do much more to avert another devastating epidemic. Some are also concerned that the WHO programme will have trouble getting the funding it needs to succeed, because of a lack of monetary support from member nations.

"African countries are still so dependent on international and global outfits that the return of Ebola or any other disease will be another déjà vu of national unpreparedness," says virologist Oyewale Tomori at Redeemer's University in Ede, Nigeria.

Tomori says that many developing nations still don't have sufficient capacity for recognizing and responding to an emerging infectious disease.

BUILDING A BRIDGE

The WHO's new programme aims to strengthen local health systems and to bridge global, organizational and governmental efforts to prevent the next outbreak. Daniel Bausch, EDCARN's technical lead, says that the network aims to fill huge gaps exposed during the Ebola crisis: a lack of knowledge about how best to care for people who have such serious diseases, and a shortage of physicians and experts who are prepared to provide that care.

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