'We mustn't rush things'

Satellites can make observations that are crucial for creating good climate models. The current uncertainty surrounding these models however can lead to the wrong political decisions being taken. The Faculty of Aerospace Engineering is therefore calling for an expansion of satellite-based Earth observations.

Desiree Hoving

More snow has fallen in the Netherlands this winter than at any time during the past thirty years. Does this mean global warming isn't as serious as it is claimed to be? That would be a decidedly simple-minded conclusion, says Professor Ramon Hanssen, of the Faculty of Aerospace Engineering: "This white winter has no implications whatsoever in terms of global warming. Our problem is that we tend to take a rather blinkered view of things. People are unaccustomed to thinking back beyond the period spanned by their own individual memories. Our perception is out of step with the time-scales of Earth's processes."

Roughly 20,000 years ago there was a real ice age, when large parts of Europe, Asia and North America were covered by ice year round, yet the Earth's average temperature at that time was only 5 °C lower than it is today. Then, between 1600 and 1850, there occurred a little ice age, during which the average temperature was only half a degree lower than it is now. In 1780, soldiers were even able to drag cannons ten kilometres across the frozen ocean from Manhattan to Staten Island. Current climate models forecast a temperature rise of between 2 and 6 °C by the year 2100. Is that significant in this historical perspective? According to Prof. Hanssen, it certainly is: "This is at least double the temperature difference between the little ice age and what we see today. The effects of global warming are being seriously underestimated."

'The effects of global warming are being seriously underestimated'

The problem with the current climate debate is that there are such large inconsistencies between climate models, which reduce the accuracy of scientists' predictions.

The professor feels that this is partly because too few observations have been made, with the direct result being that we still do not fully understand the significance of many variables. Yet these observations have nevertheless been encapsulated in climate models, which in turn are translated into political policy. "Accordingly, the climate-related options that we will spend our tax money on in years to come are highly dependent on good observational data. We mustn't rush things in this debate," says the professor of Earth Observation, who is therefore not only calling for more evidence to be gathered, but also firmly believes that he can obtain such evidence using smarter and better Earth observations by satellites.

Noise

One such approach is a new, improved Earth observation method that Dr Bert Wouters developed to accurately map the melting of Greenland's ice cap. On 19 January, Dr Wouters was awarded a PhD for his research on this topic. His research also involved using the two Grace (Gravity Recovery And Climate Experiment) satellites, which have been measuring changes in the Earth's gravitational field since their launch in 2002. "Everything that has mass also has a gravitational field," Dr Wouters explains, "so changes in the amount of ice in a given location also change the strength of the local gravitational field. If you know the strength of this gravitational field, you can therefore also calculate the degree of change in mass." As a PhD student, he calculated that Greenland loses an average of 220 gigatons of ice per year. One truly innovative aspect of his research is that he can also accurately identify the exact areas from which this ice is disappearing.

The main problem encountered when attempting to analyse satellite data is the amount of noise contained in the data. When measuring gravitational changes, the melting of ice is not the only factor involved. Ocean tides and variations in air pressure also produce local fluctuations in the Earth's gravitational field. Dr Wouters developed a statistical filtering method to reduce noise levels, thus enabling him to accurately map the areas of Greenland's ice sheet that are melting. He then combined this data with a climate model developed at Utrecht University. Wouters and his counterparts at Utrecht collected data over a period of six years, before concluding that not only is melting occurring both on the ice cap's surface and edges (i.e. in the glaciers), but that the ice has also started to melt even faster over the past two years. "The Utrecht model shows that less snow is falling on Greenland, while the melting of surface ice continues unabated," says Wouters, who is currently developing climate models for the KNMI (Royal Netherlands Meteorological Institute).

The melting of ice sheets, like those in Greenland and ▸▸

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Antarctica, will have repercussions in terms of sea level. Sea ice, like the ice around the North Pole, is already floating on water, so does not affect global sea levels when it melts. According to Wouters, the ice mass lost by Greenland caused sea levels to rise by 0.4 millimetres during the first four years of his six-year project, and by 0.75 millimetres during the final two years. Antarctica is also losing mass, a total of 150 gigatons per year, resulting in a further 0.5 mm rise in sea levels. If Greenland's entire ice sheet were to melt – a process that at this rate would take about 10,000 years – global sea levels would rise by an average of seven metres. Is this something that people in the Netherlands should already be worrying about?
"Yes," says Hanssen, "although local effects could diverge markedly from the global trend, for better or worse." In 2008, the Delta Commission started incorporating data on this presumed rise in sea levels (ranging from 0.65 metres to 1.30 meters in 2100) into policy. "However," the professor notes critically, "Veerman [the chairman of the Delta Commission – ed.] failed to take account of gravitational effects and the variable stiffness of the Earth's crust. How does an elastic crust respond to the disappearance of this ice? This varies considerably from place to place. The structure and composition of oceanic crust, for example, is completely different from that of continental crust." Hanssen is also aware that the committee ignored the impact of self-gravitation: "The Greenland ice cap attracts water molecules in the sea, which means that sea levels at more distant places actually fall. This will also have an impact on the Netherlands, given its coastal location. Unfortunately, our present understanding of the mechanisms involved leaves much to be desired. Rather than ignoring these effects, we should be intensifying our research activities in this field."
The Faculty of Aerospace Engineering uses a wide range of techniques to conduct all manner of Earth observations. One of these was previously mentioned: the gravity measurements performed by the Grace satellites. The Goce satellite, launched in 2009, is making similar measurements. Goce is the brain-child of Reiner Rummel, a former TU Delft professor. Whereas Grace primarily measures changes over time, Goce makes very precise measurements of the current mass distribution of the entire planet. "The Earth is a bit like a potato – it has more mass in some places than in others," says Prof. Hanssen. "Goce determines what the sea level would be like if there were no continents and if the Earth's dynamic processes were in complete stasis. This is a sort of reference surface against which you can map out any changes, such as those created by ocean currents."

Ramon Hanssen with a accurate gps-receiver.

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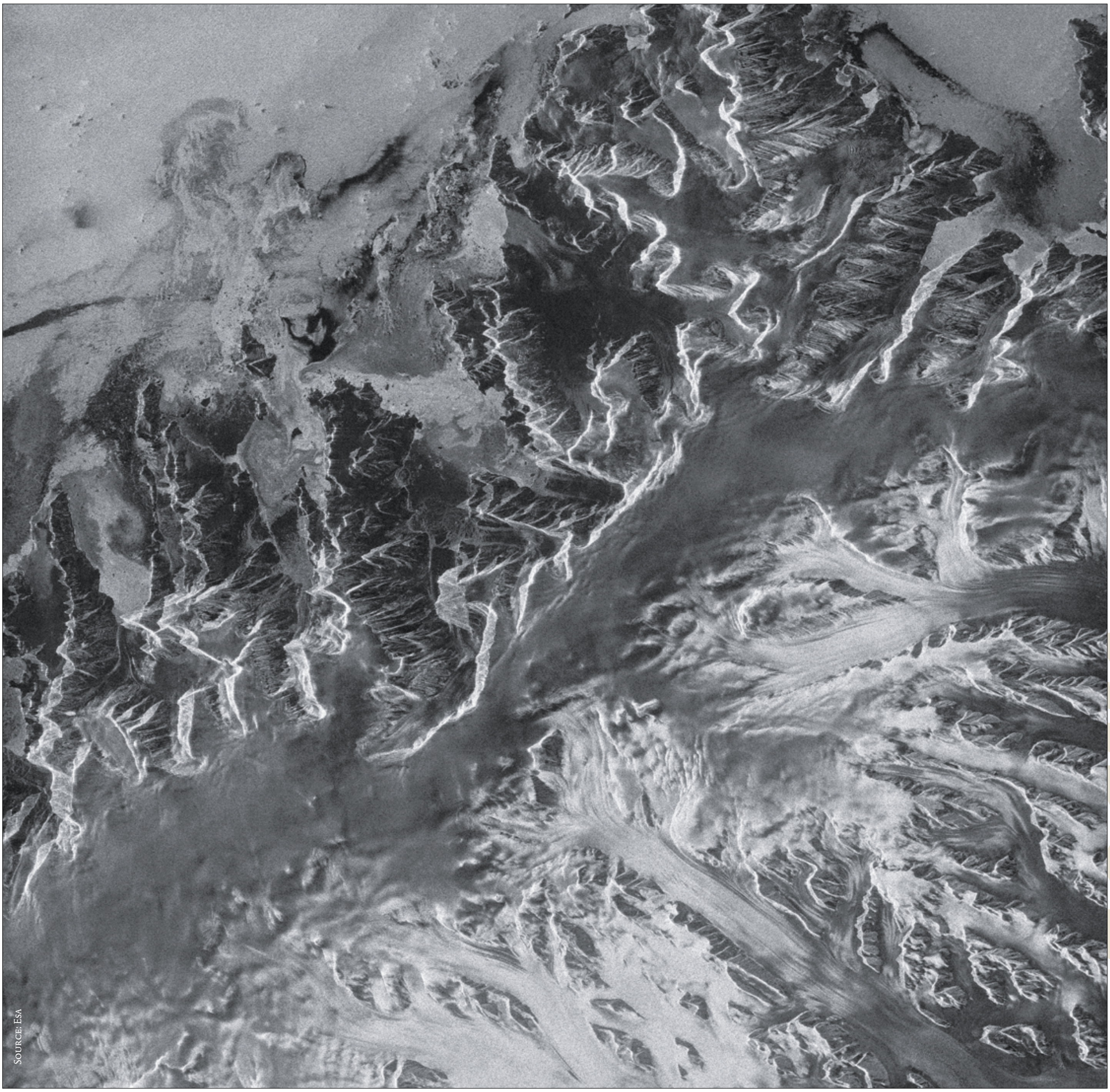
Elevation

Gravity measurements are often combined with data on elevation. Such data can be obtained using a radar or laser, like those carried by Envisat and Icesat respectively. High up in the corner of Prof. Hanssen's office hangs a gold-coloured model of the Envisat satellite. "It helps give people a more tangible impression of what we do here," he says. "The instruments it carries measure the distance between the satellite and the top of the ice. But there's a problem: the Earth's deeper, liquid zones are displaced by the sheer weight of the ice above, causing the ice to sink. As the ice

'Greenland's ice is melting both at the ice cap's surface and its edges'

melts, the surface of the Earth rebounds. It's a bit like a crust of ice on water in a ditch. When you push down on the ice with your foot, it gives way, sinking slightly into the water below. When you lift your foot up again, the ice rises too. Accordingly, you need more than a simple measurement of the ice cap's elevation to determine whether the amount of ice that it contains is increasing or decreasing."
For this reason, measurements of elevation are combined with gravity measurements. A third element is GNSS (global navigation satellite systems), the collective term for all GPS-like positioning systems. These GNSS receivers are placed on nunataks, which are mountain peaks that project up through the ice cap, thus enabling the satellite to obtain an accurate fix on the position of these peaks. In



The Antarctic Peninsula seen from SAR satellite.

places where this is not possible, SAR (synthetic aperture radar) satellites are also used to monitor the nunataks' movements. Research in this area is currently in full swing, particularly on the Antarctic Peninsula. The satellites must monitor movements of just a few millimetres per month. The radar images themselves are beautiful, detailed summaries of the distribution of ice sheets and sea ice. Earth observation is sexy again. The first measurements of the Earth were made using land-based instruments like theodolites, but since the 1970s this work has been done using space-based technology. Earth observation satellites orbit the planet at an altitude of several hundred kilometres. From this vantage point they can monitor changes in the size of ice sheets, in sea level, in CO_2 levels in the atmosphere, and in the thickness of the cloud cover, as well as the movements of volcanoes and landslides. In future, scientists will need more specific measurements and long-term observations in order to make more reliable climate forecasts; however, this will require budgets that are large enough to fund the launching of new satellites. But as Hanssen ruefully admits, politicians at the national and international level accord space technologies of this kind a very limited priority: "The really big budgets go to space travel, such as manned spaceflights to the Moon and Mars, which, among other benefits, serve to enhance people's interest in technology in general. But if we are to understand how our planet is changing, then Earth observation satellites are crucial. Many decisions about the climate are dependent on the data they collect."

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