WHILE THE ICE sheets in Greenland and Antarctic are unlikely to disappear within the next decade, their demise is nevertheless impacting the speed at which the sea level rises (SLR). With a growing population leading to increased urbanisation in coastal regions, the current estimate of people living at no more than 1 metre above sea level is over 100 million. The potential damage SLR poses to infrastructure in these vulnerable areas would result in massive societal consequences.

The Intergovernmental Panel on Climate Change (IPCC) reports that SLR could increase by almost 1 metre by the end of the century, although calculations based on empirical models have doubled this estimate. Despite the large ice sheets’ importance in SLR, projections of their future behaviour contain poorly-quantified uncertainties in ice discharge. The severity of societal impacts from rising sea level will depend on our ability to adapt to and mitigate its effects.

One of the major impacts of climate change is that of sea level rise (SLR). SLR threatens hundreds of millions of people worldwide at costs that could exceed one trillion dollars. Since 1990, the rate of SLR has approximately doubled compared to the previous 50 years and ice loss from Greenland and Antarctica has also increased steadily. The vast Greenland and Antarctic ice sheets, comprising about 7 and 58 metres of potential SLR, respectively, are by far the largest potential future contributors.

As Director of the Center for Remote Sensing and Ice Sheets (CReSIS), what does your position entail?

I am responsible for all the Centre’s operations, providing strategic leadership with the help of the management team. My position is supported by more than two decades of research and teaching experience in radar remote sensing of the Earth, predominantly polar ice sheets. Previously, I led successful multidisciplinary research projects funded by NASA and the US National Science Foundation (NSF). I served as Manager of NASA’s polar research programmes from 1997-99, during which time I functioned as an interface between science and flight project groups and as Chair of the science panel of Earth System Science Pathfinder missions. I also served as former Director of the Radar Systems and Remote Sensing Laboratory at the University of Kansas.

Why is it crucial to expand knowledge about ice and sea level dynamics?

One of the major impacts of climate change is that of sea level rise (SLR). SLR threatens hundreds of millions of people worldwide at costs that could exceed one trillion dollars. Since 1990, the rate of SLR has approximately doubled compared to the previous 50 years and ice loss from Greenland and Antarctica has also increased steadily. The vast Greenland and Antarctic ice sheets, comprising about 7 and 58 metres of potential SLR, respectively, are by far the largest potential future contributors.

Despite of the large ice sheets’ importance in SLR, projections of their future behaviour contain poorly-quantified uncertainties in ice discharge. The severity of societal impacts from rising sea level will depend on our ability to adapt to and mitigate its effects.

Clearing away the clutter

Researchers from the University of Kansas, USA, and six partner institutions are sending unmanned aircraft to uninhabited lands in an effort to uncover the elusive behaviour of fast-flowing glaciers. However, there is much uncertainty surrounding the rates of SLR. The Intergovernmental Panel on Climate Change (IPCC) reports that SLR could increase by almost 1 metre by the end of the century, although calculations based on empirical models have doubled this estimate. To get to the bottom of these disparities and develop accurate ice sheet models, a clearer picture of the bed topography of fast-flowing glaciers is required. Research is currently underway at the Earth’s remote polar regions in an effort to achieve such an aim and enable greater understanding of the glacial processes contributing to SLR.

Losing signal

An expert in radar systems at the University of Kansas School of Engineering, Distinguished Professor Prasad Gogineni presently serves as Director of the Center for Remote Sensing of Ice Sheets (CReSIS), a large multidisciplinary outfit bringing together the skills and resources of seven research facilities across the US. As well as managing the Center’s activities, the University is also responsible for advancing the applications of remote sensing technology and contributing to the modelling side of CReSIS’ research.

Dr Prasad Gogineni discusses the urgent need for more accurate modelling of the Earth’s ice sheets as a changing climate continues to increase the rates at which sea levels are rising across the globe.
processes. To make matters worse, the signal is the result of a feeble picture of these subglacial above. This causes a greater level of attenuation at the base, which absorbs the signals beamed from resulting in a degradation of remote sensing challenges to the potency of radar signals, may be derived. models from which accurate predictions of SLR at the base of ice sheets in order to formulate a whole, it is vital to understand the activity great difficulty. Critical to how they operate as humans cannot reach – or at least not without affording the opportunity to reach places that team uses it to view the processes occurring at the basal layer of fast-flowing glaciers, thereby affording the opportunity to reach places that humans cannot reach – or at least not without great difficulty. Critical to how they operate as a whole, it is vital to understand the activity at the base of ice sheets in order to formulate models from which accurate predictions of SLR may be derived. Ice sheets, however, pose considerable challenges to the potency of radar signals, resulting in a degradation of remote sensing performance. This is due in part to warm ice near the base, which absorbs the signals beamed from above. This causes a greater level of attenuation than is usually observed, and because only weak echoes are bounced back to their point of origin, the result is a feeble picture of these subglacial processes. To make matters worse, the signal is further obscured by off-vertical rough surface and volume scatter, often hiding the echo altogether. The capacity of radar operating in these conditions at a frequency of 150 megahertz (MHz), for example, would decline significantly. To overcome these challenges, CReSIS has been developing remote sensing technology that employs high-sensitivity, low-frequency radars are needed to reduce volume scatter from ice and allow us to paint a clearer picture of the bed topography. Two of the primary difficulties with sounding warm, fast-flowing glaciers are the large signal attenuation through the ice caused by the warm ice near the bed, which weakens the bed echo; and the presence of clutter (reflected energy associated with rough surfaces and volume inclusions), which masks the already weak bed response. 

Do you offer any education or training opportunities? CReSIS offers a number of education and training opportunities from primary education to the graduate level. The CReSIS K-12 Education Coordinator makes regular visits to regional grade schools to teach lessons and generate interest in STEM fields. At the undergraduate level, CReSIS offers opportunities for students in geography, geology, physics, engineering, computer science, journalism, education and remote sensing to be a part of this important endeavour as research assistants. Students also have the opportunity to participate in our annual summer Research Experience for Undergraduates (REU) internship. For graduate students, CReSIS offers a multidisciplinary graduate programme that gives them the opportunity to participate in research at the cutting-edge of technology and polar science. Assistantships are offered in radar development, platform development and education.

Remote sensing is critical to the development of improved ice sheet models. Indeed, the CReSIS team uses it to view the processes occurring at the basal layer of fast-flowing glaciers, thereby affording the opportunity to reach places that humans cannot reach – or at least not without great difficulty. Critical to how they operate as a whole, it is vital to understand the activity at the base of ice sheets in order to formulate models from which accurate predictions of SLR may be derived.

ICE SHEETS: CRITICAL TO THE POTENCY OF RADAR SIGNALS

As signal attenuation from warm ice cannot be avoided, Gogineni and the CReSIS team are looking to separate the weak echoes from the surrounding clutter by mitigating the effects of volume and surface scatter. Ice sheets are not homogeneous but contain pockets that hold, among other things; water. Volume scatter is what happens when a signal encounters one of these embedded imperfections. From a review of the group’s efforts, it is apparent that radar operating in the lower frequencies is sufficient at reducing such clutter, a finding that has led the team at CReSIS to opt for a lower band of 14 MHz, while an upper band of 35 MHz also allows for fine resolution and the range necessary to measure the thickness of ice in fast-flowing glaciers. With a specially developed surface-based system, the CReSIS team has made a significant breakthrough in remote sensing, which resulted in fine-resolution 3D topography of a bed covered in more than 3 km of ice. This means that the CReSIS team is responsible for the first-ever successful radar imaging of the ice bed with a 150-MHz radar. They also demonstrated successful imaging of the ice bed with an airborne system operating at the same frequency.

However, the impracticalities involved in using a large, low-frequency antennae array to achieve such high resolution led CReSIS to explore a field in which they are fast becoming a leader:
OBJECTIVES
To develop new technologies and computer models to measure and predict the response of sea level change to the mass balance of ice sheets in Greenland and Antarctica.

PARTNERS
The University of Kansas serves as the lead institution for CReSIS, which is comprised of six additional partner institutions: Elizabeth City State University, Indiana University, University of Washington, The Pennsylvania State University, Los Alamos National Laboratory and the Association of Computer and Information Science Engineering Departments at Minority Institutions.

CReSIS also collaborates with several international institutions and industry partners.

FUNDING
National Science Foundation (NSF) – award no. ANT-0424589

CONTACT
Dr Sivaprasad Gogineni
Director
School of Engineering
The University of Kansas
2120 Learned Hall
1530 West 15th Street
Lawrence, Kansas 66045
USA
T +1 785 8647734
E pgogineni@ku.edu
www.cresis.ku.edu

SIVAPRASAD GOGINENI is Deane Ackers Distinguished Professor in the School of Engineering at the University of Kansas and Director of NSF Science and Technology Center for Remote Sensing of Ice Sheets (CReSIS). He received a PhD in Electrical Engineering from the University of Kansas in 1984 and has authored or co-authored over 100 archival journal publications and more than 200 technical reports and conference presentations. Gogineni has been involved with radar sounding and imaging of the ice sheets for more than 15 years and contributed to the first successful demonstration of Synthetic aperture radar imaging of the ice bed through ice more than 3 km thick.

The team uses remote sensing to view the processes occurring at the basal layer of fast-flowing glaciers, thereby affording the opportunity to reach places that humans cannot reach – at least not without great difficulty.

and generate 3D topograph. Having successfully verified the G1X systems’ performance on the ground, the team has subsequently proved the aircraft’s sensing and flight capabilities 14 times in West Antarctica, seven of which were autonomous flights, including a long-range, over-the-horizon survey.

REFINING THE RADAR
Such accomplishments open the door to the researchers’ wider goals. Already, sights have been set on reducing the size and weight of the radar to 1.5 kg or less, a target in line with the Center’s ultimate aim of developing radars that fit onto a single chip. Spurred on by the opportunities, these groundbreaking advances afford, those cautiously watching the rising sea levels can begin looking in earnest at the subglacial activity that has remained a secret for so long. The most recent field seasons have allowed further testing of UAS capabilities over three ice sheets in Greenland where the rough surfaces present even more of a challenge, but sounding and imaging has yet again proved successful. The scientists can at last begin to examine the topography below the ice sheets, the basal characteristics underlying their different parts, and where water is located underneath these mammoth, rapidly changing structures. With a firmer grasp of the processes at the ice-bed interface, they may soon be able to more accurately predict the gravity of future SLR.

The team at CReSIS organises its expertise into the following, closely-related research areas:

- Sensors and signal processing
- Unmanned aerial vehicles (UAV)
- Field activities
- Satellite measurements
- Cyberinfrastructure
- Analysis and modelling