The ANTARCTIC SCIENCE bursary

The ANTARCTIC SCIENCE Bursaries are awards of up to £5000, made annually to support promising young scientists, working in any field of Antarctic scientific research.

The purpose of the award is to broaden the scope of an existing research project through:

funding extra field or laboratory work,
purchasing/contributing towards the cost of a key piece of equipment,
funding international collaboration

REQUIREMENTS:

- The title and a brief description of their existing research project, in no more than 500 words, plus references and no more than two supporting illustrations.
- A concise description of the extended research or visit for which the bursary will be used, in no more than 500 words, plus references and no more than two supporting illustrations. Applicants should make clear the relevance of the proposed research or visit to Antarctic research and indicate the aims and proposed deliverables.
- A budget justifying the money requested.
- A statement of endorsement by their supervisor or line manager, including a statement to the effect that the application is extra to work already approved or funded.
- **The applicants must attach a brief CV and a select bibliography of their publications**

CONDITIONS:

Applicants normally need to be enrolled in a PhD or normally employed as an early career researcher, with payment normally being to an institutional account.

Applications must be submitted on a standard Antarctic Science Bursary form, which may be downloaded from this website. Repeat applications will only be considered if a paper has already been submitted to Antarctic Science.

If Antarctic field work is proposed a letter of support from the National Operator is required. All field work must conform to the Protocol and follow, as a minimum, the SCAR Ethical Guidelines

Applications must be submitted to arrive at the Antarctic Science Office, **no later than midnight GMT on March 31st of each year.** Any applications received after the closing date will not be considered for an award in the stated year. Applicants will normally be notified of the outcome by June 1st of the award year.

Applications will be assessed by the Board of Directors, seeking advice as necessary. The Board will reach its decisions based on fit to the aims of the scheme, quality of science, likelihood of success, cost/benefit and timeliness within the relevant field of science.

A condition of acceptance of the ANTARCTIC SCIENCE Career Development Bursary is that the recipient must undertake to offer to ANTARCTIC SCIENCE a lead-author paper following on from the outcomes of the science activity for which the Bursary was awarded or from science activity associated with it. In addition the recipient must acknowledge the award in presentations and publications.

After completing the project the bursary holder must provide a short report on its success which will be posted on the Antarctic Science Ltd web site

If an applicant subsequently receives adequate grant funding from elsewhere they are required to return the ANTARCTIC SCIENCE Bursary.

The proposal will be judged on three principal criteria - science quality (including topicality and novelty), feasibility (incorporating both track record of the applicant and likelihood of success) and value for money.

The decision of the Antarctic Science Board is final and no correspondence will be entered into.

ANTARCTIC science

BURSARY APPLICATION FORM 2011

FIRST NAME
Reinhard

MIDDLE NAME/S
Florian

LAST/FAMILY NAME
Drews

DATE OF BIRTH (DDMMYYYY)

EMAIL ADDRESS

FULL POSTAL ADDRESS
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COUNTRY
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TELEPHONE NUMBER

FAX NUMBER

DEGREES/AWARDS HELD

TITLE: PhD
UNIVERSITY: University of Bremen, Germany
YEAR OF AWARD: 2011

TITLE: Master in Physics
UNIVERSITY: University of Bremen, Germany
YEAR OF AWARD: 2007

TITLE
UNIVERSITY
YEAR OF AWARD

TITLE OF EXISTING RESEARCH PROJECT
Measurement driven regional ice-shelf modeling

SOURCE OF FUNDING FOR EXISTING PROJECT
Fonds de la Recherche Scientifique, Belgium

TITLE OF PROPOSED EXTENDED RESEARCH
The stability of Antarctic ice shelves: The determination of the basal mass balance from space using COSMO Skymed synthetic aperture radar interferometry

NAME OF SUPERVISOR AND AFFILIATION
Frank Pattyn, Laboratoire de Glaciologie, Universite Libre de Bruxelles

I declare that the above information is correct and enclose the following documentation in support of my application

- ☐ Endorsement by supervisor/line manager
- ☐ A description of my existing research project
- ☐ A description of the proposed extended research/visit
- ☐ A budget justifying the money requested
- ☐ A brief CV and Bibliography

By Typing your name below you agree that you are applying for the Antarctic Science Bursary. Please also enter the date you are signing this form.

Signed : R. Drews   Date: 31.03.15

ANTARCTIC science

ENDORSEMENT BY SUPERVISOR or LINE MANAGER

FULL NAME OF APPLICANT

Reinhard Florian Drews

TITLE OF PROPOSED EXTENDED RESEARCH/VISIT

The stability of Antarctic ice shelves: The determination of the basal mass balance on sub-kilometer scales

STATEMENT OF ENDORSEMENT :

FULL NAME OF SUPERVISOR/LINE MANAGER

Frank Pattyn

TELEPHONE NUMBER

NAME OF UNIVERSITY/INSTITUTE

Laboratoire de Glaciologie, Universite Libre de Bruxelles

EMAIL ADDRESS

STATEMENT :

Reinhard Drews works as a Postdoc at the Laboratoire de Glaciologie, Universite Libre de Bruxelles, Brussels Belgium since 2011. He will be employed starting from June 2015 on the MEDRISM Project (Measurement-driven ice-shelf modeling, Fonds de la Recherche Scientifique (FNRS) Project, PI F.Pattyn, Co-PI R. Drews). This project secures his funding for the next 2 years. Another FNRS funded project (ICECON, PI F. Pattyn) secures the field work for the upcoming season 2015/2016. Both projects do not include any resources for satellite-based analysis.

Upon his arrival at the Laboratoire de Glaciologie, Reinhard Drews has implemented and developed the detection of ice velocities using different satellite-based methods (interferometric synthetic aperture radar, Speckle/Feature tracking). The technique is currently being further developed in the framework of a PhD thesis (S. Berger, FNRS project) that he advises in collaboration with Dr. W. Rack at the Gateway Antarctica, Canterbury University, Christchurch, New Zealand.

The proposed project envisions to analyse COSMO Skymed data in order to derive high-resolution flowfields. The scientific application will be to detect channelized basal melting in Antarctic ice-shelf channels from space using an anomaly in surface velocities near the channels. Full Stokes modeling suggests that this anomaly originates from the readjustment of the ice-shelf channels to basal melting. The COSMO Skymed archive is a unique possibility to monitor these effects both spatially and temporally and has the potential to contribute substantially to our understanding of ice-ocean interactions in general and ice-shelf stability in particular. It is a unique chance to expand the scope of existing projects and adds an extra dimension using new data and state of the art methods. I fully endorse this proposal. Please do not hesitate to contact me if questions arise.

As the supervisor/line manager of the applicant, I declare that the applicant is already undertaking an approved programme of research and that this application is for funding to extend and improve that research; existing funds are not available to support this application.

To confirm that you endorse the applicant please fill in your name and the date you are completing this part of the form

Signed : F. Pattyn **Date : 31.03.2015**

Description of the existing research project: Measurement-driven regional ice-shelf modeling (MEDRISM)

In Antarctica's interior where no surface melting occurs, ice continuously accumulates through persistent snow fall. This mass gain is offset by ice flow, which transports ice through a network of ice streams from the interior towards the coast. Once the ice reaches the ocean at the grounding line, floating ice shelves are formed which extend the continental ice sheet for hundreds of kilometers seawards. Mass is lost through iceberg calving at the ice-shelf edges, but also through melting at the ice-shelf base. Both mechanisms contribute almost equally to the overall loss of Antarctic ice (e.g. Depoorter et al., 2013). However, because the ice-shelf cavity is so inaccessible, the current understanding of ice—ocean interactions beneath ice-shelves is limited.

Virtually all ice shelves are locally pinned at the bottom or buttressed at the sides (embayments) and hence play a crucial role in regulating the ice transfer towards the ocean. In both cases the increased friction results in a back force which regulates the mass flux across the grounding line. This buttressing effect is inherently non-local, three-dimensional, and also depends on the ice-ocean interaction at the ice-shelf base. Ice-shelf disintegration inevitably causes the loss of buttressing, grounding line retreat and increased ice discharge into the ocean (e.g. Scambos et al. 2004). For reliable predictions for the future of the Antarctic Ice Sheet, this effect must be taken into account. Models which include grounding line dynamics (i.e. the transition from flow dominated by basal shear to the frictionless spreading of an ice shelf including the stress transfer between both regimes) emphasize that the knowledge of magnitude but also the spatial variability of basal melt rates is key for our understanding of the system (e.g. Gagliardini et al., 2010). Averaged values are not enough.

Our own field measurements show that ice-shelf properties vary significantly on sub-kilometre scales. Most notably is the presence of basal channels with amplitude of over half the ice thickness (Figure 1). The origin of these channels is not yet fully understood, but likely the channels are maintained by channelized melting which is significantly higher inside than outside the channels. These observations questions both the use of averaged melt rates in models and the commonly applied simplifications in the Stokes equations. The MEDRISM project aims at improving ice-shelf models, by taking the observed small-scale heterogeneities into account. The validity of approximations (such as the shallow-shelf approximation) will be tested by using a full Stokes model in combination with a unique dataset of ice thickness, ice velocity, melt rates, and accretion rates based on ground-penetrating radar, GPS and phase-sensitive radar on the Roi Baudouin Ice Shelf (Antarctica). The channel evolution has already been investigated (Drews, 2015) and the sensitivity to breakup due to ice-ocean interaction will be studied in the future. Inverse modelling will allow quantifying the ice-shelf strength and its potential to transfer stress changes to the grounding line as a function of the local ice-shelf properties.

The extended research project The stability of Antarctic ice shelves and the determination of the basal mass balance from space using COSMO Skymed synthetic aperture radar interferometry

We request financial support to order COSMO-Skymed satellite imagery. We hypothesize that these data will be suited to characterize the basal mass balance in ice-shelf channels by exploiting an anomaly in surface velocities which occurs near actively melting channels as a response of ice flow to the changing geometry (Drews, 2015). Using an extensive set of already available ground-truth data at the Roi Baudouin Ice Shelf(GPS surface velocities, radar thickness measurements, point-measurements of basal melting from phase-sensitive radar), we propose a pilot study to detect channelized melting from space, circumnavigating the need of spatially limited on-site measurements.

Recent studies have highlighted that basal melting in channels can be excessive (e.g. Langley et al, 2014 and references therein). However, it remains unclear how this impacts on ice-shelf stability. Channels may destabilize ice shelves by structurally weakening (Vaughan et al., 2012; Rignot & Steffen 2008), and equally it may stabilize ice shelves by preventing area-wide excessive melt (e.g. Gladish et al. 2012). Ambiguities remain because only few direct observations quantify melt rates inside channels (e.g. Stanton et al. 2013). Thickness variations cannot easily be derived from altimetry because satellite tracks under-sample the channels. High-resolution sensors are required to determine the basal mass balance using the continuity equation (e.g. Dutrieux et al. 2013). Currently there is no coherent framework which allows quantifying basal melting in channels temporally and spatially over the entire ice-shelf.

Our own modeling (Drews, 2015) suggests that actively melting channels imprint the surface velocities characteristically. The central hypothesis here is that these flow anomalies can be detected area-wide in high-resolution flowfields and characterize channels states (actively melting or actively refreezing versus passively advecting). The example in Figure 2 is based on interferometric velocities (InSAR), a method which delivers the highest possible spatial resolution for ice movement. The major bottelneck is the limited availability of coherent SAR pairs. We have access to archived imagery of ERS 1/2, EnviSAT, Alos PalSAR (ESA Proposal C1P.10754, PI R. Drews), TanDEM-X (CryoSat-2 Validation, PI V. Helm, Co-PI R. Drews), and most recently also Alos-2 Palsar (Grounding-line Dynamics, PI W. Rack, Co-Pi R. Drews). Apart from ERS 1/2, none of these sensors provide the required scenes with four overflights (two ascending orbit, two descending orbits).

COSMO-Skymed (CSK) acquires SAR images suited for interferometry at unprecedented 3-m horizontal resolution.

Data of coastal Antarctica, and the Roi Baudouin Ice Shelf in particular, are available. Although the interferometric capacity of CSK has been demonstrated for Antarctica (H. Han, 2012), to our knowledge, no publications exist which systematically exploit this unique dataset in the context of ice-shelf stability. In that sense CSK imagery is an immense untapped archive, untapped most likely because its access is restricted and subject to financial constraints. Together with the already developed modeling framework, and already existing ground-truth data, we will use CSK in a pilot study to coherently map basal melting from space spatially and temporally. This will advance our understanding of the role of ice-shelf channels in defining the ice-shelf stability, and facilitate to incorporate these effects models treating the ice—ocean interactions.

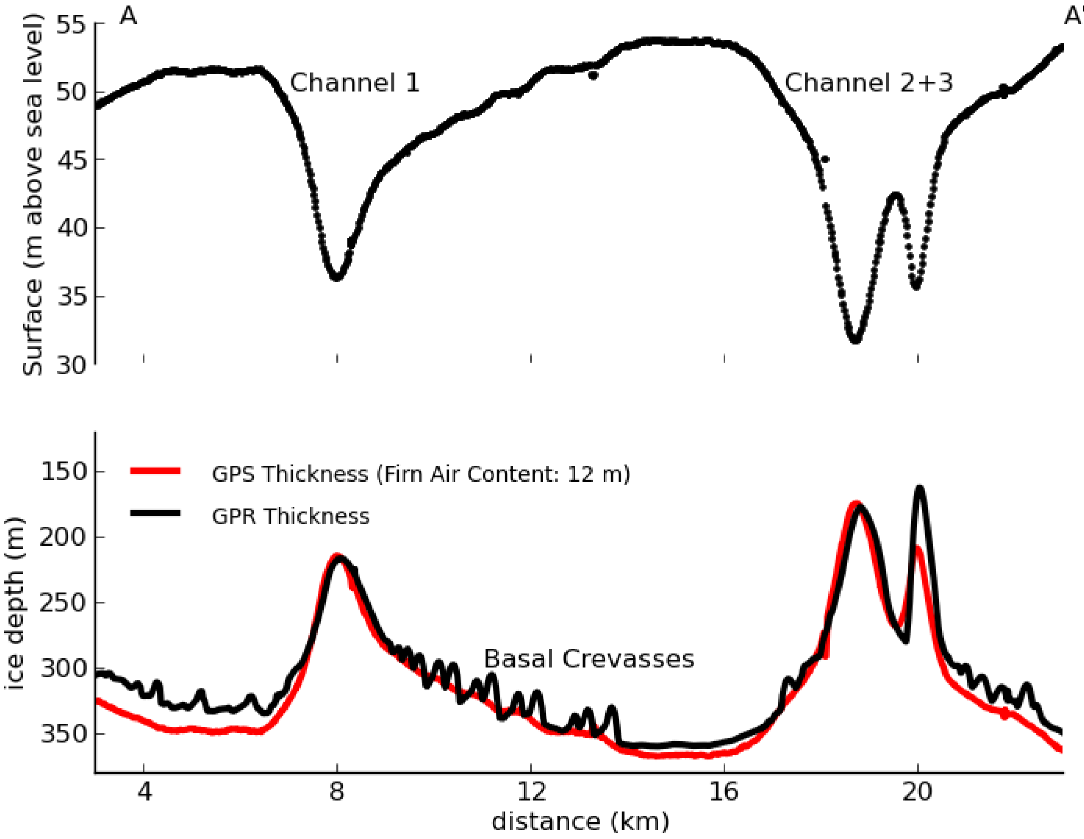

Figure 1 Surface elevation (top) and ice thickness (bottom) derived from a radar profile across ice-shelf channels observed at Roi Baudouin Ice Shelf, Dronning Maud Land Antarctica. The cross section is aligned perpendicular to the ice flow. The channels incise the ice shelf by more than half the ice thickness over an across-flow width of only a few kilometers. These kind of thickness variations are grossly undersampled in Antarctic-wide available thickness datasets. Preliminary analysis indicates that most observed channels are free of marine ice (i.e. GPS inferred hydrostatic thickness equals the radar inferred thickness). Hence these channels are prone to act as pathways for enhanced channelized melting at the ice-shelf base.

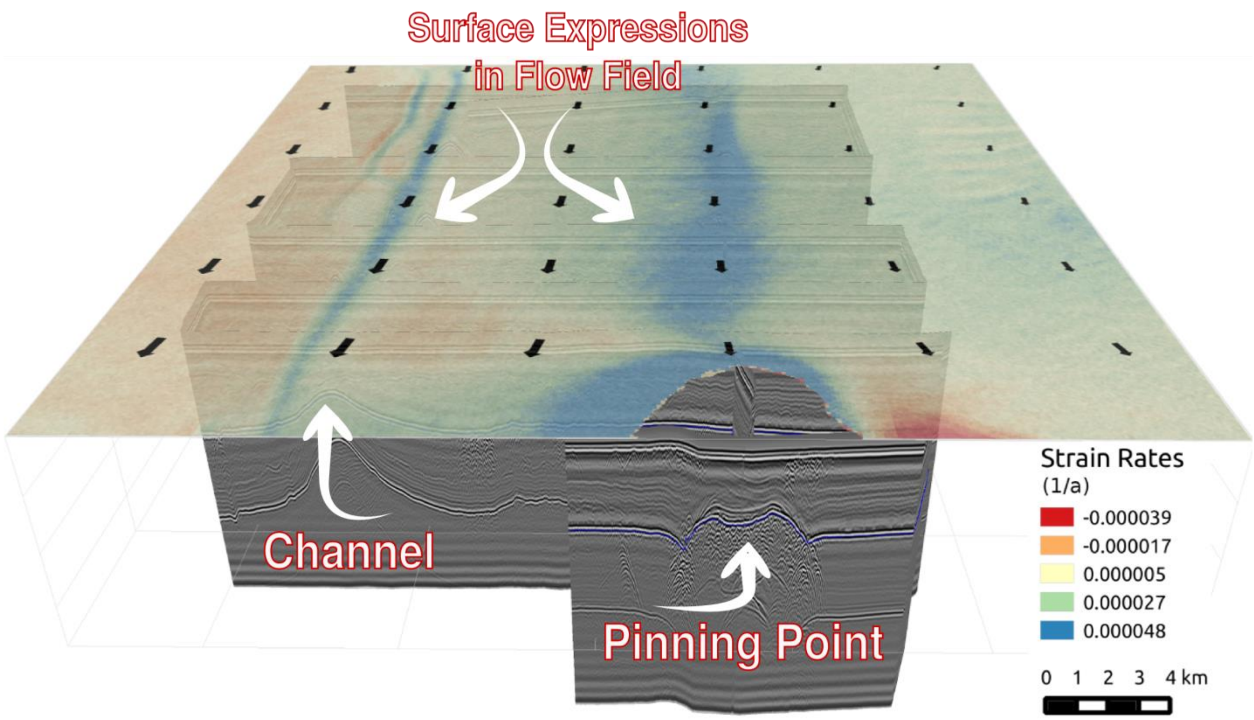

Figure 2 Composite image of radargrams (grey panels) imaging the ice-shelf bottom, and horizontal shear strain rates at the surface derived from ERS 1/2 satellite imagery. The radar data clearly reveal (1) the presence of a pinning point which strongly decelerates ice flow of the otherwise frictionless ice shelf and (2) a zone of enhance horizontal shearing in areas of ice-shelf channels. We hypothesize that the latter can be used to detect channelized melting.

References (in order of appearance)

Depoorter et al., Calving fluxes and basal melt rates of Antarctic ice shelves, Nature, 2013
Scambos et al., Glacier acceleration and thinning after ice shelf collapse in the Larsen B embayment, Antarctica, Geophys. Res. Lett., 2004
Gagliardini et al., Coupling of ice-shelf melting and buttressing is a key process in ice-sheet dynamics, Geophys. Res. Letters, 2010
Drews, Evolution of Antarctic ice-shelf channels, The Cryosph. Discuss., 2015
Langley et al., Complex network of channels beneath an Antarctic ice shelf, Geophys. Res. Lett., 2014
Vaughan et al., Subglacial melt channels and fracture in the floating part of Pine Island Glacier, Antarctica, J. Geophys. Res. Earth, 117, 2012
Rignot & Steffen, Channelized bottom melting and stability of floating ice shelves, Geophys. Res. Lett., 38, 2011
Gladish et al., Ice-shelf basal channels in a couple ice/ocean model, J. Glaciol.,58,2012
Dutrieux et al., Pine Island glacier ice shelf melt distributed at kilometre scales, The Cryosphere, 7, 2013
H. Han, Tidal deflection characteristics of Campbell Glacier, East Antarctica, observed by double differential SAR interferometry, Geoscience and Remote Sensing Symposium (IGARSS), 2012

Budget

The Italian space agency offers a single CSK scene for 360 Eur (260 GBP, under the constrained that data are purely use for science). The western part of the Roi Baudouin Ice Shelf can be covered with approximately three scenes. Four over-flights are required for each scene (to allow the combination of ascending and descending orbits) to derive two dimensional flowfields. The basic dataset hence requires 12 scenes at the cost of 4320 Eur **(3122 GBP).** Depending on the initial outcomes we either double parts of the initial dataset (4 additional scenes for 1040 GBP) to check for seasonal differences, or we request real-time data acquisition during the already planned and financed field expedition to the Roi Baudoin Ice Shelf in 2015/2016 (estimated price **1445 GBP**)

CV

Attached as separate PDF.