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ABSTRACT n° 1

Title: Estimate of the Antarctic surface mass balance evolution through the 20th and 21st century based on CMIP5 and the regional climate model MAR.

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Abstract:

The Antarctic ice-sheet surface mass balance is a significant component of the sea level budget and may mitigate the rise in sea level in a warmer climate, but this term is still poorly known. On the one hand, the Antarctic surface mass balance cannot be directly deduced from global climate models (**GCM**) because of their too low resolution (~100 km) and their unadapted physic over cold and snow-covered regions. On the other hand, regional climate models (**RCM**) adapted for polar regions can compute surface mass balance components over the ice-sheet from large scale forcings at their boundaries. Consequently, a better estimation of the Antarctic surface mass balance require appropriate GCM fields used as an input for polar-oriented RCM.

We present results of a careful evaluation of 41 CMIP5 GCM over Antarctica. We focus on GCM forcing fields for RCM runs, and particularly on those that may have the greatest impact on surface mass balance components. We consider ERA-Interim reanalysis as a reference, since previous studies shown that it is the most reliable reanalysis over the Antarctic region, but we also include the performance of 4 other reanalysis. We show that only few CMIP5 GCM outputs are suitable for RCM forcing over the Antarctic region for 20th and 21st century runs.

Then we assess the contemporary (1979-2015) Antarctic surface mass balance with MAR forced by three reanalyses : ERA-Interim, NCEP-1 and JRA-55. We evaluate (i) SMB with more than 2700 quality-controlled grounded observations (ii) precipitation, surface temperature and melt extent with remote-sensing products and (iii) surface radiative fluxes, wind, temperature and pressure from the Baseline Surface Radiation Network and Automatic Weather Stations (sub-daily and daily) and the Met-READER dataset (monthly). Based on this evaluation and on spatial analyzes, we associate an uncertainty range to the main surface variables modeled with MAR.

This work is the first step toward a robust estimate of the evolution of the Antarctic surface mass balance for the past (1900-present) and the future (present-2100) based on the CMIP5 dataset and the regional climate model MAR.

ABSTRACT n° 2

Title: Study of space weather impact on Antarctica ionosphere from GNSS data

Authors: N. Bergeot [1,2] , J.-M. Chevalier [1], C. Bruyninx [1], G. Denis [2], T. Camelbeeck[1], T. Van Dam[3], O. Francis[3]

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Abstract:

The impact of solar activity on the ionosphere at polar latitudes is not well known compared to low and mid-latitudes due to a lack of experimental observations, especially over Antarctica. Consequently, one of the present challenges of the Space Weather community is to better characterize (1) the climatological behavior of the polar ionosphere in response to variations in the solar activity and (2) the different responses of the ionosphere at high latitudes during extreme solar events and geomagnetic storms.

Toward these goals, the combination of GNSS measurements (e.g. GPS, GLONASS and Galileo) on two separate frequencies allows us to determine the ionospheric delay between a ground receiver and a satellite. This delay is a function of the integrated number of electrons, the Total Electron Content (TEC), encountered in the ionosphere along the signal ray path. It is thus possible to study the behavior of ionospheric TEC at different time and spatial scales from the observations of a network of permanent GNSS stations.

In the frame of GIANT-LISSA and IceCon projects, since 2009 we have installed five GNSS stations around the Princess Elisabeth station. We used these data in additional to that from other stations in the IGS global network to estimate the ionospheric TEC at different locations over Antarctica. This study presents the results from our regional data set during different levels of solar activity and discusses the different climatological behaviors identified in the ionosphere at these high latitudes. Finally, we show a few examples of typical TEC disturbances observed during extreme solar events.

ABSTRACT n° 3

Title: SAR observation and inverse modelling of ice shelf pinning point dynamics and channel formation

Authors: S. Berger[(1)] R. Drews[(1)]; L. Favier[(1)]; W. Rack[(2)], F. Pattyn[(1)]

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Abstract :

Antarctic ice shelves display numerous pinning points (locally grounded feature imbedded within the otherwise freely floating ice-shelves) and ice-shelf channels (along-flow lineations in which ice is thinner). Although these features are readily visible in satellite imagery, ice-thickness and ice-velocity variations in their surrounding are typically heavily undersampled. This lack of data is the main bottelneck in assessing the role of pinning-points and ice-shelf channels in defining the ice-shelf stability.

Pinning-points are often only a few kilometers wide, but the increased friction nevertheless causes an ice-shelf wide slow down in velocities. Using an inversion scheme based on an ice-flow model (BISICLES), we show the importance of the pinning-point on the ice-shelf dynamics. Without observational data which adequately resolves the pinning-point, the inversion results in an erroneous ice-shelf rheology which is problematic for prognostic simulations.

Ice-shelf channels focus channelized melting and significantly alter the basal mass balance (and hence ice-shelf stability) on short horizontal scales. Here we use interferometrically-derived TandDEM-X digital elevation models and ice-flow velocities with a horizontal gridding of 125 m illustrating the ice-shelf dynamics of the Roi Baudouin Ice Shelf, Dronning Maud Land (East Antarctica) in unprecedented detail. Using ground-based GPS surface elevation, we demonstrate that TanDEM-X is an ideal sensor to map the channel morphology at the ice-shelf surface. We find velocity anomalies surrounding the channels along the entire ice shelf potentially indicating the presence of locally elevated basal melt rates. Using mass conservation in a Lagrangian framework, we find basal melt rates averaging 0.4 m/a in the middle of the ice shelf and peaking at 12 m/a inside some channels. We illustrate the sensitivity of the method with respect to systematic biases in elevation/velocity and also with respect to lateral variations of the depth-density relationship. With the increased availability of high-resolution radar satellites (such as Sentinel1), the techniques presented here could be applied on an pan-Antarctic scale to map basal melting both in space and time at high-resolution.

ABSTRACT n° 4

Title: High precision GNSS infrastructure around the Princess Elisabeth Base

Authors: C. Bruyninx [(1)], N. Bergeot [(1,2)], T. Van Dam[(3)], T. Camelbeeck[(1)], O. Francis[(3)], S. Tabibi[(3)]

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Abstract:

Since 2009, we have installed five GNSS stations around the Princess Elisabeth station in Antarctica (see Figure 1). Four stations have been installed on stable bedrock, while the fifth station is installed at the Derwael Ice rise. The stations are used in the frame of the BELPSO projects, GIANT-LISSA and IceCon, to provide information for monitoring the horizontal and vertical motion of the Antarctic ice flows. Originally intended to operate year round, keeping some stations alive and collecting high quality GNSS data has been challenging. However, compared to other GNSS stations installed throughout Antarctica and that contribute to the international GNSS Service, the quality of the GNSS data provided by our GNSS stations is well within the expectations.

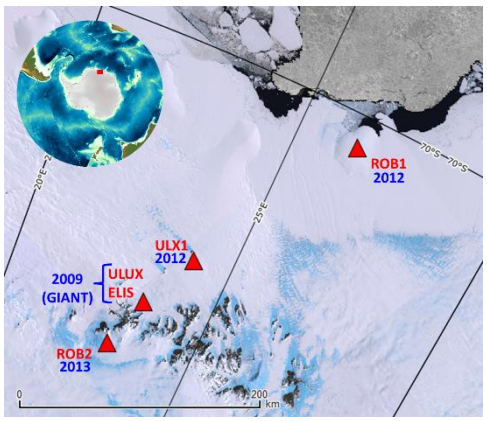

Figure 1: GNSS stations installed in the frame of the IceCon and GIANT-LISSA projects (including their installation date).

For each station, we determine its daily position in the International Terrestrial Reference Frame (ITRF) and compare the position changes of the different stations with each other. Especially the comparison of the position changes obtained for the co-located stations ULUX and ELIS provides an indication of the quality of the GNSS data and their ability to capture the motion of the Antarctic.

Apart from their role in the GIANT-LISSA and IceCon projects, our four Antarctic GNSS stations installed on bedrock offer a network of GNSS reference stations in support of scientists of neighboring disciplines requiring geolocation. In addition, because we permanently monitor their coordinates in the ITRF and maintain the stations according to the standards of the International GNSS Service, our GNSS stations can be used as reference stations for GNSS applications requiring mm-cm level precision.

ABSTRACT n° 5

Title: Ice quake activity triggered by the interaction of ice sheet flow with the Sør Rondane Mountains, East-Antarctica (LISSA-project)

Authors: Thierry Camelbeeck, Denis Lombardi, Henri Martin and Giovanni Rapagnani

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Abstract:

To investigate the interaction of the East-Antarctic ice sheet with the Sør Rondane Mountains of eastern Queen Maud Land, we installed in January 2014 six broadband seismic stations defining a seismic network of 90 x 30 km^2. Five of these seismic stations were installed on rock outcrops emerging from the ice. By processing and studying one month of seismic records, an important local seismicity has been evidenced with 138 events recorded by a minimum of four seismic stations with simultaneously P- and S-waves arrival time measurements.

Combining the analysis of those data in parallel to receiver functions from teleseisms, we determined a crustal thickness of 45 ± 5 km, an average P-wave velocity of V_P = 5.85 ± 0.70 km/s in the crust, and a P- on S-waves velocity ratio V_P/V_S = 1.715 ± 0.049 at a 0.95 confidence level.

To locate each of the 138 well-recorded events and provide robust estimation of the associated uncertainty, we derived a dataset of 5000 synthetic arrival times and associated crustal models based on Monte-Carlo simulations adding randomly a picking phase measurement error with a 0.2 s standard deviation to the original measurements and using the crustal model statistical distribution previously determined. For each analyzed event, the favored location corresponds to the mean value of the 5000 different epicenters and focal depths obtained from this procedure. Inside or near the seismic network, the epicenters are determined with a ca. 2 km precision, the latitude being better constrained than the longitude due the elongated N-S geometry of the seismic network.

By developing an original procedure, we are able to correctly evaluate the validity of the estimated focal depths. For reliable estimates, focal depth ranges between 0 and 3-4 km. This suggests that this seismicity is very shallow and directly related to the interaction of the ice flow with the bedrock and the SørRondane Mountains.

Most of the events occurred at locations where the ice flow speed is greater than 10 m/year. Using maps of surface ice flow speed and horizontal shear stress, events related to basal slip of the ice sheet on the bedrock from those associated to internal ice cracks can be discriminated.

ABSTRACT n° 6

Title: AWDA in Antarctica: Installation of a magnetic antenna at Princess Elisabeth station during the BELARE 2015-2016 campaign

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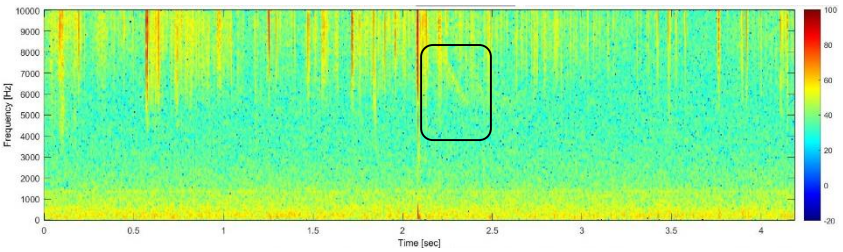
Abstract:

During the last BELARE campaign, in January-February 2016, we have installed a compact magnetic antenna augmented with data processing equipment at the Princess Elisabeth station (see http://aeronomie.be/fr/nouvelles-presse/2016-antarctique.htm). The antenna is composed of 2 search coils in a waterproof plastic box, inside a wooden thermal insulated box, fixed on the top of a wooden table (left figure). The search coils have an integrated preamplifier and the box contains a line driver amplifier that makes it possible to use a cable of up to 500-700 m to the high time precision data logger inside a shelter. The data logger then digitizes, formats and sends the data to a computer located inside the station. Another computer performs the data analysis.



This antenna records whistler waves, a particular type of electromagnetic radio waves, created by lightning and propagating from one hemisphere to another in the Earth's magnetosphere (inside black rectangle on right figure). From such data we can infer information about the state of the plasmasphere, an inner part of the magnetosphere of the Earth. The ultimate goal of this network is to provide data to feed a data-assimilative model of the plasmasphere.

Such an antenna complements another antenna that we have installed five years ago in Humain, Belgium. These antennas are part of an international global network called AWDAnet (Automatic Whistler Detector and Analyzer network; see http://awda.aeronomie.be). The Princess Elisabeth station is a very interesting place for such an instrument because of the low electromagnetic activity at and around the station, which usually perturb the measurements. Also, this location at very high magnetic latitude provides information on variations in the plasmaspheric boundary position.

This presentation will describe the instrument, its installation during the last BELARE campaign, but also the first measurements made at the Princess Elisabeth station and the future plans.

ABSTRACT n° 7

Title: Belgian-Japanese joint field campaigns for collecting meteorites on Antarctic blue ice fields

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Abstract:

Although meteorites are falling at the same rate everywhere on Earth, more than 2/3 of all classified meteorites are coming from Antarctica, and more especially from blue ice fields. The importance of those blue ice fields for collecting meteorites was recognized in 1969 by a team of Japanese geologists in the Yamato Mountains and is three-fold. First, meteorites are easily recognized, as black spots on blue ice. Second, they are kept in good freezing conditions, as meteorites are particularly vulnerable to terrestrial alteration. Antarctic meteorites are altered, but this is the place on Earth where they are the least altered. Finally, the biggest interest of Antarctica is certainly the fact that meteorites are concentrated in small area thanks to the movements of ice. When a meteorite falls on ice, it is incorporated in the glacier. As Antarctica is a continent, mountains, sometimes hidden underneath the ice layer, block the ice flow, hence forcing it to become vertical. The strong katabatic winds then erode the ice, freeing meteorites that were trapped within. Those zones were ice movement is vertical typically appeared blue on satellite images.

For the last 5 years, Belgium and Japan have joined forces, logistics and knowledge to organize three successful meteorite expeditions around the Belgian Princess Elisabeth Station in Antarctica. The first joint JARE 51 mission sampled the Balchen Ice Field, in the eastern Sør Rondane Mountains region, in 2009-2010 and recovered more than 600 meteorites. The second joint BELARE SAMBA 2010-2011 on the North-West part of the Nansen Ice Field, located to the South of Sør Rondane Mountains, recovered 220 meteorites. Finally, a third JARE 54 - BELARE SAMBA 2012-2013 joint expedition was organized in the Nansen Ice Field during the austral summer 2012-2013 and investigated the South-West and North-East parts of the ice field. This was the largest recovery party organized, with a total of 10 members searching for meteorites. A total of 425 meteorites were recovered. The South-East part of the Nansen ice field still needs to be investigated. After being collected, meteorites are defrozen under vacuum for avoiding water running on the samples. Then, they are cut in half and shared between Japan and Belgium. The Belgian share is currently conserved at the Royal Belgian Institute for Natural Sciences in Brussels, and are available on request for scientific studies.

ABSTRACT n° 8

Title: Evolution of Derwael Ice Rise in Dronning Maud Land, Antarctica, over the last millennia

Authors: R. Drews[(1)]; K. Matusoka[(2)]; C. Martin[(3)]; D. Callens [(1)]; N. Bergeot[(4)]; F. Pattyn[(1)]

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Abstract:

In the BELSPO funded project (ICECON), we have used geophysical techniques (radar, GNSS) to characterize the glaciological setting of Derwael Ice Rise which is situated within the Roi Baudouin Ice Shelf in Antarctica, approximately 200 km from the Belgian Princess Elisabeth Station. Our scientific target is to understand how long these ice rises have existed without being overrun by the main Antarctic Ice Sheet (e.g. during the last glacial).

Ice rises situated in the ice-shelf belt around Antarctica have a spatially confined flow regime within local ice divides. Beneath the divides, ice stratigraphy often develops arches with amplitudes that record the divide's horizontal residence time and surface elevation changes. To investigate the evolution of Derwael Ice Rise, Dronning Maud Land, Antarctica, we combine radar and GPS data from three consecutive surveys, with a two-dimensional, full Stokes, thermomechanically coupled, transient ice-flow model. We find that the surface mass balance (SMB) is higher on the upwind and lower on the downwind slopes. Near the crest, the SMB is anomalously low and causes arches to form in the shallow stratigraphy, observable by radar. In deeper ice, arches are consequently imprinted by both SMB and ice rheology (Raymond effect). The data show how arch amplitudes decrease as along-ridge slope increases, emphasizing that the lateral positioning of radar cross sections is important for the arch interpretation. Using the model with three rheologies (isotropic with n=3,4.5 and anisotropic with n=3), we show that Derwael Ice Rise is close to steady state but is best explained using ice anisotropy and moderate thinning. Our preferred, albeit not unique, scenario suggests that the ice divide has existed for at least 5000 years and lowered at approximately 0.03 m a^{-1} over the last 3400 years. Independent of the specific thinning scenario, our modeling suggests that Derwael Ice Rise has exhibited a local flow regime at least since the Mid-Holocene.

ABSTRACT n° 9

Title: Ice-shelf channels: where they originate and how they evolve

Authors: R. Drews[(1)]; F. Pattyn[(1)]; S. Berger[(1)]; L. Favier[(1)]; K. Matusoka[(2)]; N. Bergeot[(3)]

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Abstract:

This project (Be:Wise) was funded by the InBev-Baillet Latour Antarctic Fellowship, and partially supported by the BELSPO project ICECON. We have used geophysical & remote-sensing techniques to better understand how the floating Antarctic ice shelves buttress the mass flux from the Antartic continent. In particular, we have focused on the Roi Baudouin Ice Shelf, which is approximately 200 km away from the Princess Elisabeth Station. We found that this ice shelf is pinned by a number localized points at the ice-shelf front, and that ice-thickness is locally reduced by more than 50 % inside elongated ice-shelf channels. These channels can serve as pathways for channelized melting at the ice-shelf base, and hence have a significant impact on the ice-shelf buttressing strength as a whole.

Here, channel evolution is investigated using a transient, three-dimensional full Stokes model. The modeling confirms basal melting as a feasible mechanism for channel creation, although channels may also advect without melting for many tens of kilometers. Channels can be out of hydrostatic equilibrium depending on their width and the upstream melt history. Inverting surface elevation for ice thickness using hydrostatic equilibrium in those areas is erroneous, and corresponding observational evidence is presented at RBIS by comparing the hydrostatically inverted ice thickness with radar measurements. The model shows that channelized melting imprints the flow field characteristically, which can result in enhanced horizontal shearing across channels. This is exemplified for a channel at RBIS using observed surface velocities and opens up the possibility to classify channelized melting from space, an important step towards incorporating these effects in ice–ocean models.

Using an extensive radar-dataset around the grounding-line, we show that many channels result from hydrological outlets of the grounded ice-sheet. This is the first direct evidence, for R-type channels in Antarctica which are otherwise only indirectly inferred from the ill-constrained hydrostatic potential. Apart from pin-pointing a mechanism for ice-shelf channel formation, this finding also offers direct access to the poorly understood hydrological system at the base of the Antarctic Ice Sheet.

ABSTRACT n° 10

Title: The influence of small pinning points on ice-sheet/shelf stability in Dronning Maud Land, East Antarctica

Authors: L. Favier, F. Pattyn, S. Berger, R. Drews

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Abstract:

Most of the outlet glaciers in Dronning Maud Land, East Antarctica, have a grounding line well below sea level, resting on a bed that deepens towards the interior, which makes them vulnerable to unstable, self-sustained retreat. Here, we use the ice-sheet model BISICLES to investigate the future ice-dynamical behaviour of two neighbouring glaciers in Dronning Maud Land. Both of these glaciers are buttressed by an ice promontory situated between them. Additional buttressing stems from small pinning points at the ice-shelf fronts. Such pinning points substantially impact ice geometry, velocity and stiffness. However, due to their small size, they can be ill-represented satellite data. Initialising prognostic simulations of marine-ice sheets relies on observed geometry and surface velocity, from which data assimilation methods rectify poorly known parameters such as ice stiffness and basal slipperiness. We explore unpinning scenarios over the next millennia using a specifically taylored dataset (surface velocities and ice/bed geometry) in which the pinning points are well represented. To demonstrate the effect of ommitting a pinning-point, we initialise the ice-sheet model with Antarctic-wide datasets in which it is not currently resolved. We apply two sub-ice shelf melting scenarios of three amplitudes, and two Weertmann-type sliding laws. All of the scenarios predict an unstable retreat for one of the glaciers, even for lower sub-ice shelf melt rates than what is observed today. Unpinning accelerates the grounding-line retreat. Ommitting the pinning point in data assimilation over stiffens the ice shelf and highly decreases the timing of grounding line retreat. This stresses the need to resolve pinning points in observations, in order to accurately predict future sea level rise.

ABSTRACT n° 11

Title: The GIANT project: why gravity is increasing at the PE station?

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Abstract:

The objective of the GIANT (Geodesy for Ice in ANTarctica) project is to estimate the mass balance of the ice sheet around the Princess Elisabeth (PE) station using state-of-the-art geodetic and geophysical observations. Two permanent GPS stations (ULX1 & ELIS) are continuously operating on the bedrock at PE since 2011. In addition, absolute gravity observations are carried out every two or three years. The combination of these two kinds of measurements allows us to discriminate the averaged present ice mass changes (melting or accumulation) up to 150 km around the station from the long-term crust vertical displacement due to the Global Isostatic Adjustment (GIA). The GIA results from the visco-elastic deformation of the Earth crust compensating from the un-load of its surface caused by the ice melting since the last glacial maximum.

The observations of the last 5 years indicate an increase in gravity of 1 microgal/year and a subsidence of 3 mm/year. A simple model inversion allows us to quantify the ice accumulation. The results will be presented as well as their interpretation.

ABSTRACT n° 12

Title: Aerosol and ozone measurements from the recently-installed MAX-DOAS instrument at the Princess Elisabeth Station in the framework of the AEROCLOUD project.

Authors: Clio Gielen (1), Michel Van Roozendael (1), Christian Hermans (1), Francois Hendrick (1), Caroline Fayt (1), Hugo De Backer (2), Alexander Mangold (2), Veerle De Bock (2), Quentin Laffineur (2), Nicole Van Lipzig (3), Niels Souverijns (3), Irina Gorodetskaya (3), Stef Lhermitte (3), and Alexandra Gossart (3)

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Abstract :
The AEROCLOUD project focusses on a study of the coupling beween aerosols and clouds, with the aim of studying the role of clouds and aerosols on the climate system in East Antartica. Aerosols, mostly brought to Antarctica via long-range atmospheric pathways, strongly affect cloud formation and properties (such as cloud particle phase and size) and their ability to produce precipitation. Since precipitation is the only source of mass to the ice sheet, and precipitation and cloud processes are closely connected, an improved insight in these processes is invaluable.

It is essential that the measured boundary-layer aerosols can be linked to higher atmospheric levels. To this aim, BIRA-IASB installed a MAX-DOAS instrument in December 2015 at the Princess Elisabeth Station for continuous operation during at least two successive seasons. MAX-DOAS is a recently-developed remote-sensing technique for the automated monitoring of tropospheric gases and aerosols. By scanning the scattered sun light in successive elevations close to the horizon and analysing the atmospheric absorption signal using the DOAS method, the aerosol extinction and the concentration of atmospheric gases can be derived in a few successive layers above the surface up to approximately 3km altitude. In addition, measurements performed in the zenith viewing geometry at the end of each MAX-DOAS scan and in a continuous way at twilight can be used to retrieve column amounts of stratospheric ozone (O3) and related species like nitrogen dioxide (NO2), bromine monoxide (BrO), and chlorine dioxide (OClO). These zenith observations provide an ensemble of data to characterise the chemical evolution of the polar stratosphere during the spring period but also to validate satellite measurements over Antarctica.

In this poster we present the first results on the total aerosol optical depth and vertical profiles as measured by the MAX-DOAS instrument, and compare these with aerosol measurements from the co-located Brewer instrument and Cimel sun-photometer operated by RMI and BIRA-IASB, respectively. The synergistic use of these observations provides complementary information on both integrated and vertically-resolved aerosol distributions and properties. In addition to aerosols, we retrieve total ozone column densities by applying standard NDACC (Network for the Detection of Atmospheric Composition Change) spectral settings and air mass factors (AMFs) to zenith-sky MAX-DOAS observations. Comparison with the Brewer instrument during the O3 recovery period demonstrates the good quality of the MAX-DOAS O3 data. The corresponding variations of stratospheric NO2, BrO, and OClO column amounts will be also investigated.

ABSTRACT n° 13

Title: Remote sensing retrieval of drifting/blowing snow events: a comparison between satellite and ground-based observations at Princess Elisabeth Station, East Antarctica.

Authors: Alexandra Gossart[1], Niels Souverijns[1], Stef Lhermitte[1], Irina Gorodetskaya[1] Jan Lenaerts[1,2], Alexander Mangold[3] , Quentin Laffineur[3] , Stephen P. Palm[4] and Nicole Van Lipzig[1]

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Abstract:

While snowfall is the principal positive component to the Antarctic surface mass balance, local and regional snow accumulation strongly depends on snow transport and redistribution by the wind. Two types of phenomena are at play: drifting and blowing snow. Drifting snow occurs at shallow heights and lower wind speeds, whereas snow particles are blown away above 2 meters high and occur during large events. Our understanding of the drifting/blowing snow is still very limited due to the difficulty of observing these phenomena. Satellite-based estimates of drifting/blowing snow events detection and quantification are becoming available, but ground validation is essential.

Here we use ground-based remote sensing techniques to evaluate the drifting/blowing snow events detection by a satellite-based lidar. A suite of robust remote sensing instruments (ceilometer, infrared pyrometer, and 24GHz precipitation radar) has been set up at the Princess Elisabeth (PE) station (located in the escarpment area of Dronning Maud Land, East Antarctica) since 2009. The ceilometer provides attenuated 910 nm backscatter profiles at 15s temporal resolution and is used for estimating cloud base heights and cloud vertical structure. Besides, it can also be applied to detect the top height of the blowing snow layer during strong events extending several tens to hundreds of meters above the ground. Using both ceilometer and MRR also permits to distinguish between local precipitations and clear-sky blowing snow events.

Significant blowing-snow events during clear sky conditions have been detected using CALIPSO lidar measurements (Palm et al, 2011): the algorithm interrogates the successive layers from the ground upwards, for 10 m windspeeds and a 532 nm lidar attenuated backscatter signal that exceeds the respective thresholds indicating blowing snow.

The satellite remote sensing detection of drifting snow events is limited to layers of a minimal thickness of 20-30 m, similarly to the ceilometer-based estimates. This implied that only significant events can be identified. In addition, thick clouds can impede drifting snow detection from satellite products. Here, we study the concordance of the retrieval of the blowing snow events from lidar satellite measurements with the observations at PE during the 2010-2015 period. Further, we will combine the radar-derived snowfall rates with sublimation rates calculated using the automatic weather station measurements, as well the local snow accumulation measurements at PE in order to isolate the drifting/blowing snow erosion term and evaluate its contribution to the local surface mass balance.

ABSTRACT n° 14

Title: Elucidating diversity of thin filamentous mat-forming Antarctic cyanobacteria

Authors: Yannick Lara, Benoit Durieu, Victor Deblander, Antoine Defise, Haywood D. Laughinghouse IV, Annick Wilmotte

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Abstract:

Freshwater ecosystems range from glacial cryoecosystems, ice shelf meltwater ponds to perennially ice-covered lakes where conspicuous benthic microbial mat communities constitute most of the biomass. In these mats, cyanobacteria form matrices that shelter other organisms, and carry out the primary production.

Narrow filamentous cyanobacteria belonging to the genera *Leptolyngbya* and *Phormidium* are especially abundant in Antarctic microbial mats and are essential for the formation of matrix. However, the lack of morphological criteria and the small cell size of cyanobacteria belonging to these two genera make their identification problematic. Indeed, they are known as polyphyletic taxa according to botanical and bacteriological criteria.

The characterization of strains is the first step for an assessment of the real diversity and for understanding their role in the environment.

We designed a polyphasic approach that combines molecular analyses, environmental physiology experiments and microscopic observations. Briefly, we amplified and sequenced three loci (16S rRNA, ITS, and *rpoC1*) for 31 strains of *Leptolyngbya* and *Phormidium.* We performed whole genome sequencing for five strains. Cultures at different stage were observed by light and epifluorescence microscopy. Finally, selected strains were grown in nitrogen-limited.

The *Leptolyngbya* and *Phormidium* strains were distributed into four lineages. Phylogenetic trees supported the distribution of *P. priestleyi* strains into at least two potentially new lineages, and *L. antarctica* strains were separated into one endemic and one cosmopolitan lineage. This was supported by the microscopic observations of 1-year old cultures.

Genome analyses revealed the presence of sequences related to the production of secondary metabolites in strains from two of the studied lineages. Secondary metabolites are often known for their antimicrobial activities. Such properties would partly explain how cyanobacterial mats survive to predation and degradation by other bacteria.

This work provides the first building block to the understanding of survival strategies developed by mat-forming cyanobacteria and how they succeeded as the most abundant phototrophs on the Antarctic continent.

This work was realized in the frame of the BelSPo project CCAMBIO.

ABSTRACT n° 15

Title: Snow in large-scale sea ice models: state-of-the-art and way forward

Authors: Olivier Lecomte[1], Thierry Fichefet[1]

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Abstract:

Sea ice is a platform for snow to accumulate on and, because this platform moves and deforms with ocean currents and winds, its snow cover is astoundingly heterogeneous. Snow processes on sea ice have crucial consequences in driving the evolution of sea ice, at a cascade of temporal and spatial scales.

Although sea ice models have been developed for decades, the representation of snow in these models has remained under-addressed. This work is a contribution toward the improvement of the snow component in large-scale sea ice models. During the past few years, representations of snow physics of intermediate complexity were introduced in models of this kind, providing the tools to assess the influence of snow on sea ice. The importance, in particular, of accounting for snow stratigraphy, scattering properties and wind-driven snow processes in models has been shown using those tools. These processes are all necessary in order to realistically simulate the evolution of sea ice and, more specifically, perennial sea ice.

This work opens the way for snow-related improvements in climate models and provides modellers with some guidance in achieving this task. However, extensive In Situ observations are required to adequately constrain snow parameterizations and better quantify of the impacts of snow processes on sea ice. As such specific observations start to become available, we recommend some directions for using them in future investigations and model developments.

ABSTRACT n° 16

Title: Combining field measurements, remote sensing, and climate modelling to map surface melt on the Roi Baudouin ice shelf

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Abstract:

In West Antarctica, some ice shelves have thinned and disintegrated, leading to glacier speed-up. The mechanism behind this instability is linked to warm temperatures in summer, which lead to production of surface meltwater that is able to 'hydofracture' the ice shelf. In contrast, ice shelves on East Antarctica appear stable at present, but we expect enhanced potential for similar ice shelf instability in a further warming world. In this project, funded by InBev-Baillet Latour, we have measured the amount of surface melt and related processes (weather variables, and snow temperature, density, grain size and albedo) on the Roi Baudouin ice shelf, which is easily accessible from the Princess Elisabeth base (~200 km) during two consecutive field seasons (2014-2015 and 2015-2016). Our results demonstrate a significant gradient of surface melt over the ice shelf, with a regional maximum of melt along the grounding line. Using a climate model, we show that this gradient is linked to the presence of persistent downslope winds. In the field and in remote sensing analyses, we found evidence of englacial meltwater drainage and storage close to the grounding line, which suggests higher potential of ice shelf hydrofracturing in this region.

ABSTRACT n° 17

Title: **Dynamics of the Roi Baudouin ice shelf from seismo-geodetic experiments**

Authors: Denis Lombardi, Lionel Benoit, Thierry Camelbeeck, Olivier Martin, Christophe Meynard and Christian Thom

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Abstract:

In Antarctica, floating ice shelves bordering the continent stabilize the ice sheet flow and are a major controlling factor of the ice mass balance. Under direct influence of a warming ocean ice shelves may progressively loose their buttressing capacity. To investigate this vulnerability, we conducted two innovative experiments on the Roi Baudouin ice shelf during the 2014 and 2015 summer campaigns using collocated seismic and GPS instruments.

The first experiment consisted in investigating for a month four sites at the transition of an ice shelf with an ice rise promontory. Our study highlights this transition zone is affected by periodic seismic activity produced by surface crevassing during oceanic tide-induced flexure of the ice shelf and controlled by the tide vertical velocity. The most noticeable finding is the existence at the coastal front of the ice rise promontory of another tide-modulated seismicity characterized by a fortnightly modulation and by low frequency, long duration seismic events. A basal origin is postulated with the ocean water surge at each new spring tide triggering basal crevassing or basal slip on a local bedrock asperity.

The second experiment was conducted ca. 100 km further upstream, still at the grounding line, with 15 instruments running for a 2 month period. The preliminary results show the existence of numerous seismic events located upstream on the grounded ice in addition to tide-related seismicity. The observed ice stream flow displacements, reaching locally 80 cm/day, present semi-diurnal and fortnightly modulation.

Though further analysis is required to constrain the interpretation on the ice shelf dynamics we believe such a combination of geophysical methods may provide new insights on the identification of ice shelf most vulnerable zones to ocean forcing.

ABSTRACT n° 18

Title: Analysis of total ozone and UV radiation and of vertical profile measurements of temperature, humidity and wind data at Princess Elisabeth station, East Antarctica

Authors: Alexander Mangold[1], Quentin Laffineur[1], , Roeland Van Malderen[1], Veerle De Bock[1], Christian Hermans[2], Kevin Nys[3] and Hugo De Backer[1]

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Abstract :
In Antarctica the so-called ozone hole appears for over 30 years now each austral spring, in which ozone is destroyed almost completely in altitudes between 15 to 20 km, and reducing ozone in the total atmospheric column ('total ozone') by a third or even more. Ozone is a strong absorber in the UV-B region and has thus a large impact on the UV radiation received at the ground. In December 2010, a Brewer ozone spectrophotometer has been installed on the roof of Princess Elisabeth Station (PES). It provides near-simultaneous observations of total ozone and UV spectra between 283 and 363 nm during austral summer months. From the UV measurements, the UV index can be calculated, a measure how fast human skin is burned by the radiation. We will present an overview of the measurement results from the austral summer seasons since 2010/11 up to 2015/16. In 2015, the Antarctic ozone hole was one of the largest and most stable on record and total ozone amounts were also very low above Dronning Maud Laud, the region where PES is located. The measurements at PES showed local record minimum values between 170 to 180 Dobson Units (DU) for the end of November 2015. Normal values would be around 320 DU and values below 220 DU mark the 'ozone hole' region. Such conditions persisted until 15 December 2015 whereas they usually only persist until the end of November or until the first days of December. Consequently, the UV index reached record values up to 12, values normally expected in the tropics or at extreme altitudes.

Additional information on the atmosphere up to 30 km was derived from radio soundings via the launch of weather balloons, measuring the vertical profile of temperature, relative humidity, pressure, wind speed and wind direction above PES. These data are important for the interpretation of the larger scale meteorological dynamic conditions. They are also needed to locate temperature inversions and heights of low and high wind speed (e.g., low level jets, jet stream), and to characterise the conditions around cloud levels. Weather balloona have been regularly launched during the whole summer season have been done from November 2014 to February 2015 and again from December 2015 to February 2016. Analysis of the measured profiles in 2014/2015 has shown that the mean tropopause height was 9607 ± 836 m above sea level (asl) with a corresponding temperature of –56.6 ± 4.9 °C. The mean temperature profile for the summer season 2014-2015 revealed a distinct temperature inversion at around 2500 m asl. That inversion was not observed during the launches in December, but during almost all launches in January and February, probably marking a pronounced summer feature. The mean profile of relative humidity demonstrated the dryness of the Antarctic atmosphere with a mean relative humidity between 30 and 40 % (at very low temperatures!) throughout the troposphere. Even with standard deviations included, the mean relative humidity did not increase above 60 %, also within the altitude region 3000 to 6000 m asl where clouds often were observed. This indicates that the overall absolute humidity transported to Antarctica was extremely low. First results from November 2015 to February 2016 will also be presented.

ABSTRACT n° 19

Title: Atmospheric aerosol characterisation at Princess Elisabeth Station, East Antarctica

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Abstract:
Since 2010, several ground-based instruments for continuous measurements of the atmospheric aerosol composition within the boundary-layer have been operated at Princess Elisabeth Station (PES), in Dronning Maud Land, East Antarctica. Measured aerosol properties comprise number size distribution, total number, total mass concentration, mass concentration of light-absorbing aerosol, aerosol absorption coefficient and aerosol total scattering coefficient. In addition, a Cloud Condensation Nuclei counter (CCNc) has been operated during austral summers 2013/14, 2014/15 and 2015/16. Knowledge on atmospheric aerosols is essential because aerosols affect the Earth radiation budget and also cloud properties by acting as cloud condensation or ice nuclei.

The baseline total number concentration N_{total} was around some hundreds of particles/cm^3. During new particle formation events N_{total} increased to some thousands of particles/cm^3. Simultaneous measurements of N_{total}, size distribution and CCN number revealed that mostly the number of particles smaller than 100 nm increased and that the CCN number increased only very weakly. Further analysis of the CCN data indicated that the aerosol measured at PES consisted mainly of material with a hygroscopicity close to that of sulfate. The measured wavelength-dependent aerosol absorption and scattering coefficients gave further insight on the aerosol type, showing that mainly strongly scattering aerosol dominated. However, the fraction of light-absorbing aerosol increased during the passage of some extra-tropical cyclones or frontal systems, indicating the presence of aged, long-range transported aerosol.

Further, N_{total} values were distinctly higher during austral summer than during winter. Mean values of N_{total} in summer were between 300 and 800 particles/cm^3. In winter, the mean values dropped to 30 to 80 particles/cm^3. Irregularly, there were short periods (few hours to one day) during which the particle concentration increased distinctly, e.g., during cyclonic storms transporting air masses from the ocean or lower latitudes to Antarctica. In addition, the amount of light-absorbing aerosol has been analysed. Such particles are mainly produced during incomplete combustion processes. As no such natural sources are present in Antarctica, the detection of such particles is an indication of long-range aerosol transport. Mean concentration values from November to March were higher than during austral winter, indicating more transport during summer. In addition, during austral summer, values measured at the wavelength of 370 nm were higher than at 660 nm. As, e.g. in the case of fresh soot, the absorption values at different wavelengths are more or less the same, this indicates that the air masses transported to PES contained, in addition to aged soot, also other light-absorbing compounds (e.g., from biomass burning).

ABSTRACT n° 20

Title: Use of stable isotope ratios to delineate coastal benthic food web structure in Adélie Land (East Antarctica)

Authors:
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Abstract:

Antarctica currently undergoes strong and contrasted impacts linked with climate change. While the West Antarctic Peninsula is one of the most rapidly warming regions in the world, resulting in sea ice cover decrease, in some parts of East Antarctica sea ice cover tends to increase, possibly in relation with changes in atmospheric circulation. Changes in sea ice cover are likely to influence benthic food web structure through modifications of benthic-pelagic coupling, disruption of benthic production and/or modifications of benthic community structure (i.e. resource availability for benthic consumers). Here, we studied shallow (0-20 m) benthic food web structure on the coasts of Petrels Island (Adélie Land, East Antarctica) during an event of unusually high spatial and temporal (two successive austral summers without seasonal break-up) sea ice cover. Using stable isotope ratios of C, N and S, we examined importance of several organic matter sources (benthic macroalgae, benthic biofilm, sympagic algae, suspended particulate organic matter and penguin guano) for nutrition of over 20 taxa of benthic invertebrates (sponges, sea anemones, nemerteans, sessile and mobile polychaetes, gastropods, bivalves, sipunculids, pycnogonids, amphipods, sea stars, sea urchins and sea cucumbers) spanning most present functional guilds. Our results provide insights about how Antarctic benthic consumers, which have evolved in an extremely stable environment, might adapt their feeding habits in response to sudden changes in environmental conditions and trophic resource availability.

ABSTRACT n° 21

Title: Ice core evidence for a recent increase in snow accumulation in coastal Dronning Maud Land, East Antarctica

Authors: Morgane Philippe, Jean-Louis Tison, Karen Fjøsne, Bryn Hubbard, Helle A. Kjær, Jan T. M. Lenaerts, Simon G. Sheldon, Kevin De Bondt, Philippe Claeys, Frank Pattyn

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Abstract:

Ice cores provide temporal records of snow accumulation, a crucial component of Antarctic mass balance. Coastal areas are particularly under-represented in such records, despite their relatively high and sensitive accumulation rates. Here we present records from a 120 m ice core drilled on Derwael Ice Rise, coastal Dronning Maud Land (DML), East Antarctica in 2012. We date the ice core bottom back to 1745 ± 2 AD. $\delta^{18}O$ and δD stratigraphy is supplemented by discontinuous major ion profiles, and verified independently by electrical conductivity measurements (ECM) to detect volcanic horizons. The resulting annual layer history is combined with the core density profile to calculate accumulation history, corrected for the influence of ice deformation. The mean long-term accumulation is 0.425 ± 0.035 m water equivalent (w.e.) a^{-1} (average corrected value). Reconstructed annual accumulation rates show an increase from 1955 onward to a mean value of 0.61 ±0.02 m w.e. a^{-1} between 1955 and 2012. This trend is compared to other reported accumulation data in Antarctica, generally showing a high spatial variability. Output of the fully coupled Community Earth System Model demonstrates that sea ice and atmospheric patterns largely explain the accumulation variability. This is the first and longest record from a coastal ice core in East Antarctica showing a steady increase during the 20th and 21st centuries, thereby supporting modelling predictions.

ABSTRACT n° 22

Title: On the ability of NEMO-LIM3 to simulate sea ice dynamics using a simplified Maxwell-elasto-brittle rheology

Authors: Jonathan Raulier, Thierry Fichefet, Vincent Legat, Jérôme Weiss, Véronique Dansereau

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Abstract:

Satellite observations of sea ice reveal the existence of linear kinematic features which are quasi-linear patterns present in the strain field that stretch all across the ice pack and that are associated with the formation of leads. Current sea ice components of global climate models fail to reproduce those linear kinematic features, and the observed statistical distribution of deformation rate. In order to refine the physical representation of sea ice dynamics in large-scale sea ice models, a new approach has been proposed for the ice rheology. This approach, based on a Maxwell-elasto-brittle rheology, is integrated in the NEMO-LIM3 global ocean-sea ice model (www.nemo-ocean.eu ; www.elic.ucl.ac.be/lim). In the present study, we analyse the impact of the new rheology on the simulation of the leads and the ability of the model to reproduce the main observed characteristics of the Antarctic ice pack. We will also address the effect of the representation of leads on the air-ice-ocean fluxes.

ABSTRACT n° 23

Title: Snow accumulation retrieval in East Antarctica using GNSS-MR

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Abstract:

Although the Global Navigation Satellite System (GNSS) was designed for positioning, navigation, and timing, it has been demonstrated that it can be used for remote sensing of land surface properties. GNSS multipath reflectometry (GNSS-MR) has been emerged as a new technique that uses simultaneous reception of direct signal-to-noise ratio (SNR) observables along with surface reflections to retrieve environmental variables such as snow depth variations at an intermediate spatial scale that is proportional to the height of the antenna above the surface being observed. ROB1 that was part of IceCon project was installed at the Derwael Ice Rise in 2012 to study Antarctic plate motion. It was equipped with a Trimble NetR9 receiver and Trimble Zephyr II geodetic antenna. Here, SNR observations from ROB1 are used for a two-year period to monitor temporal variations of snow accumulation in East Antarctica.

ABSTRACT n° 24

Title: **Shining a light on exposed high-altitude Antarctic ecosystems provides a clearer view on the diversity of phototrophic bacteria**

Authors: Guillaume Tahon, Bjorn Tytgat, Karolien Peeters, Anne Willems

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Abstract:

Antarctic life is subjected to a variety of extreme environmental conditions, which have led to relatively simple and largely microbial food webs. In addition to the extreme conditions that characterize the continent, bacteria in soils of the Sør Rondane Mountains, home of the Belgian Princess Elisabeth Station, are also faced with low availability of organic matter. In their struggle for survival in this barren environment, bacteria might thus be expected to use alternative energy sources to overcome organic matter limitation.

Two major pathways for harvesting solar energy evolved among bacteria: one employing light-dependent rhodopsins, the other dependent on photochemical reaction centres that contain (bacterio) chlorophyll. Phototrophic bacteria can be found in most of the Earth's ecosystems, including Antarctica. Although little is known about their presence and diversity in this extreme environment, the at times abundant sunlight may prove very useful for certain members of the bacterial community, as light-derived energy may cover some of their metabolic needs.

To shine a light on the distribution and diversity of light-harvesting bacteria in exposed soils in the vicinity of the Princess Elisabeth Station, an Illumina MiSeq sequencing approach was used to monitor key protein encoding genes involved in the different phototrophic pathways. Although rhodopsin genes did not amplify from the samples, genes involved in different key steps of phototrophic pathways dependent on (bacterio) chlorophyll showed a broad diversity. *BchL* and *chlL* genes, required for the formation of chlorophyllide, a precursor of (bacterio) chlorophyll revealed mainly sequences grouping with Cyanobacteria. Data on BchX – needed for the subsequent conversion of chlorophyllide to bacteriochlorophyllide – however, suggested a high abundance of sequences belonging to currently unknown phylotypes. Finally, results on *pufM*, a gene directly involved in the production of bacteriochlorophyll *a*, revealed a very broad diversity of anoxygenic phototrophic bacteria with the type two reaction centre, dominated by *Roseobacter* and *Loktanella*-like sequences. No clear psychrophilic or Antarctic types could be seen in the data, however, results suggested that microbial communities inhabiting these oligotrophic exposed high-altitude soils have a high potential of harvesting solar energy.

ABSTRACT n° 25

Title: Bacterial and eukaryotic biodiversity patterns in the Sør Rondane Mountains, Dronning Maud Land, East Antarctica

Authors: Bjorn Tytgat[1], Dagmar Obbels[2], Elie Verleyen[2], Maxime Sweetlove[2], Zorigto Namsaraev[3,4], Marie-José Mano[5], Rafael Fernandez-Carazo[5], Karolien Peeters[1], Sofie D'hondt[2], Pia Clercx[1], Aaike De Wever[2,6], Damien Ertz[7,8], Josef Elster[9], Eric Van Ranst[10], Stephen Roberts[11], Koen Sabbe[2], Annick Wilmotte[5], Wim Vyverman[2], and Anne Willems[1]

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Abstract: Although microorganisms are fundamental to the functioning of Antarctic ecosystems, the microbial biodiversity of inland Antarctic regions and the factors shaping these communities are poorly understood. We used the Illumina MiSeq and the Roche 454 platforms to analyse the bacterial and eukaryotic community structure of a variety of habitats in ice-free regions of the western Sør Rondane Mountains (Dronning Maud Land, East Antarctica), including endolithic communities, cryoconite holes, water lenses where the ice sheet meets bedrock, water samples from melted lake ice, and epiphytic communities on mosses. A particular focus was put on studying the bacterial community structure in soil samples, which is the most abundant habitat type in the region, in relation to environmental variability. OTUs belonging to the Rotifera, Chlorophyta, Tardigrada, Ciliophora, Cercozoa, Fungi, Bryophyta, Bacillariophyta, Collembola and Nematoda were present with a relative abundance of at least 0.1% in the eukaryotic communities studied. Cyanobacteria, Proteobacteria, Bacteroidetes, Acidobacteria, FBP, and Actinobacteria were the most abundant bacterial phyla across the different habitats. Multivariate analyses of the 454 pyrosequencing data revealed a lack of differentiation of both eukaryotes and prokaryotes according to habitat type (aquatic versus terrestrial); in the eukaryotes, 46% of the OTUs was shared between both habitats. However, while 33% of the bacterial OTUs occurred in aquatic and terrestrial samples, the bacterial community structure appeared to be significantly different between both habitats. This was partly due to the dominance of the filamentous cyanobacterium *Leptolyngbya* in aquatic environments. In the soils, ordination analyses revealed that total organic carbon content was the most significant variable in structuring prokaryotic communities, followed by pH, electric conductivity, bedrock type and moisture content, while spatial distance was of relatively minor importance. Acidobacteria (Chloracidobacteria) and Actinobacteria (Actinomycetales) dominated mineral soil samples situated on gneiss derived bedrock, while Proteobacteria (Sphingomonadaceae), Cyanobacteria, Armatimonadetes and candidate division FCB (OP11) dominated soil samples with a high total organic carbon content mainly on granite derived bedrock. Despite these strong environmental controls, part of the unexplained variation in community structure might be related to unmeasured differences in microclimate conditions that potentially exert large effects on these barren soils. A striking feature in all datasets was the detection of a relatively large amount of sequences new to science, which underscores the need for additional biodiversity assessments in Antarctic inland locations.

ABSTRACT n° 26

Title: Antarctic data activities at RBINS: The Antarctic biodiversity Portal and the microbial Antarctic Resource System

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Abstract:

The Royal Belgian Institute for natural sciences has a long tradition in Antarctic research and data management. Here we present an overview of current Antarctic data activities at the Royal Belgian Institute for natural. The Antarctic biodiversity portal provides free and open access to terrestrial and marine biodiversity data in accordance to the Antarctic Treaty.

mARS is an information system dedicated to facilitate the discovery, access and analysis of molecular microbial diversity (meta)data generated by Antarctic researchers.

This includes the ability to upload information that describes (i) a research project that involves molecular microbial diversity sequence information (this goes into the Integrated Publishing Toolkit system that was developed by GBIF), (ii) communicating descriptive environmental information through a relatively newly accepted standard set of terms (Genomic Standards Consortium, MiMARKS), (iii) uploading links to DNA, RNA, proteomic or metabolomic data sets that have been deposited in public repositories, and the required metadata describing them.

ABSTRACT n° 27

Title: The Tweeting Ice Shelf: geophysics and outreach

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Abstract:

Over the last decade the Antarctic and Greenland ice sheets have contributed about one third of the annual sea level rise (Hanna et al., 2013). However, it remains difficult to reconcile global mass balance estimates obtained from different satellite-based methods. A typical approach is to balance the mass input from atmospheric modelling with the outgoing mass flux at the ice-sheet boundary (Shepherd et al., 2012). The flux calculations at the boundary rely on satellite-derived surface velocities, which are currently only available as snapshots in time, and which need ground truth for validation. Here, we report on continuous, year-round measurements that aim at improving the input-output method in several aspects and carefully map the flow speed allowing for detecting seasonal variability.

For this purpose, we set up in December 2014 three stand-alone single-frequency GPSes on the Roi Baudouin ice shelf (East Antarctica), close to the Belgian Princess Elisabeth Station. In January 2016, the whole data was collected and the GPSes were put again in position. The GPSes are installed across a surface depression (typical for large ice-shelf channels), where subglacial melting is expected. This setup allows us to investigate how these channels behave, i.e., if they become wider, whether or not they enhance the ice flow, and, in combination with an installed phase-sensitive radar, what amount of melting occurs below the channels in contact with the ocean.

The GPS data are transmitted on a daily basis. Ice-shelf velocity is derived from the raw hourly location following the methods described in den Ouden et al. (2010), Dunse et al. (2012), and Ahlstrøm et al. (2013). However, a reference station has not been used for the correction. Basic processing involves outliers removal, smoothing, time-series analysis and comparison with tidal models.

The project comes alongside an outreach event: on a weekly basis, the ice shelf 'tweets' its position, motion and relays other information with respect to the project. The GPS systems can be followed on Twitter via @TweetinIceShelf as well as the Tweeting Ice Shelf's blog (http://tweetiniceshelf.blogspot.com).

ABSTRACT n° 28

Title: The AEROCLOUD project: How do aerosols and clouds affect the East Antarctic climate?

Authors : Nicole Van Lipzig[1], Hugo De Backer[2], Michel Van Roozendael[3], Niels Souverijns[1], Alexandra Gossart[1], Irina Gorodetskaya[1], Stef Lhermitte[1], Alexander Mangold[2], Quentin Laffineur[2], Clio Gielen[3], Francois Hendrick[3], Christian Hermans[3]

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Abstract:

Gaining understanding of key atmospheric processes in the climate system is of critical importance for developing climate models and improving the reliability of their future climate projections. The role of clouds in the climate system, their interaction with radiation, the coupling between aerosols and clouds and the atmospheric branch of the hydrological cycle are recognized as key elements in the climate system. Although these research topics are high on the international research agenda, hardly anything is known about the interaction between clouds, precipitation and aerosols in the Antarctic. This is unfortunate, as the Antarctic ice sheet is expected to become a dominant contributor to sea level rise in the 21st century. Since precipitation is the only source of mass to the ice sheet, and precipitation and cloud processes are closely connected, an improved insight in these processes is essential. Only models that can represent clouds and precipitation correctly, can give reliable future climate projections.

AEROCLOUD's main objective is to improve the understanding and modelling of clouds, precipitation and their interaction with aerosols in Dronning Maud Land. This includes an improved insight in the so called "indirect aerosol effect", which refers to the role of aerosols to act as cloud condensation nuclei and ice nuclei, thereby affecting the characteristics of clouds. This presentation will give an overview of the results obtained so far and an outlook for the next years. The starting point is the comprehensive meteorological-cloud-precipitation-aerosol observatory that has been established during 2009-2012 at the Belgian Antarctic station Princess Elisabeth (PE). The observatory has been installed in the framework of two projects - HYDRANT and BELATMOS - financed by the Belgian Science Policy (BELSPO). The observatory is unique in its set of robust ground-based in-situ and remote sensing instruments. The first project year has been especially focussing on the data obtained from the station. In a later step, a modelling component, will be added in which the detailed measurements from the observatory will be used to evaluate and improve the regional climate models.

ABSTRACT n° 29

Title: The CCAMBIO project to characterize the biodiversity and distribution of microorganisms in microbial mats of Antarctic lakes

Authors: CCAMBIO partners: Benoit Durieu[1], Yannick Lara[1], Dagmar Obbels[2], Evelyne Pinseels[2], Igor Stelmach Pessi[1], Maxime Sweetlove[2], Bjorn Tytgat[3], Anton Van De Putte[4], Bart Van De Vijver[5], Elie Verleyen[2], Wim Vyverman[2], Anne Willems[3], Annick Wilmotte[1].

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Abstract:

The BelSPO project CCAMBIO aims to study the biogeographical distribution of microorganisms in lacustrine microbial mats using a combination of techniques including microscopical observations (light and electronic microscopy), strain isolation, and molecular diversity assessment using Next Generation Sequencing. The samples were collected in different Antarctic and sub-Antarctic biogeographical regions.

A detailed microscopic study of the Antarctic diatom diversity allowed to revise a number of taxa and discover new ones. A multivariate analysis of diatoms showed that these regions hosted different diatom flora. Endemic diatom taxa were also observed, and a multigene molecular phylogeny of Pinnularia borealis showed a high genetic diversity.

Pilot studies were conducted for the microeukaryotes and cyanobacteria to select NGS protocols and bioinformatic pipelines.Preliminary multivariate analysis of over 100 samples revealed that distinct biogeographic zones could be recognized in both the prokaryote and eukaryote data, which is in agreement with the classical subdivision of the Antarctic Realm into Maritime Antarctica, Continental Antarctica and the Sub-Antarctic Islands generally observed in plants and animals. Moreover, Sub-Antarctic assemblages harboured more complex foodwebs, with quite diverse metazoan groups. Lakes on the continent, however, were characterised by fewer metazoan groups and a greater importance of microbial herbivores and secondary consumers, including a relative high diversity of ciliates and tardigrades. Variation partitioning analysis revealed that spatial variables that approximated large-scale regional contrasts in historical (e.g. deglaciation history, geological origin) and climatic factors (e.g. mean annual air temperature) significantly explained the largest portion of the observed variation in community structure for eukaryotes, while in the prokaryote data environmental gradients related to conductivity were more important.

In a first analysis of microbial mats from five Antarctic lakes and an aquatic biofilm from the Sub-Antarctic, the majority of the cyanobacterial OTUs retrieved were related to filamentous taxa such as *Leptolyngbya* and *Phormidium*, which are common genera in Antarctic lacustrine microbial mats. However, other phylotypes related to different taxa such as *Geitlerinema, Pseudanabaena, Synechococcus, Chamaesiphon, Calothrix* and *Coleodesmium* were also found. Results revealed a higher diversity than what had been reported using traditional methods based on microscopic observations and cultivation and also highlighted remarkable differences between the cyanobacterial communities of the studied lakes.

In the next months, the molecular diversity data will be deposited into the "Microbial Antarctic Resource System (MARS)" presently developed into the webportal 'biodiversity.aq'. The better knowledge of the diversity and distribution of microorganisms will contribute to a better assessment of their resilience and local/regional responses to global change.

ABSTRACT n° 30

Title: Unravelling the Nansen Blue Ice Field (Dronning Maud Land, Eastern Antarctica) Meteorite Trap

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Abstract:

During the austral summer of 2012-2013 a joint Belgian (BELARE SAMBA 2012-2013) – Japanese (JARE 54) research expedition was conducted to the Nansen Ice Field, located approximately 120-140 km south of the Princess Elisabeth Research Station (Dronning Maud Land) on the Antarctic plateau (2900-3000 m). More than 400 meteorites were retrieved in the southwestern ('Nansen B') and the northeastern ('Nansen C') sections of the ice field, with 10 meteorites weighing more than 1 kg. As these large meteorites cannot be transported by wind, their terrestrial ages can therefore be used as a lower limit to determine the age of the underlying blue ice. Here, we present the first results on the terrestrial meteorite ages determined by the ^{14}C method, which vary from 11.5 ($\pm$1.3 ka cal BP) to > 55 ka cal BP, the upper limit of the ^{14}C method. This indicates that a large fraction of the surface of the Nansen ice field is composed of ice from the last glacial period (and potentially older interglacials-glacials). This is also supported by the isotopic composition of the surface ice, which shows clear transitions between zones with lower $\delta^{18}O$ values (from -48 to -44‰) (i.e. colder conditions) and higher $\delta^{18}O$ values (between -42 and -38‰) (i.e. warmer conditions). These zones could potentially correspond to glacial and interglacial zones, although more terrestrial meteorite ages are needed to confirm this. These additional terrestrial ages will also help to better understand the past and present ice field dynamics and ice flow mechanism and will provide new insights about the palaeo-environment in this part of the Antarctic interior.

ABSTRACT n° 31

Title : A multi-column vertical mixing scheme to parameterize the heterogeneity of oceanic conditions under sea ice

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Abstract :

The heterogeneity of ocean surface conditions associated to a spatially variable sea ice cover needs to be represented in models in order to represent adequately mixed layer processes and the upper ocean density structure. This study assesses the sensitivity of the ocean-sea ice model NEMO-LIM to a subgrid-scale representation of ice-ocean interactions. The sea ice component includes an ice thickness distribution, which provides heterogeneous surface buoyancy fluxes and stresses. A multi-column ocean scheme is developed to take them explicitly into account, by computing convection and turbulent vertical mixing separately in the open water/lead fraction of grid cells and below each ice thickness category. For the first time in a three-dimensional simulation, the distinct temperature and salinity profiles of the ocean columns are allowed to be maintained over several time steps. It is shown that, if columns are laterally mixed with homogenization time scales shorter than 10~h, subgrid-scale effects exist but the model mean state is practically unaffected. For longer mixing time scales, in both hemispheres, the main impacts are reductions in under-ice mean mixed layer depths and in the summer melt of sea ice, following decreased oceanic heat flux at the ice base. Large changes in the open water temperature in summer suggest that the scheme could trigger important feedback processes in coupled simulations.

ABSTRACT n° 32

Title: Optical Televiewing of ice boreholes on the Roi Baudouin Ice Shelf, East Antarctica

Authors: Bryn Hubbard + BELISSIMA + IceCon team members

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Abstract:

Since 2008, several boreholes have been drilled by electro-mechanical corer at different locations on the Roi Baudouin Ice Shelf (RBIS). These have been cored in order to investigate material properties, firnification processes and to enable environmental reconstruction. As well as being subjected to direct ice-core analysis, supplemented by ice surface radar, 10 of these boreholes have been logged by optical televiewer (OPTV), which provides a geometrically accurate image of the complete borehole wall at a resolution of ~1 mm. Here, we present a summary of the OPTV images obtained through these studies and an overview of the glaciological information provided by them, both alone and complemented by ice-core and geophysical data. These include: (i) the identification of different ice facies and their formation in an ice-shelf rift, (ii) the approximation of firn and ice density from OPTV calibration by ice core samples from the RBIS, (iii) the derivation of an age-depth scale and accumulation history for the Derwael Ice Rise (DIR), (iv) the identification of surface melting and infiltration ice formation across the RBIS, and (v) the high-resolution analysis of vertical strain within the firn column of the DIR. Finally, the potential utility of the technique is discussed in the context of research on other Antarctic ice shelves and more widely.

ABSTRACT n° 33

Title: RECTO, a new BRAIN project studying refugia and ecosystem tolerance in the Southern Ocean

Authors: Isa Schön [1], Bruno Danis [2], Chantal De Ridder [2], Philippe Dubois [2], Bruno Frederich [3], Marc Kochzius [4], Frederik Leliaert [5], Gilles Lepoint [3], Anton Van Den Putte [1], Ann Vanreusel [5], Filip Volckaert [6]

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Abstract:

Confronted with fast-paced environmental changes, biota in Antarctic ecosystems are strongly challenged and face three possible outcomes: adaptation, migration or extinction. Past glaciation periods have already forced marine zoobenthos of the SO into refugia, being either ice-free continental shelf areas, the deep sea or sub- or peri-Antarctic regions, followed by recolonization when the ice retreated. The collaborative Belgian BRAIN project RECTO, “Refugia and ecosystem tolerance in the Southern Ocean” (SO), will strive at understanding how such past events have driven diversification and adaptation in different animal groups and how these can be applied as proxies to understand the contemporary situation and predict future scenarios.

In a multidisciplinary approach, RECTO will tackle 6 objectives by combining genomic data with morphological, phylogenetic, coalescent, fossil, physiological, ecological and modelling approaches. RECTO will focus on six different animal groups: fish, sea stars, amphipods, bivalves, ostracods, and seabirds. In this way, RECTO will study different trophic levels ranging from micro- and macro-benthos to pelagic crustaceans and vertebrates. The selected species differ in their biology, life histories and dispersal capacities, which are all factors affecting their abilities to cope with environmental changes. Most of the species occur in the SO but RECTO will also investigate snow patrol colonies living close to the Princess Elisabeth Station.

With a molecular approach, RECTO will produce data on population histories and Pleistocene refugia and test for possible correlations with past climate data to reconstruct how the target taxa responded to past glaciations and interglaciations. For fish and amphipods, RECTO will also study in a novel phylogenetic framework how morphological diversification and trophic adaptability are interacting with each other and whether ecotypes of selected species have faster modes of evolution. Geographic models on future species and trait distributions based on physiological and energy limits and present and future climate data will be refined and integrated with coupled sea-ice-ocean and individual based models for the SO. Finally, scenarios of future dispersive abilities and possible habitat shifts of the RECTO target groups will be developed to infer how the RECTO target species will respond to future climate change.

ABSTRACT n° 34

Title: Cloud, precipitation and surface mass balance measurements at Princess Elisabeth Station: a unique observatory in East Antarctica

Authors: Irina Gorodetskaya[1], Maximilian Maahn[2], Stefan Kneifel[2], Wim Thiery[1], Kristof Van Tricht[1], Hubert Gallée[3], Jan Lenaerts[4], Niels Souverijns[1], Alexandra Gossart[1], Jan Schween[2], Stef Lhermitte[1], Alexander Mangold[5], Quentin Laffineur[5], Carleen Reijmer[4], Michiel van den Broeke[4], Susanne Crewell[2] and Nicole Van Lipzig[1]

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Abstract:

Mass loss from the ice sheets is becoming a dominant contributor to sea level rise in this century. At the same time, the Antarctic ice sheet mass balance has been characterized by large interannual variability, most of which is determined by the surface mass balance (SMB) variability. Antarctic SMB or net snow accumulation results from snowfall, which is then redistributed by the wind and modified by surface sublimation/deposition, the sublimation of drifting/blowing snow particles and melt (in the coastal areas of the ice sheet). Snowfall in turn depends on the poleward moisture transport from the lower latitudes and on the local cloud properties.

Since 2009-2010, several ground-based remote sensing instruments measuring cloud and precipitation properties (a ceilometer, an infrared pyrometer, and a precipitation radar) have been installed at the Princess Elisabeth (PE) station. In addition, an automatic weather station (AWS) has provided hourly measurements of meteorology, radiative fluxes and snow accumulation. This suite of instruments, installed within BELSPO-funded project HYDRANT, gives a unique opportunity to investigate complex mechanisms controlling the Antarctic ice sheet SMB - one of the main challenges in the modern glaciology. PE is located in a region recently experiencing dramatic changes: extreme snowfall and SMB anomalies that occurred in Dronning Maud Land in 2009 and 2011 have been unprecedented in the last 60 years, and only few other similarly large SMB anomalies occurred since the mid-eighteenth century. A combination of observational and modeling techniques allowed us to understand the nature of these extreme accumulation events, as well as to estimate cloud and precipitation properties, meteorological conditions and different surface mass balance components. At the symposium we will present the key results of the 5-year project summarizing eight peer-reviewed publications. The year 2012 provides an example of typical processes with moderate accumulation amount of 52 mm water equivalent (w.e.), which resulted from the total yearly snowfall of 110 mm w.e., from which 23% was removed by sublimation, and about 30% was eroded by the wind. The difference between total yearly SMB during other years (227 mm w.e. in 2009, 230 mm w.e. in 2011, and only 23 mm w.e. in 2010) was mostly determined by the occasional intense snowfall events. The most extreme of these events (up to 30 mm w.e. per day) have been associated with atmospheric rivers - narrow bands of strong moisture transport stretching from subtropical latitudes to the East Antarctic coast. The PE data have been also applied for evaluating satellite products and two regional climate models, and can help in developing new cloud microphysical schemes able to simulate in a much better way polar and high altitude clouds, which are poorly represented up to now in climate models.

ABSTRACT n° 35

Title: How big is the cyanobacterial diversity near the Princess Elisabeth Station?

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Abstract:

Antarctica is the only continent that is dominated by microbial (cyanobacteria and algae) and lower plant (predominantly mosses and lichens) communities. Cyanobacteria are photosynthetic bacteria that require solar light, liquid water, air and some mineral nutrients for growth. They serve as primary producers of organic matter in Antarctic ecosystems providing energy to other physiological groups of microorganisms and invertebrates. Cyanobacteria form macroscopically visible crusts or thin biofilms on the surface of soils and rocks, or occupy endolithic niches in Antarctic mountains.

Mountains exposed above the ice sheet could have remained ice-free during glaciation maxima in Antarctica. They could serve as a refuge for terrestrial biodiversity and potential source for recolonization of surrounding habitats during glacier retreat. Cyanobacterial diversity in habitats located above 1 km a.s.l. was studied in several Antarctic locations. These include Vinson Massif in Ellsworth Mountains (2000-2500 m a.s.l.), Beacon (1176 m a.s.l.) and University Valleys (1700 m a.s.l.) in the "stable upland zone" of the Dry Valleys (South Victoria Land) and the Sør Rondane Mountains (1370-1700 m a.s.l.) (Yergeau et al., 2007; Wood et al., 2008; Fernandez-Carazo et al., 2012).

The goal of our work was to study cyanobacterial diversity in the Sør Rondane Mountains in the vicinity of the Princess Elisabeth Station. Previous estimates of the diversity showed the presence of 10 morphotypes and 13 OTUs (groups of 16S rRNA sequences sharing at least 97,5% sequence similarity) in 10 samples of biofilms and microbial crusts (Fernandez-Carazo et al., 2012). We performed a broader sampling and characterized the molecular diversity using DGGE with cyanospecific primers and microscopy. In 126 samples, we observed 15 morphotypes of cyanobacteria. 28 representative samples were selected for molecular analyses that revealed the presence of 28 OTUs.

Comparison with other mountainous areas of Antarctica showed that the Sør Rondane Mountains harbor a significantly higher cyanobacterial diversity. Molecular analysis of the cyanobacterial diversity in Beacon Valley didn't show the presence of cyanobacteria (Wood et al., 2008), though a strain of *Chroococcidiopsis* sp. (CCMEE 134) was isolated from a sample collected there (Billi et al., 2011). Another strain of *Chroococcidiopsis* sp. (CCMEE 171-A789-2) was also isolated from samples collected in University Valley (Cumbers & Rothschild, 2014). Five cyanobacterial OTUs were detected in samples collected in Ellsworth Mountains despite of the presumably harsher climate (78°31'S latitude compared to 77°49'S for Beacon Valley) and higher altitude (Yergeau et al., 2007). No reliable climate data are available for the discussed areas, except for the Sør Rondane Mountains. We propose that the higher diversity of cyanobacteria detected near the Princess Elisabeth Station could be explained by a more intensive sampling or by a more northern location of the area (72°0'S).

ABSTRACT n° 36

Title: **Investigating the biases in the Antarctic sea ice - ocean system of climate models using process-oriented diagnostics**

Authors: Olivier Lecomte[1], Hugues Goosse[1], Thierry Fichefet[1], Paul R. Holland[2], Petteri Uotila[3], Casimir de Lavergne[4], Violette Zunz[5]

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Abstract:

Most analyses of Antarctic sea ice in simulations of the CMIP5 archive have so far been oriented towards the quantification of the disagreement between model results and sea ice observations only. Since the decomposition of those biases into distinct physical components is necessary to understand their origins, we propose here an ocean-sea ice-atmosphere integrated and process-oriented approach. Not only the biases in variables essential to the sea ice seasonal evolution are estimated regionally with regard to observations, but their contributions to the sea ice concentration budget are estimated.

Following a previously developed method, the sea ice concentration balance over the autumn-winter seasons is decomposed into four terms, including the sea ice concentration change during the period of interest, advection, divergence and a residual accounting for the net contribution of thermodynamics and ice deformation. Concurrently, correlations between trends in ocean temperature at depth and trends in ice concentration are calculated directly from various model output fields (including CMIP5 models) to disentangle the role of ice-ocean interactions.

Results show that the geographical patterns of all mean sea ice concentration budget terms over 1992-2005 are in qualitative agreement with the observed ones. Sea ice thermodynamic growth is maintained by horizontal divergence near the continent and in the central ice pack, whereas melting close to the ice edge is led by sea ice advection. However, significant errors in all budget terms are observed due to ice velocities that tend to be overestimated all around Antarctica in several models, leading to a relatively weak divergence in the inner ice pack and to an excessive advection in the marginal ice zone. Biases in ice drift speed and direction are ultimately related to biases in winds in all models.

This method paves the way for a systematic assessment of forthcoming CMIP6 sea ice model outputs in the Southern Hemisphere.

ABSTRACT n° 37

Title: The Roi Baudouin Ice Shelf: A case study for Ice-Shelf/Ocean interactions in East Antarctica

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Abstract

Ice shelves are the natural "tab" of ice sheets. By friction on pinning points and on coastal embayments, they buttress ice-sheet flow and therefore control the rate of continental ice discharge to the ocean, hence its contribution to sea-level rise. Reducing ice shelf mass reduces friction and therefore enhances discharge and vice versa. Ice shelf mass balance has therefore become a key player in the exercise of sea level change predictions. There are several ways to alter ice shelves' mass balance: increased/decreased flow from grounded ice upstream, net surface accumulation (snow fall vs. melting/sublimation), iceberg calving, net bottom melting (marine ice accretion vs. melting). The last of these has been invoked as the major driver of recent ice loss in West Antarctica. Until recently, East Antarctica has been known for showing a globally positive surface mass balance and negligible ice shelf losses. Today, however, isolated cases of increased ice shelf losses have been detected in East Antarctica too. Will this be a future trend?

This paper presents results from the Belspo BELISSIMA project, exploring the potential of the Roi Baudouin Ice Shelf to develop as a long-term observatory for ice shelf mass balance and stability. The project has focused on the basal mass balance of the ice shelf, in relation to ice ocean-interactions. Combining ice core drilling and optical monitoring, ocean profiling and ice dynamics modelling, we show that both melting and accretion occur at the base of the Roi Baudouin Ice Shelf. Large amounts of marine ice (frazil ice forming in Ice Shelf Water from decompression of the water mass) are shown to form in frontal rifts and to contribute more than 50% of the sea ice cover in front of the ice shelf. Melting is shown to occur along the western margin of the ice shelf, but in moderate amounts (0.15 m a^{-1}). A few radar profiles transverse to flow suggest limited accretion of marine ice at the ice shelf bottom, in the range of the potential errors generated in comparing radar profiles with hydrostatic estimates of ice thickness from GPS-derived altimetry. These observations, combined with the fact that no Ice Shelf Water was clearly detected in the CTD profiles performed along the front of the ice shelf, suggest that no Deep Thermohaline Convection is active in the sub-ice shelf cavity, and that marine ice accumulation is limited to steep depth gradients associated with rifts and the ice shelf front.

CTD profiles have also detected, below 600 m depth in a 800 m deep bedrock trough, the penetration of modified Circumpolar Deep Water (MCDW) about 1.7°C warmer than the in-situ freezing temperature at depth. The flat ocean bed below the ice shelf makes it plausible for this MCDW to reach the ice shelf grounding line, therefore potentially sustaining considerable melting. However, it is too early to determine whether this is a recent trend or not.

The recent discovery of a) large amounts of surface meltwater penetrating into the ice shelf in the vicinity of the grounding line, and b) subglacial meltwater channels emerging at the grounding line, are however likely to further complicate our picture of the Roi Baudouin Ice Shelf's mass balance.

ABSTRACT n° 38

Title: Ice rises and ice rumples in the Dronning Maud Land coast: settings, roles and unknowns

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Abstract

The Dronning Maud Land coast is characterized by many small ice shelves punctuated by locally grounded features, called ice rises and ice rumples. Ice rises are typically rise several hundreds of meters above the surrounding ice shelf and shelf flow is diverted around them. On the other hand, shelf ice flows across ice rumples, which typically rise only a few tens of meters above the ice shelf. In general, the ice rises and rumples buttress the surrounding ice shelves and eventually impact the position of the grounding line and ice discharge from the ice sheet. Nevertheless, their exact roles highly depend on their settings, which are largely variable in Dronning Maud Land. Understanding their roles is crucial especially for regions fed by fast-flowing outlet glaciers. In this talk, we briefly review properties of ice rises and rumples in general, and present their distributions and significance in Dronning Maud Land.