

Full Proposals for International Polar Year 2007-2008 Activities

Proposed IPY Activity Details

1.0 PROPOSER INFORMATION

(Activity ID No: 125)

1.1 Title of Activity

Ice and snow mass change of Arctic and Antarctic polar regions using GRACE satellite gravimetry

1.2 Short Form Title of Proposed Activity

Antarctica & Greenland mass balance by GRACE satellite gravimetry

1.3 Activity Leader Details

Guillaume RAMILLIEN
CNRS UMR5566 LEGOS
FRANCE

1.4 Lead International Organisation(s) (if applicable)

1.5 Other Countries involved in the activity

Australia
Germany
United States

1.6 Expression of Intent ID #'s brought together in this proposed activity

351, 232, 579, 593, 812, 823, 907, 910, 418, 74, 91, 94, 423, 579, 812, 813, 136, 883, 907, 910, 951

1.7 Location of Field Activities

Bipolar

1.8 Which IPY themes are addressed

1. Current state of the environment
2. Change in the polar regions
3. Polar-global linkages/tele-connections

1.9 What is the main IPY target addressed by this activity

1. Natural or social science
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2.0 SUMMARY OF THE ACTIVITY

The main objective of the proposed work is the study space and time mass variations of ice and snow over polar regions, the estimation of the water mass balance using monthly GRACE geoids

for the recent period, as well as its connection with global climate change, the global hydrological cycle, and in particular the investigation on the possible causes of the sea level rise from ice melting.

GRACE (Gravity Recovery and Climate Experiment) is the first geodetic mission dedicated to the measurement of the time-variations of the Earth's gravity field, it enables the detection of water mass transfers.

The on-going GRACE mission (launched in 03/2002 for a nominal lifetime of 5 years; quasi-polar orbit) provides monthly maps of tiny spatio-temporal variations of gravity due to the redistributions of mass inside the surface fluid envelopes of the Earth. These satellite measurements represent vertically-integrated gravity effects of water mass reservoirs (oceans, atmosphere, continental waters and ice sheets) and of the solid Earth that need to be unravelled. Monthly solutions of the continental water storage (2002 to present) have been recently extracted from the raw GRACE geoids (at the resolution of 500 km), using an iterative generalized least-squares approach developed in our laboratory (LEGOS; Schmidt et al., 2005; Ramillien et al., 2005). After correction of important geophysical effects like mass changes induced by vertical s to study the ice sheets for the following objectives:

(1) Mass balance of the ice sheets: mapping for the first time the time variations of loss/gain of ice mass observed by GRACE, in response to climate change. This will provide monthly time series and geographical maps of the integrated variations of mass over large remote regions like Antarctica and Greenland.

(2) Contribution to the sea level rise: Estimating the mass balance of these polar regions, which can be further expressed in terms of sea level contribution. Recent results indicate that over the last 50 years and last 12 years, the contribution of thermal expansion of the oceans to sea level rise is 25% and 60% respectively (Cazenave and Nerem, 2004; Lombard et al., 2005a, b). For both time spans, the water mass addition to the oceans is estimated to about 1.4 mm/yr (Miller and Douglas, 2004; Lombard et al., 2005b). Recent direct estimates of mountain glaciers and ice sheets melting only explain 0.9 mm/yr (IPCC, 2005). In addition for the ice sheets (Antarctica and Greenland), these estimates based on airborne laser altimetry and other approaches are still uncertain (e.g., Thomas et al., 2004; Krabill et al., 2005). Measuring the mass balance of the ice sheets on inter-annual time scale using GRACE will represent a major improvement.

(3) Snow pack changes: Another objective of this project is to monitor the snow pack changes in the Arctic regions using GRACE. Changes of the snow pack are currently monitored from space using passive microwave radiometry. However, interpretation of these observations in term of snow mass change is very difficult because of problems related to surface conditions and snow state. Here again, GRACE can provide important constraints on snow mass change at a global scale. Snow mass solutions have been recently computed from the monthly GRACE geoids made available by the GRACE project (GFZ and CSR) using a robust inverse method of separation of hydrological signals (Ramillien et al., 2004; Ramillien et al., 2005)

(4) Monitoring of the permafrost: GRACE is also able to provide information on melt of the permafrost in the boreal regions (e.g., Siberia) through associate water mass redistribution. Used in combination of water level (and discharge) measurements from satellite altimetry over Arctic rivers, GRACE data will allow us to detect and extract the permafrost signals.

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Church, J., J.M. Gregory, P. Huybrechts, M. Kuhn, K. Lambeck, M.T. Nhuan, D. Qin, and P.L. Woodworth, Changes in sea level, in *Climate Change 2001: The Scientific Basis, Contribution of Working Group I to the Third Assessment Report of the Intergovernmental Panel on Climate Change*, edited by J.T. Houghton, Y. Ding, D.J. Griggs, M. Noguer, P.J. van der Linden, X. Dai, K. Maskell, and C.A. Johnson, pp. 881, Cambridge Univ. Press, Cambridge, 2001.

Church J. A., N.J. White, R. Coleman, K. Lambeck and J. Mitrovica, Estimates of the regional distribution of sea level rise over the 1950-2000 period, *J; climate*, 17, 2609-2625, 2004.

Krabill W., E. Hanna, P. Huybrechts, W. Abdalati, J. Cappelen, B. Csatho, E. Frederick, S. Manizade, C. Martin, J. Sonntag, R. Swift, R. Thomas and J. Yungel, Greenland Ice Sheet : increased coastal thinning, *Geophys. Res. Lett.*, in press, 2005.

Lambeck, K., and P. Johnston, The viscosity of the mantle: Evidence from the analysis of glacial rebound phenomena, in *The Earth's mantle, composition, structure and evolution*, edited by I. Jackson, pp. 461-502, Cambridge Univ. Press, Cambridge, UK, 1998.

Lombard A., Cazenave A., Le Traon P.Y. and Ishii M., Contribution of thermal expansion to present-day sea level rise revisited, in press *Global and Planetary Change*, 2005a.

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Miller, L., and B.C. Douglas, Mass and Volume Contributions to 20th Century Global Sea Level Rise, *Nature*, 428, 406-408, 2004.

Ramillien G. and Cazenave A., First results on land hydrology fluctuations (2002-2004) from the GRACE space mission, *EPSL*, in press, 2005.

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Rignot, E., A. Rivera, and G. Casassa, Contribution of the Patagonia Icefields of South America to Sea Level Rise, *Science*, 302, 434-437, 2003.

Schmidt R., Flechtner F., Reigber Ch., Schwintzer P., Gunter A., Doll P., Ramillien G., Cazenave A., Petrovic S., Jochman H. and Wunsch J., GRACE observations of changes in continental water storage, in press, *Global and Planetary Change*, 2005.

Thomas R., E. Rignot, G. Casassa, P. Kanagaratnam, C. Acuna, T. Akins, H. Brecher, E. Frederick, P. Gogineni, W. Krabill, S. Manizade, H. Ramamoorthy, A. Rivera, R. Russell, J. Sonntag, R. Swift, J. Yungel and J. Zwally, Accelerated Sea Level Rise from West Antarctica, *Science*, 306, 255-258, 2004.

2.1 What is the evidence of inter-disciplinarity in this activity?

This research project is cross-cut though several scientific fields:

- solid Earth: mantle rheology: post-glacial rebound
- ice, snow, frozen ground
- sea level change
- climate change
- land hydrology

2.2 What will be the significant advances/developments from this activity? What will be the major deliverables? What are the outputs for your peers?

The most significant result expected from this project will be the direct estimate of the contribution of ice sheets mass loss to sea level change: in the 4th assessment IPCC report, the estimate of the present ice sheet melting/mass loss and the corresponding contribution to the sea level rise remains not well-known. For example, for the Antarctica ice sheet, partial results based on remote sensing data are available for 2002-2004 for the Antarctic Peninsula but there is no information for the whole Antarctica ice sheet.

The expected new results from GRACE will be a major contribution to the knowledge of the mass balance of the ice sheet and sea level rise with great implications for understanding climate change and climate prediction.

2.3 Outline the geographical location(s) for the proposed field work (approximate

coordinates will be helpful if possible)

Locations	Coordinates
Antarctica (the whole ice sheet)	South of 60 deg. South
Greenland	North of 60 deg. North
Boreal regions (snow and permafrost)	North of 50 deg. North

2.4 Define the approximate timeframe(s) for proposed field activities?

Arctic Fieldwork time frame(s)	Antarctic Fieldwork time frame(s)
No timeframes have been added.	

2.5 What major logistic support/facilities will be required for this project?

Further details – The proposed study is mainly based on the acquisition of GRACE satellite data from the US and German GRACE project (G. Ramillien is co-I of the GRACE project).

2.6 How will the required logistics be supplied? Have operators been approached?

Source of logistic support	Likely potential sources	Support agreed
Consortium of national polar operators		
Own national polar operator		
Another national polar operator		
National agency		
Military support		
Commercial operator		
Own support		
Other		

2.7 If working in the Arctic regions, has there been contact with local indigenous groups or relevant authorities regarding access?

3.0 STRUCTURE OF THE ACTIVITY

3.1 Origin of the activity

This is a new activity developed for the IPY period

3.2 How will the activity be organised and managed? Describe the proposed management structure and means for coordinating across the cluster

The core GRACE project formed by the Center of Space Research (CSR, Austin, Texas) and the GeoForschungsZentrum (GFZ, Potsdam) provide the series of monthly GRACE geoids since April 2002 to the PI and associated Co-I.

STEP 1: These GRACE geoid data will be used by G. Ramillien (LEGOS) as a Co-I (and other collaborators from LEGOS) to proceed the systematic computation of:

(1) the time series of solutions for ice/permafrost/snow variations in high-latitude regions (Antarctica, Greenland and boreal regions) after correcting for the post-glacial rebound (PGR) signals, and using different models of the rheology of the Earth (in association with K. Lambeck, Univ. of Canberra, Australia);

(2) the mass balance of the ice sheets from these monthly ice/snow solutions;

STEP 2: Comparison and interpretation:

The impact of the loss/gain of ice mass versus time in terms of sea level for the comparison with other possible contributors such as the global discharge of the rivers, these estimates will be provided by global hydrology models.

The GRACE-based estimates of the ice loss contribution will be also compared to the non-steric contribution that is computed combining altimetry data and climatology (i.e., vertical profiles of temperature and salinity).

The team at LEGOS will ensure the regular distribution of the results (time series and maps) to other partners of this proposal.

3.3 Will the activity leave a legacy of infrastructure and if so in what form?**3.4 Will the activity involve nations other than traditional polar nations? How will this be addressed?****3.5 Will this activity be linked with other IPY core activities? If yes please specify**

Antarctica mass balance (main cluster of this proposal #910)

Greenland mass balance

Study of the snow pack and permafrost in Boreal regions

3.6 How will the activity manage its data? Is there a viable plan and which data management organisations/structures will be involved?

All the products obtained in this project will be easily available to each partner and to international climate data banks (e.g., NSIDC):

(1) Monthly maps of the ice/snow variations over Antarctica, Greenland and boreal regions, expressed in mm of equivalent-water height since April 2002.

(2) the mass balance of the ice sheets (in mm/y), as well as the corresponding time-series of ESL versus time for the recent period of GRACE (04/2002-...)

3.7 Data Policy Agreement**Will this activity sign up to the IPY draft Data Policy (see website)**

Yes

3.8 How will the activity contribute to developing the next generation of polar scientists, logisticians, etc.?

All the results obtained by the working group will be published and regularly presented in scientific meetings. The products (i.e., gridded data, methodology details, publications) will be stored and made easily available by the team at LEGOS. PhD grants and special scientific trainings for future students on the topic: "ice mass balance of the ice sheets from space gravimetry" may also re-enforce and expand the proposed study.

3.9 How will this activity address education, outreach and communication issues outlined in the Framework document?

LEGOS has a strong communication policy and this project will follow it.

A website will be developed for the science community, taking into account the diversity of fields addressed (solid Earth, ices, sea level changes, land hydrology and climate change). For the first time, this website will have a part dedicated to citizens interested with global change.

As a participation to International Polar Year, we are now in the definition phase of an exhibition to be settled in « Cité de l'Espace » in Toulouse. This one year exhibition will address climate change as attested by polar ice caps evolution. A display of near real time GRACE monthly results could be an attractive point of this show.

3.10 What are the proposed sources of funding for this activity?

Financial support from CNES and CNRS/INSU

3.11 Additional Comments**4.0 CONSORTIUM INFORMATION****4.1 Contact Details****Lead Contact**

Dr Guillaume Ramillien
 CNRS UMR5566 LEGOS
 LEGOS - Observatoire Midi-Pyrénées 14, Avenue Edouard Belin Toulouse
 31400
 FRANCE

Tel: (+33)0561332934
Mobile: N/A
Fax: (+33)0561253205
Email: Guillaume.Ramillien@notos.cst.cnes.fr

Second Contact

Dr Anny CAZENAVE
 CNES - LEGOS UMR5566
 Observatoire Midi Pyrénées 14, Avenue Edouard Belin Toulouse
 31400
 France

Tel: (+33)0561332922
Mobile: N/A
Fax: (+33)0561253205
Email: anny.cazenave@cnes.fr

4.2 Other significant consortium members and their affiliation

Name	Organisation	Country
N. FLORSH	University of Paris VI	FRANCE
J. HINDERER	IPG, Strasbourg	FRANCE
K. LAMBECK	University of Canberra	AUSTRALIA
M. LLUBES	University of La Rochelle	FRANCE
Y. MENARD	CNES/LEGOS	FRANCE
N. MOGNARD	CNES/LEGOS	FRANCE
F. REMY	LEGOS	FRANCE
R. SCHMIDT	GFZ, Potsdam	GERMANY
C. K. SHUM	University of Ohio	UNITED STATES