Workshop on Winter Over Science in Glaciology

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Workshop Abstract

The way glaciologist conduct sciences has significantly changed over the 50 years. Year round deployments were the norm in the early IGY and post IGY days. With improvements to transcontinental transportation getting to and from Antarctica has become easier and large advances in the area of computing, remote-sensing and global satellite communication most scientists now deploy only for a few months if not only a few weeks to days, leaving Antarctica and the year round stations to technicians tending to specific projects and personal maintaining the stations and equipment in Antarctica. Long distance traverses are rarely done except for logistic reasons.

Antarctica is still a continent on which we have large data gaps and extremely limited spatial and temporal coverage. Improving such coverage is yet crucial for understanding rate controlling processes, regional specifics, spatial and temporal variability constraining numerical models for future behaviour predictions.

What are reasons for this change? Are we missing out on opportunities to conduct science over a large portion of the year? Are we as a science community obtaining a blurred picture of Antarctica during summer and missing important processes and changes in winter?

The workshop explores these questions focusing on:

- What kind of measurements would we like to extend over a longer period of the year (including winter)?
- What are the reasons for not conducting/proposing science in winter?
- What kind of work are we currently not doing because it is too difficult?
- What are the difficulties and how to overcome those difficulties?
- For more information visit glaciowinterscience.weebly.com

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Summary

There are important reasons for conducting winter over science in Antarctica. Top reason is the scientific understanding of environmental processes and the acquisition of complete (year round) baseline data used for detecting environmental changes, validation of remote sensing data, input for and validation of numerical modelling. Here the study of sea-ice break up or summer melt water runoff are only two of many examples of time critical research that needs to be conducted during a specific time of the year. A number of scientific research work is non-time critical and could, resources and weather permitting, be conducted during off-season or even winter months. In particular work such as for example mapping of internal layers and bed topography by over ice traversing, or ice coring in fixed camps would benefit from lower off season demand on resources (fall, Spring) and work during the colder winter months.

Limiting factors for conducting research activities and collecting data during off-season months are the harsher conditions of the Antarctic environment and their impact on humans as well as equipment (cold and wind). Accessibility to the Antarctic continent being in large limited to the Austral summer is another factor favouring summer science activities. With the increased use of aircrafts for accessing Antarctica, shorter deployments of even only a few days have become possible giving scientists the choice “to be home for Christmas”.

This is in contrast to large portion of work conducted during the majority of the 20th century. During these “earlier days” scientists wintered routinely together with service personnel and subsequently engaged into research activities year round. Advantages of off-season and wintering work can be summarized as avoiding the high demand on logistic resources during peak season and avoiding some of the negative environmental impacts (for example summer melt) during summer. Overall aside from its scientific value winter overing science could improve utilization of logistical resources, increase the return on investment and contribute to the strategic presence of Australia in Antarctica. Wintering science is also highly suitable for outreach activities connecting to the heroic ages and inspiring the next generation of researchers.

Current, past and potentially future winter-over science activities are diverse, ranging from simple automated small scale technical installations like automatic weather stations, tide gauge or GPS installations, via station based to human research activities like monitoring of penguin colonies, fast ice or atmospheric processes and the conduct of early/late season traverses , to the deployment of winter-over parties in deep field settings like the 1968 winter overing party on the Amery Ice Shelf,

which conducted from Feb 1968 to February 1969 a variety of glaciological work including the acquisition of an ice core.

Summary Reasons for Winter Over Science:

- Close Winter Science Gaps
- Improve Understanding Winter Science Processes
- Benefit of Accessibility to Certain Antarctic Environments
- Strategic Reasons
- Human and Logistical Resource Availability

Reasons for Winter Over Science

Several reasons for conducting science during the cold winter months were identified. The top most reason for conducting winter over science is a hiatus in scientific observations outside of the summer operation months and a lack of understanding seasonal changes and processes occurring in the Antarctic Fall, Winter and Spring. Aside from gaining better scientific understanding some environments like sea-ice/fast ice can either only be accessed or are safer to be accessed during the winter and off-season period.

In addition there are strategic reasons for increasing scientific activities during the Antarctic winter this include better utilization of national and international investments during the winter and off-season months. A large portion of our current Antarctic science operation is driven by the accessibility of the Antarctic continent by air and ship during the summer months. Since air links provide more rapid access to Antarctica wintering of science personnel has become the exception rather the rule. As a result of this accessibility the majority of work is conducted during summer despite a lot of work could also be conducted safely during the off-season. Increasing glaciological winter over science activities could benefit from lesser demand on logistical resources during late Fall, Winter and early Spring.

Winter Science Gaps
what can we measure in winter - what we can't in summer?

Time Critical Science Observations:

Observations during the winter months are critical for better understanding the Antarctic environment and developing baselines against we can measure change. Remote Sensing data can in part provide coverage of non-visible light dependent observations during the winter month and observations requiring visual light during off-season. Such data however still require validation by direct ground based observations as do models like Global Climate and Earth System Science models, which suffer from a general lack of observations in Antarctic. Areas of particular importance are across the various disciplines time series in meteorology, climate processes, mass balance, oceanography, ice ocean interactions and atmospheric sciences.

While annual repeat measurements provide a basic quantification of surface mass balance and annual mean velocities, understanding processes which lead to net accumulation or control of ice

dynamics require observations which cover the entire observation period in-between two point measurements.

Two brief examples of processes requiring higher temporal as well as spatial coverage are:
Surface net accumulation: Relationship between snow accumulation events and meteorological and climatic events, wind scouring and snow removal, sublimation processes through catabatic winds and winter warm events, snow metamorphism and firn densification processes, summer melt processes and the evolution of surface hydrological networks from summer to winter and the storage of liquid water beneath the glacier surface.
Ice dynamics: grounding zone processes like influence of ocean tides and seasonal change in sub-ice shelf processes on ice dynamics, impact of sub and supra glacial hydrology on ice sheet and glacier bed strength, basal sliding and glacier surges

Other time critical year round work includes for example fastice & sea-ice work, ice-ocean interactions, cyrosphere –ecosystem processes and atmospheric processes.

Opportunistic Winter-Over Work – Utilizing Off-Peak Season Resources

While some work requires specific timing within the year, work like mapping of internal ice sheet structure, subglacial topography, ocean bathymetry or the acquisition of multi-year ice cores can be conducted at any time of the year. In the earlier times of exploring the Antarctic continent, IGY, post IGY into the 1990th, such activities often commenced in early spring and were conducted into late fall utilizing the early and late season. In 1968 4 people wintered on the Amery Ice Shelf conducting various glaciological measurements and drilled an ice core. Aside from utilizing an extended season off-season work avoids the impact from summer melt on science and logistic operations.

- Opportunities for winter over science through collaboration with other national programs
  Access to specific locations for specific reasons

Type of Winter-Over Science

Winter Over Science work may be divided into two categories:

i) work requiring the presence of humans and
ii) work which can be conducted autonomously or with remote human intervention (e.g. satellite communication)

People based Winter-Over Science Work

People based winter-over science work is usually conducted around established stations with trips to nearby huts and shelters on mostly established. Work includes direct measurements of the environment by people, indirect through instrument deployment and instrument servicing on a scheduled or per need basis.

A portion of current work at Antarctic stations is work conducted as technical support of infrastructure, installation, maintenance, servicing of equipment and preparation for the upcoming summer season.

In previous decades traverse science was conducted and even parties wintered in the deep field.

The harsh Antarctic environment and reduced accessibility during Austral winter are most impacting working in Antarctica in winter. Of specific concern are the safety of humans working in the environment and a reduced and very limited Search And Rescue (SAR) capabilities in case of emergencies require additional contingency planning.

Other aspects of Antarctic winter over work are more of societal expectations, as there are:

- Expectations/choice of frequent visits, short-term deployments.
- Not as heroic/family commitments,
- Difficult to attract staff for longer term deployments
- Expectation for scientists to work in office/University job requirements => opportunity for early career scientists who may be more flexible
- Out of habit, loss of experience to do extensive winter field work
- Risk awareness and risk adverse, Operational Health Safety rules

In both the Australian and New Zealand Antarctic program scientific work is conducted during the dark winter month.
The New Zealand Antarctic Program has a dedicated winter over science team and Scott base has the advantage of being accessible from late August (WinFly) to late March. Pat Lanhorns sea-ice work is one of many examples . The Australian Antarctic Program also conducts significant winter over science work. In Glaciology work of the atmospheric group as well as fast-ice work are examples. A concern raised in regard to winter over sciences is that in order to provide most flexibility and accommodate as much science as possible work sometimes is accepted as discretionary and while providing and demonstrating great internal flexibility work may in this way also fall in between cracks.

Aspects which could be reviewed and improved:

- Improvement in Management of winter over science work and allocation of resources,
- Development of institutional and personal skills permitting individuals and an organisation to conduct more extensive winter over science campaigns,
- Development of risk management plans for equipment and humans

Modernisation planning of Antarctic infrastructure should also give consideration to improving winter-over science opportunities.

At the workshop a number of questions were raised:

How to access Australian Antarctic stations for winter-over science?

- Australia AAD position for technical support
- AAD winter over scientists?
- University based winter over science projects
- What determines numbers of beds on station in winter?
- How to access beds on station for winter over science?

Suitability of stations for winter over science?

- are our stations based at locations that a conducive for answering our scientific questions?

- Do we need winter over stations that are more flexible and can be moved to provide a hub, shelter, resource, access to the most suitable field location

General Examples of Winter-Over Science

- 1960's Mawson Ablation Stake network
- GPS, ice dynamic stake network
- New Zealand based McMurdo Sound Sea-ice work – win-fly
- Davis Station Fast-ice work,
- US extended season work in Dry Valleys
- Previous glaciology traverses which started early season after winter overing
- Davis station easier access to ice sheet or glacier environment travel over sea-ice.
- Remote deep field winter over work???
  1968 winter over on Amery Ice Shelf
- Automatic Weather Station network
- Amery Ice Shelf sub-ice ocean moorings
- Support/maintenance of high power equipment (GPS, Radar, DTS system…)
- UAV + AUV operation
- Year round borehole work on ice shelf
  - Water sampling, and time critical analysis
  - direct human interactive observations
  - ROV operations

Automated Winter-Over Science Work

Automated winter-over science work provides great opportunities to obtain scientific data reducing the environmental impact and risks to humans. Operation of automated science installations come with significant technical challenges:

- Power consumption
- Equipment robustness:
  - Temperature range
  - Wind loading
- Annual maintenance visit, logistical, burial,
- Risk management, redundancy …

Power consumption:

Solar power is abundant during the Austral summer from early Spring to late Fall. Wind is generally available during the winter months; however environmental impact of temperature and often the fierceness of the winter storms impacting the longevity of wind turbines as well as science installations in general. At the present, wind turbines in Antarctica have a life expectancy of 2 years, with one out of two instruments failing within the first winter season.

While solar energy is abundant in summer storage of this energy for consumption in winter is limited. Limitations are the capacity of battery storage as well the susceptibility of battery storage capacity to temperature. Battery storage is a large subject in other areas of our society. In particular energy storage from renewable power generation is a quickly developing subject (see for example http://www.australianenergystorage.com.au/). Improvements to the safety of lithium batteries as well as capacitors provide great potential. Fuel cells, hydrogen, methanol as well as ammonium based fuel cells also bear great potential to fill the winter power gap. One large problem with fuel cells however is the production of water vapour in a freezing environment, which without maintenance will shut down the fuel cell. This problem has been tackled by various and should be manageable in the future. Burial of power and electronic equipment in insulated boxes provides advantages in regard to the thermal exposure of equipment. A disadvantage is that recovery of the equipment requires significant work in particular in high accumulation areas. The rapid burial of equipment in high accumulation areas is a general problem for glaciological instrumentation. The deployment of equipment in insulated extendable pipes may be one solution, requiring further work and systematic development.

Close collaboration between industry developers and polar scientists could provide a win win situation in which polar scientists gain access to the state of the art technology and industry gains access to one of the most extreme environments for test purposes of their equipment.

Synergistic Activities Between Glaciology and Other Groups

- Ocean Observing Systems
- Terrestrial Near Shore Observing Community
- Bio-Cryosphere-Ocean linkages
- Ice- Atmosphere – Climate interactions

Appendix – Workshop Power Point Notes