

RECOMMENDATIONS FOR THE COLLECTION AND SYNTHESIS OF ANTARCTIC ICE SHEET MASS BALANCE DATA

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1. SURFACE MASS BALANCE RECOMMENDATIONS

- Continent-wide surface accumulation values at spatial (10 km) and multi-annual (5-20 yr) resolution are required through a variety of different approaches (e.g. traverse and airborne GPR and GPS “coffee can” surveys, firn cores, satellite-based remote sensing, numerical simulation, re-analysis of previous snow accumulation data). Data on the trend of snow accumulation at centennial scales (200-500 yr) at selected sites are required.
- To characterise spatial and temporal variability and covariance, comparisons are required over local (<10 km) and seasonal (<1 yr) scales at selected sites, of precipitation estimates from atmospheric models, field measurements (AWS + stake farms) and remote sensing observations.
- Field observations and modelling of atmosphere/cryosphere processes are required to estimate snow redistribution and export to the ocean, sublimation, densification, and metamorphism processes.

2. MASS OUTPUT (ICE DYNAMICS, FLUXES, MELT/FREEZE, CALVING) RECOMMENDATIONS

- Focused research is required on the large outlet glaciers draining West and East Antarctica and the Antarctic Peninsula, in particular the rapidly changing sectors of the Pine Island and Thwaites Glaciers, but also the David, Mertz, Totten, Lambert, Shirase and Jutulstraumen Glaciers. Specific requirements are for:
 - 1) Detailed measurements of ice thickness near the grounding zones, which have now been identified with InSAR.
 - 2) Observations of ice-shelf bottom melting, especially in the proximity of grounding zones, and investigations of whether basal melting may be changing with time in response to changes in ocean conditions.
 - 3) Measurements, using InSAR and ICESat, of changes in ice velocity and elevation of the glacier surface.

3. SURFACE ELEVATION CHANGE RECOMMENDATIONS

- There is a requirement for the separation of short-term (< 30 yr) vs long-term (> 30 yr) surface elevation change; this requires knowledge of firn compaction processes and the accumulation rate, or failing this, a statistical characterisation of its covariance function over the last 10 years and a knowledge of how that relates to the long-term trend.
- An understanding is required through field experiments, particularly in West Antarctica, of how much of the $\partial h / \partial t$ signal measured by satellite altimeters is related to the compaction of the firn, for annual and longer timescales.
- Determination is required, by a continuously occupied field experiment in central East Antarctica, of the extent to which the $\partial h / \partial t$ signal measured by radar

altimeters is affected by interactions of the microwave pulse with variations in the near surface layers.

- A very long term site is required in a region of ongoing surface elevation change, where firm conditions are reasonably typical, and where continuous measurements will allow the temporal variation to be examined on seasonal and longer time scales.

4. DEGLACIATION RECOMMENDATIONS

- Additional dated retreat sequences are required from the continental shelf, including sub-ice shelf regions, especially in areas exhibiting current rapid change. To improve dating more research is needed on the spatial and temporal variations of the radiocarbon reservoir in Antarctica. Surface exposure studies will provide important information on ice sheet history in subaerial regions where organic deposits are scarce or lacking. Further systematic deployment of radio-echo sounding is encouraged to obtain ice sheet layer architecture for understanding ice sheet history and constraining models of the evolution of the Antarctic Ice Sheet.
- Further collection of sea-level and crustal motion (primarily GPS) observations is encouraged, to better determine the Antarctic glacio-isostatic response. Glacio-isostatic modelling is needed to link the observations to ice sheet history and Earth rheology

5. ICE SHEET MODELLING RECOMMENDATIONS

- Inter-comparisons are required of existing models of Antarctica that focus on grounding line retreat. Investigations of stability issues are required by analytical techniques and by use of models with simplified boundary conditions. Development is required of models that can assimilate geological and dynamical data; and investigations are required that couple ice sheet models with high resolution atmosphere and ocean models.
- To substantially improve the physical basis of models of past and future deglaciation there is a requirement for (i) incorporation into the models of the effects of ice crystal anisotropy (ii) validation of geodynamical parameters, (iii) mapping of the basal interface character (warm/cold; till/rock; geothermal heat flux), (iv) use of natural high frequency forcing (e.g. tidal forcing of water pressure and ice motion) to test hypotheses about basal processes, (v) measurement of internal temperature fields using drill holes or remote probes, and (vi) continuing efforts in laboratory ice mechanics and geotechnical experiments at temperatures close to pressure melting point, and for ice containing substantial impurities.

6. SPECIAL AREAS RECOMMENDATIONS

- A programme of field work is required in the part of the West Antarctic Ice Sheet draining into the Amundsen Sea. Over the ice sheet this fieldwork must include measurement of fluctuations in recent accumulation rates, measurement of ice thickness and a characterisation of sub-glacial conditions and ice flow velocities.

In addition, detailed observations of ocean circulation and physical characteristics beneath the floating glacier tongues are needed.

- Field monitoring is required of climate, ice caps, glaciers and ice shelves, and an investigation is especially required of the grounded glaciers and ice caps affected by loss of ice shelves in the Antarctic Peninsula. We recommend continued monitoring by remote sensing and the initiation of modelling studies at a variety of spatial scales.
- Ice cores covering late-glacial to decadal time-scales are required from Antarctica, particularly from coastal sites. These will provide Holocene histories of accumulation rates, constraints on deglaciation, and an envelope for future variability of accumulation and dynamic changes in these sensitive areas.

7. CONCLUDING RECOMMENDATION

- We recommend increased synthesis of data and communication between the field, satellite observation and modelling groups.