Break-Out Group 2:
Ice Sheets: Antarctica -- Observations and Projections of Changes

Chair: Bob Bindschadler
Rapporteur: Andrew Shepherd

❖ Framing statement:

The future Antarctic contribution to sea level rise is likely to be complex to determine. The mass balance of the grounded ice sheet will vary regionally, changes in ice mass will be driven by changing precipitation, changing ocean temperature and circulation; potentially through ongoing responses to natural climate change in the distant past; and in a few regions, by changing atmospheric temperature. The possibility of magnified dynamic responses in the grounded ice resulting from the removal of ice shelves appears is also widely-discussed.

Six questions were addressed in this BOG. A summary of the discussion follows each question.

❖ To what accuracy do we know the current rate that the Antarctic ice sheet is losing mass and contributing to sea level rise? How can we reduce the uncertainty? Does the current set of committed satellite missions represent a sufficient monitoring capability?

Three independent methods have been applied to determine the mass balance of the Antarctic ice sheet: mass change (from GRACE); elevation change (from radar and laser altimetry); and volume flux (from InSAR and meteorological models). The aggregate view arising from numerous applications of these methods has revealed a pattern of increasingly negative mass balance (as in Greenland), but each method has weaknesses and intercomparisons suggest that errors of individual analyses may be underestimated. The BOG agreed to recommend to IPCC that a careful intercomparison of the analyses from each method for comparable spatial and temporal domains be conducted to strengthen each of the analyses and produce a consistent set of mass balance results with smaller uncertainties. Reduced errors would also improve the uncertainties in projections of future mass balance based on extrapolations based on the observational period.

Ancillary data, specifically ice thickness and bedrock elevation especially in coastal areas, GIA in areas experiencing rapid uplift, and surface mass balance observations in the broad regions presently devoid of surface meteorological data, would make significant improvements to knowledge of current mass balance. An additional key diagnostic of change would be grounding line migration, presently unavailable from current satellite sensors (ESA is considering moving ERS2 into a 3-day repeat orbit which would allow the first measurement of many grounding line positions since late 1990's; IPCC could consider supporting that initiative.

The record of the past 200 years of Antarctic climate collected by the ITASE program should be able to assist in quantifying the temporal variability of the SMB. "accumulation radar" data proved extremely useful in addressing this same issue and the introduction of an airborne accumulation radar could rapidly expand the spatial extent of these in data.

Satellite-based observations have been crucial in the application of three, but few of the most important sensors continue to operate. CRYOSat-2 is new but could bridge the gap between ICESat elevation data. There is currently no InSAR capability to monitor ice velocity and grounding line (see note on ESA above) and a GRACE follow-on mission is still unfunded.

Thus, at precisely the time when satellite data could prove most useful for observing the pace of ice sheet change, the suite of existing and committed satellite sensors is limited.

❖ What are the key uncertainties in predicting the change in mass of the Antarctic ice sheet over the 100-year timescale? Over what time period could an extrapolation of the current rate of mass change (if it were precisely known) be a useful tool for projection of decadal to century change?

In terms of the ability to predict the future of the ice sheet, the primary obstacle is the poor understanding of critical processes that are causing current changes, primarily the nature of ocean-ice interaction and the ice sheet response to grounding line retreat. Knowledge of coastal bed geometry and bathymetry were identified again as significant gaps. Scenarios for estimating upper/lower confidence limits of future ice mass loss may be more useful than projections, which are likely to be tricky. Progress in this area is likely to be slow as it requires considerable field work and sustained data collection, much of which has either not yet begun or is in a very early stage.

In light of the rather immature state of predictive capability, extrapolation was discussed at some length. A general sense emerged that extrapolation should not extend over a time interval greater than the time interval of observations being extrapolated. Extrapolations of linear trends have more confidence than extrapolations of higher order fits, but no additional guidance was agreed on. It was apparent that extrapolations would be improved by reducing the uncertainty of the base observations—thus, the BOG recommendation that the multiple estimates of current mass balance be reconciled to an optimum collective.

❖ Is the thinning or loss of ice shelves likely to have an imminent or long-term impact on the mass-balance of the Antarctic ice sheet? What improvements need to be made to ice sheet dynamical models in order to predict the response?

It was universally acknowledged that ice shelves are a crucial element in the dynamic contribution to present and future ice sheet mass balance. That said, there are large voids in understanding the processes of ocean-ice shelf interaction and the nature of the basal traction inland of the grounding line, as illustrated by the divergent responses of Pine Island Glacier which is retreating and accelerating in response to ice shelf thinning, and Thwaites Glaciers which is maintaining its speed while widening. There is an expectation that the bulk of work necessary for improving the treatment of ocean-ice interaction lies within the oceanographic community through the development of ocean circulation treatments for the continental shelf areas to capture the introduction of CDW from the deep ocean onto the shelf and follow its motion once there. It was suggested that oceanographers may not find this problem sufficiently exciting to put much effort into solving it. An even broader view was offered that connections must also be built between the larger, more distant climate components and the ice shelves. This led nicely to discussion of the next question.

❖ The recent strengthening of the westerly winds around Antarctica apparently had major impacts of near coastal water temperatures along the Antarctic Peninsula. What are the predictive capabilities of ocean temperature and circulation in a warming climate and how would they impact ice shelf stabilities and ice flow rates?

Pathways for such teleconnections are not well known and there is a low expectation that these links will be addressed in the short term despite the fact that AOGCMs are known to perform poorly in key regions for the ice sheet, e.g., Amundsen Sea. It was stated by some participants in the BOG that effort in the AOGCM community is directed more to simulate climate under AR5 scenarios and not to improve ice sheet coupling or skill of models in the vicinity of ice sheets. Ice2Sea was mentioned specifically as the only known integrated effort to couple the AR5 scenarios to ice sheet evolution.

❖ Estimates of surface mass balance in Antarctica are poorly constrained; how can we reduce the uncertainty in accumulation rates and the predictive capability in a warming climate?

Recently reported work casts doubt on the ability of surface mass balance models to adequately account for mass loss by blowing snow along much of the Antarctic coasts, but the dearth of data in the interior leaves uncertain the veracity of these models over much of the continent. Agreement with data has limited impact when there validating data are extremely sparse or were used in assimilation schemes and, thus, indirectly introduced into the model. The acknowledged need for well distributed observations of precipitation, water vapor and wind to improve this situation is unlikely to improve in the short term. An alternate view was offered that ice dynamic changes will dominate future significant Antarctic contributions to sea level relegating surface mass balance changes to a relatively minor role. Countering this dismissive view was the recognition that an incorrect surface mass balance leads to errors in AOGCMs through the temperature and water vapor fields, that without better validation data, the surface mass balance models will not be improved and that surface mass balance rates are often 100 times larger within the all-important coastal regions as compared with the drier interior.

❖ What can we say about the next 1000 years for the ice sheet?

In a very real sense, predictions on the 1000-year timescale are likely to be more tractable than the 100-year timescale. In a general sense, the Antarctic ice sheet will likely be smaller with losses concentrated in the areas of fastest outflow. Central East Antarctica might grow, but more than compensated by loss at the margins. West Antarctica will lose more mass that East Antarctica. Peninsula shelves will continue to erode/disintegrate with corresponding loss of mass from Peninsula glaciers. It was offered that the stated interest in the 1000-year timescale might be a legacy from earlier IPCC reports when it was not thought the ice sheets could change markedly on a centennial timescale. Nevertheless, the millennial timescale is relevant to the mitigative policy deliberations, including ethical considerations.