A Science Management Office for the United States Component of the International Trans Antarctic Expedition (US ITASE SMO) – A Collaborative Program of Research from Taylor Dome to South Pole

Duration: March 2005 – February 2008

Principle Investigators: P.A. Mayewski and G. S. Hamilton

PROJECT SUMMARY

This proposal is the lead proposal for a series of collaborative science proposals that are all related to US ITASE. It includes a description of the basic objectives, science administration, and logistics for several science proposals that will be submitted to OPP as part of US ITASE. For detailed information concerning these individual science research proposals reviewers are requested to examine the actual science proposals.

This proposal requests support from the Office of Polar Programs for:

(1) A continuation of the highly successful US ITASE field operation platform during the 2005-2006 and 2006-2007 field seasons so that US ITASE can undertake a series of scientific objectives in the region from Taylor Dome to South Pole (NVL-SP). These new activities, in combination with 1999-2003 US ITASE activities, and in cooperation with activities conducted by Italian, French, and Australian ITASE traverses, will provide US ITASE scientific coverage for the entire Ross Sea Embayment and portions of Wilkes Land.

(2) A continuation of the US ITASE SMO (one 33% time staff position plus limited hourly support) for purposes of assisting in the planning, organization of science and logistics, and organization of final products resulting from the proposed 2005-2007 activities.

(3) Traverse route selection utilizing satellite imagery, included in the West Antarctic US ITASE traverses as a separate proposal to G.S. Hamilton, and now included as part of US ITASE SMO (1 month for GSH plus 3 months for a graduate student).

(4) Operational crevasse detection using ground penetrating radar during field activities. This function was provided by S.A. Arcone under separate funding, during the West Antarctic phase of US ITASE operations, but is now included in this proposal because it is required by several of the US ITASE research components.

Intellectual Merit: US ITASE is the terrestrial equivalent of a polar research vessel. It offers the ground-based opportunities of traditional style oversnow travel coupled with the modern technology of GPS navigation, crevasse detecting radar, satellite communications, and multi-disciplinary research. By operating as a ground-based transport system US ITASE offers scientists the opportunity to experience the dynamic environment they are studying. US ITASE also provides a stimulating interactive venue for research similar to that afforded by oceanographic research vessels and large polar field camps, without the cost of the former or the lack of mobility of the latter. More importantly the combination of disciplines represented by US ITASE provides a unique, logistically efficient, multi-dimensional (x, y, z and time) view of the atmosphere, the ice sheet and their histories. US ITASE SMO activities in West Antarctica included the successful integration of 11 science programs. The US ITASE traverse team reached South Pole Station at the end of the 2002-2003 field season, concluding SMO operation and field activities for the initial four season sampling of West Antarctica.

Broader Impacts: ITASE has as its primary objective the understanding of Antarctic climate (e.g., accumulation rate, air temperature, atmospheric circulation), and environmental (eg., sea ice extent, atmospheric chemistry) variability over the last 200 years, and where possible longer. US ITASE goals include the ITASE primary objective (although typically records in the 200-1000 year and longer range are collected). In addition, US ITASE scientific objectives include those from a variety of additional disciplines, because the US ITASE logistics platform is designed to accommodate interactive research programs such as: meteorology, remote sensing, surface glaciology, geophysics, ice core glaciology, dynamical glaciology, atmospheric chemistry, and glacial geology. Data collected by US ITASE and its international ITASE partners is available to a broad scientific community. US ITASE has an extensive program of public outreach and provides significant opportunities for many students to experience multi-disciplinary Antarctic research.

C.1 RESULTS FROM THE MOST RELEVANT NSF AWARDS

NSF-0096338 – Science Management for the US Contribution to the International Trans Antarctic Scientific Expedition (1998-2003) P.A. Mayewski
This proposal presented the primary objectives, rationale and organization for US ITASE activities in West Antarctica. 11 scientific projects were organized under this structure. In addition US ITASE SMO coordinated workshops, data collection, and outreach activities (in concert with the Museum of Science – Boston). More than 150 scientific products (abstracts, papers, and reports) have resulted thus far from US ITASE research (for details see www.ume.maine.edu/USITASE).
NSF-0096299 – ITASE Glaciochemistry (1999-2004) P.A. Mayewski and L.D. Meeker
This project focused on the analysis of major ions recovered from firn/ ice cores collected on US ITASE traverses through West Antarctica. Glaciochemical series covering 200-1000+ years provide proxy records of atmospheric circulation and chemical species source strength. To date 33 peer-reviewed papers have been published or are in review from this work (for detailed citations please see NSF Fastlane for this project). Two MSc theses and part of a PhD (not yet complete) have resulted from this work.
OPP-0196441 – ITASE Mass Balance and Accumulation Rates (1999-2004) G.S. Hamilton
The objectives of this project are to understand spatial differences in the rate of ice sheet thickness changes in West Antarctica and to determine the magnitude and causes of spatial variations in snow accumulation rate. During four field seasons, 16 mass balance marker sites were installed and resurveyed, numerous shallow cores were collected, and ~5000 km of continuous high-precision elevation profiles were surveyed simultaneously with ground penetrating radar stratigraphy. Results from the mass balance marker sites indicate that large portions of the interior West Antarctic Ice Sheet are close to steady state, with no large ongoing changes in ice thickness. Sites that are close the regions of enhanced flow show ongoing thinning of about a decimeter per year. Accumulation rates are found to be highly variable over short spatial scales. Causes of the variability are tied mainly to local surface topography. The effect of this variability on mass balance calculations was investigated. Four papers were published or are in press in peer-reviewed journals; several other manuscripts are in preparation. The data provided the basis for on PhD thesis examining spatial gradients in accumulation rate (Blue Spikes, PhD awarded December 2003).

C.2 PROJECT DESCRIPTION

Background for this Proposal

The International Trans Antarctic Scientific Expedition (ITASE) is a multi-national, multi-disciplinary field research program with the broad aim of understanding the recent environmental history of Antarctica (Mayewski and Goodwin, 1997; see ITASE Science and Implementation Plan http://www.ume.maine.edu/USITASE/html/main_contents.html). Primary emphasis is placed on the last ~200 years of the record although US ITASE typically samples significantly longer periods that include the classic period of the Little Ice Age into the Medieval Warm Period. A minimum of the last 200 years was selected because it covers the onset of major anthropogenic involvement in the atmosphere and the end of the Little Ice Age. Further, the Tambora volcanic eruption (AD1815) provides an excellent stratigraphic marker for age calibration of 200-year records. In addition, overland snow traverse programs can logistically handle the collection and transport of several 200-year long ice cores.

Participants at a workshop held in Baltimore (May, 1996) agreed (see US science and Implementation Plan http://www.ume.maine.edu/USITASE/html/main_contents.html) that the US contribution to the International Trans Antarctic Scientific Expedition (US ITASE) would be comprised of individual science proposals that would each compete on their own merit. The same format is being utilized for this current round of US ITASE proposals. It was also decided that a lead proposal should be submitted to the Office of Polar Programs to assist in planning and organization of US ITASE activities. That proposal was successful and funds for the US ITASE

Science Management Office (SMO) (1998-2003) supported the PI (P.A. Mayewski, no salary) and a part-time staff member (4 months/year) to assist in communication, coordination and outreach, and student participation in field activities. Funds also supported domestic and foreign travel, and office supplies.

US ITASE SMO successfully organized 11 science programs and logistics for all four OPP supported field seasons. The US ITASE traverse team reached South Pole Station at the end of the 2002-2003 field season, concluding SMO operation and field activities for the initial four season sampling of West Antarctica.

This proposal requests support from the Office of Polar Programs for a US ITASE SMO in support of US ITASE activities in East Antarctica to include:

(1) A continuation of the highly successful, logistically efficient, multi-disciplinary US ITASE field operation style used during the 2005-2006 and 2006-2007 field seasons so that US ITASE can undertake a series of scientific objectives in the region from Taylor Dome to South Pole (TD-SP). The expansion of US ITASE activities into East Antarctica is based upon:
   - (a) extensive discussions among current US ITASE investigators that formulated the logistics and scientific objectives stated in this proposal
   - (b) announcements of opportunities and solicitation of other investigators via email messages distributed by the Ice Core Working Group, US ITASE SMO, and US ITASE investigators to colleagues in the scientific community
   - (c) presentation of the plan for an East Antarctic extension of US ITASE to the Ice Core Working Group and a special Ice Core Research meeting held in Washington, DC (April, 2002), and at a specially convened US ITASE community workshop during the Fall AGU meeting in San Francisco (December, 2003)
   - (d) continuous information access concerning past, present, and future activities through websites such as: US ITASE (www.ume.maine.edu/USITASE) maintained and operated by the Climate Change Institute (CCI), University of Maine, and www.secretsoftheice.org developed and hosted by US ITASE's outreach partner, the Museum of Science (MOS), Boston and developed through cooperation between CCI, MOS, and when P.A. Mayewski was at the University of New Hampshire, the Climate Change Research Center
   - (e) collaboration developed by the ITASE Steering Committee (P.A. Mayewski, Chair) between the 20 nations involved in ITASE under the auspices of the Scientific Committee for Antarctic Research (SCAR) and the International Geosphere Biosphere Program (IGBP) at several ITASE meetings – most recently in Durham, NH (1999), Potsdam, Germany (2002), Milan, Italy (2003) and soon to be in Bremen (2004)
   - (f) support expressed at several public meetings and in discussion by ITASE national representatives that are working geographically in closest to the proposed US ITASE activities (Dr. Massimo Frezzotti, Centro Ricerche Casaccia (Rome, Italy), Dr. Michel Fily, Laboratoire de Glaciologie et Geophysique de l'Environnement (Grenoble, France), and Dr. Ian Goodwin, University of Newcastle, Callaghan, NSW, Australia)

(2) A continuation of the US ITASE SMO (4 mos./yr staff position plus limited hourly support) for purposes of assisting in the planning, organization of science and logistics, and organization of final products resulting from the original 1999-2003 US ITASE activities in West Antarctica in combination with the proposed US ITASE 2003-2005 activities.

(3) Traverse route selection utilizing satellite imagery, included in the West Antarctic US ITASE traverses as a separate proposal to G.S. Hamilton, and now included as part of US ITASE SMO (1 mo. for GSH plus 3 mos, graduate student),

Continuing support of US ITASE activities during the 2005-2007 field seasons is requested for several reasons:

(1) US ITASE combines in one field program a variety of disciples (meteorology, remote sensing, geophysics, surface glaciology, ice core glaciology, atmospheric chemistry and potentially others) that would not necessarily interact together. The

scientific products developed from this association are more robust because of this association.

(2) As will be demonstrated in this proposal the scientific objectives for US ITASE in East Antarctica are of significant scientific importance.

(3) US ITASE has demonstrated that it is a logistically efficient program that requires significantly fewer resources than would be required if the 11 science activities involved in US ITASE in West Antarctica were treated as individual projects.

If this proposal is supported US ITASE SMO would assist in the planning and organization of logistics and science for NSF OPP selected projects, as was done for US ITASE 1999-2003.

Introduction - Antarctica's Role in Global Change

The Antarctic ice sheet plays a significant role in the global system. Encircled by the world's most biologically productive oceans, Antarctica is the largest reservoir of fresh water on the planet, a major site for the production of the cold deep water that drives ocean circulation, a major player in Earth's albedo dynamics, and an important driving component for atmospheric circulation. Thus, Antarctica plays a critical role in the dynamic linkages that couple the spatially and temporally complex components of the Earth's system (atmosphere, biosphere, anthrosphere, hydrosphere, cryosphere and lithosphere). While the existence of a complex global climate system is now recognized, the details of its functioning are still poorly understood. In the Northern Hemisphere and portions of the Southern Hemisphere, direct observational and instrumental records exist only for the last ~2000 and ~100 years, respectively, and, except at isolated sites, observational and instrumental records in Antarctica cover only the last 30-40 years.

Spatial Complexity - Antarctica exhibits significant regional contrasts in present-day climate regime (accumulation rate, temperature, atmospheric circulation). Large areas of the interior of the ice sheet are influenced by the continental temperature inversion, while other portions of the interior and the coastal regions are influenced by cyclonic systems circulating around the continent. As a consequence, these peripheral areas are mainly connected with lower tropospheric transport, whereas high altitude areas in the interior are more likely influenced by vertical transport from the upper troposphere and stratosphere.

A recent example of spatial complexity is a slight cooling of the entire Antarctic ice sheet, as observed from *in situ* and satellite temperature measurements during the period 1979-1998 (Comiso, 2000). Over the same period, the Antarctic Peninsula has experienced a gradual warming (Jacobs and Comiso, 1997). Both changes are linked to variations in sea ice extent. Alternating warm and cold anomalies in the sea ice region surrounding the continent may be related to eastward propagating temperature patterns consistent with effects of the Antarctic Circumpolar Wave reported by White and Peterson (1996). As suggested by Comiso (2000) the explanation behind the variability in sea ice and temperature requires longer time series.

Ice core records further illustrate the spatial complexity of climate over the past few centuries. Surveys of the distribution of glaciochemical proxies for atmospheric circulation reveal changes in atmospheric circulation influence as a function of distance inland from the coast, and elevation (e.g., Kreutz and Mayewski, 1999). Variability in accumulation rate on scales of tens of meters to many kilometers and complexities in accumulation rate distribution have been demonstrated to result from changes in topography (e.g., Whillans, 1975) and the interaction of several moisture-bearing circulation systems (e.g., Reusch et al., 1999).

Temporal Complexity - Deep ice coring programs in central Greenland (GISP2 and GRIP), East Antarctica (Taylor Dome), and West Antarctica (Siple Dome) demonstrate that the polar regions have experienced large, rapid, climate oscillations, on a scale that industrial age humans have not yet faced (e.g., Alley et al., 1993; Mayewski et al, 1993). These changes include temperature increases of many ^{o}C, twofold changes in snow accumulation, order-of-magnitude changes in wind-blown dust and sea-salt loading in the atmosphere and large changes in methane concentration. Changes during these events, equal to most of the glacial-interglacial difference, commonly occurred over decades or less. These abrupt changes in climate have not been restricted to the Holocene. While significantly more subdued in the Holocene they have still been sufficient to cause major disruptions to civilizations and ecosystems (Mayewski et al., in press 2004a, b). Several of these Holocene climate events may be synchronous from the Arctic to the Antarctic (Domack and Mayewski, 1999), and the most recent of these events, the Little Ice Age, appears prominently in many of these records, notably the Antarctic (e.g., Kreutz et al., 1997).

High frequency complexity in Antarctic climate is also manifested through inter-annual variability in synoptic systems such as the global scale El Nino Southern Oscillation (ENSO). Regional scale factors such as the Amundsen Sea Low and East Antarctic High (Kreutz et al., 2000; Souney et al., 2002) also have an effect, as do atmospheric blocking and sea ice variations (White and Peterson, 1996; Cullather et al., 1996).

Anthropogenic Impact - The influence of human activity on climate and atmospheric composition over Antarctica has already had profound effects. Unexpectedly, the continent has been subjected to massive ozone depletion as a consequence of its unique setting in relationship to global circulation systems and the introduction of humanly engineered CFCs that are able to destroy ozone. Recent changes in Antarctic snow accumulation and sea ice extent have been linked, in principle, to greenhouse gas warming (Morgan et al., 1991; Thompson et al., 1994; Vaughan and Doake, 1996). Human source nuclear fallout from bomb tests and the Chernobyl nuclear accident (Dibb et al., 1990) demonstrate the potential for the introduction of a variety of anthropogenic source pollutants to the continent.

Ice Dynamics and the Climate/Sea Level Connection - Antarctica's role in global climate is largely propagated through changes in its ice cover. The scale of this connection ranges from seasonal changes in sea ice extent that cause changes in albedo, atmospheric circulation, ocean productivity, and ocean circulation to potentially massive changes in sea level triggered by collapse of portions of the Antarctic ice sheet. Much of the ice in West Antarctica and portions of coastal East Antarctica is grounded below sea level, and is therefore inherently unstable. Geologic evidence affirms the potential for catastrophic disappearance of such marine-grounded ice sheets in the Northern Hemisphere. The potential exists for future ice sheet collapse in response to humanly forced changes in climate. There is sufficient marine-grounded ice in the region of particularly West Antarctica to raise sea level several meters, and immense potential for dramatic influences in the production of Antarctic bottom water as a consequence of changes in both West and coastal East Antarctica. Precise measurements of these changes are now becoming available (e.g. Wingham et al., 1998; Hamilton et al., 1998) but they are of limited distribution, require careful interpretation, and exhibit spatial variability.

Assessing Climate Change in Antarctica Through ITASE – The Role of ITASE in IGBP and SCAR

ITASE evolved from discussions between representatives from several national ice coring programs during a meeting hosted by the European Science Foundation in Grenoble, France in 1990. Twelve nations formulated the original concept (Australia, Canada, China, France, Italy, Germany, Japan, Russia, Sweden, Switzerland, the United Kingdom and the United States). Scientists from Belgium, Brazil, Chile, India, Korea, New Zealand and Norway have since joined the program. Since the initiation of ITASE, several international workshops have been held for purposes of organization and data interpretation. One of these workshops led to the development of an international Science and Implementation Plan for ITASE (Mayewski and Goodwin, 1997, see http://www.ume.maine.edu/USITASE/html/main_contents.html). Other workshops have taken place in Durham, New Hampshire (March 1999), Potsdam, Germany (September 2002) and Milan, Italy (August 2003). These workshops, sponsored by SCAR and IGBP, have provided important venues for data sharing, concept development, and coordinated logistics planning.

ITASE was formally accepted in 1991 by the Scientific Committee on Antarctic Research (SCAR) as one of its primary initiatives, GLOCHANT (Global Change in Antarctica). As a consequence of the reorganization of SCAR in 2001, ITASE is now officially a Scientific

Programme Group. It was adopted as an IGBP (International Geosphere-Biosphere Program) PAGES (Past Global Changes) Project in 1993 under PAGES Focus II. The first SCAR sponsored ITASE Project Office was housed at the University of Tasmania, Australia (I. Goodwin, Director). As of 2001 the SCAR ITASE Project Office moved to the University of Maine.

US ITASE

US involvement in ITASE is consistent with priorities established in numerous national and international science plans (e.g., Ice Core Working Group, 1989; Polar Research Board, 1986; WAIS, 1995; IGBP, 1990, National Academy Pathways (eg., Mayewski and Barron, 2000), Future of Ice Cores Meeting 2002). In addition, it is consistent with the objectives established in NSF's "Supplemental Environmental Impact Statement for the United States Antarctic Program" (SEIPS, 1990), since US ITASE provides an environmental (climate, snow, ice and atmospheric chemistry) framework from which to assess change. Further, the aims of ITASE closely parallel the objectives of NSF's Global Change Research Program, which emphasizes the need for the collection of paleoclimate records, understanding ocean-atmosphere-land-ice interactions, and scaling of dynamic behavior and biogeochemical cycling.

Over the course of a two-day workshop (Baltimore, May 1996) 37 participants formulated the focus for US ITASE (US ITASE Science and Implementation Plan, 1996) in the context of both ITASE and major US research interests such as the West Antarctic Ice Sheet Initiative (WAIS, 1995). Five major research disciplines were represented: meteorology, remote sensing, ice coring, surface glaciology and geophysics. Atmospheric chemistry has since been added. Summaries describing the state-of-the-art of these disciplines in the context of US ITASE are described in detail in US ITASE (1996, http://www.ume.maine.edu/USITASE/html/Abstracts.html).

The concept favored both by the scientists and by the NSF delegation attending the meeting was to keep the logistical impact and the science budgetary impact modest by spreading research over a number of years while maintaining a strong focus on goals and interdisciplinary coordination. In this sense, US ITASE provides a level of coordination and collaboration among several projects that can all potentially contribute to each other's scientific goals. An excellent example is the synergy between GPS activities conducted by G.S. Hamilton and shallow radar profiling conducted by S.A. Arcone on West Antarctic US ITASE traverses. Projects such as these provide information not usually available in single discipline projects. US ITASE acts as "scientific glue" allowing all US ITASE projects to fulfill their scientific goals more efficiently and robustly than if they were supported as individual efforts.

US ITASE research projects complement and support each other to produce a spatial and temporal understanding of climate, environment and ice sheet behavior. At the Baltimore meeting a mechanism for this process was developed that includes a four-phase approach (traverse planning, traverse sampling, reoccupation of selected sites, interpretation and modeling). This approach links modern meteorological and remote sensing studies to ground-based sampling (ice cores, radar, surface sampling, atmospheric sampling); continued monitoring (meteorology and ice dynamics); and interpretation and modeling.

Four traverse routes were selected at the US ITASE Baltimore meeting in order to satisfy US ITASE objectives in West Antarctica and to provide the necessary spatial sampling of West Antarctica (Figure 1). Route selection and site mapping was conducted by G.S. Hamilton under a separate award in cooperation with the US ITASE SMO and US ITASE researchers. (These activities are combined in the current proposal.)

We expect to follow a similar model, if this proposal is successful. Researchers selected through OPP peer review to be involved in the proposed traverses, will meet at the scheduled annual US ITASE meeting (usually coincident with US ITASE presentations at AGU) to develop details of traverse routes and science. They will, as in past years, also have discussed this route and logistics in detail prior to submission of the Support Information Package (SIP) to Raytheon and OPP.

A preliminary draft traverse plan, developed by several current US ITASE investigators is presented in this proposal (Figure 1). The proposed route is similar to that followed by the British Commonwealth Trans Antarctic Expedition (1958) from South Pole to Southern Victoria Land. In its current configuration the traverse route contains several side traverses perpendicular to the main route (satellite traverses). The satellite traverses allow the examination of atmosphere and ice gradients along and up flowline from several major outlet glaciers draining the Transantarctic Mountains. We expect that the final traverse route will be modified slightly to accommodate the scientific goals of successfully funded projects.

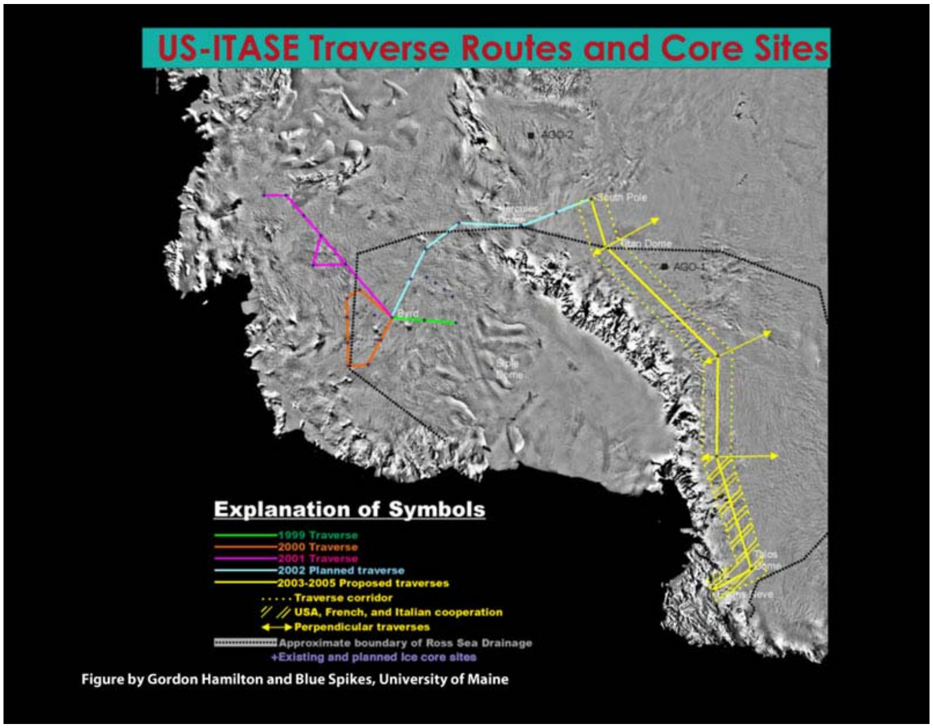

Figure 1. AVHRR mosaic of the Ross Sea sector of Antarctica showing traverse routes for the West Antarctic phase of US ITASE and the proposed route for the Taylor Dome to South Pole phase. Note satellite traverse routes and regions of research by Italian and French ITASE teams that will be integrated with US and Australian ITASE activities to produce a south to north examination of the region inland of the Transantarctic Mountains and Wilkes Land (Wilkes Land not entirely shown on this figure).

US ITASE science activities in West Antarctica (1999-2003) comprised 11 funded research programs (Table 1 – Currently funded US ITASE research programs) *denotes expressed interest in 2005-2007 activities.

Investigators	Institution	Discipline
Mary Albert *	CRREL	Snow and firn microstructure
Steve Arcone *	CRREL	High resolution radar profiling
Roger Bales *	Arizona	Hydrogen peroxide, formaldehyde
David Bromwich *	Ohio State	Meteorology
Gordon Hamilton *	Maine	Satellite image analysis
Gordon Hamilton *	Maine	Mass balance, accumulation rates
Bob Jacobel *	St Olaf	Deep radar

Paul Mayewski * Dave Meeker	Maine UNH/Maine	Glaciochemistry
Joe McConnell *	DRI	Trifluoroacetate
Deb Meese Tony Gow*	CRREL	Stratigraphy
Eric Steig * Jim White * Chris Shuman *	Washington Colorado NASA	Stable isotopes

INTELLECTUAL MERIT

US ITASE Scientific Contributions

A listing of scientific products (abstracts, papers, reports) produced by research teams involved in ITASE and US ITASE is available at (see “Toward a high resolution Southern Hemisphere Climate Reconstruction: Mapping the Antarctic ice sheet in space and time” by Members of US ITASE at http://www.ume.maine.edu/USITASE/Publications/hirespaper03/page1.html and summary Mayewski, 2003). Among the scientific accomplishments of US ITASE are:

(1) high resolution detailing of surface and deep radar reflectors as continuous time stratigraphic horizons across the thousands of km of traverse route (Arcone et al., in press 2004; Spikes et al., in press 2004)

(2) ice core calibration of radar reflectors in the upper 100 meters of the ice sheet to determine the source of these relectors (Arcone et al., in press 2004)

(3) mapping of spatial and temporal variability in accumulation rates over large distances using ground penetrating radar, and investigating the causes of these variations (Spikes et al., in press 2004; Hamilton, in press)

(4) examination of physical causes of radar backscatter variations in RADARSAT imagery (Stearns et al., in press) and other remote sensing validation work (Shuman and Comiso, 2001; Hamilton and Spikes, in press)

(5) examination of spatial variability in major ions over west Antarctica and relationship to sources (Kreutz and Mayewski, 1999; Kreutz et al., 1999, 2000; Dixon et al., in press 2004; Isaksson et al., 2001; Kaspari et al., in press 2004)

(6) ice core reconstructions of seasonal, inter-annual and decadal scale variability in accumulation rate, temperature, atmospheric circulation, volcanic activity, and sea ice extent and relation to models (Kreutz and Mayewski, 1999; Reusch et al., 1999; Qin et al., 2000; Guo et al., in review; Guo et al., 2002; Meese and Gow, 2002; Meyerson et al., in review; Isaksson et al., 2001; Souney et al., 2002; Palmer et al., 2001; Bertler et al., in press 2004; Dixon et al., in press 2004)

(7) identification of ENSO, ACW (Antarctic circumpolar Wave), PDO (Pacific Decadal Oscillation), EAH (East Antarctic High), and ASL (Amundsen Sea Low) atmospheric circulation structure in glaciochemical time-series and implications and relationship to models (Kreutz et al., 2000; Mayewski and White, 2002; Meyerson et al., 2002, in review; Bromwich et al., 1999, 2003; Mayewski et al., 2001, in press 2004c; Souney et al., 2002; Goodwin et al., 2004)

(8) assessment of modern global climate change (short-term variability in snowfall, temperature, and atmospheric circulation, pollution) in the context of decadal to centennial-scale variability (Reusch et al., 1999; Qin et al., 1999; Hamilton, in press; SCAR ISMASS Committee (including Hamilton), in press; Meese and Gow, 2002)

(9) deconvolution of local-scale variability in ice core-derived accumulation rate compared to regional scale variability (Hamilton, in press; Spikes et al., in press 2004)
(10) glaciological reconnaissance for deep drilling (Hamilton et al., to be submitted; Frey et al., 2002)
(11) high resolution mapping of subglacial topography in previously unexplored regions (Welch and Jacobel, 2001, 2002)
(12) characterization of ice flow dynamics based on deformation of internal stratigraphy, basal and ice surface topography (Hamilton and Spikes, in press; Welch and Jacobel, 2001, 2002)
(13) characterization of basal reflectivity based on changes in basal temperature and/or geology (Welch and Jacobel, 2001, 2002)
(14) identification of zones of basal melting in the interior of West Antarctica and ice stream shear along the coast utilizing satellite-derived (GPS) ice flow measurements (Hamilton and Whillans, to be submitted)
(15) air sampling in the interior of West Antarctica and air snow processes (Frey et al., 2001, 2002; Albert and Leeman, 2002)
(16) snow and firn permeability and microstructure measurements at locations with greatly differing accumulation rates and average temperature (Albert, 2001, 2002; Albert and Leeman, 2002, in prep.)
(17) physical property measurements of annual layer stratigraphy, depth/density profiles and crystal growth profiles as a function of age and in situ temperature in snowpits and ice cores (Gow and Meese, 2002)

US ITASE Technical and Logistical Accomplishments (1999-2003))

With the completion of the 2002-2003 field season, US ITASE accomplished the following technical and logistical activities:

(1) The traverse traveled a total of ~5500 km sampling a significant portion of West Antarctica (Figure 1).
(2) Continuous radar observations (crevasse detection (400 MHz) and shallow depth (400 MHz) over the ~5500 km of the traverse route and deep (2.5 MHz)) over ~3500 km.
(3) Twenty science sites occupied for periods of 2-6 days depending upon workload per site.
(4) A total of ~3100 m of ice core recovered utilizing both the 3” diameter Eclipse drill purchased by NSF for use by US ITASE and a 2.2” diameter lightweight drill built by Glacier Data for the University of Maine. A total of twenty 3” diameter ice cores collected from twenty-five sites covering a minimum of 200 years (typically >500-1000 years). Ice cores sampled at NICL for chemistry, stable isotopes, density and total beta activity.
(5) Permeability and porosity experiments conducted from 15 snowpits and 12 18 m ice cores were collected.
(6) Stratigraphy sampled at all sites utilizing snowpits excavated either exclusively for this purpose, or snowpits excavated as access for 3” ice coring, or ~10 m wide pits excavated using a Challenger 55.
(7) Ninety days of atmospheric and shallow chemistry observations conducted at twenty sites. Sampling included real-time, continuous observations of peroxides (H_2O_2 and organic peroxides), formaldehyde and ozone near surface and ozone profiles up to an altitude of 23 km.
(8) Basic meteorological observations collected at all sites and 10 m depth temperatures for comparison with infrared satellite estimates of mean annual temperature.
(9) Twenty-five high precision GPS ‘coffee can’ experiments deployed to estimate mass balance.
(10) Three AWS deployed close to the proposed inland deep drilling WAIS site.

US ITASE Style of Operation and Logistics

US ITASE is effectively a polar research vessel. It offers the ground-based opportunities of traditional style traverse travel coupled with the modern technology of GPS navigation, crevasse detecting radar, remote sensing, autonomous technology, satellite communications and multi-disciplinary research. By operating as a ground-based transport system US ITASE offers scientists the opportunity to experience the dynamic environment they are studying. US ITASE also offers an important interactive venue for research. US ITASE offers multi-disciplinary interactions similar to that afforded by oceanographic research vessels and large polar field camps, without the cost of the former or the lack of mobility of the latter. More importantly the combination of disciplines represented by US ITASE provides a unique, multi-dimensional (space and time) view of the atmosphere, the ice sheet and their histories. When US ITASE reached South Pole at the end of the 2002-2003 field season, it had sampled the physical and chemical environment of West Antarctica over spatial scales in excess of 5500 km and 3500 m in depth, and over time periods ranging from several hundred years (at sub-annual scale) from ice cores to thousands of years from geophysical techniques.

Based on the experience gained during the 1999-2003 US ITASE seasons we propose the following operation style for the 2005-2006 and 2006-2007 US ITASE traverses from Taylor Dome to South Pole. Although details of the exact route still remain to be developed based on examination of satellite imagery and scientific and logistic considerations, we plan to traverse from Taylor Dome to South Pole along the inland margin of the Transantarctic Mountains (Figure 1). The likely starting point in the 2005-2006 season will be Taylor Dome, where the traverse vehicles are currently staged. We plan to combine US ITASE data with French and Italian ITASE data taken to the north to develop a full north to south (ocean to Pole) gradient of study, and through collaboration with our Australian ITASE colleagues extend this study region westward into Wilkes Land. We plan to make between 6 and 10 several day (2-5) stops per season and conduct continuous experiments en route.

The traverse team will be comprised of 8-15 individuals (to be determined on the basis of successful science proposals submitted to OPP). Fourteen individuals were involved in the 2002-2003 season. Traverse logistics will include: two Challenger 55s, four Berco sleds (comprised of mechanics/equipment/berthing sled, ice core/science storage sled, science/berthing sled and permanent galley/berthing sled; two 3000 gallon fuel tank sleds or equivalent in drum or seal tanks, plus lighter sleds (such as Maudheims, Polar Associate, Komatiks, Nansens and Polar Pooper)). If significantly fewer than 10 science projects are involved in US ITASE, sled and vehicle requirements can be reduced accordingly. Based on past experience US ITASE is capable of traveling and conducting science over an ~2000 km traverse route in a fifty day field season. Travel is typically at an average of 10-12 km/hr, except when ground conditions are poor (5 km/hr). US ITASE has been able to operate (travel and science) more than 95% of its time in the field, making it far more efficient than projects dependent on frequent air support. LC130 support will be requested as follows: to deploy the field team, equipment, and fuel into the field, to retrograde team, ice cores, and equipment, and for air drops (unless fuel tank sleds are available). Approximately four-six LC130 flights would be required to support a field team comprised of close to 10 individual scientific projects. While LC130 support is clearly at a premium we feel that four-six flights/10 projects is an extremely efficient use of logistics. Twin Otter resupply will be requested as required. Past experience suggests between 0-1 flight per season in support of the main traverse and additional flights for reoccupation of survey markers. Ice core drilling will utilize the 3” core diameter Eclipse Drill constructed by Icefield Instruments for US ITASE and modified by Mark Wumkes of Glacier Data, Inc. The Eclipse Drill and drilling expertise are provided by Ice Core Drilling Services (University of Wisconsin). We also plan to bring a 2.2” core diameter drill, Rongbuk, designed by Glacier Data for shallow coring that was used successfully to recover 10-40 m cores during the 2001-2003 field seasons.

During the 2005-2006 season, US ITASE will travel from Taylor Dome southward along the inland margin of the Transantarctic Mountains. Exact route and stopping point at the end of that season will be determined by consensus of the funded US ITASE researchers. The US ITASE field team will identify a safe LC130 landing site and construct a runway. All necessary skills and equipment are on board the traverse including RADARSAT imagery, crevasse detecting radar, experienced glaciologists, plows, runway drags, and a Camp Manager experienced with runway construction, maintenance, and aircraft communication and loading/offloading. The 2006-2007 traverse would be resupplied and start from the 2005-2006 traverse endpoint. Two highly experienced mechanics have accompanied US ITASE in the past, and would be requested in the future, to assure vehicle safety and reliability. Once the 2006-2007 traverse is complete, several options could be considered including: (a) turning traverse platform over to another field project, (b) overland return to Taylor Dome or West Antarctica, (c) return to McMurdo overland along the British Commonwealth Expedition Route, or (d) airlift equipment to McMurdo.

Details of the 1999-2003 field season logistics plans as well as daily logs, and detailed annual field reports are available on the web (http://www.ume.maine.edu/USITASE/fieldreports/index.html and http://www.ume.maine.edu/USITASE/logbook.html) and details for the 2005-2007 seasons have been submitted to the OPP Electronic Support Planner as part of the submission process for this proposal.

US ITASE Objectives

Changes in the Antarctic environment have the potential to exert major controls on the global environmental system. US ITASE activities developed thus far and in this proposal will provide important focus to the determination of the significance of environmental change in both West and East Antarctica.

During the 1999-2003 US ITASE program, science was conducted along ground-based traverses near the ice divides of the West Antarctic Ice Sheet and adjacent regions, satellite traverses into major ice drainage basins entering the Ross Sea by way of Siple Coast ice streams entering the Ross Ice Shelf, and into the Amundsen Sea by way of ice streams entering Pine Island Bay, and traverses from West Antarctica to the South Pole.

For the period 2005-2007, US ITASE proposes traverses along the interior margin of the Transantarctic Mountains of East Antarctica. The sum of these traverses (1999-2007) will provide environmental records (e.g., change in temperature and atmospheric circulation, ice accumulation rates, ice thickness, and internal radio-echo horizons) for the region surrounding the Ross Sea Embayment and through collaboration with Italian, French, and Australian ITASE colleagues north and west through Northern Victoria Land and Wilkes Land.

The US ITASE objectives listed below represent a combination of ideas developed by current US ITASE researchers and several additional researchers who are interested in submitting proposals for involvement in future US ITASE activities or in collaborating. They include: R. Ackert (WHOI), M. Albert (CRREL), S. Arcone (CRREL), R. Bales (Arizona), H. Borns (Maine), D. Bromwich (Ohio State), F. Carsey (JPL), D. Qin (Academia Sinica), M. Fily (France), M. Frezzotti (Italy), I. Goodwin (Australia), T. Gow (CRREL), B. Hall (Maine), G. Hamilton (Maine), T. Hughes (Maine), B. Jacobel (St Olaf), K. Kreutz (Maine), P. Mayewski (Maine), J. McConnell (DRI), D. Meeker (UNH/Maine), D. Meese (CRREL). C. Shuman (NASA), T. Scambos (Colorado), E. Steig (Washington), K. Taylor (DRI), B. Welch (St. Olaf), and J. White (Colorado). Additional input and involvement is always invited.

US ITASE science objectives that can be investigated through the information developed from a Ross Sea Embayment-Wilkes Land wide investigation that combines 1999-2003 US ITASE activities in West Antarctica plus proposed 2005-2007 activities in the region between Taylor Dome and South Pole include, but are not confined to the following:

(1) What is the current rate of change in mass balance over the Ross Sea Embayment region?

The accumulation rate over Antarctica is an important parameter in understanding both the stability of the Antarctic ice sheet and change in climate (Giovinetto and Bull, 1987; Bentley and Giovinetto, 1992; Bindschadler, 1992; Jacobs and Hellmer, 1992). Numerical models of the ocean/atmosphere system (Manabe et al., 1992) suggest that increases in atmospheric CO2 may dramatically increase the precipitation at extreme southern latitudes. As an example, results from

Wilkes Land in East Antarctica (Morgan et al., 1991) have already detected increases in snow accumulation since 1960 on the order of 20% above the long-term mean (1806-present). Results from US ITASE activities in Antarctica reveal significant complexity as a consequence of distance from the ocean, topography and change in climate (Spikes et al., in press 2004; Kaspari et al., in press 2004).

The East Antarctic Ice Sheet (EAIS) stores a considerably larger volume of potential sea level rise than the West Antarctic Ice Sheet, yet is far less explored. Measurements of the rates of ice sheet thickness change are being conducted at only three sites in EAIS: South Pole, Taylor Dome and Vostok. Additional measurements are required to assess spatial variability in ice sheet change. One hypothesis is that interior portions of EAIS are close to mass balance (as suggested by results from South Pole), but this needs to be tested at other interior sites. More recent work on Byrd Glacier using satellite imagery suggests that important changes are underway on this large outlet glacier (Stearns and Hamilton, submitted). Ground-based measurements are particularly necessary in interior EAIS because ICESat (launched in 2003 to study ice sheet elevation changes) does not include coverage of the ice sheet south of 86 degrees and is also experiencing a scaled-back measurement program because of technical difficulties.

Modern rates of thickness change along an ice sheet transect bordering the Transantarctic Mountains will be important for deciphering the deglacial history contained in bedrock rebound rates. Very precise measurements of rock motions are underway as part of TAMDEF (T. Wilson, Ohio State). Once the present day ice sheet contribution is accounted for, these rebound rates will be used to constrain past ice sheet volume.

(2) What is the ice dynamics history of the Ross Sea Embayment?

US ITASE traverses (1999-2003) provided glaciological data (e.g., ice accumulation rates, ice thickness, and internal radio-echo horizons) needed to model West Antarctic ice draining north into Pine Island and west into the Ross Ice Shelf, in addition to ice entering from the south through the Bottleneck between the East and West Antarctic Ice Sheets. The Taylor Dome to South Pole traverse will provide these data for ice entering the Ross Sea Embayment from the south and west, with remote sensing investigations and proposed traverses to the Transantarctic Mountains between and along the major ice streams (notably Beardmore Glacier, Nimrod Glacier, Byrd Glacier, Mullock Glacier, and David Glacier). The imagery and traverses will provide glaciological data needed to study the transitions from sheet flow to stream flow and glacial geological data needed to determine the former elevation of East Antarctic ice before the Ross Sea Embayment formed. As the 2005-2006 US ITASE traverse moves south from Taylor Dome, it will leave a region that shows widespread evidence of extensive glacial collapse reported by Mayewski et al. (1979) (e.g., hanging glaciers), and where Anderson (pers. comm.) has mapped deep submarine glacial troughs that were eroded by former ice streams. This is evidence of enhanced gravitational collapse of the East Antarctic Ice Sheet in this region that took place when ice streams became unbuttressed by ice shelves that disintegrated during late glacial climate warming and rising sea level. Understanding this deglaciation history will provide insights on how the West Antarctic Ice Sheet may experience accelerated gravitational collapse as modern ice streams surge into regions such as Pine Island Bay.

(3) What is the detailed subglacial structure of the ice streams entering the Ross Sea Embayment and how do these ice streams form?

Early results from the first RADARSAT Antarctic Mapping Mission revealed that major outlet glaciers draining through the Transantarctic Mountains are supplied with ice from feeder ice streams that converge in the main trunk outlet glaciers, and that these feeder ice streams probably follow bedrock channels that branch from the fjord occupied by the outlet glacier. In some cases these feeder branches are hundreds of kilometers long, so that stream flow develops far into the interior of the East Antarctic ice sheet. The proposed traverse will cross the upper reaches of many of these feeder ice streams that converge on major outlet glaciers in the Transantarctic Mountains and follow several ~200 km inland. Radar sounding along the traverse route, combined with surface measurements of ice accumulation, velocity, slope and temperature, allow modeling of changing sheet flow to stream flow at the heads of these feeder streams.

Surface velocity and slope could be related to bed topography and bed deformability, allowing an assessment of the mobility of feeder streams. In addition, deep radar could: (1) define the catchment areas feeding the glaciers running through the Transantarctic Mountains and (2) show paleo changes (from internal layers) in the boundaries of these regions. Bedrock topography would give a first cut at geologic controls on the outflow, and internal layers would depict changes.

(4) What is the history of blue ice areas?

The distribution of blue ice areas can be mapped using satellite imagery, but requires ground truth for verification. On the ground, these regions may display unconformities in the internal layers, as mapped using high-resolution radar, suggesting changes in their former location and extent.

(5) What is the influence of major atmospheric circulation systems (e.g., ENSO) and oceanic circulation on the moisture flux over the Ross Sea Embayment region?

Snow and ice stratigraphy reveals regional characteristics of change in snow accumulation at several sites in Antarctica (Gow, 1961, 1963; Giovinetto and Schwerdtfeger, 1966; Yamada et al., 1978; Petit et al., 1982; Morgan et al., 1991). In the studies where such data have been compared to existing meteorological records, intriguing correlations have been developed which provide insight into major patterns of atmospheric and oceanic circulation. Examples include: positive correlations between sea ice cover in the Orcadas Island area and South Pole snow accumulation (Fletcher, 1969); possible relationships between South Pole, Dome C and Wilkes snow accumulation and sea level pressure fluctuations over the 40-50^{o}S latitudinal zone (Enomoto, 1991); and major atmospheric circulation system influences on Antarctic climate (e.g., Bromwich and Robasky, 1993; Stearns et al., 1993, Cullather et al., 1997).

US ITASE ice core investigations have already been used to develop proxies for several of these major atmospheric features including ENSO and major atmospheric systems such as the Amundsen Sea Low and the East Antarctic High (e.g., Bromwich et al., 1999; Kreutz et al., 2000; Meyerson et. al., in review, Mayewski et al., 2004b, 2004c; Souney et al., 2002). Ice core investigations in the Taylor Dome to South Pole region should provide proxies for the potential influence of major moisture-bearing air masses and katabatic flow in this region.

(6) How does climate (e.g., temperature, accumulation rate, atmospheric circulation) vary over the region of the Ross Sea Embayment on seasonal, inter-annual, decadal and centennial scales, and what are the controls on this variability?

Considerable evidence exists for short-term annual- to decadal-scale variability throughout the Antarctic from a variety of records including: decadal and greater productivity cycles in Antarctic Peninsula sediments (Leventer et al., 1997); changes in snow accumulation related to changes in atmospheric circulation (Enomoto, 1991); and annual-scale and greater variations in atmospheric circulation (Hogan et al., 1982; White and Peterson, 1996; Kreutz et al., 2000; Mayewski et al., 2001, 2004c In addition, rapid disintegration of ice shelf regions in West Antarctica has been linked to atmospheric warming (e.g., Vaughan and Doake, 1996).

US ITASE ice core records provide proxies for temperature, accumulation rate, sea ice, and atmospheric circulation that will reveal the spatial and temporal scale of climate variability in this region and have been used to demonstrate potential controls on climate variability (Mayewski et al., in review).

(7) What is the frequency, magnitude and effect of extreme climate events recorded over the region of the Ross Sea Embayment?

As noted earlier in this proposal the rapid climate change events recorded throughout the last 110,000 years of the Greenland ice core record are also recorded in Antarctica. The relationship between these events is, however, not well understood and will be a major focus of the deep ice core activities for US and European deep ice coring activities. Increasing evidence shows that Antarctica holds a unique and important record of regional to global scale extreme climate events (US ITASE Members; Mayewski, 2003).

Results covering the instrumental era suggest marked changes in moisture convergence over West Antarctica are synchronous with the portions of the Southern Oscillation record (Cullather et al., 1997). Differences in pressure patterns between normal and ENSO years (Cullather et al., 1997) reveal marked differences that could be extended back through time if related to changes in ice core parameters. Promising results come from the ice core-based ENSO record developed by Legrand and Feniet-Saigne (1991) and Meyerson et al. (2002) and changes in ice core chemistry related to deepening of Antarctic low pressure systems (eg., Kreutz et. al., 2000 and Reusch et al., 1999; Souney et al., 2002; Mayewski et al., 2001, in press 2004c).

(8) What is the impact of anthropogenic activity (e.g., ozone depletion, pollutants) on the climate and atmospheric chemistry of Antarctica?

The Antarctic continent and surrounding sea ice not only influence global climate but also appear to be sensitive to small environmental changes and, hence, could provide early indications of global change (Manabe and Stouffer, 1979). While clear indications of the industrially derived pollutants recognized in Greenland ice cores appear to be lacking in Antarctica, we have little basis in Antarctica for assessing subtle onset of such changes. Since such changes may be expected first be seen as increases in background concentration and/or shifts in input timing, it is important to develop a high-resolution record of the chemistry and dynamics of recent Antarctic climate.

(9) How much has biogeochemical cycling of S, N, O and C, as recorded over Antarctica, varied over the last several hundred years?

Changes in climate and the chemistry of the atmosphere over Antarctica could have major effects on biogeochemical cycling and climate (Mayewski et al., in review) thereby causing complex feedbacks. For example, the impact of changes in UV radiation related to ozone depletion could affect marine productivity with consequent changes in the emissions of marine biogenic gases that impact global atmospheric chemistry and climate. Changes in marine biological productivity can be assessed through the measurement of S species (e.g., MS, non seasalt sulfate) in US ITASE ice cores.

(10) What properties of ice control radar reflections?

The stronger radar reflections thus far interpreted from US ITASE are responses to changes in density and chemistry (e.g., Arcone et al., in press; Spikes et al., in press). The next generation of high-resolution radars already has superior noise suppression yielding better penetration. By comparing ice core records that penetrate radar traverses US ITASE has demonstrated that some of the radar reflectors represent layers of known age. Known age reflectors have now been traced across much of the US ITASE route in West Antarctica, allowing estimates of accumulation rate to be extended over the same range. In addition by utilizing 100-MHz profiles of the top 80 m of ice sheets it may be possible to reveal evidence of Holocene warming periods (density) or changes in atmospheric circulation and climate (chemistry).

(11) Additional opportunities offered by the US ITASE 2005-2007 traverse include:

(a) Interpretation of satellite data.

Ground-based traverses have the capability to investigate the causes of unusual features observed in satellite imagery. In addition, surface data collected during ground-based traverses will be valuable calibration data for ICESat and CryoSat (laser and radar altimeter) measurements.

(b) Operational base for new projects.

(1) The proposed traverse could offer access for glacial geology and bedrock geology teams to make several visits to sites that would normally require major logistic support.
(2) US ITASE could provide a logistic platform for testing new instrumentation such as NASA's autonomous polar vehicle (F. Carsey, JPL) and ice core sampling not routinely included in ice coring programs (e.g., biological materials).
(3) Logistics developments and route characterization may be of value for future OPP planning of science and logistics.
(4) Collaborative efforts between US ITASE and several other research activities.

US ITASE cooperates with all of the other ITASE national projects. The Taylor Dome to South Pole traverse provides complimentary results for the proposed Australian ITASE traverse (Casey to Dome C), the Italian ITASE traverse (Terra Nova Bay to Dome C), and the French ITASE traverse (Dumont d'Urville to Dome).

US ITASE SMO Tasks

We request support for a US ITASE SMO from March 2004 to February 2008 to perform the following tasks.

(1) US ITASE SMO will develop the field operations plan (SIP) on behalf of all US ITASE science investigators, streamlining logistics and administration for all projects.

(2) Route selection activities will be a component of the new proposed ITASE SMO. This work will be conducted by G.S. Hamilton with much of the mosaic preparation being carried out by a graduate student. We are already in possession of the RADARSAT imagery required to map the proposed traverse routes. New imagery will be acquired and added to the interpretation as it becomes available. Very recent ASTER data will be especially useful for mapping flow features near the heads of the Transantarctic Mountain outlet glaciers.

(3) US ITASE SMO will organize annual workshops to discuss logistics and science. These are often held in conjunction with Spring AGU, but other opportunities will be explored.

(4) US ITASE will maintain and expand the current website (www.ume.maine.edu/USITASE and www.secretsoftheice.org) for access by the public and researchers.

(5) Outreach activities for US ITASE will follow the current plan. US ITASE currently maintains an active outreach activity in coordination with the Museum of Science in Boston (www.secretsoftheice.org); numerous lectures for K-12, the public and professionals; TEA involvement and liaison with media.

(6) US ITASE will continue, as in the past, to work with researchers to develop several data products including:

   (a) arrays of environmental time-series (e.g., accumulation rate, temperature, atmospheric circulation) and change in atmospheric composition over the last several hundred years;

   (b) synoptic reconstructions and interpretation of major atmospheric circulation features (e.g., ENSO, cyclogenesis);

   (c) estimates of the modern contribution made to sea level by WAIS and EAIS ice volume changes;

   (d) an environmental base map for EAIS and WAIS that will be valuable for assessing natural variability and the influence of anthropogenic activity;

   (e) data needed to interpret ice dynamics influences and ice core properties to link planned deep ice cores and identify sites for other ice cores that extend key climate change records to10,000 years and longer;

   (f) in-situ control for remote sensing experiments;

   (g) data needed for evaluating atmosphere-snow transfer functions to broaden the scope of paleoclimate interpretations developed from ice cores.

(7) We are also beginning work on compiling data from current US ITASE activities and ITASE activities as the SCAR Project Office for ITASE. The data will be assembled at our forthcoming meeting SCAR Meeting in Bremen (2004) and also in a web-accessible GIS database, using satellite image mosaics as the base layer. Gordon Hamilton is developing this initiative. Data from all funded US investigators will be included, so that the GIS will contain a spatial record of US ITASE regions from the atmosphere to the ice sheet bed. The purpose of the web-based approach is to ensure maximum accessibility to the data to other investigators, without the need to learn technical GIS skills. The development of an ITASE GIS is not intended to compete with the ITASE data repository at the National Snow and Ice Data Center. Rather, it allows an intuitive interface for users (technical and general public) to visualize the data. Following a period of restricted access, the GIS will be made available to

the wider science community and the public. The ITASE SMO will play an important role in the development of the GIS by encouraging individual investigators to contribute or grant access to their data.

US ITASE SMO Management

US ITASE SMO has operated in the past through a process of very close involvement (electronic and in field) between the SMO and US ITASE researchers. Following this format US ITASE SMO will be comprised of a Director (Paul Mayewski) and an Associate Director (Gordon Hamilton) who are both currently US ITASE PIs (and are submitting new science proposals for continued involvement) and have considerable logistic and scientific experience. Four months of support are sought in this proposal for a Program Coordinator (Ann Zielinski) who will handle much of the office activities. Paul Mayewski has considerable experience in science adminstration as Director of US ITASE SMO since 1998 and Director of the Greenland Ice Sheet Project Two SMO from 1989-2000. An advisory committee will be assembled with consultation from US ITASE PIs and OPP.

BROADER IMPACTS

US ITASE offers a highly efficient logistics platform that could serve as a model for future OPP/NSF field activities. The project is logistically efficient because it allows as many as 11 scientific projects (thus far) to share the aircraft and surface vehicles requirements of a very much smaller number of individual projects.

Scientifically US ITASE catalyses the integration of a variety of disciplines (to date – meteorology, remote sensing, geophysics, dynamical glaciology, ice core glaciology, and chemistry plus potentially more). This disciplinary integration allows significantly more robust and creative examination of both disciplinary and multi-disciplinary problems.

US ITASE researchers will follow protocols established by ARCSS (Appendix B in US ITASE, 1996) for data and by GISP2 for sample sharing. Samples collected from shared materials will be collected so that all necessary scientific requirements are satisfied and, wherever possible, registered to exactly the same sample interval to avoid problems with sample registration when comparing high-resolution time-series. The US Antarctic Data Coordination Center (USADCC) web page (http://nsidc.org/NSF/USADCC/) functions as the access point for US ITASE researchers to enter metadata and data thus fully complying with the data sharing standards set by NSF and the international Scientific Committee on Antarctic Research (http://www.scar.org) to maximize usage of scientific data.

US ITASE has a very successful and extensive history of outreach. Much of this is based on the US ITASE association with the Museum of Science (Boston). In cooperation with MOS, US ITASE maintains a web based daily report series during the field season, twice weekly live interviews from the field to MOS, an extensive website (www.secretsoftheice.org), a US ITASE display at MOS, frequent public lectures to K-12, public groups, and universities, significant media coverage, and a University of Maine based website (www.ume.maine.edu/USITASE)

US ITASE routinely includes 3-5 graduate students per field season and several are women. One undergraduate participated in the 2000-2001 field season and another participated in the 2002-2003 season. Most of the graduate students have utilized the research for MSc and PhD topics and the undergraduates for senior projects.

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