ICSI Bureau Meeting, February 6th & 7th, 2003.
University of Münster, Münster, Germany.

Present:
Gerald Jones (President, Canada)
Elizabeth Morris (Past-President, UK)
Georg Kaser (Secretary, Austria/Italy)
Eric Brun (Vice-President, France)
Jon Ove Hagen (Vice-President, Norway)
Manfred Lange (Head, Sea, Lake and River Ice, Germany)
Julian Dowdeswell (Head, Glaciers and Ice-Caps, UK)
P.Foehn (Head, Seasonal Snowcover and Avalanches, Switzerland)
Pierre Hubert (Secretary General, IAHS, France)

Absent with regrets:
Dahe Qin (Vice-President, China)
Wilfried Haeberli (Director, WGMS, Switzerland)
T. Hondoh (Head, Ice as a Material, Japan)

1. Opening remarks

The President welcomed the Bureau Members and, in particular, extended a warm *bienvenu* to Pierre Hubert, the Secretary general of IAHS. Mr. Hubert had requested to attend the Bureau Meeting in order to participate in deliberations on the statute of ICSI within IUGG.

Manfred Lange presented an overview of the research at the Institute of Geophysics at the University of Muenster and outlined some of the work into sea ice in more detail.

2. Agenda: additions/modifications

Additions to 6 vii) "ICSI Status in IUGG: Task Force Report": a) Discussion/Recommendation and b) Next Steps 9see below). There were no modifications to existing items.

3. Minutes of the 2002 Bureau Meeting, Paris

i) ***Corrections/modifications/additions***

No corrections, additions or modifications were forthcoming.

ii) ***Acceptance***

Acceptance of the Minutes was proposed by Liz Morris and seconded by Manfred Lange and Eric Brun.

Action: the Secretary of ICSI to send the Minutes of 2002 to the Secretary general of IAHS.

4. Activities following on the Minutes of 2002

Action items

Activities following on from the Action items of the Minutes of 2002 were:

4.1**)** ***Item*** - Abramov Station: *Action 2002,* Wilfried Haeberli to send the coordinates of the person responsible for the station in 1999 to the President; *Status 2003*, **no action as yet**. Eric Brun will check possibilities with Ludwig Braun, Munich.

4.2) ***Item*** - ICSI National Representative List: *Actions 2002*, a) Georg Kaser to contact those IAHS NRs currently listed in IAHS and IUGG yearbooks; *Status 2003*, **ongoing** - the Secretary tabled a list of 44 countries to which he addressed a request concerning the confirmation of the ICSI NR. Replies so far had been received from 12 countries and replies were being anticipated from the rest before Sapporo (Appendix A). b) *Action 2002*, Eric Brun to supply Georg Kaser with a list of persons he has contacted; *Status 2003*, **Completed**. c) *Action 2002*, Liz Morris to supply Georg Kaser with IGS member and country list; *Action 2003*, **no action as yet** d) *Action 2002*, Wilfried Haeberli to write a communiqué that the ICSI Secretariat can distribute to the IAHS Newsletter (and other media – if need be) to attract interest and potential NRs for ICSI; *Status 2003*, **no action as yet.**

4.3) ***Item*** - IUGG General Assembly Sapporo 2003: *Action 2002*, The President to inquire as to whether the ICSI-proposed Union lecture 'The Cryosphere and the state of the Planet: the dynamics of change and representation in models'had been retained or not by the Sapporo Scientific Committee; *Status 2003*, **Completed**, the selection committee for the Union Lecture did not, however, retain the suggestion by ICSI.

4.4) ***Item*** - ICSU Grants 2002: *Action 2002*, The President to contact ICSU to see if submissions may still be accepted; *Status 2003*, **Completed**, submissions could not be accepted after March 1^{st}

4.5) ***Item*** - ICSI Bureau Meeting Paris 2002: *Action 2002*, The Secretary will contact the IAHS Treasurer to request funds that will allow the President to travel to the meeting; *Status 2003*, **Completed**, funds were allocated (see Secretary-Treasurer's report, Appendix B).

4.6) ***Item*** - IAHS Elections, Sapporo 2003: *Action 2002*, The President to inquire from the IAHS Secretariat as to what a legal Mail-in Vote consists of; *Status 2003*, **Completed**, mail-in votes are postal and Fax. No decision has been made as yet on e-mail votes. Comment by Pierre Hubert that Commissions may be able to define a mail-in vote themselves. However, it is not at all certain that Commissions have the terms of reference to do this.

4.7) ***Item*** - International Workshop on Snow Hydrology in Mediterranean Regions, Beirut, Lebanon, December 16^{th} – 17^{th} 2002: *Action 2003*: The President to propose to the organizing committee that ICSI becomes a cosponsor; *Status 2003*, **Completed**, ICSI became a cosponsor of the meeting.

4.8) ***Item***: The progress of the book on Snow and Climate: *Action 2002*: The President will contact Richard Armstrong and Ross Brown on the status of the Snow and Climate book; *Status 2003*, **Completed**, the book proposal has been sent to CUP and accepted after favourable review.

4.9) ***Item*** - WGMS Director's Report – combining activities with other institutes, universities and research bodies: *Action 2002*, The Director of WGMS to prepare a document on the future directions of WGMS, which takes into account the elements presented in the discussion on the issue; *Status 2003*, **no action as yet**.

4.10) ***Item*** - ICSI Logo: *Action 2002***,** Liz Morris to try and locate the original drawing; *Status 2003*, Liz was not able to find the original and will get it redrawn at BHS.

4.11) ***Item*** - Working Group on Chinese Glaciers: *Action 2002***,** Dahe Qin to propose a list of Chinese Glaciologists who would be interested in forming a WG on Chinese Glaciers. The list would then be transmitted to the Chair of the Division of Glaciers and Ice Sheets; *Status 2003*, **no action as yet**. Julian Dowdeswell had received no information from Dahe Qin.

5. Secretary-Treasurer: Report on ICSI finances

Georg Kaser tabled the Secretary-Treasurers Report on ICSI finances (Appendix B). Many members expressed their dissatisfaction at the way the Commission had to financially operate within IAHS. The Association, in effect, supplies money to ICSI on an *ad hoc* basis that requires the Commission to request funds every year. In some years IAHS will acquiesce to the request and ICSI will receive a certain amount (usually $1000). In other years the request is refused and Commission Members have to rely completely on their own personal funds to carry out ICSI activities. Thus there is no coherent consistent funding of commissions even though IAHS receives a stipend from IUGG of approximately $20,000 per year.

The Secretary of IAHS acknowledged the problem but finances were not always sufficient at the Association level. He also mentioned that the financing of inter-association commissions was favoured over that of the commissions. Why this should be was not clear. The Secretary of IAHS also suggests to examine the possibility to propose a project to IAHS-IAMAS-IAPSO, which could lead to a support of 5000 US$ per year. After some discussion on the cash flow for the year 2002-2003 and the expenses that will be incurred at Sapporo, acceptance of the Report was proposed by Julian Dowdeswell and seconded by Manfred Lange.

6. Relations with IAHS

i) *National Representatives to ICSI*

Georg Kaser reported on the on-going activity to update the list of ICSI NRs. However, it is a long-drawn out process as it involves communicating with the 58 countries cited in the IUGG Handbook as having IAHS National Representatives. The Secretary has requested that the IAHS NRs confirm the identity of the ICSI NR and, if there is no ICSI NR, that the national committees give accreditation to someone in the field of snow and ice who could assume the position. Some countries have replied but many do not do so. It is then up to the Secretary and other Bureau Members to suggest potential ICSI NRs, who could then seek accreditation through their respective national committees. It was noted that ICSI could not appoint National Representatives directly; ICSI NRs have to be appointed through the National Committees. ICSI can name ICSI Correspondents directly but these do not have the right to vote in ICSI Plenary Assemblies.

The nomination of ICSI NRs is pressing, as the IUGG General Assembly will be held in July 2003 at which time the ICSI Elections will take place.

Action: the Secretary to continue the updating of the ICSI NR; the President and other Bureau Members will collaborate by suggesting names for ICSI NRs in those cases where information is not forthcoming from National Committees and Representatives.

ii) ***Sapporo 2003:***

a) Symposium JSH01 >Remote sensing of the Cryosphere

An e-mail report had been received from Richard Armstrong the principal convenor of JSH01. 32 abstracts had been received. There was no information given on poster session or as to whether the collected papers would be published.

b) WorkshopJWH01 >Snow Processes: representation in atmospheric and hydrological models**=**

An e-mail report had been received from John Pomeroy the principal convenor of JWH01. 39 abstracts had been received. There was no information given on a poster session. The collected papers will be published in a special issue of the Journal of Hydrometeorology.

c) Other Symposia:

In addition to JSH01 and JWH01, the President noted the contribution that ICSI is making to Symposia JSM10, JSM11, JSM15, JSM16 and JSP04 at Sapporo (see 7 i) and 7 ii) below).

The Secretary General of IAHS informed the Bureau on the progress of the program for the Assembly. Approximately 7,000 abstracts had been received. The timetable will be finalized in mid-March but there will probably be little change to the IAHS Timetable, which can be consulted on the IAHS web site.

iii) ***ICSI contribution to Prediction in Ungauged Basins (PUB), the IAHS initiative***

The IAHS Decade for Prediction of Ungauged Basins was launched in Brasilia in Nov 2002. John Pomeroy represented ICSI and was asked by the IAHS President to serve on the Science Steering Group, which will prepare the Science Plan and otherwise assist in moving PUB forward. Pomeroy and Lev Kuchment (Russia) helped to make the case for a special attention to cold-region hydrology issues in PUB and a distinctive effort in areas of high latitude and altitude where snow and ice affect hydrology. The Chair of the PUB Steering Committee (Sivapalan) subsequently asked Pomeroy to assume special responsibility for PUB activities in Cold Regions.

In his report to the Bureau on PUB, John Pomeroy suggested that it was time to formalize ICSI’s PUB effort as a joint program of the Division on Seasonal Snow and Avalanches and the Division of glaciers and Ice Sheets. Paul Foehn and Julian Dowdeswell, the respective heads of the two divisions suggested that John Pomeroy propose in somewhat more detail his ideas concerning the PUB Inter-Division Working Group.

Action: the President will contact John Pomeroy and inform him of the interest of the two divisions in receiving a proposal from him on this issue.

The Secretary General of IAHS outlined some future directions of PUB. It will be defined by a series of projects in different regions linked through the common purpose of developing the scientific methodology for prediction of flow and other hydrological characteristics in ungauged basins.

iv) *IHP-VI*
Discussion centred on the Synopsis that the Vice-President of IAHS had drawn up on the possible participation of IAHS Commissions in IHP-VI (Appendix C). ICSI had been identified as having affinities with IHP-VI projects 1.1 (Global distribution of contemporary resources: water supply and water quality), 1.3 (Integrated assessment of water resourcesin the context of global change), 3.5 (Hydrology of mountainous areas), and 5.1 (Teaching techniques and material development at all levels).

The President brought the input of ICSI to IHP-VI to the attention of the Bureau. Collaboration with FRIEND, a cross-cutting theme of IHP-VI, in such projects as the HKH-Glacier Monitoring Network, the HKH/ICSI/UNESCO Training course, and the formation of an Andean Glacier Monitoring Network through an Andean FRIEND, was cited as an example of the Commission's contribution to IHP-VI.

The Secretary General of IAHS stated that financing for the traditional activities of IHP was diminishing but more money was being allocated to social issues such as water and culture, water and community, and geopolitical aspects of resource partition.

v) *IAHS Bureau Meeting, Paris, June 2002*
The President had attended the IAHS Bureau Meeting in Paris. He had already written a report of the deliberations for the ICSI Bureau (Appendix D). The original IAHS Minutes of the meeting had included misinterpretation of statements by the ICSI President. The minutes had subsequently been corrected at the request of the ICSI President.

vi) *IAHS 7th Scientific Assembly, 2005*
Pierre Hubert presented some preliminary details of the 7th Scientific Assembly. It will be held in Foz de Iguassu, Brazil, April 24-30, 2005. A Joint Argentinean-Brazilian Committee will organize the Assembly. The first provisional group has been formed: D. Barrera and J.C. Bertoni of Argentina, and M. Mine and C. Tucci of Brazil.

vii) *ICSI Status in IUGG: Task Force Report*

a) **Discussion/Recommendations:** the President resumed the steps that had been taken since the IUGG General Assembly at Birmingham in 1999. He alluded in particular presented the reports that had been prepared on the subject i.e. the internal report by the President of ICSI in 2001 and the Report of the ICSI/IPA Task Force in 2002. The meeting then was opened for discussion to all members. Bureau Members were unanimous as to their preferred choice of status of ICSI within IUGG i.e. an Association, which would be equal to each of the seven current associations of IUGG. The consensus was that the justification proposed in the foregoing reports was scientifically sound and that IUGG should accept that Glaciology is a discipline on a par with those of the other associations. This would reflect the recent changes in EGU where Cryospheric Sciences were removed from the section on hydrology to become a separate section within the Union.

In particular, the Past President of ICSI and now President of the International Glaciological Society, affirmed that IGS would strongly support the initiative of ICSI to attain Association status. She argued that ICSI and IGS could play – and should play - complementary roles in the science of snow and ice. ICSI as a member of the IUGG structure would have responsibilities and activities that would complement those of IGS as an independent scientific organization. For that to take place, however, ICSI would have to attain the status of an Association. The support of IGS could take the form of a letter to IUGG.

Consensus was also attained on the desirability of separating the cases of ICSI and IPA. It was felt that a report to IUGG on the status of ICSI should not refer to two different associations in two different unions. ICSI's case should be judged on its own merits alone and that the inclusion of different issues pertaining to the two associations and two unions would only confuse the issue. A new proposal should thus be written for submission to the IUGG Executive Council in Sapporo.

Pierre Hubert stated that he would communicate the sense of determination of the ICSI Bureau on what the status of the Commission should be within the IUGG structure. He also gave the assurance that IAHS would openly discuss the issue and that he would oppose any attempt to suppress such discussion within the IAHS Bureau. The Secretary General also affirmed that he would inform ICSI of the latest date that he needs the new proposal so that it can be tabled in Sapporo.

Action: Liz Morris will request written support from IGS for ICSI's proposal before the IUGG General assembly in Sapporo
Action: Pierre Hubert will inform ICSI as to when he requires a copy of the new proposal

Next steps: two steps are important – i) the preparation of a new proposal, which takes the appropriate elements of the ICSI Internal Report and the IPA/ICSI Task Force Report, and ii) the submission of the new proposal to IUGG before the Sapporo Meeting.

Action: The President will write a new proposal for IUGG before the General Assembly in Sapporo. A first draft must be circulated to Bureau Members and Roger Barry (Chair of the ICSI/IPA Task Force) for comment and correction well before the Assembly takes place.

7. Relations with Associations of IUGG, WMO, IPA, and WDC-A

i) *IAMAS*

Sapporo: ICSI/IAHS lead sponsor, IAMAS and IAPSO cosponsors, of *Symposium JSH01* >*Remote sensing of the Cryosphere'* ICSI Convenor Richard Armstrong.

Sapporo: ICSI/IAHS lead sponsor, IAMAS cosponsor, of *WorkshopJWH01 >Snow Processes: representation in atmospheric and hydrological models*= ICSI Convenor John Pomeroy.

Sapporo: IAMAS lead sponsor, ICSI/IAHS cosponsor, of *Symposium JSM10 'Cryosphere-climate interactions'* ICSI coconvenor Liz Morris

Sapporo: IAMAS lead sponsor, ICSI/IAHS cosponsor, of *Symposium JSM11 'Global sea-level rise, Global climate change and Polar ice sheet stability'* ICSI coconvenor Jon Ove Hagen.

Sapporo: IAMAS lead sponsor, ICSI/IAHS cosponsor, of *Symposium JSM15 'Special Nakaya-Mangono Celebration: the growth of ice crystals and snow'* ICSI coconvenor Paul Foehn.

Sapporo: IAMAS lead sponsor, ICSI/IAHS cosponsor, of *Symposium JSM16 'The role of atmospheric processes in mass balance exchange in the Polar regions'* ICSI coconvenor Liz Morris

ii) *IAPSO*
See 7 i) JSH01.

Sapporo: IAPSO lead sponsor, ICSI/IAHS cosponsor, of *Symposium JSP04 'Arctic environmental change'* ICSI coconvenor Manfred Lange.

ii) *CliC/WCRP*
Barry Goodison, the President of CliC had sent a request to the President of ICSI on the possibility of disseminating information on CliC through ICSI National Representatives. The President replied that such collaboration was welcomed and that Mr. Goodison should contact Georg Kaser, the Secretary of ICSI, for the list of ICSI NRs.

iv) *IPA*
The ICSI/IPA Task Force had tabled its report on the status of ICSI in 2002 (see 6 vii above).
ICSI is a cosponsor of the 8th IPA International Conference in Zurich, July 2003

v) *WDC*
The Annual Report had been received by ICSI. ICSI is a corresponding member of WDC

8. Relations with UNESCO

i) *The ICSI Training Manual for mass balance measurements of glaciers (see 11 iii)*

The Secretary reported that the manual was in press and would be available in late March. It will also be on the web site for consultation.

ii*) ICSI/UNESCO-IHP/HKH-FRIEND/Government of India training course, Chhota Shigri, Lahul-Spiti Valley, Himachal Pradesh, India, September-October 2002.*
Georg Kaser tabled the ICSI Report (Appendix E). The training course was held in New Delhi, Manali (H.P.) and on Chhota Shigri Glacier, Lahaul-Spiti Valley, Himachal Pradesh from September 24 to October 12, 2002. The focus of the training course was on the theory of mass balance measurements, glaciological field training, and mountaineering and rescue training. The local organisation was provided by members of the *Glacier Research Group, School of Environmental Sciences, Jawaharlal Nerhu University, New Delhi*. The lectures in New Delhi where held at the *India International Centre, IIC*. Training in Manali and on Chhota Shigri Glacier was supported by the *Directorate of Mountaineering and Allied Sports (DMAS), Government of Himachal Pradesh, Manali - 175 131, District Kullu, Himachal Pradesh*. The course was well attended. There were 33 participants including the ICSI Training Staff of 6 persons under the leadership of Georg Kaser, 21 trainees from Bhutan, India and Nepal, 4 members of the Glaciology Group from Jawaharlal Nehru University, New Delhi, and 2 private participants.

iii) ***Long-term relations with UNESCO: activities, 2002-2008.***
The President briefly outlined the longer-term relationships with UNESCO. A detailed description of these relationships can be found in the document *"The International Commission on Snow and Ice (ICSI): a proposal for the funding of two projects on training and technology transfer within the UNESCO IHP programme, 2002-2008"*, (Appendix F). This document describes two projects, ICSI/UNESCO/HKH-FRIEND and ICSI/UNESCO/ANDEAN-FRIEND, which the International Commission on Snow and Ice (ICSI) wishes to implement over the period 2002 - 2008 and for which the Commission had requested sustained funding.

A half-day workshop to initiate an ICSI/UNESCO/ANDEAN-FRIEND project will be held in Valdivia, Chile, in March 2003. Georg Kaser will represent ICSI.

9. Elections of Officers to the Bureau, Sapporo 2003

i) ***Procedure and time frame***
The President presented the procedure and time frame of the electoral procedure (Appendix G) and a brief update on the nominations received. The dead line (January 1st) for receipt of nominations from National Committees by the ICSI Nomination Group had past. The next step – to be taken before April 1st – is to draw up the ICSI Slate of preferred candidates to be submitted to the IAHS Nomination Panel. This task is the responsibility of the Chair of the ICSI Nomination Group.The ICSI Nomination Group is: Liz Morris (Past President and Chair), Michael Kuhn (Past President), Gerald Jones (President and Secretary)

ii) ***Nomination Group: Interim Report***
The Chair of the ICSI Nomination Group presented her report. The National Committees of Sweden and Finland have nominated respectively P. Jansson of Sweden for the position of Secretary-Treasurer and E. Kuusisto of Finland for the position of Vice-

President. After canvassing the incumbent members of the ICSI Bureau, and colleagues in the glaciological community, the ICSI Nomination Group had filled the ICSI Slate of preferred candidates except for one of the three Vice-President positions. During the discussion on the slate it was suggested that Goto-Azuma from Japan would be a good candidate for the office of Vice-President. The suggestion was accepted unanimously. The Bureau then requested Liz Morris to contact Goto-Azuma and inquire as to whether she would stand for Office.

Action: Liz Morris to contact Kumiko Goto-Azuma before April 1st to see if she will stand for election.

The ICSI slate is: President-Elect, *Georg Kaser*, Austria; Vice-President, *Jon-Ove Hagen*, Norway; Vice-President, *Kumiko Goto-Azuma*, Japan; Vice-President, *Koni Steffen*, USA; Secretary-Treasurer, *Peter Jansson*, Sweden.

Other Candidate not on the slate but eligible for election: Vice-President, *Syed Hasnain*, India.

This list has to be sent to Jake Peters, Chair of the IAHS Nomination Panel before April 1st.

Action: The President of ICSI as Secretary of the ICSI Nomination Group will send the ICSI Slate plus the other candidate eligible for election to Jake Peters by April 1st.

As far as the Heads of Divisions were concerned, three of the Bureau members decided to solicit new terms. They are: *Manfred Lang*, Germany, River, Lake and Sea Ice; *Paul Foehn*, Switzerland, Seasonal Snow Cover and Avalanches; and *Julian Dowdeswell*, UK, Glaciers and Ice Sheets. *Esko Kuusisto*, Finland, was nominated to the Division of Ice as a Material as the current Head of the Division, *Takeo Hondoh*, *Japan*, has announced he will not seek another term.

Finally the list of Candidates for Office including the ICSI Slate and other eligible candidates has to be sent to the ICSI National Representatives 2 months before the ICSI Plenary Administrative Session at the Sapporo general assembly. The Agenda of the Plenary also has to be submitted to the National representatives at the same time. The Election for Officers of the Commission will be held during the Plenary. Votes may be cast in person or mailed in.

Action: The Secretary will send a list of ICSI National Representatives to the President before mid-April

Action: The President will send all the relevant information on the Plenary Session and the elections including the list of candidates, the voting procedure and appropriate time delays before April 29th.

10. ICSI sponsored Conferences/Workshops

i) ***IPA Eighth International Conference on Permafrost, Zurich, 21st B 25th July 2003***

Wilfred Haeberli is the ICSI Representative and member of the Organizing committee.

ii) ***International Workshop on Snow hydrology in Mediterranean Regions, Beirut, Lebanon, December 16th B 17th 2002: Report by the President***
The President presented a report on the Workshop, which was tabled (Appendix H). The workshop had been small (35 participants; 20 presentations) but dynamic due to the presence of many young researchers. As President of ICSI, H.G. Jones had been invited to give a talk on the role of snow and ice in Mediterranean Hydrology and had been also a member of the Scientific Committee. The Secretary General of IAHS, who had also been a member of the Scientific Committee added that selected papers from the Workshop would be published in HSJ in the coming year.

iii) ***3rd WWF Forum >Water resource management in mountainous areas =***
This UNESCO Thematic Session will be held at Kyoto, Japan, in March. ICSI is a cosponsor with IAHS, IHP, MAB and other organizations. The Commission's Representative is Georg Kaser.

iv) ***Mass balance of Andean Glaciers, Valdivia, March 2003.***
The Secretary reported on the progress of this meeting, which includes a workshop on initiating an Andean Glacier Monitoring Network and a symposium on the Mass Balance of Andean Glaciers. The Secretary is a member of the Organizing Committee. The Workshop is sponsored by Centro de Estudios Cientificos (CECS), Valdivia, Chile. The Symposium is sponsored by CECS, Iniciativa Cientifica Milenio (ICM), International Commission on Snow and Ice (ICSI), Institut de recherche pour le développement (IRD), and the International Glaciological Society (IGS). Attendance is expected to be very good as 57 abstracts have been received so far.

v) ***16th International Symposium on Ice: Ice in the Environment***
The Symposium was held in Dunedin, New Zealand, in December 2002. The meeting was organized by IAHR and ICSI was one of the cosponsors. Manfred Lange represented ICSI and was also a member of the Scientific Committee and the Chair of the section on '*Environmental Concerns and Ice*' The presentations are to be published as a three-volume proceedings.

vi) ***Other conferences/workshops***
***NSF Workshop, Boulder, March 2003*; ** Jon Ove Hagen will attend.
***International Workshop on Mountain Hydrology, Einsiedeln, April 2003*;** This meeting is organized by WLS as a part of the '*100-Year Anniversary of Hydrological Research at WSL*' ICSI is not a sponsor.

vii) ***Conference on Arctic Glaciers, Geilo, Norway, August 2004;*** ICSI support by Julian Dowdeswell and Jon Ove Hagen

11. Publications

i) ***IAHS RedBooks: Sapporo General Assembly***
Papers from the ICSI sponsored JSH01 and JWH01 will not be published in the RedBook Series (see 6 ii a; 6 ii b above for details)

ii) ***Special Issue of Hydrologic Processes, Hydrology of River and Lake Ice***
This has already been published

iii) ***ICSI-UNESCO Training Manual***
See 8 i) above for details

iv) ***Snow and Climate, CUP***
To be published in CUP (see item 4.8 above for progress).

v) ***Maastricht Proceedings on High Mountain Hydrology***
Published in the Journal of Hydrology; Georg Kaser reported that 12 good quality papers had been accepted.

vi) ***IAHS 80th Anniversary RedBook***
The president tabled the text that he and the Secretary had submitted to the publication. The text describes a brief historical introduction to ICSI and the current activities of research and technology transfer (Appendix I). It will be published in April.

vii) ***Snow Ecology Book***
The President informed the Bureau that the work on Snow Ecology produced by the ICSI WG on Snow Ecology and published in 2001, is now being translated into Chinese. The Chinese Edition will be published by The Ocean Press, Beijing.

12. WGMS

i) ***Director=s Report***
In the absence of the Director of WGMS, the President tabled his report (Appendix J). The Report included a Workplan of 8 activities and a Budget for 2003 of $ 220,000.

ii*)* ***Publications***
Details were given on the preparation of ‘*Fluctuations of Glaciers 1995-2000*’ now nearing completion, the ‘*Glacier Mass Balance Bulletin No 7*’ to be published in 2003, and a statement on Glaciers and Ice Caps as key variables within GTOS for the ‘*Second Adequacy Report on Global Climate Observing Systems*’.

iii) ***Funding***
The Director emphasised the unsatisfactory funding situation and how it was hindering some activities such as direct access to the database of WGMS via the Internet. In addition, financial contributions from FAGS/ICSU may come to an end in 2003. The Report recorded the resubmission of a proposal to ICSU to partially support the funding of three activities (WEB-based data system; information system; new mass balance measurements) but it was not clear whether the proposal had actually been submitted**.**

The ICSI Steering Group on WGMS (J. Dowdeswell, J.O. Hagen and Liz Morris) requested clarification on certain issues. It was not clear how the activities listed in the Workplan for 2003 relate to the budget of $220, 000. The Bureau members also remained unconvinced that the new GTNet-G activities in New Zealand and Patagonia would add strength to the ICSU proposal.

Action: the President will write to the Director of WGMS to ask him to clarify the above issues.

13. Reports of the vice-presidents

Eric Brun gave an oral report, in which he outlined the progress of the IAHS-WMO WG on GEWEX and the future meeting in Sapporo. Eric is the ICSI Representative to the WG.

Jon Ove Hagen presented an oral report on his activities as the ICSI Representative on the ICSI/IPA Task Force and his contribution to the Task Force Report.

Dahe Qin did not submit a report.

14. Work of the Divisions and Working groups

i) ***Report by Head of Division on Seasonal snow cover and Avalanches***

Paul Foehn presented an oral report.

ia) Report of WG on Snow vegetation interactions

Sapporo Workshop JWH01 (see 6 ii b)

ib) Report of WG on Snow and Climate

Sapporo Workshop JSH01 (see 6 ii a)

ic) Report of WG SNOMIP

A comprehensive report of the WG had been received and tabled as Appendix K. The report resumes the inter-comparison of selected models on data from four sites (France, Canada, USA, and Switzerland). These results have already been presented at ISSW 2002 and WGNE 2002 meetings.

ii) ***Report by Head of Division on Ice as a material***

No report was received from the Division Head.

iia) Report of WG on Frozen Ground and Rock Glaciers

No Report has been received.

iii) ***Report by Head of Division on Ice Sheets and Glaciers***

Julian Dowdeswell presented an oral report. The main emphasis concerned the WG on Andean Glaciology

iiia) Report of WG on Andean Glaciology

The Head of the Division stated that the progress of the WG on Andean Glaciology had been very unsatisfactory due to the lack of interest shown by the Chair (J.C. Leiva). Either the Chair would have to be replaced or the WG would have to be dissolved and a new proposal submitted. Georg Kaser added that the problem could be resolved at the meeting to be held in Valdivia, Chile, in March, where all interested parties from the Andean Glaciological Community would be present. A successor (Gino Casassa, CECS) to the Chair of the WG had already been proposed and had indicated his willingness to accept the position.

Action: Georg Kaser to confirm the replacement of the WG Chair after the Valdivia Workshop.

iv) ***Report by Head of Division on River, Lake and Sea Ice***
Manfred Lange tabled the Division Report (Appendix L) Two main activities were recorded – the 16th International Symposium on Ice (see 10 v) and the Sapporo Symposium (see 7 ii)

iva) Report of WG on River Ice
No activity since the last Bureau Meeting

ivb) Status of WG on Sea-ice Terminology
Progress is slow; however, discussions are being held with IAHR to join forces in this effort

ivc) Status of WG on Extra-terrestrial Ice
No activity since the last Bureau Meeting

15. Other ICSI Activities

i) ***ICSI Web Page***
The Secretary reported that this was an ongoing activity. All appropriate documents on ICSI/UNESCO/HKH-FRIEND activities will soon be incorporated into the site

ii) ***Other***
- ***GLIMS HIGH ICE Project***: an invitation to participate in this programme had been received from Jeff Kargel (Appendix M). The Program will develop GLIMS (Global Land Ice Measurements from Space) for the greater Himalaya (including the Hindu Kush) and extensions to adjoining High Asia. The over-arching political theme of HIGH ICE is the promotion of regional peace, security, and prosperity and improved East-West relations through glaciological studies. The program will include equal emphasis on remote sensing, field studies, and education. Science will include equal emphasis on pure science (glaciology) and science-based humanitarian tasks.

ICSI had replied positively to the request. The Commission noted that the HIGH-ICE collaborative project between GLIMS, NSIDC, and international educational institutions is very complementary to its own efforts in this area. ICSI would thus be receptive to co-operation through any common interests in the glaciology of the region. However, as ICSI is not an institution of higher education, it cannot participate directly in the program in the same manner as those referred to in the proposed program.

- ***Hydrology 2020*****:** It was suggested that P.Echevers, the ICSI Representative to IAHS-Hydrology 2020, should be invited to the next Bureau Meeting.

16. Any Other Business

The President suggested that in view of the ICSI initiative to attain Association status, the Commission should consider the opportunity of co-sponsoring a major conference on the Cryosphere in 2006. Liz Morris stated that IGS might be interested to participate. Other organisations, e.g. IPA or major global programs, e.g. CliC were also mentioned as possible partners in such an effort.

Action: Liz Morris will consult the IGS agenda for a possible date that would allow the society to participate in the organisation of the conference.

17. The Next Bureau Meeting

The next Bureau Meeting will be held early in 2004; either February or March.
Many suggestions were put forward:
Quebec City, Canada, host H.G. Jones
Cambridge, UK, host J. Dowdeswell
Oslo, Norway, host J.O. Hagen
Paris, France, host UNESCO
Davos, Switzerland, host P. Foehn
Innsbruck, Austria, host G. Kaser

The choice will be made later in 2003 – most probably after the General Assembly in Sapporo.

18. Closure

Georg Kaser proposed the closure of the Meeting at 18:45 on the 6th March
Seconded by Manfred Lange.

H.G. Jones, President. Georg Kaser, Secretary-Treasurer
May 16th 2003

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Eire

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Kazakhstan (Andrey Glazowsky will look for, 25.6.2003)

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Nepal

Nhe Netherlands fax am 1.4.03 (they will nominate only in Sapporo)

New Zealand mail am 26.3.03

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Venezuela

INTERNATIONAL COMMISSION ON SNOW AND ICE

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ICSI account between 6.3.02 (bureau meeting Paris) and 4.2.03 (bureau meeting Muenster)

					5.036,49	**Paris 02**
25.03.2002	736,30		cash	Paris cash ret. (740 - banking fees)	5.772,79	
31.03.2002		2,52	Hypo/Tirol	banking/interest	5.770,27	
02.05.2002		190,95	creative liaison (€ 216)	HKH-manual ch3 translation	5.579,32	
06.05.2002	1000,00		IAHS	Paris support	6.579,32	
06.05.2002		5,25	Hypo/Tirol	banking fees 1000	6.574,07	
14.05.2002		950,00	G. Jones	IAHS meeting Paris ?	5.624,07	
14.05.2002		18,26	Hypo/Tirol + Caisse Popolaire (Ca)	banking fees (950)	5.605,81	
30.06.2002		5,07	Hypo/Tirol	banking fees/interest	5.600,74	
08.07.2002	157,90		UNESCO Paris	€ 162,45 - final balance Kathmandu	5.758,64	
08.07.2002		9,28	Hypo/Tirol	banking fees 157,9	5.749,36	
03.09.2002	8700,00		UNESCO Paris	HKH-training contract 1st rate	14.449,36	
03.09.2002		5,73	Hypo/Tirol	banking fees 8700	14.443,63	
29.08.2002		5961,69	E. Heucke	2 drills (€ 6028,00)	8.481,94	
29.08.2002		29,91	Hypo-Tirol	banking fees	8.452,03	
29.08.2002		2980,85	E. Heucke	1 drill (€3014,00)	5.471,18	
29.08.2002		8,67	Hypo-Tirol	banking fees	5.462,51	
29.08.2002		301,50	M. Knaus (€ 300)	HKH-manual ch3 preparation	5.161,01	
30.09.2002		11,33	Hypo-Tirol	banking fees/interest	5.149,68	
20.12.2002		581,33	M. Knaus	climbing tools (€ 252,5+300) HKH	4.568,35	
31.12.2002		5,65	Hypo-Tirol	banking fees/interest	4.562,70	
17.01.2003	1000,00		UNESCO Paris	HKH-training contract 2nd rate	5.562,70	
17.01.2003		9,98	Hypo-Tirol	banking fees	5.552,72	
23.01.2003	1000,00		IAHS	Muenster support	**6.552,72**	**Muenster 03**

Innsbruck, 3.2.03

G. Kaser

INTERNATIONAL COMMISSION ON SNOW AND ICE

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Workshop on Glacier Mass Balance Measurements
KATHMANDU, March 2001
+ manual

BALANCE

	US$	US$			US$
Dat.	**In**	**Out**	from/for	reason	**acc.**
20.03.01	6,000.00		UNESCO	contract 1st rate	6,000.00
20.03.01		20.29	Hypo/Tirol	banking fees	5,979.71
03.04.01		1,800.00	G. Jones	travel expenses	4,179.71
22.06.01		2,200.00	J. Kargel (USGS)	travel expenses	1,979.71
22.06.01		19.50	Hypo/Tirol	banking fees	1,960.21
19.03.02		736.30	Creative Liaisons	translation part 3 man.	1,223,91
31.12.01	157,90		UNESCO	contract 2nd rate	1,381.81
31.12.01		9,28	Hypo/Tirol	banking fees	1,372.53
29.08.02		301.50	Knaus	manual part 3	1,071.03
	6,157.90	5,086.87			1,071.03

OeAV, A. Fountain, P. Jansson, G. Kaser have contributed to the manual for free, thus **US$ 1,071.03** enter the ICSI budget.

INTERNATIONAL COMMISSION ON SNOW AND ICE

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HKH-Training BUDGET

	IN	OUT			
1.	8700,00		UNESCO Paris	HKH-training contract 1st rate	
2.		5,73	Hypo/Tirol	banking fees 8700	
3.		5961,69	E. Heucke	2 drills (€ 6028,00)	
4.		29,91	Hypo-Tirol	banking fees	
5.		2980,85	E. Heucke	1 drill (€3014,00)	
6.		8,67	Hypo-Tirol	banking fees	
7.		301,50	M. Knaus (€ 300)	HKH-manual ch3 preparation	
8.		581,33	M. Knaus	climbing tools (€ 252,5+300) HKH	
9.	1000,00		UNESCO Paris	HKH-training contract 2nd rate	
10.		9,98	Hypo-Tirol	banking fees	
Sum	**9700,00**	**9879,66**			
					-179,66
				expected from UNESCO Delhi	**549,74**

Innsbruck, 3.2.03

G. Kaser

INTERNATIONAL COMMISSION ON SNOW AND ICE

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ICSI budget between Paris 02 and Muenster 03

	IN	OUT			BUDGET
1.	5.036,49		status Paris 02		
2.		340,00	G. Jones	CliC and IAP meetings	
3.		500,00	G. Jones	ICSI meeting Paris 02	
4.		300,00	J.O.Hagen	ICSI meeting Paris 02	
5.		300,00	M.Lange	ICSI meeting Paris 02	
6.		300,00	Q.Dahe	ICSI meeting Paris 02	
7.	1.000,00		IAHS	Paris support	
8.		970,00	G. Jones	IAHS meeting Paris	
9.	1.071,03		OeAV, A.Fountain,P.Jannson,G.Kaser	HKH Kathmandu surplus	
10.	1.000,00		IAHS	Muenster support	
11.		48,06	Hypo-Tirol	banking fees/interest	
Sum	8.107,52	-2.758,06			5.349,46

Bureau meeting support: 1.400,00
Other travel support: 1.310,00

Innsbruck, 3.2.03

G. Kaser

ICSW

The views of ICWS are focussed on the FRIEND issues in IHP VI, primarily because there has traditionally been a very close link between FRIEND (ICSW) and IAHS since its inception, with IAHS red books produced for each of the three conferences, Norway (1989), Germany (1993), Slovenia (1997). The president of ICWS was also asked by UNESCO to coordinate a FRIEND response to IHP VI. The corporate FRIEND response to UNESCO accords with the ICSW view and is also supported here especially the suggestion for revision of Theme 3. These parts are accommodated in the text below for Theme 3.

ICGW

Theme 1 Global changes and water resources

It is suggested that effects of the global changes on groundwater, especially groundwater recharge in and around semi-arid regions should be evaluated in relation with water resources management.

(Key ICGW names are Warren Wood and Ken Rainwater)

Theme 2 Integrated Watershed Dynamics

Focal Area 2.4 Ecohydrological approaches in the environmental system

It is suggested to study wetland hydrology as ecotone of groundwater and surface water. Riparian zones as the ecotone of groundwater and surface water and their environmental roles need to be clarified and evaluated quantitatively.

(Key ICGW names are Masaki Hayashi, Ramon Aravena and Norio Tase)

Theme 4 Water and Society

Problem of arsenic in groundwater is one of the most serious problems in the world, especially in the developing countries. The comprehensive approach to this problem is urgently needed and international cooperation (IHP, IAHS, SCOPE, WHO, NGO etc.) should be established.

(Key ICGW name Eduard Hoehn)

ICSI:

1.1. Global distribution of contemporary resources: water supply and water quality

Here the activities of the ICSI/World Glacier Monitoring Service are important and WGMS activities (which are part of GTOS) should be included. The Director of the WGMS, Wilfried Haeberli, and the Head of the ICSI Division on Glaciers and Ice Sheets, Julian Dowdeswell, are key figures. The Vice-Presidents Qin Dahe, and Georg Kaser and Gerry Jones of the ICSI Bureau who have oversight of South American and Himalayan glaciology respectively and are aware of the water resource implications.

1.3. Integrated assessment of water resources in the context of global change

Glaciologists have a keen interest in this topic as global warming can remove important reservoirs of freshwater as glaciers shrink. Improving techniques for mass balance studies of glaciers is an important part of ICSIs work (key ICSI names are Haeberli, Dowdeswell, Qin Dahe and Kaser as above and for the polar regions Jan-Ove Hagen and Liz Morris)

3.5. Hydrology of mountainous areas

This is an area in which the hydrology of ice and snow is often vital. ICSI has two working groups on high mountain areas (Andes and Himalaya) and a working group on Snow Modelling, which is also relevant. Many ICSI activities fall under this heading (Key ICSI names are- Qin Dahe, Kaser, Morris and Jones and Eric Brun).

5.1. Teaching techniques and material development at all levels

ICSI has for some time been planning training courses in the Himalayans and in the Andes, which are hoped to be supported by UNESCO as a contribution to IHP VI.

ICWQ

The commission will focus its activities on these particular areas.

Theme 1: Global changes and water resources:

Focal Area 1.1: Global distribution of contemporary resources: water supply and water quality (and especially the UNESCO/GWP Global Water Quality Initiative in which Commission officers have already been involved)

Focal Area 1.3: Integrated Assessment of water resources

Focal Area 1.4: Changing charater of receiving waters as a consequence of landbased activities.

Theme 3: Water and Society:

Focal Area 4.3: Water conflicts at various scales

Focal Area 4.5: Development and protection of vulnerable environments.

ICWRS:

Focal Area 1.3: Integrated assessment of water resources in the context of global change.

It is suggested integrate the use of system dynamics modelling of global water resources comprising sectors like persistent pollution, nonrenewable resources, population, agriculture, economy and water into this Focal Area. This type of tool will provide an excellent support for many of Suggested Activities.

(Key ICWRS name is S. Simonovic)

ICT:

Theme 2: Integrated Watershed Dynamics

It is planned to organize a workshop in Freiburg in December 1999 concerning The International Hydrological Programme" - Involvment of Tracers, jointly with IAEA. ICT is considered to play a leading role of NGO.

(Key ICT names for this theme are: Alain Dassargues and Chris Leibundgut)

Focal Area 3.1 Arid and semi-arid zones

Suggested activities: Continuation of the IHP-V initiative on Wadi-hydrology; Improvement of analysis of hydrological processes and modelling; Development of methods for recharge of aquifers and for the protection of groundwater.

(Key ICT names are Chris Leibundgut/Jens Lange /Freiburg), who are already involved in Phase V)

Focal Area 3.5 Hydrology of mountain areas

Suggested activity: Establishement of experimental basins also in remote areas considering the requirements and advantages of nested basin approaches

(Key ICT names are Chris Leibundgut and Stefan Uhlenbrook (Freiburg))

Theme 3.7 Urban water interactions in particular climate regions

1. for arid and semi-arid regions

An activity for coping with extremes in urban runoff is suggested.

(Key ICT name is Jens Lange)

Focal Area 4.1 Water and civilization

(Key ICT name is Jeff McDonell)

Theme 5 Knowledge, Information and Technology Transfer.
(Key ICT name is Chris Leibundgut)

Report on the IAHS Bureau Meeting, 2002.

As President of ICSI and IAHS Bureau Member, I represented the Commission at the IAHS Bureau Meeting held at the UNESCO Headquarters in Paris, France, on the 16th June 2002. In the following brief report I resume some of the points of interest to ICSI. The full IAHS minutes of the meeting should be circulated to the Commissions prior to, or at, the IAHS Bureau Meeting in Sapporo.

1*) General Remarks*: The Agenda was short and the meeting, which commenced at 9:00 hr, closed at 17:00 hr. No minutes relative to the last Bureau Meeting at Maastricht were tabled. Representatives of most, if not all, of the Commissions were in attendance. However, I cannot state unequivocally who they all were as no list of attendees was circulated.

2*) The Reports of the Bureau Officers*: The President dwelt mostly on new water programme initiatives e.g. PUB and the ICSU Joint Water Project. The latter was judged to be somewhat in conflict with the interests of IAHS and also seemed to lack co-ordination between the participants i.e. IGBP, WCRP, IHDP and DIVERSITAS. The Secretary General outlined his activities since Maastricht with particular attention being paid to the general preparations for Sapporo. The Treasurer was not present but a short account of the current balance (+ 20,000$US) was given; a recent e-mail (2nd August) from the Treasurer to the IAHS Bureau and the Commissions gives a more detailed budget for the first 6 months of this year. The Editor tabled a very comprehensive report in which he gave a perspective of his first five years in office. I am quite impressed by the dedication that Dr Kundzewicz displays in his task of running HSJ. IAHS Limited tabled a report. The WG 2020 also presented a report on their first year's activities including their role as `discussers' in the Kovacs Colloquium. The session concluded with the reports by the Commissions (see 3 below).

3) *The Reports of the Commissions*: The reports were tabled. Needless to say that the ICSI report - particularly the section 5 (ii) on ICSI Status within IUGG - drew the most pointed comments and remarks. Indeed at some moments the discussion became quite heated especially when statements such as ` Glaciologists have always been inward looking' and `the ICSI attitude that IAHS are a rotten bunch of so and sos' start to creep in to the debate! ICSI was then targeted for not participating in PUB (the result of the Takeuchi Initiative). It was obvious to me that ICSI was being singled out as the reports of only three of the other Commissions included a mention of PUB. My reply was that ICSI participates in a large number of activities every year but due to limited time and resources we cannot participate in all programmes and some sort of priority has to be set. The Commission has established that the current priorities are the UNESCO programmes that have been set up in the Himalayas and - hopefully - the Andes on the Glacier Monitoring Networks, WGMS financing and other activities such as the ICSI Task Force, SNOWMIP, the Sapporo symposium, workshops etc. ICSI attempts to develop these priorities with respect to its mandate and to best serve community it represents. In

addition, ICSI has always 'pulled its weight' as they put it -and even more - in IAHS; the number of ICSI symposia, workshops, RedBooks, UNESCO programs and other initiatives are there to prove it. Although time finally limited the discussion it was suggested that all commissions delegate representatives to PUB, as it is an Association initiative. This I agreed to.

4) *The Sapporo Elections*: IAHS wishes to set up only one Nominating Panel that would cover the Association and Commission Elections. I reiterated ICSI's position, which I had already made known to the Secretary General that ICSI would not participate in such a procedure and had already established its own Nominating Group. Most of the other Commissions accepted the IAHS procedure; ICCE and ICT, however, have to consult their Bureau members on the issue.

5) *International Hydrology Prize and the Tison A*ward: Not one nomination had been received from either Commission Officers or National Representatives. Thus there will be no awards this year.

6) *Miscellaneous*: It has been suggested that HSJ and Nordic Hydrology merge to become one single journal. Although little progress seems to have been made, future meetings on the issue are planned for the coming year.

H.G. Jones 3rd August 2002.

UNITED NATIONS EDUCATIONAL, SCIENTIFIC AND CULTURAL ORGANIZATION (UNESCO)

HINDU KUSH - HIMALAYAN FLOW REGIMES FROM INTERNATIONAL EXPERIMENTAL AND NETWORK DATA (HKH-FRIEND)

GLACIER RESEARCH GROUP, SCHOOL OF ENVIRONMENTAL SCIENCES JAWAHARLAL NEHRU UNIVERSITY, NEW DELHI

INTERNATIONAL COMMISSION ON SNOW AND ICE (ICSI), INTERNATIONAL ASSOCIATION OF HYDROLOGICAL SCIENCES (IAHS)

Report of the ICSI/HKH-FRIEND/UNESCO IHP
Training Course on Glacier Mass Balance Measurements
A Training and Technology Transfer Project within UNESCO IHP.

India International Centre, New Delhi
Directorate of Mountaineering and Allied Sports, Manali
Chhota Shigri Glacier, Lahul-Spiti Valley, Himachal Pradesh
September 24-October 12 2002

Contents

Appendices

1. Introduction

During the Workshop on Mass Balance Monitoring of Himalayan Glaciers held at the *International Centre for Integrated Mountain Development (ICIMOD)* in Kathmandu from March 20 to 24, 2001 two major steps have been defined necessary for meeting the requirements of the *Snow and Glacier Group of HKH-FRIEND*. Following, the *International Commission on Snow and Ice (ICSI)* of the *International Association of Hydrological Sciences (IAHS)* has provided

A manual for monitoring the mass balance of mountain glaciers with particular attention to low latitude characteristics
(Kaser, Fountain, and Jansson 2002)

and has lead the organisation of a

Training Course on Glacier Mass Balance Measurements

which was held in New Delhi, Manali (H.P.) and on Chhota Shigri Glacier, Lahaul-Spiti Valley, Himachal Pradesh from September 24 to October 12, 2002 (Schedule as Appendix I). The focus of the training course was on:

theoretical lectures following the manual,
glaciological field training, and
mountaineering and rescue training (see schedule as appendix I).

The local organisation was provided by members of the *Glacier Research Group, School of Environmental Sciences, Jawaharlal Nerhu University, New Delhi*. The lectures in New Delhi where held at the *India International Centre, IIC*.

Training in Manali and on Chhota Shigri Glacier was supported by the *Directorate of Mountaineering and Allied Sports (DMAS), Government of Himachal Pradesh, Manali - 175 131, District Kullu, Himachal Pradesh*.

The group of trainers was coordinated and lead by *ICSI* (Appendix II).
Trainees from India, Nepal and Bhutan attended the training course (Appendix III).

1. Preparatory phase

Based on a contract between UNESCO and ICSI, 3 steam drills for the installation and the maintenance of stake networks on glaciers where ordered and build by Erich Heucke in Munich. Density measurement kits where provided by the Institutes of Meteorology and Geophysics and Geography of Innsbruck University. The equipment was shipped to New Delhi with the help of UNESCO Paris and UNESCO New Delhi.

2. Inaugural Session

The training course was opened by an inaugural session on September 25, 2002 in which the following representatives paid their esteem for the training course in context of the importance of studying glaciers as both indicators of a changing climate and water towers for societies concentrated with high population densities on the foothills of the Himalayans.

Welcome Address:	Prof. Kasturi **Datta**	Dean, SES, JNU
Address:	Shri Y.P. **Kumar**	Head, International Division, DST
Address:	Dr. Mandira **Shrestha**	ICIMOD, Nepal [1]
Address:	Prof. Georg **Kaser**	Secretary ICSI, Austria
Address:	Prof. Syed I. **Hasnain**	SES, JNU
Inaugural Address:	Prof. M.**Tawfik**	Director and UNESCO rep.
Presidential Remarks:	Prof. Balveer **Arora**	Rector, JNU
Vote of Thanks:	Prof. J. **Bihari**	SES, JNU

[1] The Nepalese contingent had arrived with a one day delay because of a flight from Kathmandu to New Delhi being cancelled. Also included was Dr. Mandira **Shresta** which not only led the group and represented ICIMOD but also is the new head of HKH-FRIEND succeeding Prof. Shures **Chalise** which had retired from this function recently. Dr. **Shresta** gave here address on September 26.

3. Technical Presentations

Following the inaugural session, several researchers from India and abroad presented findings of their studies as technical presentations:

*Syed Iqbal **Hasnain**, JNU, India:*
Presentation on Chhota Shigri (benchmark glacier)

*Yutaka **Ageta**, Nagoya University, Japan*
Glacier mass balance studies in Nepal Himalaya

*Deepak **Srivastava**, Geol. Surv. of India, Lucknow, India*
Glacier mass balance studies conducted by GSI

*Peter **Jansson**, Stockholm University, Stockholm, Sweden*
Glacier Mass balance studies on Storglaciaeren

*Rijan Bhakta **Kayastha**, Nagoya University, Japan*
Estimation of glacier ablation in the Nepalese Himalaya by the energy balance model and positive degree-day method

*Christoph **Mayer**, Geol. Surv. of Denmark and Greenland, Dept. Quat. Geol., Denmark*
Mass balance studies on the Greenland Ice Sheet

*Bernard **Francou**, LGGE, Grenoble, France*
Glacier mass balance studies on Andean glaciers

*Georg **Kaser**, University of Innsbruck, Austria*
Glacier-climate interaction

*Capt. M. S. **Kohli**, Chairman, Himalayan Environment Trust*
Mountaineering experiences in Himalaya

4. Lectures and Exercises in New Dehi and Manali

Following the “Manual for monitoring the mass balance of mountain glaciers” (Kaser, Fountain and Jansson, 2002) P. **Jansson**, Ch. **Mayer**, G. **Kaser**, and M. **Knaus** lectured on theoretical and practical perspectives of glacier mass balance measurements as well as technical aspects of safe movement and rescue techniques on glaciers and some aspects of high altitude medicine. In addition, analyses of field data measured in the Alps where practiced. Several times, interesting and intensive discussions arose from trainees´ questions, which led also to a considerable improvement of the manual. Besides, the steam drills where checked and additional field equipment, such as bamboo stakes, shovels etc., was bought.

On September 28, trainees and trainers were transferred from New Delhi to Manali, Himachal Pradesh where accommodation was provided at the *Directorate of Mountaineering and Allied Sports (DMAS)* of the Government of Himachal Pradesh. The director of DMAS, Col. H. S. **Chauhan** welcomed the group and technical introductions were given by DMAS staff.

After a careful check of the trainees´ personal equipment missing items such as plastic boots, crampons, and harnesses were rented from the DMAS equipment stock. A support group from DMAS had already left for setting up a rope bridge over the Chandra River as well as the base camp in front of Chhota Shigri terminus. Tents, kitchen service, and first aid service were provided by DMAS as well as the bus transfer from Manali to where Chandra River had to be crossed.

5. Field Courses

On September 29, we departed from Manali by bus in order to reach Chhatru in the Lahaul-Spiti Valley crossing the 4,000 m high Rhotang Pass. At Chhatru we spent the first night in tents. Early next morning the group proceeded by bus for about 16 km up-valley in order to reach the rope bridge already prepared by DMAS staff members the day before. It took most of the remaining day to take the entire luggage piece by piece and the group members one by one to the other side of Chandra River and to carry all the equipment to the close base camp at 4,500 m.

Most members approached the next day the glacier tongue of Chhota Shigri. There first exercises in moving on snowfields were carried out, crampons and harnesses were tested and adjusted for the personal use. A path through the glacier fore field was prepared and marked and first loads of scientific equipment were carried to the tongue.

During the following days groups changed from exercise to exercise in order to get every trainee to practice on:

- Safety rules when walking on glaciers, use of crampons and rope, rescue techniques carried out in a moulin in the lower part of the tongue. The exercises were lead by M. **Knaus**.
- Selecting and marking the sites for ablation stakes (G. **Kaser**, B. **Francou**).
- Drilling stakes with two of the three steam drills (Ch. **Mayer,** G. **Kaser**).
- Measuring the position of the stakes by the application of a Global Positioning System, GPS (B. **Francou**). The GPS instruments were made generously available by IRD, France).
- Digging small snow pits and measuring the snow density close to the ablation stakes. (G. **Kaser**, Y. **Ageta**). First autumn precipitation events had covered the entire tongue with a 0.5 m snow cover.
- Each group had the opportunity to have one or two rest days.

When time was left, discussions and lectures take place in the afternoon at base camp. A small group reached the accumulation zone only towards the end of the course. The distance between the base camp and the accumulation area of Chhota Shigri turned out to be to long for an effective work on snow pits. On the other side, the shift of the base camp or of parts of it up the glacier was denied for logistic reasons and because only few trainees were prepared for such a high altitude and mountaineering experience. As a consequence, only one stake was set in the accumulation zone. For the mass balance measurement starting point of view this was not a drawback since accumulation needs only to be determined at the end of a mass balance year, i.e. by September 2003. From a training point of view we had to reduce the exercises to the small pits in the ablation area and to theoretical discussions.

At the beginning, Pierre **Chevallier** from IRD France accompanied the group exploring the area for possible water runoff gauging stations to be implemented to the Chhota Shigri glacier mass balance monitoring project.

On October 8 we returned to Manali.

6. Lectures and Exercises B

On October 9 we took the opportunity to complete the experiences gained in the field by a few complementary theoretical exercises. For instance, data measured in the snow pits and synthetically composed data sets were analysed in order to determine the mass balance at selected points of the glaciers. We also repeated the technical details of the steam drill and the GPS.

7. Group Interviews

In order to address the particular skills and problems of each group, the JNU University group, the group of members of different National Services of India, the Nepalese group and the member from Bhutan were interviewed separately by the leader of the trainer´s team G. **Kaser** (ICSI). Different topics such as the need for mountaineering training, data collection, data distribution and the possibilities for starting and running one or more glacier mass balance series where addressed. These demands have to be solved differently by the different groups. A University group is, for instance, more flexible but cannot count on a regular support such as it may be true for a national service group belonging to a Ministry. It was, e.g., strongly recommended that National Services in India should change from short-term investigations on different glaciers to long series on one or two glaciers. In addition, it was recommended that already existing mass balance measurements and programs should be reported to the World Glacier Monitoring Service, WGMS, regularly. The groups shall contact WGMS. Problems in Nepal and Bhutan, in turn, are different from India not only from a logistic point of view but also because of the different structures of the National Services and their cooperation with University groups. Several possibilities for starting a glacier mass balance program were illuminated.

8. Concluding Session

The Training Course on Glacier Mass Balance Measurements was officially closed in a cheerful and amicable concluding session chaired by Prof. S.I. **Hasnain**.

On October 10, the group leaves Manali in order to return to New Delhi and back home.

9. Financial support

The training course was financed by:

UNESCO IHP, Water Science Division, Paris
UNESCO New Delhi
School of Environmental Sciences, Jawaharlal Nerhu University, New Delhi, India
Department of Science & Technology, Govt. of India
Institut de Recherche pour le Développement (IRD), France
IHP Austrian National Committee, Austria
Graduate School of Environmental Studies, Nagoya University, Japan

10. Final remarks

Chhota Shigri is a suitable glacier to monitor the mass balance although logistic problems in the accumulation part of the glacier request for mountaineering skills and a camp support on higher elevation than base camp. Still, the training course campsite is the best place for a base camp and for supporting fieldwork in the ablation area. IN addition, a small solid hut on a moraine close to the equilibrium line is recommend. In terms of mass balance measurements three visits per year are recommend:

1. at the end of the winter accumulation period and before considerable melting starts in order to measure the winter accumulation. In reality, the choice of this date is restricted to the opening of Rhotang Pass after winter closure.
2. by the end of August before first autumn snowfalls take place. This visit ensures to find all ablation stakes and to map the actual snow line, which may usually not change very much for the following weeks.
3. by the End of September / beginning of October in order to meet the end of the hydrological mass balance year. During this visit all accumulation and ablation measurements have to be carried out.

The glacier is composed by three main ice bodies, which can be clearly distinguished from each other by dynamic points of view. For mass balance purposes it is suggested to concentrate on the middle glacier, which is not only the biggest but also fairly debris free down to the terminus. For hydrological considerations the other branches must be either measured too or modelled.

Looking to a future **Glacier Mass Balance Network** the selection of benchmark glaciers in **Garhwal Himal** and **Sikkim** were discussed with the Indian groups.

In **Nepal**, in addition to the glaciers to be selected by the Department of Hydrology and Meteorology, ICIMOD plans to start a mass balance study on a glacier to be selected in **Mustang Valley**. This would provide a highly valuable and interesting site in a particular dry region. In **Bhutan**, mass balance measurements on one glacier are highly desirable too.

11. Further recommendations

It is strongly recommended

To carry out an *Assessment of the First-Year Data Acquisition from Training Course methodology,* by ICSI and HKH-FRIEND, in 2003;

To assist different groups in getting a glacier mass balance started. This is of particular need where groups cannot relay on already existing experiences such as the ICIMOD group when attempting to start a study in Mustang Valley and the Bhutanese group (2003/2004).

To complete a *Technical Appraisal of the Methodology used in the start-up of the Glacier Monitoring Network,* by ICSI and HKH-FRIEND, 2004.

Innsbruck, 19.12.2002

Georg Kaser
International Commission on Snow and Ice

APPENDIX I

HKH-FRIEND – UNESCO – ICSI

Training course on Glacier Mass Balance Measurements

New Delhi and Chhota Shigri (Himachal Pradesh)

24.9. – 12.10.2002

Training Course Schedule

September 24, 2002, New Delhi
Arrival of trainers and trainees
(participants from Nepal have come in only on September 25 due to cancellations of flights from Kathmandu to Delhi)

September 25, 2002, India International Centre, New Delhi
Inaugural Session
Technical Presentations
Lectures and exercises following the manual

September 26, 2002, India International Centre, New Delhi
Technical Presentations
Lectures and exercises following the manual

September 27, 2002, India International Centre, New Delhi
Lectures and exercises following the manual

September 28, 2002
Transfer from New Delhi to Manali

September 29, 2002, DMAS Manali
Equipment Check and completion
Adjustment to altitude

September 30, 2002
Transfer from Manali to Chattru via Rothang Pass (by bus)

October 1, 2002
Transfer from Chattru to Chhota Shigri Base Camp (by bus and walking)

October 2 - 7, 2002, Chhota Shigri Glacier
Field course in glaciology, mountaineering and rescue techniques

October 8, 2002
Transfer from Chhota Shigri Base Camp to DMAS Manali

October 9, 2002, DMAS Manali
Lectures and exercises following the manual
Interviews with individual groups
Final discussion
Closure

October 10, 2002
Transfer from Manali to New Delhi

October 11 and 12, 2002
Departure of trainees and trainers from New Delhi.

APPENDIX II

HKH-FRIEND – UNESCO – ICSI

Training course on Glacier Mass Balance Measurements

New Delhi and Chhota Shigri (Himachal Pradesh)

24.9. – 12.10.2002

ICSI team - resource persons

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travel expenses covered by IHP Austria

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P. Jansson had to leave the course after the lectures in New Delhi

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travel expenses covered by UNESCO New Delhi

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APPENDIX III

HKH-FRIEND – UNESCO – ICSI

Training course on Glacier Mass Balance Measurements

New Delhi and Chhota Shigri (Himachal Pradesh)

24.9. – 12.10.2002

Participants

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10	Sharad Joshi	Cartographer	Water & Energy Commission, Ministry of Water Resources, Kathmandu, Nepal	Nepal		UNESCO trainee
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The International Commission on Snow and Ice (ICSI): a proposal for the funding of two projects on training and technology transfer within the UNESCO IHP programme, 2002-2008.

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Summary
This document describes two projects, ICSI/UNESCO/HKH-FRIEND and ICSI/UNESCO/ANDEAN-FRIEND, which the International Commission on Snow and Ice (ICSI) wishes to implement over the period 2002 - 2008 and for which the Commission requests sustained funding. The projects are:

- **ICSI/UNESCO/HKH-FRIEND**, 2002-2004, consists of a *Field Training Course* on a chosen benchmark glacier, 2002; an *Assessment of the First-Year Data Acquisition from Training Course methodology*, 2003; and a *Technical Appraisal of the Methodology used in the start-up of the Glacier Monitoring Network,* 2004.

- **ICSI/UNESCO/ANDEAN-FRIEND**, 2004-2008, consists of preparing the *Groundwork for an Andean Glacier Network* for the Mass-balance Monitoring of Andean Ice Reserves in 2004-2006, a *Workshop to define the Andean Glacier Network* in 2005/6, a *Mass Balance Training Course* for Local Technical Personnel in 2006/7, and the *Supervision of the First-Year Data Acquisition and Data Analyses*, 2008.

The details on **ICSI/UNESCO/HKH-FRIEND**, the on-going project that was defined during the Kathmandu Workshop in March 2001, include a description of the activities, the participants and the appropriate budgets. The budgets are: Year 1, 2002, $21,202; Year 2, 2003, $8,023 and Year 3, 2004, $8,580. Total budget, 2002-2004, $37,805.

The details on **ICSI/UNESCO/ANDEAN-FRIEND**, consist only of general outlines on the objectives and the needs to achieve these objectives, and approximate budgets. The budget for 2004 is $9,600. Each two-year period would see the submission of more detailed up-dated versions of the projects as they evolve.

Contents

1) ***Introduction***

1.1) *The International Commission on Snow and Ice (ICSI)*

ICSI is the responsible body within the International Association of Hydrological sciences (IAHS) of the International Union of Geodesy and Geophysics (IUGG) for the advancement of the study of naturally occurring snow and ice. ICSI carries out its mandate through means that include the promotion of scientific investigation into the dynamics and physical characteristics of snow and ice systems, which comprise the Cryosphere, and the interactions between the Cryosphere, Atmosphere, Hydrosphere and Biosphere. The Commission also participates in programmes on problems of snow and ice that require international cooperation through the initiation and coordination of studies as well as providing a forum for the discussion, comparison and publication of research results. ICSI officers and members are able to provide expert advice on glaciological issues to governmental and non-governmental organisations.

1.2) *Climate Change: Global glacier freshwater reserves*

One of the main concerns of ICSI is the interaction between the cryosphere and climate - particularly with respect to the effects of climate change on the reserves of freshwater that are found in glaciers and ice caps. Recent changes in glacier characteristics have been noted on all continents and wastage of ice reserves is now acknowledged to be significant, albeit to different degrees, in mountainous regions of the World. The annual rate of increase or decrease in individual glacier ice reserves can be measured by the changes in the mass balance of the glacier ice. Changes in the mass balance of glaciers in most of the Earth glacier regions have been compiled and archived by the World Glacier Monitoring Service (WGMS). The data is made available through the publication series Α Glacier Mass Balance Bulletin @, Α Fluctuation of Glaciers @ and other associated works (e.g WGMS, 2001; WGMS; 1998; UNESCO, 1998). ICSI is responsible for WGMS, which is a permanent service of the Federation of Astronomical and Geophysical Services (FAGS), United Nations Environment Programme (UNEP).

1.3) *The Himalayan and Andean Glaciers: Regional reserves and implications for resource management.*

Two important regional glacier ice reserves of the Globe are the Himalayas in Central Asia and the Andes in South America. Both Himalayan glaciers and Andean glaciers are significant factors in the potential effects of Global Change. The wastage of the total Himalayan glacier ice reserves could contribute 16% and the wastage of Andean ice 13% to the total meltwater volume released from all of World glaciers and ice caps - excluding the ice in Antarctica and the Greenland Ice Cap (Haeberli, 1998). The amount of meltwater from Himalayan and Andean glaciers may seem insignificant compared to that which could be released from Antarctica and Greenland as these two latter regions harbour over 95% of the freshwater reserves of the Planet. However, the consequences of loss of regional glacier freshwater supplies to the downstream areas of Himalayan and Andean hydrological basins will bring about profound changes to the environment and social and economic life, particularly of heavily populated areas, as flow regimes become radically altered. Some Himalayan glaciers are now known to be receding rapidly (ICSI, 1999) but knowledge on the regional reaction of Himalayan and Andean glaciers to climate change, whether it be wastage, accretion or equilibrium of the ice reserves, is required. This concept of regional climate-glacier interaction requires the establishment of a Glacier Monitoring Network. The resulting data can then be used for the elaboration of regional hydrological models that will allow optimal management of water resources and sustainable development within a framework of both short- and long-term changes in downstream flow regimes.

1.4) *The Measurement and Monitoring of Glacier Change.*

Measurements of glacier change can include changes in length, area, volume and thickness and mass balance (UNESCO 1970/1973). Mass balance provides a direct signal of climatic change. The method of measurement involves selecting a number of individual points on a glacier surface from tongue to crest and determining the net balance (accumulation of snow/ice minus the ablation of snow/ice) between two time steps. Accumulation is calculated from the depth and density of the snow pack on the glacier. Ablation is measured on graduated ablation stakes installed into glacier ice. The difference between stake heights during the measurement period multiplied by the density of ice gives ablation. Iso-lines of net mass balance are drawn from point data and the total mass balance then calculated for the whole glacier (a detailed description of climate-glacier interaction and the theory and measurement of glacier mass balance can be found in ICSI/UNESCO-IHP/HKH FRIEND, 2001). The long-term monitoring of regional glacier mass balance changes involves the selection of a number of benchmark glaciers, which constitute a regional Glacier Monitoring Network (GMN).

2 ***Background to the Proposal***

2.1) *The Kathmandu Workshop of March 2001.*

In 1999-2001, ICSI collaborated with the Division of Water Sciences of the United Nations Educational, Scientific and Cultural Organisation (UNESCO) and the Hindu Kush-Himalayan regional association of countries participating in the Flow Regimes from International Experimental and Network Data Programme (HKH-FRIEND) of the UNESCO International Hydrological Programme (UNESCO/IHP), in a project on training and technology transfer within the UNESCO IHP programme. A workshop on the Mass Balance Monitoring of Himalayan Glaciers was held at the International Centre for Integrated Mountain Development (ICIMOD), Kathmandu, from March 20 to 24, 2001. The workshop was sponsored by UNESCO/IHP and organized by the Snow and Glacier Group of HKH-FRIEND in collaboration with the HKH-FRIEND Secretariat and ICSI. The workshop was attended by 21 participants and observers from the regional countries viz. Nepal (Department of Hydrology and Meteorology and Tribhuvan University) and India (Jawaharlal Nehru University), UNESCO/IHP, ICSI, and ICIMOD.

The main objectives of the workshop were:

1) To select representative basins in the Hindu Kush-Himalayas for mass balance measurements of glaciers,

2) To select techniques of mass balance measurement suitable for the Hindu Kush-Himalayas,

3) To develop a training course for technical personnel in mass balance measurement

4) To assign responsibilities to the experts to develop a manual for the training course.

2.2) *Workshop recommendations: Glacier Monitoring network*

The Workshop Report (ICSI/UNESCO-IHP/HKH FRIEND, 2001) recommended that the choice of benchmark glaciers should be based on scientific criteria. Each should have a well defined catchment area, be easy to access, be small (approx. 5-6 km^2) with clean smooth ice and at least a 1000m span with 6-7^oC temperature range from head to foot including distinct accumulation and ablation zones. There should be a well-defined tongue and relatively stable ice dynamics i.e. no surge characteristics. The glaciers should be well distributed with respect to the differences in regional climate. HKH-FRIEND is presently in the act of selecting glaciers for the glacier monitoring network. One of the benchmark glaciers would be the venue for the training of personnel in mass balance measurement techniques.

2.3) *Workshop recommendations: Field Training Course*

The measurement of mass balance focuses on snow-pit stratigraphy and the use of stakes placed according to glacier geometry. The workshop recommended that a training course be developed for the hands-on-training of the chosen monitoring techniques. Trainee candidates would be technical staff preferably with experience in fieldwork who would carry out the monitoring on a regular basis. The course would consist of basic lectures in glacier and snow cover dynamics and field training. A manual on both the theoretical aspects and field techniques of mass balance measurement would be prepared by ICSI while HKH-FRIEND would choose the institution for the theoretical course and the benchmark glacier for the fieldwork.

It was recommended that the fieldwork include, demonstrations of safety precautions and techniques on the glacier surface, use of equipment such as steam drills and GPS/ theodolites, instruction on the choice of stake network, the installing of stakes and snow pit observations, and the recording and archiving of data. The archiving of data should be formatted to be easily available to international centres on glacier data collection such as WGMS and WDC-A. On-ice work would be assigned to trainee teams of 3-4 persons, with each team being supplemented by porters for the transport of goods and field equipment.

The recommended minimum training period was two weeks. Timing of the training course was preferred to be the post-monsoon season. Initially October 2001 was proposed. However, it was agreed that the time necessary to prepare a proposal and have it funded was limited and the workshop recommendation was to shift the course to a later date.

The first part of this proposal describes the steps that have already been taken by ICSI and HKH-FRIEND in the establishment of the training course for regional technical personnel in mass balance measurements of glacier ice. It particularly specifies the role of ICSI, the personnel of the ICSI contingent, the activities involved and the budget for the years 2002-2004.

The second part of the proposal describes ICSI=s intention to extend similar activities to the

Andean Glaciers during the period 2004-2008.

3) ***The Proposal***

3.1) *Part One: ICSI/UNESCO-IHP/HKH-FRIEND Training Course, Objectives 2002-2004*

The objectives of the Course are:

1) To hold the *Field Training Course* for HKH-FRIEND trainees by a ICSI Expert Contingent on a chosen benchmark glacier, 2002;

2) To carry out an *Assessment of the First-Year Data Acquisition from Training Course methodology*, by ICSI and HKH-FRIEND, 2003;

3) To complete a *Technical Appraisal of the Methodology used in the start-up of the Glacier Monitoring Network,* by ICSI and HKH-FRIEND, 2004.

3.2) *Steps already accomplished towards holding the Training Course*

The following steps have been taken to achieve the above objectives:

1) Professor Syed Iqbal Hasnain of the Glacier Research Group, School of Environmental Sciences, Jawaharlal Nehru University, New Delhi, and member both of the ICSI Contingent to the Kathmandu Workshop and HKH-FRIEND, submitted a proposal entitled AProposal for Support to the ICSI-UNESCO Training Course on Mass Balance Measurements at Chhotta Shigri Glacier, Lahul-Spiti Valley, Himachal Pradesh@ to the Department of Science and Technology, Government of India. The proposal was accepted in September 2001. The proposal (Hasnain, 2001: Attached) covers all the costs of the training course except those incurred by international travel of the ICSI Expert Contingent and the trainees in travelling to and from New Delhi. The trainees will come from India (10), Nepal (6) and Bhutan (4). The proposal covers notably the local transport for the experts and trainees, accommodation for teachers at the India International Centre, accommodation for trainees at the JNU University Guest House, per diem for the participants, transport New Delhi to Glacier road-head and back. It also covers the hiring of tents, cooking gas, stove, certain field equipment, utensils, cook and porter charges, the construction of a rope bridge access to the site, a high altitude per diem, and certain contingency expenses. The training course will consist of a theoretical course at New Delhi, September 23-25; travel to Chhotta Shigri glacier, September 26-27; on-site field training September 28 to October 6, 2002. Chhotta Shigri has been selected as a benchmark glacier of the HKH-FRIEND Glacier Monitoring Network.

2) Professor Suresh Chalise of the International Centre for Integrated Mountain Development (ICIMOD) and Executive Secretary, HKH-FRIEND, has allocated ($12,000) to cover the travel of trainees from Nepal and Bhutan to New Delhi.

3) ICSI has formed its Expert Contingent (3.3) under the leadership of Georg Kaser of the University of Innsbruck.

3.3) *The roles and personnel of the ICSI Training Course Contingent*

The roles of the ICSI Expert Contingent are:

1) To be responsible for the teaching of the theoretical course on mass balance and its measurement to HKH-FRIEND trainees

2) To instruct trainees in the field on the techniques of mass balance measurements on glacier ice

3) To advise and guide trainees in assuring personal safety by the illustration and adoption of teamwork and mountaineering safety techniques

4) To supply trainees with a manual on the theory and practise of mass balance studies for the theoretical and field courses

5) To furnish specialised equipment, steam drills and densitometers for use in mass balance measurements, and on-ice operational gear

6) To evaluate, in collaboration with HKH-FRIEND, the results of the training course by an inspection of installed training-site equipment and an examination of the data one year after the training course

7) To compile the results and experiences of the training course and apply them, in collaboration with HKH-FRIEND, to the HKH-FRIEND Glacier Monitoring Network.

Roles 1), 2), 3), 4) and 5) are related directly to objective 1 (see 3.1), role 6) to objective 2, and role 7) to objective 3.

The ICSI Expert Contingent consists of internationally renowned scientists in the fields of theoretical glaciology and experienced practitioners in field glacier studies.

The personnel is:

1) **Professor A. Ageta**, Nagoya University, Japan. Professor Ageta will be a participant in the instruction on field techniques.

2) **Andrew Fountain**, Portland University, Oregon, USA. Dr Fountain is an author of the manual (see 4, 3.3 above) and will also participate in the theoretical course and the practical field course

3) **Martin Funk**, Federal Institute of Technology (ETH), Zurich, Switzerland. Dr Funk

will participate in the theoretical course and the practical field course and will also instruct trainees in safety techniques.

4) **Professor S. I. Hasnain**, Jawarharlal Nehru University, New Delhi, India. Professor Hasnain will be a participant in both the theoretical and practical field courses.

5) **G. Kaser**, Institut fuer Geographie, Universitaet Innsbruck, Innsbruck, Austria. Dr Kaser will lead the ICSI contingent. He is an author of the manual (see 4, 3.3 above) and will also participate in the theoretical course and the practical field course.

6) **Mathias Knaus,** Institut fuer Geographie, Universitaet Innsbruck, Innsbruck, Austria. Dr Knaus is the author of the rescue and safety chapter in the manual. He will instruct trainees in safety techniques during glaciological field work.

7) **Patrick Wagnon**, IRG-LGGE, St Martin d'Hères, Grenoble, France. Dr Wagnon is a glaciologist and high altitude 1st class climber, Bolivian Andes. He will participate in the theoretical course, the practical field course and safety instruction.

Dr Kaser will lead:

1) The whole of the above contingent to Chhotta Shigri for the September/October 2002 *Field Training Course* (3.1, objective 1)

2) A reduced contingent of three experts to Kathmandu, New Delhi and Chhotta Shigri for the *Assessment of the First-Year Data Acquisition from Training Course methodology* in October 2003 (objective 2)

3) A reduced contingent of two plus the President or President-Elect of ICSI to Kathmandu for the *Technical Appraisal of the Methodology used in the start-up of the Glacier Monitoring Network* in October 2004 (objective 3).

The ICSI/UNESCO-IHP/HKH-FRIEND project will terminate in 2004/5, the final report to be submitted in 2005 (see 5.1 below).

3.4) *Part Two: ICSI/UNESCO-IHP/ANDEAN-FRIEND Objectives, 2004-2008*

The objectives of the ICSI/UNESCO-IHP/ANDEAN-FRIEND are:

1) To prepare the *Groundwork for an Andean Glacier Network* for the Mass-balance Monitoring of Andean Ice Reserves in collaboration with a SOUTH-AMERICAN or ANDEAN FRIEND during 2004

2) To hold a *Workshop to define the Andean Glacier Network* in 2005/6

3) To develop a *Mass Balance Training Course* for Local Technical Personnel in 2006/7

4) To undertake the *Supervision of the First-Year Data Acquisition and Data Analyses*, 2008.

3.5) *Overview of ICSI/UNESCO-IHP/ANDEAN-FRIEND activities, 2004-2008*

It is difficult at the present time to foresee precisely the nature and the timetable of ICSI=s attempt to establish a project on Andean glaciers similar to that of the ICSI/UNESCO-IHP/HKH-FRIEND project. The collaboration in the development and progress of the ICSI/UNESCO-IHP/HKH-FRIEND project has been successful to the point that it could be a template for the initiation of an Andean Glacier Network program. In the development of the ICSI/UNESCO-IHP/HKH-FRIEND project, the FRIEND project of UNESCO IHP-V was chosen as the base on which ICSI could achieve its transfer of expertise and technological training. FRIEND represents an on-going (1985-) international study in regional hydrology involving research institutes, universities and operational agencies from over 90 countries. FRIEND is structured for the mutual exchange of data, knowledge and techniques on a regional basis and HKH-FRIEND proved to be conducive to the setting up of a glacier monitoring network.

FRIEND thus contains the elements that are conducive to the proposed ICSI/UNESCO-IHP/ANDEAN Glacier Monitoring Network project. However, there is presently no SOUTH AMERICAN- or ANDEAN-FRIEND equivalent to HKH-FRIEND within which ICSI could develop a training program and establishment of a Glacier Monitoring Network analogous to those of the ICSI/UNESCO-IHP/HKH-FRIEND project. Recently, there have been several indications of support notably at IHP Council meetings for the formation of a SOUTH AMERICAN- or ANDEAN-FRIEND. These are notably by UNESCO Programme Offices in Montevideo, the Director of CATHALAC in the Republic of Panama, the national representatives of Argentina and certain scientific workers in Peru (Alan Gustard and Georg Kaser, personal communications). There is also interest to initiate the process by the UNESCO Paris Office and the Chair of the FRIEND Intergroup Coordination Committee (FIGCC).

In the light of this interest shown by regional groups, UNESCO and FIGCC and the desire of ICSI to develop its training of personnel in monitoring Andean glaciers, ICSI is prepared to work closely with all interested parties in initiating and consolidating an ANDEAN-FRIEND. Although there are presently many political and economic constraints in the Andean countries to new initiatives, it is felt that a step-wise approach (2004-2008) to obtaining support among the administrative and scientific personnel of certain key countries of the Cordillera would be fruitful.

To initiate the process, the following activities will be undertaken:

1) *Formation of a ICSI/UNESCO-IHP/FIGCC Working Group*. With respect to objective 1) (3.4), ICSI and UNESCO-IHP and FIGCC will set up a small working group in 2004 to examine a step-wise approach to the formation of an ANDEAN-FRIEND that respects regional scientific and social issues. ICSI will be responsible for identifying the regional climatic and hydrological context of the Andean Cordillera and the science that has to be

taken into account in the development of any regional glacier monitoring network. ICSI will also identify the scientific community with the expertise in Andean Glaciology. Individuals from this community, who express an interest in developing the ANDEAN-FRIEND should be working group members. UNESCO-IHP will advise the working group on official procedures and identify and facilitate communications with the good offices of IHP Committees and UNESCO regional representatives. FIGCC will advise the working group on the formation, the modus operandi and integration of an ANDEAN-FRIEND into the FRIEND community.

2) *ANDEAN-FRIEND Steering Committee*. Subsequent to the above groundwork, the regional interested parties will form an ANDEAN-FRIEND Steering Committee on 2004/5. ICSI, will then collaborate with UNESCO-IHP and the secretariat of ANDEAN-FRIEND and UNESCO-IHP in holding a Workshop in one of the ANDEAN-FRIEND countries to define the Andean Glacier Network in 2005/6 (Objective 2, 3.4). ICSI would assume the responsibilities that it assumed at the ICSI/UNESCO-IHP/HKH-FRIEND Workshop at Kathmandu in March 2001.

3) *ANDEAN-FRIEND Training Course*. The recommendation of the workshop will lead to the development of a Mass Balance Theoretical and Field Training Course for Local Technical Personnel in 2006/7 (Objective 3, 3.4) followed by the Supervision of the First-Year Data Acquisition and Data Analyses in 2008 (Objective 4, 3.4).

4) ***Budget***

4.1) ***ICSI/UNESCO-IHP/HKH-FRIEND***

Year 1, September/October 2002, HKH-FRIEND Training Course, Chhotta Shigri, India.

Airfare (ICSI Contingent member, Country of Origin; international normal economy fare Country of origin-New Delhi)

1) **Professor A. Ageta**, Japan, **$3,078** ($3,028+$50 tax)

2) **Andrew Fountain**, USA, **$2,011** ($1,961+$50 tax)

3) **Martin Funk**, Switzerland, **$1,250** ($1,200+$50 tax)

4) **Professor S. I. Hasnain**, New Delhi, **$0**

5) **G. Kaser**, Austria, **$1,084** ($1,034+$50 tax)

6) **Mathias Knaus,** Austria, **$1,084** ($1,034+$50 tax)

7) **Patrick Wagnon**, France, **$1,350** ($1,300+$50 tax)

Total, international air travel, $9,857

En-route cost (meals) and incidental allowance

7 persons, 1 travel day @ $25, meals; $20, incidental allowance

Total en-route cost $315

Equipment for Chhotta Shigri Mass Balance Measurements

Steam Drills, 3, @ $2,660 per drill kit (Euro 2961 - as per estimation of the Heucke Ice Drill Eisbohrgeräte, Grafing, Germany, July 8, 2001)	**$7,980**
Densitometers 8 @ $100 per kit (as per estimation, University of Innsbruck)	**$800**
On-ice operational gear: ropes, poles, GPS, ice axes etc	**$1,750**
Equipment shipping costs	**$500**

Total Equipment cost $11,780

Total Cost (Year 1) ***$21,202***

Year 2, September/October 2003, Chhotta Shigri, India, and Kathmandu Nepal.

Airfare (ICSI Contingent member, Country of Origin; international normal economy fare Country of origin-New Delhi-Kathmandu)

1) **G. Kaser**, Austria, **$1,084** ($1,034+$50 tax)

2) **Andrew Fountain,** USA, **$2,011** ($1,961+$50 tax)

3) **To be determined**, ditto, **$1,458** ($1,408 i.e. mean international airfare+$50 tax)

Total, international air travel, **$4, 553**

Expenses: per diem (meals/accommodation) and incidental allowance New Delhi/Kathmandu

3 persons, 12 days @ $55, per diem; $20, incidental allowance

Total per diem/incidental **$2,700**

Transport: New Delhi-Chhotta Shigri-New Delhi

Hire of vehicle and vehicle operation, 7 days @ $110 per day **$770**

Total Cost (Year 2) ***$8, 023***

Year 3, September/October 2004, Kathmandu Nepal.

Airfare (ICSI Contingent member, Country of Origin; estimated future international normal economy fare Country of origin-Kathmandu)

1) **G. Kaser**, Austria, **$1,200**

2) **Andrew Fountain,** USA, **$2,300**

3) **President or President-Elect, ICSI**, Canada/???, **$2,200**

Total, international air travel, **$5, 700**

Expenses: estimated per diem (meals/accommodation) and incidental allowance Kathmandu

3 persons, 12 days @ $60, per diem; $20, incidental allowance

Total per diem/incidental **$2,880**

Total Cost (Year 3) ***$8, 580***

Total Cost ICSI/UNESCO-IHP/HKH-FRIEND (Years 1,2,3) ***$37, 805***

4.2) ***ICSI/UNESCO-IHP/ANDEAN-FRIEND***

Year 1, 2004, Formation of the ICSI/UNESCO-IHP/FIGCC Working Group

Estimated airfare, ICSI, Travel within Europe and South America/Europe/South America

2 persons, ICSI **$ 6,000**

Approximate accommodation and per diem expenses, Europe/South America

2 persons, 12 days @ $150 per day **$ 3,600**

Total estimated cost for ICSI participants, Year 1 ***$ 9, 600***

Budgets for Years 2 (2005); 3, 2006; 4, 2007, will be submitted as the project develops.

5) ***Deliverables-Progress reports***

1) August 2003, Report on the Chhotta Shigri Training Course of October 2002

2) August 2004, Report on the Assessment of the Chhotta Shigri Training Course of October 2003

3) August 2005, Final Report on the ICSI/UNESCO-IHP/HKH-FRIEND Training Programme and establishment of the HKH-FRIEND Glacier Monitoring Network

4) October 2005, Initial Report by the ICSI/UNESCO-IHP/FIGCC on the deliberations and recommendations of the ANDEAN-FRIEND Working Group.

6) ***Other pertinent information***:

The Snow And Glacier Aspects of water Resource Management in the HimalayA (SAGARMATHA) Project, which is funded by the DFID, UK, and under the management responsibility of Centre of Ecology and Hydrology (CEH), Wallingford, UK, has been set up to assess the seasonal and long-term water resources in snow and glacier fed rivers in the HKH-Himalaya region . The overall goal is to determine strategies for coping with the impacts of climate change. Two important activities of this project i.e. the installation of Glacier Monitoring Equipment and the development of a snow/glacier model are very complementary to the operations and objectives of the ICSI/UNESCO-IHP/HKH-FRIEND Glacier Monitoring Network. The SAGARMATHA project manager, Gwyn Rees of CEH foresees the installation of two Automatic Weather Stations (AWS) on Glacier sites in the summer of 2002. Both Mr Rees and the ICSI Contingent of ICSI/UNESCO-IHP/HKH-FRIEND are of the opinion that the choice of common glacier sites for both the SAGARMATHA AWS and the ICSI/UNESCO-IHP/HKH-FRIEND mass balance monitoring sites should be definitely considered. It is extremely important that the exchange of SAGARMATHA climate data and the ICSI/UNESCO-IHP/HKH-FRIEND mass balance data in calibrating and validating the snow/glacier model be undertaken with the least possible error relative to spatial variability.

The Centre for Ecology and Hydrology has also indicated its interest in the ICSI/UNESCO-IHP/FIGCC ANDEAN-FRIEND Project and may contribute funding to the working group meetings in 2004 (Alan Gustard, personal communication).

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Election of Officers at the IUGG General Assembly, Sapporo 29 June – 12 July 2003.

Nomination Procedure (Regulation 10)

1) 10 months before the Assembly i.e. August 29 2002. Formation of the ICSI Nomination Group. The Group consists of the President, who should act as Secretary, the two most recent Past-Presidents and, at most, two other past Officers appointed by the ICSI Bureau. (*Done at Bureau Meeting in Paris, March, 2002*)

1) 9 months before the Assembly i.e. September 29 2002. The ICSI Secretary informs the IAHS Secretary General of IAHS of the names of the Group. (*Done, names of ICSI Nominating Group sent to Pierre Hubert, May 13 2002*)

1) 9 to 6 months before the Assembly i.e. September 29 to December 29 2002. The IAHS Secretary General informs all National Committees of IAHS of the names of the Group and asks them to send nominations to the Chairman of the IAHS Nomination Panel.

1) 6 months before the Assembly i.e. December 29 2002. National Committees send their nominations to the Chairman of the Association Panel, who relays them to the ICSI Nomination Group. (Note that recently, Oct 8th 2002, the Secretary general of IAHS has circulated the following: i.e. ' ***1 January 2003****: dead line for receipt of nominations from National Committees by the Nomination Panel and Nomination Groups, for officers of the IAHS Bureau and Scientific Commissions, respectively*.')

1) 6 to3 months before the Assembly i.e. December 29 2002 to March 29 2003. The ICSI Nomination Group draws up, in consultation with the IAHS Panel Chairman, the final list of candidates. The list should normally contain more than one nominee for each office. A person (including the President-Elect) may be a candidate for more than one office, but may not serve in two offices simultaneously.

1) 3 months before the Assembly i.e. March 29 2003. The Chairman of the ICSI Nomination Group shall distribute the final list to the IAHS National Committees. (Note that recently, Oct 8th 2002, the Secretary General of IAHS has circulated the following: i.e. '***1 April 2003****: Publication of the lists of candidates screened by the Nomination Panel and Nomination Groups.'*)

Voting Procedure at the ICSI Plenary Administrative Session (Regulations 7, 8, and 9)

1) 2 months before the Session i.e. April 29 2003. The agenda of the Plenary, including the Election of Officers, shall be submitted to the ICSI National Representatives. Further topics shall be proposed and seconded only by people entitled to vote. (Regulation 8)

1) Each National Representative for ICSI and each ICSI Officer shall have one vote. The IAHS National Committee for each member country of IUGG should designate an

ICSI National Representative with voting rights and the Secretary of ICSI should be informed. (Regulation 7)

1) Voting procedure: Mail and Ballot; secret ballot; approbation is simple majority. The persons or deadline for the reception of the Mail Vote are not particularly specified, but it could involve both the IAHS Secretary General (IAHS Statutes 7.2 and 7.8) and the ICSI Secretary (IAHS Statute 13.4).

The International Workshop on Snow hydrology in Mediterranean Regions.

Sponsors:

Université St-Joseph Beyrouth; IRD-France; IAHS; ICSI.

Dates:

December 16 and 17 2002.

Theme:

Scarcity of water resources is becoming a major problem for many Mediterranean countries. In effect the present utilization rates of water will result in water availability per capita below that (1000 $m^3\ yr^{-1}$) of the scarcity level defined by FAO. Better knowledge of regional hydrological cycles including snow and ice resources is imperative in designing systems on the optimum management of the available water reserves.

Participants:

Mediterranean countries -e.g. Lebanon, Turkey, France, Morocco, Spain, Bulgaria, and, from further afield, Canada and Iran. 35 registered plus many students from the University.

Presentations:

Two introductory lectures i) H.G. Jones on snow and ice resources in the Mediterranean and the effects of Climate change, and ii) Pierre Hubert on IAHS hydrological programmes with special reference to PUB.

Twenty scientific presentations in both French and English. Three sessions comprising eighteen oral papers and two posters. Subject matter covered such topics as high mountain snow resources, remote sensing of snow fields, snowmelt models, isotope tracer measurements of snow meltwater routing, Climate change, and pollutant concentrations in snow cover.

Discussions and outcomes:

Detailed discussion on various points raised during presentations occurred at the end of each session.

During the plenary session at the end of the symposium, the following points were discussed and taken into consideration by the organizing and scientific committees:

i) that selected papers be submitted to HSJ (the organizing committee will contact the editor)
ii) that an ICSI WG ‘Snow and Ice Resources in the Mediterranean’ be established (the organizing committee will submit a proposal to this effect to ICSI).

H.G. Jones, January 29 2003

The International Commission on Snow and Ice.

Historical introduction

In the year 2002 the International Association of Hydrological Sciences (IAHS) will celebrate the 80th anniversary of its founding in 1922 as, the then, International Section of Hydrology (ISH) by the International Union of Geodesy and Geophysics (IUGG) at its inaugural meeting in Rome. It is worthy of note that the International Commission on Snow and Ice (ICSI), one of the nine current commissions of IAHS, actually predates IAHS by over a quarter of a century as it was originally founded as the *Commission internationale des glaciers* (CIG) in 1894. The objectives of the CIG were to promote the historical and scientific studies on glaciers throughout the World and to gather and disseminate the data through periodic publication and annual reports.

Research interests and publications

Originally, the CIG was primarily concerned with the movement of glaciers and the variations in physical dimensions with fluctuations in climatic conditions. In 1939 the CIG was merged with the Commission of Snow, founded in 1936, and in 1948 the newly-named commission (ICSI) broadened its interests to include all aspects of the science of snow and ice. Since that time the Commission has continued to explore avenues of innovative research in the physical, geochemical and biological dynamics of the Cryosphere. As a result of the efforts of working groups (WG) significant works were published in such different fields as snow mechanics, glacier mass-balance techniques, isotope chemistry, nutrient dynamics of snow, the hydrology of river and lake ice, and the ecology of snow fields. The Commission also continued to adhere to the original objectives of glacier inventory and recording glacier changes through the World Glacier Monitoring Service (WGMS), a service of the Federation of Astronomical and Geophysical Services (FAGS), under the responsibility of ICSI.

Current topics of research and technology transfer

In this, the first decade of the 21st Century, ICSI is involved not only in activities of purely a scientific exploratory nature but also in the transfer and application of scientific knowledge to the practical management and utilisation of natural cryospheric resources. At the present time, the former field of activity includes the relationship between snow and climate, the interactions between snow and vegetation, and snowmelt modelling, which are all related to the increasing interest in improving cryospheric representations in climate and hydrological models. Other subjects of interest are the dynamics of tropical glaciers, debris-covered glaciers, extraterrestrial ice, and runoff processes in cold regions. The activity involving transfer and application of scientific knowledge includes training courses in the mass-balance measurements of glaciers and the setting up of glacier monitoring networks. The following paragraphs briefly outline some of these current topics.

Snow and Climate: Snow cover is a part of the cryosphere, which is an integral part of the global climate system with important linkages and feedbacks generated through its influence on surface energy and moisture fluxes, precipitation, hydrology and atmospheric and oceanic circulation. Due to its specific radiative and thermal properties, snow cover plays a major role in the climate system. The study of snow and climate is presently a rapidly evolving science in which there are new demands for detailed representations of snow processes to provide an up to date understanding of snow physics and support modelling for climate change scenarios. An ICSI WG on Snow and Climate is in the process of writing a state-of-the-science work on the interactions between climate and snow. Subjects include new methods and techniques to study snow-climate relationships through the monitoring of snow cover extent at continental and hemispheric scales and recent advances in snow modelling physics to represent snow cover and the parameterisation of snow processes in Global Climate Models (GCMs).

Snow and vegetation: Recent inter-comparisons of snow models for open and vegetated environments have shown widely divergent results, because current parameterisations do not include the full range and dynamics of snow processes. This is of consequence as the interactions between snow and vegetation are being increasingly recognised as an extremely important factor in regulating global climate and water supply. The study of the ICSI WG on snow and vegetation consists of developing a more consistent and comprehensive approach to representing snow-vegetation interactions in various biomes such as the Arctic Tundra and sub-Arctic Boreal Forests, Mountains and Grasslands. The subject matter includes blowing snow processes, shrub-tundra snowmelt energetics, the dynamics of intercepted snow and snowmelt under forest canopies, and the impacts of ecosystem stress in the guise of deforestation, climatic fluctuations and land use change and management.

Snow model inter-comparison study: There is a wide-spread use of many different types of snow models in various applications such as hydrological forecasting, the structuring of global circulation models, and avalanche prediction. The degree of complexity of these models is highly variable, from simple index methods to multi-layer models that simulate snow cover layering and texture. This variability makes possible to investigate the relative importance of the different processes that can be taken into account and parameterised in a snow model. The ICSI WG on snow model inter-comparison uses a two-tiered approach based on i) the off-line inter-comparison of snow models forced by meteorological data and ii) the representation of internal processes in the different snow models (layering, melting-freezing, compaction, etc.). The definition of a common methodology for achieving the parameterisation of internal processes is a particular challenge but a successful outcome will provide a substantial tool to optimise snow cover representation in climate models.

Tropical Glaciers: Tropical glaciers are highly sensible indicators of low latitude global climate change as well as vulnerable resources of water supply in highly populated regions. The setting of homogenous thermal conditions where seasonality is dominated by variations in air humidity and moisture leads to a particular interaction of climate and tropical glaciers. A major challenge for water management in low latitude high mountain regions is that although the 20th century glacier retreat has contributed to an abundant water supply it has also diminished the resource capacity to support future increases in social activities. In this context, two ICSI WGs on Himalayan Glaciers and South American Glaciers have studied glacier dynamics in the two regions and also designed training courses on glacier mass balance measurements in the Himalayans (see below) and the Andes. In addition, ICSI has initiated and supported the publication of the book “Tropical Glaciers” as an issue of the International Hydrological Series published by UNESCO and Cambridge University Press in 2001.

Figure 1: In many cases, tropical glaciers provide the almost only water for fast developing societies during the dry seasons. Huaraz and the Nevado Huascarán, Peru.

Debris covered glaciers: Debris-covered glaciers are the majority of glaciers in many mountain ranges such as in the Himalayas. When retreating, they generate huge dammed lakes, which are very fragile to basin erosion and seismic tremors. These lakes represent tremendous hazards in many populated valleys of the Andes and the Himalayas but their relationships to glacier evolution are poorly understood. ICSI is presently evaluating the studies of debris-covered glaciers and an ICSI supported workshop on “Debris covered glaciers” held in Seattle in 2000 has comprehensively reviewed the present status of knowledge.

Transfer and application of scientific knowledge: Training programmes for the monitoring of glacier mass balance have been held in the Himalayas (Figure 2) by ICSI Training Contingents incorporated into teams of regional government organisations and university researchers through the office of UNESCO. UNESCO also supported the publication of a training manual. A similar exercise will take place in South America in 2003/4. The training of local technical personnel and the establishment of glacier monitoring networks are essential to the development of data acquisition systems on which local management will have to rely in optimising the use of snow and ice resources in high-mountain regions.

Figure 2: Members of the ICSI/UNESCO HKH-FRIEND training course on glacier mass balance measurements working on Chhota Shigri Glacier, Himachal Pradesh, India in September/October 2002.

H.G. Jones, President Georg Kaser, Secretary

ICSI/IAHS
GEMS/UNEP
FAGS/ICSU
UNESCO

WORLD GLACIER MONITORING SERVICE (WGMS)

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REPORT TO THE INTERNATIONAL COMMISSION ON SNOW AND ICE (ICSI/IAHS) ON ACTIVITIES IN THE YEAR 2002 OF THE WORLD GLACIER MONITORING SERVICE (WGMS)

A short description of the service and links to related glaciological sites are given on the WGMS homepage

http://www.geo.unizh.ch/wgms

The page also provides a list of relevant publications prepared within the framework of the activities of the service as well as information on the monitoring strategy. Mass balance results are reported one year after the measurement year. Data are available from the WGMS databank (World Glacier Inventory data and Glacier Fluctuation data) as well as from the mirror site at the World Data Center in Boulder, Colorado (World Glacier Inventory data).

The five main tasks of the service as defined in 1986 by a corresponding expert/steering meeting have been unchanged and are still to

(1) collect and publish standardized data on glacier fluctuations at 5-yearly intervals;
(2) manage and upgrade the existing inventory of glaciers and ice caps;
(3) prepare a bulletin reporting mass balance results of selected reference glaciers and ice caps at 2-yearly intervals;
(4) stimulate satellite observations of remote glaciers and ice caps in order to reach global coverage; and
(5) periodically assess ongoing changes.

Fluctuations of Glaciers

Preparation of volume VIII, the FLUCTUATIONS OF GLACIERS 1995-2000, is nearing completion. About 60% of the data is processed and a full set of 17 glacier maps depicting historical and present glacier extents and glacier changes in different regions of the world (e.g. Antarctica, European Alps, Uganda) is ready for inclusion. Printing is planned for 2003/2004. To produce a printed version is still considered to be an important option for a number of reasons (safety, accessibility in all parts of the world, enclosed maps, accompanying texts and bibliographies, etc.) and should in any case be done for this last volume of the 20th century. However, funding of the printing costs is still not assured.

Glacier Mass Balances

The GLACIER MASS BALANCE BULLETIN No. 7 is in preparation. Printing and distribution is planned for 2003.

Within the GTOS glacier network and according to corresponding agreements with the participating countries, mass balance summary results are made available on the WGMS homepage at the end of the year following the measurement year. The summary data for the year 2001 have been presented on the

Internet (cf. Appendix A). Until the submission day of this report, 53 data sets were available for the measurement year. A preliminary calculation of the resulting means and extremes relating to 23 available data sets with long-term records provides the following numbers:

Mean specific (annual) net balance	+	-367 mm
Standard deviation	±	707 mm
Minimum value	-	2090 mm
Maximum value	+	858 mm
Positive balances		26 %

Such values indicate that the world-wide mean specific net balance in 2000/01 has again been strongly negative but not as extreme as in the 1990s. The general trend for accelerated mass loss, however, undoubtedly continues.

Glacier Inventories and Satellite Observations of Remote Glaciers

Within the USGS-led GLIMS initiative (Global Land Ice Measurements from Space) a number of countries presently start with compiling respective satellite-derived glacier inventories mainly based on the Landsat ETM+ and ASTER instruments. The new inventories of Switzerland (cf. references below) and Canada are presently most advanced. The design of the GLIMS database at NSIDC is completed to a large extent. The integration of first test data sets has started.

Paul, F., A. Kääb, M. Maisch, T. Kellenberger and W. Haeberli (2002): The new remote sensing derived Swiss glacier inventory: I. Methods. 4th International Symposium on Remote Sening in Glaciology, Maryland. Annals of Glaciology 34, 355-361.

Kääb, A., Paul, F., Maisch, M., Hoelzle, M. and Haeberli, W. (2002): The new remote sensing derived Swiss glacier inventory: II. First results. 4th International Symposium on Remote Sening in Glaciology, Maryland. Annals of Glaciology 34, 362-366.

Periodical Assessments

A short text on glacier evolution for the WMO publication on the climate of the 20th century is in press. A chapter on glaciers and ice caps by W. Haeberli is now in press for a book about present and potential future changes in the cryosphere. A statement on glaciers and ice caps as key variables within the Global Terrestrial Observing System (GTOS) was prepared for the Second Adequacy Report on global climate observing systems (Appendix B). An article on long-term mass changes as inferred from data on cumulative glacier length change is in press with the journal Global and Planetary Change (Hoelzle, M., Haeberli, W., Dischl, M., and Peschke, W. (in press): Secular glacier mass balances derived from cumulative glacier length changes. Global and Planetary Change,36 (4), 77-89).

Administration and funding

The service continued its work with funding being almost entirely provided by Switzerland. Continuation of work during the year 2003 is possible but at a reduced intensity level due to the unsatisfactory funding situation. As a consequence, direct connection to the database of WGMS via Internet is still interrupted because of the lack of funding for website management and updating work but will hopefully be made possible again within the framework of a new EU-project (ALPIMP). The full information remains to be available via members of the WGMS staff.

Within the framework of global climate-related observations, ICSI together with the International Permafrost Association (IPA) is assumed to play a leading role in cryosphere monitoring. In order to improve this situation, ICSI again submitted a proposal to ICSU for help with

1. developing a WEB-based data management and dissemination system;
2. creating an information system (data formats, standards) with respect to new measurement techniques such as SAR, laser altimeter, GIS, etc.; and
3. initially supporting new mass balance measurements in areas with few or no existing long-term records such as New Zealand and Patagonia in the Southern hemisphere.

Financial contributions from FAGS/ICSU may possibly come to an end in 2003. It would be important to know what the future understanding is concerning the relation between FAGS and the service. The regrettable development would also mean that the service has no more international funding at all but will be exclusively based on Swiss funds. In view to adequate international funding and new data formats relating to modern observational technologies, new structures for coordinating and publishing tasks must be designed. Within this framework, it is necessary to formally design an adequate evaluation system with reviews optimally being carried out at 3-year time intervals by representatives of ICSI and the involved climate related observing systems. Such reviews will have to consider - among other points - the tasks of the service/network, the means available, the monitoring strategies followed and, especially, the still serious problems of data production in various countries involved with the observational network.

On a longer term, steps should be considered towards an integrated cryosphere monitoring system for GTOS possibly led by ICSI and the International Permafrost Association (IPA). Contacts between the presidents of ICSI and IPA have been established.

Zurich, January 2003

Wilfried Haeberli, Regula Frauenfelder, Martin Hoelzle, Andreas Kääb

Workplan and Budget

Activities 2003

Activities under ongoing data management will be:

1. Development of an adjusted directing structure for WGMS in view to new methodologies/data formats and improved funding
2. Data processing for Volume VIII, the FLUCTUATIONS OF GLACIERS 1995-2000
3. Preparation and printing of the Glacier Mass Balance Bulletin No. 7
4. Maintenance and management of the existing data base in cooperation with the WDC for Glaciology at Boulder, Colorado
5. Operation of the Global Terrestrial Network for Glaciers (GTN-G) within the Global Climate Observing System (GCOS)/ Global Terrestrial Observing System (GTOS)
6. Cooperation with the ASTER/GLIMS project concerning remote sensing for glacier monitoring
7. Methodological development and analysis with respect to glacier fluctuation and inventory data
8. Reporting to the International Commission on Snow and Ice (ICSI/IAHS)

Budget 2003

Expected FAGS contribution		4,000
Budget 2002 for part not covered by FAGS		
Director	US$	30,000
Administrative support		80,000
Travel on official business		3,000
Expendable equipment		2,000
Operation (mainly computer time)		100,000
Editorial work (English smoothing, graphs)		5,000
Total costs	US$	220,000

Zurich, January 2003

Wilfried Haeberli, Director WGMS

Appendix A

GLACIER MASS BALANCE DATA 2000/2001

1. Summary of Balance Year 2000/2001

Results from mass balance observations in 2000/2001 are listed below. A preliminary calculation of the resulting means and extremes relating to 21 available data sets provides the following numbers:

	2000/2001
Mean specific (annual) net balance	-369 mm
Standard deviation	±738 mm
Minimum value	-2090 mm
Maximum value	+858 mm
Positive balances	29 %

There are still some data missing. Consequently, the above statistics may be subject to changes.

The corresponding results of this data set from glaciers in the Americas and Eurasia are visualized in the following two graphs:

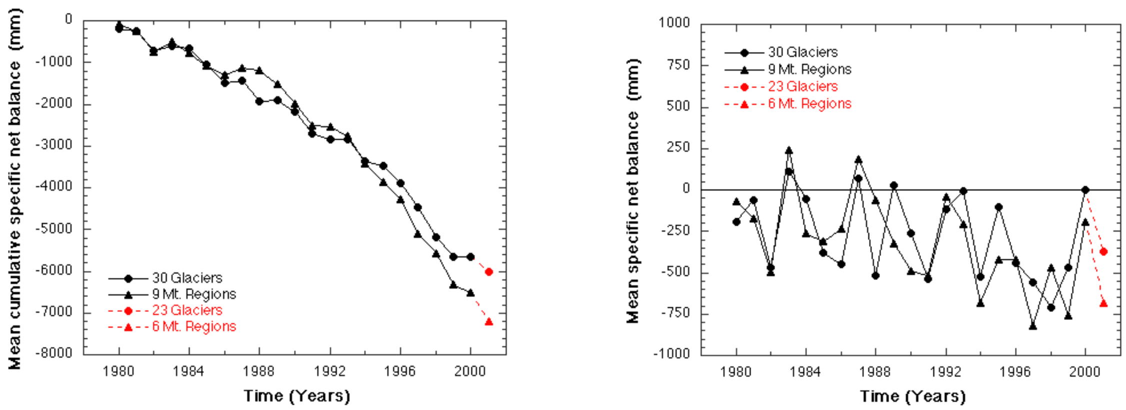


Figure: Mean net balance (left) and cumulative mean net balance (right) continuously measured for the period 1980 to 1999 on 30 glaciers in 9 mountain ranges (2000 on 29 glaciers in 8 mountain ranges), preliminary results for 2001 on 23 glaciers in 6 mountain ranges.

For more details about monitoring strategy and long-term trends (including references), see:

Haeberli, W., Frauenfelder, R., Hoelzle, M. and Maisch, M. (1999): On rates and acceleration trends of global glacier mass changes. Geografiska Annaler, 81A(4), 585–591.

2. Mass Balance Data 2000/2001 for Selected Glaciers

Name	b01
	(mm)
CANADA	
Helm (1975)	-600
Peyto (1966)	-920
Place (1965)	-760
White (1960)	-181
USA	
Gulkana (1966)	-690
Wolverine (1966)	+450
South Cascade (1953)	-1570
ECUADOR	
Antizana 15 Alpha (1995)	-598
BOLIVIA	
Chacaltaya (1992)	
Zongo (1992)	
CHILE	
Enchaurren Norte (1976)	
ARGENTINA	
Martial Este (1998)	-691
ICELAND	
Hofsjökull N (1988)	-580
Hofsjökull SW (1989)	-1890
Hofsjökull E (1989)	-1550
Brúarjökull (1993)	+110
Eyjabakkajökull (1991)	+80
Tungnaárjökull (1993)	-1710
Köldukvislarjökull (1994)	-970
Breidamerkurjökull (1997)	-1340
NORWAY	
Midtre Lovénbreen (1968)	
Hansbreen (1989)	-1070
Waldemarbreen (1977)	-767
Engabreen (1970)	-1530
Austdalsbreen (1988)	-1620
Ålfotbreen (1963)	-2090
Nigardsbreen (1962)	-220
Gråsubreen (1962)	0
Storbreen (1949)	-550
Hellstugubreen (1962)	-330
Harbardsbreen (1997)	-1110
Hardangerjøkulen (1963)	-850
Hansebreen (1986)	-2720
Jostefonn (1995)	--
Langfjordjøkulen (1989)	-2280
Midtdalsbreen	-640
Storglombreen	-1760
SWEDEN	
Riukojietna (1986)	--
Mårmaglaciären (1990)	-400
Storglaciären (1946)	-700
Rabots glaciär (1982)	-760
FRANCE	
Saint Sorlin (1959)	+390
Sarennes (1949)	+430
SWITZERLAND	
Silvretta (1960)	+858
Gries (1962)	-55
Basódino (1991)	+620
AUSTRIA	
Sonnblickkees (1959)	-399

Wurtenkees (1983)	-300
Vernagtferner (1965)	-224
Kesselwandferner (1953)	+524
Hintereisferner (1953)	-173
Jamtalferner (1989)	-62
ITALY	
Caresèr (1967)	-250
Fontana Bianca (1984)	+395
SPAIN	
Maladeta (1992)	+435
RUSSIA	
No. 125 (Vodopadniy) (1977)	
Maliy Aktru (1962)	
Leviy Aktru (1977)	
Garabashi (1987)	-750
Djankuat (1968)	-150
KAZAKHSTAN	
Ts. Tuyuksuyskiy (1957)	-560
CHINA	
Urumqihe S. No. 1 (1959)	

Note: numbers in brackets behind the glacier names indicate the beginning of continuous mass balance records.

Appendix B

WGMS-Contribution to the Second Adequacy Report on Global Climate Observing Systems

Parameter: Glaciers and ice caps

Main climate applications

Fluctuations of glaciers and ice caps in cold mountain areas have been systematically observed for more than a century in various parts of the world. The corresponding changes are considered to be indications of highest reliability concerning worldwide warming trends. Mountain glaciers and ice caps are, therefore, key variables for early-detection strategies in global climate-related observations (Fig. 2.39a in IPCC 2001).

Advanced monitoring strategies integrate detailed observations of mass and energy balance at selected reference glaciers with more widely distributed determinations of changes in area, volume and length; compilation of glacier inventories enables global representativity to be reached (Haeberli et al. 1998).

Long-term mass balance measurements provide direct (undelayed) signals of climate change and constitute the basis for developing coupled energy-balance/flow models for sensitivity studies in view to complex feed-back effects (albedo, surface altitude, dynamic response) and for use in AOGCMS (model validation, hydrological impacts at regional and global scales, etc.). They combine the geodetic/photogrammetric with the direct glaciological method in order to determine changes in volume/mass of entire glaciers (repeated mapping) with high spatio-temporal resolution (annual measurements at stakes and pits). Laser altimetry and kinematic GPS are applied for monitoring thickness and volume changes of very large glaciers which are the main meltwater contributors to ongoing sea-level rise.

Change in glacier length is a strongly enhanced and easily measured but indirect, filtered and delayed signal of climate change. It represents an intuitively understood and most easily observed phenomenon to illustrate the reality and impacts of climate change. Work on glacier recession has considerable potential to support or qualify the instrumental record of temperature change and to cast further light on regional or worldwide temperature changes before the instrumental era – particularly useful for studies of Holocene climate variability. Glacier length records complement the instrumental meteorological record because some extend further back in time; some records are from more remote areas where there are few if any meteorological observations; and on average, glaciers exist at significantly higher altitude than meteorological stations, which may be very useful in increasing understanding of the differences in temperature change at different levels of the atmosphere.

Glacier inventories are compiled by using a combination of remote sensing and GIS technologies. Repetition takes place at time intervals of a few decades – the characteristic dynamic response time of medium-sized mountain glaciers. Length and area change can be measured for a great number of ice bodies. Area changes mainly enter calculations of sea-level contributions and of regional hydrological impacts, whereas cumulative length change not only influences landscape evolution and natural hazards (especially from ice- and moraine-dammed lakes) but can also be converted to average mass balance over decadal time intervals and, thus, helps establishing the representativity of the few direct mass balance observations..

Beyond aspects of climate change indication, glaciers and ice caps are observed in connection with climate and earth system modeling, water resources management, sea-level modeling (large glaciers are expected to contribute substantially to sea level rise over the next century), natural hazard assessments and community planning with respect to tourism and recreation**.**

Contributing baseline (GCOS) observations

the TOPC has created a glacier observation network (Haeberli et al. 2000) to meet the needs of the Global Terrestrial Observing System (GTOS) and the Global Climate Observing System (GCOS). This network was developed by matching the WGMS sites against the GHOST concept, identifying critical gaps. Developing guidelines for participation in the network would ensure that GCOS/GTOS needs are met. A number of additional glaciers are planned to be selected for mass balance measurements. The recently launched USGS-led ASTER/GLIMS "Global Land Ice Measurements from Space (GLIMS)", see http://wwwflag.wr.usgs.gov/GLIMS/project, attempts to compile a worldwide glacier inventory for the time slice around the year 2000. Corresponding pilot studies are well underway (Kieffer et al. 2000; Kääb et al., in press;.Paul et al., in press).

Other contribution observations

Records of glacier mass balance and of changes in glacier length as well as a worldwide but rather preliminary glacier inventory have been compiled by the World Glacier Monitoring Service (WGMS) in Zurich, Switzerland. Some records of glacier length change are more than hundred years long and can even be extended backwards into Holocene time periods, making glacier length the most useful and comprehensive parameter related to past and especially pre-industrial glacier geometry. Resolution of 0.01 to 0.1 m is required for mass change, of 1 to 10 m for length change and of 10-100 m for model validation with inventory parameters. Time resolution on measurements is 1 year (mass balance), 1 to 10 years (length change) and a few decades for inventories.

Significant data management issues

The World Glacier Monitoring Service (WGMS) coordinates worldwide glacier monitoring and publishes corresponding data for about 60 glaciers (annual mass balance) and roughly 500 glaciers (length, area and volume change) every 5 years. The WGMS mandate is to continuously upgrade, collect and periodically publish glacier inventory and fluctuation data as well as to include satellite observations of remote glaciers and to assess ongoing changes.

The data holdings of the WGMS (http://www.geo.unizh.ch/wgms/index1.htm) include the World Glacier Inventory (WGI) containing glacier data describing the spatial distribution and the Fluctuations of Glaciers (FoG) and Mass Balance Bulletin (MBB) which contain data documenting temporal changes in glacier mass, volume, area and length. The WGMS maintains data exchange with the ICSU World Data Center for Glaciology, Boulder (http://nsidc.org/NOAA/index.html), and the UNEP Global Resource Information Database (GRID; see (http://www.grid.unep.ch/)

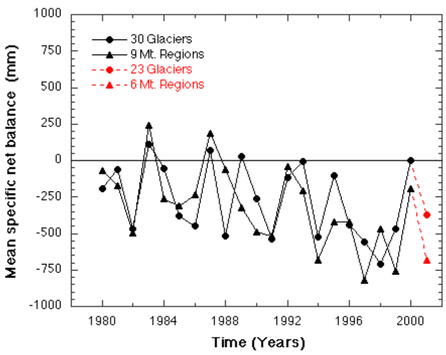
The ICSU World Data Center for Glaciology, Boulder holds an historical glacier photo collection for N America (see http://nsidc.org/glaciers/science/data.html).

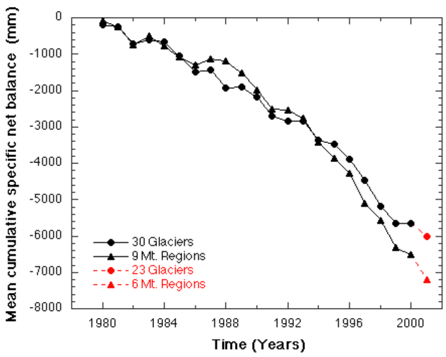
Analysis products

Trends in long time series of cumulative glacier-length and volume changes represent convincing evidence of fast climatic change at a global scale, for the retreat of mountain glaciers during the 20th century is striking all over the world.

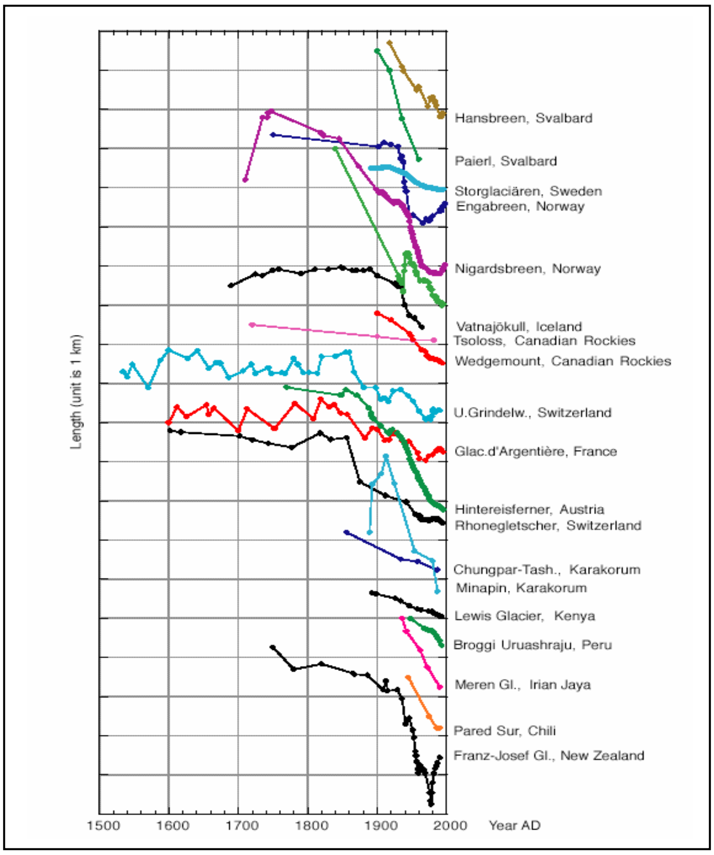
Since 1990, the IPCC has documented such changes as evidence of the existence of global warming independent of the various surface temperature datasets (this is considered valid because a worldwide retreat is unlikely to be related to a reduction in global mountain precipitation).

Characteristic average rates of glacier thinning are a few decimeters per year for temperate glaciers in humid climates and centimeters to a decimeter per year for glaciers in continental climates with firn areas below melting temperature.





Total retreat of glacier termini is commonly measured in kilometers for larger glaciers and in hundreds of meters for small ones.The apparent homogeneity of the signal at the secular time scale, however, contrasts with great variability at local/regional scales and over shorter time periods of years to decades. Intermittent periods of mass gain and glacier advance during the second half of the 20th century have been reported from various mountain chains, especially in areas of abundant precipitation such as southern Alaska, Norway and New Zealand.



Analyses of repeated glacier inventory data show that the European Alps, for instance, have lost about 30 to 40% in glacierized surface area and around 50% in ice volume between about 1850 and 1970. A further 25% of the remaining volume may have been lost since then. The recent emergence of a stone-age man from cold ice on a high-altitude ridge of the Oetztal Alps is a striking illustration of the fact that the extent of Alpine ice is probably less today than during the past 5,000 years.

Current capability

Air temperature and, to a lesser degree, precipitation are considered to be the most important factors reflecting glacier changes. Detailed data interpretation, however, is not straightforward and must be assisted by numerical modeling of physical aspects involved with individual cases.

Cumulative mass balances not only reflect regional climatic variability but also marked differences in the sensitivity of the observed glaciers. Sensitivities of temperate glaciers in maritime climates are generally up to an order of magnitude higher than the sensitivity of polythermal to cold glaciers in arid mountains. Spatial correlations typically have a critical range of about 500 km and tend to markedly increase with growing length of the considered time interval. Decadal to secular trends are comparable beyond the scale of individual mountain ranges with continentality of the climate being the main classifying factor besides individual hypsometric effects.

The frequency of climate and mass balance fluctuations reflected in glacier length change depends on the size of the observed glaciers. Small glaciers provide annual signals whereas the tongue reaction of medium-sized and long valley glaciers undergoes decadal to secular smoothing. Due to varying and predominantly slope-dependent dynamic response times of individual glaciers, analyses of glacier retreat are somewhat at odds with analyses of the instrumental temperature record and the combined hemispheric and global land and marine data. Surging, heavily debris-covered and calving glaciers have strong non-climatic driving mechanisms.

Issues and priorities

Most major mountain ranges of the world are represented in studies of glaciers and ice caps. A key priority is to continue long-term mass balance observations and expand these into additional regions such as Patagonia, the Andes and the mountains of New Zealand. More numerous observations of glacier area, thickness and length changes by application of remote sensing technologies (laser altimetry; aerial photography; high-resolution satellite, visible and infrared imagery from systems such as ASTER and Landsat) must be coordinated with the *in situ* measurements being collected by the WGMS.

Numerical modeling studies confirm that many if not most glaciers of the presently existing worldwide mass balance network could disappear within decades if warming trends continue or even accelerate. An appropriate strategy for dealing with this problem will have to be developed.

Concerning the sensitivity with respect to sea-level rise, effects of (a) firn warming in presently cold subarctic and high-mountain accumulation areas, (b) possible runaway trends with the mass balance/altitude feed-back on large/flat glaciers with long dynamic response times and (c) large ice volumes below sea level in the case of many important meltwater producers in maritime environments must be considered.

Most importantly, worldwide glacier monitoring must receive adequate funding and a new enlarged and internationally organized leading structure in view to the increasing public interest and new data formats. The opportunity of the presently running ASTER/GLIMS project should be used to further develop links with the remote sensing community.

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Appendix C

Establishing a new glacier network (GTN-G) as a contribution to GCOS/GTOS

(ICSI proposal resubmitted to ICSU)

Abstract

The fluctuation of mountain glaciers is recognized as a high-confidence indicator of air temperature trends and as a valuable element of a strategy for early detection of possible man-induced climate changes. The Terrestrial Observation Panel for Climate (TOPC), therefore, recommended that glacier mass and area be monitored as part of the Global Climate Observing System (GCOS) established in 1992 by the World Meteorological Organization (WMO), the Intergovernmental Oceanographic Commission (IOC of UNESCO), the United Nations Environment Program (UNEP) and the International Council of Scientific Unions (ICSU). A Global Hierarchical Observing Strategy (GHOST) of tiers was developed to be used for all GCOS terrestrial variables. Within GCOS/GTOS, the WGMS at University and ETH Zurich manages now the recently created **G**COS **T**errestrial **N**etwork for **G**laciers (GTN-G). The proposed poject helps establishing this important part of global climate-related observations by

developing a WEB-based data management and dissemination system;

creating an information system (data formats, standards) with respect to new measurement techniques such as SAR, laser altimeter, GIS, etc.; and

initially supporting new mass balance measurements in areas with few or no existing long-term records such as New Zealand and Patagonia on the Southern hemisphere.

Glacier observations and the Global Hierarchical Observing Strategy (GHOST)

A Global Hierarchical Observing Strategy (GHOST) of tiers was developed to be used for all GCOS terrestrial variables. According to this system of tiers, the regional to global representativeness in space and time of the records relating to glacier mass and area should be assessed by more numerous observations of glacier length changes as well as by compilation of regional glacier inventories repeated at time intervals of a few decades - the typical dynamic response time of mountain glaciers. The planned global network of glacier sites, called GCOS Terrestrial Network for Glaciers (GTNet-G), is expected to evolve over time. It would be structured to allow global and regional analyses of glacier changes and to take advantage of different intensities of measurements at various sites. The initial role of the glacier network is primarily to detect long-term climate change through its impact on the glaciers, particularly on a regional basis. With reference to the tier system proposed for global terrestrial observations, the following sites and reported observations are envisioned:

Tier 1 *(large transects): reporting details to be determined later.*

These major, intensive experimental sites are set up to emphasize detailed measurements and process understanding across environmental gradients. They should be located with a primary emphasis on spatial diversity. Capturing the range of the major glacier types is a critical priority, but the location within the regions will be opportunistic. Although all tier 1 data and research findings are important to GCOS/GTOS, special attention should be given to long-term measurements. Tier 1 sites encompass large experimental areas and various adjustments are required before they can become part of a long-term monitoring program. The long-term measurements will be a subset of those made during the initial experimental period but the transition from intensive field studies to continuous monitoring requires careful planning. Some of the observed glaciers (for instance, those in the Pyrenees - Alps - Scandinavia - Svalbard) provide large transects and could later form part of Tier 1 observations.

Tier 2 *(extensive and process-oriented glacier mass balance studies within major climatic zones): annual reporting.*

Tier 2 sites make possible glacier mass balance studies within the major climatic zones. Ideally, tier 2 sites should be located near the centre of the range of environmental conditions (though not necessarily near the geographical centre) of the zone which they are representing. The actual locations will depend more on existing infrastructure and logistical feasibility rather than on strict spatial guidelines, but there is a need to capture a broad range of climatic zones. There are about 10 glaciers with intensive research and observation activities that represent Tier 2 sites. Storglaciären in northern Sweden is an example of such a site.

Tier 3 *(regional glacier mass change within major mountain systems, i.e. reduced stake networks): annual reporting.*
Tier 3 sites are intended to sample the range of environmental variation present in the glaciers within climatic zones or regions. There is no requirement for spatial representativeness of the glaciers in this tier. There are numerous potential Tier 3 sites (about 50 glaciers where annual mass balance studies are conducted) to reflect regional patterns of glacier mass change within major mountain systems, but they may not be optimally distributed. As a result, some glacier types may have more potential Tier 3 sites than are needed for GCOS/GTOS. Other types may have too few sites, or none at all and thus GCOS/GTOS will need to stimulate efforts to enhance and balance the network.

Tier 4 *(long-term observations of glacier length change data minimum of about 10 sites within each of the mountain ranges, selected according to size and dynamic response : pluriannual reporting (frequency to be determined).*
At this level, spatial representativeness is the highest priority. Approximately 800 glaciers where only length is measured are compatible with Tier 4. Because access is infrequent, they can be located wherever necessary to ensure representativeness. The locations of Tier 4 sites should be based on statistical considerations. It is impractical to prescribe one statistical design for all countries. Hence, individual participating organizations would be responsible for locating the sites, and may choose either a systematic or a stratified-random approach (or a combination, depending on the variable or the glacier system). For the glacier network, long-term observations of glacier length change at about 10 sites within each of the mountain ranges will be selected according to size and dynamic response from the existing set of sites where glacier length is monitored.

Tier 5 *(glacier inventories repeated at time intervals of a few decades by using satellite remote sensing): continuous upgrading and analyses of existing and newly available data.*
For the most part, these fields include glacier inventories repeated at time intervals of a few decades by using satellite remote sensing. Satellite observations are usually for area averages, while ground observations are point values. Some variables require surface observations, even for tier 5. The implementation of tier 5 requires international collaboration, both in the space and ground components, to produce the required data sets. The preparation of data products from satellite measurements must be based on a long-term program of data acquisition, archiving, product generation, and quality control. Discussions are now underway in the Committee on Earth Observation Satellites (CEOS) to set up such a system. In particular coordination is needed with the GLIMS project, which will map changes in the areas of selected glaciers worldwide. Glacier observations made from space borne instruments are being used in various research investigations. However, routine glacier monitoring (Tier 5) using the Advanced Space borne Thermal Emission and Reflection Radiometer (ASTER) has been proposed by the US Geological Survey (Flagstaff, AZ), in conjunction with the EROS Data Centre, the National Snow and Ice Data Centre and regional analysis centres.

As with other components of GCOS, lack of funds is a major problem. Continuous data managing and assessments or **development and integration of new technologies in data collection and in data storage demand extraordinary financial support.** Mass balance measurements require a team of three to four people for several days each year. The funds required for drilling and surveying equipment and salaries are modest but must be available on a long-term basis. Moreover, even modest amounts can be beyond the means of many developing countries, for which scarce resources are needed for higher priority purposes. In at least one case, an offer of assistance was unsuccessful because the assistance was deemed to be inadequate. **More typically, however, the low priority assigned to glacier observations has meant inadequate funds have been available to undertake long-term monitoring.** This situation is as true in countries like Canada and the United States, where budgets for survey work have been reduced, as it is in developing countries. In some countries, lack of scientific capacity is a problem (Patagonia and New Zealand). Adequate training and provision of field equipment can remedy the problem, but this too requires funding. Tensions in remote mountainous border areas in certain parts of the world (e.g.~~,~~ Central Asia) have limited mass balance observations to some extent. Finally, some potentially valuable data (including survey records, maps, and aerial photographs) exist in countries of the former Soviet Union that have not been recorded and are in danger of being lost. High staff turnover in many of these countries as a result of general instability, as well as lack of funds, is at the root of this problem.

In 1989, a first attempt was made to build a glaciological database with the WGMS data. With the help of this database, it was possible to publish Volume VI and VII of *Fluctuations of Glaciers*. The database was subsequently increased by adding more tables and loading older data. The World Glacier Monitoring Service (WGMS) has today two main databases storing two different data sources: the World Glacier Inventory Data and the Fluctuations of Glaciers and Mass Balance Bulletin Data. Both data sources are available in a database system at the University of Zurich in the database system ORACLE. In recent years, electronic access into databases over WEB-based interfaces has been developed. In addition, new detailed glacier inventories are being compiled now and in the future in areas not covered so far or as a repetition of earlier inventories for comparison. This task will be greatly facilitated by the launching of the ASTER/GLIMS program. Remote sensing at various scales (satellite imagery, aerophotogrammetry) and GIS technologies will be combined with digital terrain information in order to overcome the difficulties of earlier satellite-derived preliminary inventories (area determination only) and to reduce costs/time of compilation. These new satellite based glacier information collection requires new database-structures within GIS for efficient spatial data handling.

Detailed Work Plan

A network of 60 glaciers representing Tiers 2 and 3 is now being established. This step closely corresponds to the data compilation published so far with the Glacier Mass Balance Bulletin but now envisages annual reporting in electronic form. With the proposal here three main gaps will be filled in the future:

1. Development of a WEB-based data management and dissemination system
2. Creation of an information system (data formats, standards) with respect to new measurement techniques such as SAR, laser altimeter, GIS, etc.
3. Initial supporting of new mass balance measurements in areas with few or no existing long-term records such as New Zealand and Patagonia on the Southern hemisphere

The first two goals focus in general on electronic data access and storage.

9. Increasing capabilities and use of WEB-based data access world-wide today requires an efficient WEB-supported information system for users and data managers. Therefore, the WGMS intends to create a new WEB-based data access system, which is based on the existing glacier database in the system ORACLE. A fast interface between the database and the WEB-clients should be developed. An existing WGMS-WEB-application should be evaluated and improved within this project. This task will be done in close cooperation with the NSIDC in Colorado, which is an existing data mirror site of WGMS.
10. New glacier information collection technologies like SAR or laser altimeter and spatial data storage possibilities in GIS demand the development of new database architecture. These capabilities have to be built up at the WGMS. At the University of Zurich a new glacier inventory is compiled based on new satellite technologies in connection with the ASTER/GLIMS project. The collected glacier information data will be archived, using GIS as a database storage system. Based on this experience and existing knowledge, a world-wide information system will be built up in close connection to the GLIMS center of USGS in Flagstaff and to the NSIDC in Colorado USA.
11. Long-term glacier mass balance series mainly cover on the Northern Hemisphere. An urgent need exists for long-term information in the Southern Hemisphere to fulfil the goals in Tier 1 to 3 of GTNet-G/GHOST. Therefore, regions such as Patagonia and New Zealand will be selected to initiate new long-term measurement programs. WGMS will help initiating such programs with a single support.

Project fits the following criteria of Category I:

A.

- New integration of spatial data from new technologies (remote sensing, GIS)
- Innovative development of user friendly interface for online data access
- WGMS works in strong cooperation with around 30 countries all over the world
- Consistent with the newly established Global Hierarchical Observing Strategy (GHOST) of their tiers.

B.

- Information transfer from scientific specialists to non-specialists by compiling and assessing the data
- World-wide dissemination of glacier network data
- Monitoring of the changes in glaciers provides a most sensitive detector of natural and anthropogenic climate variability
- Internationally coordinated glacier observations promote and support scientists in developing countries

Detailed financial budget

1. Financial Needs

Salaries

Postes	Function	Salary	
WEB-Designer (30% employment)	Design and implementation of WEB-based data management	1. year 2. year	15,000.0 USD 15,000.0 USD
Database architect (60% employment)	Development of Glacier Monitoring Information System (GMIS)	1. year 2. year	22,500.0 USD 22,500.0 USD
Total			*75,000.0 USD*

Consumables

Overheads	1,000.0 USD
Total	*1,000.0 USD*

Travel Costs

Cooperation meetings with NSIDC (Colorado) and GLIMS-center (Arizona)	2,000.0 USD
Congresses and Invitations	1,000.0 USD
Total	*3,000.0 USD*

Others

Development and initial support of new GTNet-G in N Zealand	10,500.0 USD
Development and initial support of new GTNet-G in Patagonia	10,500.0 USD
Total	*21,000.0 USD*

Summary

Total	**100,000.0 USD**

2. Available resources at WGMS

12. Staff
    - Proposer and Co-proposer W. Haeberli and M. Hoelzle (each 5%)
    - Scientific assistant R. Frauenfelder (5%)
    - Secretary (on request)
    - System administration (on request)
13. Available Infrastructure
    - 2 Ultra SPARC I stations at the Physical Geography Section at Department of Geography
    - 1 Power-Macintosh
14. Available Software
    - GIS: Arc/Info, ArcView
    - Database: ORACLE
    - Different Desktop Publishing Software

SNOWMIP(Snow models intercomparison project) working group report

January 2003

Contact : Eric Martin, Météo-France, Centre d'études de la neige, 1441 rue de la piscine, F-38406 Saint Martin d'Hères CEDEX. Eric.Martin@meteo.fr

The WG SNOWMIP was officially created by the ICSI bureau in November 1999. The WG SNOWMIP is co-chaired by Ross Brown (Canada) and Eric Martin (France). Philippe Bougeault (France), Ross Brown (Canada), Charles Fierz (Switzerland), Richard Essery (United Kingdom), Rachel Jordan (USA), Eric Martin (France), Zong-Liang Yang (USA) form the scientific committee. Pierre Etchevers and Yves Lejeune from CEN form the SnowMIP team at CEN and are extremely active in this project.

The objective of this project is to compare snow models of various complexity at four sites belonging to various climatic regions. A total of 24 models from 18 teams are involved. The models vary from simple models used for hydrology to sophisticated ones used for snow physics research.

Four sites were selected to cover a wide range of climatic conditions : Col de Porte (France, Goose Bay (Canada), Sleepers River (U.S.A) and Weissfluhjoch (Switzerland). Two winter from the Col de Porte were selected, and the data of Goose bay are 14-year long (this allows an intercomparison of interannual variability). The data for the runs were released in November 2000. After a workshop in July 2001 some teams were allowed to re-submit their results and the analysis began in January 2002. The CEN is in charge with the general analysis. SLF (Charles Fierz) works currently on comparison of observed snow pit profiles to model profiles according to a simple and standardised evaluation procedure (8 of the 26 models simulates the internal state of the snow cover). Another approach, conducted by Richard Essery intent to introduce several parameterisations in one model. Although this is was not the objective of SnowMIP, it is a good complement to the intercomparison of existing models.
Some models show a good ability to correctly simulate the snow pack features for all of the sites, whereas other models are more adapted to particular conditions. The high alpine site is the best simulated site, because the accumulation and melting periods are distinct. The current analysis show that when looking at a specific parameterisation (e.g. albedo, water retention…) the results are highly variable and some show discrepancies between observations and models. For instance an albedo parameterisation based on age only give bad results for the onset of melting at some sites.

More details on http://www.cnrm.meteo.fr/snowmip/ .

The project has been presented in 2002 at the ISSW 2002 (October) and at the WGNE meeting held in Toulouse (France) in November 2002.

Future activities :

In 2003 several presentations of the project will be done at the IGS meeting in Davos (June 2003) and at the IUGG meeting in Sapporo in July.

Presentations at IUGG Saporo JWH01 :

SNOWMIP (SNOW MODELS INTERCOMPARISON) : MAIN RESULTS OF THE MASS AND ENERGY BUDGETS SIMULATIONS,
P. Etchevers, E. Martin, R. Brown, C. Fierz ,Y. Lejeune, E. Bazile, A. Boone, Y.-J. Dai, R. Essery, A. Fernandez , Y. Gusev, R. Jordan, V. Koren , E. Kowalczyk, N. O. Nasonova, R. D. Pyles, A. Schlosser, A. B.Shmakin, T. G. Smirnova, U. Strasser, D. Verseghy, T. Yamazaki, Z.-L. Yang

SNOWMIP, AN INTERCOMPARISON OF SNOW MODELS: COMPARISON OF SIMULATED AND OBSERVED INTERNAL STATE.
C. Fierz, P. Etchevers, R. Brown, M. Lehning, Y. Lejeune, E. MartinA. Boone, Y. Gusev, R. Jordan, E. Kowalczyk, R. D. Pyles, T. Yamazaki

REPRESENTING SNOW-COVERED SURFACES IN ATMOSPHERIC MODELS : WHICH PROCESSES AND PARAMETERS MATTER
Essery et al

Presentations at IGS 2003 (Davos)

INTERCOMPARISON OF THE SURFACE ENERGY BUDGET SIMULATED BY SEVERAL SNOW MODELS (SNOWMIP PROJECT)
P. Etchevers, E. Martin, R. Brown, C. Fierz, Y. Lejeune, E. Bazile, A.Boone, Y.-J. Dai, R. Essery, A. Fernandez, Y. Gusev, R. Jordan, V. Koren, E. Kowalczyk, N.O. Nasonova, R.D. Pyles, A. Schlosser, A.B. Shmakin, T.G. Smirnova, U. Strasser, D. Verseghy, T. Yamazaki and Z.-L. Yang

SNOWMIP, AN INTERCOMPARISON OF SNOW MODELS: COMPARISON OF DETAILED SNOW-COVER SIMULATIONS
C. Fierz, P. Etchevers, R. Jordan, M. Lehning, Y. Lejeune and E. Martin

IV) REPORT BY HEAD OF DIVISION ON RIVER, LAKE AND SEA ICE

The main item to be reported since our last meeting in Paris has been my participation in *16th International Symposium on Ice: Ice in the Environment,* which took place in Dunedin, New Zealand, from December 2nd to 6th, 2002. The symposium was organized by the International Association of *Hydraulic Engineering and Research* (IAHR). ICSI has been one of the co-sponsors of this conference, which I had the honour to represent. In that capacity, I was also asked to serve on the *Scientific Committee* and to chair the section on *Environmental Concerns and Ice* of the conference. In addition, I was one of the plenary speakers at the symposium, giving a presentation on *Sea Ice Contamination: A Review* (see attachment).

While traditionally focussing on engineering aspects of glaciological problems (e.g., river icing, interactions between ice and engineering structures, ice navigation), this year's symposium had a relatively strong focus on basic research. Main themes included *Sea Ice Growth and Decay, Atmosphere-Ice-Ocean Interactions, Ice and Climate Change* and *Large-Scale Sea Ice Processes*.

The meeting was perfectly organized and provided an excellent forum for discussions on various sea ice topics. The presentations at the symposium are being published as a three-volume proceedings.

Another activity during the last few months has been the involvement in the preparation for the International Symposium on ***Arctic environmental change*** (**JSP04)**, which will be held in the framework of the next IUGG Conference in Sapporo, Japan, June/July 2003.

iva) Report of WG on River Ice

No significant actions to be reported since the last Bureau meeting.

ivb) Status of WG on Sea-ice Terminology

The progress in this WG has been very slow. The only activity worth reporting is a discussion with members of the IAHR at the above mentioned symposium. IAHR is also considering to compile sea ice nomenclatures with the aim to come up with a more unified and more generally acceptable nomenclature. We decided (more informally) to join forces in this effort. I have since been in contact with K. Evers (HSVA, Hamburg) to discuss details of our collaboration.

Status of WG on Extra-terrestrial Ice

No significant actions to be reported since the last Bureau meeting.

Sea Ice Contamination: A Review

M. A. Lange[1]

The Arctic has long been considered pristine and almost free of contaminants. Not until the late sixties, when first reports about limited visibility in Arctic air during reconnaissance flights were reported and identified as substantial air pollution, later to be named *Arctic Haze*, was it realised that the Arctic, too, is subject to substantial contamination *(Barrie, 1986; Soroos, 1992)*). More recently, it has been demonstrated that such contamination poses serious threats to the well being of nature and the inhabitants of the Arctic (*Lange and Pfirman*, 1998). While there is ample proof for the fact that much of the observed contaminants derive from outside the Arctic (*Barrie et al.*, 1992), sources from inside the Arctic have also to be considered. This comes about because of the increased utilisation of renewable and non-renewable resources, which have attained a fairly high level throughout the recent years.

The recent discoveries of large deposits of oil and natural gas on-shore and off-shore along the perimeter of the Arctic Basin (*Jumppanen*, 1991) do not only offer promising prospects for a long-term supply of these resources. Exploitation of oil and gas as well as the transport of hydrocarbons represent a potential threat to the arctic marine environment. Such operations almost inevitably result in hydrocarbon contamination of varying scales, be it through leakage of oil from production platforms or pipelines or be it as a result of a more severe accidental spills of larger proportion. The uniqueness of the arctic seas lies in their special physical, chemical, and biological characteristics, and their largely limited capability for recovery. Even small-scale anthropogenic pollution may have severe consequences (*Brinken and Pyzhin*, 1993). While a large oil spill has, so far, not occurred in the marine Arctic, the Exxon Valdez accident of 1989, even though occurring south of the marginal ice zone, provided some indications as to the effects which a large oil spill in the Arctic would have. Infrastructure in the North in general is not readily available and there is still a lack of adequate technology for combating oil spills in pack ice fields. Thus, in the case of a major spill in the Arctic, the prospects of effectively combating the spill are rather limited, given the present situation. Because of the general conditions prevailing in the Arctic (low temperatures, low light levels for long periods of time), the effects of such a spill would prevail for a long time, potentially causing very serious environmental damage.

In this paper, we will briefly review the current understanding of oil contamination in arctic sea ice. In particular, we will address methods to quantify the occurrence and transport of contaminants within the sea ice pore space and the prospects of assessing the threat to the marine ecosystems through the release of contaminants from sea ice into the water column.

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Soroos, M.S., The odyssey of Arctic Haze. Toward a global atmospheric regime, *Environment*, **34** (10), 7-27, 1992.

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HIGH-ICE
Himalayan Institutes of Glaciology: Hydrology, Ice, Climate, and Environment

American investigators:
Jeffrey S. Kargel, Rick Wessels, Hugh H. Kieffer (U.S. Geological Survey, USGS)
Jack Shroder, Michael Bishop (University of Nebraska at Omaha, UNO)
Alan Gillespie, Bernard Hallet (University of Washington, Seattle, UW).
Roger Barry, Bruce Raup (National Snow and Ice Data Center, Boulder, Colorado)

South Asian investigators:
Syed Iqbal Hasnain (Jawaharlal Nehru University, Delhi, JNU)
Syed Hamidullah (Fulbright Prof. to UNOmaha, formerly Peshawar University)

European investigator:
Andreas Kaeaeb (University of Zurich, UZ)

ADD INVESTIGATORS (to be identified):
Global/regional climate modeler (NSIDC? UW?)
Jackson International Program and/or Program on the Environment, South Asia expert (UW)?
State Department official, expert on Asia policy?
UNEP official, expert on South Asia environment?
USAID official?
ICIMOD representative?
Additional UZ researcher?
Add one more from each of India, Pakistan or Afghanistan, and a Central Asian country

DRAFT
2 May 2002

Overview of HIGH-ICE.

This program will develop GLIMS (Global Land Ice Measurements from Space) for the greater Himalaya (including the Hindu Kush) and extensions to adjoining High Asia. The over-arching political theme of HIGH ICE is the promotion of regional peace, security, and prosperity and improved East-West relations through glaciological studies. The program will include equal emphasis on remote sensing, field studies, and education. Science will include equal emphasis on pure science (glaciology) and science-based humanitarian tasks. We will explore linkages between (1) the Himalayan glacier-climate system and that of the rest of Asia and (2) between the water reserves represented by glaciers and the economic and physical well-being and security of South and Central Asian inhabitants.

The central science element will be establishment of Glacier Focus Areas in (a) the Ganges Headwaters (including the Garhwhal Himalaya, India, one of the last remaining politically stable regions of this great orogenic system; and a region of rising Maoist violence in Nepal); (b) the Indus Tributaries (a region of great turmoil, including the U.S.-led hunt for Al Qaeda and the Kashmir conflict); and (c) the Central Asia Inland Basins (a region of profound water shortages and rapid but inhomogeneous political changes in the post-Soviet, post-Maoist eras). Together, these glacier-fed river systems support over 10% of Earth's human inhabitants.

HIGH-ICE will support the establishment of glacier-monitoring field stations on glaciers in politically secure areas and the education of nine MS- and PhD-level students, most from south and central Asia. The students and their advisors will advance our understanding of the mass balance of Himalayan glaciers, project future climate-driven changes to these glaciers, and explore implications for regional water and hydropower resources, glacier lake outburst flood hazards, and regional security (environmental, economic, and military). These projects will culminate in (i) the placement of post-docs in south and central Asian research institutes and the building of glaciology programs in those areas and (ii) the development of an information database and recommendations for policy planners and resource managers.

The coherence of the multi-institutional research efforts and cross-fertilization of ideas will be reinforced by (1) annual meetings of the students and the investigators, (2) rotating term appointments of each student at two other collaborating institutions over the duration of the educational program, and (3) establishment of international thesis committees drawn from at least two institutions in addition to the student's primary host institution. A legacy of HIGH ICE will be ensured after funding terminates by the assignment of each graduate to an Asian research institute for a 2-year term appointment; it will be the primary tasks of these graduates to transfer their knowledge to an applications- or policy-driven program and assist in building glaciology programs in the host countries. The proposed funding profile assumes that most investigators are already funded through related projects and academic appointments, but seeks support for the students, for the international meetings, for the students' field projects, and minimal support for key investigators who are entirely soft moneyed. The project is estimated to cost (including all institutional overhead) $0.8M/year (U.S.) for each of 6 years.

Political and humanitarian basis of HIGH ICE.

A worthy long-term objective could be to get glaciologists together on the ultimate symbol of South Asian conflict—the Siachen Glacier ("the world's highest battlefield"). Not having any illusions about the pragmatic/political difficulties of this goal, a near-term achievable goal would be to get Pakistani and Indian scientists—among many others—together on a frequent basis, development of joint science projects on glaciers straddling the disputed border, and showing the world that these two nations (and the others in the region) can work productively together to realize their common interests. After all, a prime Indian benchmark glacier, the Chhotra-Shigri, occurs in a secure zone of undisputed Indian territory, and by past international agreements, its water runoff flows unhindered to Pakistan. On the hazards side, glacier lake outburst floods have originated in China (Tibet) and then wreaked havoc in Nepal. The recent multi-year drought in Afghanistan has played a key role in the political and military developments as well as in the economy of Afghanistan; as the world has witnessed, this drought—and the glacier contributions to providing some local relief from it—have had global security implications. In Western Chinese provinces, 10% of water supplies are due directly to melting glaciers, and locally virtually all the surface flow of fresh water is directly attributed to glaciers and high snow fields. As glaciers waste away, there will be resource implications and thus economic and political manifestations; hence, there are questions related to glaciers that are relevant to policy makers who direct develoment money: What problems with water supply are emerging and where? Where are measures needed for ensuring drinking- and irrigation-water supply? Where are flood hazard mitigations most needed? Where are hydropower schemes endangered by glacier floods or runoff decrease? (Most hydrowpower installations in this region, especially Nepal, are financed by development Money.) Glaciers and their runoff are international phenomenona, and the hazards and opportunities they present are thus multinational. These are not just local issues, but regional and global. As the U.S. and other Western nations have a vested interested in seeing the sustainable development of this underdeveloped part of the world, and since the West has interests in ensuring that enhanced security in the region benefits all nations, including those in the West, East-West scientific cooperation is vital. Pinning such cooperation on glaciers and associated issues not only makes humanitarian and scientific sense, but political sense in this post-9/11 world.

<u>HIGH-ICE Science objectives</u>:

1. *Present/very recent mass balance*
   - Field:
     - Ganges Headwater Focus Area. Benchmark glacier. Langtang and Gangotri Glaciers. JNU lead.
     - Indus Tributaries Focus Area: Benchmark glacier: Chhotra-Shigri, and others (UNO/JNU)
     - North of Himalaya: benchmark glacier to be identified, UW lead (Gillespie)
     - Database (NSIDC extended database/Raup)
   - GLIMS pan-Himalayan and High Asia glaciation.
     - India/Nepal/Bhutan: JNU lead (Hasnain).
     - Afghanistan/Pakistan: UNO lead (Bishop/Shroder).
     - North of Himalaya: UW lead (Gillespie)
     - Database (NSIDC/Raup)
   - Theoretical (Climate/glacier model) (Gillespie, Bishop, and Kaeaeb lead climate modeller selection effort)
2. *Moraines and ice cores used to calibrate glacier response to climate change.* Field and remote sensing efforts in each region. Must understand pre-1950 (pre-anthropogenic) climate change and glacier responses that were already underway. (UNO and UW lead, with ice-core and climate experts and glacier dynamics modeler).
3. *Ice dynamics—ablation, ice flow, debris accumulation, water storage and release*
   - Field component (Ganges, Indus, and Central Asia focus areas, as above)

-- Remote sensing (= GLIMS' objectives)
Ablation, ice flow, debris accumulation: By region, with overview, as in #2 above.
Water storage and release: By region and with overview, as in #1 above.
Contributions of glaciers to meltwater production in these major drainage basins must be understood in context with overall water production from all sources.
-- Global comparison of glacier lake occurrence and outburst mechanisms (UW and USGS with contributions by region, as in #1 above).

4. *Routine image-processing service* (provided by UNO under separate funding)

<u>HIGH-ICE student projects</u>:
Each investigator will serve on the thesis/dissertation committees of at least 2 students, including at least one from another country. Each student will have an advisor from his institution; in addition to that institution's usual committee, an international committee will be formed with the advisor and at least two other investigators from other countries.

1. Glaciology of Gangotri Glacier, India. Snow accumulation, ablation. Finite element model of interior flow. Erosion. Debris accumulation. Water storage and release. 20^{th} century history from moraines. Projections of 21^{st} Century behavior from regional climate models. UW PhD student, Hallet advise?
2. Regional runoff model, Indus Basin. UNO MS student, Bishop/Shroder advise?
3. Regional runoff model, Ganges basin. UZ student, Kaeaeb advise?
4. Regional runoff model, interior drainages, Central Asia. UW student, Gillespie advise?
5. Determination of equilibrium line altitude/firn line from remote sensing "snapshots." Model extended across Himalaya and Central Asia, with reality check from benchmark glaciers (field data). ASU student, Wessels advise.
6. Projection of firn line and runoff through next 50 years with use of digital elevation model, regional circulation/precipitation model, and surface radiative balance model. Test model against current-era observations (project #5). UZ student, Kaeaeb advise?
7. Socio-economic implications of glacier change, next 50 years in Pakistan/Afghanistan. UNO student from Pakistan or Afghanistan, Shroder/Bishop advise.
8. Socio-economic implications of glacier change, next 50 years in India/Nepal/Bhutan. JNU student from India.
9. Socioeconomic/security impacts of glacier change in Asia; East-West relations related to glacier change, next 50 years. UW student from U.S.

<u>HIGH-ICE applications objectives</u>:
Fresh water resources
-- Agriculture and food security related to irrigation
-- Drinking water
-- Nonagricultural industry
Lakes/flood hazards—the objective that has much public appeal and local importance
Hydropower
Socio-economic implications over the next one to two decades.

<u>MEETINGS</u>:
Co-investigator meetings will take place each year (with students starting the second year). Students will take part in field work each year starting with the second year. Workshops including a computer-based lab training component will be held the 1^{st}, 2^{nd}, 4^{th}, and 5^{th} years in the West: host institutions to include UW, UNO, NSIDC, and UZ. Field workshops will take place

during the 3rd and 6th years, one in India and another in Pakistan (if these can be made all-inclusive and secure); if security is an issue, or if politics are an obstacle, then the field workshops will be held in another Asian country. Filed workshops will include a conference component and a computer-based lab component (ideally in Delhi and Islamabad) and a field component on a secure glacier site. If security cannot be assured, then these field workshops will occur elsewhere.

REPORTING

Preliminary progress reports will be prepared by individual investigators during each year (e.g., a journal paper), and an overall progress report will be submitted by the Principal Investigator each year, these reports would be loosely coordinated. During the third and sixth years full summary reports in one volume (a journal special issue the third year; a book the sixth year) will include peer-reviewed chapters or articles from each Co-I institution and by each student, with collaborators and other outside experts also invited to submit chapters/articles.

ROUGH BUDGET:

The project/proposal assumes that the participating institutes are already funded and have projects pertaining in some regard to Himalayan or pan-Asiatic glaciology. The funding profile for this proposal will include money for students, field and workshop logistics, and a token sum to enable soft-moneyed investigators to dedicate a small part of their time to this effort. This is a super-regional program tying together the GLIMS Coordination Center and Regional Centers for South Asia, Southwest Asia, Central Asia, China, and Russia; it also brings in the core involvement of ICIMOD (International Center for Integrated Mountain Development, based in Kathmandu), the National Snow and Ice Data Center, and the pan-Asiatic glaciological expertise at the University of Washington and the University of Zurich. Co-investigator institutions may include: UW (PI institution), USGS-Flagstaff, NSIDC, UNO, ICIMOD, ETH, and JNU. After funding is secured for a core activity pertaining to the Ganges Headwater Focus Area, the project will be expanded to other institutes and across the Himalaya and adjoining parts of glaciated Asia. Additions will be considered collaborating institutions, who will receive funding to cover workshop logistical cost coverage. This 6-year program will train four PhDs, who will then have opportunities to have funded service at the two South Asian co-I institutes (JNU and ICIMOD).

NOTE: Raise each of the following applicable costs by 4% each year to account for inflation.

Unburdened costs:

-- Nine students, $25k/year excluding overhead for each of four years; includes $3k per student for travel budget. Same funding rate for 2 more years for nine recent graduates as they serve as post docs in South/Central Asia. $225k/year total for all 9 students/post docs for each of 6 years (excluding overhead).

-- Local workshop organizing funding at host institutions for workshops each of 6 years ($5k/year 1st, 2nd, 4th, and 5th years, $10k/year for 3rd and 6th years)—workshop budgets to be developed; may include meal costs, meeting space, field access, and other costs.

-- Workshop logistical costs for individuals, calculated as $2500/year for each workshop participant who travels trans-continentally, $1200/particpant for those who travel intracontinentally. Estimated roughly as $1800 average per participant each year. 22 participants 1st year, then 31 for each remaining year: $40k 1st year, $56k each remaining year.

-- 6 autonomous meteorological stations (2 for each of 3 benchmark glaciers, one high and one low elevation), one-time expense of $6k/station = $36k for only 2nd year.

-- Publication fees for annual reports:

Year 1: $1,000 (for PI report)
Year 2: $2,000 (for PI report)
Year 3: $15,000 (for journal special issue)
Year 4: $10,000 ($2k/student, $2k for PI)
Year 5: $2,000 (for PI report)
Year 6: $20,000 (for book)

-- Field camp, field training, other field costs: $5,000 each year for each of 3 Focus Area = $15k/year total starting 2nd year.

-- Data acquisition (IRS, Landsat, ASTER)-- $12k/year for each of 6 years ($2k for IRS, $5k each for ASTER and Landsat).

-- Software implementation (2 Indian software writers, JNU), $5k/year, years 1-5

-- Salary and benefits for fully soft-moneyed investigators:

Kargel, 1.5 month/year calculated at UW salary rate, $15k/year
Kieffer, 0.5 months/year at USGS: $7k/year
Wessels, 3 months/year at USGS, $20k/year
Raup, 1 month/year at NSIDC, $7k/year
Total salary + benefits, $49k/year (unburdened)

Budget totals by year, direct costs only (no overhead):

Year 1: $351,000
Year 2: $405,000 +4.0% inflation factor = $421,000.
Year 3: $387,000 + 8.2% inflation factor = $419,000
Year 4: $377,000 +12.5% inflation factor = $424,000
Year 5: $369,000 + 17.0% inflation factor = $432,000
Year 6: $387,000 + 21.7% inflation factor = $471,000.

Budget totals with overhead estimated as 52% of direct costs:

Year 1: $534,000
Year 2: $640,000.
Year 3: $635,000.
Year 4: $644,000.
Year 5: $657,000.
Year 6: $716,000.