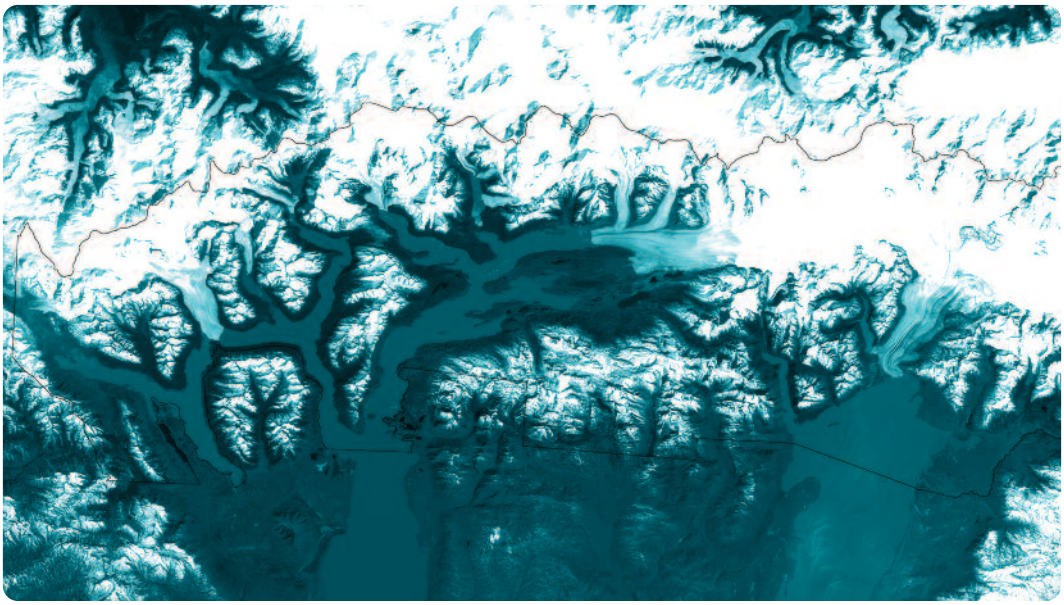
THE PONTIFICAL ACADEMY OF SCIENCES

Working Group on

Fate of Mountain Glaciers in the Anthropocene

2-4 April 2011 • Casina Pio IV



VATICAN CITY 2011

IF YOU WANT TO CULTIVATE PEACE, PROTECT CREATION

…there is a very close connection between respect for the human being and the safeguard of creation. 'Our duties towards the environment flow from our duties towards the person, considered both individually and in relation to others' (n. 12). If the person becomes degenerate the environment in which he lives deteriorates; … In fact, it is possible to note a reciprocal influence between the human face and the 'face' of the environment: 'when "human ecology" is respected within society, environmental ecology also benefits' (Encyclical *Caritas in Veritate* n. 51).

BENEDICT XVI, Message for the
43rd *World Day of Peace*, 1 January 2010

The Holy Father … found himself … in the middle of an assembly of giants: about him there were in fact more than ten peaks, all above 4000 m. They made one think of the inspired image of the prophet Habakkuk, since those great mountains like giants seemed to raise their arms to heaven, so seeming even higher: *Dedit abyssus vocem suam, altitudo manus suas levavit* (Hab 3:11). … what a great school of sciences a high mountain is! Quite apart from other teachings, the mountains say at once what great abundance of riches these rocky masses tear up from the depths of earth to launch themselves into the depths of heaven. It was all a complex of forces, of hidden secret actions in the immense workshop of nature, which prepare the verdant dowries of the hills and the beautiful waves of the waters. Certainly … those great scientists, are called to contemplate such singular wonders, and to an exceedingly beneficent end.

PIUS XI, *Address at the Solemn Audience Granted to the Plenary Session of the Pontifical Academy of Sciences*, 30 January 1938

PROLOGUE

Mountain glaciers in Europe, North America, South America, Africa, and the largest of them all in the Himalayan-Tibetan region are retreating, some at alarming rates. The hypothesized causal factors include global warming, atmospheric brown clouds, land surface modification, recovery from the mini ice-age, and large scale drying of the air among other factors. Some glaciers are expected to disappear during this century and others are predicted to experience significant loss of spatial cover and mass. The downstream consequences include glacial lake outburst floods, disrupted availability of water for agriculture and human consumption, changes to mountain eco systems, increased frequency of forest fires, loss of habitat, and other potential catastrophes. A holistic study covering the physical science, social science, and the human dimension sides of the problem has not been attempted thus far. It is our hope that this first of its kind workshop organized by the Pontifical Academy of Sciences will lay the foundation for studying and monitoring this potential disaster that will impact the entire planet.

The workshop will also explore avenues available for mitigating and adapting to this potential tragedy.

P.J. Crutzen, L. Bengtsson and V. Ramanathan

Fate of Mountain Glaciers in the Anthropocene

PROGRAMME

Saturday, 2 April 2011

9:00	*Welcome* **W. Arber**, President of the Pontifical Academy of Sciences
	Global Issues
9:15	*Past and Future Changes in the Anthropocene* **P.J. Crutzen**
9:45	Discussion
10:00	*Mountain Glaciers: A Vulnerable System Subject to Multiple Destabilizing Influences* **V. Ramanathan**
10:30	Discussion
10:45	Coffee Break
11:15	*Overview of Global Climate Change* **R.K. Pachauri**
11:45	Discussion
12:00	*Overview of Global Climate Change* **T. Stocker**
12:30	Discussion
12:45	*Observed Trends in Glaciers from Ice-core Studies* **L. Thompson**
13:15	Discussion
13:30	Lunch at the Casina Pio IV
15:00	*How Does Climate Drive Glaciers? A Process Perspective* **G. Kaser**
15:30	Discussion
	Regional Issues
15:45	*Vanishing Glaciers in the European Alps* **W. Haeberli**
16:15	Discussion
16:30	Coffee Break
17:00	*Impact of Global Warming on the Glaciers of South America, with Emphasis in Patagonia and Tierra del Fuego* **J. Rabassa**
17:30	Discussion
17:45	*Glacier Retreat in the Himalaya* **A. Kulkarni**
18:15	Discussion
18:30	*Observed Changes in the Himalaya-Tibetan Glaciers* **Ajai**
19:00	Discussion
19:15	Dinner at the Casina Pio IV with slideshow by Everest climber and photographer **D. Breashears**

Sunday, 3 April 2011

9:00	Holy Mass in the Chapel of the Casina Pio IV
	Downstream Impacts of Mountain Glaciers
10:00	*Climate Change Will Affect the Asian Water Towers* **W.W. Immerzeel**
10:30	Discussion
10:45	Coffee Break
11:15	*Potential Implication of Climate Change and Variability on the Relationship Between Mountain Glaciers and River Flow* **S. Sorooshian**
11:45	Discussion
12:00	Lunch at the Casina Pio IV
	Human Impacts on Glaciers
14:00	*Retreating Mountain Glaciers – A Warning of a Robust Climate Change?* **L. Bengtsson**
14:30	Discussion
14:45	*Atmospheric Brown Clouds* **S. Fuzzi**
15:15	Discussion
15:30	First group leaves by bus for the tour of the Roman villas, beginning at 16:00 (45' tour)
16:15	Second group leaves by bus for the tour of the Roman villas, beginnign at 16.45 (45' tour)
	Buses bring tour groups back to the Casina
19:00	Dinner at the Casina Pio IV

Monday, 4 April 2011

	Human Impacts on Glaciers (cont'd)
9:00	*Nuclear Winter and Impact on Himalayas* **O.B. Toon**
9:30	Discussion
9:45	*Role of Dust* **T. Painter**
10:15	Discussion
10:30	Coffee Break
	What can we do?
11:00	*Fast Action Mitigation* **D. Zaelke**
11:30	Discussion
11:45	*Mitigation – Global Actions* **J. Schellnhuber**
12:15	Discussion
12:30	*Geoengineering* **A. Robock**
13:00	Discussion
13:15	Lunch at the Casina Pio IV
15:15	*Geoengineering* **L. Russell**
15:45	Discussion
16:00	Coffee Break
16:30	**C. Rubbia** *Transforming Carbon Dioxide from a Liability to an Asset*
17:00	Discussion
17:15	*Regional Governance Systems* **C. Kennel**
17:45	Discussion
18:00	*Way for the Future and Conference Summary* **P.J. Crutzen, L. Bengtsson and V. Ramanathan**
18:30	Discussion
18:45	Dinner at the Casina Pio IV

Fate of Mountain Glaciers in the Anthropocene

LIST OF PARTICIPANTS

Dr. Ajai
Group Director, MPSG, Earth, Ocean, Atmosphere, Planetary Sciences & Applications Area, Space Applications Centre (ISRO)
Ahmedabad (India)

Prof. Werner Arber
President of the Pontifical Academy of Sciences
Biozentrum, Department of Microbiology, University of Basel
Basel (Switzerland)

Prof. Lennart Bengtsson
Director Earth Sciences
ISSI (International Space Science Institute)
Bern (Switzerland)

Mr. David Breashears
David Breashears Arcturus Motion Pictures
Boston, MA (USA)

Prof. Paul J. Crutzen
Max Planck Institute for Chemistry
Division of Atmospheric Chemistry
Mainz (Germany)

Mr. George Edgar
Chargé d'Affaires
at the British Embassy to the Holy See
Rome (Italy)

H.E. The Hon Timothy Andrew Fischer AC
Australian Ambassador to the Holy See
Rome (Italy)

Dr. Sandro Fuzzi
Institute of Atmospheric Sciences and Climate of CNR
Bologna (Italy)

Prof. Wilfried Haeberli
University of Zurich
Physical Geography Division
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Zurich (Switzerland)

Dr. W.W. Immerzeel
Utrecht University, Utrecht (The Netherlands)
FutureWater, Wageningen
(The Netherlands)

Prof. Georg Kaser
University of Innsbruck
Institute of Geography
Innsbruck (Austria)

Prof. Charles F. Kennel
Distinguished Professor of Atmospheric Science, Emeritus Senior Advisor, Sustainability Solutions Institute, UCSD
La Jolla, CA (USA)

Dr. Anil Kulkarni
Distinguished visiting Scientist
Divecha Center for Climate Change,
Centre for Atmospheric & Oceanic Sciences
Indian Institute of Science, Bangalore (India)

Prof. Rajendra Kumar Pachauri
Intergovernmental Panel on Climate Change (IPCC)
New Delhi (India)

Prof. Thomas H. Painter
Jet Propulsion Laboratory
California Institute of Technology
Pasadena, CA (USA)

Prof. Jorge Rabassa
Centro Austral de Investigaciones Cientificas (CADIC)
Ushuaia, Tierra del Fuego (Argentina)

Prof. Veerabhadran Ramanathan
Distinguished Professor of Climate and Atmospheric Science Scripps Institution of Oceanography, University of California
San Diego, CA (USA)

Prof. Alan Robock
Editor, Reviews of Geophysics; Director, Meteorology Undergraduate Program
Department of Environmental Sciences
Rutgers University, New Brunswick, NJ (USA)

Prof. Carlo Rubbia
Scientific Adviser of CIEMAT (Spain)
(Italy/Spain)

Prof. Lynn M. Russell
Scripps Institution of Oceanography,
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H.E. Msgr. Marcelo Sánchez Sorondo
Chancellor
The Pontifical Academy of Sciences
(Vatican City)

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Potsdam (Germany)

Prof. Soroosh Sorooshian
UCI Distinguished Professor and Director
Center for Hydrometeorology and Remote Sensing (CHRS), University of California
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Climate and Environmental Physics
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Prof. Lonnie G. Thompson
The Ohio State University
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Columbus, OH (USA)

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Department of Atmospheric and Oceanic Sciences
Boulder, CO (USA)

Dr. Durwood Zaelke
President, IGSD
Director, INECE Secretariat
Washington, DC (USA)

Fate of Mountain Glaciers in the Anthropocene

BIOGRAPHIES OF PARTICIPANTS

Ajai has been working as a Scientist at the Space Applications Centre (SAC), Indian Space Research Organisation, Ahmedabad, India since March 1978. He received his master's and doctorate degree from University of Allahabad, India. Presently, he is the Group Director of Marine, Geo and Planetary Sciences Group at SAC/ISRO. He is leading the team of scientists at SAC to study the Himalayan Snow and Glaciers. The national team has carried out large scale inventory of glaciers for the entire Indian Himalaya and part of Tibbatian Plateau. He has been involved in monitoring of a large number of glaciers, distributed climatic zones of Himalayas, for their retreat/advance. He is also carrying out a study to model the surface energy balance on glaciers. Dr. Ajai is carrying out a study on the impact of climate change/global warming on the Himalayan glaciers. In addition, he has also been responsible for inventory of desertification status for India. Desertification is an important indicator of climate change. At present he has initiated studies on the impact of debris cover on the process of melting/retreat of glaciers. He has published more than 200 scientific papers and reports. He is fellow of National Academy Sciences, India and society of Earth Sciences. He is the Chief Editor of Journal of Geomatics.

Lennart O. Bengtsson is Director of Earth Sciences at ISSI, Bern since 2008 and Professor of Meteorology at the ESSC University of Reading since 2001. He has been Director of the Max Planck Institute of Meteorology in Hamburg and Director of ECMWF in Reading. He is a member of several advisory boards and chairman of the scientific advisory boards for the Nansen Centre in Bergen and of the Italian Climate Program. He is a member of several academies and was responsible for a recent policy document on climate change by the Royal Swedish Academy of Sciences. He has taken active part in the debate on climate and energy matters. He has authored and co-authored about 220 articles on weather prediction, climate modelling and climate change studies. He recently organized a study conference on the Earth's Cryosphere and Sea Level Change. He has received many awards including the German Environmental Prize in 1998, the Descartes Price in 2005, the IMO prize in 2006 and the Alfred Wegener Medal in 2009. He is honorary member/fellow of the American meteorological society, of the Royal meteorological society and the European geophysical union. He has honorary degrees from the universities of Uppsala and Stockholm.

David F. Breashears Filmmaker, adventurer, mountaineer and Executive Director of GlacierWorks. GlacierWorks' mission is to raise public awareness about the effects of climate change in the Greater Himalaya and to encourage a better understanding of its consequences. During the past four years, Breashears has embarked on eight photographic research expeditions to several of the world's highest mountains – Everest, K2, Kangchenjunga, and Cho Oyu – to record new images that are a precise match of the earliest photographic records. Comparing the matched photographs starkly reveals glacial retreat during the intervening decades, and brings a tangible visual record to the effects of climate change on glaciers throughout the Greater Himalaya. Breashears' work has been exhibited at the Asia Society in New York City, and is scheduled for major exhibitions in Beijing, Berlin, Stockholm, London, Trento (Italy), and at the MIT Museum in Cambridge, Massachusetts. Since 1979, Breashears has combined his skills in climbing and filmmaking to become an acclaimed adventure filmmaker. He has led over forty expeditions to the Himalayan region and has worked on dozens of documentary film projects. David has produced and photographed films for the PBS series NOVA and FRONTLINE, as well as films for National Geographic Television, the BBC, ABC, NBC, and Universal Pictures. He was Producer, Director, and Expedition Leader of the IMAX film 'Everest', one of the most successful large-format films of all time. He is the recipient of numerous awards for achievement in filmmaking, including four Emmy Awards. David has reached the summit of Mount Everest five times.

George Edgar has taken over as Chargé d'Affaires at the British Embassy to the Holy See from February 2011, until the appointment of a new Ambassador later in the year. Read here biographical details about Mr Edgar. Career history (1995-to-date): February 2011– Chargé d'Affaires, British Embassy to the Holy See; April-October 2010, Head of the Papal Visit Unit, Foreign & Commonwealth Office; 2007-2010 Head, Consular Assistance Group, Foreign & Commonwealth Office; 2006-2007 FCO Envoy for Climate Security in Africa; 2004-2006 British Consul General, St Petersburg; 2001-2004 British Ambassador to the (Former Yugoslav) Republic of Macedonia; 1997-2000; British Ambassador to Cambodia; 1995-1997 Head of South Africa Section, Africa Department (Southern), FCO. Education: MA Environment, Policy and Society, Open University; MA Philosophy, Trinity College Cambridge.

Timothy Andrew Fischer was born on 3 May 1946 in Lockhart, New South Wales, and educated at Boree Creek and Xavier College, Melbourne. He is married with two sons. After graduating as an Australian Army Officer he served in the infantry in Australia and Vietnam (1966-1969). He served in the New South Wales Parliament (1971-84) and the Australian Federal Parliament (1984-2001) including as Leader of the National Party, Minister for Trade and Deputy Prime Minister (1996-99). Mr Fischer was Leader of the Official Australian Delegation which oversaw the ballot held on 30 August 1999 in East Timor. Mr Fischer has a range of agricultural, export and transport business interests. He was Chairman of Tourism Australia 2004-07, and of the Australia Thailand Institute 2005-08. He has held senior positions in various charitable organizations, including that of National

Chairman of the Royal Flying Doctor Service until 2008. He is author of several books, most recently the joint writing 'Bold Bhutan Beckons' and hosted a popular radio series: 'The ABC Great Train Show'. A number of foreign honours and decorations have been bestowed upon Tim Fischer: Argentina's Grand Cross of the 'Orden de Mayo al Merito'; Chile's Grand Cross of the 'Orden de Bernardo O'Higgins'; Brazil's Grand Officer of the National Order of the Southern Cross; Thailand's Blue Ribbon, Most Exalted Order of the White Elephant. In 2005 Tim Fischer was appointed Companion of the Order of Australia. On the 12 February 2009 he presented Credentials to Pope Benedict XVI as Ambassador to the Holy See.

Sandro Fuzzi holds a doctoral degree in Physical Chemistry from the University of Bologna (Italy). He is presently Research Director at the Institute of Atmospheric Sciences and Climate of the National Research Council (CNR) and Head of the Global Change National Program of CNR. Main research interests are the physical and chemical processes involving atmospheric aerosols and clouds and their effects on atmospheric composition change, climate, ecosystems and human health. He is/has been a member of several international Committees and Panels including the Science Panel of the European Commission on Atmospheric Composition Change, the Chairmanship of the International Global Atmospheric Chemistry Project of the International Global Geosphere-Biosphere Programme, the Atmospheric Brown Cloud Steering Committee of the United Nation Environmental Program, the Belmont Panel of the International Council for Science. He has coordinated over the years several national and international programs in the field of atmospheric composition change. He has participated to the 4th Assessment Report of the Intergovernmental Panel on Climate Change and is presently involved in the preparation of the 5th report due to appear in 2014. He has published over 120 papers in the refereed literature. He holds a position of Contract Professor of Global Change at the University of Bologna.

Wilfried Haeberli has a PhD in Geography, Geology and Biology from the University of Basel, Switzerland. His research focuses on snow and ice, high mountains, climate change impacts and natural hazards. From 1989 to 1995 he led the Glaciology Section at the Laboratory of Hydraulics, Hydrology and Glaciology at ETH Zurich. Since 1995 he is full professor for Physical Geography with specialisation in Glaciology, Geomorphodynamics and Geochronology at the Geography Department of the University of Zurich. From 1983 to 1986 he was the director of the Permanent Service on the Fluctuations of Glaciers (PSFG) and in 1986 (until 2010) he became the first director of the World Glacier Monitoring Service (WGMS) of IACS/ICSU, UNEP, UNESCO and WMO, which was established through the merger of the PSFG with the Temporary Technical Secretariat for the World Glacier Inventory. As a member of the Terrestrial Observation Panel for Climate (TOP-C) from 1996 to 2009 he was responsible for the integration of the cryosphere components as Essential Climate Variables into the terrestrial part (Global Terrestrial Observing System; GTOS) of the Global Climate Observing System (GCOS). He has been actively involved in various functions with IPCC assessments (Working Groups I and II) from the very beginning and works as an expert and consultant concerning high-mountain hazards in various countries of South America, Asia and Europe.

W.W. (Walter) Immerzeel has eleven years experience in (mountain-) hydrology, water resource management and climate change. He holds a PhD degree in physical geography at Utrecht University. His dissertation is titled 'Spatial modeling of mountainous basins; an integrated analysis of the hydrological cycle, climate change and agriculture'. He has extensive experience in the application of Remote Sensing in mountain areas for systematically assessing and monitoring climate change, flooding, droughts and food security. From December 2002 until June 2004 he worked at the International Centre for Integrated Mountain Development (ICIMOD) in Nepal and he is currently responsible for a number of projects on the cutting edge of climate change and hydrology. He is also a CASIMIR fellow supported by the Netherlands Organization for Scientific Research (NWO) and working on seasonal forecasting of Asian river discharges from the Himalayan cryosphere and monsoon feedbacks in close collaboration with Utrecht University. His research is published in top scientific journals.

Georg Kaser is a glaciologist and Professor for Climate and Cryospheric Research at the Institute of Meteorology and Geophysics of the University of Innsbruck, Austria. He was educated there in meteorology, geophysics, and geography. His primary interest is in the interaction of the atmosphere with snow and ice surfaces in different temporal and special scales as the processes that drive a glacier's reaction to climate. His expertise spans from global perspectives of glaciers' contribution to sea level rise and to regional water supply to small scale process studies as on particular tropical glacier features such as the ice cliffs on Kilimanjaro. He has visited and investigated glaciers in the European Alps, the Peruvian Andes, the Himalaya, Greenland, Alaska, and in East Africa. He was the Secretary of the International Commission of Snow and Ice (ICSI/IAHS/IUGG) and became the first President of the International Association for Cryospheric Sciences (IACS/IUGG) (2007-2009). In cooperation with UNESCO-IHP he had organised training courses on the monitoring of glacier mass changes in India, Nepal, and Bolivia. Besides having published his research results in leading scientific journals, he was also a Lead Author in Working Group I of the 4th IPCC Assessment Report as well as in the IPCC Technical Paper on Climate Change and Water, and contributes as such also to the 5th Assessment Report.

Charles F. Kennel was educated in astronomy and astrophysics at Harvard and Princeton. After a post-doctoral appointment to the International Centre for Theoretical Physics, Trieste, he joined the UCLA Department of Physics and its Institute for Geophysics and Planetary Physics, pursued research and teaching in space plasma physics and astrophysics, chaired the Physics Department, and eventually became the UCLA Executive Vice Chancellor, its chief academic officer. From 1994 to 1996, Kennel was Associate Administrator at NASA and Director of Mission to Planet Earth, the world's largest Earth science program. Kennel's experiences at NASA convinced him of the importance of Earth and environmental science, and he devoted the rest of his career to these and related fields. He became the ninth Director and Dean of the Scripps Institution of Oceanography and Vice Chancellor of Marine Sciences at the University of California, San Diego, serving from 1998 to 2006. Dr. Kennel was the founding director of the UCSD Environment and Sustainability Initiative. He presently is a distinguished professor, emeritus, of atmospheric sciences at Scripps, senior strategist for the UCSD Sustainability Solutions Institute, and co-leads the University of Cambridge/UCSD Global Water Initiative. During the winter term 2010, he was a Distinguished Visiting Scholar at Christ's College and the Judge Business School, Cambridge, UK. A member of the US National Academy of Sciences, the American Academy of Arts and Sciences, the American Philosophical Society, and the International Academy of Astronautics, Kennel has served on many national and international boards and committees, including the Pew Oceans Commission. He was a member of the NASA Advisory Council from 1998-2006 and again from 2008 to the present; he was its Chair from 2000 to 2005. He was the 2007 C.P. Snow lecturer at the University of Cambridge, and a member of the Presidential ('Augustine') Commission on human space flight in 2009. He presently chairs the California Council on Science and Technology and the Space Studies Board of the US National Academy of Sciences. He is also on the Boards of the Planetary Skin Institute, the Bermuda Institute of Ocean Sciences, the UCLA Institute of the Environment, the Caltech Jet Propulsion Laboratory, and the University of Alaska Geophysical Institute. He recently organized two special sessions of the Kyoto *Forum on Science and Technology in Society* devoted to the natural and social impacts of regional climate change.

Anil V. Kulkarni is working as Distinguished Visiting Scientist at Divecha Centre for Climate Change, Indian Institute of Science, Bangalore. He received his M. Tech. in Applied Geology from Indian Institute of Technology-Roorkee, India, MS in Geography from McGill University, Montreal, Canada and Ph. D. from Shivaji University, Kolhapur, India. His research interest are snow and glacier investigations using remote sensing methods, glacier mass balance modeling, modeling influence of climate change on distribution of Himalayan snow and glacier extent and snow and glacier melt runoff modeling. He has developed a new method to identify glacial terminus using satellite data and this method was used to estimate retreat of about 1868 Himalayan glaciers. This investigation provided, for the first time, information about fragmentation of glaciers, loss in glacial area and about the impact of climate change on Himalayan cryosphere. He has also developed a model to estimate glacier mass balance by monitoring snow line on the glaciers. This has provided, for the first time, mass balance

of large number Himalayan glaciers, which was otherwise available for few glaciers only. This work has created national and international awareness about the impact of climate change on Himalayan glaciers. He lead numerous expeditions to Himalayan glaciers and used modern techniques like Ground Penetrating Radar, Laser Range Finder, GPS and Spectral radiometer to study glaciers. His investigation has also shown that seasonal snow cover is melting in the middle of winter, and hence influencing the stream runoff. He has developed a snow and glacier melt runoff model to assess hydropower potential of small Himalayan streams. This model has shown for the first time the impact of climate change on availability of water in small Himalayan streams.

Thomas H. Painter, PhD, is a Scientist at the Jet Propulsion Laboratory/California Institute of Technology and a Research Professor at the University of California, Los Angeles. His areas of interest are snow hydrology, radiative impacts of light-absorbing impurities on snow and glacier melt, water resources from mountain snow and ice, multispectral remote sensing and imaging spectroscopy, and solar system astrobiology. Dr. Painter has pioneered our understanding of the impacts of dust emission from land use change on snow and ice cover in mountain systems and the hydrologic response. He received the PhD and MA in Geography from the University of California, Santa Barbara and the B.S. in Mathematics from Colorado State University. He is Chairman and organizer of the Working Group on Light-Absorbing Impurities in Snow and Ice. He is the Vice-Chair of the Cryosphere Focus Group of the American Geophysical Union and member of the AGU *Eos* Editorial Advisory Board.

Jorge O. Rabassa graduated as Licenciado in Geology at the Facultad de Ciencias Naturales y Museo, Universidad Nacional de La Plata, Argentina (1971), and got his doctoral degree in Natural Sciences at the same college (1974). He was a Doctoral student at the Bariloche Foundation (1971-1974) and a fulltime researcher (1974-1978) and professor at the Argentine universities of Comahue, La Plata and Buenos Aires Central, between 1979 and today. He is presently a fulltime researcher with CONICET, the National Research Council of Argentina, at CADIC, the CONICET Research Center at Ushuaia, Tierra del Fuego. He is also a part-time Full Professor at the Universidad Nacional de la Patagonia-San Juan Bosco at Ushuaia, and Director of the Graduate Field Course on Geomorphology and Quaternary Geology of Tierra del Fuego, held yearly at CADIC. His main fields of interest are Glacial Geology and Geomorphology, Glaciology, Climatic Change, Quaternary Geology, Late Cenozoic Paleoclimatology, and Late Mesozoic Paleogeomorphology, and more recently, Geomorphology of extra-terrestrial impact structures. He has been Director of CADIC (1986-1990), President of Comahue University (Northern Patagonia, 1998-2002), and Minister of Education, Culture and Science of the Provincial Government of Tierra del Fuego (2007-2008). He was a Fulbright postdoc as a Senior Research Associate, Department of Geological Sciences, State University of New York at Binghamton, New York, USA (1975-1976). He has been a visiting professor or research scholar at Lehigh University (USA, 1984), Universidade de Sao Paulo (Brazil, 1990), Universitat de Barcelona (Spain, 1997), Universidad de Santiago de Compostela (Spain, 2003), Universidade de A Coruña (Spain, 2004), University of Wisconsin-Madison (USA, 2004), University of Helsinki (Finland, 2005) and University of Illinois at Urbana/Champaign (USA, 2006). He was the Director of the postgraduate degree on Environmental Risk Management, Comahue University and Université de Poitiers (France), from 1999 to 2002. He has published over 200 papers in national and international journals and edited 3 books by international publishers, 5 special volumes of international journals and 12 volumes of the journal that he founded and edited for 16 years, 'Quaternary of South America and the Antarctic Peninsula'. He has been the advisor of 24 doctoral, postdoctoral and graduation theses in different universities of Argentina and abroad, and tens of visiting graduate students at Ushuaia. He is or has been member of the editorial board of several journals and has organized 19 international scientific meetings in Argentina, since 1982. He has gotten several awards such as the Storni Prize in 1978, by the Asociación Geológica Argentina, the Bernardo Houssay Prize in 1987, for his scientific work on the Geology and Glaciology of Patagonia and Antarctica, by CONICET, the 1998 Prize of the Asociación Geológica Argentina for his work on Quaternary Geology, and the Arturo J. Amos prize of the National Academy of Exact, Physical and Natural Sciences of Argentina in 2001. He was President of the 'Commission on the Quaternary of South America', INQUA, between 1987 and 1995. He is the only Argentine member of the Institut d'Estudis Catalans, the Catalonian Academy of Sciences, in the Science and Technology Department, since 2001. He has also had elected political positions as member of the Constitutional Assembly of Tierra del Fuego (1990-1991), member of the Provincial Parliament, Tierra del Fuego (1991-1995), and member of the Patagonian Parliament (1992-1995).

Alan Robock is a Professor II (Distinguished Professor) of climatology in the Department of Environmental Sciences at Rutgers University. He also directs the Rutgers Undergraduate Meteorology Program. He graduated from the University of Wisconsin, Madison, in 1970 with a B.A. in Meteorology, and from the Massachusetts Institute of Technology with an S.M. in 1974 and Ph.D. in 1977, both in Meteorology. Before graduate school, he served as a Peace Corps Volunteer in the Philippines. He was a professor at the University of Maryland, 1977-1997, and the State Climatologist of Maryland, 1991-1997, before coming to Rutgers. Prof. Robock has published more than 290 articles on his research in the area of climate change, including more than 165 peer-reviewed papers. His areas of expertise include geoengineering, climatic effects of nuclear war, effects of volcanic eruptions on climate, regional atmosphere-hydrology modeling, and soil moisture variations. He serves as Editor of *Reviews of Geophysics*, the most highly-cited journal in the Earth Sciences. His honors include being a Fellow of the American Meteorological Society and a Fellow of the American Association for the Advancement of Science. Prof. Robock is a Lead Author of the upcoming Fifth Assessment Report of the Intergovernmental Panel on Climate Change, which was awarded the Nobel Peace Prize in 2007. He currently serves as Past-President of the Atmospheric Sciences Section of the American Geophysical Union and Chair of the Atmospheric and Hydrospheric Sciences Section of the American Association for the Advancement of Science.

Lynn M. Russell is a Professor of Atmospheric Chemistry at the Scripps Institution of Oceanography of the University of California, San Diego. Her research interests are in aerosol composition, aerosol-cloud interactions, and aerosol evolution in the troposphere. Using a variety of techniques for both observations and modeling, her work has contributed to an improved understanding of how aerosols affect climate. Dr. Russell received her B.S. in chemical engineering and A.B. in international relations from Stanford University. She received her Ph.D. in Chemical Engineering from the California Institute of Technology in 1995.

Hans Joachim Schellnhuber has been director of PIK since the institute's foundation in1991 and Professor for Theoretical Physics at Potsdam University since 1993. He is a member of numerous national and international panels for scientific strategies and policy advice on environment & development matters like the German National Academy of Sciences (Leopoldina), the US National Academy of Sciences and the Max Planck Society and of the Editorial Boards of several scientific journals like 'Proceedings of the National Academy of Sciences'. Schellnhuber is Chairman of the German Advisory Council on Global Change (WBGU) and also a longstanding member of the IPCC. As a member of the High Level Expert Group he also advises the President of the European Commission, José Manuel Barroso, on energy and climate change issues. He authored and co-authored about 210 articles and more than 40 books in the fields of condensed matter physics, complex systems dynamics, climate change research, Earth System analysis, and sustainability science. In 2004, he was awarded the title 'Commander of the Most Excellent Order of the British Empire' (CBE) by Queen Elizabeth II. In 2007, he received the German Environment Prize for his scientific work in the field of climate impact research and its dissemination to politicians and the public and in 2008 he was awarded the Order of Merit of the State of Brandenburg.

Soroosh Sorooshian, Ph.D., N.A.E. is the Director of the Center for Hydrometeorology & Remote Sensing (CHRS) and Distinguished Professor of Civil & Environmental Engineering and Earth System Science Departments at UC Irvine. Prior to 2003 he was a faculty at the University of Arizona for 20 years. His area of expertise is Hydrometeorology, water resources systems, climate studies and application of remote sensing to earth science problems with special focus on the hydrologic cycle and water resources issues of arid and semi-arid zones. He also consults on problems related to surface hydrology and urban flooding. He is a member of the US National Academy of Engineering (NAE);

Member of the International Academy of Astronautics (IAA); Fellow, American Association for the Advancement of Science (AAAS); Fellow, American Geophysical Union (AGU); Fellow, American Meteorological Society (AMS); Fellow, International Water Resources Association (IWRA); Past Chair, Science Steering Group (SSG) of Global Energy and Water Cycle Experiment (GEWEX) of the World Climate Research Programme (WCRP); U.S. Member of the Hydrology Commission for WMO; Emeritus member of UCAR Board of Trustees and NOAA Science Advisory Board; Past-President of AGU's Hydrology Section; member of five editorial boards and former editor of AGU's Water Resources Research. He has served on numerous advisory committees, including those of NASA, NOAA, DOE, USDA, NSF, EPA, and UNESCO. Current member of the National Research Council's (NRC) Space Study Board (SSB) and past member of the Water Science and Technology Board (WSTB). He has testified to both Senate and House sub-committees on earth observations from space and water resources issues. Among his recent honors are: Recipient of the 4th Prince Sultan Bin Abdulaziz International Prize for Water Resources Management & Protection 2010, Recipient of the NASA Distinguished Public Service Medal in 2005, Recipient of Robert E. Horton Memorial Lectureship, American Meteorological Society, 2006 and the William Nordberg Memorial Lecture at the NASA Goddard Space Flight Center in 2004. In 2007 UNESCO awarded the Great Man-made River Water Prize to the Center for Hydrometeorology and Remote Sensing (CHRS) and the University of AZ Center for the Sustainability of semi-Arid Hydrologic and Riparian Areas (SAHRA). Professor Sorooshian was the founding director for both centers. Most recently, Professor Sorooshian was named the Walter Orr Roberts Lecturer, American Meteorological Society, 2009 for 'For bridging the interdisciplinary gap between hydrology, meteorology, and remote sensing'. He was also the recipient of the Orange County Engineering Council (OCEC) Distinguished Engineering Educator Award (2009); the American Society of Civil Engineers (ASCE) Orange County Branch 2007-2008 Distinguished Engineering Educator award and was selected as the 'Outstanding Professor in the Henry Samueli School of Engineering' by the UCI class of 2009. In 2010, Professor Sorooshian was elected Associate Fellow of TWAS, the Academy of Sciences for developing countries; and he was named an honorary Professor at Beijing Normal University, China (2010).

Thomas Stocker was born in Zürich and obtained a PhD in Natural Sciences of ETH Zürich in 1987. He held research positions at the University College London, McGill University (Montreal), Columbia University (New York) and at the University of Hawai'i (Honolulu). Since 1993 he is Professor of Climate and Environmental Physics at the University of Bern. His research encompasses the development of climate models of intermediate complexity, modelling past and future climate change and the reconstruction of the chemical composition of precipitation and greenhouse gas concentrations based on ice cores from Greenland and Antarctica. Thomas Stocker has published over 150 peer-reviewed papers in the area of climate dynamics and paleoclimate modeling and reconstruction. He was awarded a Dr. Honoris Causa of the University of Versailles (France) in 2006 and the Hans Oeschger Medal of the European Geosciences Union in 2009. After more than 10 years of service in the UN Intergovernmental Panel on Climate Change (IPCC) he has been elected Co-Chair of Working Group I 'The Physical Science Basis' of the IPCC in 2008.

Lonnie G. Thompson is one of the world's foremost authorities on paleoclimatology and glaciology. He has led 57 expeditions during the last 30 years, conducting ice-core drilling programs in the Polar Regions as well as on tropical and subtropical ice fields in 16 countries including China, Peru and Tanzania. Thompson and his team were the first to develop lightweight solar-powered drilling equipment for the acquisition of histories from ice fields in the high Andes of Peru and on Mount Kilimanjaro in Tanzania. The results from these ice-core derived climate histories, published in more than 200 articles, have contributed greatly toward improved understanding of Earth's climate system, both past and present. This is a prerequisite for efforts to predict future changes. Thompson's research has resulted in major revisions in the field of paleoclimatology, in particular, by demonstrating how tropical regions have undergone significant climate variability, countering an earlier view that higher latitudes dominate climate change. Lonnie is a member of the *National Academy of Sciences* and in 2007 he was awarded the *National Medal of Science*, the highest honor the U.S. awards to American scientists. Thompson has received numerous honors and awards. In 2005, he received the John and Alice Tyler Prize for Environmental Achievement and he was selected by *Time* magazine and *CNN* as one of Americas Best in science and medicine. His team's research has been featured in hundreds of publications for the general public, including *National Geographic* and the *National Geographic Adventure* magazines. The accomplishments by Lonnie and the OSU ice core team are highlighted in a 2005 book entitled, *Thin Ice: Unlocking the Secrets of Climate in the World's Highest Mountains* by Mark Bowen. He was elected as a member of the *American Philosophical Society* and received the Roy Chapman Andrews Society, *2007 Distinguished Explorer Award* (jointly with Ellen Mosley-Thompson). He is a recipient of the *Dan David Prize* (jointly with Ellen Mosley-Thompson) and the *Seligman Crystal* award, the highest professional award given in Glaciology. In 2009, Lonnie Thompson and Ellen Mosley-Thompson received the *David R. Brower Conservation* Award from the *American Alpine Club* for outstanding service in mountain conservation. In 2009 Lonnie was also elected as a foreign member of the *Chinese National Academy of Sciences* and received the 'Mountain Hero' award from The Mountain Institute in Washington D.C. Professor Thompson has Honorary Doctorate of Science degrees from both Colgate and Northwestern Universities.

Brian Toon is a Professor in and Founding Chair of the Department of Atmospheric and Oceanic Sciences, and a Professor in the Laboratory for Atmospheric and Space Physics at the University of Colorado at Boulder. He received an A.B. in physics at the University of California at Berkeley in 1969 and a Ph.D. in physics at Cornell in 1975. He was a Research Scientist at NASA's Ames Research Center from 1975 until 1997. He studies radiative transfer, cloud physics, atmospheric chemistry and parallels between the Earth and planets. He has published more than 300 papers, and is one of the most highly cited researchers in Geosciences. He received NASA's 1983 and 1989 medals for Exceptional Scientific Achievement for studies of the climates of Earth and the planets, and of the ozone hole. He won the American Physical Society's 1985 Leo Szilard Award for Physics in the Public Interest for his work on nuclear winter. He is a Fellow of the American Meteorological Society and the American Geophysical Union. He was recognized by UNEP in 2007 for contributions to the Nobel Peace Prize winning IPCC reports. In 2009 he received the University of Colorado's Robert L. Stearns Award for exceptional service to society. Brian has lead many NASA airborne field missions and has been involved in numerous satellite missions.

Durwood Zaelke is the founder and President of the Institute for Governance & Sustainable Development in Washington, DC and Geneva, where he heads IGSD's work on fast-action climate mitigation, including efforts to reduce black carbon, HFCs, and other short-term pollutants; founding Director of the Secretariat for the International Network for Environmental Compliance & Enforcement; co-founder and co-Director of the Program on Governance for Sustainable Development at the University of California, Santa Barbara's Bren School of Environmental Science & Management; co-founder and past President of the Center for International Environmental Law; and founder and past Director of the International & Comparative Environmental Law Program at the Washington College of Law at American University law school. He is the author or editor of several books and articles, including 'International Environmental Law & Policy' (4th ed. 2010), the leading law school textbook in its field, used in more than 200 schools throughout the world; and Mario Molina, Durwood Zaelke, K. Madhava Sarma, Stephen O. Andersen, Veerabhadran Ramanathan, and Donald Kaniaru, *Reducing abrupt climate change risk using the Montreal Protocol and other regulatory actions to complement cuts in CO2 emissions*, 'Proceedings of the National Academy of Science' (2009), www.pnas.org/content/early/2009/10/09/ 0902568106.full.pdf+html; A profile of Mr. Zaelke appears in the Environmental Law Institute's *Forum* magazine, www.igsd.org/docs/ZAELKE.FORUM_JAN_2008.PDF.

For the biographies of the other Academicians of the PAS, cf. Pontificia Academia Scientiarvm, *Yearbook* (Vatican City 2008), p. 15 ff. and http://www.vatican.va/roman_curia/pontifical_academies/acdscien/own/documents/pasacademicians.html

MEMORANDUM

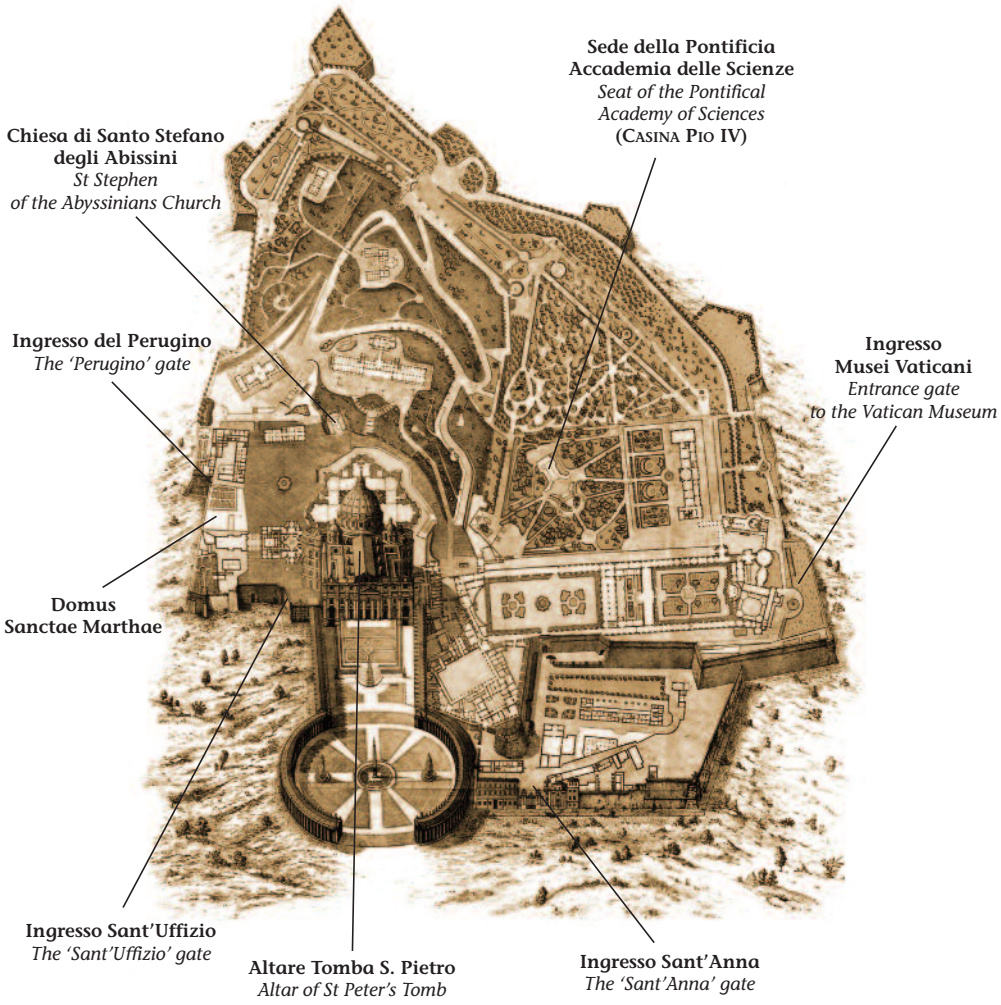
1) On 2, 3 and 4 April 2011 a bus will leave the Domus Sanctae Marthae and the Hotel Columbus for the Academy, 15 minutes before the beginning of the morning session (8.45 am). A bus will depart from the Academy after dinner at the end of the afternoon session to take participants back to the Domus Sanctae Marthae and to the Hotel Columbus.

2) Lunch and dinner for the participants will be served at the Academy from 2 to 4 April 2011.

3) On Sunday 3 April Mass will be celebrated at 9.00 am in the Academy's Chapel, before the morning session.

4) On Sunday 3 April, at the end of the afternoon session, a bus will take the participants from the Casina Pio IV to the tour of the Roman Villas (see programme).

Note
Please give your **form for the refunding of expenses** to the Secretariat at least one day before your departure so that you can be refunded immediately.



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