Participants of the 8th TPE workshop

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76	Zhang	Fuqing	Pennsylvania State University, USA
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78	Zhang	Qiong	Stockholm university, Sweden
79	Zhang	Tingjun	Lanzhou University, USA
80	Zhang	Wenjian	World Meteorological Organization
81	Zhang	Xu	Alfred Wegener Institute, Germany
82	Zhao	Jinping	Ocean University of China, China

8th TPE Workshop, Gothenburg, Sweden

Regional environmental changes: from pole to pole

September 24-26, 2018, Gothenburg, Sweden

Sunday, September 23, 2018

10:00 - 20:30	**Registration**	LOCATION – Lobby of the Scandic Crown Gothenburg

****Arranged lunch at 12:45, gather at the registration desk****

****Arranged dinners at 19:15, gather at the registration desk****

Monday, September 24, 2018		
8:00-8:30	** Registration (continued) **	LOCATION - Scandic Crown
Opening	***Moderator: Ailikun & Deliang Chen***	***Location- Dalén 2***
8:30-8:35	Deliang Chen, Director of the TPE Gothenburg Office	Welcome
8:35-8:40	Prof. Göran Hilmersson, the Dean of the Science Faculty at GU	University of Gothenburg (GU) welcome address
8:40-8:50	Tandong Yao, co-chair of TPE	Introduction of the TPE program and the aim of this workshop
8:50-8:55	Lonnie Thompson, co-chair of TPE	Vision of the three-pole synergistic study
8:55-9:10	Wenjian Zhang，Assistant Secretary-General，World Meteorological Organization (WMO)	Introduction of WMO polar priorities
9:10-9:30	Yvon Le Maho	Lesson from the Antarctic: artificial intelligence is needed to investigate further the response of polar biodiversity to global changes
9:30-9:50	Fahu Chen, Director of Institute of Tibetan Plateau Research, CAS	Climatic change, vegetation history and landscape responses on the Tibetan Plateau during the Holocene: a comprehensive review for future
9:50-10:10	Toshio Koike	Observation and Prediction of the Hydrological Processes in the Tibetan Plateau and its Surrounding Mountain Areas
10:10-10:30		*******Coffee Break (Location: Köksluckan) *******
Plenary Session I	***Chair: Jean Jouzel & Tandong Yao***	***Location- Dalén 2***

10:30-10:50	Yongqin Liu	Microbe in Glacier on the Tibetan Plateau: Past Present Future
10:50-11:10	Hans Linderholm	Arctic hydroclimate variability during the last 2000 years
11:10-11:30	Yaoming Ma	The progress on the study of energy and water cycle over heterogeneous landscape: from Tibetan Plateau to Third Pole and Pan-Third Pole
11:30-11:50	Sebastian Mernild	Glaciers and ice caps as water resources in high mountain regions, with Andes cordillera as example
11:50-12:05	Peter van Oevelen, Director, International GEWEX Project Office	The WCRP Water for the Food Baskets Grand Challenge, Convection-Permitting modelling and Crosscutting activities in TPE and ANDEX
12:15 -13:00		****** Lunch (Location: Brasseriet Crown) ******
		(After lunch, participants take the shuttle to the Gothenburg University)
Public events at the Gothenburg University		
	Venue: Hall (Hörsalen) at Department of Earth Sciences, University of Gothenburg (Guldhedsgatan 5C, Gothenburg)	
13:30-14:00	Opening ceremony for the TPE office at University of Gothenburg (Dress code: Business. For details see the invitation)	
14:00-14:10	******Group photo******	
14:10-14:40	******Coffee break with posters and tour of the TPE Gothenburg office******	
Invited lecture	***Chair: Tandong Yao & Fuqing Zhang***	
14:40-15:10	Jean Jouzel	Water isotopes from pole to pole: what do we learn from paleodata?
15:10-15:40	Lonnie Thompson	Glacier Archives from the Tropics to the Poles as Recorders and Indicators of Climate Change
15:40-16:10	Örjan Gustafsson	Thawing permafrost and light-absorbing aerosols: two grand challenges for climate research in the Arctic and the Third Pole
16:10-16:20	******Coffee break** ****	

16:20-16:40	Katarina Gårdfeldt	A short overview of the Swedish polar research
16:40-17:25	***Panel Discussion on researches in the three poles and possible synergies chaired by Deliang Chen*** ***Panelists: Lonnie Thompson, Örjan Gustafsson, Tandong Yao, Wenjian Zhang, Francesca Pellicciotti, Katarina Gårdfeldt, Sebastian Mernild, Andreas Mulch，Fahu Chen***	
17:25-17:30	Tandong Yao and Deliang Chen	Conclusions
17:45	**Shuttle back to the hotel for dinner at the Scandic Crown**	
19:00-21:00	******Welcome dinner at the Scandic Crown (Location: Brasseriet Crown)******	

Tuesday, September 25, 2018

Plenary Session II	***Chair: Céline Heuzé & Baiqing Xu***	***Location- Dalén 2***
8:30-8:50	Gerrit Lohmann	Climate variability patterns from synoptic to orbital time scales
8:50-9:10	Qiong Zhang	Contribution of sea-ice albedo and insulation effects to Arctic amplification in the EC-Earth Pliocene simulation
9:10-9:30	Andreas Kääb	Recent Glacier and Lake Changes on the Western Tibetan Plateau
9:30-9:50	Shichang Kang	Overview of black carbon in snow and ice and its impacts on cryosphere melting
9:50-10:10	Marko Scholze	Constraining terrestrial carbon and water fluxes using remotely sensed soil moisture and FAPAR data within the Carbon Cycle Data Assimilation System
10:10-10:30		****Coffee break (Location: Köksluckan) ****

Plenary Session III	***Chair: Kenichi Ueno & Julia Curio***	***Location- Dalén 2***
10:30-10:50	Bob Su	Observation and modelling of land-atmosphere radiative and heat-water transfer processes
10:50-11:10	Cunde Xiao	Tendency of solid to liquid transition of precipitation phases over cryospheric regions
11:10-11:30	Kun Yang	Impacts of complex terrain in the Third Pole on water vapour transport and precipitation
11:30-11:50	Francesca Pellicciotti	Mass losses of debris covered glaciers in High Mountain Asia
11:50-12:10	Maihe Li	Warming-induced upward migration of vegetation belts in high mountains and the underlying physiological mechanisms
12:15-13:15		****Lunch (Location: Brasseriet Crown)****

Plenary Session IV	***Chair: Fuqing Zhang & Arjen Stroeven***	***Location- Dalén 2***
13:30-13:50	Fuqing Zhang	Advanced ensemble-based regional reanalysis for the Third Pole region
13:50-14:10	Anil V. Kulkarni	Basin scale mass balance modelling to assess future changes in water availability in Satluj Basin, Himalaya
14:10-14:30	Togtokh Chuluun	Adaptation to climate change in the Gobi region of Mongolia
14:30-14:50	Yongqi Gao	Arctic warming and Eurasian climate: a short review
14:50-15:10	Bolot Moldobekov	The impact of climate change on water resources and glaciers of Kyrgyzstan
15:10-15:30		******Coffee break (Location: Köksluckan) ******

Plenary Session V	***Chair: Maihe Li & Örjan Gustafsson***	***Location- Dalén 2***
15:30-15:50	Eryuan Liang	Moisture-mediated responsiveness of treeline shifts to global warming in the Himalayas
15:50-16:10	Céline Heuzé	Upcoming first basin-wide year-round observations of the Arctic Ocean
16:10-16:30	Tingjun Zhang	Permafrost Degradation and its Carbon Contribution to the Atmosphere
16:30-16:50	Arjen Stroeven	The Last Glacial Maximum in Central Asia
16:50-17:10	Thorsteinn Thorsteinsson	The Global Cryosphere Watch
17:10-17:30	Rongxing Li	Greenland Ice Sheet and Sea Ice Change Analysis Using Multi-source Satellite Sensing Data
17:30-17:45	Irene Lake, Director, International Project Office for CORDEX of WCRP	CORDEX and opportunities for partnership/cooperation with TPE

18:00-20:00		******Dinner at the Scandic Crown (Location: Brasseriet Crown)******

Wednesday, September 26, 2018

Breakout Session I	***Chair: Hans Linderholm*** ***Rapporteur: Eryuan Liang*** ***Monitor: Keyan Fang***	***Location- Bryggmästaren 2***
8:30-8:45	Hans Chen	Arctic-Mid Latitude Linkages: Lessons Learned and Future Coordinated Modeling Experiments
8:45-9:00	Kenichi Ueno	Challenges observing precipitation by GPM mission over mountains
9:00-9:15	Shiori Sugimoto	Future changes in extreme years of South Asian monsoon and its impact on summer climate in East Asia
9:15-9:30	Julia Curio	Climatology of Tibetan Plateau Vortices in reanalyses and a high-resolution global climate model
9:30-9:45	Keyan Fang	A dipole climate pattern between Northeast Asia and Antarctica on interdecadal timescales over the past five centuries
9:45-10:00	Qiang Wang	Unstructured-mesh ocean and climate modeling and applications in polar regions
10:00-10:15		****Coffee break (Location: Köksluckan)** ****
10:15-10:30	Xu Zhang	Glacial Climate Stability: Pathway to understand abrupt glacial climate shifts
10:30-10:45	Seok-Woo Son	The role of the Central Asian mountains on the midwinter suppression of North Pacific storminess
10:45-11:45		**Group discussion**

Breakout Session II	***Chair: Sebastian Mernild*** ***Rapporteur: Kun Yang*** ***Monitor: Weicai Wang***	***Location- Bryggmästaren 1***
8:30-8:45	Lei Wang	Multi-sphere hydrological modelling over the Third Pole Region
8:45-9:00	Paolo Scussolini	Modeling past and future changes in hydrology and hydrodynamics, and understanding impacts societies – potential

		for application to the Third Pole Environment
9:00-9:15	Fan Zhang	Study on Runoff Flow Paths of Two Headwater Catchments in Northeast Tibetan Plateau
9:15-9:30	Rodney Stevens	Quantitative Analysis and New Applications of old Technology for Groundwater Infrastructure and Sustainability in arid regions
9:30-9:45	Changgui Lin	Glacier-air interaction may extend the lifetime of Himalayan glaciers
9:45-10:00	Daqing Yang	Application of remote sensing data for northern hydrology research
10:00-10:15		****Coffee break (Location: Köksluckan)** ****
10:15-10:30	Jinping Zhao	The potential changing of the surface circulation of the Arctic Ocean and its long-term observation in the three-pole synergistic study
10:30-10:45	Tinghai Ou	High resolution global reanalysis significantly improved regional climate simulation over the Tibetan Plateau
10:45-11:45		**Group discussion**

Breakout Session III	***Chair: Togtokh Chuluun*** ***Rapporteur: Ailikun*** ***Monitor: Daniel Joswiak***	***Location-Ullevi***
8:30-8:45	Pedram Attarod	How Does Climate Change Impact Net Primary Production (NPP) and Evapotranspiration (ET) from the Caspian Region of Northern Iran?
8:45-9:00	Baiqing Xu	How old are Tibetan ice caps?
9:00-9:15	Weidong Guo	Influence of Tibetan Plateau snow cover on East Asian atmospheric circulation at medium-range time scales
9:15-9:30	Ali Najafi Nejad	Assessment of climate change impacts on water resources management in Tehran province
9:30-9:45	Björn Gunnarson	Potential for detecting industry pollution in trees using Energy Dispersive X-ray Fluorescence (ED-XRF)
9:45-10:00	Mats Björkman	The sensitivity of carbon in Arctic permafrost soils to climate change

10:00-10:15		****Coffee break (Location: Köksluckan)** ****
10:15-10:30	Julia Kukulies	Temporal and spatial variations of convection and clouds over the Tibetan Plateau based on CloudSat/CALIPSO satellite retrievals
10:30-10:45	Deepak Aryal	Variability of Tropopause over South Asian Monsoon Region
10:45-11:45		**Group discussions**
11:45-12:10		**Presentation of the group discussions (5' each) and conclusion of the workshop (Chair: TPE co-chairs)**
12:15-13:00		****Lunch break (Location: Brasseriet Crown)****
13:05-18:15		****Field excursion****
19:00-21:00		****Dinner at the Scandic Crown (Location: Brasseriet Crown)****

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Variability of Tropopause over South Asian Monsoon Region

Deepak Aryal, Dibas Shrestha
Central Department of Hydrology and Meteorology, Tribhuvan University, Kathmandu, Nepal
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The seasonal variability of tropopause is studied using AIRS/Aqua L3 Monthly Standard Physical Retrieval (AIRS+AMSU) V006 (AIRX3STM) datasets from September 2002 to 2016 around two major monsoon hit locations, Central Himalayan Region (CHR, 77E-91E and 25N-30N) and Bay of Bengal Region (BoB, 80E-98E and 9N-24N), in the South Asian monsoon region. The relation between tropopause height (TH), tropopause temperature (TT) and tropopause pressure (TP) are examined. The preliminary finding shows the notable differences in tropopause characteristics between the regions. There is strong seasonal variability in TH ranging from a minimum of ~15.5 km in winter (December - February) to a maximum of ~17.7 km in mature summer season (June - August) over CHR. In contrast, very week seasonal variation of TH (< 0.4 km; 16.8 km in winter and 16.5 km in summer season) is observed over the BoB region. Despite the fact that BoB region is at lower latitude, TH is higher over CHR by ~0.5 km in summer. Over CHR the TT is warmer in winter (-70.7 oC) and cooler during summer season (-78.1 oC). On the other hand, TT is slightly warmer (-79.7 oC) in summer compared to winter (-81.4 oC). Similar pattern with strong seasonal variability of TP (minimum of 95 hpa during summer and maximum of 119 hpa during winter season) is observed over CHR. In conclusion, analysis of equivalent potential temperature calculated by using JRA-55 reanalysis data at two pressure level (200 hpa and surface) indicates strong convection during summer near Himalayan Foothills and is responsible for the reverse seasonal pattern of tropopause characteristics between the regions.

Key words: tropopause, himalayan, satellite, AIRS, potential temperature

Attarod，Pedram

How Does Climate Change Impact Net Primary Production (NPP) and Evapotranspiration (ET) from the Caspian Region of Northern Iran?

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[2]Key Laboratory of Water Cycle and Related Land Surface Processes, Institute of Geographic Sciences and Natural Resources Research, Chinese Academy of Sciences, Beijing, China

We assessed how climate change may impact the net primary production (NPP) and evapotranspiration (ET) of diverse climates in the Caspian region of Northern Iran where natural broadleaved forests are capable of growing potentially. NPP and ET were estimated by employing the reliable and efficient climate-based models of Synthetic and Penman-Monteith, respectively. We analyzed long-term meteorological data recorded by synoptic stations located throughout the region with distinct climate types ranging from extremely humid to the Mediterranean. Sensitivity coefficients were used to examine the variability of NPP and ET to changes in temperature and precipitation. NPP (t ha^{-1} y^{-1}) ranged from 8.6 for extremely humid to 6.1 for the Mediterranean climate yet for humid and semi-humid climate types located in the central Caspian region were 6.7 and 7.2, respectively. NPPs of humid and semi-humid climate types exhibited largest sensitivity (0.7) to change in yearly temperature. We estimated that 5% increase in temperature could increase yearly NPP by approximately 2.5% in both very humid and extremely humid climate types. In response to changing precipitation, greatest NPP variability was observed in the humid and extremely humid climate types (0.5). ET (mm. Y^{-1}) ranged from 894-1015 across five climate types. An estimation of 10% increase in temperature can induce a 5% increase in yearly ET from the Mediterranean climate. To buffer expected shifts in temperature and precipitation due to climate change, it may be suitable to incorporate NPP and ET sensitivities when planning for forest development and management in this region.

Bianchi, Federico

Atmospheric new particle formation: from the poles to the Everest base camp

Federico Bianchi
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The atmosphere forms a major part of the environment to which life on Earth is sensitively responsive. In recent years, substantial research has been motivated by the importance of atmospheric aerosols on the global radiation budget, cloud formation, and human health. Concentrations of reactive gases and atmospheric aerosol particles are tightly connected with each other via physical, chemical and biological processes. Human and societal actions, such as emissions-control policies, urbanization,

forest management and land-use change, as well as various natural feedback mechanisms involving the biosphere and atmosphere, have substantial impacts on the complicated couplings between atmospheric aerosols, trace gases, greenhouse gases, air quality and climate.

One of the keys to understand what is going on in the atmosphere is to understand the formation of new aerosol particles. The production of molecular clusters and their growth to larger sizes, is a world-wide phenomenon, with a significant contribution to aerosol particle number load and indirect radiative effects as well as urban air pollution. Understanding the very initial steps of atmospheric aerosol formation requires detailed knowledge of the concentrations of neutral and charged clusters, on their chemical composition, and on the gaseous compounds participating in their formation and growth.

In the presentation I will focus on our latest research where we measured how the aerosol is formed in the Poles and in the Himalaya. More specifically I will show results from the follow measurements campaigns:

- Pyramid station, Everest base camp, Nepal (28° N, 86° E)
- Aboa station, Finnish research station in Antarctica (73° S, 13° W)
- Marambio base, Argentinian Antarctic base (64° S, 57° W)
- Gruvebadet Atmosphere Laboratory, Ny-Ålesund, Svalbard (79° N, 12° E)
- Station Nord, Greenland (81° N, 16° W)

Björk, Robert G.

Implications of evergreen shrub advancement: The need for a more comprehensive view of Arctic shrubification

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Arctic shrub expansion is occurring rapidly across the tundra biome and its potential ecological repercussions have been widely discussed. These include reduced albedo, higher winter soil temperatures due to increased snow trapping and higher nutrient mineralization rates. But while the term “shrub expansion” often implicitly refers to an increase in tall, deciduous species such as birch

and willow, several studies have also found a strong increase in evergreen dwarf shrubs in response to warming, a fact which has received far less attention. The effects of an evergreen dwarf shrub expansion are markedly different compared to an increase in taller, deciduous species. While the low stature of these shrubs means that they are unlikely to influence snow cover, they also produce more recalcitrant litter, which reduces microbial activity and may thereby decelerate turnover rates. Here, we argue that basing predictions of how shrub expansion will affect tundra ecosystems on characteristics only applicable to tall deciduous shrubs, hampers our understanding of the complex feedbacks related to arctic vegetation shifts. Furthermore, we emphasize the potentially crucial role of mycorrhizal type in regulating ecosystem carbon dynamics, which has been highlighted in recent research, and propose a new conceptual model on ongoing shrub expansion that distinguishes between several important aspects connected to the ecological differences of deciduous and evergreen shrubs, and accentuates how herbivores may act as mediators between these two groups.

Björkman, Mats

The sensitivity of carbon in Arctic permafrost soils to climate change

Arctic permafrost soils contain huge amounts of stored carbon (C), which upon thaw releases ancient organic matter that has been stored in the frozen soil for centuries. However, the critical role that the Arctic C stocks may come to play in the future of our climate system has not been adequately investigated. Particularly, there is a gap in our current knowledge as to which extent permafrost-protected C is available for microbial metabolism once the soils thaw.

During 2012 samples were obtained from permafrost soils at two Arctic locations; Adventdalen (Svalbard) and Zackenberg (Greenland). At both locations sites were chosen to represent Meadow and Heath communities. Soil-pits were established and the A, B and C soil horizons were collected, together with the upper 20 cm permafrost, with three replicates for each community. Homogenized soil sample where further divided into three sub-samples. Two of the sub-samples have been incubated at +5°C with either Anaerobic or Aerobic conditions, with the third subsample sample working as a "control" incubated at -5°C.

Here we present data after three years of incubation were the CO_2 emissions from drained soils (A, B and Permafrost horizons) are generally higher from Zackenberg meadow sites then the heath communities. No difference can be found between the Adventdalen communities. Generally the organic rich A horizon generates higher fluxes then the C (mineral soil) and Permafrost soils due to the higher C content in these horizons. First CH_4 production was detected after 56 days incubation

(Zackenberg meadow A horizon) indicating that oxygen levels have dropped below the threshold for anaerobic decomposition. Furthermore, initial ^{14}C-dating of the emitted CO_2 indicate that the respired C is much younger then the bulk ^{14}C-dating of the soil.

Chen, Hans W.

Arctic–Mid Latitude Linkages: Lessons Learned and Future Coordinated Modelling Experiments

Hans W. Chen (hanswchen@gmail.com)

The Arctic has experienced an amplified warming in recent decades compared with lower latitudes, a phenomenon known as Arctic amplification. Coincident with Arctic amplification, there has been an increase in the occurrence of extreme weather events in many Northern Hemisphere mid-latitude regions, including droughts, heat waves, and cold spells. Past studies have investigated possible linkages between Arctic amplification and mid-latitude weather, but results remain inconclusive in large part because of diverging results from observational and modelling studies. This talk will summarize some of the findings from the US CLIVAR Working Group on Arctic Change and Possible Influence on Mid-latitude Climate and Weather, which convened an international workshop in Washington, D.C., on 1-3 February 2017. Furthermore, a brief overview will be given on planned work to tackle the question of Arctic-mid latitude linkages, including coordinated modelling experiments.

Cheng, Xiao

Drifting Antarctic iceberg -- natural buoy for ice-ocean interaction study

Xiao Cheng, Tian Li
College of Global Change and Earth System Science, Beijing Normal University

Antarctic icebergs are usually calved from ice sheet or ice shelf along the Antarctic coastal lines. Iceberg drifts under the force of wind or ocean currents, and shrinks with further calving and basal or surficial melting. The drifting and shrinking process are closely related to the ocean and atmosphere, especially the ocean process. The investigation of the drifting icebergs is a very important way to study the ice-ocean interaction, which means the iceberg could be looked as a natural buoy in south

ocean.

In this study, we use time series satellite remote sensing data to track and measure the evolution processes of two tabular icebergs, C28A and C28B, originating from iceberg C28. The monitoring began during the calving of iceberg C28 from the Mertz Ice Tongue in February 2010 and ended in April 2012. The evolution of the iceberg area was determined from ENVISAT ASAR images, and the freeboard change was derived from CryoSat-2 profiles. Two patterns of iceberg area decreases are observed during iceberg drifting. Calving area of the two studied icebergs is observed to be greater in the winter. The cold-water regime surrounding the iceberg can help the iceberg maintain a stable state. This study reveals the potential use of radar remote sensing when monitoring Antarctic icebergs.

Curio, Julia

Climatology of Tibetan Plateau Vortices in reanalyses and a high-resolution global climate model

Julia Curio, Reinhard Schiemann, Kevin Hodges, Andrew Turner

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The Tibetan Plateau (TP) and surrounding high mountain ranges constitute an important forcing of the atmospheric circulation over Asia, and thereby impact weather and climate of East Asia. Mesoscale Tibetan Plateau vortices (TPVs) are one of the major precipitation-producing systems on the TP. A fraction of TPVs move off the TP to the east and can trigger extreme precipitation in parts of China, e.g. Sichuan province and Yangtze River valley, that can result in severe flooding. In this study, the climatology of TPV occurrence is examined in two reanalyses and, for the first time, in a high-resolution global climate model using an objective feature tracking algorithm.

The results show that the global climate model is able to simulate TPVs at ~ 25 km horizontal resolution and in general agrees with the reanalyses. The subtropical westerly jet (SWJ) controls the distance TPVs can travel eastwards and shapes the annual cycle of TPV occurrence. Most TPVs are generated in the north-western part of the TP. The centre of this main genesis region is small and stable throughout the year, despite the large latitudinal variations in the SWJ.

Precipitation associated with TPVs accounts for up to 70% of the total precipitation over the central

TP in July. While their climatological impact on the mainland of China is low, TPVs can account for up to 40% of the total precipitation in selected months often due to individual TPVs highlighting their role in individual high-impact events.

Fang, Keyan

Pacific multi-decadal climate variability over the past 430 years

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Oceanic and atmospheric patterns play a crucial role in modulating large-scale climate variability from interannual to multi-decadal timescales. The brevity of the existing instrumental records hinders the ability to recognize climate patterns before the industrial era, which can be alleviated by using appropriate proxies. To identify stable large-scale climate signals in proxy data through time, we first identified tree-ring datasets from distant regions containing coherent variations, and then interpreted their common climate signal. With this methodology, a covarying hydroclimate pattern surrounding the entire Pacific for the past 430 years was identified, which is conspicuous on multi-decadal timescales only. This multi-decadal climate variability is closely linked to the dominant sea surface temperature (SST) mode of the Pacific Ocean, which was defined as the Pacific Multi-decadal Variability (PMV). Compared to the Interdecadal Pacific Oscillation (IPO) and mega-Niño-Southern Oscillation (ENSO) modes, the PMV is more pronounced on long timescales and it has high loadings over SST of the southern Pacific Ocean. The PMV has a lagged response to the solar irradiance.

Gao, Yongqi

Arctic warming and Eurasian climate: a short review

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The Arctic plays a fundamental role in the climate system and has shown significant climate change in recent decades, including the Arctic warming and decline of Arctic sea-ice extent and thickness. In contrast to the Arctic warming and reduction of Arctic sea ice, Europe, East Asia and North America have experienced anomalously cold conditions, with record snowfall during recent years. In this short talk, we review research history of Arctic warming and its influential mechanisms, and research history of sea ice impact on the Eurasian climate and its uncertainties. Finally, we conclude with a brief summary and suggestions for future research.

Gunnarson, Björn

Potential for detecting industry pollution in trees using Energy Dispersive X-ray Fluorescence (ED-XRF)

Björn Gunnarson, Department of Physical Geography, Stockholm University.

The use of trace elements analysis for monitoring chemical changes in soil and water is rapidly becoming an increasingly valuable technique in the measure of environmental health and protection. Traditional methods, such as well drilling or direct soil sampling, collecting water, air, and soil samples below the ground are expensive and time consuming. Chemical analyses of tree-ring data can provide information of subsurface pollutants since tree rings record environmental changes and has been used to investigate past and present pollution histories (Balouet et 2012; Vroblesky 2008). In a pilot study we assess the potential of using dendrochemistry as a forensic tool to investigate chemical contamination patterns in the surroundings of a former glass factory in Southern Sweden. Tree-ring width chronologies were produced from exposed and non-exposed sites using energy disperse X-ray fluorescence (EDXRF) technique. Traces of barium and considerable alteration of the chlorine profiles were successfully detected confirming the potential of the method to record

environmental releases. The dendrochemical analysis also highlighted the differences in the response of tree species to elements uptake (root sensitivity) and the importance of metals bioavailability. An adopted sampling strategy is of outmost importance to the success of the method.

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Guo, Weidong

Influence of Tibetan Plateau snow cover on East Asian atmospheric circulation at medium-range time scales

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The responses of atmospheric variability to Tibetan Plateau (TP) snow cover (TPSC) at seasonal, interannual and decadal time scales have been extensively investigated. However, the atmospheric response to faster subseasonal variability of TPSC has been largely ignored. Here, we show that the subseasonal variability of TPSC, as revealed by daily data, is closely related to the subsequent East Asian atmospheric circulation at medium-range time scales (approximately 3–8 days later) during

wintertime. TPSC acts as an elevated cooling source in the middle troposphere during wintertime and rapidly modulates the land surface thermal conditions over the TP. When TPSC is high, the upper-level geopotential height is lower, and the East Asia upper-level westerly jet stream (EAJS) is stronger. This finding improves our understanding of the influence of TPSC at multiple time scales. Furthermore, our work highlights the need to understand how atmospheric variability is rapidly modulated by fast snow cover changes.

Gustafsson, Örjan

Thawing permafrost and light-absorbing aerosols: two grand challenges for climate research in the Arctic and the Third Pole

Ö. Gustafsson, S. Kang and many colleague
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There are several major scientific uncertainties, or Wild Cards, in the climate system that may change the playing ground and in most cases accelerate climate change. These climate wild cards can alter the otherwise linear connection between anthropogenic emissions and warming by triggering abrupt changes in the climate. Building on long-term collaborative research, both in the Arctic and the Himalaya-Tibetan Plateau, as well as in source regions for the TP in both East and South Asia, this presentation will present key findings as well as provide an outlook for ongoing and future research both with respect to: (i) Thawing permafrost and resultant effects on large-scale carbon and greenhouse gas emissions; and (ii) fingerprinting sources, composition and radiative effects of black and brown carbon aerosols. Results from direct studies of the TP region will be complemented by studies in the Arctic, where inferences from Arctic findings of both thawing permafrost and climate-affecting aerosols for the Third Pole Environment will be emphasized.

Heuzé, Céline

Upcoming first basin-wide year-round observations of the Arctic Ocean

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Observation technologies for the Arctic Ocean have hardly evolved over the last decades, mostly consisting of scientists going at sea for a few days in summer and profiling the water column at a given location and time. As a result, there is still a lot we do not know about the spatial and temporal variability of the ice-covered Arctic. I will here report on two upcoming international field campaigns that I will join and that aim at addressing these knowledge gaps: MOSAiC and the Synoptic Arctic Survey (SAS). MOSAiC will see scientists join a research vessel frozen in the pack ice to study the fully coupled atmosphere-ice-ocean system over an entire year as they drift through the Eurasian Arctic. SAS will give the geographical perspective by having as many ice-breakers as possible at the same time in the Arctic to collect the same measurements throughout the entire basin. Lessons learnt from the logistics and coordination of such Arctic missions, from combining the national agenda with the common international programme to instrument calibration and data sharing policy, are transferable and crucial for similar observation systems of the Third Pole.

Kang, Shichang

Overview of black carbon in snow and ice and its impacts on cryosphere melting

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Black carbon (BC), the most important light-absorbing aerosol, can contribute to magnify climate warming and darken snow and ice surface, which can further accelerate melting of cryosphere. Here, we assemble the reported BC data in snow and ice globally to review the spatial distribution and temporal variations of BC deposition and its impacts on cryopshere melt. Ice cores from Tibetan Plateau, Alps, Greenland, and Arctic region indicated that BC concentrations increased abruptly in the mid-19th century and largely continued to increase into the 20th century, consistent with increases

in BC emissions from the industrialization. These historical archives of BC in ice cores can enhance to validate modeling efforts on the atmospheric transport, deposition and effects of BC on the cryospheric regions. At present, BC concentrations in snow were one or two orders of magnitude higher in the Tibetan Plateau than those in Arctic snow (several ppb), while almost comparable to those in snow of Alps. In the North America, BC concentrations typically ranged from ~0.5−70 ppb in snow; whereas in Andes mountains, BC were concentrated in the upper 5 cm of snow surface layer over time by dry deposition (~80 ppb), which were comparable to those reported in northwestern China. Abundant evidence has suggested that the shrinkage of glaciers, rapid melt of sea ice, and reduction of snow cover durations are associated with BC deposition. Latest studies indicated that BC in the glacier surface were responsible for about 20% of the albedo reduction, causing a positive radiative forcing. The instantaneous radiative forcing induced by BC in fresh snow were estimated to be about several W m^{-2}; while it can reached >100 W m^{-2} for the aged snow or granular ice in glaciers. The effect of BC can lead to an average of approximately 15%–20% of the total glacier melt or several days of reduction of snow cover duration in the Tibetan Plateau. BC and dust contributed 1.6%–5.1% to the reduction in sea ice albedo during melting, emphasizing the significance of BC in accelerating snow melting during early sea ice melt season. Aerosol-cloud interactions represent one of the largest uncertainties in global radiative forcing from pre-industrial time to the present. There remains a need to enhance observations and models for reducing uncertainties of BC impacts on cryosphere melt.

Koike, Toshio

Observation and Prediction of the Hydrological Processes in the Tibetan Plateau and its Surrounding Mountain Areas

Toshio KOIKE
International Centre for Water Hazard and Risk Management (ICHARM)

The Asian summer monsoon (ASM) is the largest global climate system affecting almost half the global population. Even though predicting the summer monsoon activity is critical for food production, water supply and the economy, our prediction skill is still poor due to lack of understandings in the ASM system. The Tibetan Plateau (TP) that has an averaged attitude nearly 5000m is suggested to play an important role to heat the troposphere as a huge, intense and elevated heat source with strong sensible heating. Even though sensible heat transfer by thermally induced dry

convections has been considered as the main cause of tropospheric heating at the pre-monsoon period over the TP, recently a wet process with the cloud activity is shown to be indispensable to warming the deep upper troposphere. The hydrological processes controlled by snow, permafrost and soil moisture and the interactions with the atmosphere above the land surface of the TP should be quantitatively monitored and predicted for improvement of understanding of the climate variability of the ASM and the impacts of the climate change impact on the ASM. An integrated observation and prediction system in the Tibetan Plateau and its surrounding mountain areas is now under constructing.

Kukulies, Julia

Temporal and spatial variations of convection and clouds over the Tibetan Plateau based on CloudSat/CALIPSO satellite retrievals

Julia Kukulies, Deliang Chen, Minghuai Wang

In this paper, seasonal and diurnal variations of cloud vertical structure and cloud properties have been derived from four combined CloudSat and CALIPSO satellite datasets and compared between three subregions in the TP which are marked by different large-scale moisture transport. The results show that the plateau is generally dominated single-layer clouds and stratiform cloud types at significantly lower levels above the ground compared to the surrounding regions. Cloud occurrence frequencies peak during the summer monsoon season between May and September and are generally higher during daytime compared to nighttime in all three subregions. The fraction of detected ice cloud layers in the TP domain exceeds 50 % during all months and 80 % between January and April. In contrast to the westerly-dominated north where ice clouds dominate the detected cloud layers at a wide range of cloud heights, ice cloud layers in the monsoon-dominated domain occur at high levels and simultaneously with lower level cumulus, indicating its linkages to convective systems. This study complements previous satellite observations of clouds over the TP and reveals firstly the high contribution of stratiform ice cloud layers in the westerly-dominated north, secondly the importance of the monsoon season which exhibits by far higher variations than between day and nighttime in all regions, and finally the significant regional differences of cloud characteristics within the plateau which seem to match with the respective seasons of either westerlies or monsoon circulation in the north and south. This work suggests therefore to ascertain the relative importance of stratification, local convection, mesoscale convective systems and advection (large-scale moisture transport) in

future studies on hydro-climatic changes in the TP region.

Kulkarni, Anil V.

Basin scale mass balance modelling to assess future changes in water availability in Satluj Basin, Himalaya

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The Satluj River is the largest tributary of the Indus River. It flows into the Bhakra reservoir, and is a primary source of water for irrigation and hydropower in the Indian states of Punjab and Haryana. The region produces almost 26% food grain of India. Therefore, comprehensive knowledge on current and future water availability is important. Here, we have estimated the influence of climate change on glacier mass loss in the Satluj basin using an improved accumulation-area ratio (IAAR) method and used to assess future variation of inflow from glaciated terrain. The mean equilibrium line altitude (ELA) (2000-2013) of the Satluj basin is estimated using field temperature and precipitation data as 5504±130 m asl. The specific and cumulative mass balance is estimated as -0.46±0.47 $mwea^{-1}$ and 9.18 Gt, respectively. The mass balance results obtained from IAAR method was validated using a geodetic method for 25 glaciers in the Satluj basin.

Future changes in glacier volume and area are estimated using climate model output data of temperature and precipitation from the GFDL-CM3 model for the RCP 8.5 scenario. As compared to year 2010 region is likely to experience 3.7^0 C rise in summer temperature and 14% reduction in winter precipitation by 2050, which will increase ELA by around 413m. This will change mass loss to -0.85 mwe/a, resulting in a cumulative mass loss of 29 Gt, three times higher than current mass loss. Volume-Area scaling suggests, it will lead to loss in 33% glacier area by 2050. However, the area loss is not uniform and glaciers located in lower altitude and small in size will lose maximum, around 55% of glaciers in the Satluj basin will disappear completely by 2050.

By the end of the century, the region will experience 7.94^0 C increase in summer temperature and 4.6% reduction in winter precipitation. Mean ELA is estimated as 6342 masl and mean annual mass balance is -1.10 mwea-1. In the second half of the century addition 25 Gt of glacier stored water will be lost resulting in 72% reduction in glacier area. From year 2014 to 2090, region will lose 85% of volume and 81% glacier area. We have used mass balance and seasonal precipitation to estimate

amount of meltwater from glacier area. In year 2010, Bhakra reservoir received 2±0.67 km^3 of water from glacier melt, which is 14% of total inflow. Our model suggests that this will increase up to 2.2 km^3/yr by 2050 and then reduce to 1.49 km^3/yr by 2090, which will need improvement in water management practices.

Lake, Iréne

CORDEX and opportunities for partnership/cooperation with TPE

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The Coordinated Regional Climate Downscaling Experiment (CORDEX) Scientific Vision is to advance and coordinate the science and application of regional climate downscaling through global partnership, which includes to better understand regional phenomena, to evaluate and improve models and techniques, to produce coordinated results and to foster communication and knowledge exchange. This global framework, with 14 domains encompassing the Himalaya region, has led to common protocols for the development and inter-comparison of high-resolution projections and for how to archive and make accessible the results.

The scientific challenges first identified to act as guidance for CORDEX, with the aim to target specific regional fine-scale features, have been further refined and pilot studies launched to address them. Furthermore, to meet the needs of the IPCC and to further streamline the work and sharing of information in the CORDEX community a succinctly structured core set of regional simulations is being developed.

In this presentation, we will provide an update on the status of the CORDEX activities and opportunities for partnership/interaction with the Third Pole Environment.

Le Maho, Yvon

Lesson from the Antarctic: artificial intelligence is needed to investigate further the response of polar biodiversity to global changes

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Compared to the huge and early development of technology in earth sciences, the methods for investigating biodiversity, and in particular of wild animals, has for long been left behind. Yet, the situation has changed during the last decades, thanks to a sequence of pioneering research on polar animals: the first satellite tracking of birds and mammals, the first use of bio-loggers to investigate the behaviour and physiology of animals and/or to use them as environmental platforms to study environments which are not readily accessible and their response to global change, the first use of RadioFrequencyIDentification (RFID) of animals and, recently, the use of robots, which may be camouflaged in fake animals, to approach and study them without disturbance. However, in my view, it's still a first step. Thanks to artificial intelligence we still have large perspectives in technical innovation to investigate wild animals and their environment. For example, the combined use of robots and drones should enable us to know in more details the life of animals which inhabit in remote and poorly accessible areas and their environment. Many species are investigated through the so-called method of capture-recapture. However, for example, the cages do not make any difference between individuals that have or not already been captured. Instead, intelligent cages could be designed.
The TPE program is a unique opportunity to develop further the use of new technology to investigate biodiversity and the impact of climate change.

Li, Mai-he

Global warming-induced upward migration of vegetation belts in high mountains and the underlying physiological mechanisms

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Global warming has resulted and is resulting in glacier retreat and upward migration of the vegetation belts in high mountains around the world. A meta-analysis covering more than 1,700 species (plants and animals) indicated that the mean rate of species range shifts was 6.1 km per decade towards the poles, or 6.1 m per decade upwards in the past (Parmesan and Yohe 2003). In this presentation, I will explain the physiological mechanisms underlying the warming-induced upward migration of vegetation belts, using large-scale data collected from the alpine treeline.

Li, Rongxing

Greenland Ice Sheet and Sea Ice Change Analysis Using Multi-source Satellite Sensing Data

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The rate of ice loss of the Greenland ice sheet has accelerated since 1992 according to the IPCC AR5 report. The ice loss is partitioned in approximately similar amounts between surface melt and outlet glacier discharge. Meanwhile, both the extent and thickness of the Arctic sea ice decreased since 1980. As more and more satellite data have become available, a number of important factors, such as mass

balance, sea ice thickness and extent, ice surface albedo and others, can be estimated in higher spatial and temporal resolutions and help multi-factor based analysis in the Arctic environment. We present our recent work on processing multi-source satellite data and the results of analyzing interactions between snow, ice, and water on and around the ice sheet using estimated mass balance, surface albedo and sea ice changes. For example, GRACE data are used to obtain estimates of the mass variations of the ice sheet; AMSR and MODIS data are applied to extract Arctic sea ice changes; and an improved algorithm is implemented to enhance the daily albedo product from MOD10A1 by a set of processing steps, including de-nosing, gap-filling and bias correction. Patterns of changes in temporal scales (e.g., decadal, annual and seasonal) are presented, as well as their correlations. These results can be extended to perform studies on the entire Arctic region and tri-polar interactions.

Liang, Eryuan

Moisture-mediated responsiveness of treeline shifts to global warming in the Himalayas

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Among forest ecosystems, the alpine treeline ecotone can be considered to be a simplified model to study global ecology and climate change. Alpine treelines are expected to shift upwards in response to global warming given that tree recruitment and growth are assumed to be mainly limited by low

temperatures. However, little is known whether precipitation and temperature interact to drive long-term Himalayan treeline dynamics. Tree growth is affected by spring rainfall in the central Himalayan treelines, being good locations for testing if, in addition to temperature, precipitation mediates treeline dynamics. To test this hypothesis, we reconstructed spatiotemporal variations in treeline dynamics in 20 plots located at six alpine treeline sites, dominated by two tree species (birch, fir), and situated along an east-west precipitation gradient in the central Himalayas. Our reconstructions evidenced that treelines shifted upward in response to recent climate warming, but their shift rates were primarily mediated by spring precipitation. The rate of upward shift was higher in the wettest eastern Himalayas, suggesting that its ascent rate was facilitated by spring precipitation. The drying tendency in association with the recent warming trends observed in the central Himalayas, however, will likely hinder an upslope advancement of alpine treelines and promote downward treeline shifts if moisture availability crosses a critical minimum threshold. Our study highlights the complexity of plant responses to climate and the need to consider multiple climate factors when analyzing treeline dynamics.

Lin, Changgui

Glacier-air interaction may extend the lifetime of Himalayan glaciers

Changgui Lin, Kun Yang, Deliang Chen, Tandong Yao, Nicolas Guyennon, Tinghai Ou, Xiaoxin Yang, Franco Salerno

The retreat of Himalayan glaciers caused by warming poses a major threat to the security of Asia’s water tower. Projections of their future changes however suffer from large uncertainties, largely due to a poor understanding of processes affecting glaciers’ variability. It is currently assumed that glaciers play a passive role in the climate system, but this ignores glacier-air interaction. In this paper, the negative feedback mediated by glacier-air interaction is identified: retreating Himalayan glaciers may push local precipitation upward, thereby enhancing snow accumulation on the upper part of glaciers. We propose that this may lead to a generic delay of these glaciers to be vanished as predicted by models that do not account for this feedback.

Liu, Yongqin

Microbe in Glacier on the Tibetan Plateau: Past Present Future

Yongqin Liu, Tandong Yao

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Microbe are dominant in glaciers and sensitive to climate change. They date the past, drive the present and influence the future of glacier and downstream ecosystem. Microbe in ice core record the past climatical and environmental change. Bacterial abundance, diversity, and community composition among Geladangdong, Ninjingangsang and Zuoqiupu ice cores was related to geographical location and annual climatic events specific to each glacier. Despite the broad environmental differences among the three ice cores studied, bacterial community composition in the ice cores converged through time. These biotic changes are related to increasing air temperature, atmosphere cycle impacts, and anthropogenic activities that have occurred on and around the Plateau during the last half-century. Microbe in glacier influence the glacier melting and carbon cycle in the present. They decrease the glacier albedo increasing the melting and drive carbon metabolism determine the amount of organic carbon in the glacier. In the future, microbe in glacier influence the downstream lake ecosystem as glacier shrinking. Glacier melting input bacteria into preglacier lake, drive the variation of bacterial community composition and diversity. Glacier melting caused the change of conductivity and nutrient status of glacier-feed lakes have a great impact on bacterial community composition and diversity.

Ma, Yaoming

The progress on the study of energy and water cycle over heterogeneous landscape: from Tibetan Plateau to Third Pole and Pan-Third Pole

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The exchange of heat and water vapor between land surface and atmosphere over the Third Pole region (Tibetan Plateau and nearby surrounding region) plays an important role in Asian monsoon, westerlies and the northern hemisphere weather and climate systems. Supported by various agencies in the People’s Republic of China, a Third Pole Environment (TPE) observation and research

Platform (TPEORP) is now implementing over the Third Pole region. The background of the establishment of the TPEORP, the establishing and monitoring plan of long-term scale (5-10 years) of it will be shown firstly. Then the preliminary observational analysis results, such as the characteristics of land surface energy fluxes partitioning and the turbulent characteristics will also been shown in this study. Then, the parameterization methodology based on satellite data and the atmospheric boundary layer (ABL) observations has been proposed and tested for deriving regional distribution of net radiation flux, soil heat flux, sensible heat flux and latent heat flux (evapotranspiration (ET)) and their variation trends over the heterogeneous landscape of the Tibetan Plateau (TP) area. To validate the proposed methodology, the ground measured net radiation flux, soil heat flux, sensible heat flux and latent heat flux of the TPEORP are compared to the derived values. The results showed that the derived land surface heat fluxes over the study areas are in good accordance with the land surface status. These parameters show a wide range due to the strong contrast of surface feature. And the estimated land surface heat fluxes are in good agreement with ground measurements, and all the absolute percent difference in less than 10% in the validation sites. The sensible heat flux has increased slightly and the latent heat flux has decreased from 2001 to 2016 over the TP. It is therefore conclude that the proposed methodology is successful for the retrieval of land surface heat fluxes and ET over heterogeneous landscape of the TP area. Further improvement of the methodology and its applying field over the whole Third Pole region and Pan-Third Pole region were also discussed.

Mernild, Sebastian

Glaciers and ice caps as water resources in high mountain regions, with Andes cordillera as example

Sebastian H. Mernild, Nansen Environmental and Remote Sensing Center, Bergen, Norway

Snow, glaciers, and ice caps are important water resources. The availability of snow, glaciers, and ice caps as freshwater resources are therefore of vital socio-economic importance for areas downstream high mountain regions. Here, South America, the Andes Cordillera, is used as an example, however, similar challenges are present downstream the Third Pole. For Andes Cordillera climate, snow, glacier mass-balance, and runoff conditions were simulated. For example, snow cover presence, duration, properties, and water amount play a major role in Earth’s climate system through its impact on the surface energy budget. NASA modern-era retrospective analysis for research and applications data sets were used to simulate first-order atmospheric forcing (e.g., near-surface air temperature and

precipitation, including the fraction of precipitation falling as snow), terrestrial snow characteristics (e.g., snow cover days, snow water equivalent depth, and snow density), and river runoff characteristics (e.g., annual runoff conditions, runoff origins from rain, snowmelt, and glacier ice, runoff spatiotemporal variability, and runoff extremes: Low and high runoff conditions were defined as occurrences that fall outside the 10th (low values) and 90th (high values) percentile values of the period of record). For example, in a water resource perspective for the domain west of the Continental Divide 86 % of the simulated runoff originated from rain, 12 % from snowmelt, and 2 % from ice melt, whereas for Chile, the water-source distribution was 69, 24, and 7%, respectively. In Colombia and Ecuador, river runoff is dominated by tropical climate conditions and rain. Basins where river runoff is dominated by rain (pluvial regimes) cluster north of 40°S. South of 40°S, including the area around the Lake District, river runoff originated from all three components, and was highly dependent on the distribution of non-glacierized and glacierized basins combined with the presence and variability in snow and glacier coverage, basin area and hypsometry, and climate conditions. In Chile, the relative rain contribution to river runoff is lower while snow and ice melt contributions are higher than any of the other three countries Colombia, Ecuador, and Peru.

Moldobekov, B.D.

The impact of climate change on water resources and glaciers of Kyrgyzstan

Moldobekov B.D., Usubaliev R.A., Mandychev A.N., Kalashnikova O., Shabunin A.

Study of changes in main climatic parameters of air temperature and atmospheric precipitation has important scientific and applied meaning for assessment of Kyrgyzstan water resources.

These investigations are carried out based on observations of Kyrgyzhydromet and CAIAG automatic station network. This information analysis shows that there is similar to global increase in the average annual temperature of surface air over the long-term period in Kyrgyzstan. Regarding the atmospheric precipitation, there is no such trend. At the same time, both the air temperature, and atmospheric precipitation have significant fluctuations with uneven periodicity of several years.

One of the important parts of Kyrgyzstan's water resources are mountain glaciers. In CAIAG, observations of representative glaciers are carried out both by remote methods using space images of various satellites, and by direct measurement of the parameters of glaciers during expeditions with the subsequent calculation of their mass balance. In 2018, the inventory of glaciers in Kyrgyzstan as of

2013-16 was completed in CAIAG and Catalog of Glaciers of Kyrgyzstan was published. Based on the interpretation of the satellite images of the Landsat 8, the boundaries and areas of modern glaciers were determined.The tendency of glaciers area reduction was confirmed; their size was determined and the fact of defragmentation of large glaciers into smaller ones with an increase in their number was established, Thus, the amount of water preserved in the glaciers of Kyrgyzstan is decreasing.

Against the background of the continuing trend, climate warming and the degradation of glaciation, it is of practical interest to assess changes in river flow. The current warming is primarily identified in the rivers flow, the regime and dynamics of one of the main sources of feeding - glaciation. A feature of the regime of rivers with glacier-snow feeding, is the confinement of the maximum flow to the summer months. This is the time of greatest water consumption in the Central Asian region, therefore any changes in the volume of flow, especially if they are directed toward a decrease, affect the economies of countries.

Studying of river flow, according to "Kyrgyzhydromet" and CAIAG separate automatic gauging stations, made it possible to reveal the long-term trend of its increase in most rivers of Kyrgyzstan. At the same time, variations in runoff are observed with a periodicity of several years, when the river runoff is higher or lower than the average. In CAIAG, in order to forecast seasonal runoff, the forecast methods are developed based on the use of data on the snow cover from the TERRA satellite from the MODIS sensor in the hydrological models.

In general, in Kyrgyzstan, the amount of dynamic water resources concentrated in rivers, increases.

Najafinejad, Ali

Assessment of climate change impacts on water resources management in Tehran province

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In this research the adaptation options to climat change are assessed for supply and demand management of Tehran Province’s water resources. Hydro-climatic variables, climatic variables were simulated for the period of 2011-2040, using CanESM2 general circulation model, SDSM statistical downscaling model and RCPs scenarios. Using the WEAP model, inflows to the area, water supply and demand and adaptation management scenarios were analyzed to increase the

balance between water supply and demand. The results of hydro-climatic trend analysis shows an insignificant increase in precipitation series in all of the stations in Alborz Province, while the stations in Tehran Province show a negative trend, except inTehran and Parandak stations. Trend study of mean air temperature data indicates that there is an insignificant upward trend in all of the investigated series. The results of the trend indentification for the evaporation datasets indicate that there is a decreasing trend in all of the stations. The findings of this study show that the surface flow follows a downward trend in all of the main river basins of the area; however, this reduction is not statistically significant in any of the studied stations. The results of mean air temperature downscaling reveale that the daily mean temperature will increase compared to the base period with different magnitudes in the area. Also, the results of mean temperature downscaling in the seasonal time scale indicate an increase in summer and autumn compared to the base time under all of the RCPs scenarios in the area. Precipitation variable predictions show that the mean daily amounts will reduce compared to the base period in the future. The results of precipitation prediction in seasonal time scale show that the decrease in autumn is more than the base period compared to the other seasons under all of the RCPs scenarios. Simulation of inflows to the study area indicates a decreasing trend compared to the current accounts and on average over the most months of the year in the future and under RCPs scenarios. The findings of water supply and demand in the area indicate an imbalance in various parts of demand in current situation. The maximum and minimum imbalance is observeable in the domestic and industry sections, respectively. Comparing and assessing adaptive management scenarios with the reference scenario reveale that different management scenarios have different effects on water supply and demand balanc by various consumer sectors. Due to increase in the region's population and also reduction of inflows into the area in the future, and the priority of supplying domestic and drinking demands to other demand sectors, scenarios that directly affect the demand for domestic water have the most effect in minimizing the gap between supply and demand in the region. Therefore reducing the population growth rate due to immigration with reducing the losses of the domestic water distribution network are the most effective options for supply and demand balance in all climate scenarios. The findings of this study can help policy makers to have an active management in adaptation to future climate change by examining the present and future water supply and demand affected by climatic changes, as well as providing and assessing adaptation options to the focus of limiting water demand.

Ou, Tinghai

High resolution global reanalysis significantly improved regional climate simulation over the Tibetan Plateau

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The Tibetan Plateau (TP), also called the Third Pole, is the water tower of Asia. In recent years, the water cycle over the TP has been subject to many studies. Because the density of in situ observation is sparse, global reanalysis datasets have been the main inputs to these studies. However, the usefulness of these datasets for the TP is limited because of their coarse horizontal resolutions, which is due to the complex terrain. A high-resolution regional dynamical downscaling is often required. This work is the first attempt to conduct a high-resolution (9-km) regional dynamic downscaling based on the high-resolution latest version of a global reanalysis of the European Centre for Medium-Range Weather Forecasts (ECMWF), ERA5, by utilizing the Weather Research and Forecast model (WRF) version 3.7.1 with spectral nudging. The ERA5 was compared with its previous version of ECMWF global reanalysis, ERA-Interim, and the 9-km downscaled climate simulations with in situ observation for three summers (June-August) from 2014 to 2016 as references. A 9-km case study in summer 2014 driven by the ERA-Interim is also compared to the 9-km downscaled simulation driven by the ERA5. The comparison shows that the ERA5 has better ability to reproduce relative humidity against radiosonde observation in the upper-level compared to the ERA-Interim, which is associated with a more realistic climate mean of summer precipitation in the ERA5 compared to that in the ERA-Interim over the TP. This advantage of the high-resolution reanalysis has been strengthened by the regional dynamic downscaling, resulting in a better spatial pattern of summer mean precipitation. Further, a more reasonable diurnal cycle of the summer precipitation can also be found in the 9-km downscaled climate simulations driven by the ERA5 compared to that from the ERA5. These demonstrate the added value of dynamic downscaling and the high-resolution global reanalysis in

depicting the regional climate over the TP.

Pellicciotti，Francesca

Mass losses of debris covered glaciers in High Mountain Asia

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Debris-covered glaciers are very common in high mountain ranges, from the Hindukush- Karakoram - Himalaya (HKH) to the European Alps, the Caucasus to the Andes of Chile, and can represent a considerable portion of the entire glacierized area. They have traditionally been studied less in comparison to debris-free glaciers, but are currently receiving increasing attention since their role in key mountain areas such as the HKH region seems of importance to understand both glacier mass changes and water resources. Few studies have suggested that debris extent is increasing with more negative glacier mass balances and a warming climate. Debris controls the melt rate of debris covered tongues and a thin layer of debris enhance the melt rate by lowering the albedo, whereas a layer thicker than a few centimetres insulates the ice and suppresses melt rates. Recent works based on remote sensing, however, have failed to find diminished rates of thinning on such glaciers compared to bare ice ones, in contrast with point scale observational studies that have documented reduced melt below a critical thickness of few centimeters of debris. This incongruence in behavior at different spatial scales points to a general lack of understanding of processes at the glacier scale, from the meteorology over debris covered glaciers to the actual mechanisms of mass loss and gain to the evolution and changes in the thickness and properties of debris.

One explanation for relatively higher ablation rates on debris covered glaciers is enhanced melt at ice cliffs and supra-glacial ponds on the surface of the glacier tongues. Such features have been observed on glacier surfaces for several decades but have only gained scientific attention recently.

Here, I present recent advancements in our understanding of the spatial distribution and temporal variability of these supraglacial features and of their role on the mass balance of debris-covered glaciers in HMA, using the Langtang catchment as a study case. I show that supra-glacial cliffs and ponds are indeed hot spot for melt as they act as windows of energy transfer from the atmosphere to the glacier ice, and demonstrate that their importance is not only local but can affect the mass balance and runoff of glaciers at the catchment scale. I provide the first catchment scale estimates of their role in enhancing glacier mass losses, and show that they can account for very high percentages of total mass losses (between 12 and 60% on single glacier tongues and for given elevation bands) and

discuss some recent advancements in modelling their energy balance, surface evolution and dynamics.

I conclude with an overview of the large variability in debris-covered glaciers characteristics in HMA and emphasise the importance of studying these glacies and their mass balance patterns across the strong climatic and geomorphological gradient of the Third Pole.

Priyadarshana， Tilak

Effect of climate change induced water scarcity and heat stress on the prevalence of CKDu in Sri Lanka

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The epidemic of chronic kidney disease of unknown etiology (CKDu) is spreading in Sri Lanka, with serious health, social, and economic concerns of the nation and that has dramatically increased and worsened during the past two decades. The understanding of the role of climate variability and changes on the prevalence of CKDu in Sri Lanka and possible future emerging areas of CKDu under different climate change scenarios is timely needed to effective risk management and water safety measures.

Several studies suggest that heat-stress nephropathy, resulting from extreme occupational heat stress and repeated dehydration is central in the pathophysiology of Mesoamerican nephropathy, and this may hold true for CKDu in other CKDu hot spots like Sri Lanka. As we know, global warming has resulted in an overall increase of about 0.8°C during the last century, and is estimated to be responsible for 75% of the extreme heat events. With the increasing of frequency of hot days and heat waves globally, the risk of heat-related illnesses and injuries is expected to rise. Therefore, it is interesting to investigate whether heat stress will increase the CKD occurrence directly.

Many studies have shown that, the climate change can exert significant impact on the regional hydrological cycle, including rainfall, river flows and groundwater etc. It’s also found that, the changes in regional water resource can further deteriorate water quality, by changing water salinity, water nutrient content, concentration of pesticides and other pollutants, salinization of groundwater, water chemistry and pH balance in water. As potential consequences of climate change, increase in the demand in regions of water scarcity can force the use of poor or unsuitable water with drastic repercussions for human health (nephrotoxicity) and agriculture productivity. Therefore it’s also

important to investigate the relationship between CKDu occurrence and water resources, which could be closely associated with the climate changes.

Scholze, Marko

Constraining terrestrial carbon and water fluxes using remotely sensed soil moisture and FAPAR data within the Carbon Cycle Data Assimilation System

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The carbon cycle of the terrestrial biosphere is important for understanding connections between climate change and Arctic ecosystem response. A key issue is to better predict carbon fluxes under future scenarios employing terrestrial biosphere models, however, these models show large uncertainties in modelled CO_2 fluxes between the terrestrial biosphere and the atmosphere. In this study, SMOS L3 soil moisture and JRC-TIP FAPAR data at multiple sites (covering also cold regions) are used to constrain process-based parameters in the terrestrial biosphere model BETHY using the Carbon Cycle Data Assimilation System (CCDAS). The parameters are related to soil water, plant phenology as well as soil and plant carbon cycle processes. We find that simultaneous assimilation of these two datasets jointly at all sites yields a set of model parameters that achieves the best model performance in terms of independent observations of carbon fluxes as well as soil moisture. This study demonstrates the potential of satellite-derived soil moisture and FAPAR data when assimilated simultaneously in a model of the terrestrial carbon cycle to constrain terrestrial carbon fluxes at site level. It furthermore shows that assimilation of soil moisture data helps to identity structural problems in the underlying model, i.e. missing management processes at sites covered by crops and grasslands.

Scussolini, Paolo

Modeling past and future changes in hydrology and hydrodynamics, and understanding impacts societies – potential for application to the Third Pole Environment

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In this poster we present the expertise of our department, and point to the links with the objectives of the Third Pole Environment program. At the Water and Climate Risk department of the Institute of Environmental Studies (Vrije Universtiteit, Amsterdam), we specialize in multidisciplinary approaches to address the impacts of climatic changes upon water-related risks, such as floods and droughts. Working at local to global scales, we combine models of climate, hydrology and hydrodynamics to reconstruct natural hazards. Using a risk framework approach, we therefore employ data on hazard, exposure and vulnerability to quantify direct and indirect impacts of disasters on the socio-economy. Our research focuses on the present, on scenarios of the future, as well as on past periods of the earth's climate. Geographically, we have studied water-related hazard and risk at multiple locations in Europe, Asia, Africa, North America. In the framework of the Third Pole Environment program, it would be interesting to develop a research framework to study how past, present and future changes in the Tibetan Plateau region convert into changes in river discharge and flood and drought risk over the surrounding hydrological basins. In this way, it would be possible to attribute past changes to each driver - climatic, environmental and human - and in turn to inform solutions and management strategies for the present and the future.

Son, Seok-Woo

The role of the Central Asian mountains on the midwinter suppression of North Pacific storminess

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The role of the Central Asian mountains on North Pacific storminess is examined using an atmospheric general circulation model by varying the height and the areas of the mountains. A series of model integrations show that the presence of the Central Asian mountains suppresses the North Pacific storminess by 20-30% during boreal winter. Their impact on storminess is found to be small during other seasons. The mountains amplify stationary waves and effectively weaken the high-frequency transient eddy kinetic energy in boreal winter.

Two main causes of the reduced storminess are diagnosed. First, the decrease in storminess appears to be associated with a weakening of downstream eddy development. The mountains disorganize the zonal coherency of wave packets and refract them more equatorward. As the zonal traveling distance of wave packets gets substantially shorter, downstream eddy development gets weaker. Second, the Central Asian mountains suppress the global baroclinic energy conversion. The decreased baroclinic energy conversion, particularly over the Eastern Eurasian continent decreases the number of eddy disturbances entering into the Western North Pacific. The "barotropic governor" does not appear to explain the reduced storminess in our model simulations.

Stevens, Rodney

Quantitative Analysis and New Applications of old Technology for Groundwater Infrastructure and Sustainability in arid regions

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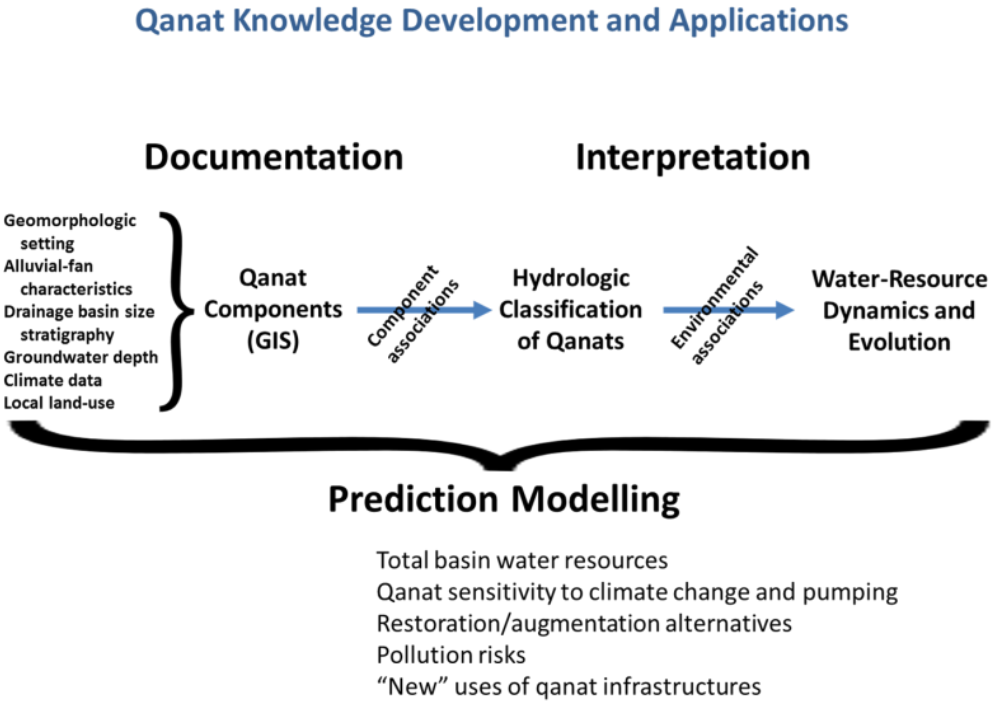
Qanats (or kārīz) are tunnels with a lower slope than the groundwater surface they intersect, typically within alluvial-fan geomorphology. Over 200,000 qanats have been used throughout western Asia to supply water to arid and semi-arid regions for nearly 3000 years.

The qanat excavation shafts are easily identified from satellite images and their topographic relationships can provide extensive proxy data for groundwater depths in many, otherwise undocumented basins. If combined with geographic and climatic information (in a Qanat GIS), there are many important applications, which we wish to illustrate in this project.

Most importantly, the basin specific information on total water resources and modeled hydrodynamic processes and conditions will provide a framework for sustainable water-resource management, especially when combined with data on climate, land-use, geomorphology and geology (see figure

below).



Their heritage and continuing importance for rural areas motivate protection of active qanats, but economic factors also suggest that qanat functionality needs often to be complemented with innovative measures, such as, surface-water infiltration to increase qanat discharge or groundwater reservoir recharge, micro hydroelectric generation using seasonally stored water within or separate from the qanats, and water distribution from pumped wells.

Stroeven, Arjen P.

Spatial and temporal patterns of maximum ice expansion in Central Asia

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The last glacial maximum (LGM), the period during the last glacial cycle (last ~100 ka) when global integrated ice volume was the largest, occurred between 23 and 19 ka. Glaciers in Central Asia, a climatically diverse region with active tectonics, responded to changes in climate and tectonics as revealed by a rich geological record of past mountain glaciations. Surface exposure ages from glacial deposits such as ice-marginal moraines, typically provide temporal constraints on former glacier expansions. The aim of this study is to investigate the published glacial record of Central Asia. Understanding the relative roles of climatic and non-climatic (glacier dynamic and

tectonic) forcing mechanisms on patterns of mountain glaciation is crucial, in particular when analysing and correlating large glacial chronological datasets over extensive regions and providing paleoglacier targets for comparison and validation of numerical glacier models. The ultimate goal is to understand the causes and trajectories of climate change over the last glacial cycle in Central Asia.

Towards building a paleoglaciological reconstruction for Central Asia, we present catchment-specific maps showing maximum glacier extents with spatial and temporal confidence intervals. We use published glacial landform data and available ^{10}Be datasets. Using these, we critically re-evaluate the dating control, infer past glacier extents (glacier lengths and elevations) from the moraine record, and evaluate valley hypsography along glaciologically-plausible flowlines, using digital elevation models in a catchment-by-catchment approach. This analysis yields information on temporal and spatial regional variability in glacier dimensions. Correlating glacial stages across this region remains a difficult task (Blomdin et al., 2016) due to the large observed scatter in surface exposure data for individual moraines.

Our results show that glacier expansions across most of Central Asia coincided with marine oxygen-isotope stage 2 (MIS 2), between 30 and 10 ka, broadly reflecting the LGM, although we do find significant variations in extent during this time slice. Extensive glacier expansions occurred in the central Tian Shan (<110 km), southern Altai (<90 km), and eastern Sayan (<60 km), while more restricted advances occurred in the eastern Tian Shan (<15 km), western Tian Shan (<5 km), and Gobi-Altai (<10 km) mountains. Initial geomorphometric analyses of investigated catchments show that some of the observed variation in glacier extents can be explained by catchment-characteristics (e.g. hypsography, slope, and aspect). In some regions, such as the central Tian Shan and the eastern Altai, maximum glacier expansions predate the global maximum ice volume signal of MIS 2, and probably occurred during MIS 5 (130–71 ka) and MIS 3 (57–29 ka), respectively. In conclusion, across Central Asia, we observe a heterogeneous spatial pattern in paleoglacier extent during the LGM, as well as a heterogenous temporal pattern in the timing of maximum glacier expansions (105–10 ka; excluding uncertainties). In order to further evaluate and evoke climatic and non-climatic mechanisms to explain the observed patterns, we propose to combine spatial analysis of glacier advances, and transient glacier- and climate simulations to evaluate modeled versus observed/reconstructed glacier dynamics and geometries.

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Su, Bob

Observation and modelling of land-atmosphere radiative and heat-water transfer processes

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Since 2006 the Tibetan plateau observatory for soil moisture and soil temperature (Tibet-Obs, Su et al., 2011, HESS) has been in operation and has provided valuable dataset for land-atmosphere process studies. The networks and collected data have been used for calibration and validation of satellite soil moisture retrieval algorithms and data products as well as for improving numerical model parameterizations (Su et al., 2013, JGR; Zheng et al., 2015a, b, JHM; 2017a, JHM, b, JGR) and for understanding passive and active microwave signals (Dente et al., 2015, RSE; Wang et al., 2016, JAG; Lv et al., 2014, RSE). Most recently an in-situ microwave radiometer (ELBARA III from ESA) has been operating at the Maqu site of the Tibet-Obs, as such coherent process observation, process modeling and radiative transfer modeling can be conducted (Zheng et al., 2017, TGRS) to examine land-atmosphere interactions. We report here recent results of these experiments in combined radiative transfer and heat-water transfer processes and in understanding satellite observation signals and data products – these are related to a new insight of the penetration depth and its quantification for soil moisture products (Lv et al., 2018, RS), benefit of synergistic use of active and passive microwave observations for soil moisture retrieval (Wang et al., 2018, ISPRS), and inference of subsurface parameters from radiometric observations. A reflection is made on modeling

land-atmosphere radiative and heat-water transfer processes as a key component of Earth System Model (Zhao et al., 2018, Lv, et al., 2018).

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Sugimoto, Shiori

Future changes in extreme years of South Asian monsoon and its impact on summer climate in East Asia

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In future climates, mean precipitation amount of South Asian monsoon is expected to increase because of an increase in atmospheric moisture content, while its interannual variation is likely to be intensified, i.e., both of extremely high and low precipitation years may increase. Using more

than 3000 years of ensemble simulations (database for Policy Decision making for Future climate change (d4PDF) under the current, +2K, and +4K climate), atmospheric conditions over and surrounding South Asia is compared between normal and extreme monsoon years. Furthermore, its teleconnection impacts on East Asian summer climate is evaluated. The standard deviation of JJA-mean-precipitation averaged over South Asia is calculated in the current climate (σ_{past}), and the extreme precipitation years in +2K and +4K climate are defined by the years with JJA-mean-precipitation higher than $+2\sigma_{past}$ or lower than $-2\sigma_{past}$. The normal years are within $\pm 0.25\sigma_{past}$ in current climate. Extreme high and low precipitation years increase over South Asia in both of +2K and +4K climate simulations relative to that in the current climate simulation. In the warmer climate, the extremely high precipitation is caused by higher precipitable water and anomalous circulation pattern at the lower troposphere, while an effect of marked change in circulation pattern is large for the years with extremely low precipitation. The teleconnection of silk road pattern enhances/supresses near-surface temperature rising over the western Tibetan Plateau and East Asian region in the $+2\sigma_{past}$ /$-2\sigma_{past}$ years, and it is particularly clear in the +2K climate simulation relative to that in +4K climate simulation.

Thompson, Lonnie G.

Past, Present and Future of Glacier Archives from the World's Highest Mountains and Implications for Our Future

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Over the past 40 years climatic and environmental histories have been recovered from cores drilled on ice fields from the Polar Regions to the Tropics. These proxy records, many extending back 25,000 years, have made it possible to compare Late Glacial Stage climate conditions throughout the world. High-resolution records of stable isotopes of oxygen, which in part indicate temperature, demonstrate that the current warming at high elevations in the lower latitudes is unprecedented over the last two millennia, although at many sites the early Holocene was warmer/dryer than today. Comparisons of records from high elevations in the Himalaya and the tropical Andes over the last 1000 years argue for large-scale Intertropical Convergence Zone and El Niño-Southern Oscillation teleconnections across

the Pacific Ocean.

Glaciers serve both as recorders of past climate variations and early indicators of future climate changes, and their history and fate provide a global perspective for the current warming trend. Observations of glacier shrinkage during the 20th and 21st centuries have been made in the Andes, the Third Pole (centered on the Tibetan Plateau), East Africa (Kilimanjaro) and near Puncak Jaya, Indonesia. The ongoing, widespread melting of these non-polar mountain glaciers provides strong evidence that a large-scale, pervasive and relatively rapid change in Earth's climate system is underway. Ice cores from these glaciers confirm their continuous existence over time spans ranging from hundreds to thousands of years, suggesting that current climate conditions are different from those under which they originated and have been sustained. Thus, the current warming is unusual when viewed from both the millennial-scale perspective provided by proxy records and the 160-year record of direct temperature measurements. The Third Pole contains one of the largest glacier stores (total area ~100,000 km^2) of fresh water that feeds Asia's largest rivers, while the Peruvian Andes contain over 70% of Earth's tropical glaciers which are critical for municipal water supplies, hydroelectricity, mining, irrigation and recreation. Ice core analyses, as well as glacier area and volume measurements, provide critical perceptions of modern climate change and the potential economic and social impacts of dwindling water resources, as well as new geo-hazards, in glacier-dependent nations.

Thorsteinsson, Thorsteinn

The Global Cryosphere Watch

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The World Meteorological Organization (WMO) has launched the Global Cryosphere Watch initiative (GCW – http://.globalcryospherewatch.org), with one of its main activities being development of a network of surface observations called *CryoNet*. Stations operating according to

specified requirements form the basic components of this network. These stations measure at least one variable of one cryosphere component (snow, glaciers, ice sheets, sea ice, lake/river ice, permafrost, seasonally frozen ground, solid precipitation) and must also carry out ancillary meteorological observations. They must have long-term operational commitment and observations have to be made available through the GCW Data Portal following the GCW Interoperability Guidelines. In order to support data sharing a software package has been developed by WSL/SLF in support of GCW. GCW also defines *CryoNet clusters*, which encompass an area greater than a conventional observing station and are operated as a coordinated unit. Finally, the GCW station network also encompasses *contributing stations* which deliver data on the cryosphere but do not fulfill all criteria required by CryoNet stations. Presently, 116 CryoNet stations, 47 GCW contributing stations, and 10 CryoNet clusters form the network on six continents. GCW also provides calibration/validation for satellite observations, engaged by its partner Polar Satellite Task Group (PSTG). The Third Pole region is currently represented by 10 stations in China, one in Mongolia, one in Nepal and one in Pakistan. In this presentation, an overview will be given of GCW, highlighting progress by various GCW working groups. Focus will be on the development of a Guide to Best Practices in measurements of cryospheric variables, to be published as a new part of the WMO Guide to Meteorological Instruments and Methods of Observation. Special requirements for cryospheric measurements at high altitudes will be discussed, inviting comment from scientists and operational staff working in the Third Pole region.

A 30-year Mass Balance Data Set from the Hofsjökull Ice Cap, Central Iceland (poster)

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Temperate ice caps cover 10% of Iceland. They are located mainly in high-precipitation regions in the central highlands or near the southern coast and their total volume corresponds to a sea-level equivalent of 9 mm. Mass-balance measurements have been carried out annually on Hofsjökull in the 30-year period 1989-2018. Standard measurements of winter and summer mass-balance have been conducted on three ice-flow basins comprising 40% of the ice cap, which currently has a total area of 825 km^2 and an estimated volume of 186 km^3. The annual mass balance has been negative in all but

five of the thirty years of measurements and mass loss occurred every year in the 20-year period 1995-2014. In total, Hofsjökull has lost more than 10% of its total volume since 1989. In recent years, digital elevation models of the ice cap have allowed more precise estimates of volume changes of the ice cap during 2-13 year time windows in the period 1986-2015. Comparison with the mass balance data set indicates that the traditional winter snow thickness and summer ablation measurements at ground locations overestimate the annual mass balance by 0.4 m w.eq. on average. We describe main results from the mass balance program, including data from snow-radar studies which have increased our knowledge of the precipitation distribution over Hofsjökull and helped explain the origin of the bias in ground-based measurements.

Ueno, K.

Challenges observing precipitation by GPM mission over mountains

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Discrepancies between the satellite and gauge precipitation strongly depend of the structure of precipitation/cloud systems. Especially over the mountains, convective systems are complicated and different depending on the synoptic conditions. Two key functions of cloud system, such as upward moisture transportation and heavy precipitation at surface, not always work at once. Validation and case studies using GPM products over the mountain ranges in central Japan are introduced to understand the four-dimensional evolution of cloud/precipitation system.

Assessment of opportunities and challenges for curriculum development for mountain studies (poster)

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To proceed interdisciplinary mountain studies, such as to focus on human dimension in the TPE regions, it would be very important to train young scientists based on plausible cross-cutting sciences

over multiple fields. Assessment of opportunities and challenges for curriculum development for mountain studies has been initiated under the project or Mountain Research Initiative, Swiss Academy of Sciences. This poster presents the concept of assessment, and discusses the international scopes of mountain studies to cultivate new sciences in the TEP project.

Wang, Lei

Multi-sphere hydrological modelling over the Third Pole Region

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In recent years, we have been committed to the development of a multi-sphere hydrological model for the Third Pole (TP) region, to improve the predictive ability of regional water resources and disasters. The major achievements can be summarized as follows. (1) Through incorporating the cryosphere processes (e.g., glacier, snow, frozen soil) into a distributed biosphere hydrological model (WEB-DHM), a multi-sphere hydrological model that is applicable to TP has been developed. (2) We have applied the multi-sphere hydrological model into various basins in the Pan-Third Pole Region, for addressing important issues of water science (e.g., short-term flood forecasting, cold-region drought monitoring, study of TP lake changes, and so on). Based on these studies, much improved understanding of TP multi-sphere interactions (atmosphere- cryosphere- hydrosphere- biosphere) has been achieved. (3) We have built various field observations over the TP region to support the numerical modeling, including the observational networks at the Yarlung Zangbo River Basin as well as the upper Dang River Basin.

Wang, Qiang

Unstructured-mesh ocean and climate modeling and applications in polar regions

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Unstructured-mesh models are common in coastal ocean modeling, but their applications are only at

the beginning stage in large-scale ocean and climate studies. Global ocean general circulation models formulated on unstructured meshes have matured during the last few years. Due to the flexibility in varying grid resolution, seamless regional focus in a global context can be easily realized with such models. In this presentation I will review the potential of unstructured-mesh modeling in large-scale ocean and climate applications, and discuss the advantages of the new generation models and considerations that should be taken when using them. More specifically, the Finite Element/volumE Sea-ice Ocean Model (FESOM) will be presented as an example. It is the first mature global ocean circulation model of its kind, which is developed and maintained by the Alfred Wegener Institute Helmholtz Center for Polar and Marine Research (AWI). Some results from the AWI Climate Model will also be presented to illustrate the status of applying multi-resolution in coupled climate modeling, including the prototype CMIP6 simulations. The recent model development will support the concept of simultaneously taking the polar regions into account in the global climate system for studies on their inter-linkage and joint impacts.

Xiao, Cunde

Tendency of solid to liquid transition of precipitation phases over cryospheric regions

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Different precipitation phases (liquid or solid) are, on the one hand, important indicators of different climate regimes, and on the other hand, exert different impacts on earth surface processes. With warming climate, more frequent liquid precipitation is occurring over the regions where traditionally only solid precipitation took place. To investigate the overall tendency of precipitation phases

globally in the last decades, we studied instrumental records of phase transition of precipitation over several key regions of cryosphere such as North America, northern Eurasia, Antarctic Peninsula, and assessed the situation in the non-instrumental areas with newly developed methods of phase transition calculation by combining with the reanalysis data over the whole Arctic and previous studies over west China. We suggest that there is a clear tendency of transition from solid to liquid precipitation over the cold regions. The seasonality of transition onset is becoming earlier over North America, northern Eurasia and central Arctic, and very likely in most of third pole too. Our study also indicates that phase changes favors melting of Arctic sea ice, and the timing of spring rainfall of Arctic is a potential indicator for sea ice prediction of later months. Further study is undertaken for its impacts to land surface processes such as energy and water exchanges, biosphere responses, as well as carbon effects, etc.

Key Words: climate warming, precipitation forms, cryosphere, sea ice melt

Xu, Baiqing

How Old are Tibetan Ice Caps?

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Ice core records reveal that the most ancient ice in the Tibetan Plateau is located at Guliya Ice Cap of the West Kunlun Mountains and Dunde Ice Cap of the Qilian Mountains. Based on ice core dating by $\delta^{18}O$ stratigraphy and glacier flow model, the bottom ice of the Guliya Ice Cap is supposed to be 700 thousand years old, and of the Dunde Ice Cap is more than 30 thousand years old. Glacier dynamics suggests the most ancient ice outcrops at the margin of an ice cap. However, the failure of ^{81}Kr-Kr radiometric dating of old ice from Guliya Ice Cap indicate a much younger age than 40 thousand years. In the present study, we drilled ice cores at the margins of Guliya and Dunde ice caps to determine the absolute ages of the ice by using radiocarbon dating of black carbon (BC). The result shows all ice samples herein is no older than 7.3 thousand years. The age of

the margin ice from the Guliya and Dunde ice caps is mostly between 4.0-1.5 thousand years. It indicates that the Tibetan ice caps are developed mainly during the Neoglaciation. This result significantly breaks the traditional knowledge of the age of Tibetan ice cap.

Zhang, Fan

Study on Runoff Flow Paths of Two Headwater Catchments in Northeast Tibetan Plateau

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Runoff flow paths of two headwater catchments of the Upper Heihe River were investogated in this study. The Binggou catchment is bigger and lower (31 km^2 and 3900 m), while the Yakou catchment is smaller and higher (1.4 km^2 and 4050 m). Water samples were collected from different water bodies including precipitation, middle-slope surface flow and subsurface flow, riparian saturated soil water, spring water, shallow ground water and stream water during spring snowmelt period (SSP) and summer rainfall period (SRP). Results based on stable isotopes by two-component mixing model revealed that contribution of old water dominated the streamflow in the Binggou catchment during both SSP and SRP (64.4% and 87.6%). However, in the Yakou catchment, contribution of new water dominated the streamflow during SSP (86.3%), while old water was the major source during SRP (73.7%). It was shown that the less buffering capacity and later thawing of frozen soil in the Yakou catchment could lead to the greater impact of new water. Results based on hydrochemical tracers by End-Member Mixing Analysis futher indicated the dominant contribution of middle-slope surface flow to spring streamflow in the Binggou and Yakou catchments (53.6% and 85.4%), while the major flow path in summer was shallow sub-surface flow (75.9% and 61.8%) promoted by the impermeable freezing front following“fill and spill” mechanism. Isolated by the freezing soil layer, deep ground

water was not a significant contributor to streamflow discharge in both catchments. The results quantitatively demonstrated the different flow paths in SSP and SRP and the controlling role of soil freezing-thawing on the runoff formation processes.

Zhang, Fuqing

Advanced ensemble-based regional reanalysis for the Third Pole region

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Penn State Center on Advanced Data Assimilation and Predictability Techniques

We will develop and evaluate a hierarchy of advanced ensemble-based data assimilation techniques based on the state-of-the-science mesoscale weather prediction model (WRF) down to the convection-permitting resolutions for the regional atmospheric reanalysis for the Tibetan Plateau and surrounding regions. Our emphasis will be on a more accurate characterization of the regional-scale water cycles including but not limited to the atmospheric moisture, clouds and precipitation, regional-to-small scale variabilities of regional circulations with regards to diurnal cycles and mountain-valley circulations that are crucial for moisture transport and precipitations in this region. Our pilot experiment of summer 2015 shows that the Penn State University WRF-based ensemble Kalman filter (EnKF) data assimilation system (PSU WRF-EnKF), even at 30-km horizontal grid resolution and without assimilating satellite radiances, can significantly outperform the most-advanced next-generation global reanalysis by the ECMWF (ERA5) over the Tibetan Plateau region during this 3-month evaluation period, in comparison to independent special field sounding observations and to 6-hr short-term forecasts as well as various precipitation observations. Our pilot reanalysis is particularly advantageous in the moisture and precipitation fields, especially the proper diurnal variations in comparison to the ERA5 global reanalysis. We will further extend the WRF-EnKF system to assimilate all-sky radiance observations. In the meantime, we plan to develop and evaluate a first-generation multi-decadal regional reanalysis dataset to be housed at Gothenburg University using the PSU WRF-EnKF system without radiance assimilation. Our future plans will be developing and evaluating the next-generation TPE regional reanalysis with all-sky radiance assimilation while in the meantime explore more advanced but affordable data assimilation techniques including the coupling and hybrid of the EnKF with variational data assimilation algorithms for this region.

Zhang, Qiong

Contribution of sea-ice albedo and insulation effects to Arctic amplification in the EC-Earth Pliocene simulation

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In the present work, we simulate the Pliocene climate with EC-Earth climate model as an analogue for current warming climate induced by massive CO_2 in the atmosphere. The simulated Pliocene climate shows a strong Arctic amplification featured by pronounced warming sea surface temperature (SST) over North Atlantic in particular over Greenland Sea and Baffin Bays, which is comparable with geological SST reconstructions from PRISM. To understand the underlying physical processes, the air-sea heat flux variation in response to Arctic sea-ice change is quantitatively assessed by a climate feedback and response analysis method (CFRAM) and an equilibrium feedback assessment (EFA)-like approach. Giving the facts that the maximum warming in SST occurs in summer while the maximum warming in surface air temperature happens during winter, our analyses show that dominant ice-albedo effect is the main reason for summer SST warming, a 1% loss in sea-ice concentration could lead to an approximate $2Wm^{-2}$ increase in shortwave solar radiation into open sea surface. During winter month, the insulation effect induces enhanced turbulent heat flux out of sea surface due to sea-ice melting in previous summer months. This leads to more heat release from the ocean to atmosphere, thus explaining the stronger surface air temperature warming amplification in winter than in summer.

Zhang, Tingjun

Permafrost Degradation and its Carbon Contribution to the Atmosphere

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Climate warming in permafrost regions was greater than the rest of Earth. Consequently, the warming results in thickening of the active layer, increase in permafrost temperatures, ground ice melt, and thermokarst development. These changes in the active layer and permafrost conditions could potentially endanger the currently 1832 Gt carbon stored in permafrost regions to be

gradually released into the atmosphere. In this presentation, we hypothesize that increase in atmospheric carbon content since the Last Glacial Maximum (LGM) was largely contributed by permafrost degradation. Furthermore, the currently warming climate would enhance permafrost degradation, increase carbon release to the atmosphere, and positively feedback to climate system. To verify this hypothesis, we will firstly estimate terrestrial and subsea permafrost extent during the LGM and its degradation rate over the past 20k years. Secondly, we will estimate how much carbon was released to the atmosphere from both terrestrial and subsea permafrost degradation since the LGM. Finally, we will discuss strategies on studies related with permafrost and carbon exchange over the Qinghai-Tibetan Plateau and the Arctic as a whole. High priorities include, but not limited to, in-situ measurements and modeling on the active layer thickness and permafrost temperatures, detecting ground ice distribution and monitoring its melting, thermokarst development, expansion of thaw lakes and creation of new lakes, lake and river ice. These changes can decrease ecosystem carbon storage by enhancing microbial activity and ecosystem respiration, but can also stimulate plant growth and lateral carbon flux, potentially increasing carbon stored in vegetation, soil, and sediment. Factors causing losses and gains in ecosystem carbon storage that relate to the scientific question: What is the magnitude, timing, and form of carbon release from permafrost zone ecosystems to the atmosphere in a changing climate?

Zhang, Xu

Glacial Climate Stability: Pathway to understand abrupt glacial climate shifts

Xu Zhang

Abrupt millennial-scale climate changes known as Dansgaard-Oeschger (DO) cycles that have been linked to variations in the Atlantic meridional overturning circulation (AMOC) are a ubiquitous feature during glacial periods in the last 800,000 years before present. These changes have drawn broad attention within the science and policy-making communities, and many studies have been dedicated to explore the underlying causes of these changes. One fundamental question that remains unclear to us is that whether these changes are the result of a gradual change in forcing applied to a system containing a threshold (tipping point) or of a large and abrupt change in forcing applied to a system with or without a threshold. Here we will discuss these aspects to highlight ongoing and future research related to the dynamics of DO(-type) events. We will discuss associated global climate responses during these events, highlighting its important role to understand Three Poles teleconnections.