Report of the 5th

Third Pole Environment (TPE) Workshop

2014
Berlin,
Germany

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December 8-9, 2014

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PREFACE

The 5th Third Pole Environment (TPE) Workshop, held at the historic Harnack House in Berlin, Germany December 8-9, 2014, marks another year of substantial progress for the TPE program. Moreover, it signifies another year of headway in cooperative research on behalf of the unique, enigmatic ecosystems and environments of the Third Pole region. For which, the TPE program would like to extend our utmost appreciation to our supporters the world over.

Due to the boundless efforts of the workshop committee, the local organizing committees, the immense hospitality on the part of the Harnack House, and the attention of our distinguished participants, the 5th TPE Workshop was a success in its objectives and goals. With the 5th TPE Workshop, we have succeeded in convening a select and talented delegation of scientists and program to participate in an open forum to present, discuss and coordinate research efforts in the Third Pole. It is our hope that outcomes from this intensive two-day event will shape the course of research in the Third Pole for years to come.

The following proceedings are put forth without omission, an accurate representation of the events, presentation and discussion as they occurred. The full report will be made available on-line and by request for any interested party.

Tandong Yao, Lonnie Thompson, Volker Mosbrugger

TPE Co-chairs

1. Introduction

1.1. TPE and Workshop Introduction

The Third Pole, the vast region encompassing Earth's highest mountain ranges in the great Asian mountain system, is a myriad of inhospitable physical landscapes and geopolitical barriers. Cooperative, multinational and transboundary research on the area's uniquely dynamic environmental processes is both extremely challenging and increasingly pressing. The Third Pole Environment (TPE) program was established in 2009 in response to the demand for heightened scientific coverage of the largely-glaciated region which aptly bears the moniker "Asia's Water tower." In that time, TPE has hosted five international workshops, bringing together scientists and stakeholders from all over the world to discuss past, current and planned research initiatives in the Third Pole. The 5th TPE workshop, held in Berlin, Germany 8-9, like the previous four, has been a point of success towards the program's mission.

To advance research and increase coordinated field campaigns in the region, scientists and stakeholders representing 13 countries gathered in December 2014 in Berlin, Germany, for the 5th Third Pole Environment (TPE) Workshop. Condensed into two intensive days, the 5th TPE Workshop gathered participants at the historic Harnack House in the Durham region of Berlin to discuss the latest progress, challenges, and future plans for scientific research in the Third Pole region. Participants shared their unique and diverse portfolios of environmental research on topics including climate and cryosphere dynamics, geologic processes, geohazards, land-atmosphere interactions, lakes and rivers, and biologic and biodiversity studies.

Given the complexities of the region, the opportunity for multidisciplinary, multinational information sharing and discussion is an invaluable component of TPE research. Common threads in the presentations were the Asian monsoon system, improving the accuracy and spatial coverage of environmental reconstructions, advancing data availability, and data sharing platforms.

Participants eagerly discussed ways to increase coordinated field campaigns, with a focus on transboundary research transects, an ongoing effort that may provide a more complete picture of the Third Pole.

The workshop agenda consisted of an opening and welcome, seven scientific sessions, and a plenary discussion session and closing. The scientific sessions were titled:

- Interactions between the Third Pole and the Asian monsoon
- Past climate and environmental changes
- Status of the cryosphere
- Status of rivers and lakes
- Geoecosystems and anthropogenic activities
- Impacts of recent climatic changes and adaptations to a changing Third Pole
- Geodynamics and geohazards

In the final, ninth session, the parallel group discussions were organized according to six main topics, or respective fields, including the atmosphere, the cryosphere, past climates, rivers and lakes, ecosystems, and geodynamics.

The workshop opened on the morning on December 9, 2014. The scientific sessions also began on the morning of December 9 and continued until the afternoon of December 10. After the scientific sessions, participants gathered into six different groups according to their individual interests. The group discussions were summarized during the final session on December 10, and the workshop concluded after final comments and summary by the TPE Co-chairs. At the conclusion of the workshop, Prof. Lonnie Thompson suggested the next, 6th TPE Workshop be held in Columbus, Ohio, USA. The complete 5th TPE Workshop agenda can be found in Appendix 1, and the list of participants can be found in Appendix 2.

2. Scientific Sessions

Session I. Interactions between the Third Pole and the Asian monsoon

The first scientific session was chaired by Erwin Appel. The following five presentations addressed some of the key interactions between the Third Pole and the Asian monsoon based on observations and modeling:

Boos, W. “Influence of the Tibetan Plateau on the South Asian monsoon”

Clift, P. “Sediment transport and storage in response to changes in the monsoon”

Immerzeel, W. “Himalayan atmospheric dynamics revealed by high-resolution atmospheric modeling and high-altitude observations”

Scherer, D. “How far reach the present-day Summer Monsoons into the Third Pole region?”

Devkota, L. “Teleconnections of tropical Pacific and Indian Ocean oscillations with monsoon rainfall variability over Nepal”

Session II. Past climate and environmental changes

The second scientific session, chaired by TPE Co-chair Tandong Yao, included the following five topics related to climate and environmental change over the Third Pole region:

Thompson, L. “Third Pole climate linkages documented by ice core-derived stable isotopes, ENSO, droughts and human history over the last millenium”

Wu, G. “The increasing dustiness in Tibetan ice cores over the past decades under warming perspective”

Gleixner, G. “Reconstruction of Asian monsoon using compound-specific isotope signals of terrestrial and aquatic biomarkers in Tibetan lake systems”

Zhu, L. “Different mechanism for Tibetan Plateau responding to climate of north Atlantic realm since LGM”

Bräuning, A. “Stable oxygen isotopes on the Tibetan Plateau as climate proxies: what exactly do they reflect?”

Session III. Status of the cryosphere

The third session was chaired by TPE Co-chair Lonnie Thompson. This session was devoted to presentations related to cryosphere studies in the Third Pole region, and included the following six presentations:

Dietze, E. “Sediment transport processes across the Tibetan Plateau inferred from lake sediments”

Yao, T. “Glaical changes on the Third Pole and their linkages to atmospheric circulations”

Fujita, K. “Climate regime and sensitivity of Asian glacier revealed by the GAMDAM glacier inventory”

Tayal, S. “Regional climate signals and linkages to glacier melting: a case study of eastern Himalaya”

Bolch, T. “A longer-term perspective: glacier mass changes in high mountain Asia since the 1970s”

Kääb, A. “Competing estimates of early twenty-first century glacier mass balance over the Pamir-Karakoram-Himalaya”

Session IV. Status of rivers and lakes

The fourth session was chaired by Dieter Scherer, Freie Universität. The session included the following seven presentations on the status of rivers and lakes in the Third Pole:

Yang, K. “Climate change impacts on water cycle in the Tibetan Plateau: A review”

Zhang, F. “Modeling of runoff and suspended sediment flux in the Mabengnong catchment on the Tibetan Plateau “

Pelliciotti, F. “Unraveling the hydrology of a Himalayan catchment using a unique combination of high elevation ground data, high resolution remote sensing and advanced glacier hydrological modeling”

Su, F. “Role of snow and glacier melt and rainfall in streamflow changes in the past 50 years for the major river basins in the Tibetan Plateau”

Salerno, F. “Warmed winters and weakened precipitation on Mt. Everest (central southern Himalaya) impacts glaciers, lakes, permafrost and river discharges”

Spiess, V. “Nam Co lacustrine sediments – new deep-penetrating hydro acoustic data”

Rahman, S. “An updated inventory of glacial lakes in Hunza and Astore River basins (Gilgit Baltistan Province Pakistan) using satellite data”

Session V. Geoecosystems and anthropogenic activities

The session devoted to geoecosystems and anthropogenic activities was chaired by Gerd Gleixner (MPI Jena). The following presentations outlined six important topics related to humans and environmental system:

Mosbrugger, V. “Ecosystem dynamics, climate change and anthropogenic impact on the Tibetan Plateau”

Liang, E. “Himalayan birch at the upper timberline is increasingly at risk for survival and downslope range shifts in response to global-change-type droughts”

Liu, Y. “Ice cores from the Tibetan Plateau reveal bacterial community convergence related to climate and anthropogenic activity”

Fraedrich, K. “Vegetation Dynamics on the Tibetan Plateau (1982 to 2006): A Attribution by Eco-hydrological Diagnostics”

Xu, B. “Black carbon in snow over the Third Pole region”

Wegner, A. “Two centuries of trace element and black carbon deposition at the top of the Himalaya: natural background vs. anthropogenic pollution”

Session VI. Impacts of recent climatic changes and adaptations to a changing Third Pole

Session Six, chaired by Robert Spicer (Open University), focused on the impacts of recent climatic changes and adaptations to a changing Third Pole. The following seven presentations were given:

Bradley, R. “Evidence of elevational-dependent warming (EDW) and the underlying mechanisms driving EDW”

Ma, Y. “Study on the change of the Tibetan Plateau climate system and the mechanism of its impact on eastern Asia”

Chen, D. “Spatial scale of climate variations over the Third Pole”

Nainwal, H.C. “Response of glacier to climate change, a study from Upper Alaknanda Basin, Uttarakhand Himalaya, India”

Su, B. “Advances in land surface processes and land-atmosphere interactions on the Tibetan Plateau”

Graf, H. “Very high resolution modeling of Tibetan Plateau land use change effects on clouds, precipitation and surface energy balance”

Goyal, R. “HKH Monitoring and Assessment Programme (HIMAP) exercise”

Session VII. Geodynamics and geohazards

Session Seven, chaired by Liping Zhu (ITPCAS), was devoted to Third Pole studies of geodynamics and geohazards. The following six presentations were given:

Ding, L. “The Andean-type Gangdese Mountains: Paleoelevation record from the Paleocene-Eocene Linzhou Basin”

Schurr, B. “Collisional tectonics and geodynamics of Pamir and Hindu Kush”

Parolai, S. “Seismic and Landslide Risk Assessment and Mitigation in Central Asia”

Korup, O. “Natural Hazards: News from the Third Pole”

Karimov, F.H. “Dynamics of large mountain-valley glacier flow in Tajikistan”

Tartari, G. “Remarks on the environmental research carried out in the last quarter of a century in the Himalayas”

A full list of presentations can be found in Appendix 4. Select presentations are also available for download on the TPE website at www.tpe.ac.cn/wkshp5/presentations.

3. Parallel Group Discussion

On the second workshop day, the Scientific Session was followed by parallel group discussions. The parallel group discussion session was chaired by T. Yao. The discussions centered on six main topics, or respective fields, including the atmosphere, the cryosphere, past climates, rivers and lakes, ecosystems, and geodynamics. The format of the group discussions was to allow participants to choose among the six main topics according to their individual interest. To focus the group discussions, the session chairs provided three main questions for discussion:

- What are the major achievements in the respective field?
- What are the major challenges for research in the respective field?
- How to link with topics of different groups?

Presentations from the group discussions, as summarized from Session 9 of the workshop, are presented in the following section.

4. Plenary Discussions Session and Closing

Session 9, the Plenary Discussion Session and Closing, was chaired by Tandong Yao. Prof. Yao began the session with opening remarks thanking the participants for their focused and productive discussions, which will lead scientific studies in the Third Pole region and further develop TPE.

4.1. Topic 1 – The Atmosphere

W. Boos presented the summary of the group discussion related to atmospheric studies in the Third Pole region. The group discussing centered on areas that need to be improved, or pushed forward. The group acknowledged that a number of the issues were already touched on by Daqing Yang's talk. Improving the general scheme of observations of the water cycle was one of the main points discussed by the group, in terms of future work. The group discussed the need to improve observations of the energy cycle and the water cycle in the Third Pole region, and the need to improve models and assess the skill of models. The group discussed a suggestion to develop a Third Pole model intercomparison project, with a standardized experiment that could be run by different modeling groups. The group also discussed several processes, or questions, that may frame the improvement of the observational networks and the assimilation of data into the models, perhaps to improve gridded data sets. Those questions were:

- How do we better understand the dynamics of the planetary boundary layer of the Plateau, especially the stable boundary layer? For example, the strong diurnal cycle that occurs at high elevation compared to low elevations.
- What are the interactions with the westerly jet, how do we view the interaction of the jet with the Plateau, to what degree is it an internal or external forcing? How does the energy of the jet cascade downscale to the mesoscale circulations as it interacts with topography? The group acknowledged the efforts discussed by Daqing Yang to understand the elevation-dependent warming that characterizes the observations. The

group discussed setting this in a broader context of assessing trends, and making sure that the observational networks that are being established now are put in place for the long term, to ensure that data that will still be collected in 10 or 20 years.

- Potential interaction of the Plateau atmospheric dynamics with the stratosphere, and the group indicated this aspect was not discussed during the workshop. The group suggested that given the vertical proximity of the Plateau to the stratosphere and the tropopause, there may be a potential to better understand its role in the documented stratospheric cooling which has been observed in a warming climate. The group acknowledged that these interactions and effects may be more important in the Third Pole compared to other regions.
- Can we clearly, through better observations of the water cycle and precipitation, help answer the question, is the water cycle accelerating over the Plateau?

There were no additional comments or questions from participants after the presentation.

4.2. Topic 2 – The Cryosphere

Tobias Bolch introduced and presented the summary of the discussion about the status of the cryosphere. In the group discussion, participants outlined five major achievements. The first achievement is the general consensus on the regional pattern of glacier changes in the Third Pole. The second achievement discussed was the multiple glacier inventories that currently exist. Third, the new in-situ mass balance measurements are a major achievement. A related achievement is the expansion of snow monitoring stations in the Third Pole. The fifth achievement discussed was the improved linkage between glaciological and hydrological models.

Dr. Bolch next presented some of the challenges and opportunities associated with cryosphere studies in the Third Pole region. One challenge is the disagreement of glacier inventories. Related to the varying glacier estimates and inventories is volume estimations, and the group discussed the need to extend the knowledge of area, length and mass changes. Long-term

continuation of mass balance measurements was stressed by the group, and it was also noted that the contribution from avalanches is poorly understood. Another particular challenge is mass balance modeling, considering the possibilities of local vs. regional models, the availability of in-situ data for calibration, and the influence of debris cover. The group also discussed the possibility for mass balance measurements/models to provide another source of data for precipitation distribution. Other challenges presented by the group include the run-off contribution of different components of the cryosphere, and the contribution of glacier silt and its importance reservoirs and hydrology. Snow cover extent vs. snow water equivalent was also stressed as a challenge, and the group also indicated that permafrost still presents major challenges, for example the extent, ice content, and hydrologic importance. In addition, the group discussed the need for additional permafrost data, and representation in modeling. The final challenge discussed by the cryosphere group, and a recurring theme for other groups as well, is the issue of data availability. Specifically, the group noted that there are many measurements, and an ever increasing amount of data. However, the group indicated the data is not really shared and made available to the scientific community. The final comment in the group discussion summary was related to mass balance measurements. It was noted that, in terms of cryosphere studies, not only are the annual mass balance measurements needed but also the seasonal mass balance measurements.

After the group discussion summary by Tobias Bolch, there was one participant comment, emphasizing the importance of energy balance. The participant suggested additional application of remote sensing and in situ data for energy balance measurements to document and explain glacier melting.

4.3. Topic 3 – Past climate and environmental changes

The summary of the group discussions about past climate and environmental changes was presented by Lonnie Thompson. In terms of general achievements, Prof. Thompson began by reiterating that the quality of the science since the 1st TPE Workshop in Beijing has greatly improved.

Regarding achievements of past climate research, Prof. Thompson acknowledged that different data streams now allow researchers to compare records, and indicated that all participants have benefited from seeing what other researchers are doing in the Third Pole region. Prof. Thompson also indicated that the understanding of proxies has improved and is a notable achievement for past climate research. For example, the group discussed the recent understanding that the southeast monsoon does not play as an important role on the Plateau as previously thought five years ago, although there is more work that need to be done in that regard.

The group also discussed the following scientific challenges for past climate research in the Third Pole region:

- Data synthesis – there are many types of past climate data, for example data related to lakes, ice, and trees. The challenge is how to bring the existing data together for a long-term perspective on climate in the Third Pole.

- Seasonality of the proxies, and the challenge of improving our understanding of what exactly is recorded in the different proxies.

- Improving the chronologies among the available records and time markers, and finding ways to link from one proxy to another.

- Finding speleothem records over the Plateau, if they exist, is a challenge. To date there are no existing speleothem records.

- Looking at shorter time scales, what has happened in the past 2,000 years, versus looking at 20,000 years or going back 1 million years, and in relation looking at roles of orbital forcing and how that influences what is observed in today's world.

- Placing the Plateau into a global perspective, what are the outside forcings, what are the roles of the Indian Ocean and the Pacific Ocean and the westerlies on the proxies that are used in the Third Pole region.

- Regional modeling of isotopes, what do the isotopes really tell us at lower elevations and at very high elevations?

- Reaching out to archaeological groups and anthropologists. We know there are records of civilizations that existed in certain places where water is not found now. The challenge will be relating these archives to the climate records.

- We have seen ongoing and new research relating climate and micro-organisms, and the possibilities now with genomics and fingerprinting represent possibilities to see how micro-organisms have changed through time.

- Inputs coming from external and internal systems, for example dust, black carbon and the associated forcings.

- Time lags between what you see and measure, for example temperature and accumulation of glaciers, or moraines, and the response time of glaciers to these changes.

- Looking at some periods involved with proxies, such as the Little Ice Age or Medieval climate anomaly in detail to see how it is has been recorded by different proxies.

Prof. Thompson acknowledged that there are a lot of research areas that still present challenges in the Third Pole region. The final task for the group discussion was to explore possible linkages with other groups, and Prof. Thompson began by suggesting the possibility to link the paleorecords to pollen, in order to better understand the processes that lead to those signals in the records. Another possible linkage was related to processes of how ecosystems are responding, for example the question of why big lakes seem to respond very rapidly to changes and what are the processes that allow that to happen. In addition, Prof. Thompson suggested linking deserts and civilizations with water studies in the Third Pole region. The past climate group also discussed the possibility link ice core proxies and lake proxies, and acknowledged the importance of this link, especially for proxies within the

same basin to better understand what exactly is being recorded in these systems. Prof. Thompson ended the group discussion summary by acknowledging that there is still a lot of past climate research still to be accomplished in the Third Pole.

4.4. Topic 4 – Status of rivers and lakes

The group discussion of the status of lakes and rivers was summarized by Francesca Pelliciotti. The summary began with an outline of the major achievements. The group indicated one major achievement is a better understanding of present river flow composition and climate change impacts on flow at various scales. The group indicated this achievement was associated with a paradigm shift since the IPCC AR4 report. Another achievement is a better understanding of regional differences in mountain hydrology in High Mountain Asia. Related to modeling, the group indicated major achievements and improved models to simulate the complexity of high altitude hydrology and cryosphere. Although the group indicated achievements in data availability, they acknowledged there is still a long way to go. The group also discussed achievements related to precipitation change dominating endorheic lake level changes and the reasons why, specifically the high dryness ratio (potential ET over precipitation).

Prof. Pelliciotti next outlined the major challenges, as discussed by the group participants. One challenge is that observations, although with scarce ground data, show a weakening of monsoon which contradicts climate model projections of increasing precipitation. The group also discussed several processes that are poorly understood or under-represented in glacio-hydrological models. These processes include:

- Precipitation distribution (snow) and precipitation generation processes
- Permafrost and soil processes
- Vegetation including atmospheric feedbacks
- Sediment transport
- Behaviours of debris covered glaciers and the role of cliffs and supra-glacier lakes

- Lakes are generally absent in hydrological models

Another challenge the group presented was, “How to bridge the scale gap between the 1.5 billion people depending on the water resources and the small scale studies most of us conduct?” The final challenges outlined by the group included data sharing mechanisms and lack of long term monitoring programs, and the poor performance of regional and global climate models in high altitude regions. The group stressed that much higher resolution is required.

At the summary of the group discussing the status of rivers and lakes, two linkages were presented for further exploration and advancement. The group stressed the linkages with the glaciers, including GLOF, glacier dynamics, and consensus on inventories. The group also suggested further linkages with climate, including high altitude observations, precipitation, and downscaling.

4.5. Topic 5 – Ecosystems

The summary of the discussion among participants interested in Third Pole ecosystems was presented by Greg Greenwood. The summary began by suggesting that ecosystem studies in the Third Pole region are still at an early stage, and participants in the group discussed key products that may come about with long-term efforts.

One product discussed was a consensus ‘map’ of TPE ecosystems. From a single delineation across the entire Third Pole region at the start, an ecosystem map may address terrestrial and aquatic ecosystems and be expanded to address additional important features. Specific features discussed among the group included agrobiodiversity, Red Book habitats, and charismatic species such as blue sheep and snow leopards. An expected outcome of an ecosystem map is the comparison of emergent characteristics, for example connectivity and fragmentation. It was suggested that developed products from many separate studies over time can further expand with different thematic layers/items and improvement in subregions.

Another key issue discussed by the ecosystem group was sensitivity, asking “what will this pixel look like N years in the future?”. In order to answer such a

question, the group discussed the need to understand internal dynamics, for example, how one structure (species) becomes another under the influence of drivers. The group agreed that many dissertations need to be written in order to understand how communities and species change. Another point stressed by the ecosystem group was that more information on the drivers themselves is needed. To summarize, the group indicated that ecosystem studies are able to obtain valuable information related to climate change, but to answer the question of "what will this pixel look like N years in the future", information on other drivers is needed. Two specific examples of other drivers given by the group included population growth and infrastructure development. As a final thought, the group asked participants to consider the question, "who will develop such information?"

4.6. Topic 6 – Geodynamics

The summary of the group discussion related to geodynamics was presented by Prof. Lin Ding. He began by acknowledging that geodynamics encompasses a wide range of topics. The geodynamics group mainly discussed achievements and scientific challenges within the Third Pole region. As a background to geodynamics, the group discussed some major achievements of better understanding since the initiation of Asia and India collision. Two other major achievements were discussed, including the advancement of paleomagnetic and the initiation collision between India-Asia research. Prof. Ding also indicated that although some research results have achieved similar paleo-latitude and paleo-elevation results, results differ depending on the area of the Third Pole that is studied. Another achievement discussed by the group was the foraminifera and oxygen isotope researches of the marine deposit being conducted in the Gangba-Dingri areas of Tethyan Himalaya of Third Pole, with results indicating the PETM and a provenance change at about 55million years ago (Mya). Another major achievement related to geodynamics is the work on paleo-elevation, and the group discussed the extensive work already conducted in the Ganges, the Qiangtang, and Himalaya areas, especially in the Ganges Arc. The group acknowledged that additional efforts to study paleo-elevation are needed.

One important linkage discussed among participants in the geodynamics group, is the linkage between paleo-elevation and paleo-monsoon records. The group also discussed the importance of expanding the spatial distribution of observed data throughout the Third Pole region. Another topic discussed by the geodynamics group was the explanation of why the surface of the Plateau is so flat.

Another challenging question is related to the change of drilling systems throughout the history of environmental studies in the Third Pole region. Future challenges the group discussed related to expanded drilling, for example in the Arabian Sea or the Bangladesh Delta. Additional challenging work discussed by the geodynamics group included the study of the southern Plateau and the Pamir area, which the group acknowledged is a difficult and challenging area of the Third Pole to study.

4.7. Special Report - TPE Precipitation Working Group Update

Prior to the group discussion summaries on the second day of the workshop, Prof. Daqing Yang, Chair of the TPE Precipitation Working Group (PWG), participated via Skype and presented an update on the progress of the TPE PWG during the past few years. Prof. Yang indicated the PWG has become an established group of scientists, working from institutions in China, in other Third Pole countries, and from around the globe. Some of the main expertise of the group is related to precipitation observations, remote sensing, and modeling.

First PWG meeting was held at ITP in Beijing in November, 2012. One of the outcomes of that meeting was the development of a research and work plan for precipitation activities within TPE. In addition, the PWG met with the Glacier Mass Balance Working Group (GMBWG) in Beijing in July, 2015 to update activities and exchange ideas. As part of the work plan, the PWG has defined science questions for precipitation research, and discussed the research approaches and potential outcomes. Through these efforts, the PWG

has stimulated very active research efforts, projects and collaborations on precipitation research over the last few years.

The recent progress of the PWG was next outlined by Prof. Yang. One focus area of the PWG is the collection of precipitation data at high elevations and on glaciers. Here, the potential link with the Glacier Mass Balance Working Group (GMBWG) was acknowledged. Another noted area of progress included the guage intercomparison experiments, which has the potential to link with the WMO SPICE program. Prof. Yang also pointed out the efforts for a TP-wide bias-corrected long-term daily precipitation, led by Y. Zhang, and the recent progress assessing remote sensing precipitation products over the Third Pole, particularly for hydrological modeling, with efforts led by F. Su. Prof. Yang also emphasized new results related to determining precipitation phase, and indicated that Third Pole research on climate change analysis and impacts on the water cycle are being led by K. Yang. Additional efforts to study monsoon rain and teleconnections, led by L. Devkota, were noted.

Prof. Yang next outlined some of the PWG objectives and role in TPE. One objective is to develop a precipitation research plan and strategy to contribute and support the TPE program. Another objective is to lead precipitation research projects for climate, hydrology, glacier, and ecosystem studies within the TPE program. Communicating and collaborating with other working groups within the TPE program is a role the PWG expects to play, the group hopes to ling TPE precipitation research activities with relevant international programs, such as the GPM and WMO SPICE projects, among others.

The PWG has identified four main research areas. The following preliminary list of names of associated researchers was also presented according to the four main research areas:

Area 1: Observation Methods

Lead: Y. Zhang and X. He

Members: Baiqing Xu, Rahmatullah Jilani, Yi Ma, B. Wang, D. Yang, Lele Zhang

Area 2: Datasets and products

Lead: J. Tong and N. Wang

Members: Vladimir Aizen, Y. Zhang, Yingzhao Ma, Kai Tong, Akiyo Yatagai, X. Pan, Z. Ji

Area 3: Glacier and Hydrology/LSM models

Lead: S. Kang and K. Yang

Members: Y. Ma, L. Tian, L. Cuo, F. Su, F. Zhang, L. Wang, D. Yang

Area 4: Precipitation dynamics

Lead: K. Ueno and Xin Li

Members: Keqin Duan, Meixue Yang, L. Ma, X. Pan, D. Yang

The PWG has also proposed and developed research projects, and Prof. Yang presented a list of the following nine proposed research projects:

- Gauge intercomparison and evaluation over TP / link to WMO SPICE
- AWS survey and improvement over TP / link to TPE glacier flagship stations
- Development of TPE bias-corrected precipitation dataset
- Assessment and evaluation of TP regional precipitation datasets
- TP precipitation trend and variation: past and future
- Impact of long-term precipitation change to glacier mass balance over TP
- Glacier/hydrology/LSM model sensitivity to various precipitation inputs
- Topography effect on TP precipitation distribution
- Process studies of precipitation over TP

A few examples to highlight the PWG activity and achievement were also presented. The first is the TPE Regional Precipitation Dataset & Bias Corrections, a paper recently published by Y. Ma, Y. Zhang, and D. Yang in the International Journal of Climatology in 2014, which will be very useful for hydrology and climate change analyses.

Another outcome of the PWG efforts is the work led by Yang Kun and others, which defined a better way to discriminate precipitation type. This is one of the

most important issues, because rain and snow can produce very different discharge in time and therefore becomes a key component of land surface models. This work was recently published in the Journal of Hydrology in 2014.

The next outcome presented was the recent precipitation assessment efforts to compare remote sensing, reanalysis, and gauge data. In particular, efforts led by Fengge Su and others at ITP were acknowledge. Recent comparison of various datasets achieved differing results, and this work was published in the International Journal of Climatology in 2013. Prof. Yang acknowledged the importance of these results to the users of precipitation data by demonstrating the dependence of results on the dataset used.

The final example of recent progress and achievements of the TPE PWG was the recent and ongoing work of lake level studies by Zhang and others. Recently published results of lake level changes in the Journal of Geophysical Research in 2014, provide important data of lake level changes in the highlands, including changes from the 1960s to 2012, with the message that precipitation is very important to lake level changes as well.

Although the PWG has done a lot, there were three main considerations and suggestions for future direction presented by Prof. Yang.

1. Better field observations with automated instruments and remote sensing. It was suggested this may be accomplished by expanding existing sites to summits, focusing on key areas/transects over the Third Pole, guage testing and intercomparison projects, and using/testing remote sensing precipitation data and products.
2. Database development and distribution. Additional efforts are needed to update datasets, develop new products, and contribute to the TPE database. In addition, it was suggested to further share data with TPE groups and other users/online.
3. Link more closely with TPE and other activities. Specifically, it was suggested to expand snow cover remote sensing and better link precipitation with glacier mass balance and accumulation, In

addition, further links and expansion of precipitation isotopes, data collection/analysis, basin glacier-hydrology modeling, and precipitation and lake changes over TP, particularly extreme events.

Prof. Yang followed the suggestions for future direction by presenting several opportunities for future PWG work. The first opportunity presented was to explore links with the WMO Solid Precipitation Intercomparison Experiment (WMO SPICE). Efforts are underway to test and develop new technologies, datasets, data analysis techniques and publications. Next, Prof. Yang discussed opportunities in the area of Elevation Dependent Warming (EDW), and noted the global campaign currently in the development phase. A Nature Climate Change paper in review on this topic was mentioned, and it was noted that TPE is already connected and linked via the PWG. A specific future need is to create a mountain climate database suitable for detecting and understanding EDW from station data. Prof. Yang next discussed the Global Precipitation Mission (GPM), and the effort to obtain global coverage including the high mountains. For this effort, high resolution snowfall/precipitation data for validation and calibration is needed. In addition, the potential for new precipitation data over remote areas for ice/water research and applications was acknowledged. Prof. Yang noted that the PWG is also connected to this effort via meetings and its member contributions and involvement. Finally, the next Ground Validation Cal/Val meeting in May 2015 at Korea Meteorological Administration was mentioned.

Prof. Yang concluded the PWG updated by putting forth several recommendations and proposed actions. The first related to the TPE program, and proposed the Science Committee review and comment on the PWG work. The second recommendation and proposed action was for the PWG to prioritize and lead the key research projects via international collaborations. The next recommendation was for TPE to consider supporting selected precipitation research projects and PWG planning activities. It was also proposed that TPE plan/support a TPE Precipitation Workshop in the summer

of 2015. The final proposed action was to update the PWG page/links on the TPE website, add new papers/talks, and share info and new datasets.

5. Workshop Conclusions

The 5th TPE Workshop attracted over 70 internationally renowned scientists from 13 nations to discuss the Third Pole environment. Among the international participants, one-third were from the Third Pole region, with the remaining participants from around the globe including the China, Germany, USA, Netherlands, Italy, U.K., Nepal, India, Tajikistan, Pakistan, Norway, Sweden and Switzerland. Scientists of various disciplines introduce their latest understanding of the Third Pole from different perspectives, including themes related to the Asian monsoon, climate and cryosphere dynamics, geologic processes, geohazards, land-atmosphere interactions, lakes and rivers, and biologic and biodiversity studies. Workshop participants made significant progress discussing both the recent achievements and the major challenges associated with interdisciplinary research in the high mountain regions of the Third Pole.

Themes discussed during the 5th TPE Workshop demonstrated a multidisciplinary approach conducive to exchange and collaboration. Some of the research presented at the Workshop has been highlighted in top international journals such as Science, Nature, and Scientific American, demonstrating the caliber and potential for Third Pole research. In addition, a presentation integrating glacier mass balance modeling with hydrological modeling revealed the unconventional finding that debris-covered glaciers may be disappearing faster than previously thought. This introduced a new perspective and called attention to both clean and debris-covered glacier contributions to glacial mass balance and water budget in the region

Ecological research gained growing attention in the Third Pole region, where bio-diversity in the region is threatened by changing climates. Ecologists at the 5th TPE Workshop shared their latest findings of downslope retreat of tree lines in the Himalayan region. In addition, the discussion group related to ecosystems presented several key products for development and clearly outlined strategies and challenges for development of products.

The workshop also highlighted the interactions between climate and geodynamics by inviting distinguished geologists and geophysicist to present some of the latest findings related to Plateau uplift. As the elevated plateau is the pretext for climatologists and environmental scientists to discuss the far-reaching impact of the Third Pole on global climate, knowledge in this aspect would contribute to a comprehensive understanding of earth system sciences in a regional and global context.

Although the TPE program has supported more than a dozen field campaigns in the past two years, undertaking expeditions in China, India, Nepal, Pakistan, and Tajikistan, participants concluded that there is an urgent need for additional efforts and expanded aerial coverage of both in situ data and remotely sensed data. Attendees agreed that the TPE program's newly established international research center in Kathmandu, Nepal, should serve as a local office and student training center, and as a base to support scientific field activities on the southern slope of the Himalayas.

Following the sessions of the workshop, a peer-reviewed assessment book on the Third Pole environment was suggested, with a target completion date of 1-2 years. Participants discussed the idea of a book that would summarize the current understanding of environments and geodynamics in the Third Pole region, and provide a solid scientific foundation for policy decisions related to regional sustainability. Contributing authors to the book will be mainly selected from the workshop participants.

The TPE program offers a platform and support for the international academic community to collaborate on Third Pole research, and is further developing with each workshop. The 5th TPE Workshop again advanced the research level of participating scientists and expanded the diversity of participating scientists and program managers. The workshop forum invited participating scientists to discuss major challenges confronting Third Pole environmental research within the international academic community. Small group discussions during the final day of the workshop encouraged participants to discuss achievements and challenges for international, collaborative research.

At the conclusion of the workshop, TPE Co-chair, Prof. Lonnie Thompson suggested the next TPE workshop be held in Columbus, Ohio, USA.

Appendix 1. Agenda

5th TPE Workshop

Third Pole Environment: The Dynamics and Global Linkages

Berlin, Germany, December 8-9, 2014

		Monday, December 8,2014
8.00am-10.00am	Registration	
		Day 1, December 8, 2014
Time	**Speaker**	**Theme**
9.00-9.30 am	Tandong Yao, Volker Mosbrugger, Lonnie Thompson, Erwin Appel	Welcome
Session 1	***Chair:TBD***	***Interactions between the Third Pole and the Asian monsoon***
9.30-9.50 am	William Boos	Influence of the Tibetan Plateau on the South Asian monsoon
9.50-10.10 am	Peter Clift	Sediment transport and storage in response to changes in the monsoon
10.10-10.30 am	Walter Immerzeel	Himalayan atmospheric dynamics revealed by high-resolution atmospheric modelling and high-altitude observations
10.30-10.50 am	D. Scherer	How far reach the present-day Summer Monsoons into the Third Pole Region?
10.50-11.10 am	Lochan Devkota	Teleconnections of Tropical Pacific and Indian Ocean Oscillations with Monsoon Rainfall Variability over Nepal
11.10-11.20 am		-----Coffee break----
Session 2	***Chair:TBD***	***Past climate and environmental changes***
11.20-11.40 am	Lonnie Thompson	Third Pole climate linkages documented by ice core-derived stable isotopes, ENSO, droughts and human history over the last millennium
11.40am-12.00pm	Guangjian Wu	The increasing dustiness in Tibetan ice cores over the past decades under warming perspective
12.00 -12.20 pm	Gerd Gleixner	Reconstruction of Asian monsoon using compound-specific isotope signals of terrestrial and aquatic biomarkers in Tibetan lake systems
12.20-12.40 pm	Liping Zhu	Different mechanism for Tibetan Plateau responding to climate of north Atlantic Realm since LGM
12.40 -12.55 pm	Achim Bräuning	Stable oxygen isotopes on the TIbetan Plateau as climate proxies: what exactly do they reflect?
12.55-2.30 pm		-----Lunch-----
Session 3	***Chair:TBD***	***Status of the cryosphere***
2.30-2.50 pm	E. Dietze	Sediment transport processes across the Tibetan Plateau inferred from lake sediments (last talk of the previous session)
2.50-3.10 pm	Tandong Yao	Glacial changes on the Third Pole and their linkages to atmospheric circulations
3.10-3.30 pm	Koji Fujita	Climate regime and sensitivity of Asian glaciers revealed by the GAMDAM

		glacier inventory
3.30-3.50 pm	Shresth Tayal	Regional climate signals and linkages to glacier melting: a case study of eastern Himalaya
3.50-4.10 pm	Tobias Bolch	A longer-term perspective: glacier mass changes in high mountain Asia since the 1970s
4.10-4.30 pm	Andreas Kaab	Competing estimates of early twenty-first century glacier mass balance over the Pamir-Karakoram-Himalaya
4.30-4.40 pm		-----Coffee break----
Session 4	***Chair:TBD***	***Status of rivers and lakes***
4.40-5.00 pm	Kun Yang	Climate change impacts on water cycle in the Tibetan Plateau: A review
5.00-5.20 pm	Fan Zhang	Modeling of runoff and suspended sediment flux in the Mabengnong catchment on the Tibetan Plateau
5.20-5.40 pm	Francesca Pelliciotti	Unravelling the hydrology of an Himalayan catchment using a unique combination of high elevation ground data, high resolution remote sensing and advanced glacier hydrological modelling
5.40-6.00 pm	Fengge Su	Role of snow and glacier melt and rainfall in streamflow changes in the past 50 years for the major river basins in the Tibetan Plateau
6.00-6.20 pm	F. Salerno	Warmed winters and weakened precipitation on Mt. Everest(central southern Himalaya) impacts glaciers, lakes, permafrost and river discharges
6.20-6.40 pm	Volkhard Spiess	Nam Co lacustrine sediments - new deep-penetrating hydro acoustic data
6.40-7.00 pm	S. Rahman	An updated inventory of glacial lakes in Hunza and Astore River basins (Gilgit Baltistan Province Pakistan) using satellite data
7.00 pm-		---Dinner---

Day 2, December 9, 2014

Time	**Speaker**	**Topic**
Session 5	***Chair: TBD***	***Geoecosystems and anthropogenic activities***
8.30-8.50 am	Volker Mosbrugger	Ecosystem dynamics, climate change and anthropogenic impact on the Tibetan Plateau
8.50-9.10 am	Eryuan Liang	Himalayan birch at the upper timberline is increasingly at risk for survival and downslope range shifts in response to global-change-type droughts
9.10-9.30 am	Yongqin Liu	Ice cores from the Tibetan Plateau reveal bacterial community convergence related to climate and anthropogenic activity
9.30-9.50 am	Klaus Fraedrich	Vegetation Dynamics on the Tibetan Plateau (1982 to 2006): An Attribution by Eco-hydrological Diagnostics
9.50-10.10 am	Baiqing Xu	Black carbon in snow over the Third Pole region
10.10-10.30 am	Anna Wegner	Two centuries of trace element and black carbon deposition at the top of the Himalaya: natural background vs. anthropogenic pollution
10.30-10.45 am		----Coffee break----
Session 6	***Chair: TBD***	***Impacts of recent climatic changes and adaptations to a changing Third Pole***
10.45-11.05 am	R. Bradley	Evidence for elevational-dependent warming (EDW) and the underlying mechanisms driving EDW
11.05-11.25 am	Y. Ma	Study on the change of the Tibetan Plateau climate system and the mechanism of its impact on eastern Asia
11.25 -11.45 am	D. Chen	Spatial scale of climate variations over the Third Pole
11.45 am-12.05 pm	H.C.Nainwal	Response of glaciers to climate change, a study from Upper Alaknanda Basin, Uttarakhand Himalaya, India

12.05-12.25 pm	Bob Su	Advances in land surface processes and land-atmosphere interactions on the Tibetan Plateau
12.25-12.40 pm	H. Graf	Very High Resolution Modelling of Tibetan Plateau Land Use Change Effects on Clouds, Precipitation and Surface Energy balance(15 min)
12.40-12.55 pm	Rajeev Goyal	HKH Monitoring and Assessment Programme (HIMAP) exercise (15 min)
12.55-2.30 pm		----Lunch----
Session 7	***Chairs: TBD***	***Geodynamics and Geohazards***
2.30-2.50 pm	Lin Ding	The Andean-type Gangdese Mountains: Paleoelevation record from the Paleocene–Eocene Linzhou Basin
2.50-3.10 pm	Bernd Schurr	Collisional tectonics and geodynamics of Pamir and Hindu Kush
3.10-3.30 pm	Stefano Parolai	Seismic and Landslide Risk Assessment and Mitigation in Central Asia
3.30-3.50 pm	Oliver Korup	Natural Hazards: News from the Third Pole
3.50-4.10 pm	F.H.Karimov	Dynamics of large mountain-valley glaciers flow in Tajikistan
4.10-4.30 pm	Gianni Tartari	Remarks on the environmental research carried out in the last quarter of a century in the Himalayas
4.30-4.45 pm		-----Coffee break-----
Session 8	***Parallel group discussion***	***Key questions for each group***
4.45-5.45 pm	Evolution and Geodynamics of the Third Pole Interactions between the Third Pole and the Asian Monsoon Past climate and environmental changes Status of the cryosphere Status of rivers and lakes Geoecosystems and anthropogenic activities Geohazards Impacts of recent climatic changes and adaptations to a changing Third Pole	1. What are the major achievements? 2.What are the three most important scientific challenges?
Session 9	***Plenary discussion session and closing***	
5.45-6.00 pm	Daqing Yang	TPE precipitation working group (PWG) update
6.00-7.00 pm	Reports from the 8 working groups	5min each
	Final remarks	20min
	-----Finale-----	
December 10-11	***Sino-German workshop on Tibetan Plateau Research***	

Appendix 2. List of Participants

No.	Name	Country	Affiliation
1	Erwin Appel	Germany	University Tuebingen
2	Tobias Bolch	Switzerland	University of Zurich
3	William Boos	USA	Yale University
4	Raymond Bradley	USA	University of Massachusetts
5	Achim Brauning	Germany	University Erlangen
6	Deliang Chen	Sweden	University of Gothenburg
7	Peter Clift	USA	Louisiana State University
8	Emily Collier	Netherlands	Utrecht University
9	Gerhard Daut	Germany	Jena University
10	Lochan Devkota	Nepal	Tribhuvan University
11	Elisabeth Dietze	Germany	Helmholtz Centre Potsdam
12	Lin Ding	China	ITPCAS
13	Todd Ehlers	Germany	University Tübingen
14	Klaus Fraedrich	Germany	Max-Planck-Institute for Meteorology
15	Koji Fujita	Japan	University of Nagoya
16	Gerd Gleixner	Germany	MPI Jena
17	Rajeev Goyal	Nepal	ICIMOD
18	Hans Graf	England	University of Cambridge
19	Gregory Greenwood	Switzerland	Mountain Research Initiative
20	Walter Immerzeel	Netherlands	Utrecht University
21	Daniel Joswiak	China	ITPCAS
22	Andreas Kääb	Norway	University of Oslo
23	Farshed Karimov.	Tajikistan	Institute of Geology, Academy of Sciences of the Republic of Tajikistan

24	Oliver Korup	Germany	University of Potsdam
25	Aljoscha Kress	Germany	Senckenberg Gesellschaftfür Naturforschung, Frankfurt
26	Frank Lehmkuhl	Germany	RWTH Aachen University
27	Eryuan Liang	China	ITPCAS
28	Yongqin Liu	China	ITPCAS
29	Yaoming Ma	China	ITPCAS
30	Volker Mosbrugger	Germany	Senckenberg Gesellschaft für Naturforschung, Frankfurt
31	H.C. Nainwal	India	HNB Garhwal University
32	Stefano Parolai	Germany	Helmholtz Centre Potsdam
33	Francesca Pelliciotti	Switzerland	ETH
34	Said Rahman	Pakistan	SUPARCO
35	Wolfgang Roesler	Germany	University of Tuebingen
36	Aljoscha Kress	Germany	SenckenbergGesellschaftfürNaturforschung, Frankfurt
37	Franco Salerno	Italy	The Water Research Institute, CNR
38	Dieter Scherer	Germany	FU Berlin
39	Bernd Schurr	Germany	German Research Centre for Geosciences Helmholtz Centre Potsdam
40	Bob Spicer	UK	The Open University
41	Volkhard Spiess	Germany	University of Bremen
42	Bob Su	Netherlands	ITC, University of Twente
43	Fengge Su	China	ITPCAS
44	Gianni Tartari	Italy	The Water Research Institute, CNR
45	Shresth Tayal	India	TERI
46	Lonnie Thompson	USA	The Ohio State University
47	Anna Wegner	Germany	Alfred Wegener Institute

48	Guangjian Wu	China	ITPCAS
49	Baiqing Xu	China	ITPCAS
50	Kun Yang	China	ITPCAS
51	Xiaoxin Yang	China	ITPCAS
53	Tandong Yao	China	ITPCAS
54	Fan Zhang	China	ITPCAS
55	Liping Zhu	China	IPTCAS

Appendix 3. List of Presentations

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