China National Report of IUGG/IACS (2010-2014)

Content

China National Committee of IUGG/IACS

(CNC-IACS)

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1. List of Committee members for the 2nd phase of CNC-IACS

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Vice- Chair: Yao Tandong Ding Yongjian Dong Wenjie
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Committee: (in alphabetical order)

Bian Lingen Chen Rensheng Chen Yaning Chen Zhenlin Ding Yongjian
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Divisions:

1. Glacier Division

   Head: Wang Ninglian and Li Zhongqin

2. Frozen Ground/Permafrost Division

   Head: Wu Qingbai and Zhao Lin

3. Cold Regions Hydrology Division

   Head: Chen Rensheng and Lv Haishen

4. Cold Regions Ecology Division

   Head: Wang Genxu and Zhao Xinquan

5. Cryosphere Change and Climate Predict Division

   Head: Luo Yong , Wu Bingyi and Dong Wenjie

6. Snow, Remote Sensing and Data Division

   Head: Zhang Tingjun and Li Xin

7. Cryosphere and Sustainable Development Division

   Head: Zhang Yili and Fang Yiping; Secretary: Yang Jianping

8. Polar Region Science Division

   Head: Xiao Cunde and Li Yuansheng; Secretary: Ding Minghu

9. Cryospheric Records Division

   Head: Kang Shichang and Jin Huijun

10. Cryosphere and Quaternary Division

    Head: Zhou Shangzhe and Lai Zhongping; Secretary: Zhao Jingdong

11. Planetary Cryosphere Division,

    Head: Tian Feng

2. Brief report for the 1st Chinese Conference on Cryospheric Sciences

The first Chinese Conference on Cryospheric Sciences was successfully held in Beijing, China during October 24-26, 2014 by Chinese National Committee on International Association of Cryospheric Sciences (CNC-IACS), Chinese National Committee on Climate and Cryosphere (CNC-CliC), and the State Key Laboratory of Cryospheric Sciences (SKLCS), Cold and Arid Regions Environmental and Engineering Research Institute (CAREERI) of the Chinese Academy of Sciences (CAS). There were more than 230 participants from thirty five organizations in China. Focusing on the theme of the cryospheric change, influences and sustainable development, the conference strives to enhance and co-ordinate efforts in monitoring the cryosphere, to model and understand the cryosphere's role in the climate system, to assess changes in the cryosphere as indicators of climate change, to quantify the frangibility of cryosphere and the influences of cryospheric changes on hydrometeorology, society and economy (such as agriculture, tourism, etc.) in sustainable development, to discuss adaptive countermeasures on cryospheric changes, to facilitate the data collection of cryospheric systems through standardized measurements, and connecting with Future Earth to provide a Chinese platform for discussions and publications of results arising from research activities as mentioned above.

On the first day, there were 11 invited presentations. On 25 and 26 October, 2014, the session presentations were held. During the conference, there were 189 oral presentations and 6 posters covering the following ten topics:

1) Climate change in cold and arid regions
2) Observed changes in cryosphere (including remote sensing of cryospheric changes)
3) Climatic and environmental record in the cryosphere
4) Cryosphere and sea level

5) Cryosphere and water resources

6) Cryosphere and ecology

7) Cryospheric simulation and projection

8) Cryospheric hazards

9) Adaptation of cryospherc changes and regional sustainable development

10) Cold regions engineering

The successful Chinese Conference on Cryospheric Sciences will develop the understanding on cryospheric science for the Chinese scientists, improve the Chinese status and influence on the international cryospheric science, and enhance the international status of Chinese research on cryospheric sciences.

Fig. 1 Group photo for most of the attendees

Fig. 2 Dr. Qin Dahe (CNC-IACS chair, also Chair of the confenrence LOC) representing a report

Fig. 3 Attendees were listening keynote speeches

3. Progresses on the Cryospheric Scientific Divisions

3.1 Glacier Division (by Wang Ninglian, Li Zhongqin)

China is the largest middle latitude country with the largest glacier area, and has the largest glacier area around the world besides Antarctic and Greenland. The investigations of glacier distribution and predict their changes are thus very important, to the evaluation of water resource and building of national defense infrastructure in western China, to the developments of Chinese cryospheric research, and also to the world's global and planetary change study. During the past five years, we have made progress in glacier inventory, glacier change and glacier models.

- **The Second Glacier Inventory of China was completed in 2014**

The Second Glacier Inventory of China (SGI-China) was compiled based on Landsat TM and ETM+ images acquired between 2006 and 2010. According to the new inventory, there are 48571 glaciers with a total area of 51840km^2 in western China, and the estimated water storage amount to 4494km^3. About 90% of the glacier area of SGI-China distributes in Xinjiang and Xizang provinces, while 30% and 34% distributes in the drainage basins of Yarlung Zangbo River and Tarim River. By comparing the finished parts of new SGI-China and the digitized FGI-China, we found that totally about 18% glacier area has vanished during last 30-50 years. The biggest glacier area shrinkage occurred at Mountain Altai and Gangdise, with change ratio of -37.2% and -32.7%, respectively. The Mountain Karakorum, Altun, Kunlun, and Qiangtang Plateau, have the lowest change ratio (-11.3% to -8.4%).

- **Glacier changes in China and its climatic background during the past half century**

Based on in situ observation data and satellite images data, the glacier changes in China and its climatic background in the past half century was discussed. Tibetan Plateau shows the smallest glacier change (about -0.2%/a), while the regions in Mountain Gangdise and adjacent north slope of Himalaya Mountain, and the source

region of Indus River around western Himalaya, show the largest glacier shrinkage (about 2.2%/a). The moderate glacier change mainly distributed around regions in Mountain Tianshan, Qilian, and northern Tibetan Plateau. The glacier status in the Tibetan Plateau and surroundings varies systematically from region to region: the Himalayas shows the greatest decrease in length and area, and the most negative mass balance, whereas the eastern Pamir shows the least reduction in length and area, and positive mass balance. The main cause for this regional trend is probably decreasing/increasing precipitation in the Himalayas/eastern Pamir regions, which results from changes in the two different atmospheric circulation patterns, that is, the weakening Indian monsoon and strengthened westerlies. Under the present warming conditions, glacier shrinkage might further accelerate in the Himalayas whereas glaciers might advance in the eastern Pamir regions.

- **Developed the glacier mass-balance models and dynamic models, and were applied to different glaciers in China.**

Glacier mass balance is regarded as the bridge and tie between the meteorology and water resources, so the monitoring and simulation for mass balance is always one of the frontier research topics. We developed the physical energy-balance models and statistical degree-day factor models based upon temperature-index, radiation-index and temperature-radiation-vapor-index, and applied to Qiyi Glacier, Urumuqi Glacier No.1, Dongkemadi Glacier, Laohugou Glaicer No.12, and Zadang Glacier. As glacier dynamic models perform satisfactorily for describing physical processes and long-term evolution of glaciers, the dynamic models have been applied to Glacier No.1 at the headwater of Urumqi River for its future variation predication. The result indicates that the response time of the glacier is in a magnitude of over one hundred year. We also develop a new method for estimating the ice thickness along glacier flow lines, using the “perfect-plasticity” rheological assumption that relates the thickness and surface slope to a yield stress. We validated the extended method on five glaciers in northwest China where thickness data are available from radio echo

soundings, finding that it can reproduce measured thicknesses with a mean absolute error of 11.8% (like the standard method).

3.2 Frozen Ground/Permafrost Division (by Wu Qingbai, Zhao Lin)

Chinese permafrost study has focused on impacts of permafrost and global warming changes on permafrost engineering, physical and mechanical properties of frozen ground and their impacts on engineering, modeling and prediction of permafrost engineering stability, gas hydrate in permafrost regions. Some advances have been made in past several years, specially, in post-construction impact evaluation and application of road-building techniques using the cooling roadbed ideas in the Qinghai-Tibet Railway (QTR), permafrost problems and its mitigative techniques in the Qinghai-Tibet Power Transmission Line (QTPTL), frost heave problems and mitigative techniques in the Harbin-Dalian High-Speed Railway (HDHSR) in the seasonally frozen ground regions, permafrost change and its environmental impacts in China, physical and mechanical properties of frozen and thawed grounds in the ice/water phase change zone.

- **Solving the scientific and technical problems in the cold regions engineering**
  - Lots of research has been conducted on long-term monitoring of permafrost thermal regime along the QTR and Qinghai-Tibet Highway (QTH), engineered problems survey, verification and evaluation of various mitigative techniques in the field, laboratory and modeling tests. Some mitigative techniques proved successfully have been applied to the Expressway of the National Highway No. 214 on the Qinghai-Tibet Plateau (QTP).
  - Field investigations, long-term monitoring of thermal regime, numerical simulation and laboratory modeling tests of permafrost tower foundation along the QTPTL have been carried out to provide scientific bases and technical supports for construction, framing towers, stringing lines, operation and maintenance.
  - In-situ deformation monitoring, mechanisms of minor frost heave and mitigative techniques have been studied in the HDHSR in the seasonally frozen ground regions. Research findings have been applied to construction and operation of the HDHSR, which remarkably reduce the cost of

maintenance.

- Aiming at problems induced by the secondary or multiple collapse in the loess roads in the seasonally frozen ground regions, some investigations have been conducted to reveal the mechanisms of multi-collapse caused by freeze-thaw and wetting-drying cycles. A countermeasures against frost heave and multi-collapse of the loess roads has been put forward, verified in the field and laboratory tests, and applied to some other loess roads in the seasonally frozen ground regions.

- **Advancing in design ideas and theories of cold regions engineering**
  - The idea adopting composite techniques to cool the roadbeds overlying the permafrost has been put forward, and some composite techniques have been developed and applied successfully to the specific permafrost engineering. This idea has dominated the design of the broad-lane expressway with a bituminous pavement in the permafrost regions and resolved some key problems induced by degradation of underlying permafrost.
  - A new design principle enhancing adfreezing and mitigating thaw settlement of permafrost tower foundation has been proposed, and has replaced the conventional one only mitigating frost heave in the QTPTL. This new design principle has played a key role in deciding construction steps and shortening construction period.
  - The testing techniques and methods in the field and laboratory, studying the properties of ice-rich frozen ground with a high temperature (> -1°C) and cold regions engineering, have been continuously improved in China, which lets us make some breakthroughs in studies on heterogeneity and sensitivity of frozen ground near a temperature at which the ice/water phase change occurs, on application of generalized Clausius-Clapeyron equation and on mechanisms of minor frost heave.
  - Evolution of permafrost have been studied based on lots of long-term monitored ground-temperature data of permafrost in China. The accuracy of mapping of permafrost distribution has been improved by considering

impacts of local factors.

- Evidence, which proves that the gas hydrate exists in the Kunlun Mountains basin, has been found. That is another important finding of gas hydrate after finding it in the Qilian Mountains areas on the QTP.

- **Monitoring Network and permafrost change**

  - Monitoring Network

The integrated monitoring network on permafrost over the Qinghai-Tibet Plateau (QTP) has been greatly improved during the period 2010-2014. With the financial support from Ministry of Science and Technology, China and National Natural Science Foundation of China, the research group have conducted several field investigations on the whole plateau. The main subjects of those field investigations were focused on the boundary of permafrost and seasonally frozen ground, the active layer thickness, soil, vegetation, and so on. Until now, there were 5 integrated sites including observations of permafrost temperatures, moisture content and soil temperature in active layer, and concerned climatic elements logged by automatic weather stations all over the QTP.

  - permafrost change

The statistical analysis showed that the ground surface temperature had increased significantly from 1980 to 2007 on the central QTP. The increasing rate of ground surface temperature on the central QTP approximated to 0.60 ℃/10a, which is apparently greater than that of air temperature on the QTP. Correspondingly, the ground surface freezing and thawing indices also showed significant changes denoting clear ground surface warming. A model was developed to estimate the time series of active layer thickness along the Qinghai-Tibet Highway from 1980 to 2010. The results indicated that the active layer thickness has increased at a rate of 1.33 cm/a, accompanying with the rise of the temperature of permafrost table, soil temperature at the depth of 50 cm and the cumulative temperature at 5 cm deep. During this period, the soil heat flux has increased at a rate of 0.1 Wm^{-2}/a, which put forward sound explanation for the increase of active layer thickness and the rise of ground temperatures in the permafrost regions. The ground temperature, the elevation, and

the vegetation types have great impacts on the changing characteristics of active layer thickness.

In the sporadic permafrost regions of Mahan Mountain, the permafrost area has decreased by 16% and the mean annual ground temperature has increased by a rate of 0.06 to 0.12 ℃/decade over the period 1993-2009. The distribution and thermal state of permafrost on Mahan Mountain closely relate to the surface conditions and soil type. A one-dimensional finite difference model of heat flux was established to estimate the important protective effects of the peat layer and ground ice. The modeling results indicated that active-layer thickness of permafrost on Mahan Mountain would increase by approximately 83 per cent under current climate conditions without the protection of the peat layer and ground ice. Based on the temperature projections of general circulation models, this study projects that permafrost will likely remain on Mahan Mountain for the next 40 to 50 years.

- **Carbon Cycle in permafrost regions**

By collecting and analyzing soil samples over the QTP, soil organic carbon (SOC) contents were examined beneath two grassland vegetation communities and cold desert sites in permafrost areas of the central western part of the Qinghai-Tibet Plateau. Mean SOC stocks in the top 150 cm were 7.73 kg m^{-2} for Stipa roborowskyi communities and 3.72 kg m^{-2} for Carex moorcroftii communities, but only 1.84 kg m^{-2} for cold alpine desert. More than 80% of SOC stocks beneath the grasslands were in the top 100 cm. Correlation analyses showed that SOC stocks in the top 150 cm are linked to soil moisture content, and the vertical distribution of SOC is mainly affected by depth and soil moisture content. Moisture content and vegetation communities are therefore important factors associated with SOC content in this cold, arid area, while active-layer thickness, vegetation cover and topographical factors play non-significant roles in SOC distribution. To determine the relationship between soil organic matter (SOM) decomposition and chemistry in the permafrost region of the Qinghai-Tibet Plateau (QTP), 300-day laboratory incubations at 25℃ and chemical fractionation were performed to characterize the mineralisation dynamics of organic carbon from soils under five vegetation conditions. These results suggest that a large proportion of

the organic matter in soils of the permafrost region in the QTP is mineralisable. Based on the changes in chemical fractions of organic matter, it could be determined that soils with higher water-soluble fractions had higher rates of carbon mineralisation, while the mechanisms involved in the respiration of different chemical fractions are complicated.

3.3 Cold Regions Hydrology Division (by Chen Rensheng, Lv Haishen)

- **Established a field observation network on alpine hydrology**

Several field observation systems on hydrology has been newly established or renewed in the cold regions of China. They are major in glacier and permafrost hydrology in the Dongkemadi small watershed in Tanggulai Mountains, focus on glacier hydrology in the Koxkar small watershed of Tien Mountains, major in cryospheric hydrology in the Hulu small watershed of Qilian mountains, and an integrated observation system on alpine hydrology in the large Shulu river basin located in the Qilian mountains. These observation system has measured large numbers of data on alpine meteorology, water and heat balance on alpine land surfaces, cryospheric changes etc., and they has been members of the Global Cryosphere Watch / WMO in February 2015.

- **New knowledge on alpine precipitation**

Precipitation is much lower estimated owing to rare observation in the higher alpine regions. According to the new measurements on or near the mountain tops, and statistical methods, the precipitation gradient along elevation and monthly precipitation data in 1km grids are acquired in the large alpine mountains such as Qilian mountains, Tien mountains, etc. The new annual precipitation is much more than before. For example, it is about 100mm more than before in the Heihe upstream basin of the Qilian mountains.

- **New Cryospheric Basin Hydrological Model (CBHM) and its initial application**

A new CBHM is updated from previous version based on ten-year field observation and research results. The simple glacier slide, permafrost evolution, snow drift and vegetation growth processes etc. are the highlights and described in CBHM. Runoff contribution of alpine underlying surfaces are quantified in Shule and Hei river basins, and it finds the moraine-talus region is the major runoff contribution in alpine basins

of China.

- **Cryospheric impacts on basin hydrology**

1) Glacial runoff have a significant impact on river runoff if the glacier coverage in the basin exceeds 5%; 2) Permafrost degradation mainly affects hydrological processes in winter. The effect is obvious in the basins with high permafrost coverage (>40%) but negligible in those with low permafrost coverage; 3) Glacier can regulate interannual river runoff by reducing peak flows and supplementing insufficient flows. Snow cover has also the regulating river runoff ability, but it is seasonal; 4) Cryospheric changes impacts on basin hydrology have been evaluated presently and in the future by using CBHM and other hydrological models in several basins, such as Hei river, Shule river, and Akesu river basin, etc.

3.4 Cold Regions Ecology Division (by Wang Genxu, Zhao Xinquan)

- Plant production, carbon and nitrogen source pools in alpine ecosystem

Warming enhanced net primary production and soil respiration, decreased CH_4 emissions from wetlands and increased CH_4 consumption of meadows, Warming-induced permafrost thawing and glaciers melting would also result in substantial emission of old CO_2 and CH_4. (*Chen, et al., 2013*). The largest CH4 uptake of grasslands was found in the Qinghai-Tibetan Plateau, which consumed 0.28 Tg CH4 yr^{-1}, about 44% of the whole uptake of grasslands in China (*Wang, et al., 2014*). Soil inorganic N is a regulatory factor of soil CH4 uptake, and its promotion or inhibition to soil CH4 uptake depends on the N status in terrestrial ecosystems (*Fang, et al., 2014*). The temperature enhancement overall resulted in swamp meadow acting as net carbon sink and alpine meadow as net carbon source. This information partly supports the hypothesis that climate warming may transform high altitude ecosystems from net carbon sinks into net carbon sources (*Li, et al., 2011*). The annual NPP in alpine grassland with an overall increase of 13.3%; 32.56% of the total alpine grassland on the TP showed a significant increase in NPP, while only 5.55% showed a significant decrease over this 28-year period (*Zhang, et al., 2014*). Warming significantly increased aboveground biomass by 19.1%, belowground biomass by 26.7%, and net photosynthetic rate by 13.6 %. The increase of photosynthetic rate was attributed to the increases in stomata conductance, apparent quantum yield, chlorophyll content, non-photochemical quenching of chlorophyll fluorescence, soluble sugar, and peroxidase (*Fu, et al., 2015*).

- **Vegetation coverage and diversity changes**

In the headwater regions of Yangtze River and Yellow River of the Qinghai- Tibet plateau permafrost area, the alpine meadow and alpine swamp meadow were more sensitive to permafrost changes than alpine steppe. The area of alpine swamp meadow decreased by 13.6–28.9%, while the alpine meadow area decreased by 13.5–21.3%

from 1967 to 2000 (*Wang et al., 2011*). In Qinghai-Tibet Plateau, vegetation in the plateau experienced a positive trend in greenness, with 18.0 % of the vegetated areas exhibiting significantly positive trends, which were primarily located in the eastern and southwestern parts of the plateau. In grasslands, 25.8 % of meadows and 14.1 % of steppes exhibited significant upward trends (*Zhang Li, et al., 2014*). The NDVI values showed an upward trend from 2000 to 2010, with 28.5% of the study area exhibiting a significant increase. The proportion of rangelands that experienced a downward trend in NDVI increased as the level of human disturbance increased. In addition, it was found that precipitation had the dominant influence on NDVI values and that higher precipitation and slighter lower temperatures over the period of the study were related to an increase in NDVI values (*Zhao, et al., 2015*). Generally, the productivity-diversity relationship found across arctic habitats, with community diversity peaking in mid-productivity systems and degrading as nutrient availability increases further. Functional diversity and species diversity have opposite responses to short-term fertilization. The increased functional diversity suggests enhanced niche differentiation between species remaining after fertilization, which caused species loss (*Niu Kechang, et al., 2014*).

- **Plant phenology**

The alpine vegetation responded strongly to snow phenology (i.e., snow melting date and snow cover duration) over large areas of the Qinghai-Tibetan Plateau. Snow melting date and vegetation green-up date were significantly correlated ($p < 0.1$) in 39.9% of meadow areas (accounting for 26.2% of vegetated areas) and 36.7% of steppe areas (28.1% of vegetated areas). Snow's positive impact on vegetation was larger than the negative impact (*Wang, et al., 2015*). Warming delayed chlorophyll degradation of perennial herbs in early phase but accelerated it in later phase, regardless of functional groups, which led to higher N concentrations in leaves and stems during the whole senescence period. Autumn warming also significantly increased total non-structural carbohydrate in roots as a result of the delayed process of chlorophyll degradation, although the magnitudes were dependent on functional

groups, which may be explained by inherent differences in growth patterns and phenology between grasses and forbs (*Shi, et al., 2015*). Nitrogen addition significantly delayed the first flowering date and reduced the reproductive allocation for all graminoid species, but accelerated flowering and increased reproductive allocation for most forb species. Species that advanced their flowering time with nitrogen addition increased their reproductive allocation, whereas those that delayed flowering time tended to decline in reproductive allocation with nitrogen addition. It suggest that species-specific switch from vegetative growth to reproductive growth could influence species performance (*Zhang, et al., 2014*). Warming delayed the reproductive phenology and decreased number of inflorescences of Kobresia pygmaea C. B. Clarke, a shallow-rooted, early-flowering plant, which may be mainly constrained by upper-soil moisture availability (*Dorji Tsechoe, et al., 2013*).

3.5 Cryosphere Change and Climate Predict Division (by Luo Yong, Wu Bingyi, Dong Wenjie)

The committee achieved corresponding works in the past five years, and those works include (1) annual meetings of cryosphere and polar meteorology, (2) selecting and training of the Antarctic observers, (3) promoting relevant research works on interactions between the cryosphere and weather/climate, (4) Application of research achievements for prediction operation.

Annual meeting of cryosphere and polar meteorology is one of tasks at the committee, and each meeting, there are about 40 multi-disciplinary researchers, including their students, to introduce their observation and research results, for example, Antarctic atmosphere and ozone observations, drilling Antarctic ice-core, the Chinese Arctic Ocean expeditions every two-year, and impacts of Arctic sea ice loss and Arctic amplification on the mid- and low-latitudes of Asian Continent.

Each year, we have to select 3-5 observers from Chinese meteorological observing stations and promote their observing capability. Finally, two observers will go to Antarctic to deal with observations.

The committee promoted studies on the feedback of the cryosphere on weather and climate, for example, how snow-cover, bipolar sea ice, and frozen soil affect climate variability. Over the past five years, the committee focused attentions on possible feedback impacts of Arctic sea ice, Eurasian snow-cover, and frozen soil on East Asian climate variability in terms of simulation experiments.

Observations and simulation experiments indicated that variations in Arctic sea ice, Eurasian snow-cover can significantly influence weather and climate over East Asia, and some results have been applied to predict Chinese winter climate trend since 2010, for example, Arctic sea ice in September is a precursor for predicting winter air temperature anomalies in China.

3.6 Snow, Remote Sensing and Data Division

So far not received from division head.

3.7 Cryosphere and Sustainable Development Division (by Zhang Yili, Fang Yiping)

- **Cryosphere Change and Water Resource**
  - Under the impact of climatic warming, the glaciers in the High Asia in China have been retreating continuously with negative glacial mass balance in recent several decades.
  - The glacial retreat in the High Asia in China has an important impact on the water resource of the arid regions in Northwest China. The impact of glacier changes on water resources would be different in the various drainage basins, depending on the proportion of glacier coverage.

- **Cryosphere Change and Vulnerability Assessment**

  More effort is going towards establishing standard and qualification vulnerability assessment methods of cryosphere change in the Qinghai-Tibetan Plateau, and in typical inland river basins of Northwest China. In the reporting period, many researchers have developed specific, measurable, achievable indicators system to measure the vulnerability for typical inland river basins, and alpine ecological system based on glacial, frozen soil change context.

- **Cryosphere Change and Adaptation of Animal Husbandry**
  - Permafrost change can have a strong impact on the productivity of alpine grassland by non-linear modelling. And the carrying capacity of theoretical livestock is declining associated with permafrost change on the Qinghai-Tibetan Plateau.
  - The adaptation framework of animal husbandry to frozen soil change was established, according to national, regional, community and household scales. Three key instruments of cryosphere change adaptation are adaptive capacity of the policies, adaptive capacity of the people, and adaptive capacity of the grassland ecosystem.
  - The impact of snow disaster on grassland animal husbandry has gained

increased attention, a nonlinear model of meat production was established in relation to snow disaster, grassland productivity, and disaster prevention by introducing a snow level index, and selecting three key indicators of grassland productivity and disaster prevention, including grass growing season precipitation concentration, sown grassland area, and warm barn area.

- **Cryosphere Change and Public Perceptions**

Conducting questionnaire survey, the focus of these studies is to illustrate the character of public perception on climate and cryosphere change, the changes' possible impacts on water resources or agricultural activities, and adaptation measure choices by the public.

3.8 Polar Region Science Division (by Xiao Cunde, Li Yuansheng)

Antarctica

- Post-IPY progress on PANDA transect

After IPY years (2007/08), Chinese National Antarctic Research Expedition has been keeping explore their efforts along Zhongshan to Dome A transect (PANDA transect). They have installed two automatic weather stations (AWS) with ~600km distance to coast, and one 15 m-AWS at Kunlun station. Shallow radar detection, firn core drilling and stake measurement were also carried out during 2013-14, to investigate the snow accumulation history of the transect. Besides, the surface mass balance and basal melting/freezing of the Amery Ice Shelf were studied based on remote sensing and simulation.

One thing worth notification is that Taishan Station has been constructed in Jan. 2014. This station probably provides important logistical support for fieldwork in central Antarctica.

- Dome A deep drilling

CHINARE has finished their primary work for deep core drilling, including surface topography, ice sheet structure, meteorology, surface mass balance, ice velocity, etc. They started the drilling work at Jan. 2013 and has obtained ~300 m ice core till Feb. 2014. The short filed season is still the main restricting factor.

- Atmospheric researches at Zhongshan Station

CHINARE set up an atmospheric composition monitoring system at Zhongshan Station during IPY years. However, some instruments failed in long-term monitoring and only few parameters re running well (greenhouse gases, surface ozone, total ozone, black carbon). The new system is expected to be finished in three years.

- International cooperation (RICE)

Chinese scientist participated “Roosevelt Island Climate Evolution” (RICE) project

and have recovered a 764 m deep ice core at Ross Ice Shelf. The aim of the project is to improve our understanding of the stability of Ice Shelf in west Antarctica.

Arctic

- Surface mass balance of Arctic glaciers

In Arctic area, China has been monitoring the movement of the front edge of Austre Lovenbreen glacier and Pedersenbreen glacier since 2005/06. The ice sheet thickness and basal structure were investigated in 2010. Based on these data, the surface mass balance has been estimated recently.

- Arctic Sea Ice

Chinese efforts on Arctic sea ice are mainly focus on sea ice reduction and its influences on mid-latitudes. They found that the albedo reduction due to black carbon deposition contributed a lot to sea ice reduction, especially in Russian Arctic. The autumn-winter arctic sea ice are responsible for the winter Siberian High and surface air temperature anomalies over the mid-high latitudes of Eurasia and East Asia.

- Atmospheric composition monitoring

With support of Xuelong Icebreaker, China measured the real-time atmospheric compositions along Shanghai to Arctic Ocean route in 2012 and 2014. These data provides basic evidences of artificial pollution.

- International cooperation of NEEM project

Chinese scientist participated “the North Greenland Eemian Ice Drilling” (NEEM) project, which aimed at retrieving an ice core reaching back to Eemian period from Greenland. This project lasted from 2007 to 2011 and succeeded in its intention.

3.9 Cryospheric Archives Division (by Kang Shichang, Jin Huijun)

For a comprehensive understanding of environment related issues on cryosphere of China during the past 5 years, it aims to investigate the climatic and environmental changes and their relationships with atmospheric circulation, to attract the relevant research groups to focus on a theme of key processes of rapid changing cryosphere. Ice cores and snowpits sampled from western China, including East Rongbuk glacier (Mt. Everest, Himalayas), Guoqu glacier (Mt. Geladaindong in the central Tibetan Plateau (TP)), Laohugou glacier No.12 (Qilian Mts.), Muztagata glacier (East Pamir), Miaoergou glacier (Eastern TianShan Mts.), were analyzed to reconstruct variabilities of dust, black carbon, heavy metals (e.g., Pb and Hg), and microorganism. Tree rings were collected from Qilian Mts., Qaidam Basin, Tienshan Mts., western Sichuan Plateau and southeast Tibet, to retrieve the chronologies of temperature, drought index and cloud cover during past hundreds of years to thousand years. Major achivements are as follows:

- Spatiotemporal pattern of climate change over the TP and its surroundings during past 1000 years: Comprehensive reconstruction of temperature by 15 high resolution paleoclimate series reflecting the climatic evolution during past 1000 years over the TP indicate that, generally, the TP has been characterized by a prominent Medieval Warm Period (MWP, the period before ~1450s), a moderate Little Ice Age (LIA, from ~1450s to 1870s), and the increase of temperature since then (the dramatic drop of temperature around 1920s and 1970s were evidently). The warmth of MWP over the TP shows agreement with that during the first half of 20^{th} century, and that in other reconstructions of temperature over the Northern Hemisphere. LIA over the TP is relatively warmer than that that over the eastern China. This study plays a vital role in the prediction of cryosphere change in such region.
- Normalized tree-ring $\delta^{18}O$ time series in western China: Normalized tree-ring $\delta^{18}O$ time series show high signal coherence at both low and high frequencies, indicating climate change since 1860 causing a shift in the hydroclimatic regime

and in the influence of regional atmospheric circulation. Climate conditions were cold and cloudy before 1860, but thereafter became sunnier and warmer. The cloud cover over the southeastern TP was modulated more strongly by sea surface temperatures in the Indian Ocean than over the Pacific Ocean, suggesting low-frequency responses to anomalous ocean warming. Comparisons among different proxies highlighted that a tree-ring $\delta^{18}O$ network has great potential to reveal common low-frequency climatic signals in monsoon Asia over long time scales.

- Environmental implications for dust in snow and ice cores: Dust in ice cores/snow is an excellent proxy for atmospheric dust and can reveal long-term dust history. Based on dust records in snow and ice cores from glaciers in the western China, the quantitative assessment of dust flux accords with the aerosol optical depth, suggesting the general dust transport route is from the northwest to southeast over the TP. Rare earth element (REE) and isotopic composition of Sr and Nd indicate that dust in snow mainly comes from mid- to long-range source areas (namely Asian deserts), demonstrating a weak event-based discrepancy but a strong concentration-independent uniformity in composition in the long-term. Dust records since 1500 AD from an East Rongbuk ice core, exhibits a positive relationship with reconstructed air temperature, showing a likely cold-humid and warm-dry climatic pattern in the dust source regions (namely central Asia). This is associated with the variability in the strength of the westerlies and its corresponding precipitation.

- Changing in heavy metal (Pb and Hg) pollution recorded in the ice cores: Cryosphere of China are profoundly affected by the anthropogenic activities. Pb isotopic compositions in snowpits from glaciers indicate that anthropogenic Pb average contribution is in a range of 10%−58.3%. It seems that anthropogenic Pb to the Tienshan Mts. and boundary area of the TP accounts for a larger contributions, which is mainly affected by the elevation of sampling site and distance from the pollutant source regions. Total Hg concentration in glacier snow

ranges from <1 to 43.6 ng/L, and exhibits clear seasonal variations with lower values in summer than in winter. Spatially, higher Hg concentrations are typically observed in glacier snows from the northern region where atmospheric particulate loading is comparably high. Glacier snowpit Hg is largely dependent on particulate matters and is associated with particulate Hg, which is less prone to postdepositional changes, thus providing a valuable record of atmospheric Hg deposition. Reconstructed Hg records from Mt. Geladaindong ice core over the past 200 years matches the atmospheric Hg depositional chronology established from Nam Co Lake as well as the history of regional and global Hg production, showing a steady concentration increase from the 1850s AD. Especially since 1950s AD, the dramatic increase of Hg of Geladaindong ice core is consistent with the other heavy metals records of Miaoergou ice cores. Such recent increases are likely to be attributed to enhanced anthropogenic emissions due to human activities in Eurasia, suggesting a significant influence of anthropogenic activities in Asia on the TP environment.

- Reconstructed the variation of culturable bacteria in East Rongbuk ice core: Ice core samples from a 22.27 m East Rongbuk ice core was incubation in two incubation ways: plate melt water directly and enrichment melt water prior plate, respectively. The abundance of cultivable bacteria ranges from 0-295 CFU mL^{-1} to 0-1720 CFU mL^{-1} in two incubations with a total of 1385 isolates obtained. Comparing to direct cultivation, enrichment cultivation recovered more bacteria. Pigment-producing bacteria accounts for an average of 84.9% of total isolates. Such high percentage suggests that pigment production may be an adaptive physiological feature for the bacteria in ice core to cope with strong ultraviolet radiation on the glacier. The abundances of cultivable bacteria and pigment-producing isolates vary synchronously along depth: higher abundance in the middle and lower at the top and bottom. It indicates that the middle part of the ice core is hospitable for the microbial survival. Based on the physiological properties of the colonies, eighty-nine isolates are selected for phylogenetic

analysis. Obtained 16S rRNA gene sequences fall into four groups: Firmicutes, Alpha-Proteobacteria, Gamma-Proteobacteria, and Actinobacteria, with the Firmicutes being dominant. Microbial compositions derived from direct and enrichment cultivations are not overlapped.

3.10 Cryosphere and Quaternary Division (by Zhou Shangzhe, Lai Zhongping)

Study on Quaternary glaciation and environment is essential aspect of Cryospheric Sciences. In the last several years, some progresses have been made in this field.

In western China (west to 105 ℃E), especially in the Qinghai-Xizang plateau and the bordering mountains, more and more dating samples have been determined by cosmogenic radionuclides (CRN), optically stimulated luminescence (OSL) and electron spin resonance (ESR) dating techniques. The new dates that have been obtained in the past five years (2010-2014) and the dates that have published before indicate that four major Pleistocene glaciations have been happened in western China. They are Kunlun Glaciation (MIS 18-16), Zhonglianggan Glaciation (MIS12), Guxiang Glaciation (MIS 6) and Dali Glaciation (MIS 4-2). The glaciations were confirmed to be associated with climatic changes and tectonics of Qinghai-Xizang Plateau. The related major tectonics are Kunlun-Huanghe tectonic uplift that led Kunlun Glaciation, and Gonghe tectonic uplift that led the Dali glaciation on the eastern margin of the Qinghai-Xizang Plateau. In addition, sub-stage glaciations, such as MIS 10-8, MIS 5b and MIS 5d have been discovered in some study areas. In some monsoon or westerly influenced regions, the combination of precipitation and temperature cause local glacial advance, such as mid-MIS3 glacial advance has been confirmed.

In 2011, an improved comparative schema between Quaternary glaciations in China and MIS has been improved on the basis of the available data. The improved comparative schema includes 15 special stages and sub-stages during the last 1 million years. However, with more and more samples been determined, the comparative schema will be improved again.

3.11 Planetary Cryosphere Division (by Tian Feng)

In our solar system, cryosphere exist on Mercury, the Earth, Mars, Pluto, all moons except Io, asteroids, Kuper Belt Objects (KBOs), and Oort Cloud objects. The distribution and physical properties of water ice on these astronomical bodies are important not only for understanding the evolution history of the solar system, but also for future exploration efforts. Studies of the cryospheres and potential underground water bodies on Mars, Europa, Ganymede, Enceladus, and Titan have important astrobiological implications. The distributions of ice can influence the habitability of exoplanets and also provide useful methods for their detection in the near future. Finally comparative studies with the cryosphere on modern Earth and during the Earth's geological history (e.g. Snowball Earth) are important aspects of planetary cryosphere research.

In the past a few years, members of the planetary cryospheres committee have focused on the following research areas:

- The extent and evolution of glaciers on early Mars, early Earth, and exoplanets;
- Observations related to the presence of water on Vista, Ceres, ISON comets, and main belt comets;
- South pole plumes and subsurface ocean on Enceladus and their influences on icy particles in Saturn's E rings;
- Distributions of water ice in polar regions of the Moon and detection method.