Foreword for IJB Special Issue on Asian Biometeorology

Spring news from the eastern hemisphere: recent advances of biometeorology in Asia

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Received: 12 April 2019 / Revised: 15 April 2019 / Accepted: 15 April 2019 / Published online: 30 April 2019
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Since its very beginning as a field of science in the 1950s, biometeorology has been regarded as an interdisciplinary study between the biological and meteorological sciences (Lieth 1981). It is a young science; however, it is something very special and proliferative. Known by definition, biometeorology is increasingly recognized for its significance in providing the science of relevance to society and well-being of the environment (Burton et al. 2009) and is one of the closest sciences to humans, other animals, and plants. For this reason, the discipline will continue serving the development of novel conceptual schemes within its scientific scope, developing its new application fields for solving more critical and a wider range of socioeconomic problems, and in the meantime, helping to put forward essential courses of actions to transfer advanced technology for biometeorological applications (Haufe 1976).

Recent progress for biometeorology in the world and in Asia

In recent years, biometeorology has made considerable progresses in all its six commonly classified concerns, e. g., plant, zoological, human, cosmic, space, and palaeobiometeorology (Tout 1987), and so it is with all the commission groups divided by the main research themes for different kinds of research

scientists, namely animal biometeorology, climate and human health, climate, tourism and recreation, phenology, and the students and new professionals group, and so on. For example, the International Society of Biometeorology (ISB) and its journal, International Journal of Biometeorology (IJB) have studied deeply the climate change features for the past few decades of almost all over the world, especially focusing on several key regions, and its impacts on the living organisms. We have made a substantial and precious contribution to climate change science, particularly to the Intergovernmental Panel on Climate Change and its authoritative Assessment Reports (ARs) (Beggs 2014). Besides, the drivers for biometeorological phenomenon changes and their complexity on humans, animals, and plants are also discussed thoroughly, which is valuable for proposing strategies of adaptation to future climate changes (Ebi et al. 2009). As far as field of tourism climatology in the scope of human biometeorology is concerned, people have applied related knowledge on identifying the tourism climate resources, rating these resources, as well as provision of weather and climate information for tourism, and eventually putting forward human's adaptation behavior and corresponding technical and business management methods (Scott et al. 2009; de Freitas 2017). Since this is a science with remarkable application characteristics and is closely related to human life, its developments in human meteorology, especially under background of climate change, are even more enormous and are studied more sufficiently, for example, the study of urban meteorology (Nastos et al. 2015), human thermal comfort assessment, and ultraviolet radiation (UVR) studies (McGregor 2012). Particularly worth mentioning is the proposition of its own theoretical system for ISB on “universal” thermal climate index (UTCI) and the development of tools for UTCI calculation (Jendritzky and Höppe 2017; Bröde et al. 2012), which proved the fact that after the first few decades' development, the focuses of ISB moved from studies on the impact of climatic and meteorological conditions on living organisms (Lieth 1981) to a more environment-related and multidisciplinary fields (Keatley 2017).

In Asia, people embrace biometeorological studies with even more enthusiasm. Many countries have set up

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organizations with close relations to ISB. The Japanese Society of Biometeorology set a very good example for other countries. Not only did they keep up with the pace of world studies in certain fields of biometeorology but they also reviewed the development of the ISB since the foundation of the society and reported on society journals regularly (Kita 1975; Yoshimura 1965; Nagai et al. 2016). In China, similarly, we set up the China Ecological Meteorology Working Committee last year, and it will be of great help to related studies. Besides, in line with advances in the world in the above fields, the progresses in Asia areas have distinctive regional features as the following. First, this discipline in Asia has developed more rapidly in recent years compared to that in the western countries, in light of the number of publications that appeared in nearly a recent 20 years. We searched on “Web of Science” with keywords “biometeorology” and restricted research address and study areas to Asia from 2000 to 2017, and found that the publication in this field increased from 267 in 2000 to 3894 in 2017, which increased for more than tenfold over the study period (Fig. 1 (left)). Second, the fate of different themes for biometeorology changed variously. Under the scope of ecology in environmental science branches, publication numbers have kept relatively stable. But as far as objects relating to geography, zoology, and marine freshwater biology are concerned, a very clear increasing trend can be seen, which may mean that with the development of the subject, people probed into deeper problems and most of them are either related to the geographical distribution of the studied objects or related to some urgent issues, such as wildlife protection and freshwater management. However, the number of publications on agriculture and pure plant science has dropped sharply in recent years and are worthy of attention (Fig. 1 (right)). Third, because this is one of the most densely populated regions in the world, human biometeorology is a field with great concern. For instance, many papers in recent years discussed seasonality of mortality, its relationship with temperatures, and other

meteorological factors in east and south Asia (Motohashi et al. 1996; Tan et al. 2007; Yang et al. 2019; Yi and Chan 2015), and some of them are published on very high-ranking journals (Xu et al. 2016; Yang et al. 2018). Fourth, phenological observations in China and other areas of Asia have a long tradition and people in the past laid a very solid foundation in the field, making it one of the most active areas in biometeorology, and some of them fill a spatial gap that did exist in the pheno-trend studies of the Northern Hemisphere using data of ground observations (Ge et al. 2015; Dai et al. 2014). Finally, the spatial distributions of these publications were very unbalanced, with a majority of them were from East Asia, including China, Japan, and Korea, and then South and Southeast Asia, mainly from India and Thailand. However, very small parts were from Central and West Asia, which accounted for 0.69 and 0.73% of these publications, respectively (Fig. 2).

Original source of biometeorology in China and related events

The Chinese people have a long history of paying attention to biometeorological phenomena. Climate scientists in China have systematically collected and compiled historical records concerning weather, climatic and atmospheric conditions, as well as information related to insect damages, famine, and disease relieves and so forth, from the twenty-third century BC to current time, which amounted to a period of more than 3000 years (Zhang 2013). Chinese people conducted the first phenological records in the Spring and Autumn Period (770–476 BC), traced back to the time of the Book of Songs (Zhu et al. 2017a). In the Western Han Dynasty (206 B.C.–A.D. 24), Chinese people finished inventing a systematic solar calendar including all the 24 solar terms, exactly the same as the current time, which is still helpful for forestry and agricultural management of today in some areas of China. Many of the solar terms were named deliberately by a phenophase name,

Fig. 1 The fast increase of total number of papers on biometeorology (left) and the percentage changes for different themes in Asia area in recent years (right)

Fig. 2 Regional distributions of lead authors in the field biometeorology in Asia areas. Among them, publications from West Asia were mainly from Saudi Arabia and Iran; South Asia from India; Central Asia from Uzbekistan and Kazakhstan; while Southeast Asia from Thailand

disclosing the relationship with certain phenological events, such as the Grain Full, appeared around May 21, which means grains in the field are getting plump but not ripe yet. It is worth noting that on November 30, 2016, China's 24 solar terms were included in UNESCO's Representative List of the Intangible Cultural Heritage of Humanity (Fig. 3). Let us move forward to more recent times, in 1995, the International Symposium on Environment and Biometeorology was held in Beijing by the support of ISB, and a total of 129 papers were accepted for presentation and also, a special issue by the Journal of Agricultural and Forest Meteorology was launched after the symposium (Leclerc 1997). The symposium and the post-conference special issue have greatly promoted the development of biometeorology in China. Chinese scientists are very active in participating in scientific events of ISB, many people

have attended all the ISB congresses after the 1980s, and reported each of the congresses on very authoritative scientific journals in Chinese (Zheng 1988; Han 1994; Dai et al. 2006). This special issue embodies the collaboration of ISB with China for the second time, and we hope it will facilitate further advances of biometeorology in China.

Contents and highlights in this special issue

The background of this special issue dates back to August 2016, when the International Geographic Union (IGU) held the 33rd International Geographical Congress (IGC) in Beijing, the current president of ISB, Prof. Pablo Fdez-Arroyabe and the former Asian Executive Board Member of

Fig. 3 Illustration of Spring Equinox (left) and Start of Autumn (right) in 24 solar terms, which happens around March 21st and August 8th, respectively. They were representatives of the poster oil paintings from China to apply for being inscribed on the Representative List of the Intangible Cultural Heritage of Humanity of the United Nations Educational, Scientific, and Cultural Organization (UNESCO). They are painted by famous oil painter Mr. Dihuan Lin, who generously granted our request to use these paintings in this article

ISB, Prof. Junhu Dai jointly applied for a session relating to biometeorology. It was approved very smoothly and then both of us co-chaired the session named Global Change and Biometeorology, which was proved to be a great success later, and this was also the 1st ISB Regional Meeting for Asian biometeorologists. Approximately over 40 people attended the session and about 20 people made oral and poster presentations. All the presentations were so wonderful and it seemed there was no reason to waste them and we felt it was better to share among biometeorologists these works, and this is also the reason for the opening of this IJB special issue on Asian Biometeorology, with the strong support by the Editor-in-chief of the journal, Prof. Scott C. Sheridan. We hope through this issue, we can spread the most recent advances in this field from Asian areas to all over the world. When the application of the special issue was approved, we invited 19 reports from the conference and finally, 13 papers were left after very strict reviewing processes.

All the papers included in this issue can be classified into six categories covering research domains of phenology, bioclimatic conditions, vegetation cover dynamics of degraded temperate steppe, climatic implication of tree-ring cellulose oxygen isotopes on Tibetan Plateau, aerobiological meteorology, and application of bio-energy for climate change mitigations. This primarily represents the dominant research fields of Asian biometeorology and its most recent advances. The authors are mainly from east and middle Asia, the former covers China and Korea, and the latter includes researchers from Kazakhstan.

Phenology

There are six papers on phenology partly because of the Asian guest-editor of this issue working in this field, also for the reason we referred to above that there were good foundations in Asia for phenological observations and studies. Among them were two papers from China Phenological Observation Network (CPON); compared to their previous jobs, Dai et al. (2017) discussed further the changes of temperature sensitivity (S_T) of spring leaf phenology and the major influencing factors through one of the most continuous phenological data series observed in Mudanjiang, Northeast China. It was put forward by them that the standard deviation (SD) of pre-season temperature exerted a significant impact on S_T . In another paper, Wang et al. (2017) studied the divergent flowering duration changes in spring in several cities in north China by using long-term observation data, and they also reminded people that the simulation of a single phenophase or two phenophases is different from the simulation of a period between two phenophases, but the reason needs to be further discussed. Unlike these two papers based on ground-observation data, Zhu et al. (2017a) used remotely sensed data and predicted the changes of spring phenology under future

climatic scenarios and concluded that future climate warming will continue to cause earlier occurrence of spring onset in general, but might increase plant damage risk in natural and agricultural systems in the warm temperate and subtropical China. The further two phenological papers were for studies of subtropical evergreen broad-leaved forest phenological changes, which posed great challenges for people in the past few decades (Morellato et al. 2013), from Prof. Jianchu Xu's group. Zhai et al. (2017) brought a fresh viewpoint telling minimum temperature in December was found to be the critical factor for the leaf phenology development of rubber trees, and Liyanage et al. (2018) investigated wintering and flowering patterns of five rubber clones in Xishuangbanna, southwest China, based on observations made from 1978 to 2011, and found the number of hours of sunshine during both the rainy season and the cold dry period in the dry season were important determinants of phenological changes in the rubber trees; besides, higher temperatures tended to delay the onset of defoliation and refoliation and were the triggering factors for the onset of flowering. Their conclusions further improved our understanding of the phenological changes of subtropical plants and helped the development of predictive models that could be applied to early warning systems of rubber powdery mildew disease. Finally, a young and talented ecologist, Jeong et al. (2018) reported their new findings for the impacts of urbanization on spring and autumn phenology by addressing the relationship between population density and phenology at nine stations in the Seoul Capital Area (SCA), South Korea, during 1991–2010, and concluded that the density of the urban population shows significant negative (positive) relationships with spring (autumn) phenology. This brings important implications for the selection of influencing factors in future ecosystem assessments.

Bioclimatic conditions

We included three papers discussing the characteristics of bioclimatic conditions and their changes in different areas in this special issue relating to China and central Asia. Zhu et al. (2017b) studied spatiotemporal variations of the start of the thermal growing season on the Qinghai-Tibetan Plateau from 1961 to 2014 and found that with the decrease of temperature thresholds, the effect of elevation became weaker, while the effect of latitude became stronger. Similarly, Yin et al. (2017) studied trends for the thermal growing degree-days (GDD) and growing season length (GSL) based on different temperature thresholds almost in the same study period but all over mainland China. It is worth noting that both studies found similar increasing and accelerated trends during the past half century on the Tibetan Plateau and in other parts of China. It was shown by Nyssanbayeva et al. (2018) that in Western Kazakhstan, the wind chill equivalent temperature (WCET) is significantly lower than the ambient temperature, but global

change may affect the situation. These conclusions lay a solid foundation for better understanding of further ecological process and human adaptation to climate change in the future and deserve close attention.

Vegetation cover dynamics of degraded temperate steppe

Based on continuous photography and image processing technology, Prof. Liu's group from Peking University, China, reported their research progress in Inner Mongolia grassland, and highlighted that the grassland phenology had mainly been influenced by plant species compositions, with the start and end of growing season being strongly related to the relative cover of climax species and grasses (Xu et al. 2017a). It is helpful to evaluate the grassland degradation in semiarid regions in future work.

Climatic implication of tree-ring cellulose oxygen isotopes on Tibetan plateau

Xu et al. (2017b) presented a detailed study in the southeastern Tibetan Plateau to investigate the influence the tree-ring cellulose oxygen isotope from environment factors. They highlighted that the trees had homogenous oxygen isotope ratios ($\delta^{18}\text{O}$) and variability along altitudinal gradients, and thus asserted that the $\delta^{18}\text{O}$ variability of different species are of high coherence, as they are mainly determined by the atmospheric relative humidity in July–August. This provides a new clue for climate reconstruction on the Tibetan Plateau.

Other topics in this issue

Biometeorological advances in the field of aerobiology and cassava-based fuel ethanol for carbon sequestration potentials were also presented in this issue. It is well known that pollen is a remarkable risk factor for nasal allergies, but there are a lot of uncertainties in the development of respiratory allergy (Cecchi et al. 2018). Here, Qin et al. (2017) introduced an empirical study for the transport pathway and source area for *Artemisia* pollen in Beijing, China, by applying numerical methods, and is of great significance for future allergic pollen forecast. The last paper of this issue estimated the potential of energy saving and carbon sequestration of cassava-based fuel ethanol and the results are very helpful for the government decision-making and for mitigation of climate change.

It was strengthened that the significance of biometeorology, the Border Science of biology and meteorology, is for the future of mankind (Krasnow and Plasterk 1984). We will make new contributions to the discipline and benefit the human well-being through new findings and discoveries in our research, and we hope that the special issue spreads major achievements from Asian biometeorological circle to the rest

of the world. We have so many phenological papers incorporated in this issue, and we introduced the Chinese 24 solar terms that rooted deeply in Chinese traditional culture in ancient times. Although it is the end of the flowering time for fructus *forsythiae* (*Forsythia suspensa*) and flowering peach (*Amygdalus persica* L. var. *persica* f. *duplex* Rehd.) in Beijing, China, the news of spring is still in the air. So, we would like to compare the scientific knowledge inside this issue to spring news, and it is from the Eastern Hemisphere. We hope this is just a beginning of cooperation with ISB in the new era, and we anticipate more fruitful harvests in the future.

Acknowledgments This work was supported by the National Key R & D Program of China, namely “The mechanism and future trend for responses of vegetation phenology to global change in China” (No. 2018YFA0606102) and a NSFC project (No. 41771056) on grassland phenological studies for temperate steppes in Inner Mongolia. We were encouraged greatly by their approvals during the compilation of the special issue. We thank all the participants of the session co-sponsored by the 33rd IGC and the 1st Asian Biometeorological Regional Symposium, Global Change and Biometeorology, and all the authors who contributed to this special issue, as they worked so hard to ensure these papers maintain high quality, and a few of them were accepted after five times of revision. We are also grateful to all the anonymous reviewers for their precious comments and suggestions.

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