Appendix

This file collects the presentation abstracts of the following two workshops (revised from May 7 through June 27):

A. **Off-line Workshop, Climate Change Risk and Adaptation (**sponsored by China National Key Research and Development Program, "global governance of climate change risks and domestic response", Grant: 2018YFC1509003)**, April 28, 2021, at Beijing Normal University, 12 potential papers.**
B. **On-line Workshop, Global Change and Natural-Social Processes (**sponsored by China National Key Research and Development Program "Assessments of regional meteorological disasters under different climate scenarios", Grant: 2019YFA0606904)**. May 7, 2021, at Tengcent Meeting ID 360 686 785, 17 potential papers.**

Collection of Abstracts

A1. Integrated assessment of meteorological hazards over Qinghai-Tibet Plateau in recent 20 years

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Abstract: Meteorological hazards refer to extreme weather and climate events that can pose a threat to human beings and their living environment. In recent decades, the Qinghai-Tibet Plateau (QTP) experienced drastic climate change, and the socioeconomic exposure performs a rising trend at the same time. Due to the backward disaster prevention and reduction capacity of QTP, the rapid environmental change will undoubtedly increase the frequency of meteorological hazards in this region, threats to personal safety and property security. In this article, four major meteorological hazards of QTP, including drought, rainstorm, snowstorm and hailstorm are selected to establish an integrated index system. Through the analysis of selected indices, the spatiotemporal evolution of major meteorological hazards of QTP is revealed. Assessment results indicate that the high-risk area of drought and rainstorm is located in the south part of the Gangdise Mountain, south Tibet Valley, east part of the Nyenchen Tanglha Mountain, Hengduan Mountain, and the north part of the Western Sichuan Plateau. The high-risk area of snowstorms is located in the Himalayas, the Balyanlkalla Mountain, and the central part of the Nyenchen Tanglha Mountain. The high-risk area of hailstorm is located in the central part of QTP, including Naqu, Hercynian, and the west part of Yushu County. In recent 20 years, the high-risk area of rainstorms and meteorological droughts in QTP has expanded rapidly, especially in Xining and Lhasa, two densely populated cities and their adjacent areas. The risk of meteorological drought in the southern Tibetan Valley and the Hengduan Mountain region, which are the grain producing areas of QTP, is also increasing. The assessments suggest that the meteorological monitoring, disaster early

warning, reduction and prevention capabilities should be further strengthened in these key regions of QTP.

A2. An assessment on the GPP simulation of the ESMs participating CIMP6 under the historical scenario

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Abstract: Gross primary production (GPP) is an important indicator that measures the carbon uptake by vegetation through photosynthesis. How the latest Earth system models (ESMs) in CIMP6 simulate GPP is critical for climate change evaluation and ecosystem security. In this study, seven ESMs from America, Europe, and China are evaluated for their capability in reproducing GPP under the historical scenario. It is found that BCC-CSM2-MR and MPI-ESM1-2-HR give the best estimation of climatological GPP at regional to national scales. In characterizing the spatial structure, MPI-ESM1-2-HR performs much better than others, but it performs badly in the temperate continental. CMCC-CM2-SR5 performs the best in the temperate monsoonal. No ESM can capture the GPP variation during the period 1980 to 2013 over any climate zone. BCC-CSM2-MR may be the most capable ESM as it provides the most positively and significantly correlated GPP grids with observation. Further analyses reveal that BCC-CSM2-MR and CMCC-CM2-SR5 can effectively capture the response of ecosystem to climate over regions other than the Tibetan Plateau. The estimated sensitivities of climate factors are within the confidence interval of the observational results. When applying the regressed function with observational climates, the two ESMs can basically rebuild the GPP series with similar explained variances as the observational. Over the Tibetan Plateau, all ESMs project too large spurious precipitation, which turns precipitation from the most confining into no longer significantly influencing. It highlights the urgency to improve the modeling of the plateau climate and the corresponding vegetation dynamics over the Tibetan Plateau.

A3. How to address climate change risks in national territory development plan in China?

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Abstract: China is one of the countries posing the highest climate risk in the world. The meteorological hazards in China are of various types and high frequency, and their seasonal and regional patterns have been changing in recent decades, leading to more extensive and

serious impacts. As global climate change continues to intensify, climate risks pose a certain threat to urban safety, infrastructure stability, and socioeconomic sustainability. Therefore, it is crucial that the strategic goals of climate change adaptation should be incorporated into the guidelines, technical standard, implementation and supervision system of the national territory development plan, so as to achieve better policies and measures to improve capability of climate governance. In the guidelines, the risk sources, priority field and key measures of different administrative units should be clarified, and a quantifiable index system should be developed. The technical standards are the basis for the approval and inspection of the development plan, which should be carefully designed and demonstrated in accordance with the guidelines. In the implementation phase, climate risk assessment should be taken as the scientific basis and constraint conditions for the demarcation of urban development boundaries, as well as permanent farmland and ecological protection red lines, in order to strengthen territory regulation. In the supervision system, climate change adaptation should be included in the Territorial Planning Law that is being drafted, so as to improve the resilience and sustainability of the territorial pattern and to ensure the realization of the climate governance goals.

A4. Locomotion of slope geohazards responding to climate change in the Qinghai-Tibetan Plateau and its adjacent regions.

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Abstract: Slope geohazards, which cause significant social, economic and environmental losses, have been increasing worldwide over the last few decades. Climate change has induced higher temperature and shifted the precipitation pattern, enhancing slope geohazard risks. This study traced the spatial transference of the slope geohazards in the Qinghai-Tibet Plateau (QTP) and investigated the potential climatic factors. The results show that 93% of slope geohazards occurred in seasonally frozen regions, and 2.6% of which are located in permafrost regions and with an average altitude of 3818 m. The slope geohazards are mainly concentrated at 1493–1988 m. Along with the time, the altitude of the slope geohazards is gradually increasing, and the

mean altitude tends to spread from 1984 m to 2562 m by 2009, while the slope gradient varies only slightly. The number of slope geohazards increased with time and it was most obvious in spring, especially in the areas above 3000 m altitude. The increase in temperature and precipitation in spring may be an important reason for this phenomenon, because the results suggested that the air warming rate and precipitation growth rate in geohazards sites increased gradually.

Based on the observation of the spatial location, altitude and temperature growth rate of slope geohazards, it is noted that new geohazard clusters (NGCs) appear in the study area, and there is still a possibility of migration under the future climate conditions. Based on future climate forecast data, we estimate that the low, moderate and high sensitive area of the QTP is mainly south of 30°N in 2030, and extends to the south of 33°N in 2060, and continues to expand to the south of 35°N in 2099, and the proportion of high sensitive areas increases from 10.93% in 2030 to 14.17% in 2060 and 17.48% in 2099.

A5. Rainstorm Resilience Assessment to Coastal Urban Areas in China

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Abstract: In recent years, extreme weather events have challenged the prosperity and safety of Chinese developed regions, especially heavy rains and floods caused by climate change are emerging climatic risks in the southeast urban regions. This article selected cities in the Yangtze River Delta and the Pearl River Delta as examples, at first, to develop a framework to measure urban resilience from two perspectives: genetic resilience and specific resilience; secondly, to classify these case cities as four categories whilst comparing the urban resilience and rainstorm hazard of each city. This article aims to facilitate the forward-looking urban planning with the definition and classification for urban rainstorm resilience.

A6. Climate Change Risk Assessment and Prediction of Three Major Urban Agglomerations in Eastern China

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Abstract: With the acceleration of urbanization, the population and industries are concentrated in the eastern coastal areas of China, and three national first-class urban agglomerations have been formed in the Beijing–Tianjin–Hebei region, the Yangtze River Delta and the Pearl River Delta. The main purpose of this paper is to study the climate risks associated with rapid urbanization in the global context of climate change. Based on the historical (1981–2019) economic data and meteorological data, this paper analyzes the spatio-temporal variation characteristics of the history. Meanwhile, based on the future economic data predicted by the grey model (2020–2050), the vulnerability degree of urban agglomeration is constructed. Based on the BCC-CSM2-MR dataset SSP1-2.6, SSP2-4.5 and SSP5-8.5, the change trends of climate factors, such as air temperature, precipitation and other climatic factors in the three major urban agglomerations in China in the future period (2020–2050), were estimated, and drought, heat wave, and flood under different emission scenarios were calculated. The vulnerability degree of urban agglomeration and the hazard of climate change were input into the climate change risk assessment model to evaluate the climate change risk of the three major urban agglomerations in eastern China in the future. The analysis results show that the Beijing–Tianjin–Hebei urban agglomeration shows good urban resilience among the three major urban agglomerations in the eastern coastal area of China. However, the climate change risk of the Yangtze River Delta urban agglomeration is different, and the regional coordination is not consistent. The overall risk is slightly higher than that of the Beijing–Tianjin–Hebei urban agglomeration. In addition, the risk of climate change in the Pearl River Delta urban agglomeration is relatively high overall. On the whole, the higher the emission intensity, the greater the risk of climate change in each urban agglomeration under different emission scenarios.

A7. Change of China's Carbon Emissions in International Trade under Tariff Adjustments

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Abstract: In order to adapt to climate change, China, as the country with the most carbon emissions in the world, is formulating a carbon emission reduction plan covering many aspects and proposes a goal of achieving carbon neutrality by 2060. With the globalization of trade, the carbon emissions produced locally in China are increasingly being consumed in other countries around the world. The policy on terms of trade between countries has a great impact. The level

of tariffs will cause changes in the trade of goods, which in turn will lead to changes of emissions in imports and exports. This article refers the trade conflicts between China and the United States, simulates the additional tariffs imposed by China and the United States, combines the results of the global trade analysis model and the input–output analysis method, and quantitatively analyzes the changes in China's import and export hidden emissions under the tariff changes. This article finds that after China and the United States imposed tariffs, although the trade between China and the United States has been greatly reduced, and the emissions involved in the trade between the two countries have been reduced, the emissions of China's exports to the world have increased. In addition, due to the impact of the import market, China's emissions from imports from all over the world have been significantly reduced, which has led to China's net exports of carbon emissions after the tariff increase, and they are concentrated in energy-intensive industries. From the results, China still exports a large amount of emissions to the world despite trade restrictions. Promoting the progress of the new energy industry through trade may better solve the problem of carbon emission reduction.

A8. Routing optimization of post-earthquake rescue based on scenario simulation training in road scarcity area

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Abstract: The Tibet Autonomous Region, which is located in the southwestern border of China, seismic activity is very strong and frequent. In this high-altitude, high-earthquake-risk and low-road mountainous region, under the influence of the overall road network vulnerability, the destruction of roads after earthquakes will be an important factor limiting rapid rescue. This research aims to investigate the impact of damage on the performance of the road network in road scarcity areas and the routing optimization in emergency rescue. By simulating the earthquake and evaluating the road damage level and optimizing the rescue route in two stages, we compare the different rescue stages and the road demand differences of rescue vehicles, and then give the optimized emergency rescue plan via the combination of Dijkstra's algorithm and ant colony algorithm. Finally, a spatial effect model was constructed, and the road network robustness index Method (NRI) was used to analyze the road safety.

A9. Comparing Ecosystem Stabilities between Anthropogenic Disturbed and Intact area in the Qinghai-Tibet Plateau

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Abstract: Climate change and human activities on terrestrial ecosystems cause interference, in which human activity may cause regional land use change and directly change the structure and spatial distribution of the ecological system; these changes will directly or indirectly affect the ecosystem adaptability to external environmental changes, especially the ability to adapt to climate change. Here, we distinguished the intact area of the Qinghai-Tibet Plateau (QTP), which is one of the most sensitive regions to global climate change. We find the regions with a significant increasing trend of NDVI accounted for 42.21% of the total area of the QTP. From the perspective of different vegetation types, the growth rate of NDVI in the human-disturbed area was higher than that in the intact area. The recovery of the ecosystem in the disturbed area of the QTP is higher than that in the non-disturbed area. Alpine meadows are distributed at the junction of disturbed and intact areas. Human activities will have a greater impact on this type of ecosystem. The recovery of the alpine meadow ecosystem in disturbed areas is higher than that of the alpine grassland ecosystem, but it is just the opposite in intact areas. The resistance of the ecosystem in the intact area of QTP is higher than that in the disturbed area. The resistance of the shrub and coniferous forest was higher than that of grassland (alpine meadow and alpine grassland) and tropical rain forest in different vegetation types.

A10. Evaluation of the latest near-real-time precipitation gridded fusion product and its advantages in extreme precipitation research

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Abstract: The latest near-real-time precipitation gridded fusion product combines the different advantages of different sources of precipitation data and has been widely used in the fields of weather and climate monitoring, climate change research, model testing and hydrological forecasting. Based on the station data, radar data and a variety of satellite data in 2020, using both independent test and non-independent test evaluation methods, this paper evaluates the latest 0.01°/h near-real-time precipitation gridded fusion product, and preliminarily tests its

application in extreme precipitation cases. The results show that the multi-source high-resolution precipitation gridded fusion product based on "PDF (probability density function) + BMA (Bayesian model average) + oi (optimal interpolation)" and downscaling technology has a very good effect on the spatial-temporal distribution of precipitation and stability of product and effectively improves the accuracy of extreme precipitation identification in extreme precipitation research. This will provide a good database for future weather monitoring, weather forecasting, extreme precipitation and climate change research.

Keywords: multi-source gridded product; near-real-time precipitation fusion; independent test and non-independent test; extreme precipitation

A11. Analyze the potential of China's food security under the background of climate change

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Abstract: Food security is a major scientific issue facing all countries in the world. Under the impact of global climate change risks, how much and how to tap the potential of China's food production constitute a natural science and economics problem. This manuscript uses time series, technological progress, and production area methods to analyze and calculate 60 years of grain statistics in China. The research has determined the food production potential index. Using the Economic–Climate Model, we calculated China's food production potential and the food production potential index of different varieties in different regions. Based on the Economic–Climate Model initially, we estimated the food production potential of China in 2030 and 2060. The results can provide scientific support for ensuring food security.

Keywords: climate change; grain production; potential index; economic–climate model

A12. Impact of CMIP6 model resolution on Precipitation over China

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Abstract: Model resolution is reported to have an important impact on simulated extreme precipitation (Zhang and Chen, 2016; Kusunoki et al., 2015; Kong et al., 2020). Increased horizontal resolution allows the model to better simulate small-scale structure of synoptic and mesoscale systems of an area. Currently, the Coupled Model Intercomparison Project (CMIP) has advanced into its 6th phase (e.g., CMIP6). CMIP6 models have been updated in resolution, and parameterization, and involve more biogeochemical processes (Eyring et al., 2016). An important sub-program high-resolution model comparison program (HighResMIP) in CMIP6

aims to assess whether global and regional models can further improve the simulation capabilities of climate elements after increasing the resolution (Zhao et al., 2018; Zhou et al., 2019). The plan provides conditions for evaluating the simulation bias of climate models with different resolutions, reasons for the biases and their impacts (Wang et al., 2019). Few studies systematically explore the impact of higher resolution of HighResMIP models on simulating the climatological distribution and projecting future changes of mean and extreme precipitation over China. The motivation of this study is to investigate the role of model resolution in simulating the climatological distribution and projecting future changes of mean and extreme precipitation over China through comparing the high-resolution models that participated in CMIP6 HighResMIP and their low-resolution versions.

Keywords: CMIP6, model resolution, precipitation, China

B1. Risk Assessment and Impact Analysis of Flood Disaster in the Piedmont Plain of Taihang Mountain, North China

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Abstract: Flood disaster, especially the fluvial floods, has always been one of the most serious and devastating natural threats for human living and economic development worldwide. Nevertheless, few studies have assessed flood risk at the piedmont plain of Taihang Mountain, which has a large and steep topographic drop, claw-like river network, concentrated rainy season, and a vast economy and population leading to severe flooding and great loss. We attempt to build a flood risk assessment index system based on the hazard of the hydrological environment and the vulnerability of the economic society. A coupled AHP (Analytic Hierarchy Process) and expert scoring method are used to determine the weights of indices. In addition, risk maps with a resolution of 1 km^2 are made through geographic information system (GIS). Results show that flood risk is high in several major cities along the eastern foothills of the Taihang Mountains, including Baoding, Shijiazhuang, Xingtai, Handan, Anyang, Xinxiang and the Xiongan New Area. Large areas of prime farmland are also a high-risk region. It is not realistic to prevent the occurrence of extreme heavy rainfall during the rainy season.

However, if effective disaster management strategies based on risk assessment are adopted, the losses caused by floods can be avoided or reduced. More in-depth research on the flood disaster in this area should be taken in the future.

Keywords: Taihang Mountain; flood risk assessment; hydrological environment; AHP; GIS

B2. Changes in Extreme Climate Comfort in the Arctic and the Impact on Tourism

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Abstract: With global climate warming, whether the Arctic climate comfort is developing in the direction of tourism activities urgently needs to be understood, and it is also an important prerequisite for the development of Arctic tourism. Based on the universal thermal climate index (UTCI) data provided by the European Centre for Medium Range Weather Forecasting (ECMWF), we used the climate tendency rate and other statistical methods and analyzed the temporal and spatial characteristics of climate comfort changes in the Arctic region from 1979 to 2018 and explored the impact of comfort change on Arctic tourism. The results showed that: (1) With global warming, the Arctic temperature increased by 2.53°C from 1979 to 2018, in which northern Russia and the Svalbard archipelago increased by a large margin, up to about 4°C; (2) From 1979 to 2019, the UTCI of annual and each season showed a significant increase trend ($P<0.01$) and both turned to "comfort"; (3) During spring and autumn, the UTCI distribution is similar to the annual distribution, climate comfort was "cold" and "extreme cold". In summer, climate comfort was "comfort" and "cool". In winter, except for northern Europe (Finland, Sweden and Norway), climate comfort was "extreme cold"; (4) Climate warming changed the Arctic climate comfort. In summer, Arctic climate comfort from "cool" to "comfort", the area of "comfort" has increased by $15.85 \times 10^6 km^2$, mainly distributed in Alaska, Canada and northern Russia. In winter, Arctic climate comfort from "extreme cold" to "cold", the area of "extreme cold" has decreased by $1.15 \times 10^6 km^2$, distributed in central Russia and northern Canada. The improvement of climate comfort has a certain reference value for the optimization of Arctic tourism industry and the development of tourist destinations.

Keywords: arctic; UTCI; climate comfort; tourism

B3. Integrated Remote Sensing and Model Approach for Estimating the Carbon Budget of Global Forest Ecosystems under Future Climate Change

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Abstract: One of the main manifestations of global change is the climate warming effect on global terrestrial carbon cycles, and this effect has important guiding significance for the development of accurate understanding of the carbon cycle process and related policies. The carbon budget is used to express the net storage of carbon in large-scale ecosystems, and it is the difference between the net primary productivity of vegetation and the heterotrophic respiration of soil. On a global scale, the NEP can indicate the carbon dioxide exchange between the terrestrial ecosystem and atmospheric system. As the main component of terrestrial ecosystems, forests have important roles in the global carbon cycle and are valued globally for the services they provide to society, slowing the increase in the contents of CO_2 and other greenhouse gases in the atmosphere and maintaining the global climate. Therefore, with global climate change becoming increasingly significant, the NEP of forest ecosystems has also attracted attentions from the scientific and social communities. With developments in remote sensing, geographic information systems and computer technology, model simulation is being developed rapidly and has become an important and irreplaceable method in the research of forests' NEP with great prospects. In recent years, with the occurrence of global change, model simulators in China and overseas have conducted a large number of meaningful research on forests' NEP and their responses to global change and obtained useful conclusions. However, owing to the poor understanding of various processes in forest ecosystems and the limitations of some methods and technologies used on the global scale, these ecosystem carbon cycle models have many key problems in simulating the carbon cycle of global forest ecosystems, which still need to be solved in model structure, parameters, boundary field and initial field. Therefore, to understand the response mechanisms of the carbon budget of global forest ecosystems to future climate change, an improved FORest ecosystem Carbon budget model for CHiNa (FORCCHN) and future Representative Concentration Pathway (RCP) scenario RCP4.5 and RCP8.5 were applied in this study. The results demonstrated that the global forest ecosystems will play a major role in the carbon sink under the future two climate change scenarios. The average carbon budget (namely, the Net Ecosystem Productivity (NEP)) of global forest ecosystems under RCP4.5 scenario was estimated to be 0.017 $kg(C)\cdot m^{-2}\cdot yr^{-1}$ from 2006 to 2100. The future carbon sink areas of global forests will increase significantly. Under RCP4.5 and RCP8.5, the carbon sink areas of global forests during the period 2026–2100 would be significantly higher than those in 2006–2025, with increases of 83.16–87.26% and 23.53–29.70%, respectively. The impacts of future climate change on the NEP of global forests will significantly vary between different regions. The NEP of forests will be enhanced in the northern hemisphere and be significantly weakened in the southern hemisphere under the future two climate change scenarios. The carbon sink regions of global forests will be mainly distributed in the middle and high latitudes of the northern hemisphere. In particular, the forests' NEP in northeastern and central Asia, northern Europe and western North America will increase by 40%~80%. The NEP of forests will decrease by 20%~40% in most regions of the southern hemisphere. In the future, in some areas of southern hemisphere, where the forests' NEP was predicted to be reduced, some measures for improving forest carbon sink, such as strengthening forest tending, enforcing prohibiting deforestation laws and scientific forest management, and so on, should be implemented to ensure immediate mitigation and adaptation to climate change. Our findings can offer important information support for the realization of global sustainable development goals and provide a scientific basis for correctly evaluating the role of forests in ecological environment construction and global climate change research.

Keywords: global forest ecosystems; carbon budget; future climate change; response

B4. Changes in population and socioeconomic exposure due to precipitation extremes in China under the future warming climate

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Abstract: Precipitation extremes affect agricultural production, infrastructure, and socioeconomic well-being in China. The frequency and intensity of precipitation extremes have increased in the past several decades. They are likely to continue to increase in the future under the influence of human-induced climate change. Exposure refers to people, property, systems, or other elements present in hazard zones, thereby subject to potential losses. Exposure to precipitation extremes and changes therein are determined by climate changes and population and socioeconomic changes. Despite the profound implications of precipitation extremes, the population and socioeconomic exposure changes due to precipitation extremes under future scenarios in China are not well quantified. Here, we analyze output for three scenarios of population growth and socioeconomic growth to estimate future exposure change considering the climate and population and socioeconomic factors. The frequency and duration of extreme precipitation and the population and economic exposure were quantified for a base period (1971–2000) and future periods (2021–2050 and 2061–2090) based on CMIP6 models with three representative concentration pathways (RCPs) and three representative concentration pathways (RCPs) and projections of population and gross domestic product (GDP) in the shared socioeconomic pathways (SSPs). The extreme precipitation indices used in this study include annual day number totals from days with precipitation exceeding the 99th and 95th percentiles of wet-day rainfall in 1961–1990 (R99p and R95p) and two duration indices: CWD and CDD. CWD was the maximum number of consecutive days with daily precipitation amount >=1 mm, and CDD was the maximum number of consecutive days with daily precipitation amount < 1 mm. These extreme indices were developed and recommended by Expert Team on Climate Change Detection and Indices (ETCCDI) for both enhancing climate change detection studies and monitoring changes in extremes. These four indices trending in China are calculated by using inter-comparison Project phase 6 (CMIP6) model simulations. The calculation of population and economic exposure is the number of days with extreme precipitation multiplied by the number of people and amount of GDP exposed to that outcome in each grid. Thirty-year averages of annual days of extreme precipitation and population and GDP projections were used to calculate exposure in both the base and future periods to minimize inter-annual variations. We find that for the higher emission scenario (RCP8.5-SSP3), the Chinese population and socioeconomic exposure increases nearly 5-fold and 9-fold by 2100. The average population and socioeconomic exposure for Guangdong province are over 25 and 42 times greater than it has been historically, while the socioeconomic exposure for Northeast increases by only a factor of four. Notably, in the absence of climate change, exposure is reduced by 75–95% globally and across all geographic regions, as compared with exposure

under the high emission scenario. Under lower emission scenarios RCP2.6-SSP1, the population and GDP exposure is reduced by 45% and 62%, respectively, highlighting the efficacy of mitigation efforts in reducing exposure to extreme heat.

Keywords: extreme weather; RCPs; precipitation; socioeconomic exposure

B5. Defining forest biomes based on remote sensing and climate data

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Abstract: Forest biomes are commonly understood as broad-scale forest ecosystems that have common formation characteristics due to similar climate. Forest biomes are generally identified using vegetation or land-use types. However, vegetation classifications rarely consider the actual forest attributes within each type. Yet, forest biomes were identified using vegetation or land-use types in biome classifications, which focus more on the potential climatic vegetation, not necessarily reflecting the actual forest attributes. To address this in an objective way across different regions and to link forest attributes with their climate, we aimed to improve the forest biome distribution to be more realistic and useful for biodiversity preservation, forest management, ecological and forestry research. To define forest biomes considering both their forest characteristics and their climatic conditions, we combined high-resolution monthly vegetation and climate datasets to produce more accurate and close-to-reality forest biome cartography at a global level using an unsupervised cluster analysis method by merging climate variables with normalized difference vegetation index (NDVI) data. No forest regions were masked out to constrict our forest biome distributions. Descriptive names were given to the defined forest biomes based on annual temperature, precipitation, and NDVI values according to their forest attributes and climate condition in a self-explaining and intuitive way. Each forest biome had distinct climate and vegetation characteristics. Regions with similar NDVI values but with different climate characteristics, which would be merged with previous classifications, could be clearly distinguished. However, at macroscale, the resulting forest biomes are largely consistent with land-cover types or vegetation types defined in previous studies. We explored the climate conditions associated with each forest biome and discuss how including the vegetation data (NDVI values) helps us to better identify biomes and produce a cartography that is more useful for many applied and scientific purposes. While our classification is largely consistent with previous ones, considering both potential and current

vegetation data allowed us to create a more realistic biome distribution that differentiates actual vegetation types and thus can be more informative for forest managers, conservationists, and forest ecologists. The newly generated biome distribution is freely available to download and use for non-commercial purposes via as a GeoTIFF file.

Keywords: NDVI; remote sensing; climate data; global forest

B6. The change in wet and dry spells with global warming during growing seasons of wheat in China

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Abstract: Consecutive climatic extremes have more intense impacts on natural ecosystems and human activities than occasional events. Many studies covered the frequency or intensity of extreme weather events, but few focused on the consecutiveness or continuousness of climatic extremes in the crop. Wheat is the largest, most productive, and widely distributed grain crop globally, and wheat production accounts for 1/3 of the world's total food production. China is the largest producer of wheat in the world. This study analyzed the temporal and spatial distributions and tendencies in the wet and dry spells during growing seasons of wheat in China during the period 1961–2019. This study chose the central wheat regions from the 2419 gauge station dataset across China during the period 1961–2019. The timespan of growing seasons for wheat in China is retrieved from the MIRCA2000 dataset. This study analyzed the characteristics of the wet and dry spells related to the winter wheat and spring wheat regions, examining the relationships between the wet and dry spell increases with air temperature for the wheat-growing seasons. A wet/dry spell is defined as the consecutive days with a precipitation amount greater/less than a threshold. The frequency of wet/dry spells is the contributions of wet/dry spells with different lengths to the total number of wet/dry days and total precipitation amount. The definition of different time scales in the longest dry and consecutive wet days is not appropriate in ETCCDI indices since it may be biased toward the longest spell lengths since those start before the beginning of a period or extend to the next period and will be cut off. This study modified the dry/wet spell calculation method to get wet and dry spells. The wet and dry spells with the most outstanding contributions to the total wet and dry days or total precipitation amount vary among different wheat regions. For the winter wheat region, the long-duration dry spells contribute more to the total number of dry days. The mean of the long-duration dry spells increases with the air temperature at about 6.2% and 6.8%, respectively. In comparison, those of wet spells decrease at about 1.4% and 2.7%, respectively, over the winter wheat region. For the spring wheat region, short-duration wet spells contribute more to the total number of wet days and total precipitation amount. The opposite relationships of shorter dry spells and longer wet spells associated with higher air temperature are observed over the spring wheat region. There were apparent differences in the spatial distributions of consecutive days of climate extremes in China. The spatial trends of the longest dry spell and the longest wet spell were significant only in several regions of China. Increases in the frequency and intensity of some consecutive climatic extremes, as well as increasing physical exposure and socio-economic exposure, were demonstrated.

Keywords: extreme events; heatwave; wet spell; wheat

B7. The trend of feature extreme heatwaves in China based on CMIP6 projections

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Abstract: Extreme high-temperature (heatwave, HW) events have a serious impact on agriculture ecosystem and humans around the world. However, there is still a lot of controversy surrounding the definition of HW, and the trend of the spatial distribution of future HW over China is still unknown. We study the HW extreme event changes in the future by a new HW index using nine GCMs from the Coupled Model Inter-comparison Project phase 6(CMIP6) under three emission scenarios of the future societal development pathway: SSP126, SSP245 and SSP585. The results show that both the heatwave intensity and frequency have a robust increase in the end of 21st century. This situation is more pronounced under SSP5-8.0 than SSP2-4.5 and SSP1-2.6 with an increasing trend of 1.9 event/decade, 1.4 event/decade and 1.1 event/decade, respectively. Jianghuai, North China, and South China have a higher increase speed than other regions in China. It means that people living there will face greater risks in the future. Therefore, it is very import to control the future temperature rise with 2 degrees or even 1.5 degrees.

Keywords: extreme event; heatwave; agriculture ecosystem; linear trend

B8. Risk assessment of flood in the Loess Plateau: a case study of Quchan Basin, China

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Abstract: The Loess Plateau is highly vulnerable to floods and landslides. This paper aims to assess the flood risk in the Quchan Basin, which is located in the east of the Loess Plateau. The FloodArea model is developed by Gemer company of Germany, which is seamlessly integrated with ArcGIS in the form of a module. The principle is based on the two-dimensional unsteady hydrodynamic model, and the calculation is based on the hydrodynamic method. Heavy precipitation, which is historically rare in this region, struck the Quchan Basin from 4 August to 7 August 2020. DEM, roughness and hourly rainfall in the basin were needed to run the

FloodArea model. Under the rainstorm scene, an hourly flooding pattern was simulated in 30 m high resolution. Land use types would be converted to roughness values since different land use types have different roughness values. The results show that the risk of flash flood is higher in the low-lying river areas and gullies of the Quchan Basin. During this flooding, the maximum flooding depth at the survey site was 3.1 m, close to the observed flooding depth. As for the disaster situations of simulation, the population affected by the flood was 5475, the GDP was 36.15 million yuan, and the disaster areas of the cultivated land and residential land were 20.7 km^2 and 0.7 km^2, respectively. Affected GDP and affected land area were well consistent with the disaster data from the survey, but the affected population was lower than the survey results. This indicates that the FloodArea model has a superior property of simulating flooding and it can be employed in the risk evaluation and early warning of rainstorm and flood disasters in the Quchan Basin.

Keywords: flood; the Loess Plateau

B9. Variation characteristics of snow changes and their relationships with spring vegetation in the Heilongjiang Province of China, 1982–2012

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Abstract: Based on the meteorological data and Normalized Difference Vegetation Index (NDVI) data from 73 meteorological stations in Heilongjiang Province from 1982 to 2012, the time and spatial changes of snow cover period, first snow cover day, last snow cover day and snow cover depth, as well as their correlation with the NDVI, in Heilongjiang Province over the past 31 years were analyzed. The possible impact of changes in the underlying surface of snow on vegetation were also discussed. Results: 1) the length of the snow cover period in Heilongjiang Province showed a decreasing trend by 6.22 d/(10a); the first day of snow cover was delayed, with a delay rate of 3.31 d/(10a); the last day of snow cover showed an advance trend of 2.59 d/(10a); the maximum snow depth rising at 1.70 cm/(10a). 2) Obvious spatial differences of the length of the snow cover period existed in Heilongjiang Province, appearing as long in the north and short in the south. The long periods mainly appeared in the northern Heilongjiang Province and the Heihe and Yichun regions; the first day of snow arose early in the north and late in the south. The first day of snow cover was earlier in the north Heilongjiang Province, Heihe and Yichun. The earliest happened in Yichun, which was October 10; the last day of snow cover was late in the north and early in the south. In thevnorthern Heilongjiang Province, Heihe and Yichun areas, the snow cover ended late. The latest occurred in Xinlin, which was April 30; the maximum snow depth also had obvious spatial differences, which was high in the north and low in the south. The areas with the highest snow depth were concentrated in the northern and eastern regions of Heilongjiang Province and northern Yichun. The highest value was 37.19 cm in Fuyuan. 3) The NDVI of Heilongjiang Province gradually increased. The NDVI of the spring vegetation showed significant positive correlation with the snow cover period, the first day of snow cover, and the snow depth, and negative correlation with the last day of snow cover. Under the climate warming circumstance, the form of warm and humid environment promotes the melting of snow and increases the shallow soil

water content, benefiting the recovery and growth of spring vegetation. This research may provide guidance for spring agricultural production.

Keywords: snow changes; NDVI; correlation; Heilongjiang Province

B10. Relationship between snow cover distribution and crop yield in major agricultural areas of Northeast China

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Abstract: Northeast region is an important grain production base in China. Snow cover has a protective effect on farmland: as an important water replenishment for soil moisture in spring, and it is a major factor affecting the yield and quality of crops in the Northeast. However, under the background of climate warming, the relationship between various element indexes of snow cover and the yield of crops is still rarely studied. This paper is based on meteorological observation data of snow depth, snow cover days, first and last days of snow cover and snow cover area of the Songnen Plain and Sanjiang Plain in the main agricultural areas of Northeast China from 47 weather stations in Heilongjiang Province from 2008 to 2017, and the main crop corn output data, using methods such as correlation analysis, variance analysis, mutation analysis, and spatial analysis to estimate the correlation between the distribution characteristics of snow cover and crop yields in major agricultural areas in Northeast China. The results showed that, from 2008 to 2017, the snow depth of Songnen and Sanjiang Plains showed a non-significant increase, the first day of snow cover was delayed, the whole day was advanced, and the snow cover period was shortened. From 2008 to 2017, there was a significant positive correlation between snow depth and crop yield, with a correlation coefficient of 0.81. With the increase in snow depth, crop yield increased significantly. When the average snow depth was 15–20 cm, the corn yield increased by 27.8% compared with 0–5 cm. The number of snow cover days was positively correlated with crop yields with a correlation coefficient of 0.64, the first day of snow cover was negatively correlated with crop yields, and the total snow cover days were significantly positively correlated with crop yields, with a correlation coefficient of 0.86. When the snow cover rate is greater than 58%, the corn yield will increase, and the corn yield will increase significantly with the increase in snow cover rate. Research shows that factors such as the depth of snow depth, days, first and last days, and snow cover area have an important impact on yield of crops and should be paid more attention to.

Keywords: relationship; snow cover; crop yield; northeast China

B11. Effects of snow cover on spring soil moisture in Songnen Plain and Sanjiang Plain

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Abstract: Spring drought occurred frequently in Heilongjiang Province, which seriously affected grain yield and quality. As a mature indicator of agricultural drought, it is important to understand the changes of spring soil moisture and its influencing factors in the main agricultural areas of Heilongjiang Province. At present, the research on the influencing factors of spring soil moisture in Heilongjiang Province is mainly focused on temperature and precipitation, while snow cover is also an important influence on spring soil moisture conservation in seasonal snow areas, of which the current research is insufficient. In this paper, Songnen Plain and Sanjiang Plain are selected as the study areas, which are two agricultural areas in Heilongjiang Province with great differences in soil moisture. Soil moisture and meteorological data of 19 agricultural meteorological stations from 1983 to 2019 in the study area are used to investigate space–time variability and influences on soil moisture during spring season, by classical statistics and geostatistics such as variance analysis, mutation analysis, and spatial analysis. The results show that the mean soil moisture (0–30 cm depth) in Songnen Plain and Sanjiang Plain in spring for the period 1983–2019 are 81.39% and 92.37%. The spring soil moisture in Songnen Plain was significantly lower than that in Sanjiang Plain. The soil moisture values of different soil layers in different months in spring in Songnen Plain are all significantly lower than that in Sanjiang Plain. The soil moisture in the two agricultural areas increased with the depth of soil layer. For the perspective of interannual variation, the soil moisture in the 20–30cm soil layer in Songnen Plain showed a significant decreasing trend in March and April. The inter-annual variation trend of soil moisture in different soil layers in different months was not significant in the two agricultural regions. Precipitation in early autumn had a great influence on soil moisture in different soil layers in different months in spring in the two agricultural regions. For the Songnen Plain, the number of days with snow cover and the first day of snow cover can continue to influence the spring soil moisture in the Songnen Plain until May and can affect the 20–30cm soil layer. As the month progresses, the effect on the shallow soil gradually disappears. The maximum snow depth and the first day of snow cover only affected the surface soil in April. However, temperature, precipitation, sunshine duration and wind speed also have different effects on spring soil moisture in Songnen Plain. However, snow cover parameters had no significant effect on spring soil moisture in Sanjiang Plain. As the weather gets warmer in May, the precipitation increases, and the temperature, precipitation and sunshine have a great influence on the soil moisture in Sanjiang Plain.

Key words: snow cover; spring soil moisture; influencing factors; Songnen Plain; Sanjiang Plain

B12. Effects of Snowfall on Spring Soil Temperature in Northeast China

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Abstract: Snow cover has an important thermal insulation effect on soil temperature in seasonally frozen soil regions. Its changes affect soil temperature, which in turn affects spring

planting and crop growth. Therefore, it is extremely important to explore the impact of changes in winter snowfall on soil temperature in Northeast China. In this paper, the multi-model data set GSWPv3 (Global Soil Wetness Project) is used to drive the land surface model CLM5.0, the soil temperature from November 2013 to March 2014 is simulated, and the model simulation performance is evaluated using the reanalysis data ERA-5, which comparatively analyzes the changes in soil temperature during the period from November 2013 to February 2014 with or without snowfall. The results show that: (1) the land surface model CLM5.0 has a better simulation performance for spring soil temperature in Northeast China. Compared with the reanalysis data ERA-5, the simulated soil moisture correlation coefficient R is 0.985 ($P<0.01$), which can effectively simulate the change characteristics of soil temperature in Northeast China. (2) Using the land surface model CLM5.0 to simulate, the average spring soil temperature in Northeast China from November 2013 to March 2014 was -7.46°C. (3) In the case of no snowfall in the winter of 2013, the average value of this period in Northeast China was -9.92°C. Comparative analysis showed that the soil moisture was reduced by 2.46°C under the condition of no snowfall. (4) Comparing the spatial distribution map of spring soil temperature in Northeast China with or without snowfall in winter, it is found that the spring soil temperature in the central part of Heilongjiang Province and most parts of Jilin Province and Liaoning Province will be more affected without snowfall.

Keywords: land surface model; northeast; soil temperature

B13. China's Ski Tourism Resources under climate changes

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Abstract: In recent years, with the introduction of the "Implementation Outline for "Bringing 300 Million People to Participate in Ice and Snow Sports" (2018-2022)", China's ski tourism has developed rapidly and the market demand is strong, and, as such, there is an urgent need for a comprehensive evaluation of the country's ski tourism resources. According to the technical evaluation standards of ski tourism resources in the United States, this article uses temperature data, DEM elevation data, China's snow depth long-term series data set (1979–2020), and China's 2000–2019 snow area of 500 meters daily cloudless products for comprehensive evaluation of China's ski tourism resources of the period 2000 to 2020. The results show that: 1. China is rich in ski tourism resources. The high-quality ski tourism resources are mainly distributed in the three regions of Northeast, Xinjiang and Tibet, concentrated in the Changbai Mountains, the Xiaoxing'an Mountains, the southern Daxing'an Mountains, the Tianshan Mountains, the eastern Qinghai-Tibet Plateau and other places; 2. High-quality ski tourism resources have tended to migrate north, and the quality of ski tourism resources in eastern Liaoning and northern China, which once had greater advantages, has a downward trend; 3. China has less developed ski tourism resources than ski tourism resources elsewhere, and the Xiaoxing'anling region, the central area of Daxing'anling, remains to be developed. Through the research of this article, we can scientifically evaluate China's ski tourism resources, promote China's ski tourism to move towards sustainable development, and promote the rapid development of ice and snow tourism.

Keywords: ice and snow tourism; skiing; resource evaluation; ice and snow sports

B14. Effects of extreme nitrogen deposition on phytolith carbon sequestration in China's northern peatlands

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Abstract: Nitrogen deposition induced by human activities has drawn profound impacts on the structure and function of the various ecosystems. Northern peatlands are extremely sensitive to the increases in the available nitrogen and, thus, change the potential of the carbon sink of northern peatlands. As a typical biomineralized carbon sink, phytolith carbon sink can store carbon at a long-time scale and can be considered as one safe carbon sink type. However, the impact of nitrogen deposition on the potential of phytolith carbon sink in peatlands in northern China is still unknown. This project carried out in-situ long-term nitrogen deposition simulation experiments by selecting the typical northern peatlands in the Great Xingan Mountains and explored the following three study aspects: 1) the impact of nitrogen deposition on the morphological characteristics of typical plants in the northern peatlands; 2) the influence of nitrogen deposition on the silicon ecological stoichiometry characteristics of typical plants in peatlands; 3) simulation and prediction of nitrogen deposition on the carbon sink potential of phytoliths in northern peatlands. The main results obtained in this study are as follows: 1) The phytolith morphology of dominant plants in the peatlands of northern China varies across different species. The types of phytoliths of dominant plants in peatlands in northern China have a tendency to decrease, and different types of phytoliths have a significant tendency to decrease in nitrogen deposition; 2) The silicon content of different dominant plants in peatlands in northern China varied in different plants. In addition, the phytolith content in the leaves of *Betula platyphylla* in the peatland of northern China has a significant change under low and medium nitrogen deposition levels. There is a significant negative correlation between the silicon and calcium elements of *Deyeuxia angustifolia*. 3) Under the background of moderate nitrogen deposition, *Betula chinensis, Deyeuxia angustifolia and Eriophyllum chinense* will evolve into dominant vegetation on peatlands. Under the background of high nitrogen deposition, *Betula platyphylla and Deyeuxia angustifolia* will evolve into dominant vegetation populations on peatlands. The current phytolith carbon sink of peatlands in northern China is 0.16 kg CO2 hm-2 a-1. The phytolith carbon sink potential of peatlands in northern China is predicted to be 0.31 and 0.58 kg CO2 hm-2 a-1 by the end of 21st under moderate nitrogen and high nitrogen deposition, respectively. This research provides the scientific basis for the comprehensive assessment of the carbon sink function of northern peatlands and also provides scientific data support for the comprehensive understanding of the carbon–nitrogen–silicon–calcium coupling mechanism of terrestrial ecosystems.

Keywords: nitrogen deposition; phytolith; peatland; global environment changes

B15. Assessment on carbon fixation and oxygen release in ecological function of forest vegetation in China

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Abstract: Forest ecosystem not only plays an important role in global material and energy cycle but also plays an irreplaceable role in regulating global carbon balance and maintaining global climate stability. Carbon fixation and oxygen release is one of the important ecological service functions of forest ecosystem, which can reduce the pressure of natural environment, weaken the influence of "greenhouse effect" and "heat island effect", and realize the self-protection and virtuous cycle of forest ecosystem. Under climate change, the quantitative assessments of carbon fixation and oxygen release in the ecological service function of forest ecosystems in China are of great significance for the correct evaluation of the forest's role in the ecological environment construction in China. In recent years, many studies on ecological service function of forest ecosystems have been carried out in China, but most of them are small-scale analyses in a certain area. So far, the research on carbon fixation and oxygen release in ecological service function of forest ecosystems in China is still weak at the national scale. Therefore, in this study, we simulated the net primary productivity (NPP) of the forest ecosystem in China during the period 1981–2020 and evaluated its carbon sequestration and oxygen release in ecological service function using the remote sensing data and China's forest ecosystem carbon sequestration model, FORCCHN. Specifications for assessment of forest ecosystem services in China are used as a reference for calculating carbon fixation and oxygen release. The results showed that: (1) From 1981 to 2020, the annual changes in the unit area NPP and the total NPP in China's forest ecosystems showed obvious increasing trend. In particular, the total NPP fluctuated between 2.02 $Pg \cdot a^{-1}$ and 2.53 $Pg \cdot a^{-1}$, with an average of 2.36 $Pg \cdot a^{-1}$. The maximum total NPP and the minimum total NPP were found in 2004 and 2010, respectively. (2) Similar to the interannual change, the interdecadal increase in NPP was also obvious. The most significant increase was found between the 2000s and 2010s. (3) The basic characteristic of the spatial distribution of NPP was high in the South and low in the North. In the past 36 years, the difference in increased NPP per unit area of forest ecosystem has been significant in different regions. Among them, the most obvious increase in per unit area NPP was found in the southwestern forest, with the maximum increase of more than 666.7 $g \cdot m^{-2} \cdot a^{-1}$. As for the southeastern forest, the maximum increased per unit area NPP was more than 444.4 $g \cdot m^{-2} \cdot a^{-11}$. (4) China's forest resources played an important role in the development of national economy and society. In the past 36 years, the carbon sequestration value and oxygen release value of forest ecosystem in China fluctuantly increased. The total value of carbon sequestration and oxygen release was 140883.27×10^9 yuan. Moreover, the value of releasing oxygen was 2.82 times of carbon sequestration value. Our results can not only scientifically answer people's concerns about the carbon fixation value and oxygen release value of forest ecological services, making people more intuitively realize the great ecological value of China's forests, but also reflect the important position of China's forest resources in the development of national economy and society.

Key words: forest ecosystem; FORCCHN model; NPP; ecological service function; carbon fixation; oxygen release

B16. Post-harvest Evaluation of Wheat Nitrogen Harvest Index and Uptake Using Harvester-Mounted Sensors

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Abstract: A method of estimating the amount of nitrogen (N) removed during wheat grain and residue harvesting is critical to proper variable rate N management in the inland Pacific Northwest. This study aimed to evaluate the relationship between grain protein concentration (GPC), which can be collected at harvest using a harvester-mounted grain protein sensor, and N harvest index and N utilization efficiency. Both of these metrics can be solved knowing only grain yield and grain protein concentration at a field location to solve for total aboveground N. This studied measured N harvest index, N utilization efficiency, and GPC at hand harvested locations across six winter wheat sites in eastern Washington and northern Idaho from 2016 to 2018. The relationship between N harvest index and GPC was inconsistent. The relationship between N utilization efficiency and GPC was strongly linearly related in all six sites with r2>0.95 at four out of six sites. Total N uptake can be calculated using this relationship, and, in turn, total N removal from grain harvest and residue harvest can be calculated. This research demonstrated the feasibility of using harvester-mounted sensors to map total N uptake and removal of winter wheat, which can serve as post-harvest evaluation of N uptake and removal and a guidance for future variable rate N applications.

Keywords: precision agriculture; proximal sensing; yield monitor; protein monitor; sensors; wheat quality; NIR spectroscopy; wheat protein

B17. Loss of Protein of Cereal due to Natural Disasters in China's Agriculture from 1988 to 2016

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Abstract: Natural disasters play significant negative roles in agriculture production. China has been facing more frequent natural disasters due to climate change over the past few decades. Although the spatio-temporal changes in natural disaster for individual disaster activities are well known, the effect of multiple disasters on cereal crop productivities and, thereafter, on their quality loss still remains unclear. Furthermore, the quality loss of cereal, here, the protein, will play negative roles in the nutrient supply due to the dominant role of cereal in China's daily diet. To bridge the gap between natural disaster and food quality of cereal crops in China, we compiled the dataset of natural disasters, crop production and protein contents in cereal crops (rice, wheat, and maize) in China using the province-level data from 1988 to 2016. Our results show that the affected areas of natural disaster activities declined significantly after 2000, and changes in the affected areas of natural disasters varied at the province level. From 1988 to 2016, total protein loss due to natural disasters from grain harvest

was 100.12 million tons. Half of the protein loss in more than half of the provinces was caused by drought.

Keywords: climatic risk; drought; hail; floods; protein