The Cryosphere Discuss.,
https://doi.org/10.5194/tc-2019-242-AC1, 2020

The Cryosphere
Discussions

Interactive comment on "The role of snow and ice thickness on river ice process in Songhua River basin, Northeast China" *by* Qian Yang et al.

Qian Yang et al.

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Received and published: 7 March 2020

Thank you for the helpful suggestions and we have carefully gone through the manuscript and improved accordingly. Our replies are listed as bellows.

The results of the correlation showed high correlation between snow depth and ice thickness as well as high correlation between air temperature and ice phenology (freeze-up, break-up and mid-winter). These conclusions are basic scientific knowledge for freshwater ice scientists and have been well established over the years.

Reply: It seems that the relationship between the ice regime and the impact facts are common sense and have been well established. Still, different scholars held a considerably different opinions on this issue. Generally, snow depth plays a more crucial

role than air temperature (Morris et al., 2005) and increasing snow depth provide a favorable condition for thicker ice cover. In comparison with other works, the air temperature had more effect on ice thickness than snow depth and attributed this to the high snowfall of study area (Gao and Stefan, 2004). Shiklomanov and Lammers (2014) documented that in situ observations at Russian river mouths where ice thickness decreased had not revealed any significant correlation between ice thickness and SND. Whether snow depth or air temperature is the primary factor influencing ice formation and decay deserves further exploration in Northeast China.

Thank you for this enlightened question. We have improved the Abstract and Conclusions to emphasize our findings in this paper. According to high correlation coefficients between maximum ice thickness and ice phenology, ice phenology closely related to ice thickness, primarily the break-up process. Compared with ice thickness, air temperature associated with ice phenology more closely. No significant correlation existed between snow depth and ice thickness unless the air temperature was falling below the freezing point. We conclude that snow depth is the primary factor when the river ice is completely frozen, and air temperature is the primary factor during the transition periods between ice-covered and open water.

Reference: Bian, Y., Yue, J., Gao, W., Li, Z., Lu, D., Xiang, Y., and Chen, J.: Analysis of the Spatiotemporal Changes of Ice Sheet Mass and Driving Factors in Greenland, Remote Sensing, 11, 10.3390/rs11070862, 2019.

Gao, S., and Stefan, H. G.: Potential Climate Change Effects on Ice Covers of Five Freshwater Lakes, Journal of Hydrologic Engineering, 9, 226-234, doi:10.1061/(ASCE)1084-0699(2004)9:3(226), 2004.

Morris, K., Jeffries, M., and Duguay, C.: Model simulation of the effects of climate variability and change on lake ice in central Alaska, USA, Annals of Glaciology, 40, 113-118, 2005

Shiklomanov, A. I., and Lammers, R. B.: River ice responses to a warming ArcticâĂŤrecent evidence from Russian rivers, Environmental Research Letters, 9, 035008, https://doi.org/10.1088/1748-9326/9/3/035008, 2014.

The data can be used for more advanced analysis than just linear regression between basic parameters.

Reply: The data are further analyzed as you suggested.Firstly, we analyzed the ice phenology using rotated empirical orthogonal function and found five typical geographic zones. Secondly, we analyzed the spatiaol changes and inner annual changes of ice thickness. Thirdly, we supplement the correlation between ice thickness and snow depth, and air temperature in the view of three basins. Besides, we adopted accumulated air temperature in this study, and found that accumulated temperature had a higher correlation with ice thickness compared with air temperature.

The overall structure of the paper is not well laid out.

Reply: We adjusted the structure of this paper, and the new structure is listed as follows.

1 Introduction

2 Materials and methods

2.1 Study area

2.2 Data source

2.3 Data analysis

2.3.1 Kriging intepolation

2.3.2 Rotated empirical orthogonal function (REOF)

2.3.3 Partial least squares regression

3 Results

3.1 General distribution of ice phenology

3.2 Changes in ice thickness

4 Discussion

4.1 Error sources

4.2 The relationship between ice thickness and ice phenology

4.3 The role of snow and air temperature

5 Conclusions

There is no literature review describing what is the current state of knowledge and what is this manuscript adding to the research community.

Reply: Thanks for the concern, we have updated the introduction as you suggested based on literature review and supplements new references and emphasized on the diversity opinions on the role of snow cover during the ice process.

Also, the objectives and how the results of this exercise will be used are not presented.

Reply: We have modified the last paragraph of the introduction and suggested the possible application. The surface-based networks, including climatic and hydrological stations, have been established for tracing climate and hydrological changes in Northeast China, which are limited by the accessibility of surface-based networks and the range of filed measurement. To evaluate the influence of ice regime on regional climate and human environment, a robust investigation and quantitative analysis on ice process is necessary, which provide helpful information for projecting future changes in ice regime. The previous work explored the ice process in at one or more locations on a given river and ignored the changing regional pattern of ice development due sparse location. The objectives of this study are to: (1) examine and compare ice phenology dynamics of three sub-basins of Songhua River from 2010 to 2015; (2) explore the relationship between ice thickness and ice phenology; and (3) analyze the primary factor influencing ice regime and ice thickness.

The analysis section is brief and does not explain the details of the data processing. It wasn't clear to me how the hydrometric data was gathered (resolution, methods, accuracy...) and processed and how the dates of ice phenology were extracted from satellite images.

Reply: Thank you for the comments and suggestions. This paper used field measurement rather than satellite data for further research. The in-situ lake ice records were available provided by the Chinese Ministry of Water Resources from 2010 to 2015, including ice phenology, ice thickness, snow depth on ice and air temperature on bank (BAT) (Annual hydrological report, 2010-2015).

Reference: Hydrographic bureau of Chinese Ministry of Water Resources, 2010-2015. Annual hydrological report: hydrological data of Heilongjiang River Basin. (in Chinese)

The conclusions are brief and is not inclusive. Reply: We have significantly improved the conclusion, as you suggested. Later on, we will upload the revised manuscript, you can check it out through the revised MS.

On a separate note, the language of the manuscript overall is not clear and it seems the text was not read-proof before submission with many repeated sentences (line 55, 60, 70...), many grammatical and spelling errors(Bian et al., 2019).

Reply: We have carefully revised the manuscript according to the reviewers' comments, and employed an English-language editing service Editsprings, to polish our wording.

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