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Hydrology and Earth System Sciences
Discussions
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Interactive comment on "China's water sustainability in the 21st century: a climate informed water risk assessment covering multi-sector water demands" *by* X. Chen et al.

X. Chen et al.

glbycx2012@gmail.com

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The authors would like to thank the editor and two anonymous referees who kindly reviewed the earlier version of this manuscript and provided valuable suggestions and comments. We present our response to the comments and suggestions from the reviewers.

Referee 1 China has been experiencing a very quick development since the 1980s. Now as the world second biggest economy body, the huge scale of industry and the large amount of population causes a water resources crisis. Based on the daily pre-

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cipitation and temperature variability over fifty years and the current water demands in political district units, this paper examined the differences in water demand and supply and their spatio-temporal distribution in China. The paper quantitatively assessed water risk as measured by the distribution of cumulated deficits. Situation of county level water deficits and the causes of water risk are given in the paper. Results of this paper revealed intrinsic features of water income and water demand in China which are very helpful for correctly realizing water problems. This paper can be accepted for publication with minor improvements.

(1) Lines 130-134, the daily water deficit is defined as the difference between the daily water demand and the daily renewable water supply. The deficits are accumulated to an annual quantity. In China such a big country, it is basically impossible to obtain daily data to calculate the daily water deficit covering the whole country. Actually, it is not necessary to do so. Monthly water demand and water supply are enough for calculation of the water balance in a county scale.

We do agree with the reviewer that finding the data at daily scale for the whole country with reasonable reliability is a challenging task and we personally experienced these challenges during our analysis for this paper and our previous works in India. However, we find the use of daily rainfall data to be important to properly account for irrigation water requirements that can vary significantly in the presence or absence of monsoon breaks. A specific monthly rainfall amount may result from a few days of high rain which cannot be utilized by crops and several dry spells, or alternately from modest rainfall almost every day with very few if any severe dry spells, The consequences for crop water requirement and the accumulated deficit in the two cases are very different. We wanted to develop and use a metric that was sensitive to this sort of variability as well as the over-year variability which the monthly series would indeed capture.

For industrial, domestic and livestock demand, we considered a uniform disaggregation of monthly or annual data into daily data. However, we do want to highlight that fact that most of the water stress models available currently [e.g. Arnell 1999, 2004; Oki et al. 2001; Alcamo et al. 2003 and references therein] primarily present metrics that reflect per-capita water availability or the annual withdrawal to availability ratio and do not consider the within year variability of rainfall or water supply. Consideration of intra-annual climate variability turns out to be very important especially for monsoonal climates. Much of the rainfall in China is monsoonal with rains occurring over a few months in the year contributing to a significant portion of river runoff. As competition for water increases across different use sectors, a metric that captures the temporal variability in availability of supply will be more informative especially as the pressure to develop more storage facilities is increasing. Moreover, demand variations in time are most pronounced for agricultural water use. As demonstrated, much of the water crisis in the country is associated with the use of ground water for irrigation, and explicit accounting of daily scale variability is warranted since the productivity is closely tied to the ability to buffer the effects of variations in rainfall onset, the number of rainfall events and the duration of dry and wet days. Hence, we made an attempt to provide a clear modeling framework that will inform the potential water stress.

We emphasized these points better in the manuscript now.

(2) Quantity of water has a concept of probability. It is important to give water deficits with return periods (frequencies). However, quantity of water resources (runoff) and water demand both in China has been changing yearly due to climate change and intensive human activities. So it should be good to illustrate the influence of non-stationarity in runoff time series. Analysis of monotonic trends in the deficit measure is presented in Figure 6. While this does not include changing demands over time, it does highlight the time trends in the water supply across the country.

We presented briefly in the paper, the probabilistic interpretation of the index using Figure 8 which provides the cumulative distribution of NDI for one county. This can be interpreted in two ways. a) If a user is interested in understanding the deficit (or storage required) for planning with a specified reliability (e.g. 90% or 99% reliability), one can either estimate the associated quantiles from the 50 years of NDI values, or fit

HESSD
10, C7034–C7039, 2014

an appropriate parametric distribution and quantify the P(X>x). b) If a user is interested in developing a frequency analysis of the index, one can use the yearly NDI value to inform the drought (variant of NDI) return periods. Our forthcoming work on demand informed drought indices will delve in to these aspects in greater details. We want to keep this paper largely to presenting the overall water stress at the Country level.

(3) Transfer of industries from regions and from planting to manufacture in China is very quick in recent years. Water use and demand in China also show different features as compared with that of several years before. Spatio difference is even bigger for the water balances in North and South, East and West of the Country. It is necessary to describe the impact of industries transfer on water use/demand and further on the water resource crisis.

We used the data obtained from the Chinese water resources bulletin, Ministry of Water Resources for the industrial water demand. They made data availability at fine resolution recently (from 2011). Prior to this, the data is available at an aggregate basin level. Since, most businesses are associated at city or county scale, a like comparison of industrial water use for the prior years with the current years is a challenging task. Furthermore, aggregate industrial water use data for entire China increased from 556.7 billion cubic meters in 2002 to 610.7 billion cubic meters in 2011, a modest increase of 9.7% over 10 years [Chinese water resource bulletin in 2002 and 2011]. We do agree with the reviewer that the spatial distribution of the water stress is likely to shift given the shift of industries. The sectoral changes from 2002 to 2011 are illustrated below. It does illustrate modes reduction in agricultural use, and dramatic increases in other areas in almost all basins. We can include this figure in the paper if the reviewer thinks it will add to the presentation. At this point it is not included.

(4) Figures 1 to 6 lost the boundary of South China Sea.

We modified the figures accordingly.

Alcamo, J., P. Döll, T. Hendrichs, F. Kaspar, B. Lehner, T. Rosch, and S. Siebert (2003),

HESSD
10, C7034–C7039, 2014

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Arnell, N. W. (1999), Climate change and global water resources, Global. Environ. Chang., 9, S31–S49.

Arnell, N. W. (2004), Climate change and global water resources: SRES emissions and socio-economic scenarios, Global. Environ.Chang., 14, 31–52.

Oki, T., Y. Agata, S. Kanae, T. Saruhashi, D.W. Yang, and K. Musiake (2001), Global assessment of current water resources using total runoff integrating pathways, Hydrol. Sci. J., 46, 983–995.

Chinese water resource bulletin in 2002 and 2011 are from http://www.mwr.gov.cn/zwzc/hygb/szygb/

Referee 2 As far as I can judge, the scientific base of this article is sound. However, I was hoping to read more about the impact of the study on China's future water management. This is only being touched briefly and leaves the reader wondering –e.g., 'enhanced water security, agricultural productivity and economy'; 'crop allocation optimization at the national level'; trade between food and water storage strategies'. Here the authors should provide stronger links to big picture of the issue – include implications for the Chinese society and the region as a whole. While it is clearly not within the scope of the study, nor within the expertise of the authors, pointing towards the consequences for society would increase the value of the study. Furthermore, the readability of the paper would benefit from another round of editing by a native speaker.

Thanks for the suggestions. The documented has been edited, and some ideas in this direction are sketched

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Interactive comment on Hydrol. Earth Syst. Sci. Discuss., 10, 11129, 2013.

HESSD

10, C7034–C7039, 2014

Interactive Comment

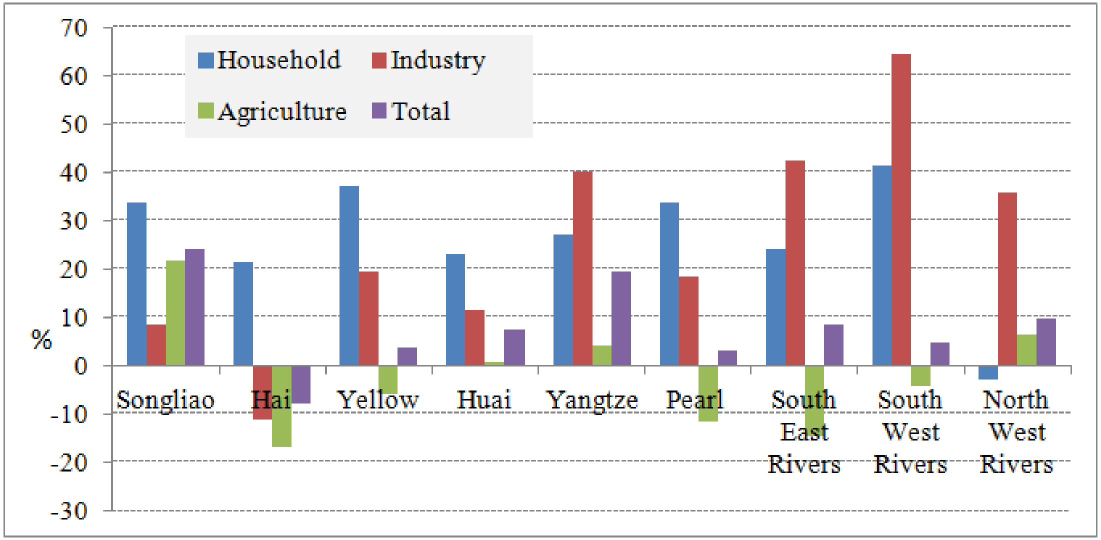

Fig. 1. The sectoral water demand changes from 2002 to 2011