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Variation of dissolved organic carbon transported by two Chinese rivers: The Changjiang River and Yellow River

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ABSTRACT

Real-time monitoring of riverine dissolved organic carbon (DOC) and the associated controlling factors is essential to coastal ocean management. This study was the first to simulate the monthly DOC concentrations at the Datong Hydrometric Station for the Changjiang River and at the Lijin Hydrometric Station for the Yellow River from 2000 to 2013 using a multilayer back-propagation neural network (MBPNN), along with basin remote-sensing products and river in situ data. The average absolute error between the modeled values and in situ values was 9.98% for the Changjiang River and 10.84% for the Yellow River. As an effect of water dilution, the variations of DOC concentrations in the two rivers were significantly negatively affected by discharge, with lower values reported during the wet season. Moreover, vegetation growth status and agricultural activities, represented by the gross primary product (GPP) and cropland area percent (CropPer) in the river basin, respectively, also significantly affected the DOC concentration in the Changjiang River, but not the Yellow River. The monthly riverine DOC flux was calculated using modeled DOC concentrations. In particular, the riverine DOC fluxes were affected by discharge, with 71.06% being reported for the Changjiang River and 90.71% for the Yellow River. Over the past decade, both DOC concentration and flux in the two rivers have not shown significant changes.

1. Introduction

As a major connector of terrestrial and ocean ecosystems, annually, rivers worldwide transport approximately 900 Tg of carbon, organic or inorganic, from various terrestrial ecosystems to marginal seas (Wang et al., 2012). The flux of riverine dissolved organic carbon (DOC) estimated by different researchers varied from 110 to 250 Tg C/year (Dai et al., 2012 and references therein). After entering the coastal seas, land-sourced DOC might change the water environment through processes such as light absorption (from visible to ultraviolet), oxygen consumption (decomposition by microorganisms), and pollution (Jutras et al., 2011; Ni et al., 2008). The monitoring of riverine DOC concentration and flux transported to coastal seas is essential to understanding and managing marginal sea environments. Moreover, riverine DOC also plays a crucial role in the carbon budget of marginal seas (Regnier et al., 2013). The great spatial diversity among different rivers and the temporal variations of a specific river must be investigated in depth, with sufficient data, to understand the influence of riverine DOC on its inflowing marginal seas.

Many studies have been conducted to explore the impact of basin characteristics on riverine DOC (Lu et al., 2012; Regnier et al., 2013; Tian et al., 2013; Wang et al., 2012; Worral et al., 2004). The factors affecting DOC exported from different rivers might vary. Tian et al. (2013) reported that air temperature, land-surface characteristics, and discharge were correlated with DOC transported by major US coastal rivers crossing different climate zones, and that land-surface processes result in DOC concentration variations up to ± 1.65 mg/l. For three US rivers (Ohio, Upper Mississippi, and Missouri), Raymond and Oh (2004) considered riverine DOC to be correlated with river discharge and watershed precipitation. Worral et al. (2004) reported that air temperature alone could only explain the 12% increase in DOC production in the UK. This may alternatively be explained by rivers draining peat areas and land management. Evapotranspiration (ET) (Raymond and Oh, 2004), land-use and land-cover change (LUCC) (Correll et al., 2001), human activities (Regnier et al., 2013), etc. could also affect the DOC flux exported from rivers. Therefore, basin characteristics have a significant impact on riverine DOC transported to marginal seas. However, the riverine DOC concentration may change over time as basin features change erratically with seasons. For example, Ni et al. (2008) reported that the DOC concentrations in the Pearl River, China, were higher in the dry season than in the wet season. The land-surface characteristics of different basins can be obtained by remote sensing, such as land-cover type (Friedl et al., 2010),

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gross primary product (GPP) (Heinsch et al., 2003), and ET (Mu et al., 2007, 2011). Remote-sensing products can aid in estimating the variations in riverine DOC concentration and flux in a long-time series with a proper model. However, research and models regarding this aspect are limited.

The Changjiang River and Yellow River in China (Fig. 1) are two of the 25 largest rivers in the world (Cai et al., 2008). Comparing with US rivers, their basins cover areas with a larger slope, such as the Qinghai–Tibet Plateau and the Chinese Loess Plateau. In 2009, about 1.58 Tg of carbon in the form of DOC was transported to the East China Sea (ECS) by the Changjiang River, and 0.032 Tg was transported by the Yellow River to China's Bohai Gulf (Wang et al., 2012). The DOC flux of the Changjiang River is comparable to other large rivers across the world, such as the Mississippi River, the Yukon River, and the Niger River (Table 1). The Yellow River is the major river emptying into China's Bohai Gulf. However, only few studies were conducted on the interannual variations of DOC in the two major Chinese rivers based on climate change and human activities (Wang et al., 2012). In this paper, the variations of DOC concentration and flux transported by the Changjiang River and Yellow River from January 2000 to December 2013 are estimated and discussed. First, three factors are selected after applying principal component analysis (PCA) to eight original factors that might describe basin features. Then, based on the selected factors, a neural network is developed to estimate the DOC concentration in the Changjiang River and Yellow River. Following this, the impact factors and decadal variations of riverine DOC in the two rivers are discussed.

Table 1
Basic information on the major rivers of the world. For a specific river, DOC concentrations might change over time and vary for different studies.

No.	River name	Discharge (km^3/year)[a]	Basin area (10^3 km^2)[a]	DOC flux (10^6 t/year)[b]	DOC concentration (mg/l)[c]
1	Amazon	6642	5854	18.6	3.6–4.8
2	Congo	1308	3699	8.9	≈6.8[e]
3	Changjiang	944	1794	0.9	1.2–2.4
4	Mississippi	610	3203	3.1	0.6–5.4
5	Yukon	212	852	0.9	6.0–17.0
6	Niger	193	2240	0.53	≈2.7[e]
7	Yellow River	47	894	0.06	1.8–3.4[d]
8	World	38,600[b]	–	200	≈5.2[e]

[a] Cai et al. (2008).
[b] Total discharge from all major rivers of the world (Ran et al., 2013).
[c] Pan et al. (2012).
[d] Wang et al. (2012).
[e] Average DOC concentration of all major rivers of the world calculated from discharge and DOC flux.

2. Study area and data

2.1. Research area

The Changjiang River and Yellow River, two large rivers in mainland China, were the focus of this study (Fig. 1). The Changjiang River is the third longest river in the world, running for 6300 km, and the Yellow River is the seventh longest river at 5465 km (Wang et al., 2012). In terms of discharge, the Changjiang River and Yellow River rank fourth

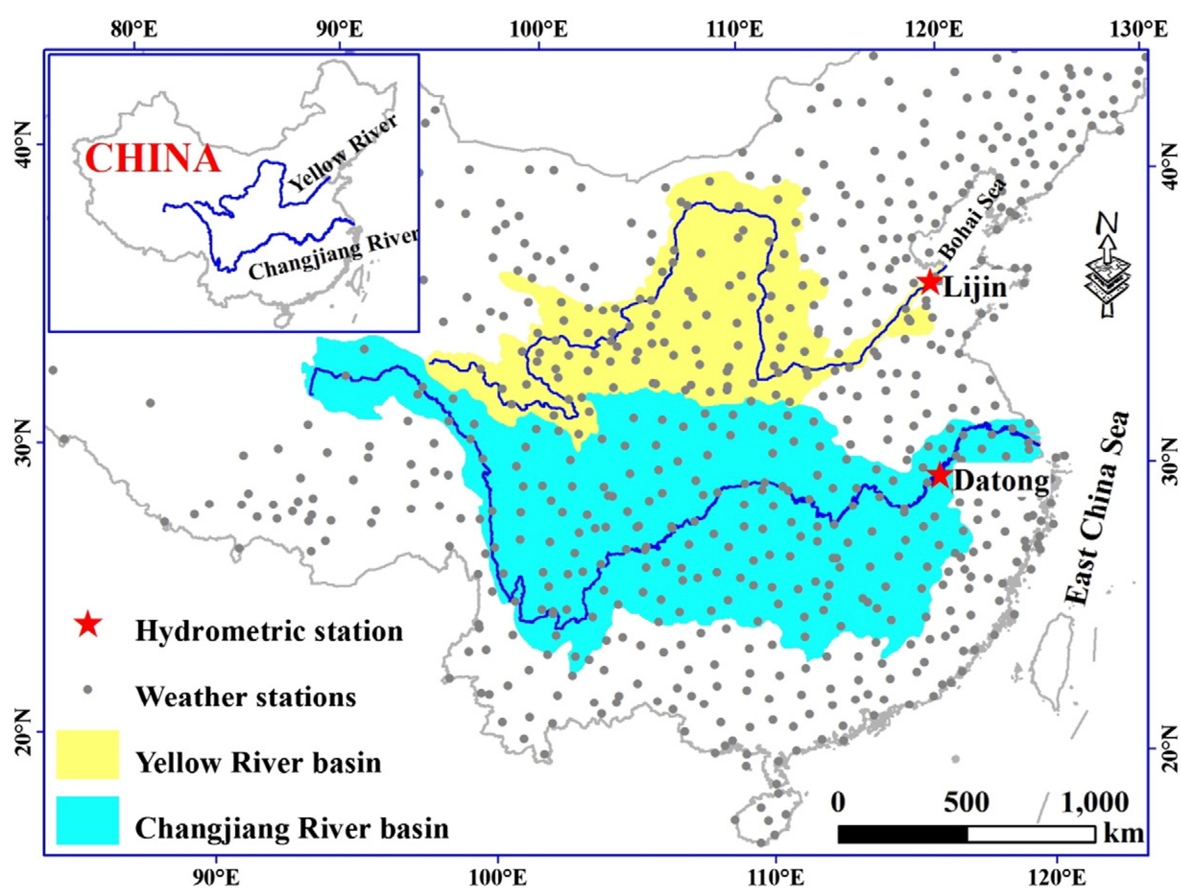

Fig. 1. Locations of the two rivers and relative basins. The gray dots (•) indicate Chinese weather stations, 756 in total; the red pentagrams (★) indicate hydrometric stations, with Datong for the Changjiang River, and Lijin for the Yellow River.