Spatial and Temporal Distribution of Sea Surface Salinity in Coastal Waters of China Based on Aquarius

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Abstract. Sea surface salinity (SSS) is a fundamental parameter for the study of global ocean dynamics, water cycle, and climate variability. Aquarius launched by NASA and the Space Agency of Argentina is a breakthrough which could achieve the remote sensing data of SSS. The present paper takes the coastal of China as study area, which is a representative area of ocean boundary and influenced by continental rivers (Yangtze River and Pearl River). After analyze the temporal and spatial variation of SSS in the coastal of China, the estuary area has obvious low salinity because the injected of freshwater from continent. Take the East China Sea (ECS) and South China Sea (SCS) as representative region to discuss the effect of freshwater to SSS. The salinity is almost equal in winter when the diluted water is inadequate in both rivers. However, an obvious decrease appeared in summer especial July in Yangtze River for abundance discharge inflow the ECS. This is a reasonable expression of Yangtze River discharge is remarkable influence the SSS in coastal area then Pearl River. Survey the distribution range of Yangtze River diluted water (SSS<31psu). The range is small in winter and expands to peak value in summer.

1. Introduction

Sea surface salinity (SSS) is a fundamental parameter for the study of global ocean dynamics, water cycle, and climate variability [1]. Meanwhile it plays an important role in ocean-atmosphere coupled system [2]. Salinity is needed to understand the large scale thermohaline circulation, driven by buoyancy, which moves large masses of water and heat around the globe. Salinity also plays an important role in energy exchange between the ocean and atmosphere (for example in the formation of stable buoyant layers at the surface). Salinity is also a surrogate for freshwater flux. In particular, changes in surface salinity reflect changes in freshwater (e.g. evaporation and precipitation, and also river run-off and ice melt). Hence, a map of the global salinity field will also help to better understand the global water cycle and how it is changing [3].

In situ SSS is the primary dataset of previous study for a long time. Aquarius is a breakthrough which could achieve the remote sensing data of SSS. Aquarius is an L-band radiometer and scatterometer instrument combination designed to map the salinity field at the surface of the ocean from space. The instrument is designed to provide global salinity maps on a monthly basis with a

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spatial resolution of 150 km and an accuracy of 0.2 psu. The science objective is to monitor the seasonal and inter-annual variation of the large scale features of the surface salinity field in the open ocean. This data will promote understanding of ocean circulation and its role in the global water cycle and climate. Aquarius is the primary instrument on the Aquarius/ SAC-D mission which is a partnership between the space agencies in the USA (NASA) and Argentina (CONAE) [4]. The primary objective of the Aquarius instrument is to monitor the seasonal and inter-annual variation of the large scale features of the surface salinity field in the open ocean. This will provide data to better understand ocean circulation and its impact on climate [3].

The present paper takes the coastal of China as study area, analyze the temporal and spatial variation of SSS. Take the Yangtze River and Pearl River estuary area as representative region to discuss the effect of freshwater to SSS. Survey the distribution range of Yangtze River diluted water (SSS<31psu). Strive to describe the spatial and temporal variation of SSS and explore influences.

2. Materials

2.1 study area
The study area is the coastal water of China (0°N ~42°N, 98°E ~ 132°E). This is a typical area of continental marginal sea. The distinctive area is located in the north Atlantic west bank with the typical monsoon climate, backed on the biggest continent and faced the biggest ocean. Select the East China Sea (ECS) (25°N ~ 35°N, 120°E ~ 130°E) and South China Sea (SCS) (4°N ~25°N, 105°E ~ 122°E) as representative region to discuss the effect of fresh water (Yangtze River and Pearl River) to SSS.

2.2 Sea surface salinity
Aquarius launched by NASA and the Space Agency of Argentina is a breakthrough which could achieve the remote sensing data of SSS. The SSS data with the resolution of 1 deg is comparable accuracy after verify with Argo data and could content the requirement of mesoscale ocean research. The sensor was launched on June 10, 2011, aboard the Argentine CONAE SAC-D spacecraft. The L-band radiometers and the scatterometer have been taking science data observations since August 25, 2011. So one whole year data was available. This data was extremely valuable for inter annual variation research of SSS.

3. Results and discussion
The remote sensing data of Aquarius cover great majority of study area, which have let to enormous progress for the spatial study of SSS. Achieve average SSS of the year by spatial overlay and the result shows as Figure 1. The SSS range is 28.6~34.8psu. The minimum value round up in the ECS, which is typical offshore waters. ECS is surrounded by China and Korean Peninsula, and terrigenous fresh water pure into the area especially the Yangtze River. Yangtze River is the third longest river in the world and the biggest river in Asia. It has a mean annual runoff of 1072 billion m³ into the ECS each year [5]. This is the primary factor of low SSS in ECS. The SCS is vaster than ECS and the Pearl River do not provide abundant terrigenous compare with Yangtze River, so the SSS is higher. In the open sea, the SSS is almost high than 33psu because lack of continent influence.
The time series of remote sensing data is more than a year which is long enough to study the inter-annual variation. In consideration of the typicality of ECS and SCS, we compare the inter-annual variation of coastal water of China (CWC), ECS and SCS. Figure 2 shows that the variation trend is similar of CWC and SCS while SSS is 0.5psu higher in CWC than SCS. Two valley values are present in winter (November and December) and spring (March and April). However, the variation in ECS is quite different from others. The SSS is similar in autumn and winter of ECS and SCS but different in spring and summer. SSS descends from spring and reaches the minimum value in July, which is quite related to the Yangtze River discharge. The discharge increases in spring and gets the maximum value in July [6]. This is a powerful proof of the terrigenous fresh water influence to the offshore SSS.
The Changjiang Diluted Water (CDW) formed by the summer freshwater discharge spreads eastwards over the broad area of the East China Sea [7]. The seasonal behavior of CDW (salinity < 30–32) is mainly controlled by the current system in and wind condition (summer monsoon) over the East China Sea [8, 9]. Define SSS < 31psu as the CDW. Calculate the monthly area ratio of CDW in ECS as Figure 3. There is a strong negative correlation between inter-annual variation of SSS and the CDW area ratio in ECS. The area ratio is hover around 30% in autumn and winter. But the ratio increase since spring and get the peak value (62%) in July. CDW is an important representation of Yangtze River discharge. Vast fresh water pour into the ECS dilute the saline water. With the effect of wind and ocean current, CDW spread to the east and east by north [7].

![Figure 3. The monthly area ratio of CDW in ECS](image)

4. Conclusion
After analyze the temporal and spatial variation of SSS in the coastal of China, the estuary area has obvious low salinity because the injected of freshwater from continent. Take the Yangtze River and Pearl River estuary area as representative region to discuss the effect of freshwater to SSS. The salinity is almost equal in winter when the diluted water is inadequate in both rivers. However, an obvious decrease appeared in summer especial July in Yangtze River for abundance discharge inflow the ECS. This is a reasonable expression of Yangtze River discharge is remarkable influence the SSS in coastal area then Pearl River. Survey the distribution range of Yangtze River diluted water. The range of CDW is small in winter and expands to peak value in summer.

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