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Rivers in Coastal Ocean Model

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Introduction

As resolution of regional ocean models is refined to hundreds of meters and less, it becomes possible and necessary accurately simulate interaction and impact of rivers on the coastal ocean circulation and environment. Ocean-rivers interaction includes a lot of complicated aspects; one of most important is modification of coastal waters salinity. Rivers also modify coastal circulation both directly, by momentum advection, and through the ocean water density modification. Rivers could transport a lot of suspended and dissolved materials that could significantly impact the coastal environment in river mouth proximity as well as on relatively large distance from it. To count for these processes, discharge of main Japanese rivers was included into the real-time tide resolving regional ocean model for the coastal waters of Japan (JCOPE-T) developed and operated by RIGC (JAMSTEC).

System structure

JCOPE-T system is based on the generalized vertical sigma coordinate model version of POM (Princeton Ocean Model) with 1/36 degree horizontal resolution and 47 vertical levels. It is nested to the North-Western Pacific (NWP) JCOPE real time modeling system. Later model provides weekly updated daily values for the open boundary conditions. Tidal processes are introduced in to the model at open boundaries using Japan National Astronomy Observatory model (NAO, Matsumoto) tidal elevation and volume fluxes. Astronomic tidal potential variations are also counted in the model; total up to 20 tidal harmonics could be simulated.

At the sea surface momentum, heat and water fluxes are estimated using latest available meteorological numerical weather analysis and forecast data.

At this moment, the freshwater discharge of major 35 Japanese rivers prescribed as monthly mean values is considered in the model. Depending on information availability, it is planned to replace it with the real-time daily information. As for many rivers model with employed horizontal resolution of order 3 km do not gives possibility to resolves directly river estuaries, the mouth depth is specified and if an adjacent coastal ocean model cells is deeper than river mouth, the fresh water is intruded into the upper model layers only.

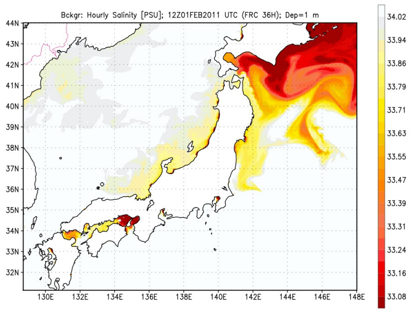
JCOPE-T system runs daily generating hourly ocean state forecasts for approximately one weekly. System operations are automated and simulation results are downloaded to the JCOPE web server at http://www.jamstec.go.jp/frcgc/jcope/vwp/

Some results

Figure 1 demonstrates modeled distribution of ocean water with salinity less then 34.1 psu at the sea surface around Japan for February 1, 2011. Except of significant intrusion of law salinity waters from the Okhotsk Sea along the eastern coast of Hokkaido, rivers discharge forms the lower salinity water belt along the Japan Sea coast as well as impacts salinity distribution along the northern Honshu and in almost all bays along the Pacific coast of Japan: Tokyo Bay, Ise Bay, Seto Inland Sea (especially in the Osaka Bay), and in the Ariake Sea near Kyushu island.

Apart of impact on salinity distribution, rivers discharge changes the coastal ocean density field and causes modification of local horizontal and vertical ocean circulation. For example, model reproduces upwelling zones adjacent to river discharge locations. Due to the induced pressure gradient, bottom waters are pushed to the river mouth direction forming bottom-concentrated coastline-directed current and coastal upwelling. In summer time this upwelling could be clearly seem in surface temperature distribution.

Compared with other ocean desalination processes like atmospheric precipitation, rivers discharge has fixed geographical location, it is continuous in time and, as result, its impact could have accumulative nature. Accounting for it seems to be important and necessary for the correct modeling of coastal circulation and environment.



Keywords: river discharge, coastal operational oceanography, ocean modeling