High-resolution Simulations for the Bay of Bengal: Sensitivity to River Input and Wind Forcing

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ABSTRACT

We present a multiscale validation and sensitivity study of a set of high-resolution (~9 km) simulations for the Bay of Bengal (BoB) region using the Regional Ocean Modeling System (ROMS). We compare and analyze four main simulations of fifteen years duration each. They utilize different climatological monthly surface wind forcing (weaker COADS or stronger QuikSCAT) and different buoyancy inputs (river inflow with seasonally varying estuarine salinity or with zero salinity). We first complete a statistical validation to establish the model's overall capability and specific sensitivity in reproducing basin-scale annual and seasonal variabilities. The basin-scale (large-to-mesoscale) performance is quantified in terms of biases, correlations, skills, and root-mean-square-differences (RMSD) against satellite and in situ monthly climatologies. The skill in reproducing the seasonal variability for sea surface temperature (SST), sea surface salinity (SSS), sea surface height (SSH), mixed layer depth (MLD) and depth of the 20°C isotherm (D20) is found to be heterogeneous in space, when compared to the overall annual skill. The skills for SST and SSS were high in all the simulations. The stronger winds and fresher river inflow increased the MLD skill by almost 10% each. The stronger winds however have a significant negative impact on the SSH skill while the added freshness increased the SSH skill minimally.

We then analyze the sensitivity to wind and buoyancy forcing in terms of the ability to capture a number of key processes and features: (i) surface circulation including the boundary currents and monsoonal circulation; (ii) vertical structure of temperature, salinity and stratification; (iii) freshwater plume dispersion; and (iv) coastal upwelling along the western boundary during late spring/summer. We find that the major effects of winds and river inputs are limited to the upper 50 m of the water column in a domain-average sense, with deeper and stronger influence in the northern BoB. The stronger QuikSCAT wind lowers (enhances) the upper ocean temperature (salinity), weakens the stratification, strengthens the springtime western boundary current, enhances eddy activity during summer monsoon, enhances coastal upwelling, and reduces both surface spreading and volume occupation of plume water during autumn. Increasing the coastal buoyancy (fresher river input) reduces the overall salinity at the surface by ~0.4 psu, increases the near-surface stratification in the northern BoB, and enhances the eddy activity from October through May. The lower salinity simulation prefers an eddy-dominant springtime Western Boundary Current (WBC), and enhances freshness, strength, and southward extent of the East India Coastal Current (EICC) core as well as the freshness and plume water inhibition by about 10% over the domain. The zero salinity river input better simulates the domain-wide surface salinity but significantly underestimates the SSS near the river mouths where the estuarine salinity input simulates more realistic SSS.

Keywords: Bay of Bengal, multiscale validation, sensitivity study, winds and rivers, stratification, circulation and coastal upwelling

1. Introduction

The circulation of the Bay of Bengal (BoB) has major contributions from both wind and river forcing. While the seasonally reversing winds force seasonally reversing boundary currents and opposing gyre circulations in spring and autumn (Cutler and Swallow, 1984; Hastenrath and Greischar, 1991; McCreary et al., 1993; Schott et al., 2009, Durand et al., 2009, Gangopadhyay et al., 2013 and references therein), the large freshwater discharge from the rivers around the northern and eastern rims of the BoB introduces one of the largest salinity contrast (Fig. 1) in