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Downscaling of sea level and fluxes in the Malacca and Singapore Straits using A2 scenario projections of AR4 GCMs

Pavel Tkalich (1), Volodymyr Koshebutsky (2), Vladimir Maderich (2), and Bijoy Thompson (1)

(1) National University of Singapore, Singapore (tmspt@nus.edu.sg), (2) Ukrainian Center of Environmental and Water Projects,Glushkov av. 42, 03187 Kiev, Ukraine (vladmad@gmail.com)

IPCC-coordinated work has been completed within Fourth Assessment Report (AR4) to project climate and ocean variables for the 21st century using coupled atmospheric-ocean General Circulation Models (GCMs). Resolution of the GCMs is not sufficient to resolve local features of narrow Malacca and Singapore Straits, having complex coastal line and bathymetry; therefore, dynamical downscaling of ocean variables from the global grid to the regional scale is advisable using ocean models, such as Regional Ocean Modeling System (ROMS).
ROMS is customized for the domain centered on the Singapore and Malacca Straits, extending from 98°E to 109°E and 6°S to 14°N. Following IPCC methodology, the modelling is done for the past reference period 1961-1990, and then for the 21st century projections; subsequently, established past and projected trends and variability of ocean parameters are inter-compared. Boundary conditions for the past reference period are extracted from Simple Ocean Data Assimilation (SODA), while the projections are made using A2 scenario runs of ECHAM5 and CCSM3 GCMs. Atmospheric forcing for ROMS is downscaled with WRF using ERA-40 dataset for the past period, and outputs of atmospheric variables of respective GCMs for the projections.
ROMS-downscaled regional sea level change during 1961-1990, corrected for the global thermosteric effect, land-ice melting and Global Isostatic Adjustment (GIA) effect, corresponds to a mean total trend of 1.52 mm/year, which is higher than the global estimate 1.25 mm/year and observed global sea-level rise (1.44 mm/year) for the same period. Local linear trend in the Singapore Strait (0.9 mm/year) corresponds to the observed trend at Victoria Dock tide gauge (1.1 mm/year) for the past period. Mean discharges through the Karimata, Malacca and Singapore Straits are 0.9, 0.21 and 0.12 Sv, respectively, fall in the range of observations and recent model estimates.
A2 scenario projections using ROMS-ECHAM5 and ROMS-CCSM3 for 2011-2099 suggest that linear trends of sea level rise in Singapore Strait are 5.4 and 6.1 mm/year, respectively. These values fall in the range of global estimates of 3.0-8.5 mm/year. Mean sea level rise is expected around 0.43 m (ROMS-ECHAM5) and 0.47 m (ROMS-CCSM3) in 2099 relative to mean sea level in 2011. These values are greater than median estimation of global sea rise 0.32 under scenario A2. Mean discharge through Singapore Strait for scenario A2 during 2011 to 2099 is projected to be 0.062 Sv for ROMS-ECHAM5 and 0.11 Sv for ROMS-CCSM3. These projections are comparable to the discharges during 1961-1990 (0.065 and 0.11 Sv, respectively). The linear trend in discharges for the period 2011-2099 is relatively small with statistical confidence level being less than 95%. An important feature computationally discovered is the transient reversal of flow in the Singapore Strait during southwest monsoon. In general, the reversals of flow in ROMS-ECHAM5 and ROMS-CCSM3 are observed respectively to occur 1/3 and 1/5 of the whole period.