Scholarship Completion Report

September, 2023

Home Institution: Goa University, India.
Host Institute: Leibniz-Institute for Baltic Sea Research, Germany

Supervisor: Prof. Dr. Hans Burchard
Visiting Period: 12-June to 7-August, 2023
Working Groups Interacted with at the Host Institute: Estuarine and Coastal Ocean Processes; Turbulence and small-scale processes.

Title: Satellite derived coastal colour components and physical processes: a numerical study.

Technical Abbreviations

GOTM – Generalized Ocean Turbulence Model; GETM – Generalized Estuarine Transport Model; FABM – Framework for Aquatic Biogeochemical Models; ERSEM – European Regional Seas Ecosystem Model; ERGOM – Ecological Regional Ocean Model; OASIM – Ocean-Atmosphere Spectral Irradiance Model.

Summary

The main objective of the proposed work was to generate remote sensing reflectance as a result of the flux of optical constituents influenced by physical forcing. This would allow the analysis of horizontal (spatial) and temporal variations in spectral remote sensing reflectance with an aim to improve satellite water quality products in optically complex regions, and thereby, provide an improved framework to monitor ecological health of estuarine and coastal waters. To achieve the objective and address several phased problems, a coupled setup of GETM/GOTM (physical model), ERSEM/ERGOM (biogeochemical model), and OASIM (spectral model) using FABM interface was required. The study area of Goa (India) with two prominent estuaries on the west coast of India, i.e., Zuari estuary and Mandovi estuary, along with four rivers, and a coastal shelf up to a depth of 30 m was chosen as a case study. This region provides shallow turbid conditions with a strong influence of freshwater input seasonality due to Indian Summer Monsoon (ISM) triggered precipitation, and long-term in-situ data (physical and spectral) exists that aids in the validation of model output, and improving the simulations.

In a one-dimensional numerical modeling approach, coupled GOTM-ERSEM-OASIM using the FABM framework were successfully compiled. The idealized case study with estuarine conditions was chosen for simulations. The simulation outputs (physical variables) were compared with data from acoustic Doppler current profiler, conductivity-temperature-depth, turbulence microstructure, and meteorological sensors. Initially, the spring-neap tidal timescales in the post-ISM season were of concern

because of the importance of decaying ISM-caused stratification that influences the dispersion of biogeochemical tracers. With efficient, regular, and process-specific discussions, the idealized setup was adapted to a realistic case. However, assessing the results it was suggested to fully resolve the processes in a three-dimensional numerical setup.

The three-dimensional numerical setup was planned to be conducted in two stages, (i) couple GETM-FABM-ERGOM to validate ideal and realistic cases in serial and parallel, and (ii) couple OASIM (spectral model within FABM) to GETM-FABM-ERGOM setup to evaluate downwelling and upwelling irradiances in a realistic case.

Several resources were exchanged to implement the three-dimensional numerical setup considering the domain being shallow, turbid, and physically energetic with meteorological forcing. An ideal case of the rectangular basin with GETM-FABM-ERGOM was successfully implemented in serial and parallel mode. To set a realistic simulation for the Goa (India) region, domain (grid and bathymetry) with two estuaries, one interconnecting channel, and four rivers was a complex geometry case that alone took two weeks with continuous reading, discussions, and analysis. To check if the domain functions, a single river test case including one estuary was run in serial and parallel mode and the output was analyzed. It required a lot of debugging and adapting of parameters to the region. The various input files with physical, biogeochemical, meteorological, and spectral variables were created by the end of the visit. The spectral upwelling irradiance codes are parallelly being tested and after satisfactory output, it will be coupled to the GETM-FABM-ERGOM setup.

Upon my return to India, I have constantly interacted at IOW, namely, with Dr. Bronwyn Cahill, Prof. Dr. Hans Burchard, and group meetings. If stuck, Dr. rer. nat. Knut Klingbeil and Dr. Xiangyu Li always made themselves available. Additionally, thorough discussions with Drs. Li and Klingbeil about numerical computing helped me focus on problem-solving.

Outcomes and Future Directions

My guest contract was extended by one year so that I can access the servers at IOW and work closely with the Estuarine and Coastal Ocean Processes and Turbulence and small-scale processes groups at IOW. In addition, the heads of the host and home institutions are also progressing and deliberating to extend the collaboration of furthering research in the Baltic Sea and Goa estuarine and coastal waters with a memorandum of understanding.

Arjun Adhikari, PhD