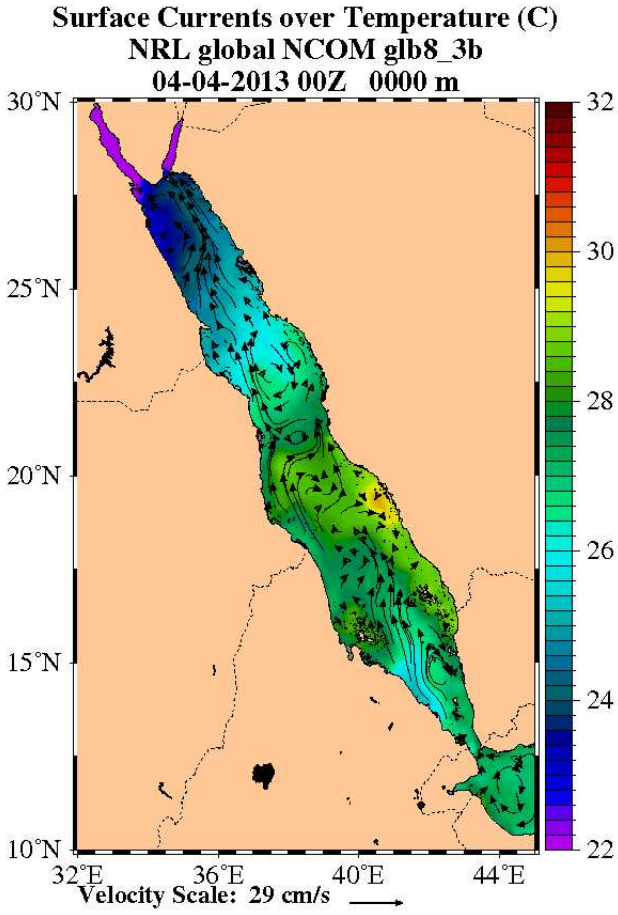
Proposed PhD Research Project:

Eddy-Resolving Modelling of the Red Sea General Circulation

1. Statement of the Problem



The Red Sea. This is a nearly enclosed marginal sea that is one of the most unexplored areas of the Northern Hemisphere ocean and the world's northernmost tropical sea, therefore, it is of particular interest to oceanographers and climatologists. The Red Sea is enclosed by deserts and semi-deserts narrow basin of about 2000 by 300 km, with a deep trench of up to 2500 m depth running along the axis of the basin, and with extensive shallow shelves, noted for their marine life and corals. The only connection of the Red Sea to the open ocean is through the Strait of Bab al Mandab in the south, that provides the link to the Gulf of Aden and the Indian Ocean. The circulation of the Red Sea is anti-estuarine in the sense that there is net inflow of water from the Gulf of Aden and massive evaporation from the sea surface (more than 2 m of water per year). The general circulation is driven mostly by the evaporation and seasonal monsoon winds, and controlled by the basin shape and bottom topography, as well as by the Earth rotation and sphericity. Very high surface temperatures and high salinities make this one of the warmest and saltiest bodies of seawater in the world. Most of the available oceanographic observations of the Red Sea are sporadic and sparse in space making any attempt to construct a picture of its 3D circulation very difficult. However, the existing fragmented information (see Figure) suggests that the circulation is characterized by large surface temperature gradients, boundary currents and multiple stationary and transient mesoscale eddies filling up the basin and making complicated flow patterns.

Modelling General Circulation. The Project will focus on fundamental understanding of the general 3D circulation of the Red Sea and its underlying physical mechanisms by employing a comprehensive and realistic eddy-resolving ocean circulation model code configured for the purpose. The model of our choice will be ROMS (*http://people.atmos.ucla.edu/alex/ROMS/roms.pdf*) developed in UCLA (*http://web.atmos.ucla.edu/roms/Welcome.html*). The model employs superior numerical algorithms and efficient parallelization, and its specific strength is in handling interactions between flow and topography. The proposed research strategy is to treat the atmospheric forcing inputs in a simple and idealized way, and to invest all computational resources into the most dynamically detailed, eddy-resolving flow simulations. Once the spatio-temporal structure of the flow solution is obtained, it will be a subject of thorough dynamical analyses, in terms of both direct diagnostics and idealized process-oriented models. The student will benefit from the interdisciplinary nature of the Project that combines Scientific Computing, Earth System Science and Geophysical Fluid Dynamics.

2. Project Specifics

Have you ever heard that advanced computer modelling may lead theory and field observations? This is precisely a project of this sort!

Research tasks. Carrying out a fair amount of original scientific computations will be the starting point. Next, we'll obtain the full phenomenology of the simulated flow features in terms of descriptive and statistical analyses. This will help us to identify the main phenomena and to pose the key research questions for subsequent in-situ and process-oriented idealized-model analyses, such as dynamical balances, mean/eddy interactions and feedbacks, potential-vorticity and energy budgets, transport properties, etc.

Collaboration. The Project assumes research collaboration with KAUST (*http://www.kaust.edu.sa/*), which is a vibrant and ultra-modern research university on the Red Sea shore that is actively involved in the Red Sea explorations. The key contact will be Prof. Gera Stenchikov (*http://www.kaust.edu.sa/faculty/stenchikov.html*), who is the world-leading expert on multi-scale modeling of environmental processes, atmospheric physics and dynamics, climate change, and regional Red Sea climate. Once the Project matures, the PhD student will benefit from several visits to KAUST. Interaction with the Red Sea modelling group in the Imperial College's Physics Department will be also encouraged.

References

Sofianos, S., and W. Johns, 2007: Observations of the summer Red Sea circulation. *J. Geophys. Res.*, **112**, C06025.

Zhai, P., L. Pratt, and A. Bower, 2015: On the crossover of boundary currents in an idealized model of the Red Sea. *J. Phys. Oceanogr.*, **45**, 1410–1425.