Three-dimensional numerical modelling of the Arabian Gulf with the Arabian Gulf Community Model

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INTRODUCTION

The Arabian Gulf is a large and relatively shallow sea basin. The motion of water within the Gulf is complex and mainly related to the tide. Besides the tide, the wind (storms) and water density differences affect the larger scale water circulations in the Gulf. The Delft3D Arabian Gulf model that was originally developed in 1993 by Deltares (previously named Delft Hydraulics) has recently been made open-source and free to use. This so-called Community Model aims at promoting collaboration between different universities and research institutes active in the Gulf area by the joint development of knowledge on the processes relevant for the Arabian Gulf circulations, including for instance the accumulating impacts of long-term discharges of effluent from power and desalination plants. The Community Model is presently being used by several international research studies, which has led to better insights in the governing circulation processes and improved model settings (Pokavanich et al., 2015 and Chow et al., 2016). Recently, the Community Model was transferred to the new Delft3D-Flexible Mesh modelling software, opening the way to flexible nesting and more efficient parallel computing.

FIELDS OF APPLICATION OF THE ARABIAN GULF COMMUNITY MODEL

The Arabian Gulf Community Model is being used to study the Gulf-wide circulations as input to e.g. large-scale water quality studies and cumulative effects of seawater desalination (i.e. brine discharges, see also Lattemann et al., 2013). In addition, the effects of increased anthropogenic loadings in the Arabian Gulf can be quantified.

The model has also been used to study the effects of climate change and of desalination on the future salinity levels and circulations in the Gulf, see Figure 1 and ElHakeem and ElShorbagy (2015).

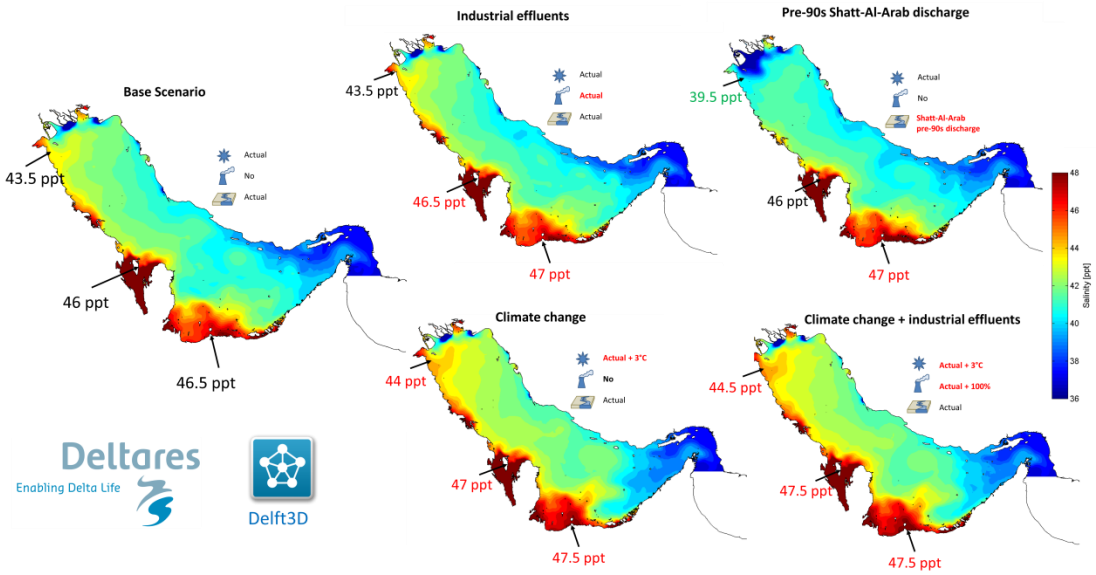

Figure 1 Example of using the 3D Arabian Gulf Model to assess the impacts of climate change, river discharges and desalination industry on the Arabian Gulf salinity levels

In addition to the tide, the Community Model can be driven by time- and spatially varying wind and air pressure fields from global climate models such as ECMWF's ERA-Interim, NOAA's GFS or NCEP-

CFSR models. With these accurate input data sources, basin-wide seasonal circulation behaviour can be studied including for instance quantifying impacts (e.g. flooding) of more severe weather conditions such as the north-westerly Shamals and of intensified storms due to climate change (including cyclones in the Gulf of Oman).
The Community Model can further serve as a basis for:

- Marine spatial planning studies and site selection studies, e.g. for power and desalination plants
- Forecast of harmful algae bloom dispersion
- Operational (oil) spill modelling system
- Effect studies of climate change on ecologically sensitive habitats
- Large-scale effect studies of coastal interventions

CURRENT STATUS OF THE COMMUNITY MODELS

Deltares has developed and maintained a well-calibrated two-dimensional (2D) hydrodynamic Delft3D-FLOW model of the Arabian Gulf since 1993 for computing the tidal and wind-induced water level elevations and currents. More recently, developments were made towards a three-dimensional (3D) version of the Arabian Gulf Model. With this model, the larger scale circulations and exchange flows that are relevant e.g. for Gulf-wide transport processes can be simulated. Developments to the 3D AGM are on-going, but the model already provides a useful basis for research projects in this field (e.g. Pokavanich et al. (2015) and Chow et al. (2016)).

The Delft3D flexible mesh models for the Arabian Gulf are presently being developed and are based on a flexible model grid that is adapted to the local water depth. This model provides a substantially higher resolution in coastal areas than the Delft3D-FLOW models. In the near future, the hydrodynamic models will be expanded further with water quality and ecological models as tool for studying larger-scale environmental aspects of the Arabian Gulf.

ARABIAN GULF MODEL COMMUNITY

These models and knowledge enclosed in them are more valuable to the region if these can be used and further developed by many parties freely and openly. This is why the Arabian Gulf Model Community was set up that aims to promote collaboration and dissemination of this knowledge and modelling tools throughout the region for all interested users (see also http://www.agmcommunity.org/; presently under construction). Several early adopters already successfully used and further developed the model and contributed their developments to the community.

The Arabian Gulf Model community develops and provides modelling tools that:

- can provide a better understanding of the physical processes that determine the basin-wide and more regional circulations in the Arabian Gulf;
- can assess the short- and long-term impacts of climate change;
- can assess the accumulative effects of continued anthropogenic loadings;
- can assist in designing an optimal long-term hydrodynamic and water quality monitoring system in the Arabian Gulf;
- form an efficient basis for hydrodynamic and water quality studies in the Arabian Gulf region;
- can be jointly further developed amongst universities, research institutes and other parties that focus on the Arabian Gulf region;
- teach students and researchers the basis of hydrodynamic and water quality modelling.

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