Institut für Wasser und Gewässerentwicklung
Fachbereich Wasserbau und Wasserwirtschaft
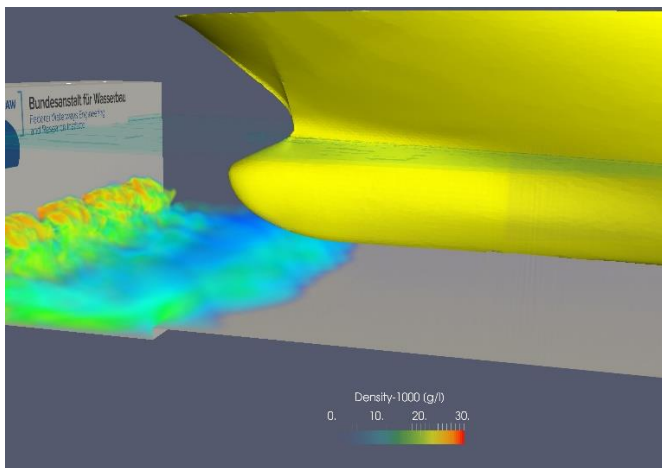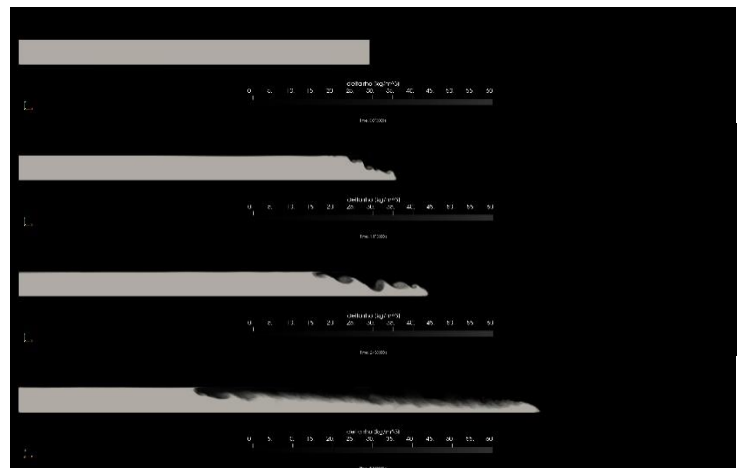Prof. Dr. Mário Franca

06.10.2022

Announcement of a MASTER-thesis

to the subject of

Evaluating the performance of Large-Eddy-Simulations for density driven lock exchange flows

Saltwater intruding into a navigation lock with a ship

Development of lock exchange in laboratory scale

Background and problem description

In navigation locks at the boundary between freshwater and saltwater, gravity currents play a major role in the hydraulic behaviour of the system and can greatly affect mooring forces, which can trigger fatal accidents. In the design process for navigation locks, the interaction between flow and vessel is of major importance, as the forces on the vessel must be kept within safe limits. Thus, detailed studies are required in advance in order to evaluate these forces. In the past, this was exclusively performed with physical models (Bousmar et al. 2017). Due to the significant effort for the physical model studies, numerical approaches have been implemented and tested for this purpose (Thorenz 2010, Van der Ven et al. 2015, Thorenz et al. 2017, Thorenz and Schulze 2021). In any numerical approach, a good foundation on validation data sets is essential (Bayon et al. 2016 or Emami et al. 2020, for instance). For ship locks, a classic validation case is the so-called lock exchange. Many researchers have performed this type of experiment yet data access is challenging in such experiment setups. Only recently a method has been developed that discloses data about the density

distribution with high spatial and temporal resolution (Nogueira et al. 2013). Another application of this method can be found in Theiler and Franca (2016), for which the resulting data is fully available.

Within the scope of this MSc thesis research, the different high-fidelity 3D numerical approaches based on Large Eddy Simulations (Rodi et al. 2013) will be tested against the available experimental data of Theiler and Franca (2016), and potentially other datasets. Based on an already prepared base setup at BAW, the impact of different numerical and physical approaches on the results is to be quantified to produce best practices guidelines. Furthermore, the experimental data should be thoroughly reviewed in terms of possible limitations and uncertainties, to identify stronger variables and potential weaknesses in the validation process. Data processing methods must be developed, which enable the comparison of the results of the three-dimensional numerical model and the experimental data. The discussion of the final results should include an in-depth comparison of the numerical results with the experimental results as well as the critical identification of fundamental limitations of the numerical approach or experimental datasets. Reasons for observed discrepancies should be discussed and future development steps be proposed.

The thesis will be jointly supervised by the Federal Waterways Engineering and Research Institute (BAW) and the IWG. The thesis work will be hosted by BAW.

Detailed work plan:

• Literature study into the relevant topics of numerical simulation, gravity currents and data processing.

• Performing of numerical simulation on large scale computer systems (high performance computing at BAW).

• Evaluation of available physical model data.

• Identification of suitable numerical schemes and turbulence models.

• Development of processing strategies for the numerical and physical model data to allow cross-comparison.

• In-depth performance assessment of the used numerical tools.

• Optional: development of enhancements to the numerical modelling strategy.

• Preparation of the written master thesis and public defence (in English).

Terms

Supervisory team	Examiner: Prof. Dr. Mário J. Franca Scientific supervisión: BAW / Ref. Wasserbauwerke Dr.-Ing. Carsten Thorenz (BAW, / Ref. Wasserbauwerke) Dr. Daniel Valero (IWG)	Recommended knowledge or interests	• Affinity to complex computer work. • Interest in the development of advanced hydraulic numerical simulations. • Data processing (available experimental and new numerical datasets) • Flow dynamics (wall sheared flows, gravity currents). Preference: previous experience as student assistant (HiWi) at BAW.
Period	On demand	Boundary conditions	Working space at BAW Laboratory data from IWG

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