A comparison of Finite Volume and Finite Element Methods for simulating The Indian Ocean Tsunami

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Tsunamis pose an enormous threat worldwide. Tsunami warning systems require accurate models that not only simulate the arrival times of tsunami waves but also accurately simulate extreme run up heights and the extent and risk associated with potential inundations. Here we compare three different low order and efficient finite element and finite volume methods; namely TsunAWI, H2Ocean and Delfin. These models are based on the $P1_{NC}$ -P1 finite element, its' finite volume equivalent and an orthogonal FV method, these models are described in Harig et al. (2008), Cui et al. (2010) and Kleptsova et al. (2010). We describe the flooding and drying algorithms and how they can be implemented in unstructured models. The first model uses an extrapolation technique, whereas the latter two models employ the flooding and drying routines described in Kramer and Stelling (2008). A number of examples are presented, and in particular we pay attention to simulations of the Indian Ocean Tsunami. Part of this work has been carried out in collaboration with the Alfred Wegener Institute in the framework of the GITEWS tsunami warning system.

The Indian Ocean Tsunami was caused by the massive Sumatra-Andaman earthquake that occurred on December 26, 2004. It was recorded by tide gauges in the Indian, Pacific and Atlantic Oceans. It was also the first tsunami to be clearly recorded by a number of satellite altimeters. Many models have been validated against the arrival of the leading tsunami waves when compared with the Jason-1 satellite data, for example, see Pietrzak et al. (2007). However, we show here that the satellite information is not enough to discriminate between tsunami source models. We first show that the three models accurately simulate the inundation of Bande Aceh. Then we use this result to show how accurate inundation models also allow us to determine the source region and discriminate between source models.

References

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