International Max Planck Research School on
EARTH SYSTEM MODELLING

Ocean Tides and the Earth's Rotation - Results of a High-Resolving Ocean Model forced by the Lunisolar Tidal Potential

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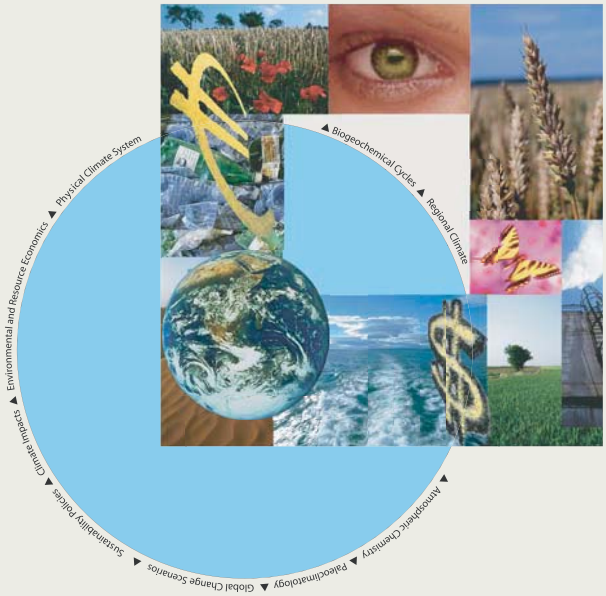
PhD Thesis prepared within the
International Max Planck Research School on
Earth System Modelling



Abstract

The Tidal Model forced by Ephemerides (TiME) has been developed. TiME is a hydrodynamic, global ocean model based on shallow water equations incorporating the complete lunisolar tidal potential of second degree. The spatial resolution has been chosen to be 5 minutes globally (2 - 10 kilometres). Tidal currents and sea surface elevations are calculated in real-time as opposed to most existing tidal models that utilise selected partial tides. The application of complete forcing and non-linear model equations allows for interactions between partial tides and, consequently, the generation of shallow-water tides. The results of the real-time simulations have been divided into partial tides through harmonic analysis in order to compare the results of this study with others. TiME has been evaluated with a set of pelagic measurements of the sea surface elevations. Correlation coefficients are higher than 0.88 for all partial tides considered, showing that the tidal oscillation system is well-captured by this new modelling approach.

The model's high horizontal resolution reveals a detailed picture of tidal propagation on shelf areas worldwide where non-linearities are shown to be most significant. Comparisons of the old partial tide approach with the new approach with complete forcing show that amplitude values of selected partial tides can locally differ by up to 50%. For the first time, global charts of a selection of non-linear shallow-water tides were predicted by an ocean model for both sea surface elevations and tidal currents.

The total energy dissipated by the complete tidal oscillation system has been calculated to be about 4.8 Terawatts (TW). The contribution of ocean tides to tidal friction, which results in an acceleration of lunar angular velocity, has been estimated to be about 4.1 TW. This value lies within the range of available measurements. Most recent studies, however, agree on a lower value of 3 TW.

TiME can calculate the contribution of the entire range of frequencies of the ocean tides to the earth rotation parameters (ERP). This further leads to a novel determination of the oceanic tidal angular momentum (OTAM) taking into account the entire tidal spectrum. The improved description of the ocean tides' influence on OTAM and ERP have been assessed. Comparisons with measurements included tidal constituents which were not investigated by a numerical model study before and show good to excellent agreement. The effects on ERP of some additional astronomical partial tides as well as a selection of shallow-water tides not yet included in any measurement or modelling study have also been calculated.