A GLOBAL OCEAN TIDE MODEL WITH HIGH RESOLUTION IN SHELF AREAS

Joachim Krohn *
Institut für Meereskunde, Universität Hamburg

A numerical finite-difference global ocean tide model with variable grid spacing has been developed. Deep-sea areas are covered by a coarse grid (4-degree meshsize) that is refined in three steps to half-degree mesh-size in most of the shelf areas. The technique of combining coarse and fine grid cells has been generalized. Thus the model is not restricted to a specific arrangement of the numerical grid.

First results for the M\textsubscript{2}-tide are presented. The computed oscillation system (corange and cotidal lines) is compared with observations and other models of the same type consisting of constant coarse or fine resolution. It is generally found that the results are improved by the better resolution of shallow seas and that the tidal wave passes through the different grid sizes without noteworthy distortions. The global distribution of energy dissipation has been computed by evaluating the energy equation belonging to the basic hydrodynamical equations. The corresponding charts are presented.

1. INTRODUCTION

To know the tidal surface of the oceans is a generally accepted requirement. This interest brings together a large variety of disciplines: oceanography, coastal engineering, geodesy, geodynamics and astrophysics among others. Especially the attempts of determining the oceanic geoid and the demand for accurate positioning of artificial satellites as well as the interest in the (present and ancient) rotation of the Earth have recently illustrated the necessity of knowing the global ocean tides. Due to the lack of empirical tide data sufficiently distributed over the whole ocean, this could only be achieved by using numerical models.

Since the first attempts (e.g. BOGDANOV & MAGARIK 1967) modellers have tried to improve their methods and techniques. Without going into details of the historical development (these can be found in the review articles by DOODSON 1958, HENDERSHOTT & MUNK 1970, HENDERSHOTT 1973,

* present affiliation: GKSS Research Center, Geesthacht, Fed.Rep.Germany
1977, PARKE 1978, CARTWRIGHT 1978 and SCHWIDERSKI 1980) it should be noted that for some of the above mentioned applications the improvements obtained so far are not sufficient (SCHWIDERSKI 1982). These include the consideration of the complete nonlinear hydrodynamical equations (HDE) by ZAHEL (1970), of secondary forces as tidal loading and self attraction processes (e.g. HENDERSHOTT 1972, ESTES 1977, ZAHEL 1978) and the computation of the most significant partial tides (e.g. ZAHEL 1973, 1980, ACCAD & PEKERIS 1978, SCHWIDERSKI 1978, PARKE & HENDERSHOTT 1980, PARKE 1982). The recently developed method of combining the theoretical results of a numerical model with empirical data at every coastal point and even at all islands where data are available (SCHWIDERSKI 1978) seems to give realistic results for the tidal elevations. A verification, however, is then restricted to very few deep-sea gauge data that are distributed very inhomogeneously over the world ocean (CARTWRIGHT 1979).

Particularly the grid resolution of the global models, though refined up to 1-degree angular mesh-size, has turned out indeed to yield more realistic results than coarser grids (ZAHEL 1977) but not to give satisfactory ones near the shelf edge and on the shelves themselves. The importance of the shelves for the progressing tidal wave is well-known (v. TREPKA 1967) and has been recently revisited on a global scale (GOTLIB & KAGAN 1982 a-c). The evolution of the solar system is influenced by the energetics of the ocean tides, i.e. the amount of dissipated energy that itself is generated by the tidal potentials of the moon and the sun (e.g. BROSCH & SÜNDERMANN 1982). Due to the large tidal currents the dissipation by bottom friction on the shelves yields the most important contribution to this process.

The presented model represents a first attempt to incorporate shelf areas in a global model. As it is neither possible to use the same fine mesh size all over the world ocean due to computer limitations nor is it necessary as is demonstrated comparing coarse and fine mesh versions of the same model (ZAHEL 1970, 1977, 1978), a more economic procedure has been chosen: the deep parts of the ocean are covered by a coarse grid (4 degrees) that is refined in several steps up to a certain minimum grid size (half degree at present) on the shelves.

In the following section (2) some properties of the model (i.e. the basic equations, the variable mesh-size global grid and the coupling mechanisms) are described; section (3) gives first results concerning the amplitudes and phases for the M2-tide and some terms of the energy equation as well.

2. MODEL CONCEPT

The model is based on the ideas of ZAHEL, but includes the advection terms for it should be applicable to the shallower regions of the shelves where nonlinear processes cannot be neglected anymore. It is driven by the tidal potential $\phi$ including the solid Earth tide by assuming an elastic yielding of the sea bottom but it excludes the effects of