IMPROVED GRAVITATIONAL AND DYNAMIC HEIGHT MODELS THROUGH THE INCORPORATION OF HYDROGRAPHIC AND OCEANOGRAPHIC INFORMATION

D.E. Smith, F. Lemoine, C. Koblinsky (NASA/Goddard Space Flight Center, USA),
R. Rapp (Ohio State University, USA),
N. Pavlis, S. Klosko(Hughes STX, USA)

The most accurate global models of the terrestrial gravitational field at long wavelength have been developed from analyses of tracking data acquired on near-earth satellites [Nerem et al., 1995]. These data have been augmented with areal means of surface gravimetry and satellite altimetry to improve the resolution and short wavelength accuracy of the models. Contemporary gravity models are computed under the assumption that a subset of the infinite series of potential coefficients can suitably model the tracking data given attenuation of the field at satellite altitude.

Efforts have been made to exhaust the gravitational signal present in satellite tracking data by extending the models to degree and order 70 [e.g. Marsh et al., 1990; Nerem et al, 1994; Tapley et al., 1996]. Given the surface character of altimetry and gravimetry, global models have been developed to very high degree and order such as the recent GSFC/NIMA EGM96 model complete to degree 360 [Lemoine et al., 1996] to exploit these well-sensed short wavelength gravity signals. A second assumption, now having to be modified as modeling demands increase, is that the potential coefficients themselves are time invariant. Through various studies, the temporal changes in the long wavelength, non-tidal field is becoming understood. For example, there are ± 3-5 cm non-tidal geoid changes which are now sufficiently well determined to improve the extraction of ocean circulation signals at annual and semi-annual time scales.

The major limitation for determination of the ocean geoid in these models arises from the signal content seen in altimeter data. While the ocean surface mapped by altimeters largely conforms to the equipotential gravity surface, ocean circulation causes a significant departure of the surface from that of the geoid. Since altimetry uniquely provides dense information for modeling the ocean geoid, the separation of the oceanographic from geoid surfaces is a pressing challenge. Our investigation is directed toward ocean gravity modeling improvements which will be accomplished principally through the introduction of hydrographic data and ocean circulation modeling products contemporaneous with the T/P, ERS-1/2 and GFO altimetry in simultaneous solutions for geopotential and dynamic topography fields. These hydrographic data will help to define the dynamic height field within these simultaneous solutions. Assessment and incorporation of improved oceanic surface gravimetric data sets will also be pursued as a third component of this investigation. All resulting models will be calibrated and reported with reliable error estimates.

For a baseline, this investigation will utilize state-of-the-art geopotential solutions which have been developed by our GSFC group through a joint effort with NIMA; this proposal represents an augmentation to this work with focus on ocean geoid improvements and improved understanding of the ocean-wide circulation. While the combination of T/P altimetry and hydrographic data has provided geoid estimation in certain regions which rivals classical satellite-tracking derived approaches, this large hydrographic data base is not utilized in current geopotential solutions. Exploiting these data to improve the isolation of the geoid signal within altimetry holds great promise |c.f. Stammer and Wunsch, 1994]. Also, improved sets of ocean gravimetry will also be used to independently assess modeling gains in well mapped regions.

This investigation has the following objectives and expected results:

A. Develop improved comprehensive gravity models complete to degree and order 70 by:
    - introducing hydrographic/OCM modeling products into the reduction of altimeter data to better extract the ocean geoidal signal;
    - incorporating improved ocean surface gravimetry.
    - provide accurate time variations of the long wavelength geoid predicted by various climatological, post-glacial rebound, and environmental sources as confirmed by independent SLR analyses as a reference for dynamic height fields.

B. Numerical models of the ocean's circulation are becoming more realistic over time as a result of improved model designs, better data sets, increases in computational power, experience gained in understanding how physical parameters affect model dynamics, and comparisons against increasingly more accurate global data. We will evaluate this source of information for inclusion in the model. We will characterize the error properties of OCM runs. This characterization will be made through a comparison of models having differing origins, spatial resolution, forcing, treatment of bathymetry, and assumptions about correlation distance in the error covariance. We will assess the temporal characteristics of the optimal model for inclusion in the geopotential solution. Whether to employ a multi-year mean OCM, or a model which has specific temporal characteristics (cycle-average, monthly average, yearly average) will be investigated.

C. We will include additional satellite tracking data sets which provide near-continuous, highly precise measurements (e.g. GPS and TDRSS). To demonstrate the benefit achieved through our recent incorporation of a large additional tracking data set in the post-TOPEX models under development by GSFC/NIMA, Table 1 compares gravity models by taking a two-year average TOPEX mean sea surface and subtracting various geoidal models. POCM_4b has provided model output over the same time period and has been likewise temporally averaged. This table sheds insight into the current state-of-the-art in N recovery using altimeter data and the progress made in the recent gravity and N models produced by GSFC/DMA.

Gravity Model	rms differences degree 14 rms (cm)	rms differences degree 24 rms (cm)
JGM-2 [Nerem et al., 1994]	14.2	15.5
JGM-3 [Tapley et al., 1995]	12.6	14.2
EGM96 [Lemoine et al., 1996]	10.9	12.4

Table 1

Comparison of TOPEX-derived N with that predicted by POCM_4b

D. Evaluate parametric representation of N. Currently, spherical harmonics are used which, by being global (i.e. defining values over the continents) and being of the same form as the gravitational model's basis functions, are not optimal. We will explore use of alternative parameterization including Proudman functions, orthonormal functions and height functions.

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