Possible Role of the Oceans in the Variations of Length of Day at High Frequencies

Thomas J. Johnson

Earth Orientation Department, U.S. Naval Observatory, Washington DC, USA

At the U.S. Naval Observatory, there are a few research studies as well as operational tasks that use data available from Global Geophysical Fluid Center (GGFC) web and ftp sites. This research includes: investigating the excitation mechanisms of Earth rotation variability on all time scales, examining the global water budget and its role in exciting Earth rotation, researching the usefulness of ocean model nowcast/forecast models in predicting Earth rotation, and investigating the role of geophysical fluids in gravity field variations on GPS satellites.

This presentation will briefly cover USNO's ongoing research to examine high frequency variations in excess Length of Day (LOD). It will also highlight the GGFC datasets used in the study as well as raise some issues with respect to the currently available GGFC datasets and what this researcher would like to see in the future to make this type of research easier.

The excess LOD has variability at time scales ranging from the sub-daily to decadal. The research appears to indicate that on decadal time scales the variability in the core and core-mantle interactions can excite LOD variability on these longer time scales (Eubanks, 1993). For periods of less than a decade to a few years it appears that the oceans excite some of these variations in LOD (Johnson et al., 1999). While for periods of a year and less the atmosphere can explain about 90% of the variations in LOD (Eubanks, 1993) with the oceans and continental hydrology contributing at a much smaller amount at specific frequencies between a few weeks and a year (Marcus et al., 1998; Johnson et al., 1999; Chen et al., 2000).

This research comes out of USNO's efforts to improve the combination solution and the near-term predictions of UT1–UTC variations that are published in the IERS Rapid Service/Prediction Center Bulletin A. In the spring of 2000, USNO began re-evaluating the usefulness of a UT1-like product estimated from atmospheric angular momentum (AAM). The AAM examined in this study was the model estimates produced by the National Centers for Environmental Prediction (NCEP) operational model. These AAM data products are made available through the GGFC Special Bureau of the Atmosphere (SBA).

The results of this study indicated the existence of variability, with periods varying between 5 and 15 days, in the AAM UT1-like quantity (UTAAM) that was not present in the UT1–UTC combination solution and once this variability was removed the UTAAM became very useful in improving our near-term predictions of UT1–UTC. This led to a technique that uses an intermediate UT1–UTC solution to estimate and remove this unobserved variability from the UTAAM data product (Johnson et al., 2002). This approach has reduced the UT1–UTC prediction error by 42% at 10-days into the future.

However, this still leaves a very important question unanswered. What is the cause of this unexplained variability at periods ranging from 5 to 15 days. It could be the result of some model limitations or errors in the NCEP operational models, or was something else contributing to the variability.

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Potentially, one of the larger sources of error in modern atmospheric models is the model's handling of water vapor and water vapor transport. Comparisons between NCEP Reanalysis, Goddard's Earth Observing System (GEOS), and the European Centre for Medium-Range Weather Forecasts (ECMWF) atmospheric models indicate that one of the biggest differences between these models is the total amount of water vapor contained in each model as well as its distribution. To examine the water budget of the NCEP model, we compared its values with those observed by satellite microwave mapping and imaging (SMM/I) aboard weather satellite 13. These comparisons showed that there is reasonable agreement between the model estimates and the SMM/I observations for water vapor mass variability and its distribution.

In addition to examining the SMM/I observations, I examined the possible contributions from the ocean and hydrology using datasets available from the GGFC Special Bureau for the Oceans (SBO) and NCEP. The SBO web site provided the oceanic angular momentum (OAM) dataset named Johnson01.oam and the NCEP web site provided daily values of water equivalent of accumulated snow depth (WEASD) and soil moisture from NCEP's Climate Data Assimilation System-1 (CDAS-1).

An examination of the WEASD and soil moisture data produced by NCEP's CDAS-1 showed little to no variability on periods less than three months and therefore this could not explain the variability that was present in the atmosphere and not present in the UT1–UTC time series. This lack of high frequency variability in the NCEP's CDAS-1 data products may be due to the influence of the climatological data used in the model.

An examination of the OAM values from the Johnson01.oam dataset clearly showed that the oceans could be the source of this variability. The cross correlation indicates that the oceans are significantly correlated with the variability unaccounted for by the atmosphere on periods less than a few months. The coherence analysis indicates that for a number of frequencies between 22 and 36 cycles per year the coherence exceeds the 95% confidence level. Analysis of the power spectra indicates that the oceanic variability has power similar to the unexplained variability at few of these frequencies. Therefore, the oceans appear to be the leading candidate in explaining this variability.

This research would have been much more difficult to undertake without the datasets that are available through the GGFC. However, it is in the opinion of this researcher that the GGFC could improve their services and data products. These improvements include but are not limited to: (1) promoting the development of new data products and the improvement of existing data products, (2) promoting product center documentation, (3) promoting the release of existing datasets (especially datasets from GGFC collaborators), (4) monitoring the performance of GGFC Special Bureaus on quality of available datasets, and (5) promoting collaborations between researchers in the atmospheric, oceanographic, hydrological, climatological, and solid Earth sciences. The GGFC has the unique opportunity to become the major source of geophysical fluids for researchers world-wide and addressing these concerns would be a good step in securing that outcome.

In closing, this researcher would like to make the following two suggestions on what the GGFC could do to improve the usefulness of the GGFC datasets. First, the GGFC must make sure that the special bureaus properly document their existing datasets. This includes correcting the dataset documentation that is clearly inaccurate and incomplete. Finally, the IERS GGFC could work on expanding the number of regularly updated atmospheric datasets that are currently available, adding near-real time/daily updated atmospheric AM datasets that use Non-IB, IB, and dynamic barometer corrections, and adding nowcast/forecast global oceanic AM datasets. These improvements would greatly increase the usefulness of IERS GGFC datasets in addressing current and future research needs.

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