ATMOSPHERIC EXCITATION OF EARTH ROTATION/ POLAR MOTION AT HIGH TEMPORAL RESOLUTION

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ABSTRACT. We have calculated atmospheric effective angular momentum functions of Earth rotation/polar motion with hourly resolution based on the NASA Goddard Earth Observation System (GEOS-4) atmospheric model. Such excitations are based on model forecasts at five of the six hours, and a mixture of model and observations at the sixth hour. This heterogeneous procedure can cause discontinuities if not mitigated by special approaches. The wind-based polar motion terms have a strong diurnal signal related to tidal fluctuations, though the phase appears to vacillate. October 2002 encompassing the intensive CONT02 Earth rotation-observing period was selected here. Time-spectra of wind-based, pressure-based, and geodetic terms reveal diurnal and semidiurnal signals with additional sub-daily spectral peaks. NASA is currently introducing the d́2Modern Era Retrospective-Analysis Research and Applications system, which should eliminate the 6-hour discontinuities. This MERRA system will give us the opportunity to investigate high temporal resolution excitation for more recent CONT campaigns.

1. ATMOSPHERIC ANGULAR MOMENTUM (AAM) AND EARTH ROTATION

The values of AAM are closely related to the excitations of variability of Earth rotation and polar motion due to conservation of angular momentum in the Earth system. Changes in winds and the atmospheric mass are responsible for the AAM variability, with winds dominating the variations in the axial (length-of-day) terms, and the pressure dominating the polar motion terms on frequencies other than the very rapid sub-daily ones.

The wind-based excitation terms have a strong diurnal signal due to the atmospheric thermal tides. These signals are, however, modulated seasonally (Zhou et al. 2006) so that signals determined at particular hours (example only at 00 UTC) are relatively smooth. The mean diurnal signals of the wind-based polar motion excitation changes phase throughout the months of the year, so for example, large diurnal amplitudes occur in the solstitial seasons, in mid-summer and mid-winter, and smaller amplitudes occur in the equinoctial seasons.

2. HIGH TEMPORAL RESOLUTION ANGULAR MOMENTUM ANALYSIS WITH NASA SYSTEM

GEOS-4 data assimilation system is run on a 1.25 degree longitude by 1 degree latitude resolution. Although it is formally updated every 6 hours by means of a data assimilation step at that epoch, we have worked with the Global Model and Assimilation Office at NASA Goddard Space Flight Center to save winds and surface pressure as well on an hourly basis during the course of the model integration in between the 6-hourly analyses. Thus the 5 hourly values in between the formal six-hour analyses are based on the forecast model results. We chose one month, October 2002, to determine the hourly excitation functions from the GEOS-4 model, during the Very Long Baseline Interferometry (VLBI) CONT02 campaign in which high temporal resolution Earth Orientation Parameter data would be available for comparisons with the atmospheric high-resolution data.

Meteorological data assimilation systems are composed of an analysis step and a forecast step, with raw observations from instruments including rawinsondes, aircraft and satellite sensors. They are combined in an optimal fashion with the results from a forecast initialized 6 hours prior. Then a new forecast is started, during which excitations may be calculated at any time step. Here we access hourly values.

The chi-1, chi-2, and chi-3 data from both winds and pressures have been computed hourly. The biggest signals occur in the chi-1 and chi-2 wind terms, with different periods during the month having a strong value, and appear sometimes to be about 1/4 day apart in phase. (Fig. 1) All fields have some visible discontinuities in the graphs that occur before all hours divisible by 6, indicating the data assimilation step. We are reasonably confident in the solution because it matches fairly well the values computed from the NCEP-NCAR reanalyses (not shown). We noted that the wind based-excitation terms diurnal signals vacillate considerably in amplitude and partly in phase throughout the month.

We address the issues of the 6-hour discontinuities evident in the data, and we have derived two methods to deal with it, one by linear removal (LDLIN) of the jumps that occur then, and the other by a statistical spectral analysis (SSA3) approach (Fig. 2). Time spectra of the rapid fluctuations up to the order of a day were computed and we note that the peaks that existed at some of the harmonics of a day in the new data have decreased but not fully disappeared in the processed data (Fig. 3). The atmosphere may thus be related, though weakly to the 8-hour fluctuations that have been detected in the geodetic series, though their amplitudes are considerably larger.

Estimates of the spectra of excitations of polar motion from geodetic measurements are given below for CONT02 and a later period of intense examination by the VLBI technique in 2005 (Fig. 4). We can see peaks around 6, 8, 9 and 12 hours, though these are strong for the CONT02 period, though less so for the CONT05 period.

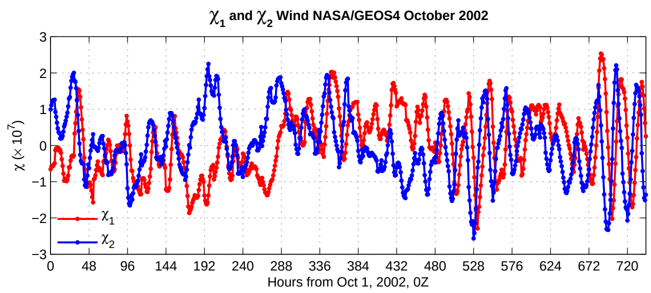

Figure 1: Hourly values of the wind-based excitations for polar motion from the GEOS-4 simulations.

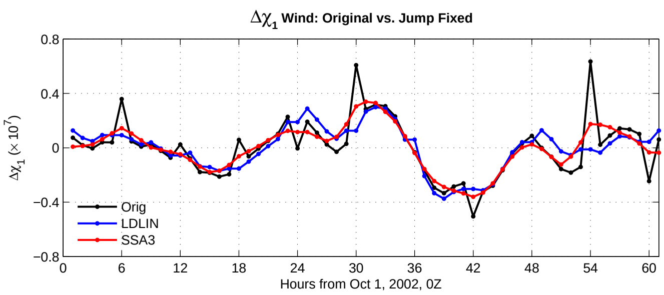

Figure 2: Time series in the first 60 hours of the chi-1 wind term with jumps removed by two methods.

3. MERRA MODERN ERA RETROSPECTIVE ANALYSIS FOR RESEARCH AND APPLICATIONS

The MERRA system is being developed at NASA Goddard Space Flight Center to be run as a reanalysis, and it is designed to make special use of remote sensing on satellites. It will have smoother transitions because of an Incremental Analysis Update technique. Although 3-dimensional and two-dimensional fields are regularly output on 6- and 3-hour intervals, respectively, we are preparing for hourly fields from the model, as we did for the GEOS-4 series, when they are available to be able to calculate the atmospheric excitation term for polar motion.

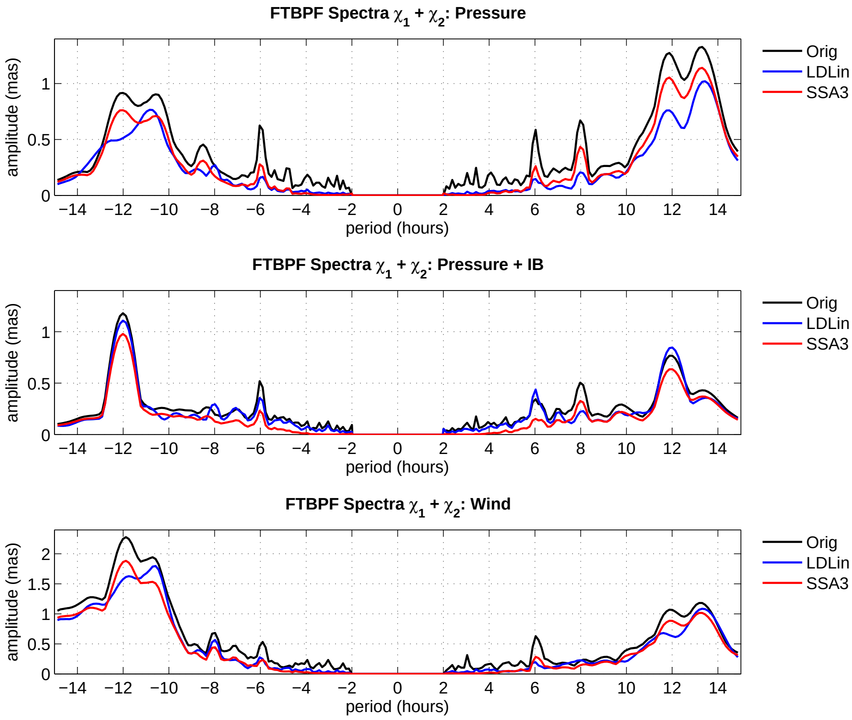

Figure 3: Power spectra of complex chi-1, chi-2 with and without jump removal.

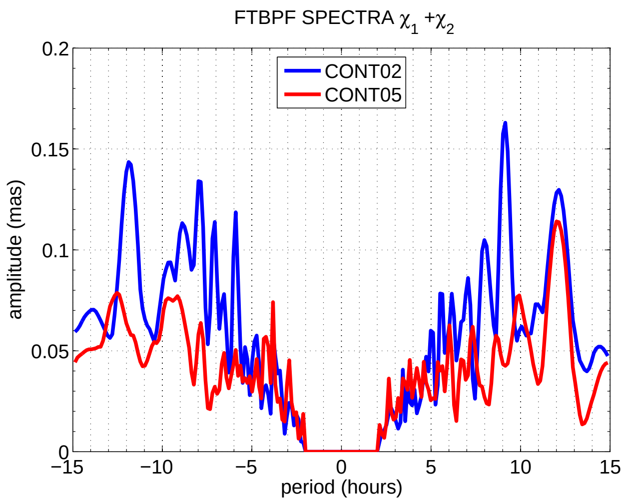

Figure 4: Power spectra of complex polar motion excitations from the CONT02 and CONT05 periods.

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4. REFERENCES

Zhou, Y.H., D.A. Salstein, and J.L. Chen, 2006, Revised atmospheric excitation function series related to Earth rotation under consideration of surface topography, J. Geophys. Res. (Solid Earth), 1111, D12108, doi:10.1029/2005JD006608.