COMPARISONS OF HYDROLOGICAL ANGULAR MOMENTUM (HAM) OF THE DIFFERENT MODELS

J. NASTULA[1], B. KOLACZEK[1], W. POPIŃSKI[2]
[1]Space Research Centre
Bartycka 18a, 00-716 Warsaw, Poland
e-mail: nastula@cbk.waw.pl; e-mail: kolaczek@cbk.waw.pl
[2]Central Statistical Office
Al. Niepodległości 208, 00-925 Warsaw, Poland
e-mail: W.Popinski@stat.gov.pl

ABSTRACT. In the paper hydrological excitations of the polar motion (HAM) were computed from various hydrological data series (NCEP, ECMWF, CPC water storage and LaD World Simulations of global continental water). HAM series obtained from these four models and the geodetic excitation function GEOD computed from the polar motion COMB03 data were compared in the seasonal spectral band. The results show big differences of these hydrological excitation functions as well as of their spectra in the seasonal spectra band. Seasonal oscillations of the global geophysical excitation functions (AAM + OAM + HAM) in all cases besides the NCEP/NCAR model are smaller than the geodetic excitation function. It means that these models need further improvement and perhaps not only hydrological models need improvements.

1. INTRODUCTION

Excitation of polar motion is related in large measure to the redistribution of atmospheric, oceanic and hydrological masses. Up to now the influence of hydrological masses variations on polar motion has not been recognised well, due to lack of data of hydrological excitation of polar motion (Hydrological Angular Momentum - HAM). Recently several models of hydrological components, land water, snow, soil moisture have been worked out and studied (Chen and Wilson, 2005). They are available in the Special Bureau for Hydrology (SBH) of the Global Geophysical Fluid Center (GGFC). Our previous investigations of influence of HAM on the polar motion in different part of spectra show that consideration of the daily HAM data available in the SBH does not improve agreement of the geophysical excitation of polar motion containing contributions from atmosphere, oceans and hydrology (AAM+OAM+HAM) with geodetic excitation function (Nastula, Kolaczek, 2005).

In the present paper hydrological excitations of the polar motion are computed from various hydrological data series. Three of them National Centers for Environmental Prediction (NCEP), European Centre for Medium – Range Weather Forecasts (ECMWF) and Climate Prediction Center (CPC) are available from the website of the SBH. The additional hydrological data are the Land Dynamics (LaD) World Simulations of global continental water for the period from 1980 to April 2004 (Milly and Shmakin, 2002). The spectra of these HAM series obtained from the four models in seasonal spectral band are compared with the spectra of geodetic excitation function (GEOD) of polar motion, computed from the polar motion COMB03 data (Gross, 2003).

2. DATA

In this paper we investigate the polar motion excitation of geophysical fluids, atmosphere, ocean and hydrosphere. The oceanic influence on polar motion is investigated by using Oceanic Angular Momentum (OAM) derived by Gross et al. (2003) from the ECCO – JPL (Estimating the Circulation and Climate of the Ocean – Jet Propulsion Laboratory) ocean model, from 1980 to 2002.2. The data are available from the web site of the Special Bureau for the Oceans (SBO) of the GGFC. Oceanic excitation is consider as sum of the signals resulting from changes in the oceanic mass and velocity fields. The input OAM series assumes an oceanic inverted barometer correction (IB) which is response to surface atmospheric pressure signals.The atmospheric angular momentum (AAM) series is derived from 6-hour time series of the U.S. NCEP/NCAR reanalysis data (Salstein et al., 1993; Kalnay, 1996). In this study we used a sum of the wind and the pressure terms with the IB correction for the ocean response, what is consistent with the OAM series. The daily hydrological excitation function HAM is obtained by two means. The one HAM is taken from the web site of the Special Bureau for Hydrology of the GGFC for the period from 1948 -2001. This HAM is computed by the SBH from the NCEP/NCAR Reanalysis soil moisture and snow accumulation data model. The three HAM excitation functions were computed using formula given by Chen and Wilson(2005) from the three water data storage: 1. HAM-LaD (Land Dynamics) model DANUBE containing monthly solutions of snow water equivalent, shallow grand water in 1980-2004 (Milly and Shamkin, 2002); 2. HAM CPC-LDAS model containing monthly solutions of soil water storage in 1980-2004 developed by National Oceanic and Atmospheric Administration (NOAA) Climate Prediction Center (CPC); 3. HAM ECMWF model containing daily solutions of water storage defined as the sum of wetness and snow water in 1979-1993 based on the ECMWF reanalysis data. The last 2 water storage data sets are available at the SBH. The HAM ECMWF model computed in shorter period of time in 1979-1993 was not considered in further analysis.

The excitation function of polar motion referred to as "geodetic" excitation (GEOD)was computed from the polar motion COMB03 data (Gross, 2003) by applying the Kalman filter developed by Brzeziński (Brzeziński, 1992; Brzeziśki et al., 2004). The input polar motion data with 12-hour sampling covers the period from 1962 to 2003.

The equatorial components of all these HAM data χ_1, χ_2 are shown in Fig. 1. It is easy to see that these functions are different and the SBH, NCEP/NCAR data are larger than others.

3. SPECTRA COMPARISONS

In order to check the character of the variations of the considered series of excitation functions of polar motion, spectra of all considered excitation functions were computed by means of the FTBPF (Fourier Transform Band Pass Filter), (Kosek, 1995). To ensure a high frequency resolution in the computation of FTBPF, appropriate values of the parameter λ, describing the filter bandwidth, have to be chosen. In this paper $\lambda = 0.02$ was chosen. The spectra of all these models show oscillations with annual, semiannual and 120 day periods both in the prograde as well as in the retrograde band (see Figures 2 and 3). It is easy to see that amplitudes of these oscillations are different in the different models. The smallest amplitudes of these oscillations are in the case of the LaD model of HAM. In the case of the NCEP/NCAR SBH model of HAM the amplitude of the annual oscillation is high and comparable with the amplitude of annual oscillation of AAM + OAM excitation function.

In the spectra of the global geophysical fluids excitation functions (AAM+OAM+HAM) the annual oscillation is the most energetic one. Amplitudes of the annual oscillation of the global geophysical fluid excitation function with the NCEP/NCAR model of HAM is much higher than in the case of the geodetic excitation function. The best agreement of the amplitudes of the annual oscillations of the global geophysical excitation function with the geodetic one is in the case of the CPC model of HAM in prograde part of the spectrum and in the case of LaD model of the HAM in the retrograde part of spectrum. In other part of the seasonal spectrum of the global geophysical fluid excitation functions amplitudes of their oscillations are much smaller than in the case of the spectrum of geodetical excitation function. Comparison of the non-atmospheric+oceanic excitation function of polar motion with the hydrological excitation shows a nearly good agreement of amplitude of their annual oscillations in χ_1 and χ_2 and of semiannual oscillations in χ_2 only (Fig. 4).

5. CONCLUSIONS

Mass fields are important to both gravity missions and the Earth rotation, and here we considered the second.

HAM excitation functions computed from different water storage model are not homogeneous and differs greatly in temporal characteristics and in their spectra in the seasonal band.

HAM excitation functions do not improve the agreement between the observed geodetic excitation function and the global geophysical excitation function of polar motion.

The HAM models need further improvements.

Acknowledgments. The research reported here was supported by the Polish State Committee for Scientific Research through project 4 T12E 04526.

REFERENCES

Chen, J.,L., and C. R. Wilson, 2005, Hydrological excitations of polar motion, 1993-2003, *Geophys J Int.*, 160, Issue 3. pp. 833-839.

Brzeziński, A., 1992, Polar motion excitation by variations of the effective angular momentum functions: considerations concerning deconvolution problem, *Manuscr. Geodet*, 17, 3-20.

Brzeziński, A, J. Nastula, B. Kolaczek and R. M. Ponte, 2004, Ocean excitation of polar motion from intrasesonal to decadal periods, Proceedings of the 23rd IUGG General Assembly, Sapporo 2003 Japan, IAG Symposia Vol.128 A window on the future of geodesy, edited by Fernando Sanso, Springer-Verlag Berlin Heidelberg 2005, pp 591-596.

Gross, R. S., 2003, Combinatios of Earth Orientations Measurements: SPACE02, COMB2003 and POLE2002, Tech. Rep. JPL Publications 02-011, JPL, Pasadena, CA.

Kalnay, E., 1996, The NCEP/NCAR 40-year Reanalysis Project, *Bull. Amer. Meteor. Soc.*, 77, 437 - 471.

Kosek, W., 1995, Time Variable Band Pass Filter Spectrum of real and complex-valued polar motion series, *Artificial Satellites, Planetary Geodesy*, 30, 1, 27 - 43.

Milly, P.C.D. and A. B. Shmakin, 2002, Global Modelling of Land Water and Energu Balances. Part I: The Land Dynamics (LaD) Model, *J. Hydrometeor*, 3, 283-299.

Nastula, J. and B. Kolaczek, 2005, Analysis of Hydrological Excitation of Polar Motion. Proceedings of the Workshop: Forcing of polar motion in the Chandler frequency band: a contribution to understanding interannual climate variations. Centre Europeen de Geodynamique et de Seismologie, Luxembourg, 149-154.

Salstein, D. A., D. M. Kann, A. J. Miller, and R. D. Rosen, 1993, The Sub-Bureau for Atmospheric Angular Momentum of the International Earth Rotation Service: a meteorological data center with geodetic applications, *Bull. Amer. Meteor. Soc.*, 74, 67-80.

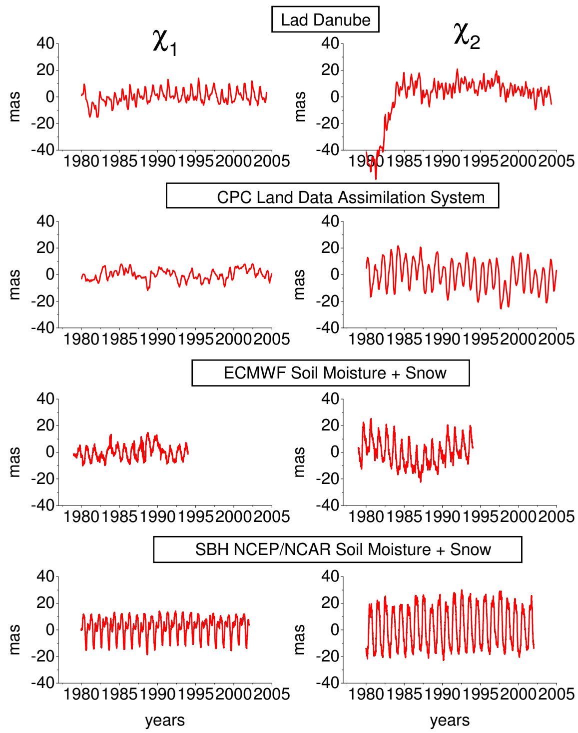

Figure 1: The equatorial excitation functions χ_1 and χ_2, computed from different hydrological data.

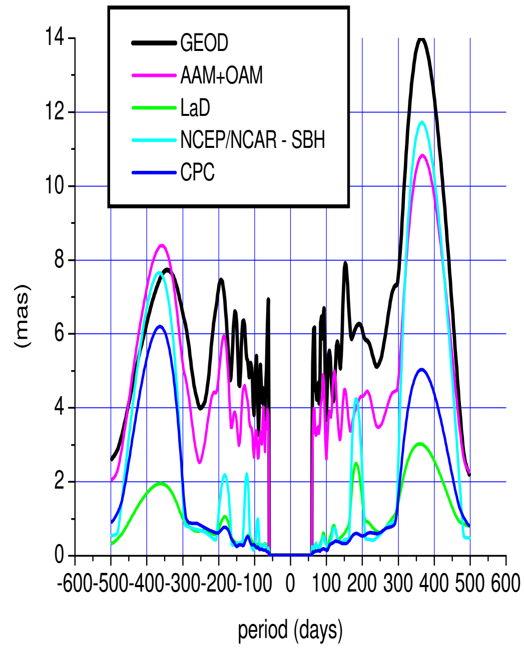

Figure 2: The FTBPF amplitude spectrum of the excitation functions in 1985-2002 filtered by the Butterworth FTBPF with the 600 day cutoff period and computed for the parameter $\lambda = 0.02$.

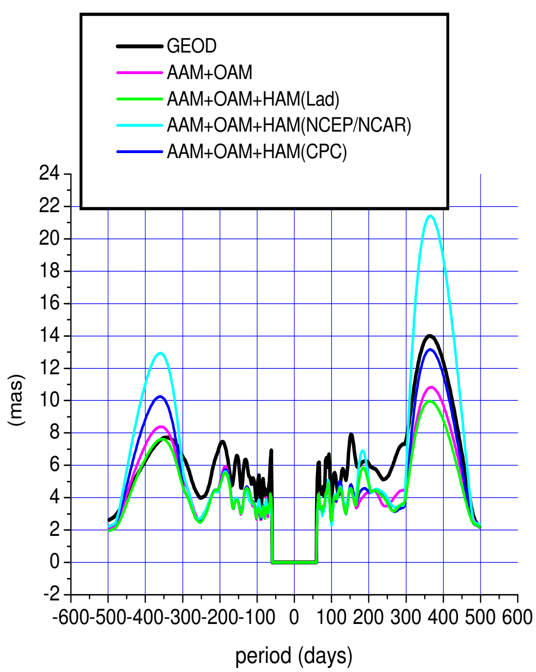

Figure 3: The FTBPF amplitude spectrum of the excitation functions in 1985-2002 filtered by the Butterworth FTBPF with the 600 day cutoff period and computed for the parameter $\lambda = 0.02$.

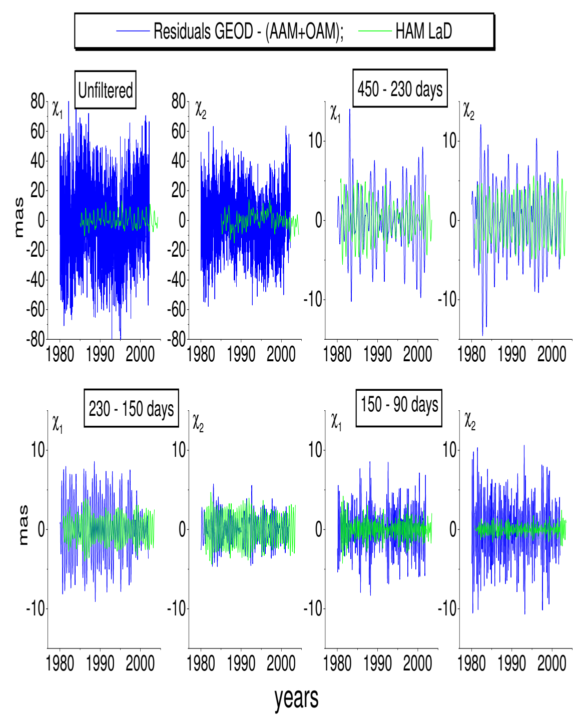

Figure 4: Comparison of the non-atmospheric + oceanic excitation function of polar motion with the hydrological excitation data in different spectral bands.