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Hydrological excitation of polar motion

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ABSTRACT

Hydrological excitation of the polar motion (HAM) were computed from the available recently hydrological data series (NCEP, ECMWF, CPC water storage and LaD World simulations of global continental water) and compared.

Time variable seasonal spectra of these hydrological excitation functions and of the geodetic excitation function of polar motion computed from the polar motion COMB02 data were compared showing big differences in their temporal characteristics and the necessity of the further improvement of the HAM models.

Seasonal oscillations of the global geophysical excitation functions containing atmospheric (AAM), oceanic (OAM), hydrological (HAM) components and their time variations were compared also. These hydrological excitation functions do not close the budget of the needed global geophysical excitation function of polar motion.

DATA

The following hydrological excitation functions were considered in the paper:
HAM-NCEP/NCAR: from the web site of the IERS Special Bureau for the Hydrology (SBH), computed from NCEP/NCAR Reanalysis, daily solution for 1948-2004.

The excitation functions computed from the data of water storage given below:
HAM-LaD: (ground water, land water, snow), monthly solution for 1980-2004; **HAM-CPC-LDAS**: (soil water), monthly solution for 1980-2004; **HAM-ECMWF**: (soil wetness and snow water) daily solution for 1979-1993; **HAM-GLDAS**: (water storage) daily solution for 2002-2005.

The following geodetic atmospheric and oceanic excitation functions are used:

GEOD: geodetic excitation computed from the polar motion data COMB02 series (Gross, 2003, Brzeziński et al.., 2005).

AAM: **(Atmospheric Angular Momentum) of NCEP/NCAR reanalysis:** pressure + IB + wind for 1948-2005.

OAM: ocean model, (Gross et al., 2004), (bottom pressure + currents), which is modification of the MIT model, forcing by surface wind stress, head flux, freshwater flux from NCEP/NCAR, sampling interval 0.5 day, for 1980-2002.2.

Water storage data

Global continental water and energy balances - the Land Dynamics (Lad) model includes: snow water equivalent, shallow ground water, soil water (Milly and Shamkin, 2002); monthly solution for 1980-2004, Euphrates.
The Land Data Assimilation System (LDAS) is one of the land surface models developed at **NOAA Climate Prediction Center (CPC)**, monthly averaged soil water storage changes are provided on a 1x1 degree grid, monthly solution for 1980-2004, (SBH).
ECMWF daily continental water storage, defined as the sum of soil wetness and snow water, is computed based on the ECMWF Reanalysis, daily solution for 1979-1993, (SBH).
NASA Global Land Data Assimilation System (GLDAS) is uncoupled to the atmosphere terrestrial modelling system that incorporate satellite and grand base observation; provides water storage changes on a 1x1 degree grid, daily solution for 2002-2005 (SBH).

GRACE gravitational data

The following series are used in the paper:

CSR Level 2 Products: Release 01; GFZ Level-2 Products: Release 03; JPL Level-2 Validation Products Release 02;

GSM - monthly gravity field estimate product from GRACE; GAC - monthly mean of the non-tidal atmospheric and oceanic variability time series.

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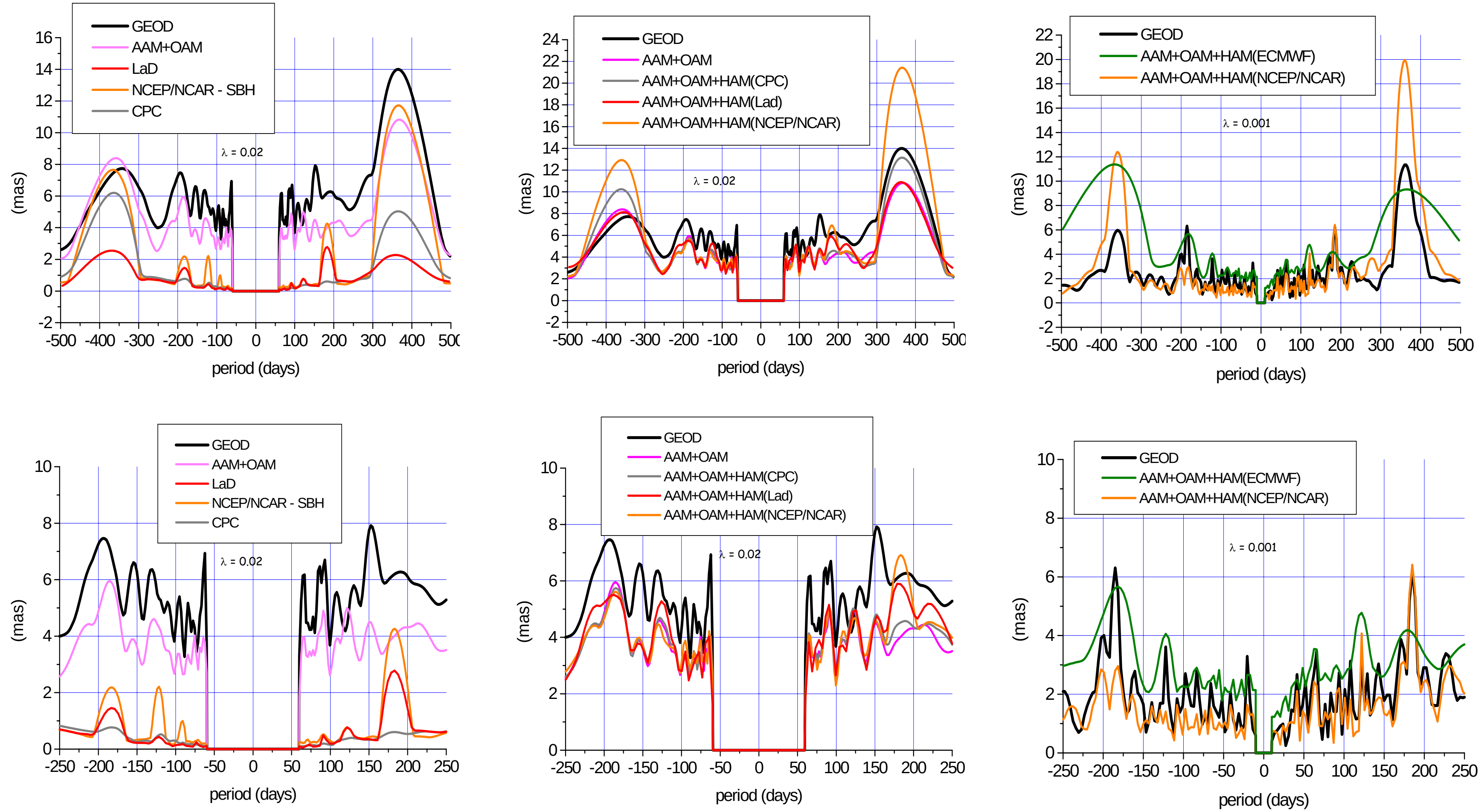

Fig. 1. The FTBPF amplitude spectra of the different complex excitation functions of the GEOD and of different hydrological and global geophysical functions in 1985-2002 filtered by the FTBPF with the 500 days cut-off period and computed for different parameter λ.

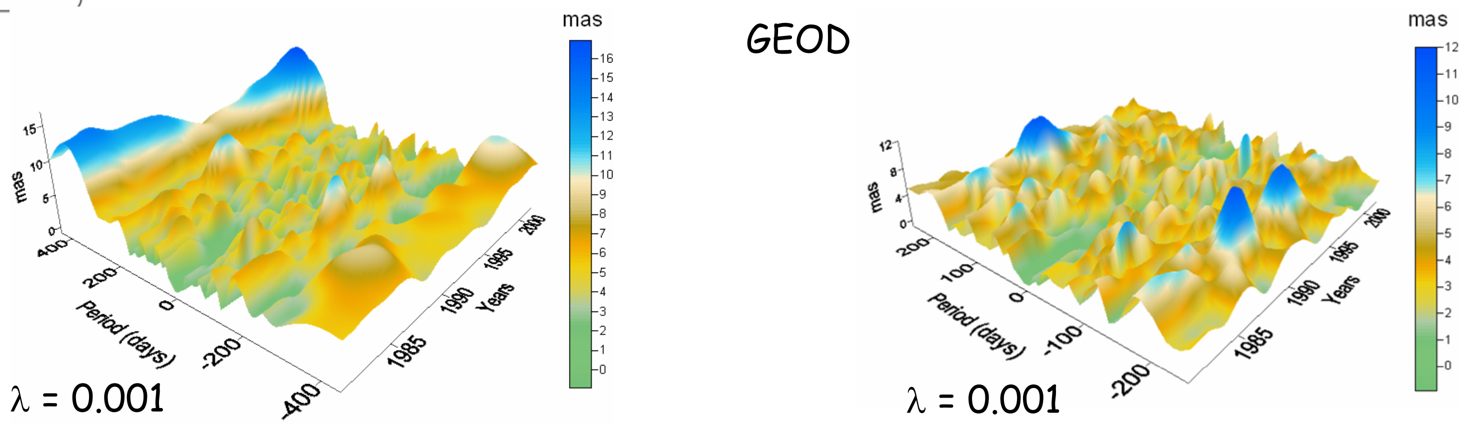

Fig. 2. The FTBPF amplitude spectra of the geodetic complex excitation function in 1985-2002 filtered by the FTBPF with -450 to 450 days and from -250 to 250 days with the parameter $\lambda = 0.001$.

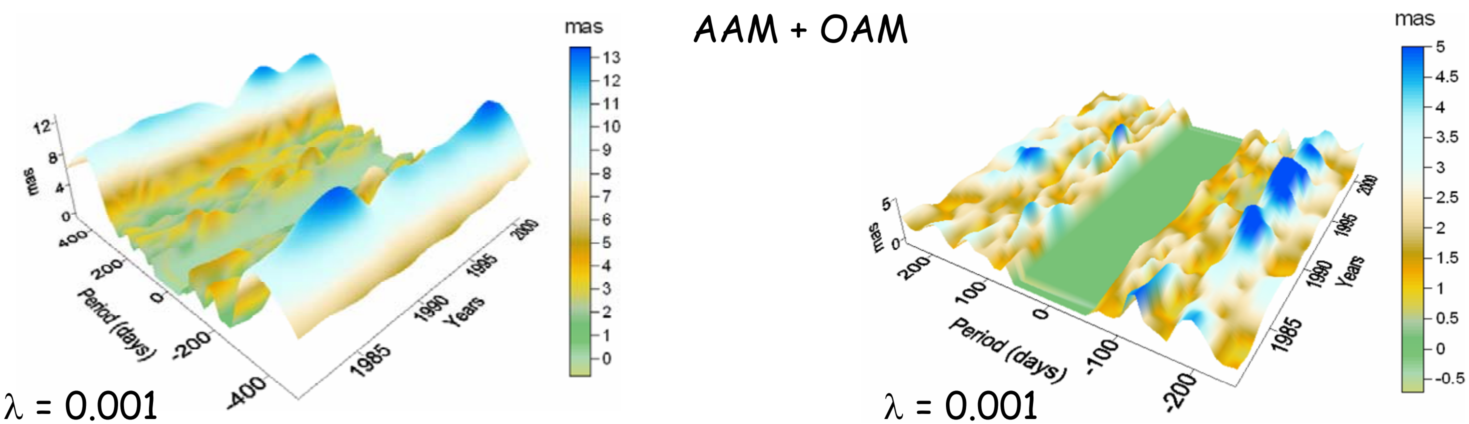

Fig. 3. The FTBPF amplitude spectra of the atmospheric and oceanic complex excitation function in 1985-2002 filtered by the FTBPF with the 500 days cut-off period and computed from -450 to 450 days and from -250 to 250 days with the parameter $\lambda = 0.001$.

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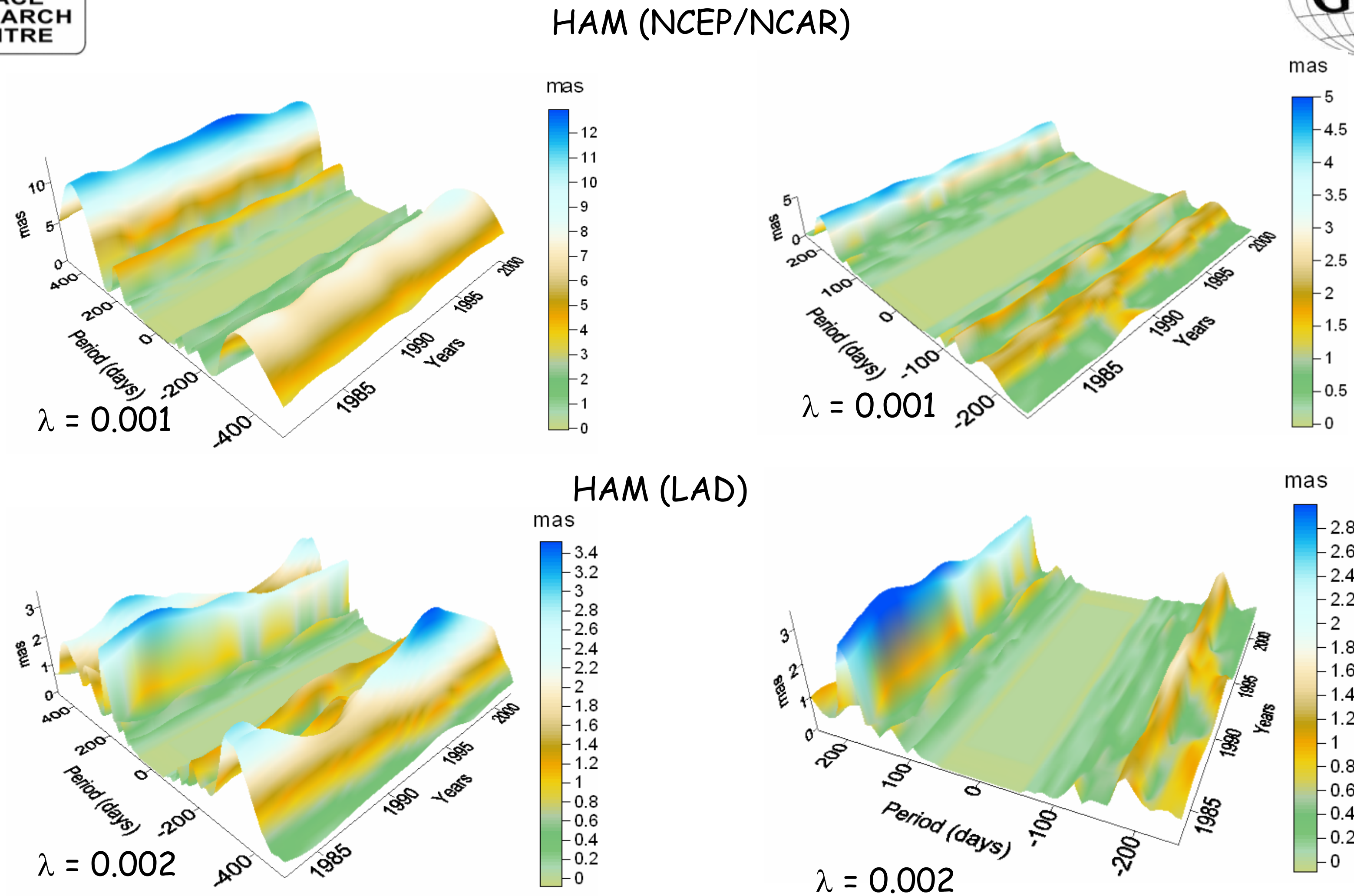

Fig. 4. The FTBPF amplitude spectra of the different hydrological complex excitation functions computed in the period ranges from -450 to 450 days and from -250 to 250 days with the different parameter λ.

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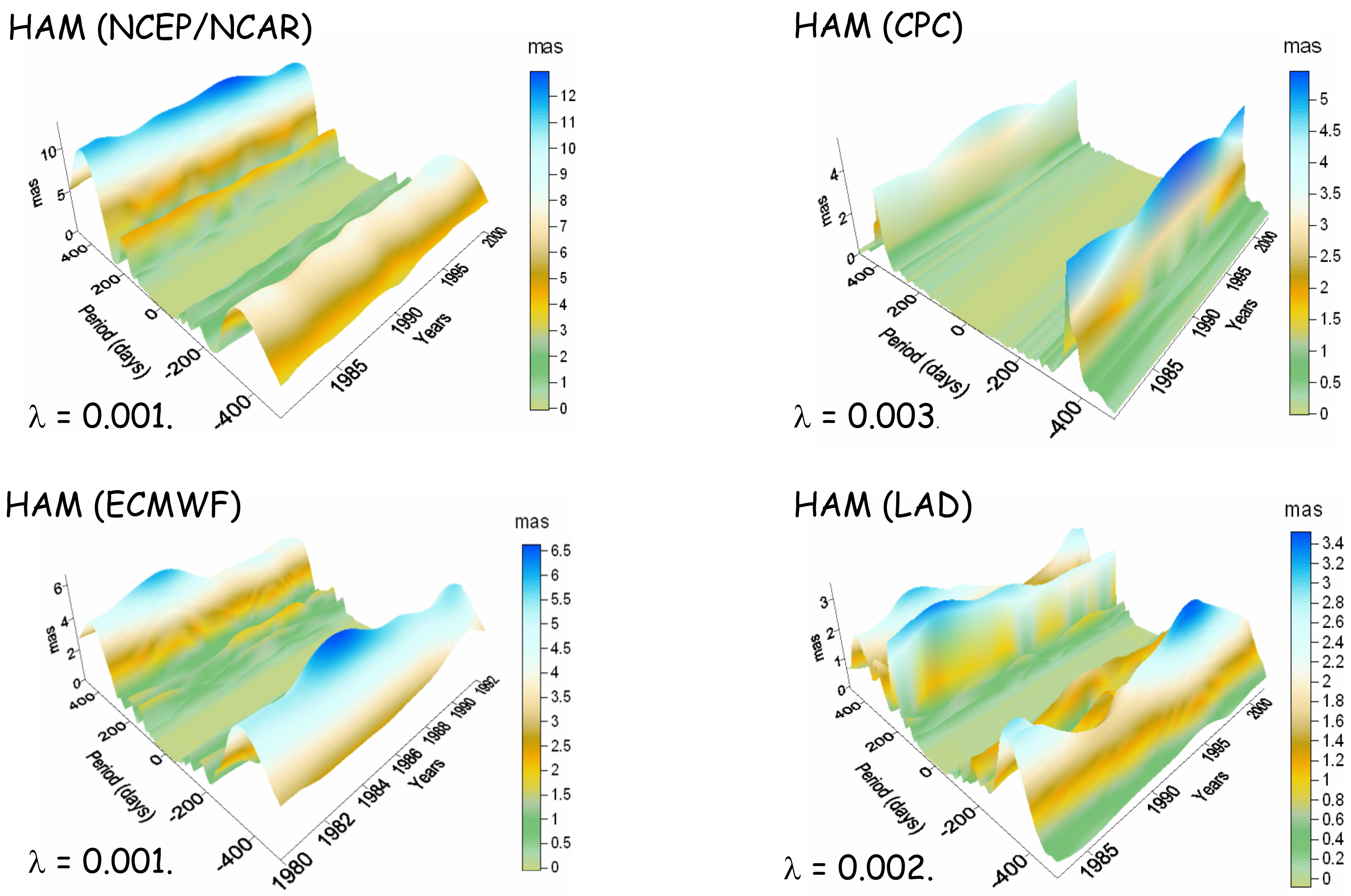

Fig. 5. The FTBPF amplitude spectra of the different hydrological complex excitation functions computed in the period ranges from -450 to 450 days with the different parameter λ.

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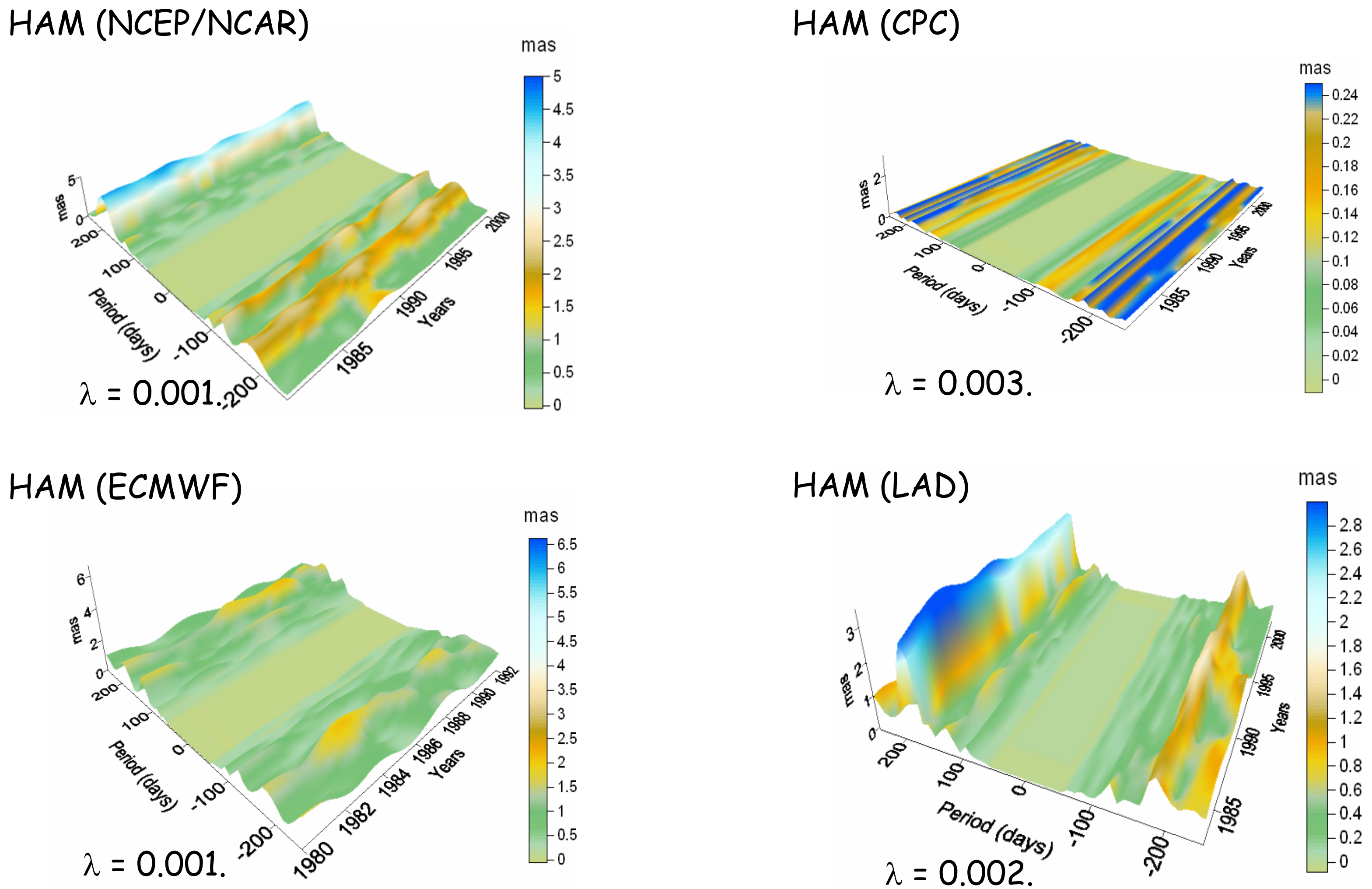

Fig. 6 The FTBPF amplitude spectra of the different hydrological complex excitation functions computed in the period ranges from -250 to 250 days with the different parameter λ.

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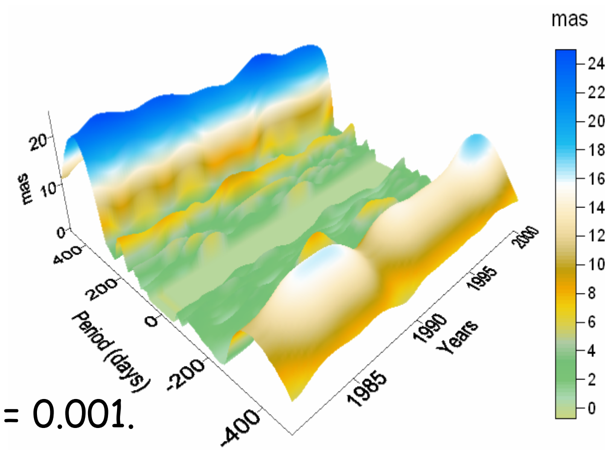
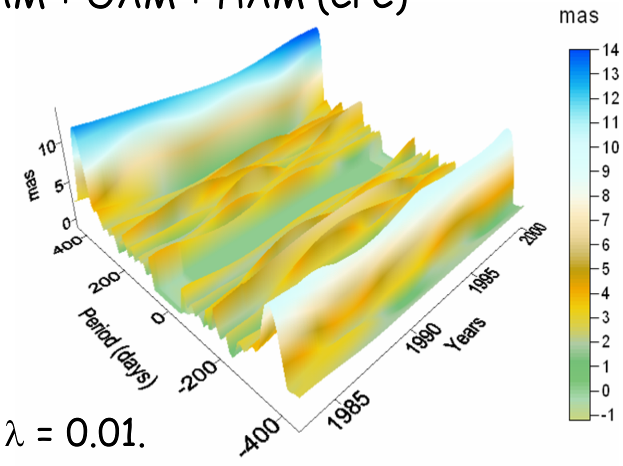
AAM + OAM + HAM (NCEP/NCAR)



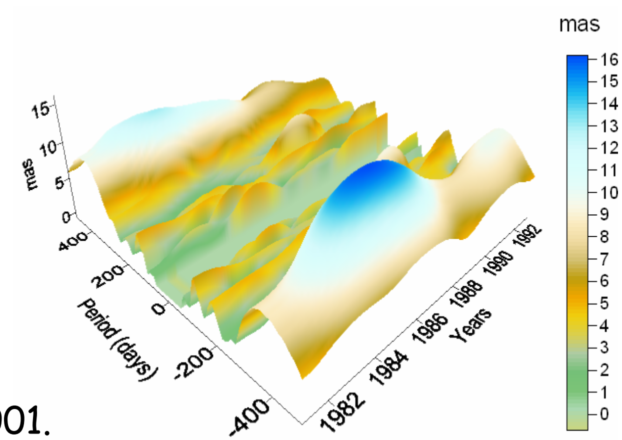
λ = 0.001.

AAM + OAM + HAM (CPC)



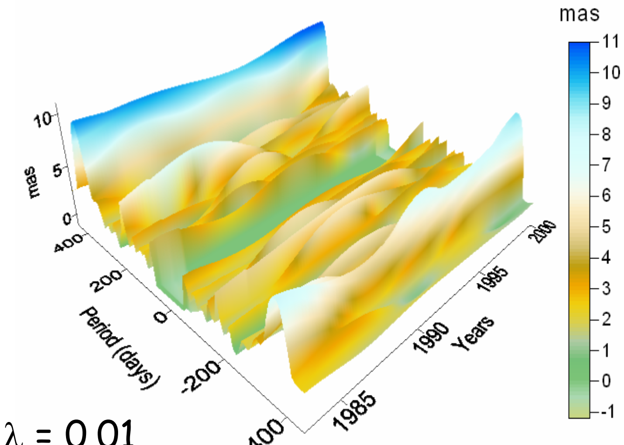
λ = 0.01.

AAM + OAM + HAM (ECMWF)



λ = 0.001.

AAM + OAM + HAM (LAD)



λ = 0.01.

Fig. 7. The FTBPF amplitude spectra of the different global geophysical complex excitation functions computed in the period ranges from -450 to 450 days with the different parameter λ.

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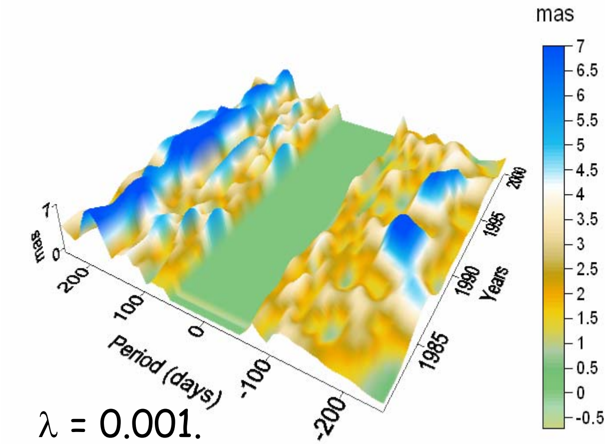
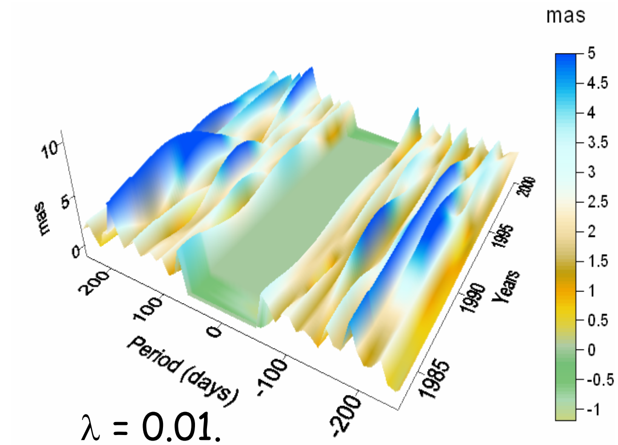
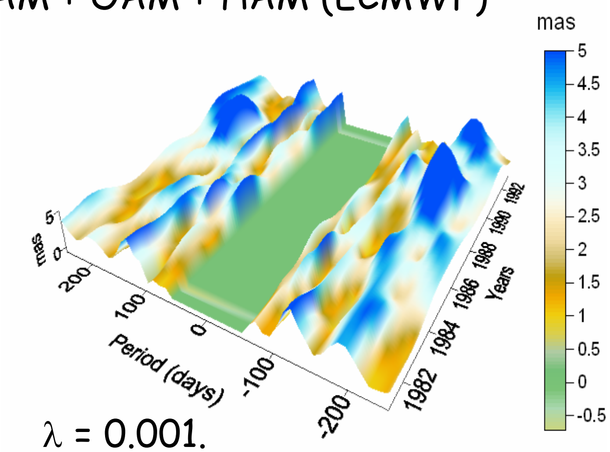
AAM + OAM + HAM (NCEP/NCAR)



AAM + OAM + HAM (CPC)



AAM + OAM + HAM (ECMWF)



AAM + OAM + HAM (LAD)

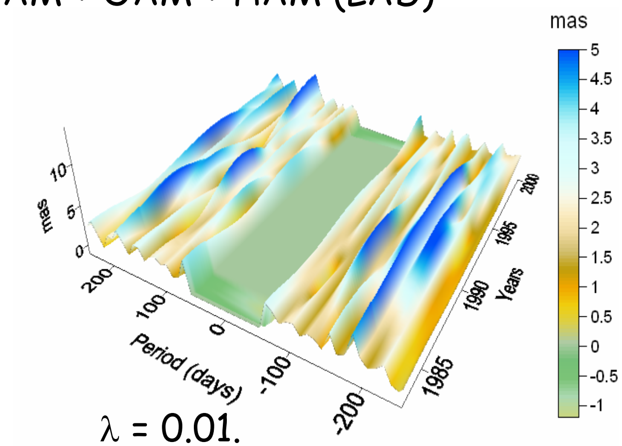


Fig. 8.The FTBPF amplitude spectra of the different global geophysical complex excitation functions computed in the period ranges from -250 to 250 days with the different parameter λ.

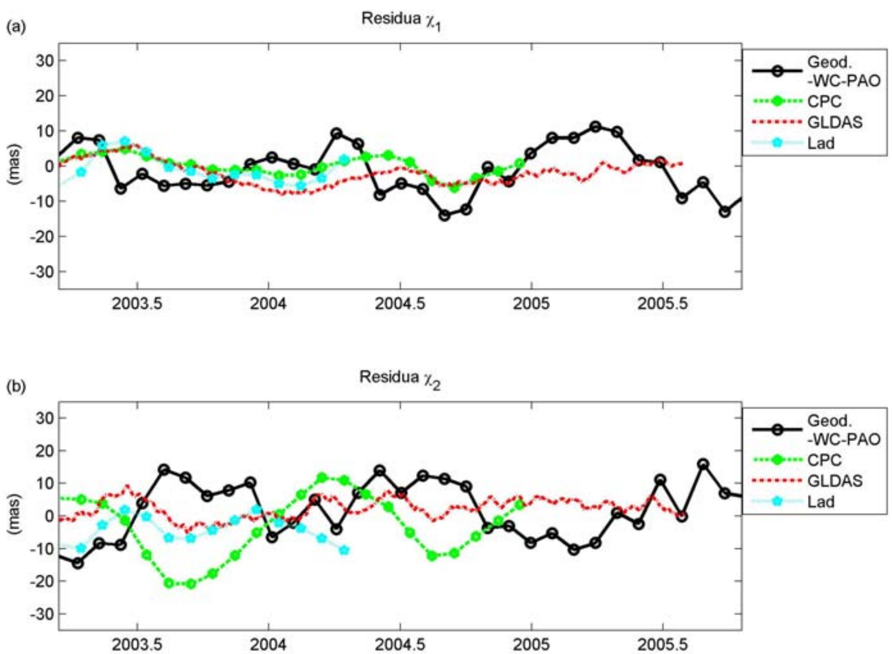


Fig. 9. Comparison of residuals between the mass term of geodetic (GEOD-WC) and the pressure term of atmospheric and oceanic (PAO) polar motion excitation functions with hydrological excitation of polar motion computed from the three hydrological models.

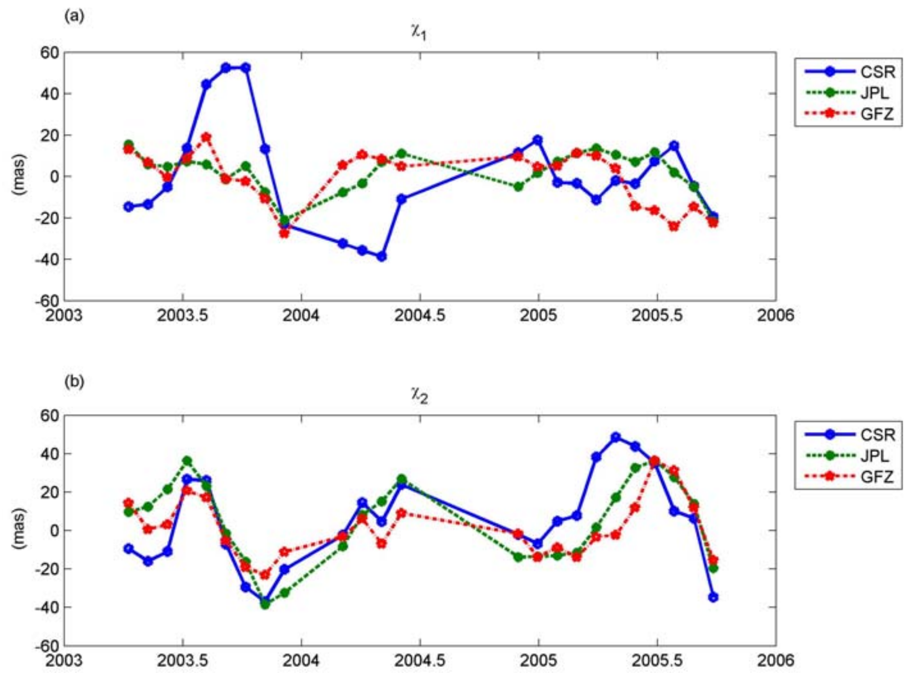


Fig. 10. Comparison of χ_1 and χ_2 components of polar motion mass excitation functions computed from the three GRACE gravity fields solutions and smoothed by using the Gaussian smoother, (Nastula et al., 2006).

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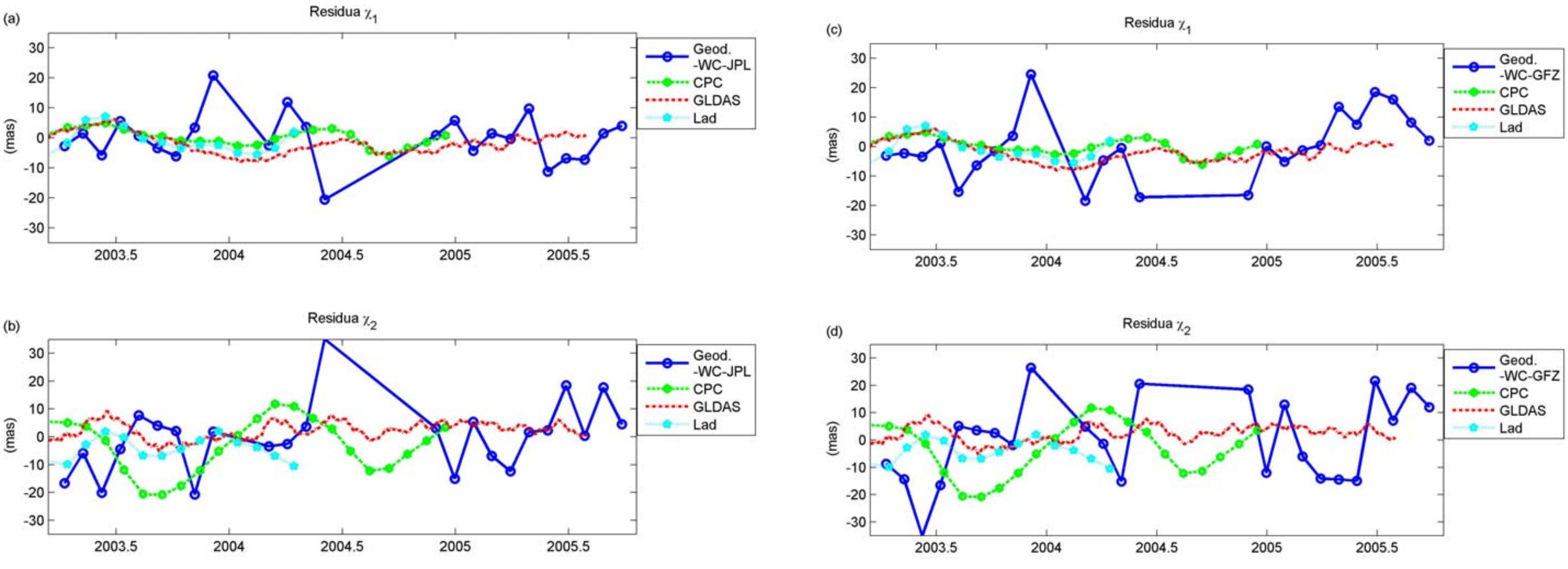

Fig. 11. Residuals between the mass term of geodetic excitation function of polar motion (GEOD-WC) and the mass excitation functions of polar motion computed from the JPL GRACE gravity fields (a, b) and the same but for the GFZ gravity fields (c,d) are compared with the hydrological excitation functions of polar motion, (Nastula et al., 2006).

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CONCLUSIONS.

-HAM excitation functions computed from different water storage models differ greatly in amplitudes and temporal characteristics and in their spectra.

-HAM excitation functions slightly improves the agreement between the observed geodetic excitation function and the geophysical excitation functions of polar motion, but they do not close the budget of the needed global geophysical excitation functions of polar motion.

-The HAM models need further improvements.

-The mass excitation functions of polar motion computed from the GRACE gravitational data are less accurate than the hydrological ones.?

-The agreement between geodetic and geophysical excitation functions and the GRACE gravitational excitation function of polar motion may serve as estimation of accuracy of HAM model solutions and GRACE data. It is important role of geodesy in the frame of the GGOS Project.

ACKNOWLEDGEMENTS. The paper was supported by the Polish State Committee for Scientific Researches through project 4 T12E 04526. We thank M. Sawicki for preparation of the graphics.

THEORY

χ_1 χ_2 - represent equatorial components of the hydrological excitation of polar motion due to change in water storage (Chen and Wilson, 2005).

$$\chi_1 = \frac{-1.098R^4}{(C-A)g}\iint \Delta g \sin\varphi \cos^2\varphi \cos\lambda d\lambda d\varphi, \qquad \chi_2 = \frac{-1.098R^4}{(C-A)g}\iint \Delta g \sin\varphi \cos^2\varphi \sin\lambda d\lambda d\varphi,$$

where:

R - (3.37101×10^6m) is the Earth's mean radius,

C and **A** - the Earth's principal moments of inertia ($C-A=2.61\times10^{35}$ kg m^2),

g - the gravitational constant ($g \sim 6,67\times10^{-11}$ m^3 kg^{-1} s^{-2}).

The factor 1.098 accounts for the combined effects of the yielding of the solid Earth to surface load, core-mantle decoupling, and rotational deformation (Eubanks, 1993).

Δ**g** - represents change in water storage at a given grid point