DETECTION OF TIME-FREQUENCY RELATIONS BETWEEN GEODETIC AND GEOPHYSICAL EXCITATION FUNCTIONS OF POLAR MOTION

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1. INTRODUCTION AND DATA

The redistribution of mass in the atmosphere, oceans and hydrology and the changes of the wind and ocean currents velocities are important sources of polar motion excitation. Relations between the geodetic excitation function and the effective angular momentum functions of the atmosphere, oceans and hydrology are examined in the time-frequency domain by means of coherence and phase synchronization. Coherence may be interpreted as a correlation coefficient between oscillations with the same frequencies present in two time series whereas phase synchronization allow to investigate the phase agreement between these oscillations.

The following data sets were used in the analysis: 1) equatorial component χ^{GEOD} of geodetic excitation function, 2) equatorial component χ^{AAM} of effective angular momentum function of the atmosphere from aam.ncep.reanalysis.*, 3) equatorial component χ^{OAM} of effective angular momentum function of the ocean from c20010701.oam and ECCO_kf049f.oam, 4) equatorial component $\chi^{\mathrm{HAM\ (NCEP)}}$ of effective angular momentum function of the hydrology from chi_ncep_water_*, 5) equatorial component $\chi^{\mathrm{HAM\ (ECMWF)}}$ of effective angular momentum function of the hydrology obtained by numerical integration of the water storage data from water_ECMWF_*.nc.

2. ANALYSIS, RESULTS AND CONCLUSIONS

Intuitive generalisation of correlation coefficient between two time series $x(t')$ and $y(t')$ is a correlation coefficient between their wavelet transform coefficients $X(t,T_0)$ and $Y(t,T_0)$ for a given value of period T_0. The absolute value of the generalised correlation coefficient is called wavelet coherence and is given by the formula:

$$\gamma_{x,y}(T_0) = \frac{|\sum_{t=1}^{N} X(t,T_0)\overline{Y(t,T_0)}|}{\sqrt{\sum_{t=1}^{N}|X(t,T_0)|^2 \sum_{t=1}^{N}|Y(t,T_0)|^2}}. \quad (1)$$

Phase agreement of the oscillations can be investigated by dividing the wavelet transform coefficients by their moduli and then calculating the coherence. The corresponding function is called phase synchronization and is given by the formula:

$$\gamma^{\phi}_{x,y}(T_0) = \frac{1}{N}\left|\sum_{t=1}^{N} \frac{X(t,T_0)\overline{Y(t,T_0)}}{|X(t,T_0)||Y(t,T_0)|}\right|. \quad (2)$$

Spectro-temporal coherence $\kappa_{x,y}(t,T_0)$ and phase synchronization $\kappa^{\phi}_{x,y}(t,T_0)$ (not shown in this paper) can be obtained by replacing correlation coefficients by running correlation coefficients.

The greatest coherence and phase synchronization occur between χ^{GEOD} and χ^{AAM} as well as between χ^{GEOD} and χ^{OAM}. Coherence and phase synchronization between χ^{GEOD} and $\chi^{HAM(NCEP)}$ and between χ^{GEOD} and $\chi^{HAM(ECMWF)}$ are similar and significant only for the annual and semiannual oscillations. Phase synchronization between χ^{GEOD} and χ^{AAM} (χ^{OAM}) is smaller than coherence between them. It shows that the variable phases of the high frequency oscillations in χ^{GEOD} and χ^{AAM} (χ^{OAM}) can not explain the observed coherence between them which is caused also by variable amplitudes of these oscillations. Coherence and phase synchronization between χ^{GEOD} and $\chi^{AAM}+\chi^{OAM}$ are greater than the coherence between χ^{GEOD} and χ^{AAM}. Adding $\chi^{HAM(NCEP)}$ or $\chi^{HAM(ECMWF)}$ to $\chi^{AAM}+\chi^{OAM}$ causes the increase or the decrease of coherence and phase synchronization depending of the frequency and polarisation of the oscillations being compared.

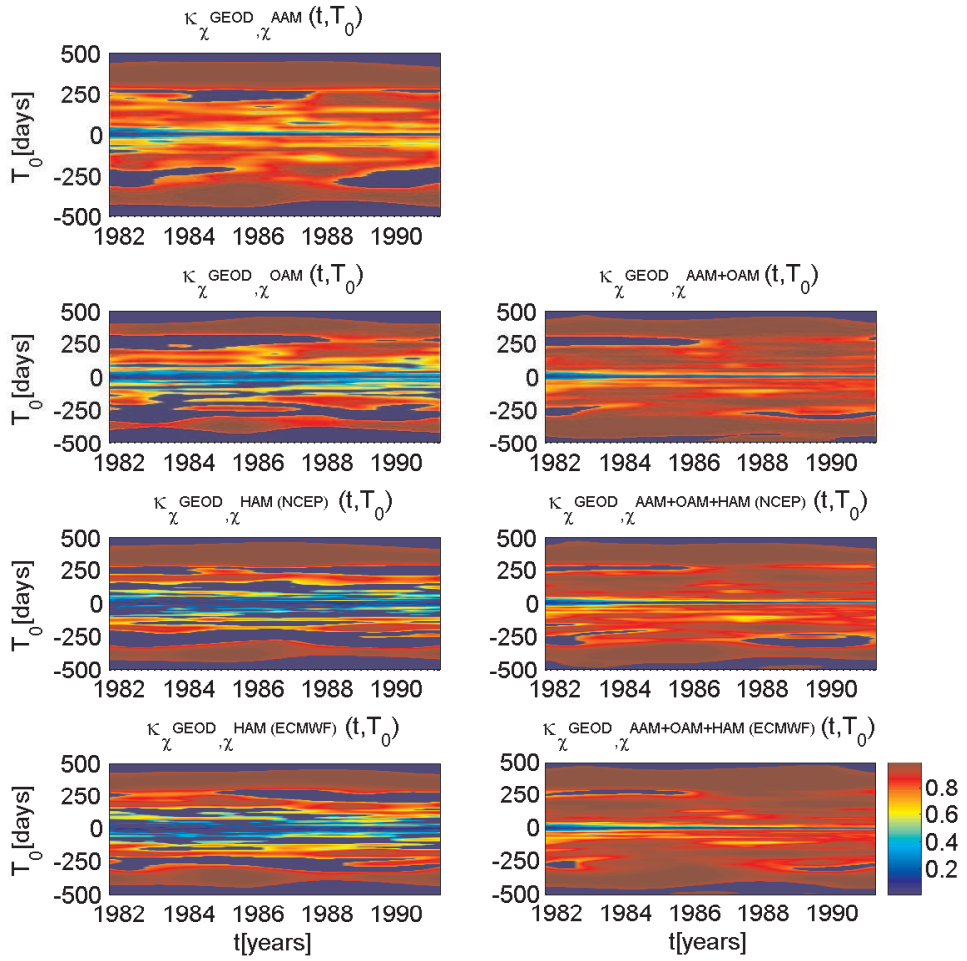

Figure 1: Spectro-temporal coherence between the equatorial component of geodetic excitation function and the equatorial components of geophysical excitation functions (letf) as well as their sums (right).

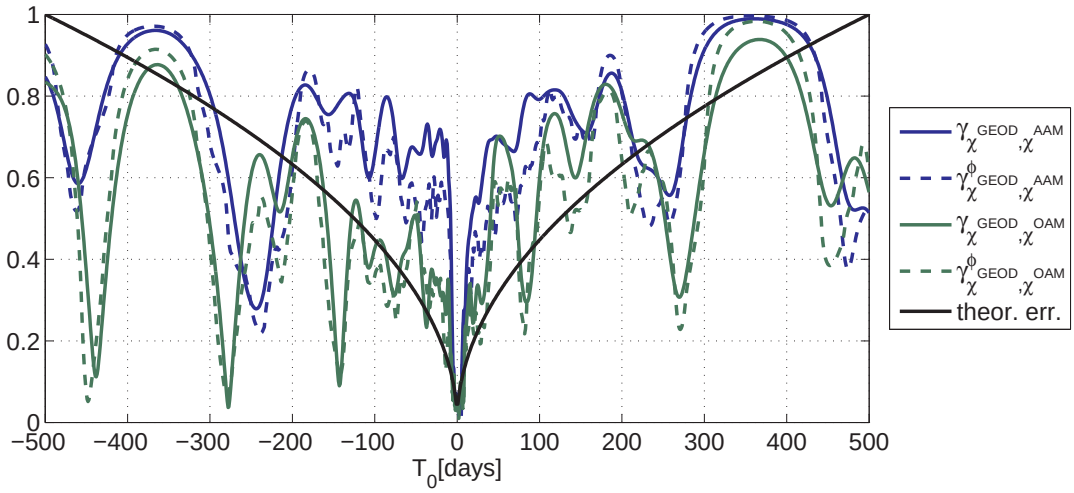

Figure 2: Coherence (solid line) and phase synchronization (dashed line) between the equatorial component of geodetic excitation function and the equatorial components of the effective angular momentum of the atmosphere (blue) and ocean (green).