EL NIÑO IMPACT ON ATMOSPHERIC AND GEODETIC EXCITATION FUNCTIONS OF POLAR MOTION

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An El Niño phenomenon is the prominent interannual fluctuation in the atmosphere-ocean system in the tropical Pacific. During El Niño epochs there are disturbances of the normal tropical easterly wind causing the dominant extensive meteorological disruption. Differences of ocean temperatures between different regions of the tropical Pacific known as the Niño 1+2, Niño 3, Niño 4, Niño 3.4 regions, extending westward from South America (see NOAA Climate Diagnostics Bulletins) and the Southern Oscillation Index (SOI), which is the standardized difference of atmospheric surface pressure between Tahiti in the central Pacific and Darwin, Australia, characterize these phenomena. The combination of El Niño-Southern Oscillation is known as ENSO.

Motion and redistribution of masses within the atmosphere are accompanied by variations in the solid Earth rotation. Influences of ENSO on Earth rotation, on variations of length of day (LOD) and polar motion have been investigated in many papers. Mostly, though, El Niño influences on LOD have been investigated (Chao, 1989; Dickey, 1993; Dickey et al., 1994; Eubanks et al., 1986; Franquis et al., 1994; Gambis, 1992; Gipson et al., 1998; Nastula et al., 1990; Rosen et al., 1984 and others) and two papers dealing with this problem are included in this volume (Dickey et al. and Gipson et al.). An example of the strength of the connection between ENSO and LOD is the maximum correlation coefficient - 0.67, between LOD and SOI, obtained with a one month lag for the time interval of 1965 - 1990 (Dickey et al., 1994).

Influences of El Niño on polar motion have already been found through correlations between geodetic and atmospheric excitation functions of short period variations of polar motion with period ranges of 20 - 150 days (Kosek et al., 1995a; Kolaczek et al., 1998; Nuzhdina et al., 1997). The correlation coefficients between temperatures in the Niño regions (NINO data) and the correlation coefficients between short period variations of atmospheric and geodetic excitation functions computed for several El Niño epochs reach values on the order of 0.5 - 0.7. (Kolaczek et. al., 1998; Nuzhdina et al., 1997. Fig.1a is given as an example).

Here, computation of correlations between the NINO data and correlation coefficients of short period oscillations (20 - 150 days) of atmospheric and geodetic excitation functions were carried out again taking into account the additional new data for the epoch of the last, strong El Niño 1997/1998 and results are presented in Fig. 1b.

Similar data series, but longer, than in our previous paper (Kolaczek et al., 1998) used here include:

- IERS Earth Orientation Parameters EOP (IERS) 97C04 (IERS, 1998);
- Equatorial Components of Atmospheric Angular Momentum χ_1, χ_2 of the reanalysis data of the NCEP/NCAR (U.S. National Center for the Environmental Prediction/National Center for Atmospheric Research) (IERS, 1998; Salstein et al., 1993, 1995);

- set of NINO temperature 4 data; (NOAA/NCEP [National Oceanic and Atmospheric Administration/NCEP])
- SOI Indices (NOAA/NCEP)
- Equatorial Components of geodetic excitation functions of polar motion ψ_1, ψ_2 computed by the deconvolution formula (Barnes et al., 1983) from the EOP (IERS) 97C04 pole coordinates data.

It was shown previously (Kolaczek et. al., 1998) that correlation coefficients between NINO 4 data and variations of correlation coefficients of geodetic and atmospheric excitation functions are higher than in the case of other NINO data series. Thus, correlation coefficients between equatorial components of atmospheric and geodetic excitation functions χ_2, ψ_2 were computed and correlated with NINO 4 data (Fig. 1b). Each correlation coefficient C was computed for a one year span with steps of 45 days. The correlation coefficient between NINO 4 data and variations of correlation coefficients of atmospheric and geodetic excitations functions for different time periods containing one or two El Niño events in the years 1986 - 1998 are given in Fig.1b. They are variable and reach in maxima the value of 0.7 - 0.9. Fig. 1a shows such correlation coefficient for El Niño phenomena in 1983/84 and 1986/87 (Kolaczek et al. 1998). The significance levels were estimated taking into account only independent correlation coefficients between atmospheric and geodetic excitation functions, that is, one point per year. It is worth mentioning that, as shown earlier, an influence of each El Niño on Earth Rotation is different. Correlation coefficients CC and time delays depend on the period of time of data taken for computations.

There are irregular variations or disturbances of polar motions in El Niño epochs, too. They are related to the transfer of perturbations of Atmospheric Angular Momentum (AAM) into correlations between geodetic and atmospheric excitation functions of polar motion (Kosek et al. 1995b, 1998). Such irregular variations are seen in Fig. 2, where differences between short period variations of the x pole coordinate and their autocovariance predictions by autocovariance methods are shown. These differences are greater than the level of values of three times the standard deviation during El Niño epochs in 1979/1980, 1983/1984, 1985/1986, 1988/1989, 1995/1996.

The MESA spectra of correlation coefficients variations between ψ/χ excitation functions, NINO and SOI data in the years 1975 - 1997 indicate two strong oscillations with periods of 4-5 years, and 2-3 years (Figs. 3,4). The period of 4-5 years is connected with El Niño phenomena, the period of 2-3 years is the period of the Quasi-Biennial Oscillation (QBO). Such spectra suggest the existence of ENSO and QBO impacts on the correlation between the ψ and χ considered excitation functions.

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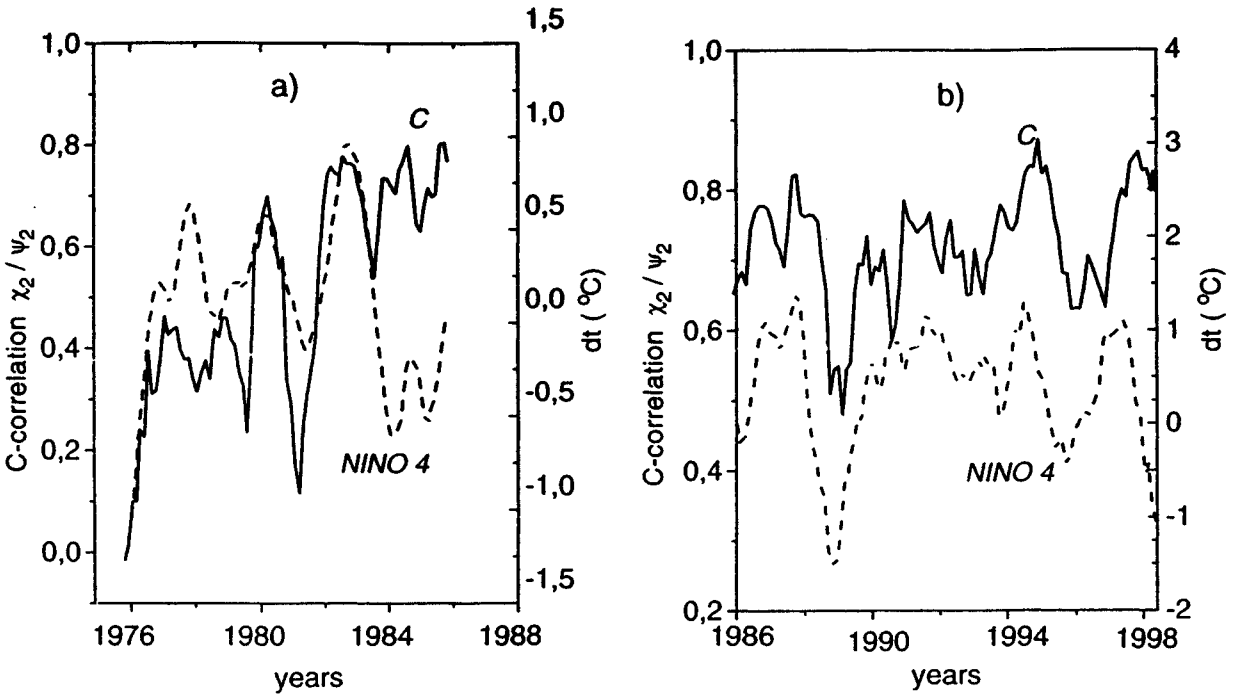

Fig. 1. Diagrams of the NINO 4 data and the correlation coefficient C between short period variations of χ_2, ψ_2 for the period range of 20 - 150 days.

a) CC = .80 (time delay = 292 days) for the period 1976-1984 (Kolaczek et al., 1998)

b) CC = .74 (time delay = 0 days) for the period 1985-1990.5; One El Nino event.
CC = .67 (time delay = 0 days) for the period 1985-1995.5; Two El Nino events.
CC = .86 (time delay = 0 days) for the period 1993-1998.5; Two El Nino events.
CC = .96 (time delay = 0 days) for the period 1995-1998.0; One El Nino event
significance level of 95%.

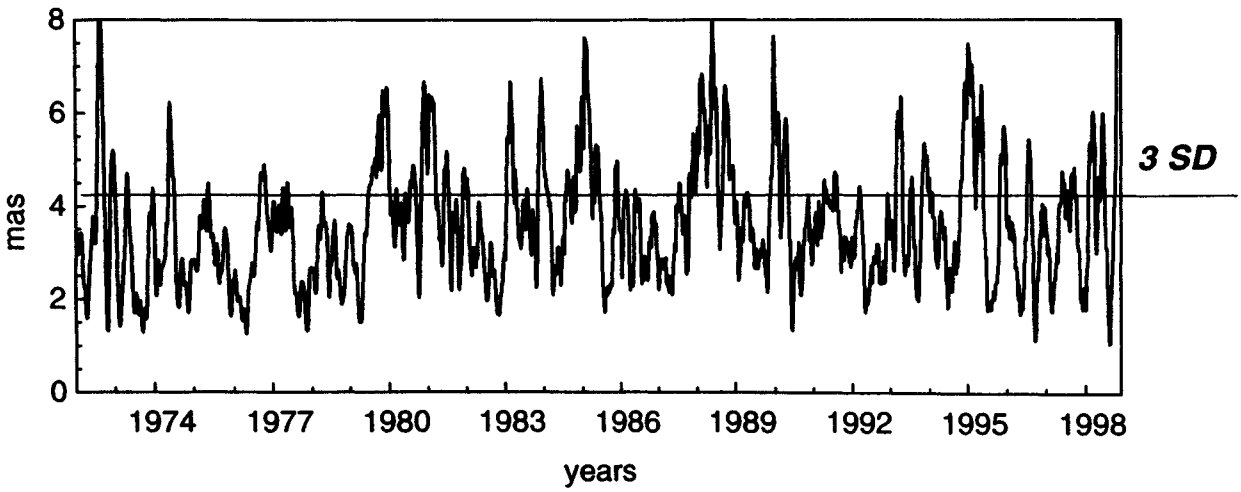

Fig. 2. The smoothed 30 point average, absolute value of the difference between x IERS (97 CO4) filtered by the Butterworth HPF with the cut-off period of 270 days and its autocovariance 14-day prediction.

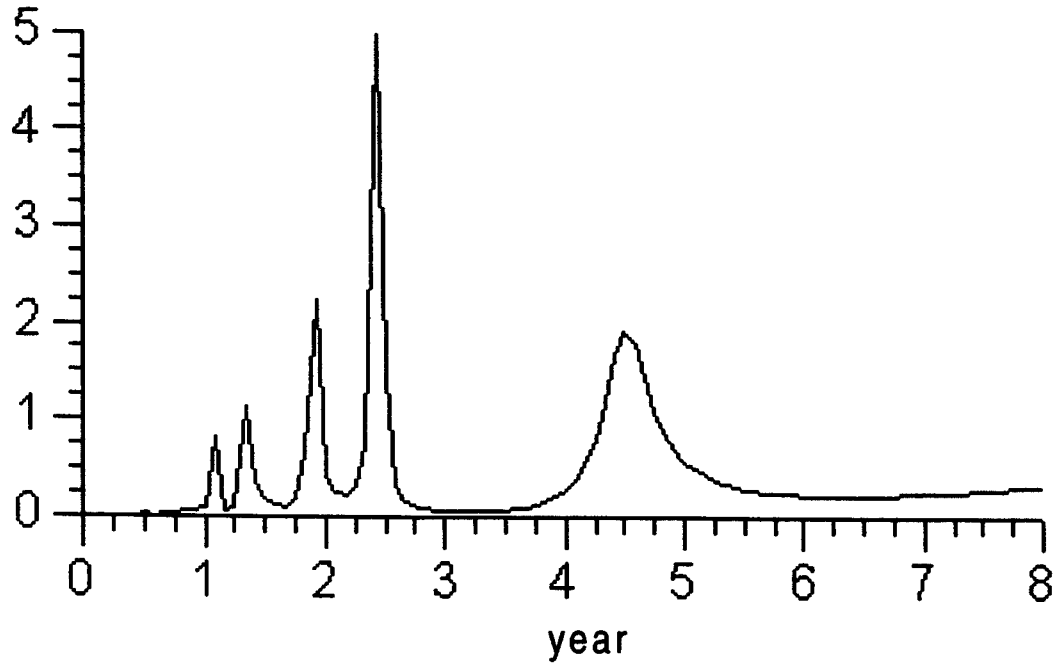

Fig. 3. MESA spectra of variations of correlation coefficients between atmospheric and geodetic excitation functions χ_2, ψ_2 for the years 1975 - 1997 in the period range 20 - 150.

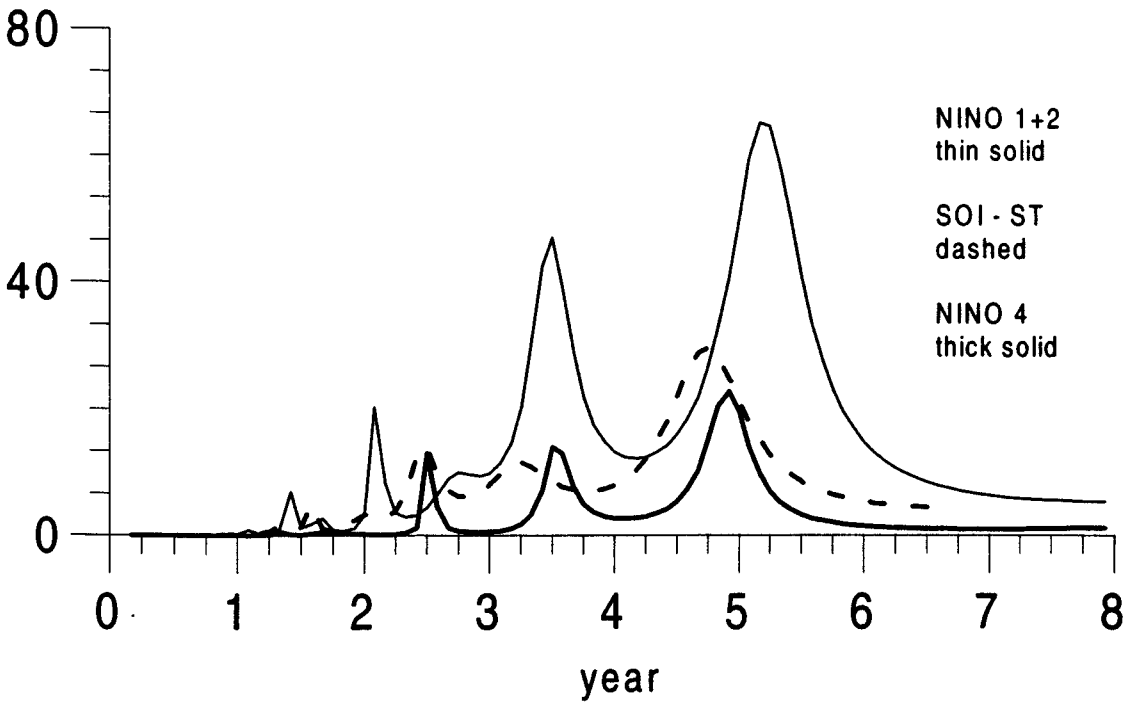

Fig. 4. MESA spectra of NINO and SOI data for the years 1975 - 1997.