QBO in solar wind fluctuations and its relation to ENSO

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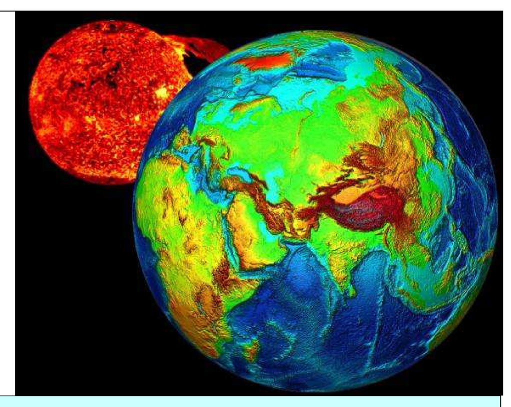

Setting the scene:

A long time ago - in the 60s - astronomers and meteorologists vividly discussed on the origin of the quasi-biennial oscillation (QBO) of the middle atmosphere.

While the astronomers argued that the Sun has itself a QBO, the meteorologists showed that atmospheric models generate a stratospheric QBO by wave-mean flow interactions (forcings from the solar QBO are too small and not required).

Mysteries on the QBO still remain: Which atmospheric waves are most important for the QBO? Why is the QBO period at 2.4a (28 to 29 months)? How is the effect of solar forcing on the QBO?

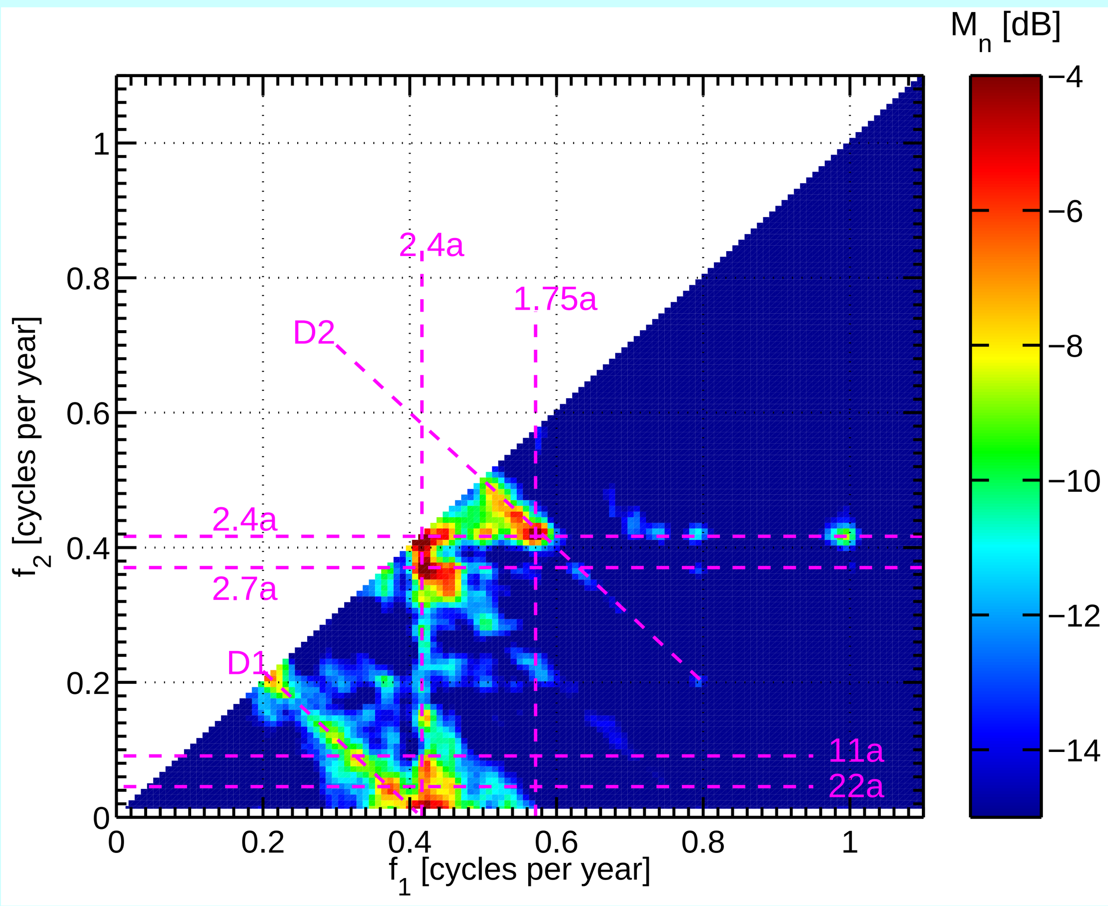

Fig.1: Magnitude of ***bispectrum of stratospheric zonal wind at equator*** *(zonal mean series of u at 30 hPa from 1948 to 2008, NCEP reanalysis)*

New insights into stratospheric QBO:

1) Bispectrum is the product of three Fourier components: $\mathbf{F(f_1)F(f_2)F(f_1+f_2)}$. High values are achieved by phase-coupled wave triads fulfilling the frequency resonance condition.

2) Bispectrum is well suited for study of nonlinear interactions and modulations of atmospheric waves and composition changes (Hocke and Kämpfer, 2008).

3) Bispectrum of equatorial zonal wind shows that the QBO consists of various components (2.4a, 2.7a, 1.75a) modulating and interacting with each other. Interactions with annual cycle (1a), solar cycle (11a, 22a) and 4.8a-cycle are present.

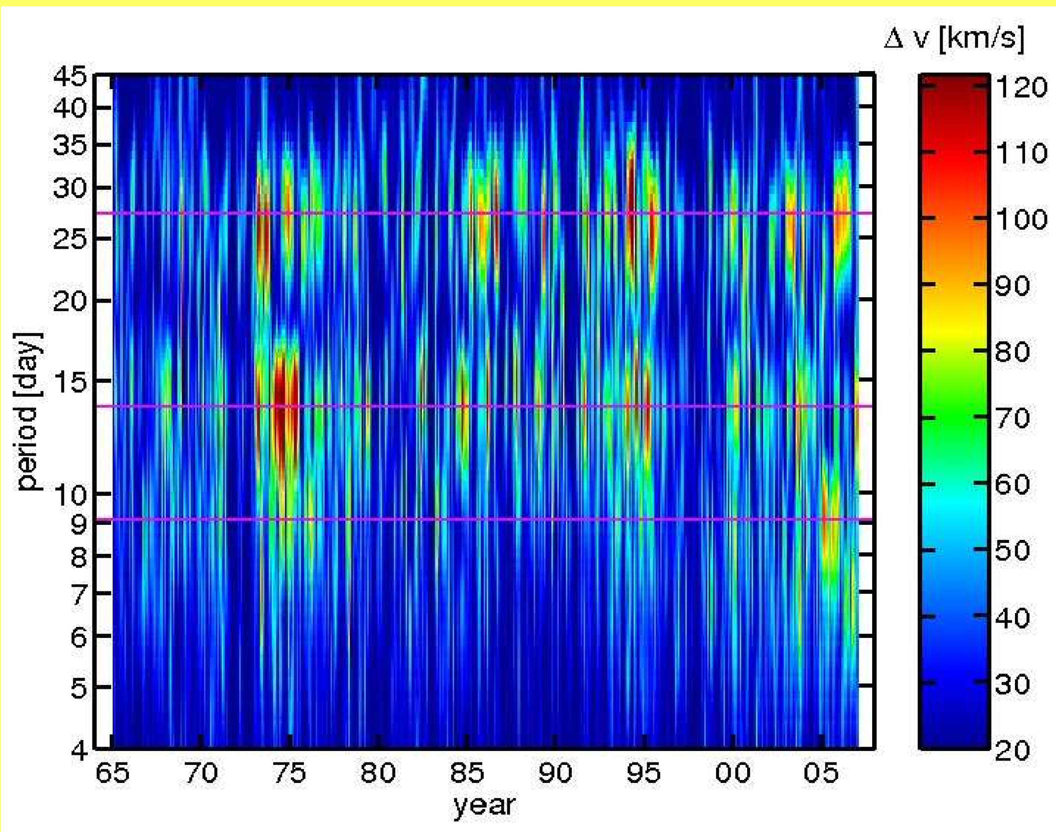

Fig. 2: Amplitude of solar wind fluctuations as function of time and wave period. Period bands of the solar rotation period 27-days and its harmonics are marked by the magenta lines. Long-term modulations of the short-term fluctuations are obvious.

Fluctuations of the solar wind speed:

Recent satellite missions (e.g., CHAMP, ENVISAT, TIMED, Aura) as well as whole atmosphere circulation models have proven that corotating solar coronal holes and solar storms change the dynamics and composition of the middle and upper atmosphere.

Solar wind speed is measured since 1963 by satellites at 30 Earth's radii.

The short-term fluctuations (4-45 days) of the solar wind speed are inducing electric fields and particle precipitations in the ionosphere.

Further impacts on cosmic ray flux, the atmospheric electric circuit, and cloud cover in the troposphere are possible.

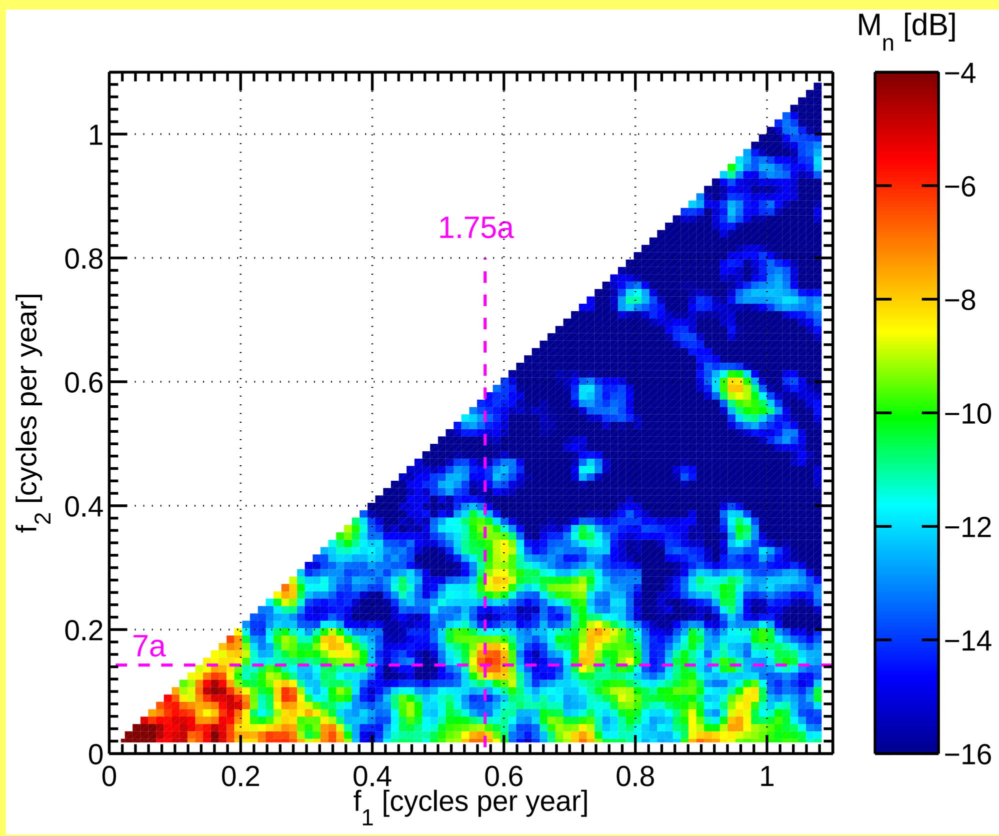

Fig. 3: Bispectrum of time series of mean amplitude of solar wind speed fluctuations (averaged for period range 4-45 days). The QBO component at ***1.75a*** *is dominant and interacts with the 7a-component.*

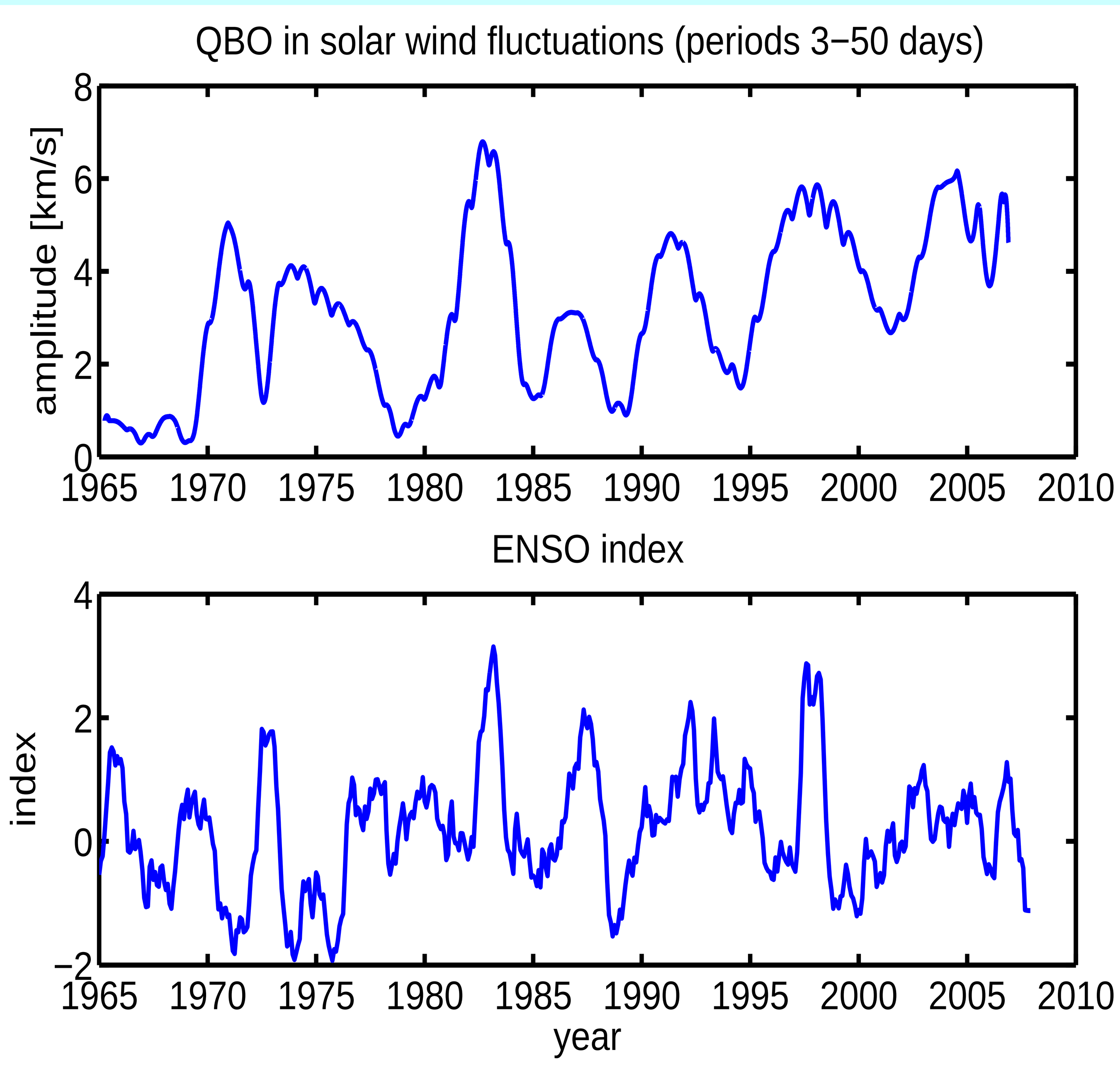

Fig. 4: Time series of the mean amplitude of solar wind fluctuations (4-45 days) are bandpass-filtered at the dominant ***1.75a****-QBO period and give this surprising result.*

Discussion:

The QBO modulation of the solar wind speed fluctuations is well correlated with the ENSO index, particularly from 1980 to 2000.
Kodera (2003) investigated the influence of the solar UV cycle on ENSO. Here we have a strong hint on a relation between the **solar wind QBO** and **ENSO:**
Corotating coronal holes and solar storms are modulated with a 1.75a QBO period and may trigger the ENSO activity of the lower atmosphere. The path could be via the global electric circuit and cloud cover (Troshichev et al., 2005).

Conclusions:

- Bispectrum gave new insights into the stratospheric QBO. Solar cycle effects are present in the bispectrum.

- Short-term fluctuations of solar wind speed have a modulation by the 1.75a-QBO component.

- The 1.75a-QBO modulation of the solar wind speed fluctuations is correlated with the ENSO index.

- Influences of solar QBO, QBO, and stratospheric dynamics on ENSO are a complex but attractive research theme.

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