МЕЖГОДОВЫЕ,
ГЛОБАЛЬНО СИНХРОННЫЕ ВАРИАЦИИ
В КЛИМАТИЧЕСКОЙ СИСТЕМЕ
И ИХ ПРЕДСКАЗУЕМОСТЬ
Надежда В. Вакуленко,
Илья В. Серых,
Дмитрий М. Сонечкин
Институт океанологии им. П.П. Ширшова,
Российская академия наук,
При участии В.И. Бышева, В.Г. Неймана, Ю.А. Романова
dsonetch@ocean.ru
After seminal researches of Ed Lorenz almost all meteorologists agree that weather variations are chaotic, i.e. they are unstable and unpredictable for more or less distant future. Moreover, the same opinion is widely accepted for climate variations.

The aim of this report is to substantiate another opinion that interannual climate variations are nonchaotic even if their shapes are very complex (strange in mathematical terms). As a result, a way is indicated how it is possible to predict El Nino with the lead time of about one year that is more than the present-day operational El Nino predictions.
Power spectrum as a signature of chaos

Because the climate is a many dimensional dynamical system it is impossible to use Lyapunov’s exponents to conclude either weather/climate variations are chaotic or nonchaotic. The only shapes of the power spectra of these variations can be used for this purpose. One can consider variations to be chaotic if the shapes of their power spectra are continuous. If these shape are not continuous (discrete in their character) these variations can not be chaotic. Instead, they are mutually ordered and self-adjusted with each other. The typical power spectrum of nonchaotic variations consists of innumerable peaks and bands of increased energy superimposed on an apparent continuous background. It has been proven in the dynamical system theory that the re-distribution of these peaks at the frequency axis forms a self-similar structure. It means any zoom of a part of such a spectrum reveals a peak re-distribution of the same character that is inherent to the whole spectrum.
Real extratropical weather spectra of the zonal indices of the H500 and H500/1000 for the Northern Hemisphere. These spectra are obviously continuous and smooth excepting the annual peak and its superharmonics.
Real tropical weather spectra (of the extended Southern oscillation and El-Nino indices). These spectra also are continuous, but with some spikes evidencing the existence of a mutual order.

The main spike of the Madden-Julian oscillation

The 5-day spike

-2

-4
Spectrum of Niño3+Niño3.4 computed on a base of monthly data (shown in RED). The same spectrum after the annual cycle and its superharmonics excluding (in BLUE).
Power spectra of the interannual climate variations mapped at the annual period

Blue - the sea-level pressure over the ±70 latitude belt and red - an extended SST index (El-Nino).

Subharmonics of the Chandler wobble in the Earth’s pole motion, and superharmonics of the Luni-Solar nutation and the Sun-spot cycle are clearly seen.
Conductors of the interannual climate variations

All of the peaks in the climatic power spectra shown above are localized at the subharmonics 2:1, 3:1,... of 1). the 14-month period of the Chandler wobble in the Earth’s pole motion, 2). the superharmonics 1:2, 1:3, 1:6 of the 18.6-year period of the Luni-Solar nutation of the Earth’s rotation axis, 3). the superharmonics 1:4, 1:6, 1:8 of the 22-year period of the Hale’s heliomagnetic cycle.

These external periodicities are powerless. In spite of this they synchronize the interannual climate variations, and so they must be considered as the climate dynamic conductors but not drivers.
A possible explanation of the Chanler wobble (Pole tide) role in the El-Nino excitation.
Dynamics of the sea level altitude during 14-month long period (satellite data)
In order to test either the above climate variations are chaotic or nonchaotic the relationship between the amplitudes of spectral peaks and these peak serial numbers must be considered (Feudel et al., 2006). A linear character of this relationship evidences that the interannual climate variations are **strange but not chaotic**.
As a result of the above periodicities conducting, the climate variations turn out to be **globally synchronized**.

It means that these variations form a spatial structure covering the whole Earth.

We call this structure **GLOBAL ATMOSPHERIC OSCILLATION**
Global Atmospheric Oscillation (upper) as seen on mapping of the sea-surface temperature difference between 23 El Ninos and 25 La Ninas and the map of the \textit{t-Student} test (below)
Global Atmospheric Oscillation (upper) as seen in the map of the sea-level pressure difference between 23 El Ninos and 25 La Ninas and its map of the $t$-Student test (below).

Stars indicate 10 points for determining the GAO1, 2 indices.
GAO as seen in six (best!) CMIP5-models
The real GAO1 spectrum (red), and the GAO1 spectra of the best CMIP5-models (blue). All of the modeled peaks are localized at combinational harmonics of the annual period, and so these models usually predict El Nino at improper time moments.
The GAO dynamics (during 42 months) started from the La Nina phase reveals a general eastward GAO propagation.
A possible explanation of the Chanler wobble (Pole tide) role in the El-Nino excitation
Tha dynamics of the sea level altitudes during the 14-month long period (satellite data)
Satellite sea-level altimetry during the first seven months of the El-Nino generating
Satellite sea-level altimetry during the first several months of the El-Nino suppressing
A pair of the monthly mean SLA- (above) and SSTA- (below) fields corresponding to December 1997 when one of the greatest El Niño was observed.
A pair of the monthly mean SLA- (above) and SSTA- (below) fields corresponding to December 1999 when one of the greatest **La Niña** was observed.
Wavelet-based cross-correlations between GAO3-index and Extended Oceanic Nino index. GAO3-index leads for 14 months.
Filtered cross-correlations between GAO-indices (GAO1, GAO2, GAO3) and an El Nino-index (EONI). GAO3 can be used to predict El Nino with one year lead time!
CONCLUSIONS

1. Variations of the extratropical weather are fully chaotic.
2. Variations of the tropical weather are chaotic, but with a mutual order.
3. Interannual climate variations are nonchaotic because these variations are conducted by three more external periodicities with incommensurate periods in addition to the annual Sun-induced heating.
4. The interannual climate variations form a global scale spatial structure called GAO as a result of these conductor actions.
5. GAO includes ENSO as well as all well-known teleconnections within itself.
6. There is a possibility to predict ENSO for one year ahead.
7. Present-day climatic models are not capable to catch temporal variations of GAO. By this reason, these is no ENSO predictability excepting very short-term one.