Evidence of a strange nonchaotic attractor in the El Niño dynamics from re-analyses versus CMIP5 models

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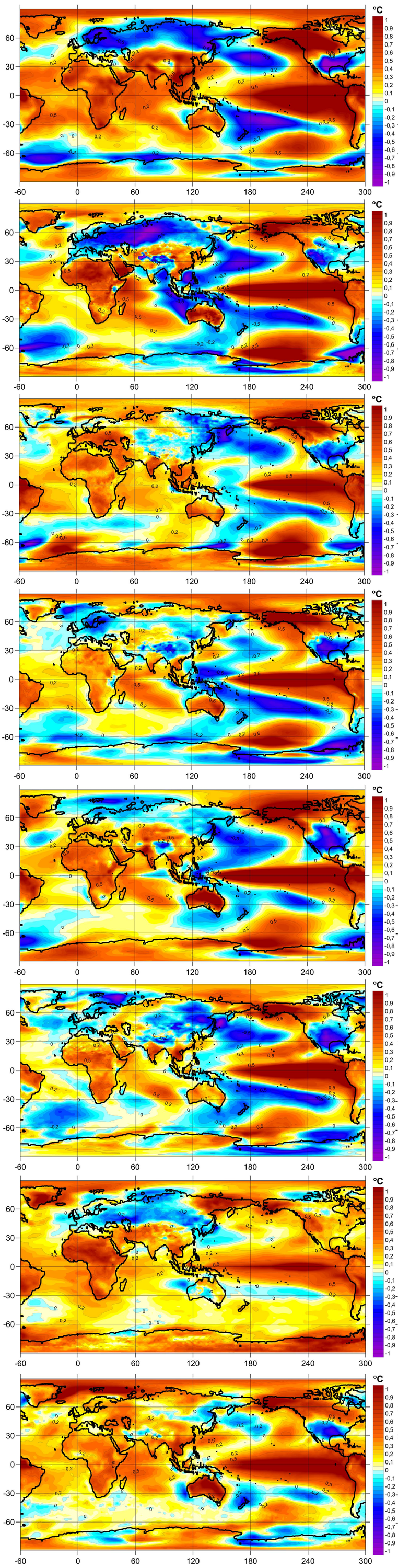

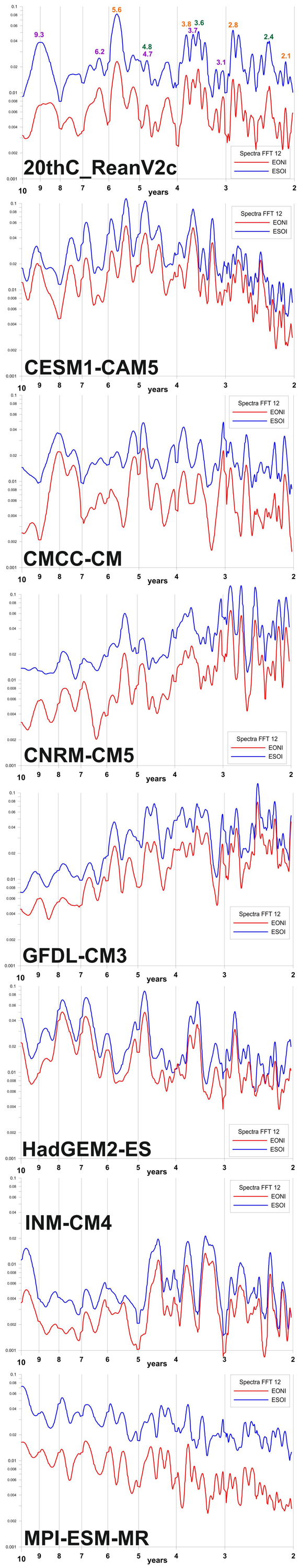

Basing on a mathematical idea about the so-called strange nonchaotic attractor (SNA) in the quasi-periodically forced dynamical systems, the currently available re-analyses data are considered. It is found that the El Niño - Southern Oscillation (ENSO) is driven not only by the seasonal heating, but also by three more external periodicities (incommensurate to the annual period) associated with the ~18.6-year lunar-solar nutation of the Earth rotation axis, ~11-year sunspot activity cycle and the ~14-month Chandler wobble in the Earth's pole motion. Because of the incommensurability of their periods all four forces affect the system in inappropriate time moments. As a result, the ENSO time series look to be very complex (strange in mathematical terms) but nonchaotic.

The power spectra of ENSO indices reveal numerous peaks located at the periods that are multiples of the above periodicities as well as at their sub- and super-harmonic. In spite of the above ENSO complexity, a mutual order seems to be inherent to the ENSO time series and their spectra. This order reveals itself in the existence of a scaling of the power spectrum peaks and respective rhythms in the ENSO dynamics that look like the power spectrum and dynamics of the SNA. It means there are no limits to forecast ENSO, in principle. In practice, it opens a possibility to forecast ENSO for several years ahead.

Global spatial structures of anomalies during El Niño and power spectra of ENSO indices from re-analyses are compared with results of the Historical experiment from the CMIP5 project. It is found that several climate models reproduce global spatial structures of the near surface temperature and sea level pressure anomalies during El Niño very similar to these fields in the re-analyses considered. But the power spectra of the ENSO indices from climate models show no peaks at the same periods as the re-analyses power spectra. We suppose that an adding to the climate model forcing terms may improve the rhythmicity of the modeled ENSO processes, and so the predictability of El Niño events.

Mean differences of the near-surface air temperature anomalies between El Niño and La Niña events.

Mean differences of the sea level atmospheric pressure anomalies between El Niño and La Niña events.

Detailed view of spectral bands of the average near-surface air temperature anomalies in region Nino3.4+Nino3 (EONI) and Equatorial Southern Oscillation Index (ESOI).

Analyzed periods: 1851-2011 for 20th Century Reanalysis V2c and 1850-2005 for climate models.