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Big whirls talking to smaller whirls: detecting cross-scale information flow

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Big whirls have little whirls that feed on their velocity,

and little whirls have lesser whirls and so on to viscosity.

These famous words written in 1922 by Lewis Fry Richardson have become inspiration for intensively developing scientific field studying scales of climate variability and their interactions. In spite of ever growing interest in this research area, the description of this session states: "We still lack an efficient methodology to diagnose the scale-to-scale energy or other physical quantities fluxes to characterize the cascade quantitatively, e.g., strength, direction, etc. " In this contribution we would like to remind the methodology able to identify causal relations and information transfer between dynamical processes on different time scales and even to quantify the effect of such causal influences. Moreover, in macroscopic systems the information transfer is tied to the transfer of mass and energy [1].

The detection of cross-scale causal interactions [2] starts with a wavelet (or other scale-wise) decomposition of a multi-scale signal into quasi-oscillatory modes of a limited bandwidth, described using their instantaneous phases and amplitudes. Then their statistical associations are tested in order to search interactions across time scales. An information-theoretic formulation of the generalized, nonlinear Granger causality [3] uncovers causal influence and information transfer from large-scale modes of climate variability, characterized by time scales from years to almost a decade, to regional temperature variability on short time scales. In particular, a climate oscillation with the period around 7-8 years has been identified as a factor influencing variability of surface air temperature (SAT) on shorter time scales. Its influence on the amplitude of the SAT annual cycle was estimated in the range 0.7-1.4 °C, while its strongest effect was observed in the interannual variability of the winter SAT anomaly means where it reaches 4-5 °C in central European stations and reanalysis data [4]. In the dynamics of El Niño-Southern Oscillation (ENSO), three principal time scales - the annual cycle (AC), the quasibiennial (QB) mode(s) and the low-frequency (LF) variability – and their causal network have been identified [5]. Recent results show how the phases of ENSO QB and LF oscillations influence amplitudes of precipitation variability in east Asia in the annual and QB scales.

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[1] J. Hlinka et al., Chaos 27(3), 035811 (2017)

[2] M. Palus, Phys. Rev. Lett. 112, 078702 (2014)

[3] M. Palus, M. Vejmelka, Phys. Rev. E 75, 056211 (2007)

[4] N. Jajcay, J. Hlinka, S. Kravtsov, A. A. Tsonis, M. Palus, Geophys. Res. Lett. 43(2), 902–909 (2016)

[5] N. Jajcay, S. Kravtsov, G. Sugihara, A. A. Tsonis, and M. Palus, npj Climate and Atmospheric Science 1, 33 (2018). doi:10.1038/s41612-018-0043-7, https://www.nature.com/articles/s41612-018-0043-7