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ADVANCEMENT IN THE UNDERSTANDING AND PREDICTION OF EL NIÑO SOUTHERN OSCILLATION

- Scientists from the Catalan Institute for Climate Sciences (IC3) have recently conducted research that has led to the better understanding of the origin and very early stages of El Niño-Southern Oscillation and to the unprecedented forecasting of the phenomenon more than 2 years in advance. These results come from two research studies just published that focus on the surface and subsurface dynamical processes that occur essentially in the western equatorial Pacific Ocean before an El Niño event.
- The first study investigates the ocean heat transfer processes and their representation during the different stages of ENSO leading to the warm phase of of this climatic oscillation. It stems from another study published in 2015 by the same authors pointing to the heat buildup in subsurface waters in the western tropical Pacific (east of Philipines and Indonesia) as the key place where ENSO originates long before (>2 years) any mature event manifests in the surface waters offshore south America and the eastern Pacific.
- The second study is dedicated to the development of a new statistical ENSO forecasting scheme capable of making use of this new theoretical knowledge to beat all current prediction schemes to unprecedented lead times. Current prediction schemes are barely capable of anticipating an El Niño event more than 9 months in advance, due to the existence of a long-known predictability barrier in spring. The new model is composed of several time-varying unobserved components and explanatory prediction variables accounting for surface and subsurface ocean and atmosphere processes occurring up to about three years before an El Niño.

Barcelona, June 13, 2016 – A series of researches led by scientists from the Catalan Institute for Climate Sciences (IC3) in collaboration with scientists from the California Institute of Technology and the Vrije Universiteit Amsterdam just published two new research studies on the El Niño Southern Oscillation – the phenomenon that occurs in the equatorial Pacific Ocean and causes natural disasters such as torrential rains or droughts that affect the life of many thousands of people worldwide.

The first study published in the Journal of Geophysical Research-Oceans has for the first time clarified in detail the timing and mechanisms of heat transfer in the ocean, which trigger the development and growing of an El Niño event. The work, stemming from a former study published in Geophysical Research Letters in 2015 demonstrates, according to the lead author Joan Ballester, that 'the initial subsurface warming in the western equatorial and off-equatorial Pacific, which later provides the heat to fuel El Niño in the eastern equatorial Pacific, occurs between 33 and 22 months before the peak of the event, and is due to vertical advection of climatological temperature by anomalous currents'. Later on, the anomalous heat accumulated in the western equatorial Pacific is advected towards the central Pacific via the climatological subsurface ocean currents. At the same time, there is also an equatorward transport of heat that can be explained with anomalies in the gradients of both subsurface temperature and the meridional ocean circulation. The differences in the propagation speed of the heat from the western Pacific towards the eastern Pacific are mainly due to the differences in the magnitude of this meridional heat advection. These important results shed new light on the origin of ENSO, a controversial but also a central issue in climate research. The study also highlights the importance of subsurface processes and heat accumulation, and have implications about the simulation and prediction of ENSO.

Based on these findings, the authors of the second study published this month in the prestigious journal Climate Dynamics a new statistical forecasting system for ENSO. According to Desislava Petrova, lead author of the study, 'the new model is based on unobserved dynamic components, and explanatory precursor variables such as ocean surface and subsurface temperatures at different depths in the ocean and zonal wind. For the first time in an ENSO modelling approach different predictors are used at different stages of the development of an El Niño (i.e. different lead times) in order to capture better its subsurface and surface evolution dynamics.' The unknown parameters associated with all these model components are calculated together in a dynamic way, so that the whole system is updated timely and correctly, and hence, is very flexible and ready to be operational soon.

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With the new model, all El Niños that occurred in the last 20 years were successfully forecast up to 34 months in advance. According to Xavier Rodó, senior author and UDIC group leader 'such long-lead forecasts of ENSO have not been documented so far in the scientific literature, and they indicate that the predictability of El Niño can be extended to at least two and a half years'. The new results downscore the alleged relevance of stochastic/random processes in its inception. While these random dynamics associated to the varying nature of trade winds are very important at very short lead times (less than 6 months), they have no relevance at long lead times. 'Instead deterministic processes linked to the magnitude of the subsurface heat pool stored at different depths in the western tropical Pacific ocean keep the key to understanding why these El Niño events occur every 3-7 years', he states. This result is very important as it indicates that preparation for climate-related disasters generated by ENSO could start early on, and thus some of the damages to human life and health, agriculture and the economy could be better prevented.

The studies were led by IC3 scientists Desislava Petrova and Joan Ballester, as well as Xavier Rodó as the senior author. For further information and details contact:
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"Heat advection processes leading to El Niño events as depicted by an ensemble of ocean assimilation products" Journal of Geophysical Research - Oceans [Paper #2016JC011718R](2016)

"Improving the long-lead predictability of El Niño using a novel forecasting scheme based on a dynamic components model", Desislava Petrova, Siem Jan Koopman, Joan Ballester, Xavier Rodó
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