PREDICTABILITY OF HEAT WAVES IN CENTRAL CHILE: IDENTIFICATION OF REMOTE INTRASEASONAL PRECURSORS USING ANALOGUES

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RESUMEN

Este estudio intenta identificar precursores remotos de olas de calor intraestacionales de verano en Chile Central. Para ello, seleccionamos casos particulares y buscamos eventos análogos en reconstrucciones climáticas, considerando el desarrollo de señales tropicales relacionadas a la Oscilación de Madden-Julian. Concluimos que es necesario definir precursores extratropicales complementarios para restringir los análogos a aquéllos que muestren anomalías cálidas en la zona de estudio y obtener una mejor predictibilidad de los casos analizados.

ABSTRACT

This study intends to identify remote precursors of summer intraseasonal heat waves in Central Chile. With this aim, we select particular cases and seek analogue events within climatic reconstructions, considering the development of tropical signals related with the Madden-Julian Oscillation. We conclude that extra-tropical complementary precursors are needed in order to restrict the analogues to those showing warm anomalies in the study zone and to obtain an enhanced predictability of the analysed cases.
Key words: heat waves, Chile, MJO.

Chile presents a wide variety of natural hazards caused by extreme meteorological events. Particularly, summer 2017 was a record-breaking season in Central Chile (defined here as the region comprised between 30° and 40°S) concerning extremely high temperatures, along with exceptional atmospheric circulation anomalies. These phenomena were reported as outstanding heat waves and were instrumental for the development and propagation of wildfires that burnt an area more than 7 times the long-term mean value. Much is speculated concerning the eventual connection between meteorological extreme events and global warming. However, due to the national lack of related studies, our ongoing research efforts have focused on a prior task: building background knowledge about intraseasonal summer heat waves in Central Chile. Besides their climatological characteristics, we are deeply interested in their dynamics. How do they form and develop? In particular, are there remote precursors of some of these events, beyond the local factors, that might induce their onset?

We aim at exploring large-scale anomalies that induce the regional temperature perturbations associated with these extreme events. In agreement with previous own results for Eastern Patagonia (Jacques-Coper et al., 2015), our current work in progress shows that summer temperature variability in Central Chile is highly driven by tropical intraseasonal sources, especially the Madden-Julian Oscillation (MJO, Madden and Julian (1971)). As a consequence, the frequency of summer heat waves in Central Chile is also modulated by the MJO. This climate mode consists of a planetary-scale eastward propagating pattern of atmospheric circulation and deep convection, associated with anomalies in various variables in both tropical and subtropical regions (Zhang, 2005). It is the dominant mode of intraseasonal variability of the tropical coupled ocean-atmosphere system, and its typical period ranges from 30 to 90 days (Zhang, 2005). Evidence states that circulation anomalies that partly trigger such extreme events might arise from the constructive interaction between MJO-related and mid-latitude circulation patterns over the South Pacific

Ocean (Jacques-Coper et al., 2015). Therefore, our specific task is to elucidate this aspect for historical heat waves affecting Central Chile. We put special emphasis on the analysis of the potential for improving the predictability of certain conspicuous extreme events. We use the Twentieth Century Reanalysis version 2, spanning 1871-2010 (Compo et al., 2011), and the 1905-2008 historical reconstruction (Oliver & Thompson, 2011) of a MJO index (Wheeler & Hendon, 2004), which uses two coordinates (RMM1 and RMM2) to divide the oscillation in 8 phases (which correspond to the longitudinal location of the convective centre) and to measure the strength of its activity.

Our research strategy consists of the following steps: we first identify intraseasonal heat waves within summer (December-February) for Central Chile, following Jacques-Coper et al. (2015). Second, we select those events that show active MJO signals at the onset day (day 0). They tend to culminate in MJO phases 6 and 8. Then, the MJO trajectory of each event is tracked backwards until day -16. In this way, we define a 17-day-long set of coordinates in the MJO index phase diagram, which constitute the *reference trajectory*. Next, for each case, we look for similar trajectories in the historical reconstruction of the MJO index, by considering both their shape (measured by running correlation) and Euclidean distance in the phase diagram. Thus, we obtain a group of *analogue events* that exhibit a comparable development of MJO-related tropical signals as the *reference heat wave*. As an example, Figure 1 shows the intraseasonal anomaly field of mean surface temperature for the reference heat wave of 29th January 1934, along with those of five of its analogues. They all depict a transition from MJO active phase 3 to 6. As expected, the temperature anomaly over Central Chile might be positive or negative, and this fact defines whether an analogue is classified as *warm* or *cold*, respectively (three cold analogues not show in Figure 1). This means that the tropical signal is not a *sufficient condition* for a warm anomaly to develop in this region. To restrict the analogues, we explore further precursors related to extra-tropical dynamical signals. Thus, lagged composites of geopotential height and vertical velocity at 500 hPa are constructed. Hence, we characterize the preferred regimes for tropical-extratropical interaction. Finally, we quantify the predictability enhancement by means of the conditional probability associated with each predictor.

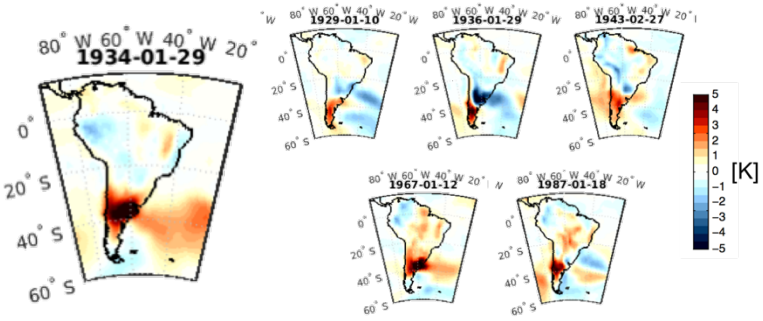

Figure 1: intraseasonal anomaly field of mean surface temperature for the reference heat wave of 29th January 1934, along with five of its analogues.

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