Linking N. Hemisphere temperature extremes to Rossby wave packets

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1 Introduction

Rossby wave activity is typically not stretched out circumglobally, but organized in eastward propagating patches of limited spatial extent; the so-called Rossby wave packets (RWPVs) (Wirth et al., 2018).

RWPVs encompass areas of high waveness, where advection of the basic-state isotherms and the consequent formation of troughs and ridges favour flow patterns and physical processes that lead to anomalously warm/cold air masses.

If, in addition, the individual troughs/ridges within the RWPVs are quasi-stationary, an extended episode of near-surface extreme temperatures is likely to occur. This calls for a closer investigation of the RWPVs nature and a better understanding of their evolution.

2 Objectives

i) Investigate the effect of RWP amplitude and phase velocity on temperature extremes.

ii) Study the RWP characteristics and impact during severe heat waves of the past.

iii) What do we learn regarding the predictability of temperature extremes? (ongoing work)

3 Method

Diagnosis of RWP amplitude

a) Meridional wind anomaly u’ (m/s) at 300 hPa; b) u’ at 50°N (green line, m/s) and its envelopes (blue line, m/s) based on Fragkoulidis et al. (2018); c) 2-D field of RWP amplitude (RWPVA, m/s)

Hovmöller diagram of 300hPa u’ (color shading) and RWP amplitude (contours: 22, 27, 32 m/s) (top) during the 2003 heat wave (bottom).

SSS prediction:

Investigating the response of RWP activity on low-frequency forcings (e.g. SST) may shed light on subseasonal aspects of temperature extremes. Systematic biases in RWP properties have implications for SSS prediction endeavours.

4 Results

Increasing probability of 850hPa temperature extremes in SE Europe with RWP amplitude

a) Scatter plot of daily mean T’ at 850hPa (averaged over [34.44°N, 18.28°E]) versus standardized RWPVA (1979-2016, JJA); b) Percentage of T’ extremes per RWPVA-bin.

Upper-tropospheric flow evolution during SE European hot extremes

d) Composite of 300 hPa u’ (color shading) and 500 hPa z’ (blue/magenta contours indicate negative/positive anomalies at ±3, ±6, ... gpdal) before JJA heat extremes.

Investigation of the 2003 and 2010 heat waves

Hovmöller diagrams of 850hPa T’ (color shading) and 300 hPa RWP amplitudes (black contours, every 2 m/s between 20 and 34 m/s) for the a) 2003 and f) 2010 heat waves. T’ is averaged over 40-60°N and 44-64°N respectively, whereas for both cases RWP amplitude is averaged over the 20 degrees with its highest value.

Role of upper-tropospheric phase velocity for the duration of temperature extremes

c) Hovmöller composites of 850 hPa T’ (color shading) and 300 hPa u’ (blue/magenta contours indicate negative/positive anomalies at ±3, ±5, ... m/s) during persistent and short-lived hot extremes in SE Europe. Stars (hatching) denote statistically significant values of T’ (u’) at α=0.10.

5 Conclusions

i) The presence of large-amplitude RWPVs in the upper troposphere is associated with a high probability of lower-tropospheric temperature extremes in SE Europe and other regions of the mid-latitudes.

ii) The phase velocity of eddies embedded in RWPVs is an important factor for the duration of temperature extremes.

iii) The 2003 and 2010 heat waves are associated with conspicuous non-circumglobal RWP activity. Equally severe heat waves can be associated with distinctly different evolution in the upper-tropospheric circulation.

Ongoing work: Local diagnostics of RWP activity help in revealing systematic biases in its prediction. Need to investigate the implications these biases have on medium and extended range forecast of temperature extremes.

6 References

Fragkoulidis, G. et al. 2018. Linking Northern Hemisphere temperature extrema to Rossby wave packets. QJRO.

Fragkoulidis, G. and Wirth, V. 2018. Synoptic circulation, persistence, temperature anomalies over Central Europe. CONSECAP proceedings, in press.
