# Linking N. Hemisphere temperature extremes to Rossby wave packets

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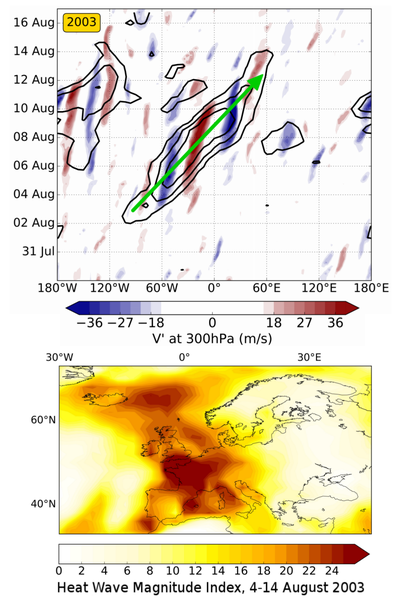
## 1 Introduction

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** (RWPs) (Wirth et al., 2018).

RWPs encompass areas of high waviness, 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 RWPs are quasi-stationary, an extended episode of near-surface **extreme temperatures** is likely to occur. This calls for a closer investigation of the RWPs nature and a better understanding of their evolution.




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

## 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)

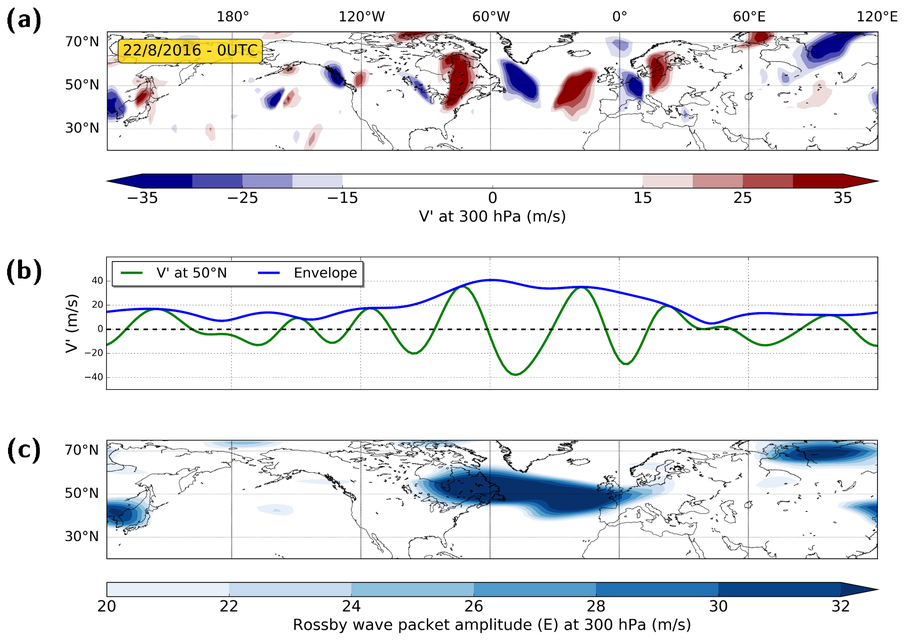
### S2S prediction:

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 S2S prediction endeavours.

## 3 Method

### Diagnosis of RWP amplitude

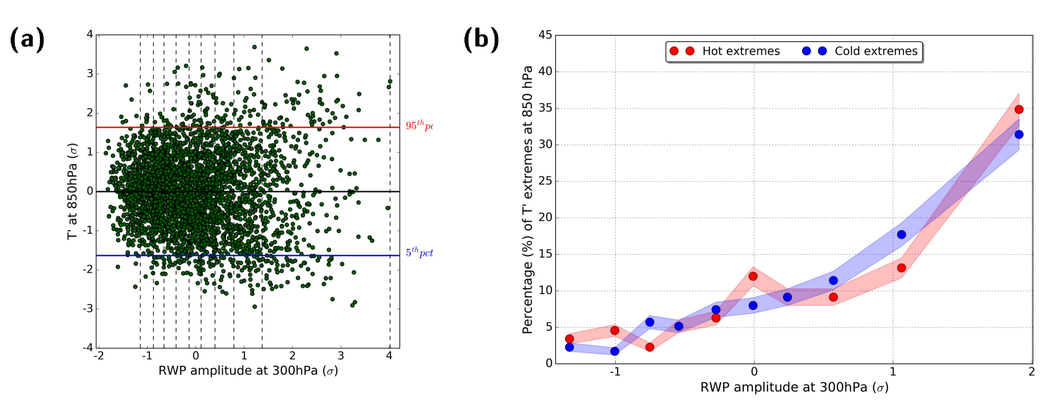
***a)*** *Meridional wind anomaly $v'$ (m/s) at 300 hPa;* ***b)*** *$v'$ at 50° N (green line, m/s) and its envelope (blue line, m/s) based on Fragkoulidis et al. (2018);* ***c)*** *2-D field of RWP amplitude (RWPA, m/s).*




## 4 Results

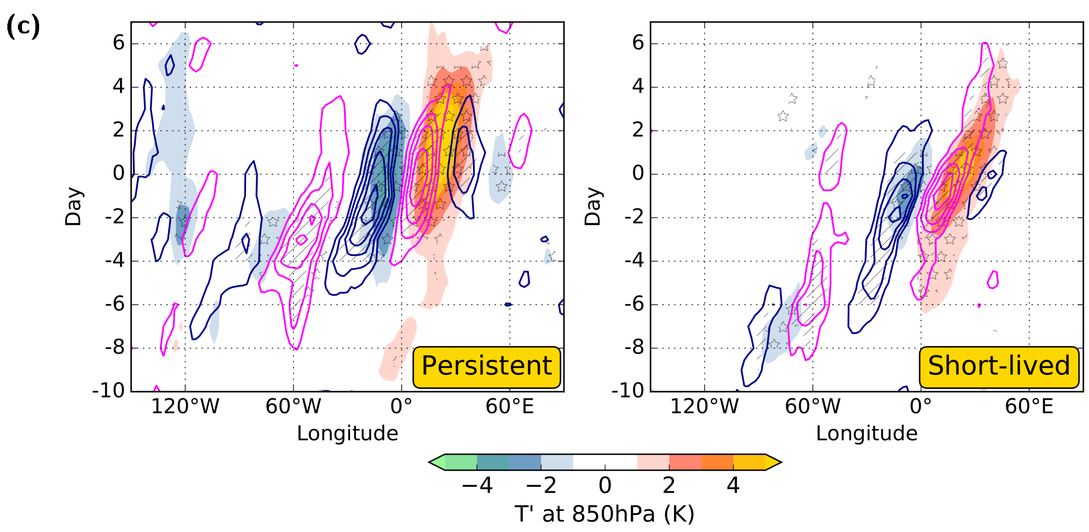
### Increasing probability of 850hPa temperature extremes in SE Europe with RWP amplitude

***a)*** *Scatter plot of daily mean T' at 850hPa (averaged over [34-44° N , 18-28° E ]) versus standardized RWPA (1979-2016, JJA).* ***b)*** *Percentage of T extremes per RWPA-bin.*



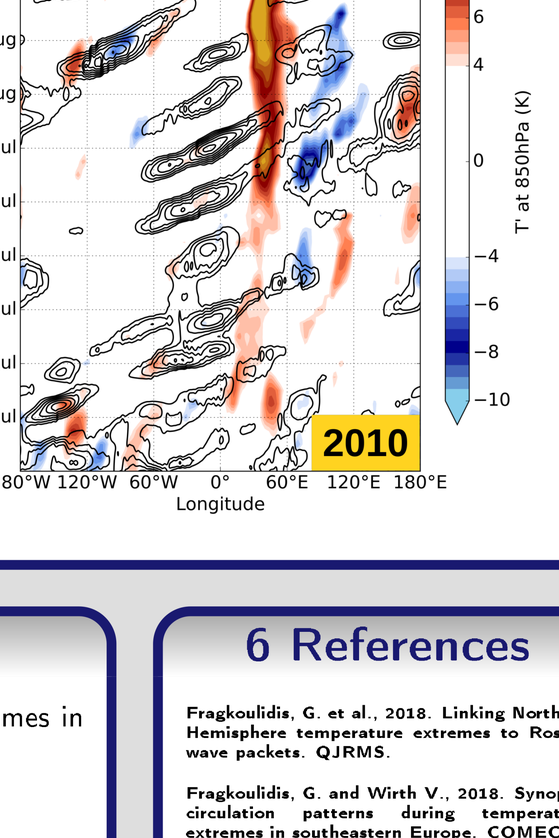

### Role of upper-tropospheric phase velocity for the duration of temperature extremes

***c)*** *Hovmöller composites of 850 hPa $T'$ (color shading) and 300 hPa $v'$ (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 $T'$ ($v'$) at $\alpha$=0.10.*



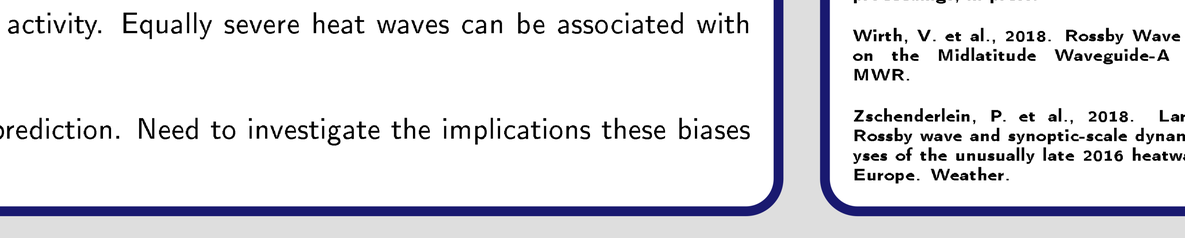

### Upper-tropospheric flow evolution during SE European hot extremes

***d)*** *Composites of 300 hPa $v'$ (color shading) and 500 hPa $Z'$ (blue/magenta contours indicate negative/positive anomalies at ±3, ±6, ... gpdam) before JJA hot 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* ***e)*** *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.*




## 5 Conclusions

**i)** The presence of large-amplitude RWPs 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 RWPs 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 extremes to Rossby wave packets. QJRMS.**

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**Zschenderlein, P. et al., 2018. Large-scale Rossby wave and synoptic-scale dynamic analyses of the unusually late 2016 heatwave over Europe. Weather.**