COMPOUND HOT-DRY AND COLD-WET DYNAMICAL EXTREMES OVER THE MEDITERRANEAN

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Method

Given two atmospheric variables their joint Poincaré recurrences in the phase-space are quantified (Faranda et al., 2020).

Two joint dynamical systems metrics are computed:

i) the co-recurrence ratio (α), which measures the strength of the dynamical coupling;
ii) the local co-persistence ($\theta^{-1}_{x,y}$), which measures the mean joint residence time of the trajectories around a given state of interest.

Definitions

Compound dynamical extremes (CDEs) are daily α values >90th quantile of the entire distribution (i.e. days when the dynamical coupling is high);

Compound summer hot-dry events are days that recorded both positive maximum temperature (Tmax) and negative total precipitation (P) anomalies. Compound winter cold-wet events are days with negative minimum temperature (Tmin) and positive P anomalies.

Motivation

The Mediterranean (MED) basin is considered a climate change hot-spot. Understanding compound events over the MED is therefore pivotal for improving disaster risk reduction measures.

Aims

- To quantify the strength of the coupling between temperature and precipitation over the MED within the 1979-2018 period;

- To observe summer and winter sea-level pressure (SLP), precipitation and temperature anomalies occurring during compound dynamical extremes (CDEs, i.e. days when the coupling is high);

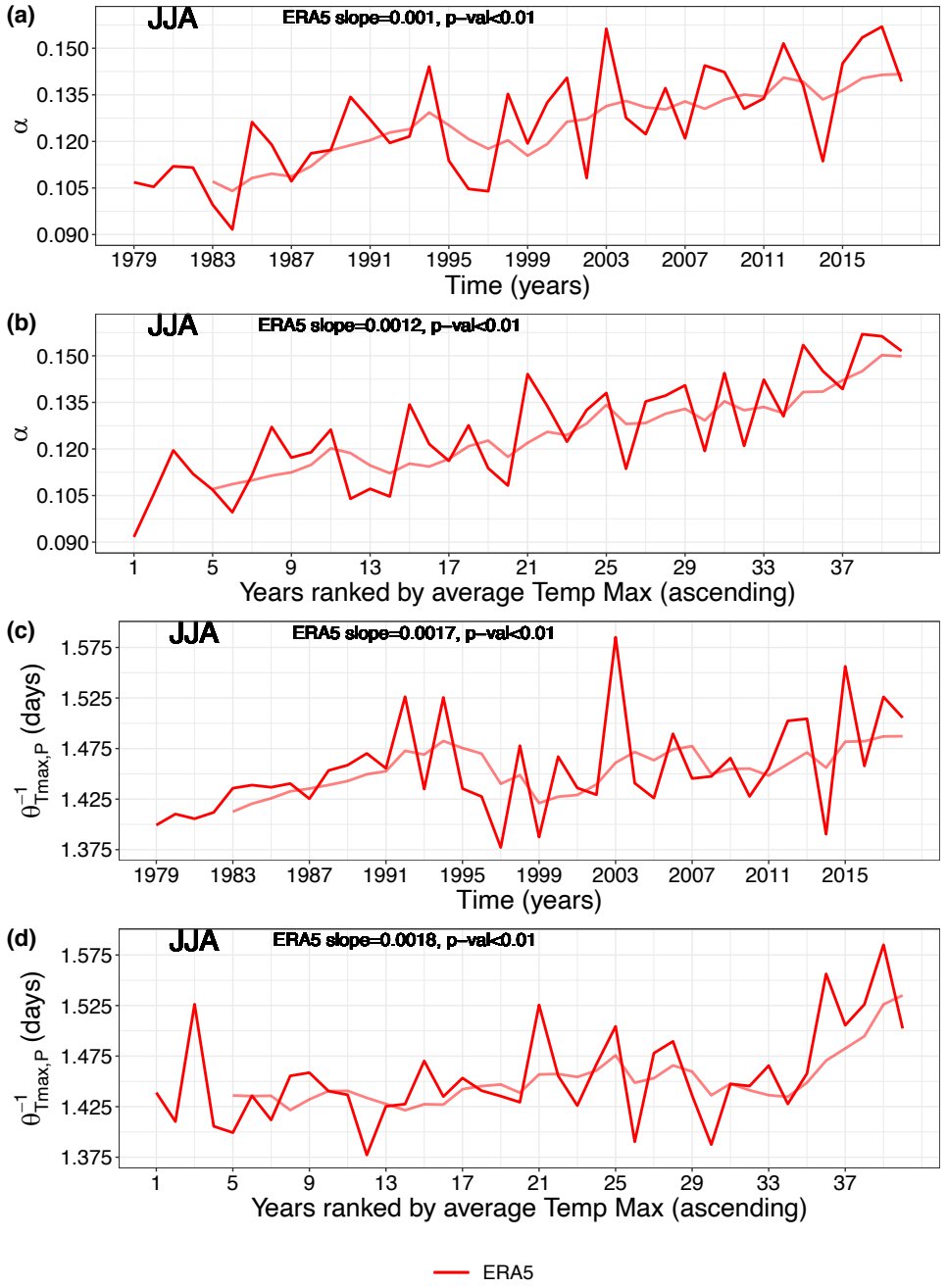
- To link summer and winter compound dynamical extremes with compound hot-dry and cold-wet events respectively.

Summer JJA: ERA5 daily temp max (K) and total precip (mm) from 1979 to 2018 -> proxy for hot-dry events;

Winter DJF: ERA5 daily temp min (K) and total precip (mm) from 1979 to 2018 -> proxy for cold-wet events.

In **JJA** α and θ^{-1} show positive and significant ($p<0.01$) trends, which are driven by surface warming over the MED;

In **DJF** trends are not statistically significant.



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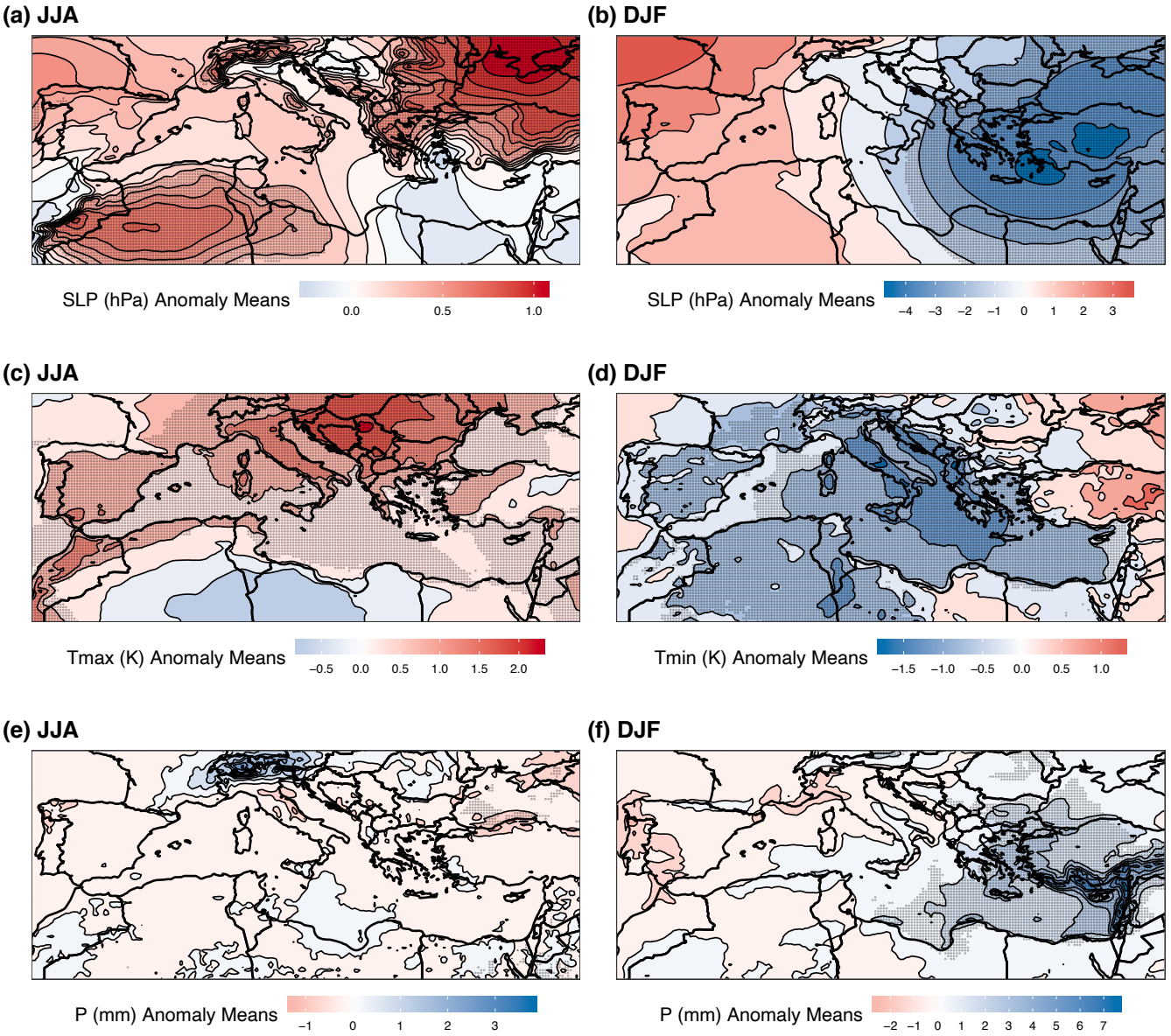
Summer and winter SLP, Tmax (Tmin) and P anomaly means observed during CDEs

JJA anomalies reflect compound hot-dry events (i.e. days with positive and negative Tmax and P anomalies);

DJF anomalies reflect cold-wet events (i.e. days with negative and positive Tmin and P anomalies).



CDEs are defined as JJA (DJF) α values >90th quantile over 1979-2018.

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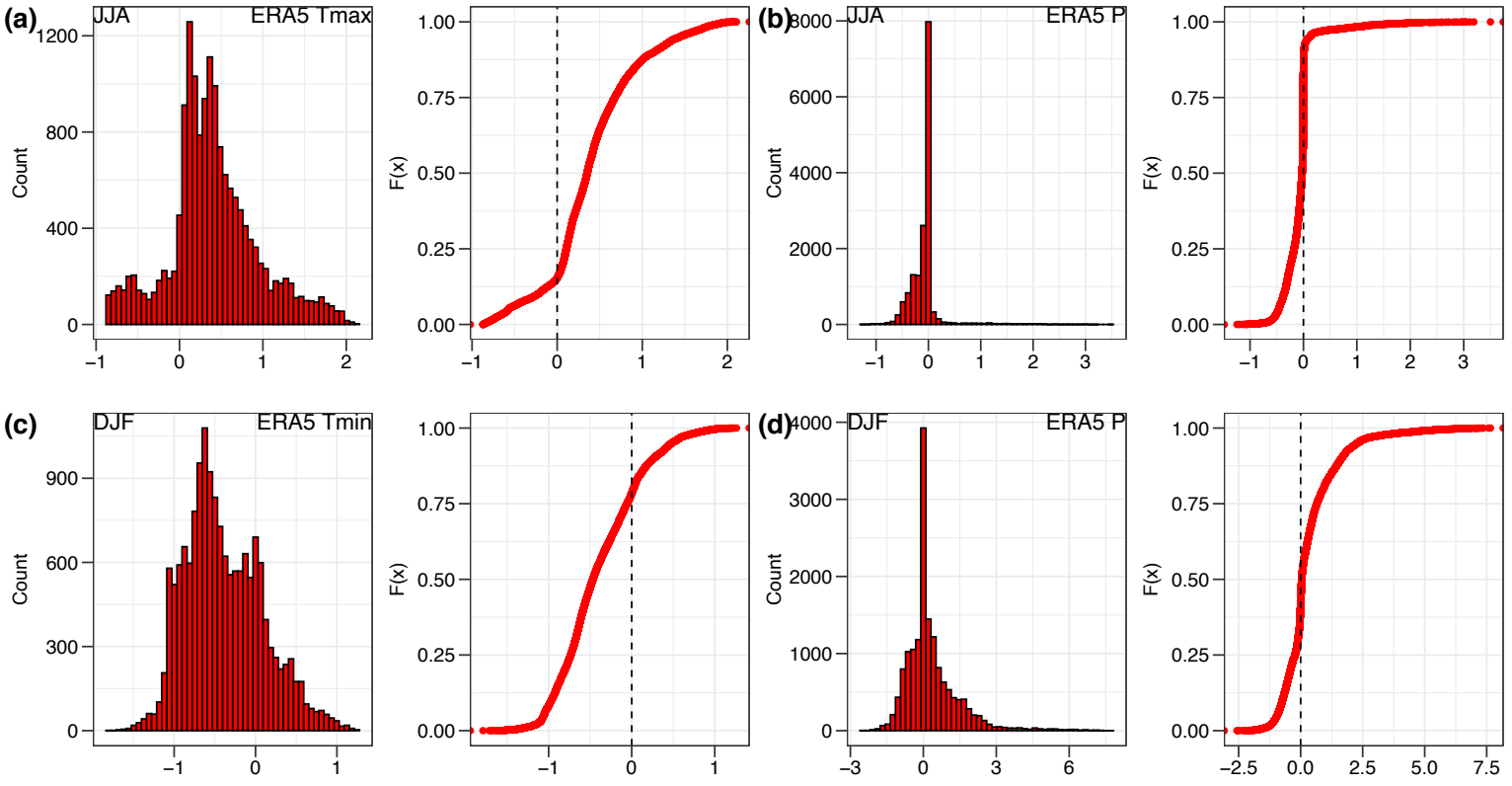

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JJA and DJF anomaly means observed during CDEs are significantly ($p<0.01$, one-sided Mann-Whitney test) stronger than the anomaly means observed during non-CDEs.

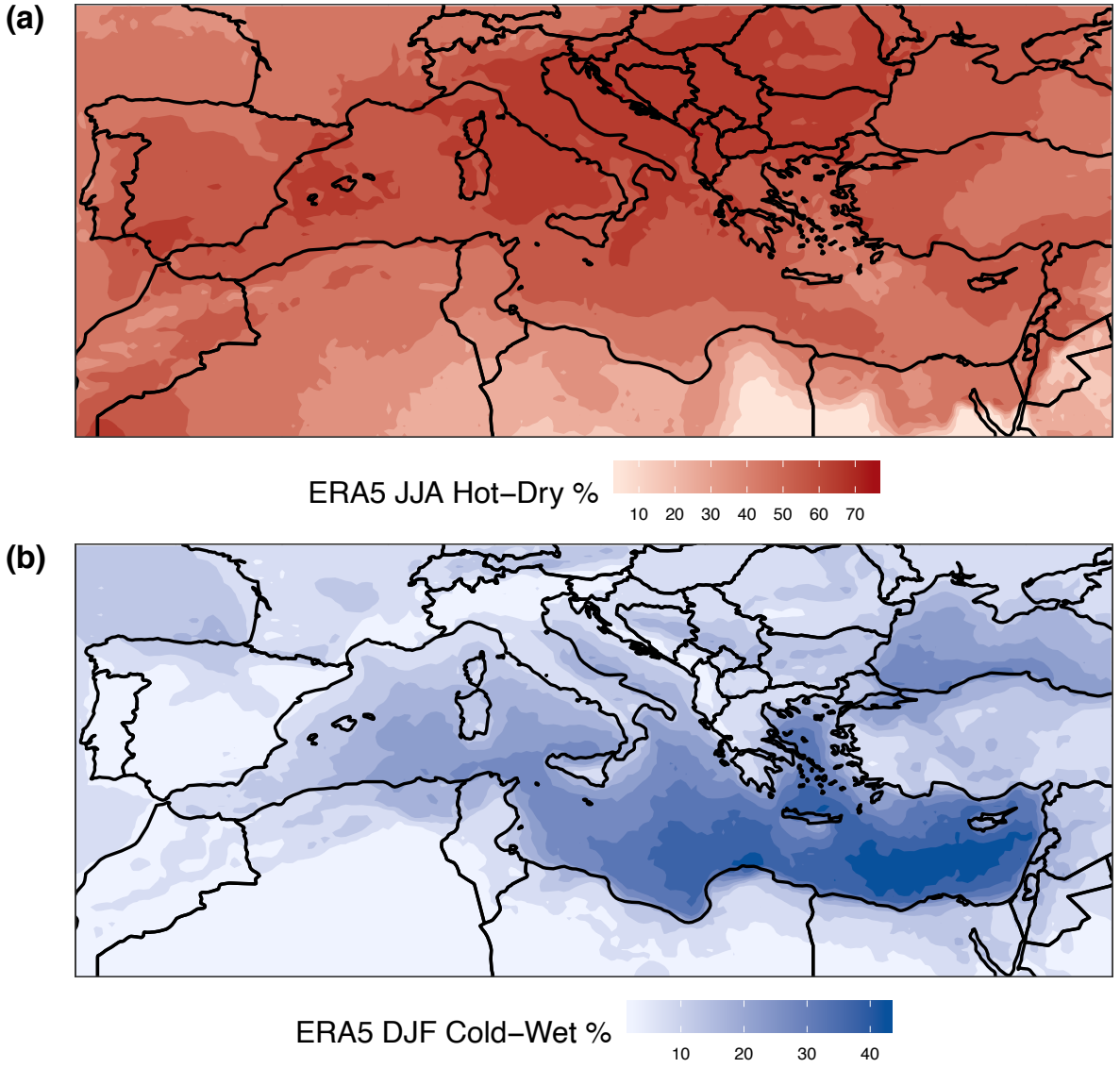
This strengthen our hypothesis that CDEs are able to capture JJA hot-dry and DJF cold-wet compound events.

Spatial patterns of hot-dry and cold-wet events

Percentage (%) of JJA hot-dry and DJF cold-wet compound events occurring during CDEs.

In JJA the % are stronger compared to DJF;

In DJF the % are stronger over the eastern MED sea.



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Conclusions

- The dynamical coupling (α) and persistence (θ^{-1}) between maximum temperature and total precipitation during JJA over the Mediterranean (1979-2018) increased significantly and they are driven by surface warming;

- summer and winter days recording strong dynamical coupling are successfully linked to compound hot-dry and cold-wet events;

- an increase in summer dynamical coupling and persistence in the future could signify stronger and more persistent compound heatwave-drought events;

- the dynamical systems approach can be used as a proxy for quantifying climatological features over the MED.

Way forward

- Future climate projections of compound dynamical extremes, with links to compound events, by making use of SSPs and abrupt 4xCO2 CMIP6 datasets;

- case studies investigating physical mechanisms of observed compound heatwave-drought events.

Thank you

Any questions?

References

De Luca, P., Messori, G., Faranda, D., Ward, P.J., and Coumou, D. Compound hot-dry and cold-wet dynamical extremes over the Mediterranean. *Earth Syst. Dynam. Discuss.*, in review (2020), https://doi.org/10.5194/esd-2020-21

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