Institute of Earth Sciences

Dynamical systems insights on cyclonic compound 'wet' and 'windy' extremes in the Eastern Mediterranean

Assaf Hochman, Eylon Vakrat

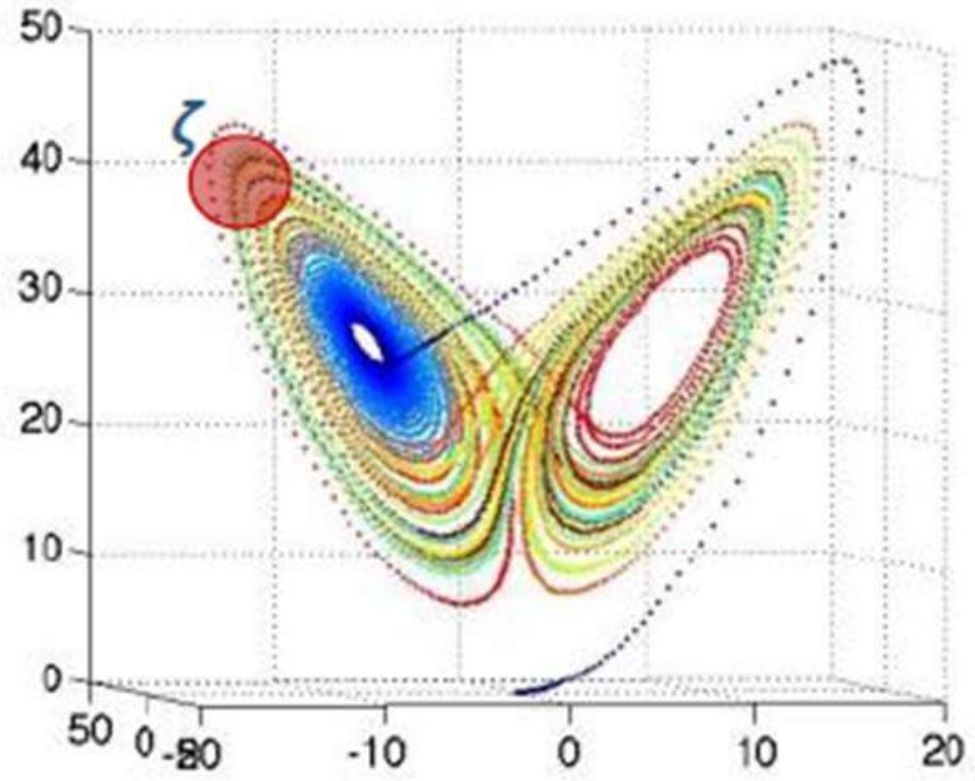
Fredy and Nadine Hermann Institute of Earth Sciences

HUJI – The Hebrew University of Jerusalem

https://en.earth.huji.ac.il/people/assaf-hochman

Background
A mathematical view of persistence and co-recurrence

- θ^{-1} = Persistence
- α = Co-recurrence ratio - $0 < \alpha < 1$

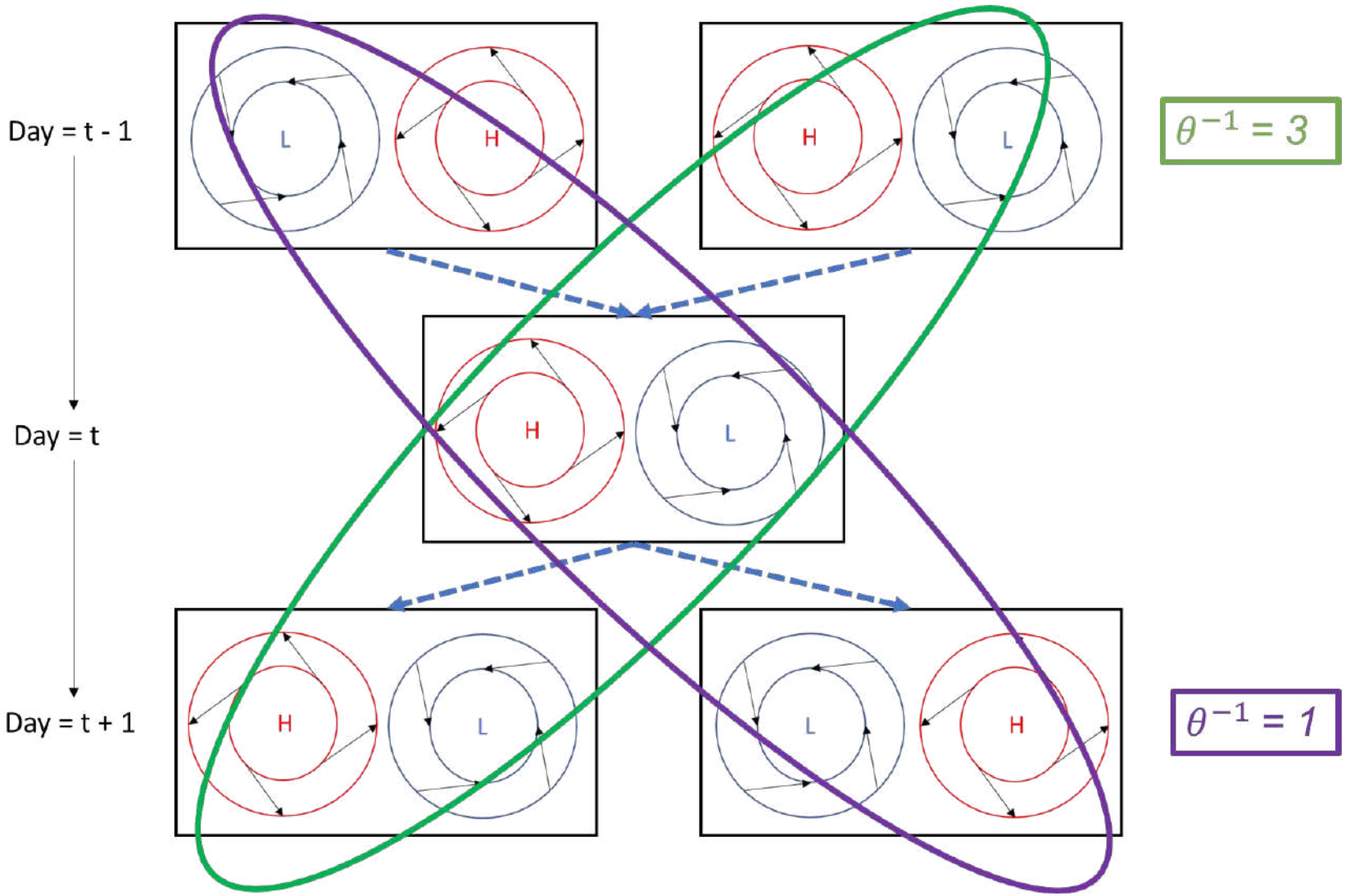


Faranda et al. 2017
De Luca et al. 2020

assaf.hochman@mail.huji.ac.il

Institute of Earth Sciences

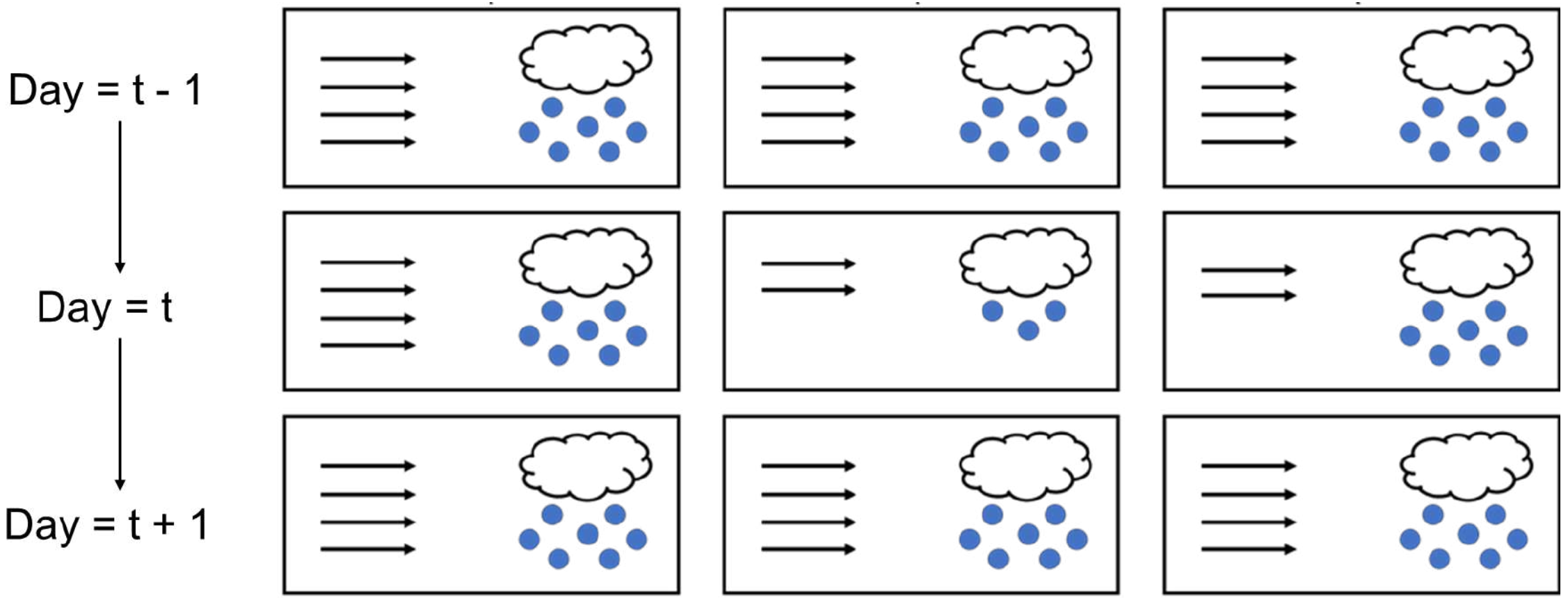
Intuitive view of persistence – (θ^{-1})



assaf.hochman@mail.huji.ac.il

Institute of Earth Sciences

Intuitive view of co-recurrence ratio – (α)



α = 7/9

assaf.hochman@mail.huji.ac.il

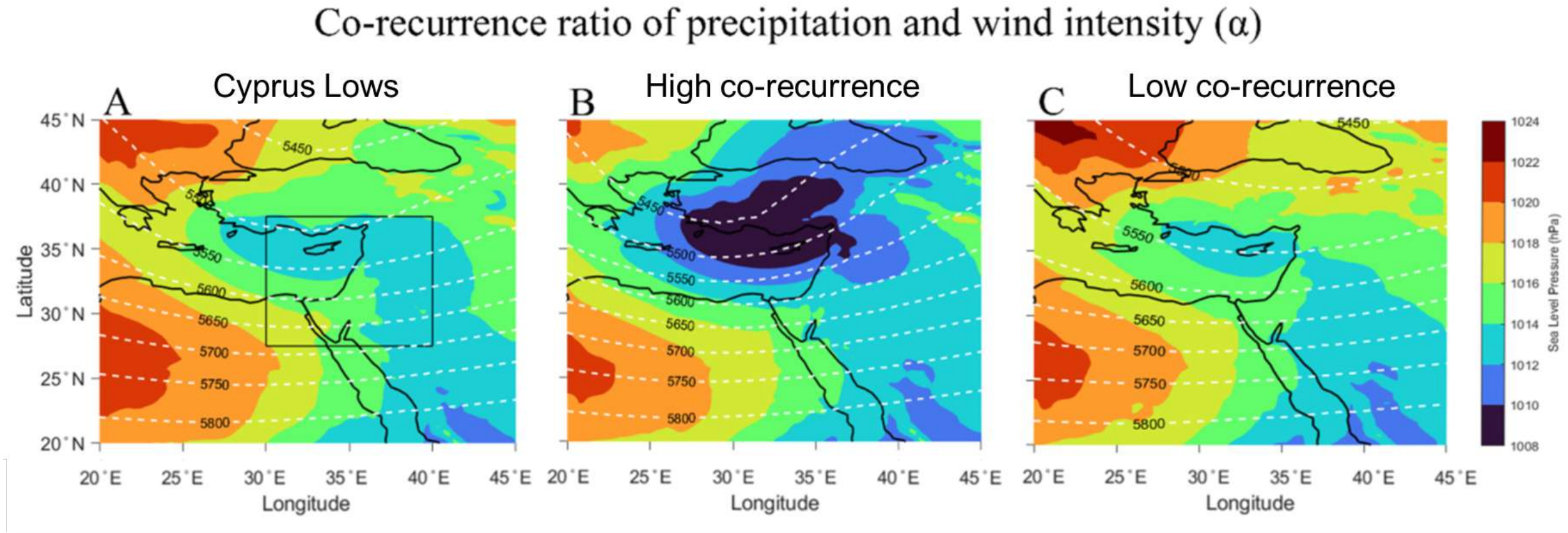
Institute of Earth Sciences

Outline

1. We define **Compound Dynamical Extremes (CDE)** based on upper and lower deciles of two dynamical systems metrics, linking them to the synoptic patterns.
2. We define **Compound Extremes (CE)**, the upper 5% of precipitation and wind co-occurring simultaneously. We link these back to the dynamical system metrics anomalies.

assaf.hochman@mail.huji.ac.il
Institute of Earth Sciences

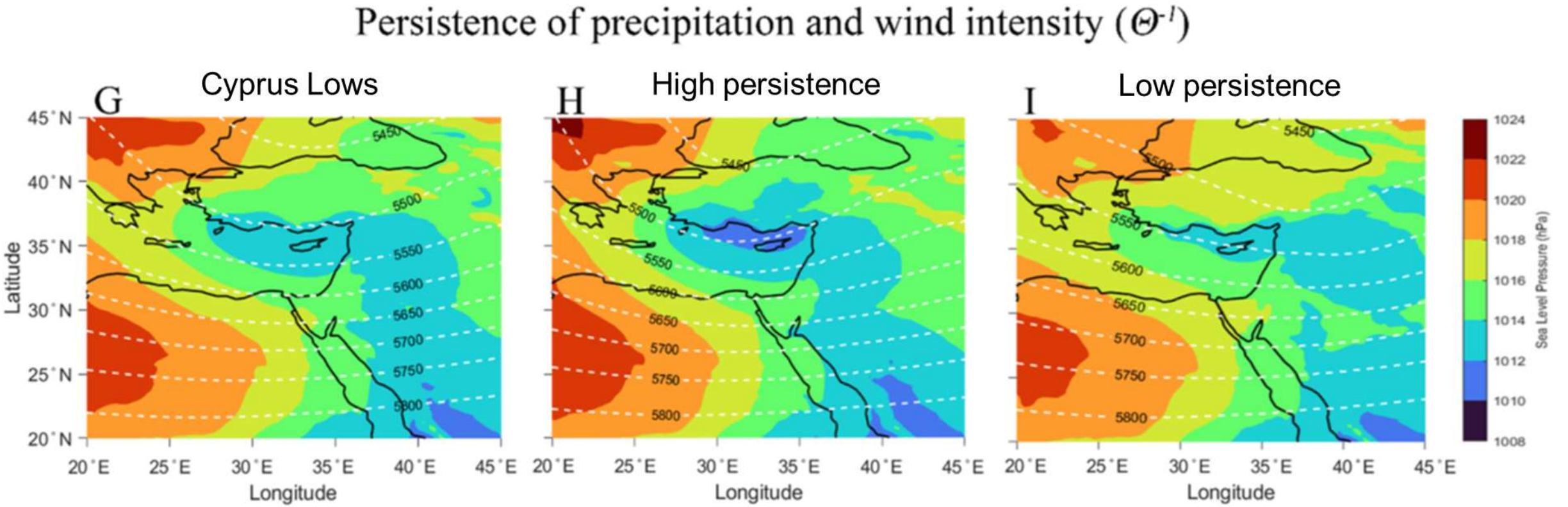
1. Composite mean synoptic maps of high and low co-recurrence



assaf.hochman@mail.huji.ac.il

Institute of Earth Sciences

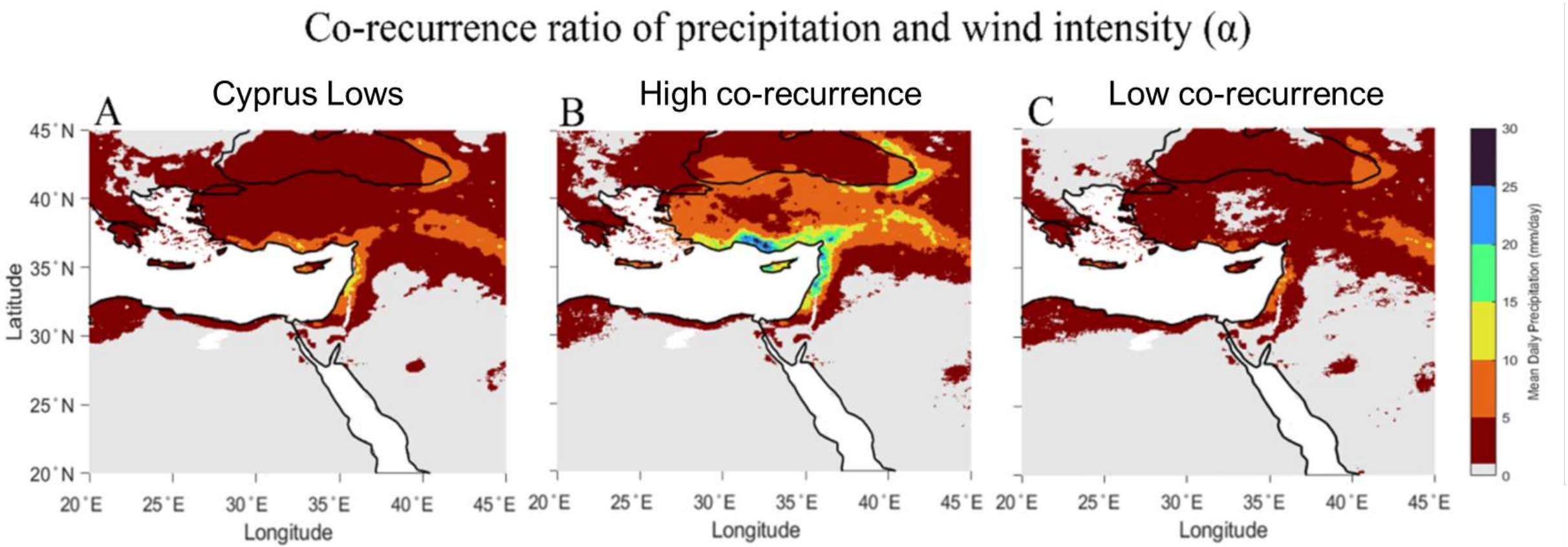
1. Composite mean synoptic maps of high and low persistence



assaf.hochman@mail.huji.ac.il

Institute of Earth Sciences

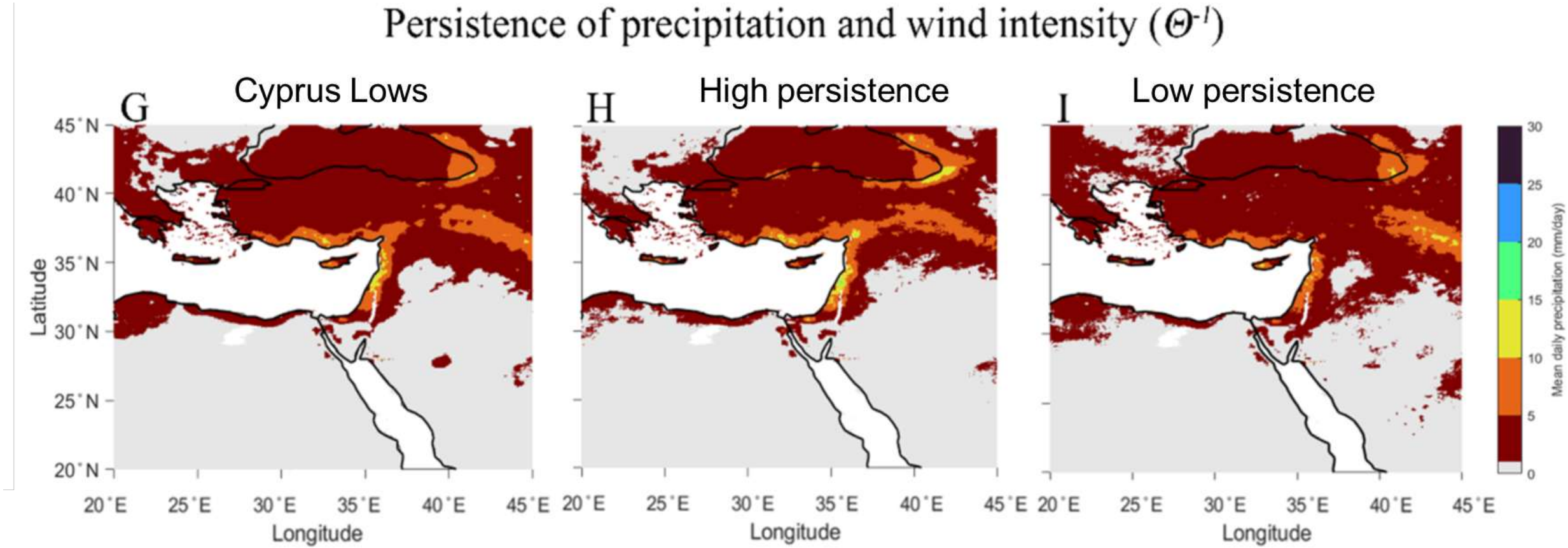
1. Composite mean precipitation maps of high and low co-recurrence



assaf.hochman@mail.huji.ac.il

Institute of Earth Sciences

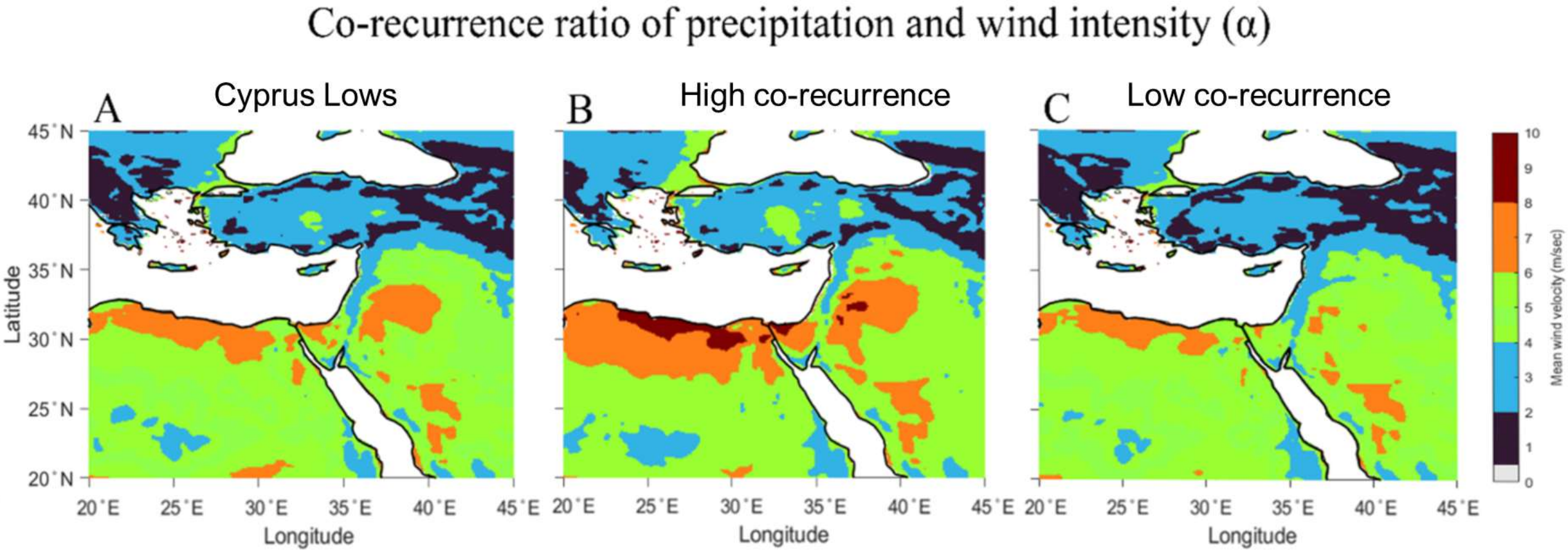
1. Composite mean precipitation maps of high and low persistence



assaf.hochman@mail.huji.ac.il

Institute of Earth Sciences

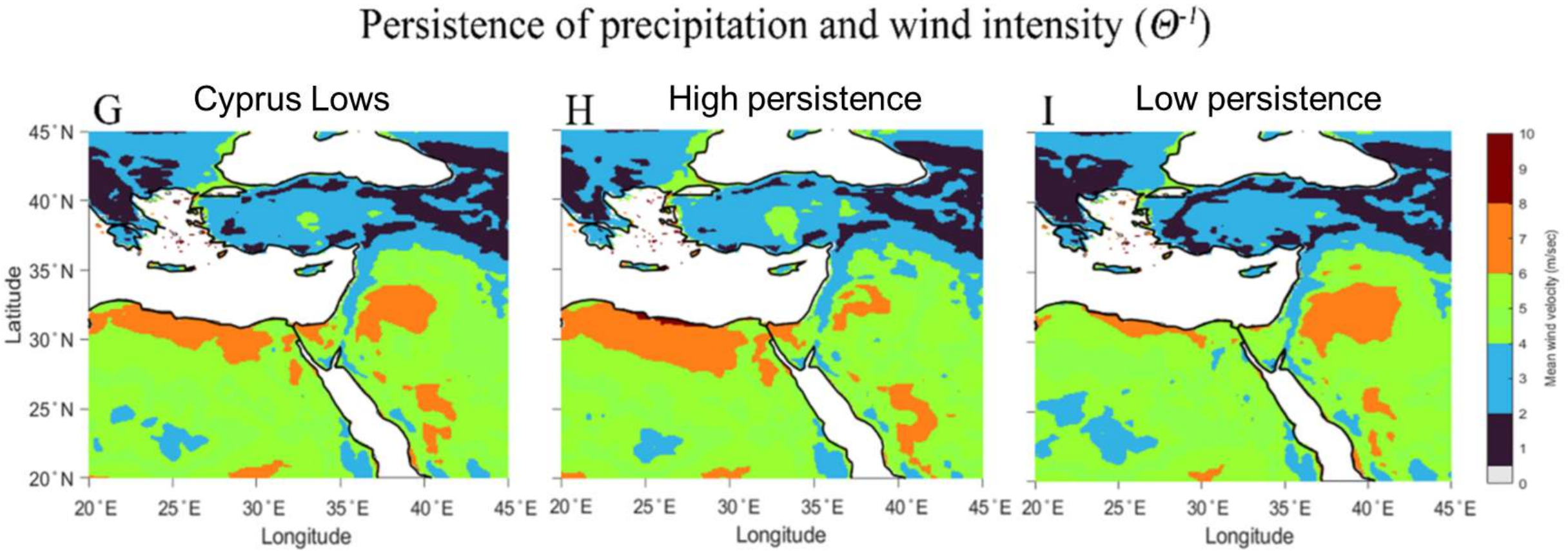
1. Composite mean wind speed maps of high and low co-recurrence



assaf.hochman@mail.huji.ac.il

Institute of Earth Sciences

1. Composite mean wind speed maps of high and low persistence



assaf.hochman@mail.huji.ac.il

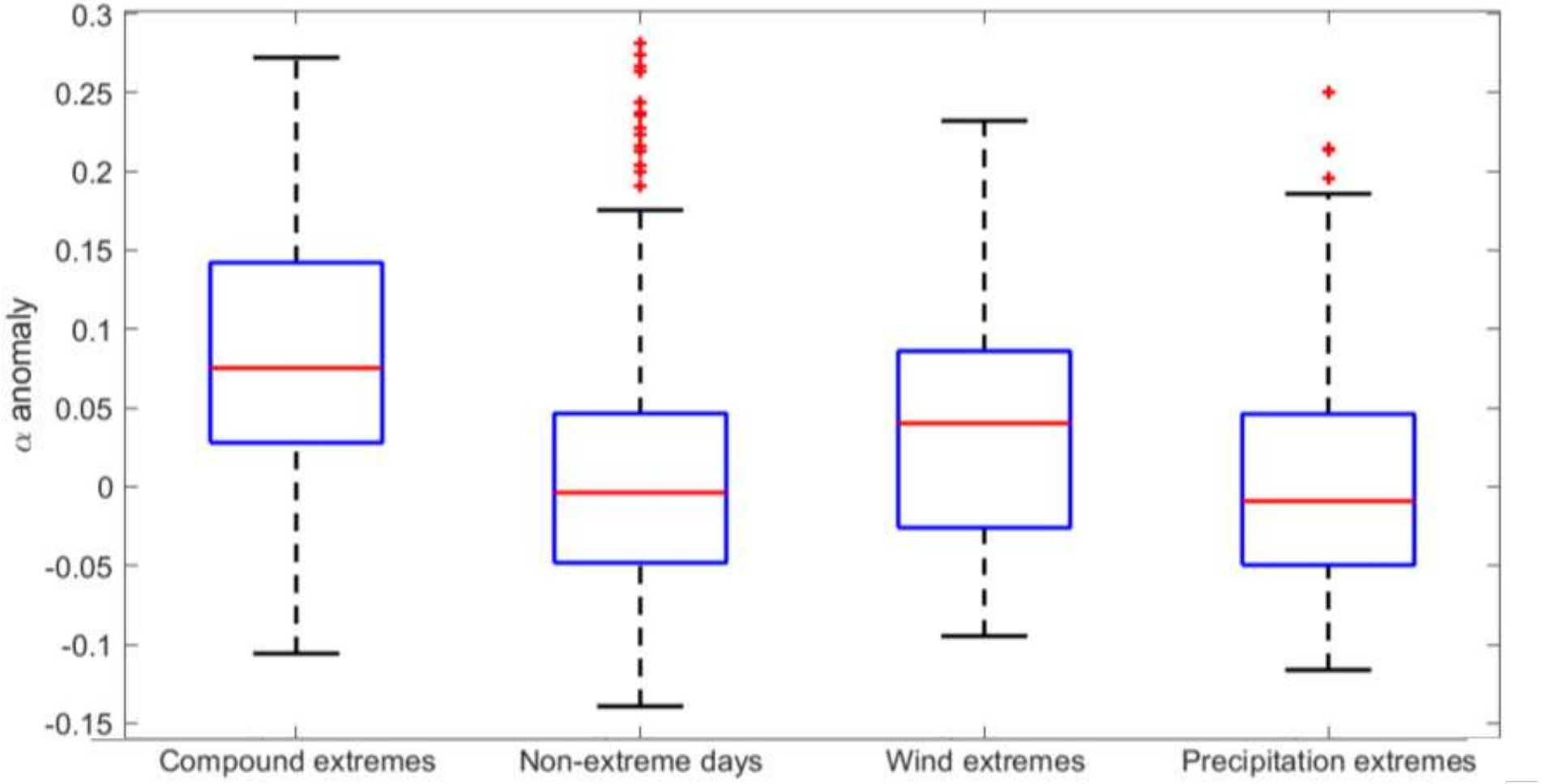
Institute of Earth Sciences

Summary of 1

- We study the relationship between the dynamical systems metrics and the atmospheric configurations in the Eastern Mediterranean.
- We find that Compound Dynamical Extremes (CDE) are related to the depth and location of the surface cyclone and upper-level trough.
- We show that high co-recurrence and persistence are associated with heavier precipitation and stronger wind speed.

assaf.hochman@mail.huji.ac.il
Institute of Earth Sciences

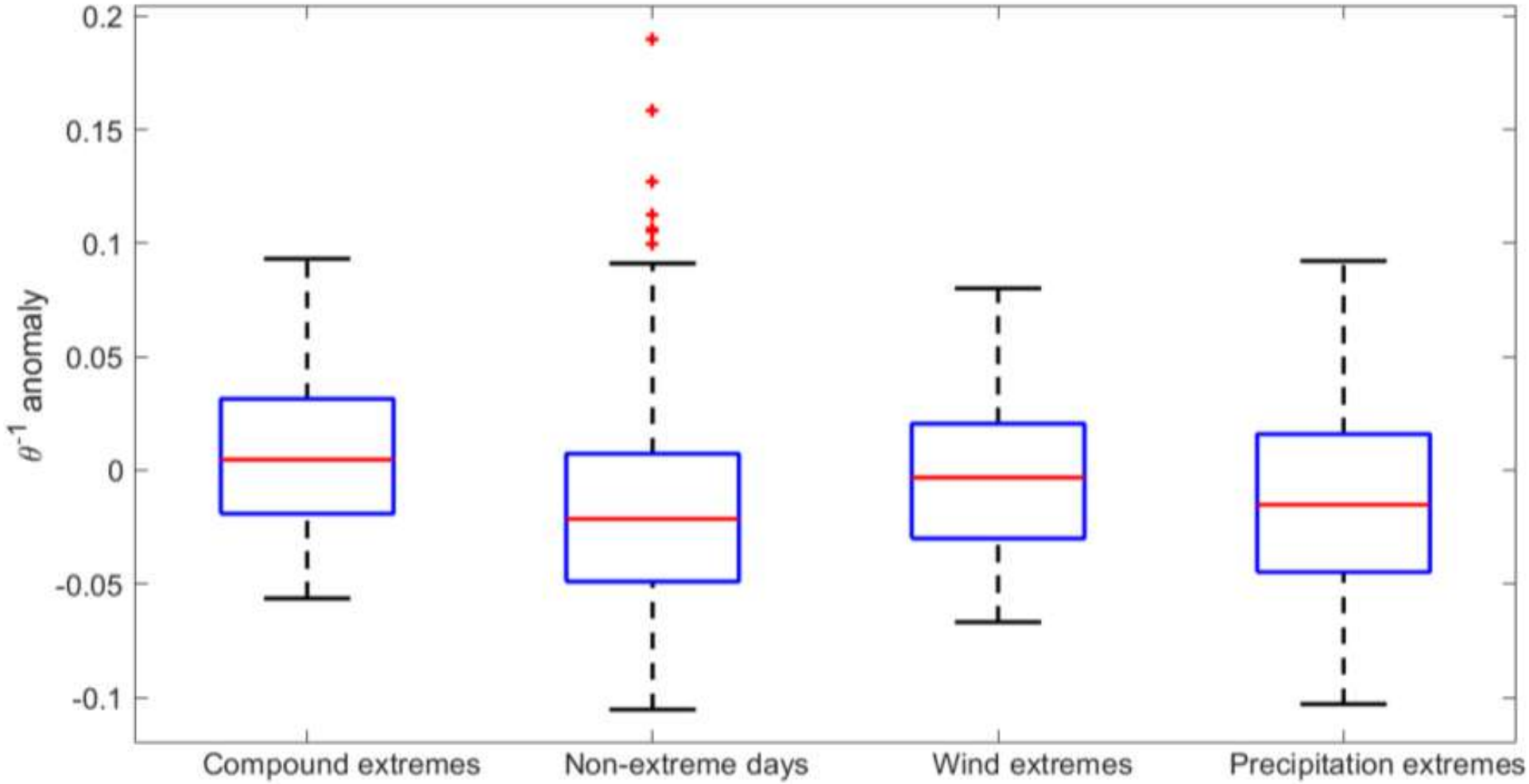
2. Co-recurrence anomalies for compound and individual extremes



assaf.hochman@mail.huji.ac.il

Institute of Earth Sciences

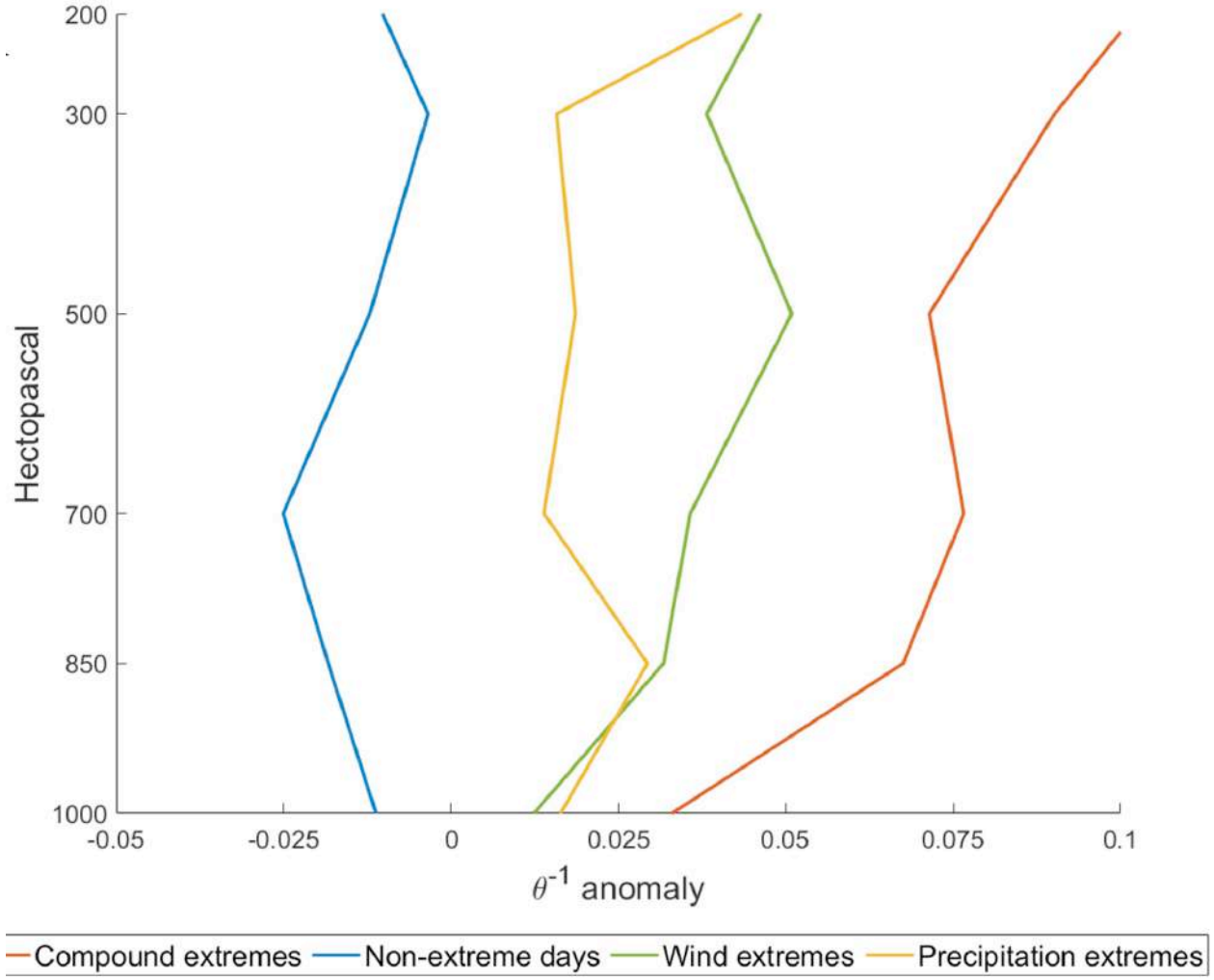
2. Persistence anomalies for compound and individual extremes



assaf.hochman@mail.huji.ac.il

Institute of Earth Sciences

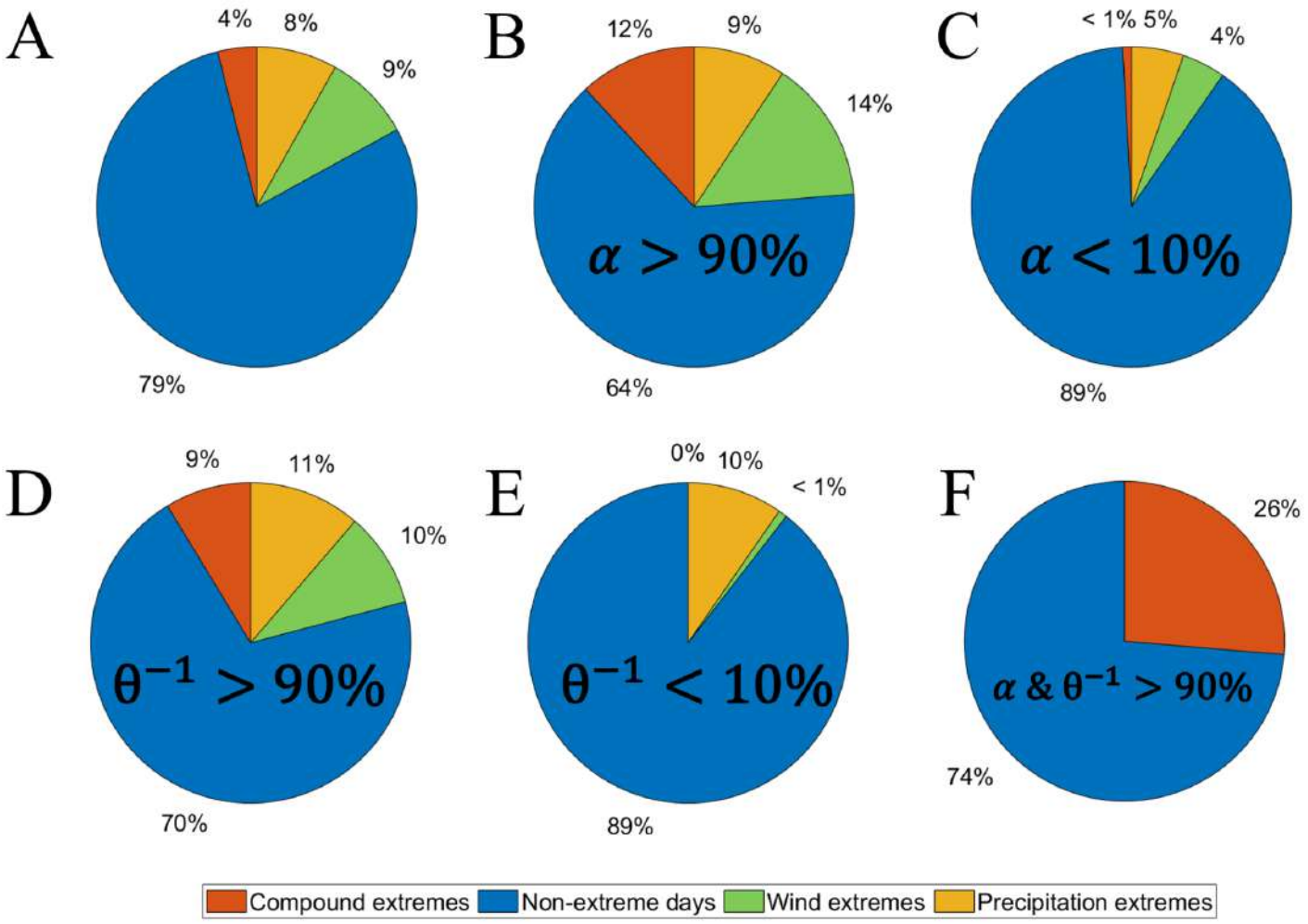
2. Vertical persistence anomalies of compound and singular extremes



assaf.hochman@mail.huji.ac.il

Institute of Earth Sciences

2. Probabilities of compound and individual extremes in high and low co-recurrence and persistence



assaf.hochman@mail.huji.ac.il

Institute of Earth Sciences

Summary of 2

- We find that Compound Extremes display significantly higher co-recurrence and persistence than individual extremes.
- We show that the upper levels are significantly more persistent than the surface flow during a Compound Extreme.
- High co-recurrence and persistence anomalies are more likely to be allied with Compound Extremes than low co-recurrence and persistence.

assaf.hochman@mail.huji.ac.il
Institute of Earth Sciences

Conclusions

- The dynamical systems viewpoint is a valuable complement to understanding the dynamics of Compound Extremes.
- We foresee it to be fruitfully applied to other Compound Extremes and regions.
- This approach may be beneficial in improving the ability to predict Compound Extremes.

assaf.hochman@mail.huji.ac.il
Institute of Earth Sciences

assaf.hochman@mail.huji.ac.il

Institute of Earth Sciences

References

- Vakrat E, Hochman A. 2023. Dynamical systems insights on cyclonic compound 'wet' and 'windy' extremes in the Eastern Mediterranean. *Quarterly Journal of the Royal Meteorological Society*. (Under Review)
- Hochman A, Alpert P, Harpaz T, Saaroni H, Messori G. 2019. A new dynamical systems perspective on atmospheric predictability: eastern Mediterranean weather regimes as a case study. *Science Advances* **5(6):** eaau0936. https://doi.org/10.1126/sciadv.aau0936
- Hochman A, Plotnik T, Marra F, Shehter ER, Raveh-Rubin S, Magaritz-Ronen L. 2023. The sources of extreme precipitation predictability; the case of the 'Wet' Red Sea Trough. *Weather and Climate Extremes* **40**: 100564. https://doi.org/10.1016/j.wace.2023.100564
- Hochman A, Marra F, Messori G, Pinto JG, Raveh-Rubin S, Yosef I, Zittis G. 2022. Extreme weather and societal impacts in the Eastern Mediterranean. *Earth System Dynamics* **13(2):** 749-777. https://doi.org/10.5194/esd-2021-55

assaf.hochman@mail.huji.ac.il

Institute of Earth Sciences