Atmospheric Dynamics Group

Research in our group aims at improving the understanding of the dynamical processes in the atmosphere that influence the weather and climate. We are interested in processes acting on a wide spectrum ranging from planetary scales down to those influencing the development of synoptic systems. A region of interest includes the Mediterranean and the Middle East. In particular, we pursue to identify remote tropical and mid-latitude drivers of climate variability over the region and the dynamical processes associated with its emergence into a hotspot of climate change. To this aim we utilise both atmospheric reanalysis products and simulations coming from a hierarchy of climate models with varying complexity.

Group Members

Evangelos Tyrlis - Assistant Professor

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Aristotelis Liakakos – PhD student

Thesis Title: "*Dynamical drivers of extreme heat in the eastern Mediterranean and the Middle East.*"

Konstantinos Konstantinidis – MSc student (completed 2024)
Thesis Title: "*An Investigation into the Meandering of Northern Hemisphere Atmospheric Circulation.*"

Συνεργασία με ομάδες στο εξωτερικό

Panos Hadjinicolaou – George Zittis (Cyprus Institute, Nicosia, Cyprus)

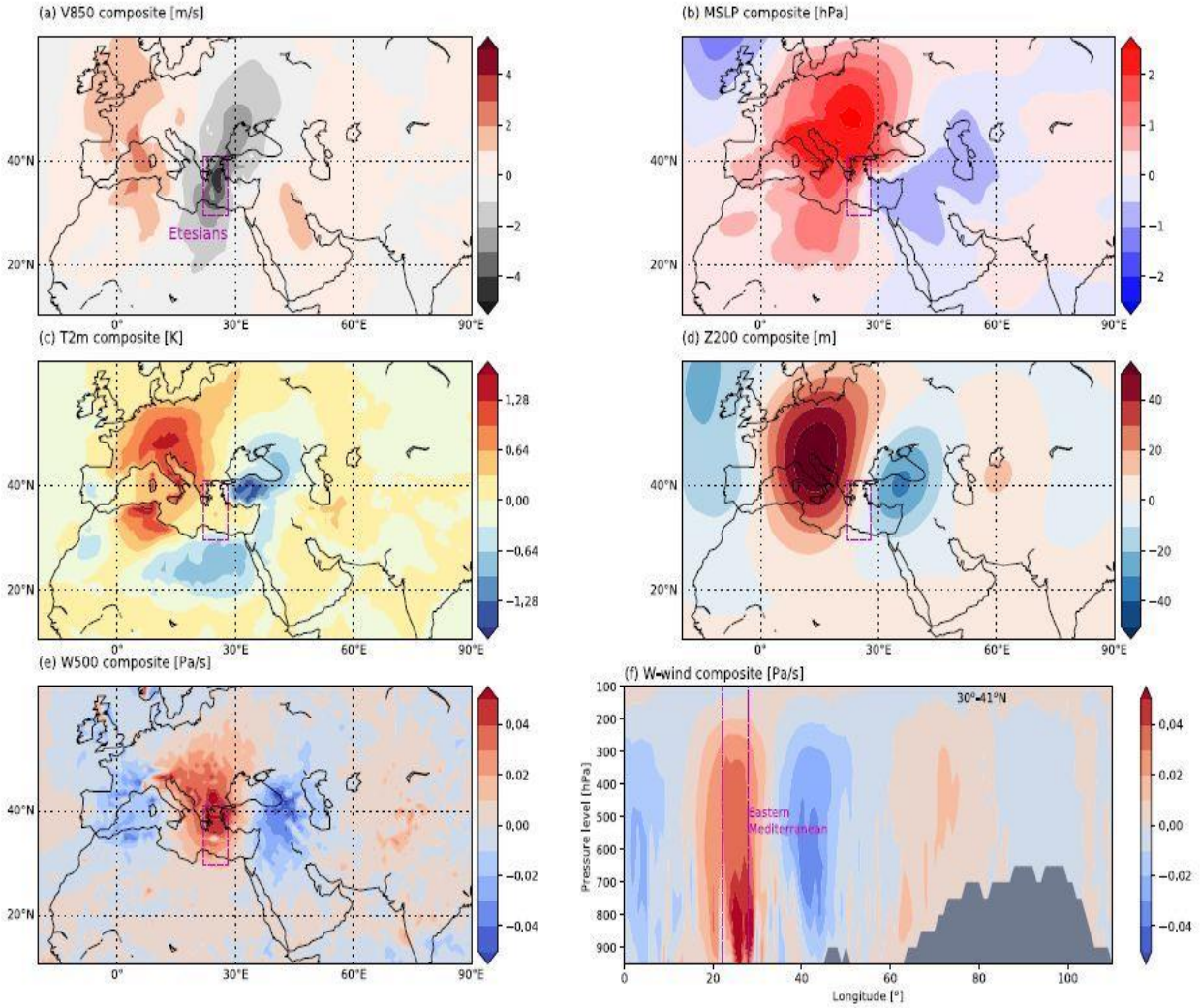
Daniela Matei (Max Planck Institute for Meteorology, Hamburg, Germany)

Giorgia Di Capua (Potsdam Institute for Climate Impact Research, Potsdam, Germany)

Research Topics

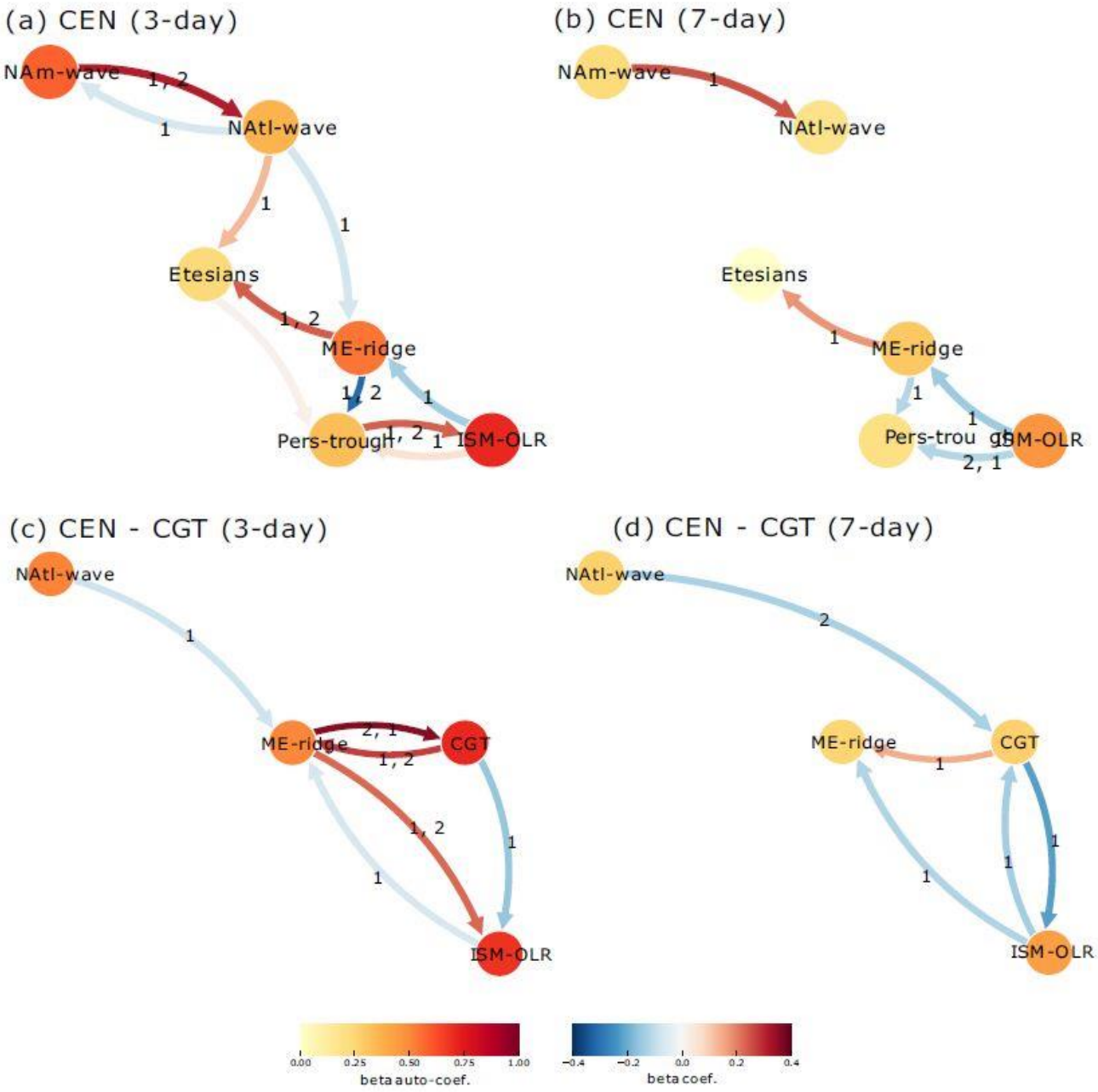
- **Tropical and mid-latitude causal drivers of atmospheric variability over the Mediterranean region**

During boreal summer, large scale subsidence and a persistent northerly flow, known as the Etesians, characterize the tropospheric circulation over the eastern Mediterranean. The Etesians bring clear skies and alleviate the impact of heat waves over the region. The intraseasonal variability of the Etesians and subsidence over the eastern Mediterranean is largely influenced by the South Asian monsoon and atmospheric processes over the North Atlantic.



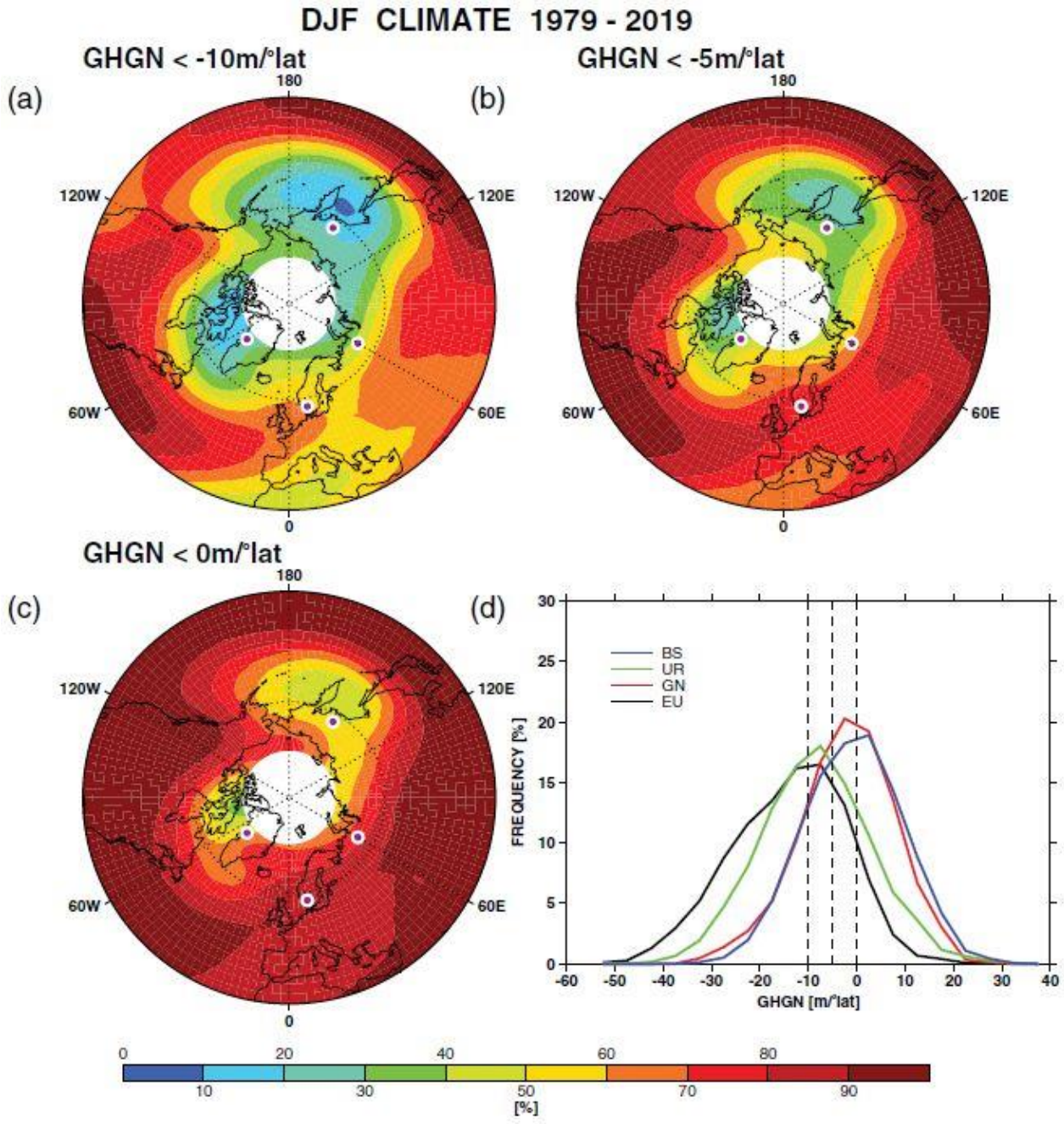
In recent work we employed causal effect networks and causal maps, obtained by applying the Peter and Clark Momentary Conditional Independence (PCMCI) causal discovery algorithm, to identify causal precursors of Etesians. In this quantitative approach we confirmed previous qualitative results that

both wave train activity over the North Atlantic region and convective activity over South Asia associated with the Indian summer monsoon (ISM) are causally related to the Etesians at 3-day time scale. Thus, intraseasonal ISM variability affects the eastern Mediterranean circulation, though its influence is conveyed via a Middle East ridge. On longer weekly time scale, the mid-latitude influenc weakens, while the influence of the tropical convective activity via the Middle East ridge remains stable.



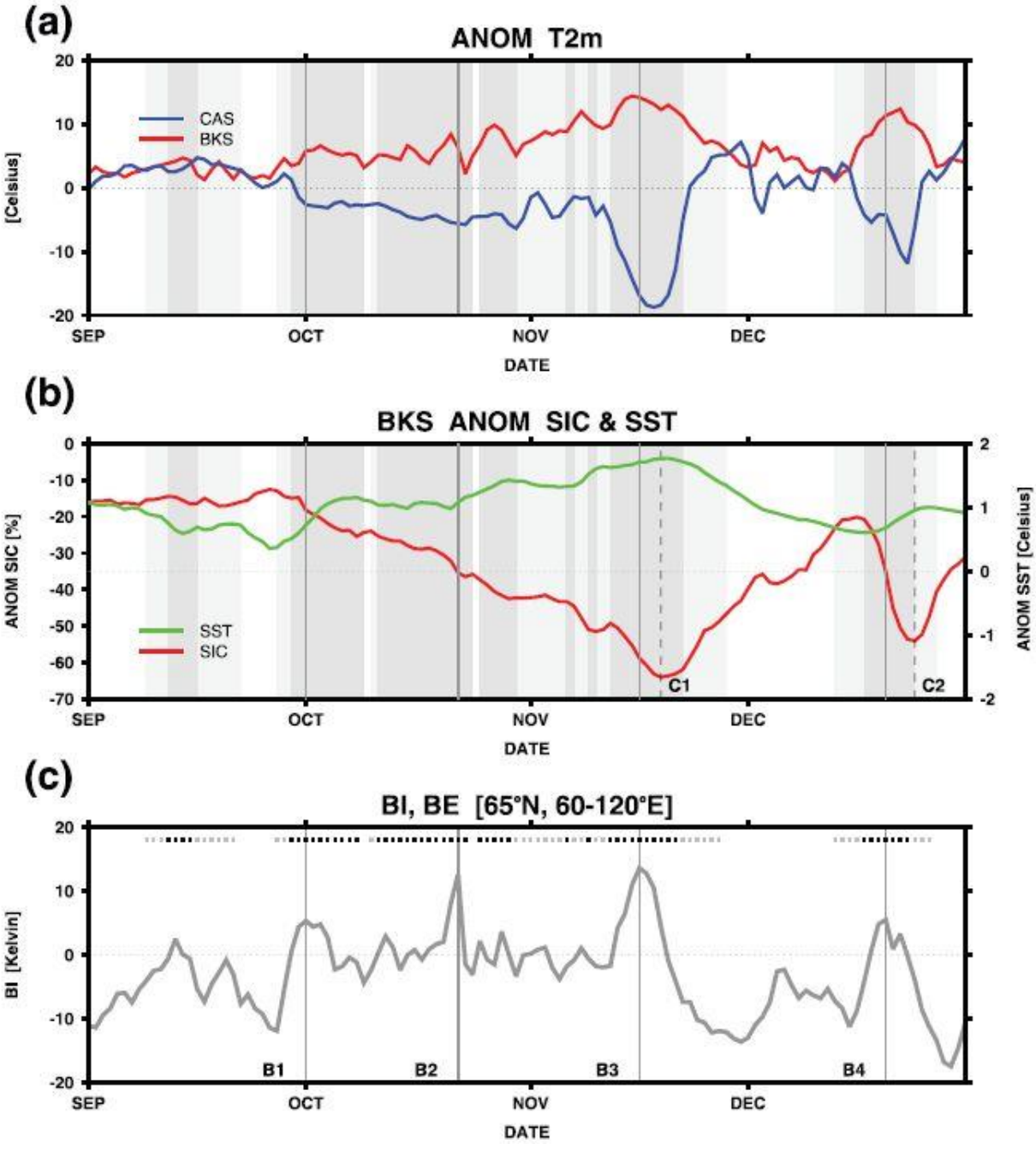
- **Improving indices of identifying blocking**

  Blocking is associated with outbreaks of easterlies induced by a continuum of features including anticyclones, cyclones or both. Blocking identification methods disagree on the levels of high-latitude blocking activity. We investigate the causes of the disagreement in high-latitude blocking activity over the Northern Hemisphere by comparing various blocking identification methods.



- **Investigation of the role of atmospheric blocking in driving the sea-ice loss over the Arctic region**

The intra-seasonal variability of sea-ice extent over the Barents-Kara Seas is largely controlled by atmospheric blocking activity over the Ural region. Ural Blocking episodes induce atmospheric circulation anomalies that result in cold anomalies to the south and warm anomalies to the north of the blocking ridge. Intrusions of warm and moist air result in the enhancement of the Arctic sea ice loss.



Selected recent publications (last 5 years)

Tyrlis E, Manzini E, Bader J, Ukita J, Nakamura H and Matei D 2019: Ural blocking driving extreme Arctic sea ice loss, cold Eurasia, and stratospheric vortex weakening in autumn and early winter 2016–2017. *J. Geophys. Res. 124, 11313–29*.

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Koenigk T, Bärring L, Matei D, Nikulin G, Strandberg G, Tyrlis E, Wang S, Wilcke R. 2020: On the contribution of internal climate variability to European future climate trends. *Tellus, Series A: Dynamic Meteorology and Oceanography, 72:1-17*.

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YIN S-Y, WANG T, HUA W, MIAO J-P, GAO Y-Q, FU Y-H, Matei D, Tyrlis E, CHEN D. 2020: Mid-summer surface air temperature and its internal variability over China at 1.5 °C and 2 °C global warming. *Advances in Climate Change Research. 11:185-197*.

Tyrlis E, Bader J, Manzini E, Matei D. 2021: Reconciling different methods of high-latitude blocking detection. *Quarterly Journal of the Royal Meteorological Society. 147, 1070-1096*.

Ghosh R, Manzini E, Gao Y, Gastineau G, Cherchi A, Frankignoul C, Liang Y-C, Kwon Y-O, Suo L, Tyrlis E, Mecking J V, Tian T, Zhang Y, Matei V 2024: Observed winter Barents Kara Sea ice variations induce prominent sub-decadal variability and a multi-decadal trend in the Warm Arctic Cold Eurasia pattern. *Environ. Res. Lett. 19 024018*

Di Capua, G, Tyrlis, E, Matei, D and Donner, R V 2024: Tropical and mid-latitude causal drivers of the eastern Mediterranean Etesians during boreal summer. *Clim. Dyn. https://doi.org/10.1007/s00382-024-07411-y*