Tropical air intrusions over the eastern Mediterranean and Mesopotamia: An atmospheric river case study and role of the East Asian trough*

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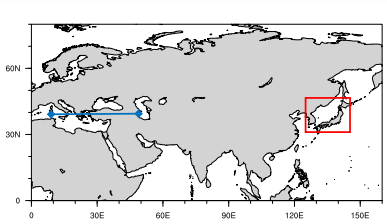
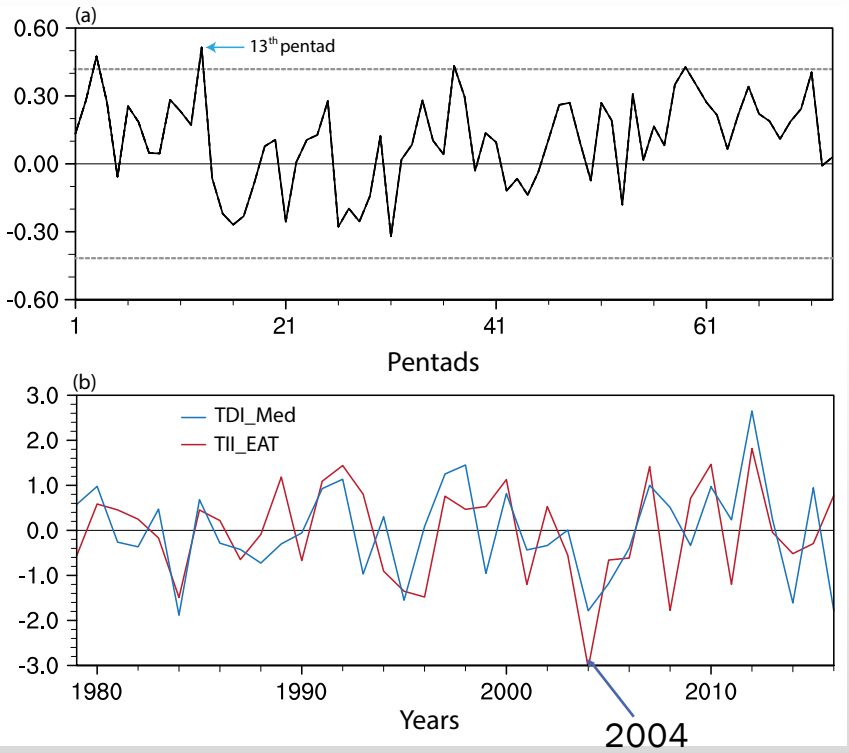
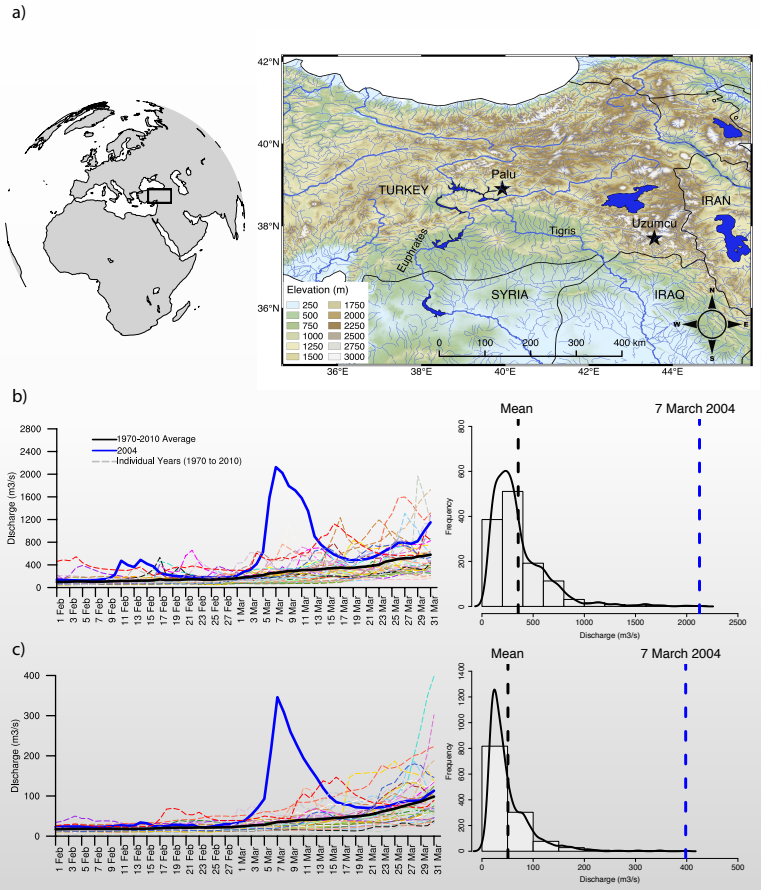
East Asian Trough (EAT) intensity and Mediterranean Trough (MedT) displacement





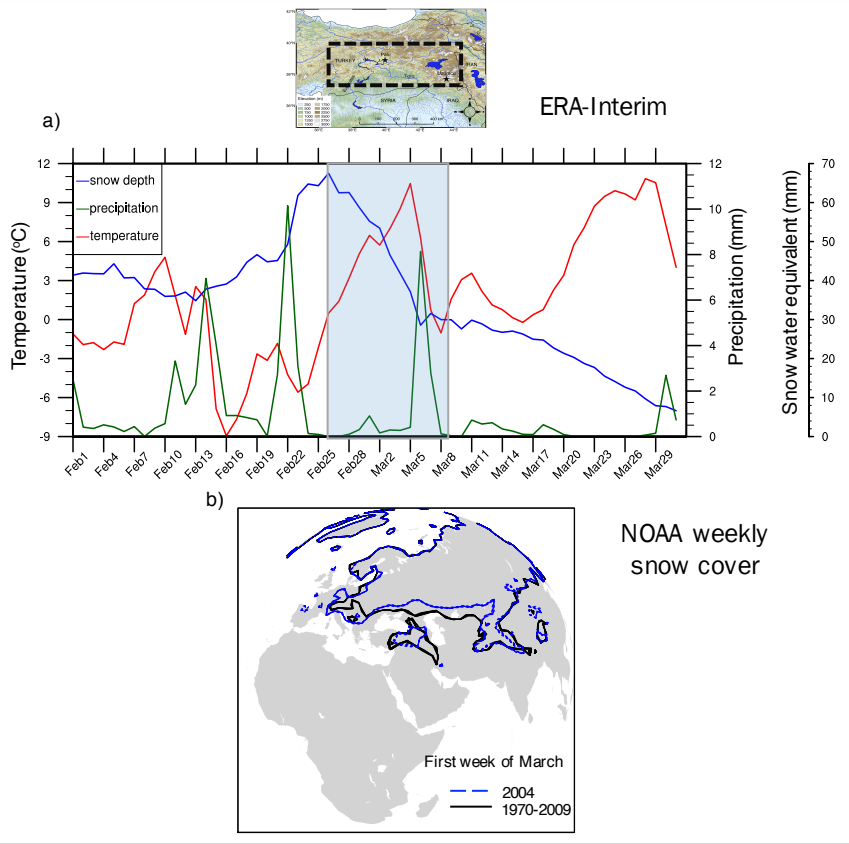
- Pentad correlations between the EAT intensity and zonal displacement of the MedT yield significant values for some pentads (e.g., 3rd, 13th and 37th) at 99% confidence level
- The analysis further reveals that the highest correlation (0.53) occurs on the 13th pentad among the 73 pentads; and this pentad corresponds to the early days of March.

What happened in March 2004?



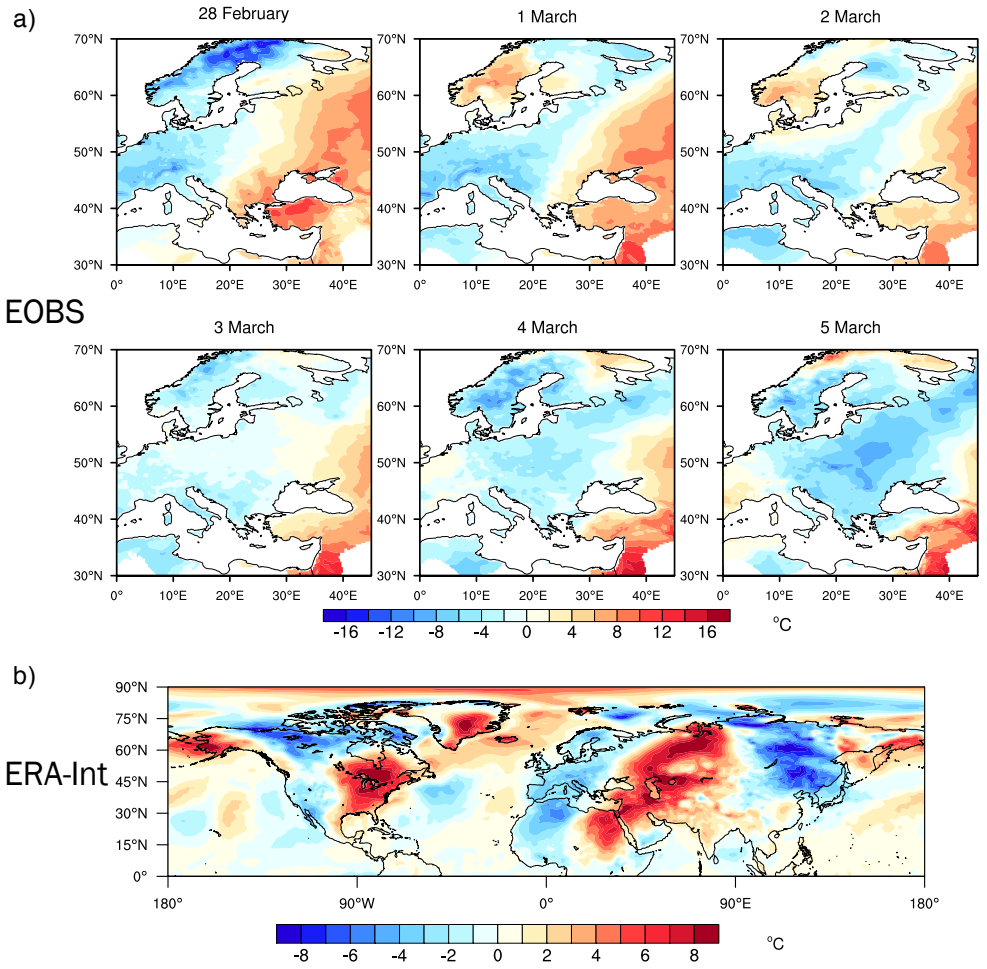
- An action was taken to release water from the dam reservoirs on the Euphrates river in response to severe precipitation and snowmelt events that took place in the Eastern Anatolia in the early days of March 2004
- 41-year observations show that early March discharges in 2004 are exceptionally high!

What happened in March 2004?



- Temperatures rise over freezing point in the region starting from late February, melting the abundant snowpack in the region
- Rainfall and snowmelt runoff together give quick rise to discharges, triggering the authorities to open dam spillway gates to release water

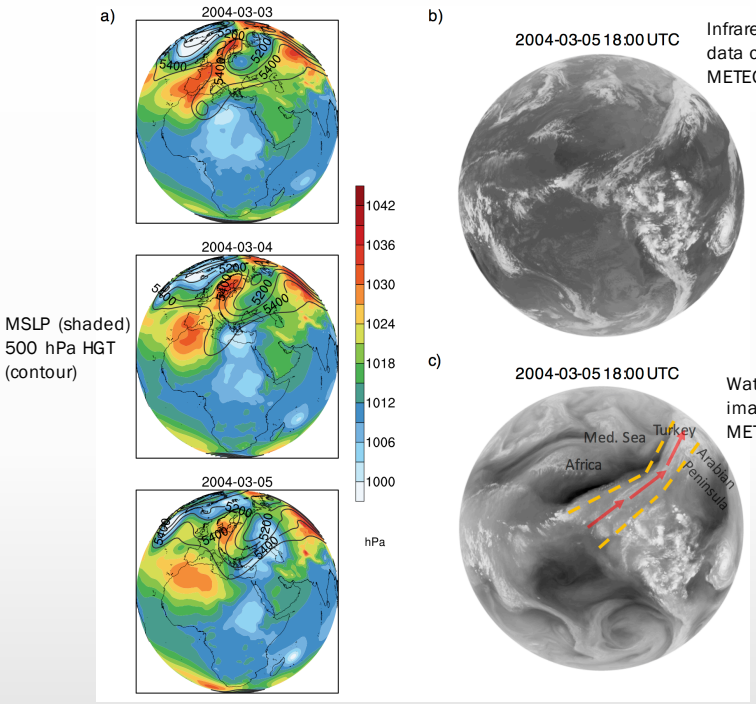
What happened in March 2004?



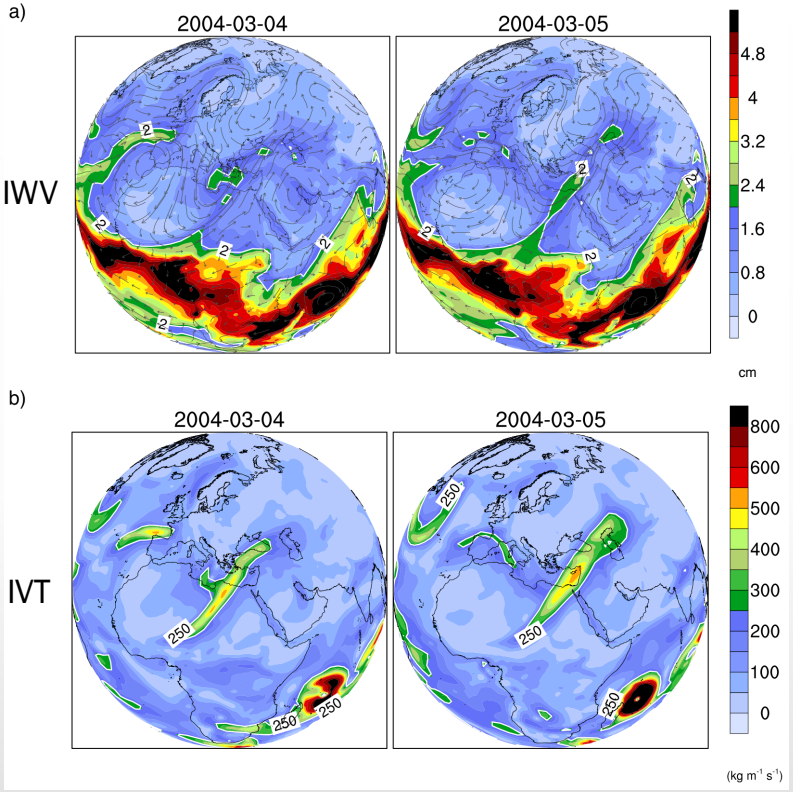
- E-OBS daily near-surface air temperature anomalies for each day between 28 February and 5 indicate a marked dipole pattern of warmer and colder temperatures. Warmer temperatures take place over the eastern Europe, Turkey and western Russia, whereas colder temperatures occur over central and western Europe.

- 6-day (28 February-5 March 2004) averaged hemispheric near-surface air temperature anomalies with respect to 1979–2016 period from ERAINT indicate a large warming pattern (more than 6 ◦C anomaly) extending from north- eastern Africa to Caucasus and Caspian regions to Siberia.

Synoptic conditions

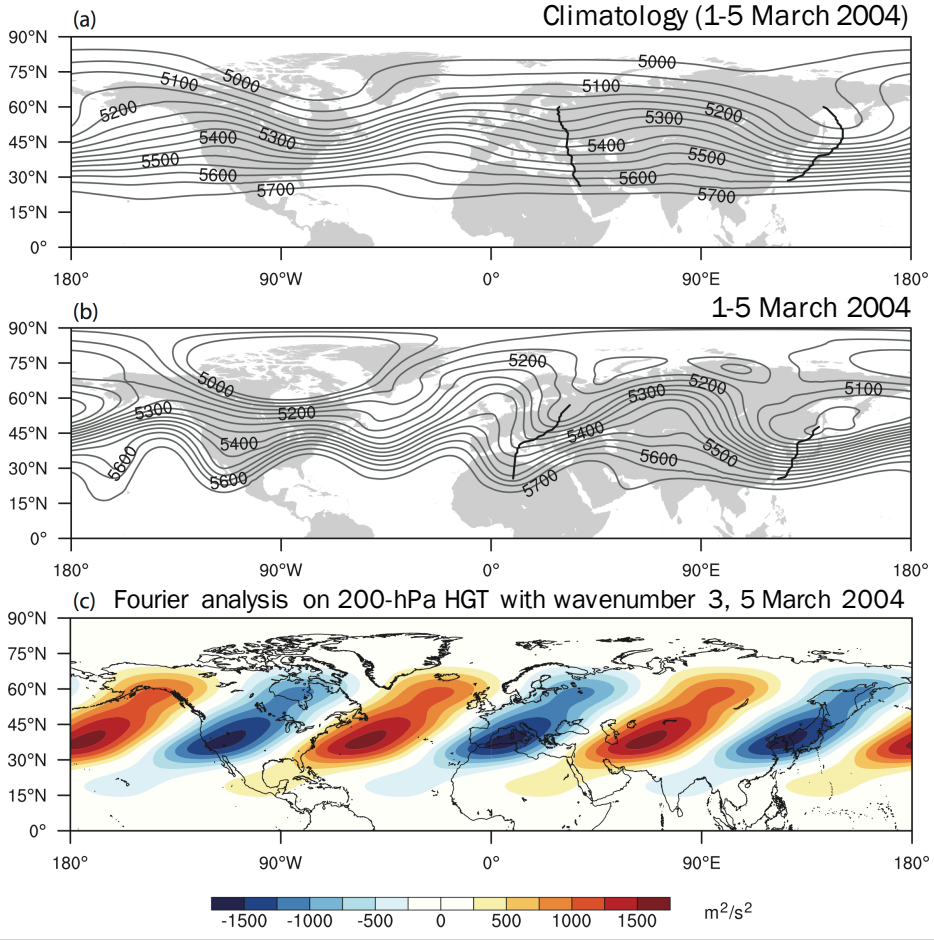


- The main synoptic-scale features during the 2004 event were an anomalous northeast-southwest tilted mid-troposheric trough and a surface cyclonic formation stretching from the tropics and sub-tropics toward the Anatolian Peninsula and western Russia. These synoptic conditions were favorable for inducing a large-scale warm air advection from tropical latitudes to higher latitudes



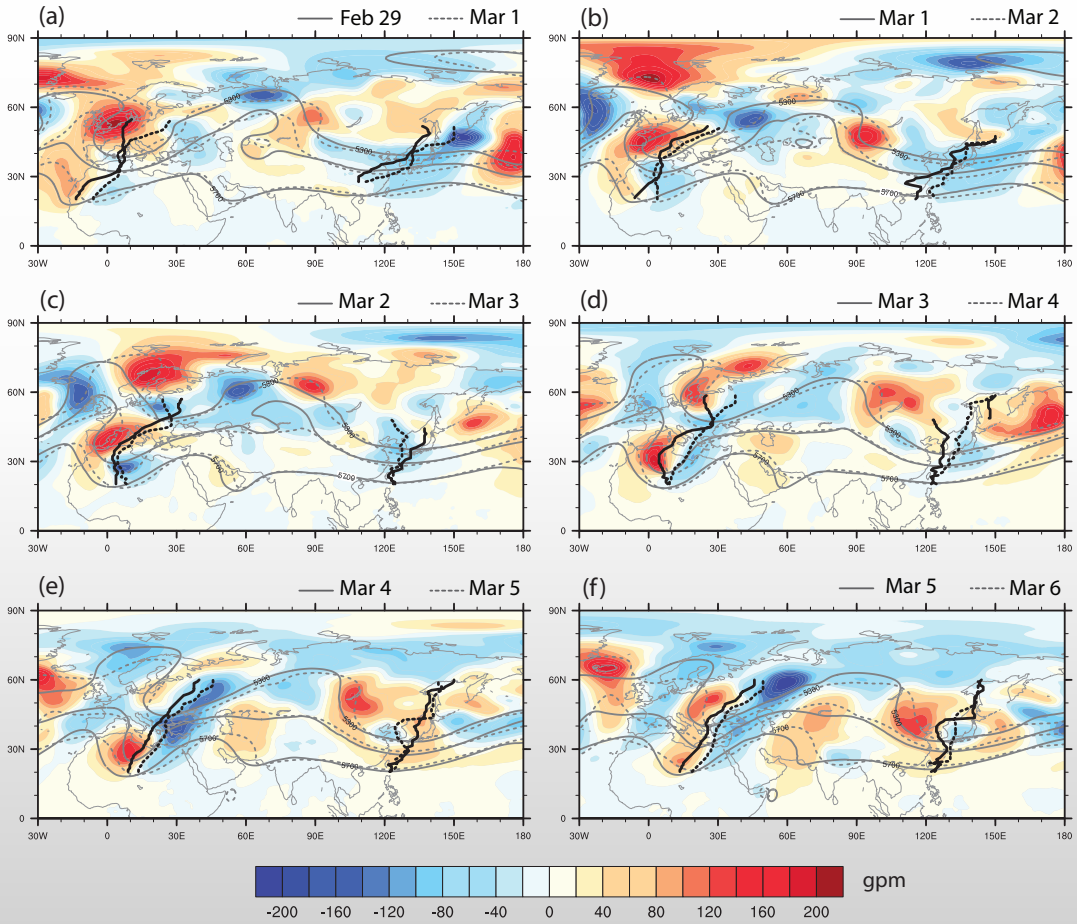
- The large-scale synoptic conditions steered an atmospheric river (AR) that reached the eastern Anatolia and western Russia from the tropics on 5 March 2004.

Links with the EAT



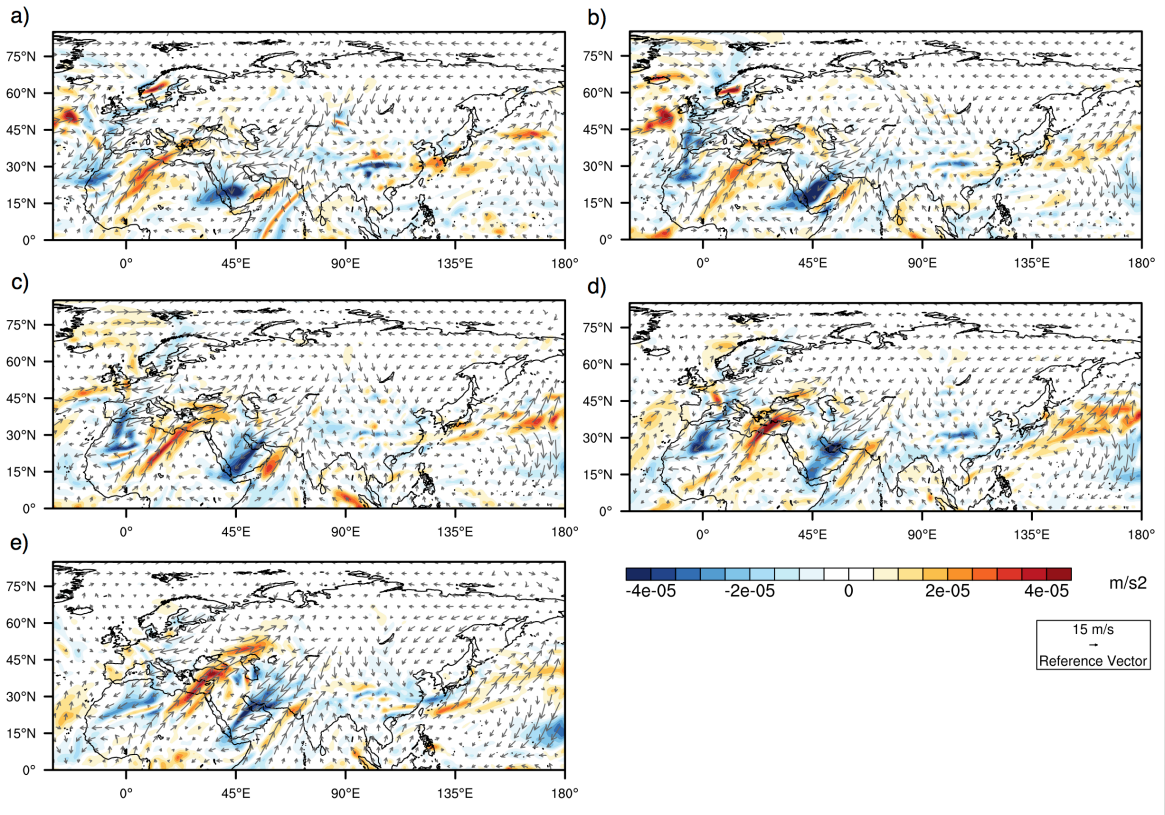
- In the early days of March 2004, the EAT was strong and the Mediterranean trough was located over central Mediterranean with a tilted axis between central north Africa to eastern Europe.
- The amplified ridge-trough system over the Euro-Mediterranean region coincided in time and space with a hemispheric Rossby wave pattern (wavenumber 3) propagating eastward in the Northern Hemisphere.
- Eventually, this wave pattern, and thus the ridge-trough formation, in the Northern Hemisphere was associated with the consecutive cold and warm pools.

Links with the EAT



- Temporal and spatial evolution of trough axis lines and *z*500 of each consecutive day in early March also illustrates the tendency of the EAT to hinder the propagation of the MedT at these latitudes during the event.
- The figure clearly shows a stalled MedT axis in the east of central Mediterranean and a strengthening EAT during the early days of March (Fig. a–c). After 4 March, however, the EAT starts to weaken and the MedT axis begins to shift eastward (Fig. e, f).

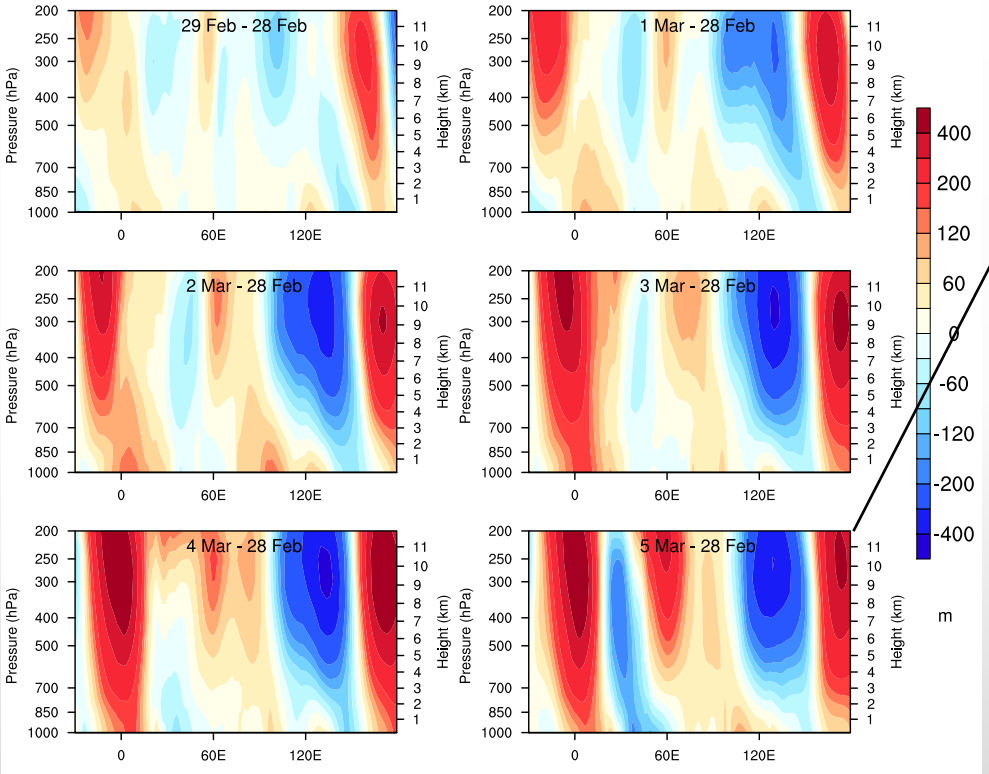
Links with the EAT



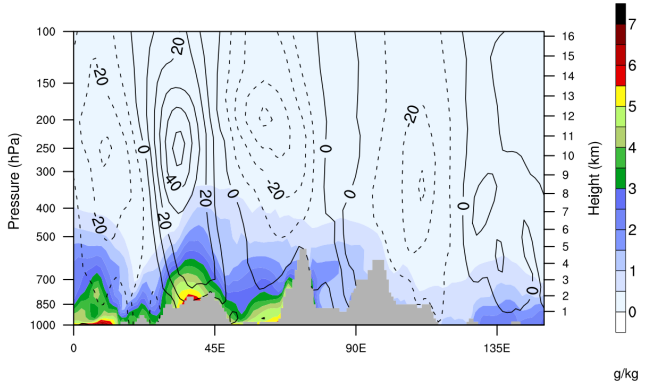
- 200 hPa divergence fields and divergent wind vectors show that especially between 3 and 5 March, convergence areas are concentrated along a tilted axis over western Asia (45–60°E), indicating the deceleration of westerly flow on the eastern side of the ridge (Fig. c–e).

- On the other hand, this pattern leads to increase in wave amplitude and eventually triggers the acceleration of westerly/southwesterly flow (positive divergence) towards the eastern Mediterranean and Anatolian highlands.

Links with the EAT



Vertical profile of geopotential height differences of each day between 29 February and 5 March with respect to 28 February (a day just before the high amplitude wave propagation) along 39°N



- A marked strengthening of the EAT around 120◦E is clearly seen in the early days of March. Concurrently, the ridge over Asia strengthens in its western flank (around 60◦E) during the same dates leading to the deepening of the trough over Mediterranean on 5 March. The core of the larger geopotential height differences is observed around 250-hPa level and extending toward the mid-troposphere (500 to 700-hPa level).

- This downward extension of the upper level circulation changes eventually causes the accumulation of moist air (e.g., > 6 g kg^{-1}) with strong northward (positive) meridional winds (~ 20 m s^{-1}) over the eastern Anatolian highlands (35–45°E)

Conclusions

- A key finding in our analysis is that the strengthening of the EAT was instrumental to the increased amplitude of the ridge-trough system over the Euro-Mediterranean region in the early days of 2004 spring
- This synoptic pattern provided favorable conditions for the development of an atmospheric river with a southwest-northeast orientation, carrying warm tropical African air towards the eastern Mediterranean and Anatolian highlands resulting in rapid melting of the snowpack as well as severe precipitation, and thus flooding events, in the eastern Anatolia.
- We highlight that the response of surface and upper level meteorological conditions to the amplitude of the ridge-trough system enhanced by the strength of the EAT might be crucial in the understanding of some of the extreme hydrometeorological events in the eastern Mediterranean region.
- Within the context of heat and moisture transport between the tropics/subtropics and higher latitudes, the response of surface and upper level meteorological conditions to the amplitude of the ridge-trough system amplified by the EAT can have a crucial role in determining the extremeness of the hydrometeorological events in the region.

On-going study

- The climatology and characteristics of the overland atmospheric rivers (African ARs) interacting with mountain ranges of the Near East in the snowmelt season

- How such overland ARs can influence the hydroclimatology of the Near East in the snowmelt season.

Bozkurt, D., Sen, O. L., Ezber, Y., Guan, B., Viale, M., and Caglar, F., 2020. Influence of African Atmospheric Rivers on Precipitation and Snowmelt over the Near East's Water Towers, Geophysical Research Letters, under review.