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Applications of MERRA-2 data for avian migration, biomass burning, and dusty atmospheric rivers

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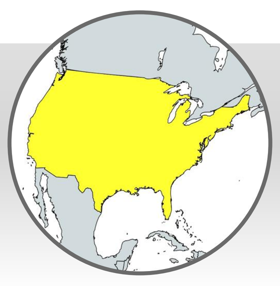
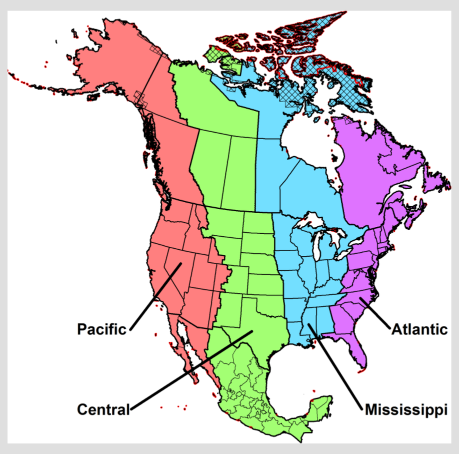
Case 1: Bird migration linked to large-scale climate in the U.S.

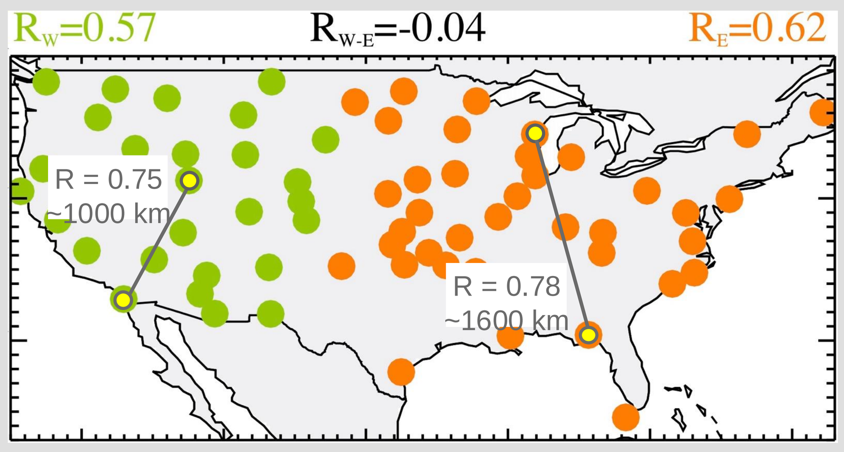


The U.S. is objectively divided into two regions based on the interannual variability of migratory bird arrival dates, retrieved from radar data. We identified specific large-scale climate features in each region that control the environmental conditions influencing bird migration.



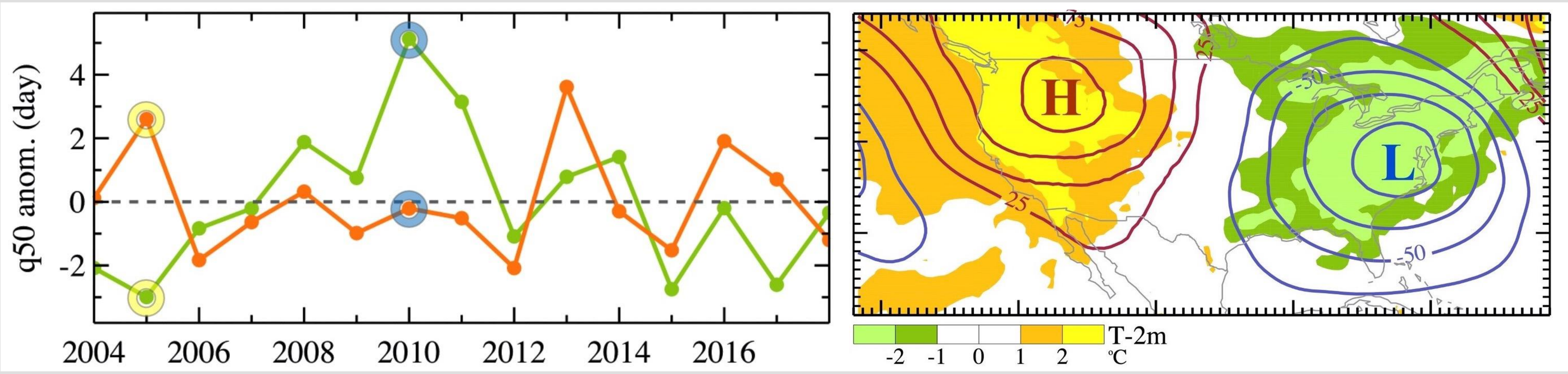
Four primary flyways:

- Historically used for management purposes.
- Doesn't reflect phenology (seasonal timing of key life cycle events).



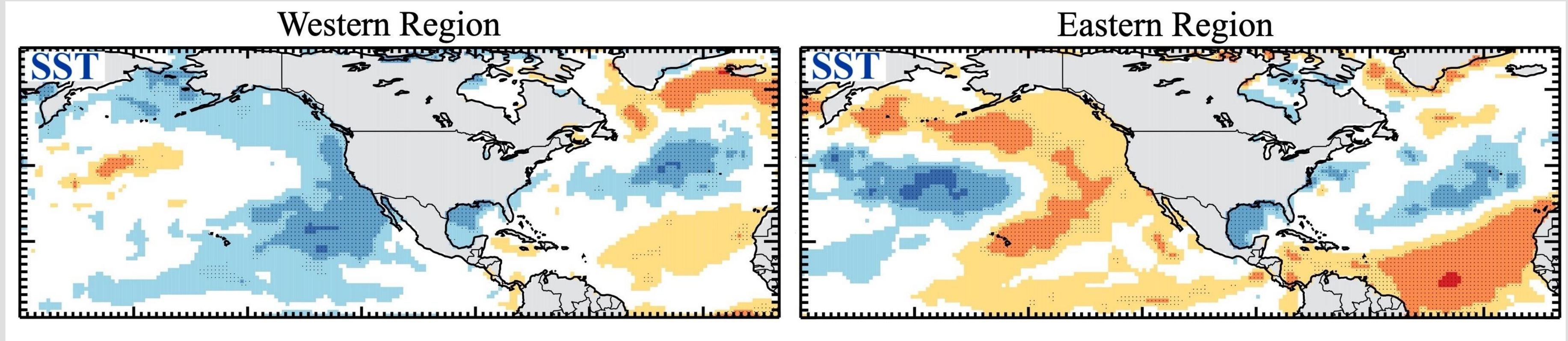
Our two-region concept:

- Based on similarity of interannual variability of arrival date anomalies, inferred from 143 radar stations (NEXRAD) across the contiguous United States.
- Each region is homogeneous with a specific variability, different from the other one.



What does the two-region approach offer?

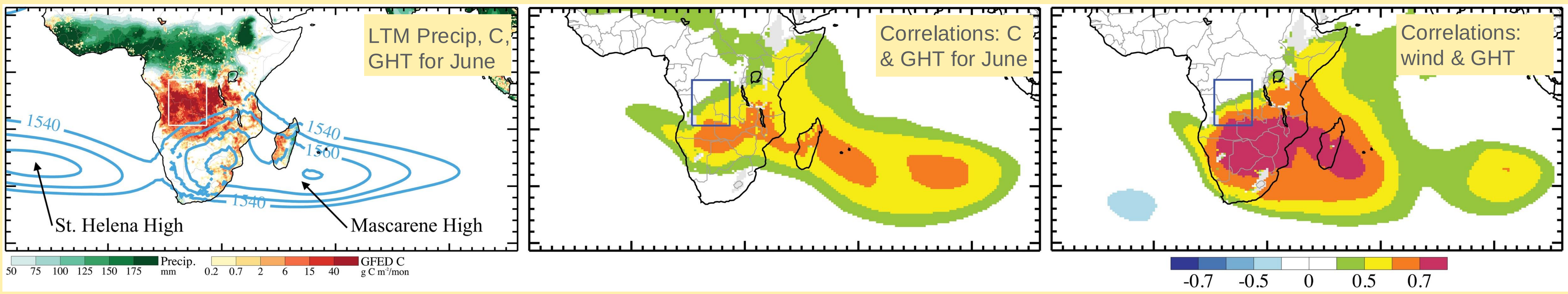
- Allows us to identify region-specific drivers of interannual variability (e.g., climatic phenomena) of bird migration at the continental scale.
- Detects years with opposite anomalies such as 2005 and 2010. Rossby waves triggered in the Central Pacific were found responsible for a dipole temperature pattern, explaining the contrast in resources.



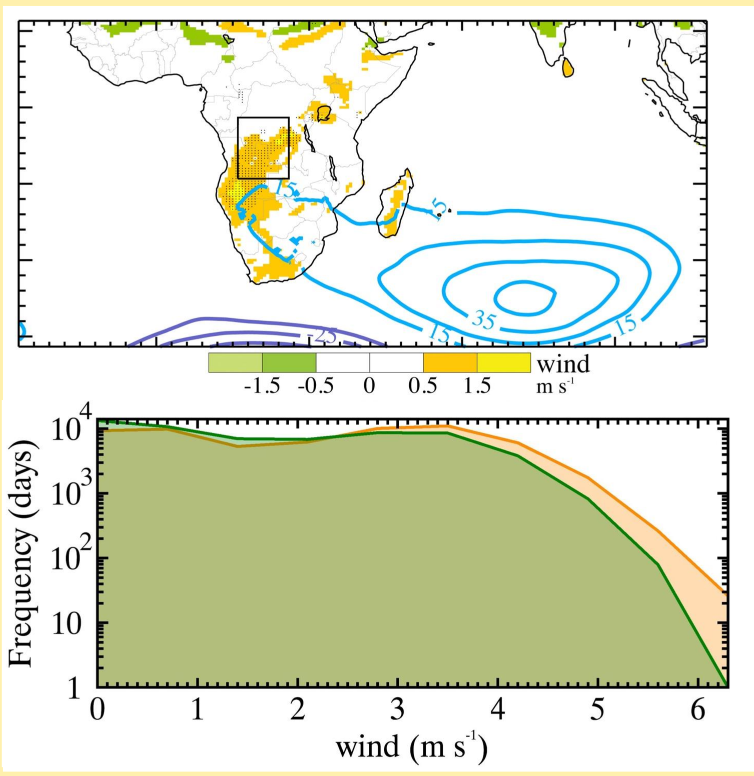
- Western and eastern regions show different links to climate variability.
- Eastern U.S. shows significant correlations with several climate modes of variability consistent with atmospheric Rossby waves.
- Western U.S. shows a strong link to regional temperature and adjacent waters.

Case 2: Impact of subtropical highs on fire emission in Africa

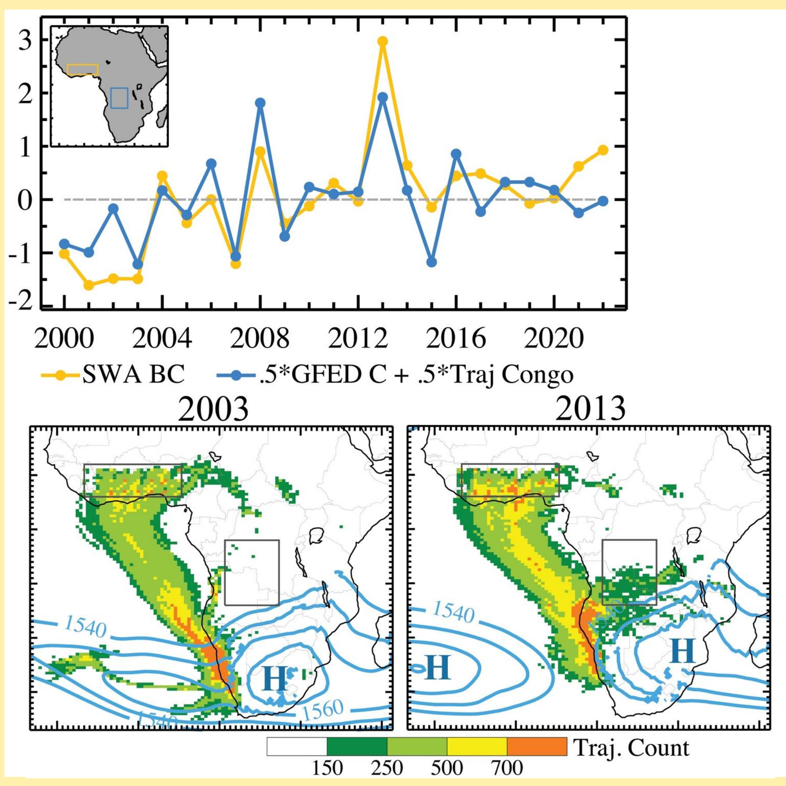
Fire emissions in the Congo Basin rise when local winds are strengthened due to intensification of the Indian Ocean subtropical high. Combined effects of these emissions and cross-equatorial southerly winds in the S. Atlantic control interannual variability of black carbon in West Africa.



- Strong correlation exists between C emissions and GHT at 850 hPa level over the Mascarene High, which controls surface winds in the Congo Basin.
- Winds impact oxygen supply to fires, their intensity, drying, and spread rate.



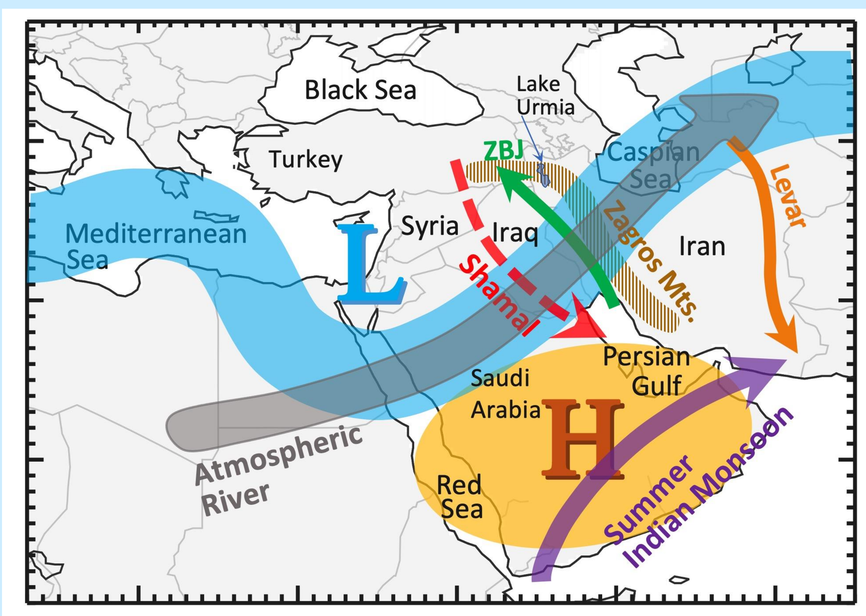
- Composite of high-minus-low C emission years reveal contrasting patterns and intensity in surface wind and GHT over Mascarene High.
- The contrast is dominated by winds with daily magnitude greater than 4 m/s.

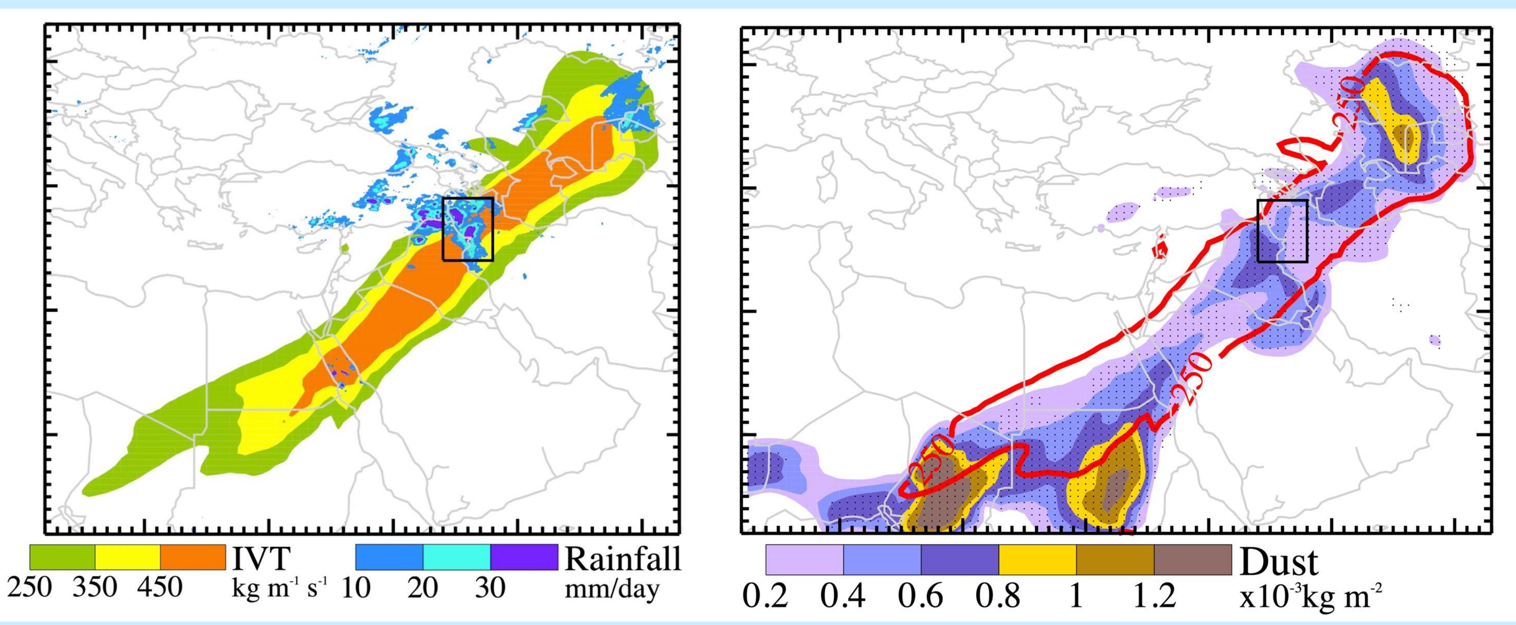


- Total back-trajectory counts from West Africa to the Congo Basin + C emissions in the Congo Basin vs. black C in West Africa: **R= 0.78**.
- Extreme years are controlled by both emission source and air masses routes. In 2003, both Mascarene and St. Helena Highs merge, the core of High is stronger and centered farther south than in 2013, when these two are separate. This separation lets St. Helena High to redirect the northeasterly flow from the Congo Basin to West Africa.

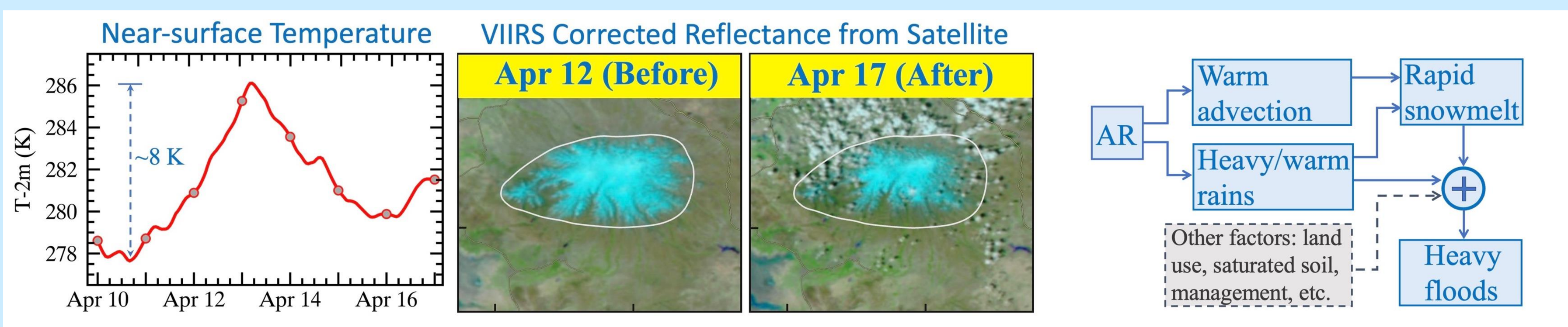
Case 3: Atmospheric rivers bring flood and dust to the Middle East

Atmospheric rivers (ARs) can cause heavy rains, rapid snowmelt, and floods in regions far from the oceans such as the Middle East. A distinct characteristic of ARs in the region is their contribution to dust transport from the major sources along their pathways.

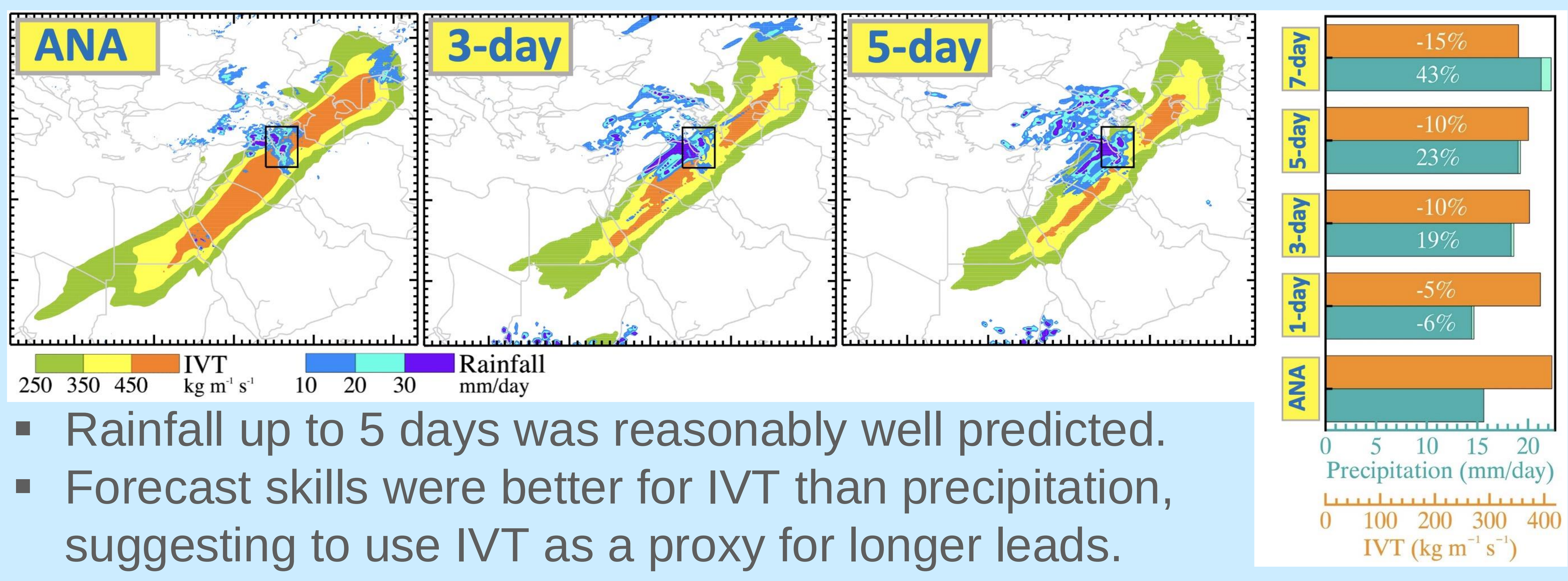




- An AR (Cat 3) caused heavy floods on 14 April 2017.
- Regional daily rainfall was ~16 mm, equivalent to the 99th percentile in April.
- Moisture supply was from Mediterranean & Red Seas through a cold Front.
- High dust column mass density during the event → "Dusty Atmospheric River."



- Warm advection by southwesterly low-level jet, combined with the rain-on-snow effect, caused rapid snowmelt, and with added AR-related torrential rain, led to heavy flooding and landslides.



- Rainfall up to 5 days was reasonably well predicted.
- Forecast skills were better for IVT than precipitation, suggesting to use IVT as a proxy for longer leads.

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