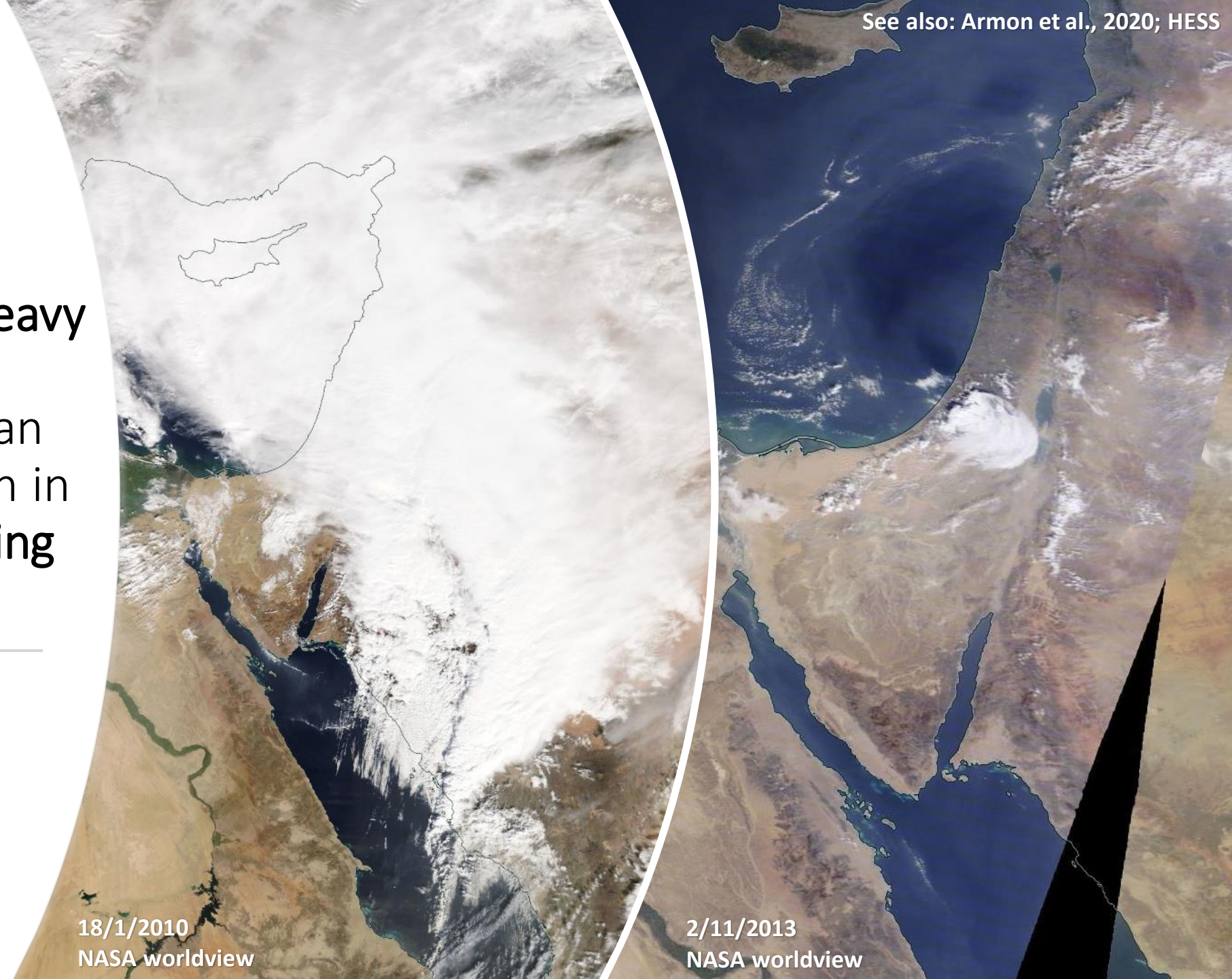
האוניברסיטה העברית בירושלים
THE HEBREW UNIVERSITY OF JERUSALEM
الجامعة العبرية في اورشليم القدس

Radar-based characterization of **heavy precipitation** in the eastern Mediterranean and its representation in a **convection-permitting model**

Efrat Morin, Moshe Armon, Francesco Marra, Yehouda Enzel, and Dorita Rostkier-Edelstein



In short

We identified **HPEs** in the eastern Mediterranean using a **weather radar archive**

These HPEs were simulated in a **convection-permitting WRF** model

Some main **characteristics of rainfall patterns** during these HPEs are:

- For short durations rain amounts are higher near the sea and far into the desert, but for long durations they are highest in the mountains
- HPEs consist of **small-scale short-lived convective rain cells**

WRF model simulations show:

- **Good representation of rainfall structure** and location, except for the highest rain amounts

Convection-permitting models can simulate most HPEs, apart from the most localized and short events

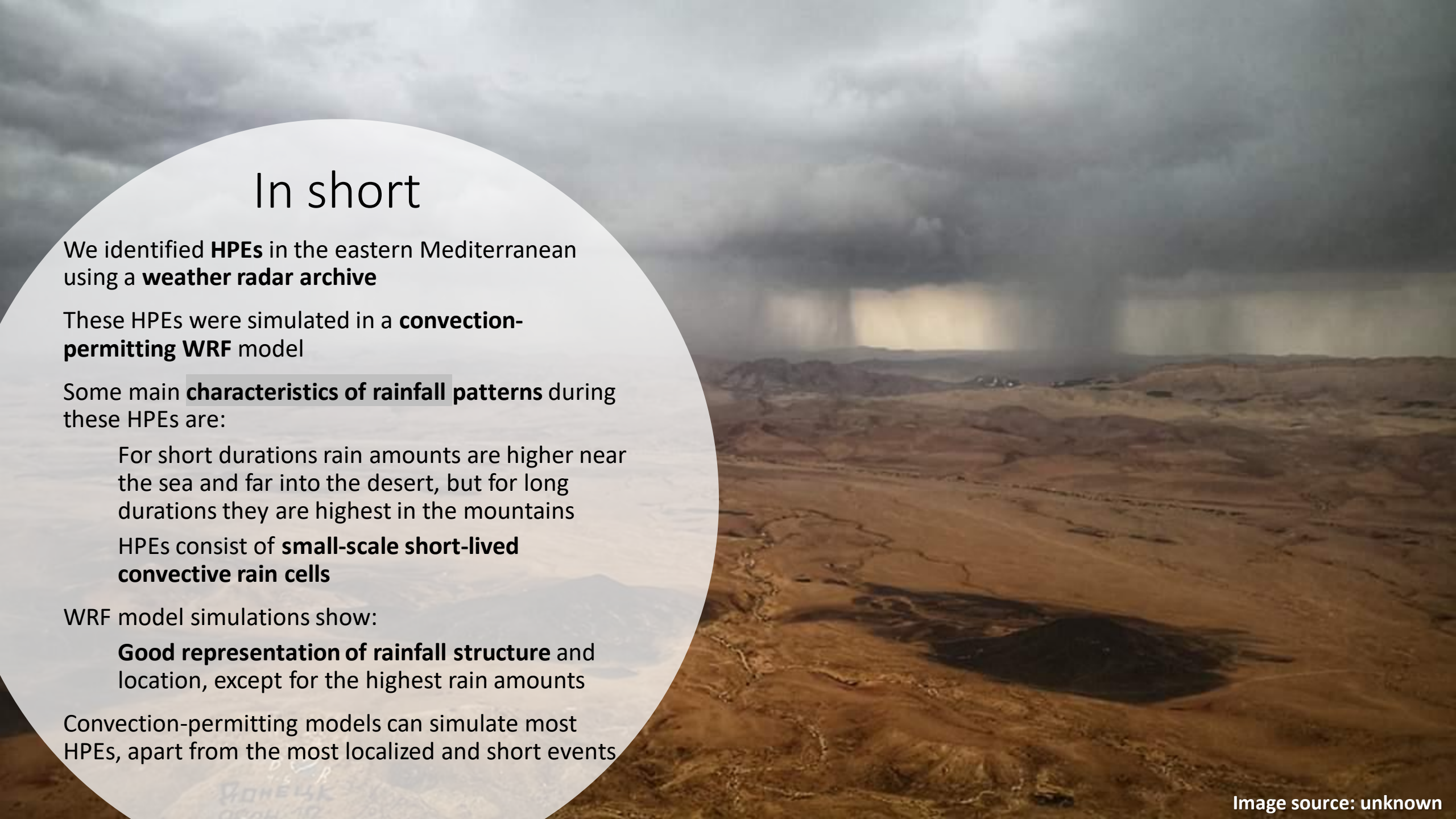
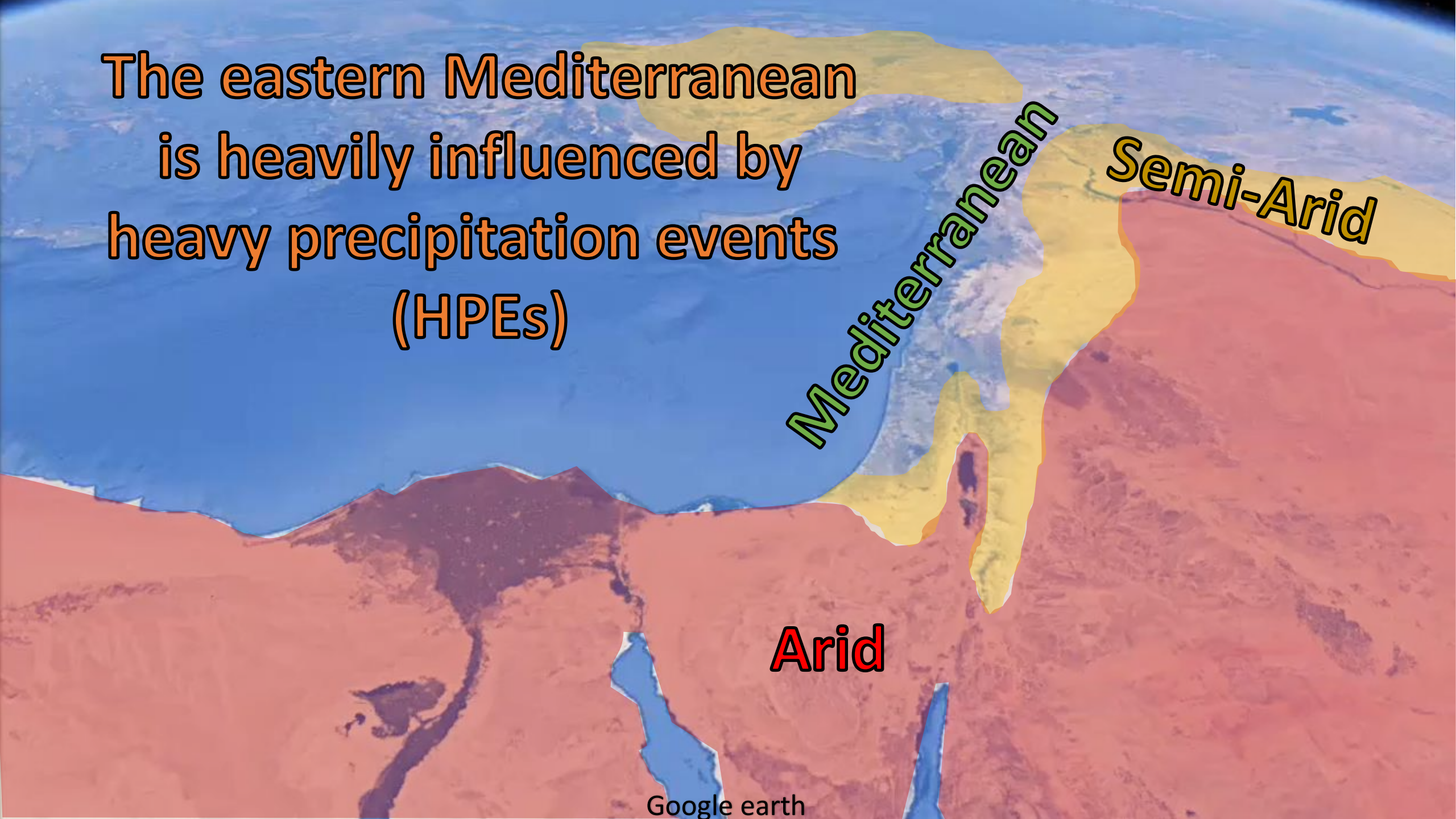


Image source: unknown

Contents

The eastern Mediterranean is heavily influenced by heavy precipitation events (HPEs)

Google earth

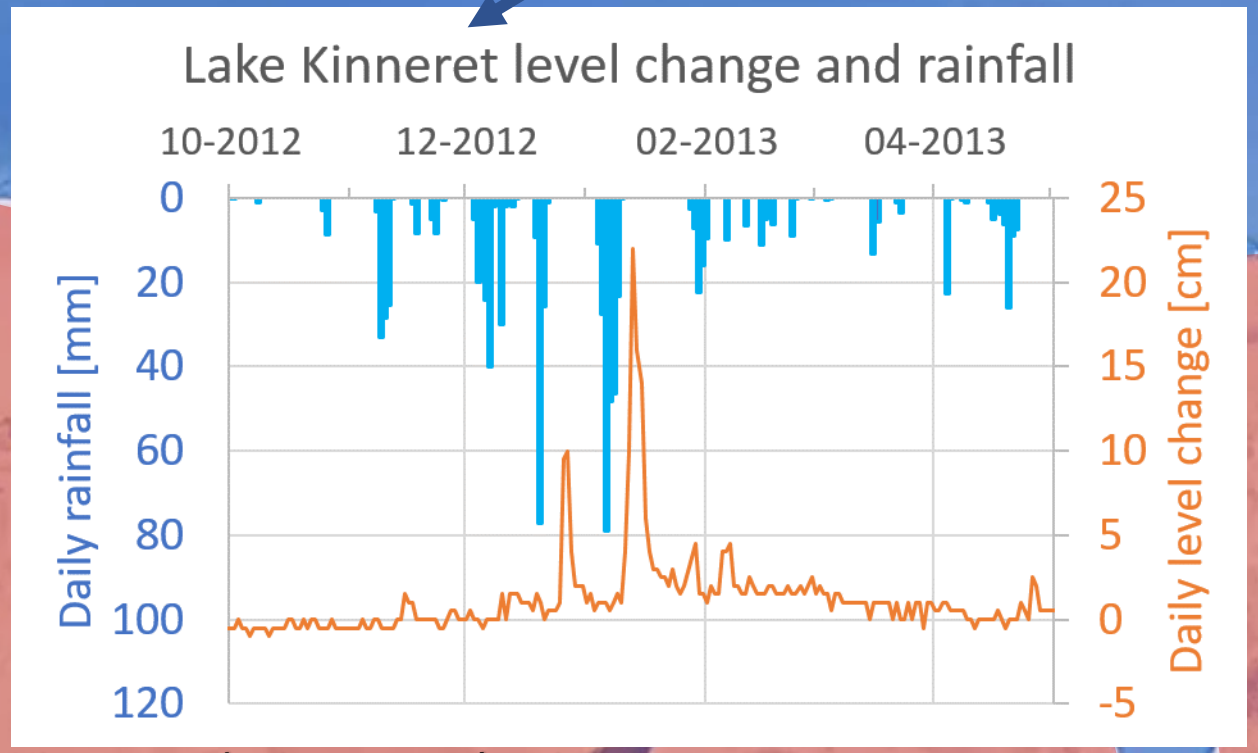

The eastern Mediterranean is heavily influenced by heavy precipitation events (HPEs)
Mediterranean
Semi-Arid
Arid
Google earth

They cause flash floods

Paran Stream – Reuters:
18/1/2010

Google earth

But also contribute to Water resources



Kinneret drainage authority

Google earth

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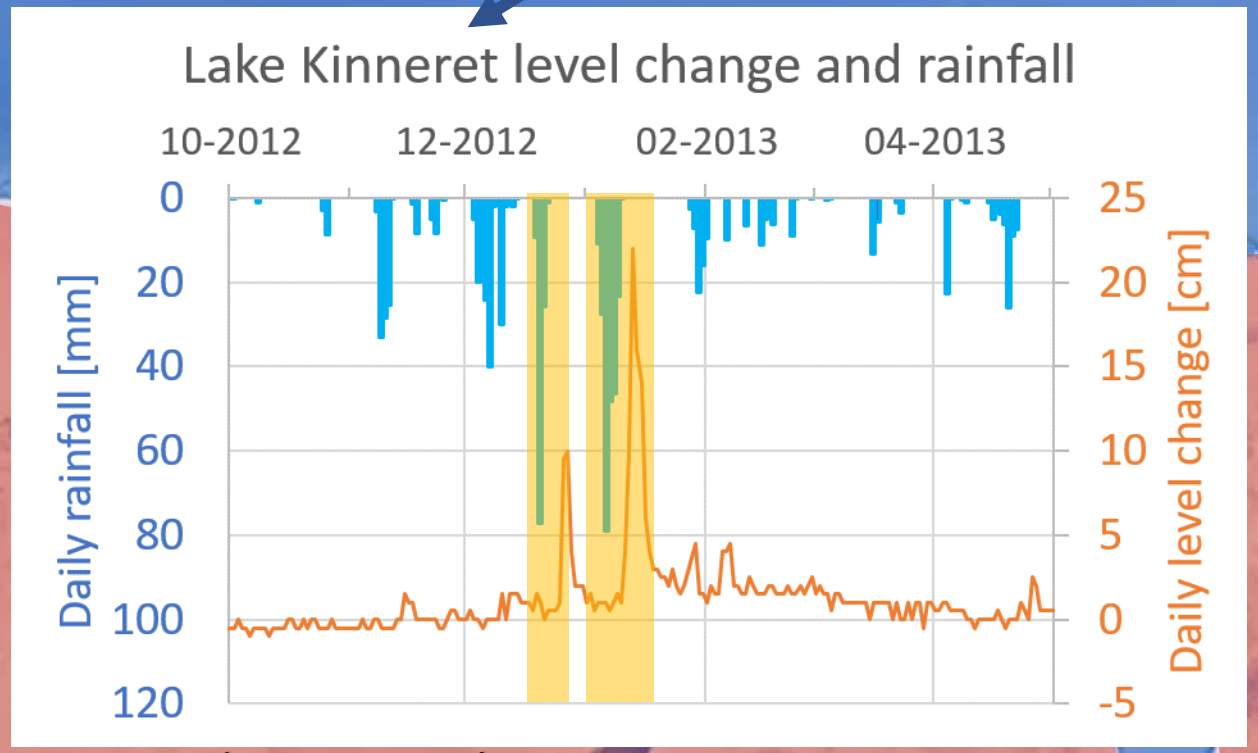
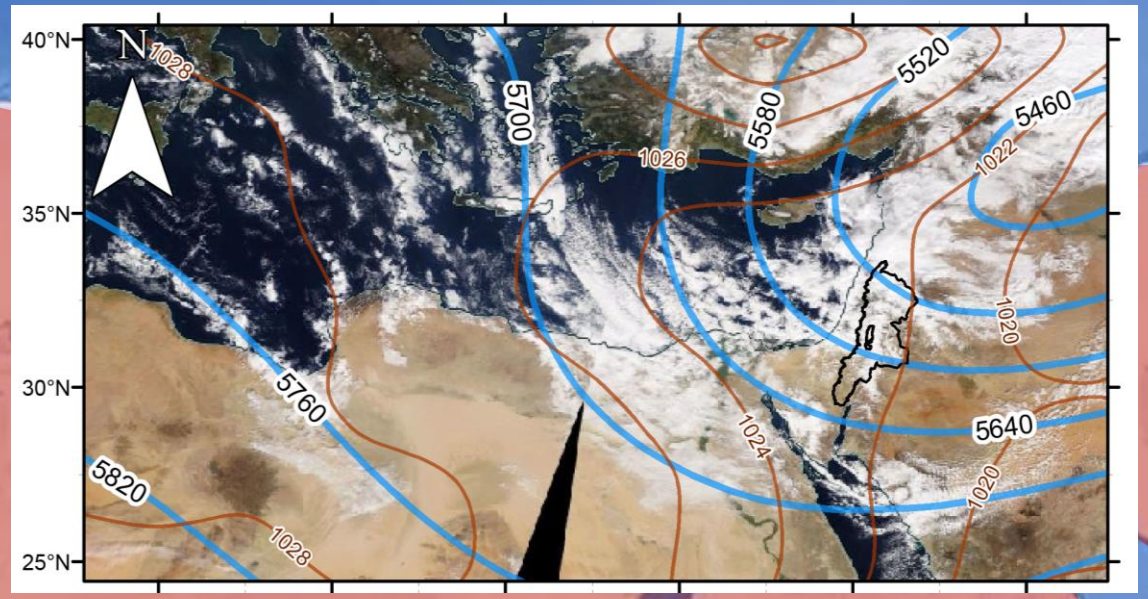


Kinneret drainage authority

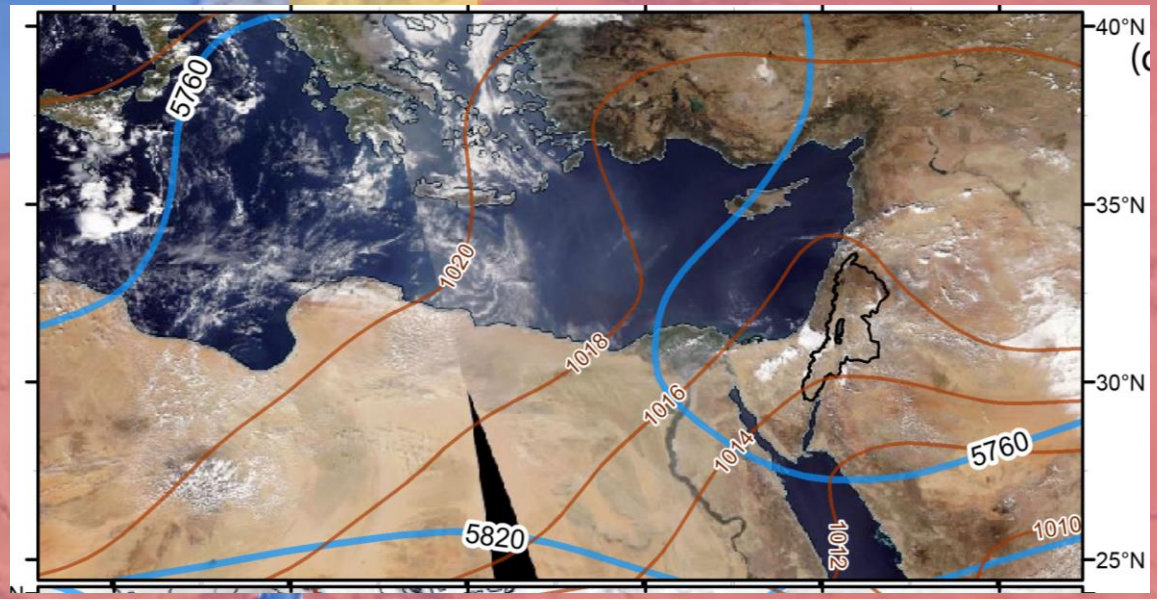
Google earth

Most HPEs are attributed to two types of synoptic systems associated with different rainfall patterns:

Mediterranean cyclones (MCs)



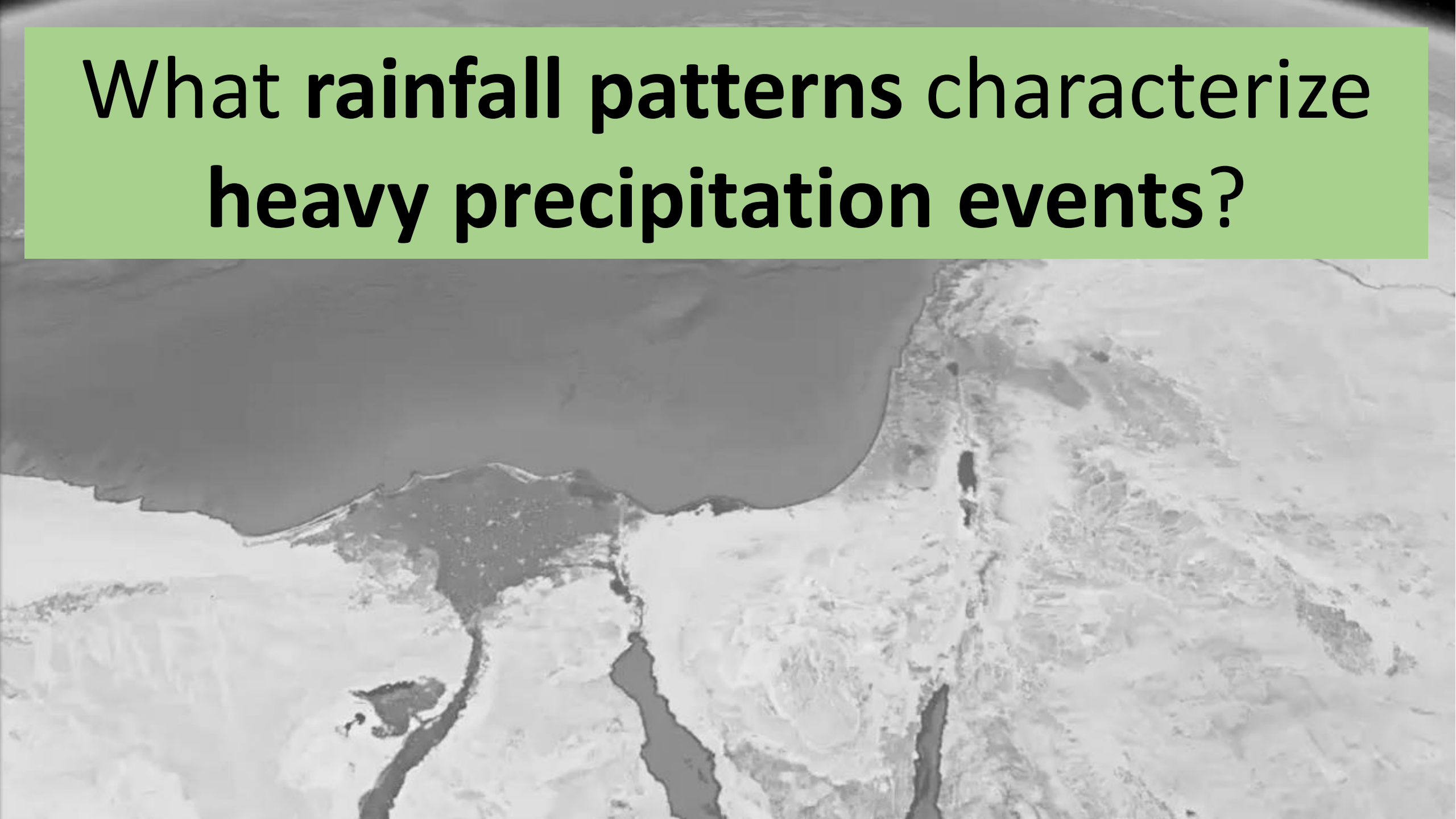
Active Red Sea troughs (ARSTs)



Modified from Armon et al., 2019

Google earth

What **rainfall patterns** characterize **heavy precipitation events**?



What **rainfall patterns** characterize **heavy precipitation events**?

Identify heavy precipitation events using a weather radar

- Long record (24 years; Marra and Morin, 2015)
- High spatiotemporal resolution (5 min, 1km^2)

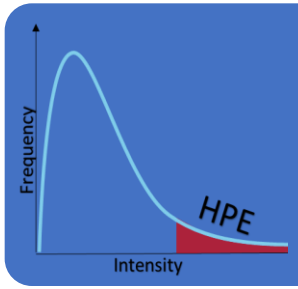
Compare high resolution model runs with observations

- High resolution, convection permitting WRF

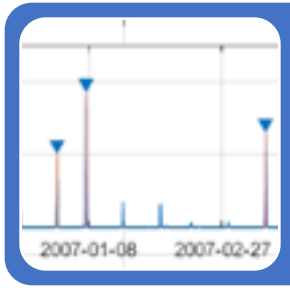
Characterize rainfall patterns

- Spatial distribution of rain amounts
- Structure of rain field

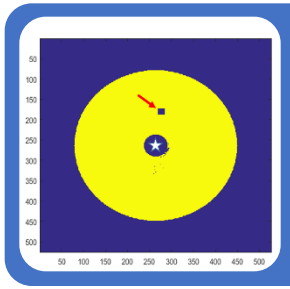
Identification of heavy precipitation events from the radar archive



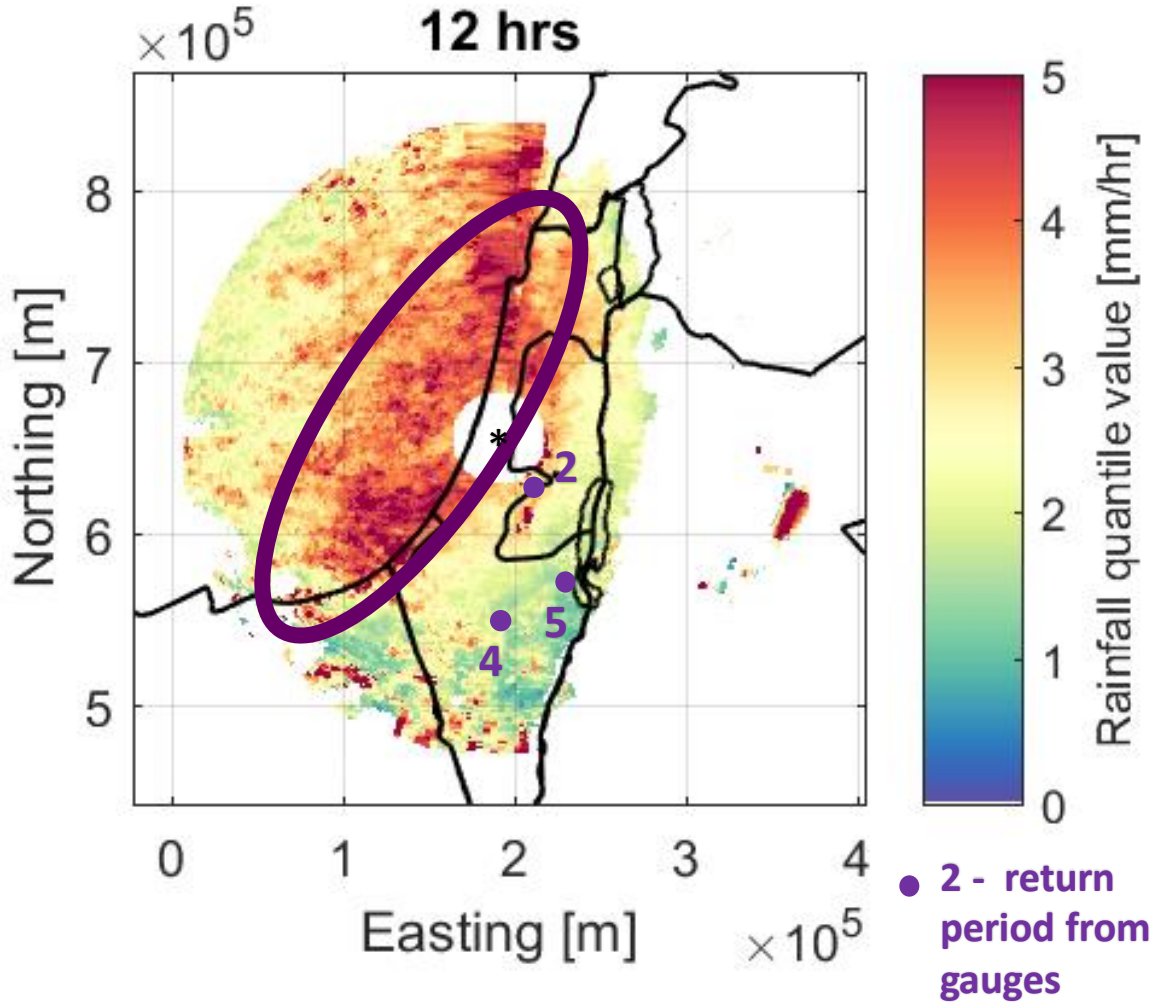
Rain depth threshold for each radar pixel (1 km^2, ~10^5 pixels, 1-72h duration, during 1990-2014)



Events were defined where >1000 pixels crossed the threshold



Automatic and manual removal of clutter and poor-quality events yielded **41 events**



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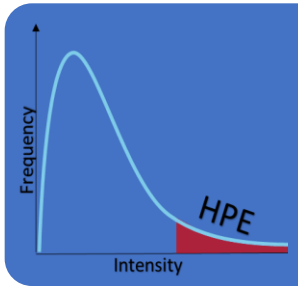

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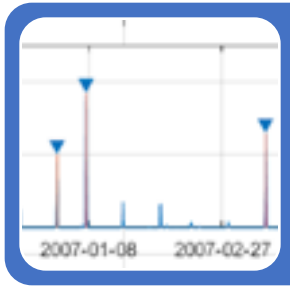

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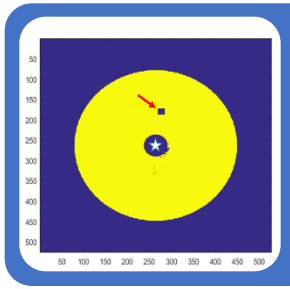

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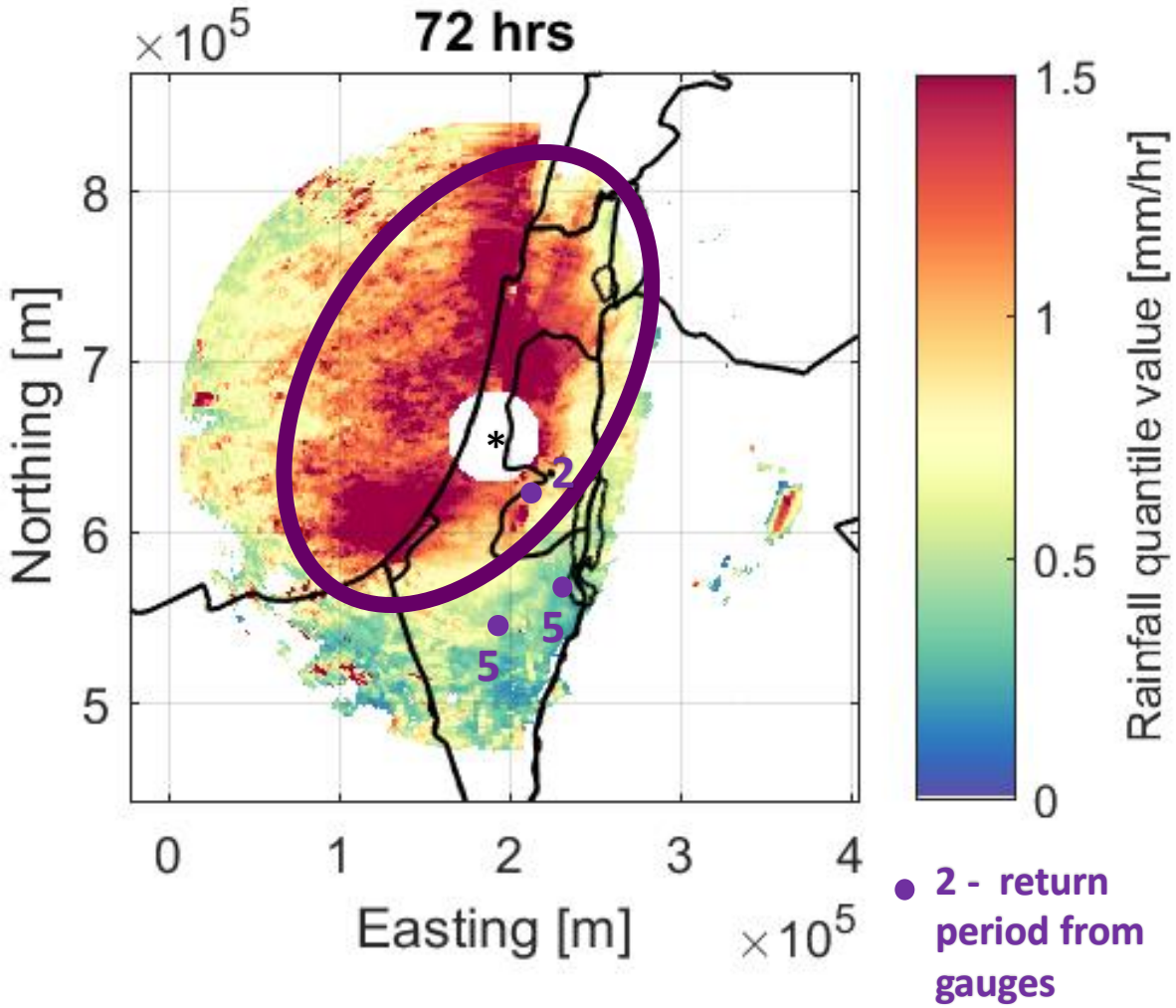

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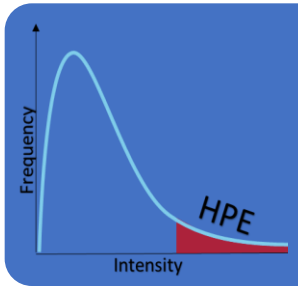

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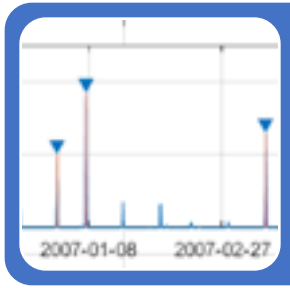

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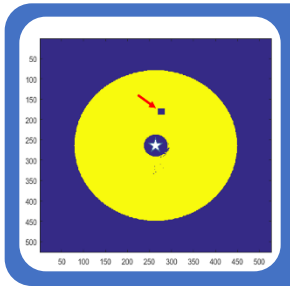

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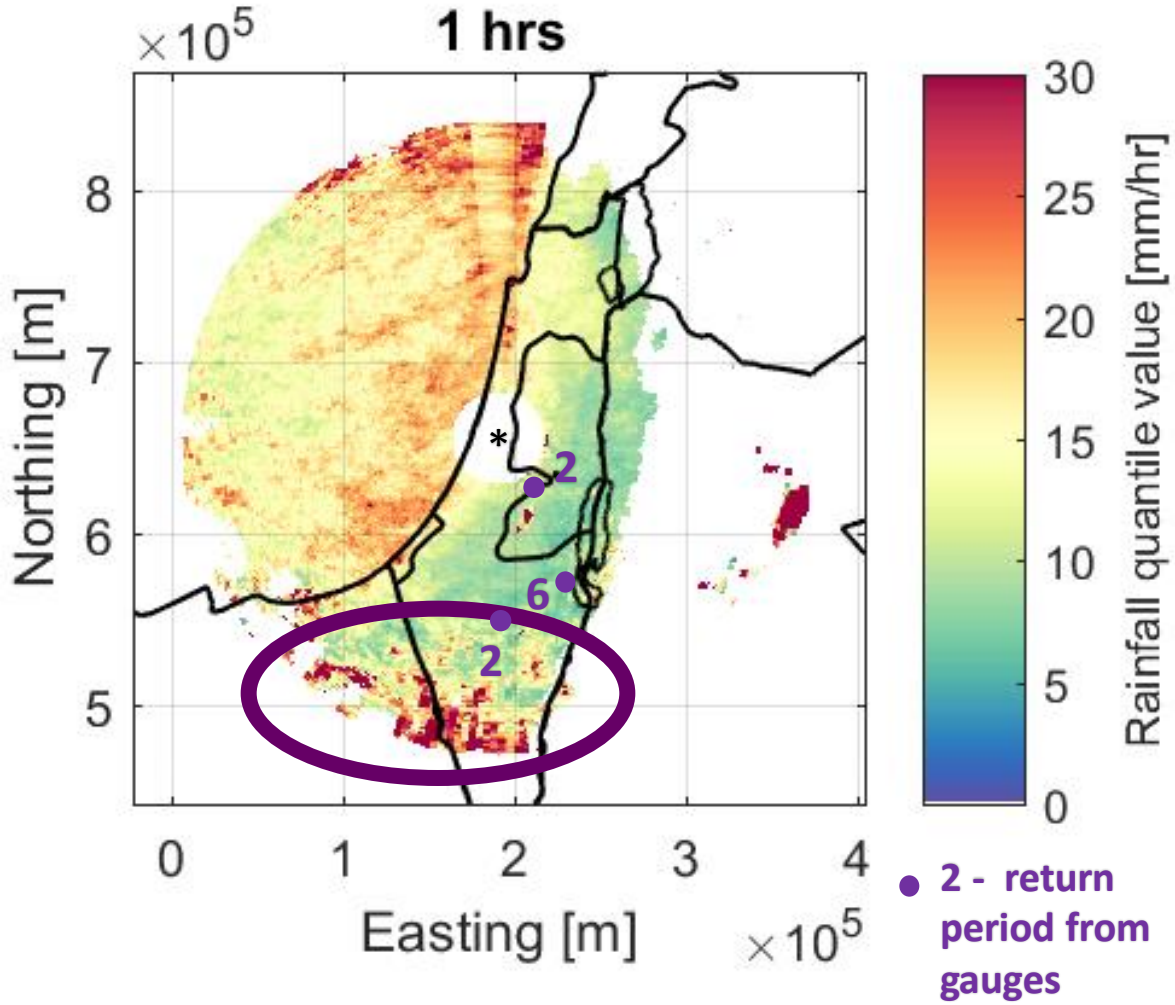
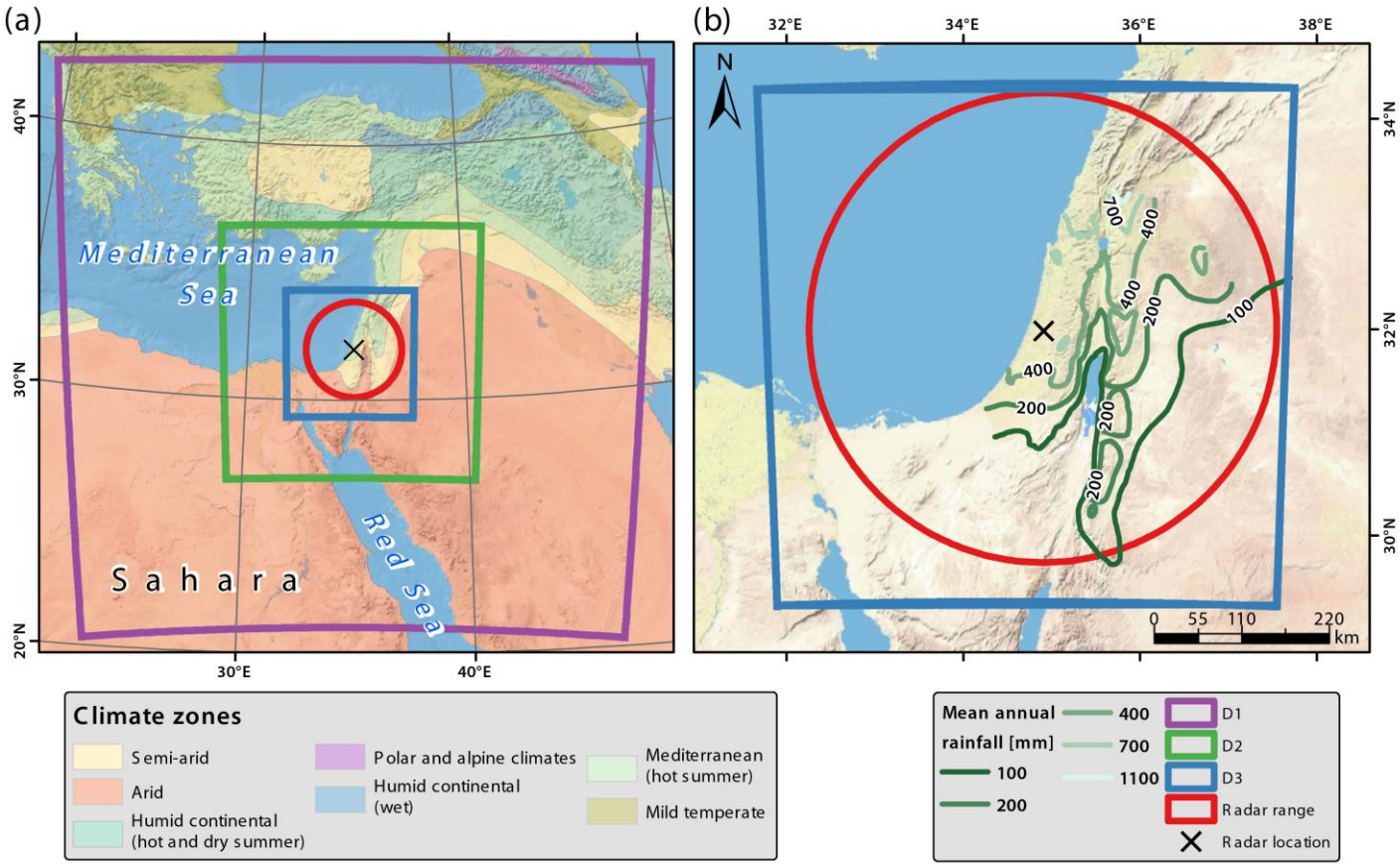


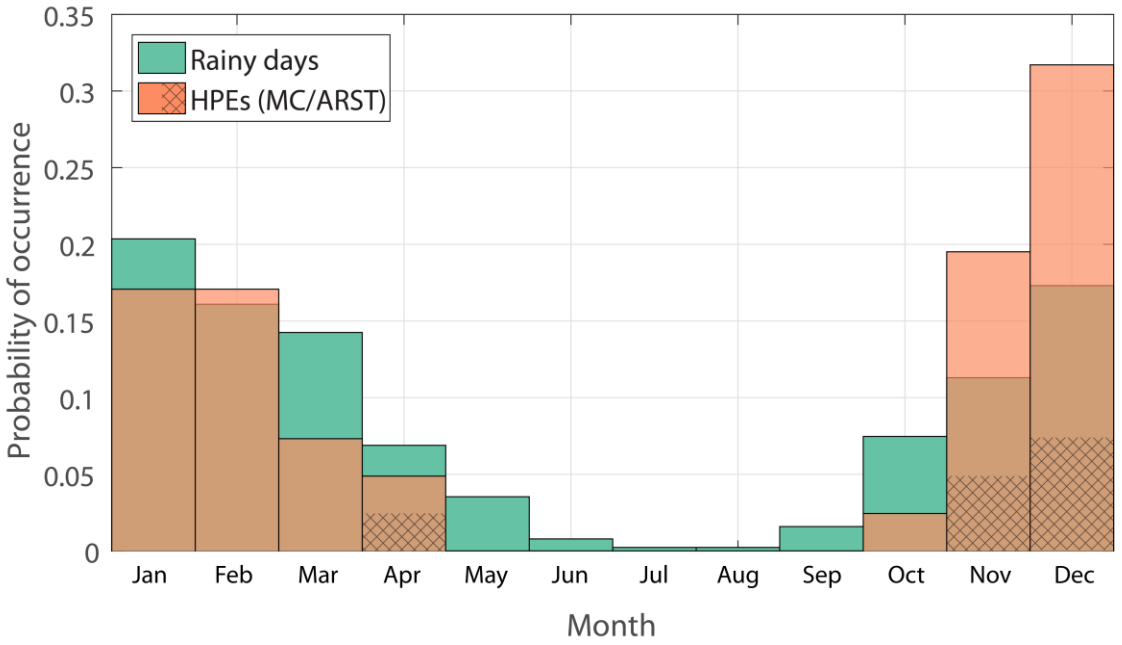
WRF simulation of the 41 identified events

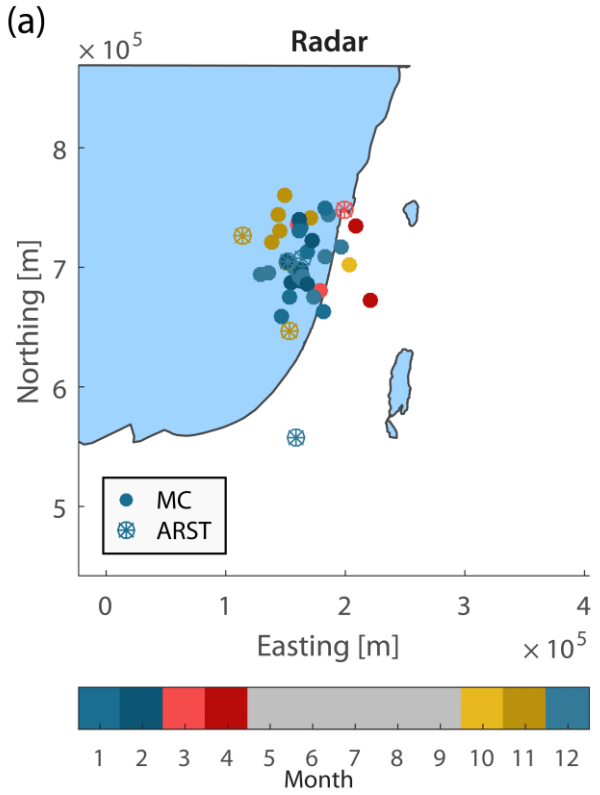
- Input: Era-Interim 6h, ~80 km, 60 horizontal levels
- Three (2-way) nested domains, 1:5 ratio
- Inner domain – **convection-permitting**, comparable to radar domain

	Outer nest	Middle nest	Inner nest
Spatial resolution [km]	25x25	5x5	**1x1**
Temporal resolution [s]	~100	~20	**4-8**
Domain size [pixels]	100x100	221x221	**551x551**
Number of vertical layers	68	68	**68**
Model top [hPa]	25	25	**25**



Climatic classification: Atlas of Israel (2011). ESRI basemap source: U.S. National Park Service



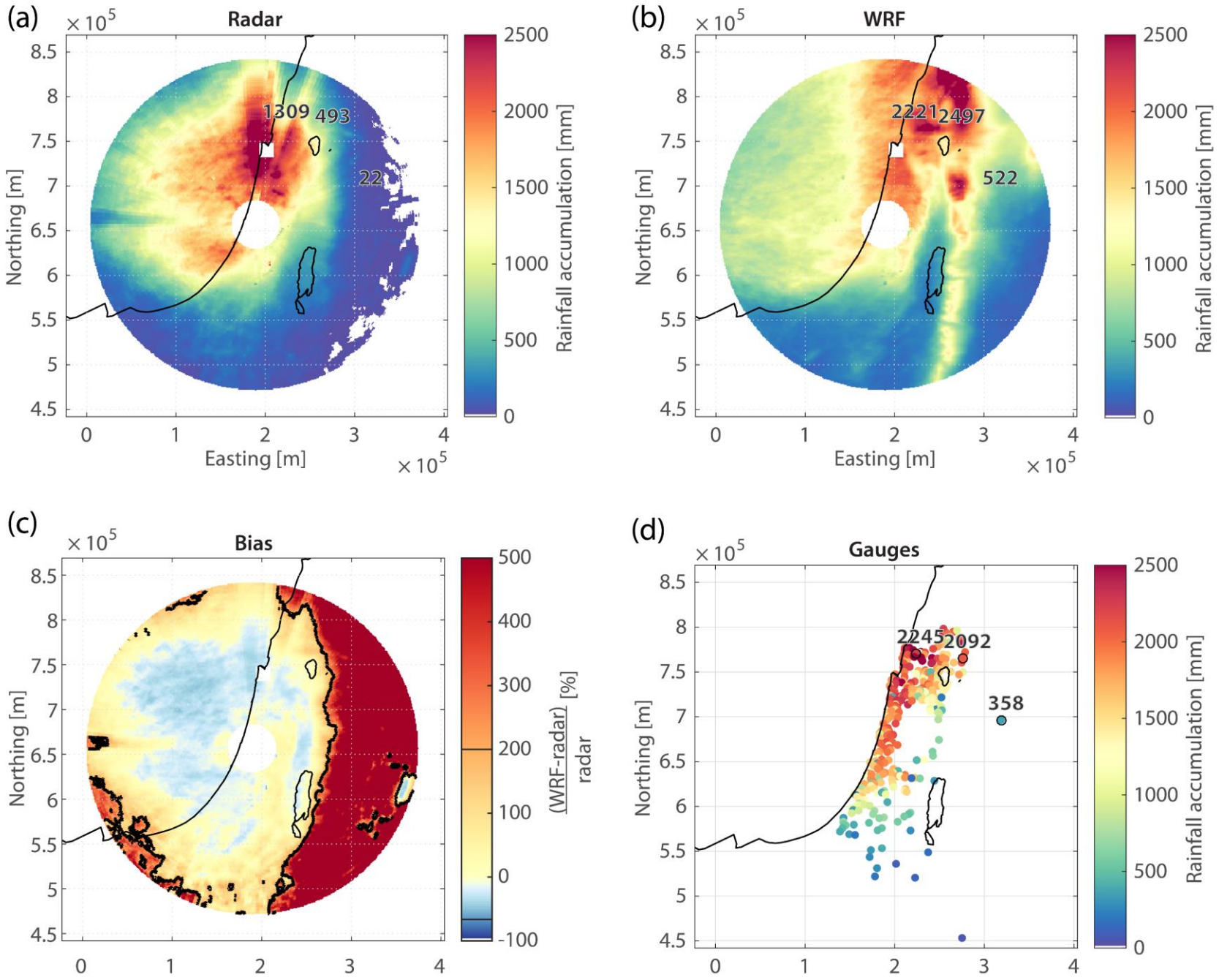


Climatology of HPEs

- HPEs occur throughout the rainy season, but concentrate mainly in early winter
- Their center of mass is located next to the Mediterranean coast and moves inland along the season

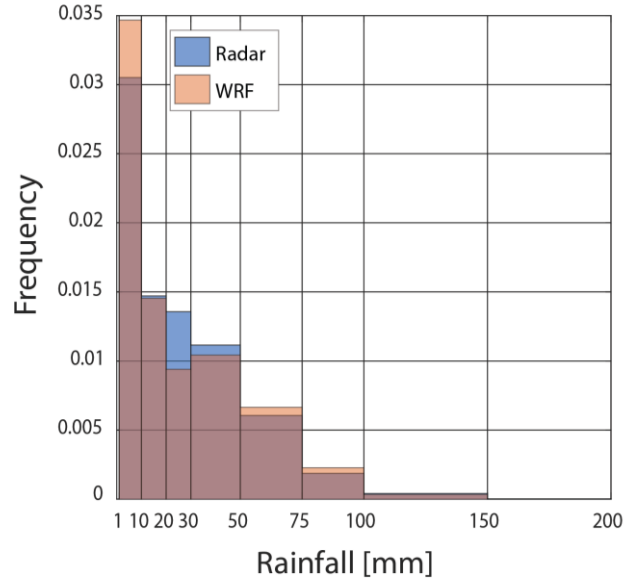
WRF vs. radar bias

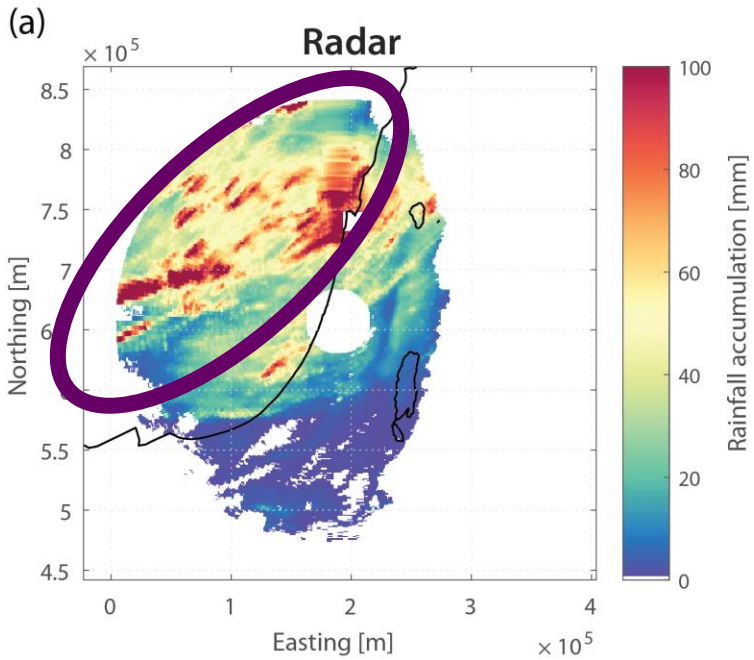
- Radar data exhibit some **range degradation** and obscured rays
- A **bias threshold** was set (-66% - +200%)

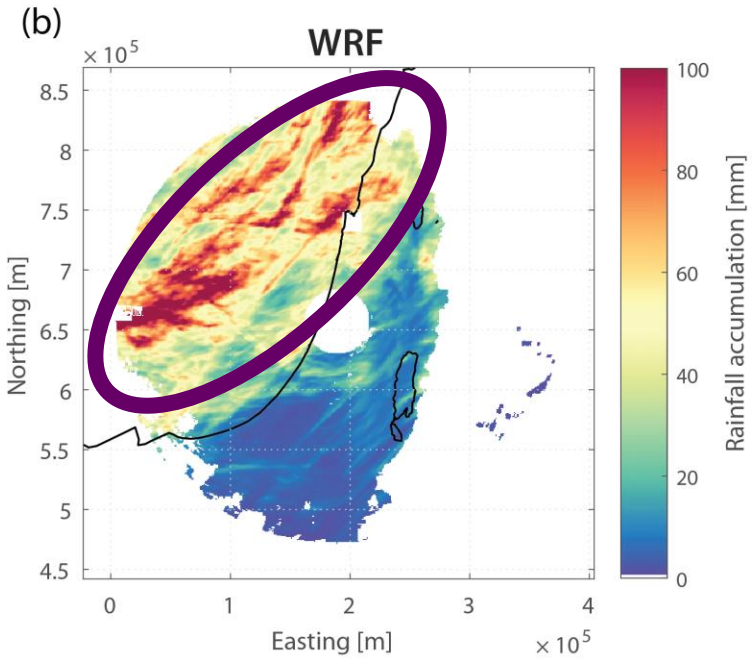


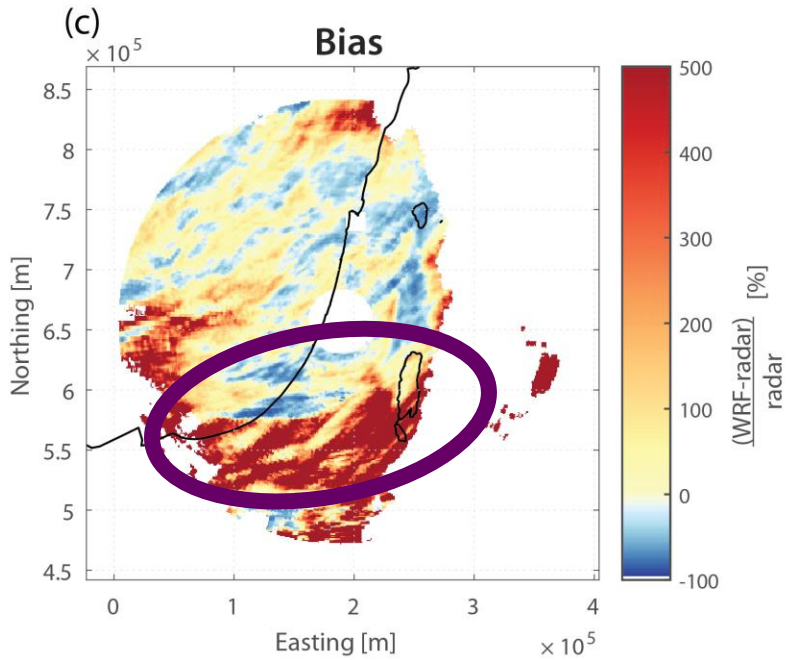
Case study: HPE #1

General pattern looks OK
Let's examine this pattern closely



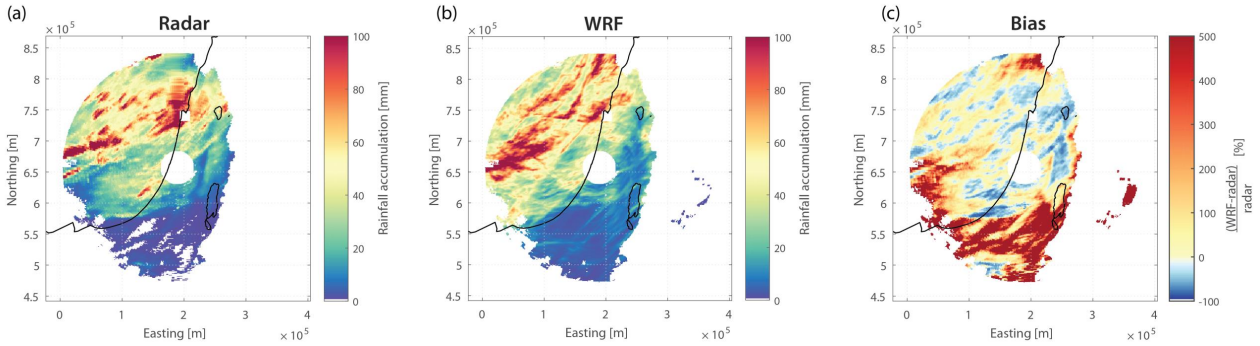






Bias = 120%; CC = 0.76; RMSE = 20 mm

Case study: HPE #1



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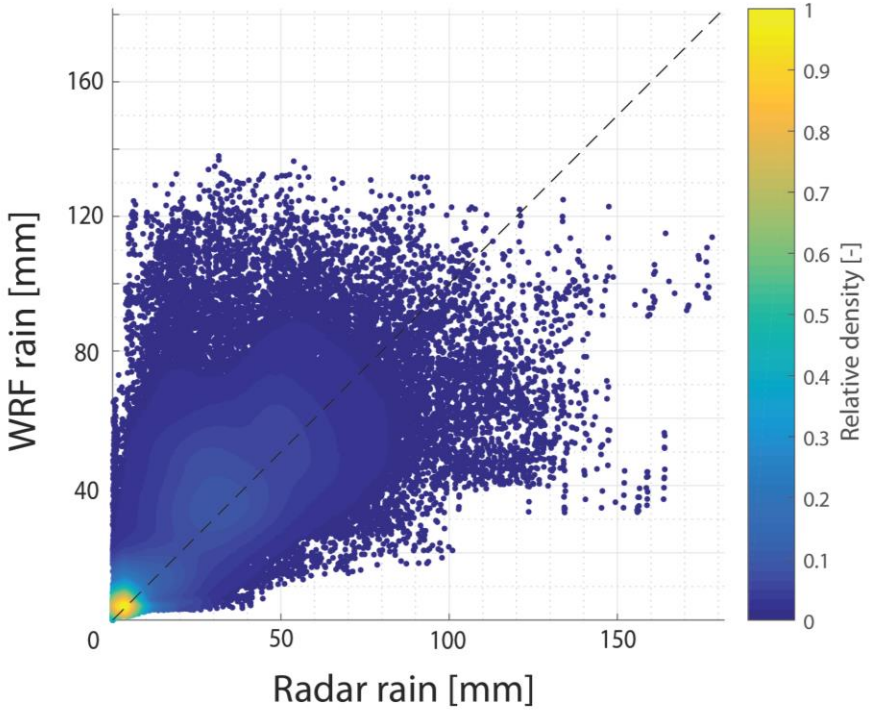
Pixel-by-pixel:
Huge spread (although the 1:1 line is apparent)



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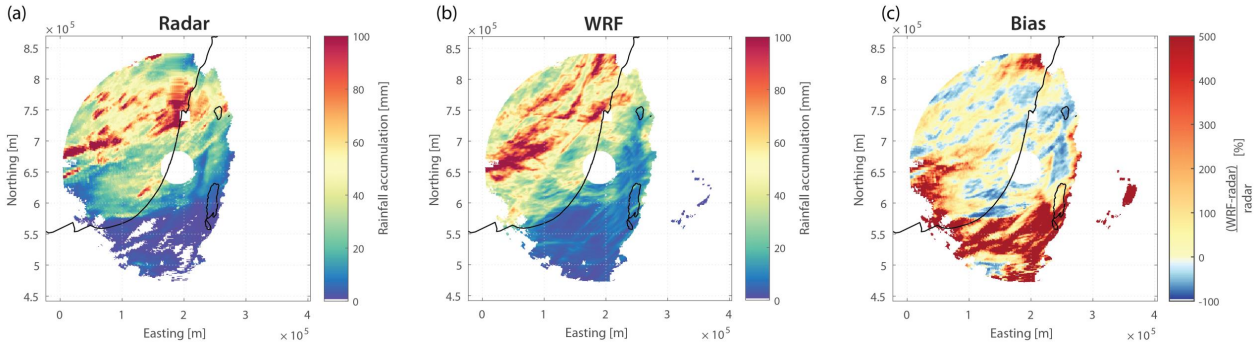
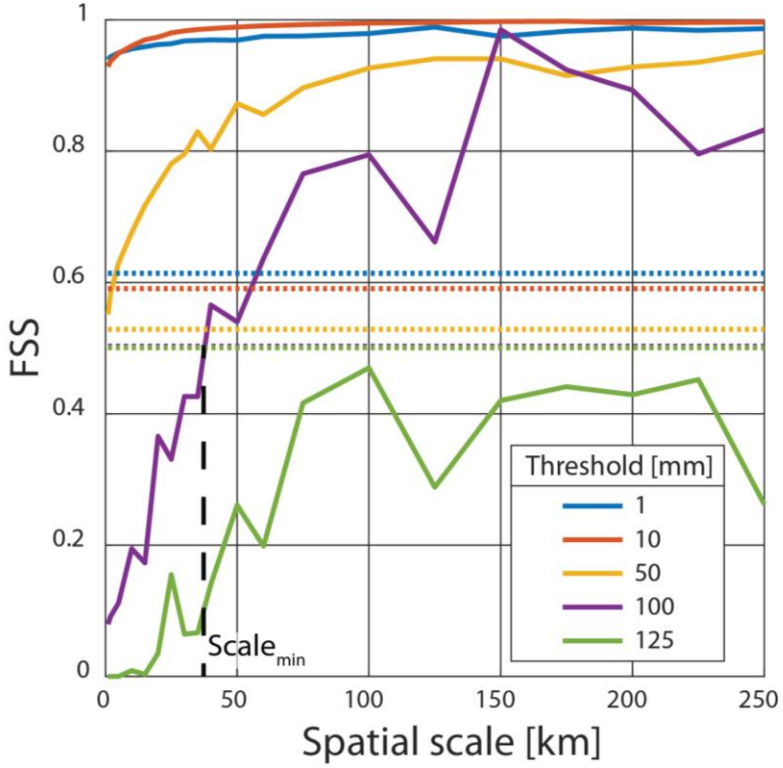


Bias = 120%; CC = 0.76; RMSE = 20 mm

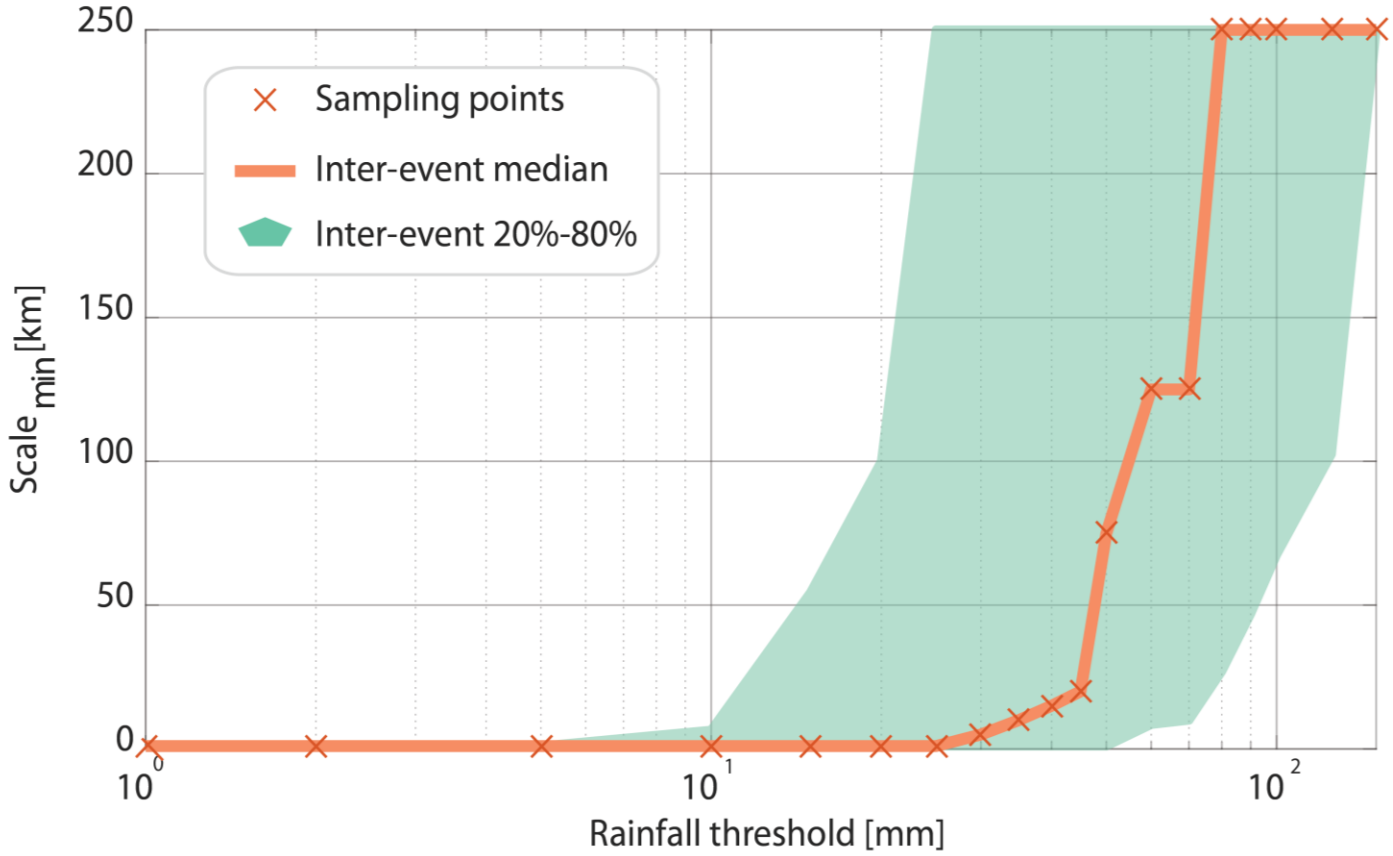
The neighborhood statistic, Fraction Skill Score (Roberts and Lean, 2008) seems good for rainfall thresholds <100 mm

The minimal scale for a skillful representation of the rainfall equals to the model resolution (1km^2)



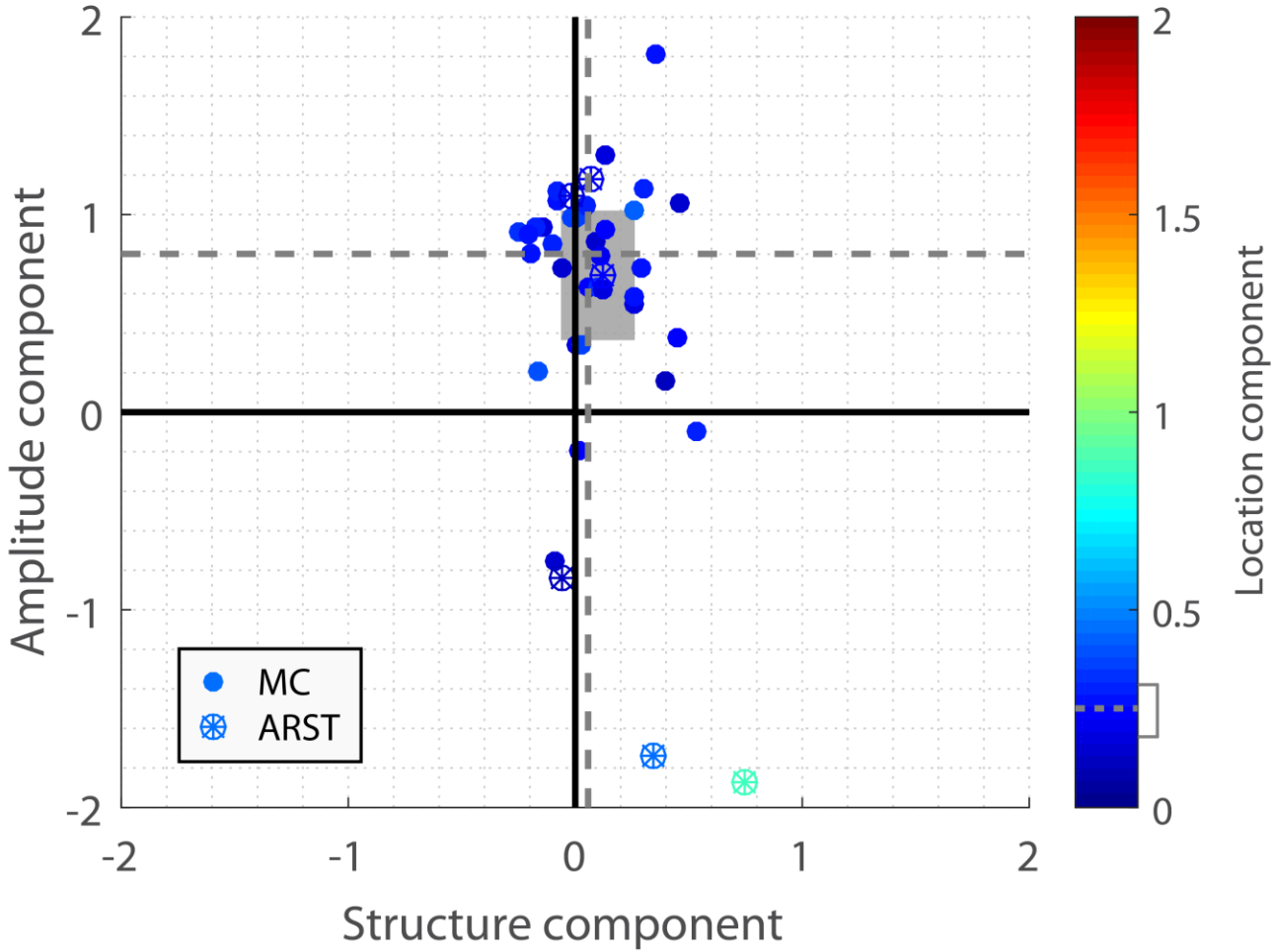
Analyses for all HPEs: **minimal scale**

- The minimal scale for a skillful forecast depends on the rainfall threshold examined.
- It is very low for low rainfall thresholds and increases sharply above 45 mm



Analyses for all HPEs: **SAL**

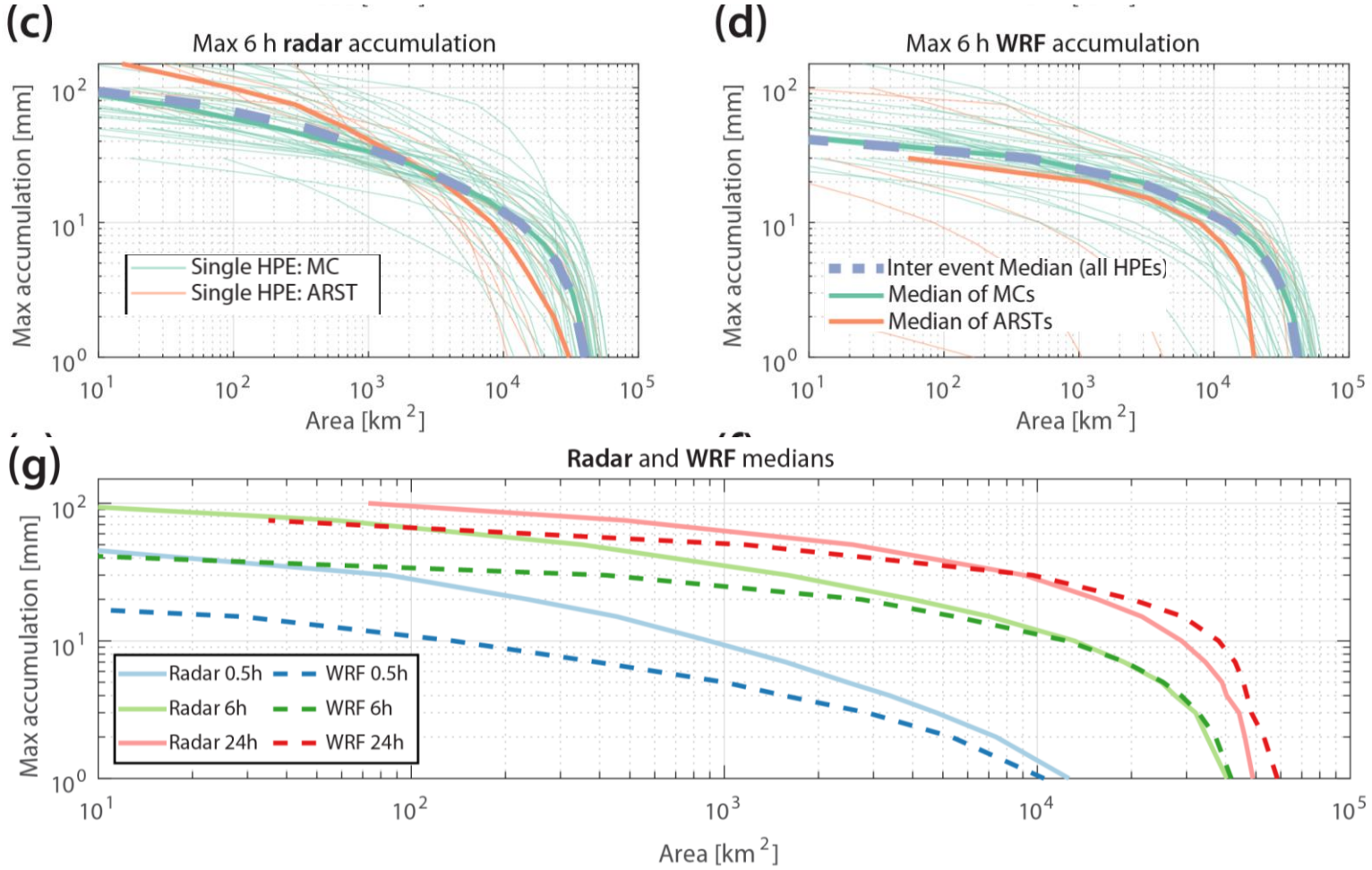
- Structure-Amplitude-Location (SAL) analysis (Wernli et al., 2008) describe model results separately for each of the three components
- Rainfall structure and location are well modelled
- There's a large amplitude bias



*Link to a description of SAL analysis

Analyses for all HPEs: **DAD curves**

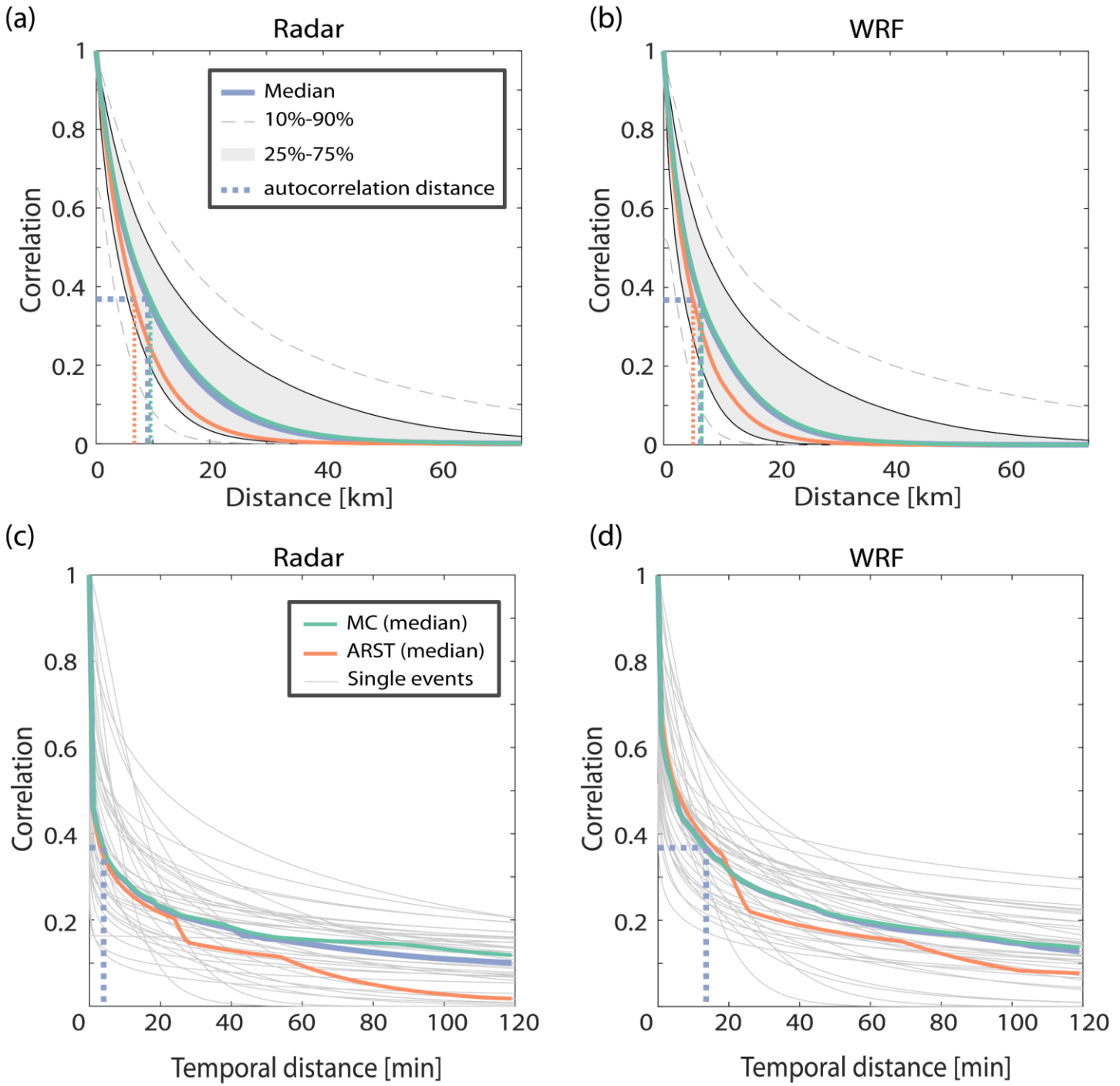
- Areal rainfall amounts are crucial drivers of the hydrological response and are important for understanding rainfall structure and triggering mechanisms
- They could be represented by depth-amplitude-duration (DAD) curves
- DAD curves are similar between WRF and Radar, but WRF underestimates rainfall during ARSTs
- Radar curves exhibit higher amounts over smaller regions than WRF curves



Analyses for all HPEs: **Autocorrelation structure**

- Rain cells autocorrelation structure emphasizes the degree of rainfall “convectiveness” and the size of rain cells
- Rainfall in HPEs is highly localized, as manifested by both radar and WRF results
- Rain cells during MCs are larger than during ARSTs

*Link to a description of autocorrelation analysis



Conclusions

We identified **HPEs** in the eastern Mediterranean using a **weather radar archive**

These HPEs were simulated in a **convection-permitting WRF** model

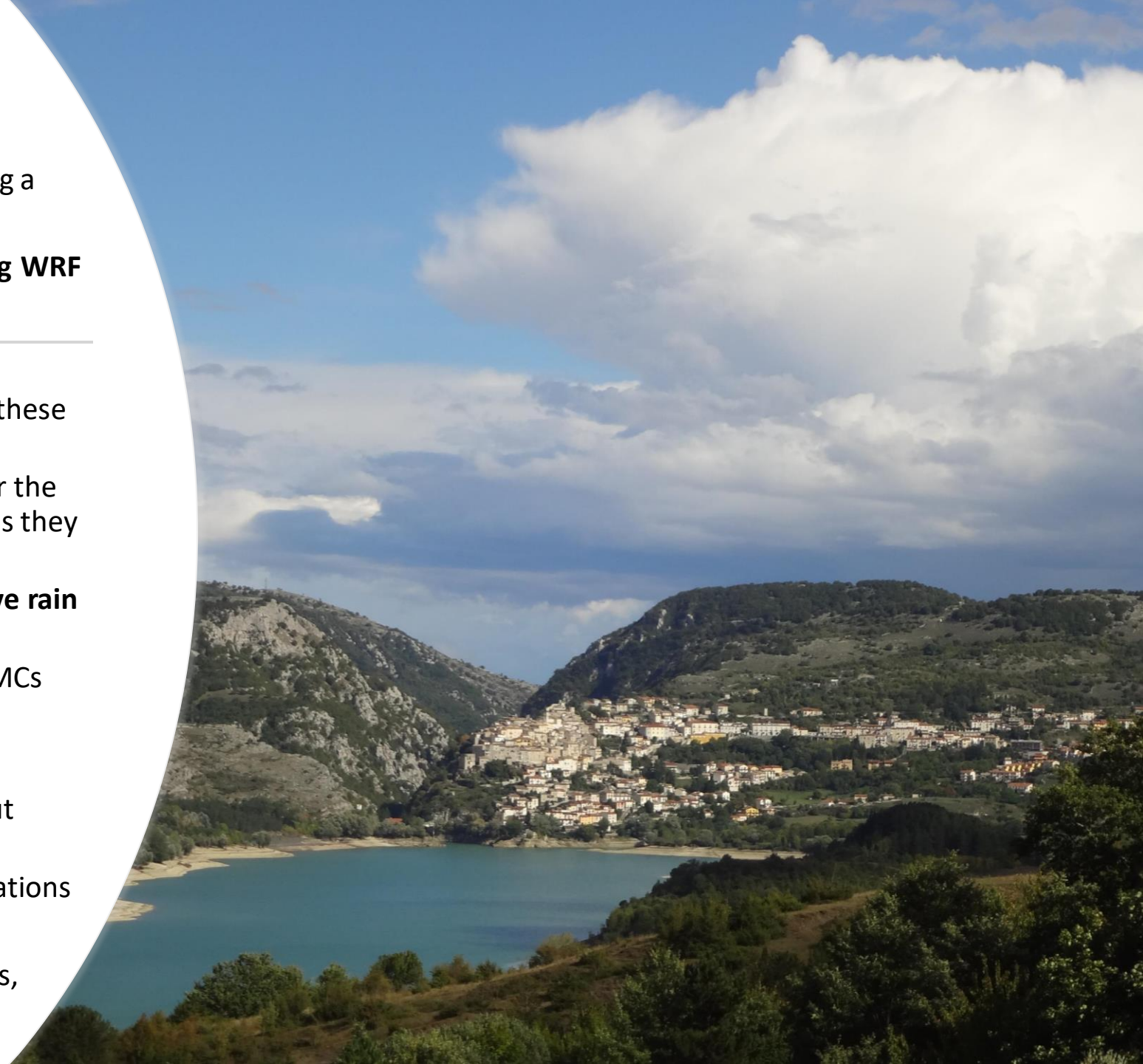
Some main **characteristics of rainfall patterns** during these HPEs are:

- For short durations rain amounts are higher near the sea and far into the desert, but for long durations they are highest in the mountains
- HPEs consist of **small-scale short-lived convective rain cells**
- **Rain cells** during ARSTs are smaller than during MCs

WRF model simulations show:

- **Good representation of rainfall structure** and location, except for the highest rain amounts, but consist of a high positive bias
- Model simulations of MCs are better than simulations of ARSTs

Convection-permitting models can simulate most HPEs, apart from the most localized and short events



Questions?

Check out our paper in HESS

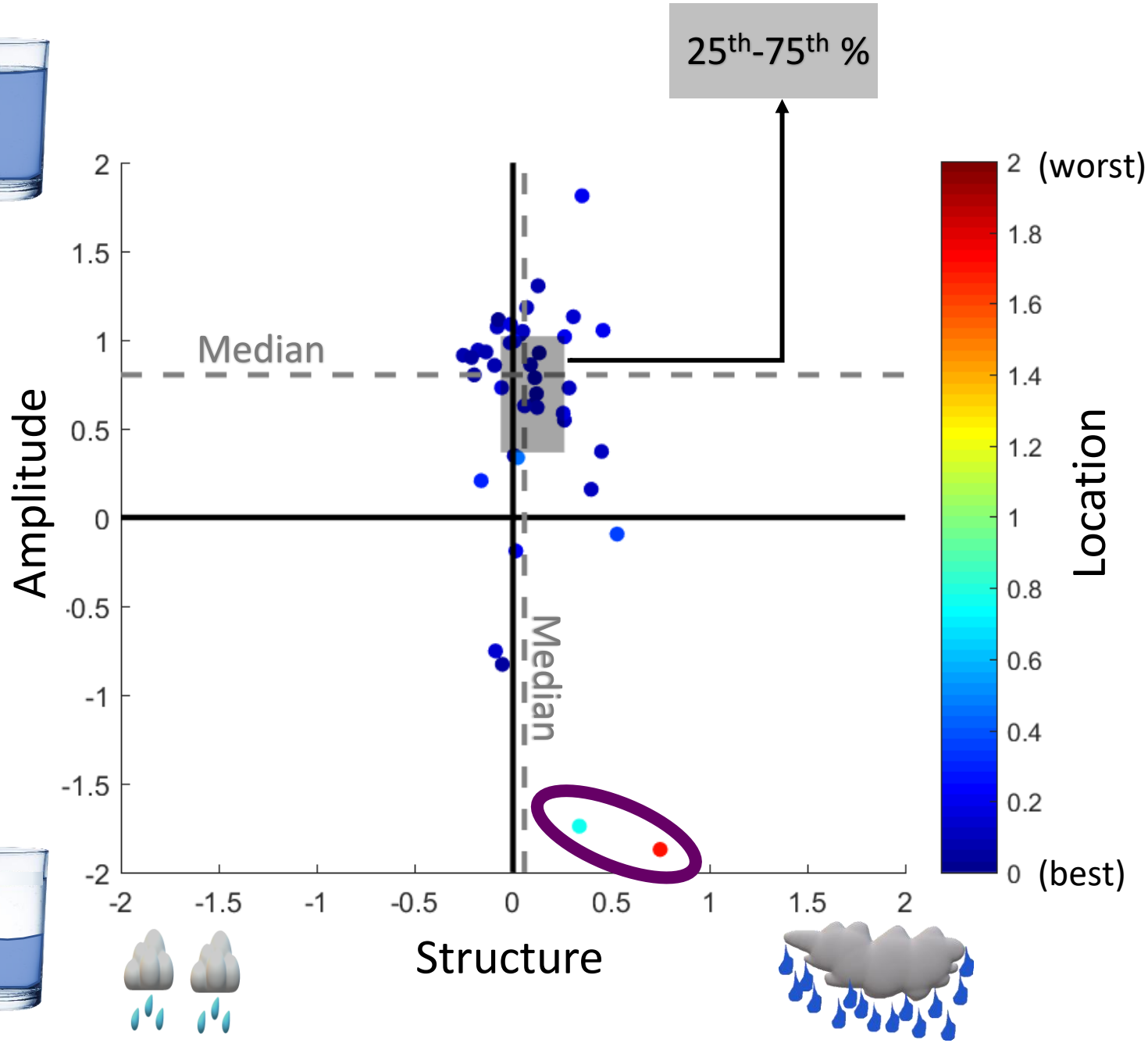
or

contact directly by email:
moshe.armon@mail.huji.ac.il

SAL analysis

Wernli et al., 2008

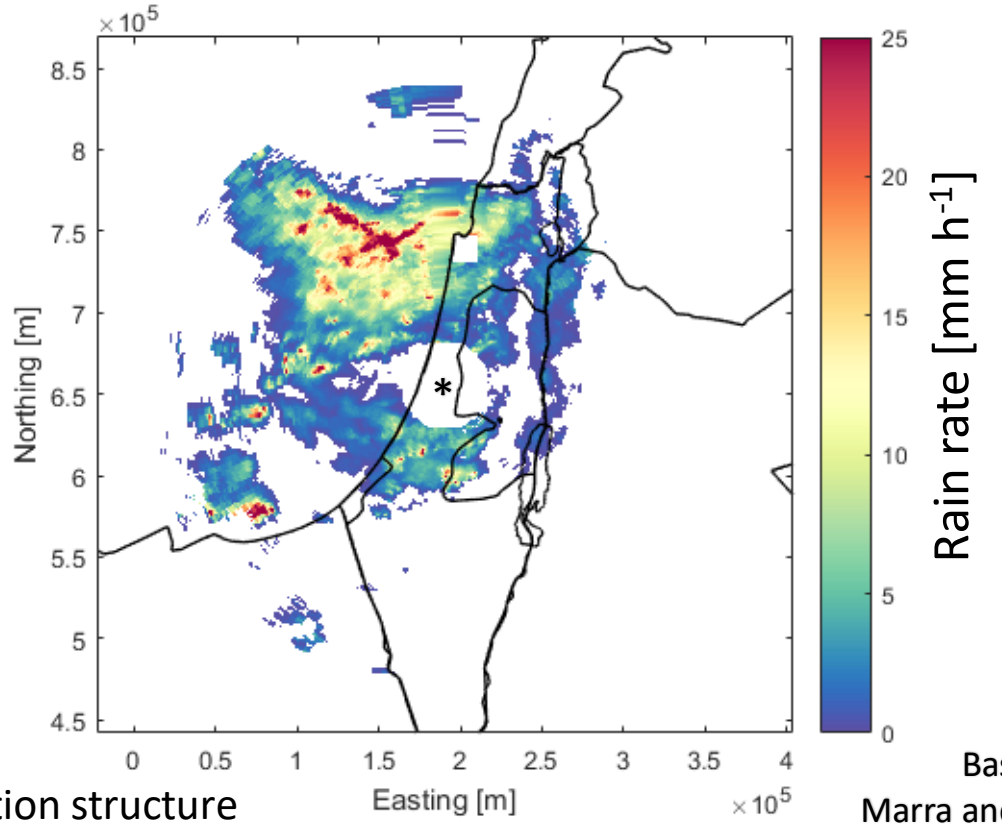
- Amplitude:
  - 0 is the best
  - 1 means over estimation X3
- Structure:
  - 0 is the best
  - S>0 too widespread
  - S<0 too small or too peaked
- Location
  - 0 is the best (both center of mass and the average distance between precipitation-objects are the same)

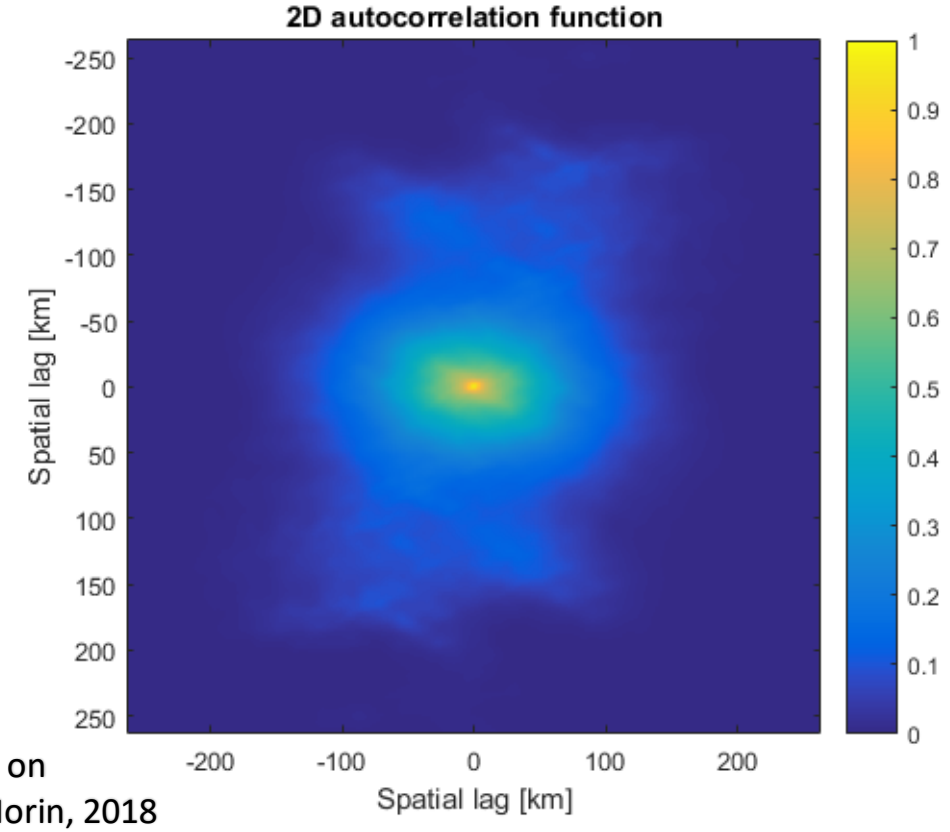


*Back to SAL analysis

Rainfall patterns: **Structure** (autocorrelation)

For each (10 min) time step → Convective? → Find 2D spatial autocorrelation → Fit 1D exponential function





Based on Marra and Morin, 2018

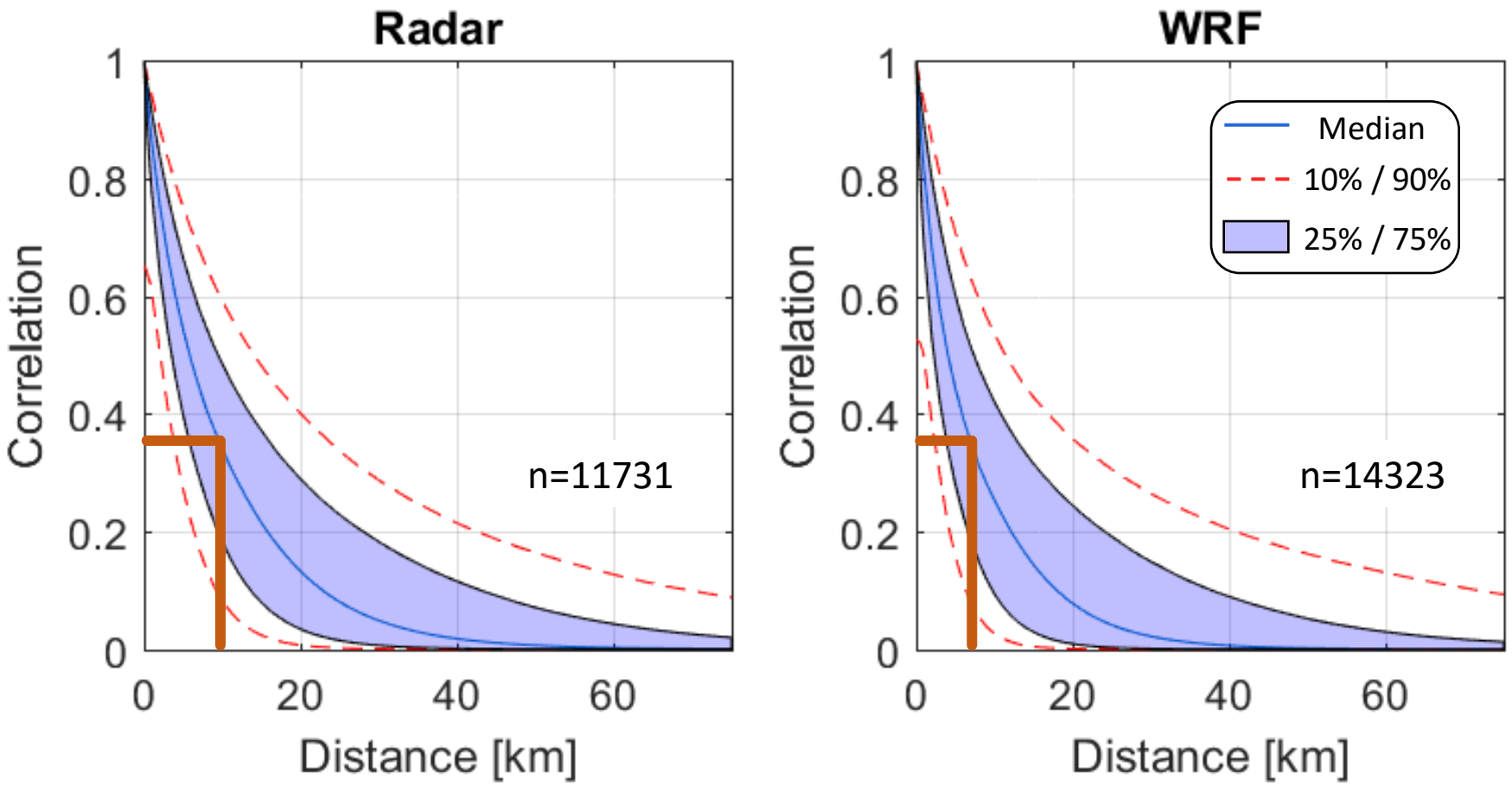
*Link back to autocorrelation structure

Rainfall patterns: **Structure** (autocorrelation)

Similar properties for both radar and WRF

- Decorrelation distance **~8km**
- Temporal decorrelation distance **~5-10min**

Convective cells of all events



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