

Compact Description & Statistical Modeling of High Resolution spatio-temporal extreme Weather events

(Bonn)

Svenja Szemkus, Petra Friederichs

Institute for geosciences; Section Meteorology; University of Bonn

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Project aims:

- Development and evaluation of stochastic methods for the compact representation of spatio-temporal weather extremes
- Stochastic simulation of spatio-temporal precipitation fields with preserved spatio-temporal characteristics

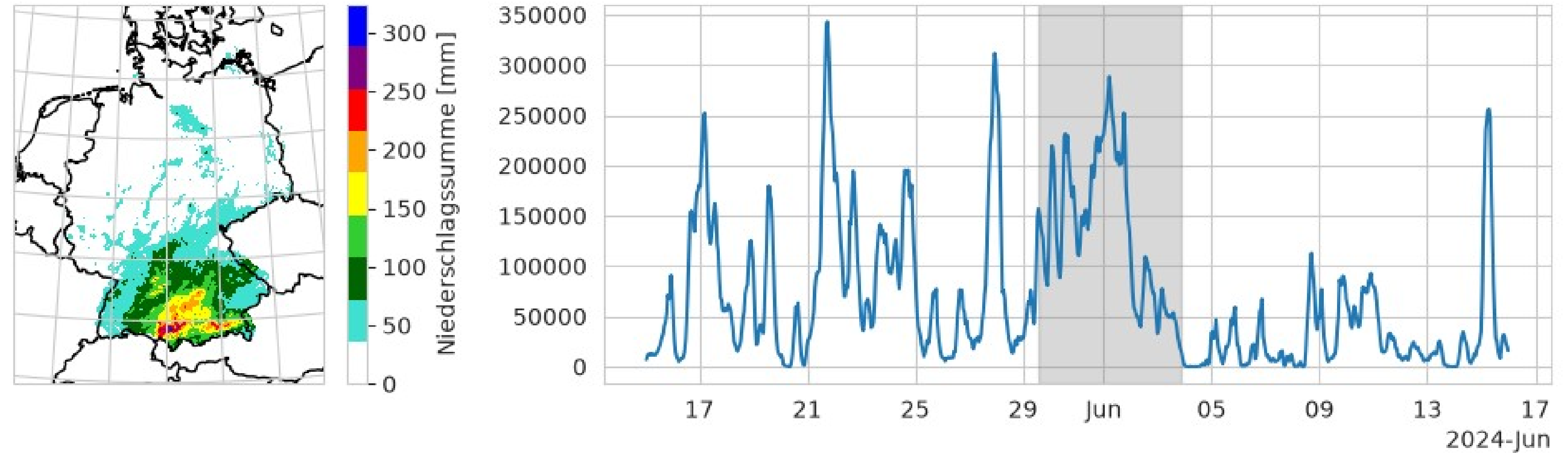


Figure: Precipitation sum during Flooding event in May/June 2024 from RadKlim hourly precipitation data. Left: Precipitation sum between main event (May 29 14:00 UTC; June 03 20:00 UTC),

Compact description of heavy precipitation events:

We introduce a spectral decomposition framework to characterize the spatio-temporal characteristics of precipitation events using wavelet transform.

Focusing on Germany, we analyze the 100 most extreme two-day summer precipitation events using the high-resolution RadKlim dataset provided by the German Weather Service.

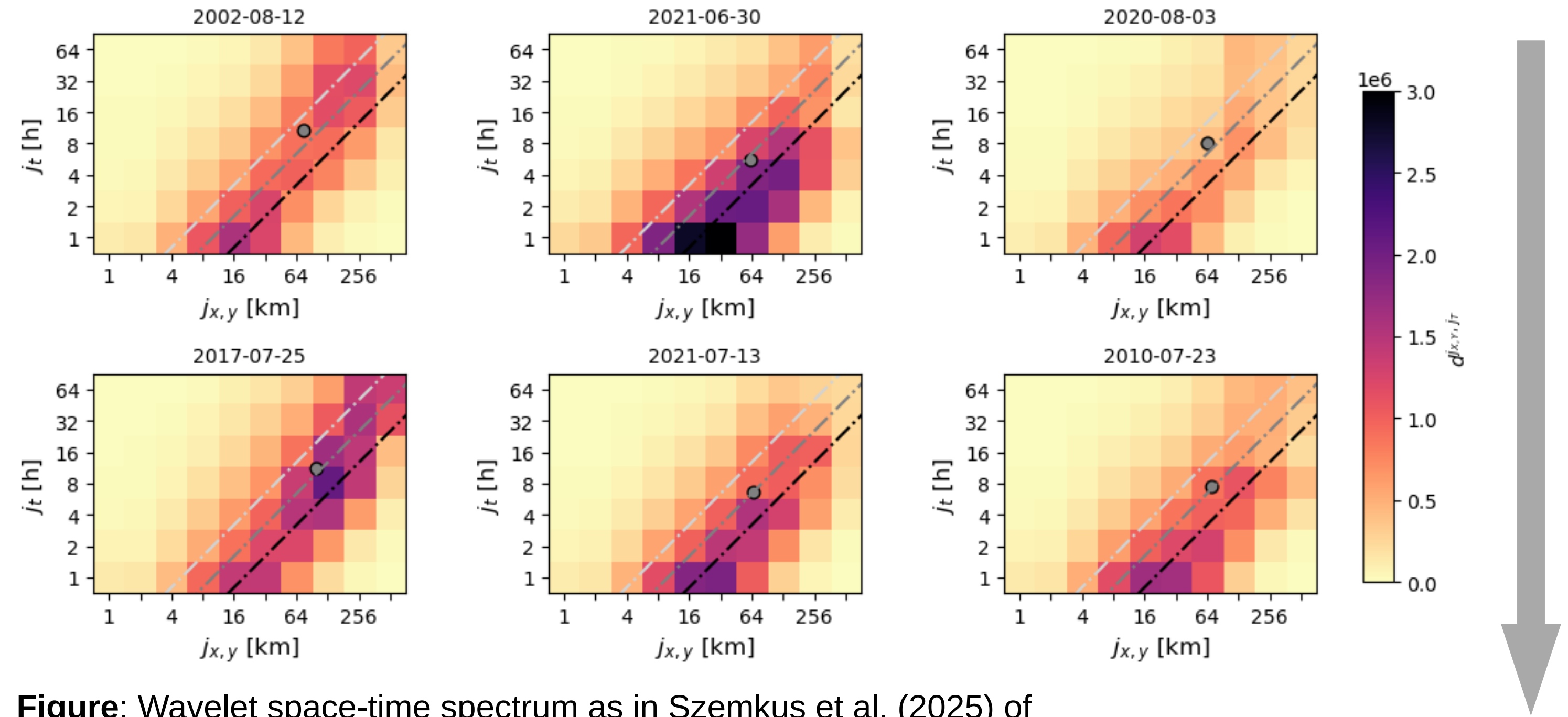


Figure: Wavelet space-time spectrum as in Szemkus et al. (2025) of six precipitation events over Germany.

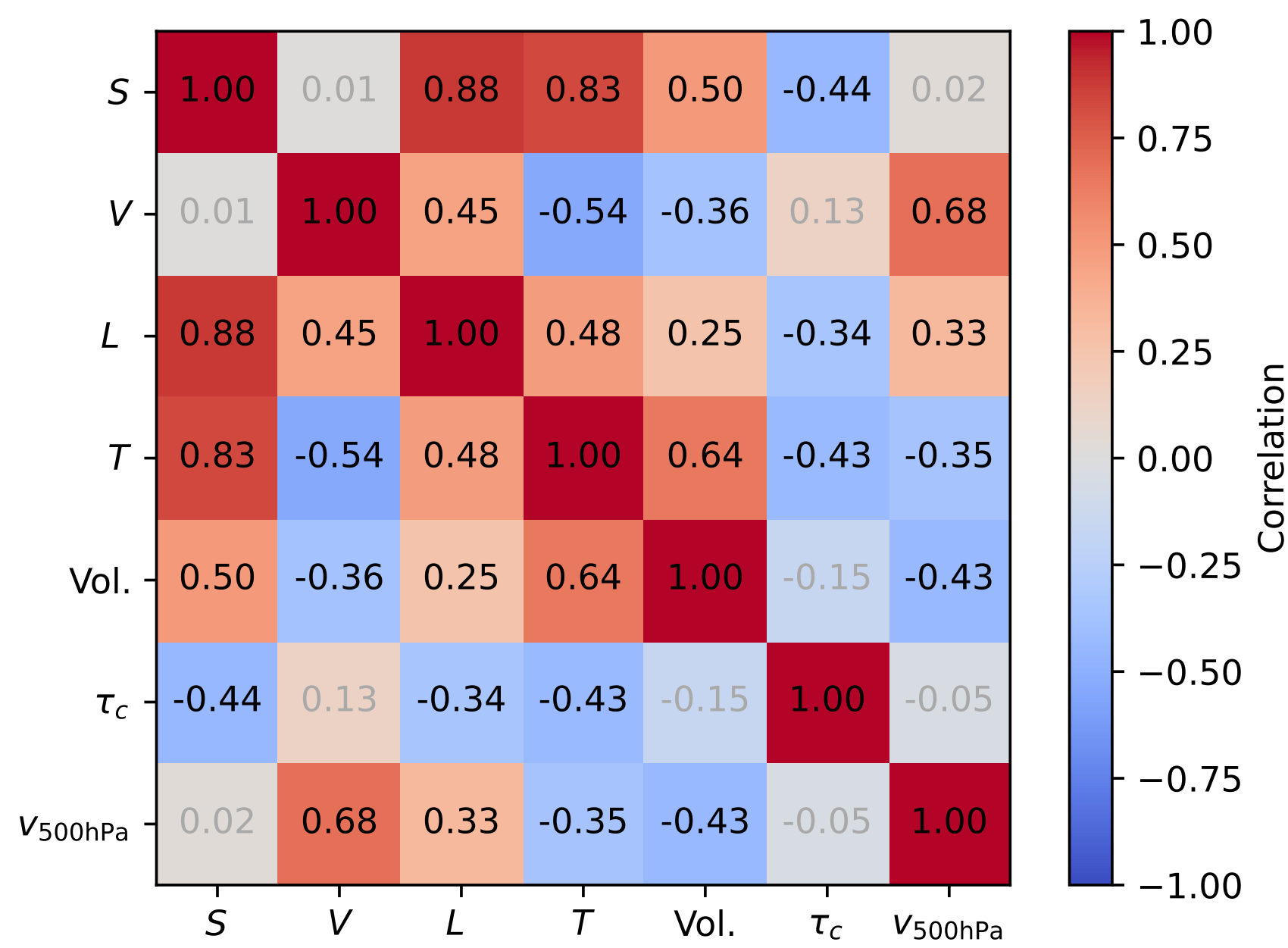


Figure: Correlation of characteristic properties (S, V, L, T) with Total precipitation volume (Vol), convective timescale (τ_c) and mean wind speed in 500 hPa (V_{500hPa})

Characteristic Length		L
Characteristic Time		T
Characteristic Speed		$V = L/T$
Characteristic Scale		$S = \sqrt{\left(\frac{L}{std(L)}\right)^2 + \left(\frac{T}{std(T)}\right)^2}$

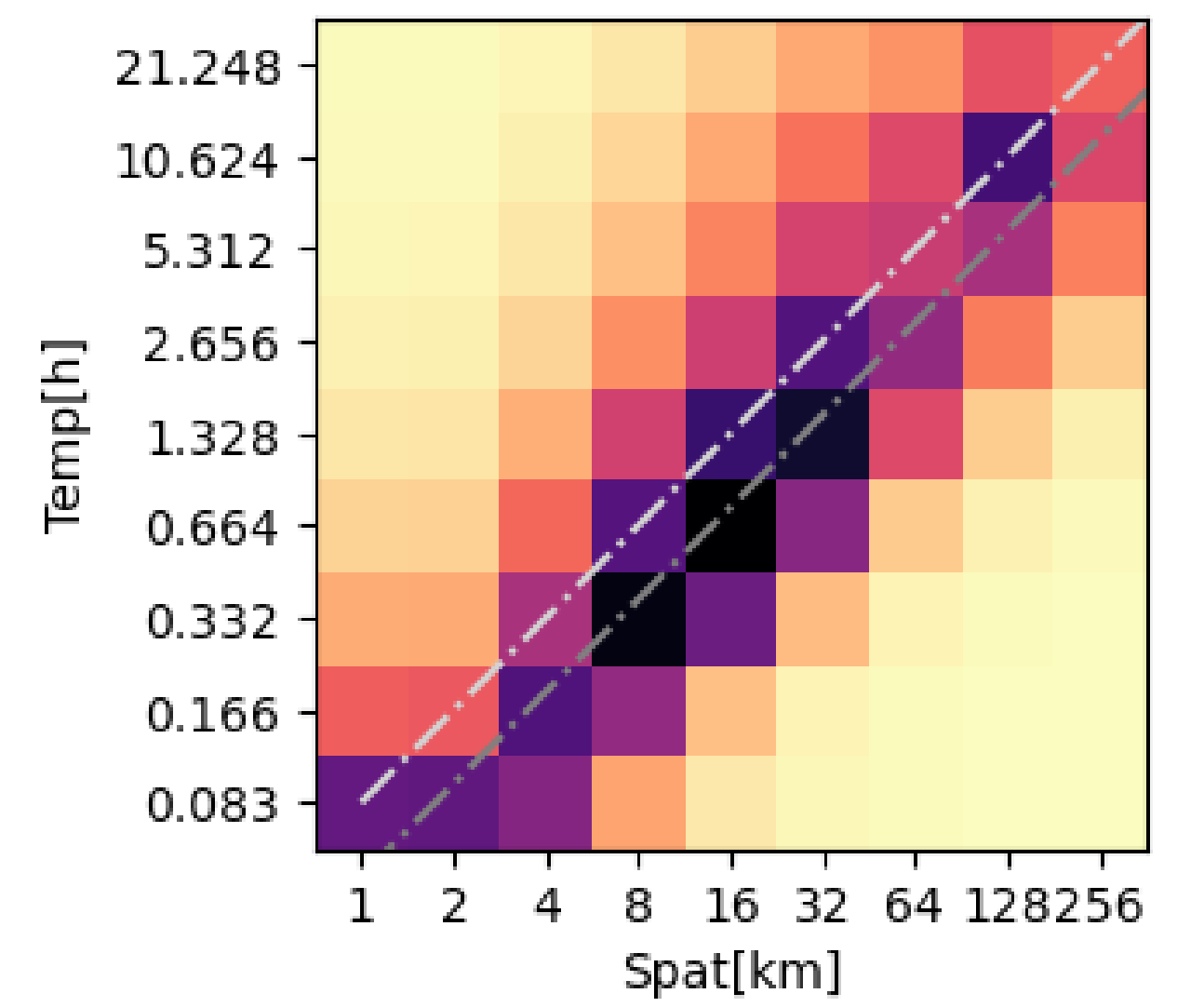


Figure: Wavelet space-time spectrum as in Szemkus et al. (2025) for May/June precipitation event from 5min RADOLAN precipitation data six precipitation events over Germany.

Stochastic simulation of heavy precipitation events:

Synthesis of space-time consistent precipitation fields, which can be calibrated against observation data (e.g. Radolan/RadKlim).

$$\frac{\partial \xi(s, t)}{\partial t} + \mathbf{v} \cdot \nabla \xi(s, t) = \zeta \xi(s, t) + \epsilon(s, t)$$

- $\xi(s, t)$: Gaussian random field (Mat'ern)
- $\zeta = \zeta(s, t) = E(t) \cdot S(s, t) \in [0, 1]$: Combined modulation field
- $\mathbf{v} \cdot \nabla \xi(s, t)$: Advection.

Postprocessing:

- Transformation in Gamma-distribution
- Separate treatment of dry and wet cells

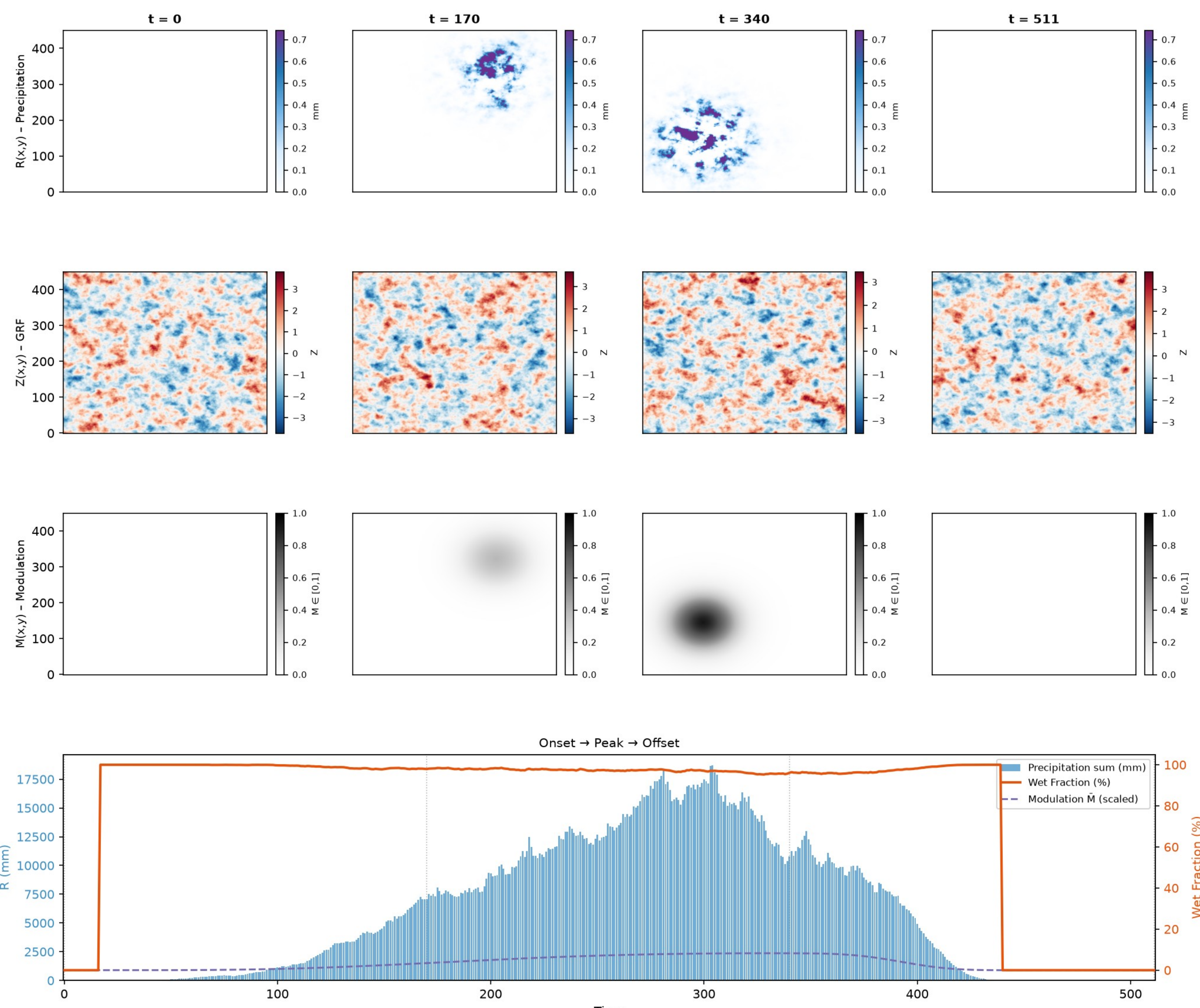


Figure: Simplified schematic of the stochastic precipitation model. From top to bottom: stochastic precipitation field, Gaussian random field (GRF), spatial modulation $S(s, t)$, and temporal modulation $E(t)$.

Gefördert durch:



Szemkus, S., Buschow, S., & Friederichs, P. (2025). Revealing the structure of precipitation extremes: a spatio-temporal wavelet approach. EGU sphere, 2025, 1-22.

Paschalis, A., Molnar, P., Fatichi, S., & Burlando, P. (2013). A stochastic model for high-resolution space-time precipitation simulation. Water Resources Research, 49(12), 8400-8417.

Wilcox, C., Aly, C., Vissel, T., Panthou, G., Blanchet, J., Quantin, G., & Lebel, T. (2021). Stochastorm: A stochastic rainfall simulator for convective storms. Journal of Hydrometeorology, 22(2), 387-404.

