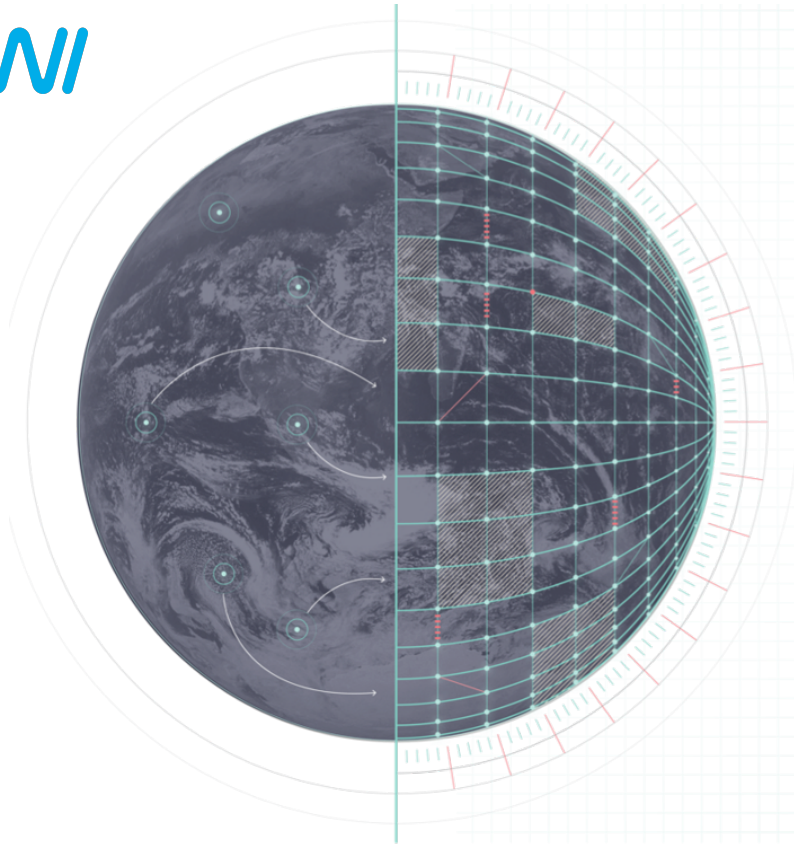




# 4th DestinE User eXchange

Using km-scale  
storylines to  
understand the impact  
of warming on  
extreme events

# What are storyline simulations?



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# Storyline simulations

- 'atmospheric nudging' using ERA5 to constrain certain meteorological fields to recreate observed weather.

By varying background climate weather events are re-created in:

- Counterfactual (cooler around 1950's)
- Actual / historical (2020 climate)
- Future (warmer around +2C)

Using the **IFS-FESOM** model at 9 km with hourly temporal

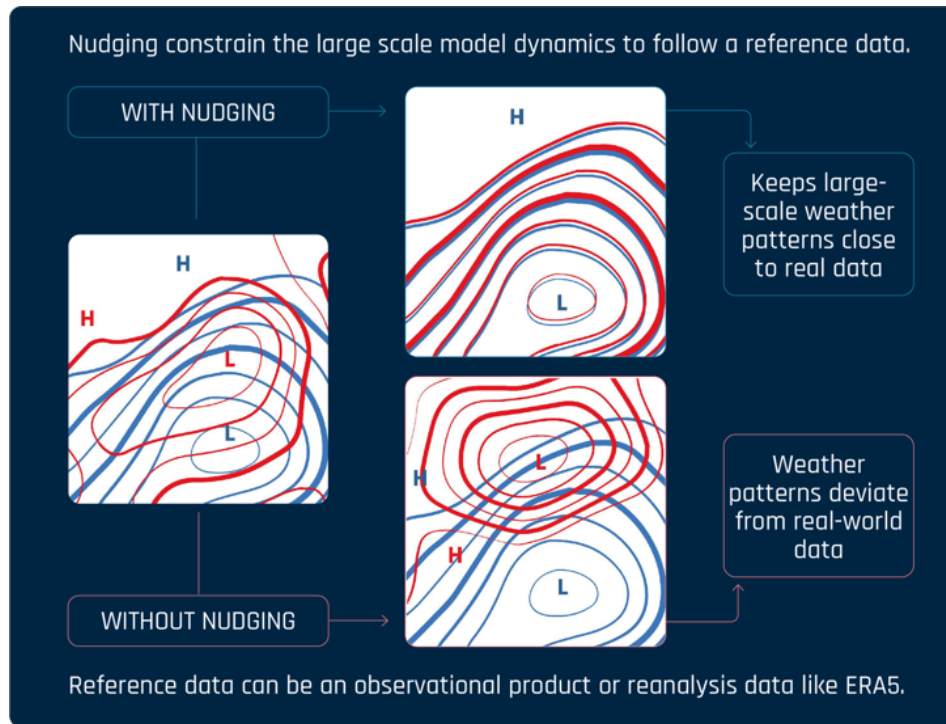


Figure: Graphical representation of how the nudging causes the model to re-create observed weather patterns based on observational or reanalysis reference data (ERA5). Credit: Amal John and Helge Goessling (AWI), (John, A., et. al. (2025))

# Do they work?



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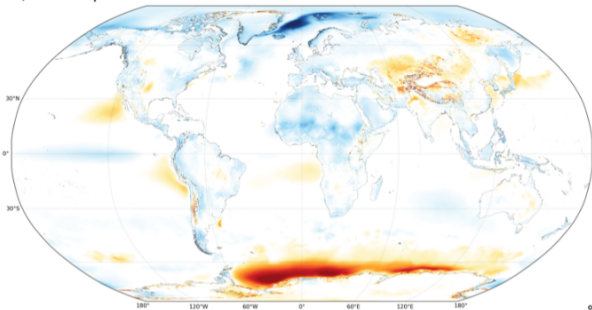
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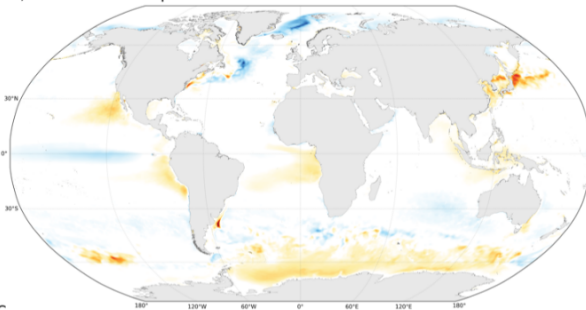
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# Validation - at a global

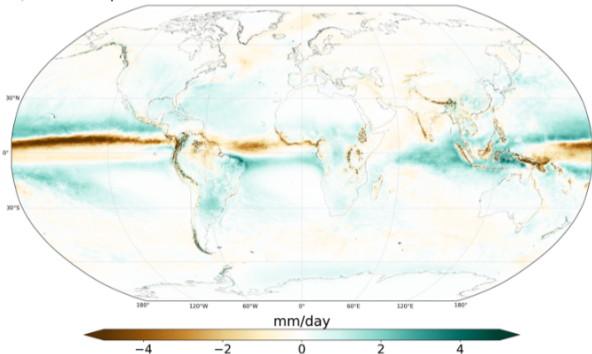
a) 2m-Temperature



b) Sea Surface Temperature



c) Total Precipitation



d) Geopotential at 500 hPa

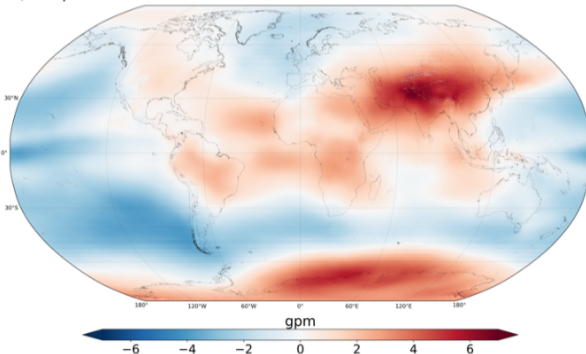


Figure: Mean bias compared to ERA5 over 2018-2024 for:

a) 2 m temperature,

b) sea surface temperature,

c) precipitation and

d) geopotential height at 500 hPa.

Credit: John, A., et. al. (2025)

# Validation - Hurricane

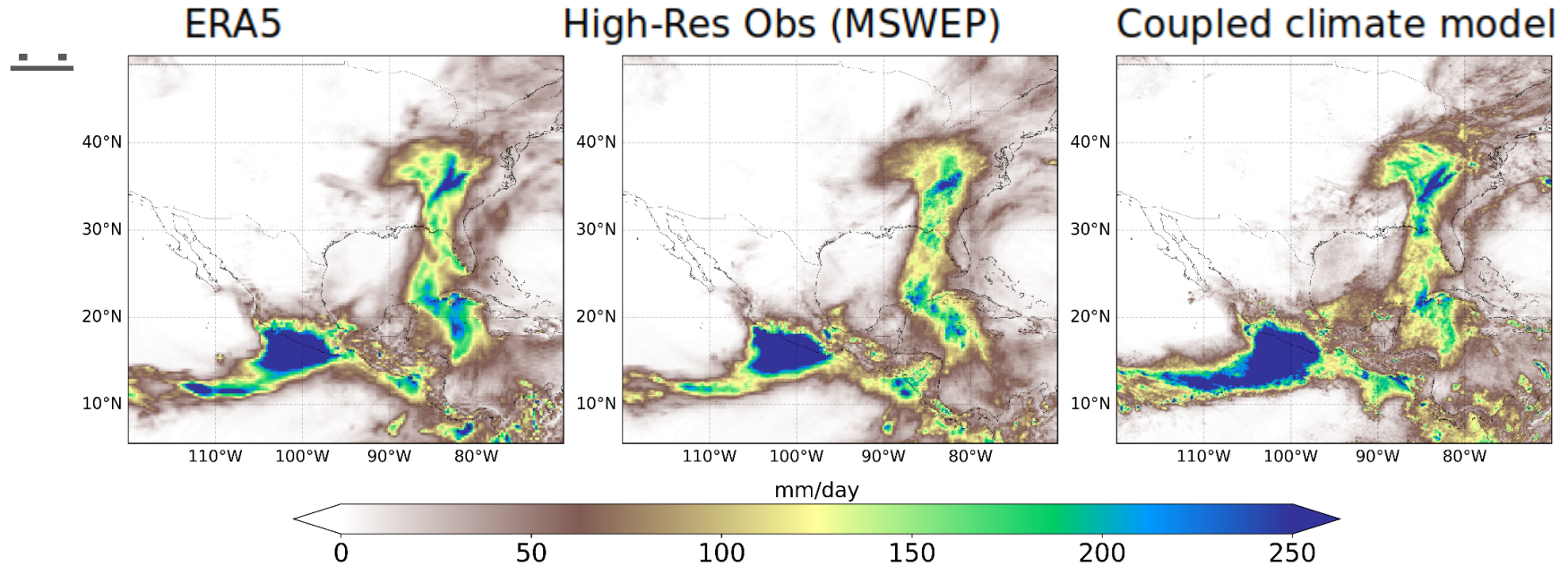


Figure: Accumulated precipitation 24-29/09/24 for Hurricane Helene. Left: ERA5 reanalysis, Middle: MSWEP precipitation observation product Right: actual climate (current day warming levels) simulation with storyline simulations. Credit: Thomas

What can we  
learn?

Valencian floods

29/10/24



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# Valencian floods

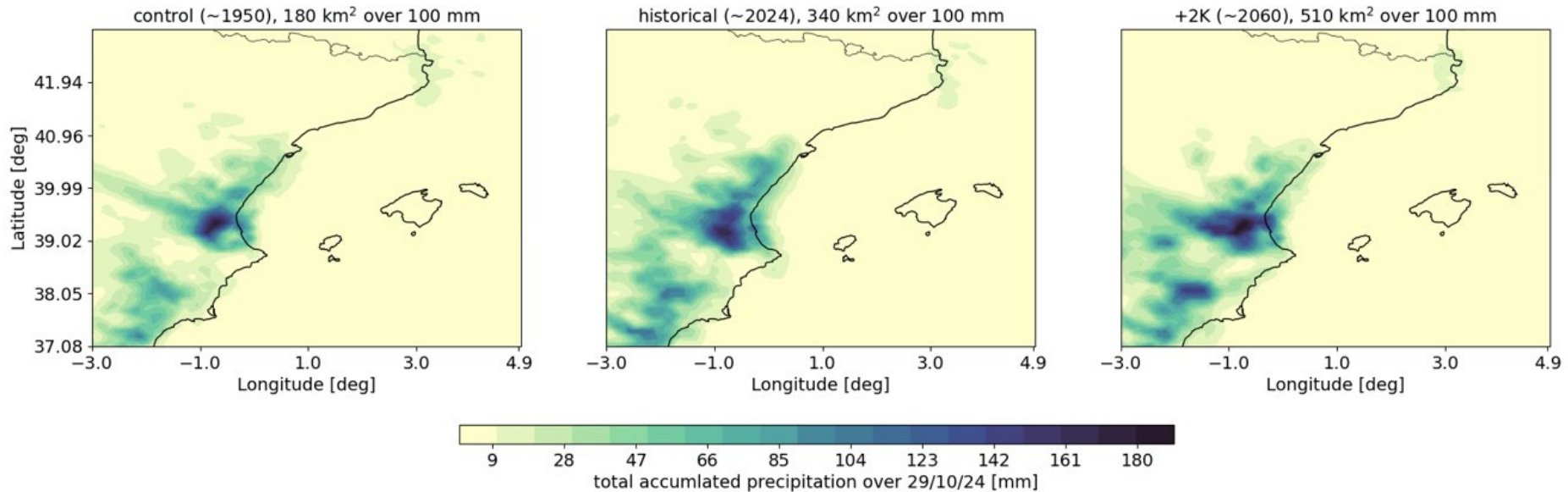


Figure: Accumulated precipitation 29/10/24 around Valencia. Left: Counterfactual 1950s climate (low global warming levels), Actual climate (current day warming levels), Future warming ~ +2K from pre-industrial levels.

# What can we learn?

## Storm Gloria 18- 24/01/20



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# Storm Gloria

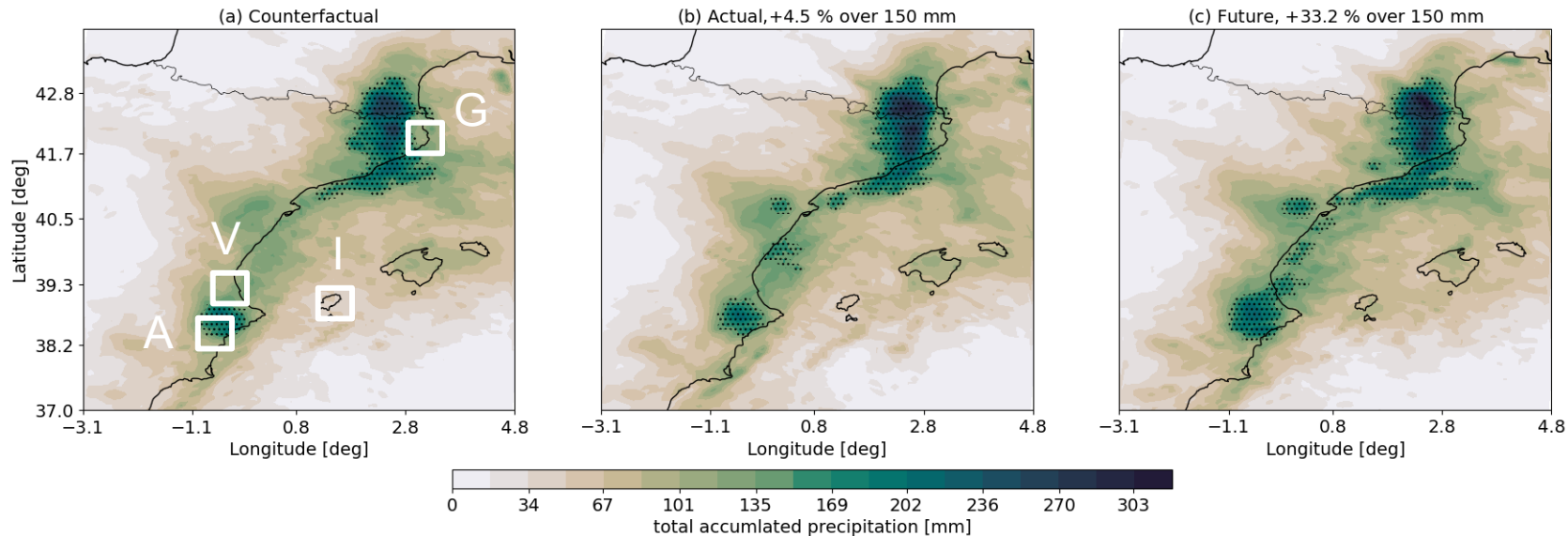
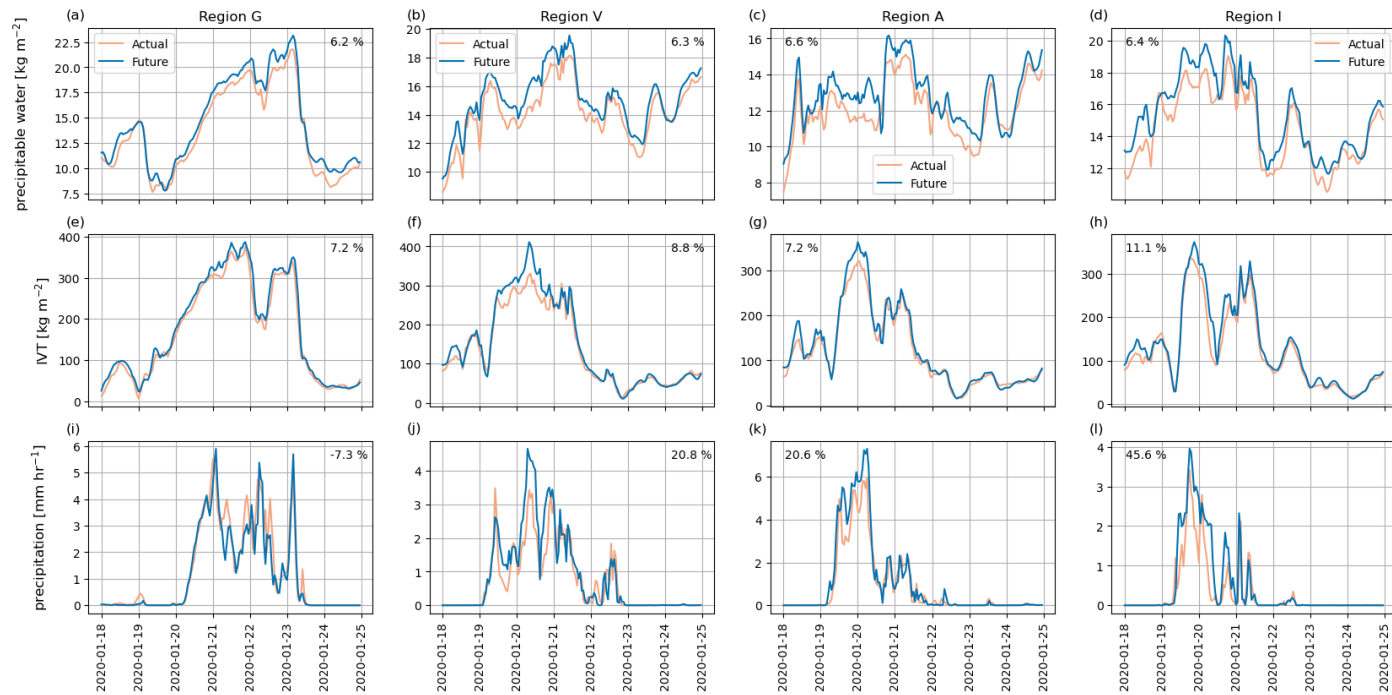


Figure: Accumulated precipitation 18-24/01/20 around Valencia. Left: Counterfactual 1950s climate (low global warming levels), Actual climate (current day warming levels), Future warming  $\sim +2\text{K}$  from pre-industrial levels.

# Storm Gloria



- Atmospheric variables (precipitable water, IVT) increase consistently in line with Clausius-Clapeyron scaling (7% increase per degree warming)
- However **precipitation is highly regionally dependant**, increasing over Ibiza by 45% and decreasing in other regions.

Figure: Time series of precipitable water, integrated vapor transport, precipitation for the Actual scenario (pink) and Future scenario (blue) for the four regions containing Girona (Region G), Valencia (Region V), Alicante (Region A) and Ibiza (Region I).



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# Connection with hydrological model

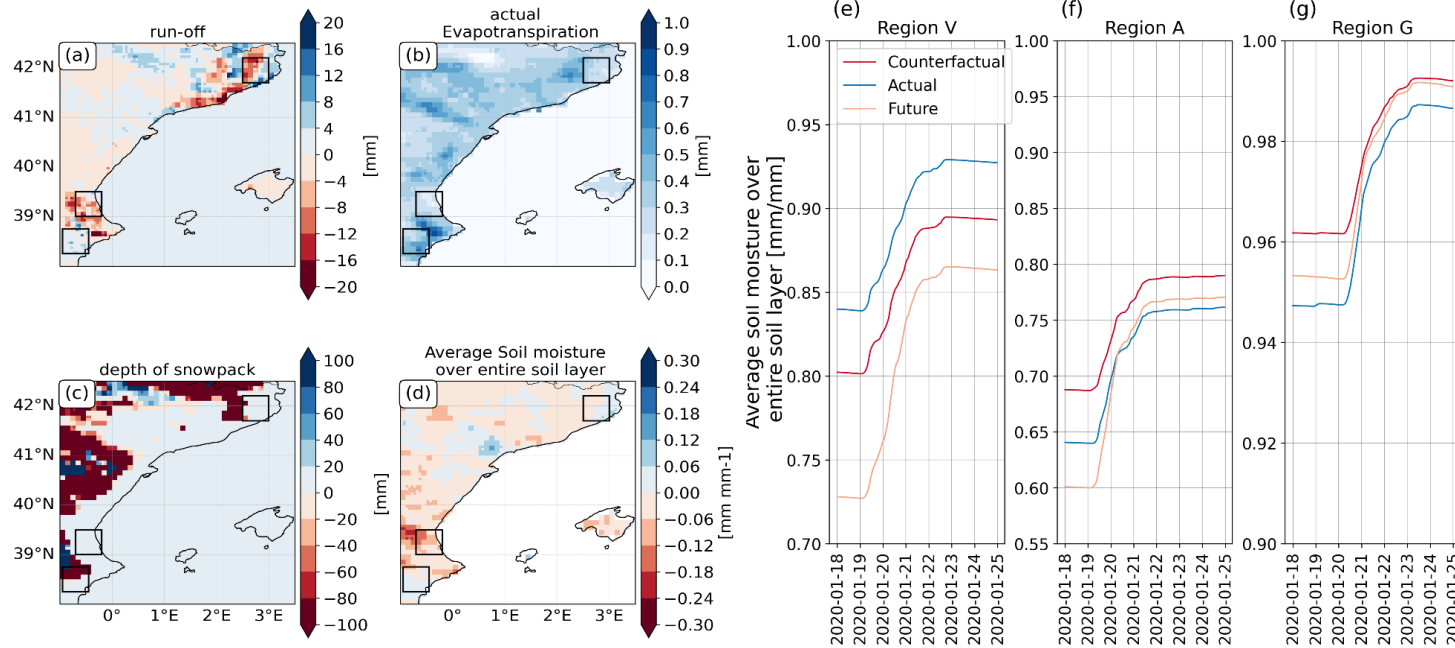


Figure: change in (a) run-off (b) evapotranspiration (c) snowpack (d) average soil moisture between the Future and Actual scenario during storylines. For (e - g) looking at the change in moisture over the difference soil levels for 3 key regions marked by the black squares. Figure credit: Jession Leal, Aparna Chandrasekar, Stephan Thober, (UFZ).

# Thanks!

# Questions?

## References:

John, A., Beyer, S., & Antonio, S., et al. (2025). Global storyline simulations at the km-scale. [pre-print]

[10.22541/essoar.173160166.64258929/v1](https://doi.org/10.22541/essoar.173160166.64258929/v1)



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