

Research opportunities for combining climate models with moisture tracking

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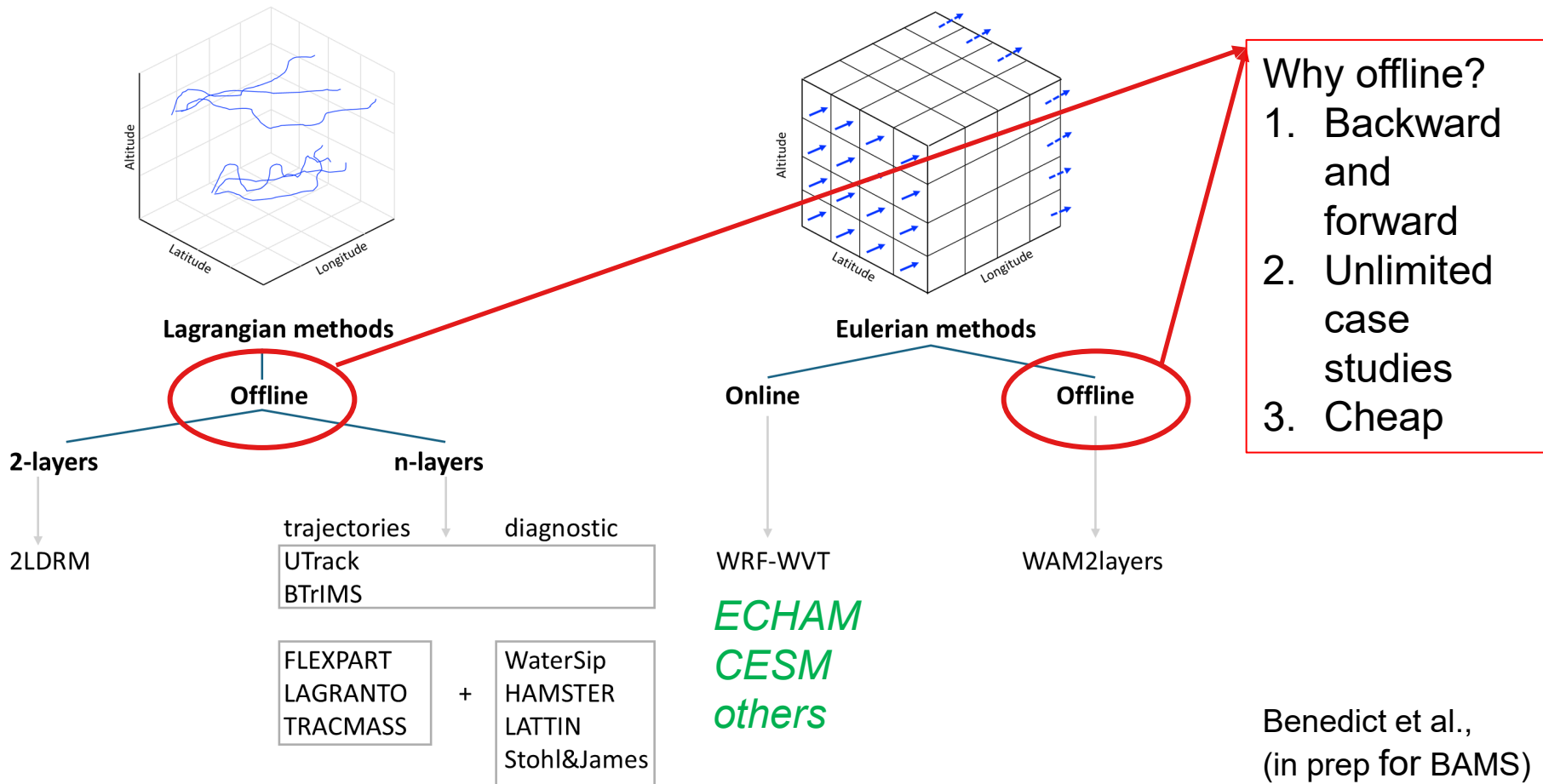
Moisture tracking



Flood event in Belgium, Germany, Luxembourg, Netherlands, summer 2021.
Sources of precipitation on 14 July 2021
Two weeks forward – Two weeks backward
Made with WAM2layers based on ERA5

(Kalverla et al., 2025, GMD)

Moisture tracking intercomparison

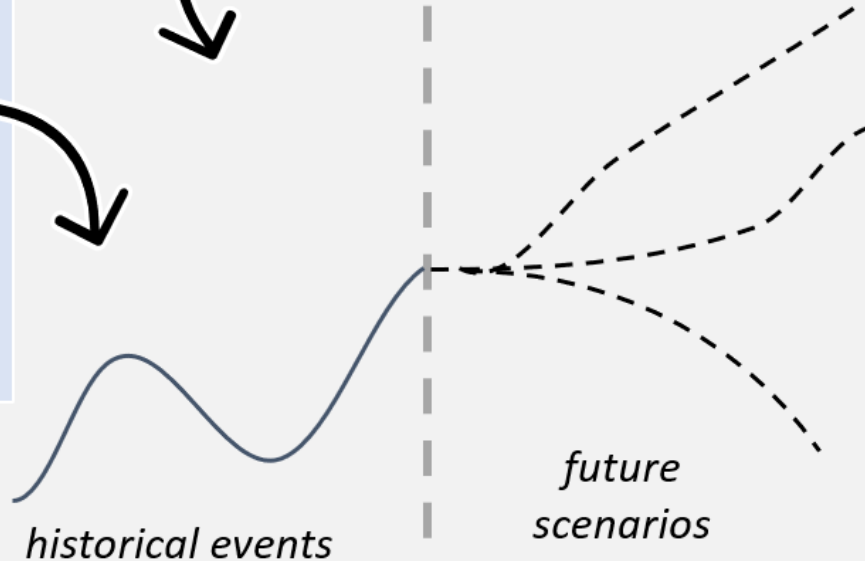




**Research
focus**

*Moisture tracking with climate data
provides a wide perspective including
historical events and future scenarios*

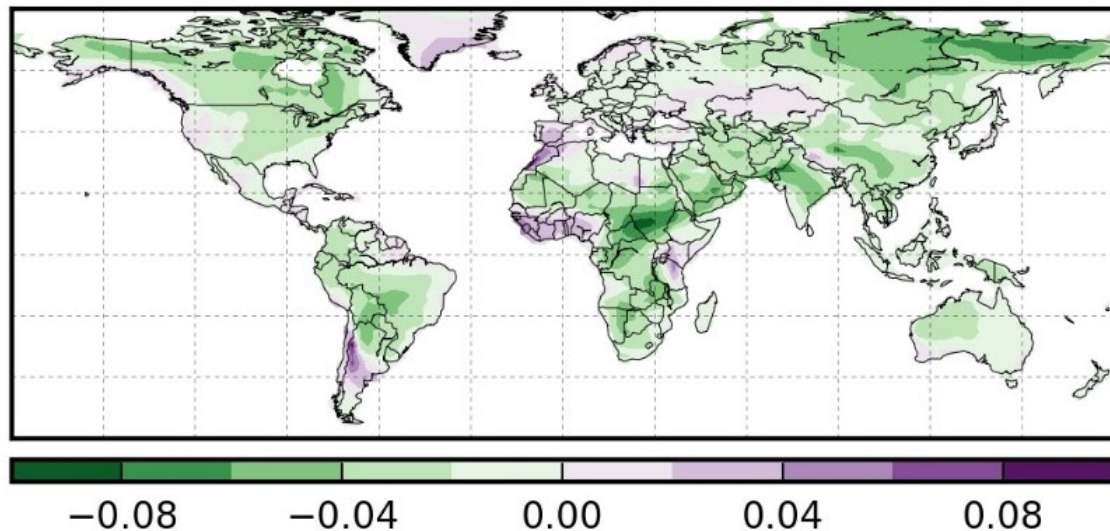
*Traditional
moisture
tracking is
focused on
analyzing
historical
events*



Time progression

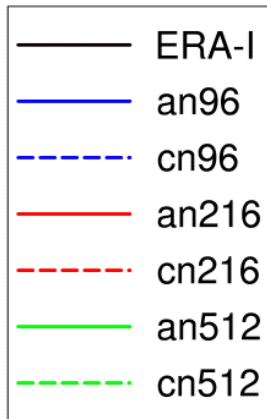
Examples

(d) End21stC - End20thC continental precip recycling ratio ρ_c

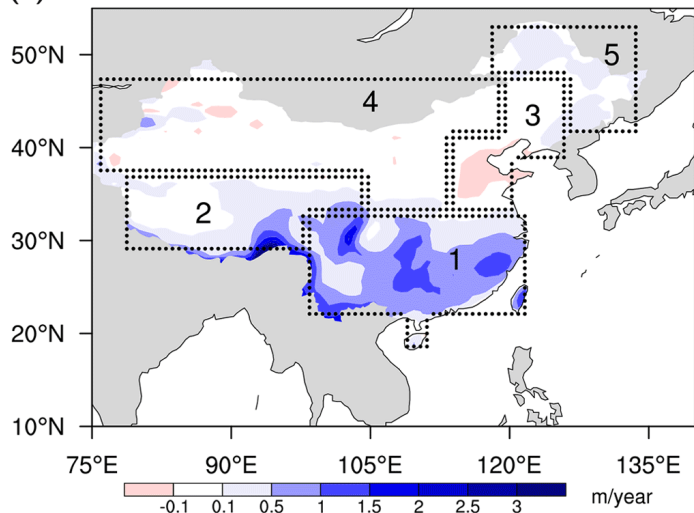


Continental moisture recycling decreases with warming as E_{land} is water-limited

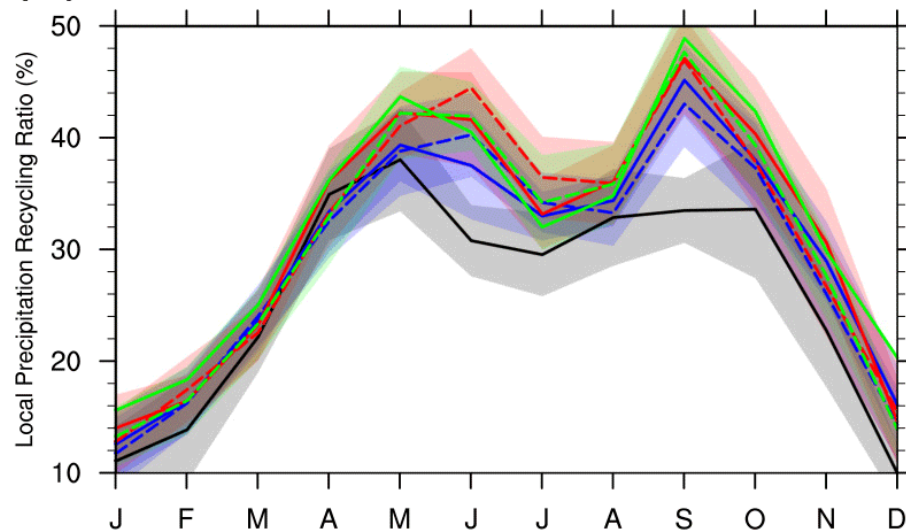
Examples



(a) P - E



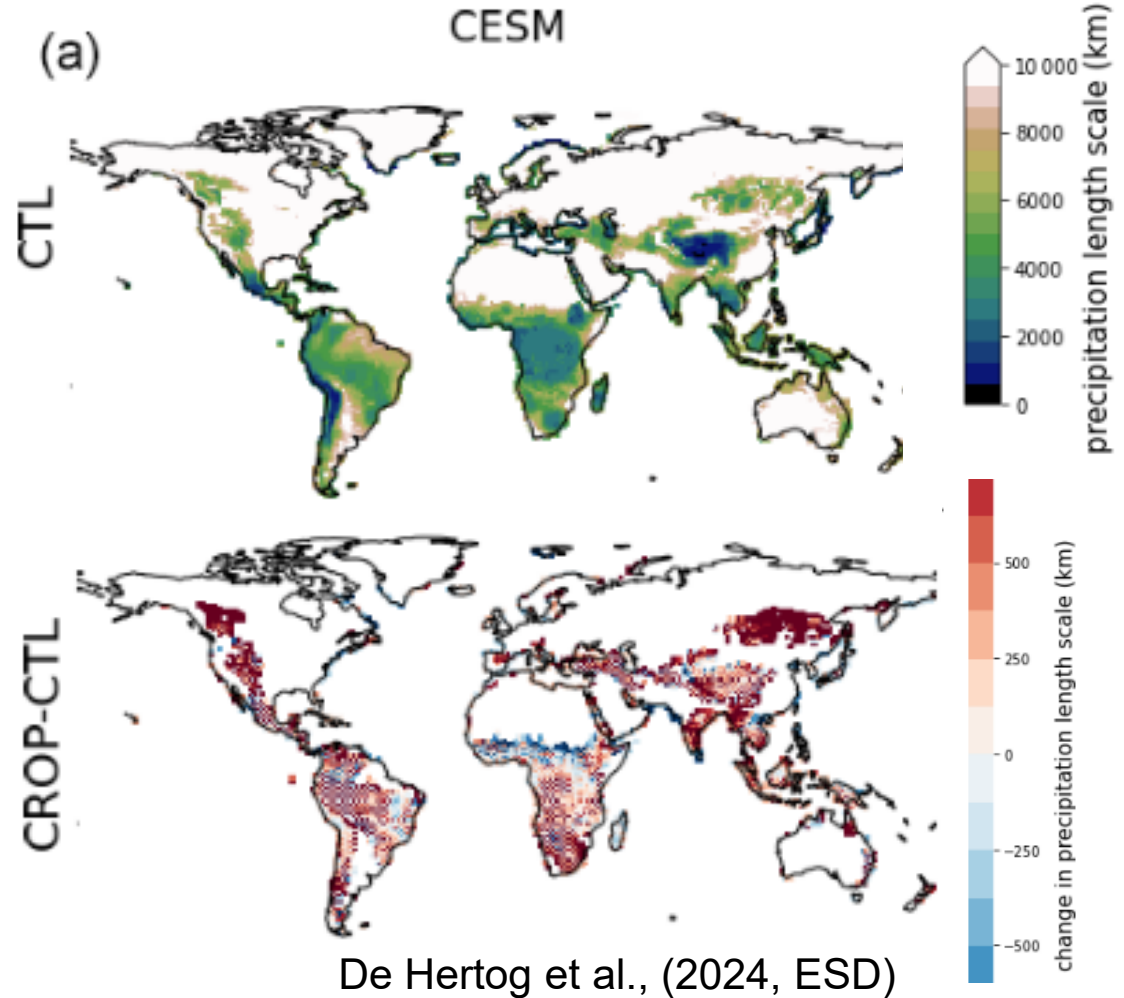
(b) Region 2



Different resolution/coupling settings reflected in moisture recycling ratios

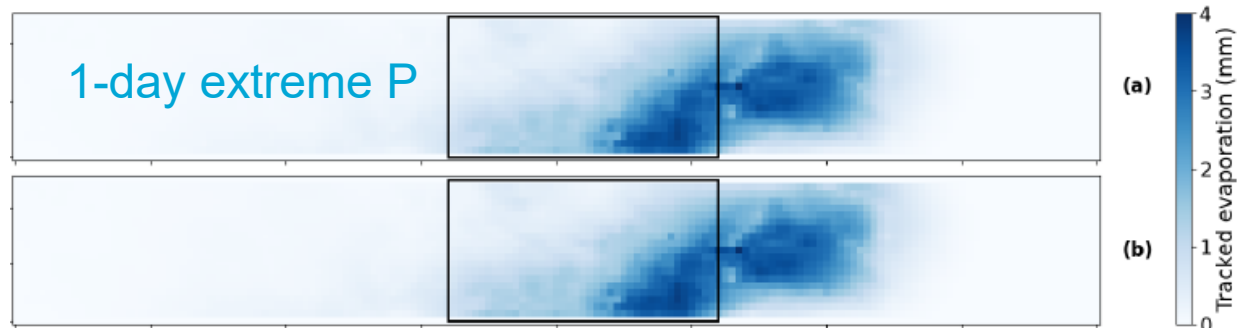
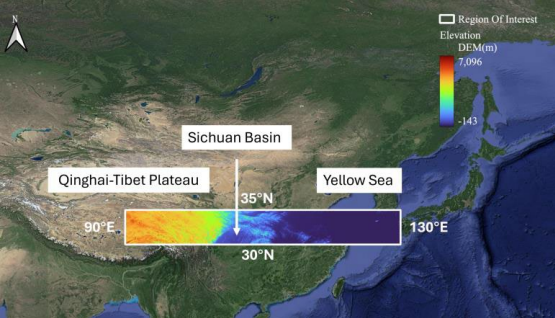
Examples

Cropland expansion generally leads to longer atmospheric transport distances



The data problem

- Examples from previous slides are:
 - ‘Private’ runs, Single models, Daily data
 - Sometimes just 5 pressure levels
- What data is typically used in moisture tracking?
 - u , v , w – wind, humidity,
 - Surface pressure, evaporation, precipitation
 - Subdaily time resolution
 - >20 levels in the atmosphere
- CMIP6: ~5 models meet requirements



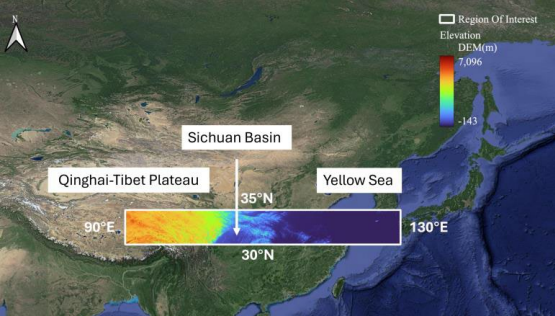
ERA5 controlled experiment

	Boundary Transport North	Boundary Transport South	Boundary Transport East	Boundary Transport West	Internal loss	Result Region	Result West	Result East
plev4	18.55%	75.00%	0.0001%	2.72%	3.72%	49.23%	33.00%	17.77%
plev7	15.32%	84.27%	0.0001%	0.40%	-	49.70%	10.97%	39.33%
plev8	13.84%	85.52%	0.0001%	0.64%	-	56.30%	16.17%	27.53%
plev14	15.33%	84.21%	0.0001%	0.46%	-	49.44%	11.41%	39.15%
plev20 without TCW	14.88%	85.07%	0.0002%	0.06%	-	46.11%	6.36%	47.53%
plev20 with TCW	14.85%	85.10%	0.0002%	0.05%	-	47.87%	6.36%	45.77%
Plev20 – 1d with TCW	17.35%	82.59%	0.0000%	0.06%	-	57.05%	8.06%	34.89%

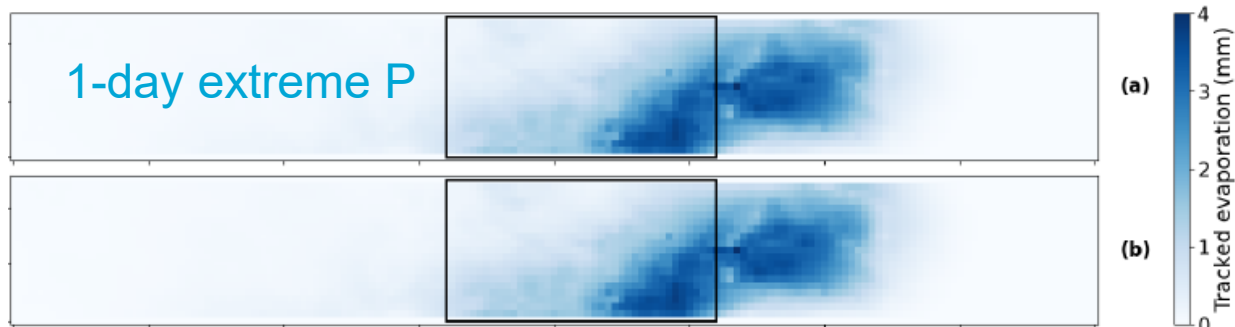
Strongest errors

benchmark

Yang (2024, MSc TUD)



1-day extreme P



etcetera

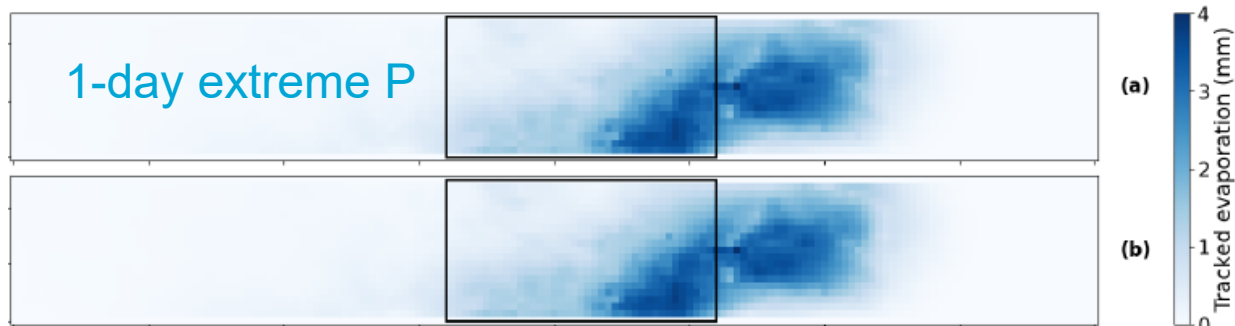
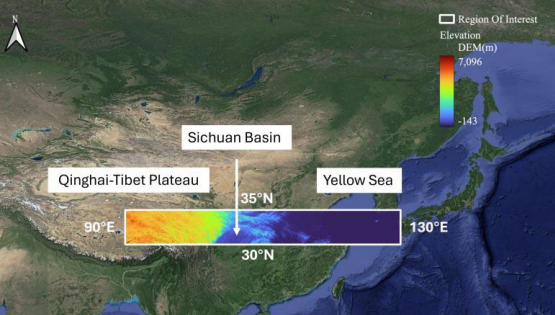
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More surface info >> more layers

Benchmark

Yang (2024, MSc TUD)



etcetera

ERA5 controlled experiment

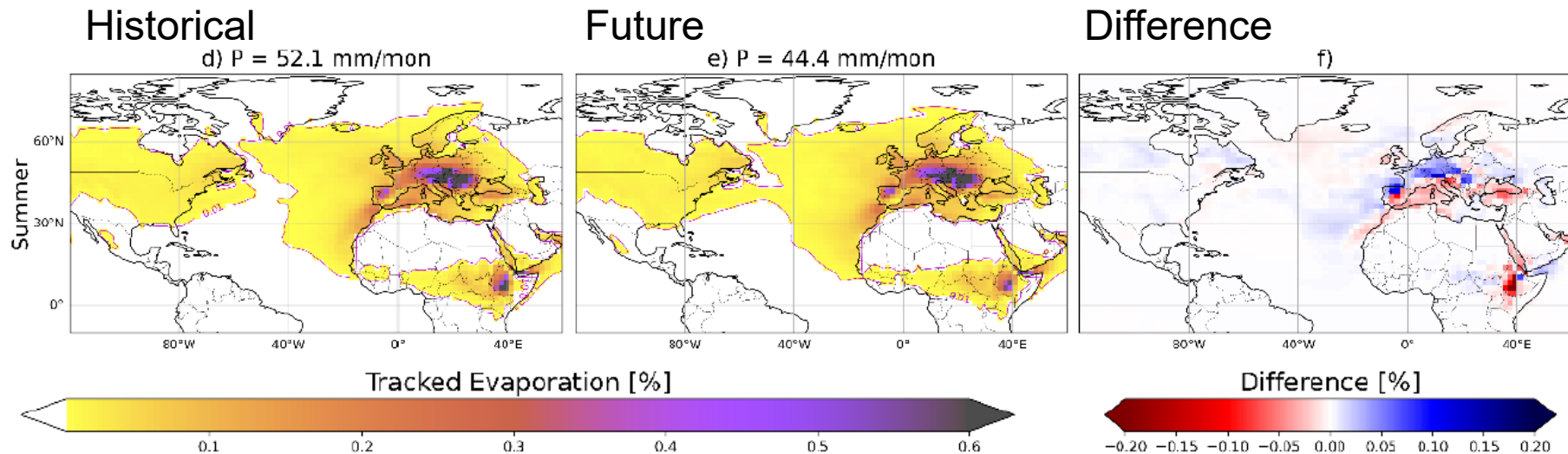
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Benchmark

Performance loss 1-day resolution vs. 1-hour minor

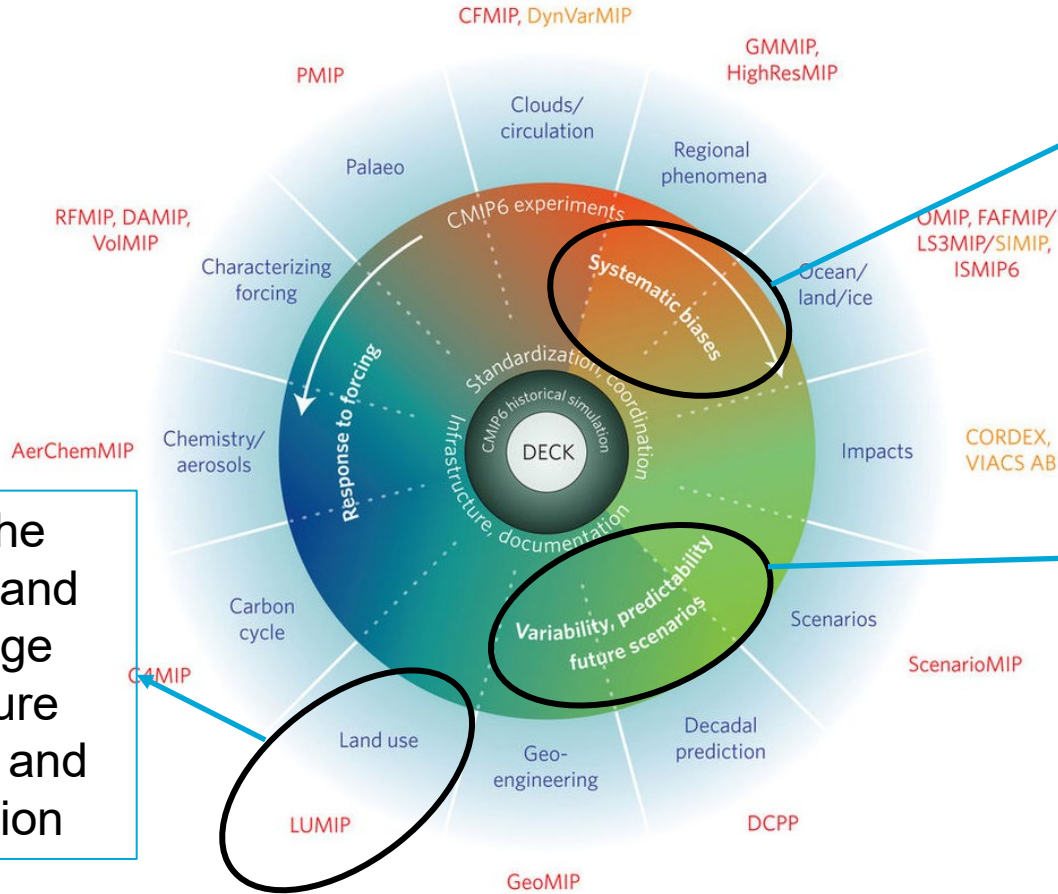
Yang (2024, MSc TUD)

Danube case study CMIP6 (MPI-ESM)



- *Less summer precipitation in the future*
- *Less moisture from Mediterranean*
- *More moisture from the ocean and Northwestern Europe*

What is the effect of land use change for moisture recycling and precipitation



Related to wrong moisture sources?

Explain processes behind precipitation projections