Identifying sources of changed precipitation in paleoclimate studies through moisture tracking

A case study for orbital extremes over the Mediterranean Sea

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Moisture tracking

What are the sources of precipitation?

What is the fate of evaporation?

Questions can be answered with ‘offline’ moisture tracking models, e.g. WAM-2layers (Van der Ent et al., 2014)

Required input is daily or sub-daily gridded fields of:

- Precipitation
- Evaporation
- Wind speed (at several pressure or model levels)
- Humidity (at several pressure or model levels)

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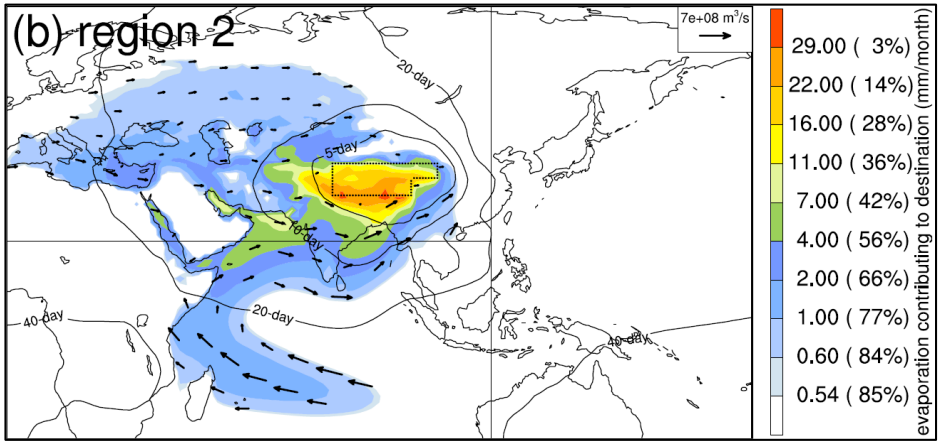
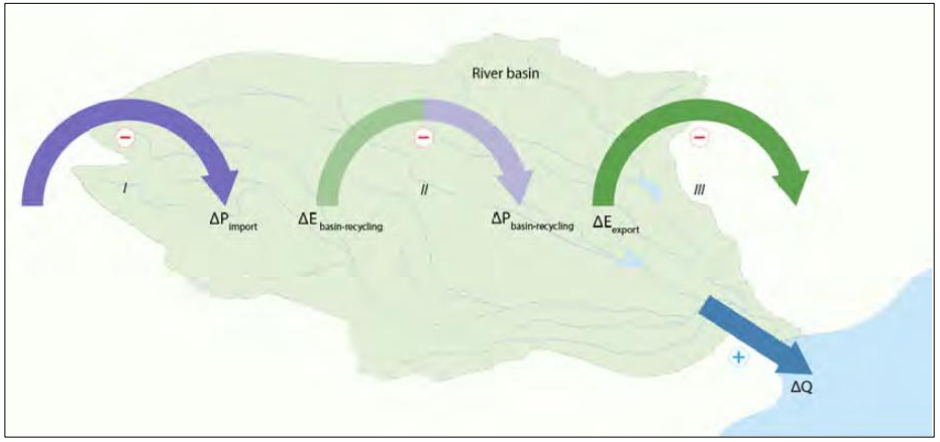
Applications of moisture tracking

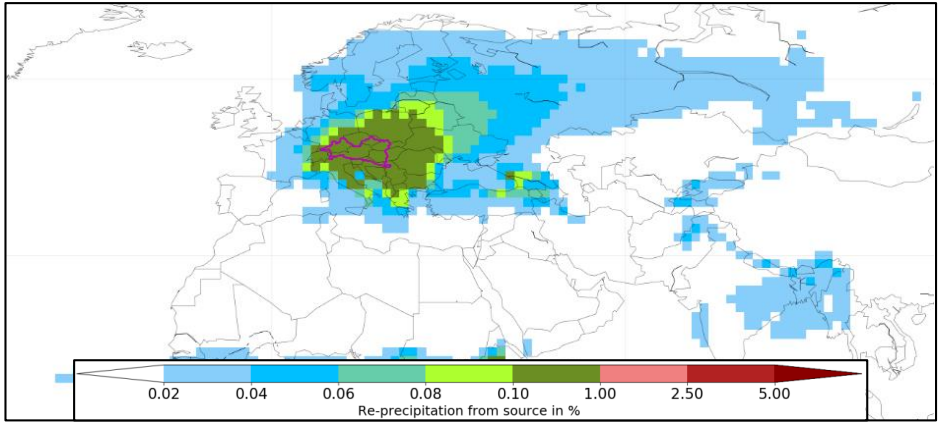
Sources of precipitation (Guo et al., 2019)



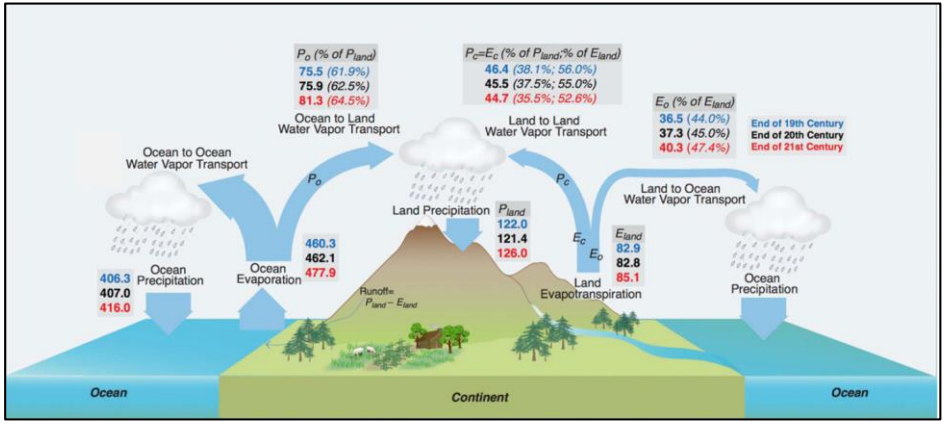
Land-use change impacts (Wang-Erlandsson et al., 2018)



Fate of land evaporation from specific river basins (Link et al., 2020)



Future water cycle changes (Findell et al., 2019)



First application in a paleoclimate study: Orbital extremes over the Mediterranean Sea

Paleoceanography and Paleoclimatology

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Key Points:

- Moisture sources for precession-induced enhanced winter precipitation are local in fall and from the Atlantic in late winter
- For obliquity, precipitation changes are smaller; local and Atlantic sources play an equal role
- The Atlantic sources are not related to storm tracks but to low-latitude surface pressure changes

Precession- and Obliquity-Induced Changes in Moisture Sources for Enhanced Precipitation Over the Mediterranean Sea

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Precession-induced enhanced precipitation over the Mediterranean

What is the source of freshwater input, thought to cause sapropels?

Winter precipitation could play an important role (Bosmans et al., 2015).

Is **enhanced winter precipitation** related to **local processes** or **Atlantic storm tracks**?

Sapropels in Sicily from the Miocene Tuenter (2004)

Methods

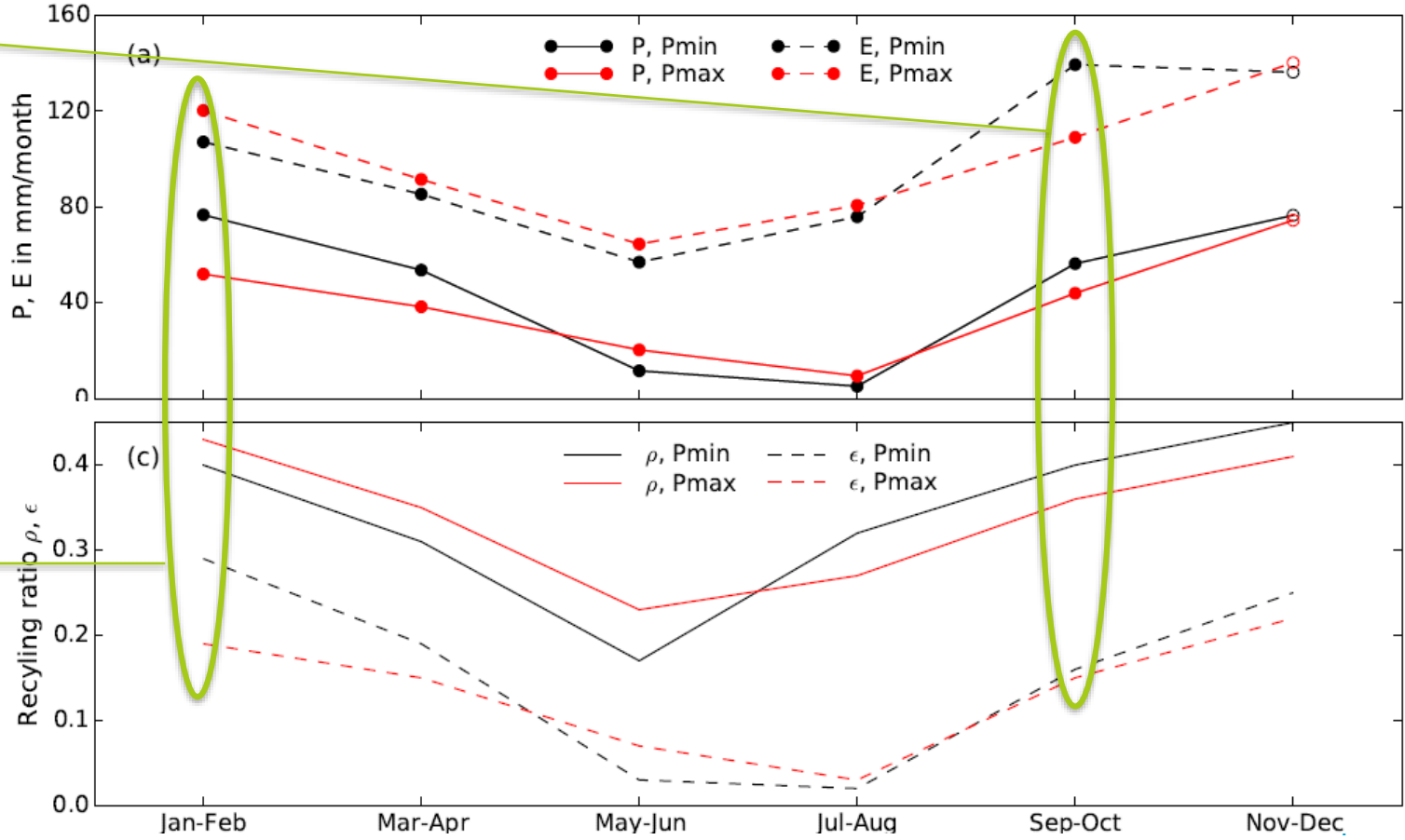
Orbitally extreme experiments performed with the state-of-the-art climate model EC-Earth.

Moisture tracking with WAM-2layers to compute:

- **ρ** = precipitation recycling ratio (fraction of precipitation over Mediterranean originating from Mediteranean evaporation)
- **ε** = evaporation recycling ratio (fraction of Mediterranean evaporation ending up as Mediteranean precipitation)

Results for precession

Precipitation differences between precession minimum (Pmin) and precession maximum (Pmax) related to changes in the importance of local vs. remote moisture sources



Precession September+October

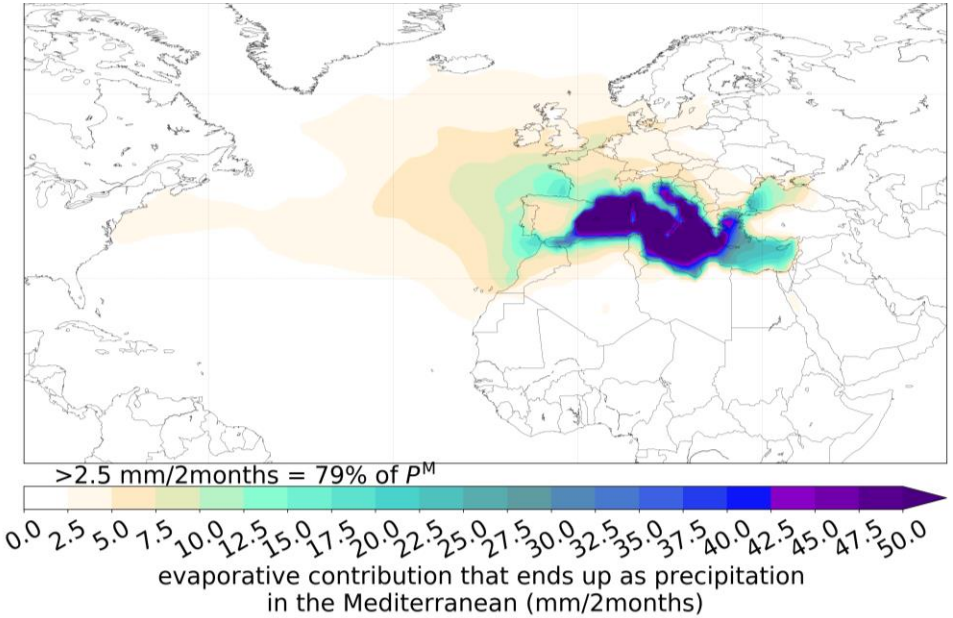
20% more precipitation during precession minimum.

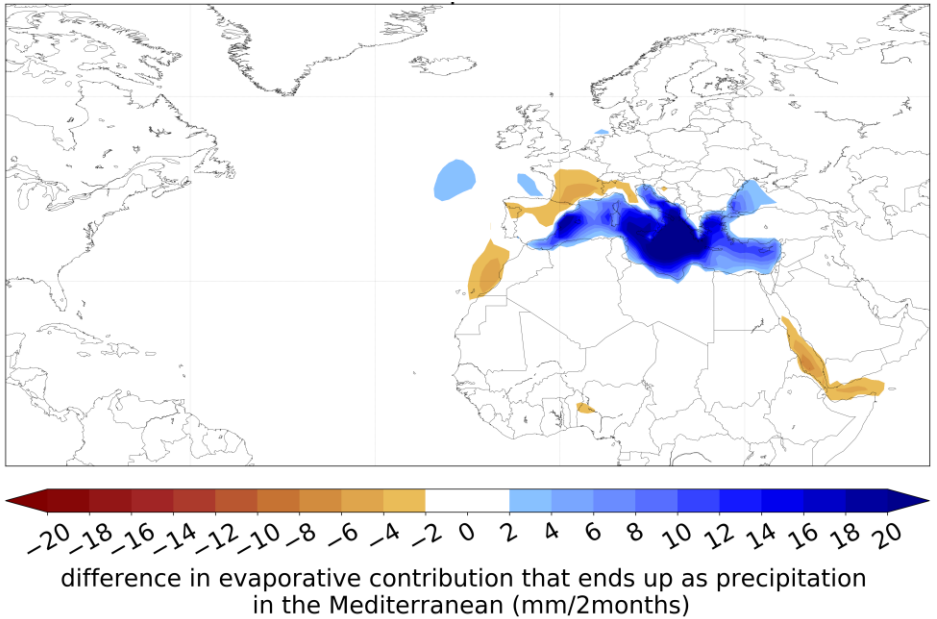
Moisture sources during Pmin:

Differences between Pmin and Pmax

Blue = stronger sources during Pmin

Red = weaker sources during Pmin

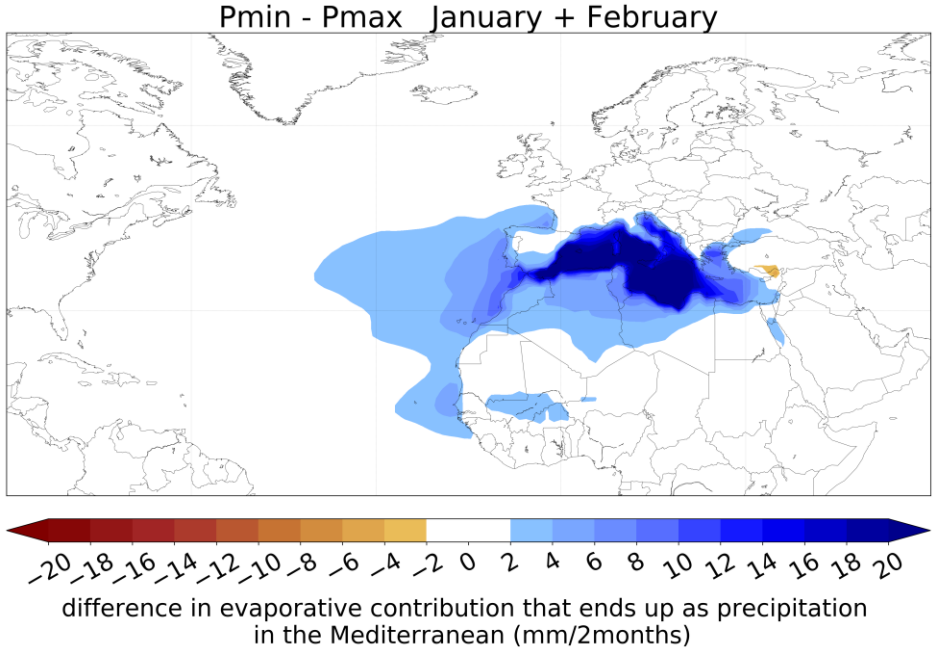




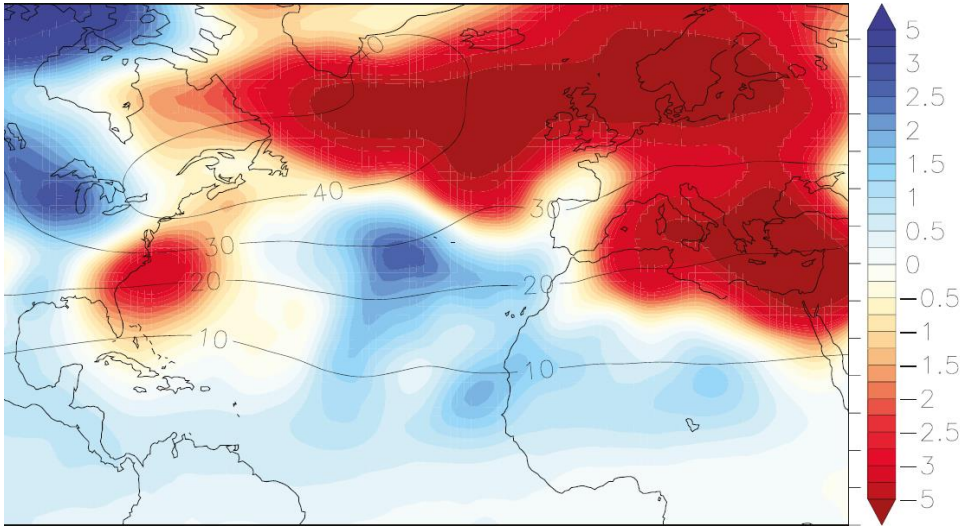
Precession January + February

50% more precipitation during Pmin.

Stronger sources locally and from the Atlantic:



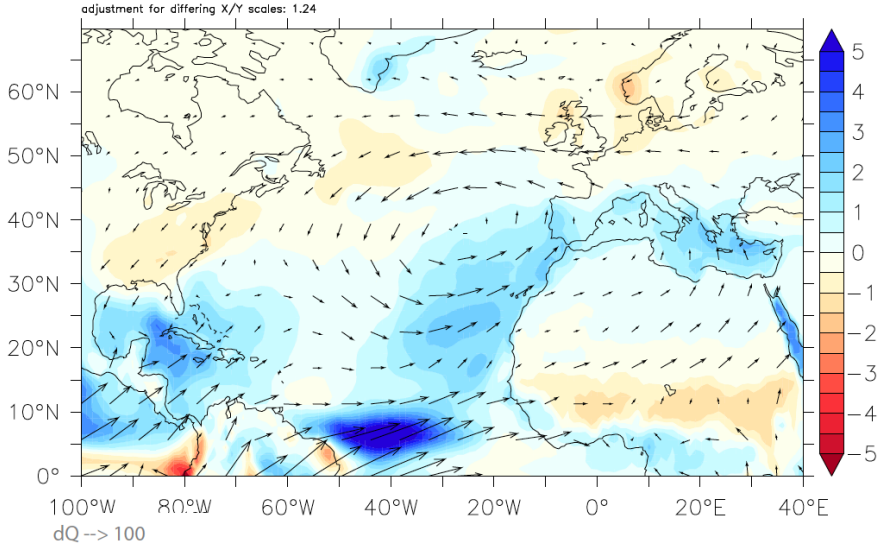
Red = less storm track activity during Pmin



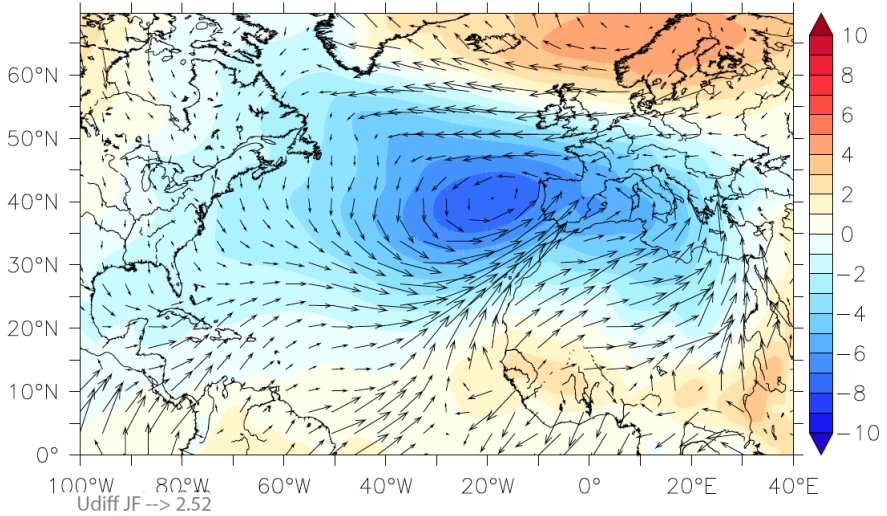
Standard deviation of 500 hPa geopotential height (m)

Enhanced precipitation NOT driven by storm track activity over North-Atlantic

Precession January + February



Pmin-Pmax changes in moisture transport (arrows) and net precipitation (P-E, colours)



Pmin-Pmax changes wind (arrows) and pressure (colours)

Enhanced moisture transport from sub-tropical Atlantic related to weaker Azores High

Conclusions

Enhanced precipitation during precession minimum due to different mechanisms.

Stronger **local moisture recycling** in September and October.

Increased sub-tropical **Atlantic moisture transport** due to weaker **Azores High** during January and February.

More information and contact

Bosmans, J. H. C., van der Ent, R. J., Haarsma, R. J., Drijfhout, S. S. and Hilgen, F. J.: Precession- and Obliquity-Induced Changes in Moisture Sources for Enhanced Precipitation Over the Mediterranean Sea, Paleoceanogr. Paleoclimatology, 35(1), 1–14, doi:10.1029/2019PA003655, 2020.

Information on orbital extremes in the Mediterranean:
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Collaborations on moisture tracking for other paleoclimate studies:
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