Tracking moisture with atmospheric data on 5 pressure levels to determine the moisture sources of the Mississippi basin in present and future climate

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Objective

So far, moisture tracking is applied on data which is available at multiple model levels. In this study, we apply moisture tracking on atmospheric data on five pressure levels to determine the present and future moisture sources of the Mississippi basin.

- Can we apply moisture tracking to atmospheric data at five pressure levels?
- Are the moisture sources of the Mississippi basin different in a future climate and why? (Outlook)

Method - data

5 pressure levels + surface pressure (sp) — 18 model levels

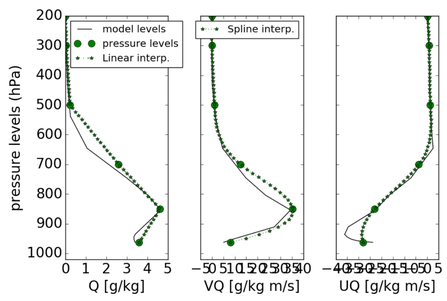
200,300,400,700,850 hPa + sp

ERA-Interim (2002-2006) ↔ Validation of method ↔ ERA-Interim (2002-2006)

Apply to GCM ↕

AGCM EC-Earth (~25 km)

- Present (6 members; 2002-2006)
- Future (6 members; 2094-2098)



Method - tracking model

Eulerian tracking model WAM2-Layers (van der Ent, 2014)

Tracking moisture (m) back in time from its sink (precipitation over the Mississippi basin; P) to its source (evaporation; E_m)

$$\frac{\partial S_m}{\partial t} + \frac{\partial S_m u}{\partial x} + \frac{\partial S_m v}{\partial y} = \delta P - E_m, \text{ where } S_m = \frac{1}{\rho_w g}\int_{p_s}^{200\,hPa} q\, dp$$

Can we apply moisture tracking to atmospheric data at five pressure levels?

- Variance within vertical profiles from model levels of u*q and v*q is much larger than the RMSE of the model levels vs pressure levels profiles (Fig.2)

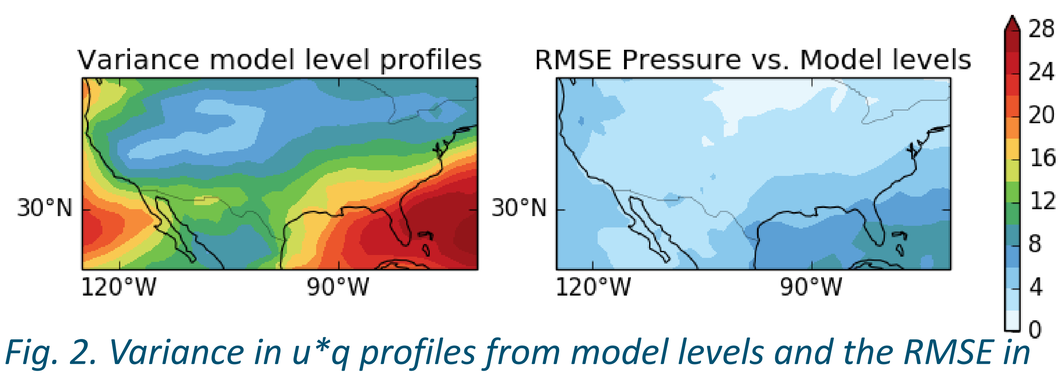


*Fig. 2. Variance in u*q profiles from model levels and the RMSE in u*q between pressure and model levels*

- Overall patterns of tracked evaporation (E_m) are similar for model levels and pressure levels.
- Consistent bias found in moisture sources from pressure levels: too less moisture from Gulf of Mexico and too much moisture from Gulf of California and Rocky Mountains (Fig 2c)

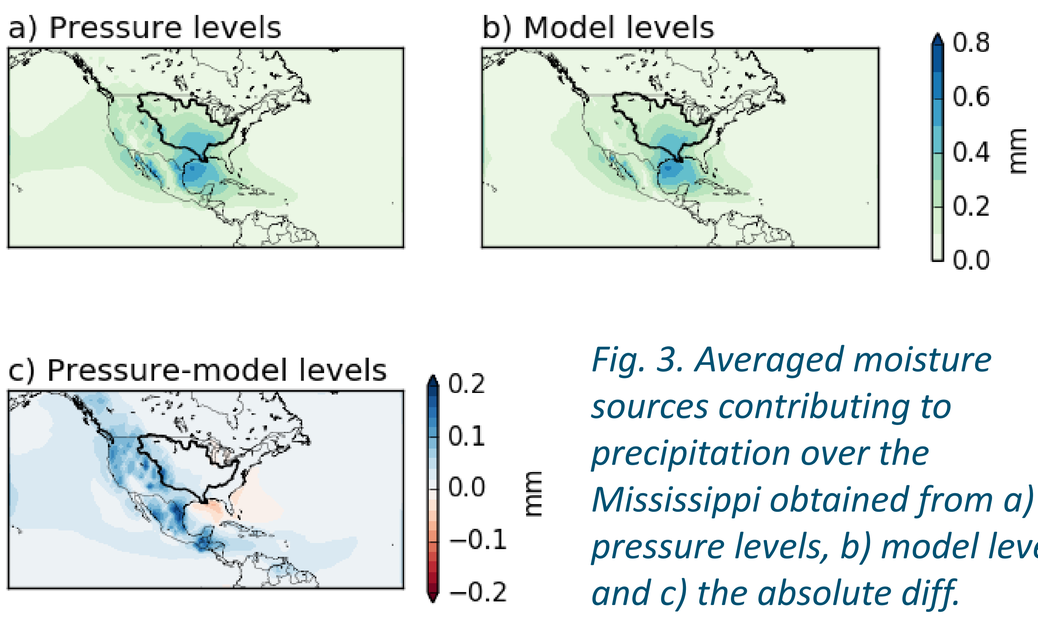


Fig. 3. Averaged moisture sources contributing to precipitation over the Mississippi obtained from a) pressure levels, b) model levels and c) the absolute diff.

Can we link the anomalies in moisture sources to anomalies in evaporation and precipitation?

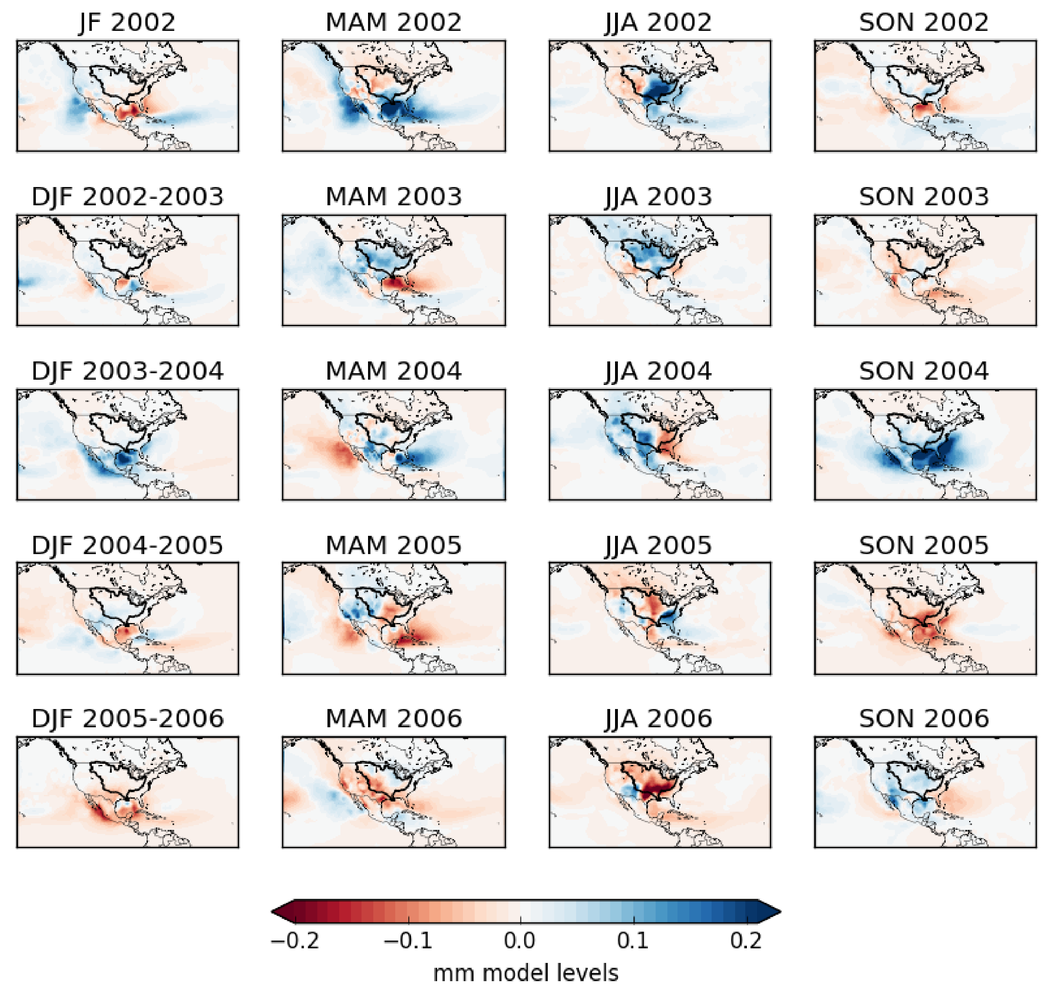


Fig. 4 Seasonal anomalies of moisture sources (2002-2006)

- Lower P in SON (2005): less moisture from the Gulf of Mexico
- Higher P in SON (2004): more moisture from the Gulf of Mexico
- Lower E in JJA (2006): less moisture from the basin itself
- Higher P in MAM (2002): more moisture transport from Gulf of Mexico and California

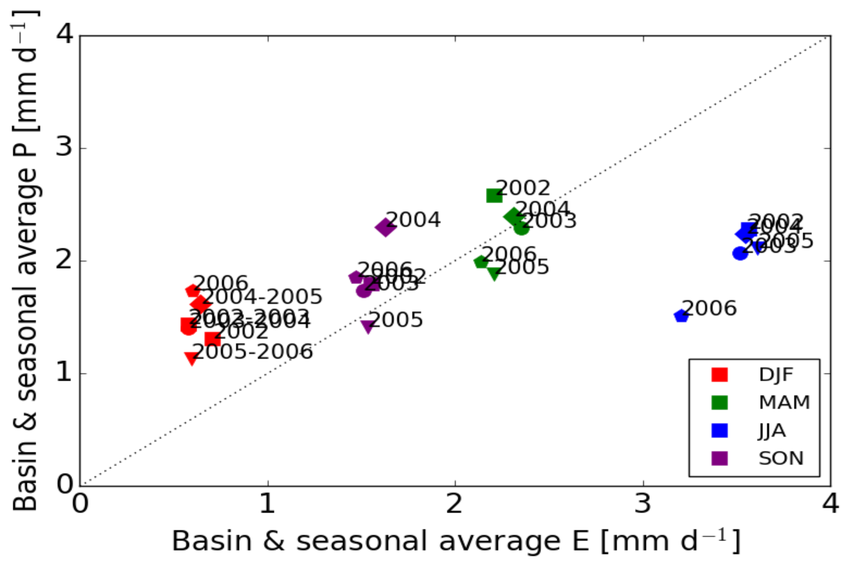
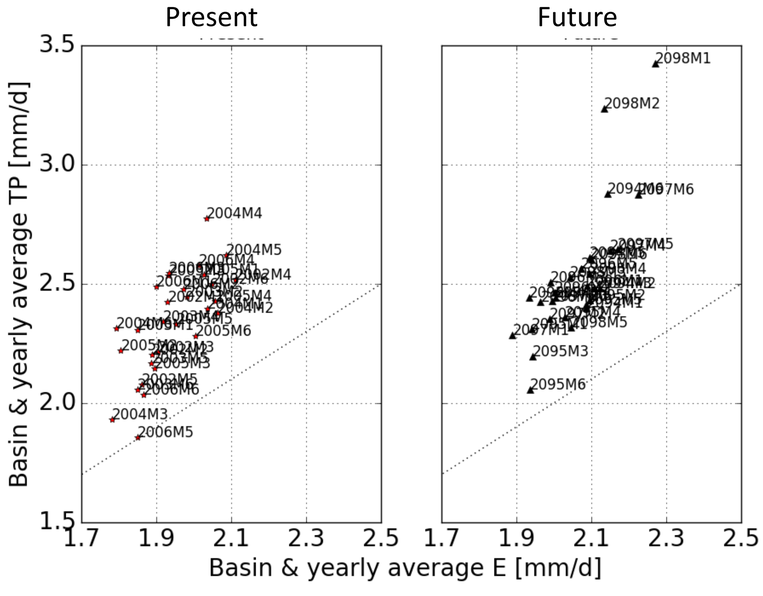


Fig. 5 Basin and seasonal averages of evaporation and precipitation over the Mississippi basin (ERA-Interim; 2002-2006)

Outlook: Are the moisture sources of the Mississippi basin different in a future climate and why?

We will apply the moisture tracking to present and future GCM EC-Earth (at high spatial resolution: ~25 km) to determine the change of moisture sources in a future climate for the Mississippi basin. The figure below shows E and P in the present and future EC-Earth runs.



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