

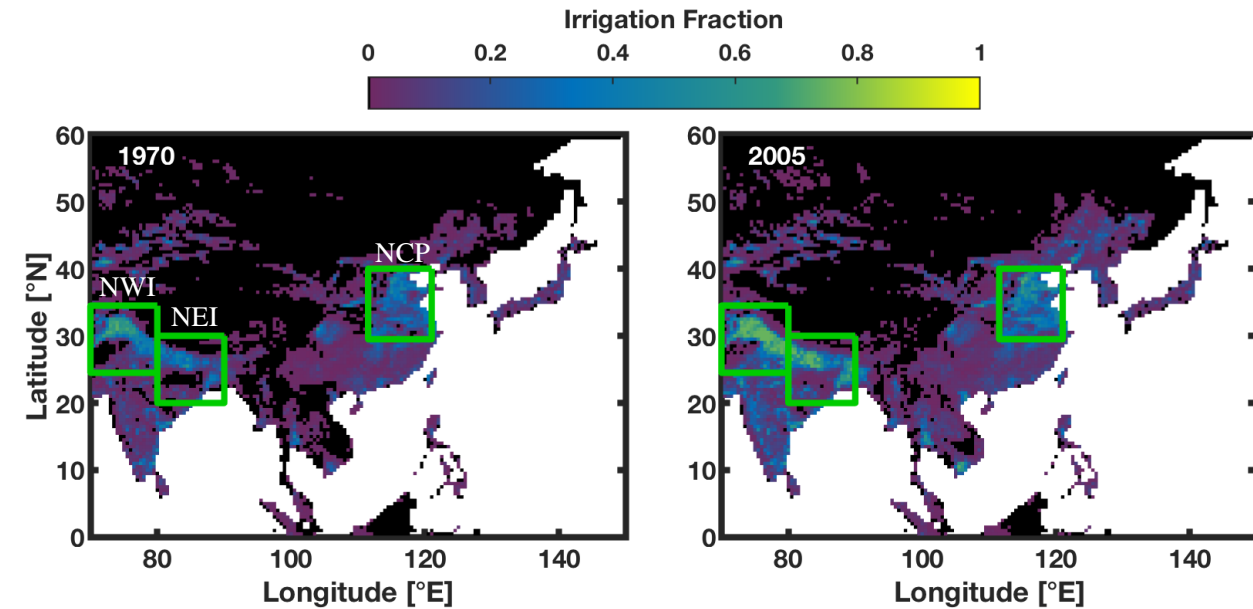
# Irrigation in JULES land-only simulations over South and East Asia

Markus Todt, Patrick C. McGuire, Omar V. Müller, Pier Luigi Vidale  
National Centre for Atmospheric Science, Department of Meteorology, University of Reading

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# Irrigation in JULES

- Irrigation still missing in most global climate models today, despite irrigated agriculture being the dominant land use in parts of Asia (*Siebert et al., 2015*)
- JULES features an irrigation scheme, which will soon be introduced to the UM
  - replenishes soil water in the top two soil layers to field capacity (*Williams et al., 2017*)
  - several timing options, in this study irrigation season prescribed as 150 days calculated based on meteorological conditions
  - physical limitation of irrigation optional, if so requires TOPMODEL which introduces groundwater layer beneath soil layers
  - when physically limited irrigation taken firstly from groundwater and secondly from rivers



- Simulations for this study:
  - irrigation of C3 grass instead of crops
  - irrigation fraction per grid cell based on dataset of historical area equipped for irrigation (*Siebert et al., 2015*)
  - control simulation (with TOPMODEL) and simulation with irrigation...
  - ...turned into ensemble via spin-up choices and irrigation fraction for years 1970 and 2005
  - driven by WFDEI data (1979-2012)

# Impact on Surface Fluxes

Irrigation seasons differ between regions, based on temperature for N-China (boreal summer and autumn) and precipitation for N-India (outside of monsoon season).

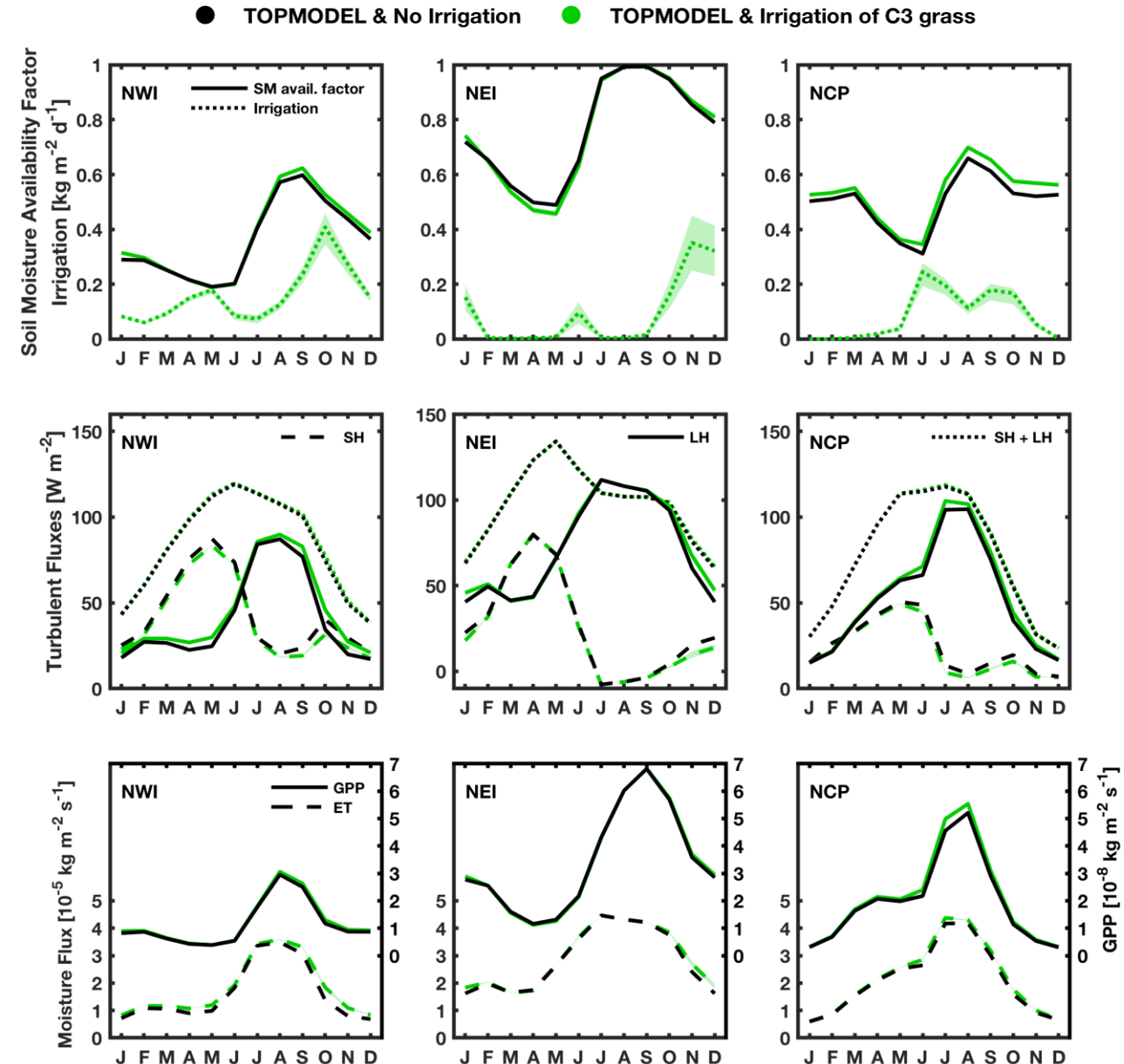
Irrigation increases SMC, even outside of the irrigation season over China.

Counterintuitively, irrigation reduces SMC over N-India.

Irrigation increases LH and decreases SH, but has only marginal impact on sum of turbulent fluxes.

Irrigation increases ET and GPP.

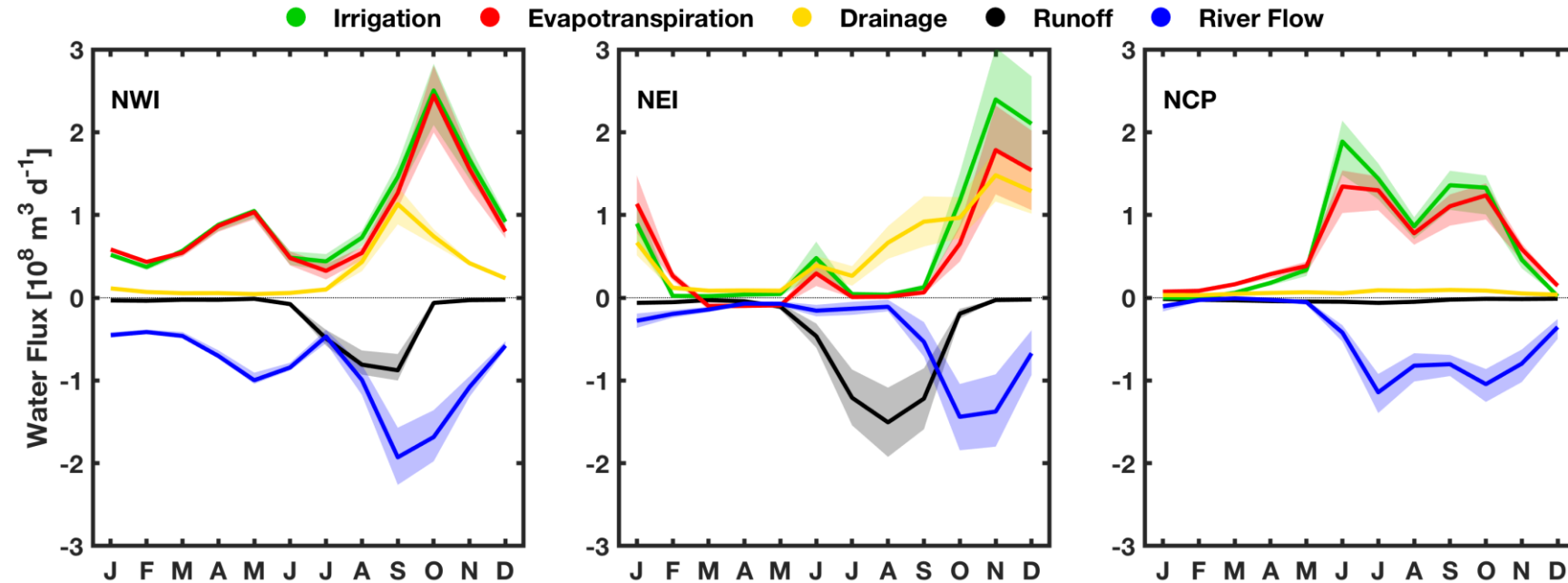
*Seasonal cycles calculated for 2001-2012.*



# Impact on Water Fluxes

N-China:

- added irrigation mostly results in increased ET, residual increases SMC
- majority of irrigation water taken from rivers for 2001-2012 as groundwater layer already depleted – independent of whether spin-up included irrigation!



N-India & Pakistan:

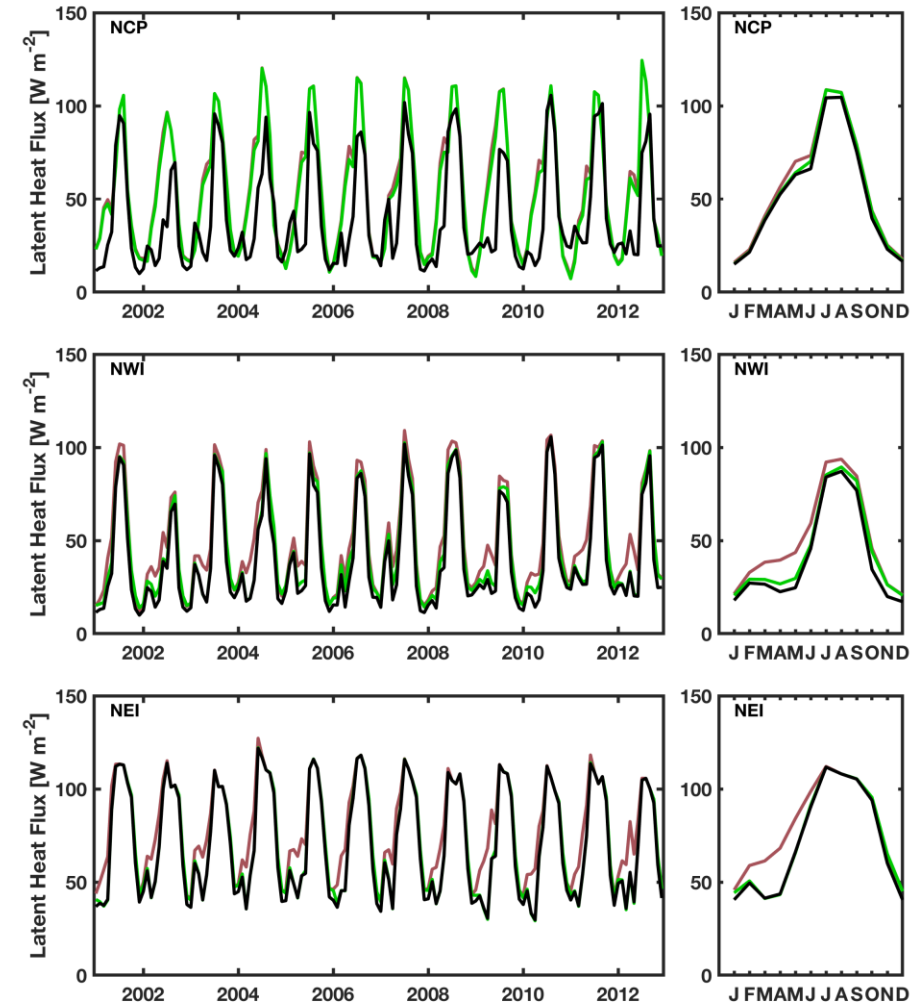
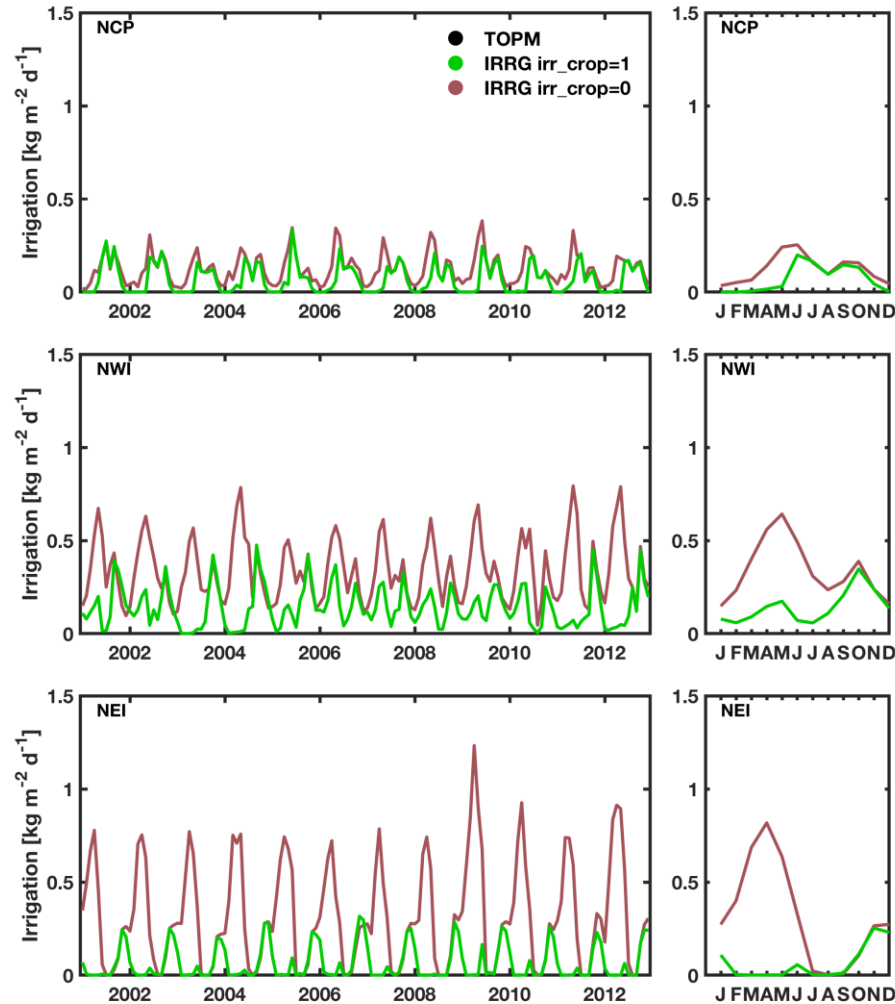
- added irrigation mostly translates to increased ET as for N-China
- irrigation sources differ: almost entirely groundwater over NE-India, both for NW-India and Pakistan but majority from rivers as groundwater layer depleted over parts
- extraction of groundwater increases drainage from soil layers to groundwater layer → reduces runoff but not enough to balance increased drainage → reduction of SMC

# Irrigation as in the UM

UM will include simpler version of irrigation scheme ( $irr\_crop=0$ ), without temporal limitation except when soil is frozen.

Irrigation between scheme versions is similar over N-China, but irrigation is substantially higher prior to monsoon season over N-India in UM version.

Likely even quicker depletion of groundwater over N-China and NW-India.



# Conclusions

Irrigation increases soil moisture and evapotranspiration, increases latent heat fluxes and decreases sensible heat fluxes.

Irrigation affects water fluxes within the soil and soil moisture outside of the irrigation season. The irrigation scheme, at least in the uncoupled land-atmosphere setting, can rapidly deplete groundwater to the point that river flow becomes the main source of irrigation.

In future work, we will explore the impact of irrigation on regional climate by conducting coupled land-atmosphere simulations with the Unified Model. This will include the more impactful, more water-demanding version of the irrigation scheme.

...Questions?

# References

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