Where in the world is subgrid heterogeneity and lateral redistribution likely important to ET over a large ESM model grid?
• Typical approach (within a grid cell of an ESM)

PCR-GLOBWB

(Wada et al. 2014, Earth Systems Dynamics)
• What happens if you have a system like this?

VarKarst-R

(Hartmann et al. 2015, Geoscientific Model Development)
Motivation

• Subsurface heterogeneity everywhere across the hydrological cycle
• Impacts on catchment/aquifer scale well studied
• Not much knowledge on impacts on larger scales

Research question

• Does subsurface heterogeneity have an impact on large-scale hydrological simulations?
Study area

- Europe’s carbonate rock regions
- Karstification expected to produce strong heterogeneity
- Definition of typical sub-regions by climatic and topographic descriptors
- Focus on groundwater recharge
Evaluation by observations

- Comparison of simulations with recharge observations
Evaluation by observations

- Simulated recharge decreases when internal runoff and subsurface heterogeneity are turned off
Evaluation by process dynamics

- Recharge sensitivity to climate variability assessed by 
  \textit{elasticity}

\[ E_R = \text{median} \left( \frac{\Delta R}{\Delta X} \right) \]

\textit{How responsive is one variable to change in another variable? (OECD, 1993)}

- Variables X:
  - Annual precipitation
  - Mean annual temperature
  - Mean intensity of upper quartile of all rainfall events
Sensitivity to climate variability

- Homogeneous representation more sensitive to P at wet regions because of surface runoff generation
- Heterogeneous representation more sensitive to P and T changes because of internal runoff and concentrated recharge

For both reasons the karst recharge model produces significantly more recharge and less ET
Present and future recharge

Heterogeneous model also produces more future recharge
Implications

- Karst regions cover ~25% of Europe’s surface
- Home of ~560 Mio.

- Lateral redistribution by heterogeneity processes significantly altered the model behaviour
- In this case, more recharge and less ET at the surface (PhD thesis F. Sarrazin, Uni Bristol)
- Possibility of more ET at places where GW emerges back from the subsurface (Rahman & Rosolem, HESS)