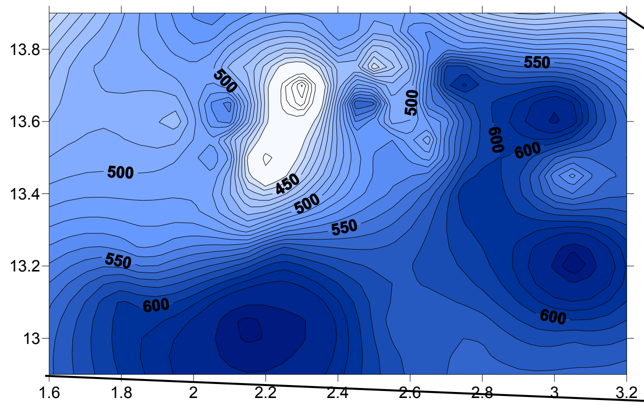
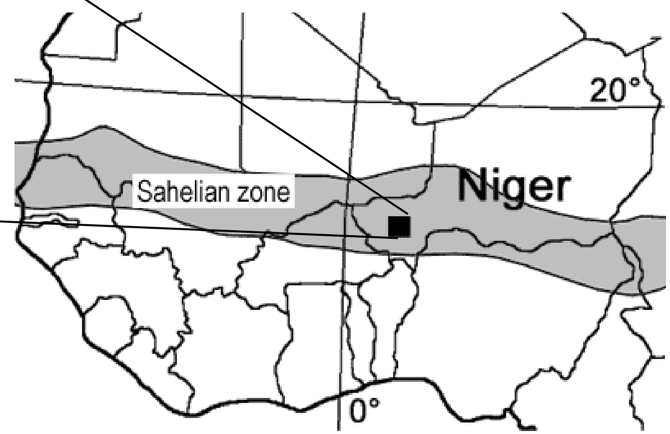
How to best use point rainfall data to drive land surface models in the Sahel ?

Feurer D., Cappelaere B., Demarty J., Vischel T., Ottlé C., Solignac P.A., Saux-Picart S., Lebel T., Ramier D., Boulain N., Charvet G., I. Mainassara, Chazarin J.P., Oi M., Quantin G.



2006 (AMMA SOP)



LSM resolution?

- Scale of interest for **outputs**:

  local/regional? daily/seasonnal ?

  depend of the modeling objectives (hydrology, agronomy, climatic, …

- Characteristic scales of **processes** ?

  - Forcing processes: space-time **intermittency of convective rainfall** at small scales
  - Surface processes: small-scale **endoreism**, strong **non-linearity**

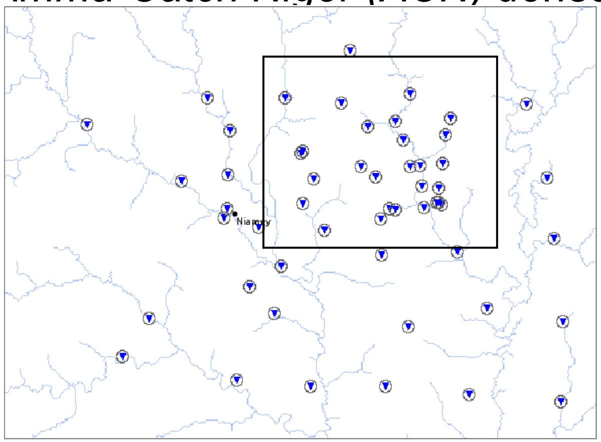
➔ **<hourly, ~km resolution** is needed to fully resolve surface processes in the Sahel *(eg., Vischel & Lebel, JH-2007)*

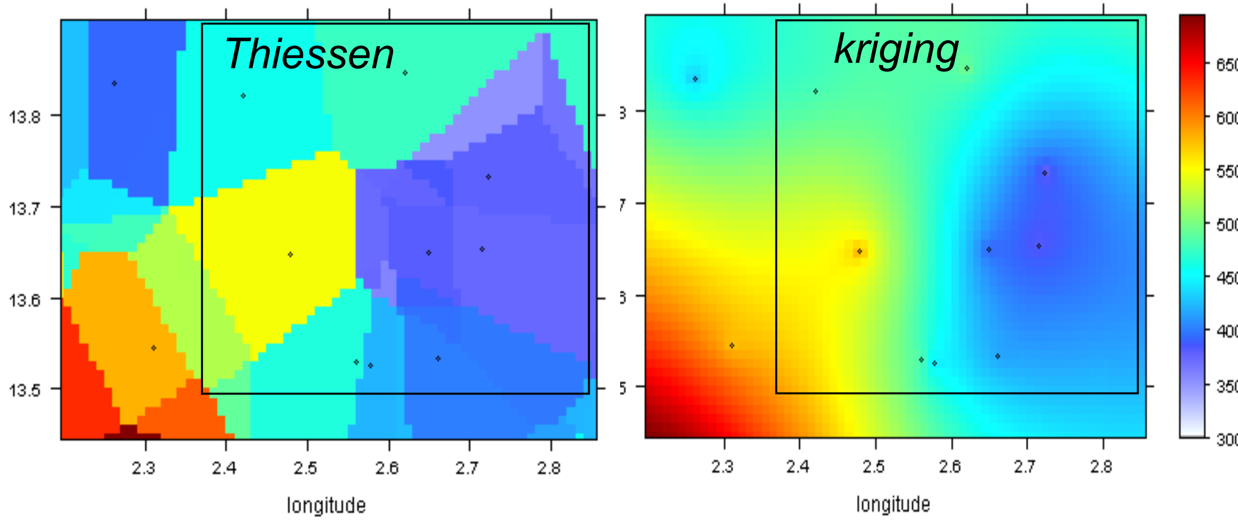
➔ HR-**raingauge networks** still needed despite loose space-sampling

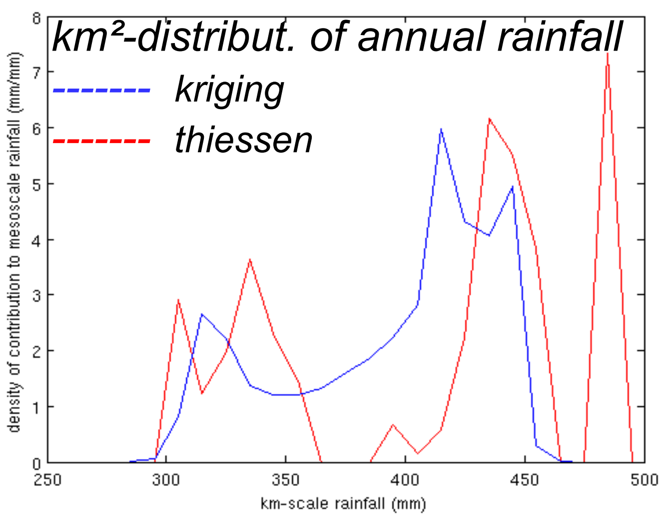
➔➔ **" *How to best use point rainfall data to drive land surface models in the Sahel ?***

Variation in annual rainfield with interpolation scheme

Amma-Catch Niger (ACN) dense







==> **Need** for :

- Assessing **performances of standard interpolation schemes** with respect to land surface applications in the Sahel context
- Evaluating **benefits from newly proposed schemes** for this region

Materials & Methods

Site : **~3.10^3 km²** of ACN mesosite (SW Niger) *(Cappelaere et al., JH-2009)*

Period : **2005** growing season (+ 2006 subsequent dry season)

Application model : **SETHYS** land surface model *(Saux-Picart et al., JH-2009)*

calibrated with ACN data

Rainfall interpolation schemes :

1 - nearest neighbor (« **Thiessen** »)

2 - « **standard »** (eulerian) **kriging**

3 - **dynamic** (lagrangian) **kriging** *(Vischel et al., JHM-2012)*

4 - **stochastic** (ensemble) rainfield **modeling** *(Vischel et al., JH-2009)*

Some specific questions

➔ « General-purpose » deterministic method(s) ok? which ?

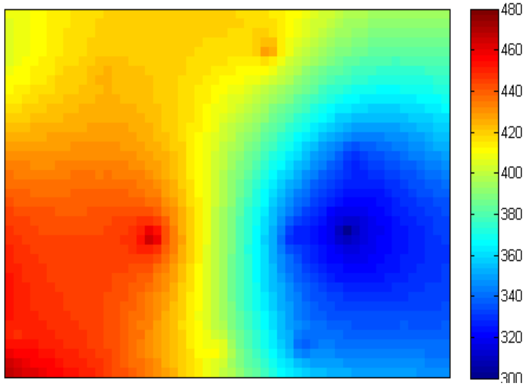
➔ Ensemble simulation necessary? To reflect uncertainty? Other?

➔ Or else could a single space-time rainfield do the job?

Distributed land surface modelling

Rainfields

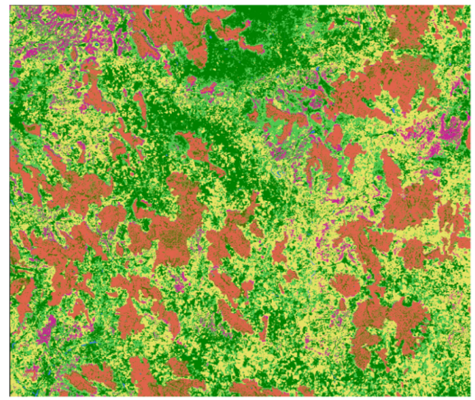
Ex : Thiessen, Std. Kriging, Dyn. kriging, Ensemble simulations



Vischel *et al.*, 2009, 2012

Land-use

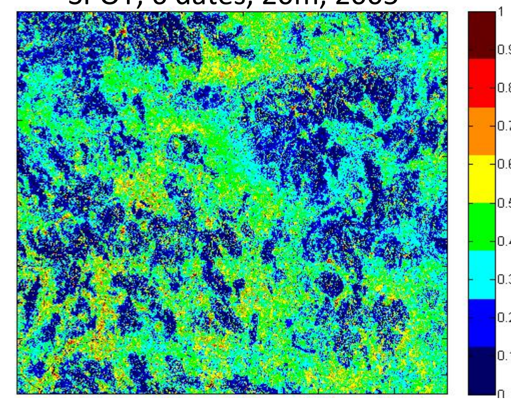
SPOT, 8 classes, 20m, 2005



Saux-Picart *et al.*, 2009

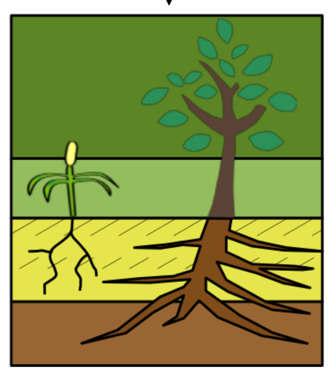
LAI

SPOT, 6 dates, 20m, 2005



Saux-Picart *et al.*, 2009

Impacts of rainfield estimation methods ?



Uniform meteorological forcing

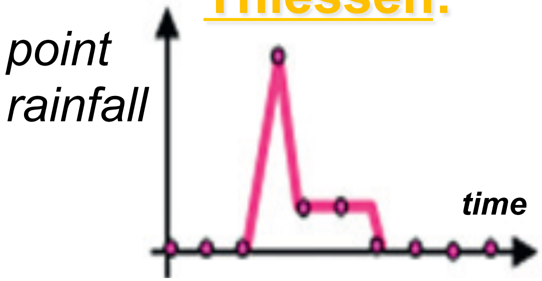
SetHyS_Savannah LSM

(dX = **1 km** , dT = **5 mn**)

➔ *Poster « Solignac et al. » (**9B11**) for model description*

3 deterministic approaches of estimation of rainfields

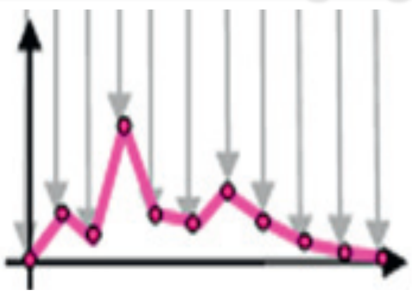
Thiessen:

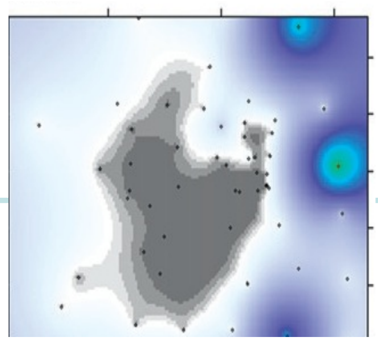


Nearest neighbor approach

Transpose point to 1km² rainfall

Standard kriging

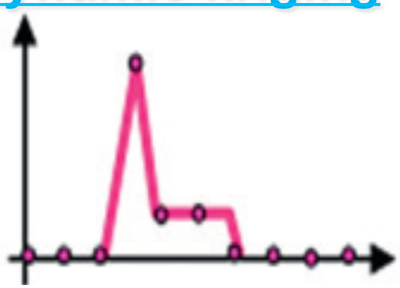


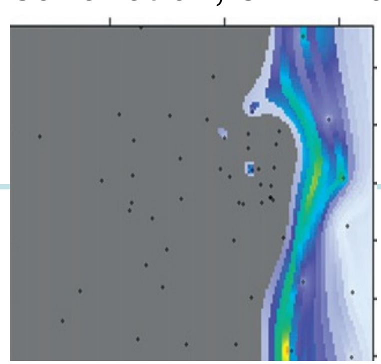


Interpolation time step by time step (variogram)

(*Vischel et al., JHM-2011*)

Dynamic kriging



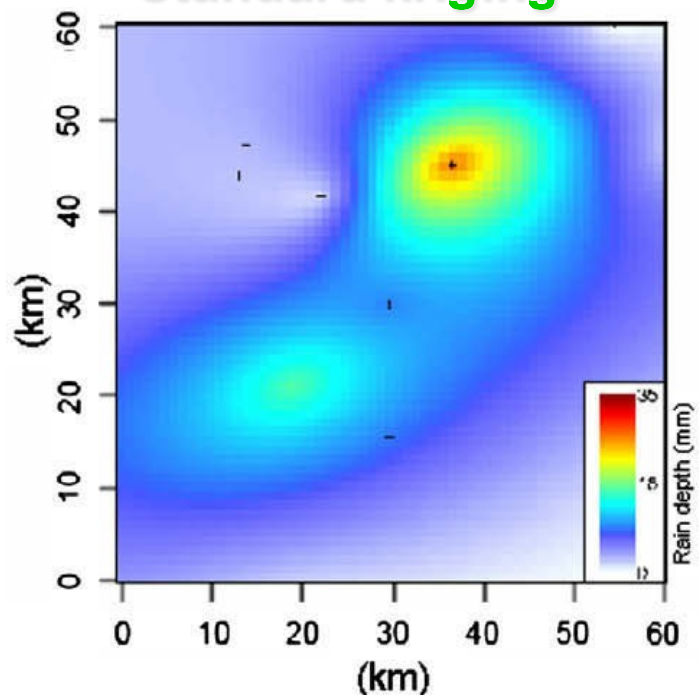


Dynamic interpolation, superpose hyetograph in a virtual temporal space

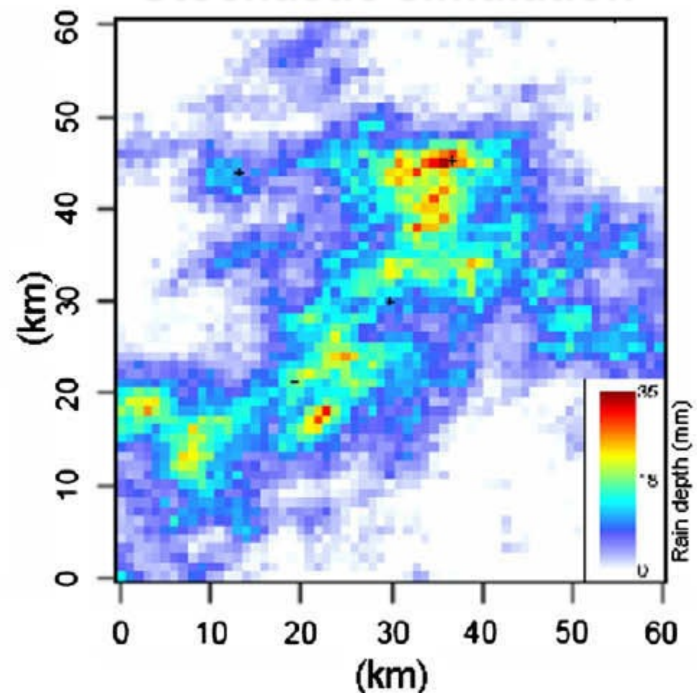
Better deterministic approach

+ 1 conditioned stochastic approach of event rainfields *(Vischel et al., JH-2009)*

Standard kriging



a conditioned
Stochastic simulation

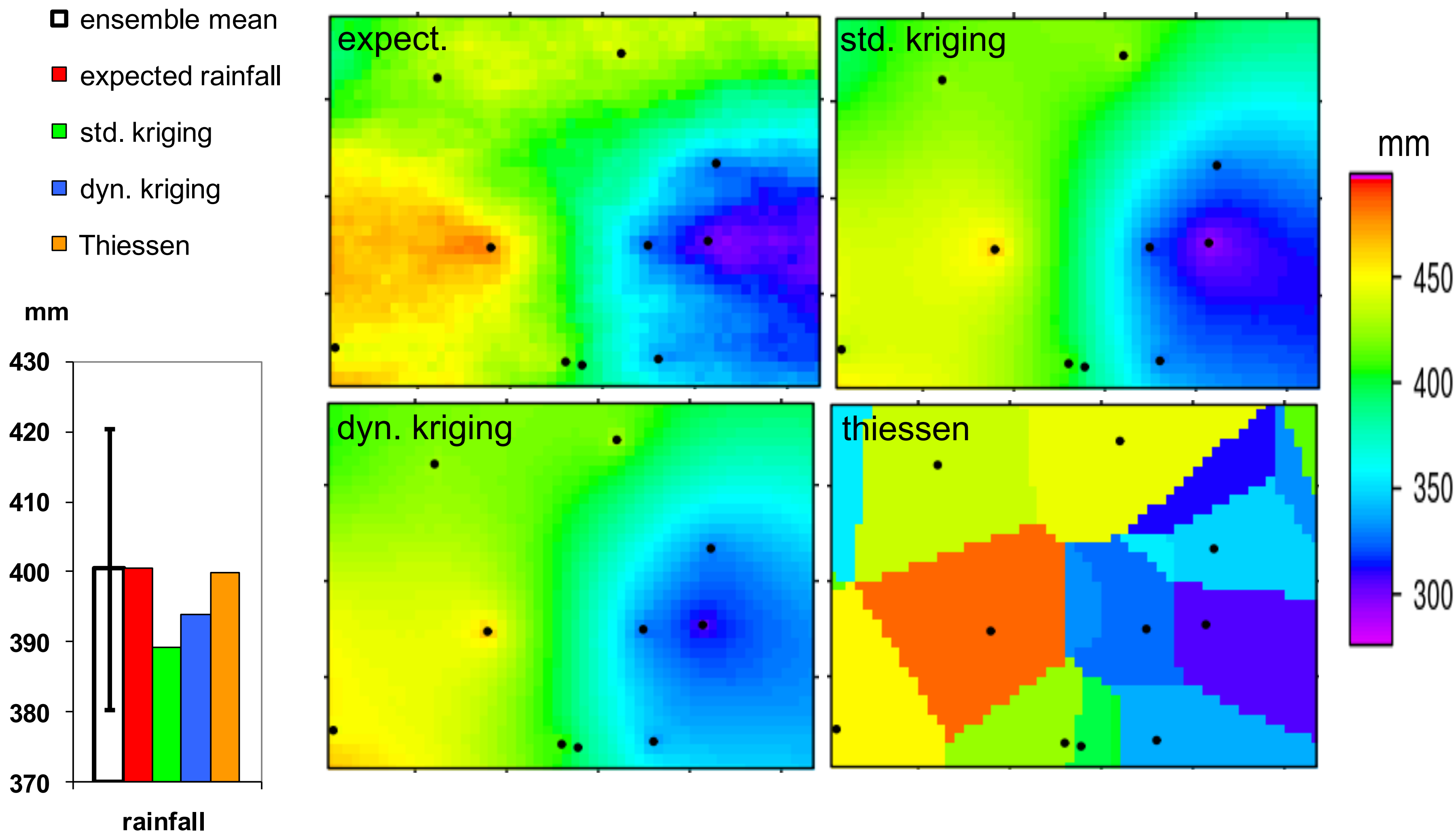


➔ *Poster « Vischel et al. » (**9B9**)*

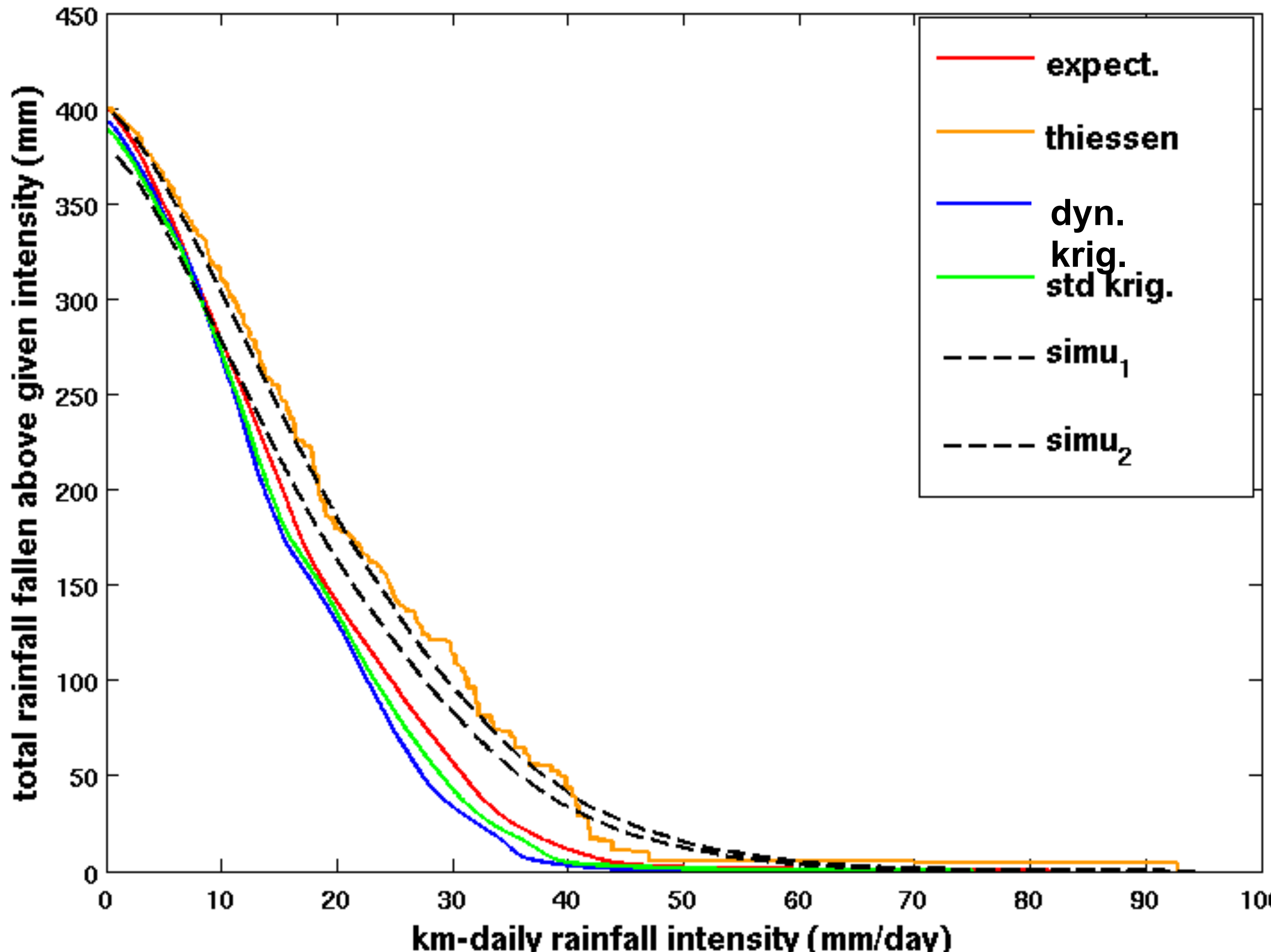
Application

- ➔ 50-member ensemble simulation (event resolution)
- ➔ Dynamical kriging–based time disaggregation (event to 5-min)
- ➔ simulation averages used as reference for comparisons here

2005 –aggregated rainfields *(start. June 15)*



km-day intensity distribution of total rainfall



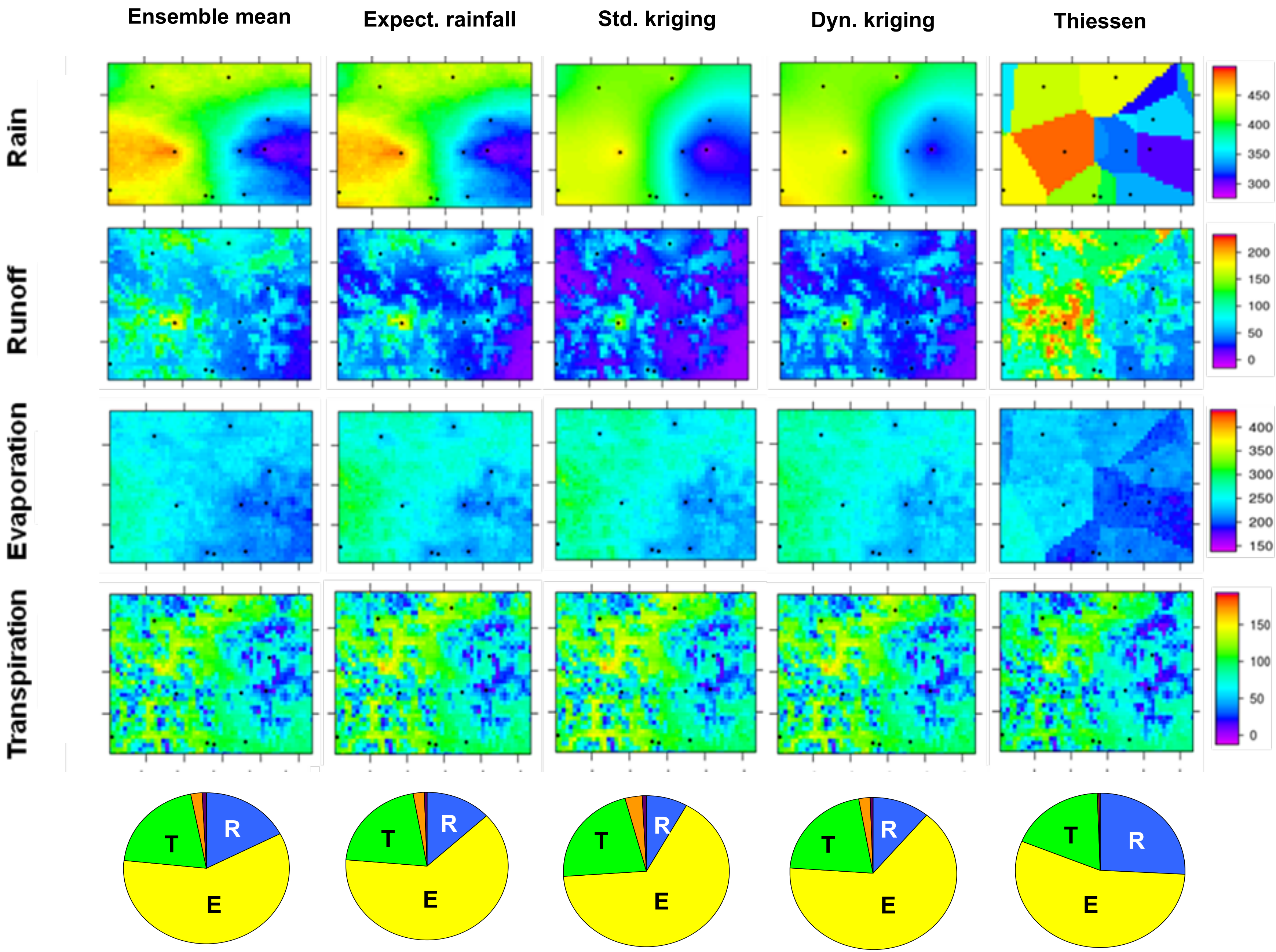
Conclusions

➔ Thiessen, stochastic : Maximise high/low intensities

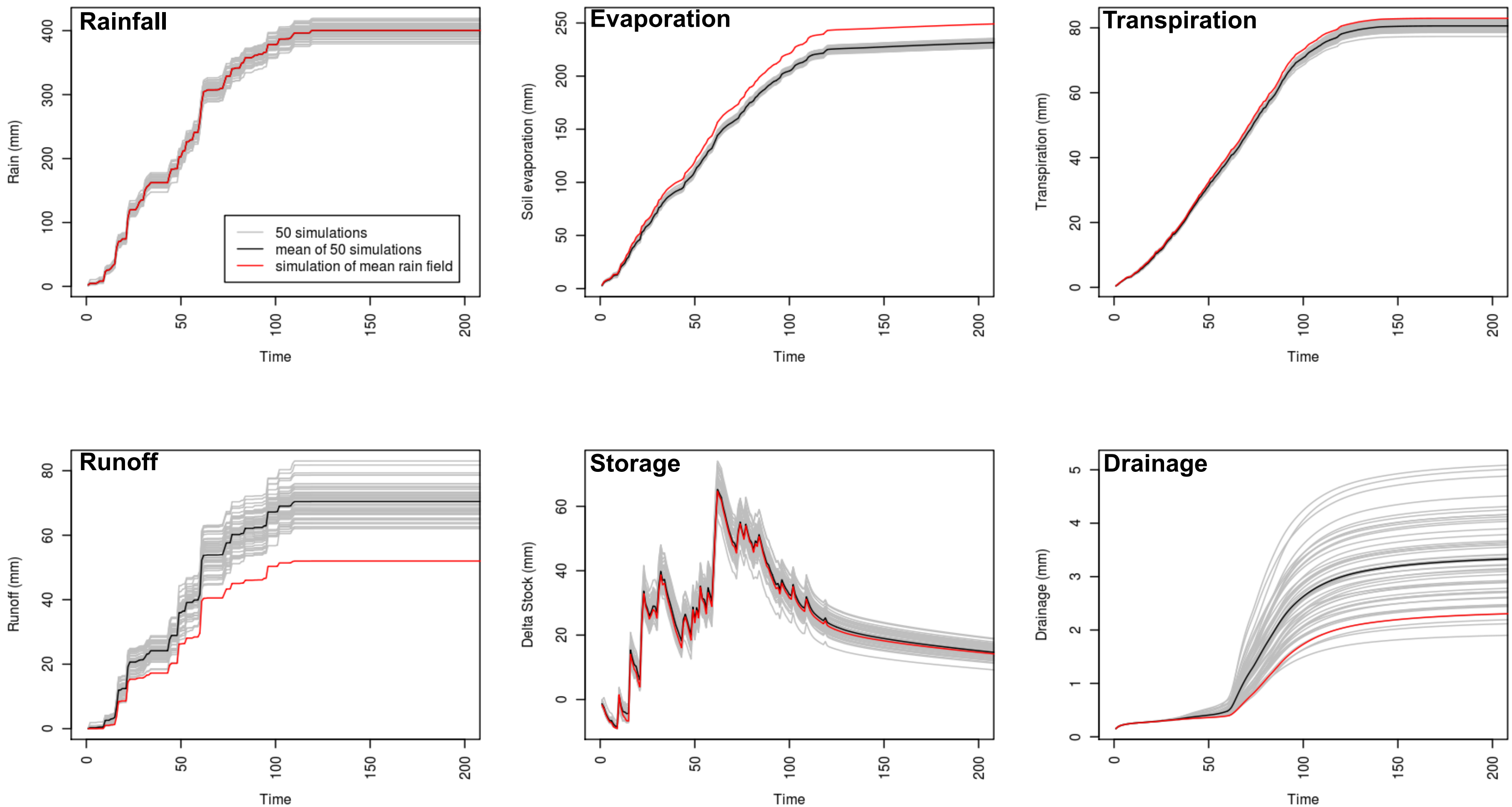
➔ Kriging, expected rainfall : Minimize high/low intensities

➔ Great impacts on hydrological processes

Simulated hydrological variables



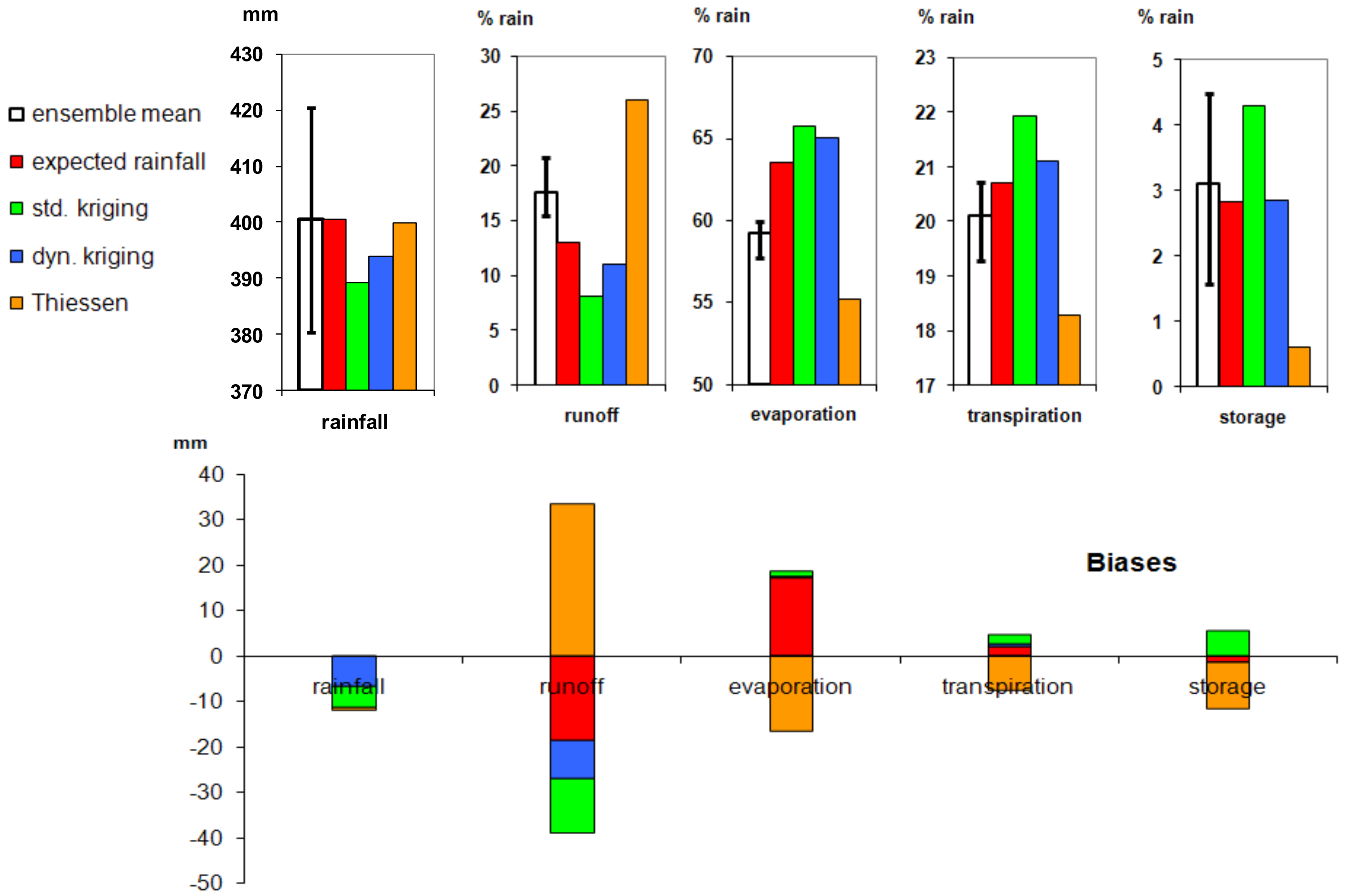
Cumulative mesoscale hydro. variables for ensemble & expected rainfall



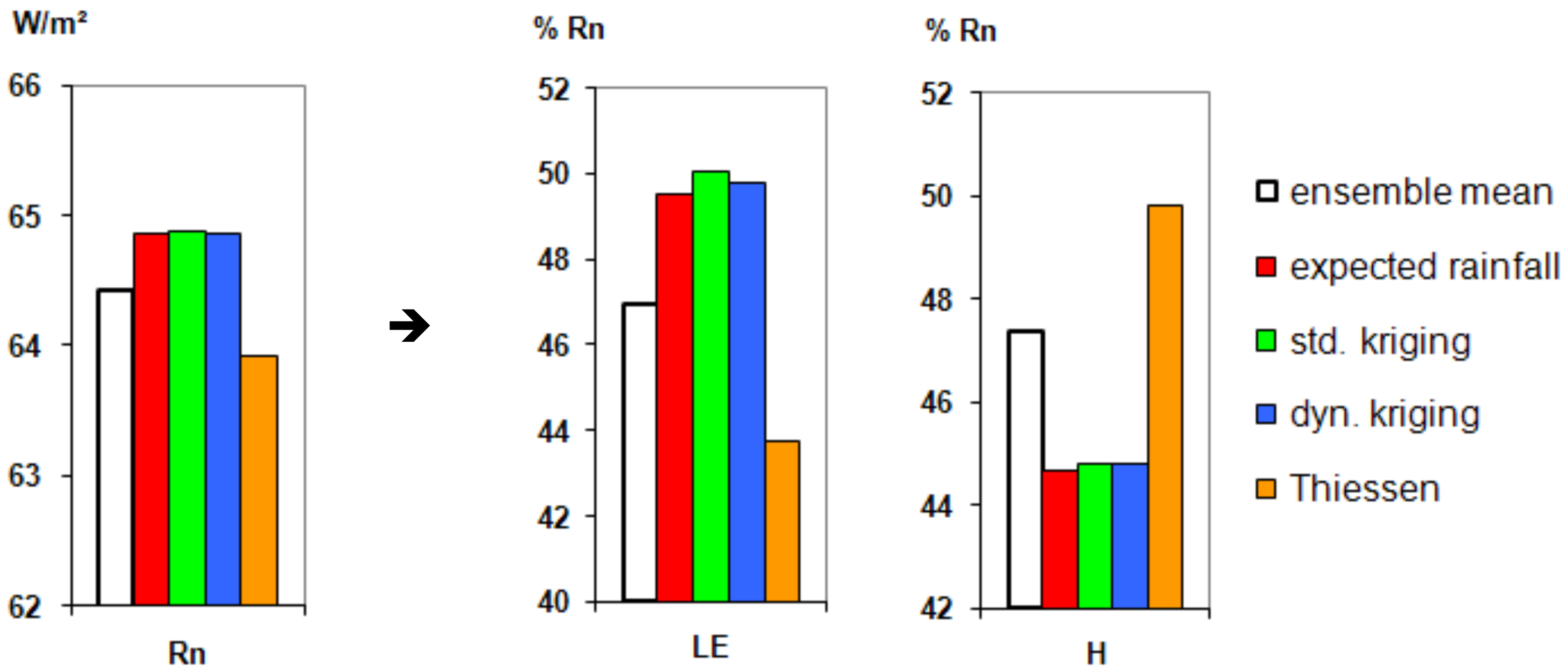
➔ **Uncertainty propagation** : % amplified for runoff & storage, dampened for evaporation

➔ **Bias generation** with expect. rainfall: larger than uncertainty for runoff and evaporation

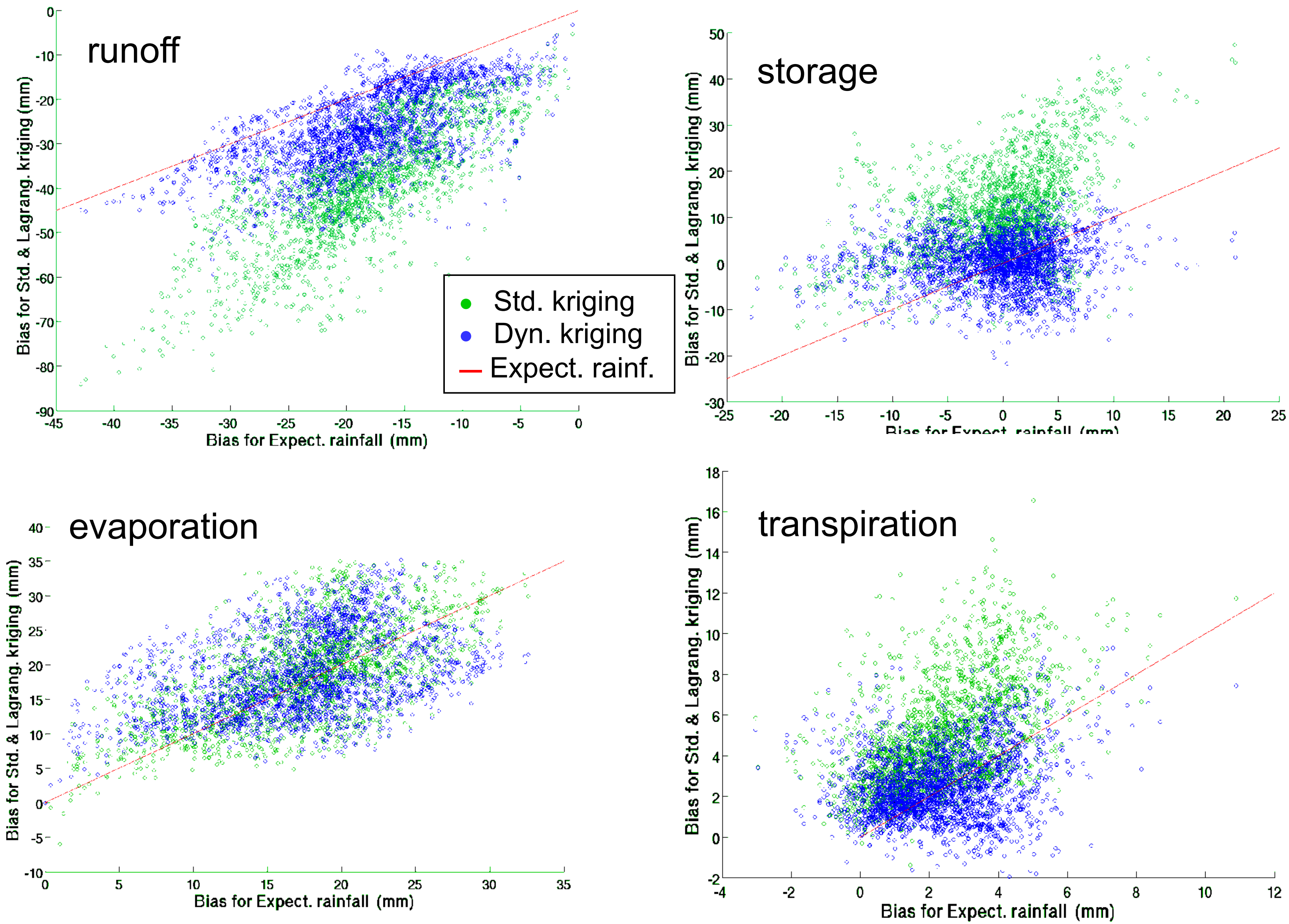
Season / mesoscale hydro. variables for 4 methods



Same for turbulent fluxes in energy budget



Bias from kriging methods vs. from expect. rainfall (year x km² scale)



Tentative conclusions

- Runoff most sensitive to rainfall uncertainty,

  - 5-25% rain in 2005 over the mesosite

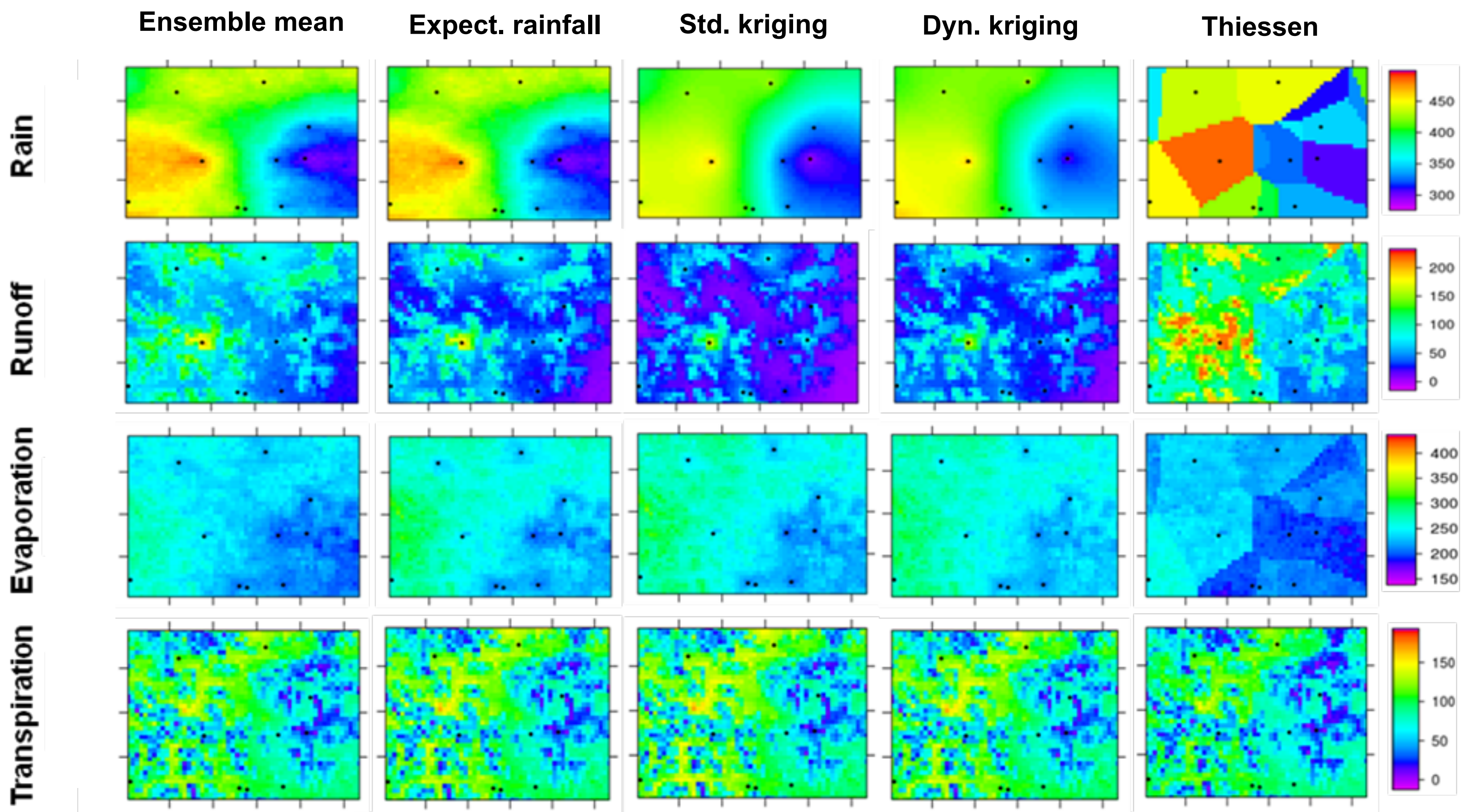
  - compensates ~evenly between evaporation, transpiration, deep storage

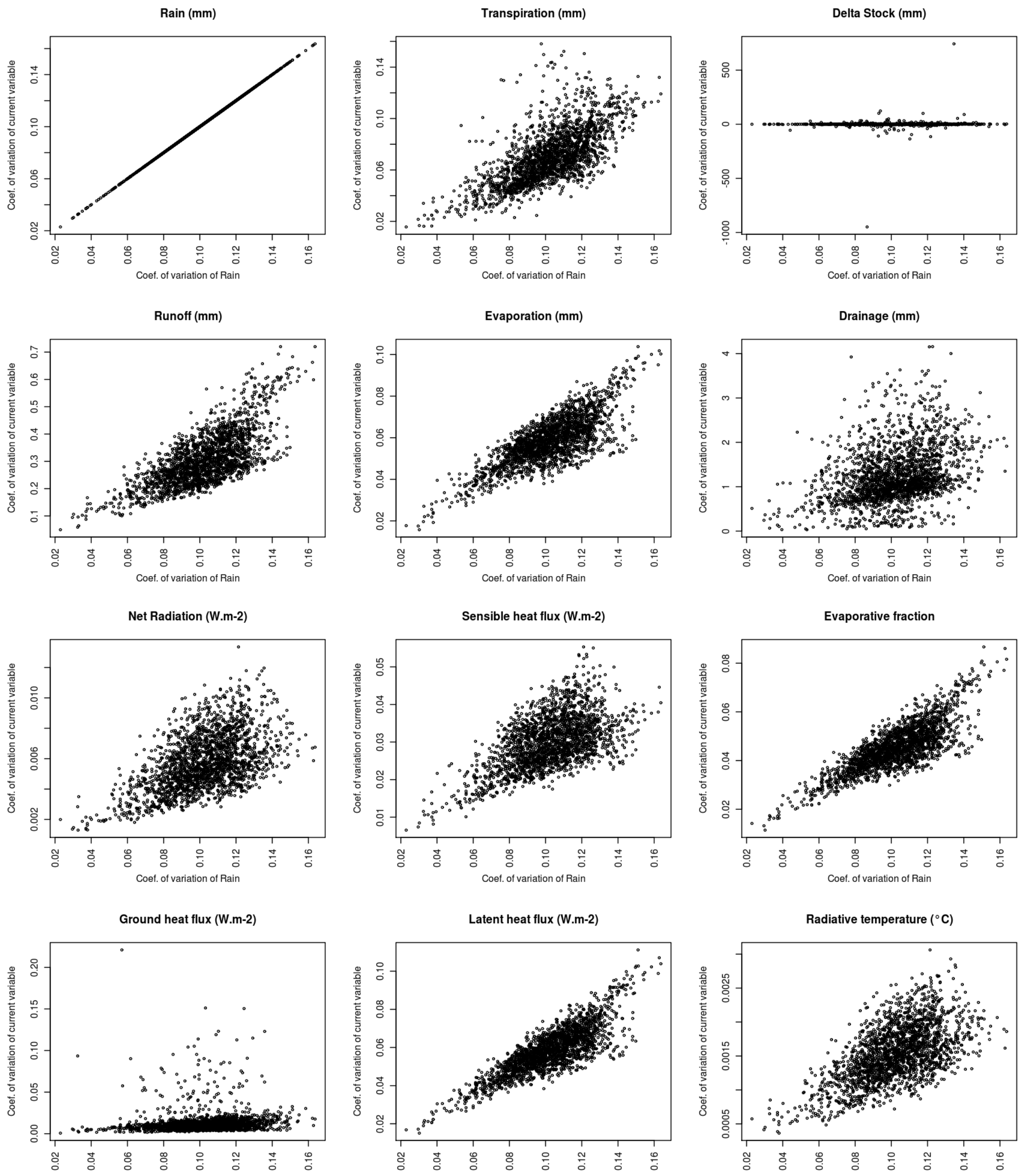
- Rainfall uncertainty generates biases on all hydrological variables with single rainfield methods (incl. expected rainfield)

- Improvement by dynamic kriging over standard kriging, coming close to expected rainfield

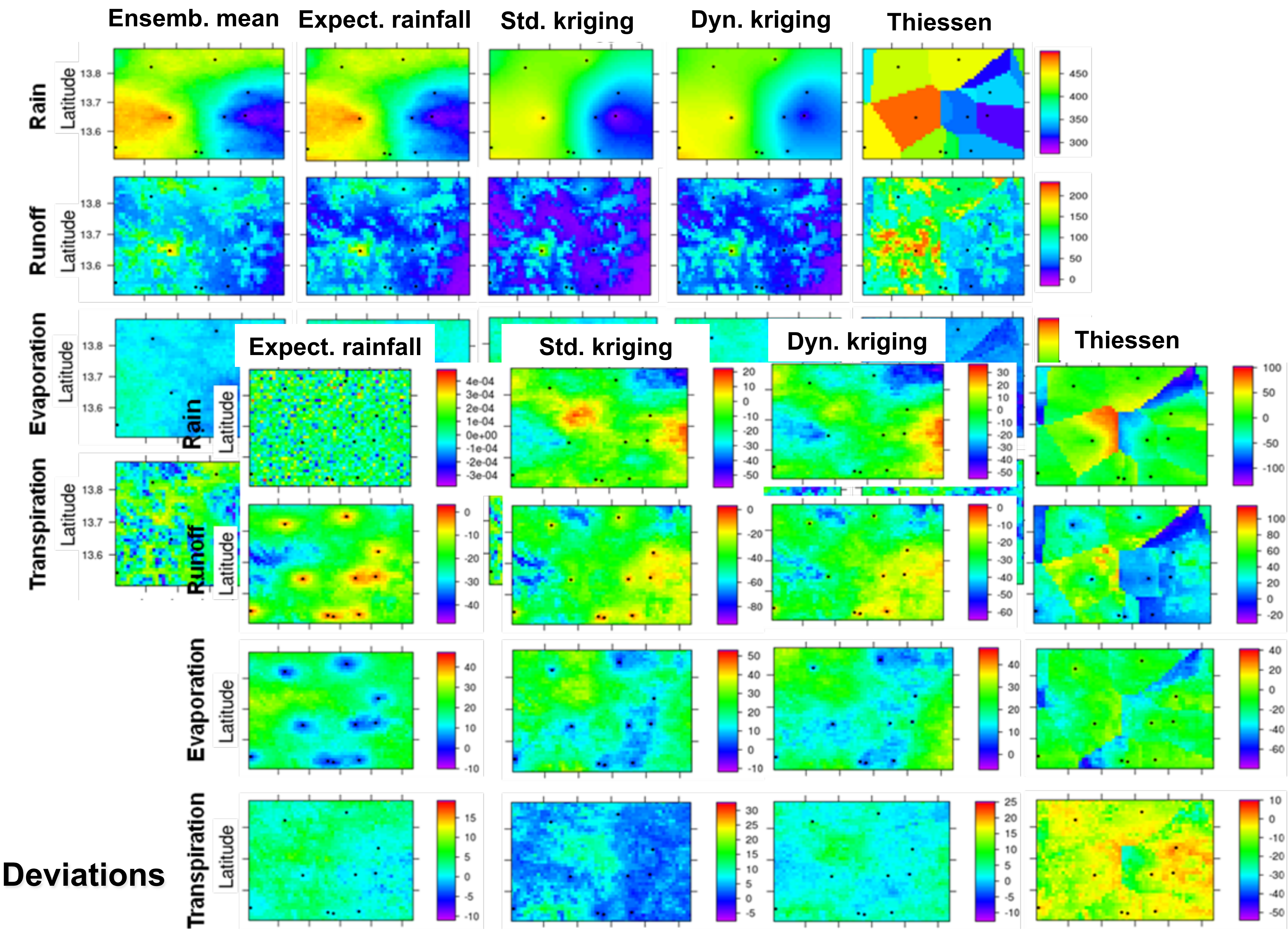
- Single stochastic rainfield better than any deterministic method (for mesoscale outputs) ?

Simulated hydro variables

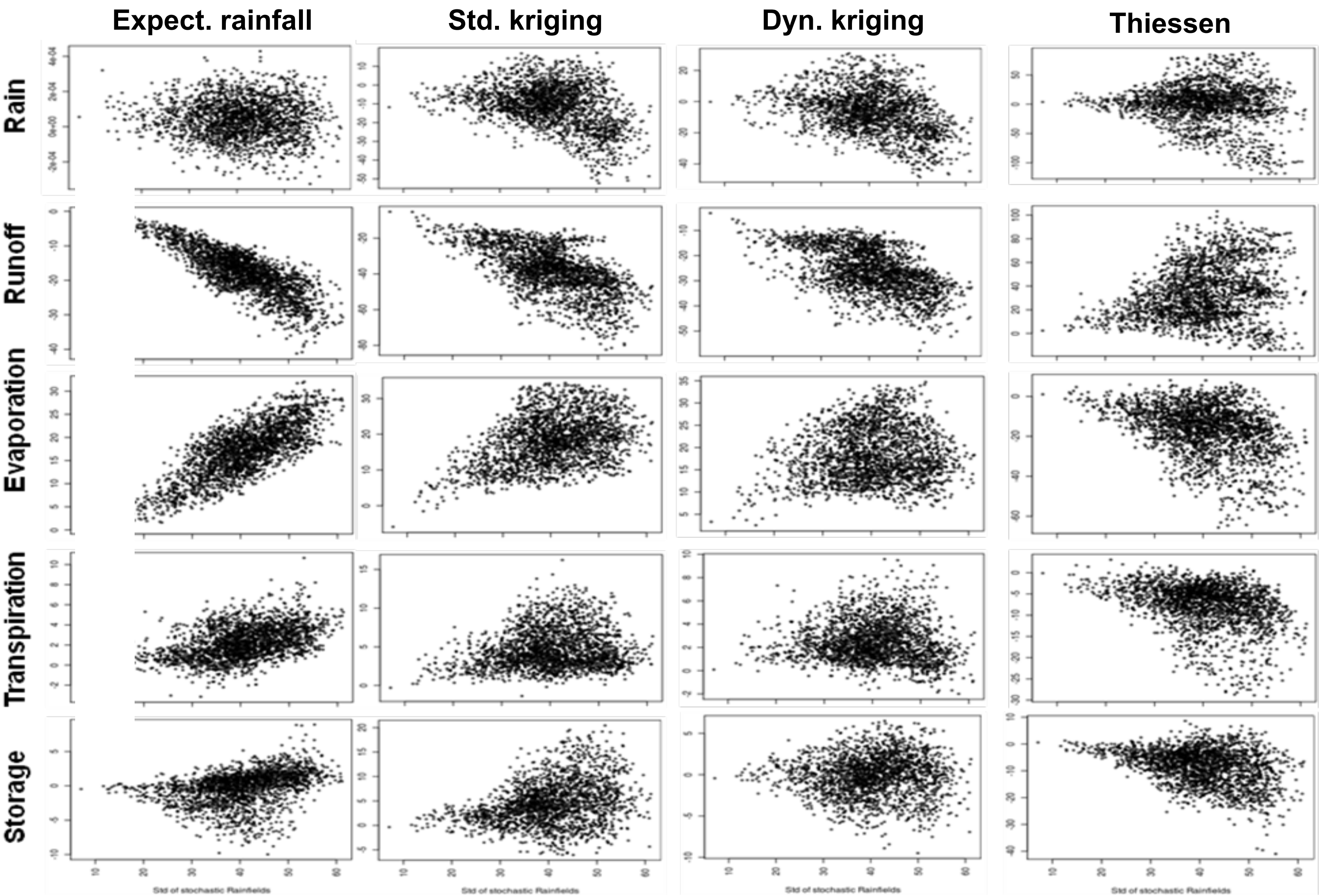




Rain (mm)
Transpiration (mm)
Delta Stock (mm)
Runoff (mm)
Evaporation (mm)
Drainage (mm)
Net Radiation (W.m-2)
Sensible heat flux (W.m-2)
Evaporative fraction
Ground heat flux (W.m-2)
Latent heat flux (W.m-2)
Radiative temperature (°C)
Coef. of variation of current variable
Coef. of variation of Rain


Ensemb. mean
Expect. rainfall
Std. kriging
Dyn. kriging
Thiessen
Rain
Runoff
Evaporation
Transpiration
Latitude
13.8
13.7
13.6
Deviations

Bias vs. Uncertainty (season x km² scale)



The End