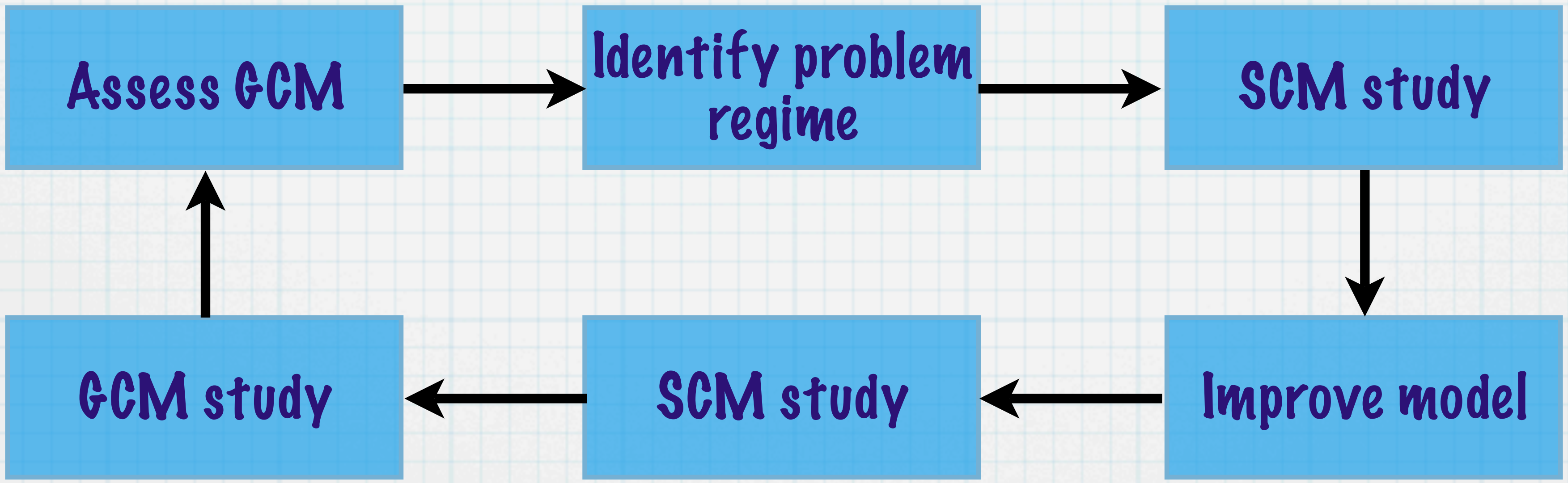
Ensemble Single Column Modelling - A new approach to an old problem

Christian Jakob (Monash University)
Tim Hume (CAWCR)
with
Kenneth Cheung (Monash) and Laura Davies (Monash)

SCMs - Why?

* simple framework for assessing and testing model physics
* computationally extremely cheap

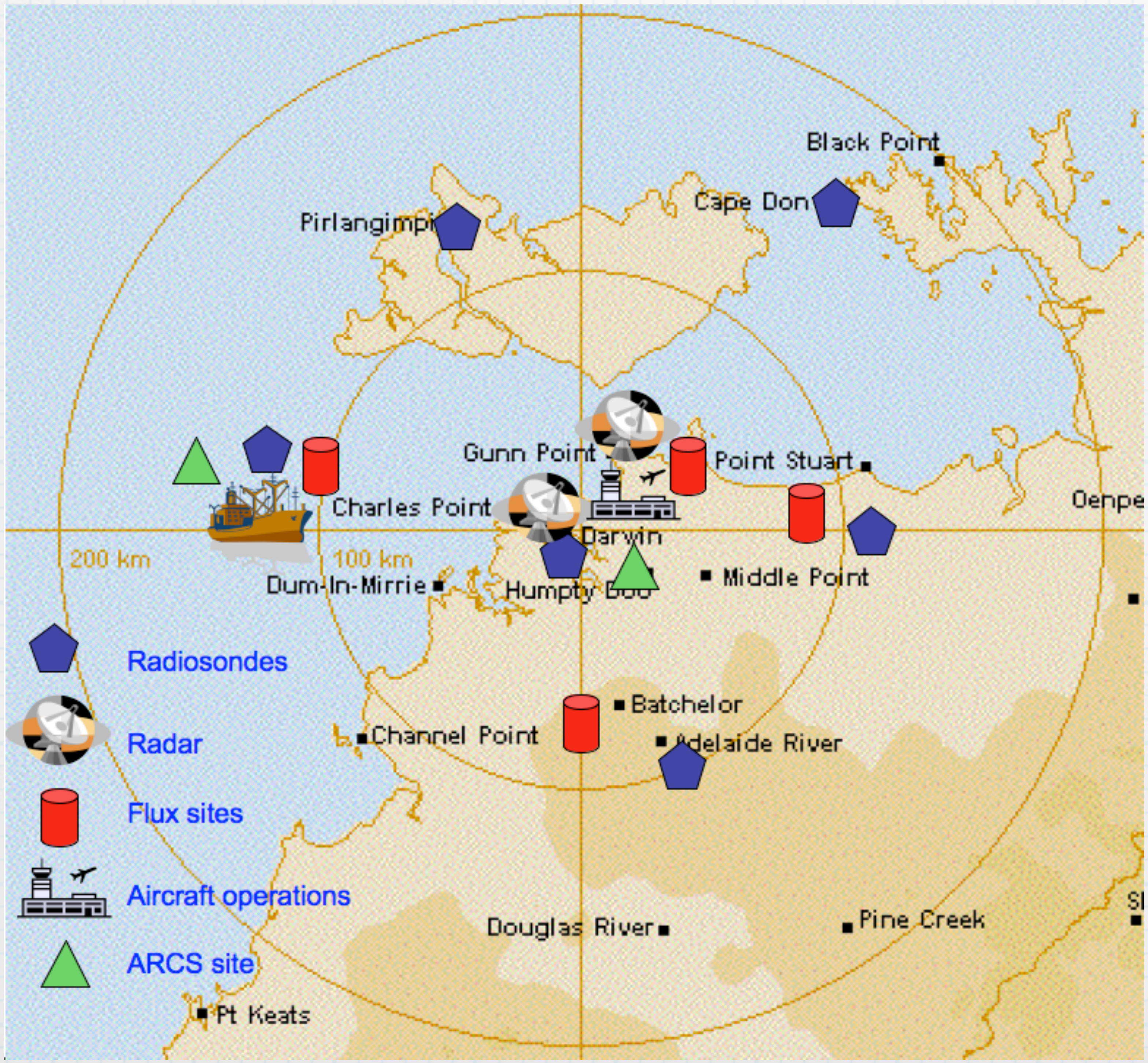


* However -> simplicity brings its own set of problems!

SCMs - Problems

* Are the SCM errors representative for the GCM? -> usually if physics has strong influence!
* Short periods of available observations limit number of cases that can be studied -> Are the cases representative?
* The total simulation error is a mixture of forcing and model error.
    * How accurate is the forcing?
    * What are the effects of forcing error on the solution?
* Ensemble Single Column Modelling to address these points!

ESCM - Observed forcing



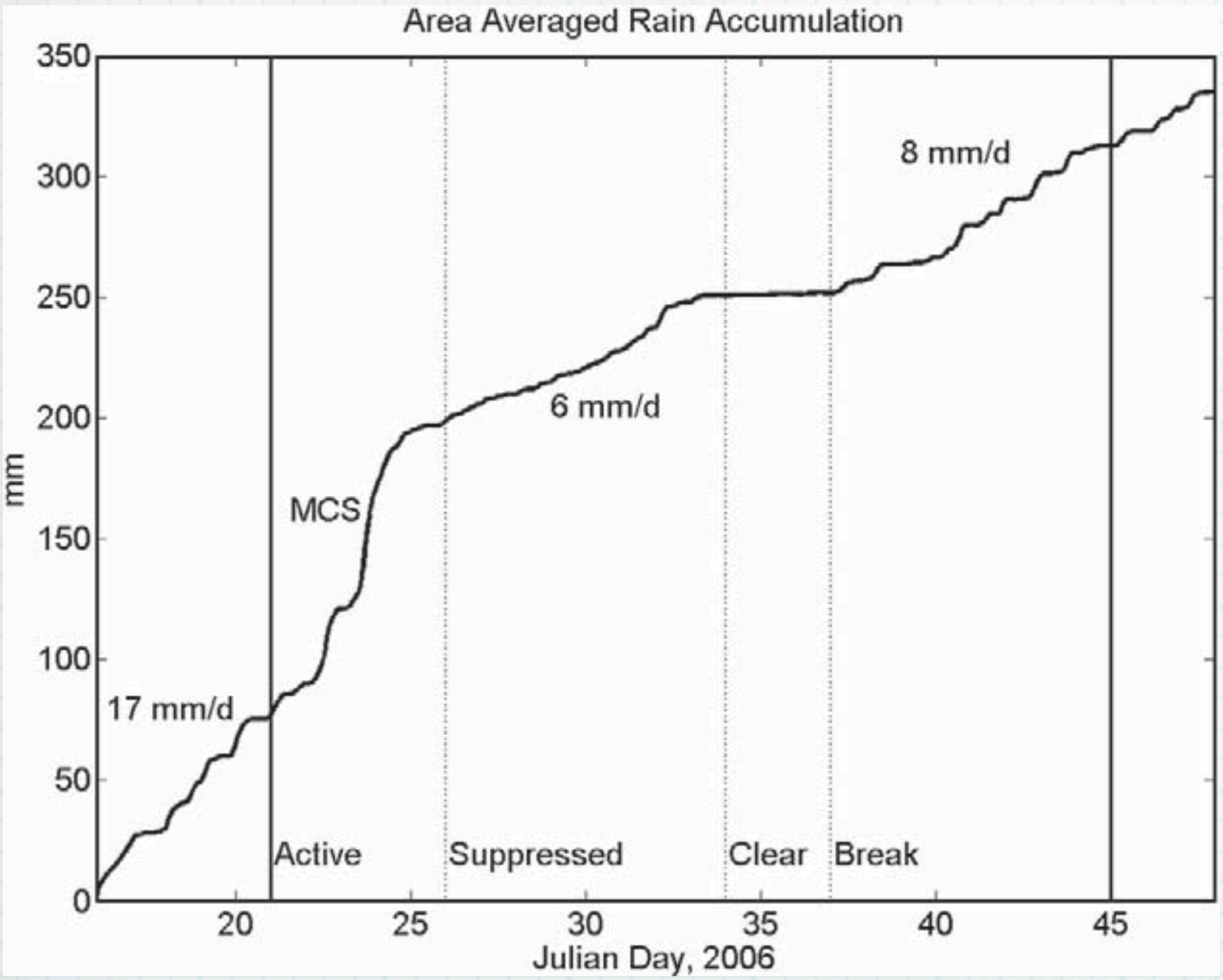
TWP-ICE
Jan/Feb 2006

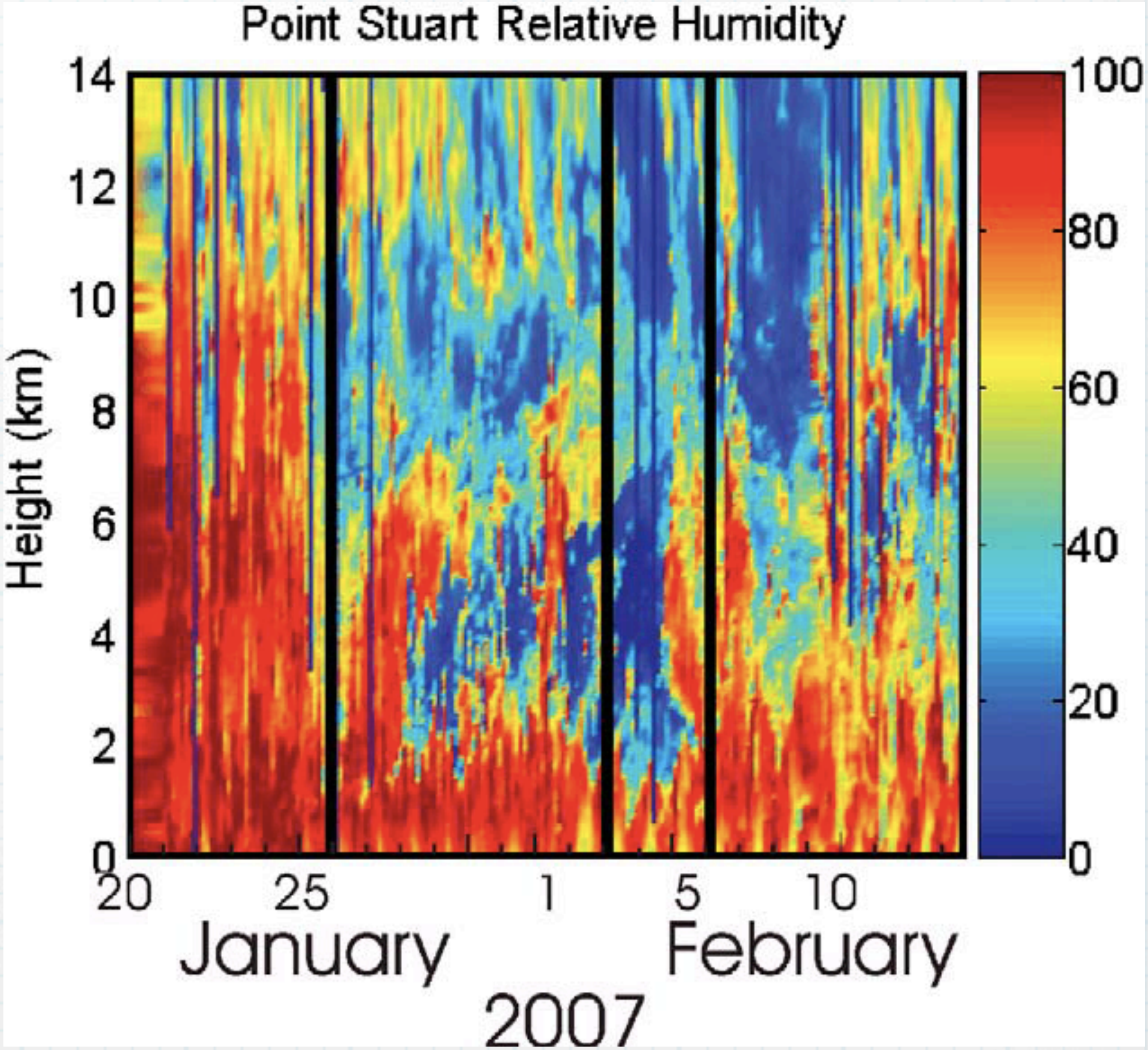
Australian monsoon season

3-h radiosondes at 5 sites

Area mean rainfall from radar estimates

TWP-ICE





May et al., BAMS, 2008

The variational analysis tool

Calculate divergence using radiosonde observations by:

$$D = \frac{1}{A}\int\int\left(\frac{\partial u}{\partial x}+\frac{\partial v}{\partial y}\right)dA = \frac{1}{A}\oint(udy - vdx)$$

and similar for advection terms under constraints given by vertically integrated equations, e.g., for moisture:

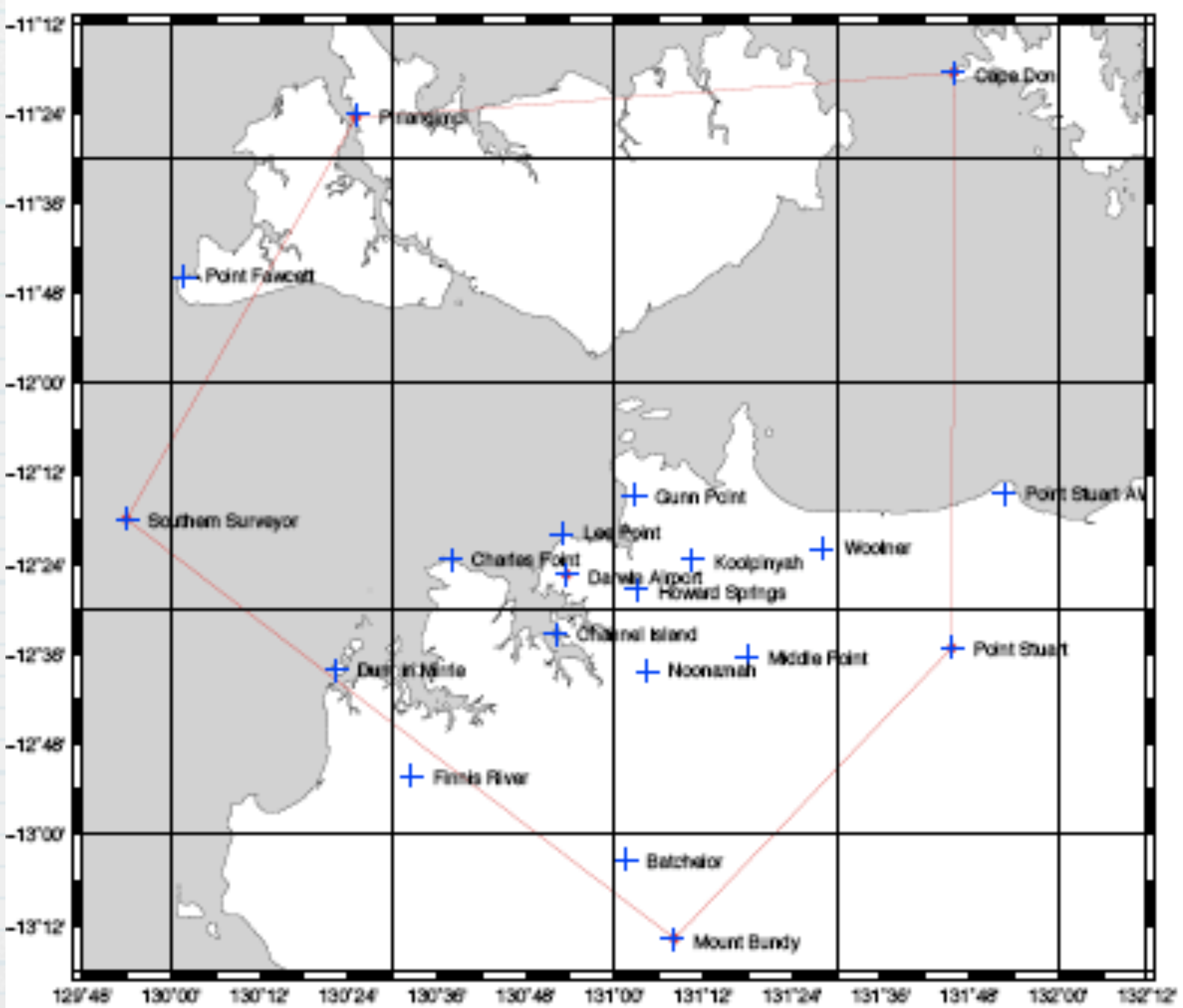
$$\frac{\partial\langle q\rangle}{\partial t} + \langle\nabla\cdot\vec{V}q\rangle = E_s - P$$

Similar constraints exist for mass, heat and momentum.

In practice the method "wiggles" the radiosonde information within observation error boundaries to achieve divergence and advection terms that are in balance with the constraints.

Zhang. M.H., and J. L. Lin (1997), Constrained Variational Analysis of Sounding Data Based on Column-Integrated Budgets of Mass, Heat, Moisture and Momentum: Approach and Application to ARM Measurements, J. Atmos. Sci., 54, 1503-1524.

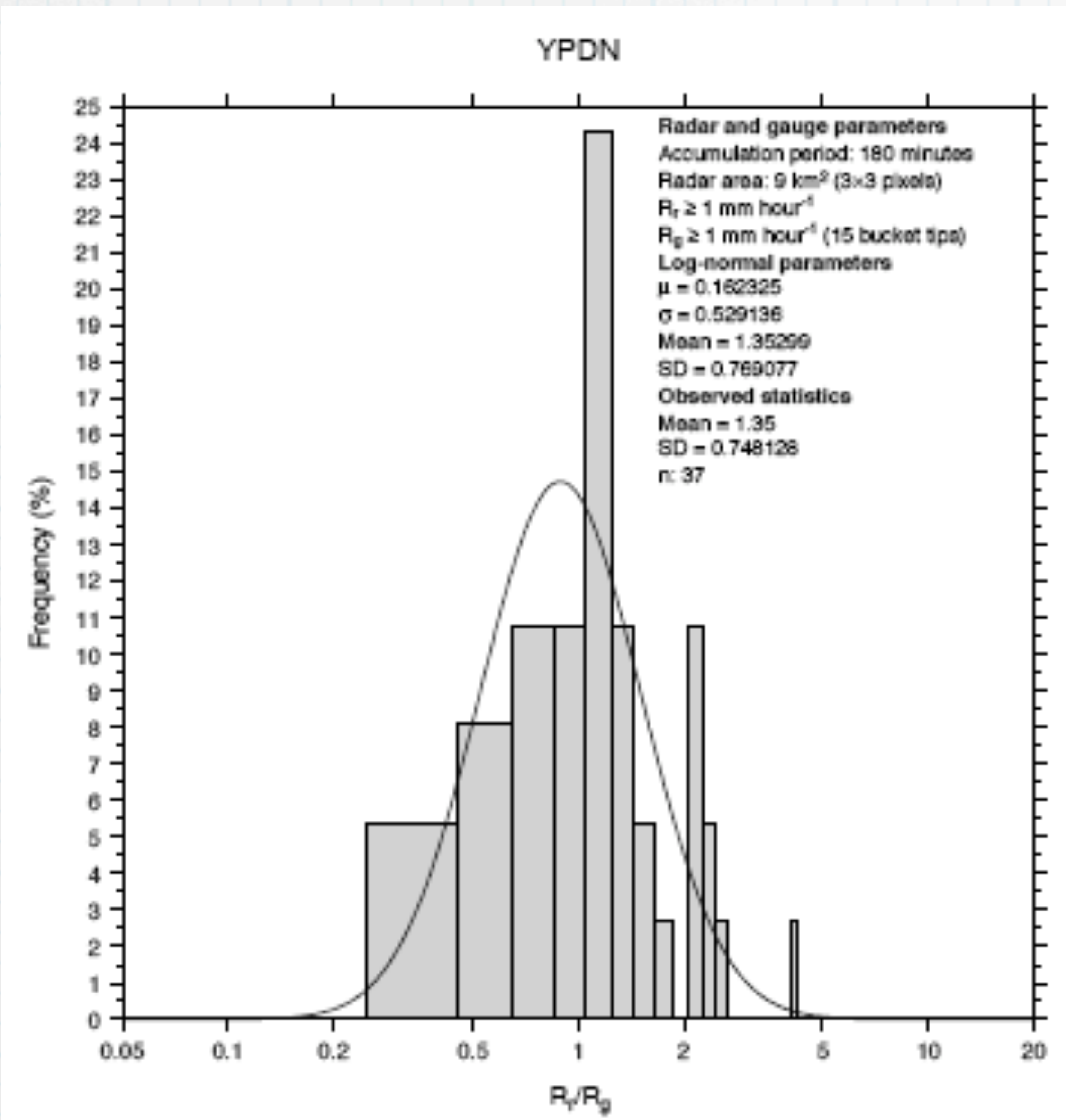
ESCM - Observed forcing



TWP-ICE domain

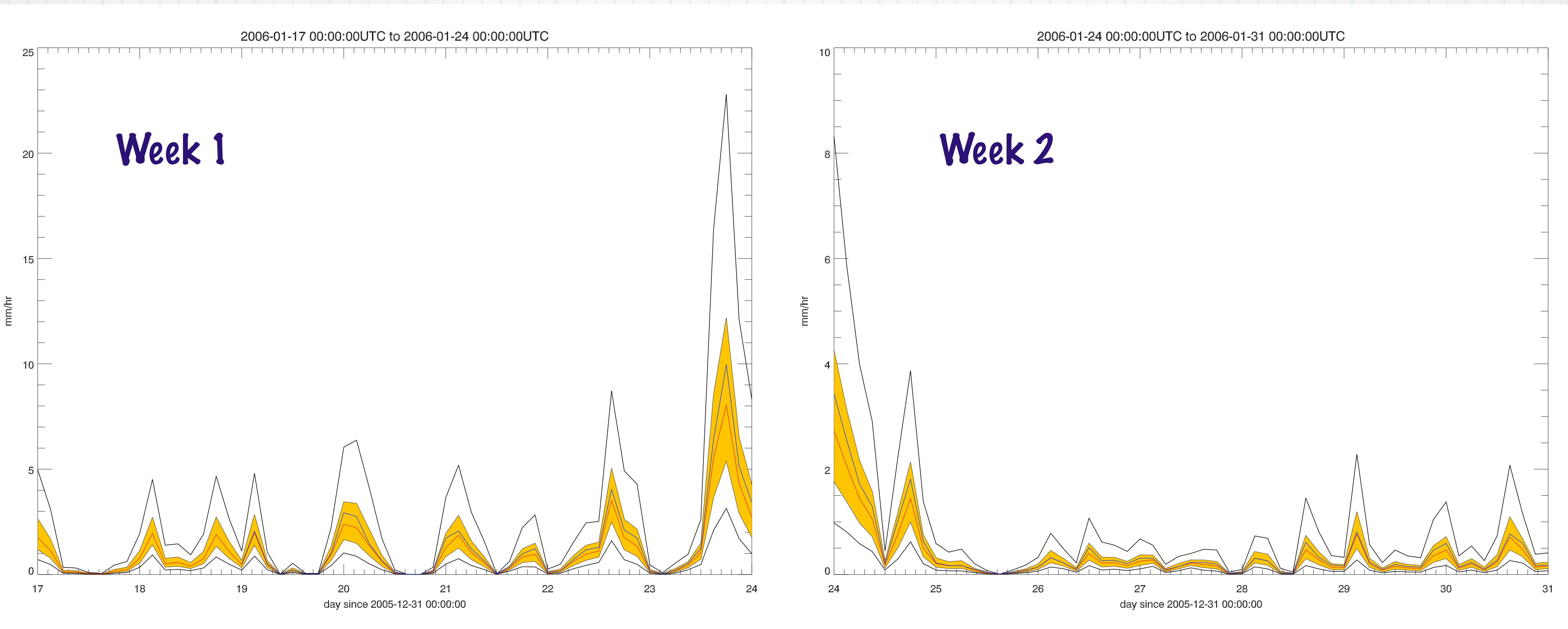
* Radiosonde u, v, T, q
* Domain-average TOA radiation
* Domain-average rainfall
* Domain-average surface fluxes (turbulent and radiation)
* Surface meteorology

Area mean rainfall scenarios



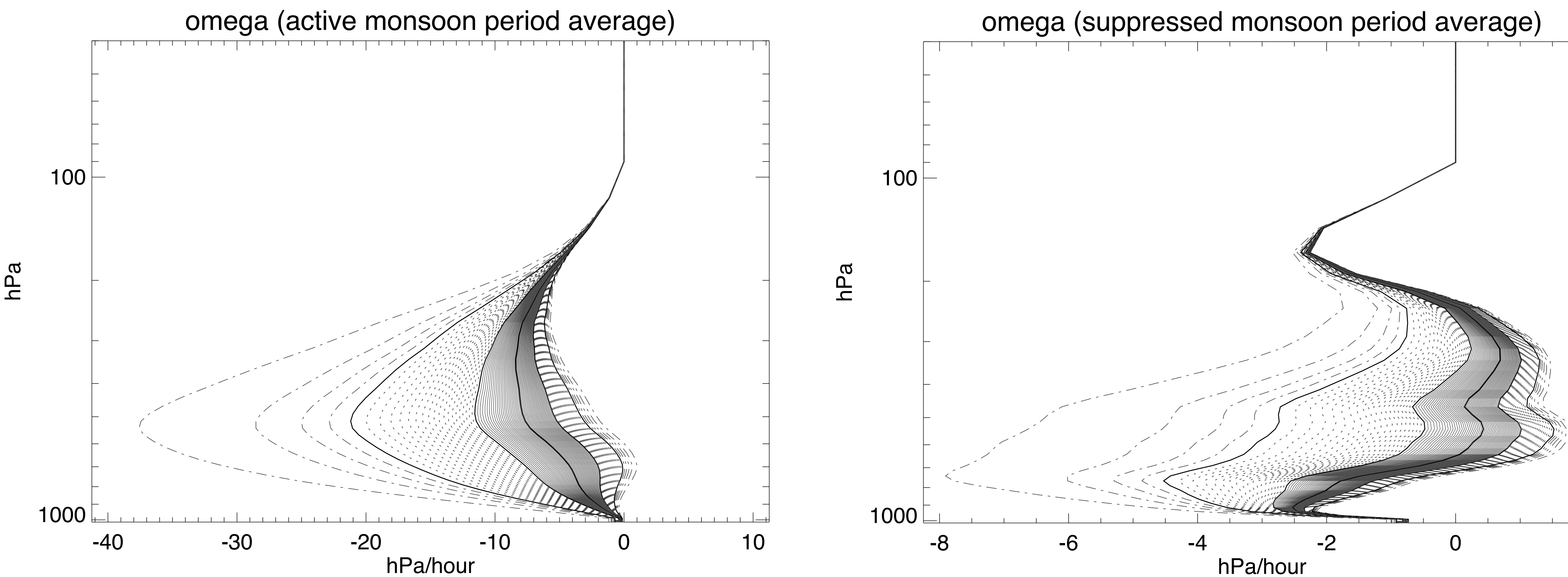
* Assess errors at pixel level against gauges (see left)
* Assign error distribution to each pixel using nearest gauge error estimate
* Assume maximum correlation of error in space and time
* Derive 100 area-mean rainfall scenarios (think: percentiles of the rainfall pdf)
* Feed the 100 scenarios into the variational analysis to yield 100 forcing data sets

Rainfall scenarios



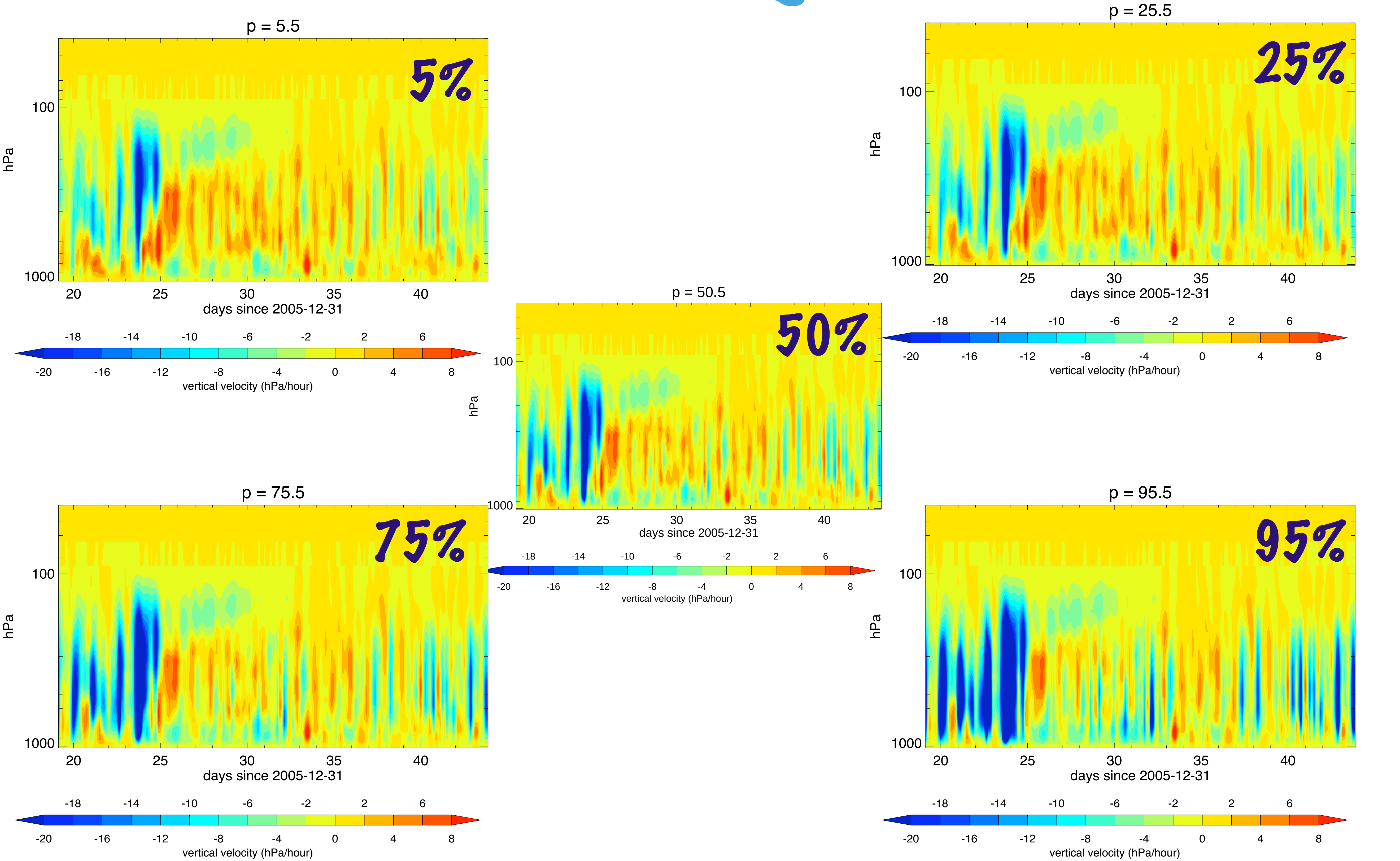
Rainfall scenarios (note change of scale) derived for week 1 and 2 of TWP-ICE

ESCM forcing data set

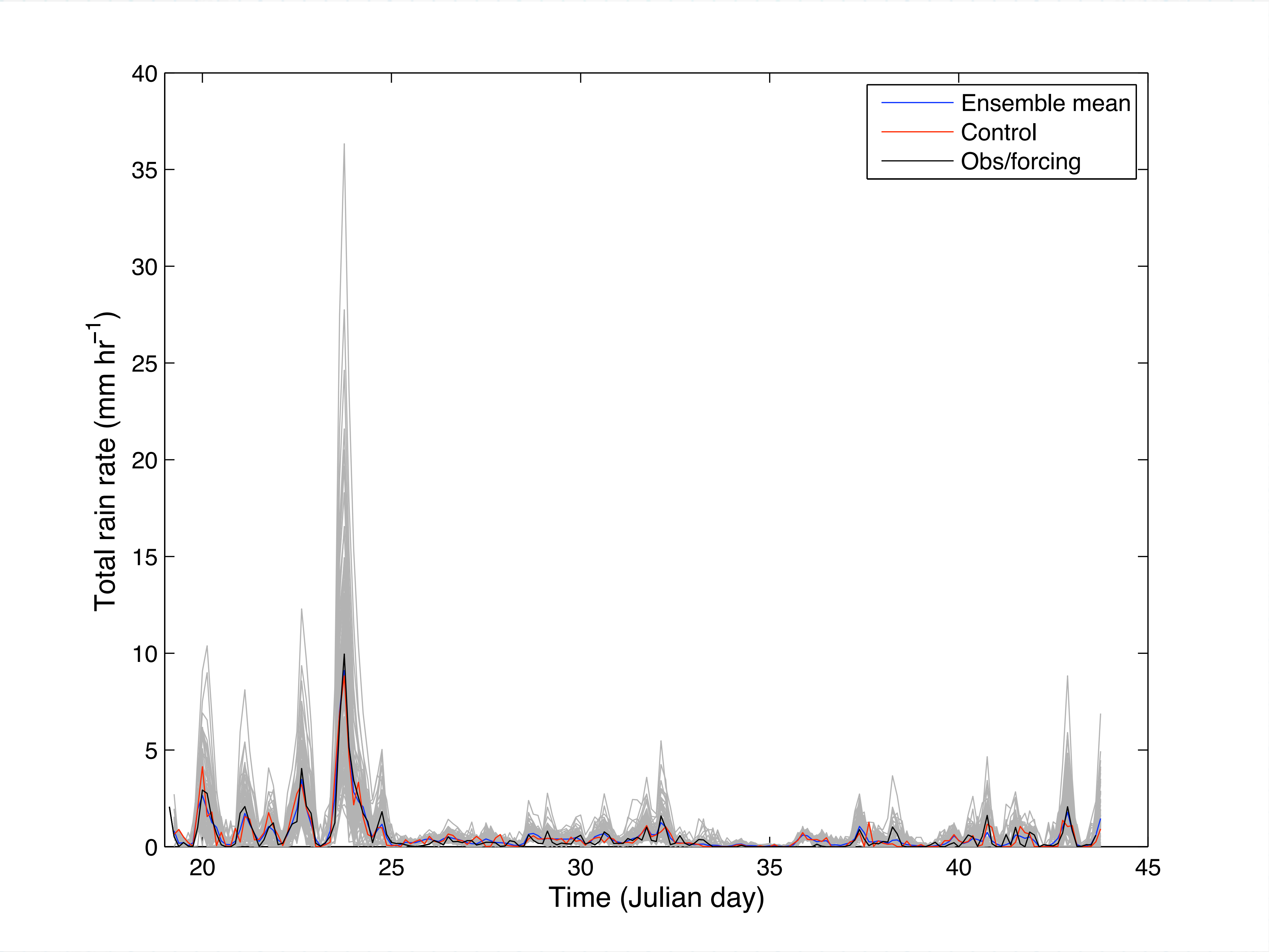


Vertical velocity

ESCM forcing data set

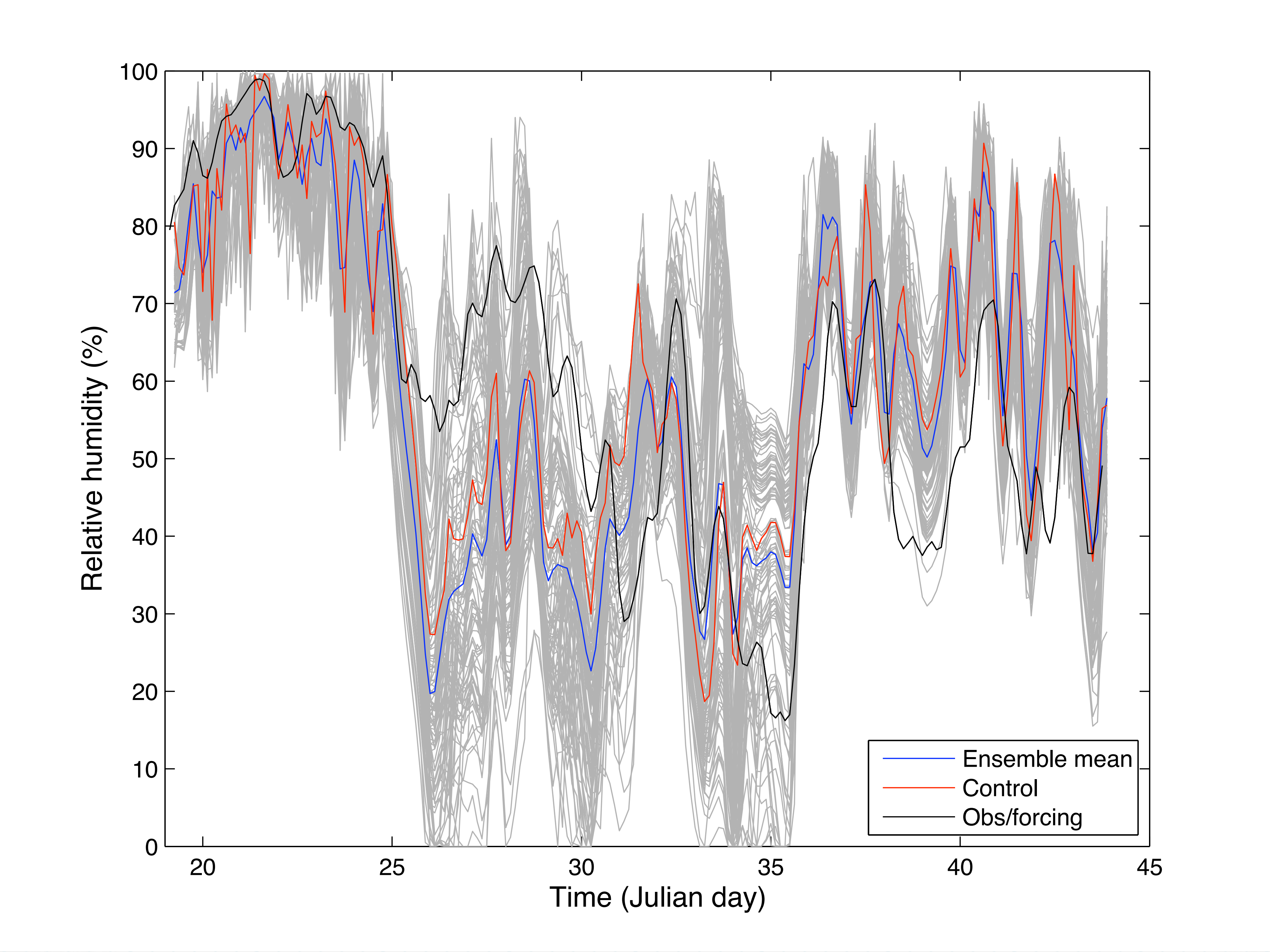


Application to an SCM



Rainfall

Application to an SCM



Relative humidity at 500 hPa

Conclusions

* Forcing errors can be large and some method to account for them is necessary
* ESCM for observations in TWP-ICE appears essential, but it is too early to tell how well it works
* Applying the method to more models (incl. some CRMs) seems a sensible next step -> TWP-ICE SCM intercomparison will include ESCM component
* ESCM technique will allow to look at model sensitivities as well as mean results -> this will likely be REALLY interesting