Towards an Ensemble System with a Stochastic Convection Scheme

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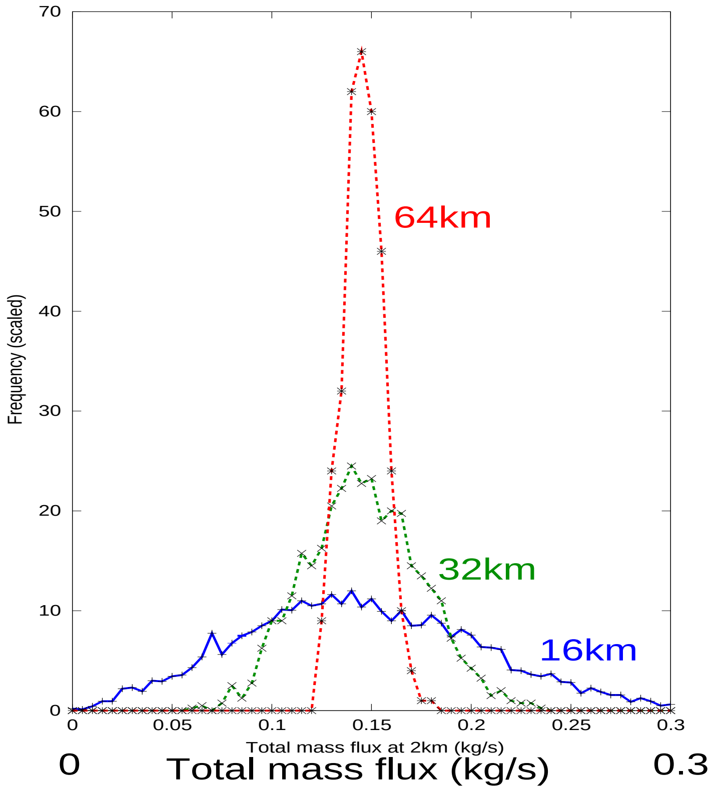
Aims

- To construct a regional ensemble which combines initial condition uncertainty and sub-grid variability
- Perform case study evaluations using CSIP cases
- A focus is on understanding the behaviour and assessing the usefulness of a stochastic deep-convection scheme

Why Stochastic? In Theory

- A deterministic scheme gives unique increments due to convection for a given large-scale state
  1. This assumes an equilibrium, with the forcing scales being large compared to the intrinsic scales of the convection
  2. It also assumes the model grid scale to be large compared to the intrinsic scales
- If (1) holds but (2) breaks down then convection on the grid scale is unpredictable but will be drawn from an equilibrium distribution
- Then a stochastic parameterization is required

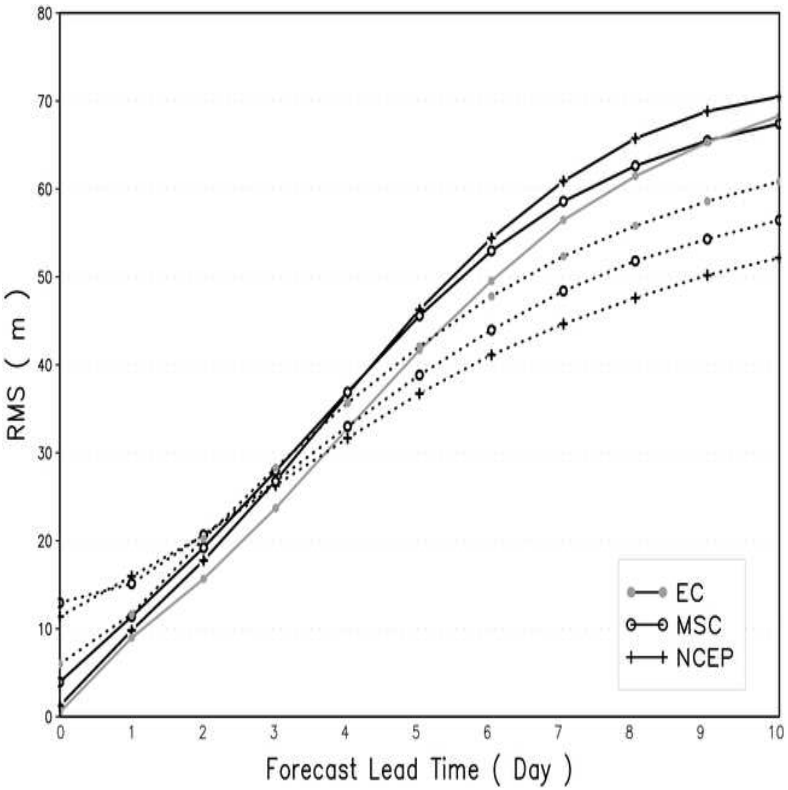
Why Stochastic? In Practice



Distribution of mass fluxes in CRM simulation of radiative-convective equilibrium over ocean.

- Wide range of sub-grid states are possible
  1. Deterministic scheme aims to calculate their ensemble mean effect
  2. Stochastic scheme aims to account for fluctuations
- Fluctuating component of sub-grid motions may have important interactions with large-scale

Possible Benefits



Buizza et al (2005)

May solve known problems with current approaches:

- NWP models have insufficient ensemble spread (improvement expected)
- GCMs have insufficient variability in tropics (improvement likely)

Some Stochastic Experiments

- In ECMWF ensemble system, scale parameterization tendencies,

$$\text{Tendency} = \text{D} + (1 + \varepsilon)\text{P}$$

  Improves ensemble spread

- Bright and Mullen (2002): stochastic perturbation to KF trigger

  Increased skill and dispersion of short-range precipitation forecasts

- Lin and Neelin (2002): add noise to CAPE closure of Zhang/Macfarlane scheme

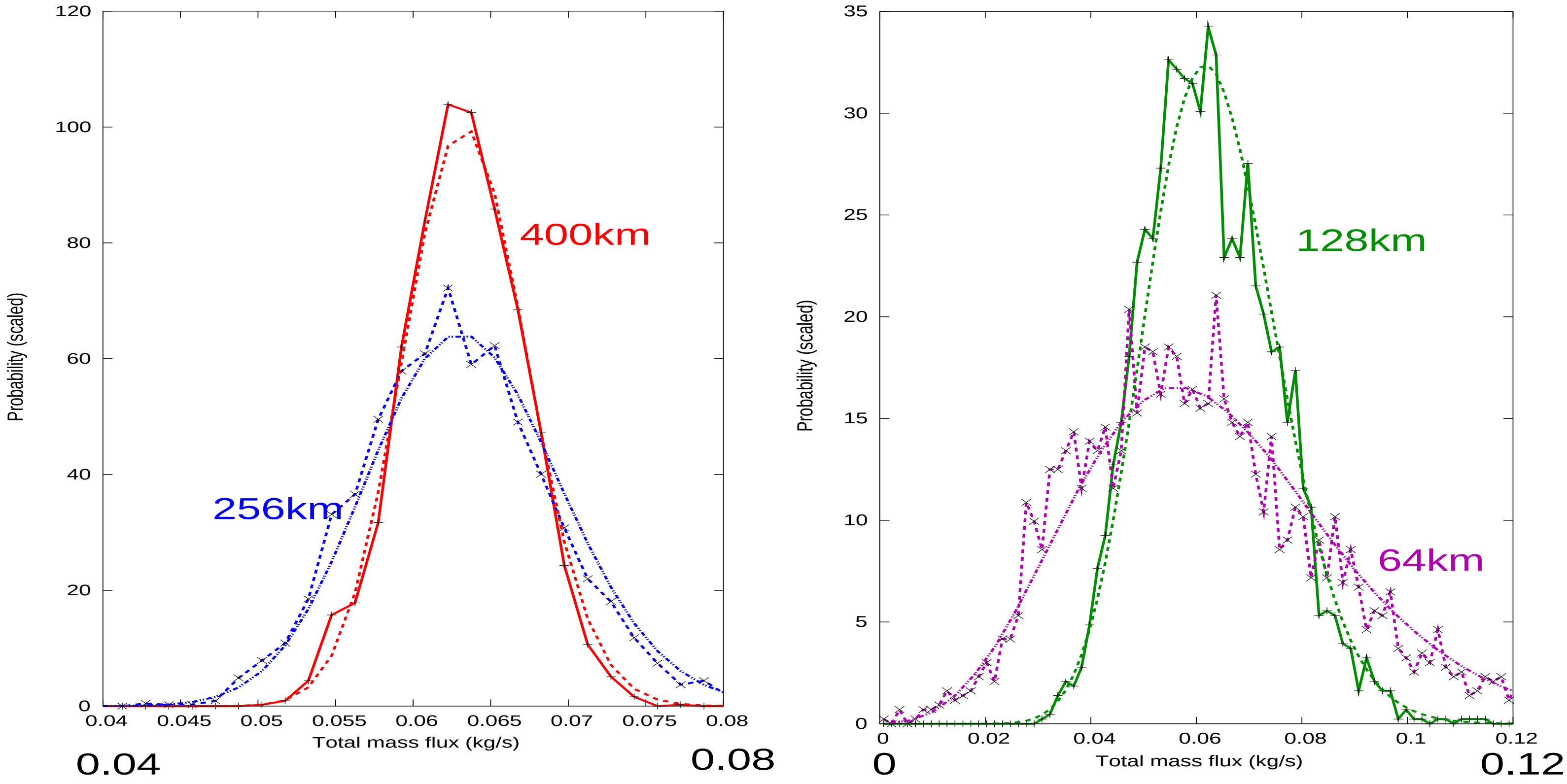
  Increase variance of daily tropical precipitation

Stochastic Scheme

- Character and strength of the noise has a physical basis, supported by CRM studies (Cohen and Craig)
- Mass-flux formalism with spectrum of possible plumes from known exponential distribution at cloud base
- Behaviour of each plume based on modified Kain-Fritsch plume model
- CAPE closure with timescale that depends on forcing. Based on full spectrum and performed for the non-local, large-scale state
- Clouds persist for finite lifetime

Idealized Tests

Extensively tested in SCM; eg, desired distribution of total mass flux reproduced for different-sized areas



The Ensemble System

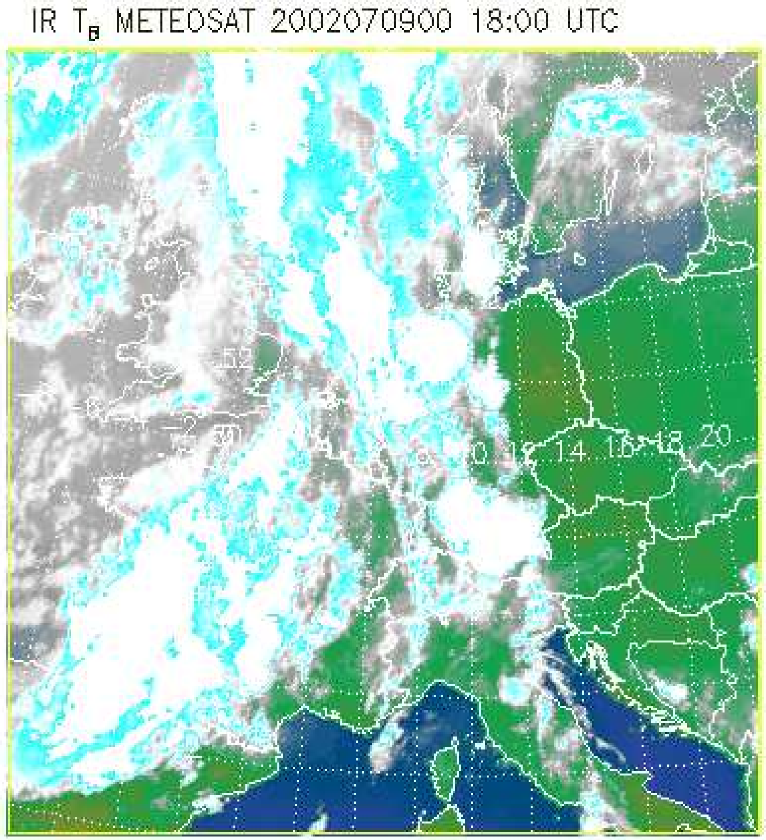
COSMO-LEPS regional ensemble (eg, Marsigli *et al.* 2004)

1. Identify 10 clusters from ECMWF 51-member, twice-daily global ensemble
2. Clustering focuses on synoptic pattern and specific humidity
3. Determine representative member from each cluster
4. Use this to provide initial and boundary conditions for a regional model (DWD Lokal model)

Performs better than global ensemble for position and intensity of local, severe weather

Example of Use

IR brightness temperatures at 18Z on 9th June 2002, T+12.



Meteosat image

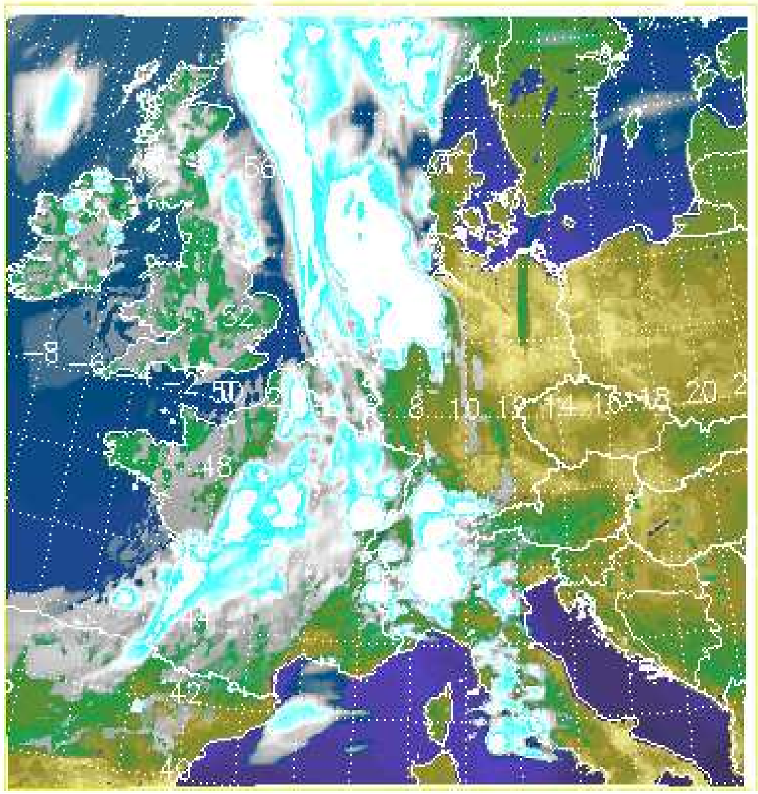
Tiedtke scheme

Example of Use

IR T_B predicted by LM using RTTOV 2002070906 012:

Kain-Fritsch scheme

IR T_B predicted by LM using RTTOV 2002070906 012:



Stochastic scheme

Issues to Address

- How often, and in what circumstances, does the stochastic variability matter?
- Trade-off between runs with different initial conditions and different realizations of stochasticity?
- Comparison with simpler methods for introducing stochastic variability?
- Do the answers to these question change with model resolution?

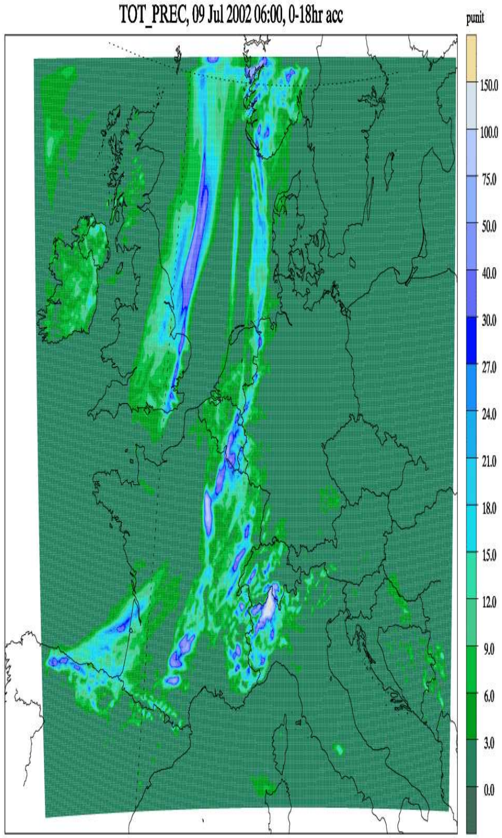
Also:

- Assist in understanding the triggering of events in CSIP

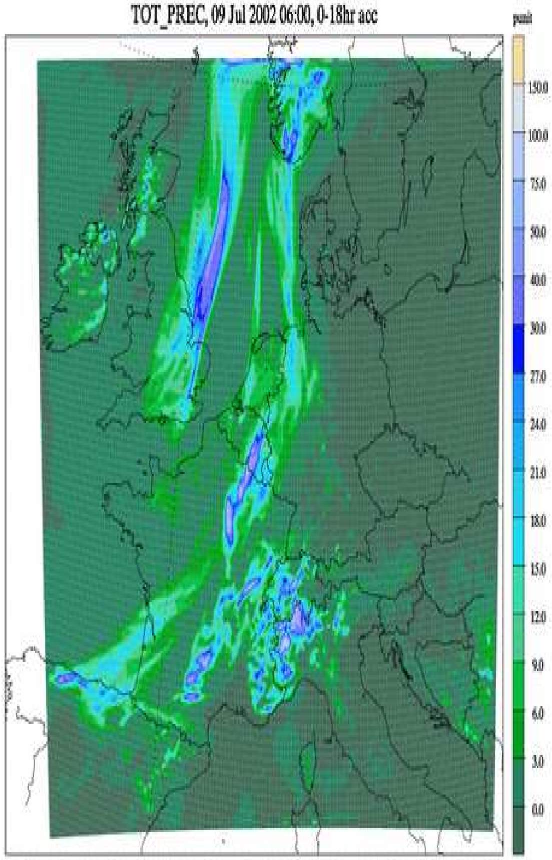
Extra slides...

Example of Use

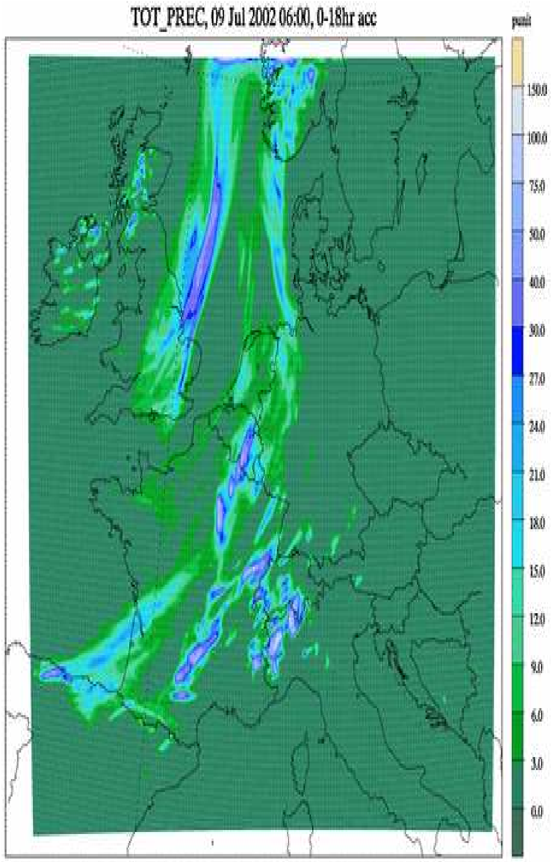
Accumulated precipitation on 9th June 2002, up to T+18.



Tiedtke



Kain-Fritsch



Stochastic