Convective Scale Ensemble for NWP

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Outline

Introduction

Ensemble Prediction Systems for NWP have been around for over a decade

- are successful and very common
- are based on techniques which are linear in character
- main target synoptic weather systems (1000 km)

At the convective scale

- thunderstorm (10 km) & organised convection (100 km)
- explicitly model clouds, need grid spacing of 1 km (or less)
- affordable only recently, on NWP type of domain

EPS are in their infancy

The Problem

- natural threshold
- initiation:
  timing and location
- several processes involved:
  - μphysics & aerosol
  - g-waves
  - cold pool
  - ...
- interaction with the larger scale

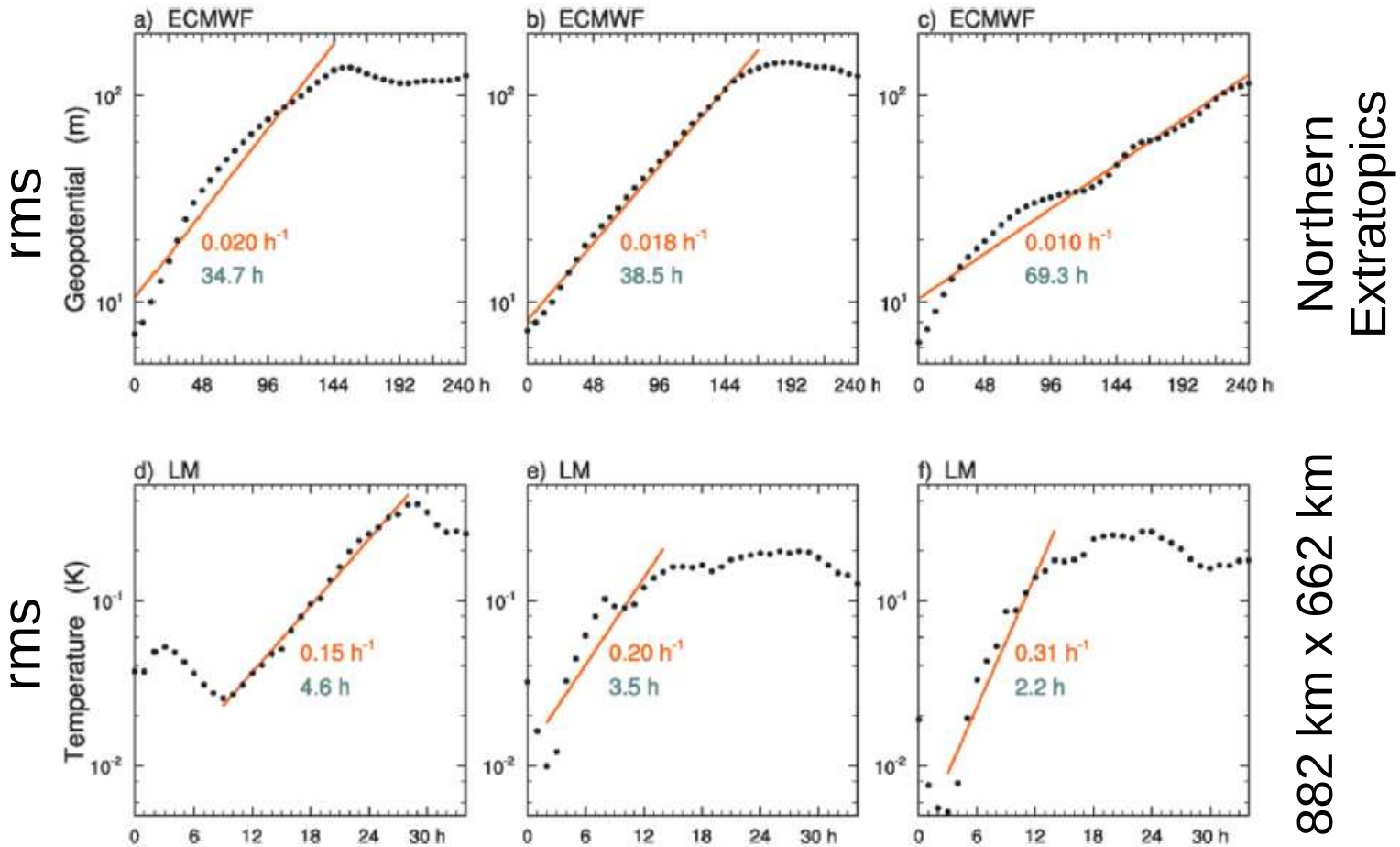
most of these processes correspond to specific *parameterisations*

The Problem

- several processes are strongly coupled
  - strong nonlinearities

Strong Nonlinearities

Hohenegger and Schar, 2007



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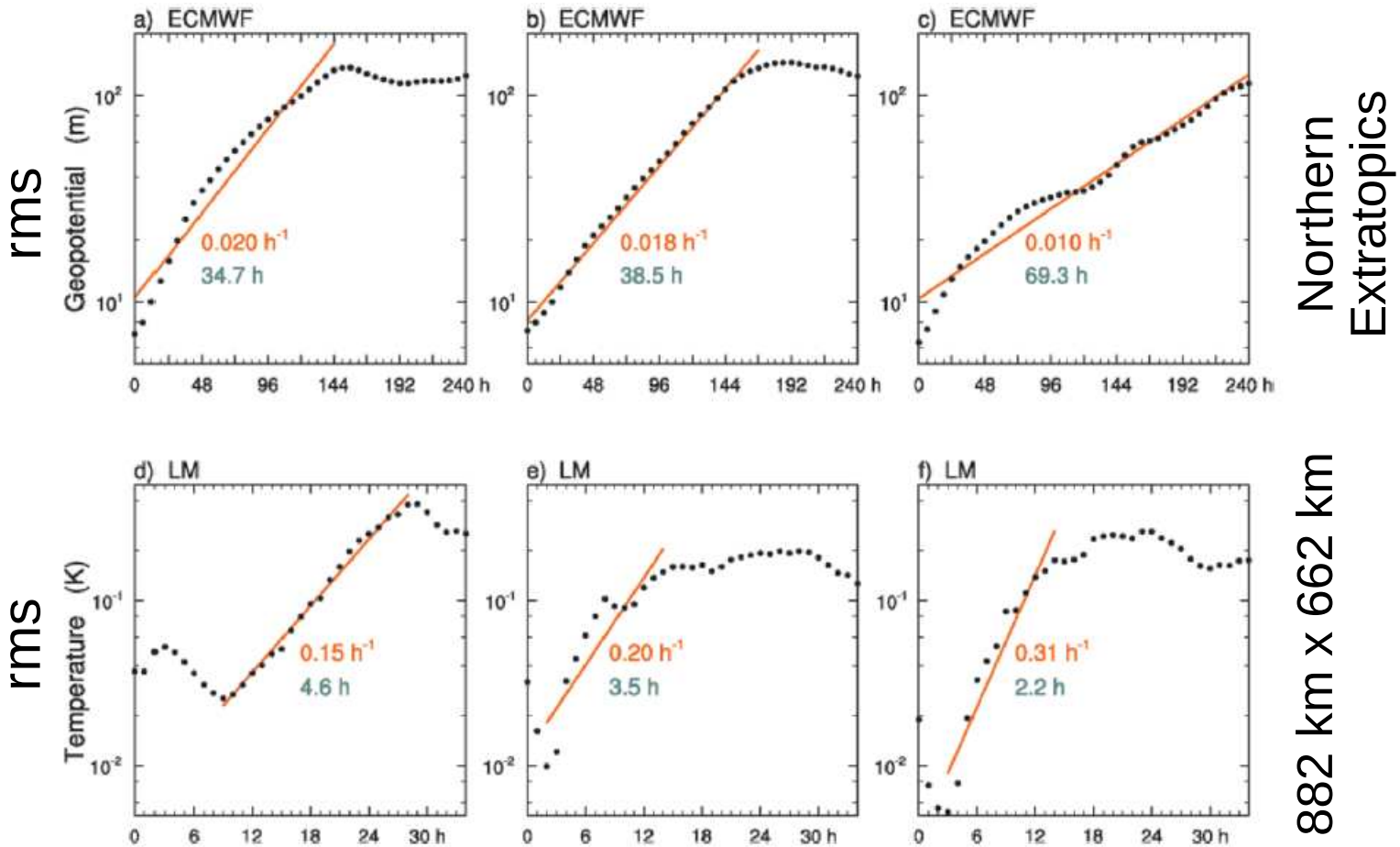

Error doubling time: a few hours, not days

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- we lack a comprehensive theoretical framework
  - convective equilibrium

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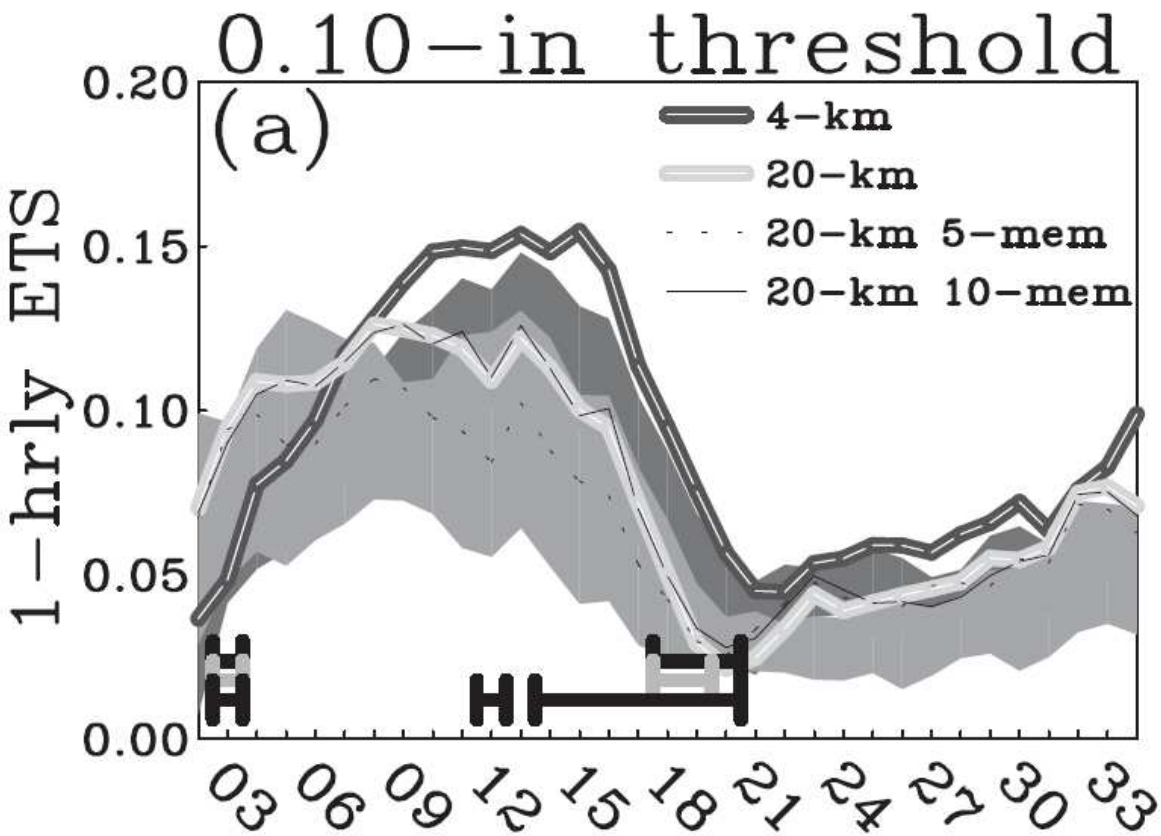
  - convective equilibrium
- threshold $\Longrightarrow$ bimodal pdf
  - LBC

High Resolution improves NWP

Clark et al, 2009



can we understand uncertainty of LowRes without HiRes?

Met Office Strategy

Development of a 1.5 km 'downscaling' ensemble system at the Met Office

- Embed UK 1.5 km model forecasts in selected MOGREPS (24 or 18 km) members
- Based on evidence that mesoscale uncertainty has the greatest impact on the accuracy of local weather forecasts
- Selection required because it will only be possible to run a few members at 1.5 km
- Target high-impact weather 12 to 36 hours ahead
- Case-study work started
- Demonstration system by 2012

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Sources of Uncertainty

- data:
  - representativity
  - no clear balance
- Later Boundary Conditions:
  - larger scale is uncertain as well
- model error:
  - *mostly* due to parameterisations:
    - many are 1D
    - based on equilibrium assumptions
    - often errors are not well known
  - can be divided in:
    - instantaneous (physics)
    - evolution

High Resolution Atmospheric Assimilation

S. Migliorini, R. Bannister, R. Brugge and M. Dixon

HRAA is developing an EPS at the convective scale

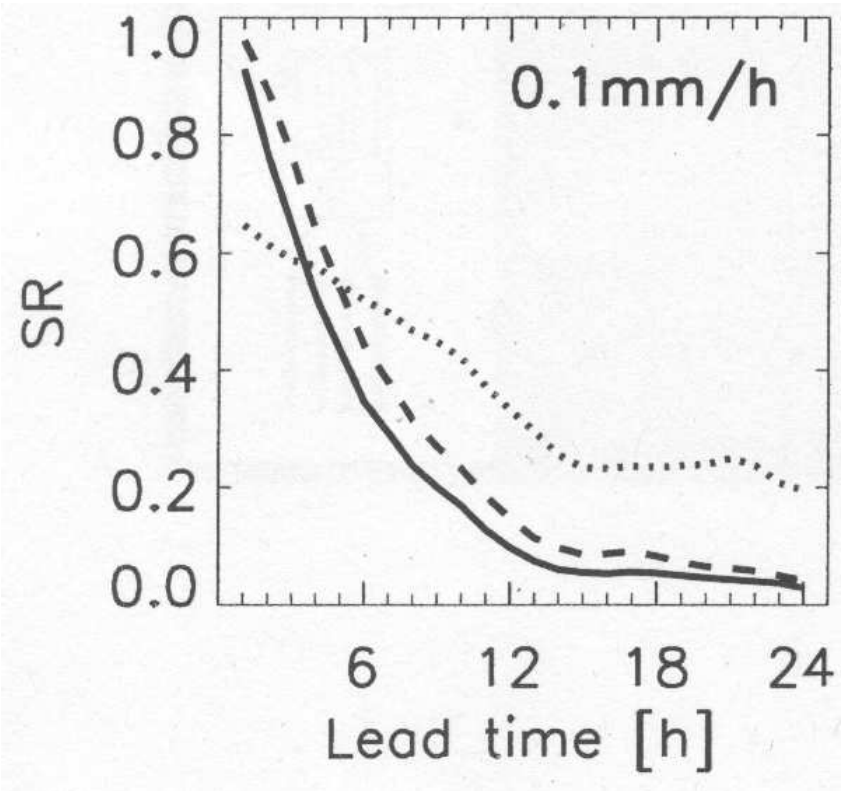
- Unified Model, 1 km, 1 hr cycle
- ETKF provides perturbations for the control forecast (4DVAR)
  - generates ICs for the next cycle
  - or the actual probabilistic forecast

Future plans:

- redesign the 4D Var system off line, using the ensemble
- update the analysis with the ensemble, only
- develop a hybrid system

Lateral Boundary Conditions

Gebhardt et al, 2009 - DWD



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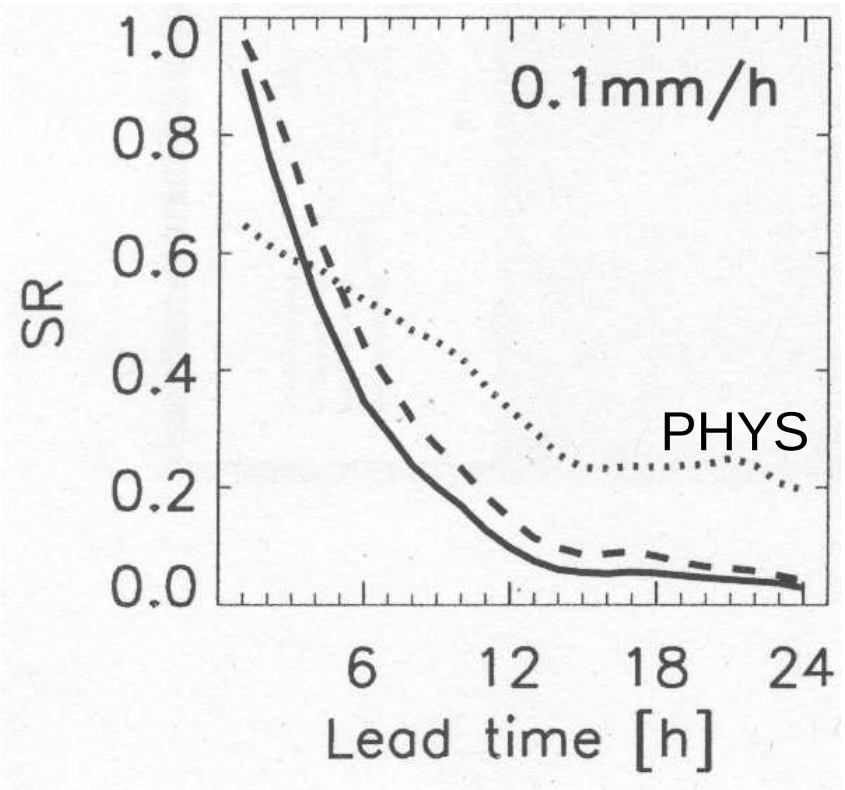

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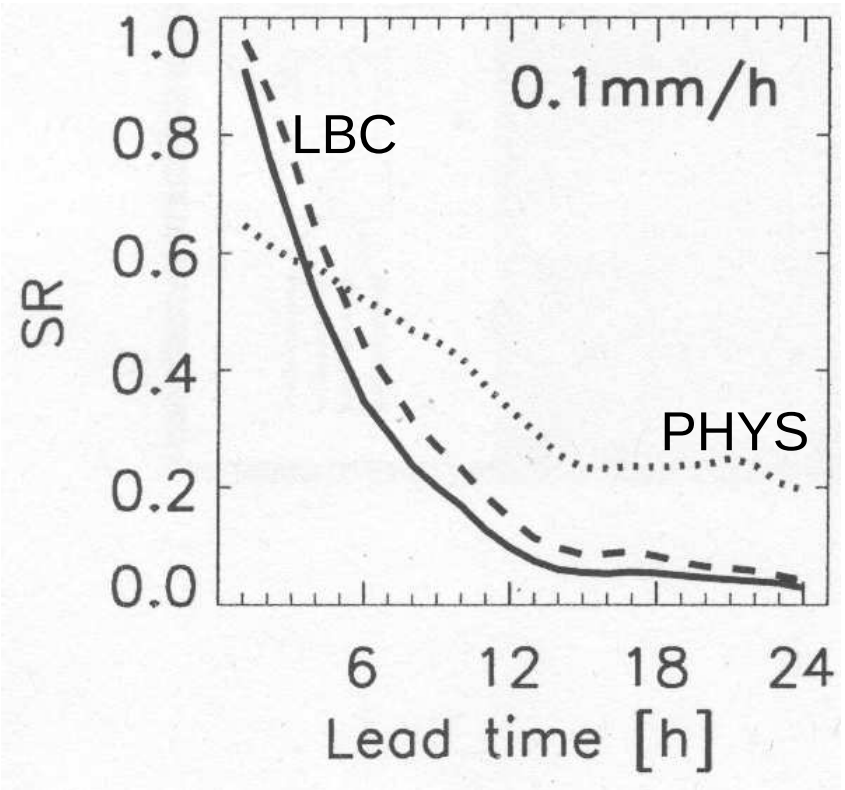

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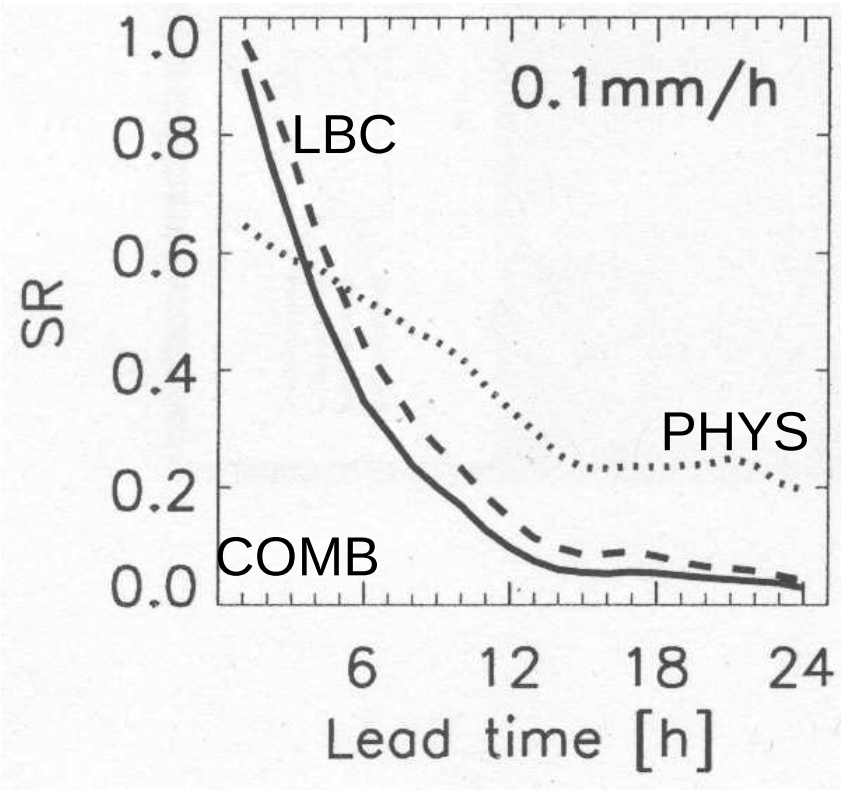

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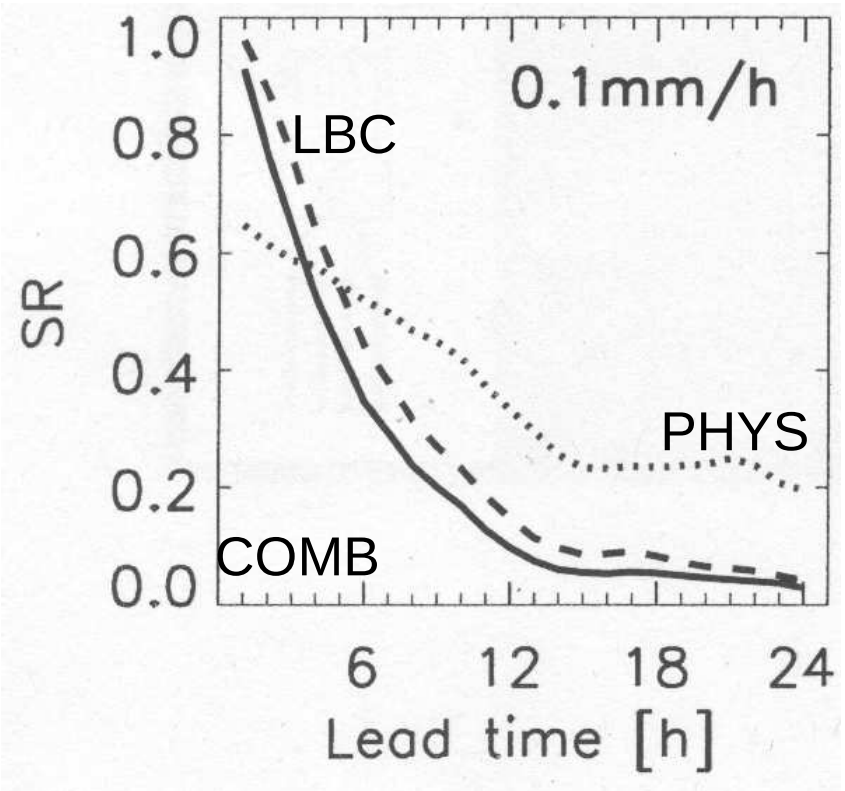

The PHYS dominates up to 6 hr, the LBC afterwards

Model Error

Current directions:

- change parameterisation (Clark et al,2009)
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  - every 30 minutes

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  - 2D random, with horizontal scale
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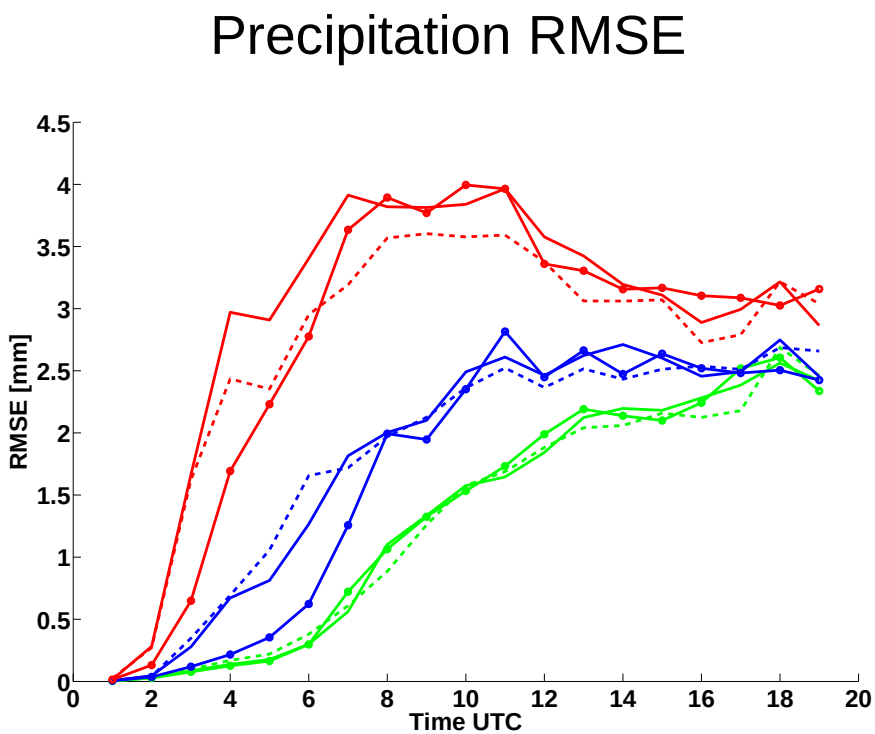
not exhaustive, but understandable:

- processes are related to error growth
- perturbation v parameterisation changes
- size

Which processes determine error growth?

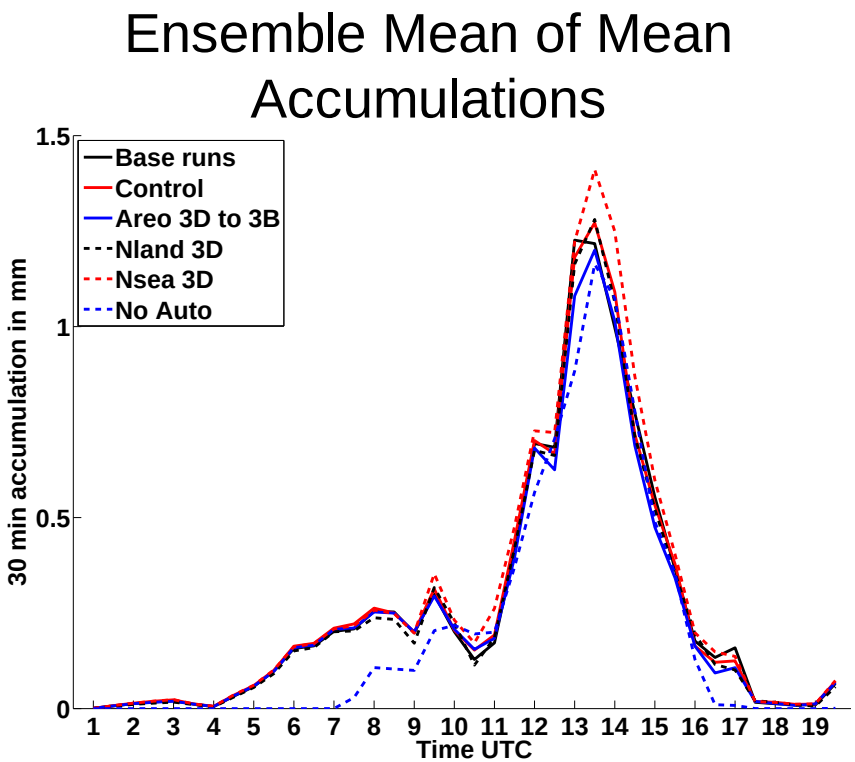
- addition/removal of a "lid"
- acoustic waves
- PBL parameterisation changes
- vertical motion



Perturbation v Parameterisation

Boscastle Flood 2004

- 5 ensembles
  - standard UM, 1 km
  - 4 realisations of warm μphysics
- Ensemble mean of the mean accumulation over Boscastle
- the perturbation seems to capture the variability of the physics
- cloud dynamics is slightly altered



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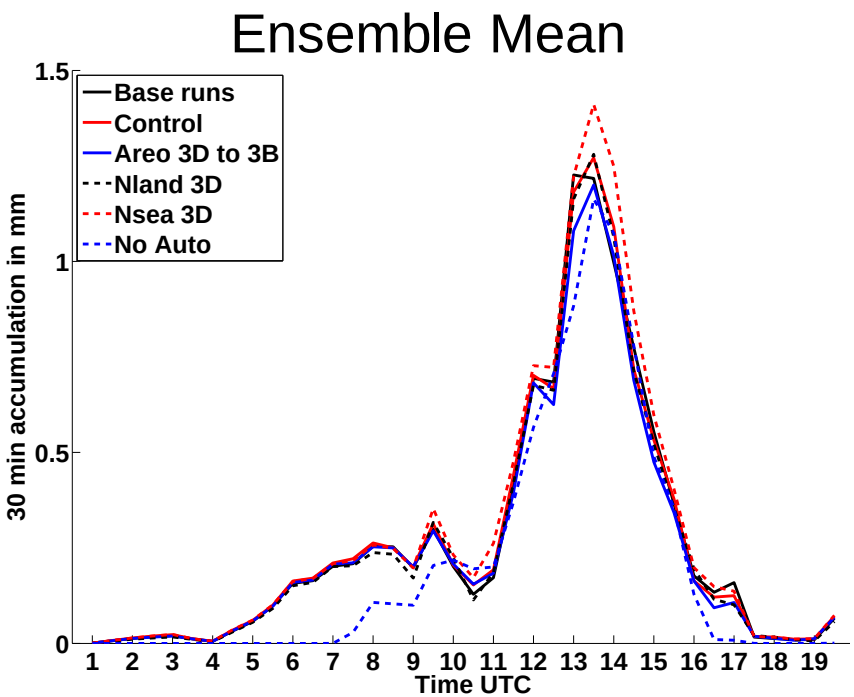
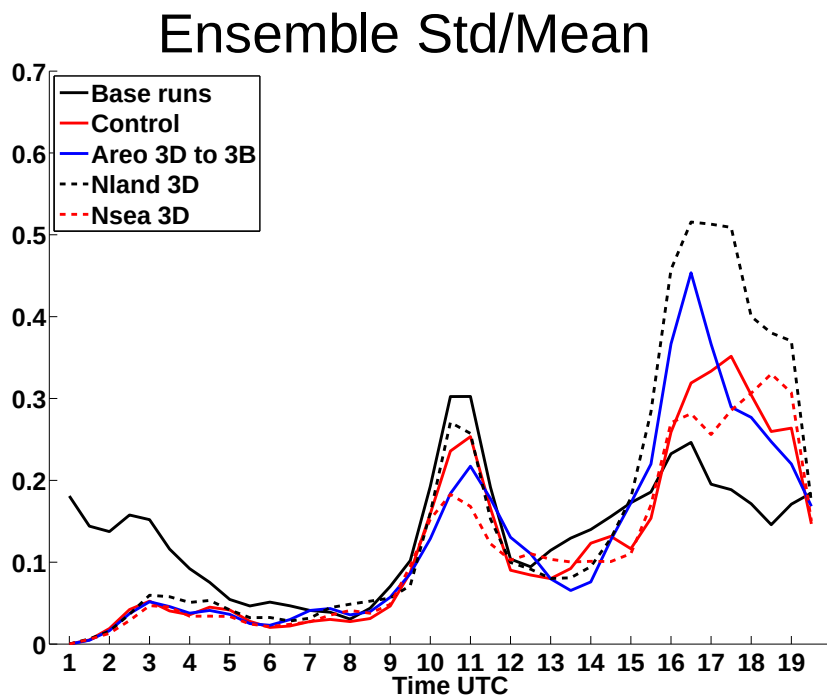
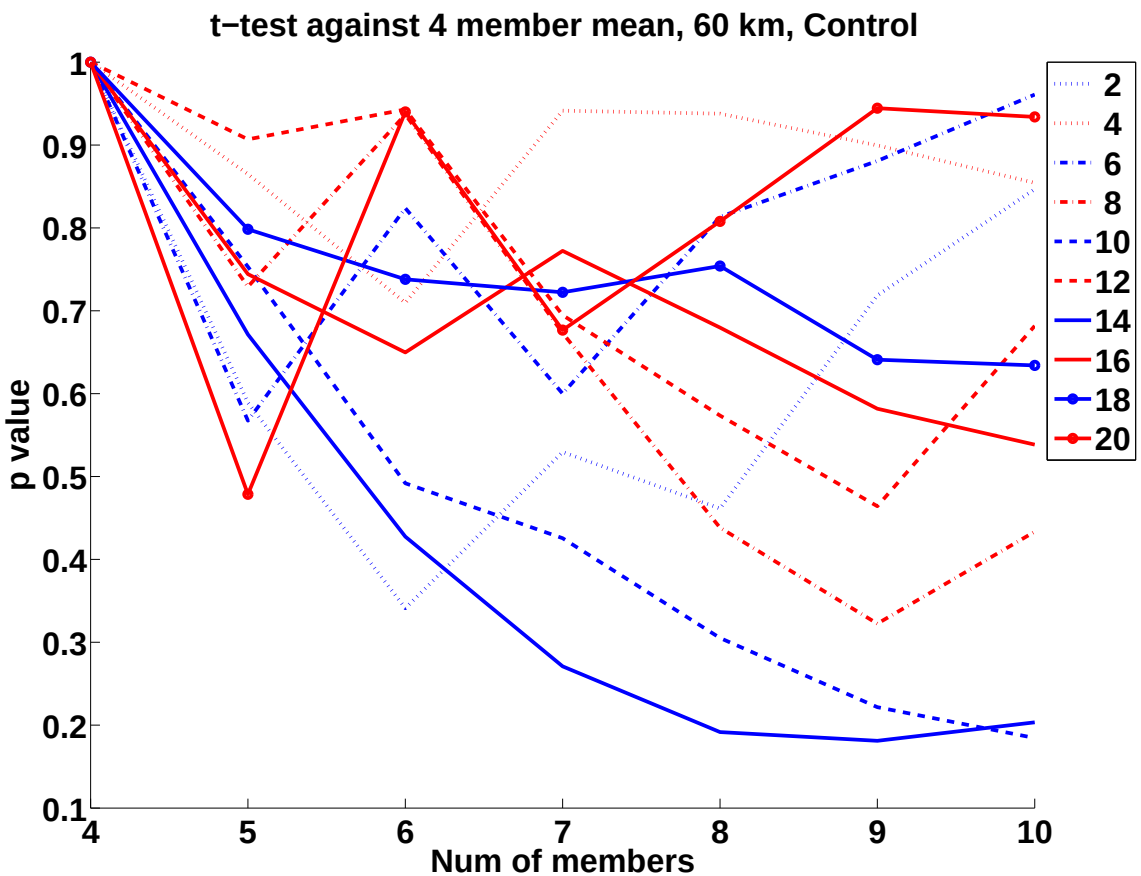




How many members?

T-test of the ensemble means



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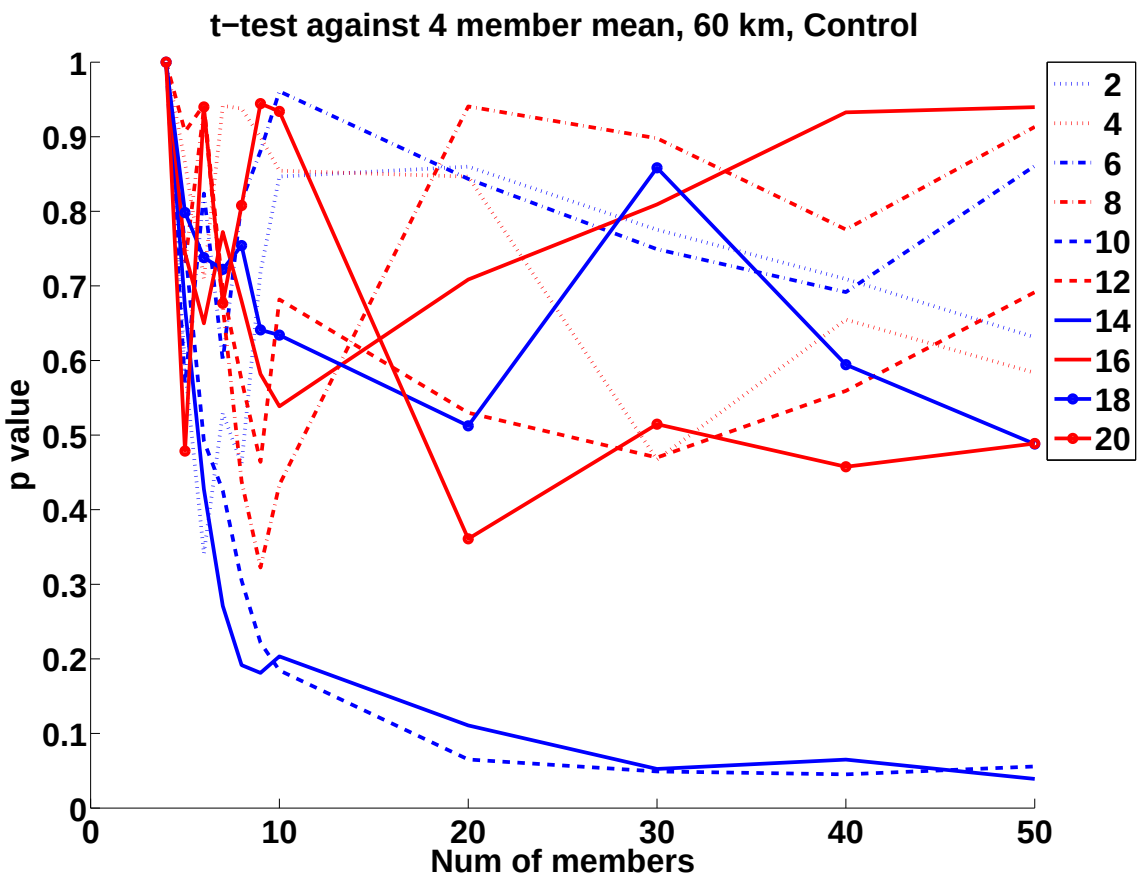

The Challenges Ahead

- better representation of processes and feedbacks
- characterise model error
  - What is model error?
  - What are the time/space scales?
  - Do they change with weather regime?
- size
- what are the growing modes?
- bimodal pdf?
- comprehensive verification?