# Error Growth at the Convective Scale

G. Leoncini[1] R. S. Plant[1] S. L. Gray[1]
P. A. Clark[2]

[1]Meteorology Department, University of Reading
[2]Met Office, Joint Centre for Mesoscale Meteorology

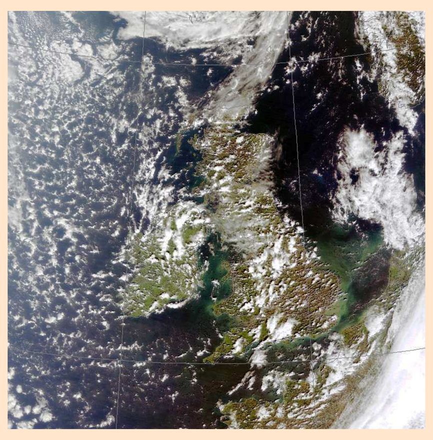
## Large Scale

Aims:

- processes involved in *error* propagation
- general overview of model response to perturbation
- introduce novel perturbation technique

### The event

- good large scale forecast
- tropopause fold
- interesting mesoscale features:
  - surface forcing
  - scattered convection
  - MCS within domain
  - cold pools



### Experiments

Standard UM 6.1, 4 km grid spacing

Single Perturbations:

- IC
- 0700 UTC
- 0830 UTC
- 1000 UTC

Sequential Perturbations:
9 combinations of

- amplitudes: 1, 0.1 and 0.01 K
- scale length ($\sigma$) : 24, 8 and 0 km

- 2 amplitudes: 0.01 and 1 K
- 1 scale length: 24 km

### Processes involved

An analysis of the Single Perturbation simulations shows that the processes involved are:

- CAPE (the 1 K perturbation removes or adds a lid on very few grid points)
- acoustic waves affect the background environment
- Boundary Layer Types:
  - the perturbation causes the boundary layer parameterisation to switch coefficients and/or sub-parameterisation

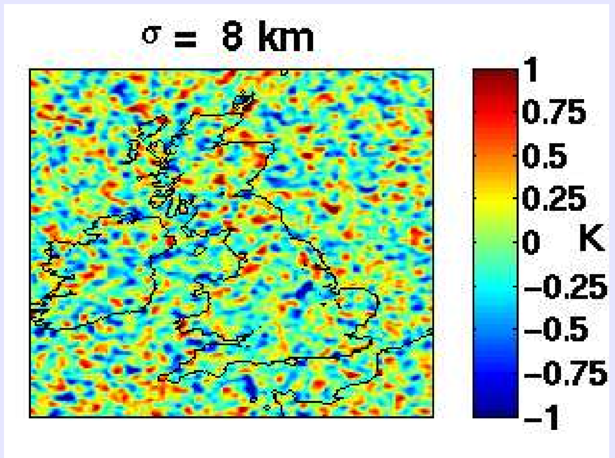
## Introduction

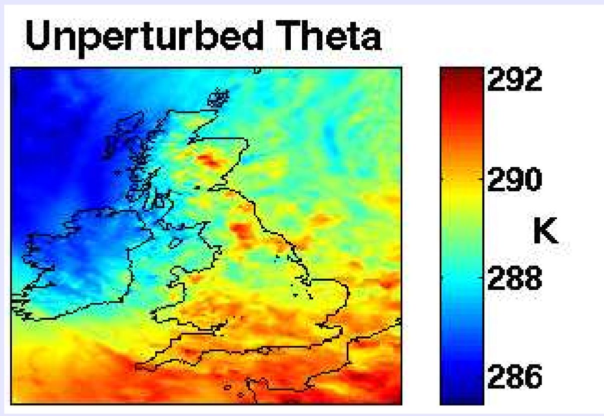
Motivations:

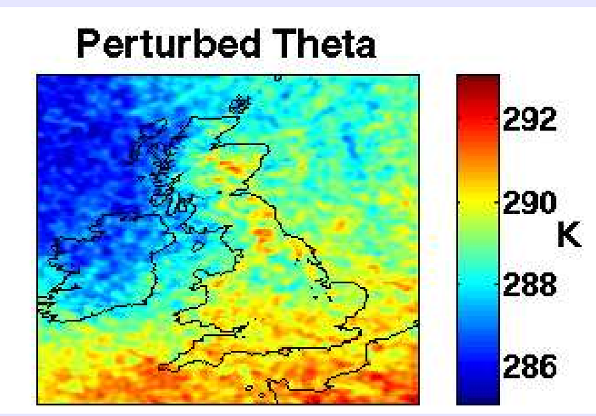
- severe convective events have high societal impact
- their forecast is still a daunting task, because of the uncertainties
- ensemble forecasting exploits data and model uncertainties to provide probabilistic forecasts

## Perturbation

- potential temperature
- applied at fixed model level
  - 0-400 m
  - 500 m
  - 1280 m
  - consistently with Lean (2006)
- at regular intervals (30 mins) with no temporal correlation
  - to capture PBL transitions
- 2D Gaussian kernel applied to random numbers



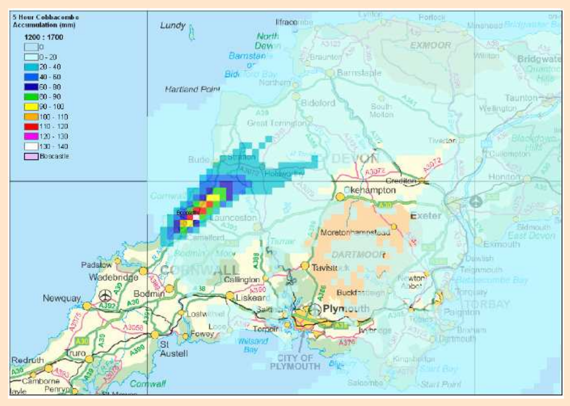

## Storm Scale

Aims:

- verify ensemble technique is useful in a different domain/weather regime
- determine impact on accumulation within an area
- what needs to be changed: $\mu$physics or perturbation?

### The Event

- very intense
- very localised
- interesting mesoscale meteorology
  - near shore convergence line
  - convective cells
  - which precipitate over the same small catchment



Corrected Radar Accumulations from the MetOffice Post Flood Study

### Microphysics

Autoconversion & the UM:

- large cloud droplets collect smaller ones
- if they are larger than a threshold they become rain
- 2 schemes for computing threshold
- each has 2 values of aerosol concentration: over sea & over land

| Scheme | Land | Sea |
|---|---|---|
| 3B | $6.0 \times 10^8$ m$^{-3}$ | $1.5 \times 10^8$ m$^{-3}$ |
| 3D | $3.0 \times 10^8$ m$^{-3}$ | $1.0 \times 10^8$ m$^{-3}$ |

### Experiments

5 unperturbed runs (base runs)

- standard UM 6.1, 1 km grid spacing
- revert 3D to 3B (autoconversion only)
- 3D land aerosol everywhere
- 3D sea aerosol everywhere
- no autoconversion

each base run has an associated ensemble

6 ensembles:

- control (8+1 members)
- 4 $\mu$physics (8+1 members)
- base runs (5-1 members)

Perturbation Strategy:

- use 0.1 K and 8 km
- 8 realisations (i.e. members)

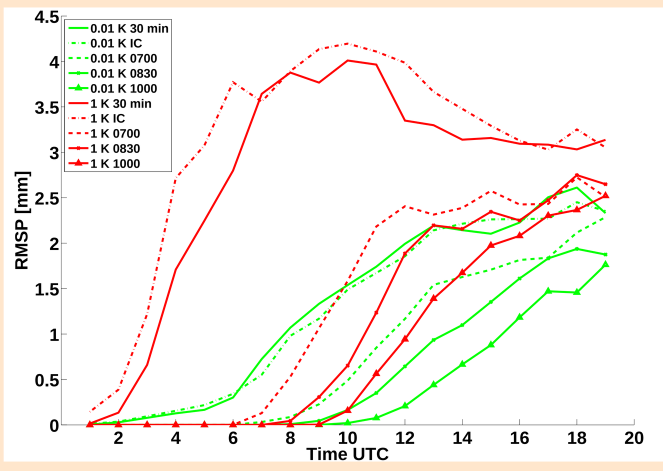
## Results

### Large Scale

#### Single Perturbations

- RMSE grows faster after 6 UTC (the slope flattens)
- perturbing the IC (1 K IC) is roughly equivalent to a sequential perturbation (1 K 30 min)

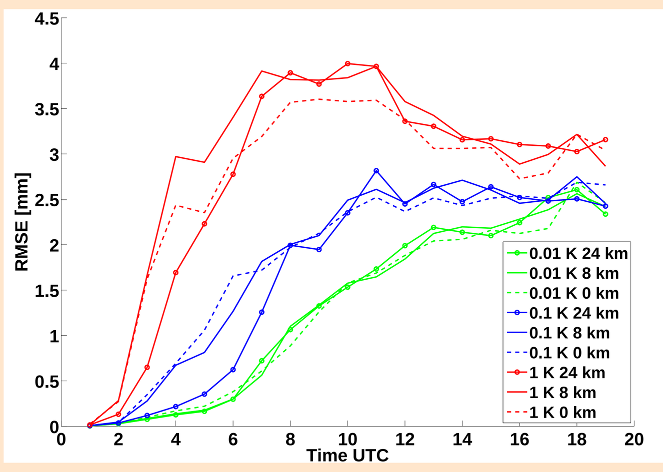
RMSE Hourly Accumulated Precip >1 mm




#### Sequential Perturbations

- RMSE depends mainly on perturbation amplitude then scale length
- all perturbations reach similar level of saturation regardless of the their amplitude and scale length

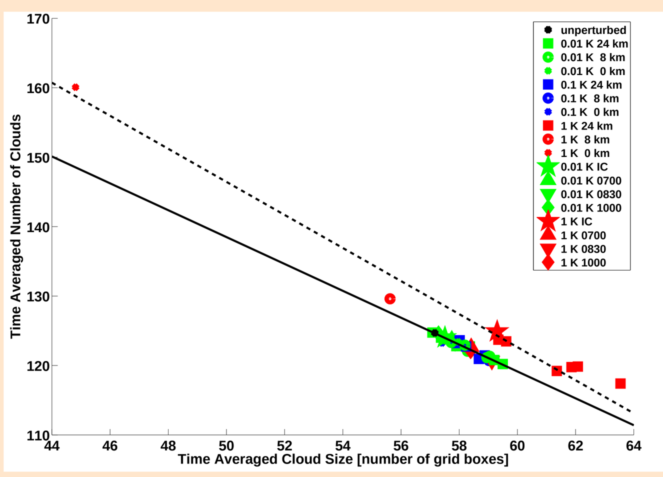
RMSE Hourly Accumulated Precip >1 mm




#### Cloud Distribution

- a larger scale length results in fewer, larger clouds
- this response is different for the 1 K perturbations, as they lie on a line with different slope

Non Cirrus Cloud Distribution

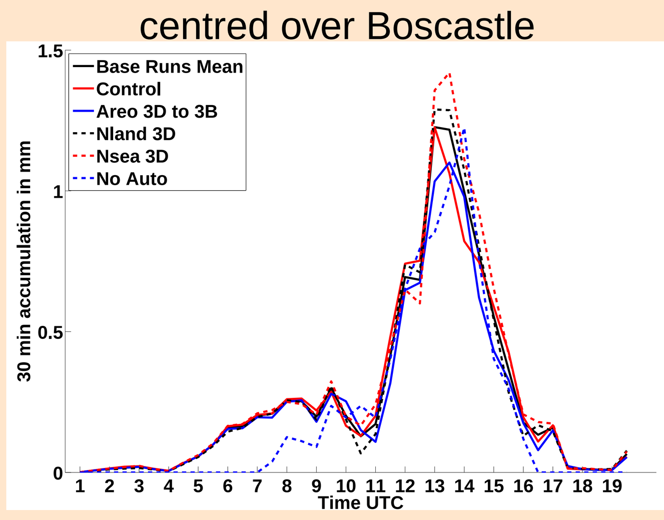



### Storm Scale

#### Base Runs Mean Accumulations

- the different base runs behave similarly
- no autoconversion simulation (No Auto) being a notable exception
- the sea aereosol run (Nsea) has the highest maximum

Mean Accumulations over a 60 km diameter centred over Boscastle

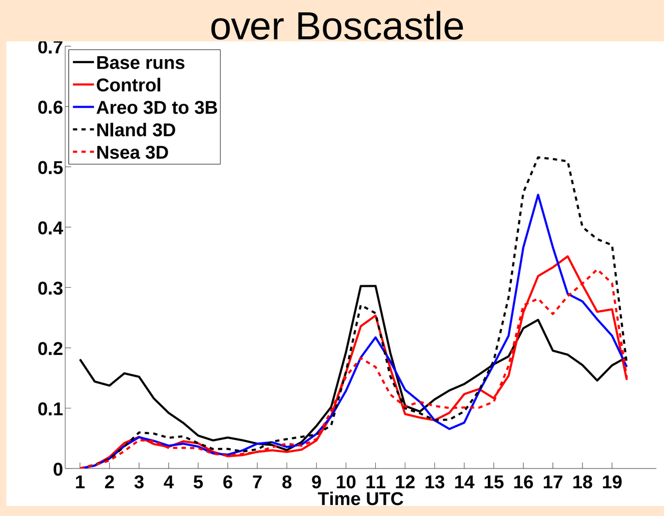



#### Std/Mean Ratio

The figure show the ratio of the ensemble standard deviation to the ensemble mean for all the ensemble, excluding the No Auto.

- the high values after 15 UTC are due to the small mean values and to the differentiation of the members
- similarly small values of the mean between 9 and 12 UTC do not result in large values of the ratio
- the ratio peaks before the strongest period of growth of the mean

Ensemble Std/Mean Ratio for the accumulations over a 60 km diameter centred over Boscastle




### Acknowledgements & Contact Info

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Giovanni Leoncini
Meteorology Department
University of Reading
Earley Gate, PO Box 243
Reading, RG6 6BB, UK
email: g.leoncini@reading.ac.uk
tel: 0118-378-5282

## Conclusions

### Large Scale

- the sequential perturbation technique successfully generates realistic ensemble members
- it also captures the sensitivity to the time of the day
- error growth depends strongly on the amplitude of the perturbation
- the 1 K simulations are qualitatively different
- the processes involved in the propagation of the error are the CAPE, acoustic waves and the PBL parameterisation

### Storm Scale

- the sequential perturbation technique captures the sensitivity to the time of the day in this case as well
- the std/mean ratio suggests that the largest spreads are achieved perturbing before or at the start of strong convection
- the ensembles with 0.1 K perturbation generates spread of the same magnitude as changes in the $\mu$physics