Error Growth at the Convective Scale

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Motivation 1

- To improve the Numerical Weather Prediction of convective events means to improve flood forecasting
- Forecast uncertainty is due to model and data error
- Ensemble forecasting provides a measure of such uncertainty by running several perturbed forecasts
- A reliable measure of the forecast uncertainty can help risk management
- At the convective scale computationally it is very intensive

Aims 2

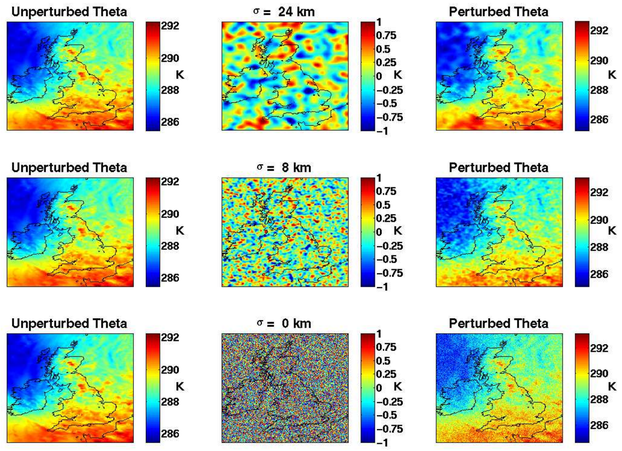
1. To identify the physical processes that lead to error growth in order to minimise the number of ensemble members necessary for a good estimate of the uncertainty
2. Test the sequential perturbation method

Sequential Perturbations 3

- 2D Gaussian perturbations
- amplitudes: 1, 0.1 and 0.01 K
- scale length (σ) : 24, 8 and 0 km
- applied every 30 minutes with no temporal correlation

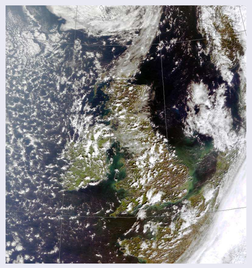
Single Perturbations 4

- 2D Gaussian perturbations
- amplitudes: 1 and 0.01 K
- scale length (σ) : 24 and 0 km
- applied once at initial conditions (IC) , 0700, 0830 and 1000 UTC



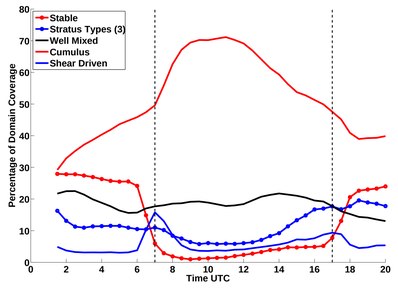
Case Study: CSIP - IOP 18 5

- High large scale predictability
  - Strong large scale, upper-level forcing
  - Well forecast
- Storm evolution driven by smaller scale processes
- Plenty of mesoscale phenomena
  - Scattered convection
  - Squall line
  - Interaction amongst cold pools
  - Coastal forcing
- Ideal test bed
- Domain covers UK and is composed by 4 km grid boxes



Terra visible image at 1126 UTC August 25th 2006 - NERC SRS, Dundee

Atmospheric Lower Boundary Layer Types 6



- The Met Office Unified Model categorises the lower boundary layer in 7 types
- Two transitions: morning ($\sim$ 7 UTC) and evening ($\sim$ 17 UTC)

Processes involved 7

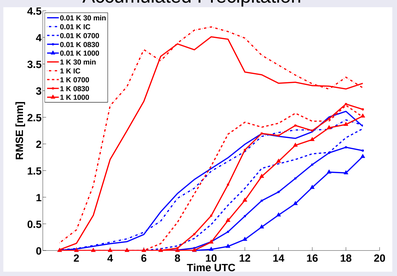
The main processes involved in error generation are:

1. Boundary Layer type changes: trigger model changes
2. Acoustic waves: modify the vertical velocity background
3. Static stability: temperature perturbation alters the environment ability to sustain/suppress storms in a discontinuous way
4. Temperature and cloud condensate: change in response to the perturbation, affecting storm development

Precipitation Error - Single Perturbations 8

- 1 K perturbation applied at initial condition (IC-1) has similar growth to the other 1 K experiments
- there is a sensitivity to the time of the day
  - the slope diminishes during the morning
- values of RMSE reach values of the same magnitude

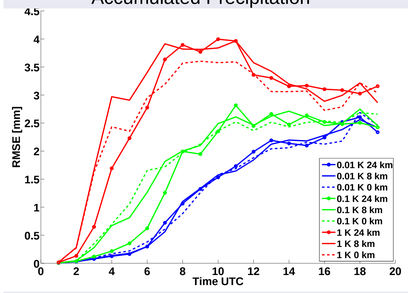
Root Mean Square Error for the Hourly Accumulated Precipitation *



(*)for all the grid boxes with at least 1 mm accumulation

Precipitation Error - Sequential Perturbations 9

Root Mean Square Error for the Hourly Accumulated Precipitation*

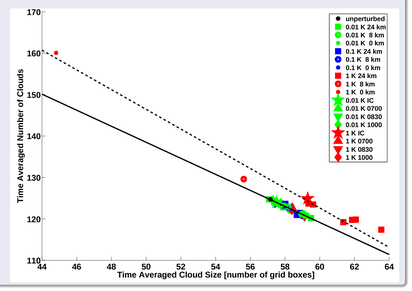


(*)for all the grid boxes with at least 1 mm

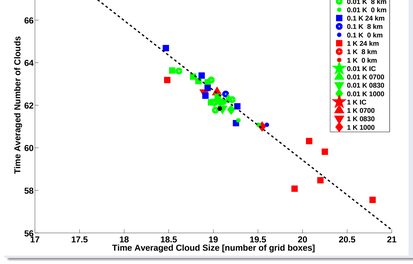
- RMSE depends mainly on the perturbation amplitude
- the scale length has a modulating effect
- the 1 K simulations are qualitatively different:
  - quicker growth
  - achieve saturation

Low and Middle Level Clouds Distribution 10

- 1 K experiments:
  - smaller scale length results in a larger number of smaller clouds
  - the 1 K experiments are on different linear regime
  - cloud dynamics is altered
- for the 0.01 and 0.1 K experiments the role of scale length is less obvious



Precipitating Clouds Distribution 11



- only one linear regime
- modulating effect of scale length
- IC-1 is an outlier, for the precipitation bias as well

Conclusions 12

Effects on the Simulations

- sensitivity to time of the day
- 1 K are qualitatively different:
  - saturates earlier
  - cloud distribution is significantly altered
  - 1 K displaces/generates storms more effectively (not shown)
- all experiment reach similar vales of error
- perturbing the initial conditions can push the model on a different trajectory
- sequential perturbations can generate significant error growth

Main Processes Involved

Vertical static stability (CAPE)
Acoustic waves
Cloud condensate and temperature

affect the background state

Boundary layer type changes

affect the model

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