Contrasting Convective-Scale Perturbation Growth in Two Cases Over the UK

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We introduce a novel technique:

perturb model state as the simulation progresses

at the large scale

- several storms within domain
- processes involved in error propagation
- general overview of model/convection response to perturbation

at the storm scale

- focus on one specific flood
- verify ensemble technique is useful in a different domain/weather regime
- accumulation within an area
- what needs to be changed: $\mu$ physics or perturbation?
Perturbation Structure

- potential temperature
- applied at fixed model level
  - 1280 m
- at regular intervals (30 mins)
  - to capture PBL transitions

- 2D Gaussian kernel applied to random numbers
- amplitude: 1, 0.1, 0.01 K
- $\sigma$: 24, 8, "0" km
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flow independent ...
understandable
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Overview

Perturbation

Scattered Convection

Flood

Conclusions

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flow independent ...

understandable

$\sigma = 8$ km

Unperturbed Theta
Perturbation Structure

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flow independent ...
understandable
Perturbation Strategies

Scattered Convection

Aim: model/convection response

- 24, 8, 0 km
- 1, 0.1, 0.01 K
- MetUM, 4 km, 38 levels

Flood

Aim: perturbation v $\mu$ physics

- ensembles: 0.1 K, 8 km
- change warm $\mu$ physics
- MetUM, 1 km, 76 levels
Which processes determine error growth?

Scattered Convection

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

Note that:
- cloud distribution not affected *directly*
- vertical motion helps

![Precipitation RMSE](image-url)
Perturbation v Parameterisation

Flood

- perturbation \( \sim \) parameterisation
- event is quite predictable
  - location of cells changes the most
  - number and intensity not so much
- cloud dynamics slightly affected
Perturbation v Parameterisation

Flood

Ensemble Means of Areal Averages

- Base runs
- Control
- Areo 3D to 3B
- Nland 3D
- Nsea 3D
- No Auto

30 min accumulation in mm

Time UTC

Std/Mean Ratio

- Base runs
- Control
- Areo 3D to 3B
- Nland 3D
- Nsea 3D

Time UTC
Conclusions

The sequential perturbation has proven to
- generate realistic ensemble members
- capture error growth due to w
- affect cloud dynamics

Scattered Convection

Strategy:
- A: 1, 0.1 and 0.01 K
- $\sigma$: 24, 8 and 0 km

We found:
- error growth due to:
  - lid
  - acoustic waves
  - BL types changes
- amplitude controls growth

Flood

Strategy:
- fixed A and $\sigma$
- 0.1 K, 8 km

We found:
- accumulations are fairly predictable
- perturbation $\sim \mu$physics
- model response is sensitive to parameter values
Cloud Distribution
Scattered Convection

Low and Mid-Level Clouds

Time Averaged Number of Clouds vs. Time Averaged Cloud Size [number of grid boxes]
Experiments

Standard Run

5 ensembles, 8 km, 0.1 K (8+1)
standard UM 6.1, 1 km grid spacing
2nd autoconversion model
land value for CCN
sea value for CCN
no autoconversion

Observations

Member 1