Error Growth at The Convective Scale

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Introduction

We introduce a novel technique:

perturb model state

as the perturbation progresses

at the large scale several storms within domain

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

at the storm scale focus on one specific flood

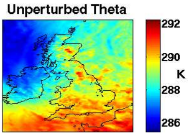
- verify ensemble technique is useful in a different domain/weather regime
- accumulation within an area
- what needs to be changed: μphysics or perturbation?

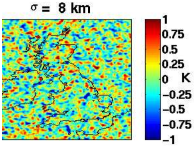
Overview

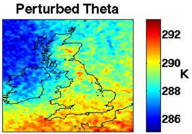
- UM, 1 km grid spacing
- Vary warm μphysics parameters
- Run sequentially perturbed ensembles
- Use model error scales to analyse precipitation accumulations
- Compare growth due to perturbation v warm μphysics changes

Perturbation Structure

- potential temperature
- applied at fixed model level
  - 0-400 m
  - 500 m
  - 1280 m
  - consistently with Lean (2006)
- at regular intervals (30 mins)
  - to capture PBL transitions
- 2D Gaussian kernel applied to random numbers
- max amplitude is 0.1 K (θ^*)
- scale length is 8 km







Methodology

Autoconversion & the UM:

- large cloud droplets collect smaller ones
- if they are larger then 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	6.0×10^8 m^{-3}	1.5×10^8 m^{-3}
3D	3.0×10^8 m^{-3}	1.0×10^8 m^{-3}

Experiments

5 unperturbed runs (base runs)

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

each base run has an associated ensemble

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6 ensembles:

- control (8+1 members)
- 4 μphysics (8+1 members)
- base runs (5-1 members)

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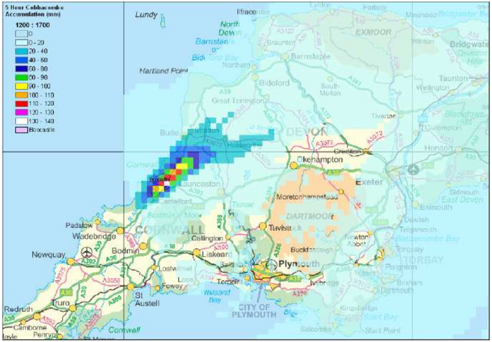
Perturbation Strategy:

- use 0.1 K and 8 km
- 8 realisations (ie members)

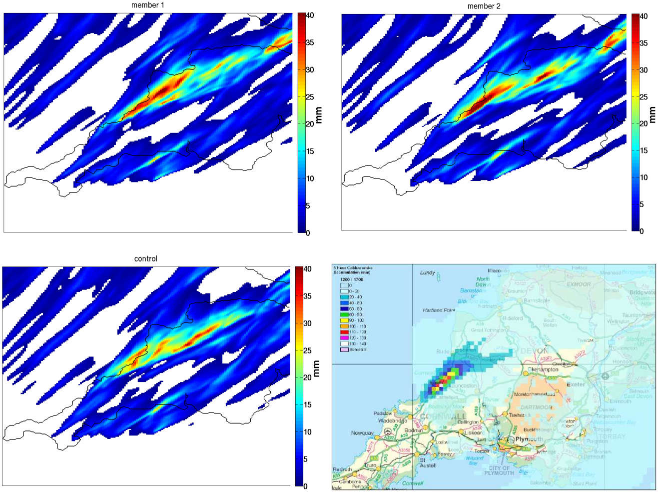
The event - Boscastle flood of August 16th 2004

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



from MO Post Flood Study

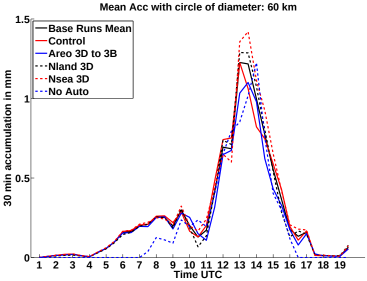
Perturbation Effect

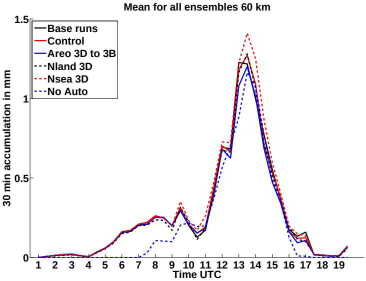


Diagnostics

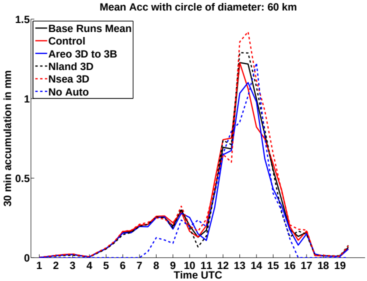
- Accumulation is the quantity of interest:
  - model reaches acceptable skills between 40 and 70 kilometres (Roberts and Lean 2007)
  - flooded river catchment is really tiny (~20 km^2)
  - accumulations on a circle centred over Boscastle with diameters of 20, 40 and 60 km
- std deviation of ensembles as measure of spread

Results


Mean Acc with circle of diameter: 60 km
Base Runs Mean
Control
Areo 3D to 3B
Nland 3D
Nsea 3D
No Auto
30 min accumulation in mm
Time UTC
1.5
1
0.5
0
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19


Mean for all ensembles 60 km
Base runs
Control
Areo 3D to 3B
Nland 3D
Nsea 3D
No Auto
30 min accumulation in mm
Time UTC
1.5
1
0.5
0
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19

Results



Mean Acc with circle of diameter: 60 km
Base Runs Mean
Control
Areo 3D to 3B
Nland 3D
Nsea 3D
No Auto
30 min accumulation in mm
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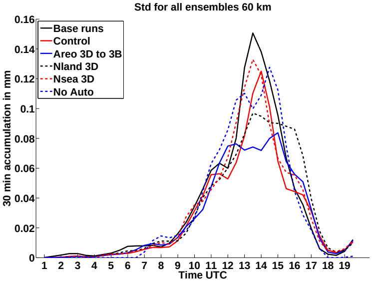
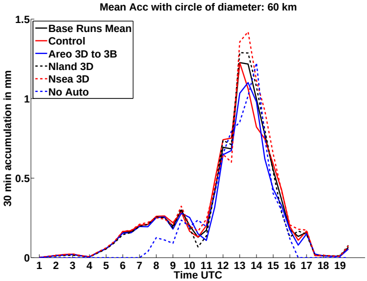


Std for all ensembles 60 km
Base runs
Control
Areo 3D to 3B
Nland 3D
Nsea 3D
No Auto
30 min accumulation in mm
Time UTC

Results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30 min accumulation in mm
Time UTC
Base Runs Mean
Control
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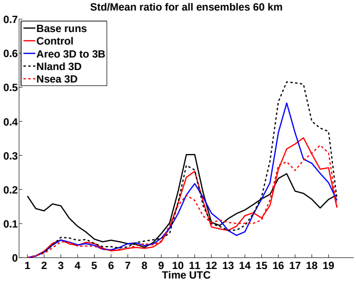
Nland 3D
Nsea 3D
No Auto


Std/Mean ratio for all ensembles 60 km
Time UTC
Base runs
Control
Areo 3D to 3B
Nland 3D
Nsea 3D

Conclusions & Future Work

- results consistent for 60 and 40 km, a bit less for 20 km
- spread generated by perturbation similar to changed μphysics
- accumulations of the same order as well
- perturbation before and at convection start is crucial for differentiation

- change ice and sfc roughness
- how are these changes achieved?

Summary

- fundamental processes are: CAPE, BL type changes and acoustic waves
- scattered convection regime: error growth driven by amplitude and time of the day
- flood storm: ensemble generates variability comparable to μphysics
- perturbation technique useful, particularly to capture the sensitivity to the time of the day