Ensemble spread in MOGREPS-UK

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Anne McCabe, Aurore Porson, Nigel Roberts, Stu Webster, David Walters, Steve Willington, Mike Bush
MOGREPS-UK
Ensemble spread project
Initial results of sensitivity tests
‘Useful spread’ – do we know what it is, and if so, can we measure it?
Summary and future work
Up to the end of 2018, MOGREPS-UK has run as a 6-hourly ensemble model with 12 members.

The UK convective scale ensemble:
- 12 members
- 54 h forecast length
- Runs 4 cycles per day at 03, 09, 15 and 21 UTC
- 2.2 km resolution on the inner domain, 4 km in the variable resolution zone
- Boundary conditions from the Met Office global ensemble, MOGREPS-G
- Initial conditions for each ensemble member are provided by the deterministic UK model (UKV) analysis with perturbations from MOGREPS-G added to these
- Stochastic physics from the Random Parameter (RP) scheme
- Stochastic boundary layer perturbations are applied to all members, including the control, to aid the initiation of convection

In 2019, we moved to a new hourly configuration, which includes 18 members. This new hourly configuration runs to T+120.
Aim: to bring together scientists and operational meteorologists to evaluate the ensemble and develop new strategies to improve the value of MOGREPS-UK to forecasters

First phase: to understand what we mean by ‘lack of spread’ and / or what is ‘the correct spread’ → any ‘improvements’ we make must translate to improvements for meteorologists

Operational meteorologists have identified lack of spread in MOGREPS-UK as a top model development priority

A Process Evaluation Group (PEG) has been formed to investigate further
Sensitivity Tests
Phase 1: Exploring sensitivity to sources of uncertainty

Back-to-basics sensitivity tests

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<th>STPH</th>
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<td>Exp 3 – uncertainty from stochastic physics only</td>
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Initial results from sensitivity tests – work in progress

Initial conditions are most important in the early part of the forecast – they begin to lose significance after 12 hours but dominate over LBC’s until T+30.

The impact of the LBC’s shows a steady increase throughout the forecast.

Stochastic physics generates 30 – 40% of the full ensemble spread.
How much do the different sources of uncertainty contribute to the spatial ensemble spread?

Use the dispersive Fraction Skill Score (FSS) to understand the scales the different perturbations are working on.

Dispersive FSS for 21Z cycle. Time of interest is T+20

IC & RP ensembles show variability at similar scales

White dashed line gives ‘believable scale’
What happens if we use a different cycle?

- Note the different contribution of the RP ensemble in each case
  - T+20 – IC & RP closest to CTRL ens
  - T+14 – IC closest to CTRL but RP ens gives the least spread

- The balance between the RP scheme and IC uncertainty depends on the cycle time and the lead time
Dispersive FSS for 03Z cycle. Time of interest is T+14.

Contribution from BL parts and RP scheme are swamped by IC and LBCs.

White dashed line gives ‘believable scale’
21Z cycle
T+20

03Z cycle
T+14

nbhood length 9

nbhood length 9

nbhood length 15

nbhood length 15

nbhood length 1
Next steps for sensitivity tests

- Do we see similar results for other cases and variables, e.g. fog?
- Are the results regime dependent?
- What can we observe about how the different sources of uncertainty interact with one another?
- How can we maximise the impact of stochastic physics on the spatial spread?
- What characteristics of the ensemble can we identify to pass on to forecasters to inform their use of the ensemble?
‘Useful Spread’

Some initial thoughts
What do we want to get out of a convective scale ensemble?

• Standard answer … “Confidence in the forecast”

• Ideal ensemble … “Represent the true uncertainty in the atmosphere”

• Pragmatically, what would be useful?

• And once we know, can we measure it?
‘Useful’ spread – spatial uncertainty matters

*Sometimes*, but (crucially) **not all the time**, we would like the ensemble to …

... strongly support the deterministic forecast

... show a large spread of possible outcomes (and quantify the scale of that spread)

... do something more interesting
But how do we know how often we forecast these different scenarios?

- The dispersive FSS can tell us how spatially spread the members are, but it does not differentiate between these two scenarios:
  - Standard ‘following the control’ forecast
  - Majority of members shifted away from the control

- But the difference is really important to our forecasters
- Future work: develop a measure to show us how frequently these different scenarios occur and whether their occurrence can be linked with regime
Summary and Future Work
Summary

- We are currently running a specific project to investigate the lack of spread in MOGREPS-UK.
- Our main focus is to make improvements that benefit the forecasters.
- Sensitivity tests show how the different sources of uncertainty contribute to the ensemble spread.
- Case study analysis shows that the stochastic physics and initial condition uncertainty are sometimes (i) giving similar results or (ii) adding to the small scales and giving extra detail in the probabilities, but not extra spread.
- Discussions on the topic of ‘useful spread’ with forecasters have indicated that we need a measure of how different the ensemble storyline is to the control member.
Future Work

• Continue work with sensitivity tests

• Evaluate and develop metrics to assess different types of ensemble spread and how it may link to regime

• Investigate the sensitivity of the ensemble to the driving model by using ECMWF to drive MOGREPS-UK

• Improve the range of ensemble products available to our forecasters

• Investigate predictability of fog using a high resolution ensemble over a small domain
Thank you for listening

Contacts:
anne.mccabe@metoffice.gov.uk
aurore.porson@metoffice.gov.uk
nigel.roberts@metoffice.gov.uk
stuart.webster@metoffice.gov.uk
steve.willington@metoffice.gov.uk
david.walters@metoffice.gov.uk
mike.bush@metoffice.gov.uk
Additional slides

RP Scheme

• Parameters
• AR1 scheme

BL Perturbations
Parameters are chosen to target uncertainty at the small scales.
Improved RP algorithm

- Slower, more smoothly varying parameter path
BL Perturbations

• **Motivation:**
  UKV & MOGREPS-UK can struggle when convection is initiated ‘randomly’, i.e. Growing from small (sub-grid) scales to larger (resolved) scales without resolved forcing.

• **Basic Idea:**
  To represent this up-scale transfer, we add random perturbations to the resolved scale flow whose magnitude is dependent on the subgrid flow
  ➢ *the larger the surface heat flux, the larger the "backscatter" of temperature variability to the resolved scales in convectively unstable atmospheres*

• **Extension to ensembles:**
  • Developed for UKV but used in MOGREPS-UK – adds variability by using a different random seed for each ensemble member.