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Ensemble spread in MOGREPS-UK

EWGLAM Sofia, Bulgaria 2019

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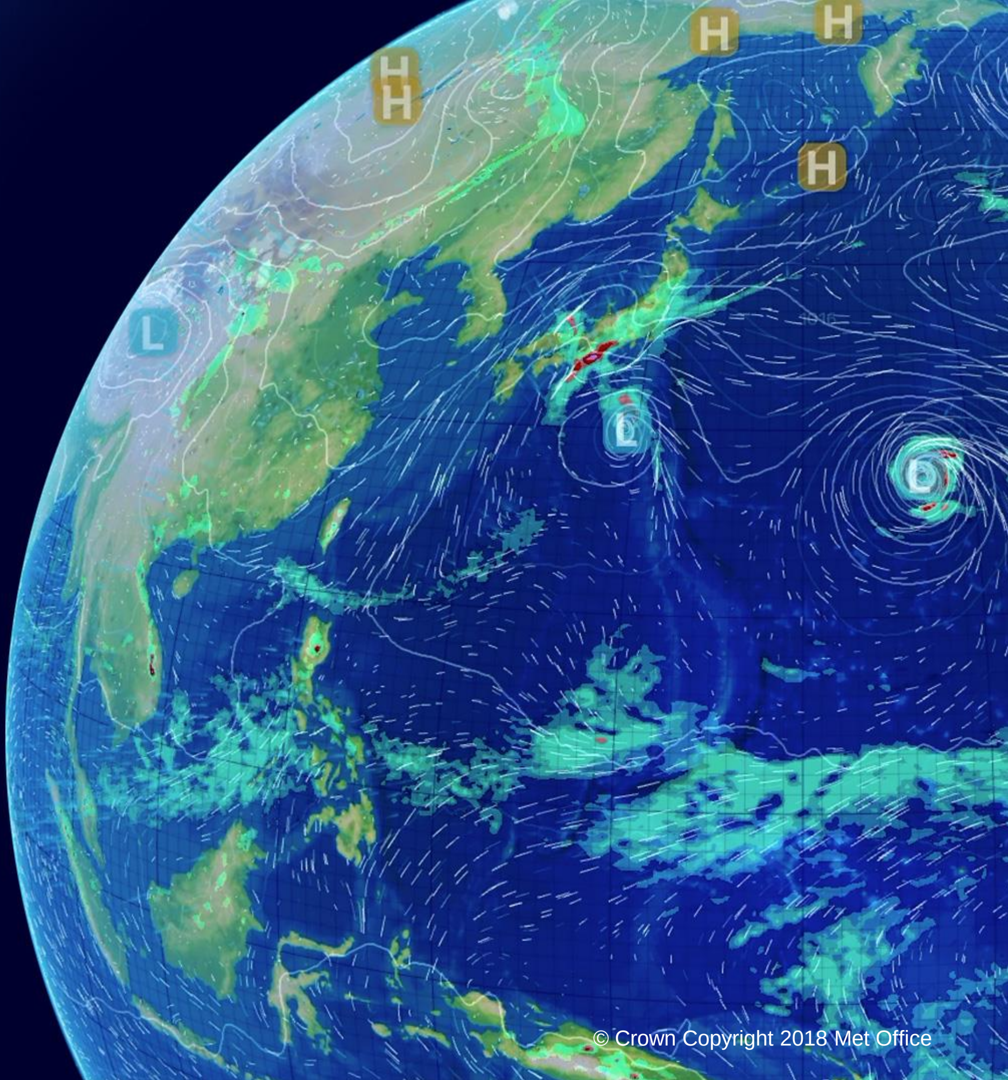
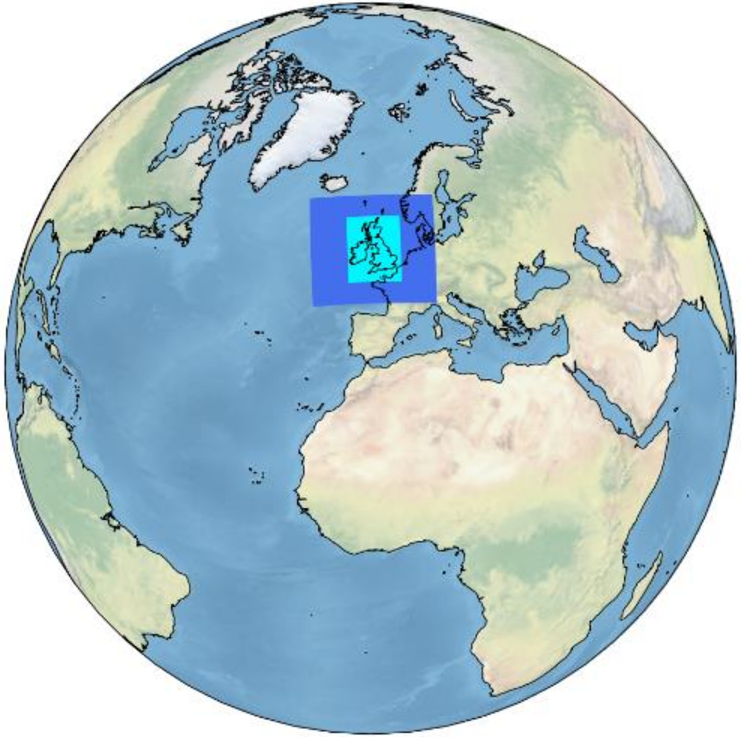


Outline

- 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.

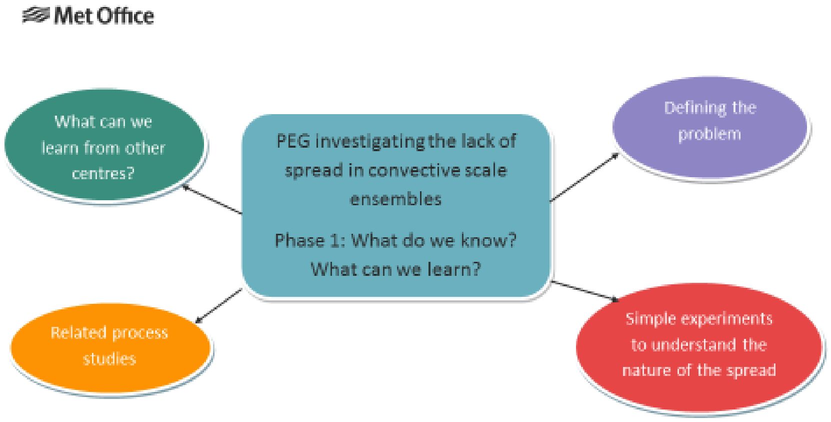
Investigating the lack of spread in convective-scale ensembles

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

A **P**rocess **E**valuation **G**roup (PEG) has been formed to investigate further

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



Sensitivity Tests

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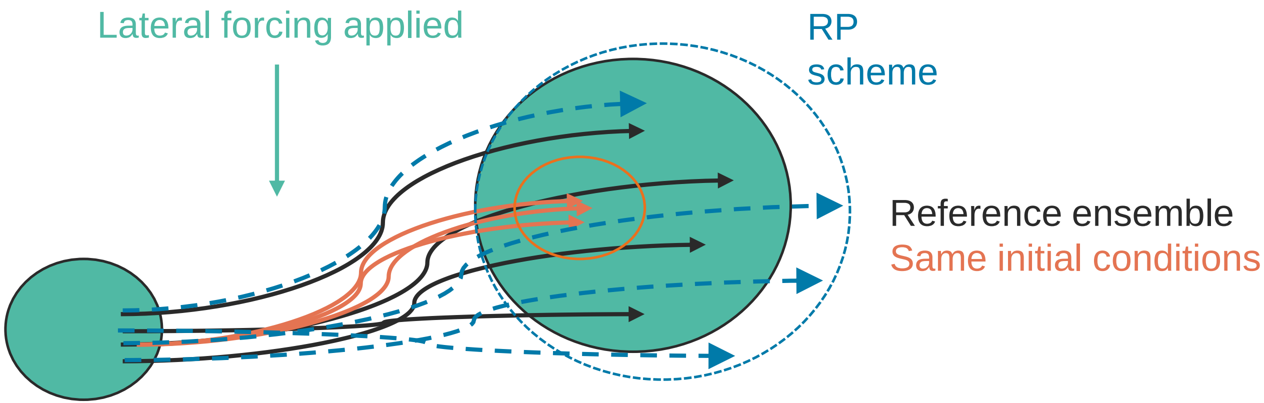
Phase1: Exploring sensitivity to sources of uncertainty

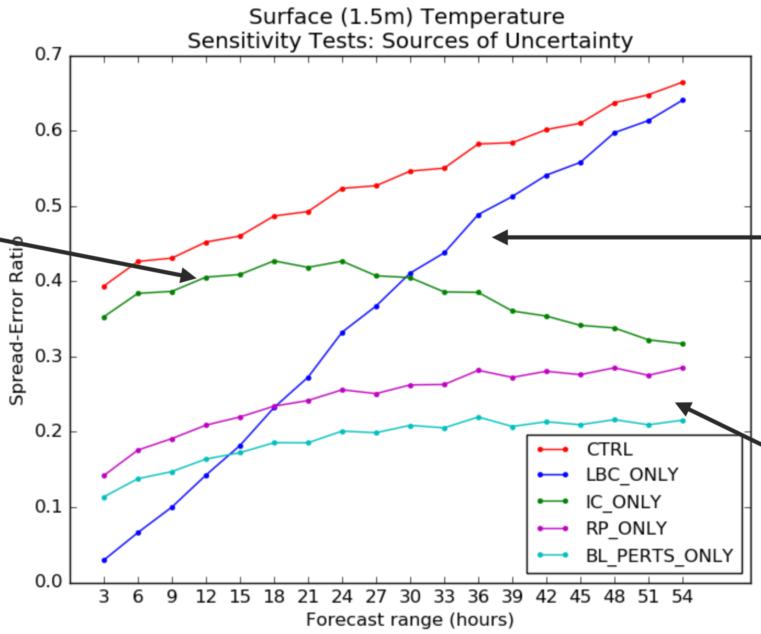
Back-to-basics sensitivity tests

Experiments	Start dump	LBCs	STPH
Exp 1 – uncertainty from initial conditions only	Perturbed	Control	Off
Exp 2 – uncertainty from LBCs only	Control	Perturbed	Off
Exp 3 – uncertainty from stochastic physics only	Control	Control	Perturbed



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

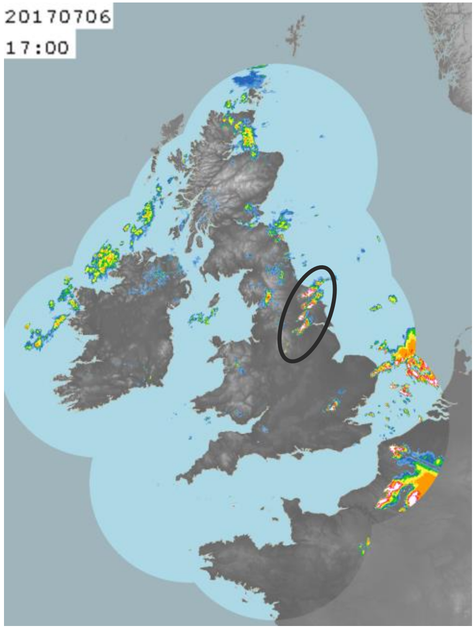
Stochastic physics generates 30 – 40% of the full ensemble spread

Case Study: Thunderstorms 6th July 2017

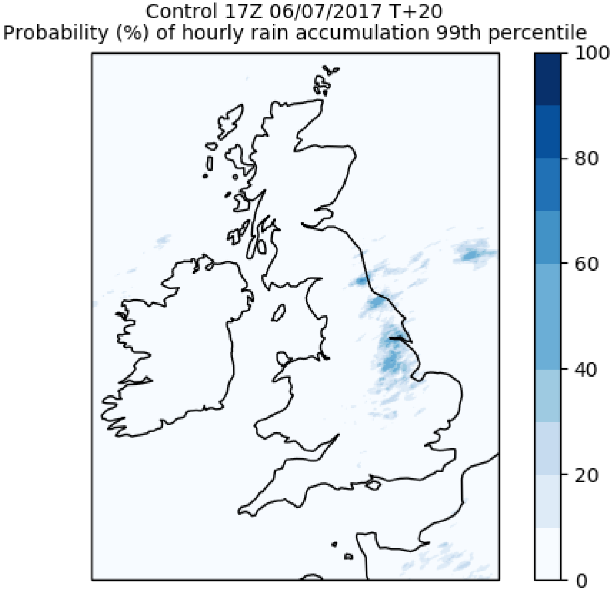
How much do the different sources of uncertainty contribute to the spatial ensemble spread?

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

Radar



Control Ensemble



References: Dey et al (2014), Roberts (2008), Roberts & Lean (2008)

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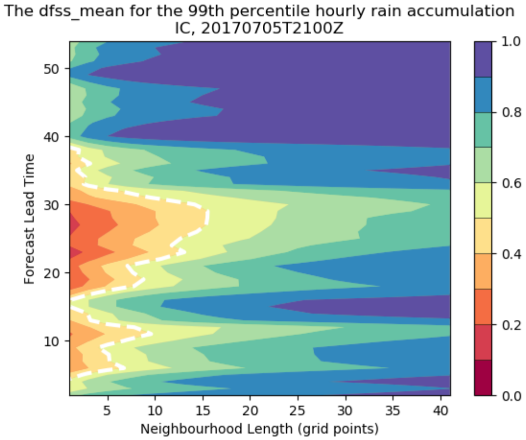
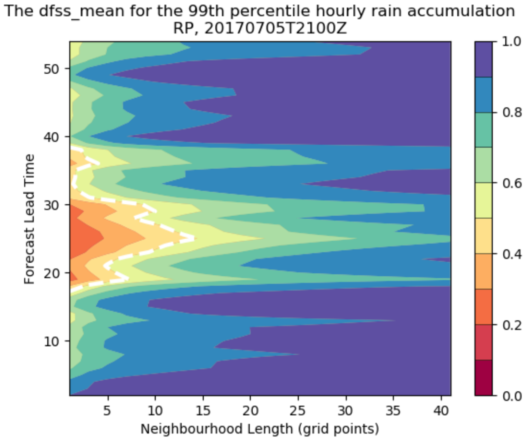
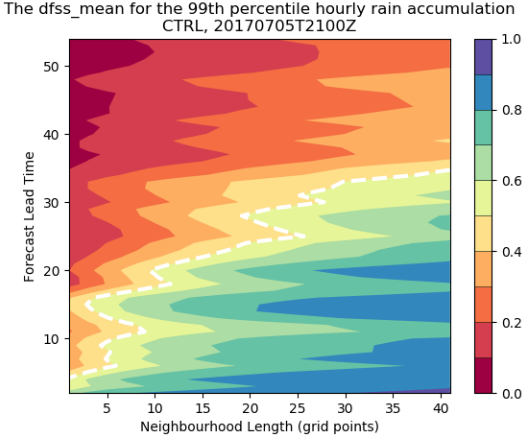
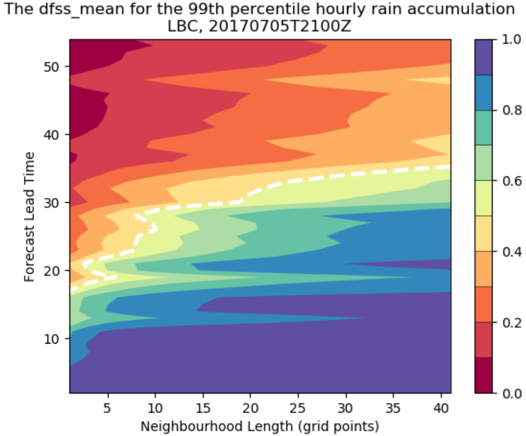
Dispersive FSS for 21Z cycle. Time of interest is T+20

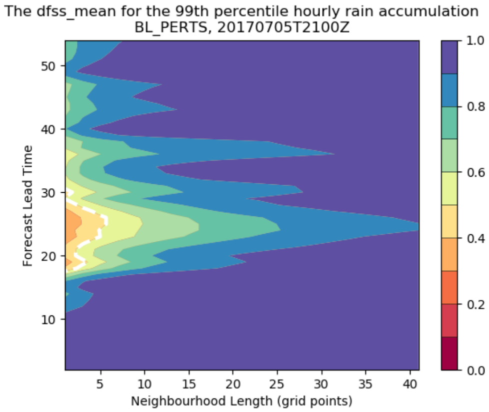
IC & RP ensembles show variability at similar scales









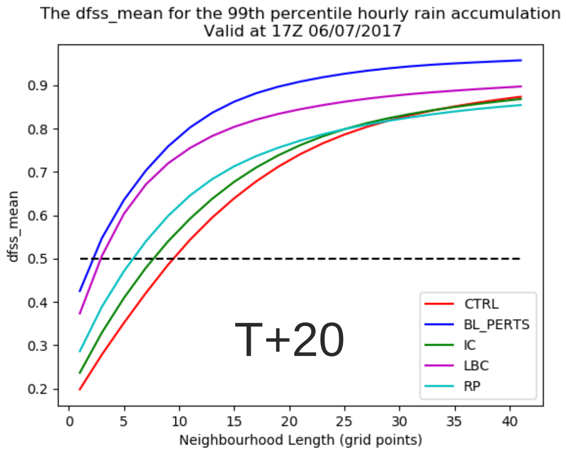


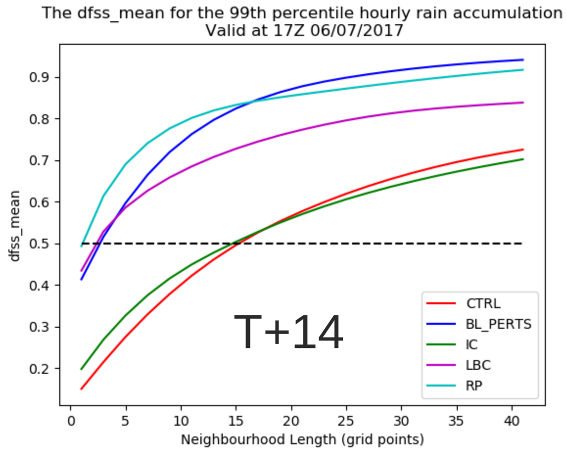
White dashed line gives ‘believable scale’

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





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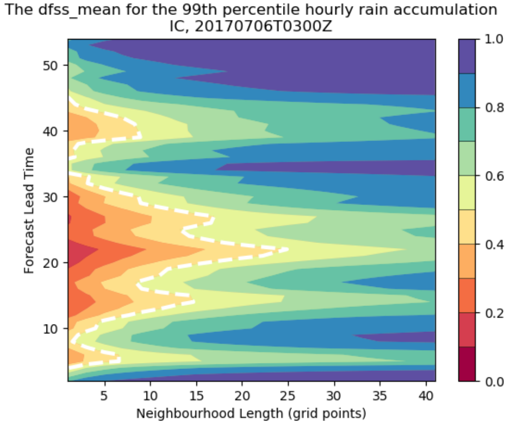
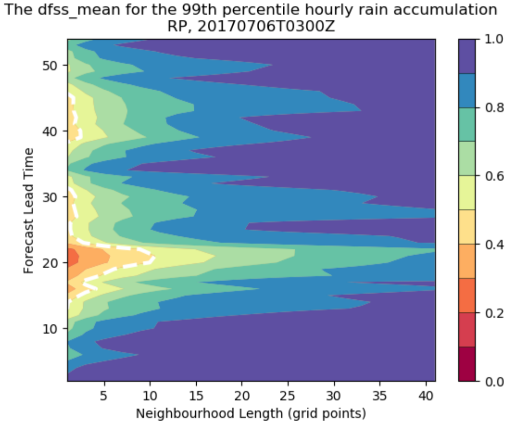
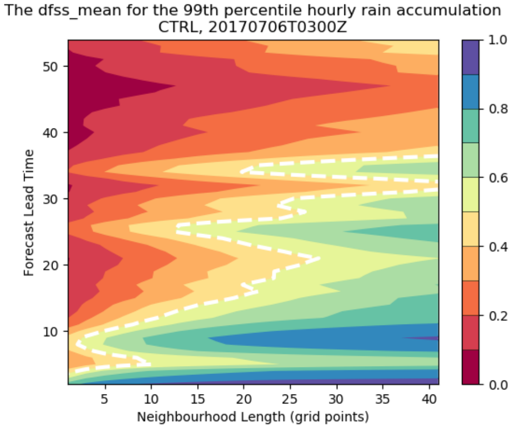
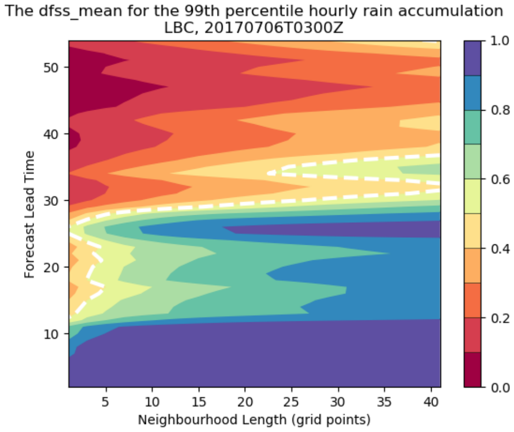
Dispersive FSS for 03Z cycle. Time of interest is T+14.

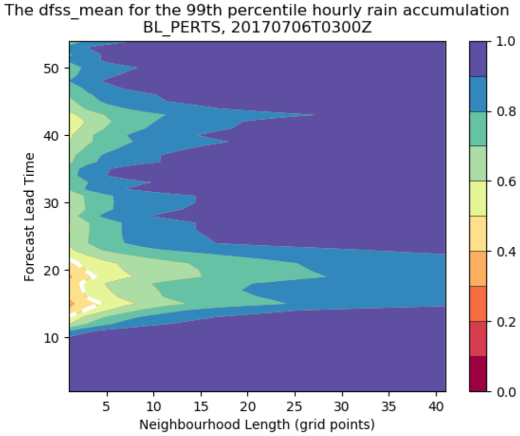
Contribution from BL perts and RP scheme are swamped by IC and LBCs.





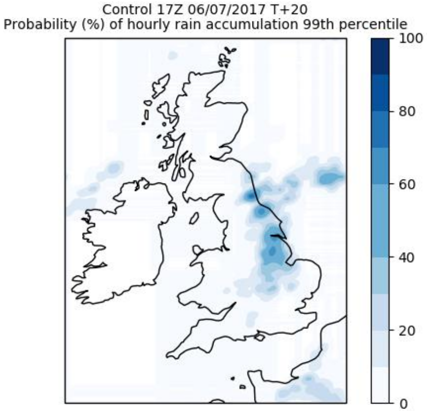




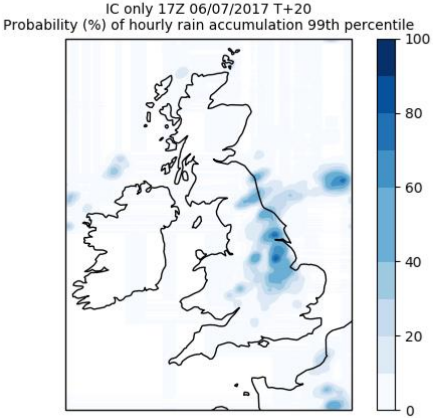


White dashed line gives ‘believable scale’

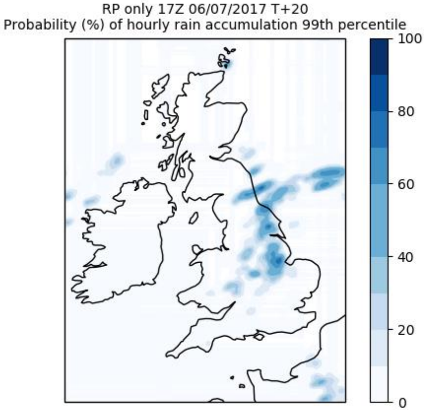
21Z cycle
T+20



nbhood length 9

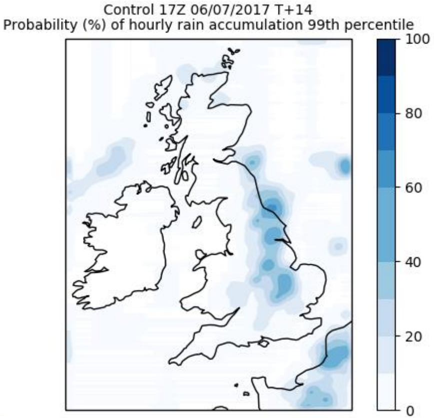


nbhood length 9

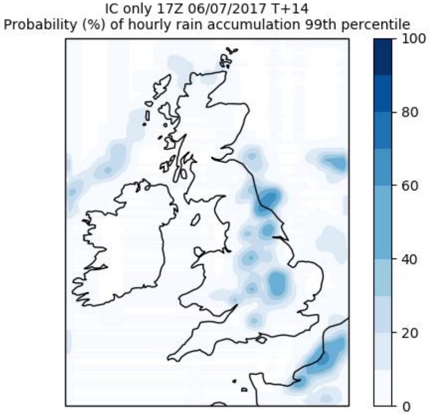


nbhood length 7

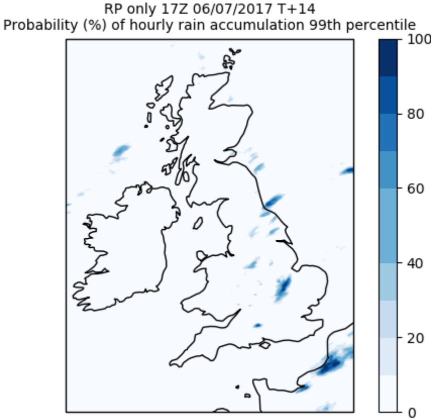
03Z cycle
T+14



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’

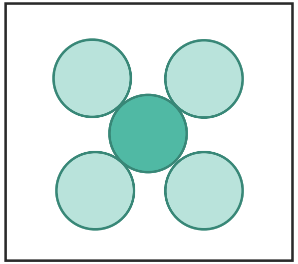
Some initial thoughts

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

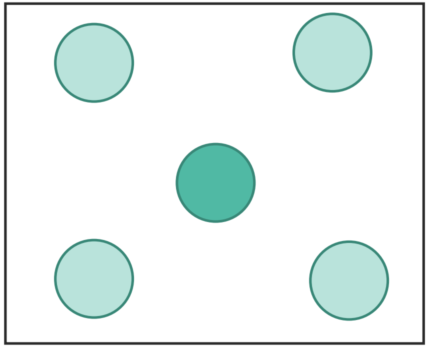
- Standard answer … “Confidence in the forecast”
- Ideal ensemble … “Represent the true uncertainty in the atmosphere”
- Pragmatically, what would be useful?
- And once we know, can we measure it?

‘Useful’ spread – spatial uncertainty matters

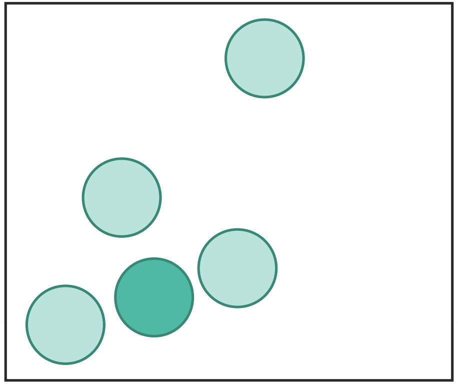
Sometimes, but (crucially) ***not all the time***, we would like the ensemble to …



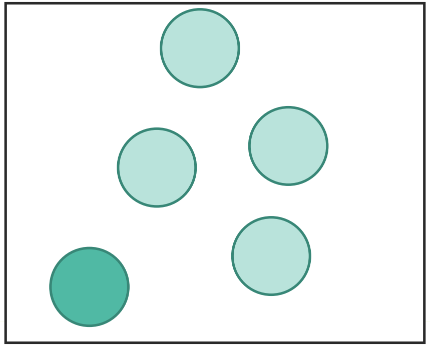
… strongly support the deterministic forecast



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



… do something more interesting



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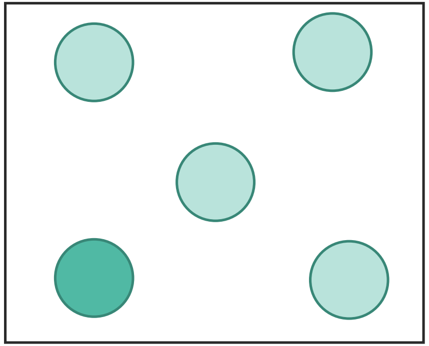
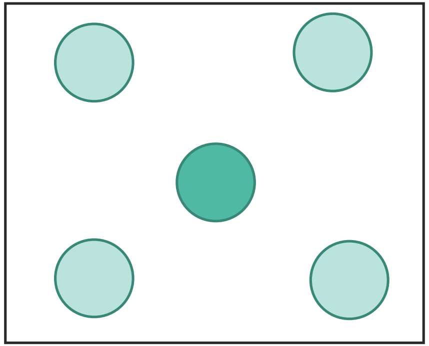
But how do we know how often we forecast these different scenarios?

- 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

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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

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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

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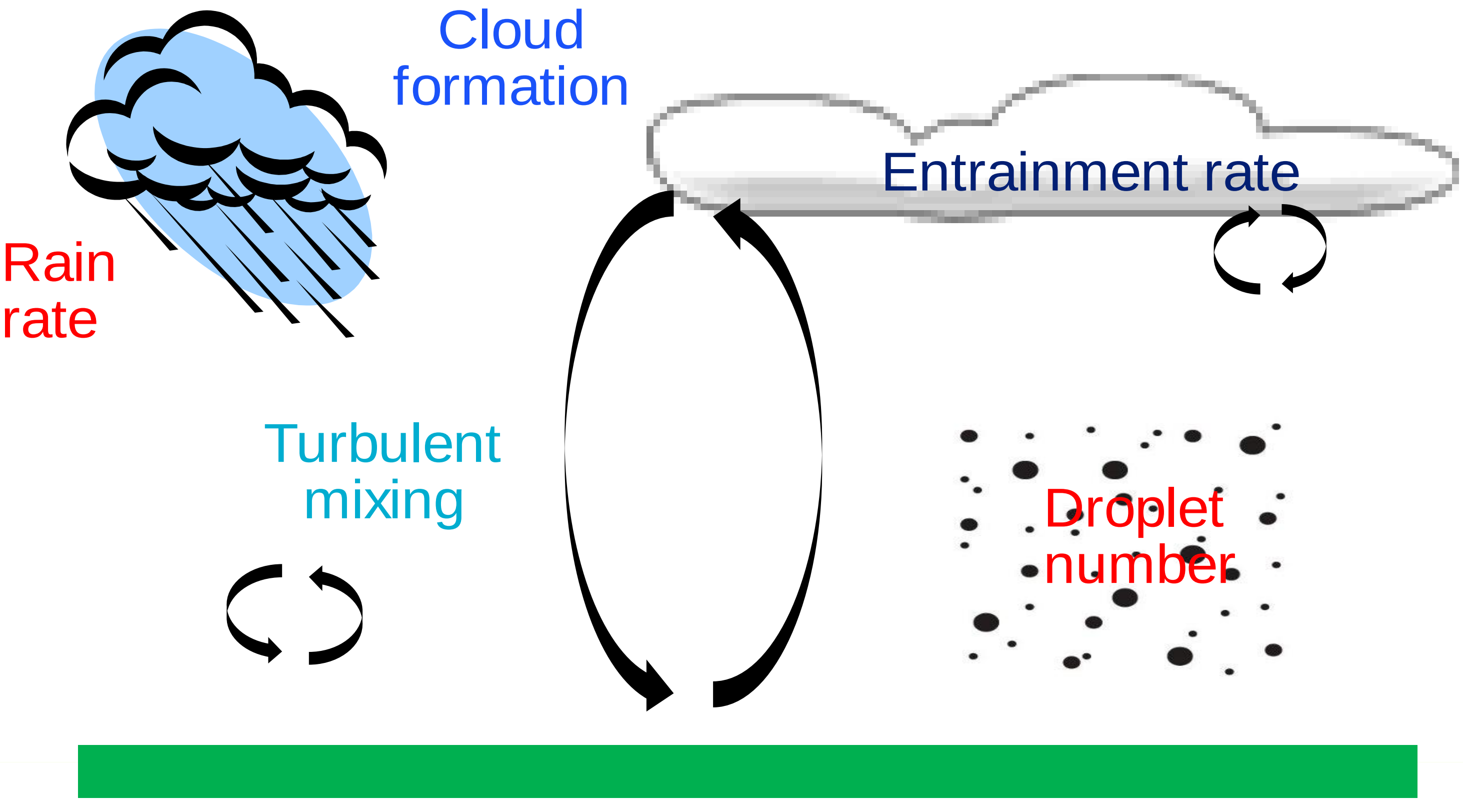
Additional slides

RP Scheme

- Parameters
- AR1 scheme

BL Perturbations

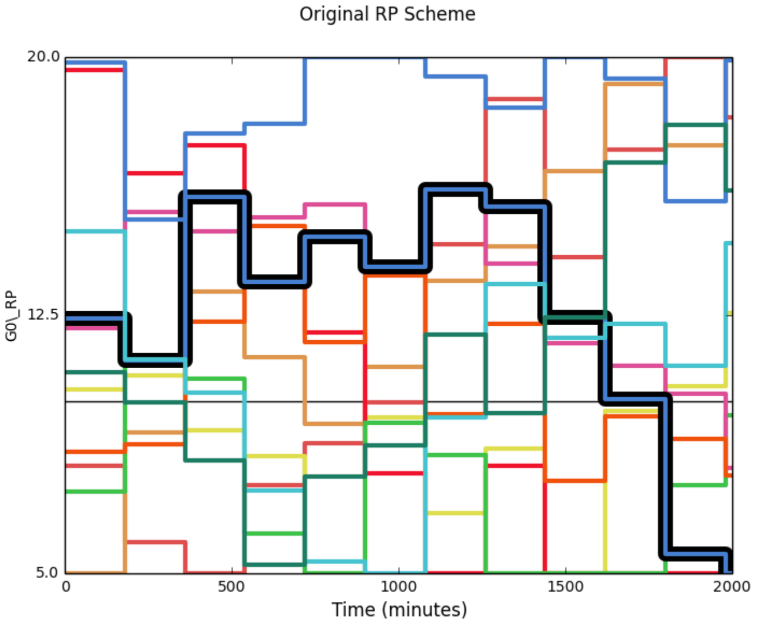
Parameters are chosen to target uncertainty at the small scales



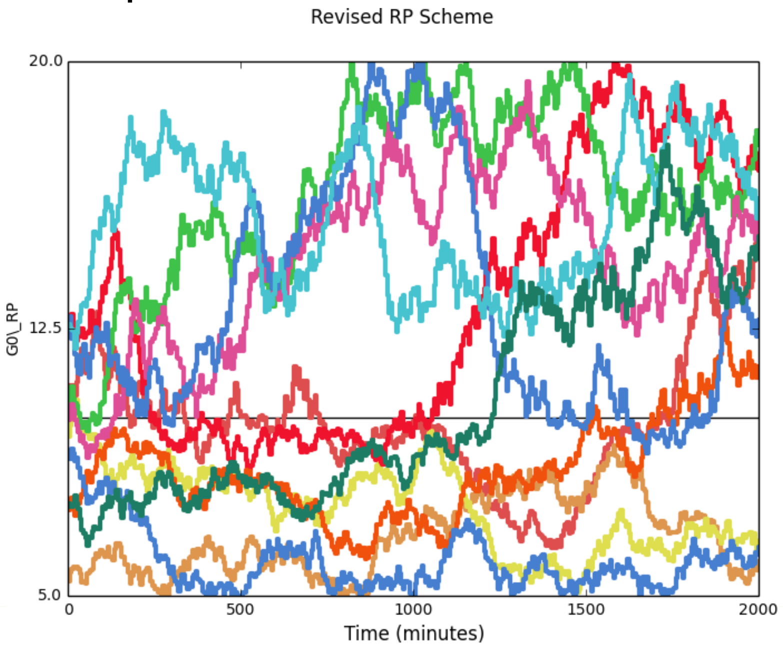
Improved RP algorithm

- Slower, more smoothly varying parameter path

Original



Improved



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.