SOFOG: Ensemble Fog Forecasting

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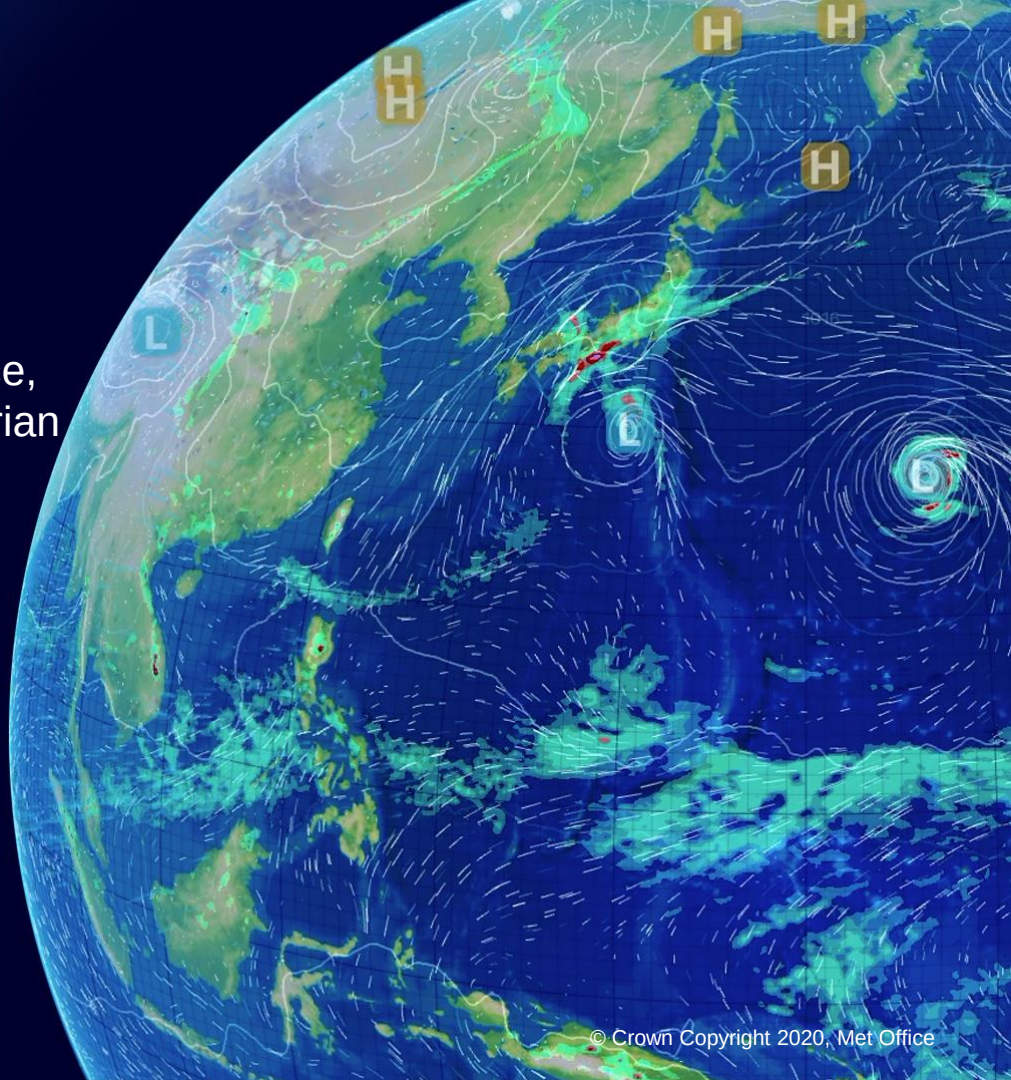
SOFOG Meeting March 2021



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Outline

- Aims of the ensemble evaluation
- Ensemble set-up
- Overview of ensemble performance
- Two case studies (following on from Jenna’s work)
- Summary and future plans

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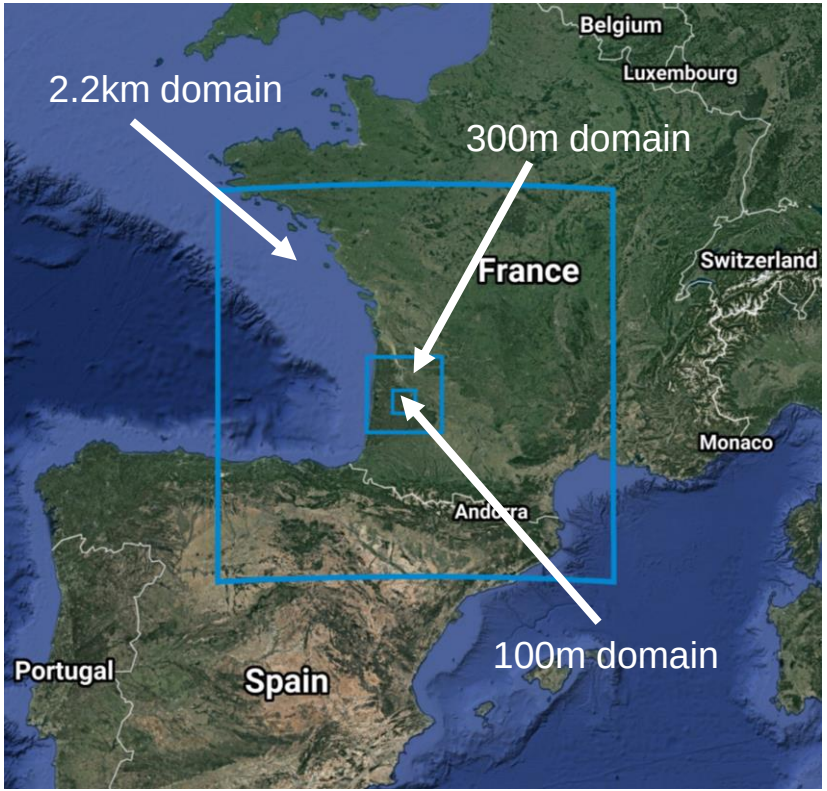
Questions we would like to answer …

- How well do our ensemble systems capture the observed fog?
- Can we identify any characteristics of the ensemble that we could use to highlight areas for improvement?
- What value do ensembles give us over deterministic systems in terms of forecasting fog?
- How sensitive are the results to horizontal resolution? Does a high resolution ensemble give us any benefit over our current resolution?
- What are the challenges of using ensemble output to forecast fog. How can we best present the output for use by operational meteorologists?
- Can we understand anything more about the nature of ensemble spread in fog forecasting?
- Can we use the ensemble to learn more about how we model fog?

Ensemble experiments



18 members

IC & LBC's from MOGREPS-G

<u>3 ensembles</u>:

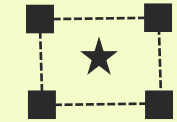
- 2.2km nested inside MOGREPS-G with RP scheme to represent model uncertainty
- 300m ensemble nested inside 2.2km ensemble
- 100m ensemble nested inside 300m ensemble

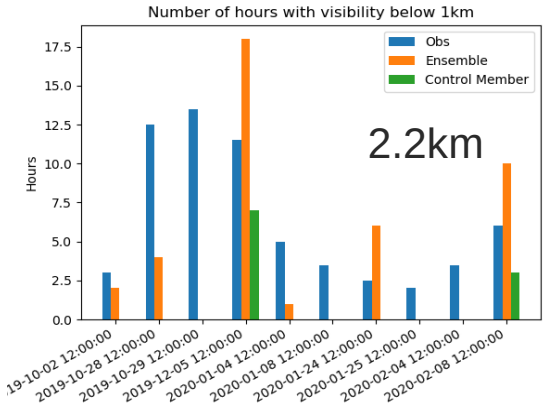
These are the same domains as used for the deterministic forecasts

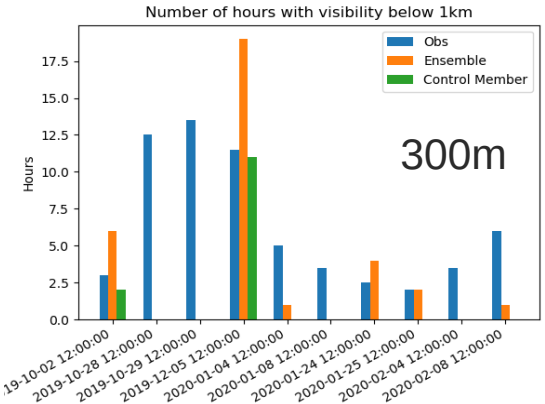
Overview of ensemble performance – does the ensemble give any indication of the observed fog event?

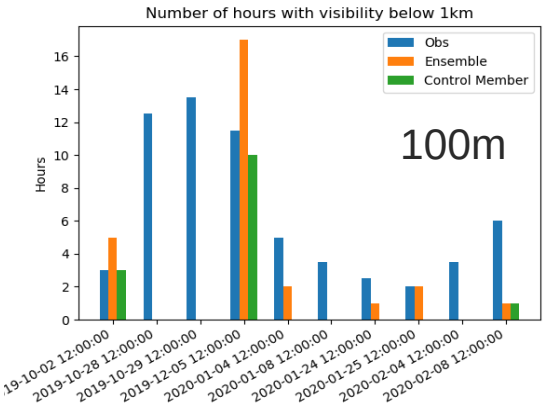
- Graphs show the number of hours of observed fog compared with number of hours that *any* ensemble member forecast fog
- Uses the mean visibility of the four grid points surrounding the site
- Ensemble predicts some fog at around 60% of the cases considered
- The control member predicts fog less frequently
- There are differences between the resolutions but no clear winner

Mean visibility over four grid points surrounding the site





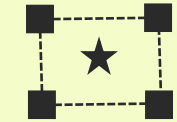


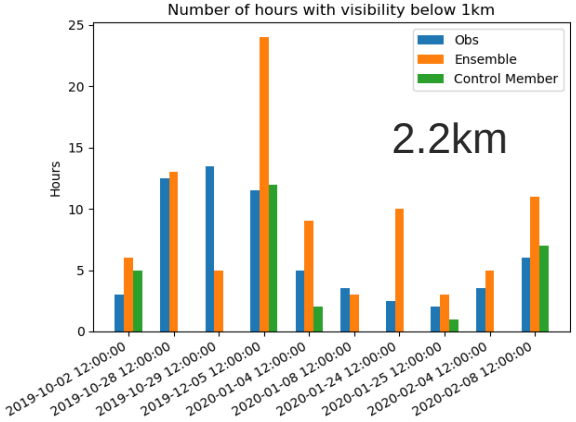


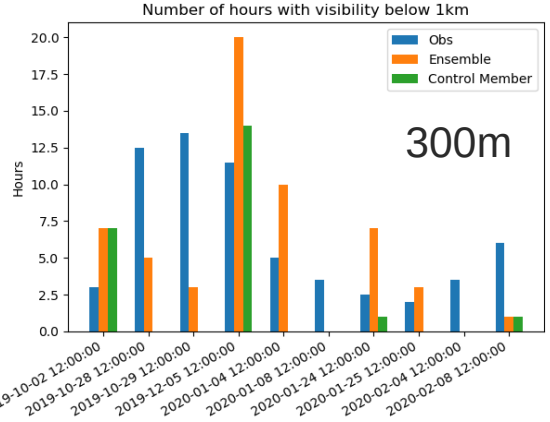
Overview of ensemble performance – minimum visibility in a 2.2km x 2.2km area

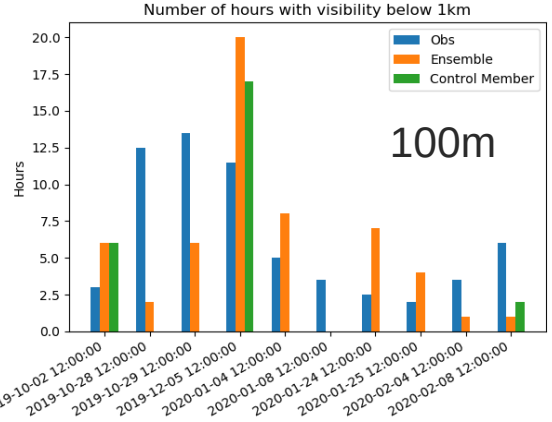
- The ensembles are now doing a better job of indicating the occurrence of a fog event
- The 2.2km ensemble predicts some hours with low visibility for all the observed fog events with the control member predicting fog in half the cases
- Using this metric, the 2.2km ensemble appears to do a better job than the higher resolution ensembles
- However, this technique does not take account of the timings of the fog events, the depth of the fog or the related probabilities

Min visibility in a 2.2km x 2.2km square surrounding the site





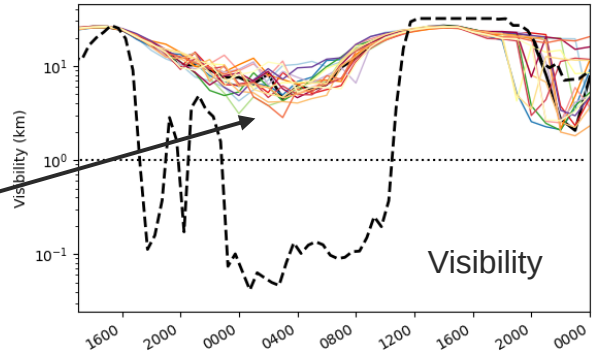


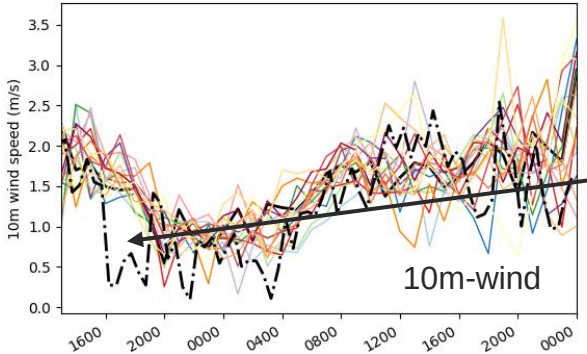


Case Study 29th – 30th October 2019

Mean values of the 4 surrounding grid points

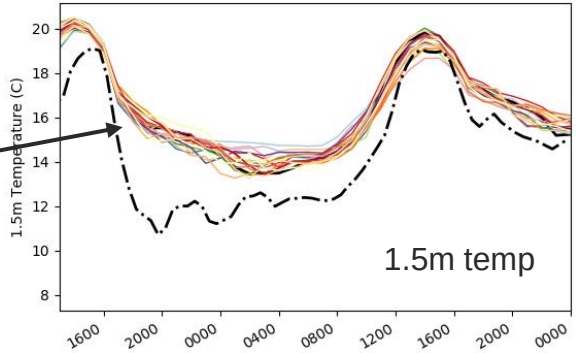
All ensemble members miss the fog event giving false confidence in the deterministic forecast

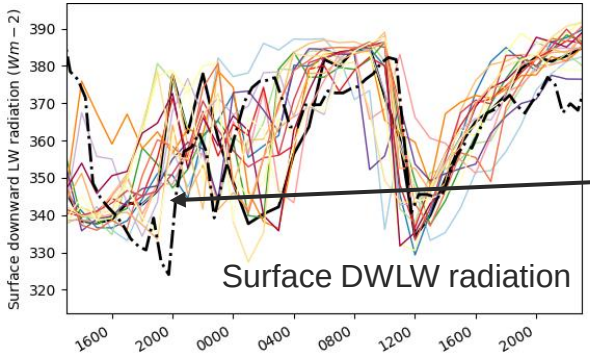




The ensemble misses the sharp drop in wind speed that occurred just before the onset of fog

None of the members show the sharp drop in screen temperature

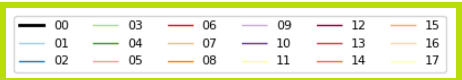




There is reasonable agreement between the surface downward LW radiation and the observations around the time the sharp drop in screen temperature was observed

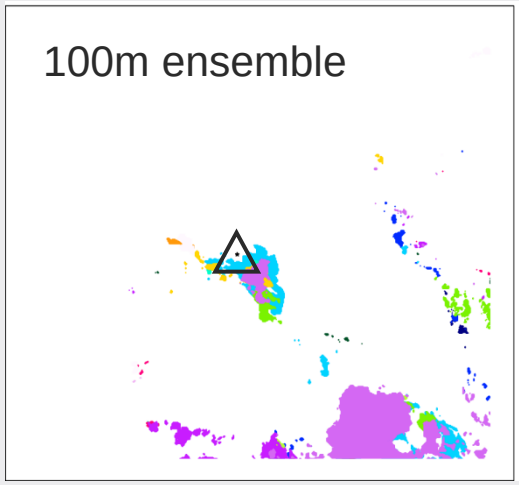
100m ensemble

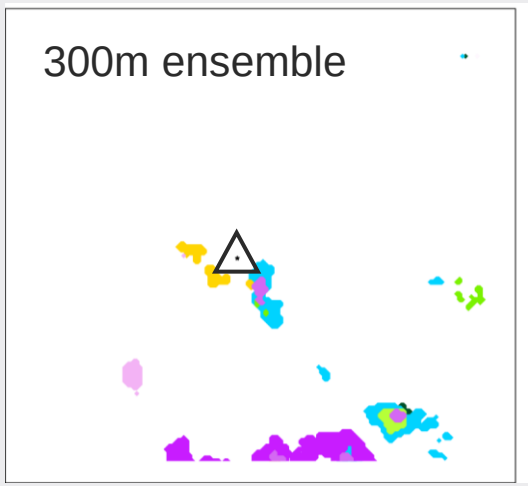
Time

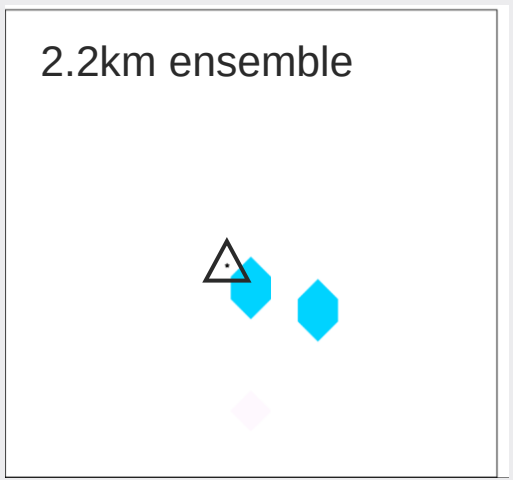


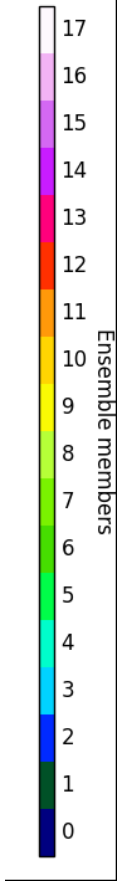
Paintball plots at 00UTC, 30th October 2019

All ensembles show some fog in the local area, with the higher resolution ensembles showing fog in more members





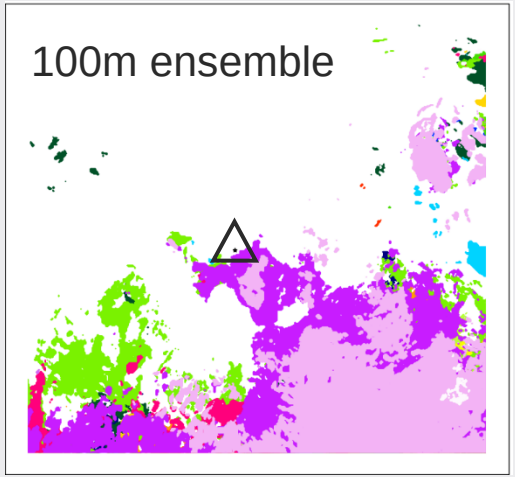


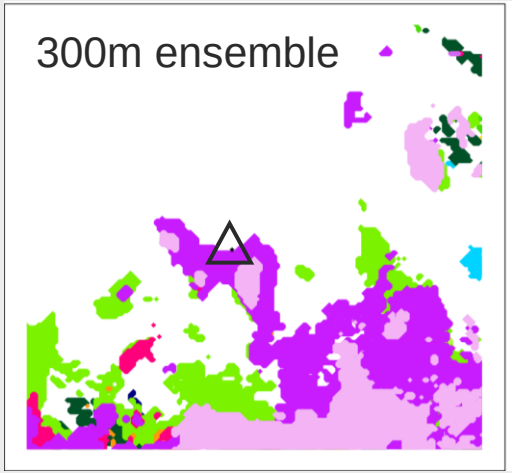


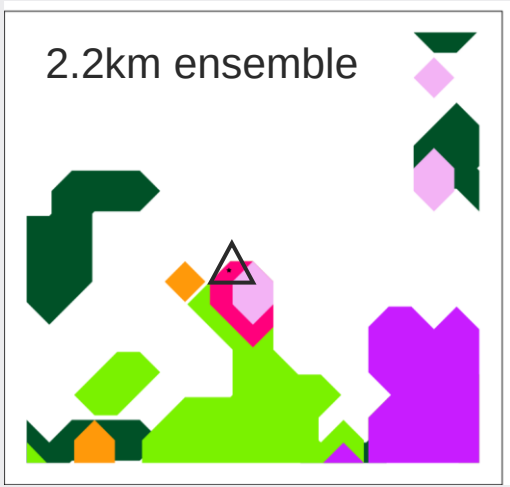
Each colour shows where the ensemble members are predicting visibility < 1km

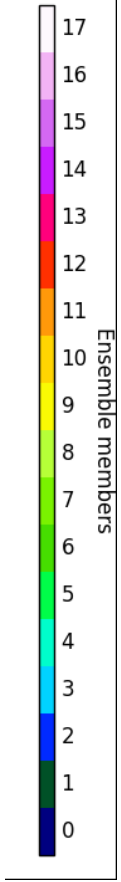
Paintball plots at 02UTC, 30th October 2019

- Around the time that the observed fog becomes deeply adiabatic, all ensembles are predicting large areas of fog close to the site in some members
- Note that the control member is not predicting fog at this time







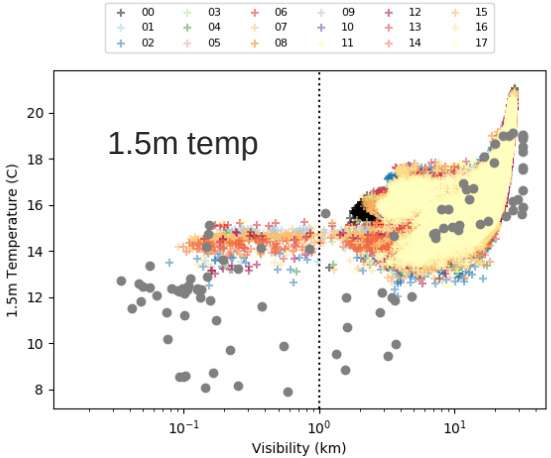


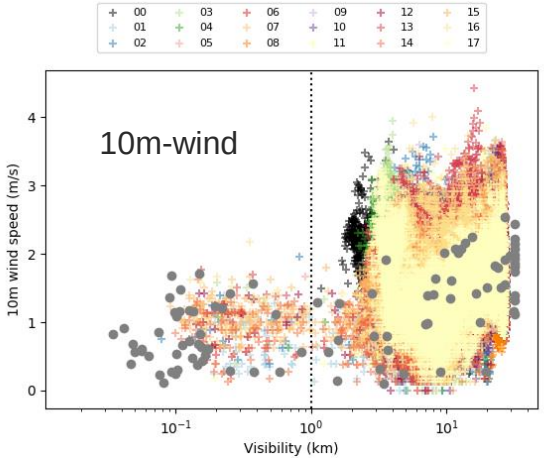
Each colour shows where the ensemble members are predicting visibility < 1km

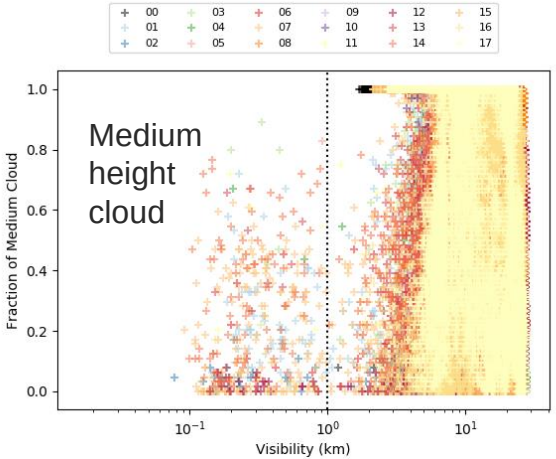
So what are the conditions where the model did form fog?

- Cool surface temperatures but not as cool as observed
- Low winds matching observations
- Less cloud
- Note that none of the foggy points predict low enough visibilities

Medium height cloud corresponds to cloud between 1949m and 5574m



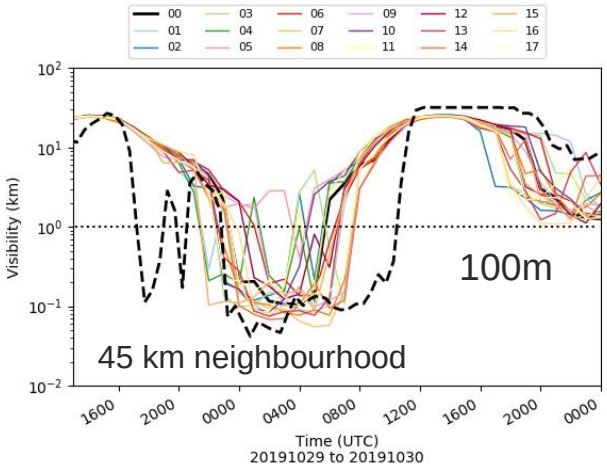


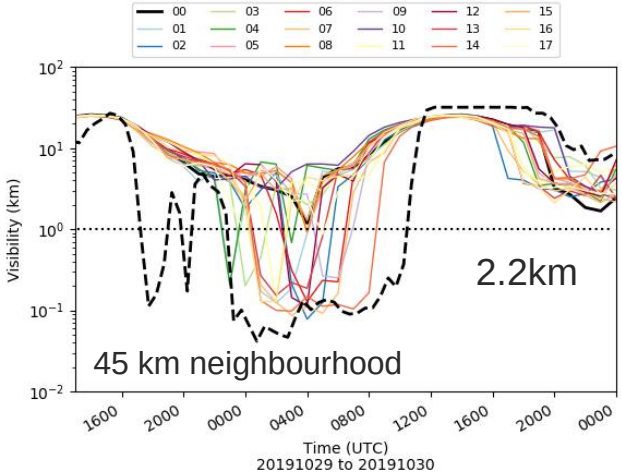


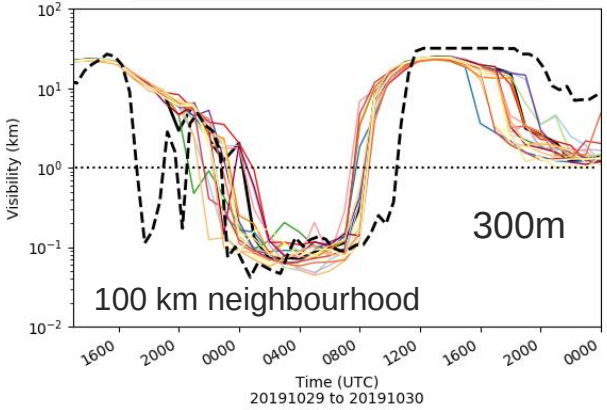
2.2km ensemble

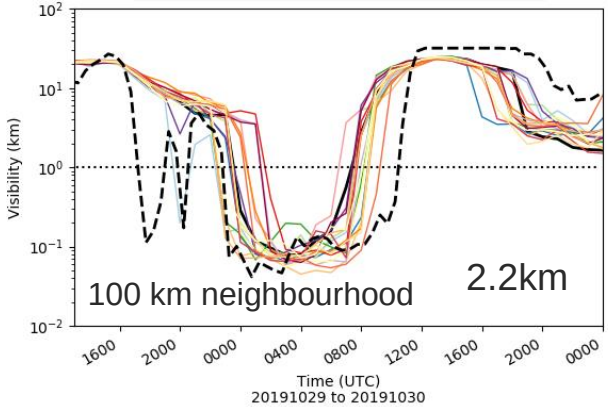
Time series showing minimum fog values in the vicinity of the SOFOG site

The ensemble shows some indication of the fog event within the 100m domain but clearer signal when extending the neighbourhood outside of the domain



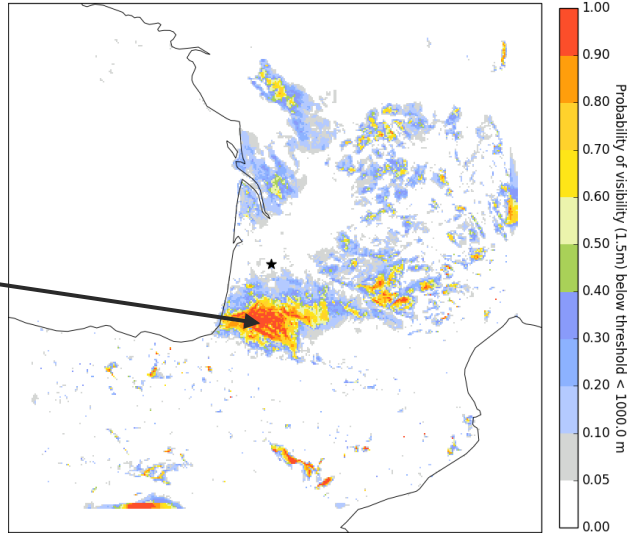




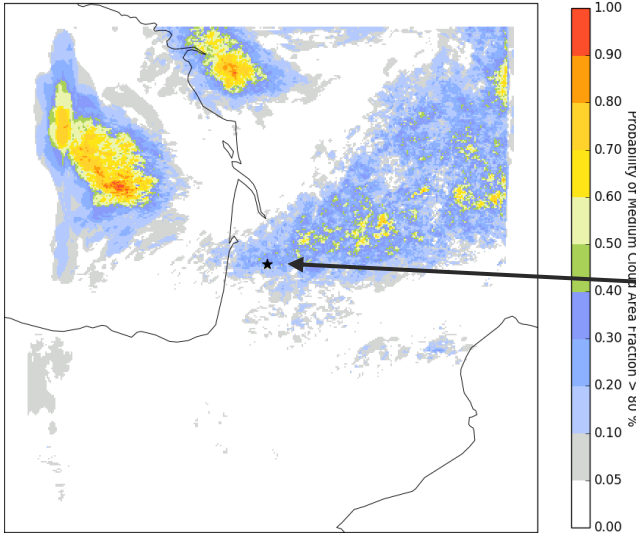


What is happening at larger scales?

Probability of visibility below 1km



Probability of medium height cloud area fraction > 80%



0200UTC

High probabilities of fog in the area south of the site.

Around 40% of the ensemble members forecasting medium height cloud over the Le Couye site

Possible error in the large scale positioning of the fog or cloud?
Or an issue with the cloud scheme?

Experiments with physics settings

Further runs with slightly different settings. These science configurations are applied at each resolution. Visibility output is at level 1 (5m).

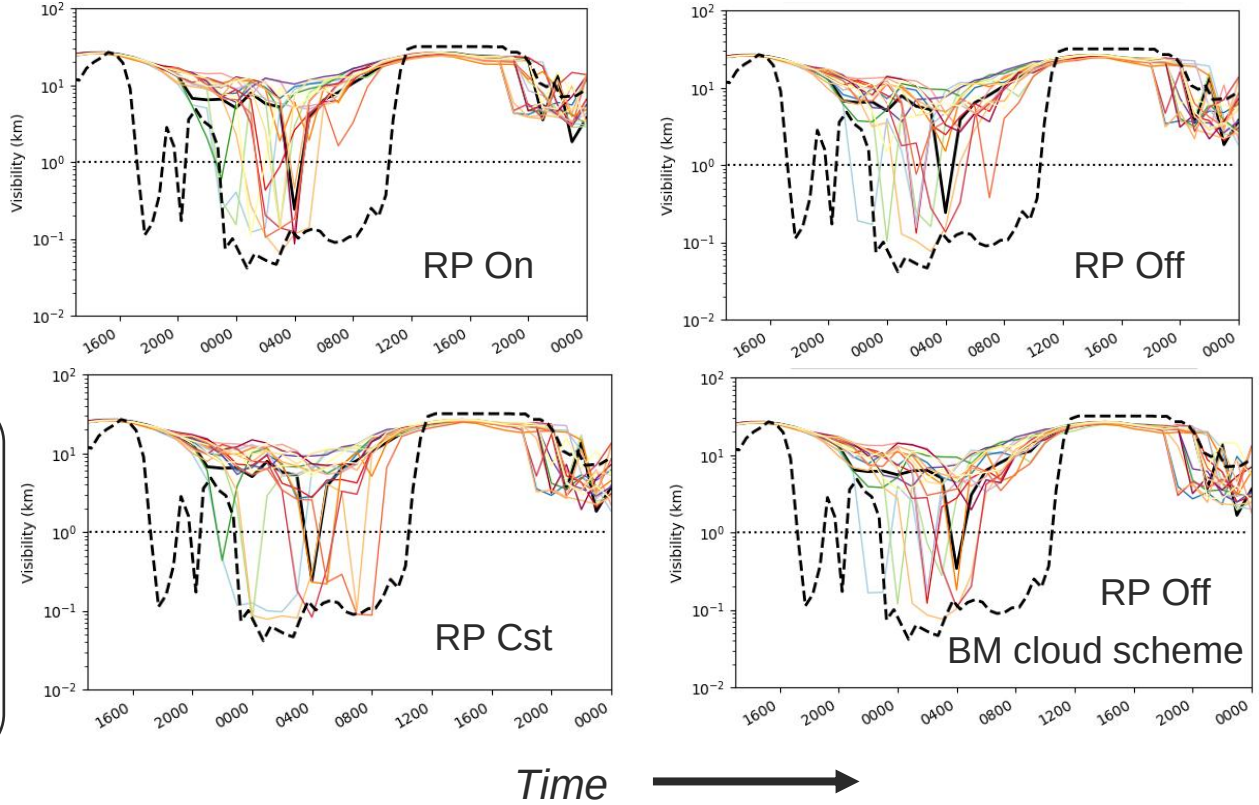
1. Random Parameters scheme switched on (RP on)
2. Random Parameters scheme switched off (RP off)
3. Random Parameters held constant (a different set-up of the RP scheme – no time variation) (RP Cst)
4. Random Parameters scheme switched off and the Bi-modal cloud scheme (from November – there may be a more up-to-date scheme now) (RP Off + BM)

Physics Experiments

Level 1 visibility, minimum of the 4 surrounding grid points

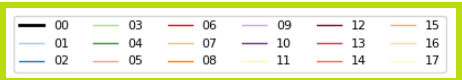
Clear differences between the two versions of the RP scheme

RP Cst does the best job of matching the duration of the fog event and the timing of the dissipation



One member shows sensitivity to the cloud scheme but for most ensemble members there is no difference at all

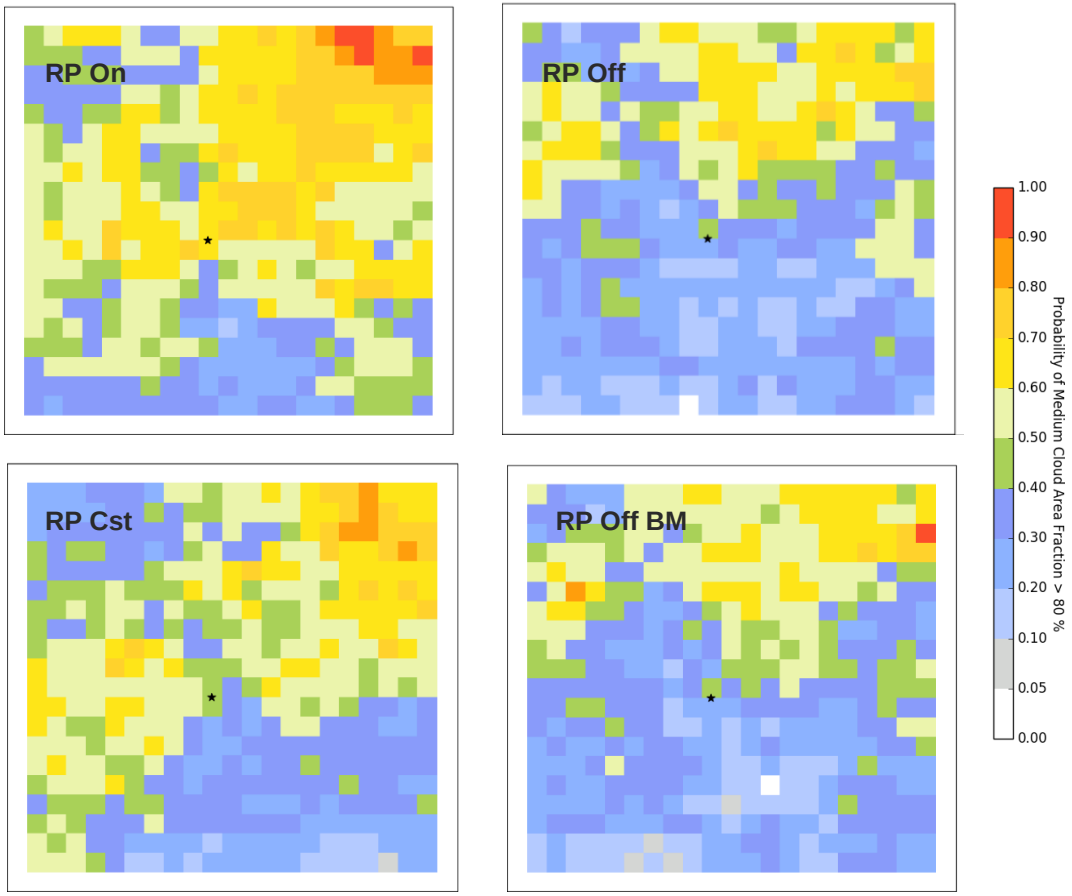
2.2km ensemble



Probabilities of medium-height cloud area fraction above 80% (0000UTC)

There are differences between all the settings but larger differences between whether the RP scheme is used or not than can be seen with the difference in cloud scheme

The RP scheme appears to increase the number of members with cloud at the site (for this time)



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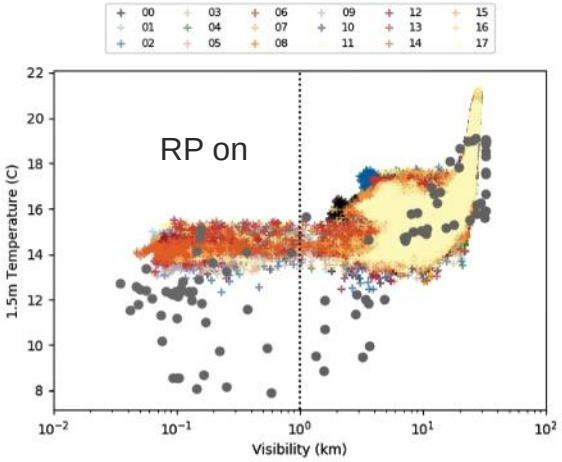
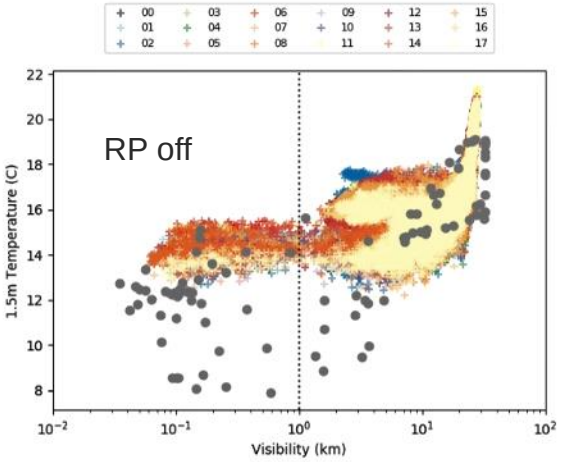
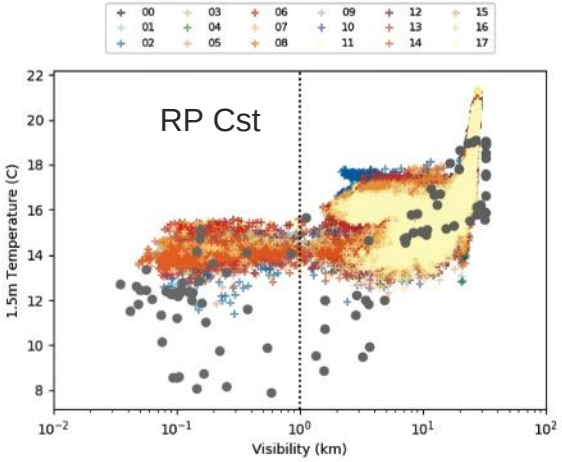
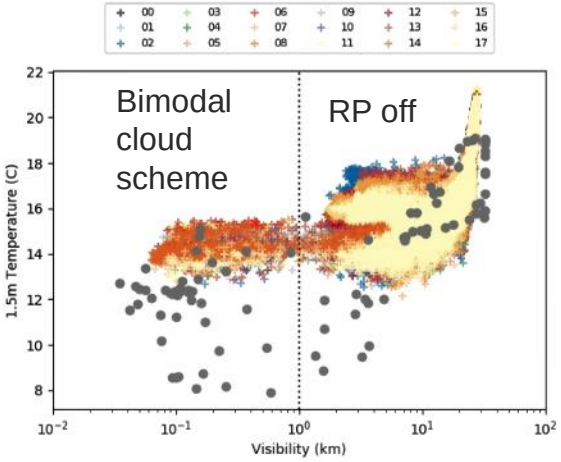
Comparison of surface temperature and visibility in the 100m domain for the 2.2km ensemble

The RP Cst ensemble shows cooler temperatures where fog is forecast



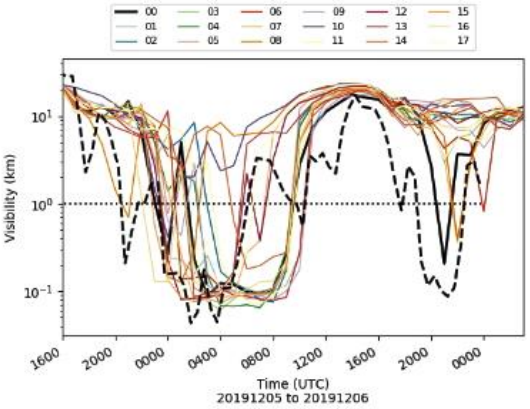


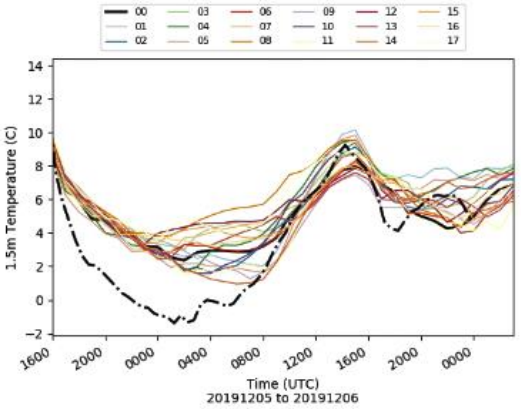


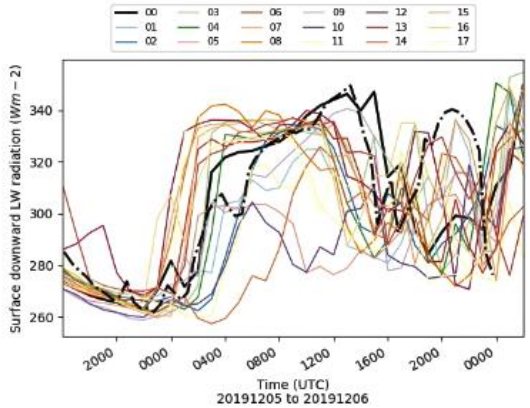


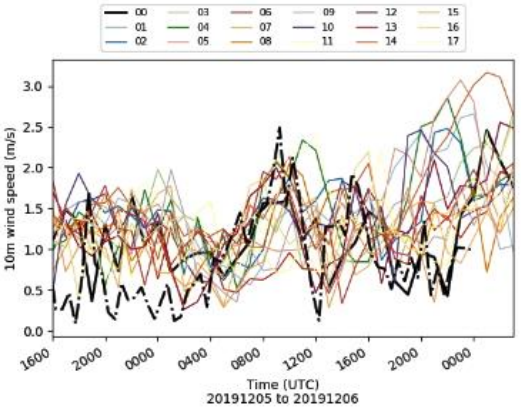
Case study: 5th-6th December 2019

- The ensemble captures the main features of the fog event
- Lots of spread in this case with some member of the ensemble capturing the timing of the observed dissipation of the fog
- Model is still warm compared with the obs but temperatures are lower overall for this case study (-2C to 2C for the fog event)

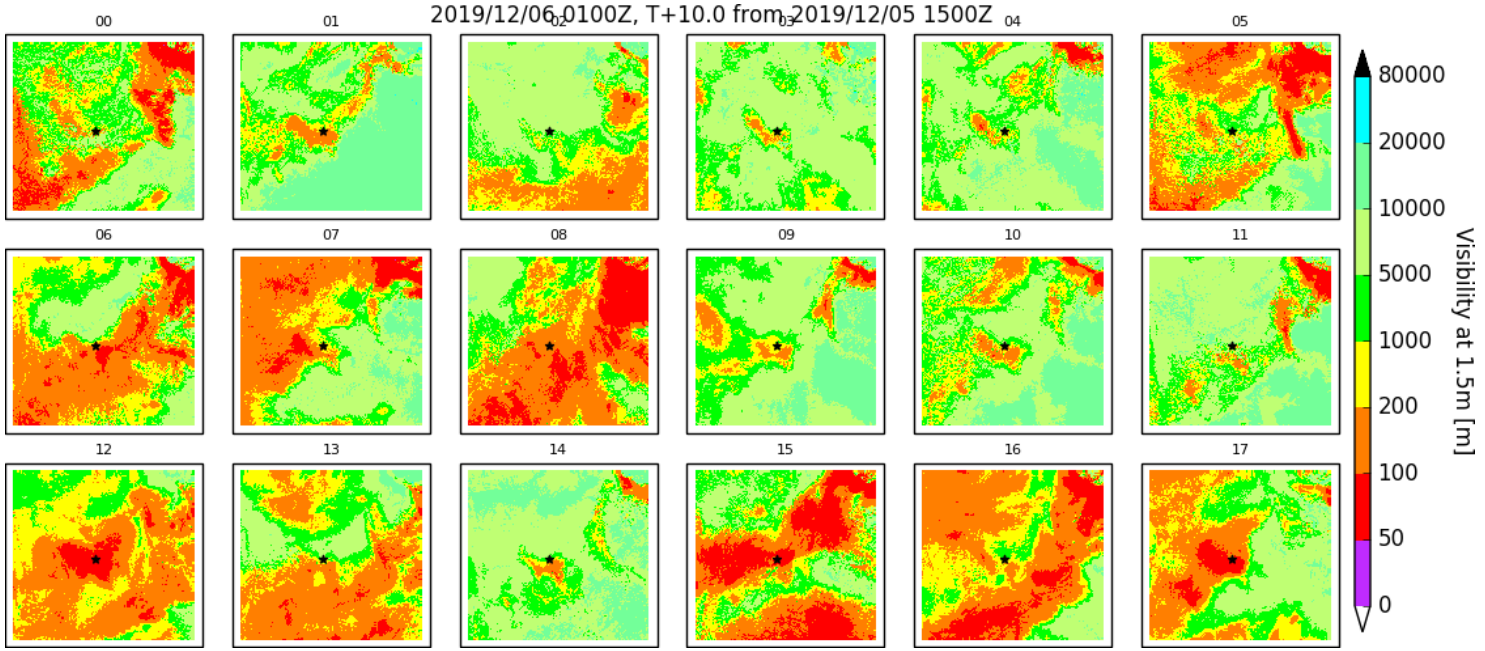








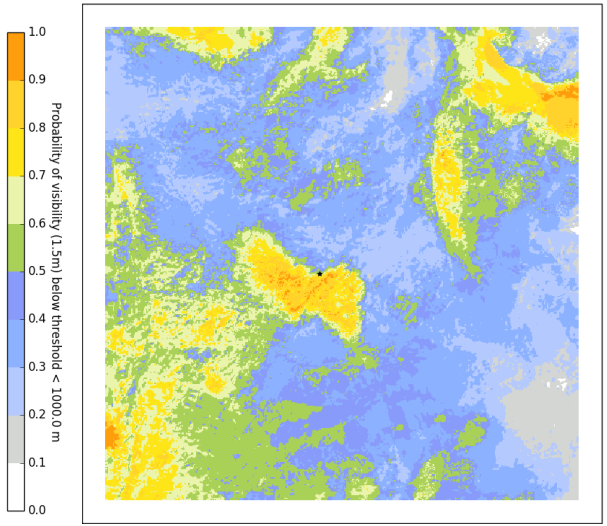
Postage Stamps of 100m ensemble at 01UTC, 5th December 2019



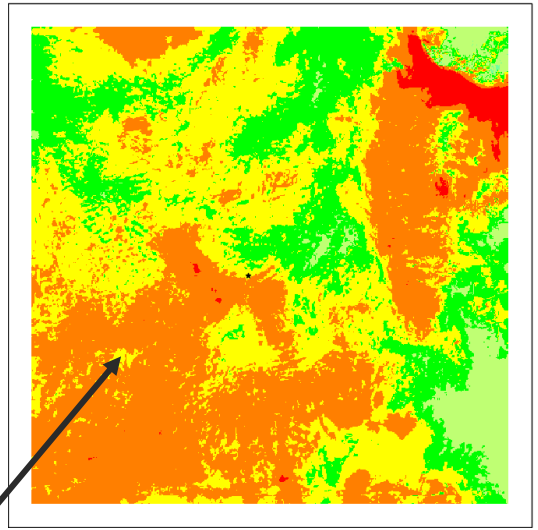
All members show low visibilities with around 60% of members forecasting widespread fog

How should we present this information? Probability plots? Postage stamps suggest two scenarios …

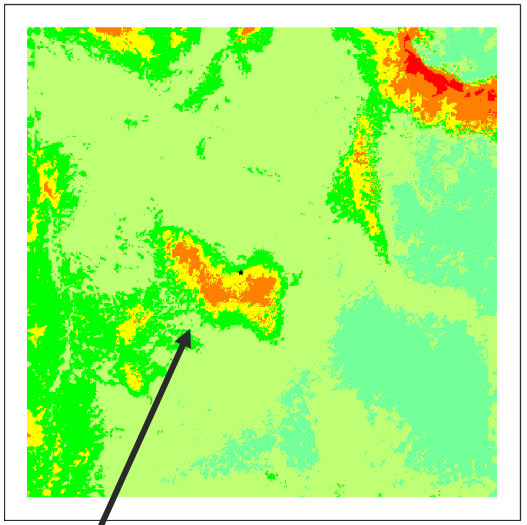
Probability of vis < 1km



50th percentile of 11 foggiest members



50th percentile of 7 least foggy members



60% chance of this scenario

40% chance of this scenario

Summary and next steps …

Summary:

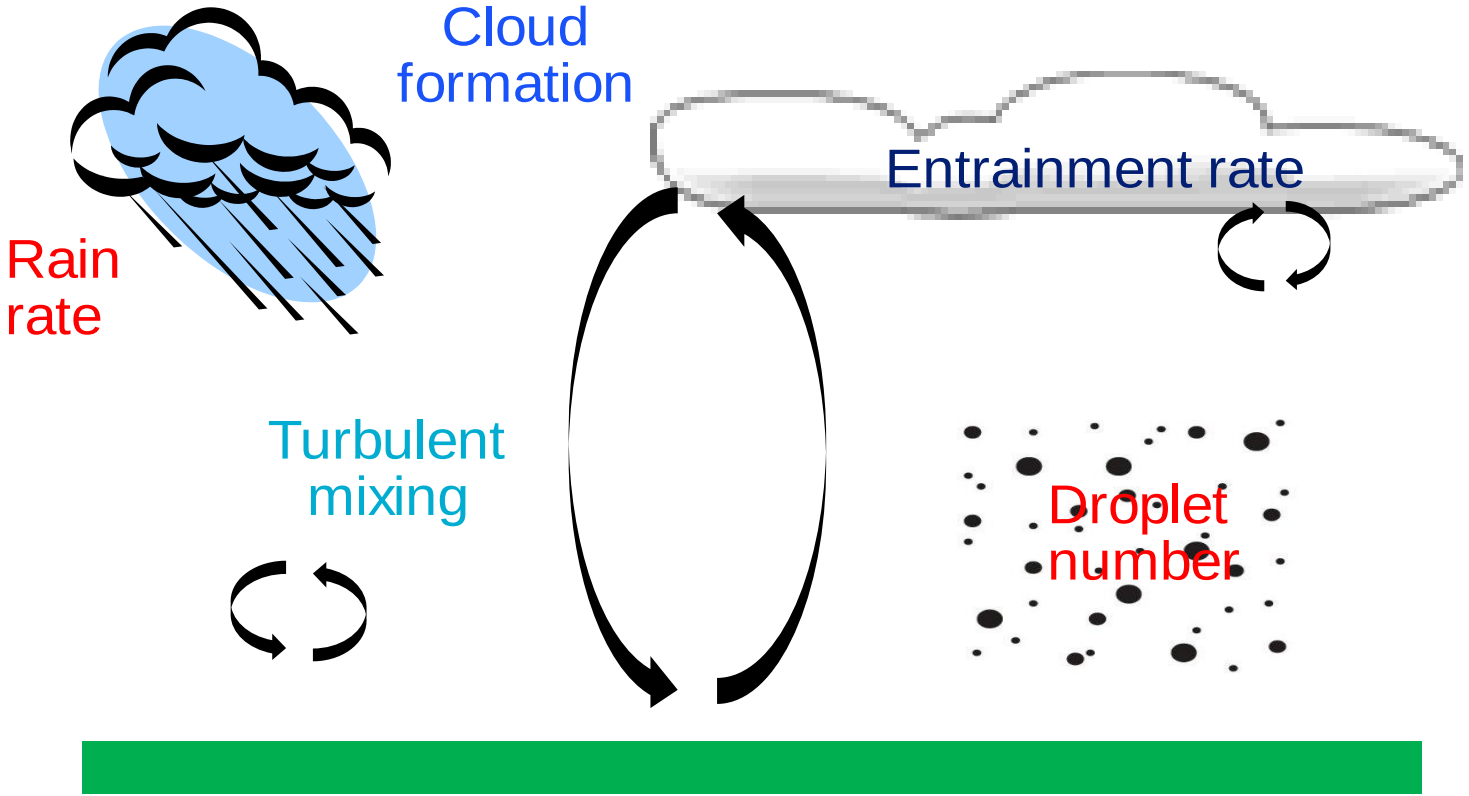
- Ensemble appears to be giving some value over the control member
- Improvements can be seen when using the minimum of the surrounding grid point rather than the mean → this suggests that the model is often predicting patchy fog around the site
- For the case study considered, the ensemble showed more sensitivity to changes to the RP scheme than to the change in cloud scheme
- When the ensemble has a lot of spread, plots of different scenarios may be a useful way to present the information

Next Steps:

- Further evaluation of the sensitivity to physics changes
  - Can we see more sensitivity to the cloud scheme in different cases?
  - What can we learn from the differences in the RP scheme?
  - Can we consider additional parameters for the RP scheme?
  - Other sensitivities, e.g. RH profile between resolutions?
- Comparison of the Vera diagnostic with the ensemble probabilities
- Expand evaluation to include data from surrounding sites
- Continue detailed evaluation of the case studies – can we identify any trends? What are the main differences between foggy and non-foggy members? Do these differences come from the driving model or the resolution?

Extra slides

Random Parameters are chosen to target uncertainty at the small scales



RP algorithm

- Parameters are initialised randomly from a specified range
- Assumed to be equally likely to be above or below the default value
- Parameters are updated at regular time intervals using an auto regressive process