Evaluation of the Plant-Craig stochastic convection parameterisation in MOGREPS

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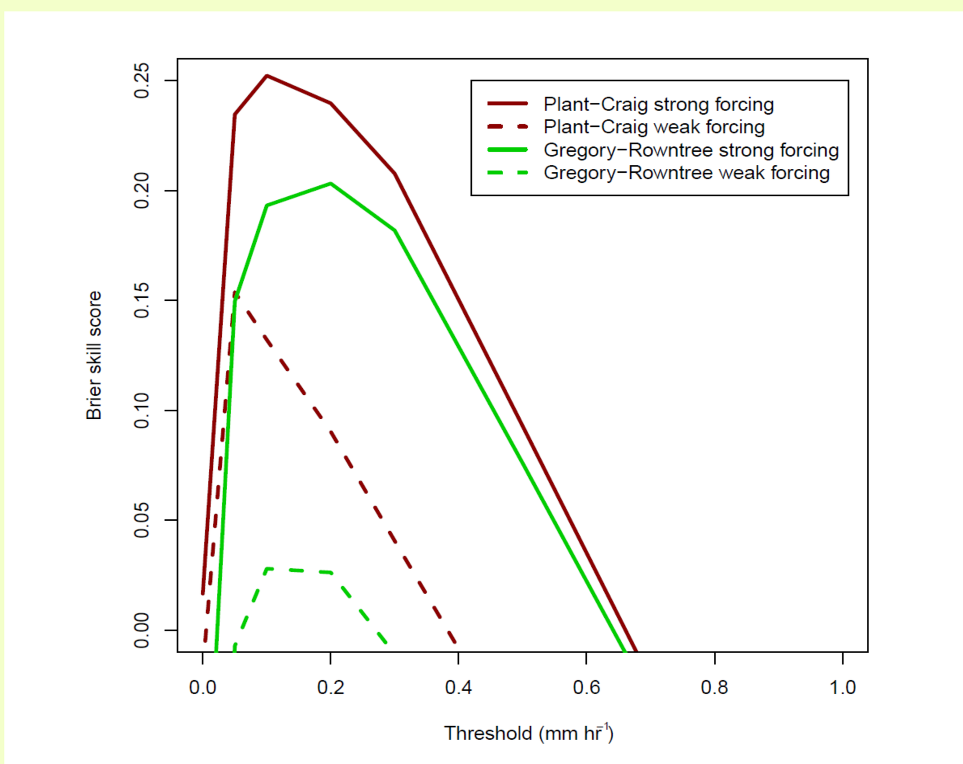
Overview

- The Plant-Craig (PC) scheme is a stochastic, spectral generalisation of the Kain-Fritsch scheme for deep convection.
- In this study, it was implemented in MOGREPS-R (NAE domain)
  - This system has now been retired, but the resolution (24km) is similar to typical global NWP resolutions currently used for ensemble forecasting.
- 34 forecasts were produced for dates in July 2009, starting at 06 or 18 UTC, running for 54 hours.
- These were compared with equivalent forecasts taken from the operational archive
  - These are identical except they use the UM standard (non-stochastic) Gregory-Rowntree (GR) scheme instead.
- Forecast 6-hour accumulations were verified against Nimrod radar data, covering the UK and immediate surroundings.

Probabilistic verification

- We used the Brier skill score (using the climatology of the observations as reference) to assess the skill of the forecasts.
- The PC scheme produces slightly improved forecasts for the strongly-forced cases.
- For the weakly-forced cases the improvement is much greater
- Neither setup has skill at higher thresholds for this period.
- Figure taken from Keane et al. (2016); values represent averages over all lead times.



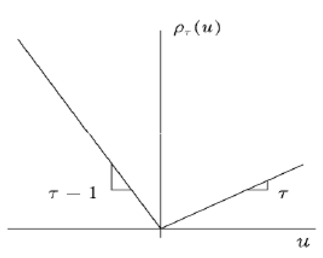
Ensemble added value

- This metric was developed by Ben Bouallegue (2015), and aims to evaluate the added value of an ensemble forecast relative to its underlying single forecasts (see description, right).
- It is reasonable to assume that structural differences between the Plant-Craig and Gregory-Rowntree schemes will affect the skill of the underlying forecasts and the whole ensemble in a similar way
  - These differences should therefore have a small effect on the Ensemble added value.
- The stochasticity of the Plant-Craig scheme, however, will have far more effect on the skill of the overall ensemble, than on the skill of the underlying single forecasts.
- The fact that the Plant-Craig scheme yields a significantly improved Ensemble added value (see Figure, right, taken from Keane et al., 2016) suggests that its stochasticity is responsible for a significant part of the improvement in the Brier skill score.

Based on quantile score:

$$QS\{\tau\} = \rho\left(x_{\mathrm{obs}} - x\{\tau\}\right)$$

$$\rho(u) = \begin{cases} \tau u & \text{if} \quad u > 0 \\ (\tau - 1)u & \text{if} \quad u < 0 \end{cases}$$



This can be decomposed into a reliability component and a potential component

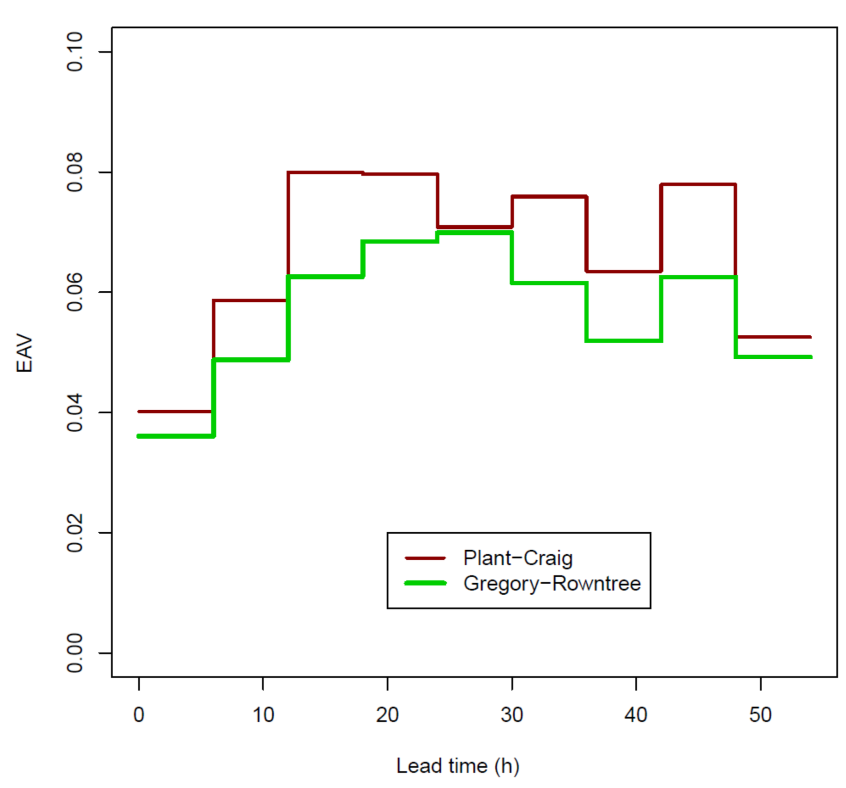
→ The potential component is the potential score after calibration

$$QS = QS_{\mathrm{rel}} + QS_{\mathrm{pot}}$$

The ensemble added value is then given as a skill score as

$$EAV = 1 - \frac{\sum_\tau QS_{\mathrm{pot}}\{\tau\}}{\sum_\tau QS_{\mathrm{pot,ref}}\{\tau\}}$$

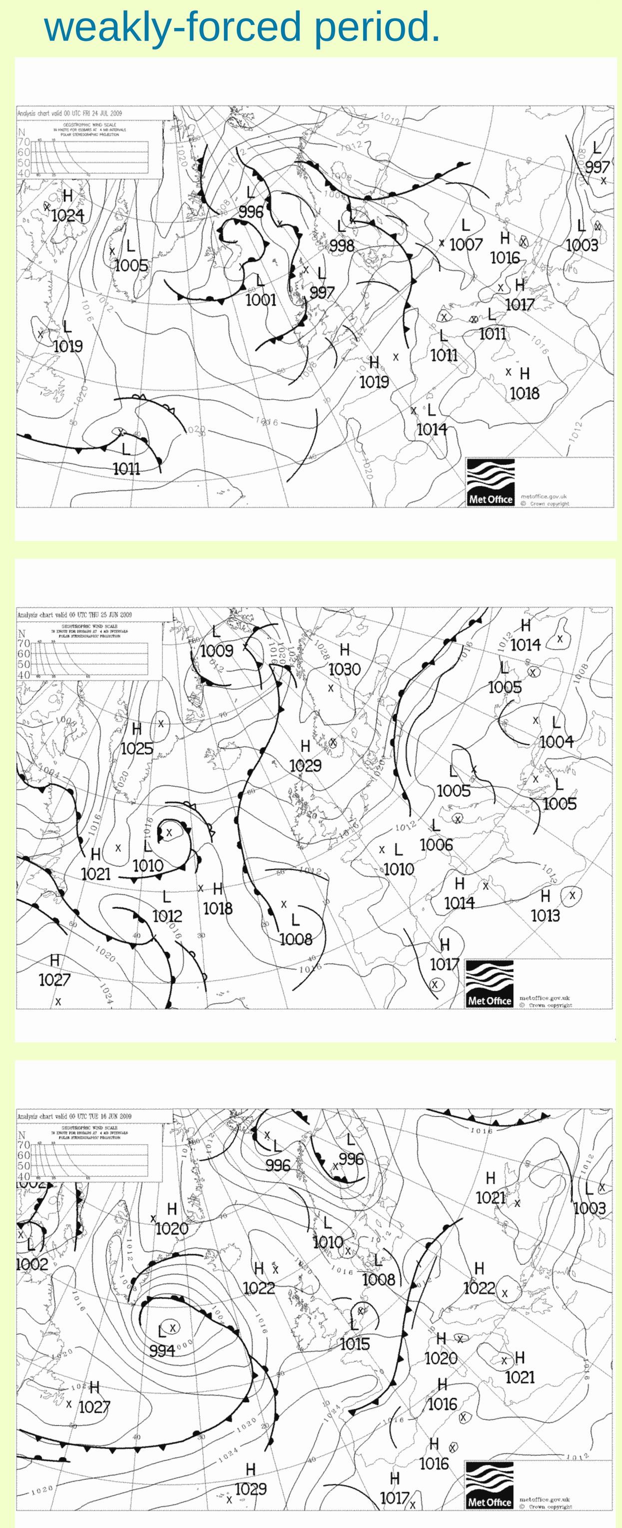
Where here the reference is a randomly selected ensemble member



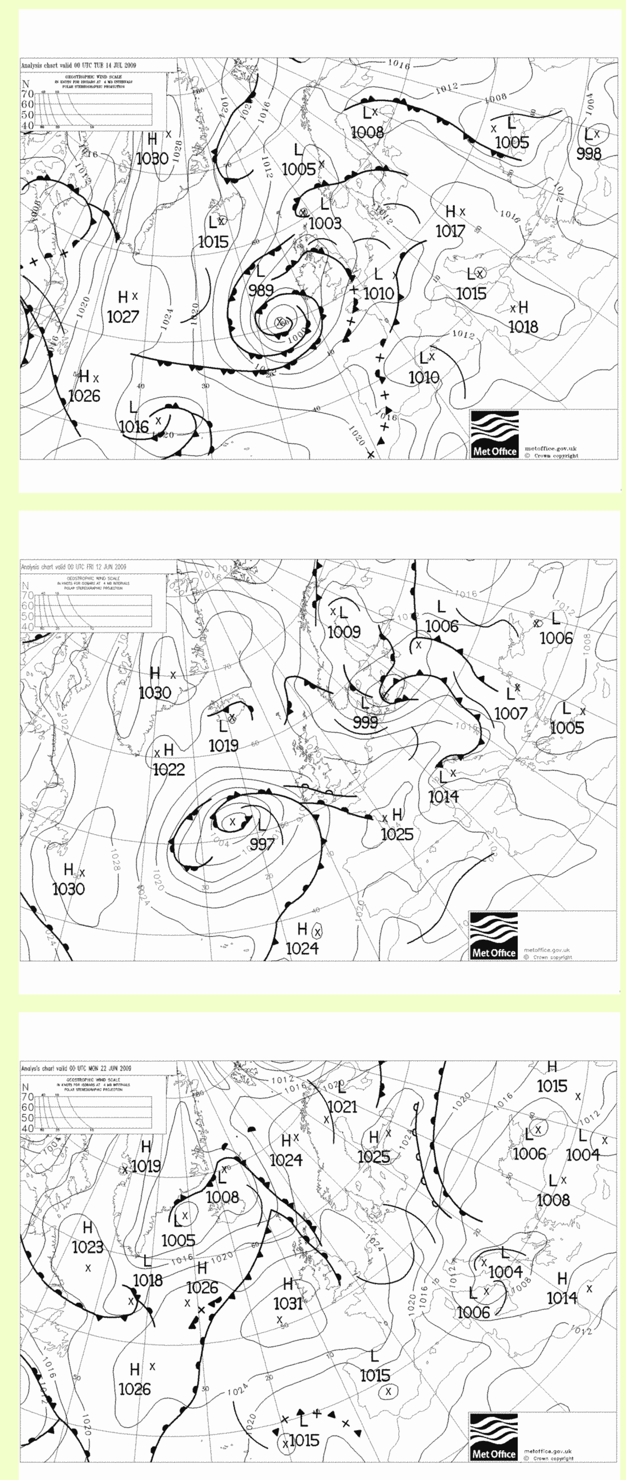
Separation into weakly- and strongly-forced cases

- Groenemeijer & Craig (2012) and Kober et al. (2015) showed that the stochasticity of the PC scheme is more effective in weakly-forced cases than in strongly-forced cases.
- We separated our verification period into weakly- and strongly-forced periods by inspecting the 00 and 12 UTC analyses and evaluating the amount of synoptic forcing present at each time.

Examples of analyses defining a weakly-forced period.

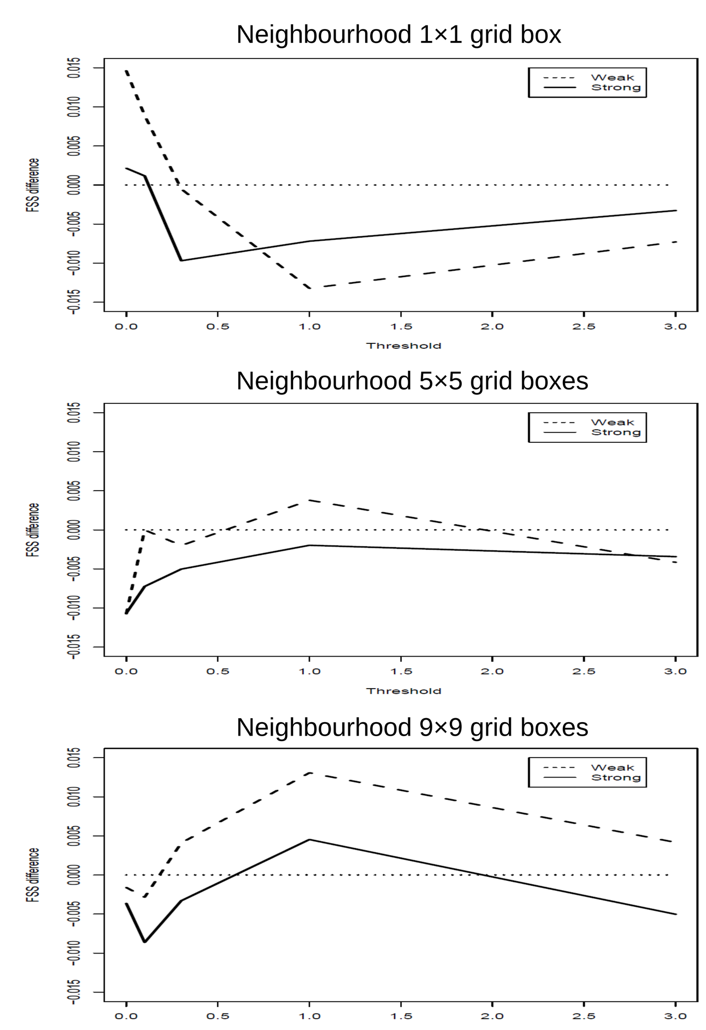


Examples of analyses defining a strongly-forced period.



Deterministic verification

- We used the Fractions skill score (Roberts & Lean 2008) to assess the quality of the two sets of forecasts at different scales.
- The difference in this score between the two schemes (PC minus GR) is plotted, for three different neighbourhood sizes.
  - The values are averaged across all lead times.
  - The thresholds are in units of mm/hr
- For a neighbourhood size of just the grid box, the GR scheme mainly performs better (the lines are mainly below zero).
- As the assessment scale increases, the performance of the PC scheme improves relative to that of the GR scheme (the lines move upwards), and this effect is much more pronounced for the weakly-forced cases (dashed lines).
- The Figure is taken from Keane et al. (2016)



Summary

- The Plant Craig scheme improves the MOGREPS 54-hour forecast for a 20-day period in July 2009.
  - The greatest impact is for **weakly-forced** cases, and for scales of **a few grid points**.
- These results could provide a useful reference benchmark to compare against future convection schemes.
  - The same methodology has been successfully applied by Wang & Zhang (2016), using Zhang-McFarlane as an underlying scheme in place of Kain-Fritsch.
- It would be interesting to carry out a similar analysis for a longer verification period, using the global version of MOGREPS.
  - The Plant-Craig scheme has a deterministic mode, which could be used to provide a third set of forecasts, in order to isolate the effects of the stochasticity of the scheme.

References

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- The surface analysis charts were taken from http://old.wetterzentrale.de/topkarten/fsfaxbra.html

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