Probabilistic Global Convective Hazard Forecasts and Verification

Rebecca Stretton, Piers Buchanan, Will Hand, Dan Suri, Steve Willington

Severe convection can cause a range of weather hazards which are a danger to both the general public and commercial sectors such as aviation.

The Met Office produce forecasts for a range of convective hazards using the Met Office Convection Diagnosis Procedure (CDP).

This work explores CDP forecasts produced using the Met Office Global Regional Ensemble Prediction System in the global configuration (MOGREPS-G).

MOGREPS-Global CDP

- 33km model resolution
- 12 ensemble members
- Produces a probability of occurrence.
- Run for 0Z and 6Z MOGREPS-G run each day only.
- Lead times of T+12, 18, 24, 30, 36, 42, 48, 60.
- Convective parameters:
  - Lightning
  - Hail
  - Tornado
  - Precipitable water
  - CAPE (Convective Available Potential Energy)
  - Lifted Index

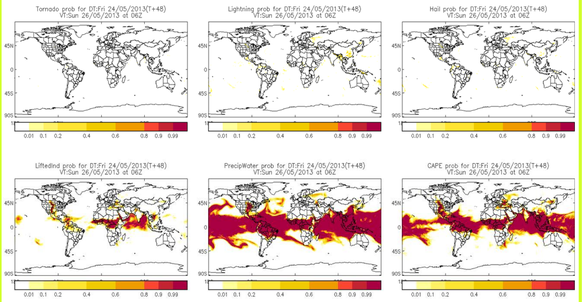

Figure 1: MOGREPS-G convective forecasts for 26/05/2013 at 6Z.

Verification: Lightning in Europe

This objective verification of the lightning diagnostic includes 1116 civil airports across Europe during the 2013 summer (June-August).

Lightning Observations

The ATDnet (Arrival Time Difference) system is an automatic lightning location network that senses lightning strokes over a geographical area. A stroke count is processed to give the number of strokes within a 50km radius of each airport over a 6 hour period.

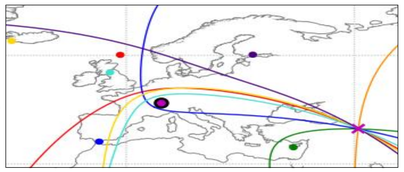

Figure 2: Hyperbola plot - the potential locations of the lightning source from every pair of stations, the intersection of all the hyperbolae is the lightning location.

Lightning Probability

Lightning probability is derived using the lightning index (LI) of each ensemble member at the airport. Lightning index has 3 outcomes: 0, 1 or 10 as displayed in Table 1 depending on a variety of convection parameters.

LI 0	Lightning unlikely
LI 1	Risk of lightning
LI 10	Deep convectively stable environment, lightning possible

Table 1: Chance of lightning associated with each lightning index.

Probability of Lightning Index ≥ 10

Hits	Misses
2.2%	9.8%
False alarms	Correct rejections
3.0%	85.0%

- The rare nature of lightning focuses the points on the ROC curve closer to the origin.
- LI10 displays fewer false alarms as the confidence of lightning is higher.

Probability of Lightning Index ≥ 1

Hits	Misses
2.4%	9.4%
False alarms	Correct rejections
5.4%	82.8%

- MOGREPS-Global shows good reliability for available probabilities.
- LI1 captures more hits as the broader conditions allow weaker/smaller storms to be forecasted, however this increases the false alarms.

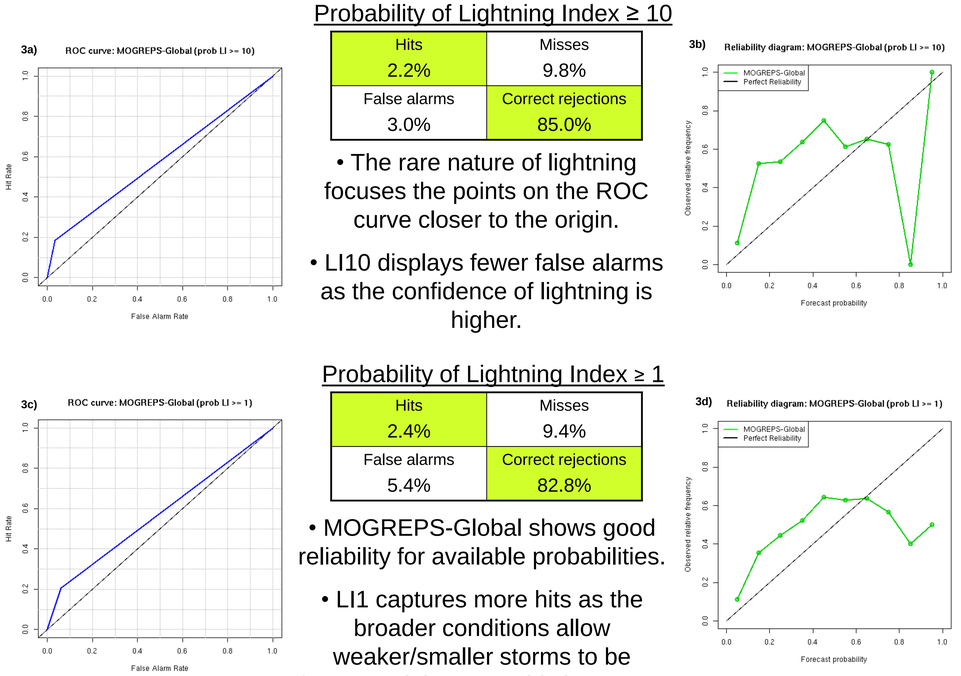

Figure 3: a) ROC curve for probability of LI ≥ 10, b) reliability plot for probability of LI ≥ 10, c) ROC curve for probability of LI ≥ 1, d) reliability plot for probability of LI ≥ 1. The contingency tables are calculated by classifying a hit as 2 or more strokes observed and a non zero probability of lightning forecasted within a 50km radius of the airport.

Case Study: Hail in Australia

16th November 2013 in South-East Queensland, Australia

The hail diagnostic derives the probability of hail > 10mm in diameter (Hand and Cappelluti, 2010), using various parameters to provide an indication of hailstone size. Additional checks of rain rates < 0.5mm/hour and Lifted Index > 0 set the probability of hail to zero.

On 16th November the model indicated the probability of hail across SE Queensland at a lead time of T+30. Figure 4 shows the agreement between model output and observed rainfall.

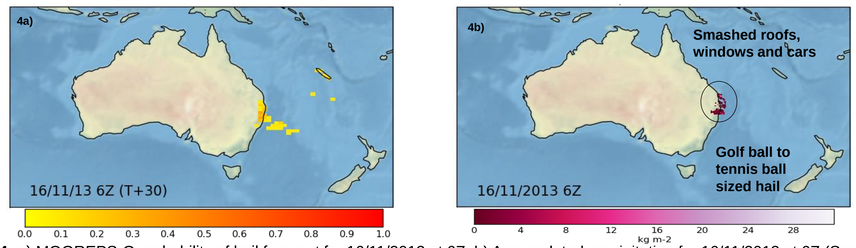

Figure 4: a) MOGREPS-G probability of hail forecast for 16/11/2013 at 6Z, b) Accumulated precipitation for 16/11/2013 at 6Z (Seed, 2007).

Case Study: Tornadoes in USA

31st May 2013 in Central Plains, USA

The tornado diagnostic produces a probability of tornadic activity based on the Fuzzy Tornado Parameter (FTP). FTP is calculated by combining values of CAPE, Lifted Index, precipitable water and rain rate. Any non-zero value indicates a signal for a tornado, higher values show greater propensity for tornado formation.

On 31st May tornadoes were reported across the central plains (NOAA SPC) , the model captured this area at risk at a lead time of T+60.

As seen with lightning using a lower threshold produces a wider forecast area, however when forecasting tornadoes this could create many more false alarms.

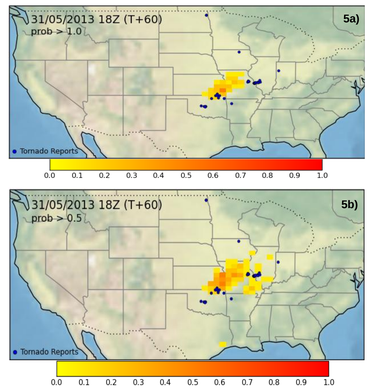

Figure 5: MOGREPS-G probability of tornado forecast for 31/05/2013 at 18Z a) prob FTP>1 b) prob FTP>0.5.

Conclusions and Future Work

The forecasts show skill and reliability given the resolution and global capability. They are global forecasts intended to give early warnings of potential hazardous weather.

The lightning diagnostic shows slight under forecasting and recalibration could improve results. Further verification research into the diagnostic will be carried out. Future work would also include more objective verification of the lightning diagnostic and potential additions to the tornado diagnostic to create a probability of supercells.

References

Hand, W. H. and G. Cappelluti, 2010: A global hail climatology using the UK Met Office convection diagnosis procedure (CDP) and model analyses. *Meteorol. Appl.*
NOAA Storm Prediction Center's Tornado Database [available online at: http://www.spc.noaa.gov/climo/online/]
Seed, A. W. et al., 2007: Rainfields: The Australian Bureau of Meteorology system for quantitative precipitation estimation. *33rd American Meteorological Society Radar Conference*, Cairns, Australia.

Met Office FitzRoy Road, Exeter, Devon, EX1 3PB United Kingdom
Tel: 01392 884213 Fax: 01392 885681
Email: rebecca.stretton@metoffice.gov.uk