Report for SWFDP-SG Meeting on Feature-based Diagnostics for Severe Weather Alerting from NWP Systems

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Severe weather is commonly associated with specific identifiable features in the atmosphere, such as cyclones, fronts or troughs. These features are widely used by forecasters to describe the behaviour of the atmosphere in a conceptual way. Objective identification of features from NWP forecasts can be beneficial for severe weather prediction because:

- The severity of weather is often underestimated by NWP fields, especially in the lower resolution models used in ensembles, but the features themselves can still be well represented and predicted within the model resolution.
- It can help forecasters interpret model or ensemble outputs in terms of the conceptual features which they are trained to use in synoptic meteorology.
- Features can be individually identified or tracked in each member of an ensemble forecast, offering the possibility of a clear summary of the wealth of information within an ensemble forecast.

As part of its contribution to the THORPEX project, the Met Office has developed a number of feature-based diagnostics for identification of high-impact weather in ensemble forecasts. Some of these may be useful in the context of the SWFDP for the effective presentation of ensemble forecasts of severe weather hazards to forecasters in regional centres or NMHSs. Furthermore, the concept may be suitable to be extended to new diagnostics suitable for identification of different types of hazard, for example in the tropics.

Tropical cyclones

One of the most standard feature-based diagnostics is tropical cyclone (TC) tracking, as TCs are very well-defined features associated with extremely severe weather, but are too small to be resolved in global models or even properly resolved in most regional models. Figure 1 shows a TC-tracking product generated from the MOGREPS 15-day ensemble which is now distributed experimentally to TC RSMCs. The three charts show the tracks of the storm in each member of the ensemble, the probability that the storm will pass within 75 miles of any location, and a summary of the deterministic, ensemble control and ensemble mean forecasts.

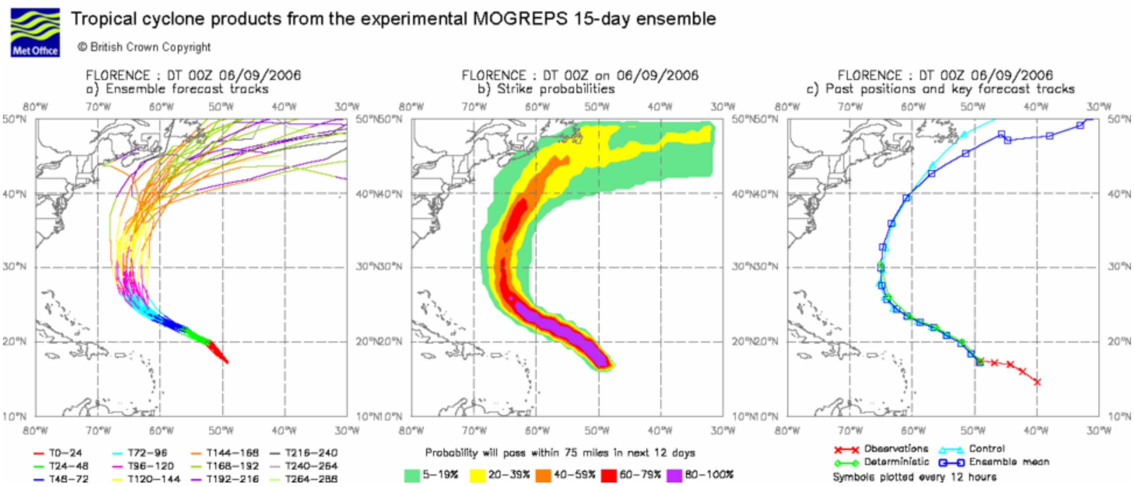


Figure 1: Example of tropical cyclone track product from the Met Office MOGREPS 15-day ensemble.

Also of interest is the genesis of new TCs, which a few high-resolution global models are starting to show some skill in predicting. Figure 2 shows an example chart giving the probability that a storm will be located in each 10 degree square. Note that the square east of Madagascar develops a storm after the early part of the forecast.

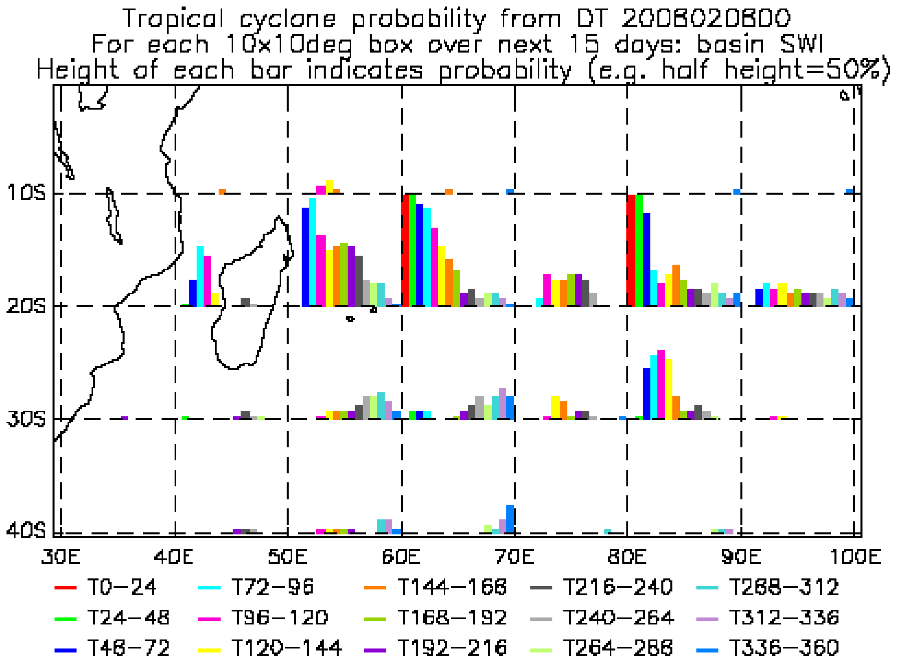


Figure 2: Tropical cyclone probability in each 10x10 degree square of the map at different forecast lead-times, as forecast by the MOGREPS ensemble.

Extratropical cyclones and fronts

The Met Office has a system called the cyclone database which allows the objective diagnosis of both extratropical cyclones and also frontal systems and frontal waves. This system has been adapted for use with ensemble forecasts, and combined with a tracking system allowing individual features to be tracked through the forecast including their evolution from incipient frontal wave through to mature barotropic cyclone. Once these features are stored in the "database", plots can be generated showing characteristics of the feature in each member of the ensemble, or probabilities similar to those generated for the tropical cyclones. Figure 3 shows an example "spaghetti" chart of objectively derived fronts; figure 4 shows three different diagnostics associated with a cyclone as it develops in the ensemble forecast.

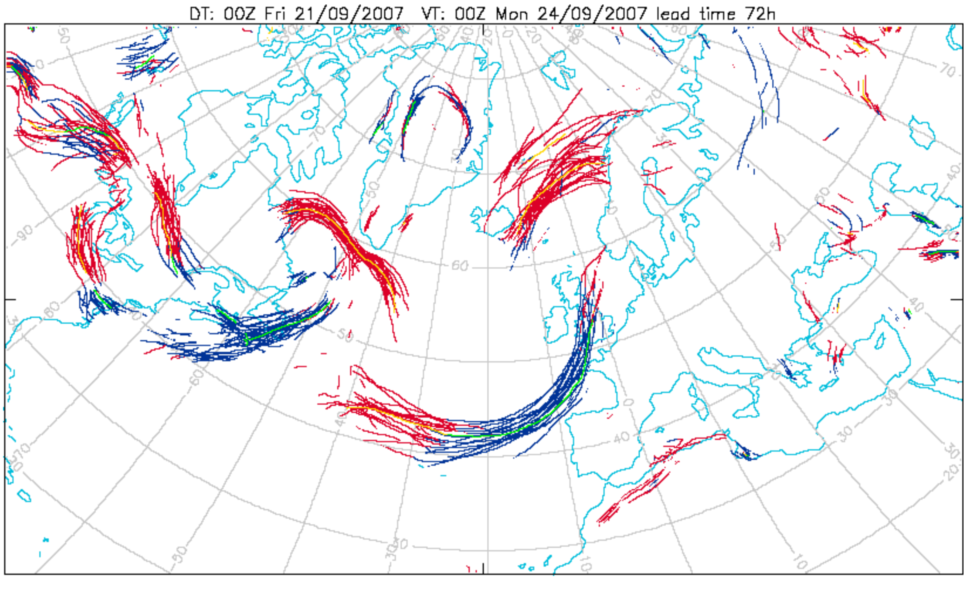


Figure 3: Objectively derived fronts in 24 members of a MOGREPS ensemble forecast at T+72.

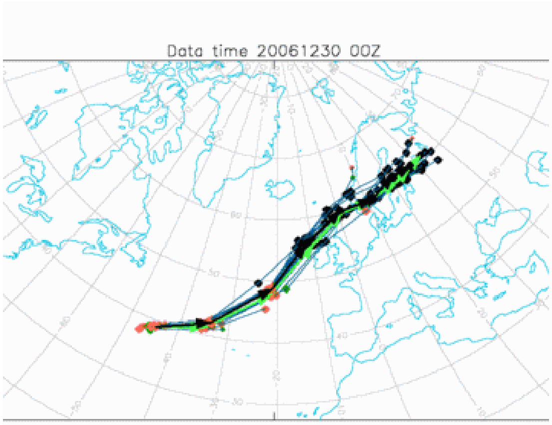
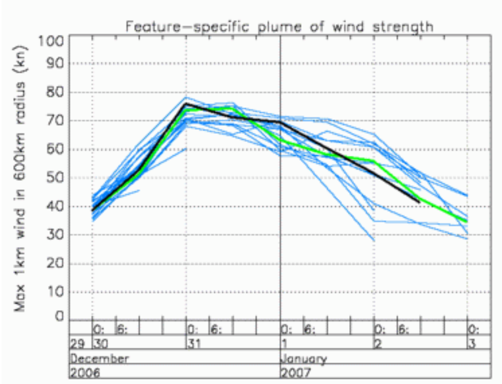
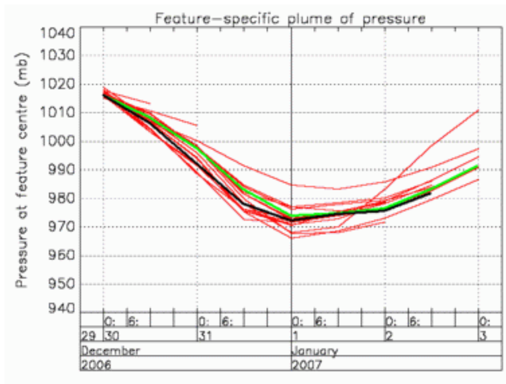


Figure 4: Plots of feature-specific characteristics of a developing extratropical cyclone from the cyclone database system. Left: Tracking of cyclone centre. Below left: Max windspeed (at height of 1000m above sea level) within 600km of cyclone centre. Below: MSLP at storm centre.





The plots in figure 4 can only be generated for a defined individual feature which can be identified at analysis time. The forecaster is also interested in the possibility of features which develop during the course of the forecast. For this purpose, an alternative plot, shown in figure 5, gives the probability of a cyclone of a given intensity (1000m windspeed > 60 knots) passing within 300km in a 24 hour period. This allows the identification of the risk of encountering a storm of sufficient strength to be hazardous.

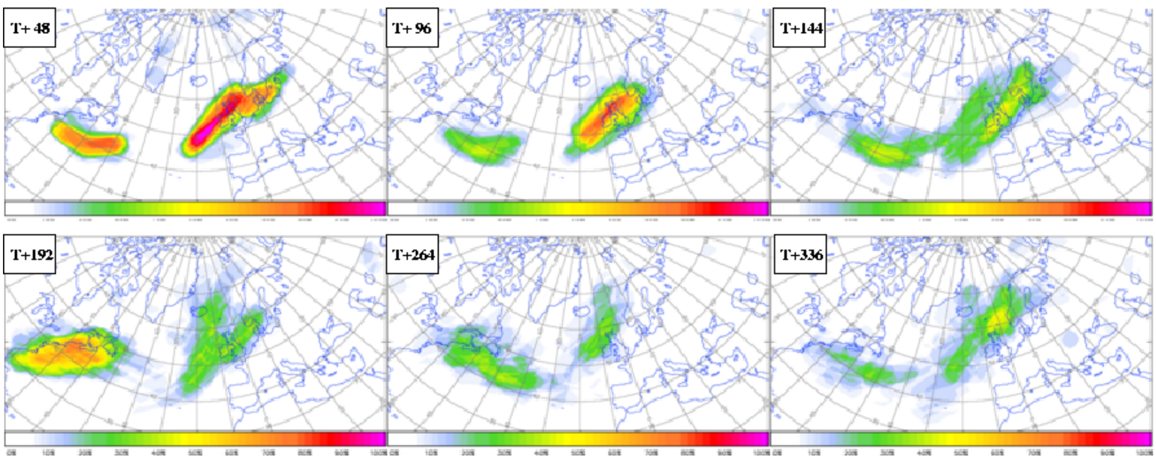


Figure 5: Probability of a cyclonic feature with 1km winds > 60 knots tracking within 300km in 24-hour period centred on VT 12Z.

Relevance to SWFDP

The above examples were developed under the THORPEX project to aid with the identification of high-impact weather risks from ensemble forecasts. The types of features analysed may be relevant for SWFDP in some regions of the world, for example the tropical cyclone products may be useful in the Mozambique and Madagascar area for the Southern Africa SWFDP. More generally they are shown here as illustrations of the concept of feature-based diagnostics which may be applied to relevant features within a region.

Possible Developments of Feature-Based Diagnostics for SWFDP

One of the limitations of the SWFDP framework identified in the final report from the first project in Southern Africa was the inability of NWP output to identify areas of tropical convection. In discussions with SWFDP forecasters in the South African Weather Service, a few ideas were raised around the techniques used by forecasters to identify severe weather development areas in the tropics. Key development areas may sometimes be identified by either upper-level divergence or by convergence lines identified in surface streamline charts, for example. It is believed that at times model forecasts may accurately represent these areas of convergence or divergence even though they do not result in a heavy precipitation signal from the model's parameterised convection. It may therefore be of interest to investigate whether such regions of convergence or divergence can be objectively identified from model fields as "features" which could then be plotted from all ensemble members. It is therefore proposed that the SWFDP Steering Group might support the and encourage some further investigation of additional feature-based diagnostics for other types of weather, noting in particular a strong interest in (tropical) convection.

Summary

Feature-based diagnostics can offer the possibility of quickly identifying and summarising the features in the atmosphere liable to be associated with high-impact weather. They are particularly useful for interpretation by forecasters as they use techniques similar to conventional synoptic analysis. They can be particularly effective when used with ensemble forecasts where it is necessary to summarise information from many ensemble members in a concise way. Some existing feature-based diagnostic tools may be useful in extending the products supplied through the SWFDP, but also there may be scope to help forecasters with some of the gaps in current capability identified in the first phase of the SWFDP by development of new feature-based diagnostics targeting features such as tropical convection.