Forecasting Severe Convective Hazards

- Forecasting Severe Convective Hazards
  - Use of EFI with CAPE and CAPE-shear
  - Care needed in Interpretation of ecChart Presentation.
  - Additional Sources of Information

Forecasting Severe Convective Hazards

Use of EFI with CAPE and CAPE-shear

Deep moist convection happens when deep instability (steep mid-tropospheric lapse rates), moisture and lift are all in place together. If any of these ingredients is missing, deep moist convection is impossible.

Presentations of EFI for CAPE and CAPE-shear can help with the early identification of the potential for severe weather related to convection.

- CAPE gives information on the convective energy and the availability of low-level moisture. It is only one measure of the potential for severe convection and thunderstorms - sufficient lift to overcome any capping inversion and to release that instability is also necessary.
- CAPE-shear combines CAPE and deep-layer bulk shear (computed at ECMWF between 925hPa and 500hPa). High values of this parameter indicate the potential for well-organised and long-lived convective storms such as MCSs and supercells.

A combination of convective EFI parameters and a precipitation forecast (probability of precipitation (PoP), available on ecCharts) highlights areas where severe convection is likely and is a powerful indicator of timing and location given some method of initial uplift to release the instability.

![Fig8.1.4.16: 500hPa contour heights, forecast data time 00Z 21 June 17, T+48 verifying at 00Z 23 June 17. CAPE-shear EFI for the period T+24 to T+48 coloured Yellow >0.4, Orange > 0.7, Red > 0.8.](attachment:fig8.1.4.16.png)
Fig8.1.4.17: As Fig8.1.4.16 but with HRES precipitation totals over 9hrs added: purple > 10mm. In practice, the fact that there is precipitation indicates sufficient availability of moisture while the very high EFI indicates that unusual (i.e. climatologically high as defined by M-climate) convective available potential energy (CAPE) is available in the north Germany area. Precipitation totals in the very active storms that are likely to form will be greater than ENS or HRES show (here HRES precipitation) and with associated significant downdraught gusts.
Fig8.1.4.18: CAPE-shear EFI from a sequence of forecasts data times 00UTC on 18, 19, 20, 21, 22 June 2017. Note the increasing Extreme Forecast Index (EFI) and the Shift of Tails (SOT) above 0 and reaching above 1 at T+24 on the last forecast over North Germany and Poland.

Fig8.1.4.19: CAPE-shear EFI, data time 00UTC 22 June 2017, valid for 00-24UTC 22 June 2013 (as on Fig8.1.4.18). EFI colours orange and red taken indicating an extreme event likely. SOT values indicate the ratio of departures of ENS forecast values from the M-climate extreme considering the greatest 10% ENS members. The other charts show CAPE-shear values in the M-climate (derived on 19 June 2017) wherein only 1 in 10 occasions realises more than the values shown. The existence of significant EFI and SOT, even some days in advance, should not be overlooked, particularly if the actual forecast CAPE-shear values are much greater than the M-climate values (at say the 90th or 99th percentiles) for the area.
Fig8.1.4.20: Maximum gusts (kph) during the period 12UTC to 18UTC 22 June 2017. Over 100kph in Central Germany associated with the widespread active thunderstorms.

Fig8.1.4.21: Rainfall (mm) in 6hrs during the period 12UTC to 18UTC 22 June 2017. Over 50mm of rain fell in Central Germany associated with the widespread active thunderstorms.
Care needed in Interpretation of ecChart Presentation.

It is tempting to simply observe on forecast charts where large CAPE or CAPE-shear EFIs coincide with high rainfall from HRES when assessing the release of severe convection. HRES forecast rainfall may be used in combination with convective EFIs in the short-range (up to T+48hr), but it should be remembered that HRES is just another individual possible forecast. In the short-range it is probably the most likely one, but in the medium-range its relative weight compared to ENS members decreases and it becomes just as likely as any other ensemble member. Then it is best to use a probability of precipitation forecast (PoP > 1mm/24hr) rather than a simple precipitation forecast throughout the whole forecast period (both short-range and medium-range). These concepts are discussed below using one case as an example.

All the charts below correspond to the same example. All are for data time 00UTC 6th August 2017, and we focus on the forecast for 8th August. Fig8.1.4.22 and Fig8.1.4.23 show 6-hour HRES precipitation forecasts for 00UTC on the 8 and 9 Aug 2017 as displayed by ecCharts, and it appears an area of significant rainfall associated with an upper trough moves from southwest France to Austria. However, precipitation data is not shown for 12UTC on 8 Aug. Meanwhile 24-hour total precipitation EFI (0.9) and CAPE-shear EFI (0.85) are available for 00UTC 9 Aug and show very high values. CAPE EFI (0.6) is only moderate illustrating the significant impact of bulk shear to give the high CAPE-shear EFI values. The precipitation meteogram for the western Alps shows heavy rainfall in that area during the day and this is confirmed by data on Figs8.1.4.27 and 8.1.4.28 (note that these charts have different but overlapping validity periods).

Fig8.1.4.22: ecChart showing 300hPa height with stratiform and convective rainfall (convective rainfall is plotted on top of stratiform) over the last 6 hr for T+48hr verifying at 00UTC 08 Aug 2017 based on HRES data time 00UTC 6 August 2017.

Fig8.1.4.23: ecChart showing 300hPa height with stratiform and convective rainfall over the last 6 hr for T+72hr verifying at 00UTC 09 Aug 2017 based on HRES data time 00UTC 6 August 2017.
Fig8.1.4.24: ecChart showing 300hPa height with total precipitation EFI at T+72hr verifying at 00UTC 09 Aug 2017 based on ENS data time 00UTC 6 August 2017

Fig8.1.4.25: ecChart showing 300hPa height with CAPE EFI for the 24hr ending at 00UTC 09 Aug 2017 based on ENS data time 00UTC 6 August 2017
Fig 8.1.4.26: ecChart showing 300hPa height with CAPE Shear EFI for the 24h ending at 00UTC 09 Aug 2017 based on ENS data time 00UTC 6 August 2017.

Fig 8.1.4.27: ECMWF chart showing stratiform and convective rainfall over the last 6 hr for T+60hr verifying at 12UTC 08 Aug 2017 based on HRES data time 00UTC 6 August 2017. Also shown are surface isobars.
Fig8.1.4.28: ecChart showing the probability of precipitation 20mm in 24hrs ending 18UTC 9 August 2017. The forecast probability of heavy rainfall is concentrated at about 6ºE, in amongst the forecast CAPE-shear EFI maxima in Fig8.1.4.22.

Fig8.1.4.29: 15day meteogram with M-climate for 45N06E based on ENS data time 00UTC 6 August 2017. An exceptional event is forecast for 8 Aug; the median lies above the 99th percentile of M-climate (green line).
Forecasts with a data time of 00UTC 6th, as on the other plots above, are denoted by the darkest of the two dashed blue lines. There is a consistently high EFI for rainfall (over 80%) which is sufficient for forecasting a significant and maybe an extreme rainfall event. Some ENS members show rainfall totals close to the M-climate maxima. The slope of the precipitation CDF shows the variation within ENS members, but all members show greater than M-climate values. For greater confidence the slope of the CDF should be more vertical.

**Fig8.1.4.30:** CDF and associated EFI for west Alps region (45N06E). Forecasts with a data time of 00UTC 6th, as on the other plots above, are denoted by the darkest of the two dashed blue lines. There is a consistently high EFI for rainfall (over 80%) which is sufficient for forecasting a significant and maybe an extreme rainfall event. Some ENS members show rainfall totals close to the M-climate maxima. The slope of the precipitation CDF shows the variation within ENS members, but all members show greater than M-climate values. For greater confidence the slope of the CDF should be more vertical.

**Additional Sources of Information**

(Note: In older material there may be references to issues that have subsequently been addressed)

- Further information is available on EFI forecasting for severe convection.
- Guide to Instability Indices in ECMWF output

Updated/Amended 30/12/19 - Minor changes in first three paras.