

Report on review of product requirements
from Member States and Co-operating States
and
Review of the verification measures applied
to medium-range forecasting

Expert Team reviewing methods for
the verification of severe weather
events (9-10 September 2008)

and

TAC sub-group on Verification
Measures (16-17 March 2009)

Products and verification for severe weather

- **The ECMWF Strategy 2006-2015 puts emphasis on the early warning of severe weather and the need to develop appropriate verification.**
- **The Strategy has set overall performance targets in terms of Z500 for the deterministic model and T850 for the EPS.**
- **ECMWF is developing a range of additional verification measures, focusing on severe weather.**

There is a need to identify which performance measures are the most relevant for medium-range forecasting activities in the Member States and Co-operating States.

Consultation with the MSs and CSs, Aug 2008

In order to understand the user requirements more fully and to build on the expertise that already exists in MSs and CSs for short-range forecasts, a letter was sent inviting TAC representatives to provide input on this topic.

In particular:

- 1) What severe weather events are most relevant to you in your daily forecasting duties to governments and citizens?*
- 2) What verification methods do you use to assess severe weather forecast performance?*
- 3) What additional products would you like to have available from ECMWF?*
- 4) What additional verification measures would you like to see applied to the Centre's medium-range forecasts?*

Input was received from 18 countries

ECMWF's current verification of surface parameters

- T2m, RH2m, U10m, TCC and precipitation are routinely verified against SYNOP, received via the GTS, since 1988.
- For precipitation, TSS, ETS and FBI are computed for thresholds up to **20 mm/day**.
- Verification for precipitation over Europe is also computed using **gridded high-resolution observations** based on data sets provided by MSs and CSs (not real time).
- Comparison of weather parameters from other NWP centres using forecast data available from the TIGGE archive.

ECMWF's verification of severe events

ECMWF's standard presentations of verification results to committees include:

- **The extreme forecast index (EFI) - Routine verification will continue to monitor the trends in EFI performance.**
- **Tropical cyclone tracks and intensity**
- **Tracking of extra-tropical cyclone features and fronts**

There is a need to extend the set of headline scores to include measures appropriate for severe weather.

Performance measures should be based on the most important surface weather parameters and the products developed specifically to provide guidance for early warnings of severe weather.

Conclusions of the expert team (1/4)

The most relevant severe weather events for the MSs and CSs are:

- **Heavy precipitation**
- **Strong winds**

These correspond to flooding and wind storms, which are the two main categories of weather-related insurance losses in Europe.

Conclusions of the expert team (2/4)

Consideration should be given to the development of additional products. The proposed new products are:

- **Visibility/fog**
- **Stability indices – or gusts, hail risk, lightening risk?**
- **Freezing rain and/or freezing level**
- **Height of lowest significant cloud base**
- **Rainfall accumulations over long durations (several days or for specific events)**
- **Classification/clustering/regimes (*Corti and Ferranti*)**
- **Calibrated probability products (percentiles) of model and observed climate for extreme events**

New products require extensive validation through comparison with measurements

Conclusions of the expert team (3/4)

The verification measures used in the NMSs are essentially the same as are used at ECMWF (the traditional scores, contingency table-based scores, TSS and ROC).

Additional verification measures that are being tested in the NMSs and show promise include:

- **Feature-based verification, including SAL (Structure, Amplitude and Location)**
- **The Extreme Dependency Score (EDS)**
- **Feature-based tracking and verification of extra-tropical cyclone features**

Conclusions of the expert team (4/4)

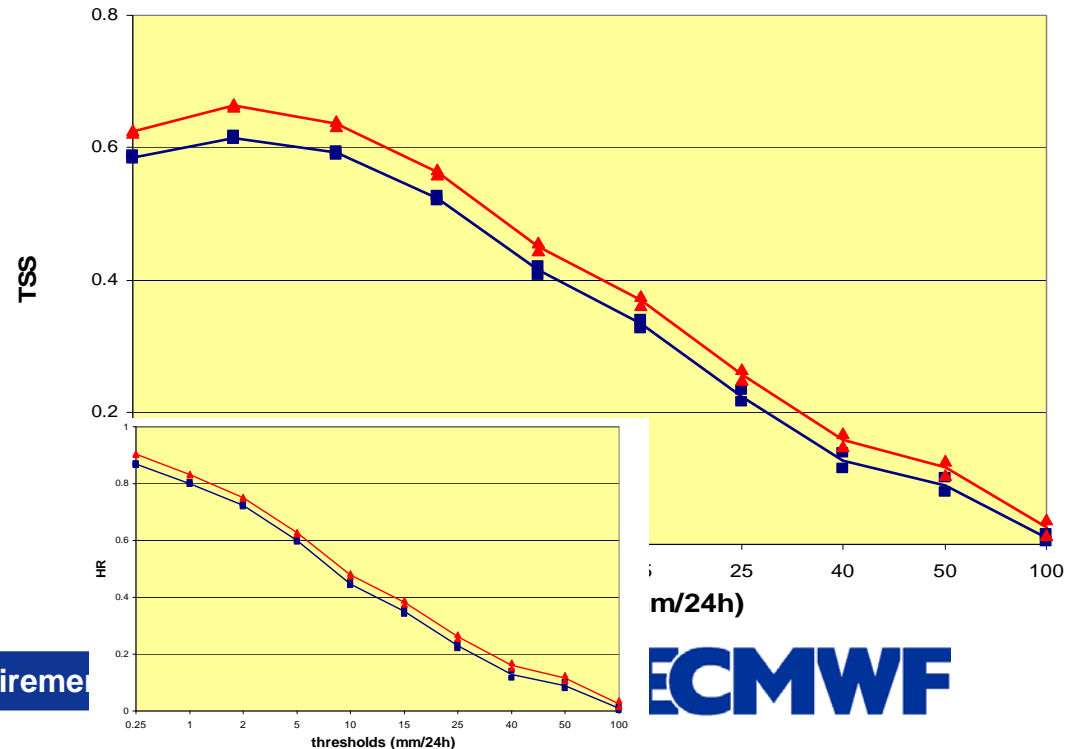
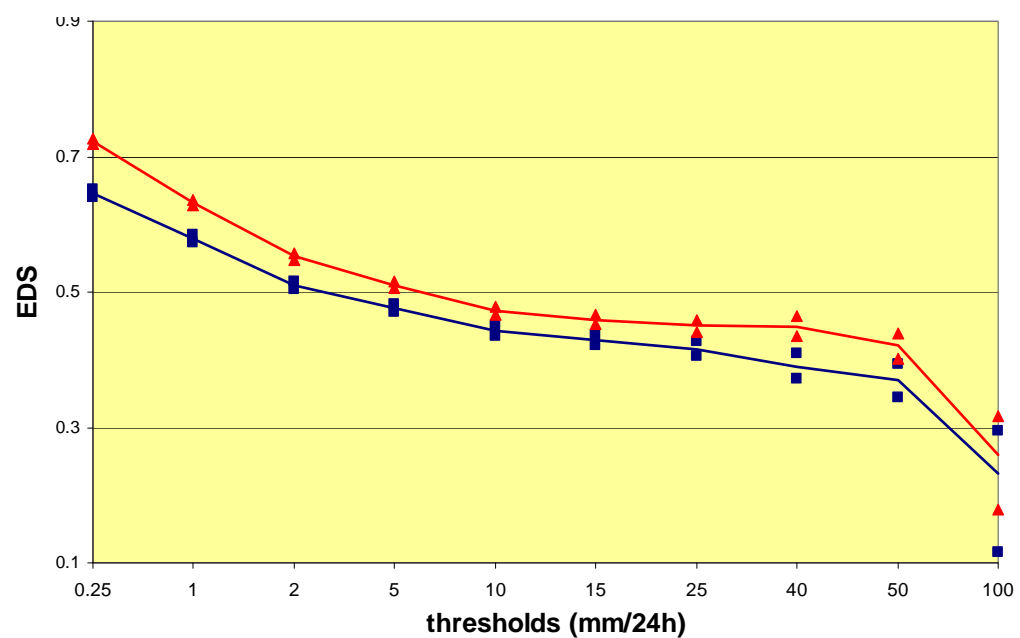
Many of the most commonly employed, conventional measures of forecast accuracy converge to trivial limits (e.g. zero) for rare events.

- **An area of current statistical research.**
- **A common challenge experienced in many MSs and CSs.**
- **Systematic, practical application of verification methods suitable for rare events is nevertheless a priority (ECMWF Strategy)**

A list of the desired properties of a good score for extremes was established by the Expert Team

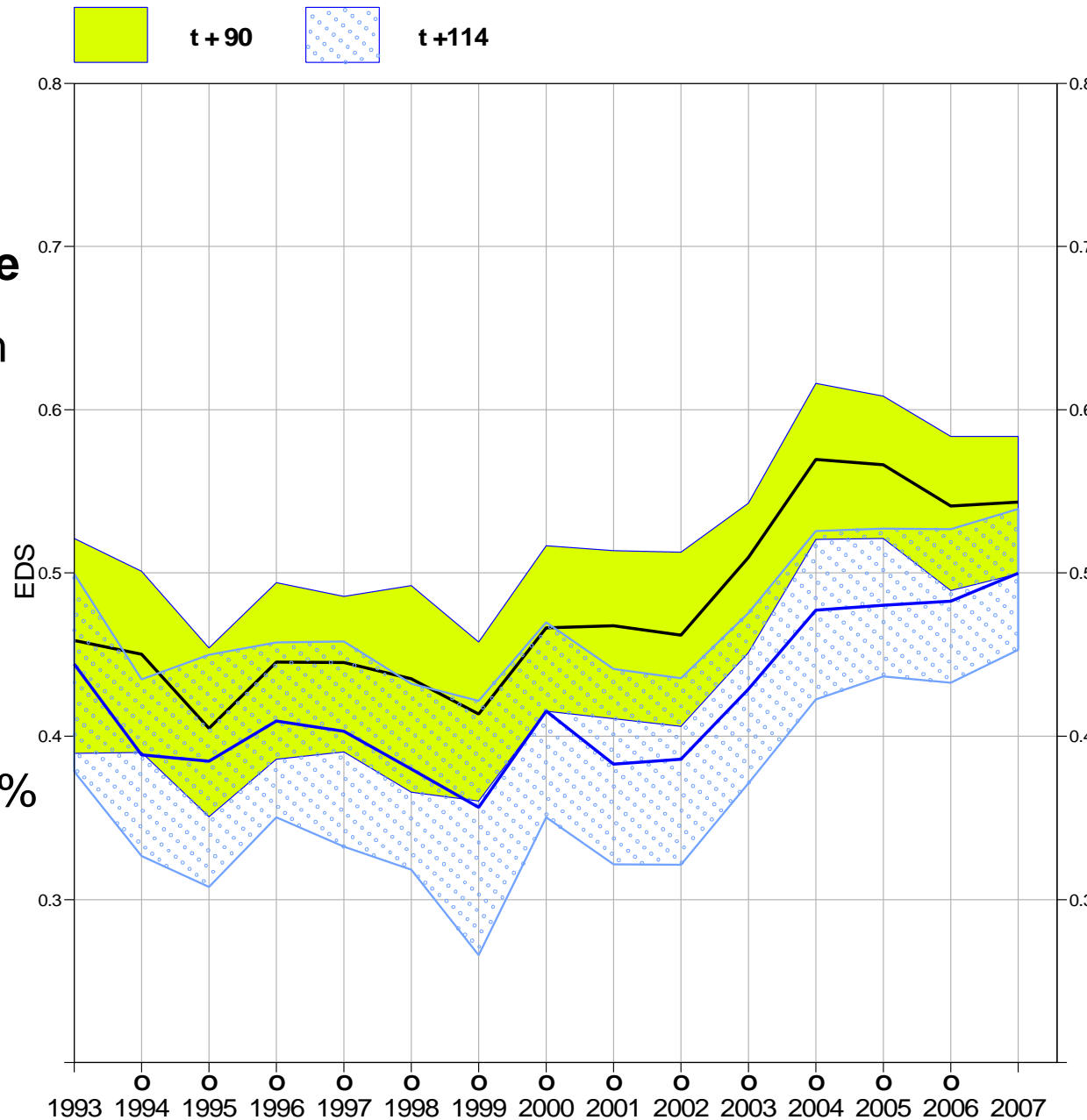
Example

- **24h accumulated precipitation – Europe**
- Forecast range: t+42
- All year
 - Jan-1994 to Nov-2000
 - Dec 2000 to Aug 2008
- Scores shown
 - Extreme Dependency Score (EDS)
 - True Skill Score (TSS)
 - Hit Rate (HR)



Example

- 24h accumulated precipitation – Europe
- Threshold > 40mm/24h
- October to April from 1993 to 2008
- The shaded areas represent the 5 and 95% confidence intervals



ECMWF plans for severe weather products and verification

Taking into account the feedback from MS/CSs and the recommendations of the Expert Team:

- **ECMWF will continue to develop the current set of products and verification procedures for severe weather:**
- **ECMWF will investigate the use of the extreme dependency score (EDS), applied to heavy precipitation and strong winds;**
- **ECMWF will assess the feasibility of providing additional weather parameters relevant to severe weather, in response to the requests from the MSs and CSs.**
 - **This will require outputting of new parameters from the model**
 - **It also depends on the availability of appropriate verification data.**

Definition of EDS

	Observed yes	Observed no
Forecast yes	a hits	b False alarm
Forecast no	c misses	d Correct negative

- Hit Rate = $a/(a+b)$
- False Alarm Rate = $b/(b+d)$
- Extreme Dependency Score = $-1 + 2 * (\log(a+c/n))/\log(a/n)$
- True Skill Score = (Hit Rate – False Alarm Rate)