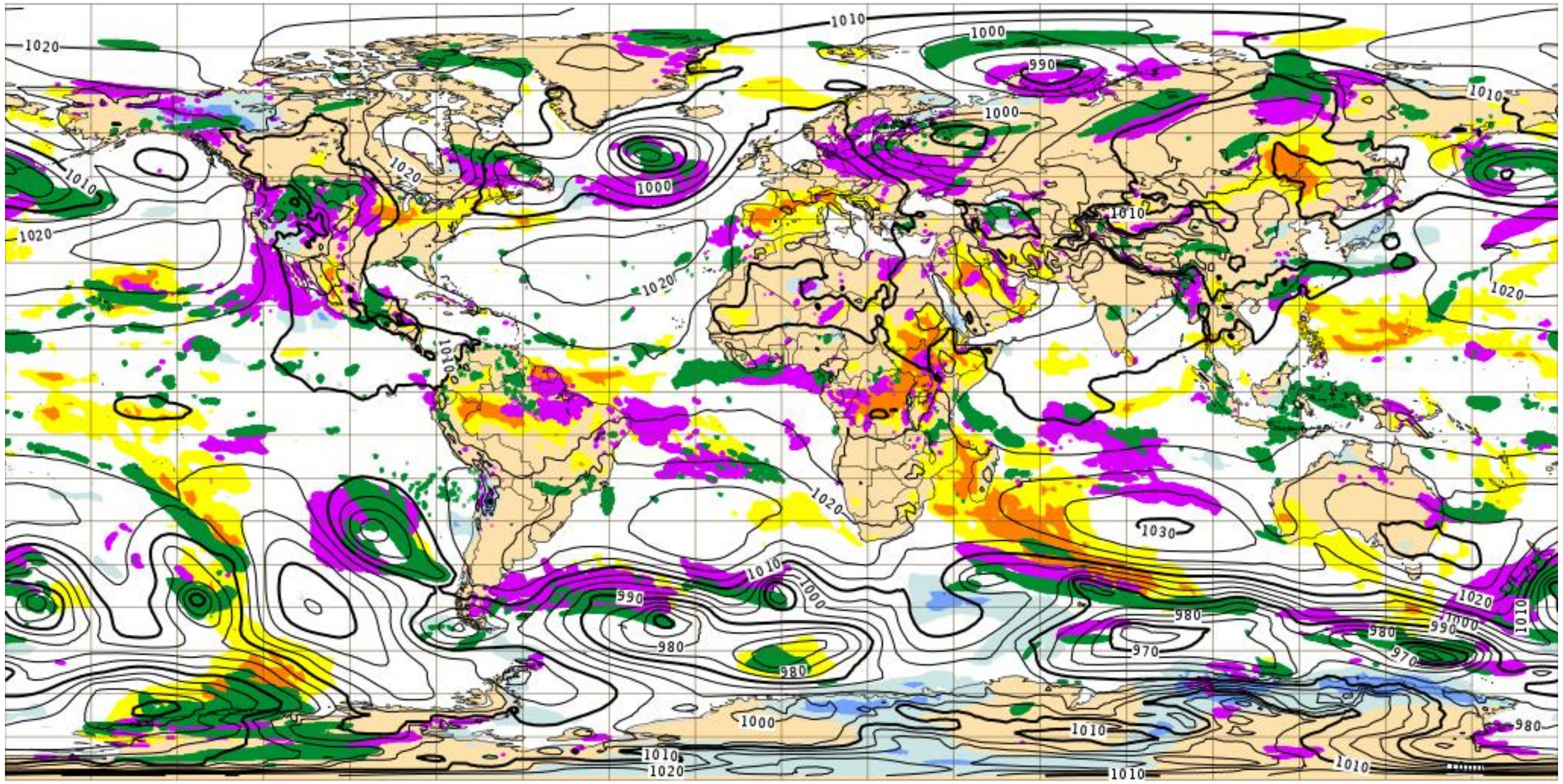
Multi-scale predictability of severe weather

Linus Magnusson

UEF2017

Thanks to: Laura Ferranti, Mark Rodwell, David Lavers, Thomas Haiden, …

ECMWF



Global prediction of extremes on various time and horizontal scales poses several questions:

What is the predictability for different types of extremes?

On what time-ranges are the forecasts useful?

What do we need to improve to obtain better predictions of extremes?

Disclaimer

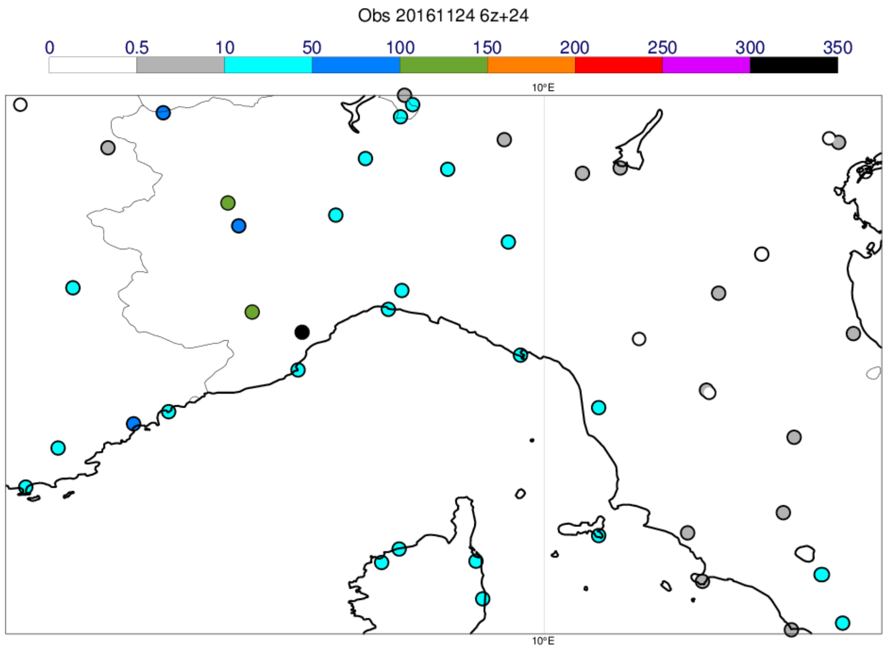
- Single probabilistic forecasts for life-threating events cannot be verified!
  - The true probability distribution function is not known – only the single outcome
  - Life-threating events usually rare – return periods often >20 years – too small sample to do a probabilistic verification of operational system
  - Life-threating events are usually a composite of sub-events and unique in horizontal and temporal scales
    - Series of precipitation events leading to river flooding
    - Combination of waves, storm surge, tides and precipitation leading to costal flooding
    - Length and magnitude of heatwaves
    - …..

What can we do:

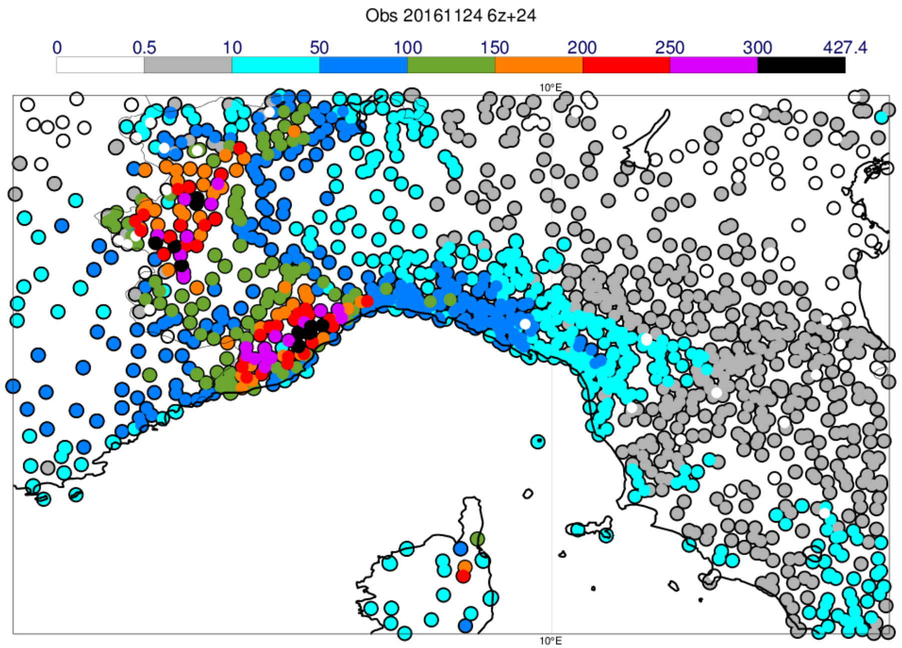
- Statistical verification of less extreme events
- Evaluate model climate of extremes
- Learn about important aspects from case studies

Importance of high-resolution observations for verification: Rainfall in Northern Italy

Observations on GTS

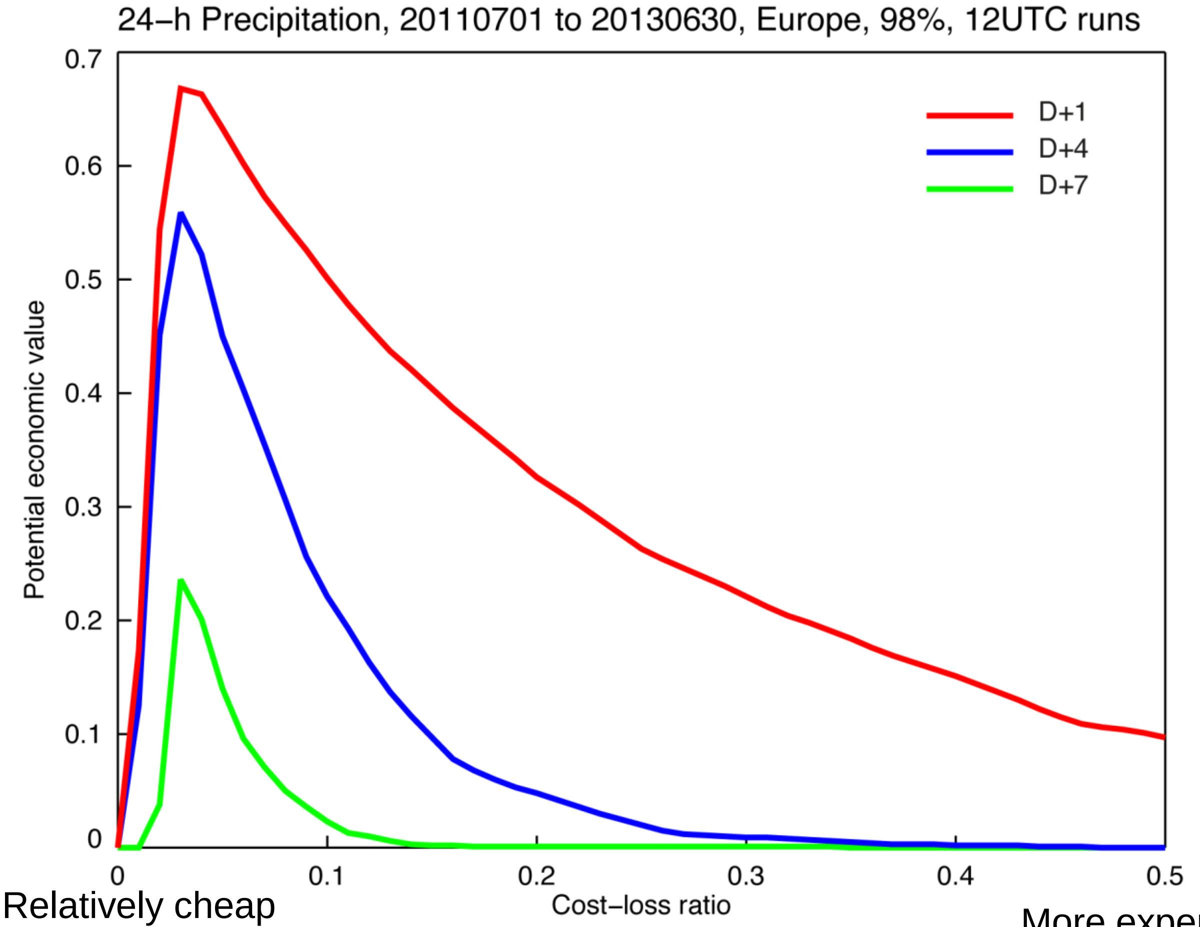


GTS + regional network



HDOBS project at ECMWF to collect regional network, thanks for all contributions so far!

Potential economical value: are the forecasts useful?



Relatively cheap actions = acting on low probabilities

More expensive actions

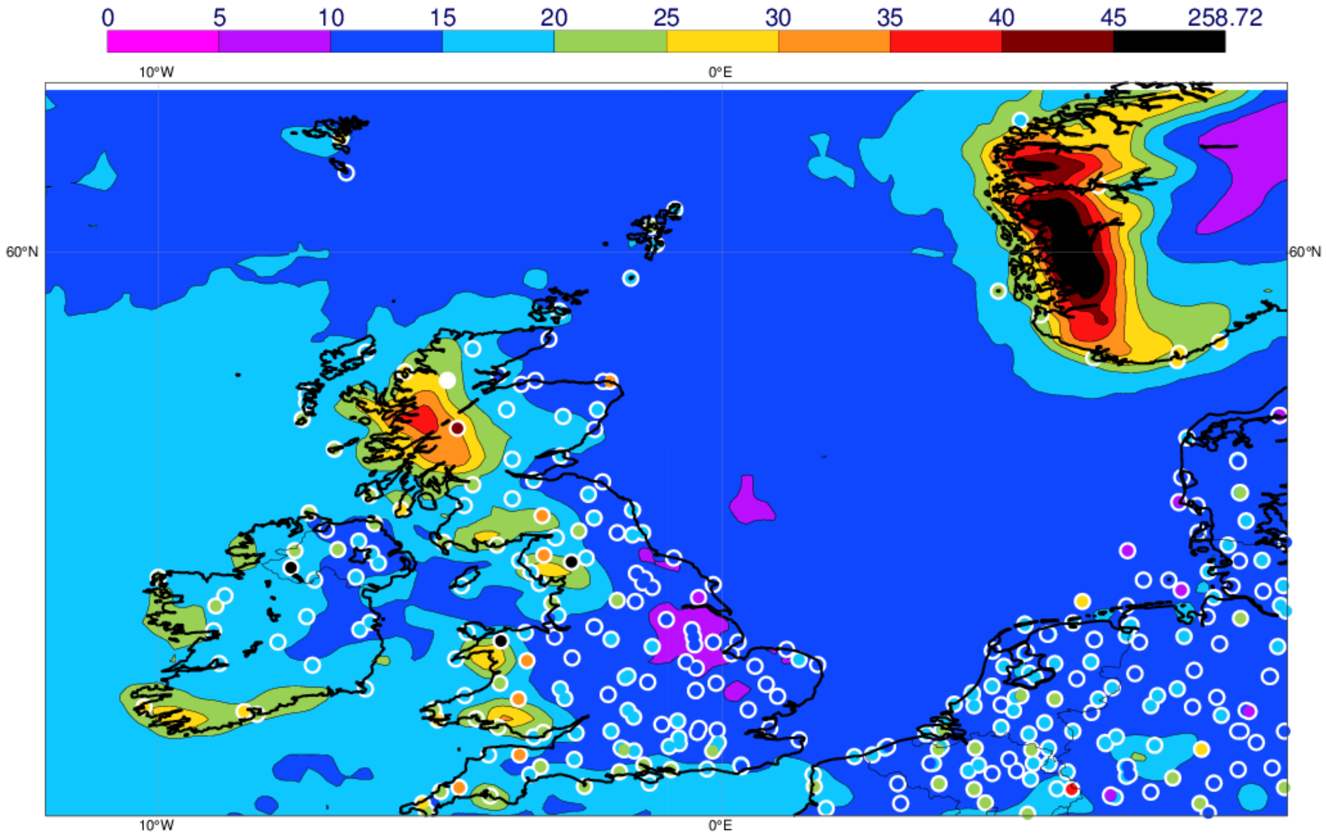
Is 98th percentile really extreme?
(~2 events per season in each point)

Many actions 7 days before are less expensive than 1 day before

Thanks to T. Haiden
(ECMWF Tech Memo 731)
Richardson (QJRMS, 2000)

Is the model able to predict the event?
– Use of reforecast to compare with observed values of extremes

98th percentile of 24-hour precipitation December



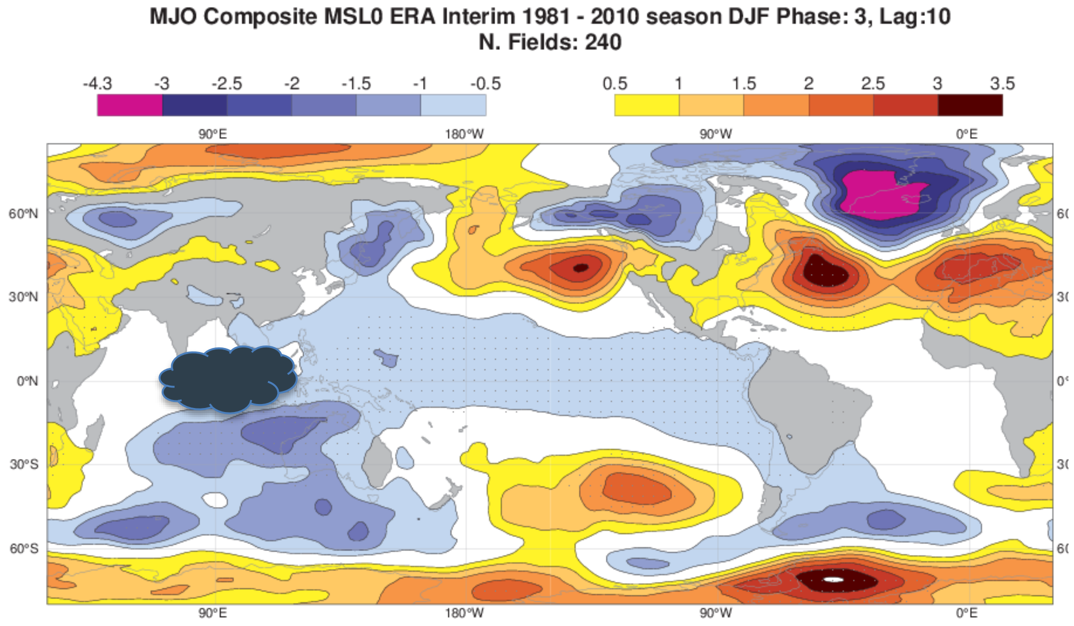
Helps us to understand geographical differences

Magnusson et al. (ECMWF Tech Memo 731)

Teleconnections to large-scale forcing patterns for extremes

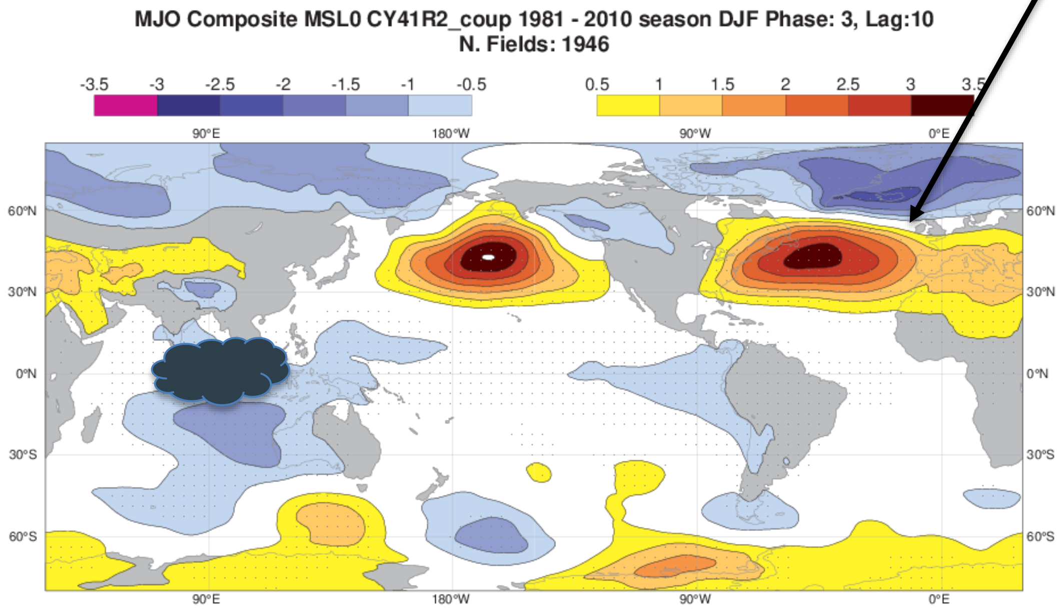
Composites of MSLP 10 days after MJO in phase 3

Reanalysis



Model

Windstorms more likely!



What can we learn from case studies?

Severe event catalogue (~100 cases since 2013):

https://software.ecmwf.int/wiki/display/FCST/Severe+Event+Catalogue

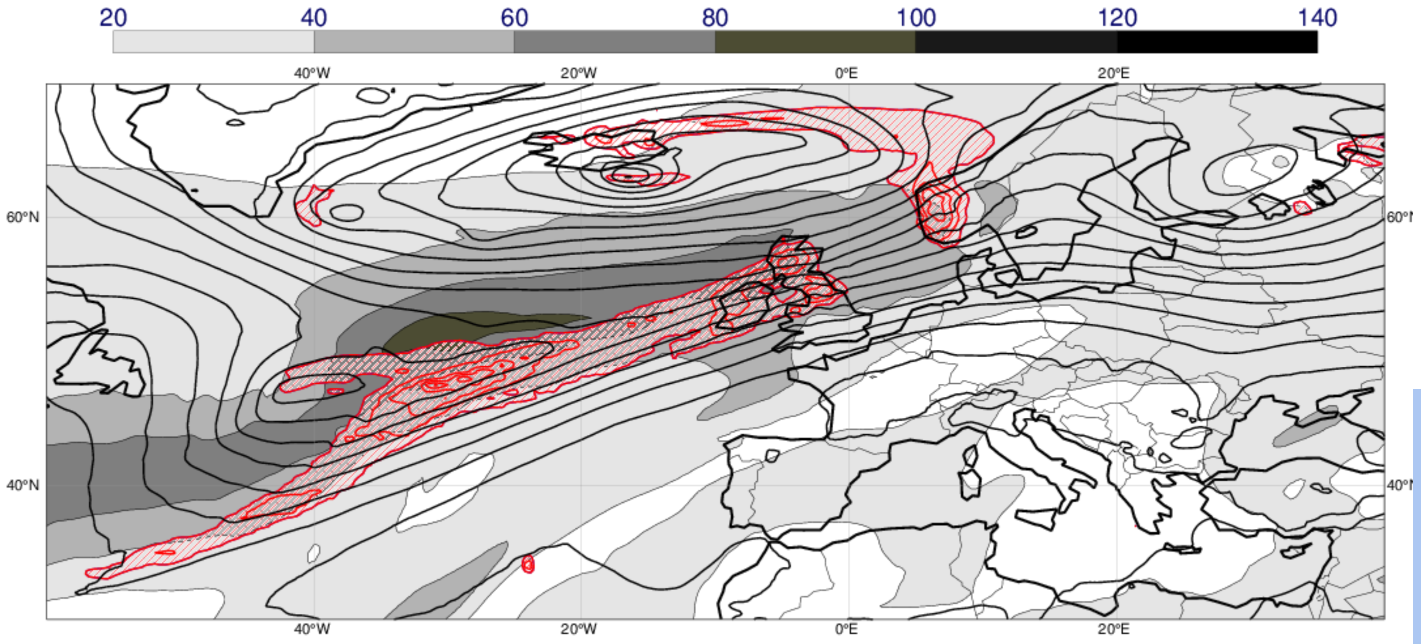
List of ECMWF Newsletter articles on severe events:

- 139 - Windstorms in northwest Europe in late 2013
- 140 - Forecasting the severe flooding in the Balkans
- 141 - Recent cases of severe convective storms in Europe
- 142 - Forecasts for a fatal blizzard in Nepal in October 2014
- 143 - Forecasts for US east coast snow storm in January 2015
- 144 - ECMWF forecasts for tropical cyclone Pam
- 145 - Predicting this year's European heat wave
- 146 - Forecasting flash floods in Italy
- 147 - Wind and wave forecasts during Storm Gertrude/Tor
- 148 - Forecasts showed Paris flood risk well in advance
- 149 - Predicting heavy rainfall in China
- 150 - Flash floods over Greece in early September 2016
- 151 - The cold spell in eastern Europe in January 2017

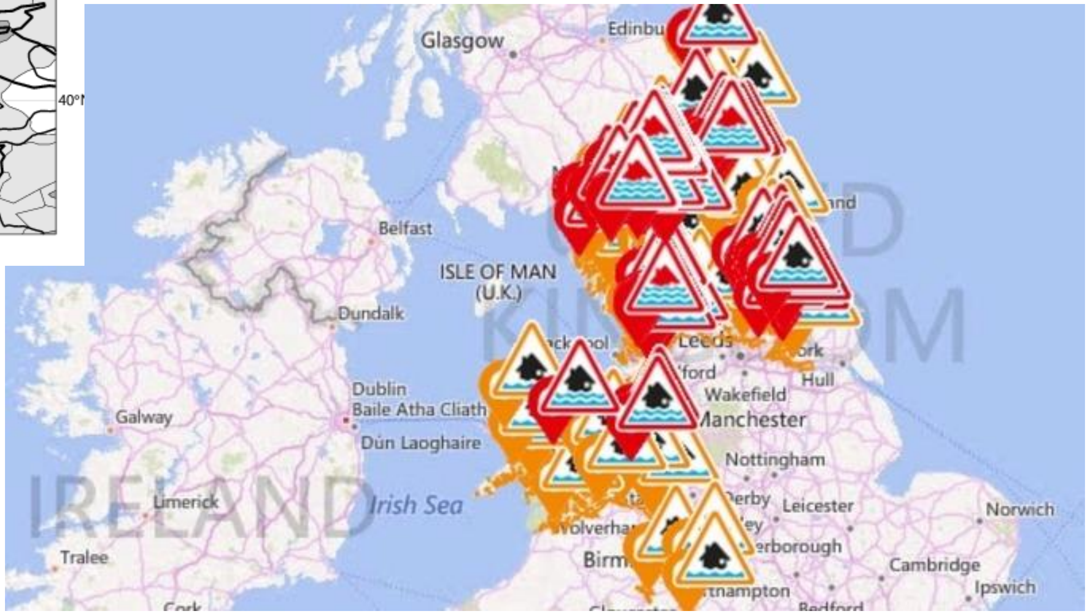
http://www.ecmwf.int/en/about/news-centre/media-resources

Storm Desmond in December 2015

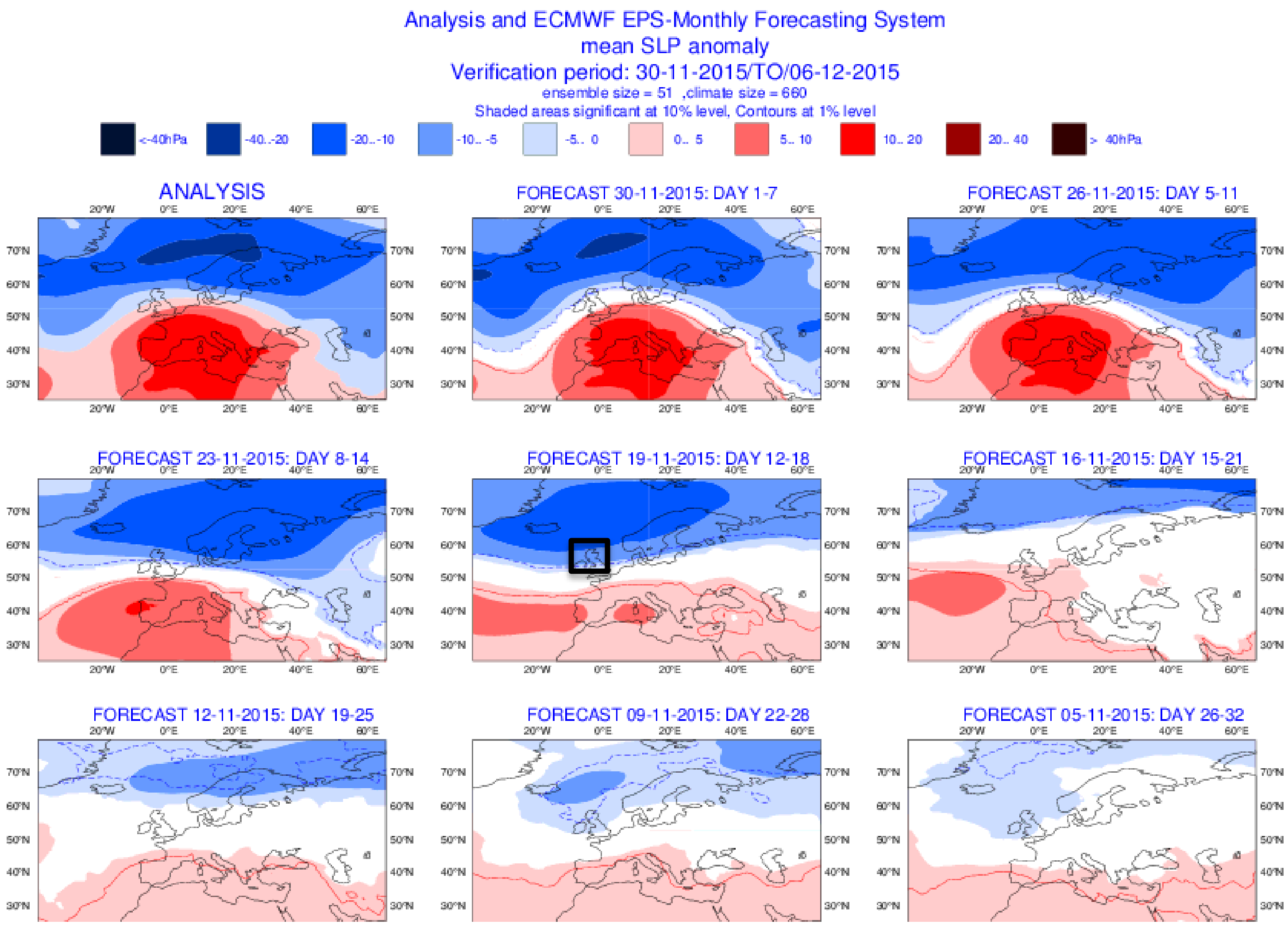
MSLP, 200hPa wind speed and precipitation 5 December



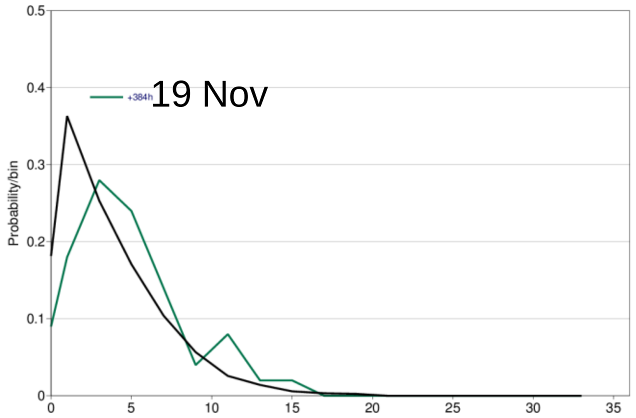
Flood warnings for UK

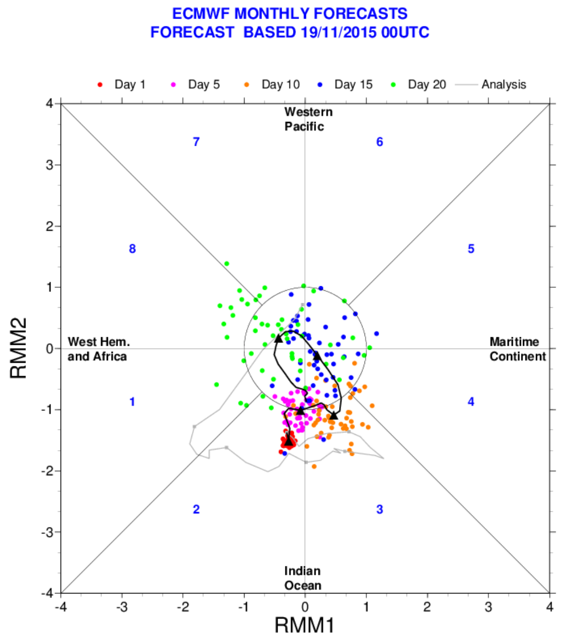


Extended-range prediction
Weekly anomalies of MSLP 30 November – 6 December 2015



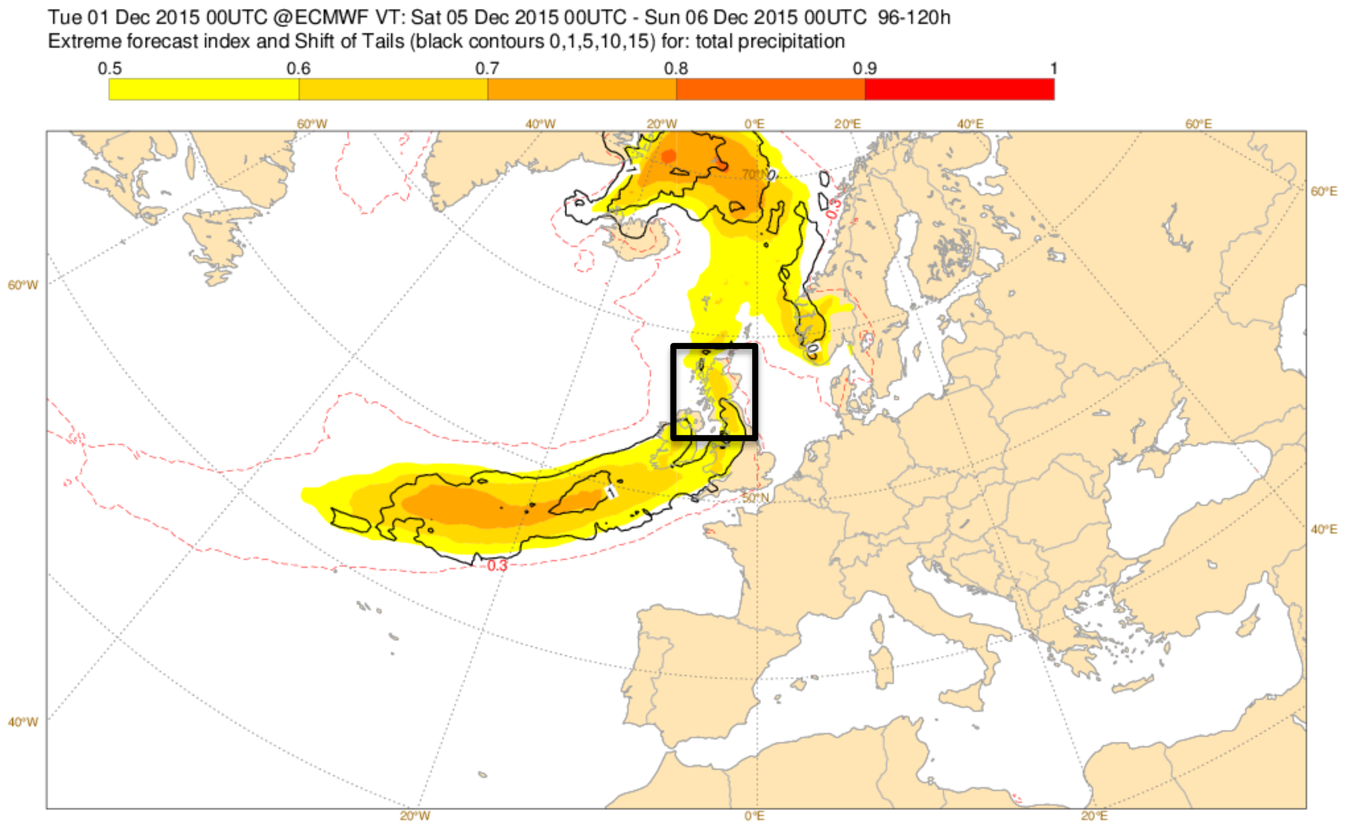
Precipitation for 5 Dec



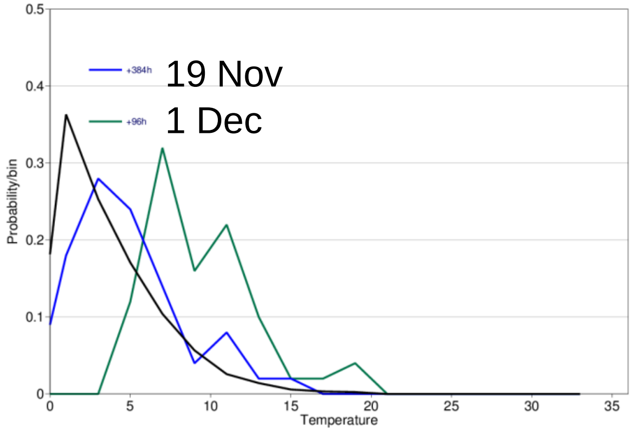


EUROPEAN CENTRE FOR MEDIUM-RANGE WEATHER FORECASTS

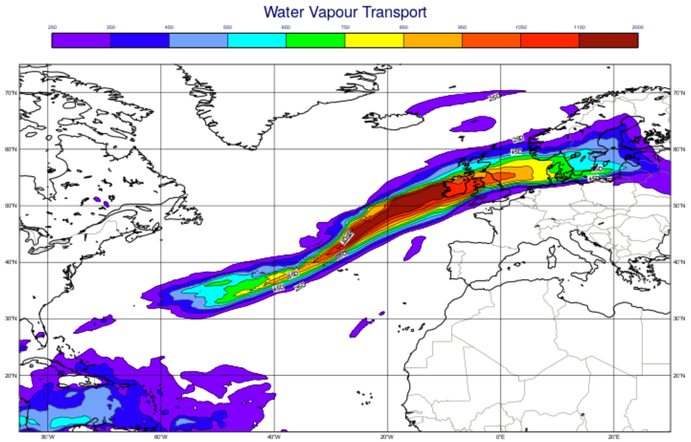
Medium-range prediction



Precipitation for 5 Dec

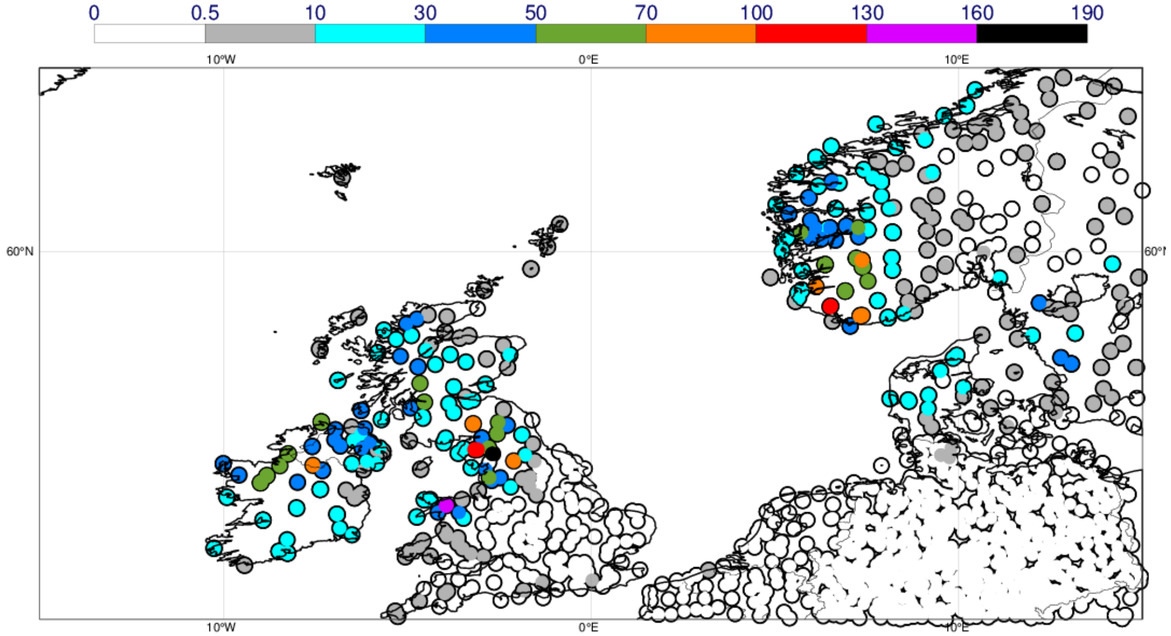


Water vapour transport field in analysis
(12UTC 4th Dec. 2015 - 12UTC 5th Dec. 2015)

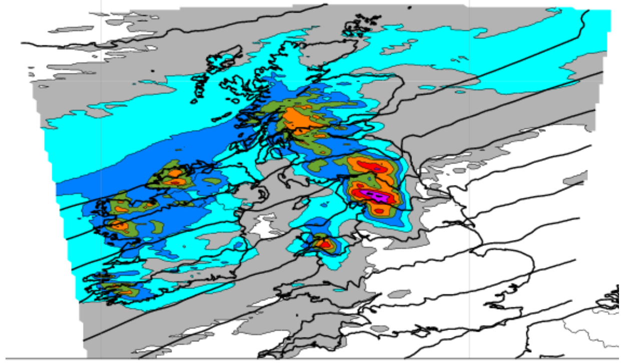


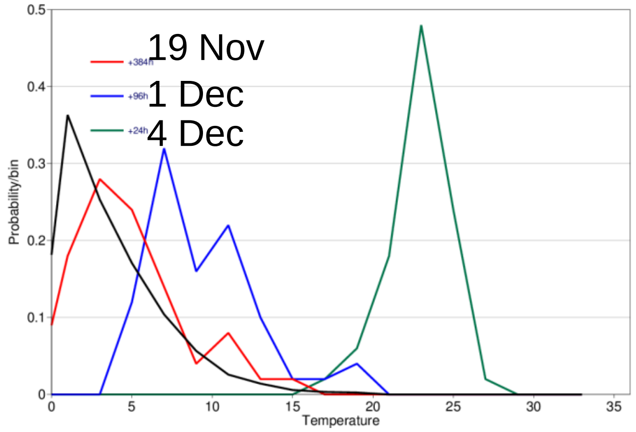
Short-range forecasts and observations

Precipitation for 5 Dec

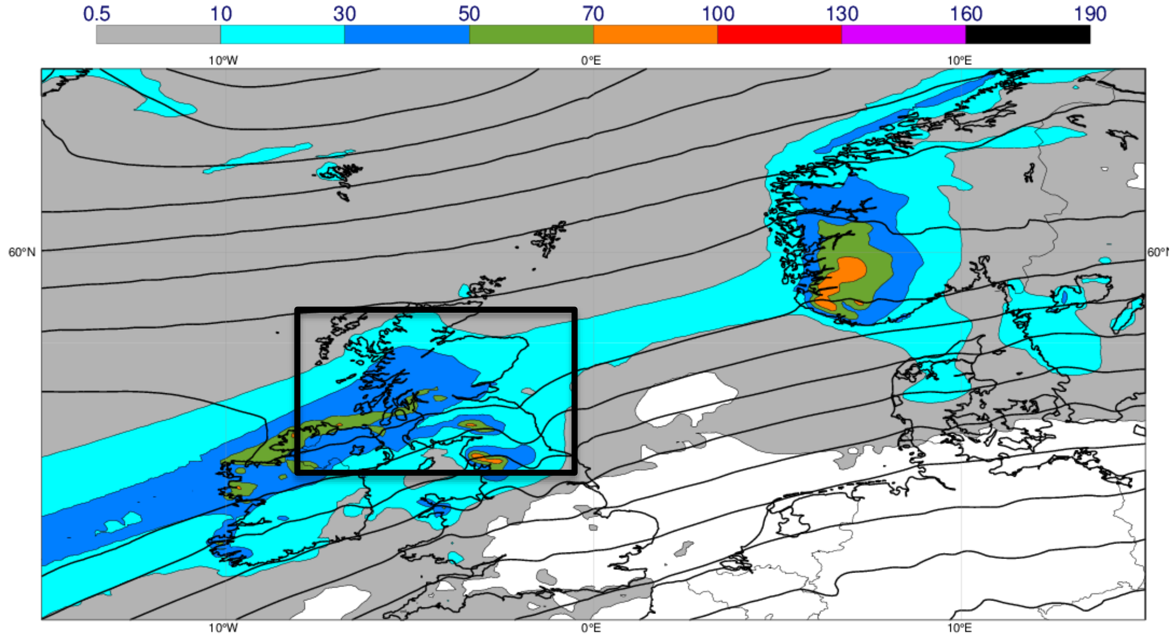


Limited-area model from UKMO (from TIGGE-LAM)

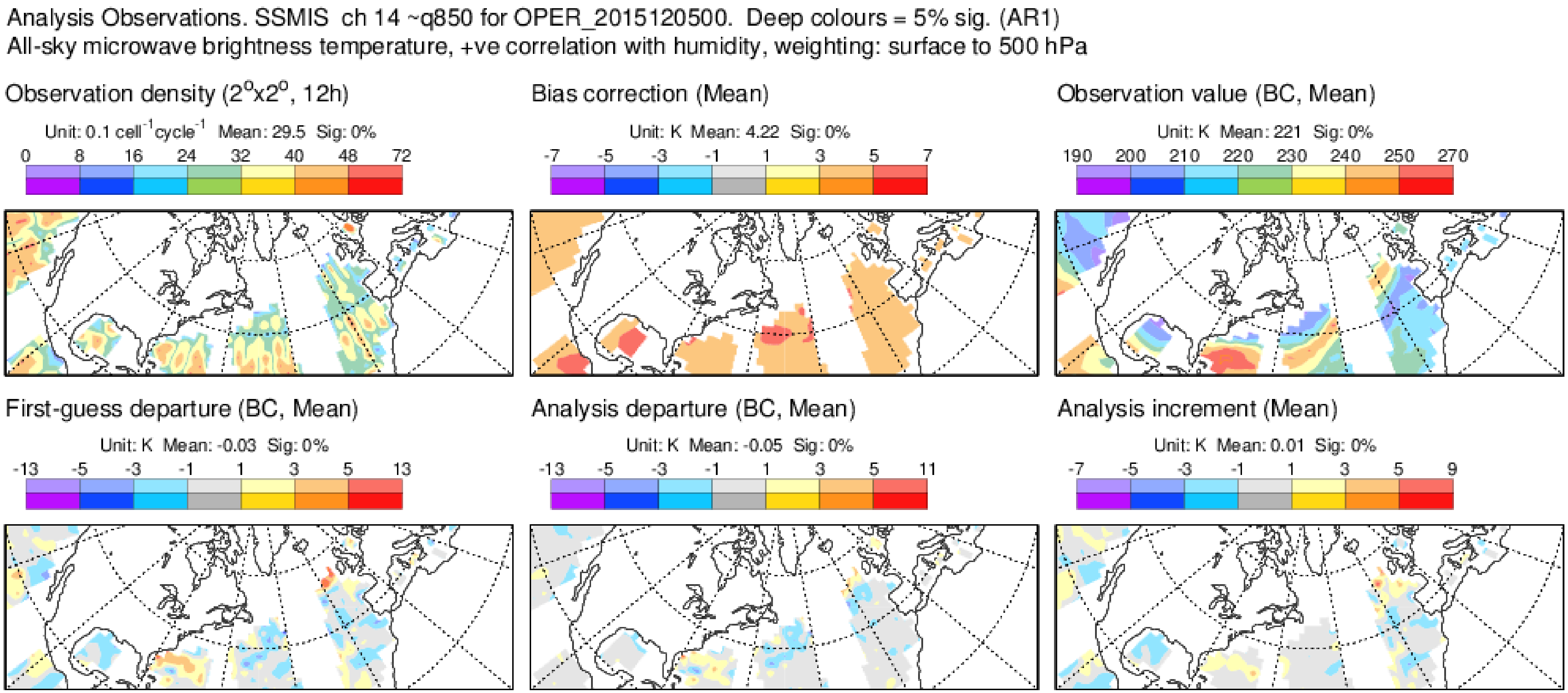




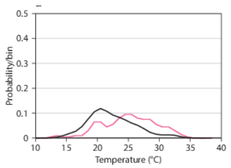
HRES forecast from 4 December 00z

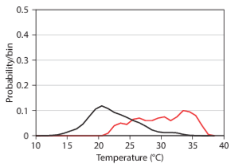


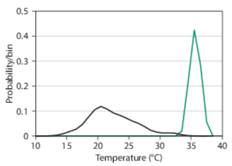
Using data assimilation to understand errors –SSMI observations



Important aspect for extremes on different time-scales







	Extended range (2-4 weeks)	Medium range (3-7 days)	Short range (0-3 days)
N. European extreme rainfall	North-Atlantic oscillation	Presence of Atmospheric rivers	Exact position of the system, strength of orographic precipitation
European heatwave	Soil moisture	Rossby wave train	Local heating and evaporation
Tropical cyclones	SST, MJO, African easterly waves	Steering flow	Landfall intensity
N. European windstorm	North-Atlantic oscillation	Jet-stream propagation	Timing of development, wind gust parameterisation
Flooding in Europe	Soil wetness, Predict cut-off low	Position of cut-off low	Moisture advection, precipitation processes, runoff into rivers
Severe convection		Upper-level troughs, Positions of fronts, CAPE, wind shear	Convective triggering, organisation, life-time

Long-lived flow patterns, teleconnections and boundary conditions

Capturing synoptic situation, global DA

DA and model physics suitable for extreme conditions

Discussion – how to improve prediction of severe weather?

- General improvement of the prediction system e.g data assimilation, model activity and ensemble reliability but also physical processes associated with severe weather, …

Different priorities:

- Sample from a climatology as close as the possible to the true climate PDF – model resolution and complexity
- Resolve the forecast PDF as good as possible – more ensemble members to capture scenarios
- Increase the sharpness in the forecast PDF – reduction in initial uncertainties (improved analysis)
- Include more components to better forecast boundary conditions and improve teleconnections

Meanwhile…

- Need for post-processing?
- Use proxies to predict event (e.g convective indices, atmospheric rivers, etc)?

Tsonevsky (ECMWF Newsletter 144)
Lavers et al. (GRL, 2017)