ECMWF

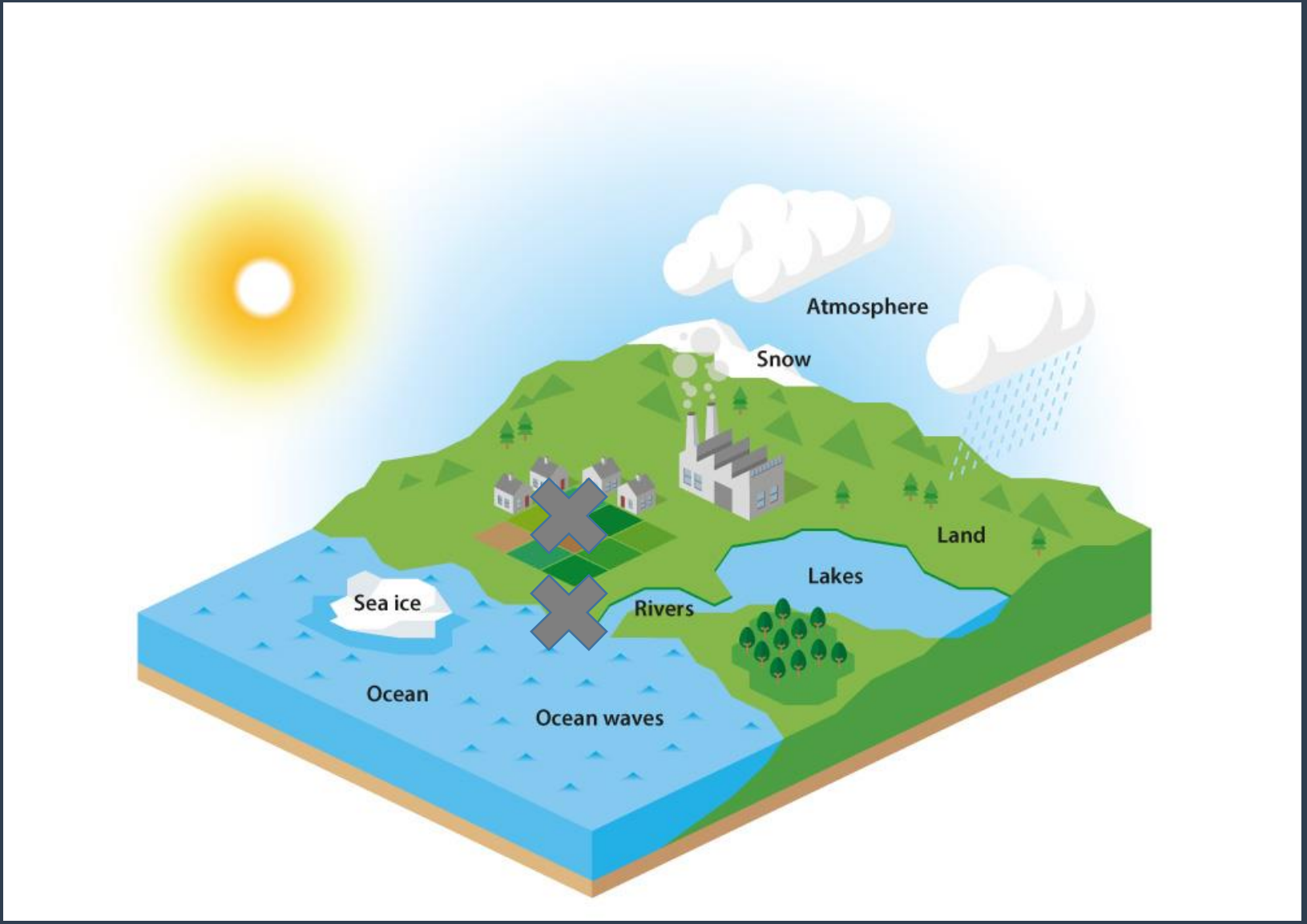
ECMWF model components relevant for coastal flooding

Linus Magnusson, ECMWF

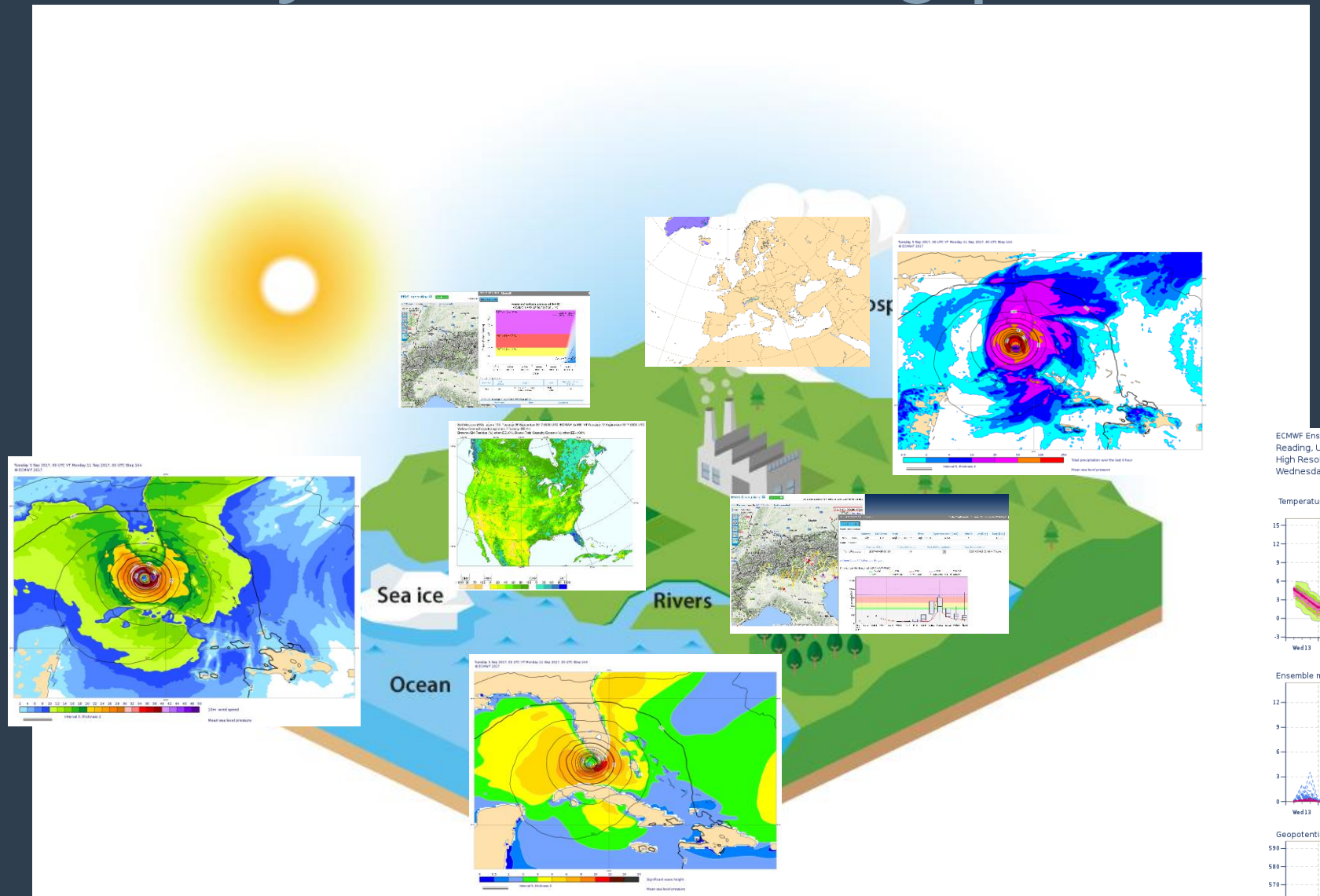
Thanks to: Jean Bidlot, Christel Prudhomme, Fredrik Wetterhall, David Lavers, …

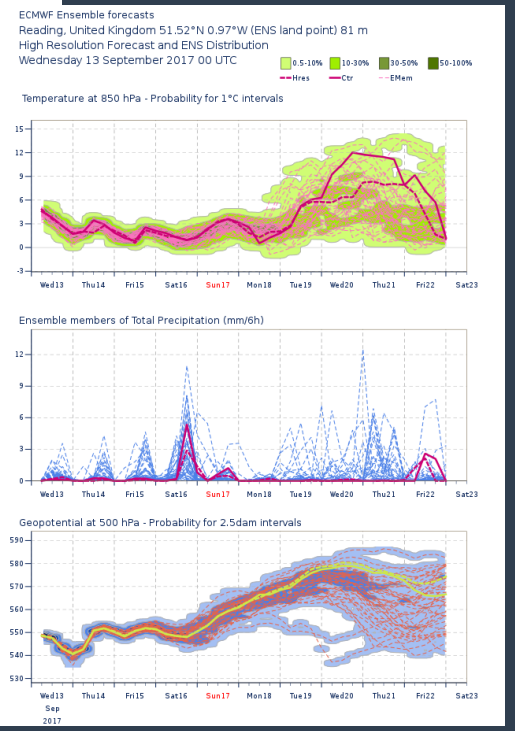
September 29, 2017

ECMWF earth system modelling



Earth System modelling products





ECMWF

Model components

		HRES reso	ENS reso
		10 days twice day	15 day twice day/ 46 days twice week
Atmosphere	IFS	9 km	18 km (- 36 km)
Soil	H-TESSEL	9 km	18 km
Lake	FLAKE	9 km	18 km
Waves	ECWAM	14 km	28 km
Ocean + sea ice	NEMO/LIM	*	0.25°
Rivers	LISFLOOD**	5 km	5 km

* Planned to be introduced early 2018
** Offline

Key messages:

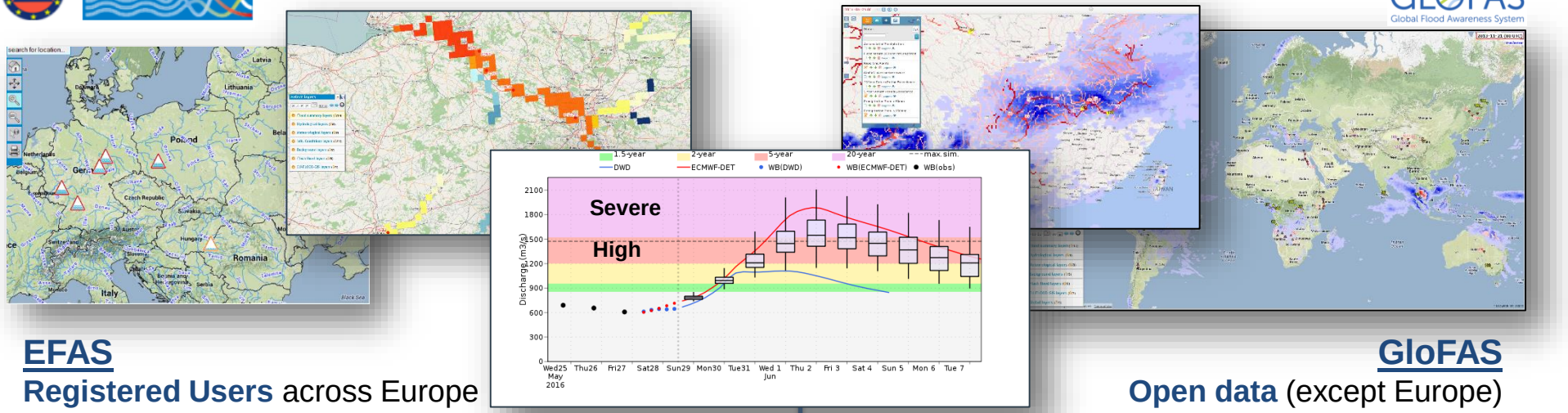
- Medium-range
- Global
- Ensemble

ECMWF

European and Global Flood Awareness Systems

European and Global-scale ensemble-based flood forecasting systems

A collaborative product between JRC and ECMWF



EFAS

Registered Users across Europe
Hydro-Met services, civil protection, etc..

Flood probabilities from **nowcasting** (every 15 mns to 3 hrs) to **medium-range** (twice daily up to 15 days, except flash-floods up to 5 days) to **seasonal** (once a month up to 2 months, to be extended to 7 months from oct 17)
Flood notifications
Regional risk mapping for significant floods only

Accessible through web interface

GloFAS

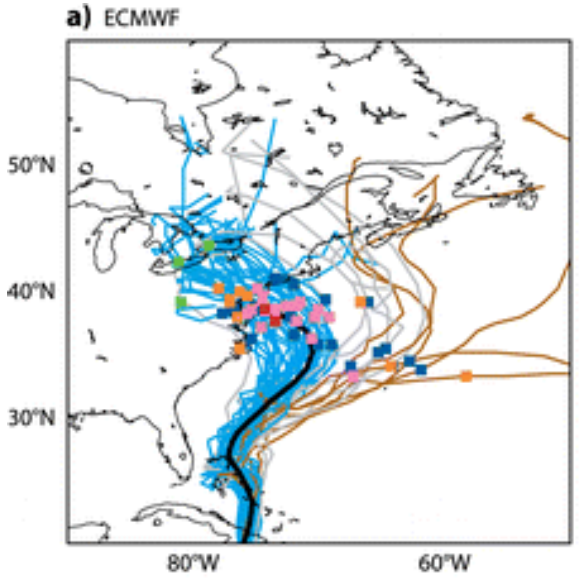
Open data (except Europe)
>1000 registered users incl. NGOs, regional hydro-met, academics etc…

Flood probabilities (daily up to 30 days, > 2000 reporting points), rainfall maps (daily up to 10 days), and flood inundated areas (100yr RP flood only)
New product (Nov. 17)
Probabilistic high/low flow
(once a month up to 7 months)

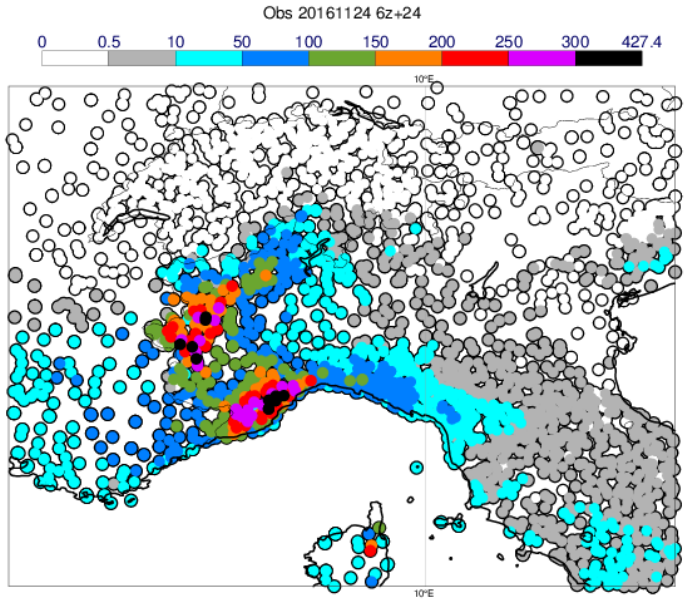
Accessible through web interface and ftp

3 examples of coastal flooding events

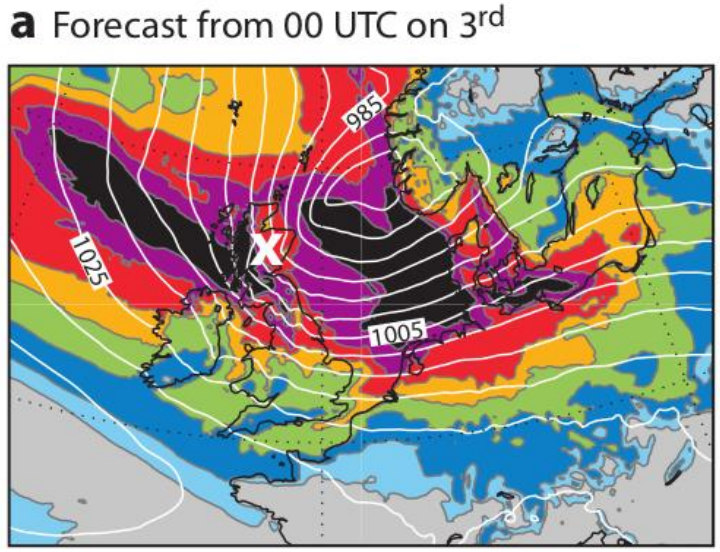
Hurricane Sandy (2012)



Italy rainfall (2016)



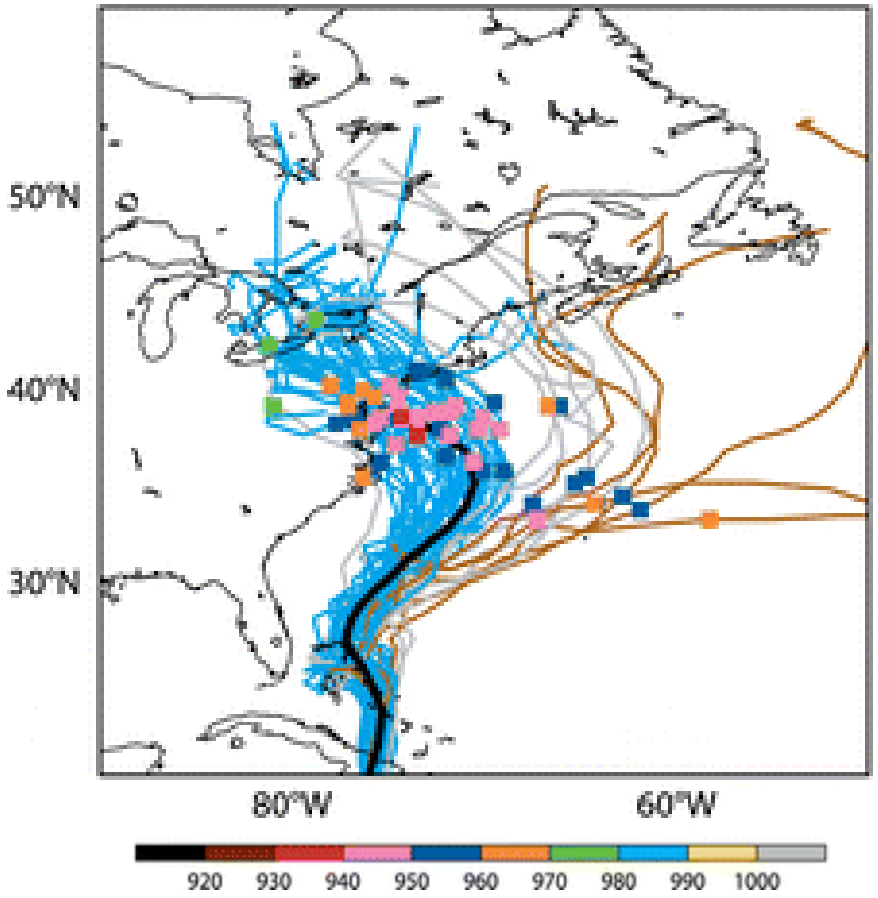
Windstorm Xaver (2013)



For more cases, see ECMWF Severe Event Catalogue:
https://software.ecmwf.int/wiki/display/FCST/Severe+Event+Catalogue

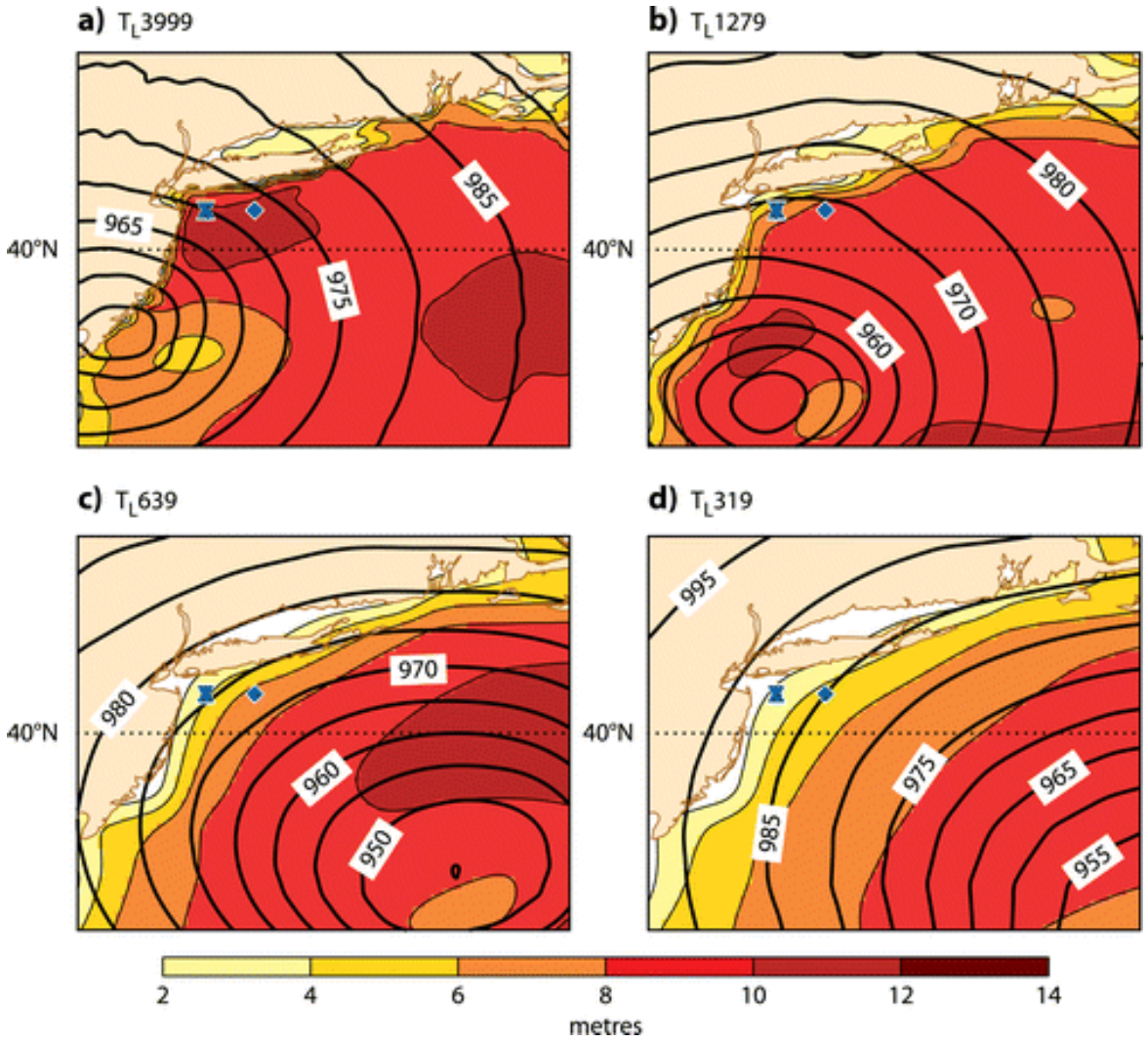
Example 1 – Storm surge, waves, precipitation - Hurricane Sandy

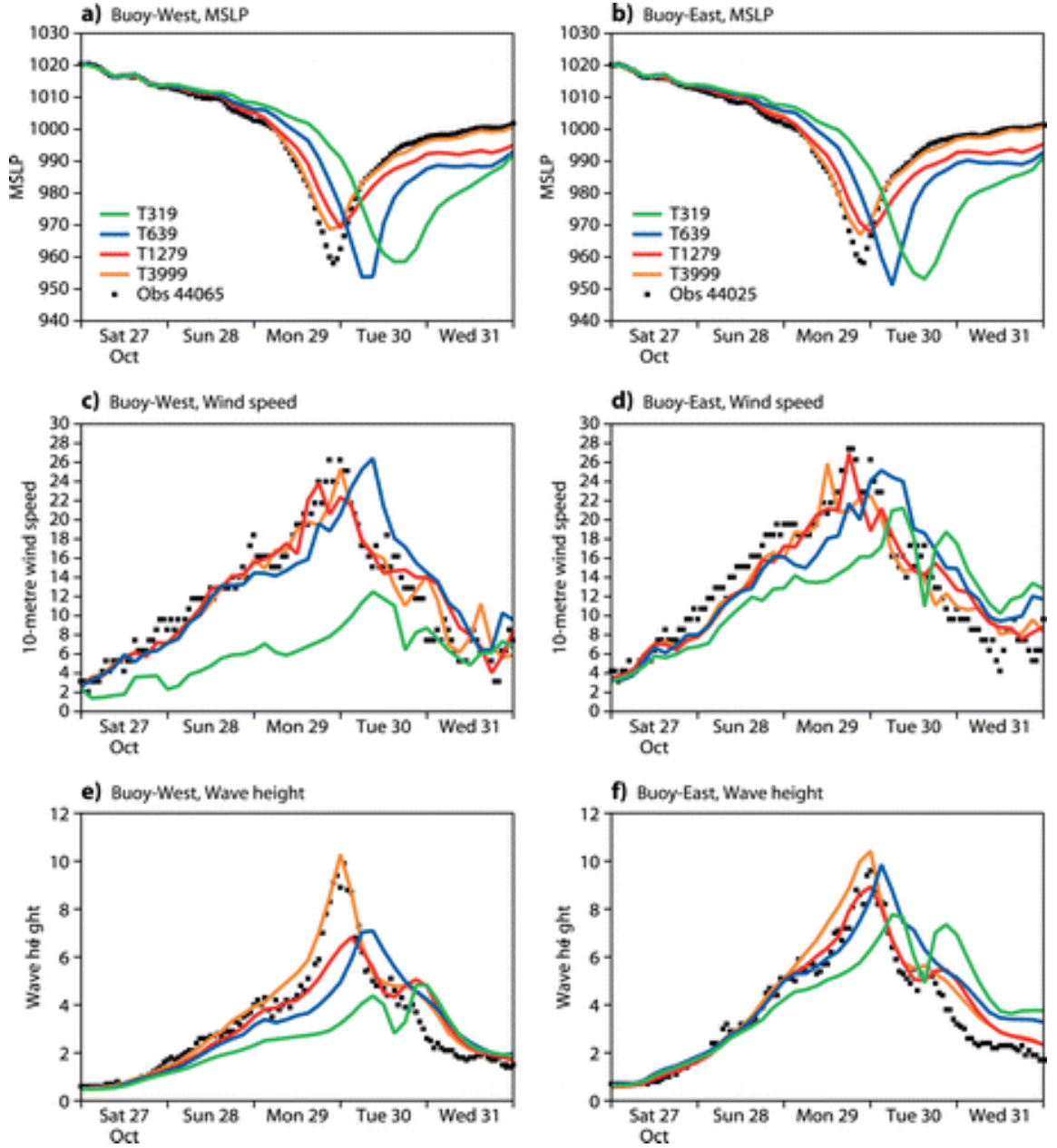
Ensemble forecast from 25 Oct 2012



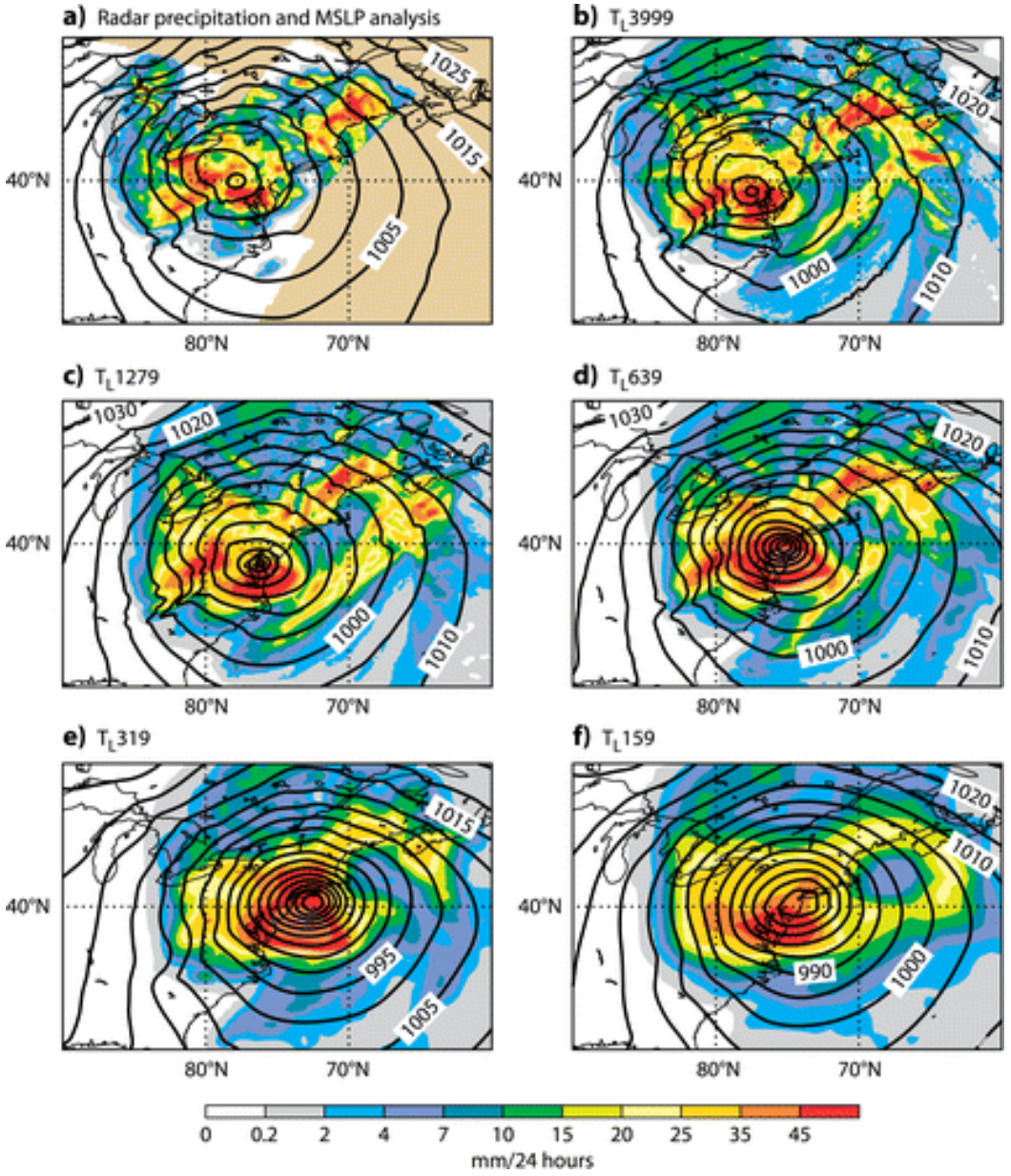
Magnusson, L., J. Bidlot, S.T. Lang, A. Thorpe, N. Wedi, and M. Yamaguchi, 2014: Evaluation of Medium-Range Forecasts for Hurricane Sandy. Mon. Wea. Rev., 142, 1962–1981, https://doi.org/10.1175/MWR-D-13-00228.1

Example 1 - Significant wave height forecasts by different resolutions



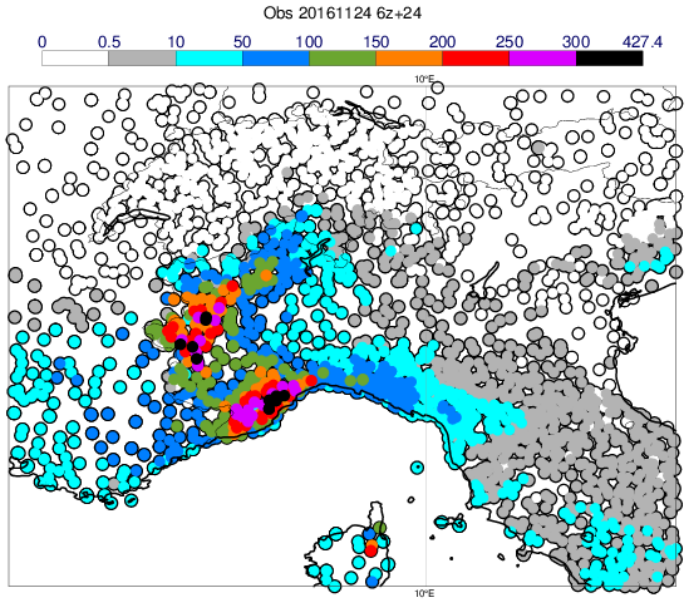


Example 1 - Total precipitation forecasts by different resolutions

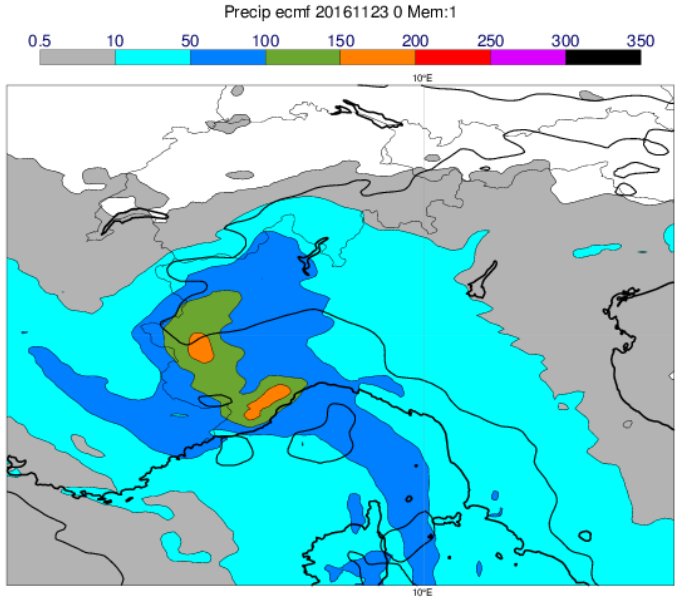


Example 2 - Precipitation and runoff – Case from November 2016

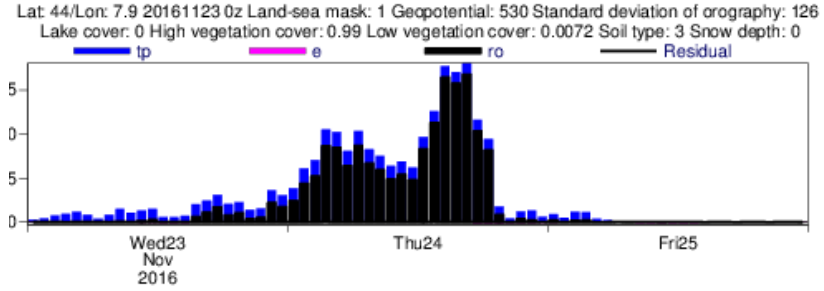
Observations



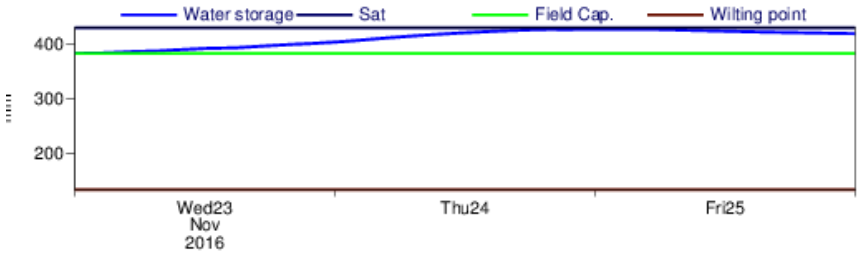
1-2 day forecast



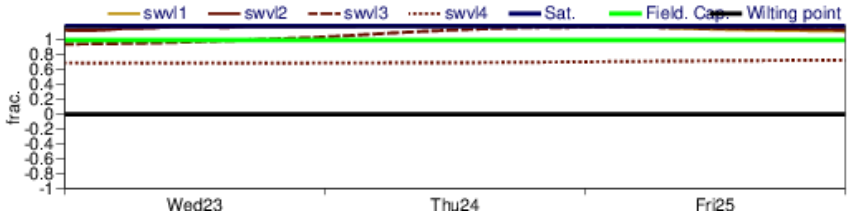
Soil water impact for point along Italian coast



Precipitation and runoff from HTESSEL



Total storage

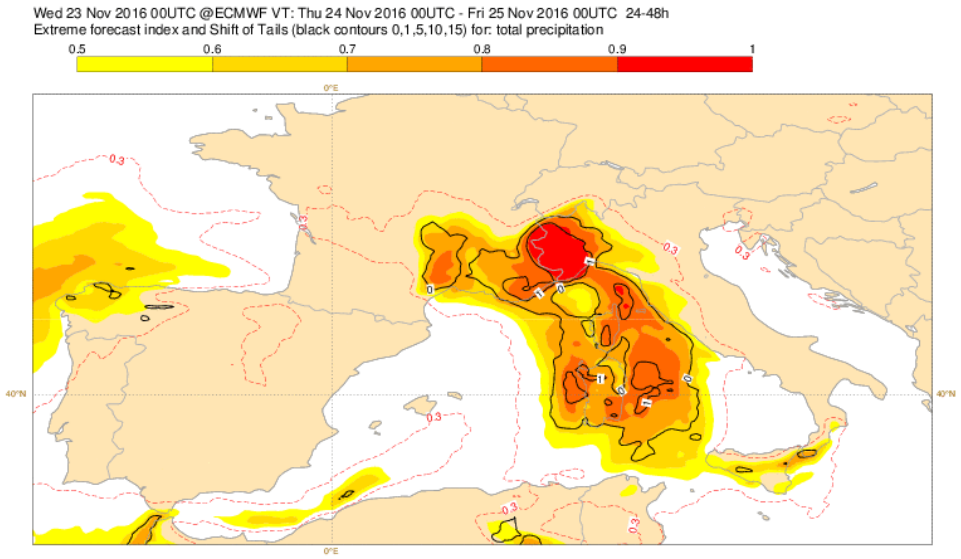


Storage in each layer

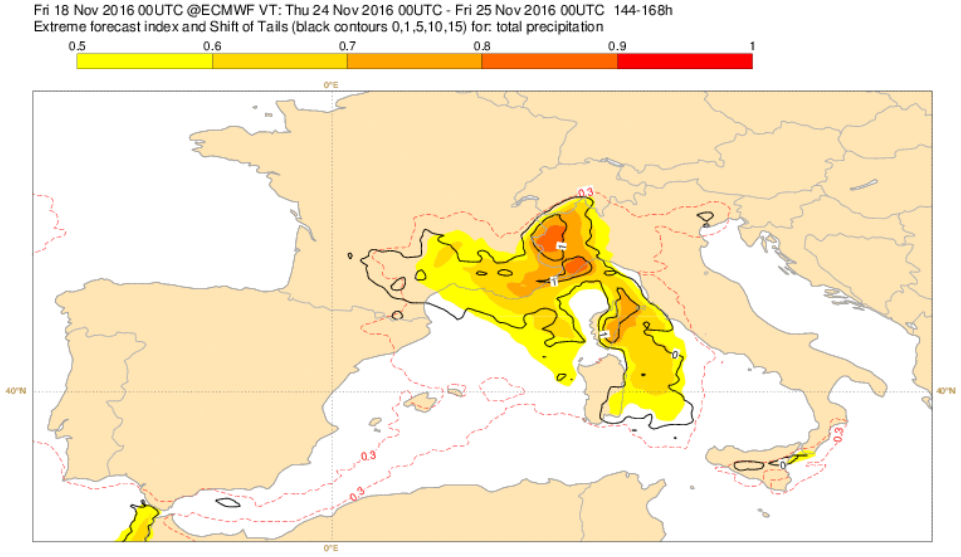
Example 2 - Medium-range prediction

Extreme forecast index for precipitation
(compares ensemble to climate PDF)

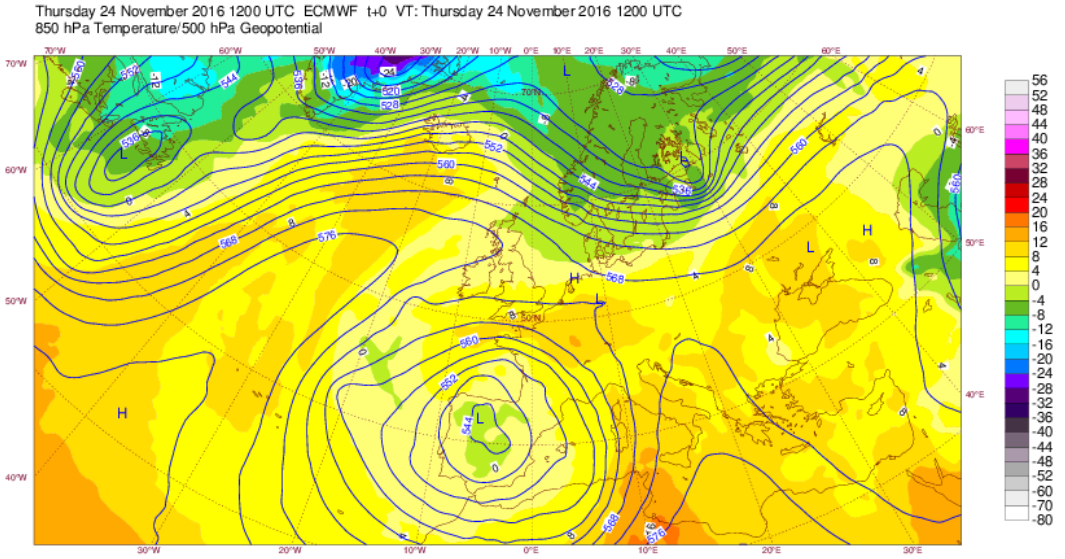
1-2 day forecast



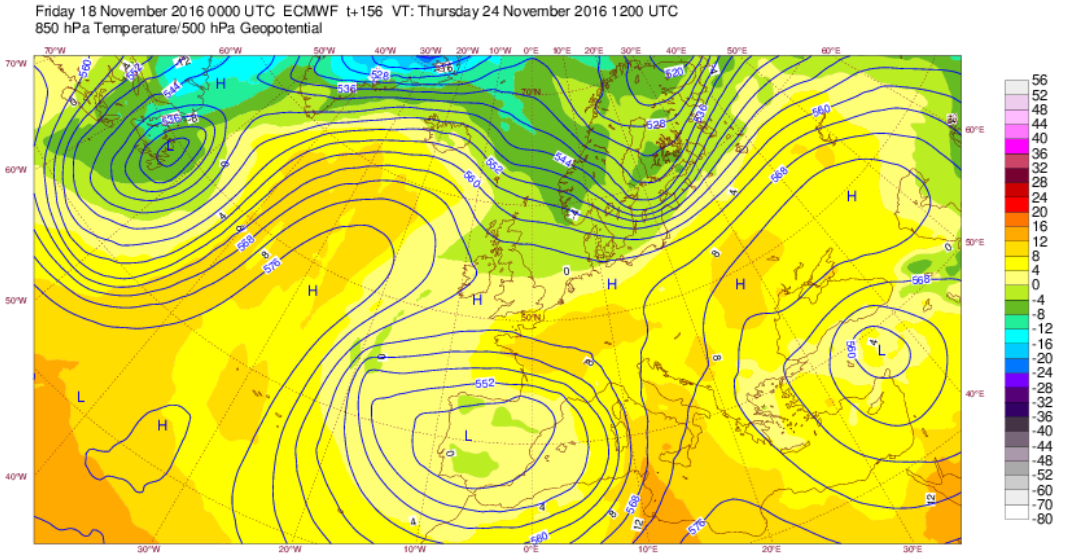
6-7 day forecast



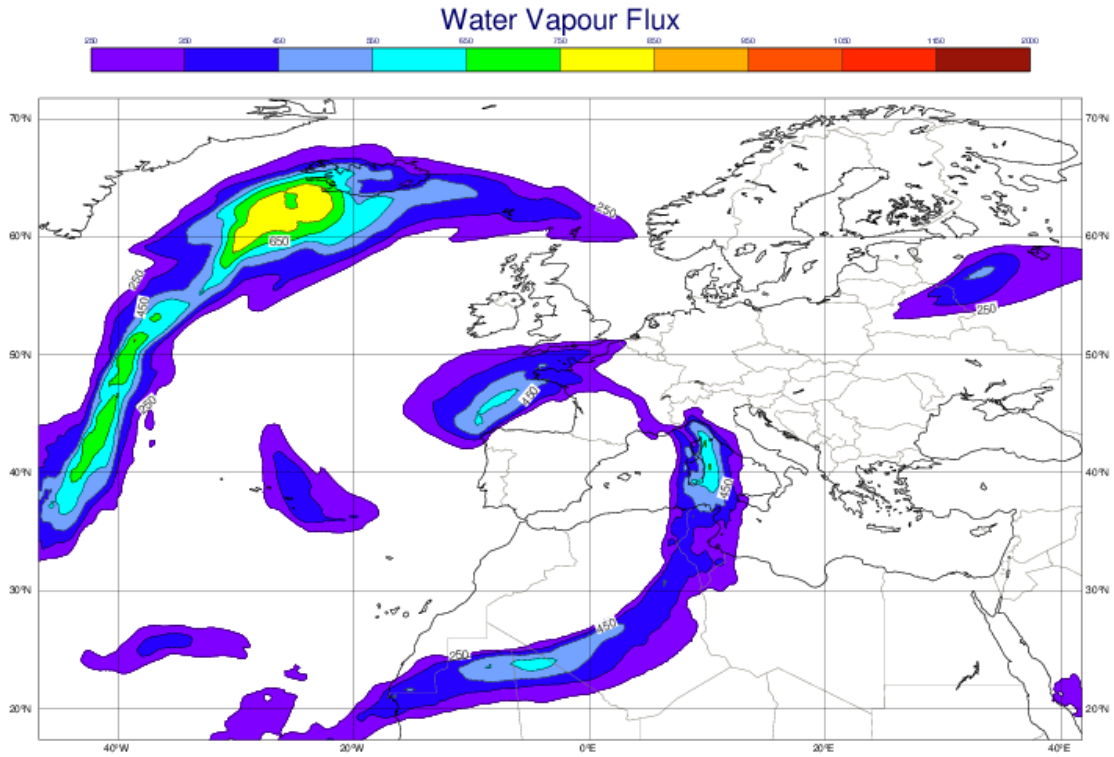
Analysis 24 November



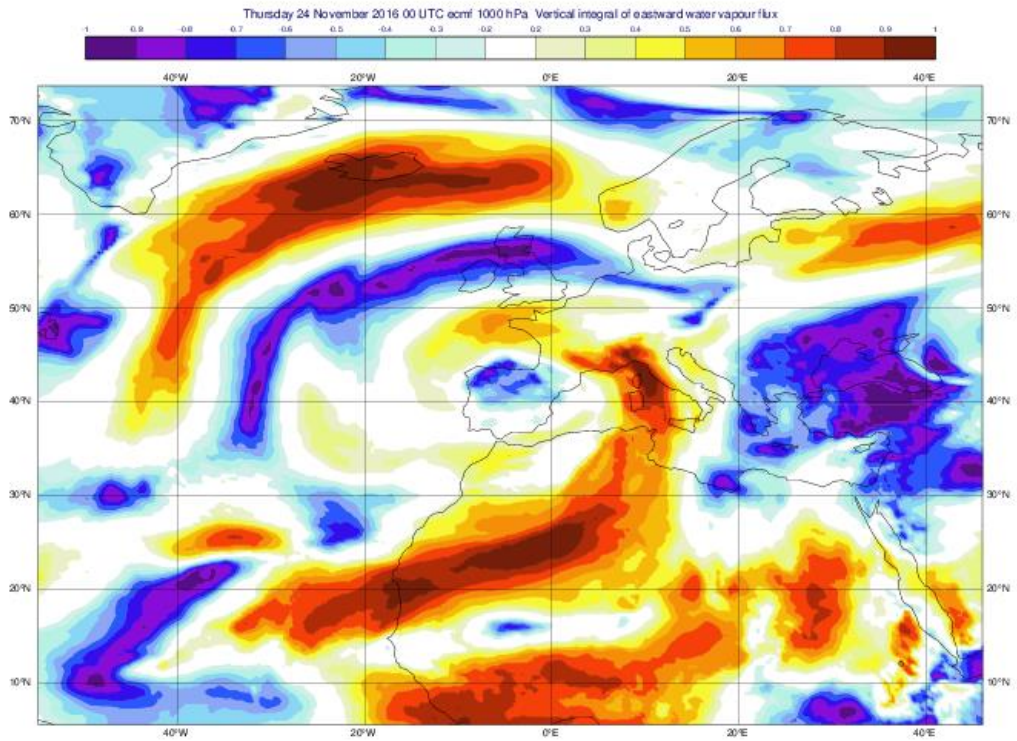
6-day deterministic forecast



Example 2 – “Atmospheric rivers” on 24 November



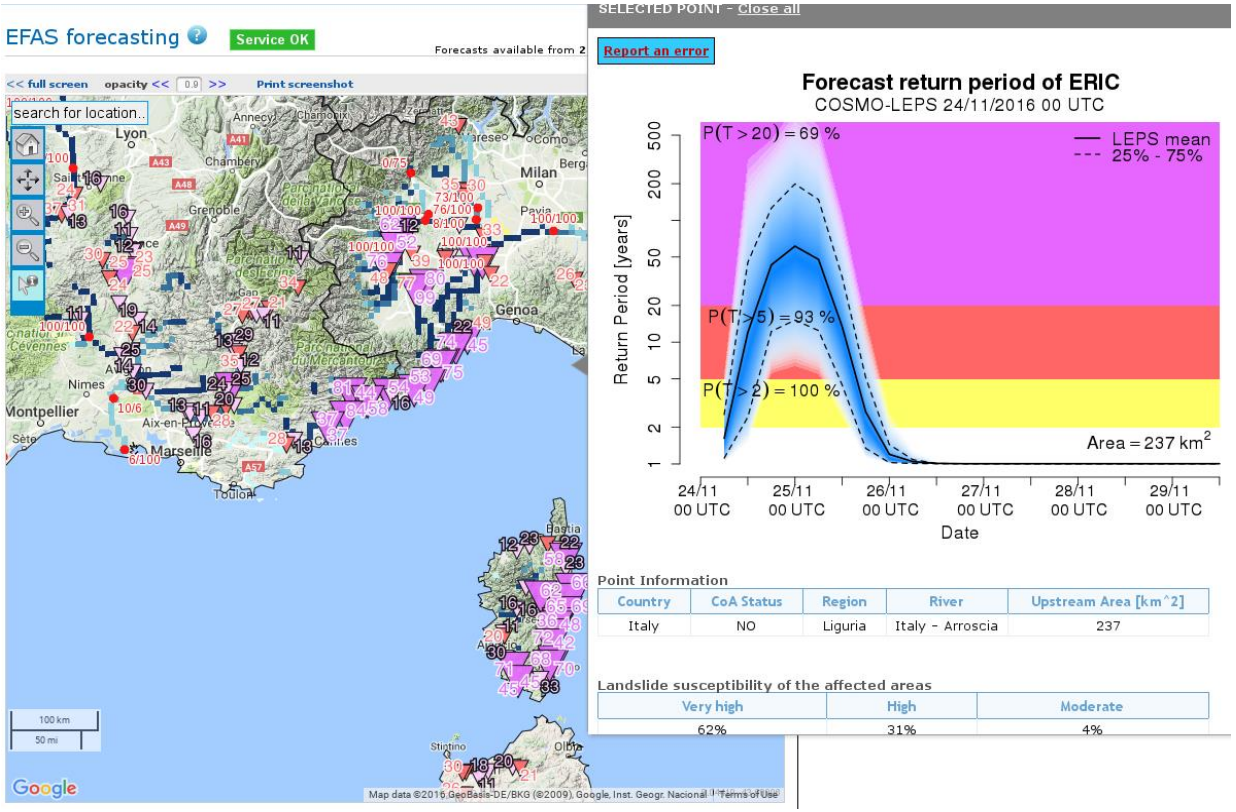
EFI for water vapour flux



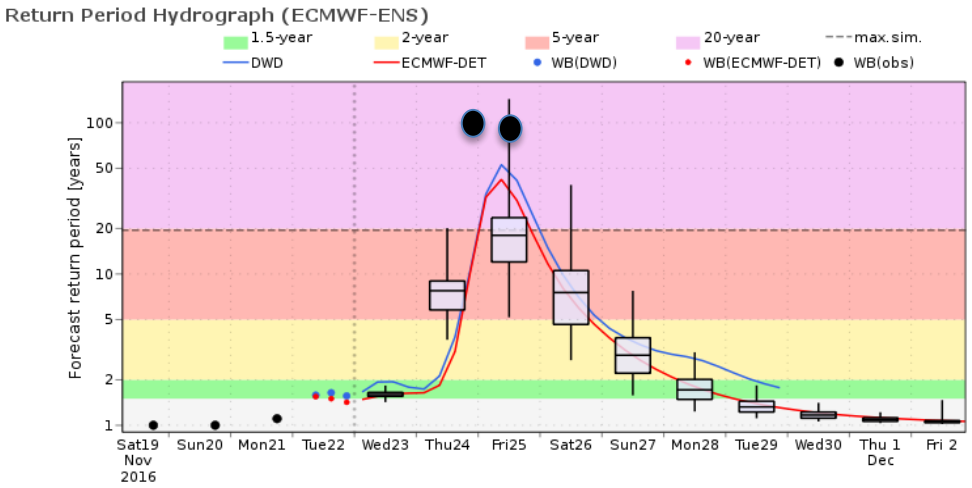
Thanks to David Lavers, ECMWF

Example 2 - Flood forecasting - EFAS

Short-range flash-flood warnings



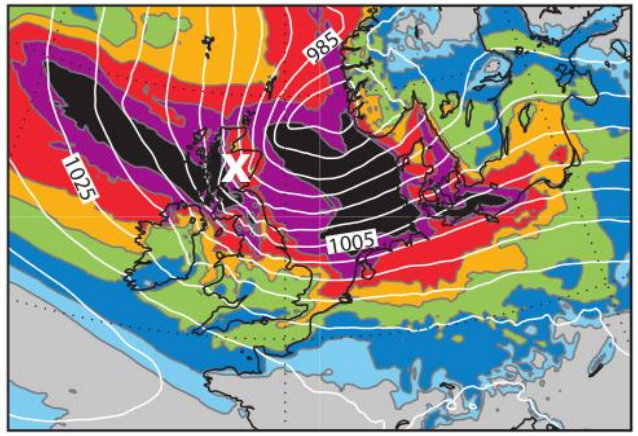
Flood forecast for a point on Tanaro (44.94N, 8.68E)



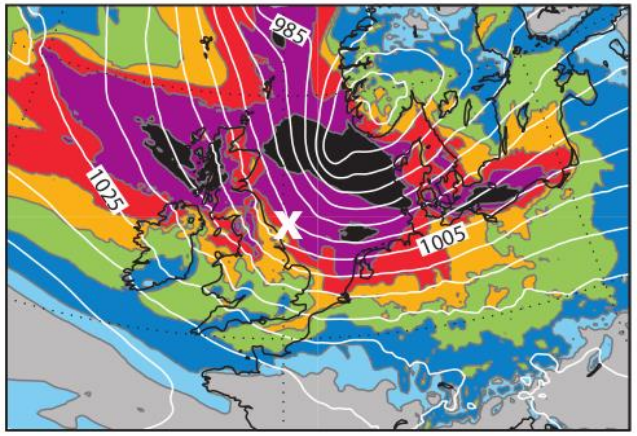
Example 3 - Ocean Waves, wind and pressure – Xaver (2013)

ECMWF Newsletter No. 139 – Spring 2014

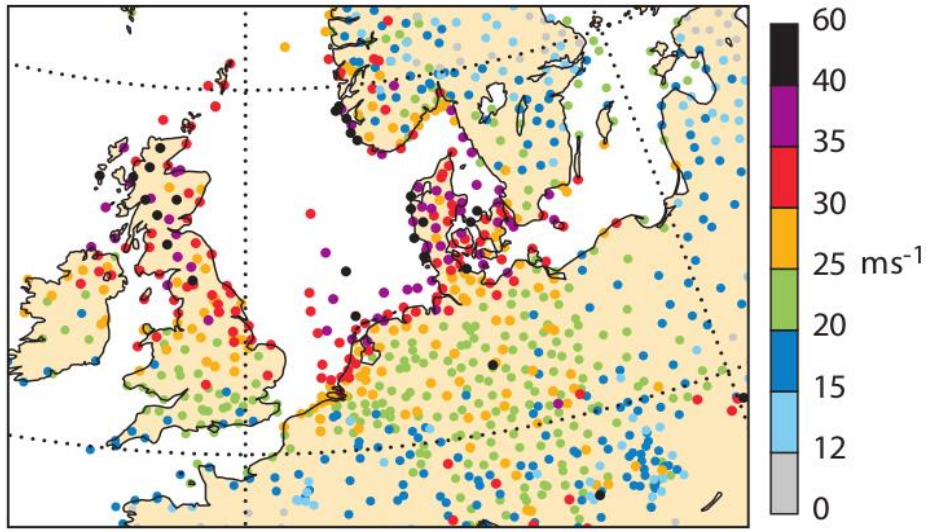
a Forecast from 00 UTC on 3rd



b Forecast from 00 UTC on 5th



c Observed maximum wind gust on 5th



Wave forecast

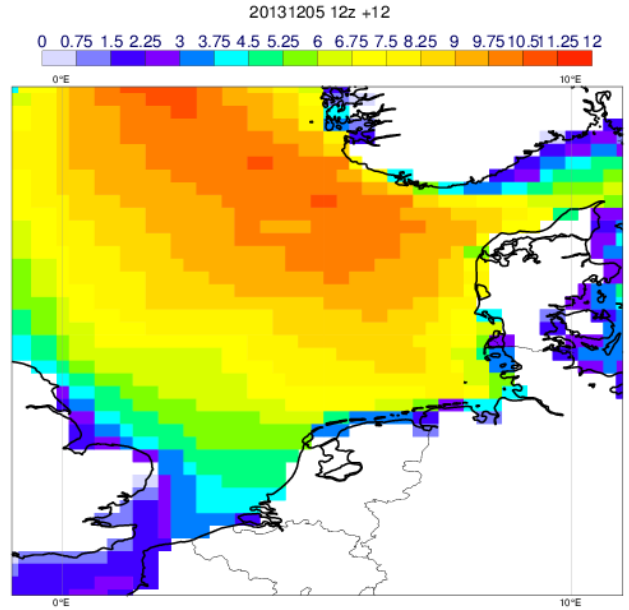


Figure 5 Forecasts, of 24-hour maximum wind gust between 00 and 24 UTC on the 5th (shading) with mean-sea-level pressure for 12 UTC on the 5th (contours) from data times of (a) 00 UTC on 3 December and (b) 00 UTC on 5 December 2013. White crosses denote the remnants of a meso-vortex discussed in the text. Panel (c) shows verifying data from observations.

Example 3 - Medium-range prediction

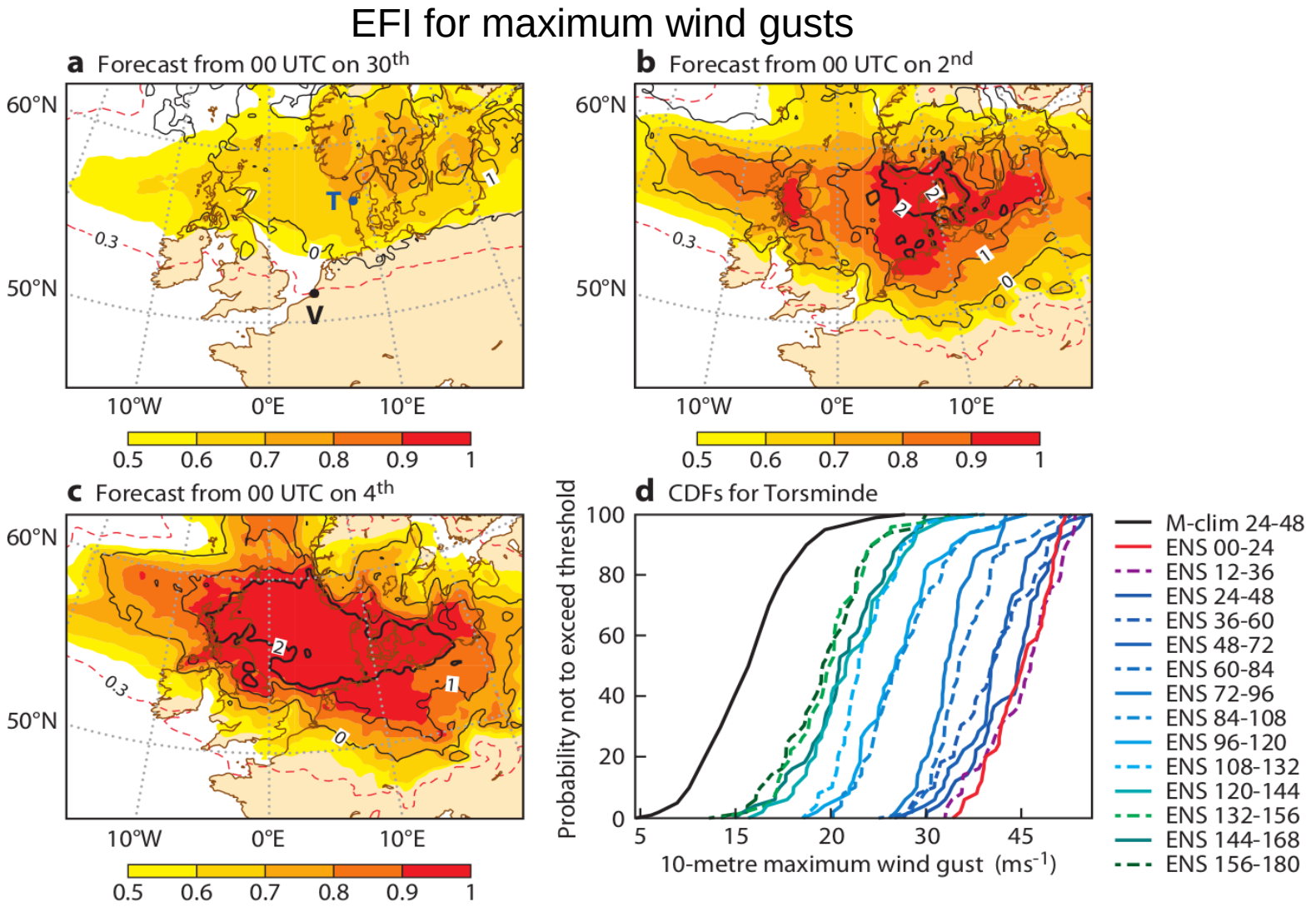


Figure 6 Maximum gust forecasts from ENS represented as the EFI (shading as on legend, and red contours = 0.3) and SOT (black contours = 0, 1, 2, 5) for 00 to 24 UTC on 5 December 2013 from data times (a) 00 UTC on 30 November, (b) 00 UTC on 2 December and (c) 00 UTC on 4 December 2013. Panel (d) shows, for the same 24-hour period, maximum wind gust CDFs for Torsminde in northwest Denmark (location 'T' marked on panel (a) from 14 ENS runs (see legend). M-clim (black line) is the model climate, as in Figure 3.

Example 3 - Storm surge model from The Netherlands

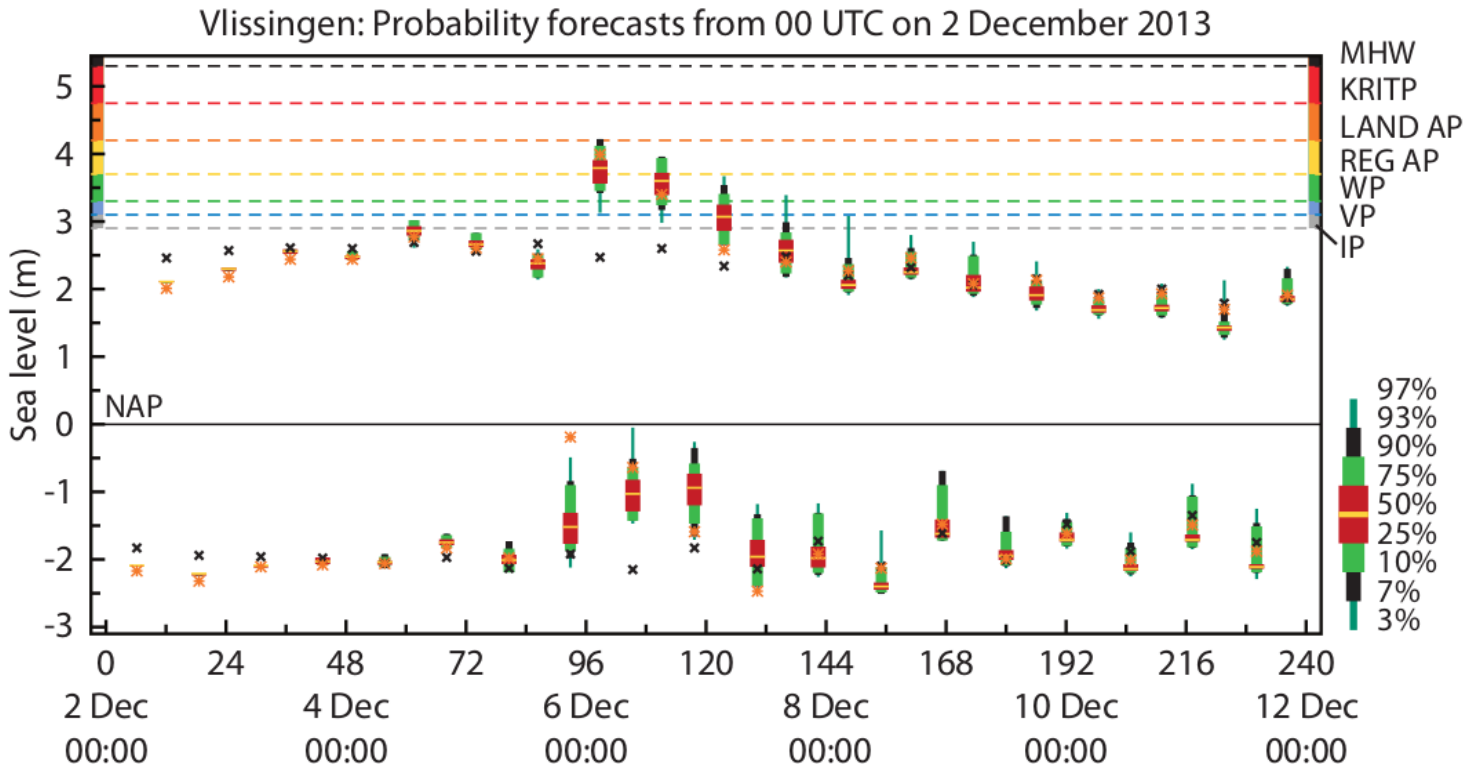


Figure 7 The ensemble storm surge forecast for Vlissingen (location marked on Figure 6a), from 00 UTC on 2 December 2013. Box-plots show water level probabilities for high and low waters as derived from the 51 ENS inputs. Marked with black through to grey dashed lines are various risk levels for the coastal district. The semi-diurnal tide is clearly visible as the box-plots jump between high and low water roughly every six hours. The fortnightly spring-neap tidal cycle is less visible, but reaches its peak on 4 December, 1.5 days before the peak of the storm surge. Orange asterisks are the observed water levels and grey crosses show, as a reference point, the pure astronomical tides.

Vries, **J.W. de**, 2009. Probability forecasts for water levels at the coast of The Netherlands. *Marine Geodesy*, **32**,100–107, doi:10.1080/01490410902869185.

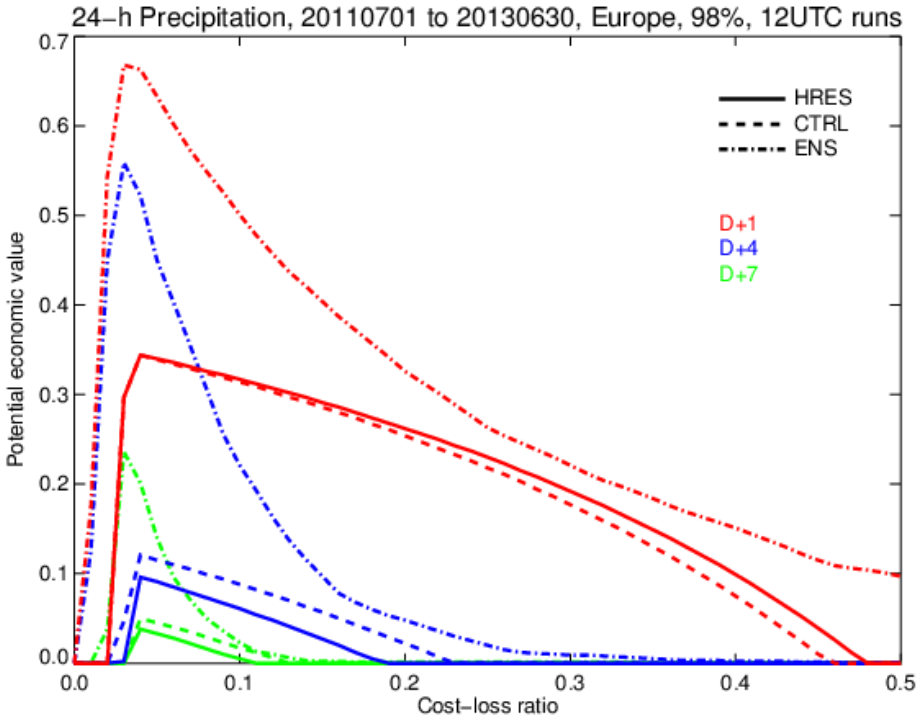
Summary

- What we do:
  - Medium range and long-range forecasts
  - Global “earth system” model (incl. atm., ocean, waves, soil, ..)
  - Ensembles
  - River discharge (via EFAS)
- What we (currently) do not do:
  - Limited-area models
  - Storm surge modelling
  - Urban modelling
  - Flood inundation maps

Challenges

- Is the skill in the medium-range sufficient to be useful?
- Timing-errors and tides
- The devil is in the details

- Keep the wall-time clock limit



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)?