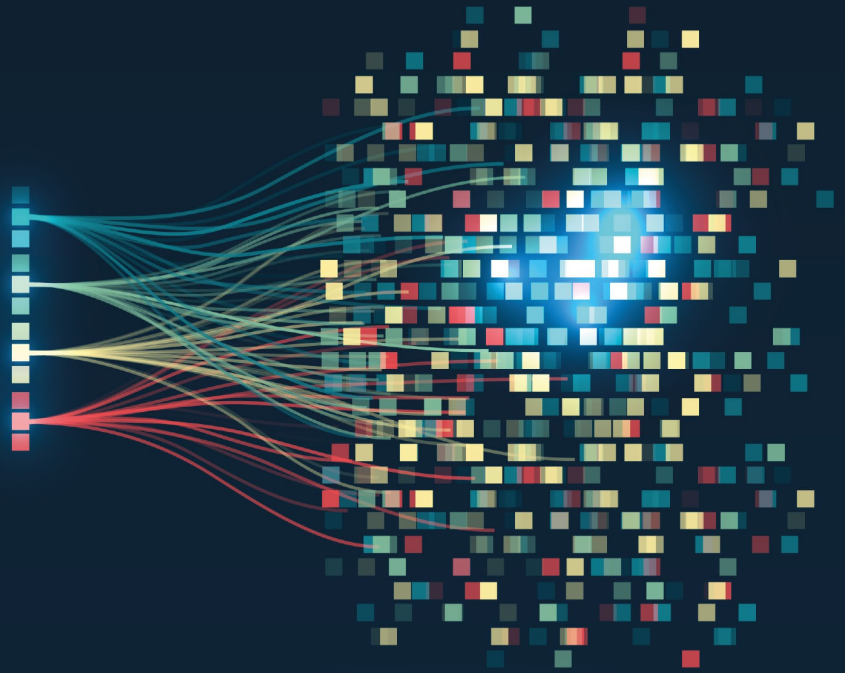
UEF 2023

Ensemble Forecasting

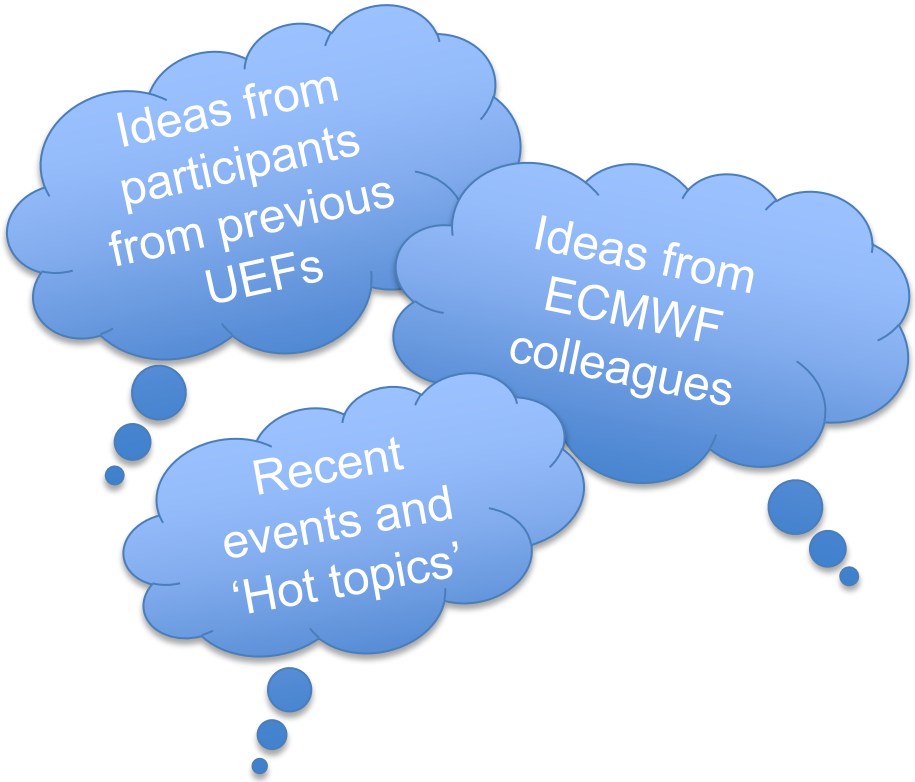
5–8 June 2023

#UEF2023



ECMWF

How was the theme decided?



ECMWF
@ECMWF

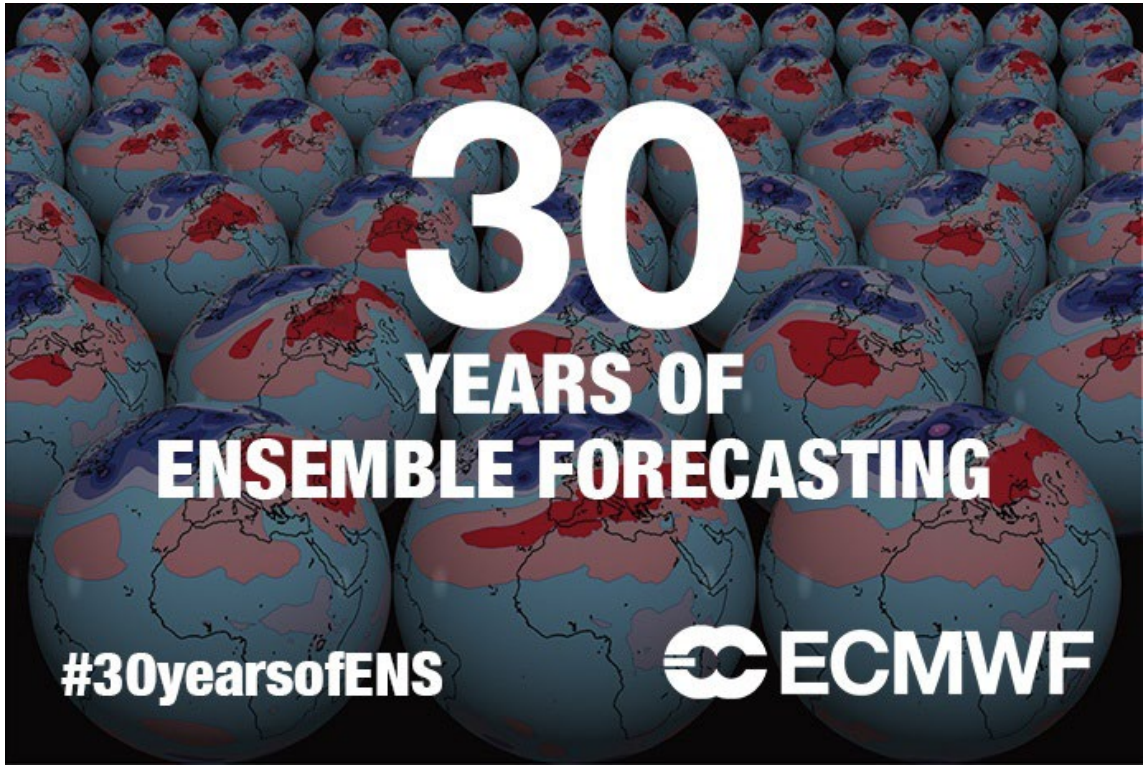
What do you think the theme of 'Using ECMWF's Forecasts' #UEF2023 should be?
Have your say on what you'd like to learn more about!
Make sure you submit your vote before this poll closes on 24 October.
The theme will be announced in November.

Ensemble Forecasting	**61.7%**
Forecasting for industry	37.2%
Other – please comment	1.1%

94 votes · Final results

3:18 PM · Oct 18, 2022 · Twitter Web App

Ensemble Forecasting



The first ensemble (ENS) ran at:

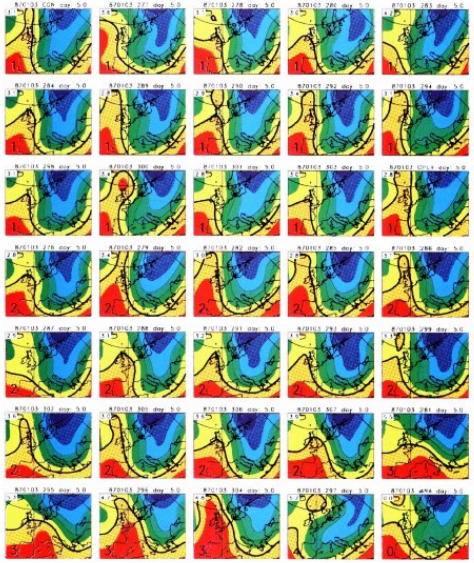
- 210 km resolution
- 19 levels
- 33 members

Daily ensemble prediction system from 1 May 1994

Ensemble Forecasting – a short ECMWF history

ECMWF Newsletter

Number 58 - June 1992



Shinfield Park, Reading, Berkshire RG2 9AX, England. Telephone: U.K. (0734) 499000, International (+44 734) 499000. Telex: 847908 ECMWF G. Telefax (0734) 869450

European Centre for Medium-Range Weather Forecasts
Europäisches Zentrum für mittelfristige Wettervorhersage
Centre européen pour les prévisions météorologiques à moyen terme

ENSEMBLE PREDICTION

Introduction

This coming winter, we hope to conduct an experiment to introduce ensemble prediction to Member States. An ensemble forecast will be made on a regular basis, and a selection of products will be disseminated. Each ensemble will comprise about 30 to 40 integrations of the T63L19 model, the integrations differing only in their initial conditions. These differences are consistent with our uncertainty in the initial state, and are chosen to project onto the dynamical instabilities of the flow during the first day of the forecast period. The disseminated products reflect the amount the initial small differences amplify during the forecast period, and therefore give an estimate of forecast reliability.

Chaos and predictability in a simple model

The potential value of ensemble forecasting can be illustrated quite effectively using the prototype chaotic model discovered by Lorenz in his search for a simple way to characterise the limited predictability of the atmosphere. Fig. 1 shows the famous Lorenz attractor, superimposed on which are three ensemble forecasts, started from different parts of the attractor. The attractor describes the "climate" of this simple model in phase space; it is inhomogeneous in structure with two symmetric regimes represented by the two "butterfly wings". The real atmosphere also appears to have regime structure giving rise, for example, to blocked and zonal flow. The ensembles of initial points are shown as small heavy dots around some point on the attractor. The distance of the dots from this centre point represents the uncertainty in determining the initial conditions for the integration.

In Fig. 1a, all members of the integration make the transition from left to right hand regime; as such, the regime transition is very predictable. Put another way, the relatively small dispersion of the ensemble implies that the probability of a regime transition is extremely high. In Fig 1b, the forecast ensemble diverges more rapidly. By the end, the best one can say is that there is about a 60% chance that there will be no regime transition, and about a 40 % chance that one will occur. In the final example, the final forecast dispersion is very large, and forecast evolution is essentially unpredictable.

It has been argued that the essence of medium-range forecasting lies in the prediction of changes in large-scale weather type. As such, these examples illustrate problems for current medium-range forecasting practice. Returning to Fig. 1, suppose we were only given a single forecast from each of the three ensembles, and that in each case this single forecast indicated a regime transition; from these alone we would not know that in the first case the forecast transition was reliable, whilst in the last case it was utterly unreliable.

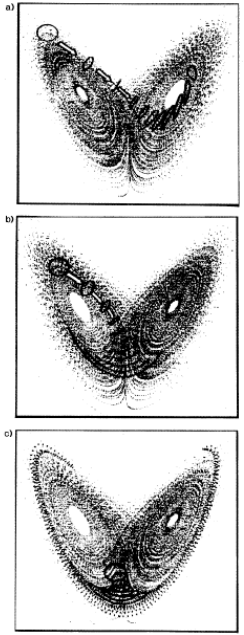


Fig. 1 a)-c) Three ensemble integrations of the 3-component Lorenz model shown in phase space, superimposed on the attractor set (or climate) of the model. The ensemble of initial points differ only in their position on the attractor.

Ensemble Forecasting – a short ECMWF history

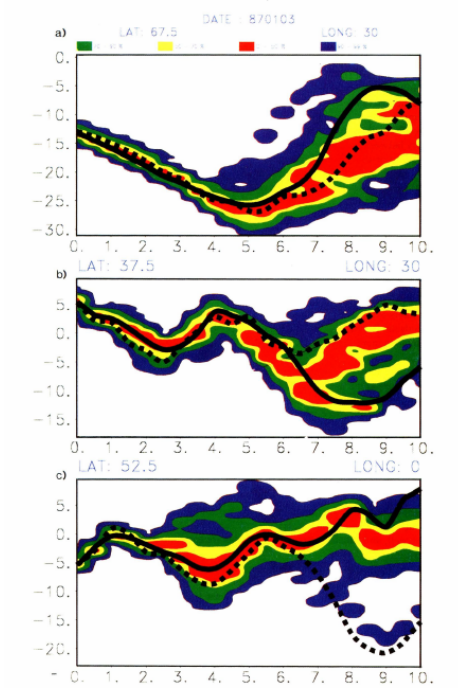


Fig. 2 a)-c) Confidence intervals for the ensemble forecast from 3 January 1987 of 850hPa temperature. Shown at three grid points throughout the forecast range. Contours shown are 99%, 90%, 70% and 50%.

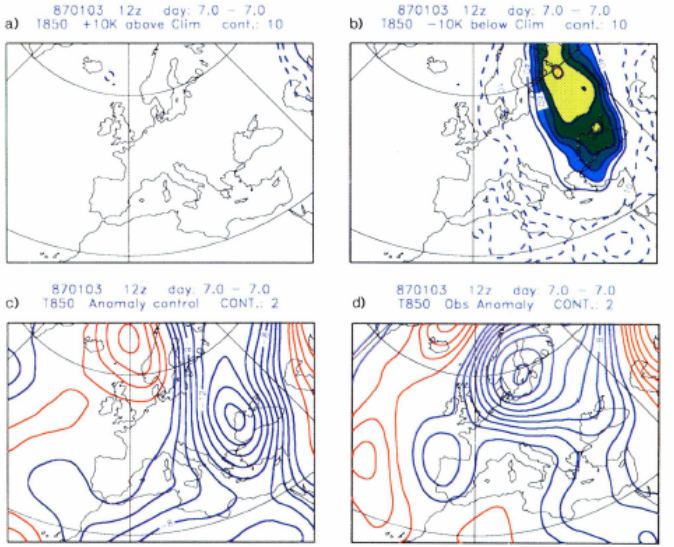


Fig. 3 Day 7 forecast of 850hPa temperature from 3 January 1987.
a) the probability that temperatures are at least 10K above climatology
b) the probability that temperatures are at least 10K below climatology
c) the forecast anomaly of the control
d) the observed anomaly

Ensemble Forecasting – a short ECMWF history

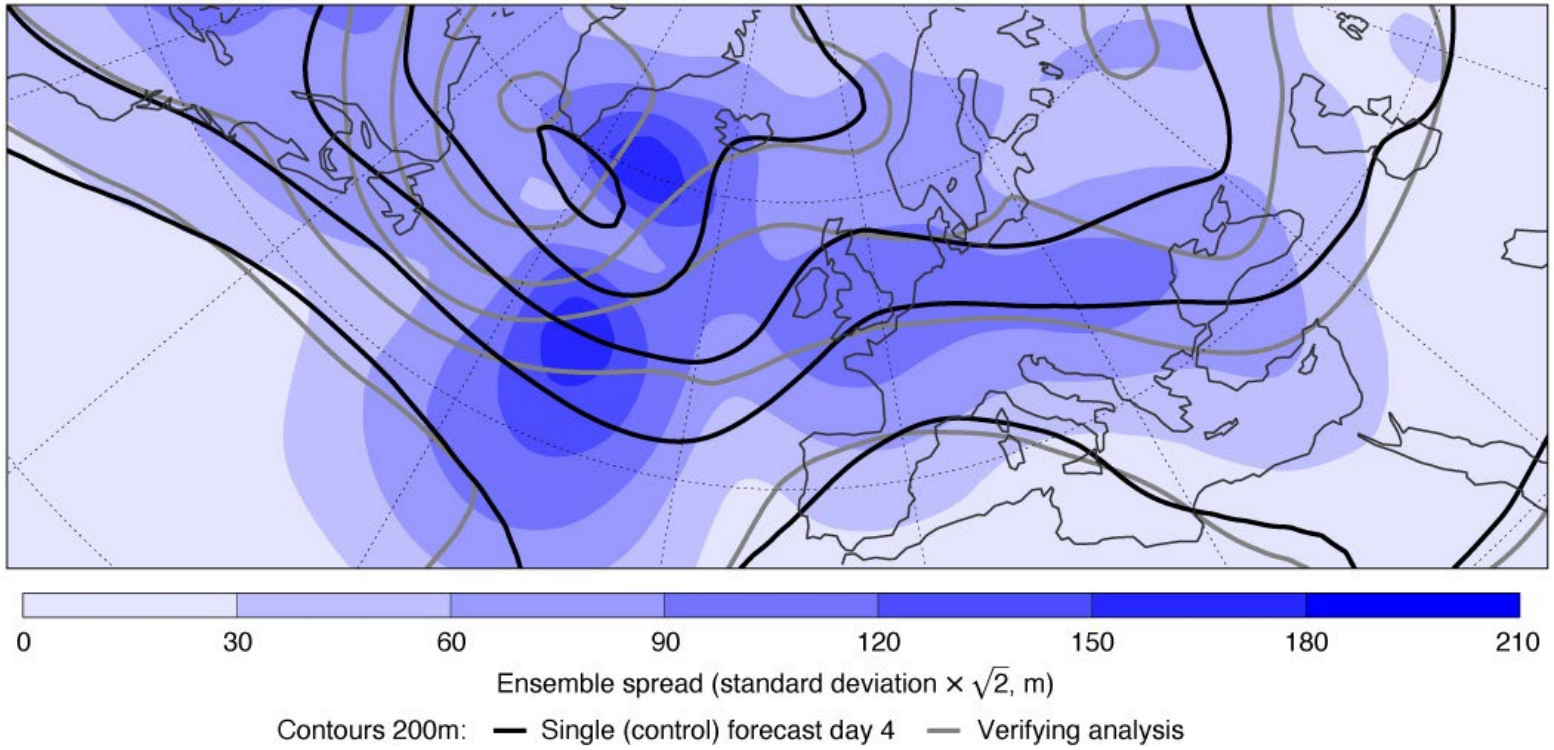
Future developments

Just as deterministic NWP developed from modest beginnings, so (it is hoped!) the ensemble forecast will evolve to become an indispensible part of the medium-range forecast product.

Of course, the technique is only as good as the basic model. Model systematic errors could have a very detrimental effect on the perception of the ensemble forecast.

As computer power increases, and numerical techniques become more efficient, we have to consider whether it would be more beneficial to integrate the ensemble with a higher resolution model, or to increase the size of the ensemble. With a larger ensemble, the probability estimates will in general become more reliable. Indeed, we believe that an ensemble size of 100 or more members would be desirable. On the other hand, with a higher resolution (eg T106) model, estimates of the probability of extreme wind speeds and extreme precipitation rates may become more reliable.

First ensemble forecast produced operationally at ECMWF in 1992



Ensemble Forecasting – Now

High resolution forecast (HRES) :

- 4 times per day, **9 km**, 137 levels, to 10 days ahead

Major updates in 48r1 27th June 2023

Ensemble forecast (ENS):

- 2 times per day, 51 members, **18 km**, 137 levels, to 15 days ahead
- **ENS-extended:** twice a week (Monday/Thursday 00UTC), **36km**, 137 levels, to 46 days ahead

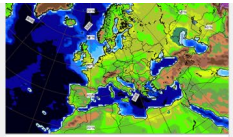
Ocean waves:

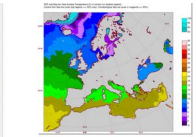
- **HRES-WAM**: 4 times a day, 10 days ahead at **14 km** (coupled)
- **ENS-WAM:** 4 times a day, 15 days ahead at **28 km** (coupled)

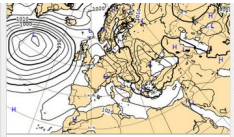
Seasonal / Long Range:

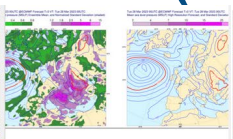
- **SEAS5**: Once a month, 51-members, **36 km** 91 levels, to 7 months ahead
- Sub-set of 15 members is run for 13 months every quarter (**30 years of hindcasts**)

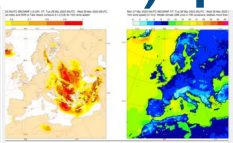
Ensemble forecast (ENS) products

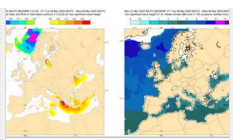

Orography and sea depth

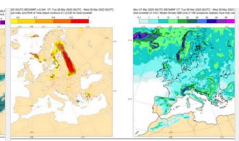

Sea surface temperature

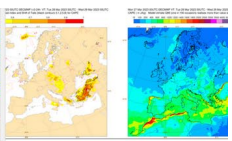

Ensemble mean and spread for mean sea level pressure

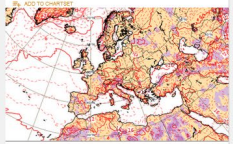

Ensemble mean and spread: four standard parameters

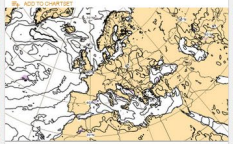

EFI wind speed

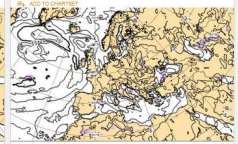

EFI significant wave height

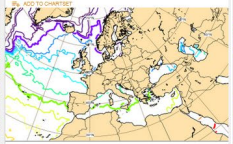

EFI snow fall

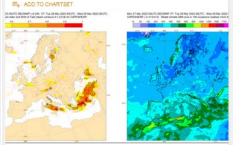

EFI CAPE

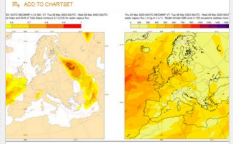

Ensemble mean and spread: 2 m temperature

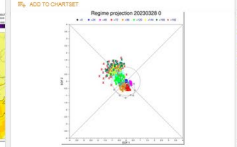

Ensemble mean and spread: 10 m wind speed

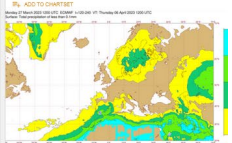

Ensemble mean and spread: 100 m wind speed

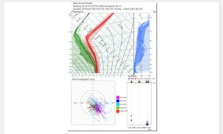

Ensemble mean and spread: sea surface temperature

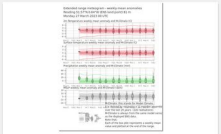

EFI CAPE shear

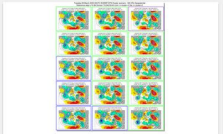

EFI water vapour flux

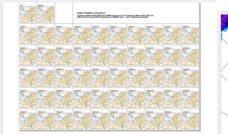

Ensemble

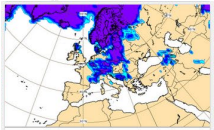


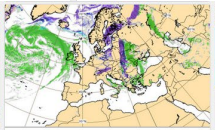

Vertical profiles

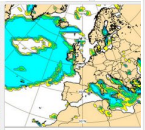

ENS extended meteograms

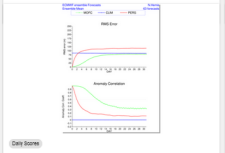

Cluster scenario

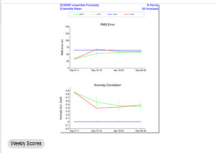

Postage stamp charts

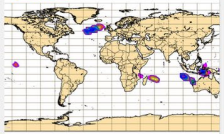

Probabilities: 2 m temperature below 0°C

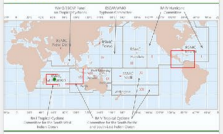

Probabilities: most probable precipitation type

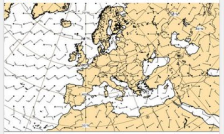

Probabilities: 10 m wind speed

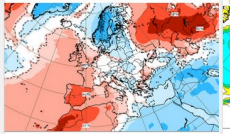

Daily Scores

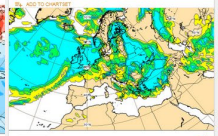

Weekly Scores

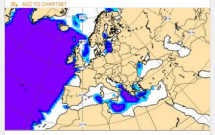

Tropical cyclone activity (including genesis)

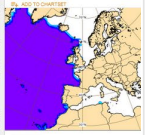

Tropical cyclone

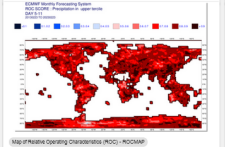

Winds at various levels: Weekly mean anomalies

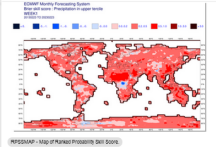

2 m temperature: Weekly mean anomalies

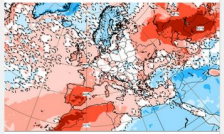

Probabilities: total precipitation, last 24 hours

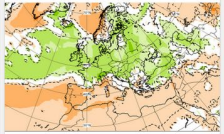

Probabilities: significant wave height

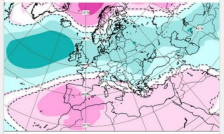

Probabilities: mean wave period

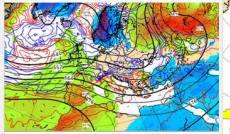

Map of Relative Operating Characteristics (ROC) - ROCMAP

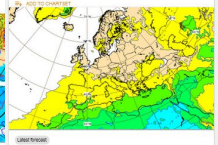

RPSSMAP - Map of Ranked Probability Skill Score.

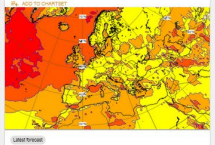

Surface temperature: Weekly mean anomalies


Precipitation: Weekly mean anomalies


Mean sea level pressure: Weekly mean anomalies


Multiparam: Weekly mean anomalies


Probabilities: total precipitation (day 10-15)


Probabilities: 10 m wind gust (day 10-15)

Probabilities: significant wave height (d

Monsoon Indices – Long Range Forecast – SEAS5

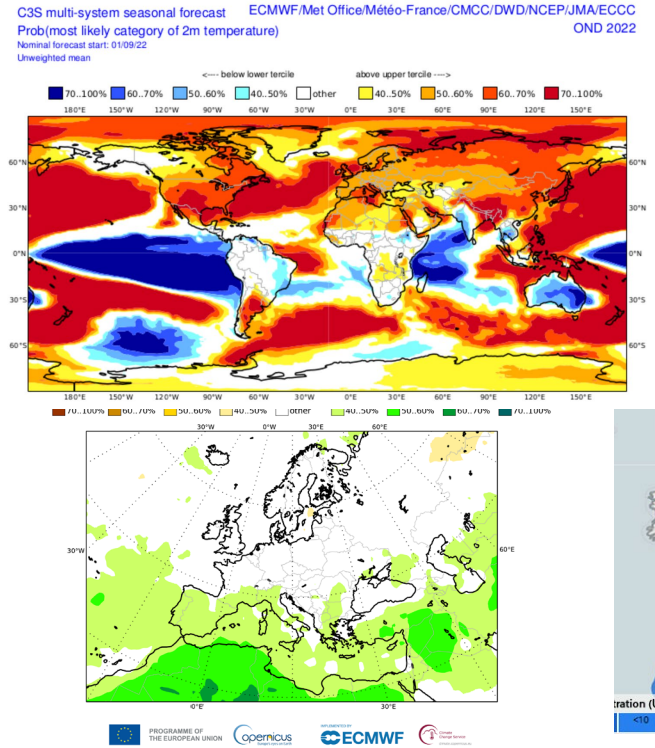
Precipitation Area Averages – Long Range Forecast – SEAS5

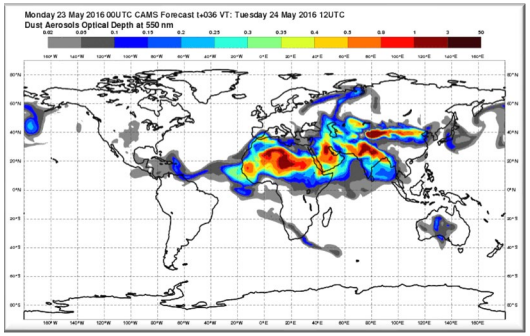
Ensemble forecast (ENS) products

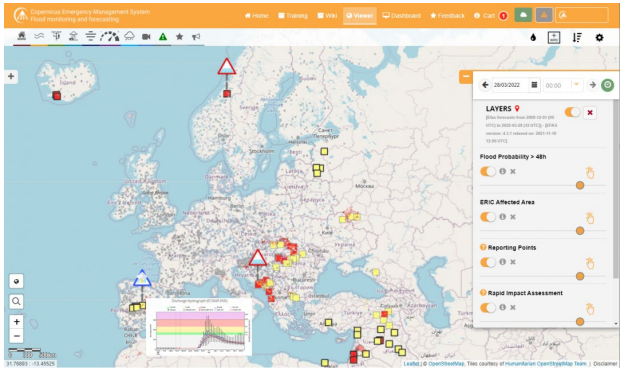
Climate Change Service

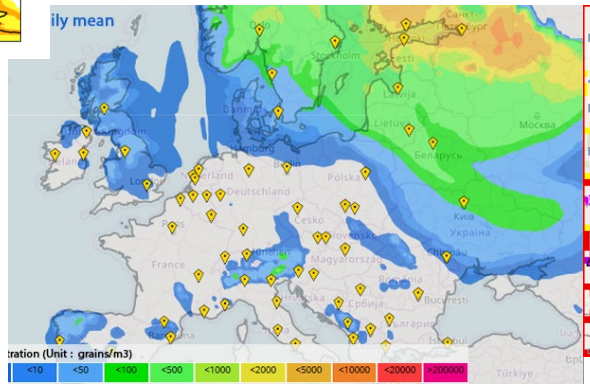
Atmosphere Monitoring Service

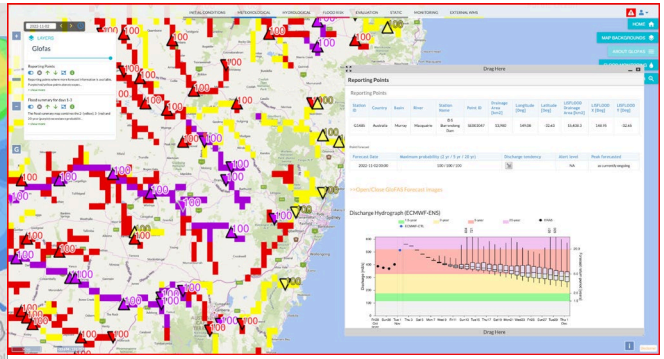
Emergency Management Service





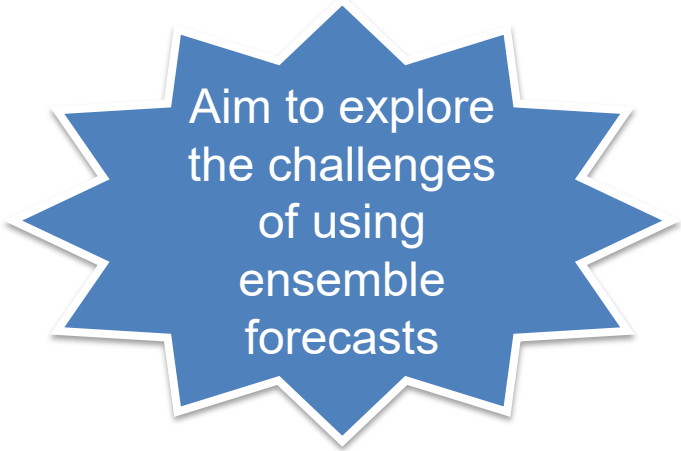






PROGRAMME OF THE EUROPEAN UNION · Copernicus · ECMWF

UEF2023 Thematic Areas



- The science of ensemble forecasting
- Using ensemble models and data
- Ensemble forecast applications and products
- Communication of ensembles and probabilities

UEF2024 Theme…

Flipchart in the Weather Room waiting for your ideas for themes

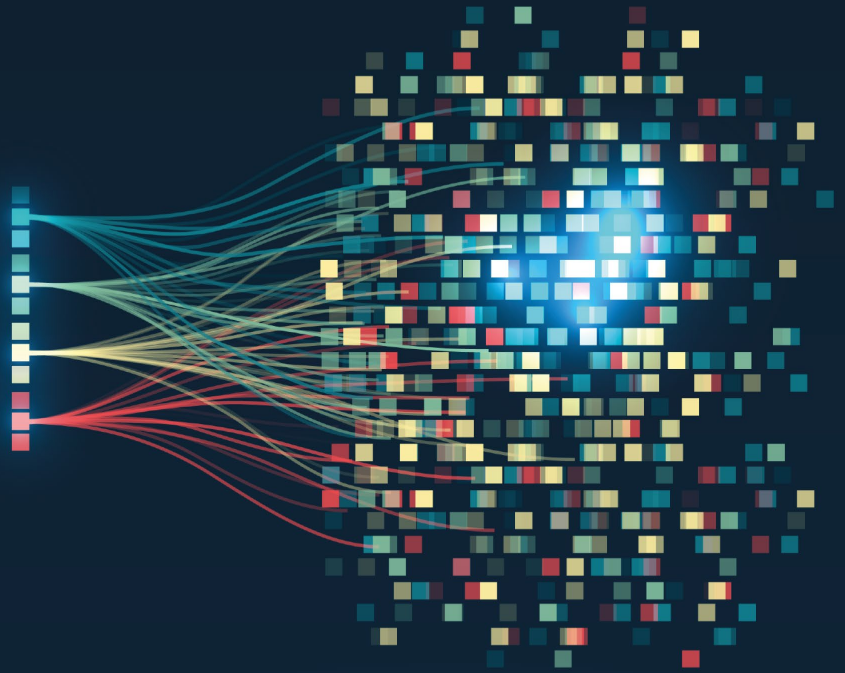
UEF2023 survey will ask for ideas for future UEF themes

UEF 2023

Ensemble Forecasting

5–8 June 2023

#UEF2023



ECMWF