Ensembles and ECMWF ensemble products

Baltic+ course 2023

8th November 2023

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User Outreach and Engagement

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ECMWF

ECMWF – Who we are

Established in 1975, Intergovernmental Organisation

- 23 Member States | 12 Cooperating States
- 400+ staff

24/7 operational service

- Operational NWP – 4x HRES+ENS forecasts / day
- Supporting NWS (coupled models) and businesses

Research institution

- Experiments to continuously improve our models
- Reforecasts and Climate Reanalysis

Operate Two EU Copernicus Services

- Climate Change Service (C3S)
- Atmosphere Monitoring Service (CAMS)
- Support Copernicus Emergency Management Service

Destination Earth

- Operates the DestinE Digital Twin Engine (DTE)
- Operates two Digital Twins

The operational forecasting system

Major updates in 48r1 27th June 2023

High resolution forecast (HRES) :

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

Ensemble forecast (ENS):

- twice per day, 51 members, **9 km** 137 levels, to 15 days ahead
- **ENS Extended:** once a day 100 members, **36km**, 137 levels, to 46 days ahead

Ocean waves:

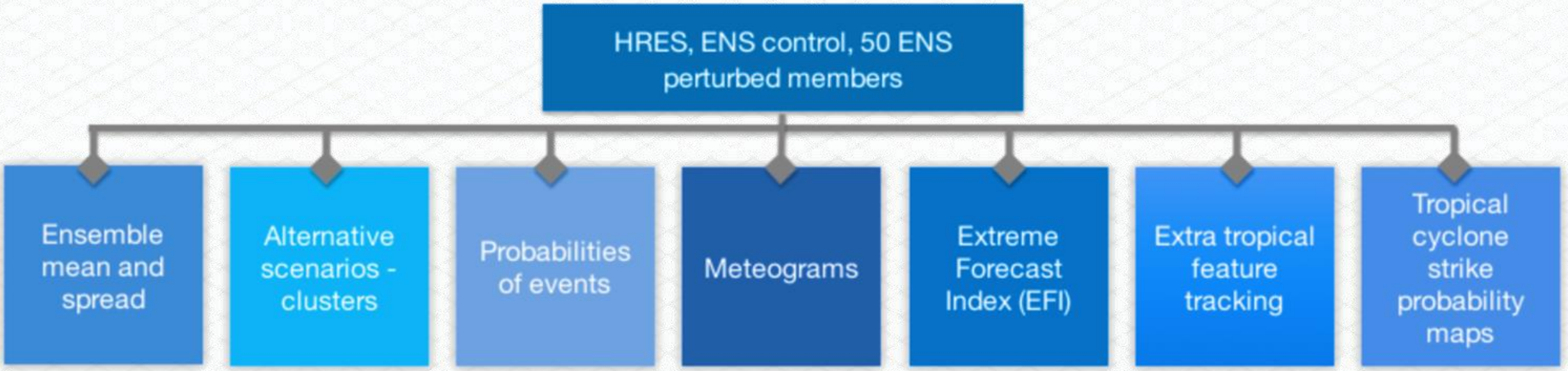
- **HRES-WAM**: 4 times a day, 10 days ahead at **14 km** (coupled)
- **ENS-WAM:** twice a day, 15 days ahead at **28 km** (coupled)

Long range:

- **SEAS5**: Once a month, 51-members, **36 km**, 91 levels, to 7 months ahead

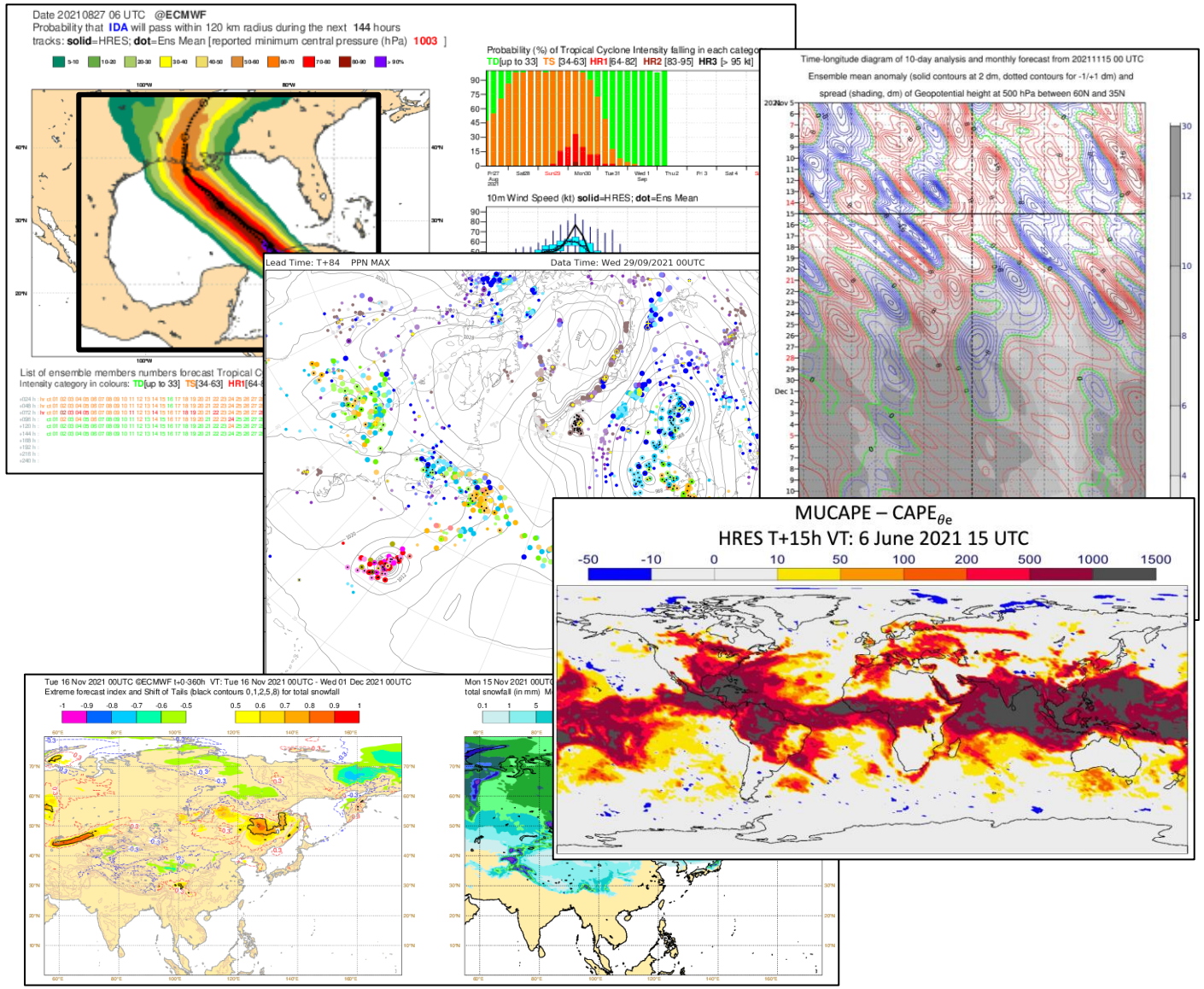
SEAS6 in 49r1

ECMWF forecast products



ECMWF Products

- We have 100s of products!!!
- Specialise in Medium Range
- Large number of short-range forecast products
- Don't specialise in aviation forecasting or nowcasting however we do our best to help the whole community. In cycle 47r3 a new model output field for clear air turbulence and in 48r1 visibility meteograms were added



Other interesting ECMWF stuff

Information on ECMWF Forecasts and data

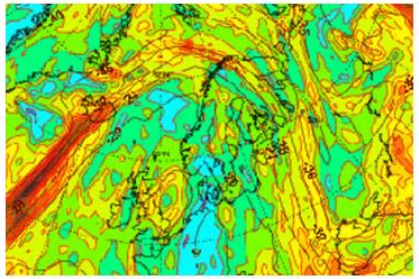
https://www.ecmwf.int/en/forecasts

ECMWF

Search site... Help Becky Hemingway

Home About Forecasts Computing Research Learning Publications

Charts | Datasets | Quality of our forecasts | About our forecasts | Access to forecasts



Charts

Our Integrated Forecasting System (IFS) provides forecasts and associated verification at different resolutions and for multiple time ranges. The verification provides essential feedback on the quality of the forecasting system.

- Medium range
- Extended range
- Long range

Quick access:

Datasets

Real-time and archive forecasts, analyses, climate re-analyses, reforecasts and multi-model datasets.

- Real-time datasets
- Archive datasets
- Open data

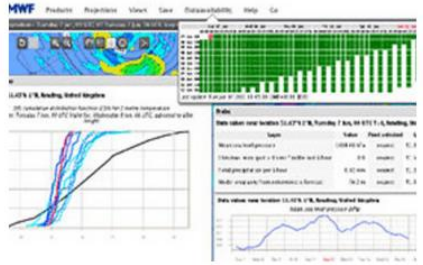
Quick access:

Public Datasets ›

Monitoring of the observing system

We continually monitor the quality and availability of the different components of the global observing system used at ECMWF.

- Availability
- Satellite data monitoring
- Conventional data monitoring
- Ocean observation monitoring



The Integrated Forecasting System

Key characteristics of the Integrated Forecasting System (IFS), documentation on specific areas, and description of our forecasts.

- Medium range overview
- Extended range overview
- Long range overview
- Changes in the IFS

Forecast User Guide

https://confluence.ecmwf.int/display/FUG

ECMWF Spaces Calendars Create Search

Forecast User Guide

SPACE SHORTCUTS

Forecast User Portal

PAGE TREE

- 1 Introduction
- 2 The ECMWF Integrated Forecasting Syste
- 3 Availability and Interpolation of NWP outp
- 4 NWP Evolution versus Reality
- 5 Forecast Ensemble (ENS) - Rationale and
- 6 Using Deterministic and Probabilistic Fore
- 7 ENS Products - Dealing with Uncertainty
- 8 ENS Products - What they are and how to
- 9 Physical Considerations when Interpreting
- 10 Interfaces for displaying Model Output
- 11 Conclusion
- 12 Appendices

Space tools

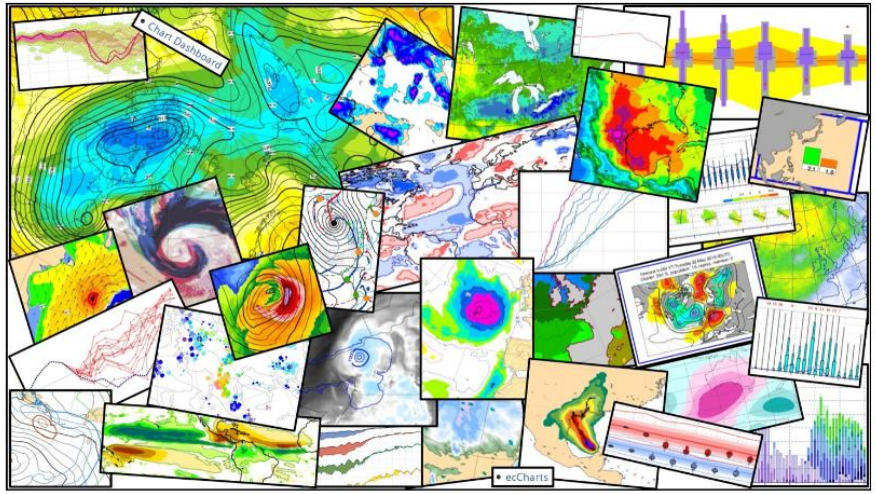
Pages

Save for later Watch Share

Forecast User Guide

Search this user guide for ...

"Behind good forecast practices are often hidden good theories; equally, good theories should provide a basis for good forecast practices." Professor Tor Bergeron, personal communication, 1974



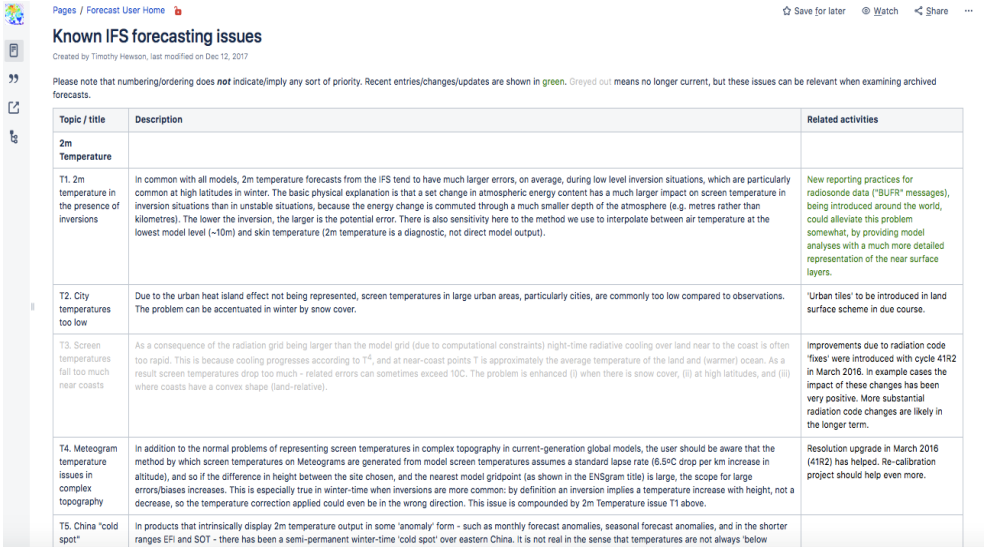
The aim of this User Guide is to help meteorologists make the best use of the forecast products from ECMWF - to increase understanding of the ensemble forecast process, to develop new products, to reach new sectors of society, to satisfy new demands. The User Guide presents the Integrated Forecasting System (IFS) and advises on how best to use the output, not least on how to build up trust in the forecast information. A good forecast that is not trusted is a worthless forecast. The emphasis is on the medium-range forecast products, as this is ECMWF's primary goal, and because medium-range NWP output generally differs significantly from that dealing with short-range or seasonal NWP. Extended range forecast (days 16 to 42) output concentrates on the probabilities of anomalies from the norm during a 5-7day forecast period at a location and the time of year. Seasonal forecasts give an indication of likely conditions beyond 6 weeks ahead. These are run monthly giving forecasts to 7 months ahead, and run quarterly with forecasts extended to 12 months ahead. Output concentrates on the anomalies relative to the seasonal climate.

New products increasingly aid early warning of severe or hazardous weather.

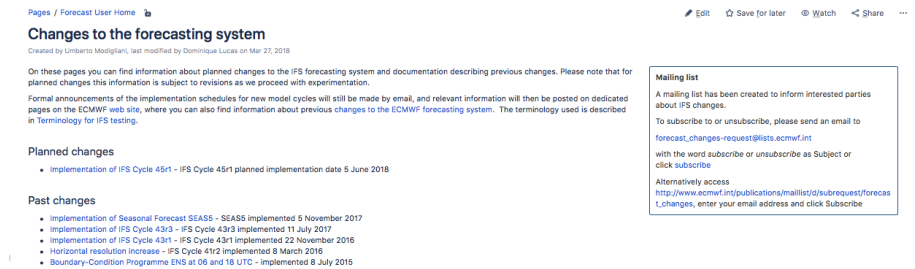
This guide is intended to give an outline of structure and use of the ECMWF IFS and how the high-resolution forecast (HRES), ensemble forecast (ENS), extended range forecast and seasonal forecast models inter-depend and interact. Links

Severe Event Catalogue

Forecasting Issues



Changes to forecasting system



Forecast User Home:
https://software.ecmwf.int/wiki/display/FCST/Forecast+User+Home

Twitter handle: #newfcsystem @ECMWF

Training and Learning

Learning.ecmwf.int

New, Moodle based, Learning Management System (LMS)

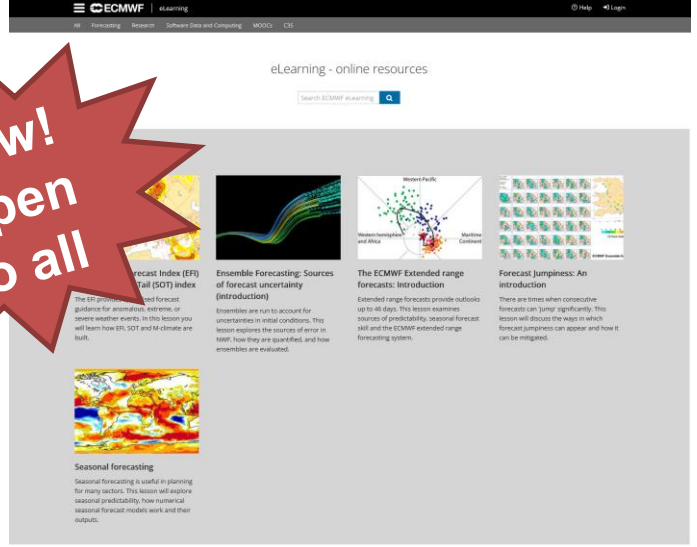
Organised by user/interest:

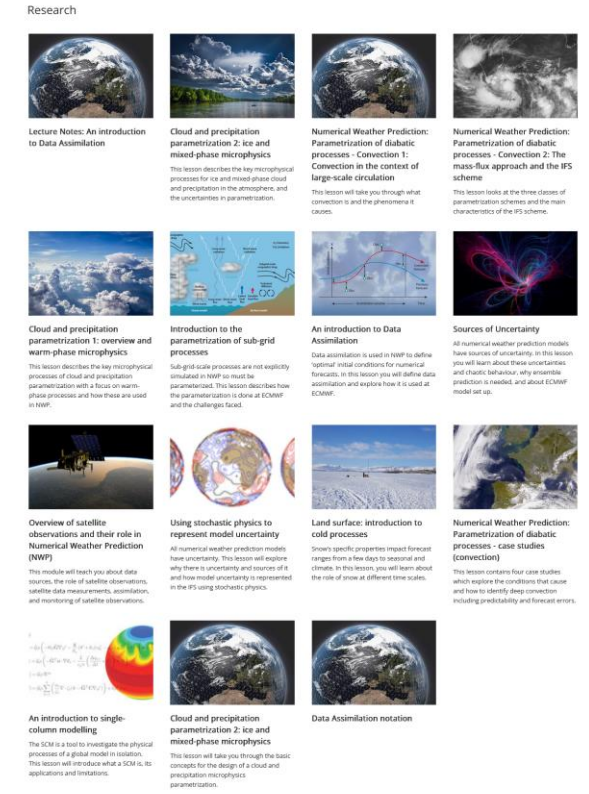
- Forecasting
- Research
- Data, Software and Computing
- Copernicus Climate Change

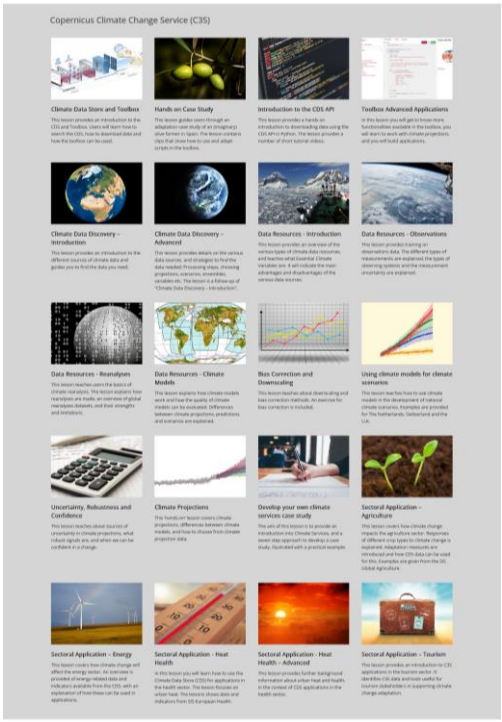
The lessons take participants through a certain topic in an interactive way including quiz questions to test learning

Take on average 20-30 minutes

New! Open to all







ECMWF

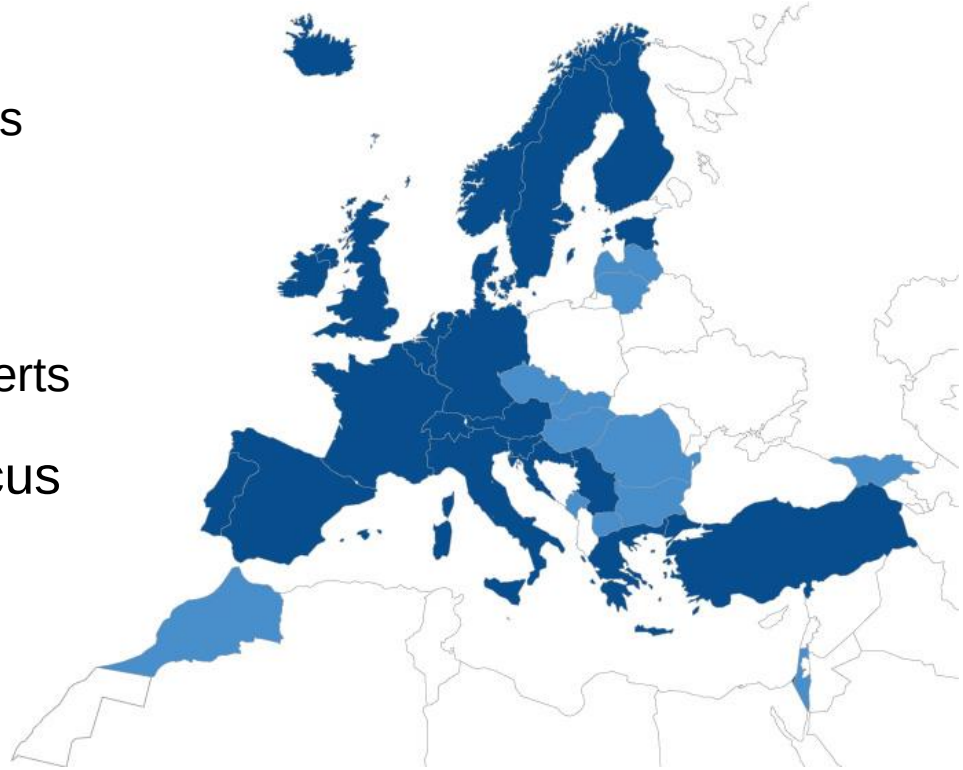
MS/CS short-term secondments to ECMWF

- From Member State and Co-operating State hydro-meteorological institutes
- The secondee needs to propose a project
  - It needs to be of mutual interest to the secondee's current organisation and ECMWF and in line with ECMWF's strategy
  - Projects can cover all areas of work, typically science, forecast delivery, computing, environmental applications, administration and communication
- Any secondment proposal must be agreed with line management
- ECMWF can offer partial funding to support the secondments
- Can be any period from several weeks to a year, either as a continuous stay or a sequence of shorter stays
- Can be at any level, from trainee to experienced staff

https://www.ecmwf.int/en/about/jobs/application-member-state-short-term-secondment-ecmwf

Member / Co-operating State visits programme

- Visits aim to:
  - Learn how you use ECMWF products and services
  - Gather feedback and issues
  - Present and discuss ECMWF updates and plans
  - Discussions on specific topics of interest with experts
- Across forecasting, research, computing, Copernicus and Destination Earth
- Working / technical level
- Visits in Baltic+ area:
  - Estonia – 12th and 13th September 2023
  - Latvia – April 2024
  - Lithuania – April 2024



Useful Links

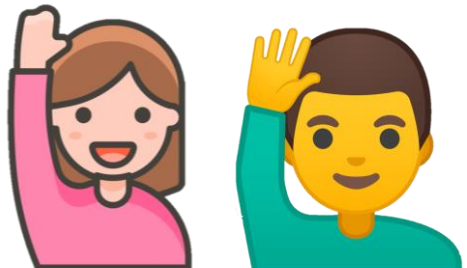
- Open Charts: https://charts.ecmwf.int/
- Forecast User Guide: https://confluence.ecmwf.int/display/FUG/Forecast+User+Guide
- Forecast User Forum: https://confluence.ecmwf.int/display/FUF/Forecast+User+Forum
- Severe Event Catalogue: https://confluence.ecmwf.int/display/FCST/Severe+Event+Catalogue
- Forecast System Changes: https://confluence.ecmwf.int/display/FCST/Changes+to+the+forecasting+system
- Forecasting Issues: https://confluence.ecmwf.int/display/FCST/Known+IFS+forecasting+issues
- Newsletters: https://www.ecmwf.int/en/publications/newsletters
- Learning Resources: www.learning.ecmwf.int
- MetView: https://metview.readthedocs.io/en/latest/
- Secondments: https://www.ecmwf.int/en/about/jobs/application-member-state-short-term-secondment-ecmwf
- Special Projects: https://www.ecmwf.int/en/research/special-projects/special-project-application

How to access ECMWF products and data:

OpenCharts / ecCharts

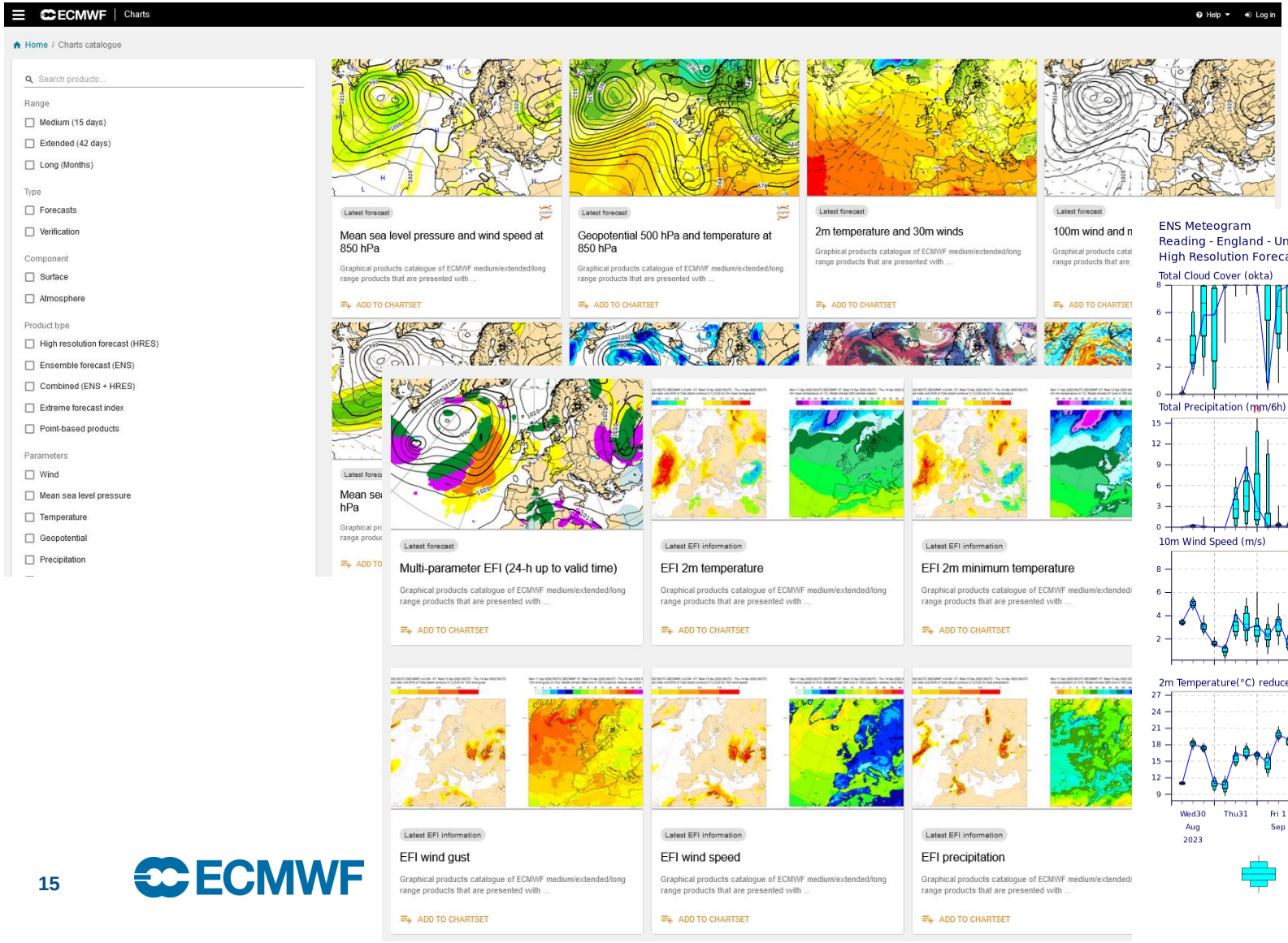
ECMWF's web chart applications

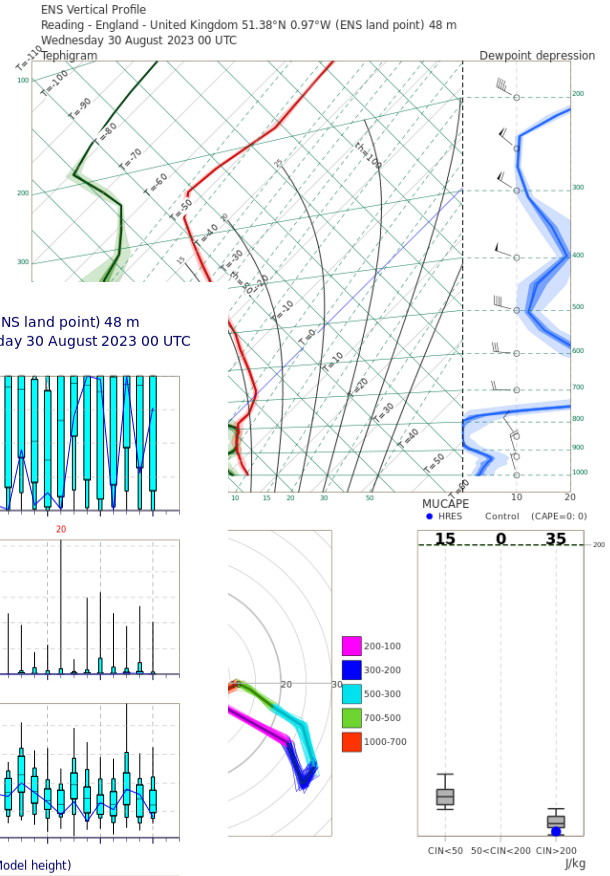
❓ Who has used these before?

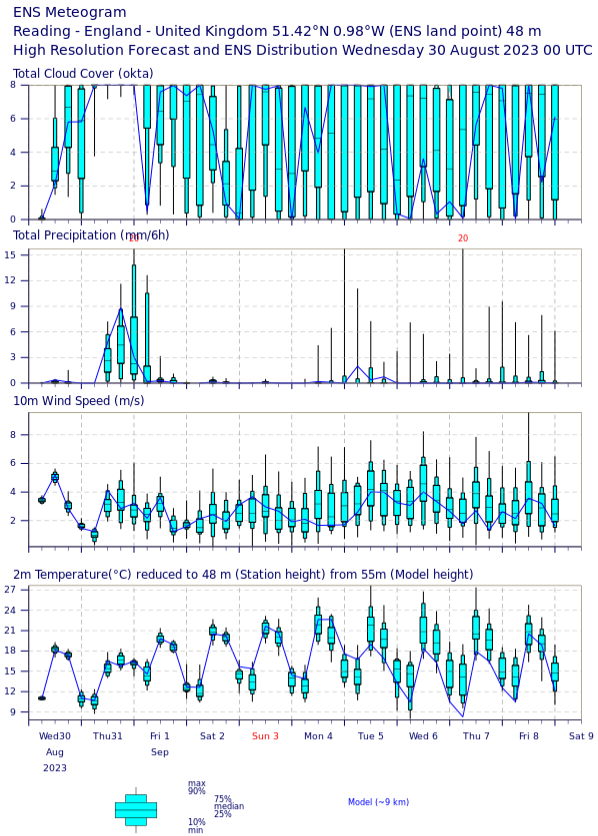


OpenCharts – free to access

https://charts.ecmwf.int/



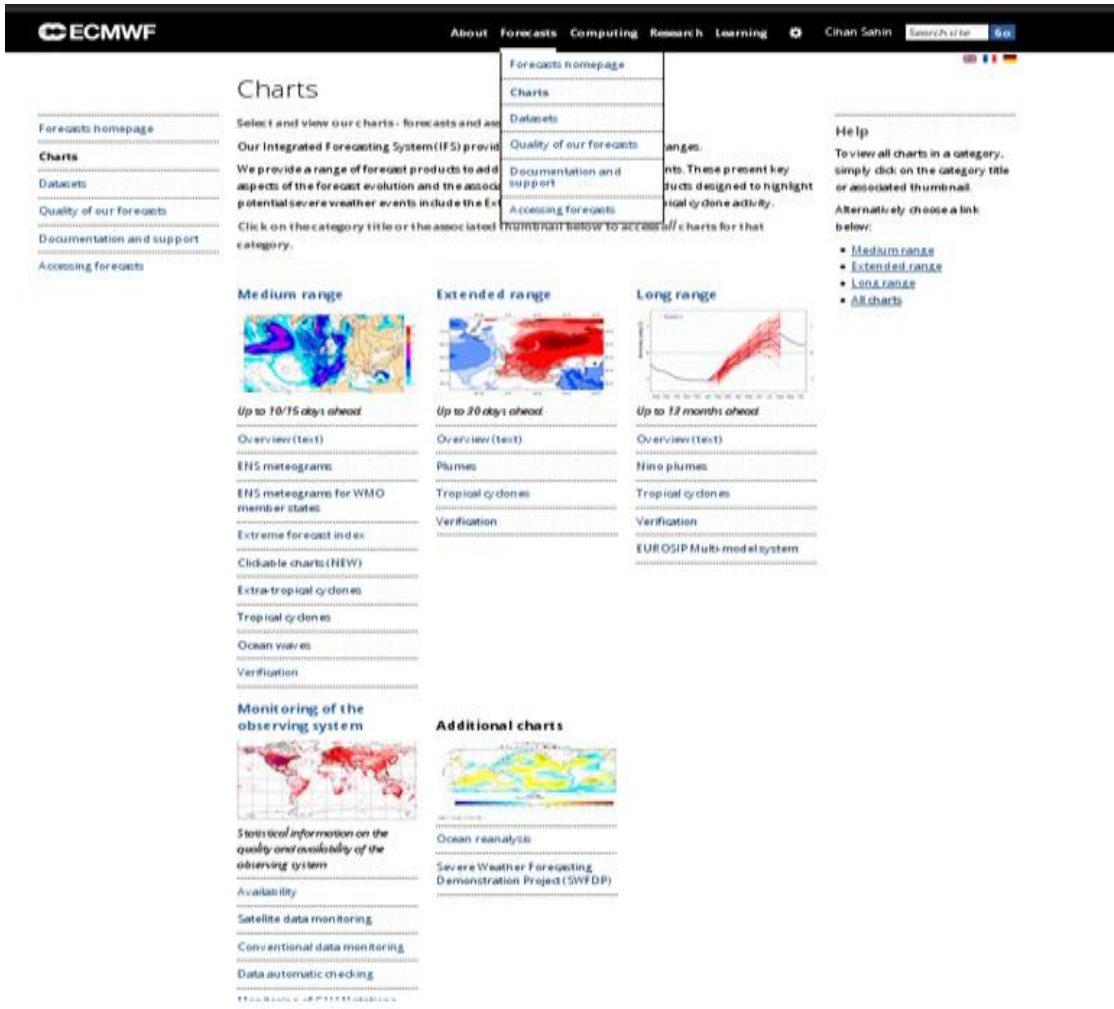




ECMWF

OpenCharts

- High resolution (HRES) forecast charts (Updated at 06:55,12:12,18:55, 00:12)
- Ensemble prediction system (ENS) charts up to 10 days (Updated at 7:20 and 19:20)
- Ensemble prediction system (ENS) charts 10-15 days (Updated at 7:40 and 19:40)
- Point-based time series from Ensemble, so called ENS meteograms / ENS vertical profiles
- Extended range charts (Updated at 20:00)
- Long range (seasonal) charts (once a month)
- Verification charts
- Others (Tropical cyclone tracks, Observation monitoring …)



https://confluence.ecmwf.int/display/DAC/Dissemination+schedule

Open Data at ECMWF

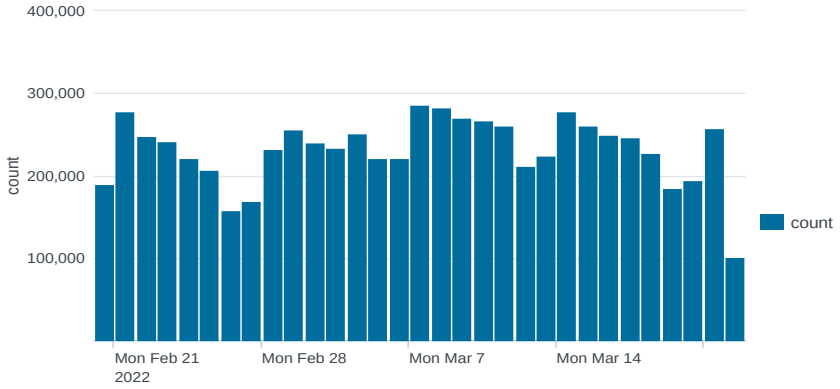
Free and open charts including meteograms (OpenCharts)
https://apps.ecmwf.int/webapps/opencharts

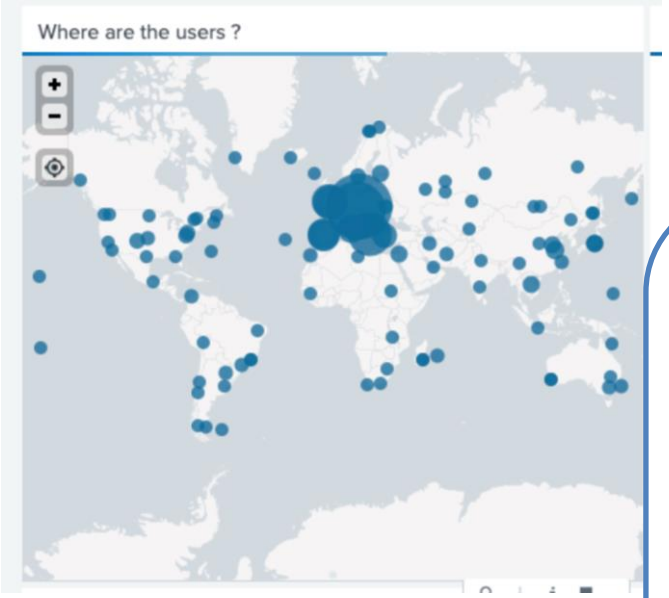
Free and open data available on public https service and in Microsoft Azure and Amazon AWS

Contents of the ECMWF archive catalogue provided with an open licence (CC-BY-4)

Reduced fees for some licence types

Open Charts products served daily



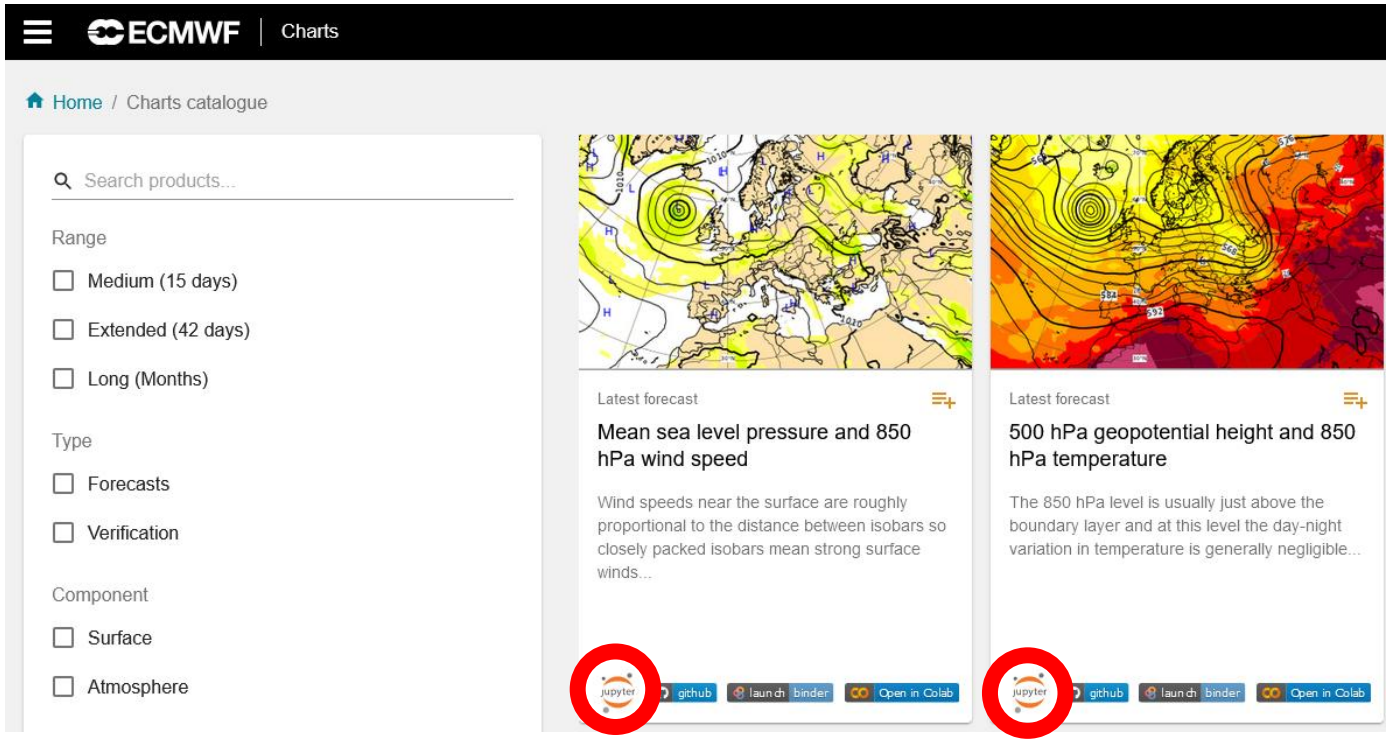


Access here:
https://data.ecmwf.int/forecasts

Supporting Documentation:
https://confluence.ecmwf.int/display/UDOC/ECMWF+Open+Data+-+Real+Time

Open Data – ECMWF data free to access

- From 25 January 2022 a wide range of ECMWF forecast data was made available to anyone
- Prepared Jupyter notebooks to help access and visualise the data – OpenCharts shows which data can be accessed this way



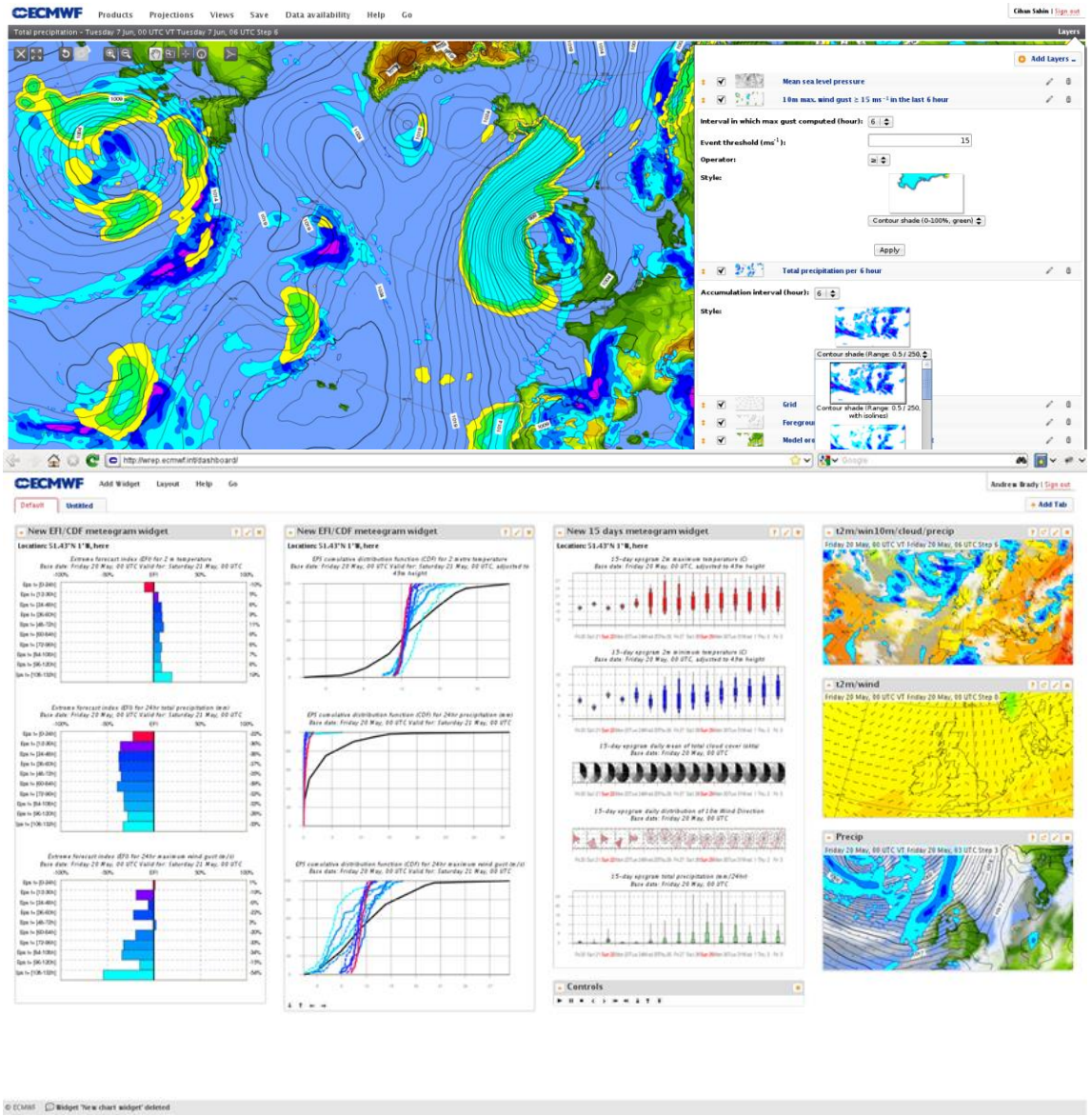
Access here:
https://data.ecmwf.int/forecasts
Supporting Documentation:
https://confluence.ecmwf.int/display/UDOC/ECMWF+Open+Data+-+Real+Time

ecCharts

Web based interactive application to inspect and visualize ECMWF medium-range and extended-range data

- Rich and dynamically growing content
- Web based immediate access to charts
- Native data resolution
- Interactive features (zoom, pan, click, extract data information, …)
- User controlled visualization
- Customisable parameters
- Download charts (through WMS)
- Build your own products
- Restricted access – every WMO country will have access in 2024

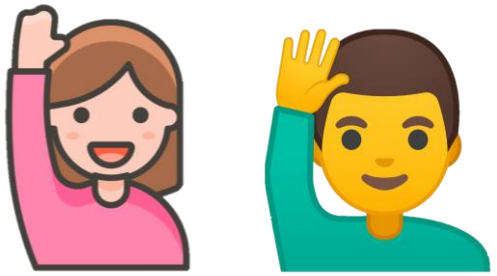
https://eccharts.ecmwf.int



ECMWF

Ensembles and Ensemble (ENS) Products

How do you currently use ensemble products?

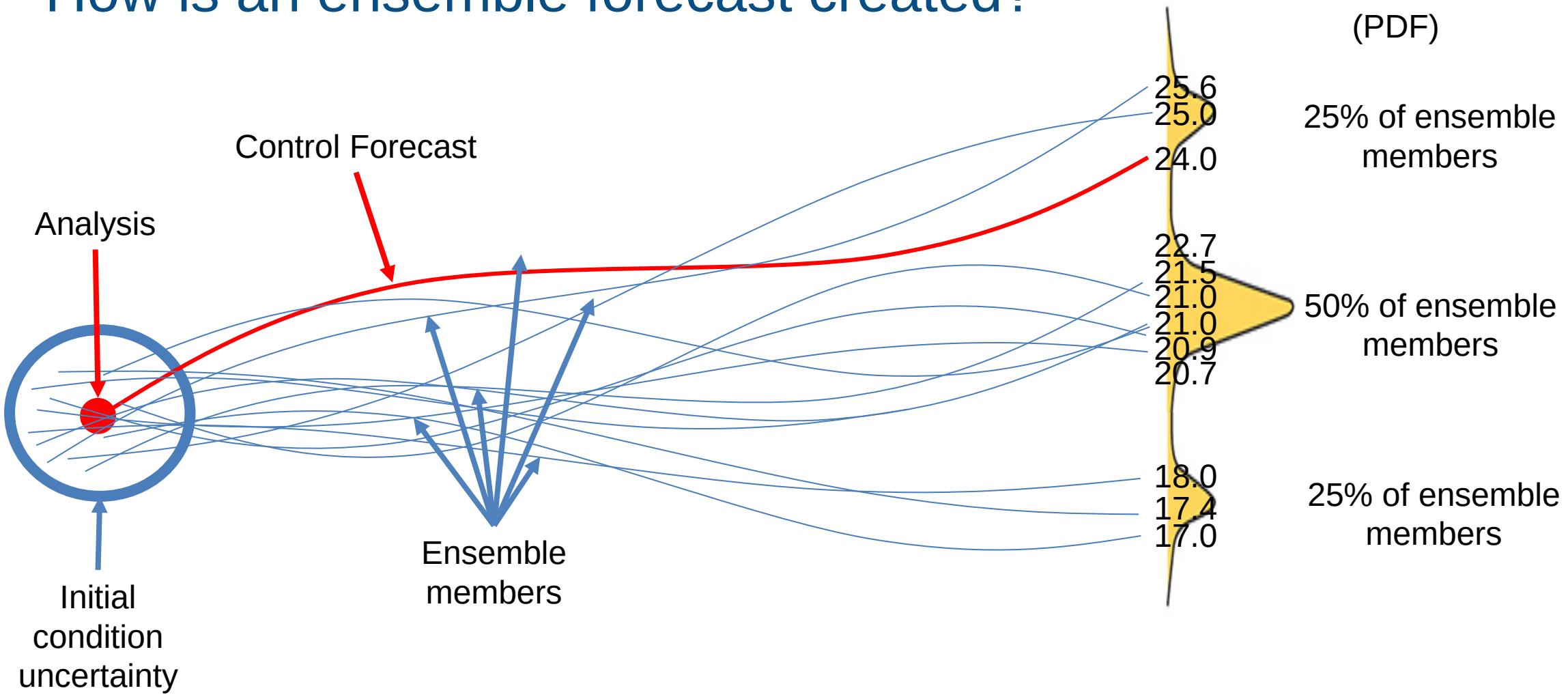


A. All the time – only use ensemble products
B. A lot – but also use some deterministic products
C. Sometimes – but mainly use deterministic products
D. Never – only use deterministic products

What is an ensemble?

- An ensemble is a **set of forecasts** run from **different initial conditions** to account for initial uncertainties
- The NWP model is not perfect so we should also **take account of model error**
- By running the forecast many times from slightly different starting conditions we have a **better understanding** of how the atmosphere can evolve
- Ensemble forecasts provide a **range of future scenarios** consistent with our knowledge of the initial state and model capability

How is an ensemble forecast created?



Important to have the 'right spread' to the ensemble

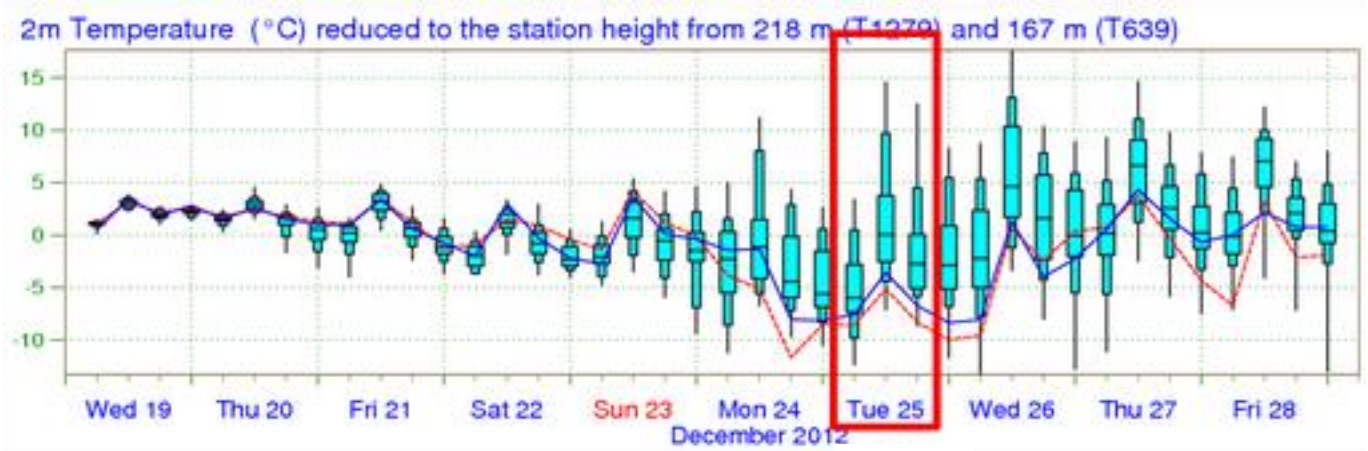
ECMWF

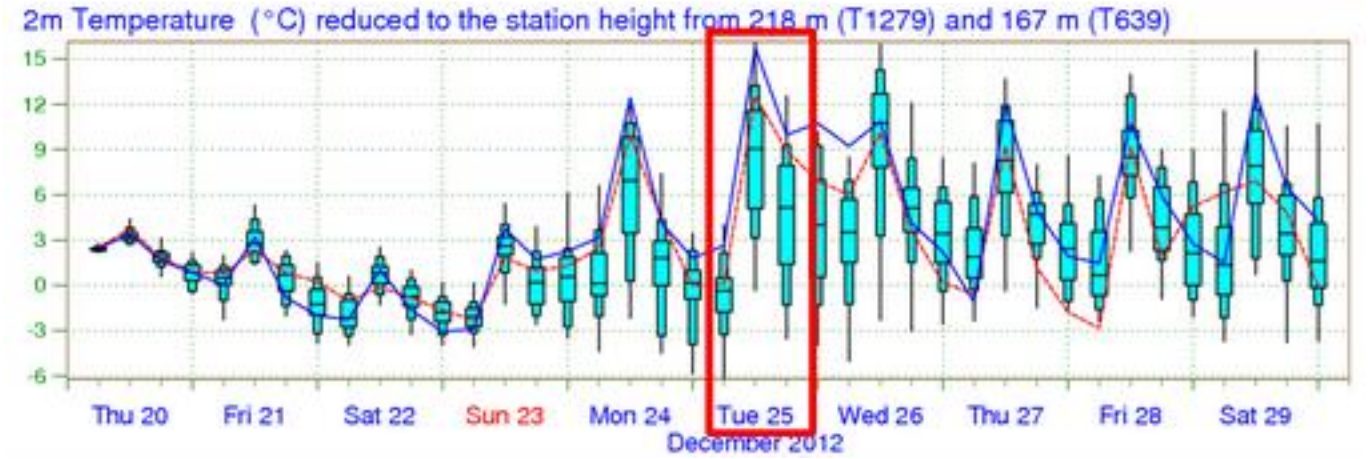
Forecast jumpiness

- There are times when the consecutive forecasts, for a given date, can change or ‘jump’
- Some jumpiness is expected, else there would be something wrong with the forecasting system
- Jumpiness is not a good indicator of likely error, but spread is
- Dynamic sensitives – e.g. related to strong jets – can increase jumpy behaviour at short ranges in severe weather situations
- Using other models to build a more comprehensive picture of the forecast situation may sometimes help to decide whether or not to follow a jump

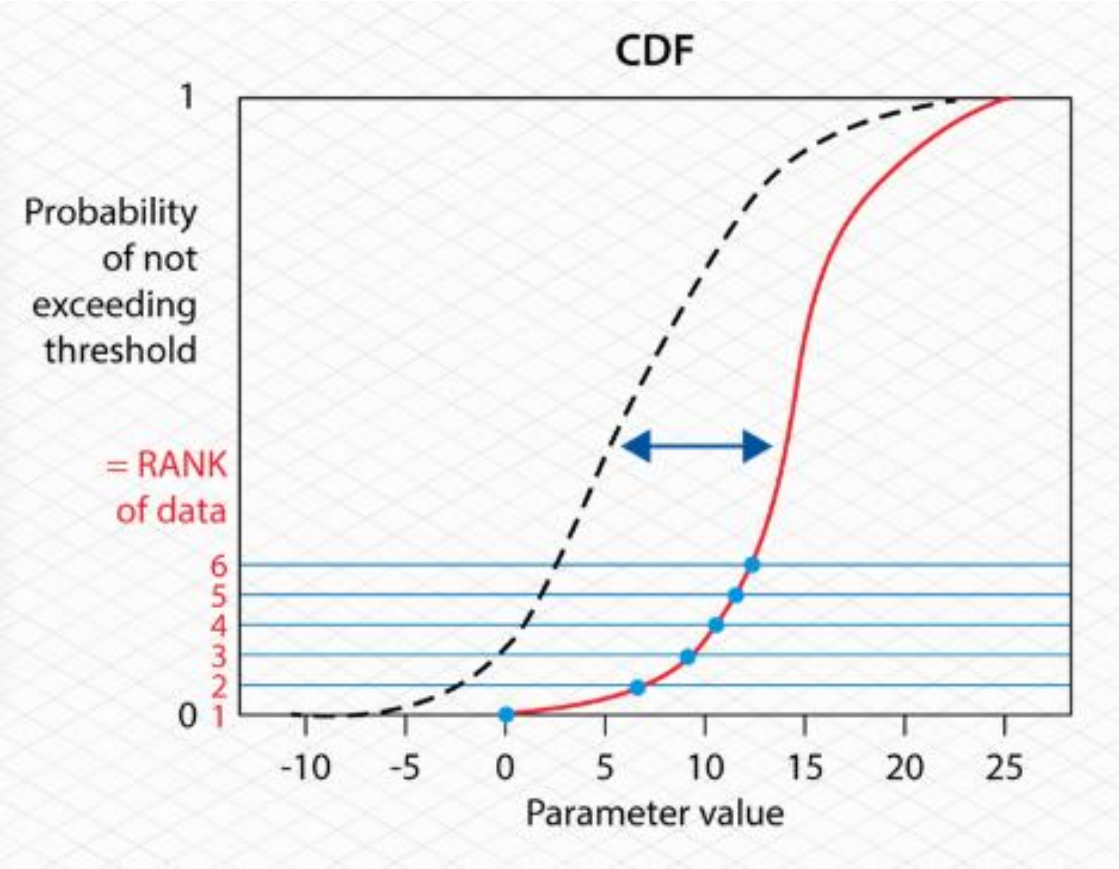
Forecast jumpiness in meteograms

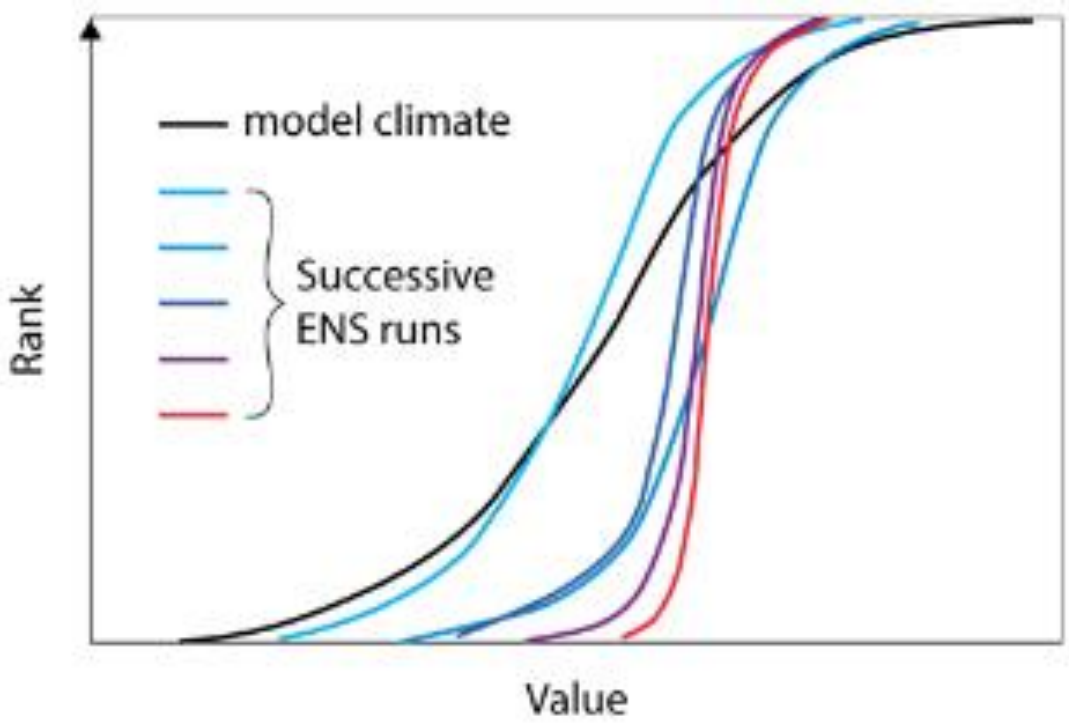
- Sometimes the more extreme of the possible outcomes will become much more likely as the event approaches – part of the function of the ENS is to show possible scenarios
- Control forecast more likely to jump than the ensemble mean
- If there is a large jump and the ENS spread is large, be cautious following the jump
- If there is a large jump and ENS spread is small, you can be more confident in following the new forecast





Cumulative Distribution Functions (CDFs) – A good way to see jumpiness

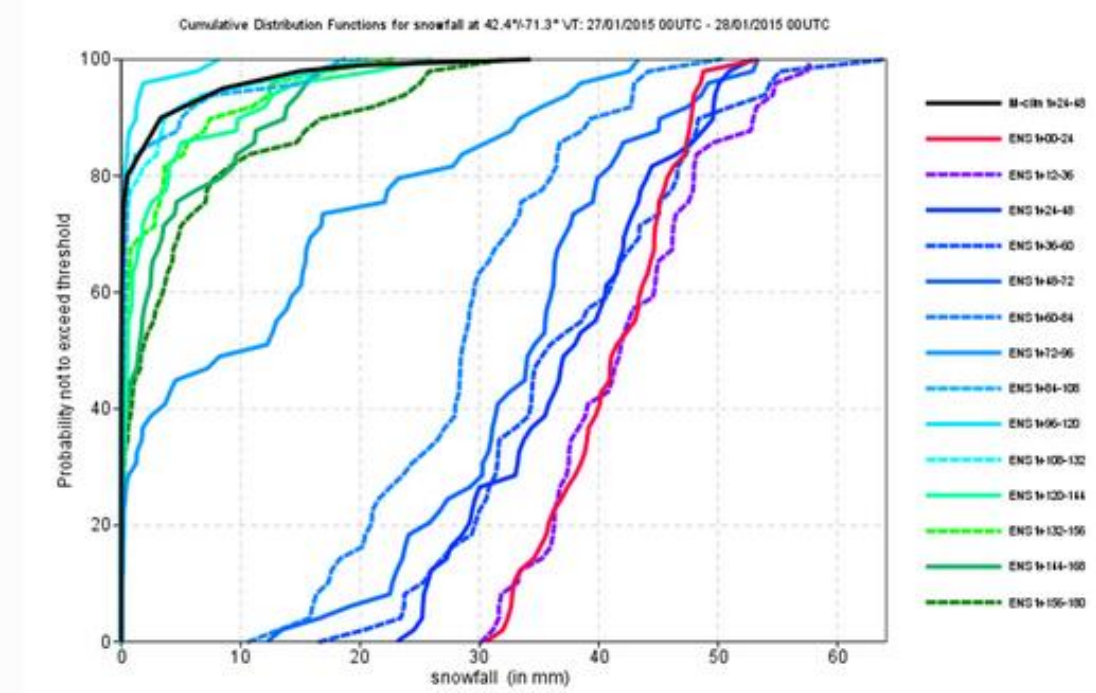




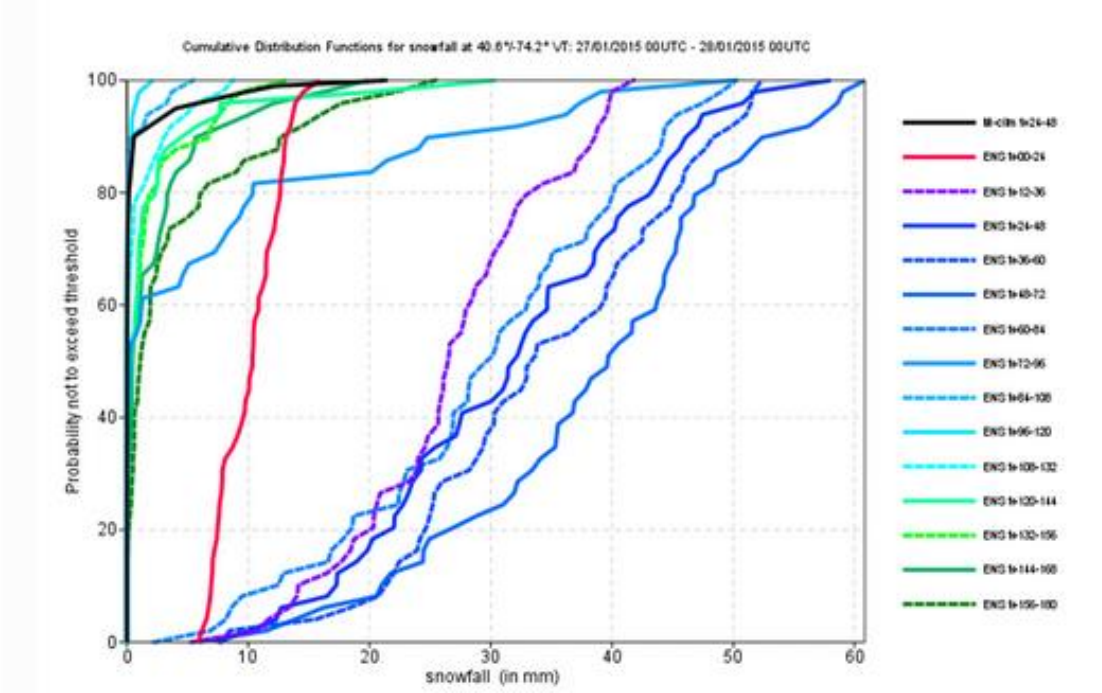
The more vertical the CDF the more the ensembles members agree

Cumulative Distribution Functions (CDFs) – A good way to see jumpiness – snow example

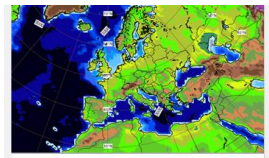
- Recent forecasts are similarly steep and quite similar indicating consistency in the forecast
- Quite vertical lines slows little spread and therefore low uncertainty

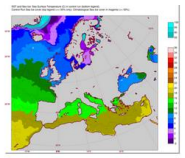


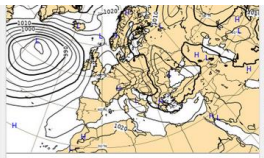
- Most recent forecast (red line) is near vertical suggesting small spread
- Previous forecasts consistent but less steep suggesting large spread
- Look at other models

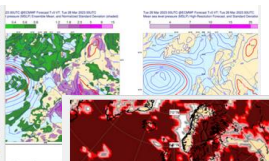


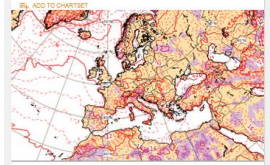
Ensemble forecast (ENS) products

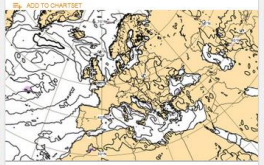

Orography and sea depth

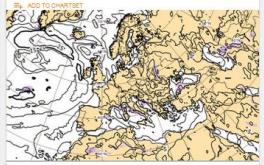

Sea surface temperature

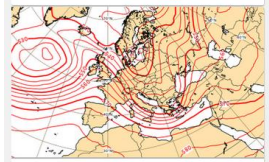

Ensemble mean and spread for mean sea level pressure

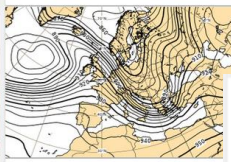


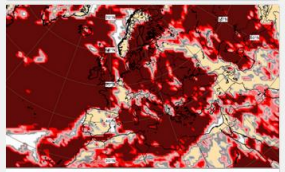

Ensemble mean and spread: 2 m temperature

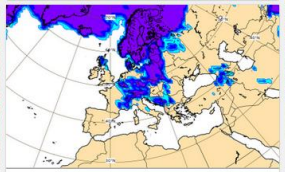

Ensemble mean and spread: 10 m wind speed

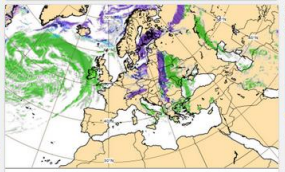

Ensemble mean and spread: 100 m wind speed

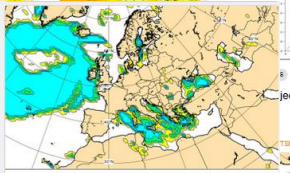

Ensemble mean and spread: 500 hPa geopotential height

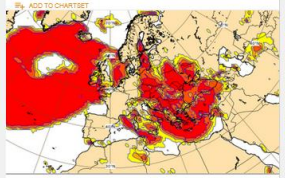

Ensemble mean and spread: 300 hPa geopotential

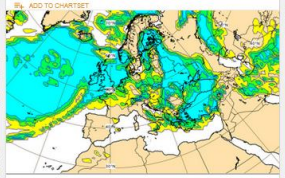

Probabilities: 100 m wind speed

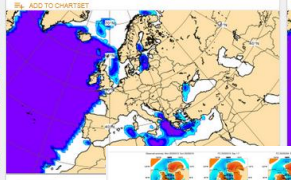

Probabilities: 2 m temperature below 0°C

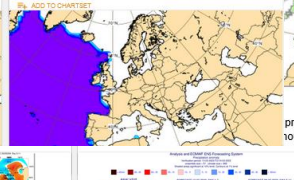

Probabilities: most probable precipitation type

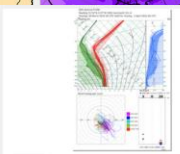

Probabilities: 10 m wind speed

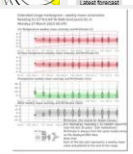


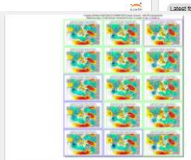




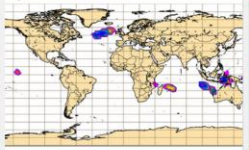


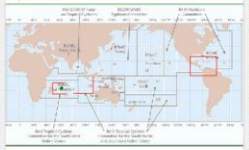

Vertical profiles

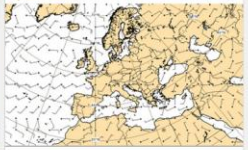

ENS extended meteograms

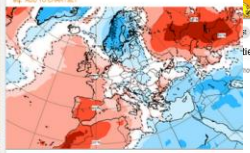

Cluster scenario

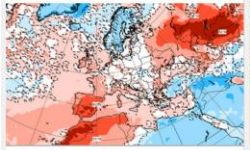

Postage stamp charts

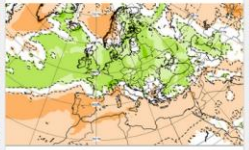

Tropical cyclone activity (Including genesis)

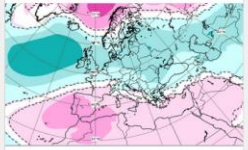

Tropical cyclone

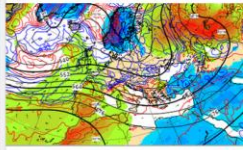

Winds at various levels: Weekly mean anomalies

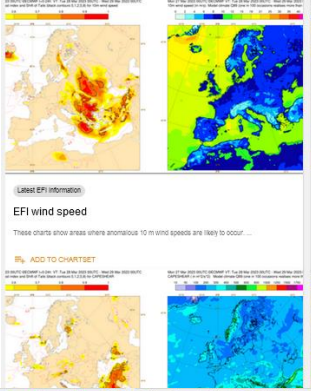

2 m temperature: Weekly mean anomalies

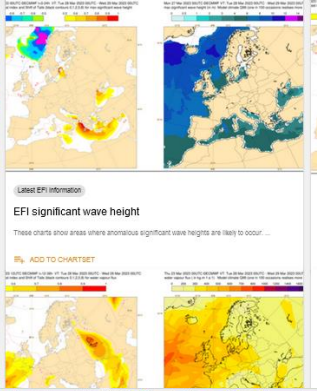

Surface temperature: Weekly mean anomalies

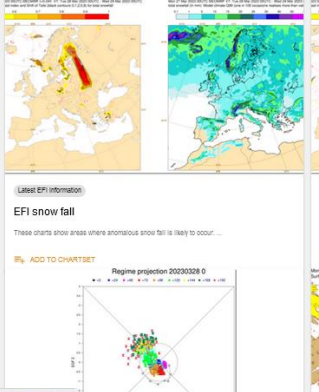

Precipitation: Weekly mean anomalies

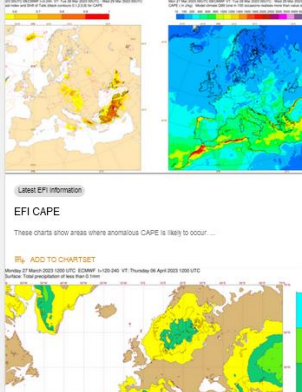

Mean sea level pressure: Weekly mean anomalies


Multiparam: Weekly mean anomalies

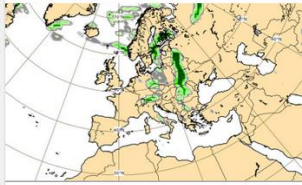

EFI wind speed

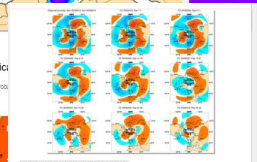

EFI significant wave height

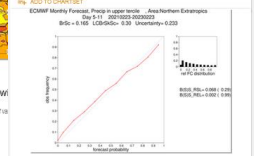

EFI snow fall

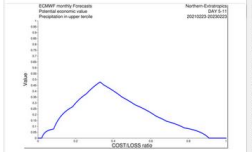

EFI CAPE

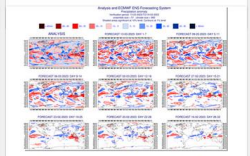
Probabilities: multi-day precipitation


Probabilities: snowfall during last 6 hours


Northern Hemisphere 500 hPa height anomaly


Reliability


Value


Global and regional 500 hPa height anomaly

Relative Operating Characteristics (ROC)

2 m Temperature Area Averages – Long Range Forecast – SEAS5

Daily Scores

Map of Relative Operating Characteristics (ROC) - ROCMAP

Monsoon Indices – Long Range Forecast – SEAS5

Weekly Scores

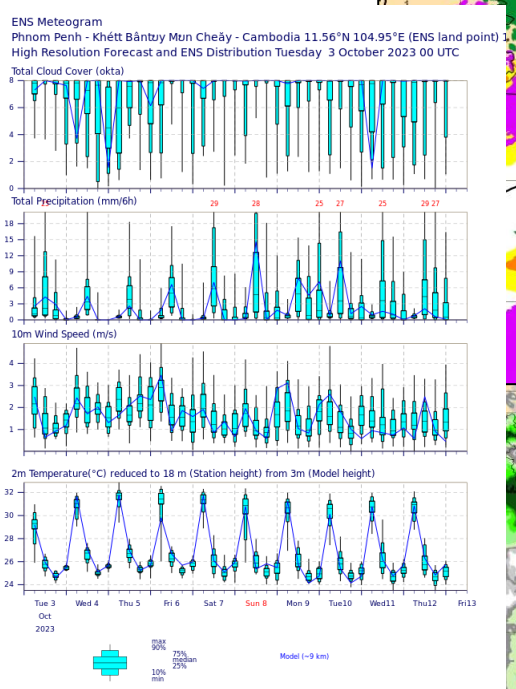
RPSSMAP - Map of Ranked Probability Skill Score.

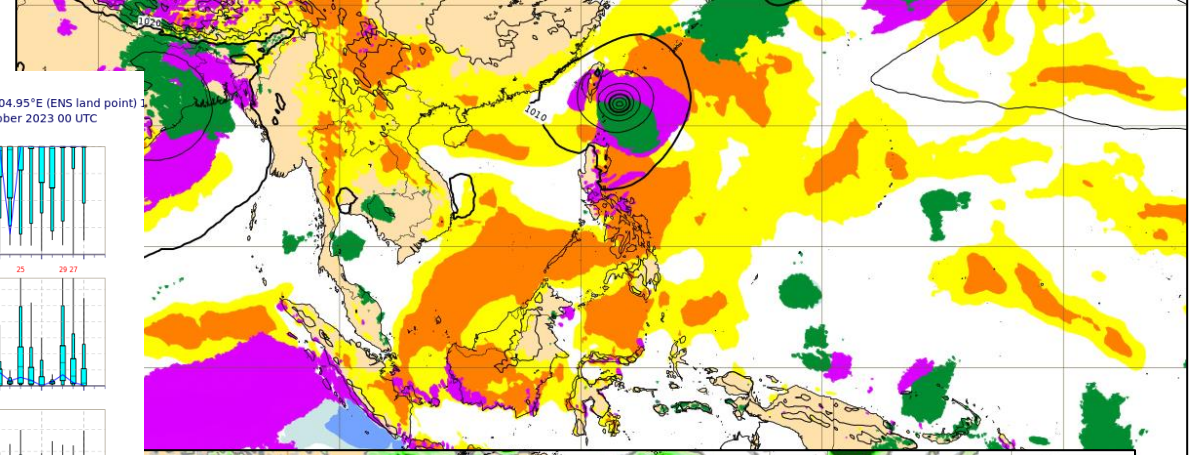
Precipitation Area Averages – Long Range Forecast – SEAS5

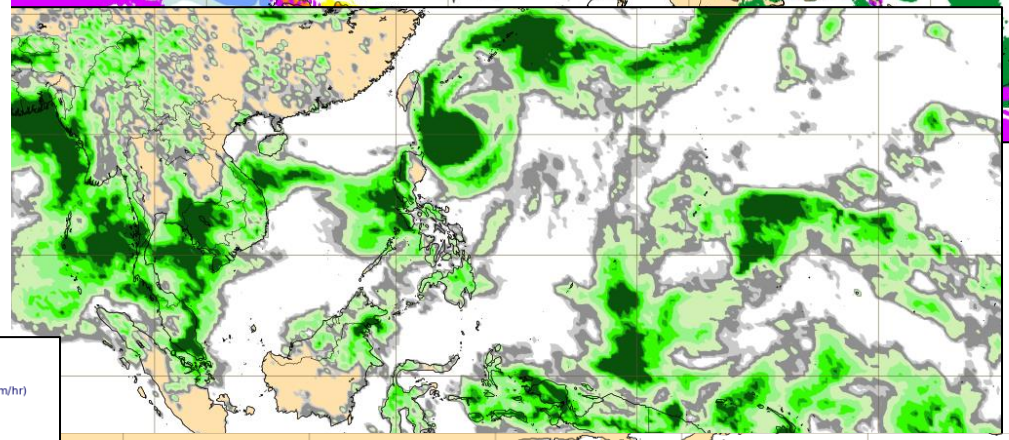
ECMWF

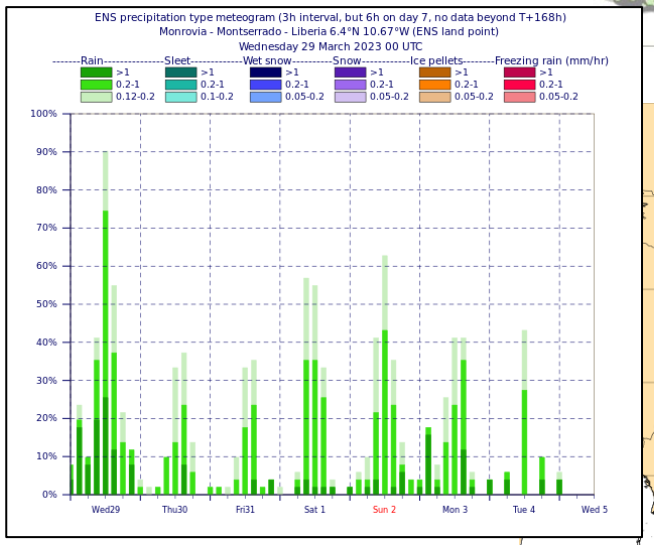
Ensemble products

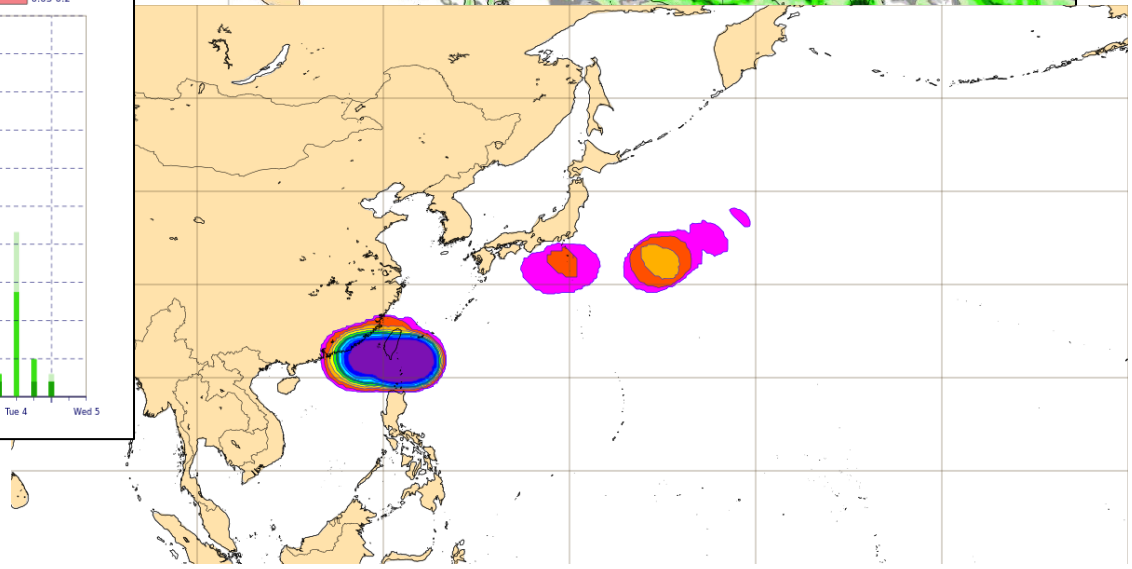
- Meteograms
- Ensemble (ENS) combined and weighted probabilities
- ENS mean and spread
- Extreme Forecast Index (EFI) and Shift of Tails (SOT)
- Cyclone strike probabilities
- Model-climate
- Spaghetti plots
- Post processed products
  - Precipitation Type
  - Point rainfall …











ECMWF

Ensemble forecast (ENS) products - OpenCharts

ECMWF | Charts

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Search products...

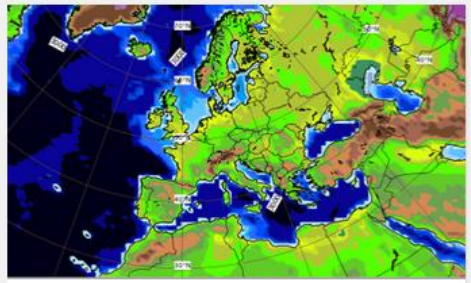
Range
- Medium (15 days)
- Extended (42 days)
- Long (Months)

Type
- Forecasts
- Verification

Component
- Surface
- Atmosphere

Product type
- High resolution forecast (HRES)
- Ensemble forecast (ENS)
- Combined (ENS + HRES)
- Extreme forecast index
- Point-based products

Parameters
- Wind

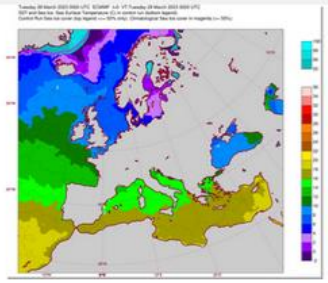


Latest forecast

Orography and sea depth

The height of topography above mean sea level and the depth of the sea for each model grid box ...

ADD TO CHARTSET

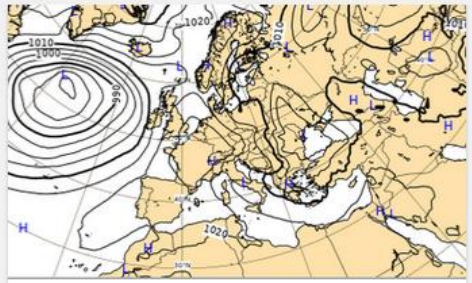


Sea surface temperature

Sea surface temperature

These charts show the model sea surface temperature (degC) and sea ice ...

ADD TO CHARTSET

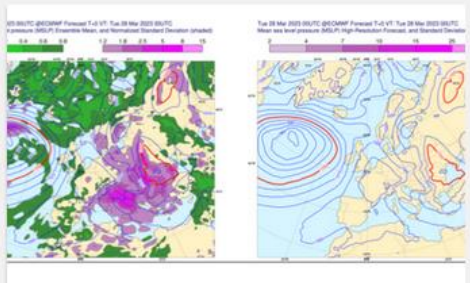


Latest forecast

Ensemble mean and spread for mean sea level pressure

These charts show the mean and variation in the latest ECMWF ensemble forecast ...

ADD TO CHARTSET

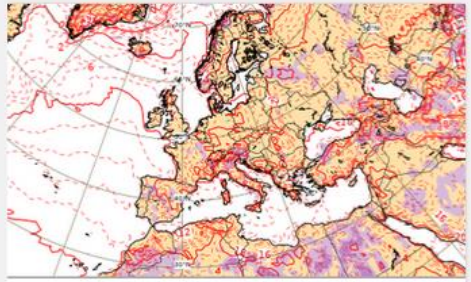


Ensemble mean and spread: four standard parameters

Ensemble mean and spread: four standard parameters

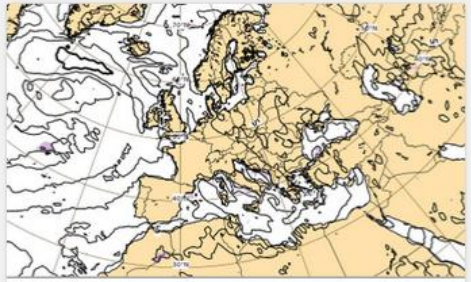
These charts show the mean and variation in the latest ECMWF ensemble forecast (ENS). ...

ADD TO CHARTSET



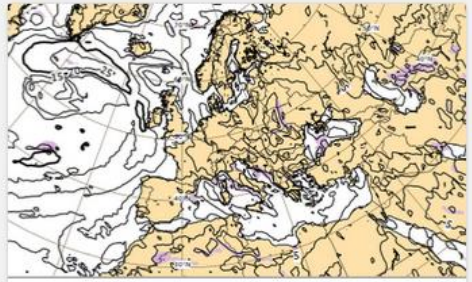
Latest forecast

Ensemble mean and spread: 2 m



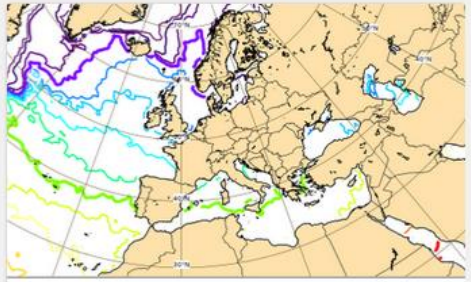
Latest forecast

Ensemble mean and spread: 10 m



Latest forecast

Ensemble mean and spread: 100 m



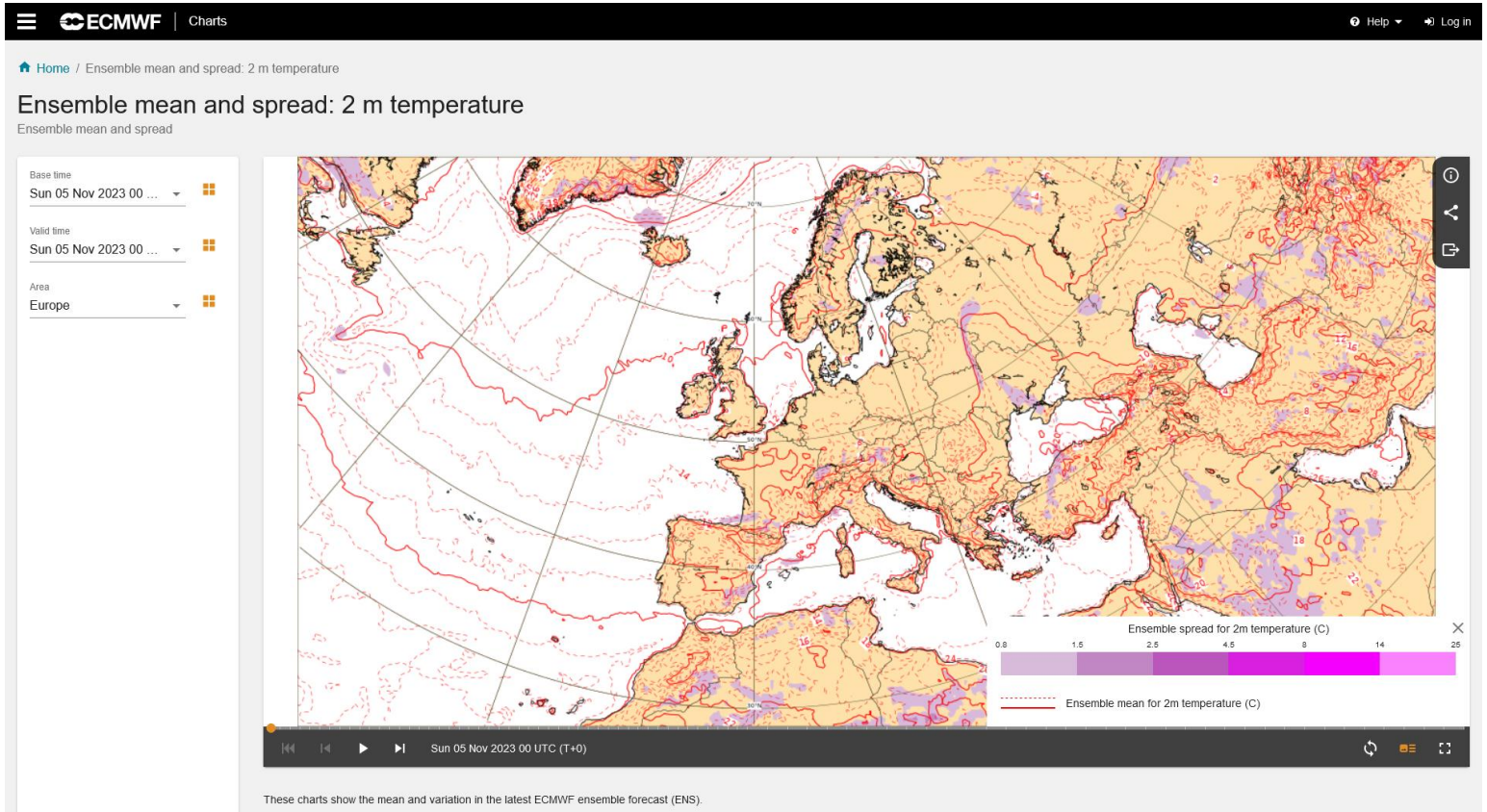
Latest forecast

Ensemble mean and spread: sea

Ensemble mean and spread

Many products use the **Ensemble Mean**

The **Ensemble Mean** is the mean (average) value derived from all the ensemble members (50 + control). This value attempts to capture the general picture while smoothing out extremes.



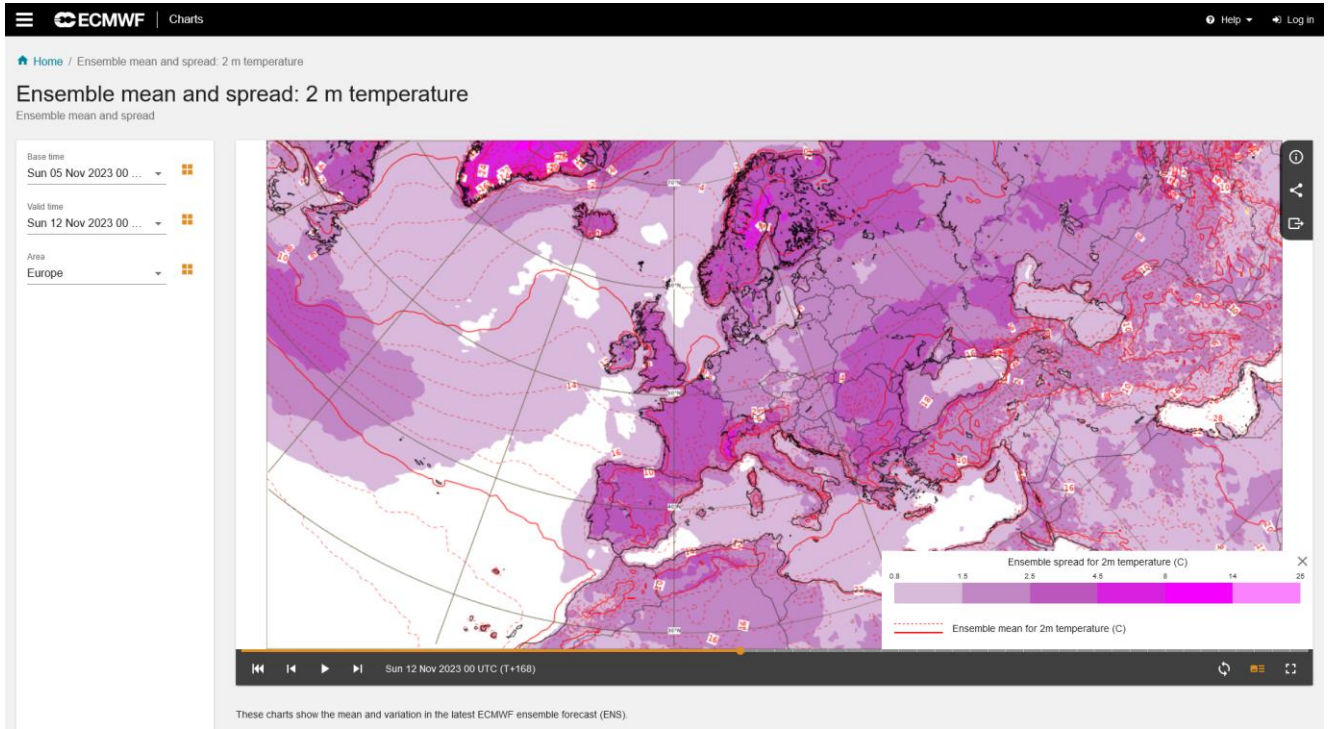
ECMWF

Ensemble mean and spread

Uncertainty is captured by '**Ensemble Spread**'. This gives an indication of how spread the ensembles members are in the probability distribution function (PDF)

Higher spread = higher uncertainty

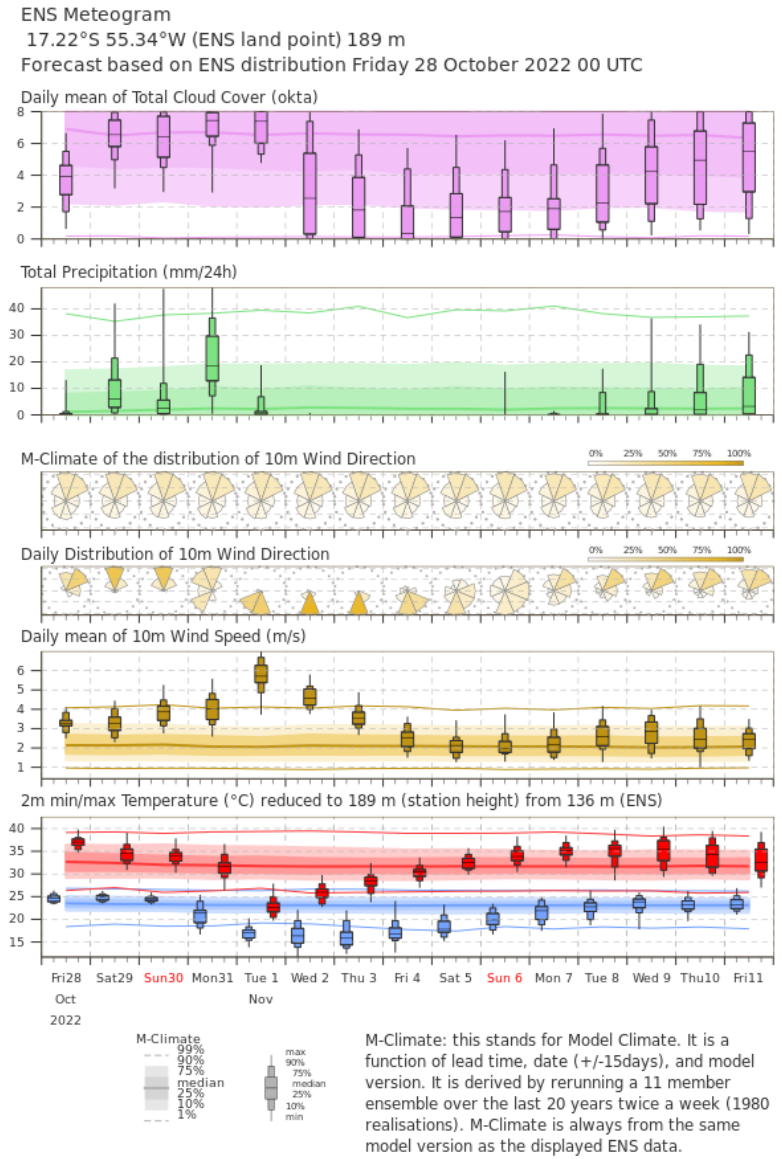
More uncertainty generally at longer lead times and in some areas e.g. extra tropics

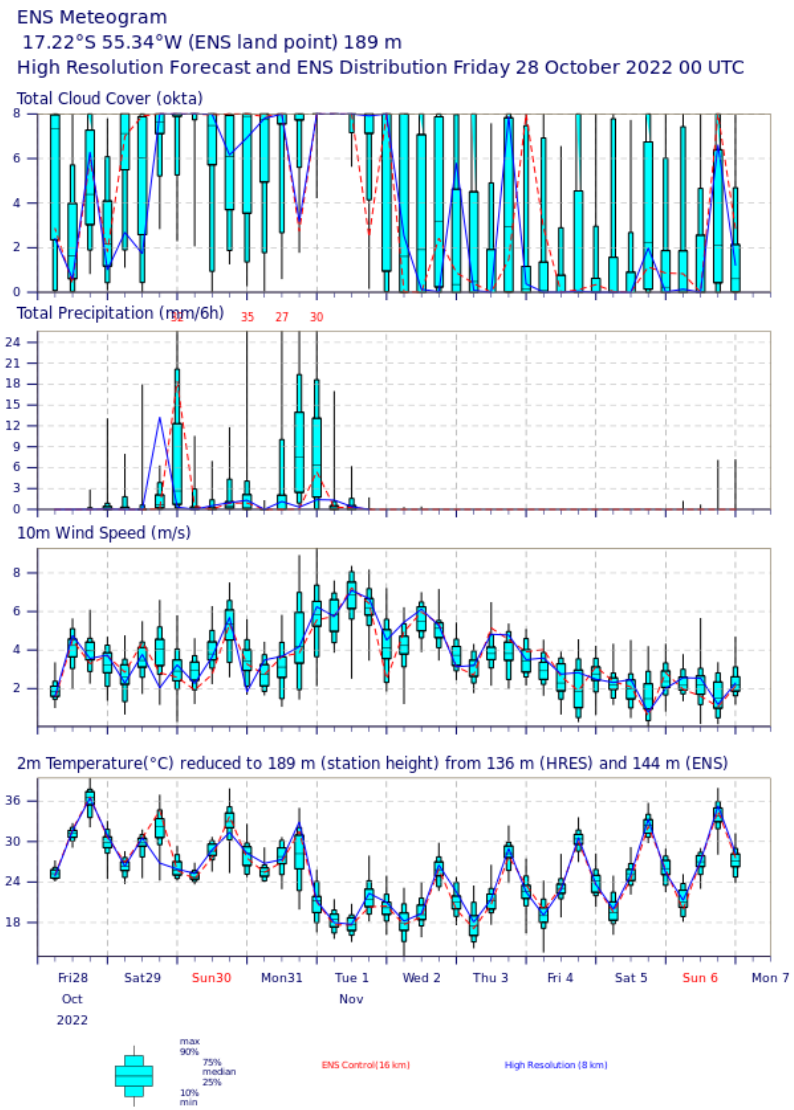


ECMWF

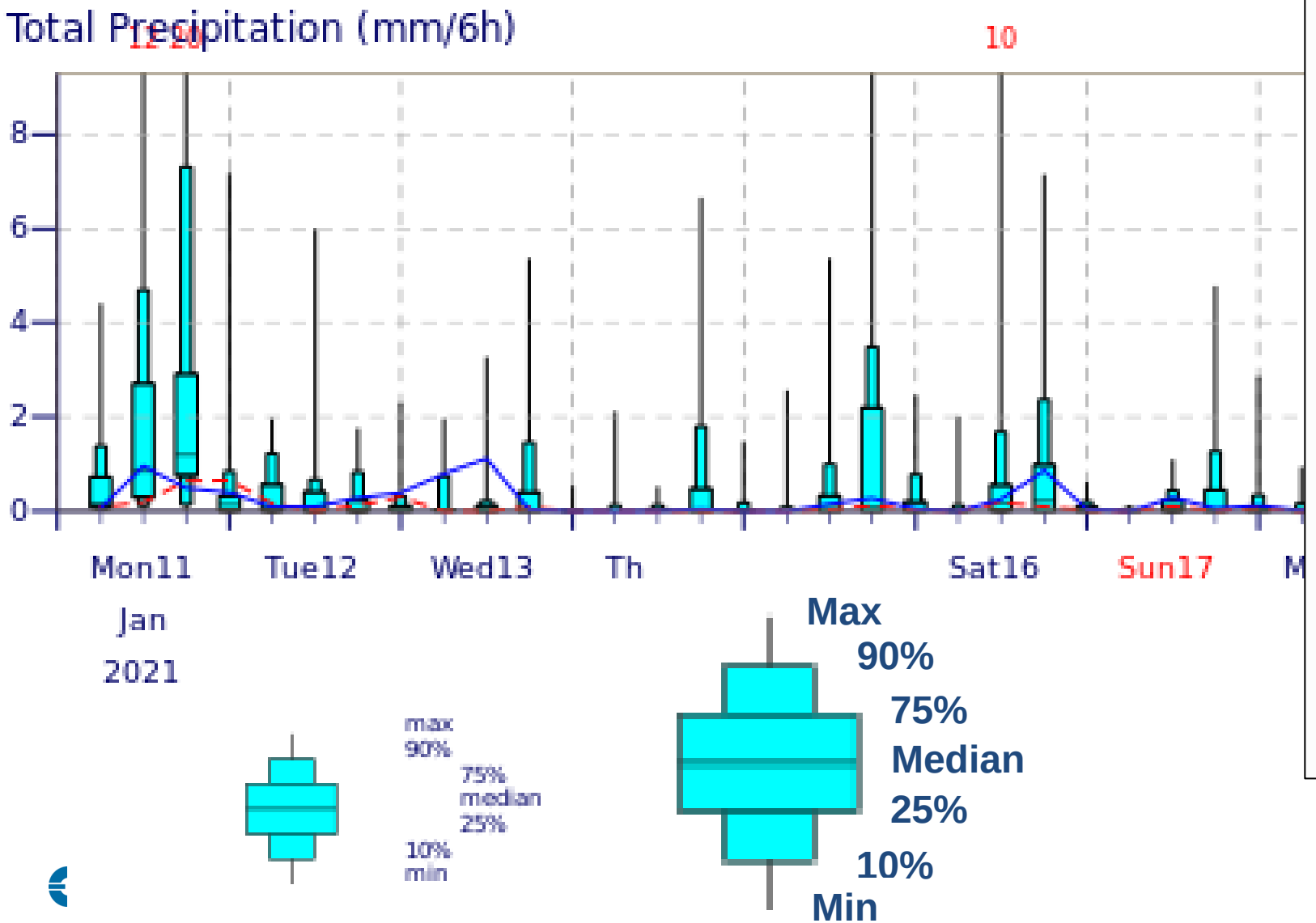
Meteograms

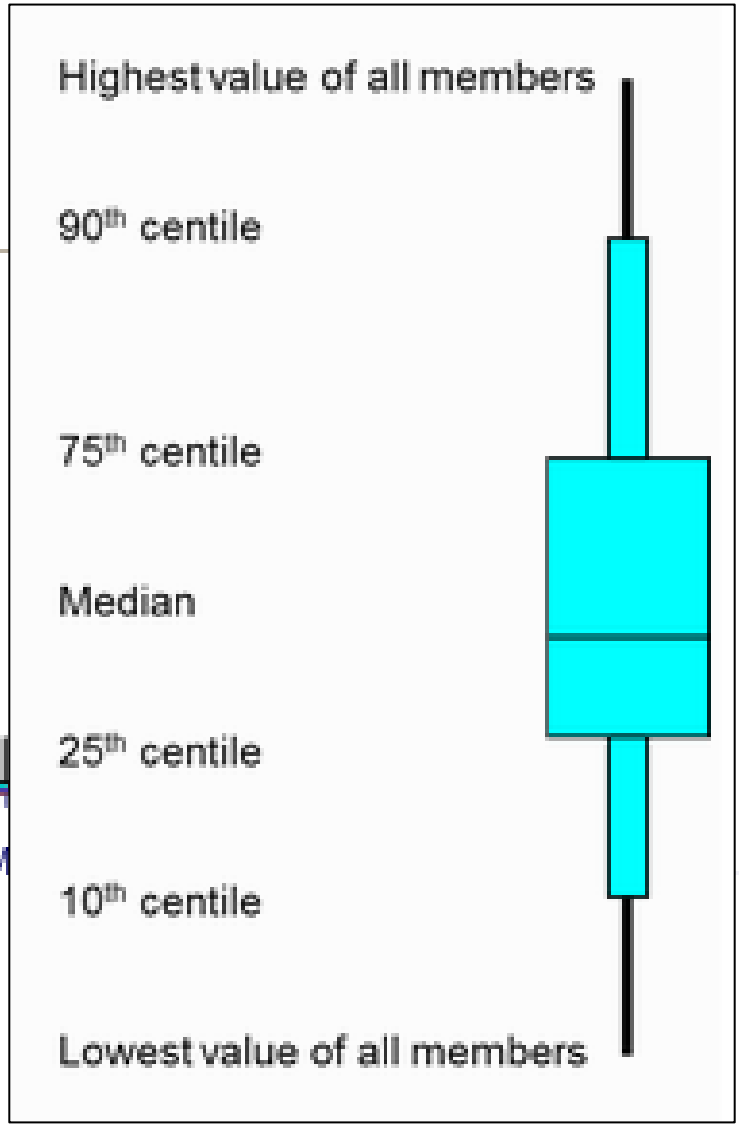
- Presents an ensemble forecast for a single location
- Ensemble data summarised in a box and whisker plot every 6 hours
- Provides a quick way to access information on confidence / uncertainty in the forecast



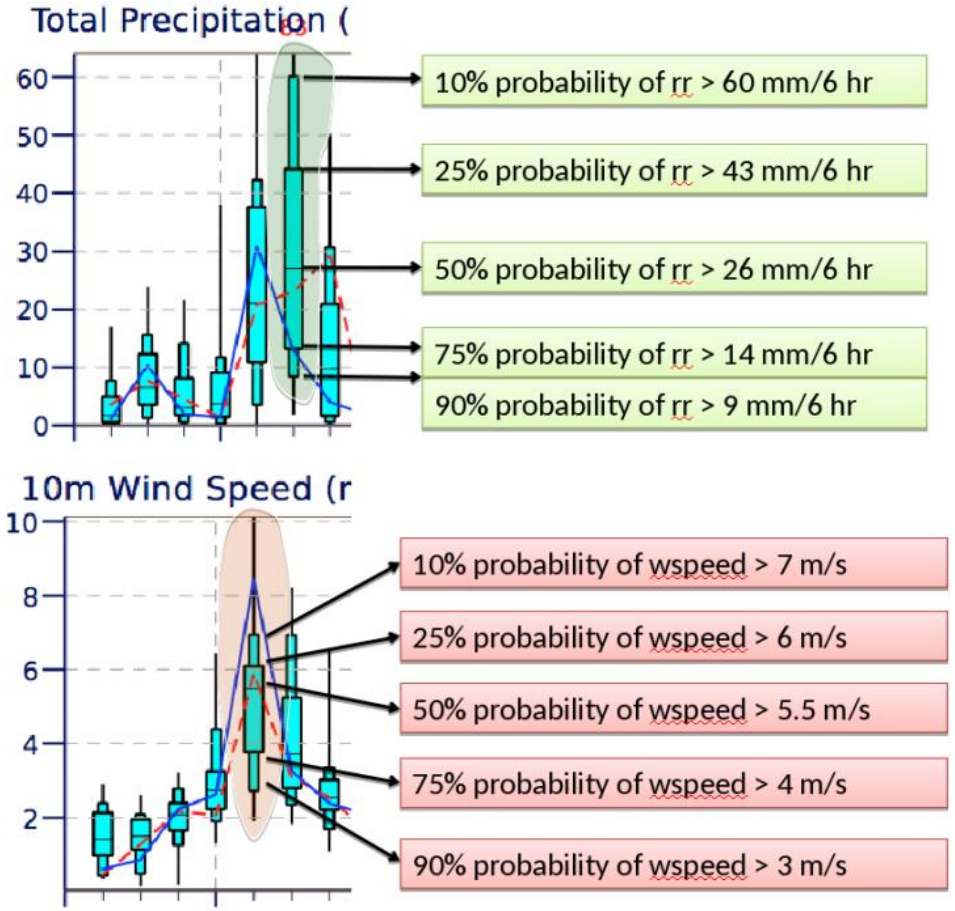


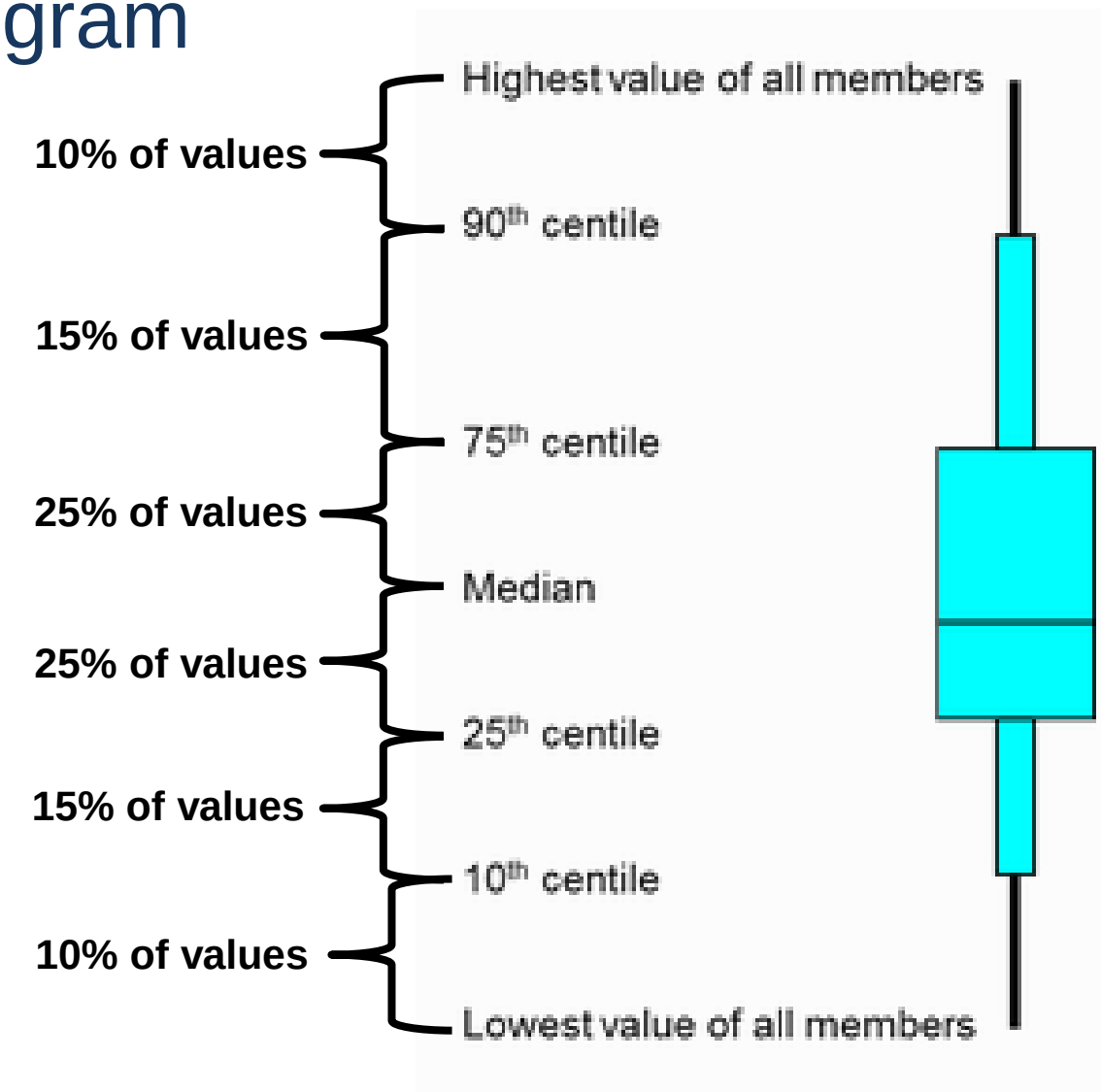
Example ENS meteogram





Understanding the ENS meteogram

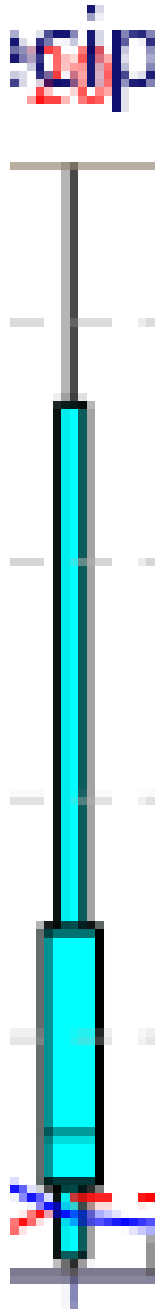




Uncertainty

You will generally see smaller ranges closer to the initial timestep and larger ranges with increasing lead time because there is less uncertainty in forecasts closer to the initial timestep than forecasts further ahead

Tall box and whisker plot = High uncertainty / low confidence



Short / squashed box and whisker plot = Low uncertainty / high confidence

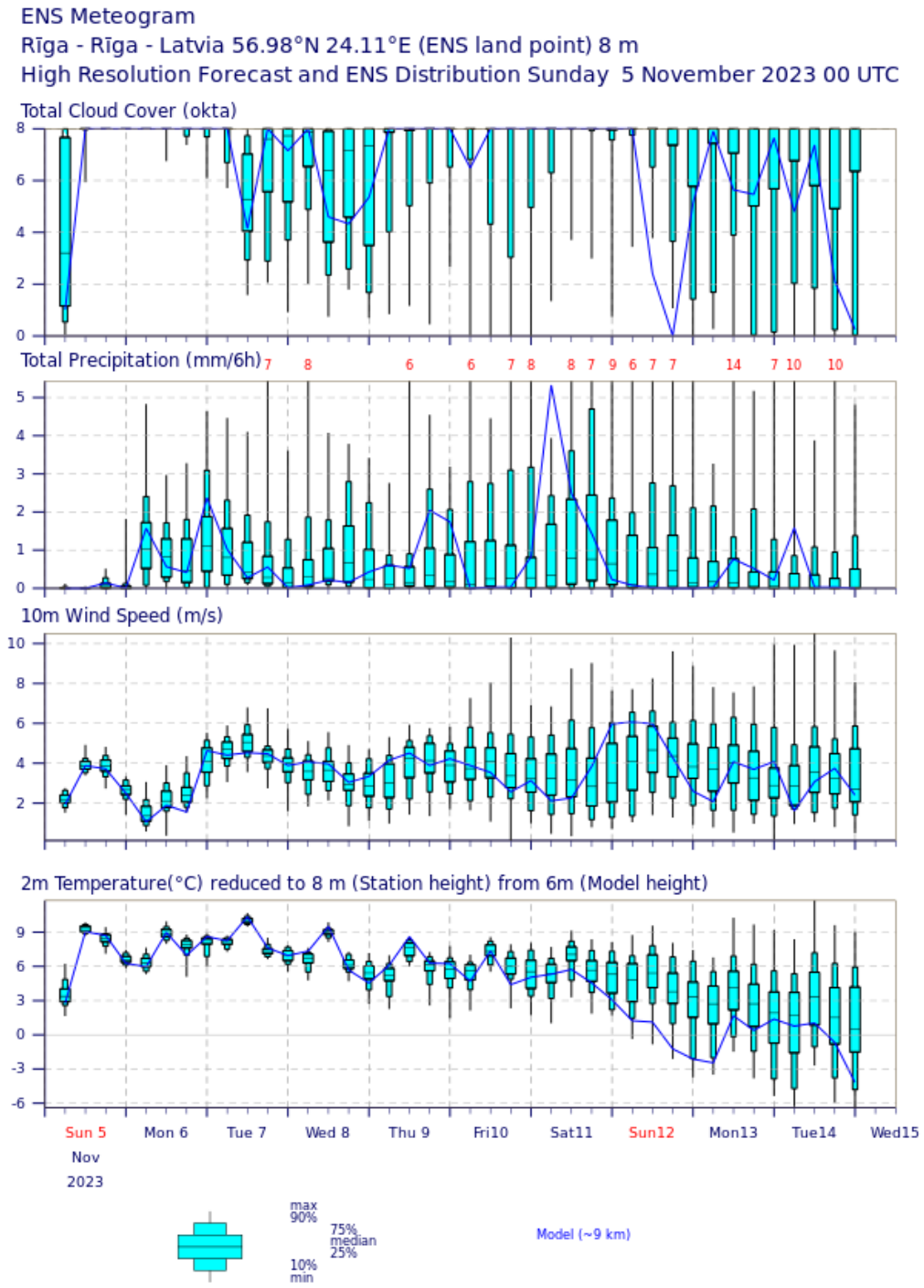
10-day ENS Meteogram

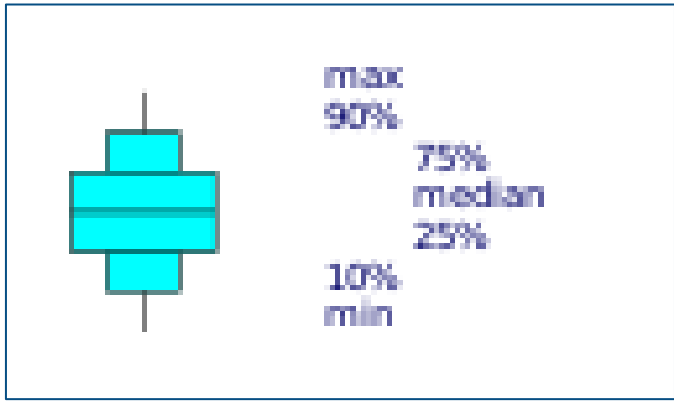
Total Cloud Cover oktas

Precipitation mm/6h

Wind Speed m/s

2m Temperature ^{o}C





10-day ENS Meteogram

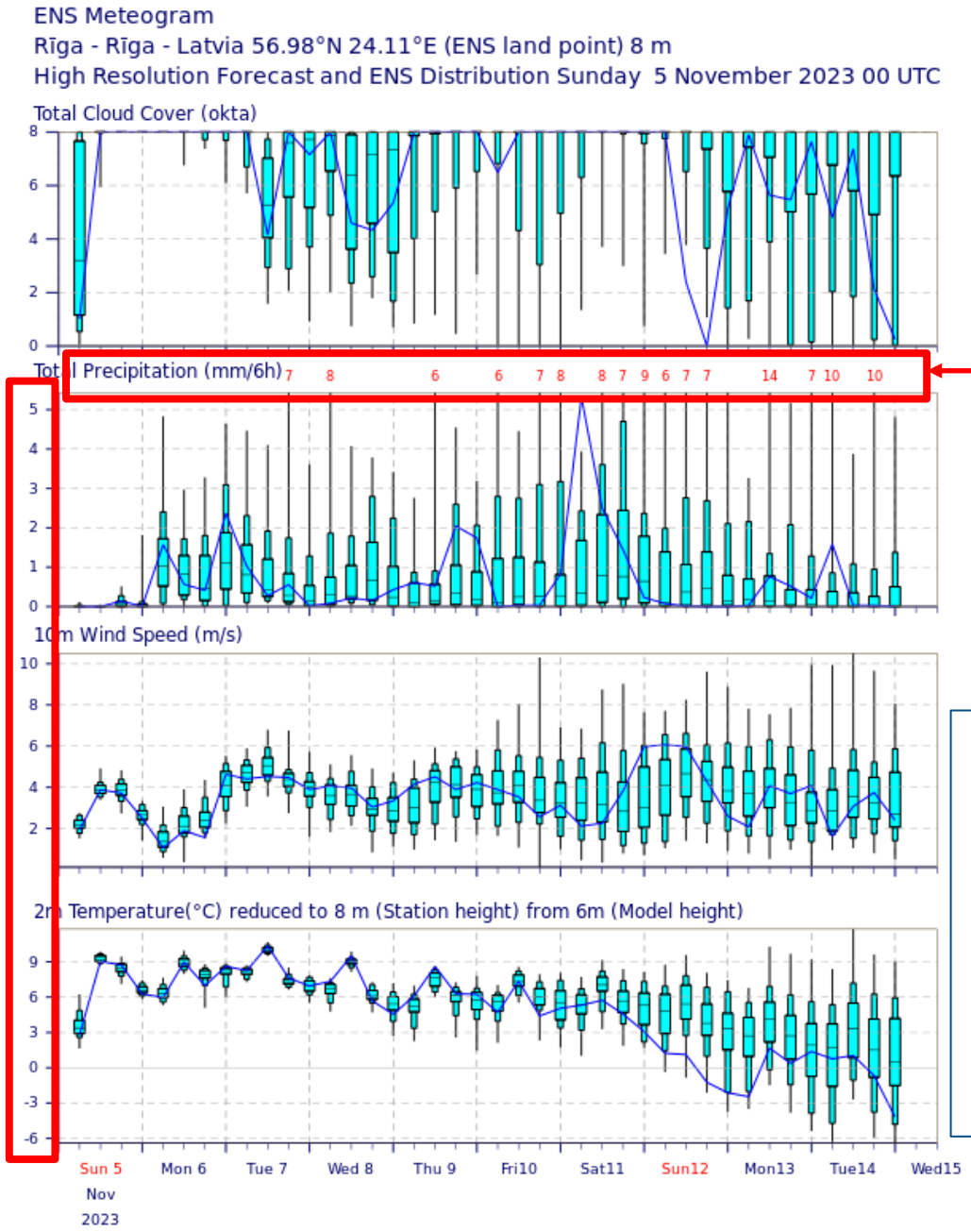
Total Cloud Cover oktas

Precipitation mm/6h

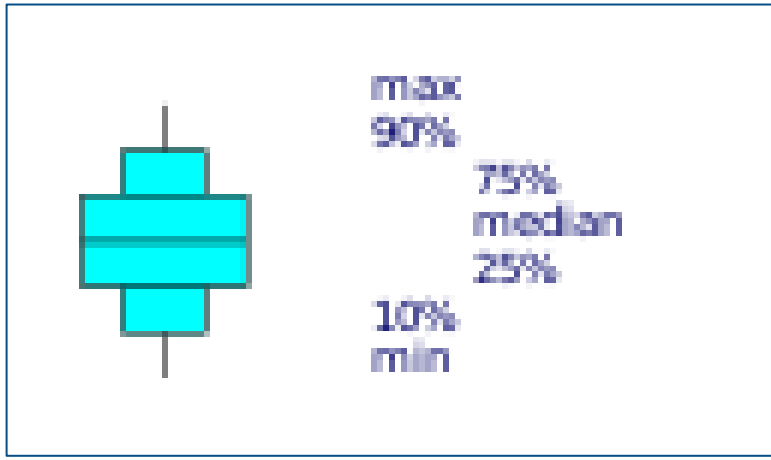
Wind Speed m/s

Keep an eye on the y-axis values

2m Temperature ^{o}C

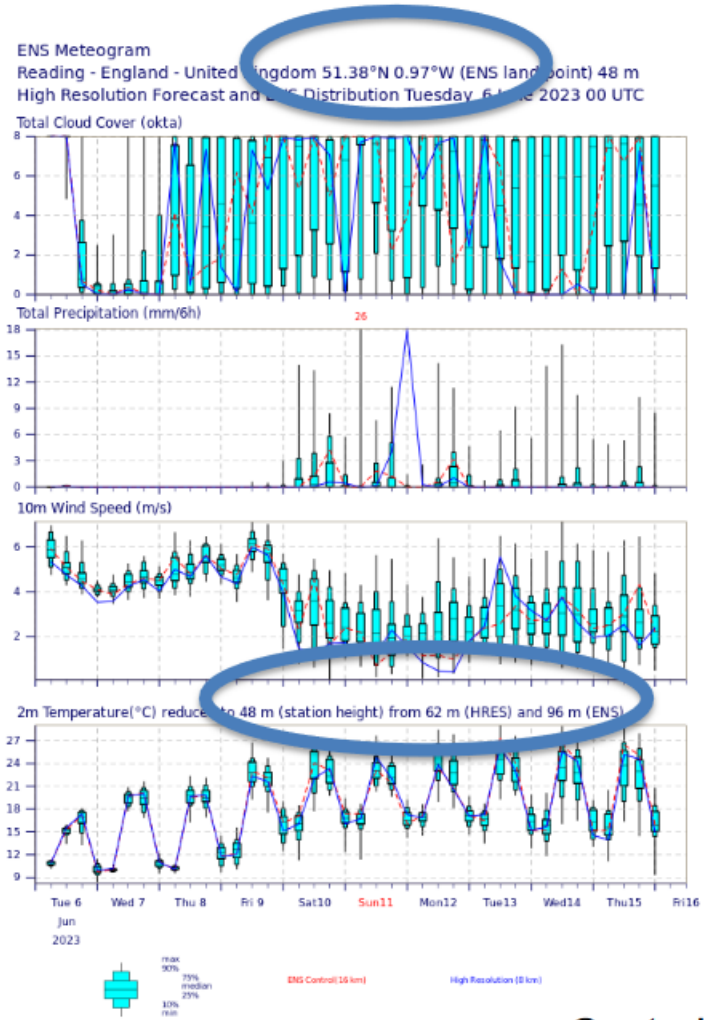


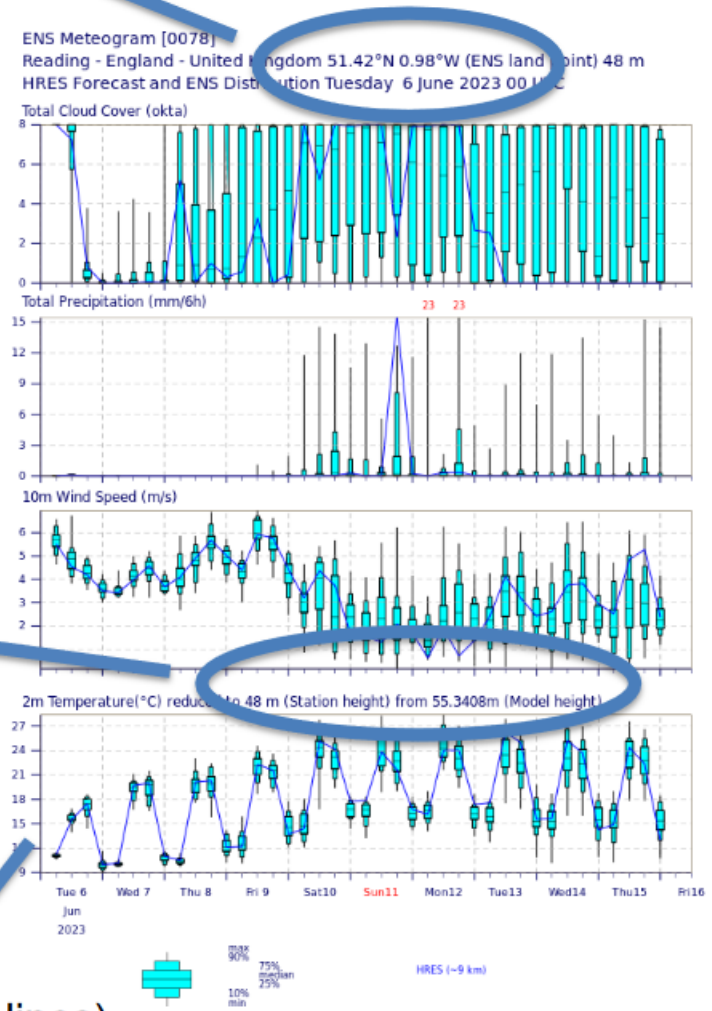
Max ENS value beyond y-axis / extremes



48r1 changes - Meteograms

Different nearest grid point – mostly closer





HRES model orography T correction different

Control removed (No red lines)

Meteograms in OpenCharts

Probabilities: total precipitation

Probabilities

Base time
Tue 10 Oct 2

Valid time
Tue 10 Oct 2

Area
South East A

- 10 days ENSgrams
- 15 days ENSgrams
- 15 days ENSgrams with Climate
- Plumes
- 10 days Waves ENSgrams
- Precipitation type meteogram
- Aviation visibility ranges
- General-purpose visibility ranges
- ENS EFI/CDF diagram
- Vertical profile

METEOGRAMS

10 days ENSgrams

The returned point is at 17 km in the north-east

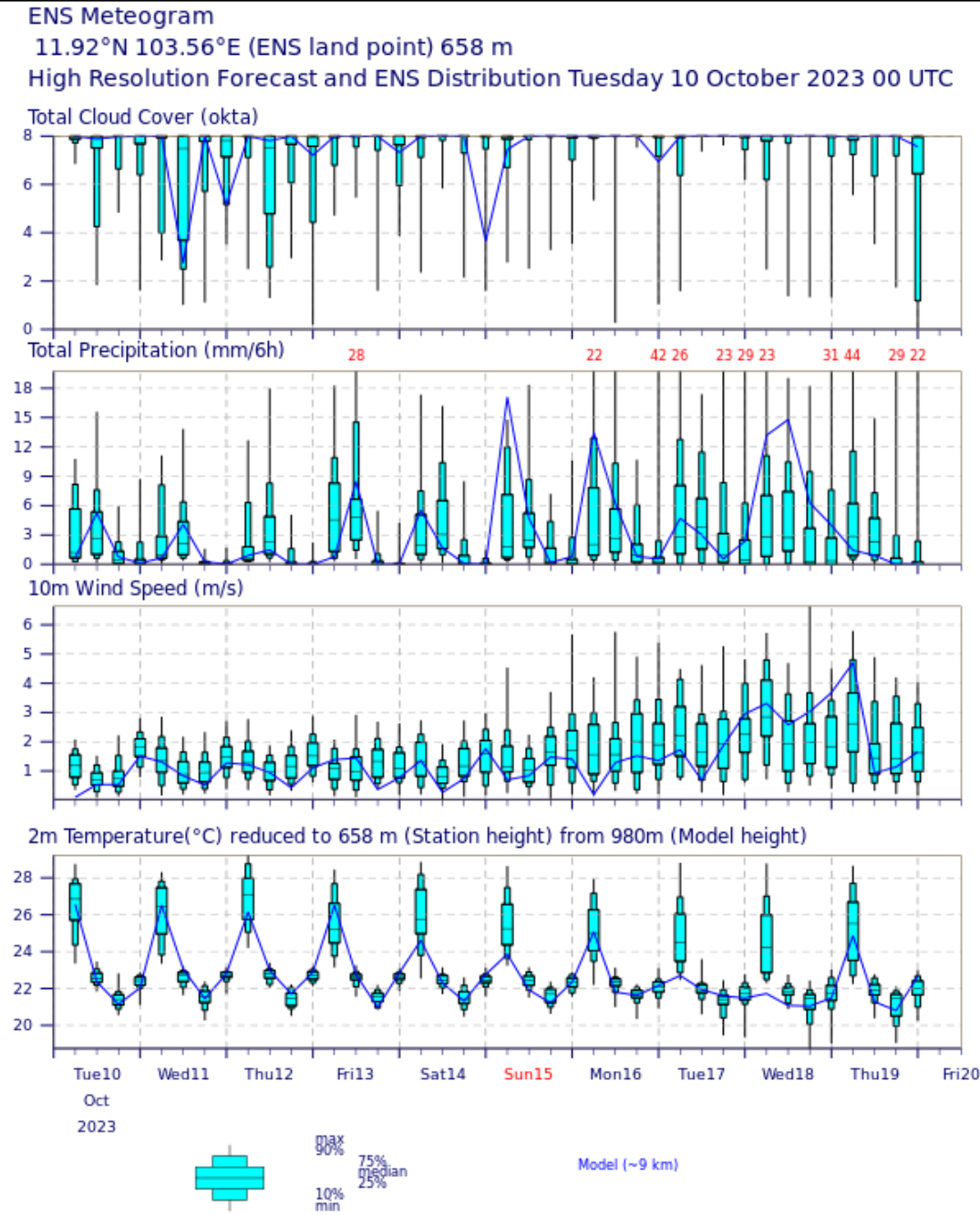
ENS Meteogram

(ENS land point) 30 m

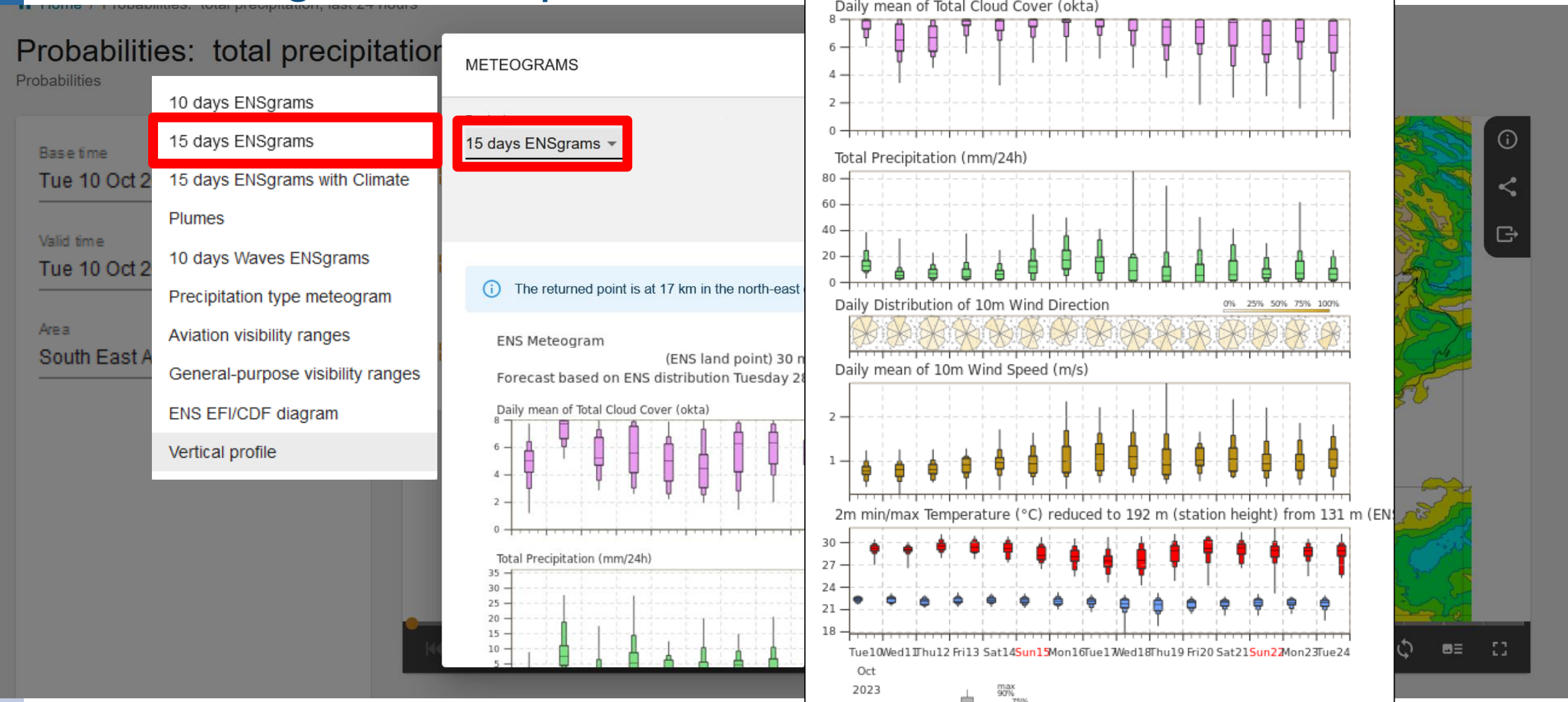
High Resolution Forecast and ENS Distribution

Total Cloud Cover (okta)

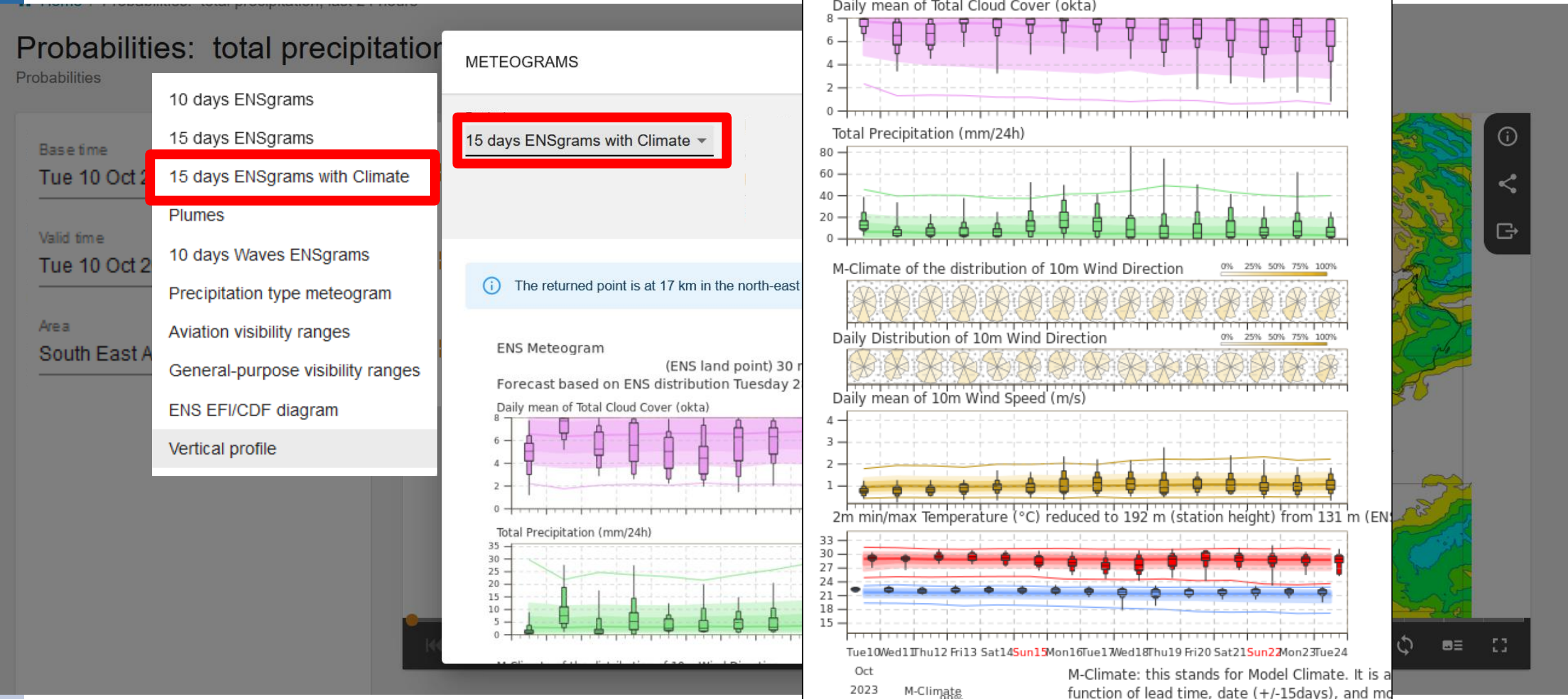
Total Precipitation (mm/6h)



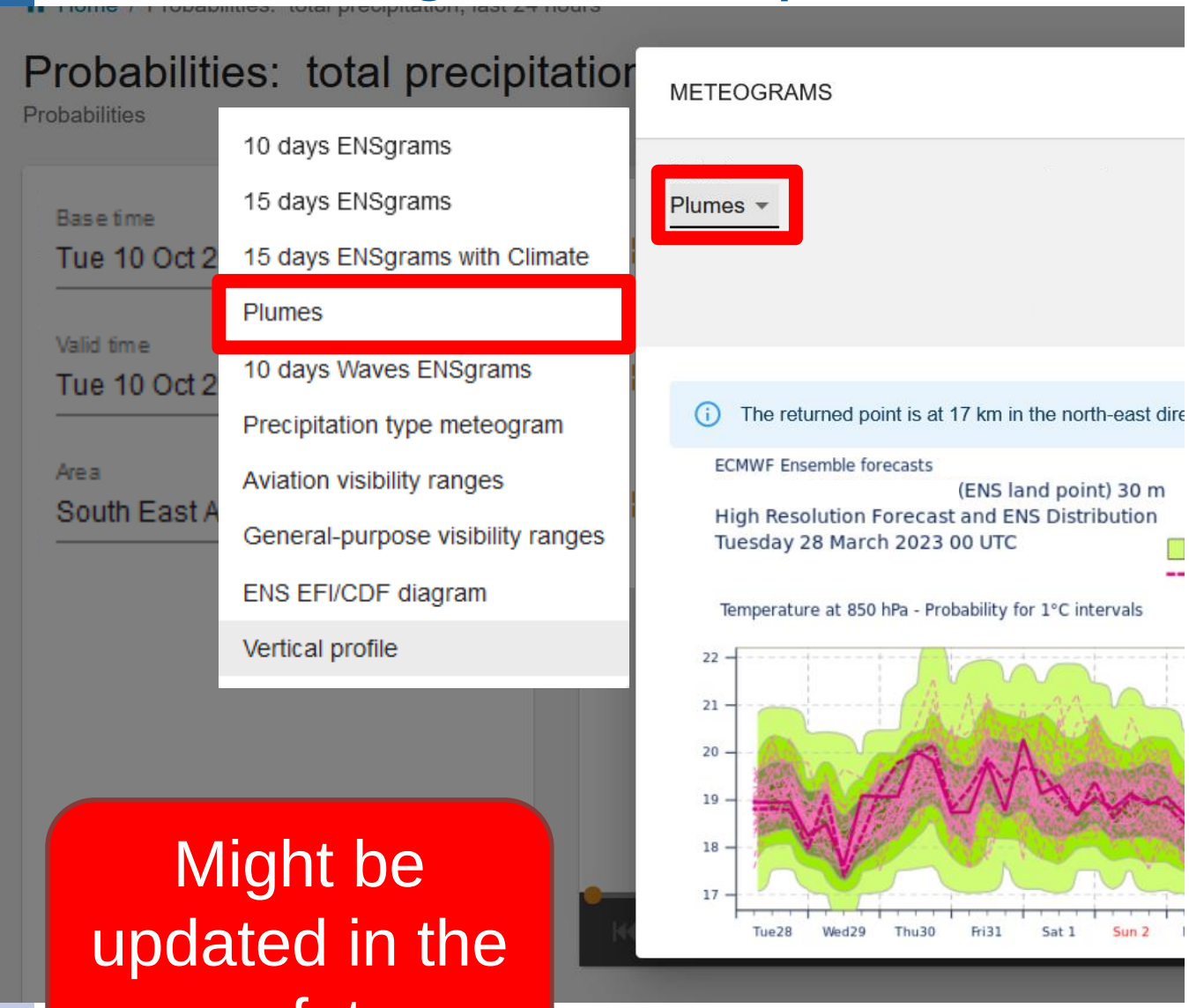
Meteograms in OpenCharts



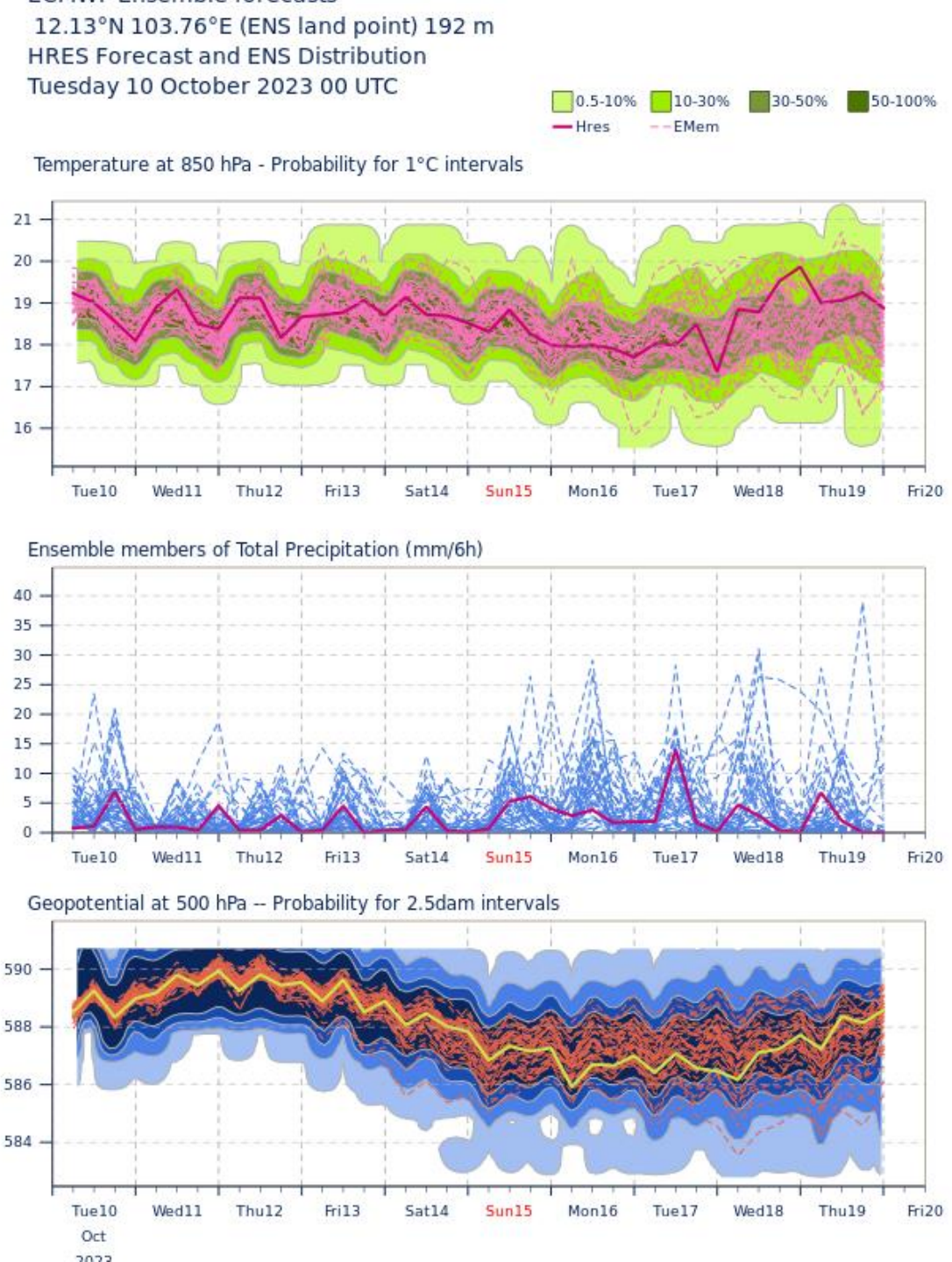
Meteograms in OpenCharts



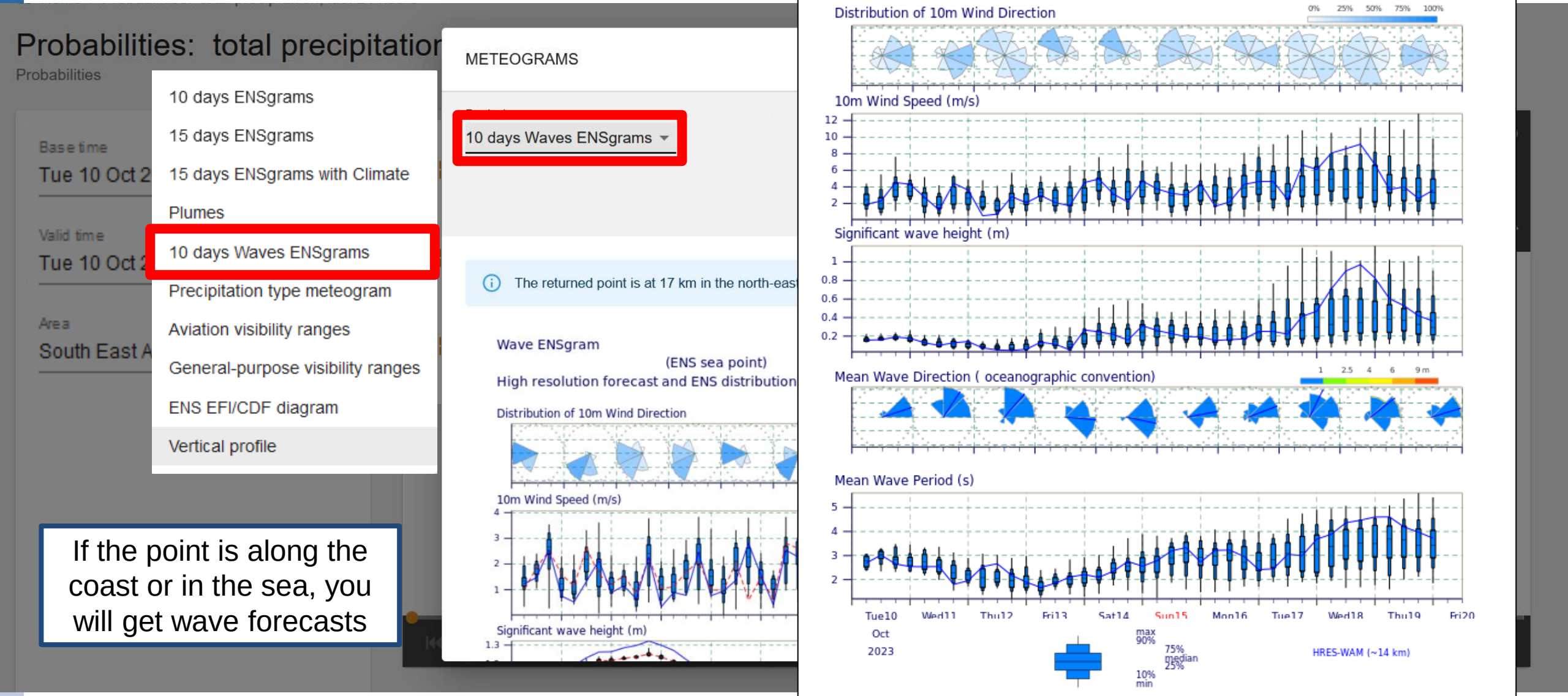
Meteograms in OpenCharts



Might be updated in the near future



Meteograms in OpenCharts

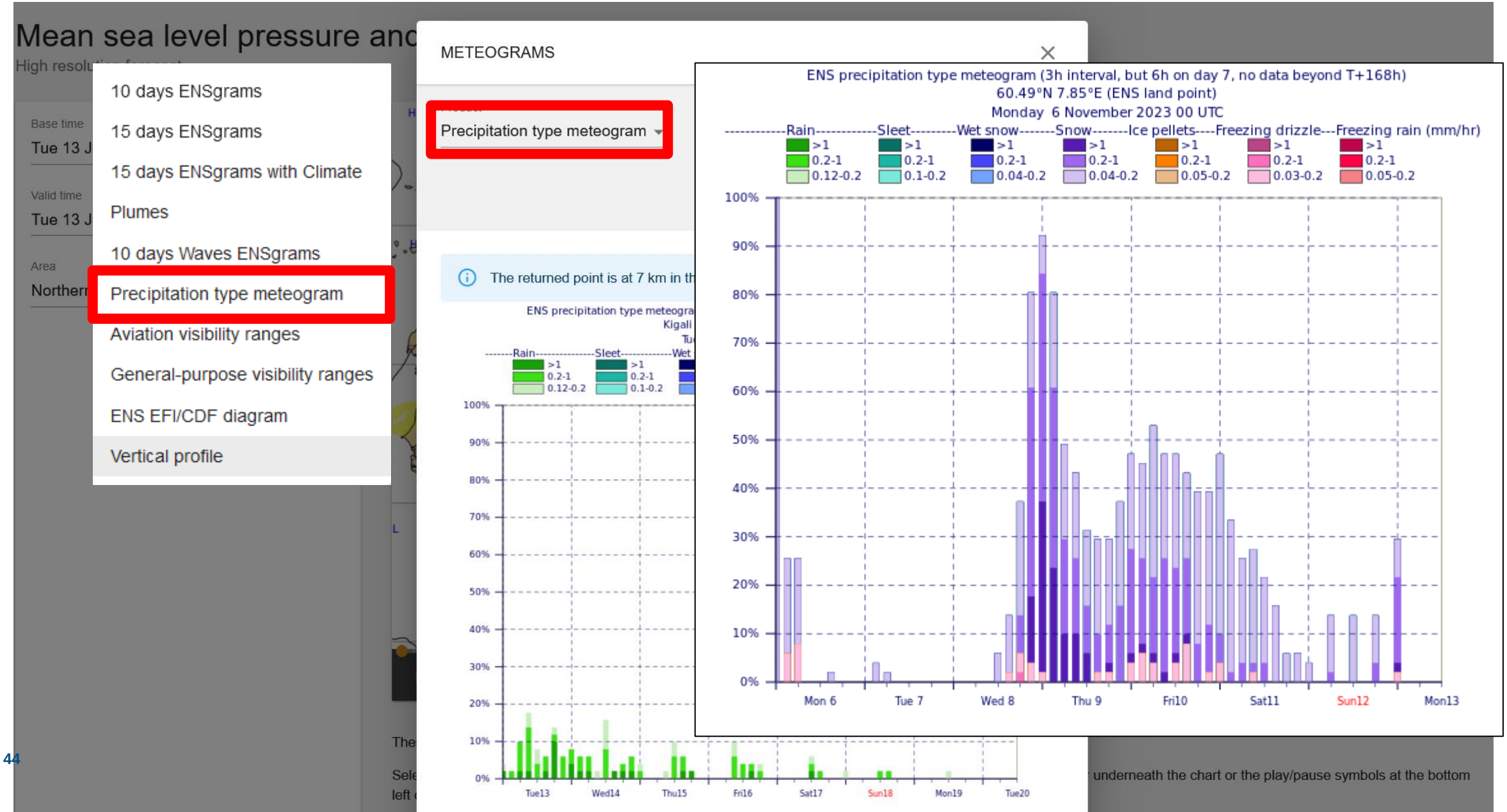


If the point is along the coast or in the sea, you will get wave forecasts

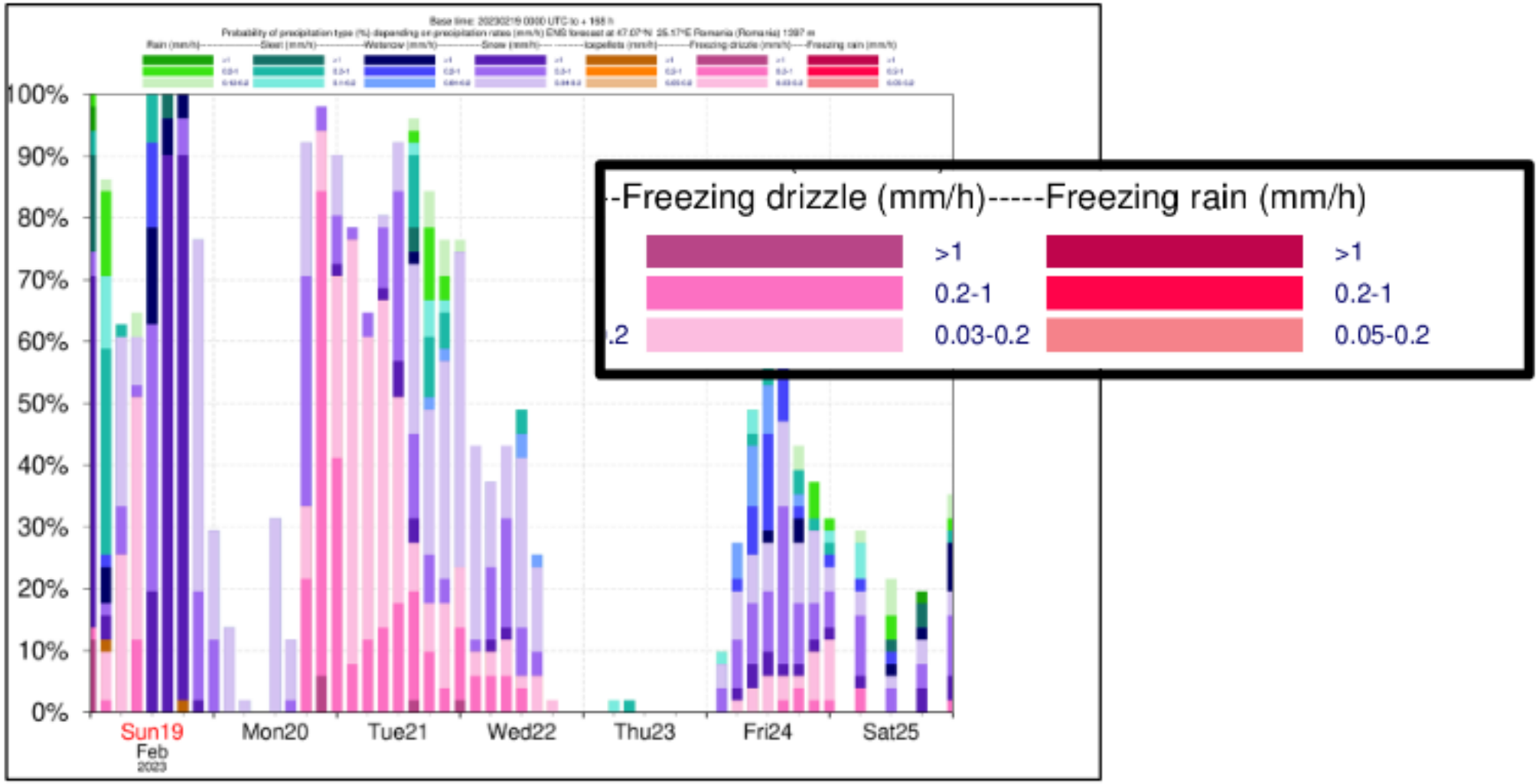
ECMWF EUROPEAN CENTRE FOR MEDIUM-RANGE WEATHER FORECAST

Meteograms in OpenCharts

New in 48r1



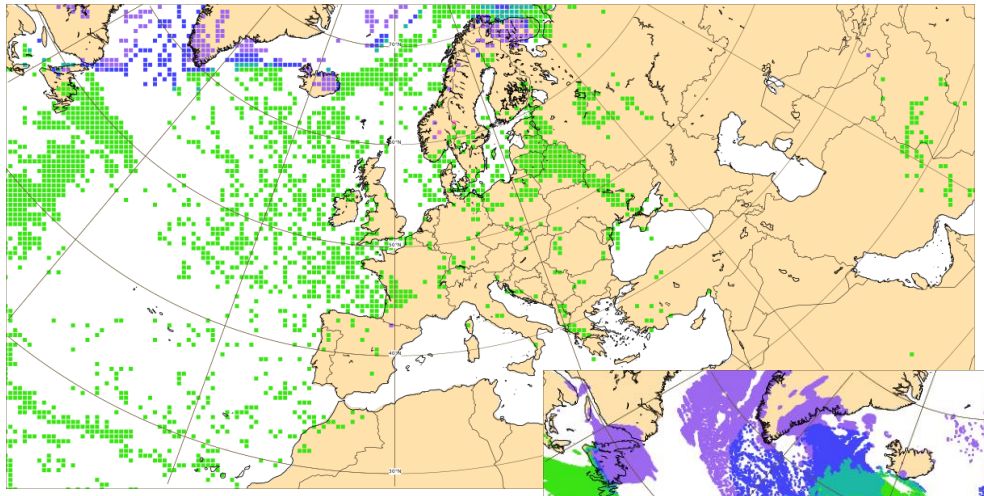
Probability of precipitation type meteograms

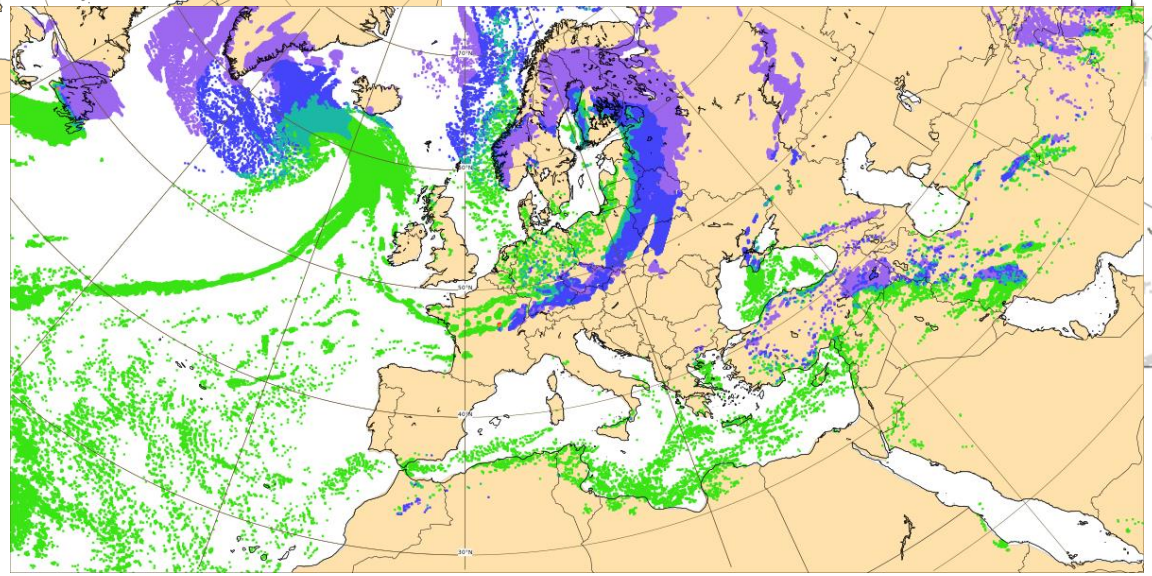


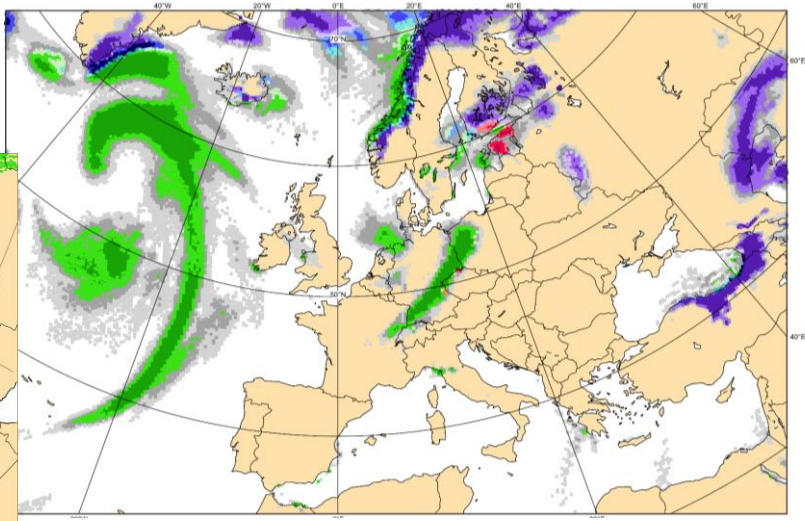
Most probable precipitation type product

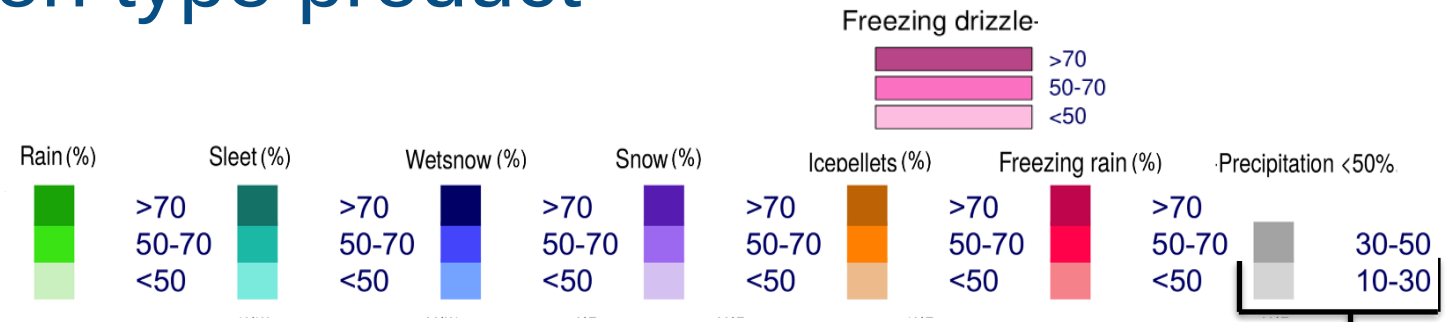
Colours: most probable precipitation type if **total precip > 50 %**

Visualisation in OpenCharts









Grey shading: when the probability of any type of precipitation is **10-30%** or **30-50%**. **THE TYPE OF PRECIPITATION IS NOT SPECIFIED**

ECMWF

Tips for how to use Precipitation Type

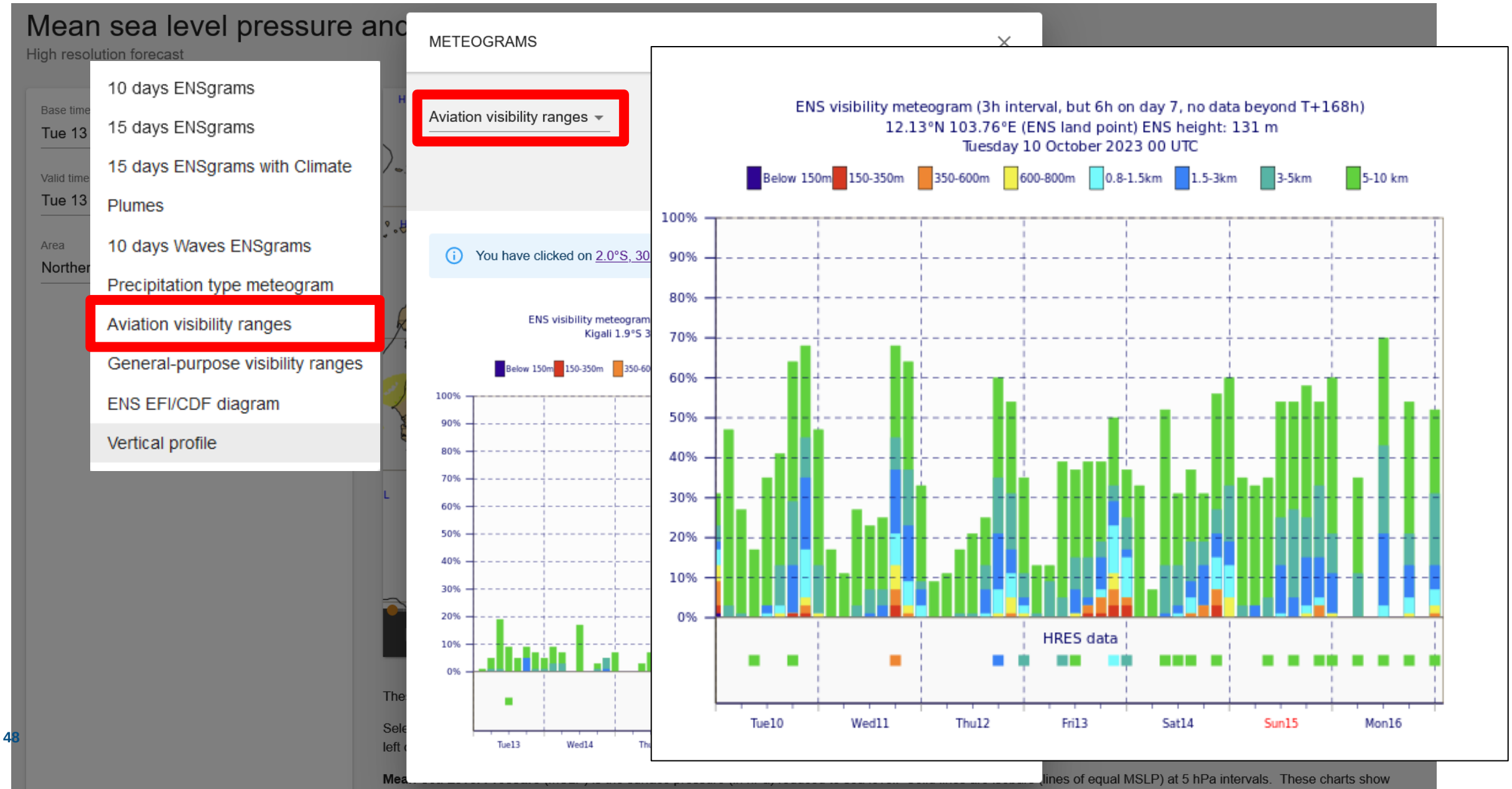
- Take into account the height of the ENS in your meteogram location (in the title of precipitation type meteogram), because the observation height can be very different, especially in mountainous areas (improved in 48r1 with the 9km ENS!)

- In the meteogram, the bars are stacked in such a way that the nominally most hazardous type (freezing rain in the high intensity category) is shown at the bottom, and the least hazardous (low intensity rain) at the top

- Whenever the lightest shade, of a given colour (except grey) appears on the map, the user immediately knows that more than one precipitation type has been predicted at that time, which can serve as an initial alarm bell for “uncertainty”

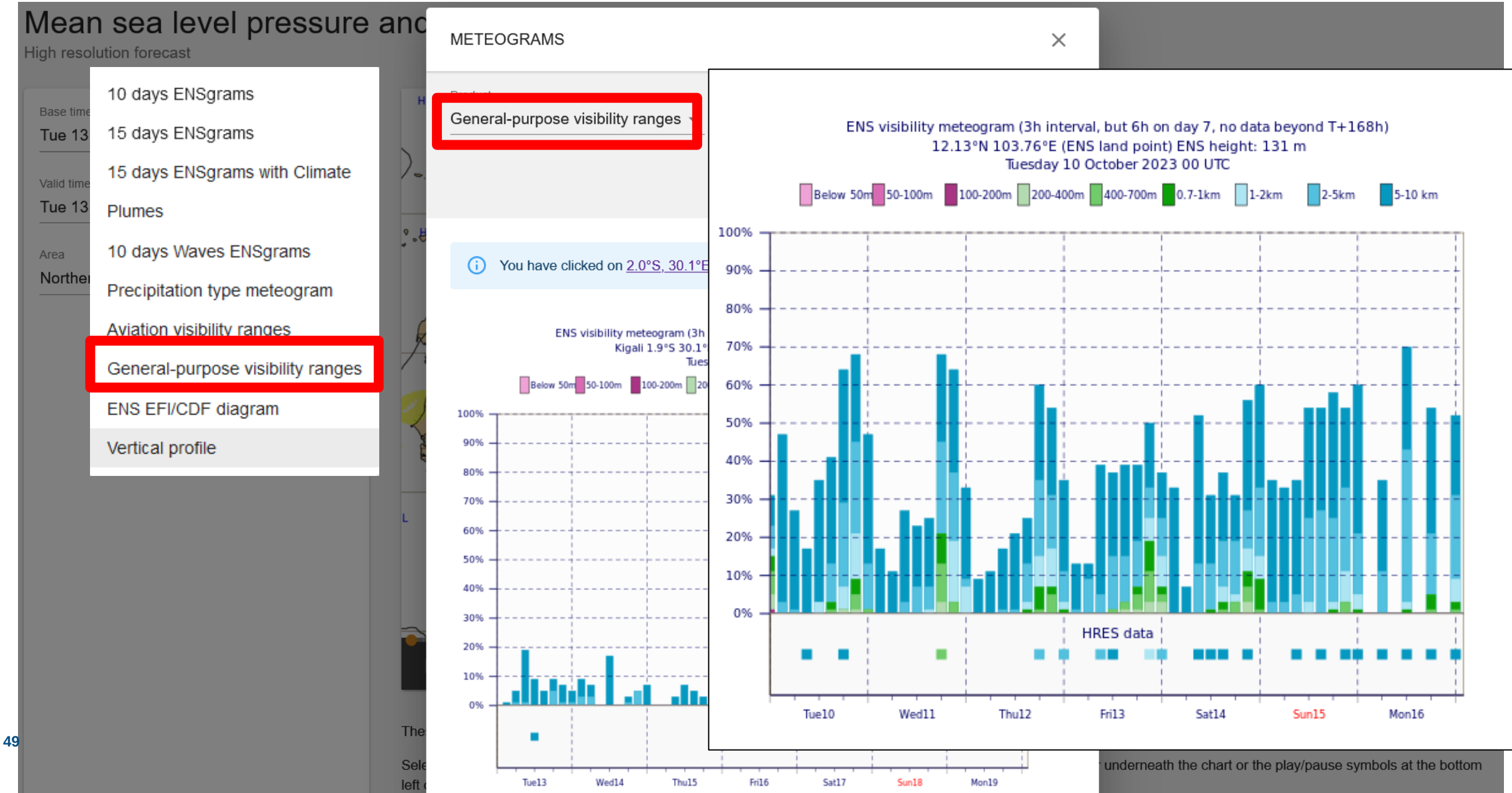
Meteograms in OpenCharts

New in 48r1



Meteograms in OpenCharts

New in 48r1



Meteograms in OpenCharts

Probabilities: total precipitation

Probabilities

Base time
Tue 10 Oct 2

Valid time
Tue 10 Oct 2

Area
South East A

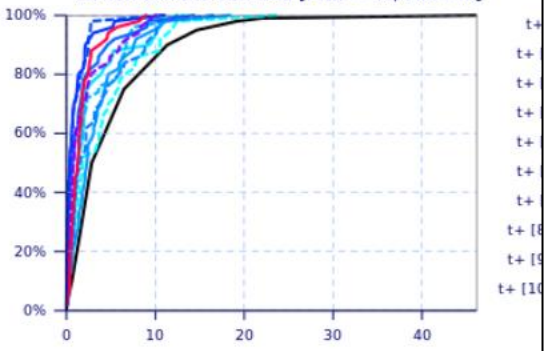
- 10 days ENSgrams
- 15 days ENSgrams
- 15 days ENSgrams with Climate
- Plumes
- 10 days Waves ENSgrams
- Precipitation type meteogram
- Aviation visibility ranges
- General-purpose visibility ranges
- ENS EFI/CDF diagram
- Vertical profile

METEOGRAMS

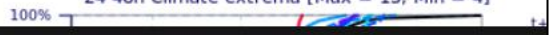
ENS EFI/CDF diagram

The returned point is at 17 km in the north-east d

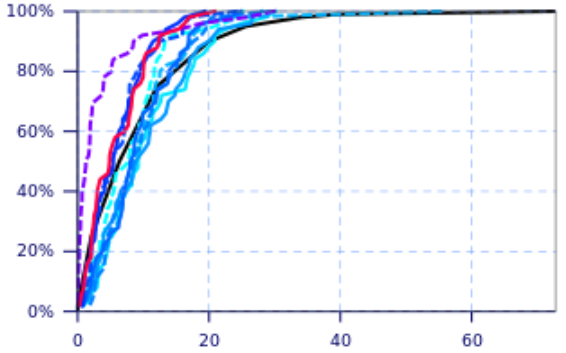
Forecast and M-Climate cumulative distribution functions
6.4°N 10.67°W
Valid for 24 hours from Tuesday 28 March 2023 00 UTC t
CDF for 24h precipitation (mm)
24-48h Climate extrema [Max = 46, Min = 0]

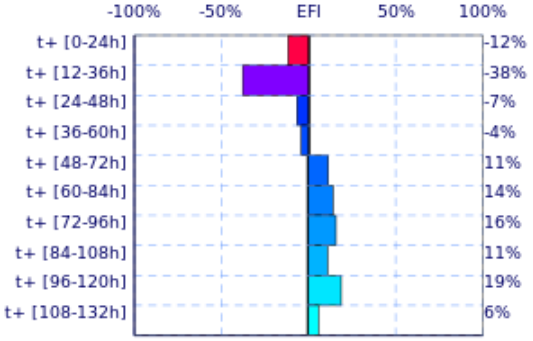


CDF for 24h maximum wind gust (m/s)
24-48h Climate extrema [Max = 13, Min = 4]

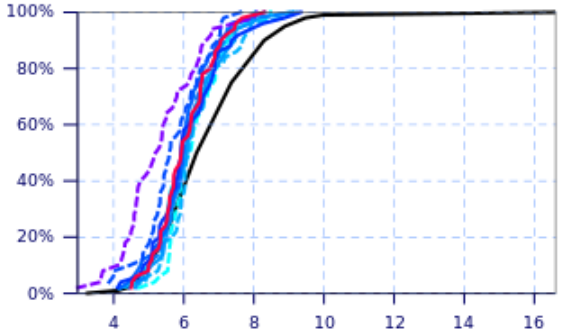


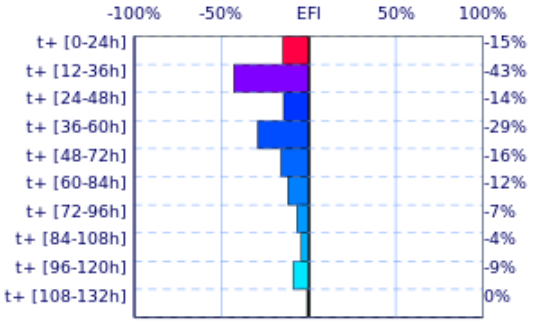
Forecast and M-Climate cumulative distribution functions with EFI values
12.13°N 103.76°E
Valid for 24 hours from Monday 9 October 2023 00 UTC to Tuesday 10 October 2023 00 UTC
CDF for 24h precipitation (mm)
24-48h Climate extrema [Max = 73, Min = 0]



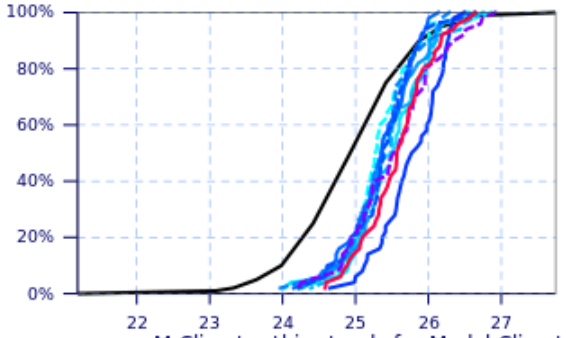


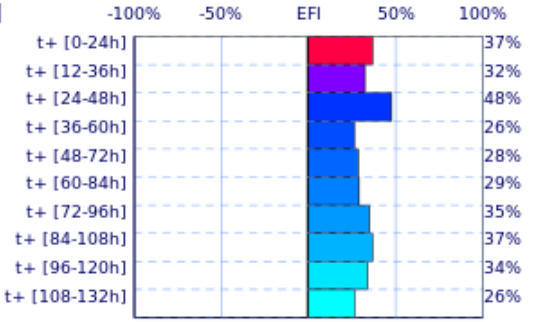
CDF for 24h maximum wind gust (m/s)
24-48h Climate extrema [Max = 17, Min = 3]





CDF for 24h mean 2m temperature (°C)
24-48h Climate extrema [Max = 28, Min = 21]

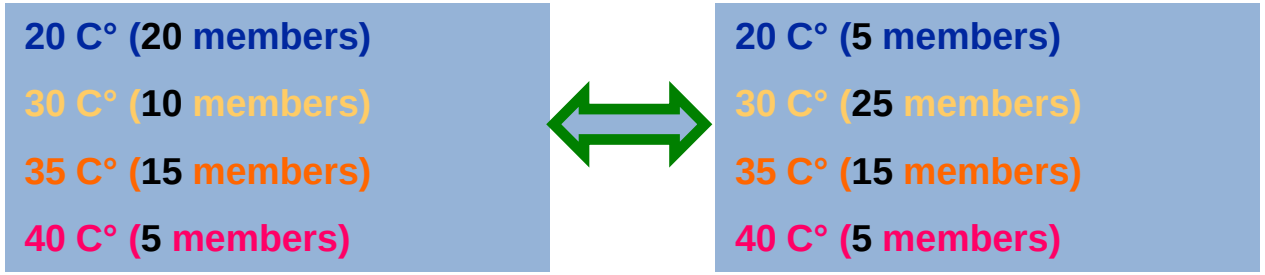




M-Climate: this stands for Model Climate. It is a function of lead time, date (+/-15days), and model version. It is derived by rerunning all member ensemble over the last 20 years twice a week (1980 realisations).
M-Climate is always from the same model version as the displayed ENS data.
On this page only the 24-48 lead M-Climate is displayed.

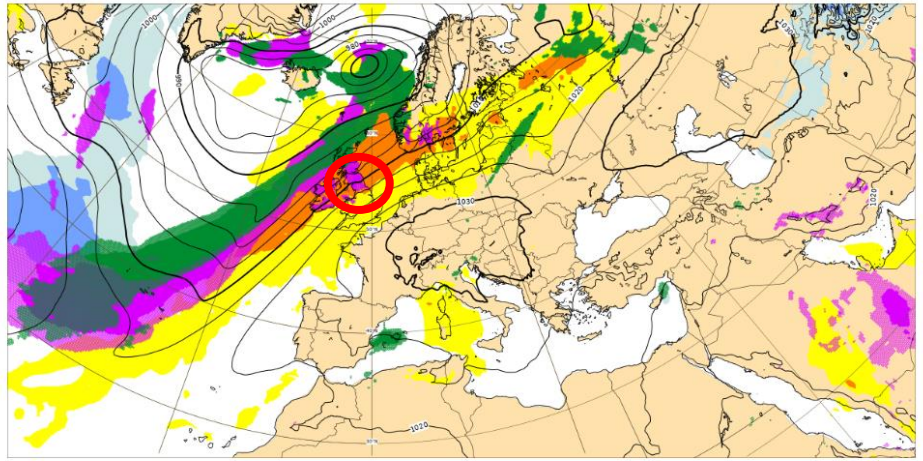
Extreme Forecast Index (EFI)

- **Extreme Forecast Index (EFI)** is designed to measure how extreme a given ensemble forecast is.
- EFI is a measure of the difference between the ensemble forecast distribution and a reference distribution - **model climate (M-climate)**.
- EFI delivers model-climate-related information, therefore it can be used as an “alarm bell” for extreme weather situations over any area without defining different space- and time-dependent thresholds.
- Simple probabilities (e.g. > 32°C) will not highlight the differences in the distributions below. EFI will, by accounting for the distribution of all the ensemble members

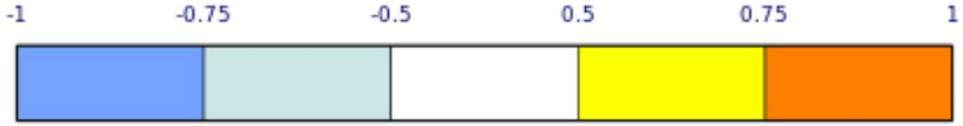


Multi-parameter EFI during last 24 hours

Base time: Thu 10 Nov 2022 00 UTC Valid time: Fri 11 Nov 2022 00 UTC (+24h) Area : Europe



2m temperature extreme forecast index



10m wind gust extreme forecast index

0.6-0.8 0.8-1

Total precipitation extreme forecast index

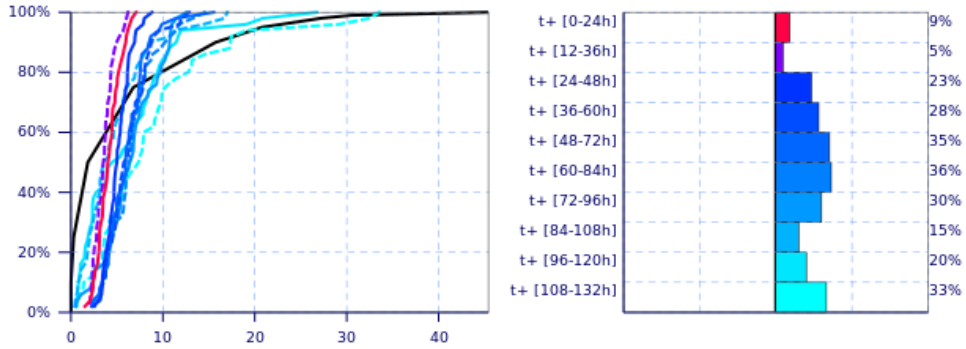
0.6-0.8 0.8-1

Ensemble mean for mean sea level pressure

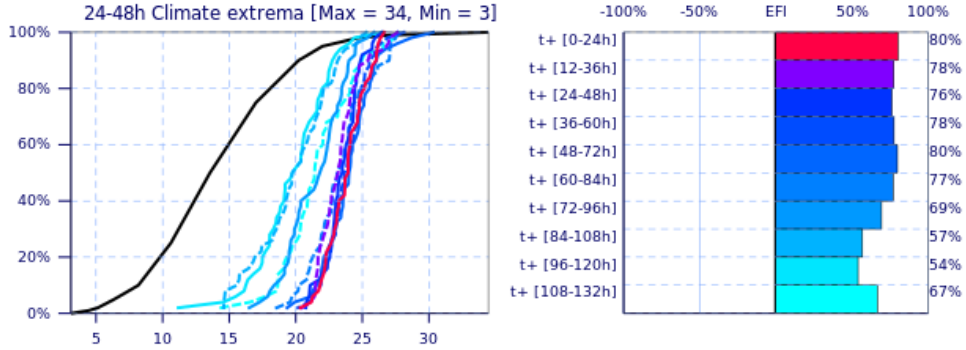
Interval 5, thickness 2

Forecast and M-Climate cumulative distribution functions with EFI values
55.45°N 3.24°W
Valid for 24 hours from Thursday 10 November 2022 00 UTC to Friday 11 November 2022 00 UTC

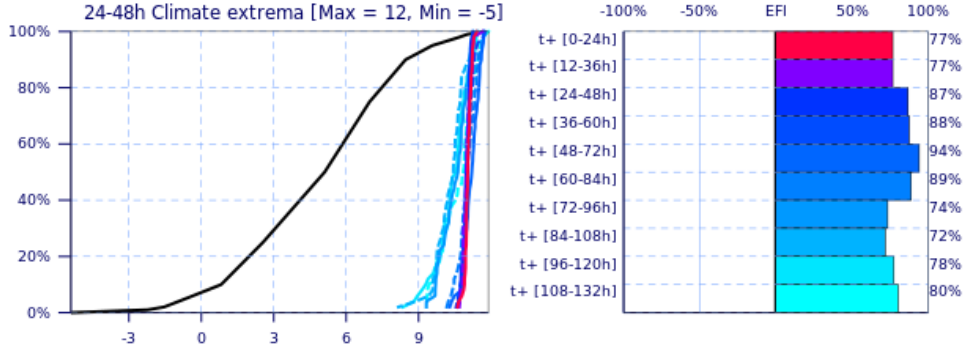
CDF for 24h precipitation (mm)
24-48h Climate extrema [Max = 45, Min = 0]



CDF for 24h maximum wind gust (m/s)
24-48h Climate extrema [Max = 34, Min = 3]

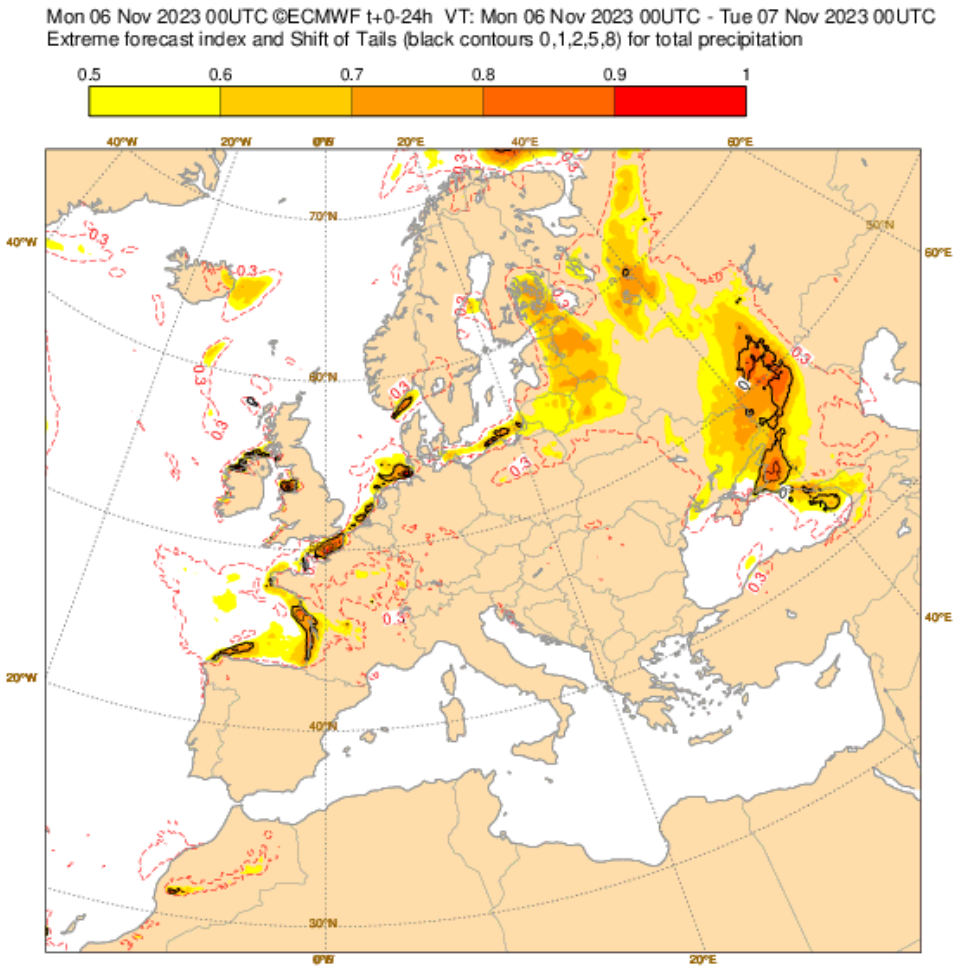


CDF for 24h mean 2m temperature (°C)
24-48h Climate extrema [Max = 12, Min = -5]

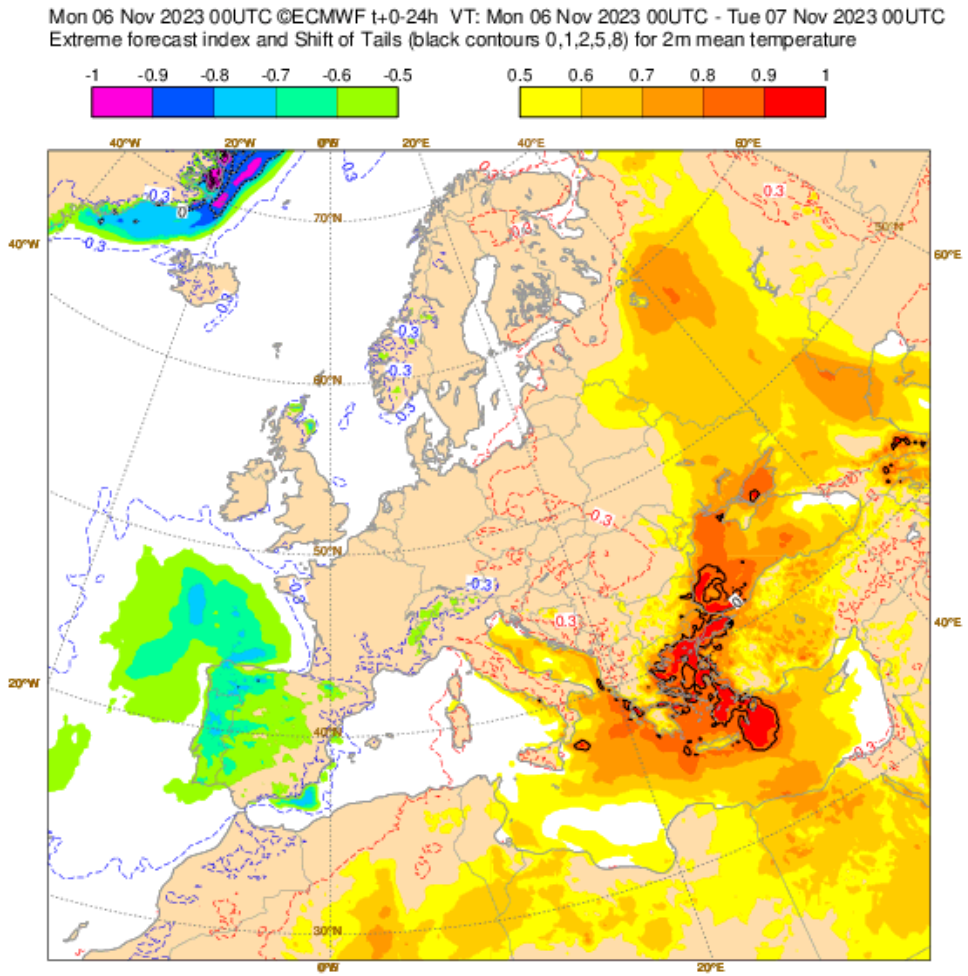


M-Climate: this stands for Model Climate. It is a function of lead time, date (+/-15days), and model version. It is derived by rerunning all member ensemble over the last 20 years twice a week (1980 realisations).
M-Climate is always from the same model version as the displayed ENS data.
On this page only the 24-48 lead M-Climate is displayed.

EFI – Total Precipitation



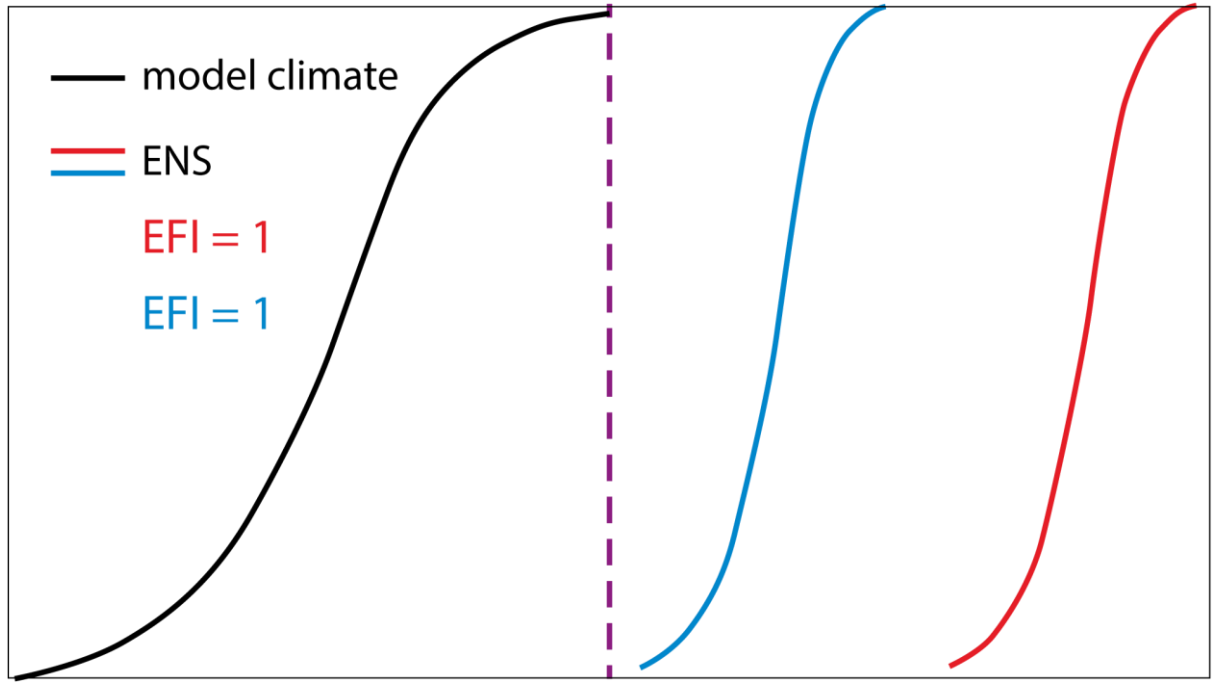
EFI – 2m temperature



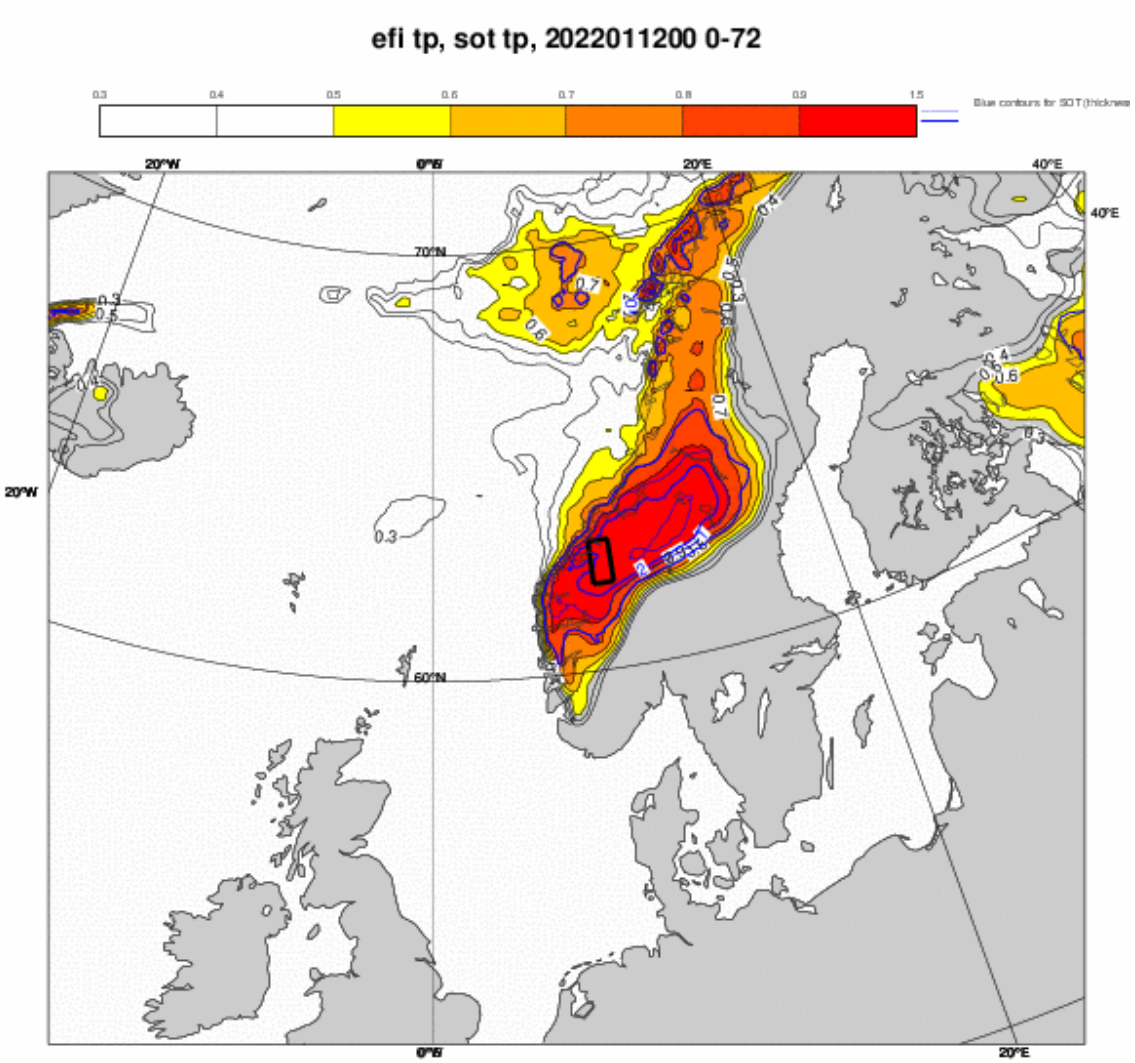
EFI is shown by colours given by the scale above each chart (±0.3 is shown by the dashed coloured contours)

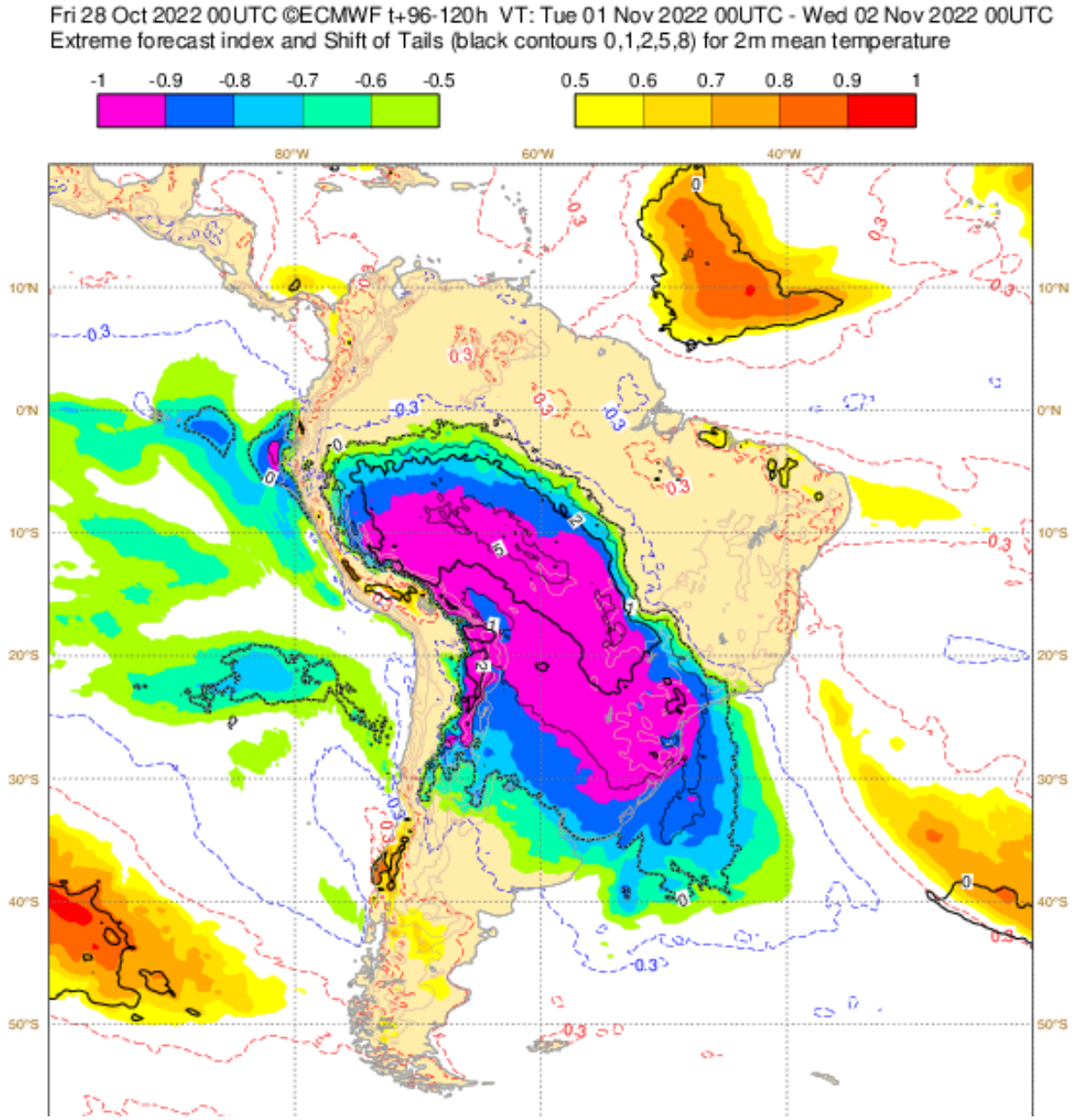
Shift of Tails (SOT)

- As EFI does not take direct account for members which are beyond the M-climate, once EFI reaches its maximum value of 1 or minimum value of -1, it does not provide further information about the magnitude of extremity
- SOT compares the tails of both distributions M-climate and ENS
- SOT is based on 90th and 99th (upper tail) and 1st and 10th (lower tail for temperature only) percentiles
- **Positive** SOT values indicate that at least 10% of the ensemble is forecasting an extreme event; the higher the SOT the more extreme that top 10% is
- Shift Of Tails (SOT) has been operational since 19 June 2012 to complement EFI by providing information about **how extreme an extreme event might be**



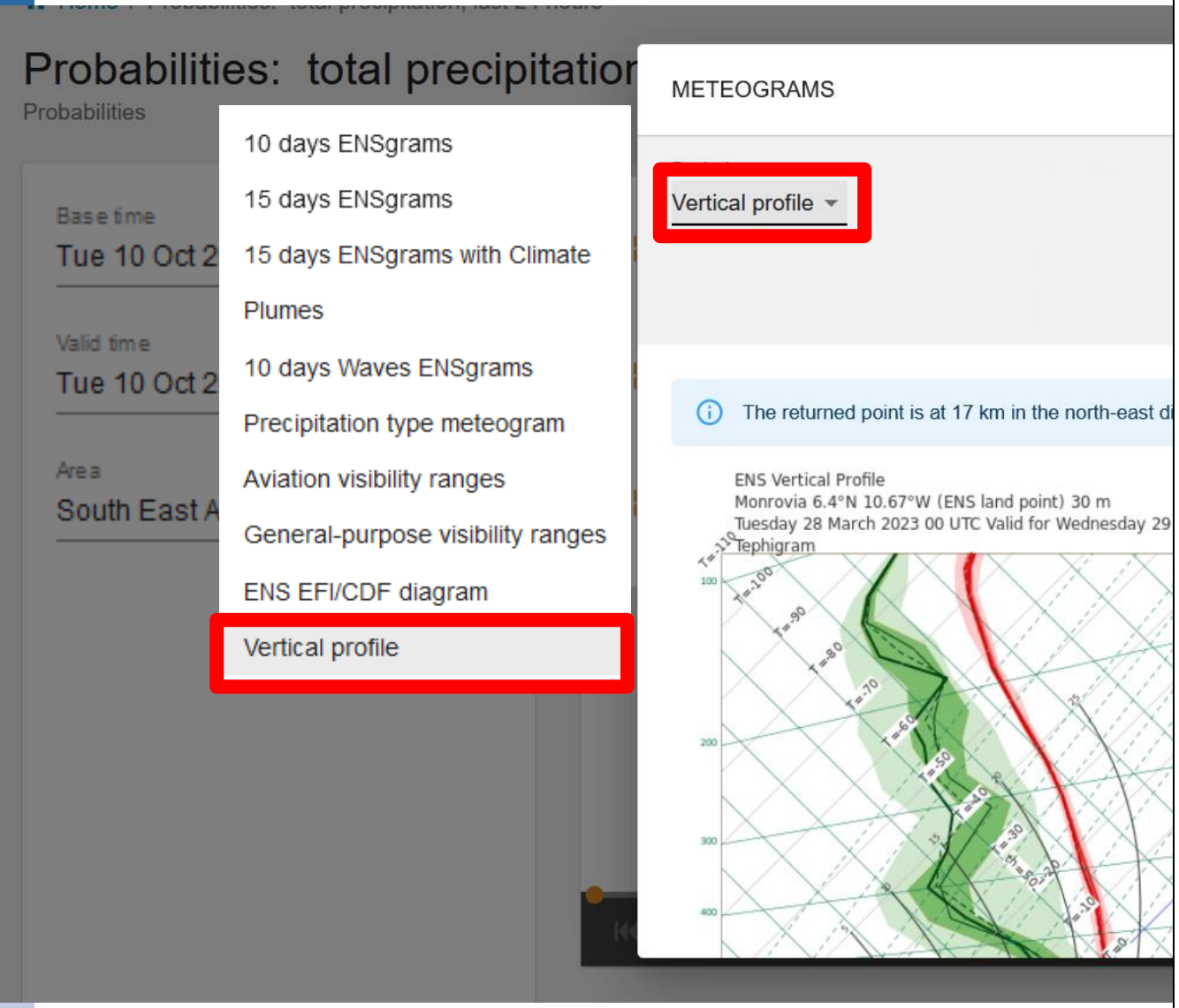
SOT in Open Charts – denoted by black/blue contouring

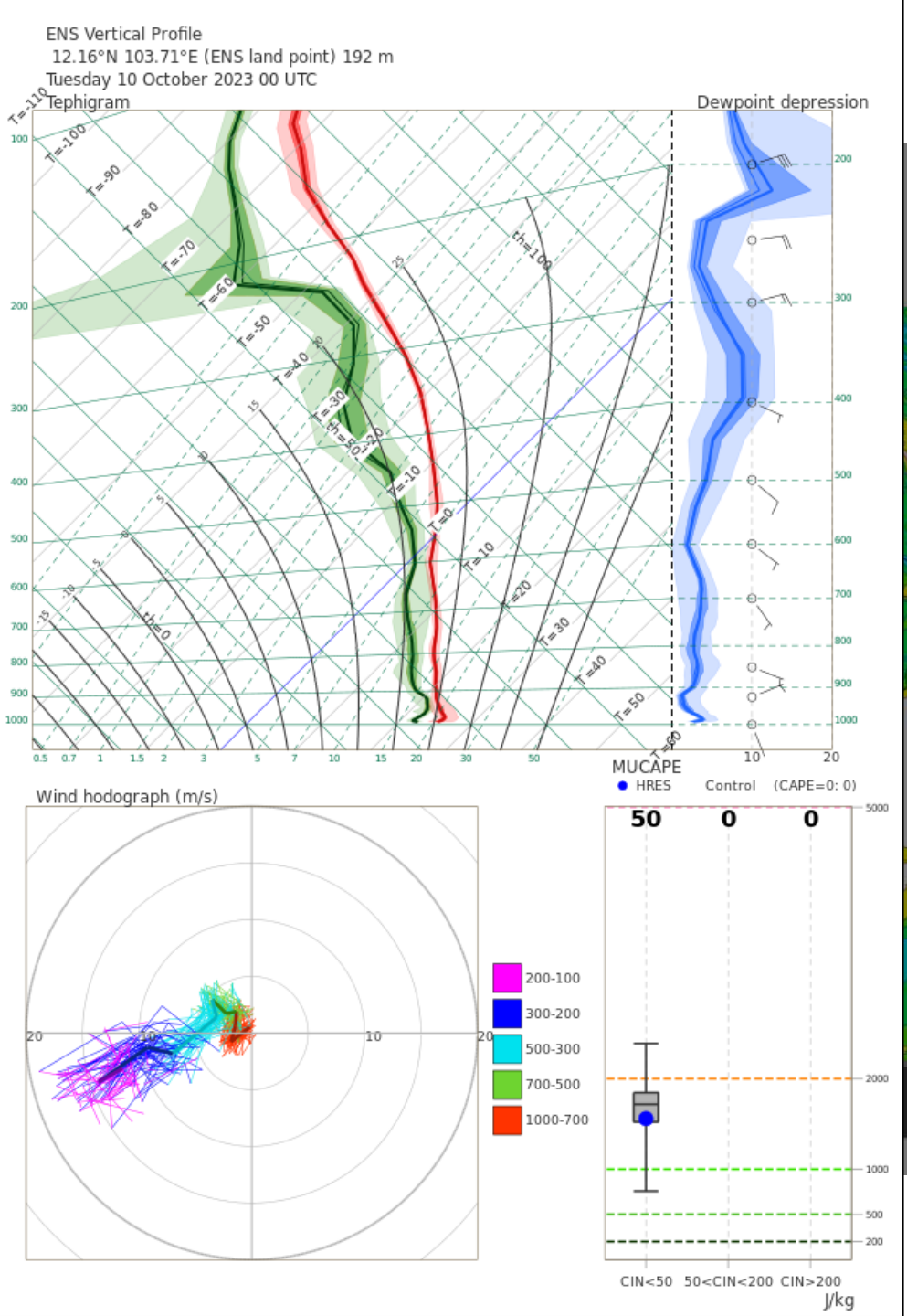




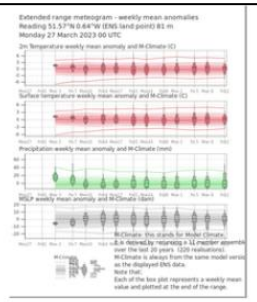
ECMWF EUROPEAN CENTRE FOR MEDIUM-RANGE WEATHER FOR

Meteograms in OpenCharts





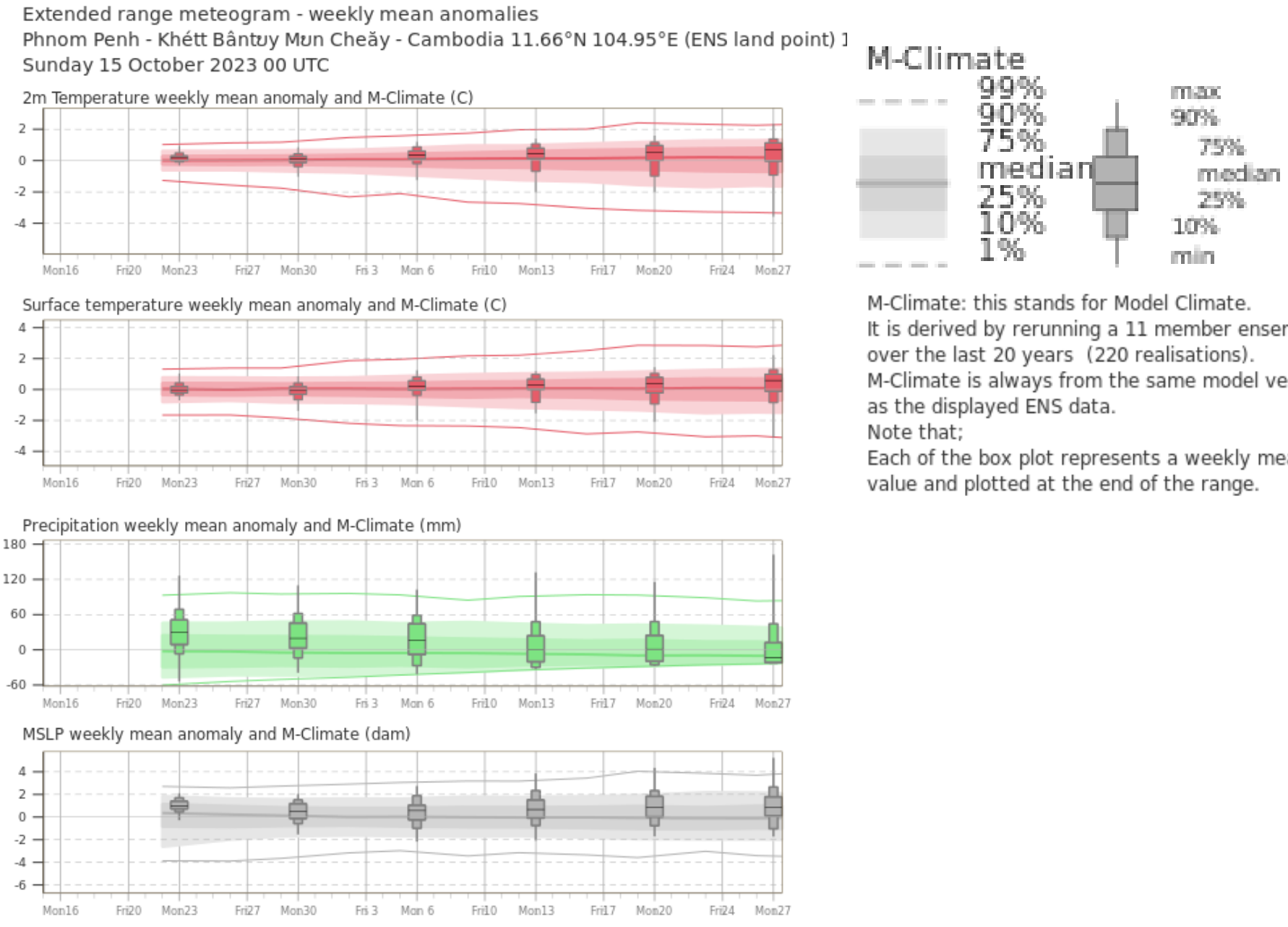
Extended Range Meteograms in OpenCharts



ENS extended meteograms

ENS extended meteograms

ADD TO CHARTSET



M-Climate: this stands for Model Climate.
It is derived by rerunning a 11 member ensemble over the last 20 years (220 realisations).
M-Climate is always from the same model version as the displayed ENS data.
Note that;
Each of the box plot represents a weekly mean value and plotted at the end of the range.

ECMWF

Other types of Ensemble (ENS) Products

Probabilities of maximum temperatures exceeding thresholds

Home / Probabilities: maximum 2 m temperature, last 6 hours

Probabilities: maximum 2 m temperature, last 6 hours

Probabilities

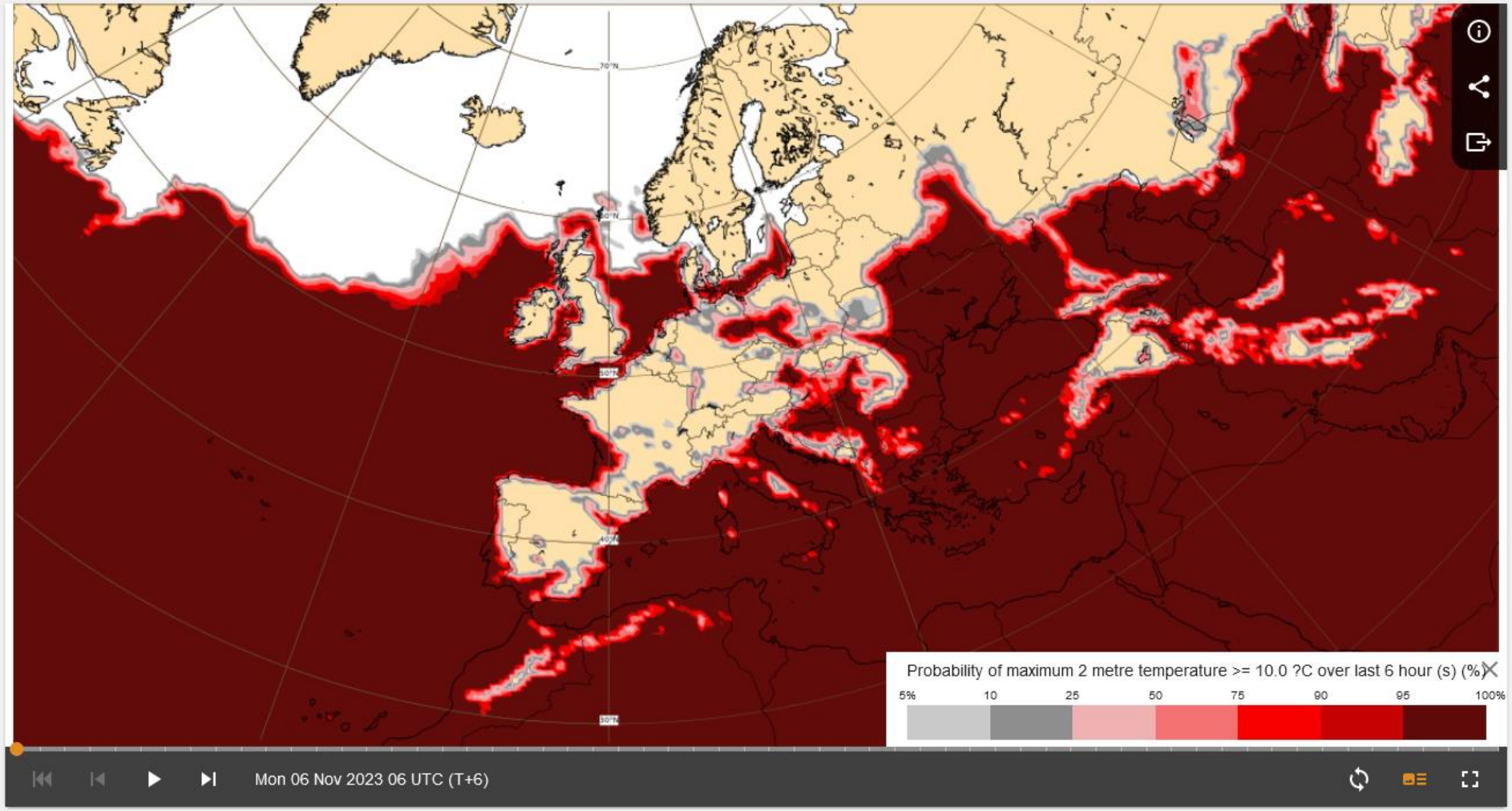
Base time
Mon 06 Nov 2023 00 UTC

Valid time
Mon 06 Nov 2023 06 UTC (T+6)

Area
Europe

Event threshold
>10 C

Can change
the threshold
>0 C
>10 C
>20 C
>25 C
>30 C
>40 C



Probabilities of 2m temperature below 0ºC

ECMWF | Charts

Help Log in

Home / Probabilities: 2 m temperature below 0ºC

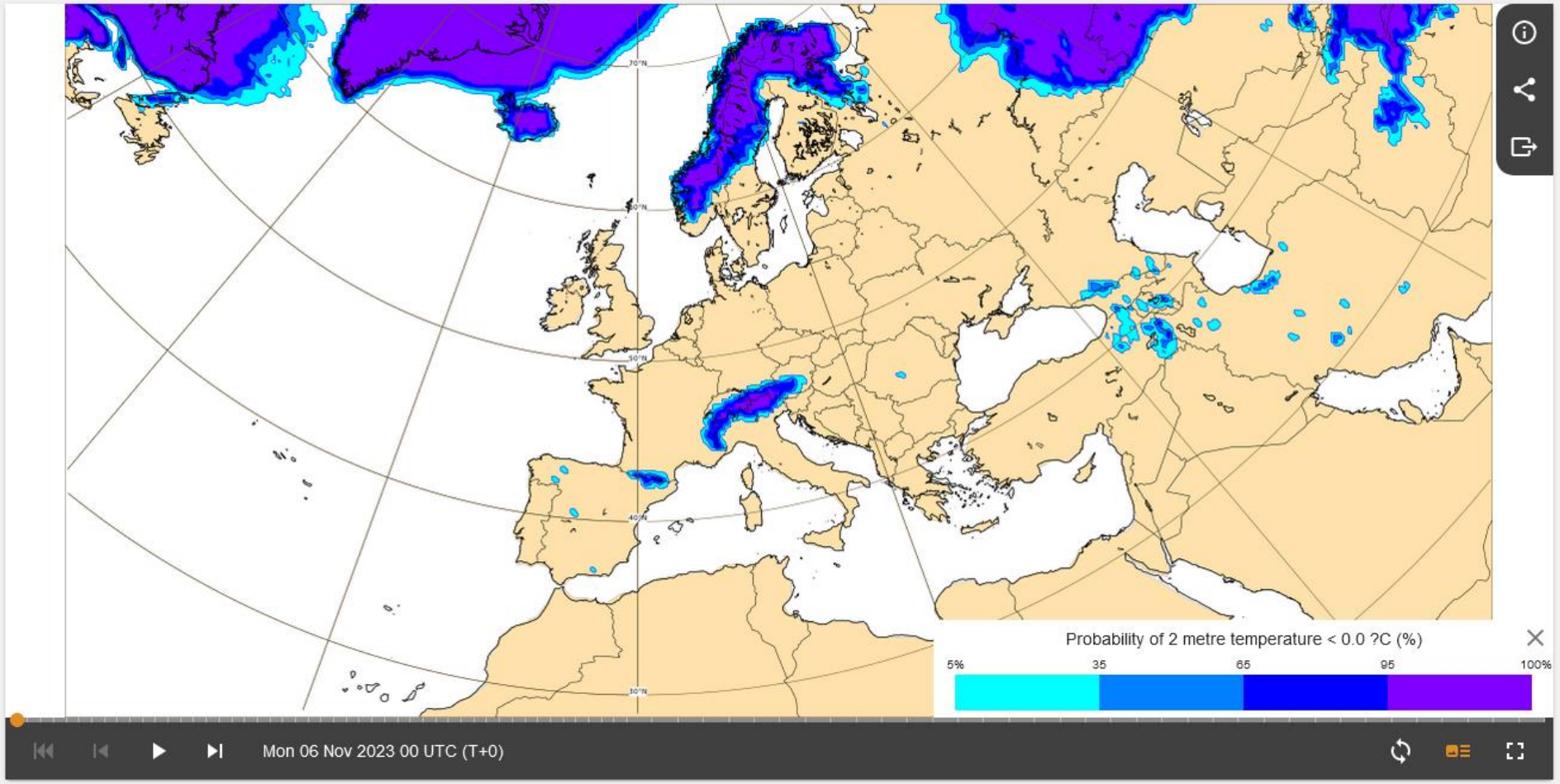
Probabilities: 2 m temperature below 0ºC

Probabilities

Base time
Mon 06 Nov 2023 00 UTC

Valid time
Mon 06 Nov 2023 00 UTC (T+0)

Area
Europe



Probabilities of rainfall in 12 hours exceeding thresholds

ECMWF | Charts Help Log in

Home / Probabilities: point rainfall during last 12 hours

Probabilities: point rainfall during last 12 hours

Probabilities

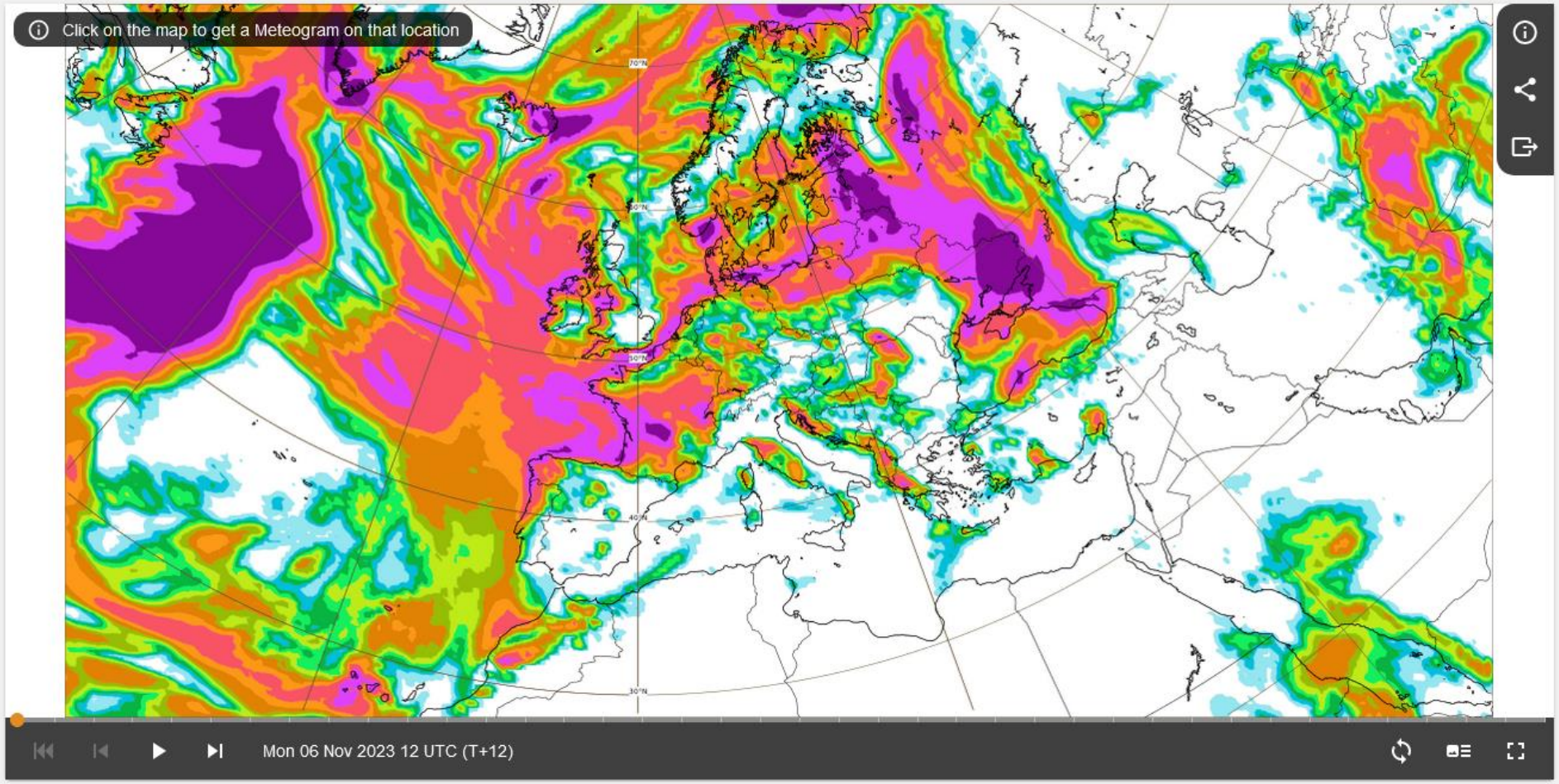
Base time
Mon 06 Nov 2023 00 UTC

Valid time
Mon 06 Nov 2023 12 UTC (T+12)

Area
Europe

Event threshold
>1 mm

Can change
the threshold
>1 mm
>5 mm
>10 mm
>25 mm
>50 mm



Probabilities of significant wave height

ECMWF | Charts Help Log in

Home / Probabilities: significant wave height

Probabilities: significant wave height

Probabilities

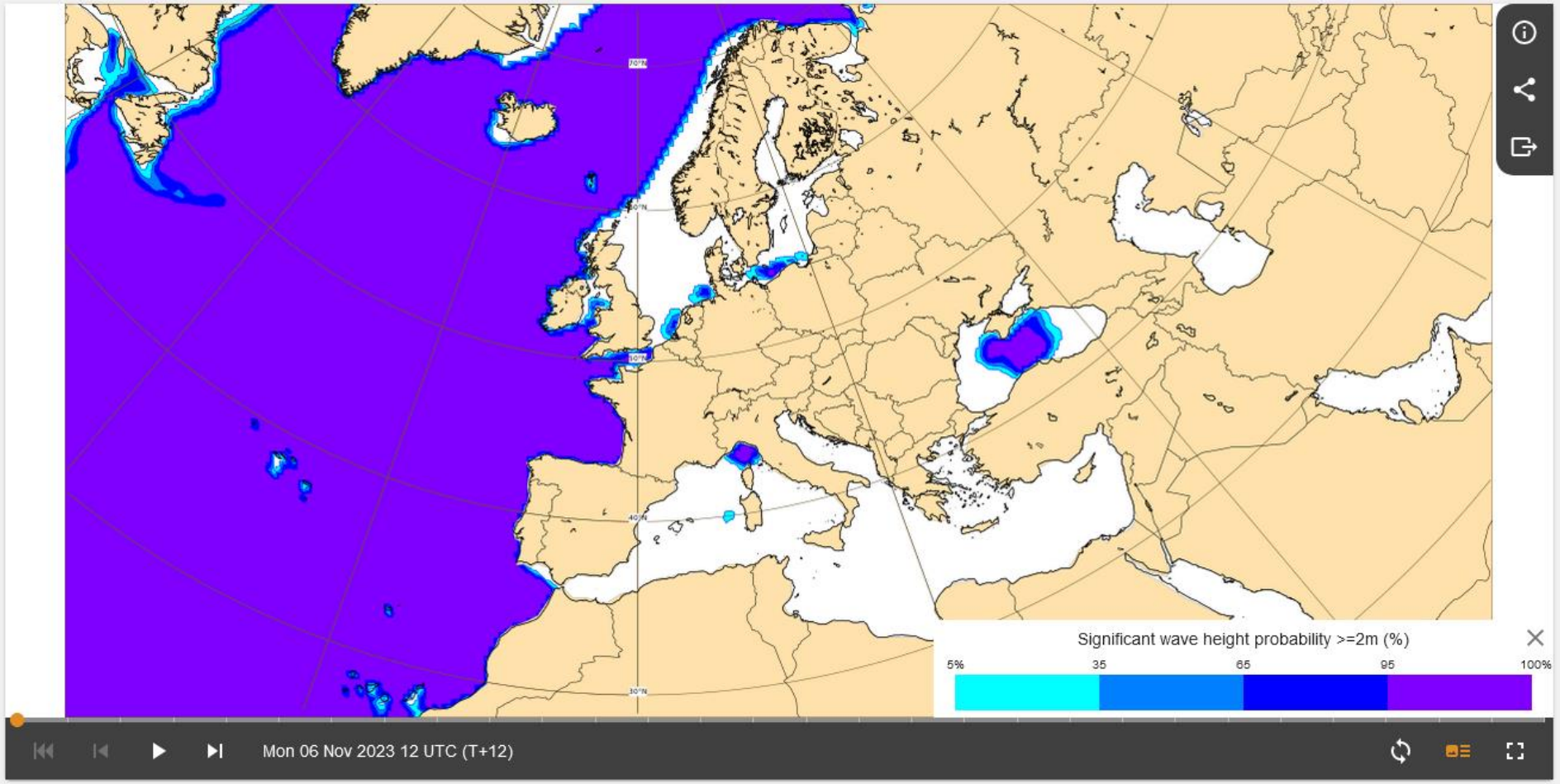
Base time
Mon 06 Nov 2023 00 UTC

Valid time
Mon 06 Nov 2023 12 UTC (T+12)

Area
Europe

Threshold
>=2m

Can change
the threshold
>=2m
>=4m
>=6m
>=8m



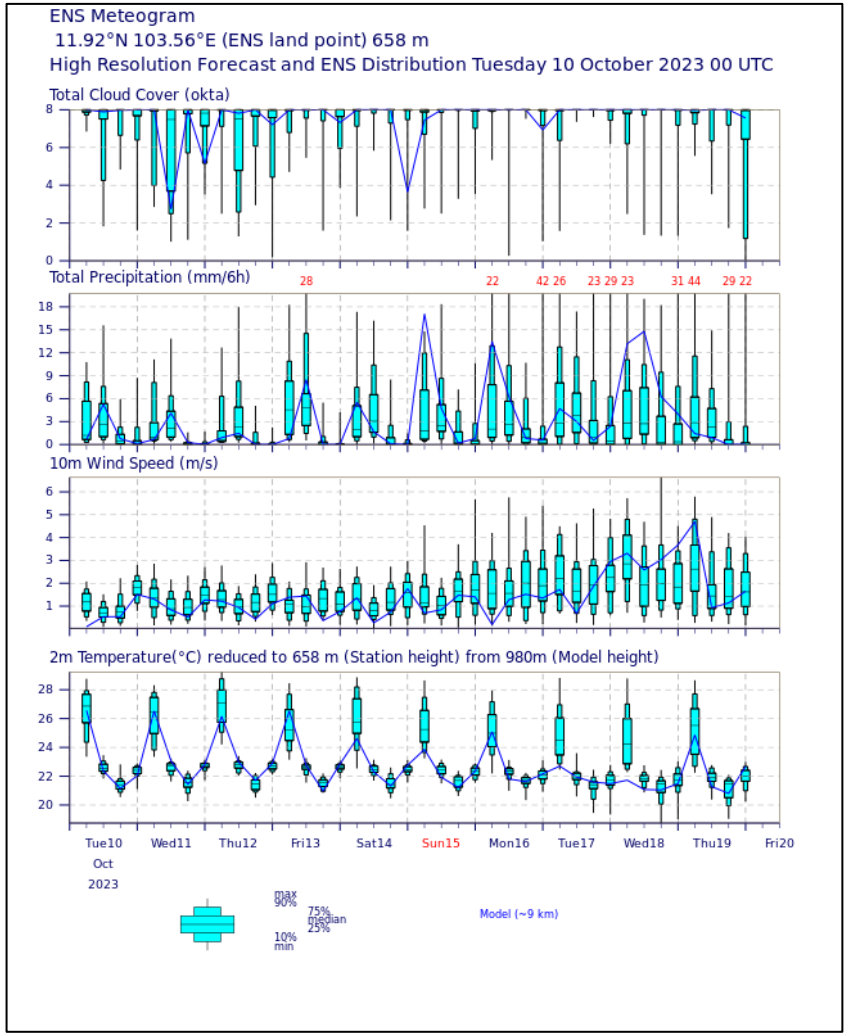
Communicating Uncertainty

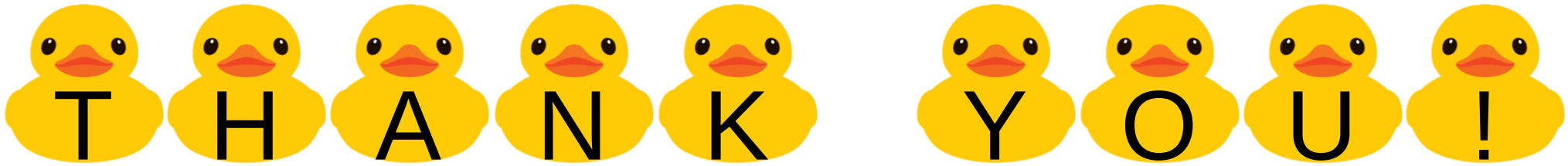
This can be difficult!

This is an example I like from the UK Met Office showing possible tracks of a storm and their likelihood

Recap of what we have learned so far!

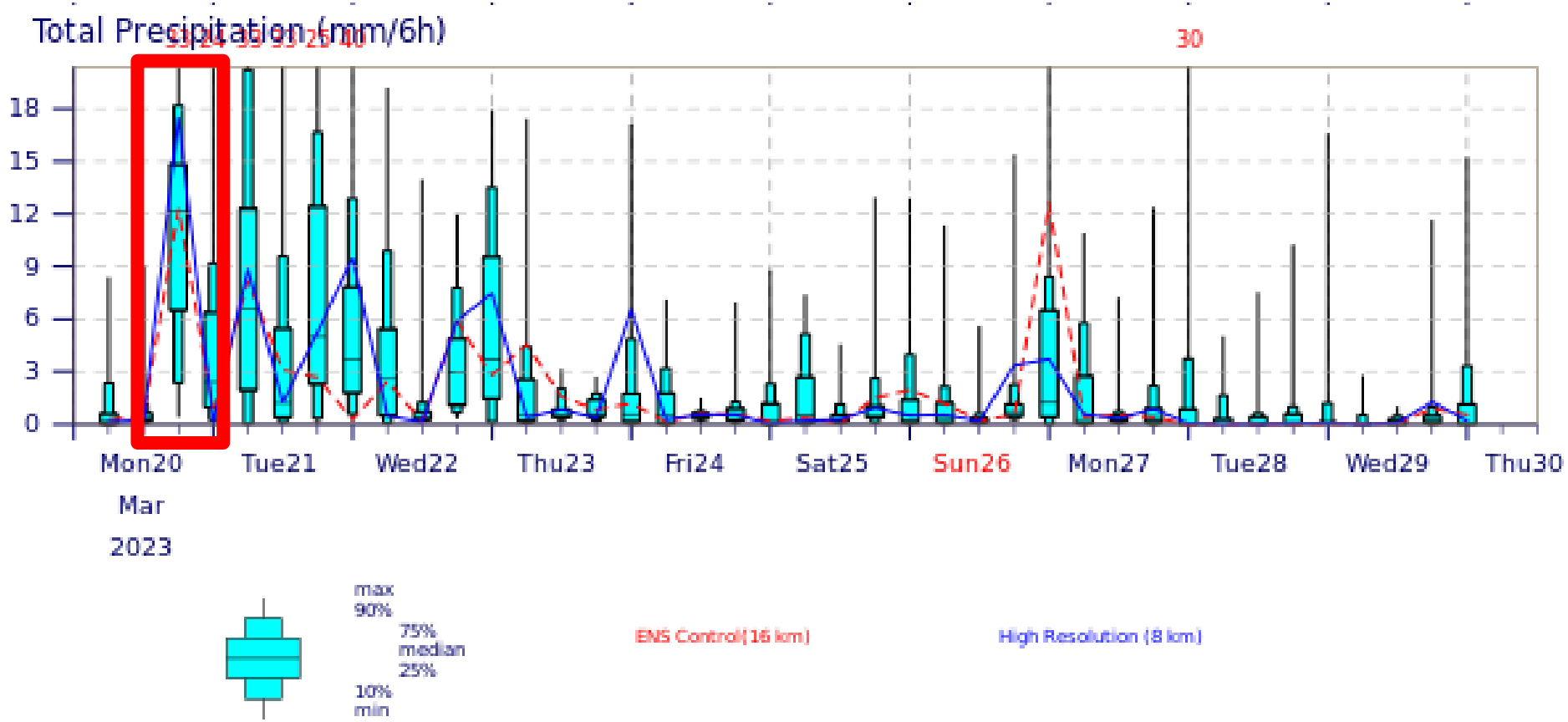
- How to access ECMWF products and information including ensemble products with Open Charts
- How an ensemble forecast is created
- Why forecast jumpiness occurs
- Meteograms
  - How a meteogram is created with ensembles
  - How to read a meteogram including uncertainty
  - All the different types of meteograms available at ECMWF
- ECMWF Ensemble Products available on OpenCharts
  - Precipitation Type
  - EFI and SOT
  - +many others!





Any Questions?

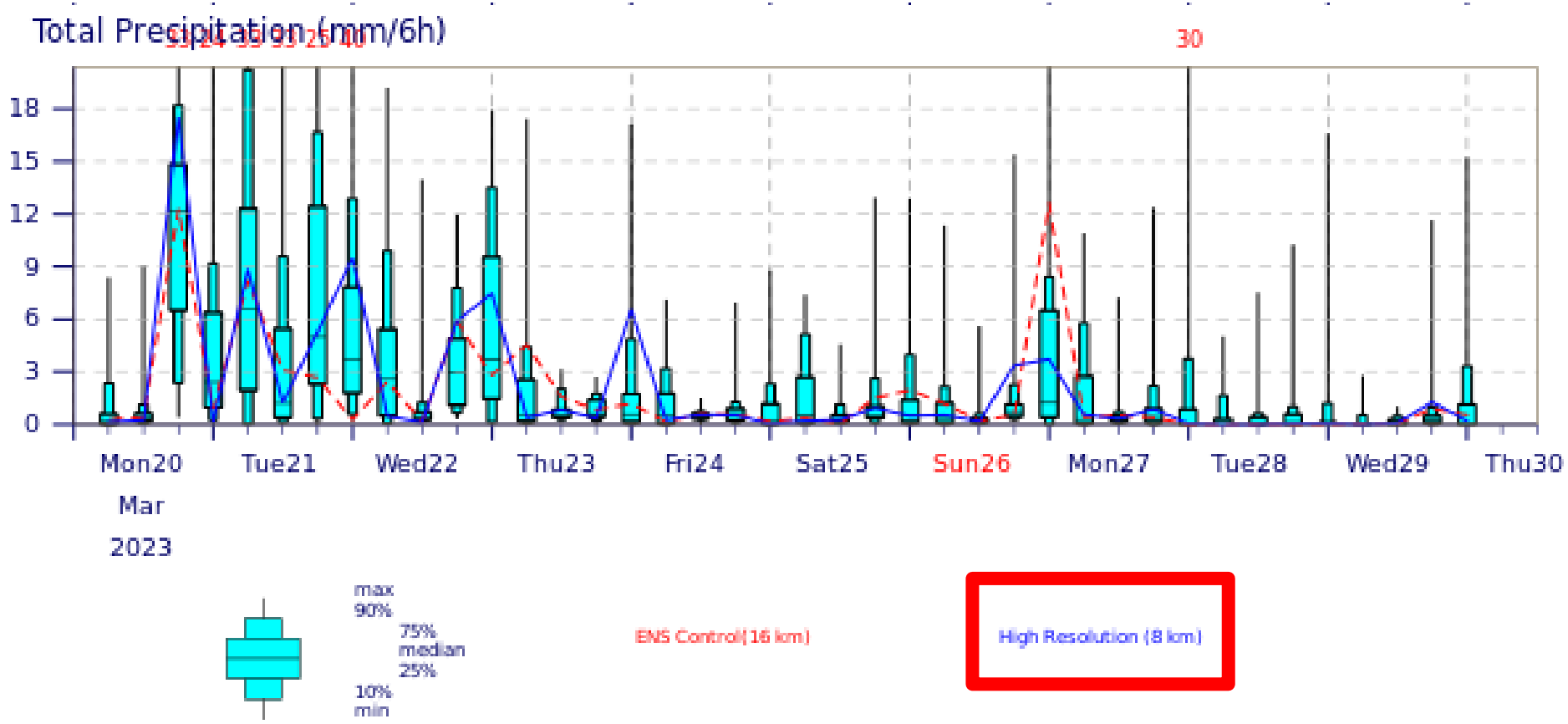
Answers



a. On Monday 20 March in the afternoon there is **LOW** / **HIGH** uncertainty in the total precipitation total.

ECMWF

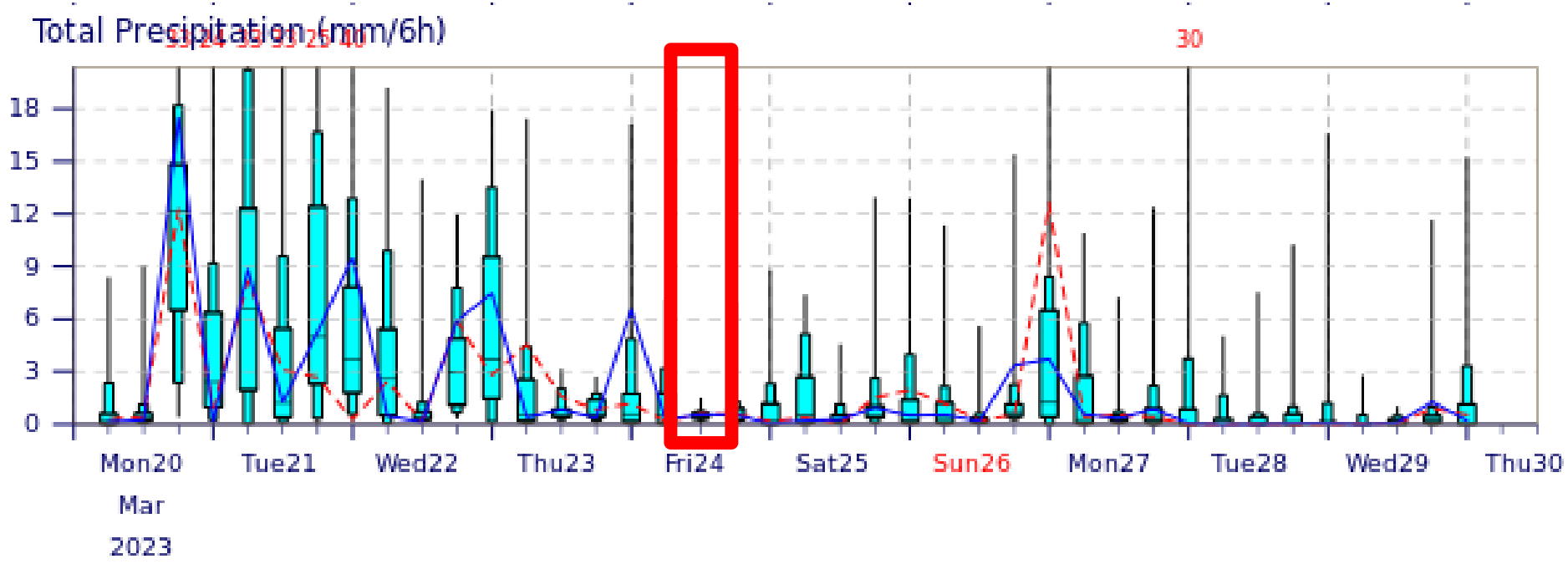
Answers



b. The High Resolution forecast (blue line) generally **AGREES** / **DISAGREES** with the ensemble forecast

ECMWF

Answers



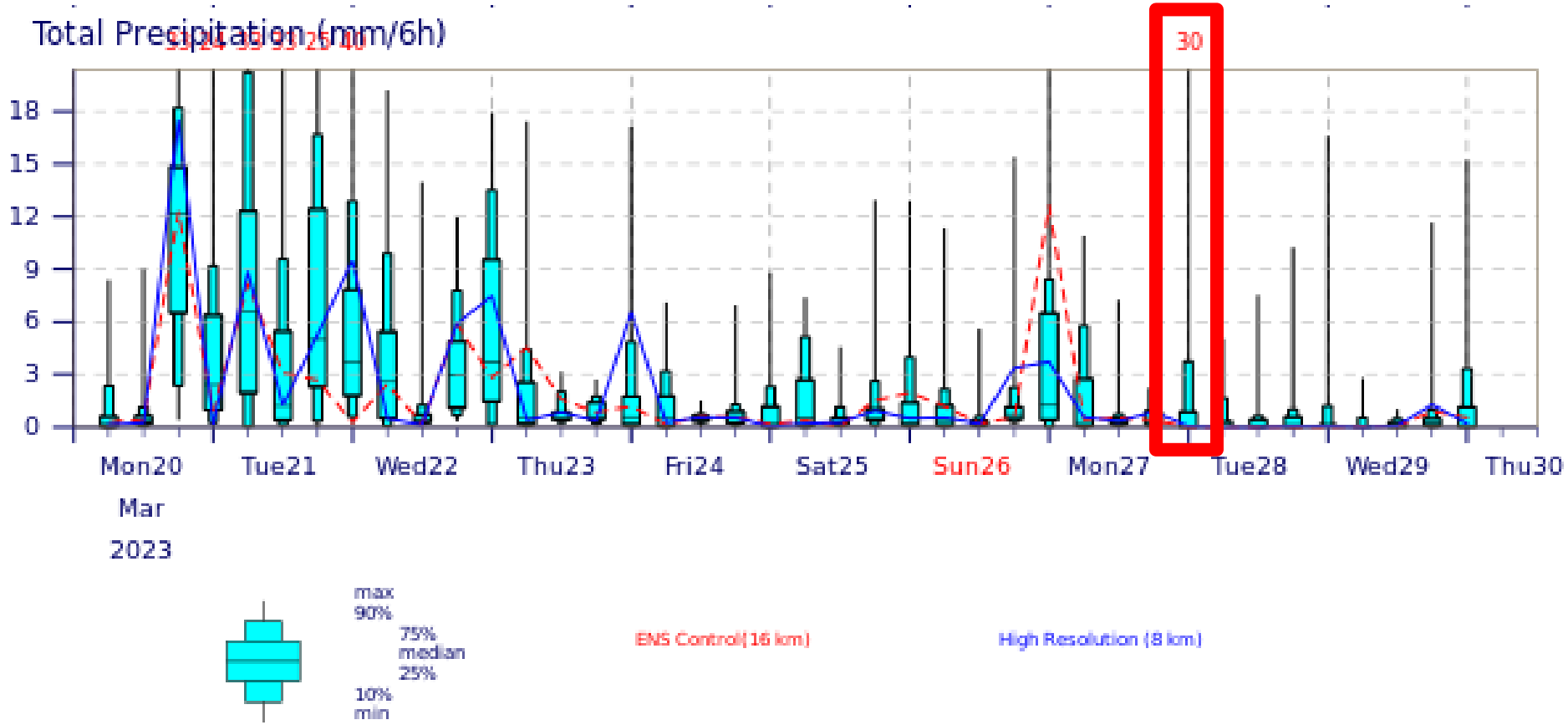
c. At midday (12 UTC) on Friday 24th March:

d. The forecast is for **NO RAIN** / **A LITTLE RAIN** / **LOTS OF RAIN**

e. The ensemble members generally **AGREE** / **DISAGREE** this suggests **LOW UNCERTAINTY** / **HIGH UNCERTAINTY**

ECMWF

Answers

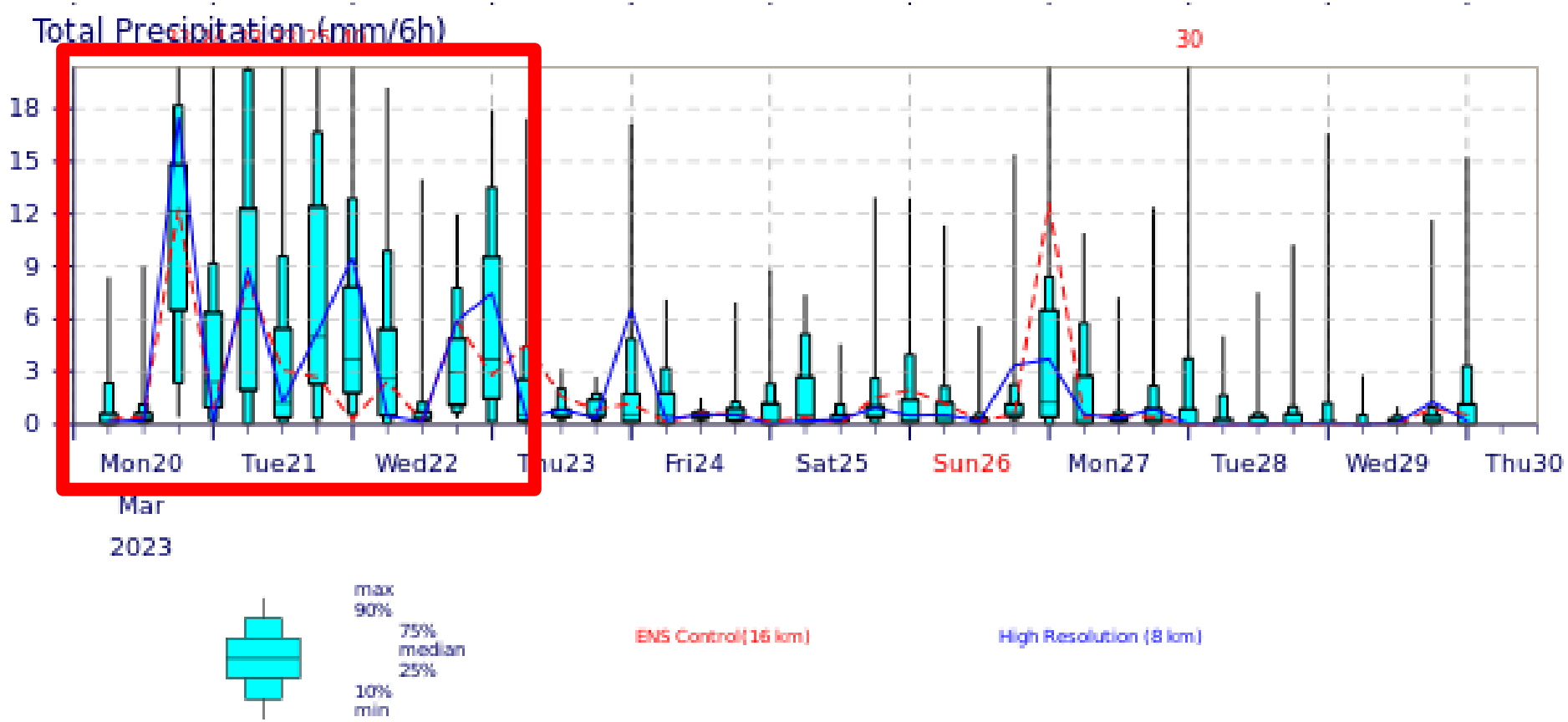


f. At 00 UTC on Tuesday 28th March, one ensemble member is forecasting a high of **30** mm of rain, this is **AN OUTLIER** / **THE MEAN VALUE** / **VERY LOW**

ECMWF

Answers

High uncertainty in precipitation amounts for Monday to Wednesday, high likelihood of rain but totals uncertain

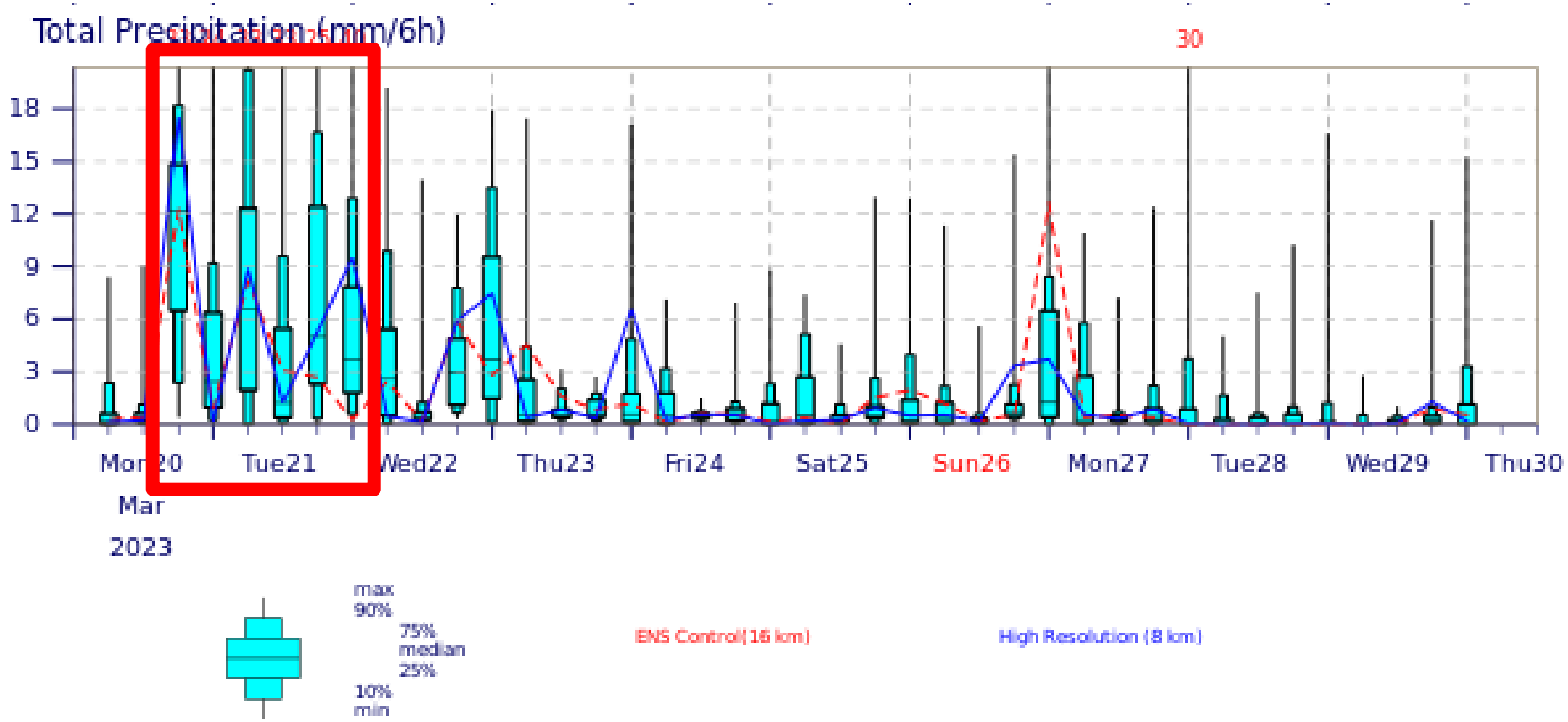


g. Write two sentences summarising what this meteogram is forecasting for precipitation over the next 10 days

ECMWF

Answers

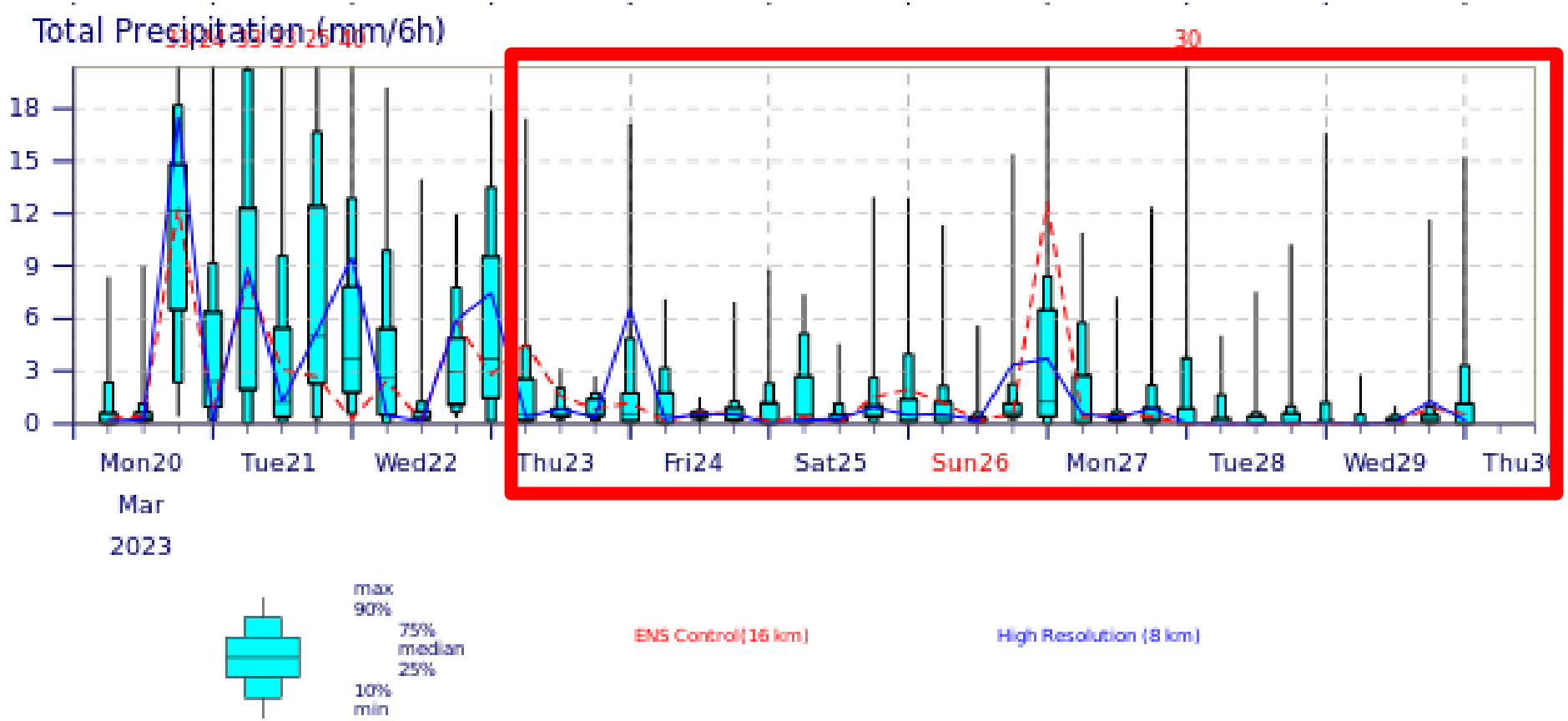
Monday evening to Wednesday morning, rainfall highly likely, the ensemble is showing high uncertainty



g. Write two sentences summarising what this meteogram is forecasting for precipitation over the next 10 days

Answers

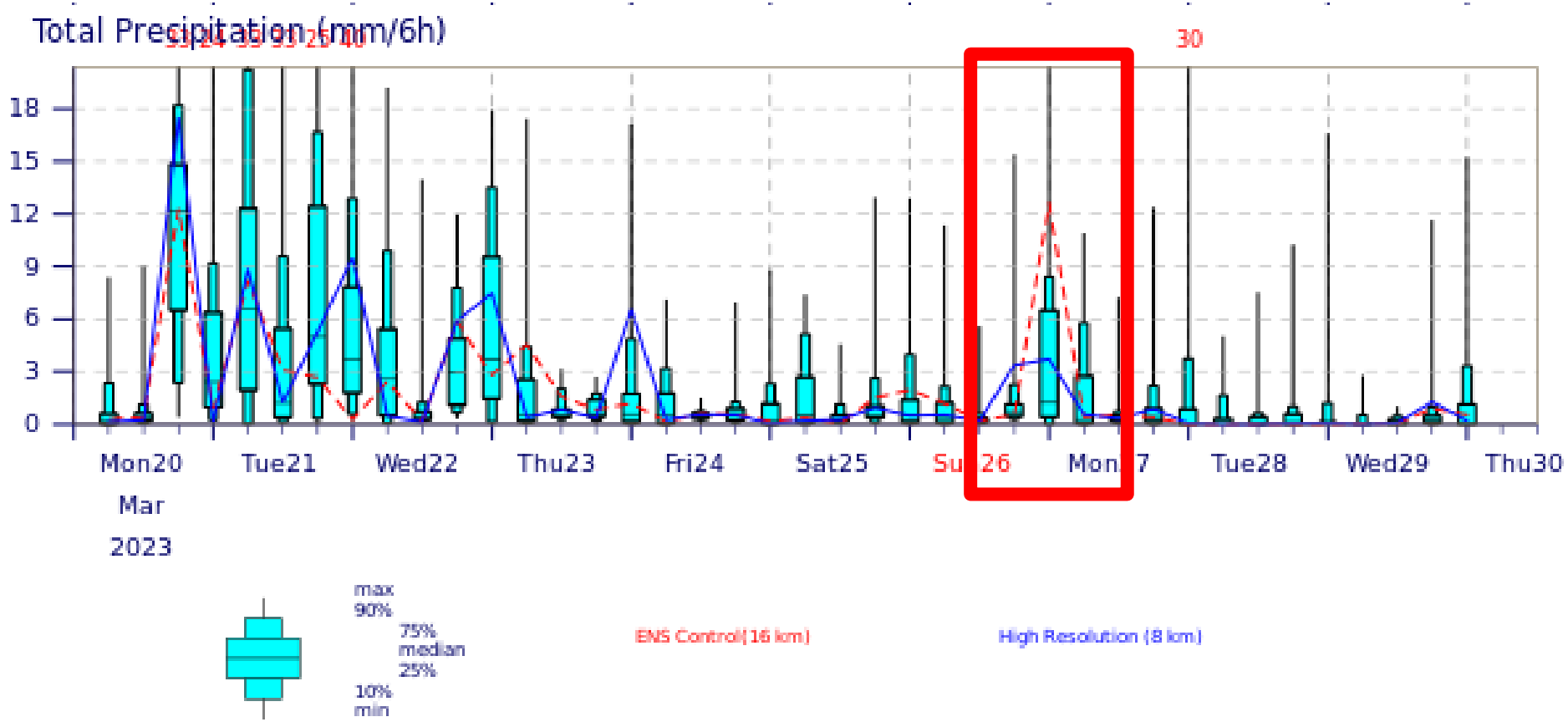
Thursday onwards, chance of rainfall however current forecasts are generally for low amounts



g. Write two sentences summarising what this meteogram is forecasting for precipitation over the next 10 days

Answers

Higher chance of rain Sunday evening into Monday morning



g. Write two sentences summarising what this meteogram is forecasting for precipitation over the next 10 days

Answers

a. What is the main advantage of an ensemble forecast?

i. To provide forecasts months in advance

ii. To give minute-by-minute forecasts

iii. To give a quantitative assessment of risk

b. What are the three main sources of error in NWP forecasts?

i. Initial condition uncertainty, model uncertainties and human errors

ii. Initial condition uncertainty, model uncertainties and boundary condition uncertainty

iii. Model uncertainties, time uncertainties and boundary condition uncertainty

Answers

c. What does a nearly vertical Cumulative Distribution Function (CDF) suggest?

i. Bi-model distribution of values

ii. Good agreement between ensemble members

iii. Ensemble members don't agree

d. Why do we use Shift of Tails (SOT)?

i. To indicate which type of weather will be extreme

ii. Because it has a nice name

iii. Because it provides information on how extreme an event might be

Answers

e. What is the control ensemble member?

i. The member run from unperturbed initial conditions

ii. The highest resolution member

iii. The member started from the largest perturbation of initial conditions

f. What are meteograms?

i. A product that shows information about the tracks and intensities of storms in the forecast

ii. A way to represent the ensemble forecast for a single location

iii. A product focusing on the extremes of the distribution

Answers

a. How many perturbed ensemble members does ECMWF run?

i. 50 in both the 15-day ENS and extended range

ii. 50 in the 15-day ENS and 100 in the extended range

iii. 100 in both the 15-day ENS and extended range