# Web services for forecasters and applications
# ie: Vertical profiles
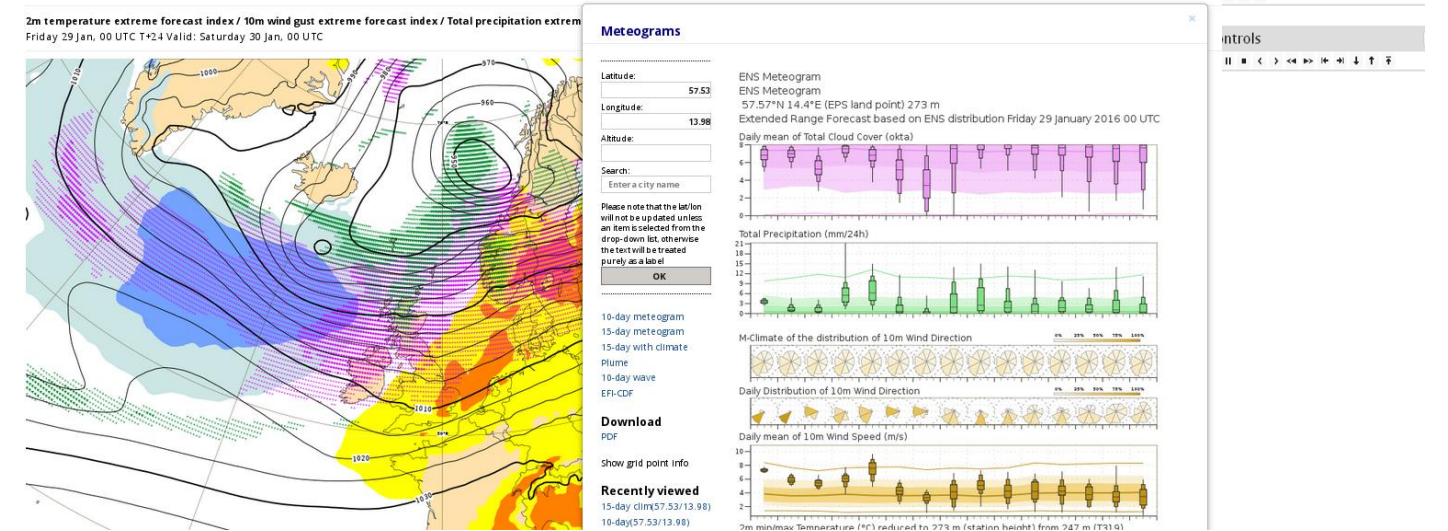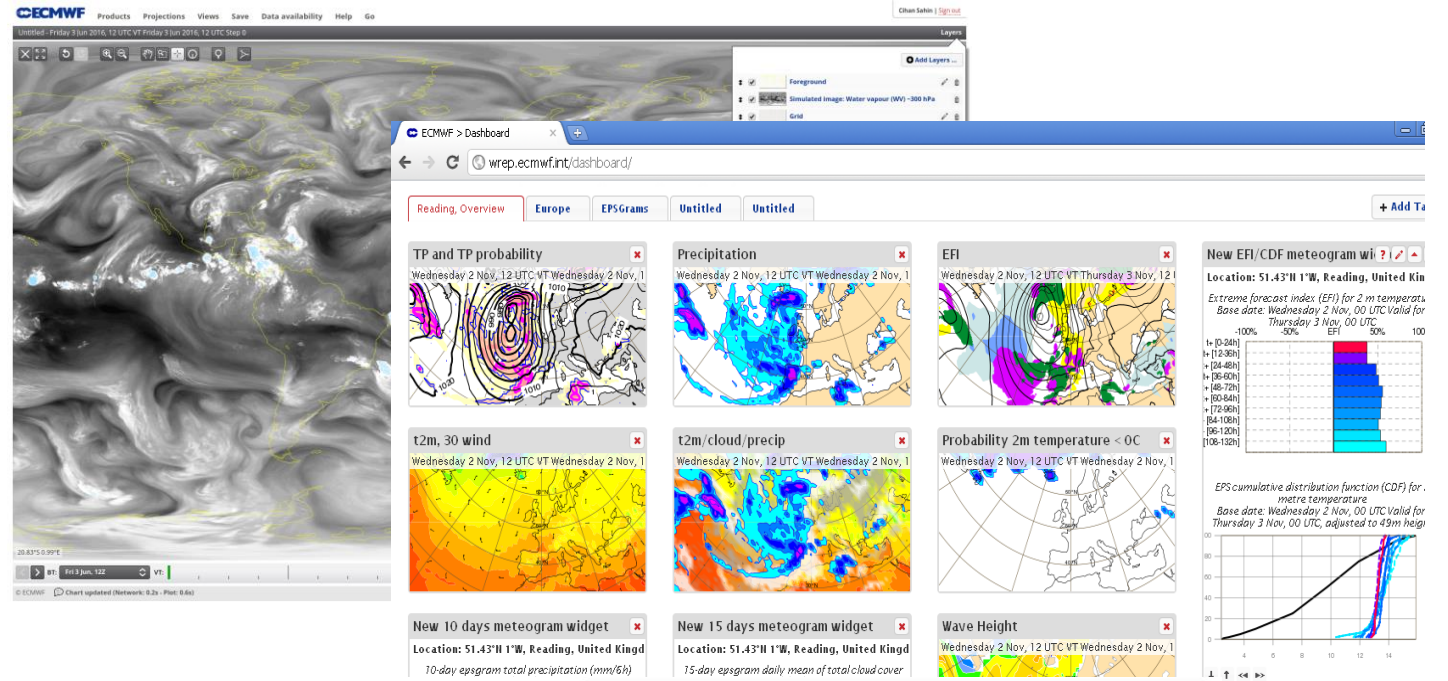
Cihan Sahin

On behalf of Web development team

Sylvie Lamy Thepaut, Tim Orford, Carlos Valiente, Cristian Coderean, Milana Vuckovic

**ECMWF**

# Content

- Web system

- Interfaces

- Point data

- Recent updates

- Upcoming changes

# Web system components

- Backend by Django

- Brokering by  RabbitMQ & Caching by Memcached

- Catalogue of products/layers/styles, user products …

  - MongoDB

- User interfaces by Javascript (Jquery)

- Data store (data layer)

  - GRIB fields for 2D fields

  - Special DBs for post-processed point databases

  - MongoDB for metadata

- Compute nodes (service layer)

  - Micro-services mostly in Python managed by celery workers

    - Retrieve, compute

    - GRIB field operations
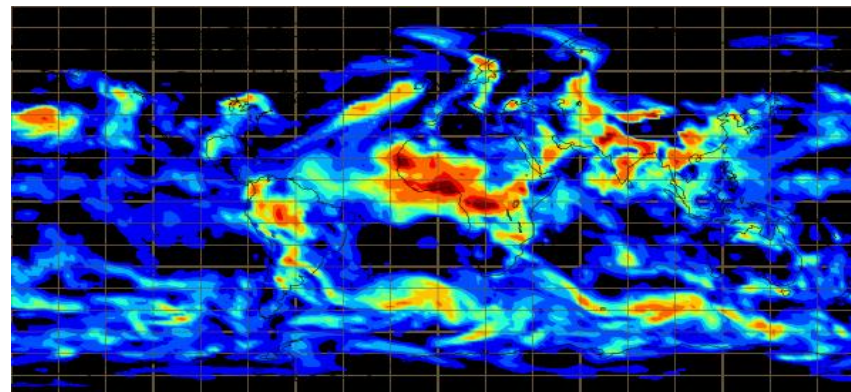
    - Plotting by Magics

# Interfaces to graphical products
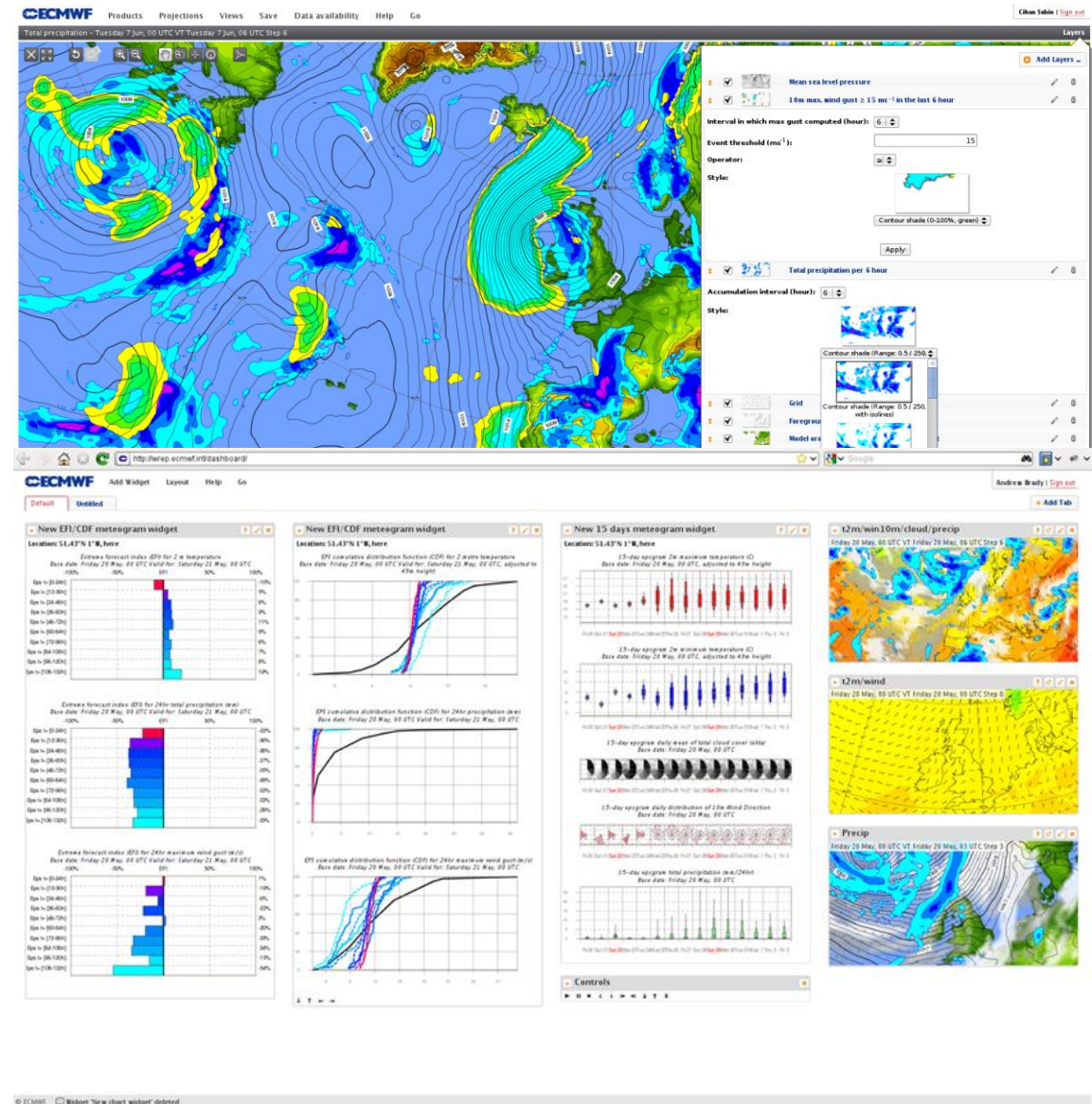
## ecCharts / Dashboard / WMS / Web charts
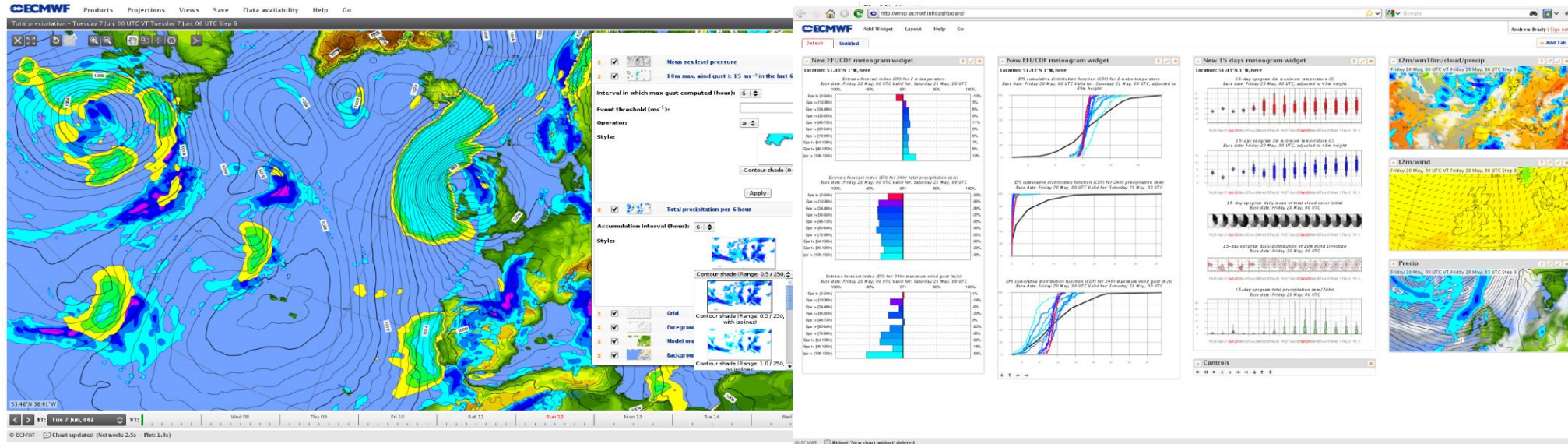
https://apps.ecmwf.int/wms/?token=public&request=GetMap&layers=composition_aod550,grid,foreground&width=600&bbox=-180,-90,180,90

**ECMWF**   EUROPEAN CENTRE FOR MEDIUM-RANGE WEATHER FORECASTS
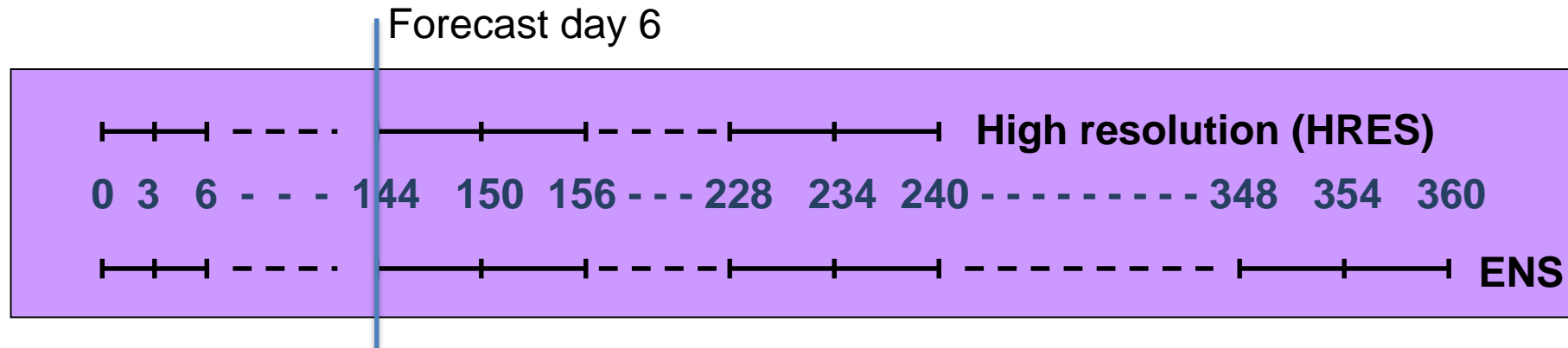
# ecCharts

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

- Native data resolution
- Immediate access to charts
- Interactive features (zoom, pan, click, extract data information, …)
- User controlled visualization
- Design and save products
- Customisable parameters
- Download charts (through WMS)
- Comparison of IFS parallel runs



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# Data in ecCharts

Forecast day 6



High resolution (HRES)

0  3   6  - - -  144   150  156 - - -  228   234  240 - - - - - - - - -  348   354   360

ENS

- High resolution and Ensemble model output (atmospheric & wave parameters)

- Point  data

  – Time series from ecCharts layers

  – ENS meteograms /ENS vertical profiles for a selected parameter set

- Ensemble derived data

  – Probabilities, Percentiles, EFI/SOTs, Model-climate, Ensemble mean and spread …

- Extended range data (Up to 6 weeks)

# Data in ecCharts

- 2D fields
  - Mostly in GRIB
  - 900 GB / cycle  *2 cycles a day *5 days retention ~= 9 TB
  - Octahedral grid (non-regular), O1280 for HRES, O640 for ENS
  - If we are on IFS testing mode (e-suite), then this may go up to ~15 TB.

- Point data for ENS meteograms/vertical profiles
  - Pre-defined set of parameters
  - Pre-defined percentiles
  - ENS grid (Octahedral 640)
  - 400 GB / cycle * 2 cycles * 7 days retention ~= 6TB
  - If we are on IFS testing mode (e-suite), then this may go up to ~10 TB.

# Chart dashboard

- Collect charts / meteograms on a single "page".

- Display your favourite products together.

  – ecCharts products

  – WWW charts

  – Meteograms

  – Vertical profiles

- Create tabs each containing many products.
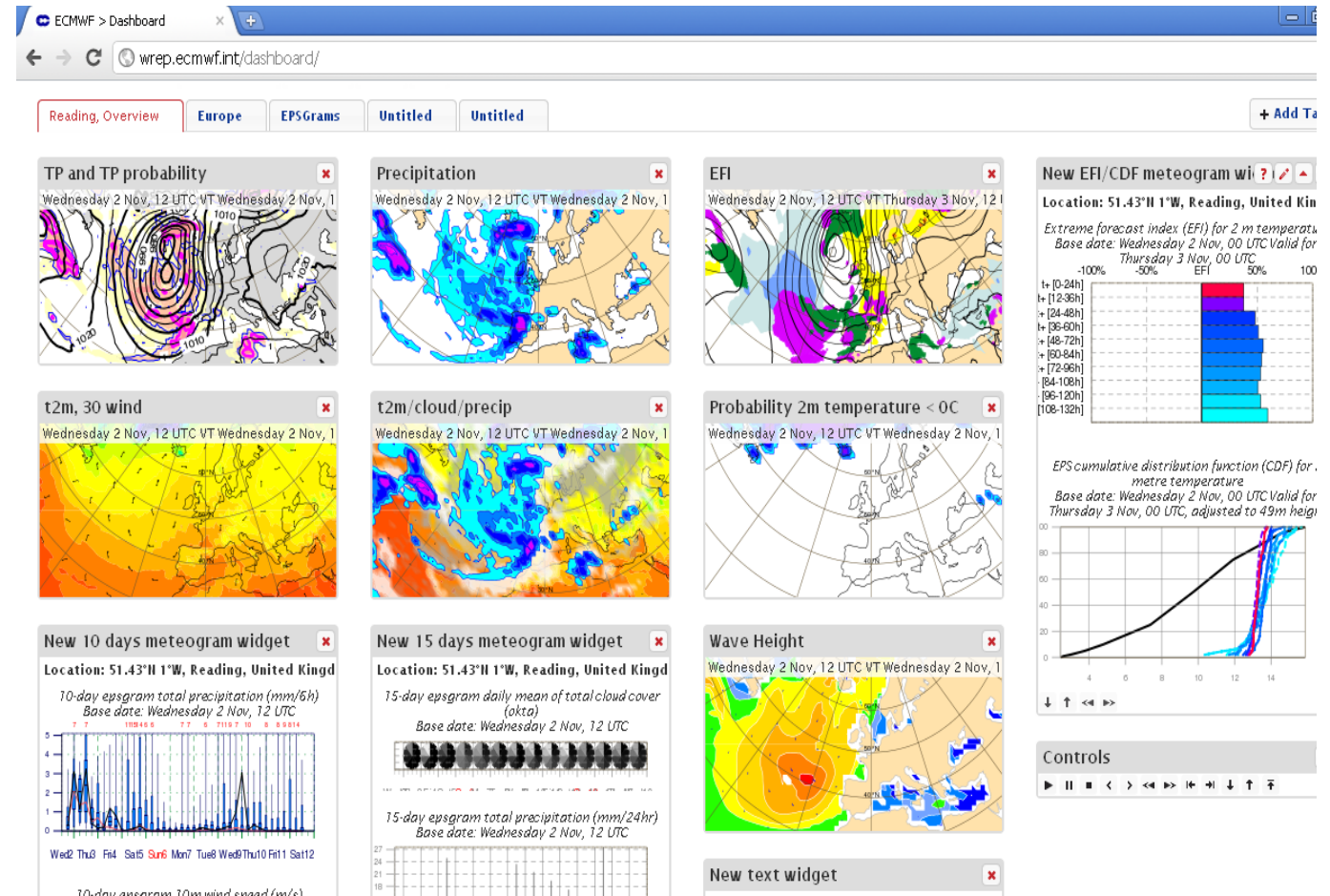
# Web Map Service (WMS)

- Automatically download geo-referenced images from ecCharts system.

- Intended to be consumed by other visualisation systems.

Your user wants to be able to see probability product for temperature.

They want to choose any area any zoom level and any threshold.

- Download all ENS data

- Ingest to your visualisation which displays global fields, zoom, and generates any probability …

- Prepare visualisations (Colours, ranges …)

- Single parameter GBs

Time cost : ?

Option 1

Option 3

Option 2

Use ecCharts
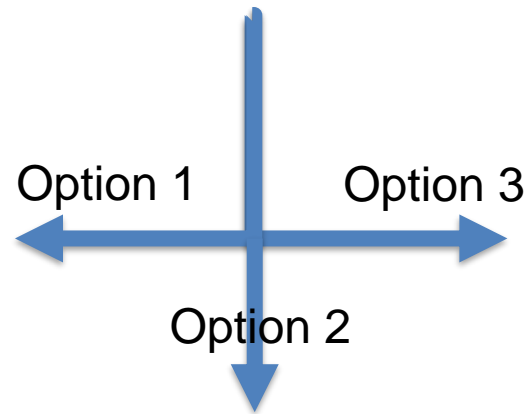
- Request for any bounding box/probability threshold, colour styles …

- Make request to ECMWF WMS, get the chart

- Display or overlay with your own charts

Time cost : 3-10 seconds

# WMS

- Available versions:  1.1.1, 1.3.0 (1.3.0 is default)

- Available projections: EPSG:4326, EPSG:3857, EPSG:32661

- Almost all ecCharts layers are available (~ 250)

- Many other layers also served through WMS

  – Atmospheric composition (CAMS)

  – Some EFAS parameters
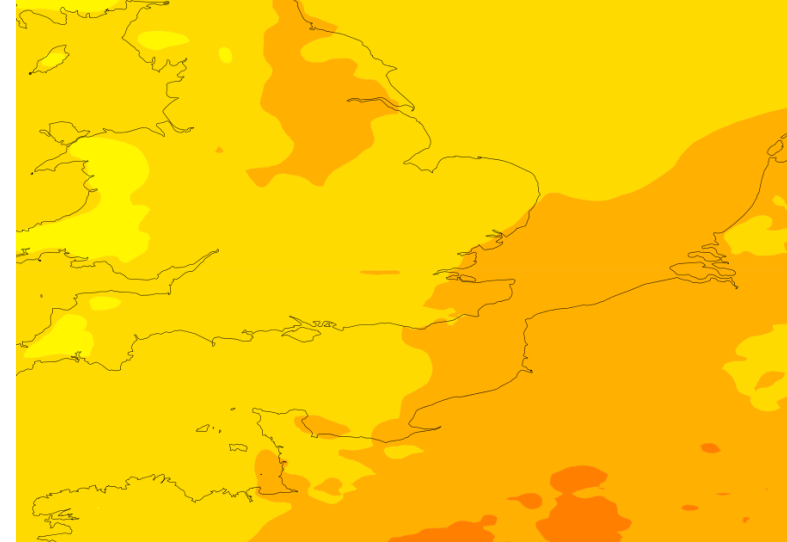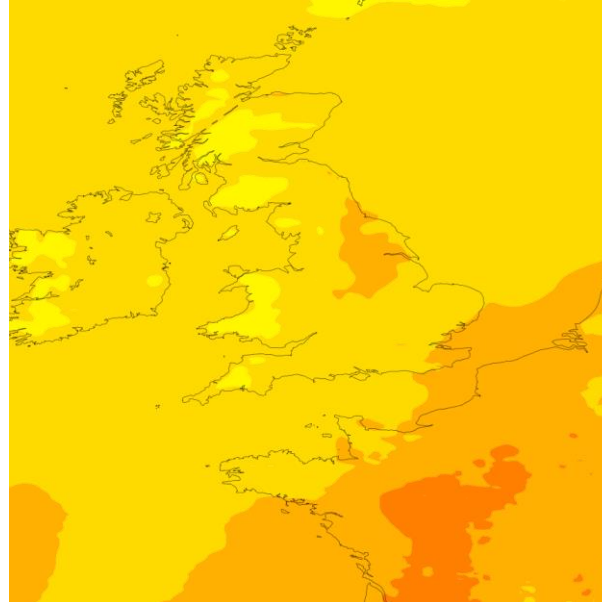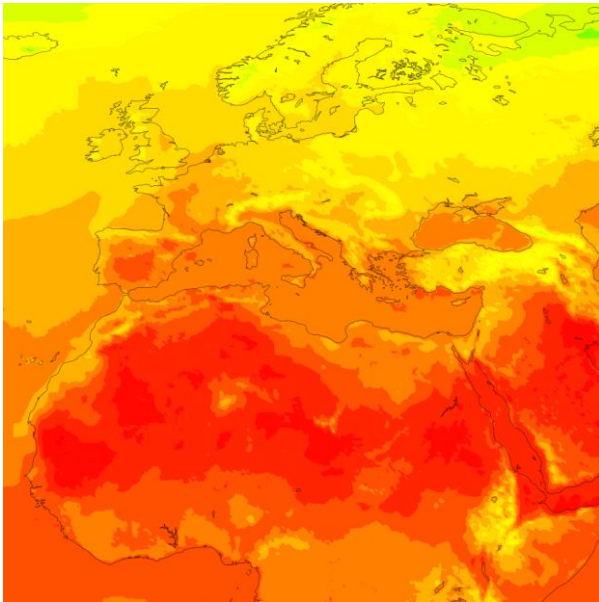
# Ensemble data

ecCharts provides an easy way to access and visualise ECMWF Ensemble data

Ensemble data = 50 perturbed forecasts (lower resolution) + Control forecast (No perturbation)

What is the probability of precipitation > 5 mm/ 6 hr ?
How about over 24 hr ?

Show ENS temperatures for 90 th percentile ?

How about ENS distribution for a given point ?

What is the probability of precipitation > 5 mm/ 6 hr AND wind speed > 10 m/s ?
How about over 24 hr ?

Customising charts is the key functionality to explore Ensemble data in detail.

- Charts need to be generated dynamically from raw data.

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# ENS data in ecCharts



What is the probability of precipitation > 5 mm/ 6 hr ?
How about over 24 hr ?
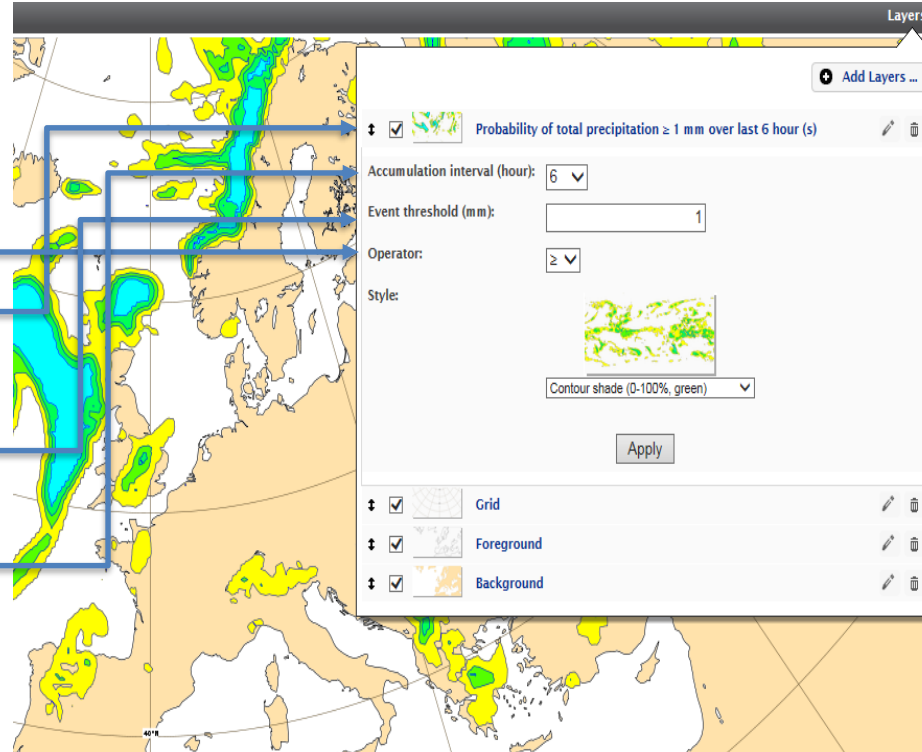
- ENS probabilities
- ENS percentiles
- ENS combined and weighted probabilities
- ENS mean and spread
- EFIs
- SOTs
- Cyclone strike probabilities
- Cyclone tracks
- Model-climate
- Most probable precipitation type
- Spaghetti plots
- …

- Similar customisation applies for percentiles and probability of combined events and weighted probabilities …

- Also available in WMS

# Point data

- 2 main systems
  - Extracting time-series point data from a given ecCharts layer
  - Specially designed DBs for ENS data.

- Graphical access
  - ecCharts layers (time series)
  - ENS percentiles as time series (Meteograms)
  - ENS vertical profiles

- Data access
  - Meteogram data in Web API
  - Vertical profile data in Web API soon
  - Data from any layer in ecCharts by getFeatureInfo

# ENS meteograms

- Position based forecast plots displaying pre-defined ENS percentiles.

- Distributions are displayed using a box and whisker plot.

- Types of meteograms;

    – 10-day meteograms

    – 10-day meteograms for wave parameters

    – 15-day meteograms

    – 15-day meteograms with model climate
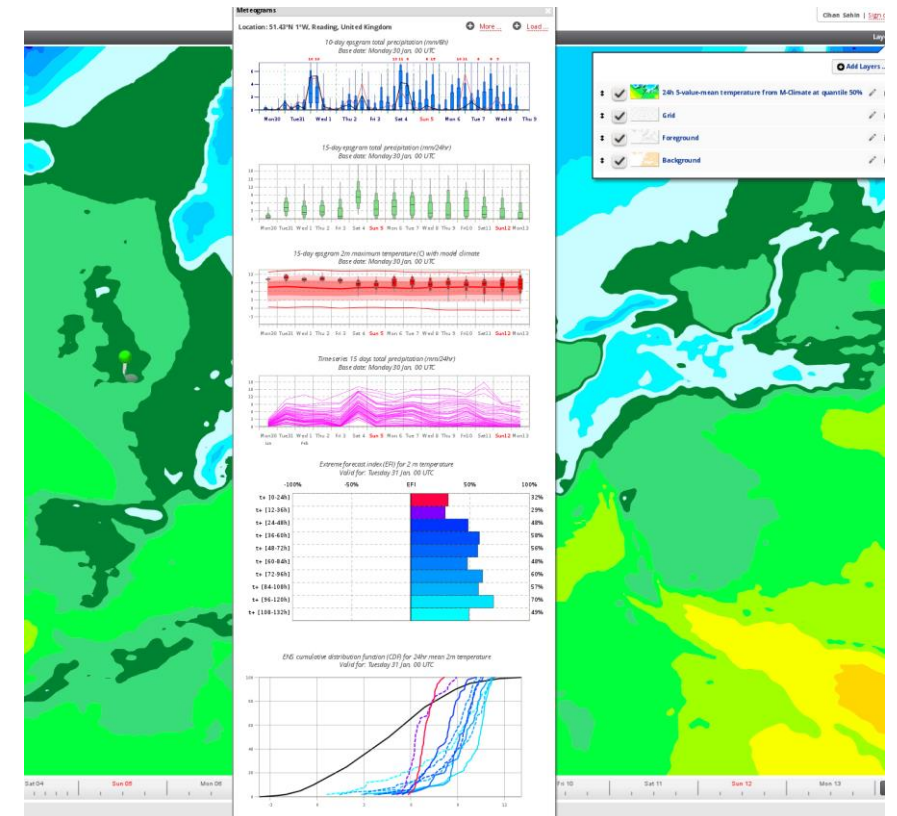
    – Plumes

    – ENS members (individual lines)

    – EFI and CDF diagrams

    – Extended range meteograms (Anomalies)

- Access through ecCharts/web charts / download …



10-day epsgram 10m wind speed (m/s)
Base date: Saturday 6 Jun, 00 UTC
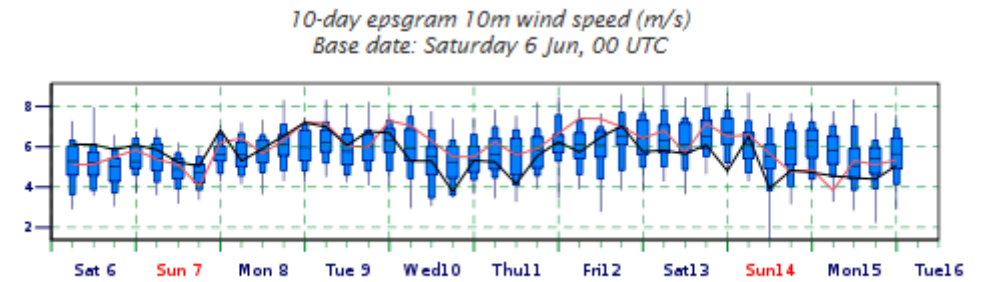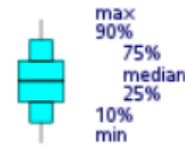
ENS Control (31 km)    High Resolution (16 km)

# Meteogram data on Web API

- Data we use to generate ECMWF meteograms are available to download by Web API

- Only available for Meteogram parameters and only on the percentiles displayed on Meteograms

- Output in JSON format

  https://software.ecmwf.int/wiki/display/WEBAPI/Meteogram+RESTful+Web+Service

```
{
    "meteogram": "10days",
    "param": "2t",
    "location": "51/0.5",
    "date": "20170614",
    "time": "1200"
}
```

→

```
{
    control: […]
    hres: [ …]
    min,max,median,ten,twenty_five …: […]
    date,time,expver
    user_location
    ens_location
    distance
    ens_height, hres_height,land_sea_mask:
}
```

# Point data from ecCharts layers

- Delivers point data from WMS layers. (GetFeatureInfo)

- **https://apps.ecmwf.int/wms/?token=YOUR-TOKEN&request=getfeatureinfo&layers=2tprob&width=900&height=900&BBOX=-5,55,5,48&VERSION=1.1.1&threshold=290.15&x=898&y=450&SRS=EPSG:4326&info_type=timeseries**

- Only available on EPSG:4326
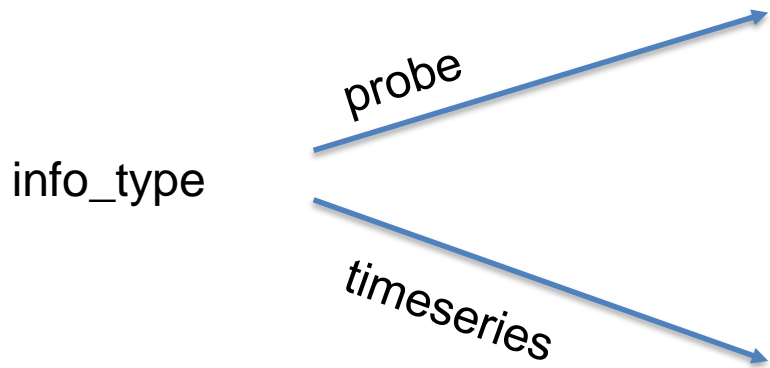
```
Name: 2tprob
Title: 2m temperature probability
Value: 0 %
Input latitude: 51.5
Input longitude: 4.97777777778
Grid point: nearest Distance: 8.67418 km
Grid point latitude: 51.5189

Grid point longitude: 4.85612
```

info_type

probe

timeseries

```
"Data" : [0, 0, 52.9375, 88.25, 100, 100, 100, 100, 0, 0, 100, 100, 100, 100, 100,
100, 43.125, 66.6562, 100, 100, 100, 100, 100, 100, 80.4062, 78.4375, 100, 100, 100,
100, 100, 100, 100, 100, 100, 100, 100, 100, 100, 92.1562, 82.3438, 100, 100,
100, 100, 100, 100, 96.0938, 100, 100, 100, 100, 100, 100, 100, 100, 100, 100, 100,
98.0312, 100, 100, 100, 100, 100, 100, 100, 100, 100, 100, 100, 100, 100, 100, 100,
98.0312, 100, 100, 100, 98.0312, 100, 100, 100, 98.0312] }
```

# ENS vertical profiles – a use case as a new development

- A vertical structure of atmosphere for a given point at a given forecast lead time.

- Continuously requested by users.

## Challenge

- 91 ENS vertical levels, each contains 50+1 ENS members.
- Post-processing: dew-point / percentiles.
- Input data (21 steps) ~800GB / cycle
- ~ One hour buffer time for computation/database generation
- Efficient DB design for fast retrieval

## Reduce data size

- 42 ENS vertical levels
- Parallel post-processing: 65 simultaneous tasks
- Input data ~350GB / cycle
- ~ 45 minutes processing time

## Result

- Output DB ~300GB / cycle
- Data at ENS resolution (O640)
- Plot delivery: 2-3 seconds / step

# ENS vertical profiles

- Available for all ENS grid points globally.

- Every 6 hourly up to day 5 (21 time steps)

- Accessible from

  – ecCharts (Menu > Views > Vertical profile window) and click on the map

  – Dashboard (Menu>Widgets>Vertical profile)

  – Clickable www charts (Click and choose vertical profiles)

- ecCharts /Clickable charts will show the vertical profile valid on the time of the background chart shown.

- To go through different time steps quickly, use Dashboard. Set your point. Use arrows to go on steps.
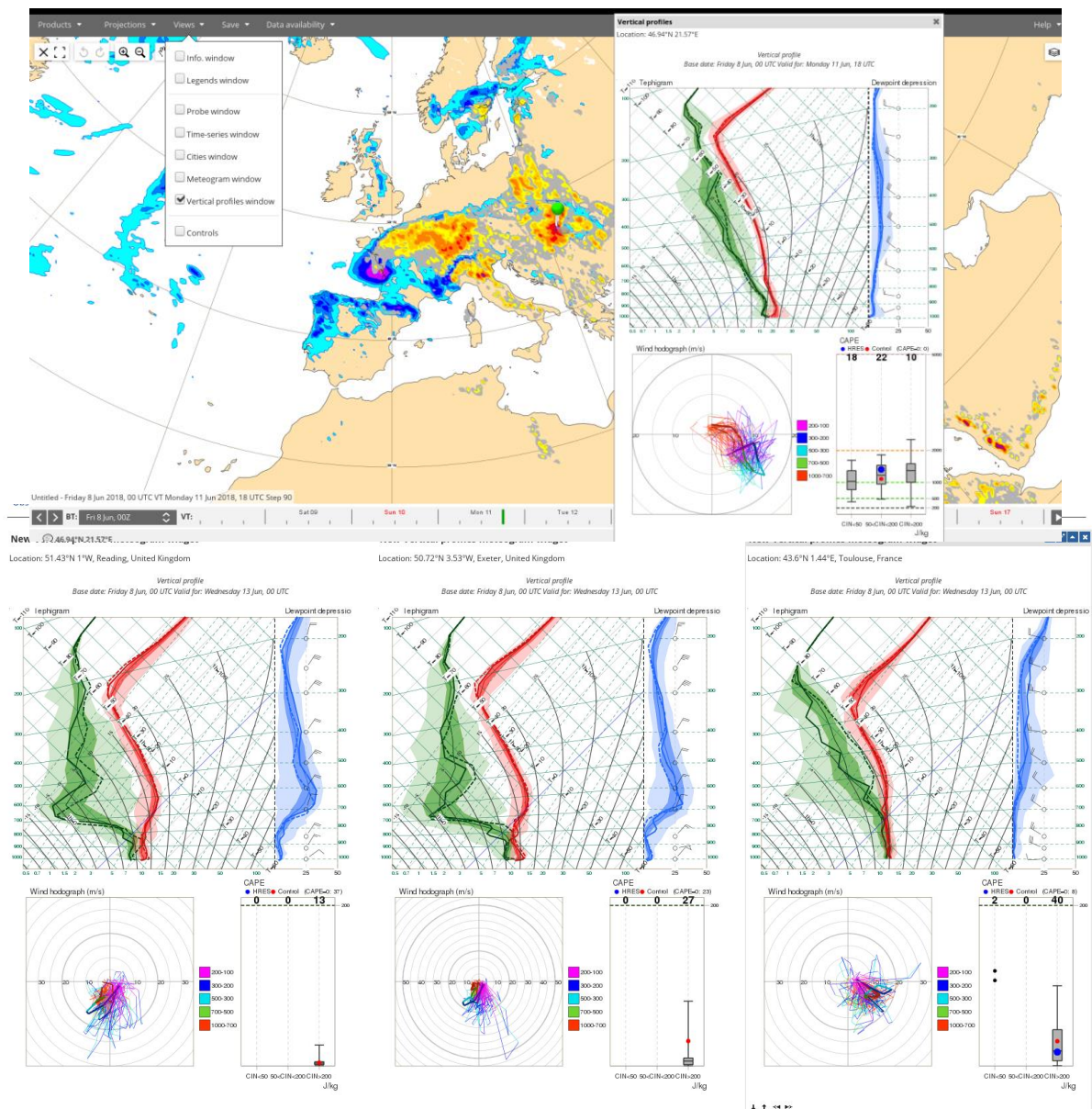
# ENS vertical profiles - II

- A tephigram, is used to show temperature and dewpoint ranges at different levels within the ENS.

  - Min/Max/25th/75th percentiles as shades

  - HRES: Thick line, Control: Dashed line, ENS Median: Thinner line

- Dewpoint depression (Shown similar to tephigram)

  - HRES wind at pressure levels

- Vertical wind distribution from ENS in hodograph form

  - A line for each ENS member, HRES thicker line

  - Colours for pressure level ranges

- Box and whisker plot showing distributions of CAPE for 3 different categories of CIN.

  - CAPE likely to be released (CIN<50 J/kg)

  - CAPE may be released (50<CIN<200 J/kg)

  - CAPE release not expected (CIN > 200 J/kg)
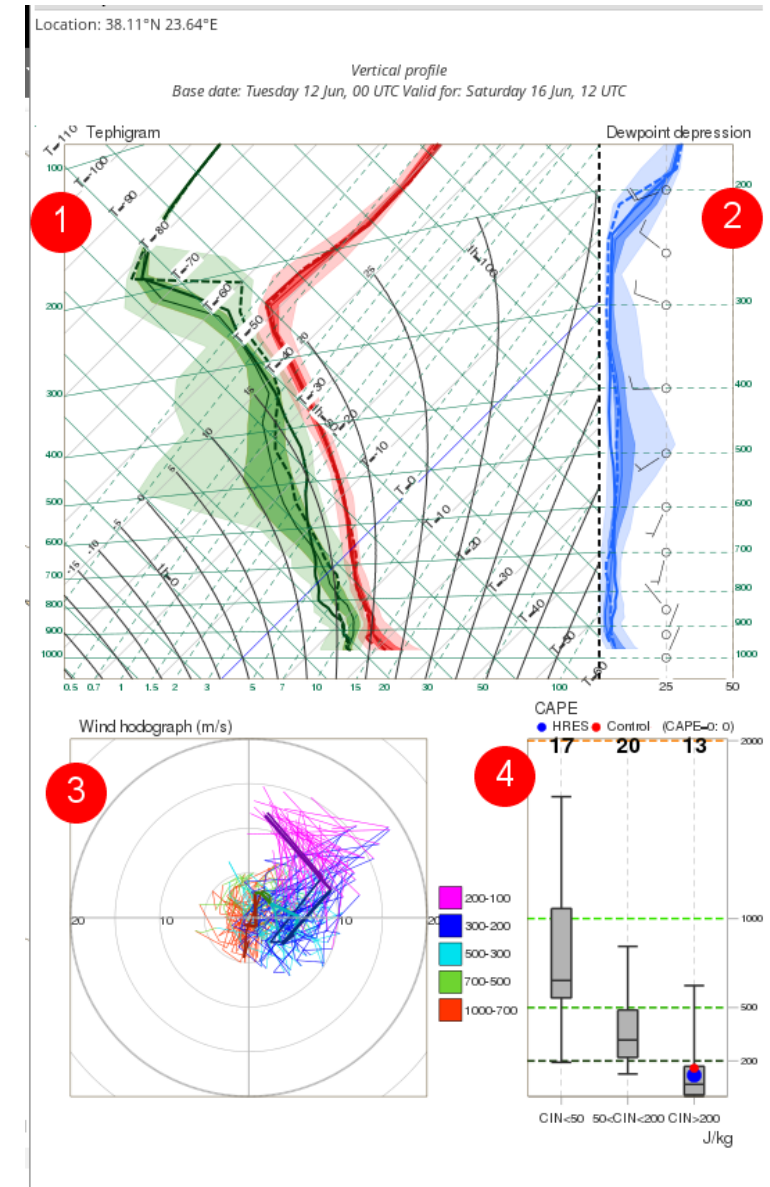
# Beyond medium range - Extended range charts

- First ever charts from extended range

  - Produced twice a week

  - Weekly time steps

  - Up to 6 weeks

- Ensemble mean anomaly charts

  - 2t, soiltemp/sst, precipitation, mslp, wind at various levels, sunshine duration, 500 geopotential …

- Probability quantiles (terciles, deciles …)

- Extended range meteograms

  - Ensemble mean anomalies with Model-climate
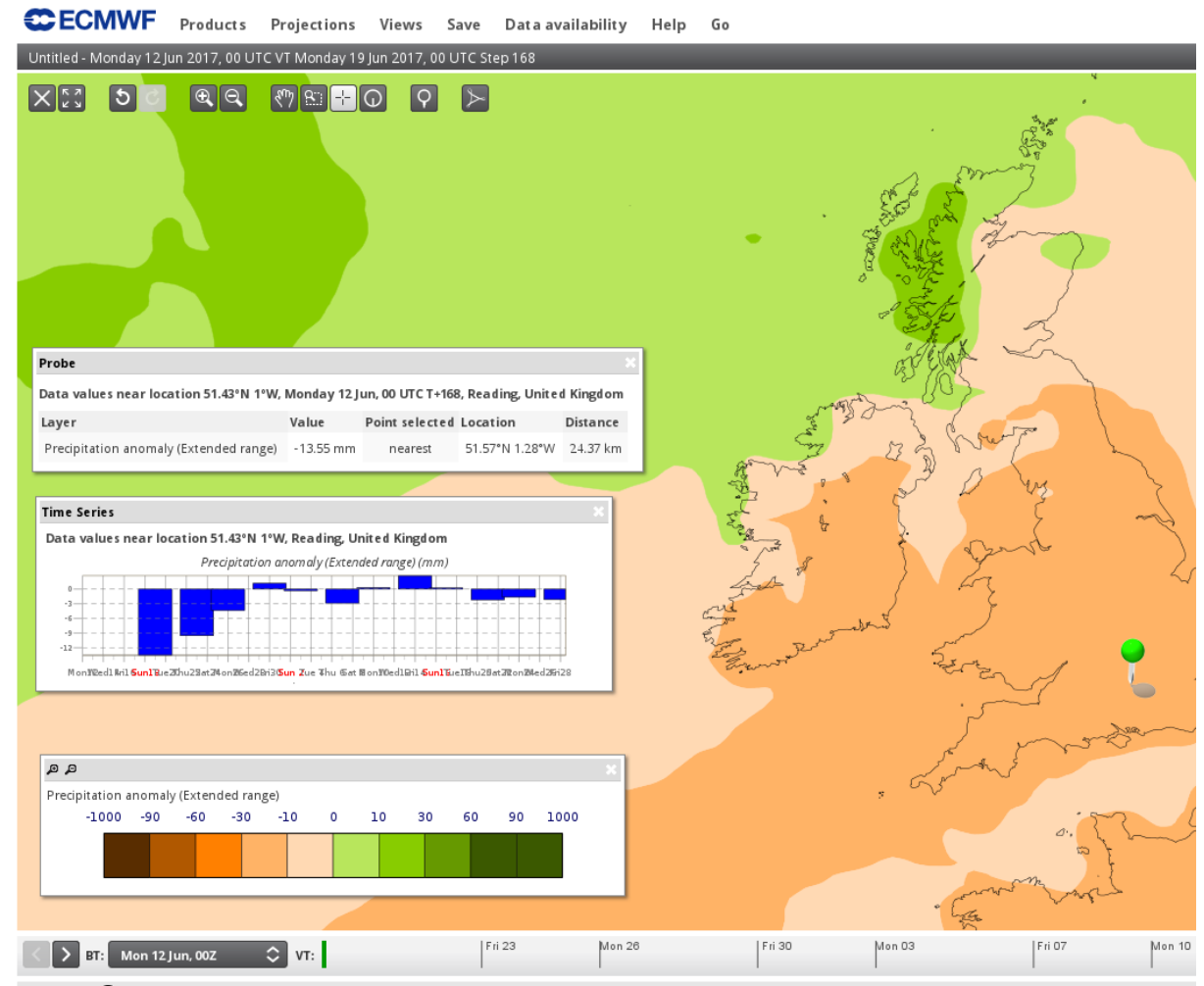
# Upcoming changes

- ecCharts is "slow" (Let's put it to context)

- Access to ~15 TB of data

- High quality charts from archived resolution

  - HRES, ENS derived data usually < 5 secs

  - ENS probabilities  < 10 secs for the first request

    - Following requests < 3 secs

- Point data ENS meteograms/vertical profiles

  - Access around 2-3 secs

  - Composite ones (EFI/CDF)  ~5 secs.

- No fixed size images (Size of browser)

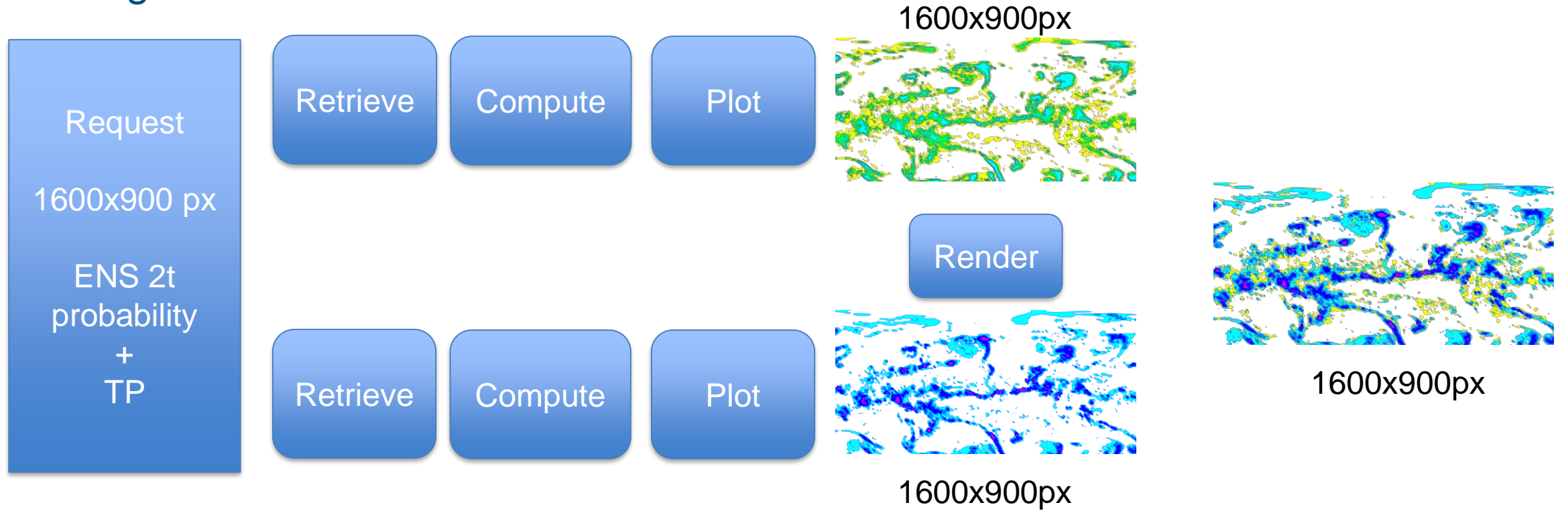- All involves;

  - Retrieval

  - Computation

  - Plotting

- ecCharts is almost 10 years old
- IFS horizontal resolution is updated twice (Data growth in latest resolution update ~4 times )
- More layers/data added continuously based on user requests.

- We continuously update/optimize the software & hardware

BUT …

- We still generate the charts the same way …

- Users say slow when a chart does not react "almost immediately"  to pan, zoom and click events.
- Users ready to wait a bit longer to load a new layer / product.

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# Chart generation



Request

1600x900 px

ENS 2t probability
+
TP

Retrieve → Compute → Plot

1600x900px

Render

1600x900px

Retrieve → Compute → Plot

1600x900px

Change image size, zoom level, bounding box ?    Re-Plot ⟶ And it feels slow !

# ecCharts 2.0

- Limited to change the chart handling in the ecCharts UI

  - WMS based requests.

- Use standard client software (Openlayers)

- Users happy with the UI. So no changes there.

- Expectation: faster response time especially for pan and zoom.

  - Use of tiles

    - Better caching

    - Smoother zoom and pan

  - Less helpful for initial layer loading (still improvement)

### Issues
- Limited caching
  - Too much data
  - Too little time
- Tiles mostly need to be generated dynamically
- Handling animations
  - Synchronized update of tiles
  - Single tile for animations ?

- Extensive testing

# Other changes

- ecCharts in the Cloud

  - Some preliminary work done early Summer, with promising results.

- Point data access optimization

  - Investigation on XArrays

- Additional layers as requested by users.

# To sum up … ecCharts provides a complementary service

- Tries to help with non-trivial issues
  - Highly available service
  - Native resolution, global fields
  - Immediate availability
  - Utilizing Ensemble data both as charts and meteograms
  - User oriented, large set of products
  - Downloadable charts by following standards