

# ECMWF Web re-engineering project

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# The web re-engineering project

- **Motivation:**

- Many of our users rely on our graphical web products for their daily work in their forecast offices, and have requested that our web services be continuously available
- At the Annual Users' meetings, we have received requests to create tailored products (e.g. control the event threshold on probability maps)

- **Goals:**

- Redesign the web infrastructure so that the web service is highly available and supported at the same level as the field dissemination
- Provide more interactivity (e.g. zoom, pan, overlay parameters)
- Allow product customisation (e.g. control the event threshold on probability maps)
- Use open (OGC) standards so that ECMWF products can be embedded in users' own software

# The web re-engineering project (cont.)

- **2-year project to implement new ECMWF web service that is:**
  - **Highly available and operationally supported (same support as current dissemination)**
  - **Aimed at forecasters**
  - **Highly interactive**
  - **Suitable for deployment as computer-to-computer standard 'web services'**
  - **Flexible to meet future requirements**
- **Milestones**
  - **First prototype - November 2009**
  - **Alpha release - February 2010**
  - **Beta release - January 2011**
  - **Operational release - June 2011**

# Requirements

- **Highly available – Operationally supported**

- H/A Hardware
- H/A Software
- Operator monitoring

- **Performance**

- Target: deliver a plot under 1 second

- **Interactivity**

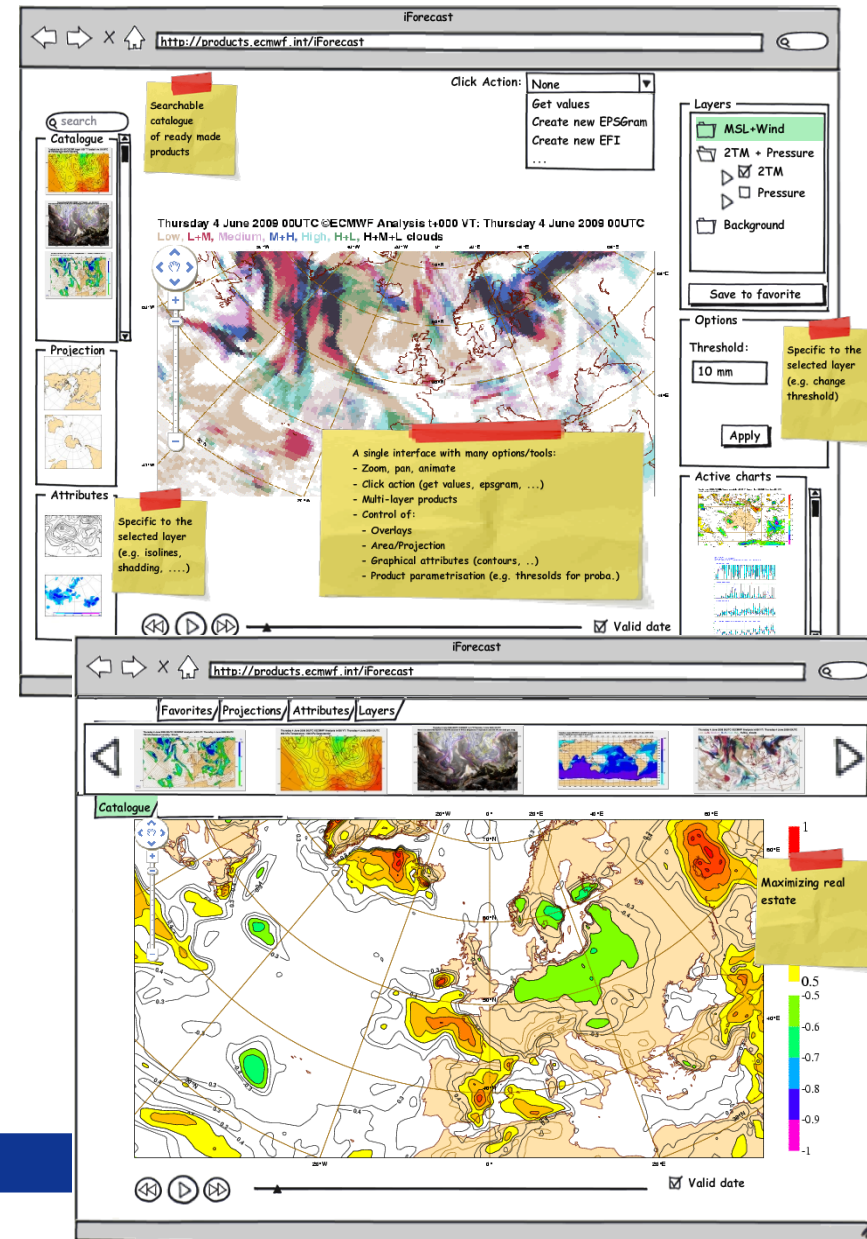
- Pan, zoom, overlay (à la GoogleMap)
- Customisation, plots on demands (e.g. changing event probability threshold)

- **Scalability**

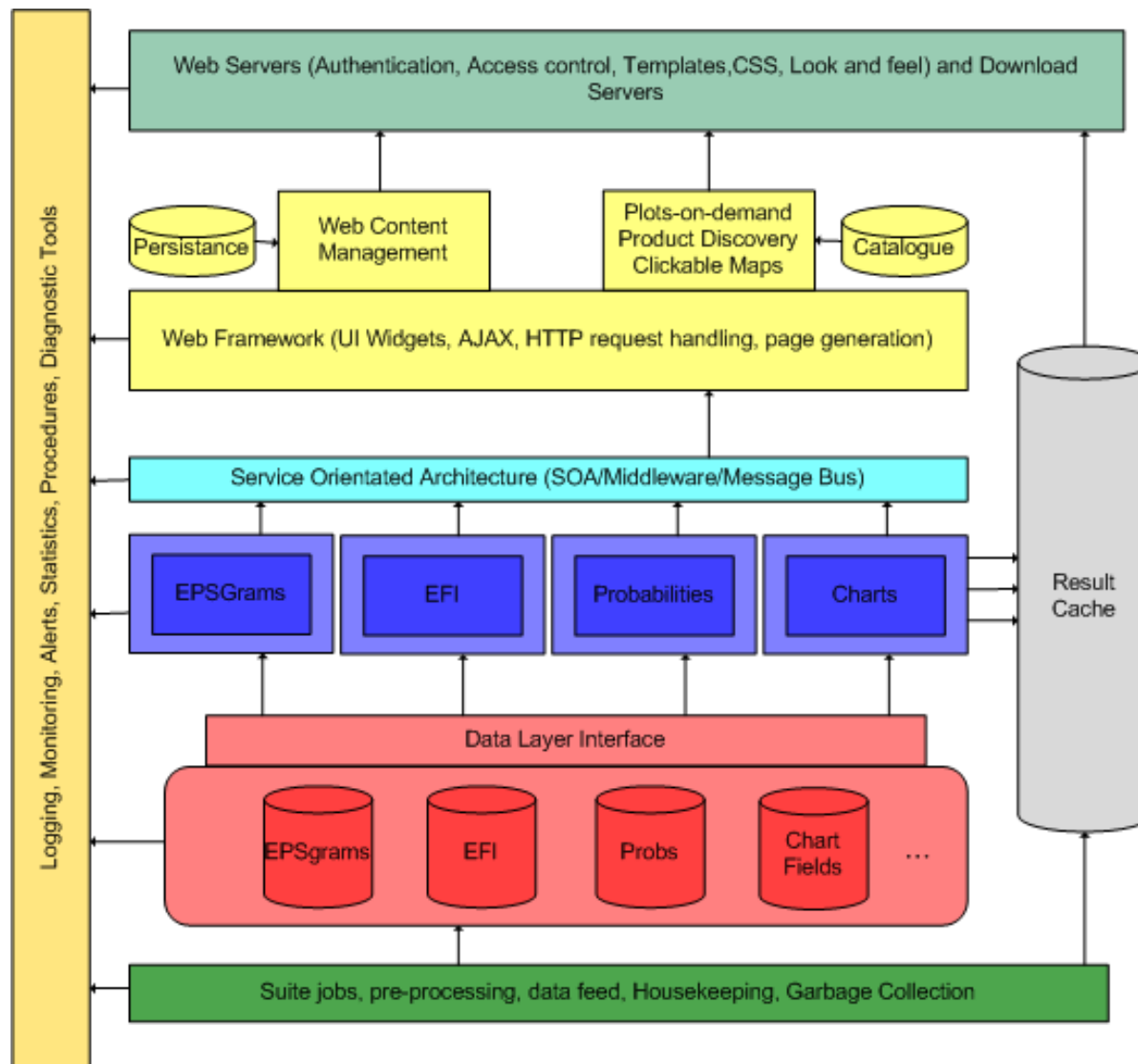
- Support any future user load
- Extensible: easy addition of new products

# Gathering of user requirements

- The project has been presented on several occasions:
  - ECMWF Forecast Products Users' Meeting, Computer Representatives Meeting
  - Very positive feedback from forecasters
  - Most forecaster requests focused on the desire to be able to create customised products
  - Requests for new products
- Consultation process will continue throughout the project



# Service Oriented Architecture



# Hardware



- **Systems located in different parts of the building, attached to different routers and different power sources**

- **2 Foundry Load Balancer ServerIronGT**
- **3 servers hosting web servers**
- **3 servers hosting web application**
- **3 servers hosting several virtual machines**
- **6 servers hosting storage, compute and plot services**
- **HP DL360 G5 Dual 2.5Hz Quad Core Xeon**
- **OpenSuSE Linux 11.1**



# Software

- **We investigated technologies used by the “big players” (e.g Google, Yahoo, Amazon, Facebook, Wikipedia ...):**
  - **Memcached (Very fast distributed memory)**
  - **Tokyo Tyrant (Scalable, distributed persistent space)**
  - **Hadoop (High availability and redundant distributed data)**
  - **Xen ( Virtualisation)**
  - **DRDB (Network RAID)**
  - **Ganeti (H/A Cluster management)**
  - **Nagios (Alerts system)**
  - **Scribe (Distributed logging)**



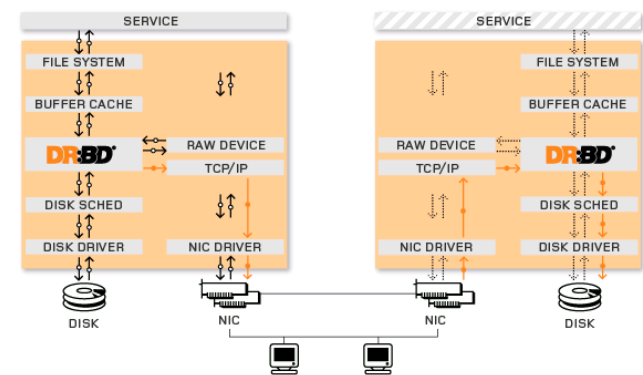
# Software (cont.)

- ...
  - **Ganglia (Distributed monitoring)**
  - **Django (Python based Web framework, server side)**
  - **jQuery (JavaScript based web framework, client side)**
  - **OpenLayers (JavaScript based OGC WMS-client)**
  - **Apache 2.2 (Web server)**
  - **MySQL (Database)**
- **And of course:**
  - **Magics++**
  - **grib\_api**
  - **Mars**
  - **Metview ...**

# About Hadoop

- **A framework that supports data intensive distributed applications**
- **Inspired by Google's MapReduce and Google File System (GFS) white papers.**
- **Yahoo, Amazon, IBM, Facebook, AOL, Fox, Last.fm, Microsoft, ...**
- **Hadoop – HDFS - Distributed storage, with a filesystem like API (HDFS)**
  - **Data nodes hold blocks of data. Each node uses local storage**
  - **Name node holds the file names and the blocks location (single point of failure)**
  - **Each file is spread of several data nodes**
  - **Each block has several copies distributed over the cluster**
  - **Designed for large blocks (64 MB)**
- **MapReduce facility to be investigated**

# About Ganeti (H/A Pairs)



- **Ganeti is a cluster virtual server management software tool built on top of existing virtualization technologies (Google)**
- **Xen virtual machines (Hardware assisted virtualization: 3% overhead)**
- **DRBD (Distributed Replicated Block Device)**
  - “Network RAID1” (20% overhead write, 0% read)
- **Live migration**
  - Two passes memory migration: 10s for 12GB memory (Stoppage of around 60~300 ms is required to perform final synchronization)
  - No interruption of service: IP connections not broken (MAC address move)
  - Fail over : restart VM on backup machine.
  - Command line tools: can be done by operators

# Service Oriented Architecture

- **Multi-tier architecture, deployed on a series of Linux clusters:**
  - **Web frontend (Web server)**
  - **Web backend (Dynamic page generation)**
  - **Services (Plotting, probability computations, EPSgrams, ...)**
  - **Data layer (Raw fields)**
- **Cluster approach provides built-in scalability, redundancy and load balancing**
- **Critical components run on virtual machines that can be redeployed dynamically**

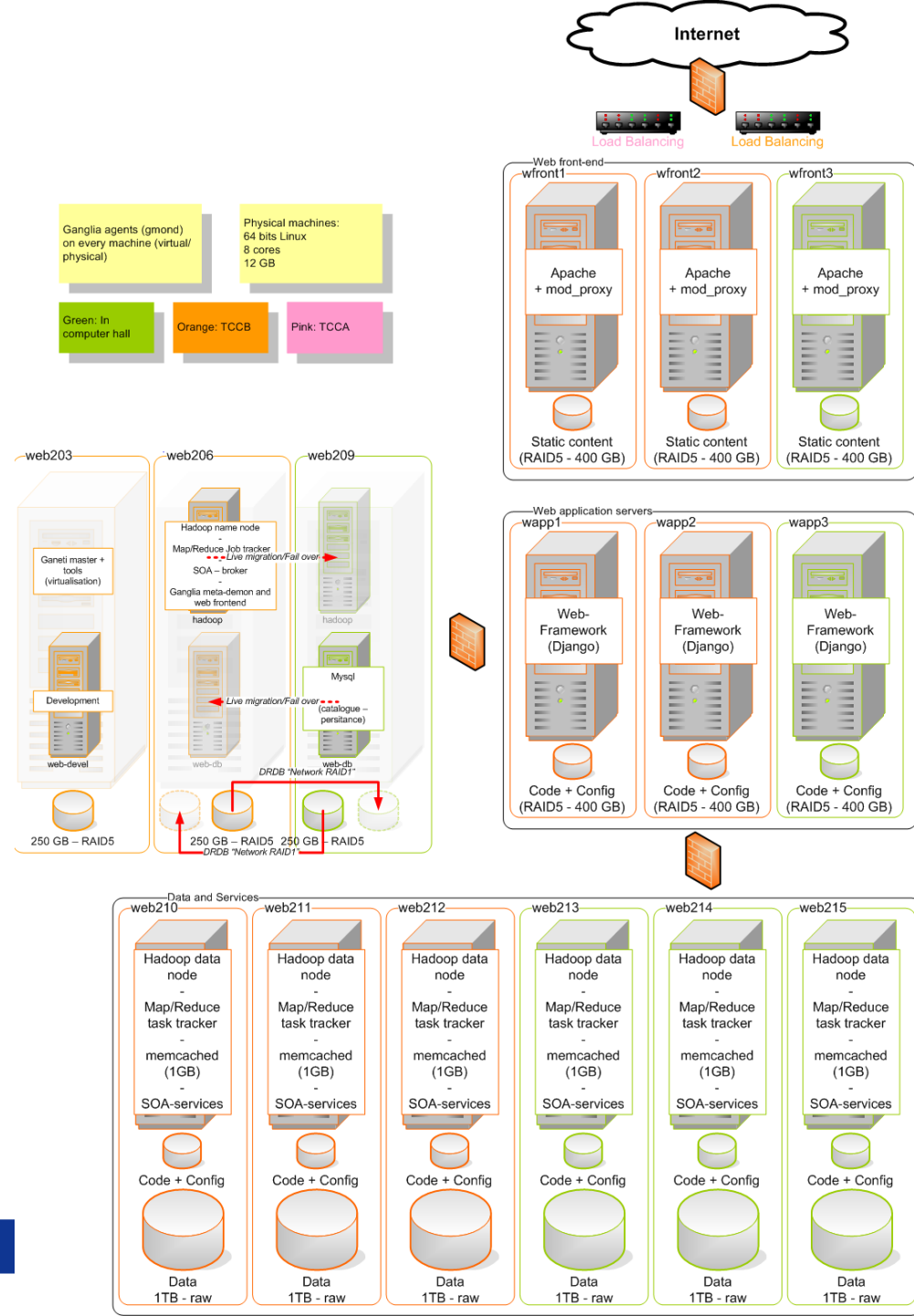
# Deployment

- **Virtual machines for critical components and single points of failure**

- Hadoop name node
- SOA Broker
- Spot database
- Catalogue (MySQL)
- All virtual machines sized in such a way that they can fit in a smaller number of nodes if necessary

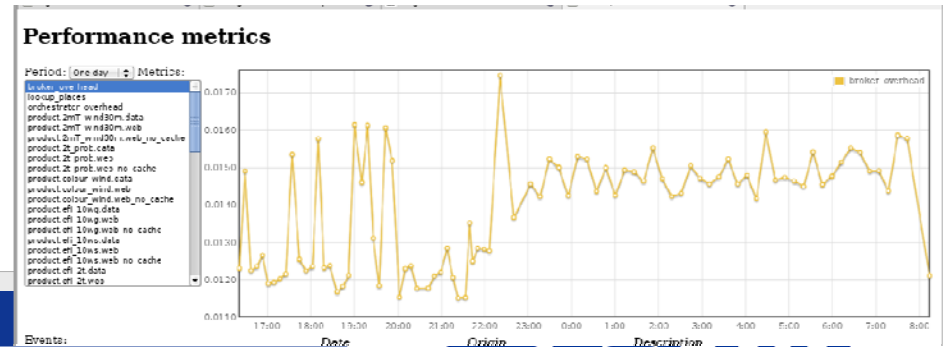
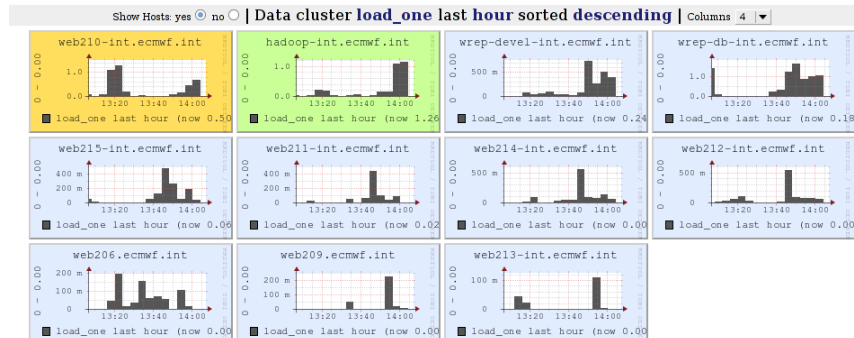
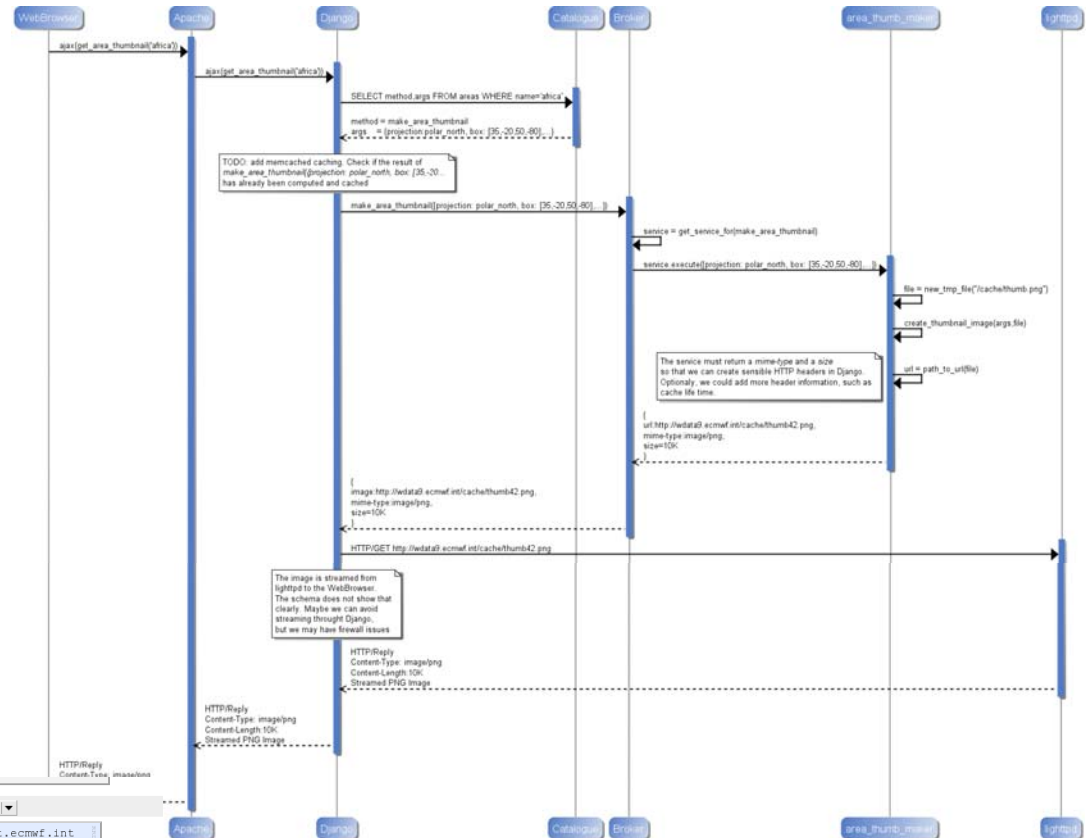
- **Physical machines for components with built-in redundancy**

- Hadoop data nodes
- Memcached servers
- Services (plot, retrieve, probabilities, epsgrams, ...)



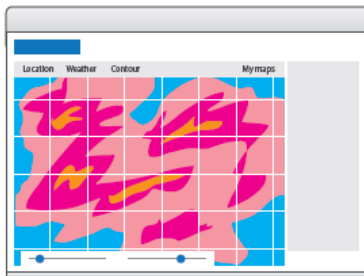
# Developing in an SOA environment (is hard)

- Distributed design
- Troubleshooting
- Diagnostics tools
- Instrumentation
- Regression tests

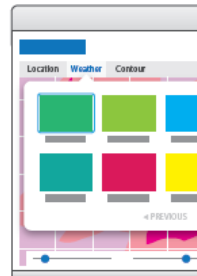


# Web user interface

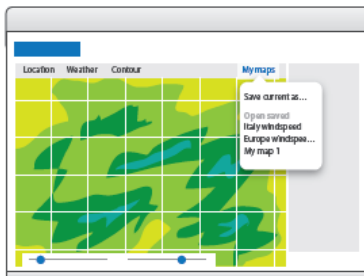
- Involvement of external design companies
- Focus on usability



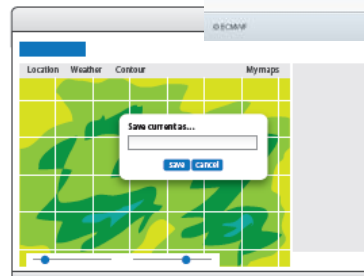
1. The user would arrive and be greeted by a default map. Along the top are the main selectors, along the right is the legend and the time controls are along the bottom.



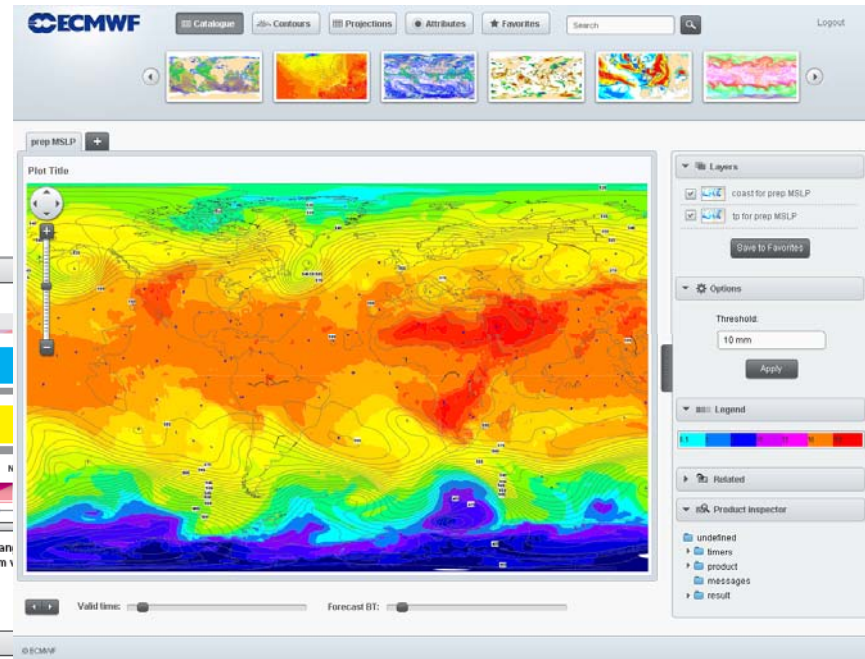
2. The selectors allow the user to change color and contour style on the fly. Custom way to no.6 in option 1.



4. Users can save their settings using the 'my map' menu. Users can also use this screen to access previously saved maps.



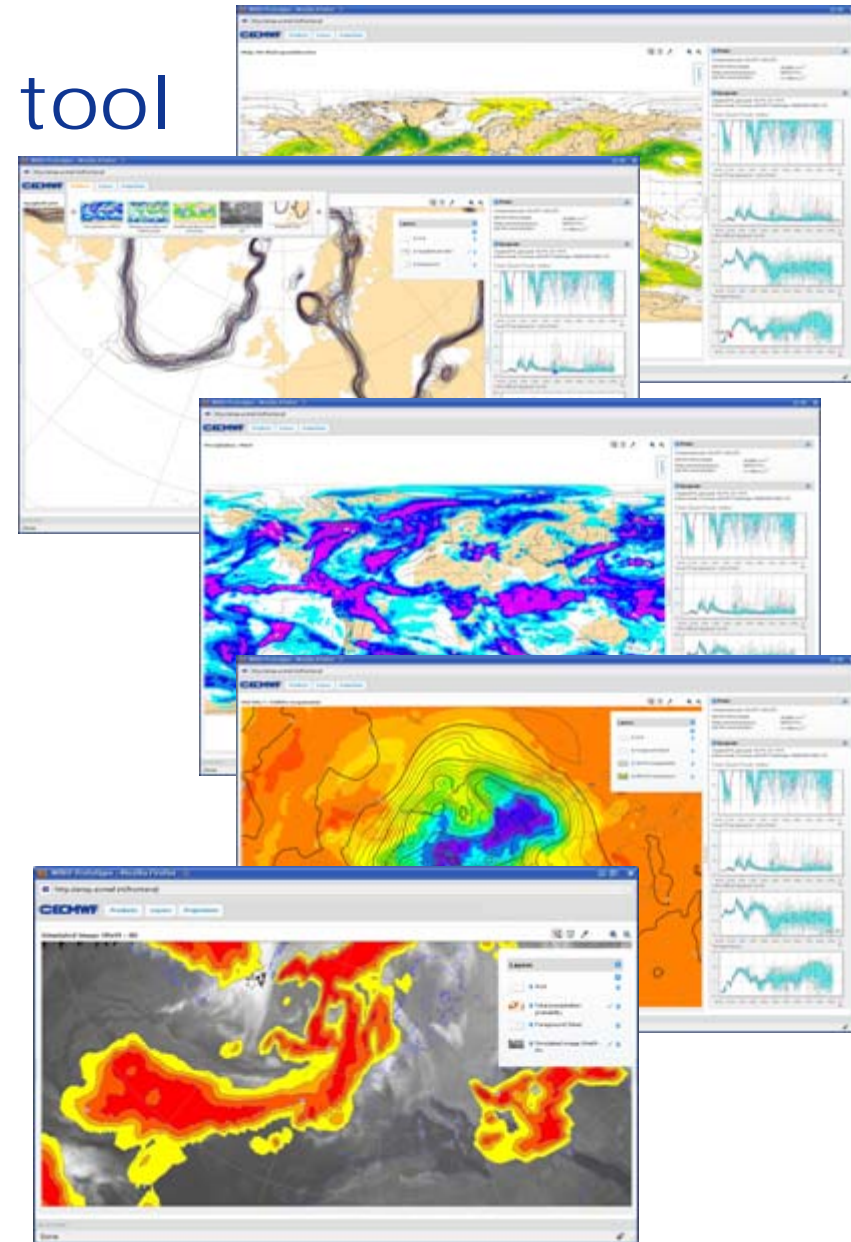
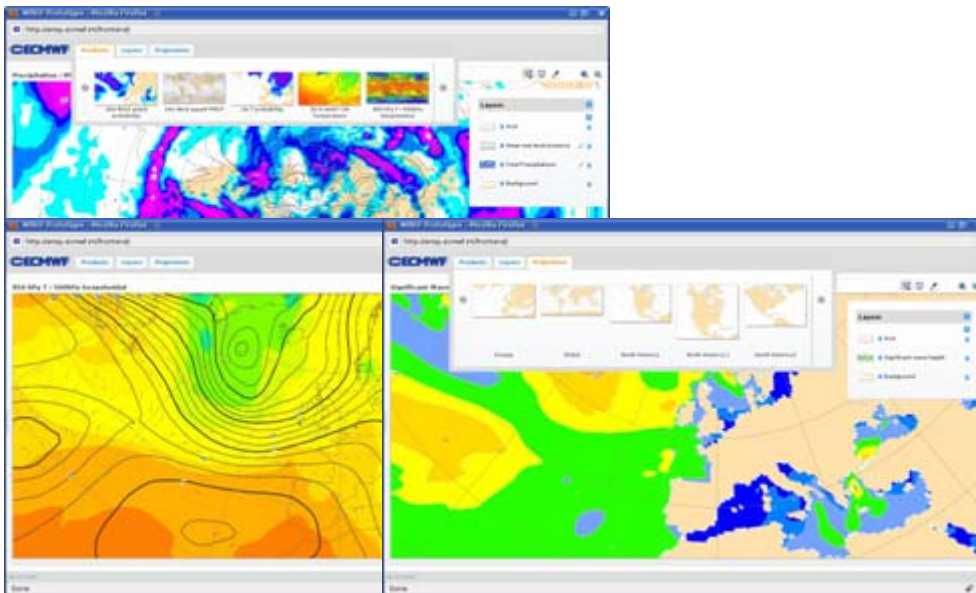
5. If the user chooses to 'save current as...' a popup box will prompt them to give the map a name. They will then be returned to their map.





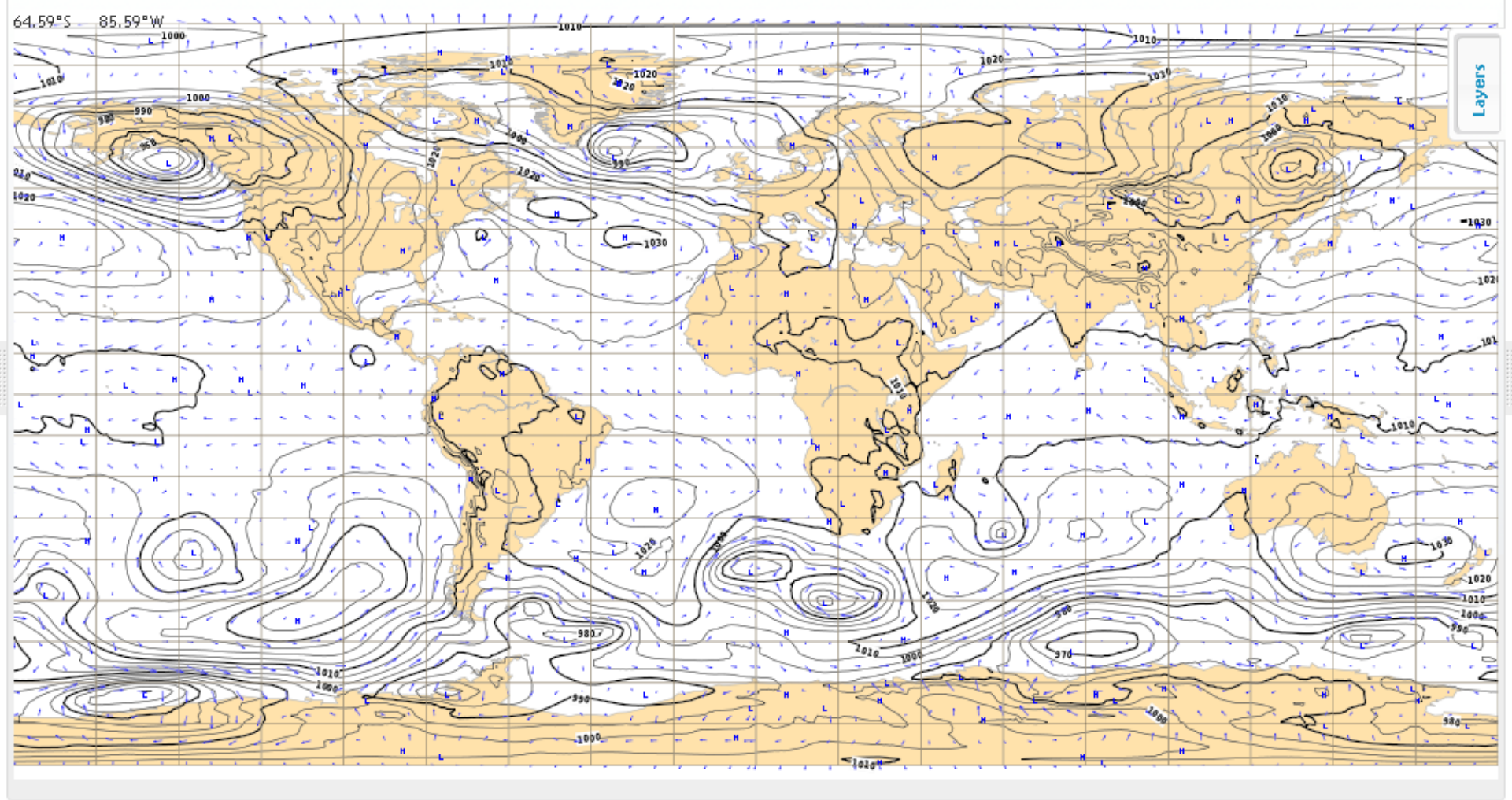
# Prototype: Forecasting tool

- **Interactivity: zooming, panning, ...**
- **Customisation:**
  - Probabilities threshold, ...
  - Show/hide, add/remove layers
- **Related products: Epsgrams**





Products > 10m Wind speed/ MSLP



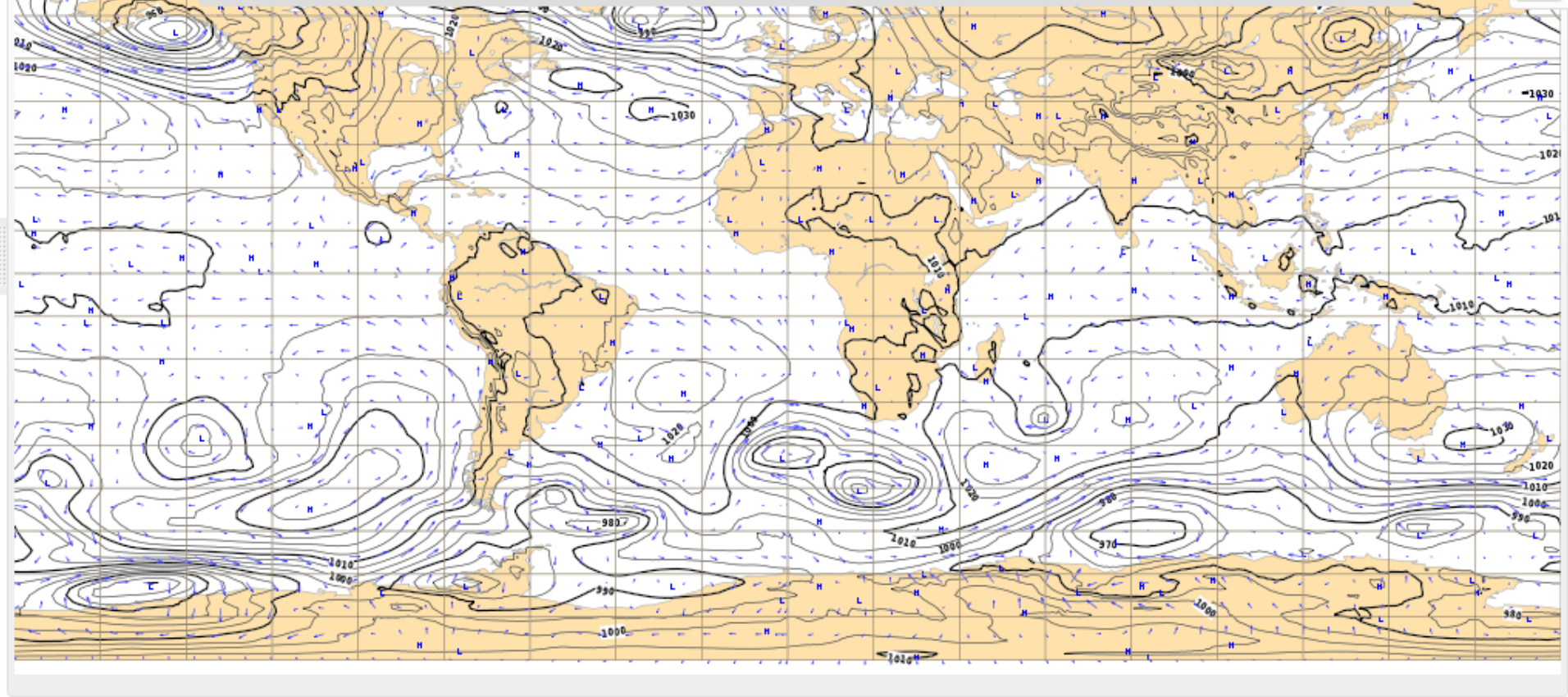
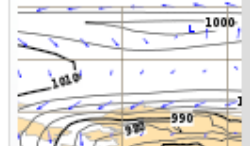


Products Layers Projections

Products > 10m Wind

Thumbnail navigation bar with five items:

- 10m Wind speed probability
- 10m Wind speed / MSLP
- 2m T probability
- 30 m wind / 2m Temperature
- 850 hPa T / 500hPa Geopotential



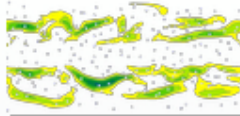
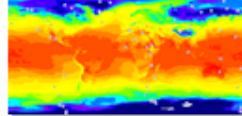



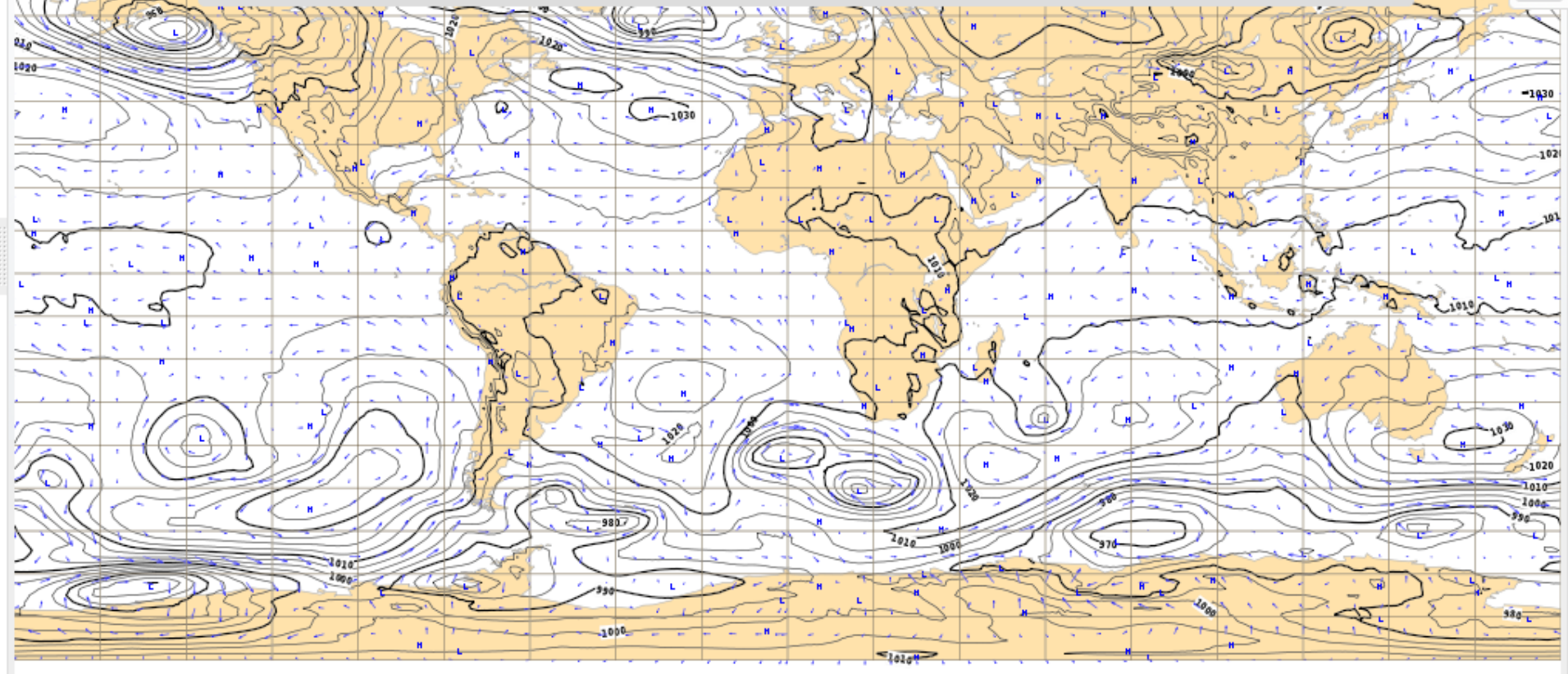
Map navigation controls including zoom in (+), zoom out (-), and a vertical 'Layers' button.



Products > 10m Wind

Navigation: ◀ ▶

				
10m Wind	200 hPa wind direction	200 hPa Wind Speed	2m Temperature	2m Temperature probability

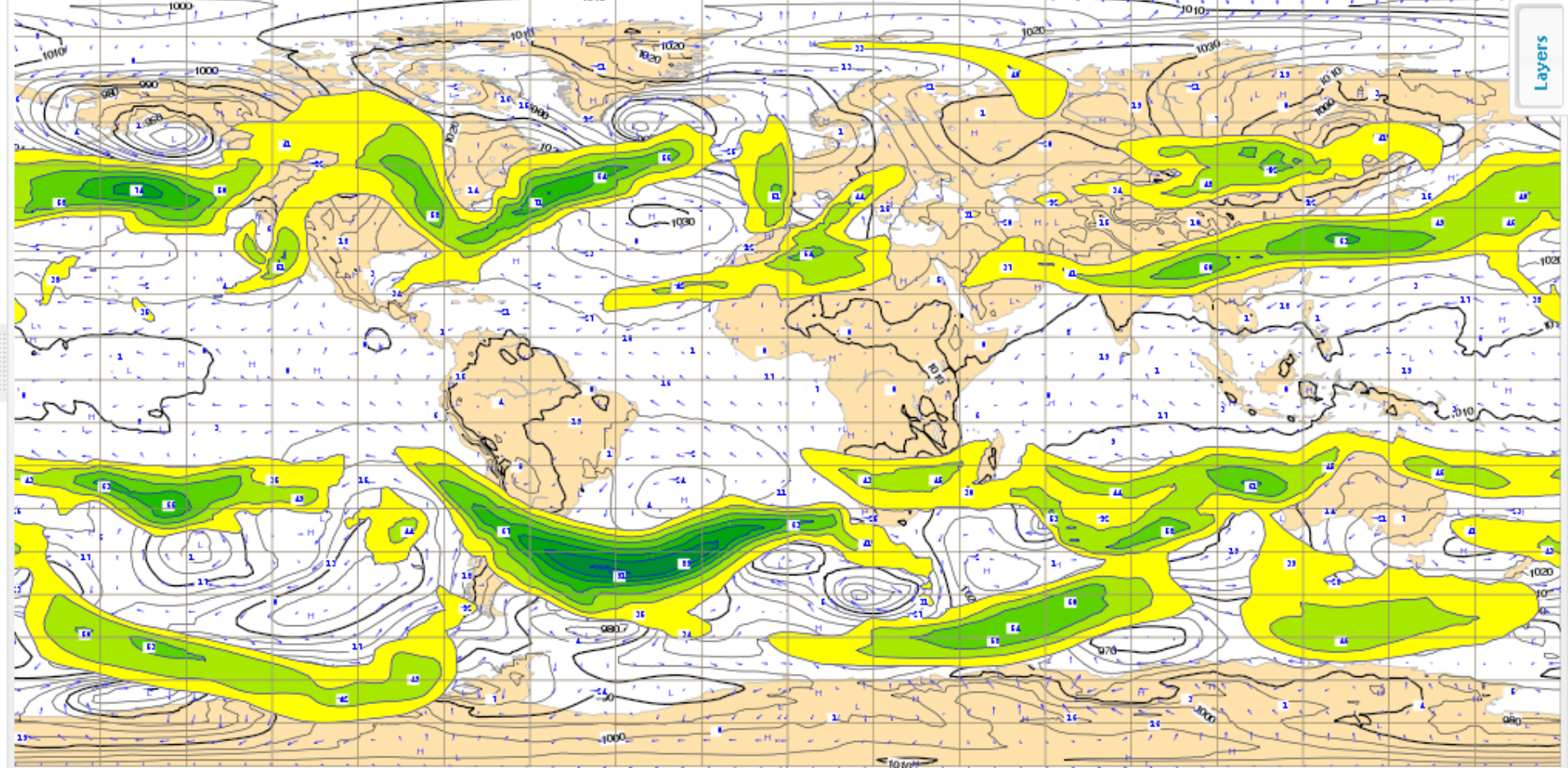


Layers

Navigation: + -

Products > 10m Wind speed/ MSLP

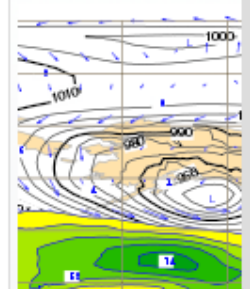
85.95°N 29.9°W



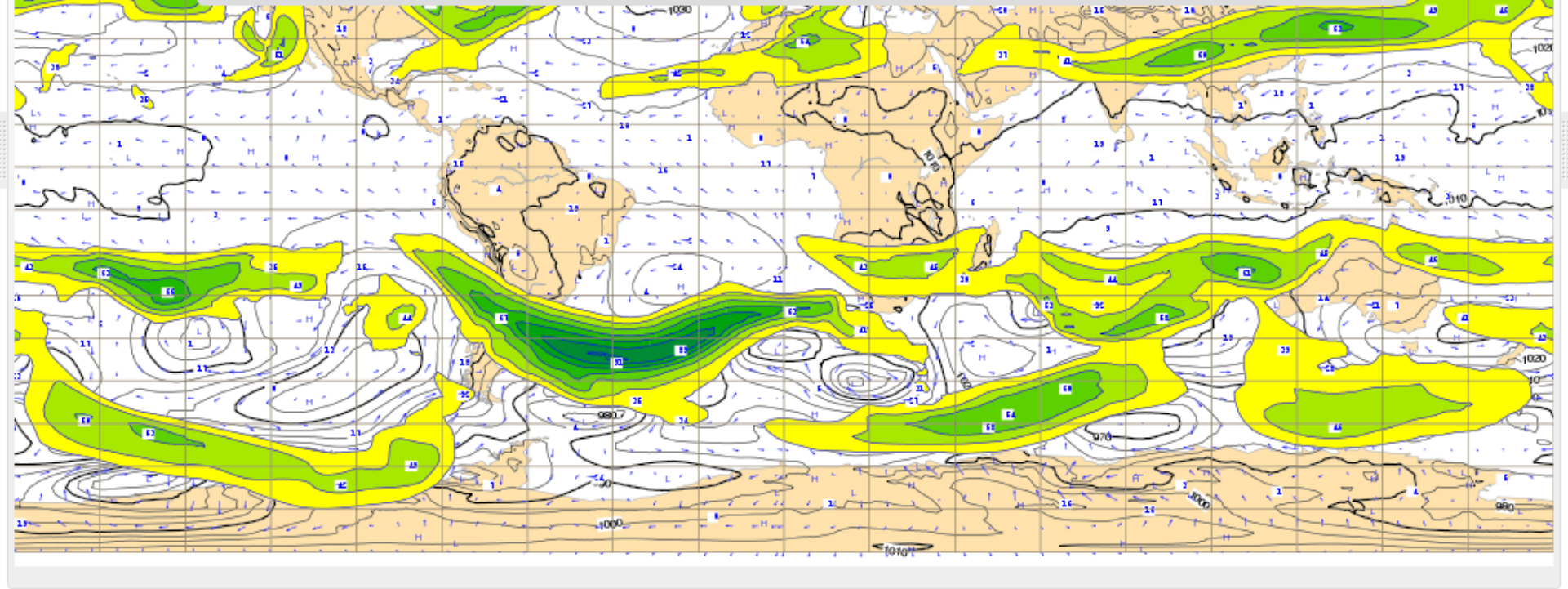


Products > 10m Wind

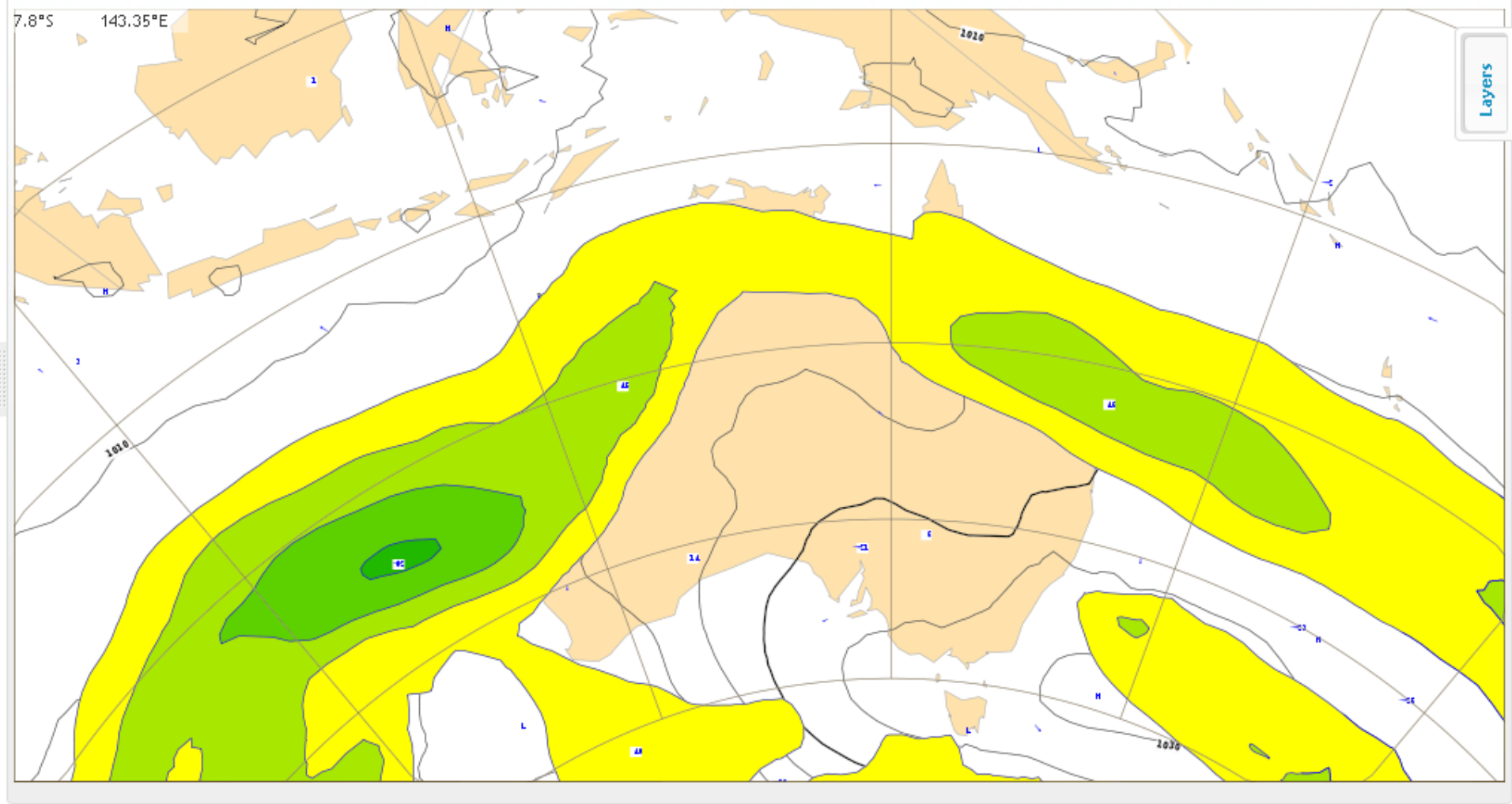
A horizontal gallery of five map projection thumbnails. From left to right, they are labeled: Africa, Asia, Australia, Australia2, and Euro atlantic. Each thumbnail shows a different geographical region with a grid overlay. Navigation arrows are visible on the left and right sides of the gallery.



Map navigation controls including a magnifying glass icon for zooming in and out, and a vertical 'Layers' panel on the right side.



Products > 10m Wind speed/ MSLP

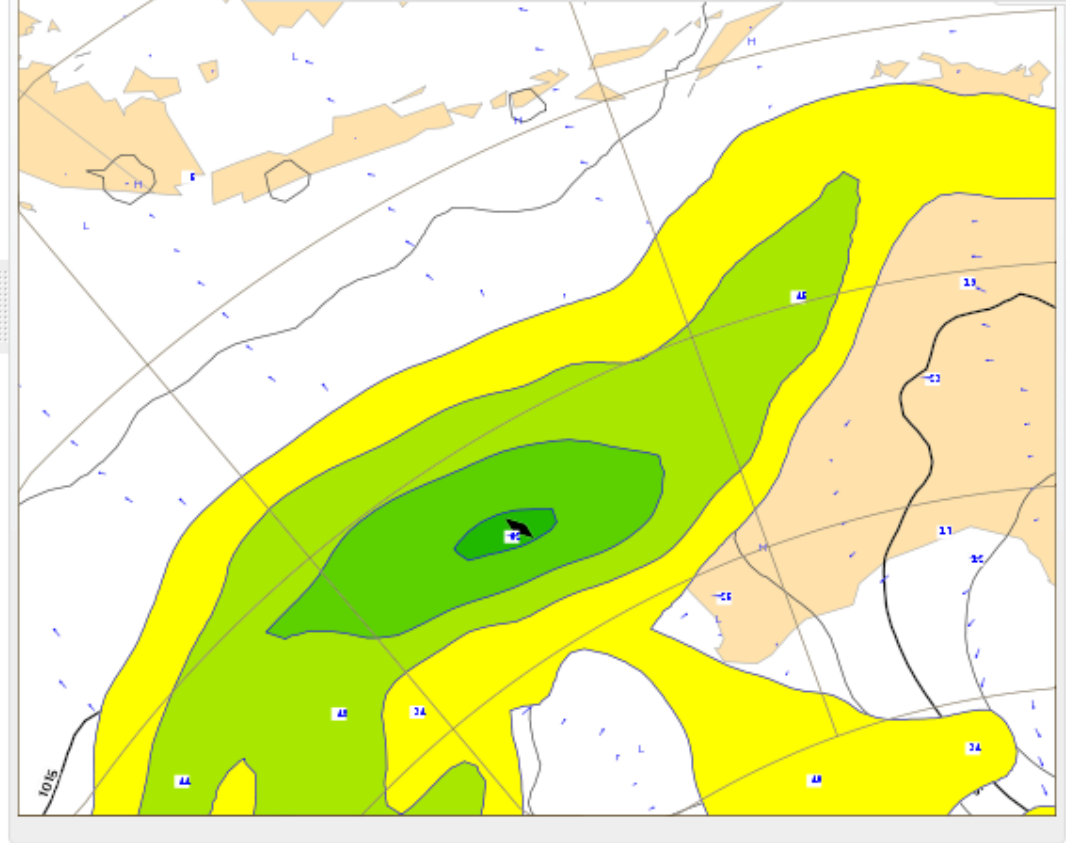




Products > 10m Wind

Product thumbnails:

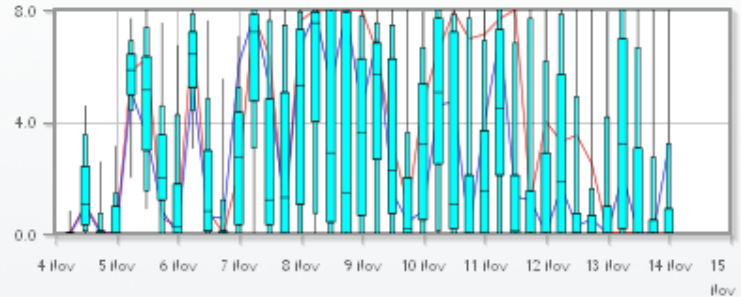
- Simulated image (Met9 - IR)
- Spaghetti plot
- Total precipitation over an interval
- TP / TP probability
- Wind Speed



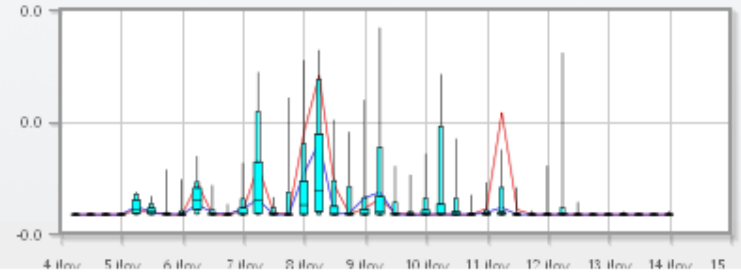
Epsgram

Closest EPS grid point: 25.39°S 145.44°E  
 Deterministic Forecast and EPS Distribution 20091104 0000 UTC

Total Cloud Cover (okta)

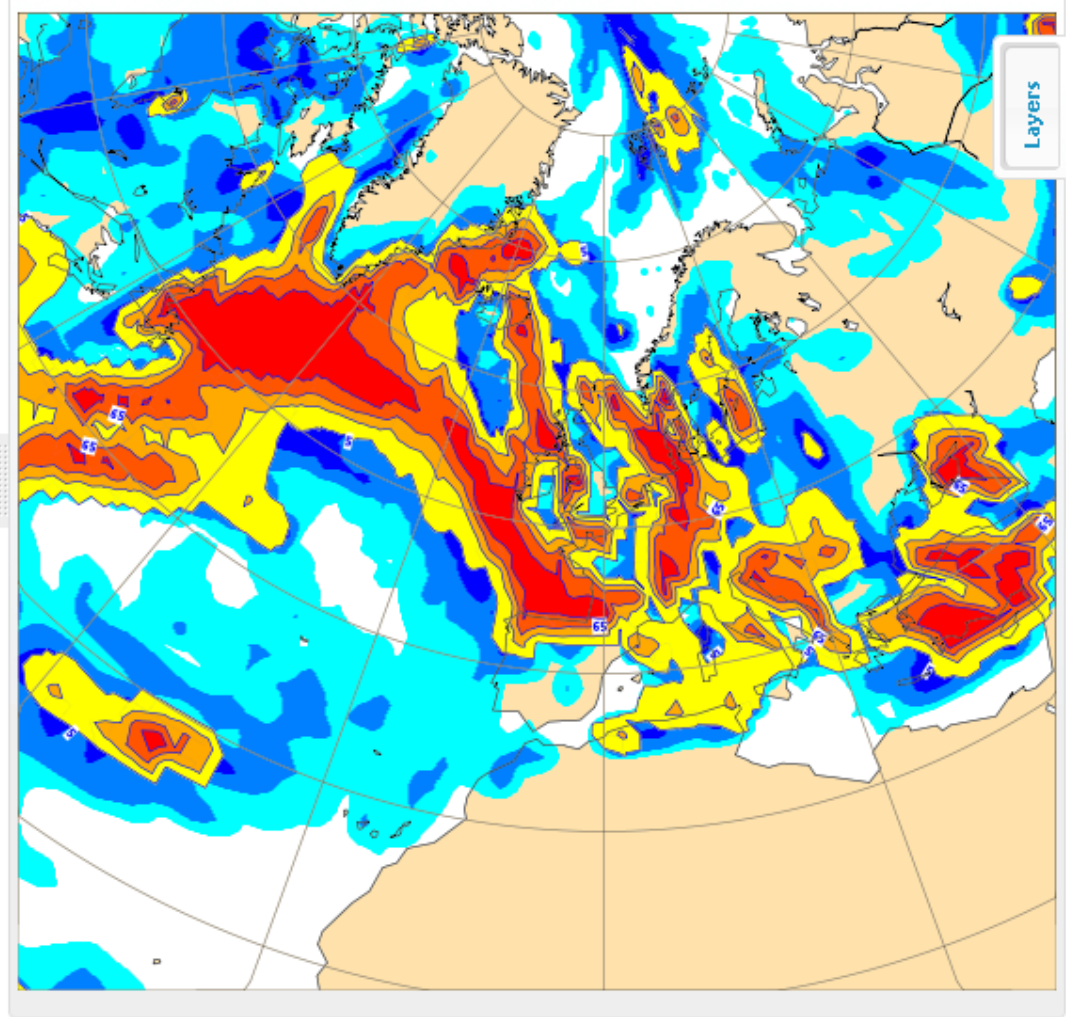


Total Precipitation (mm/24h)





Products > TP / TP probability

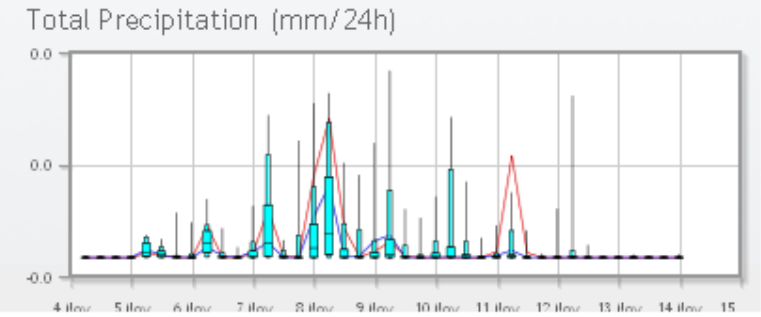
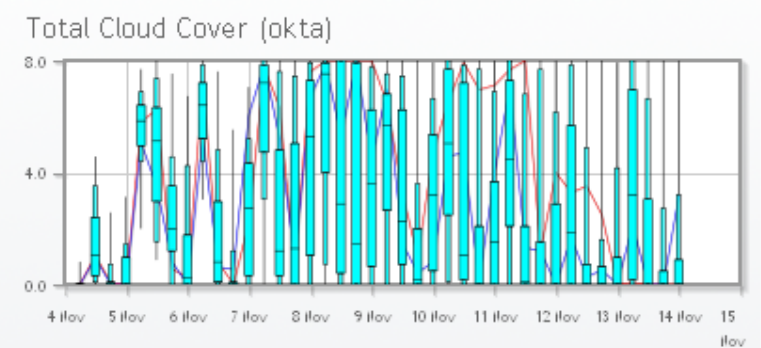


Probe

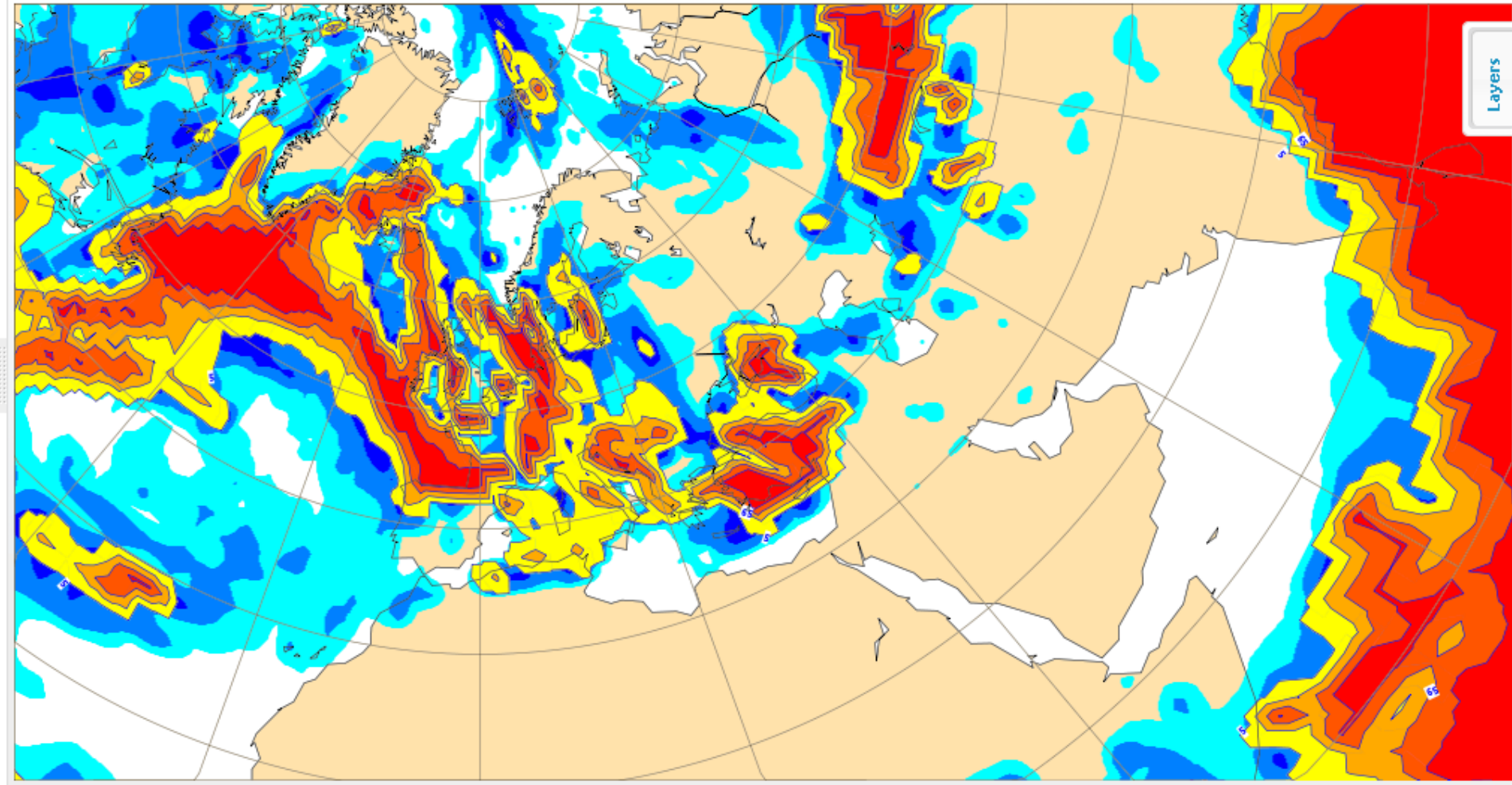
Closest grid point:	25.23°S 145.37°E
Mean sea level pressure:	101666 Pa
10m Wind:	-3.26648 m s <sup>-1</sup>
200 hPa Wind Speed:	19.64 m s <sup>-1</sup>

Epsgram

Closest EPS grid point: 25.39°S 145.44°E  
 Deterministic Forecast and EPS Distribution 20091104 0000 UTC

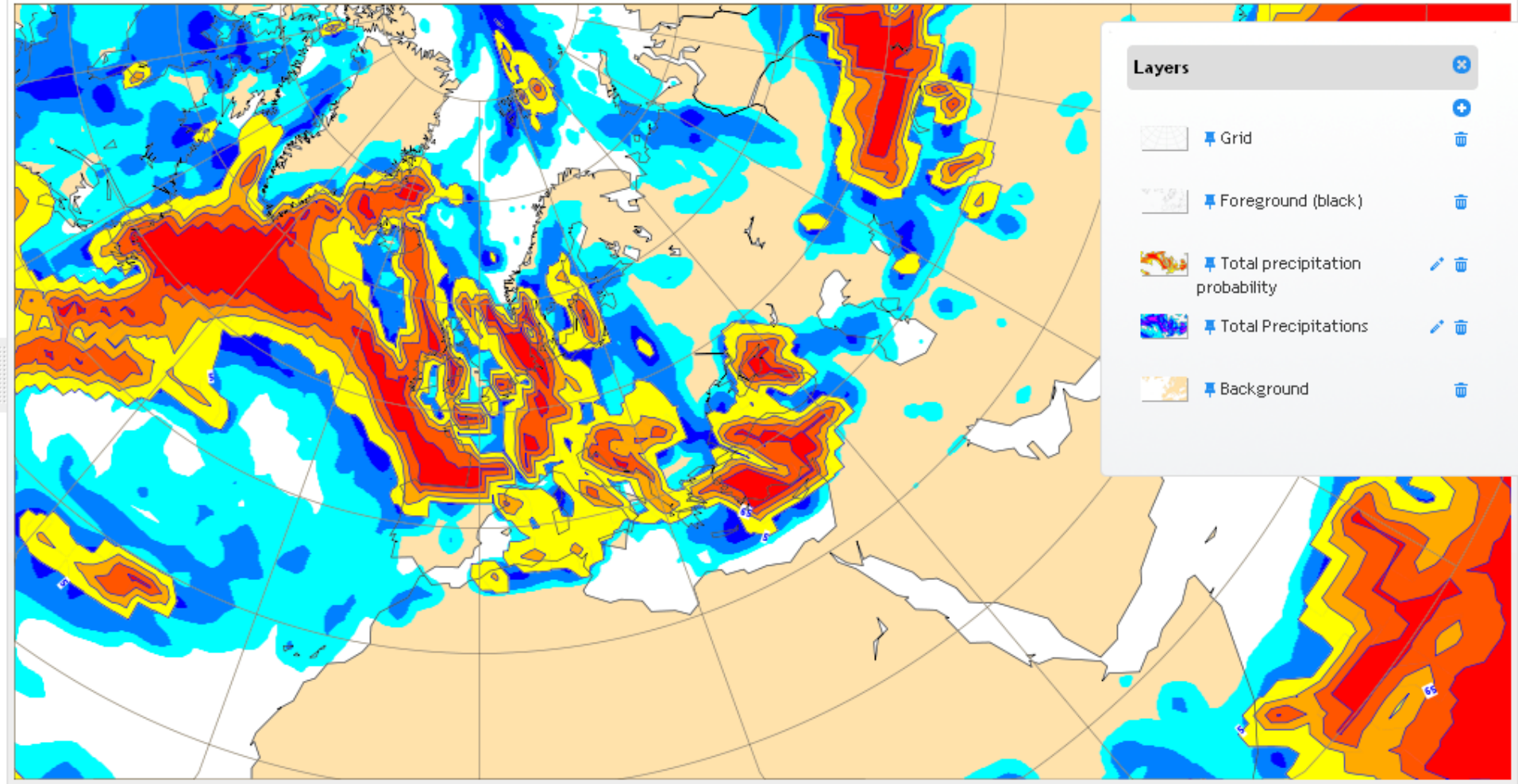


Products > TP / TP probability



Layers

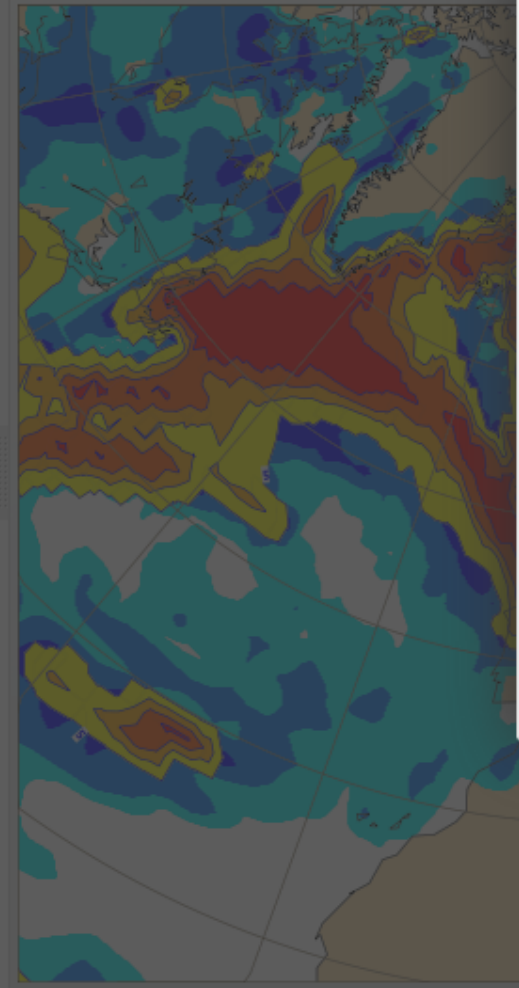
Products > TP / TP probability



**Layers**

- Grid
- Foreground (black)
- Total precipitation probability
- Total Precipitations
- Background





**Total precipitation probability**

Event threshold

Operator

Style

Probabilities (blue)

Probabilities (green)

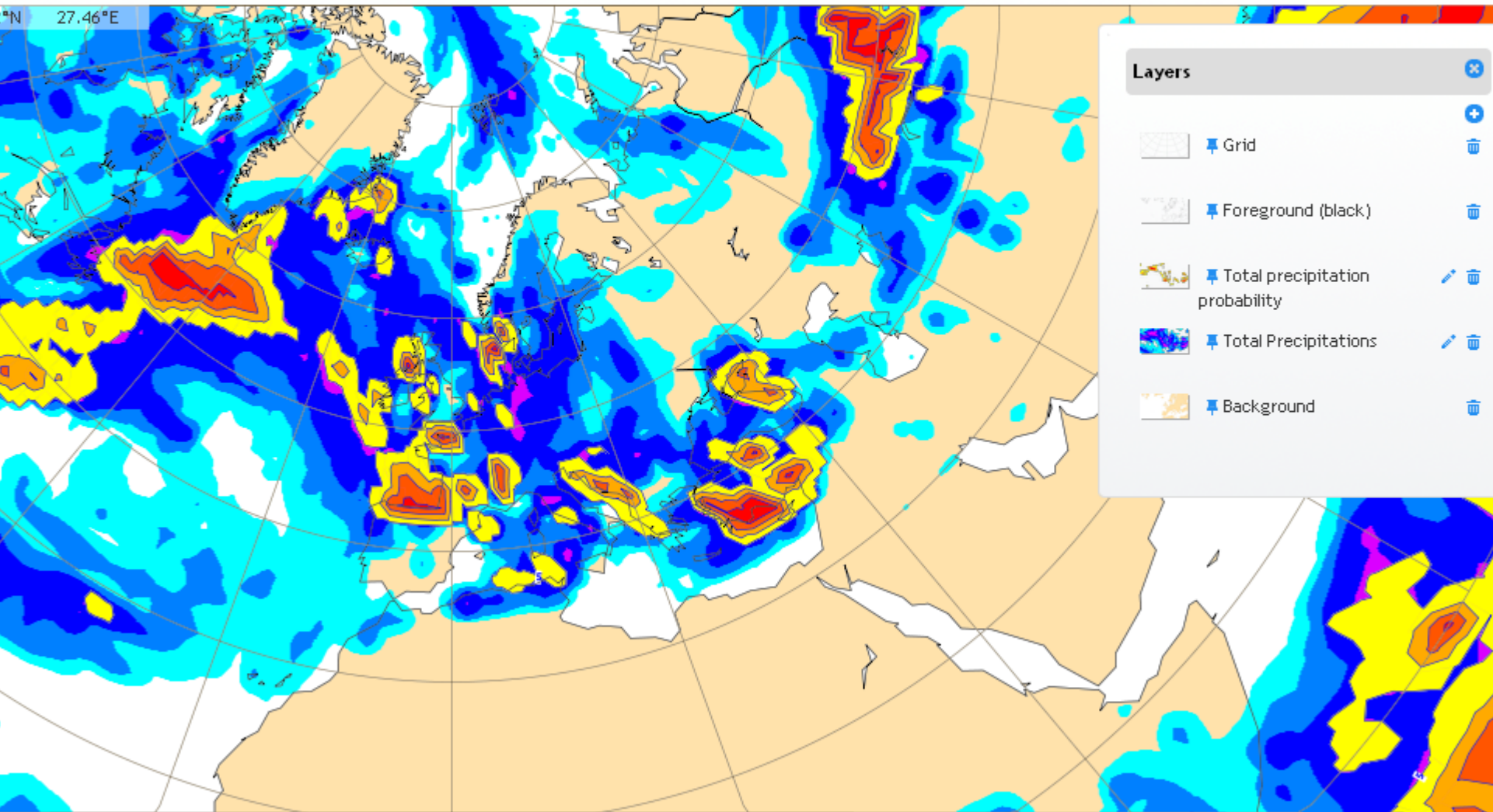
Probabilities (red)

Layers

- Grid
- Foreground (black)
- Total precipitation probability
- Total Precipitations
- Background

Products > TP / TP probability

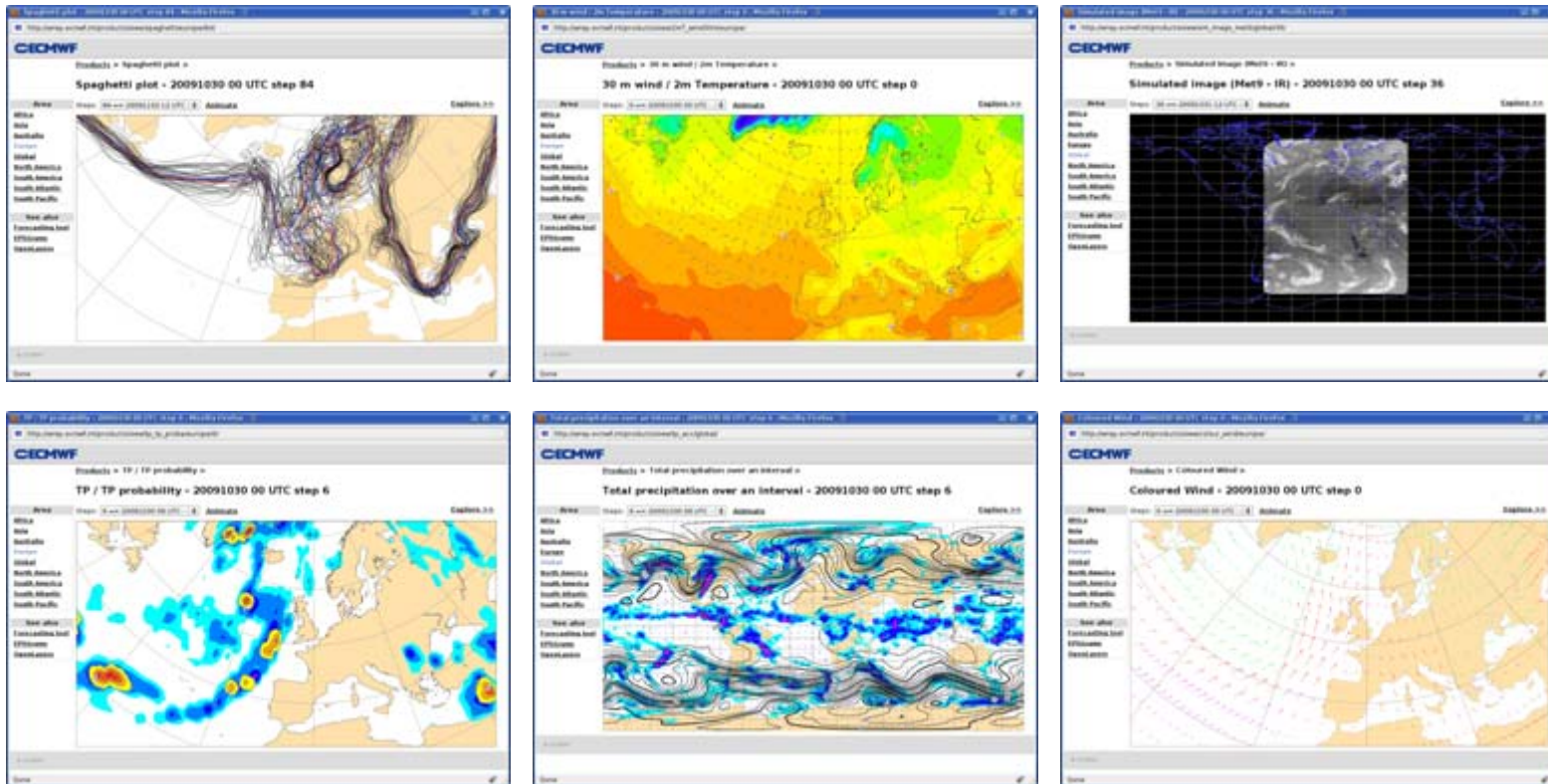
50°N 27.46°E



**Layers**

- Grid
- Foreground (black)
- Total precipitation probability
- Total Precipitations
- Background

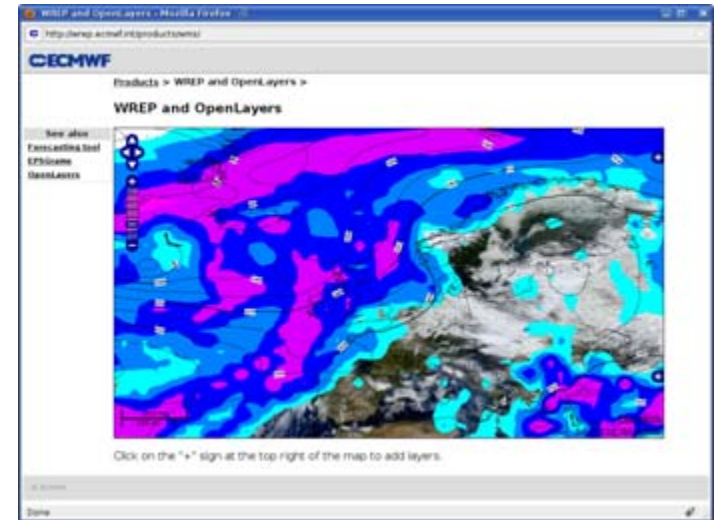
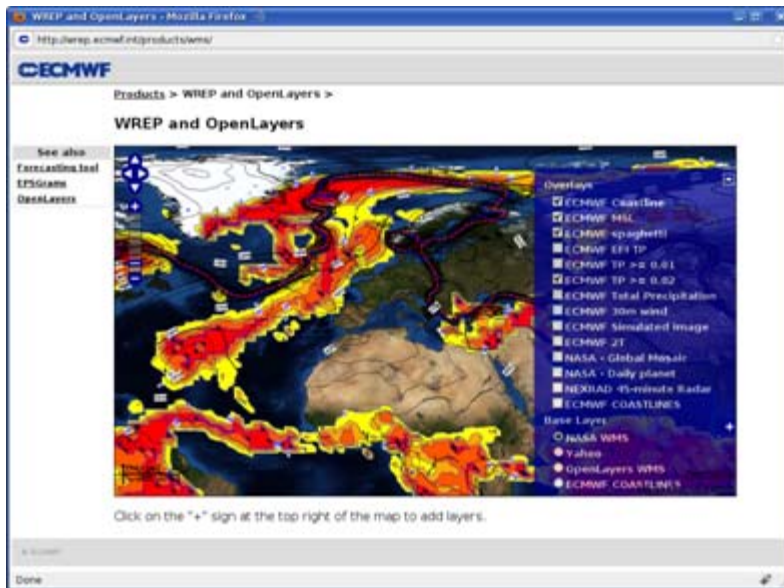
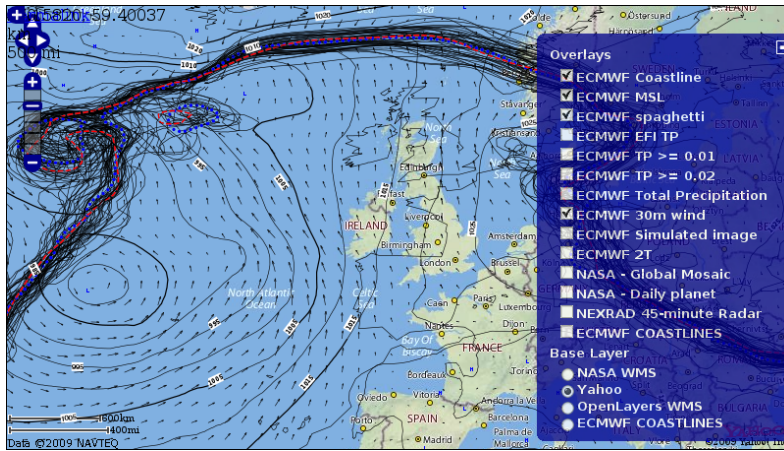
# Prototype: Catalogue browsing



- **Browsable catalogue – Link to Forecaster tool**
- **Limited interactivity – Preset number of projections, animation**
- **Similar to current web catalogue, but use the WREP infrastructure**



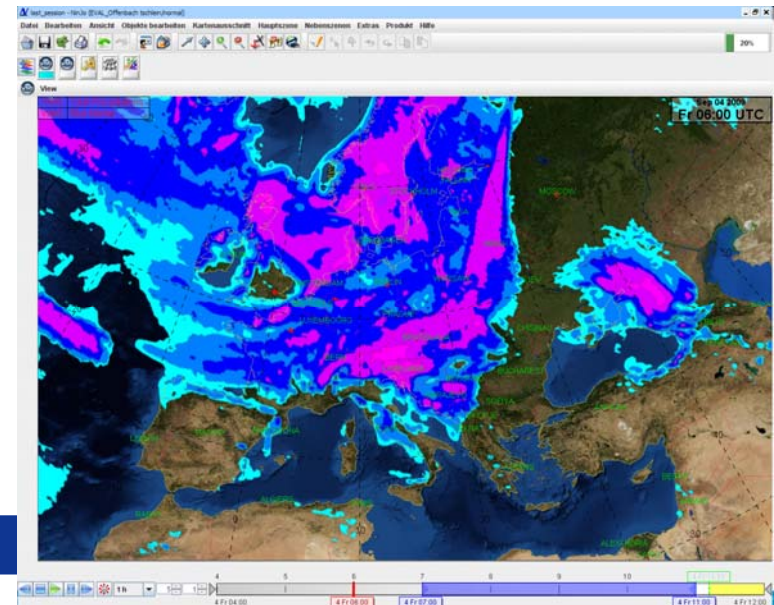
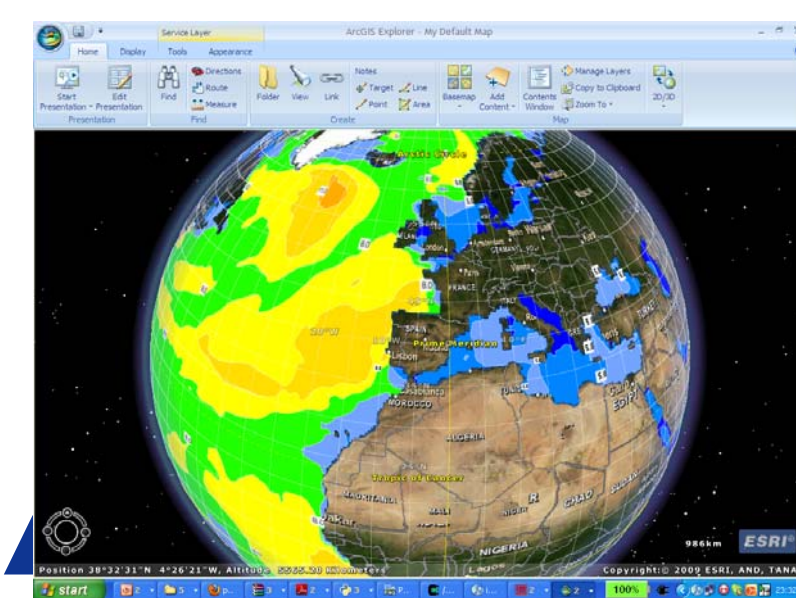
# Prototype: OpenLayers integration



- Alternate interface under investigation
- Overlay layers, addition of external data sources
- On top of WREP infrastructure: tiles are created on-demand

# Prototype: OGC Web Map Services

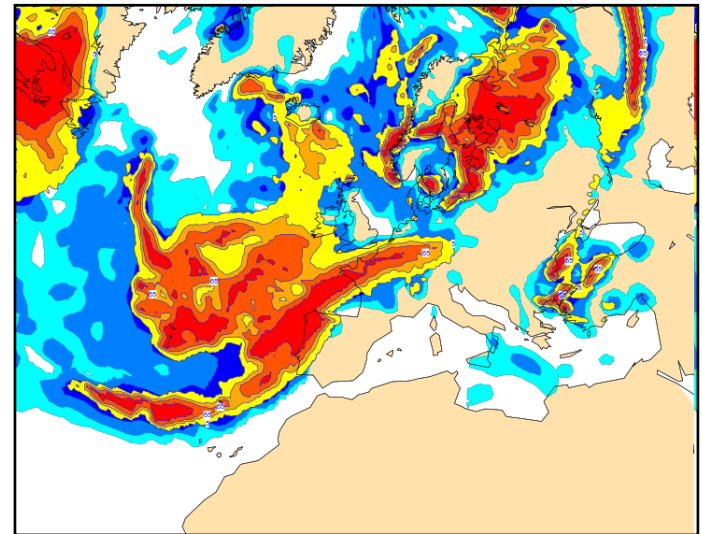
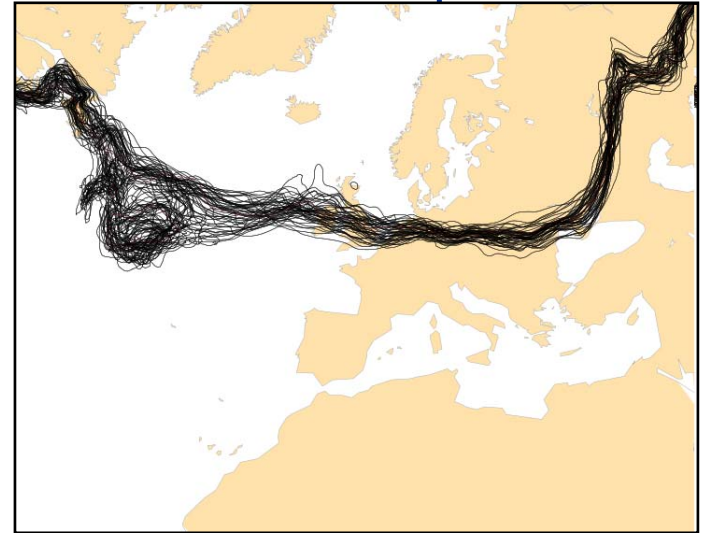
- **Aim: to make it possible to embed ECMWF products directly in the forecasters' workstations**
- **On top of WREP infrastructure:**
  - **“GetCapabilities document” build dynamically from product catalogue content**
  - **Layers are created on-demand**
- **Challenges: access control, time dimension, customisation**





# Conclusion: fully functional proof of concept

- All products created “on-demand” (2D maps, EPSgrams)
- Zoom, pan, overlay
- Customisation: setting of probability thresholds, contouring
- Browsible catalogue
- Initial user interface
- OGC Web Map Service (WMS)



# Future work

- **Persistence**
- **Security and access control**
- **Monitoring, alerts and service statistics**
- **Management tools**
- **Performance tuning**
- **Develop further WMS aspect**
- **More products**
- **User testing**

# Thank you

**Come to see our demo at the exhibition  
Meeting Room 1**