

# Use of visualisation at ECMWF

A bit of history and what challenges remain

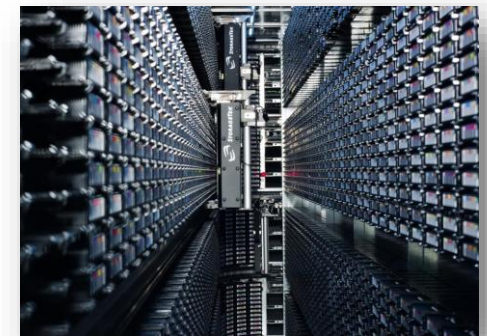
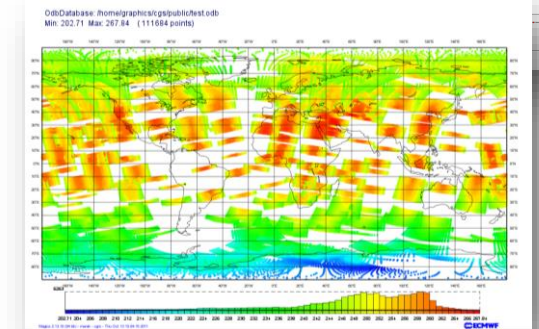
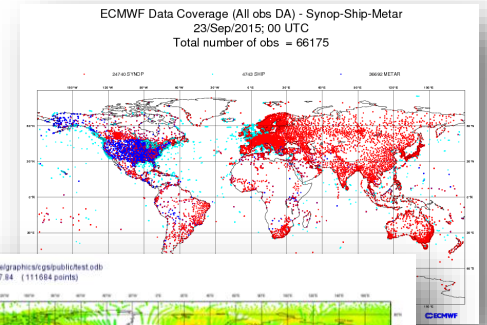
Stephan Siemen

Development Section, ECMWF

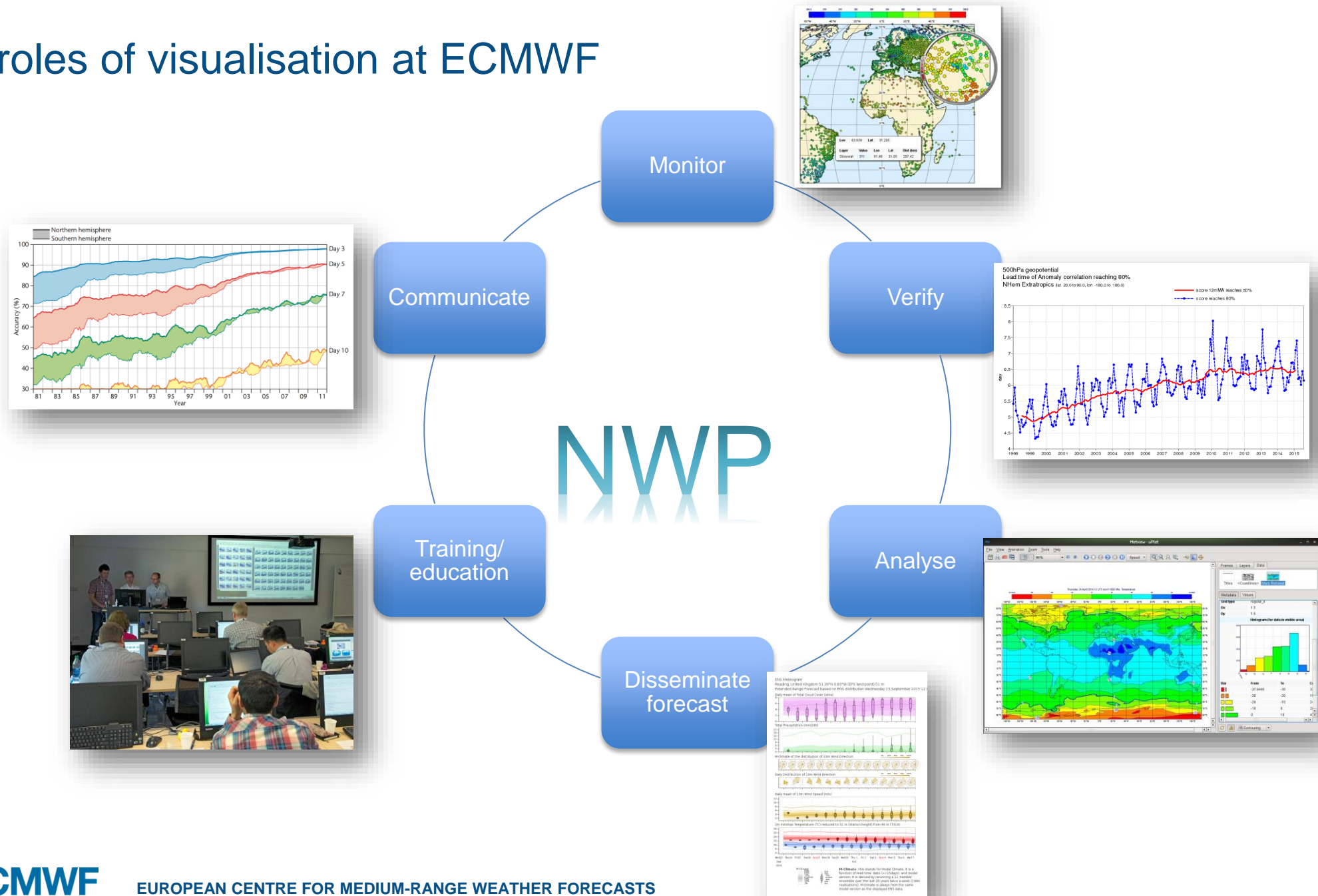
Thanks to Jens Daabeck, Glenn Carver, Sylvie Lamy-Thepaut,  
Iain Russel, Fernando li, Sandor Kertesz

# Why is visualisation so important for ECMWF?

- Large amount of data without visualisation is too large for a human to comprehend
    - Currently ECMWF receives **300 million** observation from 130 sources daily
    - ECMWF operational models produce **13 millions** fields daily; a total of around **8 TB**
    - **77 million** data products disseminated daily every day
    - MARS (Meteorological Archive and Retrieval System) has past the **80 PB** mark
  - The human eye and brain are still unbeatable to detect patterns
    - It is much easier to grasp geographical location and relations when plotted on a map
    - Important for analysts and scientist alike
- **Visualisation is helping the user to capture all this information as simply and quickly as possible**



# The roles of visualisation at ECMWF



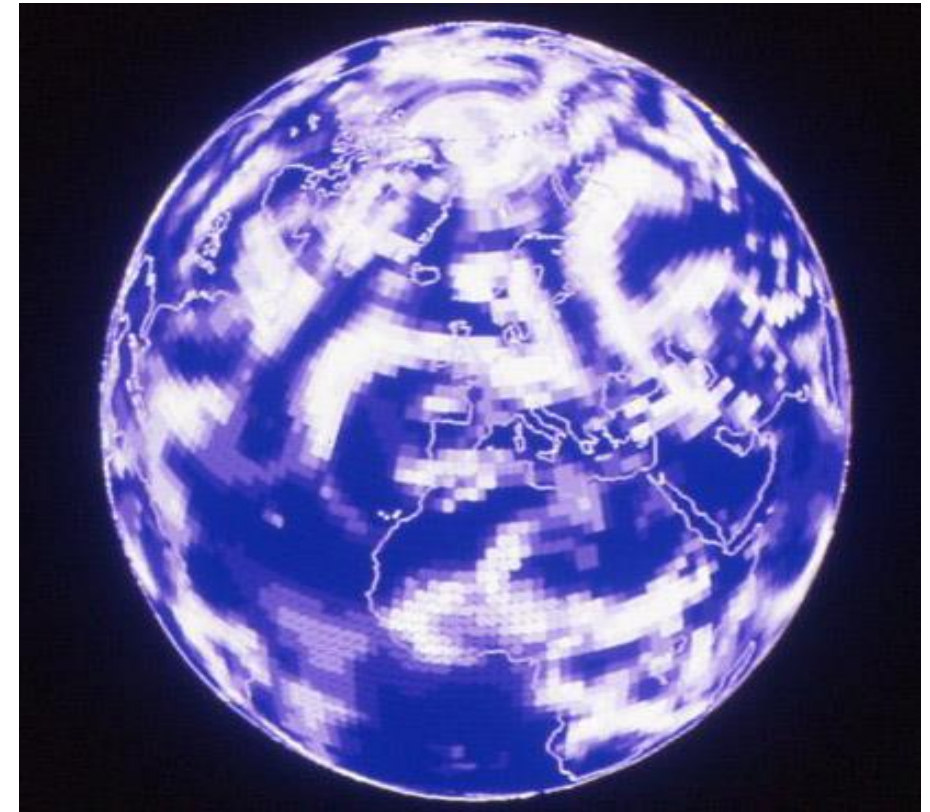
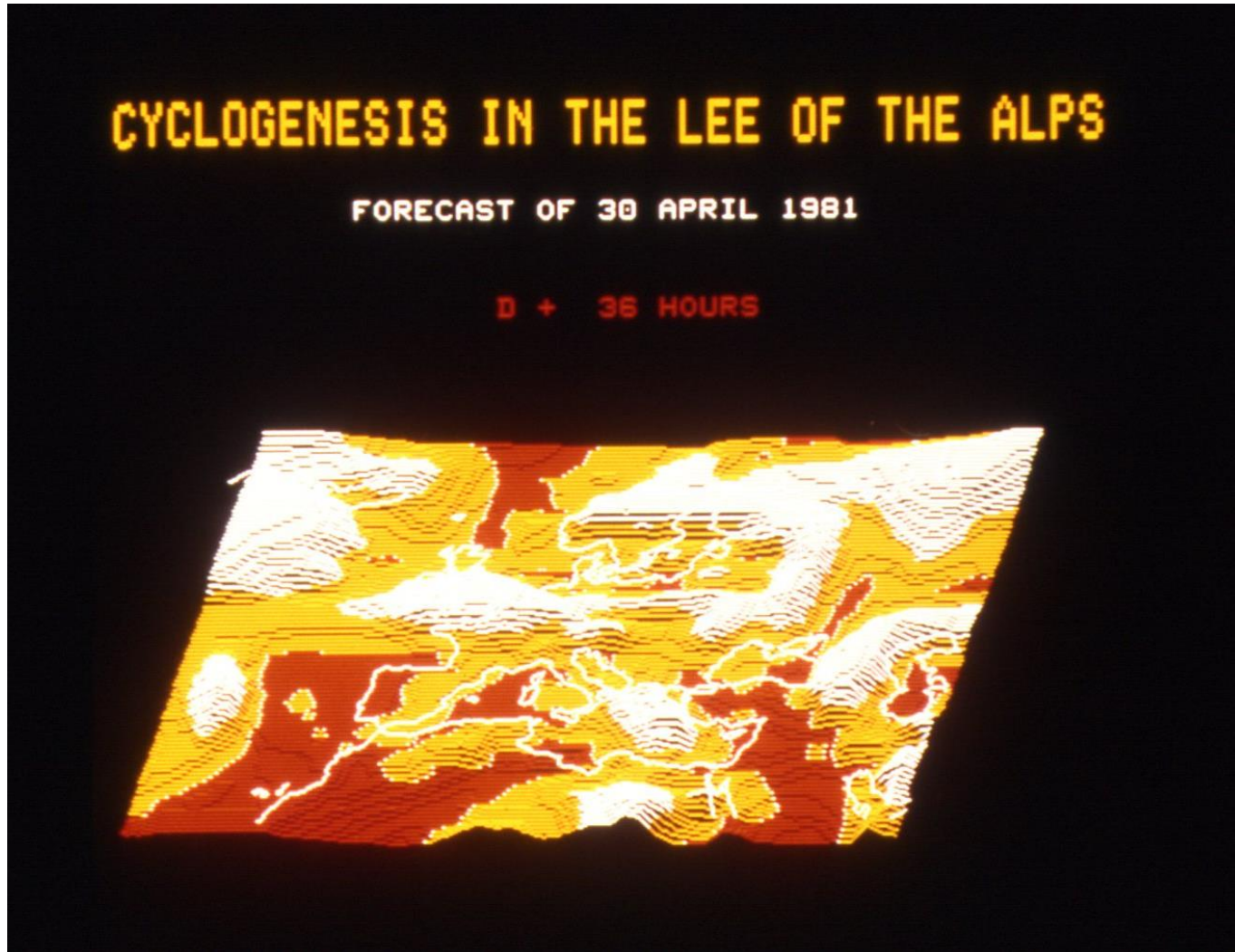
A bit of history ...



# Early days at ECMWF ...

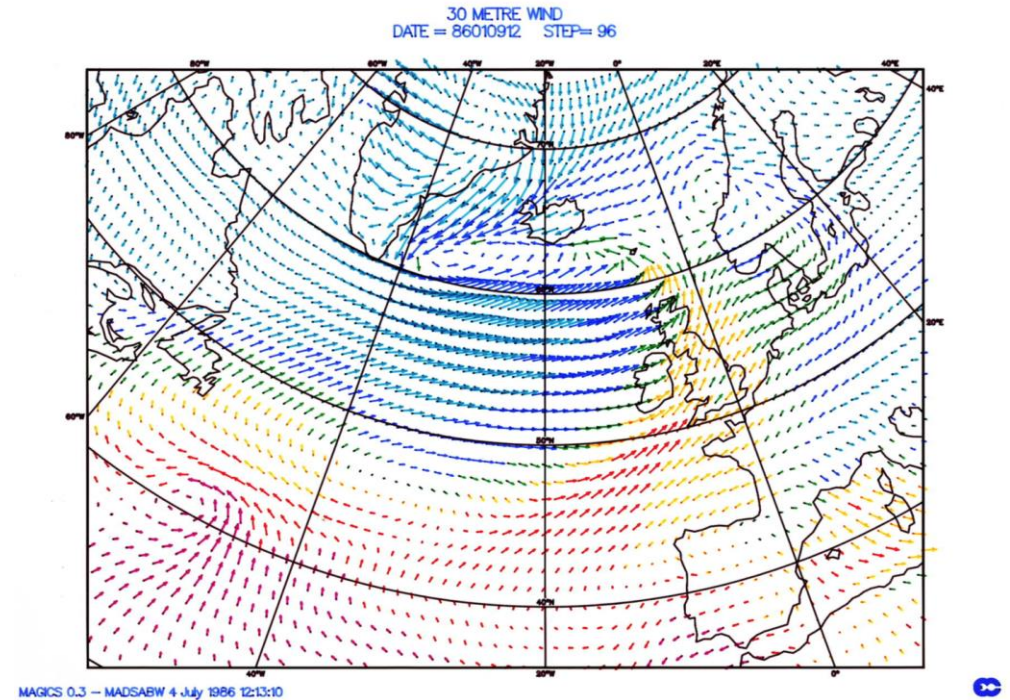


## On screen graphics ...



# History of graphics/visualisation at ECMWF

- In the early days *Contlib*
- 1983 Start developments on **M**eteorological **A**pplication **G**raphics **I**ntegrated **C**olour **S**ystem
  - Library with extensible API running on HPC
- 1985 MAGICS 0.3 plotting coloured wind arrows
- 1987 MAGICS 1.0
- 1988 MicroMagics (on DOS by INPE)
- 1990 Metview 1.0
- 2003 Start work on Magics++
  - Increasing call for on on-demand web plots
- 2012 Release of Metview as Open Source
- 2013 Dedicated graphics/visualisation team is merged with other development teams



→ Challenges move from hardware (networks, printers) to software and styling

# Metview's desktop & Batch system

Allows fast prototyping and conversion to Macro for batch processing

The screenshot displays the Metview desktop environment with several windows open:

- Metview - Desktop <2>**: The main interface showing a file explorer with icons for various tools like Annotation View, Average Data, Axis Plotting, and Clean File.
- Metview - uPlot**: A window displaying a global map of temperature data for Thursday 24 April 2014 at 12 UTC. The map uses a color scale from blue (cold) to red (hot). A histogram for the visible area is shown on the right, with a bar chart and a legend.
- Coastlines**: A window showing the configuration for map coastlines, including options for color, style, thickness, and resolution.
- File Properties**: A window showing metadata for a file named 'course\_prep/2015/1000.grb', including permissions, owner, group, size, and modification date.
- Table**: A table listing data points with columns for Index, Name, Date, Time, Step, Level, and LevType.

Index	Name	Date	Time	Step	Level	LevType
01	t	20150206	1200	0	1000	pl
02	t	20150206	1200	6	1000	pl
03	t	20150206	1200	12	1000	pl
04	t	20150206	1200	18	1000	pl
05	t	20150206	1200	24	1000	pl
06	t	20150206	1200	30	1000	pl
07	t	20150206	1200	36	1000	pl
08	t	20150206	1200	42	1000	pl
09	t	20150206	1200	48	1000	pl



# Web as a medium

ECMWF About Forecasts Computing Research Learning Stephan Siemen Search site Go

## Charts catalogue

Showing 1-59 of 59 results for **Medium (15 days)** **Forecasts**

**High resolution forecast**

**Surface parameters**

**Filter charts**

Filter charts Go

**Range**

- Medium (15 days) (59)
- Extended (30 days) (16)
- Long (Months) (23)
- Analysis (32)

**Type**

- Forecasts (59)
- Verification (27)

**Component**

- Atmosphere (38)
- Surface (34)
- Geography (4)

**Product type**

- ENS (34)

ECMWF About Forecasts Computing Research Learning Stephan Siemen Search site Go

## Tropical storm frequency - Long range forecast

Forecast base time

ECMWF Seasonal Forecast  
Tropical Storm Frequency  
Forecast start reference is 01/09/2015  
Ensemble size = 51, climate size = 300

System 4  
ONDJFM 2015/16  
Climate (initial dates) = 1990-2009

Forecast mean Standard deviation Climate mean

Back to charts

**Related charts**

- Accumulated Cyclone Energy - Long range forecast
- Hurricanes Typhoon frequency - Long range forecast

Stephan Siemen Sign out

ECMWF Products Projections Views Save Data availability Help Go

## 700 hPa relative vorticity and wind - Thursday 21 May 2015, 00 UTC VT Thursday 21 May 2015, 00 UTC Step 0

Layers

- Grid
- Foreground
- 700 hPa wind
- 50 % percentile for 2m temperature
- Background

**Probe**

Data values near location 51.54°N 0.33°W, Thursday 21 May, 00 UTC T+0

Layer	Value	Point selected	Location	Distance
700 hPa wind	7 ms <sup>-1</sup> N-W	nearest	51.52°N 0.22°W	7.81 km
50 % percentile for 2m temperature	8.1 °C	nearest	51.57°N 0.42°W	6.86 km

BT: Thu 21 May, 00Z VT: Thu 21 Fri 22 Sat 23 Sun 24 Mon 25 Tue 26 Wed 27 Thu 28 Fri 29 Sat 30

© ECMWF Chart updated (Network: 7.2s - Plot: 0.6s)

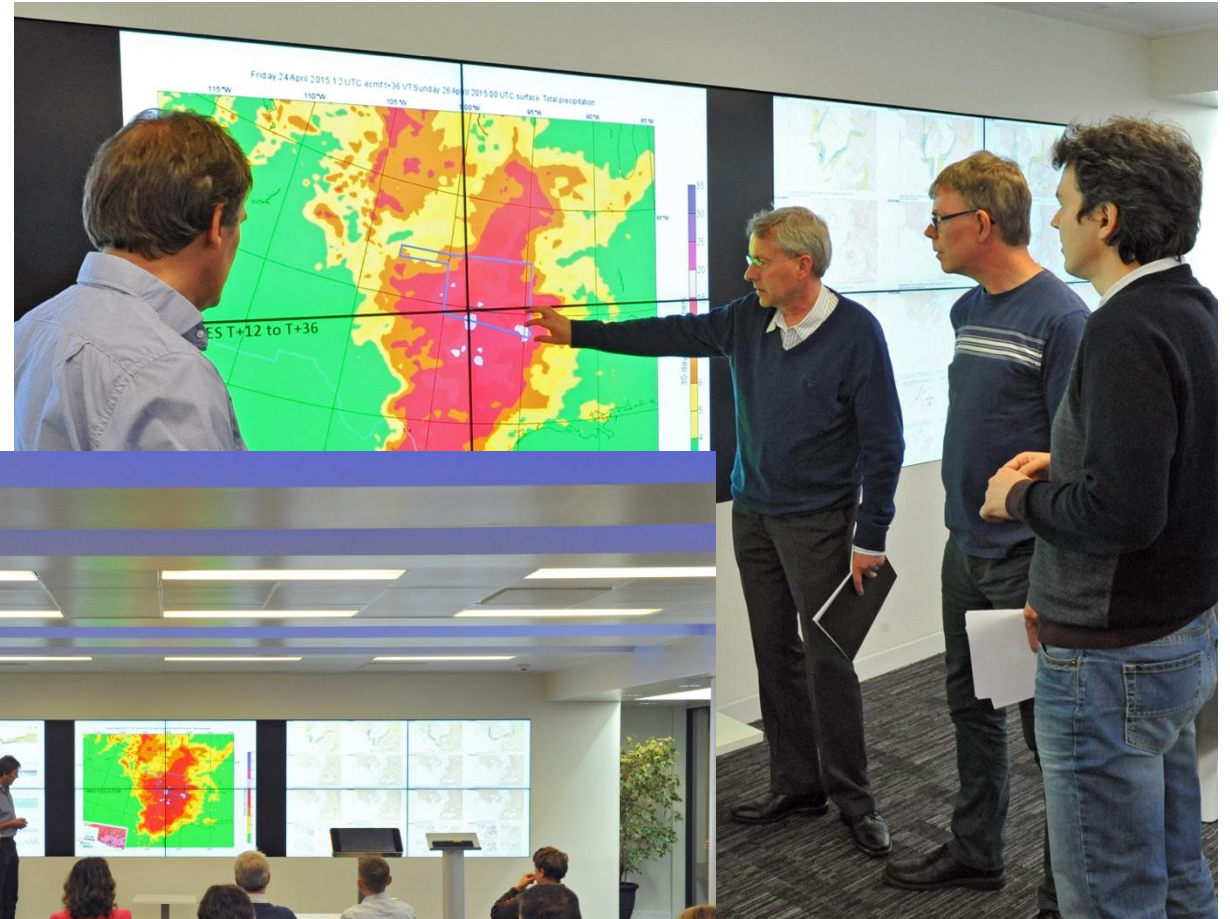
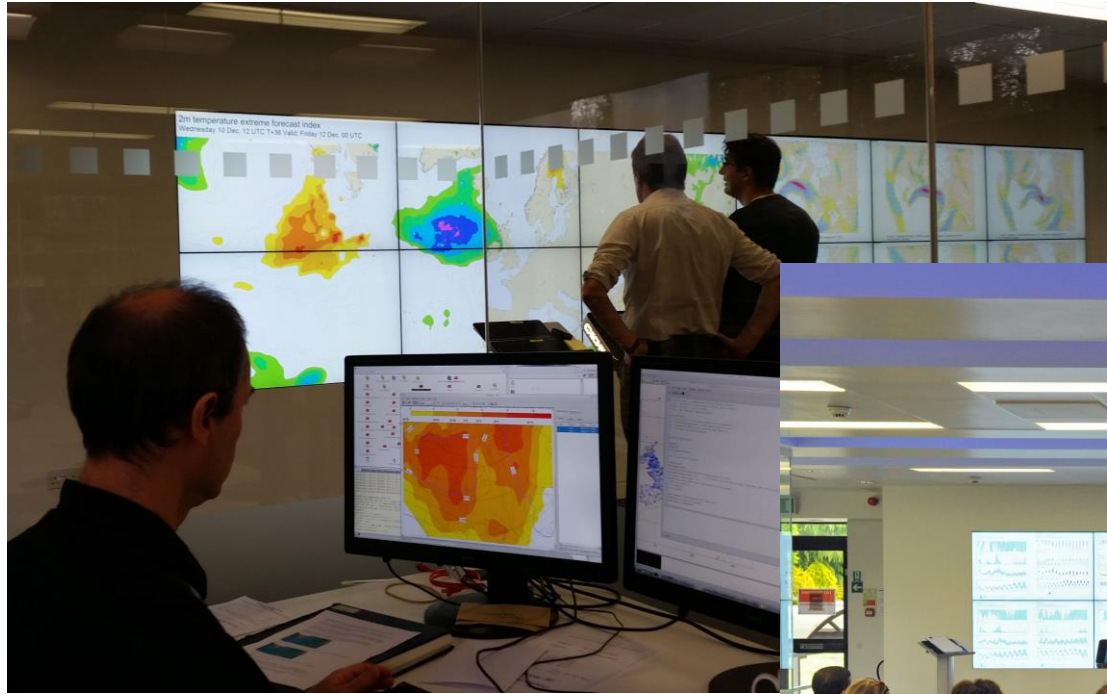
For long time paper was the main medium ...



Meteorological Operations "MetOps" Room  
1999 - 2014



# Now is more interactive screens ...

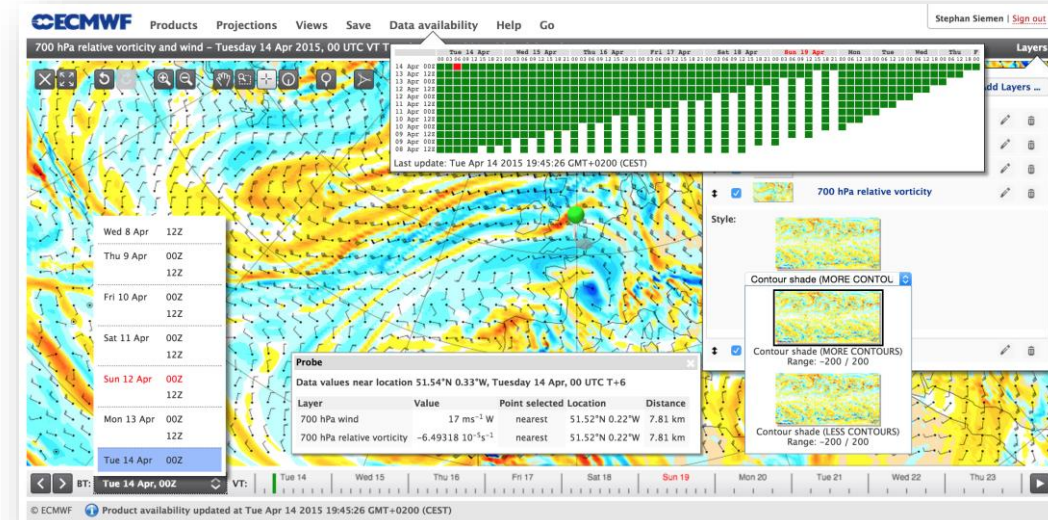


Weather Room  
2014 -

## The challenges today ...

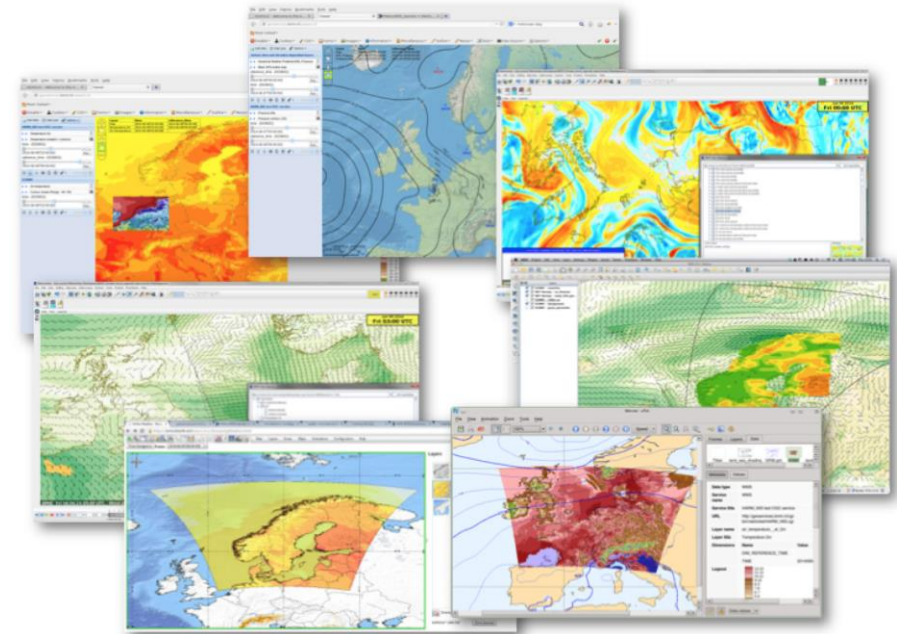
# Visualisation challenges in a Big Data world (1)

- Big data analytics – process, analyse and visualise massive amounts of data
- Build new base products – Allow users to see complex data sets without having all the data
  - e.g. expressing probabilities
- Build graphical products where the data is
  - On-demand (web) services
  - Challenge of offering flexibility for users with simple interfaces!
- Reproducibility – building trust with users
  - Build workflows
- Heterogeneous data sources – Meteorology, Climate, Ocean, ...
  - Includes formats: GRIB, NetCDF, HDF, BUFR, ...
- Flexible scalable architectures – services need to grow with data
  - ECMWF's Scalability Programme

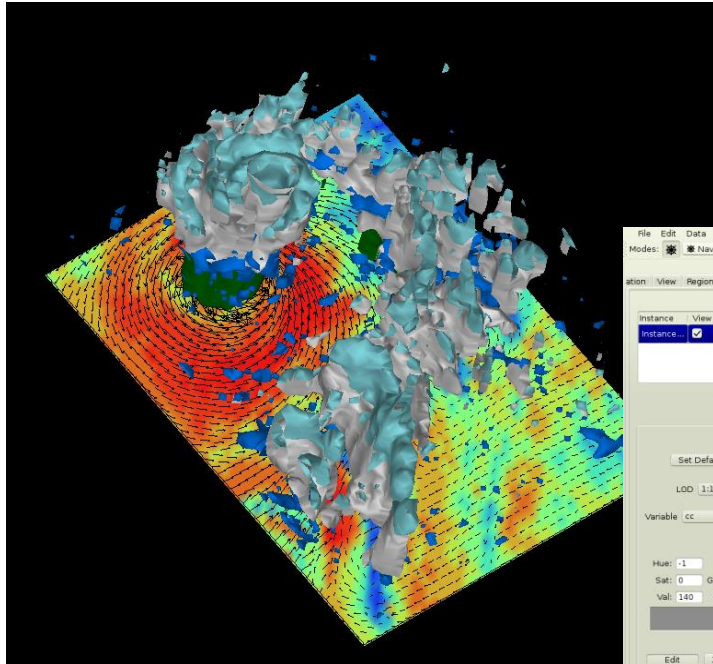


## Visualisation challenges in a Big Data world (2)

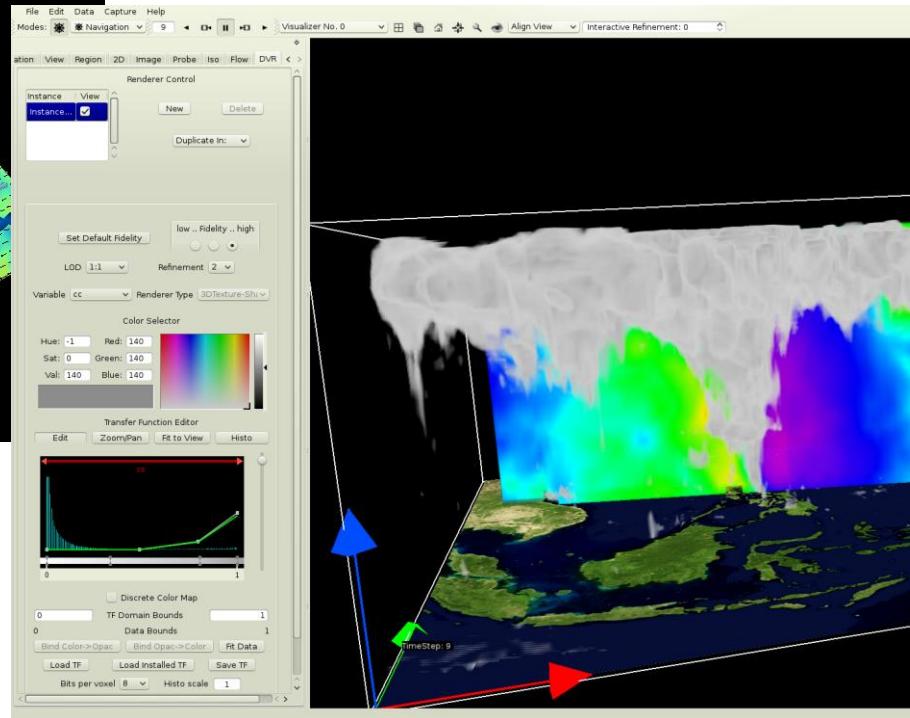
- Ensure quality of generated graphical products
  - A good and reliable regridding/interpolation is key to process and visualise NWP results
  - ECMWF is therefore working on a new interpolation package
- Tools need to help analysts and scientists to quickly detect problems
- How to integrate NWP (graphical) products with users
  - Support common standards for services and formats
    - OGC web standards – Web Map Service (WMS)
    - PNG, SVG, KML
- With increasing model resolution how to help scientists to explore new parameters and vertical processes
  - Three dimensional visualisation



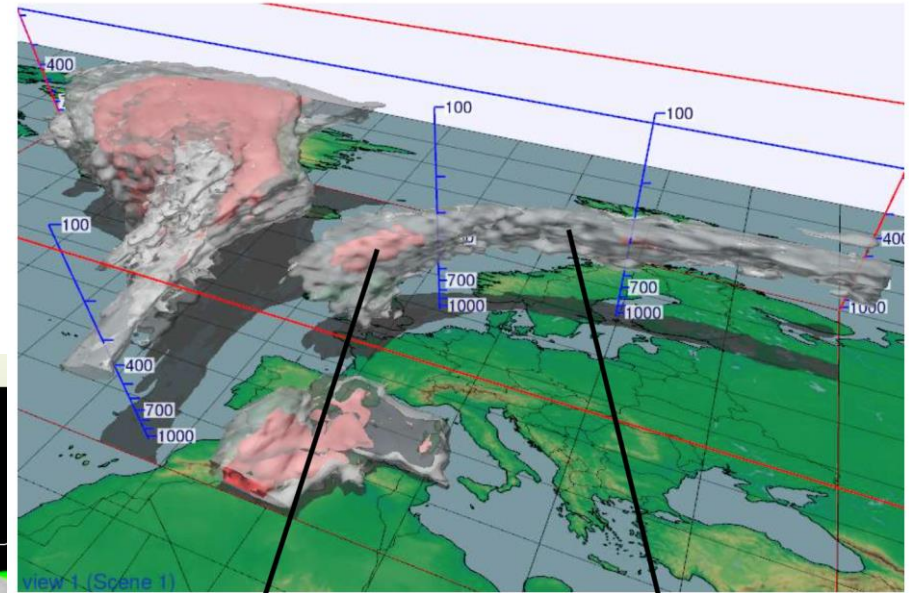
# 3D/4D



Vis5D



Vapor



30% probability

10% probability

Met3D

# The comeback of 3D/4D?

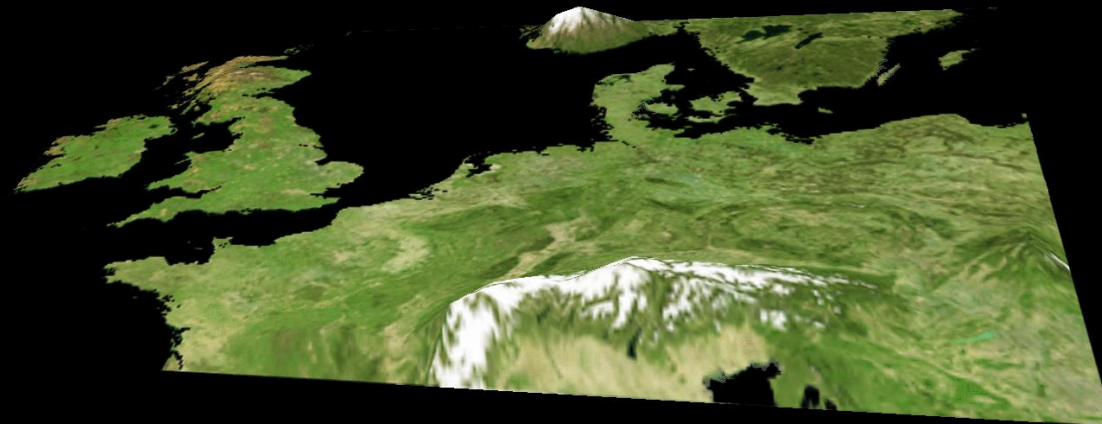
## St Judes storm visualisation

12Z 27th October 2013: 48 hr forecast

IFS T1279. Hourly frames.

Glenn Carver, Sandor Kertesz : ECMWF

Produced with VAPOR (CISL, NCAR)

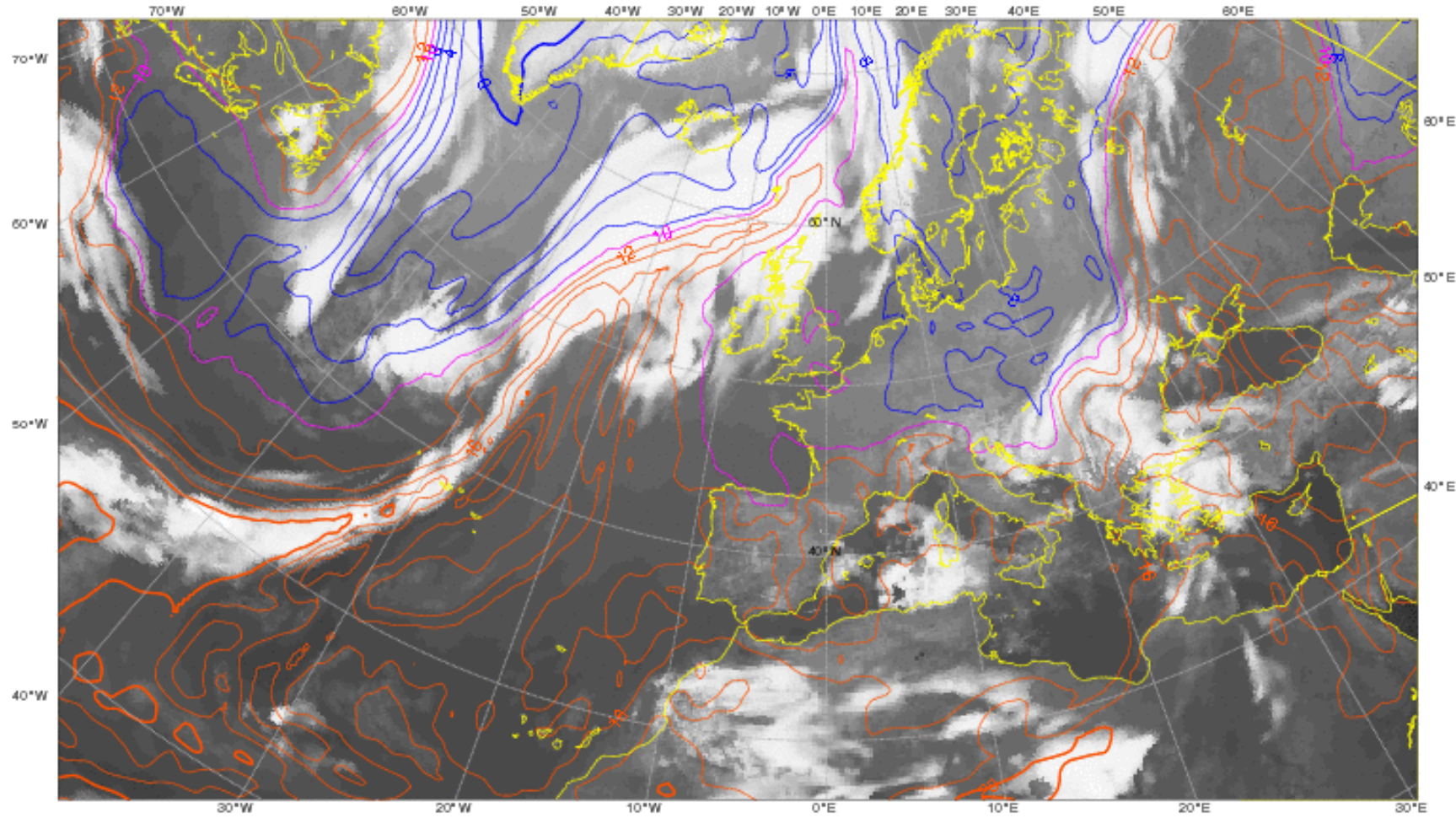


St Judes storm, 27<sup>th</sup> October 2013  
Thanks to Glenn Carver from the OpenIFS project  
(Using Metview and Vapor)



# Overlay is essentials

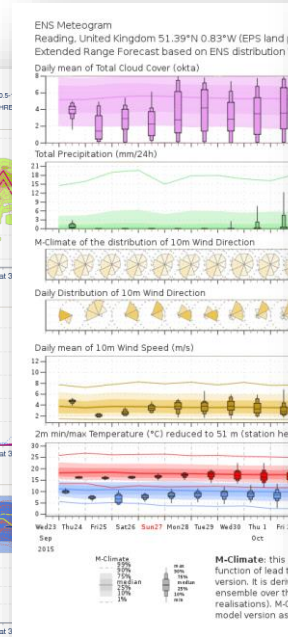
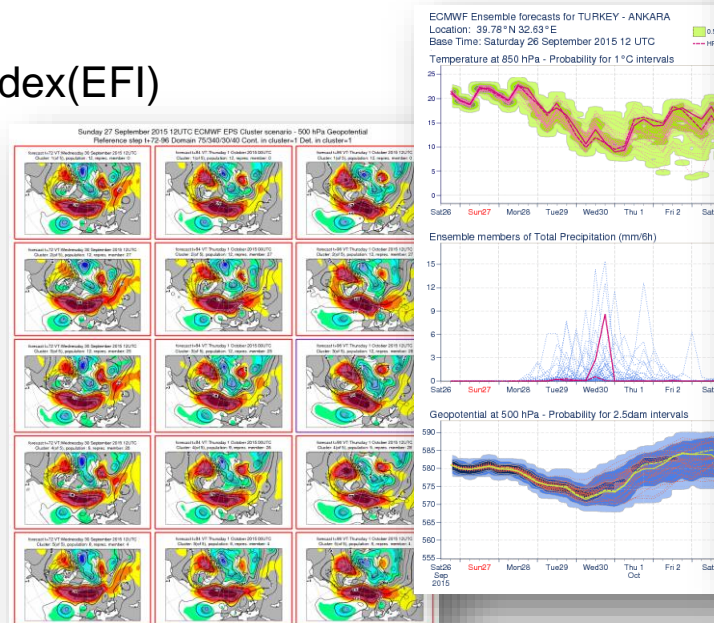
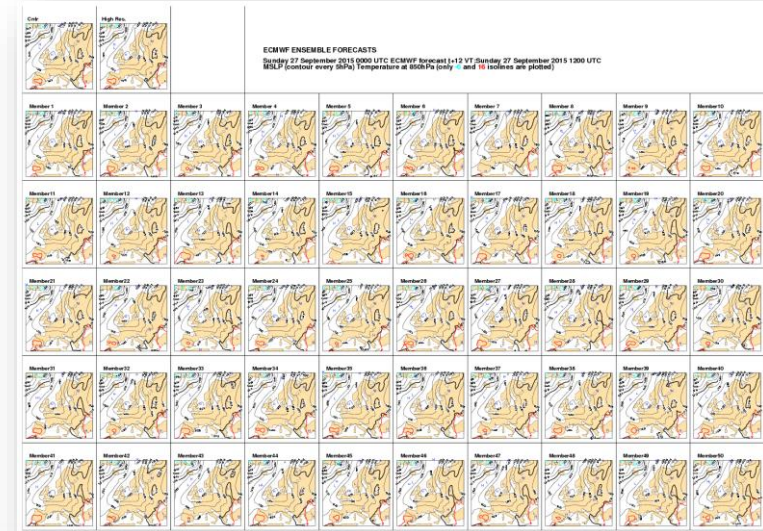
Monday 28 September 2015 0000 UTC +3 VT: Monday 28 September 2015 0300 UTC  
Model simulated METEOSAT 10 SEVIRI (Channel 9 IR10.8) Brightness Temperature and 850 hPa wet bulb pot. temp.



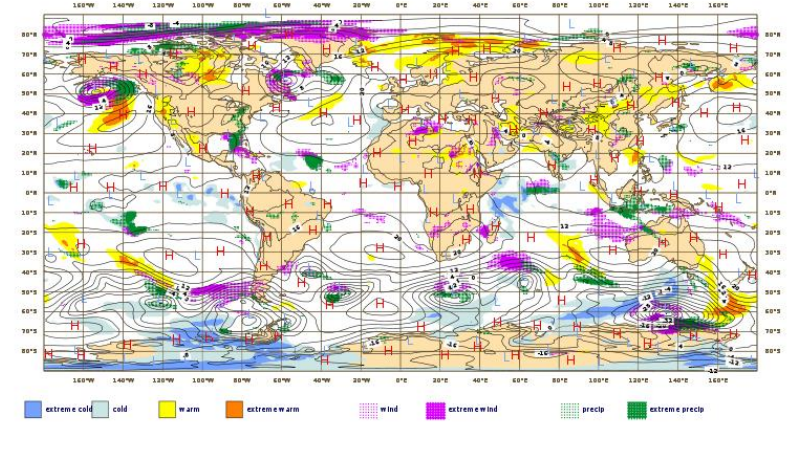
# The challenge of Ensemble forecast (ENS) products

- Operating ensemble of forecasts brings its own challenges
  - Ensembles should be seen only in their context, not on their own
  - The 51 forecasts are too much for most users to process
- Users can make use of statistical products
  - Mean, Standard-deviation, ...
- ECMWF can offer graphical products

- ENS Metgrams & Extreme Forecast Index(EFI) are successful examples of this



Anomalous weather predicted by EPS: Wednesday 05 June 2013 at 12 UTC  
 1000 hPa Z ensemble mean ( Thursday 06 June 2013 at 12 UTC )  
 and EFI values for Total precipitation, maximum 10m wind gust and mean 2m temperature (all 24h)  
 valid for 24hours from Thursday 06 June 2013 at 00 UTC to Friday 07 June 2013 at 00 UTC

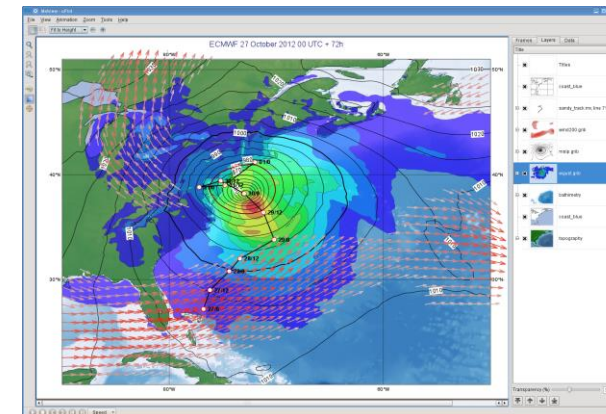
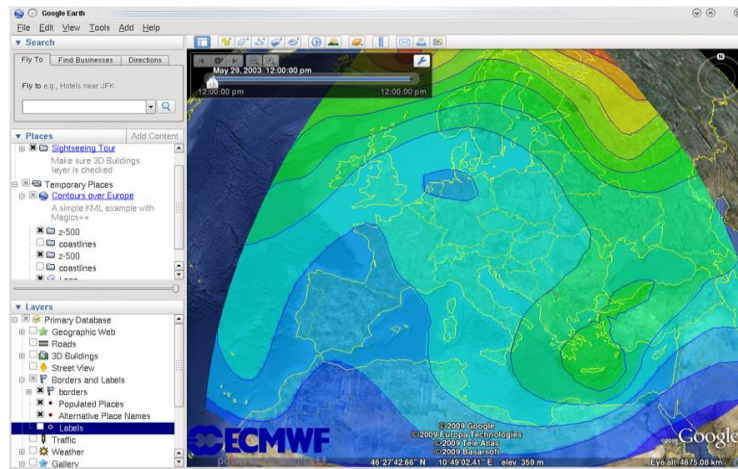
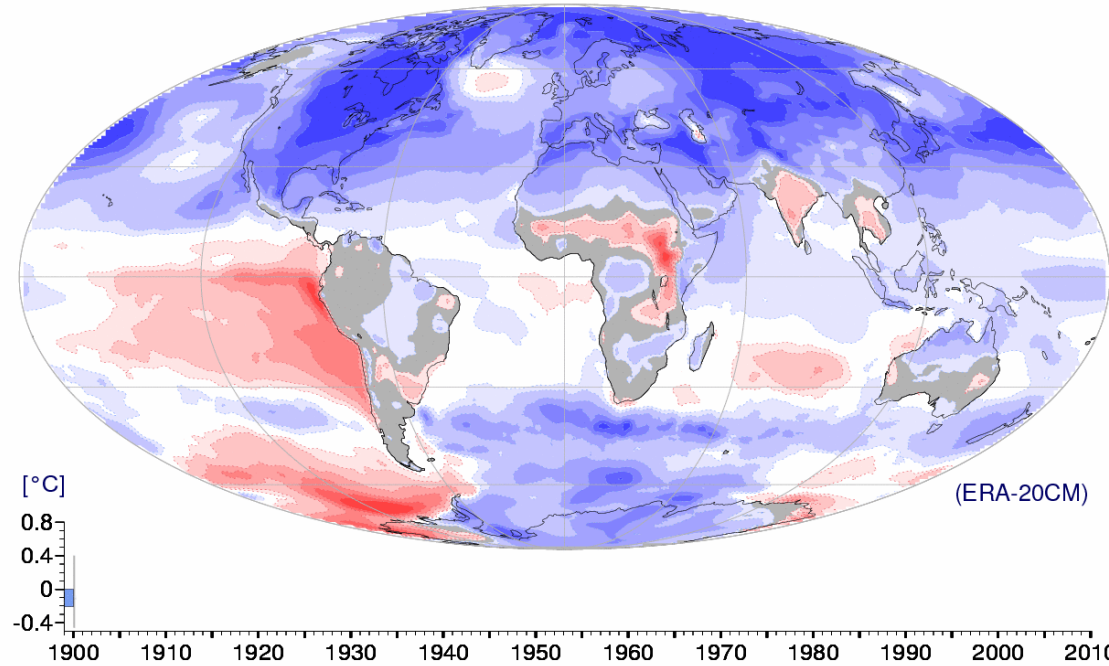
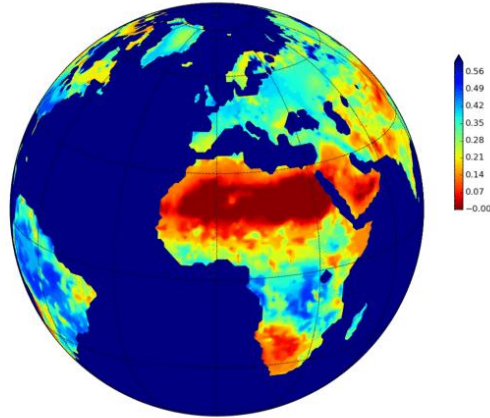


Extreme Forecast Index (EFI)

# Supporting communication ...

## Global warming relative to 20th-century average

Root-Zone Soil moisture (0-100cm)  
January 1993



# Any questions?

