Visualisation and use of ensembles – a real world example

Gabriella Szépszó, Glenn Carver

Overview

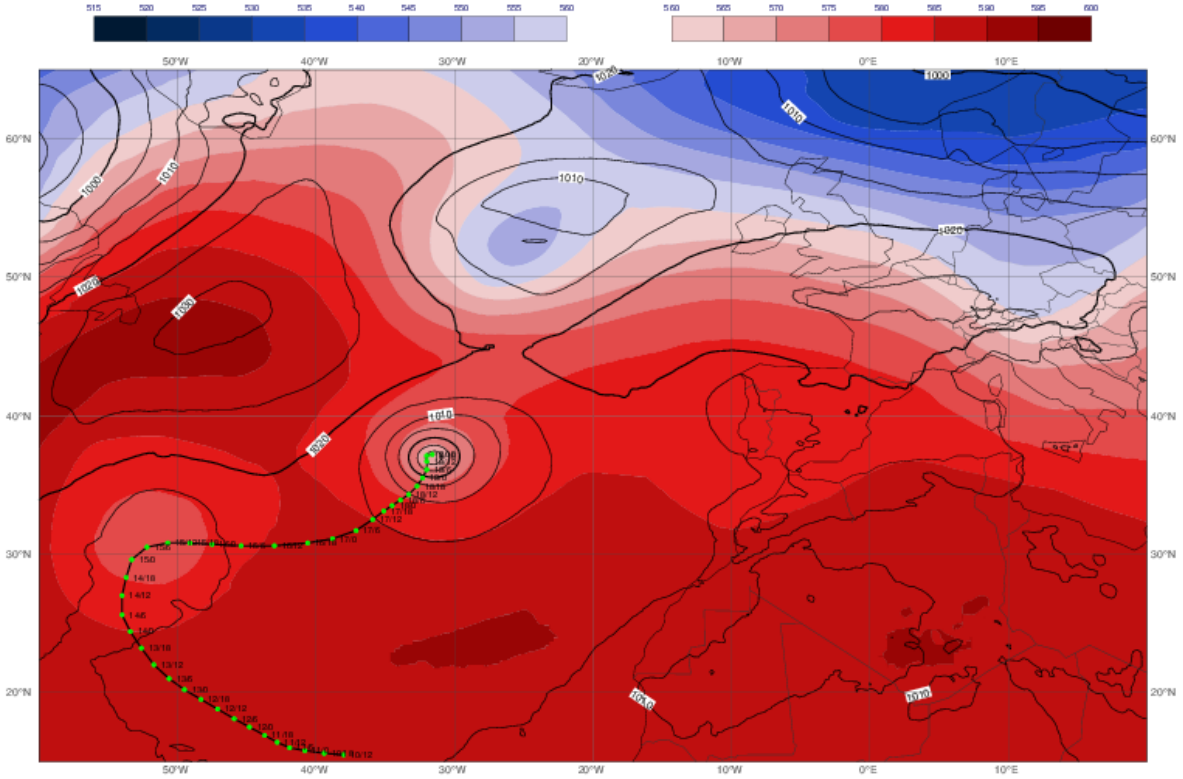
- The exercise is based on Pantillon et al., 2015: Vortex-vortex interaction between Hurricane *Nadine* and an Atlantic cutoff dropping the predictability over the Mediterranean, doi: 10.1002/qj.2635
- **Interaction of Hurricane Nadine with an Atlantic cut-off low** in September 2012 (forecast difficulties during the HyMEX field campaign over France)
- Case study imitating the job of a duty forecaster:

    1. Available analysis
    2. High-resolution forecast
    3. Ensemble forecast
    4. Probabilistic information using clustering
    5. Forecast performance

- Prepared exercises: data of IFS forecasts and analyses, Metview macros and tutorial (https://confluence.ecmwf.int/x/qxfxBw)

Analysis

500 hPa geopotential and mean sea level pressure with Nadine track
Valid: 00 UTC 20 September 2012



- Further parameters are available from 15 September 2012: temperature, humidity, wind, surface fields
- Plots can be animated

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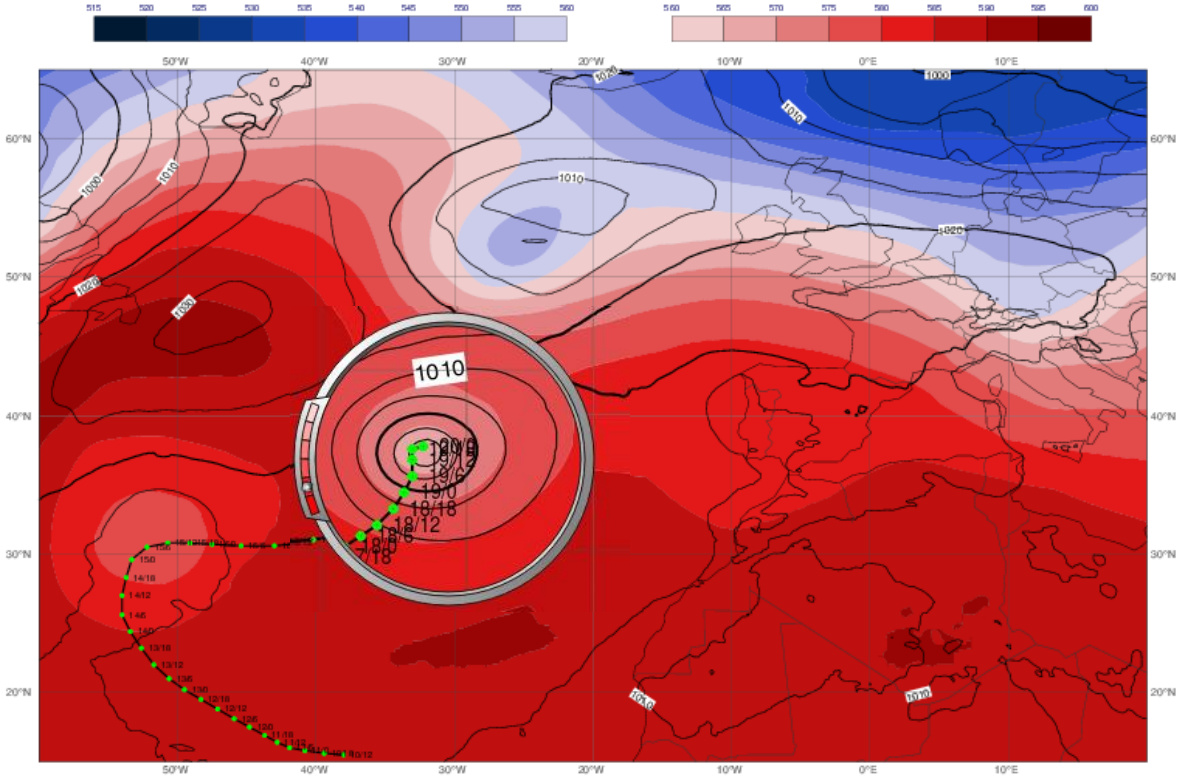

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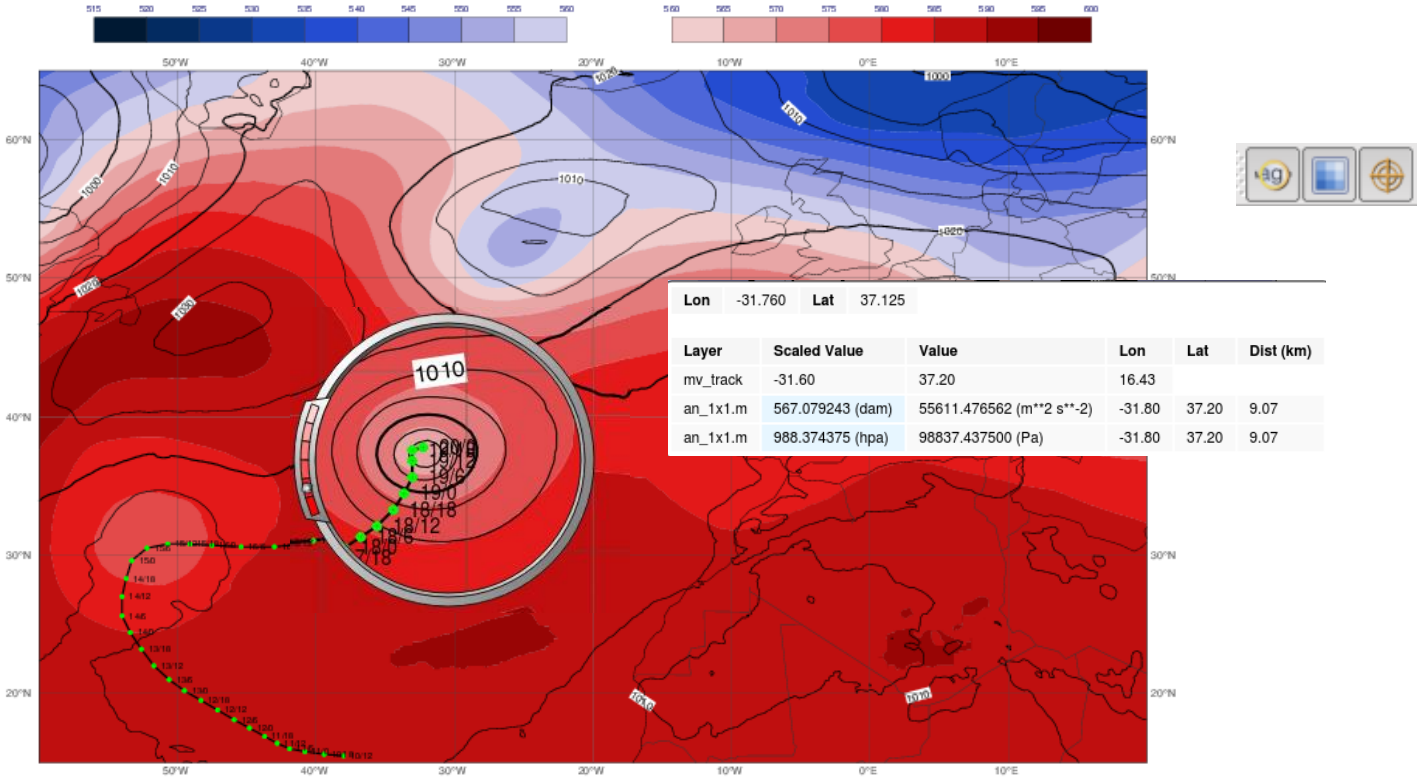

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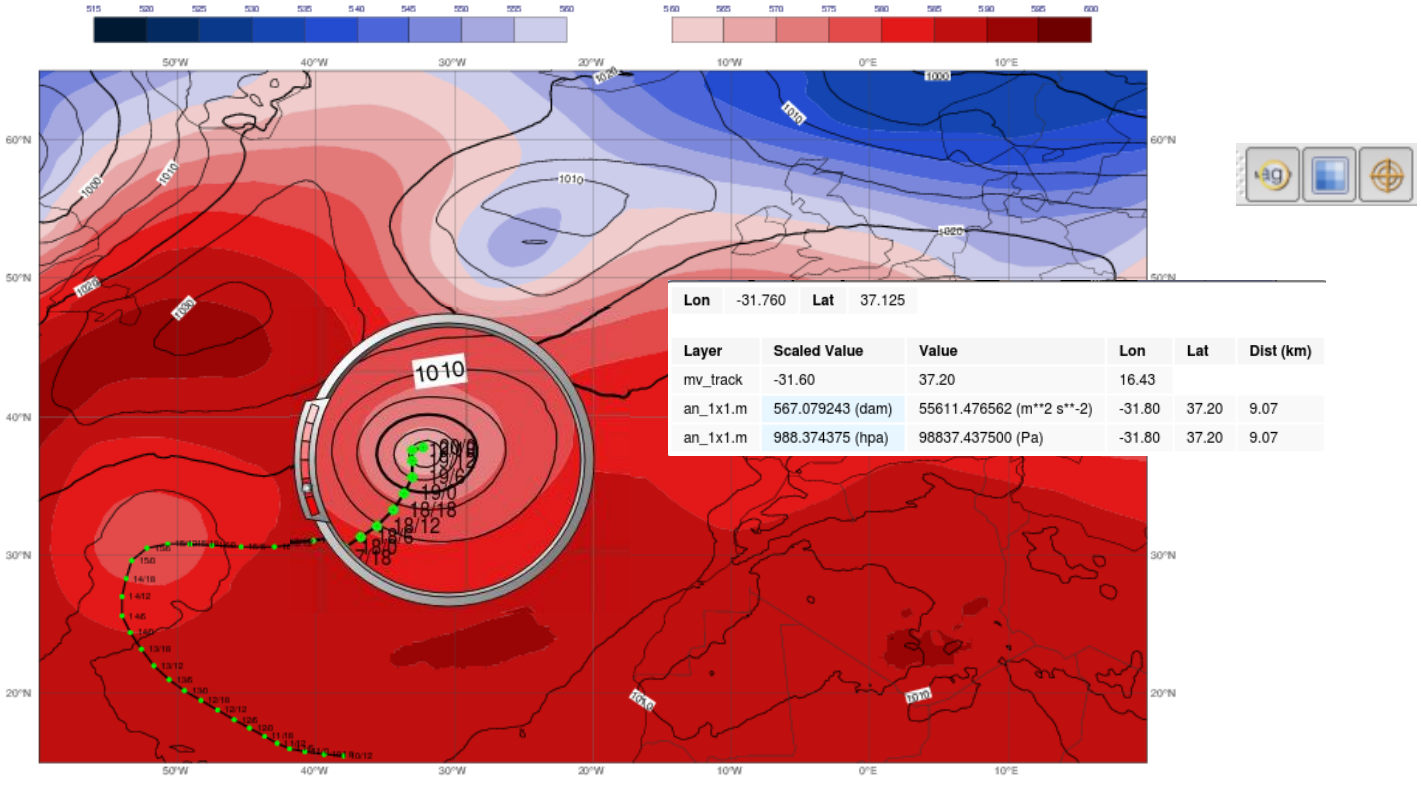

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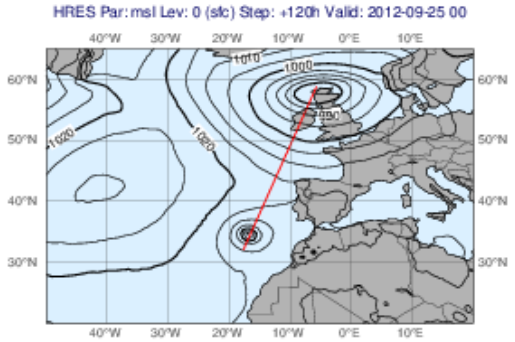
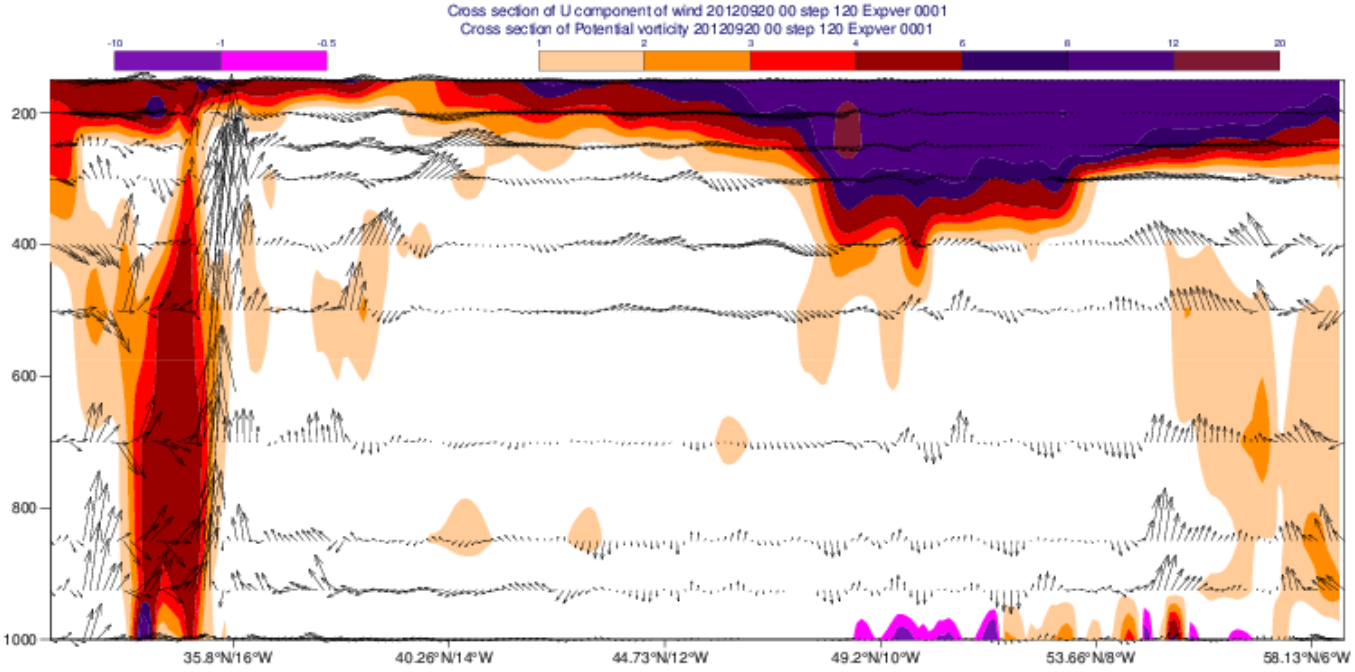
High-resolution forecast (HRES)

- 10-day HRES forecast from 20 September, plots can be animated



Cross section of
potential vorticity and u component of wind
Valid: 00 UTC 25 September 2012

See the appendix of the tutorial

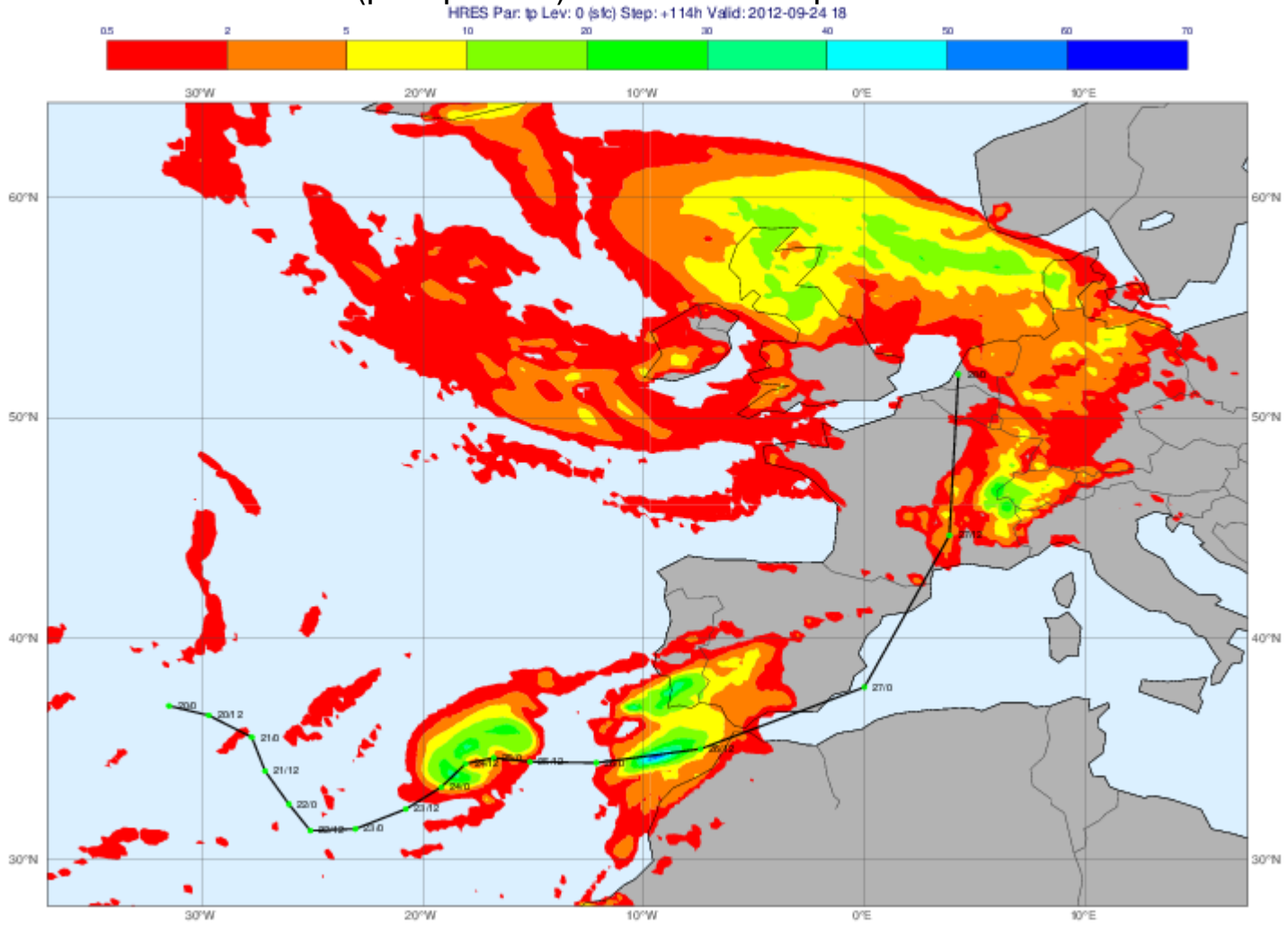


Change the position of the line for different time steps

High-resolution forecast (HRES)

- Same variables as for analysis + precipitation

6-hour precipitation amount with Nadine track
Valid (precipitation): 18 UTC 24 September 2012



Ensemble forecasts

- **Initial error**
  - Ensemble data assimilation (EDA): represents analysis uncertainty
  - Singular vectors (SV): represent fastest growing modes
- **Model error**
  - Stochastically perturbed parameterisation tendencies (SPPT): applied to physics tendencies
  - Stochastic backscatter (SKEB): dynamical uncertainty (off since 2018)
  - SV / EDA / SPPT / SKEB act at different timescales
- **Ensembles**
  - **Control run**: unperturbed forecast
  - **HRES**: high-resolution forecast (double of the ensemble resolution) from the same initial state as the control forecast
  - **Spread**: range of forecasts (uncertainty)
  - **Mean**: mean of ensemble forecasts (smooth field – not a forecast)

ECMWF ensembles in 2012 and 2016

- **September 2012** ensemble (`expId=ens_oper`):
  - Horizontal resolution: 36km (T_L639)
  - Climatological SST fields used for days 1-10
  - EDA members: 10
- **March 2016** ensemble (`expId=ens_2016`):
  - Different grid (cubic octahedral)
  - Higher grid resolution (18km) (same spectral: $T_{Co}639$)
  - SST from ocean model (NEMO) coupled from t+0
  - EDA members: 25
- **Note: analysis was not rerun**, so 2016 reforecast of this case study still uses original 10 EDA members
- HRES (double of the ensemble resolution) from the same initial state as the control forecast → **control(2016)~HRES(2012)**

Ensemble forecast

Stamp diagram for 500 hPa geopotential
Valid: 18 UTC 23 September 2012

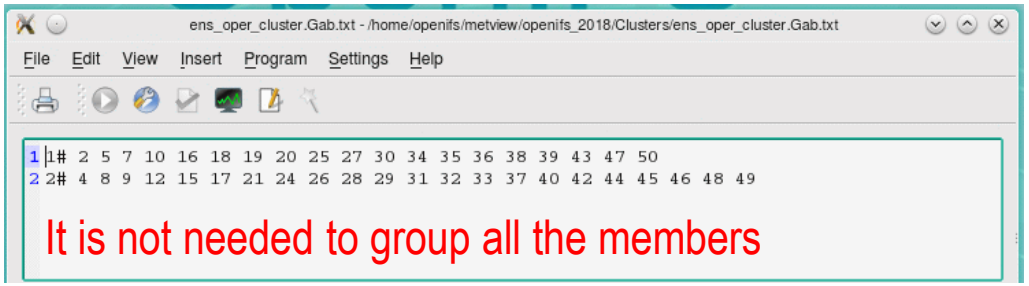
`clustersId="off"`

- Slow plotting, you can focus on one time step

Probabilistic information

- Probabilistic approach:
  - Equiprobable members
  - Likelihood of occurrence
- Visualization**:**
  - Plume diagrams
  - Meteograms
  - **Stamp diagrams**
  - Probability maps
  - **Clustering:** manual and automatic clustering
  - etc.

Manual clustering

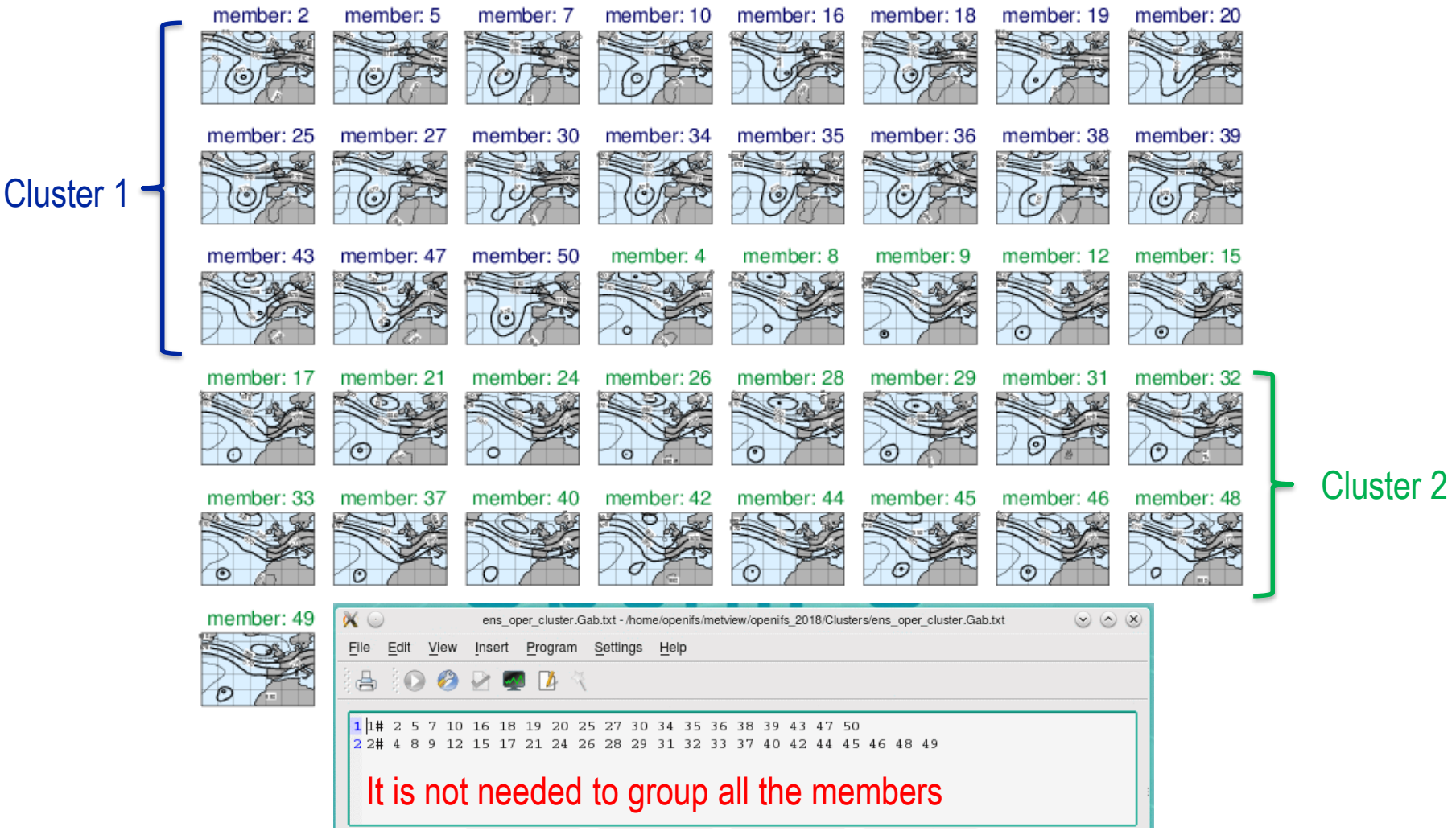


clustersId="**Gab**"

Input: ens_oper_cluster.**Gab**.txt

Manual clustering

Stamp diagram for 500 hPa geopotential with 2 manual clusters
Valid: 18 UTC 23 September 2012

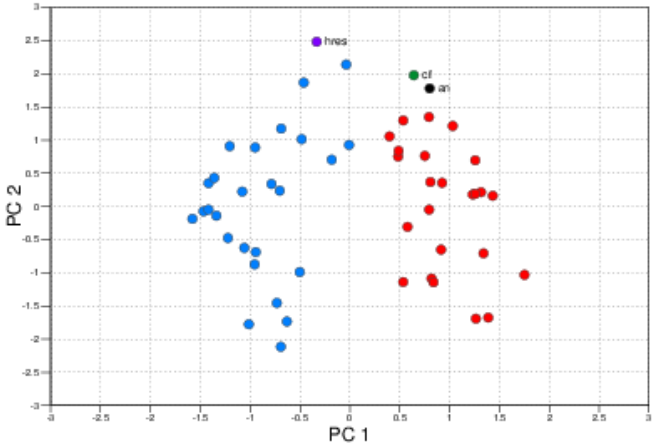


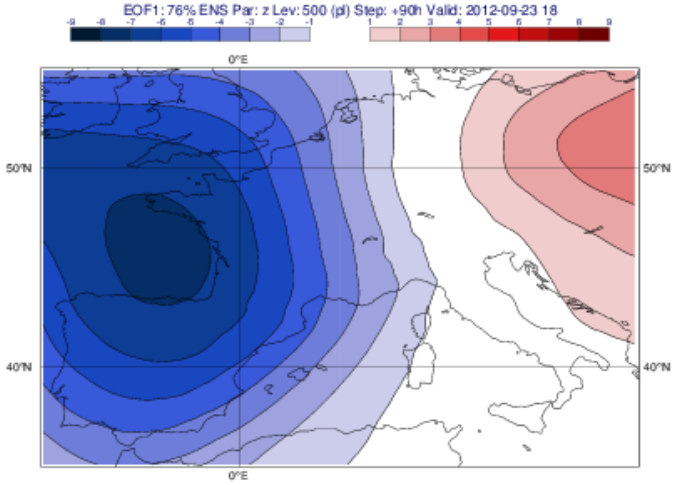
clustersId="**Gab**"

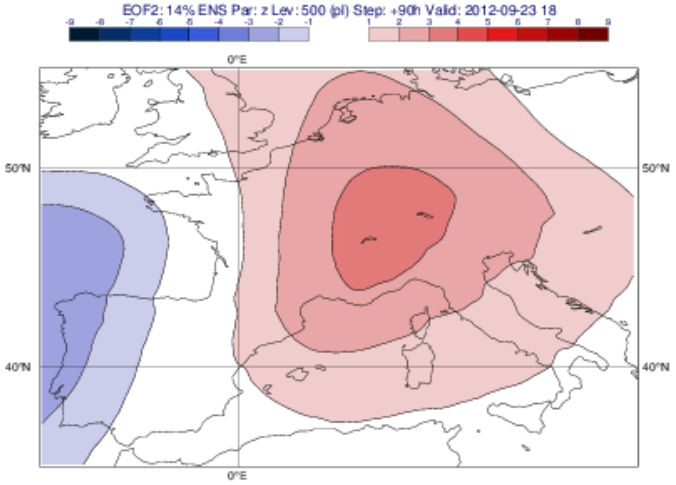
Input: ens_oper_cluster.**Gab**.txt

Clustering using principal component analysis

Principal component analysis for 500 hPa geopotential
Valid: 18 UTC 23 September 2012



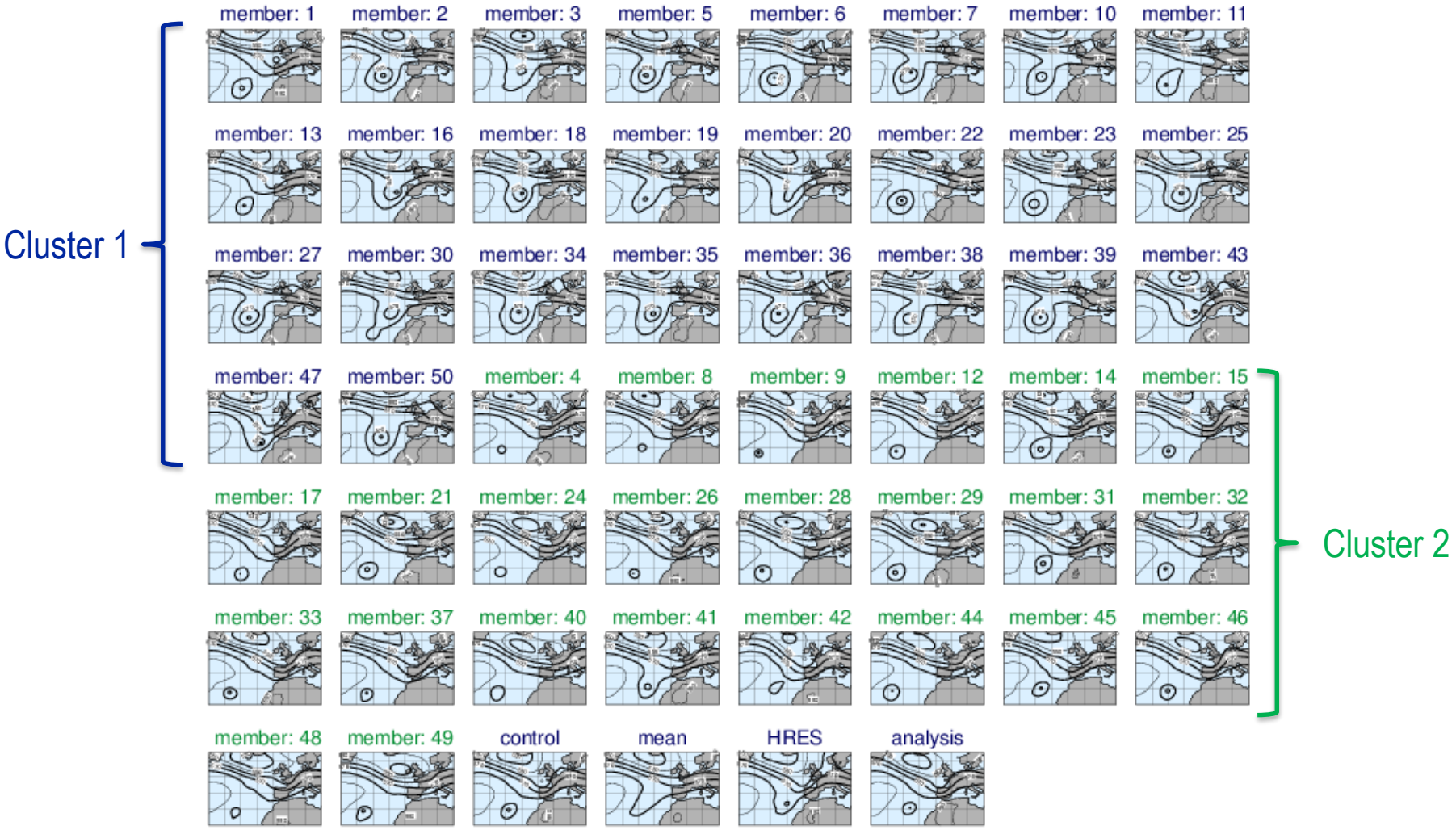




Output: `ens_oper_cluster.eof.txt`

Clustering with PCA

Stamp diagram for 500 hPa geopotential with 2 clusters using EOF
Valid: 18 UTC 23 September 2012



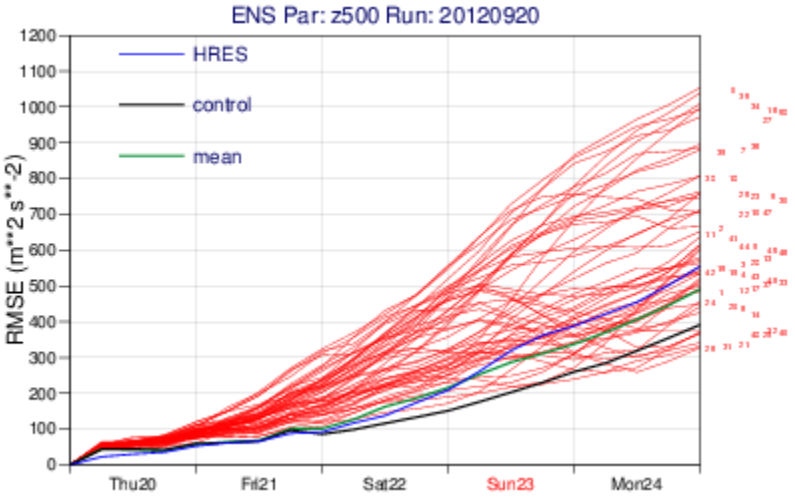
clustersId="eof"

Input: ens_oper_cluster.eof.txt

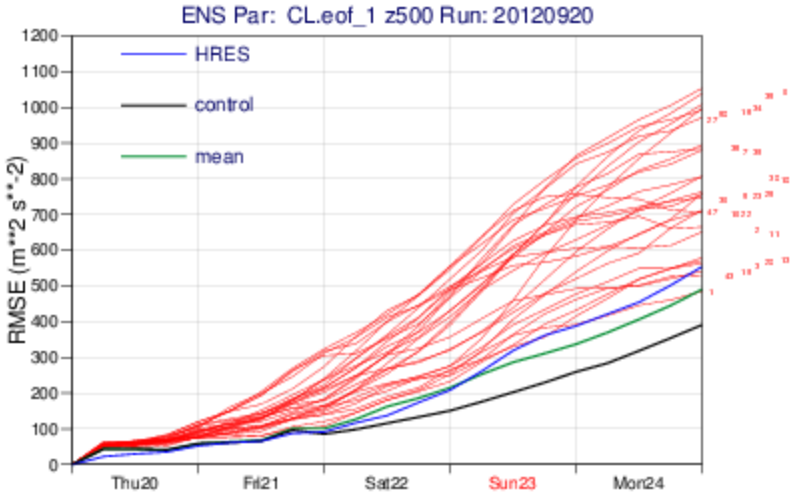
Forecast performance

- Verification with collection of large forecast samples, but also with case studies
- Reference: ECMWF analysis
- Specific measures:
  - Root mean square error (**RMSE**)
  - Brier score, BSS, CRPS, CRPSS
  - ROC curve & area, etc.

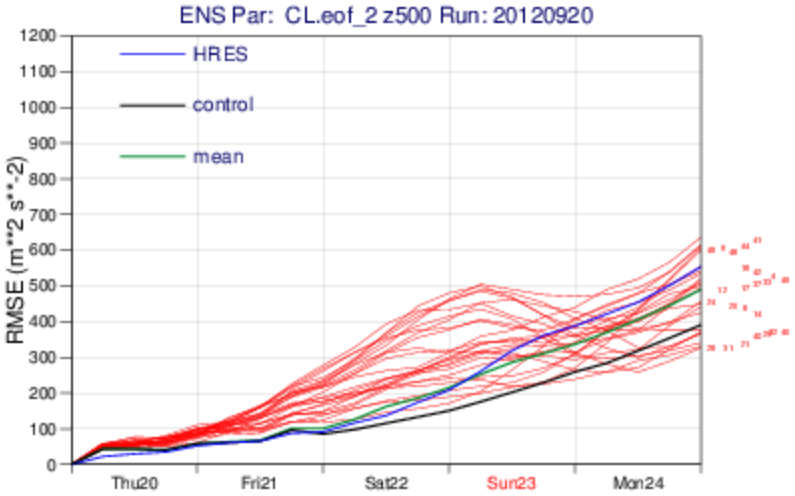
500 hPa geopotential RMSE



500 hPa geopotential RMSE for cluster 1



500 hPa geopotential RMSE for cluster 2



Key points

- Interaction of Nadine and the cut-off low
- HRES vs. control forecast (recall: effect of resolution)
- Temporal characteristics of the ensemble spread
- Spread–skill relationship
- Average skill of ensemble mean vs. case study
- Compare the SST fields in the two ensemble forecasts

5th OpenIFS user meeting 2019

- Topic: the impact of moist processes on weather forecasts
- Location: University of Reading / ECMWF
- Monday training on the OpenIFS model, science programme (presentations, poster and practical sessions) from Tuesday to Friday
- Abstracts on related topics are welcome as well as on research or education use of IFS and OpenIFS
- Registration (free; deadline: 15/31 March): https://events.ecmwf.int/event/126

More information:
openifs-support@ecmwf.int

Invited speakers

- Christian Grams, Karlsruher Institut für Technologie, Germany,
- John Methven, University of Reading, UK,
- Mark Rodwell, ECMWF, UK,
- Victoria Sinclair, University of Helsinki, Finland,
- Chris Thorncroft, University of Albany, USA,
- Heinli Wernli, ETH, Switzerland,
- Keith Williams, Met Office, UK,
- Klaus Wyser, SMHI, Sweden,
- Nedjelka Žagar, University of Ljubljana, Slovenia

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