Verifying sensitivity climatologies of Mediterranean intense cyclones for optimal adaptive observations

L. Garcies and V. Homar

Universitat de les Illes Balears
Departament de Física
Grup de Meteorologia

6th European Conference on Severe Storms, ECSS
Palma, 3-7 October 2011

Outline

Introduction

The **Mediterranean region** is an active cyclogenetic area, frequently affected by **cyclones that produce hazardous weather** such as strong winds and heavy rain.

Many efforts are being devoted to improve the prediction of these events.

Two main sources of forecast error:

Imperfections in the models

Uncertainty in the initial conditions

How the uncertainty of a particular forecast aspect can be attributed to different uncertainty aspects of the initial conditions?: **Sensitivity Analysis**

Adaptive observing strategies: long-term and real-time perspectives

Sensitivity Climatologies of Mediterranean Intense Cyclones

Adjoint Sensitivities

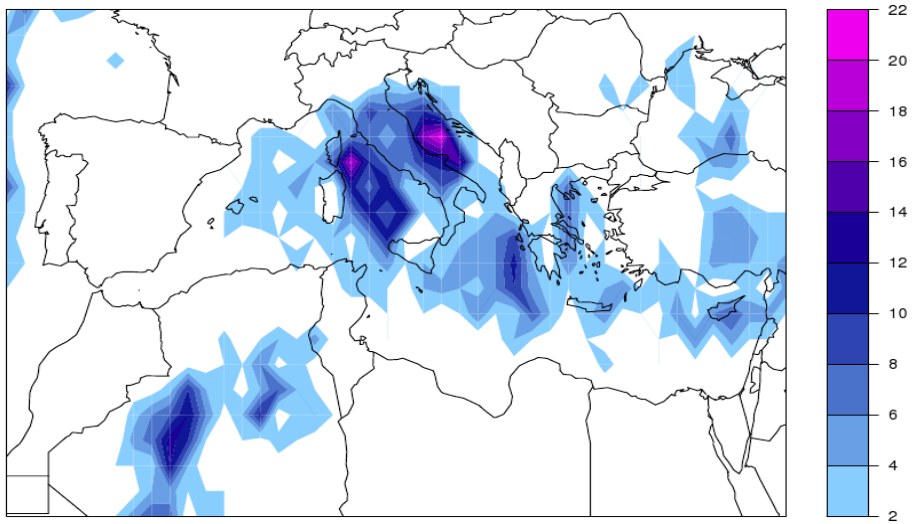
Ensemble Sensitivities of the Real Atmosphere

Classification 1

Classification 2

Sensitivity Climatologies of Mediterranean Intense Cyclones

DATABASE: 1359 Mediterranean Intense Cyclones



Classification 1:

1202 cyclones in 25 clusters

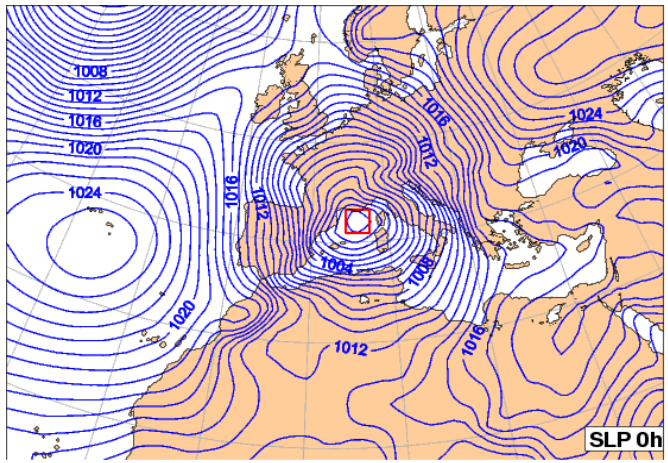
Classification 2:

406 cyclones in 23 clusters

Forecast aspect of interest (Response Function):

Cyclone's depth at the time

of maximum intensity of the cyclone.



2 Sensitivity Methods: Adjoint Model and Ensemble Sensitivity.

Adjoint Sensitivities

Ensemble Sensitivities of the Real Atmosphere

Classification 1

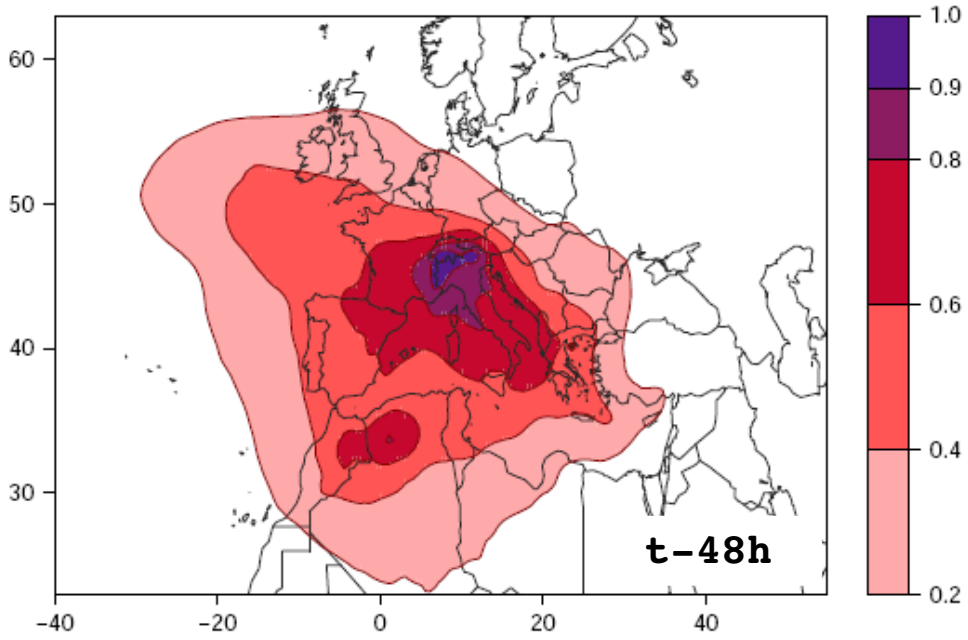
Classification 2

Adjoint Sensitivities

Jansà and Homar (2006)

Sensitivity Method	Mediterranean intense cyclone classification	Sensitivity Products
Adjoint	1202 cyclones classified into 25 clusters Clustering steps: regional classification, subclassification considering precursor conditions. Jansà and Homar (2006)	Times: $t - 48\ h$. IC considered: T, U, V, PP, Q for the centroid. J: centroid cyclone's depth. Jansà and Homar (2006)

- Significant climatological sensitivities are obtained over Western Mediterranean region, Northern African lands and parts of east North-Atlantic for *t-48h*



Sensitivity Climatologies of Mediterranean Intense Cyclones

Adjoint Sensitivities

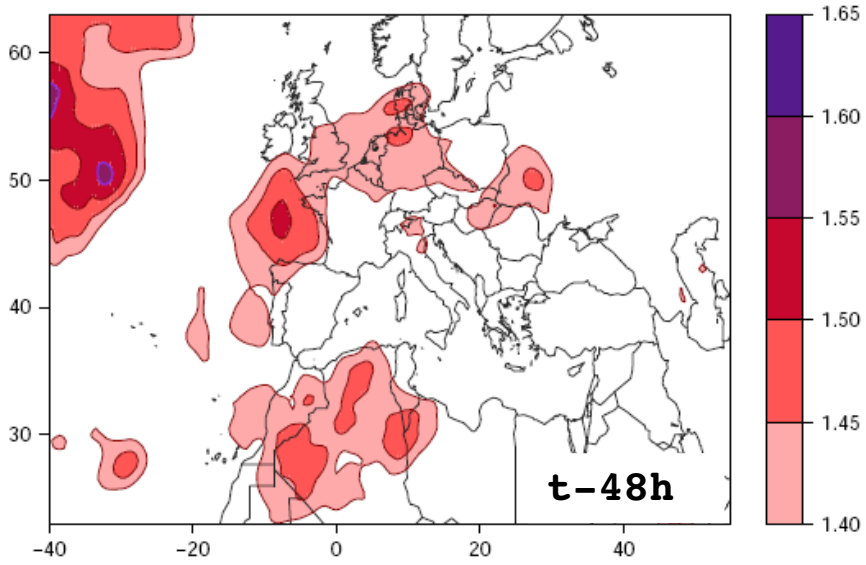
Ensemble Sensitivities of the Real Atmosphere

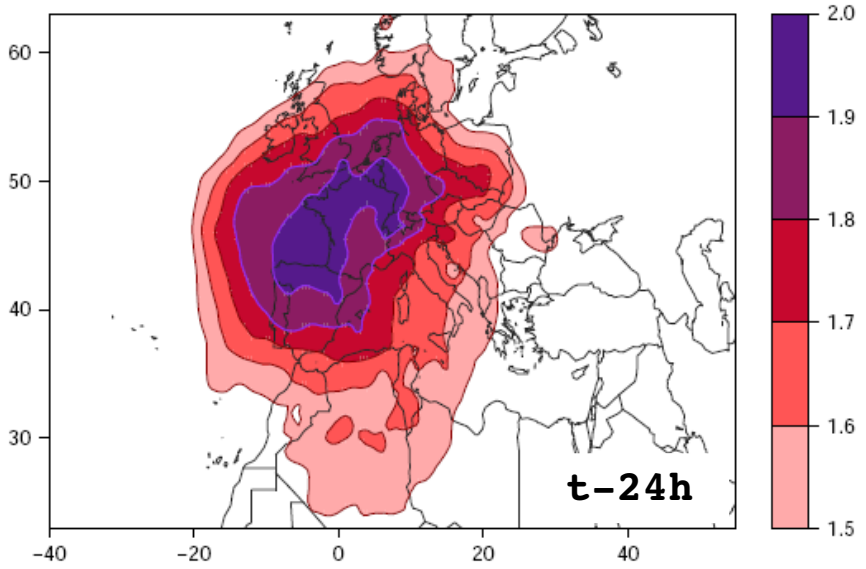
Classification 1

Classification 2

Ensemble sensitivities of the real atmosphere: Classification 1

Sensitivity Method	Mediterranean intense cyclone classification	Sensitivity Products
Ensemble-1	1202 cyclones classified into 25 clusters Clustering steps: regional classification, subclassification considering precursor conditions. Jansà and Homar (2006)	Times: $t-48\ h$ and $t-24\ h$. IC considered: H, T, UV. J: individual MSLP at centroid's cyclone center. Garcies and Homar (2009)





- At t-48h the lack of homogeneity of the clusters affects the correlation coefficients and consequently the derived sensitivities. This motivates the objective of rebuilding the classification, optimizing the statistical sensitivity calculations.

Available Sensitivity Climatologies

Adjoint Sensitivities

Ensemble Sensitivities of the Real Atmosphere

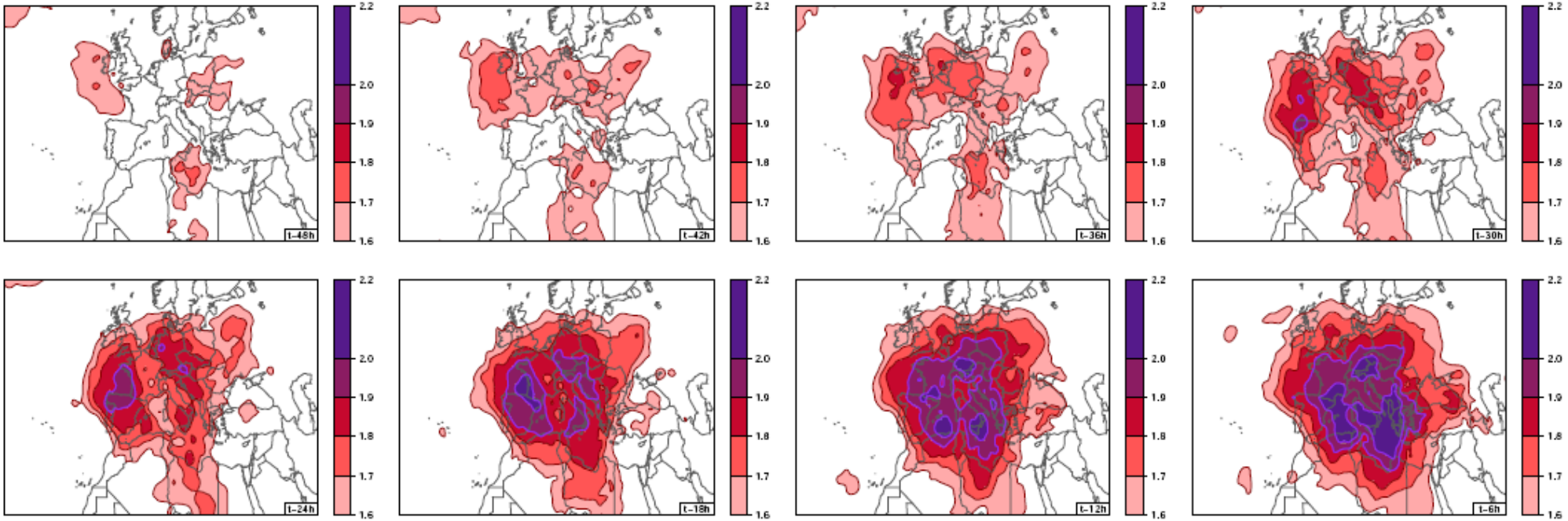
Classification 1

Classification 2

Ensemble sensitivities of the real atmosphere: Classification 2

Sensitivity Method	Mediterranean intense cyclone classification	Sensitivity Products
Ensemble-2	406 cyclones classified into 23 clusters Clustering steps: regional classification, subclassification considering precursor conditions, cluster prunning. Garcies and Homar (2010)	Times: from $t - 48\ h$ to $t - 6\ h$ every 6 h. IC considered: H, T, UV, R. J: individual cyclone's depth. Garcies and Homar (2010)

- As we get closer to the cyclone maturity the central Mediterranean region becomes increasingly relevant:



Verification of Sensitivity Climatologies

3 available Sensitivity Climatologies of Mediterranean intense cyclones

But... How reliable?

▼

Verification of the climatological sensitivity results to unequivocally guide policy-makers on plans **to redefine routine observational strategies**

▼

Verification Methodology:

- **Observation System Simulation Experiments (OSSEs)**
- Case studies: **25 of the most intense mediterranean cyclones of ERA-40**
- Numerical experiments with NCAR Advanced Research **WRF ARW** model

Verification of Sensitivity Climatologies

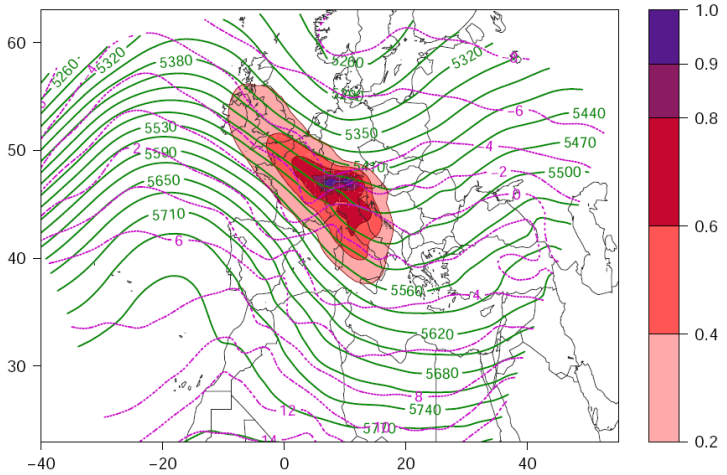
Illustrative example

Results for all cases

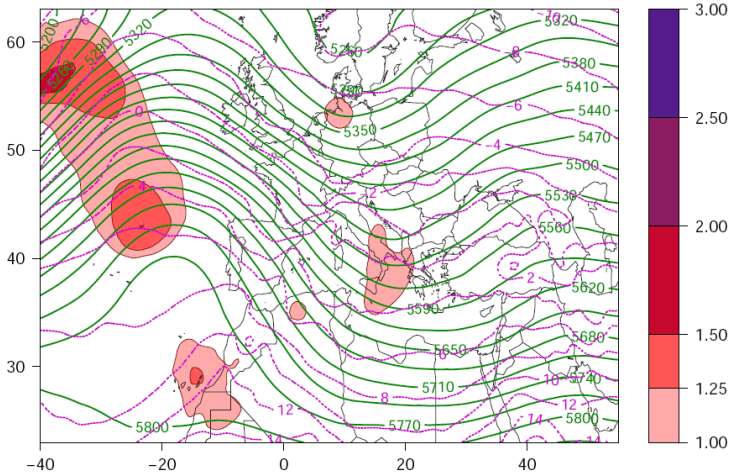
Illustrative example

Case Study: December 2nd 1983. Ionian Sea Cyclone. Corresponding sensitivity fields:

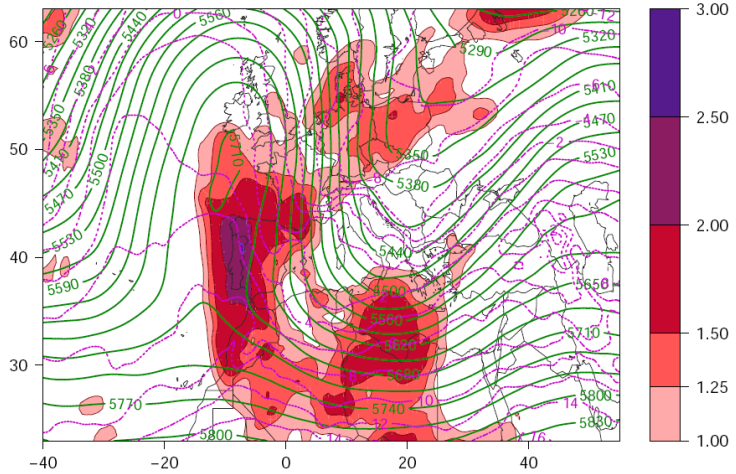
ADJOINT



ENSEMBLE-1



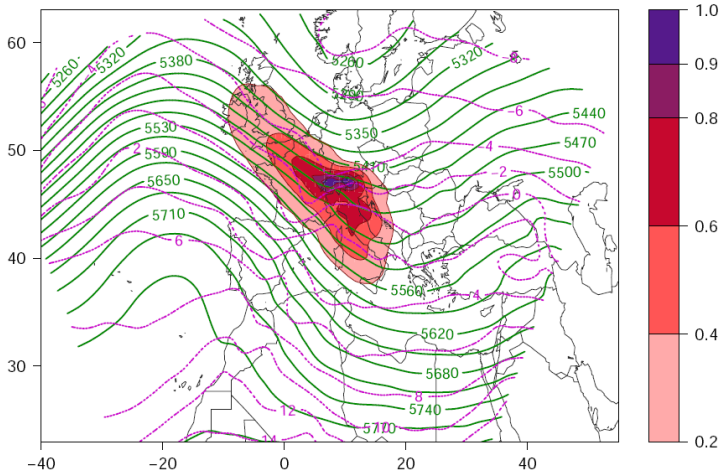
ENSEMBLE-2



Illustrative example

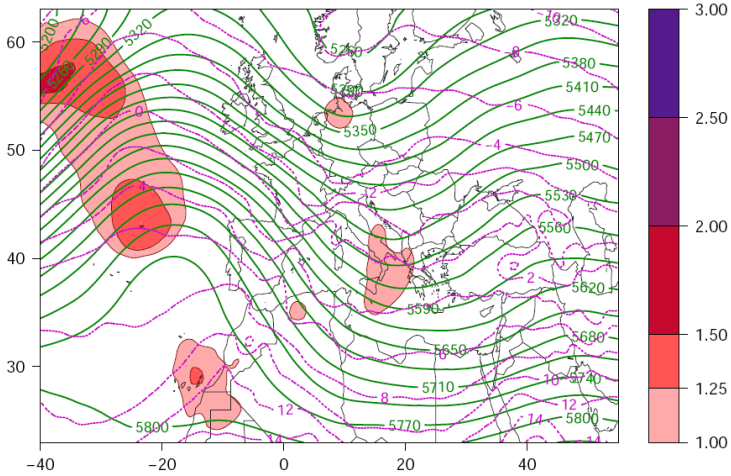
Case Study: December 2nd 1983. Ionian Sea Cyclone. Corresponding sensitivity fields:

ADJOINT

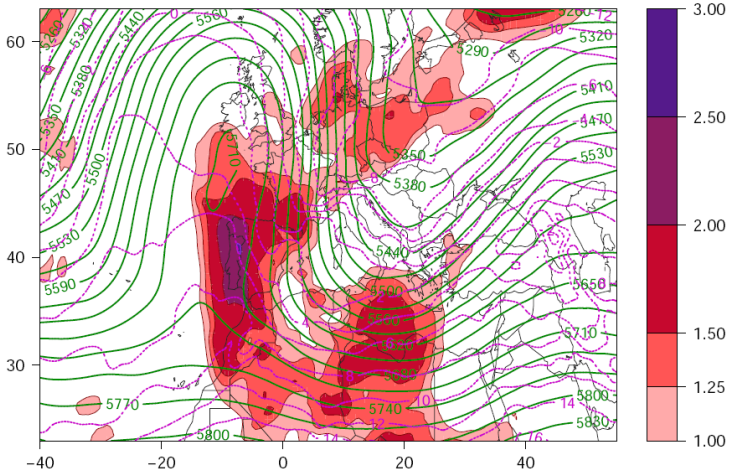


HUMAN

ENSEMBLE-1



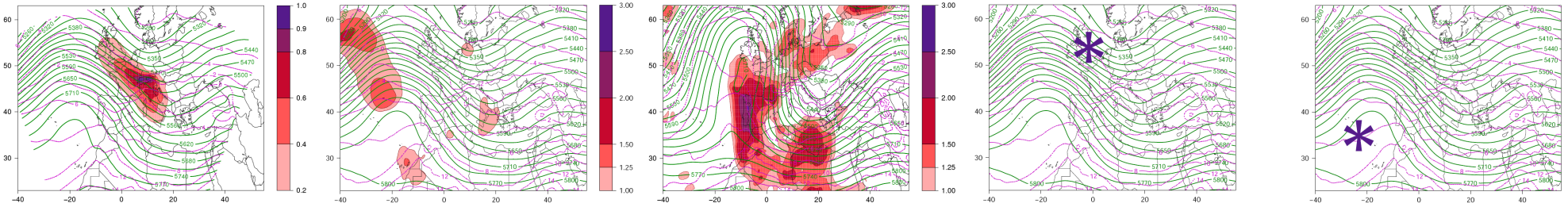
ENSEMBLE-2



Illustrative example

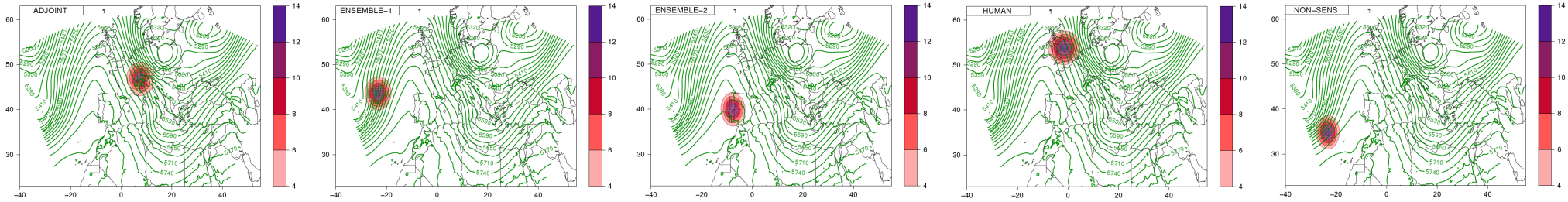
- Sensitivity locations:

ADJOINT	ENSEMBLE-1	ENSEMBLE-2	HUMAN	NON-SENS

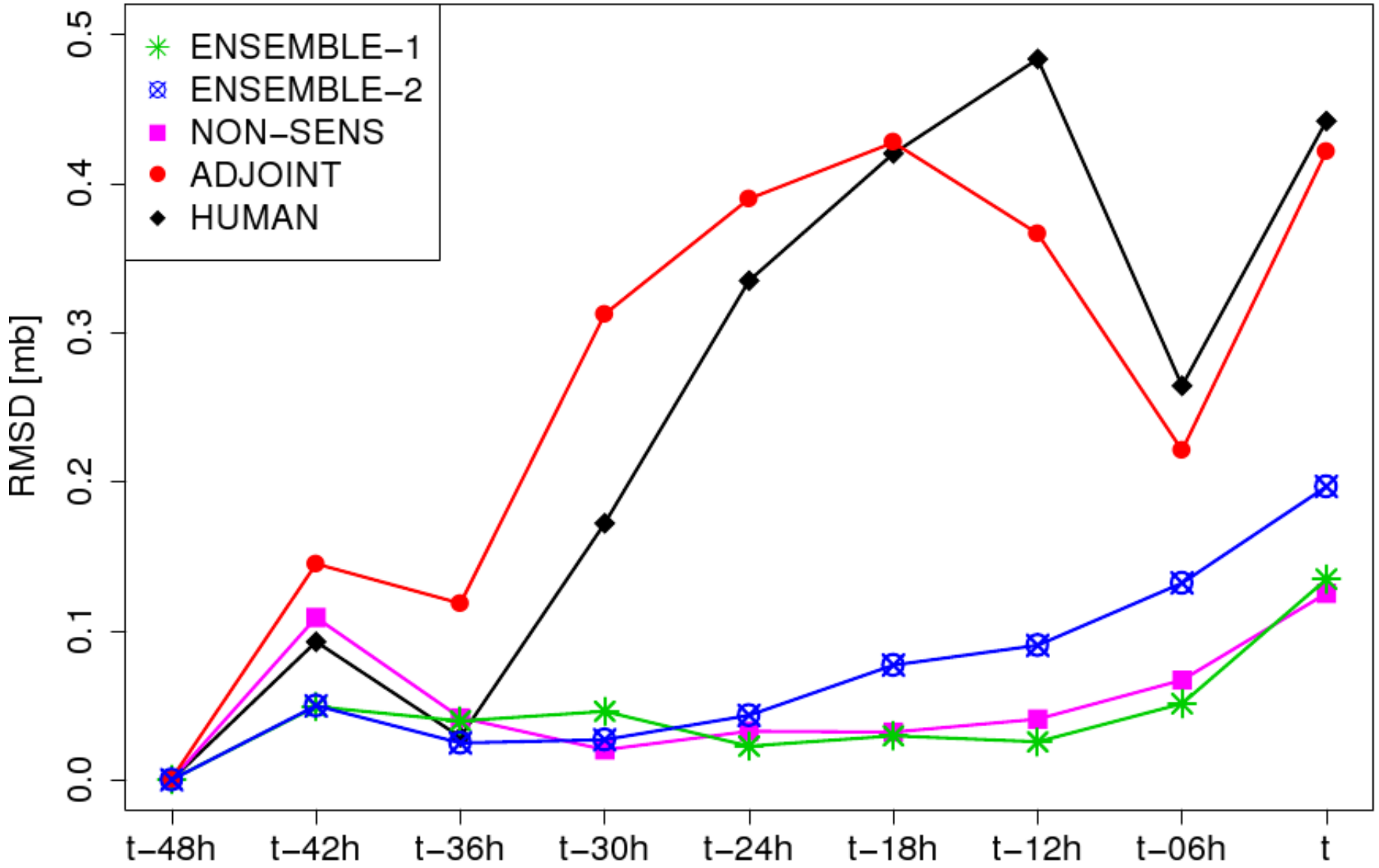


- A **cylindrical gaussian perturbation** is applied at *t-48h* to the IC with an **amplitude proportional to their zonal standard deviation** and **centered on the maximum** of the mean sensitivity field. Geopotential height at 500hPa:

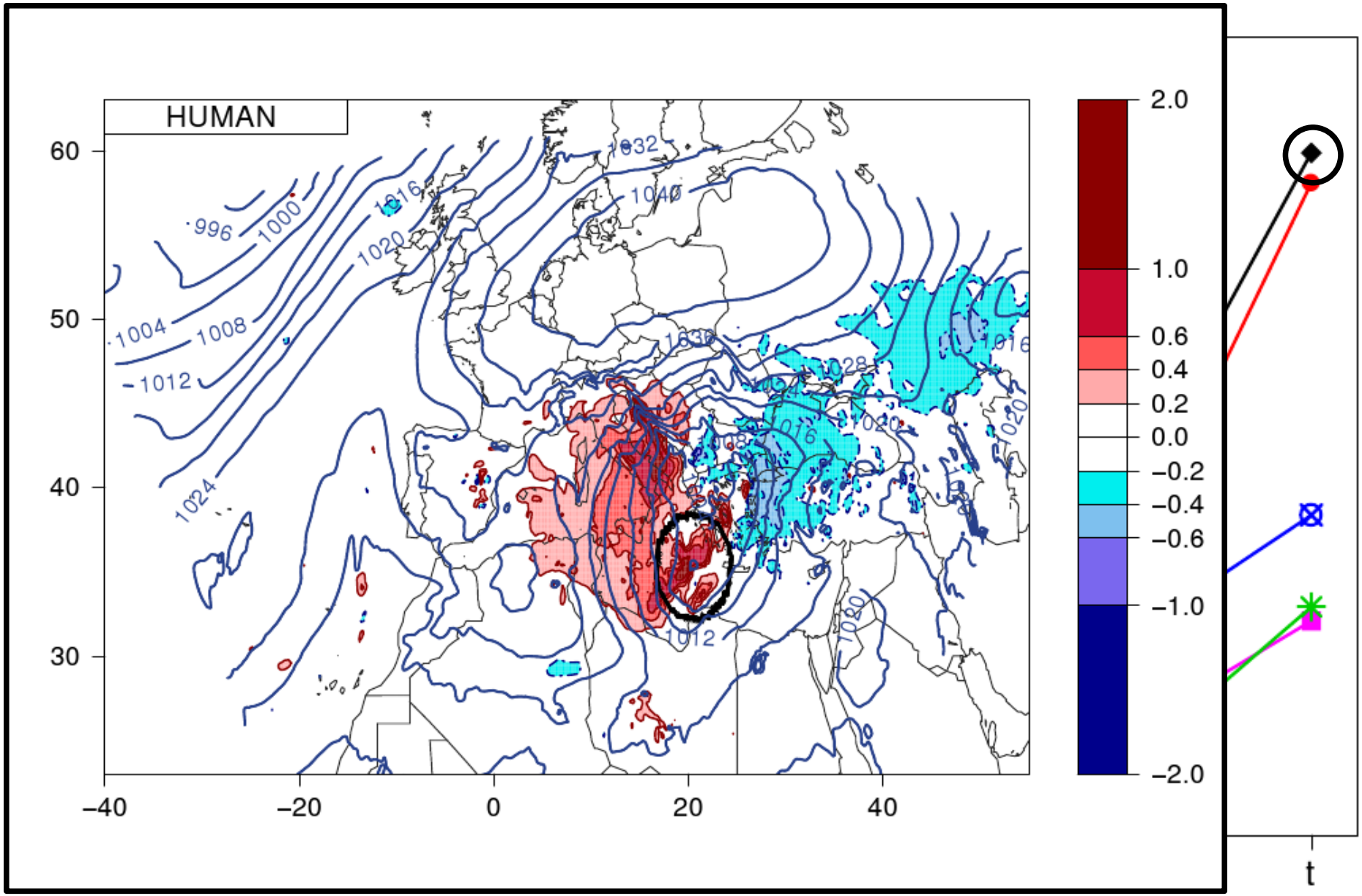
ADJOINT	ENSEMBLE-1	ENSEMBLE-2	HUMAN	NON-SENS



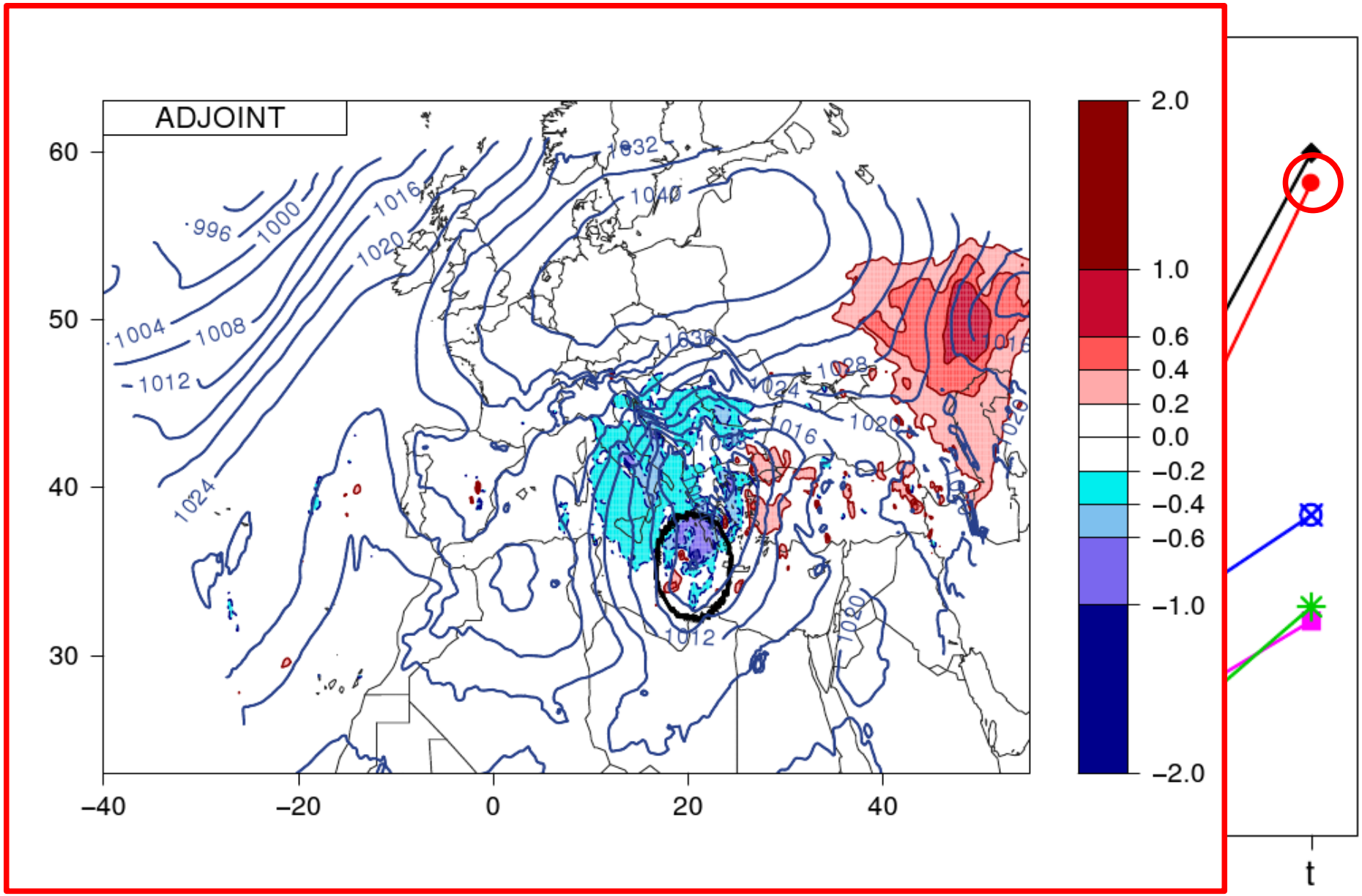
Illustrative example: RMSD of MSLP



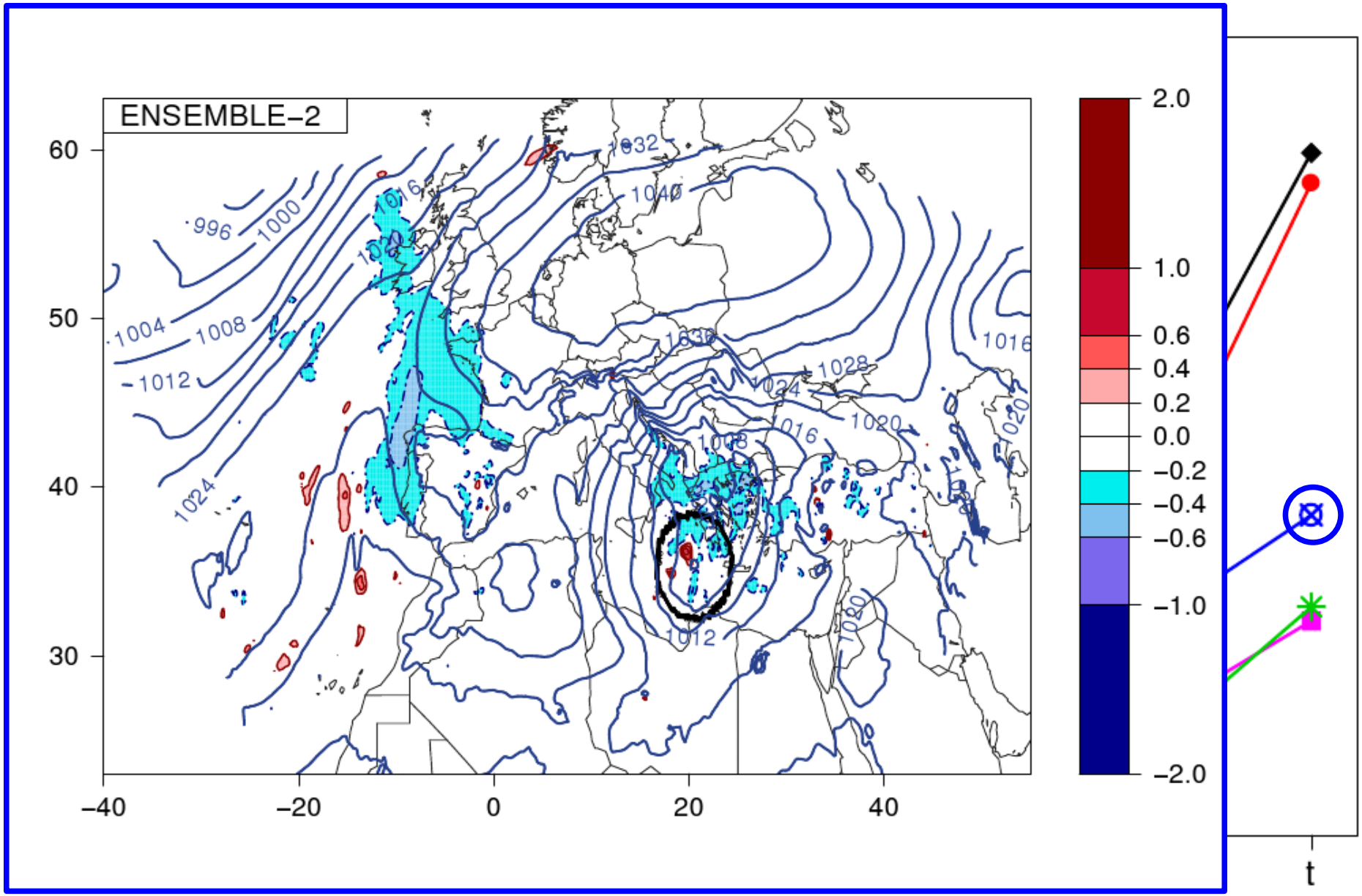
Illustrative example: RMSD of MSLP



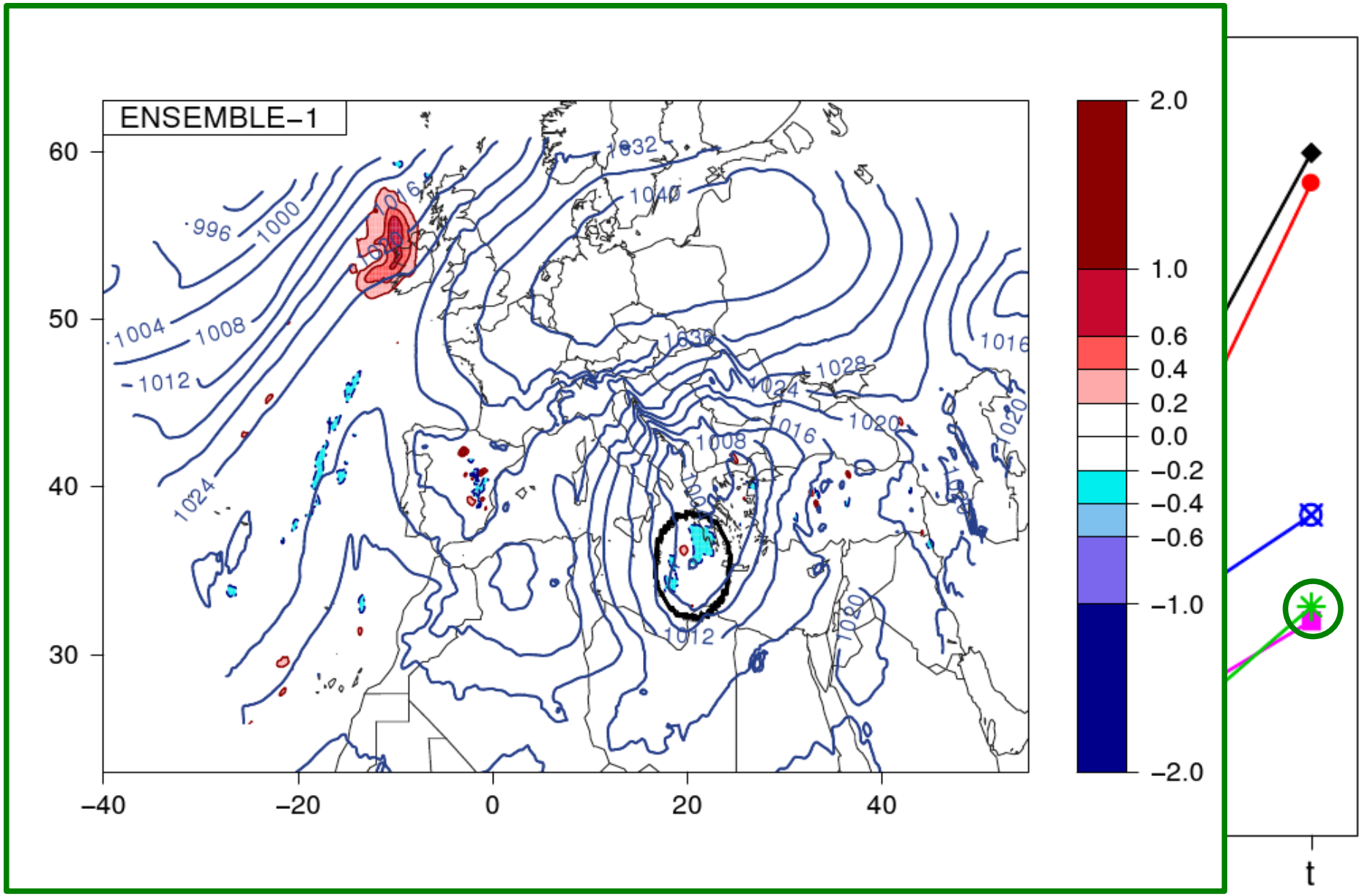
Illustrative example: RMSD of MSLP



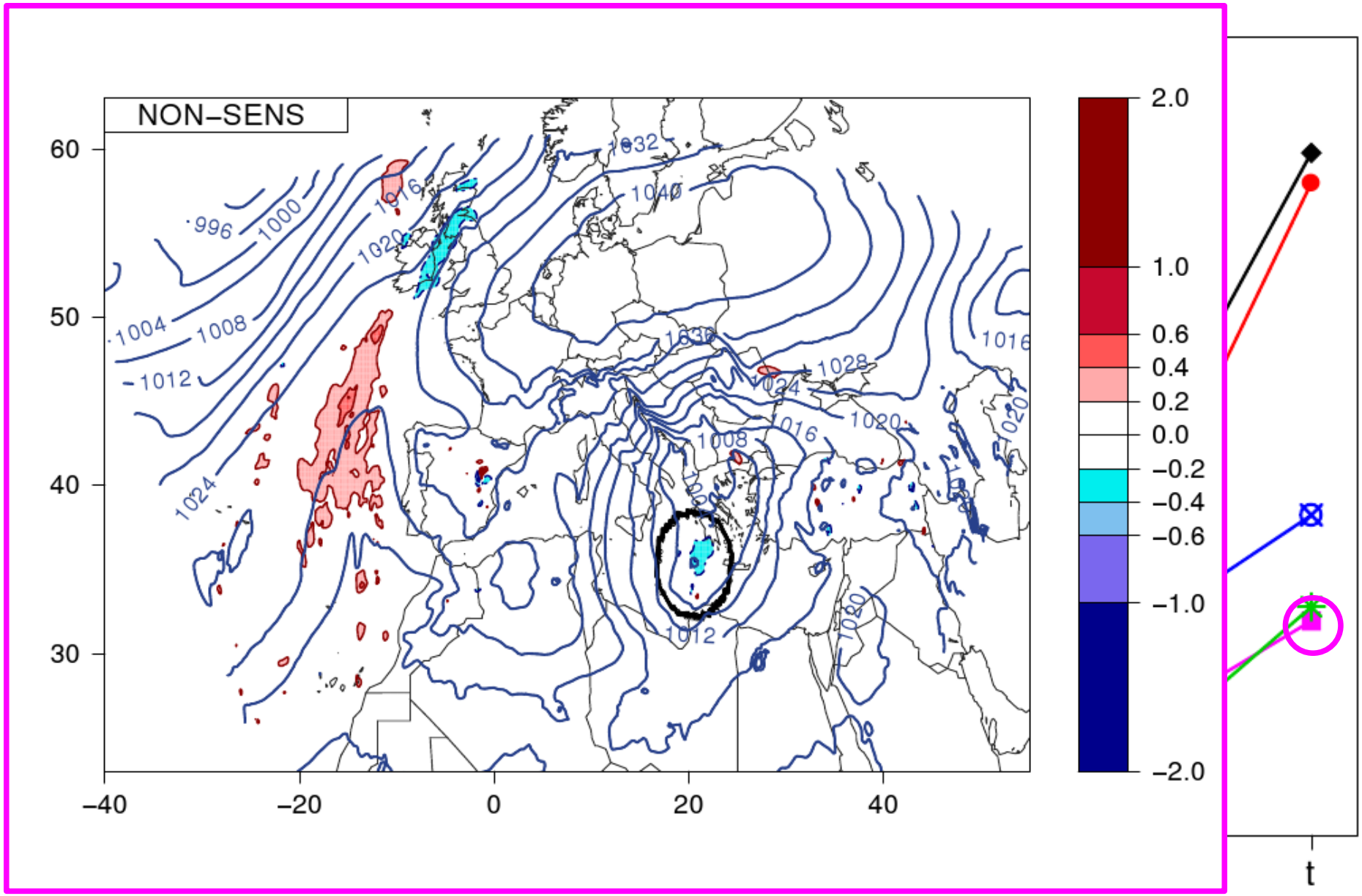
Illustrative example: RMSD of MSLP



Illustrative example: RMSD of MSLP



Illustrative example: RMSD of MSLP



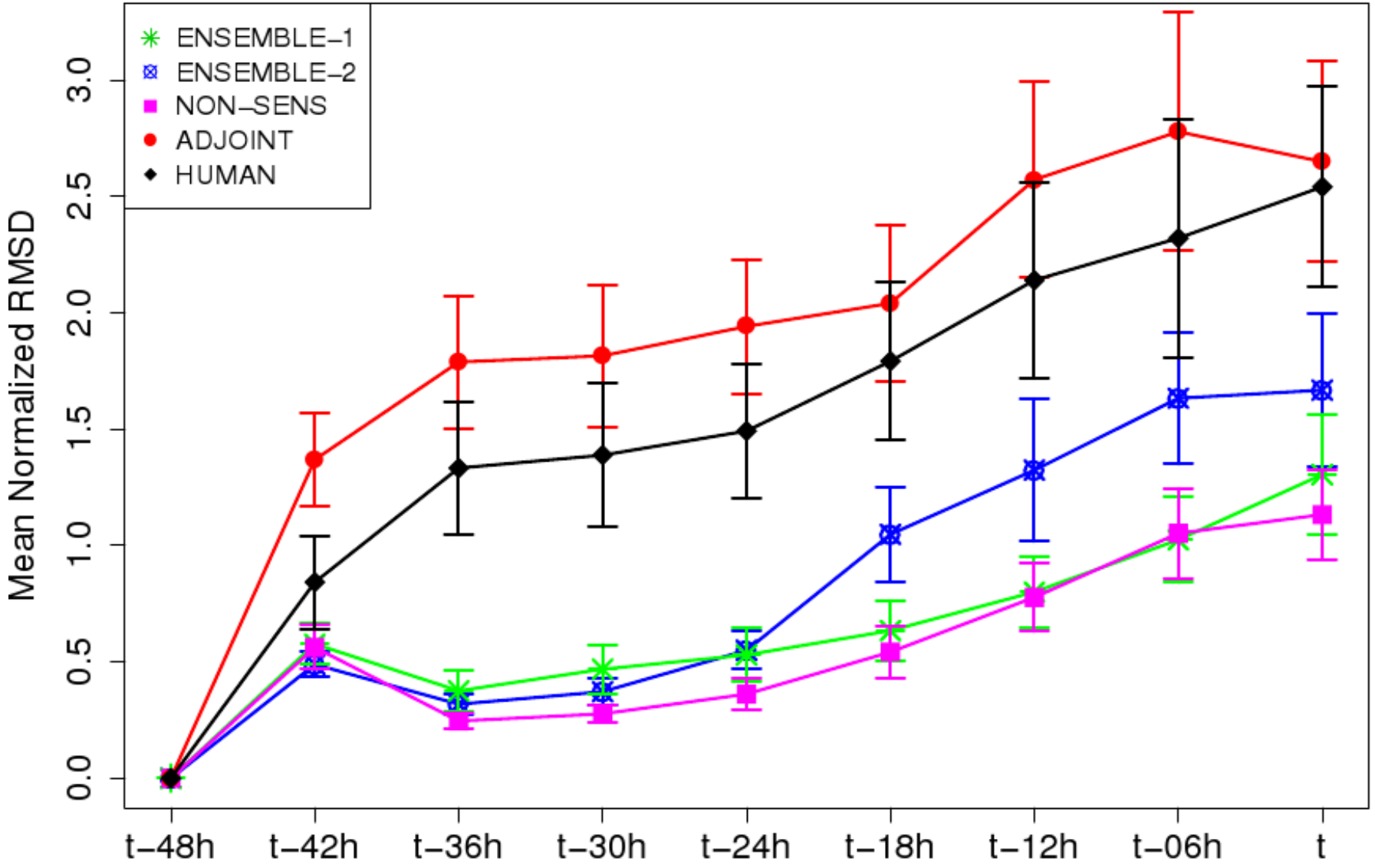
Verification of Sensitivity Climatologies

Illustrative example

Results for all cases

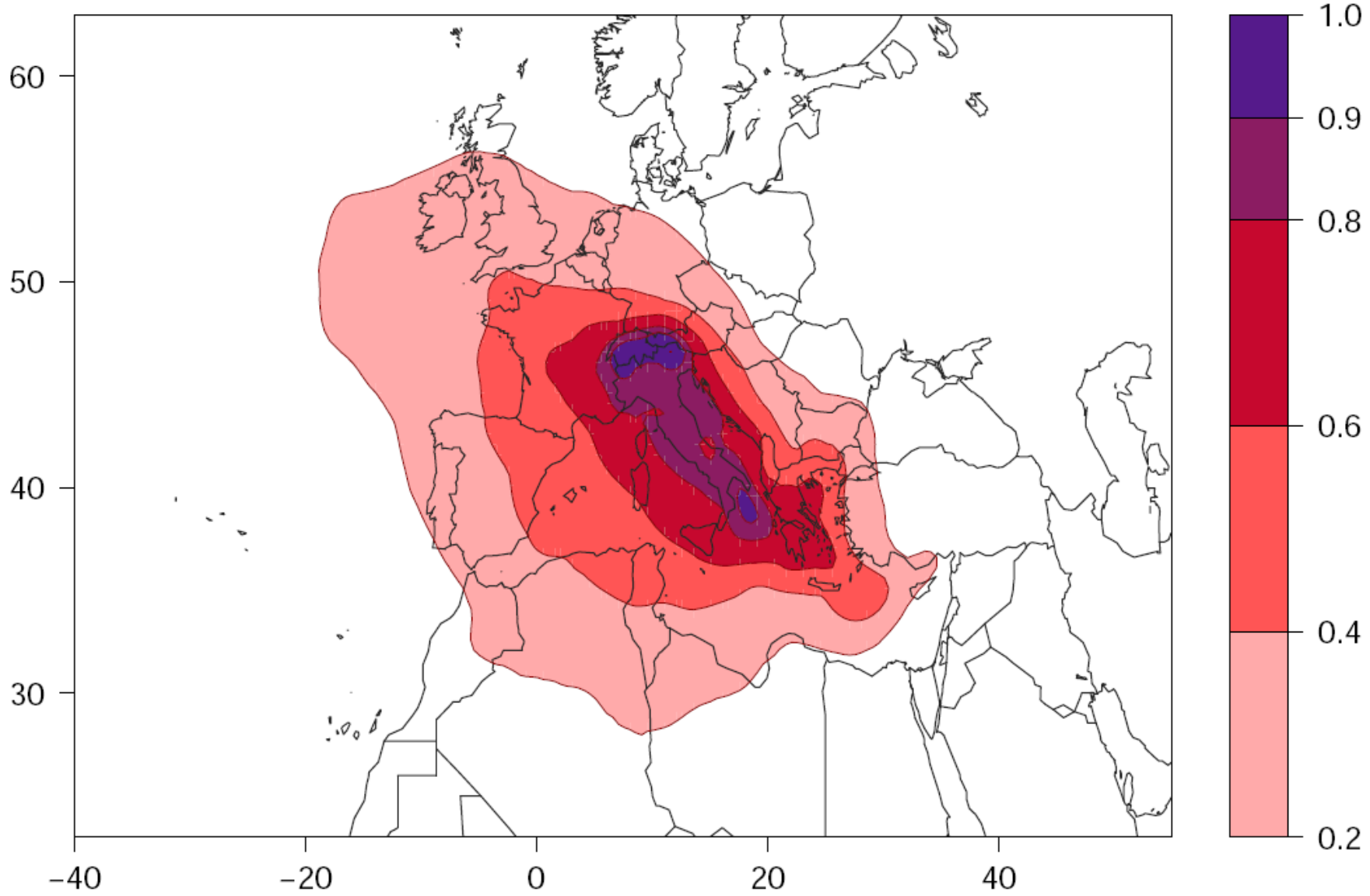
Results for all cases

- **Mean normalized RMSD of MSLP** over the 25 verification cyclone cases:



Results for all cases

- **Adjoint verified sensitivities** over the 25 verification cyclone cases:



Summary

- Information derived from **sensitivity analysis opens the door for establishing optimized** routine observing network and special targeted **observation strategies**.
- A **new approach** is proposed to compute **climatological statistical sensitivities** with no dependence on any forecasting system.
- From a climatological perspective, the **best skill identifying reliable sensitivity** areas is shown for the **human and adjoint sensitivity fields** against both ensemble sensitivity climatologies.
- Results confirm the **improvement** of climatological **ensemble sensitivities** when an **ad hoc classification** of cyclones **is used**.
- Adjoint verified sensitivities reveal the **Italian peninsula, eastern Atlantic and Nord-African coasts as sensitive regions** to be considered in future designs of observational networks accounting **for Mediterranean cyclones**.