



Cut-off Sanchez and its downstream impact over southern France – verification of Météo-France forecasts

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Carole Labadie³ and Karine Maynard³

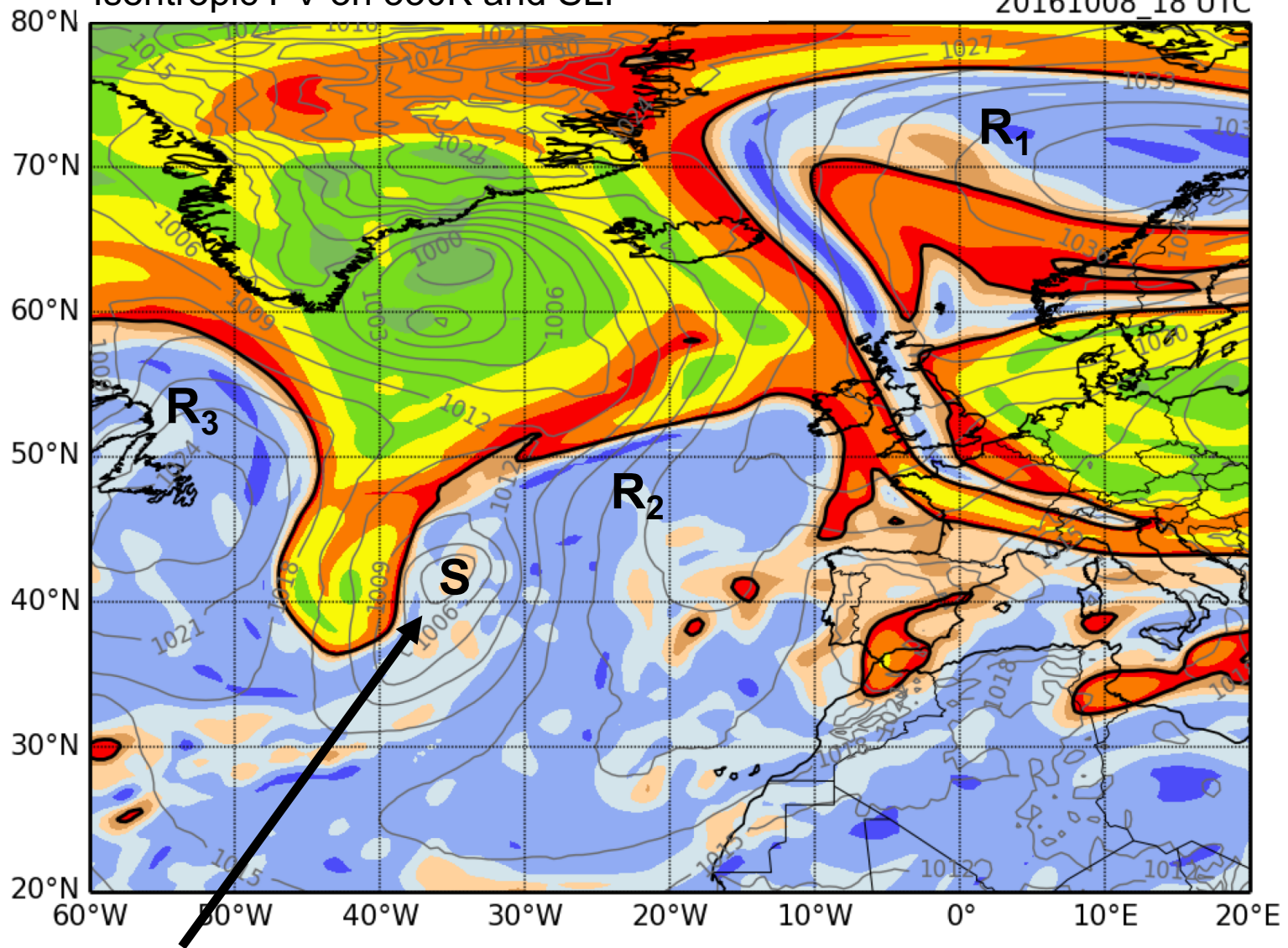
¹LMD-ENS Paris/SNSF ²LMD-ENS Paris/CNRS ³CNRM/Météo-France

Réunion ANR DIP-NAWDEX, 29 January 2019, Toulouse



Isentropic PV on 330K and SLP

20161008 18 UTC

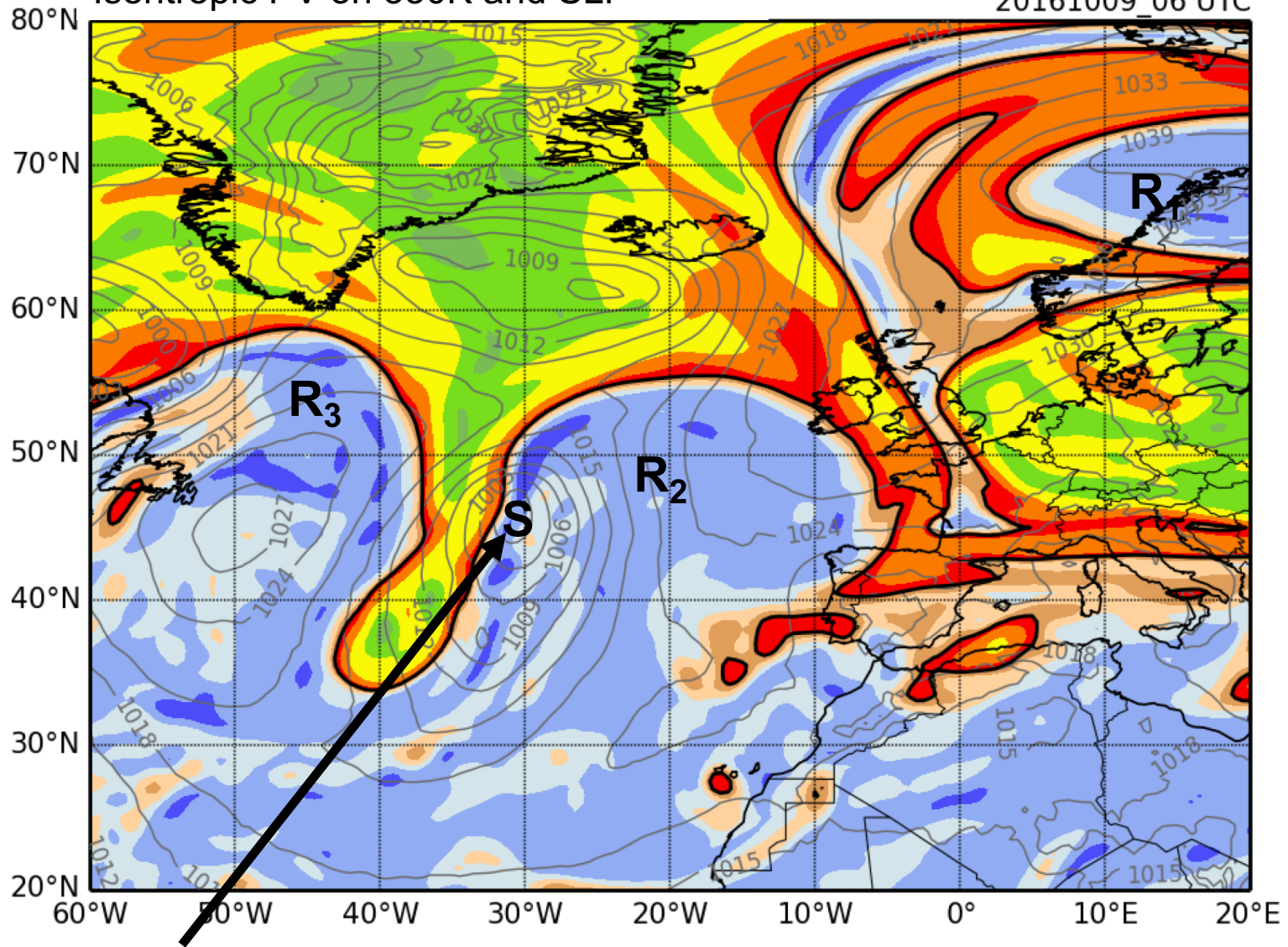


Surface cyclone
"Sanchez"

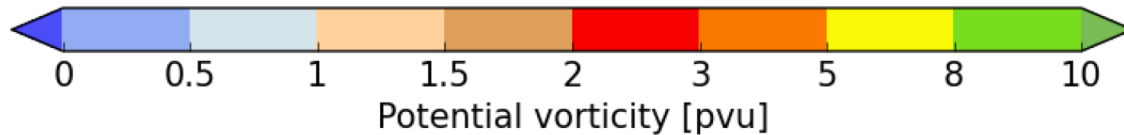


Isentropic PV on 330K and SLP

20161009 06 UTC

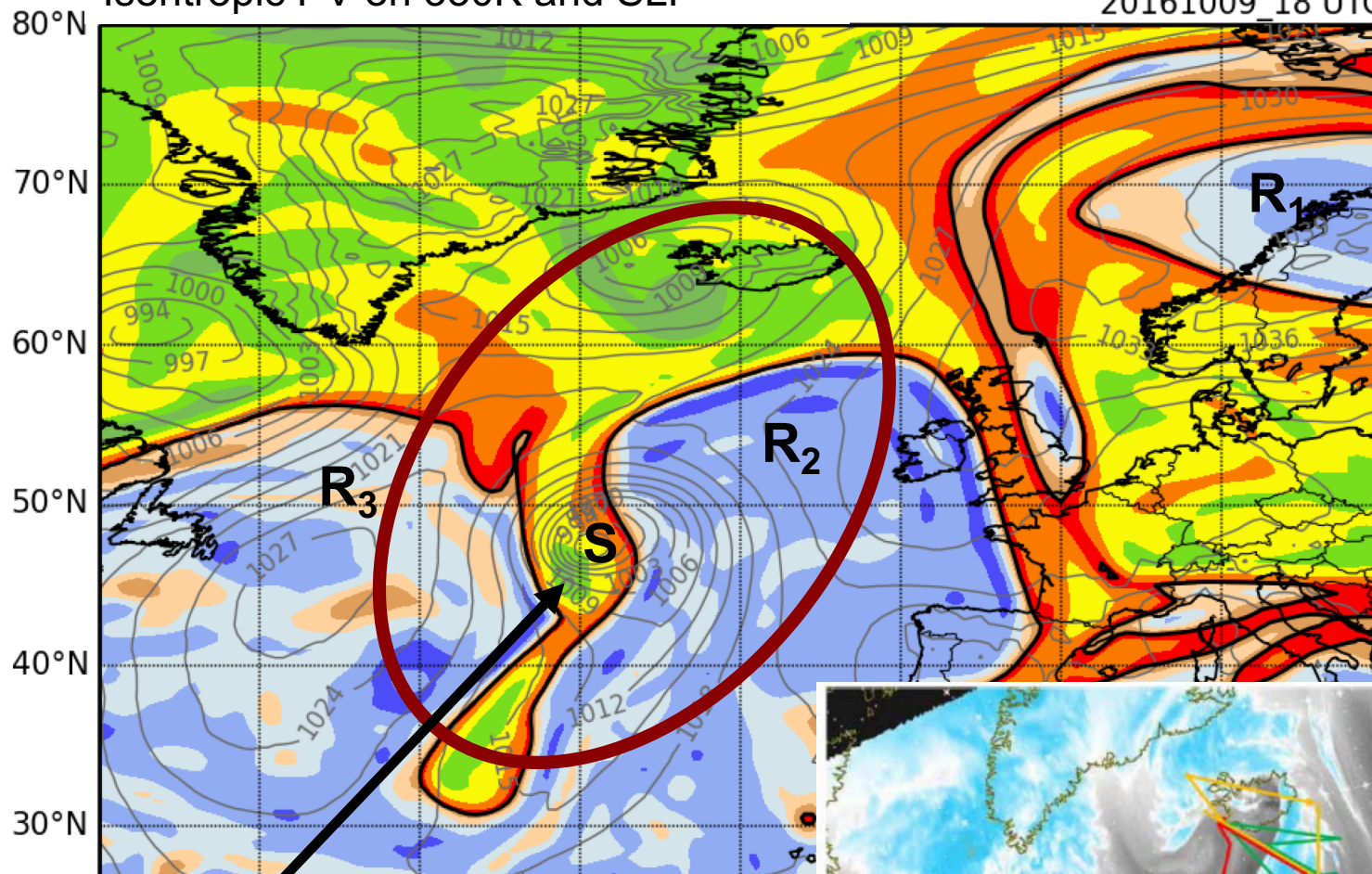


Surface cyclone
"Sanchez"

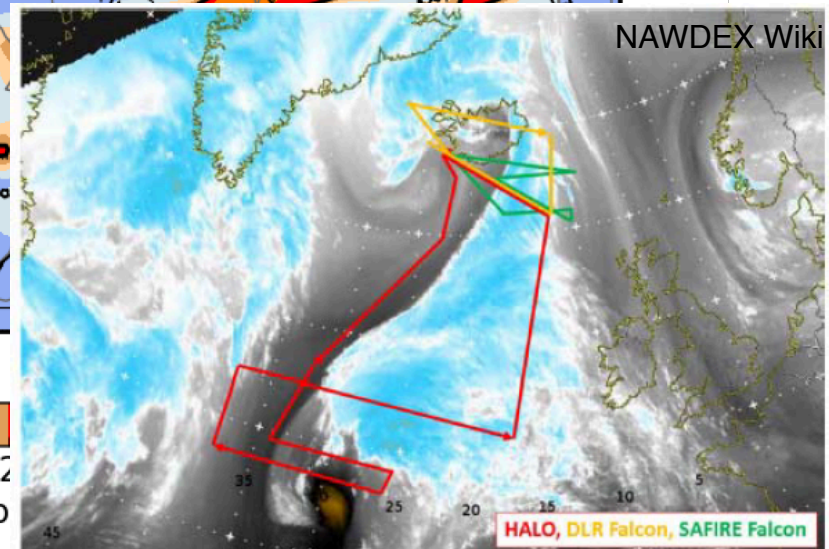
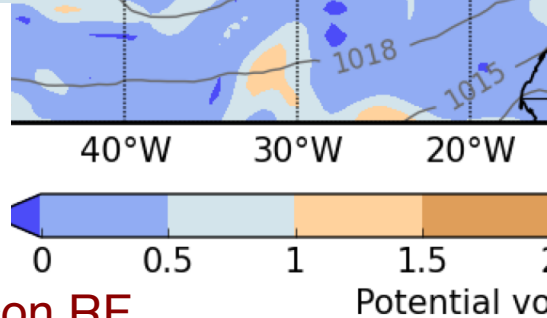


Isentropic PV on 330K and SLP

20161009 18 UTC



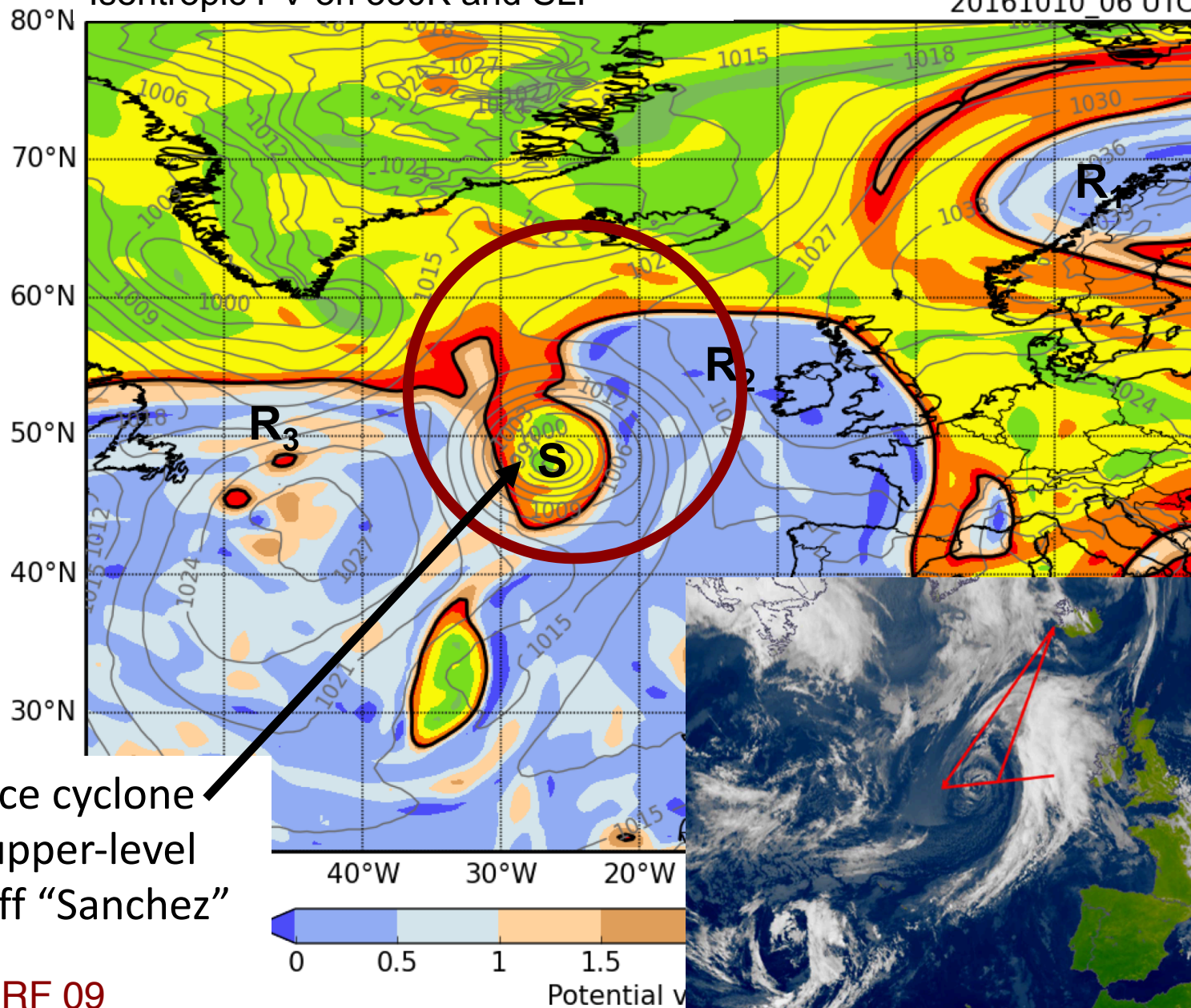
Surface cyclone
and upper-level
cut-off "Sanchez"



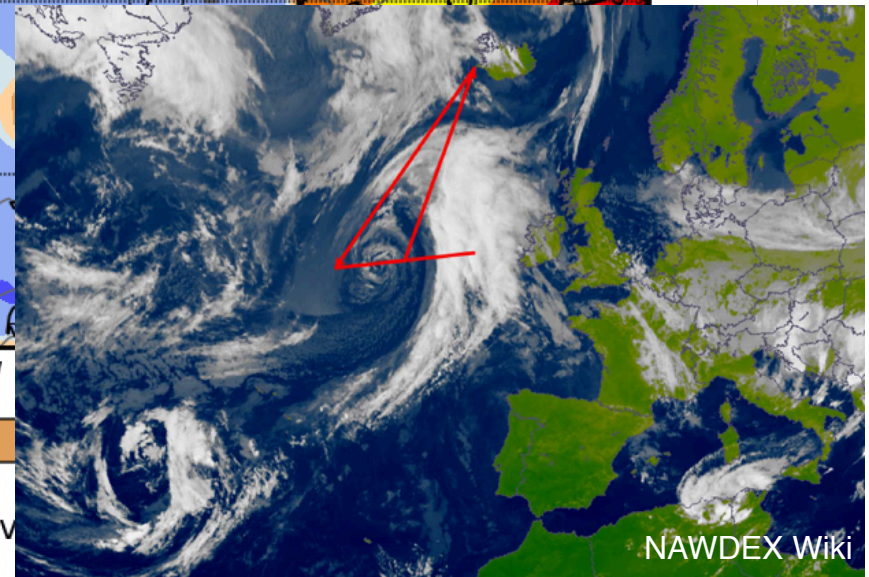
HALO RF 08 – G-Falcon RF
10 – F-Falcon RF 11/12

Isentropic PV on 330K and SLP

20161010_06 UTC



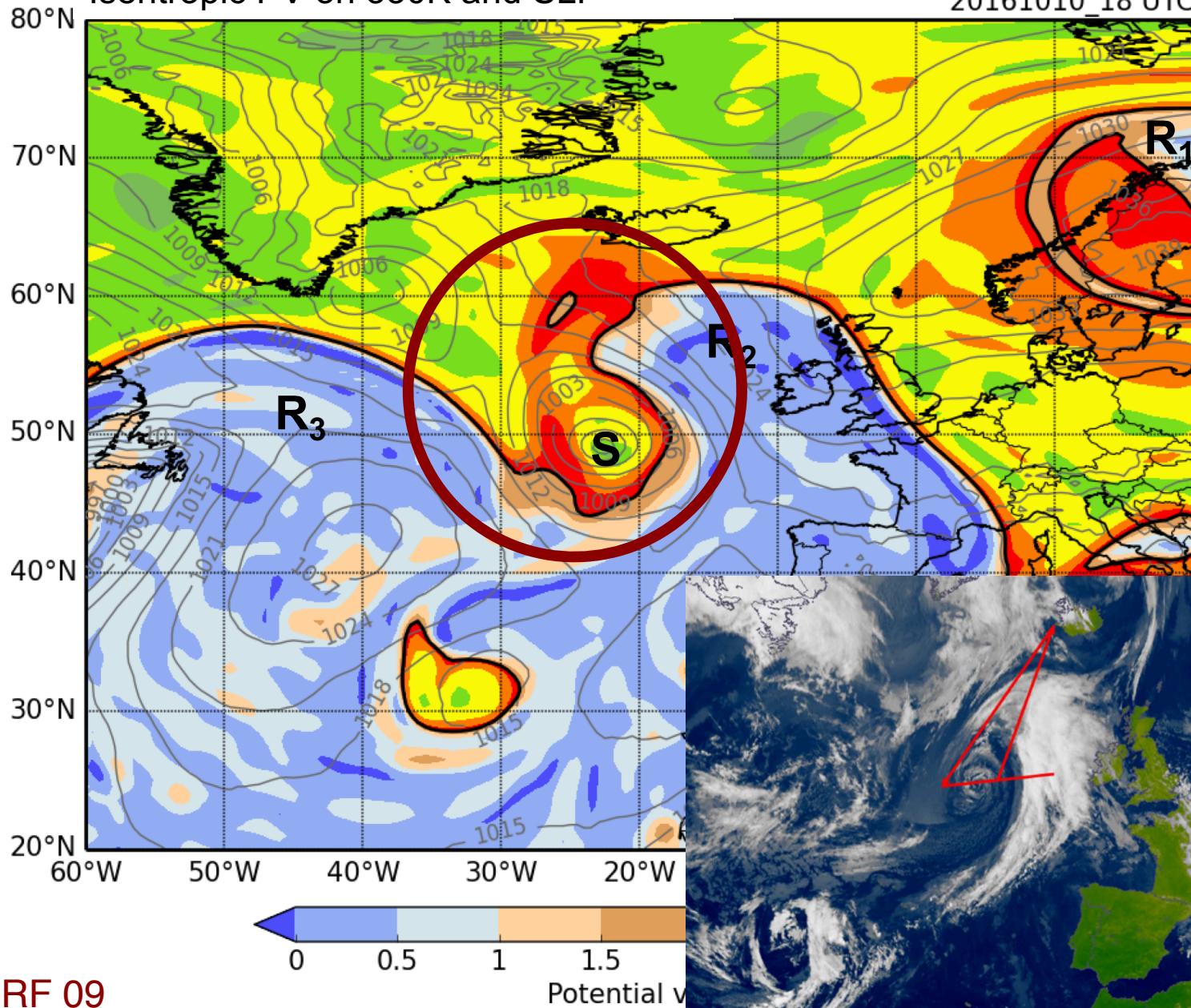
Surface cyclone
and upper-level
cut-off "Sanchez"



HALO RF 09
F-Falcon RF 13

Isentropic PV on 330K and SLP

20161010 18 UTC

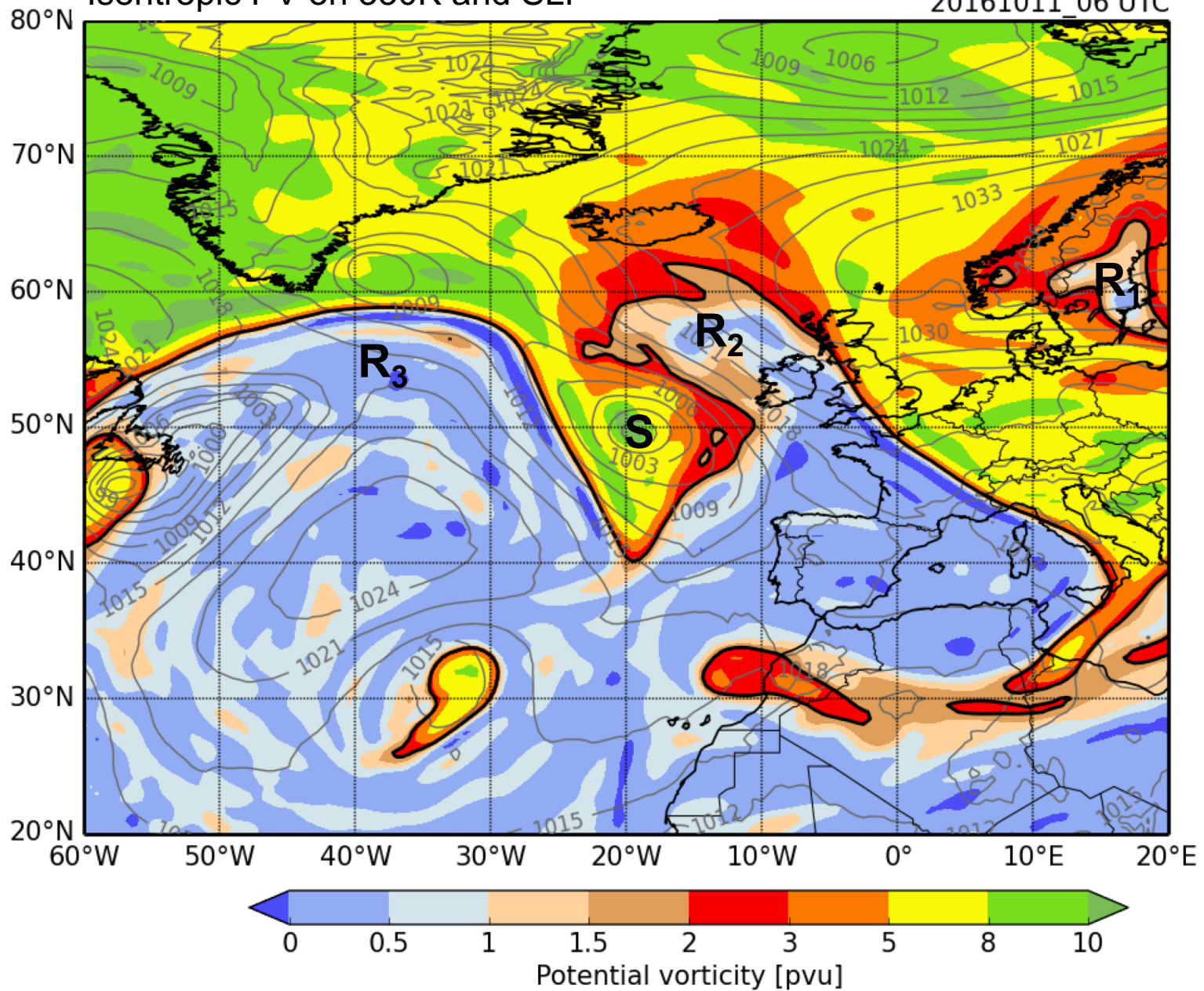


HALO RF 09
F-Falcon RF 13

NAWDEX Wiki

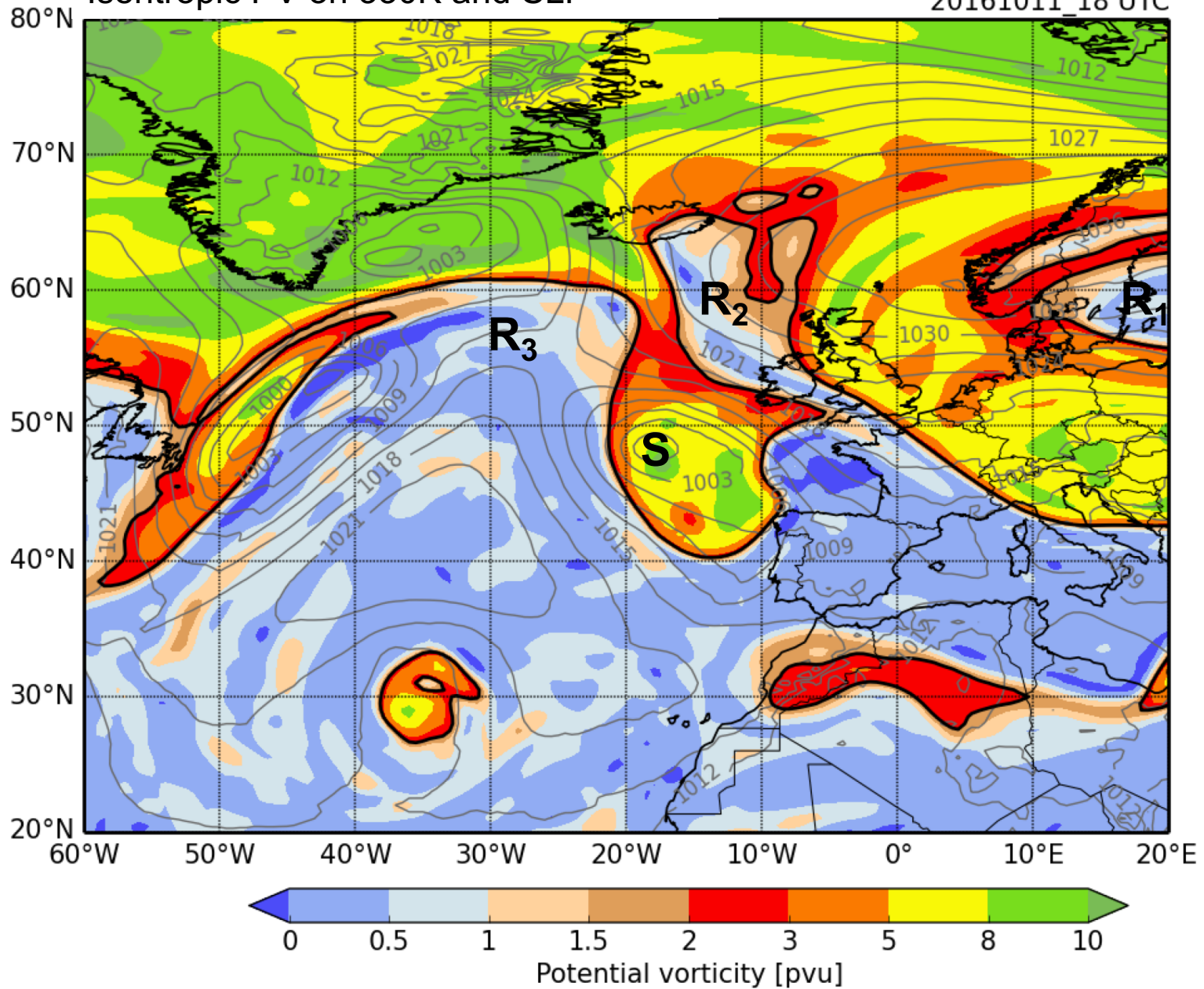
Isentropic PV on 330K and SLP

20161011_06 UTC



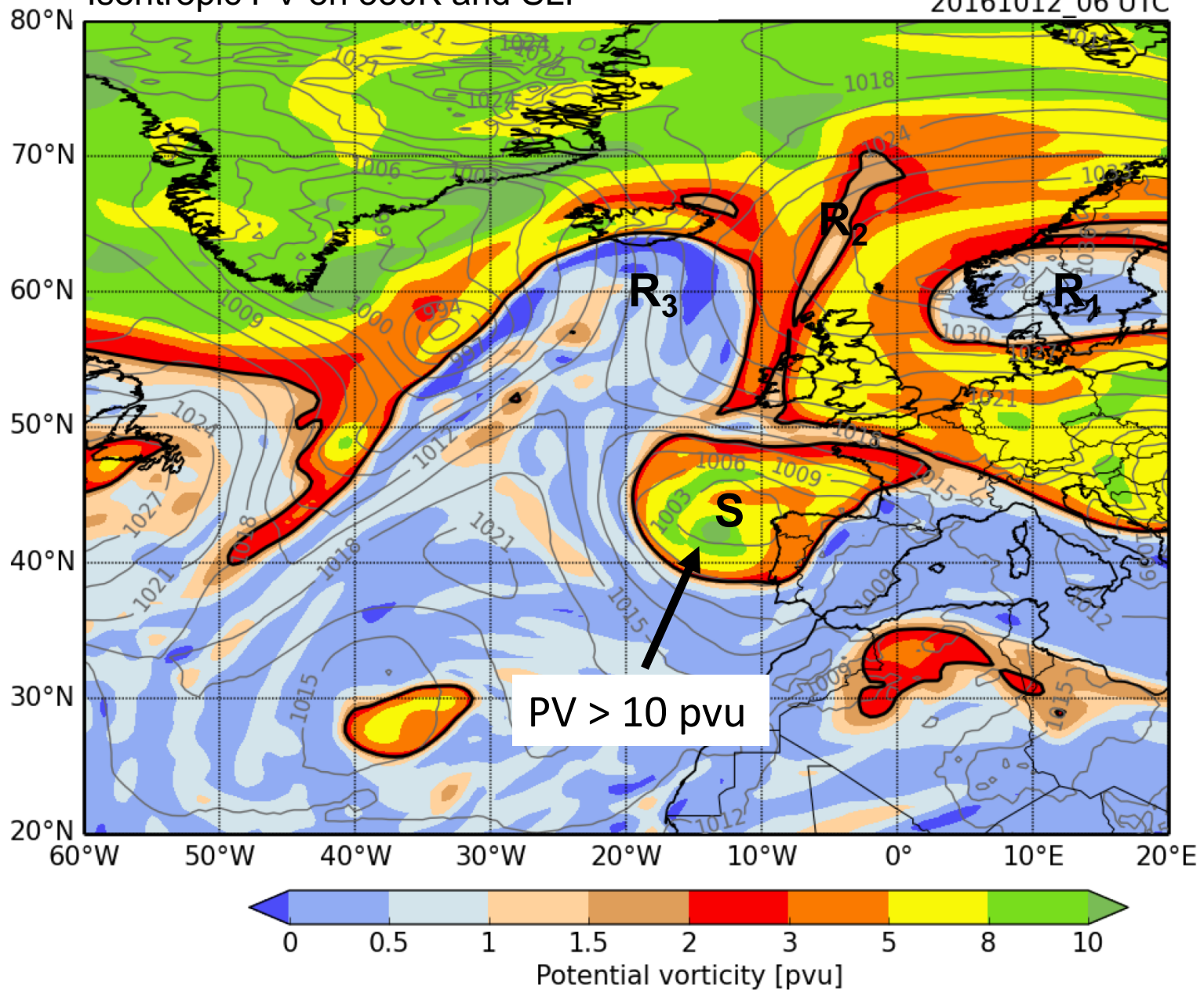
Isentropic PV on 330K and SLP

20161011 18 UTC



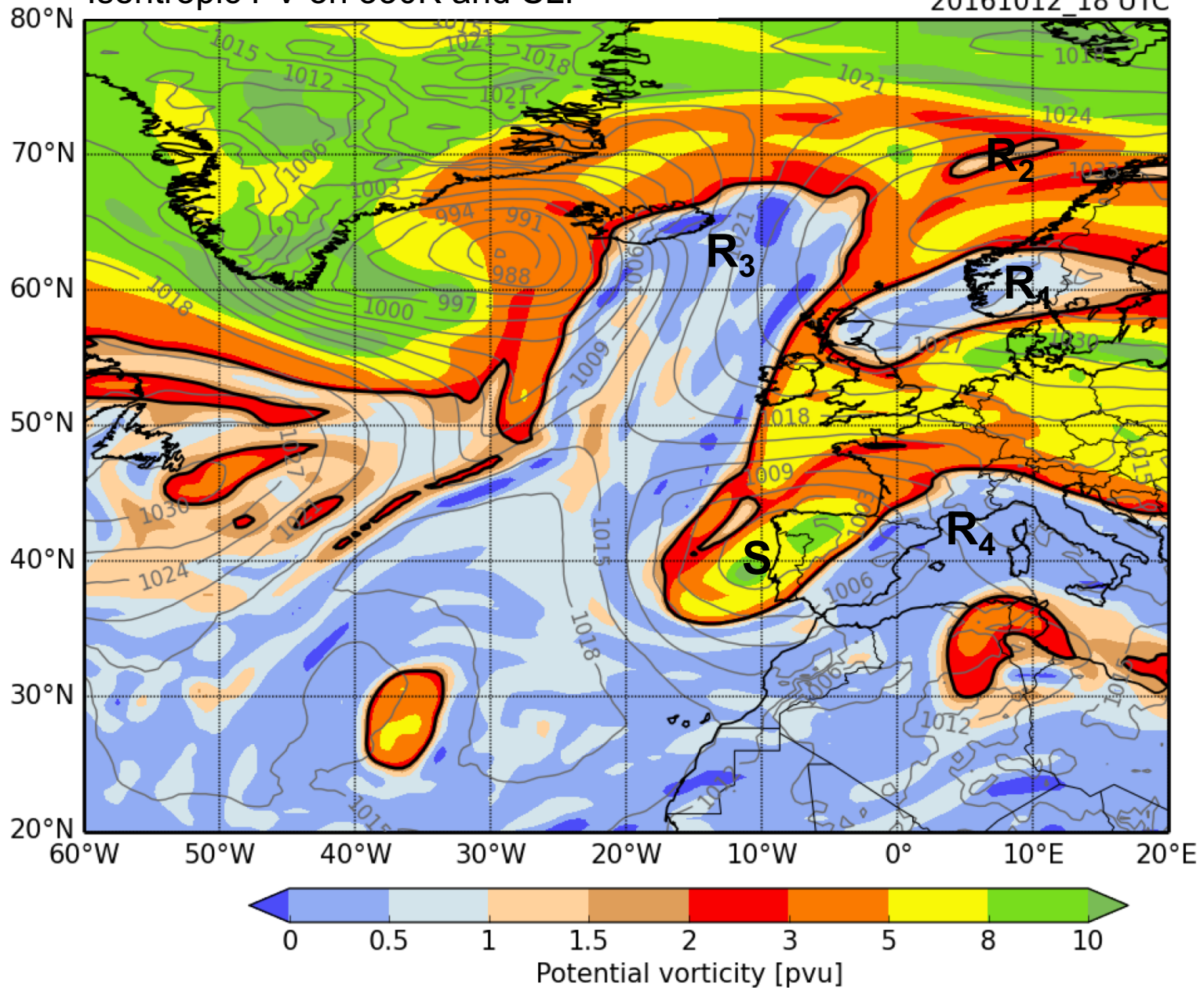
Isentropic PV on 330K and SLP

20161012_06 UTC



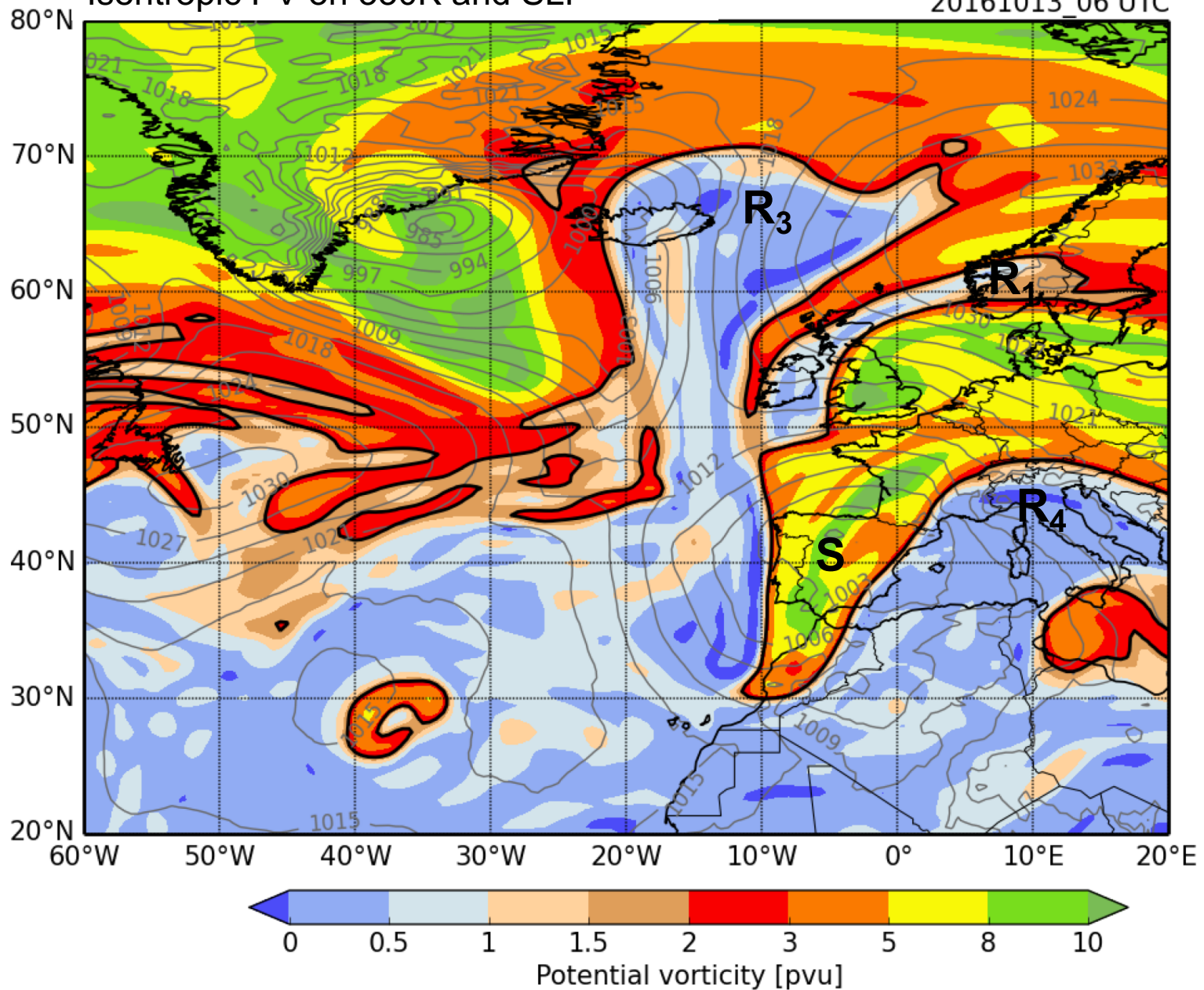
Isentropic PV on 330K and SLP

20161012_18 UTC



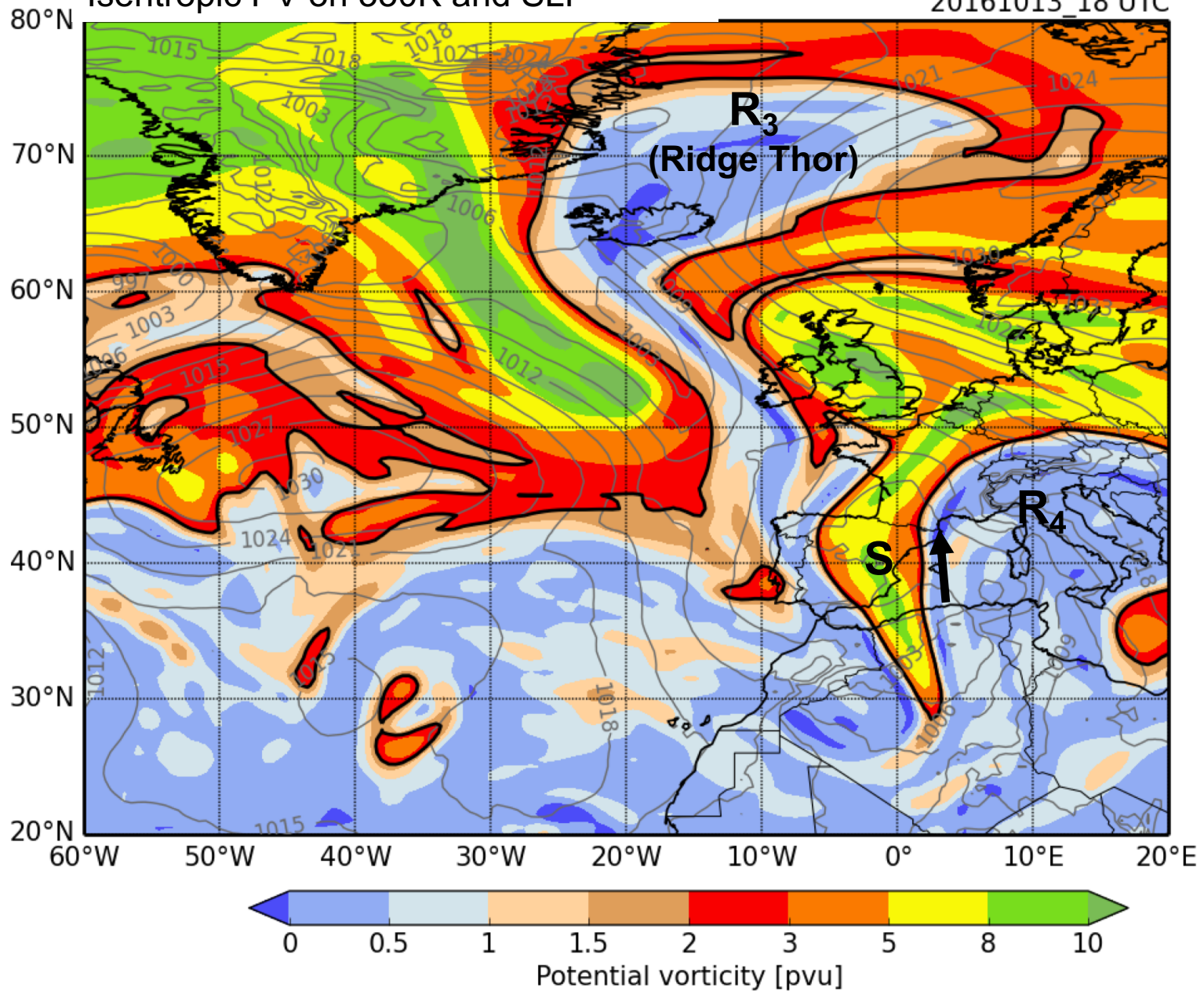
Isentropic PV on 330K and SLP

20161013_06 UTC



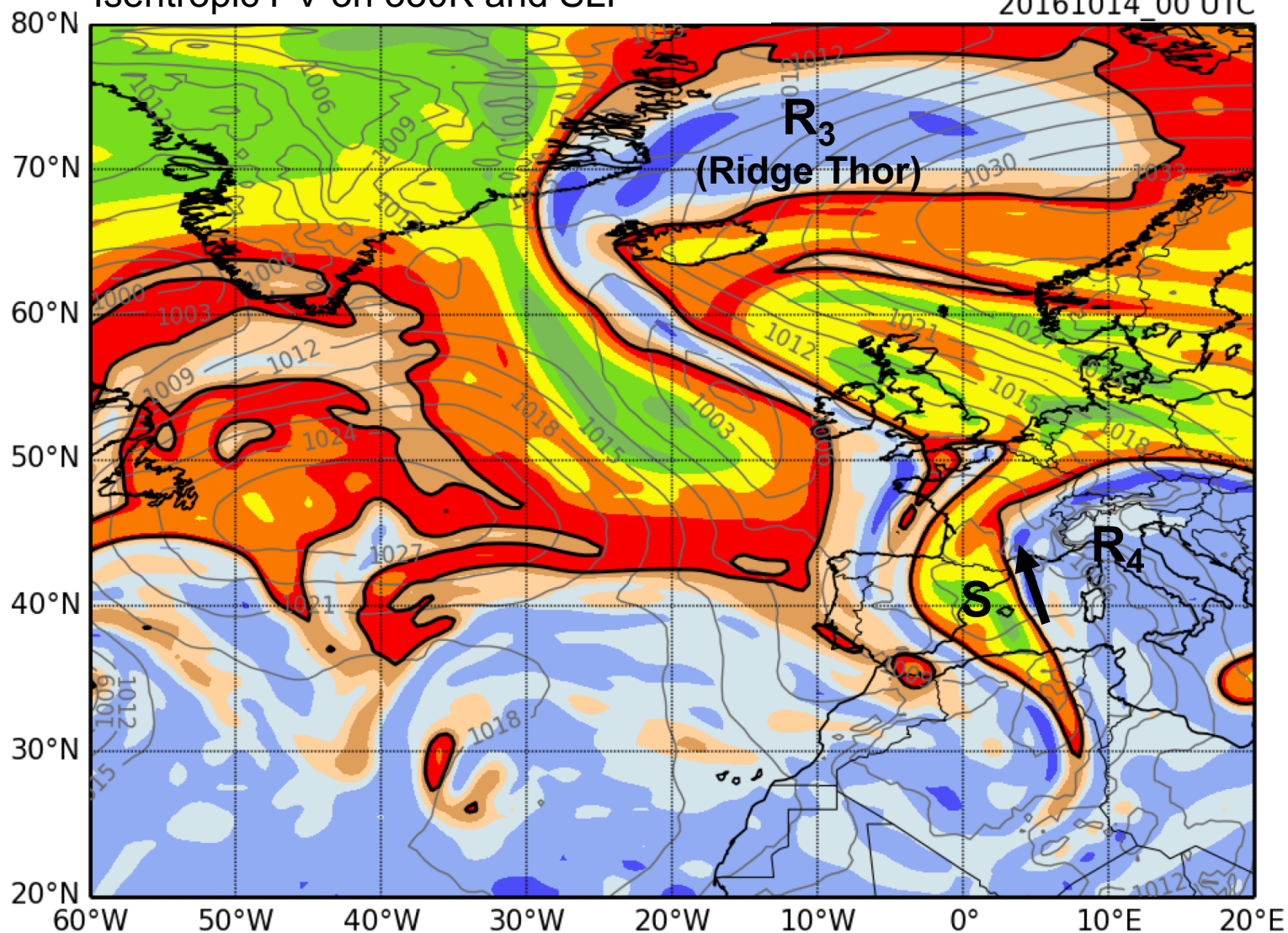
Isentropic PV on 330K and SLP

20161013_18 UTC



Isentropic PV on 330K and SLP

20161014 00 UTC



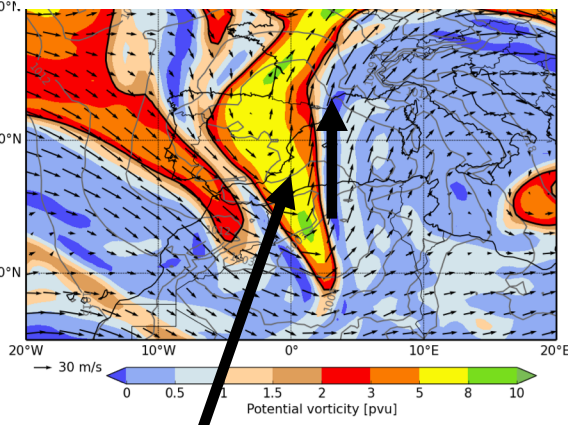
High-impact weather over southern France on 14 Oct 2016 related to cut-off “Sanchez”

Objective:

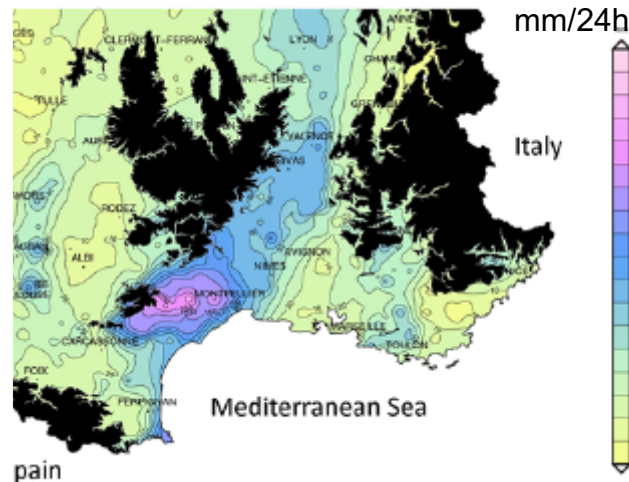
Evaluate the representation of the HIW event and the associated upper-level flow structure in probabilistic and deterministic Météo-France forecast data

- Are the HIW forecasts sensitive to the representation of cut-off Sanchez?

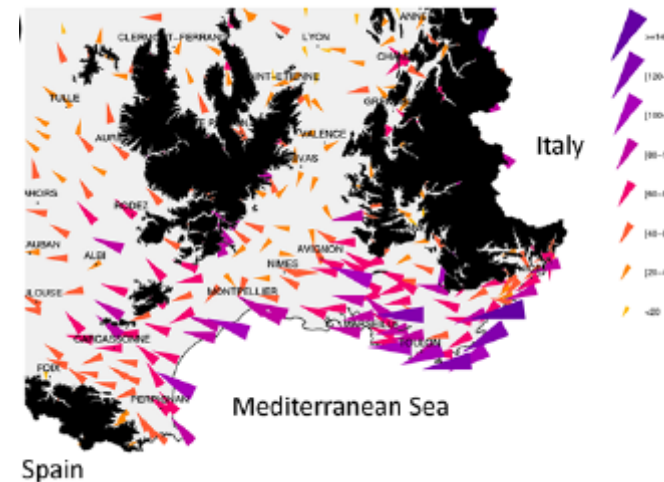
PV and wind at 250 hPa
18 UTC 13 Oct 2016



PV Streamer „Sanchez“



~250 mm daily accumulated precipitation over S France



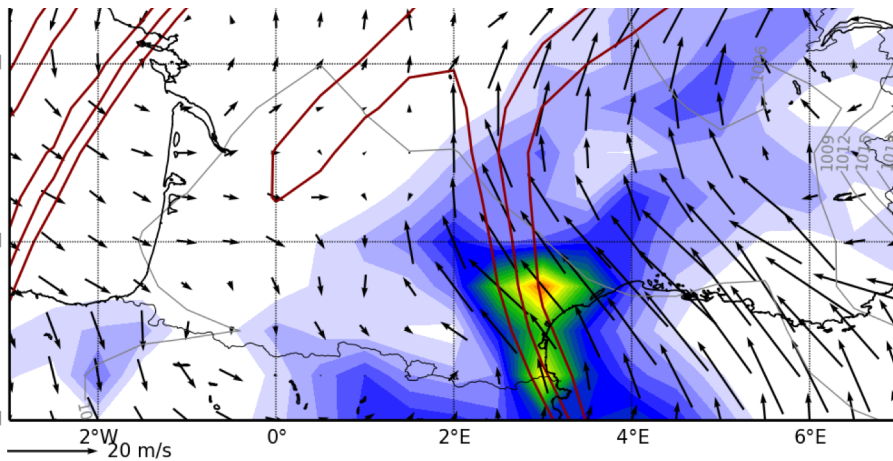
Strong wind gusts > 100 km/h

Data

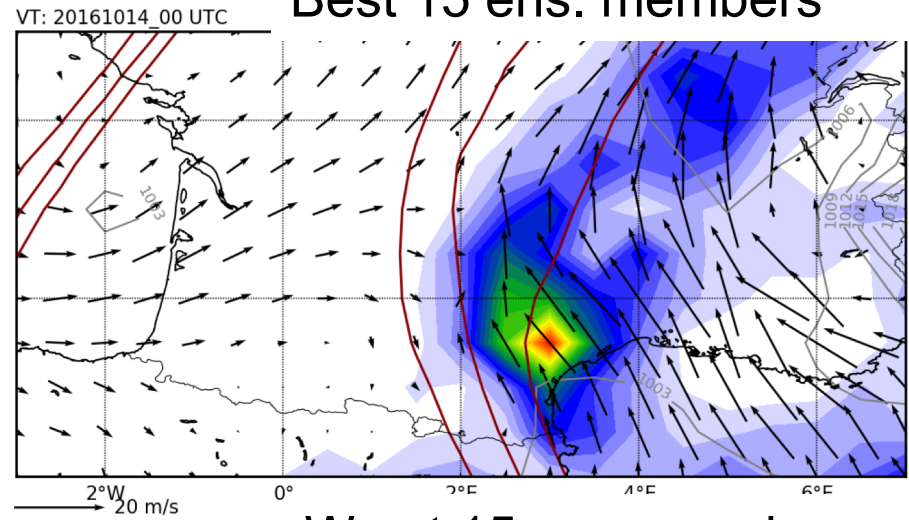
1. Ensemble reforecasts of the Météo-France global operational model Arpege, version PEARP4 (Descamps et al. 2015, Boisserie et al. 2016a,b)
 - 10 ensemble members
 - Same initial conditions (Arpege op. analyses)
 - 10 different physical parameterization sets to represent model uncertainties associated with
 - deep convection (2 different schemes)
 - shallow convection (3 different schemes)
 - solar radiation (2 different schemes)
 - turbulence (2 different schemes)
 - cloud cover (2 different schemes)
- High-resolution deterministic forecasts of Arpege for PV inversion experiments (Arbogast et al. 2008)

00 UTC 14 Oct 2016, 15 best vs. worst precipitation forecasts in terms of ACC, BT10/00Z to 12/00Z

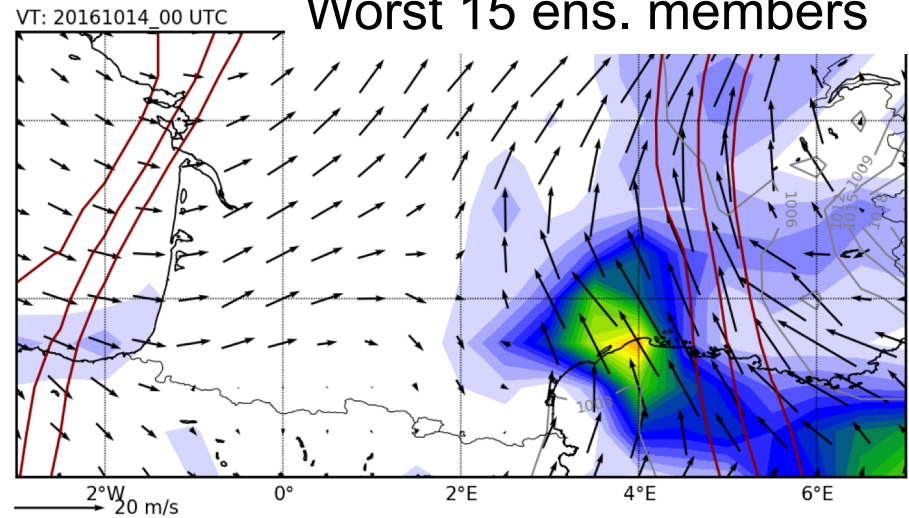
Operational analyses



Best 15 ens. members

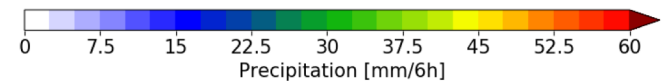


Worst 15 ens. members



30mm contour of 6h accum. precip.

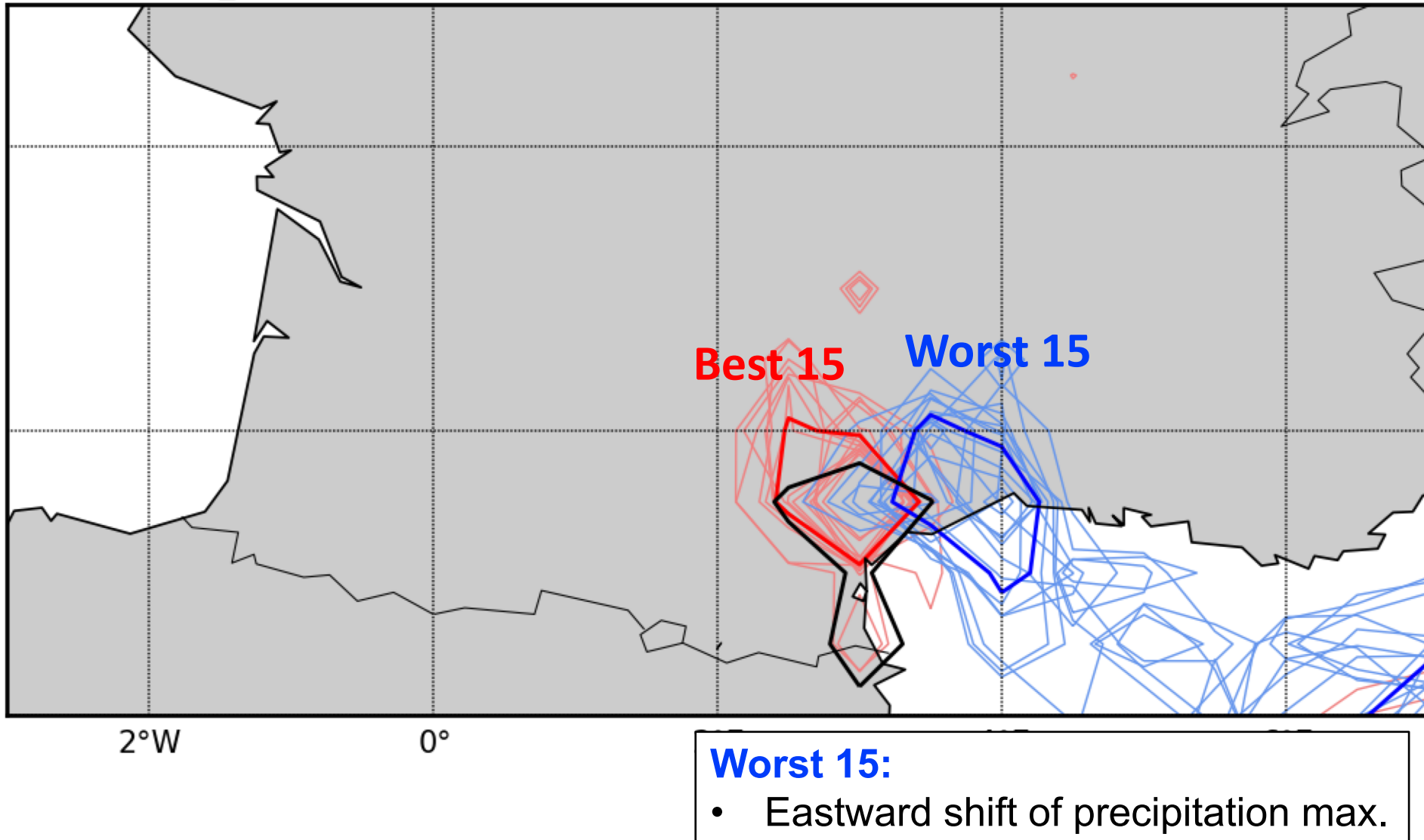
— Best — Worst — Analysis



— 1,2,3pvu at 330 K ← 850-hPa wind

15 best vs. worst precipitation forecasts at VT14/00Z

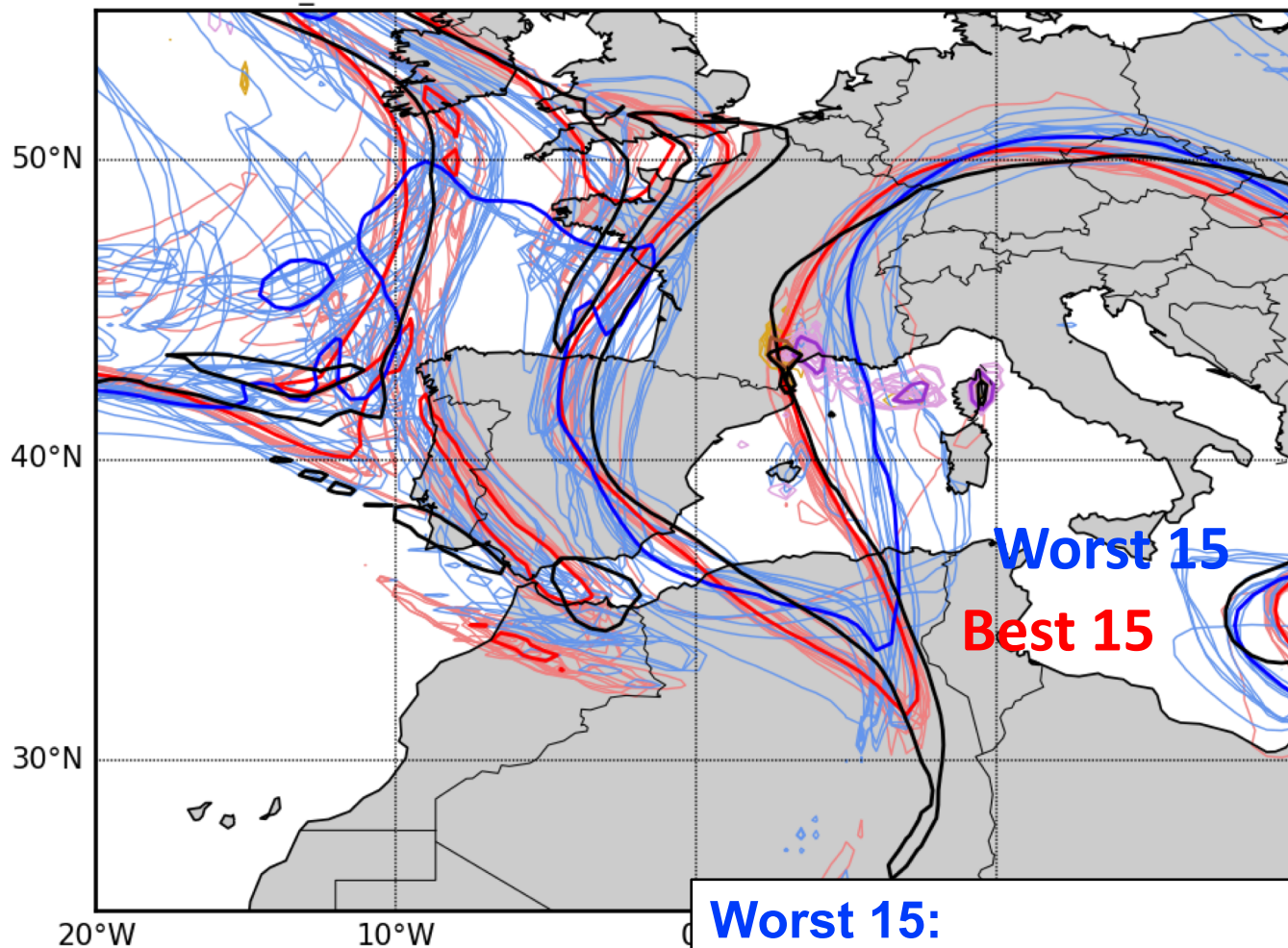
(BT10/00Z to 12/00Z)



15 best vs. worst precipitation forecasts at VT14/00Z

2pvu at 330K and 30mm contour of 6h accum. precipitation

VT: 20161014_00 UTC



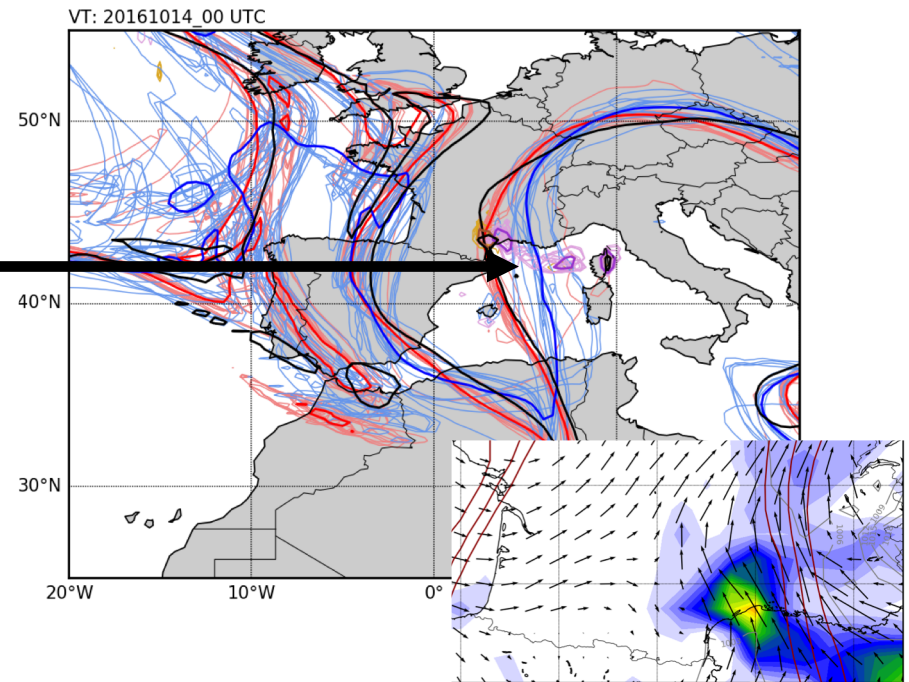
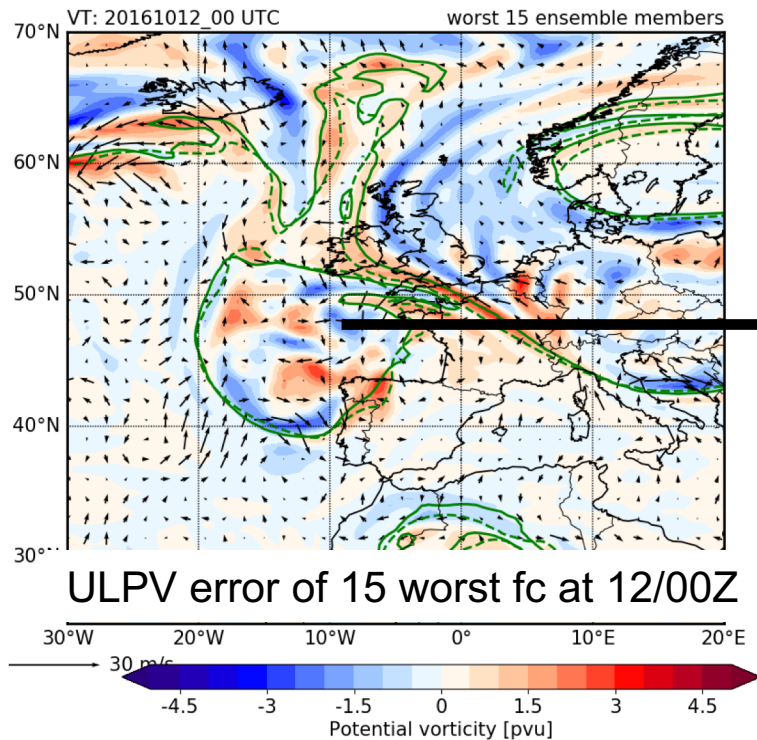
Worst 15:

- Eastward shift of precipitation max.
- Eastward shift and different tilt of 2pvu@330K

Best **Worst** **Analysis**

Errors in the intensity of the cut-off and the upstream ridge

Are upstream upper-level errors at early fc times important for the errors in the representation of PV streamer Sanchez and the extreme precipitation at 00 UTC 14 Oct?



- Ensemble sensitivity analysis (ESA)
- PV inversion experiments

Ensemble sensitivity analysis (ESA)

Ancell and Hakim 2007, MWR
Torn and Hakim 2008, MWR

How does a change in an **initial state variable x** change a **forecast metric J** ?

$$\frac{\delta J}{\partial x} = \frac{cov(J, x)}{var(x)}$$

→ Sensitivity of the ensemble mean value of fc metric J to the initial state variable x for an **ensemble of size M**

x and **J** : 1 x M ensemble estimates of initial state variable x and fc metric J

x = **PV at 330K** at 12/00 UTC

J = **Anomaly correlation coefficient (ACC)** of precipitation over S France at 14/00 UTC

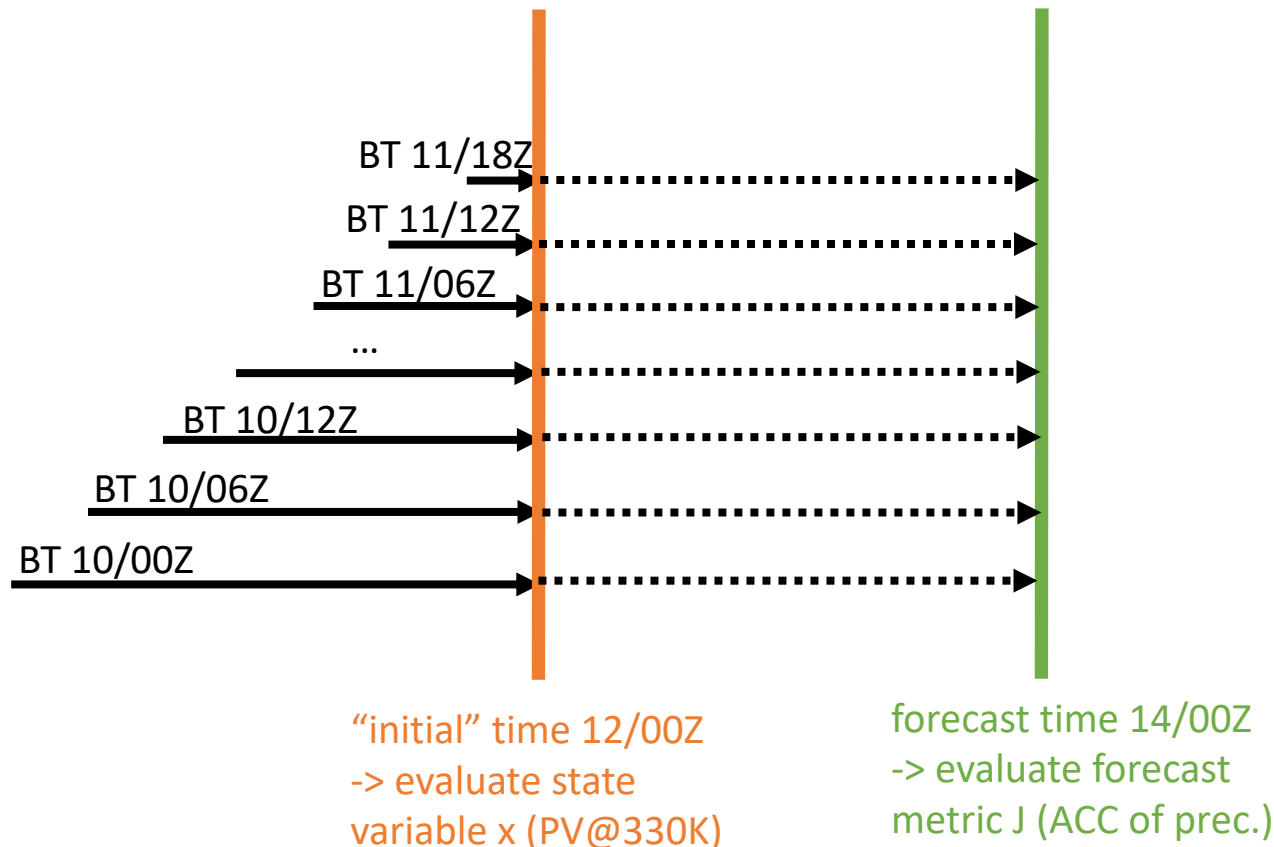
$$\frac{\delta ACC}{\partial PV_{330K}} = \frac{cov(PV, ACC)}{var(PV_{330K})}$$

Ensemble sensitivity analysis (ESA)

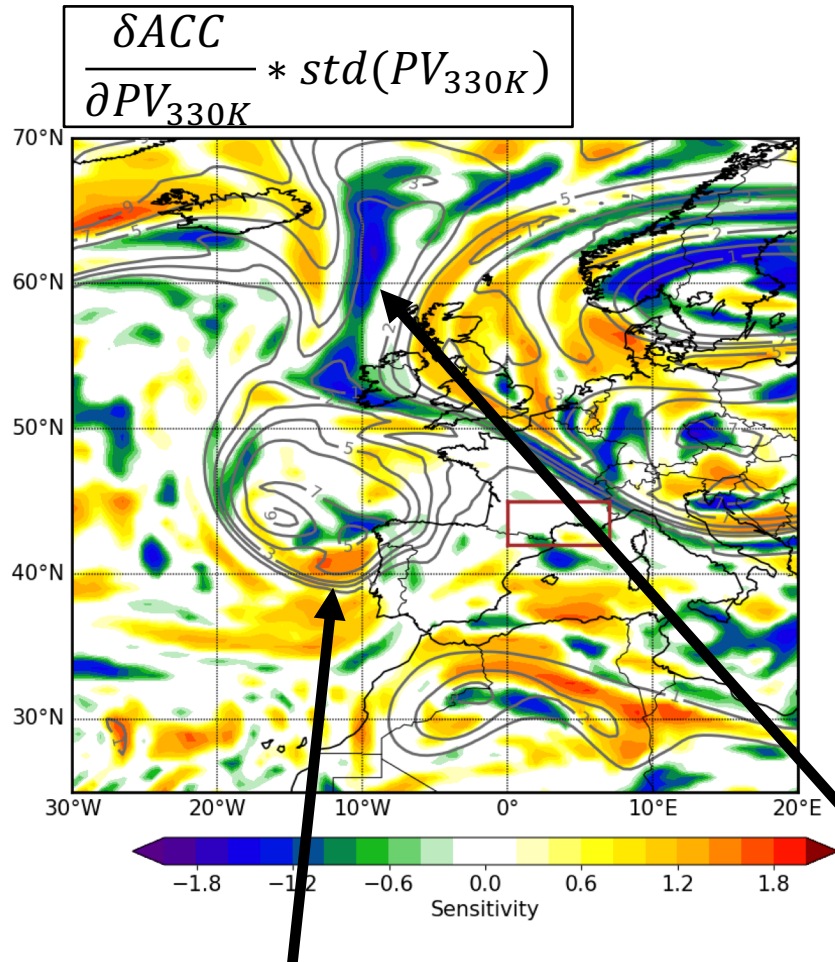
Ancell and Hakim 2007, MWR
Torn and Hakim 2008, MWR

Ensemble size M must be large to increase the signal to noise ratio

- increase M by using all fc starting between BT 10/00 and 11/18 from two reforecast data sets with slightly different initial cond.
→ $M = 2 \text{ rfc sets} \times 8 \text{ fc base times} \times 10 \text{ members} = 160 \text{ members}$



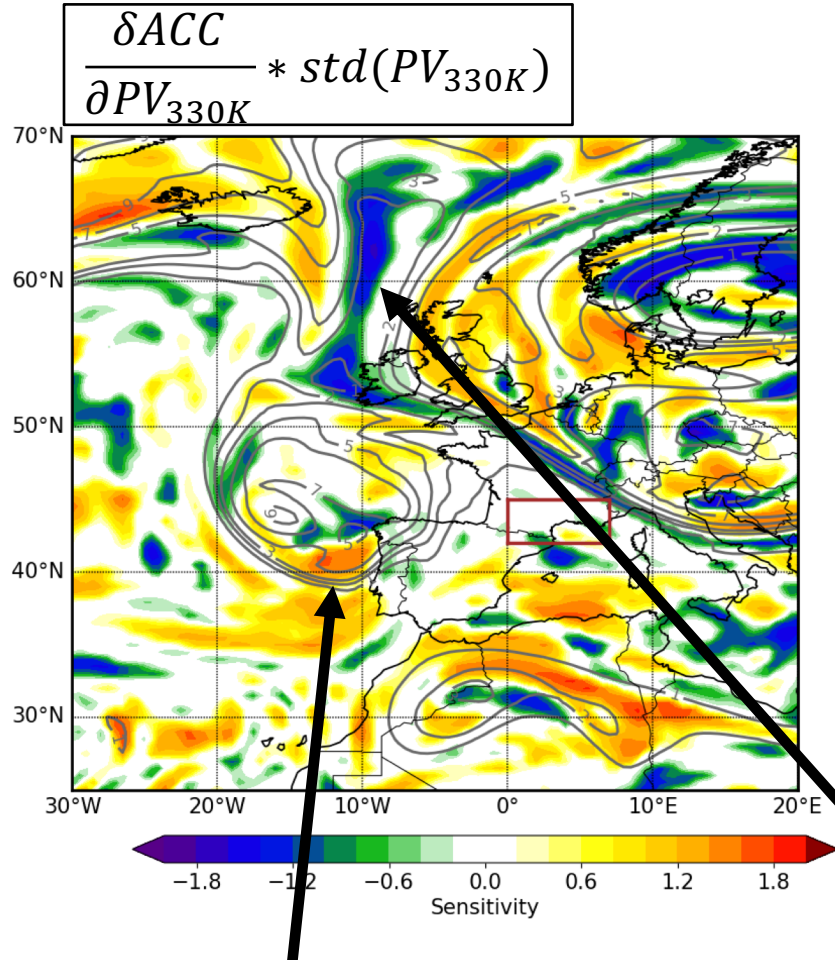
Ensemble sensitivity analysis, M = 160 ensemble members



Pos. sensitivities: Members with **higher PV** at 12/00Z in that area are associated with a **better precip. fc** at 14/00Z

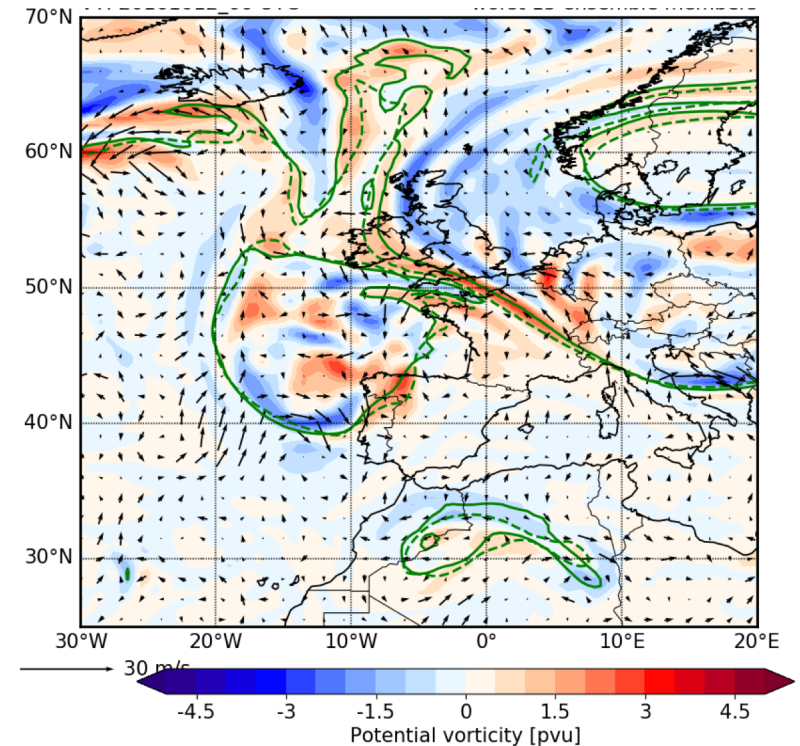
Neg. sensitivities: Members with **lower PV** at 12/00Z in that area are associated with a **better precip. fc** at 14/00Z

Ensemble sensitivity analysis, M = 160 ensemble members



Pos. sensitivities: Members with **higher PV** at 12/00Z in that area are associated with a **better precip. fc** at 14/00Z

PV error at 330K at 12/00Z of 15 worst ensemble members



Neg. sensitivities: Members with **lower PV** at 12/00Z in that area are associated with a **better precip. fc** at 14/00Z

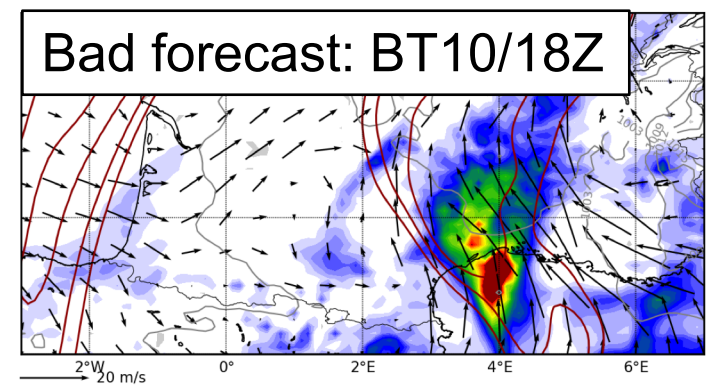
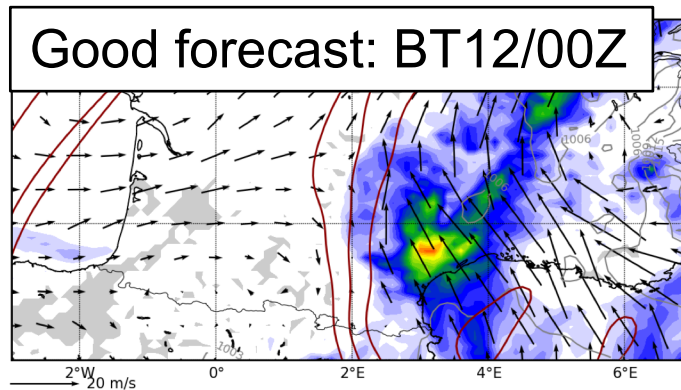
PV inversion experiments in high-resolution deterministic runs

Modification of the ULPV at 12/00Z over the eastern North Atlantic

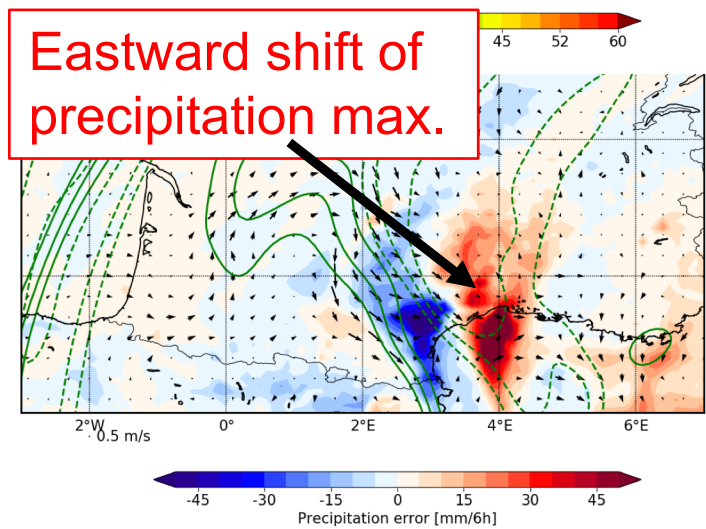
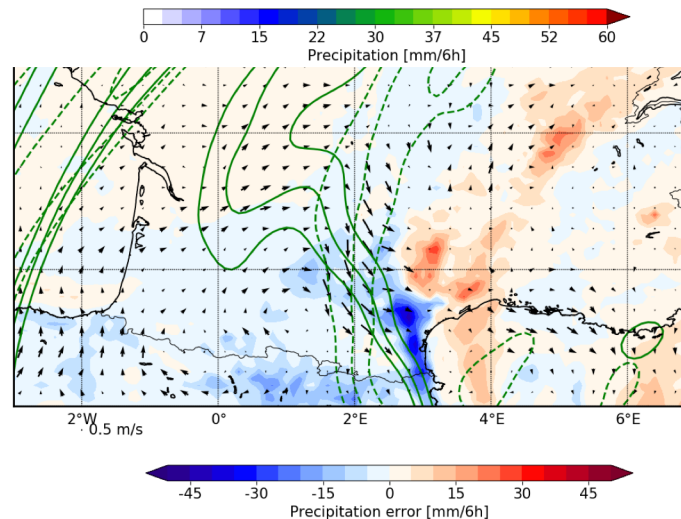
Two control runs:

1. A good fc in terms of UL PV and precip. at 14/00Z: BT12/00Z
2. A bad fc in terms of UL PV and precip. at 14/00Z: BT10/18Z

Precipitation
at 14/00Z



Precipitation
error (fc-ana)
at 14/00Z



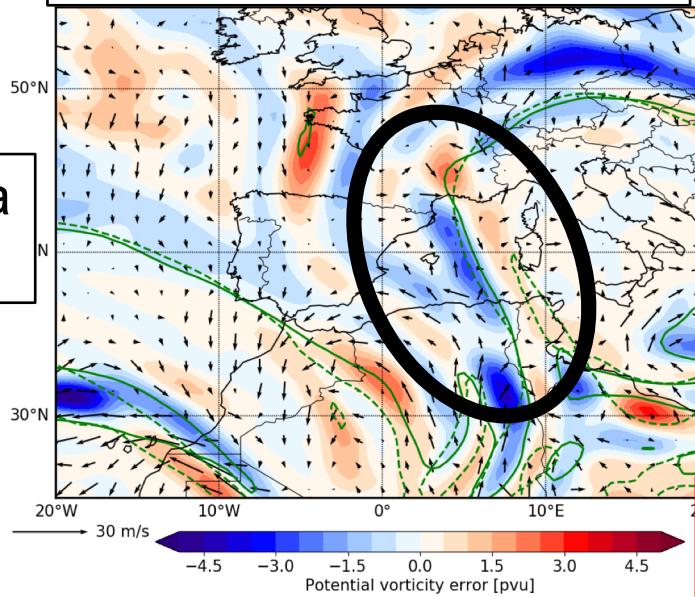
PV inversion experiments in high-resolution deterministic runs

Modification of the ULPV at 12/00Z over the eastern North Atlantic

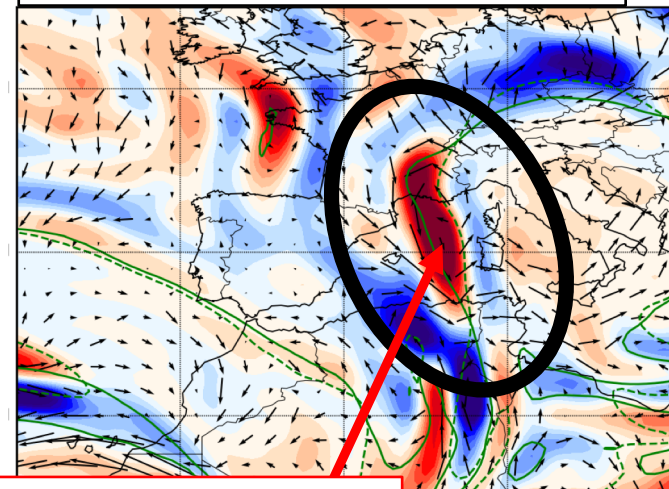
Two control runs:

1. A good fc in terms of UL PV and precip. at 14/00Z: BT12/00Z
2. A bad fc in terms of UL PV and precip. at 14/00Z: BT10/18Z

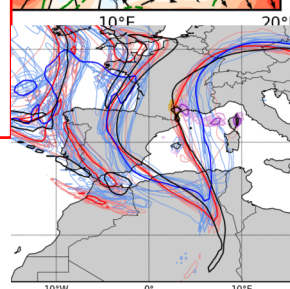
Good forecast: BT12/00Z



Bad forecast: BT10/18Z



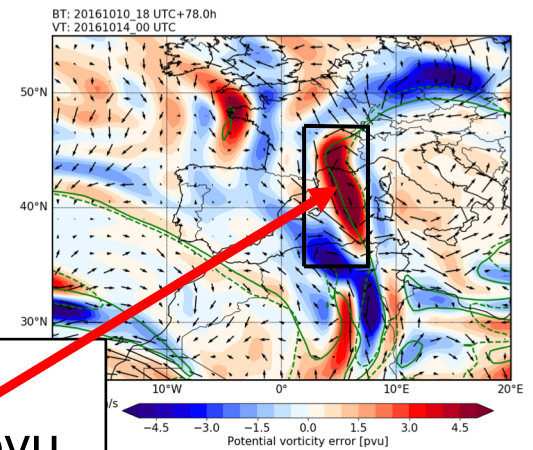
Eastward shift of
2pvu@200hPa



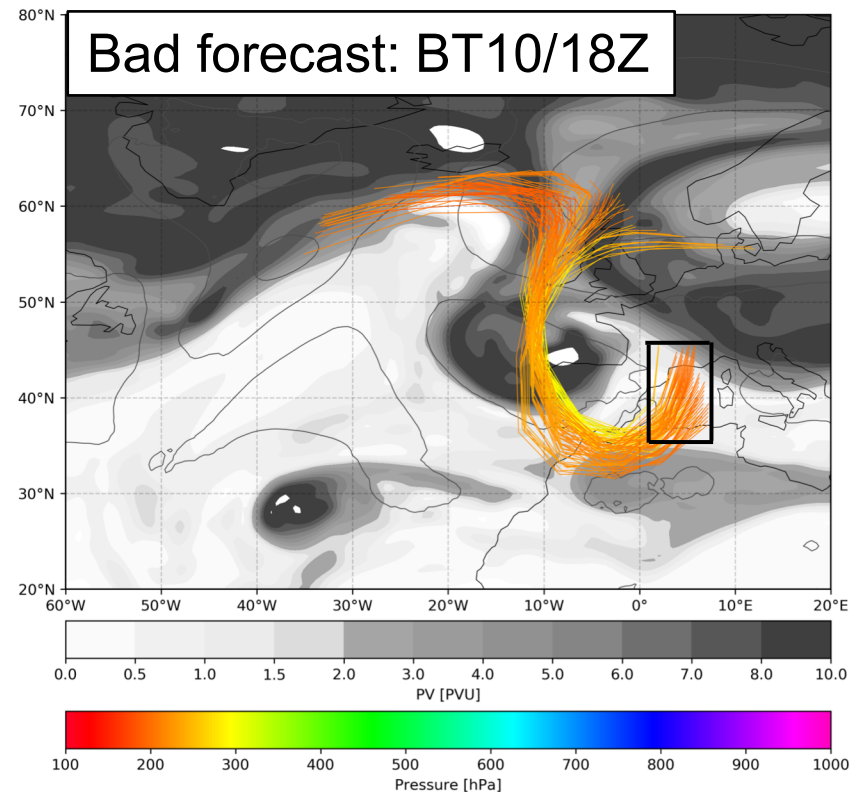
PV error at 200hPa
(fc-ana) at 14/00Z

Backward trajectories in control runs

48h backward trajectories starting at 14/00Z from grid points where in bad fc PV errors > 2 pvu and $PV_{ANA} < 2$ pvu (at 2-8E/34-46N, 600-100hPa)

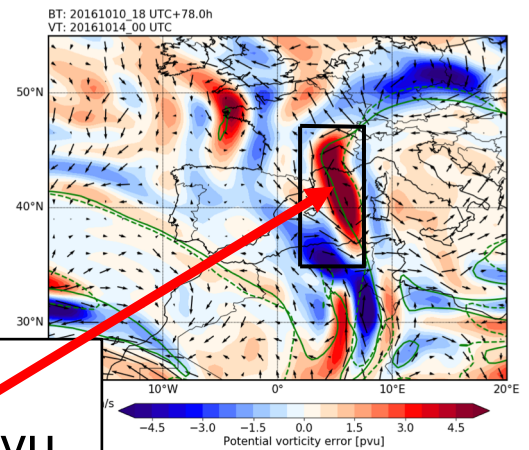


48h backw tra. starting at 20161014_00 and PV at 200hPa at 20161012_00

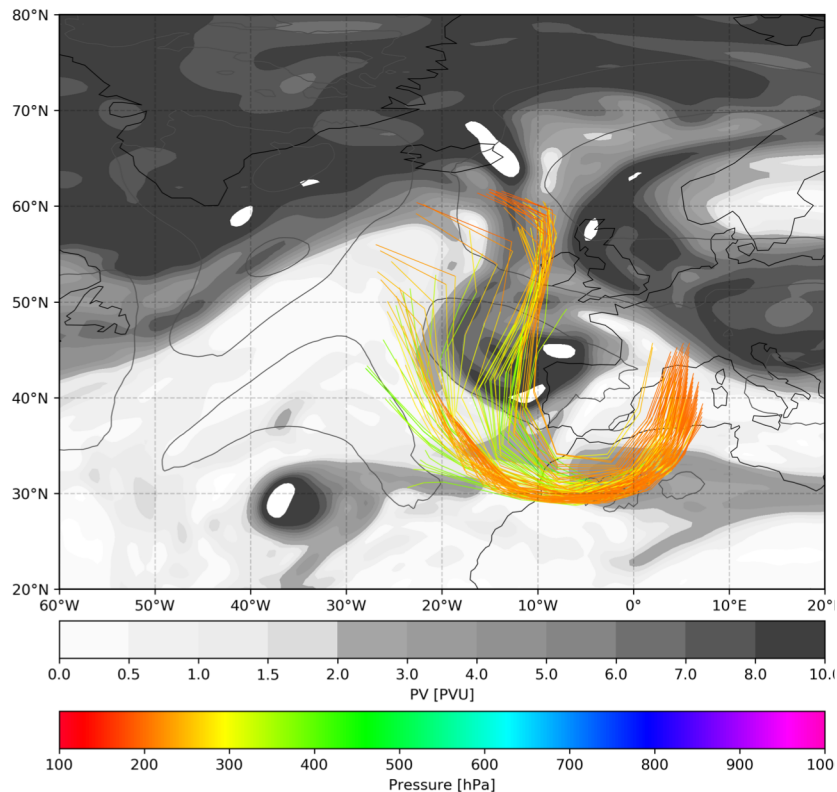


Backward trajectories in control runs

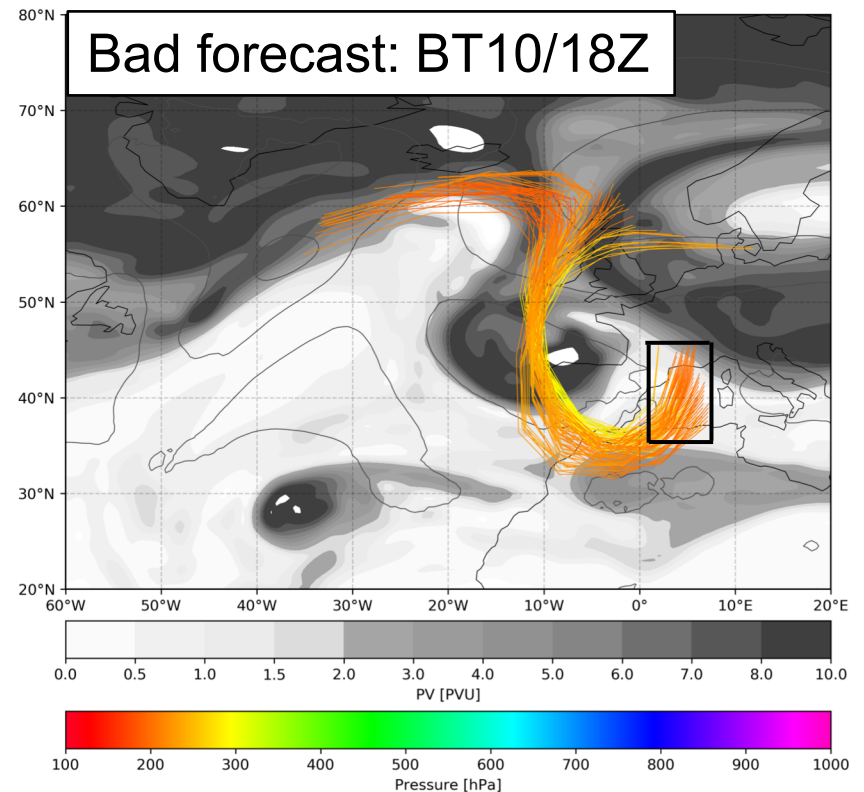
48h backward trajectories starting at 14/00Z from grid points where in bad fc PV errors $> 2\text{pvu}$ and $\text{PV}_{\text{ANA}} < 2\text{pvu}$ (at 2-8E/34-46N, 600-100hPa)



48h backw tra. starting at 20161014_00 and PV at 200hPa at 20161012_00

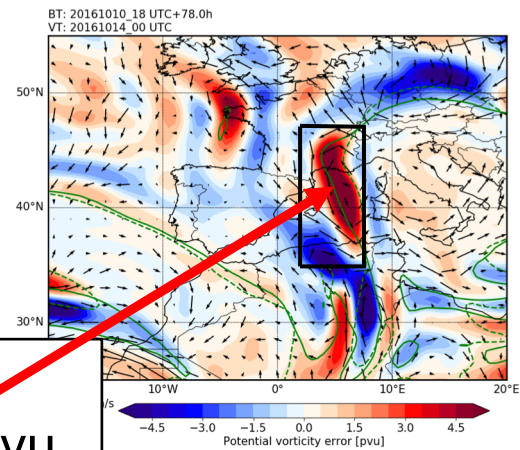


48h backw tra. starting at 20161014_00 and PV at 200hPa at 20161012_00

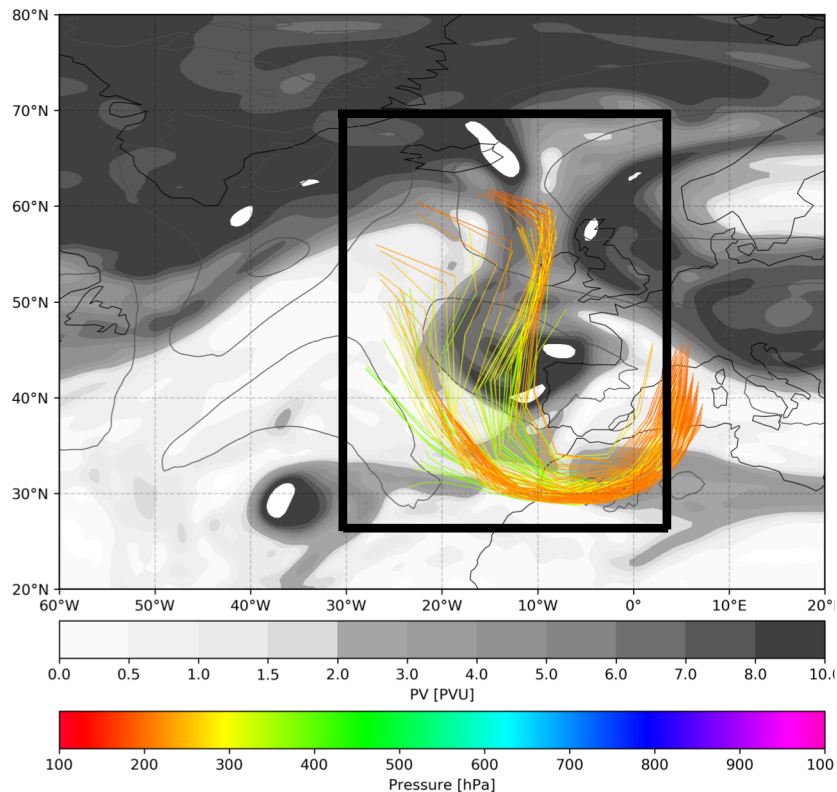


Backward trajectories in control runs

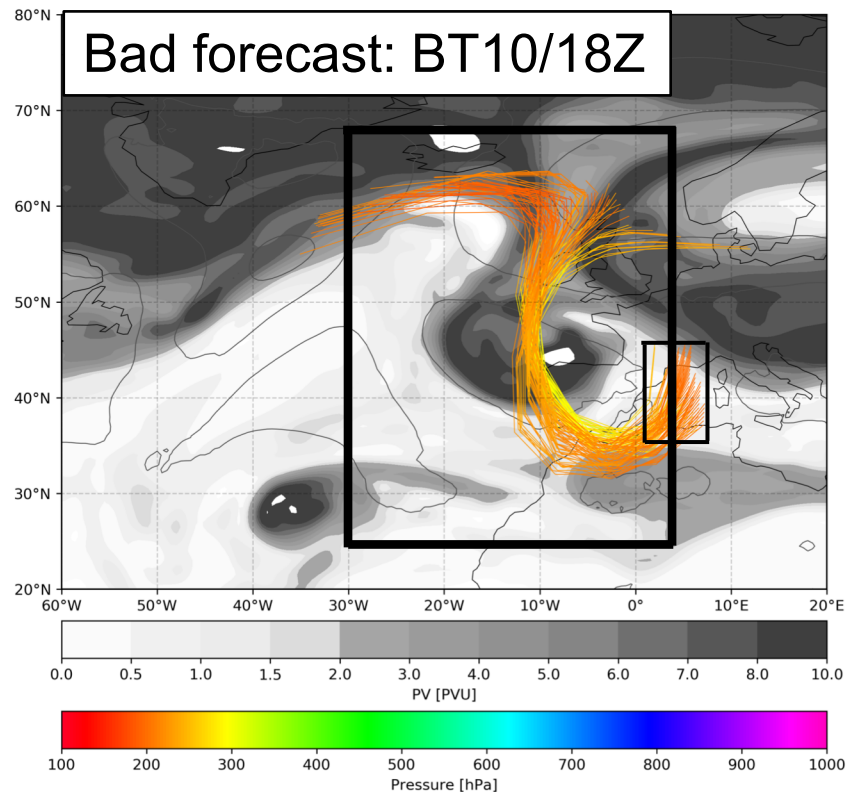
48h backward trajectories starting at 14/00Z from grid points where in bad fc PV errors $> 2\text{pvu}$ and $\text{PV}_{\text{ANA}} < 2\text{pvu}$ (at 2-8E/34-46N, 600-100hPa)



48h backw tra. starting at 20161014_00 and PV at 200hPa at 20161012_00



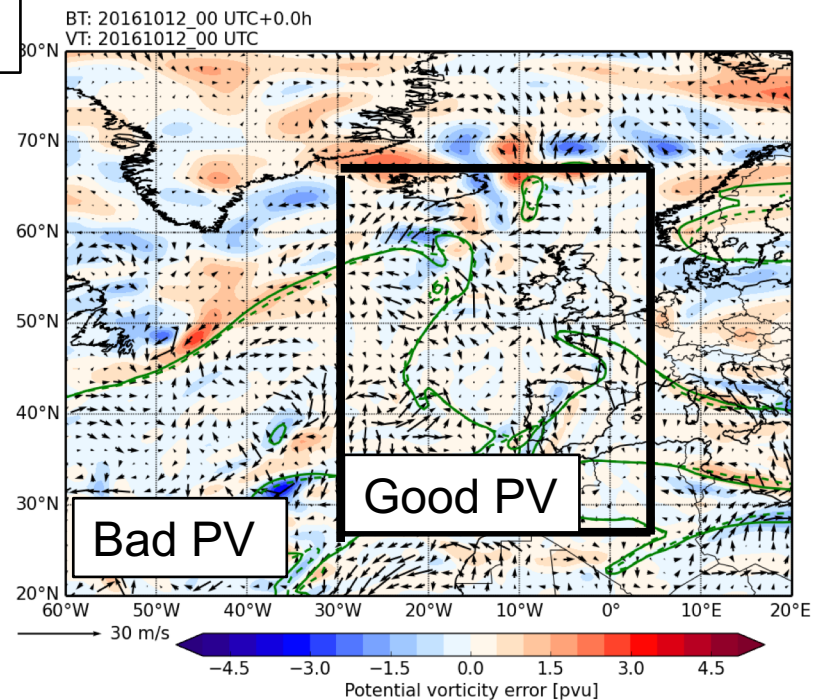
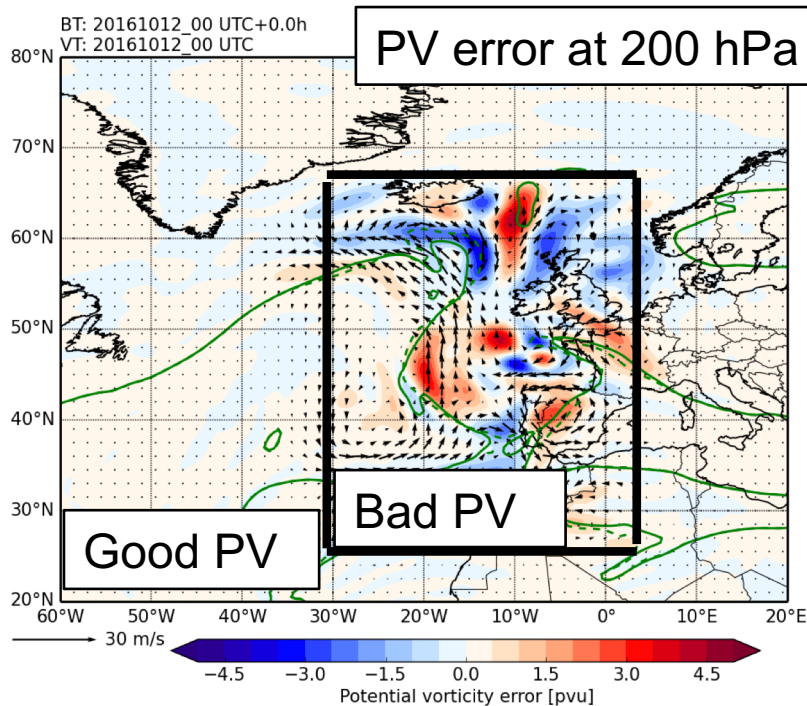
48h backw tra. starting at 20161014_00 and PV at 200hPa at 20161012_00



PV inversion experiments in high-resolution deterministic runs

Exp 1: At 12/00Z, the **good PV** is replaced by the **bad PV** at 100-600 hPa in the domain 25-68N/30W-5E

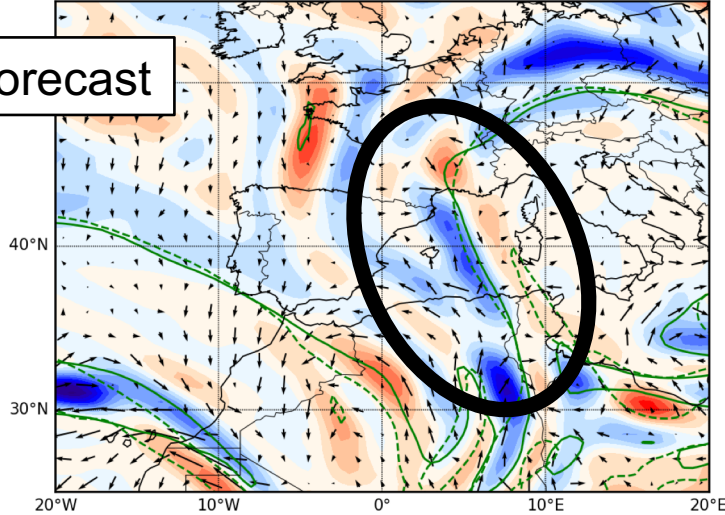
Exp 2: Opposite of Exp. 1
(**bad PV** replaced by **good PV** in the same domain)



PV error at 200 hPa, forecast – analysis, at 14/00Z

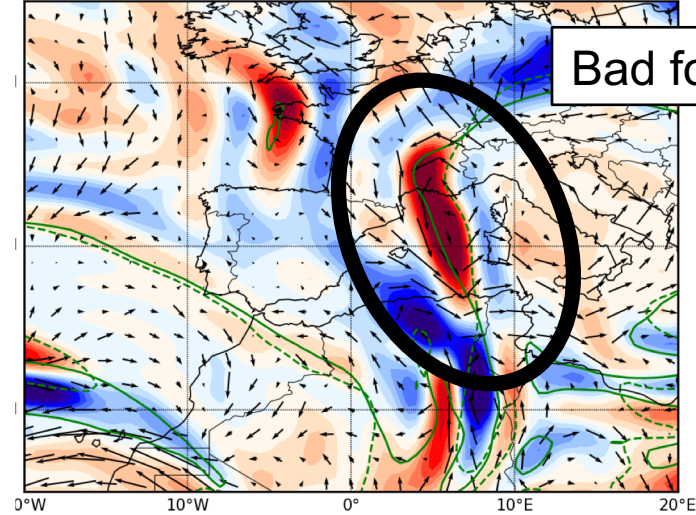
BT: 20161012_00 UTC+48.0h
VT: 20161014_00 UTC

Good forecast



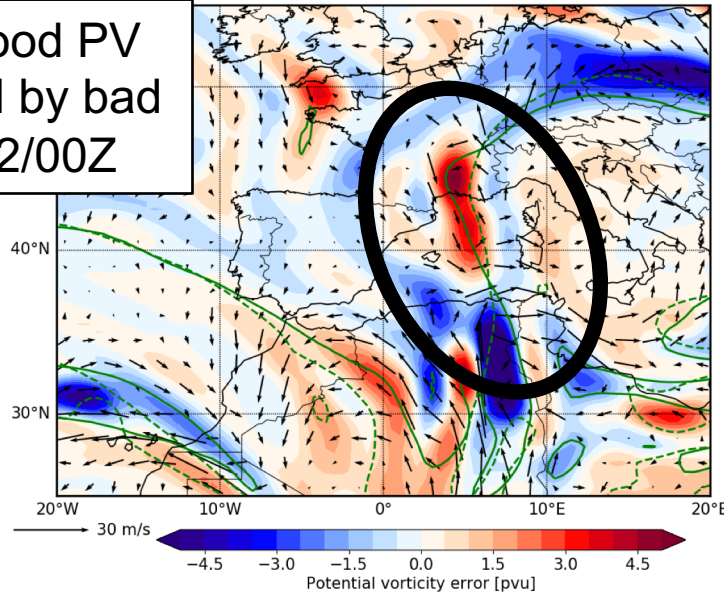
BT: 20161010_18 UTC+78.0h
VT: 20161014_00 UTC

Bad forecast



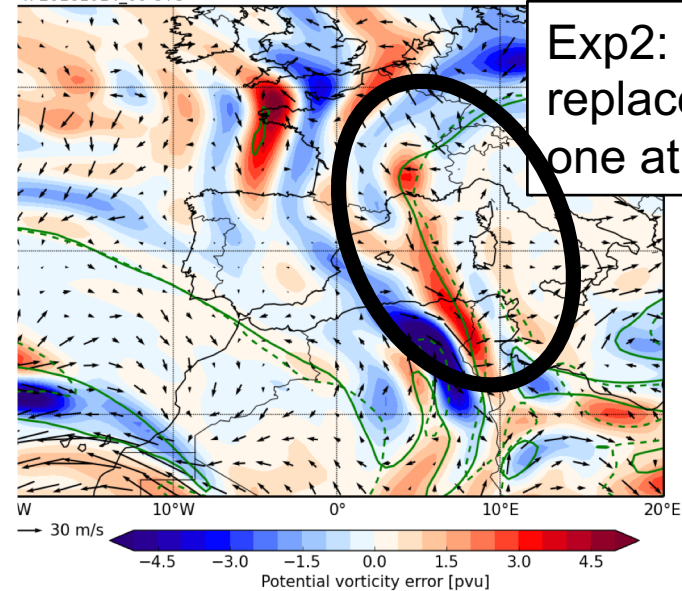
BT: 20161012_00 UTC+48.0h
VT: 20161014_00 UTC

Exp1: good PV
replaced by bad
one at 12/00Z



BT: 20161012_00 UTC+48.0h
VT: 20161014_00 UTC

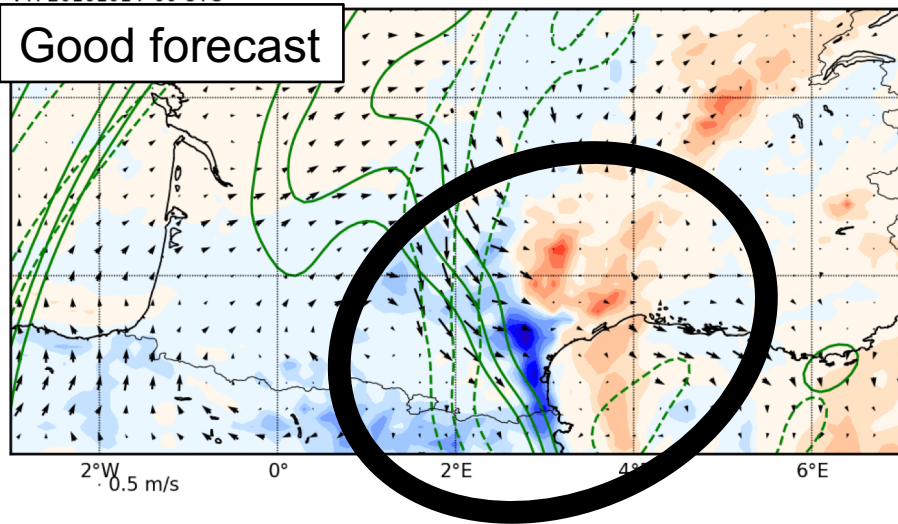
Exp2: bad PV
replaced by good
one at 12/00Z



Precipitation error, forecast – analysis, at 14/00Z

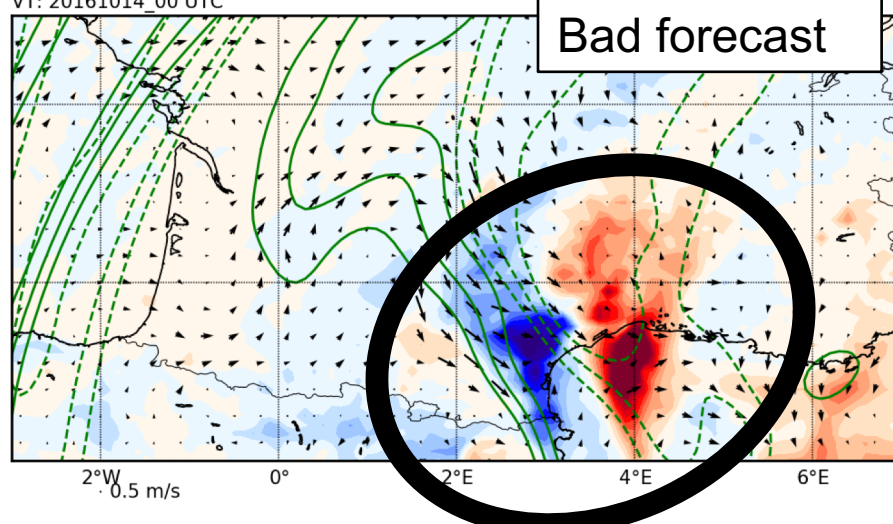
BT: 20161012_00 UTC+48.0h
VT: 20161014_00 UTC

Good forecast

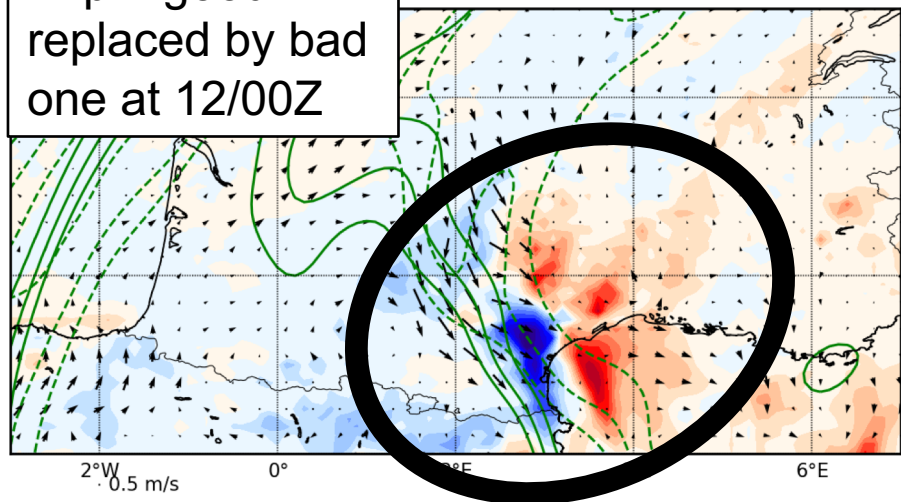


BT: 20161010_18 UTC+78.0h
VT: 20161014_00 UTC

Bad forecast

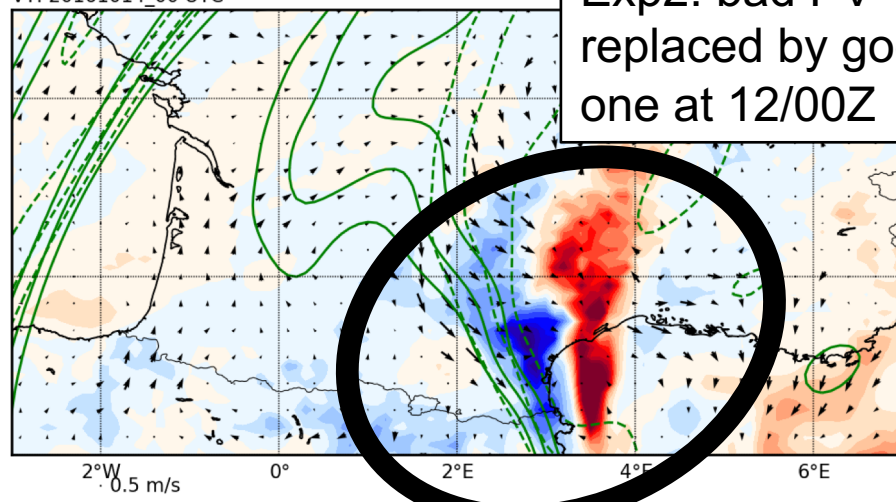


Exp1: good PV
replaced by bad
one at 12/00Z



BT: 20161012_00 UTC+48.0h
VT: 20161014_00 UTC

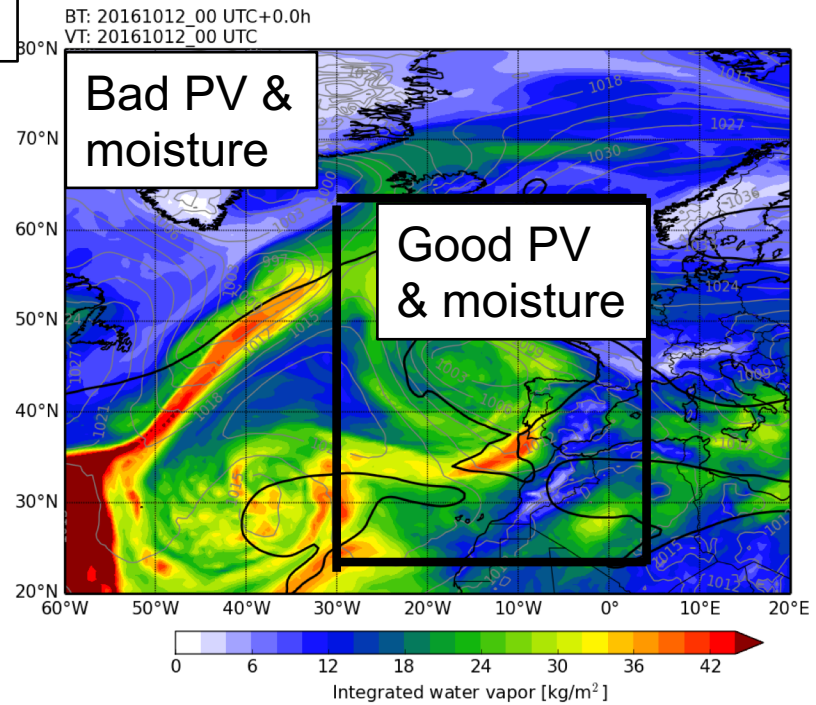
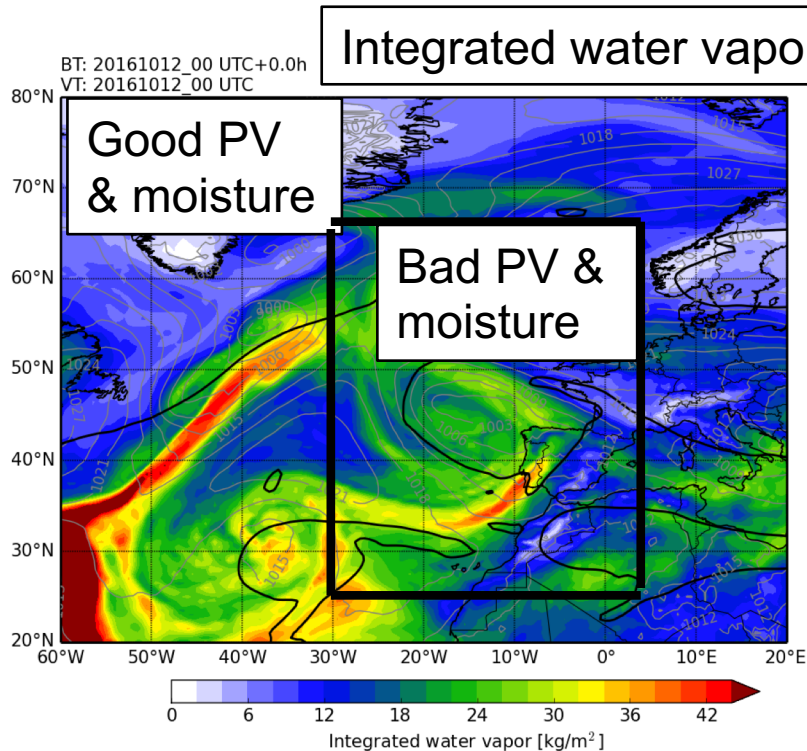
Exp2: bad PV
replaced by good
one at 12/00Z



PV inversion and moisture experiments

Exp 3: At 12/00Z, the **UL PV** and the **low-level moisture** structure (1050-500 hPa) in the **good** run are **replaced by the bad ones**

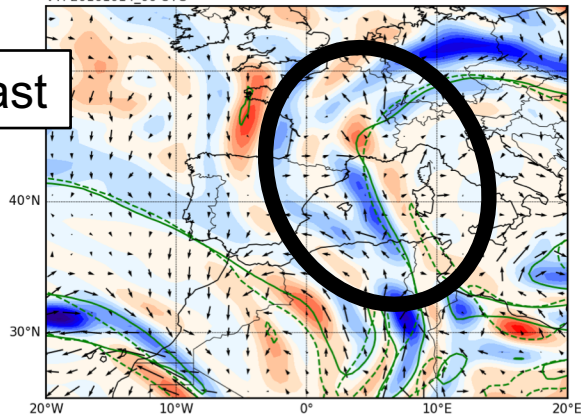
Exp 4: Opposite of Exp. 3
(**bad PV and moisture** replaced by **good ones**)



PV error at 200 hPa, forecast – analysis, at 14/00Z

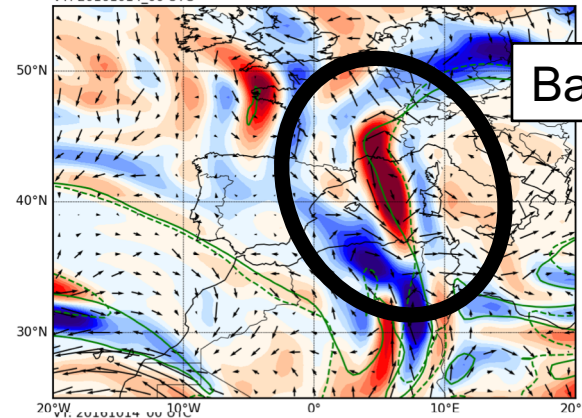
BT: 20161012_00 UTC+48.0h
VT: 20161014_00 UTC

Good forecast

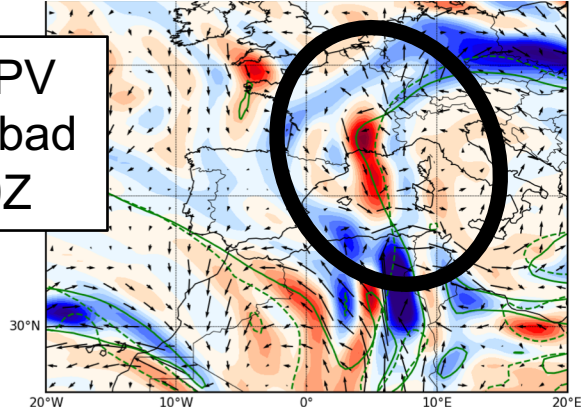


BT: 20161010_18 UTC+78.0h
VT: 20161014_00 UTC

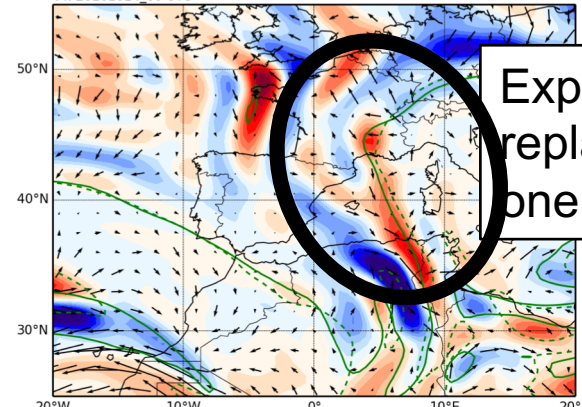
Bad forecast



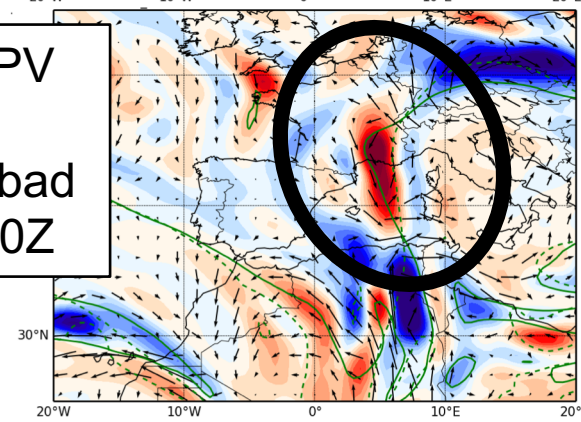
Exp1: good PV
replaced by bad
one at 12/00Z



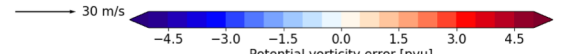
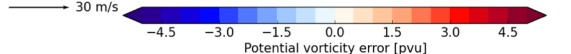
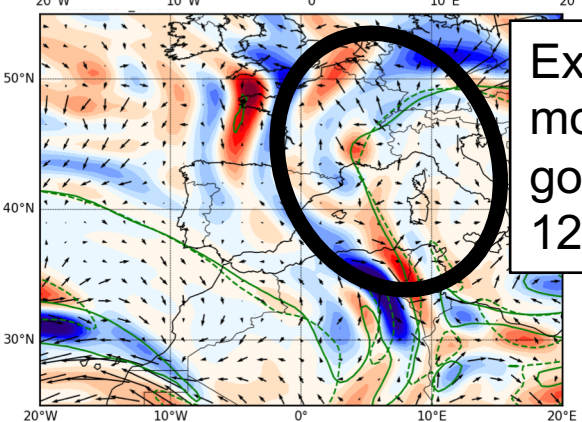
Exp2: bad PV
replaced by good
one at 12/00Z



Exp3: good PV
& moisture
replaced by bad
ones at 12/00Z



Exp4: bad PV &
moisture repl. by
good ones at
12/00Z



Precipitation error, forecast – analysis, at 14/00Z

Good forecast

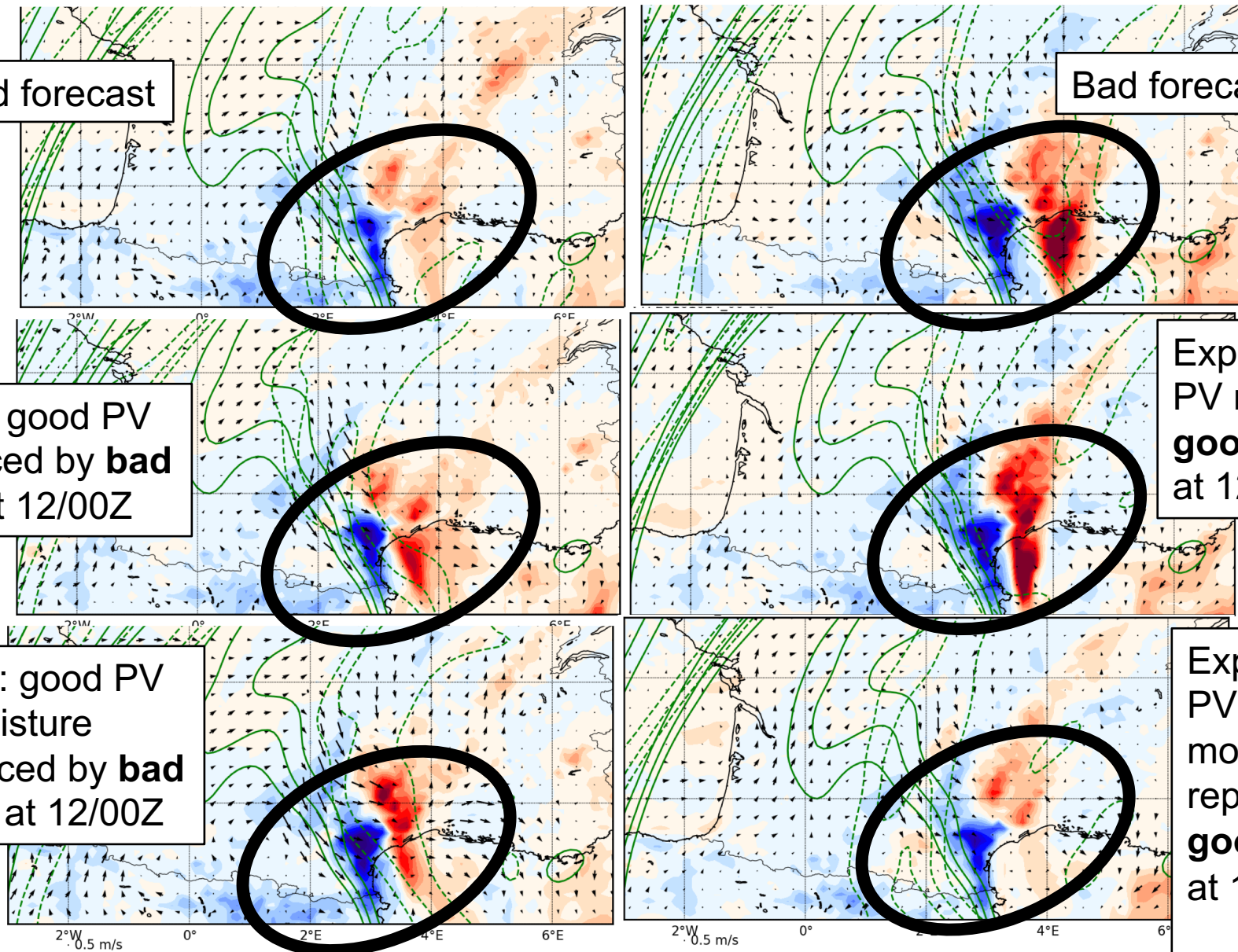
Bad forecast

Exp1: good PV
replaced by **bad**
one at 12/00Z

Exp2: bad
PV repl. by
good one
at 12/00Z

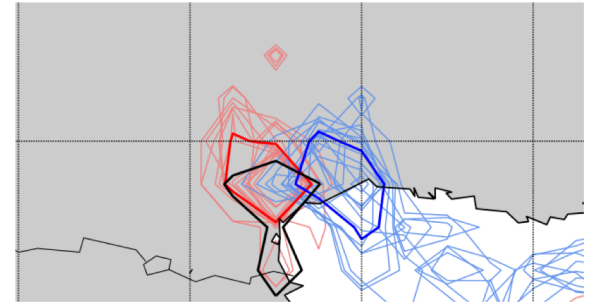
Exp3: good PV
& moisture
replaced by **bad**
ones at 12/00Z

Exp4: bad
PV &
moisture
repl. by
good ones
at 12/00Z



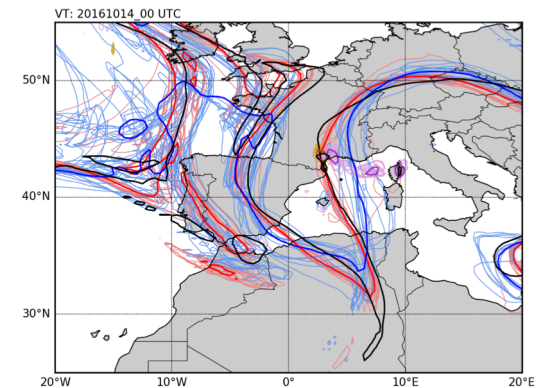
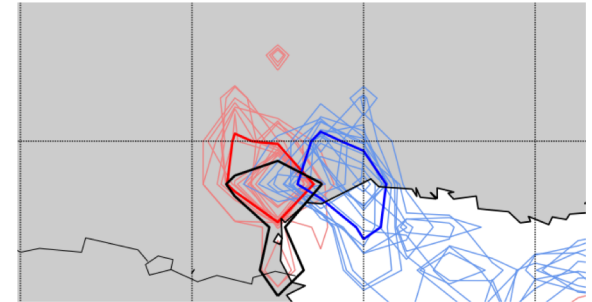
Summary

- Eastward shift of forecasted precipitation max. in many ensemble members in 2-5 day forecasts.



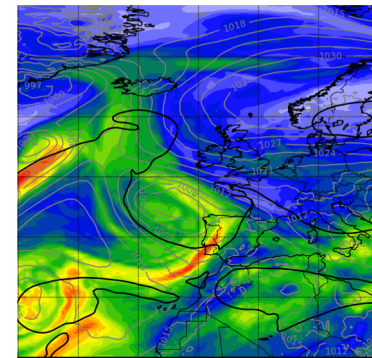
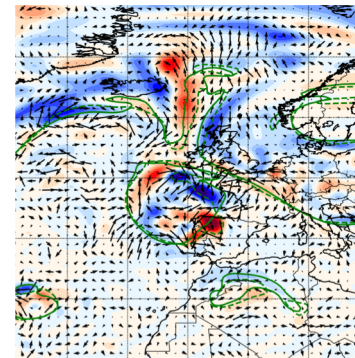
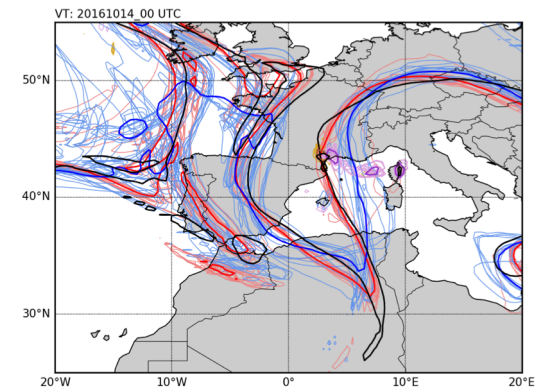
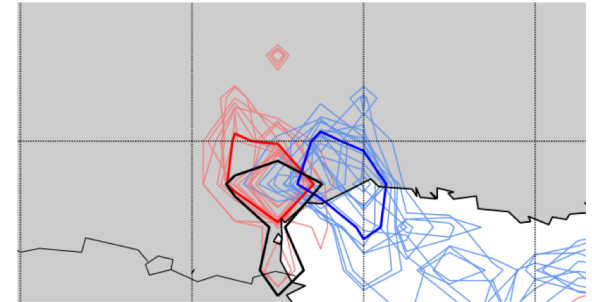
Summary

- Eastward shift of forecasted precipitation max. in many ensemble members in 2-5 day forecasts.
- The displacement of the precipitation forecast seems to be linked to errors in the location and structure of the UL PV streamer Sanchez.



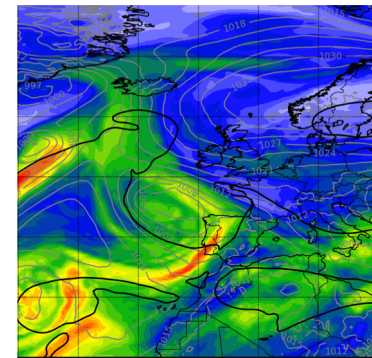
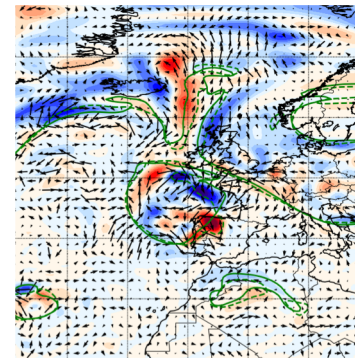
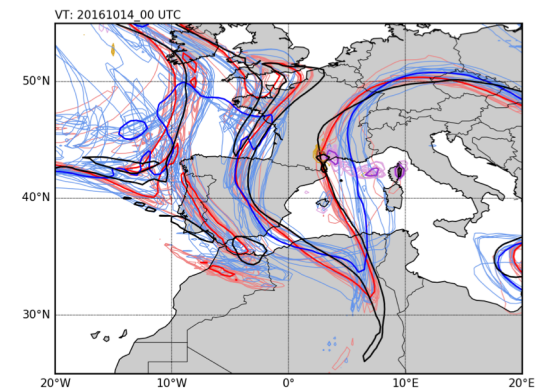
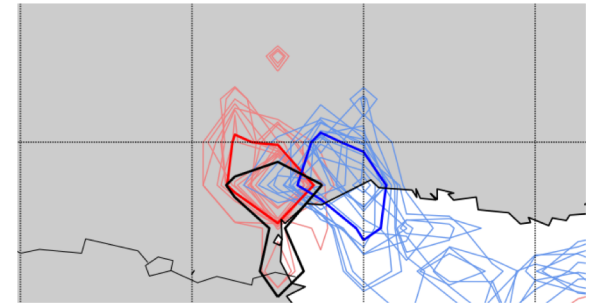
Summary

- Eastward shift of forecasted precipitation max. in many ensemble members in 2-5 day forecasts.
- The displacement of the precipitation forecast seems to be linked to errors in the location and structure of the UL PV streamer Sanchez.
- The forecasts are sensitive to both the representation of the upper-level flow and the low-level moisture over the North Atlantic at earlier forecast times.



Future work

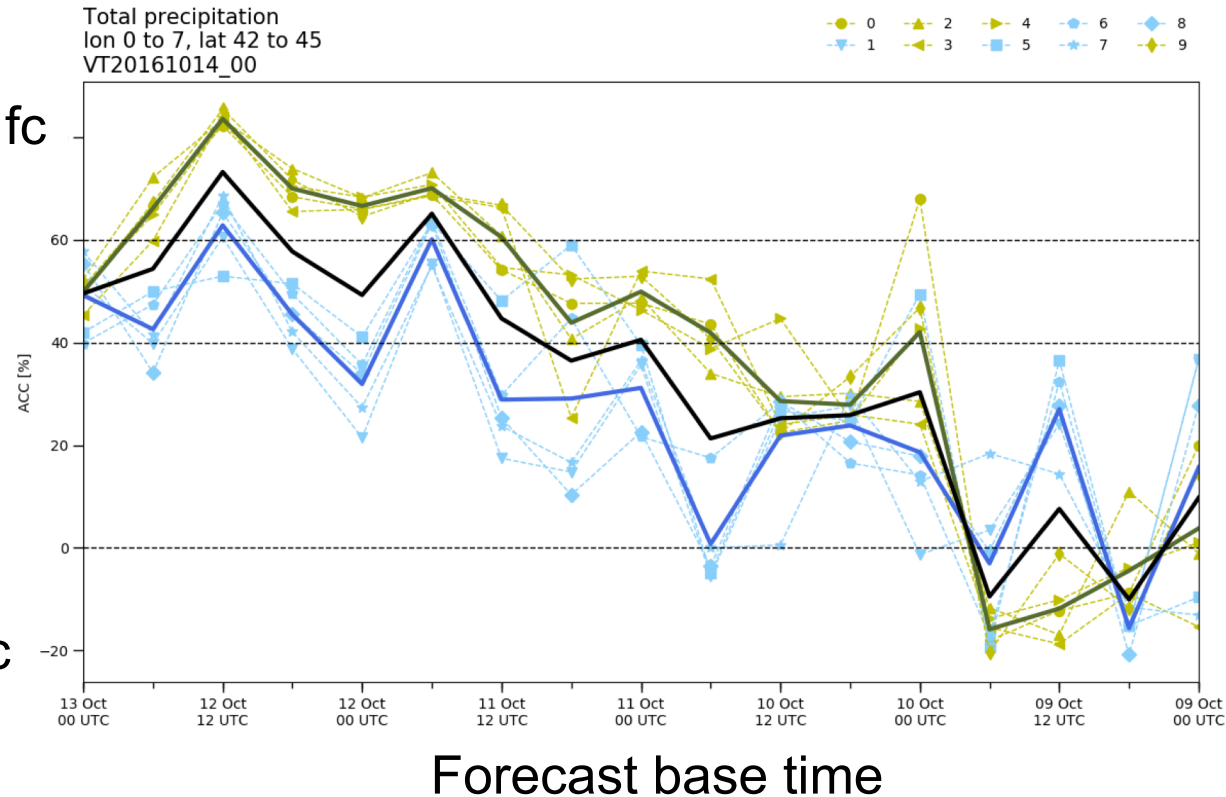
- Understand the adiabatic and diabatic processes responsible for the UL PV and precipitation errors over southern France.
- Decrease the modified domain in the PV inversion and moisture experiments to narrow down the sensitive regions.



Additional slides

Forecast quality of precipitation at 00 UTC 14 Oct 2016

Anomaly correlation coefficient (ACC) over southern France



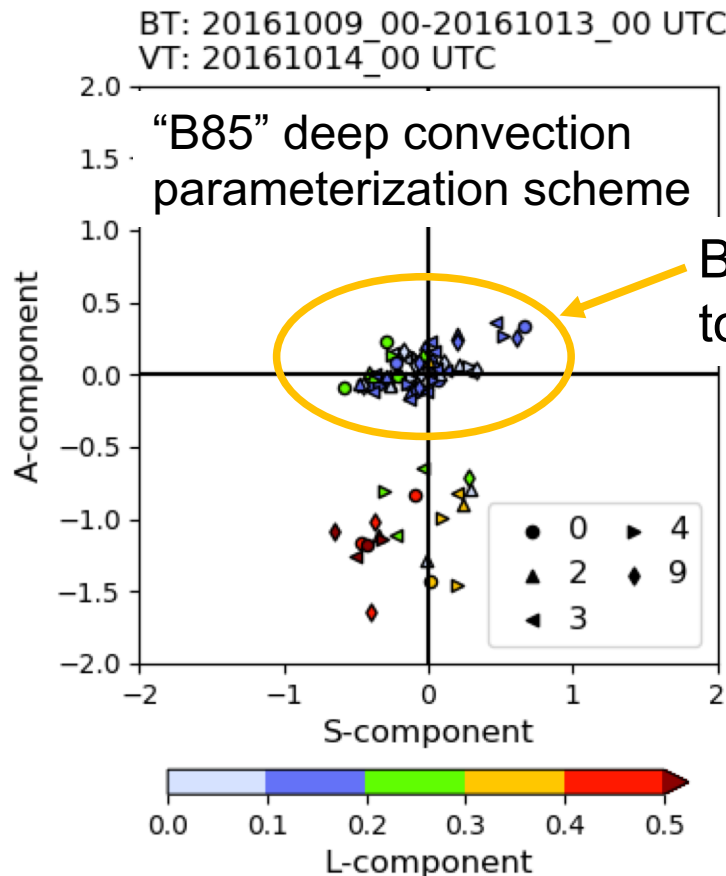
Deep convection parameterization:

- Mass flux scheme (Bougeault 1985)
- PCMT (Prognostic Condensates Microphysics and Transport)

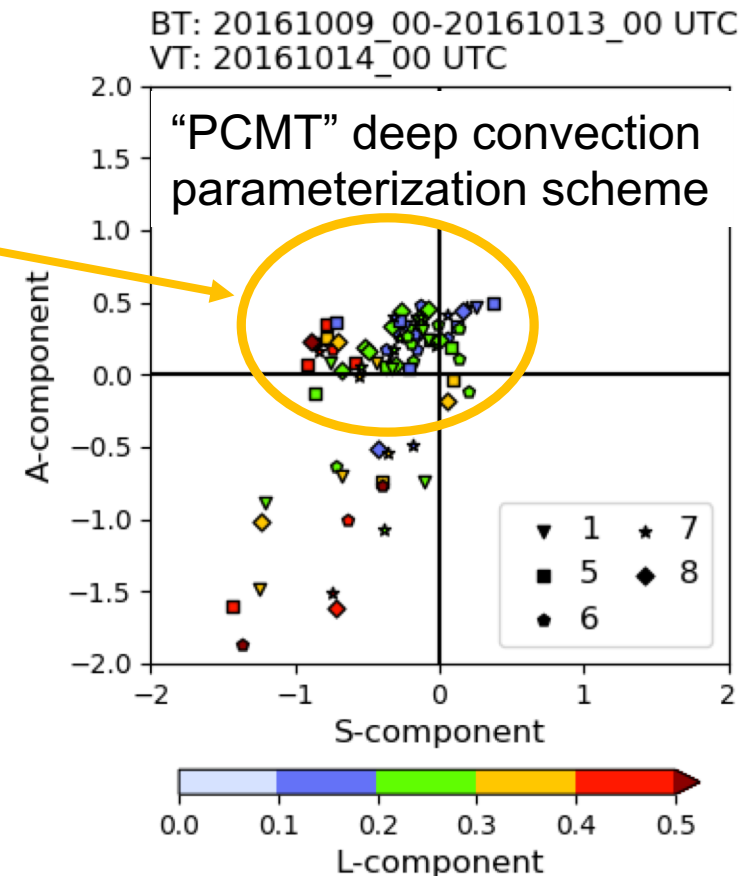
- Most forecasts are relatively poor in terms of ACC
- FC quality decreases with increasing lead time
- FC quality depends on deep convection scheme (B85 generally better than PCMT)

Forecast quality of precipitation at 00 UTC 14 Oct 2016

SAL (Wernli et al. 2008, MWR) → Perfect when $S=0$, $A=0$ & $L=0$



BT10/00Z
to 13/00Z



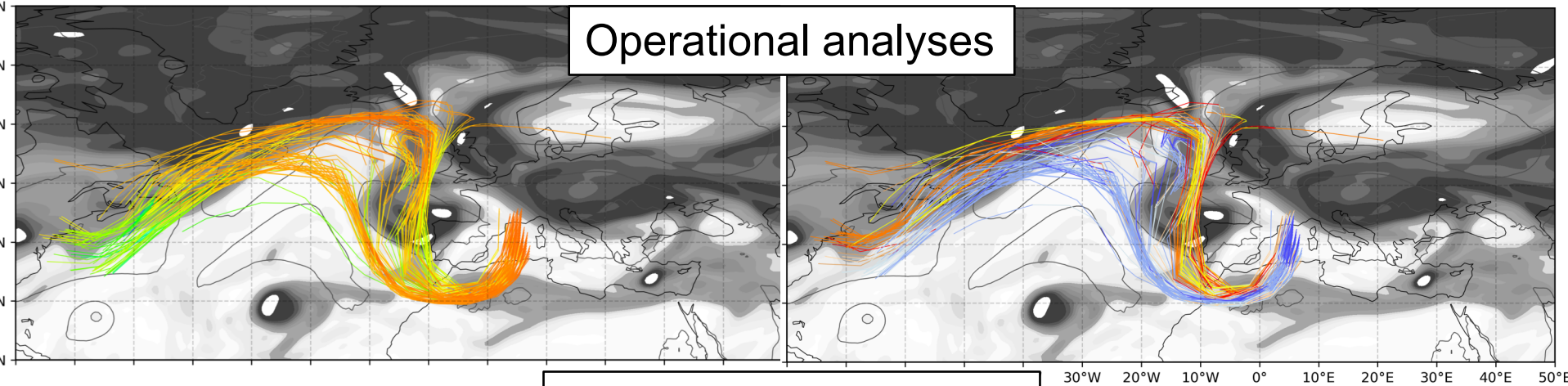
- From BT10/00Z onward fcsts of most B85 members are relatively good
- PCMT members: location error ($L>0$), amplitude slightly overestimated ($A>0$) and structure error ($S<0$)

78h backward traj. in op. ana and bad run

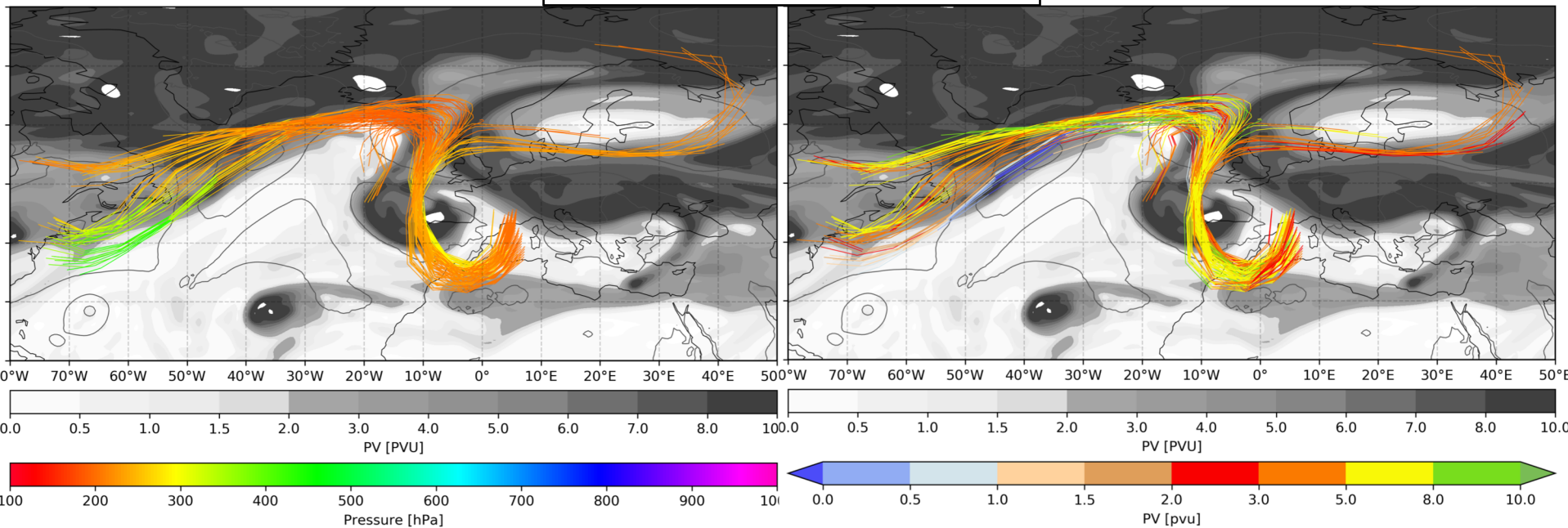
78h backw tra. starting at 20161014_00 and PV at 200hPa at 20161012_00

78h backw tra. starting at 20161014_00 and PV at 200hPa at 20161012_00

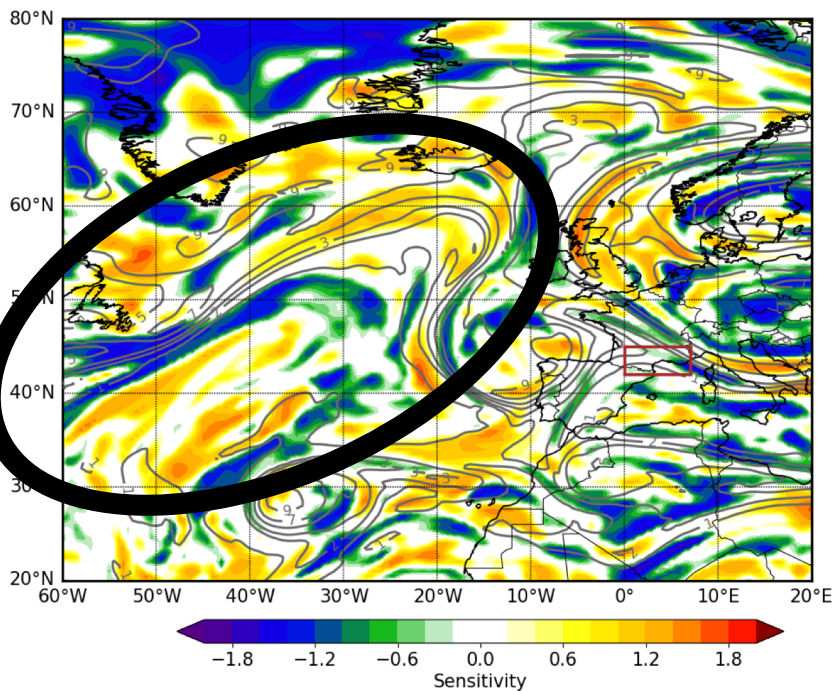
Operational analyses



Bad forecast: BT10/18Z



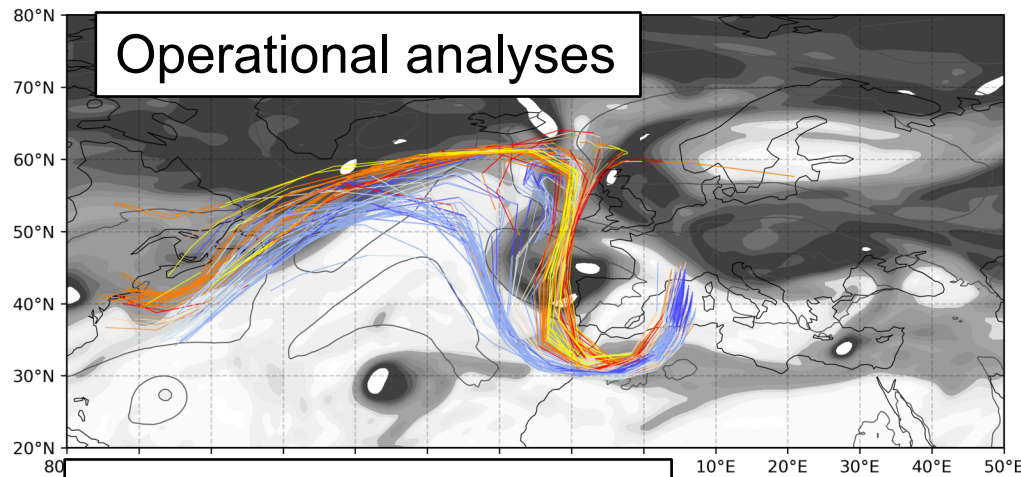
$$\frac{\delta ACC}{\partial PV_{200hPa}} * std(PV_{200hPa})$$



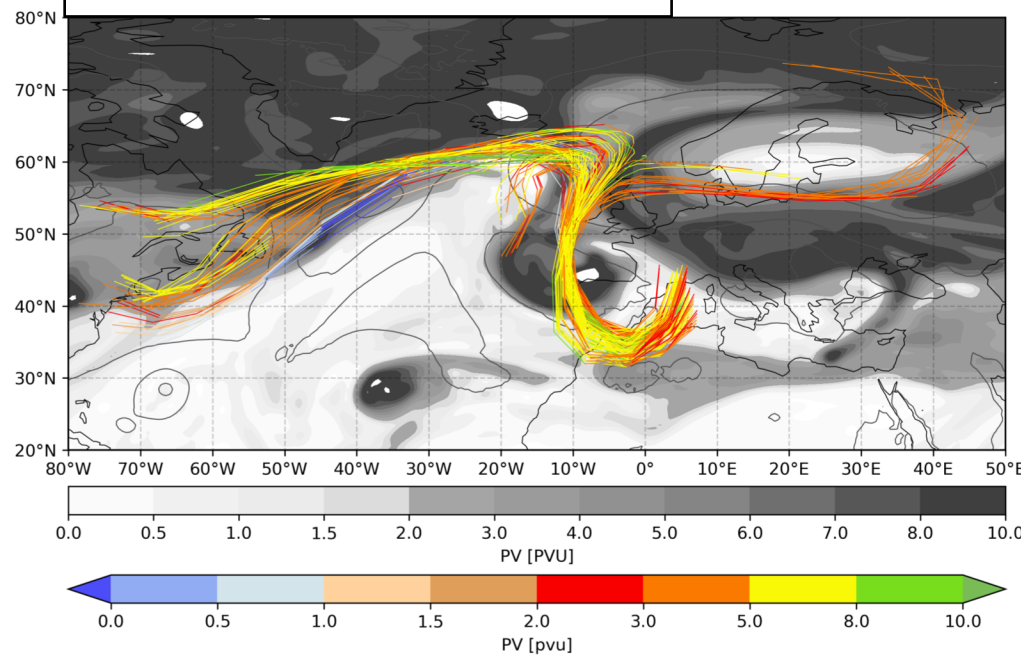
IC12/00, BT10/00-11/18, 160ens

78h backw tra. starting at 20161014_00 and PV at 200hPa at 20161012_00

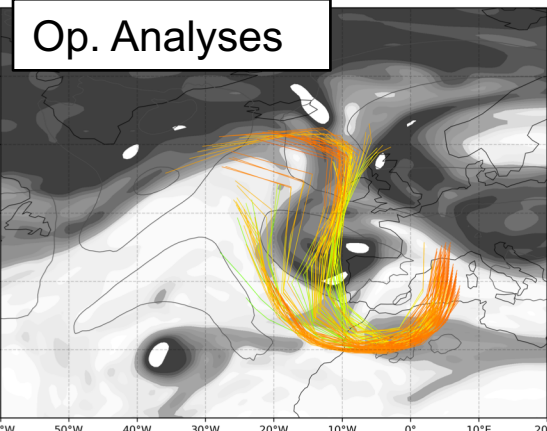
Operational analyses



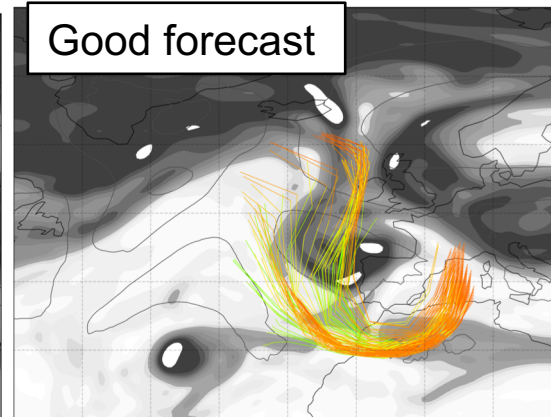
Bad forecast: BT10/18Z



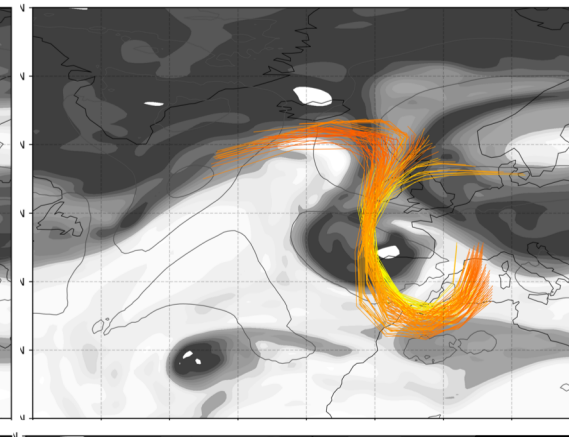
Op. Analyses



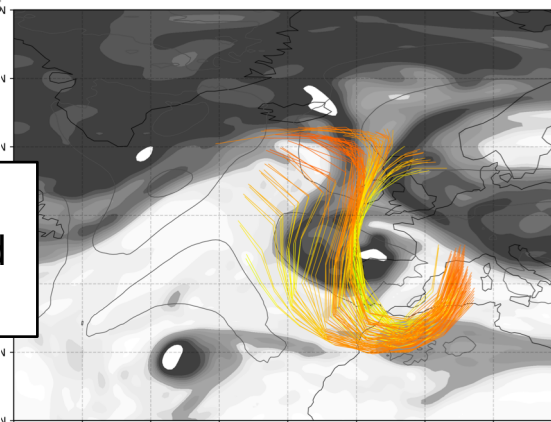
Good forecast



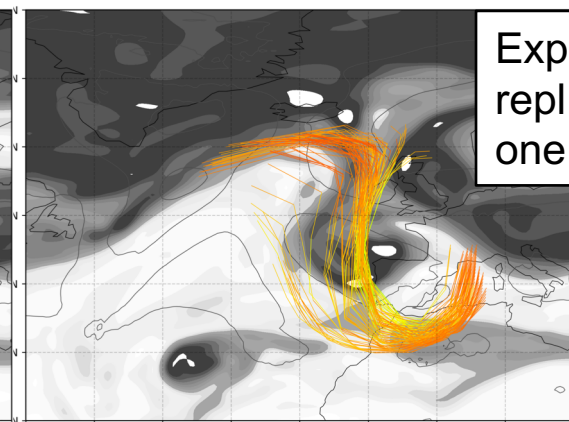
recast



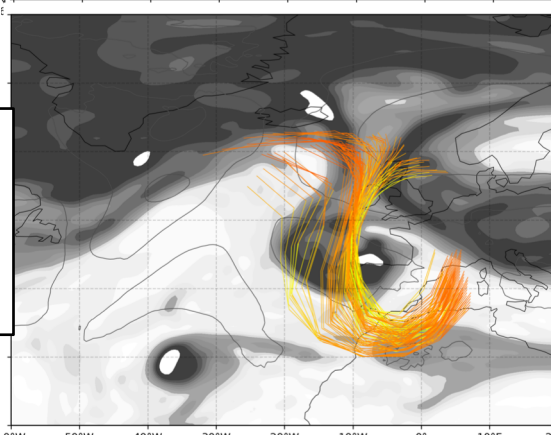
Exp1: good PV
replaced by bad
one at 12/00Z



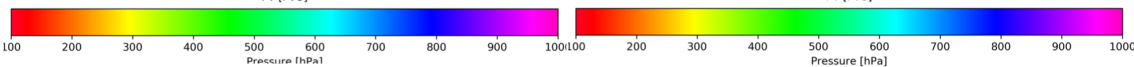
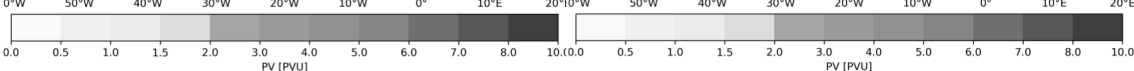
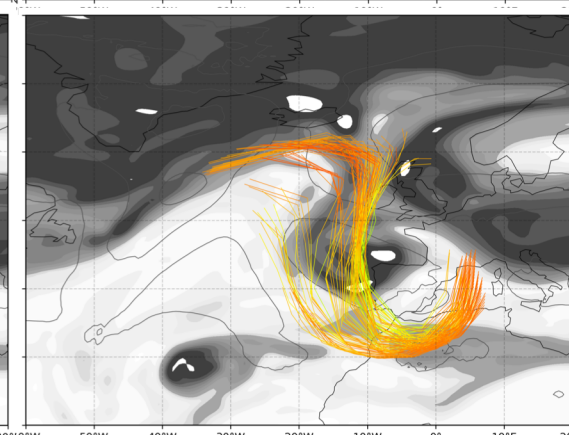
Exp2: bad PV
repl. by good
one at 12/00Z

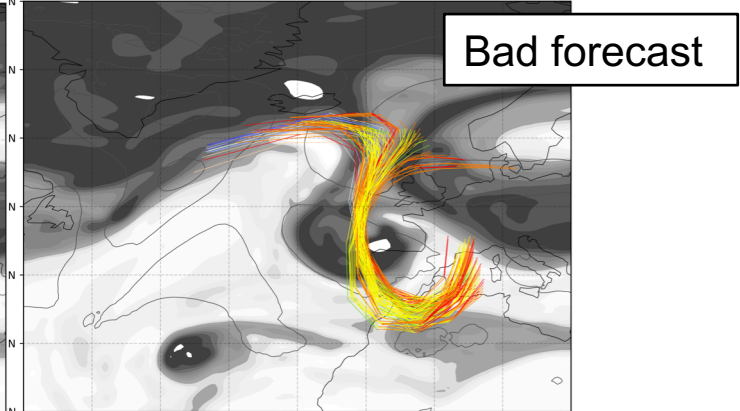
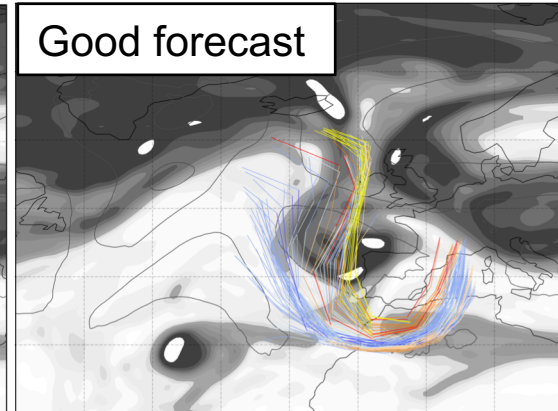
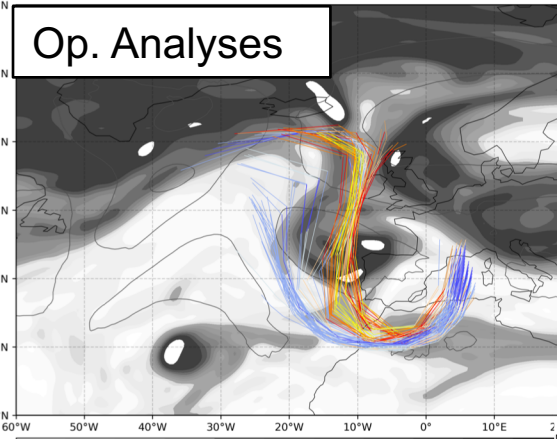


Exp3: good PV
& moisture
replaced by bad
ones at 12/00Z

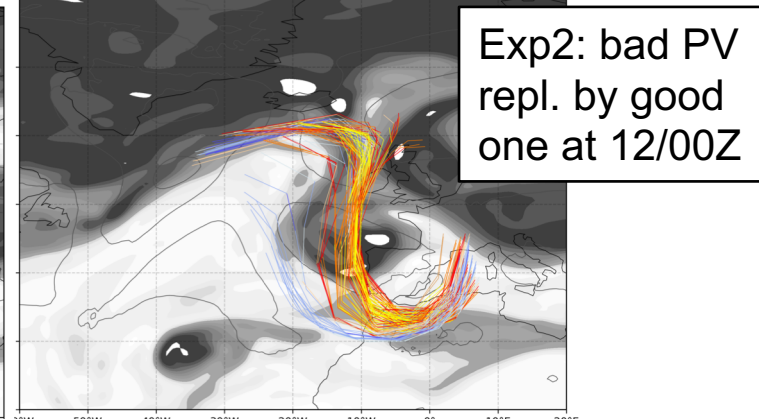
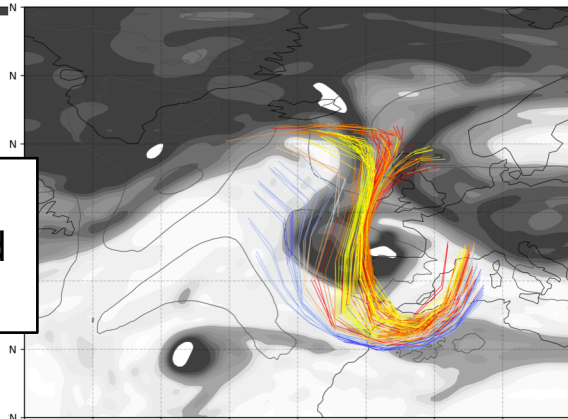


Exp4: bad
PV &
moisture
repl. by
good ones
at 12/00Z

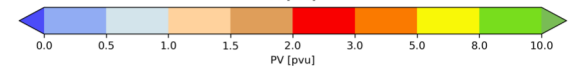
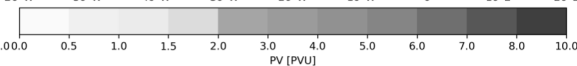
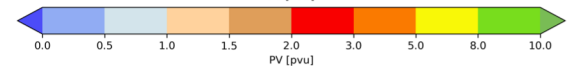
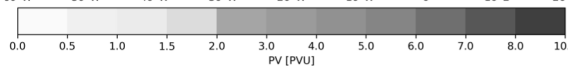
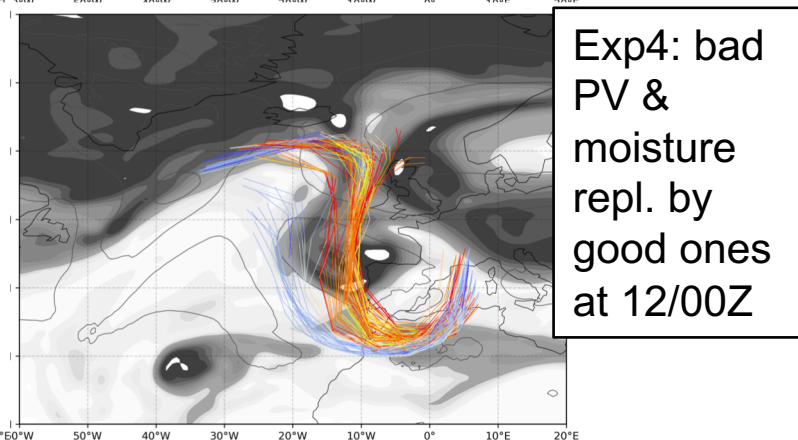
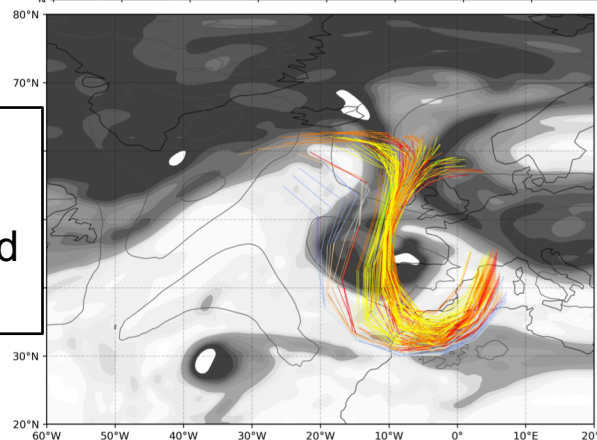




**Exp1: good PV
replaced by bad
one at 12/00Z**



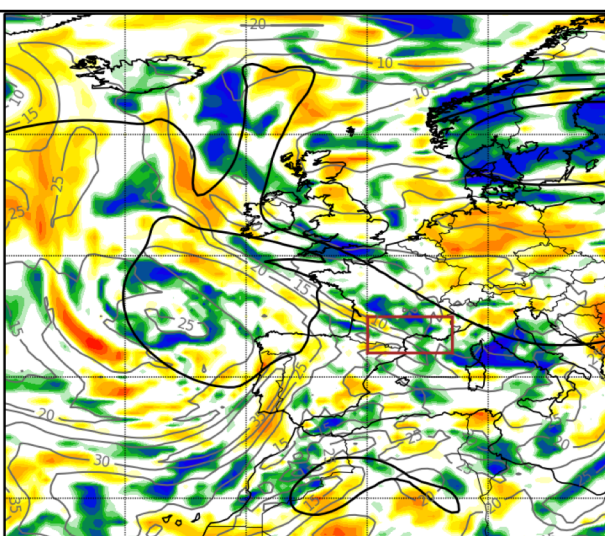
**Exp3: good PV
& moisture
replaced by bad
ones at 12/00Z**



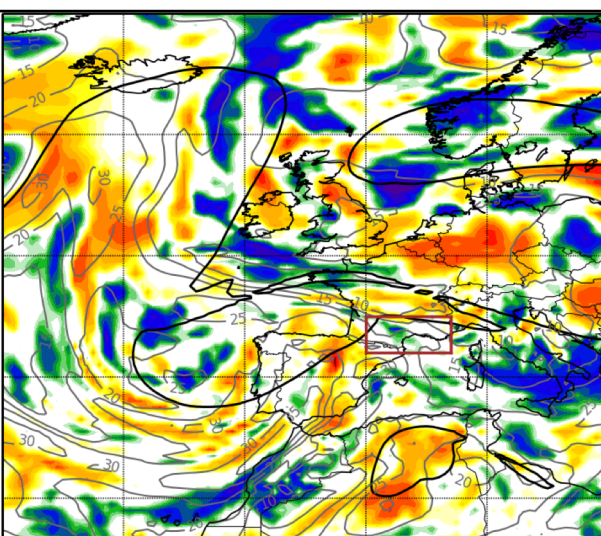
Ensemble sensitivity analysis, IWW

$$\frac{\delta ACC}{\partial IWW} * std(IWW)$$

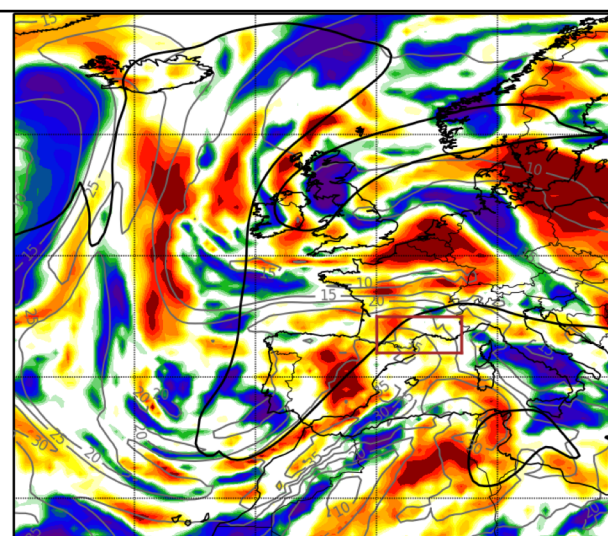
IC12/00, BT10/00-11/18, 160ens



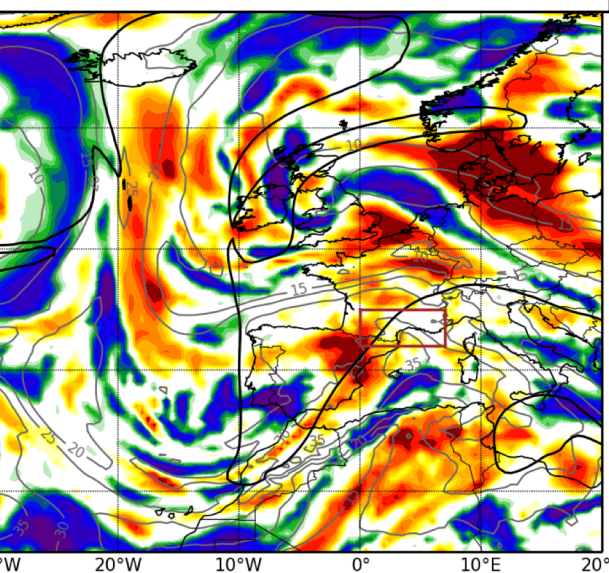
IC12/12, BT10/00-12/06, 200ens



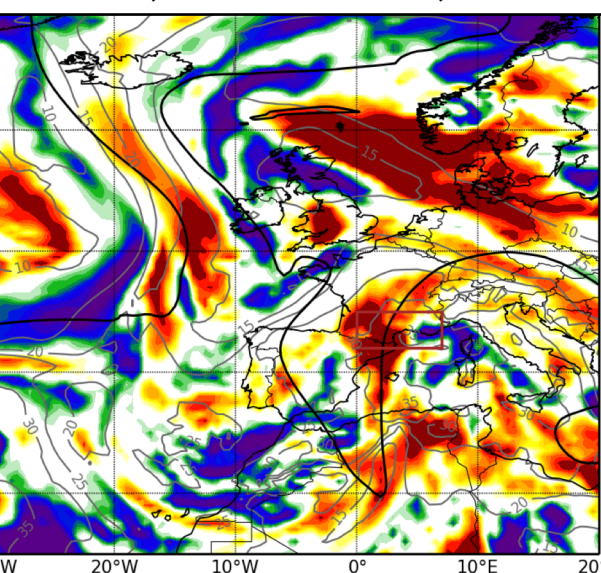
IC13/00, BT10/00-12/18, 240ens



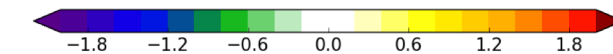
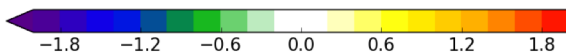
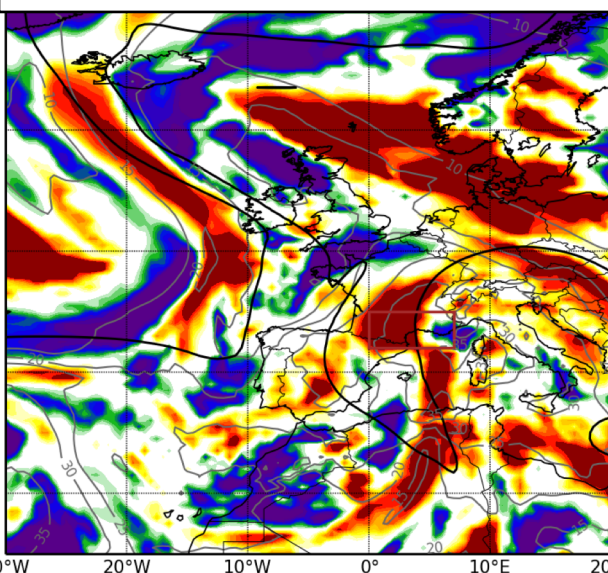
IC13/06, BT10/00-13/00, 260ens



IC13/18, BT10/00-13/12, 300ens



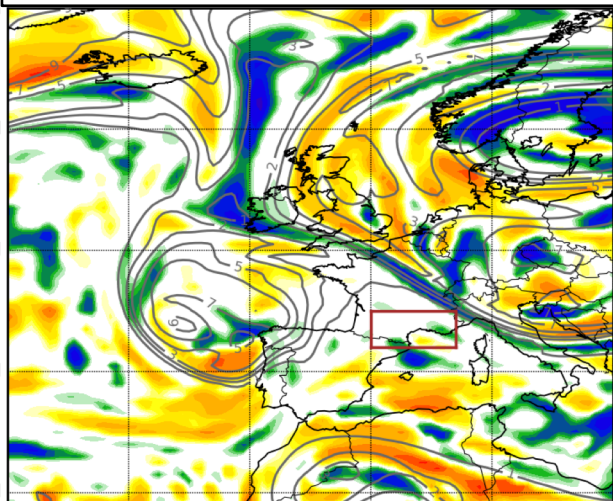
IC14/00, BT10/00-13/18, 320ens



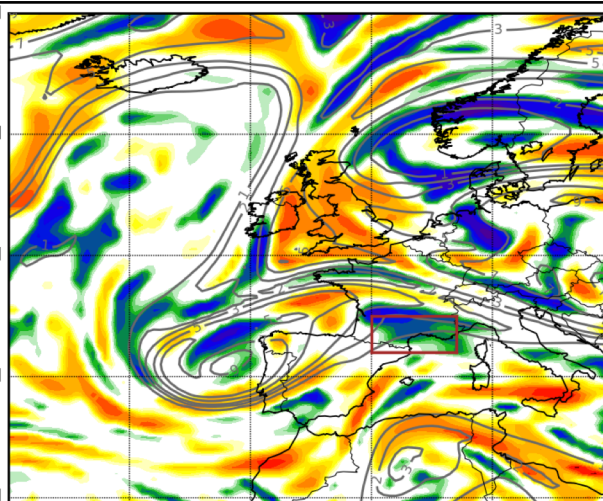
Ensemble sensitivity analysis, PV@330K

$$\frac{\delta ACC}{\partial PV_{330K}} * std(PV_{330K})$$

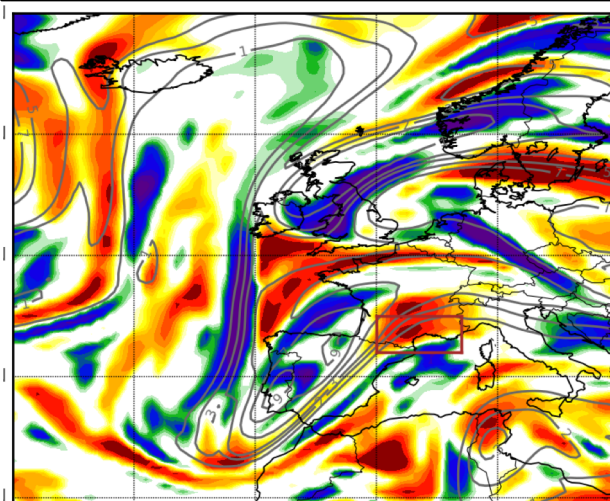
IC12/00, BT10/00-11/18, 160ens



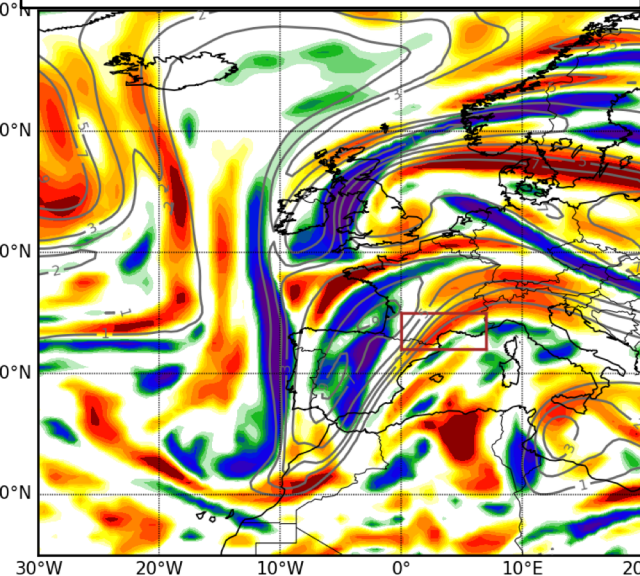
IC12/12, BT10/00-12/06, 200ens



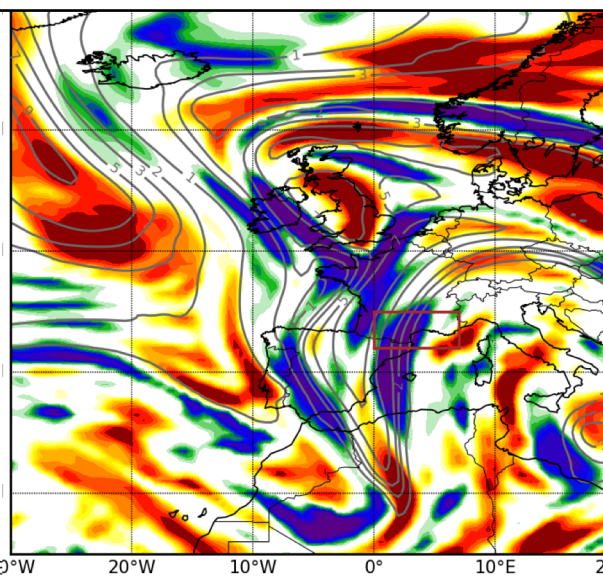
IC13/00, BT10/00-12/18, 240ens



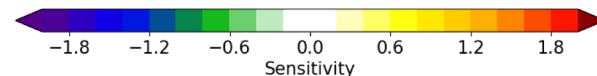
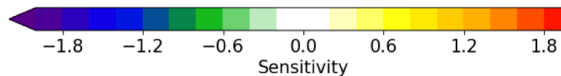
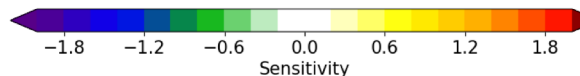
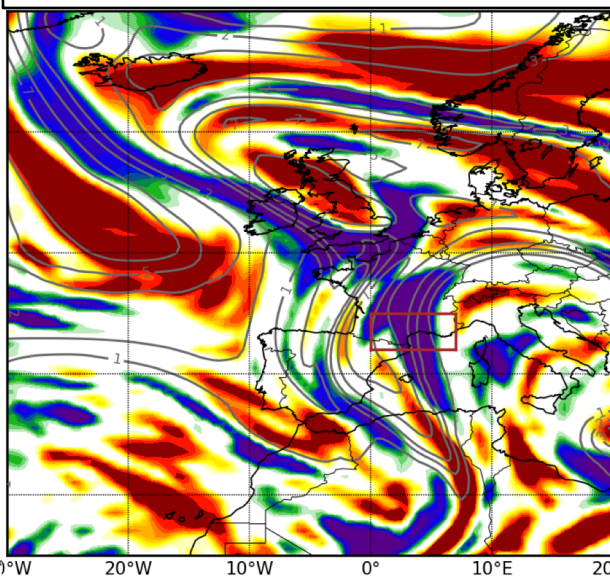
IC13/06, BT10/00-13/00, 260ens



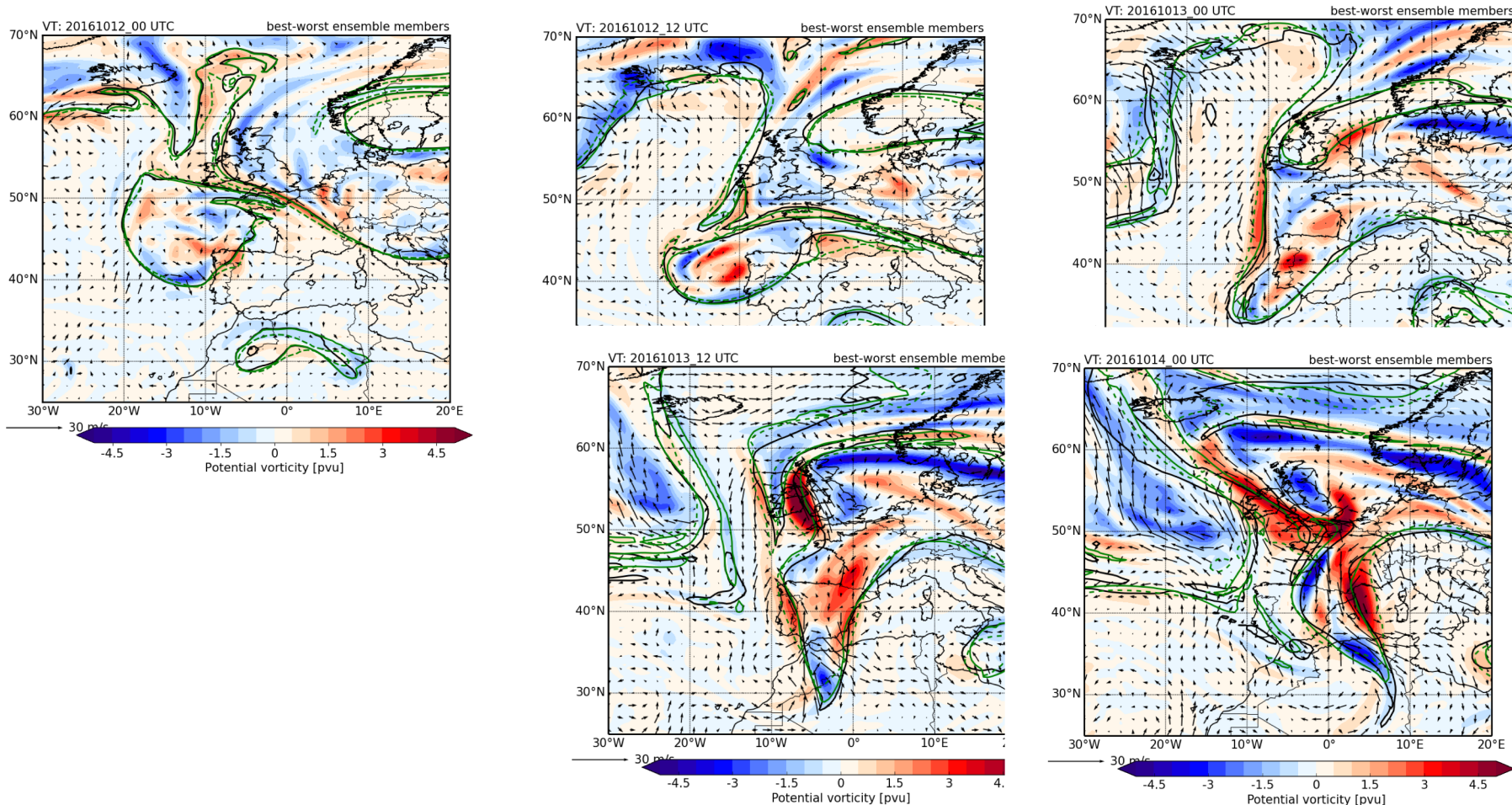
IC13/18, BT10/00-13/12, 300ens



IC14/00, BT10/00-13/18, 320ens



Difference in PV at 330K between 15 best vs. worst precipitation forecasts



Shading: PV error at 320K: forecast – analysis

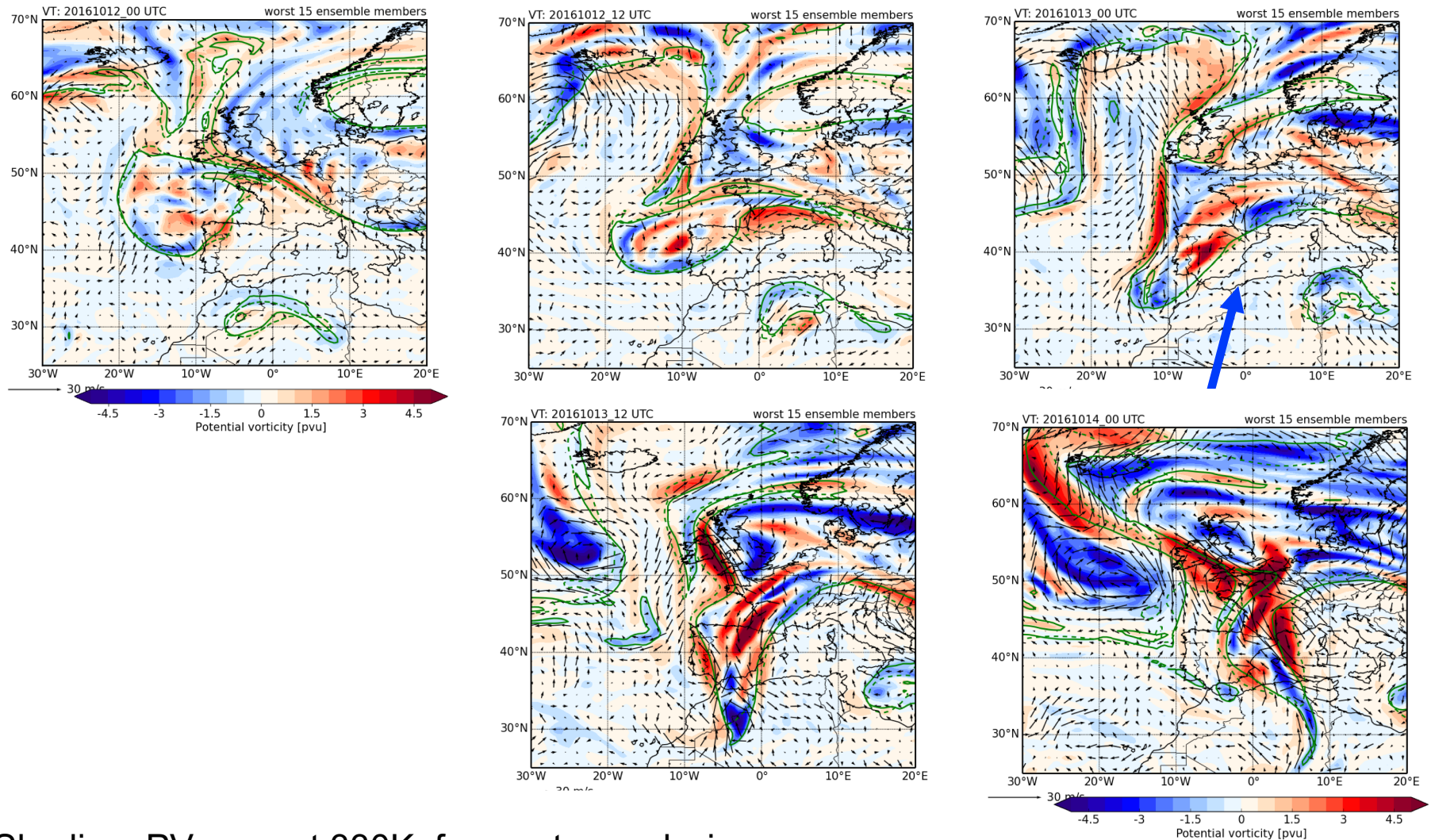
Red: Overestimation of forecasted UL PV

Blue: Underestimation of forecasted UL PV

— 2pvu at 320K in the analysis

... 2pvu at 320K in the forecast

Evolution of the upper-level PV error in the 15 worst members



Shading: PV error at 330K: forecast – analysis

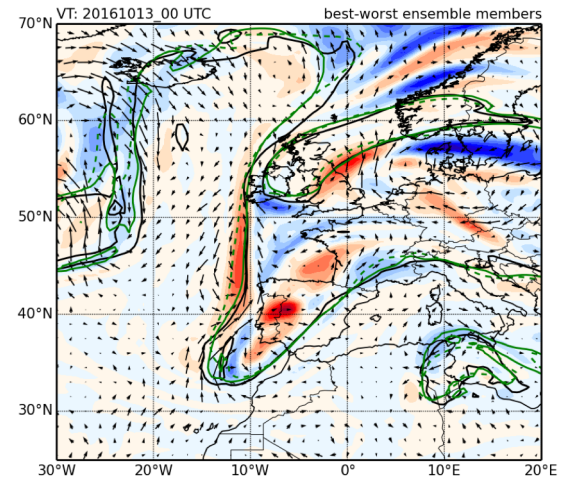
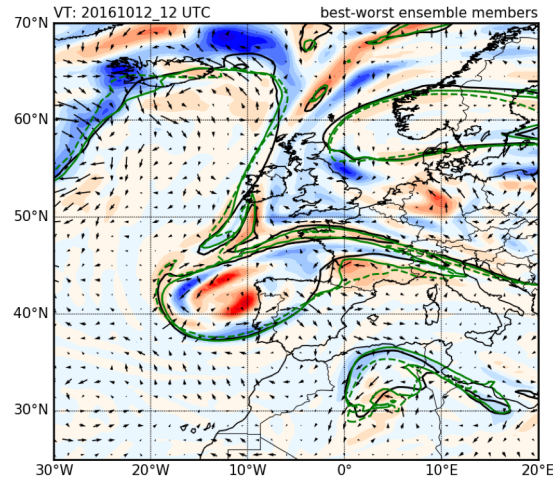
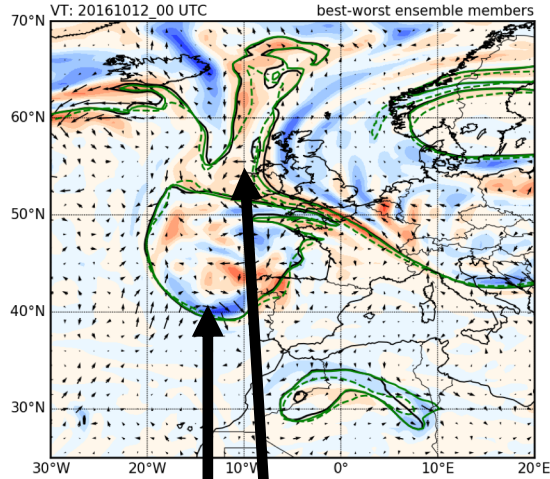
Red: Overestimation of forecasted UL PV

Blue: Underestimation of forecasted UL PV

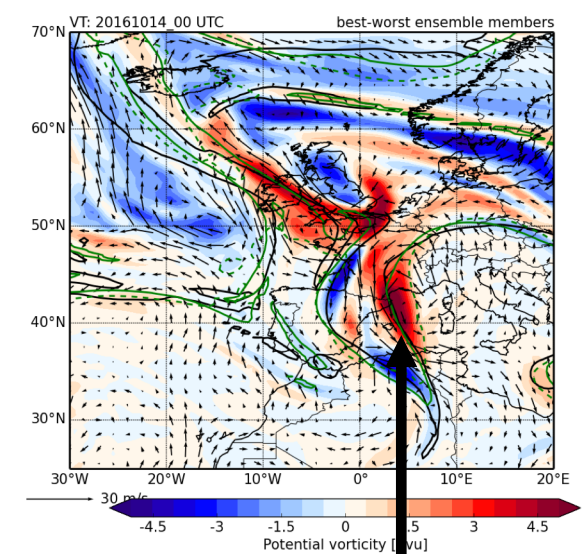
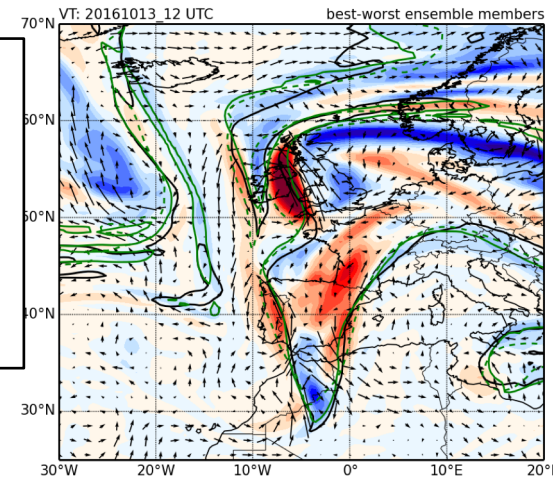
— 2pvu at 320K in the analysis

... 2pvu at 320K in the forecast

Difference in PV at 330K between 15 worst and best precipitation forecasts



Differences in the representation of cut-off Sanchez and the upstream ridge



Shading: PV at 330K of 15 worst – best forecasts

Red: Higher UL PV in bad compared to good fc

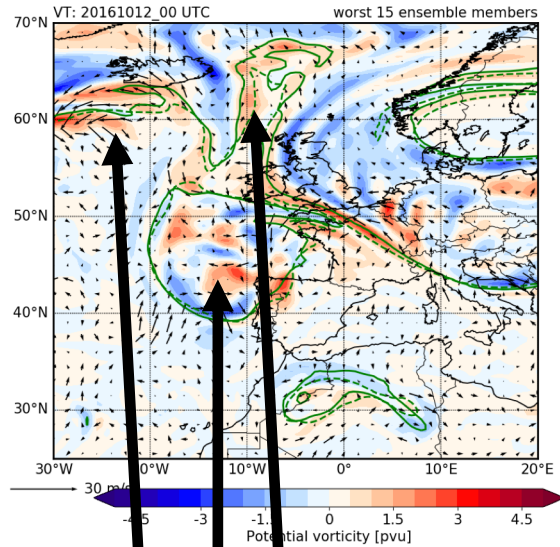
Blue: Lower UL PV in bad compared to good fc

— 2pvu at 320K in the analysis

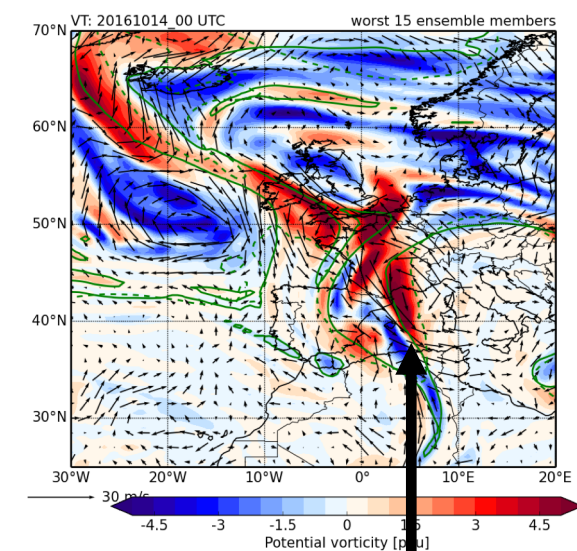
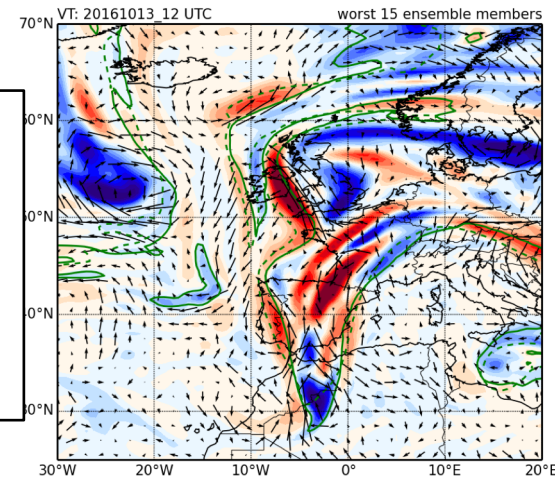
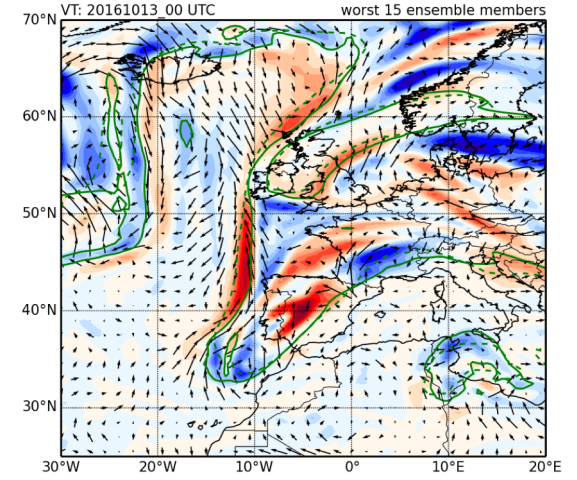
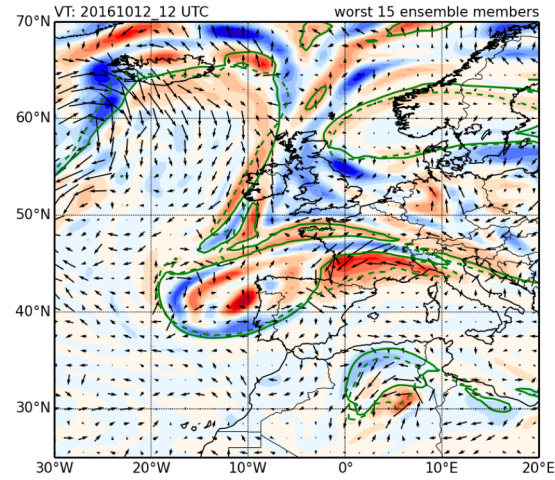
... 2pvu at 320K in the forecast

Eastward shift of PV streamer in bad fcs

Evolution of the upper-level PV error in the 15 worst members



Errors in the representation of cut-off Sanchez and the upstream ridge



Eastward shift of PV streamer in bad fcs

Shading: PV error at 330K: forecast – analysis

Red: Overestimation of forecasted UL PV

Blue: Underestimation of forecasted UL PV

— 2pvu at 320K in the analysis

... 2pvu at 320K in the forecast