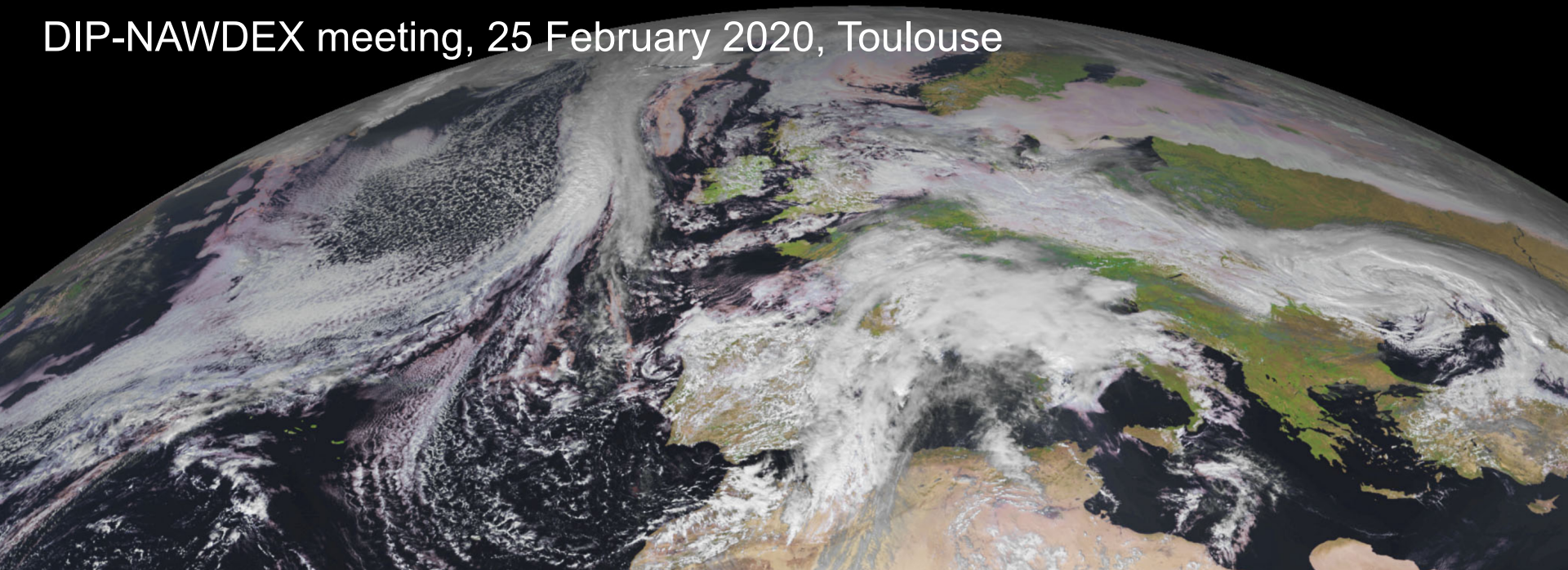


Understanding the dynamics of cut-off Sanchez and its downstream impact over southern France using probabilistic and deterministic Météo-France forecasts

Hanin Binder¹, Gwendal Rivière², Philippe Arbogast³, Bruno Joly³,
Carole Labadie³ and Karine Maynard³

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

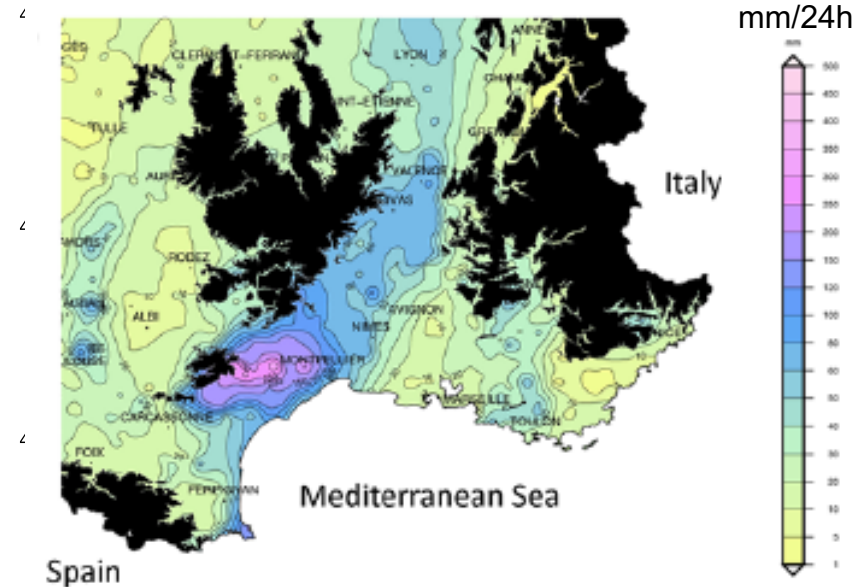
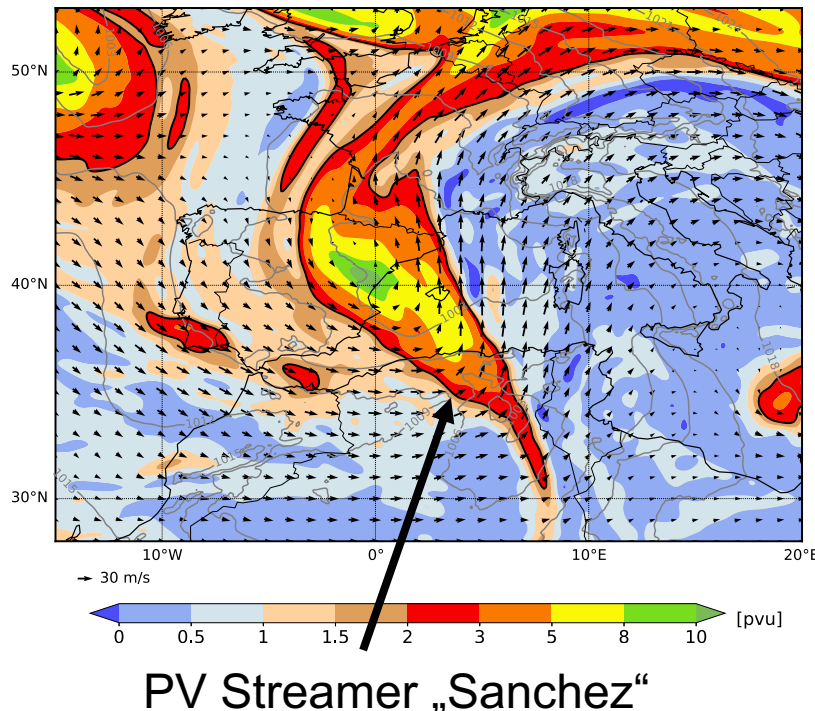
DIP-NAWDEX meeting, 25 February 2020, Toulouse



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

Objectives:

- Evaluate the **representation** of the HIW event and PV streamer Sanchez in probabilistic and deterministic **Météo-France forecasts**.
- Quantify the **sensitivity** of the forecasts to the representation of the **upstream upper-level flow** and the **low-level moisture** at earlier times.



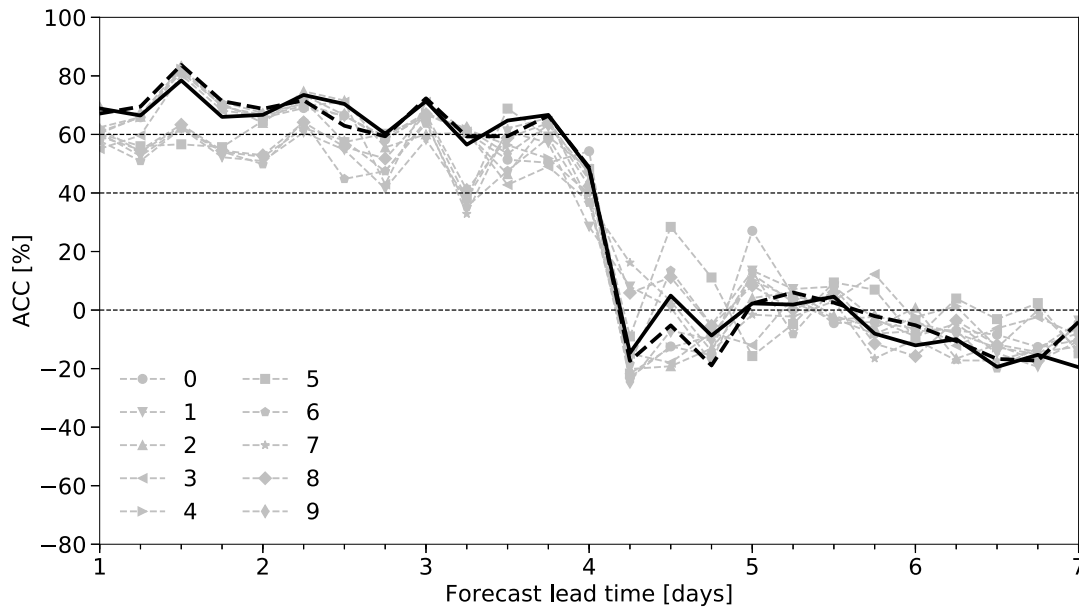
~250 mm daily accumulated precipitation over S France

Data

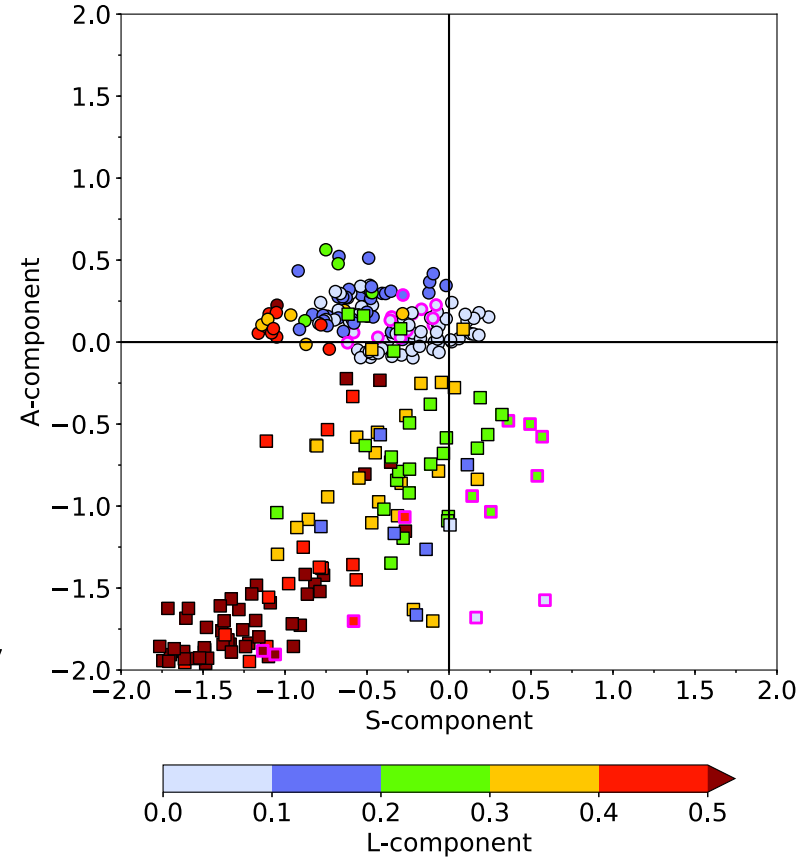
1. **Ensemble reforecasts** of the Météo-France global operational model Arpege, version PEARP4 (Descamps et al. 2015, Boisserie et al. 2016a,b)
 - 10 ensemble members
 - Same initial conditions (Arpege op. analyses)
 - 10 different physical parameterization sets to represent model uncertainties associated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

Forecast quality of precipitation at 00 UTC 14 October

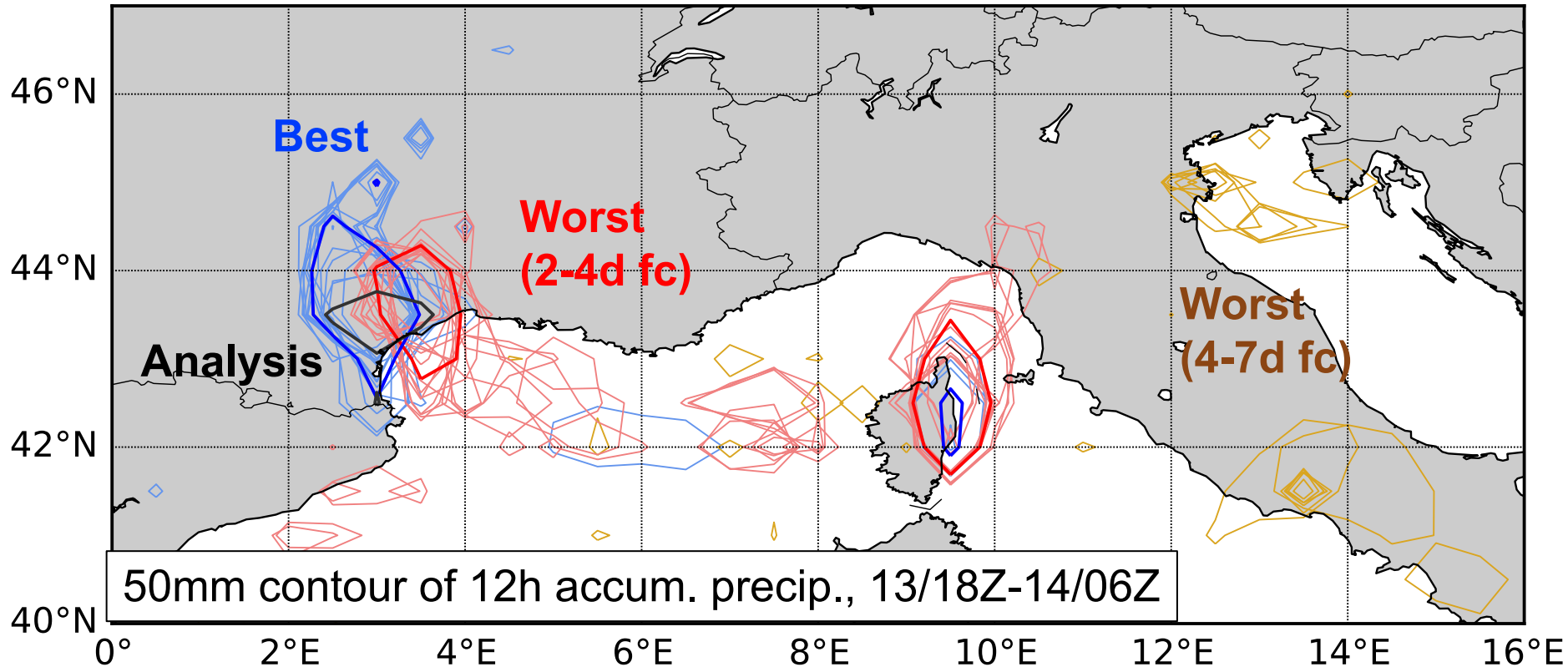
ACC of precipitation



SAL of precipitation



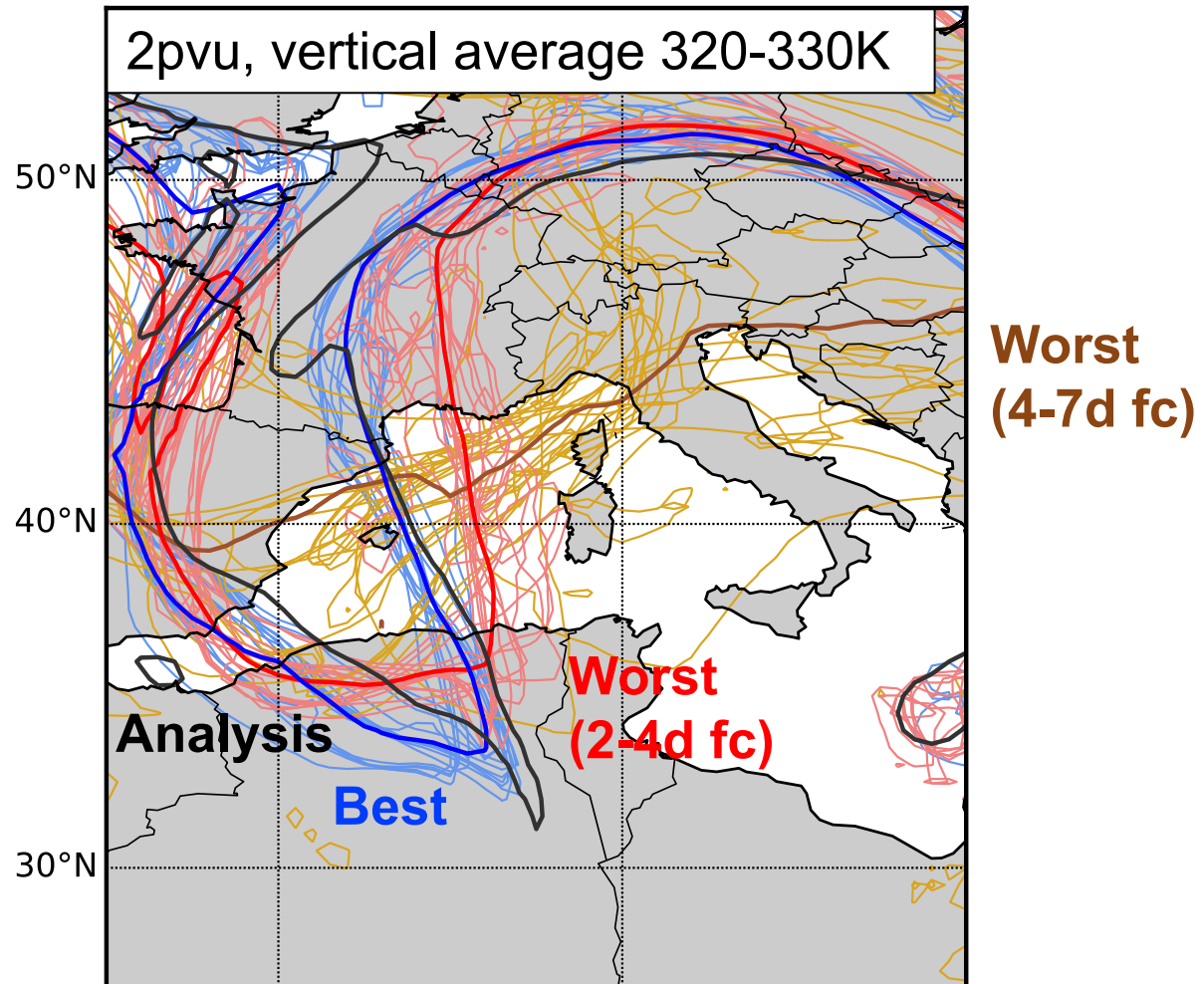
Best vs. worst 15 precipitation forecasts



Worst 15:

- **Eastward shift** of precipitation max.

Best vs. worst 15 precipitation forecasts

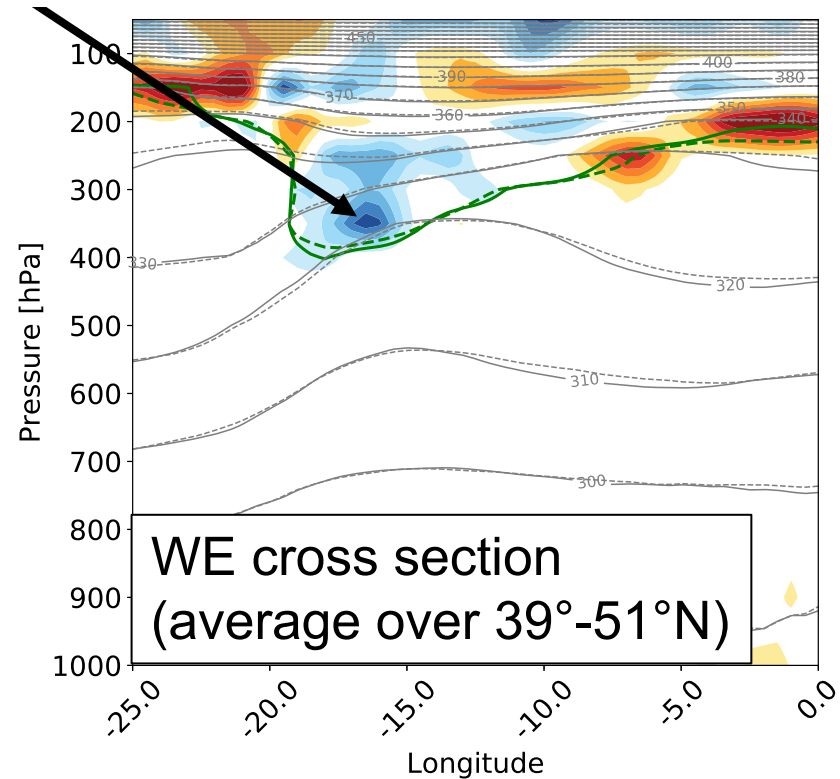
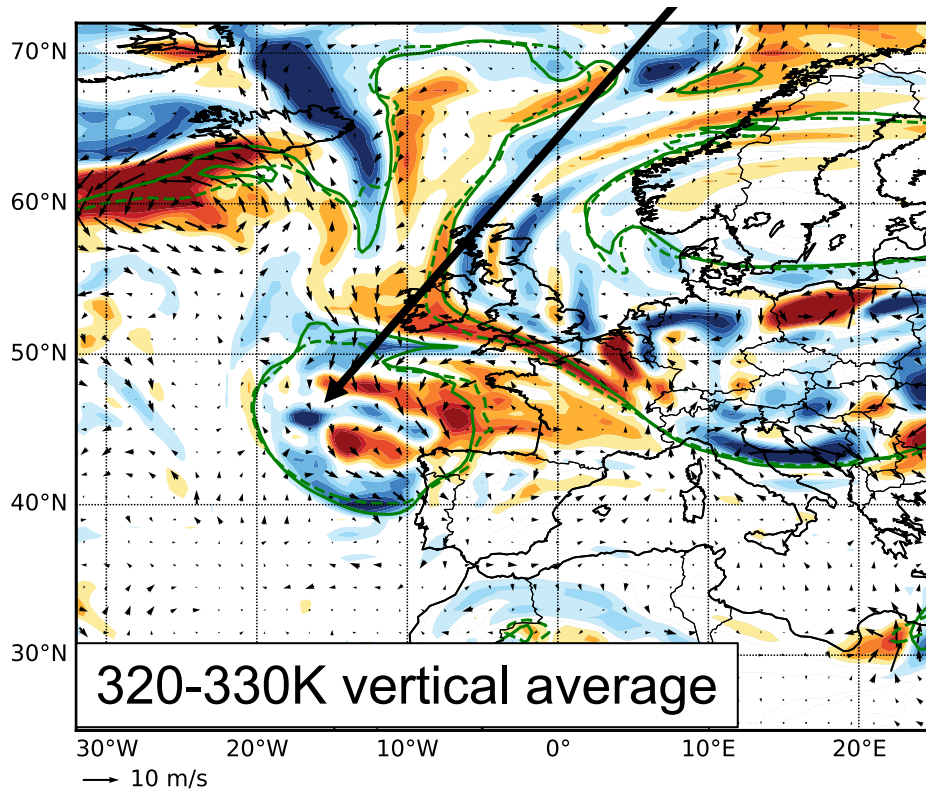


Worst 15:

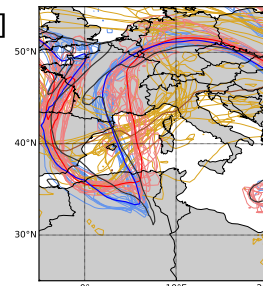
- **Eastward shift** of precipitation max.
- Eastward shift of 2pvu at upper levels

PV difference worst-best members at 00 UTC 12 Oct (only “medium-bad” fc with BT 10/00-12/00Z considered)

Underestimation of PV within Sanchez
in bad forecasts 2 days before HIW



→ Is this underestimation of PV important for the ULPV and precipitation errors over southern France 2 days later?



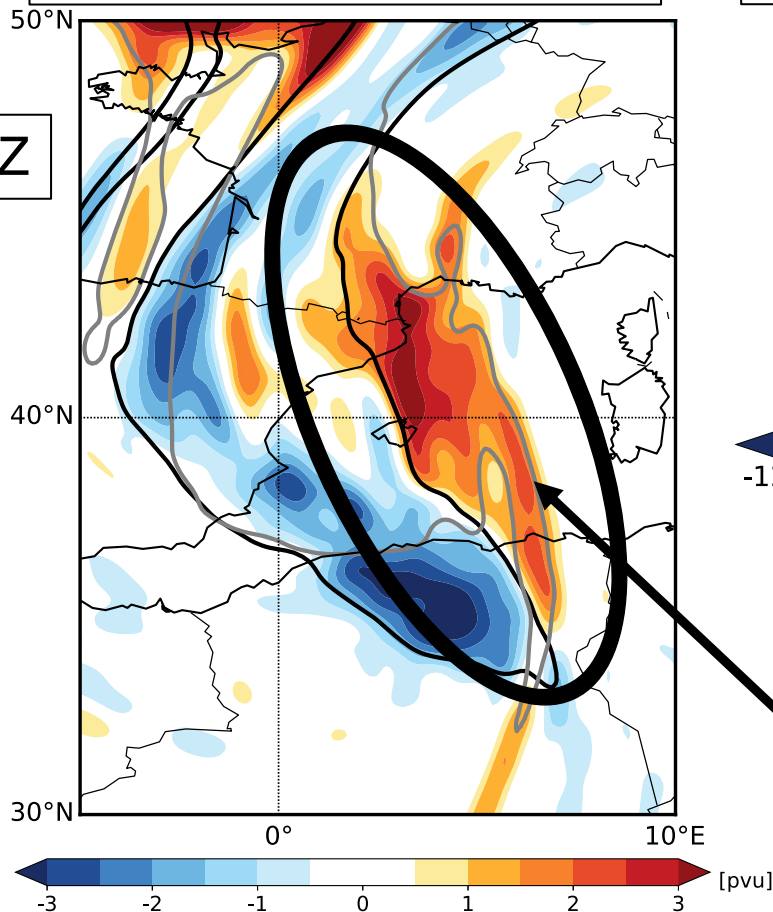
Sensitivity to initial upper-level PV in 2-day forecasts

Two deterministic control forecasts:

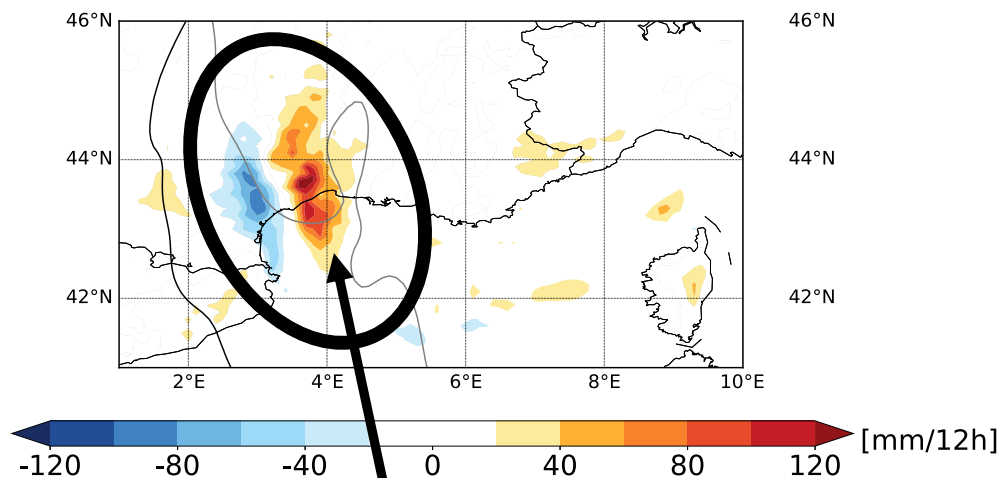
- **Ctrl_{Good}**: A good HIW forecast (BT12/00Z)
- **Ctrl_{Bad}**: A bad HIW forecast (BT10/18Z)

ULPV diff. Ctrl_{Bad}-Ctrl_{Good}

14/00Z

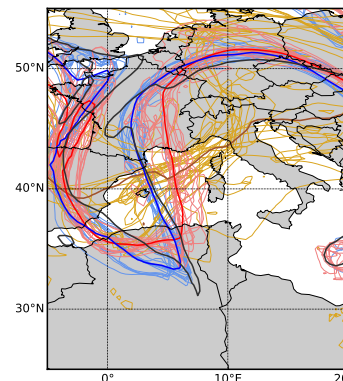


Precipitation diff. Ctrl_{Bad}-Ctrl_{Good}



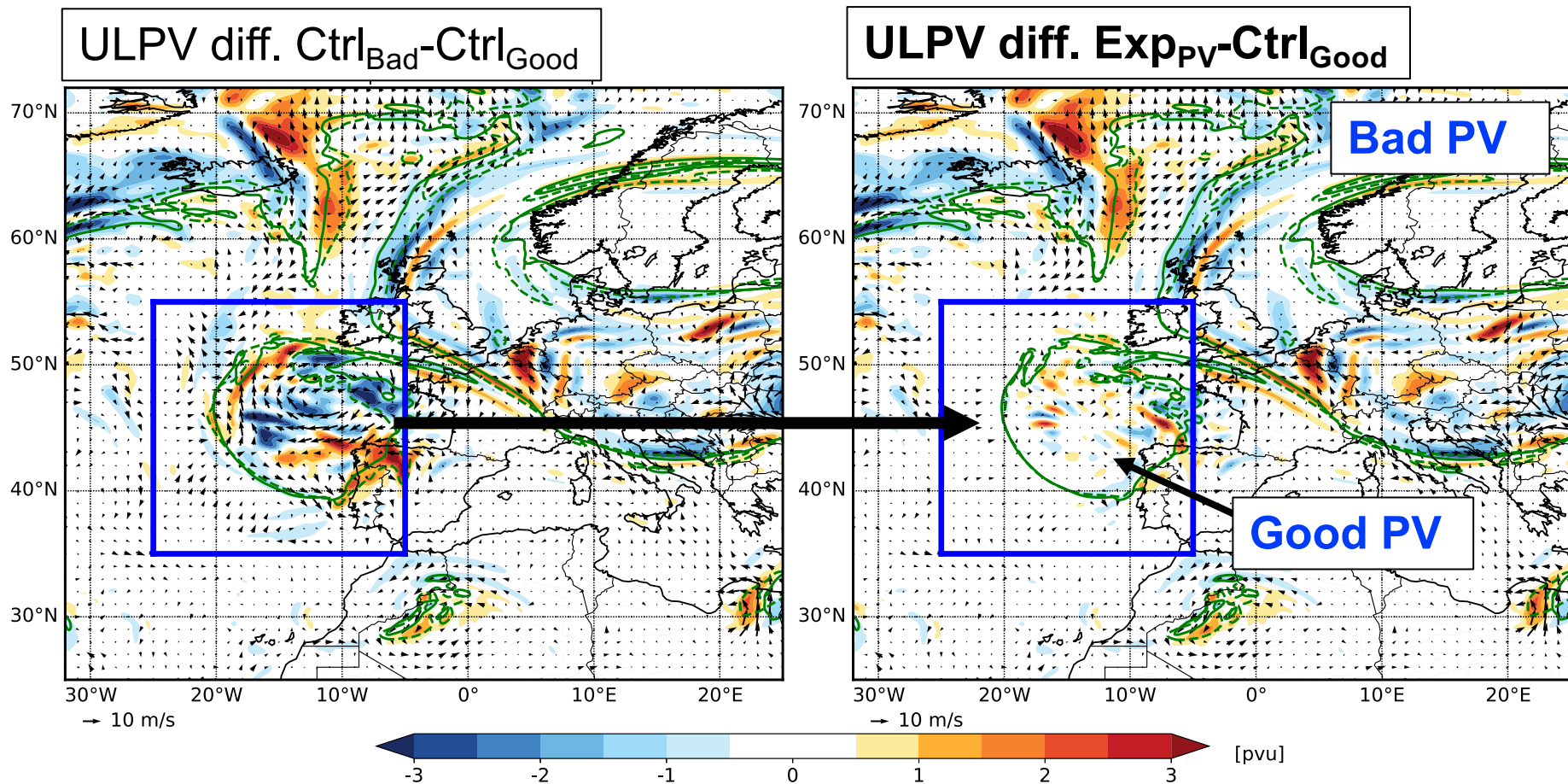
Eastward shift of
precipitation in Ctrl_{Bad}

Eastward shift of PV
streamer in Ctrl_{Bad}



Sensitivity to initial ULPV within cut-off in 2-day forecasts

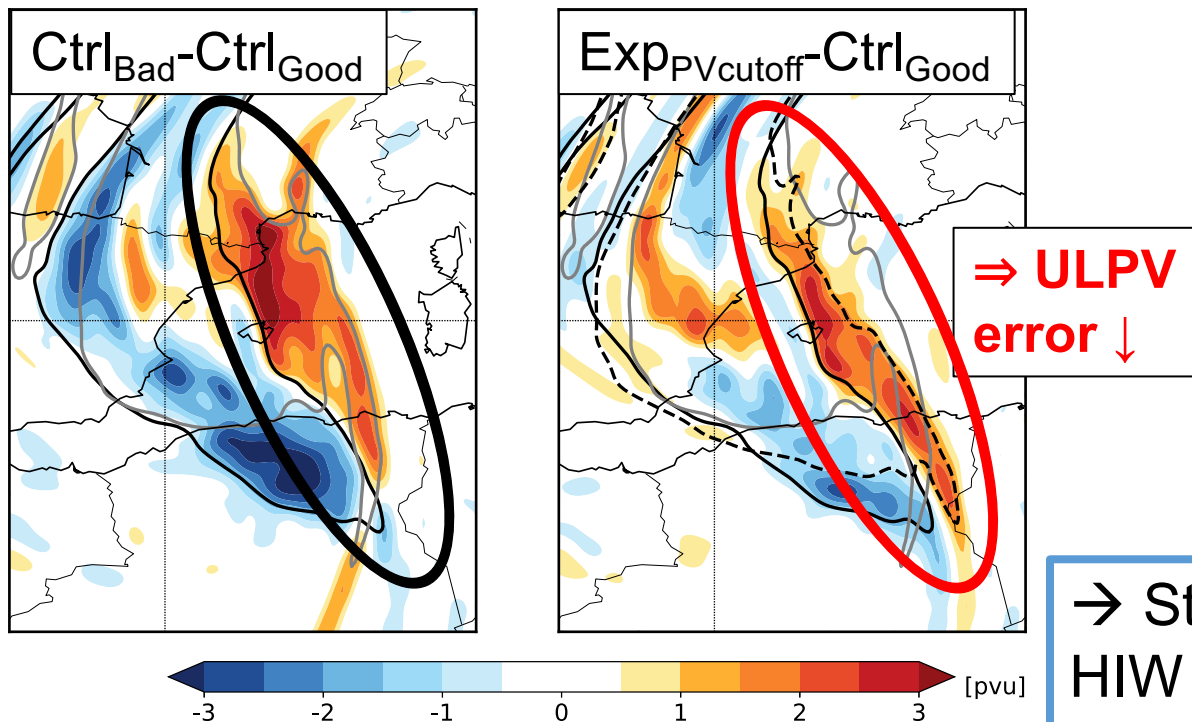
Exp_{PV}: At 12/00Z, the **bad ULPV** is **replaced by the good** one in the region of **cut-off** Sanchez



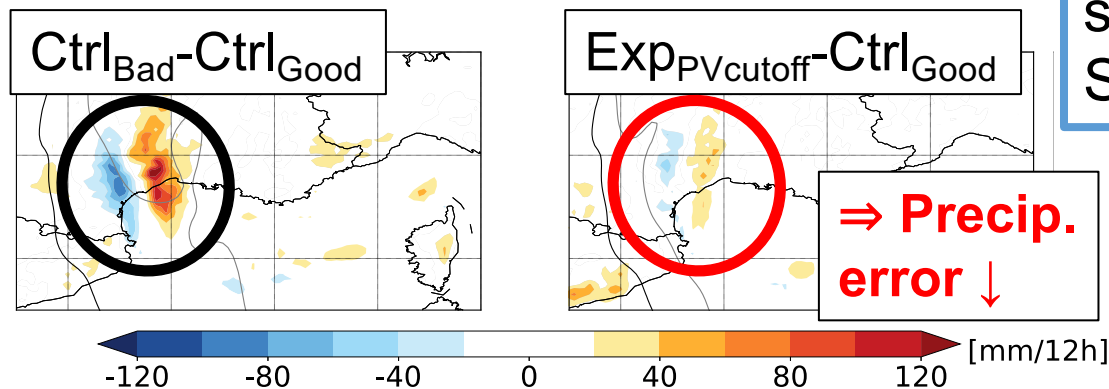
→ Fc expected to improve if sensitive to errors in target region

Sensitivity to initial ULPV within cut-off in 2-day forecasts

ULPV error with respect to good fc



Precipitation error wrt good fc



→ Strong error decrease:
HIW forecasts are highly
sensitive to initial **ULPV**
structure within **cut-off**
Sanchez

PV error evolution

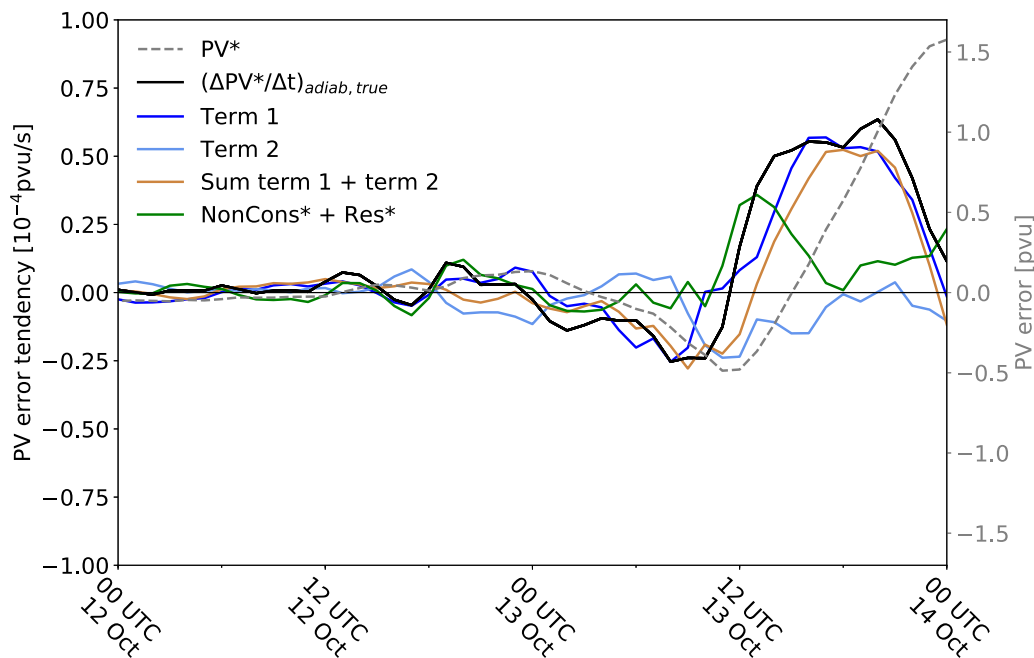
Davies and Didone 2013, Baumgart et al. 2018

$$\frac{D}{Dt} PV^* = \underbrace{-\vec{v}^* \vec{\nabla} PV_{\text{true}}}_{\text{Advection of analysis PV by wind error}} - \underbrace{\vec{v}^* \vec{\nabla} PV^*}_{\text{Advection of PV error by wind error}} + \text{Noncons}^* + \text{Res}^*$$

$$PV^* = \text{PV error} = PV_{\text{forecast}} - PV_{\text{true}}$$

Sensitivity to initial ULPV within cut-off in 2-day forecasts

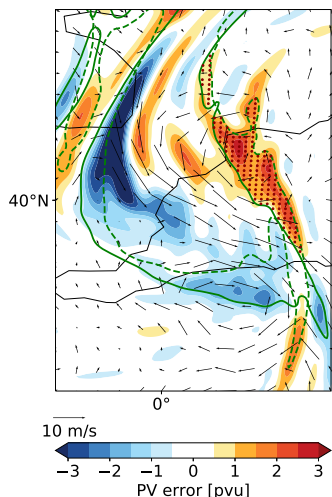
Backward trajectories starting at 00 UTC 14 Oct from pos. PV error



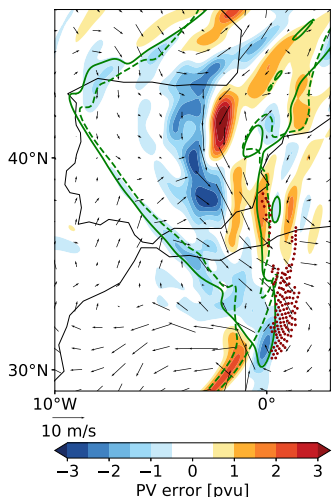
$$\frac{D}{Dt} PV^* = -\vec{v}^* \vec{\nabla} PV_{\text{true}} - \vec{v}^* \vec{\nabla} PV^* + \text{Noncons}^* + \text{Res}^*$$

with $PV^* = \text{PV error}$
 $= \text{PV in Ctrl}_{\text{Bad}} - \text{PV in Exp}_{\text{PVCutoff}}$

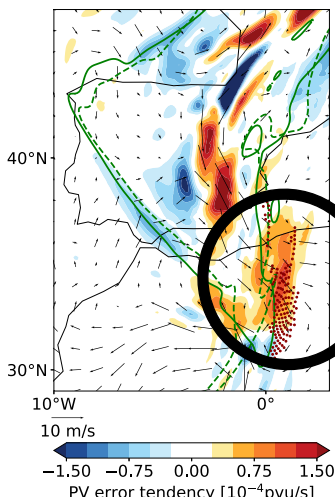
b) PV^* at 00 UTC 14 Oct



c) PV^* at 15 UTC 13 Oct



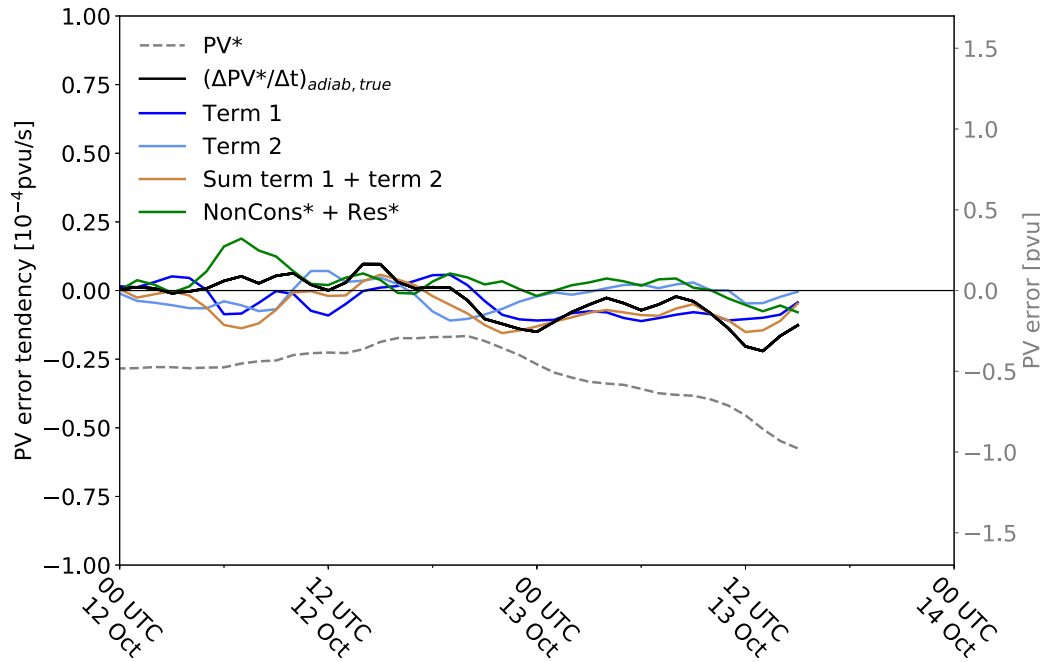
d) Term 1 at 15 UTC 13 Oct



→ Growth of pos. PV error due to $-\vec{v}^* \vec{\nabla} PV_{\text{true}}$

Sensitivity to initial ULPV within cut-off in 2-day forecasts

Backward trajectories starting at 15 UTC 13 Oct from negative PV error

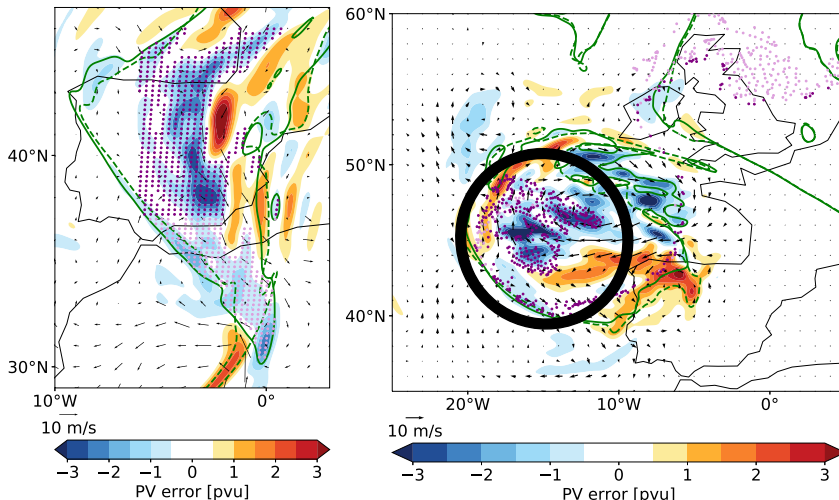


$$\frac{D}{Dt} PV^* = -\vec{v}^* \vec{\nabla} PV_{true} - \vec{v}^* \vec{\nabla} PV^* + \text{Noncons}^* + \text{Res}^*$$

with $PV^* = \text{PV error}$
 $= \text{PV in Ctrl}_{\text{Bad}} - \text{PV in Exp}_{\text{PVCutoff}}$

b) PV^* at 15 UTC 13 Oct

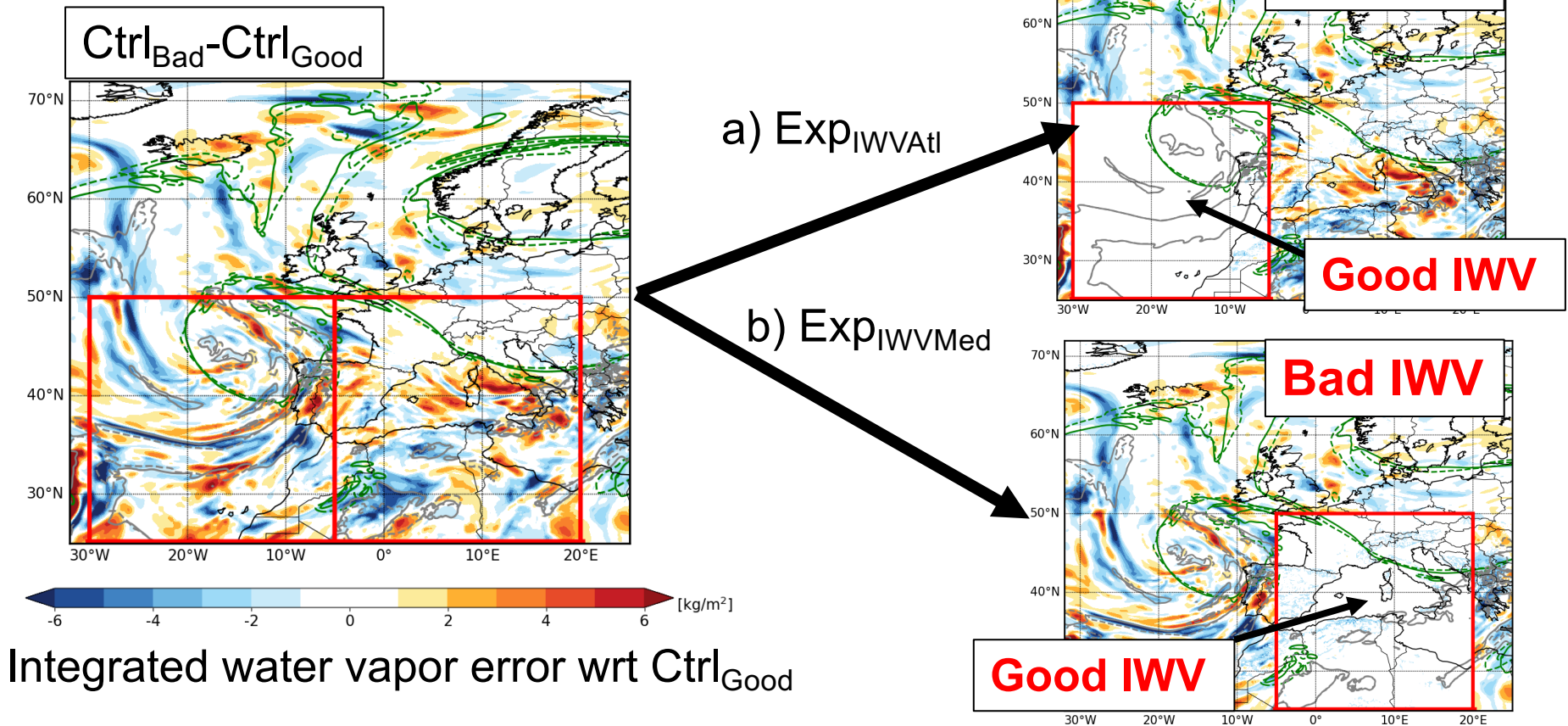
c) PV^* at 00 UTC 12 Oct



→ Initial negative PV errors are advected downstream

Sensitivity to initial North Atlantic / Mediterranean humidity

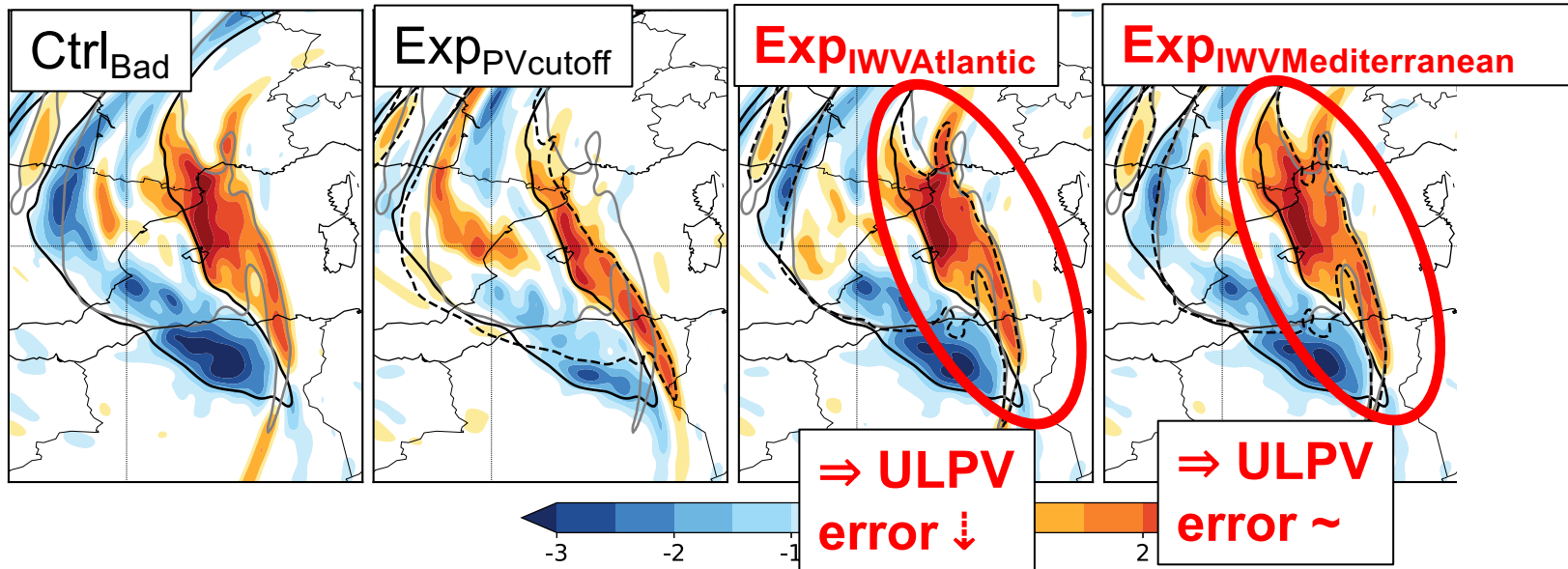
a) **Exp_{IWVAtl}** and b) **Exp_{IWVMed}**: At 12/00Z, the bad low-level **humidity** is replaced by the good one in a) the eastern **NAtlantic** and b) the **Mediterranean**



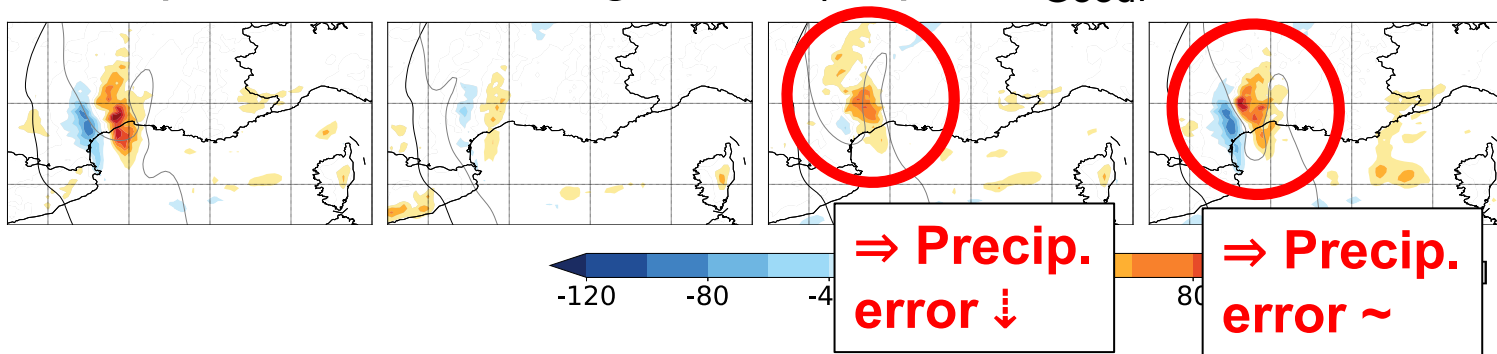
→ Fc expected to improve if sensitive to errors in target region

Sensitivity to initial North Atlantic / Mediterranean humidity

ULPV error with respect to good fc ($\text{Exp} - \text{Ctrl}_{\text{Good}}$)



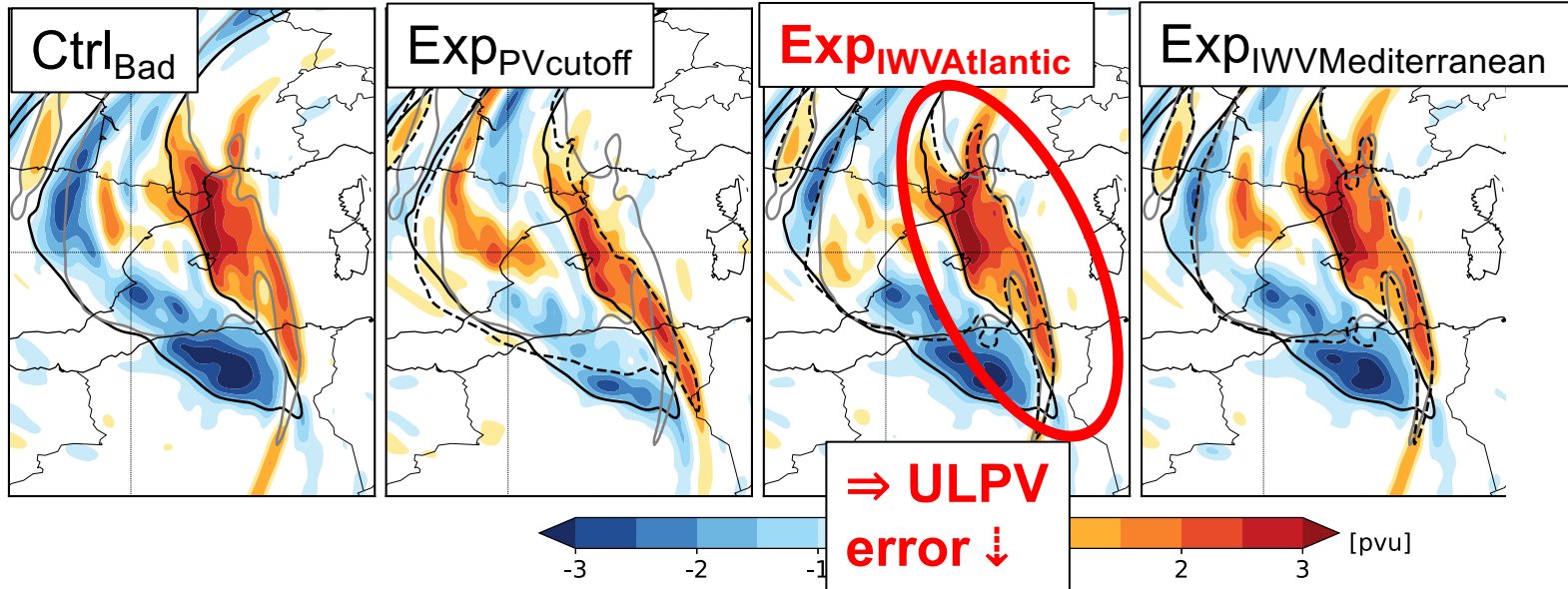
Precipitation error wrt good fc ($\text{Exp} - \text{Ctrl}_{\text{Good}}$)



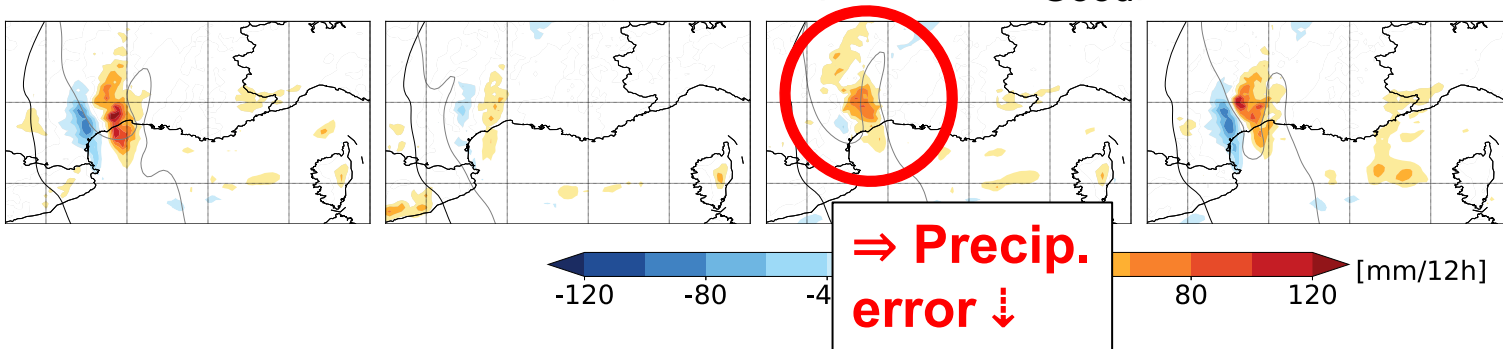
- $\rightarrow$ Some sensitivity to initial North Atlantic moisture structure
- $\rightarrow$ Almost no sensitivity to the Mediterranean moisture structure

Sensitivity to initial North Atlantic / Mediterranean humidity

ULPV error with respect to good fc ($\text{Exp} - \text{Ctrl}_{\text{Good}}$)



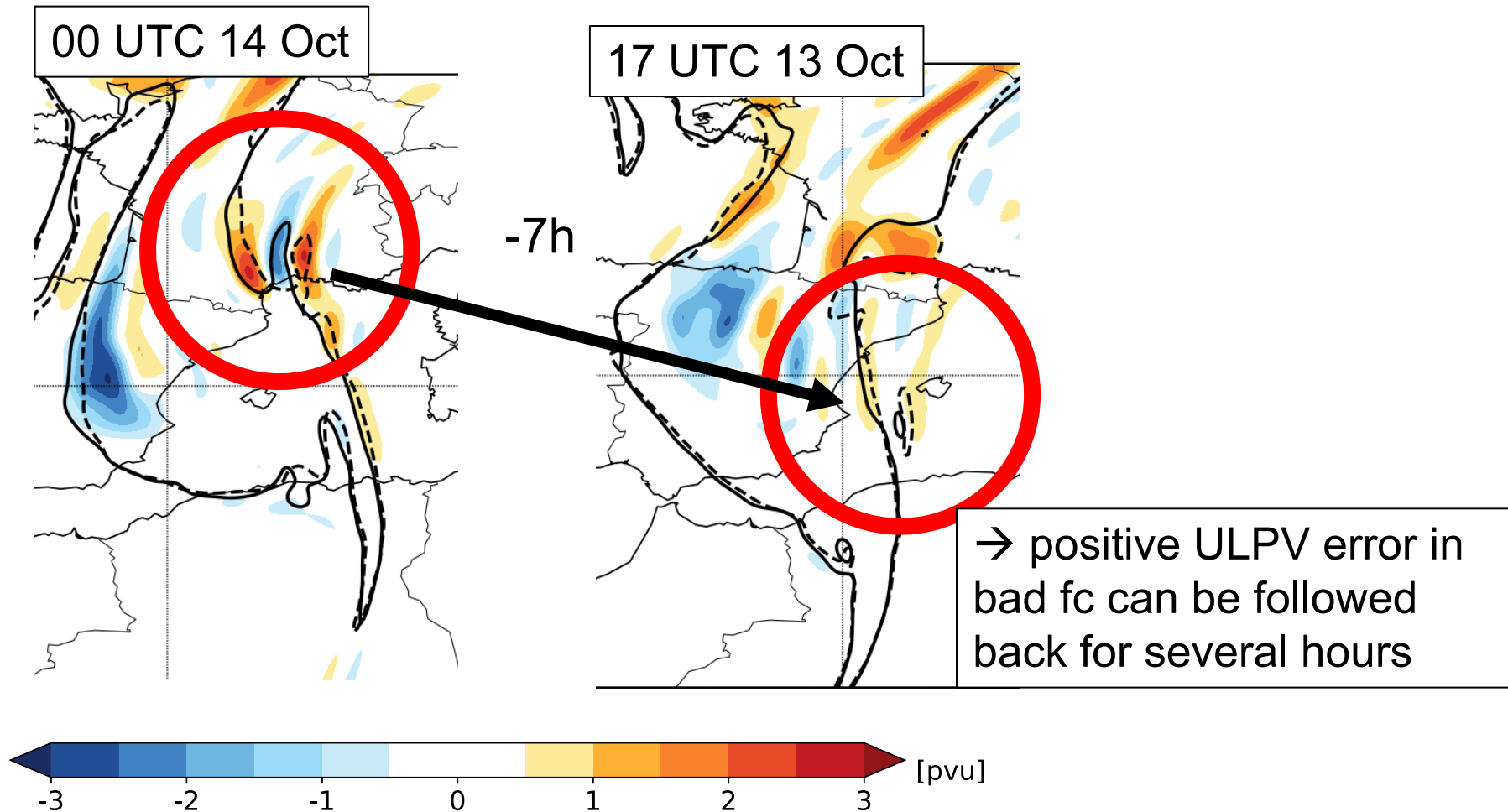
Precipitation error wrt good fc ($\text{Exp} - \text{Ctrl}_{\text{Good}}$)



- $\rightarrow$ Some **sensitivity** to initial **North Atlantic moisture structure**
- $\rightarrow$ Almost **no sensitivity** to the **Mediterranean moisture structure**

Sensitivity of ULPV to initial North Atlantic moisture structure

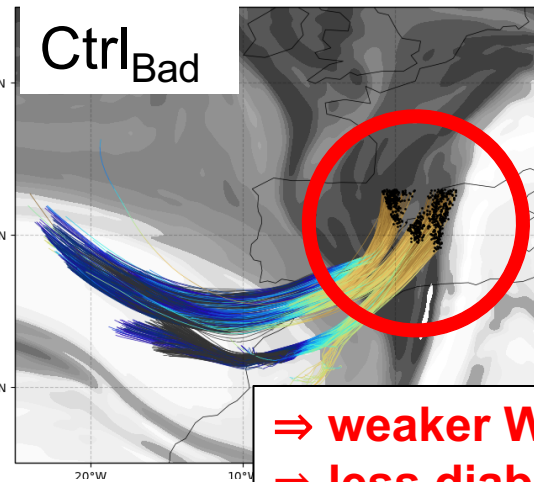
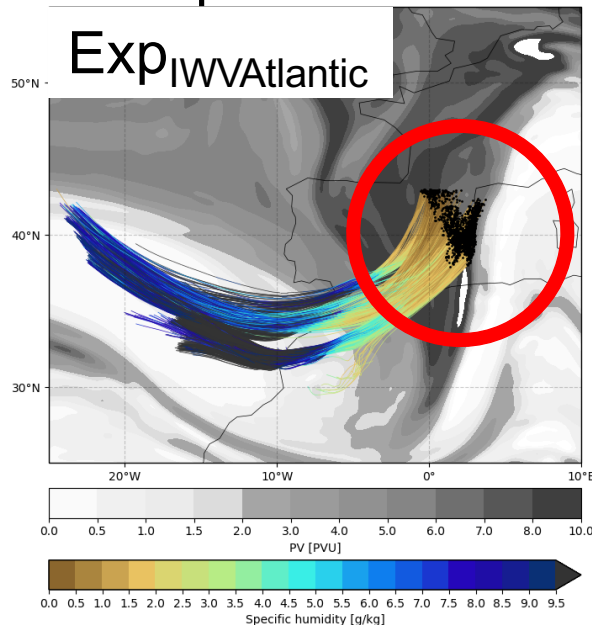
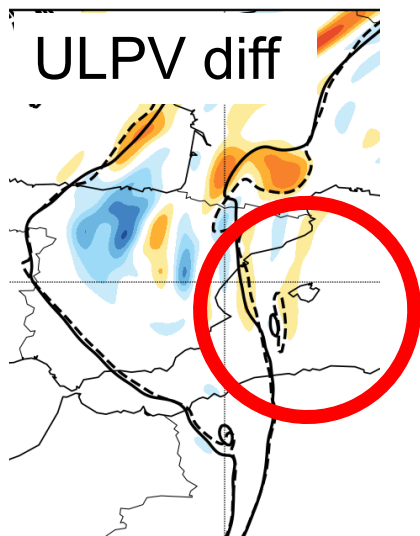
ULPV difference $\text{Ctrl}_{\text{Bad}} - \text{Exp}_{\text{IWWAtlantic}}$



Sensitivity of ULPV to initial North Atlantic moisture structure

17 UTC 13 Oct

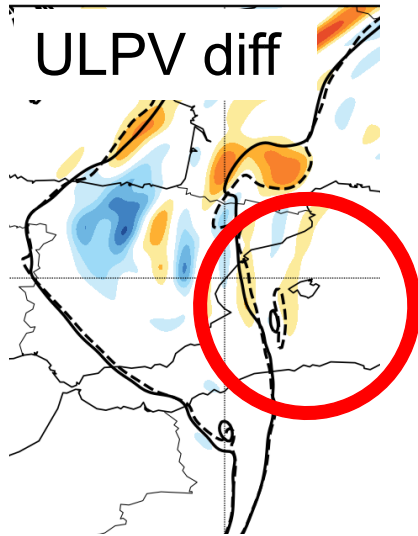
WCB traj. arriving at the tropopause in the region of the positive ULPV error



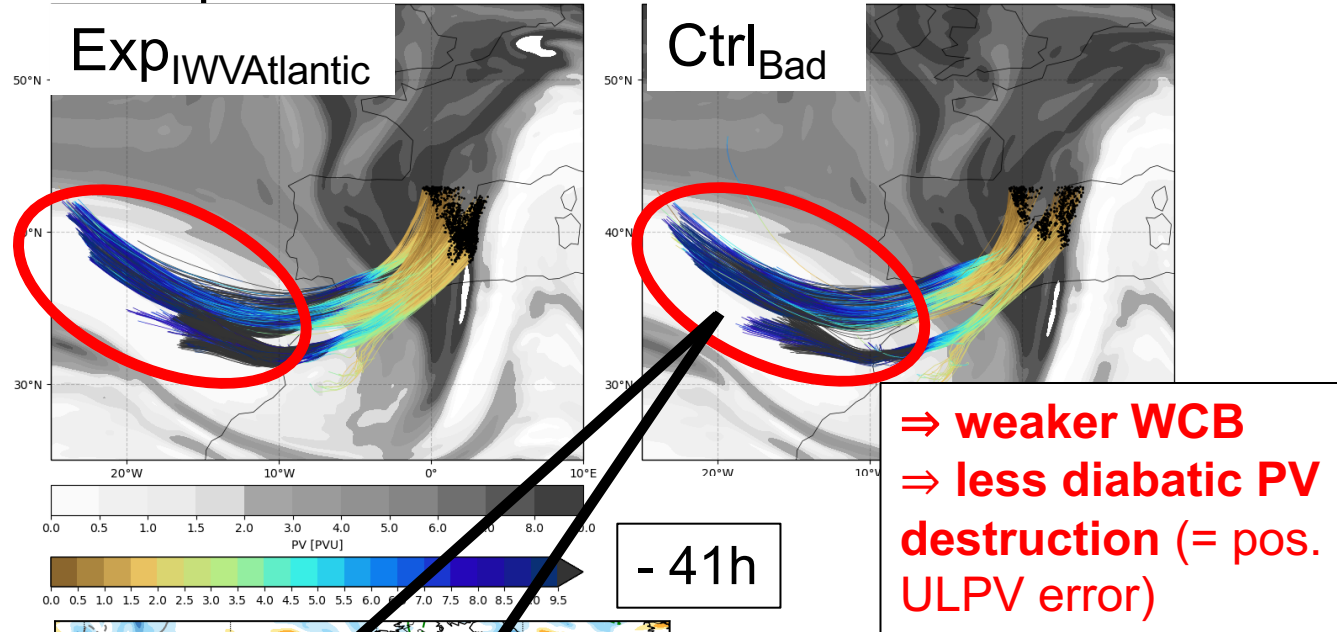
⇒ weaker WCB
⇒ less diabatic PV destruction (= pos. ULPV error)

Sensitivity of ULPV to initial North Atlantic moisture structure

17 UTC 13 Oct



WCB traj. arriving at the tropopause in the region of the positive ULPV error

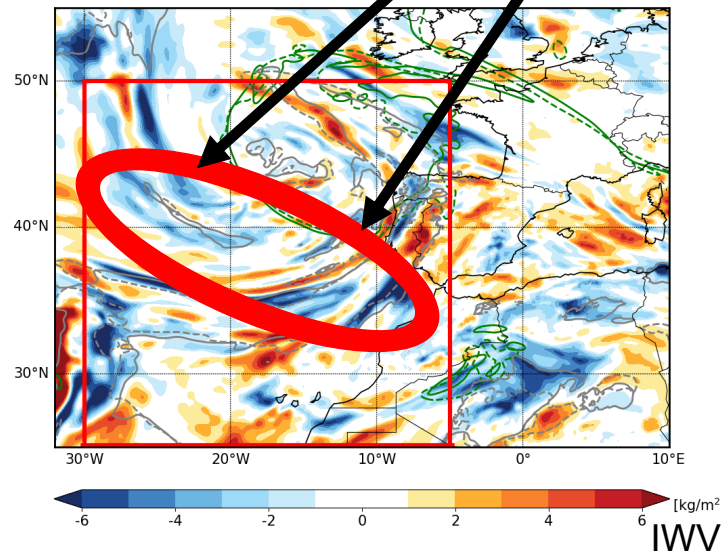


⇒ weaker WCB
⇒ less diabatic PV destruction (= pos. ULPV error)

Underestimation of WCB strength in Ctrl_{Bad} due to **underestimation of moisture in WCB inflow region**

12 Oct 00 UTC

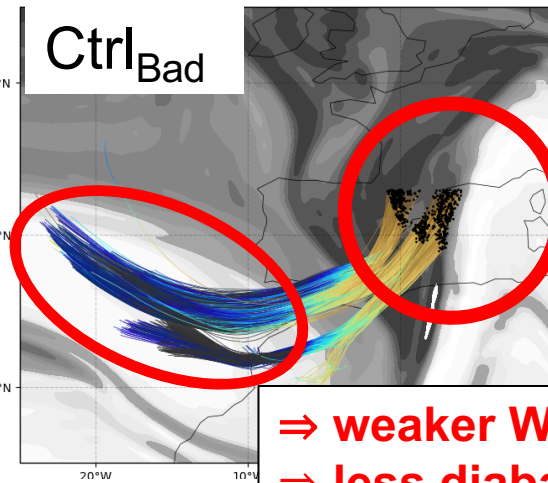
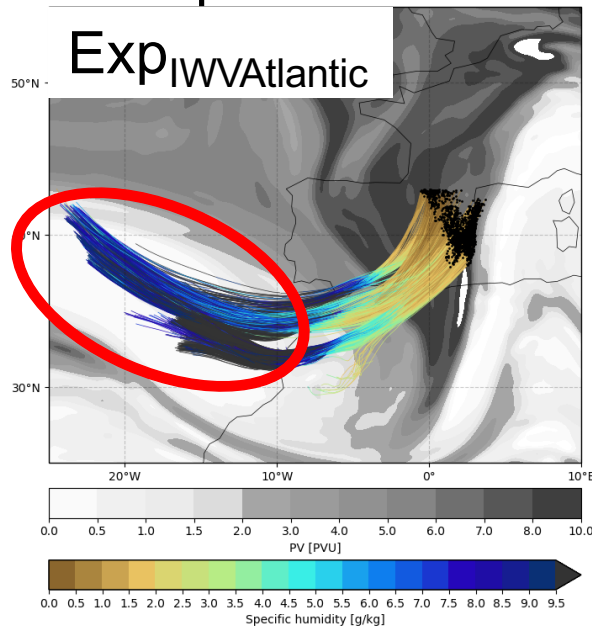
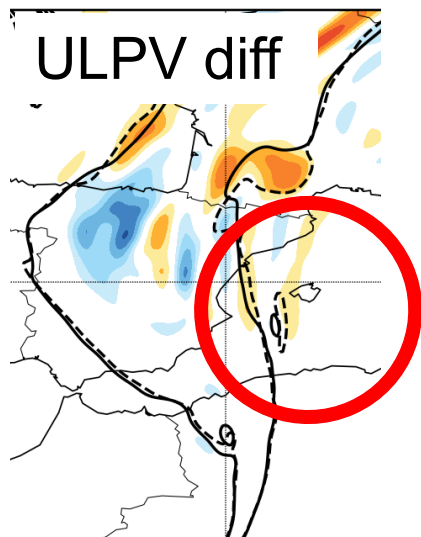
WCB inflow region



Sensitivity of ULPV to initial North Atlantic moisture structure

17 UTC 13 Oct

WCB traj. arriving at the tropopause in the region of the positive ULPV error

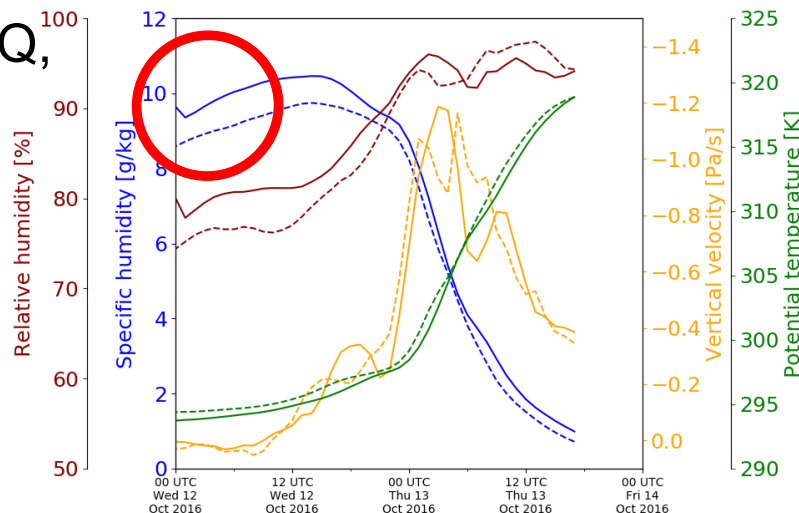


- 41h

⇒ weaker WCB
⇒ less diabatic PV destruction (= pos. ULPV error)

Evolution of RH, Q, w and TH along WCB traj.

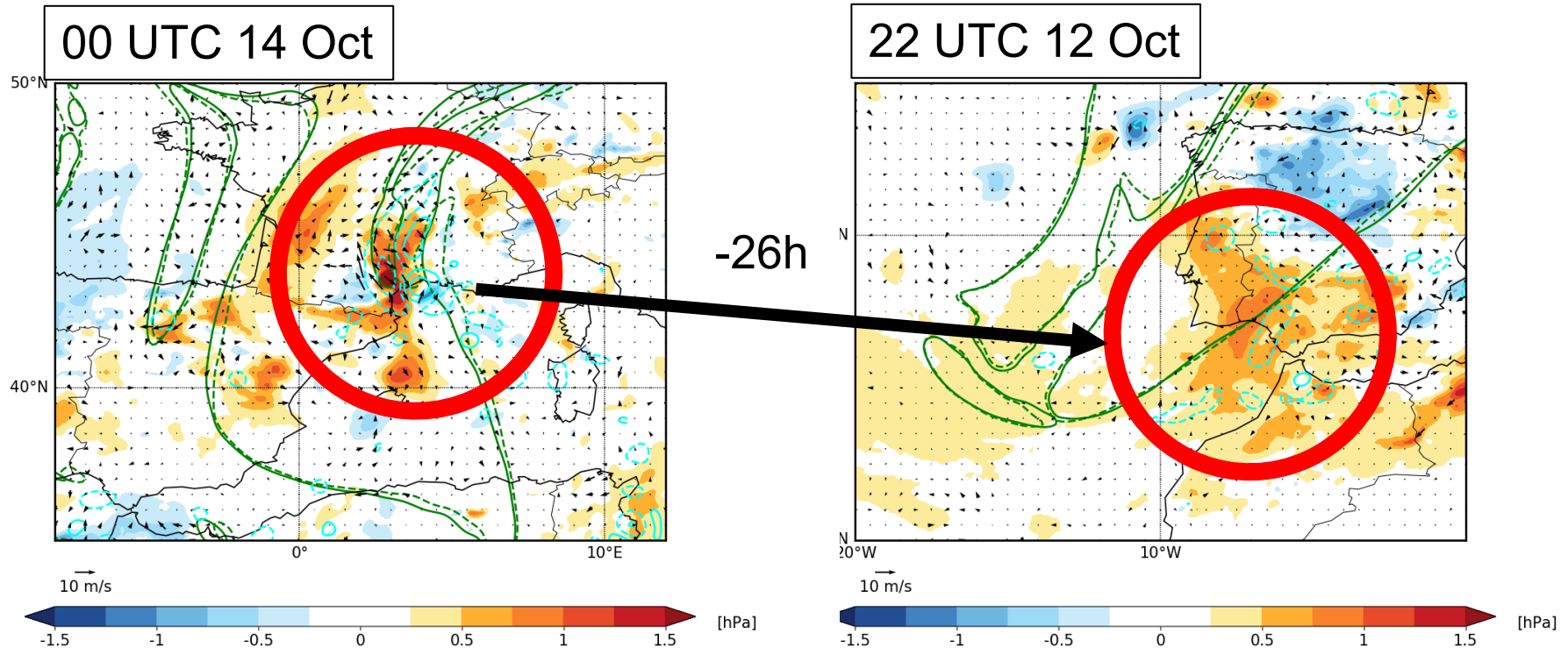
— Exp_{IWVAtlantic}
--- Ctrl_{Bad}



Underestimation of WCB strength in Ctrl_{Bad} due to **underestimation of moisture in WCB inflow** region

Sensitivity of precip. to initial North Atlantic moisture structure

SLP and low-level wind difference $\text{Ctrl}_{\text{Bad}} - \text{Exp}_{\text{IWWAtlantic}}$

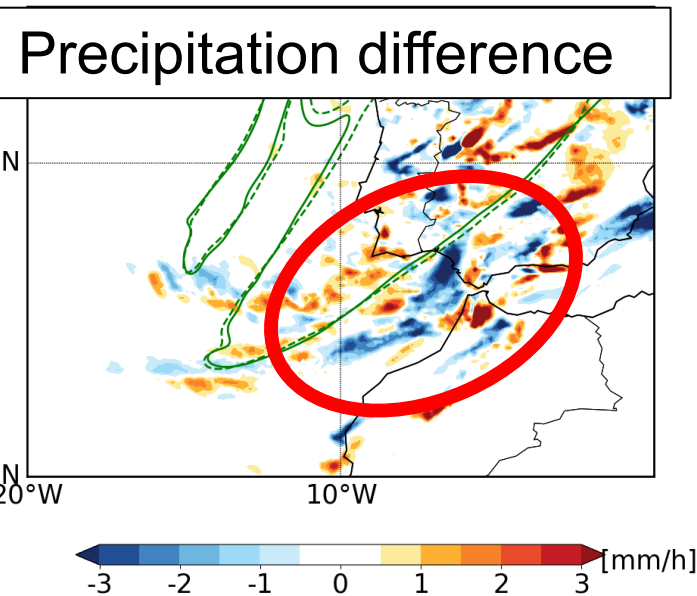
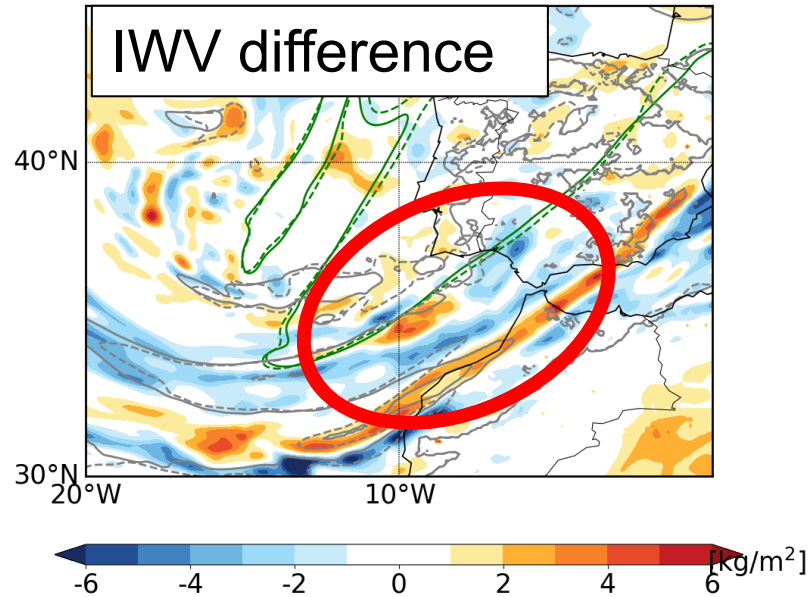
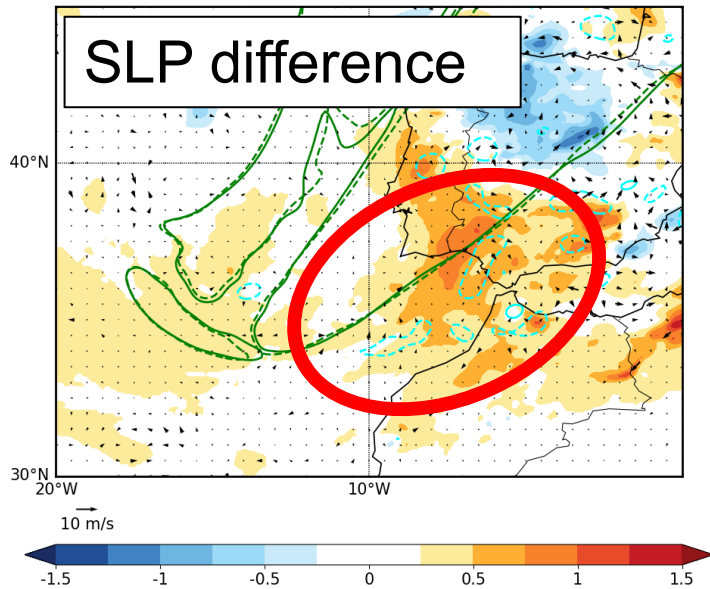


→ Too high SLP and anticyclonic circulation error in Ctrl_{Bad}
→ eastward shift of convergence line and precipitation

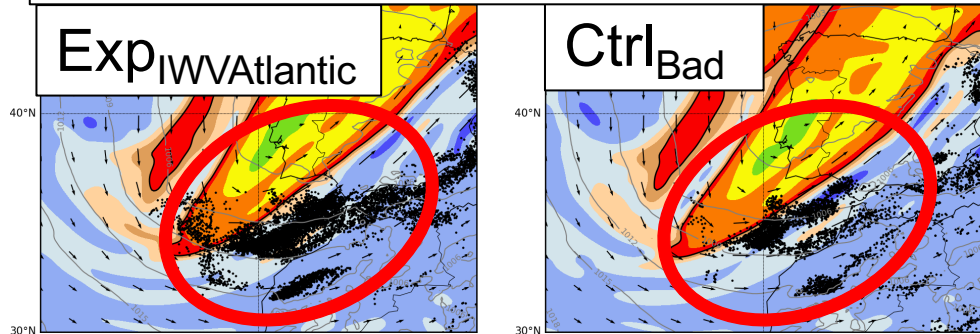
→ positive SLP error in Ctrl_{Bad} can be followed back into eastern NAtlantic

Origin of positive SLP error in Ctrl_{bad} with respect to $\text{Exp}_{\text{IWVAtl}}$

$\text{Ctrl}_{\text{Bad}} - \text{Exp}_{\text{IWVAtlantic}}$ at 22 UTC 12 Oct



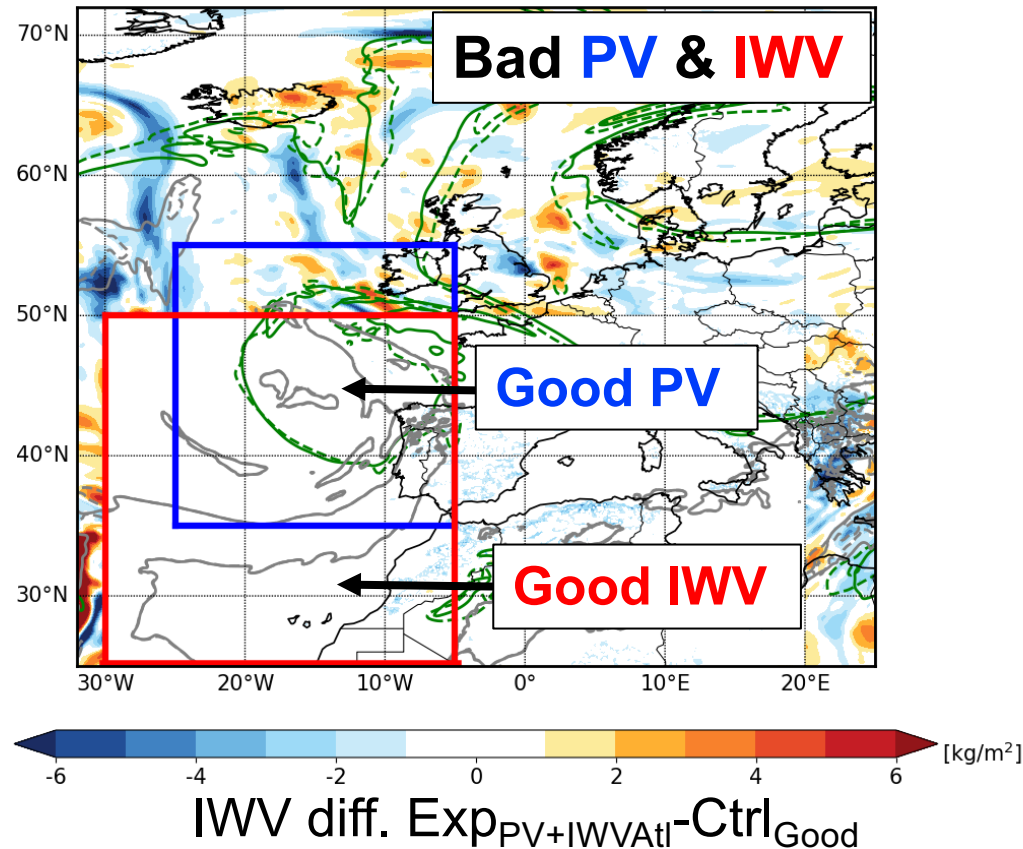
WCB positions (PBL to tropopause)



Underestimation of IWV → too weak WCB ascent, latent heating and precipitation
→ pos. SLP error

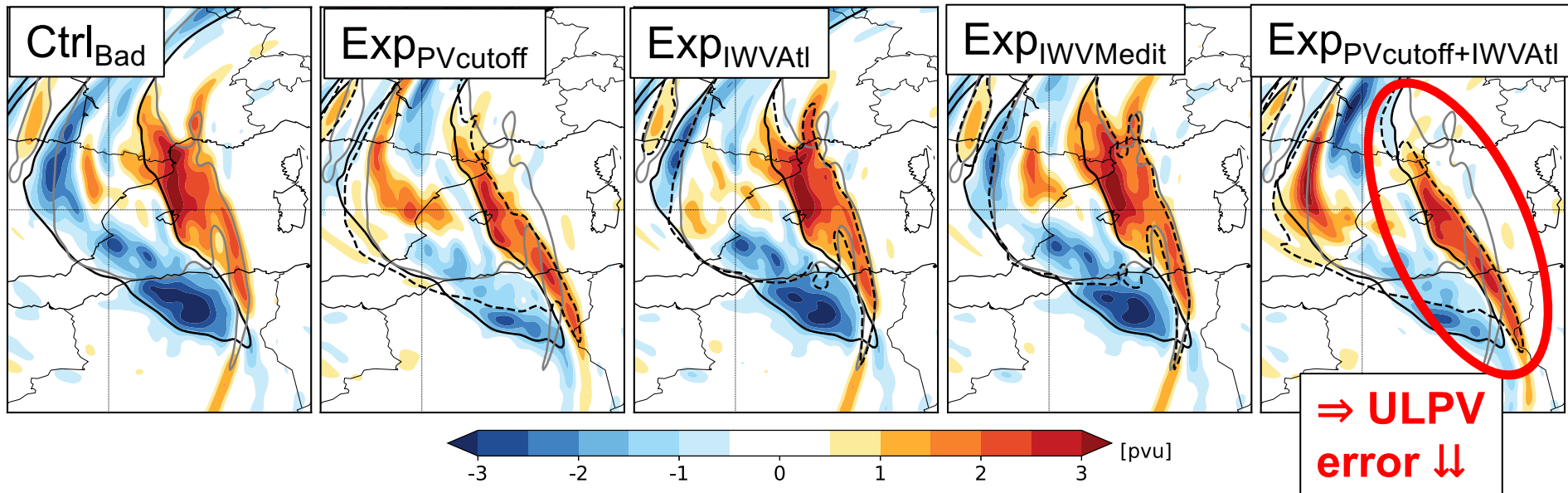
Sensitivity to initial ULPV and North Atlantic moisture

Exp_{PV+IWVAtlantic}: Combination of Exp_{PV} and Exp_{IWVAtl}: At 12/00Z, the **bad ULPV in the cut-off** and the **bad NAtlantic moisture** are replaced by the good ones

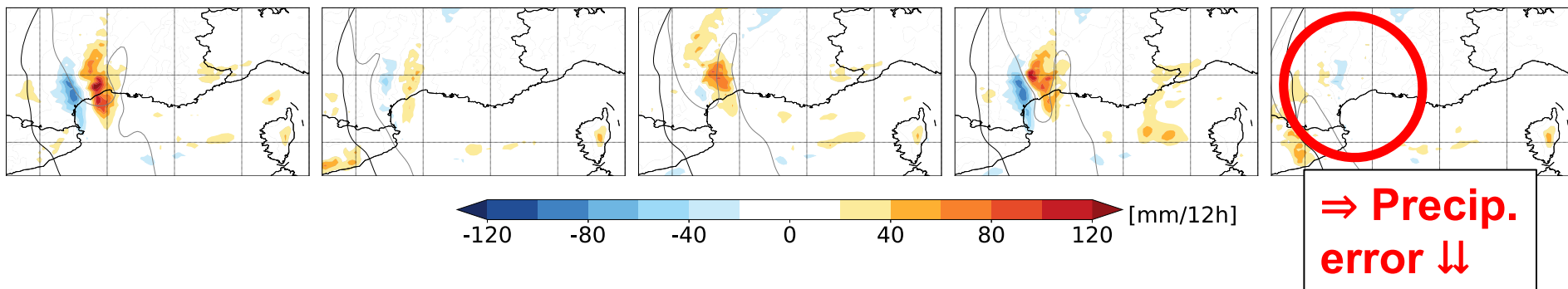


Sensitivity to initial ULPV and North Atlantic moisture

ULPV error with respect to good fc ($\text{Exp}-\text{Ctrl}_{\text{Good}}$)



Precipitation error wrt good fc ($\text{Exp}-\text{Ctrl}_{\text{Good}}$)



→ Strongest sensitivity of forecasts to combination of initial ULPV within cut-off Sanchez and North Atlantic moisture

Summary and conclusions

- Eastward shift of forecasted PV streamer Sanchez and precipitation max. in many 2-7 day forecasts.
- The fc were highly sensitive to the the PV structure within cut-off Sanchez 2 days earlier. Specifically, an underestimation of the initial cut-off strength was crucial for the misrepresented HIW.
- The fc were also sensitive to the initial low-level humidity in the eastern North Atlantic, but not to the humidity in the Mediterranean.
- The findings illustrate the importance of downstream error propagation and local moist dynamics for an accurate prediction of HIW over Europe.

