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**UNIVERSITÄT
BERN**

**OESCHGER CENTRE
CLIMATE CHANGE RESEARCH**

THE IMPACT OF VB-CYCLONES ON EXTREME PRECIPITATION OVER CENTRAL EUROPE IN THE PAST AND FUTURE

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Juan José Gómez-Navarro^{1,2}

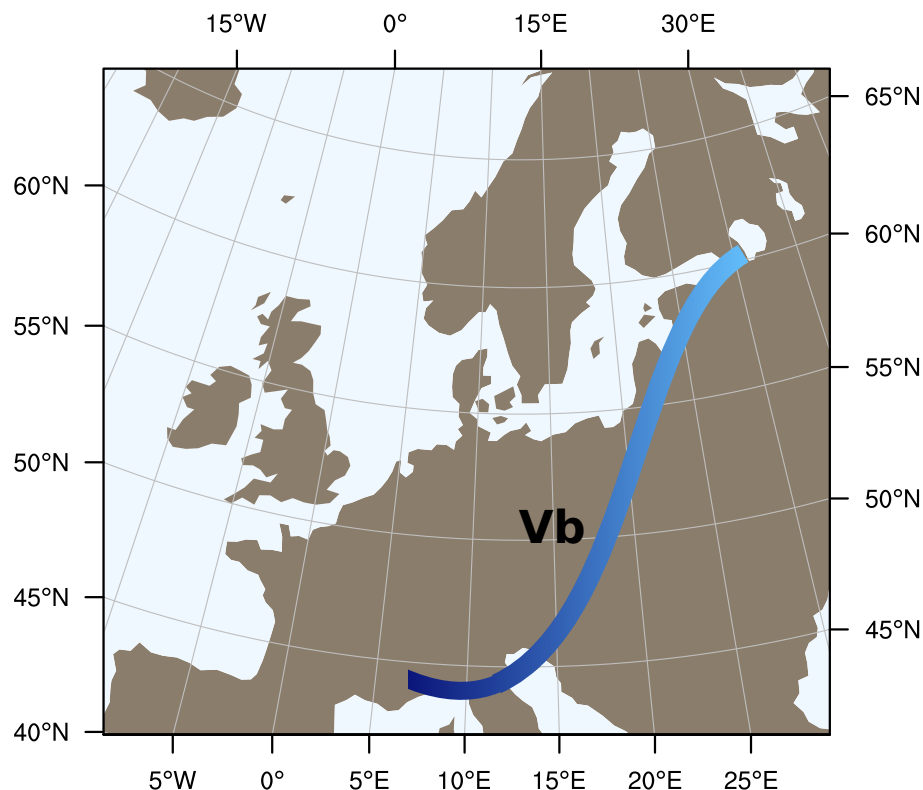
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Definition and Motivation

- ▶ Vb-cyclones were named and classified by W. J. van Bebber
- ▶ They are associated with heavy precipitation in Central Europe



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- ▶ **European Flood:**

- in August 2002
- damage ~20 bn €



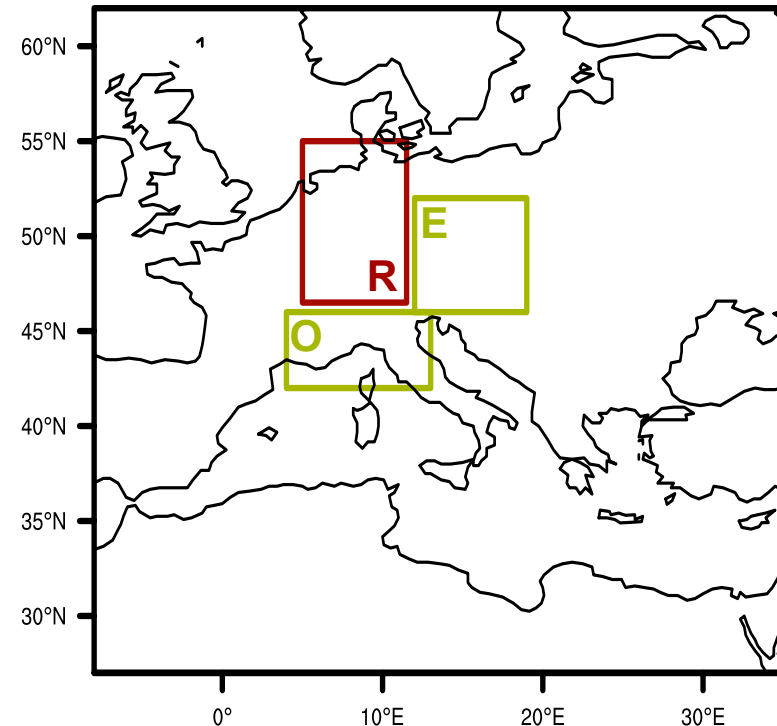
- ▶ **Alpine Flood:**

- in August 2005
- damage ~4 bn €



Cyclone Tracking

- ▶ ERA-Interim reanalysis period 1979-2013 is used
- ▶ Cyclone tracking tool is applied to geopotential height at 850 hPa
- ▶ Automatic filter with a criterion based on origin and end of the track identifies Vb-events



O: origin box, **E**: end box,
R: restriction box

adapted from Messmer et al. 2015

Basic Climatology

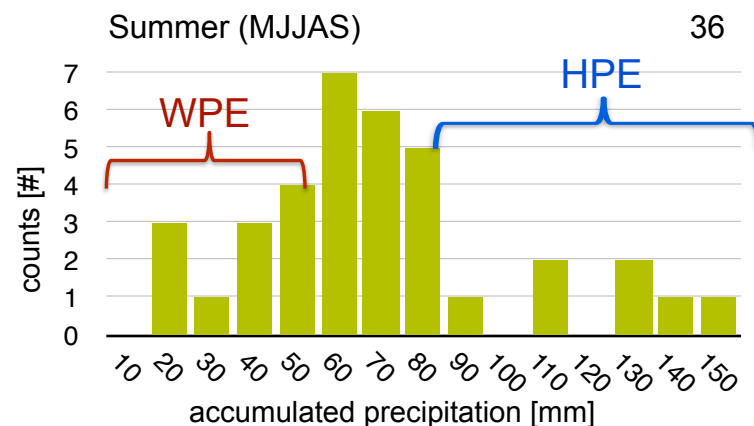
- ▶ In period 1979-2013: **82** Vb-cyclones can be tracked
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- ▶ Vb-cyclones are responsible for **15%** of extreme precipitation days (> 99 percent.) on the N-side of the Alps
- ▶ Vb-events in summer:
high variability in precipitation amounts on N-side of Alps
- ▶ Focus analysis on summer months

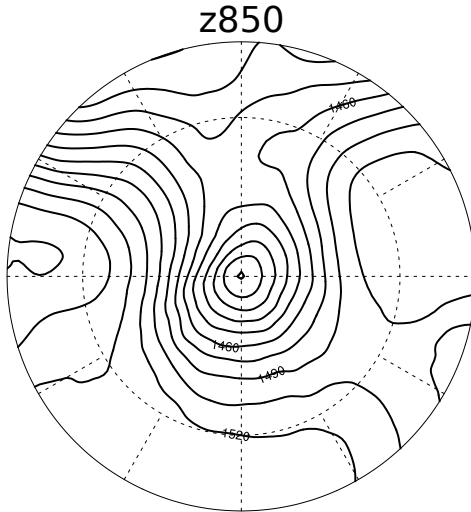


WPE: weak precipitation events (10)
HPE: heavy precipitation events (10)

Results on Climatology (Past)

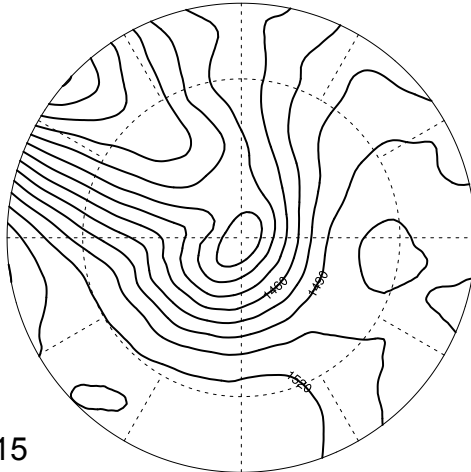
Geopotential height at highest precipitation

HPE



CONTOUR FROM 1100 TO 1600 BY 15

WPE



- ▶ Composites in geopotential height:
- ▶ **HPE** show distinct depression in the centre of storm

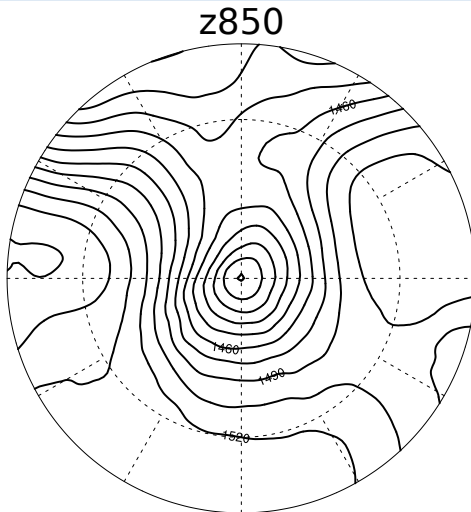
- ▶ **WPE** show weaker depression and strong influence from deeper depression in NW

Messmer et al. 2015

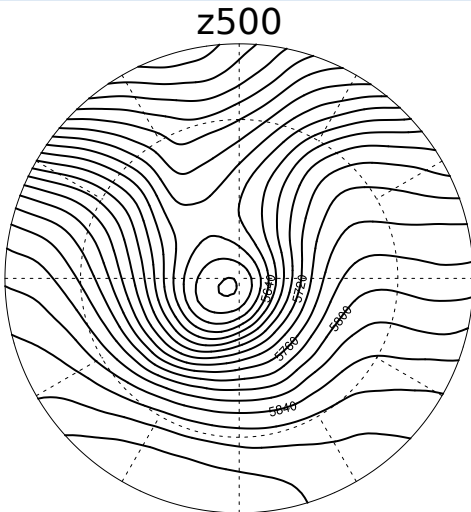
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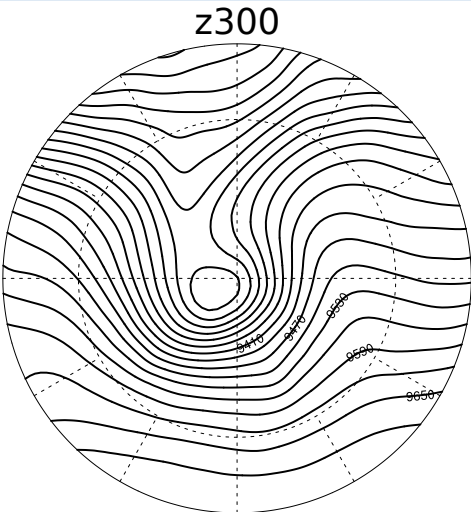
HPE



CONTOUR FROM 1100 TO 1600 BY 15

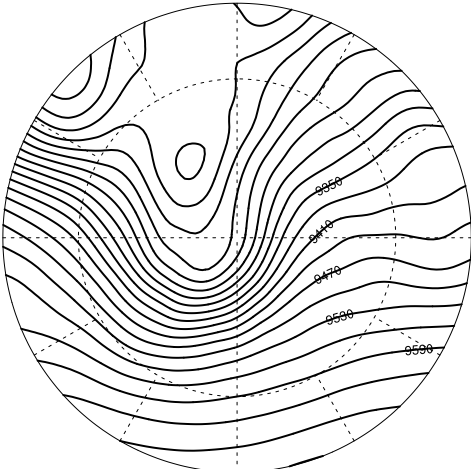
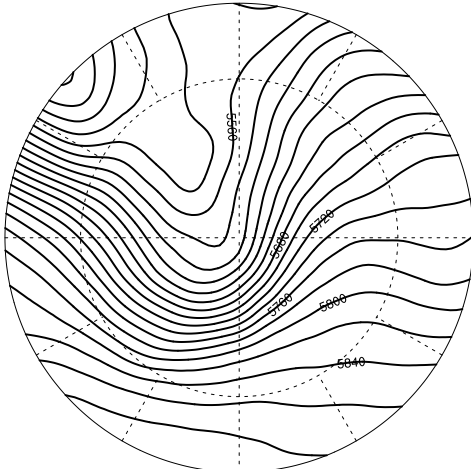
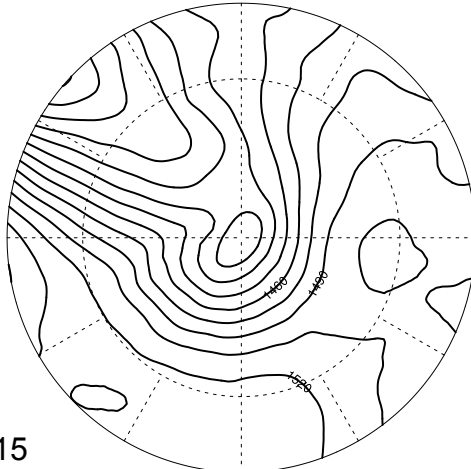


CONTOUR FROM 5100 TO 6100 BY 20



CONTOUR FROM 8600 TO 10000 BY 30

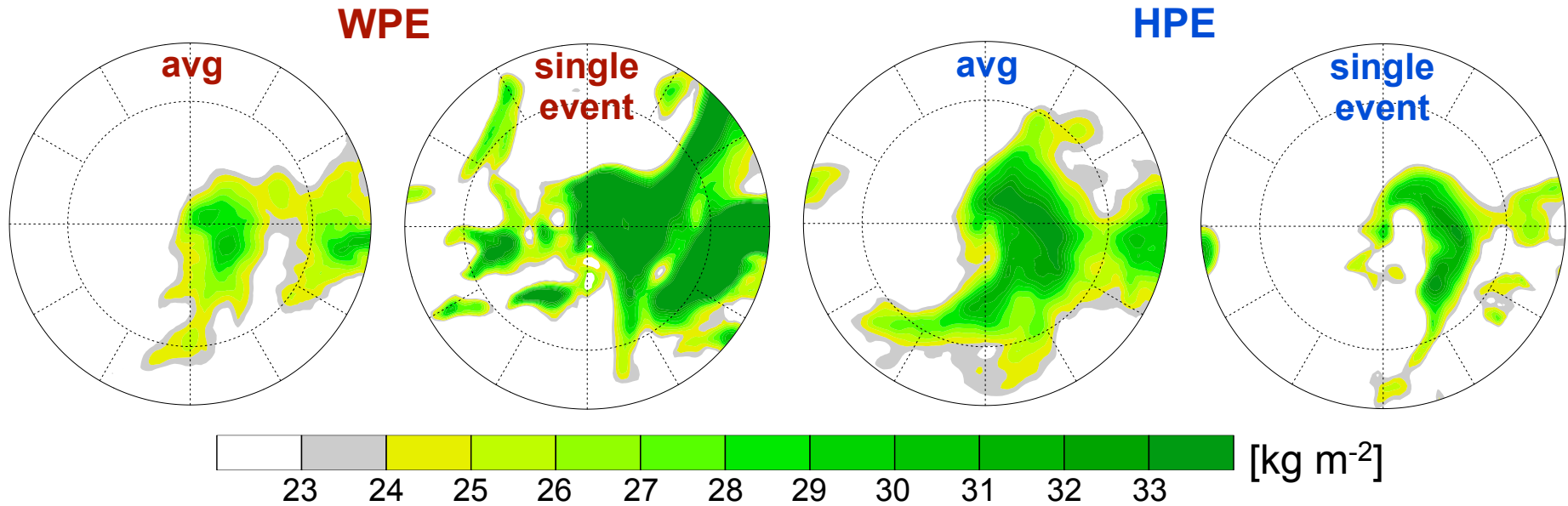
WPE



Messmer et al. 2015

Results on Climatology (Past)

Moisture at highest precipitation



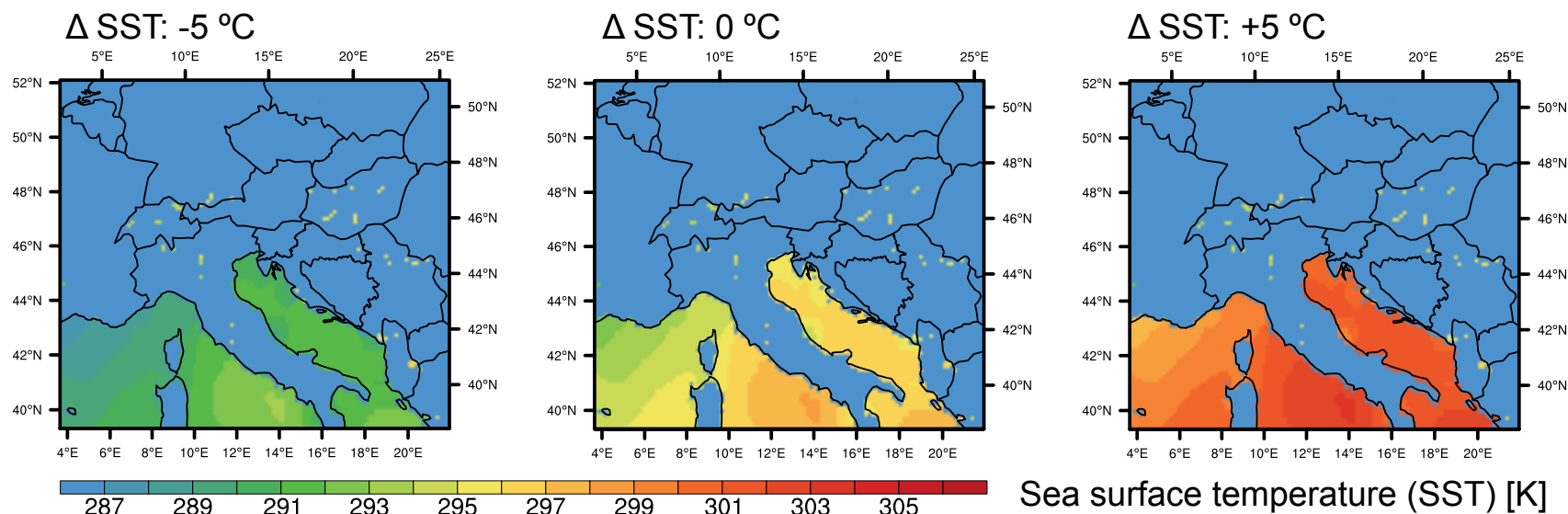
- ▶ Composites of precipitable water is much higher for **HPE** than for **WPE**
- ▶ **BUT:** Case-to-case variability is very large

Motivation Sensitivity Studies

- ▶ Reason for high summer precipitation in Vb-events can probably be found in large-scale dynamics
- ▶ Influence of moisture during Vb-events is still unclear

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- ▶ Influence of moisture during Vb-events is still unclear
 - ➔ Sensitivity study with Mediterranean SST might help to understand its role as moisture source



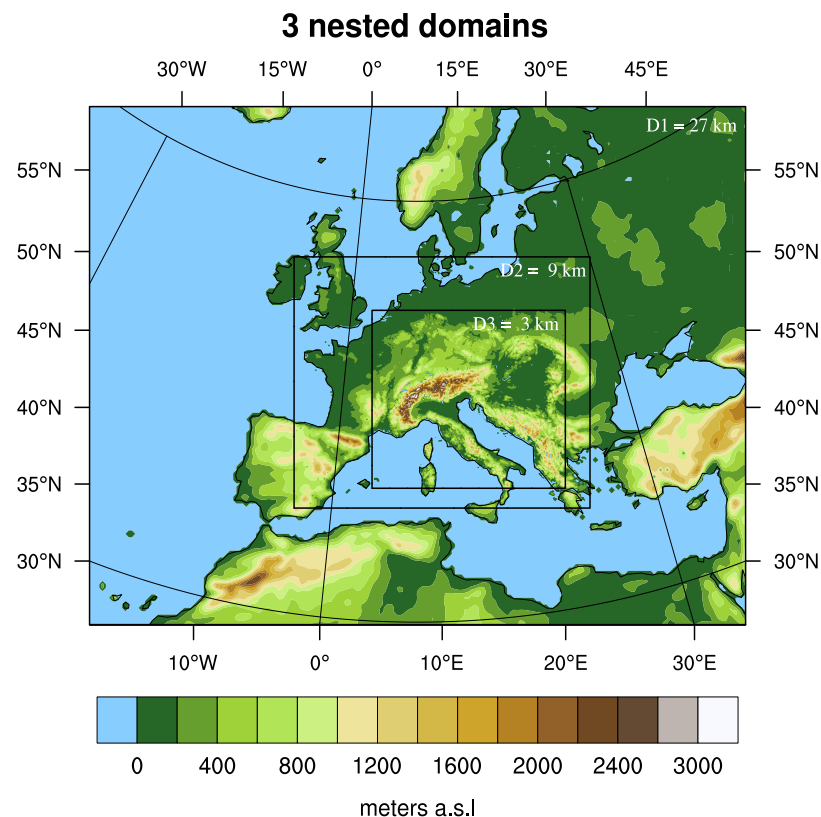
Sensitivity Studies

- ▶ Dynamical downscaling of 5 heavy precipitation Vb-events

- ▶ Downscaling performed with WRF (3 nested domain setup)

- D1 spatial resolution: 27 km
- D2 spatial resolution: 9 km
- D3 spatial resolution: 3 km

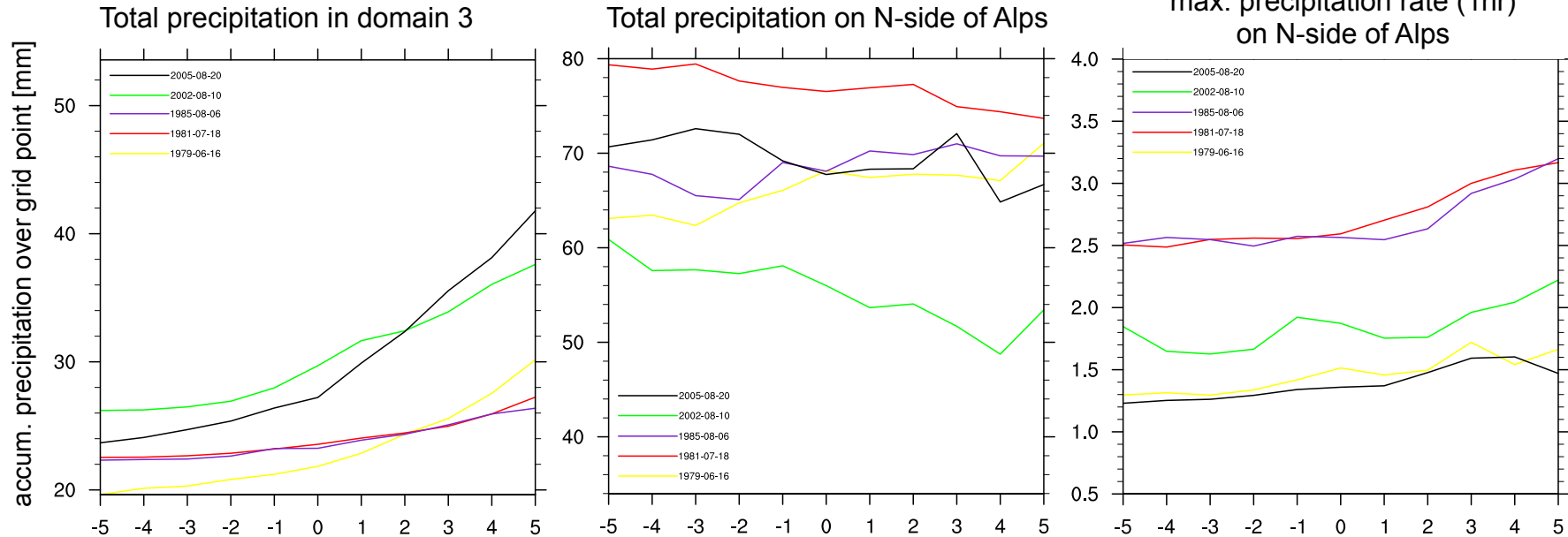
- ▶ Driven by ERA-Interim reanalysis



Results on Sensitivity Study (Future)

Accumulated precipitation with increasing SSTs

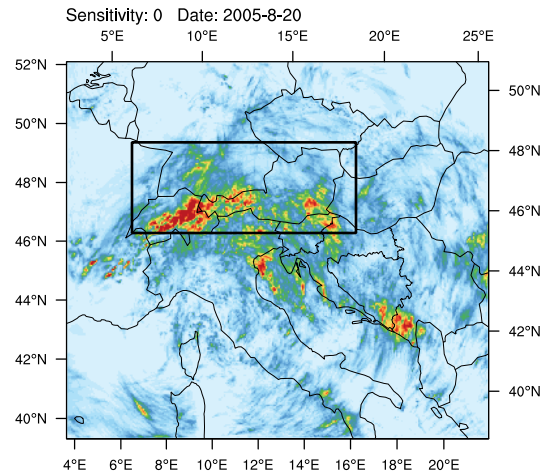
- ▶ As expected precipitation over D3 increases
- ▶ precipitation over the N-side of the Alps decreases
- ▶ maximum hourly precipitation rate increases on the northern side of the Alps



Results on Sensitivity Study (Future)

Accumulated precipitation with increasing SSTs

Δ SST: 0 °C

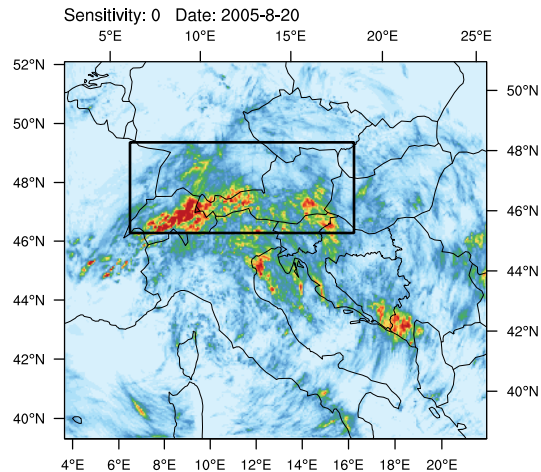
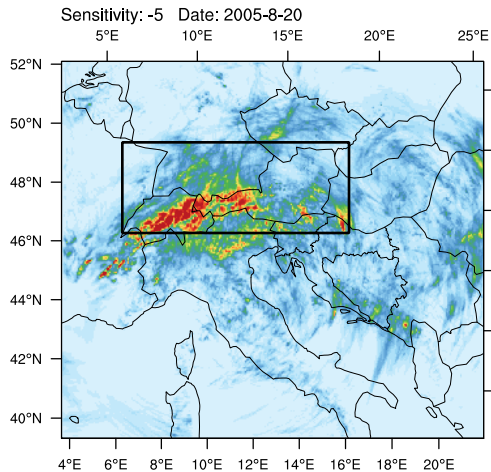


Results on Sensitivity Study (Future)

Accumulated precipitation with increasing SSTs

Δ SST: -5 °C

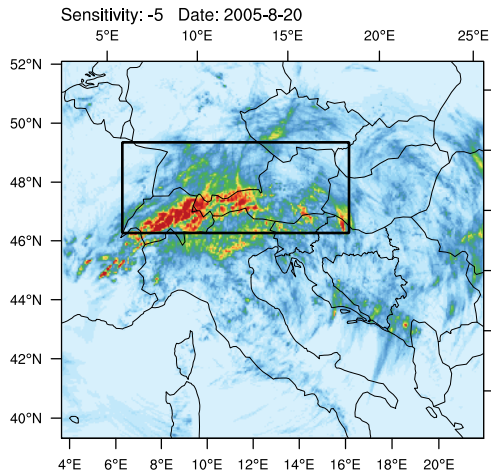
Δ SST: 0 °C



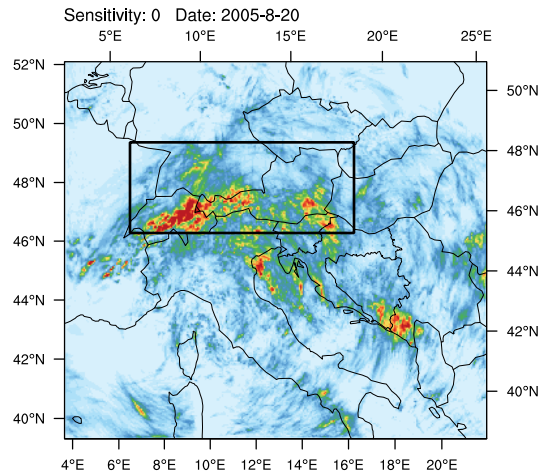
Results on Sensitivity Study (Future)

Accumulated precipitation with increasing SSTs

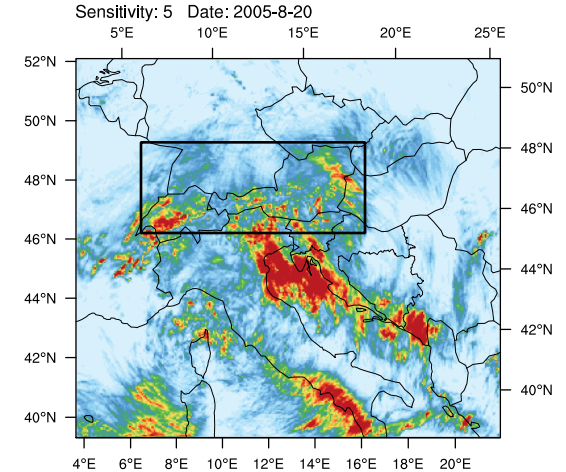
Δ SST: -5 °C



Δ SST: 0 °C



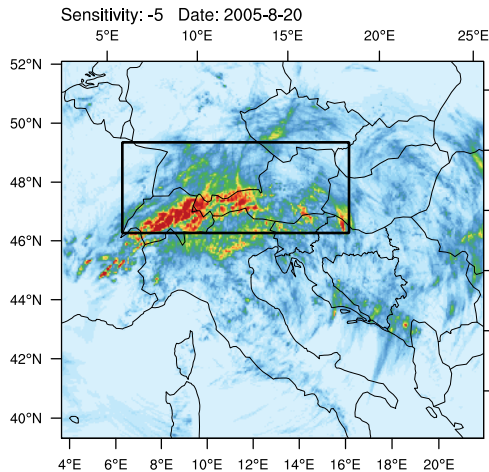
Δ SST: +5 °C



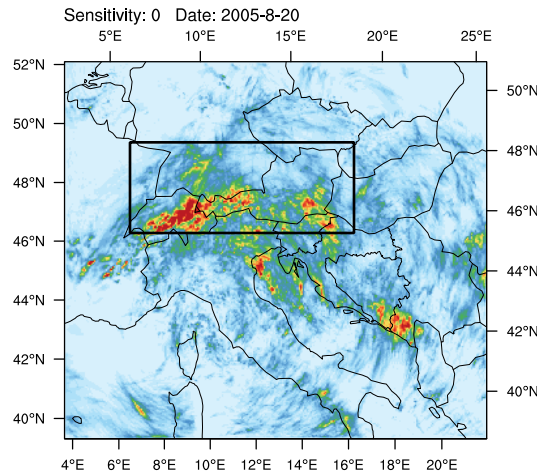
Results on Sensitivity Study (Future)

Accumulated precipitation with increasing SSTs

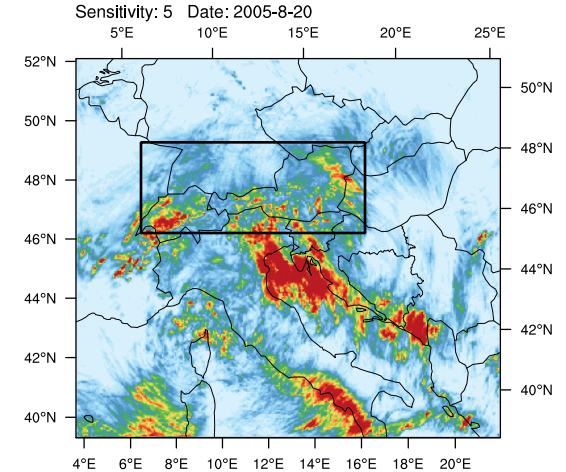
Δ SST: -5 °C



Δ SST: 0 °C



Δ SST: +5 °C



- precipitation on the N-side of Alps is negatively correlated to increase of Mediterranean SST

Conclusions

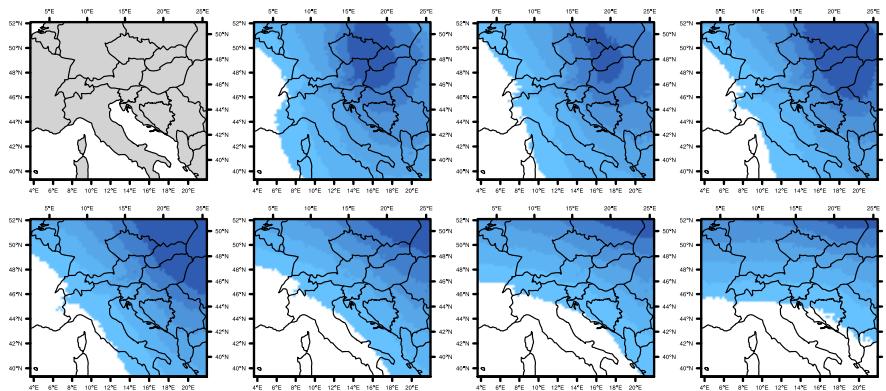
- ▶ Warming of the Mediterranean Sea has a negative effect on precipitation amounts on northern side of Alps
- ▶ This could be due to the fact that:
 - Most of extra water is precipitated over Italy and east Adriatic coast
 - Vb-cyclones are faster moving
 - Vb-cyclones decay faster or merge sooner with other low-pressure systems
 - Mediterranean Sea is not the main water source for precipitation
- ➡ Further analysis is needed
- ➡ Other sensitivity studies are planned (Atlantic Ocean, soil moisture)

THANK YOU FOR YOUR ATTENTION!

ACKNOWLEDGEMENT: The authors thank the Bretscher-Fund for the support provided in this project.

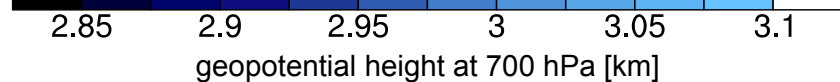
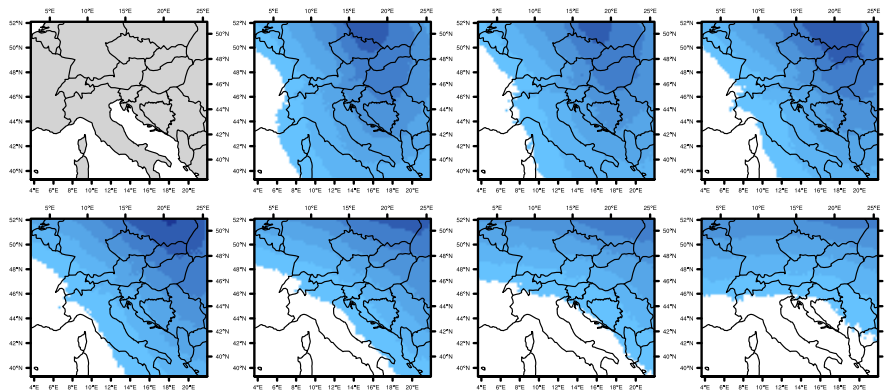
a) SST: -5 °C

1981-07-20 - 1981-07-21



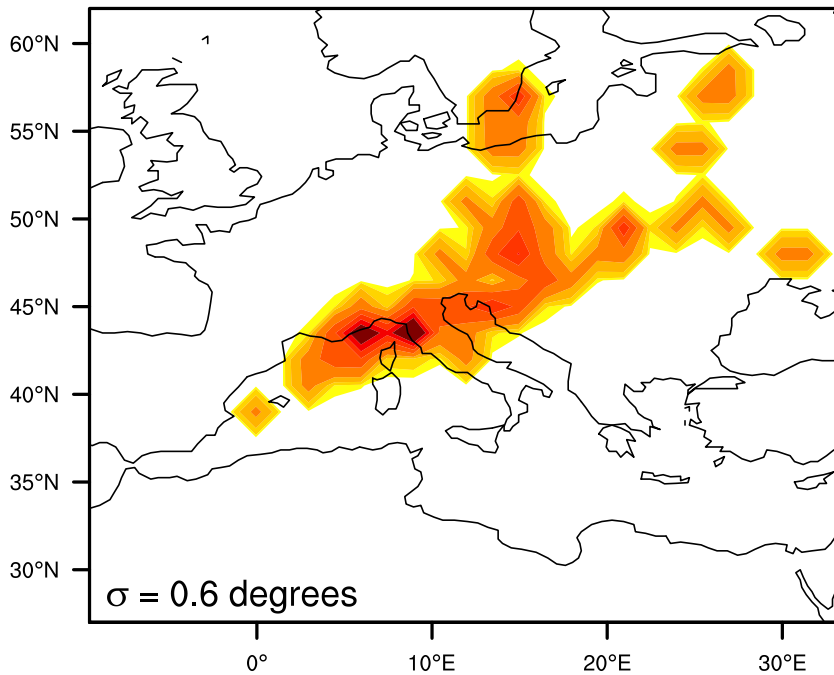
b) SST: 5 °C

1981-07-20 - 1981-07-21

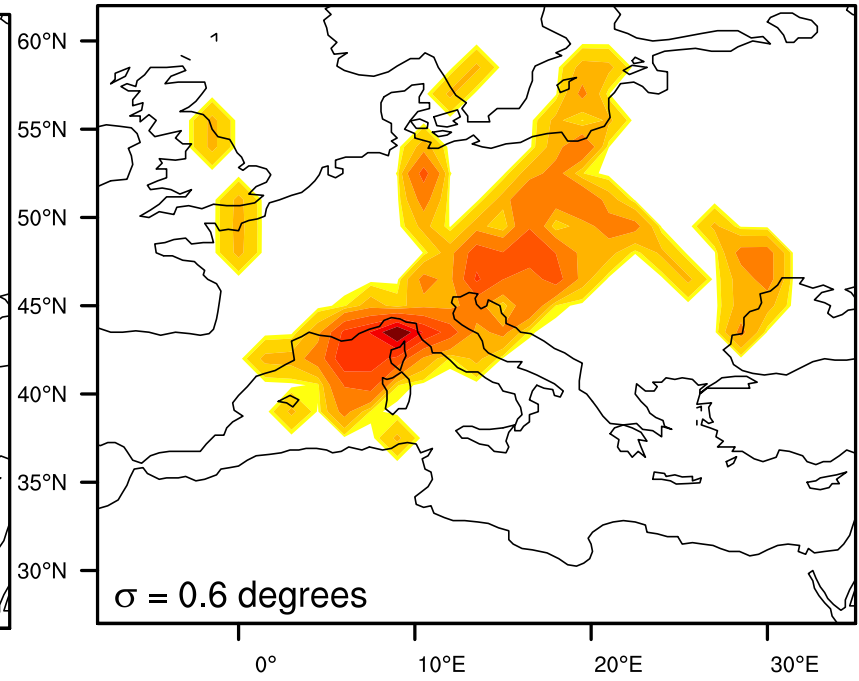


Cyclone centre probability density

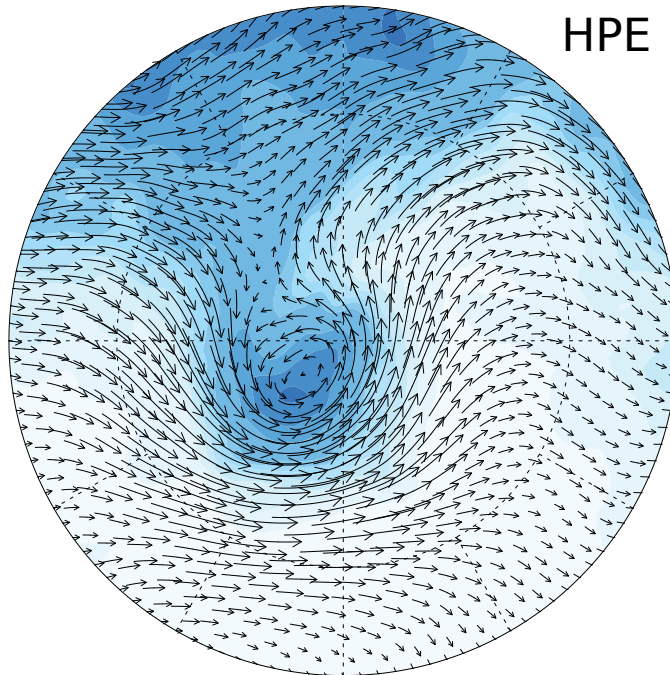
WPE



HPE



Potential Vorticity

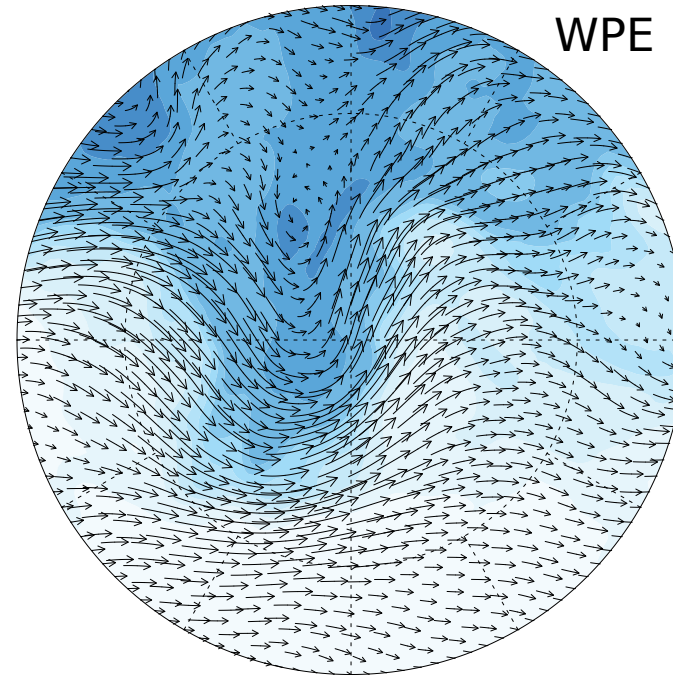


10
→
ms⁻¹



0.5 0.75 1 1.25 1.5 1.75 2 3 4 5 6 7 8

potential vorticity [PVU]



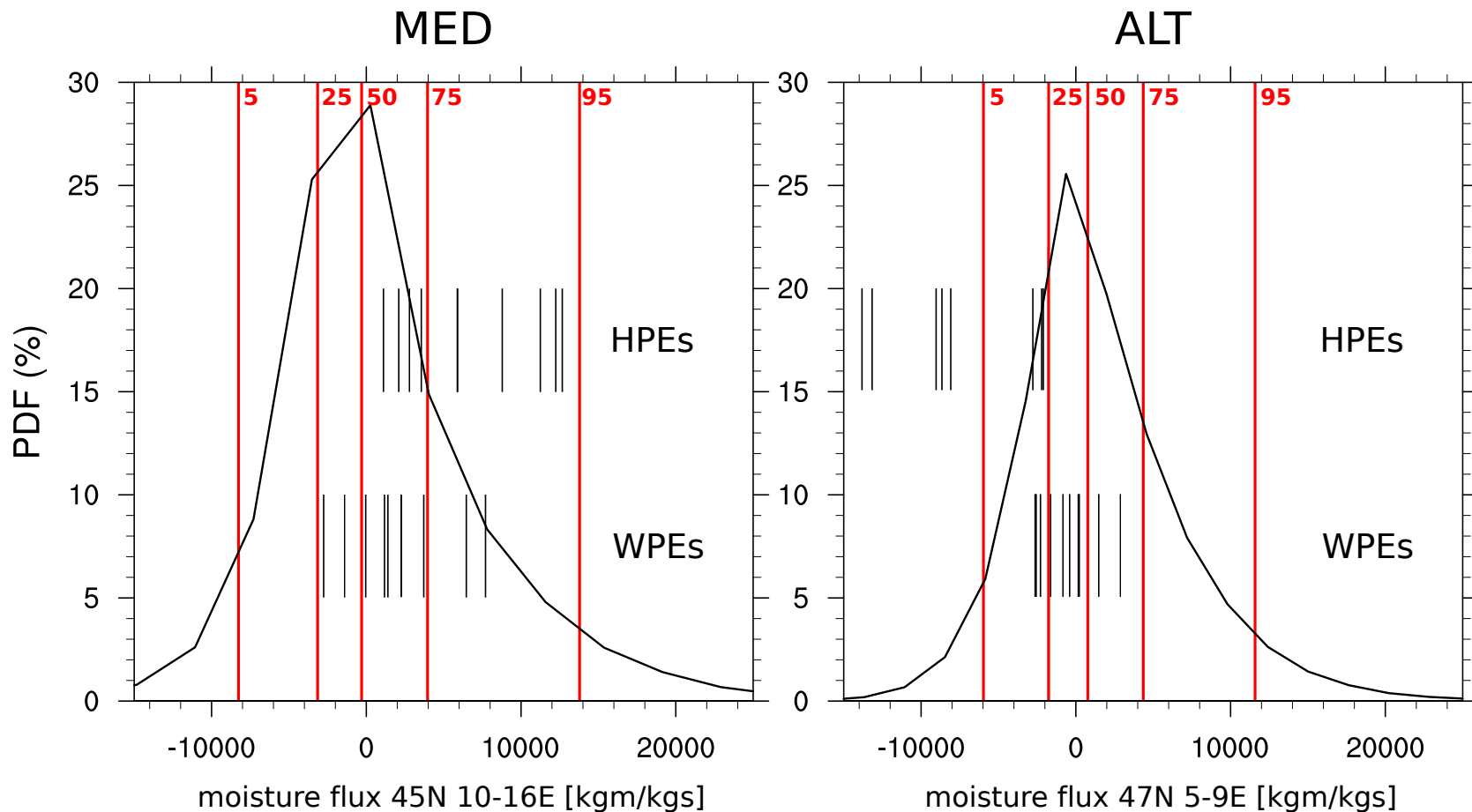
10
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ms⁻¹



0.5 0.75 1 1.25 1.5 1.75 2 3 4 5 6 7 8

potential vorticity [PVU]

Moisture flux through specific latitude



accumulated total precipitation [mm]

