Royal Netherlands
Meteorological Institute
Ministry of Infrastructure and the Environment

Top-down vs. bottom-up approach in compound event research

The Role of Atmospheric Rivers in compound events along the Dutch coast

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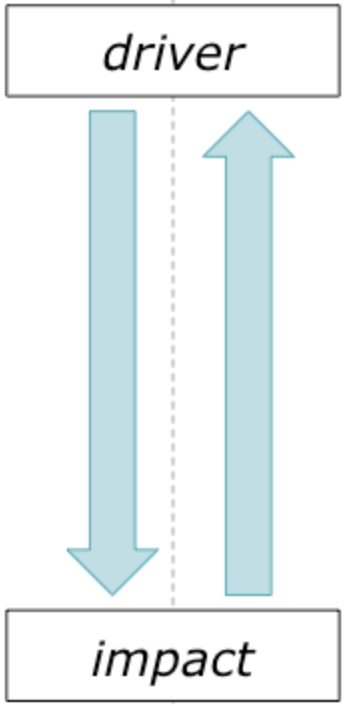
Concept

(*Hazeleger et al., Nat. Clim. Change, 2017)*

Top-down

Future conditions are mapped using a scenario framework

not every extreme climate variable also causes extreme impact



Bottom-up

Focusing on one specific impact (or hazard) and aims to use "Storytelling"-approach

not every extreme impact is caused by extreme value in driver

Concept

(*Hazeleger et al., Nat. Clim. Change, 2017)*

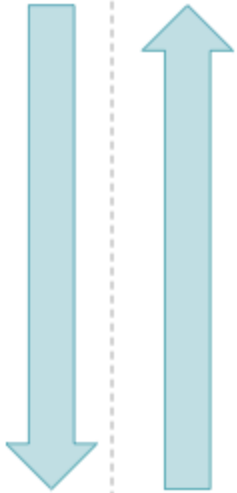
Top-down

Bottom-up

atmospheric river

Future conditions are mapped using a scenario framework

not every extreme climate variable also causes extreme impact



Focusing on one specific impact (or hazard) and aims to use "Storytelling"-approach

not every extreme impact is caused by extreme value in driver

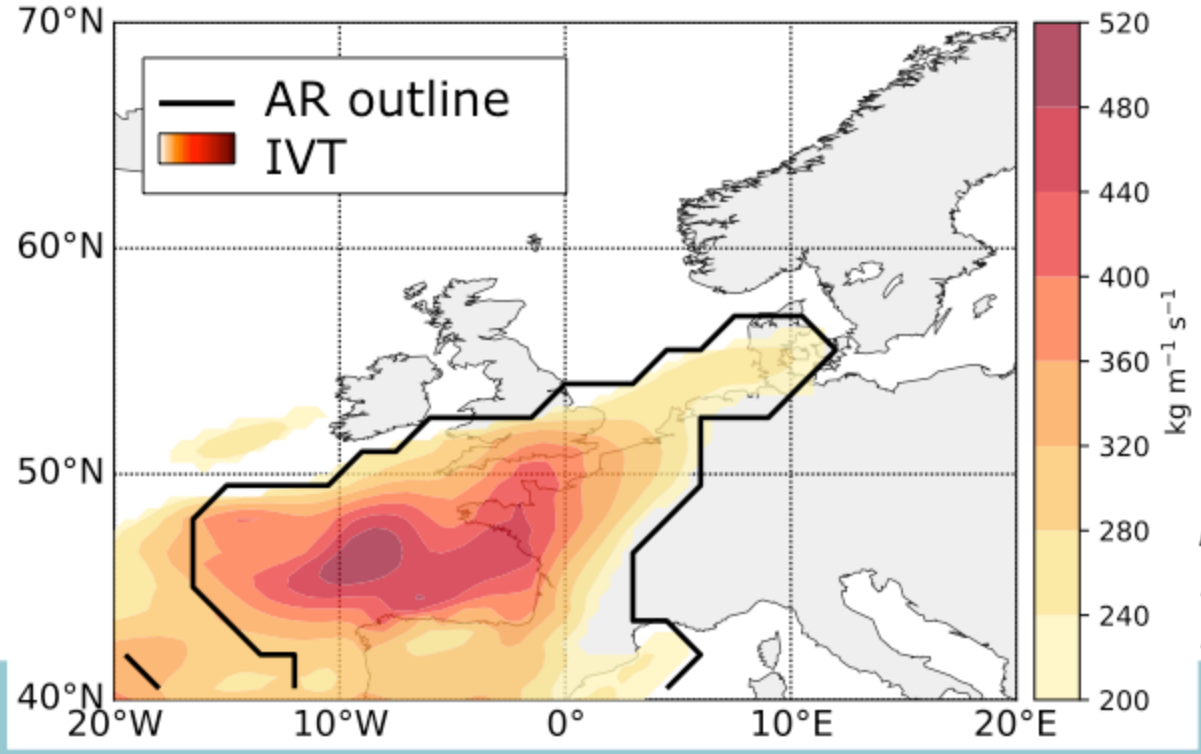
coinciding heavy precip. & high water levels

Aim

- Demonstrate the **strengths and limitations of** both the **top-down and bottom-up approach** and
- **Highlight their complementing nature** essential for the thorough investigation of compound events

Atmospheric rivers (ARs)

- ARs are long filament of high water vapour transport typically located in the lower troposphere
- Their landfall (LF) had been shown to be associated with <u>heavy precipitation and strong winds</u> *(Waliser & Guan, Nat. Geosci., 2017)*



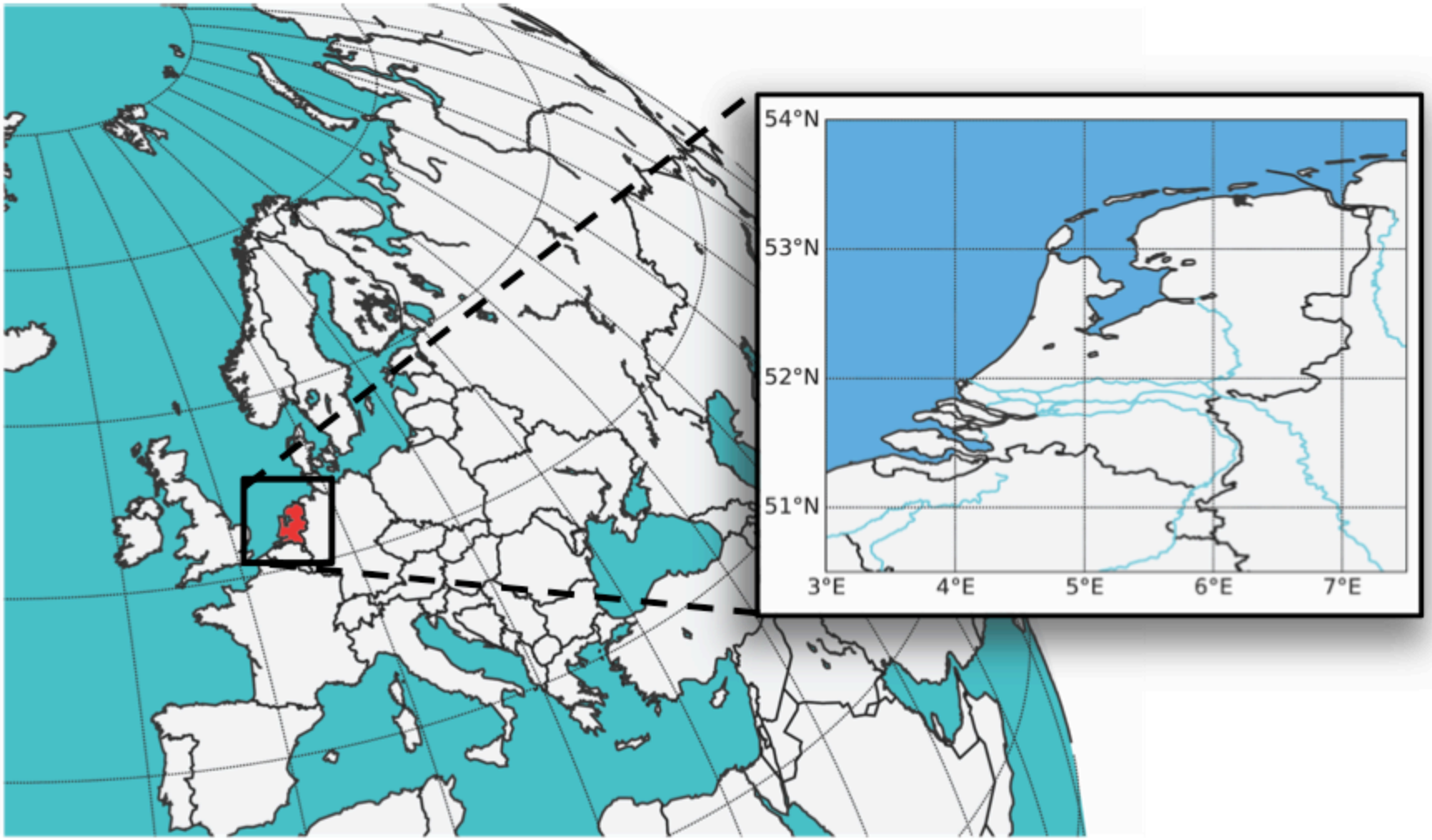
ERA-Interim:
1st of Feb 1979
12:00

Motivation for AR example

Hypothesis:

Landfall of ARs has the potential to be associated to local compound extremes consisting of precipitation and storm surge

The Netherlands



Method

Data sets:
(1 Jan 1979 – 31 Dec 2015)

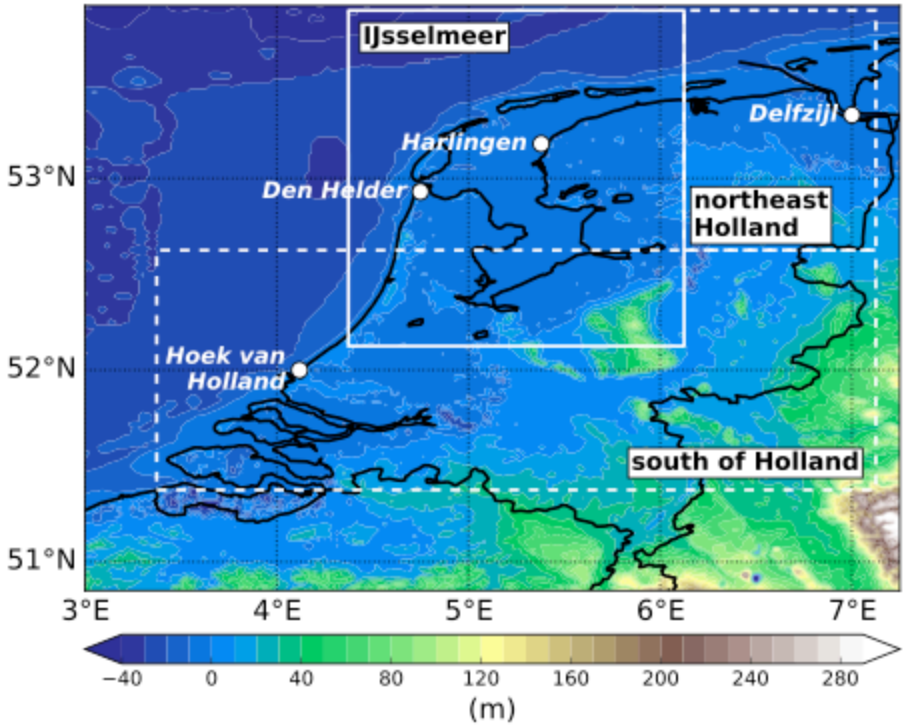
ERA-Interim

- Total water levels (h) from WAQUA/DCSMv5
- AR database derived from integrated vapour transport (*Guan & Waliser, J. Geophysical Res., 2015)*

EOBS

- daily local precipitation (P) over specific regions

Study area:



Definition of compound events (CEs)

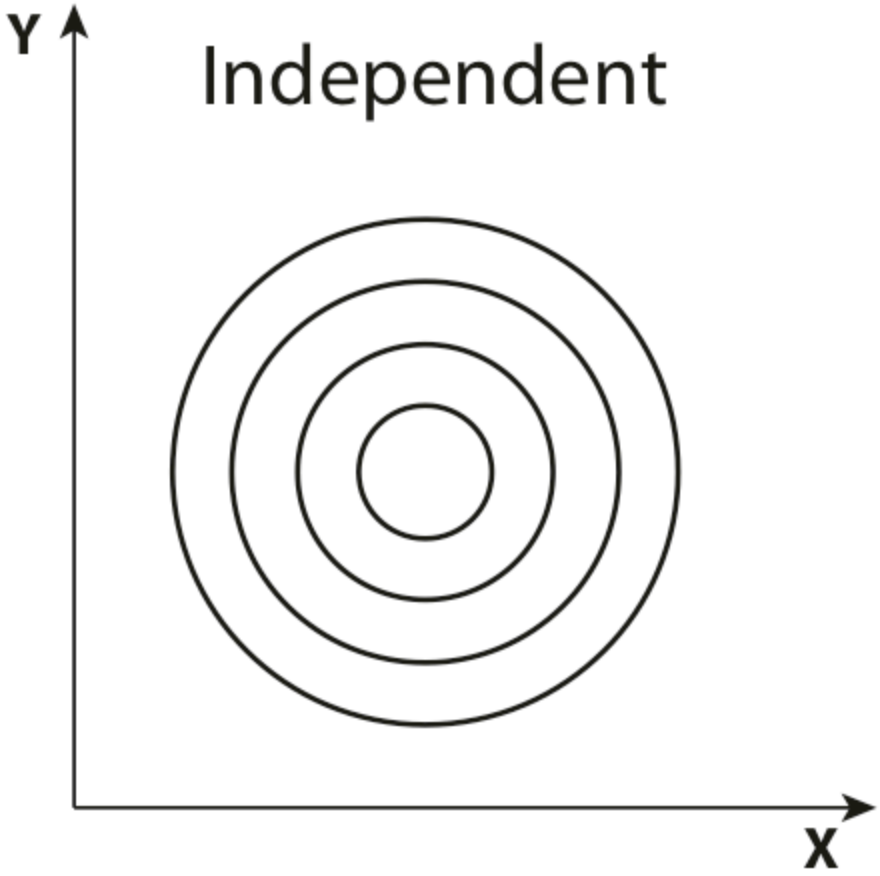
An event is considered to be **compound** if the centred **3-day precipitation sum** and the **maximum total water level** within these 3 days are both bigger than their respective **95th percentile**

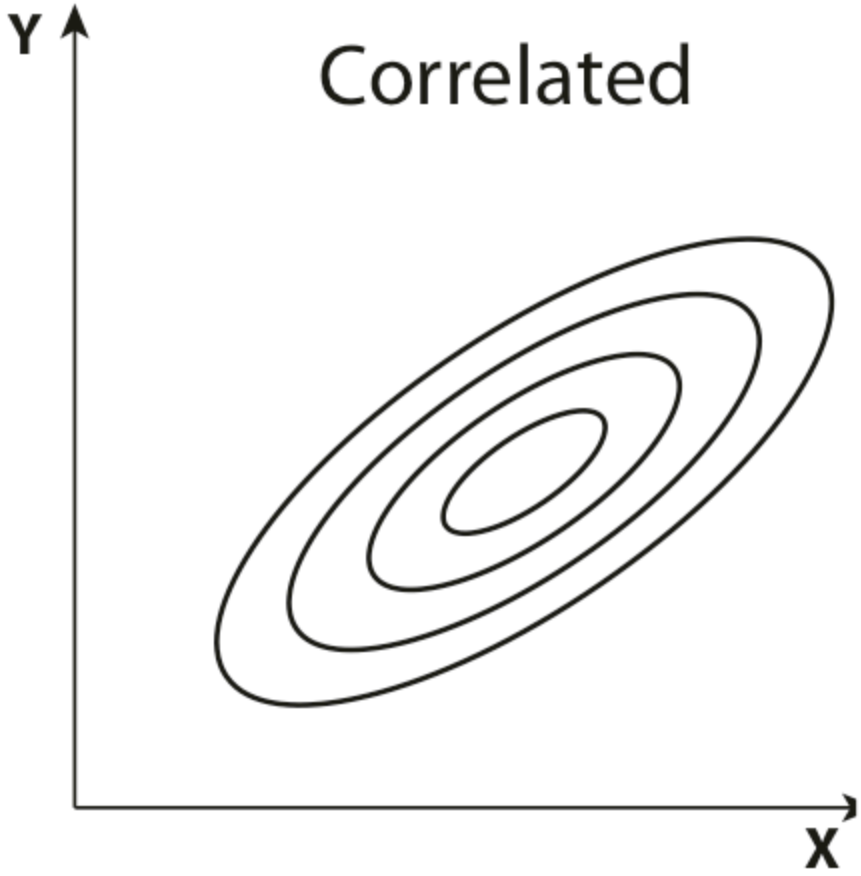
Top-down approach

Starting from the atmospheric phenomenon

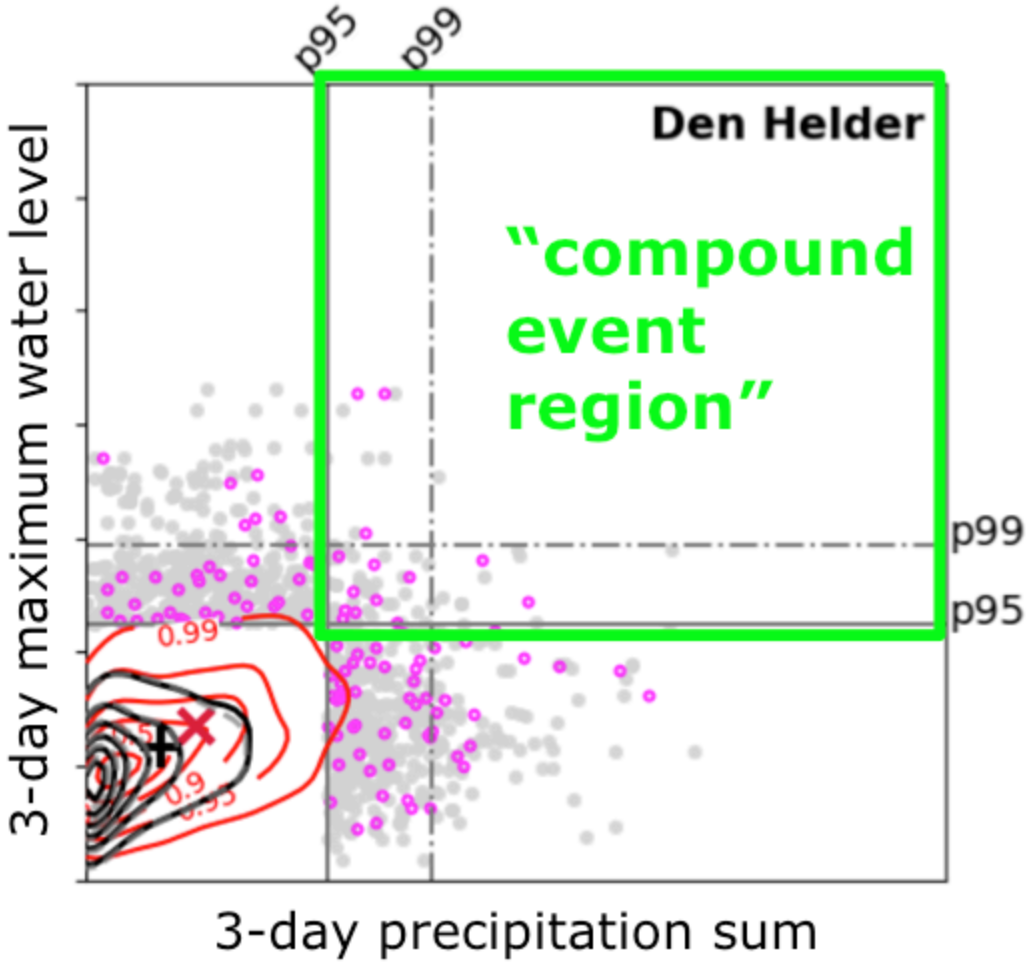
→ AR landfall

Reminder: Joint density distributions





Joint density distributions during AR LF in NL



Density distribution of :

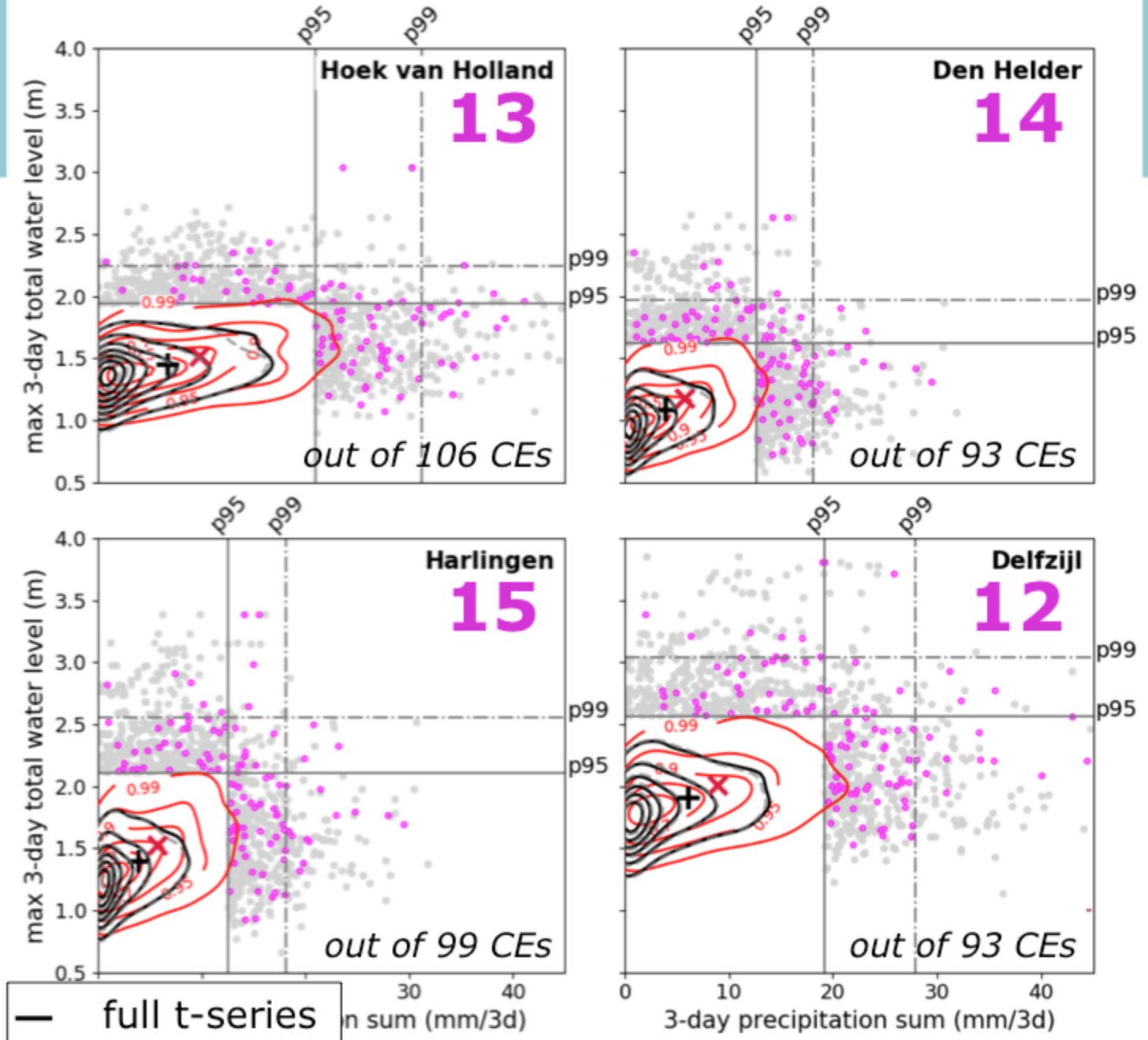
- full t-series
- AR LF events only
- time series w/o AR LF events

Data points:

- with AR LF in NL
- full t-series

Joint density distributions during AR landfall in NL

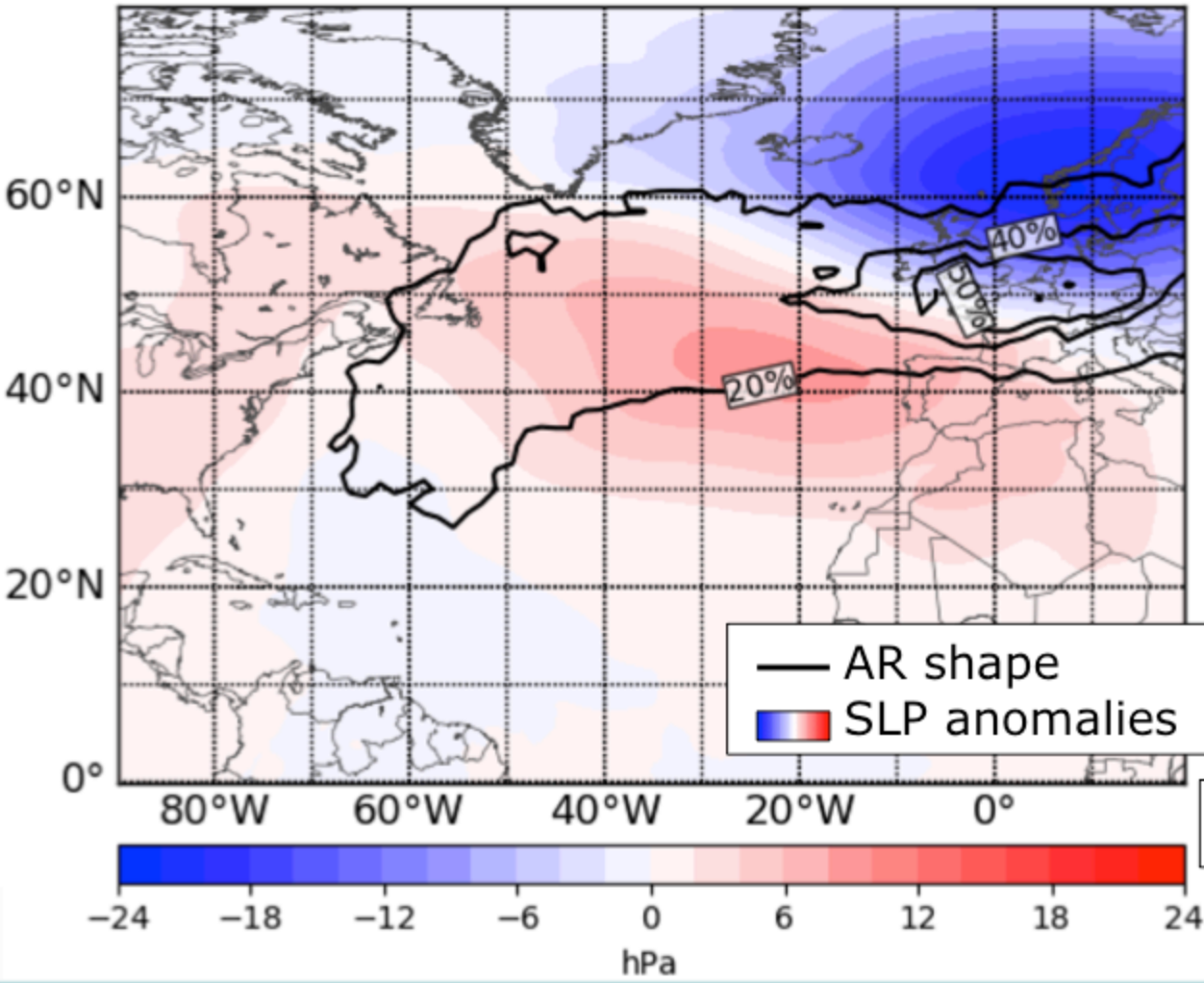
(325 events)



Bottom-up approach

Starting from the compound events

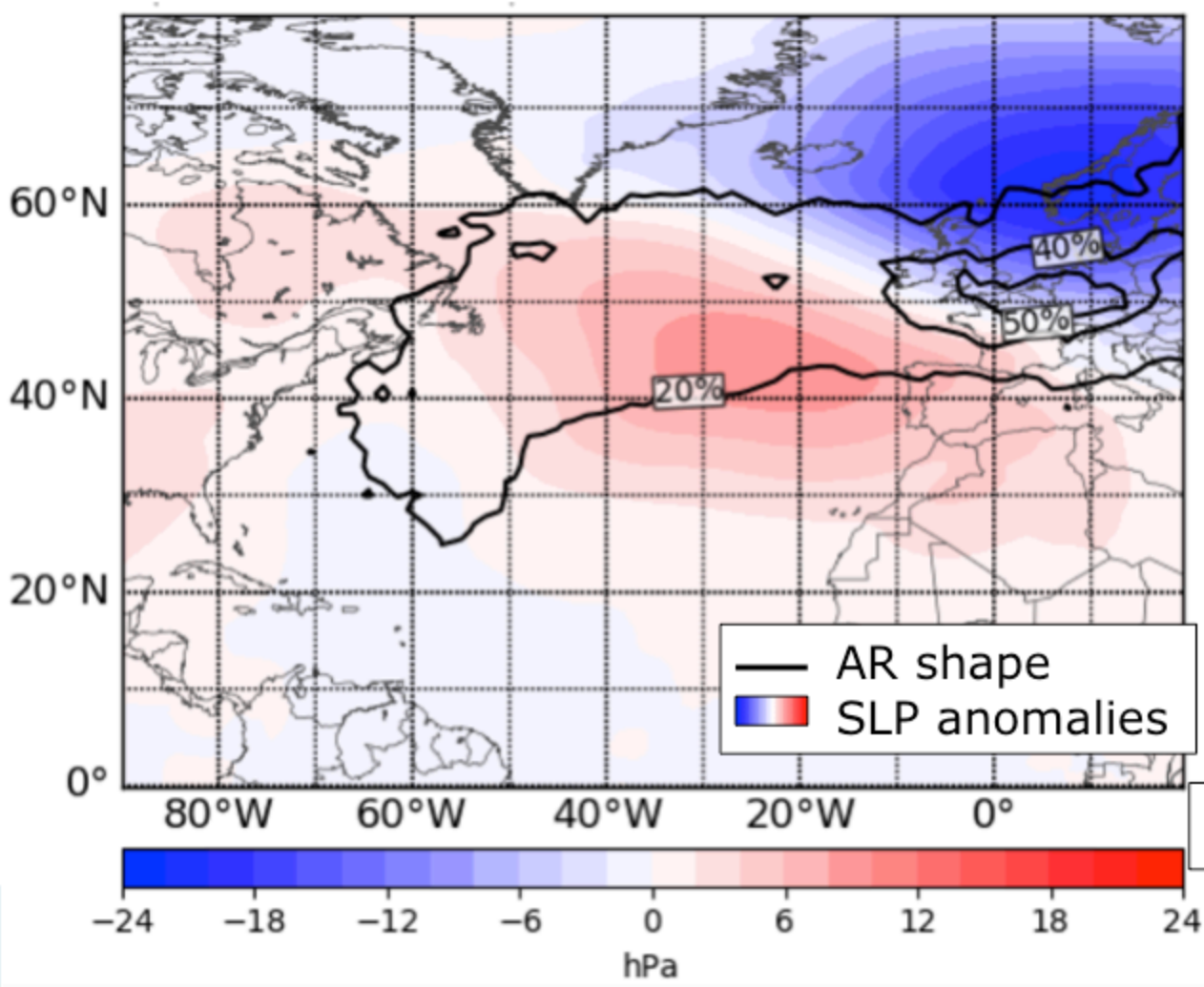
Mean conditions during **all compound events** at Den Helder in winter six months



86 events

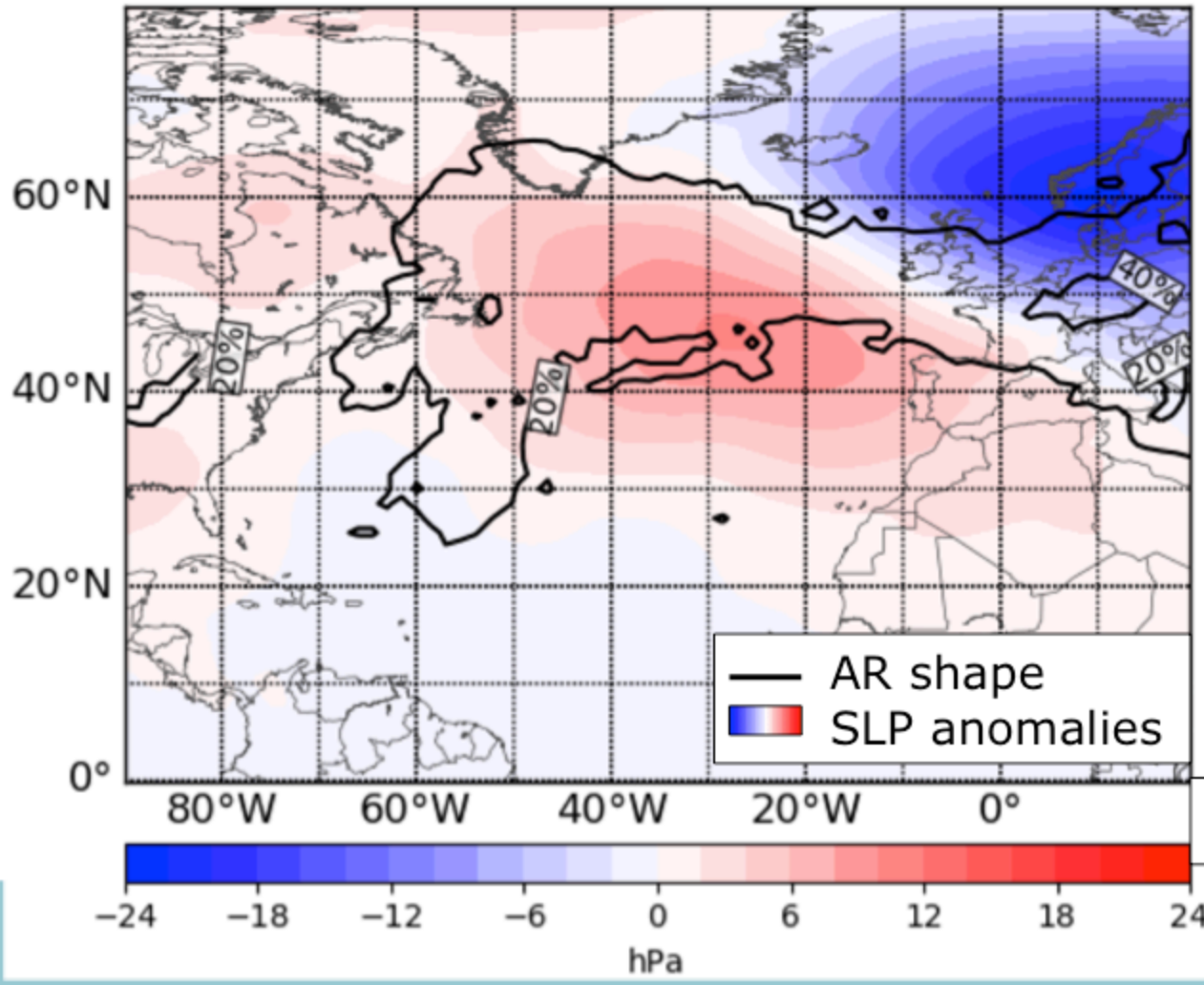
winter: OND+JFM

Compound events at Den Helder **without AR landfall in NL**



73 events

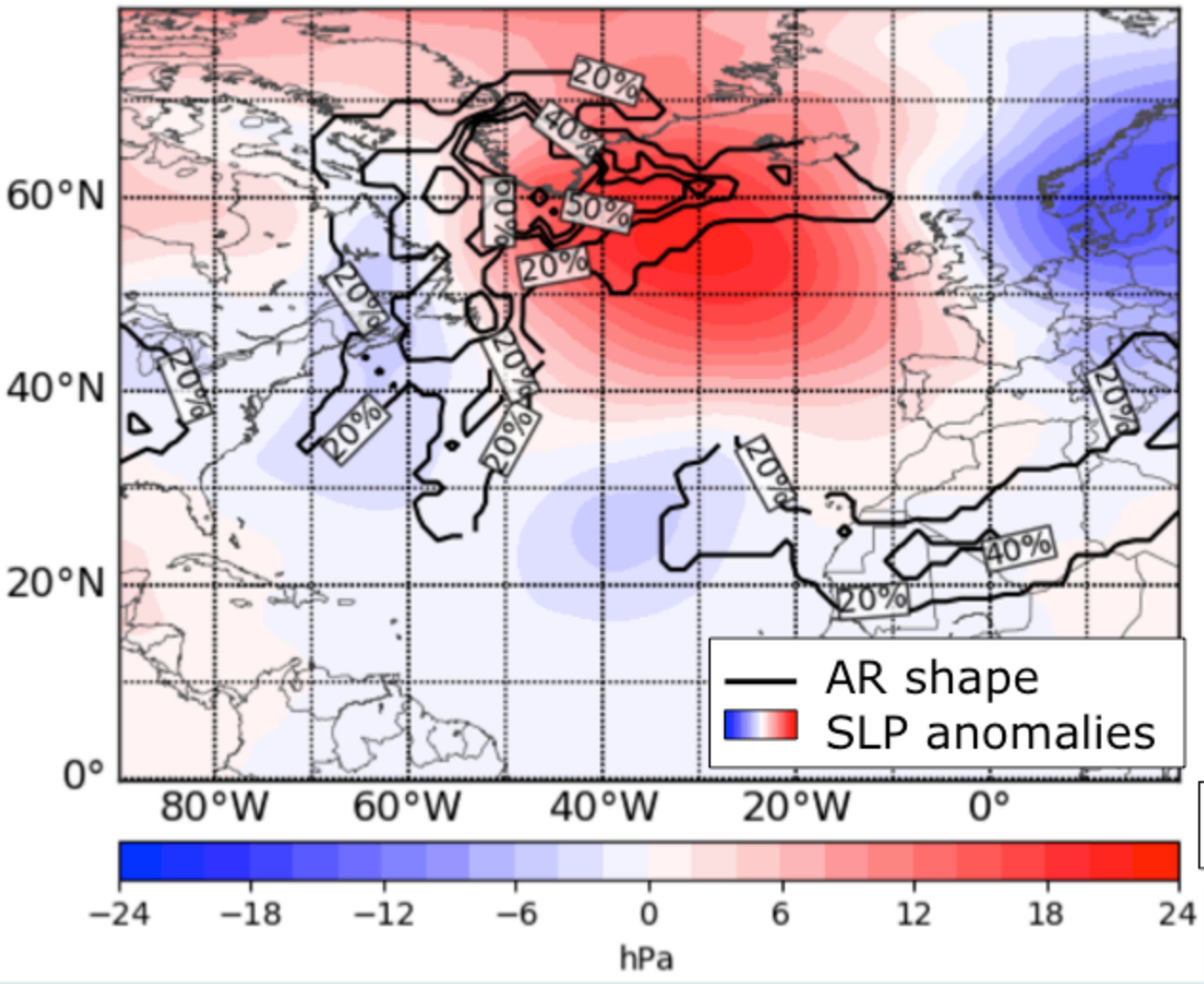
Compound events at Den Helder **without AR landfall*** in Europe *(UK, E&P, FR, NL, D or DK)*



52 events

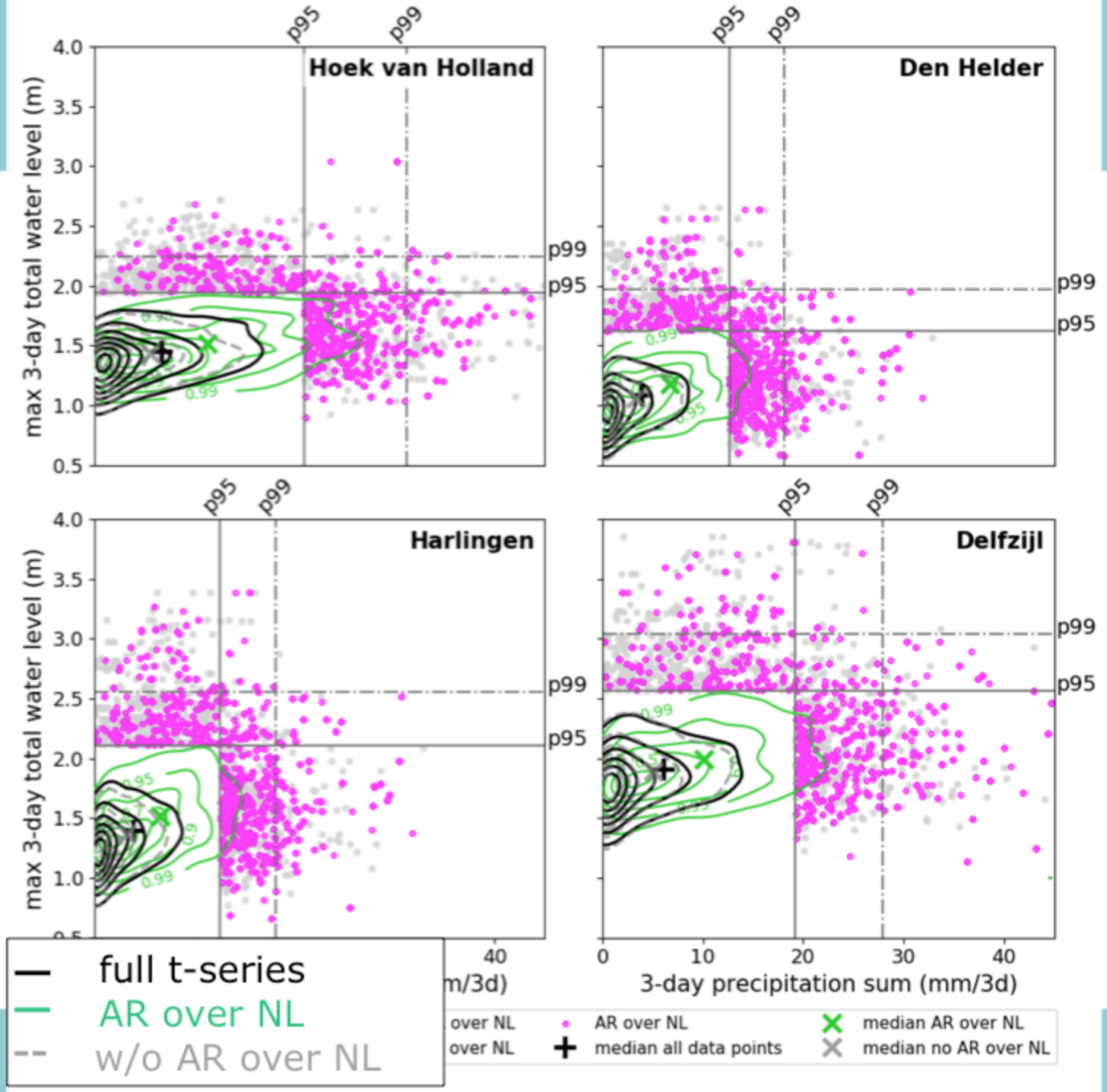
*+/- 1 day

Compound events at Den Helder **without ARs over NL and without LF in Europe** within 24 hours



12 events

Joint density distributions during AR over NL



Summary and conclusions

➢ AR landfall in the NL

Top-down

- show an affinity to **higher precipitation and water levels** with a **positive correlation** between the two variables
- can be **associated** with **past CEs**, however a small subset of local AR LF events only

Bottom-up

- are associated with only **~10% of past CEs**
- are **not necessary** requirement **for an AR systems to cause CEs**

➢ only a **small number of CEs** (10 – 15%) have occurred **without the presence of AR** over Europe

⇨ identification of **two different types of CEs**

Thank you!

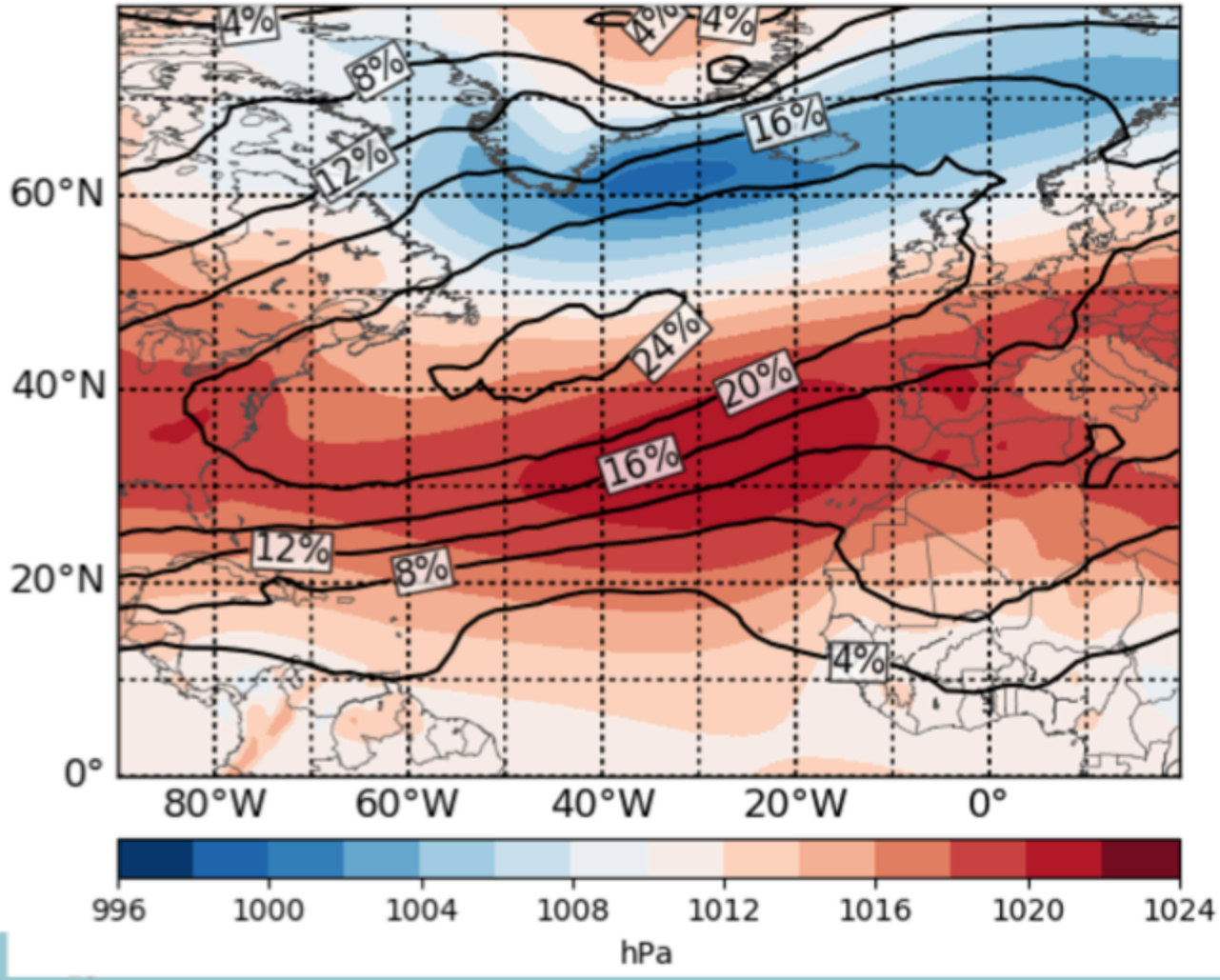
References

Guan, B., & Waliser, D. E. (2015). Detection of atmospheric rivers: Evaluation and application of an algorithm for global studies. Journal of Geophysical Research: Atmospheres, 120(24), 12514-12535.

Hazeleger, W., Van den Hurk, B. J. J. M., Min, E., Van Oldenborgh, G. J., Petersen, A. C., Stainforth, D. A., ... & Smith, L. A. (2015). Tales of future weather. Nature Climate Change, 5(2), 107.

Waliser, D., & Guan, B. (2017). Extreme winds and precipitation during landfall of atmospheric rivers. Nature Geoscience, 10(3), 179.

AR and SLP daily mean climatology



During the study period 4,315 days with an AR over NL

→ **~1 AR/3 days**

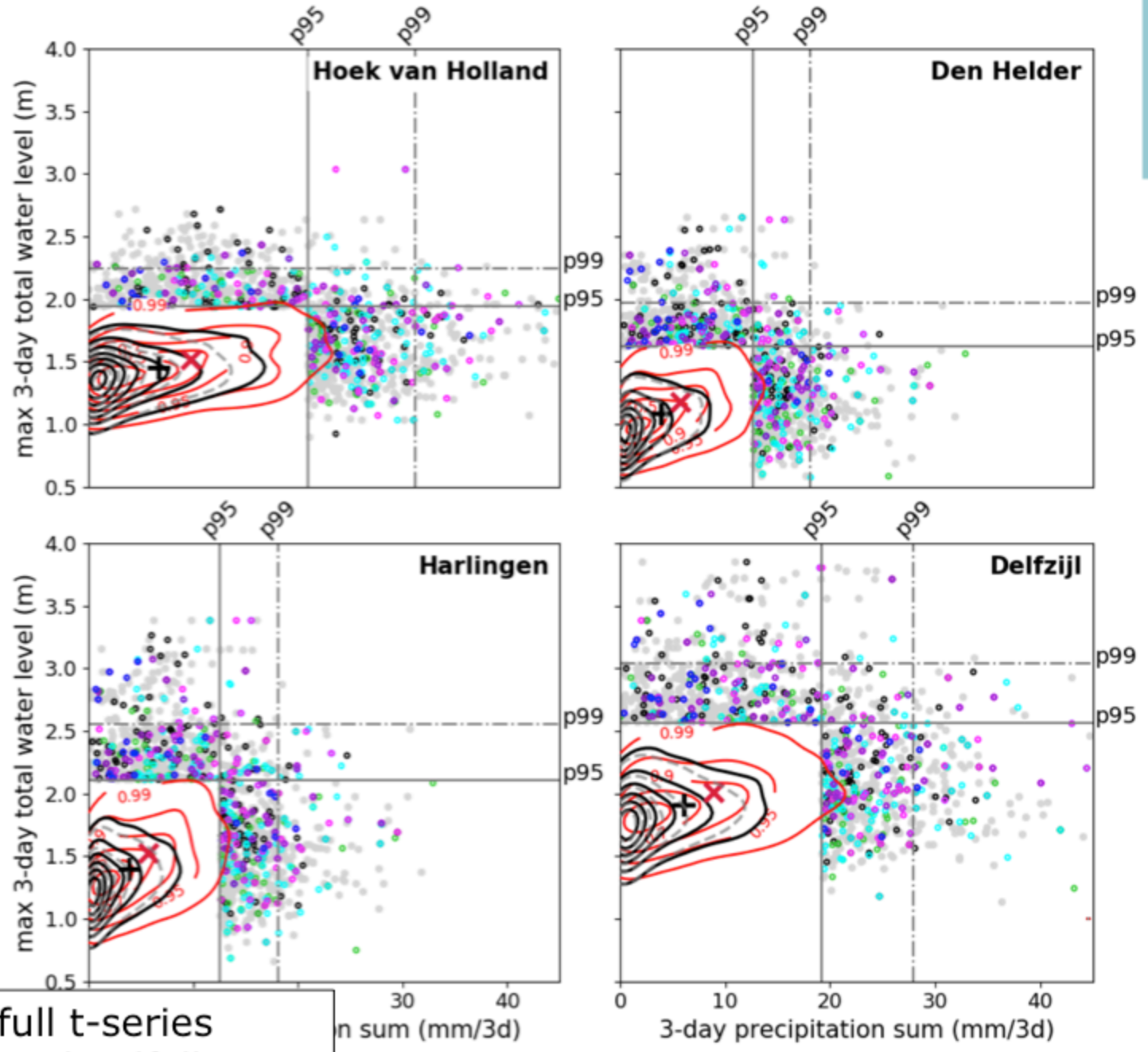
AR shape
SLP

Definition of compound events (CEs)

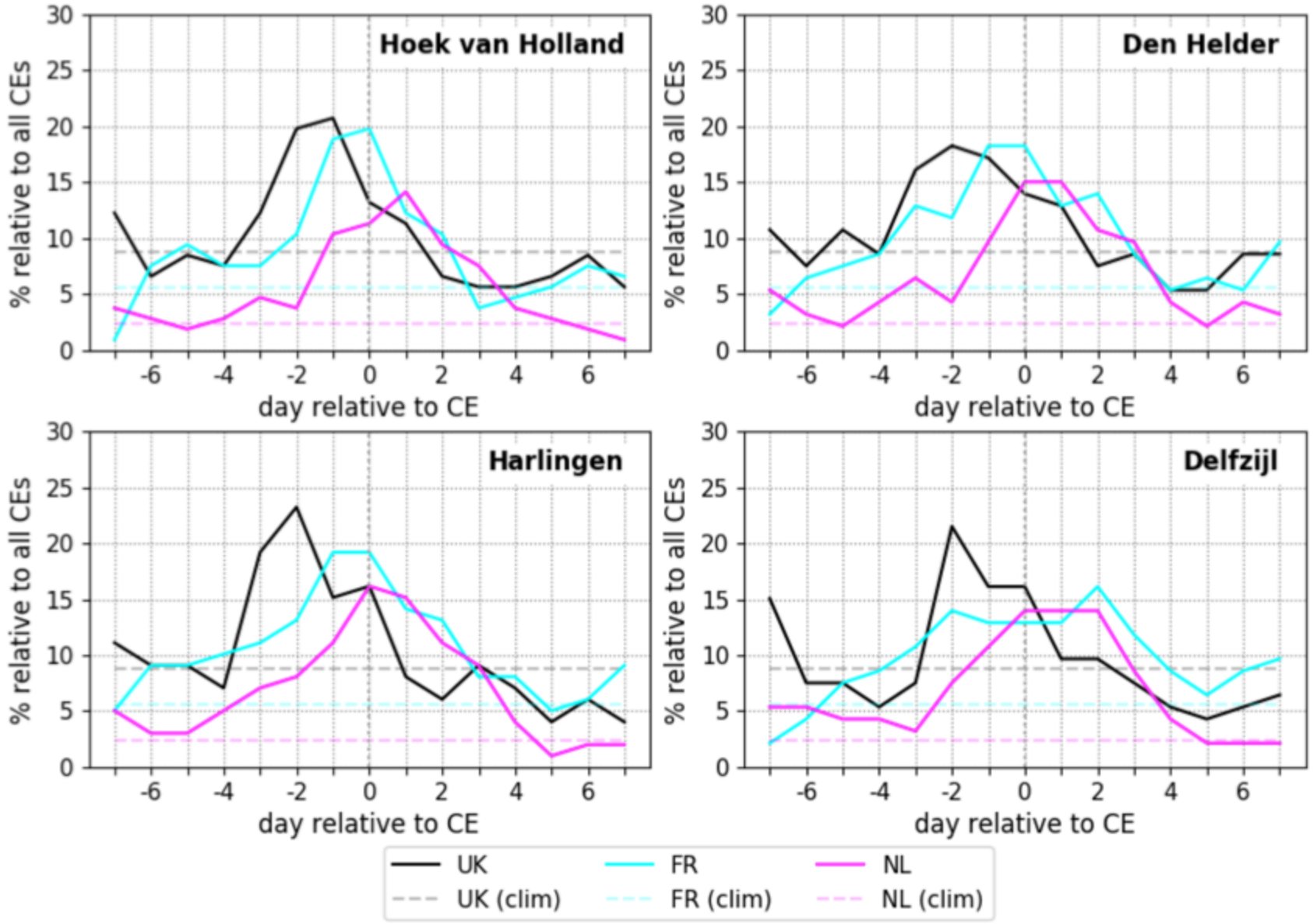
Definition needs to take into account:

1. **Time** constraint that is:
   a) long enough local hydrological processes to take place which allow interactions between precipitation & coastal water level
   b) shorter than the time scale at which larger river catchment processes become relevant
2. **Threshold** considering relatively short study period of 37 years, i.e. limited data availability

Joint density distributions during AR landfall in UK, E&P, FR, DK, NL & D

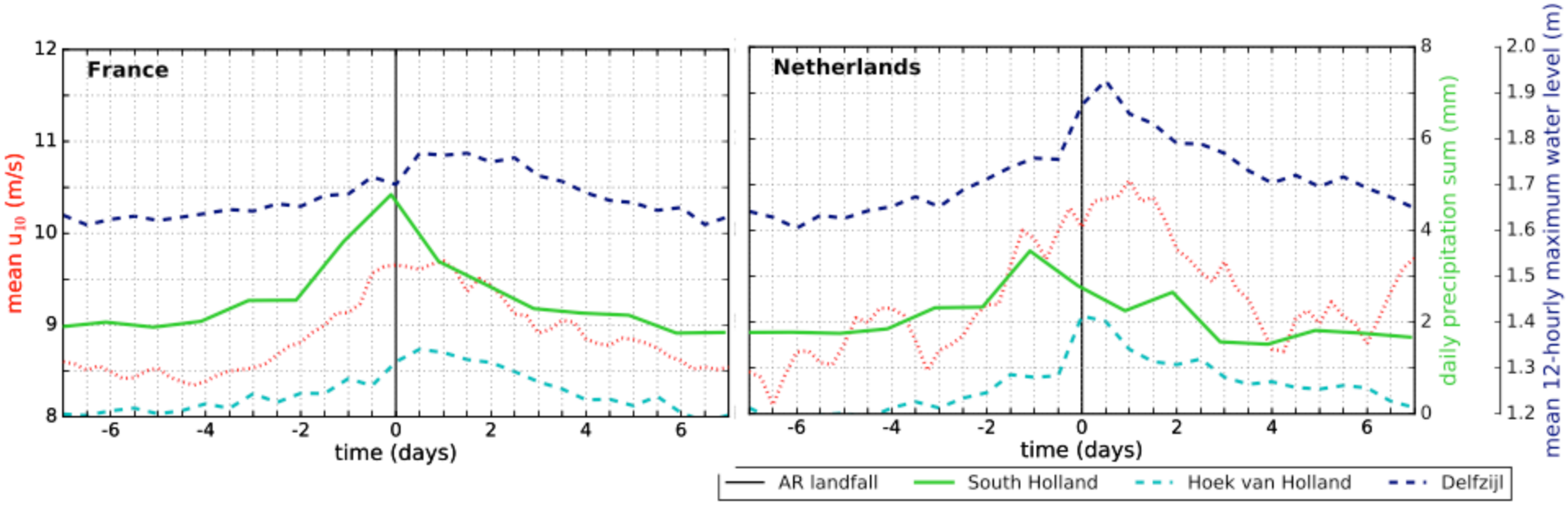


AR LF relative to day of CE



Results

Relating AR landfall with precipitation (P) & water levels (h)
(mean over all LF events)



⇨ Landfall of AR systems have the potential to cause compound events