Characterizing large-scale circulation triggering heavy precipitation in the northern French Alps

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Context / Objectives

- Large-scale circulation (LSC) explain a significant part of Alpine precipitation.
- Heavy precipitation LSCs are usually characterized using weather-type classifications, providing useful information on the different weather patterns. However, the discrete nature of weather-types leads to a loss of information.

This work proposes a **continuous characterization of heavy precipitation LSC using atmospheric descriptors based on analogy.** The atmospheric descriptors describe both **the stationarity of LSCs** and **their relative position in the atmospheric space.**

Region of study / Data

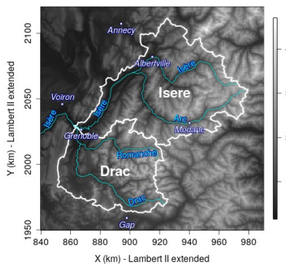


Fig. 1 : Left : 500 hPa analogy window (light blue) and region of study (red). Right : The Isère and the Drac River catchments

- **The Isère River catchment at Grenoble (5800 km²).** Main influence : **Atlantic circulations (zonal flows).**
- **The Drac River catchment at Grenoble (3600 km²).** Main influences : **Altantic and Mediterranean circulations (zonal and meridional flows).**
- **3-day catchment precipitation**
- **Daily 500 hPa geopotential height fields** from the 20CR-V2c reanalysis
- **1950-2011 period**

The atmospheric descriptors

- Based on analogy in geopotential shape using the **Teweles Wobus Score (TWS).**

Celerity

TWS between one day and its previous day.

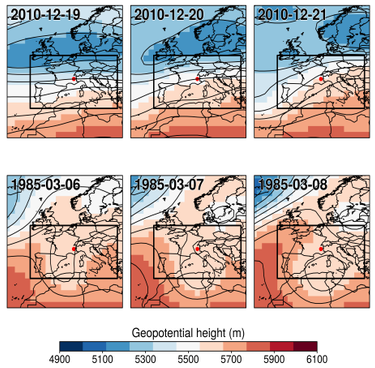


Fig. 2 : 3-day sequence of minimum (top) and maximum (bottom) celerity

=> To measure the stationarity of geopotential shapes

Singularity

Mean TWS between one day and its 112 (0.5%) closest days.

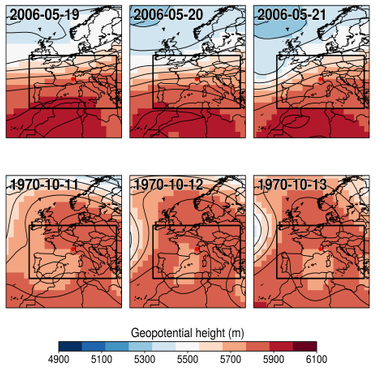


Fig. 3 : 3-day sequence of minimum (top) and maximum (bottom) singularity

=> To measure the usualness of geopotential shapes

Relative singularity

Singularity normalized by the TWS with the 112th closest day.

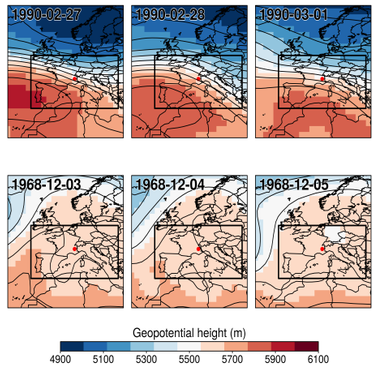
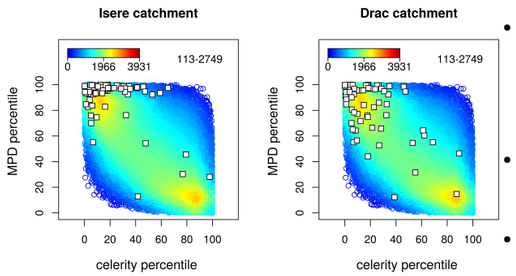


Fig. 4 : 3-day sequence of minimum (top) and maximum (bottom) relative singularity

=> To measure the clustering of geopotential shapes

Characteristics of heavy precipitation LSC

Stationarity



- For both catchments, heavy precipitation LSCs feature **among the most stationary geopotential shapes (low celerity values)**
  => slow-moving geostrophic wind direction
- Heavy precipitation LSCs associated with zonal flows (Isère catchment) show **among the strongest centers of action (high MPD)**
- **=> strong geostrophic wind**

*Fig.5 : Scatterplot of the 3-day sequences in the plan of the celerity against the maximum pressure difference, expressed as percentiles. **The maximum pressure difference (MPD)** is the range of geopotential height, averaged over 3-days. **It informs about the strength of the centers of action, and therefore about the strength of the geostrophic wind.** The points are colored with respect to the density of points in the scatterplot. The top-right numbers indicate the range of values actually taken in the corresponding panel. **The white squares show the 62 sequences that triggered the annual maxima of 3-day precipitation in the Isère catchment (left) and in the Drac catchment (right).***

Singularity

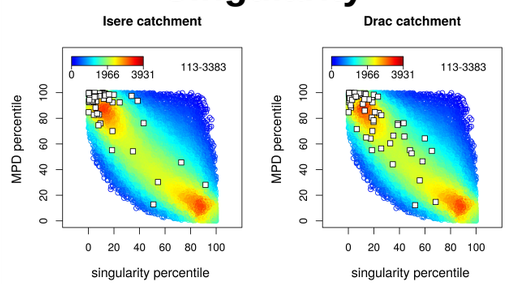


Fig.6 : Same as Fig. 5, for the singularity descriptor

- Heavy precipitation LSCs associated with zonal flows (Isère catchment) show **among the most twinlike circulation patterns** (low singularity)
- Heavy precipitation LSCs associated to meridional flows (Drac catchment) feature less twinlike circulation patterns

Clustering

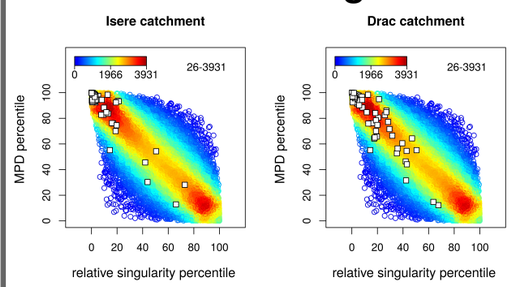


Fig.7 : Same as Fig. 5, for the relative singularity descriptor

- Heavy precipitation LSCs associated with zonal flows (Isère catchment) show **among the highest degree of clustering** (low relative singularity)
- Heavy precipitation LSCs associated to meridional flows (Drac catchment) feature a lower degree of clustering

Conclusions

- Whatever the circulation patterns, heavy precipitation LSCs feature **among the most constant geostrophic wind direction, corresponding to quasi stationary situation in altitude.**
- Heavy precipitation LSCs **associated with zonal flows feature more twinlike circulation patterns than other LSCs.** They show **among the strongest geostrophic wind and among the highest degree of clustering in the atmospheric space.**

References : • ***Blanchet et al., 2018***, *doi : 10.1002/asl.809* • ***Blanchet and Creutin., 2020***, *doi : 10.1175/JAMC-D-19-0112.1* • ***Faranda et al., 2016***, *doi : 10.1038/srep41278*