# Supplement to: The simultaneous occurrence of surge and discharge extremes for the Rhine delta

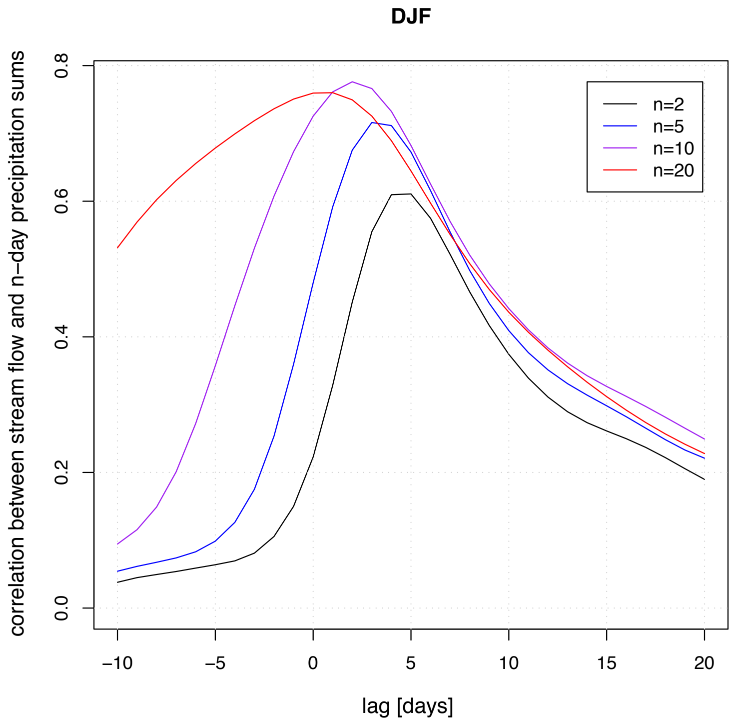


Figure S1: Correlation between daily measured streamflow at Lobith and $n$-day Rhine basin precipitation (see key for colour coding) from the E-OBS dataset for DJF in the years 1950–2000, as a function of the lag between the end of the $n$-day precipitation aggregation period and the day of the streamflow measurement. E-OBS (Haylock et al., 2008) is a daily gridded observational dataset extending from 1st Jan 1950 – recent months, for precipitation, temperature and sea level pressure in Europe, based on ECA&D (European Climate Assessment & Dataset) information. We use E-OBS precipitation fields, which are supplied at a resolution of 0.25°, but then averaged over the area 46.5°N–51°N, 4°E–10°E, approximately corresponding to the Rhine basin box in Fig.1 of the manuscript. Note that we use E-OBS precipitation instead of our model precipitation because the model ensemble was used to generate new sequences of rain-bearing systems and thus does not contain the historical sequence that gave rise to the observed streamflow.

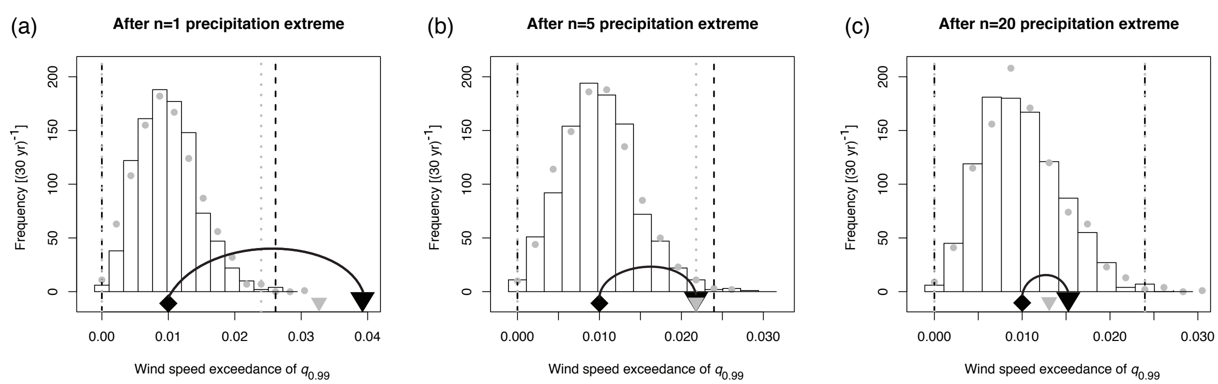


Figure S2: Exceedance of the climatological wind speed $q^w_{0.99}$ for days immediately following extreme $n$-day precipitation sums (marked on the horizontal axis by a black triangle for 1950–1980, and grey triangle for 2070–2100) and, for comparison, for the 1000 random samples (see Section 2.3 for details on construction of the samples) presented as a histogram (bars for 1950–1980, dots for 2070–2100). The vertical lines enclose 99% of the 1000 samples (black dashed for 1950–1980, grey dotted for 2070–2100). The climatological exceedance, 0.01, is marked by a black diamond.

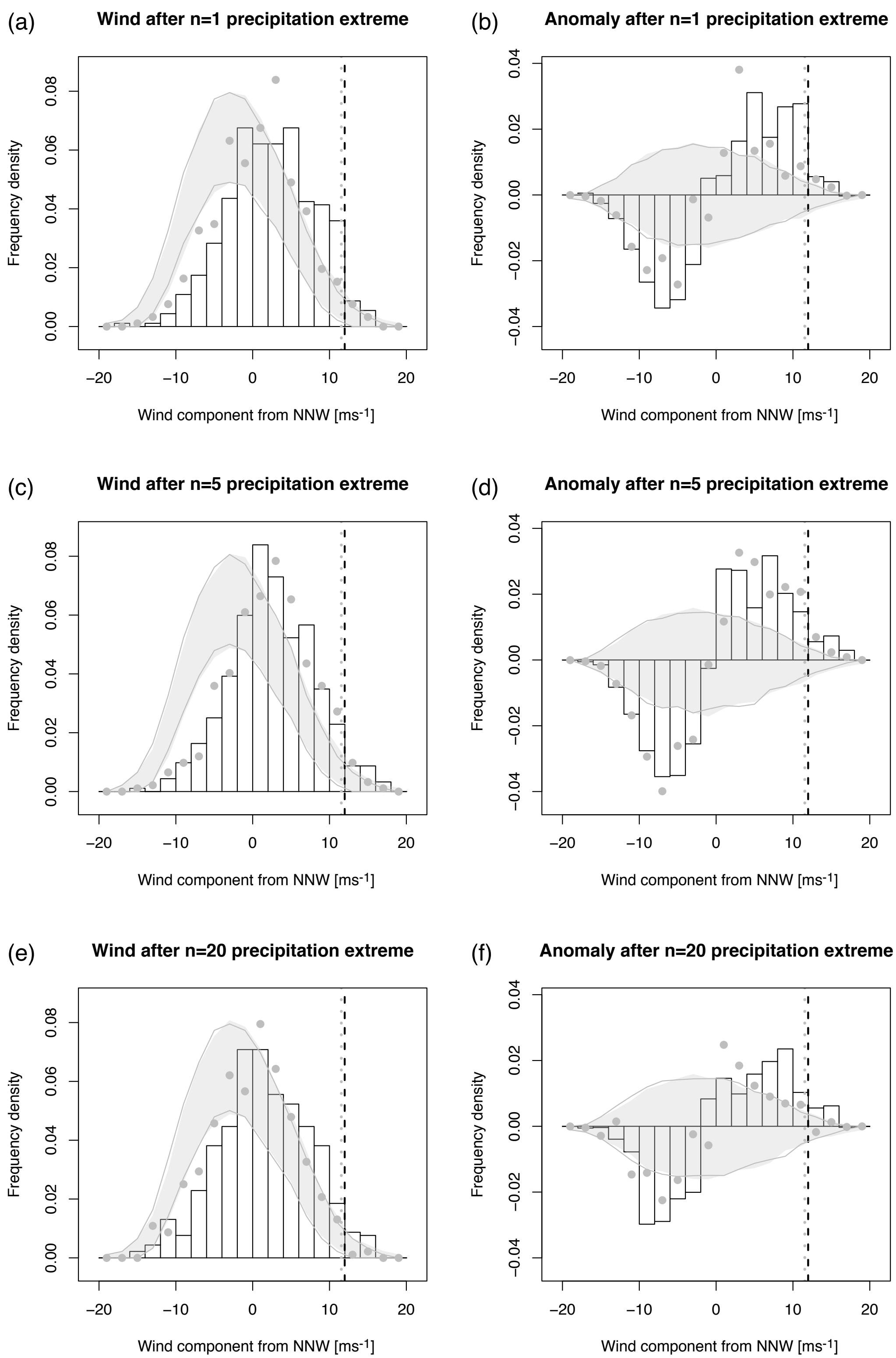


Figure S3: NNW wind component following extreme (bars for current climate 1950–1980, dots for future 2070–2100) and random samples (95% density range, shaded for current climate, outlined for future) of $n$-day precipitation sums (left) and their anomaly with reference to climatology (right). The $q^{w}_{0.99}$ threshold is marked with a dashed line (black for current climate, grey for future).

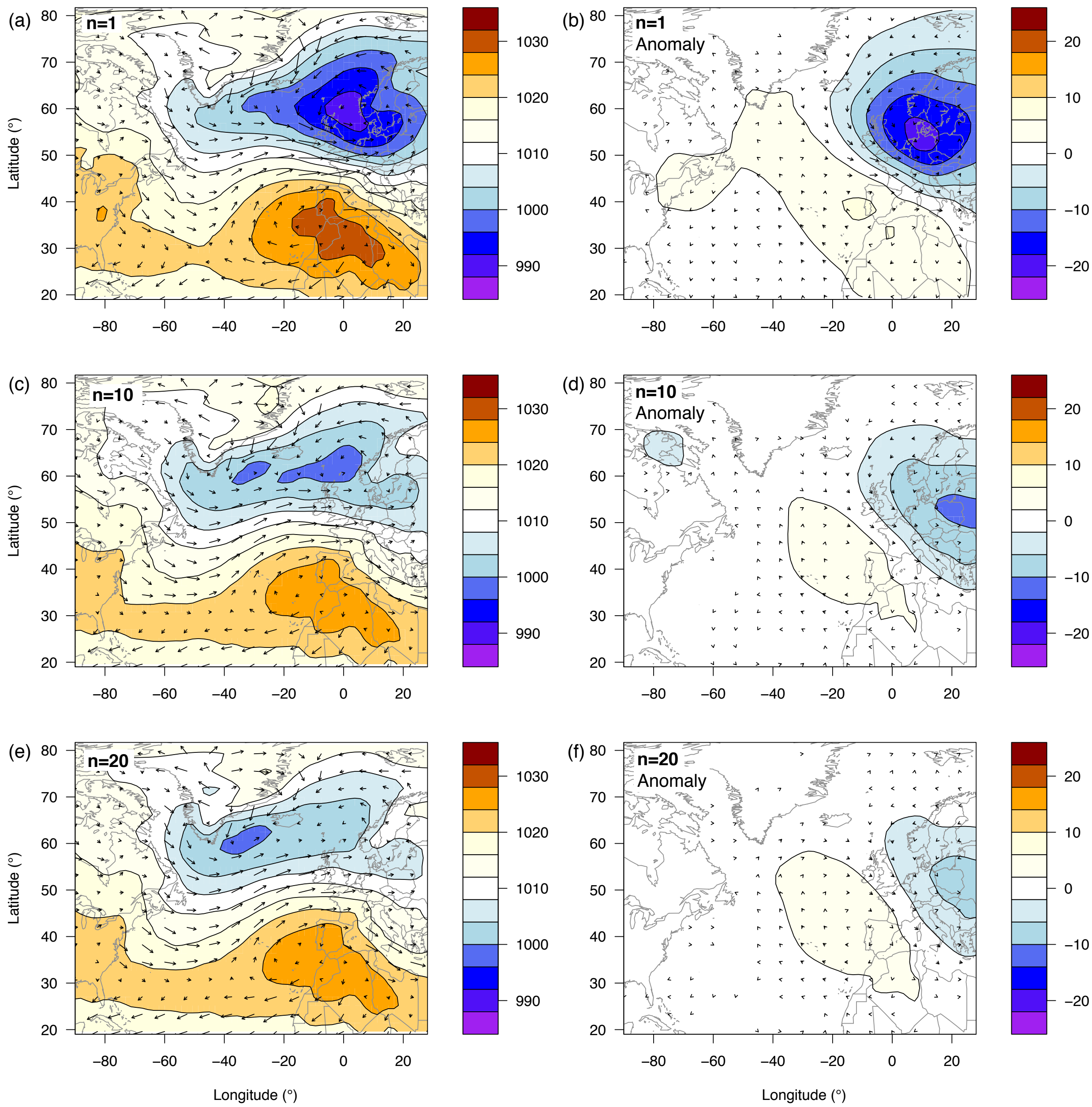


Figure S4: Precipitation conditioning: SLP climatology in hPa conditioned on 1-day (a-b), 10-day (c-d) and 20-day (e-f) precipitation extremes, for which the rainfall has fallen over the $n$-days preceding the synoptic situation shown. Each panel contains 459 entries. Left hand column contains conditional SLP climatologies, right hand column contains the anomaly of the conditional climatology with respect to the full climatology in Fig. 6a).

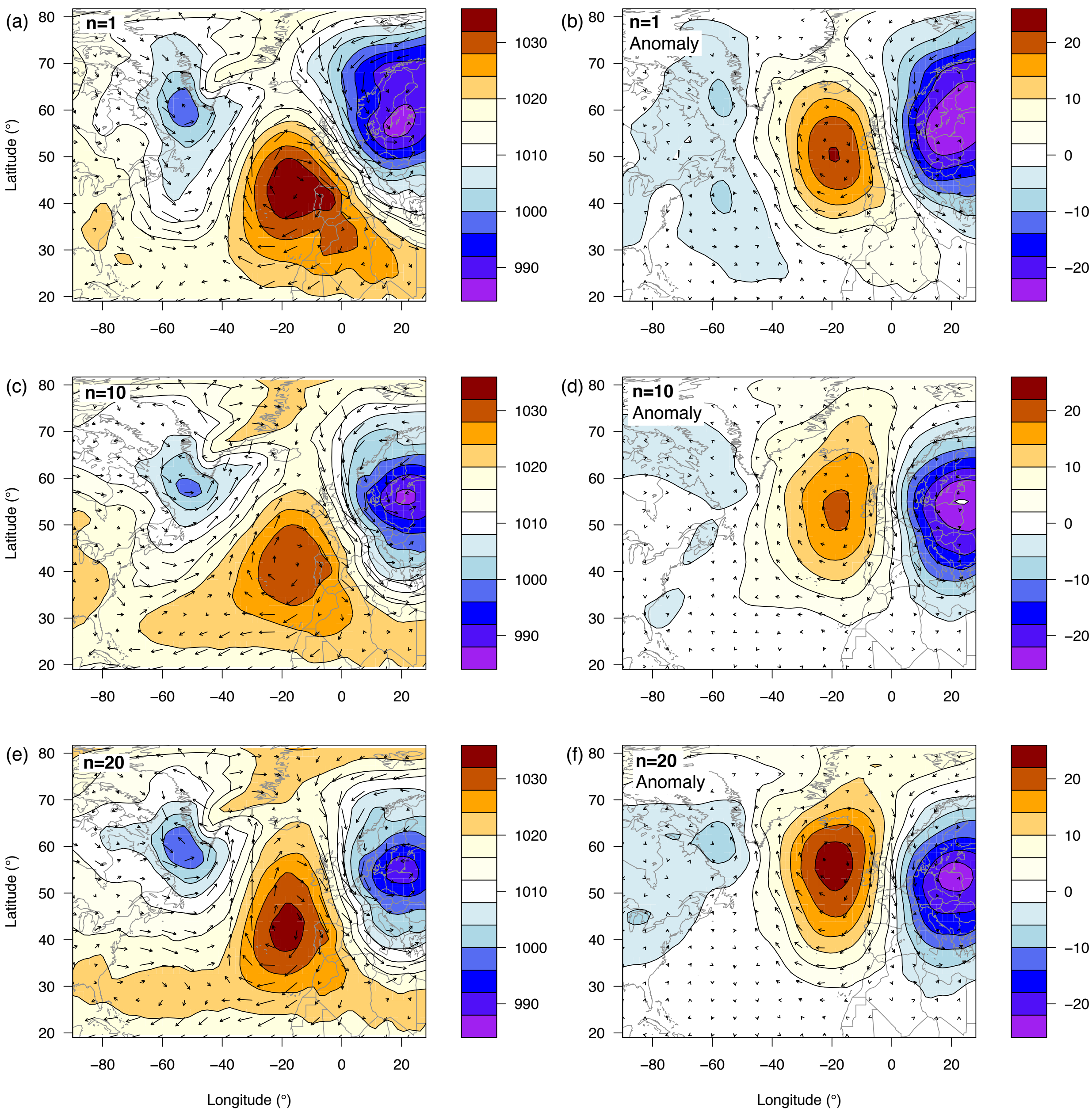


Figure S5: Joint event conditioning: SLP composite in hPa for events satisfying both wind and precipitation extremes following 1-day (a-b), 10-day (c-d) and 20-day (e-f) precipitation sums. Each panel contains on the order of 20 entries. Left hand column contains conditional SLP climatologies, right hand column contains the anomaly of the conditional climatology with respect to the full climatology in Fig. 6a).

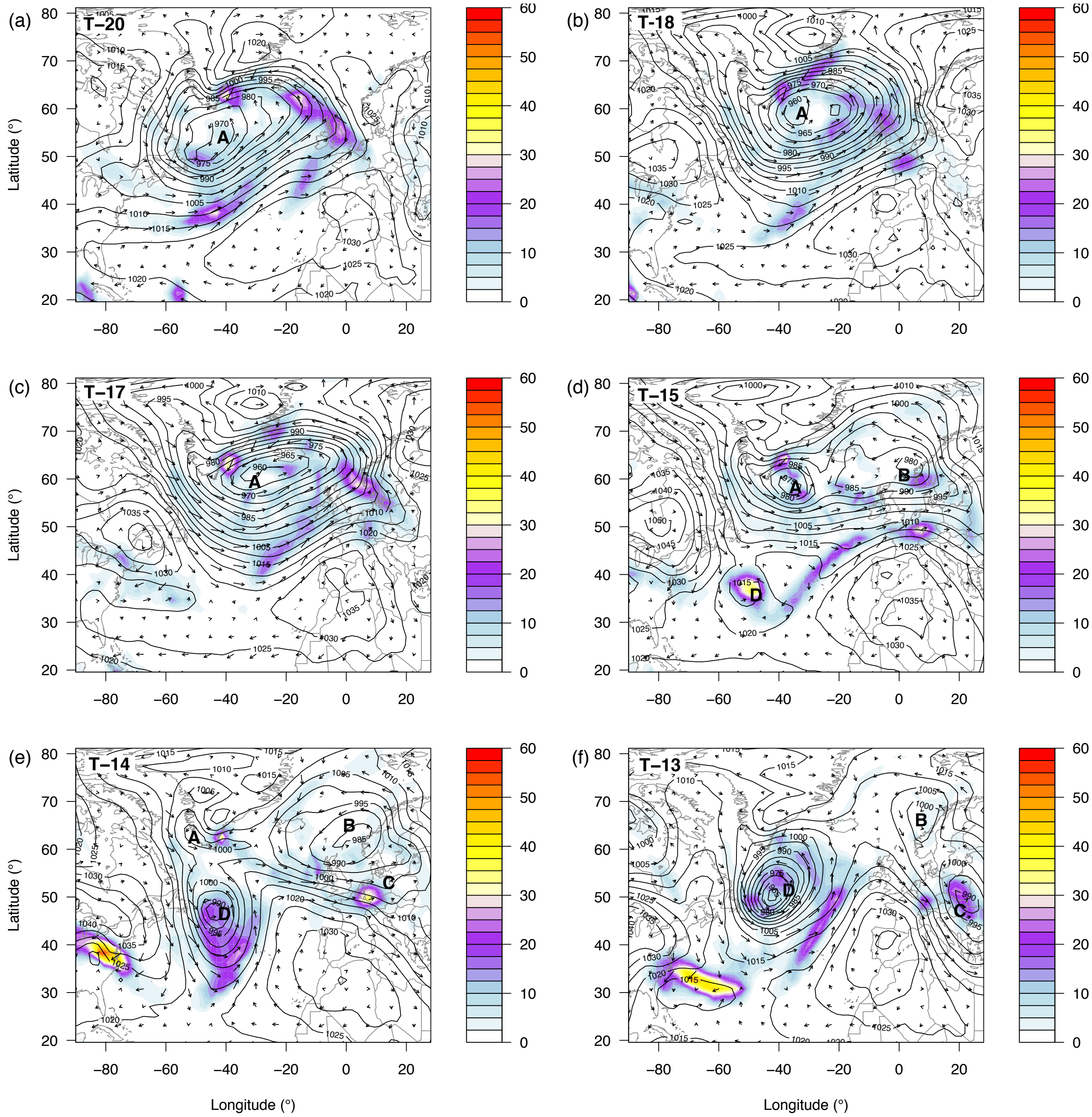


Figure S6: Evolution of synoptic situation for a single event that satisfied the joint extreme condition ($n = 20$ for precipitation) at time $T$. Time references are in days relative to $T$. The SLP field (12 UTC) in hPa is contoured, precipitation in mm/24h is shaded, daily average wind vectors are superimposed.

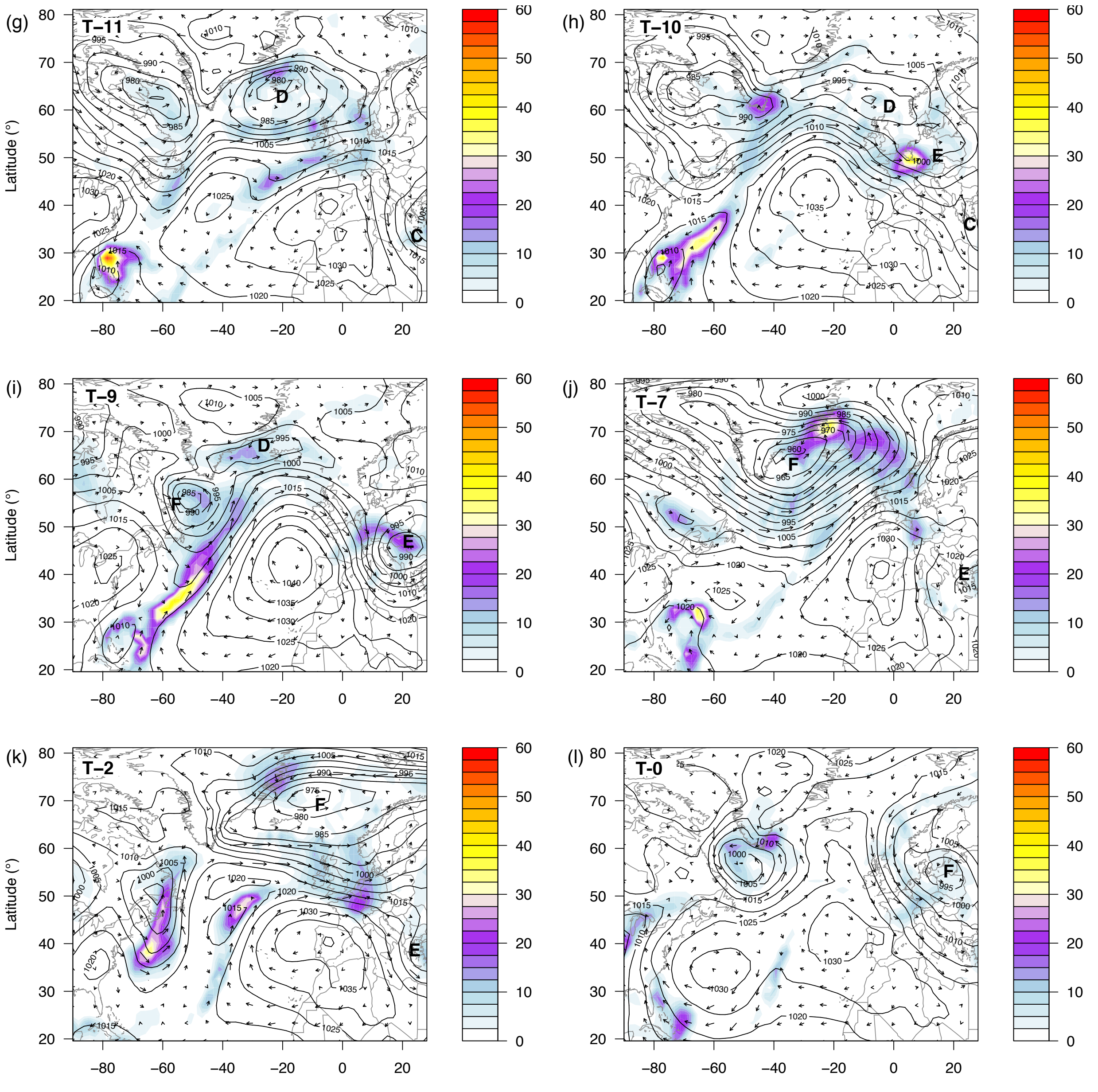

Figure S6: continued

## References

Haylock, M.R., N. Hofstra, A.M.G. Klein Tank, E.J. Klok, P.D. Jones and M. New.: A European daily high-resolution gridded dataset of surface temperature and precipitation. J. Geophys. Res (Atmospheres), 113, D20119, doi:10.1029/2008JD10201, 2008.