

Supplement of

Increases in flash flood events and flash flood favouring atmospheric conditions in temperate regions of Europe

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S2: Comparison of trends on differing pressure levels (500 hPa, 700 hPa, 850 hPa) for specific humidity (q), relative humidity (RH), and wind speed (WS). These figures are related to Figure 5 in the manuscript.

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S2.1 Specific humidity (q) at 700 hPa and 850 hPa

For this supplement we have used the same thresholds as initially identified for the 700 hPa level. As specific humidity is decreasing with height, we were not able to count enough values above 0.004 kg kg^{-1} at 500 hPa to be able to plot or compare them. At 850 hPa, the positive trend found at 700 hPa remains (Figure 1 e, g). It is, however, less strong in the East of the study area, where it is moreover insignificant (Figure 1 f).

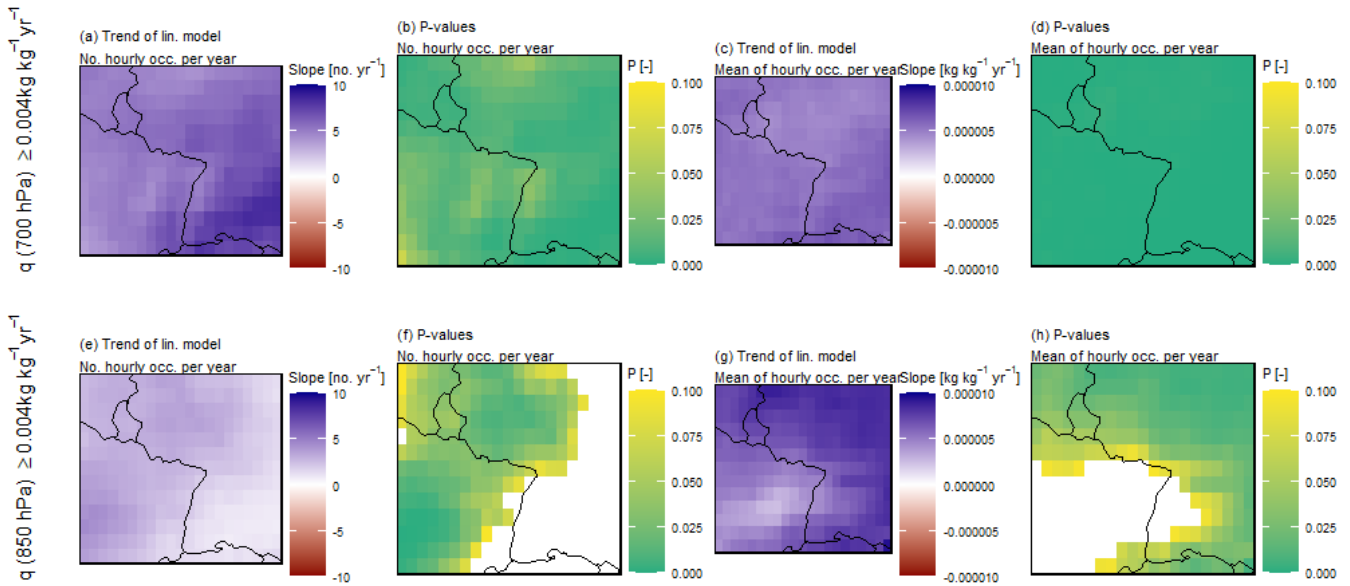


Figure 1: Trend analysis of the specific humidity (q) above the identified threshold of 0.004 kg kg^{-1} at two differing pressure levels: 700 hPa and 850 hPa. The first column (a, e) shows the trends of the numbers of hourly occurrences of values above the threshold, including their significance-levels p in the second column (b, f). The third column (c, g) shows the trends of the mean values of all hourly occurrences above the threshold and the last column (d, h) their respective significance-levels p. White areas mark insignificance.

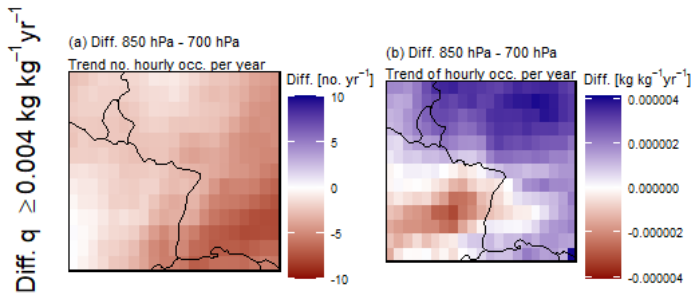
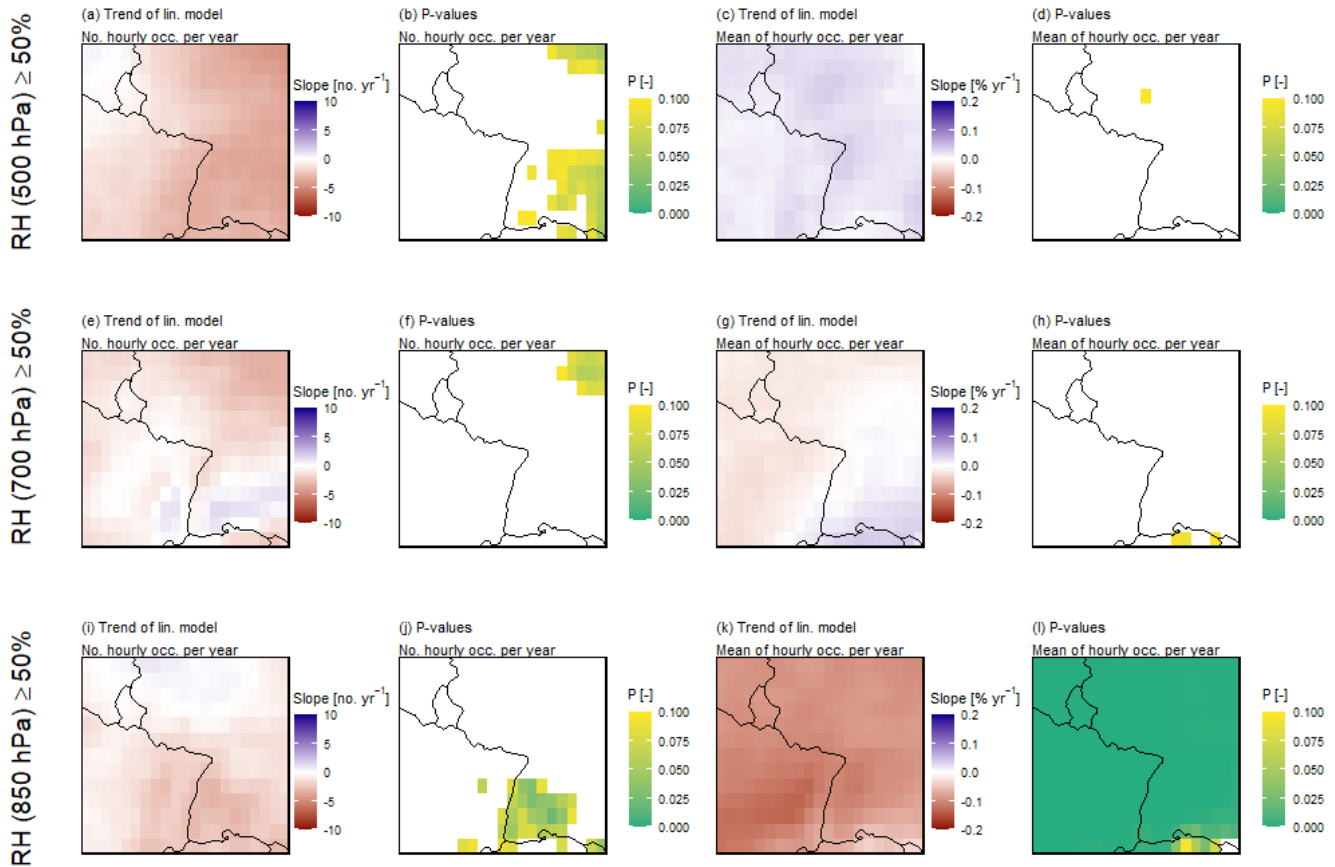


Figure 2: The difference of trends in specific humidity (q) above 0.004 kg kg^{-1} between the pressure levels 850 hPa and 700 hPa regarding the annual number of occurrences (a) and the actual values (b).

S2.2 Relative humidity (RH) at 500 hPa, 700 hPa, 850 hPa

35 The decrease in relative humidity (RH) is stronger at lower levels of the atmosphere (850 hPa) (Figure 3 i, k), where especially the mean of high RH is decreasing at a significant level (Figure 3 l). At the 500 hPa pressure level, the decrease in the number of occurrences is also stronger (Figure 3 a, b), than at 700 hPa. The actual values above the threshold increased however insignificantly at a very low rate (Figure 3 c, d). The 700 hPa level therefore shows a good proxy in the middle of the troposphere.



40 **Figure 3:** Trend analysis of the relative humidity (RH) above the identified threshold of 50% at three differing pressure levels: 500 hPa, 700 hPa and 850 hPa. The first column (a, e, i) shows the trends of the numbers of hourly occurrences of values above the threshold, including their significance-levels p in the second column (b, f, j). The third column (c, g, k) shows the trends of the mean values of all hourly occurrences above the threshold and the last column (d, h, l) their respective significance-levels p. White areas mark insignificance.

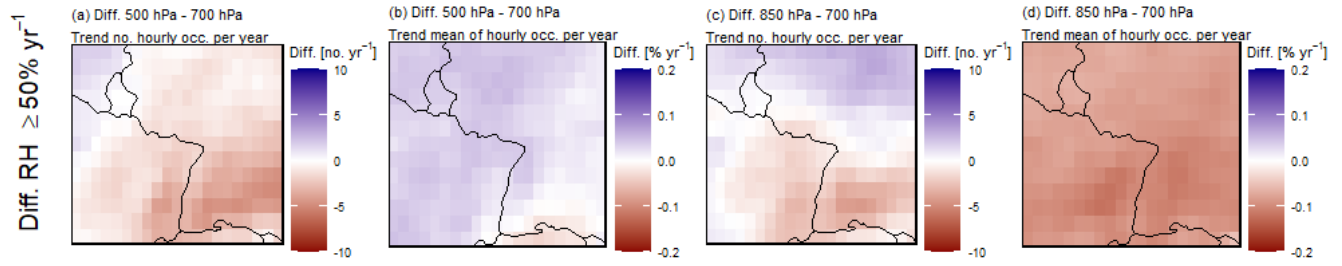
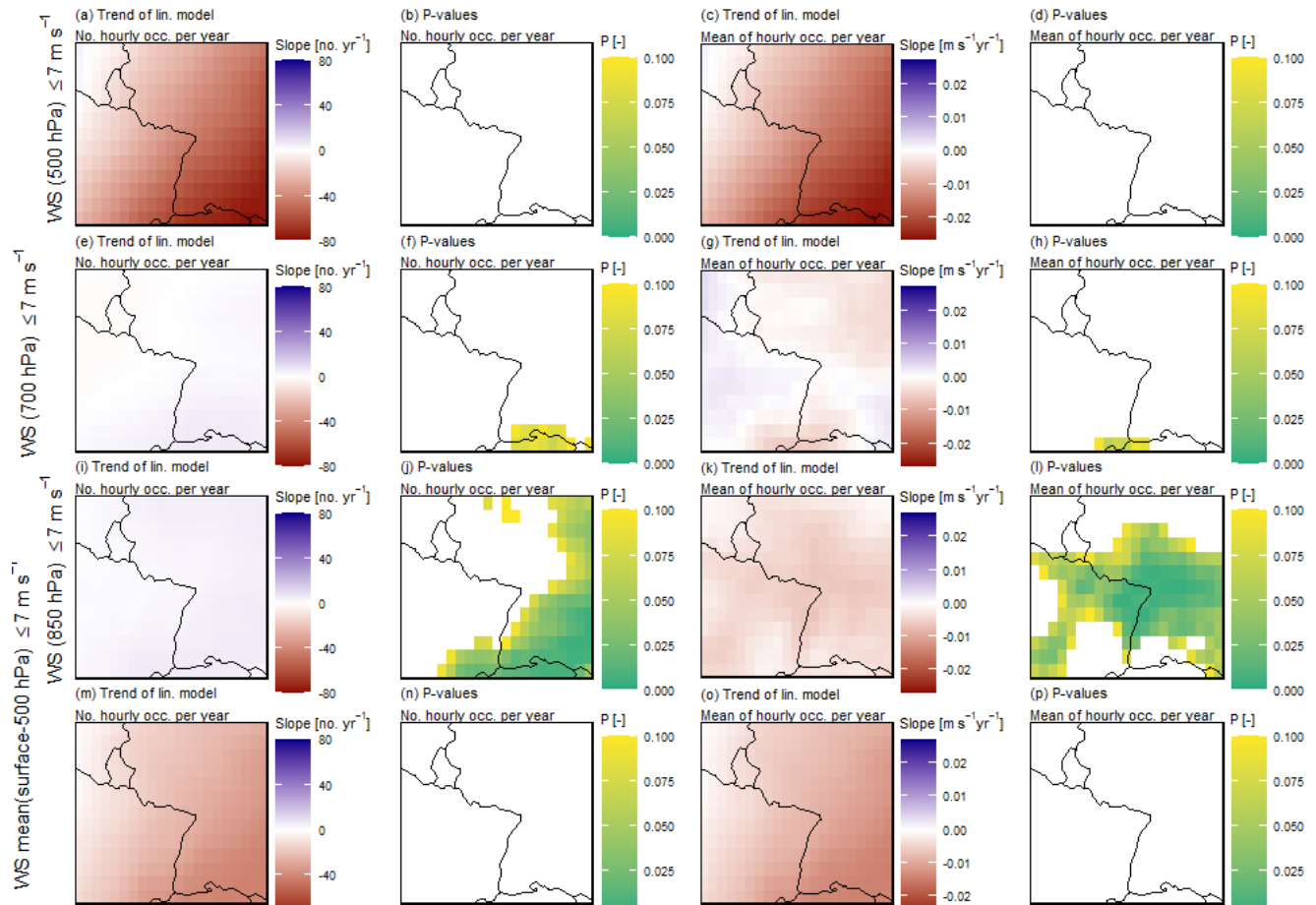


Figure 4: The difference of trends in relative humidity (RH) above 50% between the pressure levels 500 hPa and 700 hPa (a, b), as well as 850 hPa and 700 hPa (c, d).

S2.3 Windspeed (WS) at 500 hPa, 700 hPa, 850 hPa, and mean between 10m & 500 hPa

50 At 500 hPa trends in windspeed $\leq 7 \text{ m s}^{-1}$ are showing a stronger, but insignificant decrease compared to the 700 hPa level (Figure 5 a-d, Figure 6 a, b). The decreases in the mean WS below 7 m s^{-1} at the pressure level 850 hPa are even partly significant (Figure 5 k, l) and occur more often (Figure 5 i-j). Another common calculation of WS is the mean between the surface level (10 m above ground) and 500 hPa. It shows a stronger but insignificant decrease in the number of occurrences of low WS, as well as its mean compared to the 700 hPa level (Figure 5 m-p).

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60 **Figure 5: Trend analysis of the wind speed (WS) above the identified threshold of 7 m s^{-1} at three differing pressure levels (500 hPa, 700 hPa and 850 hPa) as well as considering the mean between the surface (10 m) and the pressure level at 500 hPa. The first column (a, e, I, m) shows the trends of the numbers of hourly occurrences of values above the threshold, including their significance-levels p in the second column (b, f, j, n). The third column (c, g, k, o) shows the trends of the mean values of all hourly occurrences above the threshold and the last column (d, h, l, p) their respective significance-levels p. White areas mark insignificance.**

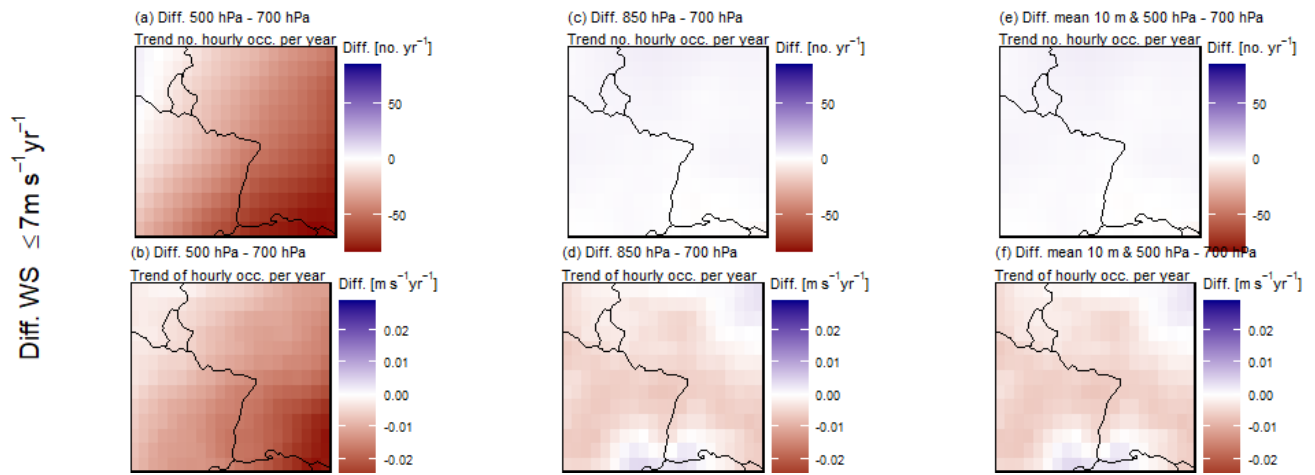


Figure 6: The difference of trends in wind speed (WS) below 7 m s⁻¹ between the pressure levels 500 hPa and 700 hPa (a, b), as well as 850 hPa and 700 hPa (c, d), and the mean of 10 m and 500 hPa and 700 hPa (e, f).