Supplement S3: Sensitivity of thresholds to the calculation method of atmospheric conditions during precipitation events

We added this supplement to demonstrate the differences between slight variations of our calculation methods to identify the atmospheric data during a precipitation event (P event), illustrated in Figure S3.1. The first method (Figure S3.1 a), extracted the atmospheric data for a P event only in the ERA5 grid cell in which the P event occurred. This method was applied in a preliminary version of this study. The second method also includes the mean of a buffer zone of ERA5 grid cells around the identified P events to get more representative values of the atmosphere and is the method applied in this manuscript. This approach is shown in Figure S3.1 (b)-(d). Figure S3.1 (c) shows the most common occurrence of P events within one ERA5 grid cell with the neighbouring grid cells. Figure S3.1 (b) shows two possible exceptions, when the P events occur at the boundary of the study area (i.e. a reduced number of surrounding cells) whereas Figure S3.1 (d) illustrates the selection of surrounding ERA5 grid cells, when P events are spread over multiple ERA5 grid cells.

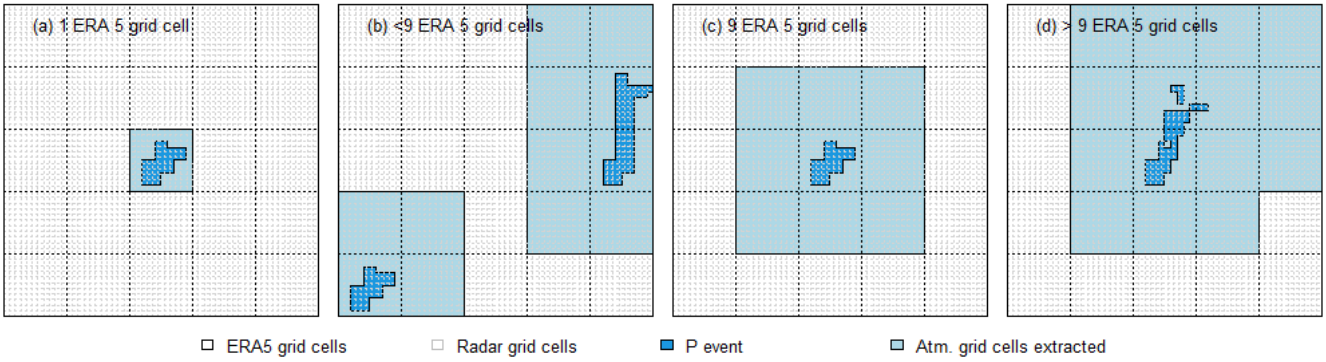

Figure S3.1: Schematic representation of the differing extraction methods compared, with (a) the case of one ERA5 grid cell, (b) including a buffer zone at the boundary of the study area, (c) the standard case of a buffer zone of a one ERA5 grid cell P event and (d) the case of larger P events. Mean values of <9, 9 and >9 ERA5 grid cells are used in the manuscript.

Table S3.1 and Table S3.2 show the number and percentage of P events for different numbers of ERA5 grid cells per P event. Almost 80% of all precipitation events occur within one ERA5 grid cell (Table S3.1), which leads to almost 70% of precipitation events (Table S3.2), that end up with the constellation of Figure S3.1 (c), including 9 ERA5 grid cells to determine the atmospheric conditions during a precipitation event.

Table S3.1: Number and percentage of P events per number of covered ERA5 grid cells

No. of ERA5 grid cells per P event	No. of P events	Percentage of P events [%]
1	3054	79.6
2	677	17.6
3	65	1.7
4	39	1.0
6	1	0.03

Table S3.2: Number and percentage of P events per number of ERA5 grid cells including a buffer zone.

No. of ERA5 grid cells per P event incl. buffer zone	No. of P events	Percentage of P events [%]
4	18	0.5
6	470	12.3
8	78	1.9
9	2631	68.6
11	5	0.1
12	551	14.4
15	52	1.4
16	30	0.8
18	4	0.1
20	1	0.03

For each analysed atmospheric variable (e.g. CAPE, q, WS, …) the parameter range during identified precipitation events is shown in Figure S3.2. The left boxplot (1) of each panel in Figure S3.2 shows the parameter value within the one ERA5 grid cell (Figure S3.1 a), in which the precipitation threshold was crossed. The third column (Figure S3.2 9) shows the applied approach of 80 % of the P events, where the P event occurred within one ERA5 grid cell. To get a representative value for atmospheric conditions, a mean was calculated for each P event including a buffer zone around the ERA5 event cell (eight neighbouring ERA5 grid cells) (Figure S3.1 c). The second boxplot (<9) of each panel in Figure S3.2 shows the exceptions, when precipitation events occurred at the boundary of the study area and the mean could therefore only be calculated from less than 9 grid cells. On the fourth boxplot per panel (>9), the spatially large precipitation events are represented, that cover more than one ERA5 grid cell. The mean of the atmospheric parameters is therefore calculated from more than 9 ERA5 grid cells. The value ranges of all four groups are rather stable and the different approaches do not make big differences. Therefore, we chose to use all precipitation events, independent of the number of ERA5 grid cells that were used to calculate the mean of the area, to calculate the thresholds.

Figure S3.2: ERA5 atmospheric parameter values that are present during precipitation events. The first row (a)-(c) shows the instability parameters. The second row (d)-(f) shows the moisture parameters, the third (g)-(j) the parameters related to system motion and organisation and the fourth (k)-(m) a few parameters related to soil moisture. The left column of each panel shows the parameter range within a single ERA5 grid cell, in which a precipitation event was identified. The second column shows events at the boundary of the study area, where a mean was determined with less than the full surrounding buffer. The third column shows the standard approach of the mean of a regular buffer zone and the fourth shows the precipitation events that span more than one ERA5 grid cell and therefore use a larger number of ERA5 grid cells.