The key role of meteorological preconditions in triggering large-scale floods

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Flooding

Severe and large-scale flooding is triggered by the interaction of

- Precipitation and topography
- Land use and vegetation
- Soil moisture, soil type (infiltration and surface runoff)
- Timing of precipitation and flood peak discharge of tributaries
- Snow cover
- Hydrological and hydraulic aspects of rivers
- Structural measures (dikes, retention reservoirs)

Fig.: Neckar at RT-Mittelstadt during 2013 flood event. © M. Kaschuba

Meteorological preconditions

Antecedent precipitation index (API) is used as a proxy for moisture stored in a catchment in the period before the event precipitation

Calculated for each grid point (1 km horizontal resolution)

API is given by the sum of daily precipitation weighted with respect to the time span (here: n = 30 days) of rainfall occurrence before the reference day

Event precipitation and antecedent precipitation is clearly seperated

$$\mathrm{API}(x,y) = \sum_{i=1}^{30} 0.9^{i}\, R_i(x,y)\ (n-i),$$

where Ri(x,y) is the 24-hr total at a specific grid point (x,y) and i represents the day prior the 3-day maximum

Extreme rain event (SW-Germany, November 2015) in comparison to 2013 flood event

Table: Top 8 rain events since 1 January 1951 (Federal state of Baden-Württemberg (BW), Germany, ~ 35.000 km²):

Rain amounts are given in mm per 24, 48 and 72 hours (spatial mean, horizontal resolution 1 km). Date represents last day of rain event. Data source: DWD

Date	RRacc 24h
07 Aug 1978	49.6 mm
06 Oct 1982	47.4 mm
20 Nov 2015	47.2 mm
22 May 1978	44.1 mm
23 May 1978	41.8 mm
24 Jul 1982	40.9 mm
03 Jun 1992	40.7 mm
19 Sep 1968	39.8 mm

Date	RRacc 48h
23 May 1978	85.9 mm
20 Nov 2015	61.8 mm
07 Aug 1978	58.0 mm
17 Dec 1982	57.5 mm
07 Oct 198 2	56.7 mm
05 Dec 1988	56.1 mm
14 Feb 1990	55.9 mm
29 Oct 1998	55.6 mm

Date	RRacc 72h
24 May 1978	89.0 mm
23 May 1978	86.1 mm
25 May 1983	73.1 mm
01 Jun 2013	68.5 mm
15 Feb 1990	68.4 mm
30 Oct 1998	67.1 mm
21 Nov 2015	66.9 mm
21 Mar 2002	66.9 mm

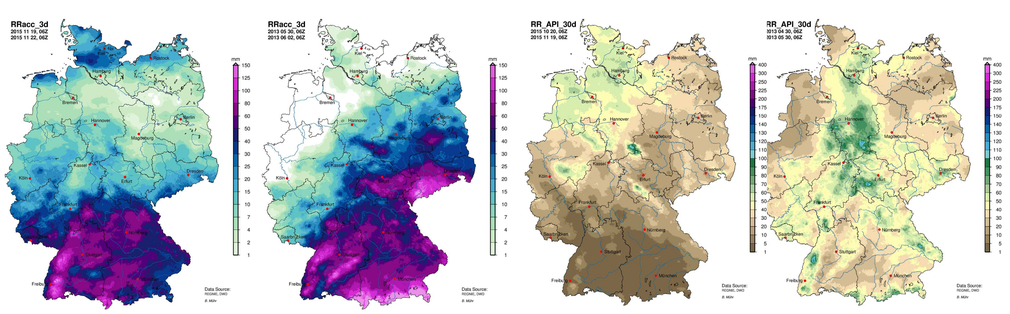

Fig.: 72hours accumulated rain amount (19 – 22 Nov 2015 (left) and 30 May – 02 Jun 2013) and 30 day API (20 Oct – 19 Nov 2015 (left) and 30 Apr – 30 May 2013). Data source: REGNIE, DWD

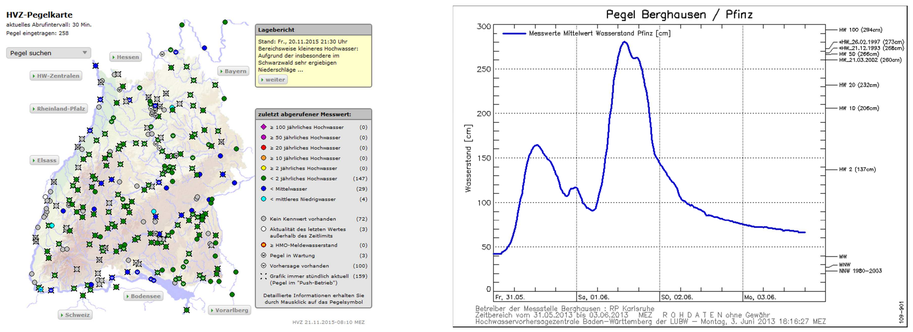

Fig.: None of the gauges in Baden-Württemberg were in flood stage in Nov 2015 (left); in 2013 e.g. the gauge of Pfinz near Karlsruhe reported a dischagre of 50-100 years flood.

Image source: Hochwasservorhersagezentrale Baden-Württemberg, HVZ

Conclusions

Precipitation

- Rain event Nov 2015 ranks 2nd since 1951 in BW in 48 hours
- 150-200 mm within 36-48 hours are extraordinary
- Several new daily records of rain amount within 24 hours
- Rain event in BW even heavier than 2013

Meteorological Preconditions

- Very low API values. No rain in 30 days before event
- Very dry months since February 2015 (!) in Bavaria, BW, Switzerland
- Nearly all rivers in BW were at low water, many of them close to their absolute minimum low water
- No snow cover neither in the Alps nor in the Black Forest

Consequences

- Nearly no flooding at all. Recurrence interval of nearly all gauges remained below 2 years
- Under normal circumstances, Nov 2015 rain event would have caused major flooding at least in Black Forest tributaries (rivers Kinzig, Murg, Nagold, Enz, Neckar)
- **Preceding rain (initial soil moisture) is crucial for flooding**

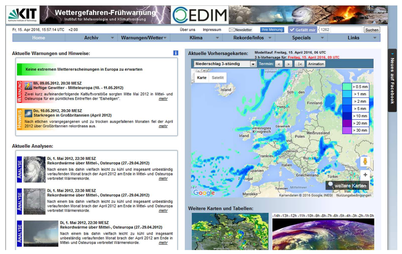

Fig.: Screenshot of Wettergefahren-Frühwarnung. Monitoring, weather prediction and reports on all extreme weather events worldwide within CEDIM's Forensic Disaster Analysis group.

Further information:

www.wettergefahren-fruehwarnung.de

www.cedim.de

[1] KIT – The Research University in the Helmholtz Association

[2] CEDIM – Center for Disaster Management and Risk Reduction Technology