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The millennium flood of July 1342 revisited

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ABSTRACT

The precipitation event in July 1342, which happened over an area now situated in central Germany, most probably exceeded in damage any other reported event in historic and recent times in Central Europe. According to historic sources, the event lasted several days and resulted in widespread and extreme soil erosion with gullies up to 10 m deep which devastated landscapes and ruined farmers. In several regional records the resulting river levels were the highest of their entire records. Remarkable are also observations of extreme flood levels also in regions without significant rainfall. Occasionally the spatial extent of the flooding was reported to reach from the North Sea coast to northern Italy, but other studies hint at missing flood reports from catchments in-between. Due to these and other partially contradicting reports we critically review the body of evidence in order to come to a more conclusive synopsis of the event.

Based on confirmed reports on floods and related rainfall, the millennium flood, we come to the conclusion that the event was generated by an extended convective system mainly confined to the catchment of the River Main and adjacent headwaters of tributaries of the Rivers Danube, Elbe, Weser and, Lahn. The intensity of the rainfall was sufficient to cause devastating soil erosion and extreme flood magnitudes along the river catchments even far downstream the precipitation area. Based on circulation patterns most likely related to extreme summer precipitation over the area indicated by those reports to which we attribute the highest confidence a Central European trough (TRM) configuration seems more plausible than the frequently postulated "Vb-track cyclone" (Genoa Low).

Peak discharge estimations along the Rivers Main (Würzburg, Frankfurt) and Rhine (Mainz, Cologne) suggest values up to approximately twice the largest flood ever observed by a gauge; for most downstream gauges the values are the largest of the entire historic record. Several findings previously related to this flood event fit to our explanation, when considering that during the year 1342 four additional severe floods took place in Central Europe.

1. The July 1342 flood in Central Europe — findings and contradictions

A multitude of historic reports, analyses, and reconstructions exist related to exceptional historic flood events in Europe (e.g. Brázdil et al., 2012, Glaser et al., 2010, Herget, 2012 and Schmidt, 2000). Besides the infamous Flood of Thuringia of 1613 (e.g. Militzer and Glaser, 1994) and the ice flood of 1784 (Brázdil et al., 2010) the extreme precipitation and succeeding flood event of July 1342, often termed the Magdalena flooding (since July 22 is the name day of St. Maria Magdalena) attracts attention. Due to its extreme intense precipitation and extensive flooding consequences (e.g. Tetzlaff et al., 2002, Dotterweich and Bork, 2007, Kiss, 2009, Zbinden, 2011) the event is often referred to as the millennium flood (Schmidt, 2002) or the hydrological worst-case scenario (Pfister and Hächler, 1991, Zbinden, 2011). The chronology of flood events of the Rivers Main at Würzburg and the Rhine at Cologne (Fig. 1) documents the extreme characteristic of this flood in the historic framework.

Numerous reports cited e.g. in Hennig (1904), Weikinn (1958), Alexandre (1987), and Schmidt (2000) or the TAMBORA-database (www.tambora.org) exist, which describe the exceptional water level, the spatial extent, and the destructions of the Magdalena Flood. According to Bork et al. (2006, 118f) precipitation started on the 19th of July 1342 in Franconia and Thuringia and spread out from Franconia to the Northwest. The authors assume that the precipitation area reached from the Danube Valley in the South to Northern Friesland in the North, and from the River Meuse in the West to the River Oder in the East, and they suggest a so-called Genoa low ("Zugstrasse Vb" cf. Mudelsee et al., 2004) moving from the Gulf of Genoa of the Mediterranean Sea to the Northeast. Other authors also speculate about a spatial extent reaching further to the South and affecting also the southern French city of Avignon (Balzius or Eccard according to Weikinn, 1958, 202 as well as Tetzlaff et al. (2002, 41)areas south of the mountain ridge of the Alps including Carinthia and Lombardy (HND Bayern), Austria in general (Weikinn, 1958, 204) and towards the East to the

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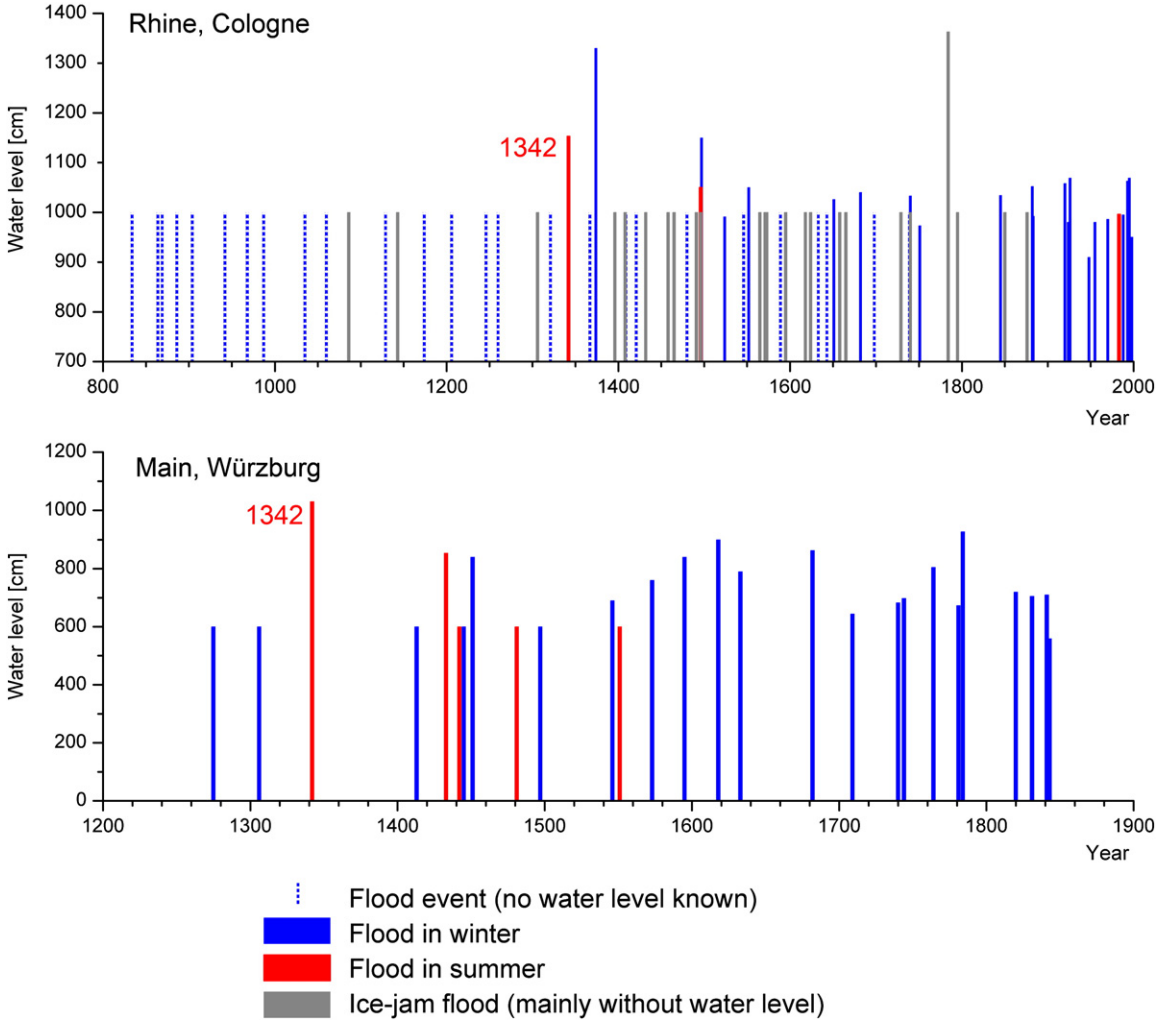

Fig. 1. Extreme flood levels of the River Rhine in Cologne and of the River Main in Würzburg. Modified from Herget (2012).

Vistula Valley (Bork and Kranz, 2008, 124). First discharge estimates related to the event exist for the rivers Main and Rhine, which exceed the highest values recorded so far: according to Schiller (1987) the River Main discharge at Würzburg reached approximately 3300 m^3/s, Tetzlaff et al. (2002) estimate for the same river 3500 m^3/s at Frankfurt, and according to Meurs (2006) the Rhine in Cologne might have reached a discharge of 11,100 m^3/s.

The flood destroyed or damaged many bridges, mills and buildings in several catchment areas of Central Europe. The intensive precipitation caused widespread soil erosion with deep gullies reaching several metres (e.g. Bork et al., 2003, Dotterweich and Bork, 2007, 39; Bork, 2014). Due to the degradation of the fertile top-soil and the extreme dissection, agriculture was abandoned in many places (Dreibrodt et al., 2010). It can be speculated, that a connection exists with the aftermath of the flood the bubonic plague during the years of 1348 to 1350, which caused mass mortality. Together with the hunger crisis during the second decade of the 14th century these events led to a decline in population in Germany by one third (Bork and Kranz, 2008) and numerous villages were abandoned (Abel, 1976).

There are, however, also reports related to the Magdalena Flood, which hint at missing precipitation and inundations in some regions and thus contradict the assumption of wide-spread precipitation almost covering the whole of central Europe. There are indications of missing precipitation especially over the Neckar catchment (Röckel, 1994, 34), the entire region of Württemberg in south-western Germany (Düwel-Hösselbarth, 2002), the Bavarian foothills of the Alps (Böhm, 2011), the Austrian Alps (Rohr, 2007, 275), Bohemia (Brázdil et al., 2005, 352, Brázdil et al., 2012, 147) as well as Hungary and the surrounding Carpathian Basin (Kiss, 2009, 41). The missing evidence of extensive precipitation in particular over Bohemia and reports of floods between Avignon and Friesland contradicts the Genoa low hypothesis, which is usually related to a northeastward air flow after passing the Alps in the east (Mudelsee et al. 2004).

Possibly these contradicting interpretations are caused by confusing different floods, which occurred in 1342. Hennig (1904) mentioned five flood periods in 1342: a) 23rd of January in the Upper Rhine region of the Alsace caused by a thunderstorm, b) 2nd and 3rd of February in Austria and Bohemia, c) in April at the Rivers Rhine and Main following cold days probably connected with snowmelt, d) 21st to 25th of July the exceptional summer flood discussed here, and finally e) around the 11th of November heavy thunderstorms in Lombardy in northern Italy. Rohr (2007, 226f) distinguishes three flood periods in this year with an ice-jam flood which e.g. destroyed the bridge at Prague in Bohemia, snowmelt floods in April, and the flood towards the end of July; he concludes that each of these floods was less dramatic in the eastern Alps but caused significant floods of the upper catchment of the River Danube down to Lower Bavaria. For Central Europe, Kiss (2009) also mentions three flood periods (February, April and July), her detailed analysis for the Carpathian Basin even suggests seven flood events in 1342 with the remarkable conclusion that the disastrous July event did not affect this region.