INTERANNUAL TO MILLENNIAL SCALE VARIABILITY OF THE RIVER AMMER FLOODS AND ITS RELATIONSHIP WITH EXTREME CLIMATE AND SOLAR FORCING

Norel Rimbu, Monica Ionita and Gerrit Lohmann (Norel.Rimbu@awi.de)
Alfred Wegener Institute Helmholtz Center for Polar and Marine Research, Paleoclimate Dynamics, Bremerhaven, Germany
The River Ammer is located in the Bavarian Alpine Foreland (southern Germany). It is one of the main tributaries of the lake Ammer (48°00’N, 11°07’E). High water tables of the moorlands in the vicinity to the lake Ammer and low water-holding capacity of the Alpine soils favor the translation of precipitation extremes into floods by surface discharge. Late moraine, flysch and molasses formations in the Ammer catchment provides abundant, easy erodible detrital material for downstream transport into the lake during a flood. We analyze variability of observed (1926-1999) and proxy (3553 BC to 1999 AD) annual resolution river Ammer flood frequency.

Research questions

What are the extreme weather and climate patterns associated with flood frequency variability?

What is the dominant forcing on flood frequency variability at centennial to millennial time scales?

Figure source: Rimbu et al. 2020
Positive upper level PV anomalies are associated with:
- unstable atmosphere
- strong WVT (atmospheric rivers)
- explosive cyclogenesis
- cut-off lows

extreme weather

**PV 330 K** potential vorticity on 330K isentropic surface
**PVU** potential vorticity unit
**WVT** Vertically Integrated Water Vapor Transport
**LA** Lake Ammer
DAILY FLOODS AND ROSSBY WAVE BREAKING

- High (>2PVU) upper level potential vorticity in the flood region
- Wave-breaking over Europe
- Hemispheric wave-structure (wavenumber ~6)

LA-Lake Ammer
SEASONAL PATTERNS

-More (less) high PV days over western Europe (Eastern Europe-western Russia) during flood years

-Northern Hemisphere pattern consistent with PV pattern associated with daily floods

PV INDEX
- number of days in a summer with PV>2PVU
Flood year - a year with at least one daily discharge higher than 125m3/s
Period of analysis: 1926-2015
LA-Lake Ammer
Large-scale extreme precipitation anomaly patterns associated with flood years

R20mm-very heavy rain days (number of days with total surface precipitation higher than 20mm)
R75PTOT-percent of total precipitation due to daily precipitation higher than the 75th percentile
hatched-significance higher than 90% level
Period of analysis: 1950-2015
LA-Lake Ammer
PV INDEX - number of days in a summer with PV > 2PVU
LOW (HIGH) SOLAR - open solar flux lower (higher) than minus one (one) standard deviation
Period of analysis: 1836-2015
hatched - significance higher than 90% level
LA - Lake Ammer

Large-scale PV anomaly patterns associated with solar forcing
More frequent high PV events over western Europe for low solar forcing
Large-scale extreme precipitation anomaly patterns associated with low- solar forcing and flood years are similar

- **R20mm**: very heavy rain days (number of days with total surface precipitation higher than 20mm)
- **R75PTOT**: percent of total precipitation due to daily precipitation higher than the 75th percentile
- **hatched**: significance higher than 90% level

**Period of analysis**: 1950-2017

LA - Lake Ammer
More than 60% of the flood variability is described by the Eddy (~900 yr) and Bray(Hallstatt) (~2300yr) solar cycles

LIA-Little Ice Age; MWP-Medieval Warm Period; RWP-Roman Warm Period; HM-Homeric Solar Minimum; BPO-Before Piora Oscillation; SSA-Singular Spectrum Analysis; TSI-total solar irradiance

Figure Source: Rimbu et al. (2020)
SUMMARY & CONCLUSIONS

- River Ammer floods are related to large-scale extreme climate anomaly patterns

- Blocking pattern over Eastern Europe-western Russia during low solar irradiance summers increases the probability of waves breaking over western Europe. This upper level forcing increases the probability of extreme weather including extreme precipitation and floods over western Europe

- The dominant forcing on flood frequency and the associated extreme climate patterns at centennial to millennial time scales is the solar irradiance

- Possible statistical predictability of flood frequency and precipitation extremes at centennial to millennial time scales
REFERENCES & DATA

References


Data

-Flood layer record for the last 5500 years- https://doi.pangaea.de/10.1594/PANGAEA.803368
-Solar irradiance index (open solar flux)-https://climexp.knmi.nl/data/iosf_merged.dat