Variants of meteorological conditions during large-scale rain floods

Marek Kašpar (1), Miloslav Müller (1,2)
(1) Institute of Atmospheric Physics AS CR
(2) Charles University in Prague, Faculty of Science
Selection of flood events

**Assumption**
Rain floods on major rivers in Central Europe are caused by widespread and relatively intense rainfalls which often last several days.
*Müller et al., NHESS, 2009, 441-450*

Rainfalls are usually linked with circulation conditions in synoptic scale.
*Müller and Kaspar, J. Phys. Chem. Earth., 2010, 484-490*

**Selection criterion**
- Sum of the products of the areas of affected catchments (>100 km²) and the return periods of respective peak flows
- Lower threshold value of the criterion was applied.
- 41 events were selected in the period 1951-2010.
- Flood events vs. rain events
  *Kaspar and Müller, NHESS, 2008, 1359-1367*
  - both sets almost identical;
  - rankings of their magnitudes different.
Methods

Anomalies in (thermo)dynamic variables
- Anomaly
  *Cavazos, J. of Climate, 1999, 1506-1523*
  - area of climatologically low or high values
- Meso-alpha scale anomalies
  *Müller et al., Atmos. Research, 2009, 308-317*
  - typical of widespread and steady rains;
  - in specific regions and stages of the events.

Divisive clustering of the events
- Criterion of similarity
  - magnitude (mean $P$) of typical anomalies
- PC analysis
  - reduction of considered anomalies (40/238)
- Optimization of clustering
  - reduction of considered PCs using cophenet & inconsistency coeffs. & scree test (8/40)

Data
- NCEP/NCAR reanalysis, 1951-2010, Europe & N. Atlantic, resolution 2.5°.
Variants of conditions

Thermobaric conditions

Mean geopotential (850, 500 hPa) & temperature (850 hPa)
Variants of conditions

Thermobaric conditions

Mean geopotential (850, 500 hPa) & temperature (850 hPa)

Relative vorticity

Typical anomalies
Variants of conditions

Thermobaric conditions

Mean geopotential (850, 500 hPa) & temperature (850 hPa)

Typical anomalies

SW-NE temperature gradient

T [°C]

-10  -5   0   5   10   15   20   25   30

D-2

D+1, 500 hPa

D+1, 850 hPa

cold  mean P  warm
cold  mean P  warm
Variants of conditions

Thermobaric conditions

Typical anomalies

Mean geopotential (850, 500 hPa) & temperature (850 hPa)

Vertical velocity in p-system

$T \quad [\degree C]$

Vertical velocity in p-system

<table>
<thead>
<tr>
<th>Mean geopotential (850, 500 hPa) &amp; temperature (850 hPa)</th>
</tr>
</thead>
<tbody>
<tr>
<td>$-10$</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Vertical velocity in p-system</th>
</tr>
</thead>
<tbody>
<tr>
<td>$0.01$</td>
</tr>
</tbody>
</table>

mean P
Variants of conditions

Thermobaric conditions

Typical anomalies

(a) Convergence of moisture

(b) W-E gradient of meridional wind
Variants of conditions

Thermobaric conditions

Typical anomalies

(a) Convergence of moisture

(b) W-E gradient of meridional wind
Mean geopotential (850, 500 hPa) & temperature (850 hPa)

T [°C]
II

Variants of conditions

Thermobaric conditions

Typical anomalies

Mean deopotential (850, 500 hPa) & temperature (850 hPa)

S-N gradient of zonal wind
Variants of conditions

Thermobaric conditions

Mean geopotential (850, 500 hPa) & temperature (850 hPa)

Typical anomalies

S-N gradient of zonal wind

Mean geopotential (850, 500 hPa) & temperature (850 hPa)
Variants of conditions

Thermobaric conditions

Mean geopotential (850, 500 hPa) & temperature (850 hPa)
III Variants of conditions

Thermobaric conditions

Typical anomalies

Mean geopotential (850, 500 hPa) & temperature (850 hPa)

SW-NE flow of heat

SW-NE flow of moisture

T [°C]

-10 -5 0 5 10 15 20 25 30

mean P
Variants of conditions

Thermobaric conditions

Mean geopotential (850, 500 hPa) & temperature (850 hPa)

Typical anomalies

Lagrangian tendency of geopotential
IV

Variants of conditions

Thermobaric conditions

Mean geopotential (850, 500 hPa) & temperature (850 hPa)
IV

Variants of conditions

Thermobaric conditions

Mean geopotential (850, 500 hPa) & temperature (850 hPa)

Typical anomalies

Specific moisture

D, 850 hPa

Dry
mean P
Moist

T [°C]

-10
-5
0
5
10
15
20
25
30
IV

Variants of conditions

Thermobaric conditions

Typical anomalies

Mean geopotential (850, 500 hPa) & temperature (850 hPa)

Specific moisture

T [°C]

30 25 20 15 10 5 0 -5 -10

D-2
Selection of flood events
- 41 events 1951-2010;
- criterion: area of affected catchments & return period of peak flows.

Variants of meteorological conditions
- divisive clustering of the events according to the magnitude of meso-α anomalies;
- 4 consistent clusters of 2nd level.

2 cyclonic variants (I + II):
  Anomalies connected with strong baroclinity and conditions favorable for production and orographic enhancement of precipitation.

1 transitional variant (frontal zone & cyclone, III):
  Initially, anomalies connected with arriving of warm and moist air.

1 non-cyclonic variant (IV):
  Anomalies connected with moist air at lower levels.

Cyclonic variants (especially I) are the most noticeable and dangerous in respect of the magnitude of anomalies, floods and affected area.
Conclusions

- **Selection of flood events**
  - 41 events 1951-2010;
  - criterion: area of affected catchments & return period of peak flows.

- **Variants of meteorological conditions**
  - divisive clustering of the events according to the magnitude of meso-α anomalies;
  - 4 consistent clusters of 2nd level.

- **Possible outlook**
  - application of a fuzzy clustering approach;
  - confirmation of applicability in other regions;
  - better comparison of various regions in view of circulation causes;
  - detection of past flood events in case of lacking direct data
See also posters A5/151 describing some variants by moisture fluxes and Hovmöller diagrams across Central European catchments and A6/231 containing comparative study of 2010 rain floods.