Intense rainfall and flood event classification by weather type

Presentation at the XIX EGS General Assembly
Session HS6/NH3 "Forecasting and Mitigation of Flush Flood and Mud Flow"

By N. Mamassis, D. Koutsoyiannis and I. Nalbantis

Department of Civil Engineering
Division of Water Resources, Hydraulic & Maritime Engineering
NATIONAL TECHNICAL UNIVERSITY OF ATHENS

Topics of the presentation

★ Objectives
★ Classification of weather types
★ Presentation of hydrometeorological data
★ Analysis of intense rainfall events by weather type
★ Analysis of flood events by weather type
★ Statistical tests
★ Conclusions
Objectives

A study in the framework of AFORISM/EPOCH programme
"A comprehensive flood forecasting system for flood risk mitigation and control"

- Can the knowledge of the prevailing weather pattern, help to estimate the probability of occurrence of intense rainfall and flood events?
- Can the general classification of events per weather type, explain a significant part of the variance of the rainfall and runoff process?
- If the answers are positive the weather type classification could contribute to the forecasting of future rainfall and runoff process

Classification of weather types
Definition and classification of weather types in Greece (by Maheras)

<table>
<thead>
<tr>
<th>Criteria</th>
<th>The location of centers of anticyclones</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>The main trajectories of cyclones</td>
</tr>
<tr>
<td></td>
<td>Some special synoptic situations in surface and 500 mb level</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Seasons</th>
<th>Wet (October - April)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Dry (May - September)</td>
</tr>
</tbody>
</table>

| Weather types | 5 anticyclonic (A1, A2, A3, A4, A5) |
|               | 6 cyclonic (SW1, SW2, NW1, NW2, W1, W2) |
|               | 2 mixed (MT1, MT2) |
|               | 3 characteristic (DES, MB, DOR) |

| Time period | Maheras developed a daily calendar of weather types in Greece for the period 1950-1990 |
Classification of weather types
Main trajectories of cyclonic weather types

- DEPRESSIONAL WEATHER TYPES AS INTRODUCED BY MAHERAS

Presentation of hydrometeorological data

Study area and measuring stations
- Evinos River Basin (885 km²)
- 3 rain recording stations
- 1 stage recording station
- 20 years of continuous operation (with few gaps)

Selection of intense rainfall and flood events
- Daily depth > 25 mm or Hourly depth > 7 mm
- Daily discharge > 100 m³/sec at one day at least

Data set

<table>
<thead>
<tr>
<th>Data set</th>
<th>POINT RAINFALL</th>
<th>AREAL RAINFALL</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total number of rainfall events :</td>
<td>293</td>
<td>358</td>
</tr>
<tr>
<td>At rainy season (Oct - Apr) :</td>
<td>200</td>
<td>220</td>
</tr>
<tr>
<td>At dry season (May - Sep) :</td>
<td>93</td>
<td>138</td>
</tr>
<tr>
<td>108 flood events</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Meteorological data
- Weather maps at surface and 500 mb level
- Daily calendar of weather types in Greece (as developed by Maheras)
Analysis of Intense Rainfall Events by Weather Type

Dry Season

Wet Season

Probability of occurrence of intense rainfall events per weather type.

Location of stations

Presentation of hydrometeorological data
Analysis of intense rainfall events by weather type

Rainfall event characteristics (wet season)

**Duration**

- Hourly depth

**Total depth**

- lag 1 autocorrelation coefficient

Rainfall event characteristics (dry season)

- Duration

- Hourly depth

- lag 1 autocorrelation coefficient

**INTENSE RAINFALL AND FLOOD EVENT CLASSIFICATION BY WEATHER TYPE**
Analysis of intense rainfall events by weather type
Cross correlation and autocorrelation of hourly depths

SW2 of wet season

DOR of wet season

INTENSE RAINFALL AND FLOOD EVENT CLASSIFICATION BY WEATHER TYPE

Analysis of intense rainfall events by weather type
Cross correlation and autocorrelation of hourly depths

SW2 of dry season

DOR of dry season

INTENSE RAINFALL AND FLOOD EVENT CLASSIFICATION BY WEATHER TYPE
Analysis of flood events by weather type

Probability of occurrence of flood per weather type

A: W1, W2, NW1, SW1
B: SW2, NW2
C: MT2, DOR
D: A1-A5, MT1, DES, MB

Mean daily discharge

Peak daily discharge

INTENSE RAINFALL AND FLOOD EVENT CLASSIFICATION BY WEATHER TYPE

Statistical tests

<table>
<thead>
<tr>
<th>Remarks for evaluation</th>
<th>Statistical test</th>
<th>Results</th>
</tr>
</thead>
<tbody>
<tr>
<td>The probability of occurrence of intense rainfall and flood events is different for each weather type</td>
<td>Statistical test to check the hypothesis that the portions of events in two populations, are equal</td>
<td>Statistically significant differences in probability of occurrence of intense rainfall and flood events</td>
</tr>
<tr>
<td>The intense rainfall and flood event characteristics are different for each weather type</td>
<td>Kruskal-Wallis statistical test to verify the hypothesis that two samples belong to the same population</td>
<td>No significant differences in the rainfall and flood event characteristics among the weather types of the wet season. Slight significant differences among the weather types of the dry season</td>
</tr>
<tr>
<td>A large amount of variance of rainfall event characteristics, is explained from the concept of weather types</td>
<td>Analysis of variance</td>
<td></td>
</tr>
</tbody>
</table>

INTENSE RAINFALL AND FLOOD EVENT CLASSIFICATION BY WEATHER TYPE
Statistical tests
Analysis of variance

<table>
<thead>
<tr>
<th>PERCENTAGE OF VARIANCE WHICH IS EXPLAINED BY:</th>
<th>WEATHER TYPE</th>
<th>DURATION</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>POINT RAINFALL</td>
<td>AREAL RAINFALL</td>
</tr>
<tr>
<td>WET SEASON</td>
<td></td>
<td></td>
</tr>
<tr>
<td>DURATION</td>
<td>7</td>
<td>11</td>
</tr>
<tr>
<td>TOTAL DEPTH</td>
<td>3</td>
<td>10</td>
</tr>
<tr>
<td>MEAN INTENSITY</td>
<td>7</td>
<td>4</td>
</tr>
<tr>
<td>HOURLY DEPTH</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>DRY SEASON</td>
<td></td>
<td></td>
</tr>
<tr>
<td>DURATION</td>
<td>18</td>
<td>28</td>
</tr>
<tr>
<td>TOTAL DEPTH</td>
<td>18</td>
<td>22</td>
</tr>
<tr>
<td>MEAN INTENSITY</td>
<td>8</td>
<td>9</td>
</tr>
<tr>
<td>HOURLY DEPTH</td>
<td>2</td>
<td>2</td>
</tr>
</tbody>
</table>

Intense rainfall and flood event classification by weather type

Conclusions

- Statistically significant differences in the probability of occurrence of intense rainfall flood events, among the various weather types.
- Large variance in all rainfall event characteristics, for all weather types.
- Significant differences in the stochastic structure and characteristics of the intense rainfall events, between dry and wet season.
- No statistically significant differences in the rainfall and flood event characteristics among the weather types of the wet season. Slight significant differences among the weather types of the dry season.
- A small percentage of the total variance of rainfall characteristics, is explained by introducing the concept of weather type. The double percentage is explained merely by the duration of the event.