CONTRIBUTION OF ENSEMBLE FORECASTING APPROACHES TO FLASH FLOOD NOWCASTING AT GAUGED AND UNGAUGED CATCHMENTS

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2018 HEPEX Workshop, 6-8 February 2018, Melbourne, Australia
Flash floods

Côte d’Azur: inondations meurtrières

Cannes: 180 mm
(107 mm in 1 h, 8pm-9pm)
High-impact events

Cost M€

<table>
<thead>
<tr>
<th>Event</th>
<th>Date</th>
<th>Cost (M€)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Xynthia</td>
<td>02/2010</td>
<td>700</td>
</tr>
<tr>
<td>Rhône</td>
<td>10/2003</td>
<td>500</td>
</tr>
<tr>
<td>Gard</td>
<td>09/2002</td>
<td>300</td>
</tr>
<tr>
<td>Alpes Maritimes</td>
<td>10/2015</td>
<td>100</td>
</tr>
<tr>
<td>Var</td>
<td>06/2010</td>
<td>0</td>
</tr>
</tbody>
</table>

Victims

<table>
<thead>
<tr>
<th>Event</th>
<th>Victims</th>
</tr>
</thead>
<tbody>
<tr>
<td>Xynthia</td>
<td>590</td>
</tr>
<tr>
<td>Rhône</td>
<td>20</td>
</tr>
<tr>
<td>Gard</td>
<td>10</td>
</tr>
<tr>
<td>Alpes Maritimes</td>
<td>40</td>
</tr>
<tr>
<td>Var</td>
<td>0</td>
</tr>
</tbody>
</table>

Most important flood events since 1989

Caseri (2017)

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Nowcasting

Provide early warnings with sufficient lead time: forecast the location, magnitude, onset, end of events

Caseri (2017)

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Nowcasting + ensemble approach

Provide early warnings with sufficient lead time: forecast the location, magnitude, onset, end of events

Caseri (2017)

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Ensemble nowcasting

Pre-/Post processing

Data assimilation/initial conditions

Verification

Real-time alert

Risk Maps
Inundation Maps
Damage estimation

Comparison with thresholds

Rainfall-runoff transformation

Rainfall uncertainty quantification (space, time, intensity)

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Ensemble nowcasting

- Pre-/Post processing
- Rainfall and hydrologic real-time data
- Rainfall runoff transformation
- Rainfall uncertainty quantification (space, time, intensity)
- Comparison with thresholds
- Data assimilation/initial conditions
- Damage estimation
- Inundation Maps
- Risk Maps
- Verification
- Real-time alert

Rainfall and thresholds: Q20yrs, Q5yrs

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No research has been conducted to compare the performance of different flash flood forecasting methods.
[Ensemble] nowcasting: approaches

- Methodologies and data:
  - Relation between rainfall thresholds or accumulations and flooding
  - Identification, tracking, and nowcasting of storms through the most recent storm images
  - ‘Geometric approaches’: statistical features of storms (birth, growth and decay, etc.) extracted from past events
  - High resolution, limited area NWP models, based on convection-parameterized or convection permitting models (within a poor man’s ensemble, a time-lagged, or an error dressing approach)
  - ‘Mixed approaches’ (radar-NWP blending)
    - Radar data (advection), lightning activity (in-cloud and cloud-to-ground) and satellite tracking of MCS (life cycle of convective cells)
    - Representation of the initial soil moisture conditions triggering runoff and hydrodynamic responses

Younis et al. (2008); Norbiato et al. (2008); Kohn et al. (2011); Randrianasolo et al. (2011); Alfieri et al. (2011); Zahraei et al. (2013); Tsun-Hua et al. (2015); Vincendon et al. (2016); Seo et al. (2017); Corazza et al. (2018), etc.
[Ensemble] nowcasting: approaches

- Most common features:
  - Combination of data-based and distributed modeling techniques
  - Focus on unungaged catchments/spatially distributed information (model parameter transposition) and vulnerable areas (urban)
  - Linking info: flood hazard to vulnerability (population, roads); ‘flood susceptibility scoring procedure’ (Collier and Fox, 2003)
  - Assessment using contingency tables (POD, FAR, CSI, etc. scores, ROC curves), errors in hydrographs patterns (peak time, volume)
  - Effects of sampling problems (event-based evaluations)
Ensemble nowcasting: conditional simulation

Rainfall real-time data

SAMPO TBM - PI

AIGA-PI Ensemble

Rainfall-runoff transformation

Rainfall uncertainty quantification (3D geostatistical simulation)

Comparison with thresholds

Probability of flooding

Application:
- Var Department (Med. Area of 6050 km²)
- 17 events
- 472 rainfall hours
Ensemble nowcasting: conditional simulation

LEFT: Hourly precipitation fields (PI-GAE) for three time steps (rows): initialization 15 June 2010 at 10 am, 1 and 2 hours ahead. Weather radar data (1st col.) and two members of the 30-member generated precipitation ensemble

RIGHT: Area under the ROC curve for four tested methods (precipitation forecast)


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Ensemble nowcasting: conditional simulation

05/11/2011 8pm (prob Q> Q10 year)
Observation (radar as input, damages)


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Ensemble nowcasting: conditional simulation

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Ensemble nowcasting: conditional simulation

05/11/2011 8pm (prob $Q > Q_{10}$ year)
Observation (radar as input, damages)


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Ensemble nowcasting: high res AROME-NWC

Flood vigilance service complemented by new warning system for flash floods

Current: A fully automated and deterministic system, based on real time observations (no rainfall forecasts)

Future: AROME-NWC

Demargne et al. (2017)
Ensemble nowcasting: high res AROME-NWC

AROME-NWC precipitation forecasts from Météo-France (operational since March 2016): convection modeling, hourly updated, 1.3km resolution, +6hr lead time

Account for forecast uncertainty
(AROME timelag ens, celerity parameter)

Courtesy of J. Hoffman

Demargne et al. (2017)
Ensemble nowcasting: high res AROME-NWC

Event-based contingency for 5yr flood alert (81 obs. floods vs. 106 floods with Vigicrues Flash)

- **Prob. Of Detection** (conditioned on obs.)
  \[ \text{POD} = \frac{H}{H+M} \]

- **Success Ratio** (conditioned on fcst.)
  \[ \text{SR} = \frac{H}{H+FA} \]

  - \( H \): nb Hits (with lead time \( \geq 0 \))
  - \( FA \): nb False Alarms
  - \( M \): nb Misses

AROME: improved detection but reliability loss depending on selected probability level

Bias: nb FA > nb M

POD +31%

SR -13%

Demargne et al. (2017)
Final remarks

- Improvements in flash flood anticipation (gains of 1h to 3h), but strongly dependent on rainfall forecast (location) and event
- Several possible ways:
  - Downscaling & Blending
  - Multiple source data techniques
  - Understanding governing process
  - Ensemble Hazard-Vulnerability forecasting
  - Forecasting impacts
  - Data base of flash flood events and verification robustness
  - Influence of automation / human expertise (Pagano et al., 2016)


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Merci beaucoup!

ANR French National Project PICS (2018-2022)
Towards Integrated Nowcasting of Flash Flood Impacts

Visit Daniela Peredo’s poster:
ASSESSMENT OF THE 2016 FLOOD EVENT ON THE SEINE AND LOIRE RIVER BASINS USING ENSEMBLE FORECASTS

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