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

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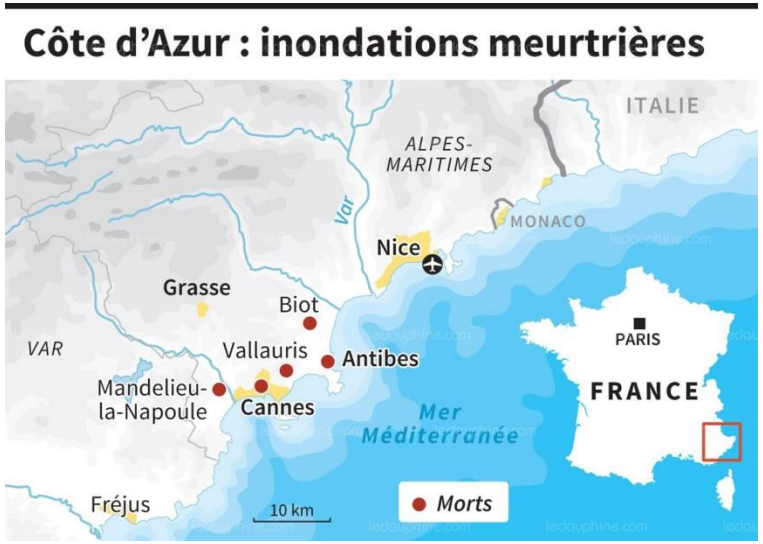
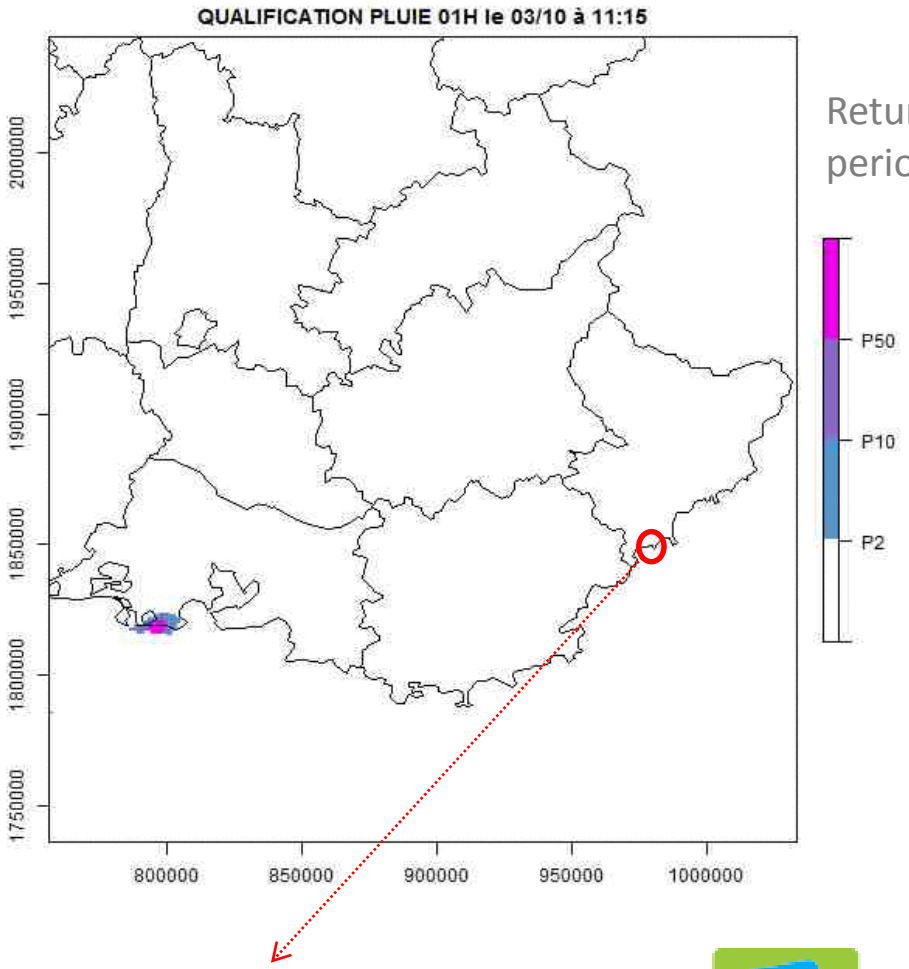
1. Irstea Antony, 2. Hydris Hydrologie, 3. Irstea Aix-en-Provence, France

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

Flash floods

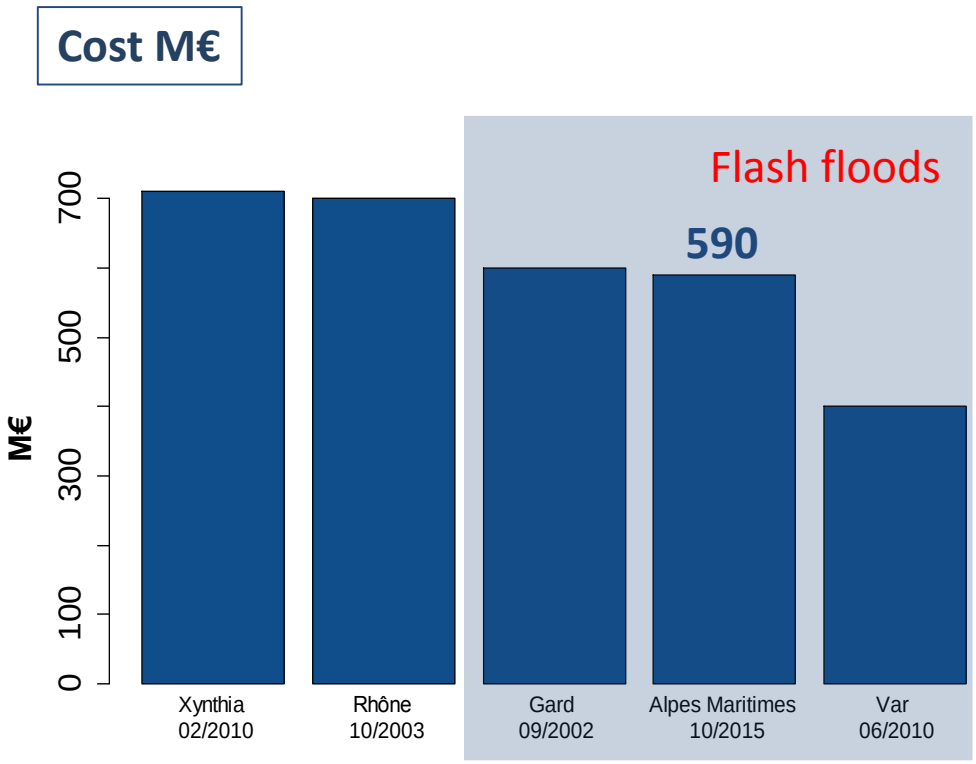
Octobre 2015

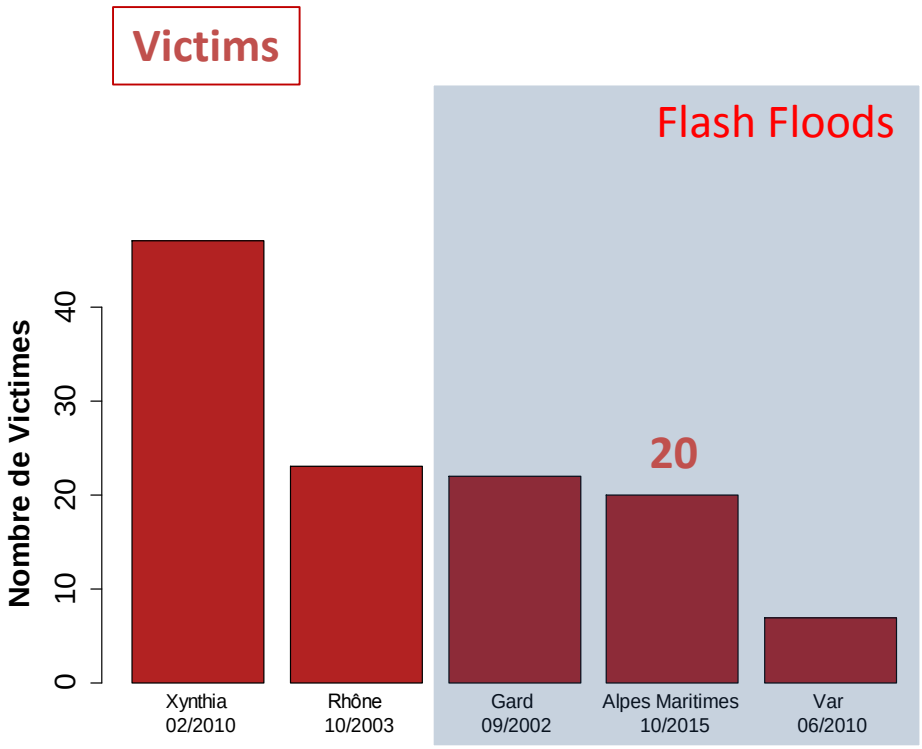




Cannes: 180 mm
(107 mm in 1 h, 8pm-9pm)

High-impact events



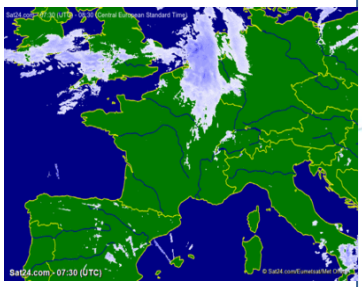


Most important flood events since 1989

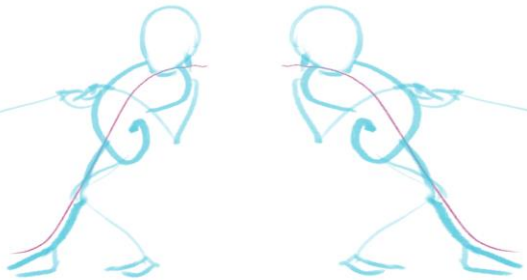
Caseri (2017)

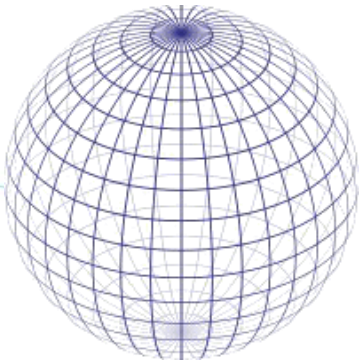
Nowcasting

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



Observation





Numerical weather model

Nowcasting

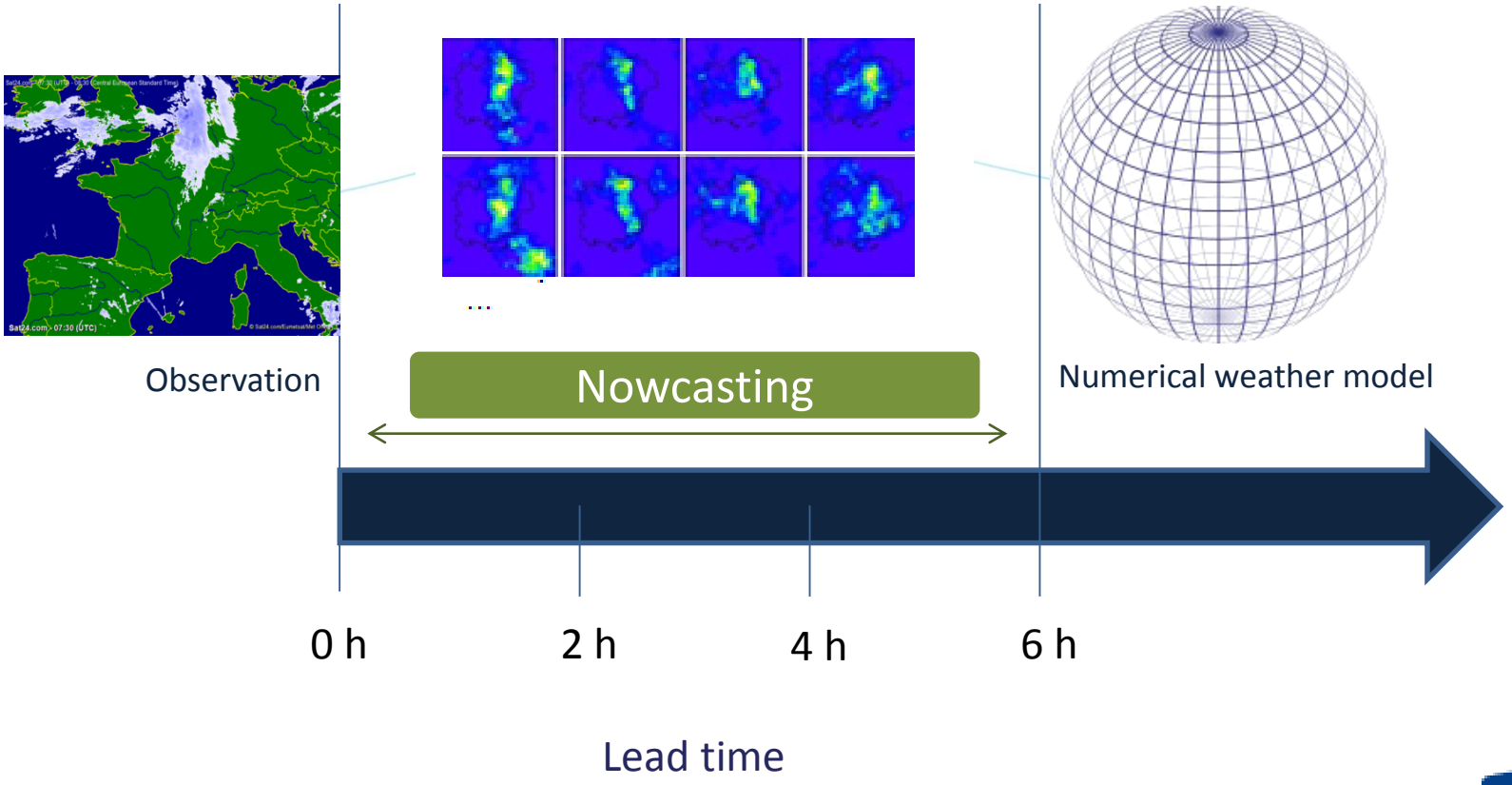
0 h 2 h 4 h 6 h

Lead time

Caseri (2017)

Nowcasting + ensemble approach

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

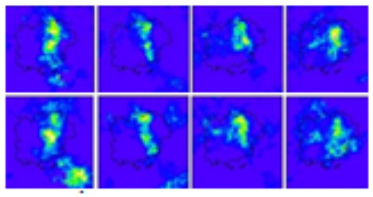


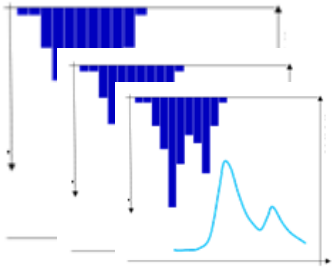
Caseri (2017)

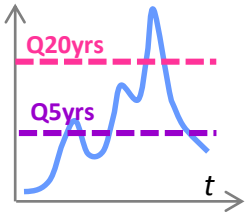
Ensemble nowcasting

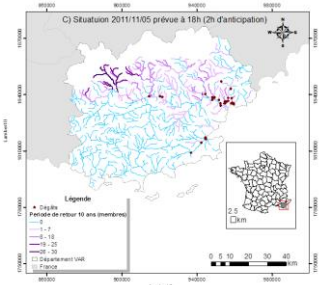
Verification

Pre- / Post processing









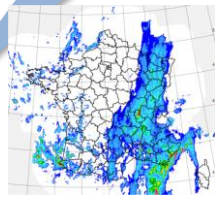
Real-time alert

Comparison with thresholds

Rainfall-runoff transformation

Risk Maps
Inundation Maps
Damage estimation

Rainfall and hydrologic real-time data



Rainfall uncertainty quantification (space, time, intensity)

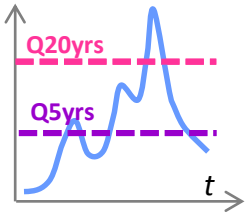
Data assimilation/ initial conditions

Ensemble nowcasting

Verification

Pre- / Post processing

?



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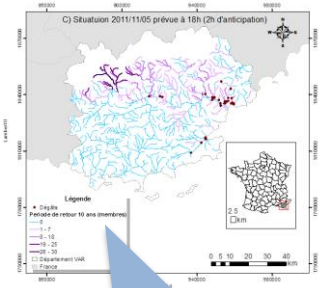
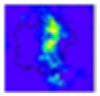


Real-time alert

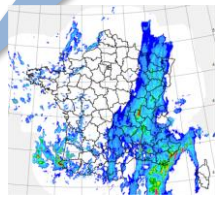


Comparison with thresholds

~~Rainfall runoff transformation~~

Risk Maps
Inundation Maps
~~Damage estimation~~

~~Rainfall uncertainty~~ quantification (space, time, intensity)



Rainfall and ~~hydrologic~~ real-time data

Data assimilation/ initial conditions

?

[Ensemble] nowcasting: approaches

www.csiro.au

A review of methods and systems available f
flood forecasting

H. A. Prasantha Hapuarachchi and G

July 2008

Report for the Bureau of Meteorology, Australia

A water information R & D alliance between th
and CSIRO's Water for a Healthy Country Flags

Australian Gove
Bureau of Meteorol

4.4. Summary

In this section, the different methods for flash flood forecasting have been discussed. Only the rainfall induced flash floods are considered in detail due to their frequent nature. A summary of methods available for flash flood forecasting and their advantages and

No research has been conducted to compare the performance of different flash flood forecasting methods

spatial scales, and objectives of the application (e.g. required output, forecast variables such as river flow, rainfall, and inundation).

[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.

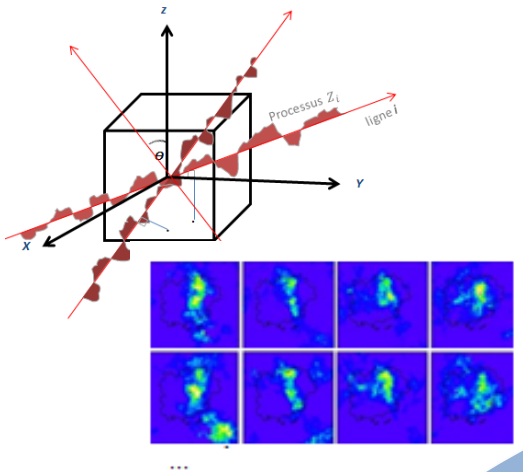
[Ensemble] nowcasting: approaches

- **Most common features:**

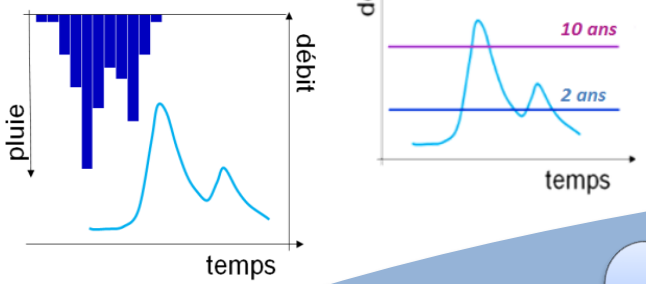
- ❑ Combination of data-based and distributed modeling techniques
- ❑ Focus un ungaged catchments/ spatially distributed information (model parameter transposition) and vulnerable areas (urban)
- ❑ Linking info: flood hazard to vulnerability (population, roads); 'flood susceptibility scoring procedure' (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)

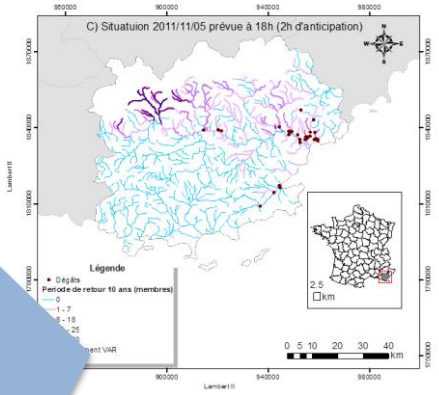
Ensemble nowcasting: conditional simulation

SAMPO TBM - PI



AIGA-PI Ensemble



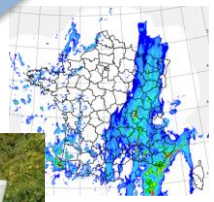


Probability of flooding

Comparison with thresholds

Rainfall-runoff transformation

Rainfall uncertainty quantification (3D geostatistical simulation)



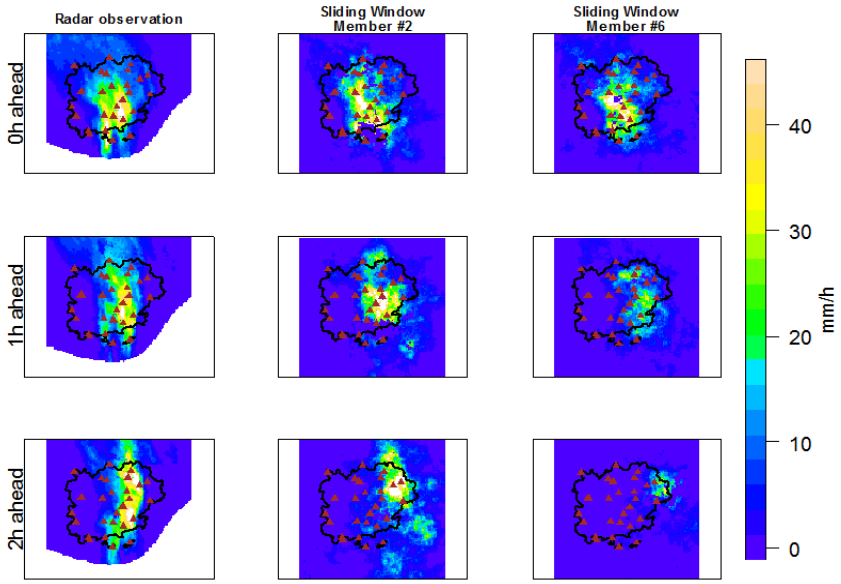
Rainfall

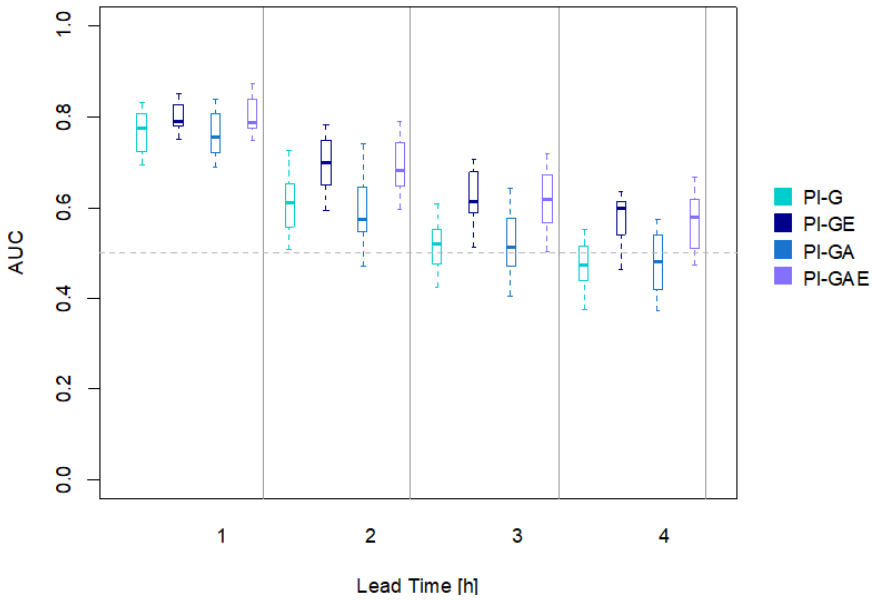
real-time data

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)

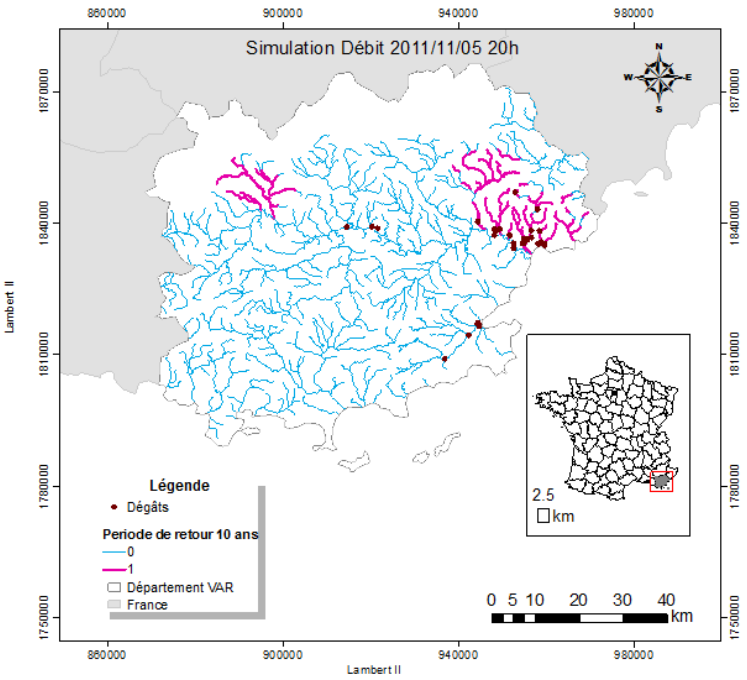
Caseri, A., P., Javelle, M.-H., Ramos, E. Leblois, 2016. Generating precipitation ensembles for flood alert and risk management, *Journal of Flood Risk Management*, 9, 4, 402-415,

Caseri, A., Ramos, M.-H., Javelle, P., Leblois, E., 2016. A space-time geostatistical approach for ensemble rainfall nowcasting. *Proceed. FLOODrisk 2016 – 3rd European Conference on Flood Risk Management, E3S Web of Conferences*, 7 18001 (2016), 5p.

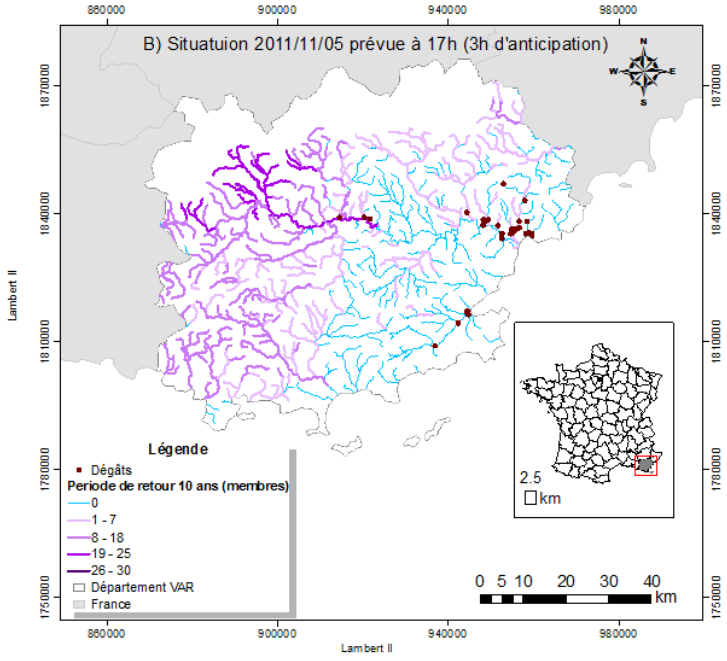
Ensemble nowcasting: conditional simulation

05/11/2011 8pm (prob Q> Q10 year)

Observation (radar as input, damages)



3h ahead



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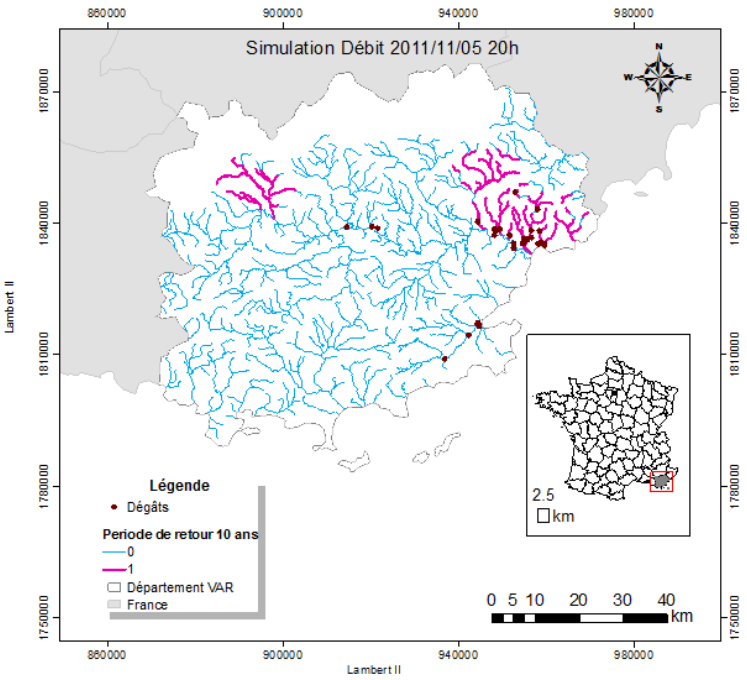
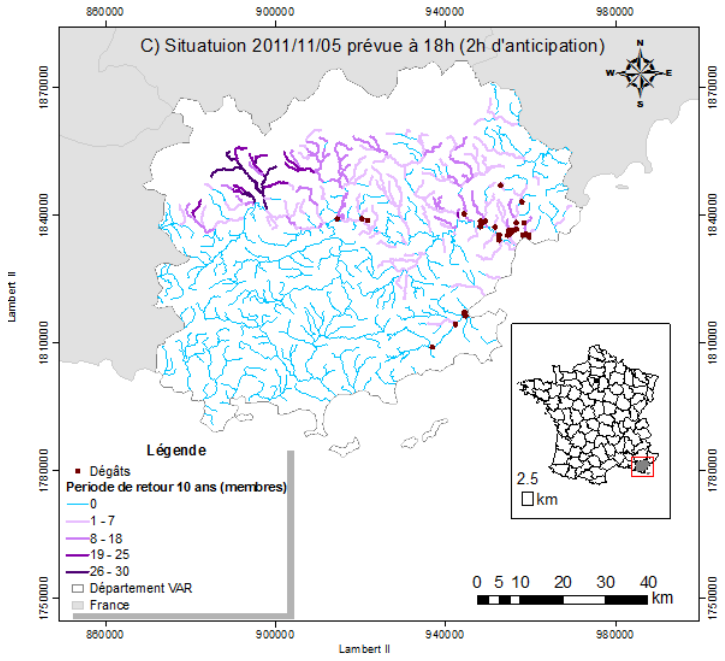


2h ahead



Caseri, A., P., Javelle, M.-H., Ramos, E. Leblois, 2016. Generating precipitation ensembles for flood alert and risk management, *Journal of Flood Risk Management*, 9, 4, 402-415,

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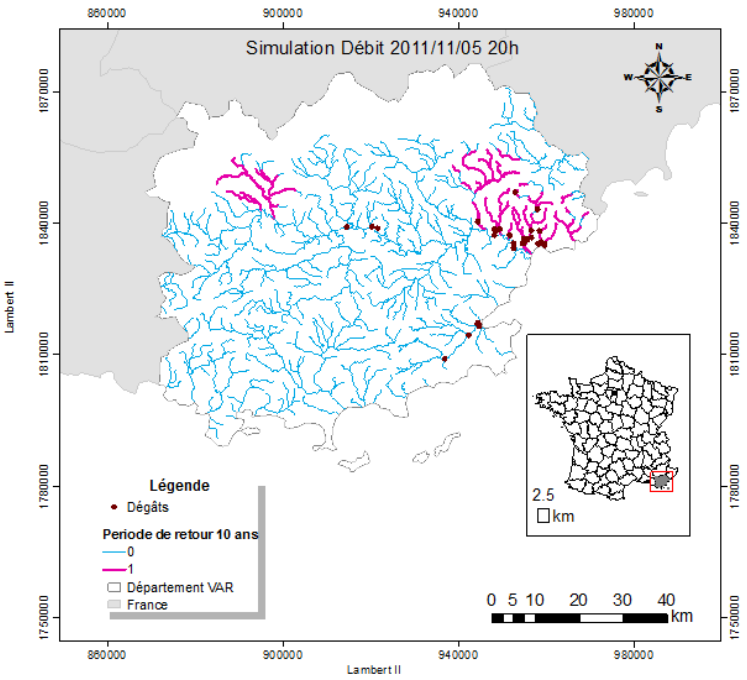
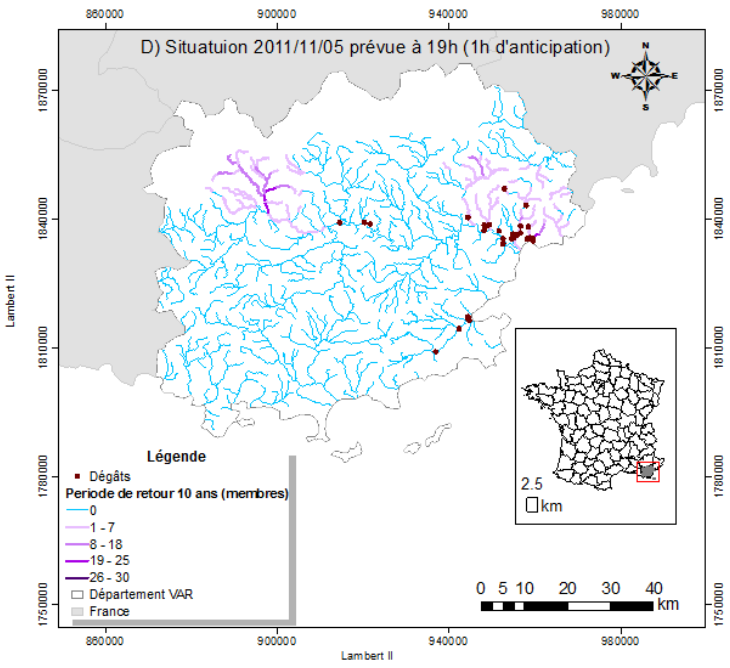


1h ahead



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Ensemble nowcasting: high res AROME-NWC

Flood vigilance service complemented by new warning system for flash floods

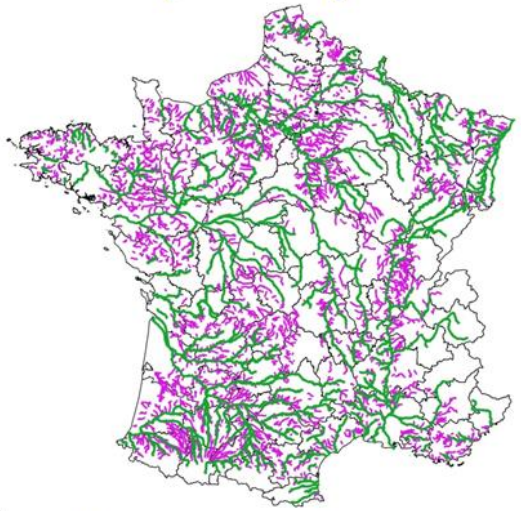
VIGICRUES

Flood warnings for the next 24 hours for 22,000 km of monitored rivers

www.vigicrues.gouv.fr

VIGICRUES FLASH

Flash flood warnings for ~10,300 municipalities



Vigicrues monitored rivers
Vigicrues Flash network (March 2017)

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

Future: AROME-NWC

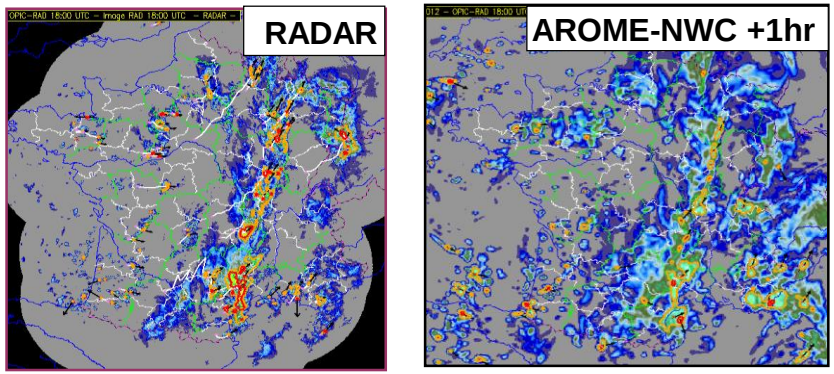
Demargne *et al.* (2017)

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)

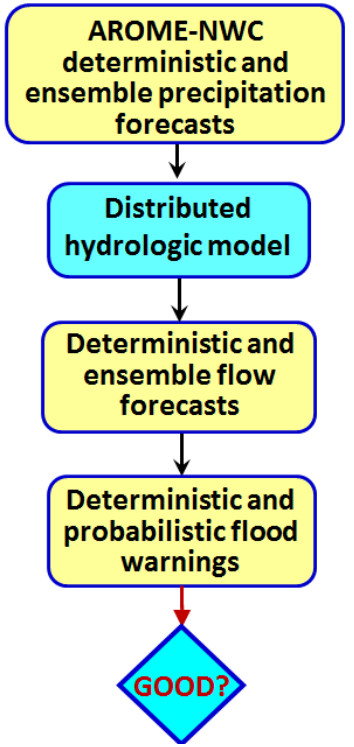
Account for forecast uncertainty

(AROME timelag ens, celerity parameter)



METEO FRANCE
Toujours un temps d'avance

Courtesy of J. Hoffman



Demargne *et al.* (2017)

irstea

Ensemble nowcasting: high res AROME-NWC

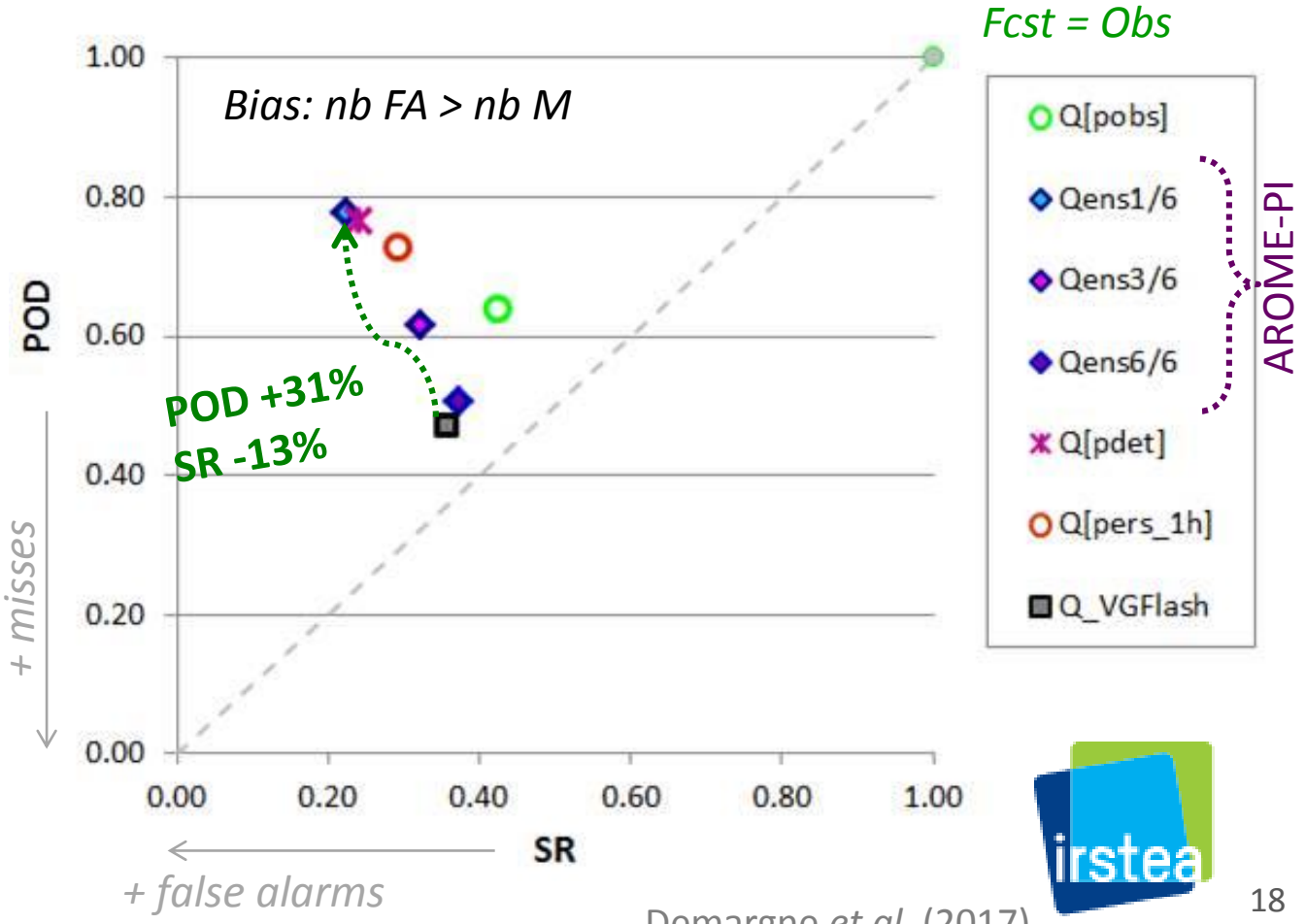
Prob. Of Detection
(conditioned on obs.)
POD = H/(H+M)

Success Ratio
(conditioned on fcst.)
SR=H/(H+FA)

H: nb Hits
(with lead time ≥ 0)
FA: nb False Alarms
M: nb Misses

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

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



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)

Are these still challenges for Hepex?

Reading 2004…


Hydrological Ensemble Prediction Experiment (HEPEX)

workshop, Reading, 8 – 10 March 2004

Evaluation of uncertainty propagation in an operational flash flood forecasting chain

Boni, G., Ferraris L., Gabellani S., Parodi A., Provenzale A., Rebora N., Roth G., Rudari R., Siccardi F. and von Hardenberg, J.

Gruppo Nazionale per la Difesa dalle Catastrofi Idrogeologiche, Italy
(National Group for the defence from hydro-geological Disasters, Italy)

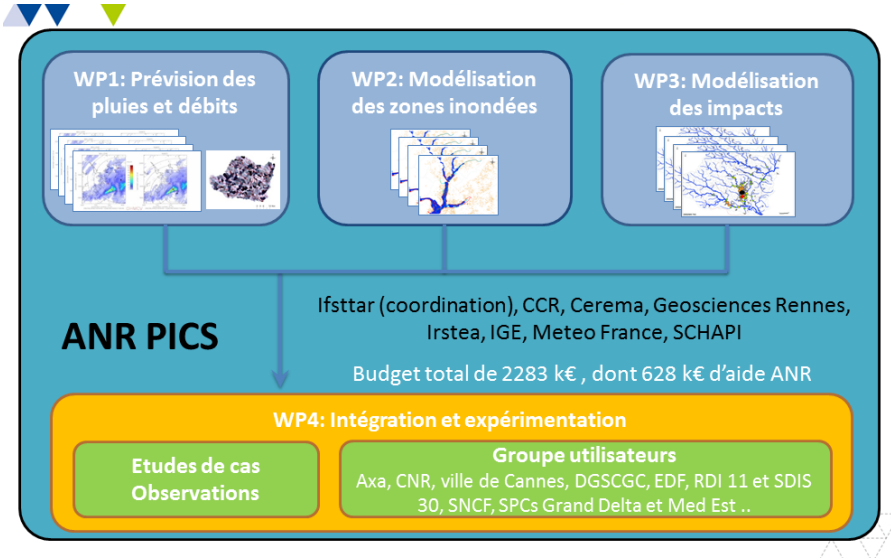
CIMA - Centro di ricerca Interuniversitario in Monitoraggio Ambientale (Centre for Environmental Monitoring Research), Italy

Pagano, T. C., Pappenberger, F., Wood, A. W., Ramos, M.-H., Persson, A., Anderson, B., 2016: Automation and human expertise in operational river forecasting. *WIRES Water* 2016, 3, 5, 692-705.

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