

Advances and challenges of the French operational flash flood warning system

Julie Demargne⁽¹⁾ (julie.demargne@hydris-hydrologie.fr), Catherine Fouchier⁽²⁾, Didier Organde⁽¹⁾, Olivier Piotte⁽³⁾, Anne Belleudy⁽³⁾

(1) HYDRIS Hydrologie

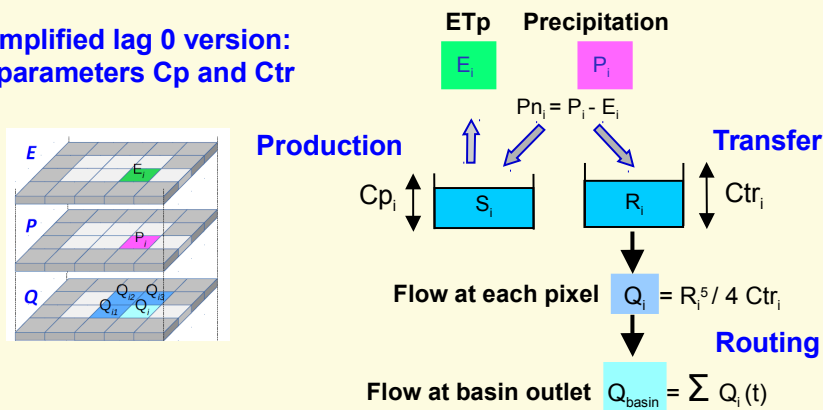
(2) INRAE, team RECOVER

(3) SCHAPI (national flood forecasting services)

Main goal: improve estimation of distributed model parameters to better anticipate flash floods (FF) and extend Vigicrues Flash coverage

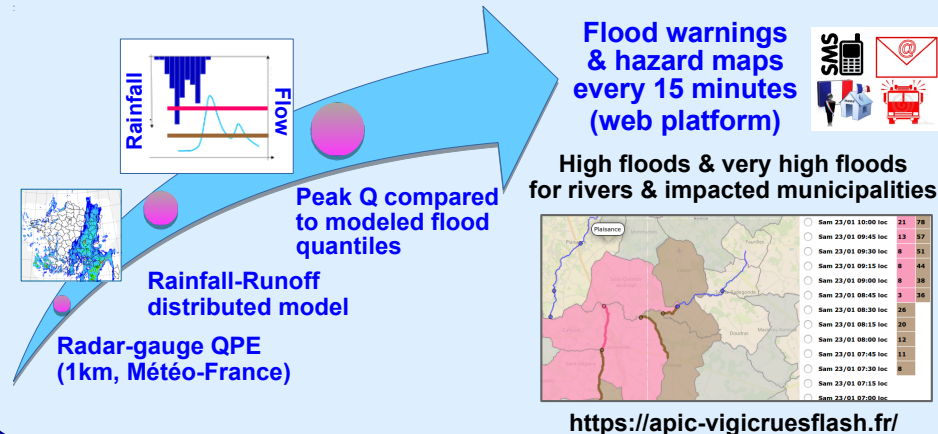
Spatially-distributed Modelling and ASSimilation for Hydrology (SMASH) platform

Simplified lag 0 version:
2 parameters **Cp** and **Ctr**



Simplified version of distributed model run at 1-km resolution and 15-minute time step with 2 parameters to estimate on each pixel:
Cp (production reservoir capacity) and **Ctr** (transfer reservoir capacity)
Method: cross-validation analysis to select robust calibration criteria that optimizes contingency scores (relevant to operational services)

Vigicrues Flash warning system (based on AIGA method)



Operational service since March 2017 to provide warnings for small-to-medium ungauged basins for ~10,000 municipalities
Public website since 26/04/2021: dissemination and communication of warnings and hazard maps over last 72h with the APIC heavy rainfall warning service from Météo-France
Only QPE (Quantitative Precipitation Estimate) inputs currently

Cross-validation study to select calibration criteria

Methodology: cross-validation study with 15 combinations of scores

(linear combinations of NSE, CSI, peak error, peak lead time computed on 2-yr flood events)

Objective: select calibration criteria that optimizes contingency scores (CSI, POD, SR)

with robust parameter values (stability of calibrated parameter values on each 6-yr period)

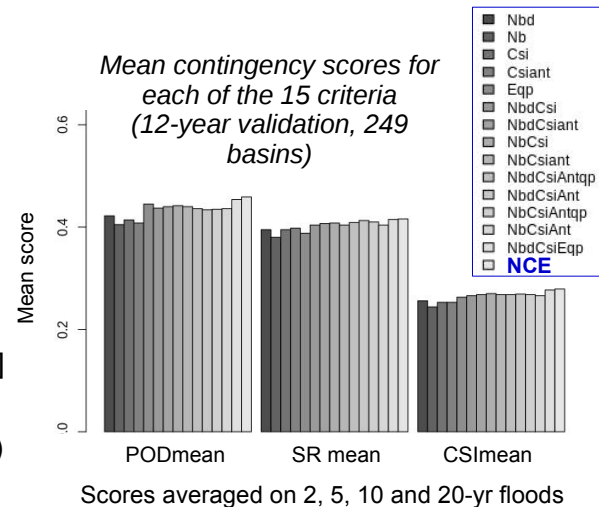
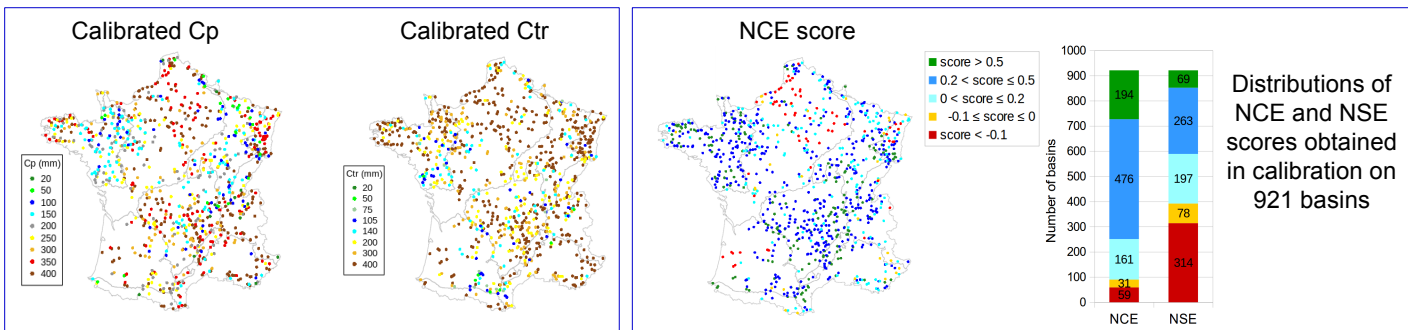
Analysis with 249 basins on 12-year period (08/2007-07/2019):

→ split-sample calibration and validation on 2 periods of 6 years

→ calibration based on sensitivity analysis with 72 sets of Cp-Ctr values in [20mm, 400mm]

Best criteria that optimizes contingency scores: **NSE - CSI - peakError** combination (NCE score)

Application: calibration on 921 basins and on 12-year period



Contingency scores (relevant to operational services) (best score=1):

- Critical Success Index $CSI = H/(H+M+FA)$
- Probability of Detection $POD = H/(H+M)$
- Success Ratio $SR = H/(H+FA)$

with H nb of hits, M nb of misses, FA nb of false alarms

Selection of 493 basins with NCE > 0.2 & NSE > 0 to regionalize Cp-Ctr parameters

Parameter regionalization and warning performances

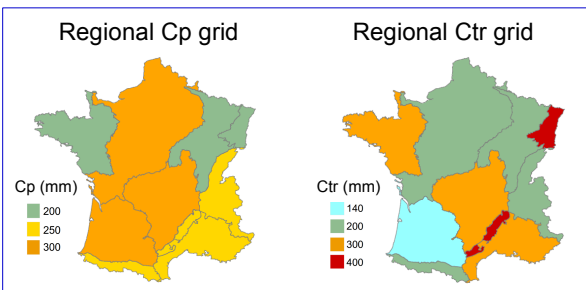
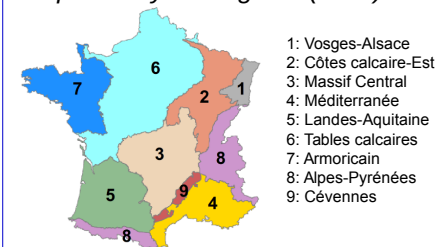
Methodology: tests of 2 **regionalization methods** with calibrated Cp-Ctr parameters (on 493 basins)

- regressions with physiographic basin characteristics: poor results ($R^2 < 0.3$)
- regional median values based on 9 hydroecological French regions (HER)

Application: regional median values per HER to generate Cp and Ctr grids

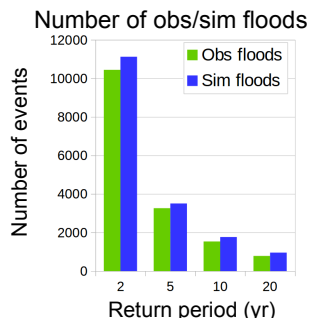
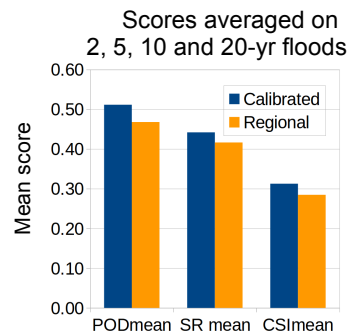
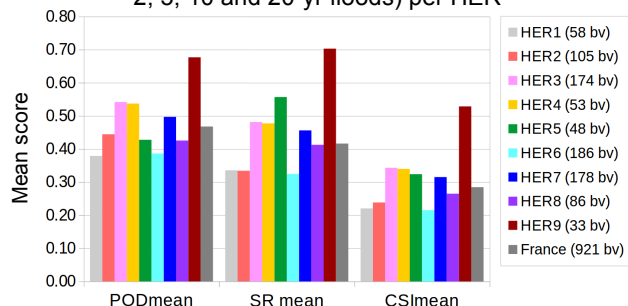
- successive regionalization of Cp and Ctr based on optimization of contingency scores
- evaluation on 921 basins and per HER (scores on 12-yr period)
- evaluation on independent validation period (scores on 15-month period)

Map of 9 'hydro' regions (HER)



Averaged contingency scores
POD, SR and CSI obtained for 921
basins and 12-yr period with
calibrated & regional parameters
Trade-off between *detection*
(*POD*) vs. *reliability* (*SR*)
depending on risk-aversion of
end users

Regional model: scores (averaged on
2, 5, 10 and 20-yr floods) per HER



Contingency scores (relevant to operational
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with H nb of hits, M nb of misses,
FA nb of false alarms

Evaluation of regional model on 15-month
period (01/08/2019 - 24/10/2020)

Performance	5-yr flood	20-yr flood
POD	0.65	0.52
SR	0.37	0.26
CSI	0.31	0.21
Median lead time (h)	5.3	4.4
Mean lead time (h)	4.8	3.5
Nb Hits	327	59
% hits with lead time $\geq 0h$	84.1	84.7
% hits with lead time $\geq 2h$	61.2	50.8

Significant effective lead time for all events
correctly forecasted even with only QPE inputs

Warning performances depend on
hydro regions: worse scores
obtained on mountainous regions
(HER 1 and 8) and for basins with
significant base flow (HER 6) and
karst areas (e.g. HER 2)

→ more complex hydrologic model
needed to better represent
catchment behaviour

Ongoing work:

- include cell-to-cell routing
- use variational calibration schemes (Jay-Allemand et al. 2020)
- integrate additional hydrologic modules and functions (e.g. snow component)
- best combination of radar-raingauge QPE products (new 15-minute products from Météo-France, Piotte et al. 2020)

Main challenges:

- include high-resolution precipitation nowcasts (new AROME-radar blending nowcasts from Météo-France)
- account for main sources of uncertainty (precipitation ensembles, Demargne et al. 2019)
- include vulnerability and impacts components to produce flood risk maps
- evaluate on ungauged basins with flood damages (e.g. DamaGIS database, Saint Martin et al. 2018)

See ongoing PICS research project (<https://pics.iffstar.fr>)

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Contact: julie.demargne@hydris-hydrologie.fr , catherine.fouchier@inrae.fr