

COMMUNICATING PROBABILISTIC FLOOD FORECAST MAPS TO DIFFERENT USER GROUPS

Valérie Jean, Marie-Amélie Boucher, Anissa Frini
and Dominic Roussel

marie-amelie.boucher@usherbrooke.ca

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UQAR



Environnement
et Lutte contre
les changements
climatiques

Québec



UDS

Université de
Sherbrooke

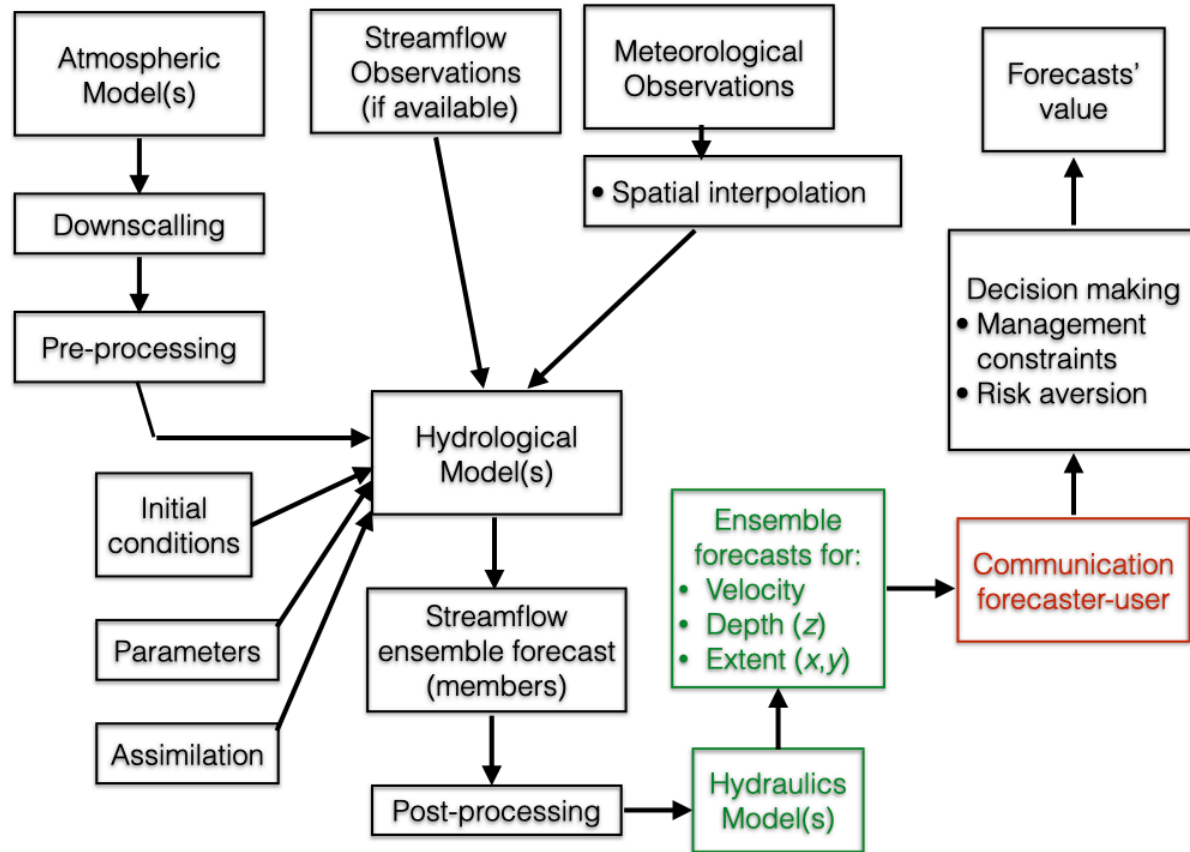
THE INFO-CRUE PROGRAM

- Major floods during Spring 2017
 - Rain on snow
 - 180 municipalities
- *Forum Inondations 2017* (Fall 2018)
 - Action plan relative to civil security specific to floods, Public Security Ministry (MSP)
 - Special funds for municipalities from the Ministry of municipal affairs and habitation (MAMH)
 - For flood zones delimitation



<https://ici.radio-canada.ca/nouvelle/1032244/inondations-degradation-precipitations-pluie-quebec-rivieres-niveau-eau>

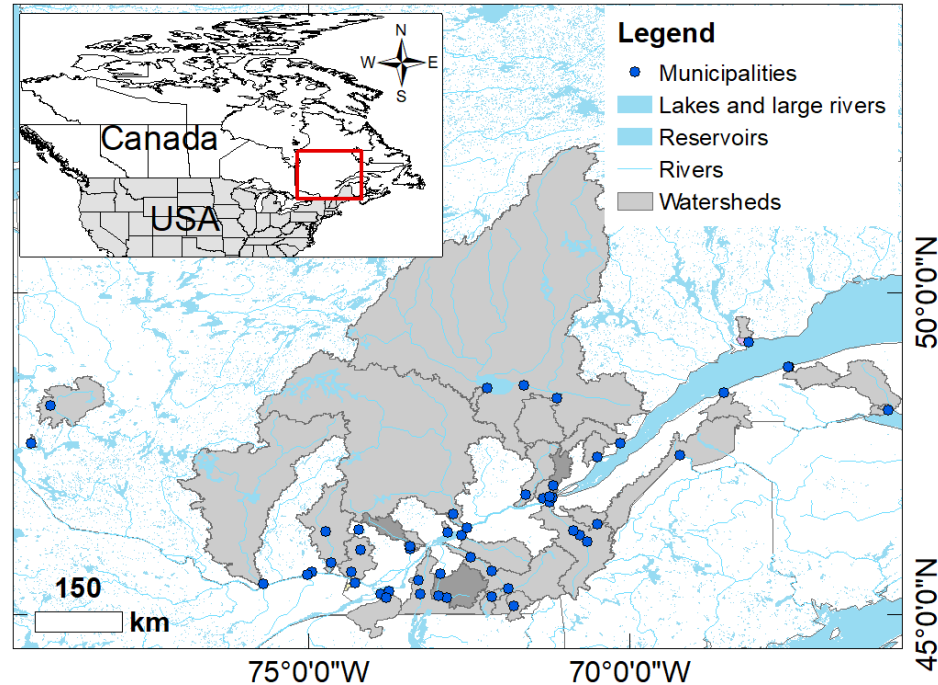
ENSEMBLE FORECASTING





FORECAST COMMUNICATION

- Ministries: 24 interviews with 28 participants
- 52 municipalities (62 participants)
- Organisations: 9 interviews with 12 participants
- 11 discussion groups with 33 citizens and 4 farmers



FORECAST COMMUNICATION

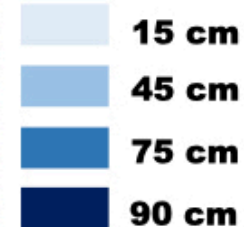
Reach	Capitale-Nationale	PROBABILITY OF EXCEEDING THE DEPTHS ON THE MAP:	
JC0508_0010	River: Jacques Cartier	Forecast for :	Highly probable
		Mon. April 5 	



Very unlikely : approximately 5% probability
 Unlikely : approximately 25% probability
 Probable : approximately 50% probability
 Highly probable : approximately 75% probability
 Almost certain : approximately 95% probability

Legend

Water depth





FORECAST COMMUNICATION

From a citizen:

« I don't understand how I select what is going to happen. I had it in my head that I would actually be told »

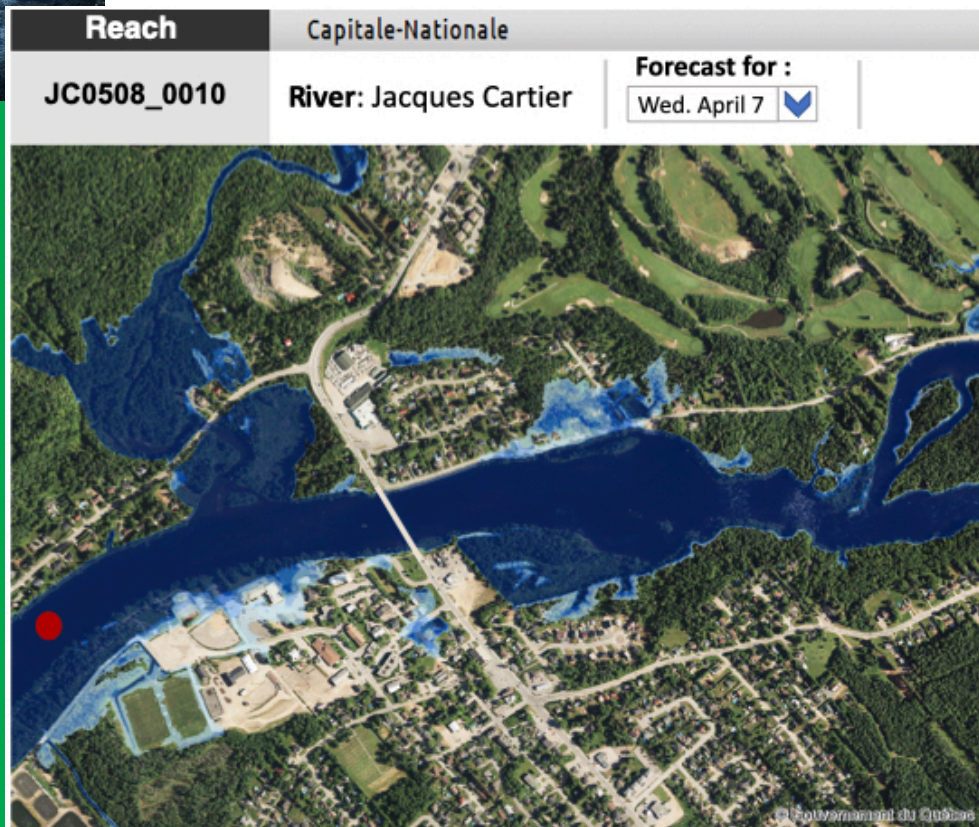
(Je ne comprends pas comment je sélectionne ce qui va se passer. J'avais en tête qu'on me le dirait en fait)

From a citizen:

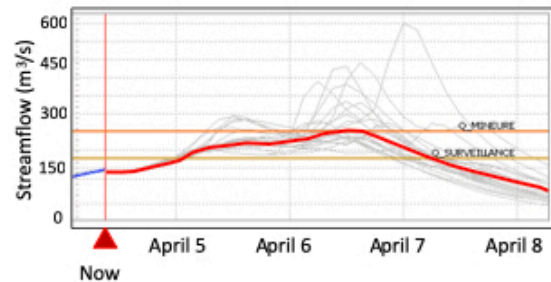
«But for me, when you presented that to me « likely », « unlikely », « very likely », you just lost me »

(Mais moi quand vous m'avez présenté ça « probable », « peu probable », « très probable », vous venez de me perdre.)

FORECAST COMMUNICATION

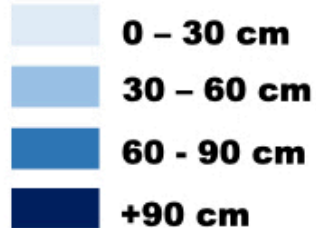


MEDIAN STREAMFLOW SCENARIO:



Legend

Water depth





FORECAST COMMUNICATION

From the director of public works for a municipality:

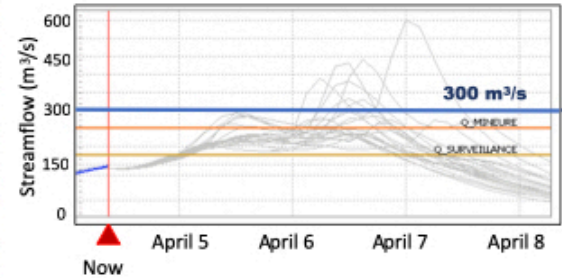
«I think it would also be good to include a probability next to the median scenario. Because in Prototype 1, we talked about the probability of this happening, so we should include the same element. What is the probability that the average or median flow will occur? Maybe it would be good to have the probability next to it. »

(Moi je pense que ça serait bon également de mettre une probabilité à côté du scénario médian. Parce que dans la maquette 1, on parlait de probabilités que ça arrive, alors, il faudrait apporter le même élément. Quelle est la probabilité que le débit moyen ou médian arrive? Ça serait peut-être bon d'avoir la probabilité à côté)

FORECAST COMMUNICATION

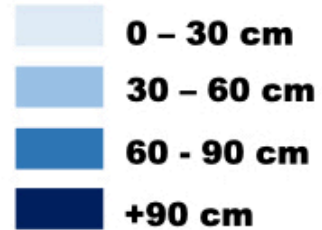


Reach	Capitale-Nationale	DOWNSTREAM FLOW:
JC0508_0010	River: Jacques Cartier	300 m ³ /s



Legend

Water depth



FORECAST COMMUNICATION



Reach	Capitale-Nationale		PROBABILITY OF EXCEEDING A DEPTH OF:
JC0508_0010	River: Jacques Cartier	Forecast for : Mon. April 5 <input type="button" value="v"/>	30 cm <input type="text" value=" "/>



Legend :

- Low : less than 25%
- Average : 25% to 50%
- High : 50% to 75%
- Very high : more than 75%



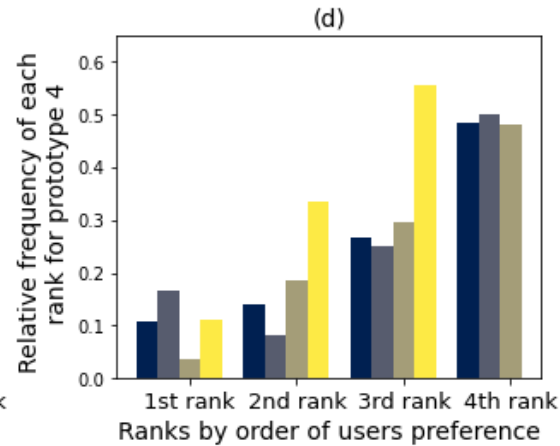
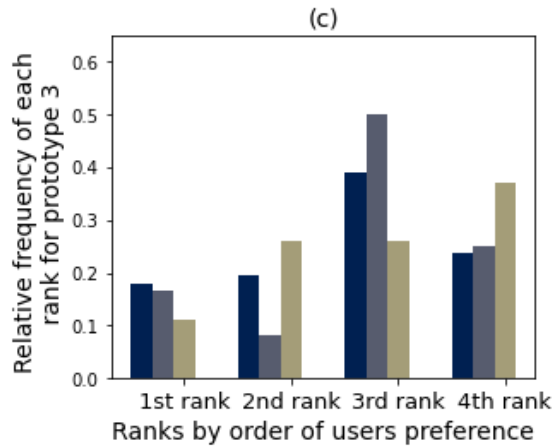
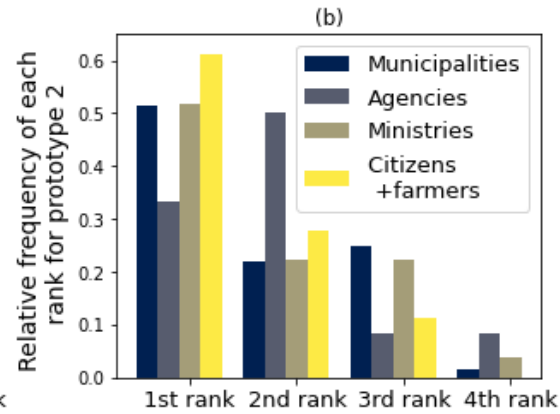
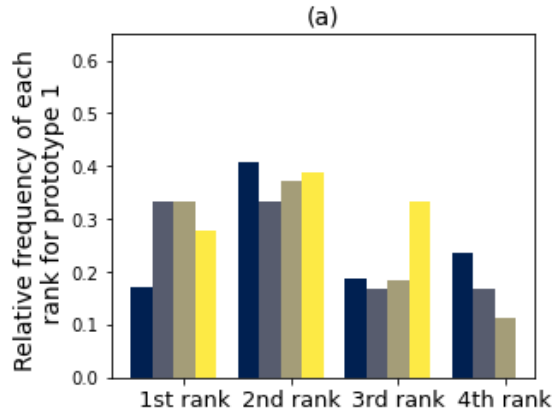
FORECAST COMMUNICATION

The director of services for a municipality :

« It's going to be hard to explain this, I see myself trying to present this to elected officials, phew! It seems like it's more real when the colour represents a thickness of water.»

(Ça va être difficile d'expliquer ça, je me vois essayer de présenter ça aux élus, ouf! On dirait que c'est plus réel quand la couleur représente une épaisseur d'eau)

FORECAST COMMUNICATION





CONCLUSION

- There is a need (and an appetite!) for information
 - Hydrological modeling and forecasting
 - What is accounted for by the model?
 - Probabilities!
 - People refer to the probabilities of precipitation
 - Probability of exceeding/non exceeding: new for most people
- A dilemma:
 - Provide all the information, including the uncertainty
 - ...ideally without using probabilities
- Solutions?
 - Prototype #2
 - Not providing the water depth to the public?



CONCLUSION

Jean V., Boucher M.-A. and Frini A. And Dominic Roussel (2023a): Fully integrating probabilistic flood forecasts into the decision-making process across southern Quebec, Canada: some factors to consider, *Canadian Water Resources Journal*, DOI: [10.1080/07011784.2023.2238696](https://doi.org/10.1080/07011784.2023.2238696)

Jean V., Boucher M.-A., Frini A. and Dominic Roussel (2023b): Uncertainty in three dimensions: the challenges of communicating probabilistic flood maps, *Hydrology and Earth System Sciences* (Accepted)



EXTRA



FLOODS IN QUEBEC

- Delft-FEWS/**HYDROTEL**:
 - 28 035 simulation points
 - Gauged basins
 - Ungauged basins (Lachance-Cloutier et al. 2017)
 - Probabilistic forecasts
 - 3h00 time step with lead time from 3 to 120h00
 - Since January 1st, 2019
 - Contribution of human forecasters



1 LAYER
SNOWPACK,
MIX OF DEGREE-DAY
AND ENERGY BUDGET

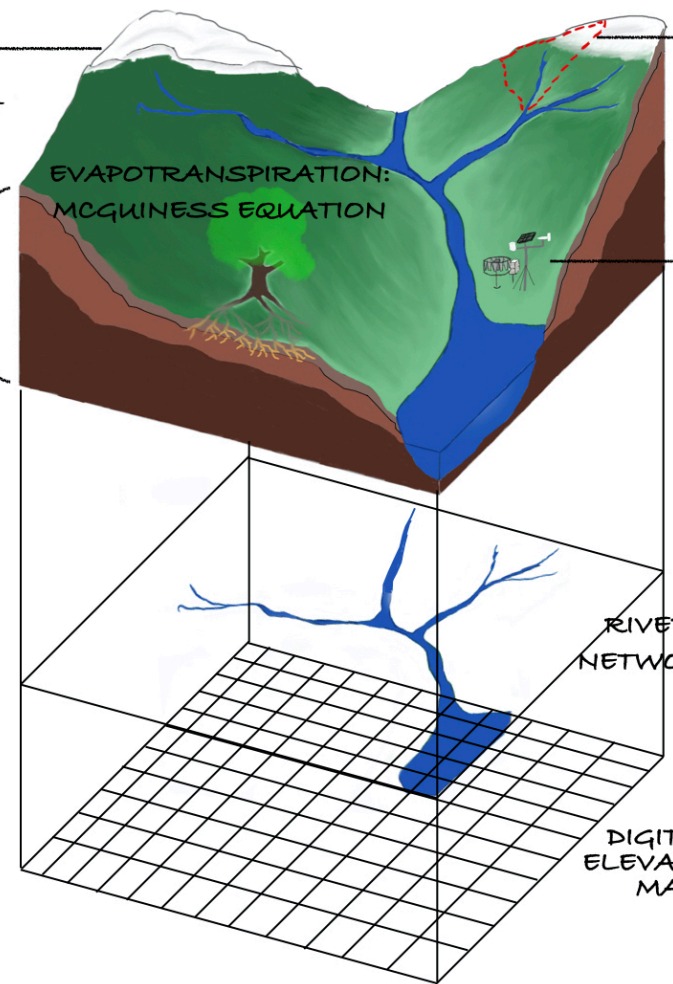
BV3C:
3 LAYER
VERTICAL
WATER BUDGET

EVAPOTRANSPIRATION:
MCQUINN'S EQUATION

HRU

FLOW ROUTING:
KINEMATIC WAVE

INTERPOLATION OF
METEO. DATA:
THIESSEN'S
POLYGONS



RIVER
NETWORK

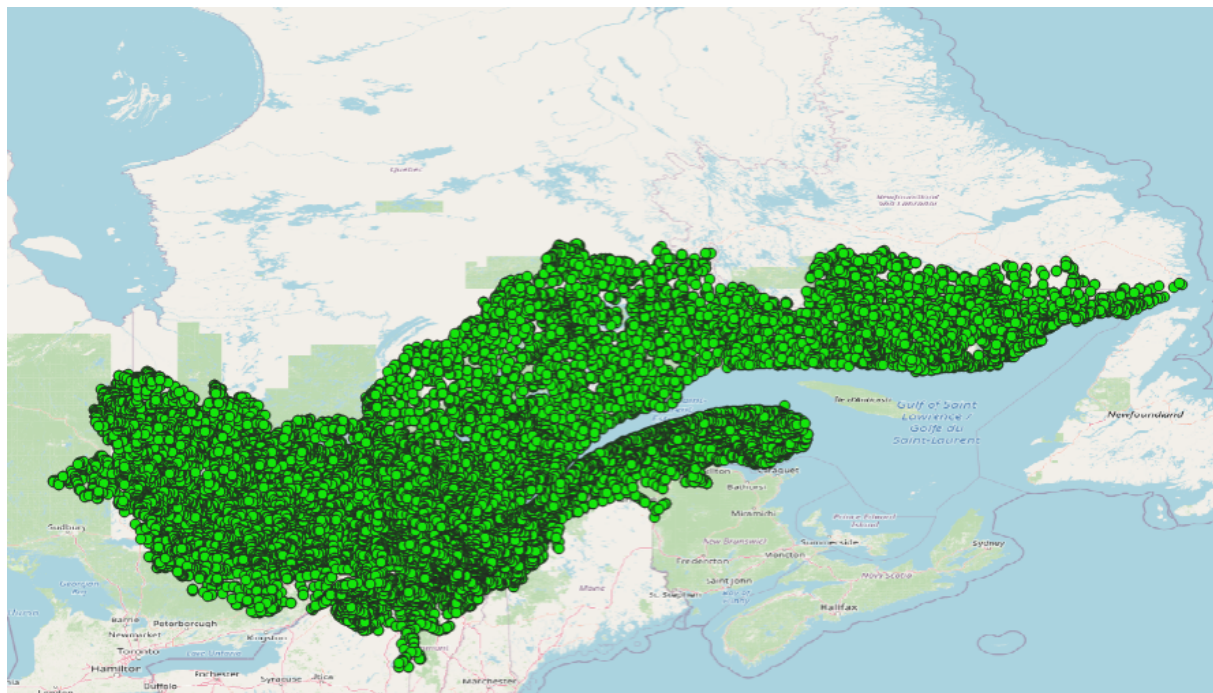
FLOW
DIRECTIONS

DIGITAL
ELEVATION
MAP

Fortin J.-P., et al. 2001. A distributed watershed model compatible with remote sensing and GIS data, part I: Description of the model. J. Hydrol. Eng. – Am. Soc. Civil Eng. 6 (2), 91–99.



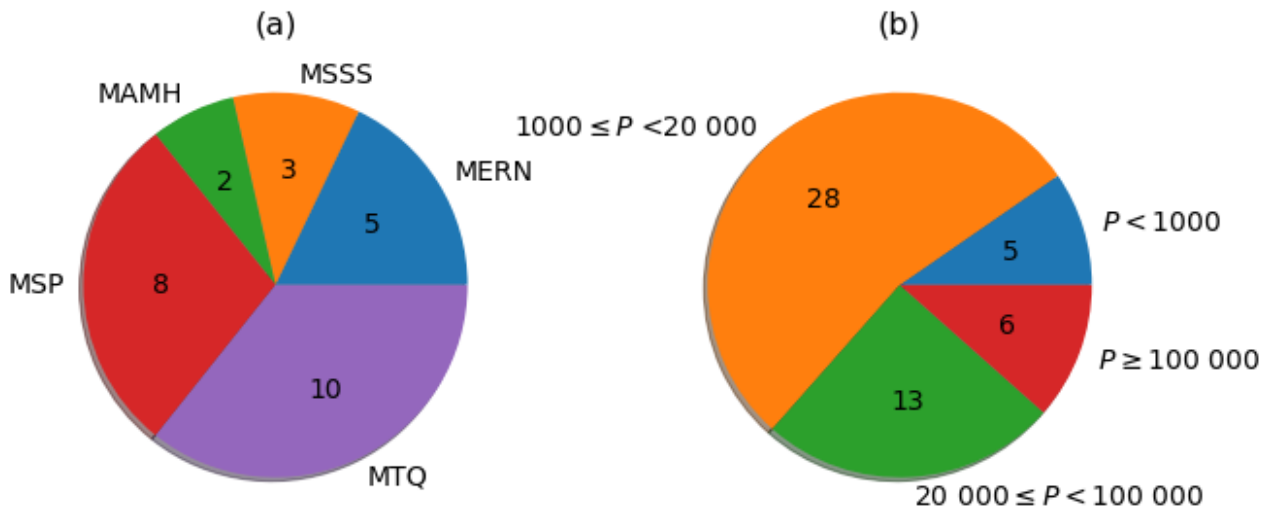
FLOODS IN QUEBEC





FORECAST COMMUNICATION

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FORECAST COMMUNICATION

Table 1. Discussion topics and questions asked to the interviewees.

Discussion topics	Questions asked
<p>Flooding</p> <ul style="list-style-type: none"> ● Definitions ● Consequences ● Perception of flood risk <p>Decision-making and forecasting</p> <ul style="list-style-type: none"> ● Role and utility of forecasting ● Organizations and their decision-making capacities ● Intervention plan <ul style="list-style-type: none"> ● Integrating uncertainty into decision-making ● Consultation and collaboration ● The impacts of bad forecast <p>The preference between a flow forecast and a depth and extent forecast</p> <p>Confidence in the forecast</p>	<ul style="list-style-type: none"> ● What is your definition of a flood? ● What are the possible consequences of flooding in your area? ● Do you consider your territory to be at risk of flooding? And how do you rate this risk (low, medium, high)? ● When a flood occurs, what decisions must you make to reduce flood impact on your area? ● What information in the forecast triggers the decision-making mechanism and is this useful to you? ● What decision-making mechanisms are put in place upon the reception of a forecast? Do you have a response plan? How are decisions made? ● What is a bad forecast, and what is the worst consequence from a bad forecasting system? ● What format do you think would be more useful for you: a flow forecast or a depth and extent forecast? ● How would you describe your level of confidence in the forecasts issued by the DEH (Ministry of the Environment)? What would increase your level of confidence?



FORECAST COMMUNICATION

Table 7 Elements to include on a flood forecast map according to the various participant groups

Participant group	Elements to include on a map	Needs
Ministries, municipalities, agencies	Infrastructure, such as cottages and residences, public buildings, and critical buildings, e.g., schools, hospitals, and daycare centres	Ability to localize elements in relation to the actual territory
Ministries, municipalities, agencies, farmers	Roads closed due to flooding and detours when issuing the forecast	
Ministries, municipalities, agencies	Municipal boundaries	
Agencies (UPA), farmers	Agricultural land	
Ministries, municipalities,	Watercourses and their names	



FORECAST COMMUNICATION

Table 7 Elements to include on a flood forecast map according to the various participant groups

Participant group	Elements to include on a map	Needs
Municipalities	At-risk areas with a vulnerability indicator	Need to quickly identify the vulnerability of at-risk areas
Ministries, municipalities, agencies	Material and immaterial consequences of flooding	
Ministries	Photos of critical areas	
Ministries, municipalities, farmers	Spatialized representation of predicted rainfall	
Ministries, municipalities, agencies	A function to extract information or add layers of information from user-specific tools	Need to integrate the use of the tool with user-specific issues



FORECAST COMMUNICATION

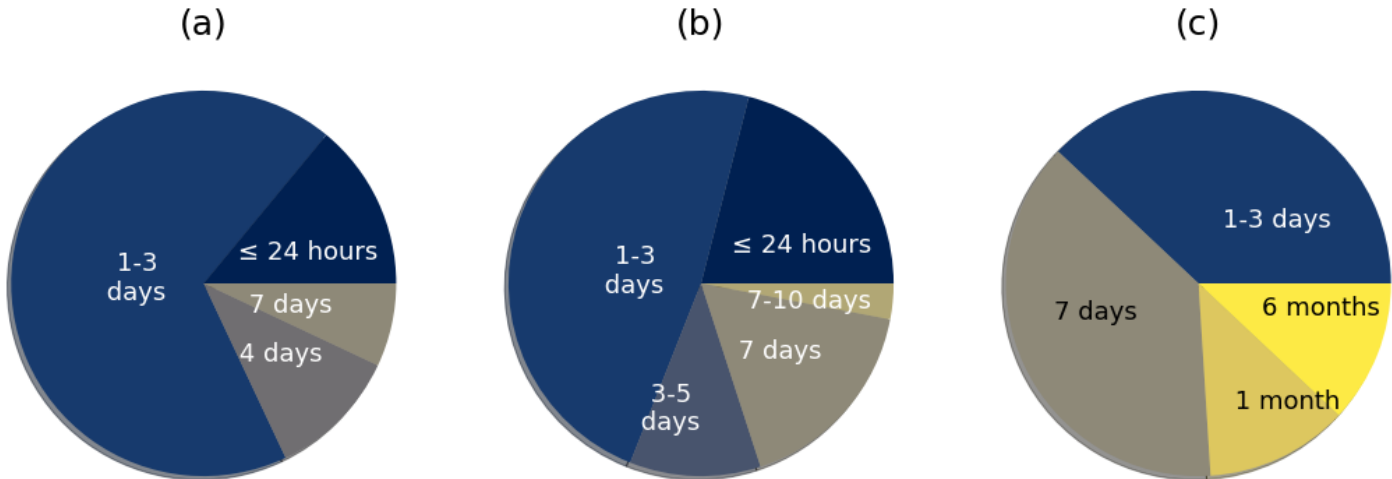
- Preferences for the expression of uncertainty by participant group

Participant group	Expression of uncertainty
Ministries, municipalities, agencies	Probability expressed as a percentage Colour-coded from least to most likely
Ministries, municipalities	Colour-coded scenarios (optimistic, median, pessimistic) Confidence interval
Agencies (1 OBV)	Standard deviation and/or margin of error



FORECAST COMMUNICATION

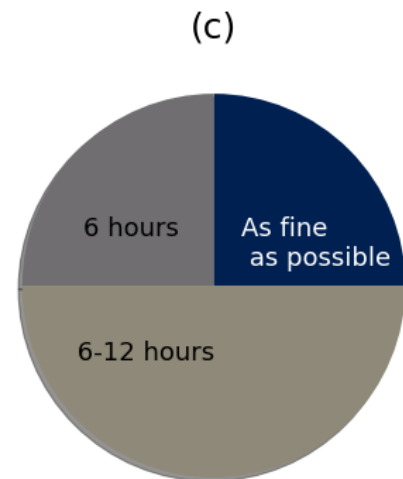
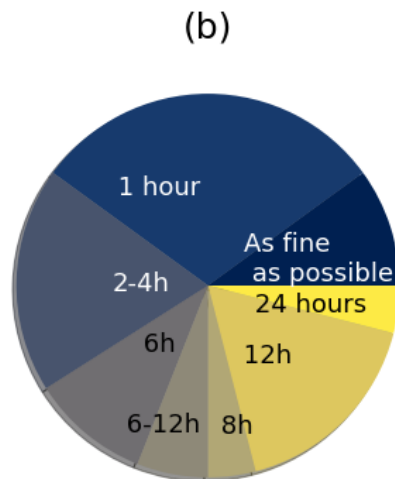
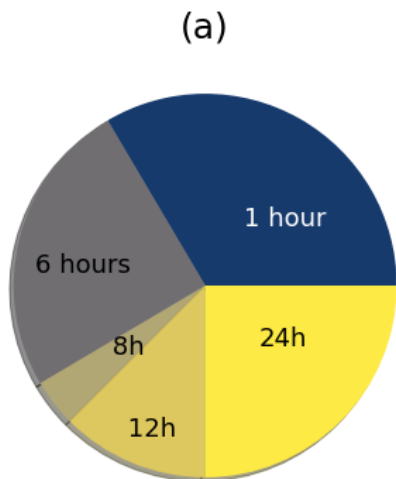
Preferred forecast time horizon according to (a) ministries (b) municipalities and (c) agencies





FORECAST COMMUNICATION

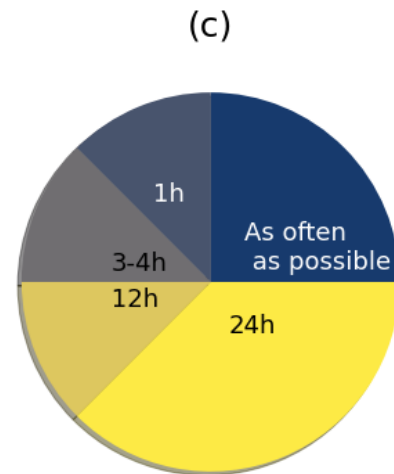
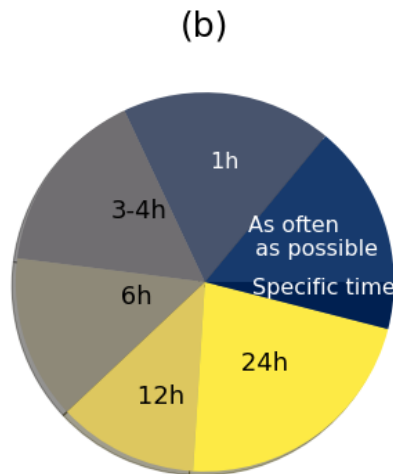
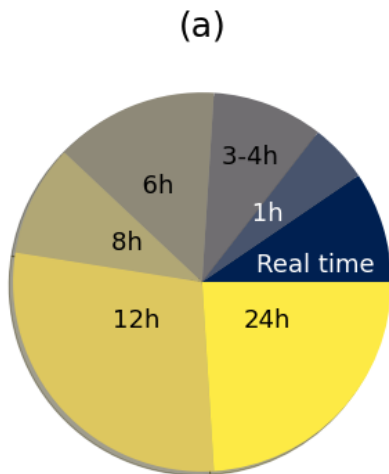
Preferred forecast temporal resolution according to (a) ministries (b) municipalities and (c) agencies





FORECAST COMMUNICATION

Preferred updating frequency according to (a) ministries
(b) municipalities and (c) agencies



FORECAST COMMUNICATION

From the chief executive officer of a municipality:

« I expect to have data that is analysed, not to have to analyse data, so I think I prefer the second prototype and rely on something that has been worked on by professionals. »

(Moi je m'attends à avoir des données qui sont analysées, par à devoir analyser des données donc je pense que je préfère la deuxième maquette. Me fier sur quelque chose qui a été travaillé par des professionnels finalement.)