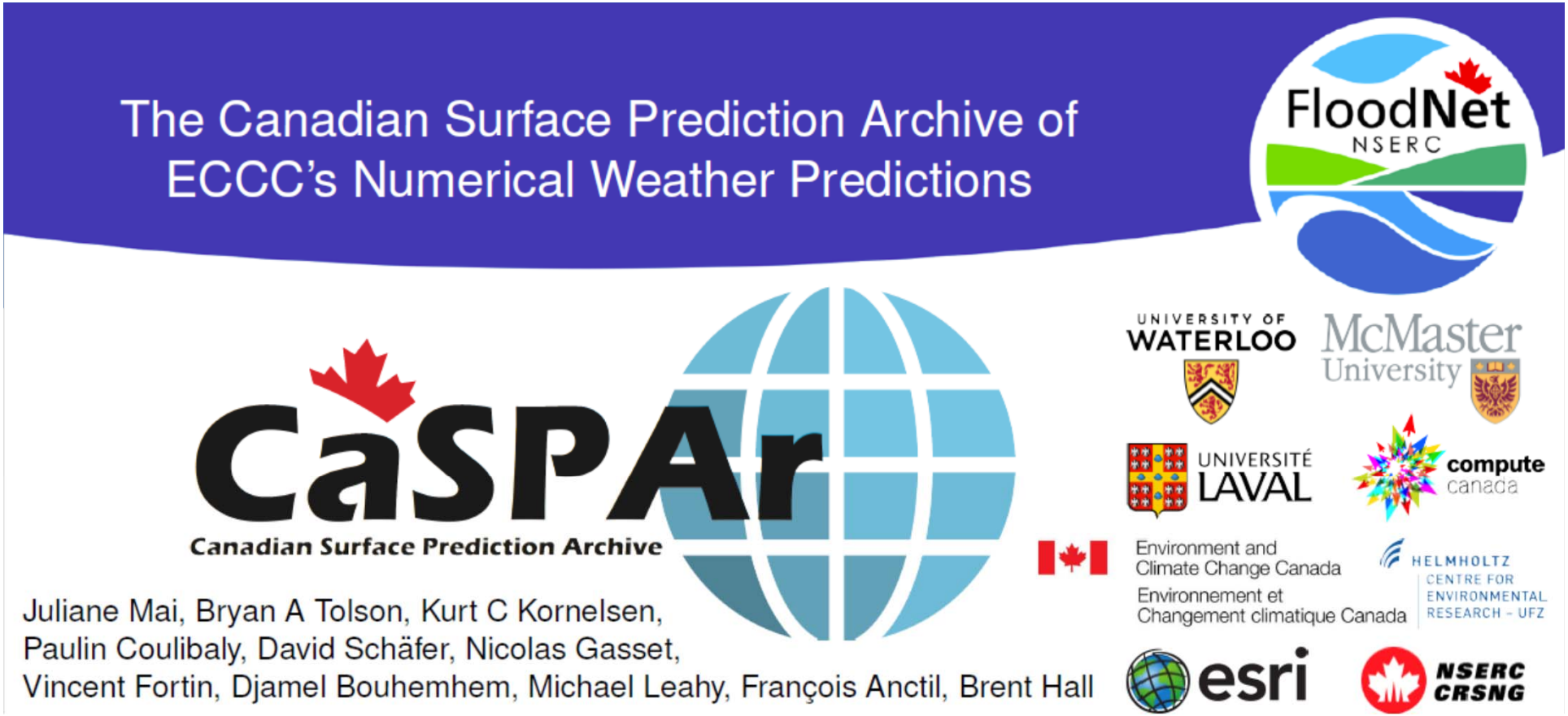
The Canadian Surface Prediction Archive of ECCC's Numerical Weather Predictions



Juliane Mai, Bryan A Tolson, Kurt C Kornelsen,
Paulin Coulibaly, David Schäfer, Nicolas Gasset,
Vincent Fortin, Djamel Bouhemhem, Michael Leahy, François Anctil, Brent Hall

Flood Modelling and Mapping
The Cornerstones of Flood Safety and Management in Ontario
Mar 5, 2019

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Origins of CaSPAr

- NSERC Canadian FloodNet Strategic Network led by Dr. Paulin Coulibaly
  - 5 year, $5,000,000 grant 2014-2019
  - Many partners including 3 CAs, hydropower & prov. forecasting agencies
  - A key focus was improving state-of-art and state-of-practice in flood and flow forecasting in Canada

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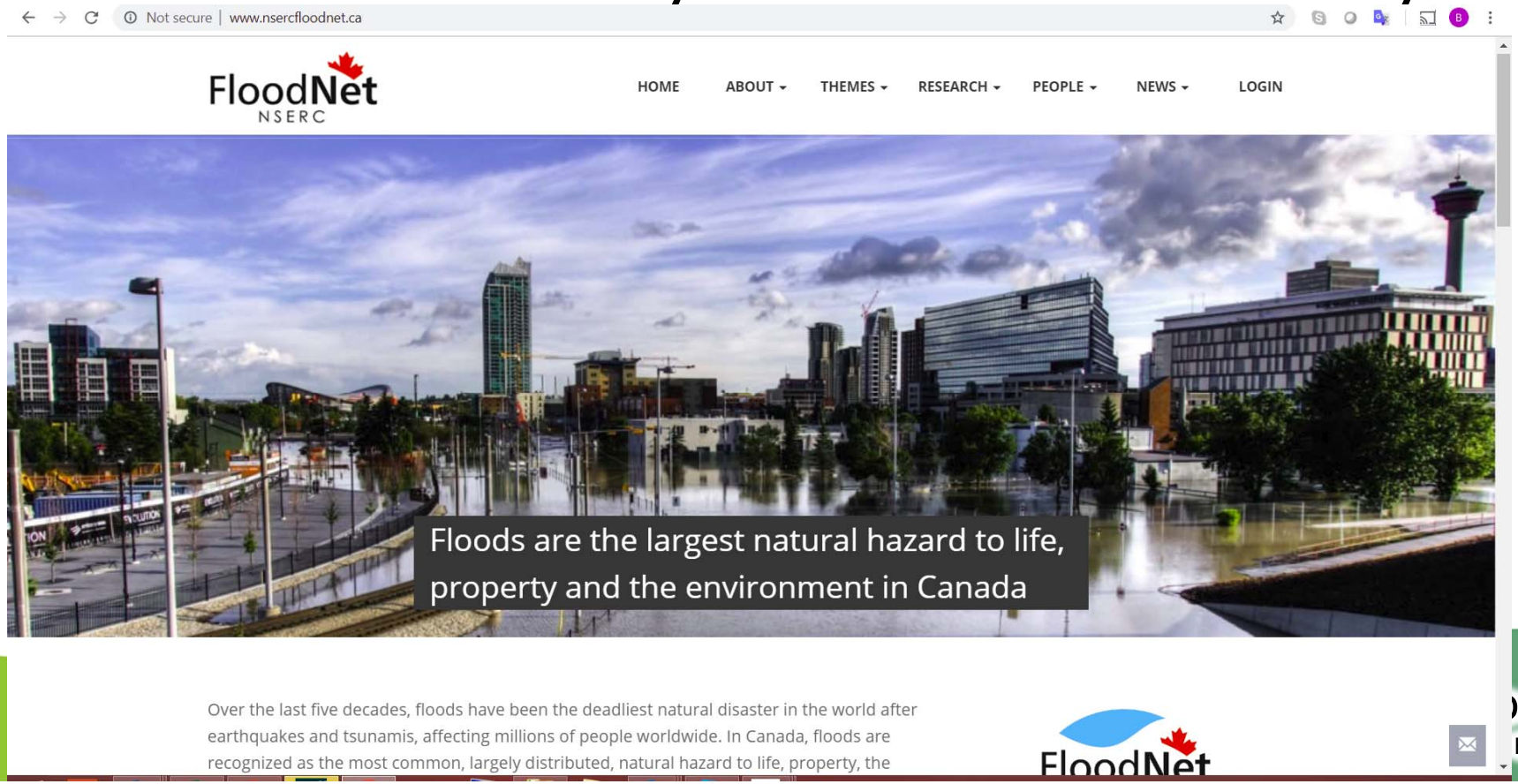
Origins of CaSPAr

- NSERC Canadian FloodNet Strategic Network led by Dr. Paulin Coulibaly



Origins of CaSPAr

- One key problem
  - Forecasting flows requires weather forecasts … ***archived*** weather forecasts
  - Original belief in FloodNet was that such archived forecasts would be supplied by ECCC
    - By Sept. 2016: clear this was impractical and there was no accessible weather forecast archive for ECCC forecasts

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Origins of CaSPAr

- Sept. 2016: Group of FloodNet researchers decide to build this archive
- Nov. 2016: apply for supercomputing resources
- March 2017: supercomputing resources granted and CaSPAr is a full-go!
- **CaSPAr**: **Ca**nadian **S**urface **P**rediction **Ar**chive
- June 2018: CaSPAr portal is finally live

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CaSPAr Overview

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FloodNet
NSERC

CaSPAr Overview

- CaSPAr built as a tool for research but it is also useful in practice
  - 200+ TB data archived May 2017 to seven days ago
  - Data added daily from ECCC
  - 9 ECCC numerical weather products

- CaSPAr is NOT an operational weather forecast distribution tool

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- *To PDF slides …*

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FloodNet
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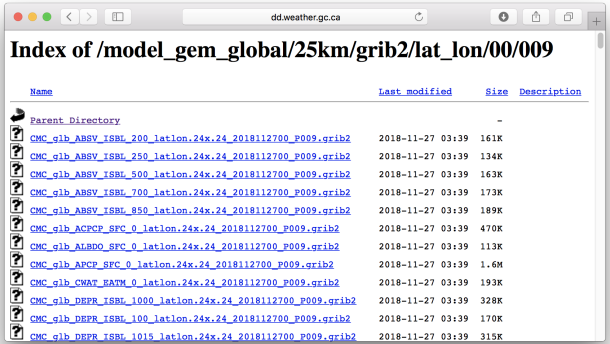
State of the art

DataMart

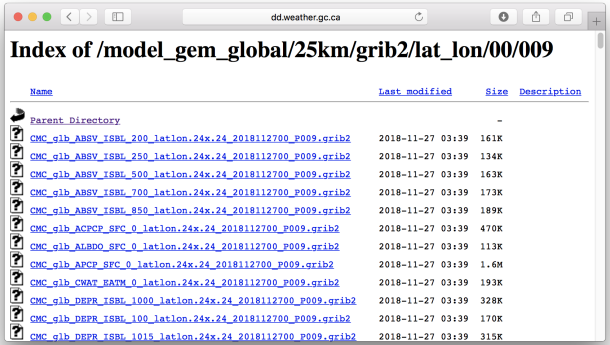
http://dd.meteo.gc.ca/about_dd_apropos.txt



State of the art

DataMart

http://dd.meteo.gc.ca/about_dd_apropos.txt



- no archive
- data interpolated to grib2 supported grid
- no spatial cropping
- heavy post-processing

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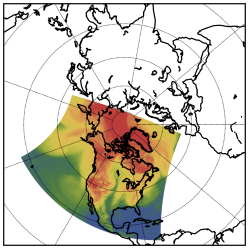
Aim of CaSPAr

archive
forecasts & analyses
produced by

Environment and
Climate Change Canada

Environnement et
Changement climatique Canada

convert
raw FST data to
standardized NetCDF



provide
gis-based web interface
to make data available

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Architecture

Community

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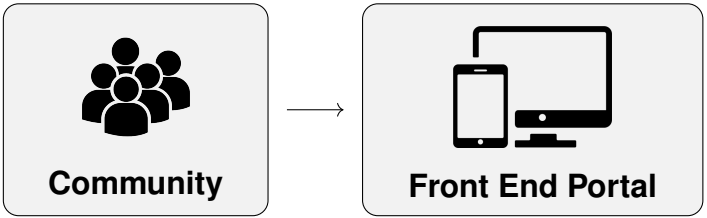
Architecture



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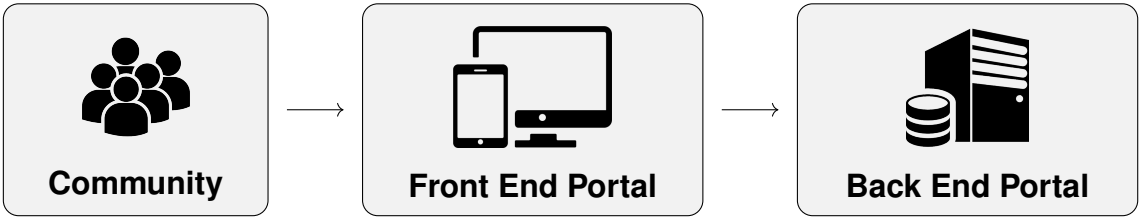
Architecture



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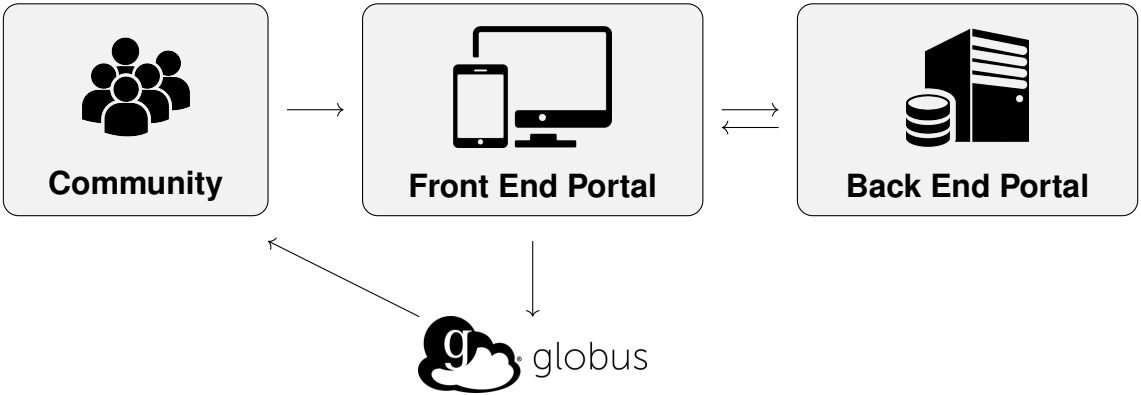
Architecture



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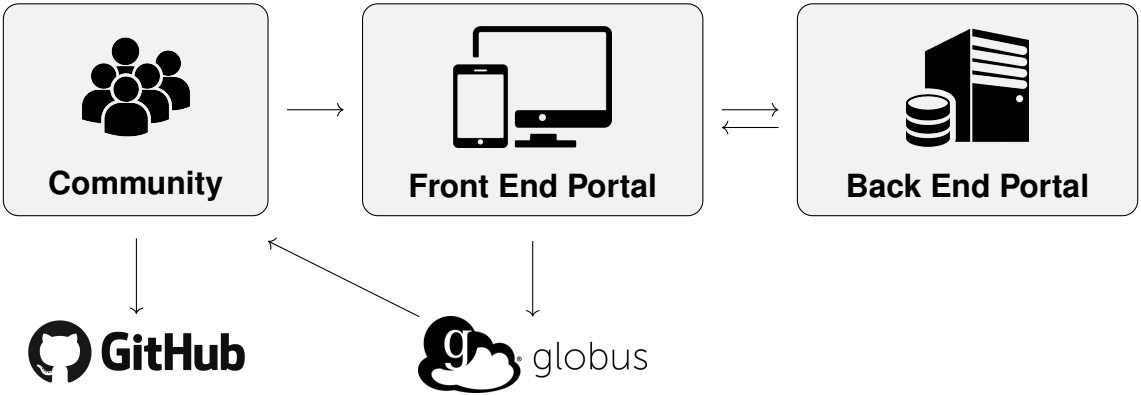
Architecture



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#1

Individual Subsetting of Data

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Frontend

– Submit Your Request –

- ☐ Select product
- ☐ Credentials
- ☐ Domain
- ☐ Variables
- ☐ Horizons
- ☐ Issues
- ☐ Time period
- ☐ Submitted!

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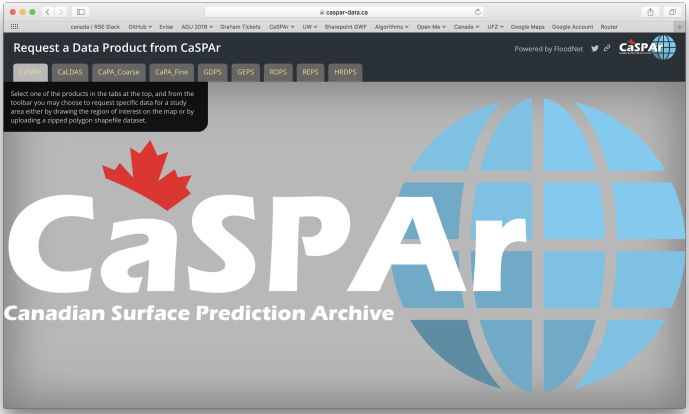
Frontend

– Submit Your Request –

- ✓ Select product
- ☐ Credentials
- ☐ Domain
- ☐ Variables
- ☐ Horizons
- ☐ Issues
- ☐ Time period
- ☐ Submitted!



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Frontend

– Submit Your Request –

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- ☐ Horizons
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- ☐ Time period
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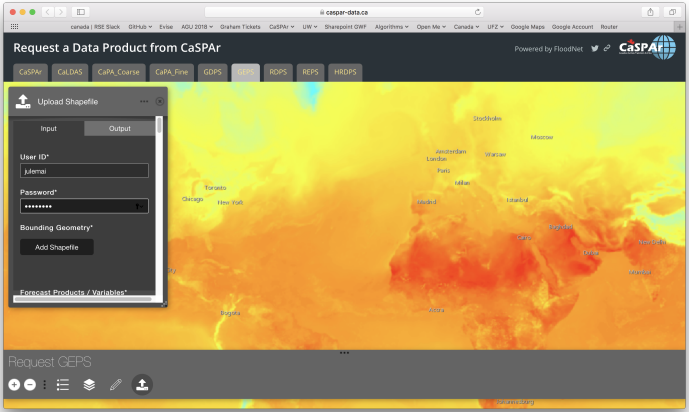

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Frontend

– Submit Your Request –

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- ☐ Horizons
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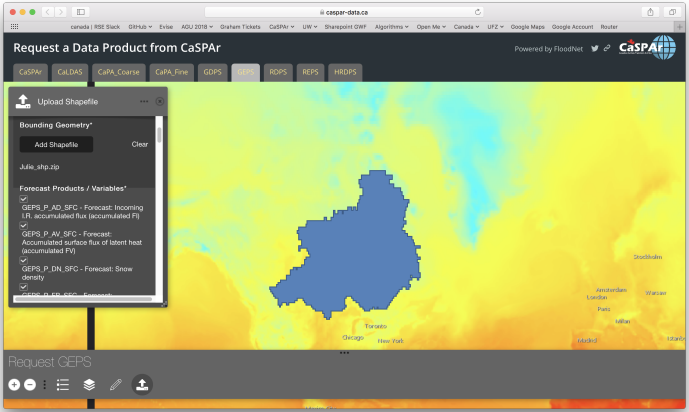
- ☐ Time period
- ☐ Submitted!



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Frontend

– Submit Your Request –

- ✓ Select product
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- ✓ Domain
- ✓ Variables
- ☐ Horizons
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- ☐ Time period
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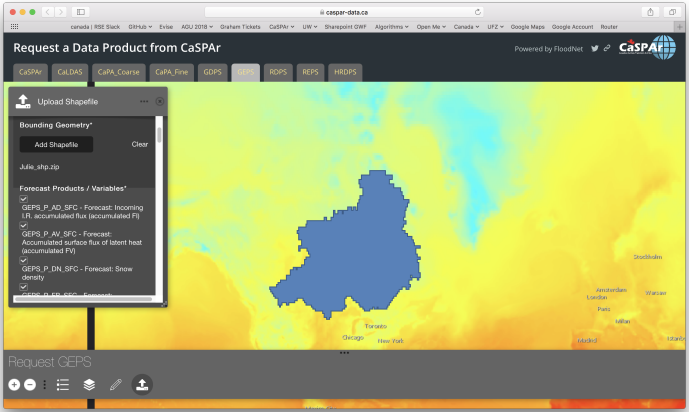

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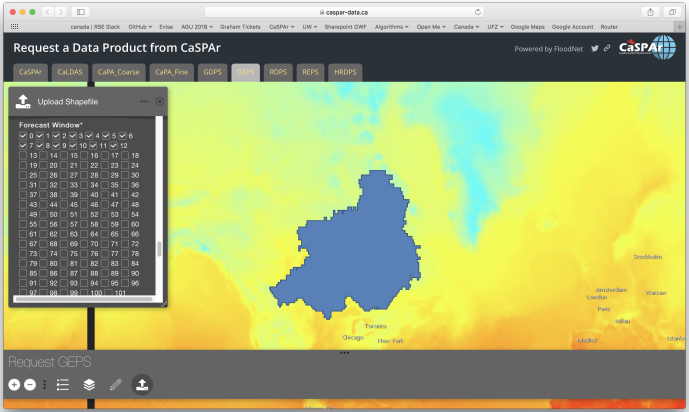
Frontend

– Submit Your Request –

- ✓ Select product
- ✓ Credentials
- ✓ Domain
- ✓ Variables
- ✓ Horizons
- ☐ Issues
- ☐ Time period
- ☐ Submitted!



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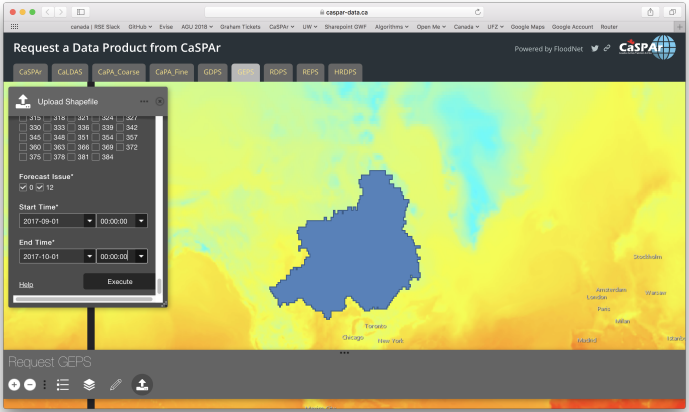
Frontend

– Submit Your Request –

- ✓ Select product
- ✓ Credentials
- ✓ Domain
- ✓ Variables
- ✓ Horizons
- ✓ Issues
- ☐ Time period
- ☐ Submitted!



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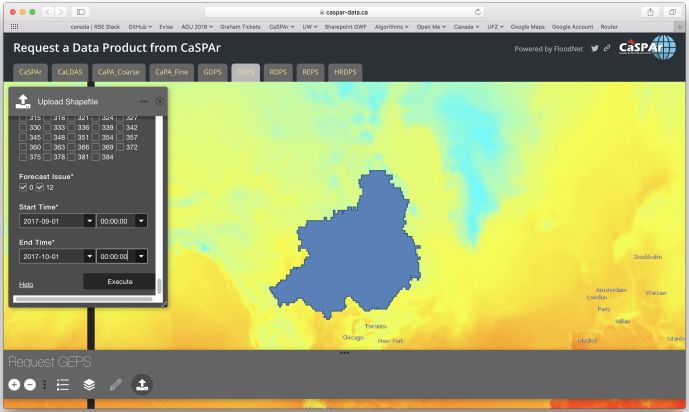
Frontend

– Submit Your Request –

- ✓ Select product
- ✓ Credentials
- ✓ Domain
- ✓ Variables
- ✓ Horizons
- ✓ Issues
- ✓ Time period
- ☐ Submitted!



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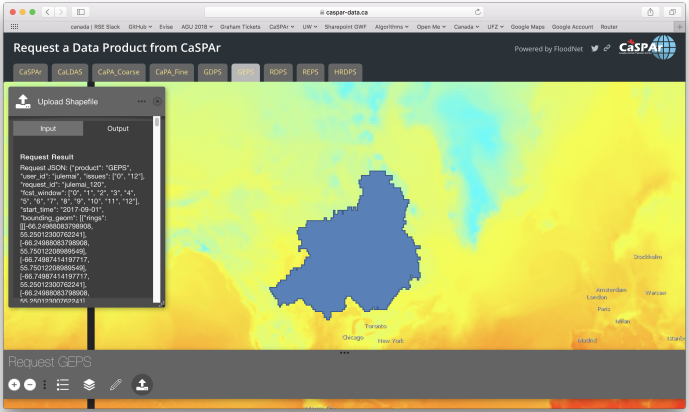
Frontend

– Submit Your Request –

- ✓ Select product
- ✓ Credentials
- ✓ Domain
- ✓ Variables
- ✓ Horizons
- ✓ Issues
- ✓ Time period
- ✓ Submitted!



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#2

Easy Comparison of NWP Products

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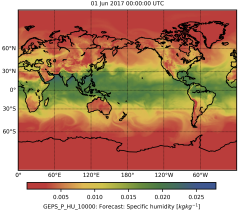
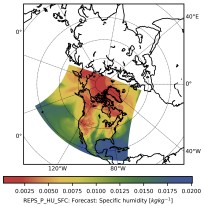
Easy Comparison of NWP Products

– Products Available –

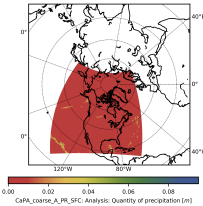
GEPS



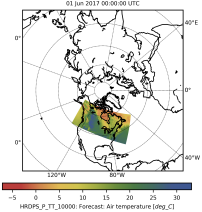
REPS



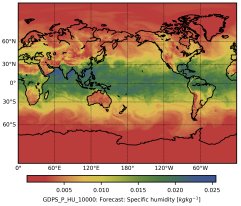
CaPA 10.0k



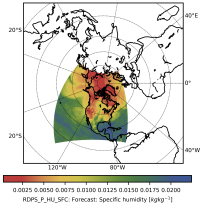
HRDPS



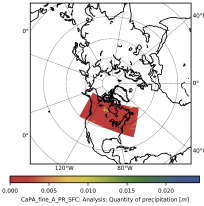
GDPS



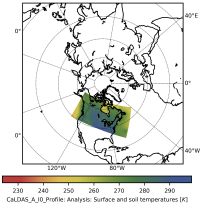
RDPS



CaPA 2.5k



CaLDAS



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Easy Comparison of NWP Products

– Products Available –

8+ TB
new data
per month

(20+ months are archived to date)

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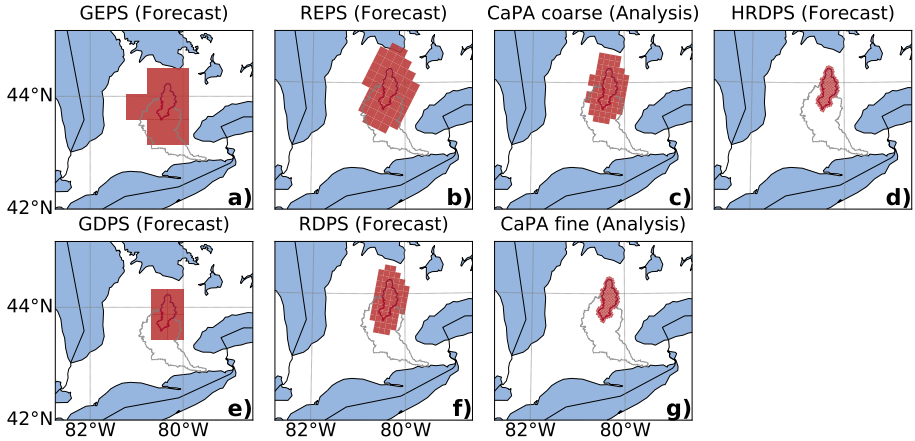
Easy Comparison of NWP Products

– Grand River Flood Event June 2017 –



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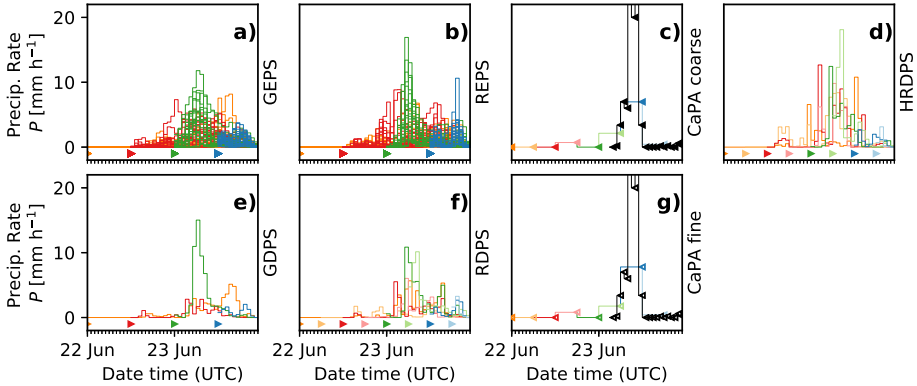
Easy Comparison of NWP Products

– Grand River Flood Event June 2017 –

Forecasted precipitation – Grand River watershed upstream of West Montrose



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#3

Drastic Reduction of Data Amount to Download

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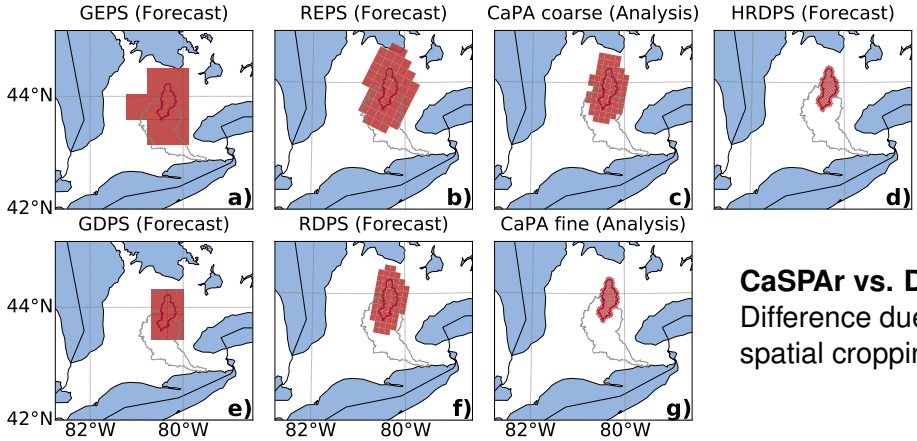
Drastic Reduction of Data Amount to Download

– Grand River Flood Event June 2017 –



CaSPAr vs. DataMart

Difference due to spatial cropping

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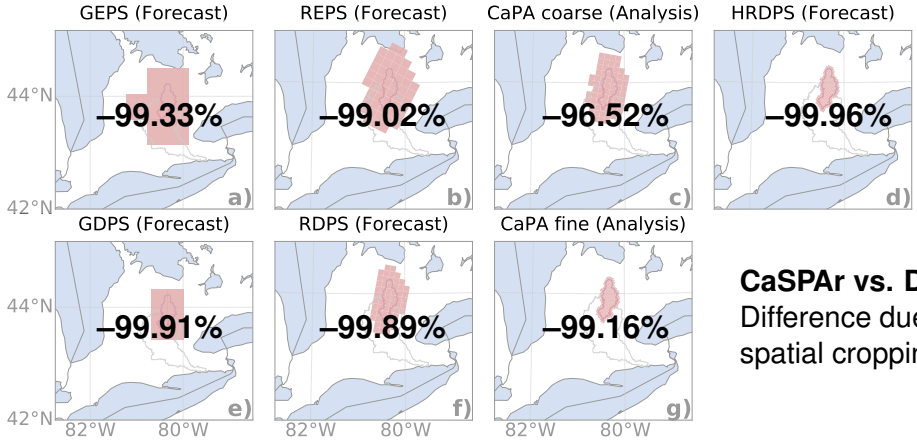
Drastic Reduction of Data Amount to Download

– Grand River Flood Event June 2017 –



CaSPAr vs. DataMart
Difference due to spatial cropping

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#4

Standardized File Format

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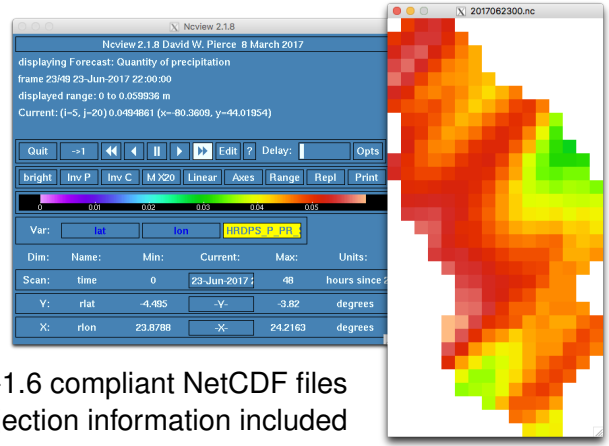
Standardized File Format



- ✓ CF-1.6 compliant NetCDF files
- ✓ projection information included

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#5

Seamless Utilization of Input Data

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Seamless Utilization of Input Data

– Models running with NetCDF inputs directly –

- Hydrologic Modeling Framework RAVEN
- Hydrologic Modeling Framework SUMMA
- Variable Infiltration Capacity Model VIC v5.0
- Mesoscale Hydrologic Model – mHM
- MEC-Surface & Hydrology model – MESH
- Weather Research and Forecasting Model – WRF-Hydro
- Community Land Model – CLM
- Multi-parametrization Land Surface Model – Noah-MP

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Summary of Products in CaSPAr

Product	Archived since	Archived until	Forecasted time steps [h]	Issues	Ensemble size	Number of variables	Resolution	Memory [GB/month]
GEPS	2017-05-23	today	1,2,..., 72, 96,..., 384	2/day	21	55	~50.0km	4662
GDPS	2017-05-22	today	1,2,..., 144, 147,..., 240	2/day	1	55	~25.0km	426
REPS	2017-05-23	today	1,2,..., 72	2/day	21	52	~15.0km	1638
RDPS	2015-01-01	today	1,2,..., 84	4/day	1	55	~10.0km	684
RDRS	2010-01-01	2014-12-31	1,2,..., 24	1/day	1	12	~15.0km	5
HRDPS	2017-05-22	today	1,2,..., 48	4/day	1	50	~2.5km	840
CaLDAS	2017-05-22	today	N/A	8/day	25	14	~2.5km	281
CaPA_coarse	2012-09-17	today	N/A	4/day	1	2	~10.0km	1
CaPA_fine_exp	2016-06-01	2018-03-02	N/A	4/day	1	2	~2.5km	2
CaPA_fine	2018-03-03	today	N/A	4/day	1	2	~2.5km	2

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CaSPAr Utility Demo 2: CaPA

- ECCC CaPA precipitation product
  - Blends numerical weather model plus ground and radar observations
  - *Are my case study area rain gauges incorporated into CaPA?*

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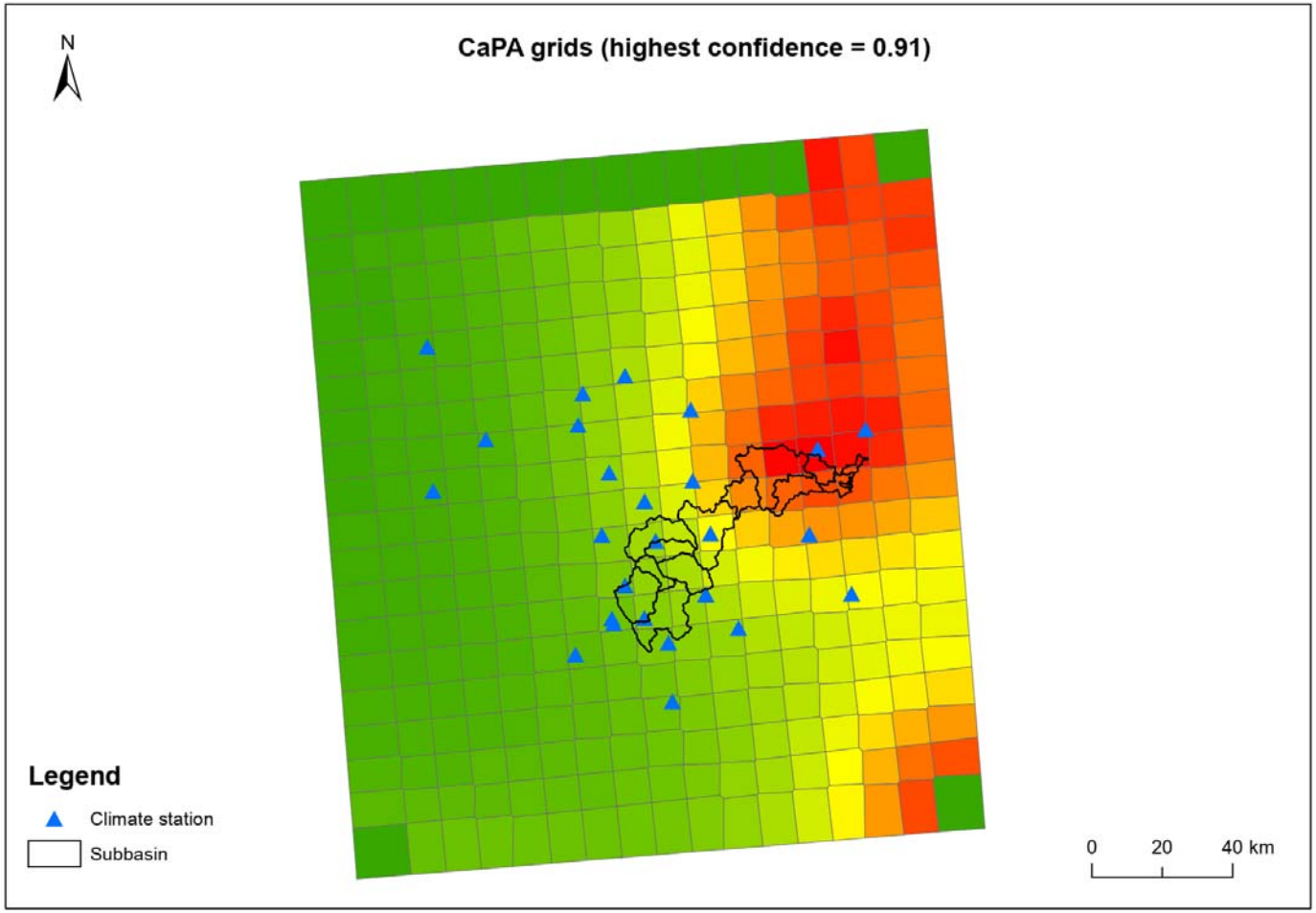
CaSPAr Utility Demo 2: CaPA

- Building City of Calgary hydrologic model …



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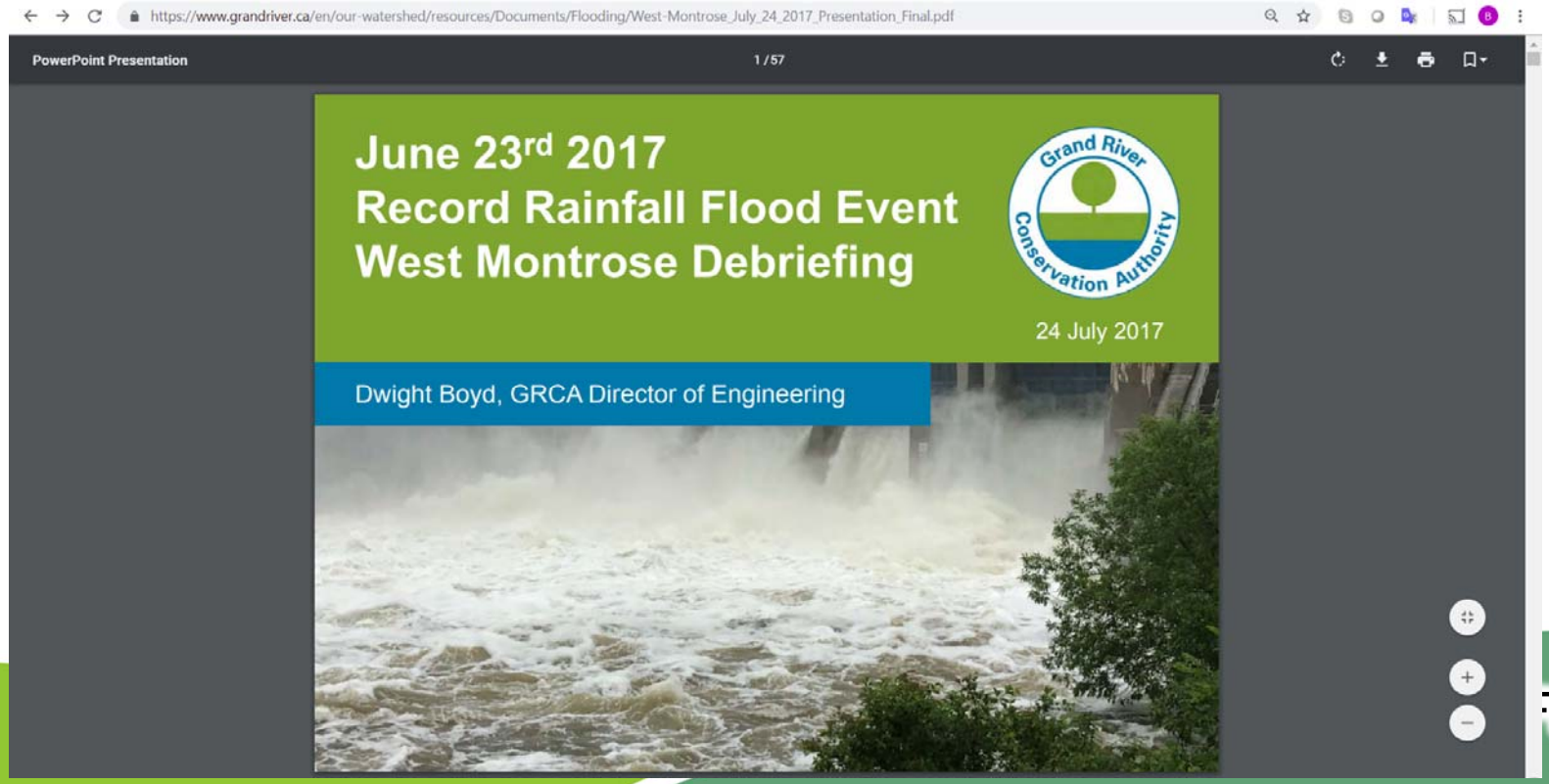
CaSPAr Utility Demo 3: Post June 23, 2017 flood event analysis in GRCA

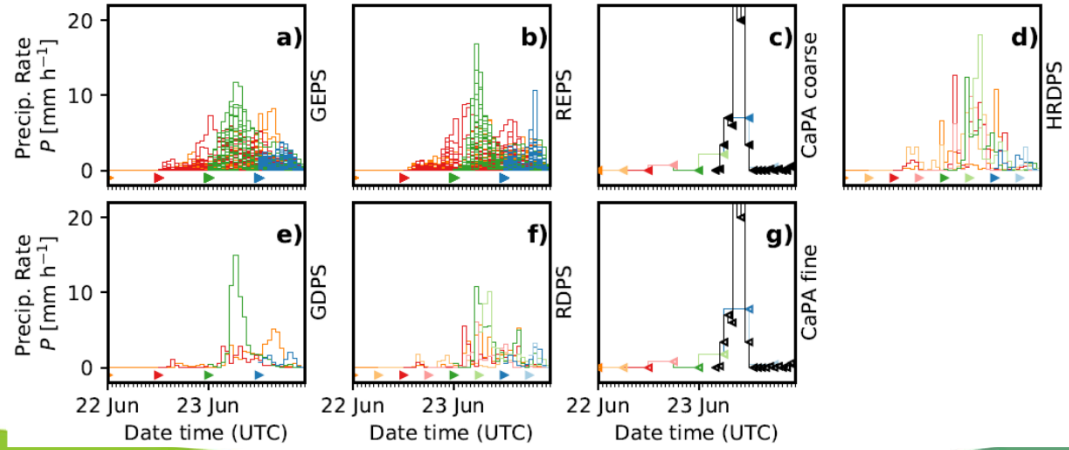
- I found this GRCA presentation: https://www.grandriver.ca/en/our-watershed/resources/Documents/Flooding/West-Montrose_July_24_2017_Presentation_Final.pdf



FloodNet NSERC

CaSPAr Utility Demo 3: Post June 23, 2017 flood event analysis in GRCA

- I found this GRCA presentation: https://www.grandriver.ca/en/our-watershed/resources/Documents/Flooding/West-Montrose_July_24_2017_Presentation_Final.pdf
- Since CaSPAr was not yet built in July 2017, the GRCA analysis did not include evaluation of ECCC weather forecast products for this event



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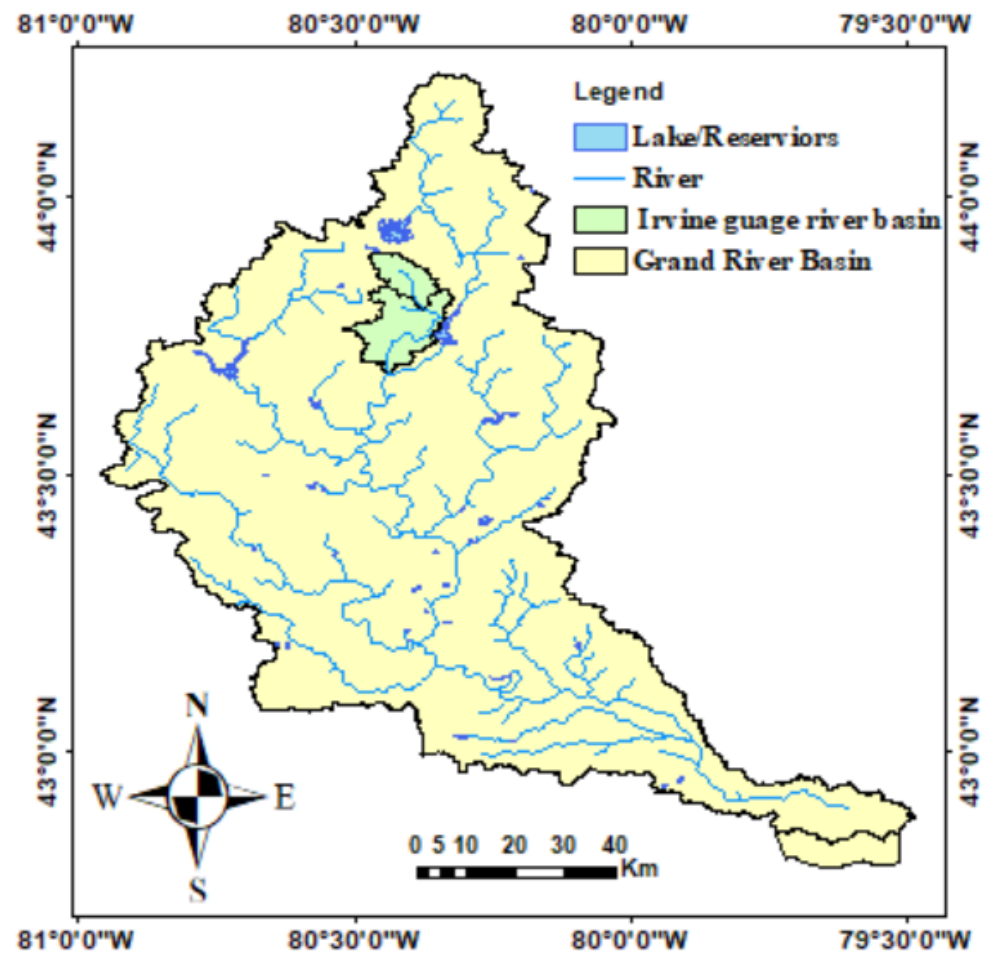
FloodNet NSERC

CaSPAr Utility Demo 3: Post June 23, 2017 flood event analysis in GRCA

- Direct ingestion of CaSPAr NetCDF file into Raven model of Grand River (Irvine River)
- Raven: http://raven.uwaterloo.ca/Main.html
  - Developed at University of Waterloo since 2007 (led by Dr. J. Craig)
  - Raven is a flexible hydrologic modelling framework (lumped to distributed, users select processes to model)
  - Operational forecast model for multiple agencies across Canada
- Steps:
  - Use prexisting semi-distributed Raven hydrologic model of Grand River
  - Download HRDPS precip forecast for June 23 (0:00 UTC) → .nc file
  - Determine weightings for Raven to remap grid cell precip data to modelled spatial units (quick GIS analysis)
  - Raven reads nc file to produce hydrographs …

CaSPAr Utility Demo 3: Post June 23, 2017 flood event analysis in GRCA

- Irvine River



Raven

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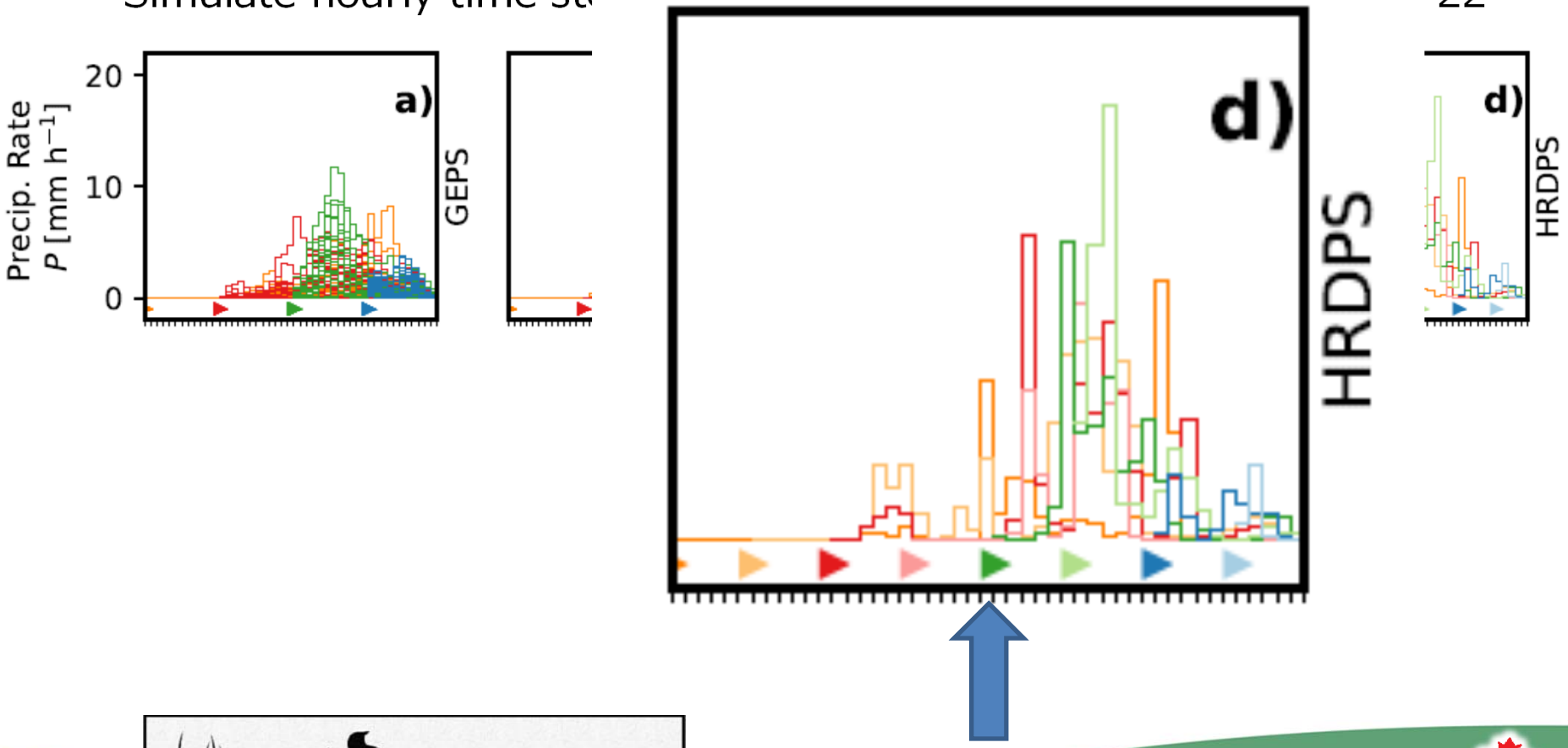
CaSPAr Utility Demo 3: Post June 23, 2017 flood event analysis in GRCA

- Simulate hourly time step w HRDPS forecast issued @ 7 pm June 22



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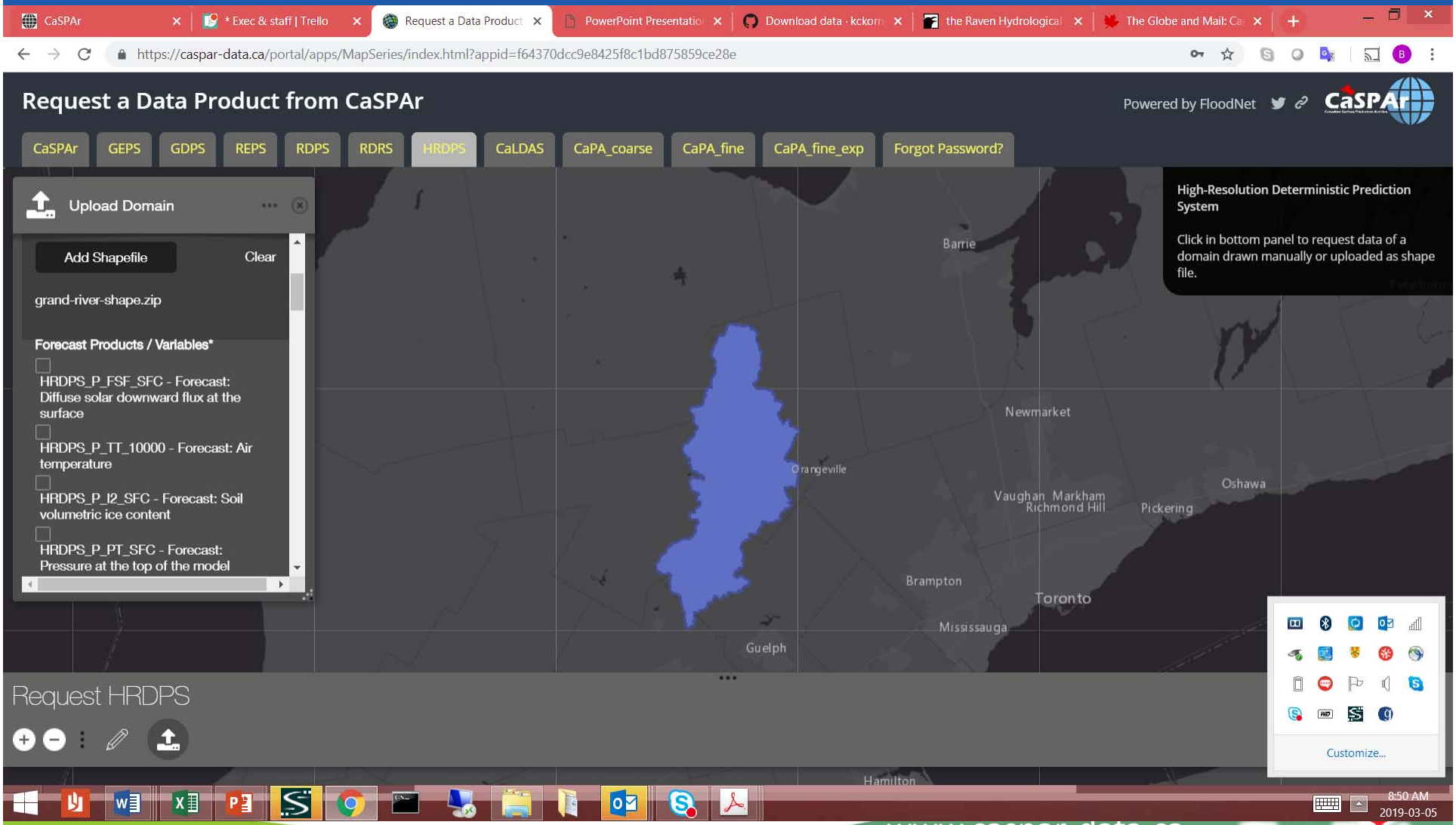
Demo screen cap



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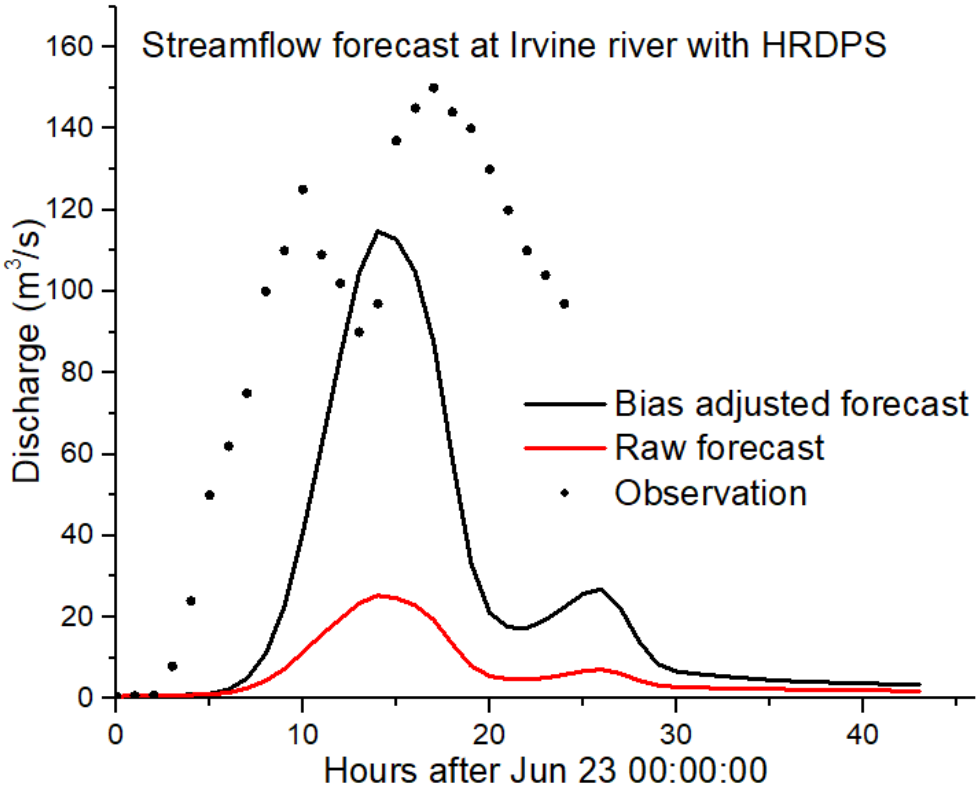
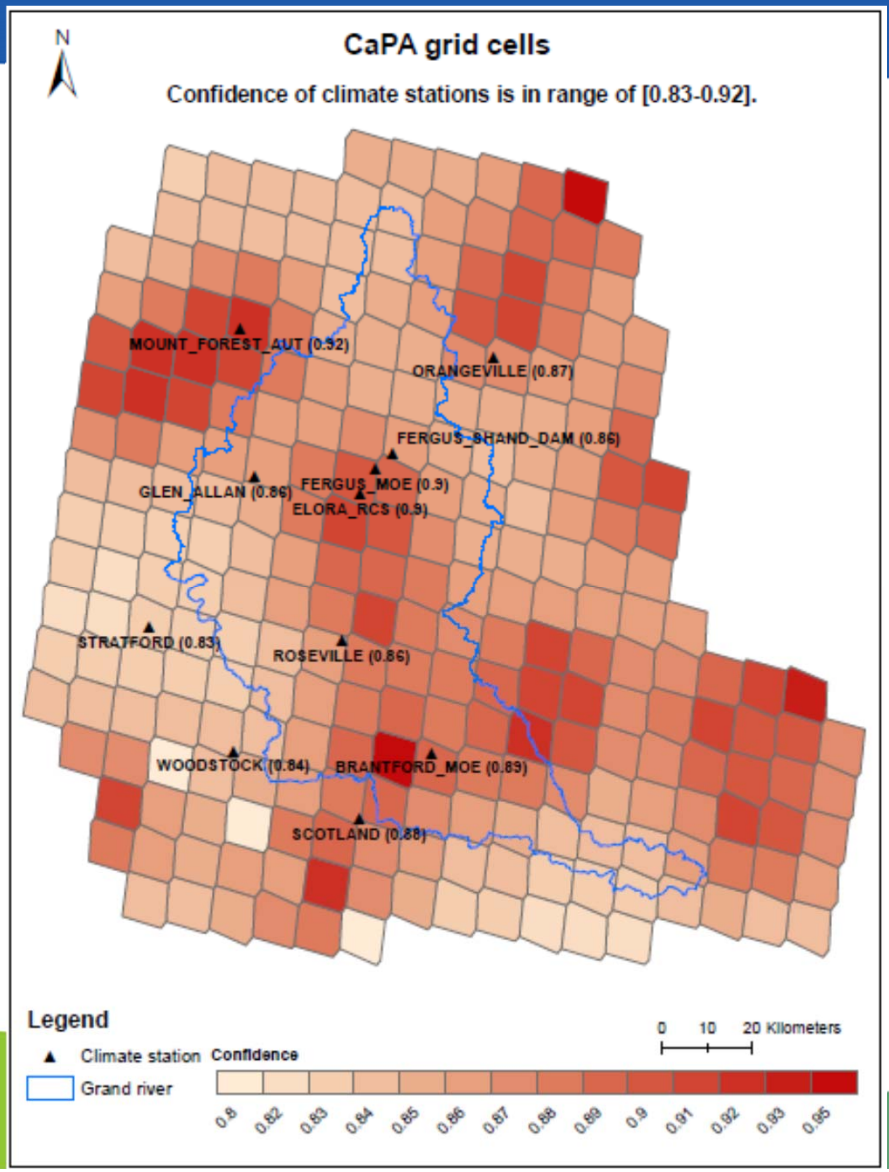


Raven

CaSPAr Utility Demo 3: Post June 23, 2017 flood event analysis in GRCA



- Grand River Watershed rain gauges in CaPA?
- Only ECCC gauges shown on map

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The Future of CaSPAr

- CaSPAr (version 1.0) is a research product

  → *CaSPAr-research v1.0*

- Beyond flow forecasting researchers, *CaSPAr-research* is a valuable tool for forecasting agencies:
  1. Archived data are required to develop new forecasting systems
  2. Archived data are required to test new forecasting approaches (e.g., using HRDPS)
  3. Forecasting agencies can look back at suite of ECCC numerical weather products on past events like we did on June 2017 Grand River flood event

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The Future of CaSPAr

CaSPAr-research v1.0

- Dr. Julie Mai supports this portal
- Support for running CaSPAr portal runs out April 1!
- We hope ECCC will support CaSPAr beyond this
- We could use your help ...

The Future of CaSPAr

CaSPAr-research v2.0

- would continue to function as ECCC NWP archive
- Include pre-processing tools for bias correction, interpolation etc.
- Incorporate new NWPs from ECCC (e.g., radar rainfall fields, experimental NWPs for efficient sharing across and/or outside ECCC
- Customized output file formats for directly feeding forecast systems (e.g., avoid all local pre-processing)

Support from this would come from future research grant … FloodNet2 hopefully and we would love to see many of you as partners in FloodNet2

The Future of CaSPAr

- The FloodNet team decided to build CaSPAr to improve Flood Forecasting in Canada
  - Originally we believed archived access to ECCC forecasts would be enough
  - Now, we believe more can and should be done to improve the operational distribution of ECCC numerical weather forecasts → *how many agree?*
  - Julie and I want to help do this somehow but we need support from ECCC
- How feasible is it to operationalize CaSPAr?
  - From a purely code modification perspective – super easy!
  - Successful implementation within reach provided there is some support ($) and a desire to do this
- Advocacy/requests could help

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Summary and Conclusions

- CaSPAr is available for you to make use of

https://github.com/kckornelsen/CaSPAr_Public/wiki/Download-data#submit-request

- Perhaps CaSPAr workshops focused on NetCDF file format processing would be helpful?
- Please speak with me or email me if you have an interest in actively supporting CaSPAr through advocacy or other means: **btolson@uwaterloo.ca**
- Please speak with me or email me if you have an interest in joining a future FloodNet2 grant as a partner
  - Come to final FloodNet meeting in Hamilton June 18-20. For info, email **floodnet.manager@mcmaster.ca**
  - What do CAs need from research community?

Summary and Conclusions

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Thanks and Questions?

- *ECCC staff (Vincent, Nicolas, Djamel) were incredibly supportive and devoted huge amounts of time to this: without them, CaSPAr would not have been possible!!*

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Overview of Other FloodNet Project 2-1 Case Studies

- Humber River (ON.) → TRCA
- Kaministiquai River (ON.) → OPG
- Lake of the Woods (ON.)→ LWCB
- 20 Quebec catchments → MELCC

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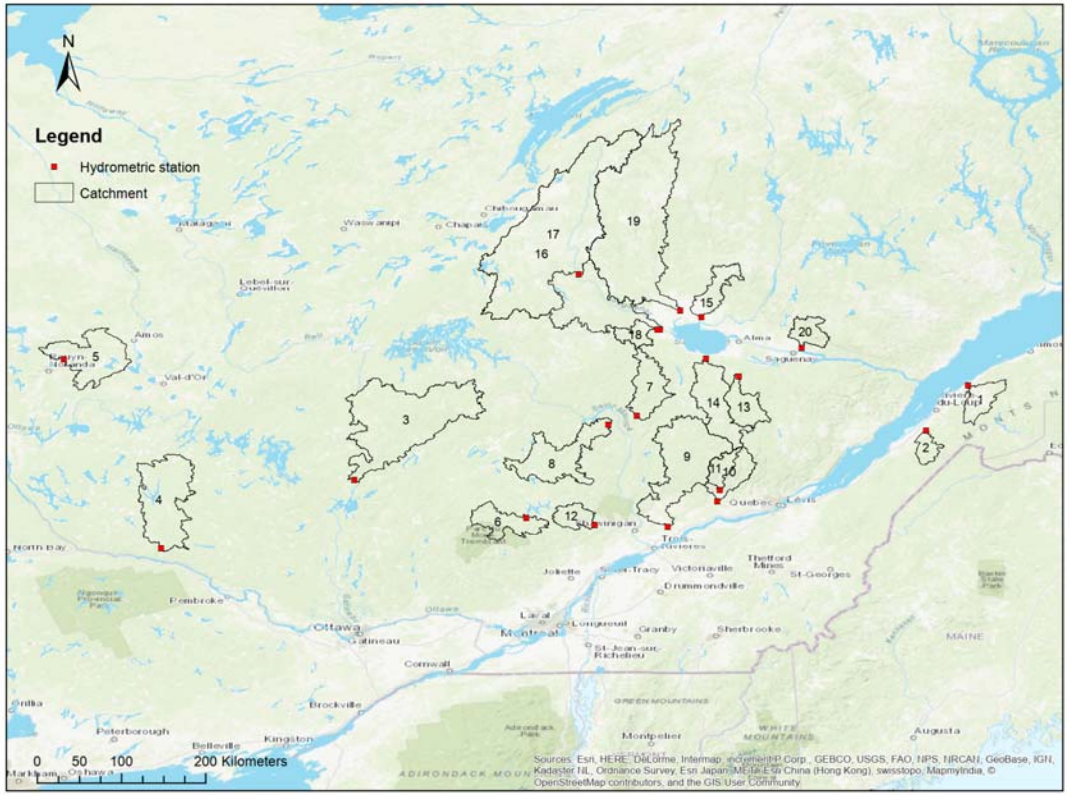
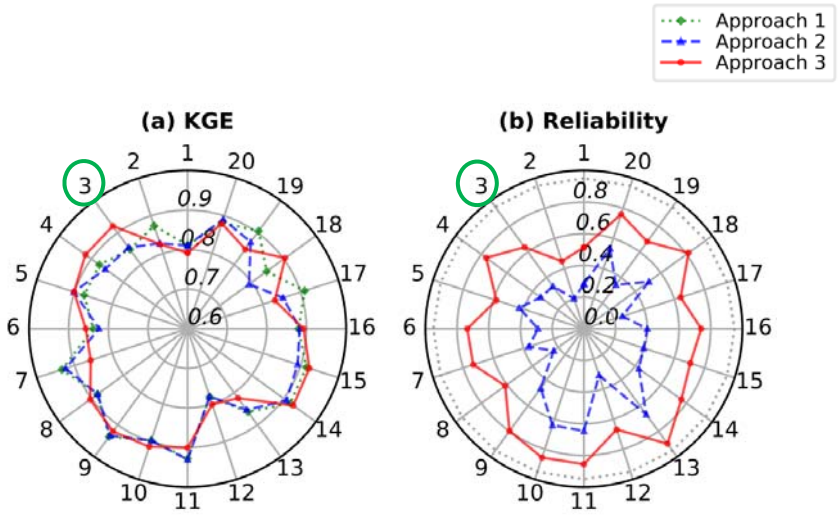
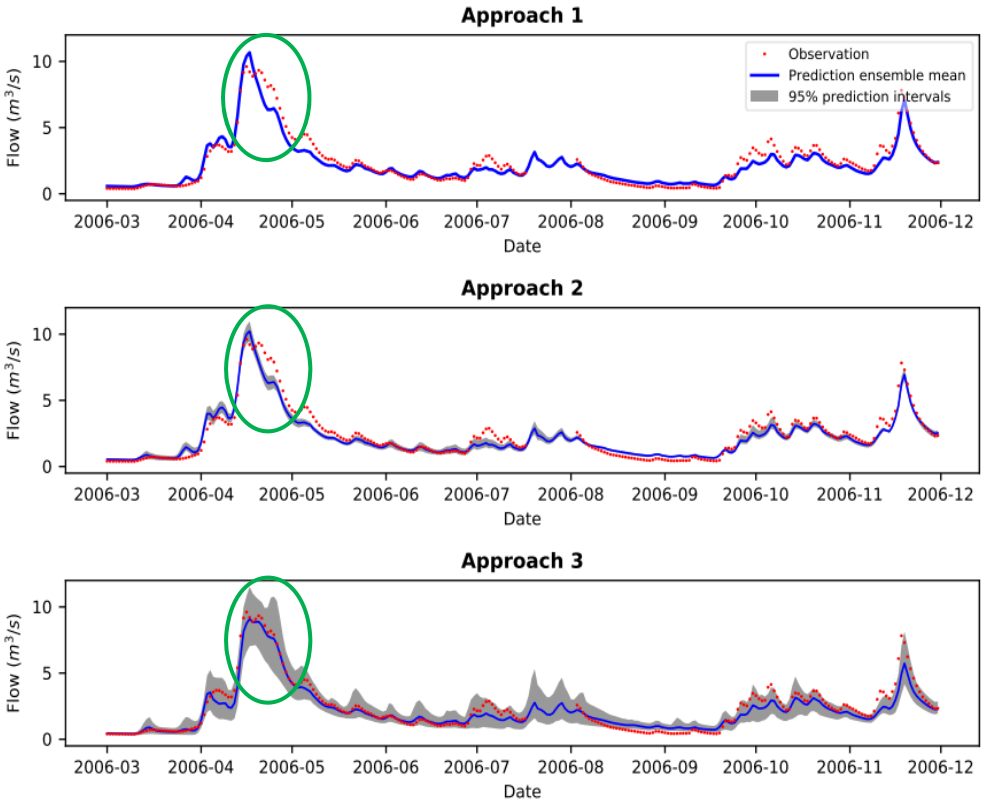
Case study design

- Research areas
  - 20 catchments in southern Québec, Canada.
- Hydrologic model
  - GR4J
- 6 parameters to be optimized in total



Flow prediction evaluation results





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