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IMPROVING SNOW ANALYSES FOR HYDROLOGICAL FORECASTING AT ECCC

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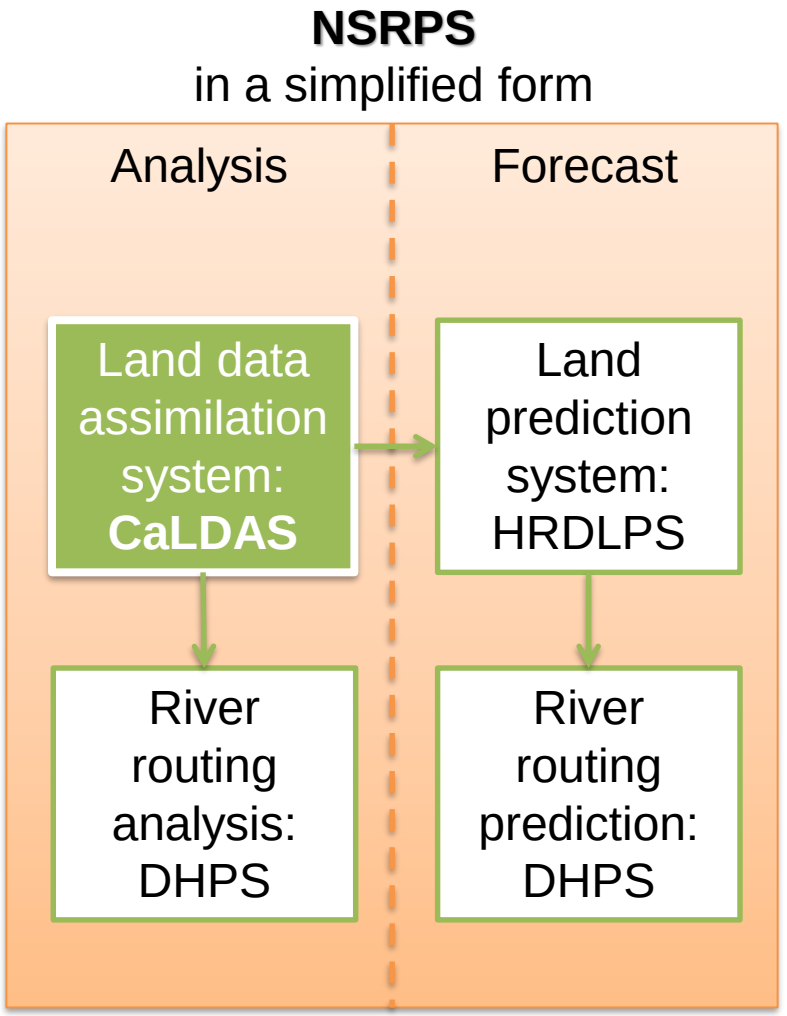
4th IESWG, April 2022

Canada

A BIT OF CONTEXT

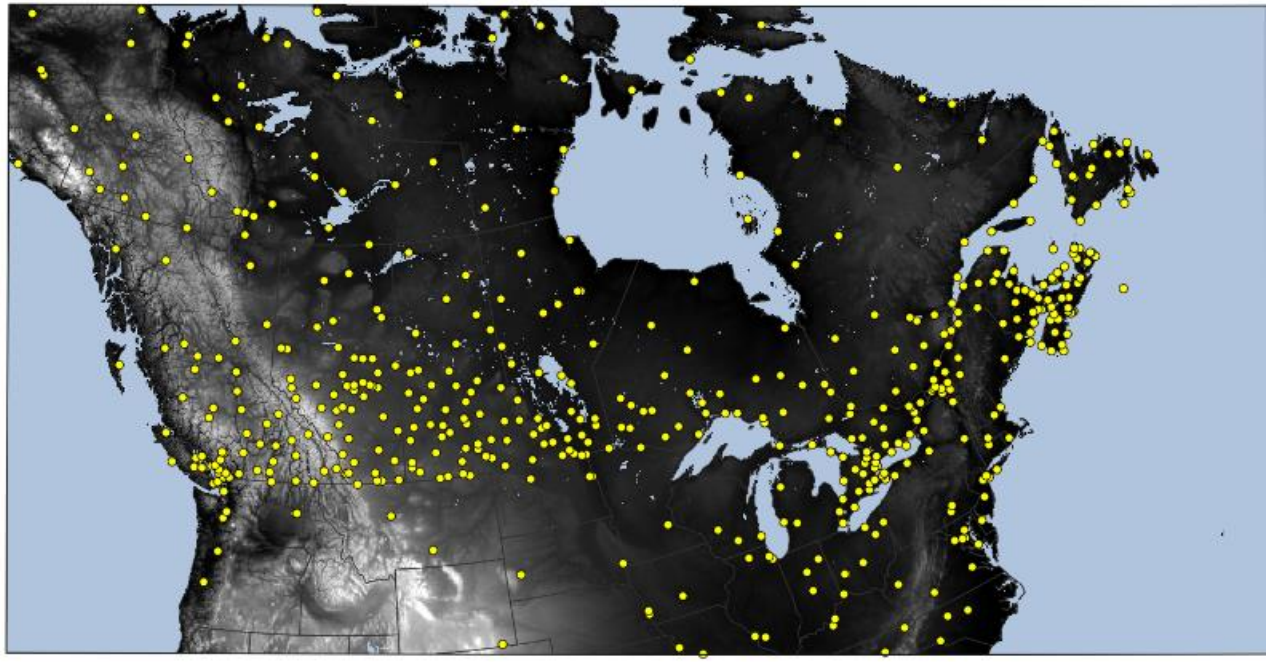
- ECCC recently designed and implemented the National Surface and River Prediction System (**NSRPS**) in order to provide surface and river flow analysis and forecast products across Canada
- Within NSRPS, the Canadian Land Data Assimilation System (**CaLDAS**) produces snow analyses that are used to initialise the land surface model, which in turn is used to force the river routing component (DHPS)
- Land surface model (including snowpack modeling): SVS



WHAT SEEMS TO BE THE ISSUE?

- Originally, CaLDAS was designed to improve atmospheric forecasts with less focus on hydrological processes

- Assimilation method: OI (Brasnett, 1999)
- Assimilated data: in situ SD data from SYNOP, SWOB, METAR
- Assimilation frequency: 6 hours



Position of observation network used in CaLDAS_REF (Garnaud et al, 2021)

WHAT SEEMS TO BE THE ISSUE?

- When snow data assimilation occurs, the related increments remove/add water from/to the system
  - Throughout the snow season
  - Up to 4 times a day

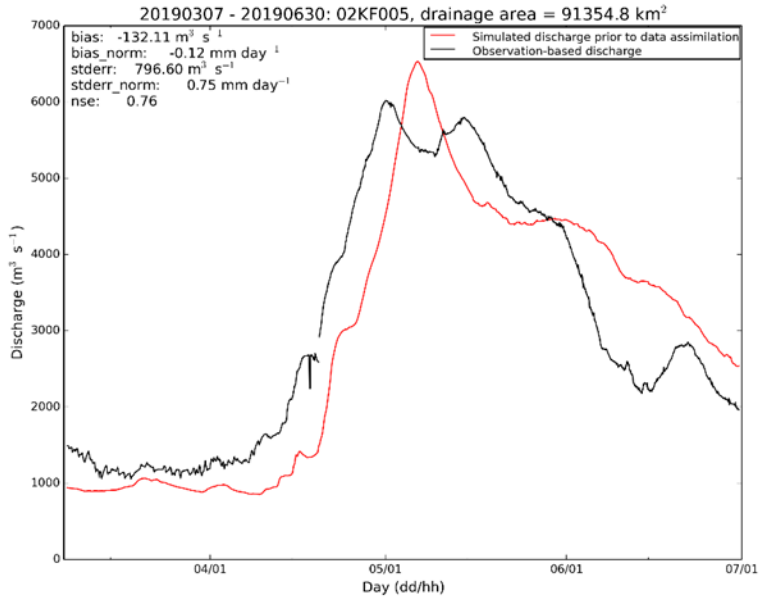
- Lack of water conservation is problematic for streamflow forecasting, in particular during the snowmelt period

What we expect:

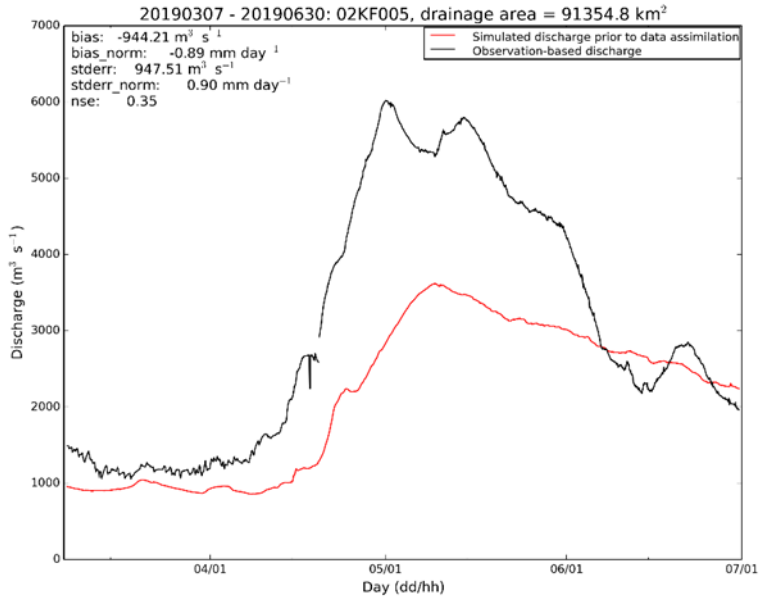
What we get:

WHAT SEEMS TO BE THE ISSUE?

River routing driven by
land surface prediction system
(**no DA**)



River routing driven by
land data assimilation system system
(**with DA**)



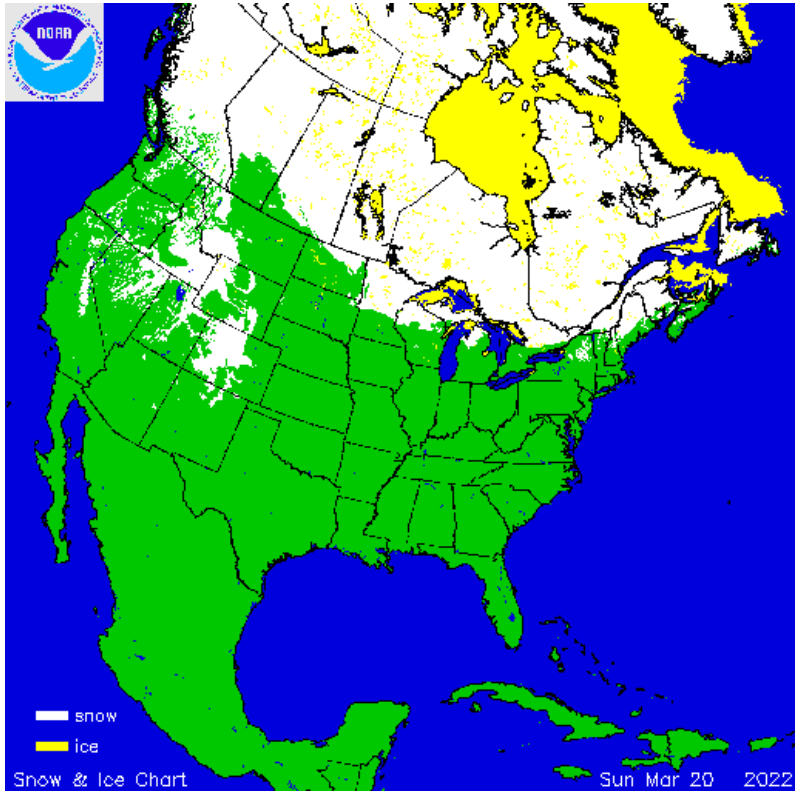
- Hydrologists thus decided to use the simulated snow data (**no DA**) until a solution was found

TESTING A NEW SNOW DA METHOD

- Data assimilation of in situ SD observations replaced by DA of SD derived from IMS SCE, based on what is done at ECMWF

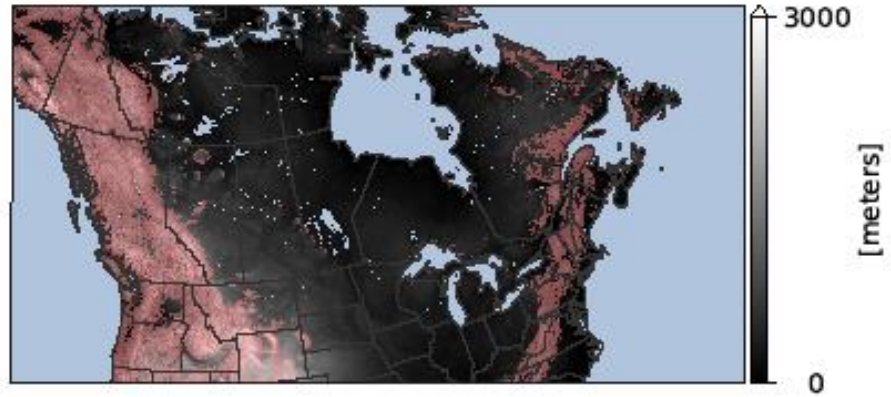
Model \ IMS	Snow-Free	Snow
Snow-free	DA of SD = 0 cm	DA of SD = 5 cm
Snow	DA of SD = 0 cm	no DA

- No DA in mountainous regions
- Fix negative precipitation bias in mountainous regions through a debiasing of the snowpack depth



IMS snow and ice chart
usicecenter.gov

EXPERIMENTAL SET-UP

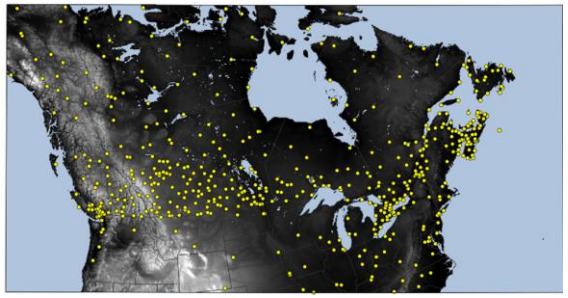


- Sept 2018 to June 2019
- 2.5-km resolution
- Driven by HRDPS forcings, and CaPA for precipitation
- Mountain mask from Karagulle et al. (2017)

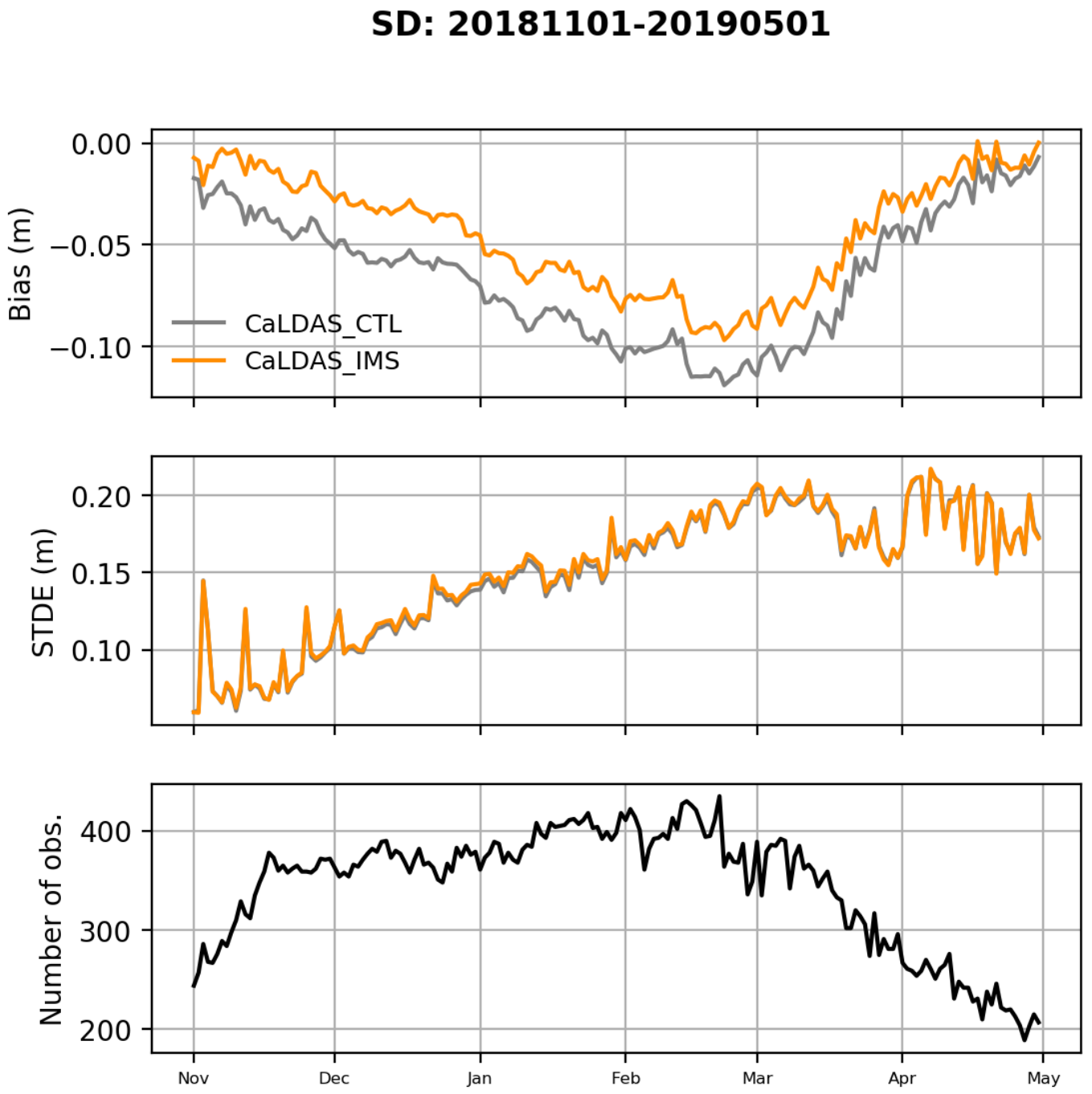
	CaLDAS_CTL	CaLDAS_REF	CaLDAS_IMS
Data assimilation	No	Yes	Yes
Assimilated data	-	In situ SD	SD derived from IMS SCE
Assimilation method	-	OI	OI
Assimilation frequency	-	6-hour	24-hour
SD debiasing in mountainous regions	-	No	Yes
Data assimilation in mountainous regions	-	Yes	No

SD EVALUATION

- Against in situ SD data used in CaLDAS_REF

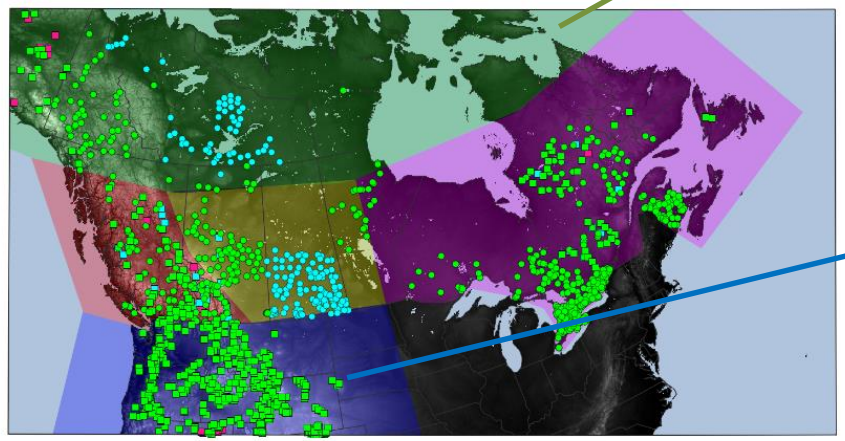


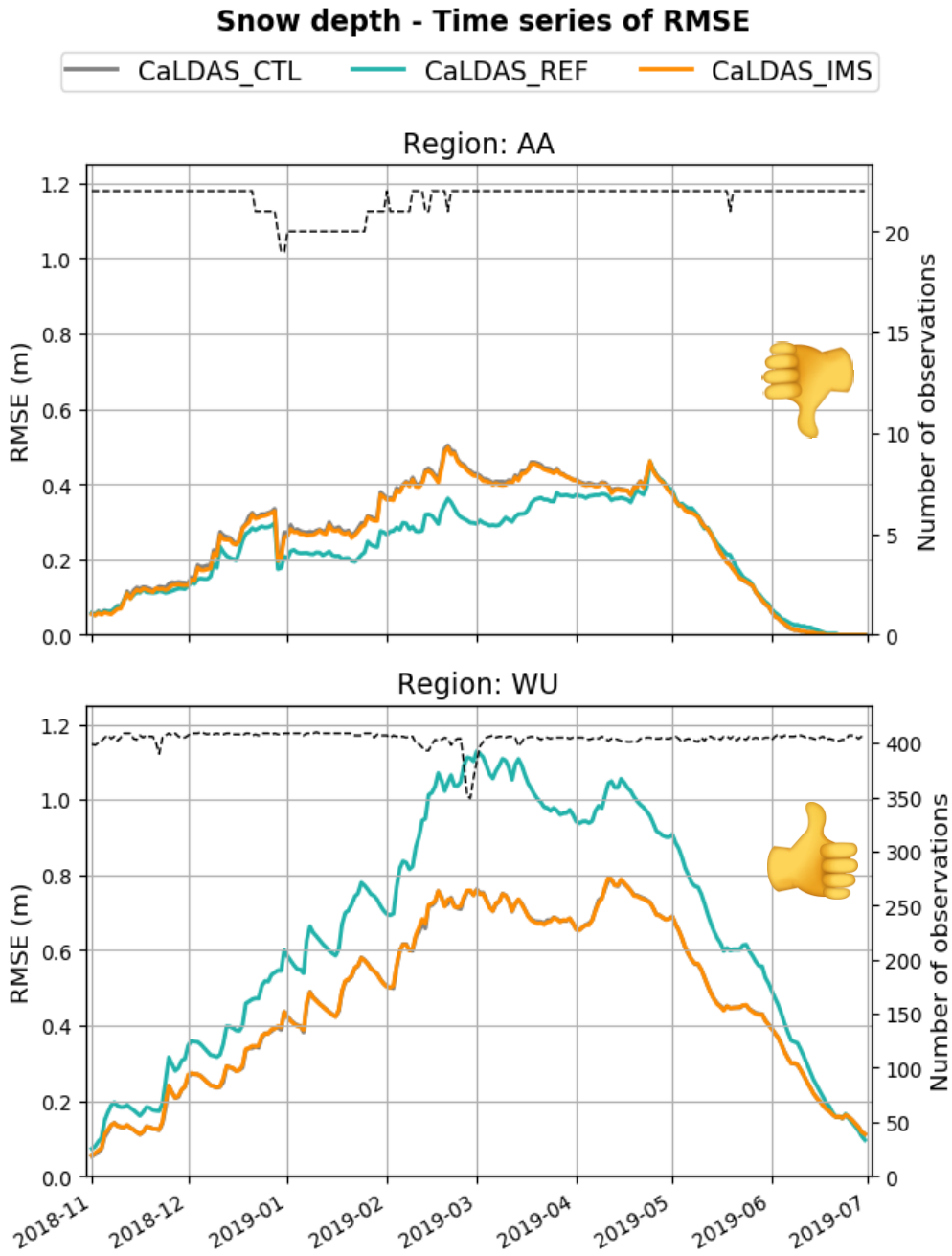
- Decreased negative bias in CaLDAS_IMS compared to CaLDAS_CTL



SD EVALUATION - REGIONS

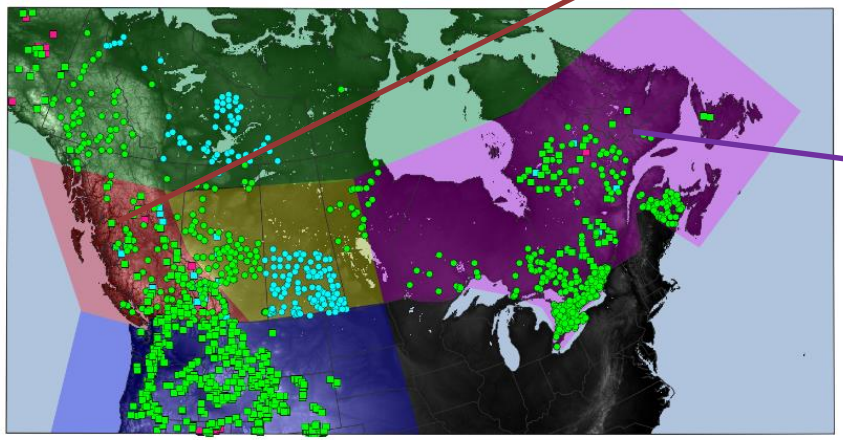
- CaLDAS_IMS relies heavily on snow model:
  - In snow covered regions: AA
  - In mountainous areas: WU

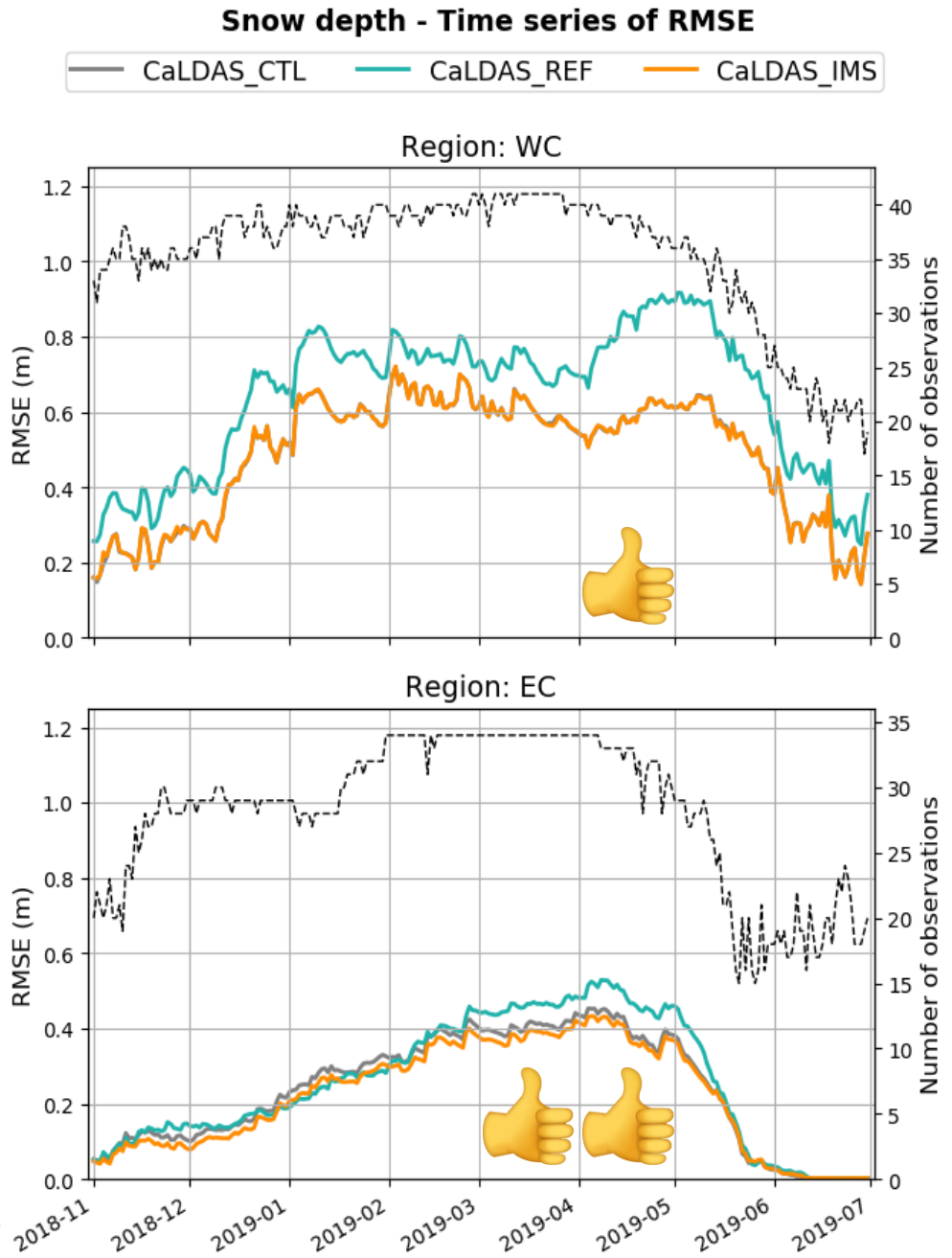




SD EVALUATION - REGIONS

- CaLDAS_IMS relies heavily on snow model:
  - In mountainous areas: WC
- CaLDAS_IMS corrects snow line:
  - In non-mountainous areas: EC

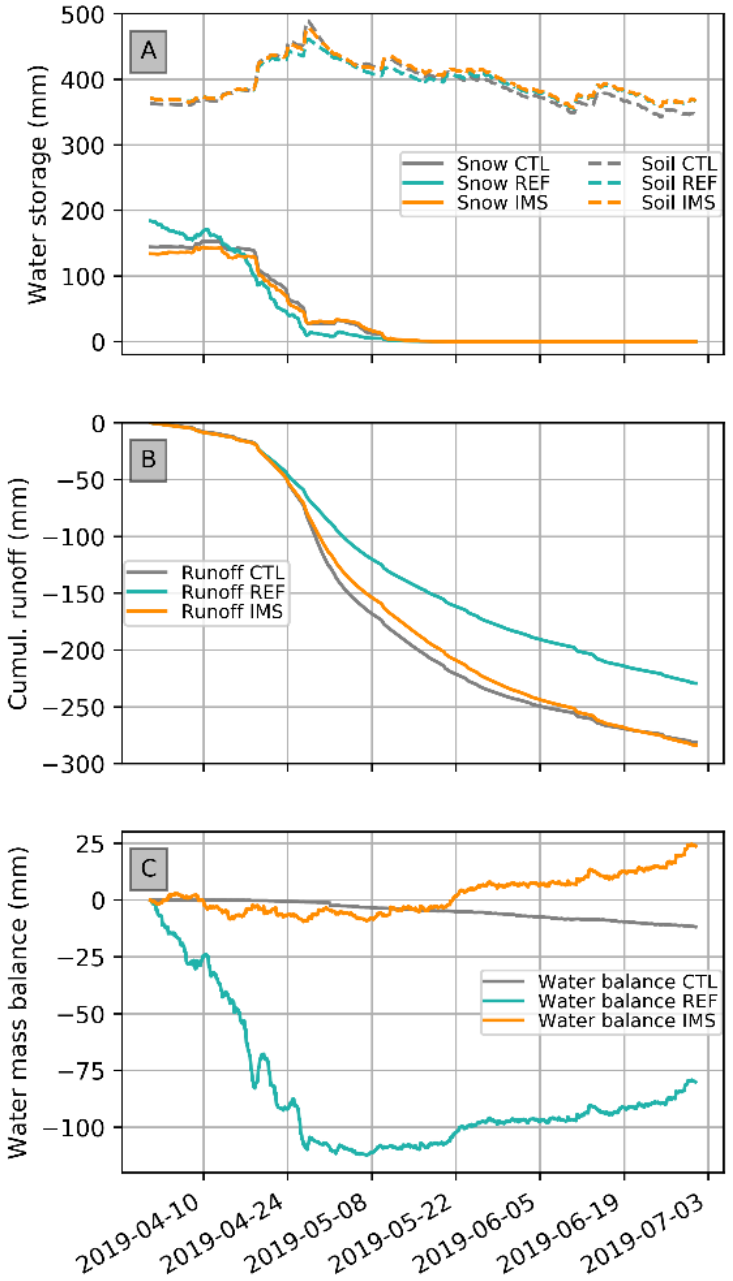


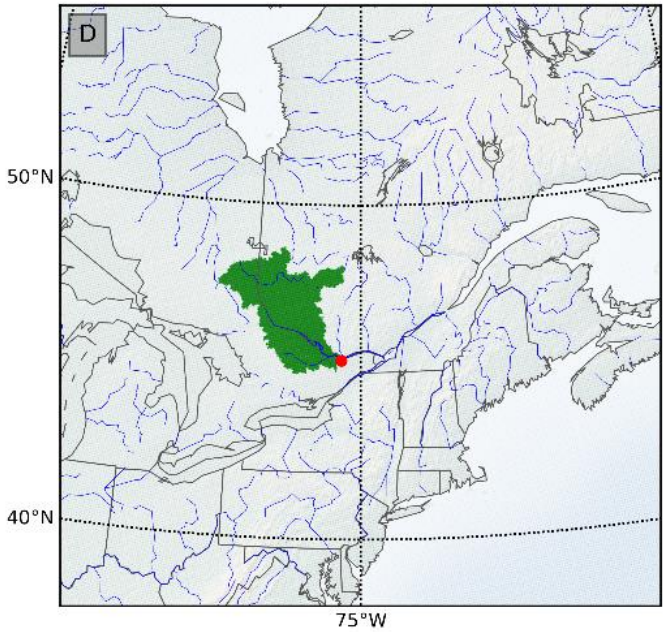


IMPACT ON HYDROLOGY

- Observing station (red dot) on the Ottawa river during Spring 2019

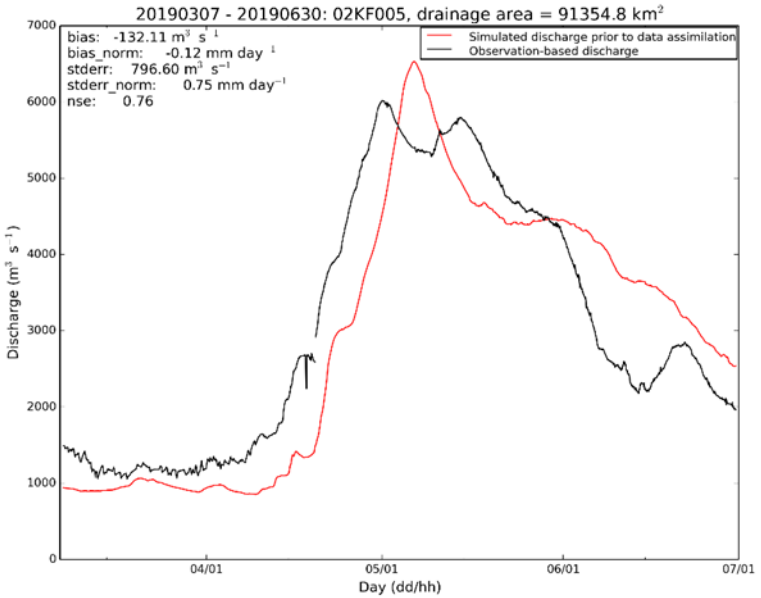
- In CaLDAS_IMS compared to CaLDAS_REF:
  - Increased runoff
  - Much improved water balance (conservation)

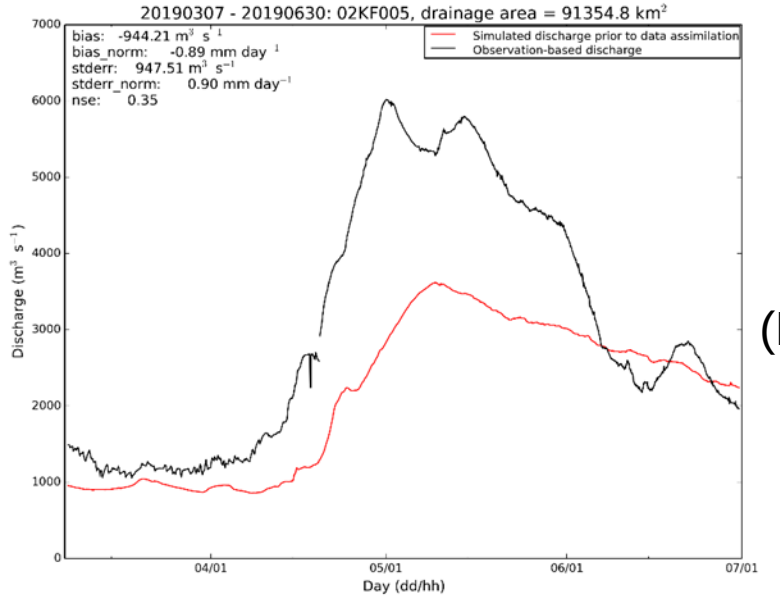




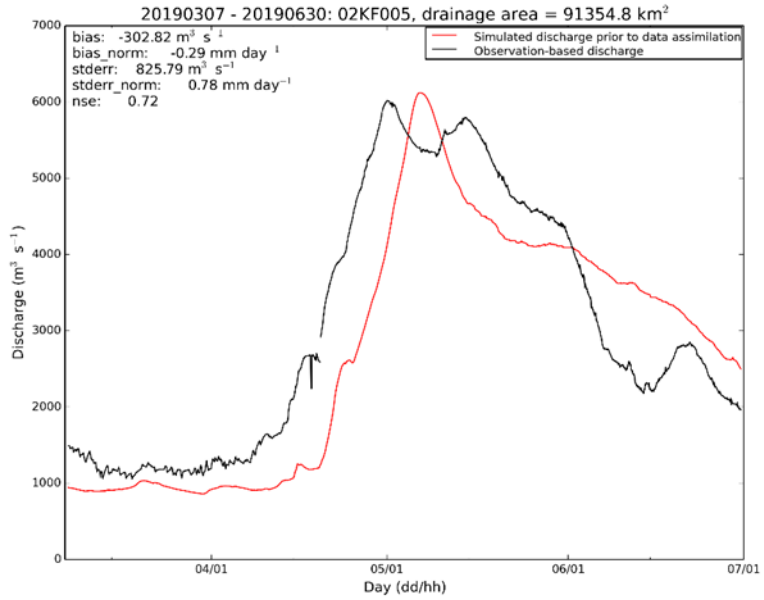
IMPACT ON HYDROLOGY: OTTAWA RIVER DISCHARGE

CaLDAS_CTL
(no DA)





CaLDAS_REF
(DA of in situ SD)



CaLDAS_IMS
(DA of IMS SCE)

CONCLUSIONS

- The new snow DA method:
  - brings an overall improvement to snow analyses and
  - substantially enhances water conservation,
  - reflected in the generally improved streamflow simulations
  - but relies heavily on the snow model (SVS)

- This work represents a first step towards a new snow data assimilation process in CaLDAS, with the final objective of producing a reliable snow analysis to initialise and improve NWP as well as environmental predictions, including flood and drought forecasts.

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ANY QUESTIONS?

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Improving Snow Analyses for Hydrological Forecasting at ECCC Using Satellite-Derived Data

by Camille Garnaud [1,*], Vincent Vionnet [1], Étienne Gaborit [1], Vincent Fortin [1], Bernard Bilodeau [1], Marco Carrera [1] and Dorothy Durnford [2]

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Academic Editors: Clement Albergel, Patricia De Rosnay and Sujay Kumar

Remote Sens. **2021**, *13*(24), 5022; https://doi.org/10.3390/rs13245022

Received: 25 August 2021 / Revised: 19 November 2021 / Accepted: 7 December 2021 / Published: 10 December 2021

(This article belongs to the Special Issue Remote Sensing of Land Surface and Earth System Modelling)