Technical Overview of the CLEVER Model 2021 Presentation
Presented April 29, 2021 by Dr. Charles Luo
Summary of Questions and Answers

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Question: Thank you for the great presentation Charles! Will the RFC be producing forecasts past freshet this year? I noticed last year the RFC was producing forecast well past September 2020?

Answer: We were happy to have this opportunity to present the CLEVER Model to our stakeholders and thank you for joining us! As of 2021, the CLEVER Model can be run for all year round. As you noticed, we ran the model until middle November last year, but the frequency of updating was lower after the freshet, about once or twice a week as the flood risks were much lower. Also please be noted that the CLEVER Model was not designed for low flow forecast. Moreover, due to icy conditions of some of the WSC real-time hydrometric stations, the CLEVER Model forecast may not useful for these stations for the icy periods. If you are looking for low flow forecasts, for your information, we are currently test-running the low flow forecast model – the ELF model for 30-day low flow forecast (http://bcrfc.env.gov.bc.ca/lowflow/map_elf.html).

Question: Do you have an intuition about how much of the discharge forecast uncertainty generally comes from the routing and how much from the hydrological watershed models?

Answer: If "routing" means model calibration, based on our experience, most uncertainties come from the model calibration. As I pointed out in the presentation, sometimes the forecast climate data also contributes significantly to the forecast uncertainty.

Question: Does the 42,215 KM length include all water courses? Or just over a certain discharge size?

Answer: A good question! Hmm, I would say this length includes "all water courses" which are "over certain discharge size." Ha, this is not a real answer. Please refer to the following book, which have returned to the library, for details:

Smith, S., 2001. Chapter 5 Water resources, in: Wood, C.J.B. (Ed.), British Columbia, the Pacific Province: Geographical Essays, Department of Geography, University of Victoria, pp. 27-44.

Question: What is the % increase in possible run off rates between a forested area and a logged area? With and without snow coverage?

Answer: Answering your questions requires one or two case studies with a fully distributed, physics-based watershed model. Generally speaking, the rates of evapotranspiration and infiltration are larger in a logged watershed than those in in a forested one, and the overland flow is faster (because of smaller manning's roughness coefficients) in a logged watershed than that in a forested one. Moreover, for a forested watershed, there are effects of canopy interceptions of precipitation (rainfall and snowfall) and incident radiation for evaporation and snowmelt. I had a case study about the hydrologic implications of clear cut in the mountain pine beetle infected watershed - the Baker Creek. (https://www.researchgate.net/publication/286448980_A_DISTRIBUTED_HYDROLOGICAL_MODEL_OF_A_LARGE_MOUNTAIN_PINE_BEETLE_ATTACKED_WATERSHED)

Question: I believe you stated that the model takes into consideration Forest Fire information. Are you saying that the model takes into consideration the higher water run-off due to a forest fire burning off the undergrowth? And as a related question, does your model take into consideration higher water run-off due to clear-cutting and man-made hard surfacing such as highways and utility corridors? We suspect higher flows on the Coquihalla River after Highway #5 was constructed and after the pipelines were built. Maybe coincidental but flows appear to go to normal once the hillsides started to green.

Answer: The CLEVER Model is calibrated to the observed flows within a particular watershed for a period of 20 days immediately prior to the day when the model is run. As such, these flow characteristics should reflect all of the physical processes that impact how water flows through a landscape, including fire/harvest/road construction. However, as it is an operational flood forecast model with a lumped watershed routing sub-model for the entire watershed, it does not account for the percent of a watershed impacted. In order to fully address concerns in your questions, case studies using a fully distributed, physics-based hydrologic model are necessary. For this purpose, please refer to the answer to the above question.

Question: Great to see the improvements. In 2020 the Clever model appeared to struggle with weather inputs and that caused some pretty big variations particularly for the Fraser which caused us to ramp up response efforts. Has the model been tweaked to better handle weather inputs?

Answer: In the presentation, the importance of the forecast climate data (and its accuracy as well) was emphasized. We understand that meteorological modeling is extremely complicated with respect to its global scale and difficulties in setting model boundary conditions. The CLEVER Model has to rely on the forecast climate data. Even though we carry out bias corrections to the forecast temperatures every day (no correction to the forecast precipitation data due complexity), but the corrections do not guarantee the accuracy of the forecast temperatures, or sometimes the “corrections” themselves may even introduce extra errors to the data. What we can do and are doing is to reduce the uncertainty from the model itself and model calibration. Everyday, we are trying our best to produce forecasts with as high as possible accuracy. However, as the nature of the flood forecasting, it is impossible to eliminate the uncertainties completely. This means that the forecasts may always be either overestimated or underestimated. We understand that ramping up responses is costly, while downgrading responses might be disastrous. From this perspective, the uncertainty of overestimation in the forecast climate data might not be a bad thing.

Question: What is the difference between COFFEE and CLEVER? If a site has both models (for example, Vancouver Island), which model is most appropriate?

Answer: Generally speaking, the CLEVER Model may be more accurate than the COFFEE Model because the CLEVER Model are more physics-based. However, giving all the uncertainties in the forecasts for small watersheds (please refer to the technical reference of the COFFEE Model like those on the Vancouver Island: http://bcrfc.env.gov.bc.ca/fallfloods/TechnicalRefCOFFEEModel.pdf), the COFFEE Model could be more accurate from time to time. What we recommend is that check with both models, take the average as the forecast with higher confidence, and keep the largest upper bound as the possible extreme and prepare for the worst.

Question: Thank you for all the information I was just wondering where to go to possibly learn more on how to read these charts and learn more about the specific lingo or language so that it's easier to follow the discussion ?

Answer: To learn more about how to read the forecasts, there are materials at this website: http://bcrfc.env.gov.bc.ca/freshet/for_chart.pdf. Additional technical information about the CLEVER Model can be found on this website: http://bcrfc.env.gov.bc.ca/freshet/cleverm_ref.html. You do not need to learn a specific computer language to understand the model forecasts.

Question: To confirm I heard correctly: my understanding is that calibration is done using the past 20 days of data, and calibrations can be updated daily as needed but are normally kept for 30 days?

Answer: The model runs for a period of 30 days (I didn't mention that all the model state variables were saved and loaded again for the next runs), and so the parameters are constant for the 30 days. The parameters may be changed at any run and they keep unchanged for the 30 days of this run only. For the past 20 days, the model uses WSC observed (provisional) discharges or water levels to calibrate the model to produce a 10-day forecast. For example, today is April 30, 2021, and today's modeling will use WSC's observation from Aril 10 to Aril 29 (and up to the latest data for the morning of April 30 before we run the model) to produce forecast for April 30 to May 9, 2021.

Question: When calibration (and forecasting for that matter) are done, is there consideration given to potential backwater at the river gauging stations? Since data is primarily determined using a stage-discharge relationship, preliminary Water Survey discharges will over-estimate flow until the river is ice free. Is this potentially causing over/under-estimation of real flows for early spring model runs? If this data is being used for a calibration of the model for the next 30 days, I would think this could cause some substantial differences. I'm guessing the Fraser itself and basins driven by high elevation snow/glacier melt hit their freshet peak late enough in the spring, this isn't as big a concern…but for stations driven by lower elevation snow in the interior, the freshet peak can occur quite quickly after the station comes out of ice. I'm wondering if calibration using ice-affected data could be a cause here, or if it is more an impact of real vs. forecast weather, snow data, or something else. Any insight would be appreciated.

Answer: The model is not able to simulate back water effects due the kinematic wave open channel routing. For the Fraser in the early period of freshet, we understand the Upper Fraser is always under icy conditions and the provisional flow data are always overestimated. In this circumstance, we do NOT calibrate the Upper Fraser but rather calibrate the Middle and Lower Fraser. If we try to match the flow in the Upper Fraser in calibration, then we overestimate the Middle Fraser and Lower Fraser too much. But when we produce forecasts for the Upper Fraser, we may select to line up with WSC's provisional data by doing 100% bias corrections, unless the provisional data was so large that may cause flooding concerns.

Question: Is CLEVER actually a VBA scripted model run out of an Excel macro?

Answer: If "out of" means "within," the answer to the question is "yes." The CLEVER Model is built within the Excel spreadsheet, including more than 100 macros, rather than a single macro, to accomplish all kinds of tasks such as pre- and post-data processes and scientific computations of watershed runoff and channel routing. There is no standalone VBA script independent of Excel. This means that the CLEVER Model must be run inside the Excel spreadsheet.

Question: How come you guys don't have access to the ECMWF model which always seems to be referenced as the "best" and instead are using the RDPS and GDPS?

Answer: Scientifically speaking, meteorological modeling is very complicated and the accuracy depends on the boundary conditions of the local land surface and weather observations. We believe that ECCC's CMC regional and global models, which are Canadian local meteorological models, have much more accurate land surface conditions and weather observations for Canada, and thus provide much more accurate weather forecasts for geographic locations within Canadian. Meanwhile, the Canadian CMC models produce forecasts at times and intervals which are more suitable for Canadian users living in Canadian time zones. Therefore, using the CMC forecasts allows our models to incorporate the timely/latest weather conditions and to increase the forecast accuracy.

Technically speaking, the CMC provides very convenient means and tools for modelers to download and process their digital data, so that RFC can automatically download and downscale a large number of files (160) from the ECCC DataMart site. This is very critical for RFC to accomplish our daily modeling tasks in a very time-efficient way.