Multi-model Intercomparison Project on the Saskatchewan-Nelson-Churchill River Basin (Nelson-MiP project)

Monthly meeting - April 08th, 2020

Agenda

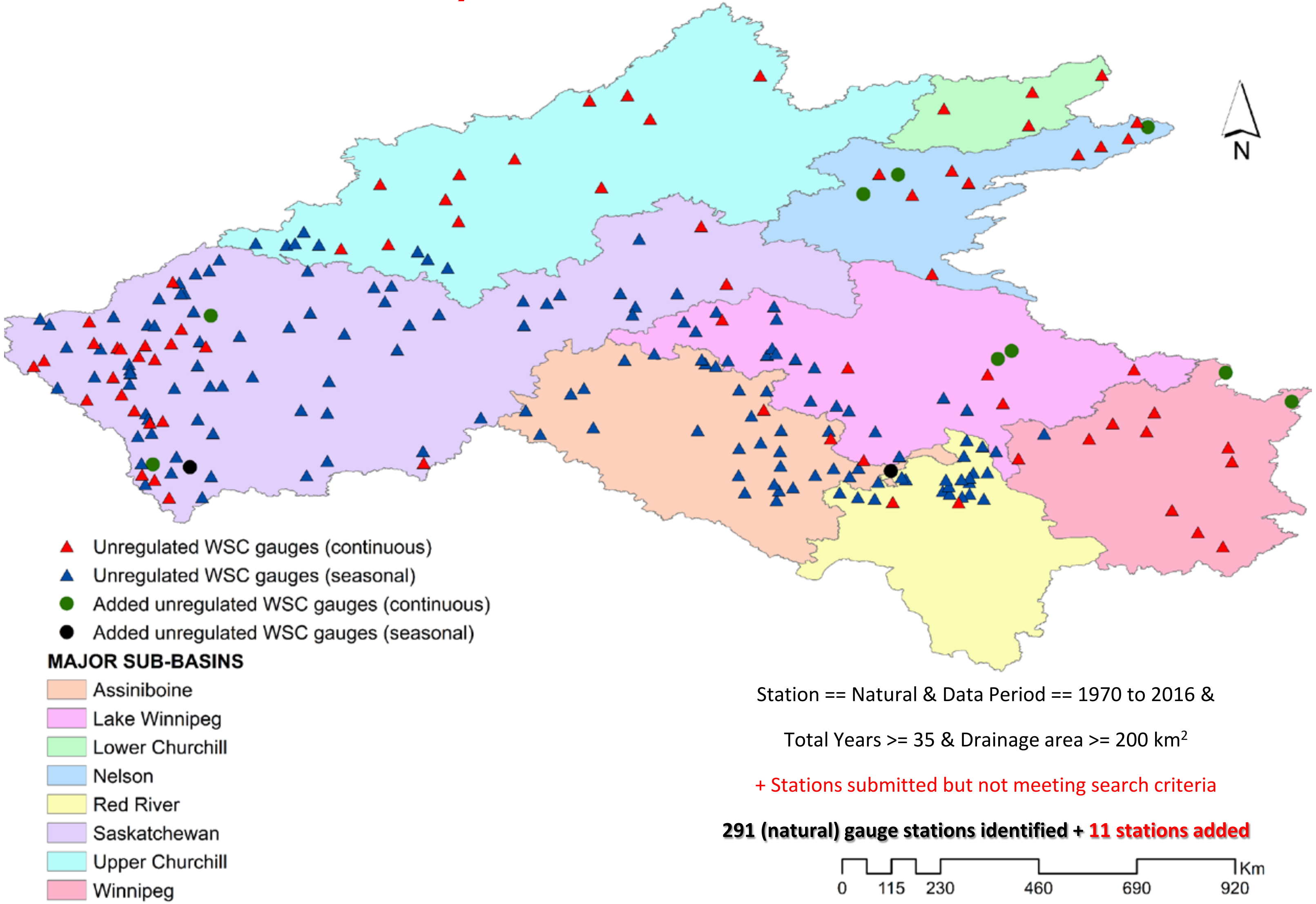
1. Decision on time periods for model calibration/validation
2. Selection of natural gauge stations for calibration for Phase 1
3. Presentation of HYPE configuration and input (Ajay - UofC)
4. Presentation of SWAT-GIW configuration and input (Ameer - WSA)
5. Presentation of MH-WATFLOOD and input (Manitoba Hydro)
6. Presentation of SWAT-RRB configuration and input (Yinlong - UofM)
7. Deliverables for next meeting & follow-up

Time periods for calibration/validation

<table>
<tr><td>Years</td><td>80</td><td></td><td></td><td></td><td></td><td>85</td><td></td><td></td><td></td><td></td><td>90</td><td></td><td></td><td></td><td></td><td>95</td><td></td><td></td><td></td><td></td><td>00</td><td></td><td></td><td></td><td></td><td>05</td><td></td><td></td><td></td><td></td><td>10</td><td></td><td></td><td></td><td></td><td>15</td><td></td><td></td><td>18</td></tr>
<tr><td>Periods</td><td></td><td colspan="5">WET</td><td colspan="10">DRY</td><td colspan="10">WET & DRY</td><td colspan="5">WET</td><td colspan="8">WET & DRY</td></tr>
</table>

- **Model spin-up:** Sept./Oct. 1979 - 1982
- **Calibration period:** 1992 - 2008
- **Validation periods:** 1983 - 1991; 2009 - 2016

Selection of natural gauge stations for calibration/validation - continuous vs seasonal



Station == Natural & Data Period == 1970 to 2016 &

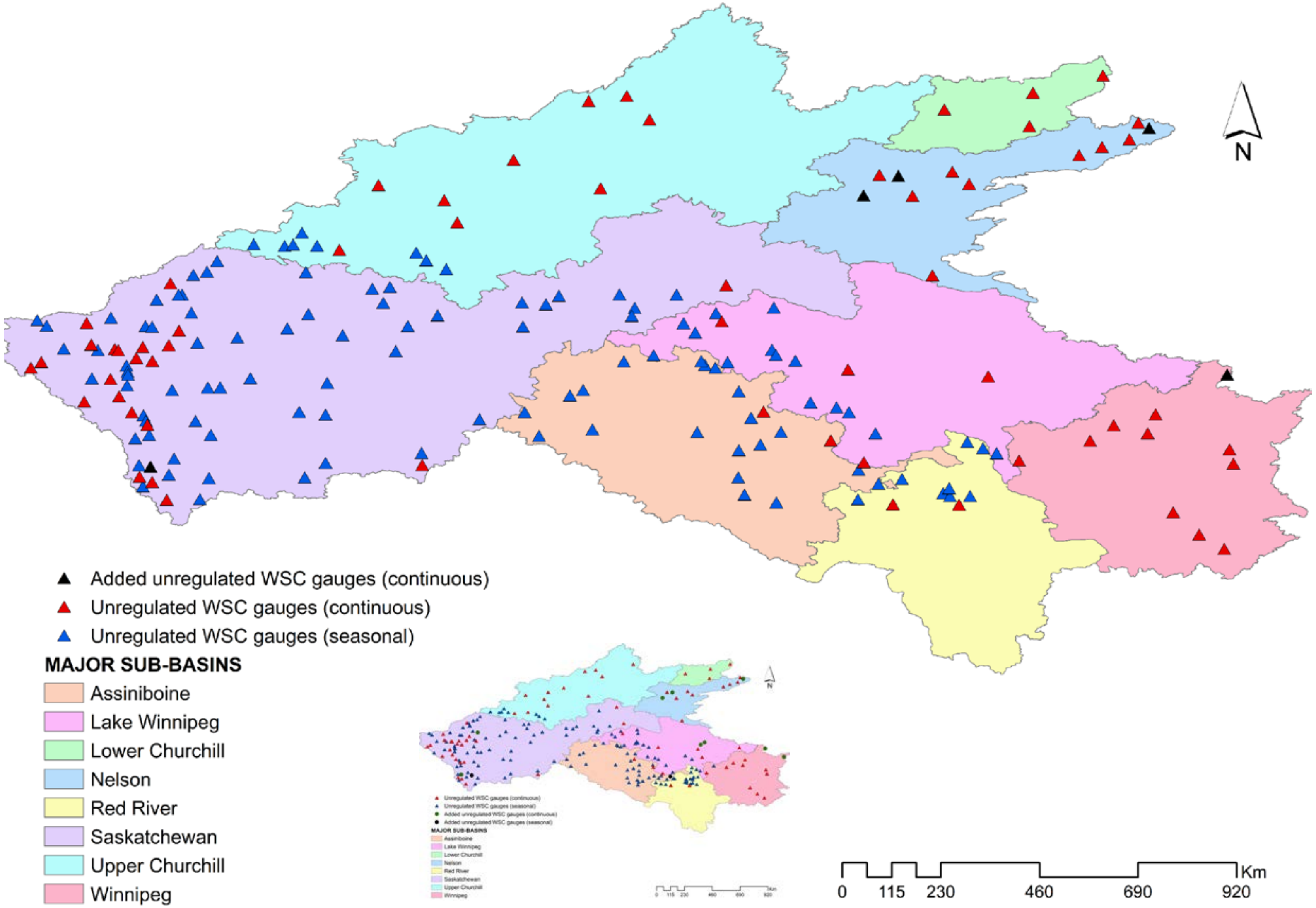
Total Years >= 35 & Drainage area >= 200 km^2

+ Stations submitted but not meeting search criteria

291 (natural) gauge stations identified + 11 stations added

Sub-basins	Number of WSC natural stations
Assiniboine	32
Lake Winnipeg	28
Winnipeg river	13
Upper Churchill	20
Lower Churchill	4
Saskatchewan river	94
Red River	23
Nelson river	12

Selection of natural gauge stations for calibration after QA/QC of measured streamflow time-series



Sub-basins	Number of WSC natural stations
Assiniboine	22
Lake Winnipeg	17
Winnipeg river	11
Upper Churchill	17
Lower Churchill	4
Saskatchewan river	85
Red River	10
Nelson river	12

User-selected stations to be removed if agreed

- 05BL012 --> Sheep river at Okotoks (MH-WATFLOOD)

- 05FA011 --> Battle river at Duhamel (MESH)
- 05AB046 --> Willow Creek at Highway NO. 811 (MESH)

- 05RD007 --> Berens river at outlet of Long Lake (HYPE)
- 05RD008 --> Pigeon river at outlet of Round Lake (HYPE)

- 05OF009 --> Roseisle creek near Roseisle (HEC-HMS)
- 05OF010 --> Boyne river near Treherne (HEC-HMS)

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Hydrological Prediction for the Environment – HYPE

By:

Ajay Bajracharya

(University of Calgary)

1. Study Area

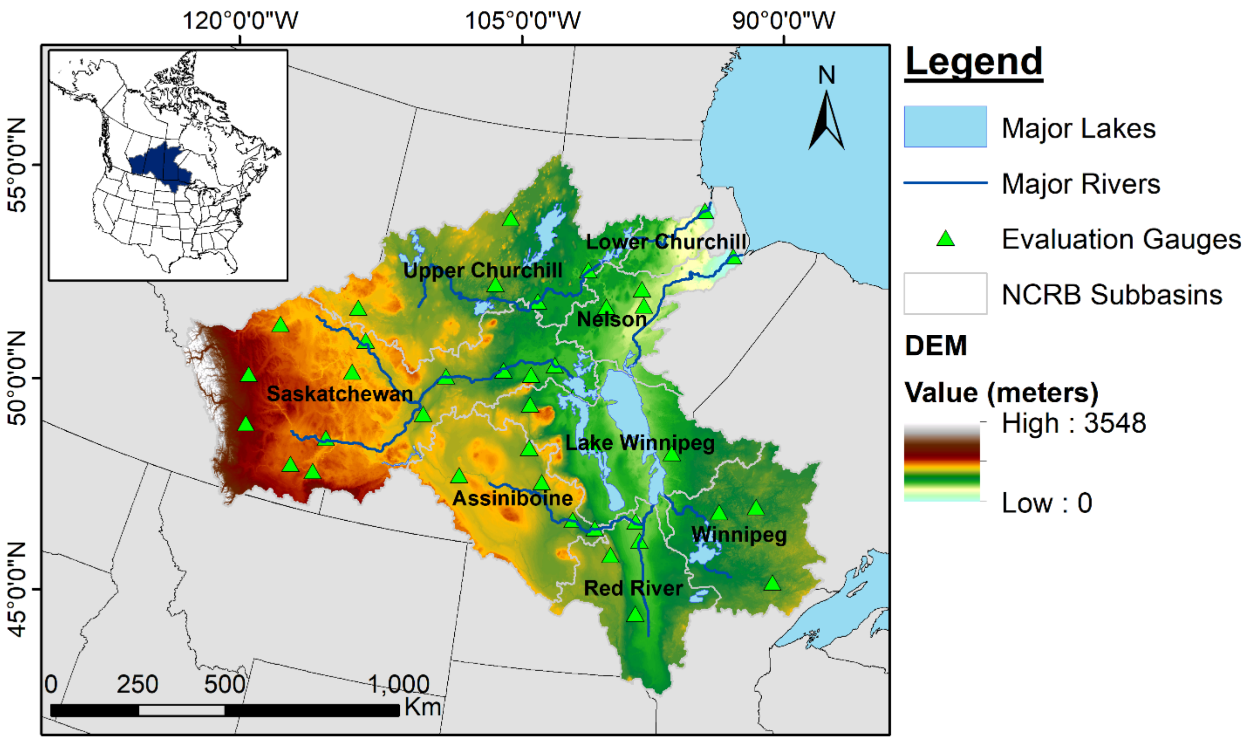

Figure 1 Map of your study Area showing major topographic features, gauging stations and river network

Nelson Churchill River Basin

Gross Area

1.4 million square kilometers

Elevation Range

Sea level to 3548 M.S.L.

2. Model Description

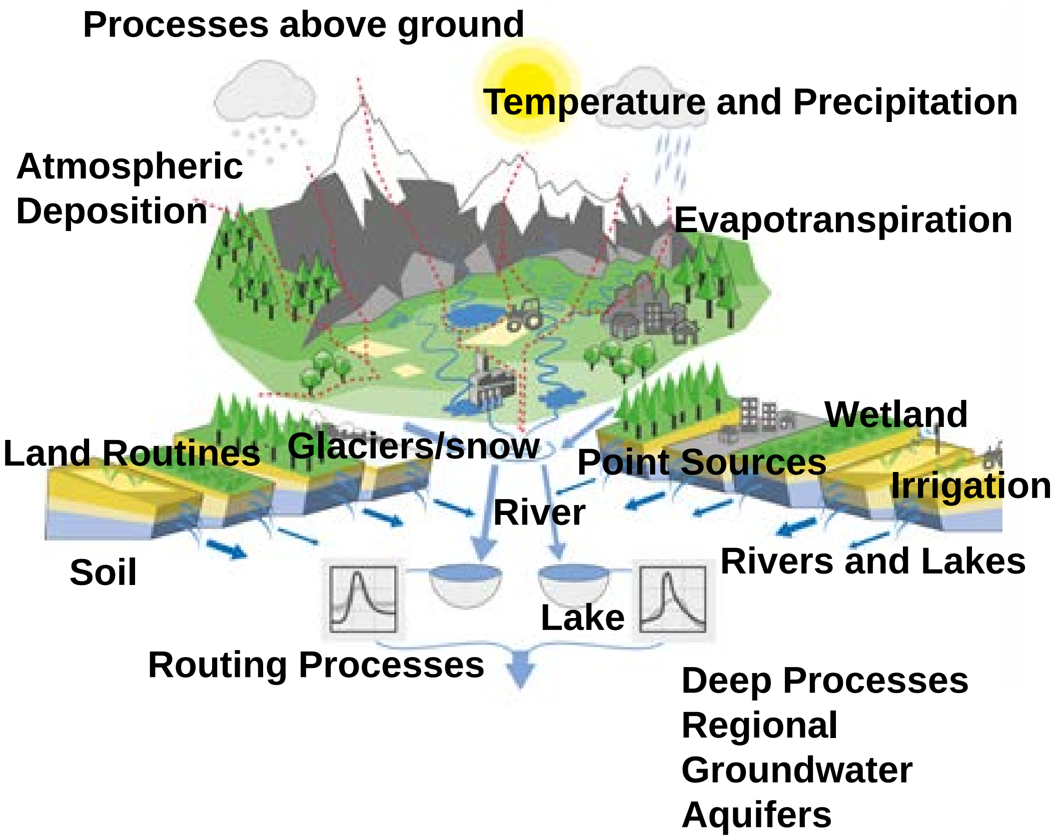

Figure 2 Components of HYPE model

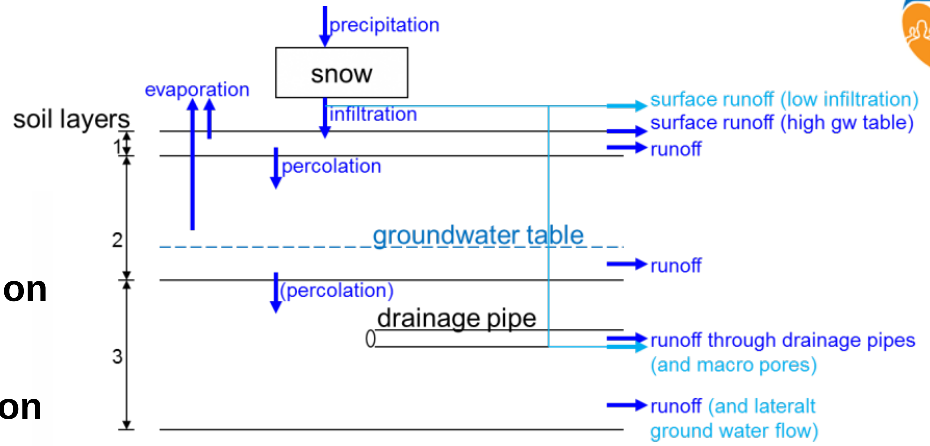

Figure 3 Illustrations of flow path in the soil in the HYPE model

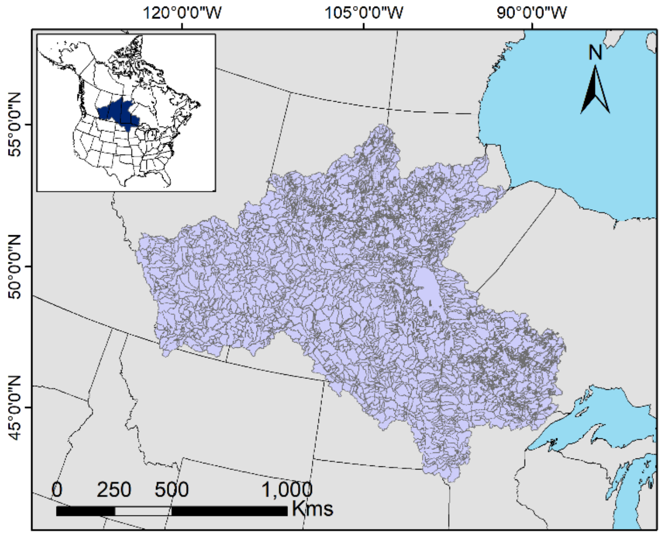

Figure 4 Sub-basin discretization in your Model (eg. HYPE)

3. Input Data Used

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Table 1 Description of the input data used for the model setup and their sources

Characteristic/Data type	Information/Product	Source
Topography	USGS: Hydro1K	https://lta.cr.usgs.gov/HYDRO1K
Soil characteristics	Harmonized World Soil Database V1.2	Nachtergaele et al. (2010)
Land use	ESA CCI LC 2010 v1.4	ESA Climate Change Initiative
Lake and wetland	Global Lake and Wetland Database (GLWD)	Lehner and Doll (2004)
Reservoirs	Global reservoir and Dam database (GRanD) v1.1	Lehner et al. (2011)
Discharge	1. HYDAT, 2. USGS	1. Environment Canada 2. waterdata.usgs.gov/nwis
Meteorological	Hydro-GFD	Berg et al. (2017)
Snow	GlobSnow	www.globsnow.info
Glacier fluctuations	World Glacier Monitoring Service (WGMS)	Zemp et al. (2009)
Evapotranspiration	FLUXNET	fluxnet.ornl.gov

SWAT-GIW

By:

Ameer Muhammad

(Water Security Agency)

1. Prairie Pothole Region

Figure 1 Prairie Pothole Region (PPR): source (USGS)

Prairie pothole Region

Known for its complex topographic landscape

- Fill-Spill processes
- Variable contributing area dynamics

Cold Region processes

- Blowing snow
- Infiltration to frozen ground

Agriculture expansion
Climate change

1. Study Area

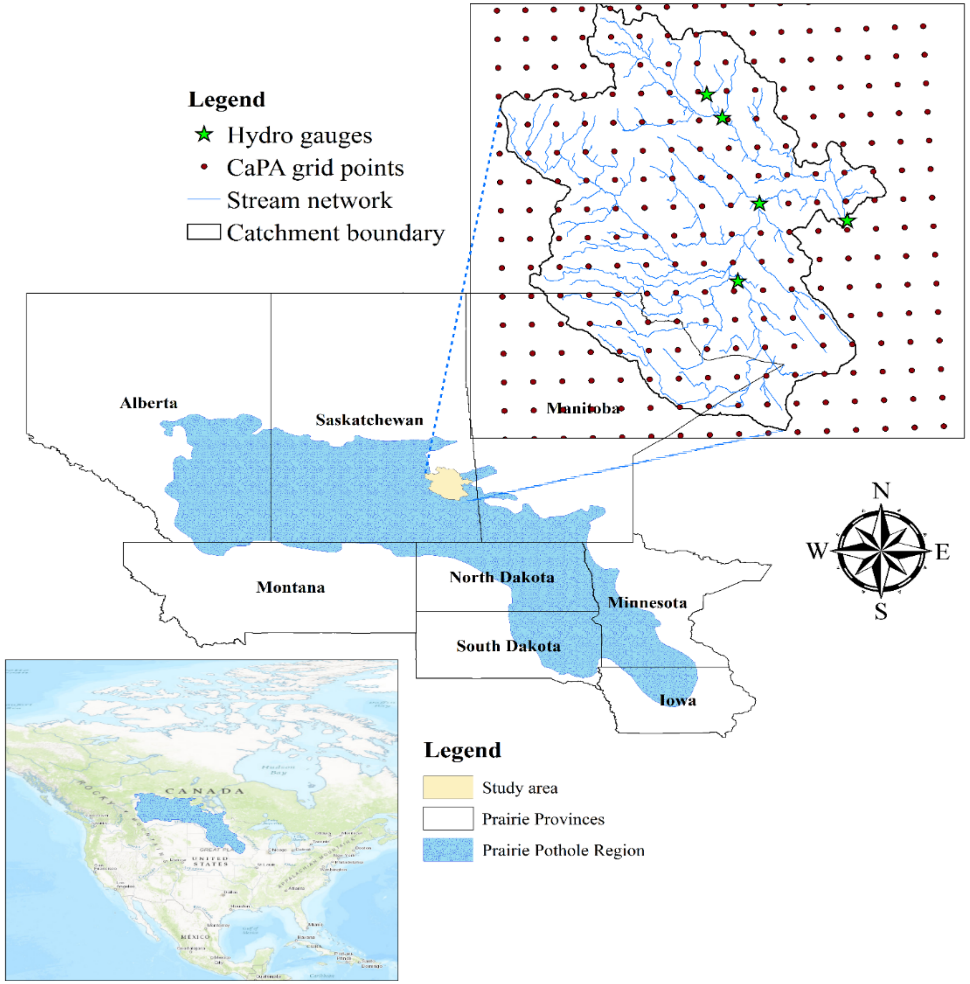

Figure 2 Geospatial location of Upper Assiniboine River Basin (UARB)- along with CaPA gridpoints and hydrometric station

Upper Assiniboine River Basin

- Importance to SK and MB
- Shellmouth reservoir

Basin Characteristics

- Area = 13,000 km^2
- Agriculture = 72%
- Forest = 12%
- GIWs (Potholes) = 140 km^2
- Density of GIWs = 3.5/km^2

2. Model Description

SWAT works based on Hydrologic Response Unit (HRU): Soil type+ land use +DEM

Wetlands in each subbasin are aggregated: lumped pothole wetland representation

Modified concept added another attribute, shape file of Geographically Isolated Wetlands (GIWs), while generating HRUs: spatial enhancement of pothole wetlands + fill-spill processes + Variable contributing area dynamics

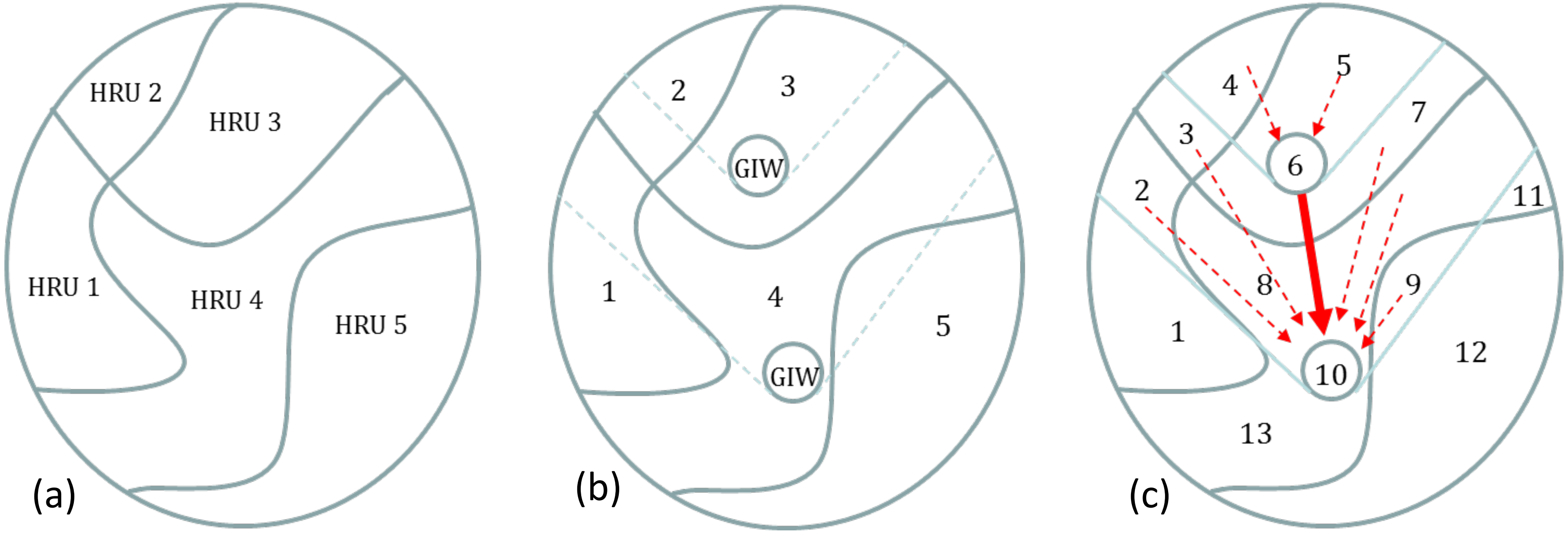

Figure 3 Modified concept of HRU representation: (a) Standard SWAT model (b) GIW atop HRU with along with drainage area (c) Revised HRUs

3. Input Data Used

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Table 1 Description of the input data used for the model setup and their sources

Characteristic/ Data type	Information/Product	Source
Topography	CDED: 20- m	http://geogratis.gc.ca/
Soil characteristics	AAFC- Manitoba regional office	http://www.globalsoilmap.net/
Land use	Circa 2000 land use data	http://geogratis.gc.ca/
Meteorological	1.CaPA, 2. NCEP-CFSR	1. https://weather.gc.ca/ 2. https://globalweather.tamu.edu/
Discharge	Water Survey of Canada	https://wateroffice.ec.gc.ca/

Thank you

References

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- **Muhammad, A.;** Evenson, G.R.; Stadnyk, T.A.; Boluwade, A.; Jha, S.K.; Coulibaly, P. Impact of model structure on the accuracy of hydrological modeling of a Canadian Prairie watershed. J. Hydrol. Reg. Stud. **2019**, 21, 40–56.
- **Muhammad, A.;** Evenson, G.R.; Stadnyk, T.A.; Boluwade, A.; Jha, S.K.; Coulibaly, P. Assessing the Importance of Potholes in the Canadian Prairie Region under Future Climate Change Scenarios. Water **2018**, 10, 1657.

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MH-WATFLOOD

By:

Mark Gervais, Shane Wruth, Kevin Sagan & Phil Slota

(Manitoba Hydro)

1. Study Area

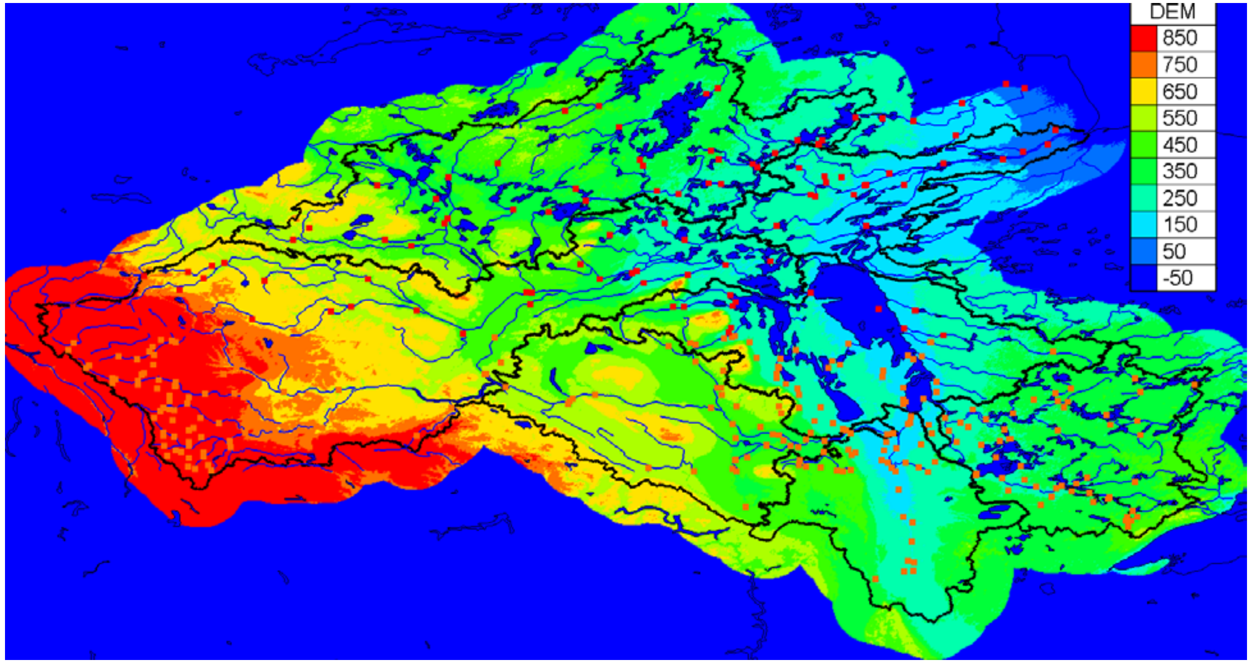


Figure 1 Manitoba Hydro Study Region

Nelson Churchill River Basin

Gross Area

1.4 million square kilometers

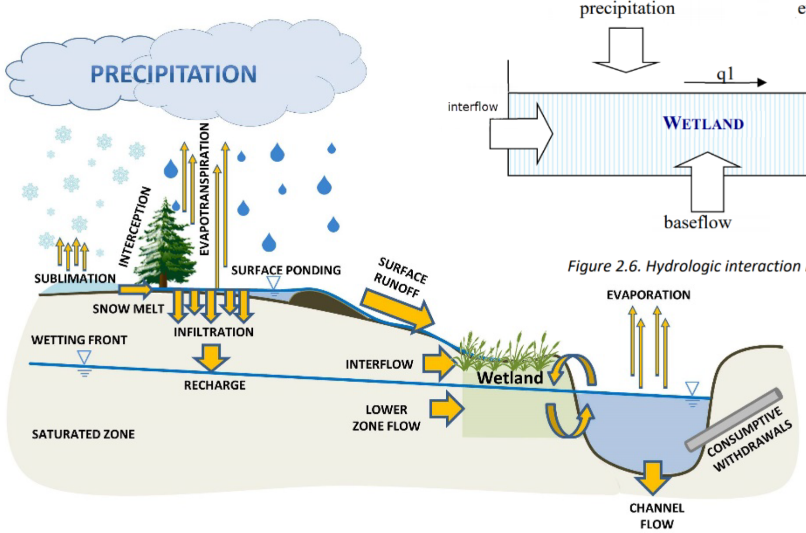
Elevation Range

Sea level to 3548 M.S.L.

Contains many unique hydrological processes:

- **Permafrost**
- **Non-contributing areas**
- **Mountainous processes**
- **Wetlands**

2. Model Description



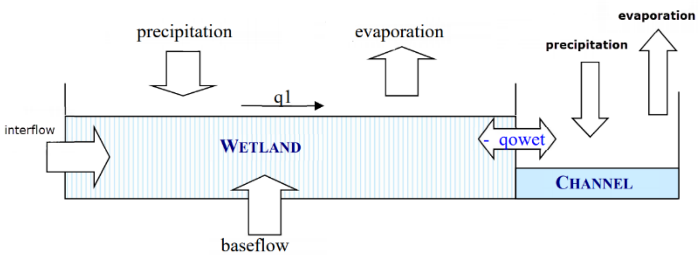


Figure 2.6. Hydrologic interaction between the wetland and the channel.

Figure 2 Schematic Diagram of WATFLOOD

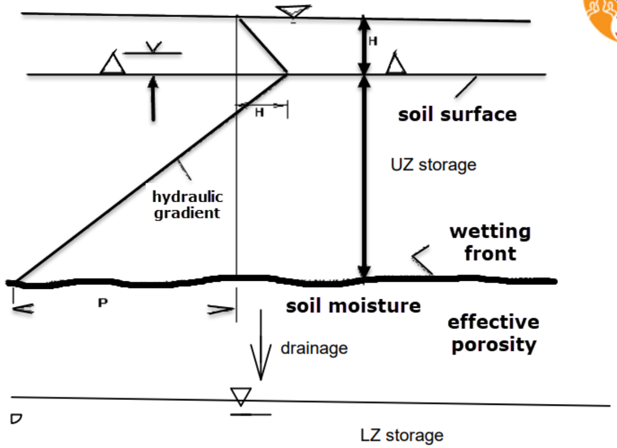


Figure 2.2. Schematic of the infiltration process.

Figure 3 Illustrations of flow path in the soil in WATFLOOD

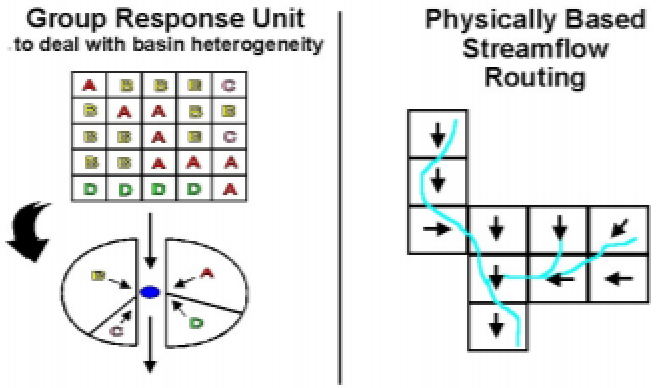


Figure 1.1 - Group response unit and runoff routing concept (Donald, 1992).

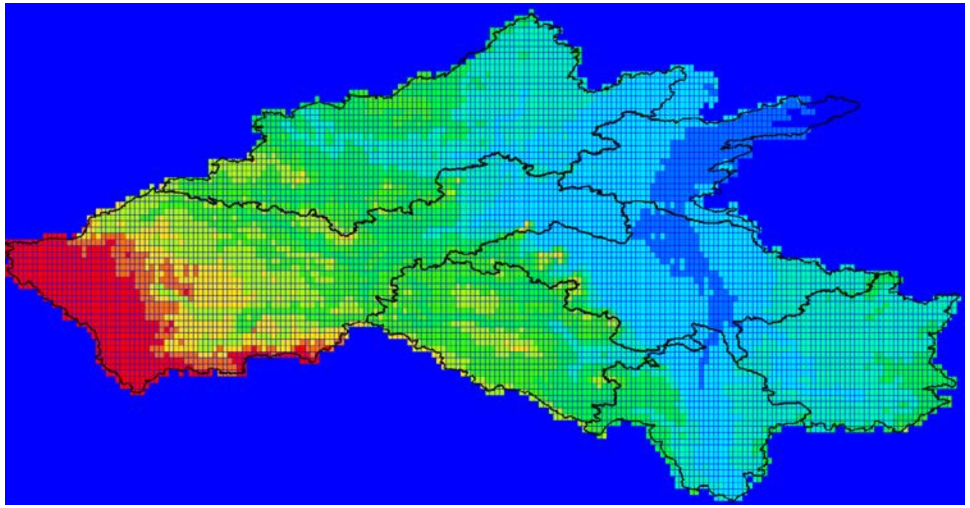


Figure 4 Sub-basin discretization in WATFLOOD

3. Input Data Used

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Table 1 Description of the input data used for the model setup and their sources

Characteristic/ Data type	Information/Product	Source
Topography	Shuttle Radar Topography Mission (SRTM)	https://www.usgs.gov/centers/eros/science/usgs-eros-archive-digital-elevation-shuttle-radar-topography-mission-srtm-1-arc?qt-science_center_objects=0#qt-science_center_objects
Soil characteristics	Surficial Materials of Canada/ Surficial Materials in the Conterminous United States	https://geoscan.nrcan.gc.ca/starweb/geoscan/servlet.starweb?path=geoscan/downloade.web&search1=R=295462 https://pubs.usgs.gov/ds/425/
Land use	The North American Land Change Monitoring System	http://www.cec.org/tools-and-resources/map-files/land-cover-2010-landsat-30m
Lake and wetland		
Reservoirs		
Discharge	1. HYDAT, 2. USGS	1. Water Survey of Canada 2. waterdata.usgs.gov/nwis
Meteorological	1. CaPA (precipitation) 2. ECCC (temperature)	1. https://weather.gc.ca/grib/grib2_RDPA_ps10km_e.html 2. https://climate.weather.gc.ca/
Snow		
Glacier fluctuations		
Evapotranspiration		

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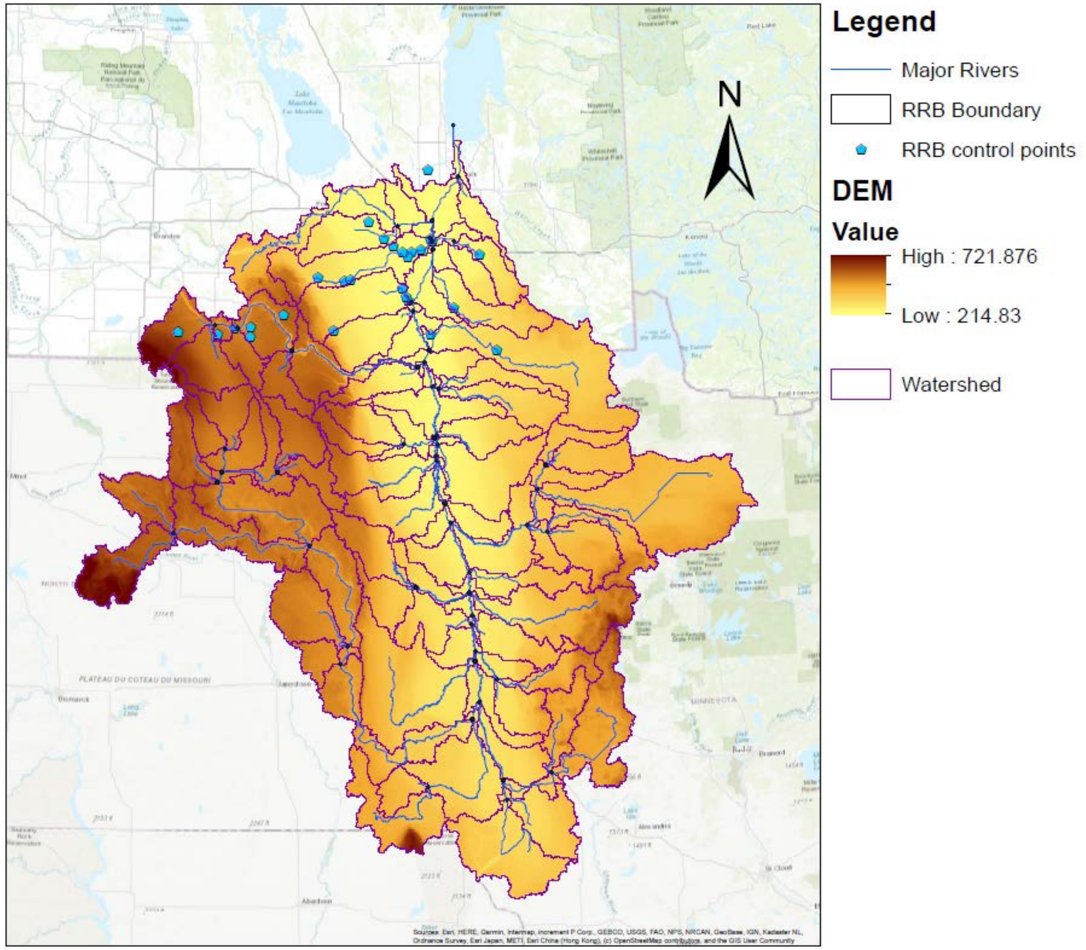
ArcSWAT modelling of hydrologic behavior for Red River Basin with control points

By:

Yinlong Huang

(University of Manitoba)

1. Study Area



Red River Basin

Gross Area

128,148 square kilometers

Elevation Range

702 to 2366 M.S.L.

Figure 1 Red River Basin with major rivers, major control points and DEM

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2. Soil Map Processing

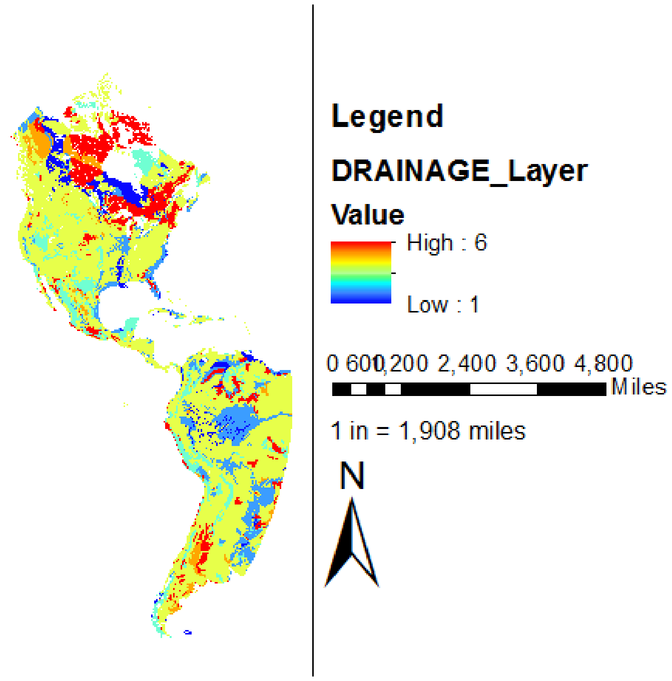

Figure 2 Initial Soil Properties File: Drainage Class NetCDF file (apart from hydraulic conductivity)

NetCDF file can be read by ArcMap: Multidimensional tool ⟶ Make NetCDF raster layer (use default setting)

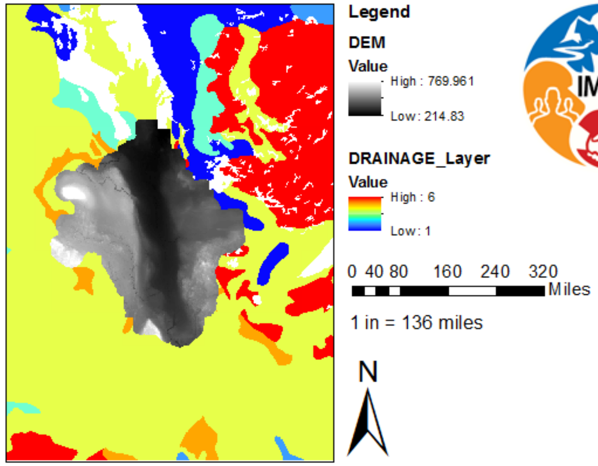

Figure 3 Illustrations of soil data extraction

Spatial Analyst Tool ⟶ Extraction ⟶ Extract by mask

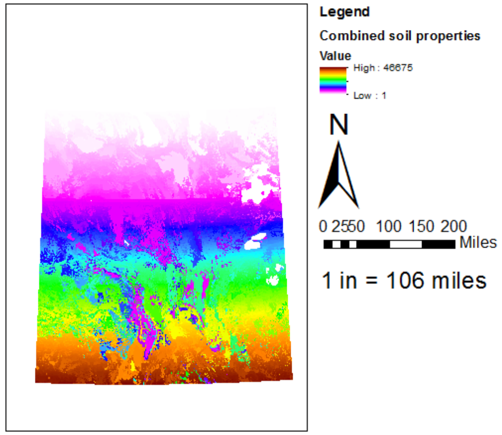

Figure 4 Combination of multiple soil properties

Spatial Analyst Tool ⟶ Local ⟶ Combine

3. Hydraulic Conductivity Processing

Soil Hydraulic Conductivity General Information

Soil hydraulic conductivity data was provided from a different database.
Link: http://globalchange.bnu.edu.cn/research/soil5.jsp

File format: unprocessed binary file, no header
Data format: log 10 transformed hydraulic conductivity
Content: 8 separate files for 8 different layers, depth varies according to different vertical resolution

4 vertical resolution:

1. SoilGrids (0 - 0.05 m, 0.05 - 0.15 m, 0.15 - 0.30 m, 0.30 - 0.60 m, 0.60 - 1.00 m, and 1.00 - 2.00 m)
2. Noah-LSM (0 - 0.1 m, 0.1 - 0.4 m, 0.4 - 1.0 m, and 1.0 - 2.0 m)
3. JULES (0 - 0.1 m, 0.1 - 0.35 m, 0.35 - 1.0 m, and 1.0 - 3.0 m)
4. CoLM/CLM (0 - 0.0451 m, 0.0451 - 0.0906 m, 0.0906 - 0.1655 m, 0.1655 - 0.2891 m, 0.2891 - 0.4929 m, 0.4929 - 0.8289 m, 0.8289 - 1.3828 m, 1.3828 - 3.8019 m)

Processing procedures

1. Matlab code developed to extract data and save as ASCII file
   a. Save the file and Matlab code under same file path
   b. Input desired latitude/longitude range (starting lat/long and ending lat/long)
   c. Run the code. ASCII file are created under the same path
2. Transform 8 layers into 2 layers
   a. Import all ASCII file into excel
   b. Use each hydraulic conductivity value and divide by depth of each layer, obtain total time for each cell on each layer
   c. Sum up total time for layer 1 to 4 and layer 5 to 8
   d. Use total time and divide by total depth of layer 1 to 4 and layer 5 to 8
   e. Once finished, use another Matlab code to save excel file as txt file, space delimited
3. Create header

Header for saved .txt file should follow this order:

```
ncols 1440
nrows 1200
xllcorner -103.0000000000
yllcorner 42.0083333333
cellsize 0.0083312988
nodata_value 2147483647
```

Once finished, use ArcMap tool to import hydraulic conductivity:

Conversion tool → To Raster → ASCII to Raster

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Deliverables & Follow-up

1. Other modellers can also prepare a 5-min presentation of their model for the next meeting. 1-3 slides presentation should be sent to Hervé by **May 6, 2020 at the latest**.

   Presentation on: VIC (UNBC), SUMMA (USask), SWAT-GWF (UAlberta), HBV-EC, WATFLOOD-MI (Manitoba Infrastructure), USASK (MESH), HEC-HMS (Strategic Consulting)

2. Scott from Strategic Consulting will be presenting on a comparison of ERA5 with another meteorological reanalysis product.

3. Hervé to follow-up with Bruce Davinson for the selection of USGS unregulated gauge stations.

4. A SLACK channed is available to facilitate informal communication for Nelson-MiP. We are all encourage to use it.

   Channel link: https://uc-hal.slack.com/archives/C011BTG7GL8

   Channel name: #ncrb_mip

5. Next meeting scheduled for **Wednesday May 13, 2020 @10:00AM MST**