Simulating the Effects of Nelson-Churchill River Regulation Controls on Freshwater Export to Hudson Bay Model Performance

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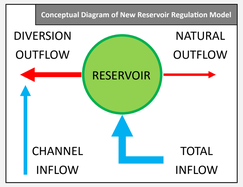
Project Objective: Regulation and Climate Change

- To distinguish effects of regulation and climate change on freshwater exports to Hudson Bay
- Using 19 of the CMIP-5 climate scenarios
- Requires improved regulation module in HYPE
- Hydrological model used in BaySys set of projects

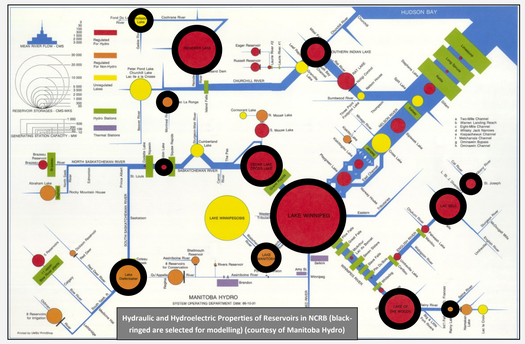


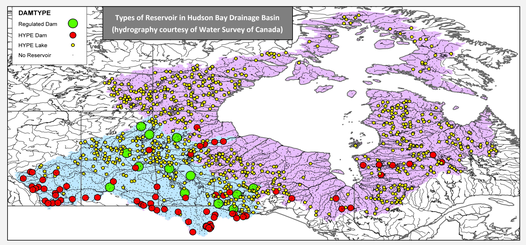
- Run future scenarios with complete regulation
- Compare against model without any regulation or development

Work Made Possible By Contributions From:

Manitoba Hydro · OURANOS · CEOS Centre for Earth Observation Science · Hydro Québec · University of Manitoba Est. 1877 · NSERC CRSNG · ASP Arctic Science Partnership

Study Area: Hudson Bay Drainage Basin

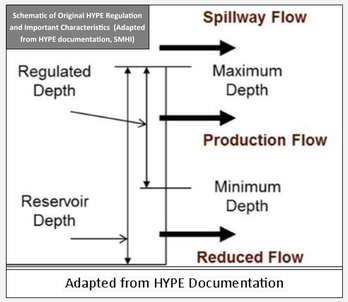


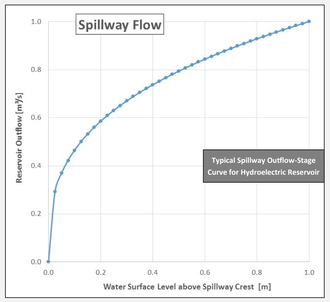


- 13 regulated reservoirs selected in Nelson-Churchill River Basin (NCRB)
- Regulated by variety of operators for different purposes
- Disparate volumes, flows, surface areas, settings (urban or remote)
- Selected by needs of Manitoba Hydro, BaySys project and modelling

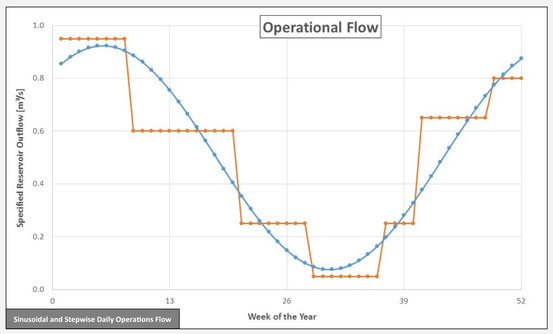
Knowledge Gap: Previous Regulation Module in HYPE (SMHI)

- Developed by SMHI (Lindstrom, 2010)
- Breaks regulated reservoirs into 3 levels, each with their own algorithm
- Fourth tier can be specified for complex res-ervoirs, none done so for BaySys
- Realistic, but simplistic set-up of reservoirs with minimal parameterization
- Performs well in high water-level situations, poorly in productions level, low-flow



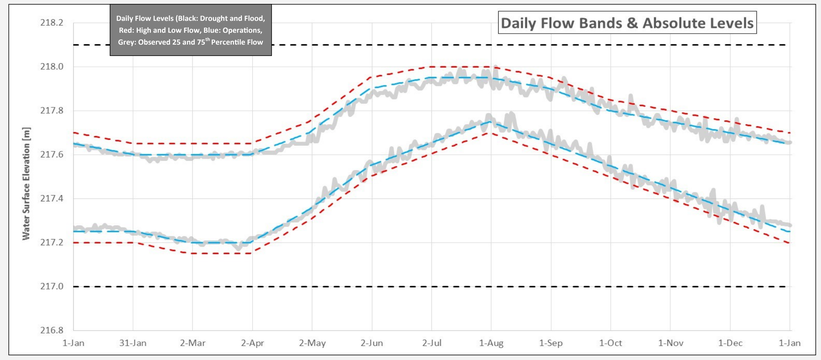


- Operational (or 'production') flow specified per day-of-year by stepwise or sinusoidal function
- Not responsive to actual water level, causes problems under non-stationary climatology, extreme-flow years



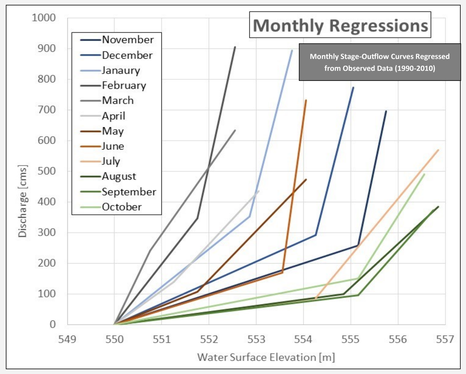
- Spillway flow dictated by water level using weir-type equation for outflow based on physical characteristics
- Shows strong performance due to water-level sensitivity
- Many spillways have well-defined parameters, easily accessible through literature

Novel Research: New Regulation Module for HYPE

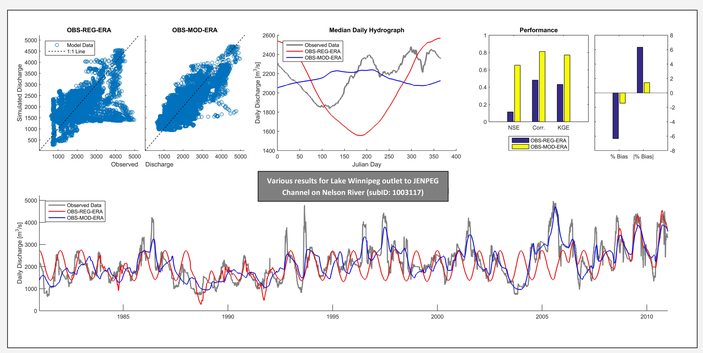


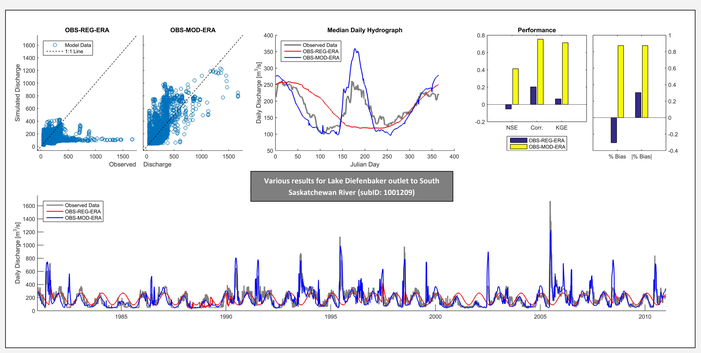
- Separates reservoir into 7 levels instead of 3
- Now includes extreme low and high stages
- Each level has customizable algorithms
- Also includes transition zones for smoothing
- Can use monthly outflow-WSL curves
- Or fixed equations for fixed installations
- Or use gradients to move to ideal water level

- More realistic response to climate change is ben-eficial to modelling future scenarios
- More resilient to effects of prolonged drought, flood conditions



Results: Changes to Performance in Individual Reservoirs

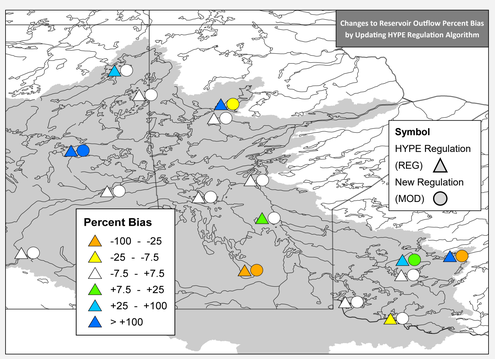


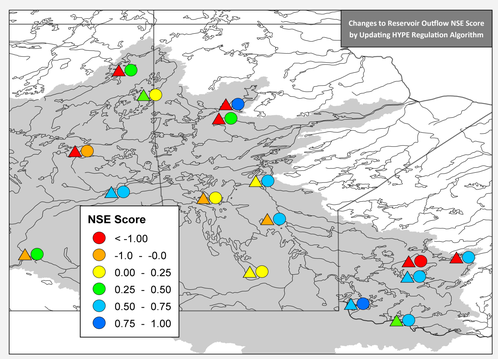


- New regulation module (MOD) compared to HYPE regulation (REG) as calibrated for BaySys Task 2.1
- HYPE regulation (REG, red lines above) shows strong performance under extended high flow
- In long droughts or median flows, sine curve dominates behaviour, missing summer peak outflows
- In drought conditions, reduced flow without transition show noisy hydrograph

- In variety of flow conditions, new model (MOD, blue lines above) shows reliability
- New module able to duplicate observed outflows for variety of climatic conditions
- Through extended drought (early 2000s) to extended flood (late 2000s)
- Average daily hydrograph shows much better replication of yearly trend

Conclusion: Overall Improvements in Nelson-Churchill River Basin





- Comparison uses observed inflows for all reservoirs
- Creates a more focused evaluation of regulation performance
- New regulation module consistently improves statistical performance
- Improves *logical* performance of reservoir operations

- Nash-Sutcliffe scores improve due to seasonal trending or dual-peaking
- To capture winter production-levels and spring freshet drawdown
- New regulation module will be used to model climate change and regu-lation effects on Hudson Bay (2040-2070)