Modeling Future Climate Projections in HEC-HMS

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Objectives

- Demonstrate application of HEC-HMS within the Columbia River watershed and compare results to SUMMA (NCAR hydrology model), for both historical and future periods.
- Define a workflow that demonstrates how to modify existing USACE models for application to climate change studies.
- Identify improvements for HEC software to streamline the workflow and provide needed modeling capabilities for future climate modeling applications.

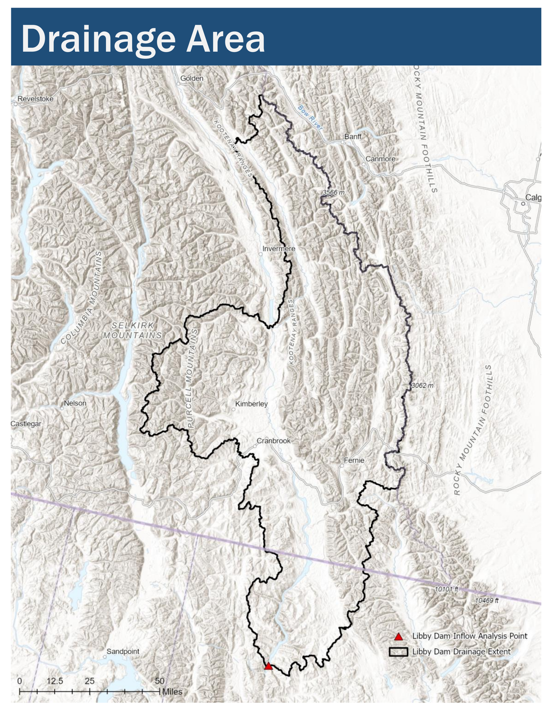
Investigations

- Does the trend in precipitation and temperature change in the future?
- Does the trend in timing and magnitude of snow water equivalent change in the future?
- Does flood risk increase under future climate scenarios, i.e. does the future flow-frequency curve shift upwards from the historical flow-frequency curve?
- Are critical flow thresholds exceeded more often in future climate scenarios?
- Does the seasonality of flood flows change?

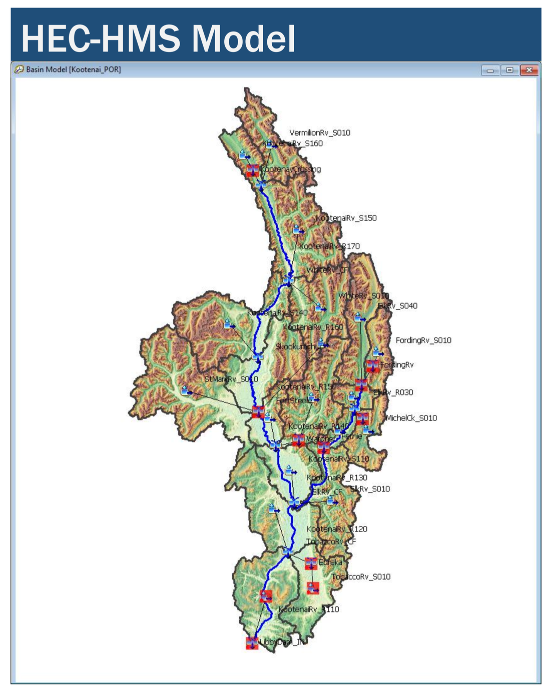
This pilot study that focused on process. The results shown do not reflect a robust analysis using a full suite of future climate projections.

Study Area

Drainage Area



HEC-HMS Model



- This study examined historical and projected inflow to Libby Dam (9,004 sq. mi.) on the Kootenai River in northwest Montana, U.S.A., with headwaters in British Columbia, Canada.
- Land Use: The land use of the upper Kootenai watershed is comprised of mainly agriculture, urban development, timber harvesting and mining.
- Climate: The Kootenai is a snowmelt driven basin. Snowmelt generally peaks in May and June.

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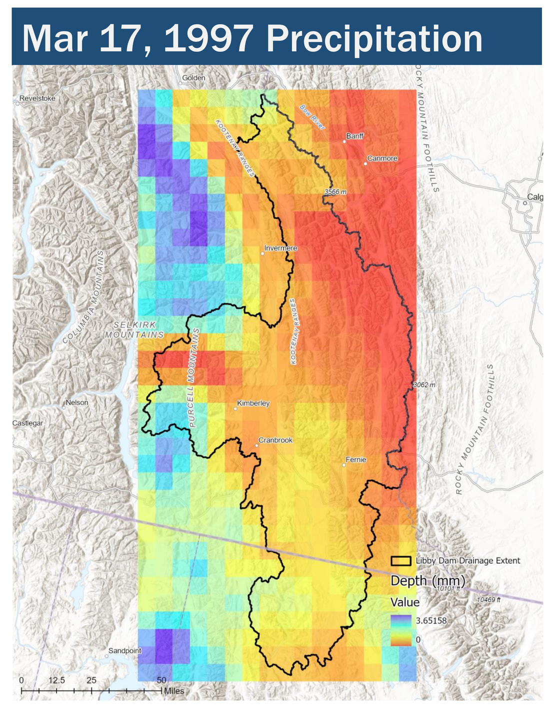
Procedure

1. Reconfigure the existing Kootenai River HEC-HMS model, originally developed for use in the Corps Water Management System, to match the study domain and use more recent modeling options.
2. Import historical precipitation and temperature datasets provided by NCAR. The precipitation records were provided in a 3-hour gridded format.
3. Calibrate multiple basin models to the No Regulation No Irrigation (NRNI) flow dataset for the period October 1, 1971 - September 30, 2020.
4. Process results from model calibration to demonstrate model performance and adequacy for future climate simulations.
5. Import climate model meteorologic datasets as provided by NCAR.
6. Configure simulations using climate model datasets and calibrated models.
7. Process results from historical and future period climate model forced simulations and identify trends.

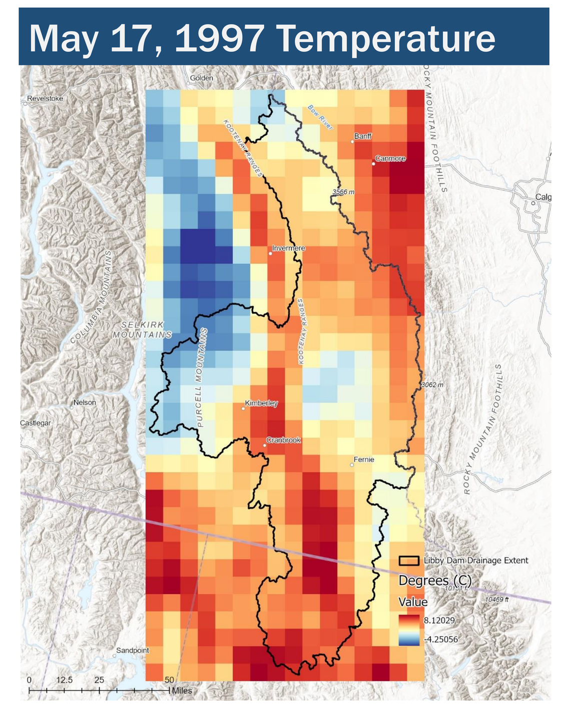
Historic Meteorology

- NCAR's Gridded Meteorological Ensemble Tool (GMET)
- Precipitation and Temperature
- October 1, 1971 to September 30, 2020, 3 hour time step
- Vortex was used to clip data to study area domain, project to Standard Hydrologic Grid, resample to 10 km grid cell size, and convert to HEC-DSS format

Mar 17, 1997 Precipitation



May 17, 1997 Temperature



Model Calibration

- The historic calibration period was 1-Oct-1971 to 1-Oct-2020
- 7 different HEC-HMS model configurations were calibrated

Model Configuration

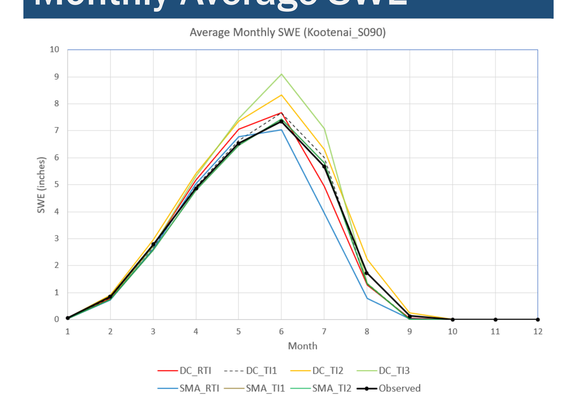
Model	Snow	Loss
M1	RTI	D&C
M2	TI	D&C
M3	TI	D&C
M4	TI	D&C
M5	RTI	SMA
M6	TI	SMA
M7	TI	SMA

Calibration Locations

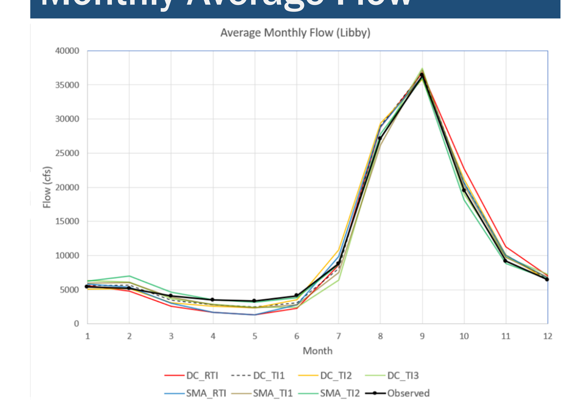
Location	Data Source
Fernie	USGS
FortSteele	USGS
KootenaiRv_S090	UA SWE
KootenayCrossing	USGS
Natal	USGS
TobaccoRv_S010	UA SWE
LibbyDam_IN	USACE NRNI

Model Calibration Results

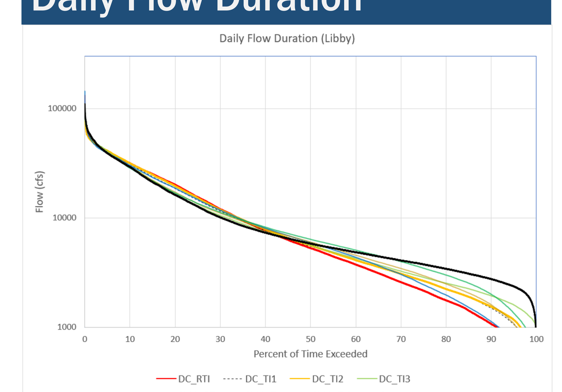
Monthly Average SWE



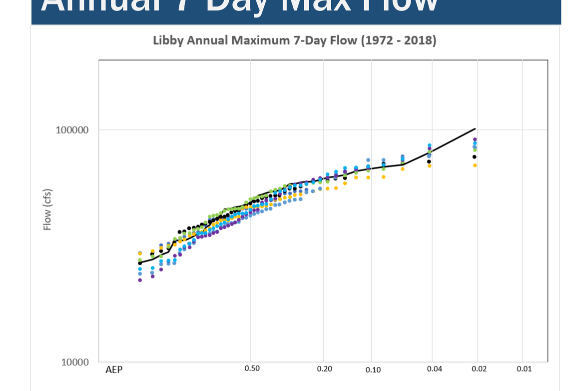
Monthly Average Flow



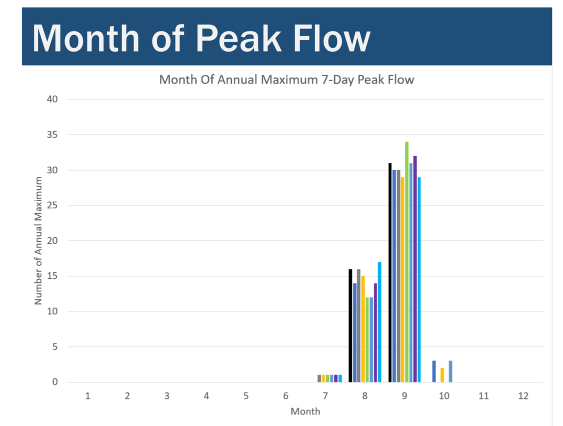
Daily Flow Duration



Annual 7 Day Max Flow



Month of Peak Flow



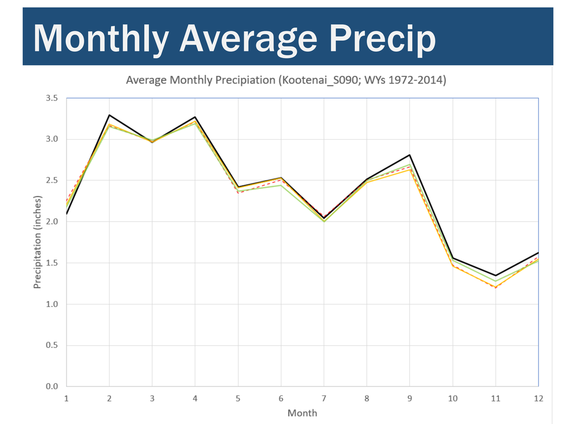
Metrics at Libby Dam

Model	NSE	PBIAS
M1 (D&C + RTI)	0.89	0.33
M2 (D&C + TI)	0.91	0.87
M3 (D&C + TI)	0.88	1.79
M4 (D&C + TI)	0.91	-1.66
M5 (SMA + RTI)	0.90	-0.54
M6 (SMA + TI)	0.91	-1.07
M7 (SMA + TI)	0.89	1.21

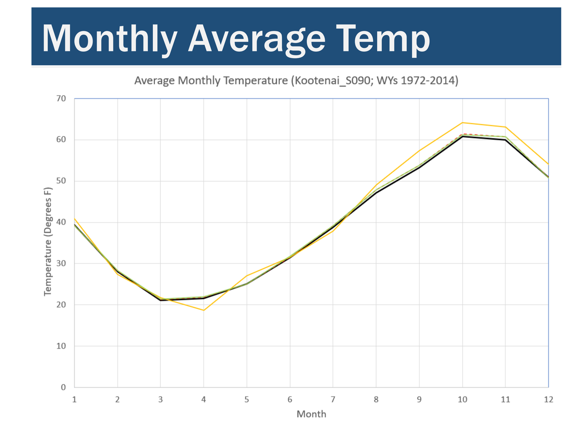
Climate Models Historic Period

Climate Model	Scenario	Downscaling	Rationale
CanESM 5	SSP 370	ICAR	Wet
MPIESM 1 2 LR	SSP 370	ICAR	Dry
NorESM2-MM	SSP 370	ICAR	Top performer
NorESM2-MM	SSP 585	ICAR	Extreme

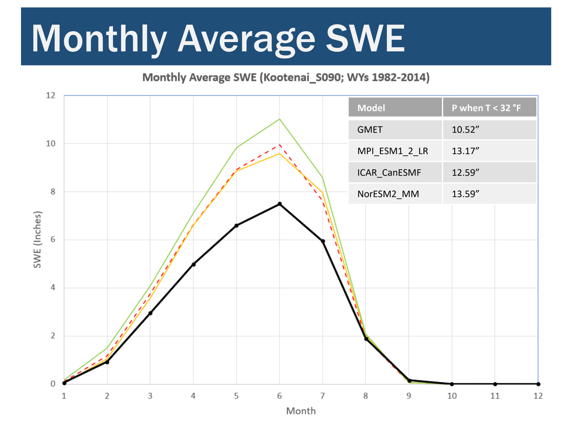
Monthly Average Precip



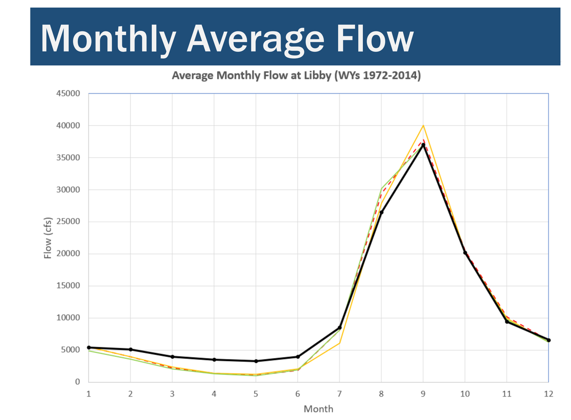
Monthly Average Temp



Monthly Average SWE

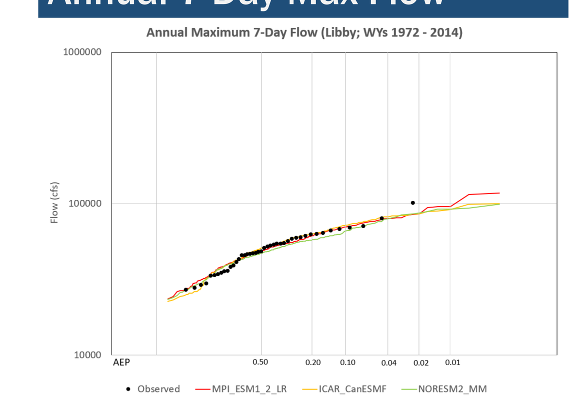


Monthly Average Flow

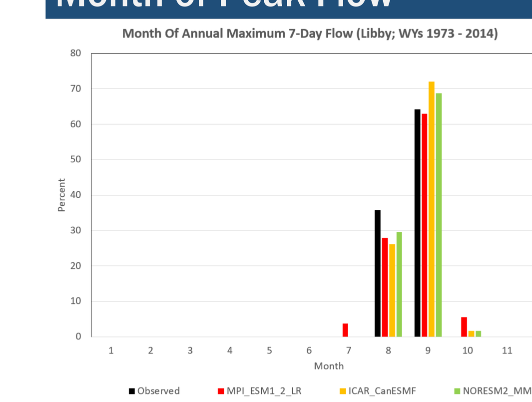


Climate Models Historic Period Cont'd

Annual 7 Day Max Flow

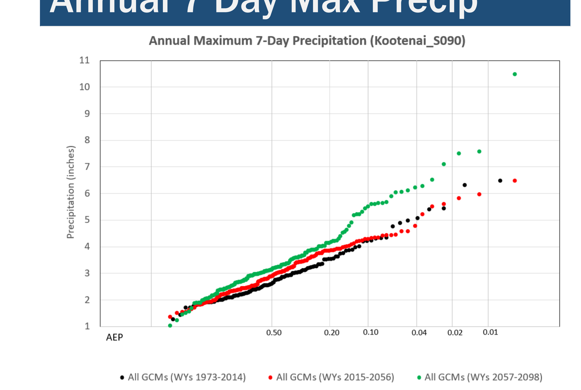


Month of Peak Flow

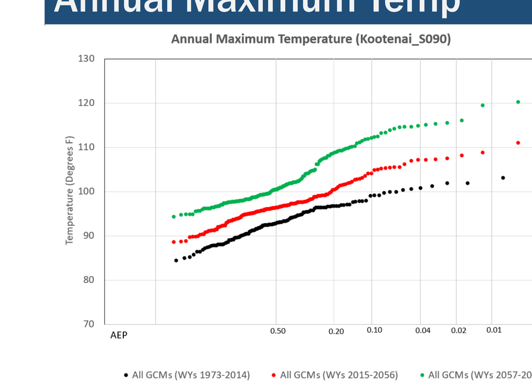


Climate Models Future Period

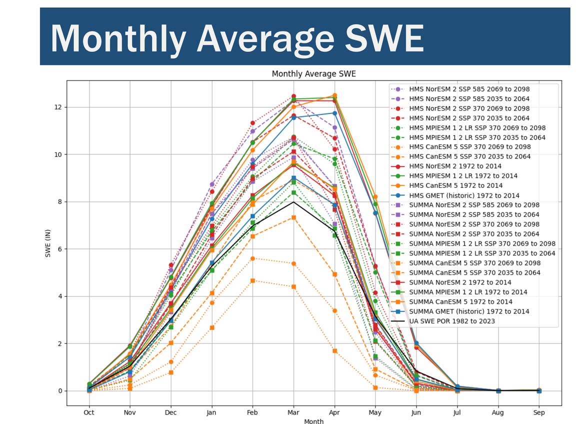
Annual 7 Day Max Precip



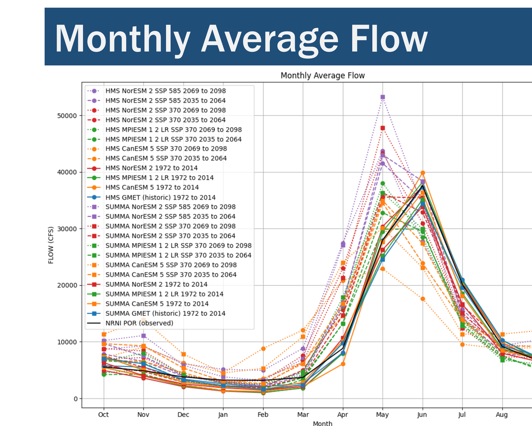
Annual Maximum Temp



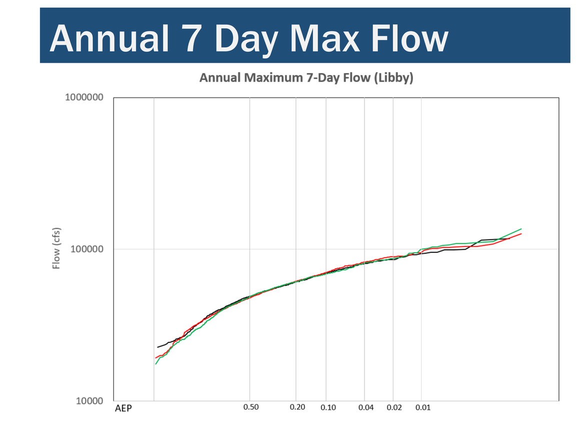
Monthly Average SWE



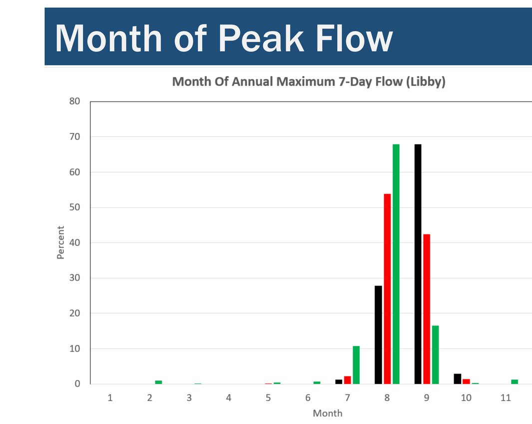
Monthly Average Flow



Annual 7 Day Max Flow



Month of Peak Flow



Conclusion & Future Direction

HEC-HMS is fit for performing in-depth climate analyses.

- Identify funding partners to implement software improvements related to output and performance.
- Use HEC-HMS in production on an in-depth climate analysis.
- Continue building climate analysis capacity in USACE.

Acknowledgments

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