Probable Maximum Precipitation (PMP) Assessment Under Climate Change Scenarios. Statistical and Physical Approach

Key words : Probable Maximum Precipitation, PMP, Climate Change, CMIP6, Hershfield, Moisture Maximization.

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1 Introduction

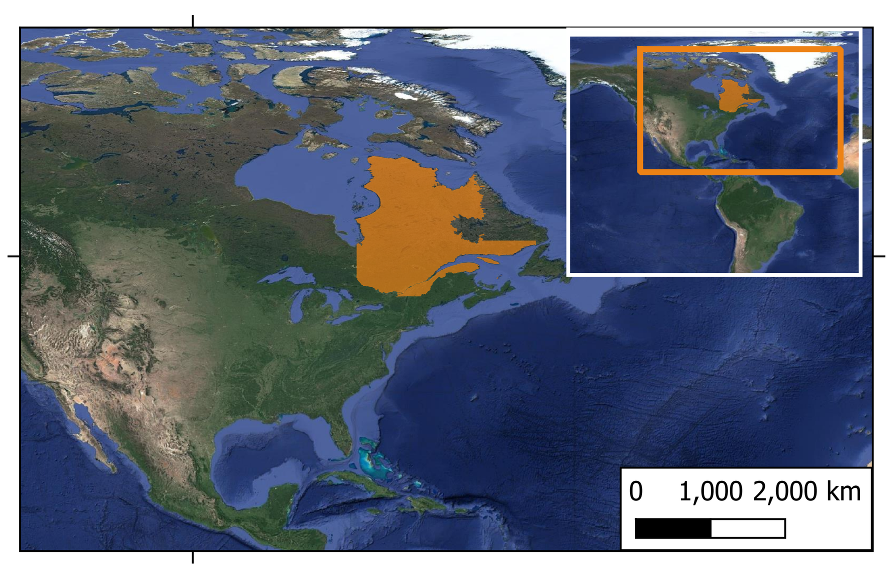
Integrating climate change assessment into the project lifecycle is an industry standard for mining projects. Probable Maximum Precipitation (PMP) represents the maximum possible precipitation for a given duration, watershed, or storm area. PMP, along with other hydroclimatic variables, is expected to change over time under the current climate scenario. Recent studies have observed an increasing trend in PMP in various regions.

Accurately estimating PMP under a changing environment is a crucial challenge during dam design, operation, closure, and post-closure stages. Minimizing uncertainty associated with PMP and its impact on critical infrastructure design, cost, and stakeholder decisions is necessary while effectively utilizing available information.

This study present a PMP estimation using statistical approach, know as Hershfield, and a physical or meteorological approach, in this case moisture maximization.

2 Site Location

Quebec, Canada



3 Data Sources

Historical site data

Environment and Climate Change Canada

- Daily precipitation (Pp)

Copernicus Europe's eyes on Earth
ECMWF

- Hourly dew point temperature (Tdew)

Climate change models

NASA
NCCS NASA CENTER FOR CLIMATE SIMULATION
HIGH PERFORMANCE COMPUTING FOR SCIENCE

- CMIP6 NASA Earth Exchange Global Daily Downscaled projections
- 30+ General Circulation Models (GCM)
- Scenarios: SSP2-45 and SSP 5-8.5

4 Methodology

- Baseline PMP estimation using Pp from site (Hershfield method)
- PMP for 30+ GCMs, 2 scenarios and 3 period: statistical and physical approach
- PMP - Hershfield:
  - Bias correction of daily Pp from GCMs considering baseline Pp.
  - Times series of annual maximum Pp and application of Hershfield's equation
- PMP – Moisture Maximization :
  - Estimate daily Tdew from GCMs using relative humidity and temperature
  - Use ERA5-Land to define a relation among daily and 12-hr persistent Tdew
  - Bias-corrected Tdew series using Tdew from ERA5-land:
    - Daily maximum annual 12-hr Tdew for each GCMs, SSP and period
    - Convert daily to 12-hr persistent Tdew for each GCMs, SSP and period
    - Frequency analysis to obtain 1:100 years 12-hr Tdew (Tdew-100)
    - Convert Tdew-100 to maximum precipitable water, W (WMO relations)

PMP
PMP baseline: 279 mm

Statistical Approach Hershfield	Physical Approach Moisture Maximization
Future periods 2040s (2030-2059), 2060s (2070-2099), 2080s (2070-2099)	
Time series of daily maximum annual precipitation per model, scenario and period (PMP^{fut}_{Hersh})	Estimate 12-hr persistent Tdew for 1:100 years to obtain maximum precipitable water (*Wmax*)
$RoC = \dfrac{PMP^{fut}_{Hersh} - PMP^{base}_{Hersh}}{PMP^{base}_{Hersh}}$	$RoC = \dfrac{W^{fut}_{1:100yr} - W^{base}_{1:100yr}}{W^{base}_{1:100yr}}$

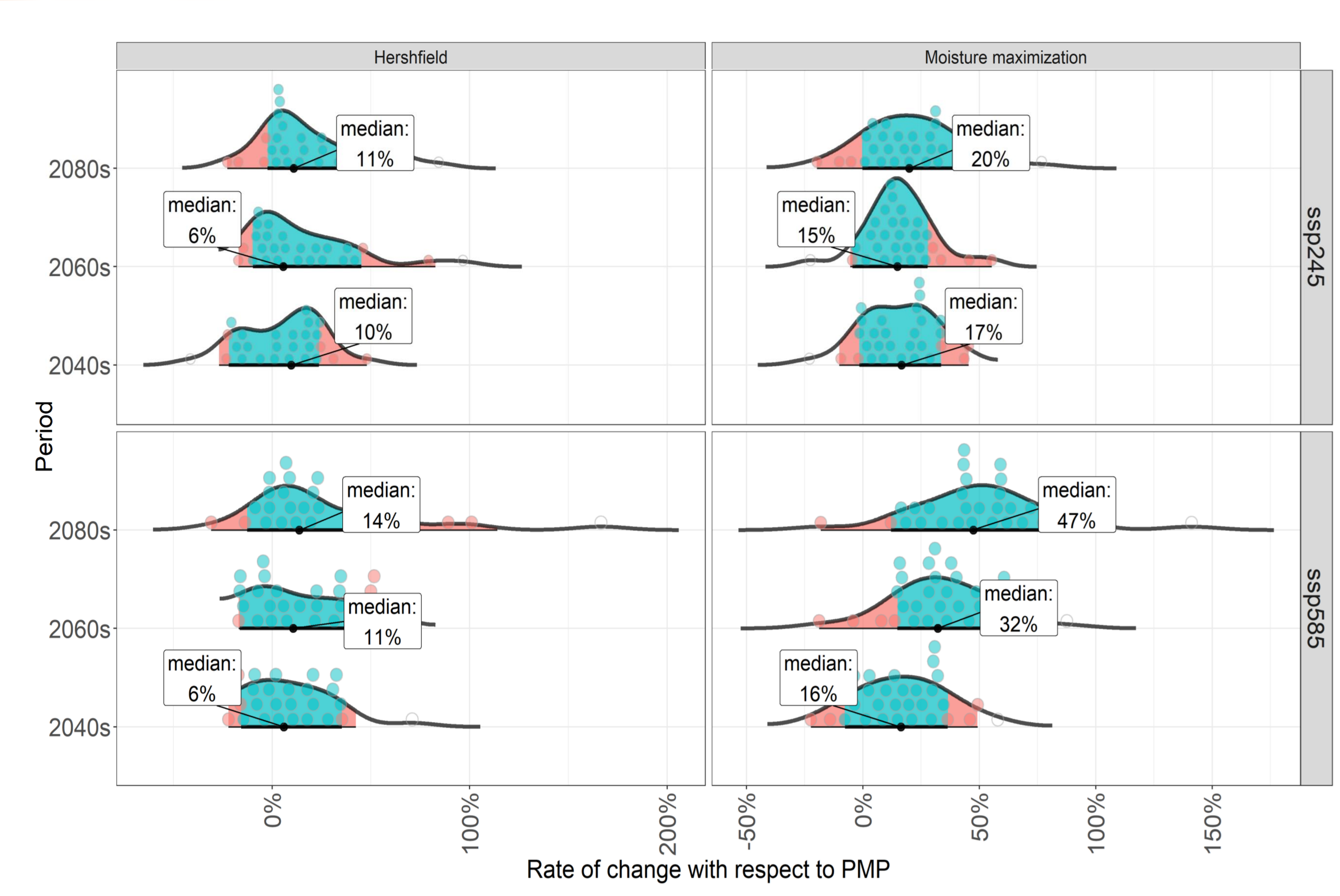
RoC = Rate of Change

5 Results

PMP (mm)		
Period	Hershfield	Moisture max
SSP2-4.5		
2040s	307	326
2060s	296	321
2080s	310	335
SSP5-8.5		
2040s	296	325
2060s	310	368
2080s	318	410

Probable Maximum Precipitation - Rate of change (%)

Period	95%L	85%L	mode	median	85%H	95%H	95%L	85%L	mode	median	85%H	95%H
SSP2-4.5	Hershfield						Moisture Maximization					
2040s	-23.1%	-23.1%	17.3%	10.0%	23.8%	48.1%	-9.5%	-1.9%	22.3%	17.0%	33.6%	45.4%
2060s	-17.0%	-17.0%	-2.4%	6.0%	41.9%	79.2%	-4.4%	-4.4%	14.5%	15.0%	30.1%	55.4%
2080s	-22.7%	-4.0%	5.3%	11.0%	62.9%	62.9%	-19.7%	-5.0%	18.9%	20.0%	44.5%	51.1%
SSP5-8.5												
2040s	-22.1%	-17.2%	-0.9%	6.0%	35.4%	35.4%	-22.3%	-14.0%	17.7%	16.0%	36.4%	49.3%
2060s	-16.9%	-16.9%	-3.6%	11.0%	50.0%	53.0%	-18.7%	13.7%	31.0%	32.0%	61.2%	61.2%
2080s	-30.9%	-30.9%	7.5%	14.0%	58.2%	101.0%	-18.0%	12.1%	51.2%	47.0%	81.6%	94.1%



6 Conclusion

- For both methods, three scenarios, and three periods mean PMP are higher in comparison with baseline value (279 mm)
- Rate of change over baseline tends to be higher among the periods.
- SSP5-8.5 estimates higher rates of change in comparison with SSP2-4.5
- PMP (median) is expected to vary between 296 to 410 mm

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