Climate Change in the Mining Industry:

Where we are now and where we're heading

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SMA
Saskatchewan Mining Association

srk consulting

Mining and Climate

- Operations are driven by the surrounding climate
  - Water demand and water supply for process plant
  - Preparing for seasonality of work, including site access and construction capabilities
  - Interactions of water and temperature on waste rock geochemistry
  - Storing and discharging runoff from mine waste
  - Managing freeboard and beach length in tailings impoundments

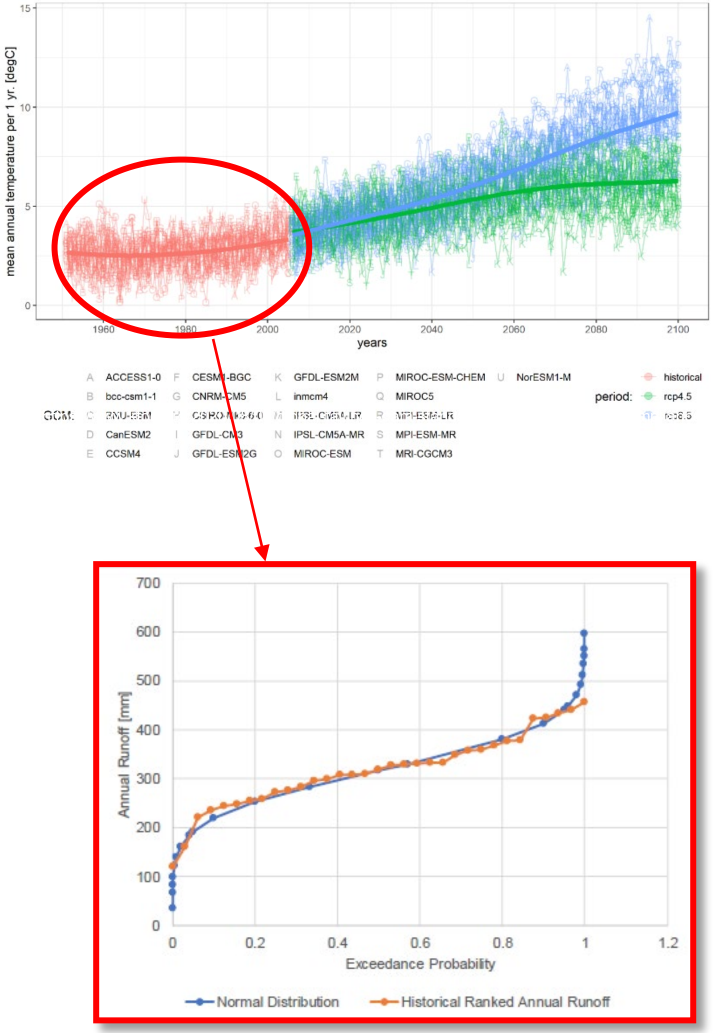
https://www.ktoo.org/2020/08/07/global-tailings-dam-standards-rest-on-voluntary-compliance/

http://geokatse.gtk.fi/2018/01/15/science-blog-will-happen-waste-rock-dump-hundreds-years-stochastic-multicomponent-reactive-transport-model-can-support-prediction/

https://www.riotinto.com/en/operations/canada/diavik
David Gardiner & Associates. (2011). Physical Risks from Climate Change: A guide for companies and investors on disclosure and management of climate impacts. Oxfam America, Calvert Investments, Ceres.

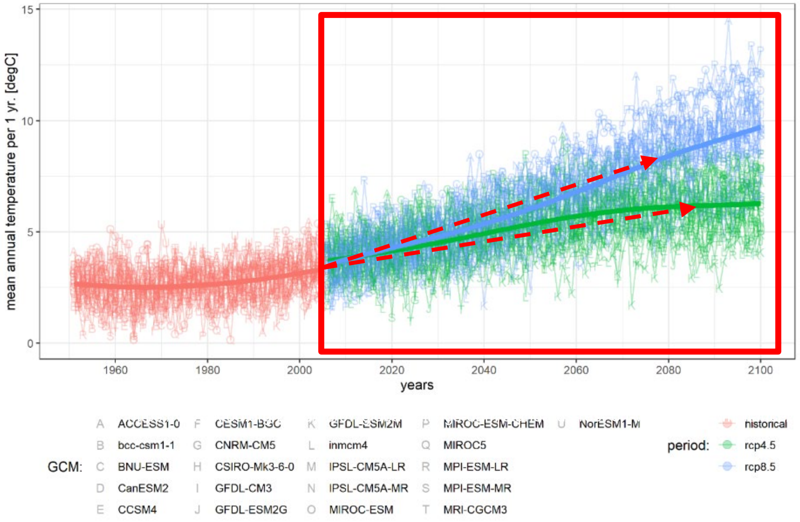
Mining and Climate

- Operations are driven by the surrounding climate
- Mining systems are designed based on the availability of information and knowledge of climate at the time of implementation
  - We rely on historical trends and models to understand expected conditions



Mining and Climate

- Operations are driven by the surrounding climate
- Mining systems are designed based on the availability of information and knowledge of climate at the time of implementation
- Assuming stationarity of historical climate is no longer an acceptable option, but we are limited to the current knowledge of climate change to plan for the future



How do we develop engineering designs to account for this shift from historical norms?

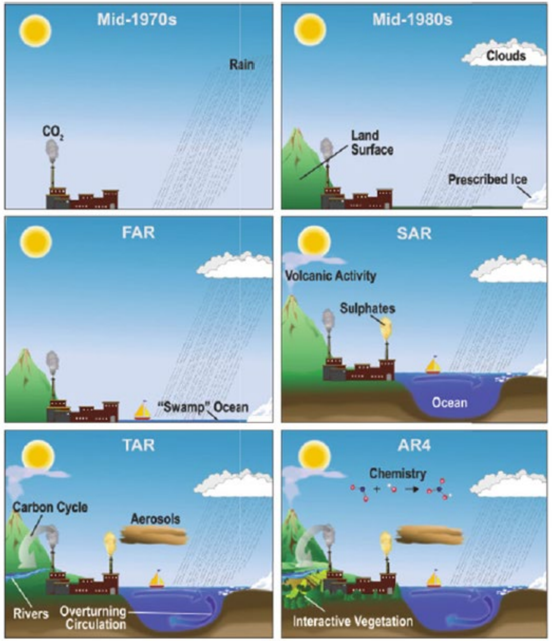
Presentation Overview

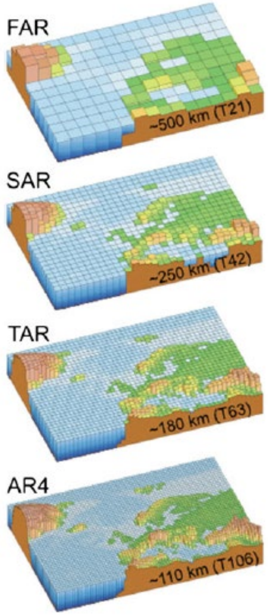
1. Overview of key information to consider when looking at climate change models and forecasts
2. Understand the inherent uncertainties associated with climate projections
3. Design with adaptation and flexibility in mind
4. Review and update

Science is Evolving

- Different organizations have developed individual global circulation models (GCMs)
- Models incorporate the available knowledge at the time of release and make calculated projections for future potential conditions
- Intergovernmental Panel on Climate Change (IPCC) compiles model results and issues Assessment Reports every ~5 years
- Base knowledge is advancing rapidly
- Each new Assessment Report (AR) combines new information of global circulation processes and improvements in data collection

They will continue to evolve!

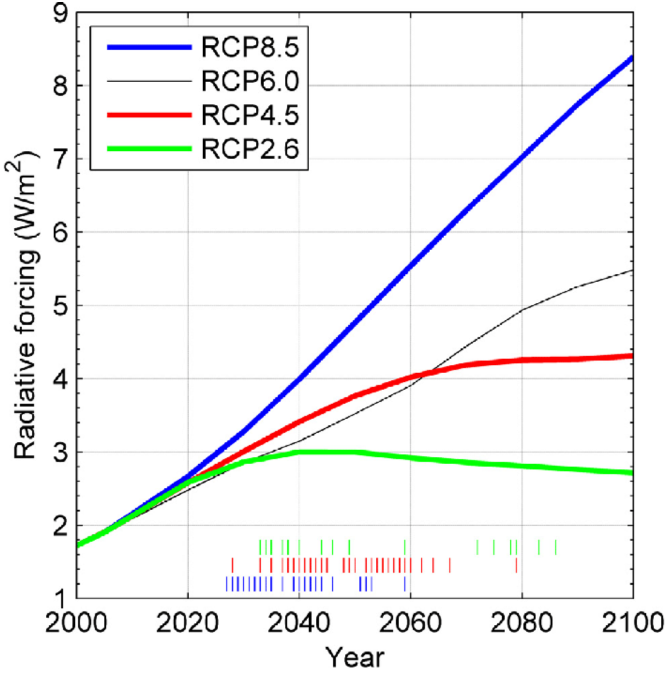




Assessment Reports Changing with Time

Scenarios

- Each GCM incorporates a series of scenarios, which account for different assumptions about the amount of heat in balance within the planet, or radiative forcing (W/m^2) in the atmosphere by the year 2100
- Scenarios represent pathways of land use and emissions of air pollutants and greenhouse gases that spanned a wide range of future outcomes through 2100
  - Path to reach a heat level or **Representative Concentration Pathways (RCPs),** from 2.6 (less heat) to 8.5 (most heat)



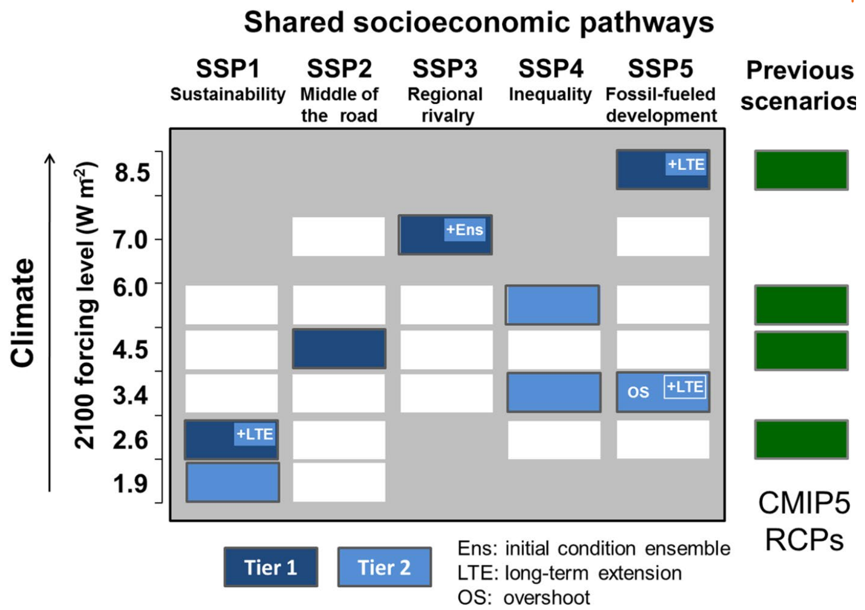
Shift to Assessment Report 6

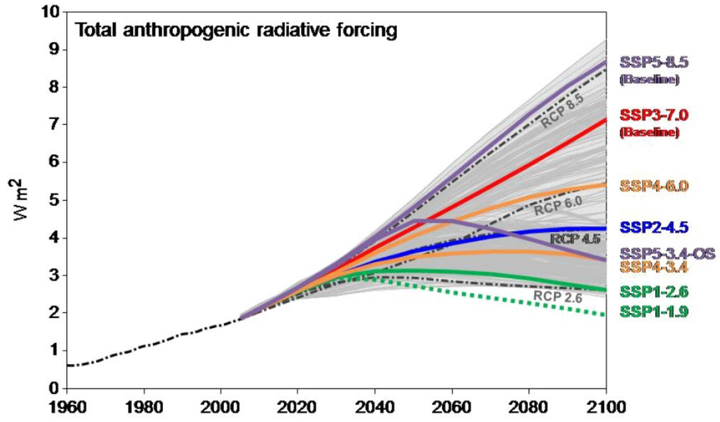
AR6 Shared socioeconomic pathways (SSPs) based on evolution of human society in the **absence of climate change or climate policy**

AR5

Standard scenarios, (**RCPs**)

i.e. How HOT is the planet?



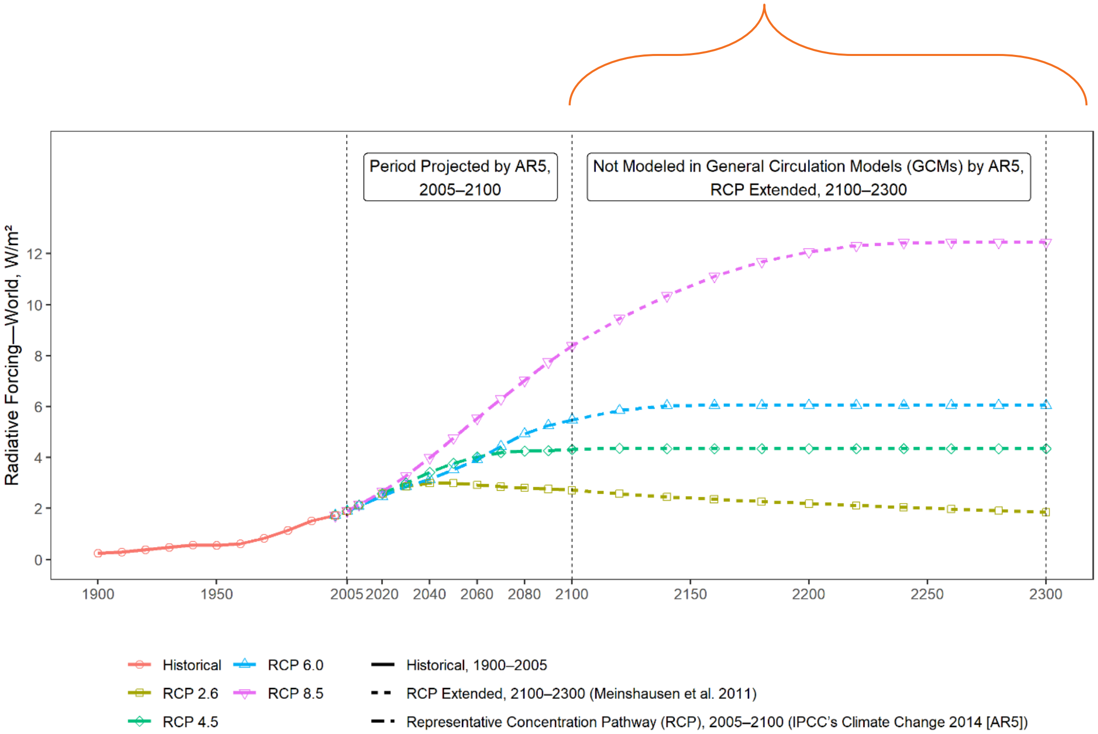


Outcome = matrix of possible integrated scenarios that lead to a final emissions forcing

Projection Periods

- Models provide historical baseline results from 1900 through 2011 and projections from 2011 through 2100
- Typically grouped in 30-year chunks
  - 2011-2040
  - 2040-2070
  - 2070-2100

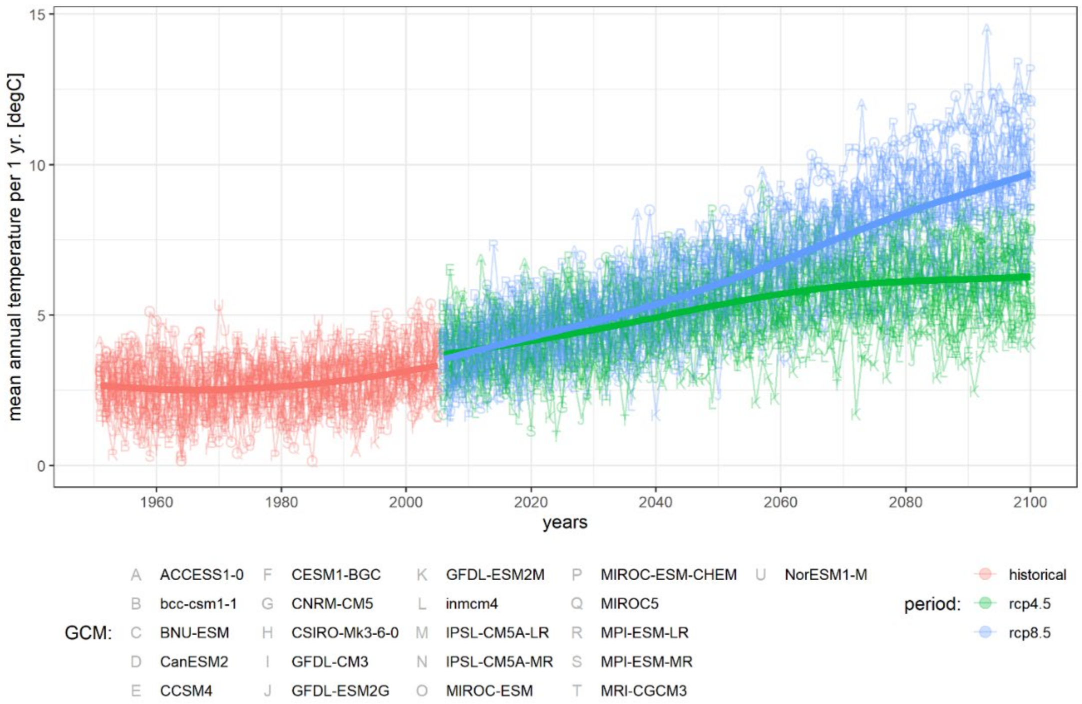
Projections beyond 2100 are not typically presented – important to think about the long-term for closure and structures in perpetuity



2. Understanding Uncertainty

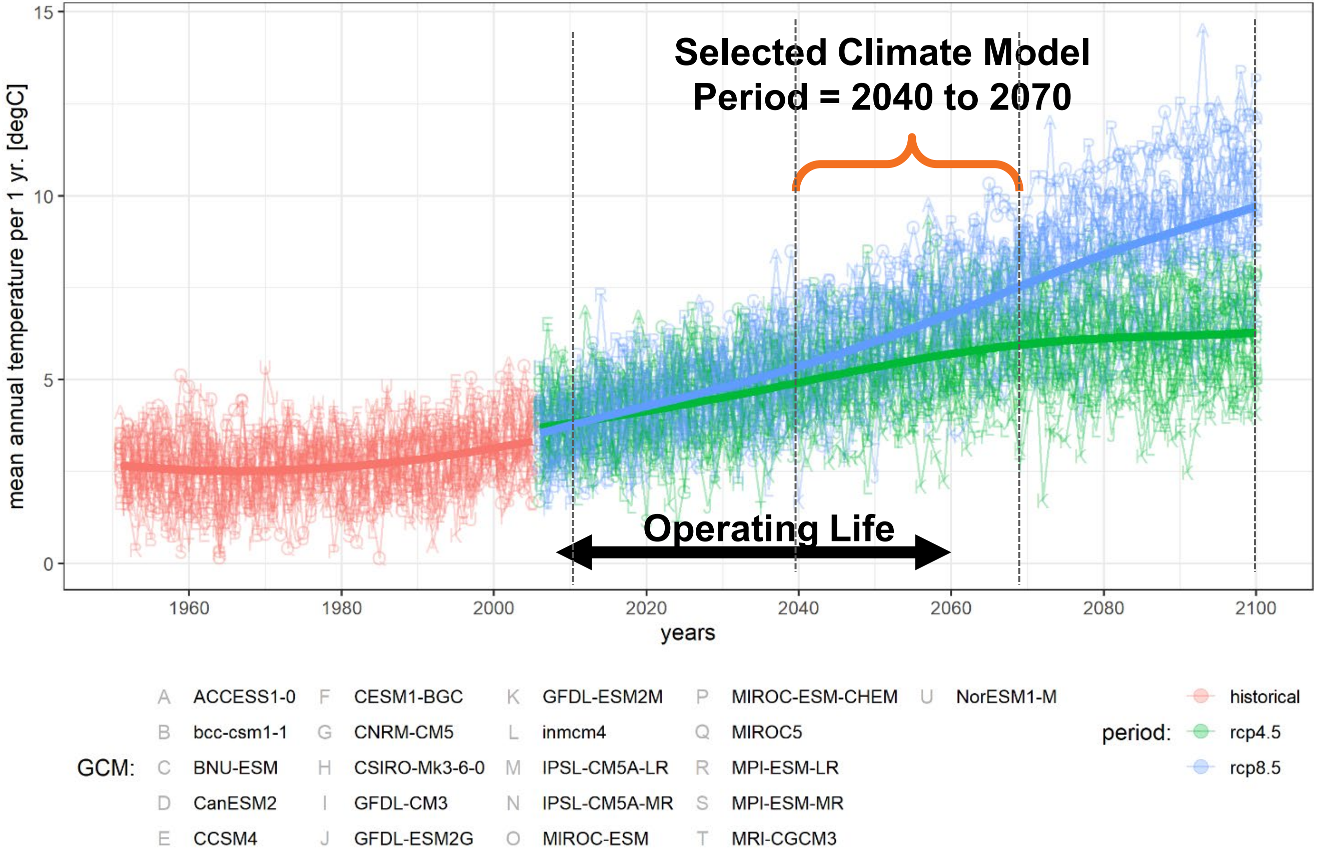
Example: Projections for Saskatoon

- AR5 model projections for Mean Annual Temperature through 2100
- Each model presents climate projections for each RCP scenario
  - Green = RCP 4.5
  - Blue = RCP 8.5
  - Red = Historical



Choosing the Projection Period

1. *Consider the operating period of infrastructure*
2. *Choose the appropriate climate model projection period*

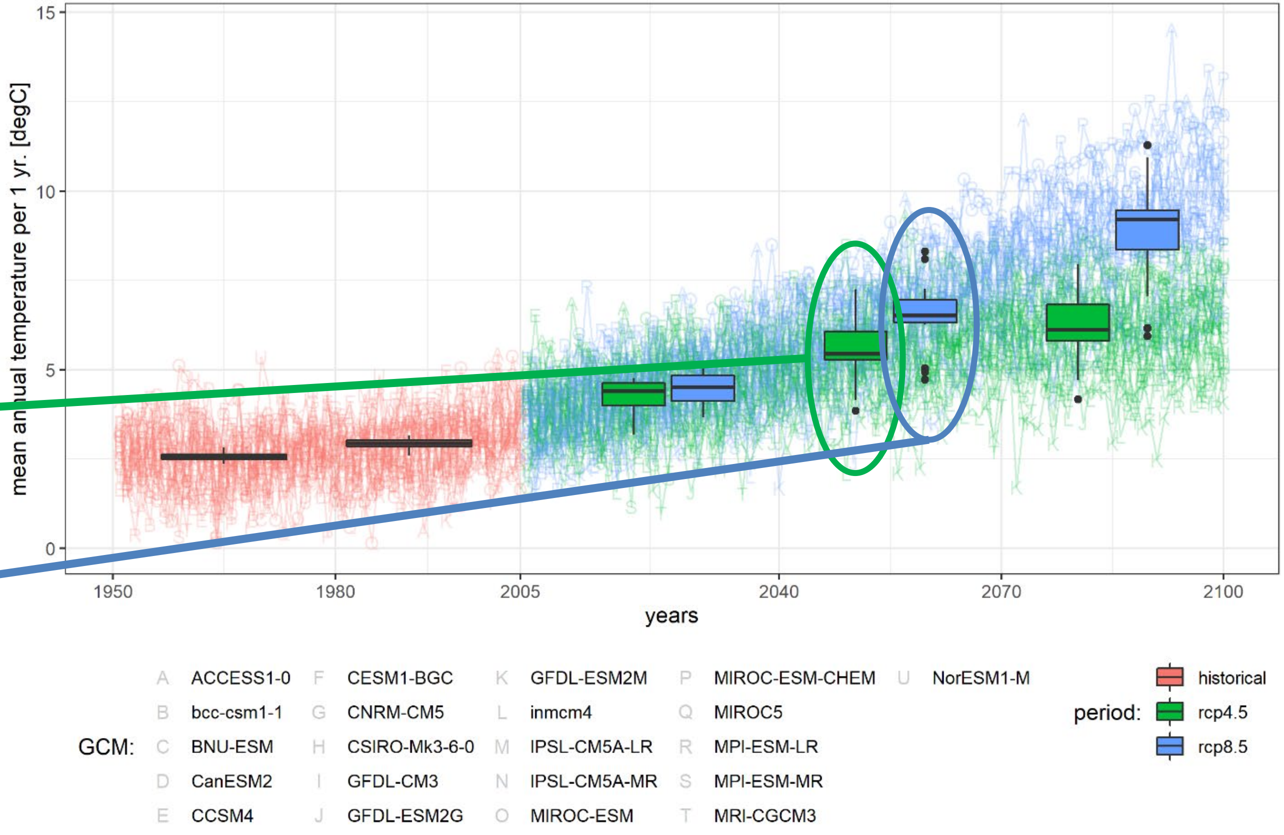


Range in Model Results

Review range of results from different RCP scenarios

RCP 4.5:
= **3.5** deg C to **6.5** deg C

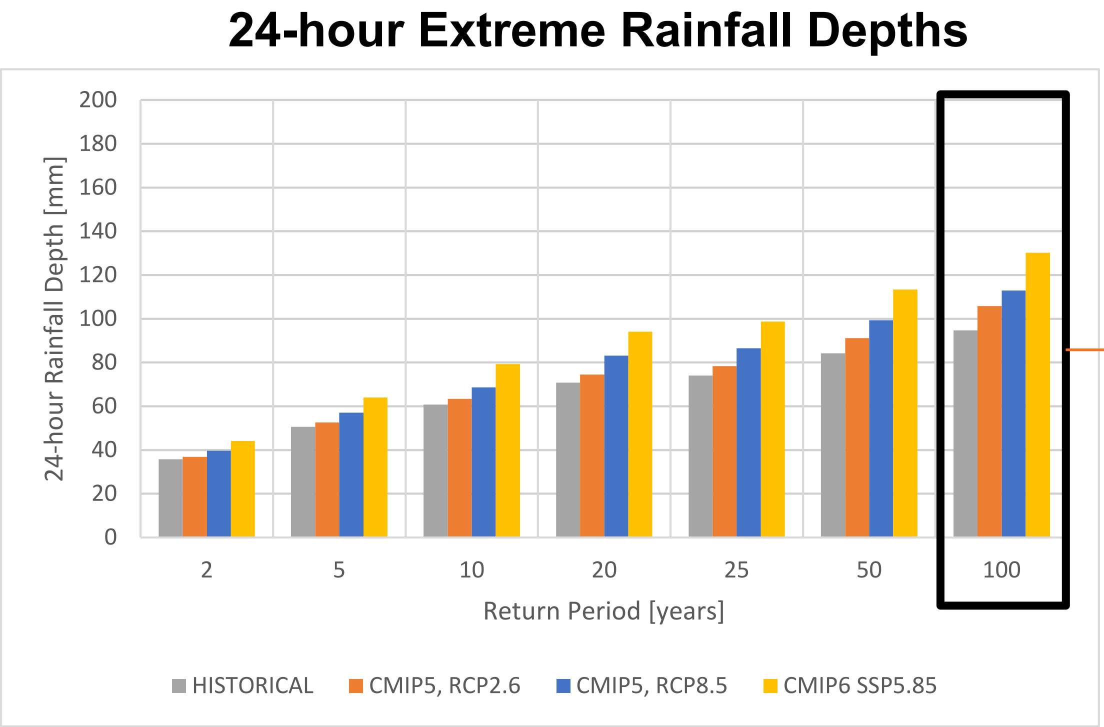
RCP 8.5:
= **4** deg C to **9.5** deg C



How do you select one result over the other?

2. Understanding Uncertainty from Projections

Range in Model Results

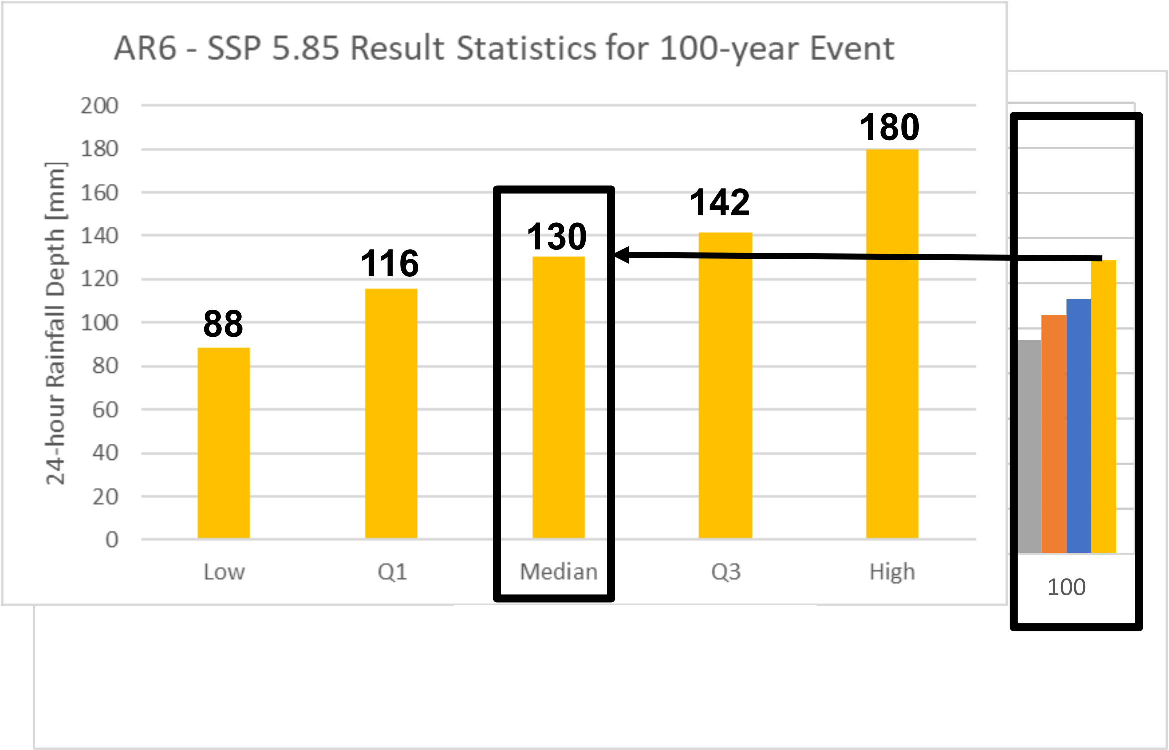


Designing for the 100-year event:

- **95** mm using historical data
- **105** mm using the median result from models based on *AR5 RCP2.6*
- **120** mm using the median from models based on *AR5 RCP 8.5*
- **130** mm using the median from models based on *AR6 SSP 5.85*

Source: IDF-CC Webtool, ICLR 2021. Saskatoon RCS station. Projections for 2071-2100

Range in Model Results



Even with a selected scenario, there is high variability

Example: AR6 SSP 5.85

- Model results show further variability
- *100-year 24-hour precipitation from **88 mm to 180 mm***

Source: IDF-CC Webtool, ICLR 2021. Saskatoon RCS station. Projections for 2071-2100

3. Managing Uncertainty

- Climate models produce a wide range of potential conditions
- Selecting a single value for design requires selection of the following:
  - Operating life and projection period (2040-2070 or 2070-2100?)
  - The 2100 radiative forcing value (4.5? 8.5?)
  - A percentile of model results (median? 95^{th} percentile?)

???

OR

3. Managing Uncertainty

1. Use ***risk-based approach*** to select appropriate criteria
   - What kind of impact would occur if the infrastructure was overwhelmed from excess precipitation or high temperatures?
     - High consequence, consider using the median model outcome from RCP 8.5
     - Low consequence, consider using the median outcome from RCP 4.5
2. ***Carry the range into design***
   - Test infrastructure and systems under a ***range of conditions***
   - Build contingencies and mitigation measures to operate under the upper range of potential conditions
3. ***Re-evaluate*** when new information becomes available
   - Design for AR5, revisit when AR6 outcomes are released

How to deal with the changes?

- Understand climate sensitivities
  - What processes and infrastructure are sensitive to climate variables?
  - What are the hazards associated with more extreme or variable climate?
  - What mitigations are currently in-place and at the ready?
  - What additional mitigations can be made available?

Input from stakeholders, operators, designers, at all stages

How to deal with the changes?

- Think about associated variables
  - Ground temperature, evaporation, streamflow, groundwater recharge, etc

Additional models to characterize these variables means more uncertainty – be sure to carry this into design

Robustness and Flexibility

- **<u>Goal</u>**: Robust systems that are flexible to varying conditions
  - *Look for options that are easy to adapt in the future*
- Examples:
  - Nyrstar Myra Falls Mine experienced a 1 in 200-year flood event in 2012
  - Invested in early-warning systems for storms and snowmelt events
  - Increased conveyance capacity of upstream diversion structures around tailings facility
  - Updated emergency flood recovery plans, ensuring infrastructure is in-place to respond to extreme events
    - *Consider effects to access during an extreme event*
    - *Contingency water conveyance, storage and treatment options*

Fraser Basin Council. (2013). *Enhancing weather resiliency at Nyrstar Myra Falls. A climate adaptation case study in Canada's mining sector.* Mirarco Mining Innovation

Robustness and Flexibility

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  - *Look for options that are easy to adapt in the future*
- Examples:

  - Centerra Gold's Mt. Milligan Mine experienced dry year with limited snowpack and spring rainfall in 2018
  - Incorporated new water supply options for extreme droughts, preparing permits to limit downtime

3. Managing Uncertainty

Robustness and Flexibility

- **<u>Goal</u>**: Robust systems that are flexible to varying conditions
  - *Look for options that are easy to adapt in the future*
- Examples:

- Saskatchewan Mining Company updating the Inflow Design Flood to be stored within existing Tailings Management Facilities during **Closure Plan Update**
- Incorporate results into freeboard and emergency flood recovery response plans

Robustness and Flexibility

- **<u>Goal</u>**: Robust systems that are flexible to varying conditions
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- Examples:

- Warm winter in 2006 forced early closure of ice roads doe multiple northern diamond mines in Northwest Territories
- Rio Tinto opted to use cargo airlifts for product shipments, resulting in increase to operating costs
- ***Be prepared for transport alternatives for access to site where ice roads are relied upon***

https://www.riotinto.com/en/operations/canada/diavik

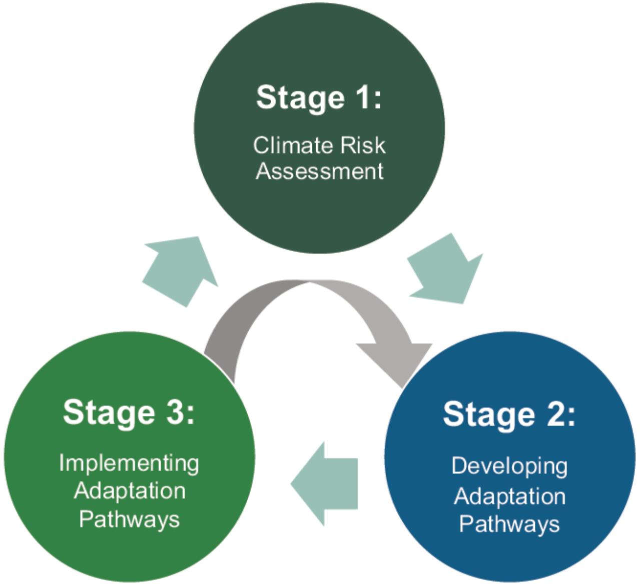
David Gardiner & Associates. (2011). *Physical Risks from Climate Change: A guide for companies and investors on disclosure and management of climate impacts.* Oxfam America, Calvert Investments, Ceres.

Robustness and Flexibility

- **Goal**: Robust systems that are flexible to varying conditions
  - *Look for options that are easy to adapt in the future*
- Other Strategies:
  - Update design criteria/factor of safety for new infrastructure to account for uncertainty in future conditions
  - Engage with regulators to understand flexibility for discharge under extreme events
  - Contingency storage solutions or conveyance infrastructure with plans in-place to act quicky

4. Review and Update

- Incorporate climate change evaluation and hazard identification at regular intervals throughout mine planning and operations
  - Closure plan updates
  - Geotechnical inspections
  - Mine expansion planning
  - IPCC Assessment Reports updated every ~5 years
  - Annual reporting
- Take advantage of free tools to review projections



Mining Association of Canada (2021). *Guide on Climate Change Adaptation for the Mining Sector.* Prepared by Golder Associates.

Summary

1. Acknowledge that historical statistics are insufficient to predict future conditions
2. Understand the uncertainty associated with climate change projections
3. Choose appropriate selection criteria based on consequence of failure and lifetime of infrastructure
4. Test systems under a range of conditions and design with flexibility in mind
5. Update and re-evaluate frequently – atleast every 5 years

Questions?