Climate and post-closure safety

What are the potential long-term implications over centuries to millennia *(and beyond…)*?

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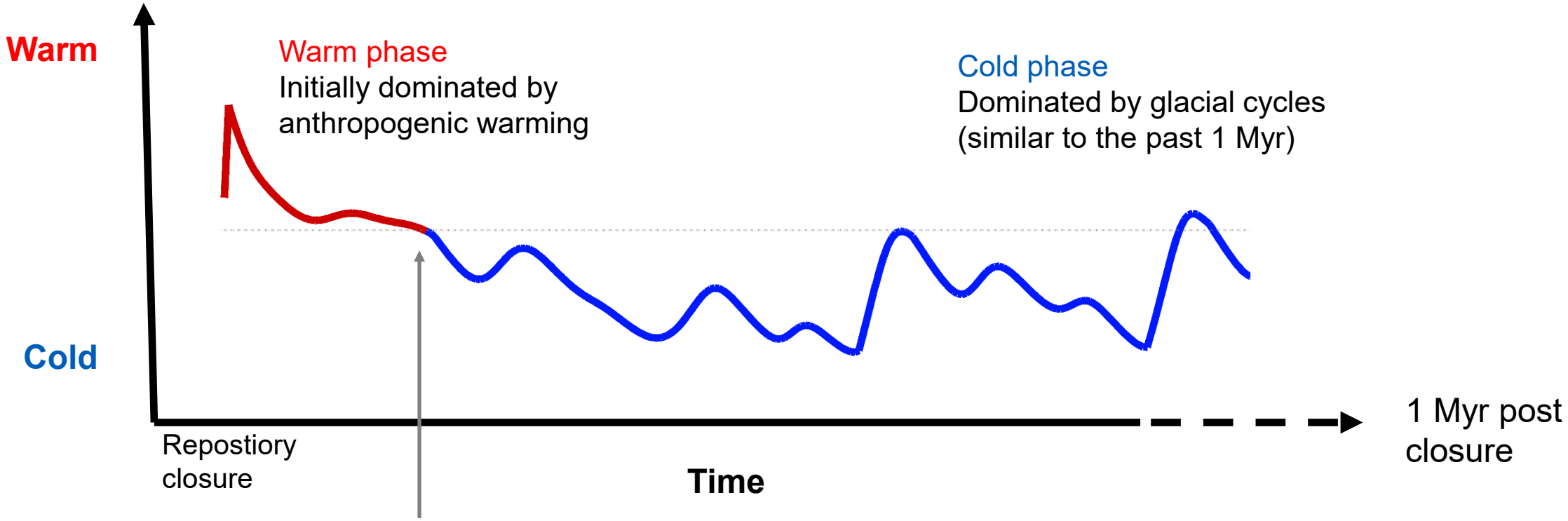
Relevance of climate to post-closure safety

- Changes in climate and climate-related processes can impact the natural environment and the performance of engineered barriers of a nuclear waste disposal system.
- Potential impacts of future climate change is analysed in the **post-closure safety assessment** -> input to site selection and repository design.
- In post-closure safety assessments, climate uncertainty is evaluated by a range of climate scenarios. These scenarios are developed based on uncertainties in **long-term climate evolution** and **climate-related processes** as well as **repository-specific factors**.

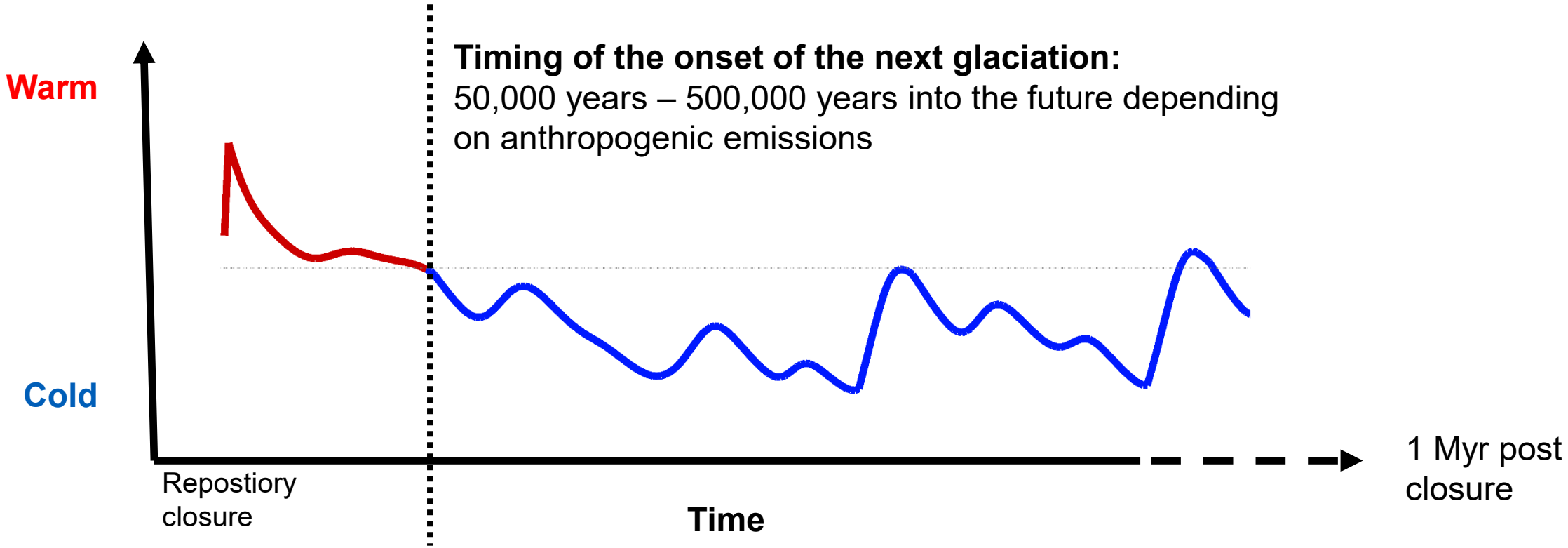
Long-term future climate change

SCHEMATIC OVERVIEW OF GLOBAL TEMPERATURE CHANGE (NOT TO SCALE!)

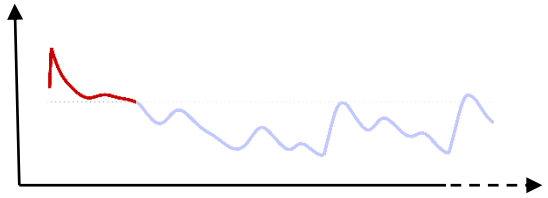


- Reduced atmospheric CO_2
- Low summer insolation at high latitudes due Earth's orbital variability

Onset of the next glaciation



Examples of climate impacts and potential consequences for post-closure safety during the warm phase



How much will the climate warm due to anthropogenic greenhouse gas emissions?

Potential climate impact	Potential consequence(s) for post-closure safety
Changes in precipitation and evapotranspiration	- **Altered groundwater flow patterns,** affecting e.g. radionuclide transport. - **Human adaptation**: changes in land and water use, including cultivation of new crops and freshwater sources

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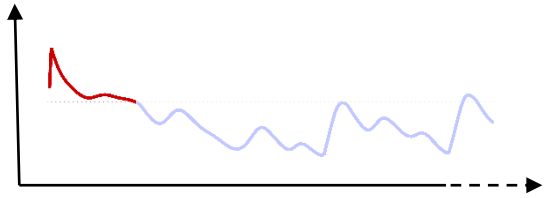

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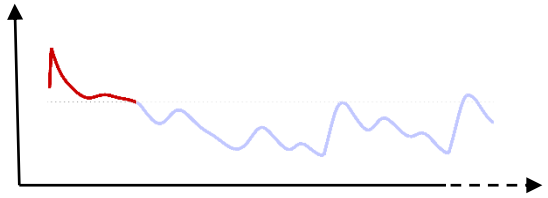

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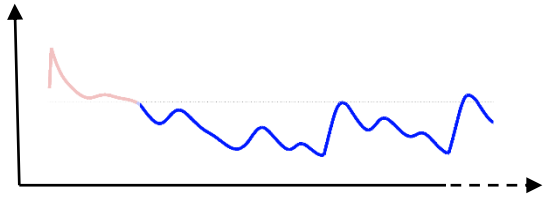
Examples of climate impacts and potential consequences for post-closure safety during the cold phase



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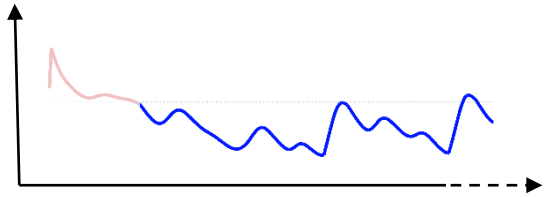

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- **Type of repository**

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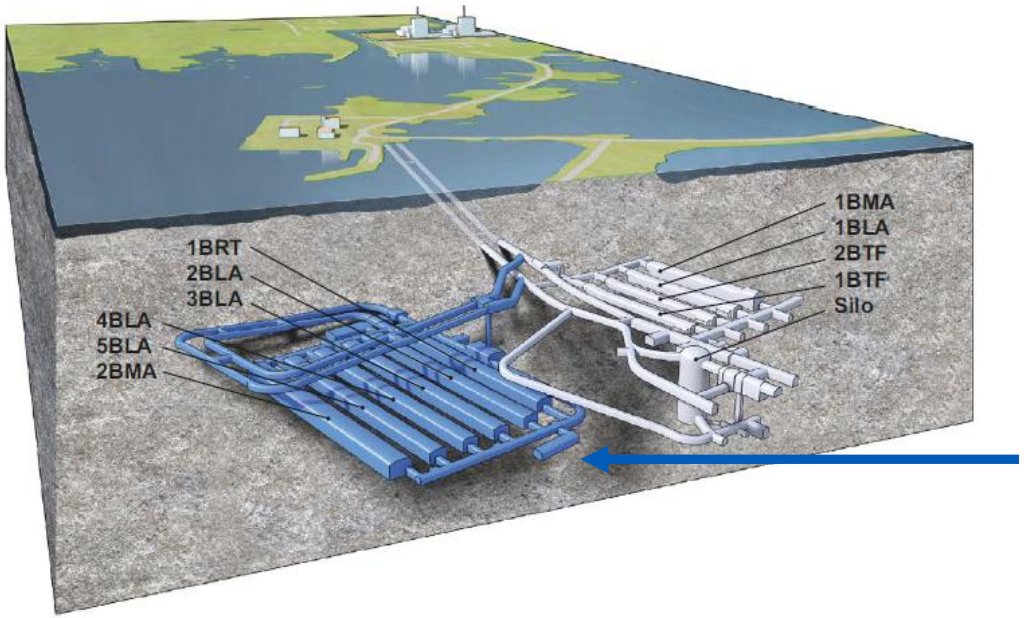
- **Site**
- **Type of repository**
- **Repository concept (primary safety function)**

→ **ISOLATION**: cold climates (especially ice sheets)

RETENTION OF RADIONUCLIDES: warm climates

SFR (low- and medium-level waste)



Type: **Deep Geological Repository**

Site: **Forsmark, Sweden**

Various engineered barriers, e.g. concrete structures

Primary safety function: **RETENTION OF RADIONUCLIDES**

Extension is currently being constructed.

Post-closure safety assessment supporting the construction licence application (PSAR).

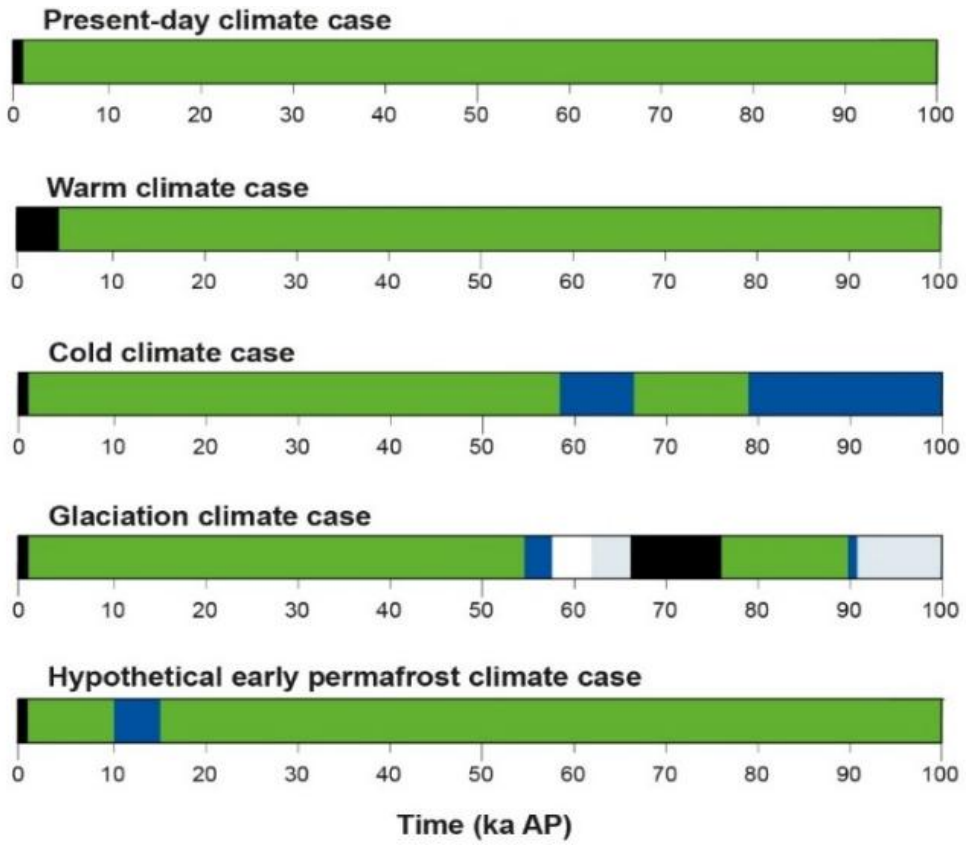
Report: SKB TR-23-01

Climate scenarios

Example: PSAR SFR
post-closure safety assessment supporting the construction licence application

Assessment period: 100,000 years

The surface above SFR is currently **below sea level** but is expected to rise above sea level as a result of post-glacial land uplift.



Green = temperate
Blue = periglacial (permafrost)
White/grey = glacial
Black = submerged conditions

Reference case (base case): assuming present-day climate and no sea-level rise

Business-as-usual global warming: warmer (and drier) climate, longer submerged period.

Strong climate-change mitigation, resulting in permafrost after 50 000 years.

Unlikely case featuring glaciation within the next 100 000 years.

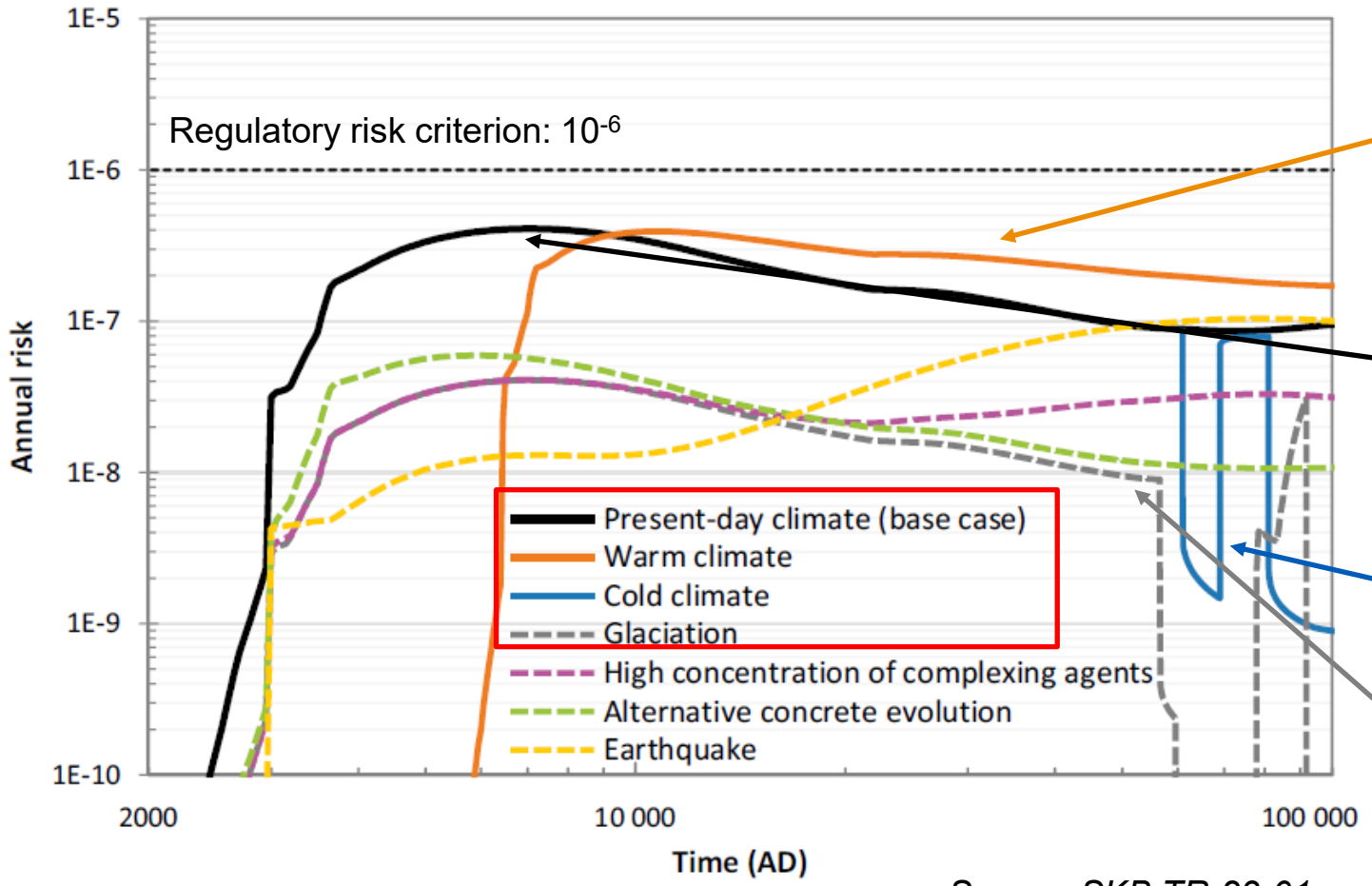
What-if case featuring hypothetical early permafrost (not included in risk assessment)

Source: SKB TR-23-05

Effect of climate on radiological risk

Example: PSAR SFR
post-closure safety assessment supporting the construction licence application

Annual radiological risk of harmful effects after closure for a representative individual in the most exposed group



Highest risk for most of the assessment period is associated with the warm climate

The **maximum risk** over the assessment period is obtained with the present-day climate

Permafrost is associated with a significantly lower risk

Glaciation is overall associated with a very low risk (due to lower probability)

Source: SKB TR-23-01

Summary

- Climate and climate-related processes can affect post-closure safety under both warm and cold climate conditions.
- These effects are evaluated in the post-closure safety assessment through a range of climate scenarios.
- Climate scenarios should be tailored to the long-term climate evolution, site characteristics, repository type, and repository concept.
- Warm climates are generally more important for radionuclide transport, whereas cold climates may have a greater impact on the performance and integrity of engineered barriers.