Reduction of scenario uncertainties through climate models (REDUKLIM)

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URS Retreat hosted by BGE

Outline

- Background of the project
- Work program
- First results: Impact of climate modeling and uncertainties on the evolution of a repository system
- Status of the work: Consequence analysis
- Summary and interaction with other URS projects

Background of the project

- Part of the URS project cluster by BGE
  - Topic 4: „Physics-based scenario modelling and impact models“
- Project background and goals:
  - Assumptions regarding the suitability as a location with the best possible safety according to site selection act (StandAG) are necessary.
  - Assumptions are based on geological and geophysical results and model calculations based on them.
  - Each of these components is fraught with uncertainties.

➢ Goals of the project:

- Reduction of complexity, e. g. by
  - assigning uncertainties to categories
  - developing recommendations for dealing with and characterizing uncertainties
  - quantifying uncertainties

➢ Improvement of the robustness of the repository system and thus of the safety

- For more info, visit URS website: https://urs.ifgt.tu-freiberg.de/en/about/what

BGE BUNDESGESELLSCHAFT FÜR ENDLAGERUNG

Aufruf zu Forschungsbeiträgen

Ungewissheiten und Robustheit mit Blick auf die Sicherheit eines Endlagers für hochradioaktive Abfälle

BGE-Forschungsauftragsnummer STAFuE-21-4-Klei

Stand 17.03.2021

Steckbrief für Forschungsvorhaben

BGE BUNDESGESELLSCHAFT FÜR ENDLAGERUNG

Ungewissheiten und Robustheit mit Blick auf die Sicherheit eines Endlagers für hochradioaktive Abfälle

Kurztitel/ ggf. Akronym:	URS
Projektziel:	Das Forschungsvorhaben zielt darauf ab, unterschiedliche Themen hinsichtlich Ungewissheiten anhand verschiedener Fragestellungen zu untersuchen, um hierdurch die Robustheit und damit die Sicherheit eines Endlagers für hochradioaktive Abfälle zu verbessern. Dies beinhaltet u. a. die Erweiterung des Kenntnisstandes von Ungewissheiten, aber auch die Entwicklung von Methoden zum Umgang mit Ungewissheiten.
Forschungsfeld:	Vorläufige Sicherheitsuntersuchungen
Projektpartner:	Siehe Tabelle 1
Fördervolumen (Netto):	6.023.271,00 €
Projektlaufzeit:	2022 bis 2025
Forschungsauftrags-nummer:	STAFuE-21-4-Klei
Weiterführende Informationen:	-

Projektbeschreibung

Im Zuge der vorläufigen Sicherheitsuntersuchungen (vSU) wird in § 11 Endlagersicherheitsuntersuchungsverordnung (EndlSiUntV) die „Bewertung von „Ungewissheiten“ geregelt. Gemäß § 11 Abs. 1 - 3 EndlSiUntV soll mit Ungewissheiten, die zum Zeitpunkt der Erstellung der jeweils durchzuführenden vSU bestehen, wie folgt verfahren werden:

- Ungewissheiten sollen systematisch ausgewiesen und charakterisiert werden (Abs. 1),
- Der Umgang mit Ungewissheiten und deren Auswirkungen auf die Aussagekraft auf die Ergebnisse der vSU und auf die Zuverlässigkeit sicherheitsgerichteter Aussagen soll dokumentiert werden (Abs. 2) und
- Es soll dargestellt werden, ob und in welchem Umfang bestehende Ungewissheiten durch weitere Erkundungs-, Forschungs- und Entwicklungsmaßnahmen reduziert werden können (Abs. 3).

Geschäftszeichen: SG01203/16/14-2022#9 – Objekt-ID: 923755 – Stand: 14.03.2022 Seite 1 von 4
www.bge.de

[BGE, 2022]

Background of the project

- Collaboration project of GRS and PIK

Gesellschaft für Anlagen- und Reaktorsicherheit (GRS) mbH

POTSDAM-INSTITUT FÜR KLIMAFOLGENFORSCHUNG

- 2 PhD theses (Christine Kaufhold - PIK / Marc Johnen - GRS)
- Thesis supervision (GRS): RWTH Aachen (Prof. Fischer-Appelt & Frank Charlier)

Chair of Repository Safety

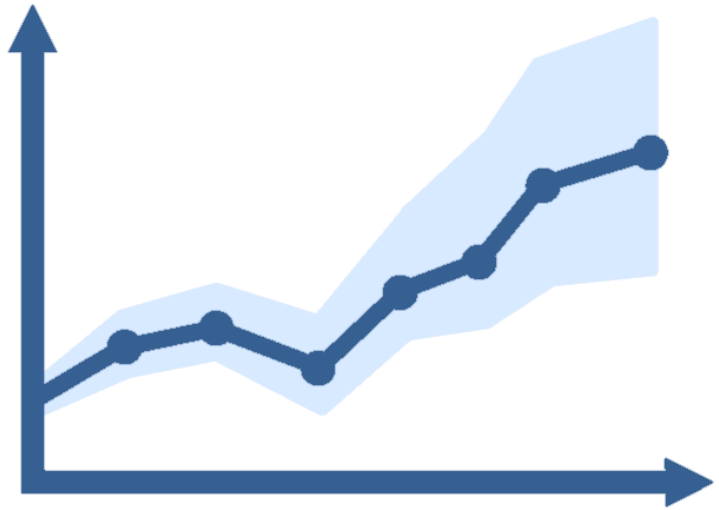
RWTH AACHEN UNIVERSITY

- Project duration (to be extended):
  - GRS: 15 November 2021 – 31 October 2024
  - PIK: 01 December 2021 – 15 October 2021

Background of the project: Research question and aims

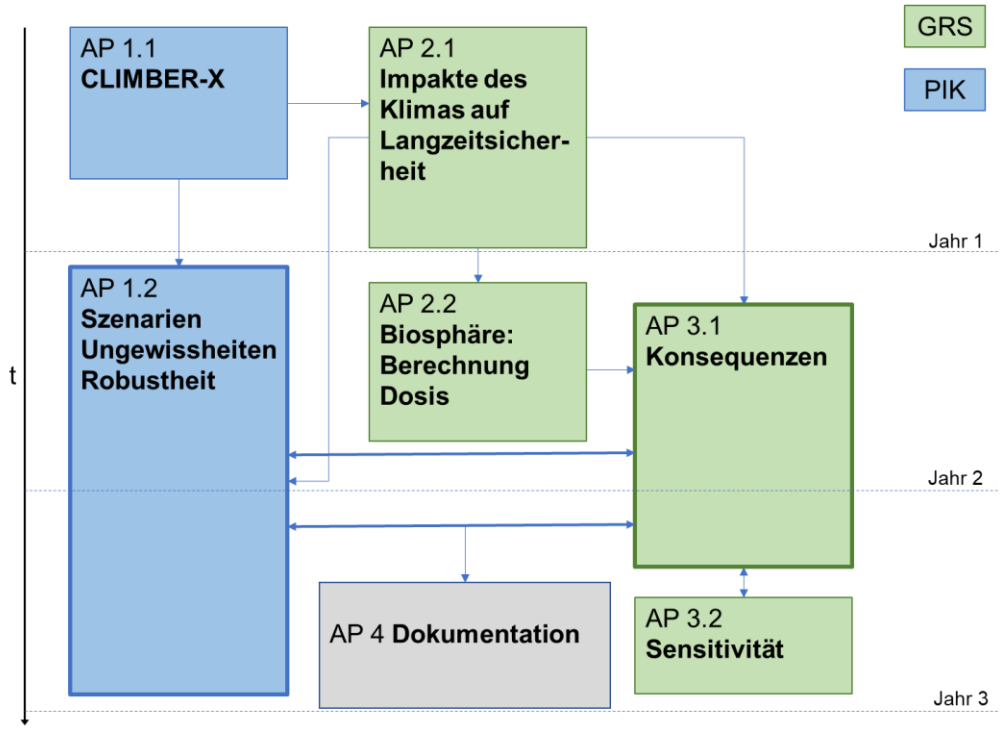
How can **future climate developments** be taken into account in the context of **long-term safety** and which **uncertainties** do these developments have?

- Assessment period of one million years (EndSiAnfV § 3)
- ➢ Consideration of the geological and climatic situation
  - Developing a better understanding of potential future climate developments
  - Linking of climate modelling to groundwater processes for the safety assessments
- Consideration of uncertainties in the context of the site selection



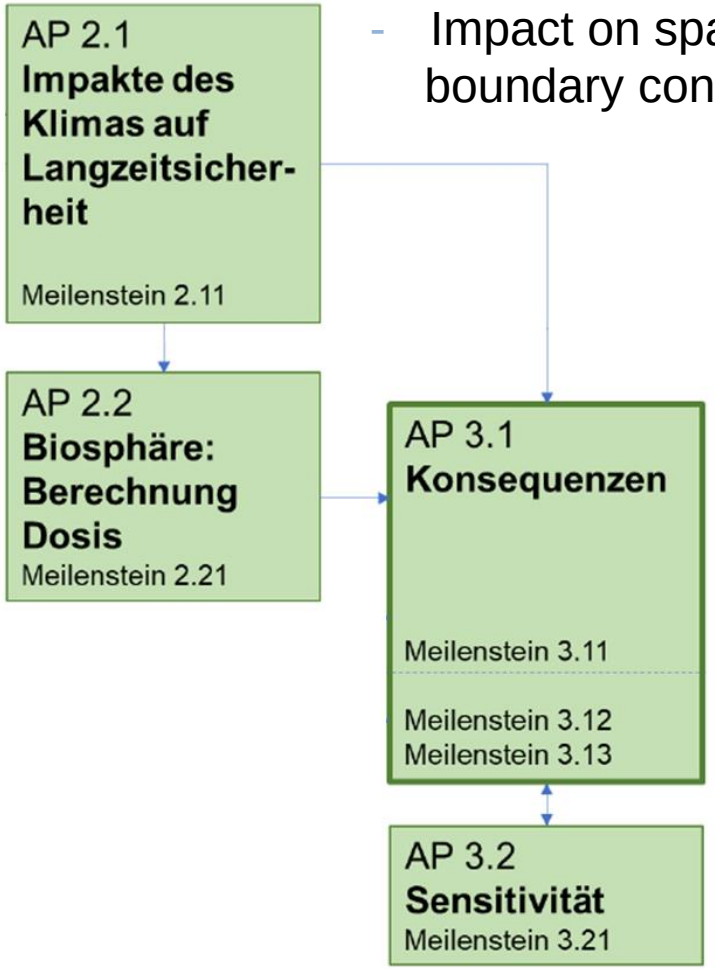
Work program

- Goals and steps of the work program
  - Beginning of the next glacial and it's dependency on cumulative anthropogenic CO_2 emissions
  - Identification of regions in Germany to be affected
  - How big are the uncertainties?
  - Change of glacial cycles within the next million years, e. g. longer cycles with more extensive ice advances?
  - Converting the results of climate modeling into stylized climate states for assessing the dose
  - Impact of the results of the climatic modeling on the uncertainties regarding the safe confinement of radio-nuclides in a repository for high-level radioactive waste?



Work program - GRS

Literature review:
- Influence of climate developments on long-term safety
- Impact on spatial distribution, time frame and boundary conditions for a European ice shield



Model development (dose):
- Describe stylized climate states
- Calculation of dose using parameters and climate states

Consequences
- Groundwater flow
- (THM behaviour)
- Release of contaminants
  - Radiologic consequences

Sensitivity
- Influence of parameter variations on results
- Model understanding

First results: Impact of climate and uncertainties on the evolution of a repository system

- Compilation of the important impacts from climate development for long-term safety
  - Step 1: Review of international literature on climate modeling

nwmo NUCLEAR WASTE MANAGEMENT ORGANIZATION

SKB

U.S.NRC United States Nuclear Regulatory Commission *Protecting People and the Environment*

Posiva

GRS

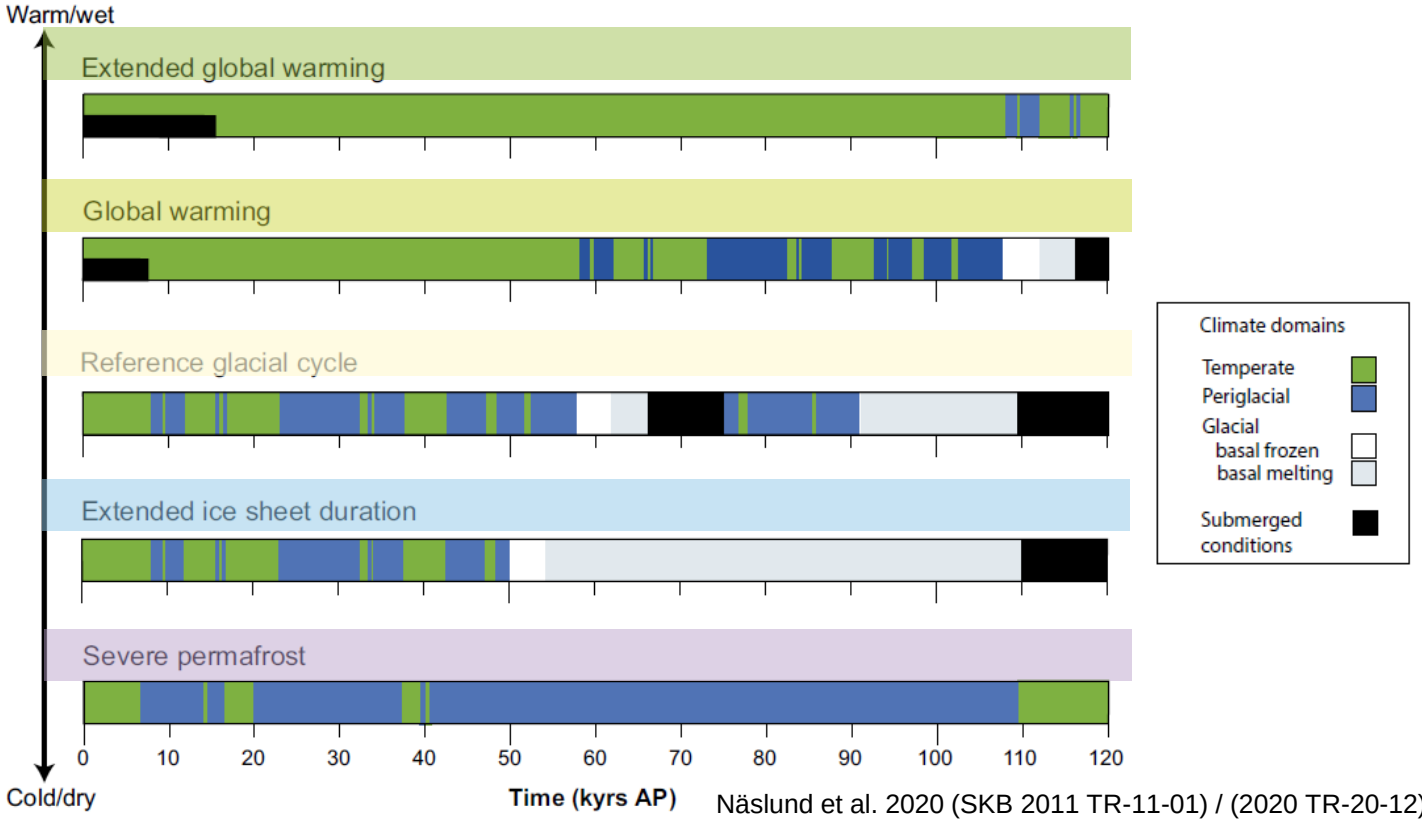
nagra.

BGE BUNDESGESELLSCHAFT FÜR ENDLAGERUNG

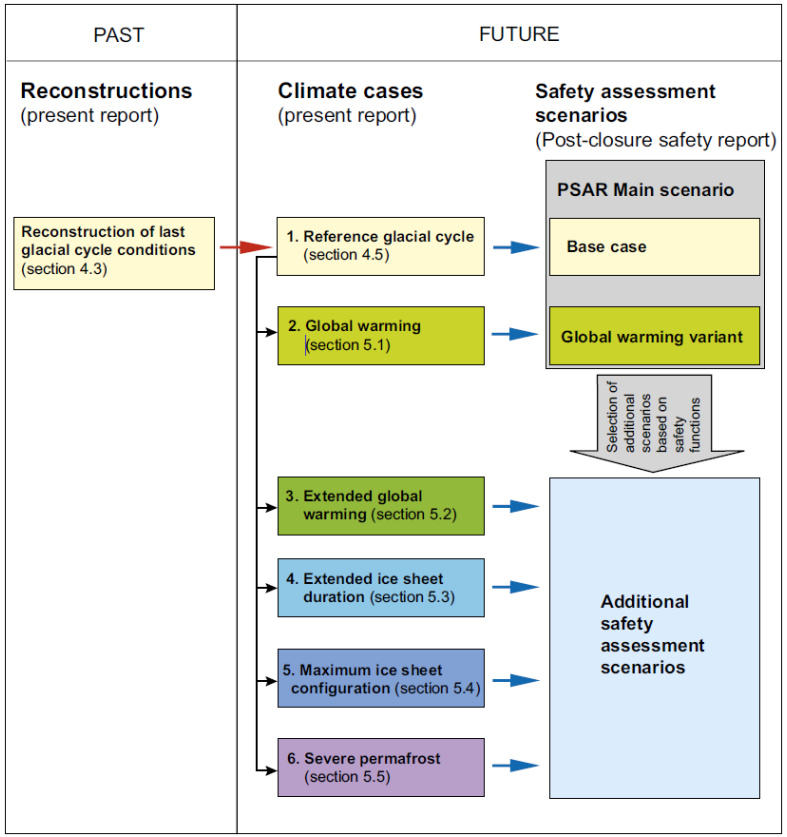
and many more…

First results: Impact of climate and uncertainties on the evolution of a repository system

- Compilation of the important impacts from climate development for long-term safety
  - Step 2: Evaluation of the role of various climate factors
    (e. g. changes in temperature and precipitation, rise/fall in sea level, spatial extent of ice sheets and ice caps)
    - Climate scenarios – SKB

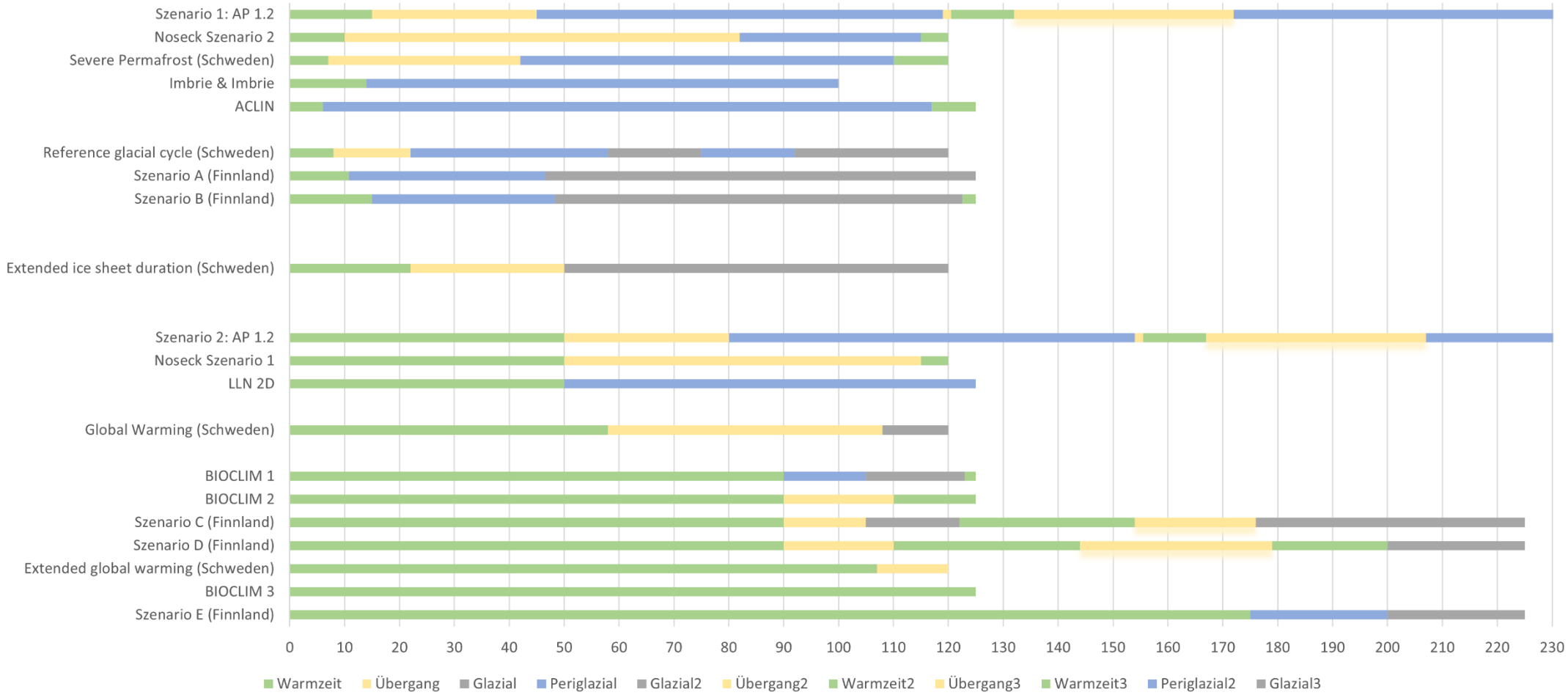


Näslund et al. 2020 (SKB 2011 TR-11-01) / (2020 TR-20-12)



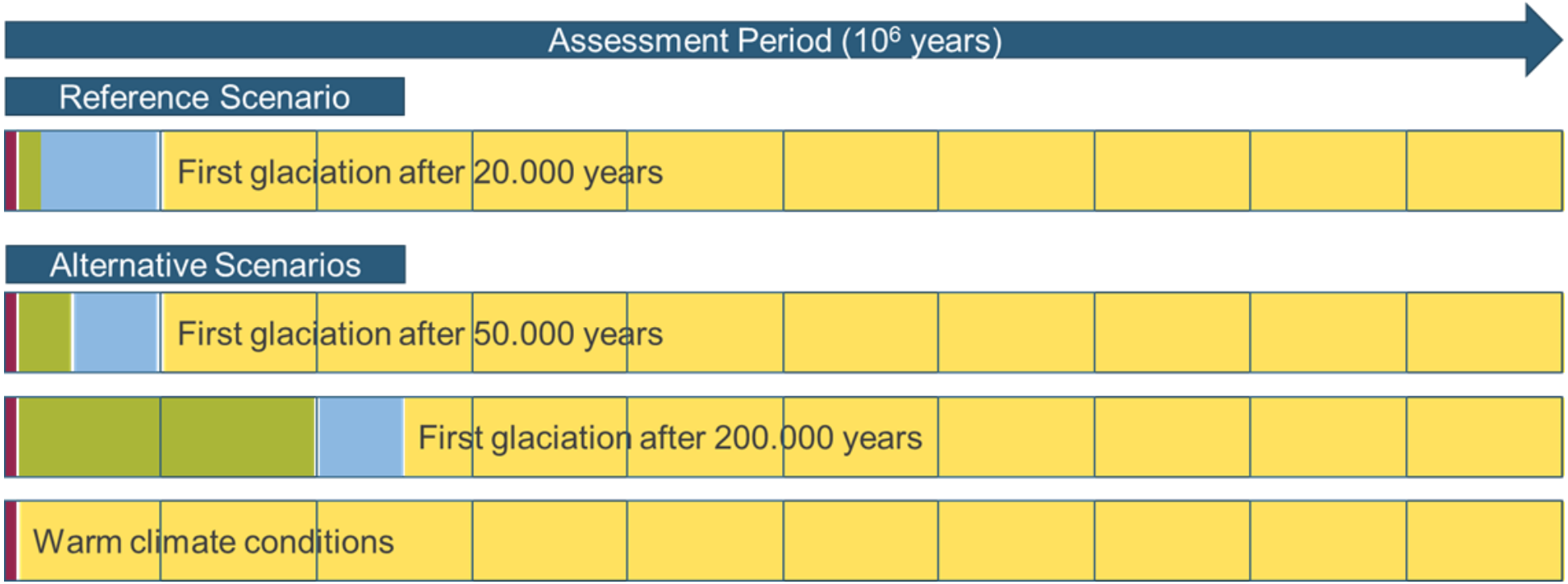
First results: Impact of climate and uncertainties on the evolution of a repository system

- Compilation of the important impacts from climate development for long-term safety
  - Comparison of the identified climate scenarios (this project) with previously published climate scenarios for Central and Northern Europe



First results: Impact of climate and uncertainties on the evolution of a repository system

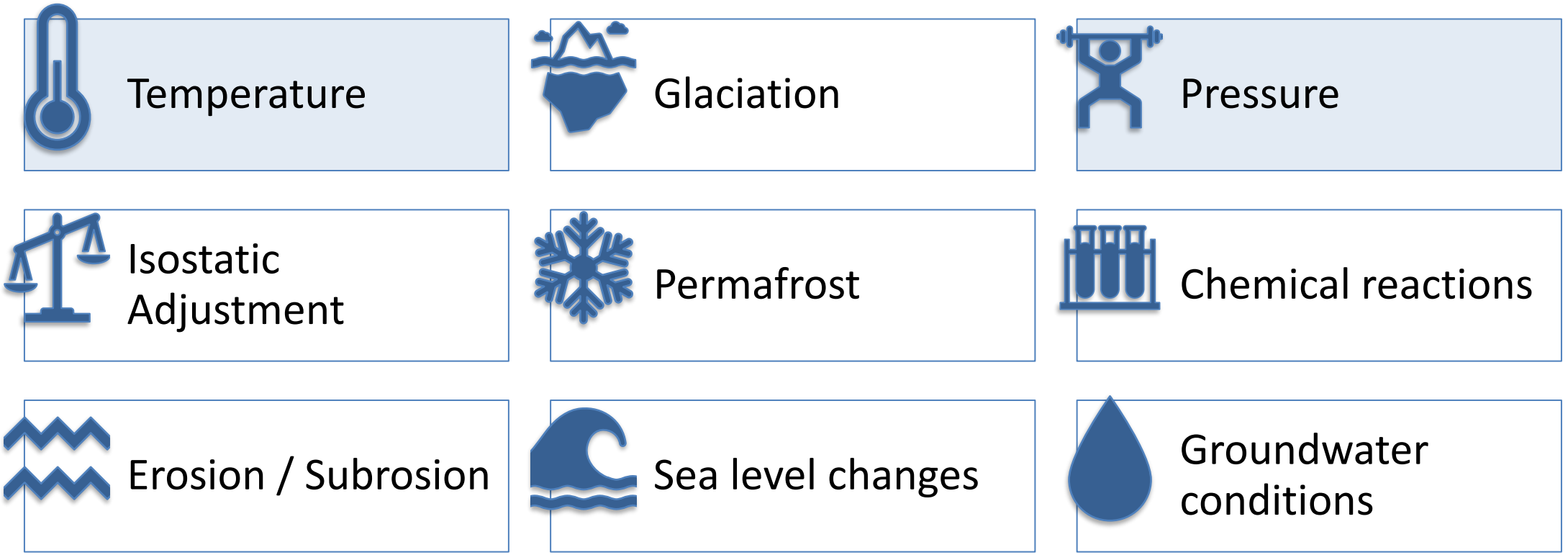
- Compilation of the important impacts from climate development for long-term safety
  - Outcomes of the Climate Workshop (hosted by BGE, 06 February 2023)



  - Glacial cycles: First glaciation will occur after 20.000, 50.000 and 200.000 years (duration: 100.000 years)
  - Boundary conditions will be set by the Elsterian and Saalian glaciations (parametrization to be defined)
  - Pliocene conditions for warm climate scenario

First results: Impact of climate and uncertainties on the evolution of a repository system

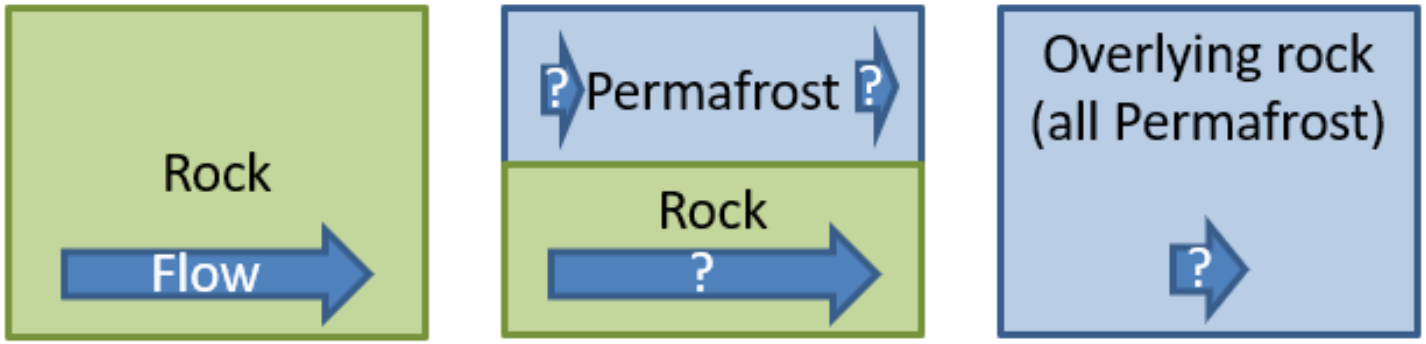
- Compilation of the important impacts from climate development for long-term safety
  - Step 2: Evaluation of the role of various climate factors
    (e. g. changes in temperature and precipitation, rise/fall in sea level, spatial extent of ice sheets and ice caps)
    - Temperature and pressure conditions influence all subordinate developments



Status of the work: Consequence analysis

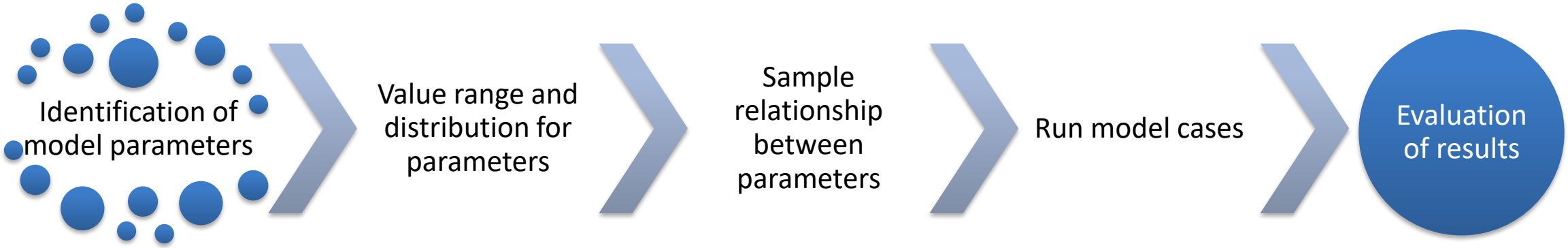
- Strategies for dealing with uncertainties regarding the long-term safety of a repository for high-level radioactive waste
  - Dealing with scenario uncertainties, analysis of consequences
    - Definition of model cases to assess scenario uncertainties and their consequences
    - Stylized states/ processes/ scenarios

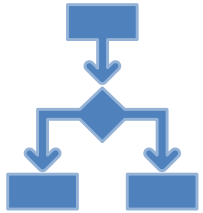
  - Most important impacts for hydrogeological system
    - Permafrost
    - Glaciation
    - Sea Level changes
    - Isostatic adjustment
    - Erosion/ Subrosion

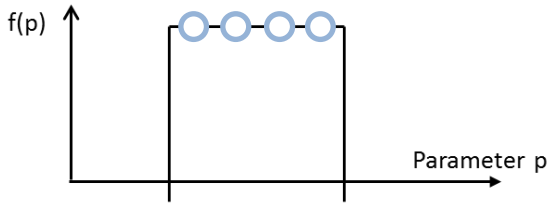


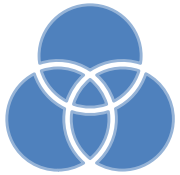
Status of the work: Consequence analysis

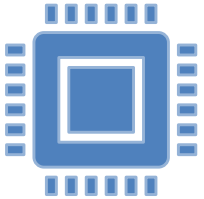
- Strategies for dealing with uncertainties regarding the long-term safety of a repository for high-level radioactive waste
  - Dealing with scenario uncertainties, analysis of consequences
  - Sensitivity study to quantify uncertainties
  - Run many model cases to obtain a statistical significance





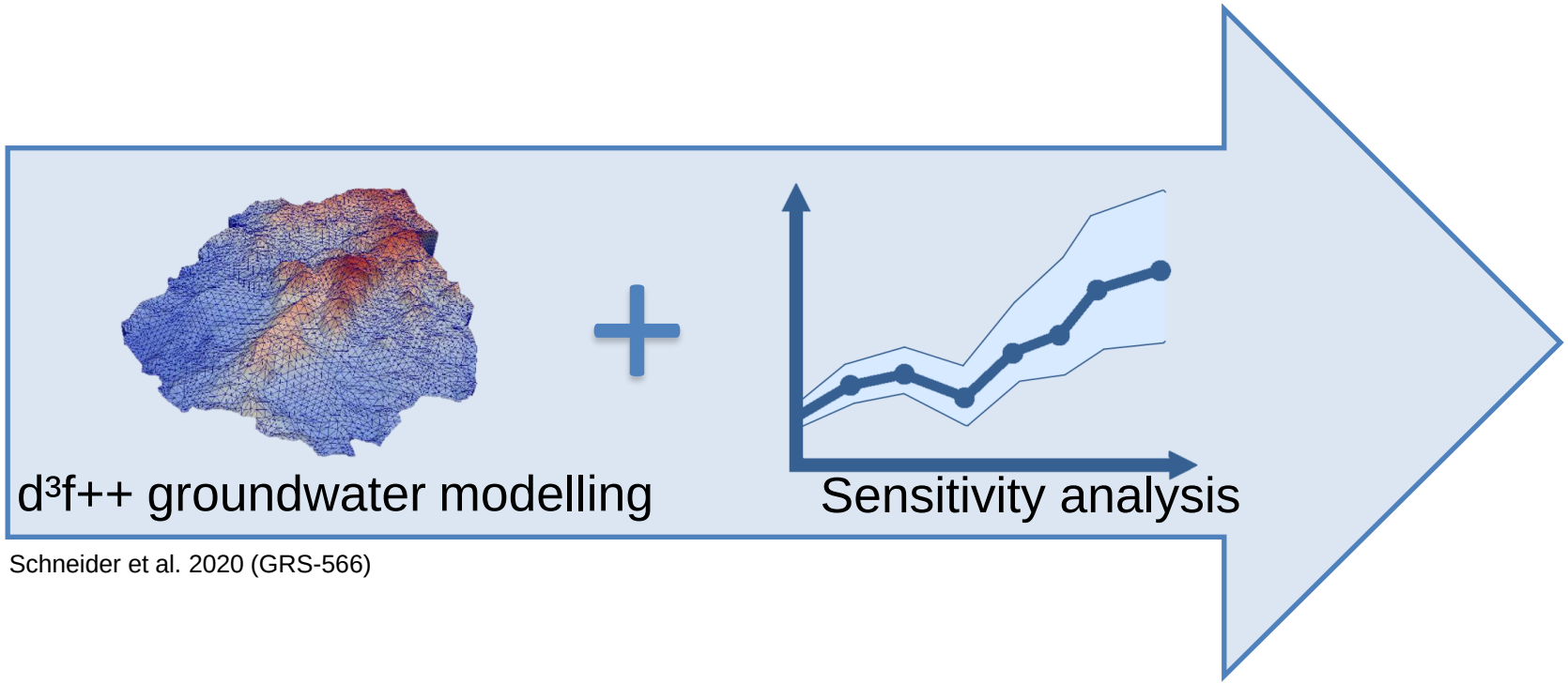






Status of the work: Consequence analysis

- Strategies for dealing with uncertainties regarding the long-term safety of a repository for high-level radioactive waste
  - Dealing with scenario uncertainties, analysis of consequences
  - Sensitivity analysis to quantify uncertainties
  - Run many model cases to obtain a statistical significance
  - Tools and methods to be used in REDUKLIM to assess uncertainties in future climate scenarios



Schneider et al. 2020 (GRS-566)

Identify those climate factors, that have strongest influence on hydrogeological system

First results: Consequence analysis

- Strategies for dealing with uncertainties regarding the long-term safety of a repository for high-level radioactive waste
  - Dealing with scenario uncertainties, analysis of consequences
    - Definition of model cases to assess scenario uncertainties and their consequences
    - Stylized states/ processes/ scenarios

➢ Definition of model cases:

- Impact on groundwater flow direction and velocity
- (Impact on thermo-hydraulic-mechanical behavior of the repository system)
- Release of pollutants from the repository, their transport with the groundwater in the geosphere into the near-surface groundwater and finally to the biosphere as well as the associated radiological consequences
- Uncertainty and sensitivity studies

➢ Definition of model cases, assumptions and input parameters is the subject of current work.

Summary and interaction with other URS projects

- Climate models (PIK):
  - Future simulations will be performed for a wide range of possible anthropogenic scenarios
  - Climate models will provide information about climate change and ice sheets evolution for the next 1 Ma

- Compilation of the important impacts from climate development for long-term safety (completed)
- Climate impact models (GRS, current work):
  - Assumptions are based on results from climate models.
  - Input parameters will be chosen based on the specific task to be addressed.
  - Climatic changes are implemented as changes in boundary conditions (to be defined).
  - Systematic evaluation of the influence of parameter uncertainties on the uncertainty of the model results

- **Interaction with other URS projects to be discussed during this event**

Thank you for your attention!

We are looking forward to discuss with you!

This work is funded by Bundesgesellschaft für Endlagerung mbH (BGE) under the contract number 45206427.