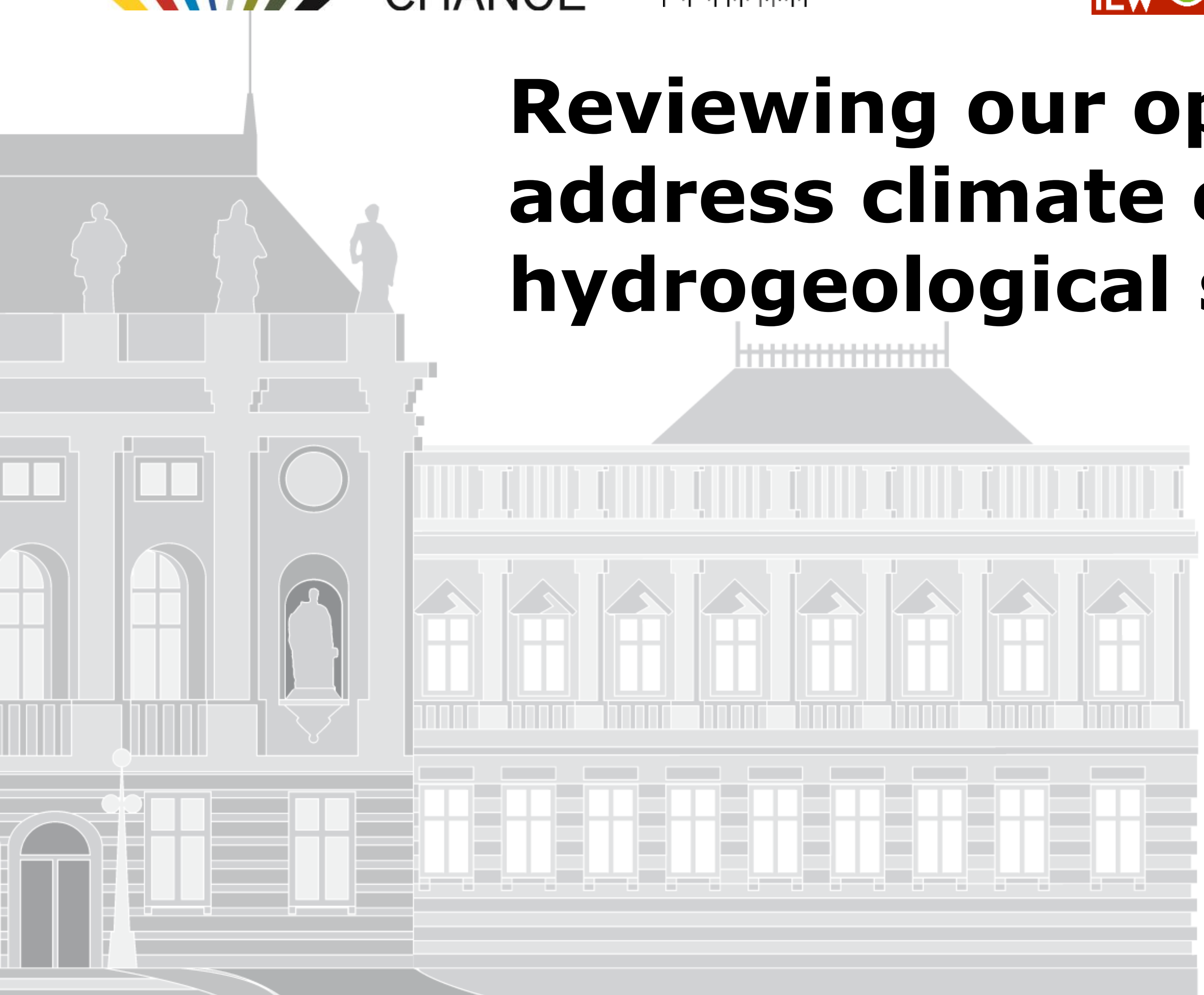
DOCTORAL PROGRAMME CLIMATE CHANGE

NAWI Graz GEOCENTER

KARL-FRANZENS-UNIVERSITÄT GRAZ
UNIVERSITY OF GRAZ
FWF-DK Climate Change

Reviewing our options: How can we address climate change impacts in hydrogeological studies?



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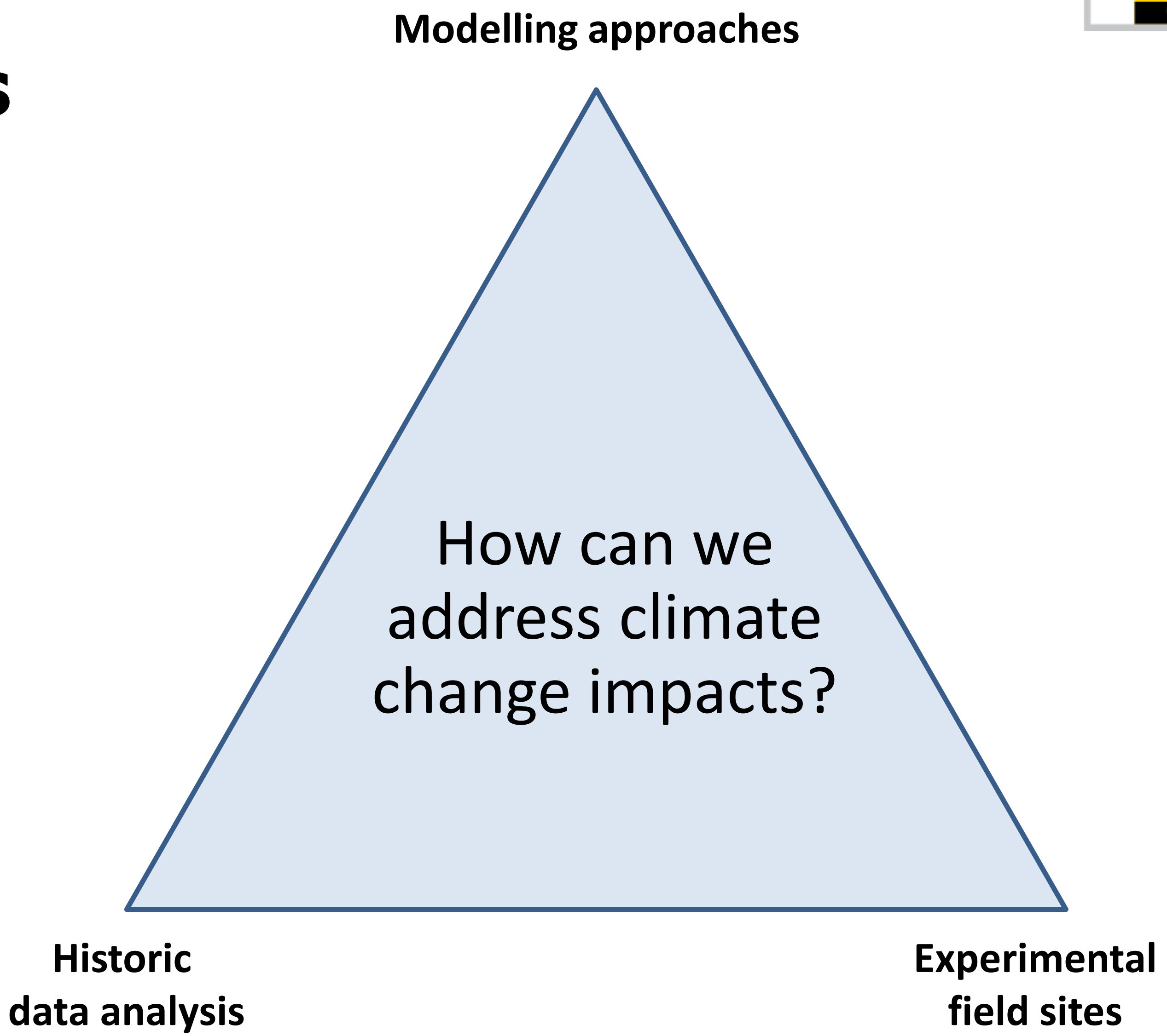
Reviewing our options

Presentation Content:

- Slide 3-7: Examples introducing subcategories of these approaches
- Slide 8: Contributions from this session classified into this scheme
- Slide 9: Approaches for different objectives
- Slide 10: Tentative conclusions

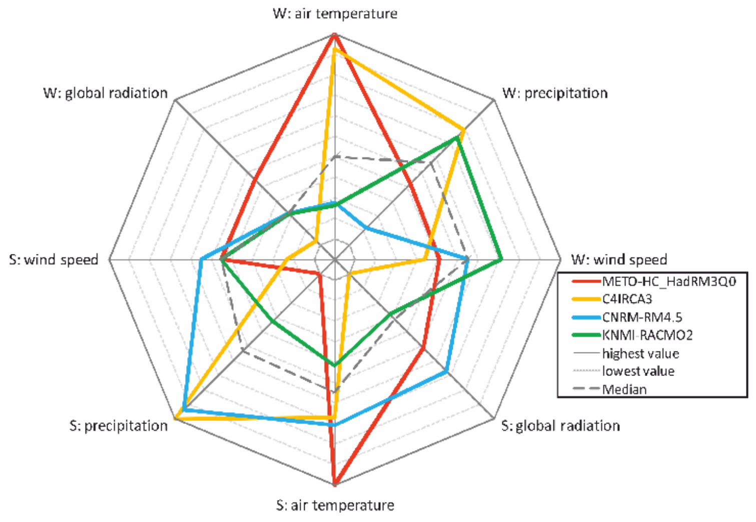


Scenario-led modelling

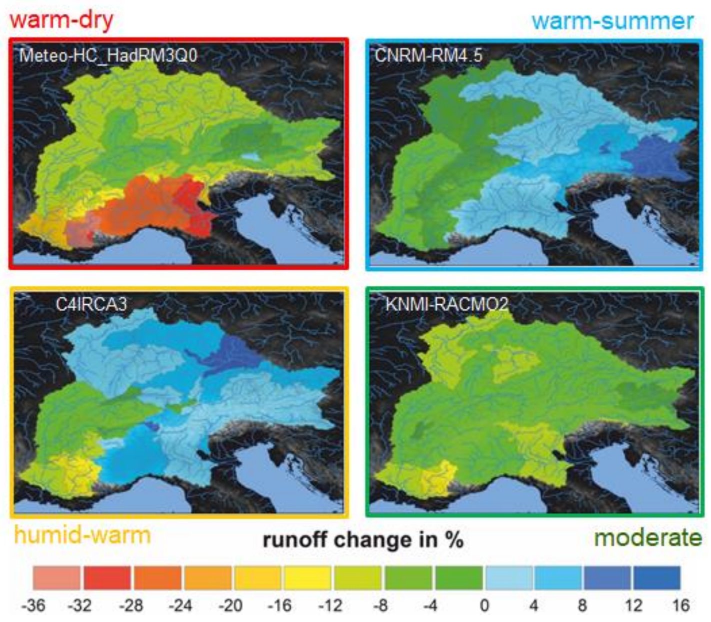
- Multi-model climate ensembles
- Model-chain
  - Emission scenarios
  - Global and regional climate models
  - Hydrological Impact models

- Pros:
  - Internally consistent scenarios
  - Range of scenarios accounts for uncertainty
- Cons:
  - Demanding with regard to climate information
  - Uncertainty increases step by step such that the result may be of little practical use

Example of various regional climate model scenarios …



… leading to uncertainty in projected runoff change from 1961-1990 to 2031-2050

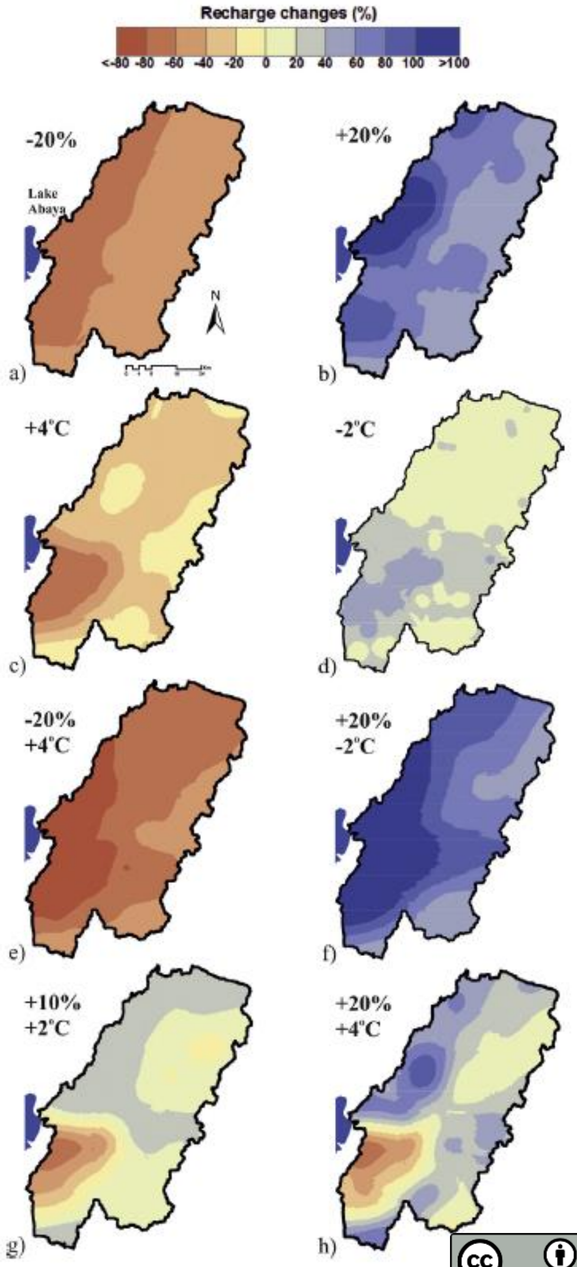


Wagner, T., Themeßl, M., Schüppel, A., Gobiet, A., Stigler, H., Birk, S. (2017): Impacts of climate change on stream flow and hydro power generation in the Alpine region. Environmental Earth Sciences 76 (1), 4: 1-22. doi:10.1007/s12665-016-6318-6

Vulnerability-based modelling

- Identification of factors relevant for coping with climate change
  - Sensitivity analysis
  - “Storylines” representing uncertainty in an event-based rather than probabilistic way (Shephard et al., Climatic Change, 2018)
- Pros:
  - Decision-led approach that might better serve the needs of stakeholders (Wilby and Dessai, Weather, 2010)
  - Less demanding as regards the need for climate scenarios and computational efforts
- Cons:
  - Potentially oversimplified, physically inconsistent assumptions

Example of an analysis of the sensitivity of groundwater recharge distribution to changes in temperature and precipitation



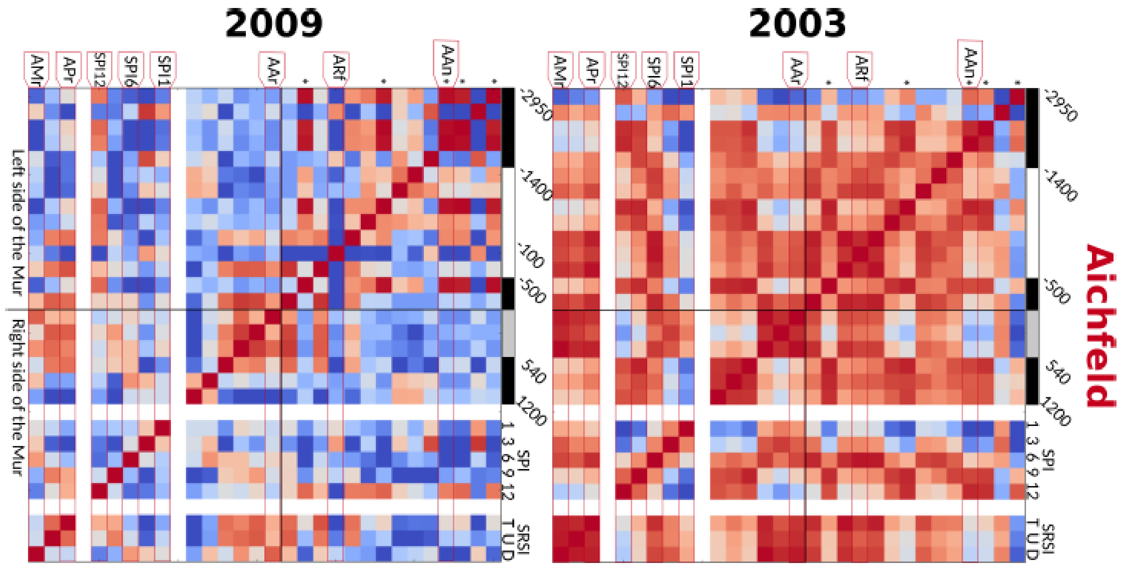
Mechal, A., Wagner, T., Birk, S. (2015): Recharge variability and sensitivity to climate: The example of Gidabo River Basin, Main Ethiopian Rift. Journal of Hydrology: Regional Studies 4: 644-660. doi:10.1016/j.ejrh.2015.09.001

Historic data analysis

- Makes use of existing (time series) data
- Aimed at identifying controlling factors, assessing sensitivities, etc.

- Pros:
  - If data is available, less demanding than scenario-based modelling, experimental approaches, etc.
  - Might fit well to a decision-led approach
- Cons:
  - Correlation does not equal causation
  - Findings might be invalid if changes go beyond those observed in the past

Example of an analysis of the correlations between standardized groundwater levels (SGI), precipitation (SPI), and river stages (SRSI) in a dry (2003) and wet (2009) year (Haas & Birk, 2017)



Haas, J. C., Birk, S. (2017): Characterizing the spatiotemporal variability of groundwater levels of alluvial aquifers in different settings using drought indices. Hydrol. Earth Syst. Sci. 21: 2421-2448. doi: 10.5194/hess-21-2421-2017

Controlled experiments

- Controlled change of climate variables
- Measurement of effects on water fluxes and state variables

For example: Heating of grassland and observation of soil moisture and soil water budget using lysimeters

- Pros:
  - Direct observation of effect resulting from change in climate variables
  - Non-additive effects of variables can be detected
- Cons:
  - Challenges regarding representativeness of the observation and regionalization of results
  - Questionable whether applicable to questions other than recharge

ClimGrass site operated by HBLFA Raumberg-Gumpenstein

- 54 plots with various treatments:
  - Heating and free air carbon enrichment (T-FACE)
  - Drought experiments (rain shield)
- 6 plots equipped with lysimeters

See for example, Vremec et al., EGU2020-15486, https://doi.org/10.5194/egusphere-egu2020-15486

Trading-space-for-time

- **Within experimental approaches:**

  Example TERENO-SOILCan: Lysimeters transferred to other locations using temperature and rainfall gradients to mimic future climatic conditions (Pütz et al., Environmental Earth Sciences, 2016)

- **Within historic data analysis:**

  Example of a study on the lake and wetland distribution across the Prairie Pothole Region "suggests that detailed modern spatial data can be used to interpret hydrologic system behaviors under past or future climate conditions" (Liu and Schwartz, Water Resources Research, 2012)

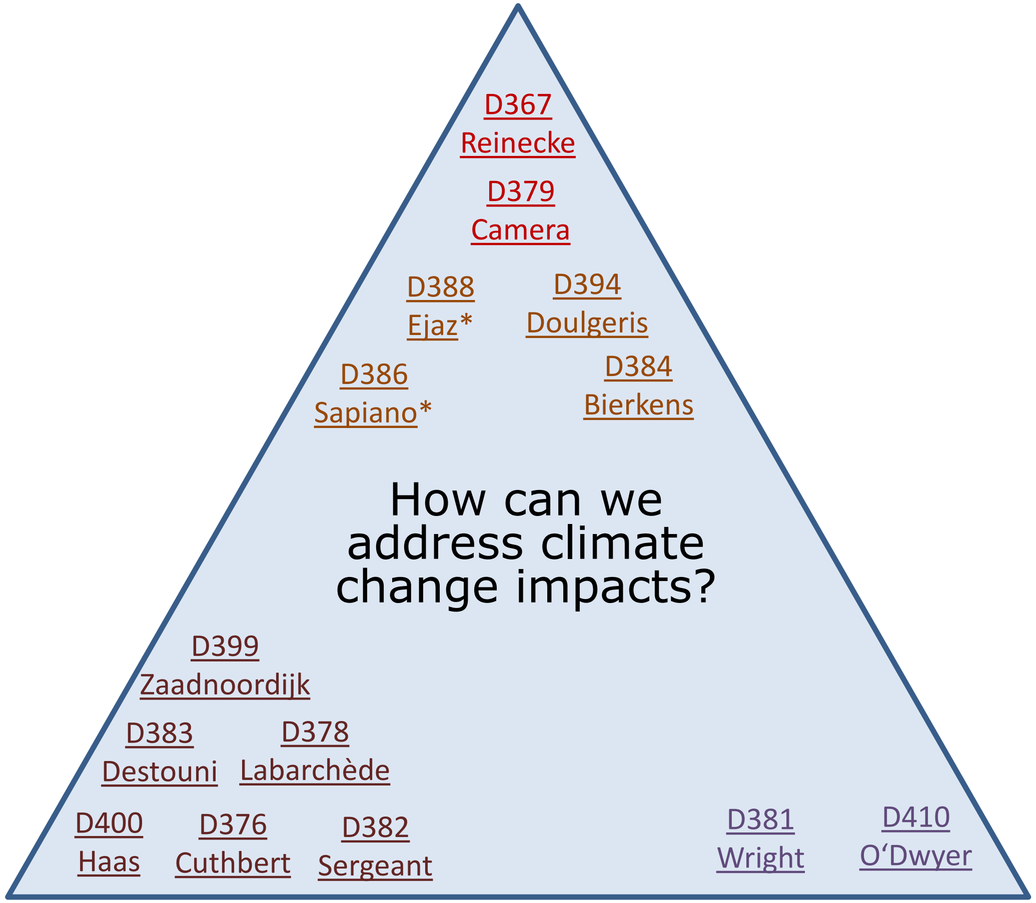
Can these approaches be applied for assessing climate change impacts on groundwater?

Examples from Session HS8.2.1

Modelling approaches

- Scenario-led (top down)
- Vulnerability-based (bottom up)

*Model development/proof-of-concept, potentially can be applied both top down and bottom up



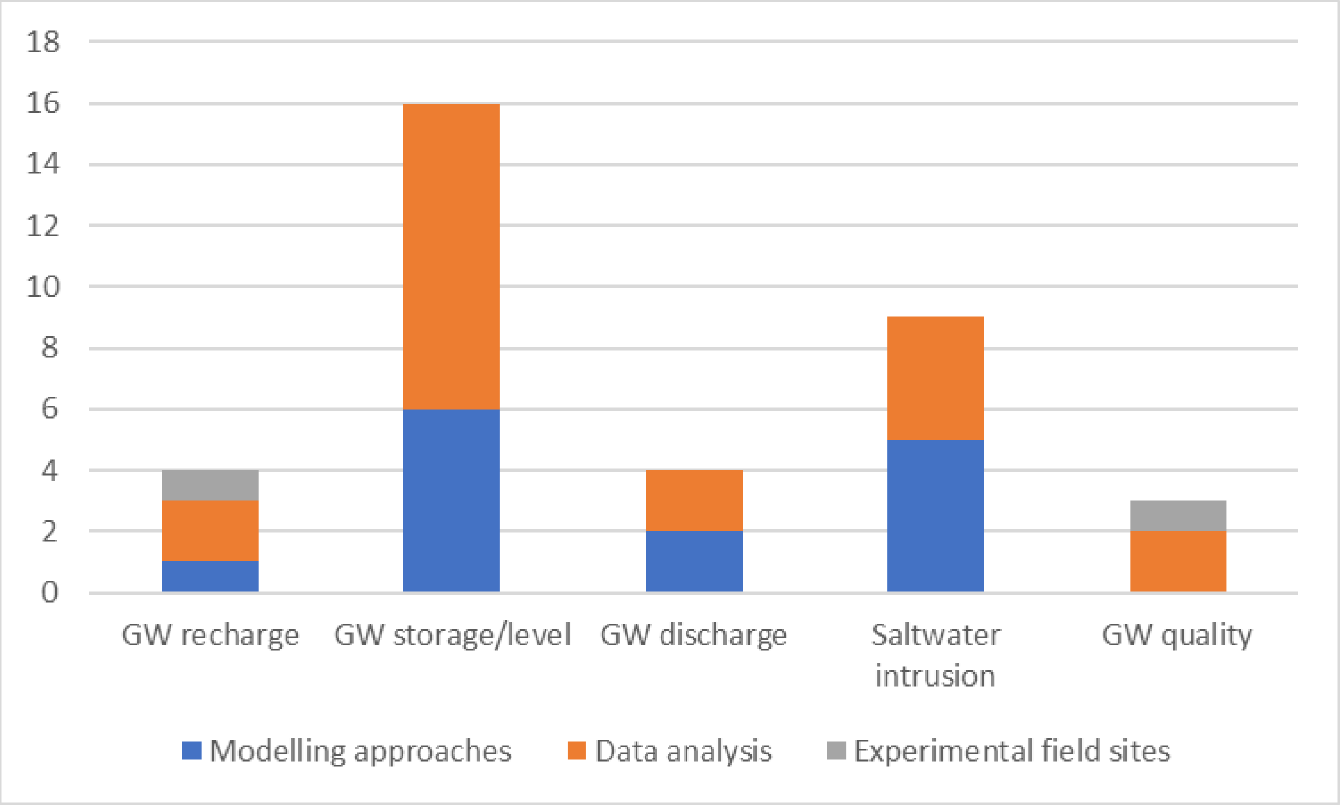
Historic data analysis

- (Historic) time series
- Trading-space-for-time

Experimental field sites

- Controlled experiments
- High-resolution monitoring
- Trading-space-for-time

HS8.2.1: Approaches for different objectives



Tentative conclusions

Studies addressing climate change impacts on groundwater …

… are predominantly based on modelling approaches and (historic) data analysis and only rarely on experimental field studies;

… are mainly aimed at groundwater quantity, particularly changes in storage;

… address only rarely on groundwater quality, except for saltwater intrusion;

… address groundwater recharge when dealing with groundwater storage but rarely as the ultimate objective.