Assessing the impacts of climate change on groundwater and dependent ecosystems:
Experiences from cold regions (Finland)

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GENESIS
groundwater and dependent ecosystems

- 7 FP project
- 25 partners
- 2009-2013

- About 100 researchers active

MAIN TOPICS

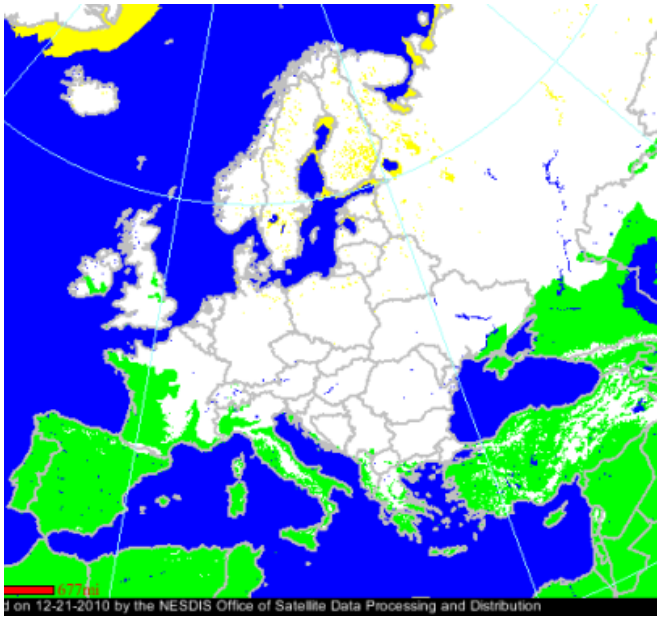
- Flow characterization
- Pollution leaching
- Ecosystems
- Modelling
- Management and social and eoonomic issues

Final conference In Prague March 2014

www.thegenesisproject.eu

Content of presentation

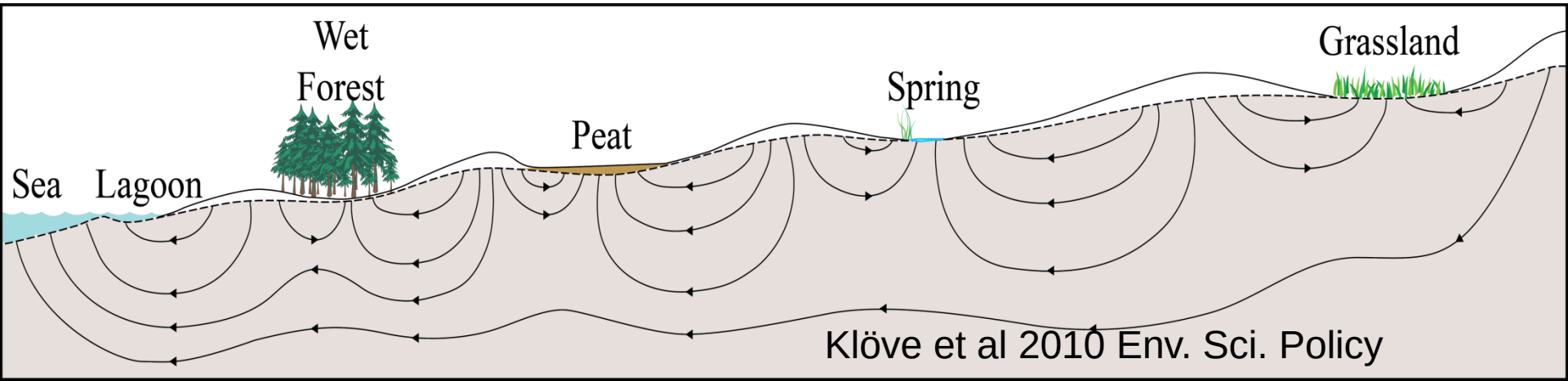
- Groundwater and dependent ecosystems
- Cold climate hydrology: critical processes
- Impacts of climate change on groundwater and dependent ecosystems



Figures on winter snow cover in Europe

GDE - GROUNDWATER DEPENDENT ECOSYSTEMS?

- Surface water systems such as springs, lakes, river and coastal lagoons
- Terrestrial systems such as peatlands, forests etc.



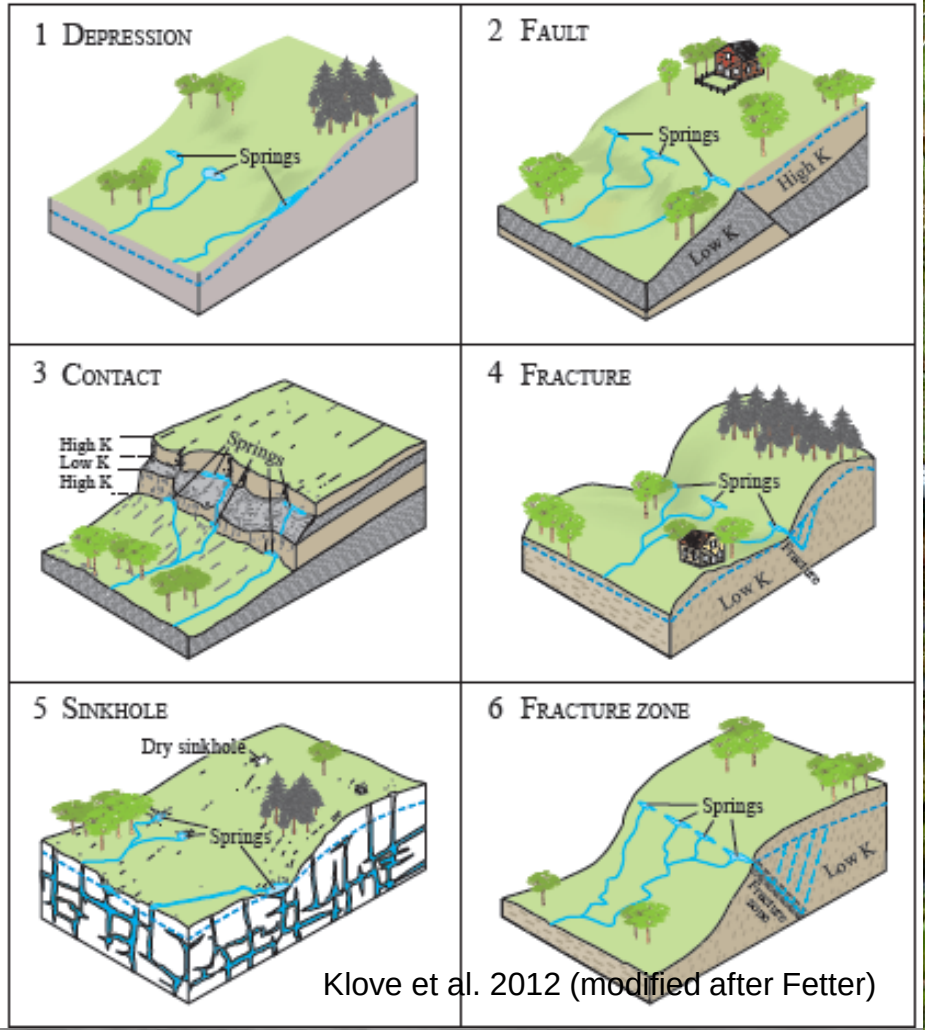
Why are GDEs important?

- Unique ecosystems with many functions
- Biodiversity rich
  - e.g. several Natura 2000 sites are GDEs
- Recreation and other socio-economic functions such as tourisim and recreation
- Groundwater levels vulnerable to land use changes and water extraction
  - qualitative and quantitative pressures on GDEs
- European water legilsation require consideration of GDEs (Groundwater directive and WFD)


Plitvice
Photo: Photo Nico Goldscheider

Rokua Geopark, Finland

Springs

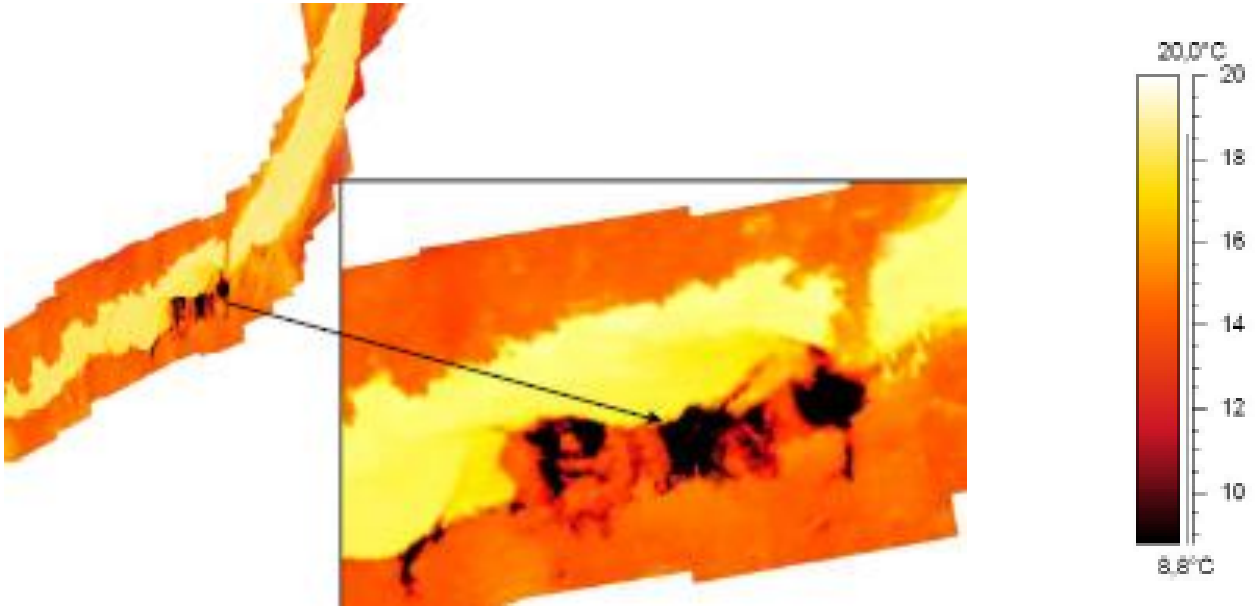


Klove et al. 2012 (modified after Fetter)

Oulanka nature reserve, Finland
Study site in AKVA programme Academy of Finland

Spring in a stream

Rivers: Gaining stream and GW input



Illustrations from Jukka Ikäheimö, Pöyry consulting company Ltd.

Cold climate hydrology

- Snow, ice, frost accumulation and melt are dominant processes in hydrology and influence:
  - Annual peak and low flow
  - Frost depths
  - Floods and to some extent droughts
  - Infiltration and recharge
  - Erosion and pollution related processes
- Climate change expected to influence cold periods of the year remarkably

Ice jam 2014 near Oulu caused by rapid mel

Load variation during snow melt (Øygarden, 2000)

January 30

Runoff: 25 mm

Soil loss: 2 kg ha^{-1}

January 31

Runoff: 77 mm

Soil loss: 3 050 kg ha^{-1}

Snow infiltration

- Soil frost can reduce infiltration (if soil freezes in wet conditions in the autumn)
- Soil frost reduce K and promote overland flow
  - Reduces recharge
  - Results in focused infiltration

FOCUSED INFILTRATION GRUE (GENESIS REPORT D2.2 - PHOTO KVAERNER)

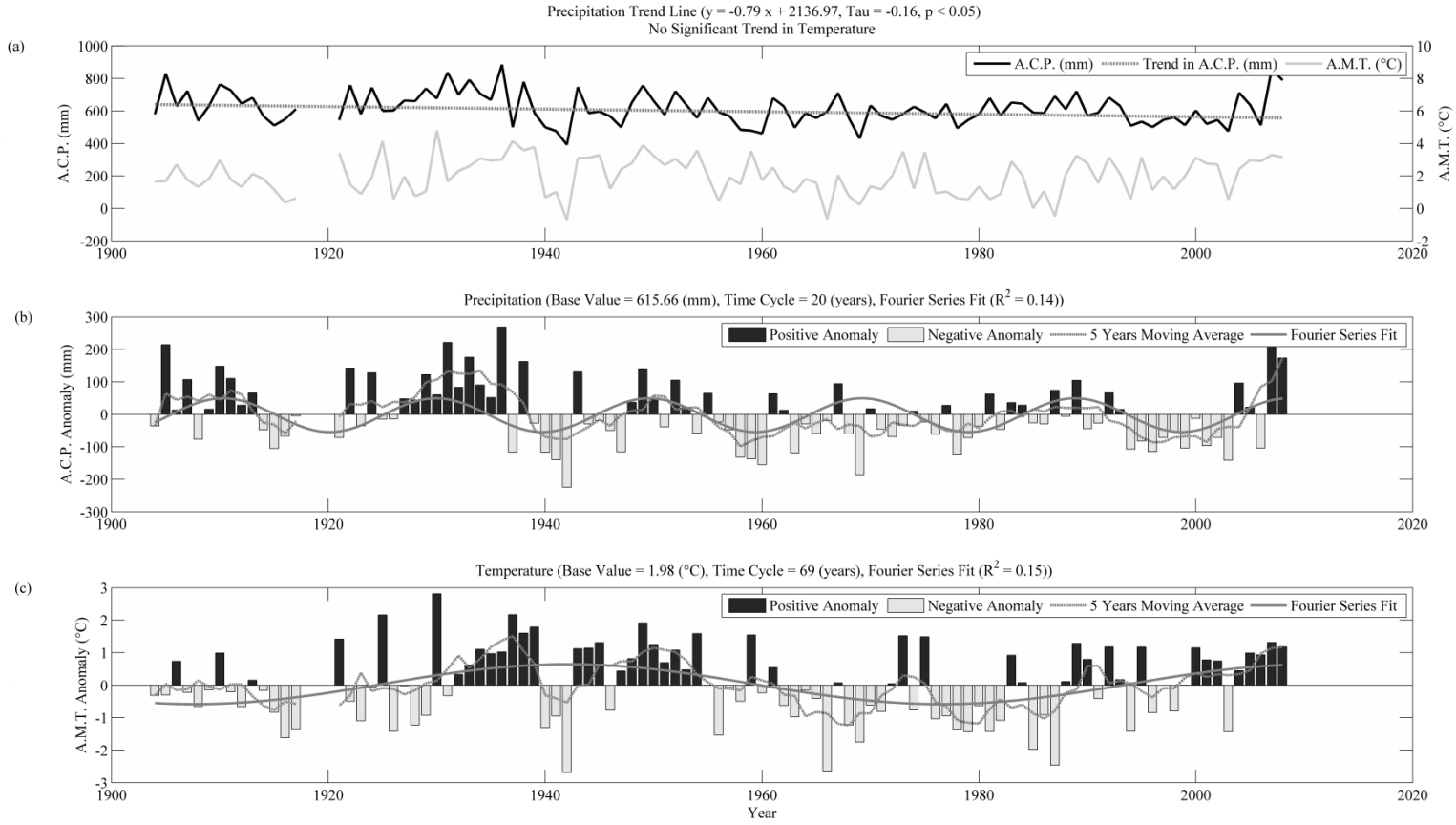

melt Finland

Climate change

- Climate change may be perceived as alterations in the local or global climate on different time scales.
- Human activities can also cause climate change locally by changing land use, water use and vegetation, with consequent impacts on hydrology
- Several natural phenomena related to atmospheric and (or) oceanic circulation can affect the climate locally or globally, causing changes and (or) variability. Many of these phenomena are related to the circulation of the oceans and (or) of the atmosphere.
- The increase in greenhouse gas emissions since the industrial revolution has affected the climate of the Earth. A small but constant increase in mean atmospheric temperature has been observed.

REF Klove et al 2013 JHydrol (accepted)

EXAMPLE OF CLIMATE CHANGE SIGNAL KAJAANI, FINLAND



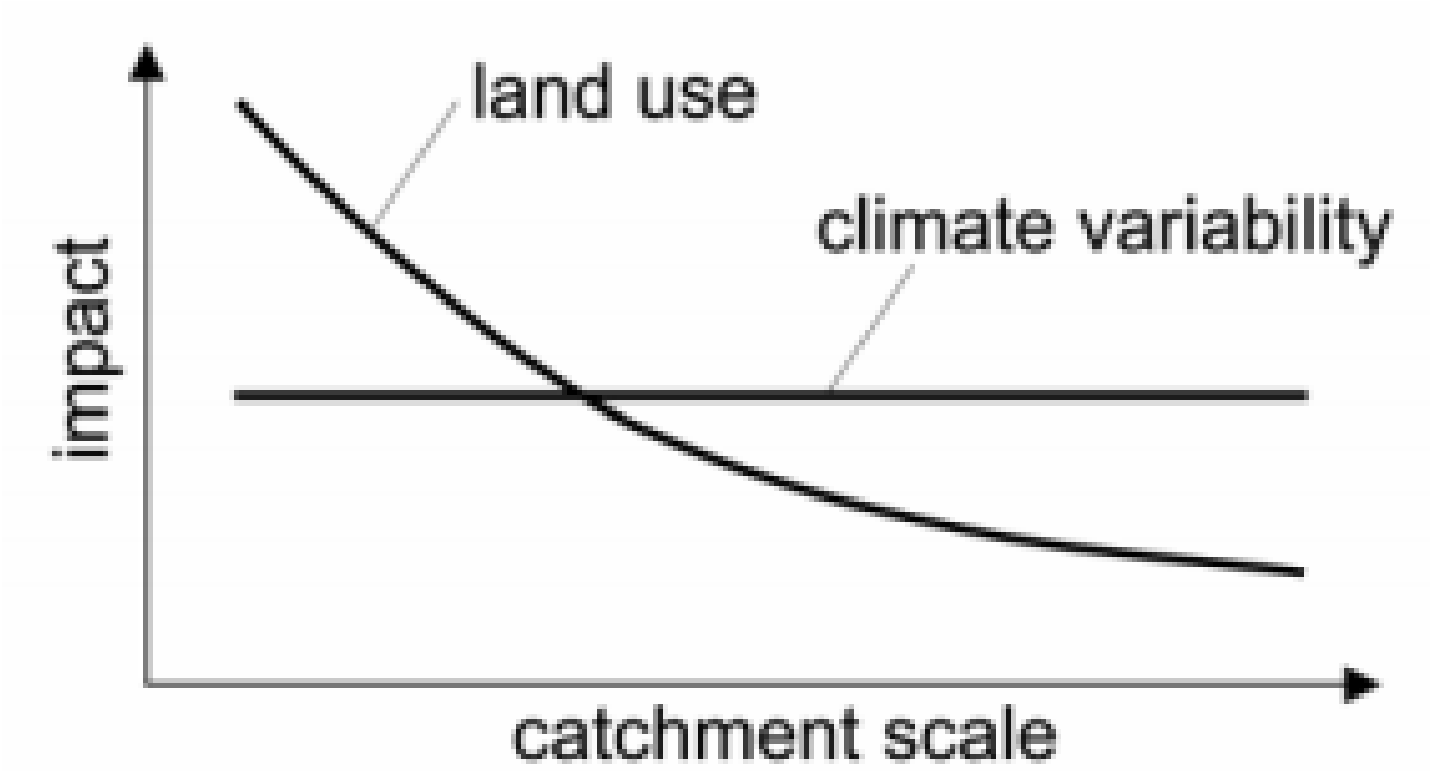
Irannezhad, Ronkanen and Klöve 2013 (submitted)

OBSERVATIONS IN FINLAND

1) Temperature analysis indicated an increasing trend for warming only at an urban study site in southern Finland. This warming may be partly caused by the heat island effect, which must be better studied.
2) Precipitation data showed a decreasing trend during the 20th century only in central Finland. A strong correlation between precipitation and temperature was found at all stations.
3) Analyses of periodic patterns in precipitation and temperature variations indicated that a warm climate period was dominated by more wet years, while a cold climate period was associated with more dry years in northern, central and southern Finland.
4) Trends and periodicities of climate variability in the study areas were strongly associated with climate teleconnection indices (e.g. NAO, SCAND), both of which also influenced SWE.
5) SWE decreased over the 105-year study period and was affected by precipitation variability more than variations in temperature. A high SWE period (1903-1957) was associated with wetter climatic mode, and a low SWE period (1958-2008) with drier than normal climatic mode.

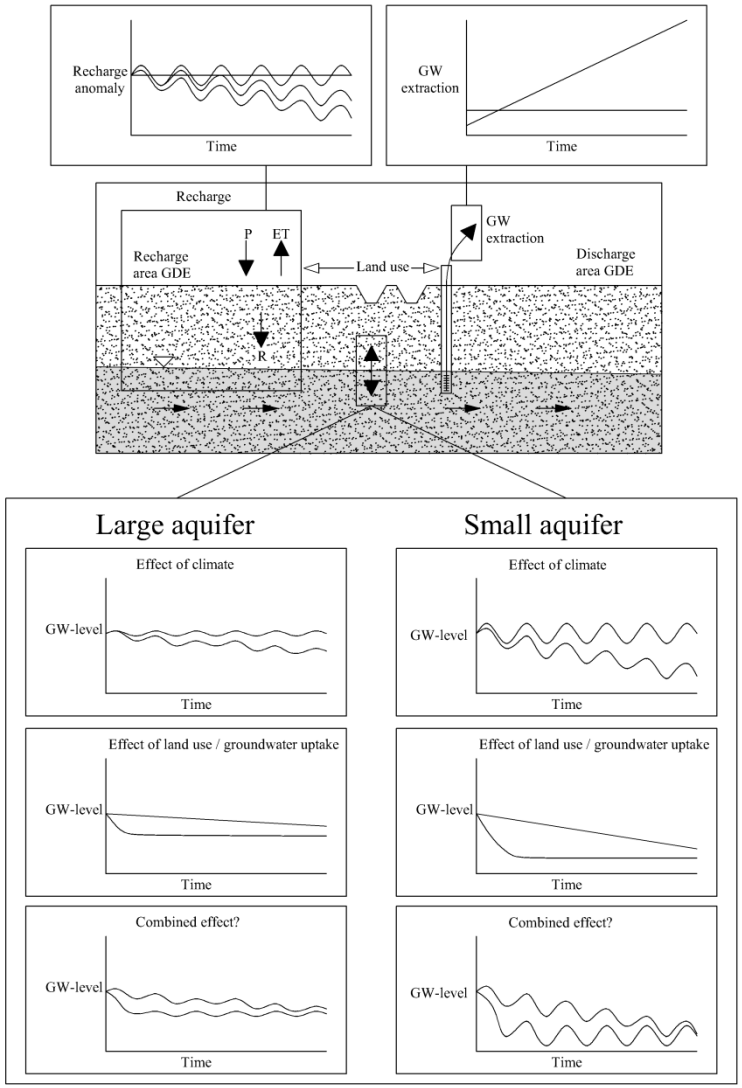
Irannezhad, Ronkanen and Klöve 2013 (submitted)

CLIMATE CHANGE VS LAND USE CHANGE



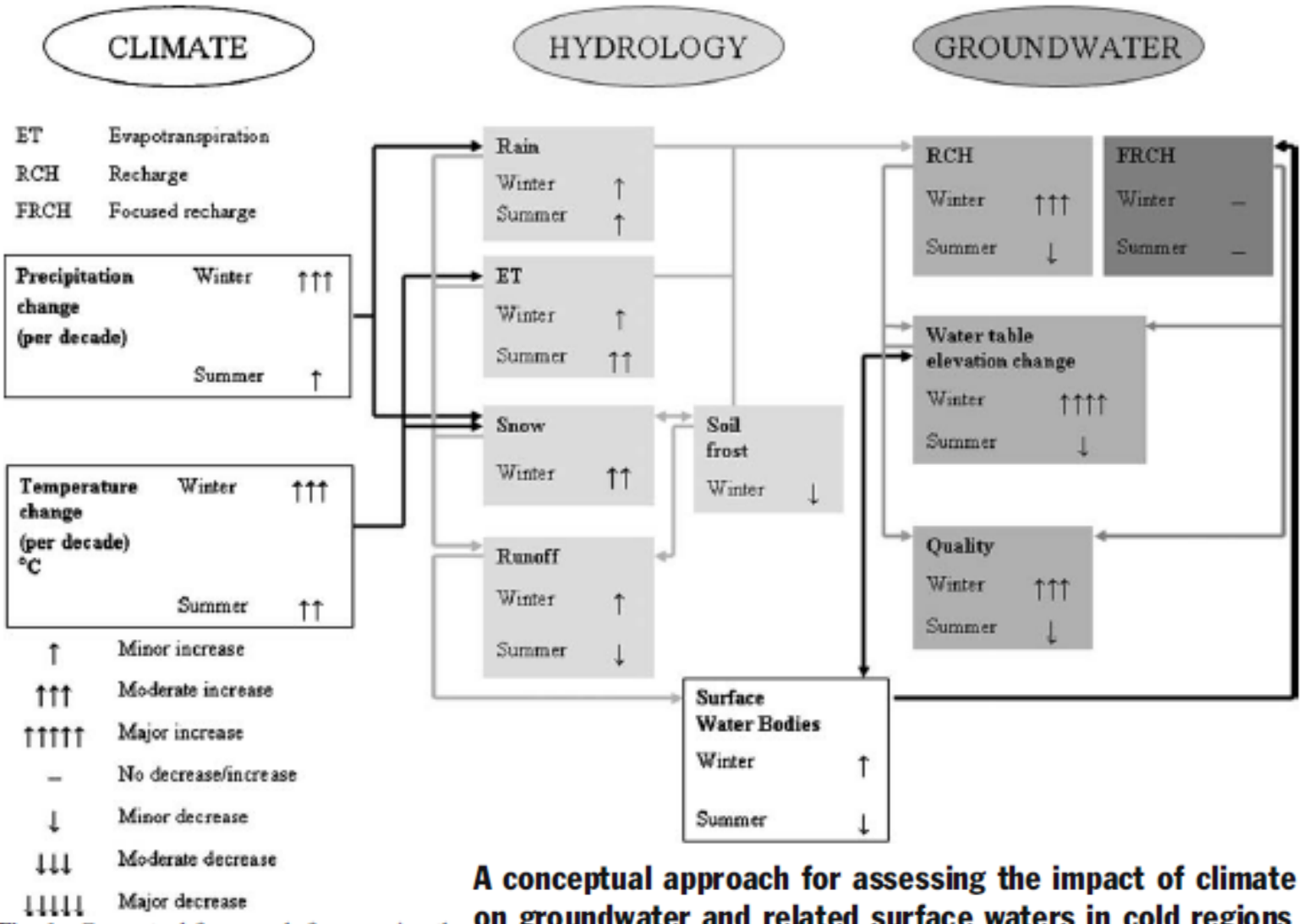
Ref Blösch WRR

CC,GW and GDEs



Ref. Klove et al 2013 JHydrol (accepted)

CLIMATE CHANGE IN COLD CONDITIONS



A conceptual approach for assessing the impact of climate change on groundwater and related surface waters in cold regions (Finland)

Fig. 1 Conceptual framework for assessing the Finland where surface water bodies are present

1.

Jarkko Okkonen · Mikko Jyrkama · Bjørn Kløve

GDES AND CLIMATE CHANGE

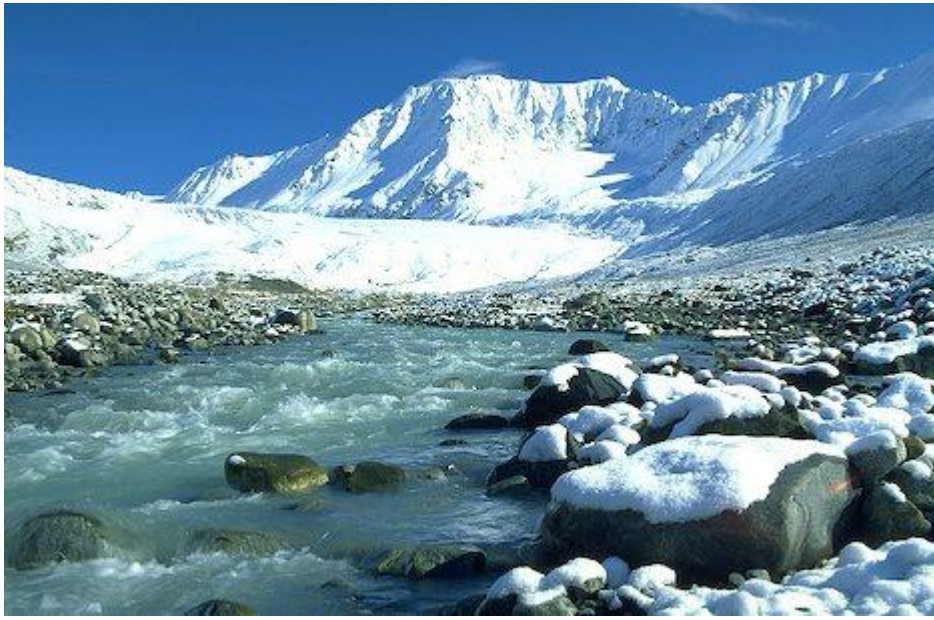
- GDEs comprise different systems that will respond to climate chnage in many different ways
- GDEs are often wet ecosystems and rely on groundwater
  - Changes in groundwater can change GDEs
- Essential to understand changes in:
  - Changes in recharge, GW level and pressure
  - Groundwater surface water interaction
  - Impacts of Land use and Climate Change
- Little information is available so the issue must be approached from a knowledge on hydrology and surface water systems

Examples

- Esker recharge and summer low flows
- Glacier melt
- Stream water temperature
- Esker lake systems

Glacier melt with CC

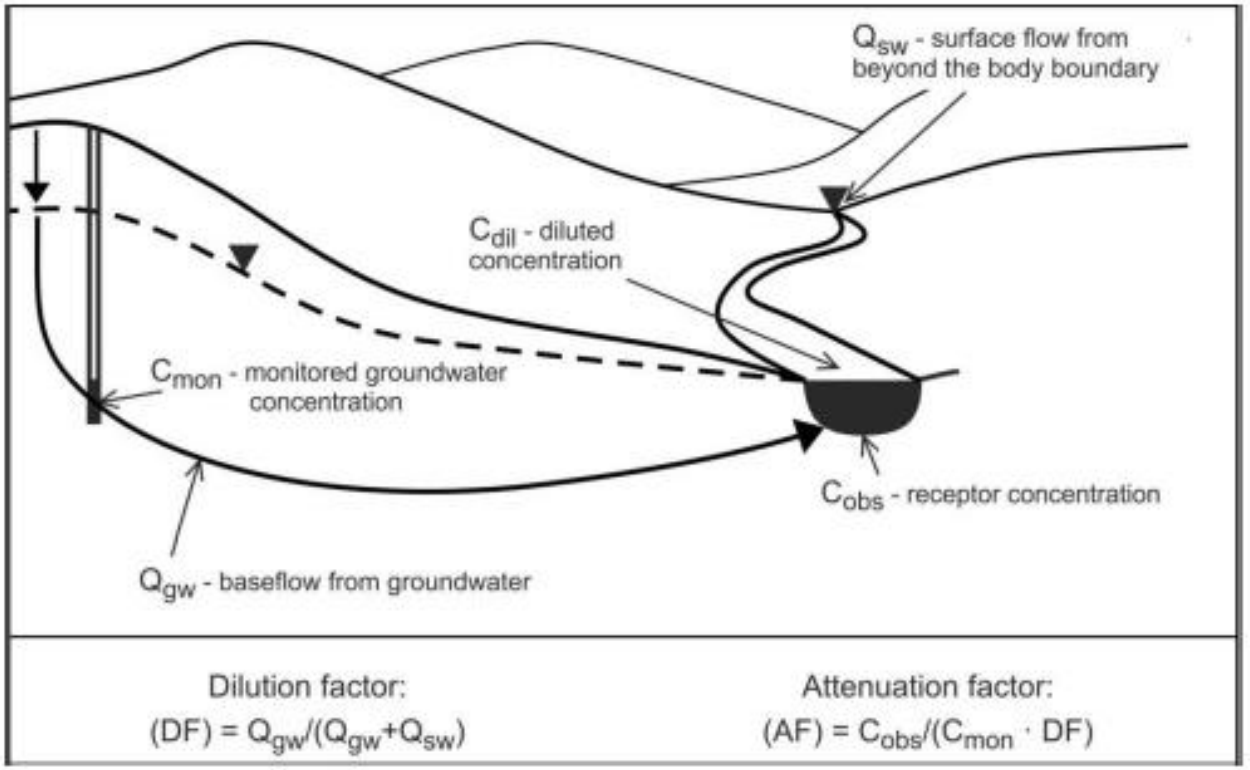
- Higher temperature will first increase glacier melt
- Reduced glaciers reduce galcier size an evantually the melt amount leading to less summer base flow



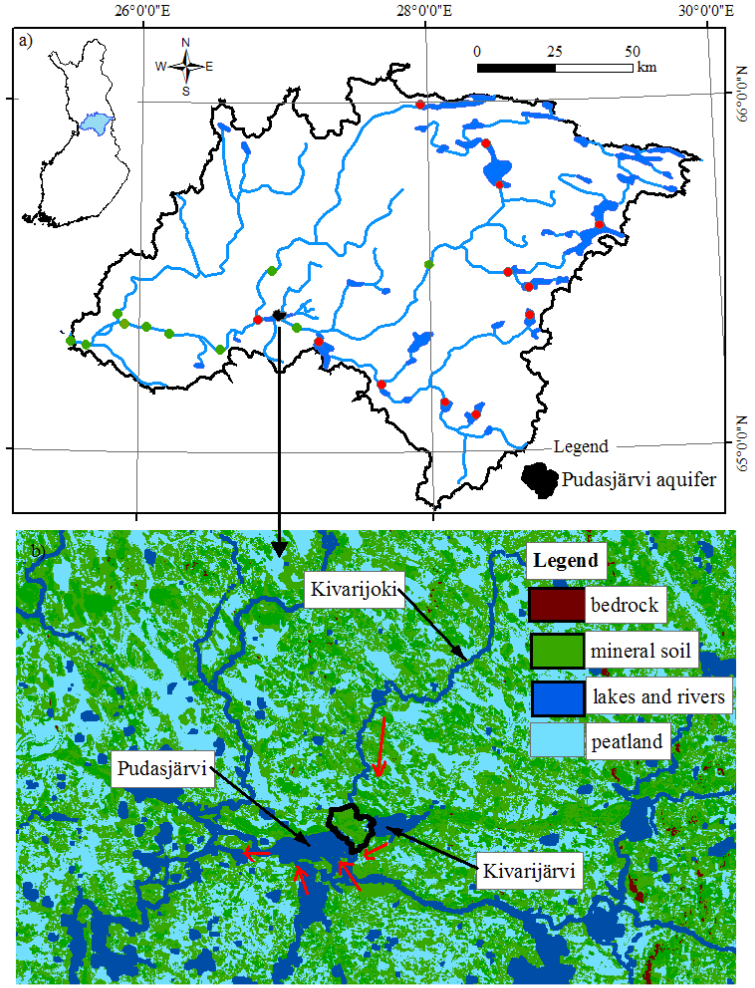
STREAMS AND CC

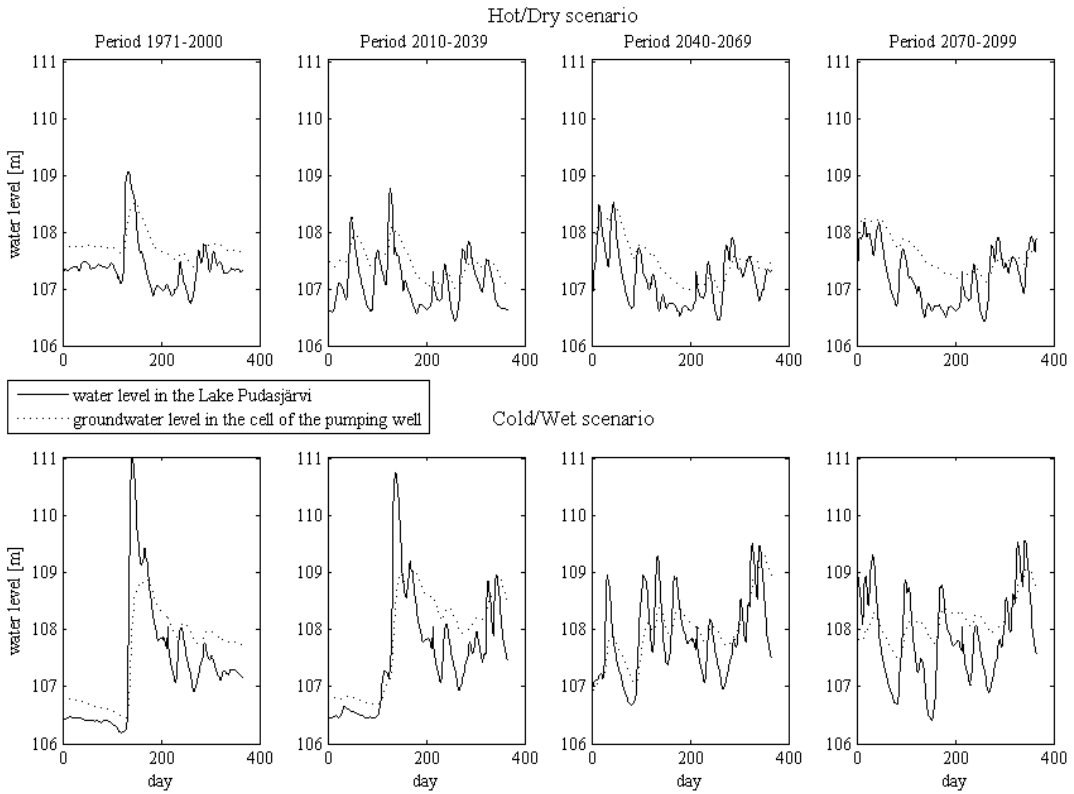
•Stream interact with its surface water catchment and groundwater capture zone

•Water temperature changes if baseflow is reduced (Kane et al., 2013



Esker recharge and low flow

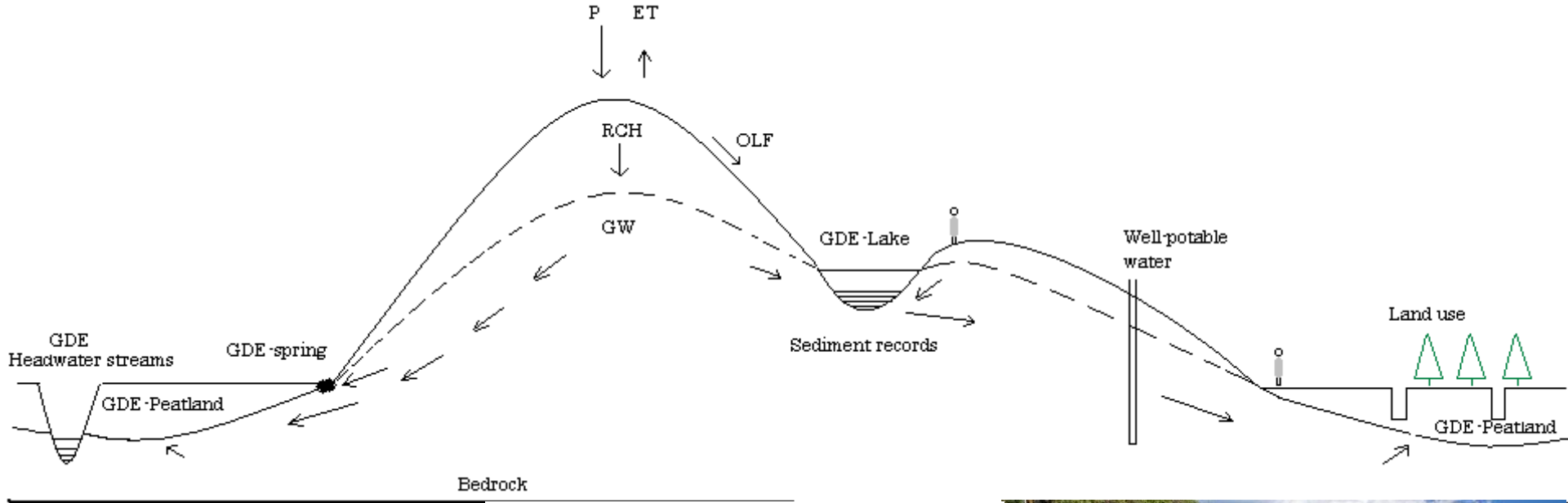


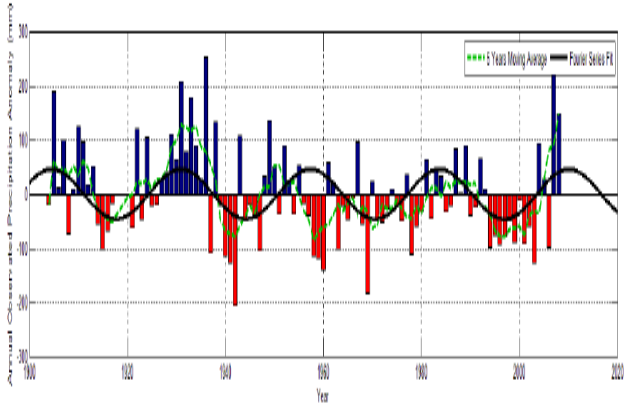


Okkonen and Klove Jhydrol 2011

Esker aquifers and lakes

some lakes sensitive to CV and CC





Conclusions

- In cold regions snow and ice accumulation and melt effect the water systems in many ways
- Climate changes in cold regions will probably results in less snow accumulation, earlier snowmelt and shorter season
  - Irregular GWL (depends more on rainfall)
  - Higher GWL in winter and lower in summer
- GDEs are highly vulnerable to hydrological changes
- Little information yet available on GDEs and CC
  - Essential to understand the link between climate, groundwater and how it is linked to ecosystems
  - Impacts must be related to land use and climate variability

Uncertainties on CC in Finland

- **Temperature?**
  - No significant trend detected in 100 year data of central and northern Finland (only trend observed in Helsinki)
- **Evapotransipiration?**
  - Increased CO_2 can reduce ET and compensate for the increase in T
- **Precipitation?**
  - Climate models scnarios highly uncertain
    - In Finland reducing trend observed for P and SWE

Thank you for your attention

Sunset at midnight in Central Norway

www.thegenes