Influence of Climate Change on the Hydrological Regime of Coastal Areas – a Study in Northern Germany

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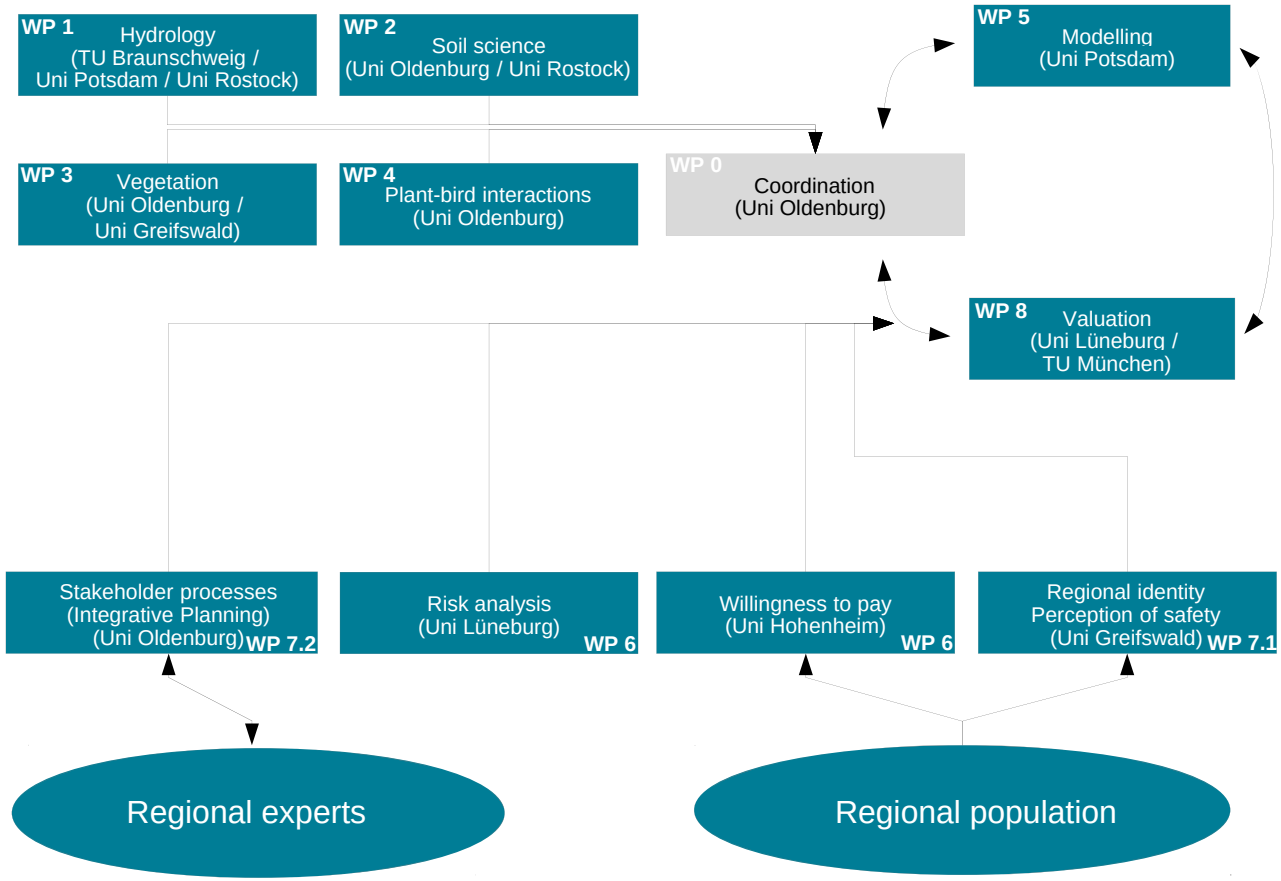
COMTESS

Sustainable **CO**astal Land **M**anagement: **T**rade-offs in **E**co**S**ystem **S**ervices

SUSTAINABLE LAND MANAGEMENT

FONA

Project structure



Outline

1. Motivation
2. Concept
   - 2.1 Groundwater model
   - 2.2 Simplified surface model
3. Results
4. Conclusion

1.Motivation

12 million people living in the flood-prone area of the southern North Sea region

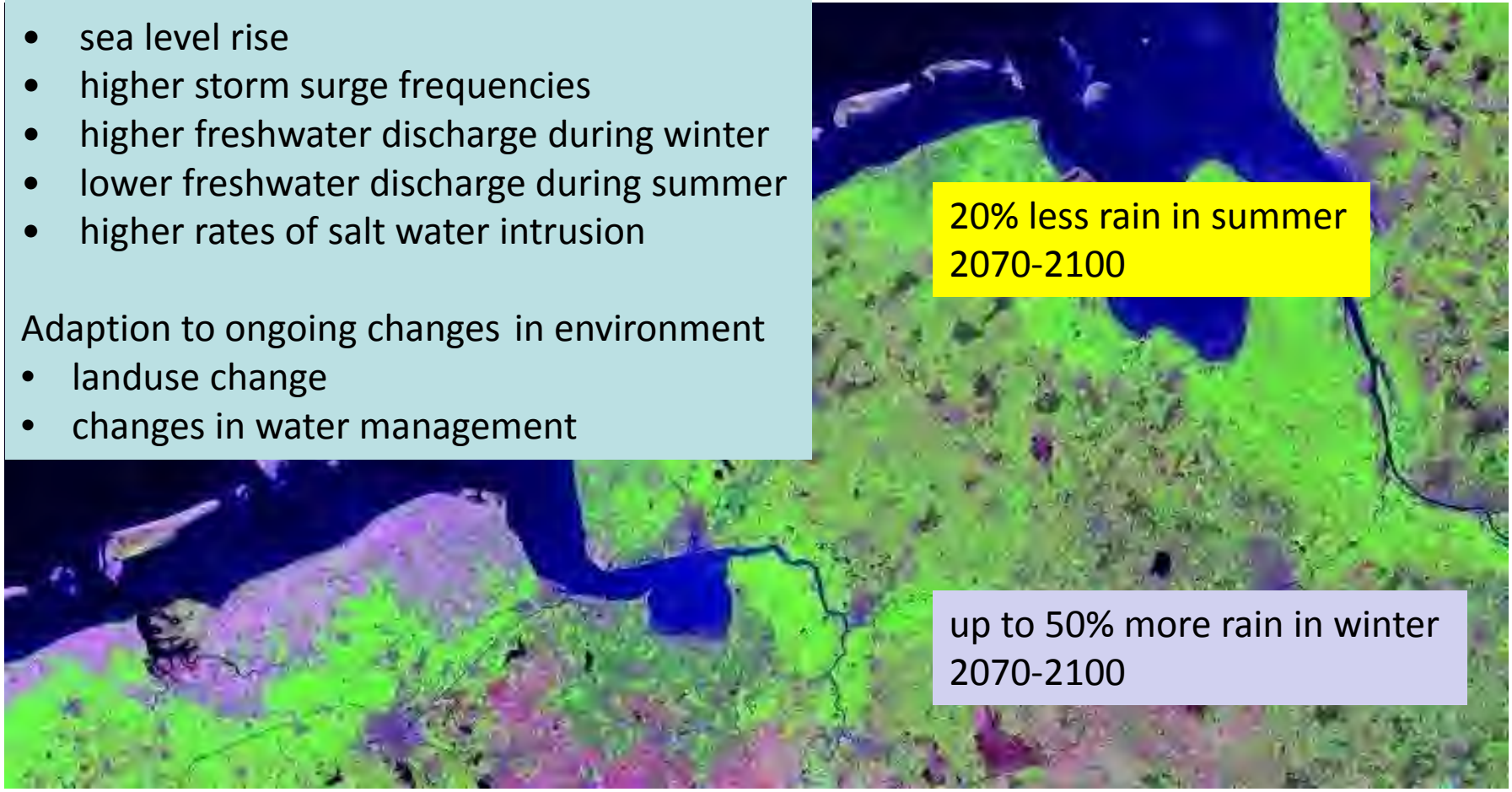
1.Motivation

Climate change leads to:

- sea level rise
- higher storm surge frequencies
- higher freshwater discharge during winter
- lower freshwater discharge during summer
- higher rates of salt water intrusion

Adaption to ongoing changes in environment

- landuse change
- changes in water management



2. Concept

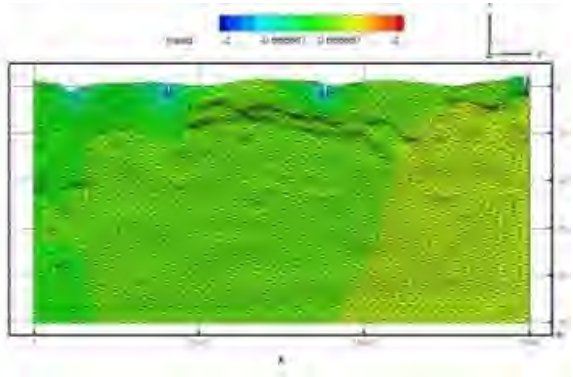
Bottom-Up-Approach to understand and simulate hydrological processes

2.1. physically based model

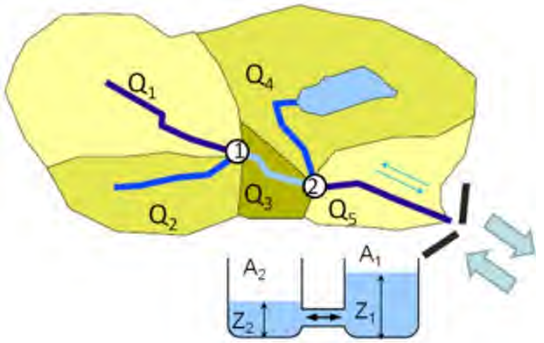
cross-section simulation

investigation of saltwater intrusion and preferential flow paths

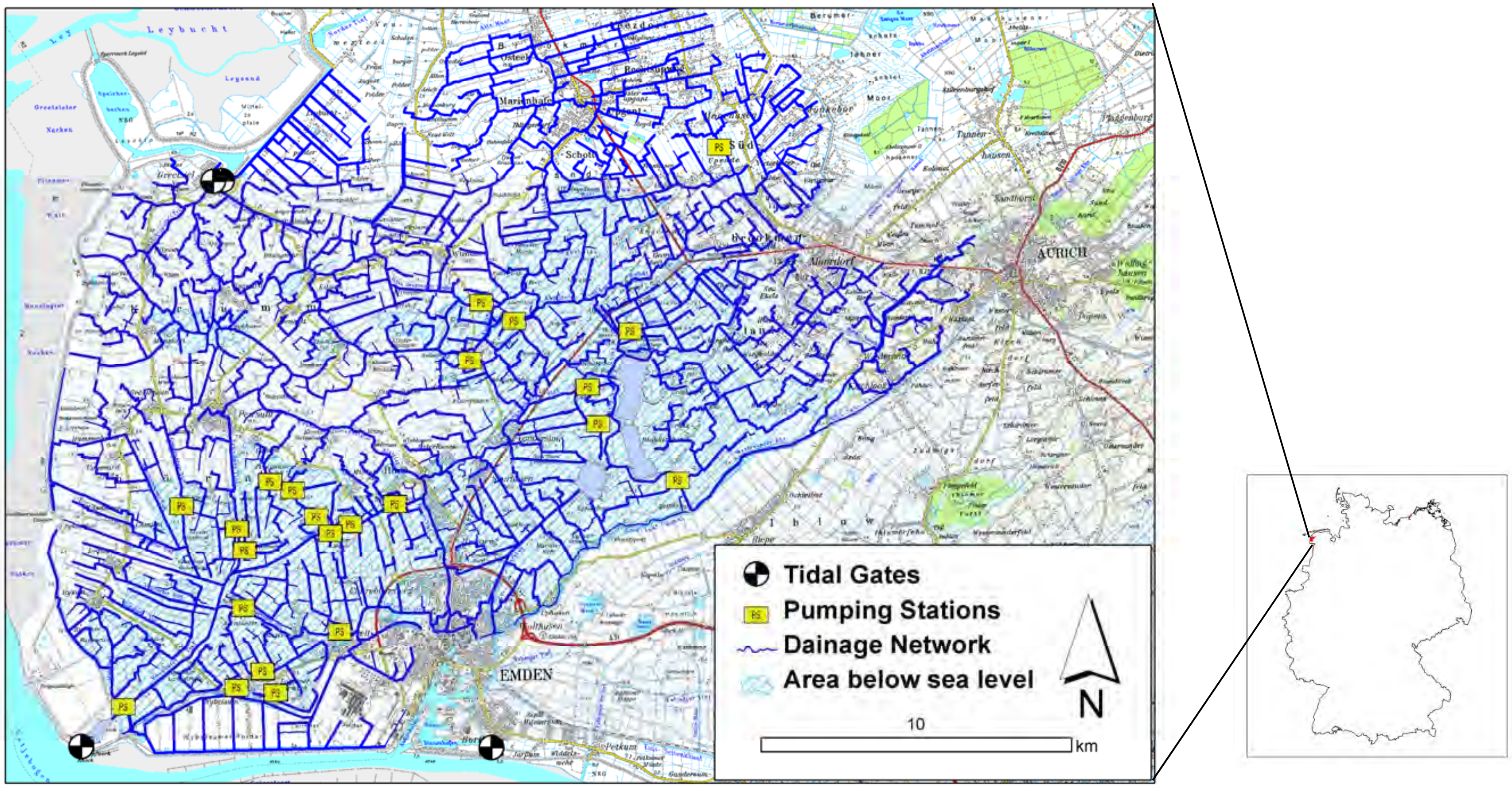
only for a view years



2.2. conceptual based model to simulate water management, desalinisation for the complete period based on the loads of 2.1



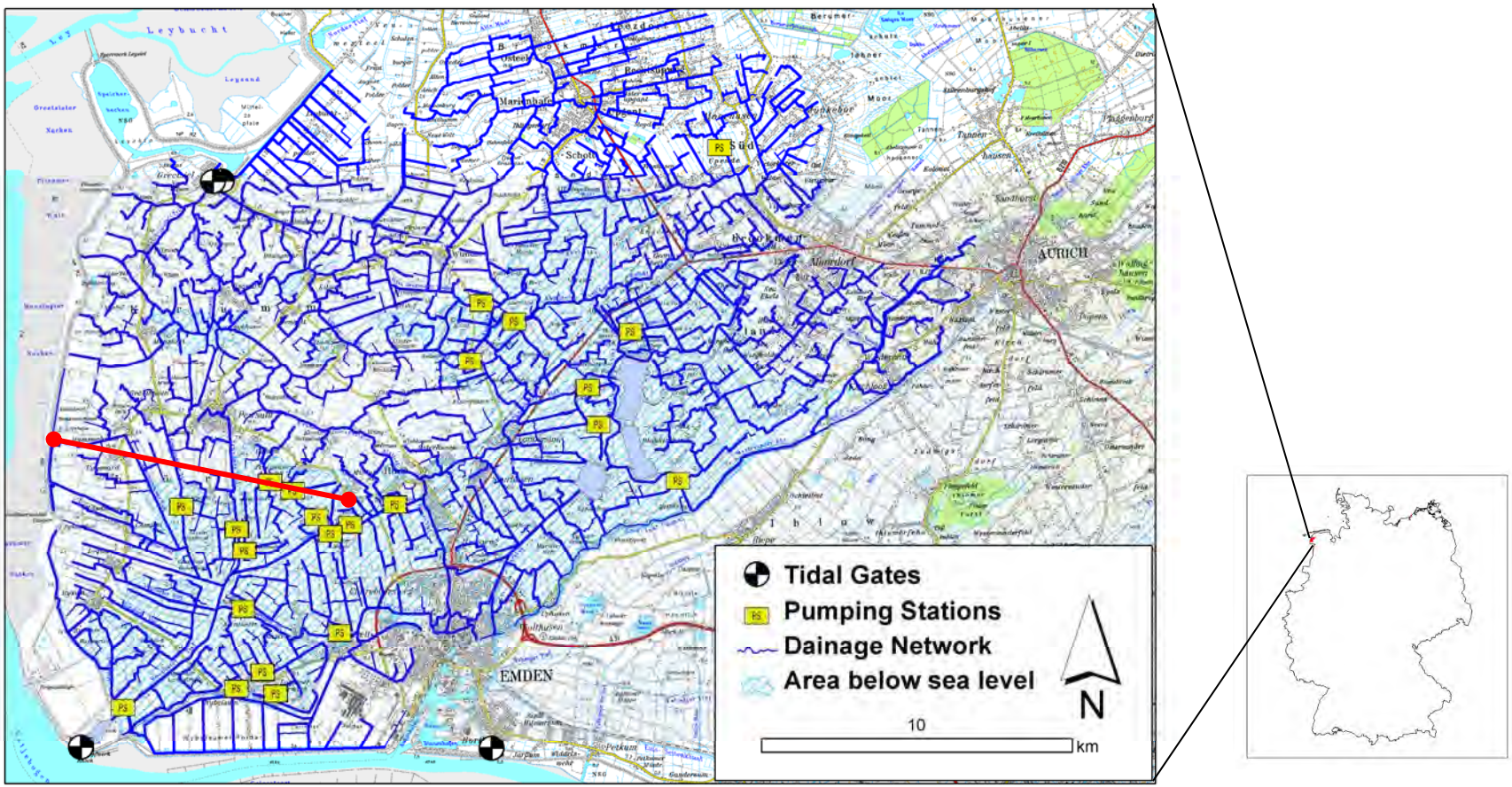
Study Site



East Frisia/Krummhörn (North Sea) close to Emden

drainage area of tidal gates Greetsiel/Knock 485 km²

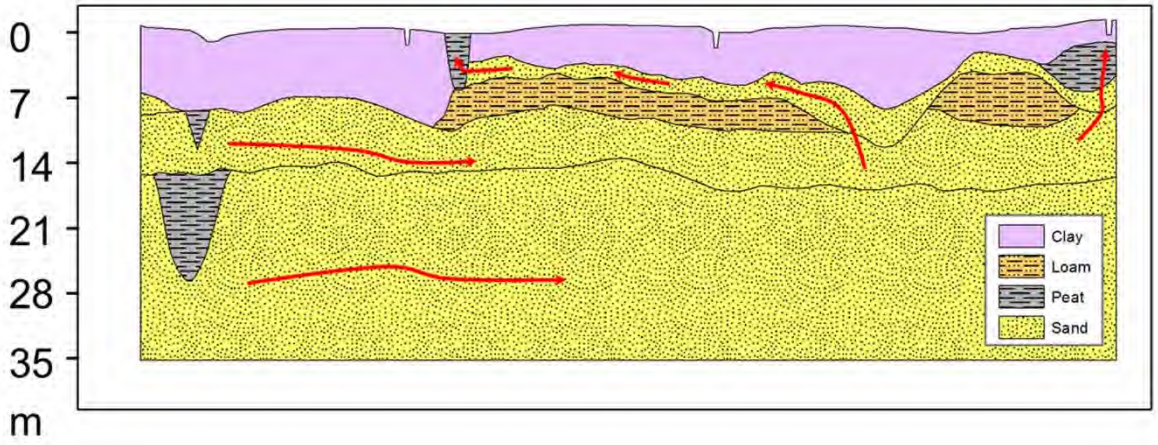
Study Site



East Frisia/Krummhörn (North Sea) close to Emden
drainage area of tidal gates Greetsiel/Knock 485 km²

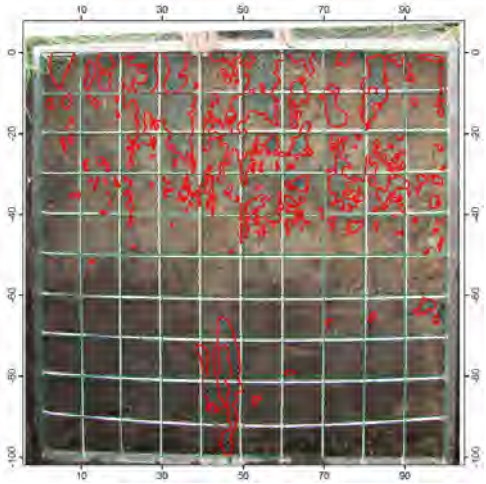
Flow Patterns

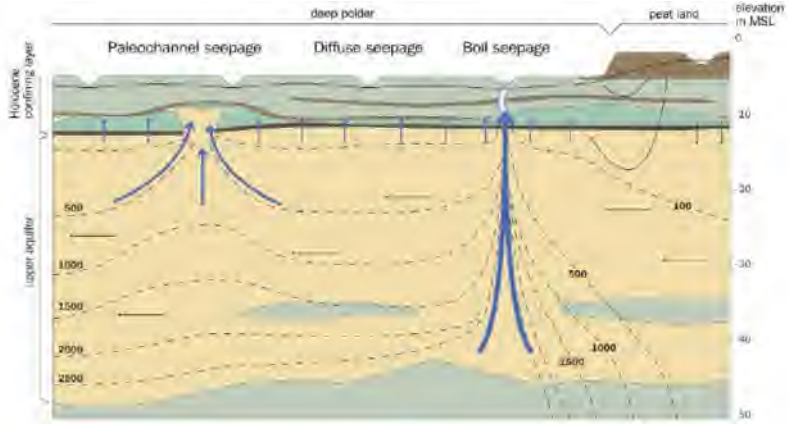
Geology



- less impermeable marsh soils on the top
- high permeable sandy material in the depth

Dye Tracer experiments



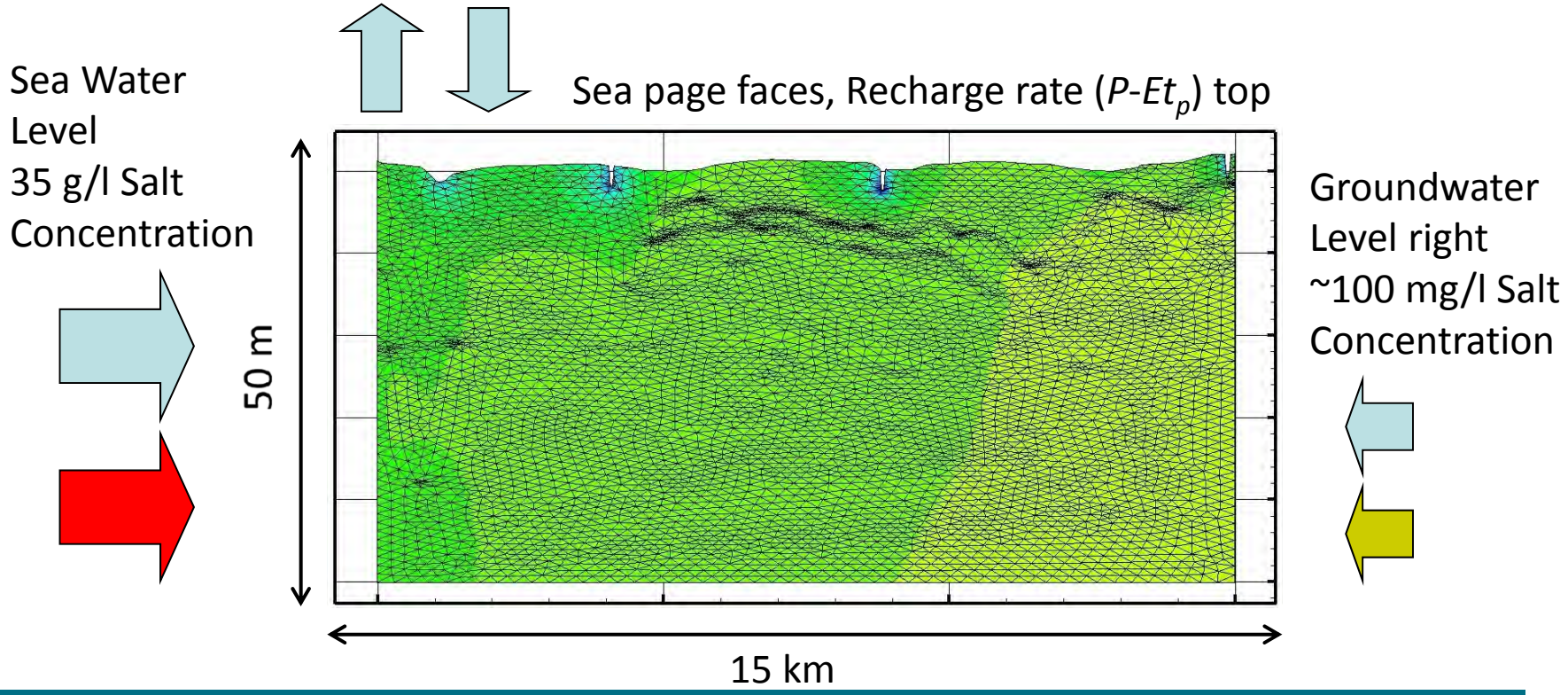


de Louw et al., 2010

2.1 Physically Based Model Setup

- **Objective**: estimation of salt water intrusion under rising sea level
- Simulation period: 1195 d (2008 – 2011)
- Spatial Set Up: 60,000 Nodes

Boundary Conditions:

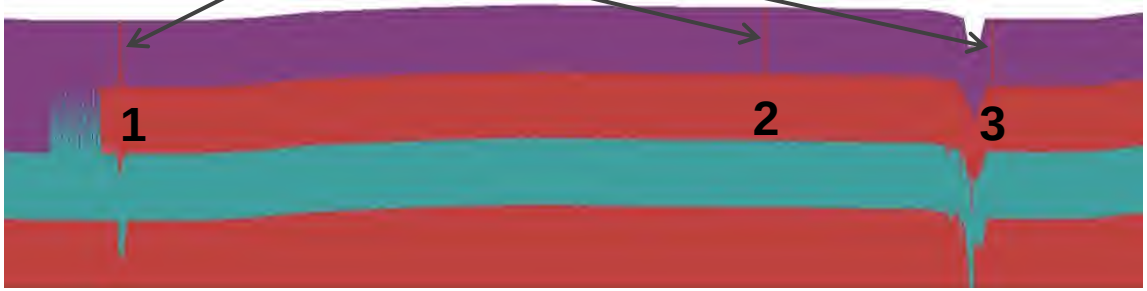


Meteorological BC and Spatial Setup

[mm/d] / a	GW-Recharge	P	ET_p
2008	161	878	717
2009	2	752	750
2010	48	781	733

without flow path ways

with flow path ways



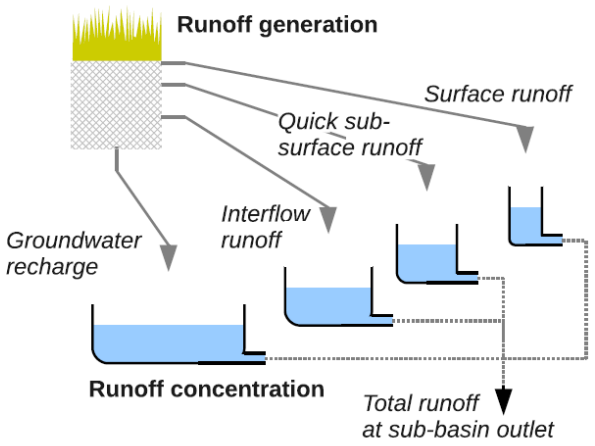
K_s values
10^{-4} m/s
10^{-7}
10^{-9}

2.2 Conceptual Approach

ECHSE (Eco-Hydrological Simulation Environment), Kneis (2011)

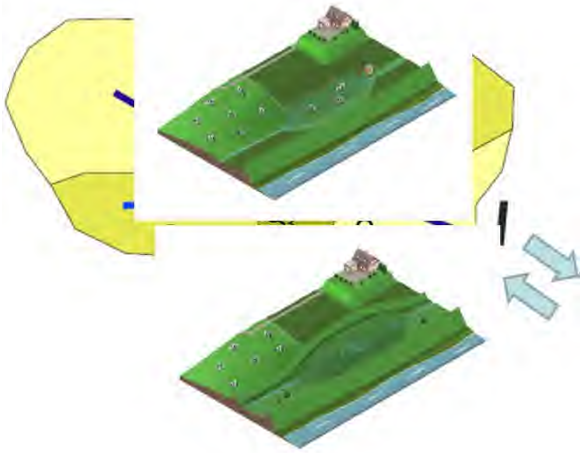
Processes:

- *ET* after Makkink
- snow Energy balance
- soil is represented with 4 storage concept
- salt is treated as conservative transport



Boundary Conditions:

- meteorological RCM data (REMO A1B,A2, B1)
- salt load estimated with physically based model

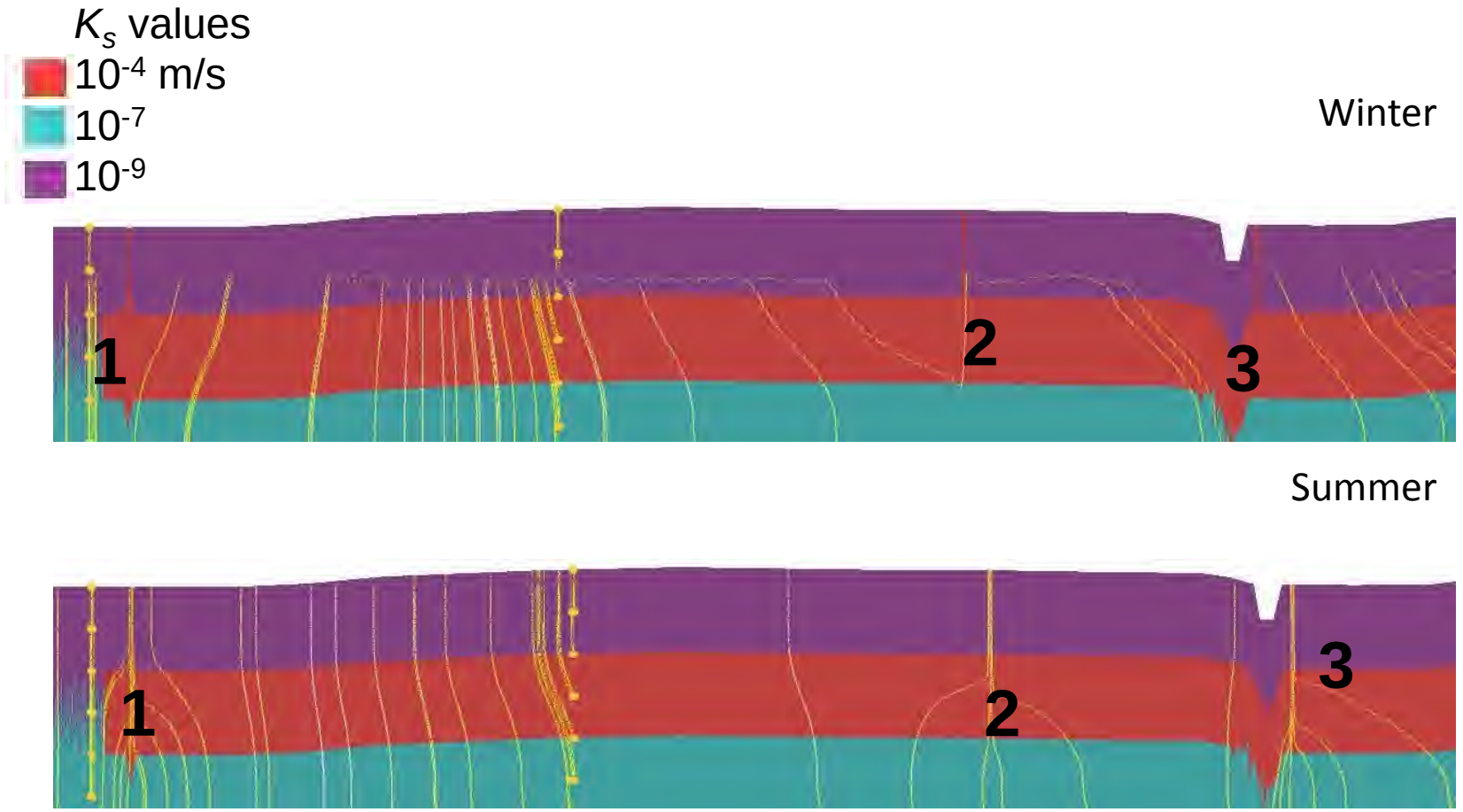


Landuse Scenarios:

- business as usual
- establishing of a polder to buffer water during winter periods

3. Results

Results Physically based Model, Preferential Flow



Comparison the Mass Budget of the Flow Path Ways

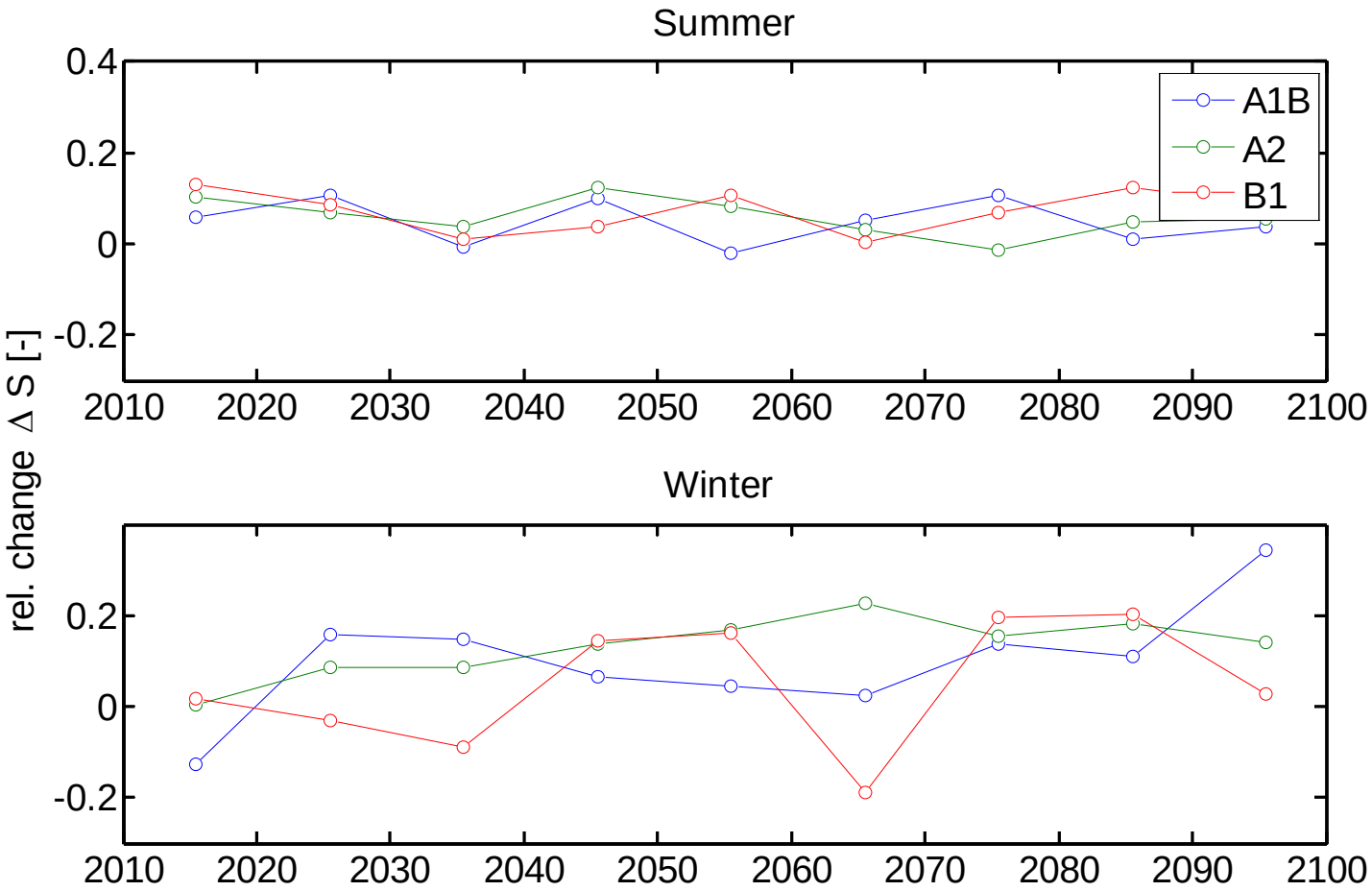
Differences of the Means in % for Mass Rate Output with Flow Paths Compared Without Flow Paths			
	Profile 1	Profile 2	Profile 3
2008	258	78	30
2009	185	115	14
2010	123	191	0
1195 d	181	212	10

→2 g/l m² upconing salt concentration in areas with preferential flow path ways

Results: conceptual Model

reference period from 1970-2000

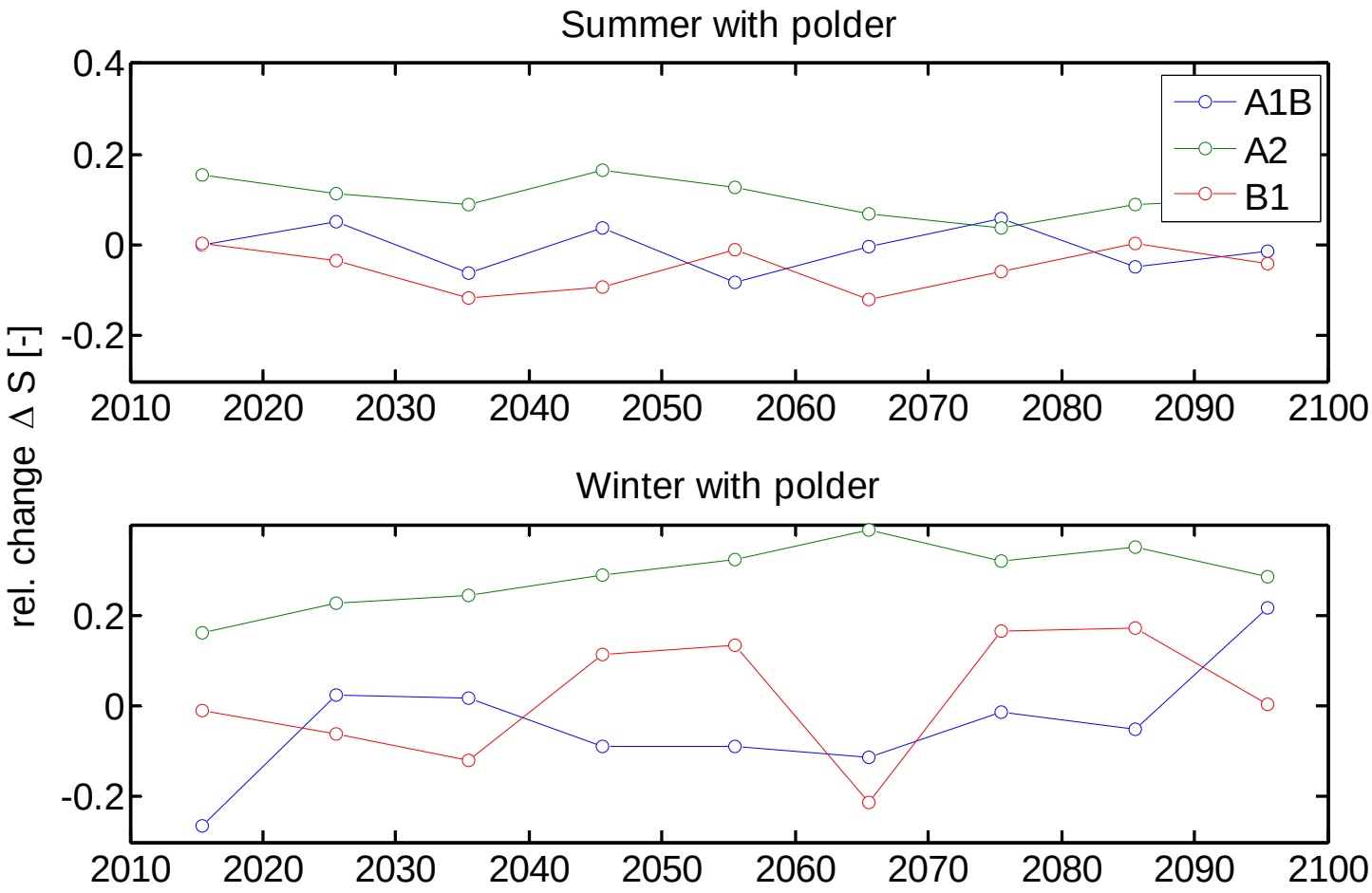
rel. Changes in water storage $\Delta S = P\text{-}q\text{-}ET_a$



Results: conceptual Model with Polder

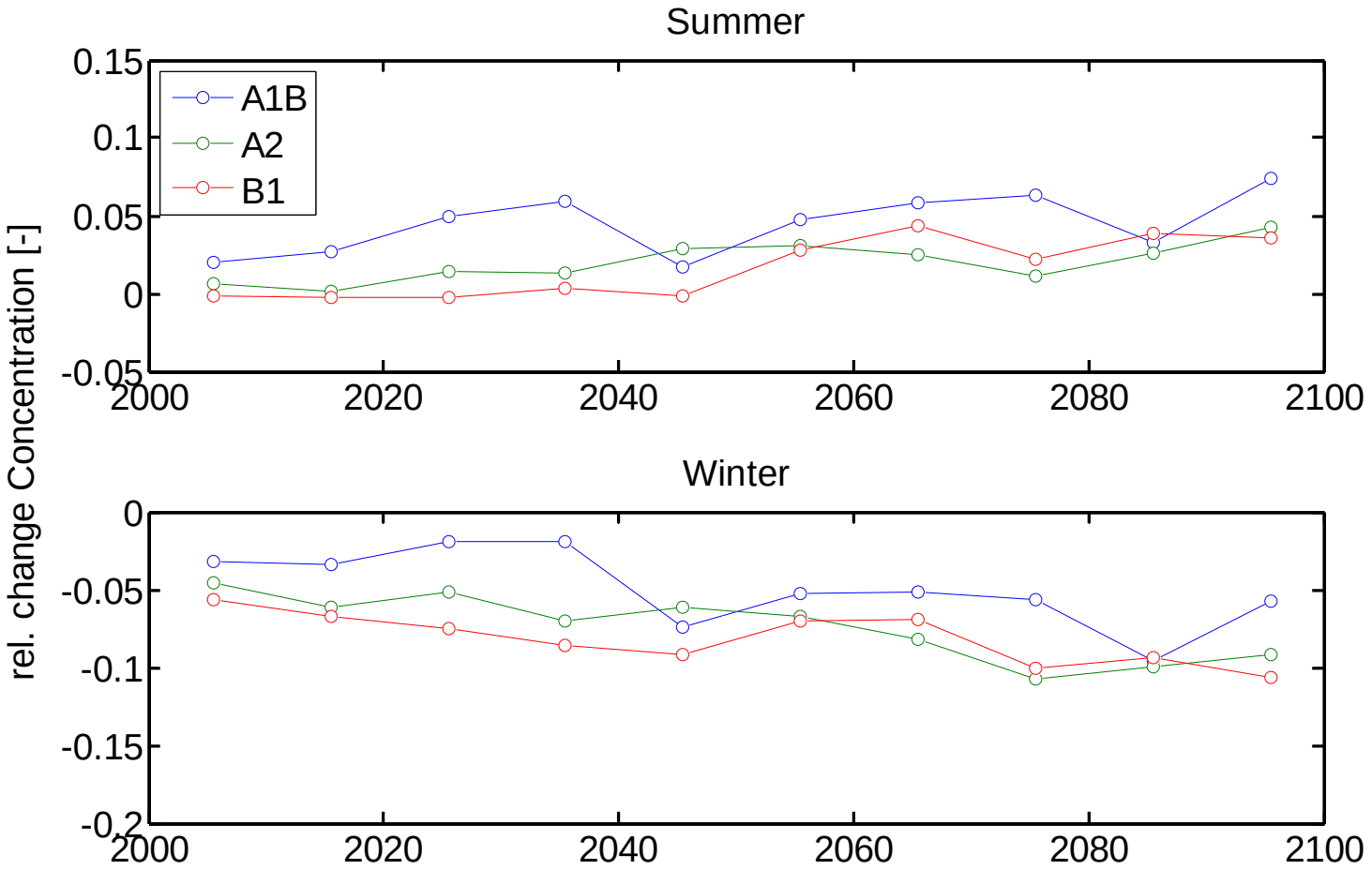
reference period from 1970-2000

rel. Changes in water storage $\Delta S = P\text{-}q\text{-}ET_a$



Results: changes in Salt Concentration

reference period from 1970-2000



4. Conclusion

- during drier periods preferential flow through flow path ways dominates
- geological disturbance in the layering has a high impact on saltwater input to surface
- an increase in salt water concentration is simulated in summer period
- polder area has a buffering effect in the winter period

Outlook

- implementation of more complex salt water transport
- implementation of inundation and backwater
- sensitivity analysis
- analysis of different meteorological scenarios from different GCMs and RCMs

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