Multi-decadal lake-level dynamics in north-eastern Germany as derived by a combination of gauging, proxy-data and modelling

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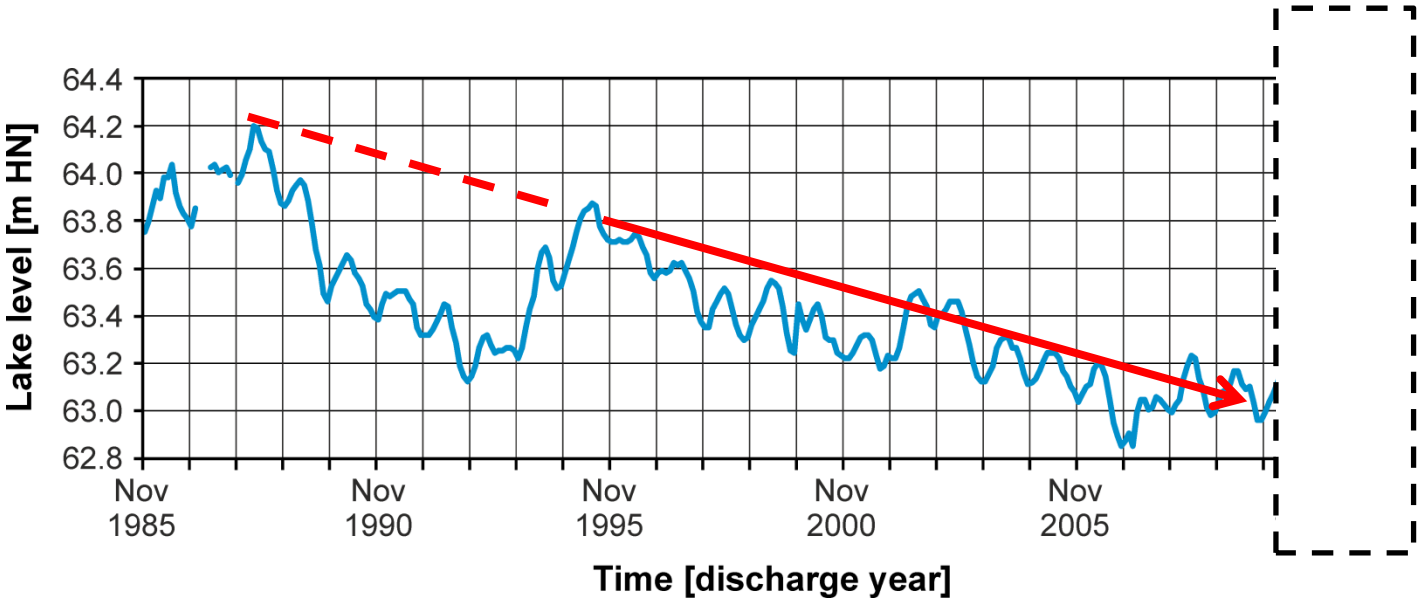
Lake Redernswalder See, 09/2009

Lake Krummer See, 09/2009

Thanks a lot my coauthors!

One important ‘selling’ argument for establishing the TERENO Northeastern German Lowland Observatory in 2009/2010:

Decreasing lake (and groundwater!) levels in NE Germany since decades…



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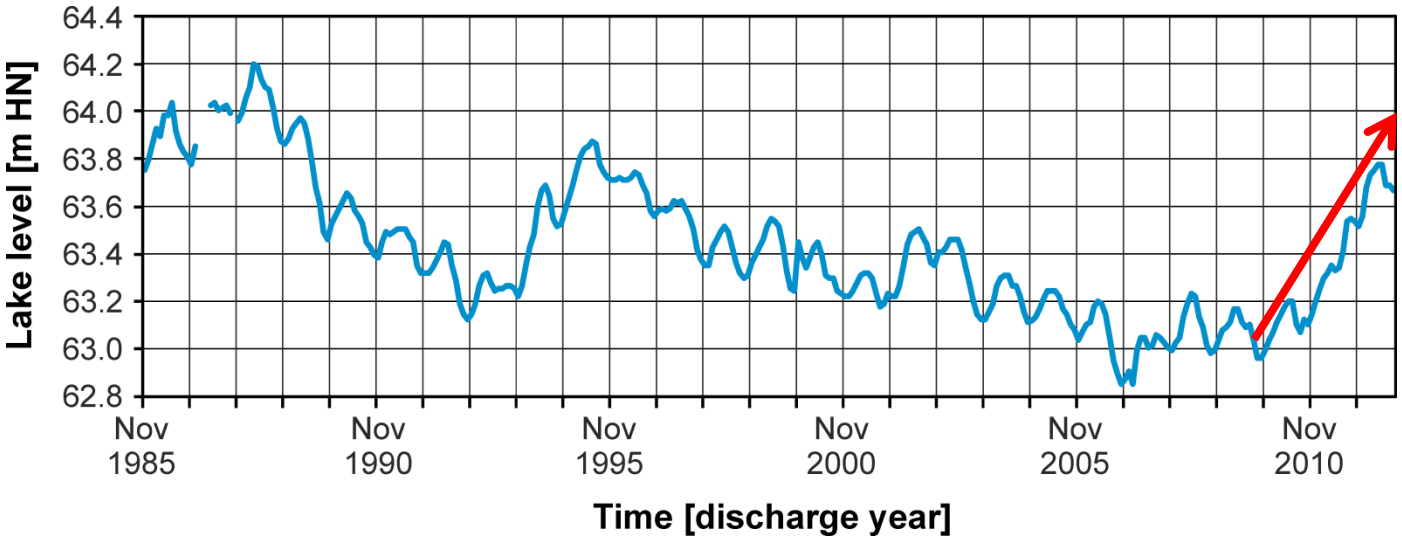
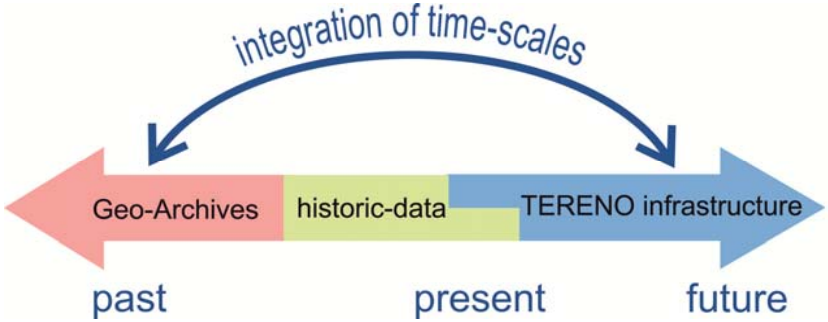


…but things (weather) have changed again and more the general longterm variability of the environment is in the focus now!

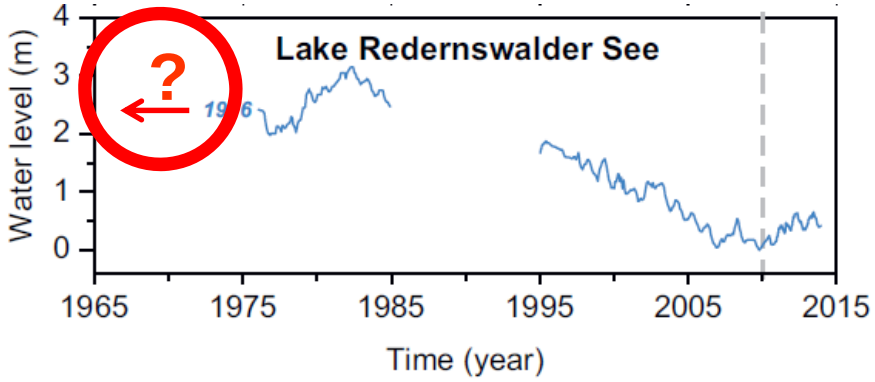
Motivation



One basic concept of the TERENO Northeastern German Lowland Observatory is the integration of time-scales extending measured time-series of several environmental parameters into the past (nexus of observation and reconstruction)

With view on the landscape water budget pronounced changes took place in the last decades rising the general questions:

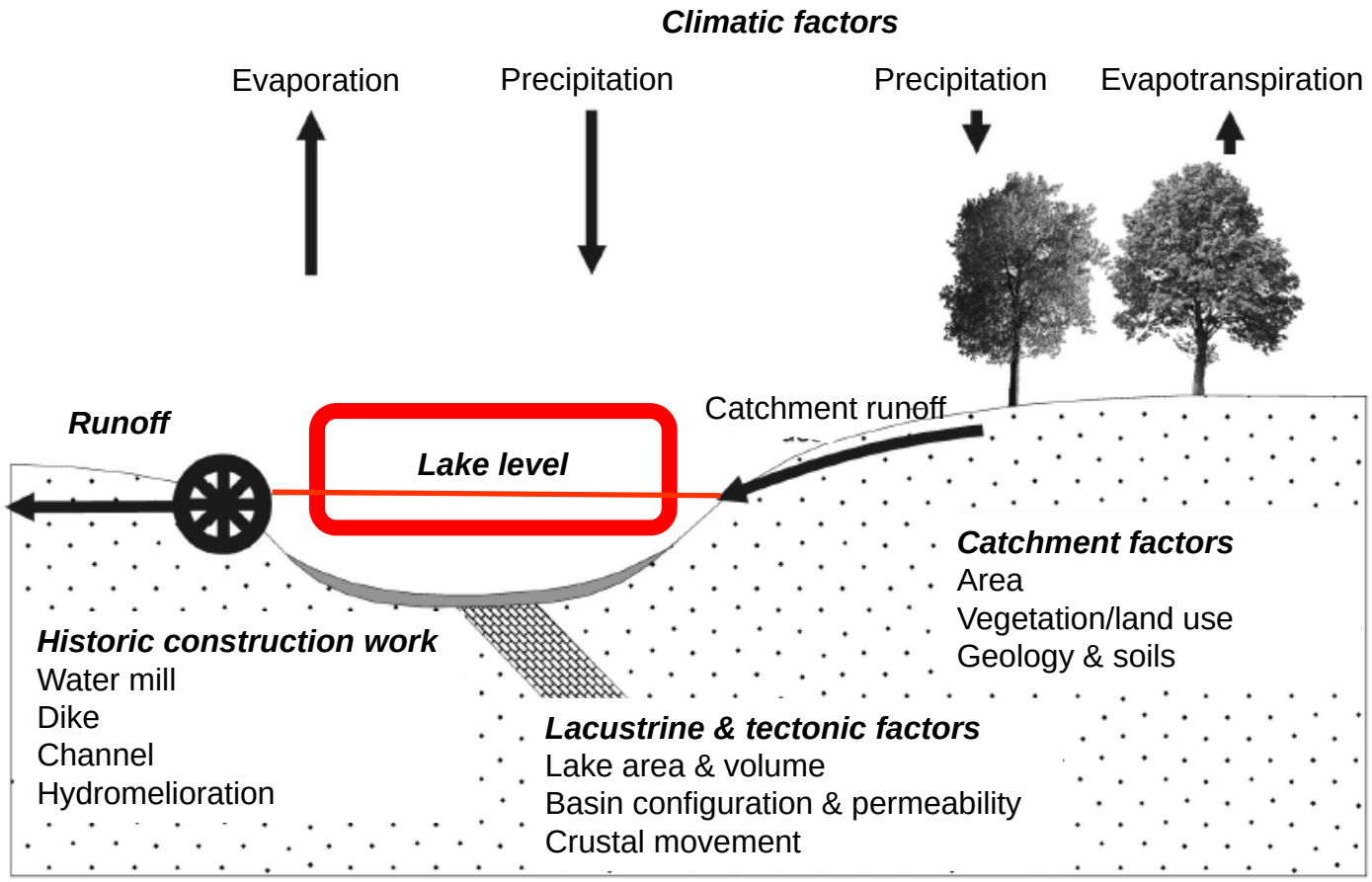
- How lake levels and related groundwater levels perform in a long-term perspective (this talk: c. 100 yrs)?
- What is the natural variability (variance) of these parameters (identification of high and low frequency dynamics)?



Example: lake level of RS (1980-2007: 3 m decline)

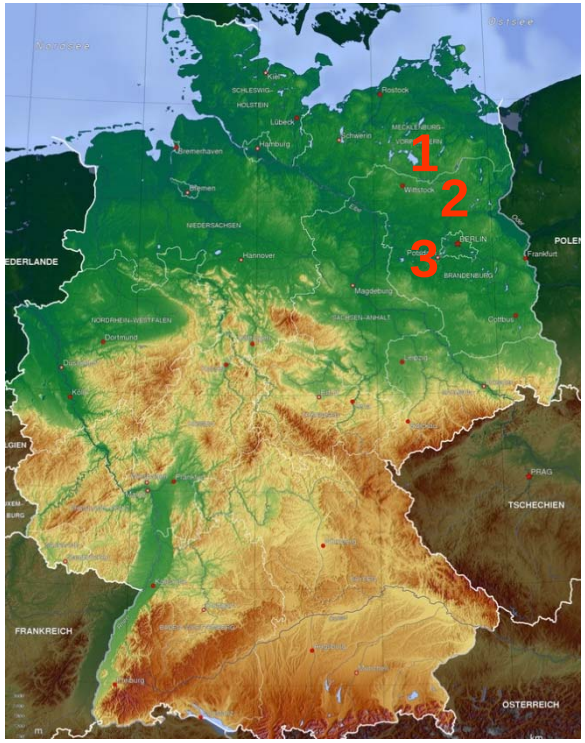
As gauging records are ususally to short to cover a sufficiently long time period, reconstruction by using proxy-data is required

Lake-level as an ‘integral’ (‘mirror’) of the landscape water-budget (and of further factors!)



after Dearing & Foster 1986, modified by Küster 2014

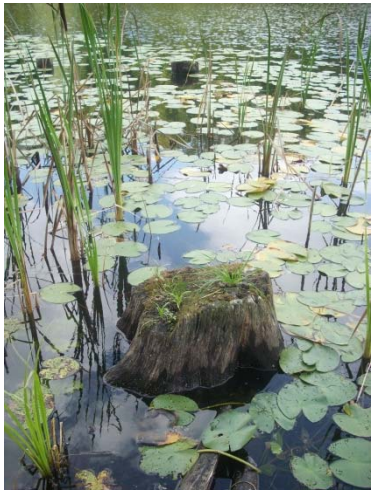
TERENO / ICLEA lake-level studies in NE Germany (selection)

Study area with example	Temporal focus	Location
Müritz National Park (1) *e.g. Lake Fürstenseer See*	Decadal Centennial Millennial	
Schorfheide area (2) *e.g. Lake Redernswalder See*	Decadal Multi-decadal Millennial	
Havel-Spree river area (3) *e.g. Middle reach of the Havel river*	Millennial	

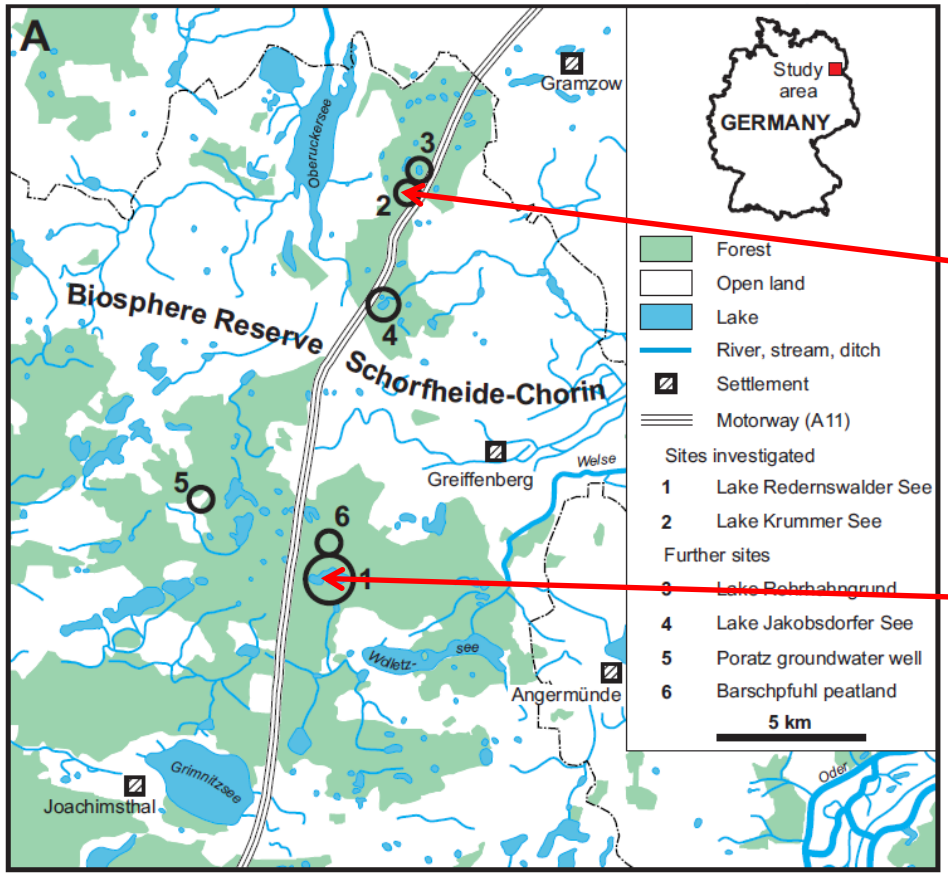
2009: Discovery of in-situ tree remains in two lake basins

Redernswalder See

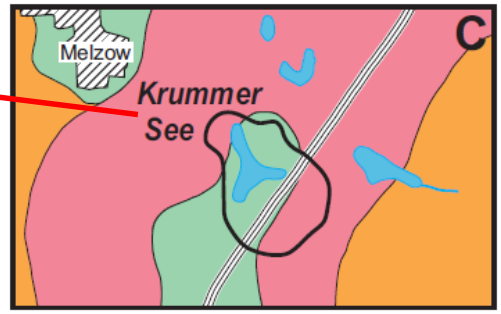
Krummer See

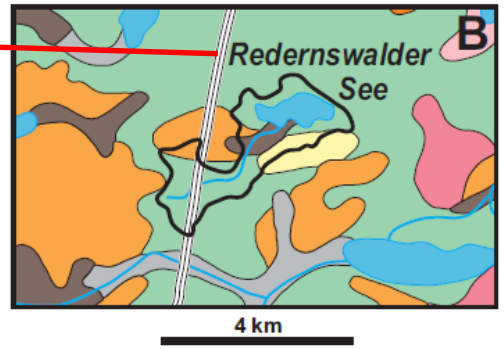


Study sites

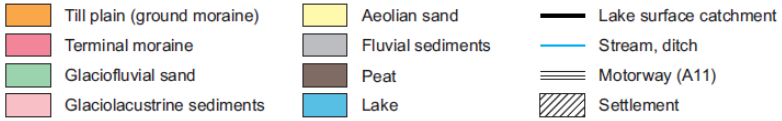


Topography

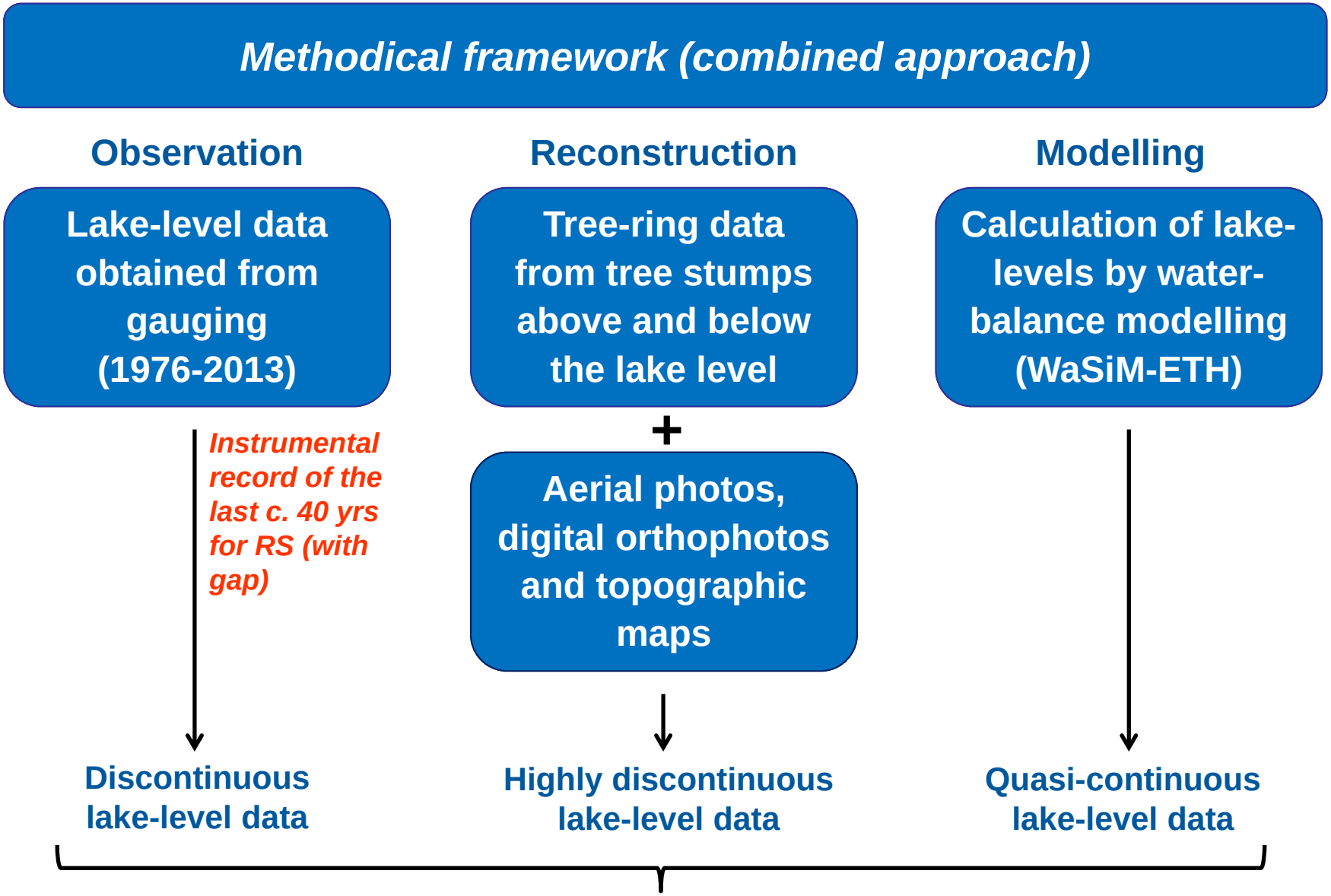


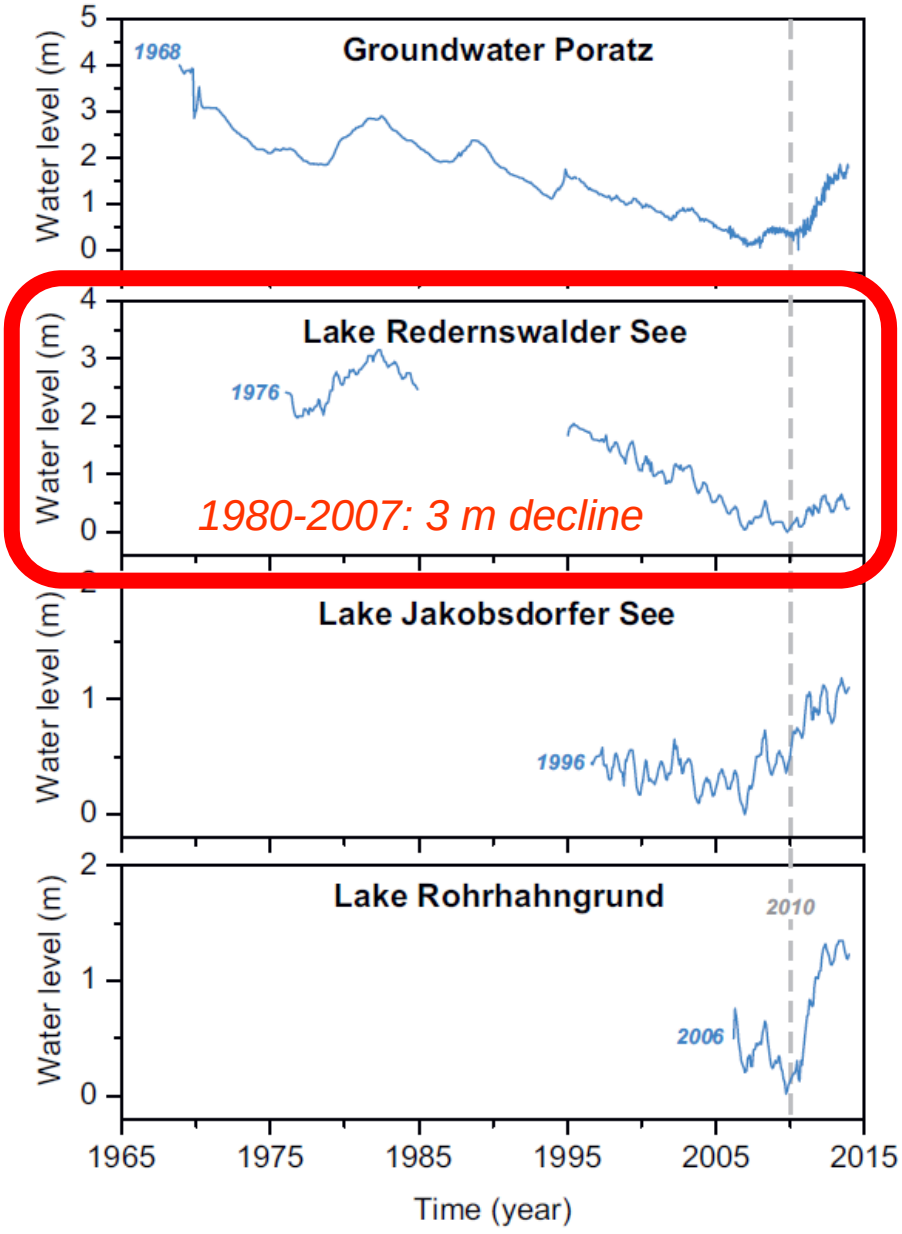


Geology



- Climate: T_a=8.6 C, P_a=529 mm, ET_0=570 mm
- Landcover: forest
- Lake size: 55 ha (RS) / 4 ha (KS)
- Hydrology and genesis: closed groundwater-fed glacial lakes (formed by dead-ice melting)


Methodical framework (combined approach)
Observation
Reconstruction
Modelling
Lake-level data obtained from gauging (1976-2013)
Tree-ring data from tree stumps above and below the lake level
Calculation of lake-levels by water-balance modelling (WaSiM-ETH)
+
Instrumental record of the last c. 40 yrs for RS (with gap)
Aerial photos, digital orthophotos and topographic maps
Discontinuous lake-level data
Highly discontinuous lake-level data
Quasi-continuous lake-level data
2 cross-checked (composite) lake-level records covering the last c. 90 yrs



Observation: lake-level data obtained from gauging (1976-2013)

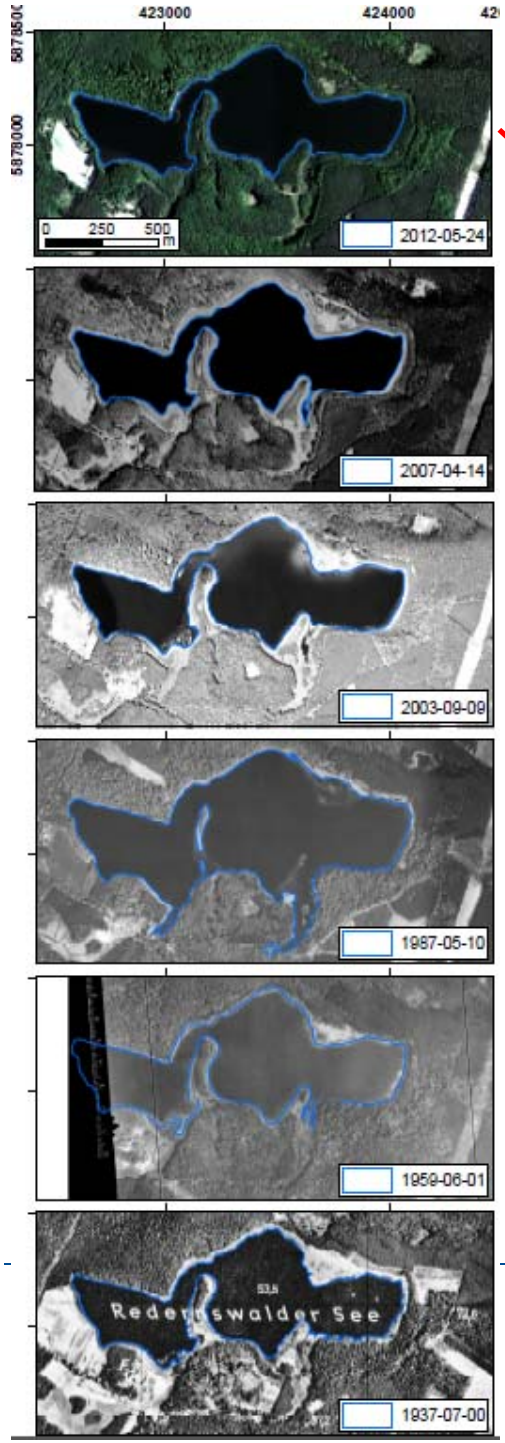
analogous gauge

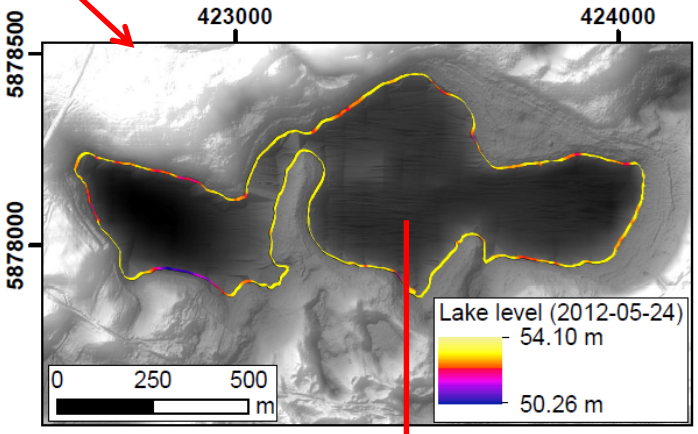
automatic gauge

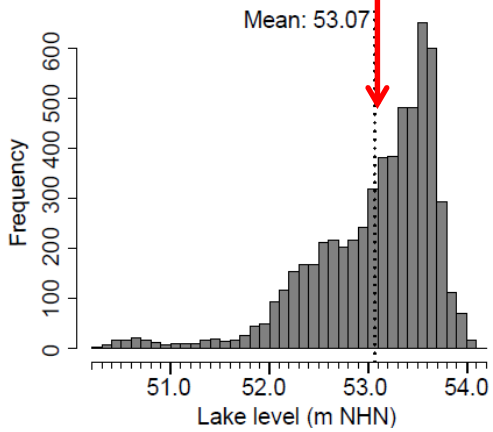
Reconstruction: tree-ring data from (in-situ) tree stumps above and below the lake level

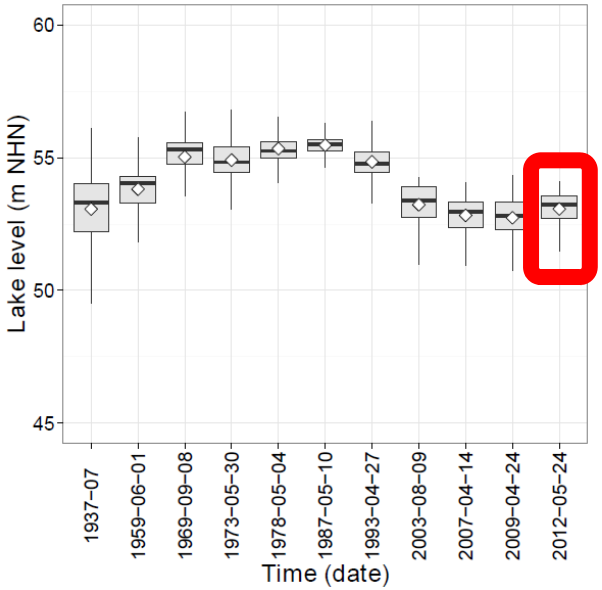
RS: Trees died in the early 1950s were flooded in the 1980s by 3 m water
KS: Trees died in the late 1960s are flooded today by 5 m water in max.

Reconstruction: aerial photos, digital orthophotos and topographic maps



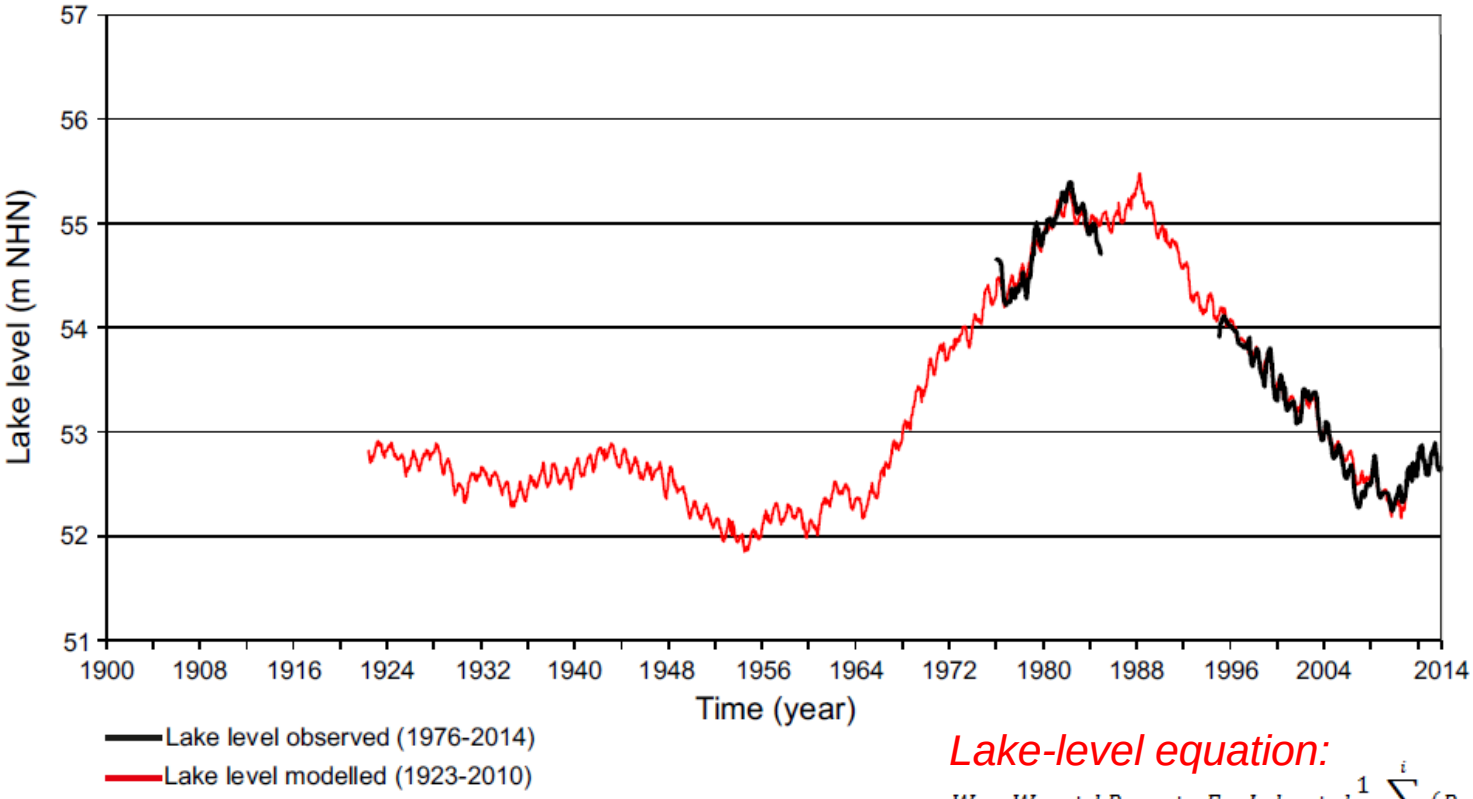






Merging of digitised former shorelines with a lake basin DEM in order to derive lake levels (using the means of the derived histogram)

Modelling: calculation of lake-levels by water-balance modelling (WaSiM-ETH)

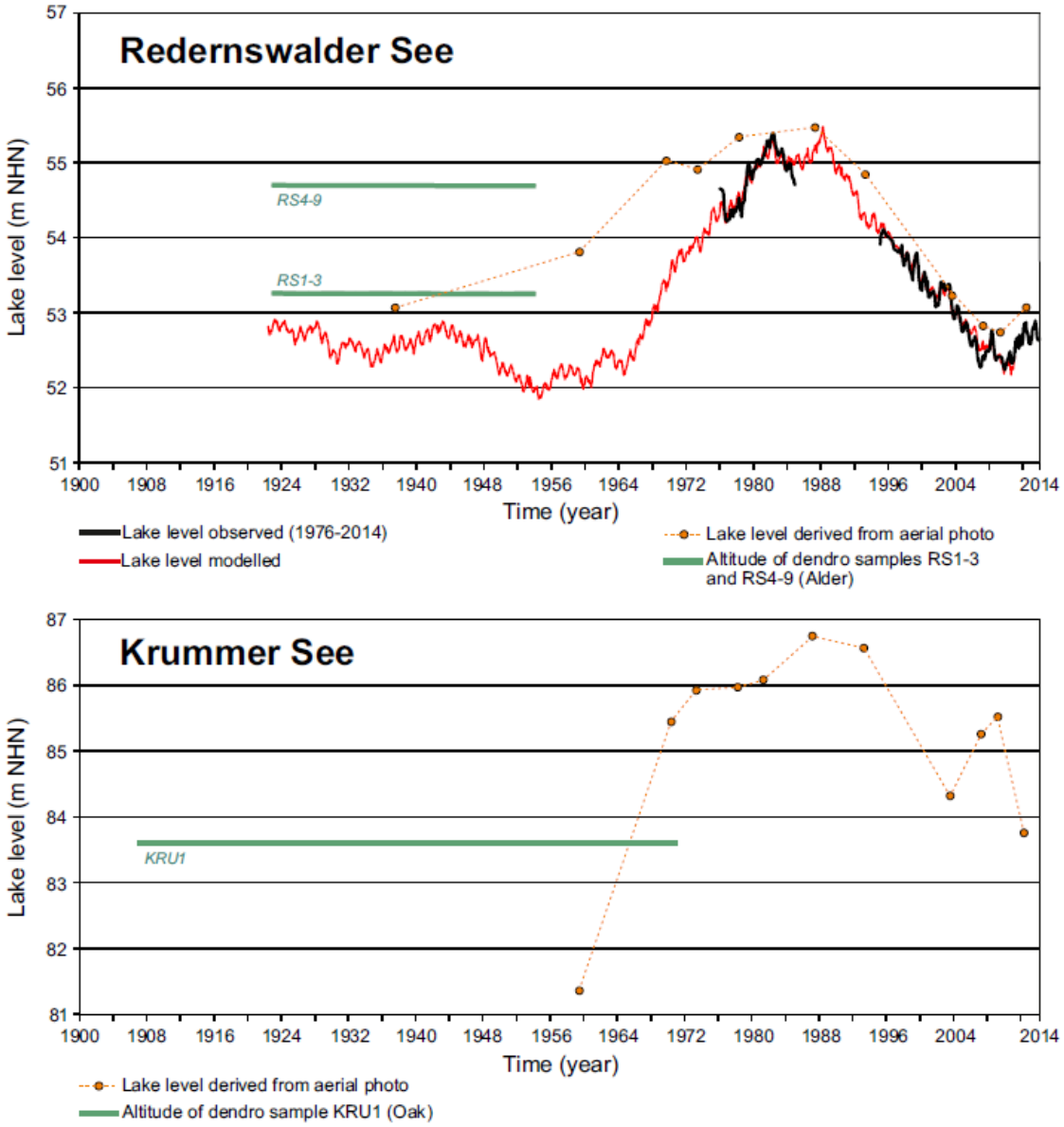


Lake-level equation:

$$W_i = W_{i-1} + bPrec_i + cEvaLake_i + d\frac{1}{n}\sum_{k=i-n}^{i}(Prec_k - EvaCatch_k) + (1 - e^{\frac{W_{i-1}-BC}{a}})$$

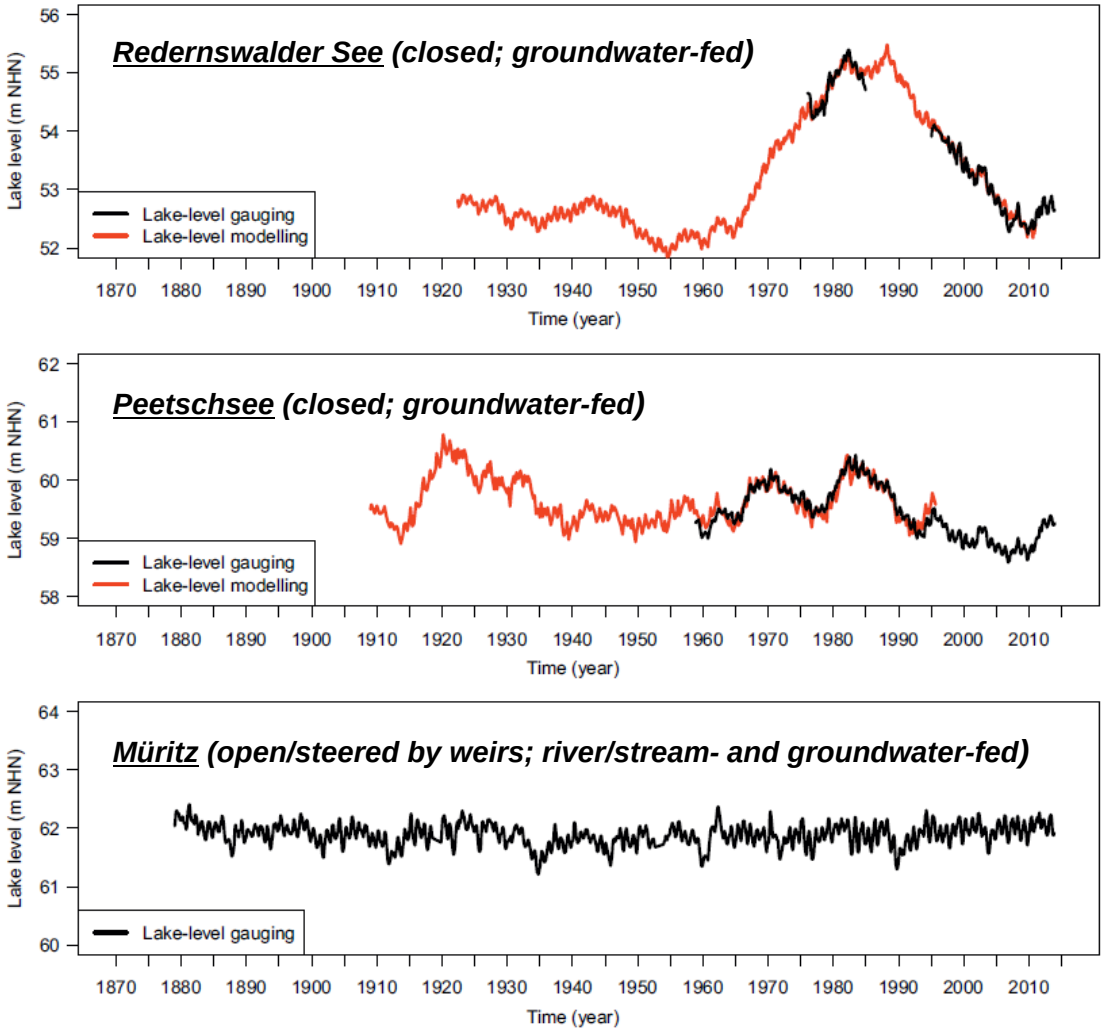
with
W_i – water level of time interval i in mm
W_{i-1} – water level of previous time interval in mm
$Prec_i$ – precipitation in mm
$EvaLake_i$ – evaporation from lake surface in mm
n – first interval of the analysed time period
BC – groundwater level of the lower boundary condition with 35 m a.s.l.
a, b, c, d – empirical parameters used for calibration

Synthesis

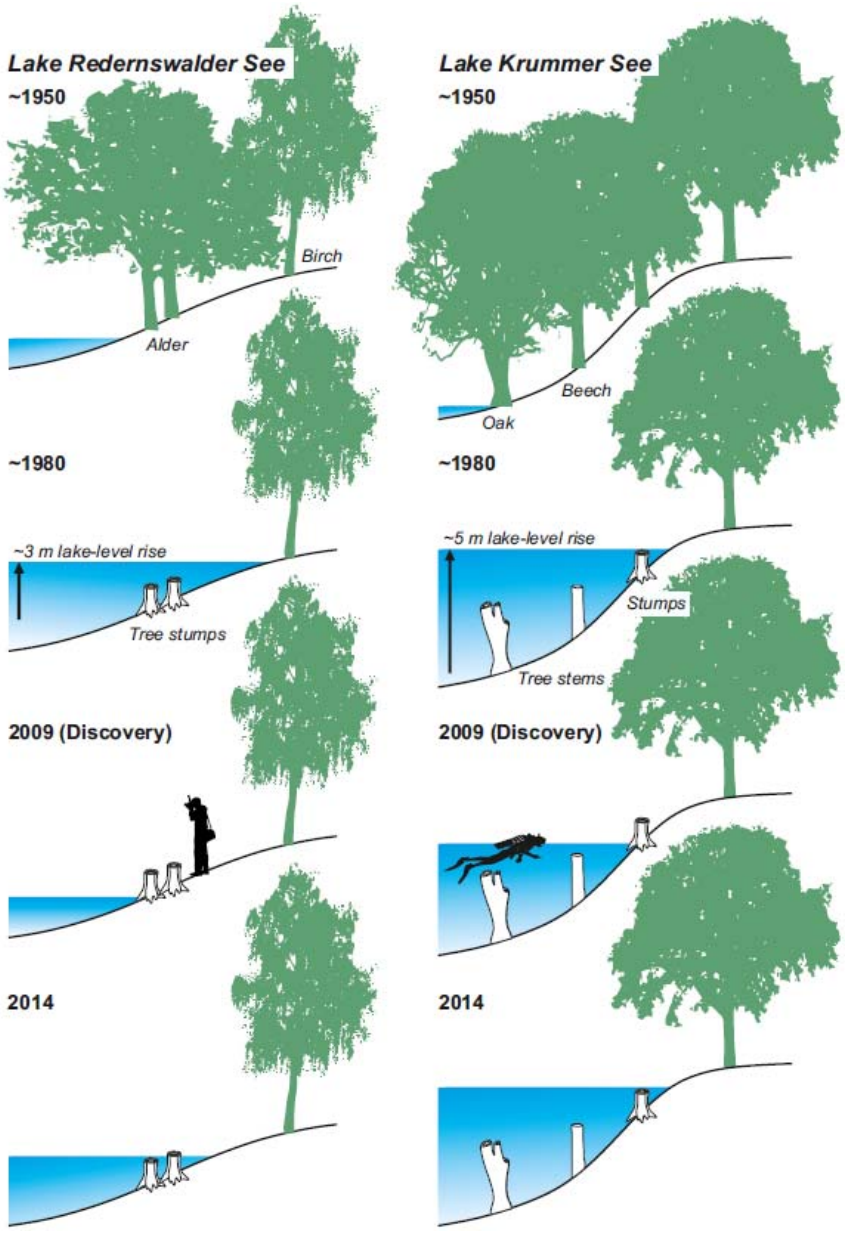


Both lakes show the same general (widely climate-depending!) lake-level dynamics during the last c. 90 yrs

Comparison of multi-decadal lake-level records from NE Germany



Available records differ depending on the hydrological lake type which modifies water feeding and lake level

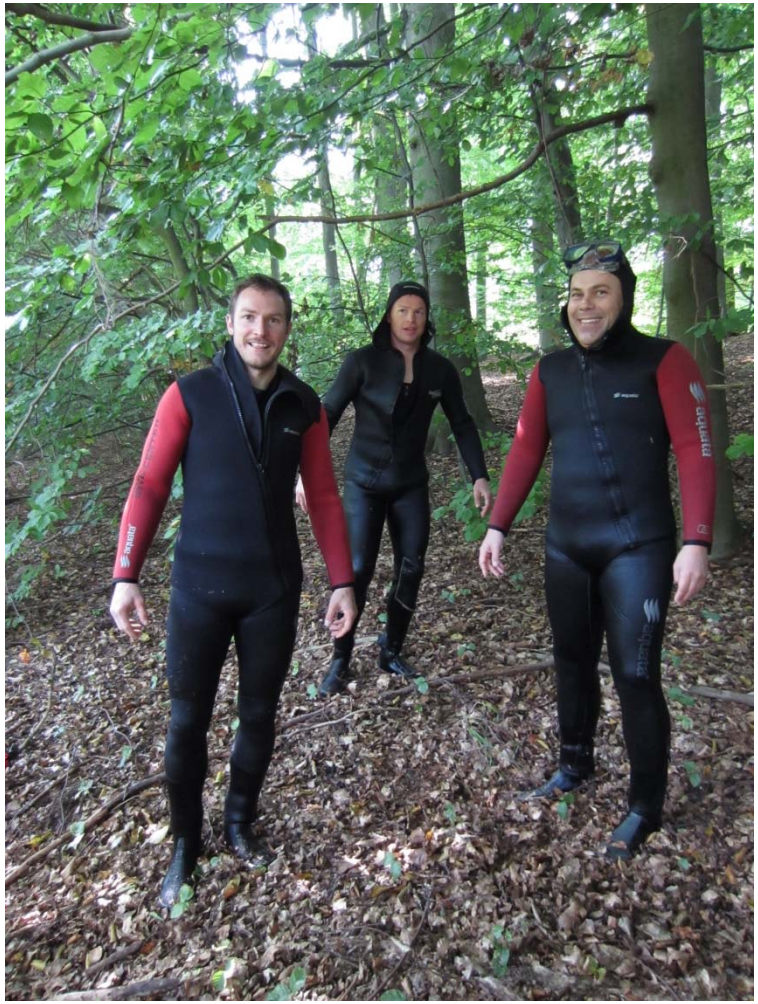


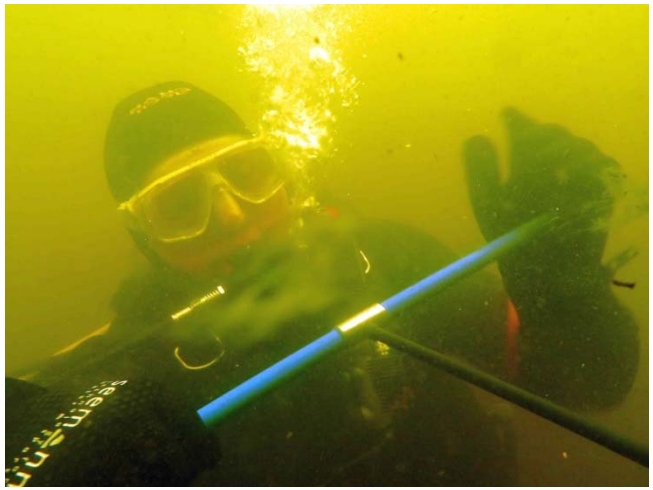
Synoptic sketch showing water-level dynamics, vegetation development and taphonomic processes

Conclusions

- Multi-decadal lake-level and groundwater-level dynamics help to understand the long-term water budget and its effects
- By applying a combined approach of gauging and proxy-data analysis as well as of retrograde modelling we were able to establish two consistent lake-level records covering the last c. 90 yrs
- Further multi-decadal records from the region reveal considerable variability

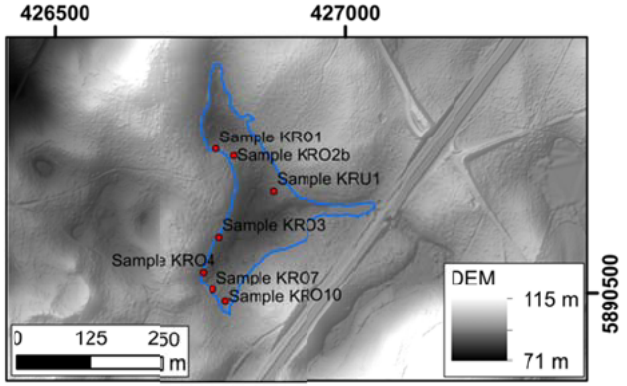
Switching between antagonistic environments: diving dendrochronologists...

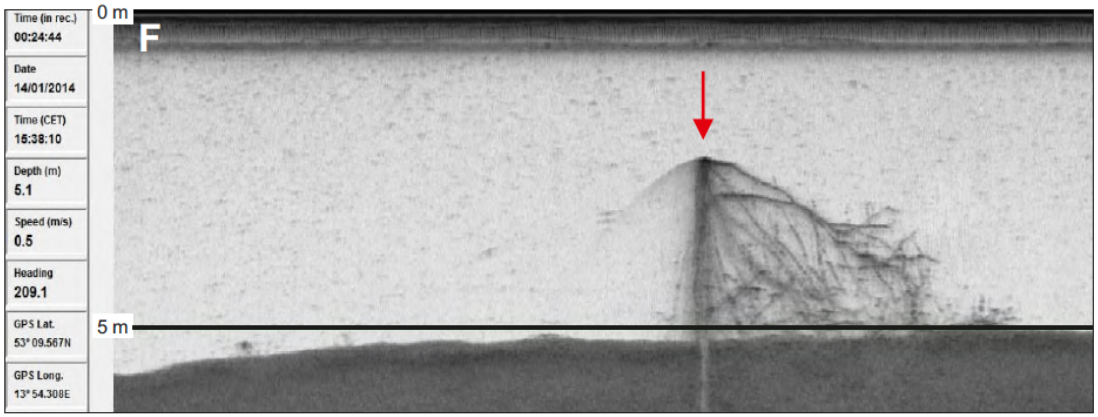


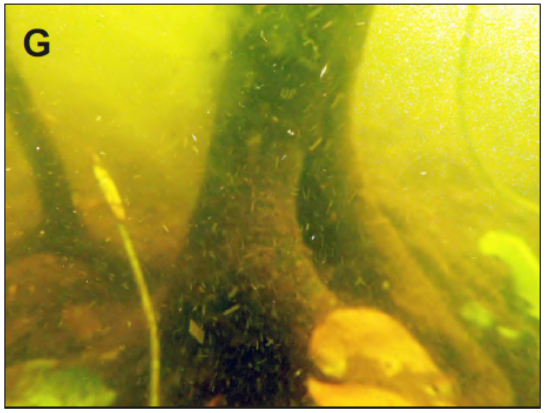


Thank you!

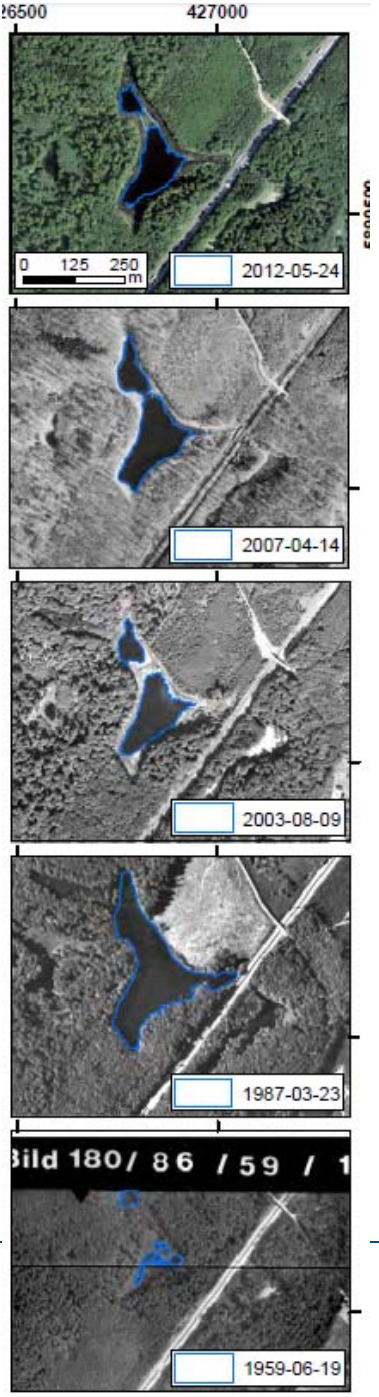
Tree remains in Lake Krummer See



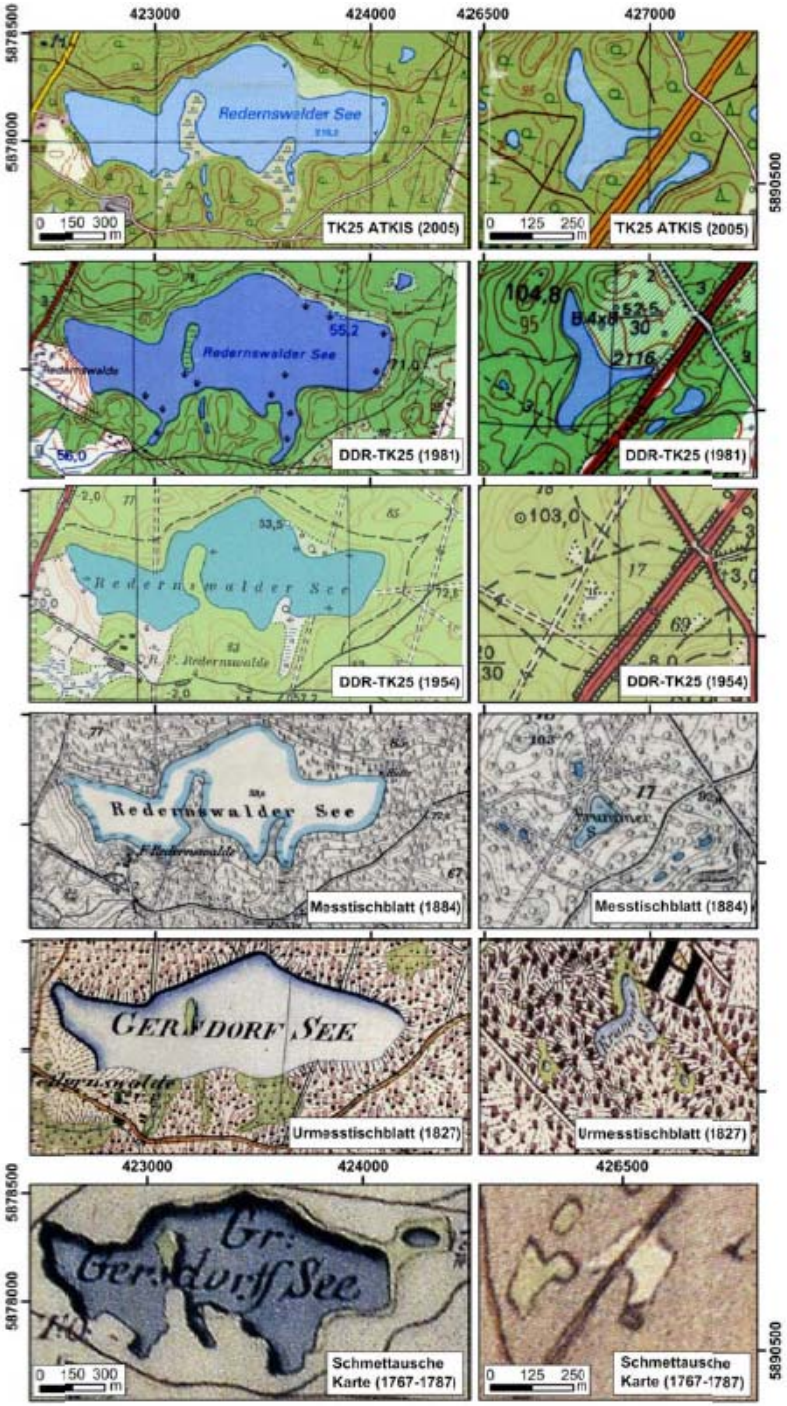




Aerial photos and digital orthophotos from Lake Krummer See



Sequences of historic-topographic maps



GFZ Helmholtz-Zentrum Potsdam

TERENO TERRESTRIAL ENVIRONMENTAL OBSERVATORIES

Supplement

AFT