Impact of Climate Change on Lake Neusiedl and potential adaptation strategies

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Outline

- Motivation
- Methods
- Results
- Adaptation strategies
- Some Conclusions

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Motivation

- Lake Neusiedl is a shallow “Steppensee” which means, that he has no natural outflow.

- Observed low lake levels showed first negative effects on tourism (especially sailing) in 2003.

- Drying out of lake Neusiedl has been observed several times in the past (last time in 1860s).

- Tourism at Lake Neusiedl and surrounding is an important regional economic factor.

- This region is an important European bird breeding region.
Motivation

Observed lake level fluctuations

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Die Ganglinie des Neusiedler Sees
1932-2003

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Method - Hydrology

Lake Catchment: 1.120 km²

Lake Area: ~ 315 km²

From this ~ 175 km² Reed

and 140 km² free water:

Lake depth: < 2m
Method - Hydrology

Water balance

Inflow:

Precipitation on the Lake 78 %
River discharge (manly the river Wulka) 20 %
Ground water inflow 2 %

Losses:

Evaporation 90 %
Channel (flood protection) 10 %
Lake evaporation:

**Dalton approach with reed correction**

\[ E_w = f(v) \times (e_s(T_{wo}) - e) \]

- \( E_w \) = Evaporation
- \( e_s \) = saturation water vapour at water temperature
- \( e \) = water vapour in air
- \( f(v) \) = wind function (linear for lake Neusiedl)
Method - Hydrology

Lake temperature: Richter approach

Observed and simulated water temperature in 2003

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Skills of the lake level model

Annual maximum and minimum Lake levels observed and modelled

Pegel [m ü.A.]


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Method - Climate

Observed climate

Temperature anomaly at the lake Neusiedl area

Datasource: ZAMG
Method - Climate

Observed climate

Precipitation anomaly in the Lake Neusiedl region

Datasource: ZAMG
Method - Climate

Scenario preparation:

- Based on ECHAM4 IS92a GHG only for 2000 - 2049.
- Statistical downscaling for temperature with analogue technique using relative topography 850-700 hPa as predictor field on daily base.
- Calibrating a weather generator (Lars Wgen) for periods 1961-1990 and 1991-2004 to Station Neusiedl.
- Run the weather generator for the periods 2010-2030 and 2030-2049 using only the temperature changes.
- Relative humidity is estimated from the Temperature diurnal range.
- Wind speed is set to observed monthly means.

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Climate change signal:

Observed and scenario for Temperature change in the lake Neusiedl region compared to 1961-1990

Graph showing temperature changes from January to December for the years 1991-04, 1991 to 2004, and 2030 to 2050, with a trend indicating warming throughout the year.

Jahresmittel:
91-04: 0.7
10-30: 1.9
30-50: 2.5

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Method - Climate

Model set up:

- With the average climate of the periods 1961-1990, 1991-2004 and the temperature change for 2010-2030 and 2030-2049 the weather generator was run for 500 years.
- For the scenario periods the weather generator was rerun with modified precipitation from -20% to +20% in 5% steps.
- The Lake model was driven by the several 500 year weather data on daily base.
Results

Increase of Lake Neusiedl evaporation compared to 1961-1990 due to temperature increase.

<table>
<thead>
<tr>
<th>Periode</th>
<th>Änderung [%]</th>
</tr>
</thead>
<tbody>
<tr>
<td>1991-2004</td>
<td>9.6</td>
</tr>
<tr>
<td>2010-2030</td>
<td>18.3</td>
</tr>
<tr>
<td>2030-2050</td>
<td>23.3</td>
</tr>
</tbody>
</table>

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Results

Modelled frequency distribution of lake levels beyond a given threshold (no precipitation change).

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Results

Return periods for lake levels beyond 115.2 m for different periods and precipitation changes.
Results

Return periods for different lake levels for the different periods and precipitation as in 1991-2004.

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Adaptation strategies

Only possibility to stabilize the lake level is to bring in water -
Two options are discussed:

- Water from the ground water table (Uferfiltrat) of the Danube.
- Water from the river Raab from the Hungarian side.
Adaptation strategies

Problem is the large amount of water – to rise the lake level 1 mm ~ 300,000 m³ water are needed.

To bring the water from the Danube to lake Neusiedl it has to be bumped an altitude of more than 30 m – Very energy intensive.

When the water is needed most, the river Raab also has very low discharge.
Adaptation strategies

Additional problems:

The mixing of the salty lake water with the Danube water may cause a clearing of the water, leading to massive growth of water plants.

Large additional water inflow may decrease the salinity and accelerate the growth of reed.
Some Conclusions

- Lake Neusiedl is very sensitive to climate change.
- A warming of 2.5 K leads to an evaporation increase of more than 20%.
- To compensate the evaporation losses an precipitation increase of + 20% is needed, which is not very likely looking on state of the art regional scenarios.
- Critical lake levels for tourism as 150.0 m will change there return period from some 250 years in the past to less then 10 years within the next decades.
- Adaptation seems to be possible but may be expensive and include some possible negative biological reactions in the lake.
Thank you for your attention!