Projecting the future levels of Lake Victoria

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Promotor: Prof. Dr. Nicole Van Lipzig
Copromotor: Prof. Dr. Wim Thiery
Future climate projections (RCP8.5)

Decreasing lake precipitation

Increasing lake evaporation

Source: Thiery et al (2016)
# Previous studies with water balance models

<table>
<thead>
<tr>
<th>Publication</th>
<th>Precipitation</th>
<th>Evaporation</th>
<th>Inflow</th>
<th>Outflow</th>
<th>Period</th>
<th>Resolution</th>
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<tr>
<td>Tate, 2004</td>
<td>Series of Sene and Plinston, 1994</td>
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<td>1925-2000</td>
<td>Monthly</td>
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<tr>
<td>Swenson and Wahr, 2009</td>
<td>Satellite observations (TRMM 3B43) combined with rain gauge data</td>
<td>Bulk formulae with satellite derived wind speeds, sea surface temperatures, near surface atmospheric humidity and temperature. Surface pressure from operational analyses</td>
<td>Decomposing of inflow in overland flow and subsurface flow. Overland flow: modelled proportional to precipitation. Subsurface flow: related to groundwater storage (GRACE satellite data)</td>
<td>Measurements until 2005 Afterwards: (i) residual term in WB. (ii) estimated from downstream satellite observations</td>
<td>1993-2008</td>
<td>Monthly</td>
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<td>Smith, 2014</td>
<td>Non-linear function of average rain gauge precipitation at 6 stations. Station precipitation obtained by interpolating satellite derived gridded precipitation (CRU TS 3.2)</td>
<td>Constant (1595 mm/yr)</td>
<td>Solved following parametrization of Tate (2007).</td>
<td>Agreed Curve solved iteratively</td>
<td>1959-2009</td>
<td>Monthly</td>
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</table>

→ Lack of observations over the lake
→ Large uncertainties
→ No research on future lake levels
→ GCMs have too coarse resolution

Note: GCMs = General Circulation Models
Objectives

1. Develop observation-based **water balance model** for Lake Victoria

2. Assess the skill of **present-day regional climate models** in reproducing historical levels of Lake Victoria

3. Project the **future levels** of Lake Victoria

4. Investigate the **role of the human management scenarios** at the dam for future fluctuations in water level of Lake Victoria
Water Balance Model

\[
\frac{dL}{dt} = P - E + \frac{Q_{in} - Q_{out}}{A_{lake}}
\]

- \( L \) = lake level [m/day]
- \( P \) = precipitation on the lake [m/day]
- \( E \) = lake evaporation [m/day]
- \( Q_{in} \) = inflow (rivers) [m³/day]
- \( Q_{out} \) = outflow (dam) [m³/day]
- \( A_{lake} \) = lake surface area [m²]

• Daily basis
• Observational period: 1993-2014 (21 years)
\[ \frac{dL}{dt} = P - E + \frac{Q_{in} - Q_{out}}{A_{lake}} \]

**Precipitation**

- **PERSIANN-CDR satellite product** (Ashouri et al., 2015)
- **COSMO-CLM² model output** (Thiery et al., 2015)

**Inflow**

- Curve Number method

**Outflow**

- Agreed Curve

**Evaporation**

- Annual evaporation map (mm/year)
- Satellite and model output maps for precipitation and evaporation
\[
\frac{dL}{dt} = P - \sum_i E_i - \sum_i Q_i
\]
CORDEX ensemble members

Precipitation

Evaporation
CORDEX ensemble members
CRCM5 – two model simulations (RCP4.5)
Future dam management scenarios

1. Constant outflow
   - low (outflow 1955)
   - high (outflow 1964)

2. Following Agreed Curve
Future lake levels following the Agreed Curve
Future outflow following the Agreed Curve

Future daily outflow according to Agreed Curve (following the CRCM5 RCP 4.5 simulation)
Main conclusions and outlook

1. Water balance model based on observations works

2. Current generation models are typically not able to reproduce the observed lake levels

3. Future lake levels according to one RCM and RCP4.5: decreasing trend following Agreed Curve outflow scenario

More climate simulations are needed!
- Bias correction on CORDEX simulations
Thank you for your attention
\[
\frac{dL}{dt} = P - E + \frac{Q_{in} - Q_{out}}{A_{lake}}
\]
Lake levels

Histograms of lake level change (CORDEX evaluation simulations)

CCLM4-8-17

CRCM5

HIRHAM5

RACMO22T

RCA4

REMO2009
Inflow

Histograms of inflow (CORDEX evaluation simulations)

- CCLM4-8-17
- CRCM5
- HIRHAM5
- RACMO22T
- RCA4
- REMO2009
Precipitation

Histograms of lake precipitation (CORDEX evaluation simulations)

CCLM4-8-17

CRCM5

HIRHAM5

RACMO22T

RCA4

REMO2009
CRCM5 – 2 model simulations
Simulations of CRCM5 with MPI-ESM-LR
CRCM5 – Climate change
Outflow in constant lake level scenario