HYDROLOGICAL MODELS
WULCA INPUT ON GLOBAL MODEL COMPARISON

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Main questions

- Water availability: total, surface water?
  - The models in the WATCH project provide both
  - Differences are very high (see also comparison paper of Boulay et al 2014)
  - WATERGAP has calibrated surface water flows, the other flows are probably even worse

- Specific groundwater/ surface water scarcity?
  - Or just overall availability

- Temporal resolution (monthly/annual)
- Spatial resolution (watershed / subwatershed/ grid cell)
Models

- Comparison of WATCH models vs. others
  - Fekete et al.
  - Aqueduct (any scientific publication?)
Enhanced availability data: Multi-model approach

- **Data source:** WATCH data for different models on a daily bases from 1953 to 2001 (average of 29 non-leap years) We take discharge of the grid cell with the largest mean annual discharge as the water availability of the corresponding watershed.

<table>
<thead>
<tr>
<th>Model name</th>
<th>Global discharge [E+13 m3/y]</th>
</tr>
</thead>
<tbody>
<tr>
<td>WaterGAP</td>
<td>4.8</td>
</tr>
<tr>
<td>JULES</td>
<td>5.3</td>
</tr>
<tr>
<td>H08</td>
<td>5.6</td>
</tr>
<tr>
<td>MPI-HM</td>
<td>3.3</td>
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<tr>
<td>LPJmL</td>
<td>6.2</td>
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</tbody>
</table>

Model results deviate even on a yearly global scale. As non of the models can be assumed to deliver more accurate results than another we will average the discharge over the above mentioned models.
**Enhanced availability data: Temporal resolution (I)**

- **Data source:** WATCH data for different models on a daily bases from 1953 to 2001

The total monthly discharge as well as the discharge distribution is model dependent.
Enhanced availability data: Timely resolution (II)

• How relevant is it for the different watersheds to consider monthly discharge?

![Map of the world showing different discharge variations.]

Ratio of the monthly difference between the average and the monthly discharge to the average discharge (for the WaterGAP model)

• The watersheds indicated in blue show smaller yearly discharge variations.
• The ones in yellow and reddish have larger discharge variations. For these watersheds it will therefore be of particular importance to consider an increased temporal resolution.
Groundwater recharge (I)

- **Data source:** Subsurface flow provided in the context of the WATCH project

Groundwater recharge is used as proxy for groundwater availability. It mainly depends on the precipitation (standardized in WATCH) and the separation factors assumed between surface and subsurface runoff.
Agricultural water consumption and withdrawal

- **Data source:** Timely resolute agricultural water consumption (and withdrawal) from Pfister et al. (2011)

Water consumption for crop irrigation on a watershed level.

- Yearly global water consumption for irrigation amounts to 844 km³.
- Comparison: This is approximately 60% of 1364 km³ reported by Rost et al. (2008) as consumptive blue water used for irrigation. Mekonnen et al. have similar results.

The monthly water consumption for irrigation is available too.
Sectoral water consumption and withdrawal

- **Data source:** Yearly sectoral water consumption and withdrawal (except for agriculture) for every 6th year from 1900-2002 (0.5°x0.5° cell size) provided by WATCH without temporal resolution.

- We use 2002 data for the manufacturing, the domestic, the electricity producing and the livestock sector aggregated to a watershed level.

Results for the domestic water withdrawal (left) and consumption (right)

- The yearly global consumptive water use (without agriculture) amounts to 200 km³
- Total yearly global water consumption (incl. agriculture) is 1044 km³/y with agriculture making up for 80 % of the total water consumption.
Groundwater use fraction (I)

- **Data source:** Time invariant fraction of the entire consumed water for agriculture that is assumed to be groundwater according to Döll et al (2011) (left) and the aggregation to watershed level (right).

Groundwater use fraction is specific to agricultural water consumption. The published use fractions for the domestic and industrial sector are assumed to be highly uncertain.
Groundwater use fraction (II)

- **Data source:** Alternatively the total groundwater abstraction given by Wada et al. (2010) could be used (not done so far).

Groundwater abstraction [mm/y] by Wada
Consumption to availability ratio (CTA)

• **Data source:** Watershed CTA provided by Flörke et al. (left) compared with the new CTA based on new consumption data (WATCH and Pfister et. al) and the WaterGAP (WATCH) discharge data (right).

• Same overall picture but with new data generally a smaller CTA ratio due to smaller water consumption
Water source specific CTA

• **Data source:** Total discharge (availability) and groundwater recharge based on WaterGAP model (WATCH).

Groundwater CTA (left) and surface water CTA (right) preliminary estimate modeled with the WaterGAP (WATCH) model

• In particular in south Asia (India) and the Arabic peninsula the CTA is larger if groundwater consumption and availability is considered instead of total water availability (compare to previous slide)