An Earth systems approach to irrigation research

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(and many, many others)

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Irrigation in the Earth System

June 2023 - Cross-disciplinary workshop to identify key needs for irrigation research

Advances and uncertainties in data and models

Key research questions

Entry points for transdisciplinarity

Irrigation in the Earth system: Priorities for data, modeling, and cross-disciplinary research

Irrigation in the Earth System

~70% of global freshwater withdrawals are used for agriculture

Reported data on areas equipped vs actually irrigated

Remotely sensed data:
- space vs time trade-offs
- may not resolve water applications or losses

Uncertainties in how much water is applied, to what crops, at what scales and when
Irrigation in the Earth System

Irrigation in the Earth system

Irrigation water requirements estimated with:
- root-zone soil moisture deficit
- crop-specific potential evapotranspiration

Results sensitive to these modeled processes and soil-root-plant-water formulations
Irrigation impacts on the Earth system

- Alters surface energy partitioning and water balance, feedbacks to atmosphere
- Impacts on agroecosystem carbon and nitrogen cycling
- Variability over space (local vs remote) and time (intraseasonal vs interannual)
Irrigation can decrease dry heat wave occurrences . . .

But maybe increase *humid* heat wave occurrences

WRF-CLM4 predicted irrigation *minus* census-constrained irrigation

Potentially overestimates irrigation-driven cooling
Convection resolving models can help to address irrigation impacts on precipitation.

Increased groundwater pumping during drought can draw water contaminated with agricultural nitrate.
Freshwater limitations pose major constraint
Agricultural development scenarios matter (increasing efficiencies and water infrastructure)
Future irrigation expansion should directly incorporate irrigation–Earth system interactions
**Coordinated irrigation research**

**IRRigation MIP (IRRMIP) Protocols**

Table 1: Configuration of the 1901-2015 AMIP-style simulations, all Tier1. For each ensemble, three perturbed initial condition ensemble members are requested.

<table>
<thead>
<tr>
<th>Experiment ID</th>
<th>Description</th>
<th>Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>hist-irr</td>
<td>Transient irrigation extent</td>
<td>For models in which transient irrigation extent is not possible, prescribed present-day irrigation extent can be used as an alternative (please document this in the IRRMIP spreadsheet if this is the case).</td>
</tr>
<tr>
<td>hist-nolrr</td>
<td>Irrigation extent kept constant at 1901 level</td>
<td>For models which apply irrigation flux as a forcing, the flux should be kept constant at 1901 levels. For models whose implementation of irrigation is parameterised in the source code, the input land cover data should be modified to keep the area equipped for irrigation constant throughout the simulation.</td>
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**Leads:** Yi Yao and Wim Thiery, VUB
Future work towards transdisciplinarity

Efforts to “better represent” irrigation in Earth system models/model components will benefit from cross-disciplinary - or even transdisciplinary - approaches

- **Epistemological concerns:**
  - Who is represented in “irrigation model” development
  - For whom - or to what ends - are we modeling irrigation?

- **Irreducible uncertainties:**
  - Where are important uncertainties located in both irrigation data and modeling?
  - Which can be addressed now, and how, and which cannot be reduced?

- **Model complexity:**
  - Adding more “realism” (notwithstanding uncertainties) leads to complexity
  - How to manage complexity? Leverage emerging thought/efforts on this
Thank you!

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