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Global dataset of monthly crop-specific irrigated areas around the year 2000

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Abstract

To assess virtual water trade in a globalised world, we need to differentiate water requirements of rainfed and irrigated agriculture in agricultural water balance modelling. The knowledge which crops grows where and when under either rainfed or irrigated conditions enables the modellers to calculate the shares of "blue" and "green" water and virtual water content more precisely than in previous studies. To obtain this aim, a global dataset of monthly crop-specific irrigated areas around the year 2000 is developed. The dataset considers 26 irrigated crop classes including all major food crops, permanent cultures, cotton, and irrigated managed grassland. For each month of the year (representative for the time period 1998 to 2002 around the year 2000) the irrigated area of each crop in each 5 arc minute grid cell (size 8 km × 8 km at the equator) is provided. As data sources mainly national statistics on harvested areas for both irrigated and rainfed crops and cropping calendars were combined with spatially explicit 5 arc minute grids of areas equipped for irrigation and a global data set of main crop types. The dataset generation is quite complex. First results are cropping calendars with harvested area for 221 countries and the intersection of areas equipped for irrigation with cropland extent. Global, continental and regional studies could take profit of the final dataset. It might be used for a broad range of applications such as water use, food production, biogeochemical cycles, besides the currently foreseen "blue" and "green" water balance calculation at global scale with WaterGAP. A similar global dataset of monthly crop-specific rainfed areas which is consistent with the irrigated areas is also being developed.

1 Introduction

Agricultural water balance modelling helps to assess the stress on water resources, especially on the scarce "blue water" in rivers, lakes and aquifers. The knowledge which crops grow *where* and *when* under either *rainfed or irrigated* conditions enables the modeller to calculate the volumes of "blue" and "green water" (the part of precipitation that evaporates or transpires through vegetation) used for crop growth more precisely than in former studies (CHAPAGAIN, A. K. and HOEKSTRA, A. Y. 2004; YANG, H. et al. 2006). The dataset under development considers 26 irrigated crop classes including all major food crops, permanent cultures, cotton, and irrigated managed grassland. For each month of the year the irrigated area of each crop in each 5 arc minute grid cell (size 8 km by 8 km at the equator), representative for 1998 to 2002, will be provided. A similar dataset of rainfed crops will also be produced.

2 Data and Methods

4 major datasets (A-D) are combined to calculate monthly crop-specific irrigated areas at a 5 arc min grid, all using comparable periods around the reference year 2000 (Fig. 1), for crop classes specified in Tab. 1.

A) Areas equipped for irrigation (AEI), 5 arc min grid, SIEBERT, S. et al. (2006).

B) Cropland extent, 5 arc min grid (University of Wisconsin). Last published in RAMANKUTTY, N. and FOLEY, J. A. (1998).

C) Cropping calendars of 26 irrigated crop classes, with monthly actually irrigated area and total (annual) harvested area of each crop. Level: national (221 countries or areas) or sub-national (for 7 of the countries, on regional and province or state level: Argentina, Australia, Brazil, China, India, Indonesia, USA). Calendars are from e.g. FAO (2005) and USDA (1994).

D) Harvested crop areas for currently 23 crop classes, irrespective of whether being irrigated or rainfed, 5 arc min grid (University of Wisconsin). Last published in LEFF, B. et al. (2004).

From datasets A and B the minimum areas is derived. Joining with the maximum monthly crop area for each entity from the tabulated cropping calendar (C) results in the maximum extent of irrigation within the year on a 5 arc min grid.

Finally, the maximum monthly extent, the cropping calendar (C) and the rainfed and irrigated harvested area (D) are combined in different steps in order to spatially distribute the crop-specific irrigated areas for each crop and each month of the year on a 5 arc min grid.

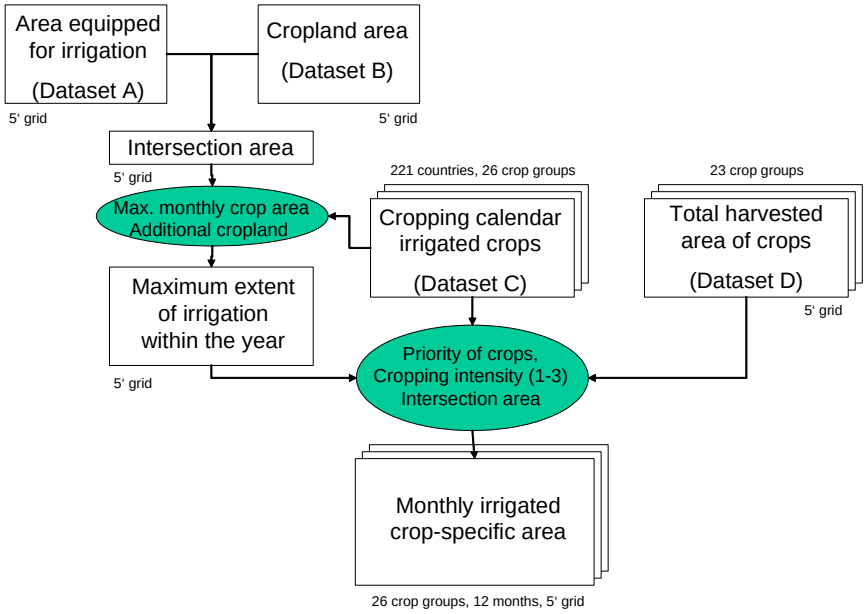

Fig. 1: Data fusion scheme for the calculation of monthly crop-specific irrigated areas

Tab. 1: Considered crop classes

No.	Crop	No.	Crop
1	Wheat	14	Oil palm fruit
2	Maize	15	Rapeseed / Canola
3	Rice	16	Groundnuts / Peanuts
4	Barley	17	Pulses
5	Rye	18	Citrus
6	Millet	19	Date palm fruit
7	Sorghum	20	Grapes/Vine
8	Soybeans	21	Cotton
9	Sunflower	22	Cocoa
10	Potatoes	23	Coffee
11	Cassava	24	Others perennial
12	Sugar cane	25	Managed grassland
13	Sugar beets	26	Others annual

3 Preliminary results

Starting from AEI as the reference that includes possibly fallow land, the cropland extent dataset not necessarily covers the equipped areas. However, for most grid cells, more than 95 % of AEI is covered by cropland as given in the cropland extent dataset (Fig. 2).

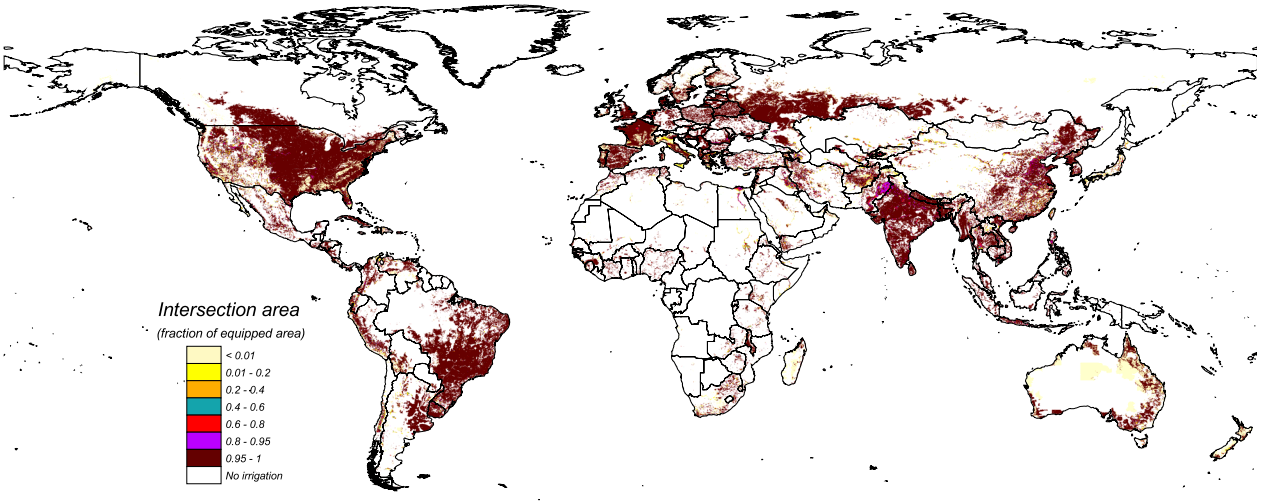

Fig. 2: Fraction of AEI that is covered by cropland extent dataset, for 2000

Global sums of monthly irrigated crop area of 4 major selected crops (wheat, rice, maize, cotton) show different annual cycles (Fig. 3). The rice cycle reflects multi-cropping in the major production regions, while irrigated wheat production is predominantly winter wheat. Maize and cotton are mainly grown during northern hemisphere summer.

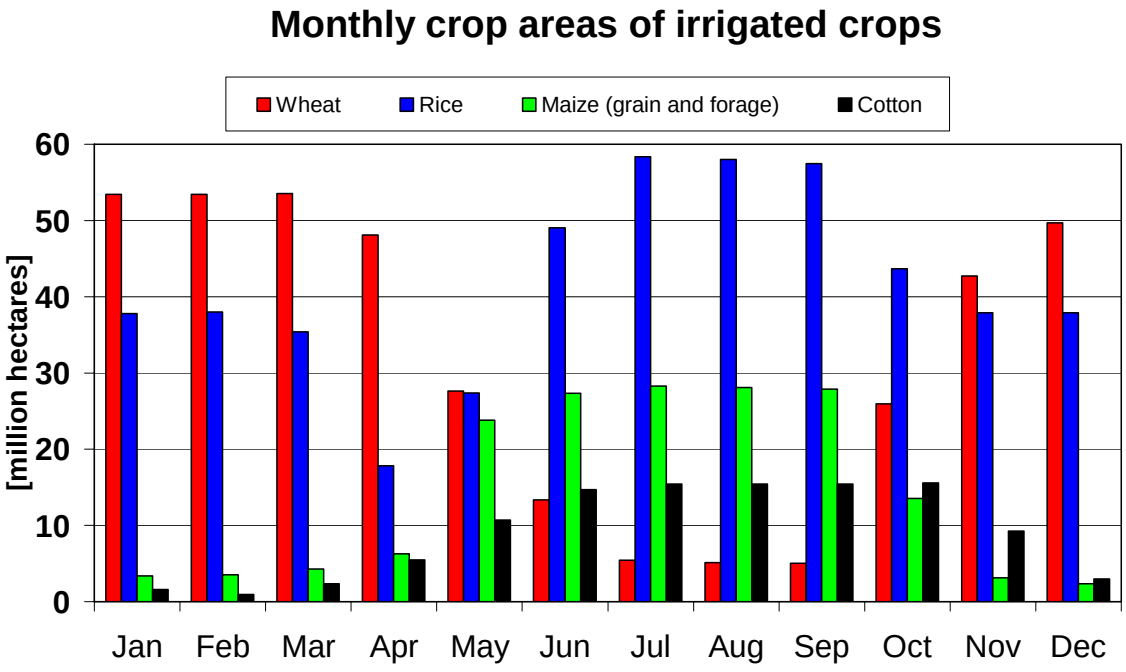

Fig. 3: Global monthly irrigated crop area of wheat, rice, maize, and cotton, in ha, for 1998-2002

4 Discussion

The generation of the global monthly crop-specific irrigated areas on a high-resolution 5 arc min grid is quite complex, as consistency to defined values of area equipped for irrigation (AEI) and harvested area is required.

Spatial resolution of the gridded data sources is high (8 km by 8 km at the equator) and location mismatch of AEI, cropland extent, and crop harvested area could result in zero overlap. However, the spatial match is good on a global scale (Fig. 2).

In the statistics, the discrimination of irrigated/non-irrigated areas for whole crop groups or for specific crops is not always present. Unspecified crops were put into the group "others". This means, that the area of crops no. 1 - 23 is a conservative estimation.

The cropping calendars are simplified, especially with respect to multiple cropping periods.

The global averages of monthly crop-specific irrigated area of 4 selected major crops show different annual courses (Fig. 3).

Our preliminary work results in global irrigated harvested area of 315 million ha, on 279 million ha of area equipped for irrigation as defined by SIEBERT, S. et al. (2006). Based on remote sensing, THENKABAIL, P. S. et al. (2006) estimated 481 million ha harvested area.

The final dataset can be used for assessing at global, continental, or regional scales

- "blue" and "green" virtual water trade
- water use, e.g. with WaterGAP (DÖLL, P. and SIEBERT, S. 2002)
- food production
- biogeochemical cycles.

References

FAO - FOOD AND AGRICULTURE ORGANIZATION OF THE UNITED NATIONS (2005): Aquastat review of agricultural water use per country - irrigation cropping calendar. http://www.fao.org/ag/agl/aglw/aquastat/water_use/index.stm, 2005-09-19.

USDA - UNITED STATES DEPARTMENT OF AGRICULTURE (1994): Major world crop areas and climatic profiles. USDA Agricultural Handbook, No. 664, Joint Agricultural Weather Facility (JAWF) of United States Department of Agriculture (USDA) - World Agricultural Outlook Board and of United States Department of Commerce - National Oceanic and Atmospheric Administration (NOAA), Washington, D.C., xii, 279.

CHAPAGAIN, A. K. and HOEKSTRA, ARJEN Y. (2004): The water footprint of nations - volume 1: Main report. Value of Water Research Report Series No. 16 - Vol. 1, UNESCO-IHE Institute for Water Education, Delft, 76.

DÖLL, PETRA and SIEBERT, STEFAN (2002): Impact of climate change and variability on irrigation requirements: A global perspective. *Climatic Change*, 28(4): 8.1-8.10.

LEFF, BILLIE; RAMANKUTTY, NAVIN and FOLEY, JONATHAN A. (2004): Geographic distribution of major crops across the world. *Global Biogeochemical Cycles*, 18(GB1009): 1-27.

RAMANKUTTY, NAVIN and FOLEY, JONATHAN A. (1998): Characterizing patterns of global land use: An analysis of global croplands data. *Global Biogeochemical Cycles*, 12 (4): 667–685.

SIEBERT, STEFAN; HOOGEVEEN, JIPPE; DÖLL, PETRA; FAURES, JEAN-MARC; FEICK, SEBASTIAN and FRENKEN, KAREN (2006): The digital global map of irrigation areas - development and validation of map version 4, Tropentag 2006, Bonn.

THENKABAIL, P. S.; BIRADAR, C. M.; TURRAL, H.; NOOJIPADY, P.; LI, Y. J.; VITHANAGE, J.; DHEERAVATH, V.; VELPURI, M.; SCHULL, M.; CAI, X. L. and DUTTA, R. (2006): An irrigated area map of the world (1999) derived from remote sensing. Research report No. 105, International Water Management Institute (IWMI), Colombo, Sri Lanka, 65.

YANG, HONG; WANG, L.; ABBASPOUR, KARIM C. and ZEHNDER, ALEXANDER J. B. (2006): Virtual water trade: An assessment of water use efficiency in international food trade. *Hydrology and Earth System Sciences*, 10: 443-454.