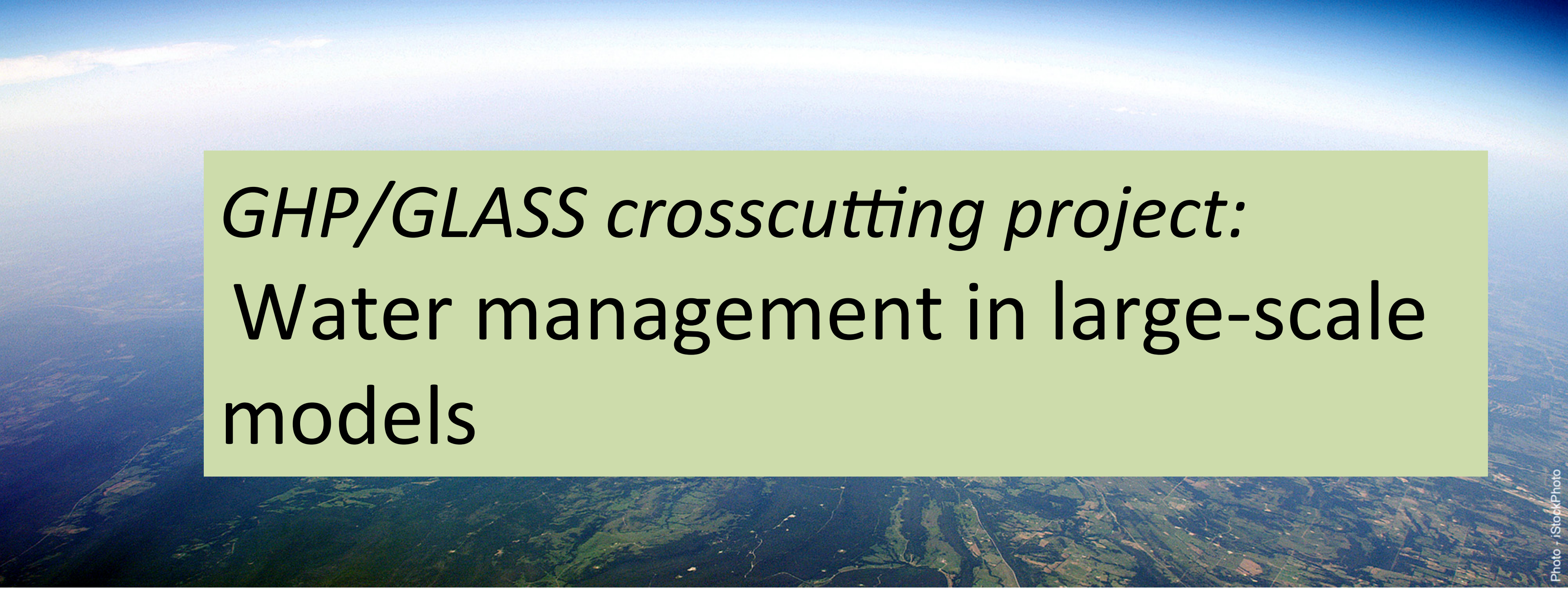

GHP/GLASS crosscutting project: Water management in large-scale models

Jan Polcher , Richard Harding , Aaron Boone , Martina Flörke , Taikan Oki and Pere Quintana Seguí and others

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Background

WCRP Grand Challenge:

Water for the Food Baskets of the World

"how will a warming world affect available fresh water resources globally, specifically in the food basket regions, and how will it change human interactions with these resources and their value to society?"

GEWEX question 3

Global Water Resource Systems: *How do changes in land surface and hydrology influence past and future changes in water availability and security?*

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The Nexus of Land, Food, Energy and Water

In 2012 850 million (or 15 percent) of the world population were chronically undernourished

By 2050 there will be a further 2 billion people to feed by 2050

One-fifth of the world's population already live in countries with water scarcity

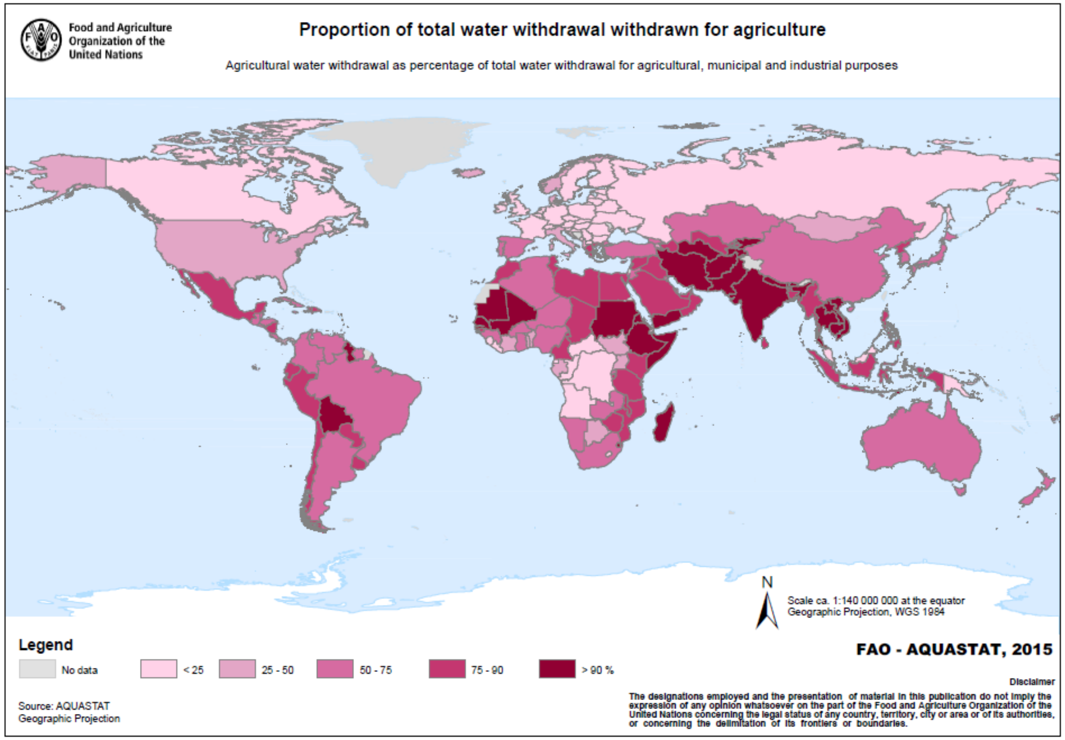
48% of the worlds rivers are moderately or severely affected by dams

Groundwater levels are dropping over most of the major irrigated regions of the world

Global Water Resources

TOTAL ANNUAL LAND PRECIPITATION = 115×10^3 KM^3
TOTAL ANNUAL RUNOFF = 49×10^3 KM^3
TOTAL CAPACITY OF RESERVOIRS = 7.4×10^3 KM^3
ANNUAL WATER USE FOR IRRIGATION = $\sim 1.5 \times 10^3$ KM^3
UNSUSTAINABLE GROUNDWATER EXTRACTION = 0.23×10^3 KM^3 YR^{-1}

Total global land area = 149×10^3 km^2
Total irrigated area (year 2000) = 2.6×10^3 km^2



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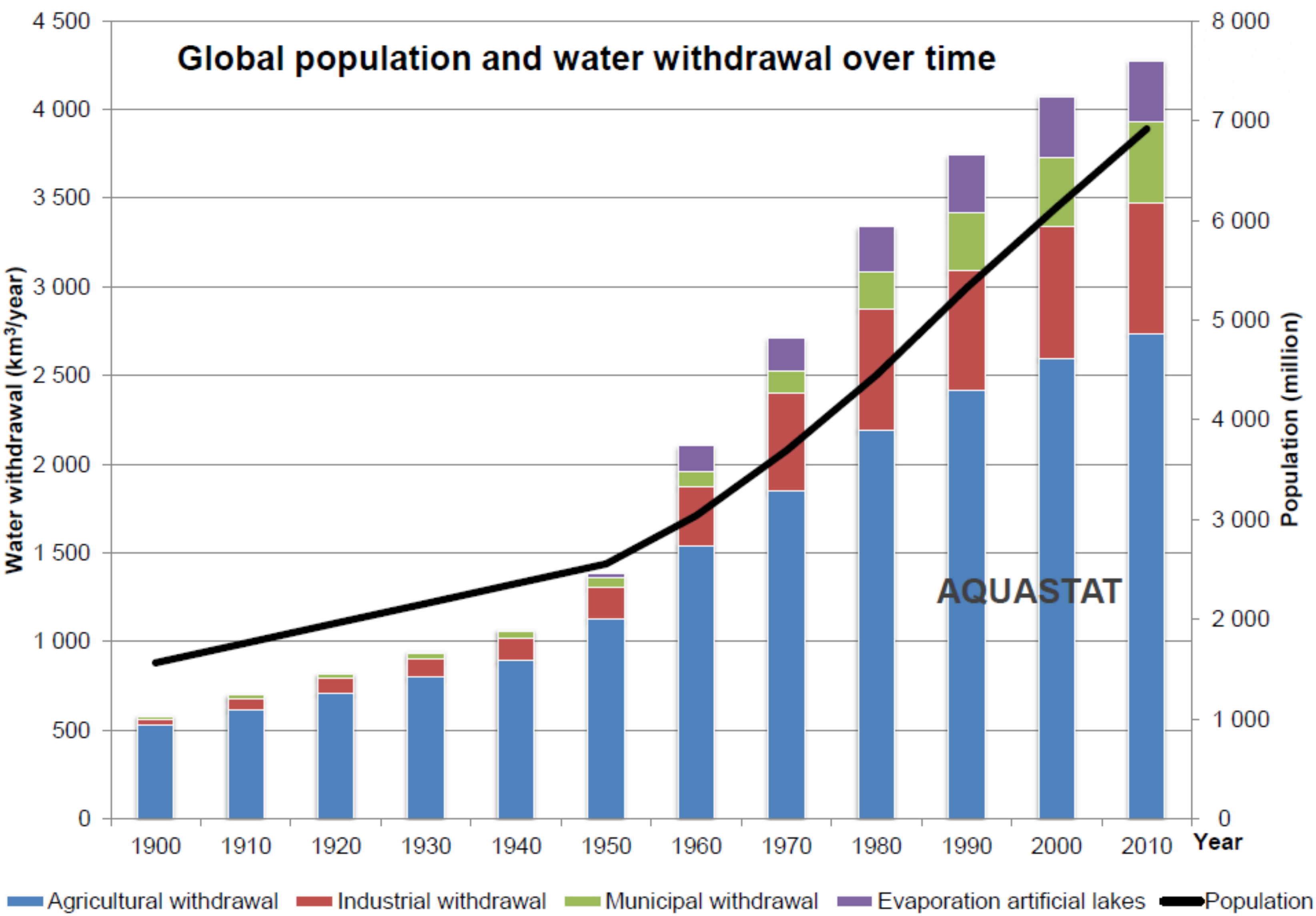
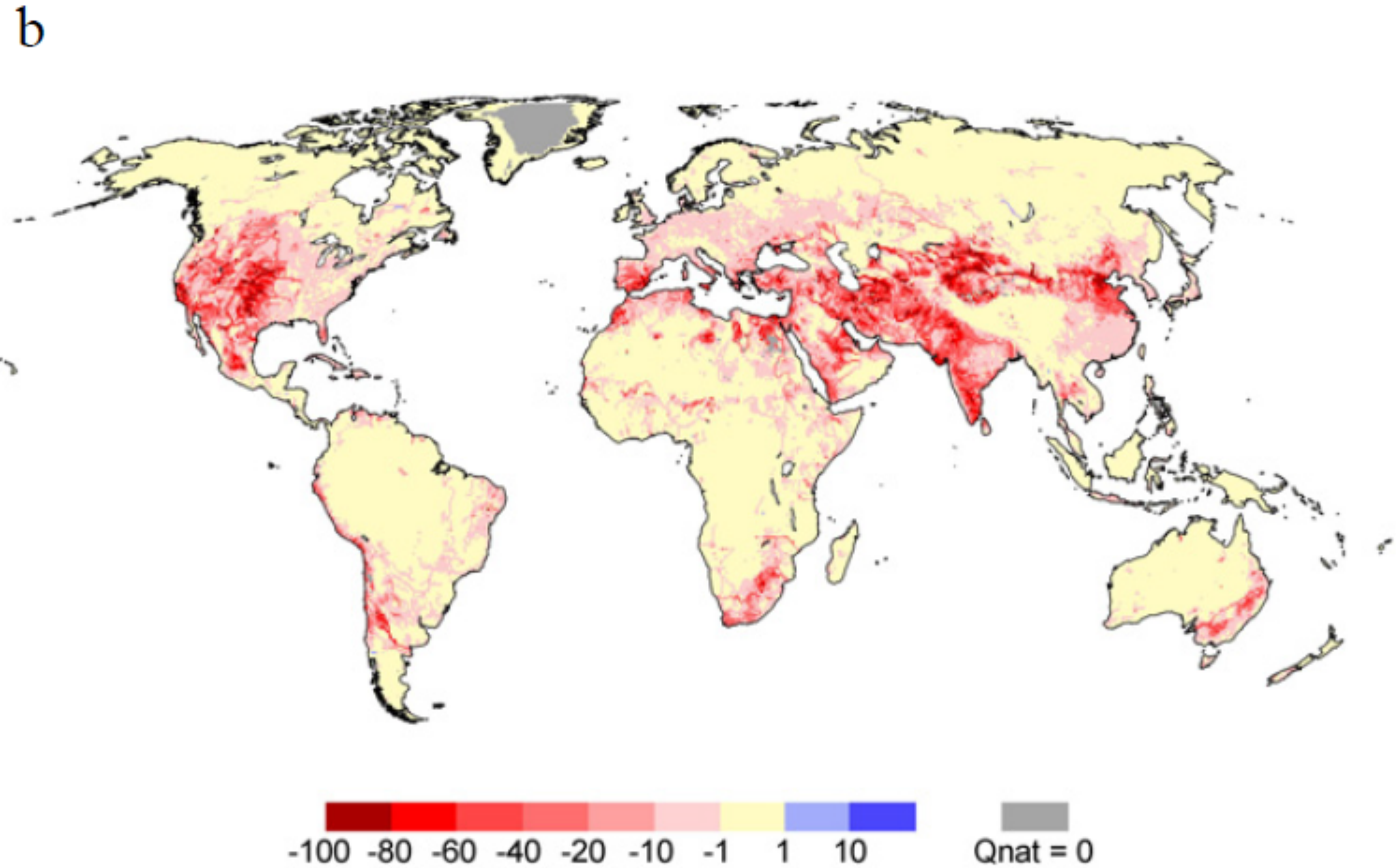
Global Water Use



http://www.fao.org/nr/water/aquastat/water_use/index.stm

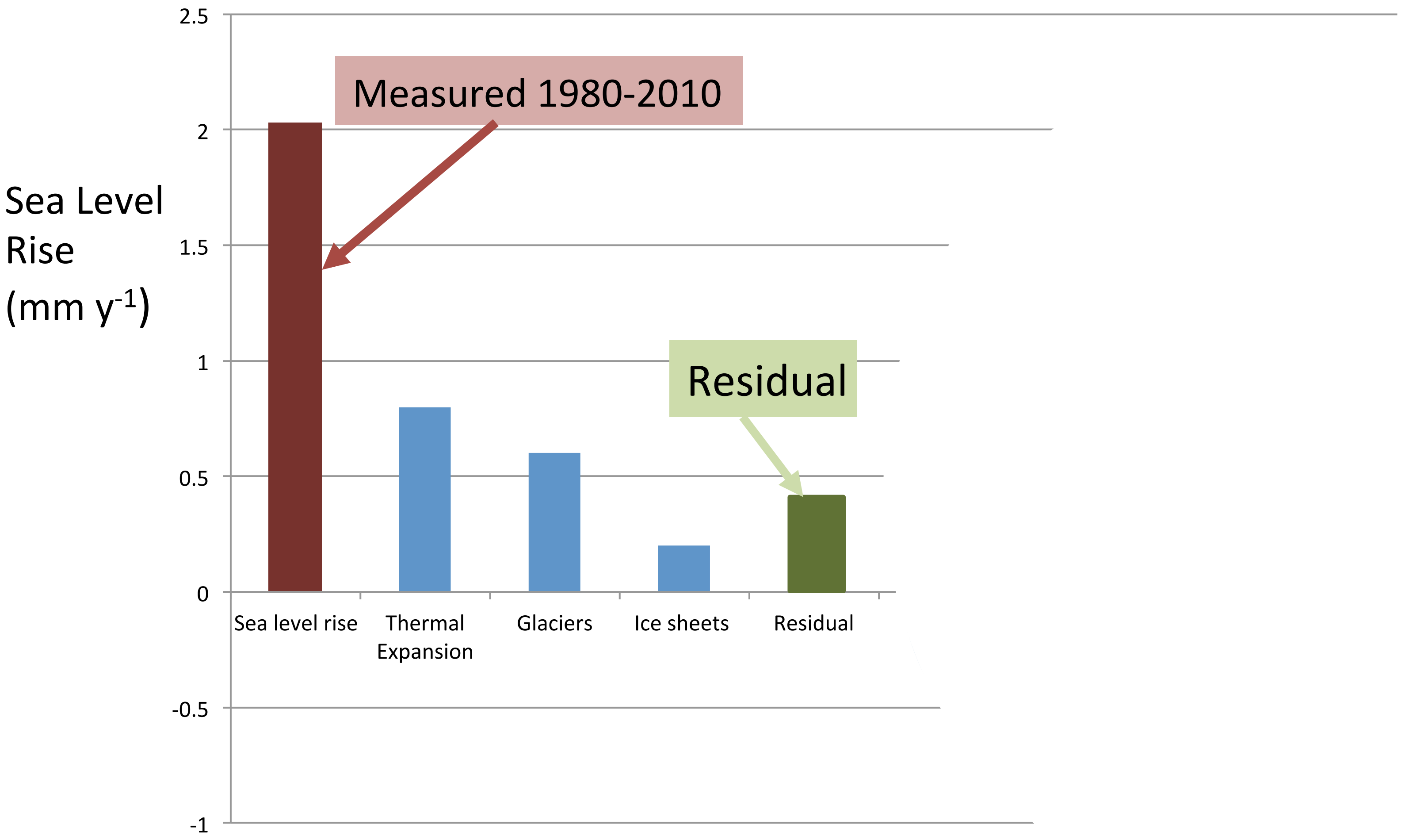
Date of preparation: September 2015

Anthropogenic impact on long-term average (1961–90) annual river discharges,



Doll et al 2009

Impact on sea level rise



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Water Scarcity 20th and 21st C

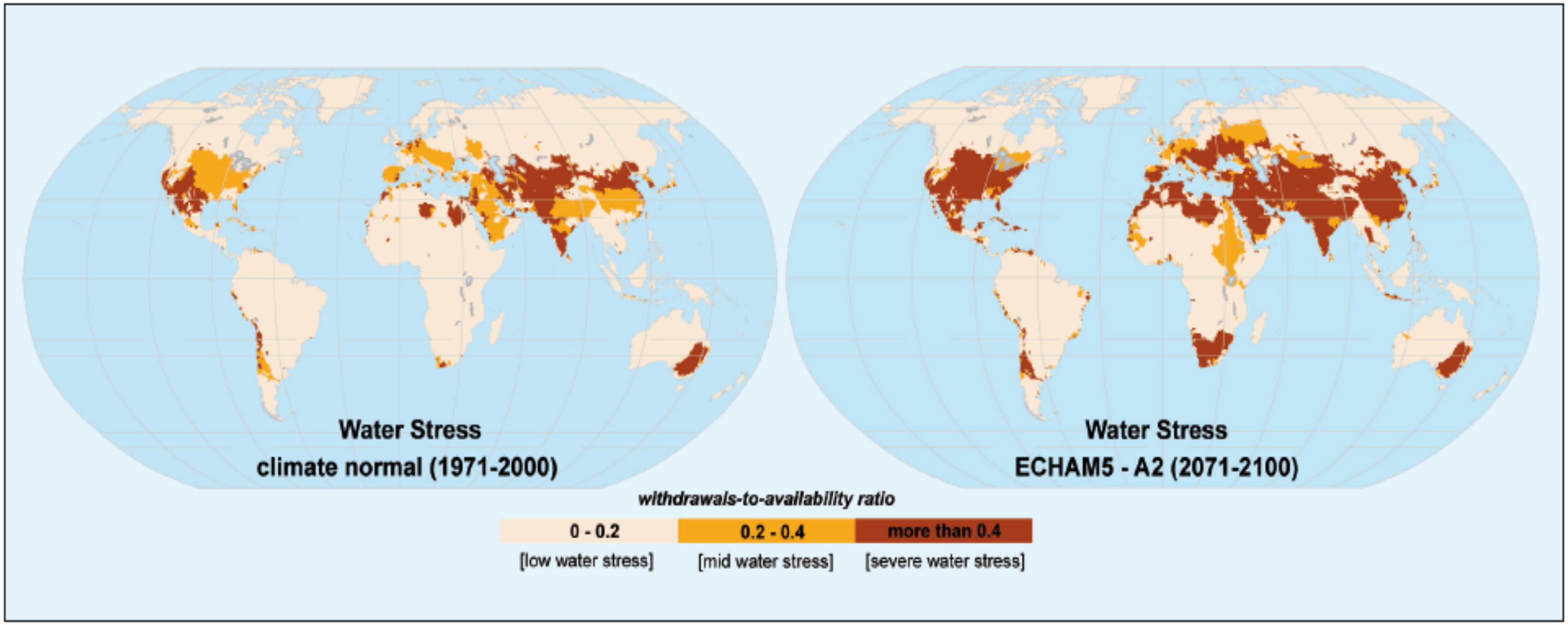

Figure 1: Water stress, calculated as the ratio between water withdrawals and availability, for the late 20th and 21st centuries (see Flörke and Eisner 2011).

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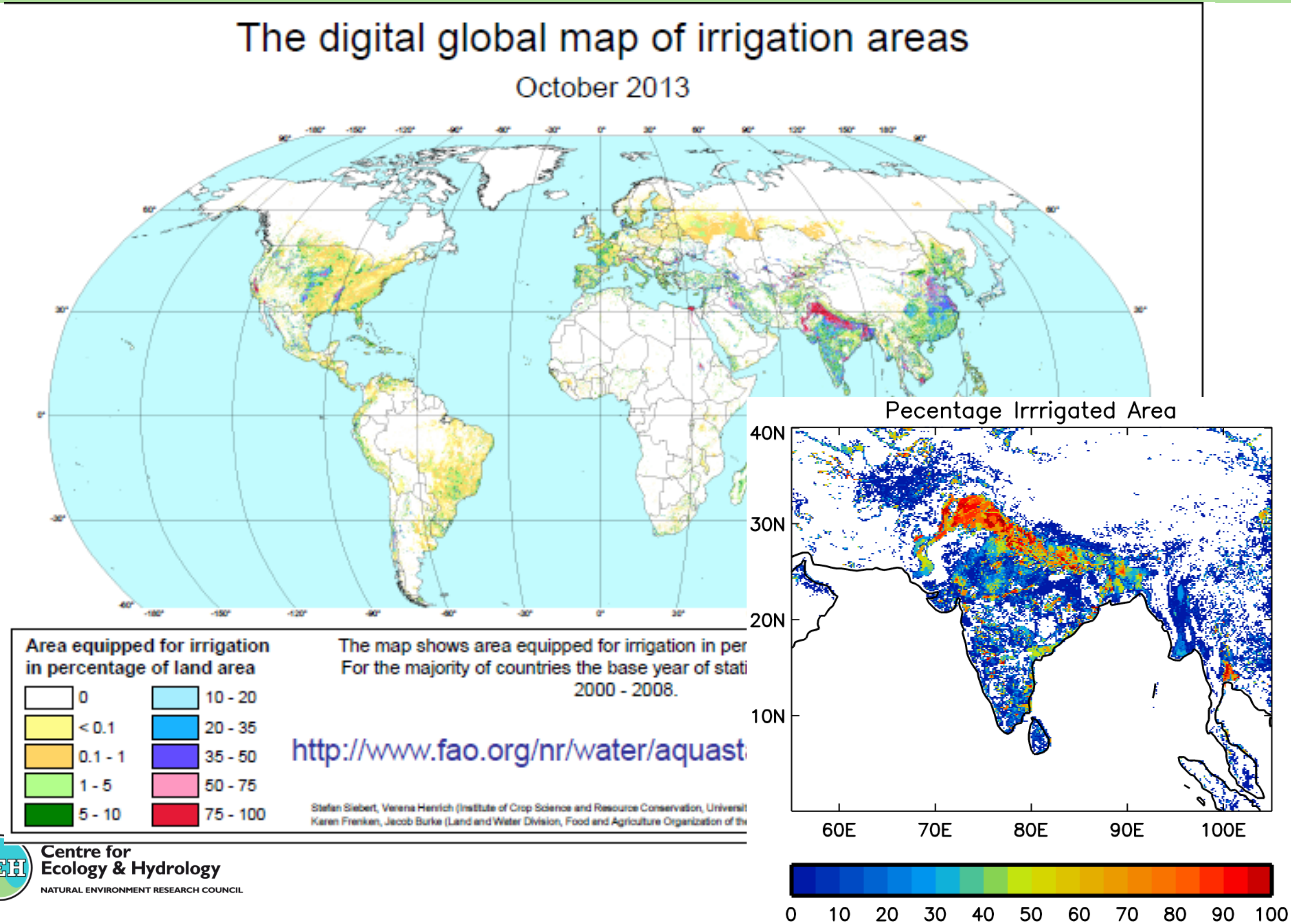
WATCH Water and Global Change

Percentage Irrigated area



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India: Water: sources and use

Renewable freshwater resources	
Precipitation (long-term average 1 170 mm/yr)	3.8×10^3 km^3 yr^{-1}
Internal renewable water resources (long-term average)	1.4×10^3 km^3 yr^{-1}
Total actual renewable water resources	1.9×10^3 km^3 yr^{-1}
Total dam capacity 2005	224 km^3
Water withdrawals	
Total water withdrawal 2010	761 km^3 yr^{-1}
per inhabitant 2010	630 m3/yr

Surface water and groundwater withdraw as % of total actual renewable water resources 2010 — 40 %

Non-renewable extraction (Wada et al 2011) — 68 km^3 yr^{-1}

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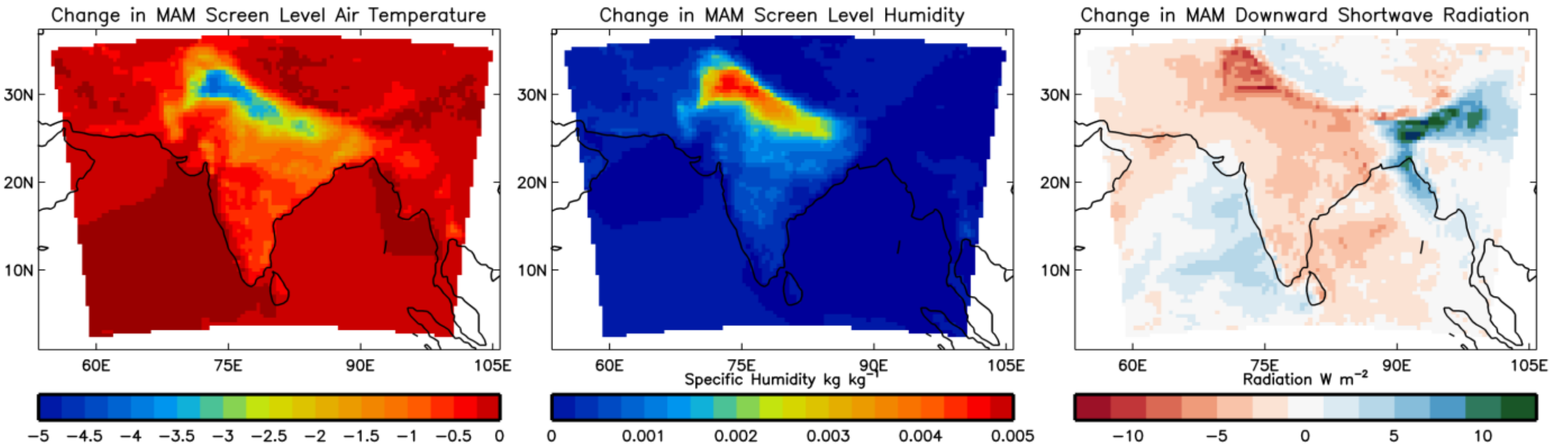
Impact of irrigation on temperature, humidity and cloud



changes in air temperature, humidity and downward shortwave radiation due to presence of irrigation in the RCM model during March, April and May averaged over a ten year period between 1990 and 2000

Rainfall recycling ratios of up to 60% for the whole of the Ganges basin during June, July and August

(Harding et al 2012)

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Clouds suppressed over irrigated areas

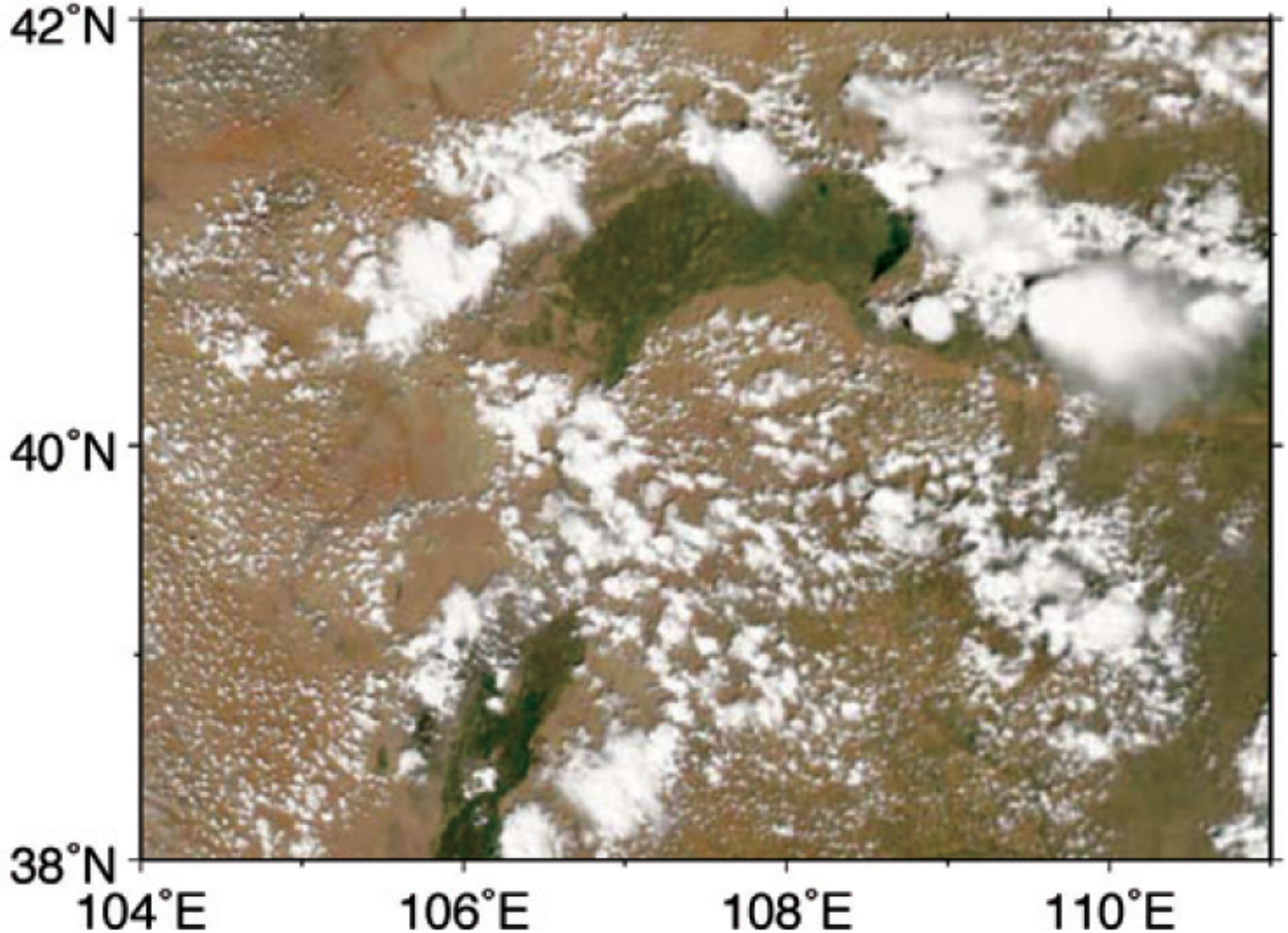
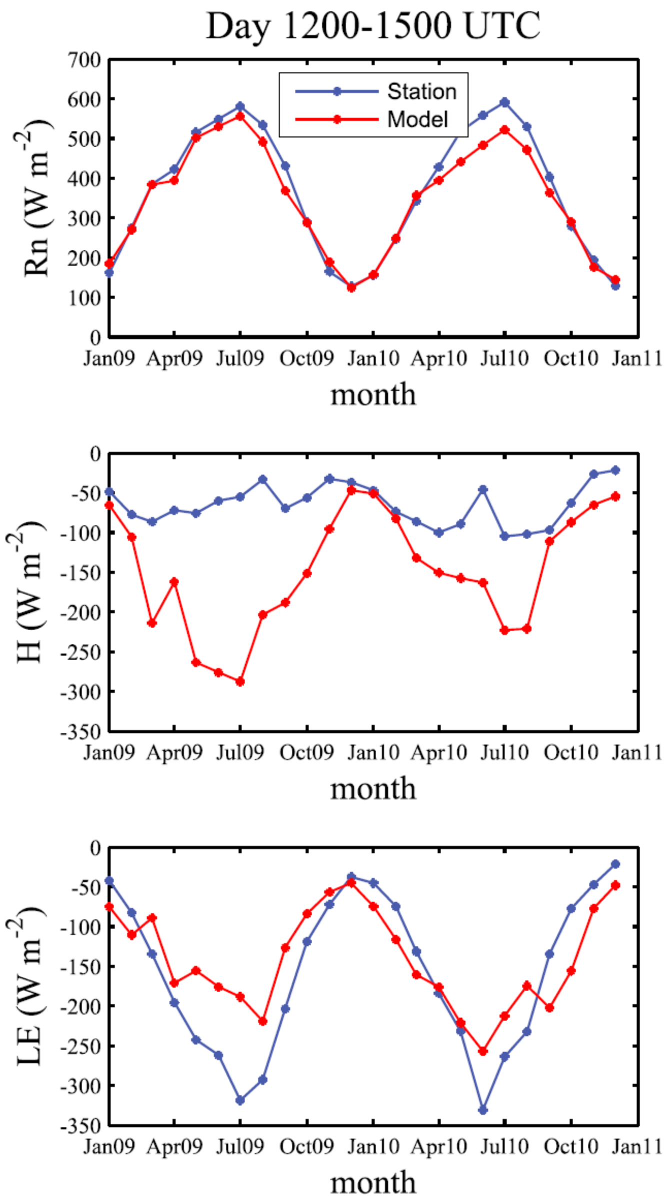


Figure 2. Clouds forming around the Heato irrigation district on the Yellow river in China. MODIS/AQUA true color image provided by T. Sato (personal communication).

ECMWF vs station measurement

Irrigated field,
Ebro Valley, Spain

Cuxart et al 2015



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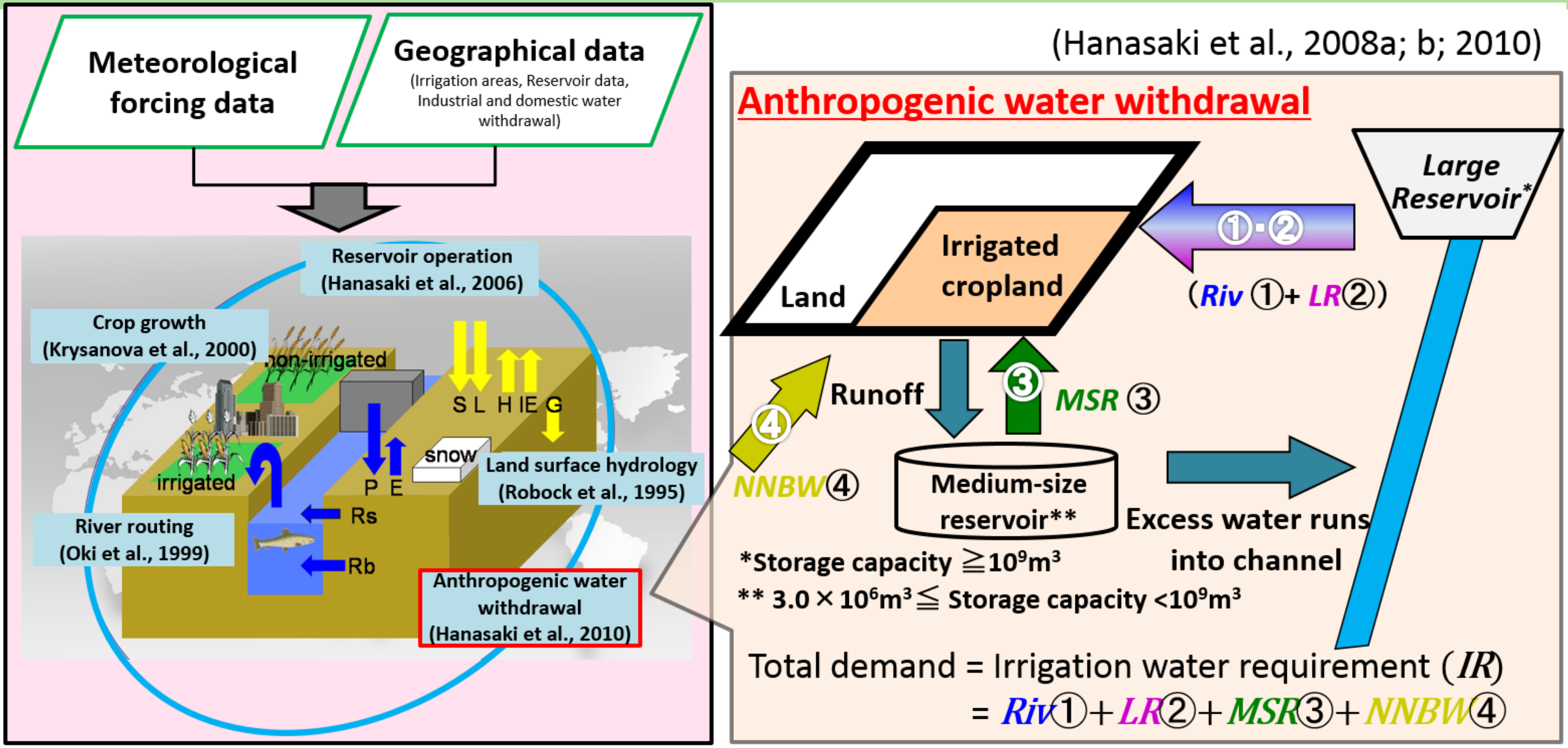
A Global Hydrology Model



S. Yoshikawa et al, 2014. An assessment of global net irrigation water requirements from various water supply sources to sustain irrigation: rivers and reservoirs (1960–2050). Hydrol. Earth Syst. Sci., 18, 4289–4310

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Demand and allocation into Climate models?

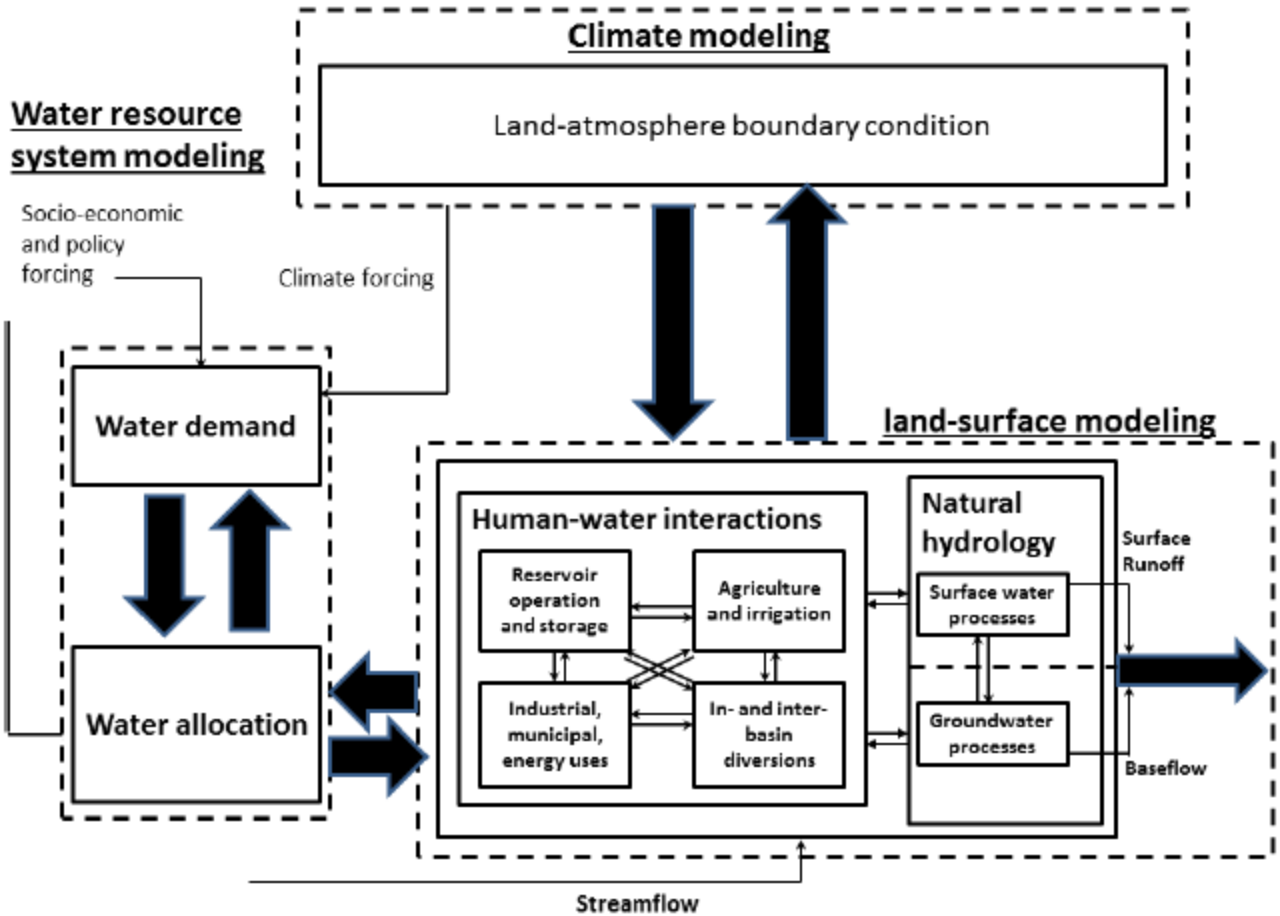

Figure 1. A fully coupled framework for inclusion of water resources management in a typical LSS grid.

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Nazami and Wheater 2014

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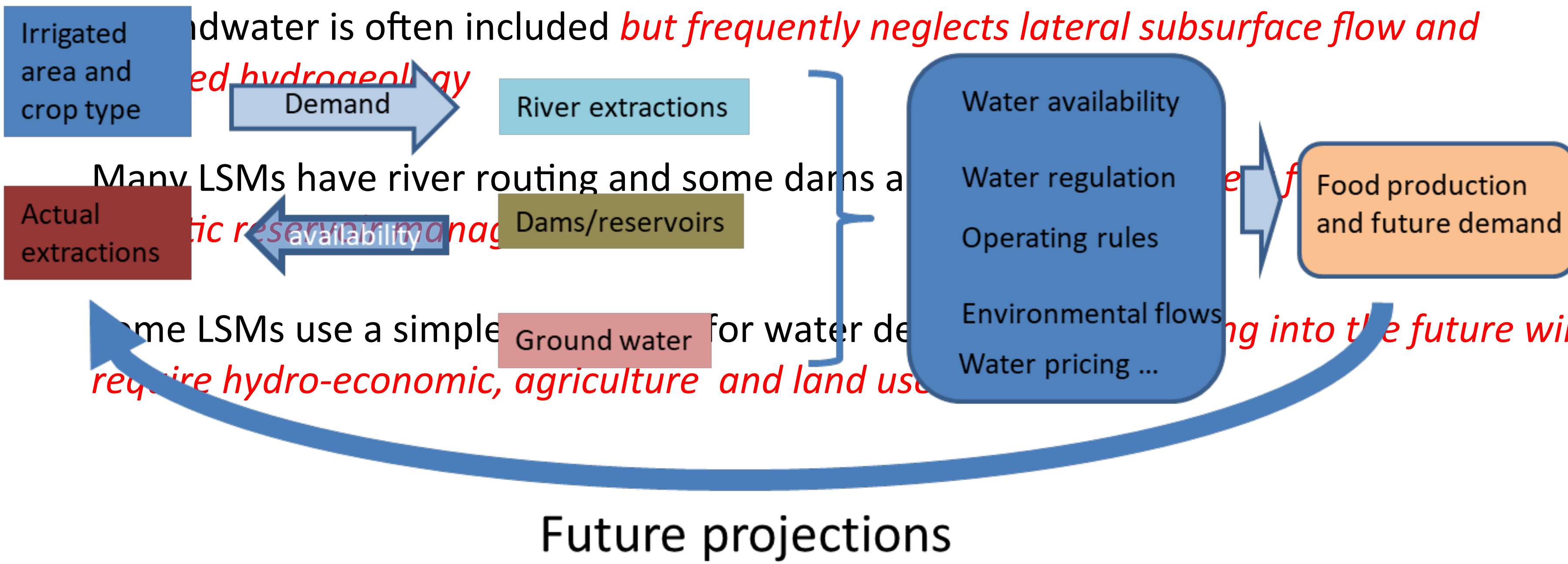
Current state of LSMs

Irrigation can be included by modifying soil water *stress* *but little scope for actual management and water conservation can be lost*

ndwater is often included *but frequently neglects lateral subsurface flow and*

Many LSMs have river routing and some dams a

me LSMs use a simple for water de *ng into the future will require hydro-economic, agriculture and land us*



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Gif-sur-Yvette Workshop conclusions

- Improve representation of dams *and operating rules*
- Improve representation of groundwater (IGRAC)
- Improve representation of actual irrigation use and extractions
- Develop strong links to agricultural and socio-economic communities and models to project future scenarios for agriculture and water use
- Work with RHPs to develop test beds for model development and validation
- Developing a GEWEX crosscutting theme: *Human Regulation of Water Cycle or Water Management in Large-scale Models?*

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Future activities?

- Modelling case studies in RHPs?
- Review paper and or white paper?
- GEWEX Conference: Nexus of water, energy, and food Session
- What else?

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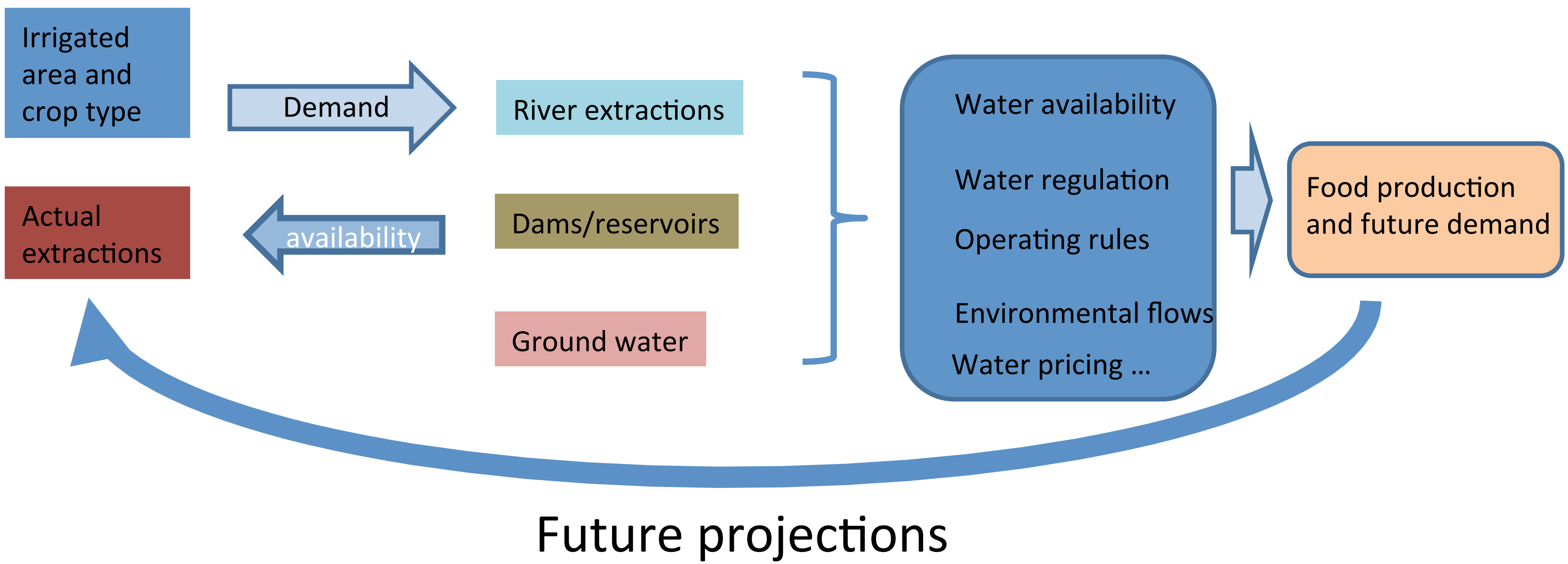
Priorities for Model development



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