Extensive validation of the global water resources model PCR-GLOBWB 2.0: incorporating human impacts

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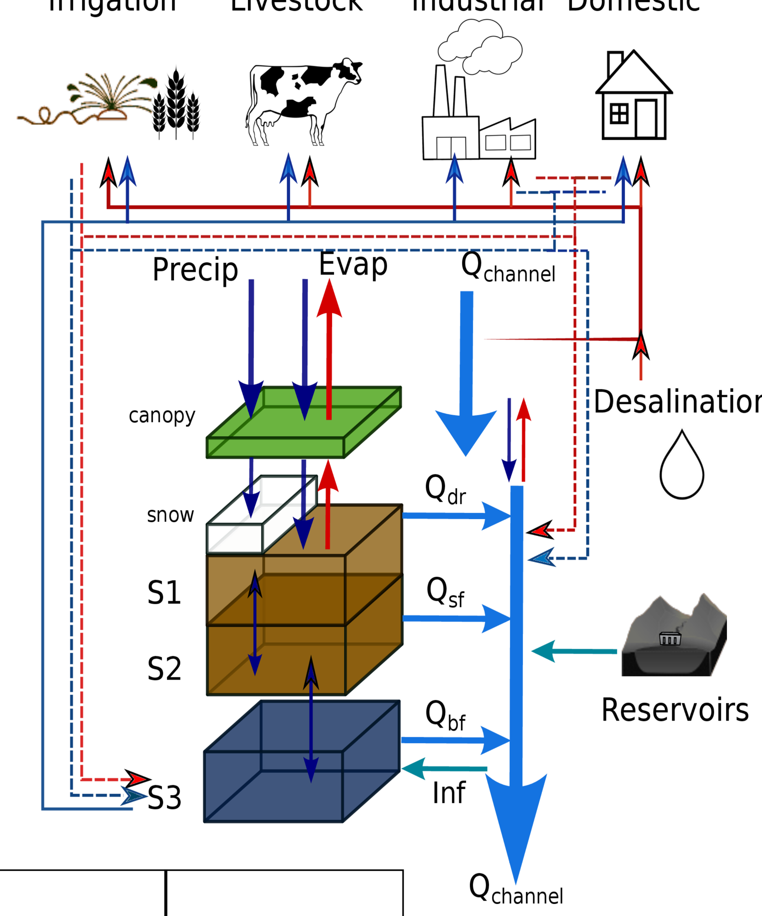
1 Introduction

With growing populations, economic expansion and rising standards of living the demand for water is increasing across the globe. Demographic developments and a changing climate will further aggravate the pressure on global water resources. In the EU FP7 project EartH2Observe in-situ data, earth observations, and models are assimilated to provide a comprehensive reanalysis of the global water resources, accounting for all components of the global water cycle including information on the impacts of human activities. Syntesizing as many sources of information as possible bears great potential to improve global water balance estimates and to consequently allow for consistent decisions in water management. One of the modelling suites participating in EartH2Observe is the global hydrological model PCR-GLOBWB[1] which accounts for anthropogenic perturbations in the water cycle. Here we present an extensive validation of the latest model version PCR-GLOBWB 2.0

2 Data and Methodology

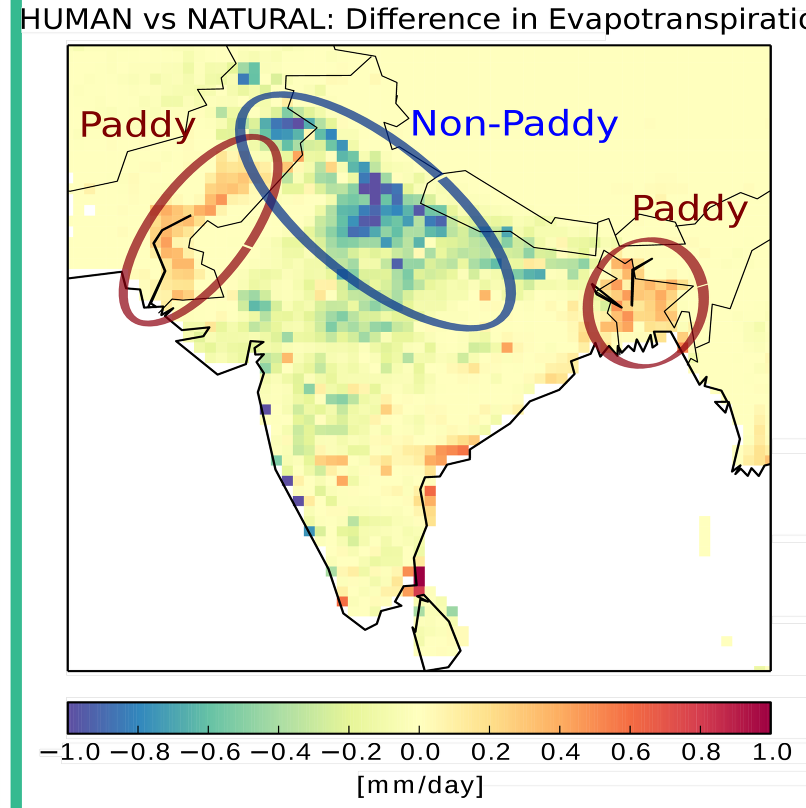
PCR-GLOBWB is a large-scale hydrological model providing a grid-based representation of terrestrial hydrology with a typical spatial resolution of less than 50×50 km (currently 0.5° globally) on a daily basis. The two presented model runs 'NATURAL' and 'HUMAN' were driven with the WFDEI[2] forcing data. While land cover consists of short and tall vegetation for the NATURAL run the additional cover types paddy and non-paddy are used under anthropogenic influence.



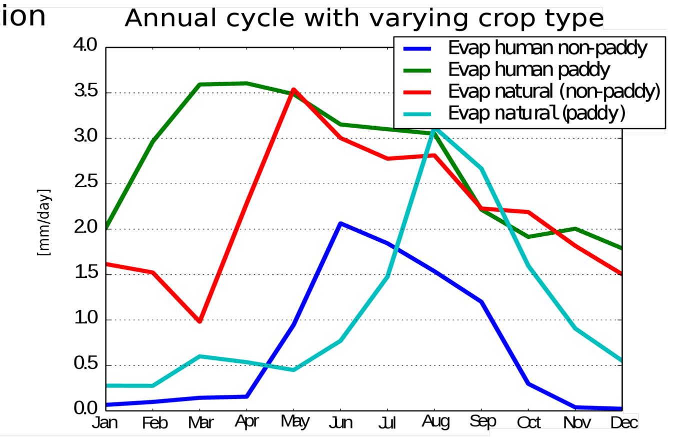
Human Impact	Irrigation	Water demand: livestock, industry, households	Desalination	Reservoirs
Modelling Approach	demand driven (ET deficit)	allocation and consumptive use of ground- and surface water resources; return flows for industry/ housholds	reduce abstraction	demand and storage driven reservoir operations
Data Source	irrig. areas: MIRCA2000[3]	Wada et al. (2014)	Wada et al. (2014)	GRanD[4]

Validation: We evaluate the HUMAN and NATURAL model simulations for different parts of the hydrological cycle. Evaporation is validated with FLUXNET-MTE[5] and ERA-I LAND[6], soil moisture with ESA CCI SM[7] and the base flow index (BFI) with GSCD[8]. Discharge is compared with GRDC[9] data.

HUMAN vs NATURAL: Difference in Evapotranspiration

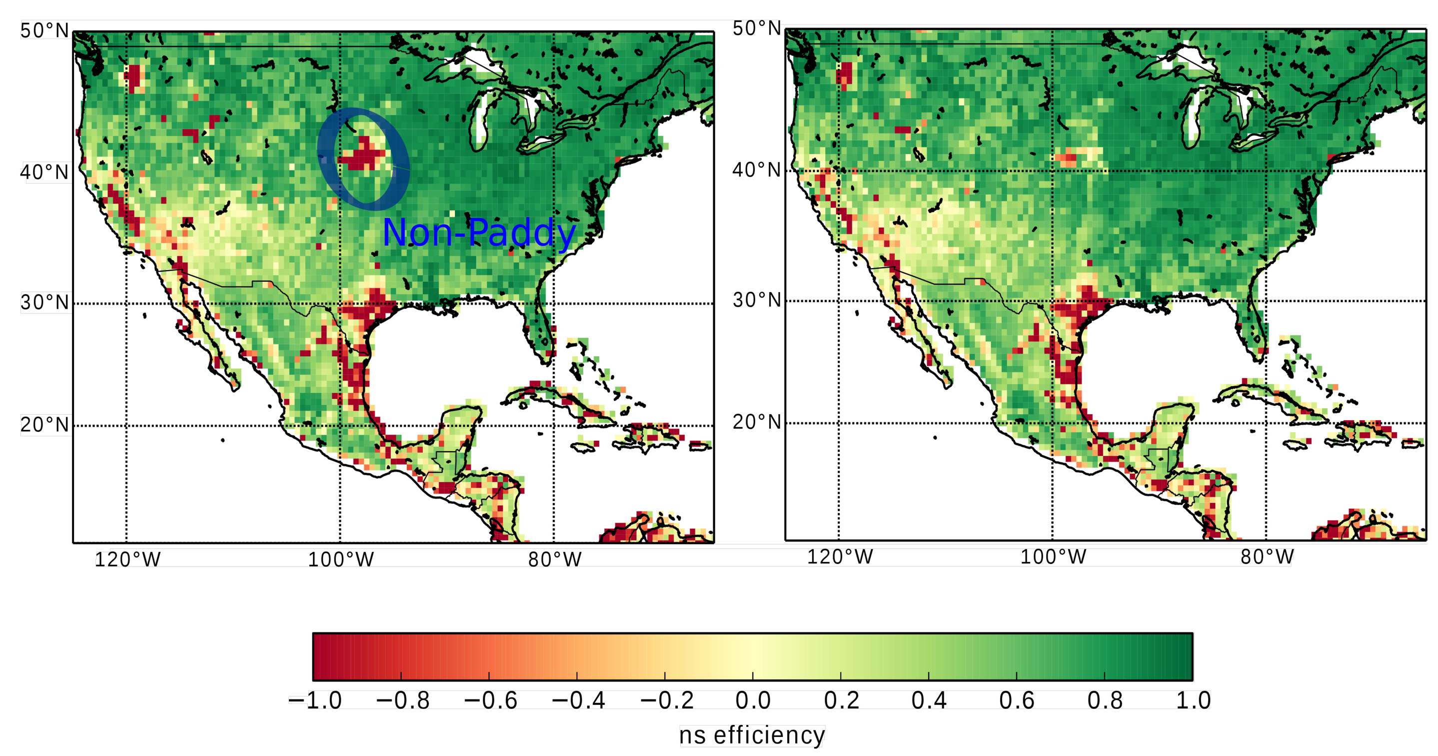


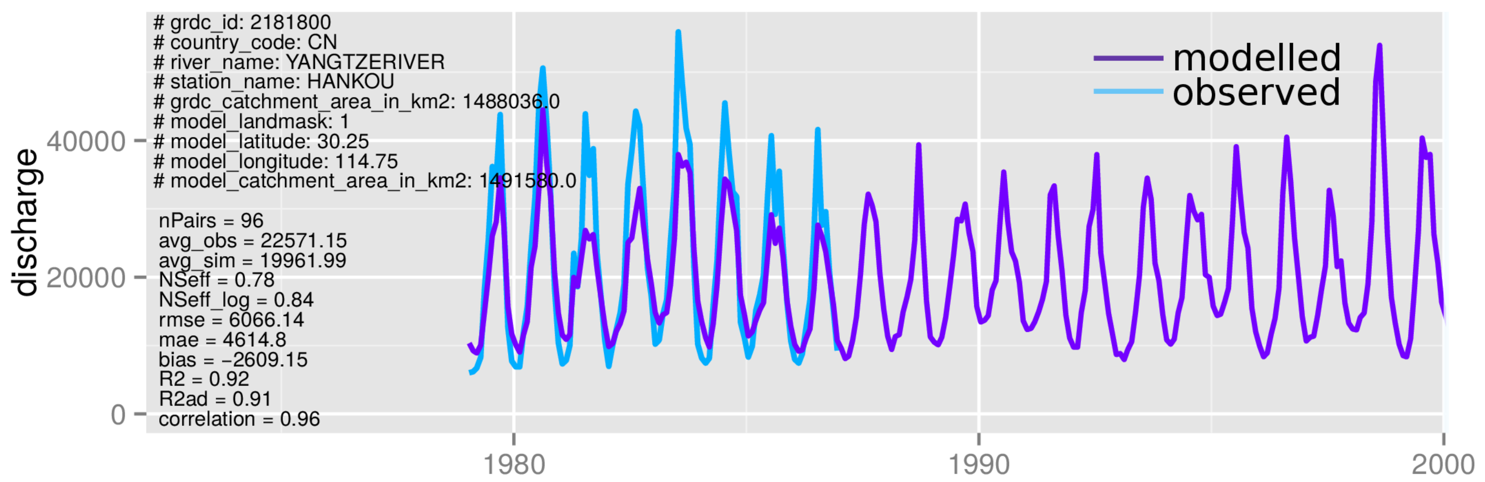
Annual cycle with varying crop type



Including irrigated areas (paddy and non-paddy crops) leads to a difference in mean evapotranspiration. The water layer on paddy fields produces more evaporation than the natural vegetation. A lower crop-coefficient for non-paddy crops results in lower (than natural) evapotranspiration.

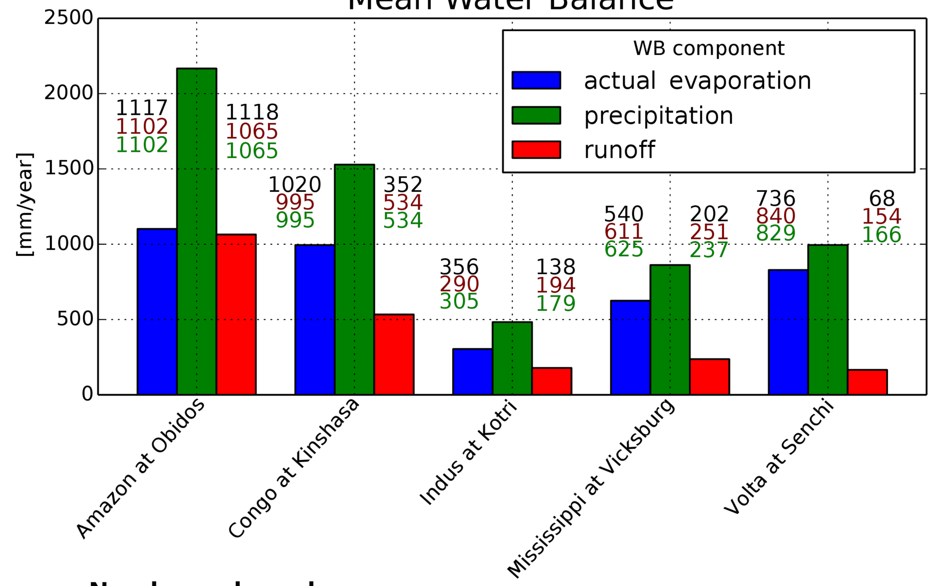
HUMAN NATURAL





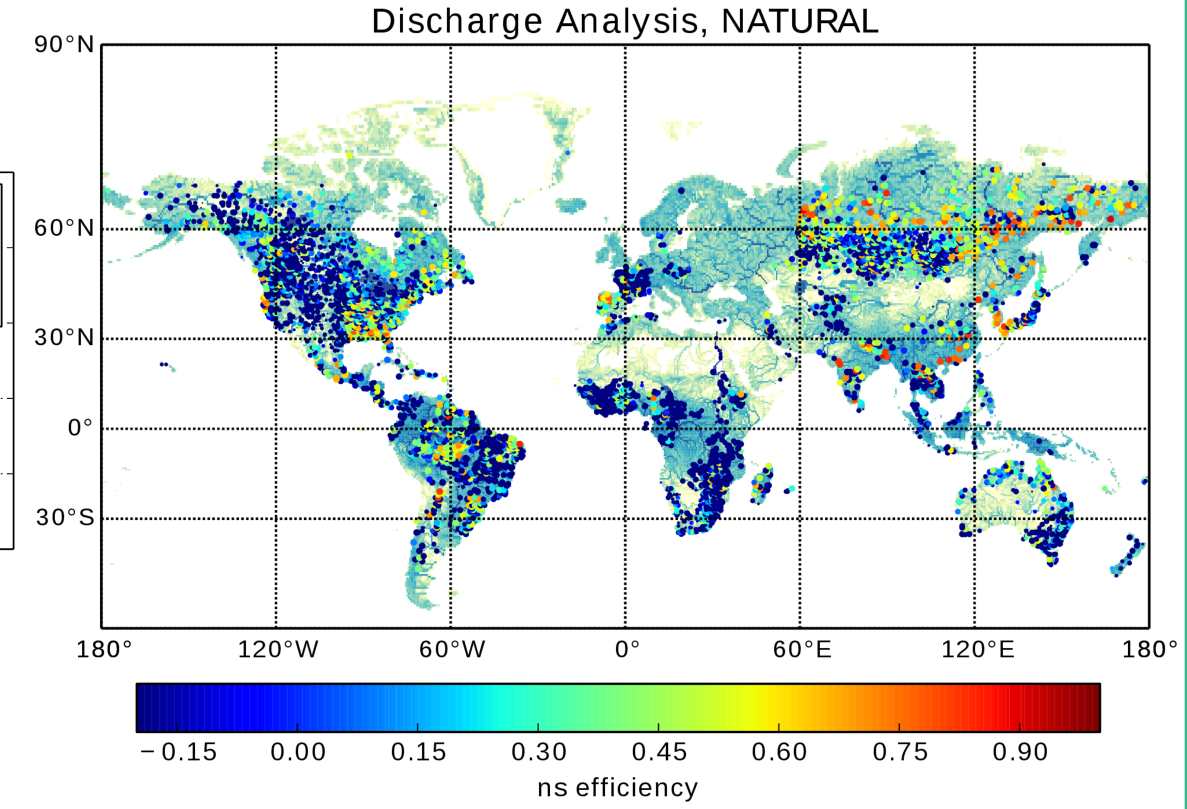
3 Results

Mean Water Balance

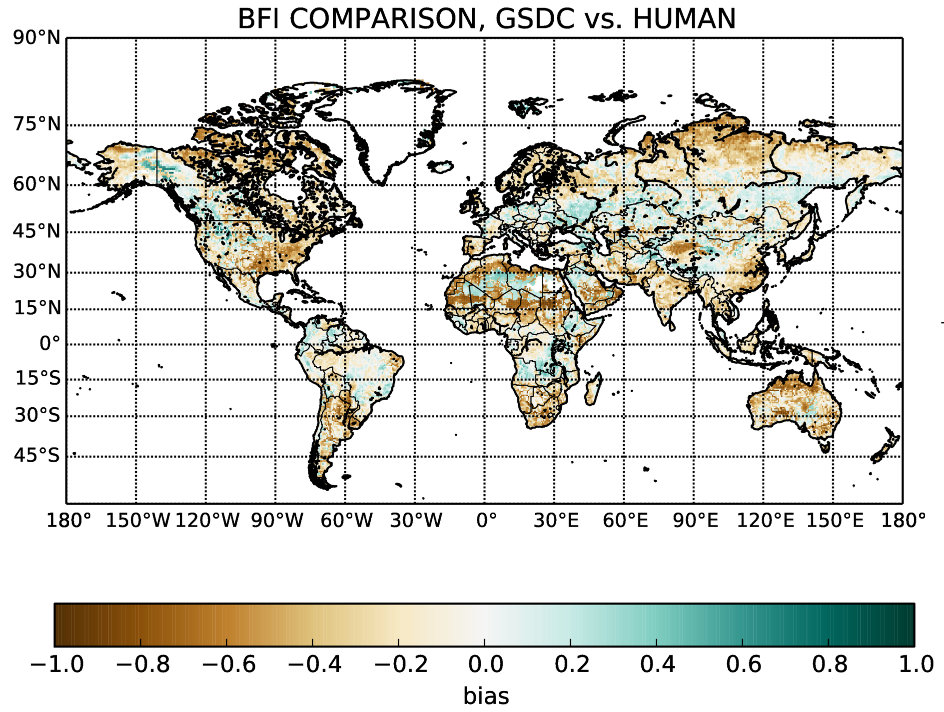


Numbers above bars:
Green: Natural, Red: Human, Black: Measured

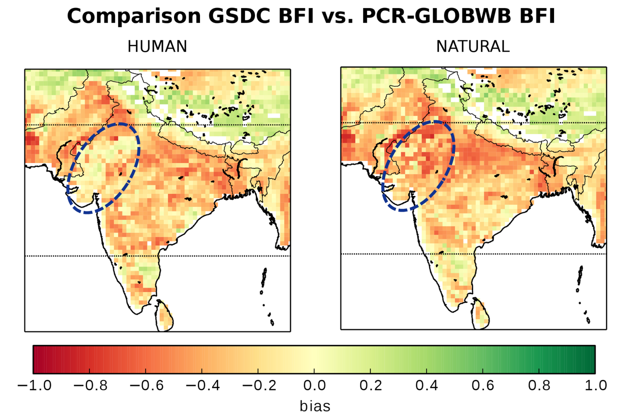
Discharge Analysis, NATURAL



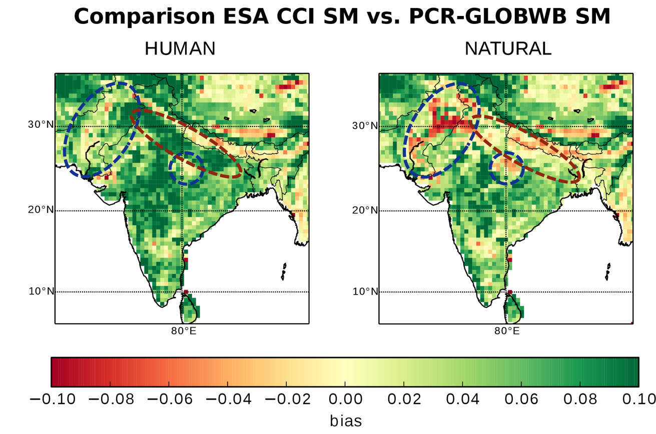
BFI COMPARISON, GSDC vs. HUMAN



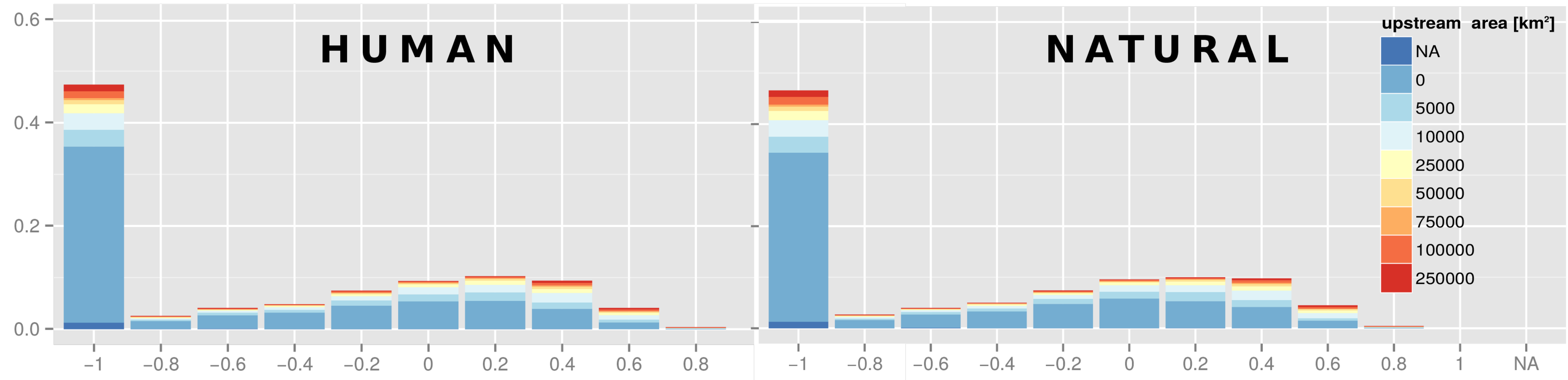
Comparison GSDC BFI vs. PCR-GLOBWB BFI



Comparison ESA CCI SM vs. PCR-GLOBWB SM



Model performance summary (discharge): NS efficiency



4 Summary, Discussion and Outlook

The impact of dynamically incorporating human influences into PCR-GLOBWB was shown for different parts of the terrestrial water cycle.
In general the model agrees well with the observations. Due to an on average smaller crop factor of non-paddy crops compared to grassland evaporation reduces over non-paddy fields, which also results in a weaker model performance for some areas of the world. For monthly mean discharges the incorporation of anthropogenic impacts lead in total to some decrease in model performance.

Soil moisture simulations could partly be improved through incorporating human influences as could simulations of the baseflow index. Using BFI and Evaporation (validation) datasets to calibrate PCR-GLOBWB can help to overcome some of the weaknesses of the model and will be analyzed in a future study. The use of additional/different land cover types and improving the reservoir scheme are further promising developments.

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References:
1 Sutanudjaja et al. (2014), Van Beek et al.(2011)
2 Weedon et al. (2012)
3 Portmann et al. (2010)
4 Lehner et al. (2011)
5 Jung et al. (2009)
6 Balsamo et al. (2012)
7 Wagner et al. (2012), Liu et al. (2011)
8 Beck et al. (2014)
9 Global Runoff Data Centre (GRDC)

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