Implementing irrigation techniques in CESM2

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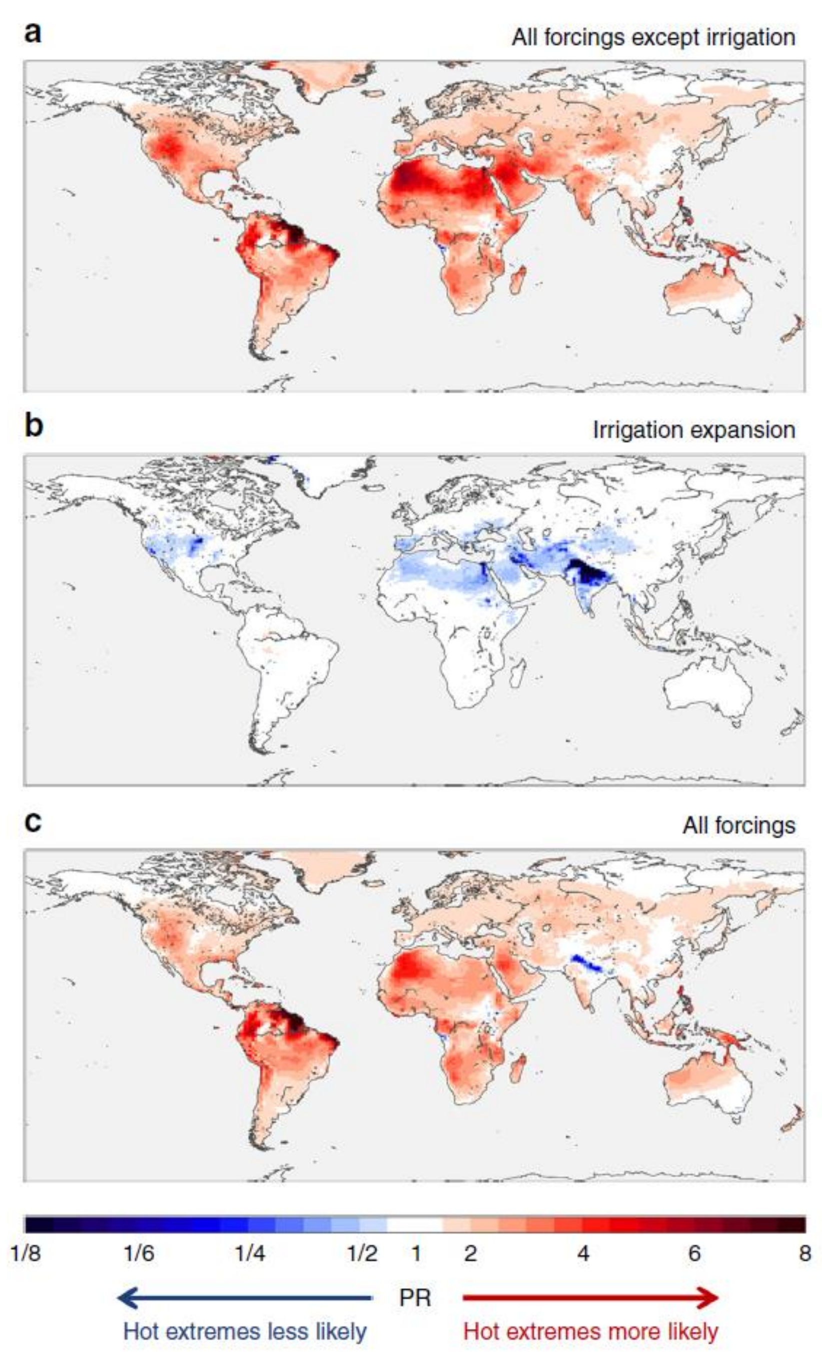
BACKGROUND



Simulated impacts on the occurrence of cold&hot extremes by (a) all forcing except irrigation, (b) only irrigation forcing and (c) all forcings. (Thiery et al., 2020)

Irrigation have significant impacts on near-surface climate, especially on climate extremes. Thus, it's important to implement the irrigation activities in the model more realistically.

CURRENT IMPLEMENTION

Conditions for activating irrigation:

crop leaf area > 0 & available soil water < threshold

The soil moisture threshold:

$$w_{thresh} = f_{thresh}\left(w_{target} - w_{wilt}\right) + w_{wilt}$$

(w_{target}: target soil moisture, w_{wilt}: wilting point, f_{thresh}: tuning parameter (1.0))

The soil moisture deficit:

$$D_{irrig} = w_{thresh} - w_{avail}$$

(w_{avail}: soil moisture available)

The amount of irrigation per second:

$$a_{irrig} = \frac{D_{irrig}}{T_{irrig}}$$

(T_{irrig}: irrigation period)

Irrigation water is applied directly to the ground surface, without canopy interception.

The amount of water is removed from river storage.

METHODS AND DATASETS

Considering three main irrigation techniques in CESM, surface, sprinkler and drip, based on their way of applying water into fields.

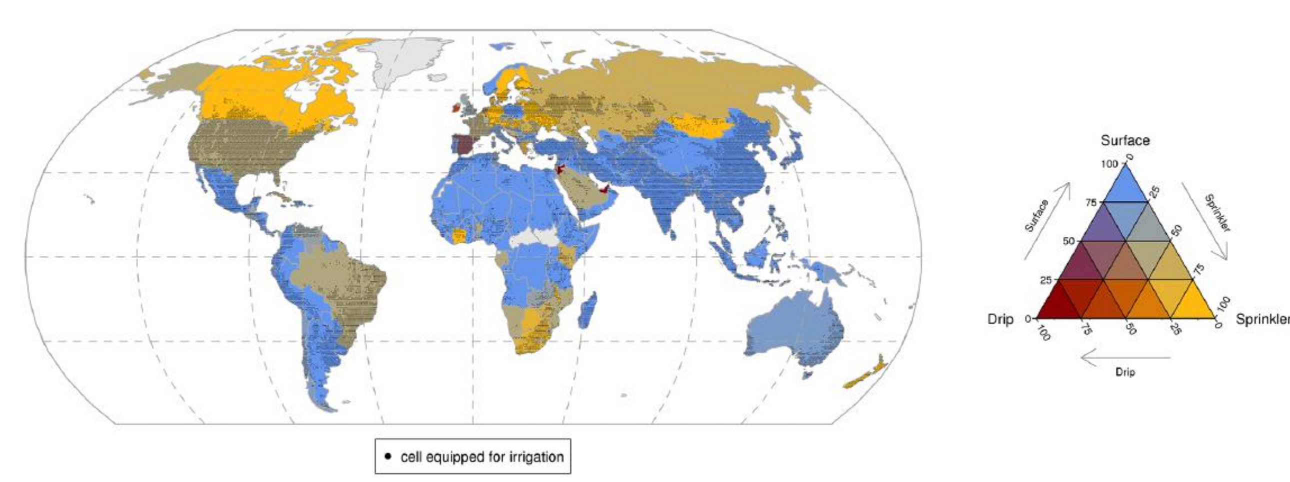
Creating a new surface data which contains the distribution of different irrigation techniques.

Two experiments are conducted, one with the improved irrigation scheme and another without irrigation. We will evaluate the outputs from two experiments by comparing with observed land-surface parameters (ex: soil moisture), surface fluxes (ex: latent heat flux) and meteorological variables (ex: near-surface temperature).

The results will also be analysed as the irrigation-induced impacts.

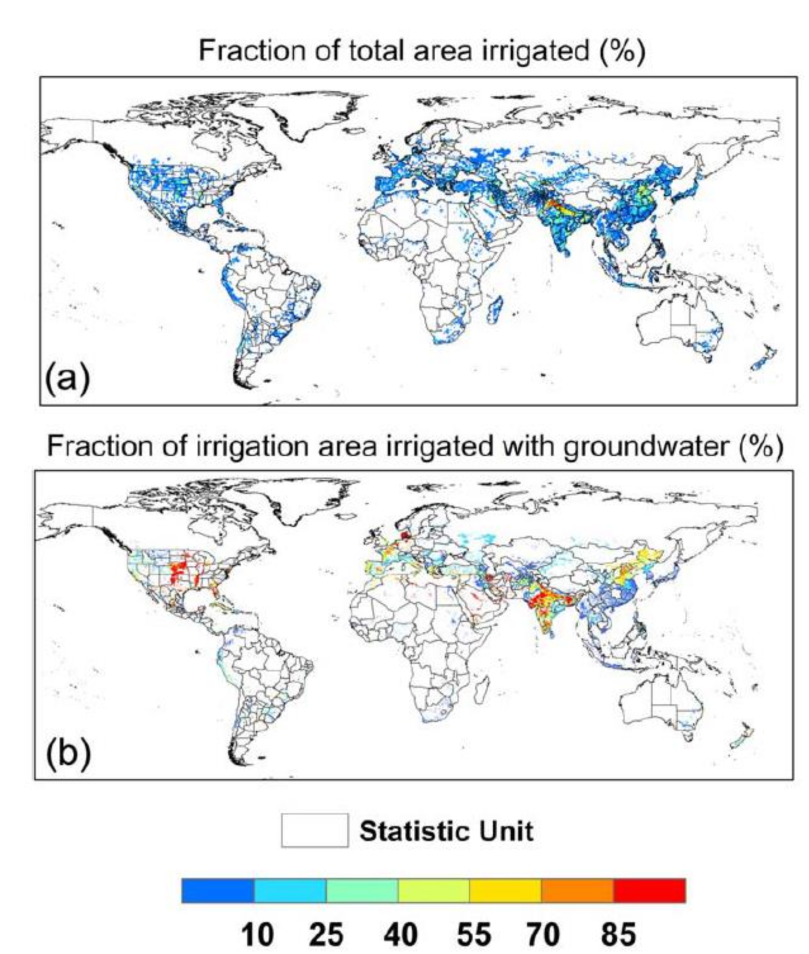
Irrigation system	Distribution uniformity scalar	Conveyance efficiency[1]	Soil evaporation	Interception	Runoff	Irrigation threshold[2]	Minimal irrig. amount
Surface	1.15	open canal: sand 0.7, loam 0.75, clay 0.8	unrestricted	no	surface, lateral, percolation	C4: 0.7	1 mm
Sprinkler	0.55	pipe: 0.95		yes	lateral, percolation	C3 (prec < 900): 0.8 C3 (prec >= 900): 0.9	
Drip	0.05		soil evap. of irr. water reduced by 60 %	no	none, only indirect precip. leaching	Rice: 1.0	none

Key parameters of three main irrigation techniques (surface, sprinkler and drip). (Jägermeyr et al., 2015)



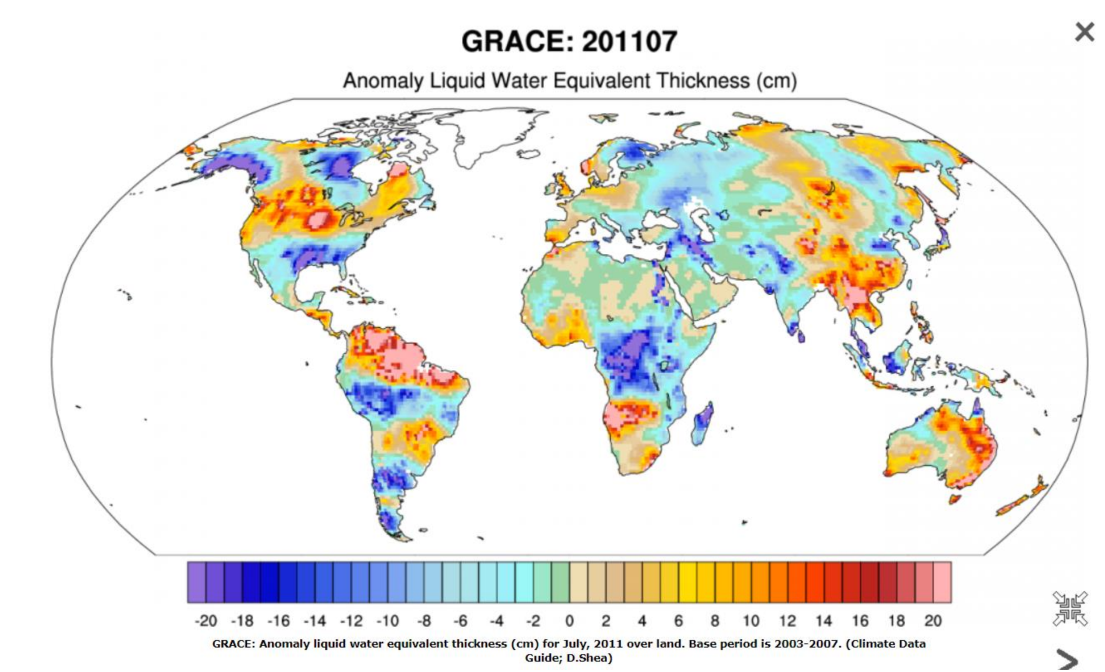
Global distribution of the land equipped for irrigation by different techniques (surface, sprinkler and drip). (Jägermeyr et al., 2015)

Apart from the implementation of different irrigation techniques, the different sources of water will also be represented. In current model, all the water applied were removed from river (surface water), thus we want to consider both surface water and groundwater extraction. Here we introduce an index, $\boldsymbol{F_{grd}}$, which denotes the proportion of water from groundwater, in the model.

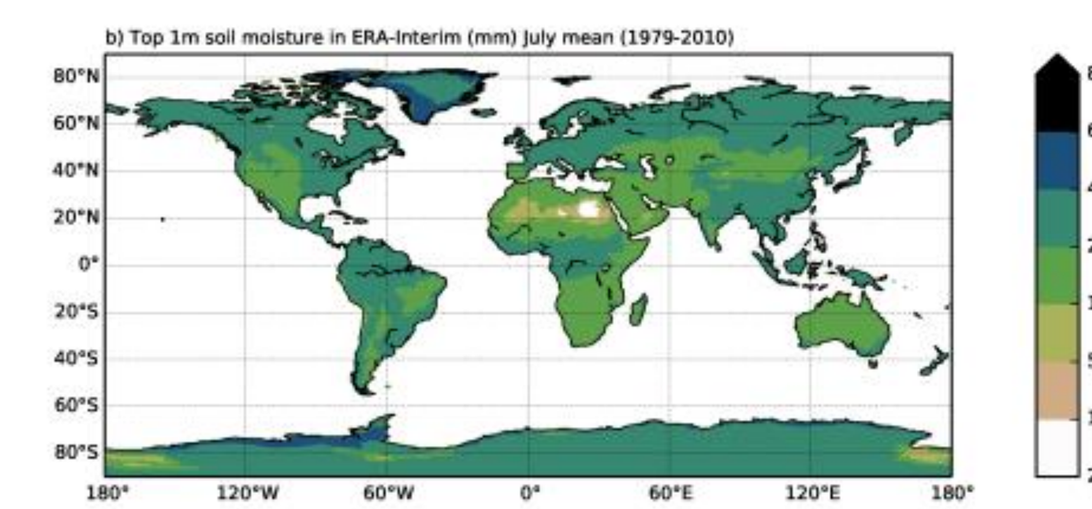


Global fraction of total area irrigated and area irrigated with groundwater. (Siebert et al., 2010)

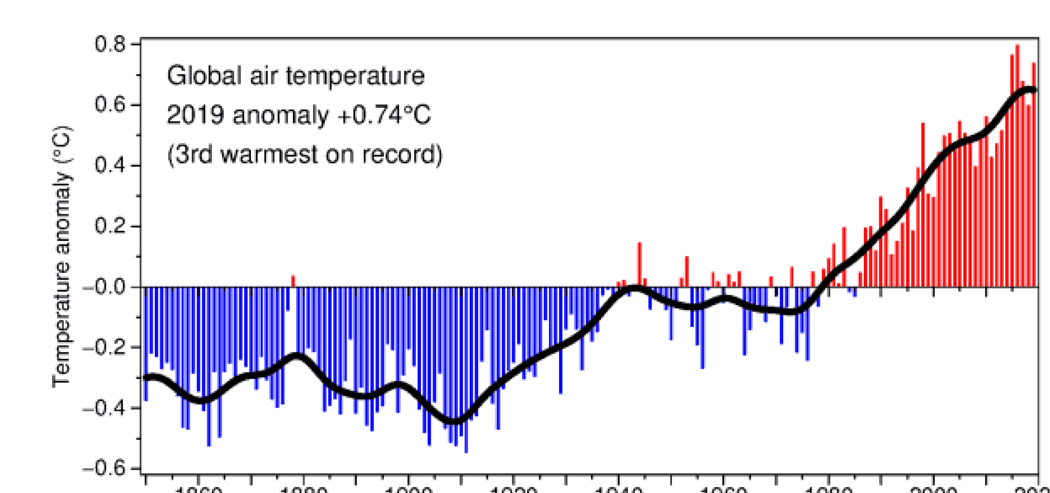
DATASETS USED FOR EVALUATION



Gravity Recovery and Climate Experiment (GRACE)



ERA-Interim/Land: global reanalysis of land-surface parameters



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Siebert S, Burke J, Faures JM, Frenken K, Hoogeveen J, Döll P, Portmann FT. 2010. Groundwater use for irrigation – a global inventory. Hydrology and Earth System Sciences, **14**: 1863-1880. DOI: 10.5194/hess-14-1863-2010.

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