DEVELOPING GLOBAL CROP WATER REQUIREMENTS BY INTEGRATING REMOTE SENSING DATASETS AND FAO-CROPWAT MODEL

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Abstract

Currently, almost 90% of global water consumption is for irrigation purpose. Many researchers studied water budget in the global ecosystem field but many of them were not focus on analyzing water budget for cropland area purpose. One of the study regarding global irrigation water budget did not use crop stage calendar and has a coarse spatial resolution (0.5 degrees), therefore developing higher resolution which includes crop stage analysis is needed. The increasing availability and reliability of satellite remote sensing product make it feasible to estimate the global terrestrial crop water requirement (CWR) at fine spatial resolution. To assess global crop water situation, we generate 1km high-resolution global crop water requirement product by combining various remote sensing product and FAO-CROPWAT model. Global CRW product is projected to simulate global crop water budget that is more realistic by considering plant growth phase with higher pixel resolution. This high resolution of global CWR can be utilized not only in global scale but also in regional and country scale, also can be analysed in major River basin area. Crop stage additional data that was converted into Kc value becomes an added-value in developing this global CWR product compared to the previous product so that it is projected to produce a more realistic product for stimulating global crop water requirement.

***Keywords**: global crop water requirement, FAO-CROPWAT model, crop-evapotranspiration*

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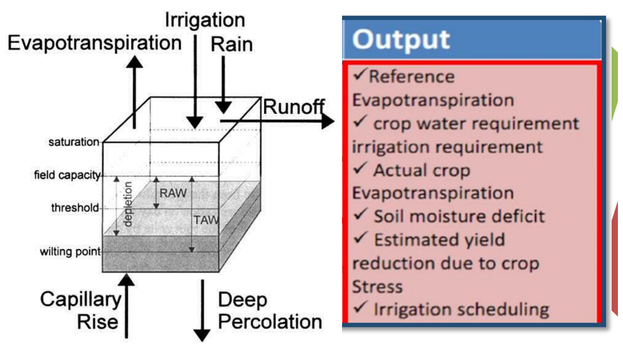
Introduction

For the assessment of future water and food situation, it is necessary to estimate the water requirement of agriculture. ‘‘Water requirement’’ means the amount of water that must be applied to the crop by irrigation to achieve optimal crop growth. Modelling of today’s irrigation water requirements as a function of irrigated crop area, climate, and crops stage phase provides the basis for estimating future impact of climate change as well as demographic, socioeconomic, and technological changes.

FAO-CROPWAT and CLIMWAT

- The FAO-CROPWAT is use for the design and management of irrigation.
- The water budget approach is used for calculation of irrigation schedules in CROPWAT, which means that the incoming and outgoing water flows from the soil profile are monitored.



Water balance of the root zone. Image source: FAO

Methodology

Net Irrigation Requirement (NIR) formula

Following the FAO-CROPWAT model of Smith [1992]

$$I_{net} = E_{pot\_c} - P_{eff} = k_c E_{pot} - P_{eff} \quad \text{if } E_{pot\_c} > P_{eff}$$
$$I_{net} = 0 \quad \text{if } E_{pot\_c} \le P_{eff},$$

Where;
Inet net irrigation requirement per unit area [mm/d]
Epot_c crop-specific potential evapotranspiration [mm/d]
Peff effective precipitation [mm/d]
Epot potential evapotranspiration [mm/d]
Kc crop coefficient [dimensionless].

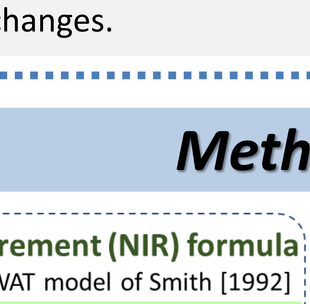
A. Effective rainfall (P eff)

Effective rainfall refers to that portion of rainfall that can effectively be used by plants.

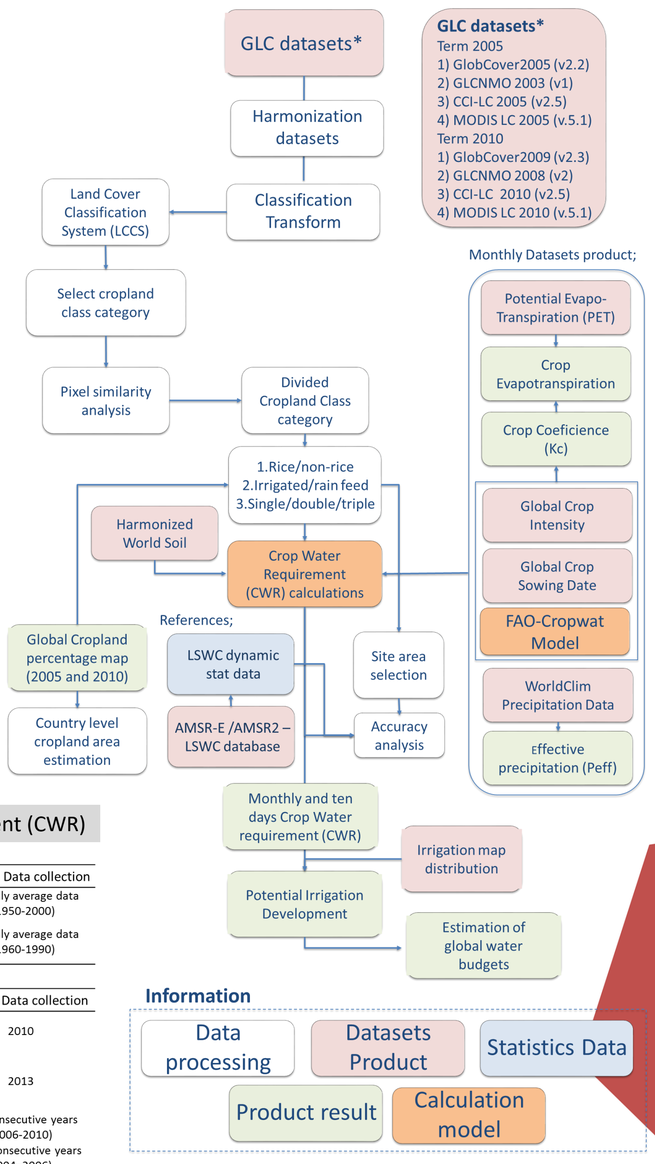
$$P_{eff} = P(4.17 - 0.2P)/4.17 \quad \text{for } P < 8.3\ \text{mm/d}$$
$$P_{eff} = 4.17 + 0.1P \quad \text{for } P \ge 8.3\ \text{mm/d}.$$

B. Crop Coefficients

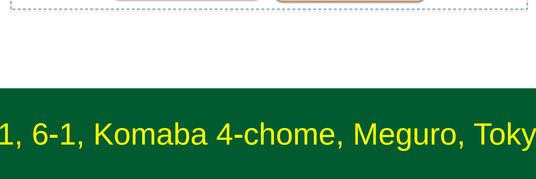
Crop coefficients are properties of plants used in predicting evapotranspiration (ET).



Overall flowchart of this study



Information



Data description for developing the global crop water requirement (CWR)

I. Meteorological data

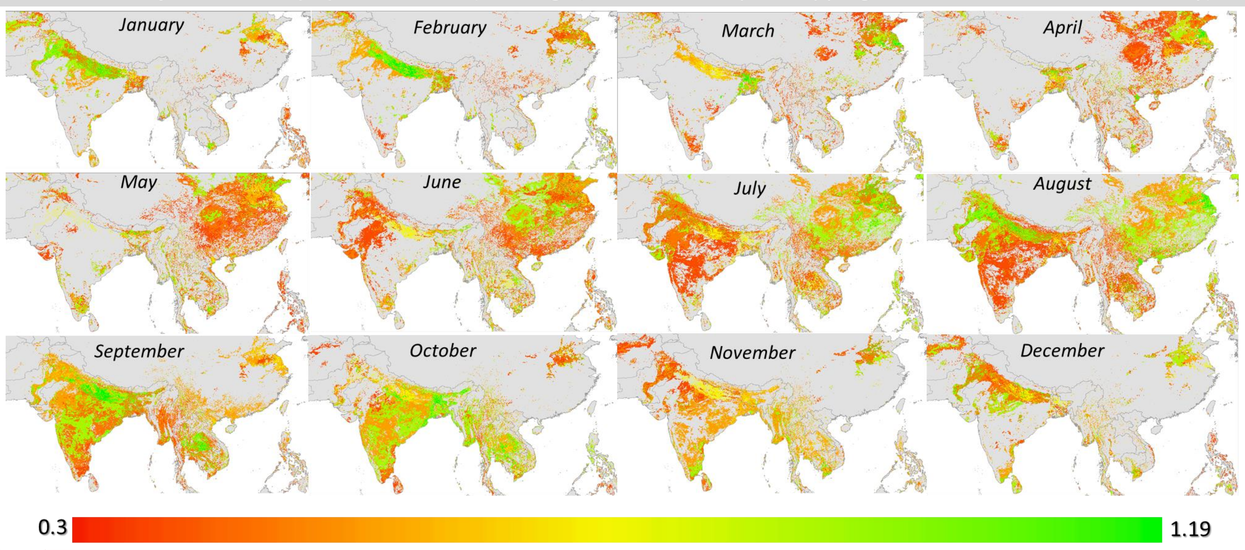
No	Product name	Data Provider	Input Data	Spatial resolution	Time of Data collection
1	Potential Evapo-Transpiration (PET)	IWMI & ICIMOD	WorldClim Global Climate Data	30 arc seconds (~ 1 km at equator)	monthly average data (1950-2000)
2	WorldClim Version 1 Precipitation Data	University of California, CIAT, Rainforest CRC	WorldClim Global Climate Data	30 arc seconds (~ 1 km at equator)	monthly average data (1960-1990)

II. Geographical data

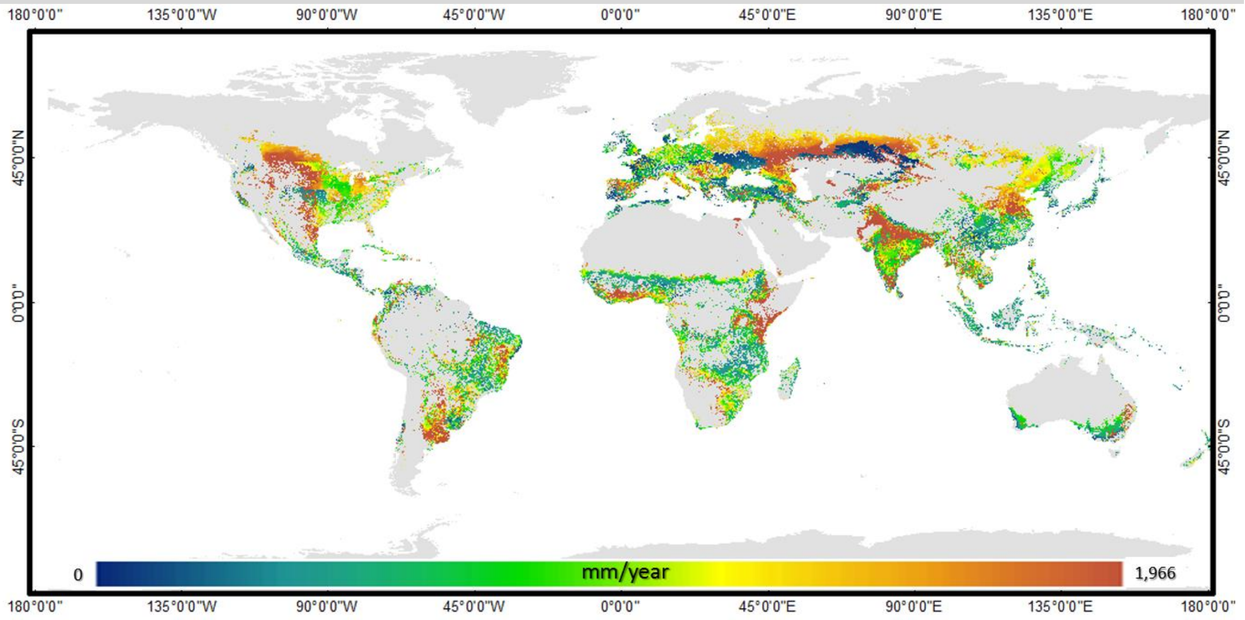
No	Product name	Data Provider	Input Data	Spatial resolution	Time of Data collection
3	Cropland Agreement Level (CAL)	In This Study	ESA CCI-LC, GlobCover, GLCMNO and MODIS LC	300 m	2010
4	GLCNMO Global Rice Paddy map	GSI Japan, Univ. Chiba, ISCGM	16-day composite, 7-band, 500-m MODIS data of 2013, Landsat ETM+, DMSO-OLS	500 m	2013
5	Global Crop Intensity	IIS, U Tokyo	NDVI	1 km	Five consecutive years (2006-2010)
6	Global Crop Sowing Date	RIKEN, Japan	nNDVIsw and nNDVIhv.	5 arc-minute ~ 10 km	three consecutive years (2004–2006),
7	Harmonized World Soil Database Version 1.2	FAO	15 000 different soil mapping from worldwide	0.5 degree ~ 50 km	2012

Results and Discussion

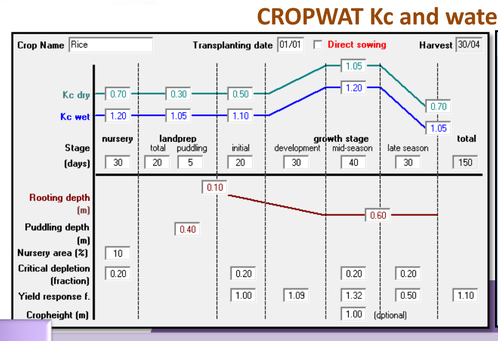
A. Global crop coefficient (Kc) distribution (For Single, double and triple Cropping – with Rice and Non-Rice Paddy)



B. Total Global Crop Water Requirement in 2010



CROPWAT Kc and water requirement result for rice paddy



Month	Decade	Stage	Kc coeff	ETo mm/day	ETc mm/dec	Eff rain mm/dec	Irr. Req. mm/dec
Jan	1	Init	0.30	1.14	11.4	48.8	0.0
Jan	2	Init	0.30	1.20	12.0	47.6	0.0
Jan	3	Deve	0.45	1.94	21.4	46.5	0.0
Feb	1	Deve	0.72	3.31	33.1	44.5	0.0
Feb	2	Deve	0.97	4.77	47.7	43.0	4.7
Feb	3	Mid	1.17	6.13	49.1	45.2	3.9
Mar	1	Mid	1.19	6.64	66.4	48.2	18.2
Mar	2	Mid	1.19	7.04	70.4	50.2	20.3
Mar	3	Mid	1.19	7.33	80.6	50.3	30.3
Apr	1	Late	1.15	7.35	73.5	51.1	22.4
Apr	2	Late	0.89	5.95	59.5	51.9	7.6
Apr	3	Late	0.62	4.36	43.6	48.7	0.0
May	1	Late	0.41	3.10	15.5	23.1	0.0
					584.0	**599.1**	**107.3**

Conclusions

The study result shows that integrating satellite remote sensing product combine with FAO-CROPWAT model could be applicated in estimating the global terrestrial crop water requirement (CWR) at fine spatial resolution. To enhance the accuracy of CWR in rice paddy area, calculating specific water consumption during land preparation stage for Rice paddy will be included in next CWR processing. MODIS NDVI and LSWC AMSR2 spatiotemporal datasets utilization as reference to measure accuracy of global distribution Kc and net irrigation value is the originality in this study.

References

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2. Smith, M., CROPWAT – A computer program for irrigation planning and management, Irrigation and Drainage Pap. 46, Food and Agric. Org. of the U. N., Rome, 1992.

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