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12 APRIL 2019

# The missing information for hydrological modelling in agricultural areas: IRRIGATION

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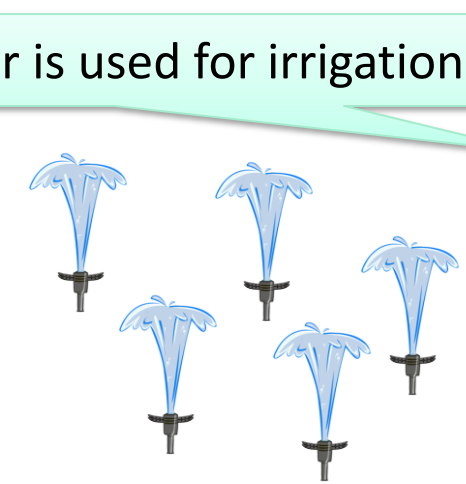
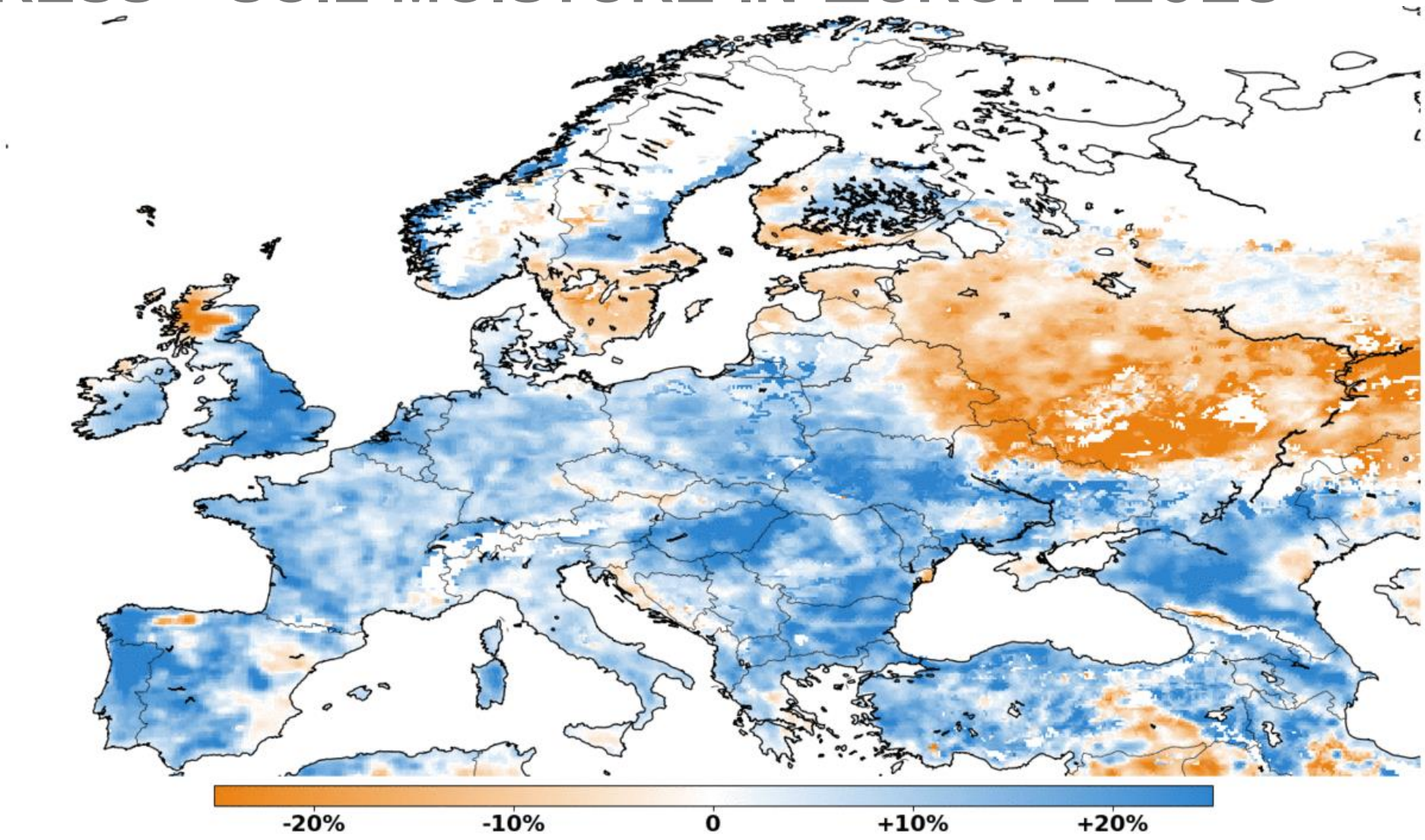
How much water is used for irrigation?



# WATER STRESS - SOIL MOISTURE IN EUROPE 2018

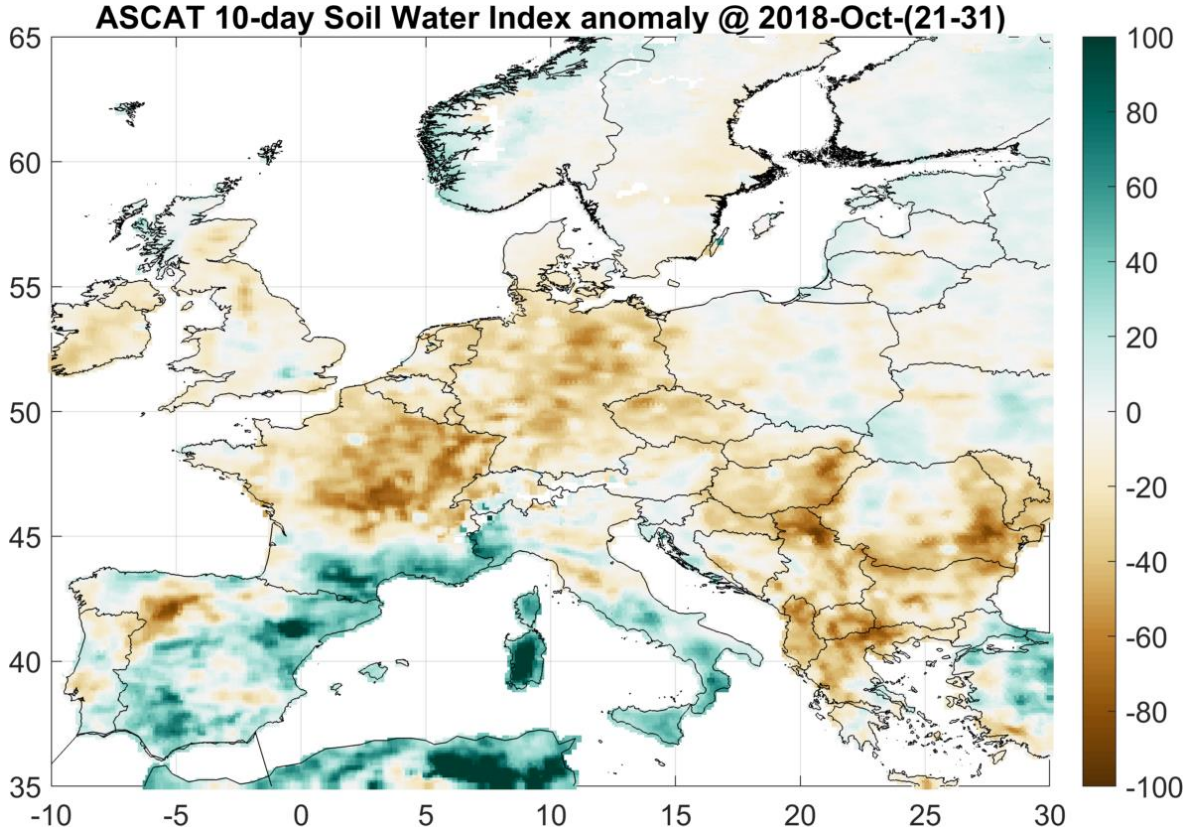
**2+ billion people are currently affected by water stress**, a number that will only increase with population growth, continued economic development and climate changing (United Nations, 2018)



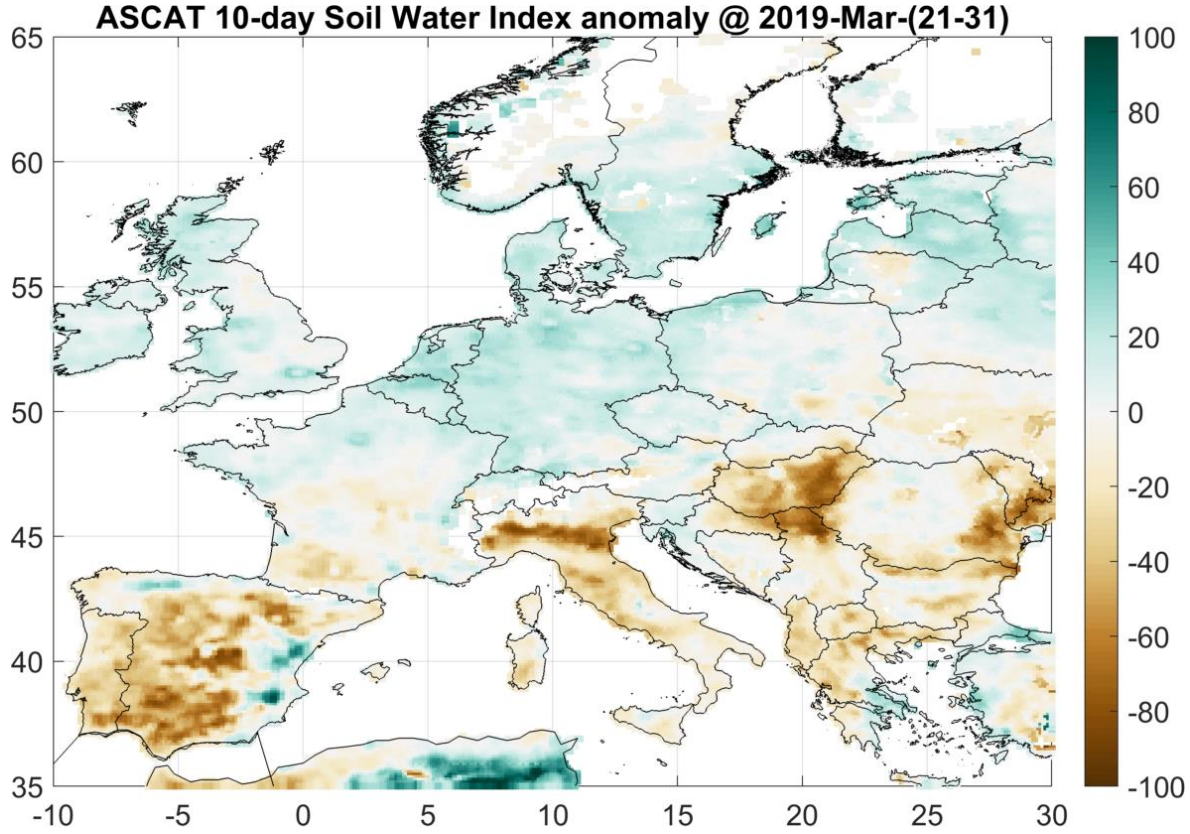

Courtesy by Prof. Wolfgang Wagner

# WATER STRESS - SOIL MOISTURE IN EUROPE 2018/2019

***October 2018***




***March 2019***

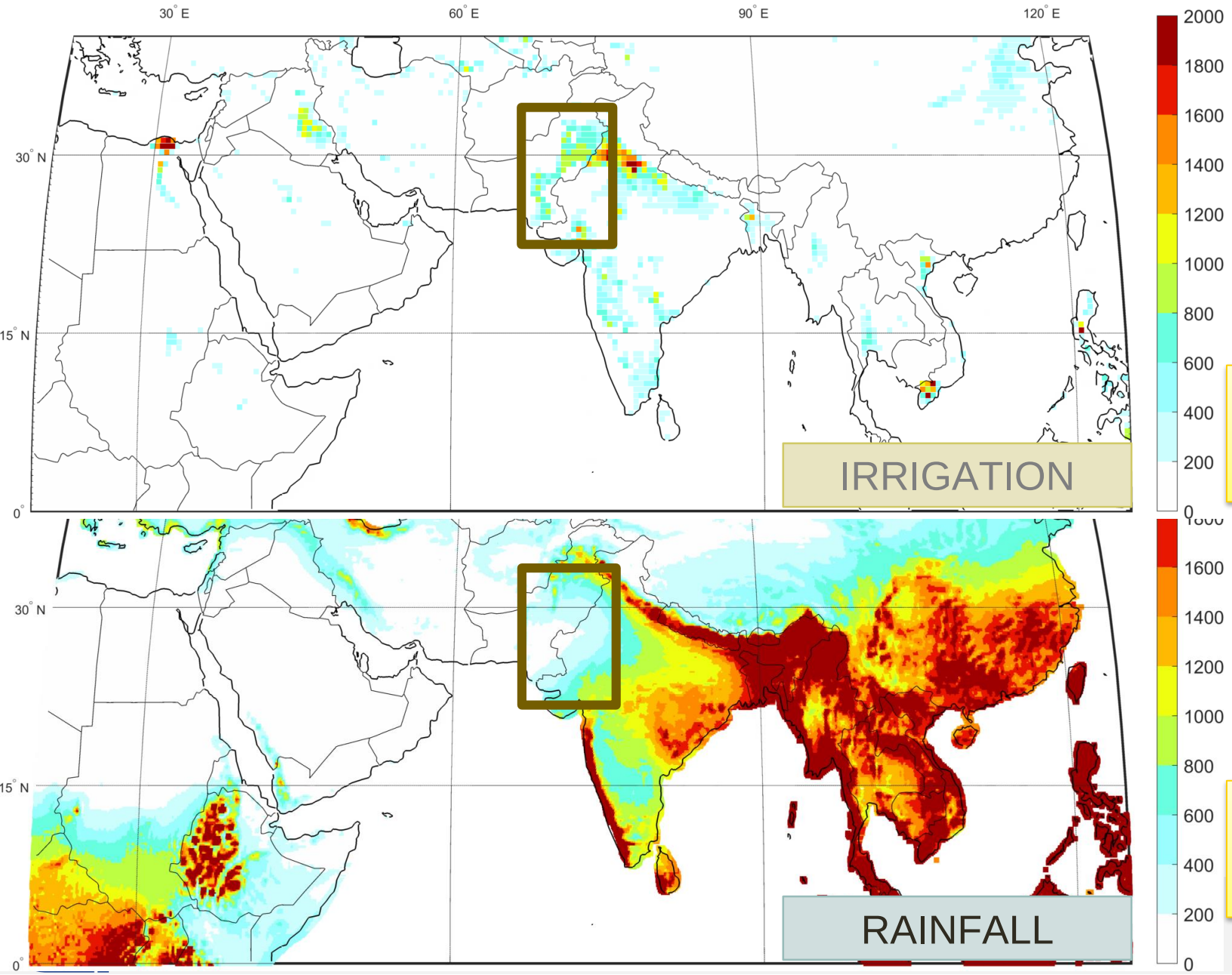


# How do we (humans) solve the problem?

**IRRIGATION**

Feeding the world's growing and more affluent population will require **25-70% increase in agricultural production by 2050** → increase in **agricultural water withdrawals**, which already account for **70% of global water demand**

# How do we (humans) solve the problem?



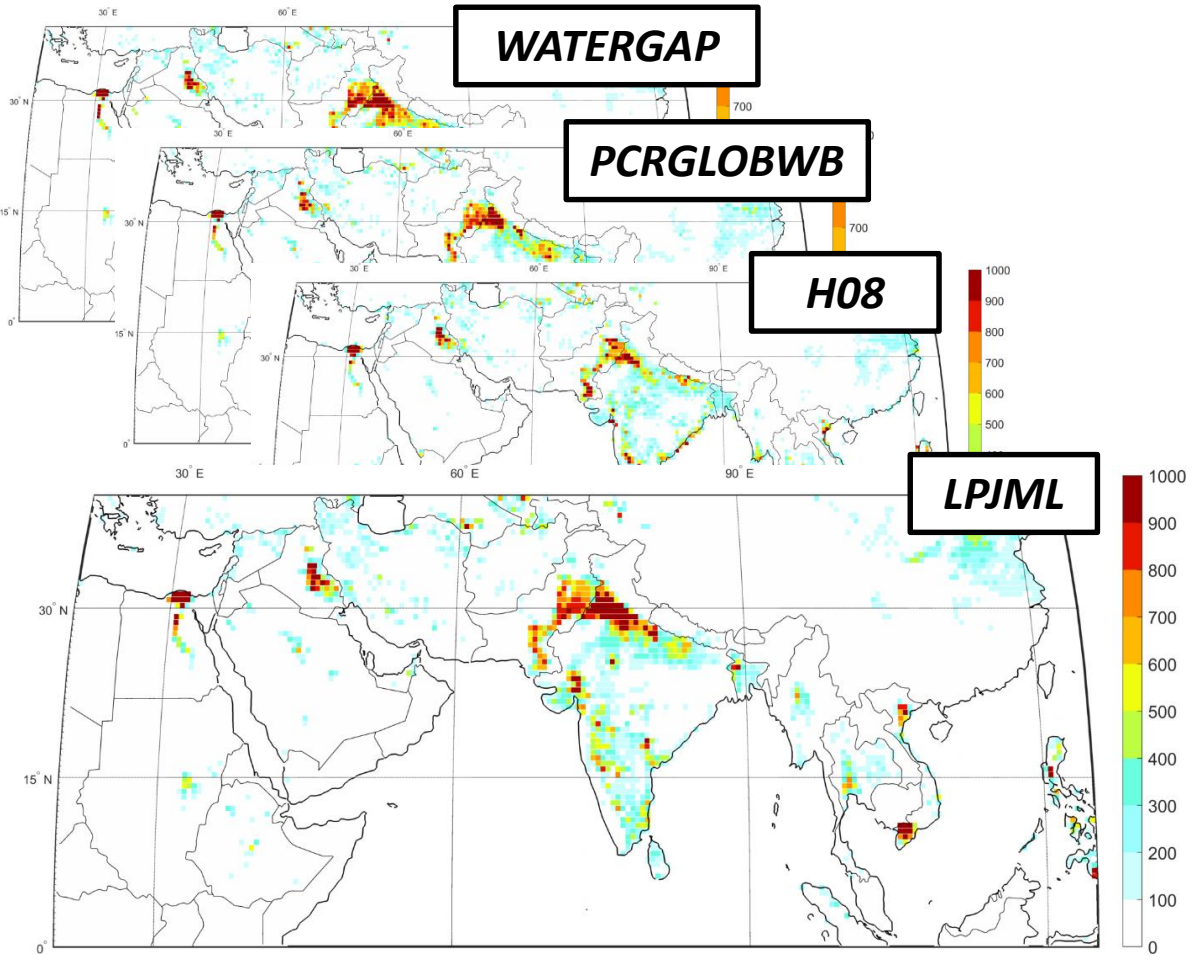

In some regions (e.g., India), **annual irrigation water withdrawn is more than 1000 mm/year**, even larger than annual rainfall (Pakistan)

***LPJML Global Hydrological Model***
***https://zenodo.org/record/1209296***

***SM2RAIN-ASCAT rainfall dataset***
***https://zenodo.org/zenodo.2591215***

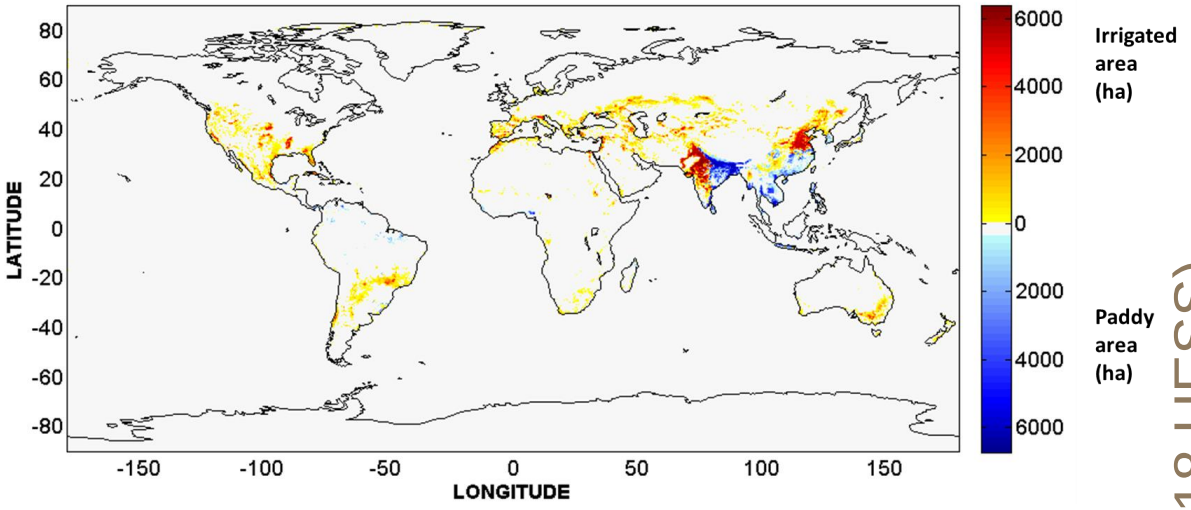
Huang et al. (2018 HESS)
Brocca et al. (2018 JAG)

# How do we "measure" irrigation?




MODELLING

STATISTICAL SURVEYS + REMOTE SENSING

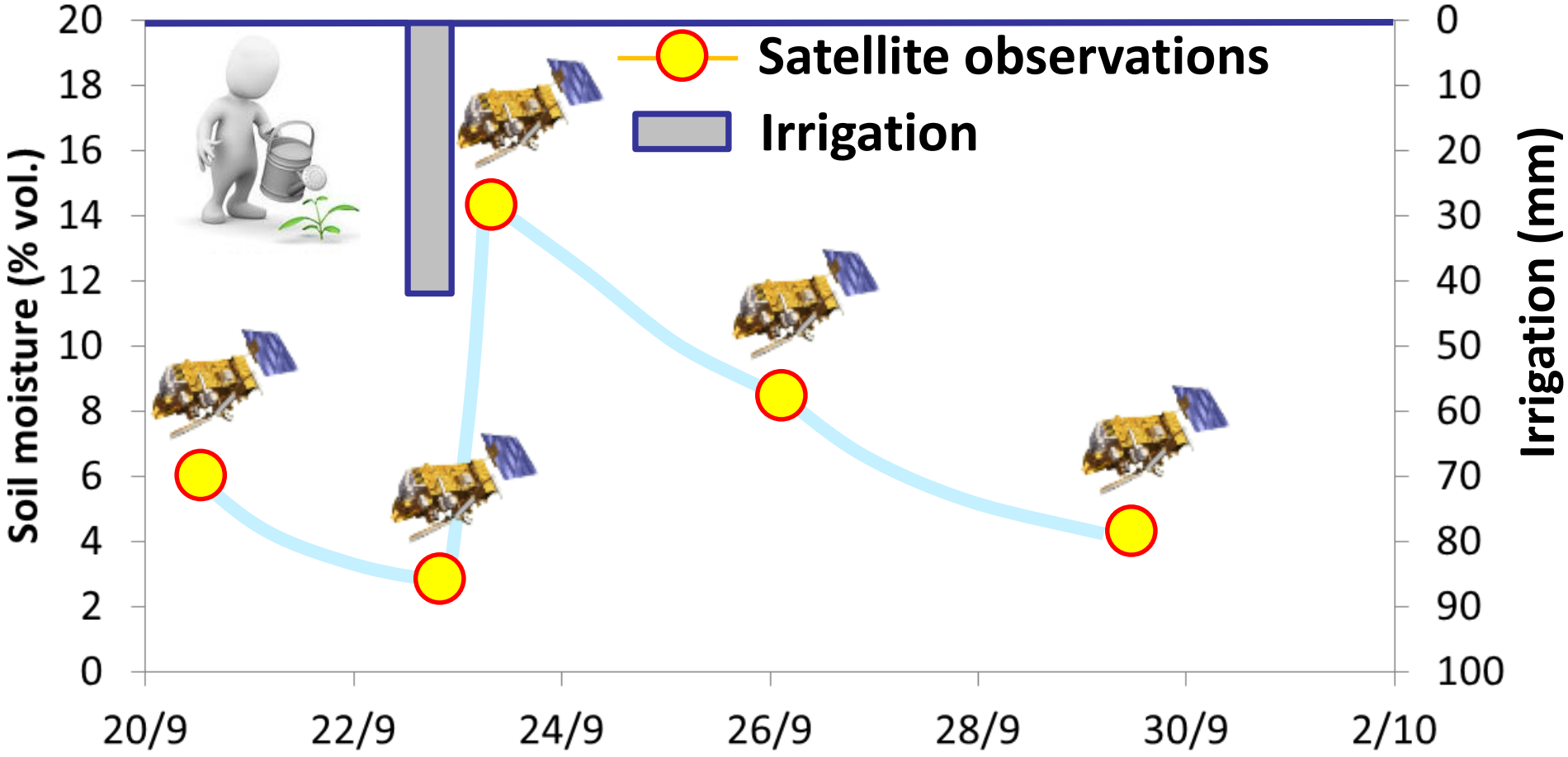



**We do not have information about the actual volume of water used for irrigation**

except for statistical inventories (small regions and short time periods, outdated) or modelling

Huang et al. (2018 HESS)
Salmon et al. (2015 JAG)

# WE HAVE THE ("ONE") SOLUTION!


**Exploitation of the well-established SM2RAIN algorithm** for estimating the amount of water entering into the soil from satellite soil moisture observations. **Over irrigated areas, SM2RAIN measure the amount of water applied for irrigation**.

Brocca et al. (2014 JGR)
Brocca et al. (2018 JAG)

# INVERSION OF THE SOIL WATER BALANCE

relative soil moisture

precipitation

irrigation

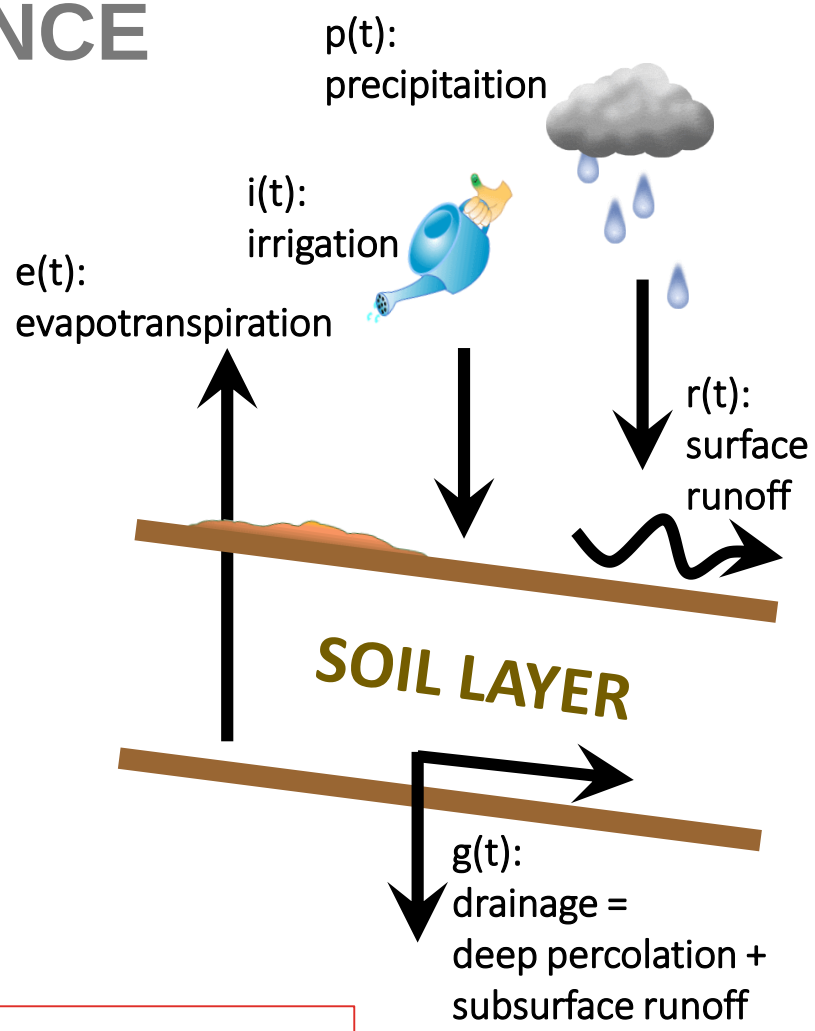
surface runoff

drainage

$$Z^{*}\frac{ds(t)}{dt}=p(t)+i(t)-r(t)-e(t)-g(t)$$

soil water capacity = soil depth X porosity

evapotranspiration



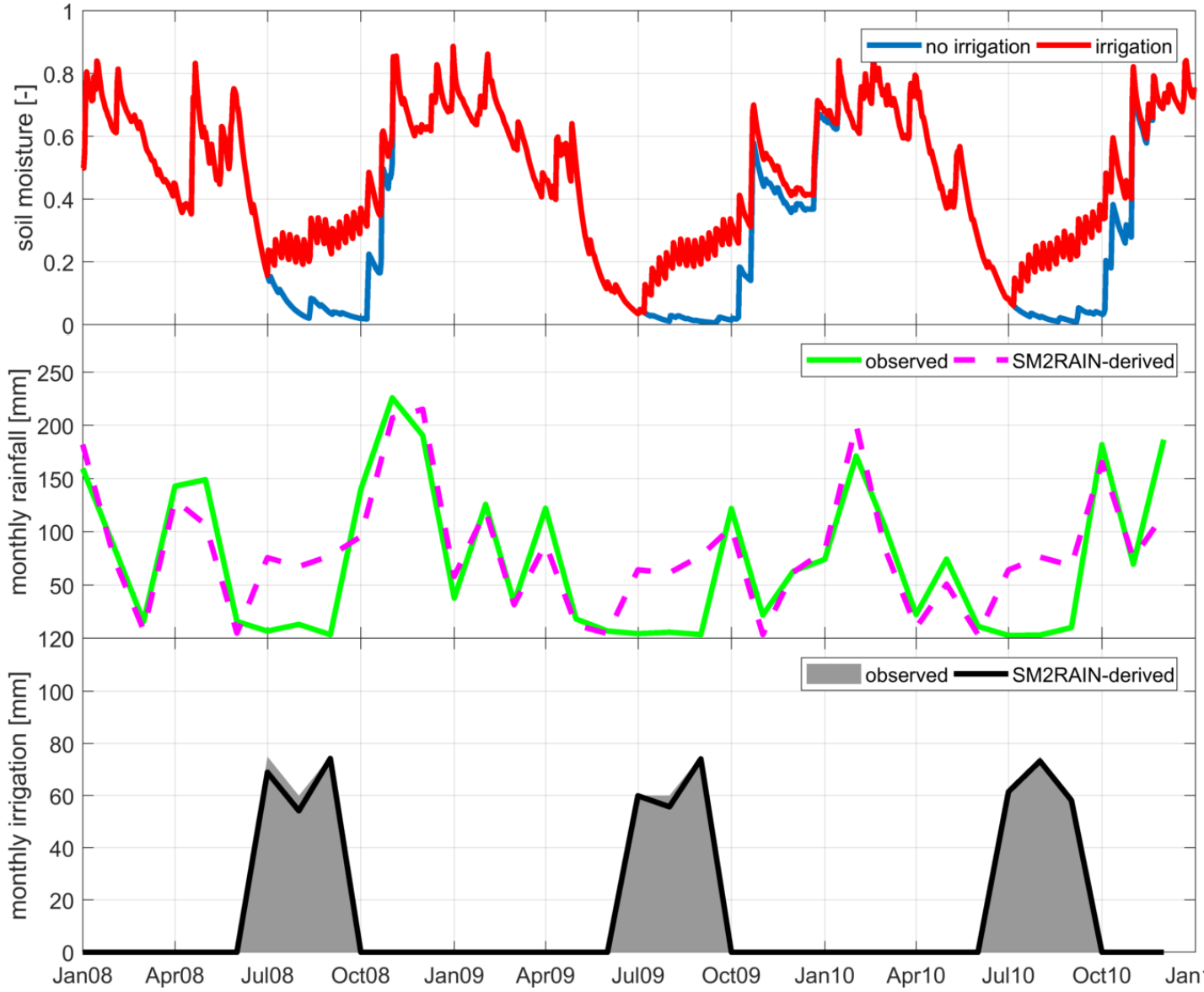

Inverting the water balance equation for i(t), assuming:

$g(t)=as(t)^{b}$
$r(t)=0$
$e(t)=ET_{pot}(t)s(t)$

$$i(t)=Z^{*}\frac{ds(t)}{dt}+a\,s(t)^{b}+ET_{pot}(t)\,s(t)-p(t)$$

Brocca et al. (2018 JAG)

# SYNTHETIC SOIL MOISTURE FOR IRRIGATION



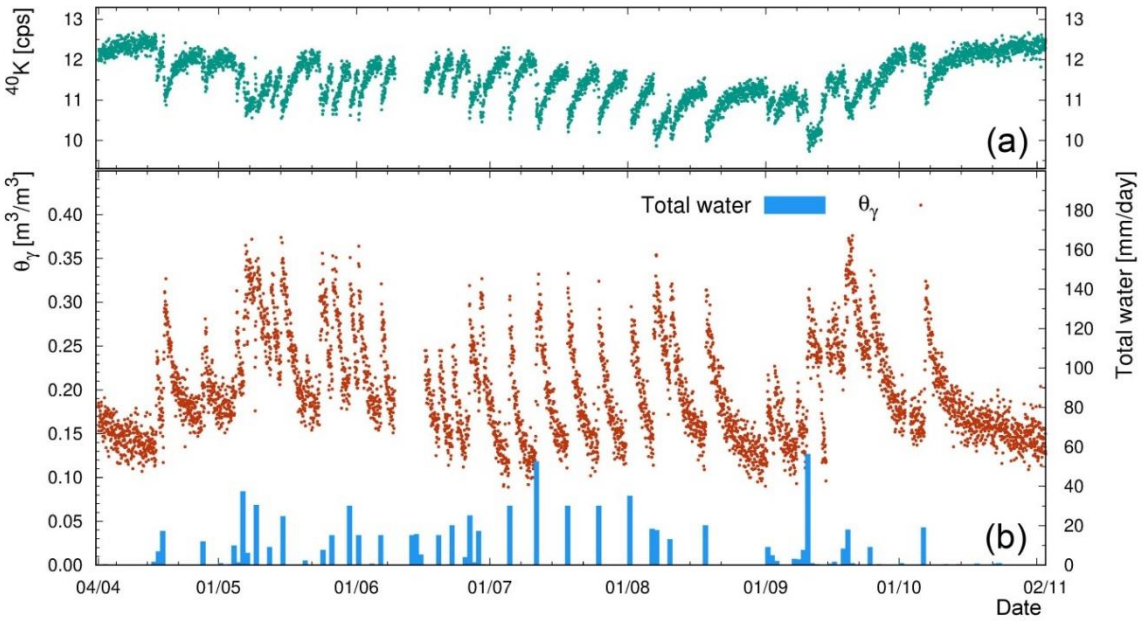

We simulate soil moisture without (**blue line**) and with (**red line**) irrigation

We apply SM2RAIN to synthetic soil moisture to obtain SM2RAIN-derived rainfall+irrigation (**magenta line**), compared with observed rainfall (**green line**).

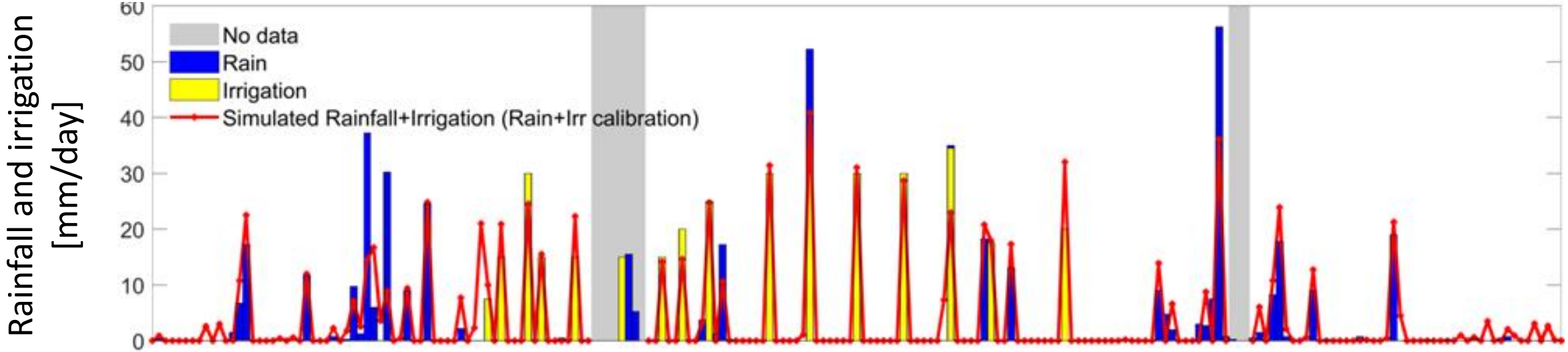
We subtract observed rainfall (**green line**) from SM2RAIN-derived rainfall+irrigation (**magenta line**) to obtain irrigation (**black line**), compared with observed irrigation (**grey area**)

Brocca et al. (2018 JAG)

# IN SITU SOIL MOISTURE FOR IRRIGATION



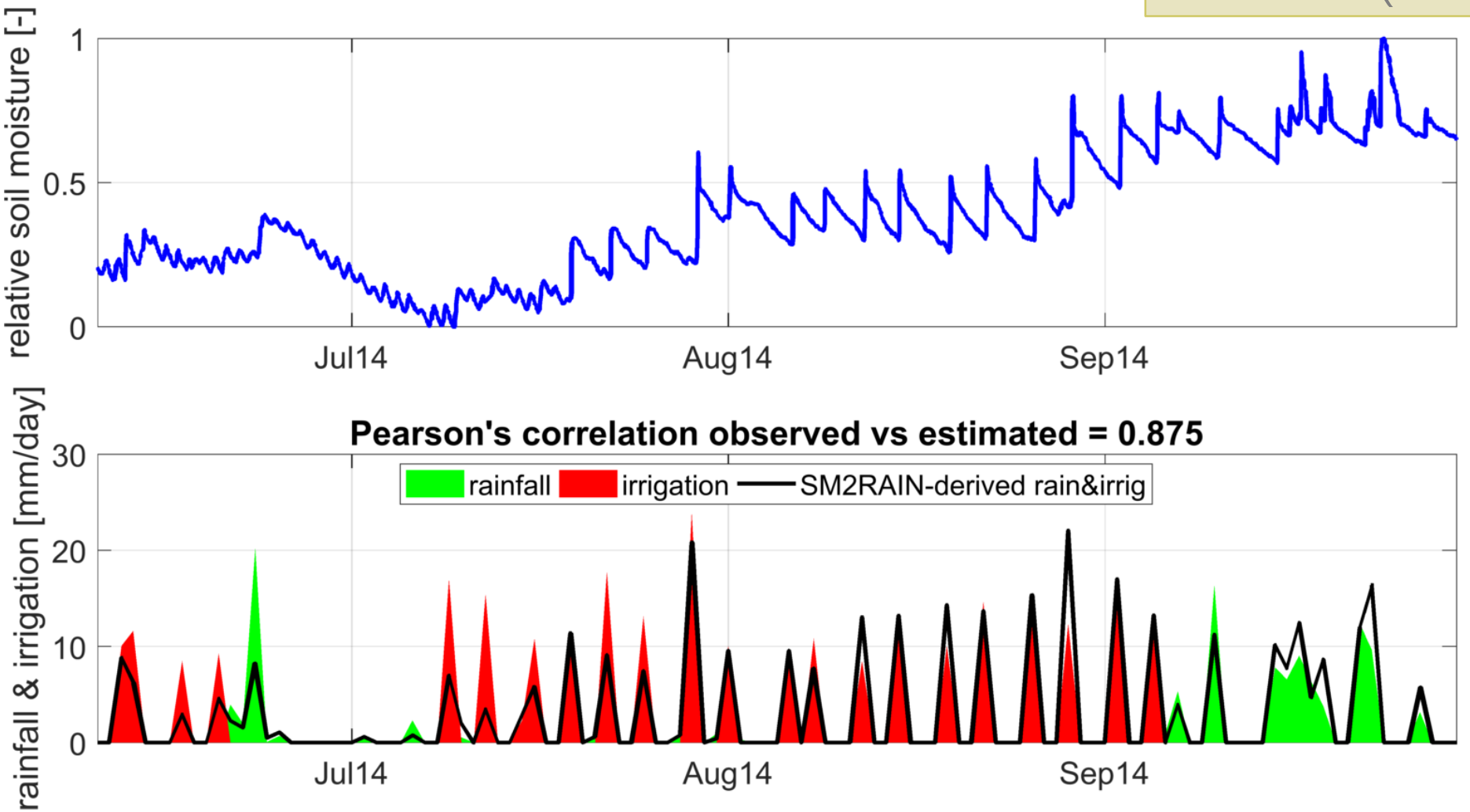

Emilia Romagna (Italy)


Filippucci et al. (2019 submitted)

# IN SITU SOIL MOISTURE FOR IRRIGATION

Coruche (Portugal)

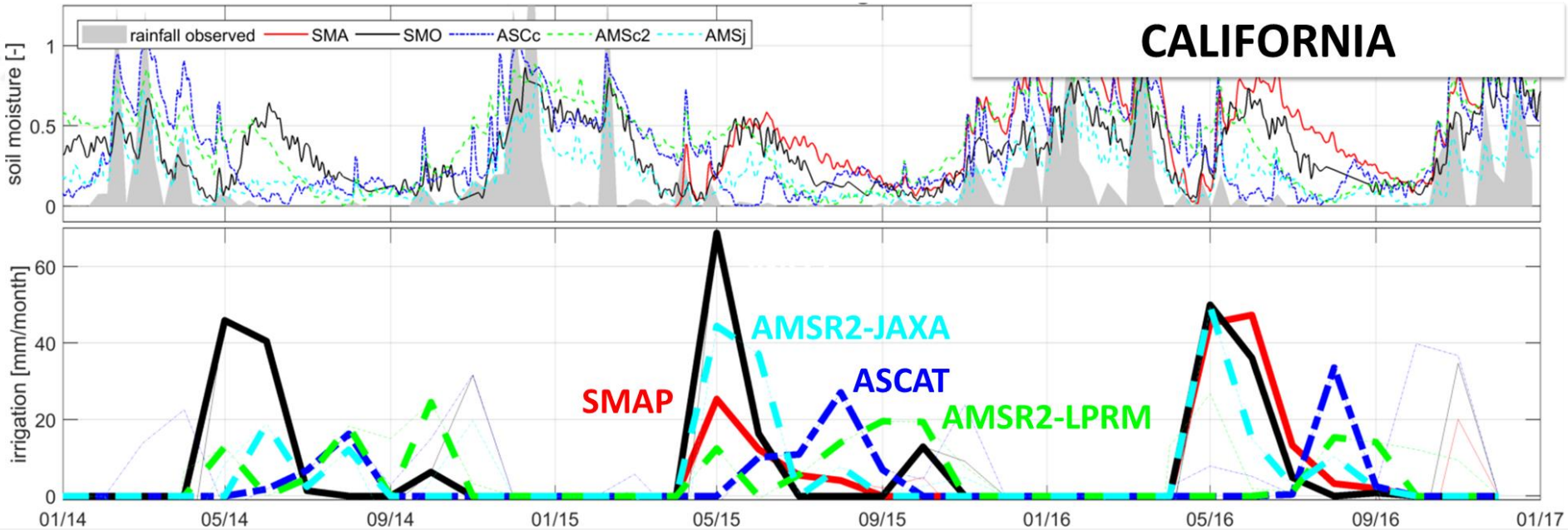



**The method works very well with in situ observations**, however the scale of in situ measurements (few meters) might not fit the need of agricultural applications

Simionesei et al. (2018 WATER)

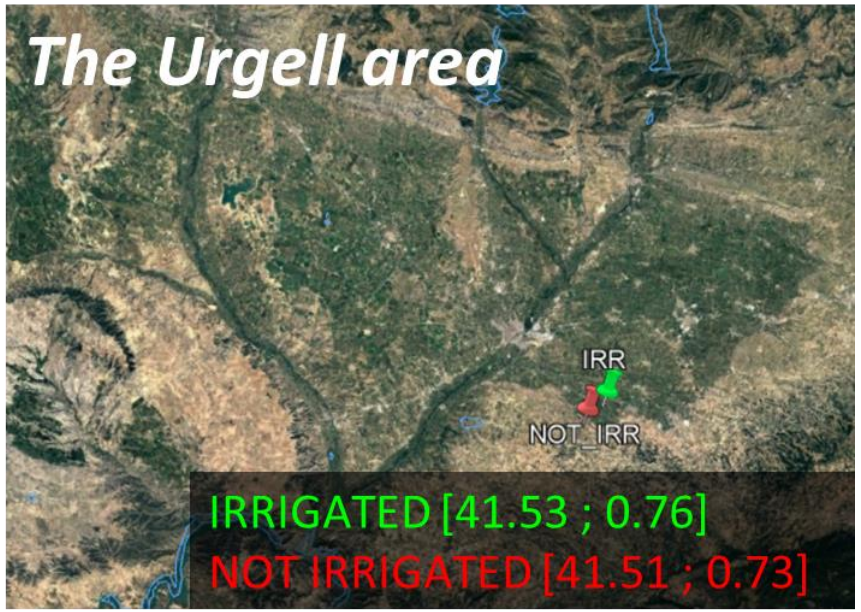
# SATELLITE SOIL MOISTURE FOR IRRIGATION


**Coarse scale satellite soil moisture** data are found able to quantify water used for irrigation through SM2RAIN algorithm but the **large spatial scale** of soil moisture observations (25-50 km) can be a serious **obstacle for agricultural applications**.

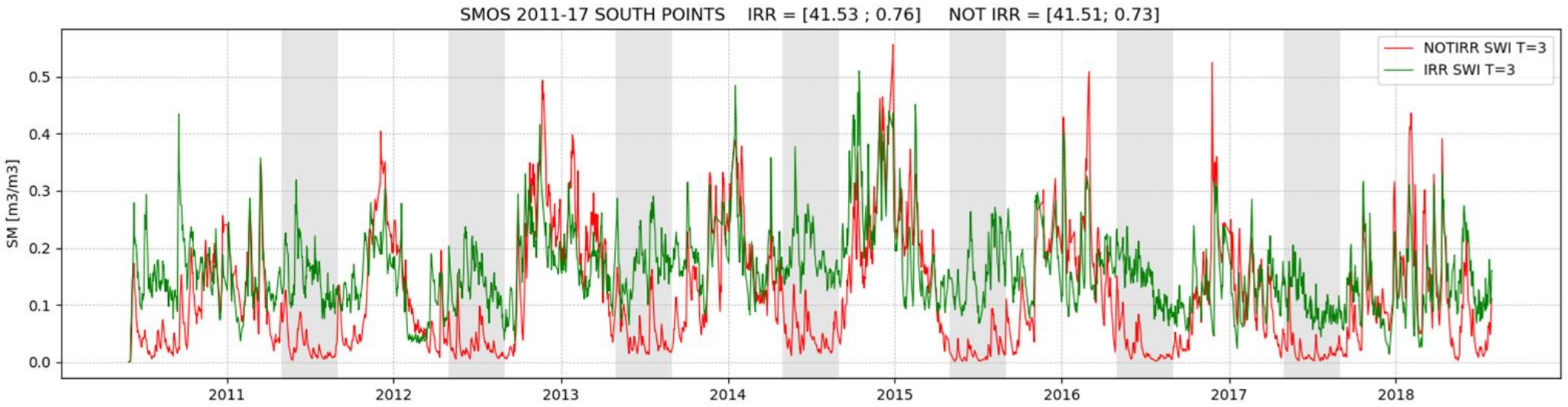




Brocca et al. (2018 JAG)
Zaussinger et al. (2019 HESS)

# SATELLITE SOIL MOISTURE FOR IRRIGATION




**Disaggrated SMOS soil moisture data** are able to see the irrigation signal over the Urgell area in Spain. Irrigated pixels show higher soil moisture content than non-irrigated pixel in the summer (irrigation) season.




Dari et al. (PICO, last Tuesday ☺)

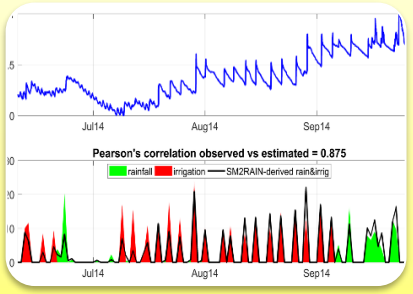
# SATELLITE SOIL MOISTURE FOR IRRIGATION



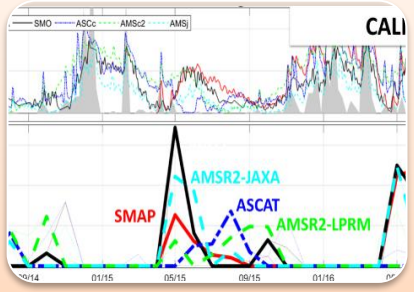


**Sentinel-1 (S1)** seems to be able to see the irrigation signal at small spatial scale, differently from coarse resolution ASCAT soil moisture.

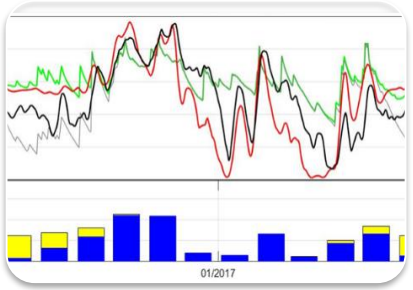
# TAKE HOME MESSAGE




Soil moisture observations **has large potential** for measuring irrigation (the missing info!)




**Coarse resolution** satellite soil moisture products have shown some potential over large irrigated areas




**High resolution** satellite soil moisture products are more suitable for irrigation quantification:

**ARE THEY ACCURATE ENOUGH?**

ADDITIONAL INFO
http://hydrology.irpi.cnr.it/research/irrigation/