

Relative impact of irrigation techniques and climate change on hydroclimatic regimes in the Mediterranean region

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Study region

Results

Modelling framework

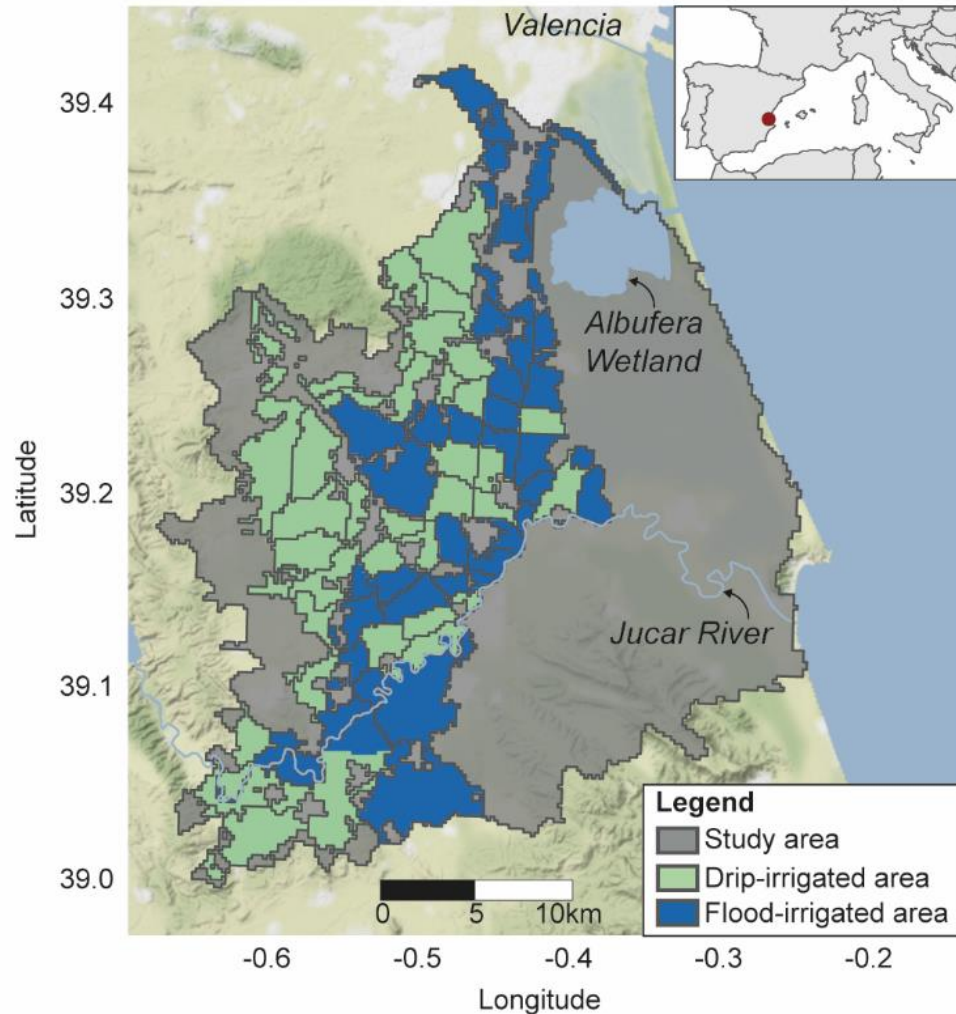
Conclusions

i

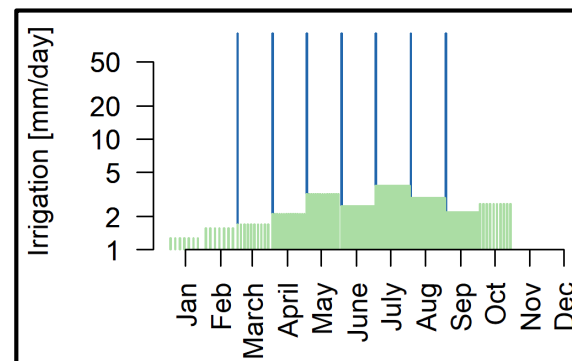


Image from www.acequiarj.es

Study region



- The semi-arid region of Valencia is the major citrus producer in Europe.
- Irrigated agriculture consumes 87% of the total freshwater withdrawals (CHJ, 2014).
- Currently, about 50% of the area is drip irrigated (see map).
- The still ongoing transition from flood to drip irrigation is seen as an important step towards increased resilience to water scarcity.



Flood irrigation (in blue): 630 mm/year applied in seven turns between March and Sep.

Drip irrigation (in green): 490 mm/year applied at high frequency from Jan to Oct.



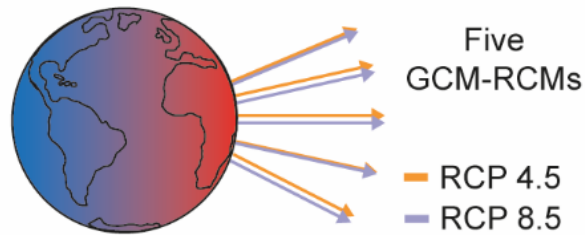
Modelling framework I



1

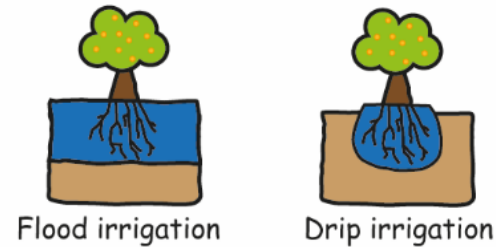
Climate models

Climate models were selected based on agro-hydrological criteria and data was bias corrected using quantile mapping.



Irrigation scenarios

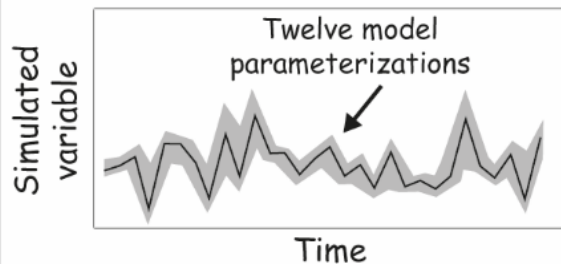
The irrigation transformation was simulated using a “flood” and a “drip” irrigation scenario.



2

Hydrological modelling

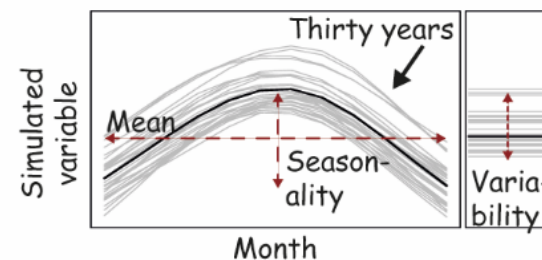
Hydrological simulations were run for a control (1971-2000) and two future periods (2020-2049; 2045-2074).



3

Evaluation of future changes

A wilcoxon signed rank test was applied to statistically compare past and future regime components.



Definition of the regime curve components:

The regime curve (black line) is the long-term mean daily value of multiple years (grey lines) and was described by three components: (1) the annual mean (mean of all months), (2) the seasonality within a year (difference between highest and lowest monthly value), and (3) the variability between years (difference between highest and lowest annual mean).

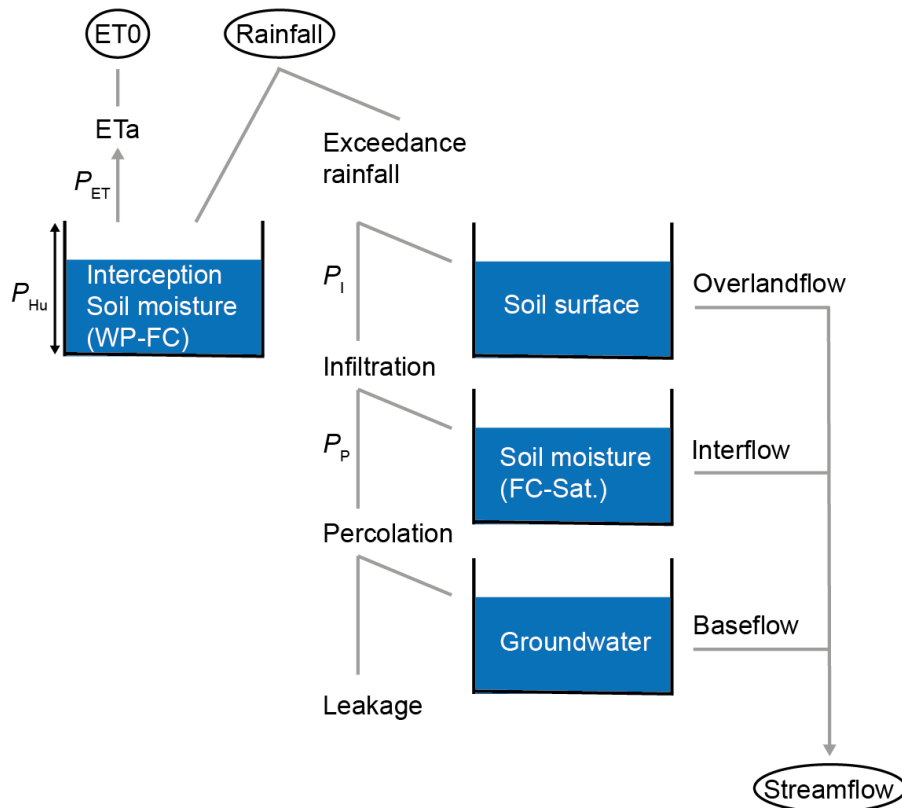


Modelling framework II



The TETIS model

A spatially distributed, physically based, bucket-type model (Francés et al., 2007).



Model calibration

Evaporative index: $ETa/(P+I)$

- Water balance (volumes)
 - Annual time scale (2015)
 - Irrigation sector scale (1 location)
- ⇒ Drip vs. flood irrigation

Groundwater table

- Recharge (volume, dynamics)
- Monthly time scale (1994-2015)
- 1km x 1km (4 wells)

Soil moisture

- Water balance (dynamics)
 - Daily time scale (2015)
 - Plot scale (1 location)
- ⇒ Drip irrigation (ETa vs. E)

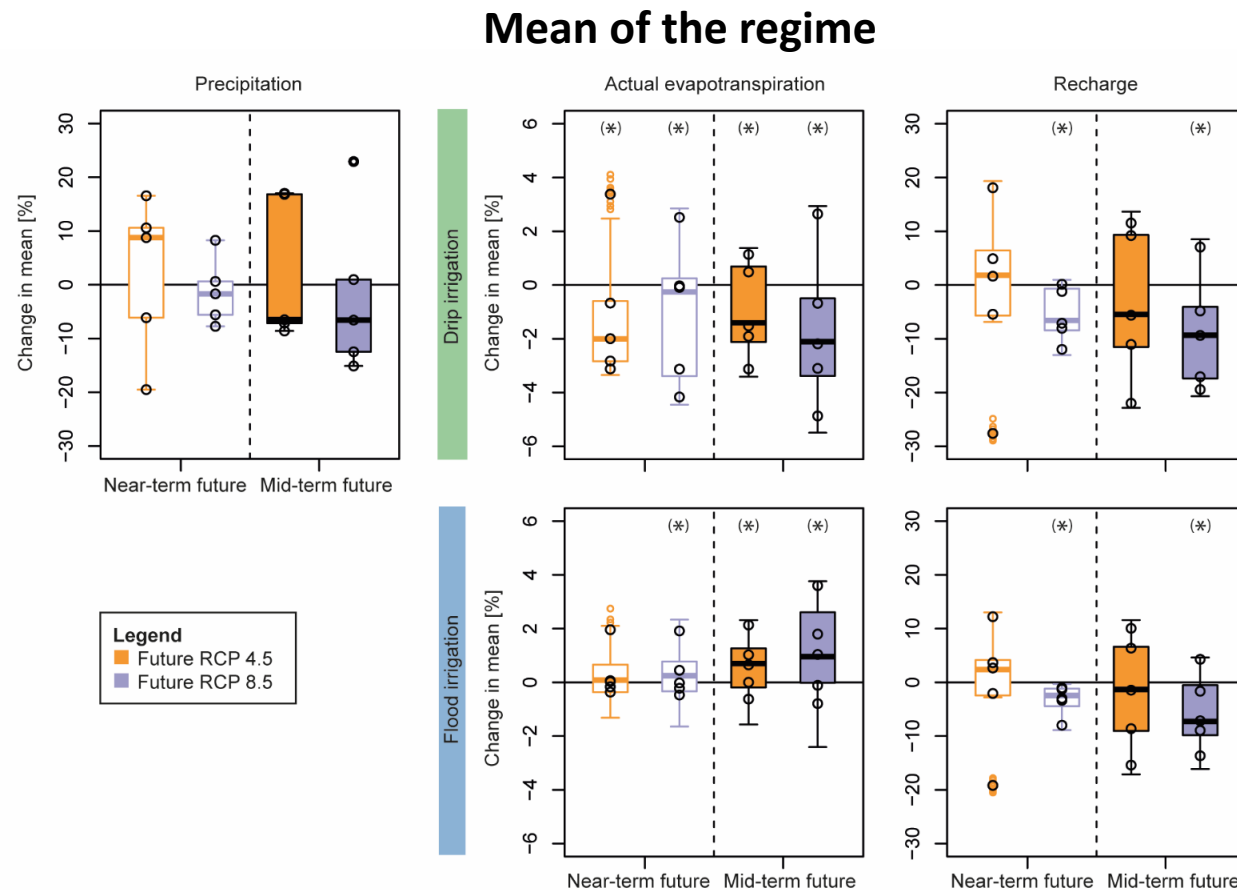
Process, temporal, spatial scale



Results I



What is the effect of climate change on future hydroclimatic regimes in irrigated Mediterranean agriculture?



(1) Future changes in temperature and precipitation could lead to a statistically significant (*) decrease in **mean** groundwater recharge of up to -6.6% under flood irrigation and -9.3% under drip irrigation.

(2) Opposed changes of +1% and -2.1% are projected for **mean** *ETa* in flood and drip irrigation, respectively (assuming *business as usual* irrigation volumes).

⇒ Definition of the mean regime component

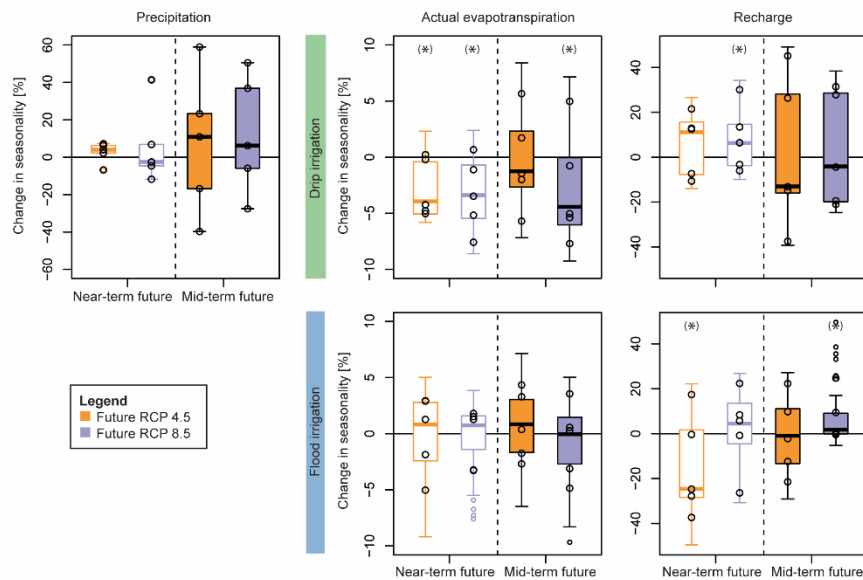


Results I

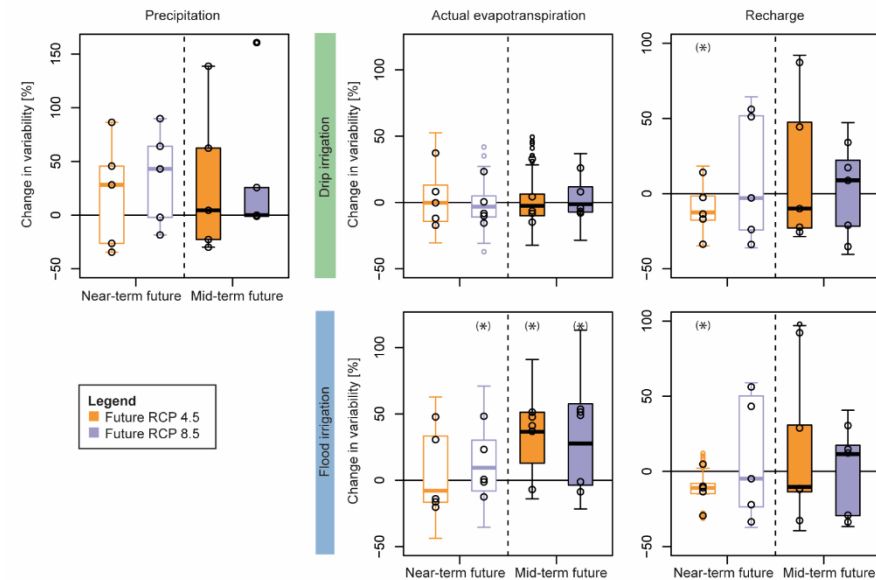


What is the effect of climate change on future hydroclimatic regimes in irrigated Mediterranean agriculture?

Seasonality of the regime



Inter-annual variability of the regime



- (1) Climate change impact on future seasonality and inter-annual variability in ETa and recharge are not entirely consistent.
- (2) Exceptions are the expected significant (*) decrease in ETa seasonality in drip-irrigated areas, and the significantly (*) higher future ETa variability in flood-irrigated areas.

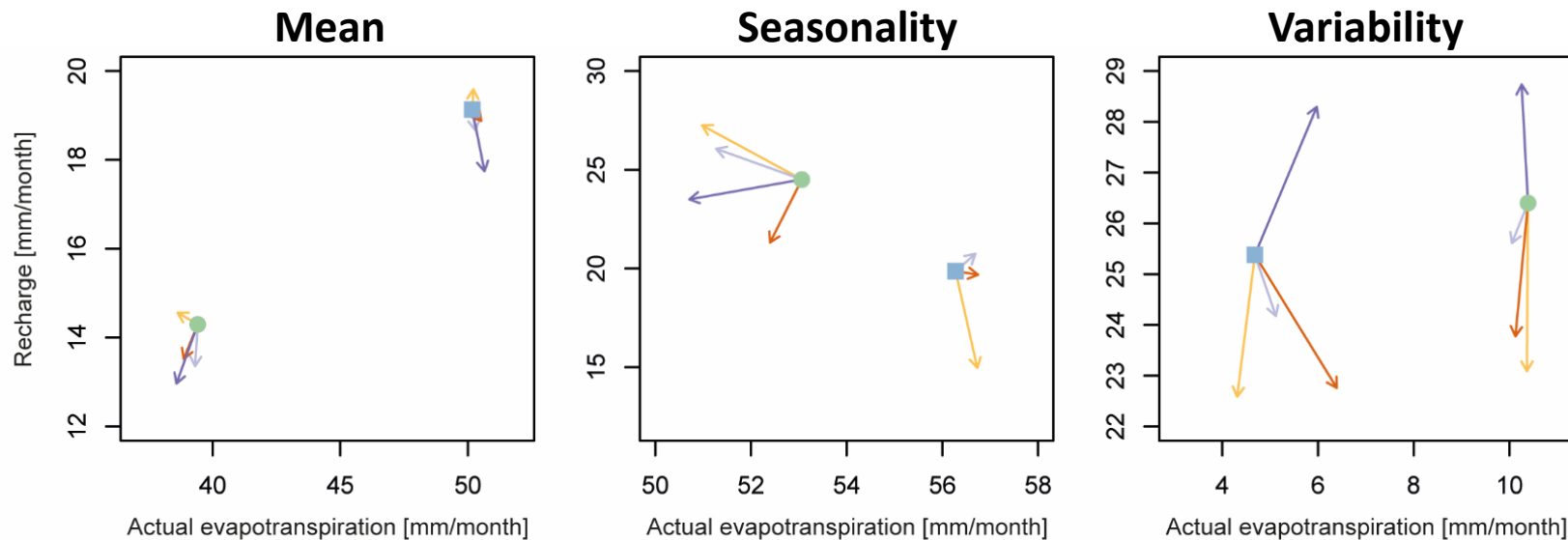
⇒ Definitions of seasonality and variability



Results II



What is the relative importance of climate change and irrigation techniques for changes in groundwater recharge and *ETa*?



Legend

● Drip irrigation control period
■ Flood irrigation control period
→ Near-term future RCP 4.5
→ Near-term future RCP 8.5
→ Mid-term future RCP 4.5
→ Mid-term future RCP 8.5

⇒ Definition
of regime
components

The figures show the current mean monthly groundwater recharge and *ETa* under flood and drip irrigation (squares and points) and how much they could change in the future due to climate change (arrows).

(1) Differences in groundwater recharge and *ETa* between flood and drip irrigation under current climatic conditions are often larger than potential future changes due to climate change.

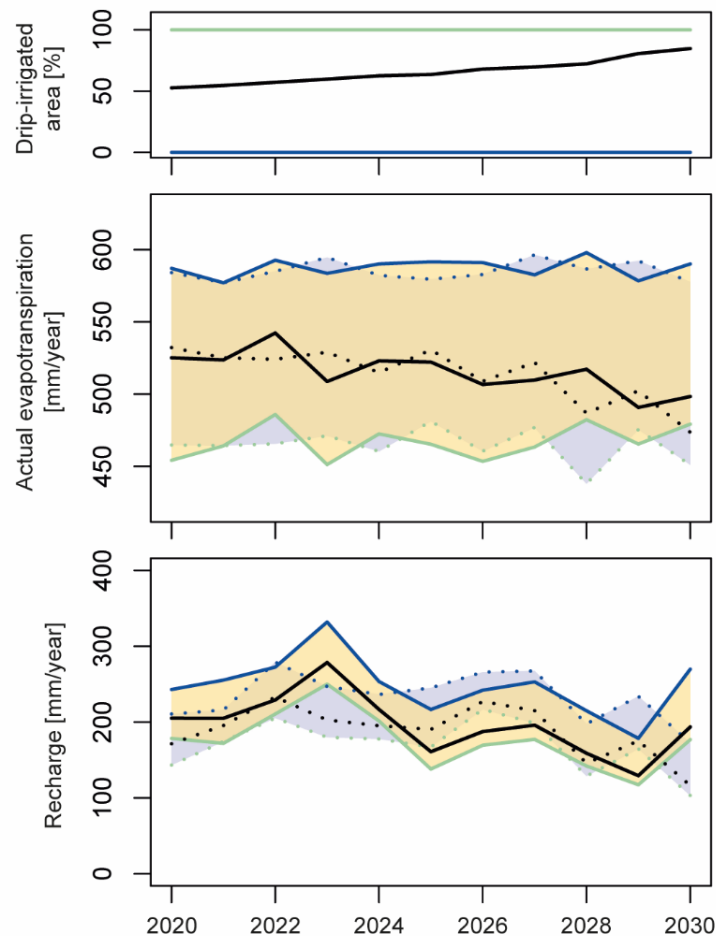
(2) Therefore, the choice of an irrigation technique may have a greater impact on *ETa* and groundwater recharge than climate change alone.



Results III



How is the future regional hydroclimate affected by the modernization plans of Valencia for the next ten years?



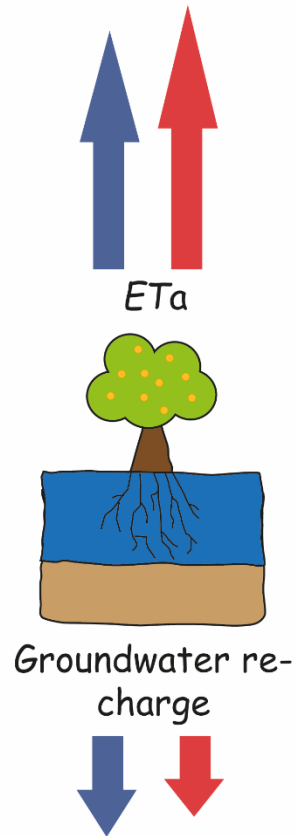
- (1) Irrigation modernization plans for the study region include the transformation of another 33% of the agricultural land to drip irrigation until reaching 85% in 2030.
- (2) Extending the drip-irrigated area under climate change conditions could reduce annual *ETa* at a rate of about 3-5 mm/year until 2030 (assuming *business as usual* irrigation schedules).
- (3) Climate change together with the planned transformation could decrease annual groundwater recharge by 5.1-7.0 mm/year until 2030.



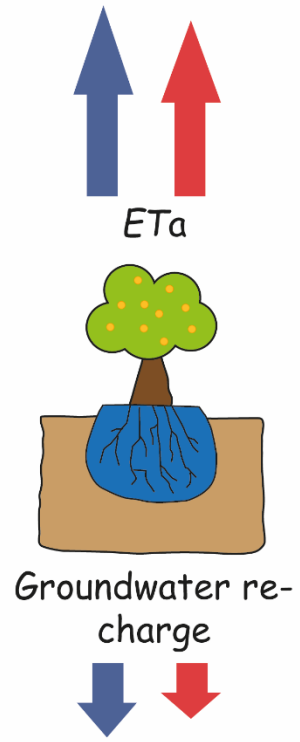
Conclusions



Flood irrigation



Drip irrigation



■ Past ■ Future

- (1) In the Mediterranean region of Valencia, climate change is expected to significantly reduce groundwater recharge in irrigated agriculture.
- (2) Actual evapotranspiration ET_a could increase in flood irrigation, but decrease in drip irrigation under *business as usual* irrigation (indicating a potentially increased irrigation water demand).
- (3) The ongoing irrigation transition in Mediterranean areas may have a greater impact on evapotranspiration and groundwater recharge than climate change.
- (4) Future decisions on water allocations in Eastern Spain will likely be made in the challenging context of reduced water availability and considerable uncertainty about the expected changes.



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This work is a collaboration between:



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References



Results of this study are published in:

- Pool S., Francés F., Garcia-Prats A., Puertes C., Pulido-Velazquez M., Sanchis-Ibor C., Schirmer M., Yang H. and Jiménez-Martínez J., 2021. From flood to drip irrigation under climate change: impacts on evapotranspiration and groundwater recharge in the Mediterranean region of Valencia (Spain), *Earth's Future*, accepted for publication, [DOI:10.1029/2020EF001859](https://doi.org/10.1029/2020EF001859)

Further References:

- CHJ, 2014. Plan Hidrológico de la Demarcación Hidrográfica del Júcar Ciclo 2015–2021. 684 *Confederación Hidrográfica del Júcar*, Valencia, www.chj.es.
- Francés, F., Velez, J.I. and Vélez, J.J., 2007. Split-parameter structure for the automatic calibration of 737 distributed hydrological models. *Journal of Hydrology*, 332(1-2), pp.226-240, [DOI:10.1016/j.jhydrol.2006.06.032](https://doi.org/10.1016/j.jhydrol.2006.06.032)

Image on the first slide and map of the study area:

- Acequia Real del Júcar: Una de las instituciones de regadío más antiguas de España (desde 1258), www.acequiarj.es
- Stamen, 2019. Map tiles by Stamen Design, under CC BY 3.0. Data by OpenStreetMap, under ODbL, <https://stamen.com/>

