Climate-driven local assessment of future irrigation requirements and available water resources in North-West Italy

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Background

In recent years, Northern Italy has been exposed to **major problems of irrigation supply**, due to increases of crop water requirements and lack of available water. Prolonged and **more severe summer droughts**, combined with **lack of snowfall** during winter months, expose agriculture to high risks. Moreover, climate models show that agricultural **water-related criticalities may be even more severe in the next decades**.

Objectives

- **Climate-driven modelling** of agricultural water needs and hydrological regimes, for the analysis of present criticalities.
- Comparison of **available water resources** and **crop irrigation requirements** for the next decades, according to several **RCP scenarios**.

Studied area

The analysis was performed over the densely cultivated area of **Demonte basin** (Piedmont, Italy). As shown in Figure 1, most of the croplands are concentrated in the northern lowlands.

- The distribution of **croplands** has been reconstructed on a field scale, according to regional datasets[1].
- **98 products** were considered (including types of cereals, fruit trees and vegetables).
- Yearly crop classification for the **period 2015-2021**.

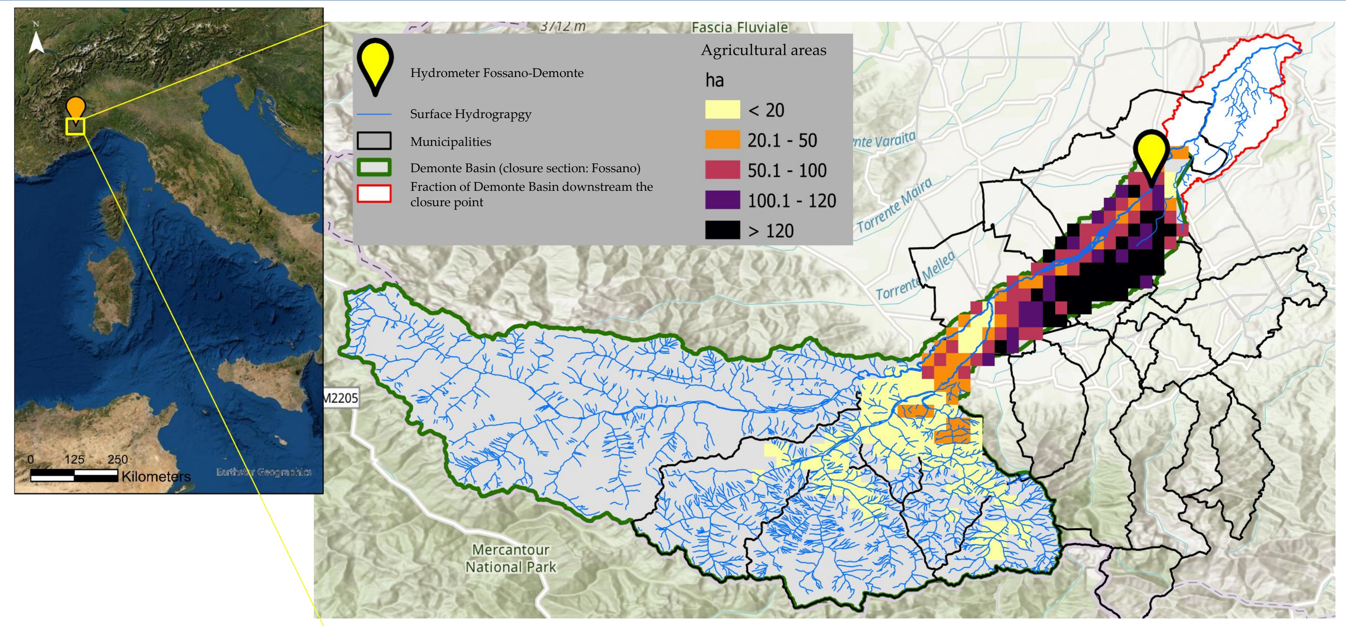
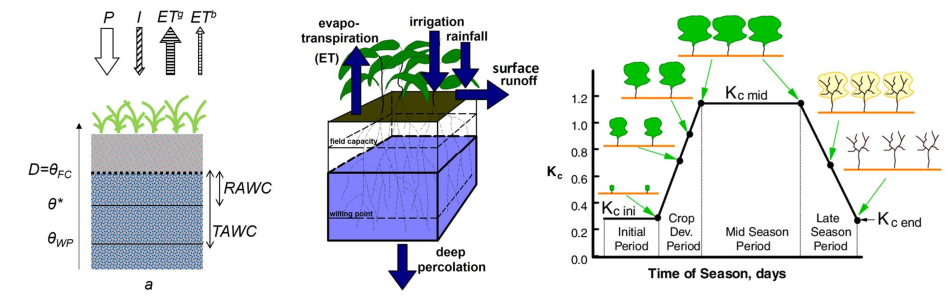


Figure 1. Location of studied area and density of agricultural areas. The discharge of the Stura di Demonte river is measured at the «Fossano-Demonte» section.

Climate-driven assessment of irrigation requirement

The **daily crop water requirement** was calculated through a **soil water balance model**, based on gridded data of daily precipitations and temperatures.

- Model based on **FAO guidelines**[2].
- The **Reference Evapotranspiration** (ET_0) was calculated according to the Hargreaves-Samani method.
- The **Irrigation Requirement** (I) is defined as the amount of water ideally needed by crops to avoid water-stress conditions, in case of low rainfall, per unit of area.
- The **volumes** of Irrigation Requirements were calculated by multiplying the I rate and the extend of each crop-specific gridded area.



MODEL OF SOIL WATER BALANCE[3]

CLIMATE DATA	CROPLANDS	SOIL PROPERTIES
• Precipitation & ET0 • Source: ARPA[4] & CORDEX[5]	Source: *Anagrafe Agricola di Regione Piemonte* [1].	• Available Water Capacity • Source: *SoilGrids_250*[6]

Daily water balance

$$\Delta S = ET_a - I - P$$

Actual Evapotranspiration (ET_a) → $ET_a = ET_0 \cdot k_c \cdot k_s$

k_s: water stress coefficient; k_s=1: well watered soil (no stress); k_s=0: wilting point.

Future scenarios of water needs and available resources

- The **HBV-EC hydrological model** was used to simulate the discharge of the *Stura di Demonte* river for the 2030-2050 period. Most of the irrigation water used in the studied area is withdrawn from this river. The 2007-2009 years were used as reference period for the **calibration** of the HBV-EC parameters.
- The **CORDEX-EU**[5] data were used to model future scenarios of available water and irrigation requirements for the **period 2030-2050** (5 models were used, for RCP 2.6 & RCP 8.5 scenarios).
- The future irrigation requirements were modeled using **bias-corrected** CORDEX-EU data. For the bias correction, groung-measured data from the local environmental agency[4] were used, choosing 2006-2020 as reference period (Figure 2).

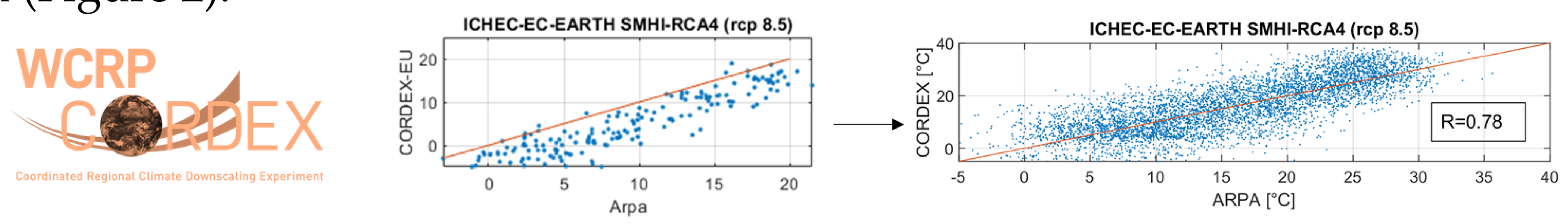


Figure 2. Bias correction of CORDEX-EU data, according to local climate data over the period 2006-2020 (in figure, Temperature correction is shown)

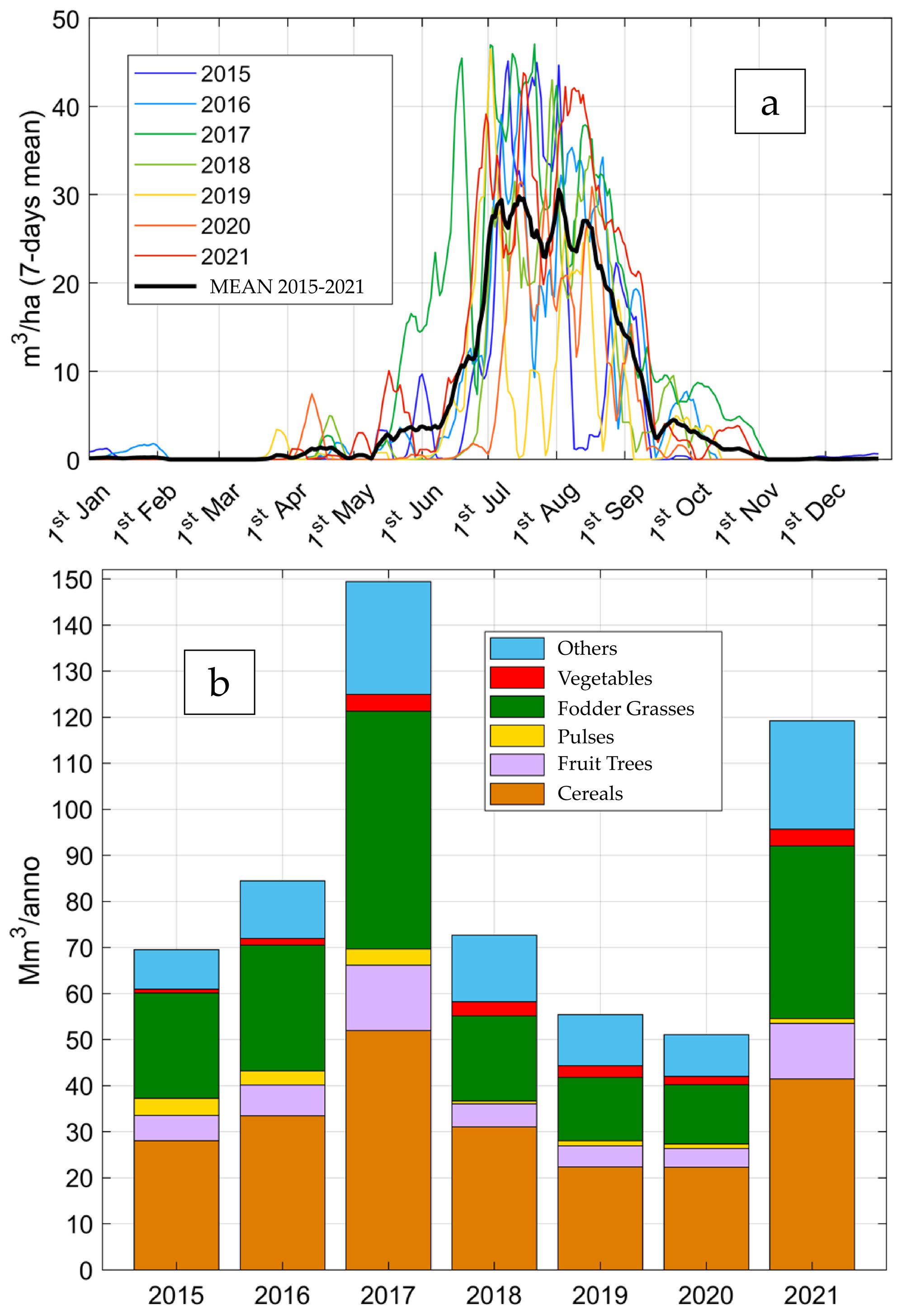


Figure 3. (a) time series of daily irrigation requirements for the period 2015-2021 (average in black). (b) crop-specific volumes of irrigation requirements for the 2015-2021 period.

Results

- Currently, the **average irrigation needs** reach values close to 30 m³/ha/day between July and August (Figure 3a). Most of the irrigation is required by **cereals** (especially maize) and fodder grasses (Figure 3b).
- The calculation of **volumes by type of product** is little influenced by crop rotation, since although every 3-4 years summer cereals, forage grasses and fallow land are locally alternated, the total hectares over the whole area are little variable from year to year.
- The factor with the **highest impact** on the time series of irrigation requirements is the **frequency of precipitation** events (more than the total amount of precipitation during the growing season).
- For future decades, it is reasonable to assume that **irrigation needs are destined to grow progressively** in the summer months of the next decades (Figure 4), up to equal (or exceed) the water levels available in the Stura di Demonte (e.g. For the period 2030-2050, irrigation requirements could be higher than the capacities of the Stura di Demonte of more than 40% during August).
- Most of the discharge of Stura di Demonte is expected to be **concentrated during spring months**, when no irrigation is required (Figure 4b). This information is important to set-up effective local policies of water management and future planning of water storaging.

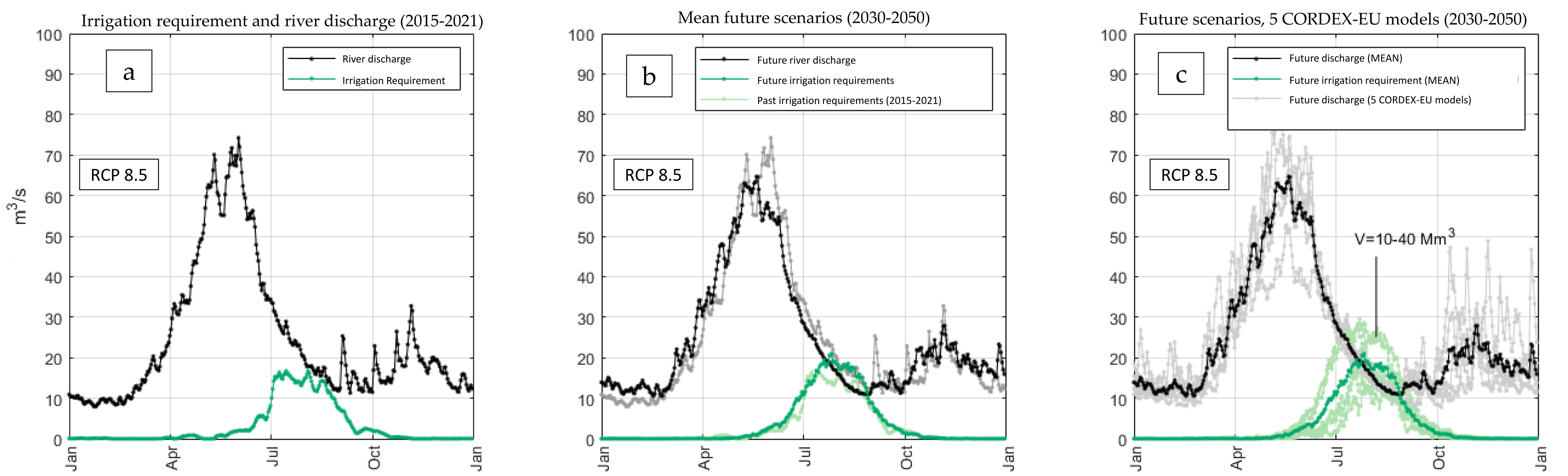
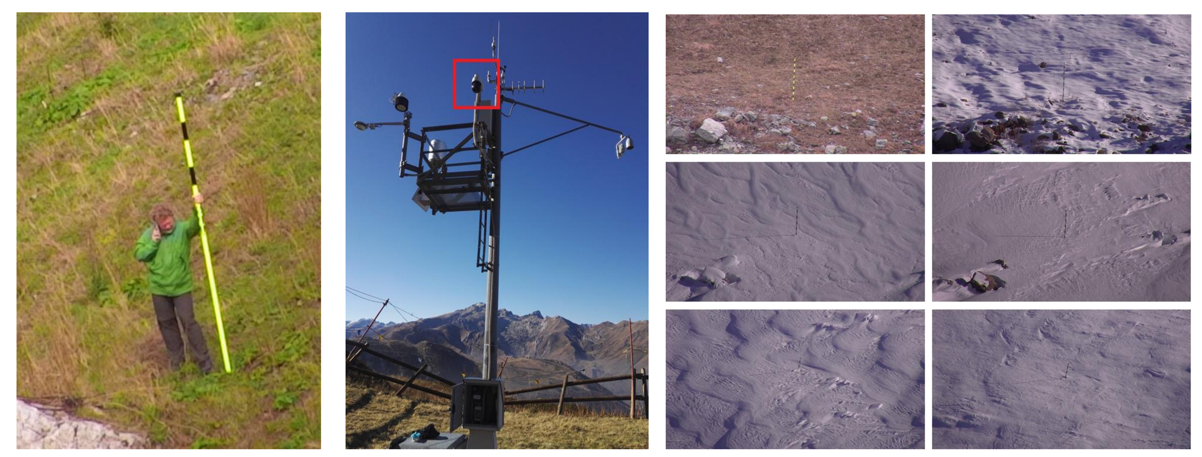


Figure 4. (a) Comparison of current average annual irrigation requirements and discharge in the Stura di Demonte river; (b) mean future scenarios of irrigation requirements and river discharge, for the period 2030-2050 (in grey, the mean discharge for the 2015-2021 period; in light green, the mean irrigation requirement for the period 2015-2021); (c) comparison of mean future scenarios of irrigation requirements and river discharge, detailing the outputs obtained using 5 CORDEX-EU models.

Future insights

- Installation of snow cover **measuring instruments** in the high-elevation mountain part of the river basin.
- Monitoring the **snowfall** of future years to improve the quality of the hydrological modelling.
- Supporting the local and national planning of future **water storage** infrastructures.



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[3] Tuninetti, Marta, et al. "Global sensitivity of high-resolution estimates of crop water footprint." *Water Resources Research* 51.10 (2015): 8257-8272.
[4] ARPA Piemonte. www.arpa.piemonte.it
[5] CORDEX-EU climate data. https://www.euro-cordex.net/060378/index.php.en
[6] Hengl, Tomislav, et al. "SoilGrids250m: Global gridded soil information based on machine learning." *PLoS one* 12.2 (2017): e0169748.

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