1ST LIAISE CONFERENCE AND DETERMINING EVAPOTRANSPIRATION CROSSCUT WORKSHOP

MAR 27 - 29, 2023 | LLEIDA, SPAIN

Analysis and forecast of crop water demand in the irrigation districts of Lleida: estimation of ET through Copernicus-based Inputs

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Climate Change:

Lower rainfall, but higher crop water demands

Many irrigated areas have low water use efficiency. On average, only 40% of the water diverted for irrigation is actually used by crops.

Distribution/Transport

Irrigation Scheduling

Real-time systems capable to quantify and to forecast crop's water demands to enhance the productivity and sustainibility of irrigated agriculture

Find a balance between crop water demands and supplies

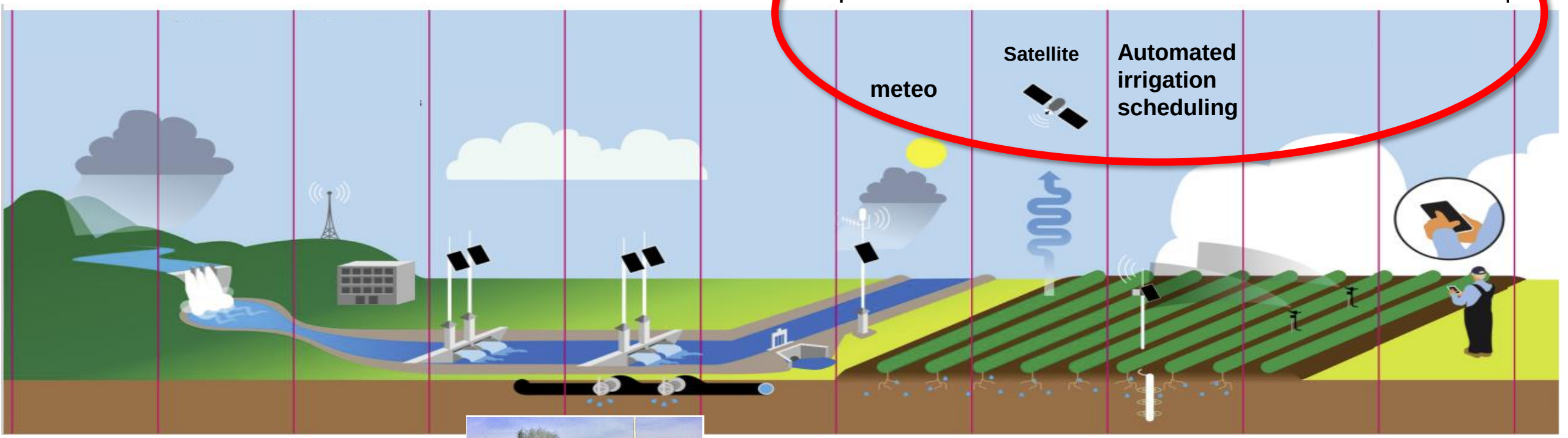
Water supplies

Crop water demands

meteo

Satellite

Automated irrigation scheduling

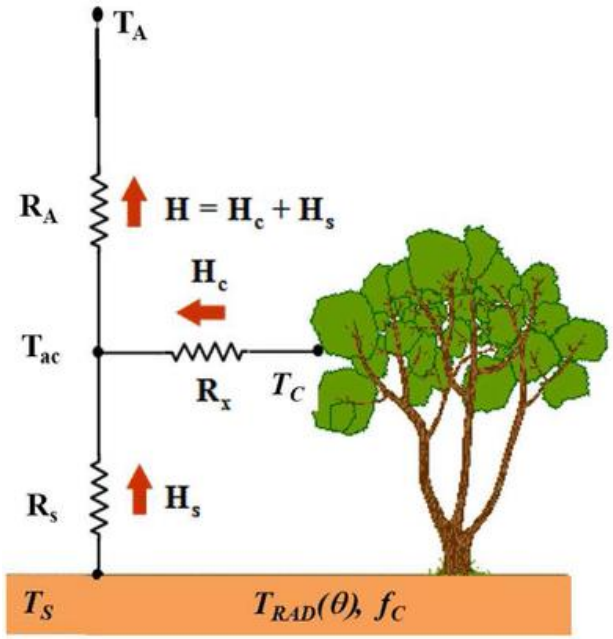


Automated gates

Modelling Evapotranspiration (ET)

Two Source Energy Balance (TSEB) modelling scheme

- Introduced by Norman et al. (1995)



SENSIBLE HEAT FLUX

Norman and Kustas, et al. (1995)

System, soil, canopy budgets

$R_n = H + \lambda E + G$

$R_{n,s} = H_S + \lambda E_S + G$

$R_{n,c} = H_C + \lambda E_C$

Two-source approximation

$T_{RAD}(\theta)^4 \sim f_C(\theta)\, T_C^4 + [1-f_C(\theta)]\, T_S^4$

Temperature constraint

$H_C, H_S, R_{n,c}, R_{n,s}, G$

PT, PM or LUE R_C model

λE_C

Residual

$\lambda E_S = R_n - H - G - \lambda E_C$

Iterative solution

github.com/hectornieto/pyTSEB

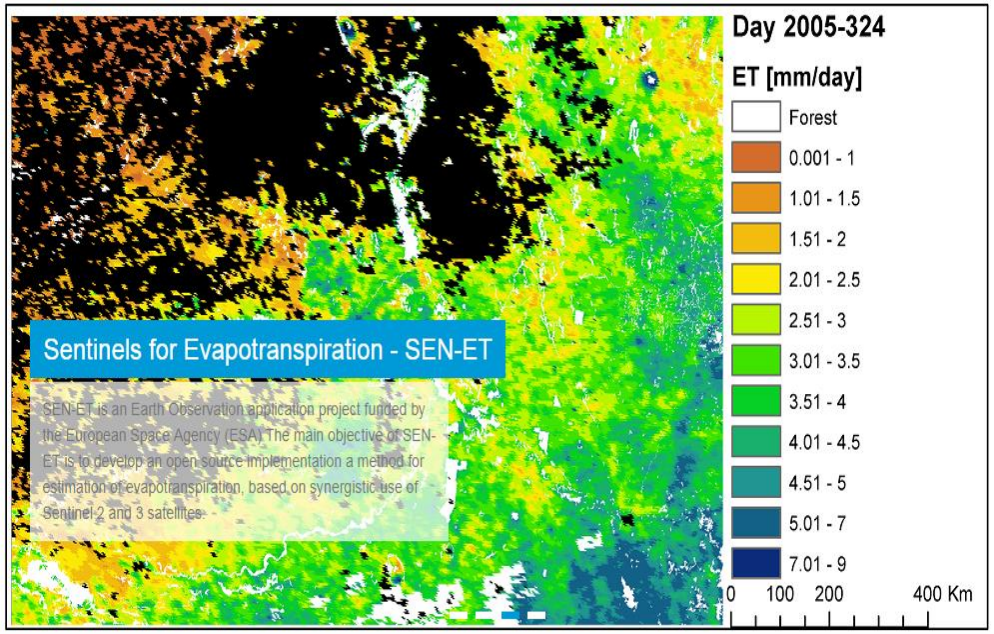
Modelling Evapotranspiration (ET)

IRTA

sen-et
sentinels for evapotranspiration

SENTINELS FOR EVAPOTRANSPIRATION

Copernicus
Europe's eyes on Earth



Sentinel-2

Sentinel-3

Climate Change

Land Monitoring

ERA-5 reanalysis

TSEB - PT

ET maps at 20 m resolution

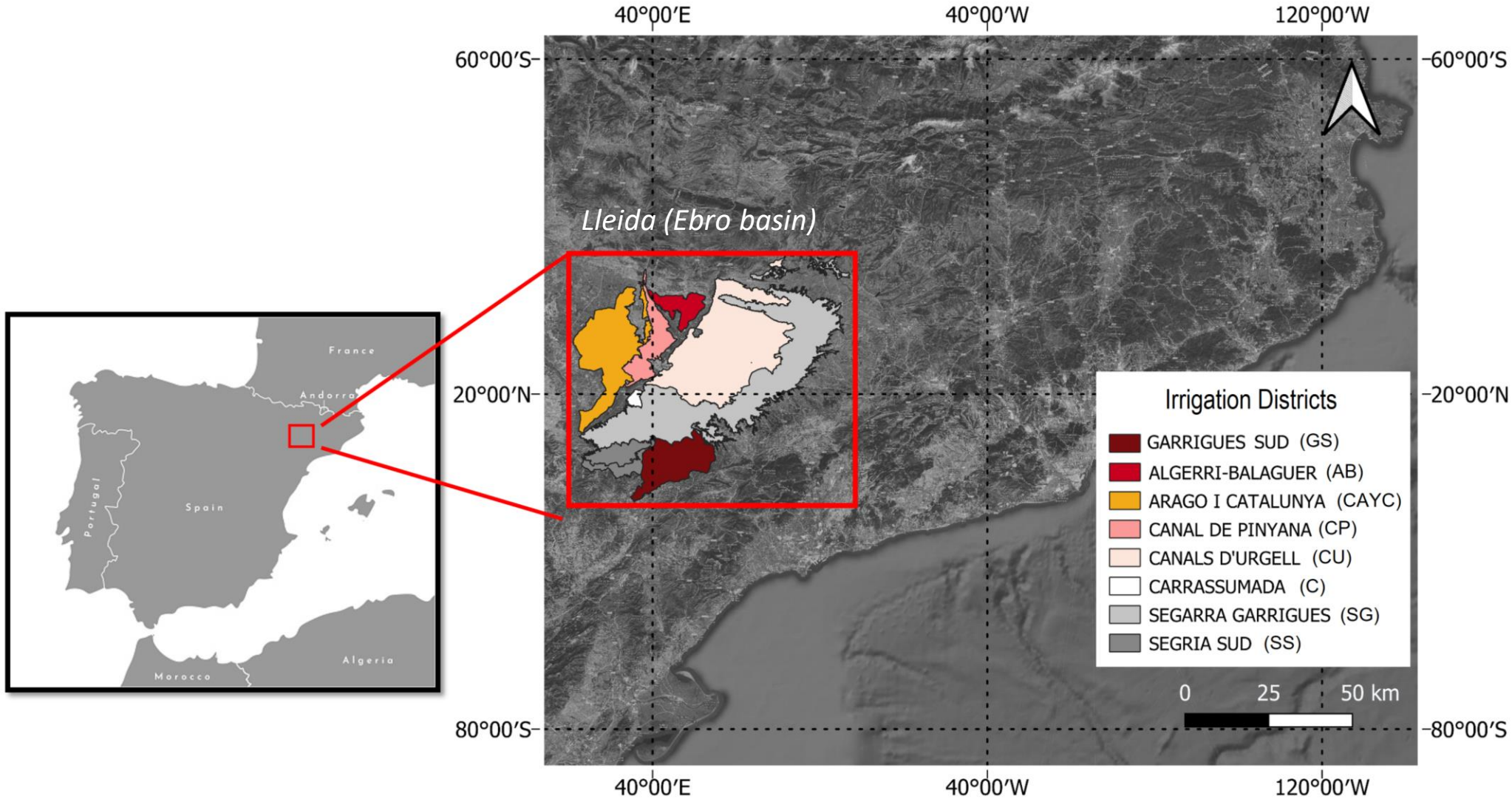
VALIDATION

Guzinski et al. (2020)
Bellvert et al. (2020)
Guzinski et al. (2021)
Jofre-Cekalovic et al. (2022)

RMSE in ET < 1 mm/day

www.esa-sen4et.org

Study site

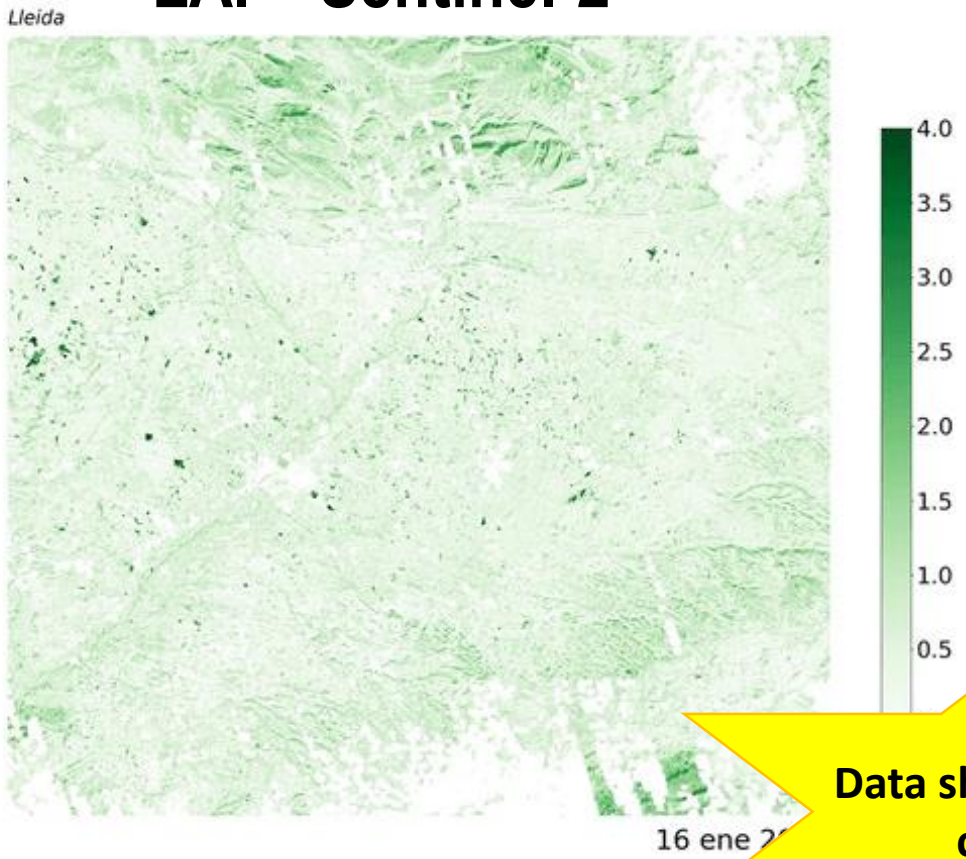

40°00'E
40°00'W
120°00'W
60°00'S
20°00'N
80°00'S
Lleida (Ebro basin)
France
Andorra
Portugal
Spain
Algeria
Morocco
Irrigation Districts
GARRIGUES SUD (GS)
ALGERRI-BALAGUER (AB)
ARAGO I CATALUNYA (CAYC)
CANAL DE PINYANA (CP)
CANALS D'URGELL (CU)
CARRASSUMADA (C)
SEGARRA GARRIGUES (SG)
SEGRIA SUD (SS)
0
25
50 km

Information for each irrigation district

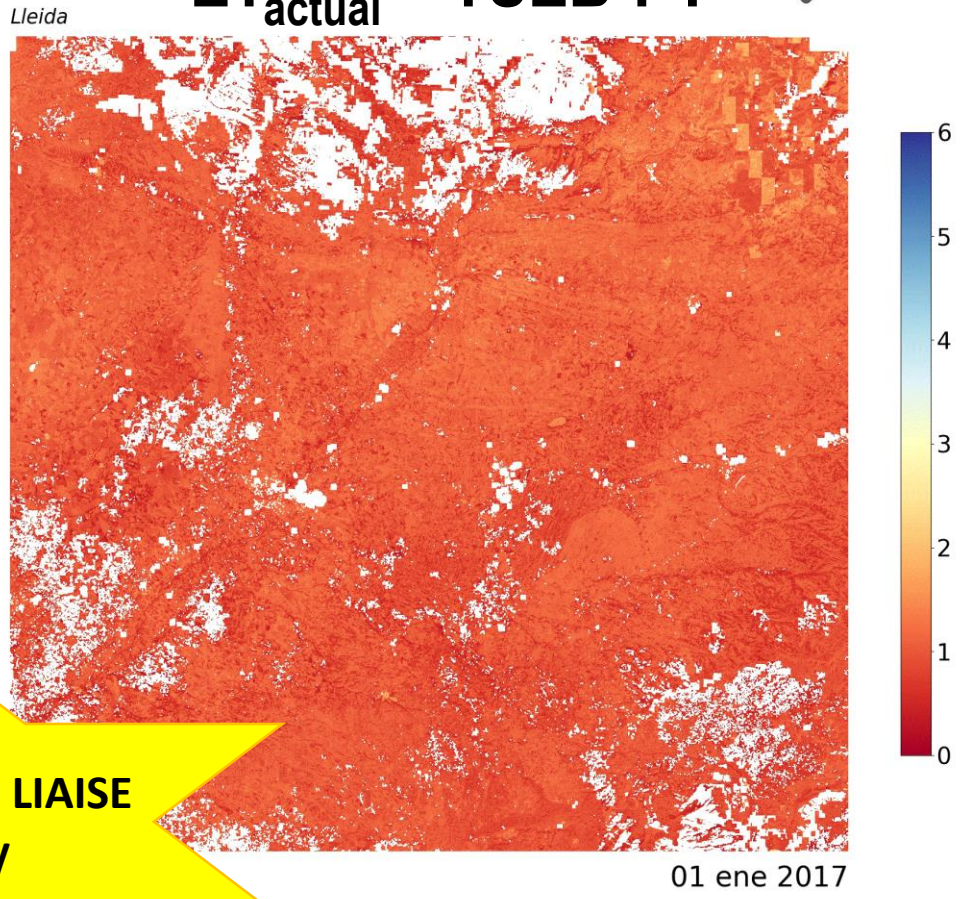
ID	Total area (ha)	Area of irrigated fields (ha)	Water allocation (m^3/ha)	Irrigation system (%)		
				Drip	Sprinkler	Flood
AB	7881	6148	~6000	22.3	76.1	1.6
C	1351	1346	~7000	84.1	14.1	1.8
CAYC	29955	29635	~8000	33.0	65.1	1.9
CP	12051	9223	~10000	35.1	40.2	24.7
CU	64088	61494	~9000	13.0	6.0	81.0
GS	8748	7365	~1300	100	-	-
SG	68328	25383	1500-6500	82.5	15.4	2.1
SS	7687	6448	~2000	94.4	0.1	5.5

Since 2017 up to now ...

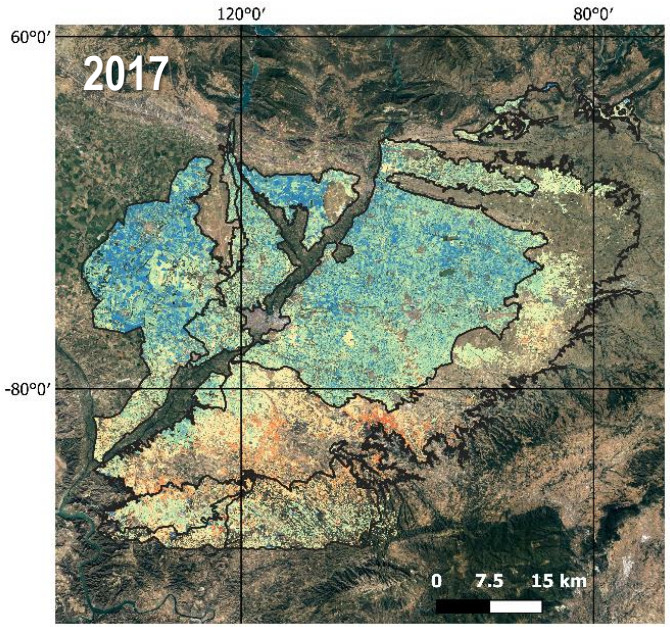
LAI – Sentinel-2

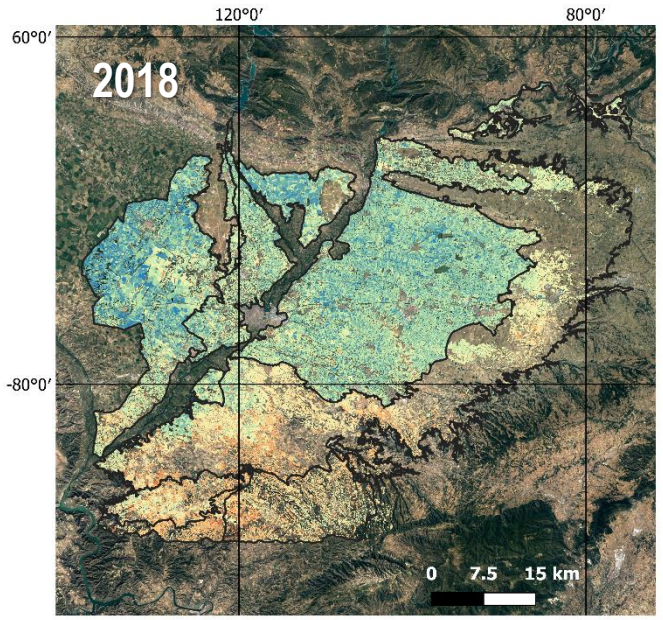


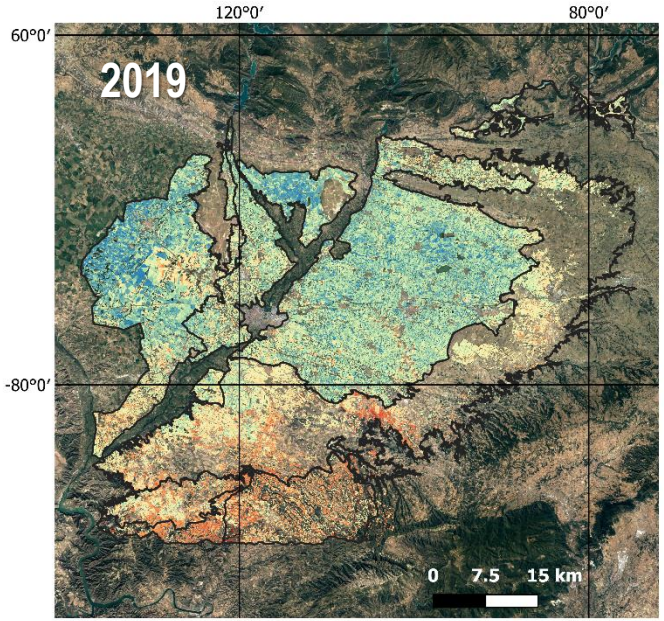
ET_{actual} – TSEB-PT

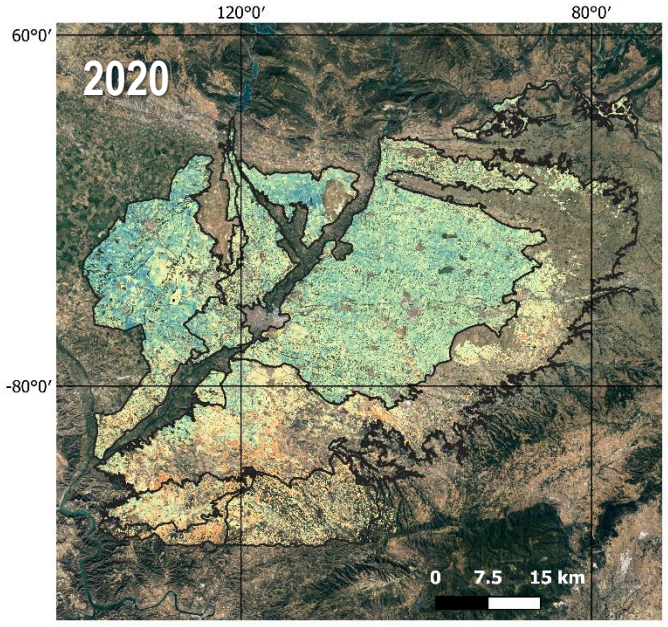


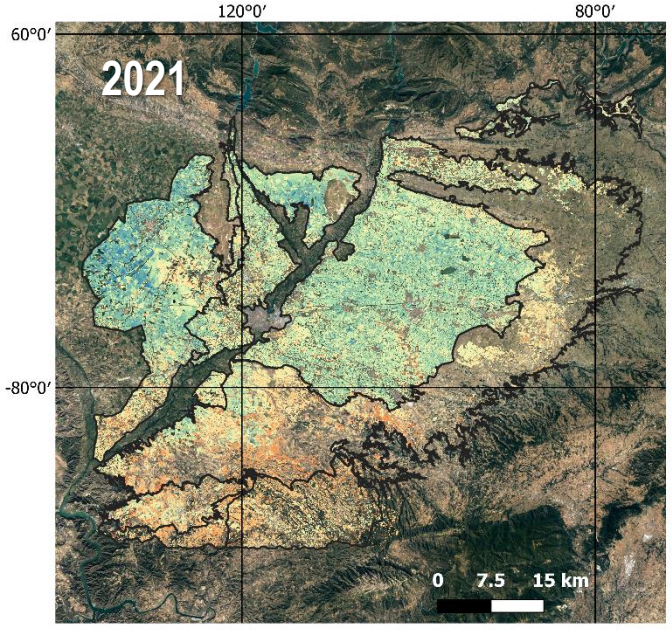
Data shared with LIAISE community

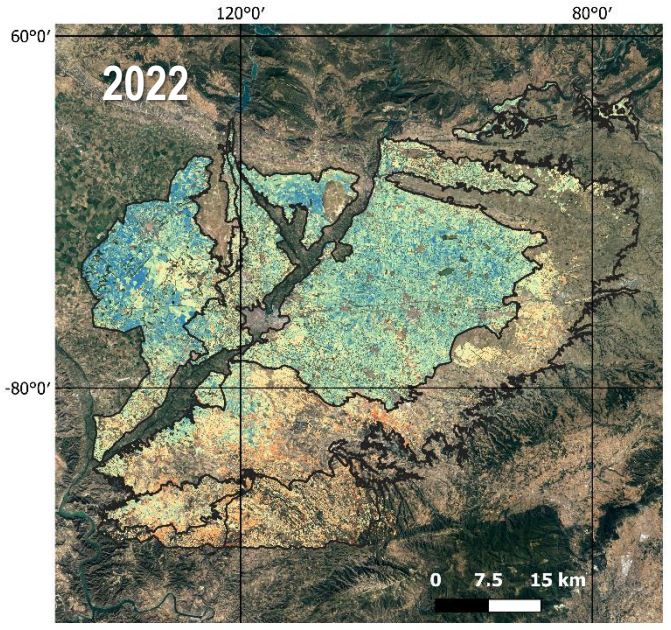








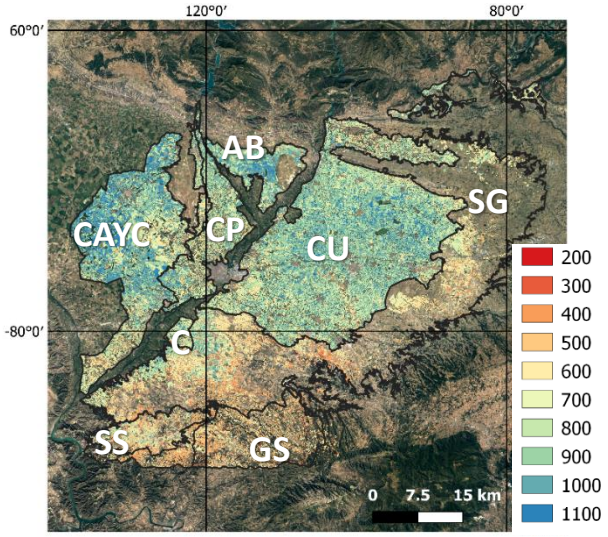




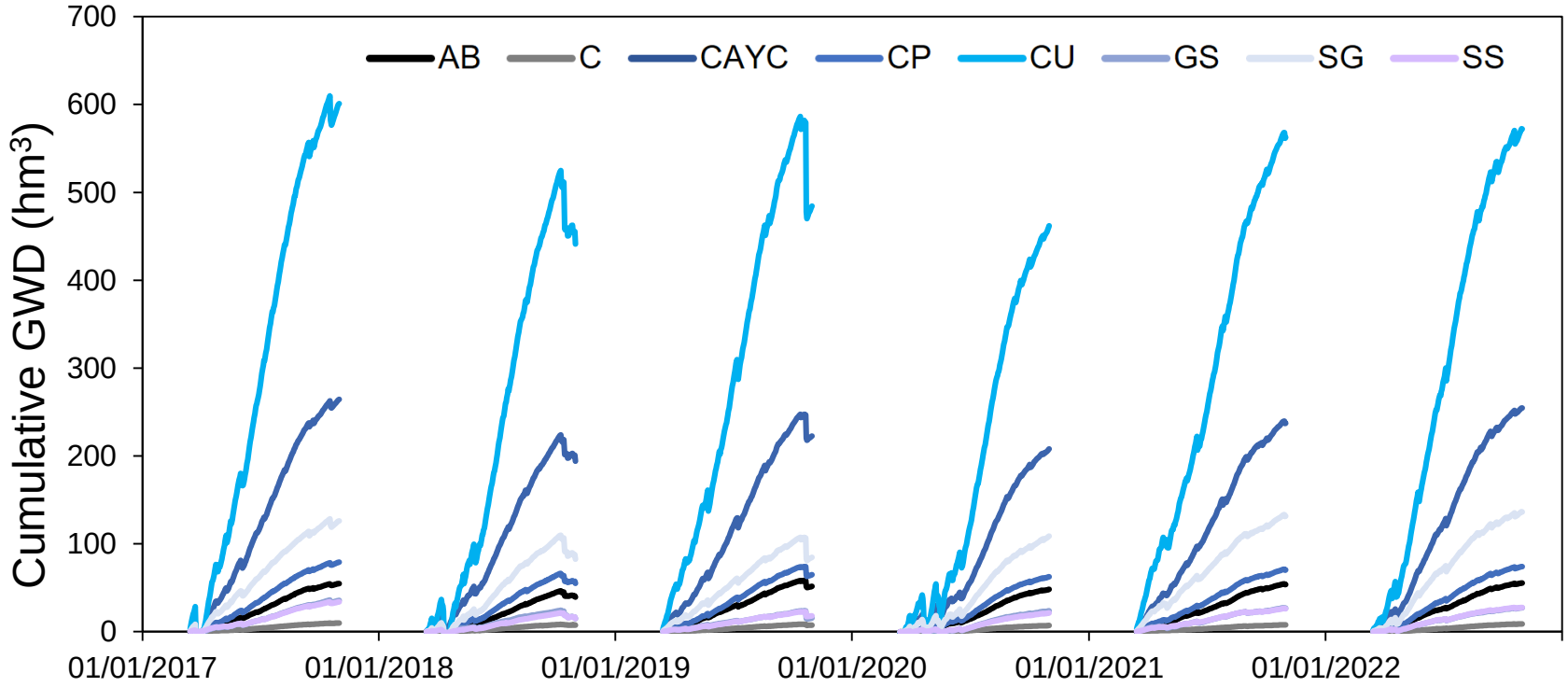
Cumulative ETa (mm)

- 200
- 300
- 400
- 500
- 600
- 700
- 800
- 900
- 1000
- 1100

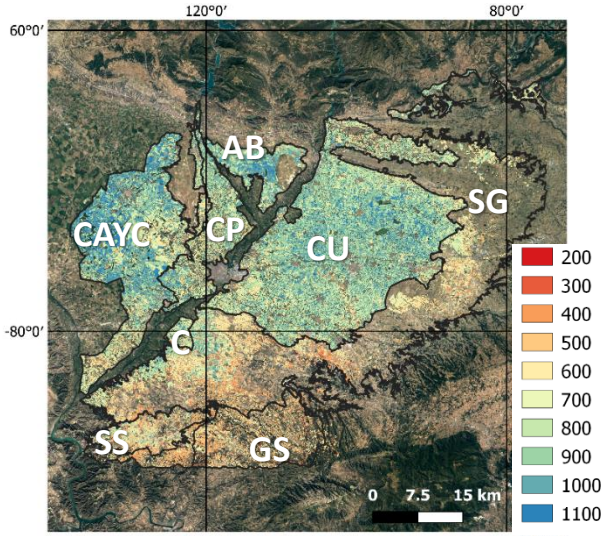
What are the differences in irrigation crop water requirements among irrigation districts ?



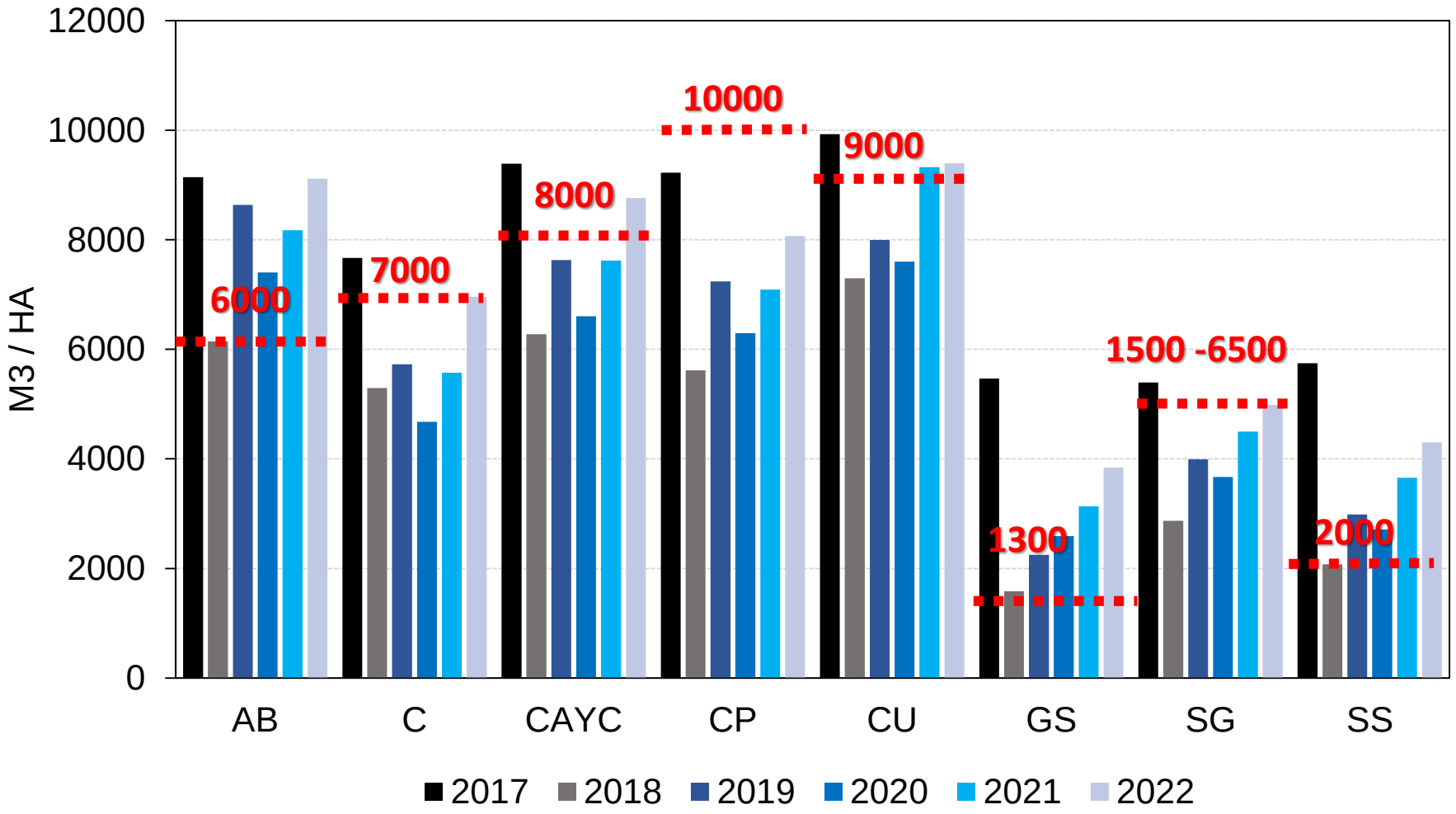
GWD = (ETa – effective rainfall) / Efficiency irrigation system



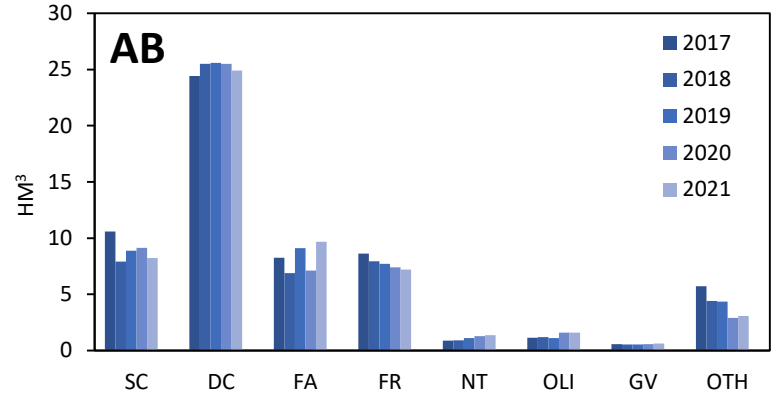
How much irrigation water needs each Irrigation District?

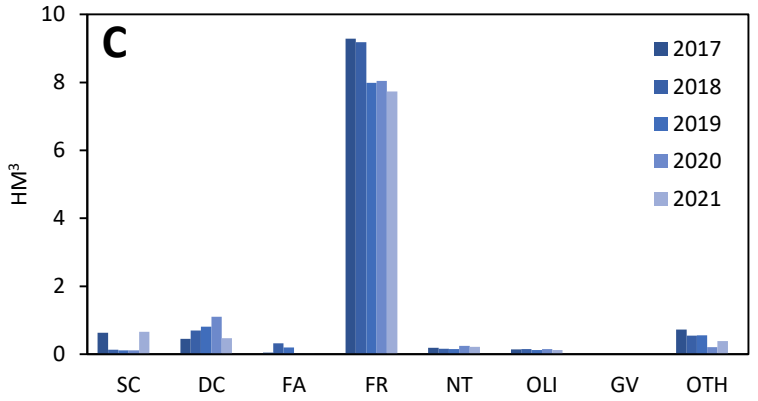


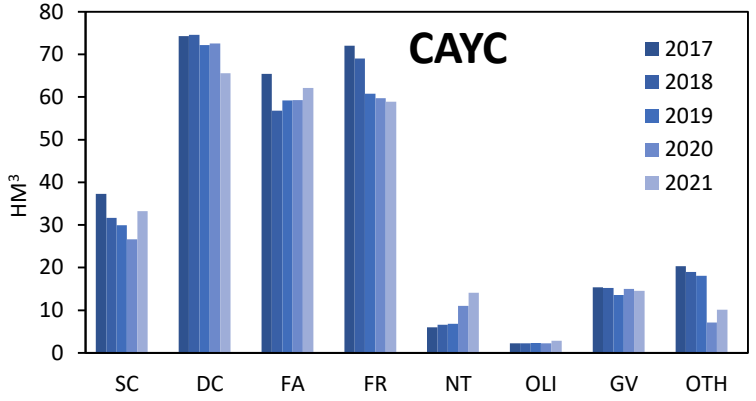
Theoretical water allocation

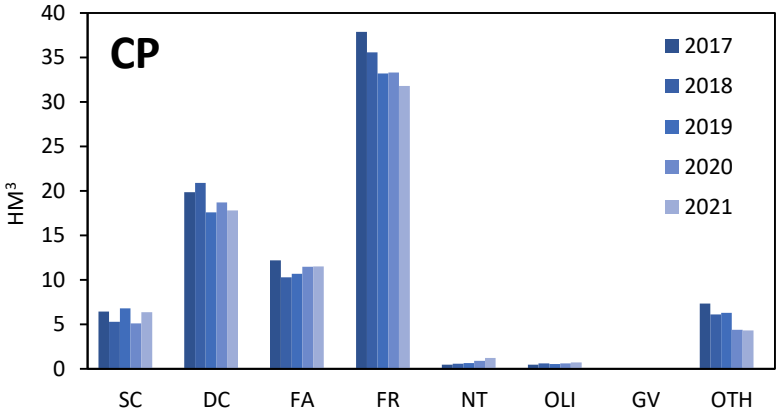


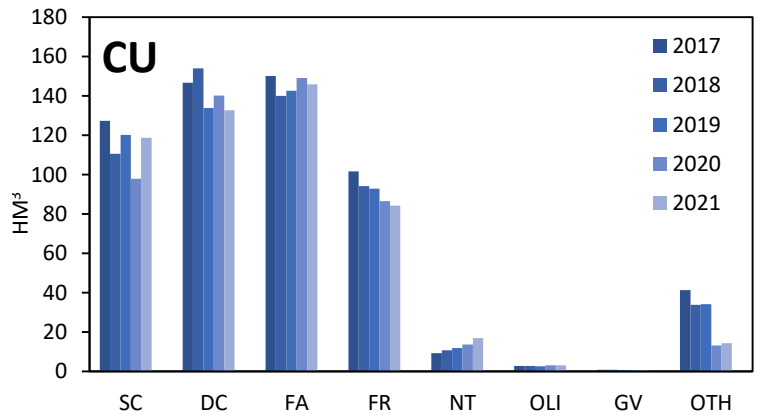
Cumulative crop water demand by crop type

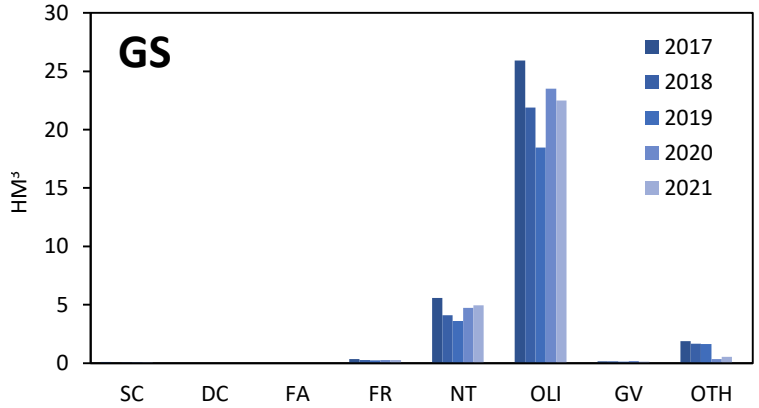


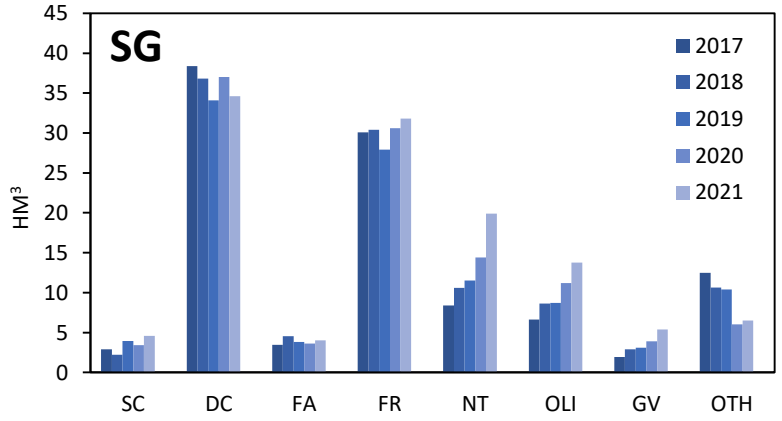


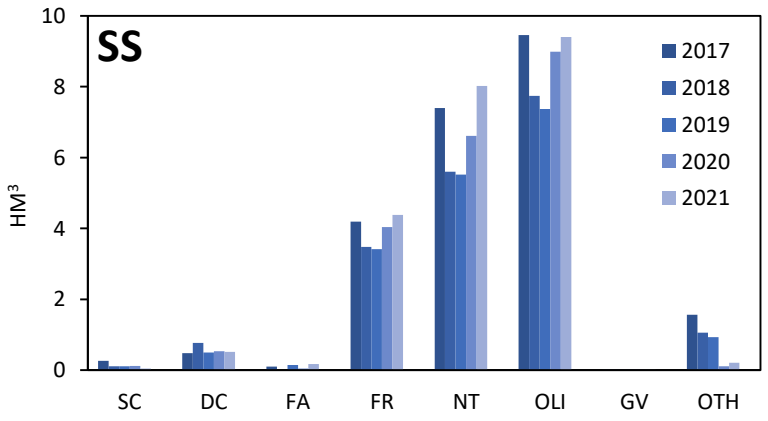










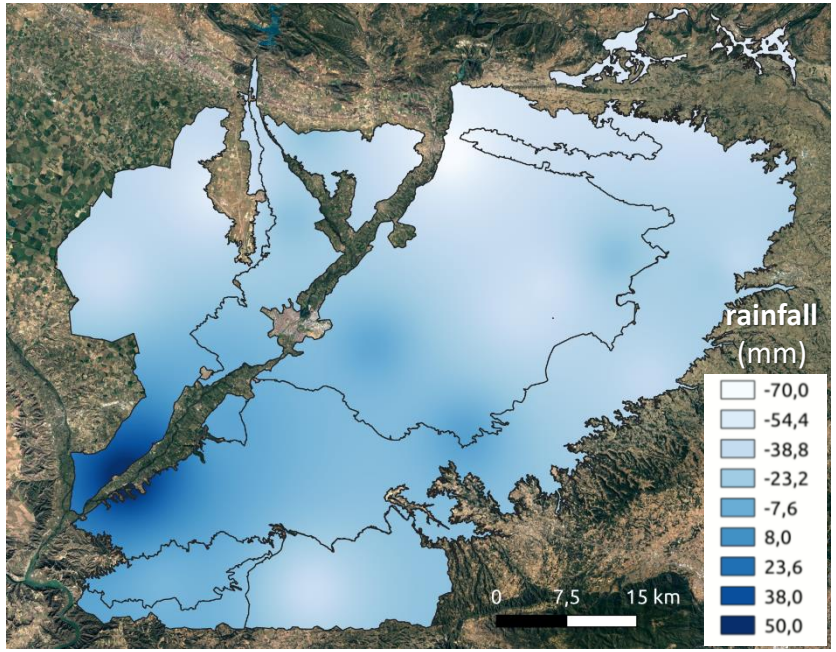


SC – Summer crop
DC – Double cropping
FA – Farrages
FR – Fruit trees
NT – Nut trees
OLI – Olive trees
GV - Grapevines

What has happened in 2022 (severe drought) in comparison to previous years (2017-2021) ?

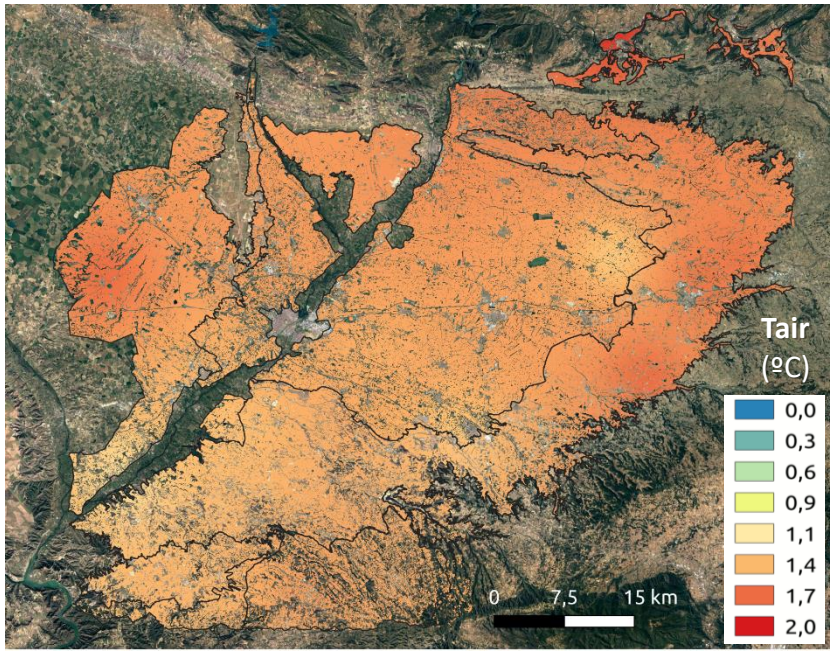
Meteorological variables

Rainfall



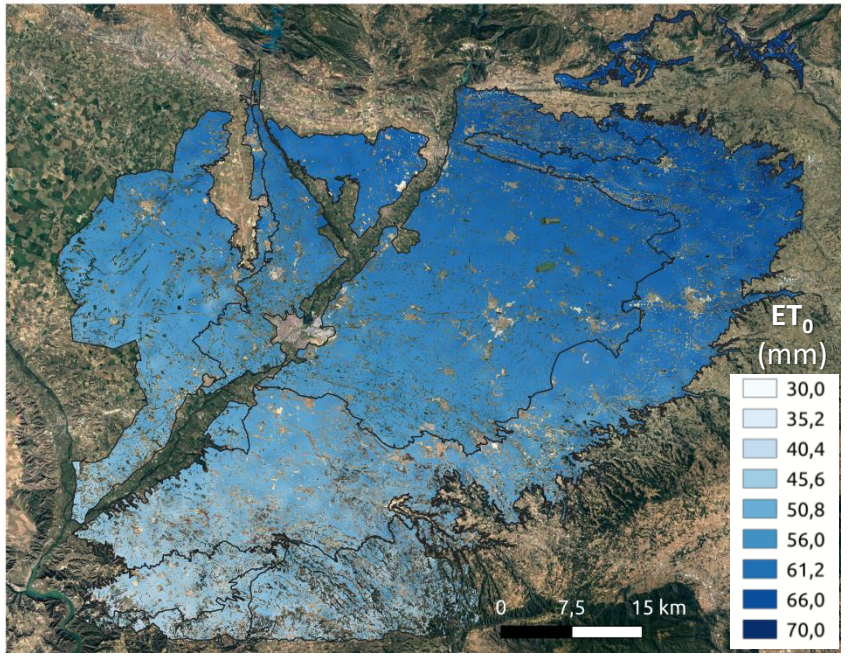
13% less rainfall

Air Temperature



+1.5ºC

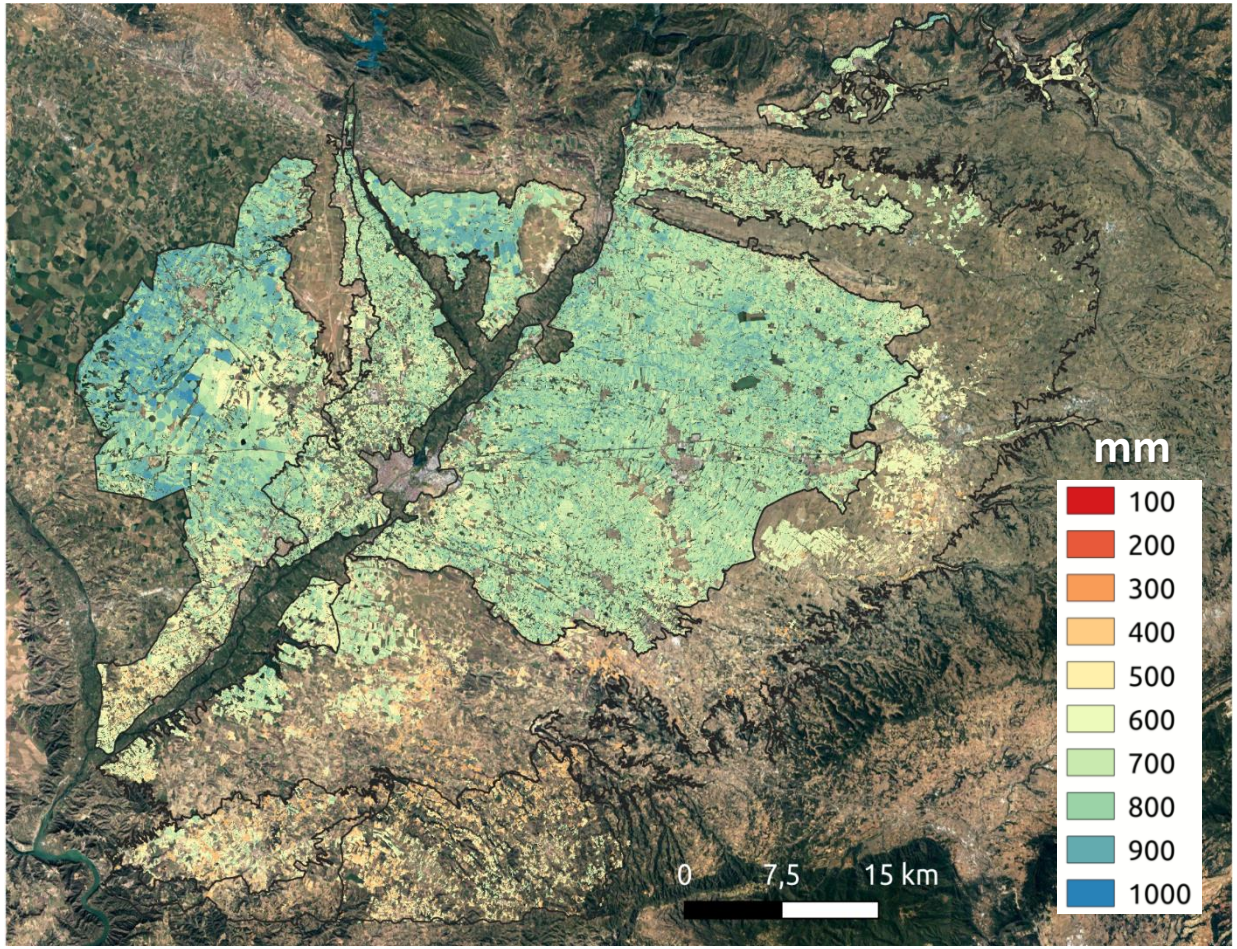
Reference ET_0



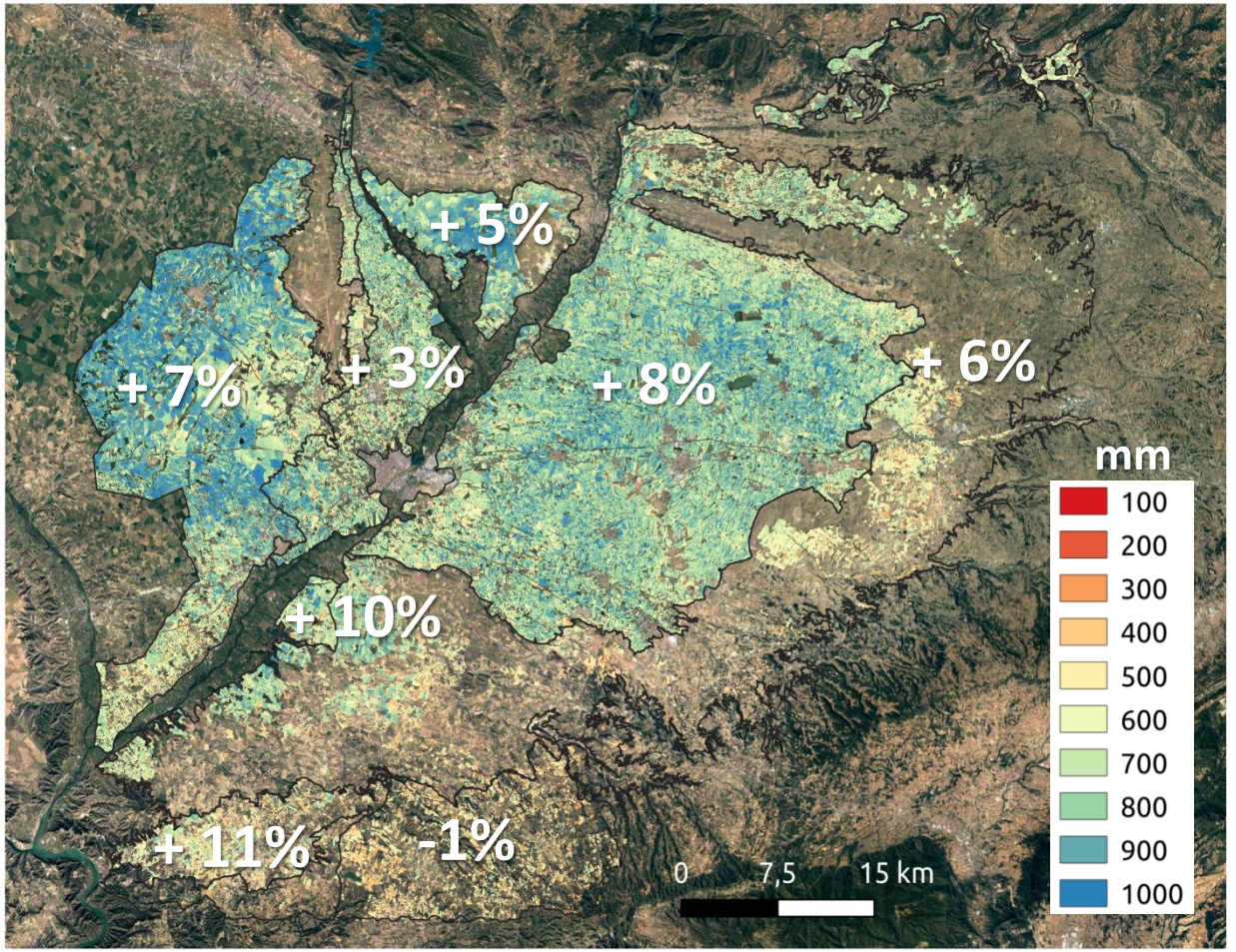
6% more ET_0

Actual crop Evapotranspiration (TSEB-PT$_{S2+S3}$)

Averaged cumulative ETa for: 2017-2021

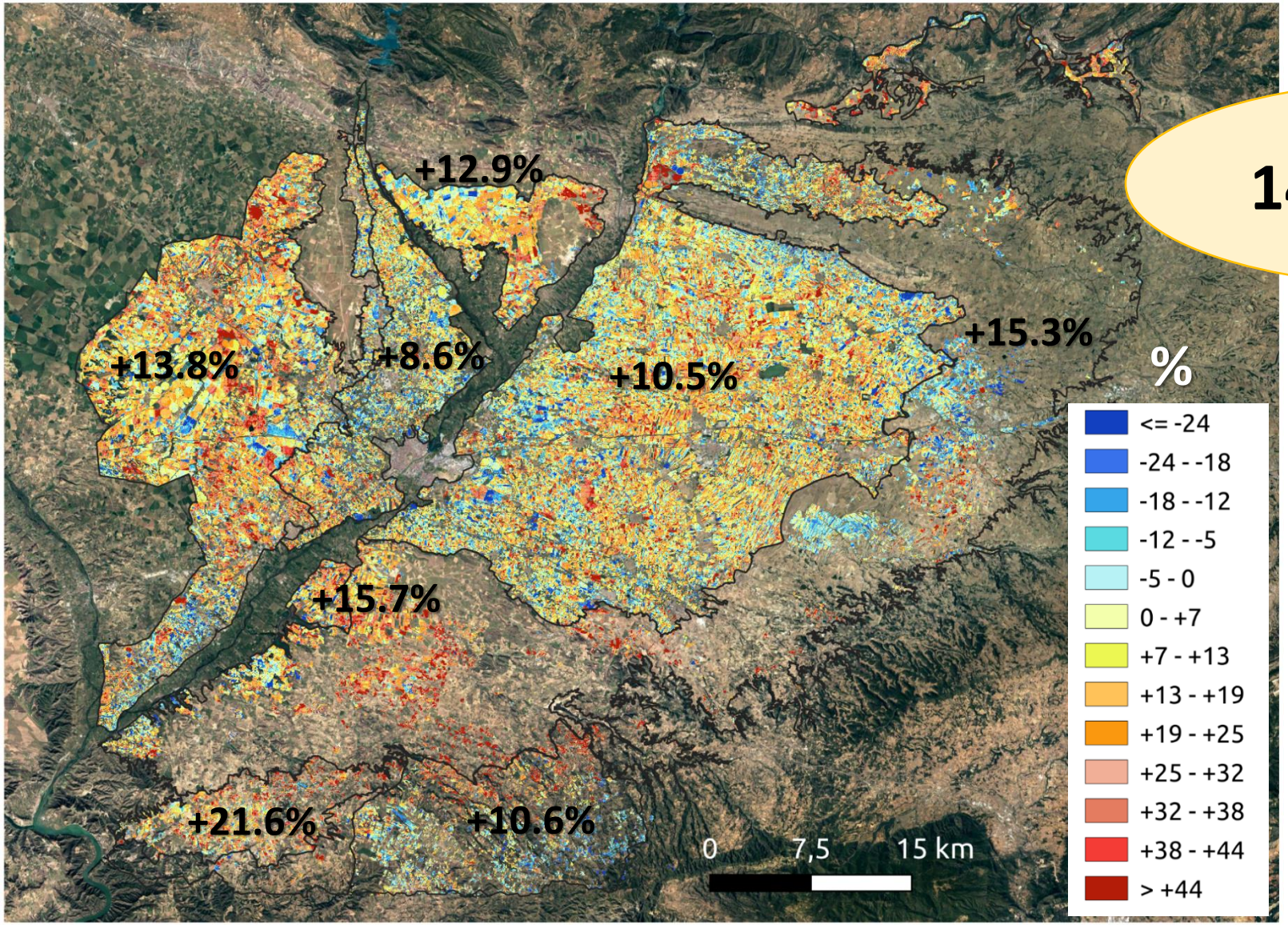


Cumulative ETa for: 2022



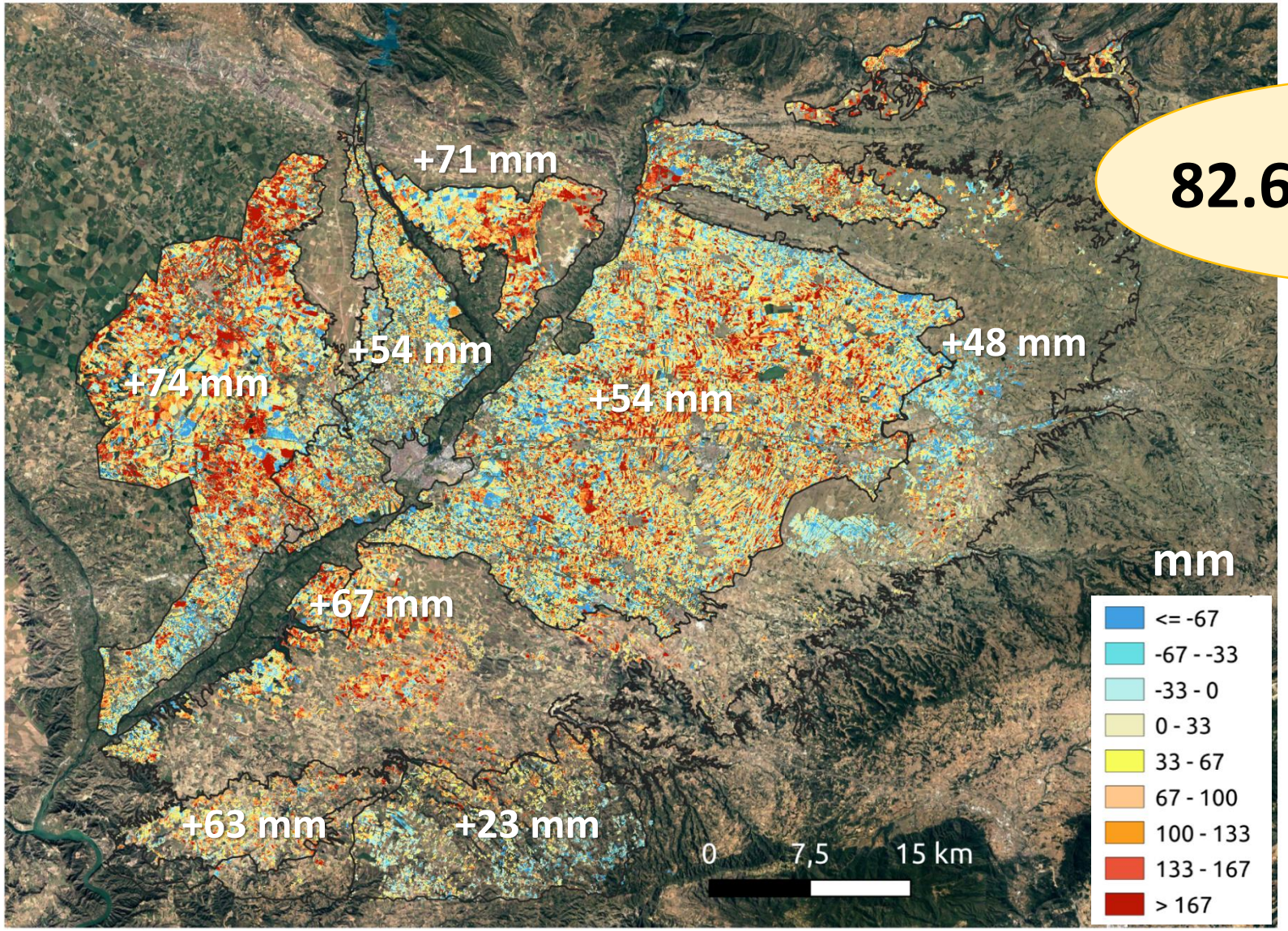
+8% more crop water demand!

Differences in Gross Irrigation water requirements
Avg. 2017-2021 vs. 2022



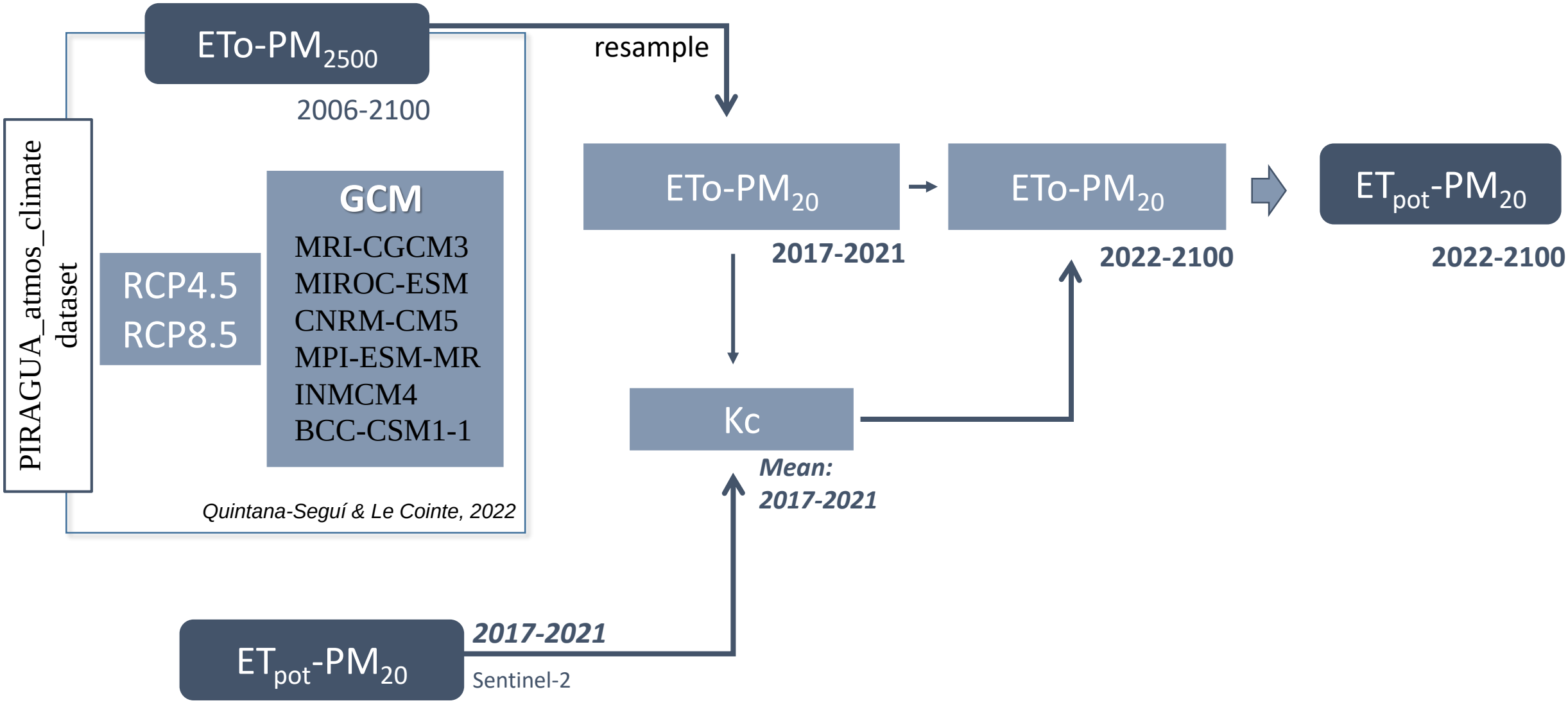
14% more !

Differences in Gross Irrigation water requirements
Avg. 2017-2021 vs. 2022

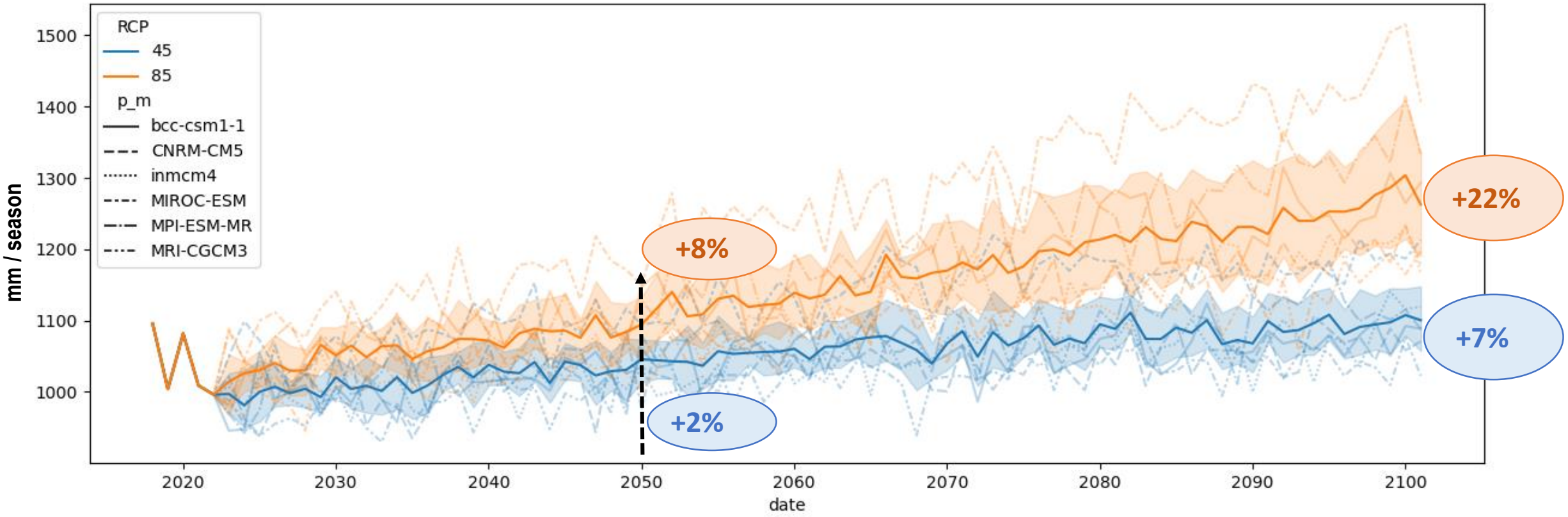


82.6 hm³ more !

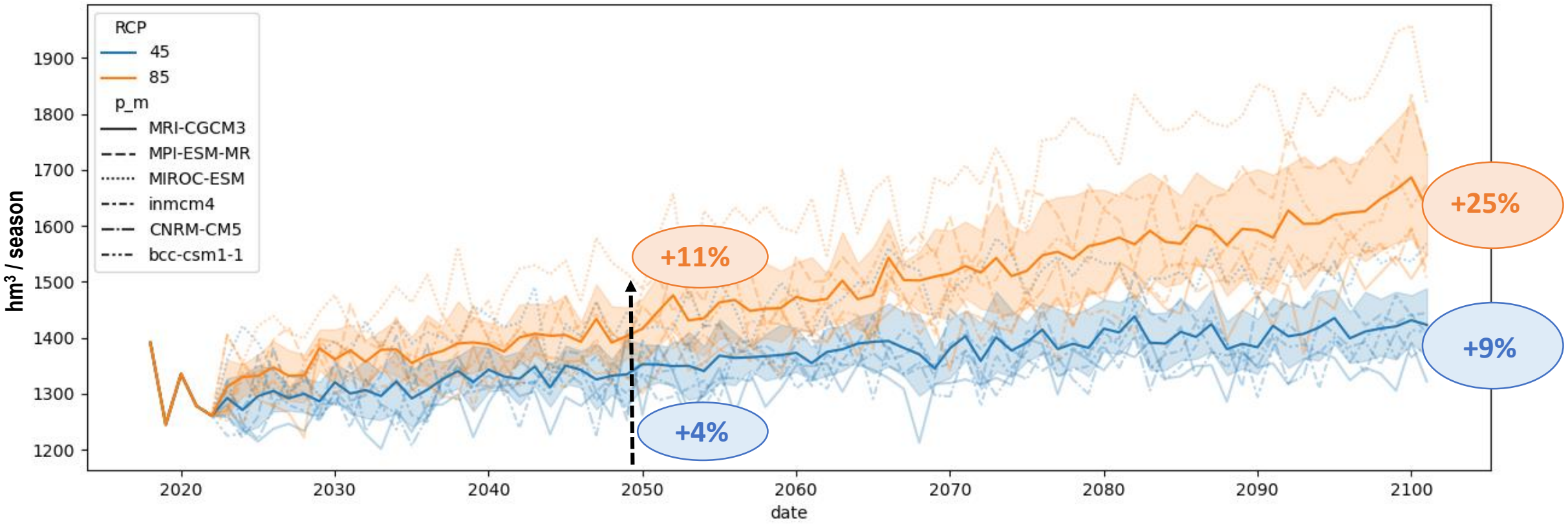
What are the projections of crop water demands until 2100 ?

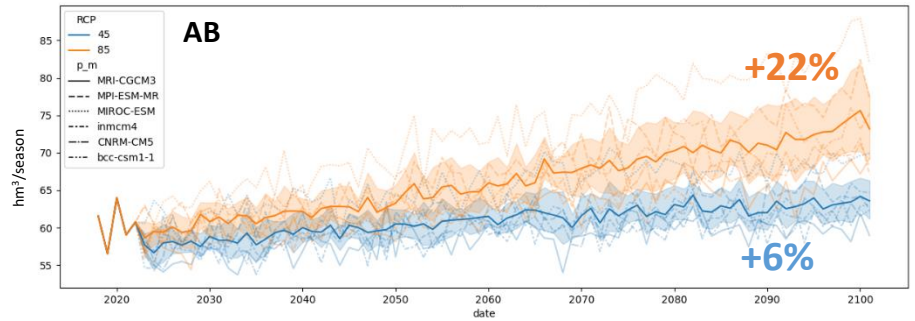


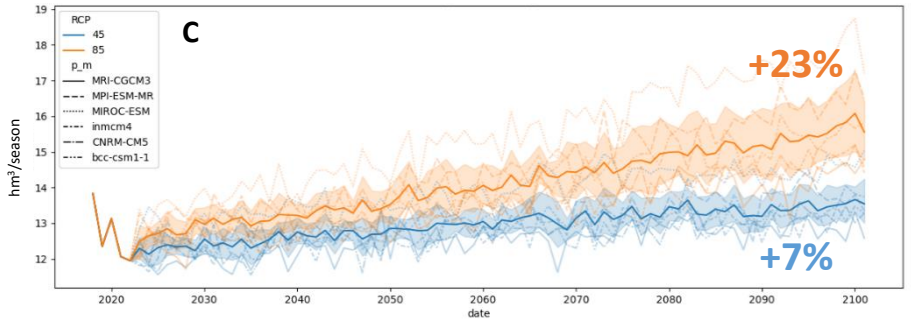
Penman-Monteith reference evapotranspiration (ETo)

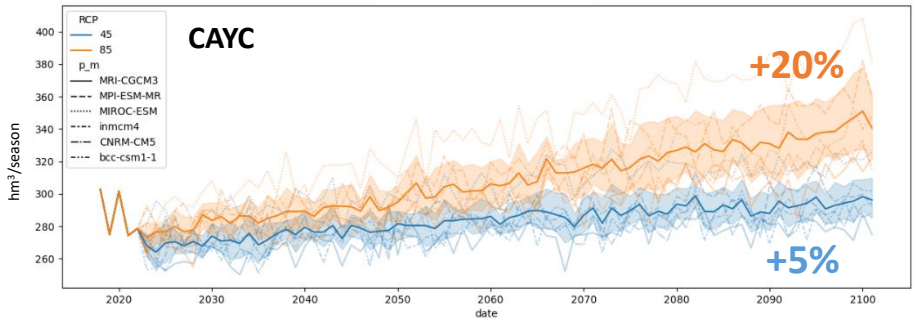


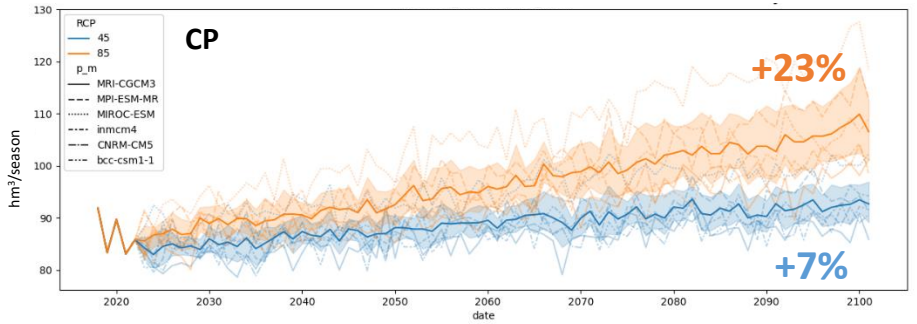
Cumulative Potential crop evapotranspiration (ET_{pot})

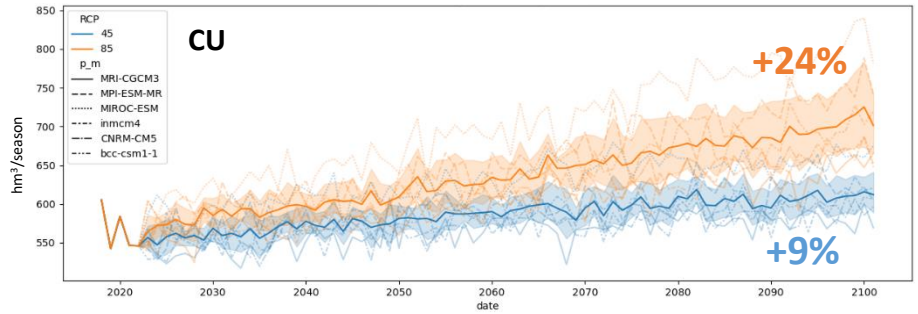


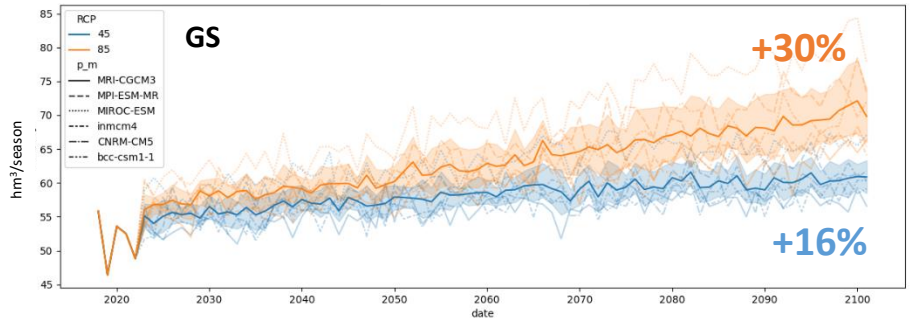

AB
+22%
+6%
RCP
45
85
p_m
MRI-CGCM3
MPI-ESM-MR
MIROC-ESM
inmcm4
CNRM-CM5
bcc-csm1-1
hm³/season
date

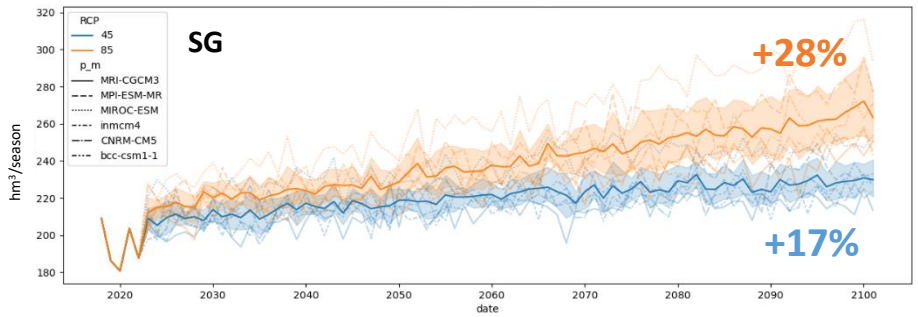

C
+23%
+7%
RCP
45
85
p_m
MRI-CGCM3
MPI-ESM-MR
MIROC-ESM
inmcm4
CNRM-CM5
bcc-csm1-1
hm³/season
date

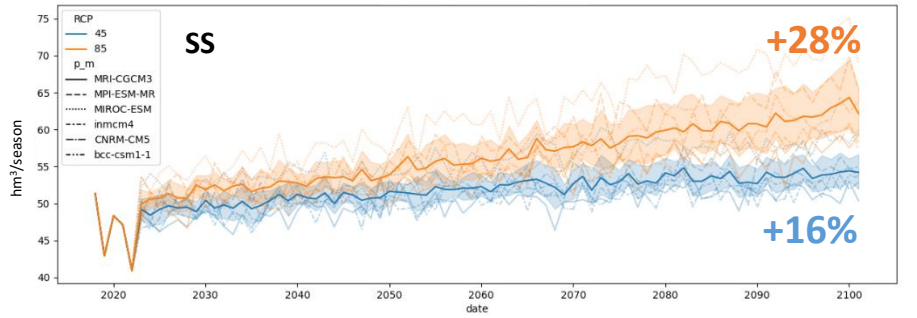

CAYC
+20%
+5%
RCP
45
85
p_m
MRI-CGCM3
MPI-ESM-MR
MIROC-ESM
inmcm4
CNRM-CM5
bcc-csm1-1
hm³/season
date

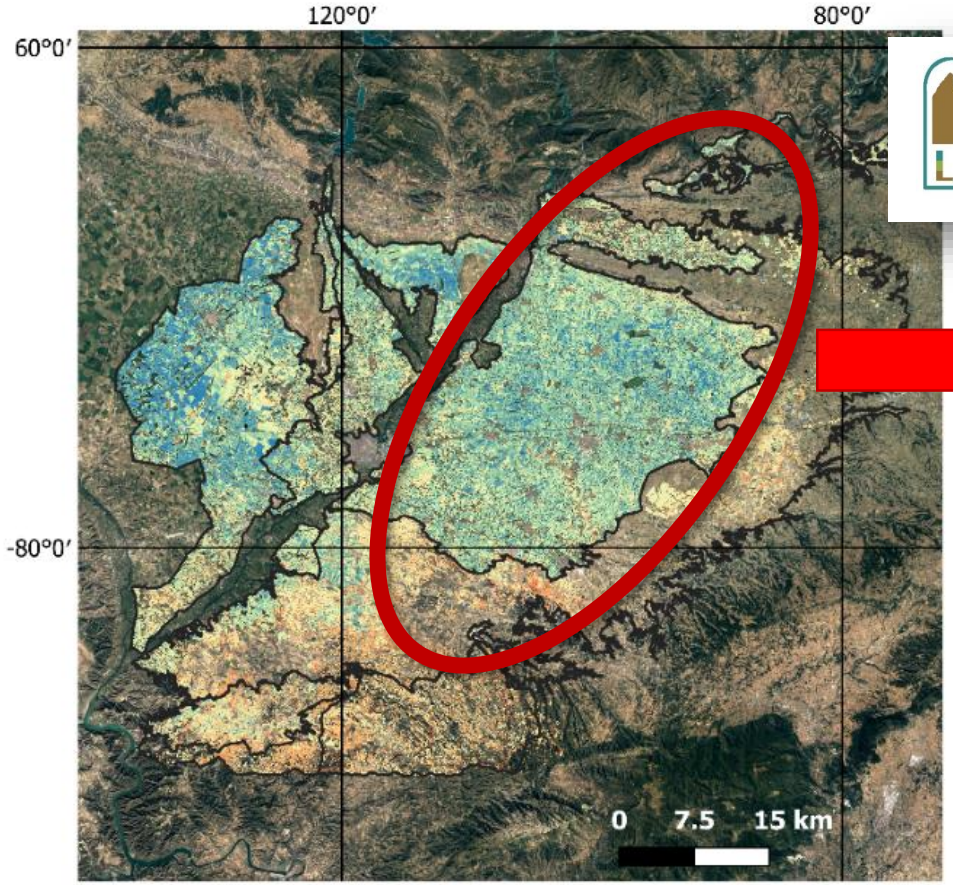

CP
+23%
+7%
RCP
45
85
p_m
MRI-CGCM3
MPI-ESM-MR
MIROC-ESM
inmcm4
CNRM-CM5
bcc-csm1-1
hm³/season
date


CU
+24%
+9%
RCP
45
85
p_m
MRI-CGCM3
MPI-ESM-MR
MIROC-ESM
inmcm4
CNRM-CM5
bcc-csm1-1
hm³/season
date


GS
+30%
+16%
RCP
45
85
p_m
MRI-CGCM3
MPI-ESM-MR
MIROC-ESM
inmcm4
CNRM-CM5
bcc-csm1-1
hm³/season
date


SG
+28%
+17%
RCP
45
85
p_m
MRI-CGCM3
MPI-ESM-MR
MIROC-ESM
inmcm4
CNRM-CM5
bcc-csm1-1
hm³/season
date

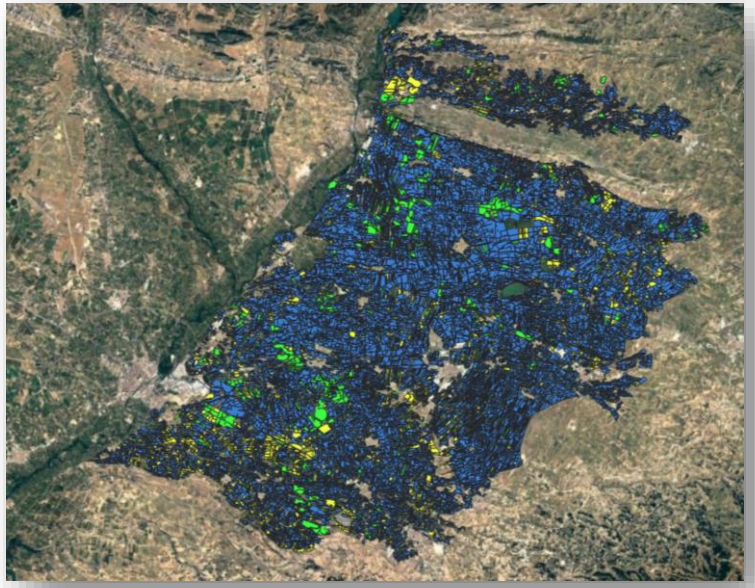

SS
+28%
+16%
RCP
45
85
p_m
MRI-CGCM3
MPI-ESM-MR
MIROC-ESM
inmcm4
CNRM-CM5
bcc-csm1-1
hm³/season
date



Canals d'Urgell

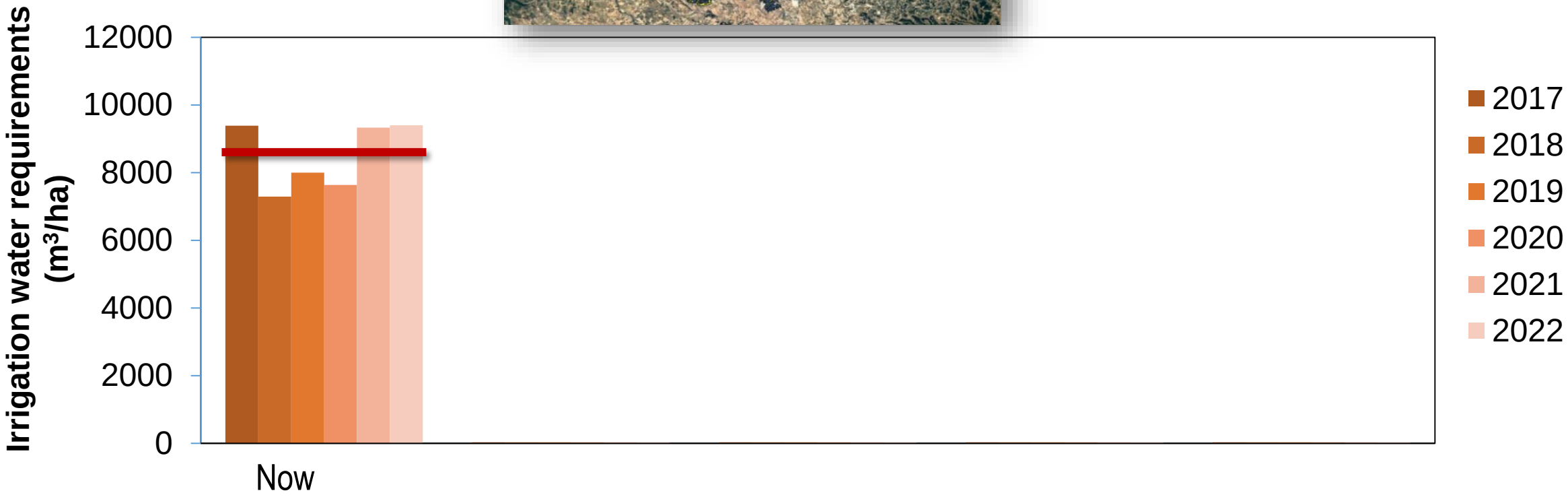
	Flood	Sprinkler	Drip
	81%	6%	13%
Efficiency	0.55	0.75	0.90

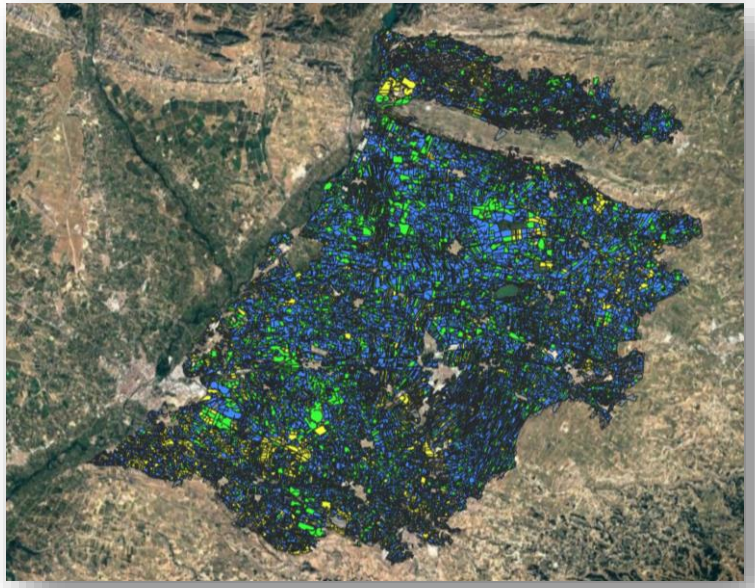
How much water can be saved by modernizing the irrigation systems ?



Currently

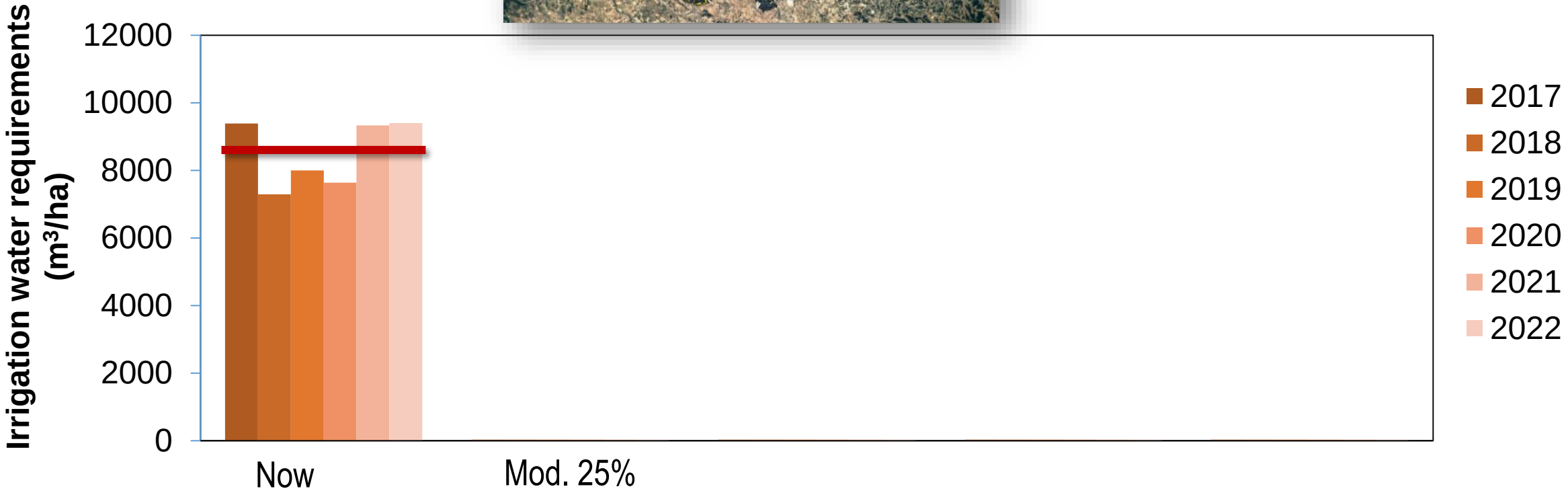
Inundació	**81%**
Aspersió	**6%**
Goteig	**13%**

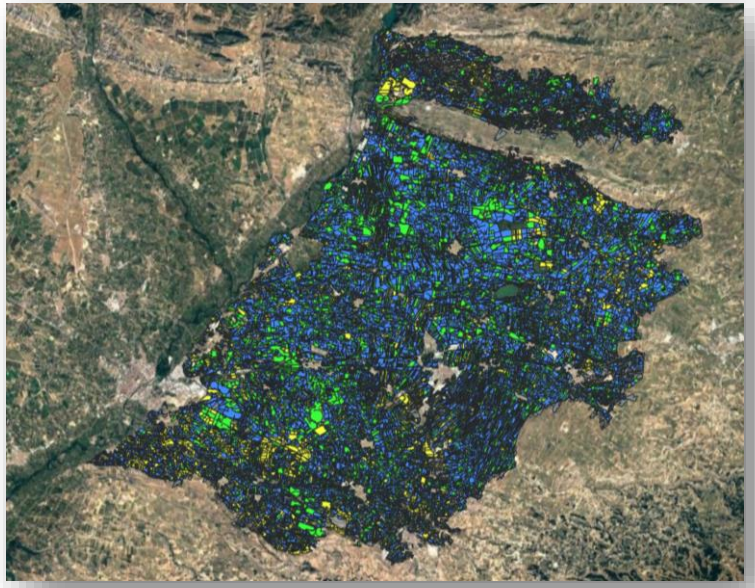




Modernize 25% ?

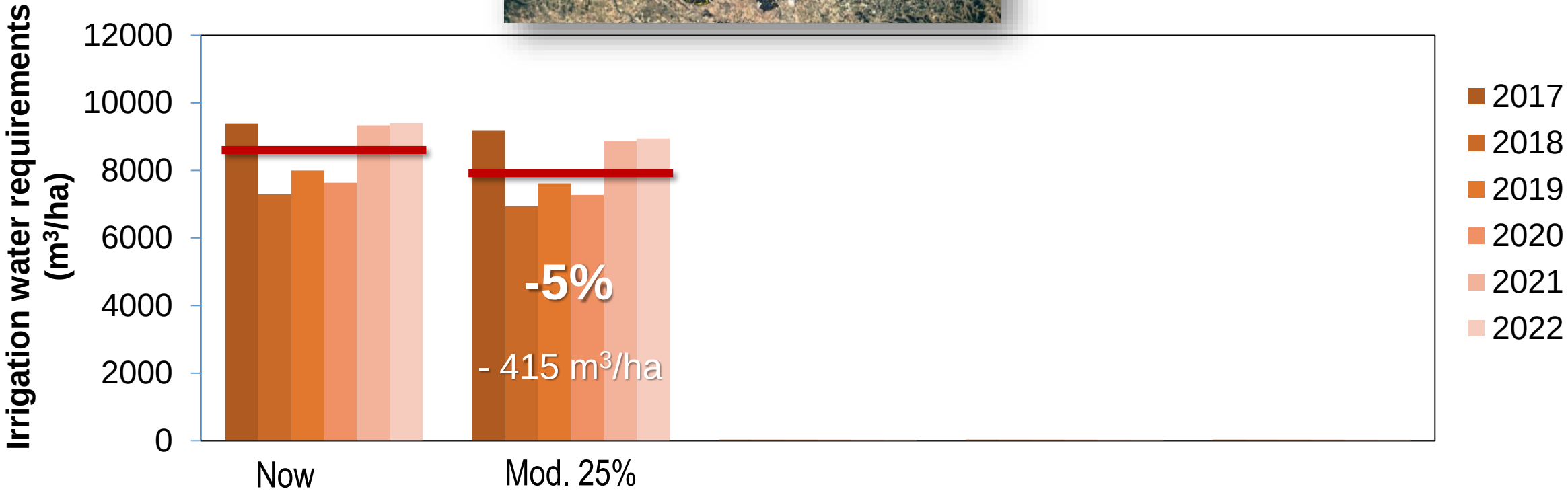
Flood	63%
Sprinkler	24%
Drip	13%

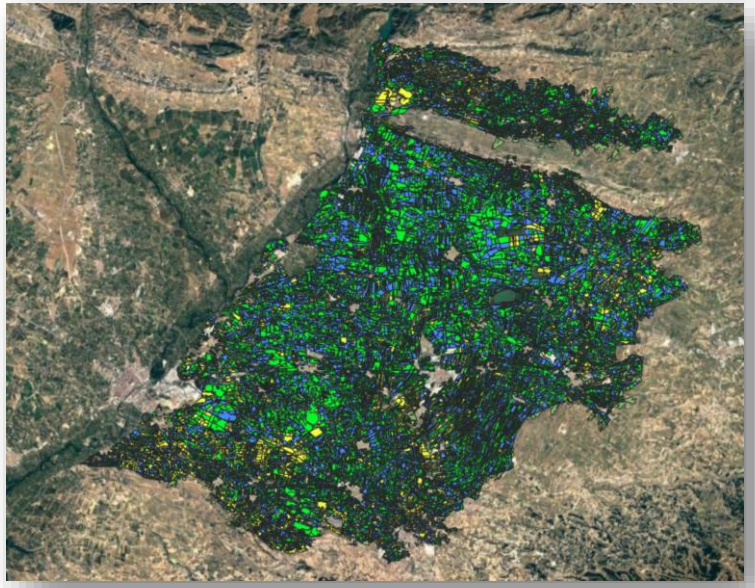




Modernize 25% ?

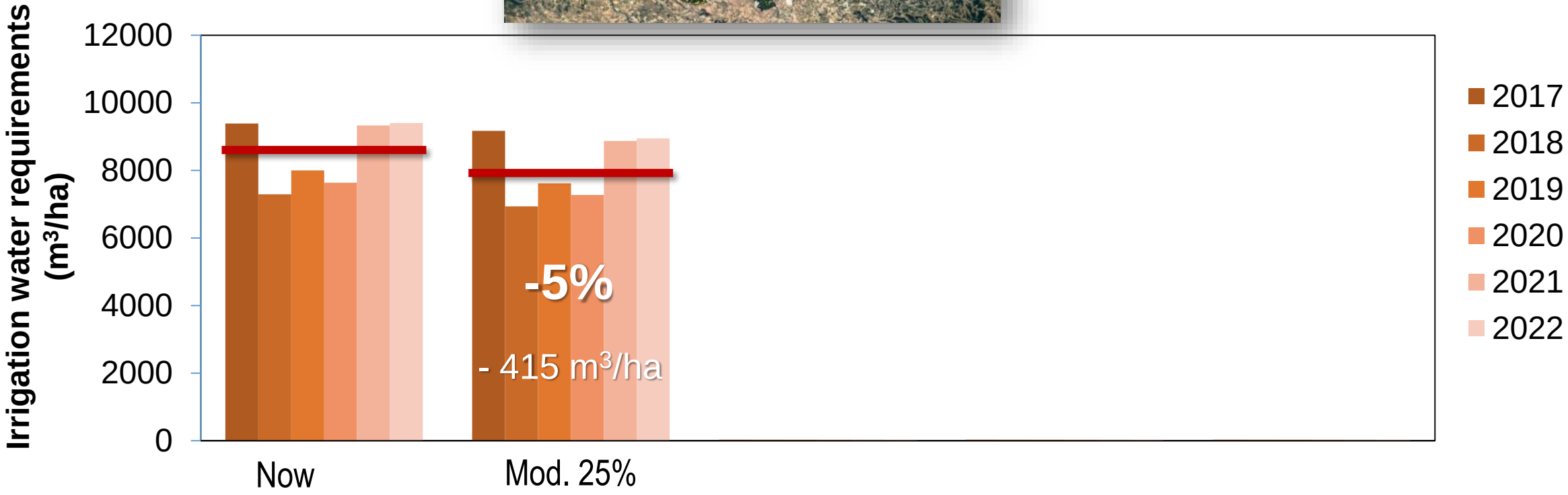
Flood	63%
Sprinkler	24%
Drip	13%

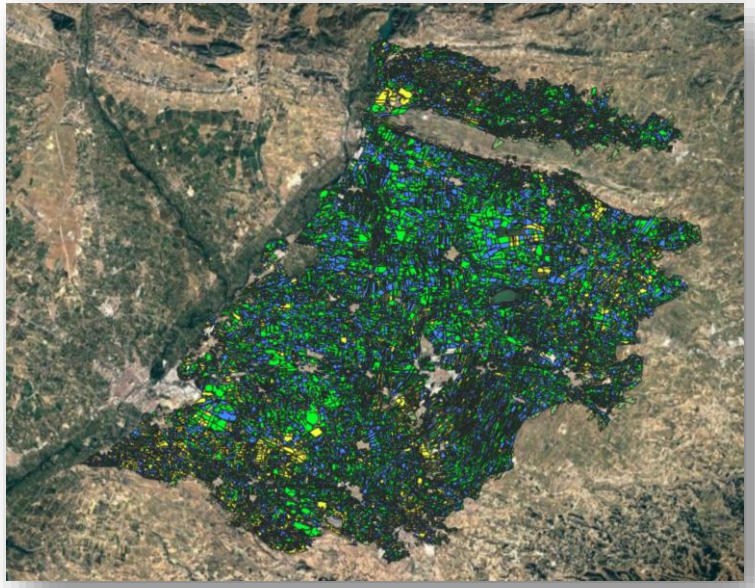




Modernize 50% ?

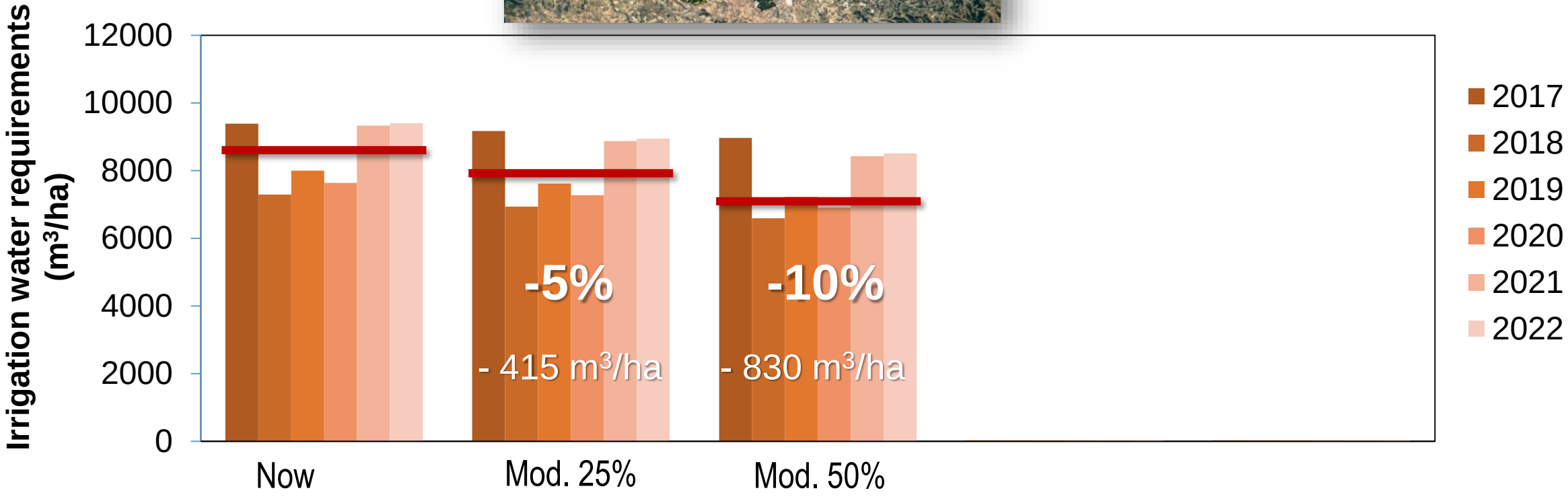
Flood	42%
Sprinkler	42%
Drip	16%

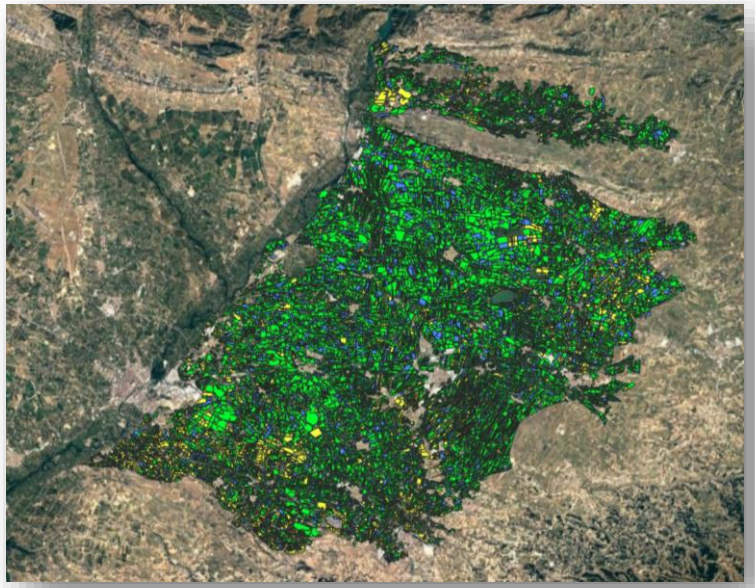




Modernize 50% ?

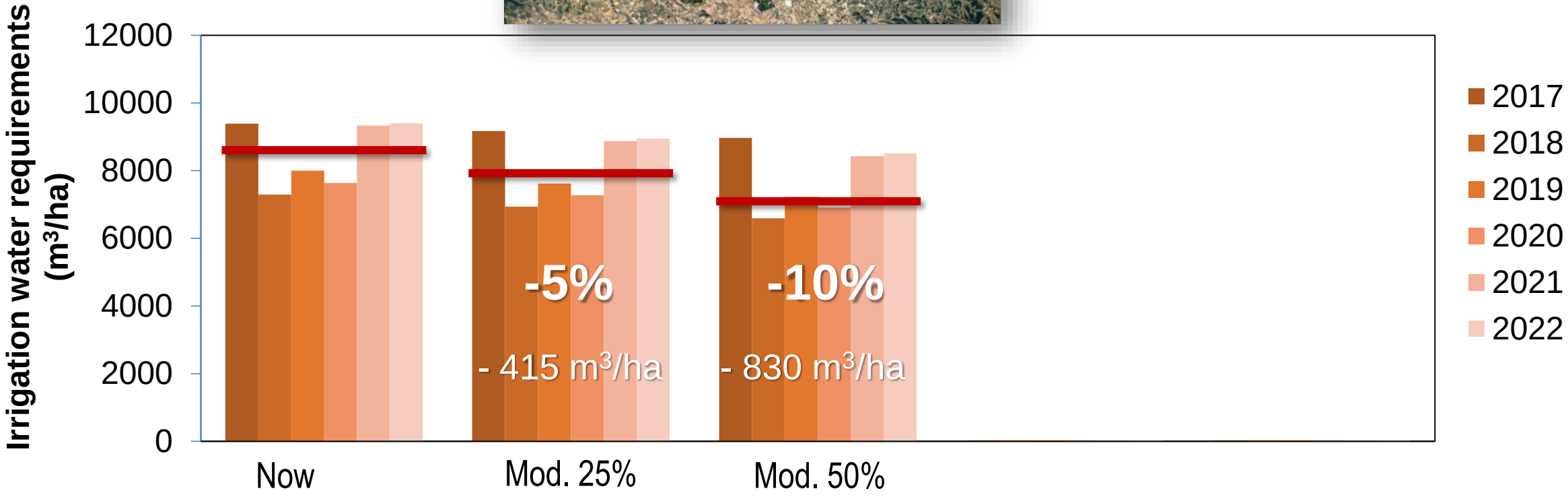
Flood	42%
Sprinkler	42%
Drip	16%

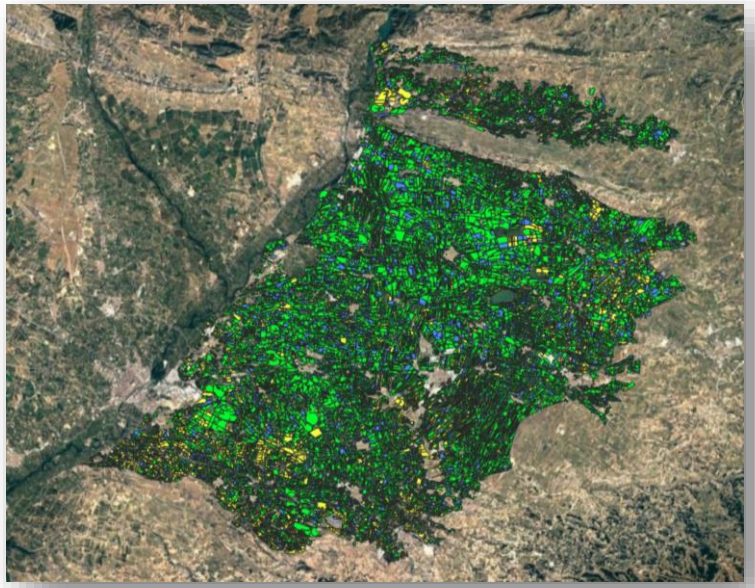




Modernize 75% ?

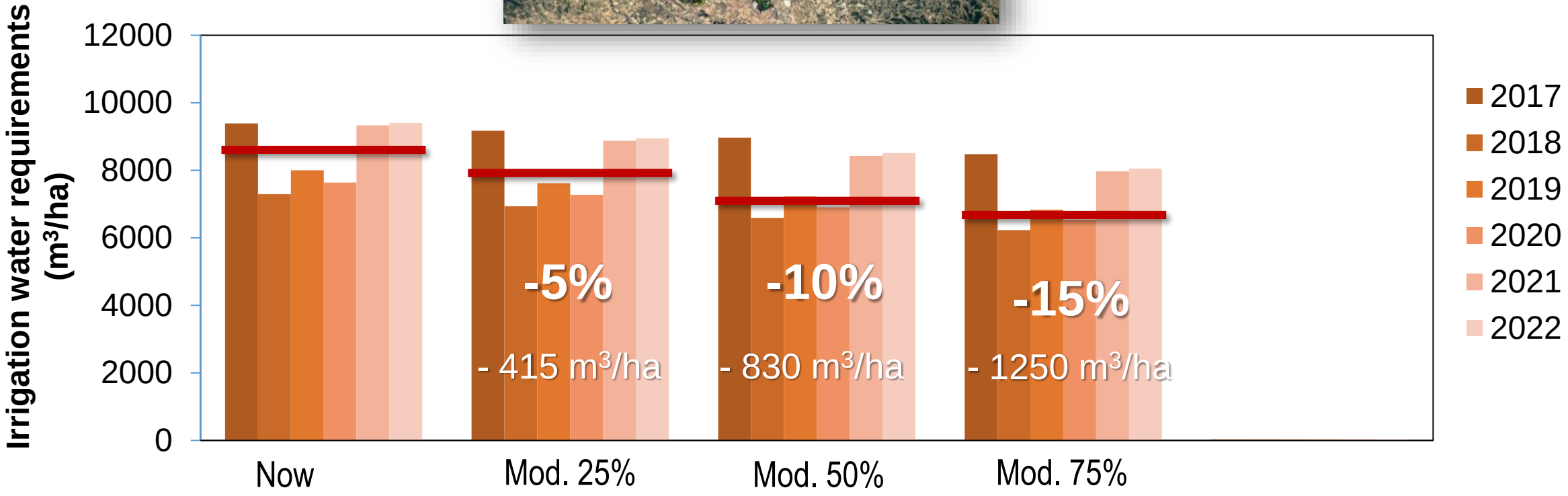
Flood	20%
Sprinkler	62%
Drip	18%

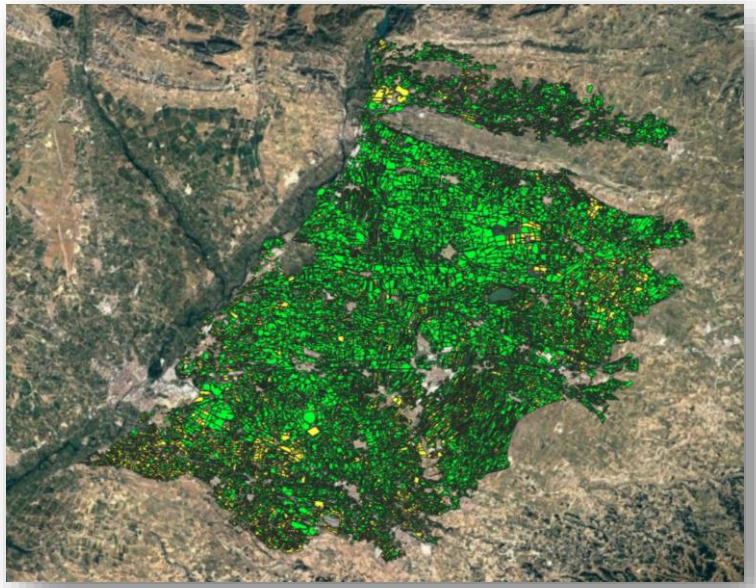




Modernize 75% ?

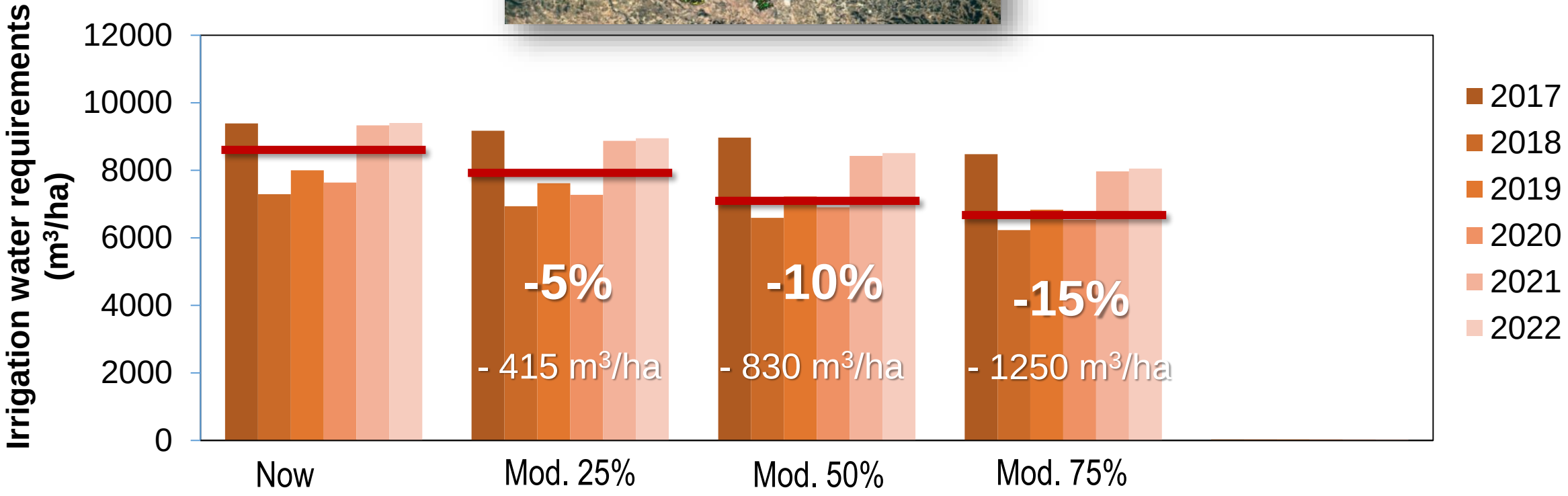
Flood	20%
Sprinkler	62%
Drip	18%

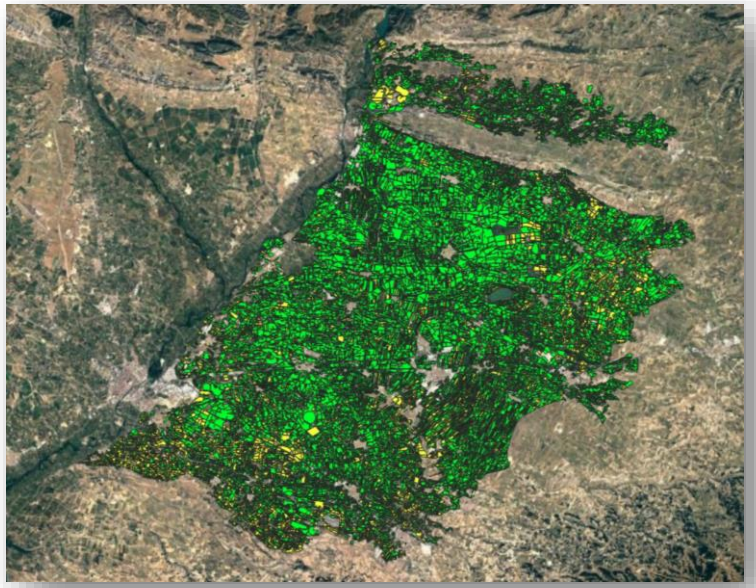




Modernize 100% ?

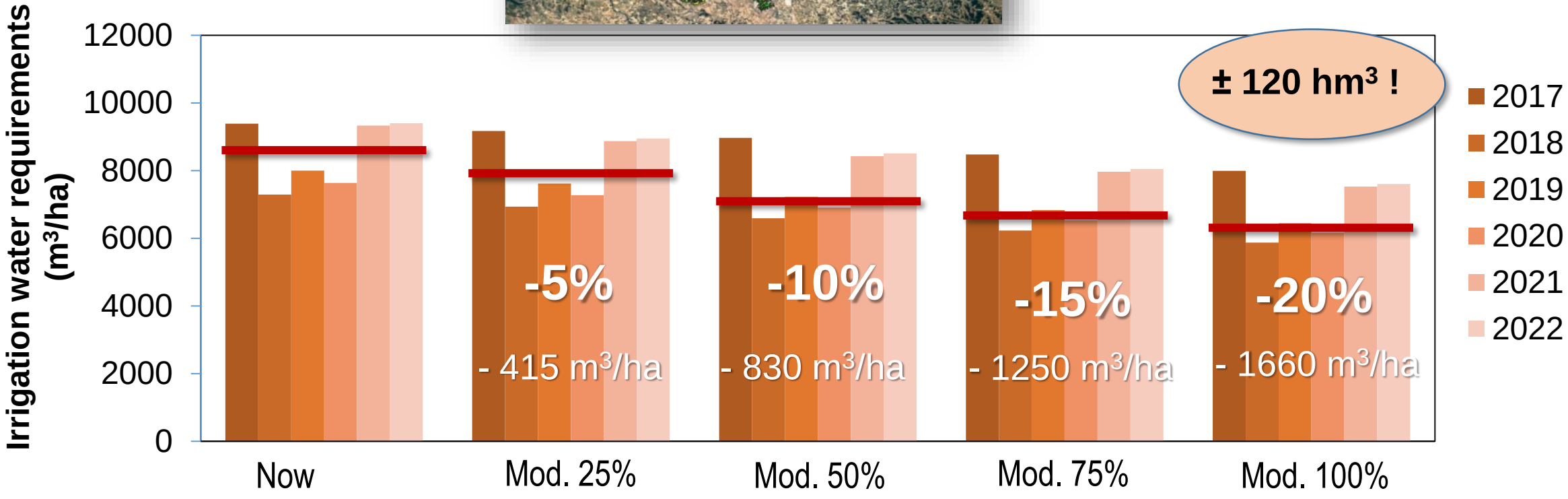
Flood	0%
Sprinkler	80%
Drip	20%





Modernize 100% ?

Flood	0%
Sprinkler	80%
Drip	20%



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Thanks for your attention !

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