

SUPPLEMENTARY MATERIALS

Robust assessment of uncertain freshwater changes: the case of Greece with large irrigation- and climate-driven runoff decrease

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Figure S1. Location and extent of CRU cells considered for each study catchment.

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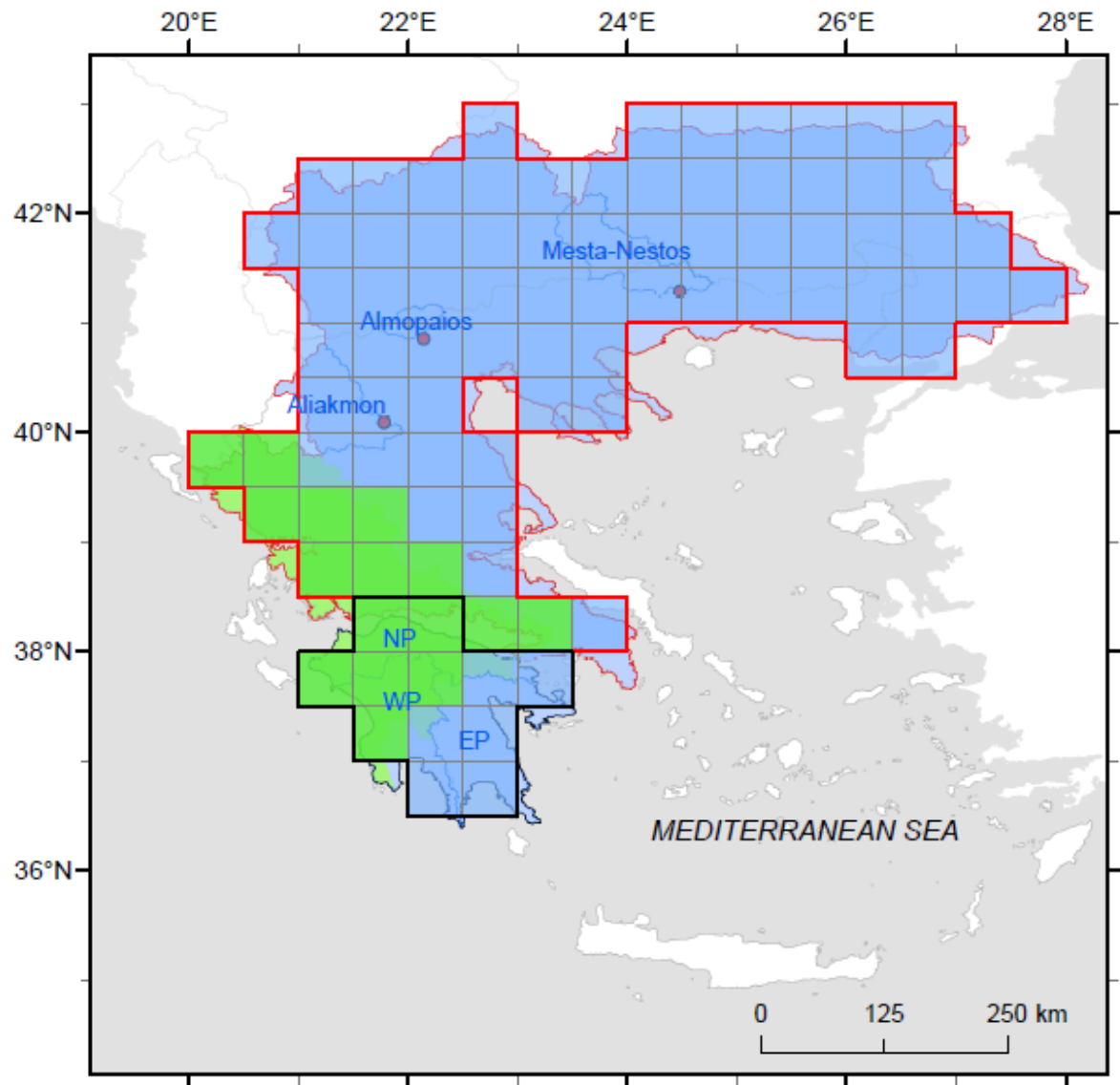


Figure S1. Location and extent of CRU cells considered for each study catchment: total regional catchment (colored), Mainland (red outline), Peloponnese (black outline), Ionian (green) and Aegean (blue).

Table S1. Base case and alternative (Alt.) quantification scenarios and their variations for different catchments. The scenario definitions (Base, Alt.) are as given and explained in main Table 3 for the total regional catchment. The terms P , ET , I_{ww} , α_{irr} and Per represent precipitation, evapotranspiration, irrigation water withdrawal per irrigated area, ratio A_{ai}/A_{a2} between irrigated area (A_{ai}), and time period. The latter is period 1 (1930-1949) or period 2 (1990-2009).

	Mainland		Peloponnese		Ionian		Aegean	
Scenario	<i>Per1</i>	<i>Per2</i>	<i>Per1</i>	<i>Per2</i>	<i>Per1</i>	<i>Per2</i>	<i>Per1</i>	<i>Per2</i>
Base P (mm/yr)	663	622	773	693	861	767	637	602
	-41		-80		-95		-35	
Alt.1 P (mm/yr)	722	678	827	741	943	839	690	653
	-44		-86		-104		-37	
Alt.2 P (mm/yr)	748	702	933	837	1029	916	715	676
	-46		-96		-113		-39	
Base ET/P		0.59		0.62		0.59		0.59
Alt.1 ET/P		0.55		0.55		0.55		0.55
Alt.2 ET/P		0.72		0.72		0.72		0.72
Base I_{ww} (mm/yr)	253	591	253	591	253	591	253	591
	338		338		338		338	
Alt.1 I_{ww} (mm/yr)	175	591	175	591	175	591	175	591
	416		416		416		416	
Alt.2 I_{ww} (mm/yr)	331	591	331	591	331	591	331	591
	260		260		260		260	
Alt.3 I_{ww} (mm/yr)	175	747	175	747	175	747	175	747
	572		572		572		572	
Alt.4 I_{ww} (mm/yr)	253	747	253	747	253	747	253	747
	494		494		494		494	
Alt.5 I_{ww} (mm/yr)	331	747	331	747	331	747	331	747
	416		416		416		416	
Base α_{irr}	0.25		0.25		0.25		0.25	
Alt.1 α_{irr}	0.20		0.20		0.20		0.20	

Table S2. Freshwater changes and main uncertainty estimates for the Mainland catchment. The terms P , ET and R represent precipitation, evapotranspiration and runoff, respectively, while Δ stands for change, and subscript *clim* and *irr* indicate climate driven and irrigation driven change, respectively. Scenario definitions (Base, Alt.) are as given and explained in main Table 3.

	ΔP (mm/yr)	ΔET_{clim} (mm/yr)	ΔET_{irr} (mm/yr)	ΔET (mm/yr)	ΔR_{clim} (mm/yr)	ΔR_{irr} (mm/yr)	ΔR (mm/yr)
P scenarios ± Irrigation uncertainty	-41	-9.5		27.7 ± 6	-31.5		-68.7 ± 6
	-44	-7.5		29.7 ± 6	-36.5		-73.7 ± 6
	-46	-7		30.2 ± 6	-39		-76.2 ± 6
Irrigation (I_{ww}) scenarios ± P uncertainty			32.4 (Base)	24.4 ± 1.3		-32.4	-68.1 ± 3.8
			33.6 (Alt. 1)	25.6 ± 1.3		-33.6	-69.3 ± 3.8
			31.2 (Alt. 2)	23.2 ± 1.3		-31.2	-66.9 ± 3.8
			43.2 (Alt. 3)	35.2 ± 1.3		-43.2	-78.8 ± 3.8
			42 (Alt. 4)	34 ± 1.3		-42	-77.6 ± 3.8
			40.8 (Alt. 5)	32.8 ± 1.3		-40.8	-76.5 ± 3.8
All scenarios ± Total uncertainty	-43.7 ± 2.5	-8 ± 1.3	37.2 ± 6	29.2 ± 7.3	-35.7 ± 3.8	-37.2 ± 6	-72.9 ± 9.8

Table S3. Freshwater changes and main uncertainty estimates for the Peloponnese catchment. The terms P , ET and R represent precipitation, evapotranspiration and runoff, respectively, while Δ stands for change, and subscript *clim* and *irr* indicate climate driven and irrigation driven change, respectively. Scenario definitions (Base, Alt.) are as given and explained in main Table 3.

	ΔP (mm/yr)	ΔET_{clim} (mm/yr)	ΔET_{irr} (mm/yr)	ΔET (mm/yr)	ΔR_{clim} (mm/yr)	ΔR_{irr} (mm/yr)	ΔR (mm/yr)
P scenarios ± Irrigation uncertainty	-80 (Base) -85.5 (Alt. 1) -96 (Alt. 2)	-36.5 -35 -34		2.6 ± 6.3 4.1 ± 6.3 5.1 ± 6.3	-43.5 -50.5 -62		-82.6 ± 6.3 -89.6 ± 6.3 -101.1 ± 6.3
Irrigation (I_{ww}) scenarios ± P uncertainty			34 (Base) 35.3 (Alt. 1) 32.8 (Alt. 2) 45.3 (Alt. 3) 44.1 (Alt. 4) 42.8 (Alt. 5)	-1.2 ± 1.3 0.1 ± 1.3 -2.4 ± 1.3 10.1 ± 1.3 8.9 ± 1.3 7.6 ± 1.3		-34 -35.3 -32.8 -45.3 -44.1 -42.8	-86 ± 9.3 -87.3 ± 9.3 -84.8 ± 9.3 -97.3 ± 9.3 -96.1 ± 9.3 -94.8 ± 9.3
All scenarios ± Total uncertainty	-87.2 ± 8	-35.2 ± 1.3	39.1 ± 6.3	3.9 ± 7.6	-52 ± 9.3	-39.1 ± 6.3	-91.1 ± 15.6

Table S4. Freshwater changes and main uncertainty estimates for the Ionian catchment. The terms P , ET and R represent precipitation, evapotranspiration and runoff, respectively, while Δ stands for change, and subscript *clim* and *irr* indicate climate driven and irrigation driven change, respectively. Scenario definitions (Base, Alt.) are as given and explained in main Table 3.

	ΔP (mm/yr)	ΔET_{clim} (mm/yr)	ΔET_{irr} (mm/yr)	ΔET (mm/yr)	ΔR_{clim} (mm/yr)	ΔR_{irr} (mm/yr)	ΔR (mm/yr)
P scenarios ± Irrigation uncertainty	-94.5 (Base) -104 (Alt. 1) -113 (Alt. 2)	-29 -27 -26		13.9 ± 6.8 15.9 ± 6.8 16.9 ± 6.8	-66.5 -77 -87		-108.4 ± 6.8 -119.9 ± 6.8 -129.9 ± 6.8
Irrigation (I_{ww}) scenarios ± P uncertainty			37.4 (Base) 38.7 (Alt. 1) 36 (Alt. 2) 49.7 (Alt. 3) 48.4 (Alt. 4) 47 (Alt. 5)	10.1 ± 1.5 11.4 ± 1.5 8.7 ± 1.5 22.4 ± 1.5 21.1 ± 1.5 19.7 ± 1.5		-37.4 -38.7 -36 -49.7 -48.4 -47	-113.9 ± 10.8 -115.2 ± 10.8 -112.5 ± 10.8 -126.2 ± 10.8 -124.9 ± 10.8 -123.5 ± 10.8
All scenarios ± Total uncertainty	-103.8 ± 9.3	-27.3 ± 1.5	42.9 ± 6.8	15.5 ± 8.3	-76.5 ± 10.8	-42.9 ± 6.8	-119.4 ± 17.6

Table S5. Freshwater changes and main uncertainty estimates for the Aegean catchment. The terms P , ET and R represent precipitation, evapotranspiration and runoff, respectively, while Δ stands for change, and subscript *clim* and *irr* indicate climate driven and irrigation driven change, respectively. Scenario definitions (Base, Alt.) are as given and explained in main Table 3.

	ΔP (mm/yr)	ΔET_{clim} (mm/yr)	ΔET_{irr} (mm/yr)	ΔET (mm/yr)	ΔR_{clim} (mm/yr)	ΔR_{irr} (mm/yr)	ΔR (mm/yr)
P scenarios ± Irrigation uncertainty	-35 (Base) -37 (Alt. 1) -39 (Alt. 2)	-9 -8 -8		27.2 ± 5.8 28.2 ± 5.8 28.2 ± 5.8	-26 -29 -31		-62.2 ± 5.8 -65.2 ± 5.8 -67.2 ± 5.8
Irrigation (I_{ww}) scenarios ± P uncertainty			31.6 (Base) 32.7 (Alt. 1) 30.4 (Alt. 2) 42.1 (Alt. 3) 40.9 (Alt. 4) 39.7 (Alt. 5)	23.3 ± 0.5 24.4 ± 0.5 22.1 ± 0.5 33.8 ± 0.5 32.6 ± 0.5 31.4 ± 0.5		-31.6 -32.7 -30.4 -42.1 -40.9 -39.7	-60.3 ± 2.5 -61.4 ± 2.5 -59.1 ± 2.5 -70.8 ± 2.5 -69.6 ± 2.5 -68.4 ± 2.5
All scenarios ± Total uncertainty	-37 ± 2	-8.3 ± 0.5	36.2 ± 5.8	27.9 ± 6.3	-28.7 ± 2.5	-36.2 ± 5.8	-64.9 ± 8.3

Table S6. Evapotranspiration (*ET*) conditions and changes showing insignificant influence of choice of *ET/P* scenario for the example of the total regional catchment. The terms *P* and *I_{ww}* represent precipitation and irrigation water use (withdrawal) per irrigated area, respectively. Index 1 stands for period 1 (1930-1949) and index 2 stands for period 2 (1990-2009). Scenario definitions (Base, Alt.) are as given and explained in main Table 3.

		<i>I_{ww}</i> (Base)		<i>I_{ww}</i> (Alt. 2)		<i>I_{ww}</i> (Alt. 3)	
		<i>ET1</i> (mm/yr)	<i>ET2</i> (mm/yr)	<i>ET1</i> (mm/yr)	<i>ET2</i> (mm/yr)	<i>ET1</i> (mm/yr)	<i>ET2</i> (mm/yr)
<i>P</i> with no correction (Base)	Mean <i>ET/P</i> (Base)	354	374	355	374	343	374
		20		19		31	
	Min <i>ET/P</i> (Alt. 1)	327	347	328	347	316	347
		20		19		31	
	Max <i>ET/P</i> (Alt. 2)	434	454	435	454	423	454
		20		19		31	
<i>P</i> with undercatch correction (Alt. 1)	Mean <i>ET/P</i> (Base)	386	407	387	407	375	407
		21		20		32	
	Min <i>ET/P</i> (Alt. 1)	356	377	357	377	345	377
		21		20		32	
	Max <i>ET/P</i> (Alt. 2)	473	494	474	494	462	494
		21		20		32	
<i>P</i> with undercatch and orographic correction (Alt. 2)	Mean <i>ET/P</i> (Base)	403	426	405	426	393	426
		23		21		33	
	Min <i>ET/P</i> (Alt. 1)	372	395	374	395	362	395
		23		21		33	
	Max <i>ET/P</i> (Alt. 2)	494	517	496	517	484	517
		23		21		33	