Analysis of different configurations of Noah-MP land surface model over the Iberian Peninsula considering energy fluxes

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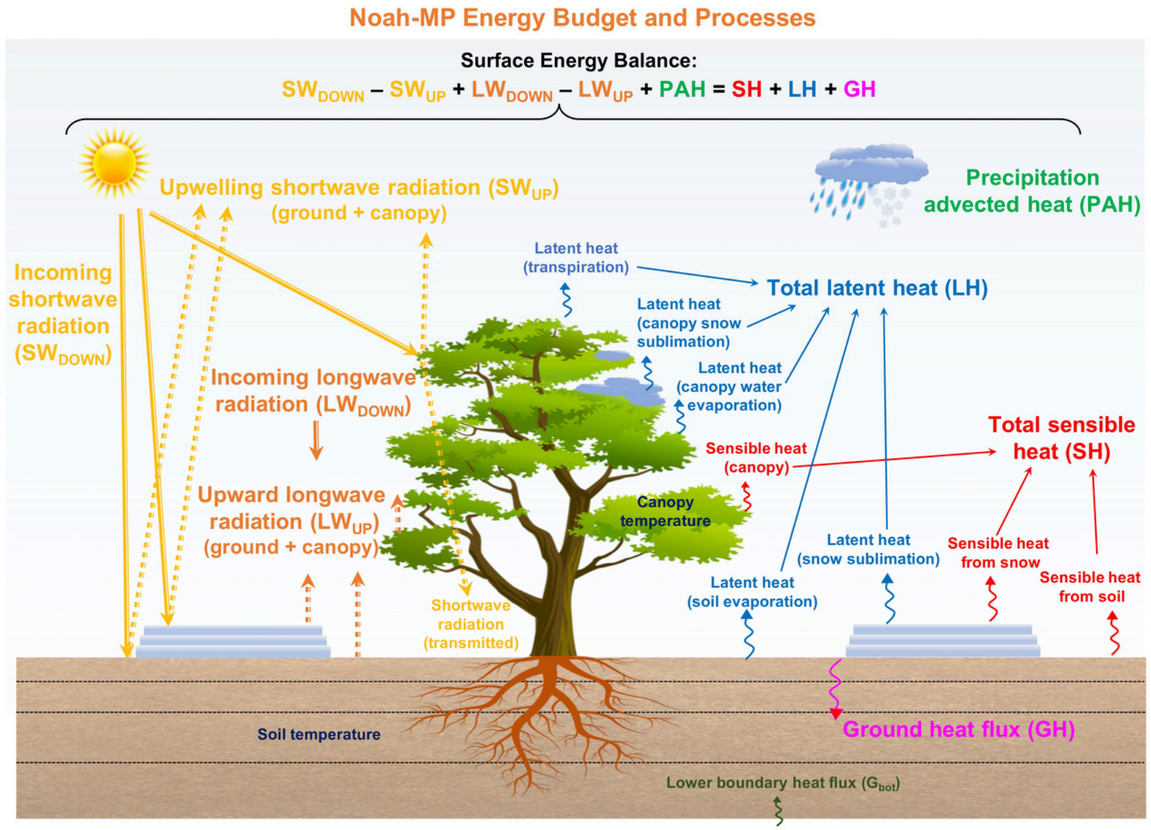
Noah-MP LSM



- **What is Noah-MP?**

It is an advanced land surface model that allow us to **describe with a high detail the land surface critical processes**, improving Noah-LSM.

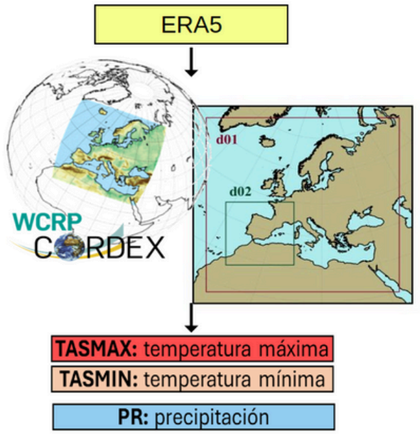
- **Noah-MP parameters**

Physical processes are summarized using several **parameters** that play an **important role in the model equations**.

- **Motivation**

The **high amount of parameter option combinations makes a sensitivity analysis necessary** to find optimal schemes **in different contexts** (orography, surface land usage, climate, etc.)

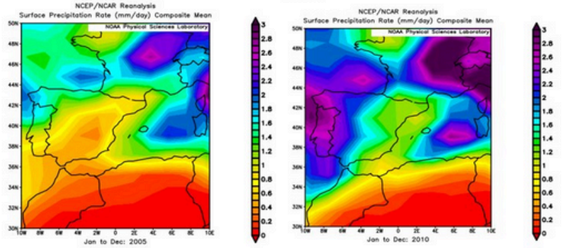
Datos y metodología



- Nested domains:
  - d01: EUROCORDEX, ~50Km
  - d02: Iberian Peninsula ~10Km
- Parameterization schemes (Argüeso et al., 2011; García-Valdecasas Ojeda et al., 2017, 2020):
  - Microphysics: WSM3C
  - Cumulus clouds: BMJ
  - Short/long wave radiation: CAM 3
  - Surface layer physics: MM5 similarity.
  - Planetary boundary layer: ACM2
- 30 years of spin up (Hu et al., 2023)

3

Annual accumulated precipitation in peninsular Spain. Source: AEMET

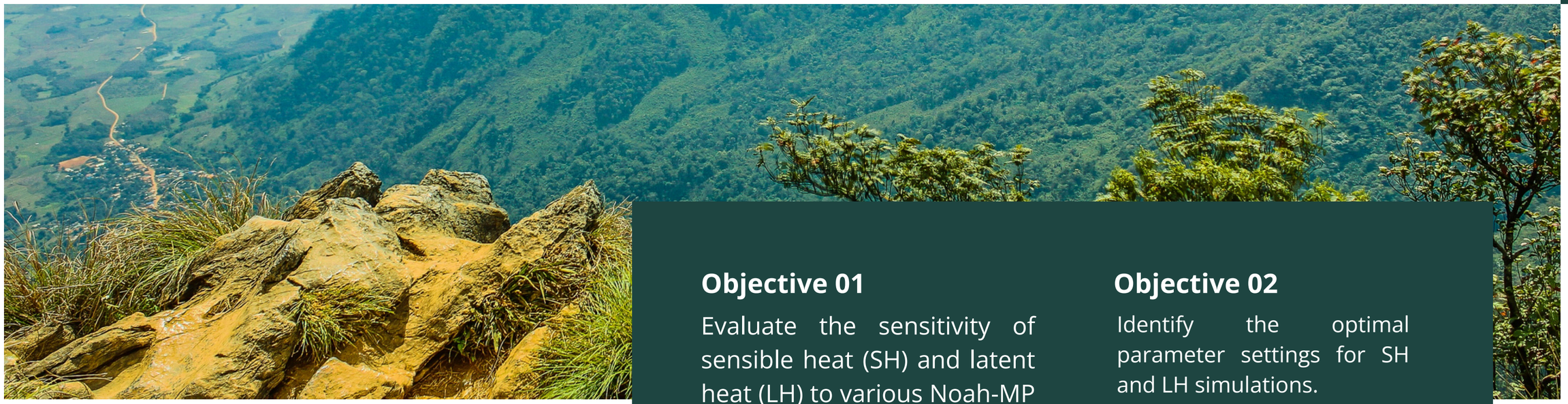


Precipitation rate (mm/day) for 2005 (left) and for 2010 (right). Data: NCEP/NCAR 40-year reanalysis (Kalnay et al. 1996)

6

Variable physical meaning/definition	New name	Original name
Namelist		
options for dynamic vegetation	OptDynamicVeg	OPT_DVEG
options for canopy stomatal resistance	OptStomataResistance	OPT_CRS
options for soil moisture factor for stomatal resistance	OptSoilWaterTranspiration	OPT_BTR
options for surface runoff	OptRunoffSurface	OPT_RUNSRF
options for subsurface runoff	OptRunoffSubsurface	OPT_RUNSUB
options for surface layer drag coeff	OptSurfaceDrag	OPT_SFC
options for supercooled liquid water (or ice fraction)	OptSoilSupercoolWater	OPT_FRZ
options for frozen soil permeability	OptSoilPermeabilityFrozen	OPT_INF
options for canopy radiation transfer	OptCanopyRadiationTransfer	OPT_RAD
options for ground snow surface albedo	OptSnowAlbedo	OPT_ALB
options for partitioning precipitation into rainfall & snowfall	OptRainSnowPartition	OPT_SNF
options for lower boundary condition of soil temperature	OptSoilTemperatureBottom	OPT_TBOT
options for snow/soil temperature time scheme (only layer 1)	OptSnowSoilTempTime	OPT_STC
options for surface resistent to evaporation/sublimation	OptGroundResistanceEvap	OPT_RSF

	Exp	dveg	crs	sfc	btr	run	frz	inf	rad	alb	tbot	stc	rsf
Default →	0	4	1	1	1	3	1	1	3	2	2	1	1
Common references and basic combinations	1	2	1	1	1	1	1	1	1	1	1	1	1
	2	3	1	1	1	1	1	1	1	1	1	1	1
	3	2	2	1	1	1	1	1	1	1	1	1	1
	4	2	1	1	2	1	1	1	1	1	1	1	1
	5	2	1	2	1	1	1	1	1	1	1	1	1
	6	2	1	1	1	1	1	1	2	1	1	1	1
	7	2	1	1	1	1	1	1	3	1	1	1	1
	8	2	1	1	1	1	1	1	1	2	1	1	1
	9	2	1	1	1	4	1	1	1	1	1	1	1
	10	2	1	1	1	1	2	1	1	1	1	1	1
	11	2	1	1	3	1	1	1	1	1	1	1	1
Dry scenario	12	5	1	1	1	1	1	1	1	1	1	1	1
	13	5	1	1	1	1	1	1	1	1	1	1	3
	14	5	1	1	2	1	1	2	1	1	1	1	1
	15	5	1	1	2	1	1	2	1	1	1	1	3
	16	5	1	1	2	4	1	2	1	1	1	1	3
	17	5	2	1	2	4	2	2	1	1	1	1	3
Wet scenario	18	2	1	2	1	1	1	1	2	2	2	1	1
	19	2	1	1	2	1	1	1	1	1	2	1	1
	20	2	1	1	3	1	1	1	1	2	1	1	1
	21	2	1	1	3	1	1	1	3	2	1	1	1
	22	2	1	1	3	1	1	1	3	2	2	1	1
	23	5	1	1	2	1	1	1	3	2	2	1	1
	24	1	1	1	1	1	1	1	1	1	1	1	1
	25	2	1	1	3	3	1	1	3	2	2	1	1
	26	2	1	1	3	3	1	1	3	2	1	1	1
	27	2	1	1	3	3	1	1	1	2	1	1	1
Combination	28	5	2	1	3	1	2	1	3	2	1	1	1



Objectives

Objective 01

Evaluate the sensitivity of sensible heat (SH) and latent heat (LH) to various Noah-MP parameters.

Objective 02

Identify the optimal parameter settings for SH and LH simulations.

Objective 03

Select the best parameterization schemes from the chosen options for improved accuracy.

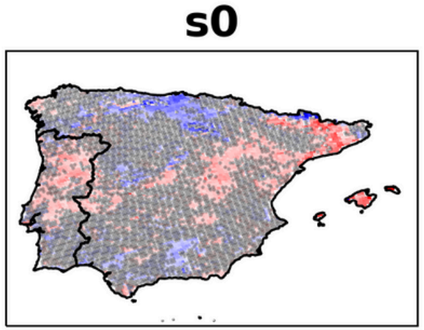
Data and metodology

Database reference: CERRA-Land

01 Spatial patterns

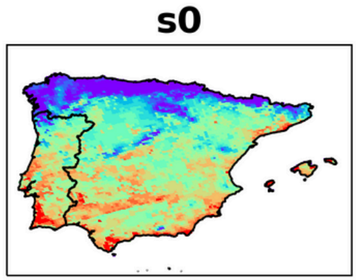
Bias accumulated energy fluxes

Area with no significant differences with **Mann-Whitney U test**



Spatial correlation of accumulated energy fluxes

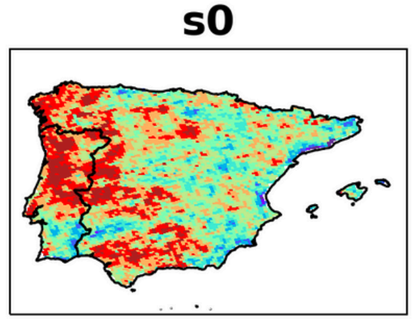
Spatial correlation with **Spearman test**



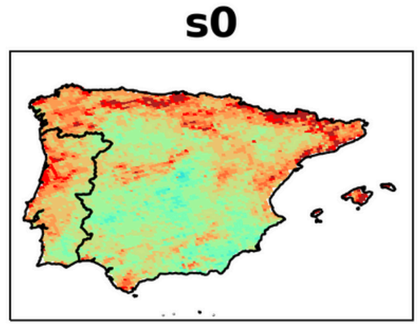
02 Temporal performance

Annual correlation

Temporal correlation with **Pearson test**

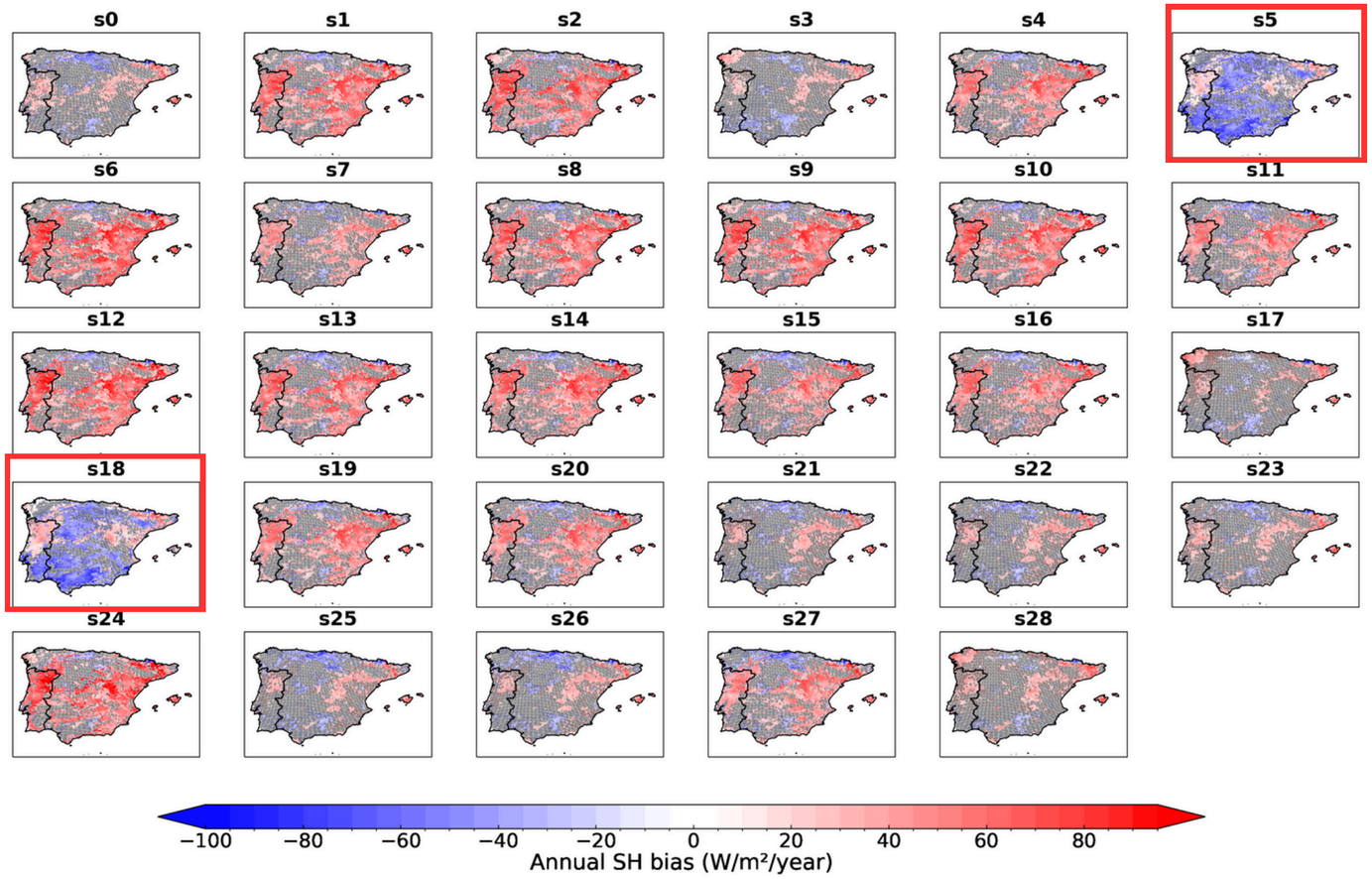


Annual RMSE



Results Spatial patterns

2005 SH accumulated bias



	SH-2005	LH-2005	SH-2010	LH-2010
s0	68,32	32,29	62,36	24,89
s1	39,9	41,58	35,36	46,41
s2	41,22	43,64	34,92	58,91
s3	71,36	27,43	44,34	29,09
s4	48,1	43,71	39,38	65,21
s5	38,22	41,46	48,54	63,06
s6	36,52	42,79	31,5	51,15
s7	58,36	34,99	41,69	41,14
s8	40,28	40,82	34,18	48,85
s9	39,11	43,74	29,85	59,96
s10	40,06	40,46	35,07	46,87
s11	49,33	41,33	41,95	63,33
s12	39,43	41,25	30,85	48,65
s13	43,74	30,53	38,22	38,27
s14	43,3	42,56	33,98	64,51
s15	52,66	48,02	40,82	65,61
s16	51,9	46,16	38,62	66,34
s17	76,55	28,15	45,24	23,49
s18	36,05	43,35	42,01	62,54
s19	48,34	43,37	39,77	64,87
s20	49,96	42,71	41,93	65,29
s21	72,33	40,45	53,48	61,31
s22	72,72	39,38	53,67	60,73
s23	72,54	46,47	57,44	56,55
s24	39,83	43,98	30,37	55,82
s25	71,59	43,26	59,09	46,16
s26	70,88	41,87	60,3	48,91
s27	49,67	45,76	42,35	51,43
s28	74,32	37,07	42,27	43,95

Area with no significant differences (%)

Surface layer drag coefficient

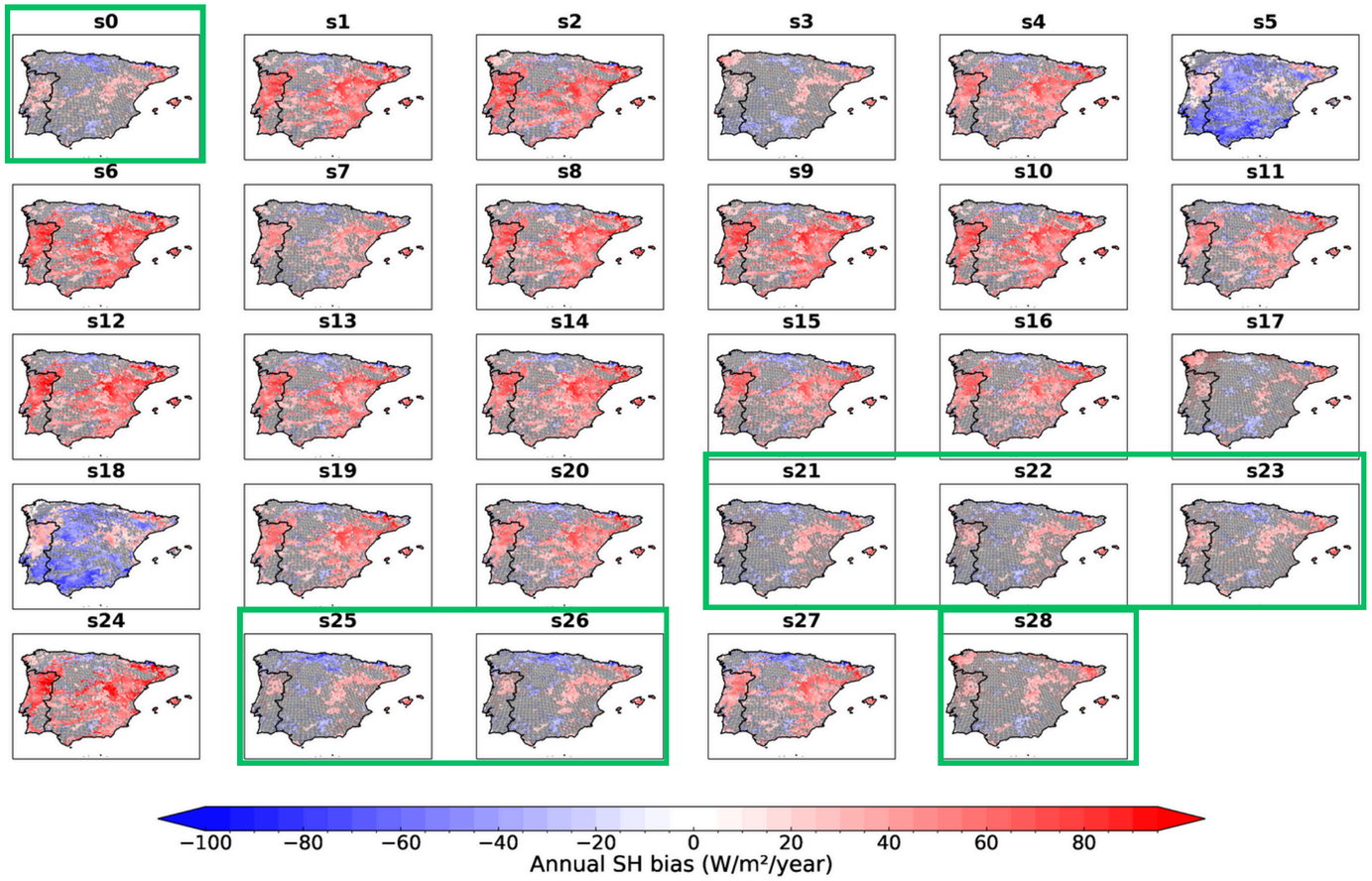
SFC = 2 → $Z_{ot} = Z_{om} \exp\left(-kC_{zil}\sqrt{R_e}\right)$

Czil empirically fixed
Chen et al. (1997)

(Original Noah LSM)
Zhang et al. (2022)

Results Spatial patterns

2005 SH accumulated bias



Affects the energy available for evapotranspiration and soil heating.

RAD = 3 + ALB = 2

It defines the **surface albedo**

More complex radiation treatment

Dynamical computation of albedo

Area with no significant differences (%)

	SH-2005	LH-2005	SH-2010	LH-2010
s0	68,32	32,29	62,36	24,89
s1	39,9	41,58	35,36	46,41
s2	41,22	43,64	34,92	58,91
s3	71,36	27,43	44,34	29,09
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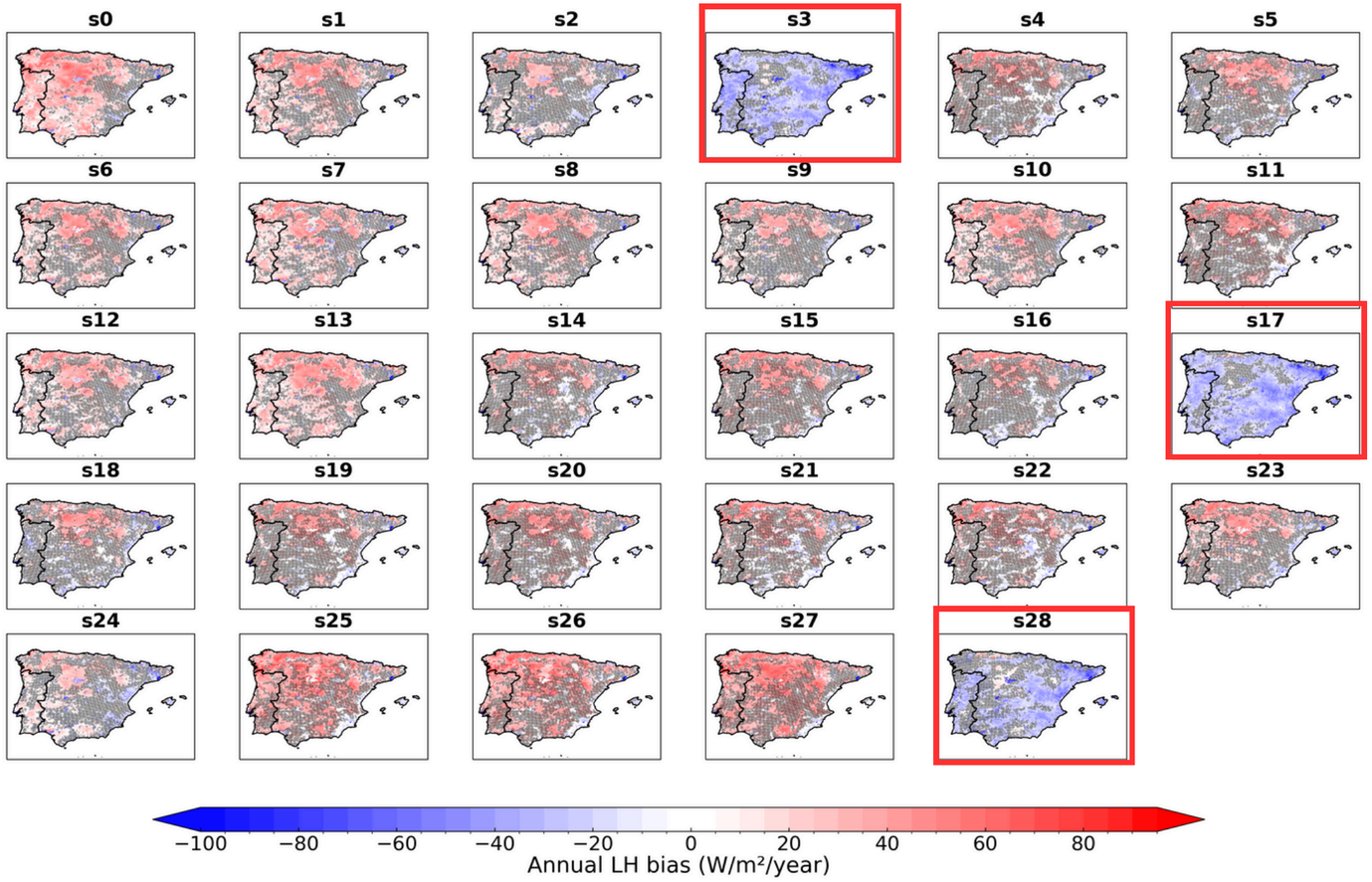
s27	49,67	45,76	42,35	51,43
s28	74,32	37,07	42,27	43,95

Niu et al. (2011)

Results Spatial patterns

2010 LH accumulated bias



Canopy resistance to water vapor flux

CRS = 2

Chen et al. (2020)

Use an empirical and simplified scheme.

Jarvis et al. (1976)

Area with no significant differences (%)

	SH-2005	LH-2005	SH-2010	LH-2010
s0	68,32	32,29	62,36	24,89
s1	39,9	41,58	35,36	46,41
s2	41,22	43,64	34,92	58,91
s3	71,36	27,43	44,34	29,09
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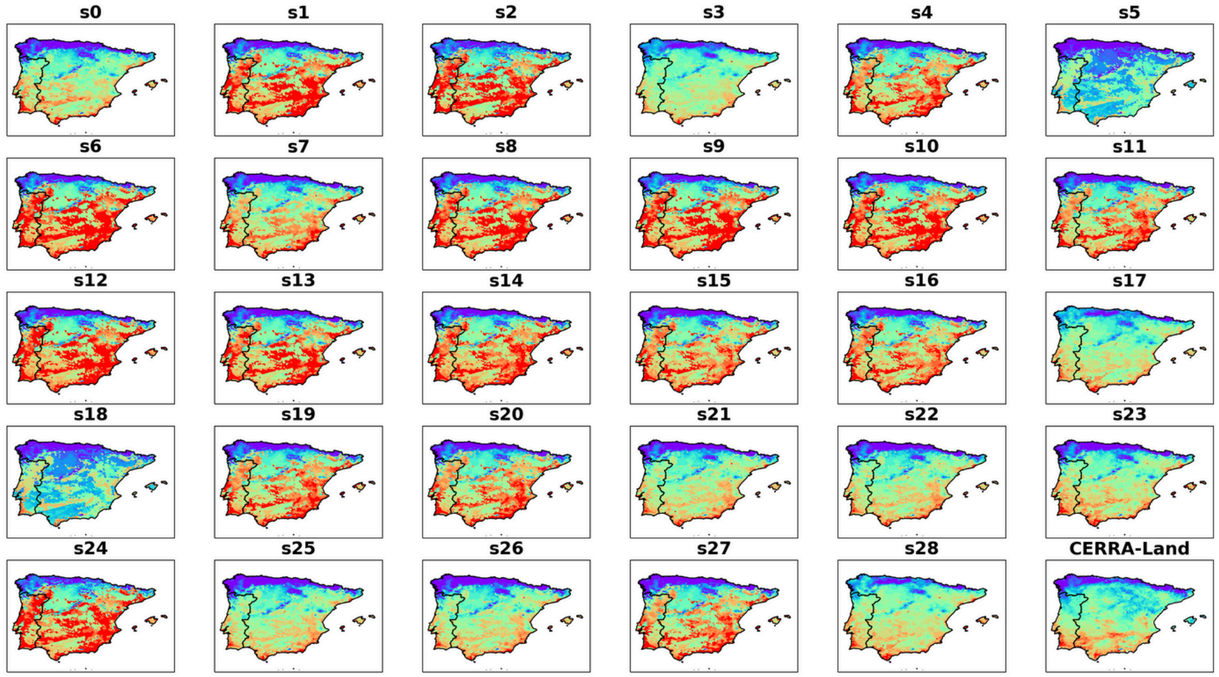
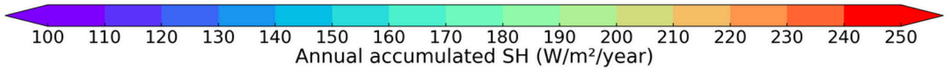
Results Spatial patterns

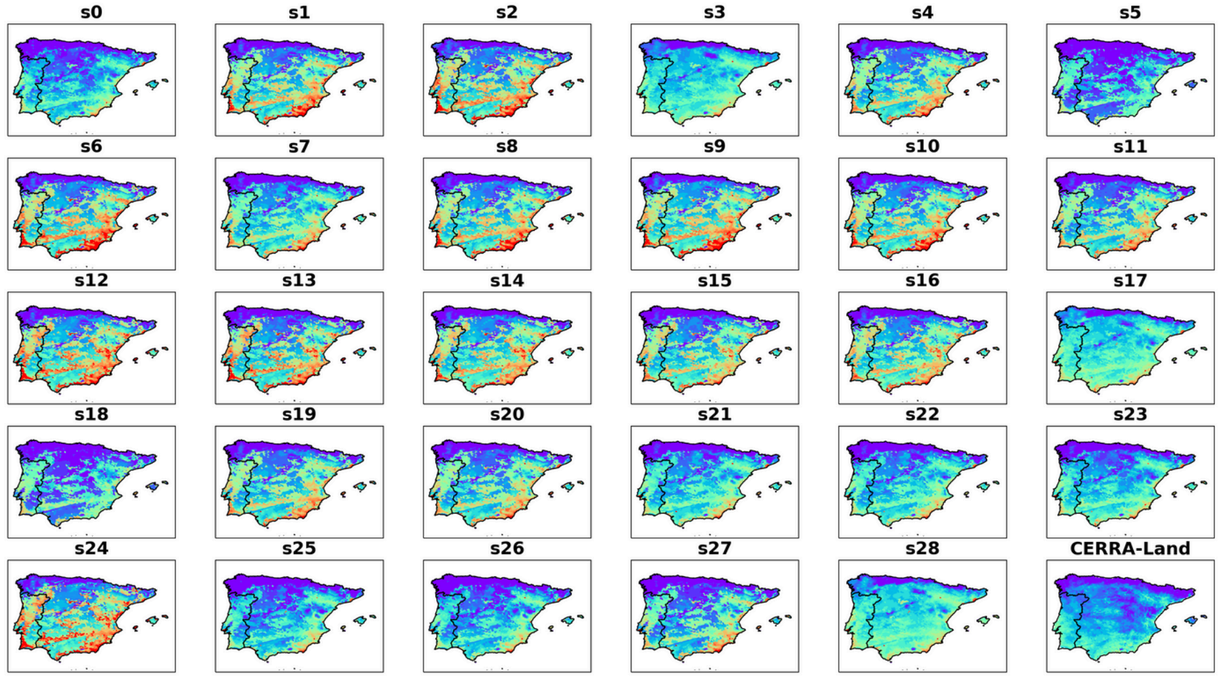
Accumulated SH

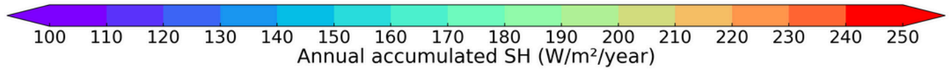
2005





2010

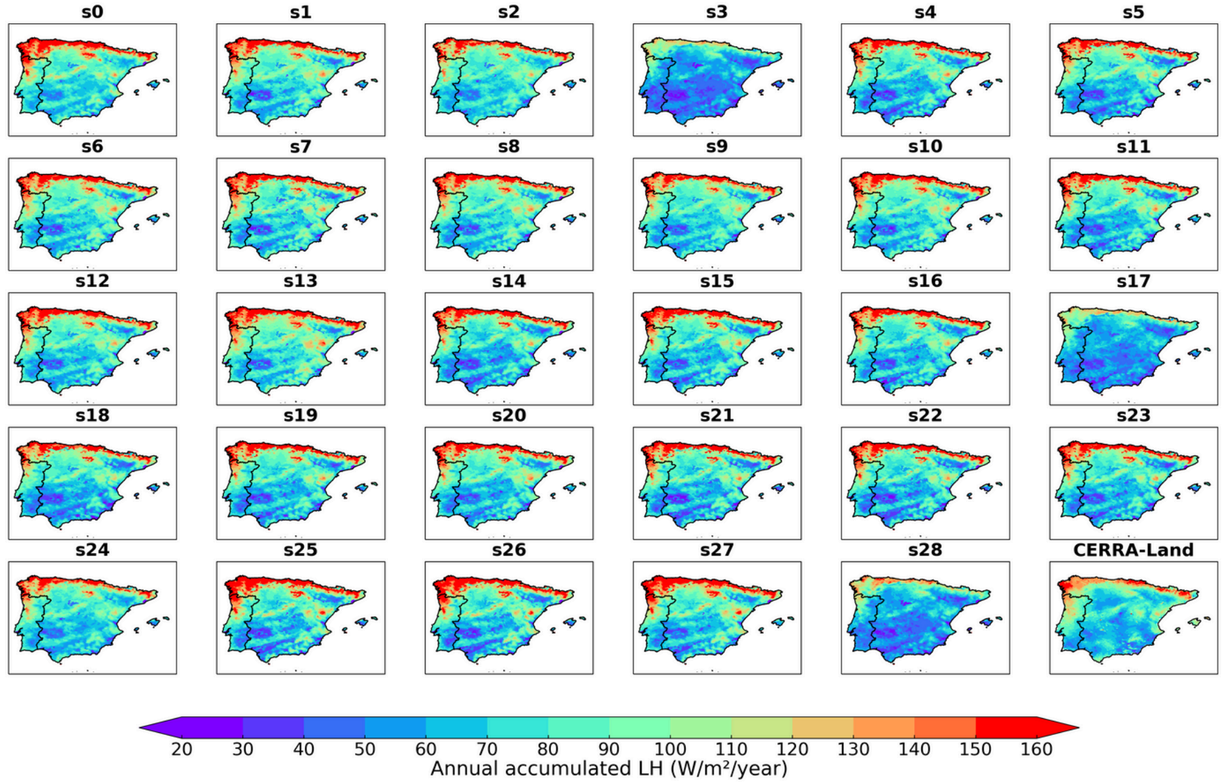




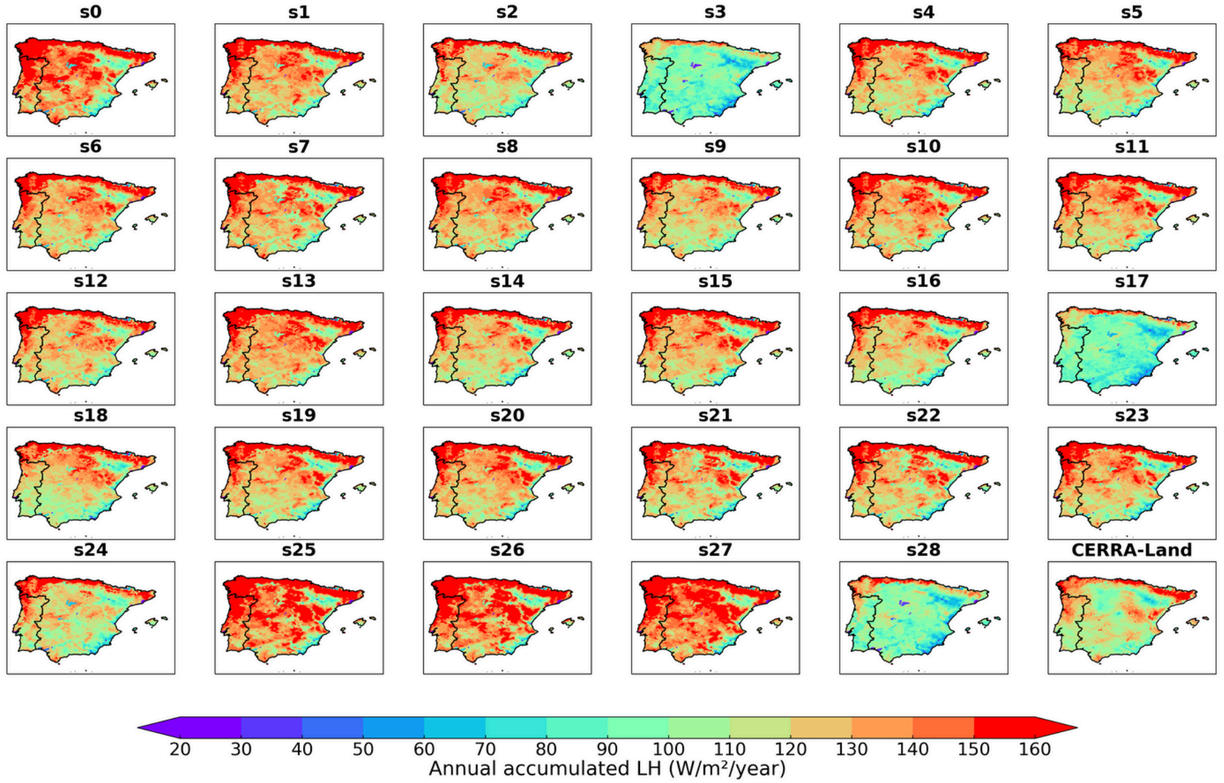
Results Spatial patterns

Accumulated LH

2005



2010



Results Spatial patterns

Area with no significant differences (%)

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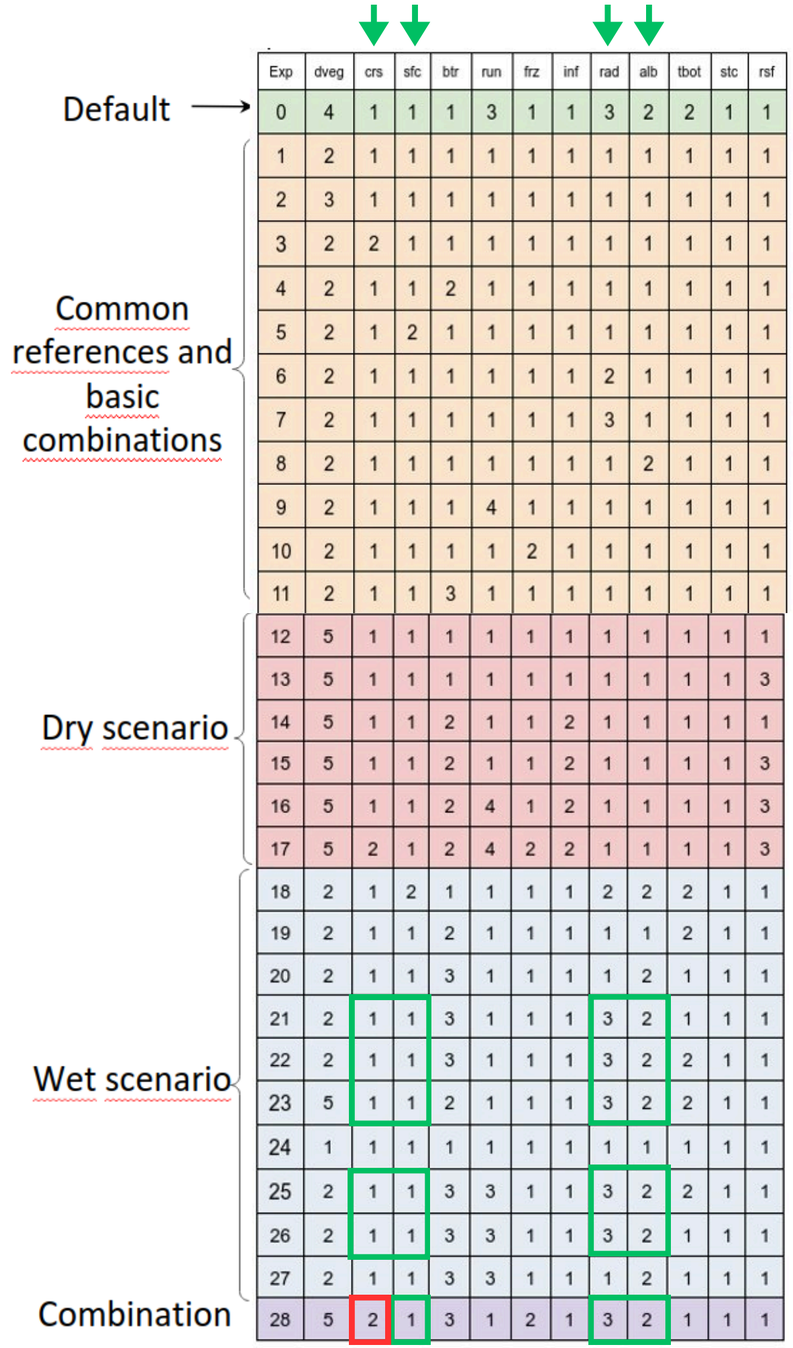
s27	49,67	45,76	42,35	51,43
s28	74,32	37,07	42,27	43,95

Spatial correlations

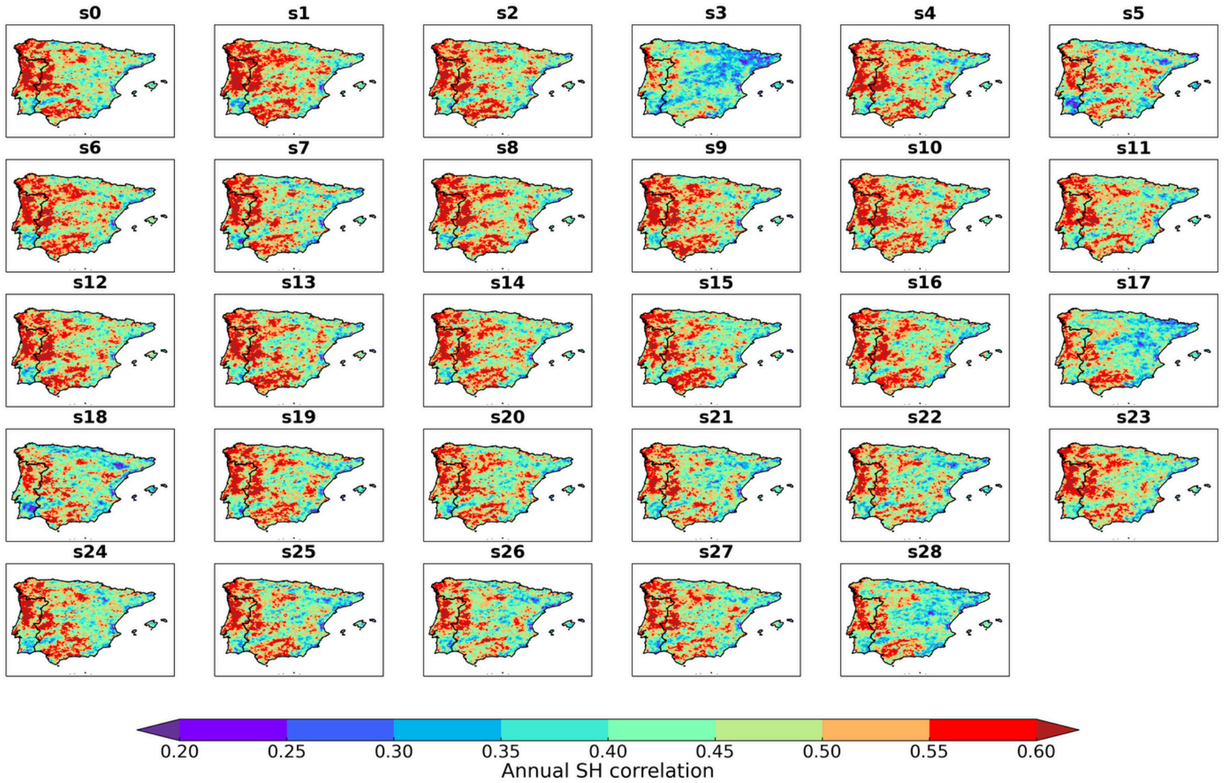
	SH-2005	LH-2005	SH-2010	LH-2010
s0	0,805	0,8108	0,7406	0,6714
s1	0,6872	0,7732	0,6507	0,6493
s2	0,6657	0,7826	0,6424	0,6473
s3	0,805	0,7728	0,7438	0,5749
s4	0,6669	0,7782	0,6368	0,6651
s5	0,5556	0,7694	0,6146	0,5932
s6	0,6801	0,7715	0,6404	0,6505
s7	0,7488	0,7612	0,6917	0,6839
s8	0,6856	0,7758	0,6537	0,6506
s9	0,6756	0,7849	0,645	0,6722
s10	0,6881	0,77	0,658	0,6591
s11	0,672	0,7752	0,6356	0,6244
s12	0,663	0,7897	0,6215	0,6388
s13	0,6909	0,7656	0,6275	0,619
s14	0,6653	0,787	0,6185	0,6691
s15	0,6879	0,771	0,6256	0,6607
s16	0,682	0,7814	0,6236	0,6562
s17	0,8194	0,7601	0,7782	0,5995
s18	0,5366	0,7821	0,5989	0,5681
s19	0,66	0,7747	0,6317	0,6576
s20	0,6648	0,7824	0,6345	0,6533
s21	0,7732	0,7748	0,6997	0,7007
s22	0,7771	0,7746	0,6872	0,7064
s23	0,8335	0,7933	0,7929	0,6859
s24	0,6267	0,8047	0,5879	0,658
s25	0,7814	0,7802	0,6975	0,7241
s26	0,782	0,7779	0,705	0,733
s27	0,6835	0,7777	0,6379	0,6764
s28	0,8354	0,7759	0,768	0,6033



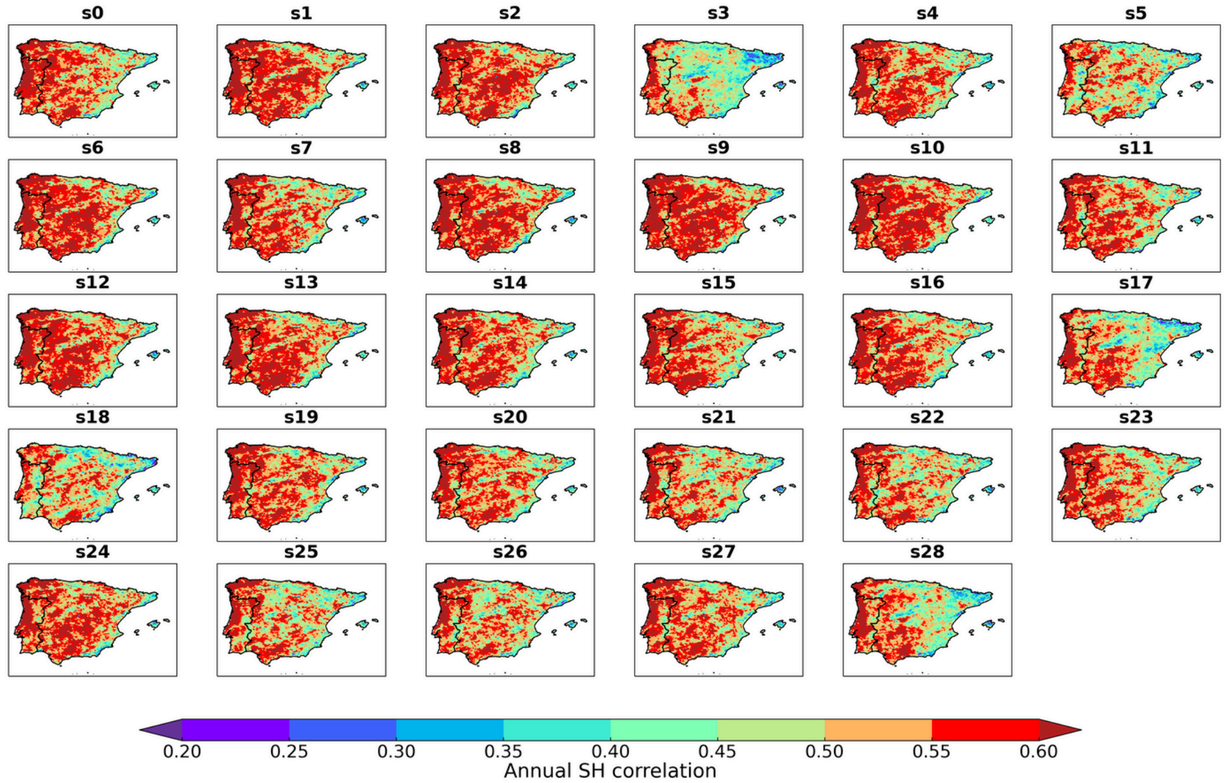
Results Temporal performance

SH correlation

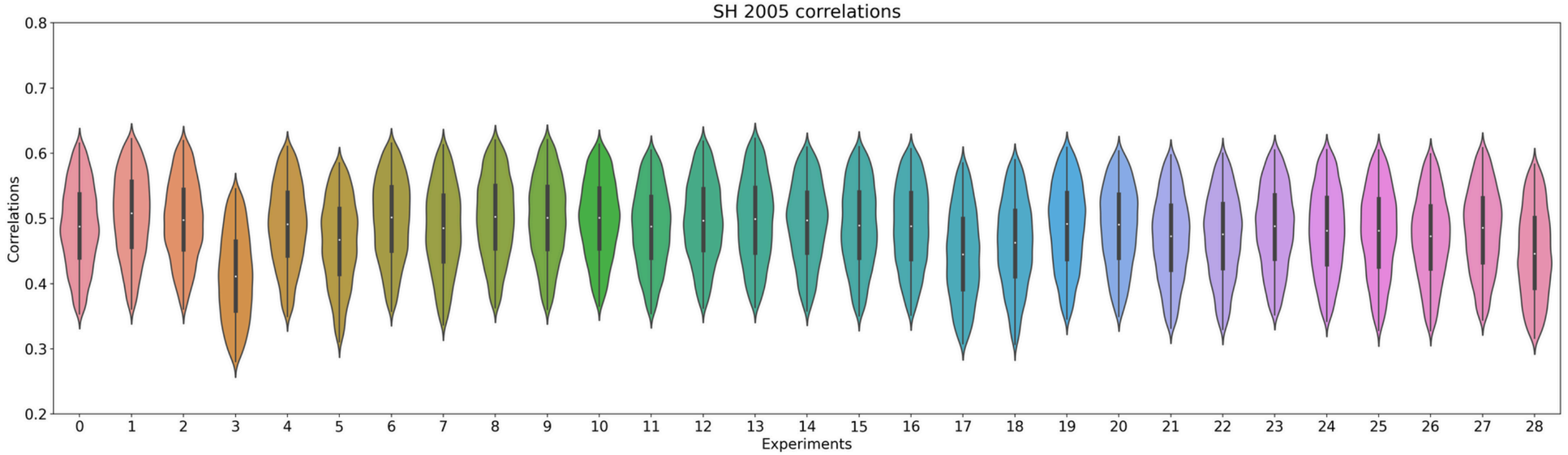
2005

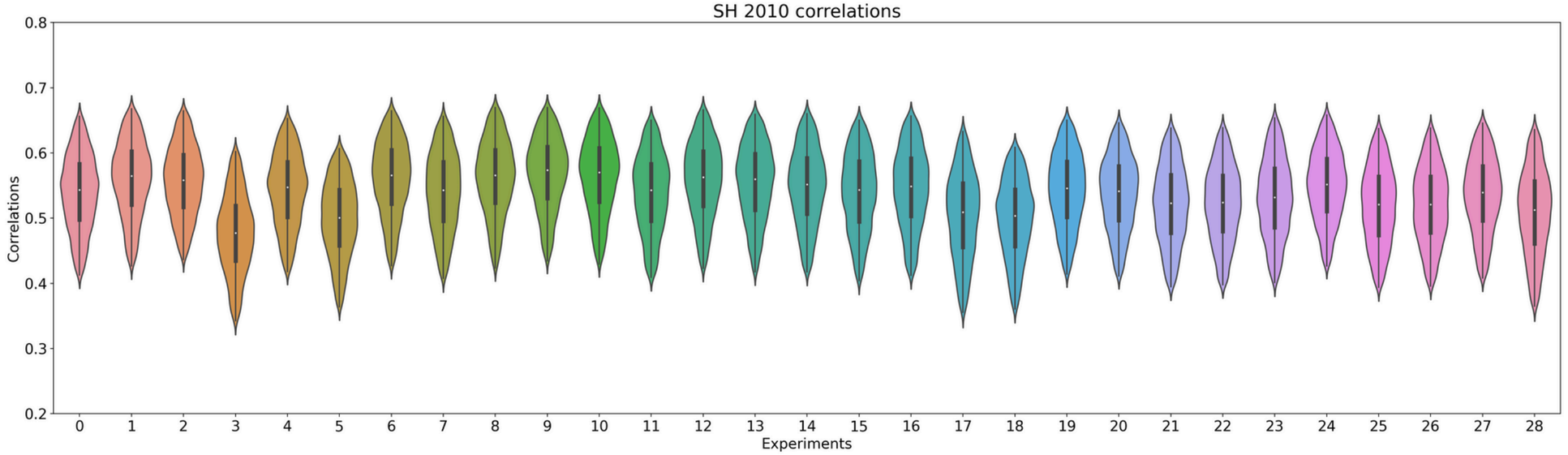


2010

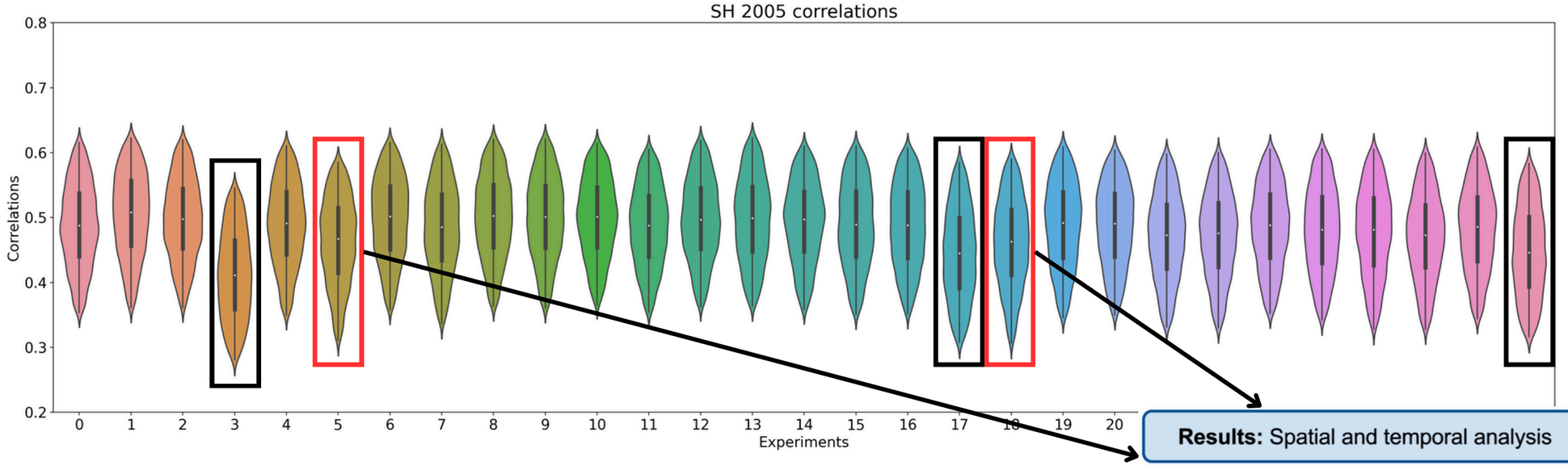


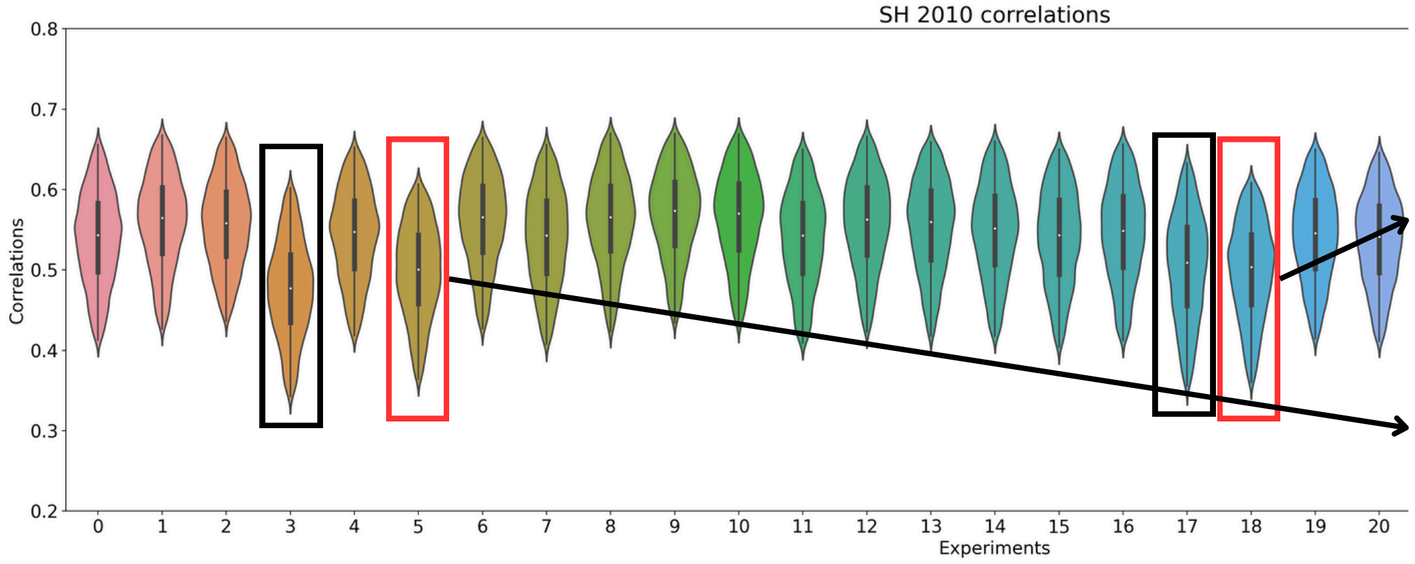
Results Temporal performance





Results Temporal performance

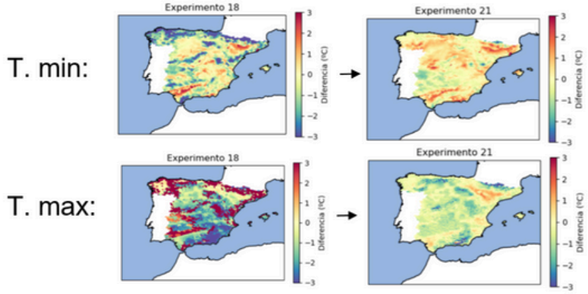




Results: Spatial and temporal analysis

OptSurfaceDrag	1*	Monin-Obukhov (M-O) Similarity Theory (Brutsaert, 1982)
options for surface layer drag/exchange coefficient	2	original Noah (Chen et al. 1997)

Temperatures: big improvement over Noah-LSM



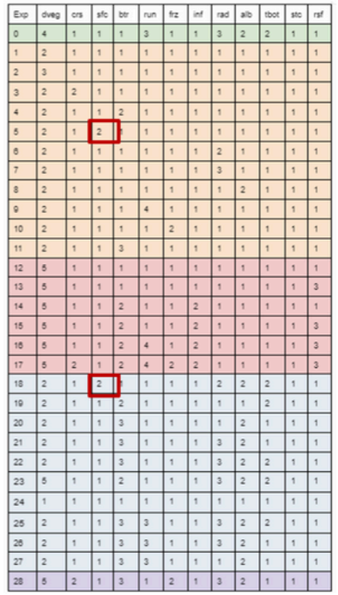
Annual average differences (Model - AEMET)

SFC = 2

Zhang et al. (2022)

CRS = 2

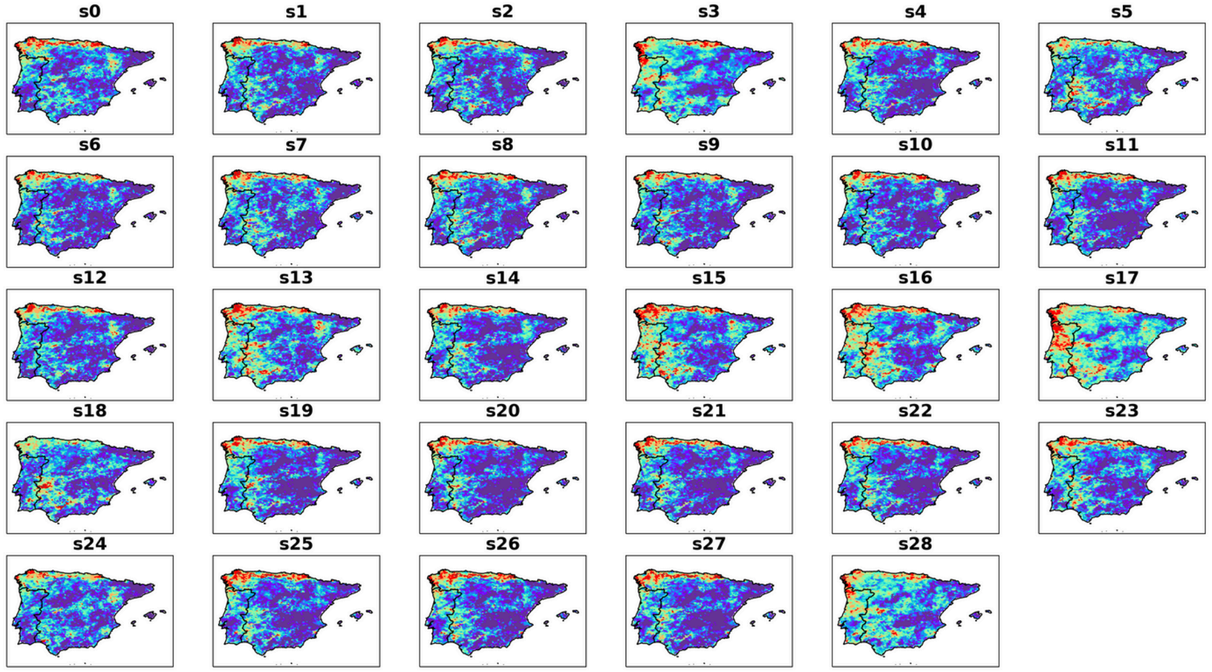
Chen et al. (2020)

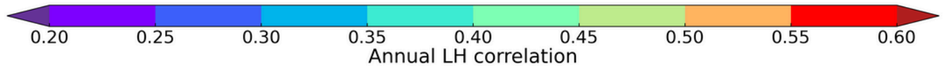


Results Temporal performance

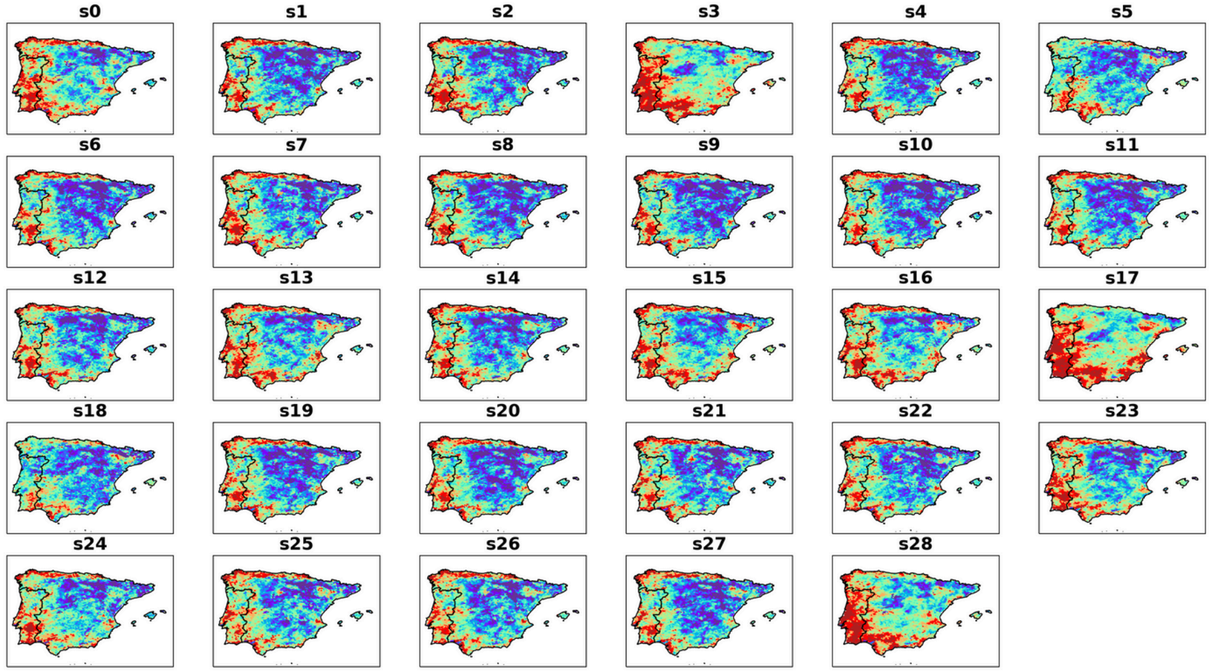
LH correlation

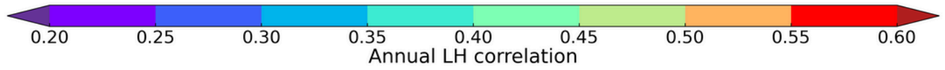
2005



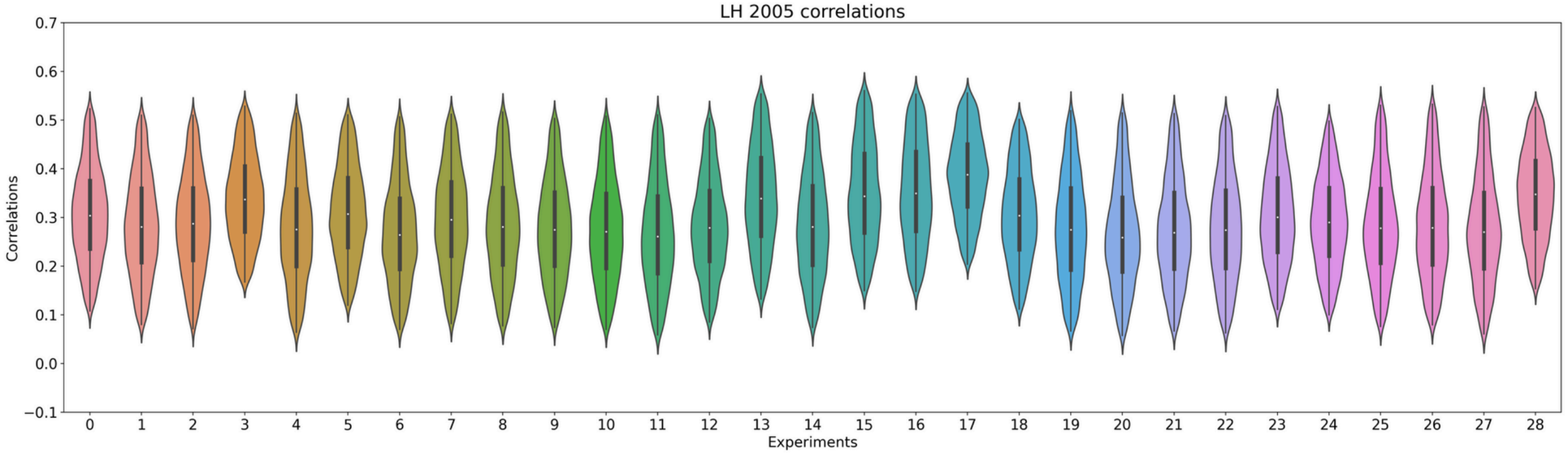


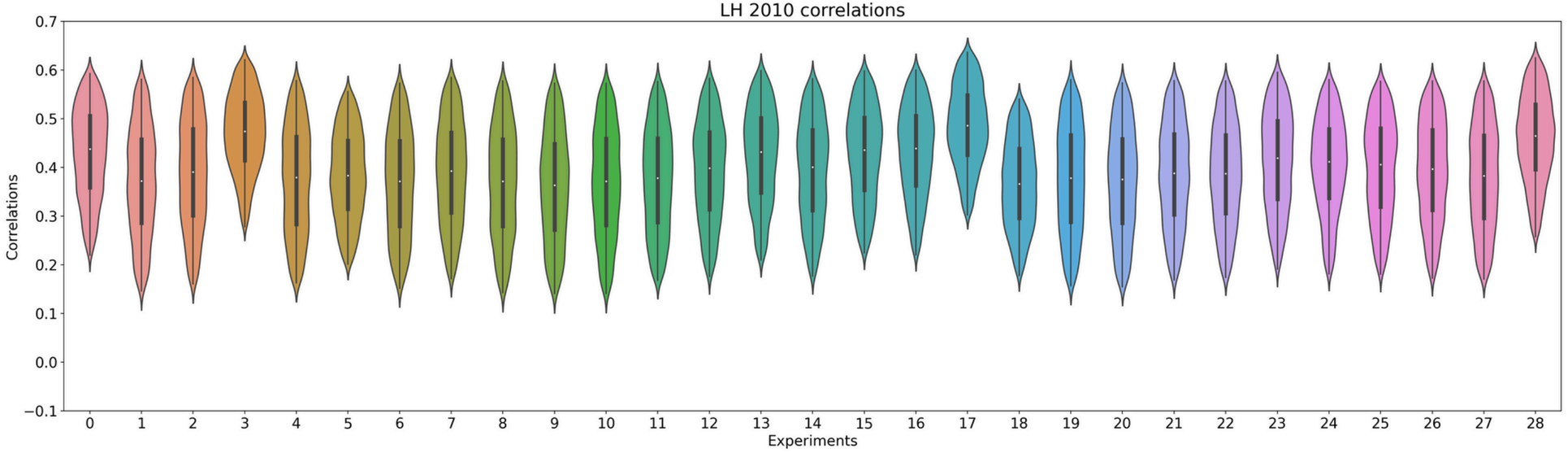
2010



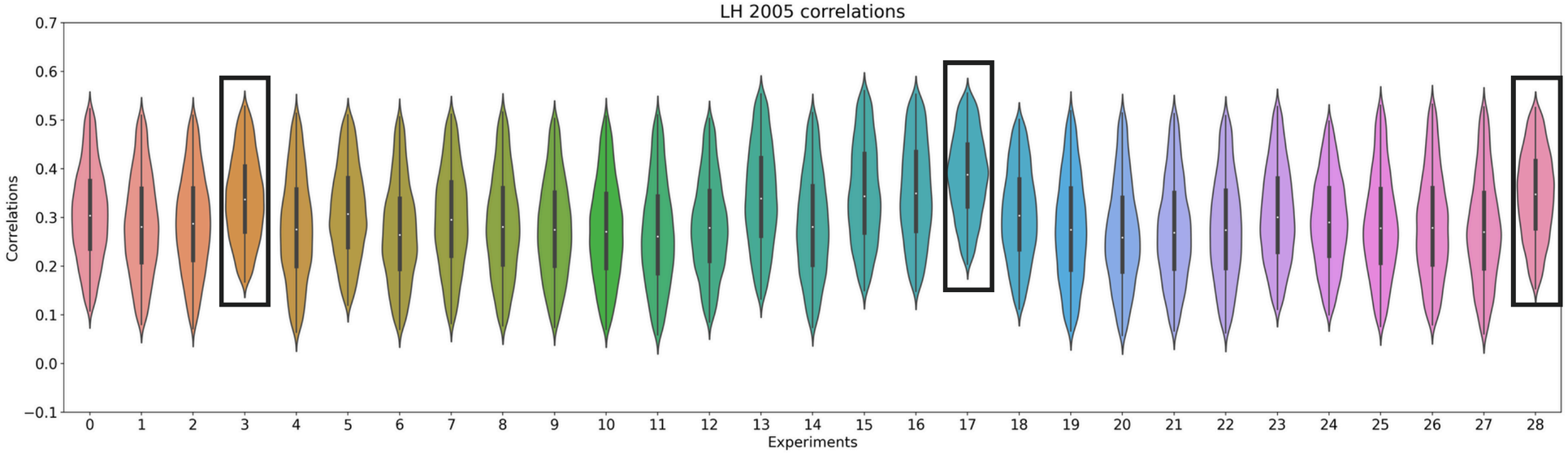


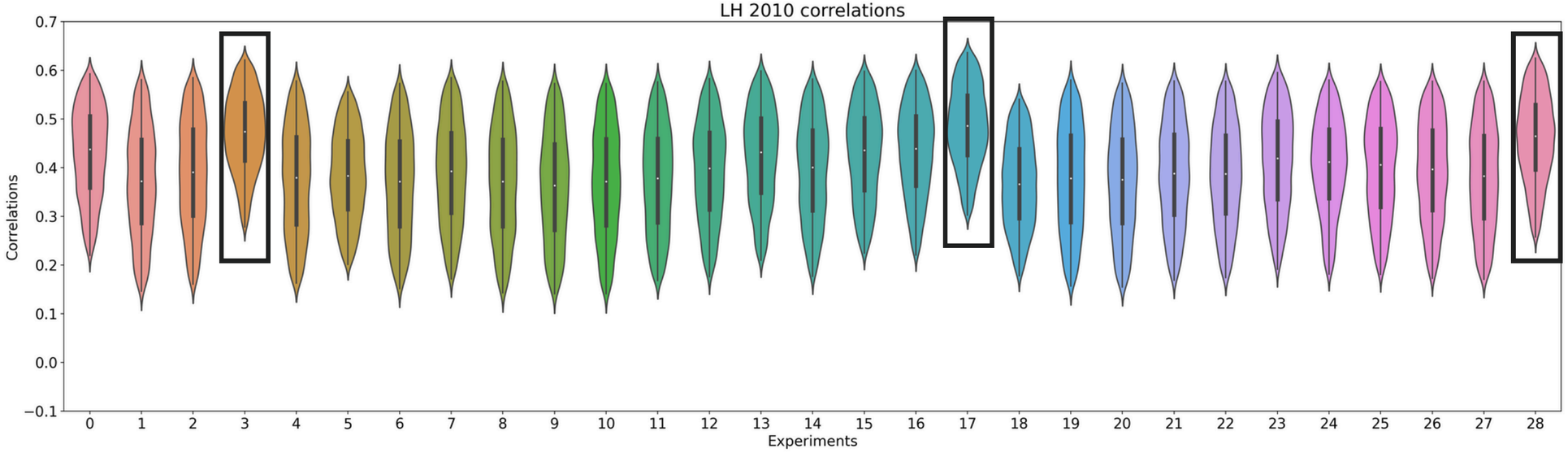
Results Temporal performance





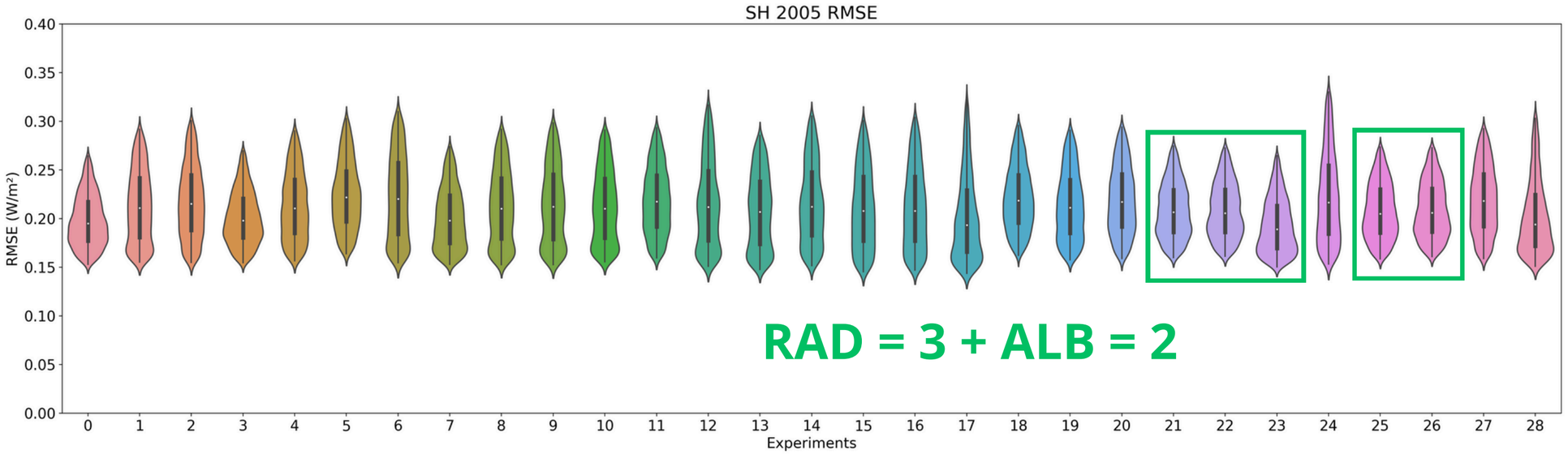
Results Temporal performance

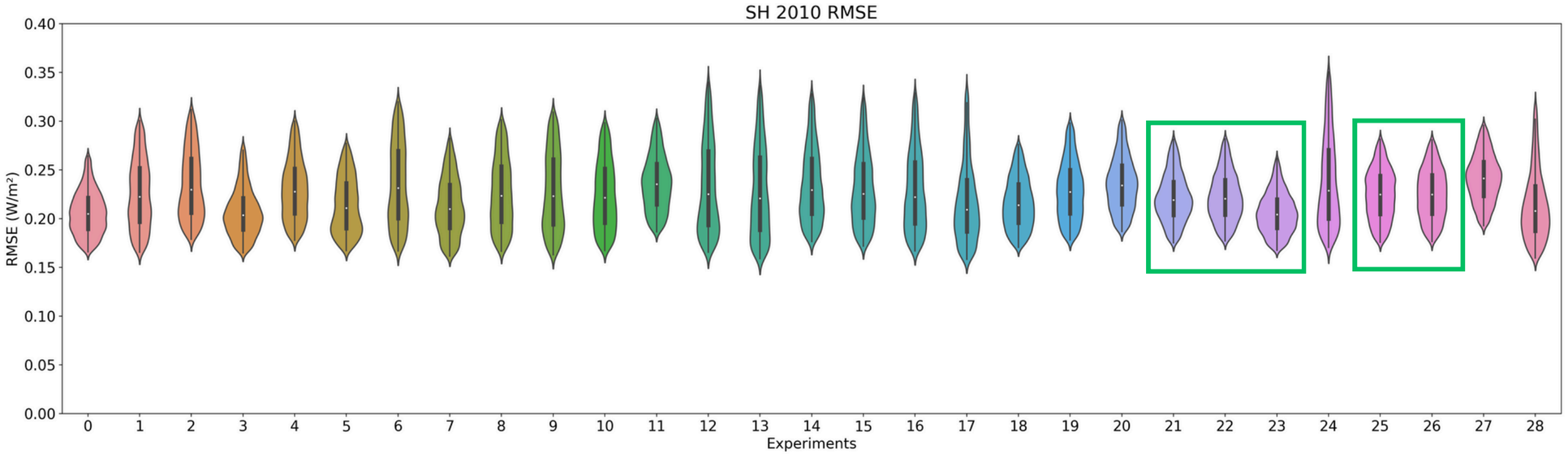




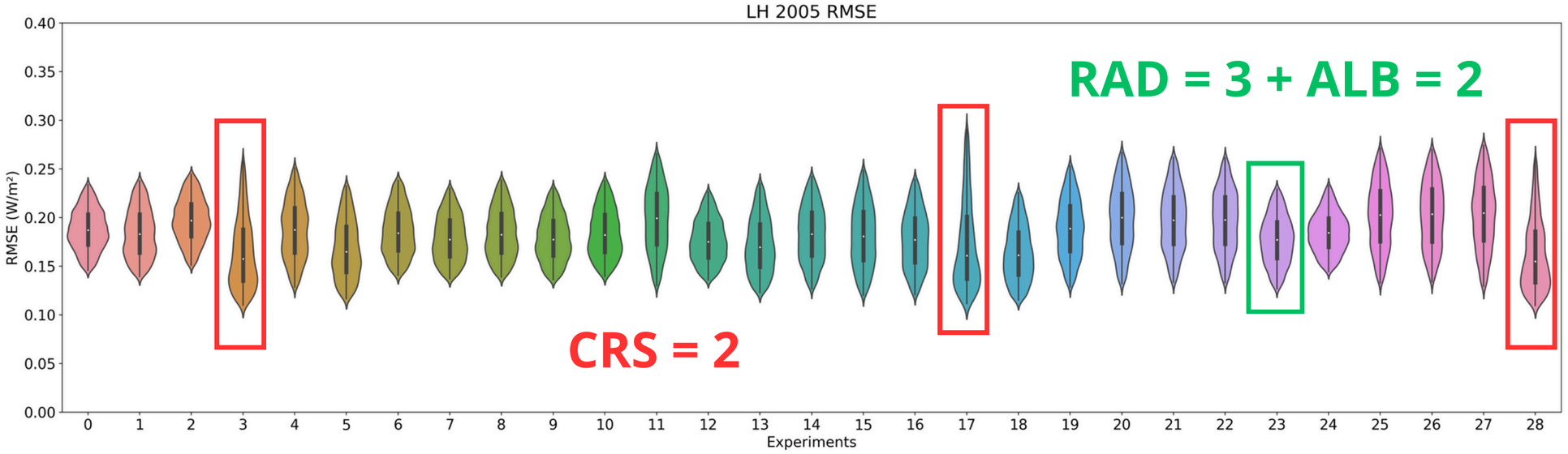
CRS = 2

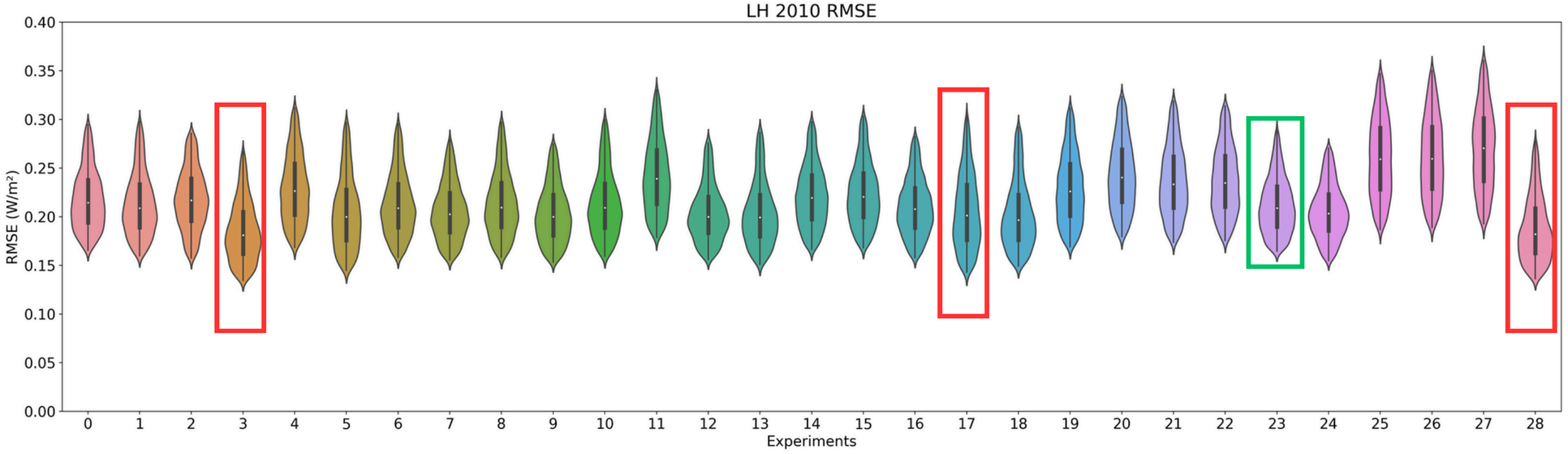
Results Temporal performance





Results Temporal performance





Conclusions

- SH and LH variables are more sensitive to parameters **SFC**, **CRS**, **RAD,** and **ALB**.

- Best configurations for these parameters are the following:

SFC = 1 (M-O); **RAD = 3** (Gaps-veg-frac); **ALB = 2** (CLASS); **CRS = 1** (Jarvis).

- From the selected schemes, **best performance are obtained with 21, 22, 23, 25,** and **26**.

- There is **consistency between the precipitation and temperature assessment and that of heat fluxes**: option 21 represents a good performance of the simulations for dry and wet conditions over the Iberian Peninsula.

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Thank You