Calibration and sensitivity analysis of SWAT for a small forested catchment, north-central Portugal

Rial-Rivas, M.E.[1]; **Santos, J.** [1]; **Bernard-Jannin L.** [1]; **Boulet, A.K.** [1]; **Coelho, C.O.A.** [1]; **Ferreira, A.J.D.**[4]; **Nunes, J.P.** [1]; **Rodríguez-Suárez J.A.** [1, 2]; **Rodríguez-Blanco M.L.** [1,3]; **Keizer, J.J.** [1]

[1]CESAM and Dept. Environment & Planning. University of Aveiro. PORTUGAL
E-mail: m.rial@ua.pt
[2]Vegetal Biology and Soil Science Department. University of Vigo. SPAIN.
[3] Faculty of Sciences. University of A Coruña. SPAIN.
[4]CERNAS, Coimbra Agrarian Technical School. PORTUGAL

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HIDRIA project

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HIDRIA project

“A multi-stage approach for addressing input data uncertainties in process-based rainfall-runoff modeling for small forested catchments upstream of the Ria de Aveiro”

The project foresees the development of:

A stepwise approach to rainfall-runoff modelling

To assess the implications of existing data constraints

To establish priorities for additional field and laboratory data gathering

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SPECIFIC OBJECTIVE WITHIN THIS WORK

Assess the influence of:

- Number of parameters included in the auto-calibration.
- Ranges of variation of these parameters

in the **SWAT model auto-calibration results** for the study catchment.

METHODS

SENSITIVITY ANALYSIS *(ArcSWAT 2009 interface)*	Latin Hypercube (LH) and One-factor-At-a-Time (OAT) sampling.
AUTO-CALIBRATION *(ArcSWAT 2009 interface)*	Parameter Solution (ParaSol) with uncertainty analysis
MODEL EVALUATION	Nash-Sutcliffe efficiency (NSE)
	Percent bias (PBIAS)
	Root Mean Square Error (RMSE)

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STUDY AREA

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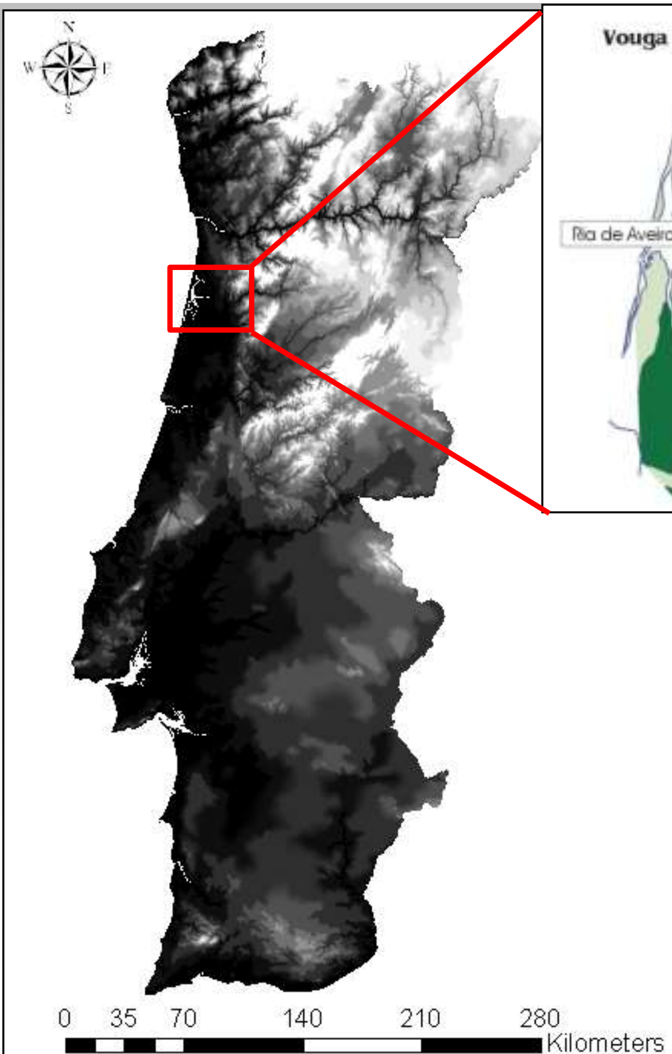
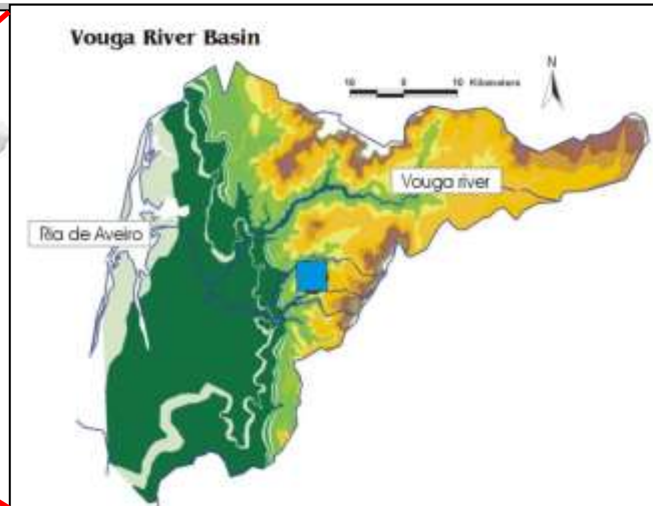
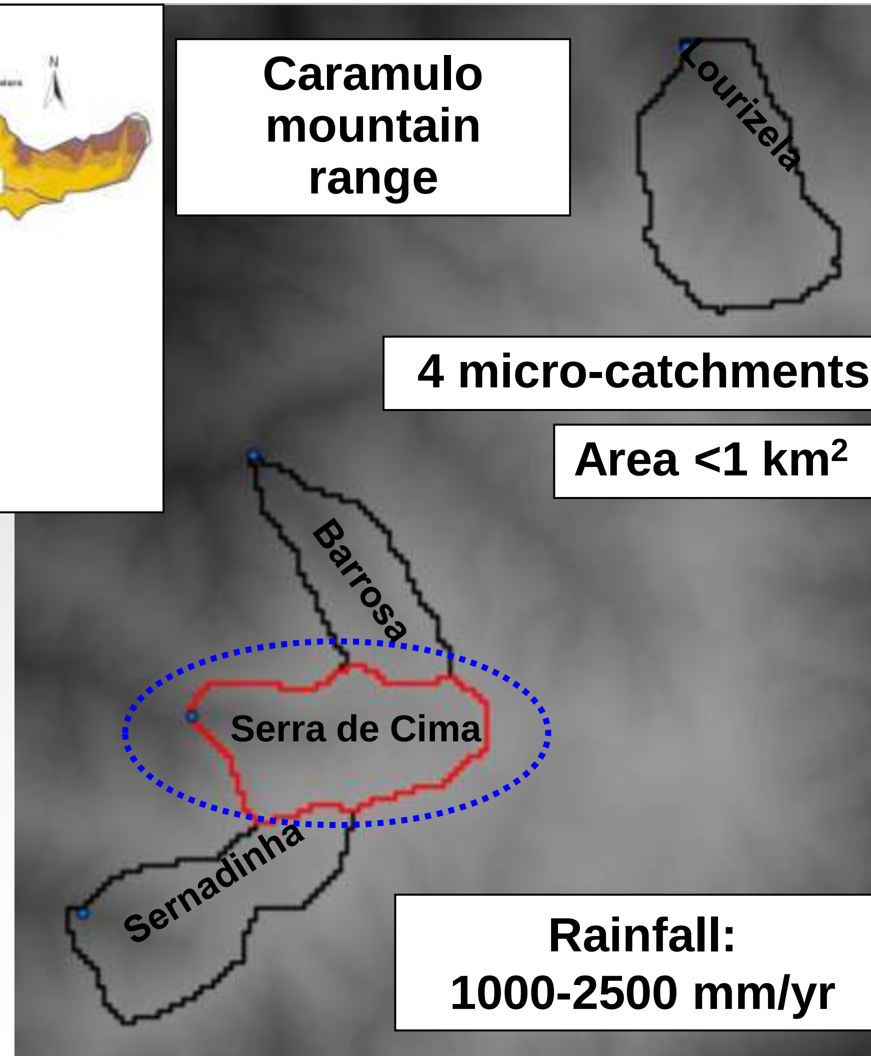
STUDY AREA







HYDROLOGICAL MODELLING: Input Data

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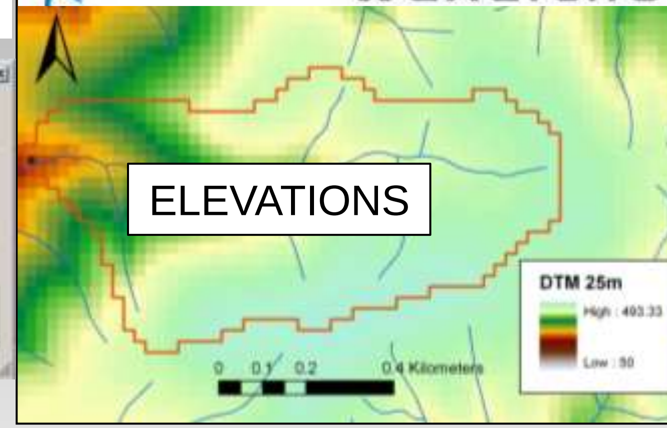
HYDROLOGICAL MODELLING: Input Data

<u>Data widely available in Portugal</u> (e.g. to hydrologists from a consultancy company developing a Watershed Management Plan)

<u>ArcSWAT 2009</u>

Instituto geográfico do Exército



INSTITUTO DE METEOROLOGIA, IP PORTUGAL

SNIRH - Sistema Nacional de Informação de Recursos Hídricos

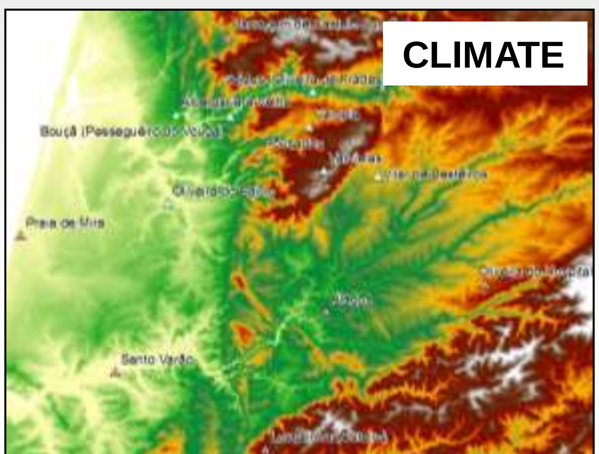
National Water Resources Information System

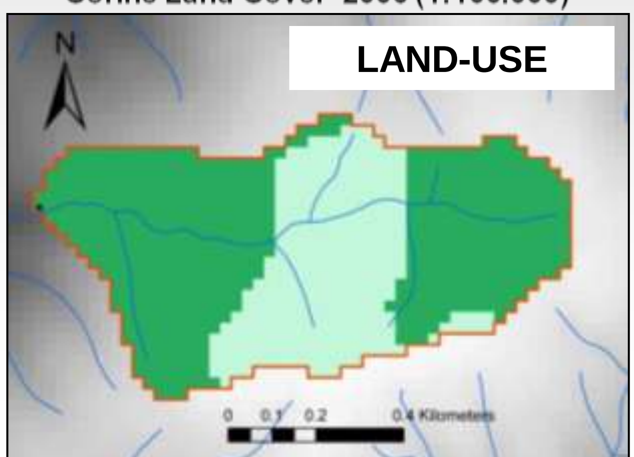
European Environment Agency

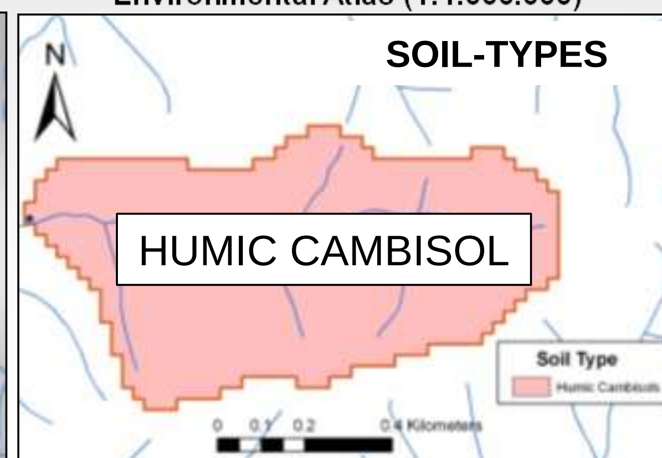
Corine Land Cover 2006 (1:100.000)

AGÊNCIA PORTUGUESA DO AMBIENTE
Ministério do Ambiente, do Ordenamento do Território e do Desenvolvimento Regional

Environmental Atlas (1:1.000.000)







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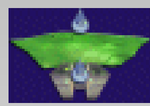
HYDROLOGICAL MODELLING: CLIMATE Input Data

DAILY



- Rainfall
- Temperature
- Relative Humidity
- Wind velocity
- Solar radiation

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WEATHER GENERATOR

- Temperature
- Rainfall

IM: Coimbra_G

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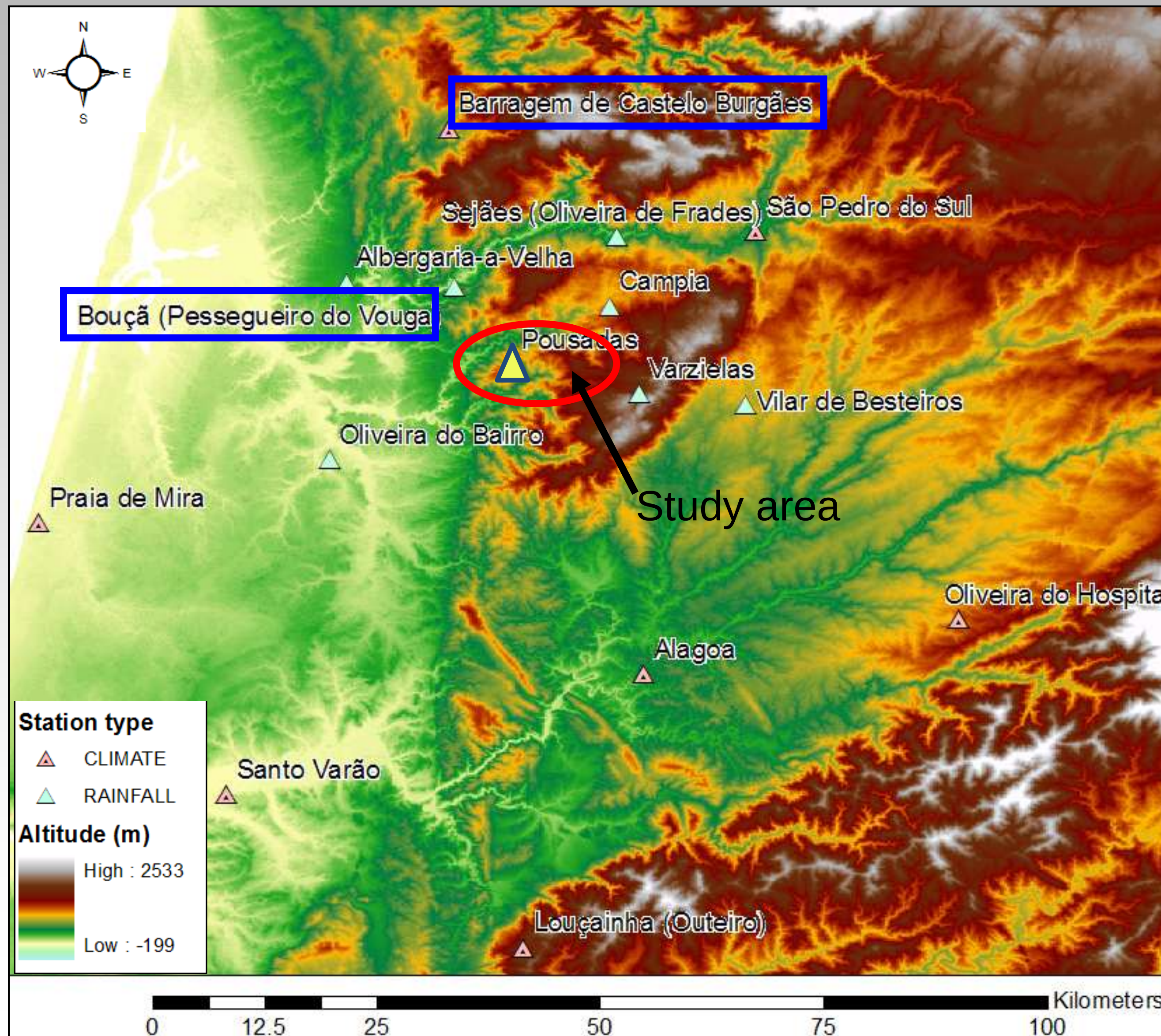

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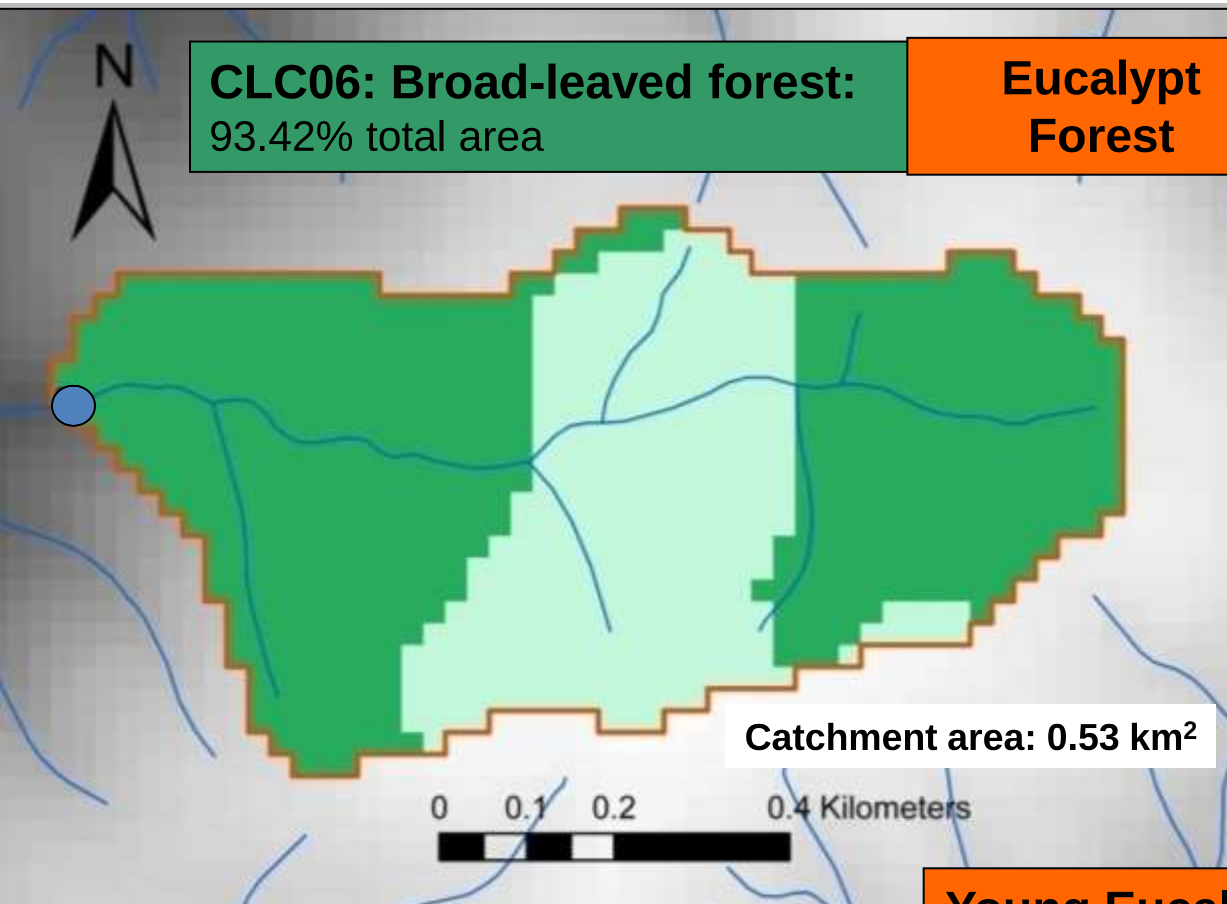
HYDROLOGICAL MODELLING: LAND-USE Input Data

CORINE LAND-COVER 2006

CLC06: Broad-leaved forest:
93.42% total area

Eucalypt Forest



CLC06: Transitional woodland-shrub
6.58% total area

Young Eucalypt plantations

HYDROLOGICAL MODELLING: Simulated period

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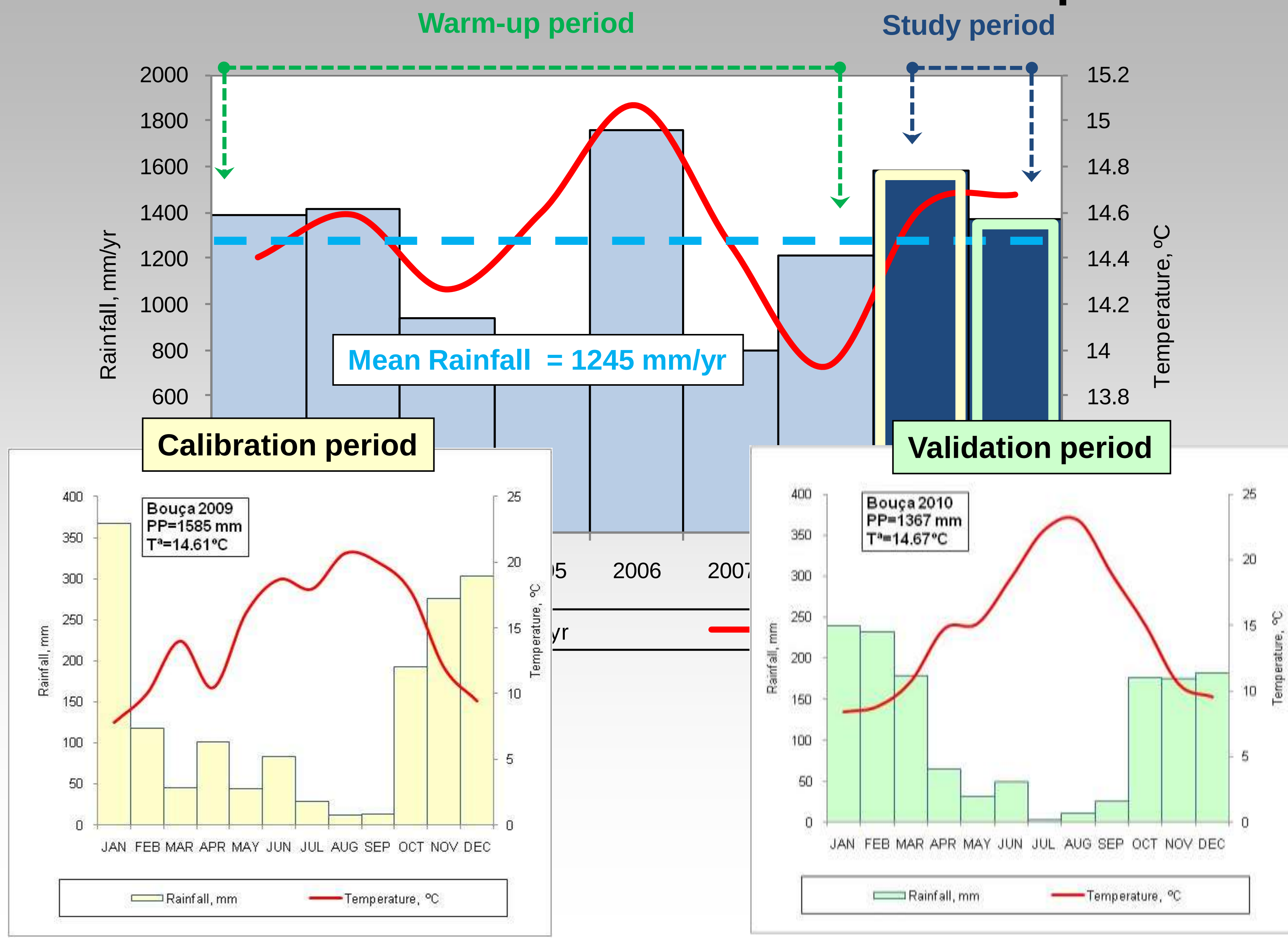
HYDROLOGICAL MODELLING: Simulated period



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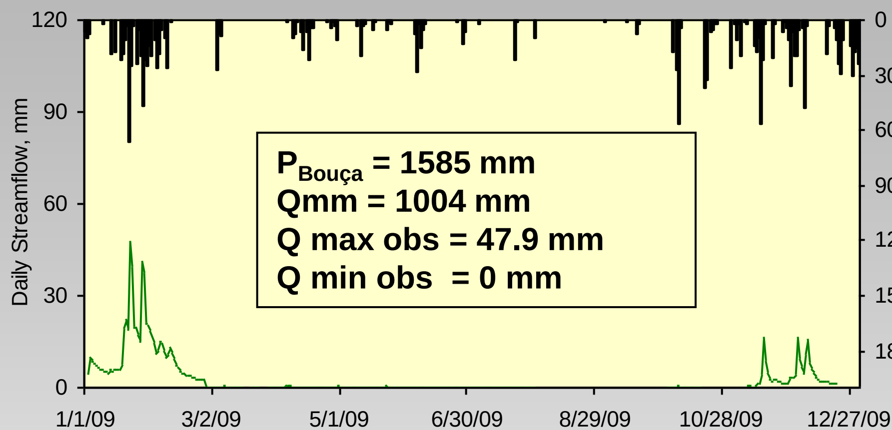
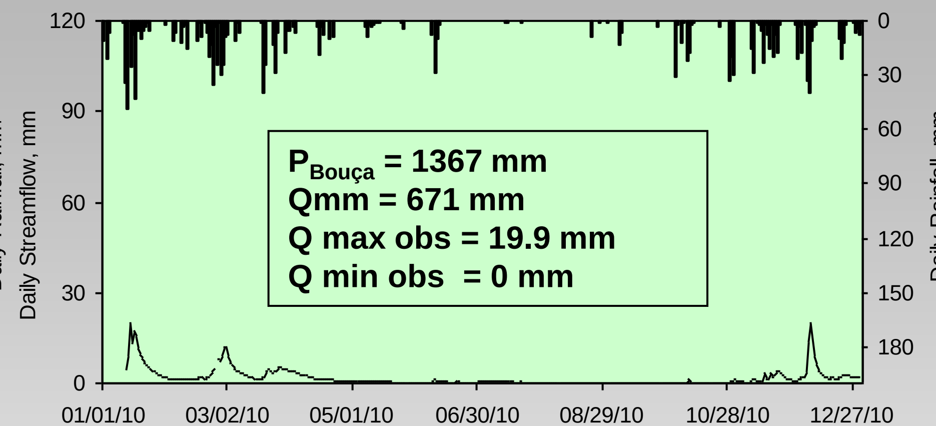
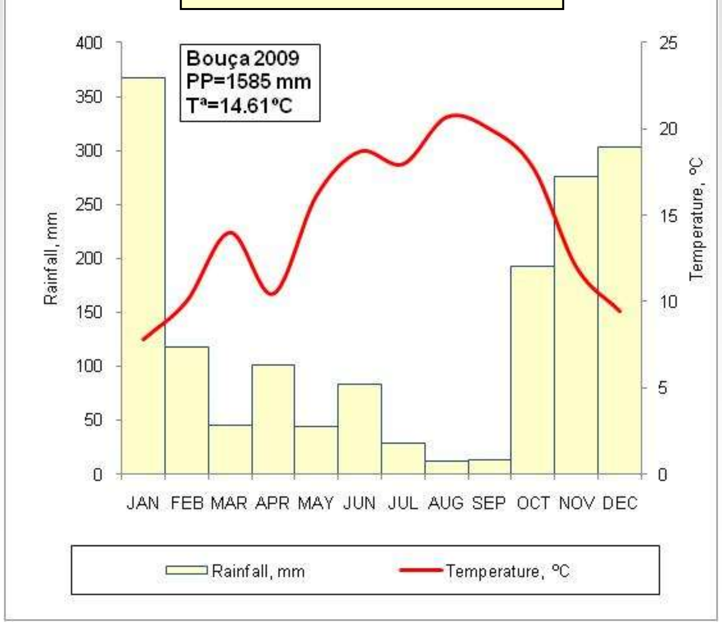
HYDROLOGICAL MODELLING: Simulated period

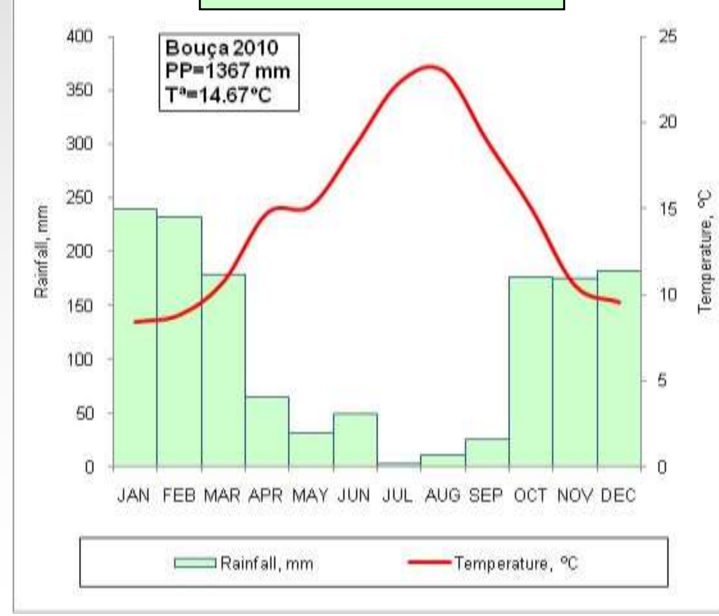




Calibration period



Validation period



HYDROLOGICAL MODELLING: Sensitivity Analysis

HYDROLOGICAL MODELLING: Sensitivity Analysis

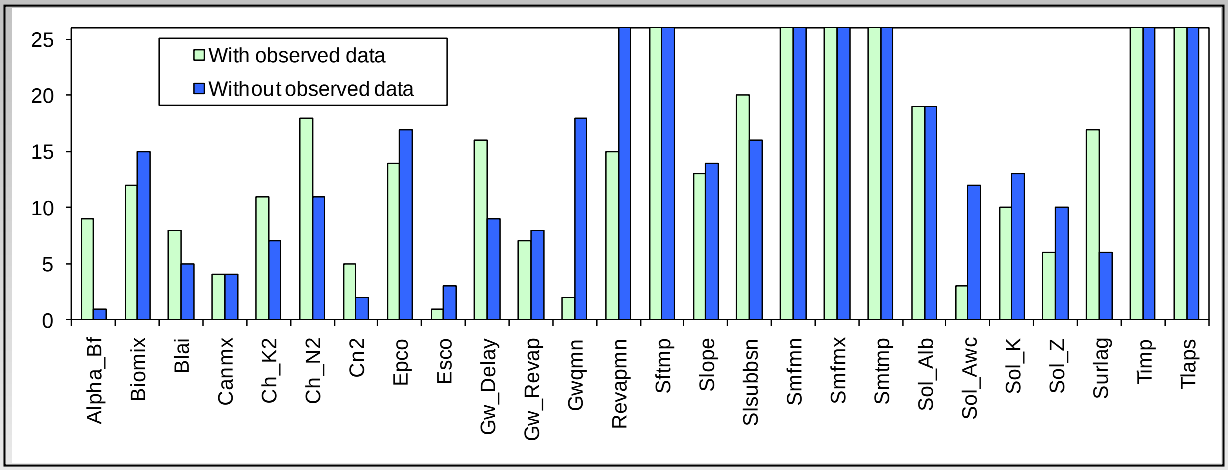
INPUT

26 flow-related parameters

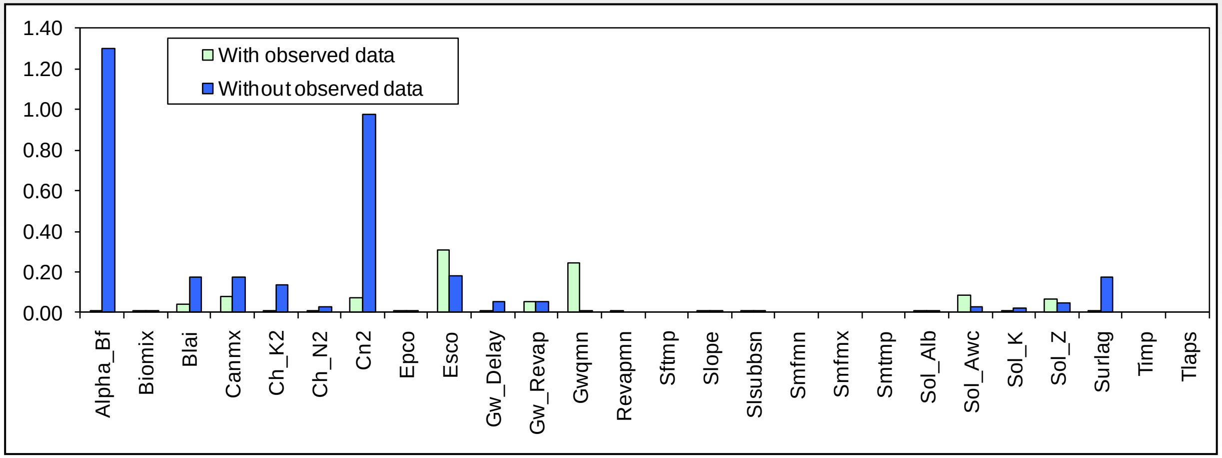
PARAMETER	LO BOUND	UP BOUND	iMet
Alpha_Bf	0	1	1
Biomix	0	1	1
Blai	0	1	1
Canmx	0	10	1
Ch_K2	0	150	1
Ch_N2	0	1	1
Cn2	-25	25	3
Epco	0	1	1
Esco	0	1	1
Gw_Delay	0.001	10	2
Gw_Revap	0.001	0.036	2
Gwqmn	0.001	1000	2
Revapmn	0.001	100	2
Sftmp	0	5	1
Slope	-25	25	3
Slsubbsn	-25	25	3
Smfmn	0	10	1
Smfmx	0	10	1
Smtmp	-25	25	3
Sol_Alb	-25	25	3
Sol_Awc	-25	25	3
Sol_K	-25	25	3
Sol_Z	-25	25	3
Surlag	0	10	1
Timp	0	1	1
Tlaps	0	50	1

OUTPUT

Ranking



Mean



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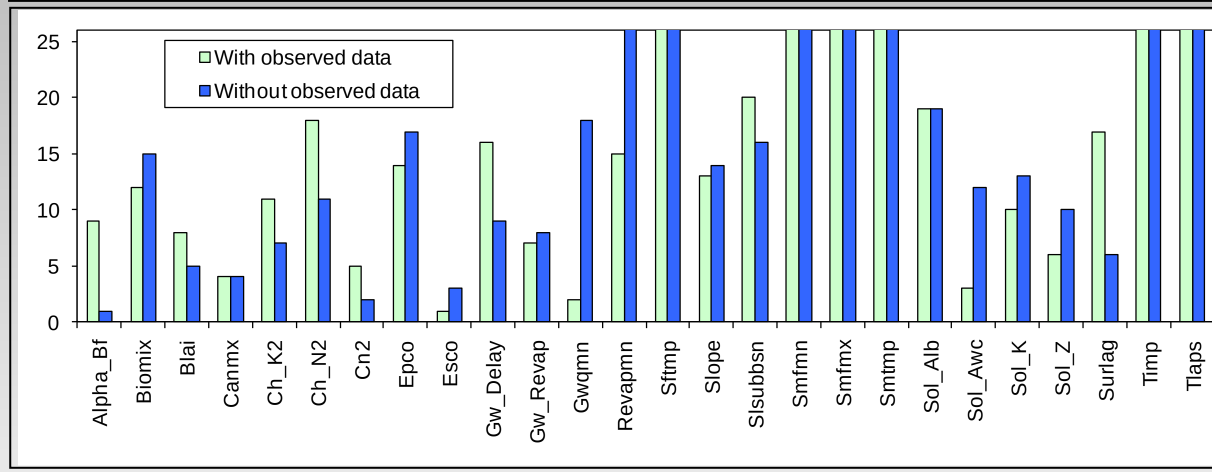
HYDROLOGICAL MODELLING: Sensitivity Analysis

26 flow-related parameters

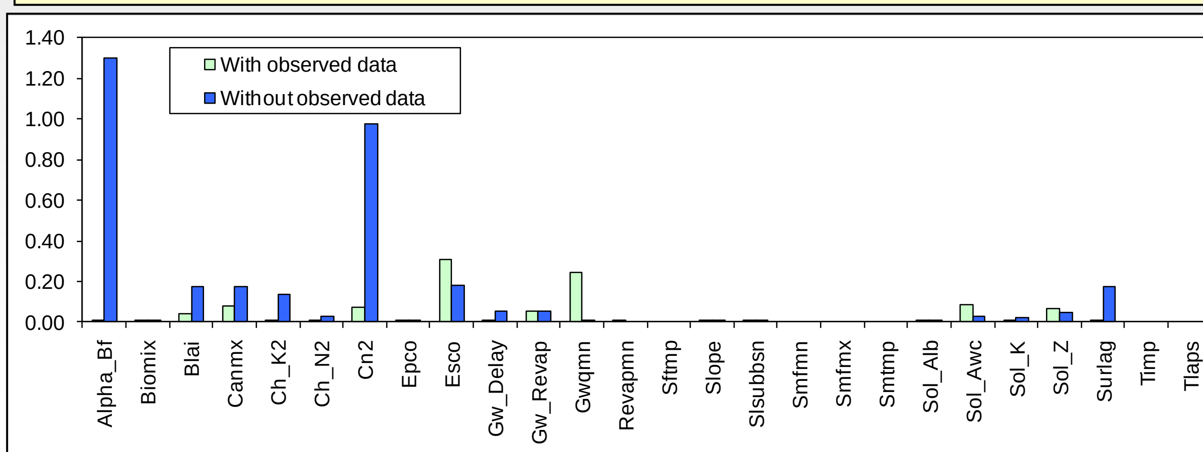
WITHOUT OBS DATA	WITH OBS DATA
Alpha_Bf	Esco
Cn2	Gwqmn
Esco	Sol_Awc
Canmx	Canmx
Blai	Cn2
Surlag	Sol_Z
Ch_K2	Gw_Revap
Gw_Revap	Blai
Gw_Delay	Alpha_Bf
Sol_Z	Sol_K
Ch_N2	Ch_K2
Sol_Awc	Biomix
Sol_K	Slope
Slope	Epco
Biomix	Revapmn
Slsubbsn	Gw_Delay
Epco	Surlag
Gwqmn	Ch_N2
Sol_Alb	Sol_Alb
Revapmn	Slsubbsn
Sftmp	Sftmp
Smfmn	Smfmn
Smfmx	Smfmx
Smtmp	Smtmp
Timp	Timp
Tlaps	Tlaps

OUTPUT

Ranking



Mean



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HYDROLOGICAL MODELLING: Auto-calibration

HYDROLOGICAL MODELLING: Auto-calibration

Three auto-calibrations were carried out using:

- **ParaSol** with uncertainty analysis
- Fixing the number of simulations runs in 20000 and the optimization settings as the default.

Auto-calibration A	*Auto-calibration B*	*Auto-calibration C*
26 flow-related parameters and full default ranges of variation	13 flow-related parameters and full default ranges of variation	13 flow related parameters and **narrow ranges** of variation

	MAX	MIN
Esco	0.49	0.07
Gwqmn	31.7	8.09
Sol_Awc	0.17	0.13
Canmx	8.29	4.17
Cn2	51-98	50-95
Sol_Z1	265	248
Sol_Z2	1058	992
Gw_Revap	0.052	0.021
Blai	0.736	0.058
Alpha_Bf	0.299	0.166
Sol_K1	5.1	3.2
Sol_K2	5.0	3.1
Ch_K2	128	107
Biomix	0.920	0.029

The 13 most sensitive parameters selected from **Sensitivity Analysis using observed data**.

Upper and lower bounds for narrow ranges using max and min values from the good parameter sets from Auto-calibration A.

HYDROLOGICAL MODELLING: Auto-calibration RESULTS

Calibration period

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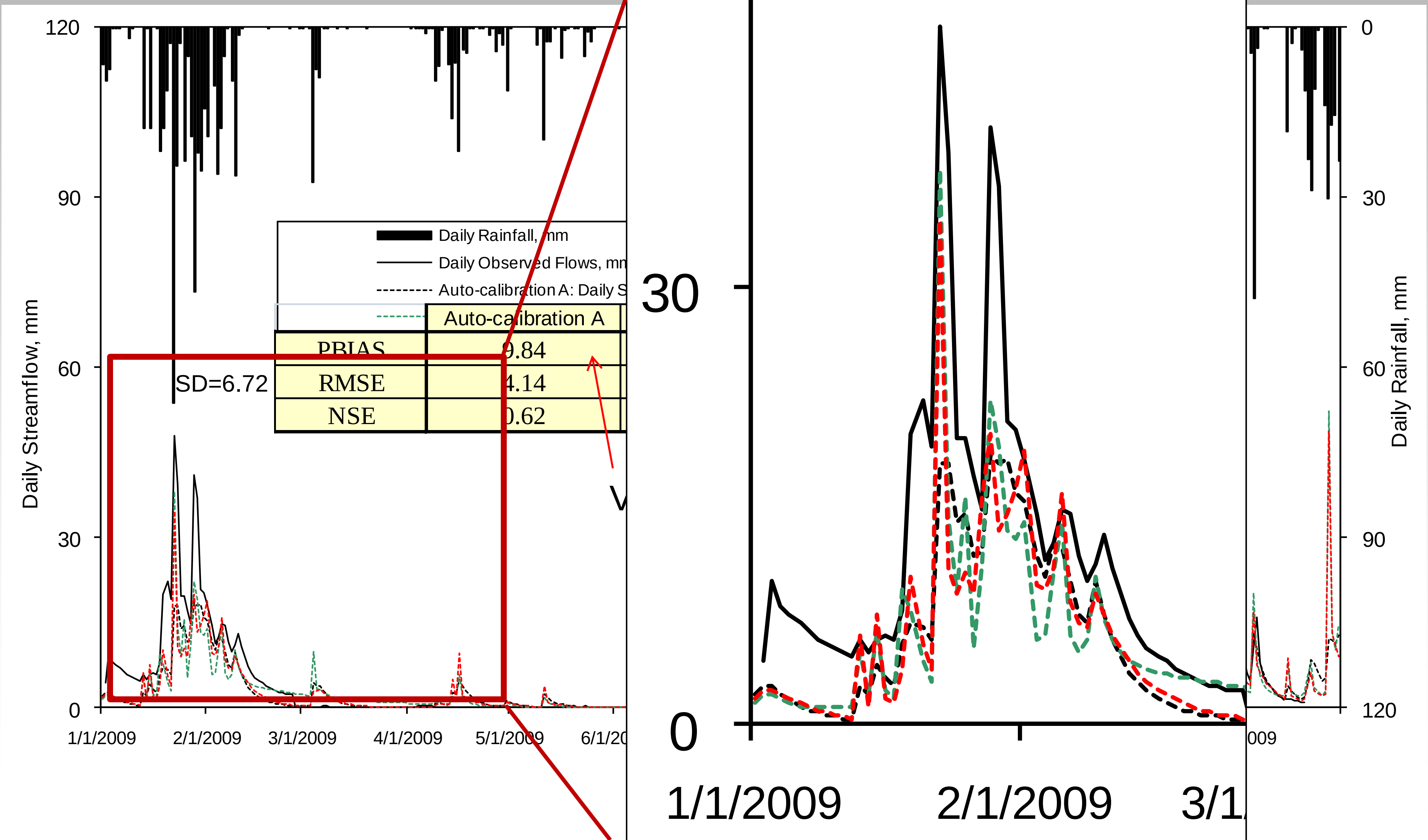
HYDROLOGICAL MODELLING: Auto-calibration RESULTS

Calibration period



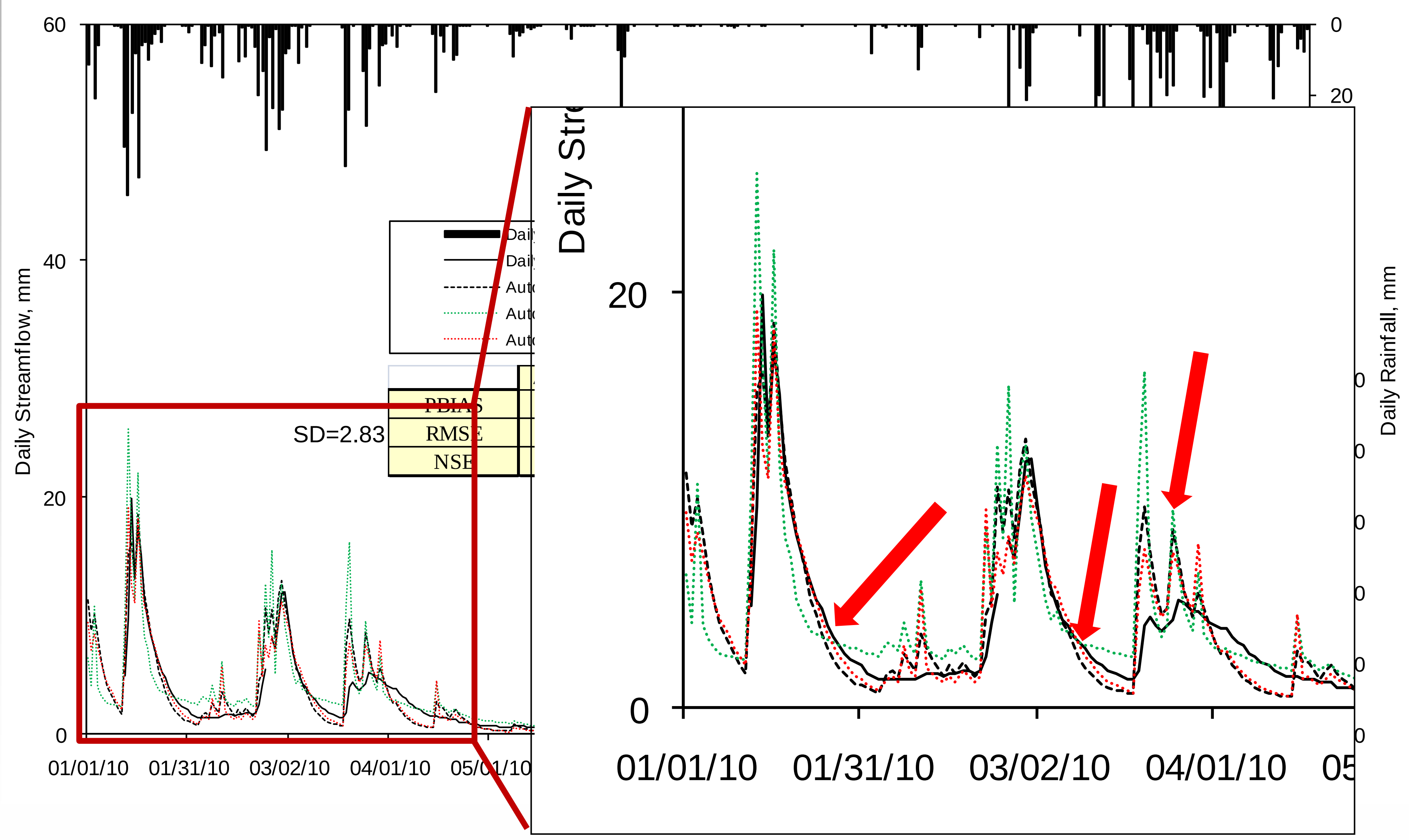
	Auto-calibration A
PBIAS	9.84
RMSE	4.14
NSE	0.62

HYDROLOGICAL MODELLING: Auto-calibration RESULTS

Validation period

HYDROLOGICAL MODELLING: Auto-calibration RESULTS

Validation period



HYDROLOGICAL MODELLING: Auto-calibration RESULTS

Comparison between best parameter sets for each auto-calibration

HYDROLOGICAL MODELLING: Auto-calibration RESULTS

Comparison between best parameter sets for each auto-calibration

	Auto-calibration A	Auto-calibration B	Auto-calibration C
Alpha_Bf	0.269	0.562	0.195
Biomix	0.677	0.218	0.180
Blai	0.156	0.061	0.059
Canmx	4.412	7.327	7.421
Ch_K2	127.6	106.9	126.4
Cn2	50-95	56-100	51-97
Esco	0.131	0.198	0.139
Gw_Revap	0.050	2.009	0.060
Gwqmn	933	962	1858
Sol_Awc1	0.169	0.203	0.193
Sol_Awc2	0.130	0.157	0.149
Sol_K	3.46	4.28	4.15
Sol_K2	3.41	4.22	4.09
Sol_Z1	335	358	334
Sol_Z2	1342	1432	1337

Depth from soil surface to bottom layer

Baseflow recesion coefficient is a direct index of groundwater flow response to changes in recharge

Canopy Interception and Max. Potencial LAI

Groundwater "revap" coefficient
Afects the amount of water that recharges the capillary fringe after evaporation during the dry periods.

Threshold depth of water in the shallow aquifer required for the return flow to occur (The ground water flow to the main channel is allowed only when the depth of water in the shallow aquifer is equal to or greater than

CONCLUSIONS

The best results were obtained for the set with the largest number of parameters and the widest ranges of variation.

Sensitivity analysis was helpful in reducing the number of parameters included in the auto-calibration and, auto-calibration time, without seriously affecting model results.

The use of narrow ranges of variation for the parameters also reduced the time needed for auto-calibration whilst still producing results that can be regarded adequate, especially for general-purpose studies.

The fact that several parameter sets have given good results, indicating a problem with equifinality of model parameterization.

ONGOING WORK

1.- Check the feasibility of the obtained parameters
2.- Check other auto-calibration methodologies and with different objective functions.
3.- Testing SWAT with data obtained from a meteorological station in the study area as well as from fieldwork in the Serra de Cima catchment, aiming at improving model results and decrease problems related with equifinality.

Thanks for your attention

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