Verification of the SimSphere SVAT Model Performance In Simulating Land Surface Parameters At Selected CarboEurope IP Sites

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1. INTRODUCTION:

Comparison of model simulations versus corresponding validated *in-situ* observations forms an integral and important validatory check of a computer simulation model before the developed code is used in performing any kind of analysis or other operation.

The present study objective is to examine the ability of the SimSphere SVAT model in simulating key parameters characterising land surface interaction processes.

The present study is also very timely, given that this SVAT model is being considered in a methodology being developed by National Polar-orbiting Operational Environmental Satellite System (NPOESS), for the operational retrieval of surface moisture content from satellite platforms due to be launched from 2012. (Chauhan et al., 2003).

2. TESTING BED:

In-situ validated observations obtained from selected test sites and days belonging to the CarboEurope IP measurement network, representing a variety of climatic, topographic and environmental conditions were collected for

Site NAME	Borgo Cioffi	Roccarespampani 3 years	Roccarespampani 11 years	Monte Boldone	Malga Arpaco	Lavarone	Renon	Loobos	Lelystad
site abbreviation	BC	ROC11	ROC3	MB	MA	LA	RE	LO	LE
Geographic coordinates	40° 31'31.54"N 14°7'29.84"E	42° 24' 29.22" N 11° 55' 48.073"E	42° 23' 24.92" N 11° 55' 15.34"E	46°01'46.64"N 11° 04' 8.27"E	46° 07' 00" N 11° 42' 10" E	45°57'18.93"N 11° 16' 2.23"E	46°35'16"N 11°26'04.90"E	52° 10' 04.29" N 05° 44' 38.25" E	52° 10' 04.29"N 05° 44' 38.25" E
Country	ITALY	ITALY	ITALY	ITALY	ITALY	ITALY	ITALY	NETHERLANDS	NETHERLANDS
land use	Crop/ grass	oak	oak	grassland	grassland	spruce	spruce	Scots Pine	grassland
Ecosystem type / Land cover	Cropland	Forest	Forest	Grassland	Grassland	Forest mixed	Conifers Forest	Conifers Forest	grassland
Dominant Species	Maize corn / Lolium grass	Quercus cerris	Quercus cerris	Alpine grassland Nardum stricta	Arrhenathertum	Abies alba	Picea abies, spruce	Pinus sylvestris	Not specified
Elevation	20	243.8	223.9	1550	1699	1353	1720	25	0
Topography	Flat	Flat to slightly sloping (<7 degrees)	Flat to slightly sloping (<7 degrees)	Gently sloping (<7 degrees)	Gently sloping (<7 degrees)	Gently sloping (<7 degrees)	Gently sloping (<7 degrees)	Flat	Flat
Climate description / class	Temperate arid	Mediterranean / mondane	Mediterranean mondane	sub continental	sub continental	sub continental	Sub alpine-continental	Temperate / oceanic	Temperate / oceanic
Mean annual temperature (C)	18	15.5	15.5	5.5	6.3	7.8	4.1	9.8	10
Mean annual precipitation (mm)	600	876.2	876.2	1189	1200	1150	1010	786	780
LAI	2	3	4	3-4	3	7	4	2	1-3
soil type	Clay-silt	Cambiso	Cambisol	Fine loamy	fine loamy	Calcaric Cambisol	Haplic Podsol	Podzolic	Clay

Table2: *Summary of key characteristics of the test sites used in the SimSphere SVAT model validation*

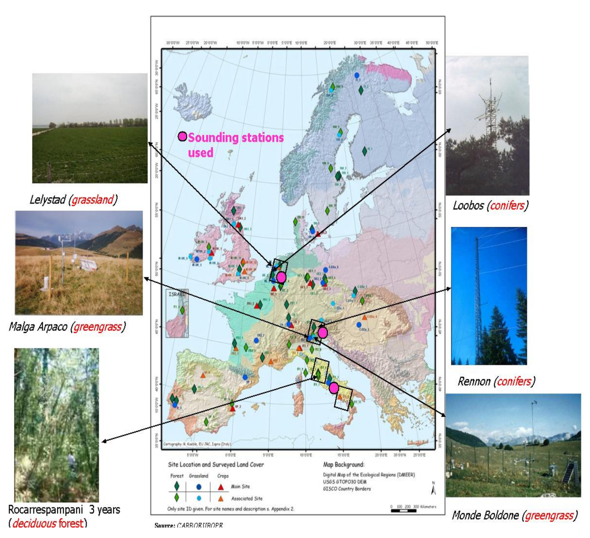


Figure 2: *Some of the selected test sites used in the present study*

3. SimSphere SVAT:

It is a **1-D** SVAT, describes the transport of water and energy in a column from the root-zone below the Surface, through the Vegetation, to the lower Atmosphere.

The processes and quantities are allowed to evolve in time during a day and *night (up to 24 hours).*

SimSphere requires **52** input parameters & produces **29** outputs.

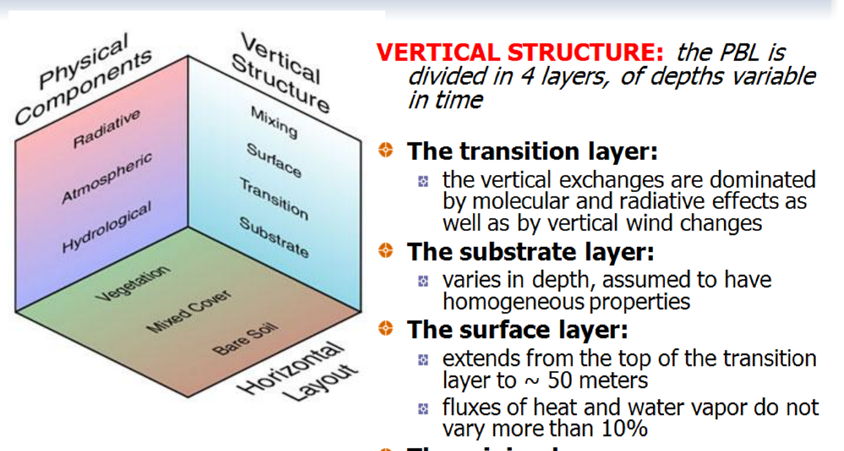


Figure 2: *Facets of SimSphere architecture*

A review of the model use, originally developed by Carlson and Boland (1978) has been provided by Petropoulos et al., (2009). The model is freely distributed at https://courseware.e-education.psu.edu/simsphere/

4. METHODS:

Name	Description	Mathematical Definition
Bias / MBE	Bias (accuracy) or Mean Bias Error	$bias = MBE = \frac{1}{N}\sum_{i=1}^{N}(P_i - O_i)$
Scatter / MSD	Scatter (precision) or Mean Standard Deviation	$scatter = \frac{1}{(N-1)}\sum_{i=1}^{N}(P_i - O_i - \overline{(P_i - O_i)})^2$
RMSD	Root Mean Square Difference	$RMSD = \sqrt{bias^2 + scatter^2}$
R^2	Linear Correlation Coefficient of Determination of P_i to O_i	$R^2 = \left[\sum_{i=1}^{N}(P_i - \overline{P})(O_i - \overline{O}) \Big/ \left[\sum_{i=1}^{N}(O_i - \overline{O})^2 \sum_{i=1}^{N} P_i - \overline{O})^2\right]^{0.5} \right]^2$
MAD (or MAE)	Mean Absolute Difference (or Mean Absolute Error)	$MAD = N^{-1}\sum_{i=1}^{N}\lvert P_i - O_i \rvert$
MAPD	Mean Absolute Percentage Difference of P_i to O_i	$MAPD = \frac{100}{n}\sum_{i=1}^{n}\frac{\overline{P_i - O_i}}{\overline{O}}$
d-index	Index Of Agreement of P_i to O_i	$d = 1 - \frac{\sum_{i=1}^{n}(P_i - O_i)^2}{\sum_{i=1}^{n}(\lvert O_i - \overline{O}\rvert + \lvert P_i - \overline{O}\rvert)^2}$

Table 3: *Definition of the quantitative measures used to assess the performance of parameters simulated from SimSphere.*

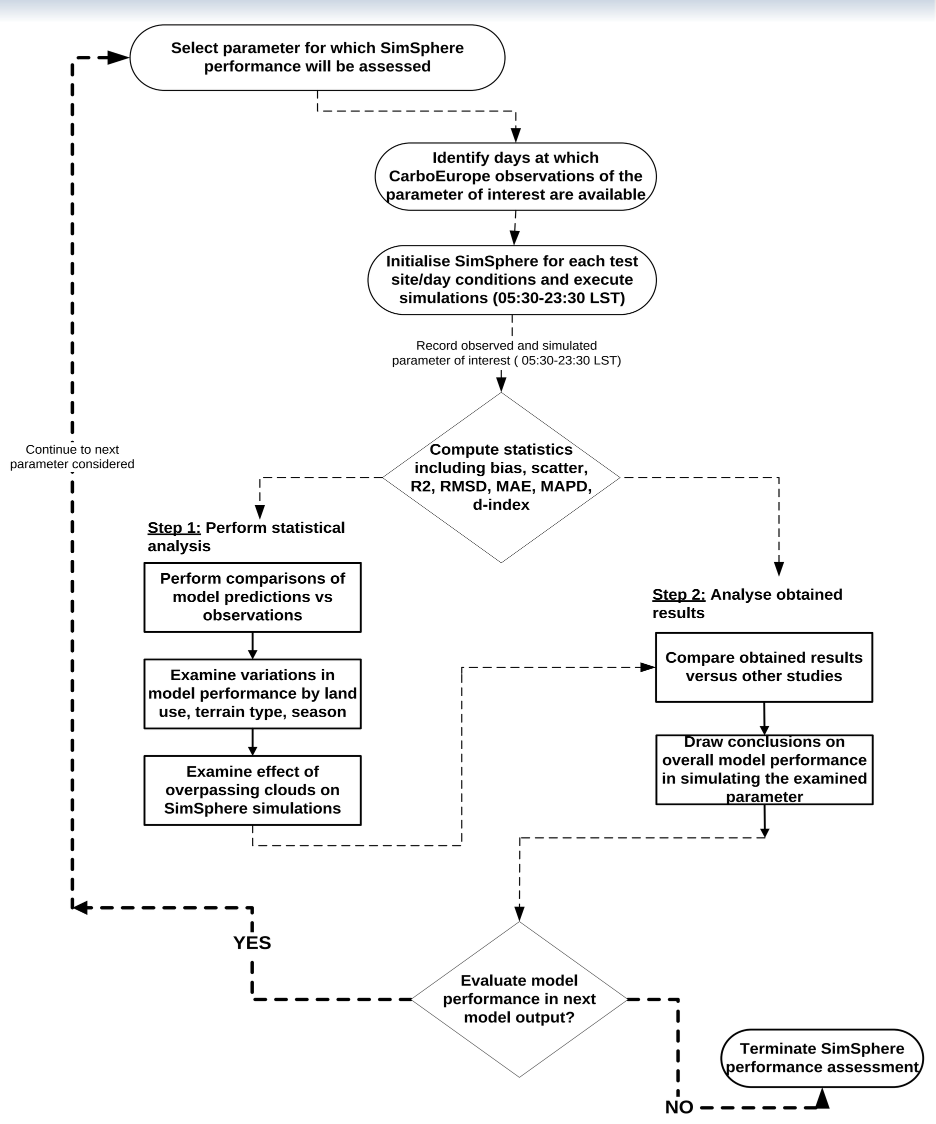
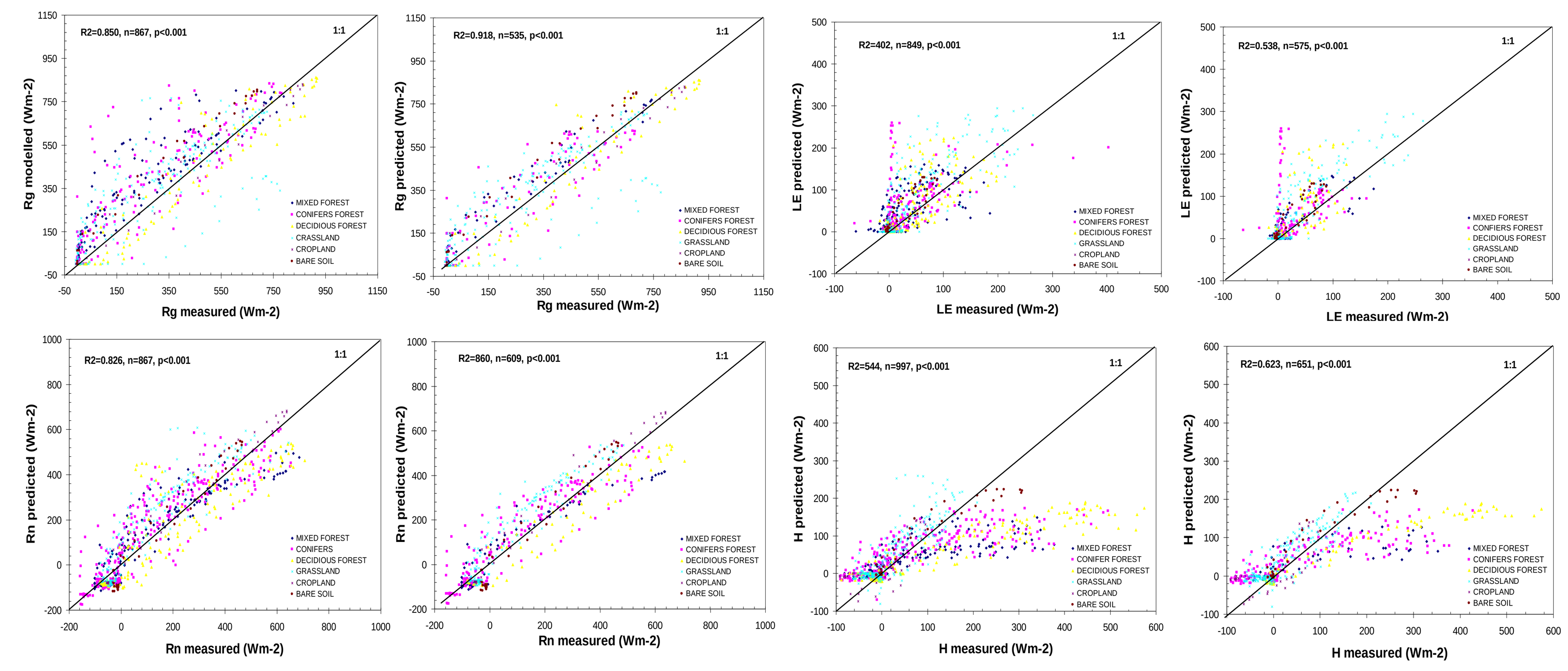


Figure 3: *Overall methodology followed*

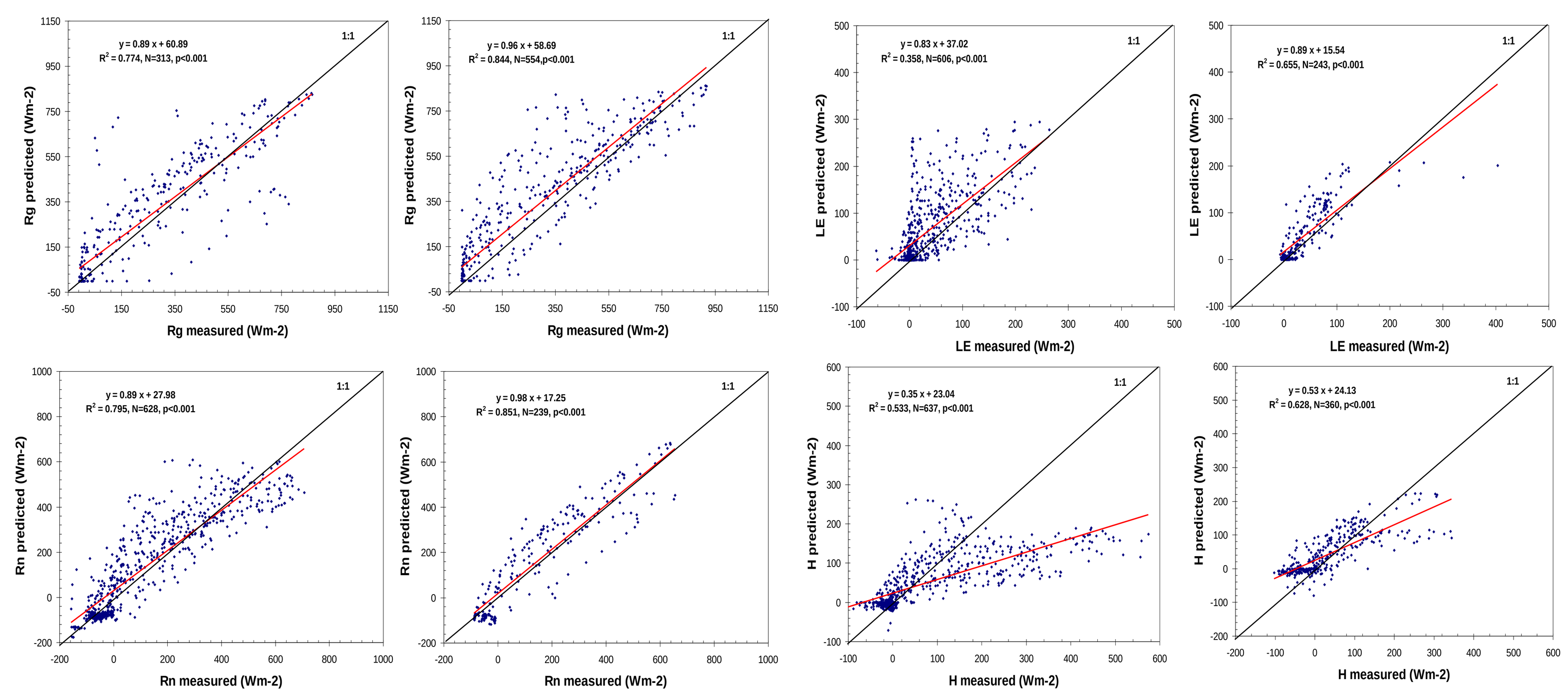
5. RESULTS: *comparisons by land cover/use type*

Comparisons for all days of comparison (right) and those only flagged as cloud-free (right). Each symbol corresponds to one 30-min flux measure.



6. RESULTS: *comparisons by terrain type*

Comparisons for the sites of sloped terrain (left) and for the sites of flat terrain (right). Each symbol corresponds to one 30-min flux measure.



7. RESULTS: *examples from other comparisons performed*

(Rn) Net Radiation comparisons	N	slope	R^2	Bias	Scatter	RMSD	MAD	MAPD	d-index
all days:	867	0.93	0.875	12.84	78.90	91.12	69.67	21.19	0.940
cloud free days:	572	0.92	0.917	14.47	67.69	82.81	63.06	27.84	0.946
cloud free and flat terrain:	203	1.03	0.944	20.93	63.87	78.48	61.46	35.32	0.942
cloud free and flat terrain, with EBC validated:	108	0.82	0.935	2.94	63.72	76.72	54.97	44.79	0.935

(LE) Latent Heat flux comparisons	N	slope	R^2	Bias	Scatter	RMSD	MAD	MAPD	d-index
all days:	849	0.88	0.622	21.24	38.87	46.64	33.11	208.05	0.780
cloud free days:	575	1.07	0.661	22.36	35.61	43.21	30.60	265.62	0.798
cloud free and flat terrain:	212	1.37	0.808	13.97	25.19	29.54	20.84	51.15	0.889
cloud free and flat terrain, with EBC validated:	108	0.8	0.834	10.59	23.94	27.11	19.39	33.21	0.881

(H) Sensible Heat flux comparisons	N	slope	R^2	Bias	Scatter	RMSD	MAD	MAPD	d-index
all days:	997	0.38	0.750	-18.08	69.40	80.67	56.68	-4.30	0.753
cloud free days:	651	0.41	0.781	-13.82	61.31	73.05	53.21	3.68	0.777
cloud free and flat terrain:	288	0.39	0.732	11.06	45.51	52.18	43.13	24.52	0.826
cloud free and flat terrain, with EBC validated:	108	0.46	0.753	2.01	63.03	68.75	57.50	92.10	0.762

8. CONCLUSIONS:

Overall, despite the occasionally inferior performance of the model in simulating the examined parameters (mainly the underestimation of H flux), SimSphere was able to identify the patterns of change expected, if not always the magnitudes.

Accuracies obtained, particularly for the subset of the cloud-free days and flat terrain sites, were in agreement with analogous verification experiments of the model carried out in dissimilar conditions (e.g. Taconet et al., 1986; Ross and Oke, 1986), and indicated the usefulness of the model in practical applications either as a stand alone tool or in combination with remote sensing observations.

8. REFERENCES:

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