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## INTRODUCTION AND OBJECTIVES

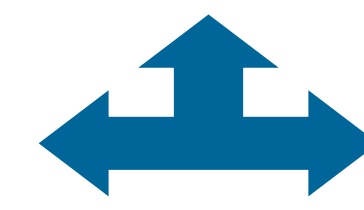
Snow and melting in Sierra Nevada → important inflow to the rivers

Background:

Physically-based Snowmelt Model (Herrero *et al.*, 2009)

Equations of mass and energy balance  
Single layer with homogeneous characteristics

Point Snowmelt Model  
(Refugio Poqueira)



Distributed Snowmelt Model  
(Southern slope Sierra Nevada)

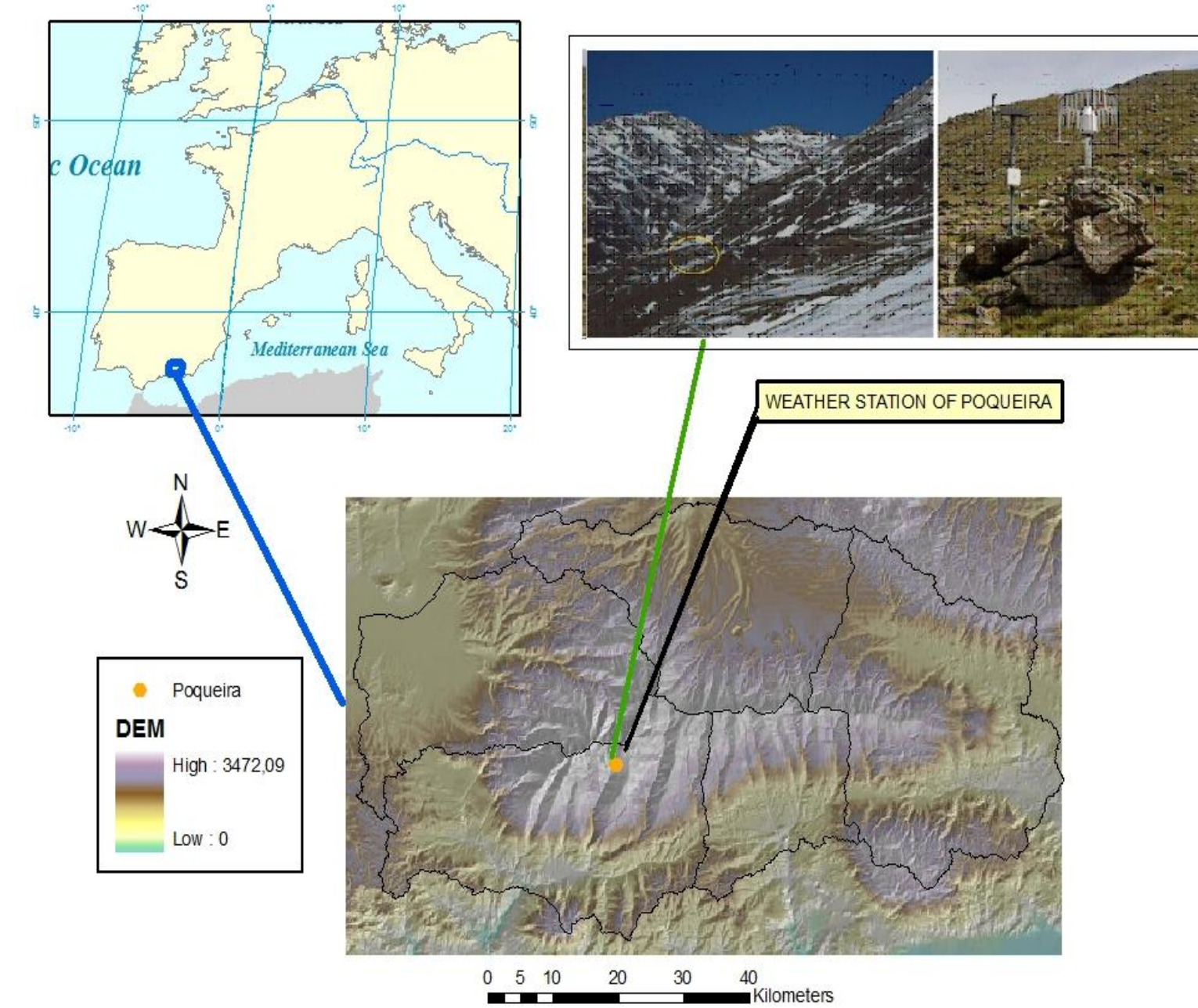
### Objectives:

- Extension of the accumulation and snowmelt model (Herrero *et al.*, 2009) in the whole area of the Natural Park of Sierra Nevada (NPSN) and validation of the results with Landsat images for the period 2008-2009.
- Incorporation of a two-layered structure into the point snowmelt model of Herrero *et al.* (2009). Validation of the results by field information from the period 2004-2007 and comparison with the previous model estimates.

## STUDY SITE DESCRIPTION

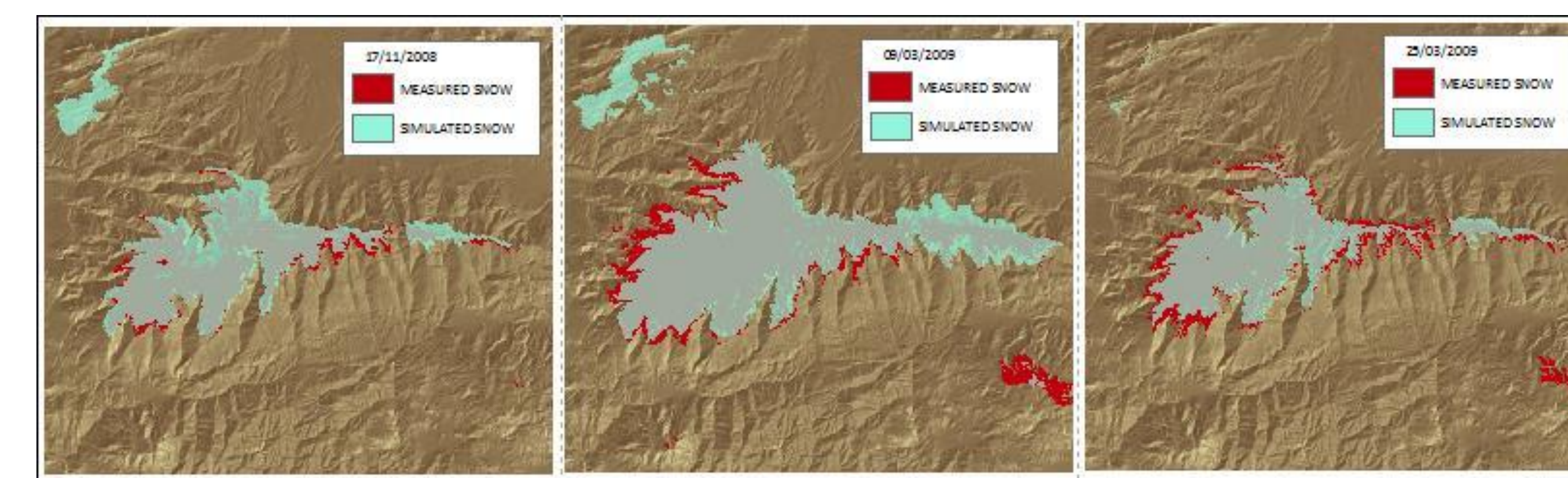
### Sierra Nevada

- Located in South-Eastern Spain; with mean latitude of 37 N and stretching from 2000 km.
- The highest mountain peaks in the Iberian Peninsula (3480 m), at only 40 km from the coast.
- Semi-arid Mediterranean environment with an important variability (e.g. precipitation and temperature) in short periods of time.



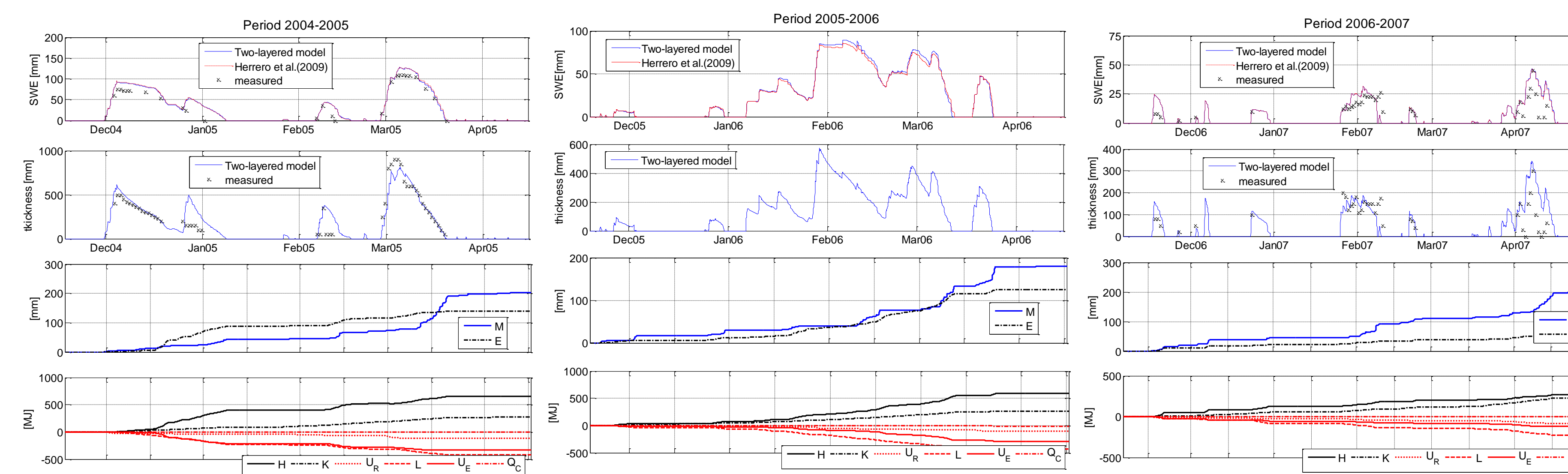
## RESULTS

### Distributed Snowmelt Model over the whole Natural Park Sierra Nevada



Date	Pss	Pnn	Psn	Pns	Ist	Isa	Bisa
17/11/2008	5.21%	90.85%	3.39%	0.55%	0.96	0.57	0.28
09/03/2009	9.91%	83.75%	4.52%	1.82%	0.92	0.61	0.57
23/03/2009	4.95%	91.64%	1.98%	1.43%	0.97	0.59	0.84

### Point Snowmelt Model

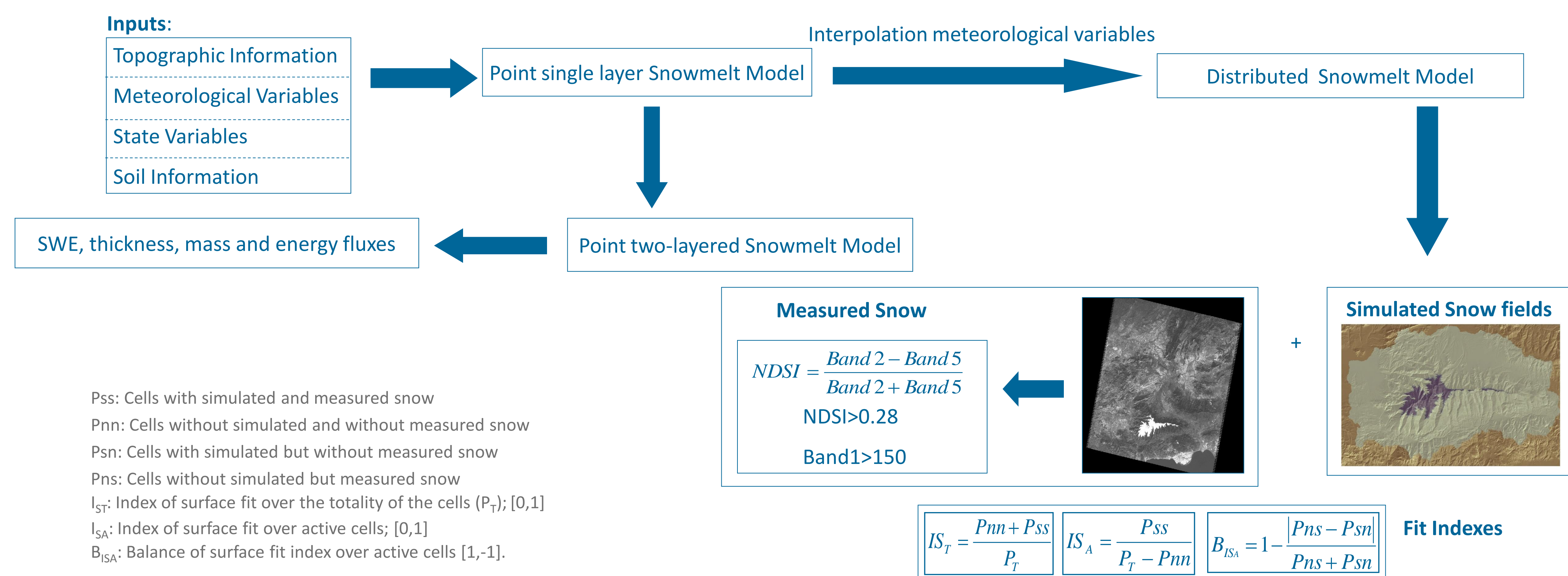


	Period 2004-2005		Period 2005-2006		Period 2006-2007	
	Two-layered	Herrero <i>et al.</i> (2009)	Two-layered	Herrero <i>et al.</i> (2009)	Two-layered	Herrero <i>et al.</i> (2009)
$E_m$ (mm)	-12.08	-13.63	-	-	-3.94	-4.08
$E_{ma}$ (mm)	13.42	14.53	-	-	8.5	8.2
$R_{ecm}$ (mm)	15.73	16.63	-	-	11.13	11.09
Melting	62.11%	59.95%	56.85%	52%	81.43%	80.92%
Evaporation	39.07%	41.56%	44.5%	48.82%	20.5%	20.9%

25/03/2009: the simulated snow water equivalent (SWE) over the whole NPSN was 5.08 hm<sup>3</sup>. As the evaporation simulated with the point single layer model was 4% higher than the obtained with the point two-layered, the simulation of the SWE for the whole study site with the two-layered model, was approximated to 5.28 hm<sup>3</sup>.

The evaluation of the simulation fit degree with respect to measured values (SWE) is confirmed by mean error  $E_m$ , absolute mean error  $E_{ma}$  and root mean square error  $R_{ecm}$ .

## METHODS



Pss: Cells with simulated and measured snow  
Pnn: Cells without simulated and without measured snow  
Psn: Cells with simulated but without measured snow  
Pns: Cells without simulated but measured snow  
 $I_{ST}$ : Index of surface fit over the totality of the cells ( $P_t$ ); [0,1]  
 $I_{SA}$ : Index of surface fit over active cells; [0,1]  
 $B_{ISA}$ : Balance of surface fit index over active cells [1,-1].

## CONCLUSIONS

✓ The application of the model in the whole area of the Natural Park of Sierra Nevada allowed the estimation with a sufficient approximation of the surface occupied by accumulated snow, with 96%, 93.6% and 96.6% of cells with snow correctly simulated for the two simulation periods studied, and a certain overestimation in the total area simulated due to the imbalance between the passage of time of the calculation and the time at which the satellite image was taken, the advective transport associated with the wind, not included in the model, and the calculation error inherent to the calibration.

✓ At a point scale the two-layered model sufficiently reproduces the snow melting cycles, with a mean error of -12.08 mm and -3.94 mm, opposite to -13.63 mm and -4.08 mm obtained by single layer model, for the period 2004-2005 y 2006-2007 respectively.

✓ Evaporation is estimated as a very significant fraction of the snowfall, with values reaching 39% for the period 2004-2005, 44.5% for the period 2005-2006 and 20.5% for the period 2006-2007. These values are very similar than the obtained values with the one layer model; 41.56%, 48.82% and 20.9% respectively.

### ACKNOWLEDGEMENTS

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