Calibration and Comparison of three SVAT (Surface-Vegetation-Atmosphere Transfer) models.

P. Dobesberger (1), A. Zeidler (1), G. Wohlfahrt (2)

(1) Department of Natural Hazards and Alpine Timberline, Federal Research and Training Centre for Forests, Natural Hazards and Landscape (BFW)

(2) Institute of Ecology, University of Innsbruck (UIBK)

Bundesforschungs- und Ausbildungszentrum für Wald, Naturgefahren und Landschaft

BACKGROUND AND OBJECTIVES

Make everything as simple as possible, but not simpler - Albert Einstein. Climate change is likely to affect the return period and magnitude of natural hazards, such as avalanches, debris flow or sediment transport. Important factors to be considered when researching those hazards are the alteration of soil and snowpack properties as well as the varying conditions for the vegetation. Here we will use SVAT models for assessing climate change impact on the soil, the snowpack and the growth conditions for the vegetation on a long term perspective. Therefore we will calibrate and compare three SVAT models with different theoretical backgrounds and degrees of complexity in order to find the most suitable model for the purpose of this study. The objective of the present study is to qualitatively and quantitatively evaluate three SVAT models of differing complexity using a common set of calibration data. Particular emphasis is placed on tradeoffs between model complexity (i.e. number of parameters), the information content of the calibration data, and model skill in simulating key processes for natural hazards. (Fig. 1).

METHODS

The **first objective** of the present study is a systematical and comprehensible calibration of the models with data from different Alpine weather stations in Tyrol/Austria. Therefore a Bayesian model calibration framework via Markov chain Monte Carlo method will be used, called Differential Evolution Adaptive Metropolis (DREAM, Vrugt et al. 2008, 2009). This algorithm runs multiple chains simultaneously for global exploration, and automatically tunes the scale and orientation of the proposal distribution in order to find the set of parameters which fits the target best, e.g. soil water content (Fig.2). Hence the outcome of these simulations will be the range for each parameter of the model to fit the set target. Here the major interest will be, how well parameters of the three models of different complexity are constrained by the same set of calibration data.

The **second objective** of this study is the comparison of the measured and simulated water and energy balance parameters of the soil, the snowpack and the vegetation as well as the selection of the most suitable SVAT model for the purpose in this study. Therefore several well accepted statistical methods, like Root Mean Squared Error (RMSE), Model Efficiency (ME), or Residual Analysis (RA) will be used besides the Akaike Information Criterion (AIC) and the Bayesian Information Criterion (BIC). The above mentioned methods will be used to compare the simulated and observed results and to point out the advantages and disadvantages of each particular SVAT model in simulating the processes in an Alpine environment. Special attention will be paid to the differences in the model design and their influence on the reliability and accuracy of the simulated outputs. Therefore we chose three SVAT models with different theoretical background and degrees of complexity.

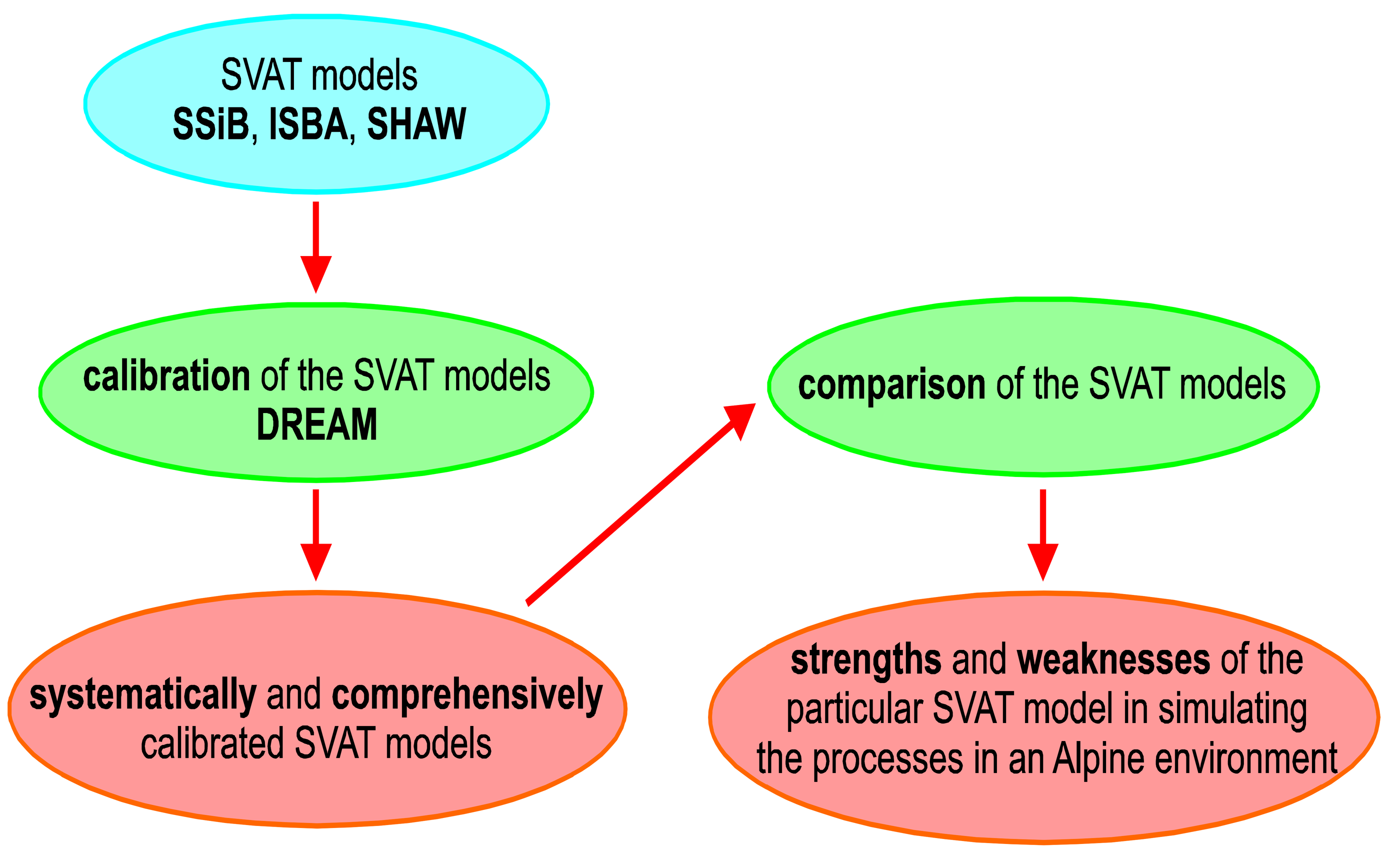

Fig. 1: Flowchart of the concept of the presented study.

SVAT MODELS

The used SVAT models are, in the order of their level of complexity, beginning with the least sophisticated, the Interaction Soil Biosphere Atmosphere model (ISBA, Noilhan and Planton 1989, Noilhan and Mahfouf 1996), the Simplified Simple Biosphere model (SSiB, Xue et al. 1991, 1996) coupled with the Snow-Atmosphere-Soil Transfer model (SAST, Sun et al. 1999, Sun and Xue 2001) and the Simultaneous Heat and Water model (SHAW, Flerchinger and Saxton 1989, Flerchinger et al. 1998). To give a short insight into their theoretical background and degrees of complexity, some basic facts of the particular SVAT models are summarized in Tab. 1.

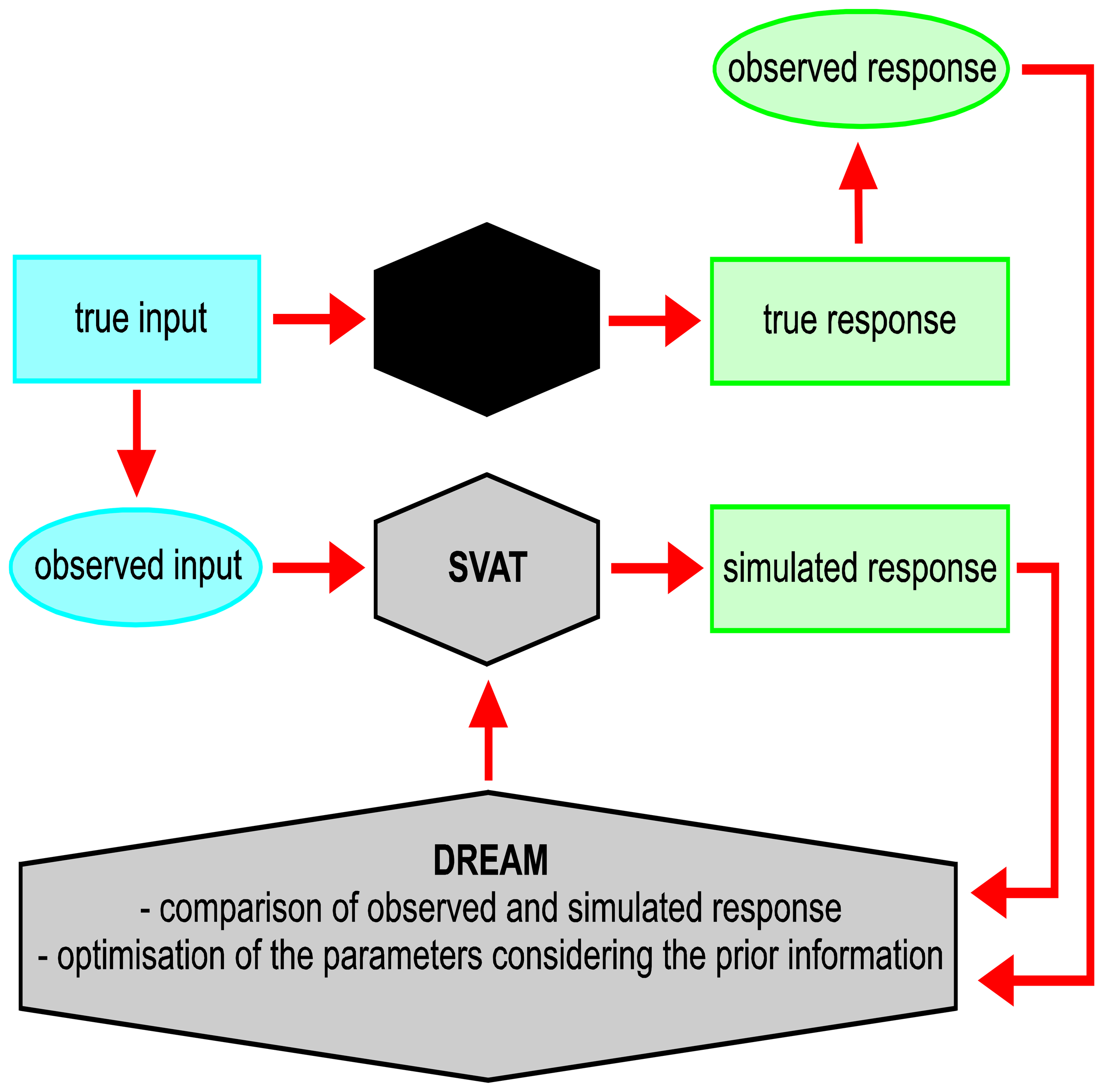

Fig. 2: Flowchart of calibration procedure in this study.

REFERNECES

Flerchinger, G. N., and K. E. Saxton, 1989: Simultanious Heat and Water Model of a freezing Snow-Residue-Soil System I - Theory and Development. *Transaction of the ASAE*, **32** (2), 565-571.

Flerchinger, G. N., W. P. Kustas, and M. A. Weltz, 1998: Simulating Surface Energy Fluxes and Radiometric Surface Temperatures for Two Arid Vegetation Communities Using the SHAW Model. *Journal of Applied Meteorology*, **37**, 449-460.

Noilhan, J., and S. Planton, 1989: A Simple Parameterization of Land Surface Processes for Meteorological Models. *Monthly Weather Review*, **117**, 536-549.

Noilhan, J., and J.-F. Mahfouf, 1996: The ISBA land surface parameterisation scheme. *Global and Planetary Change*, **13**: 145-159.

Sun, S., J. Jin, and Y. Xue, 1999: A simple snow-atmosphere-soil transfer model. *Journal of Geophysical Research*, **104** (D16), 19,587-19,597.

Sun, S., and Y. Xue, 2001: Implementing a new snow schema in Simplified Simple Biosphere Model (SSiB), *Advanced Atmosphere Sciences*, **18**, 335-354.

Vrugt, J. A., J. F. ter Braak Cajo, M. P. Clark, J. M. Hyman, and B. A. Robinson, 2008: Treatment of input uncertainty in hydrologic modeling: Doing hydrology backward with Markov chain Monte Carlo simulation. *Water Resources Research*, **44**, 1-15.

Vrugt, J. A., C.J.F. ter Braak, C.G.H. Diks, B. A. Robinson, J. M. Hyman, and D. Higdon, 2009: Accelerating Markov Chain Monte Carlo Simulation by Differential Evolution with Self-Adaptive Randomized Subspace Sampling. *International Journal of Nonlinear Sciences & Numerical Simulation*, **10** (3), 271-288.

Xue, Y., P. J. Sellers, J. L. Kinter, and J. Shukla, 1991: A Simplified Biosphere Model for Global Climate Studies. *Journal of Climate*, **4**, 345-364.

Xue, Y., F. J. Zeng, and A. Schlosser, 1996: SSiB and its sensitivity to soil properties a case study using HAPEX-Mobilhy data. *Global and Planetary Change*, **13**, 183-194.

Tab. 1: Summary of some basic facts of the used SVAT models

	ISBA	SSiB	SHAW
Layers	2 soil, 1 snow, 1 canopy	3 soil, 3 snow, 1 canopy	2-50 soil, multiple snow, 0-10 canopy, 0-10 residue
Heat (soil)	Force restore method (Bhumralkar 1975, Blackadar 1976)	Force restore method (Deardorff 1977)	Implicit finite difference equation
Water content (soil)	Force restore method (Deardorff 1977)	Finite difference approximation to the diffusion equation	Implicit finite difference equation
Heat (snow)	Force restore method	Budget equation of enthalpy	Implicit finite difference equation
Water content (snow)	Force restore method	Force restore method	Implicit finite difference equation

Contact:
Paul Dobesberger
Department of Natural Hazards and Alpine Timberline
Unit of Snow and Avalanches
Hofburg-Rennweg 1, A-6020 Innsbruck, Austria
Mail: paul.dobesberger@uibk.ac.at
Homepage: www.bfw.ac.at/naturgefahren

Acknowledgment:
This poster is part of the RIMES project funded by the Climate and Energy Fund and carried out within the Austrian Climate Research Program (ACRP).