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Sensitivity of numerical simulations in an idealized valley to surface parameters

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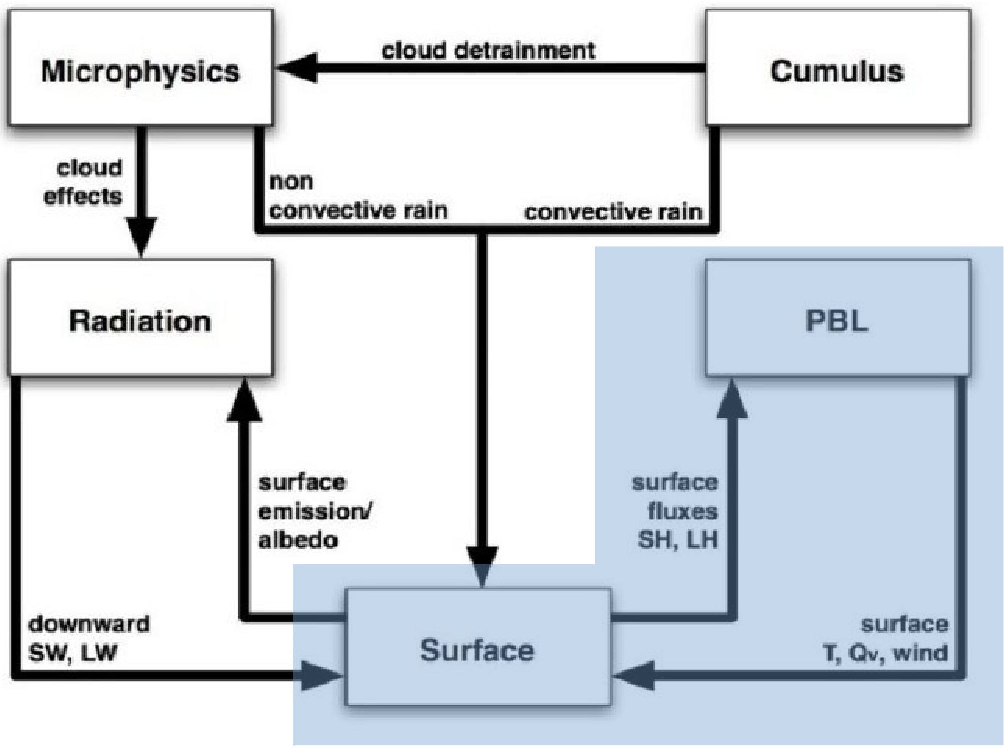
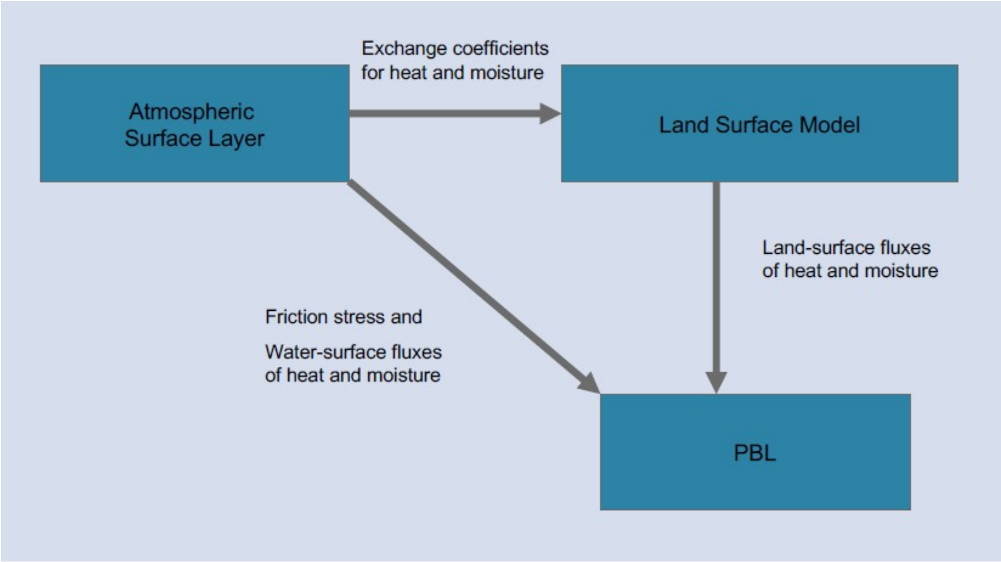
Introduction

Weather Research and Forecasting Model schemes interaction

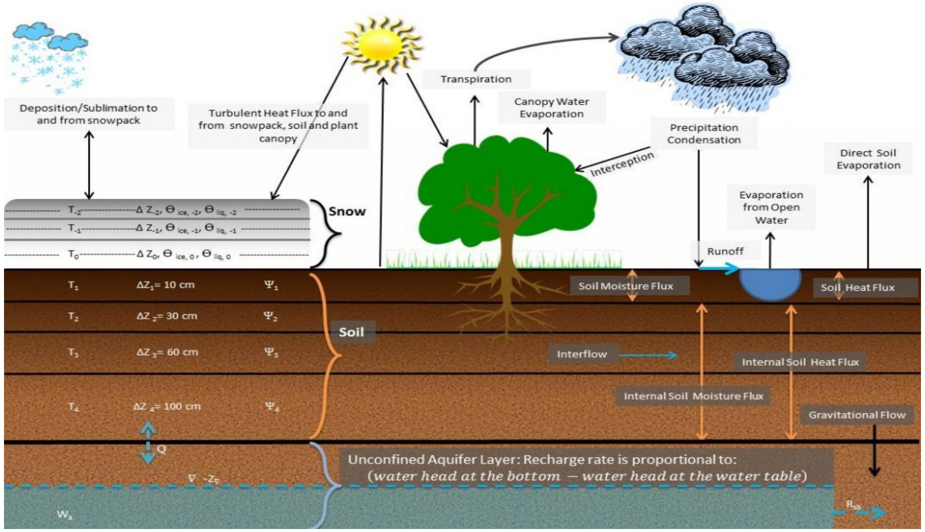
WRF Physics





Surface physics components

Weather Research and Forecasting Model: NOAHMP Land Surface Model



NOAHMP MODIS VEGETATION TYPES:

! 1 'Evergreen Needleleaf Forest'
! 2, 'Evergreen Broadleaf Forest'
! 3, 'Deciduous Needleleaf Forest'
! 4, 'Deciduous Broadleaf Forest'
! 5, 'Mixed Forests'
! 6, 'Closed Shrublands'
! 7, 'Open Shrublands'
! 8, 'Woody Savannas'
! 9, 'Savannas'
! 10, 'Grasslands'
! 11 'Permanent wetlands'
! 12, 'Croplands'
! 13, 'Urban and Built-Up'
! ...

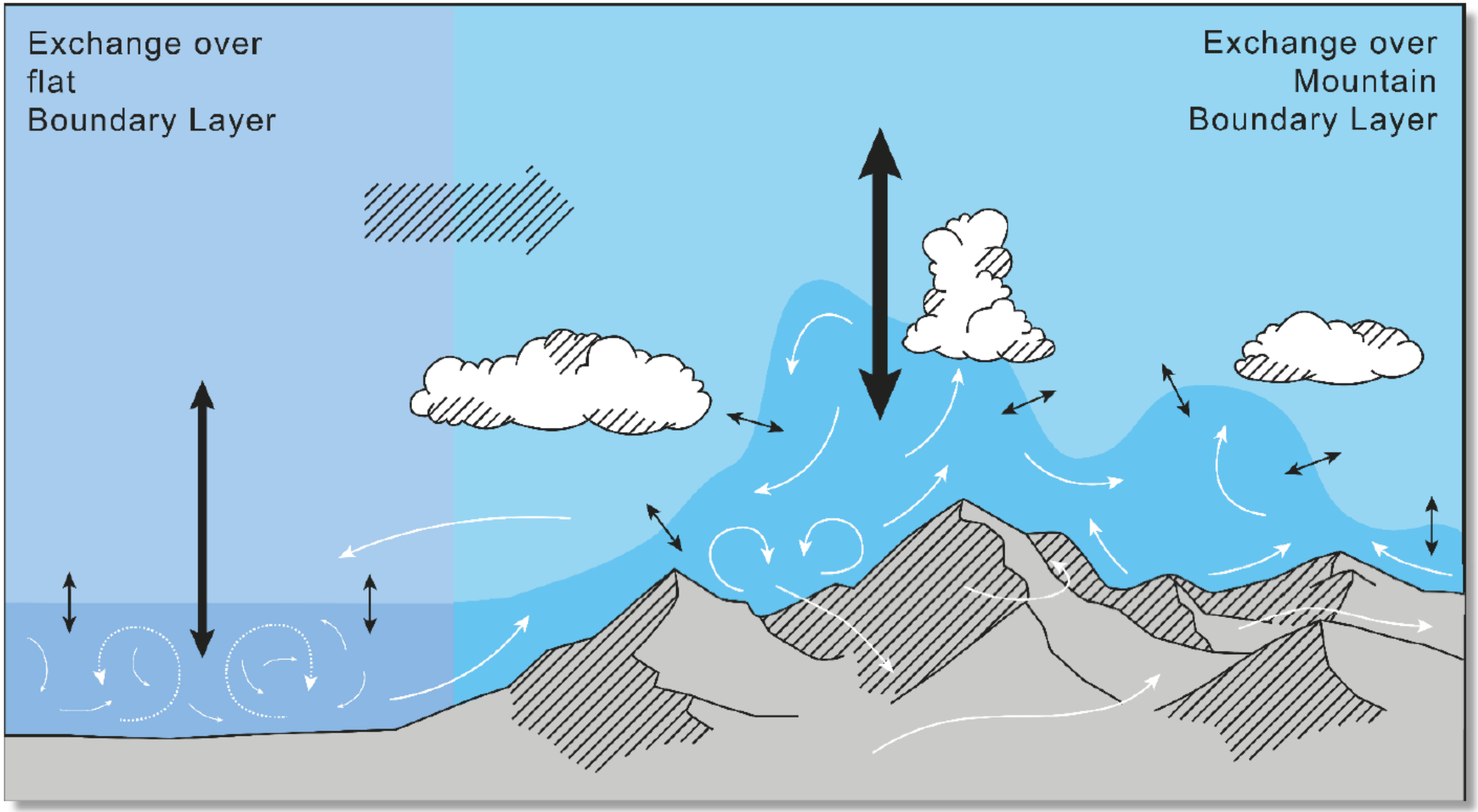
!--

!	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
Z0MVT =	1.09,	1.10,	0.85,	0.80,	0.80,	0.20,	0.06,	0.60,	0.50,	0.12,	0.30,	0.15,	1.00,	0.14,	0.00,	0.00,	0.00,	0.30,	0.20,	0.03,
HVT =	20.0,	20.0,	18.0,	16.0,	16.0,	1.10,	1.10,	13.0,	10.0,	1.00,	5.00,	2.00,	15.0,	1.50,	0.00,	0.00,	0.00,	4.00,	2.00,	0.50,
HVB =	8.50,	8.00,	7.00,	11.5,	10.0,	0.10,	0.10,	0.10,	0.10,	0.05,	0.10,	0.10,	1.00,	0.10,	0.00,	0.00,	0.00,	0.30,	0.20,	0.10,
RC =	1.20,	3.60,	1.20,	1.40,	1.40,	0.12,	0.12,	0.12,	3.00,	0.03,	0.75,	0.08,	1.00,	0.08,	0.00,	0.01,	0.01,	0.30,	0.30,	0.30,

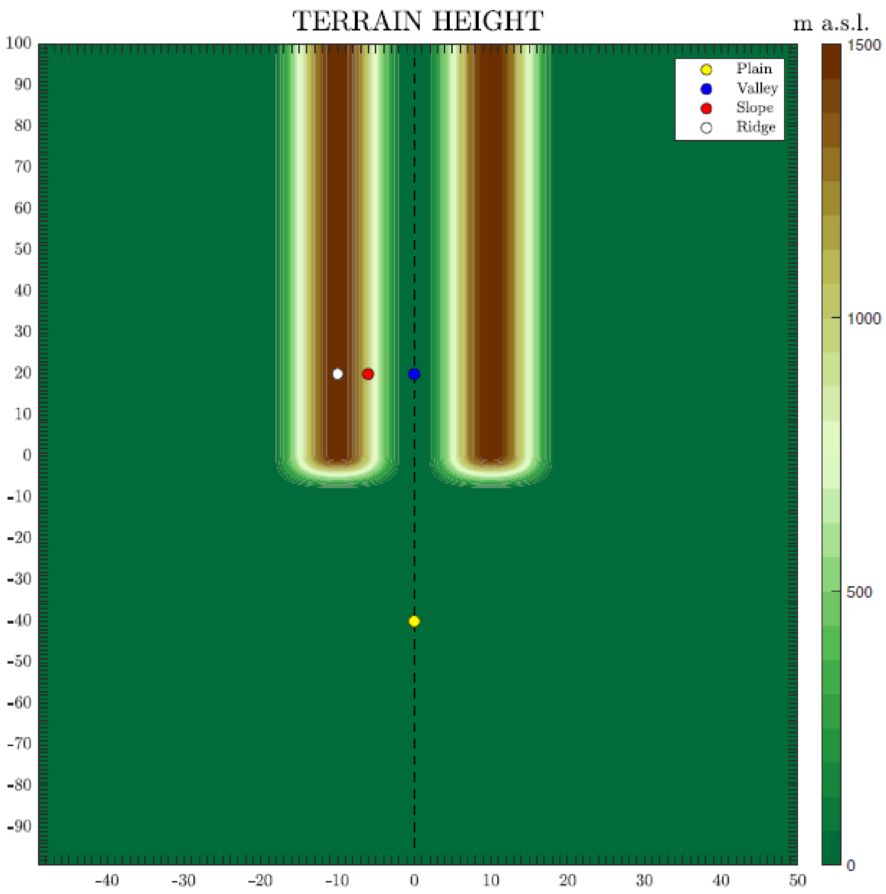
...

No uncertainty ranges!

Exchange processes over complex terrain



RANS domain: idealized valley geometry



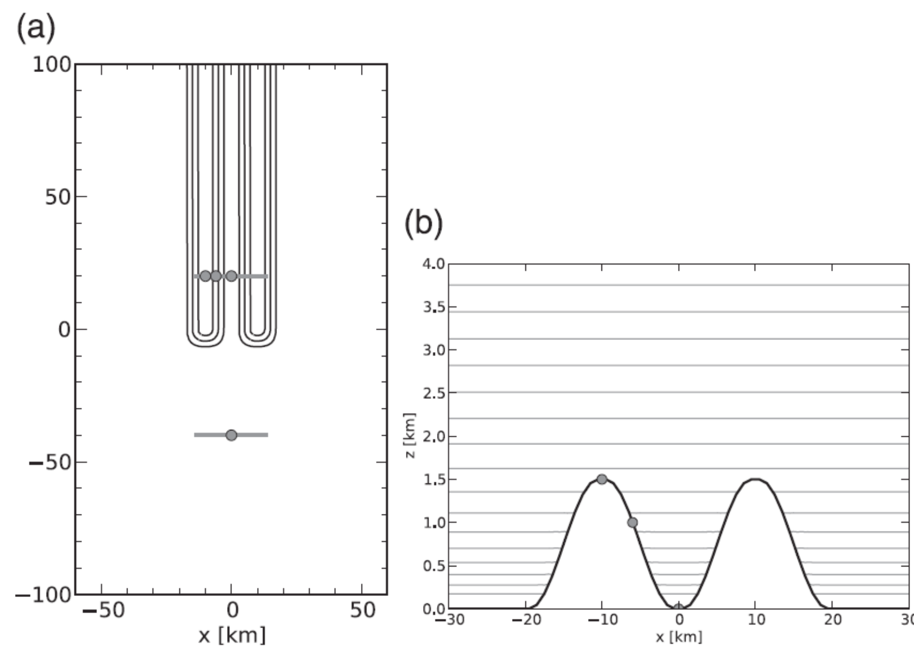
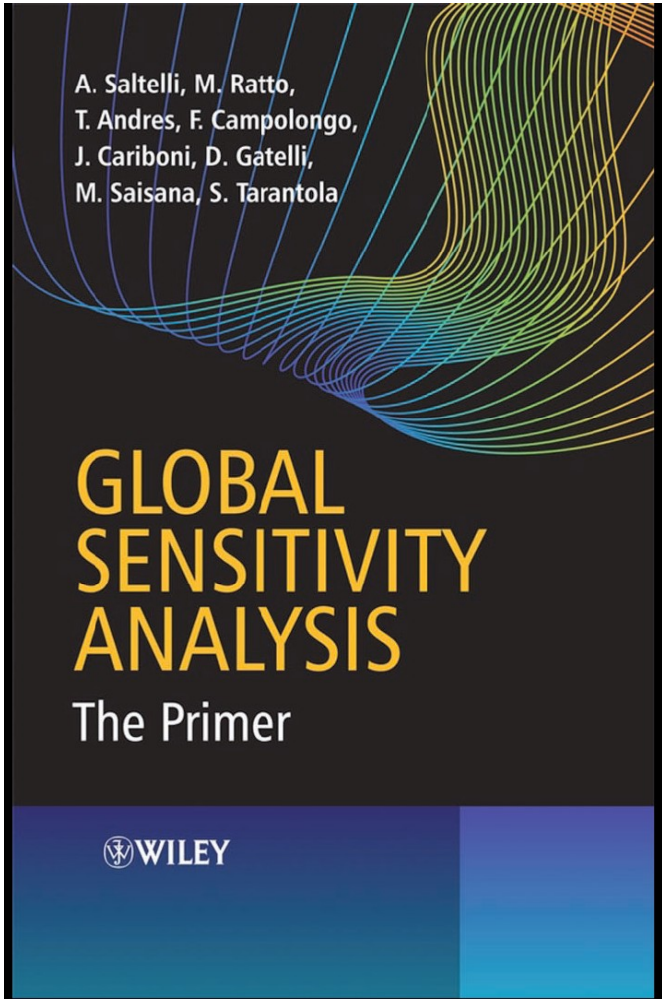


FIG. 1. (a) Contour plot of the three-dimensional valley-plain topography (contour values are 250, 750, and 1250 m) and computational domain adopted; only the southern half of the domain is shown. The gray lines denote the locations of the vertical cross sections and the circles denote the locations of the soundings to be shown. (b) Cross section of topography and initial potential temperature distribution (contour interval is 1 K).

Intercomparison of Mesoscale Model Simulations of the Daytime Valley Wind System (Schmidtli et al. 2011)

Global Sensitivity Analysis: Morris Method



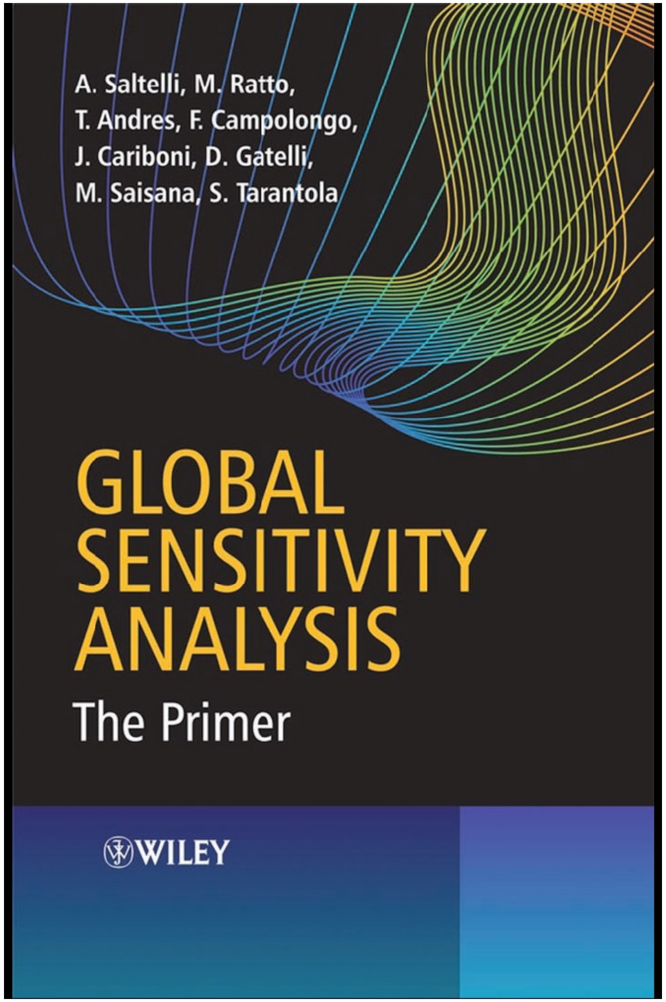
1) Take the following parameters as input factors:

- **HVT** – Height of the canopy
- **LAI** – Leaf area index
- **RHOL-nir** – Leaf longwave reflectivity
- **SAI** – Stem area index
- **MAXSMC** – Maximum soil moisture capacity
- **RC** – Canopy crown radius
- **BEXP** – Wetness of the soil

2) Change their values inside predefined ranges and look at the change in the output:

- **Which of these input factors have more and less influence on the model's response?**
- **Are there subranges of the input factors that map into significant (e.g. extreme) output values?**

Global Sensitivity Analysis: Morris Method



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2) Change their values inside predefined ranges and look at the change in the output:

Which parameter needs to be handled with greater care while simulating complex terrains?

Results

CASE STUDY: Latent Heat Flux

CASE STUDY:
LATENT HEAT FLUX

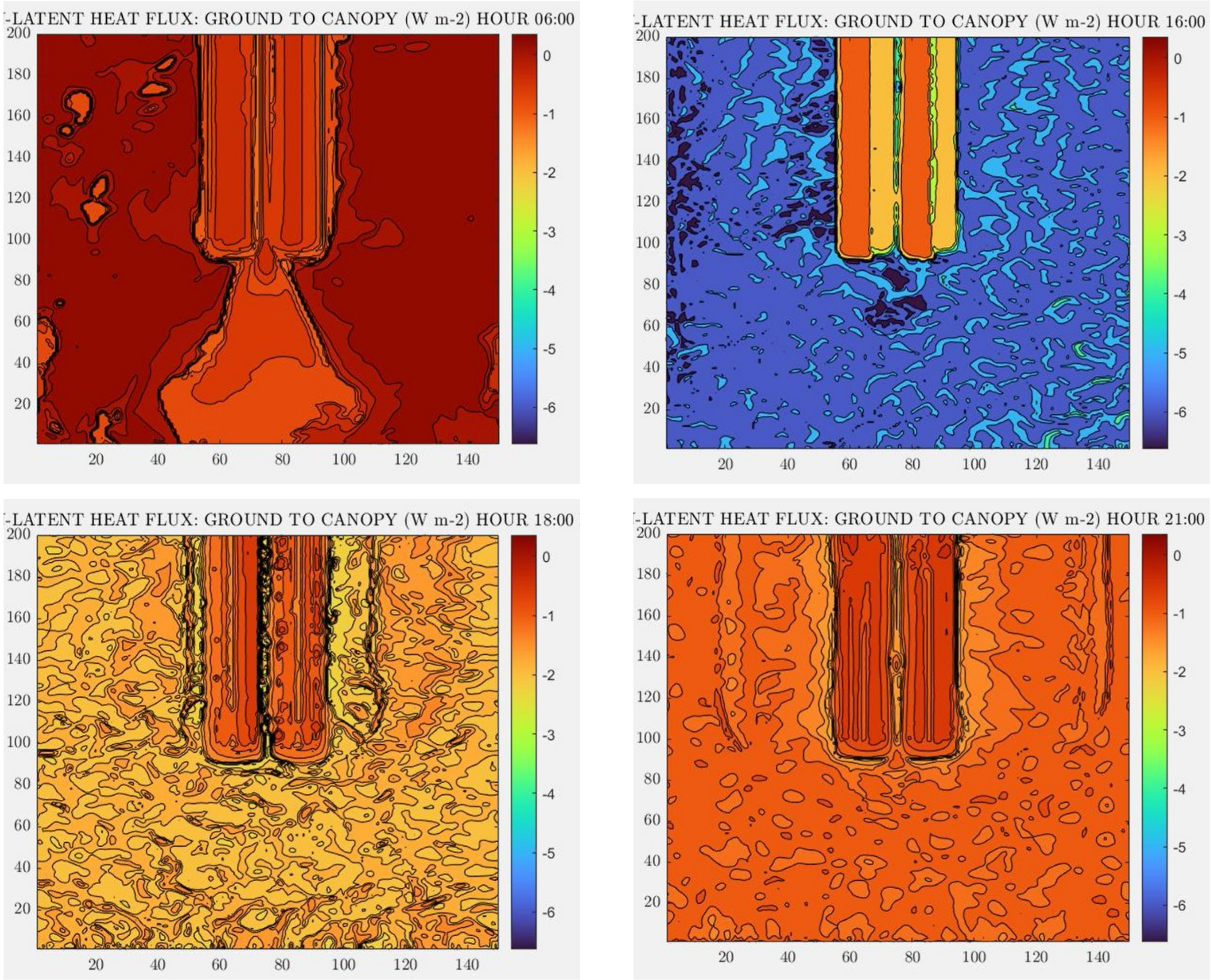
Schematized Defant cycle (from *Defant, 1949*):

A) Strong outflow

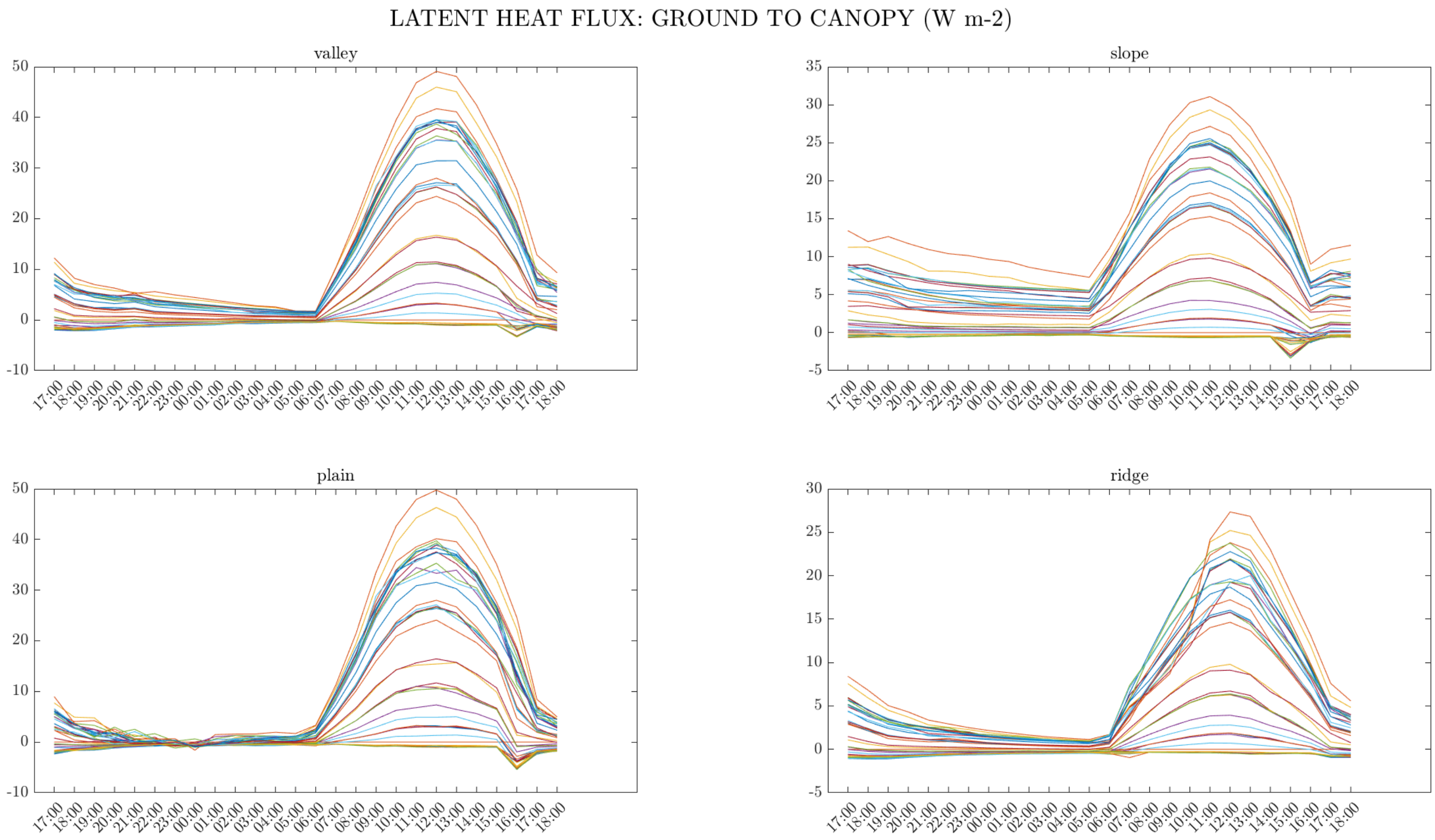
B) Strong anabatic

C) Strong inflow

D) Strong katabatic



How much does the output changes?



Why does it changes?

$$EVG = CEV \cdot (ESTG \cdot RHSUR - EAH)$$

$CEV = RHOAIR \cdot CPAIR / (GAMMAG \cdot (RAWG+RSURF))$

$EAH = (EAIR \cdot CAW + ESTG \cdot CGW) / (CEW+CAW+CGW+CTW)$

latent heat conductance, canopy air to ZLVL (ref height over canopy) air (m/s)

$CAW = 1 / RAWC$

evaporation latent heat conductance, leaf to canopy air (m/s)

$CEW = FWET \cdot VAI/RB$ $\quad RB = (DLEAF/UC)^{1/2} \cdot CWPC \cdot 50 /(1- EXP^{-CWPC/2})$

transpiration conductance, leaf to canopy air (m/s)

$CTW = (1-FWET) \cdot (LAISUN/RB + RSSUN) + LAISHA/RB + RSSHA$

latent heat conductance, ground to canopy air (m/s)

$CGW = 1 / (RAWG + RSURF)$

$RSURF = -ZSOIL(1)/(2.71828-1) \cdot (EXP^{(1-min(1,SH2O(1)/SMCMAX(1)))^{RSURF\_EXP}})/(1-SMCWLT(1)/SMCMAX(1)) \cdot 2.2 \cdot 10^{-5} \cdot SMCMAX(1))^{(2+3/BEXP(1))}$

aerodynamic resistance for latent heat evaporation canopy related(s/m)

$RAWC = 1/ (CH \cdot UR)$

$CWPVC = CWPT \cdot VAI \cdot HVT \cdot f(MOZG)$

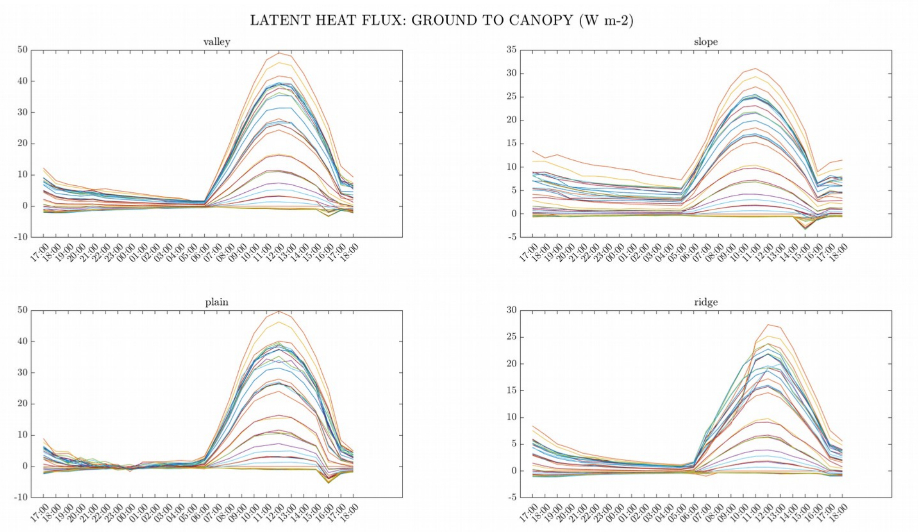
aerodynamic resistance for latent heat evaporation ground related(s/m)

$RAWG = RAHG \qquad RAHG = \frac{e^{-CWPC^{1/2} \cdot 0.002}}{CWPC} \cdot (e^{-0.002 \cdot CWPC/HTOP} - e^{-CWPC(Z0H+ZPD)/HTOP})$

relative humidity in surface soil/snow air space

$RHSUR = -EXP^{(PSI \cdot GRAV)/(RW \cdot TG)}$

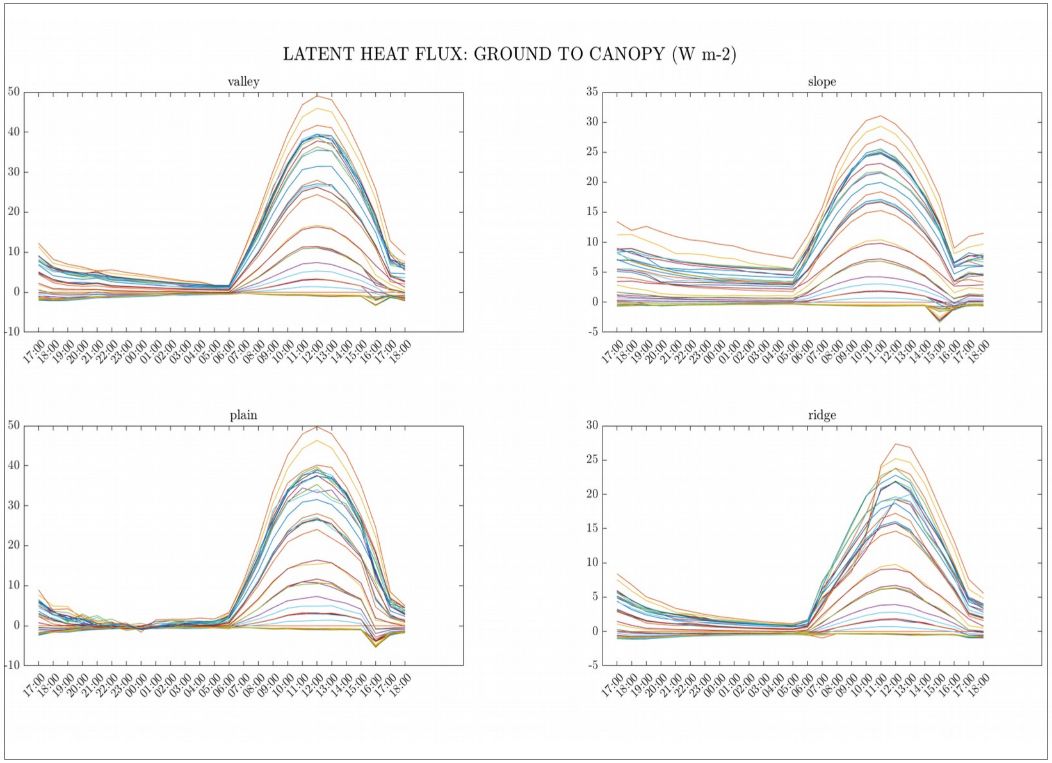
$$PSI = -PSISAT \cdot (SH2O(1)/SMCMAX(1))^{-BEXP(1)}$$



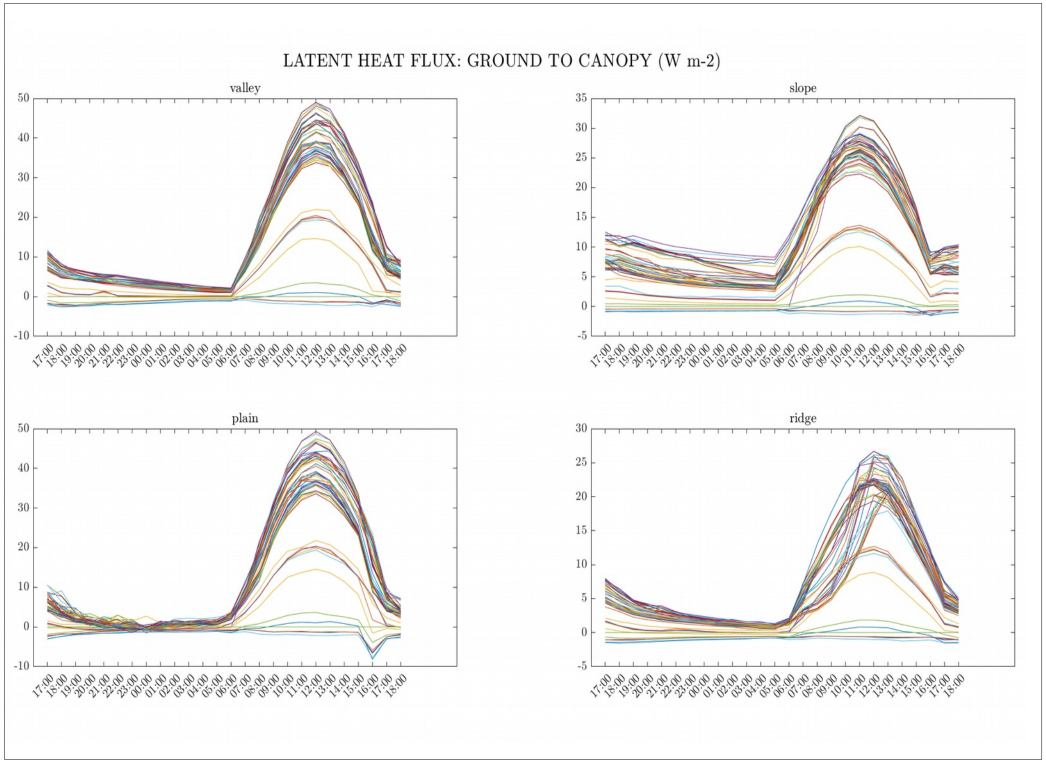
Test for consistence: Morris A vs Morris B

Total number of simulations: 160

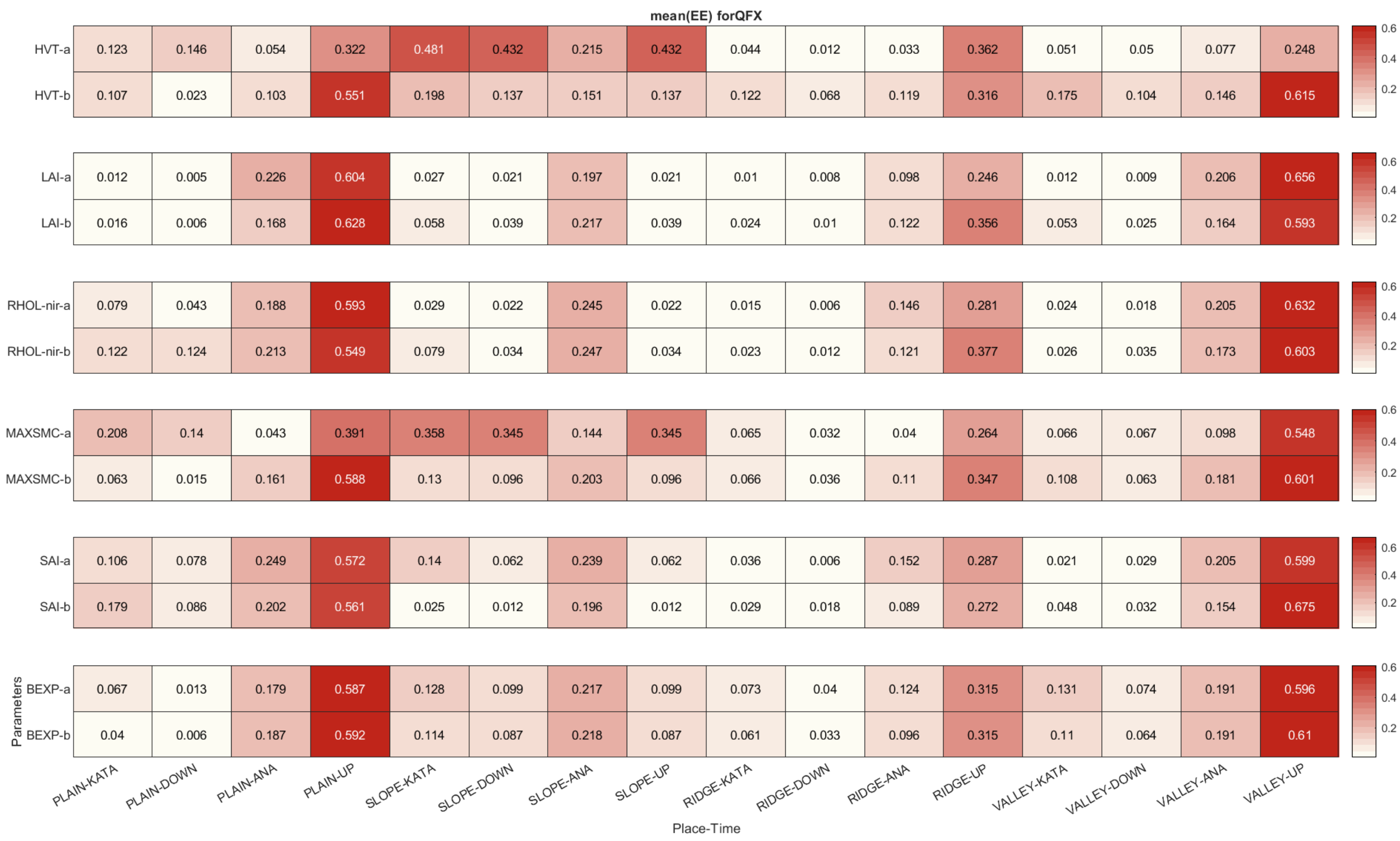
Sample A outputs (80 runs):



Sample B outputs (80 runs):



What can we get from Morris Method?
Time and Positional patterns: Latent Heat Flux



Future directions

Future Directions

Next steps:

- The carried out Morris method will be followed by a ranking of the parameters for each variable through the use of the "Sobol method".

  Morris indices are considered to be a good proxy of the Sobol indices, but the latter is a more robust and quantitative method (although very computational demanding)

- Each parameter spatial distribution can be modified into an heterogeneous configuration to answer the question: "how much the lack of knowledge of a parameter spatial heterogeneity can affect the output of a simulation?"

Thanks for the attention

Acknowledgments

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