Improving the SURFEX/TEB scheme: 1-D validation in a street canyon

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SURFEX coupled off-line to ALADIN: preliminary results over Belgium

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ALADIN-2007-Oslo (Norway) 23-26 April 2007

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R. Hamdi[1] and V. Masson[2]

1. Royal Meteorological Institute, Brussels, Belgium.
2. CNRM, Météo-France, Toulouse, France.

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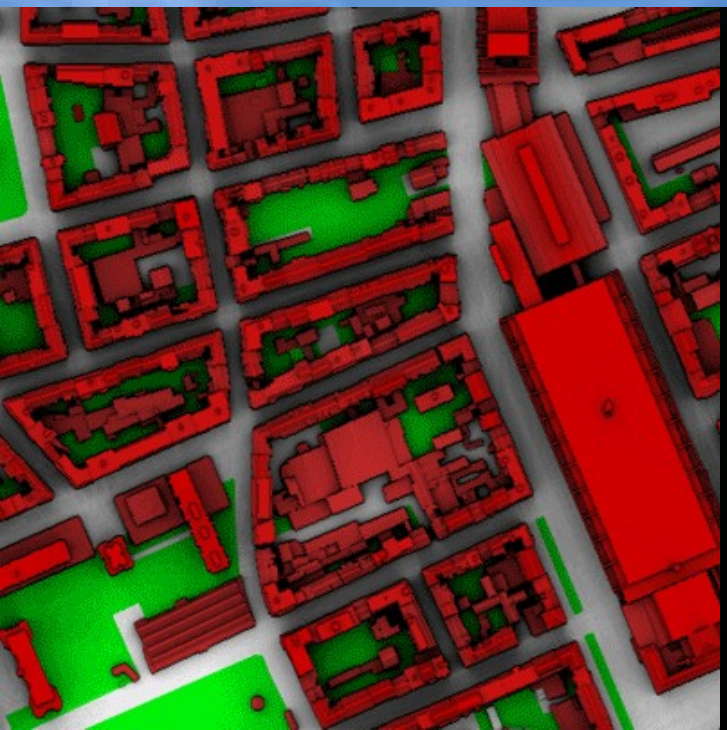


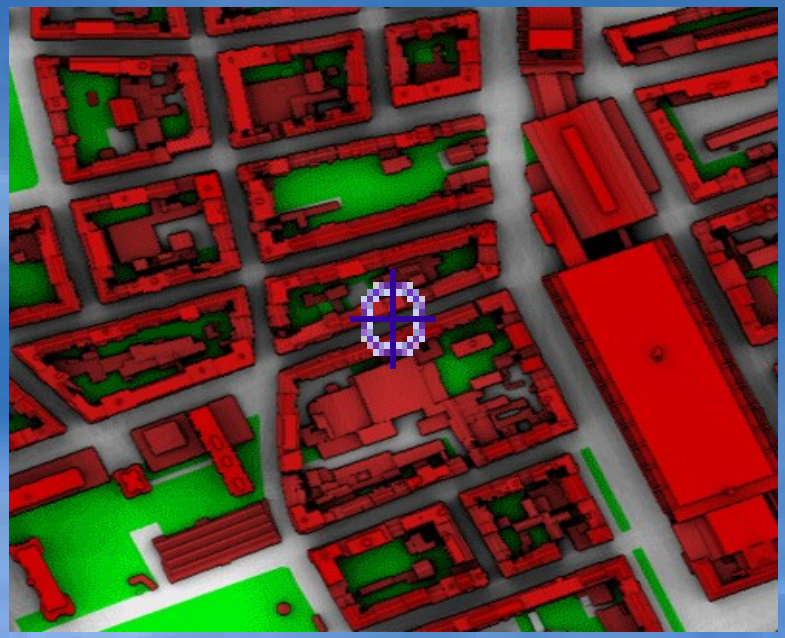
Plan

- Measurement site (BUBBLE)

  (Basel UrBan Boundary Layer Experiment)

- The TEB scheme
- Improving the parameterization
- Results and discussions
- Conclusion

Basel Sperrstrasse (U1)



Tower height	:	32 m
Building height	:	14.6 m
% Roof	:	54%
% Vegetation	:	16%
Wall/plane area ratio	:	0.68
Canyon aspect ratio H/W	:	1

T, U, V, q, TKE, Q_H, Q_E $\Rightarrow$ A, B, C, D, E, F (Ultrasonic anemometer-thermometer)

Q^*, K↓, K↑, L↓, L↑ $\Rightarrow$ 3.2 m et 31.5 m (Pyranometer, Pyrgeometer)

Urban parameterization

TEB (Masson 2000)

* **Ensemble of urban canyons**

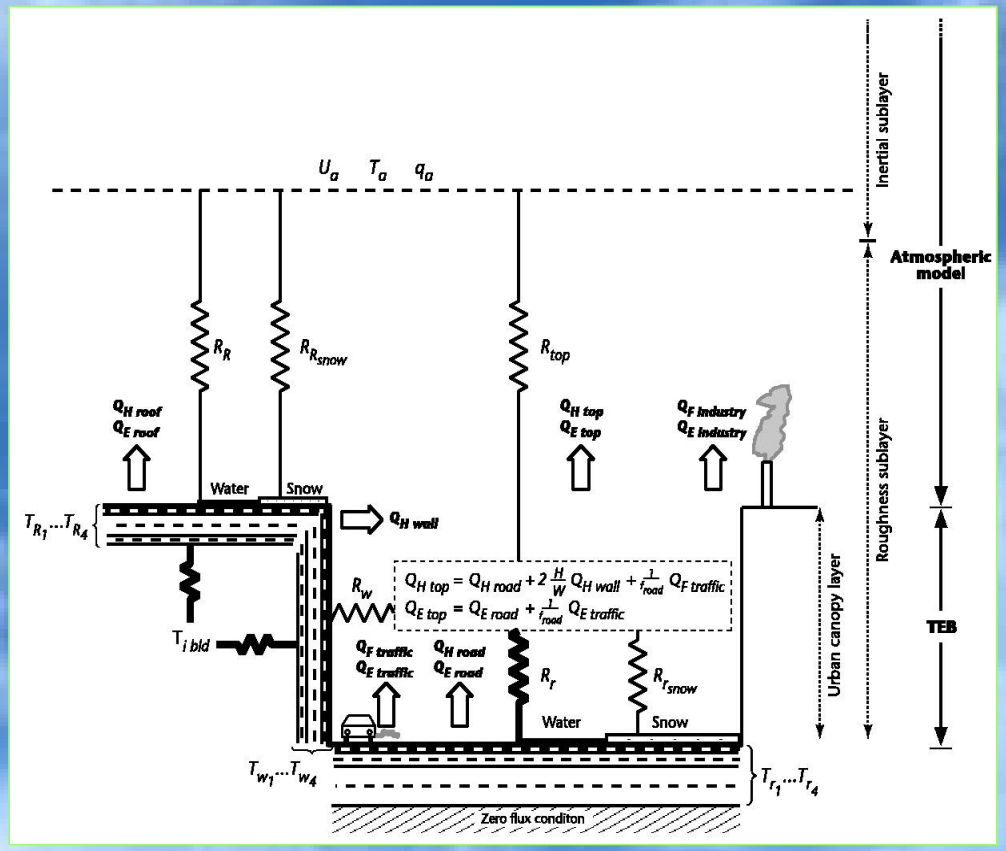
* **Surface temperatures resolved for each of the 3 urban surfaces**

  roads, roofs and walls

* **Surface energy budget resolved for each urban surface**

* **The averaged fluxes are calculated at the top of the canyon via the aerodynamic resistances**

* **Diagnostic temperature and wind inside the canyon**



Masson et al. 2002

Improving the parameterization (1)

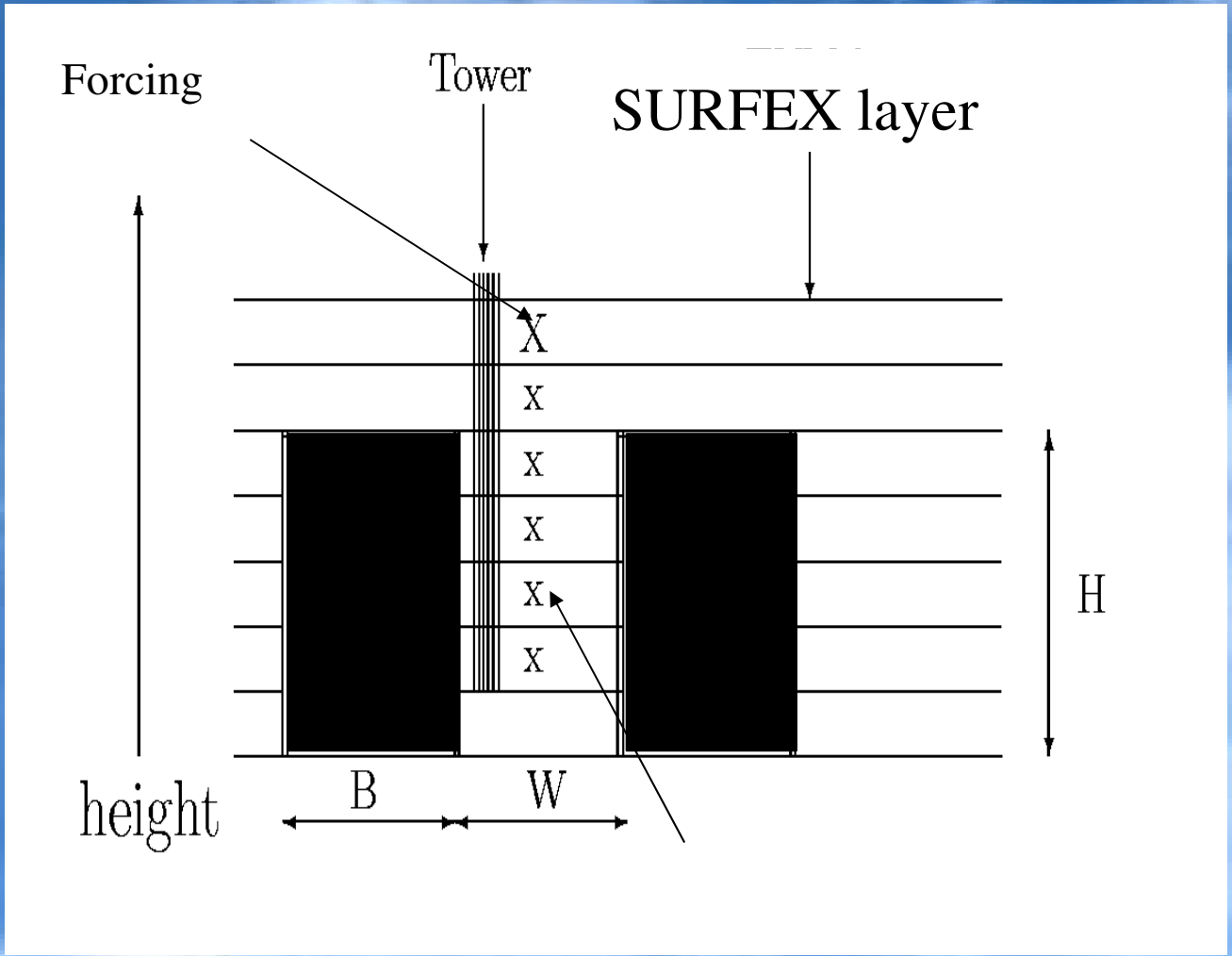
1. Surface scheme

$$\frac{\partial u}{\partial t} = \ldots + \frac{\partial u}{\partial t}\Big|_{TEB}$$

$$\frac{\partial T}{\partial t} = \ldots + \frac{\partial T}{\partial t}\Big|_{TEB}$$

$$\frac{\partial Tke}{\partial t} = \ldots + \frac{\partial Tke}{\partial t}\Big|_{TEB}$$

$$\frac{\partial q}{\partial t} = \ldots + \frac{\partial q}{\partial t}\Big|_{TEB}$$



Improving the parameterization (2)

1. Momentum

* Vertical surfaces (Walls):

$$\frac{\partial U}{\partial t}\Big|_{TEB} = -C_D (S_v / V_{air}) U^2$$

U wind speed, S_v ; S_h vertical (horizontal) surface area of the buildings, C_D drag coefficient.

* Horizontal surfaces (roads, roofs):

$$\frac{\partial U}{\partial t}\Big|_{TEB} = -U_*^2 (S_h / V_{air})$$

2. Turbulent kinetic energy

Production of turbulence by walls:

$$\frac{\partial Tke}{\partial t}\Big|_{TEB} = C_D (S_v / V_{air}) U^3$$

3. Temperature

* The heat turbulent fluxes Q_h are calculated between roof/road/wall and the atmosphere.

* This term is added at each atmospheric level in contact with the buildings.

$$\frac{\partial T}{\partial t}\Big|_{TEB} = \frac{(Q_h^{roof} + Q_h^{road})}{\rho C_p}(S_h / V_{air}) + \frac{Q_h^{wall}}{\rho C_p}(S_v / V_{air})$$

4. Mixing length

Modification of the mixing length L_m in the presence of buildings according to (Macdonald, 2000 ; Belcher et al. 2003):

$$L_m = H \quad \text{if} \quad z < H$$

$$L_m = H + \frac{z - H}{z(top) - H}[L_m(top) - H] \quad \text{if} \quad z \geqslant H$$

(H : mean buildings height)

1-D SURFEX configuration

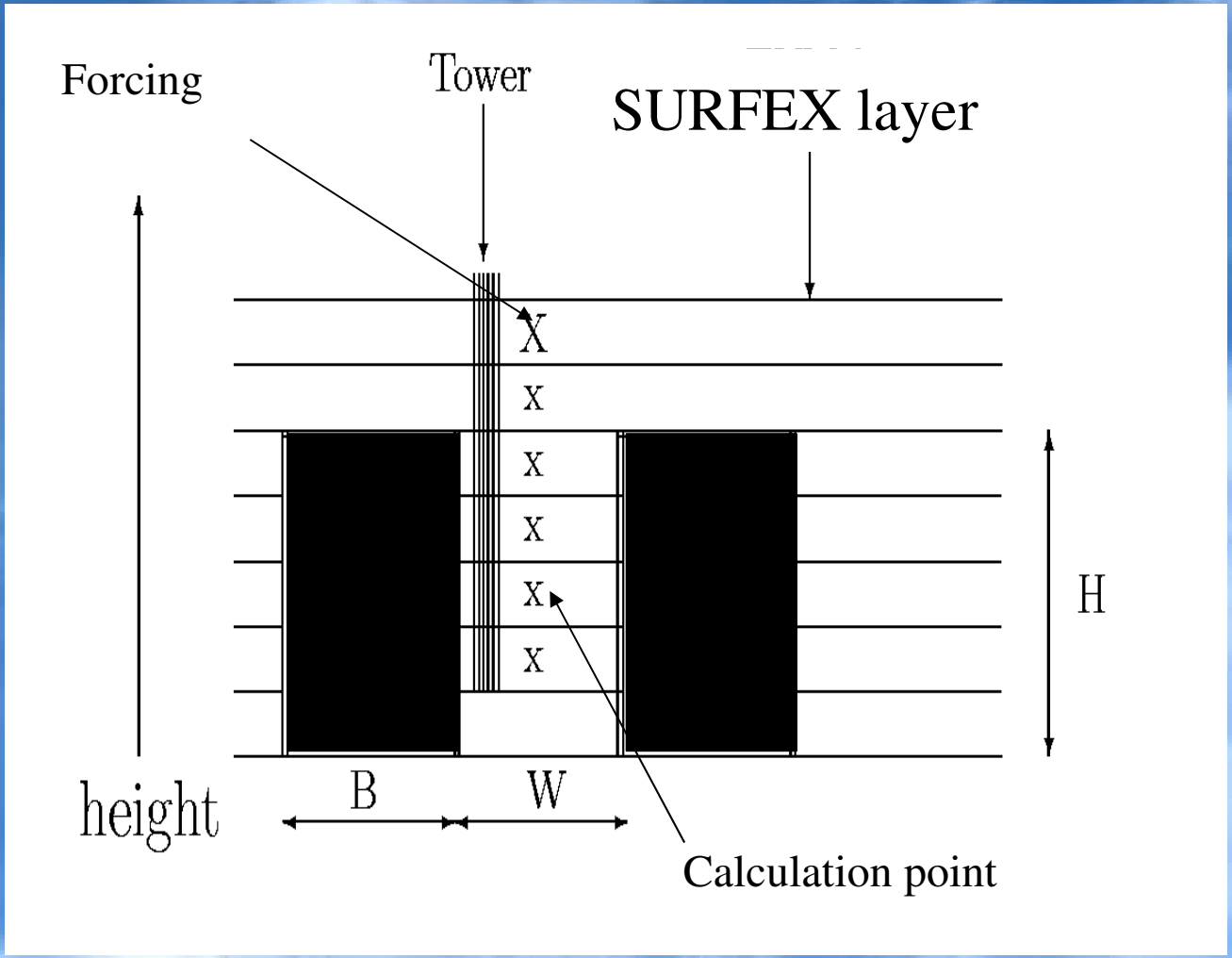
% ISBA = 16%

% TEB = 84%

with % roof = 54%

The period of the simulations from 16/06/2002 to 30/06/2002

Forcing is applied with 10-min time step to:
wind
Temperature
Humidity
downward global short- and long-wave radiation.

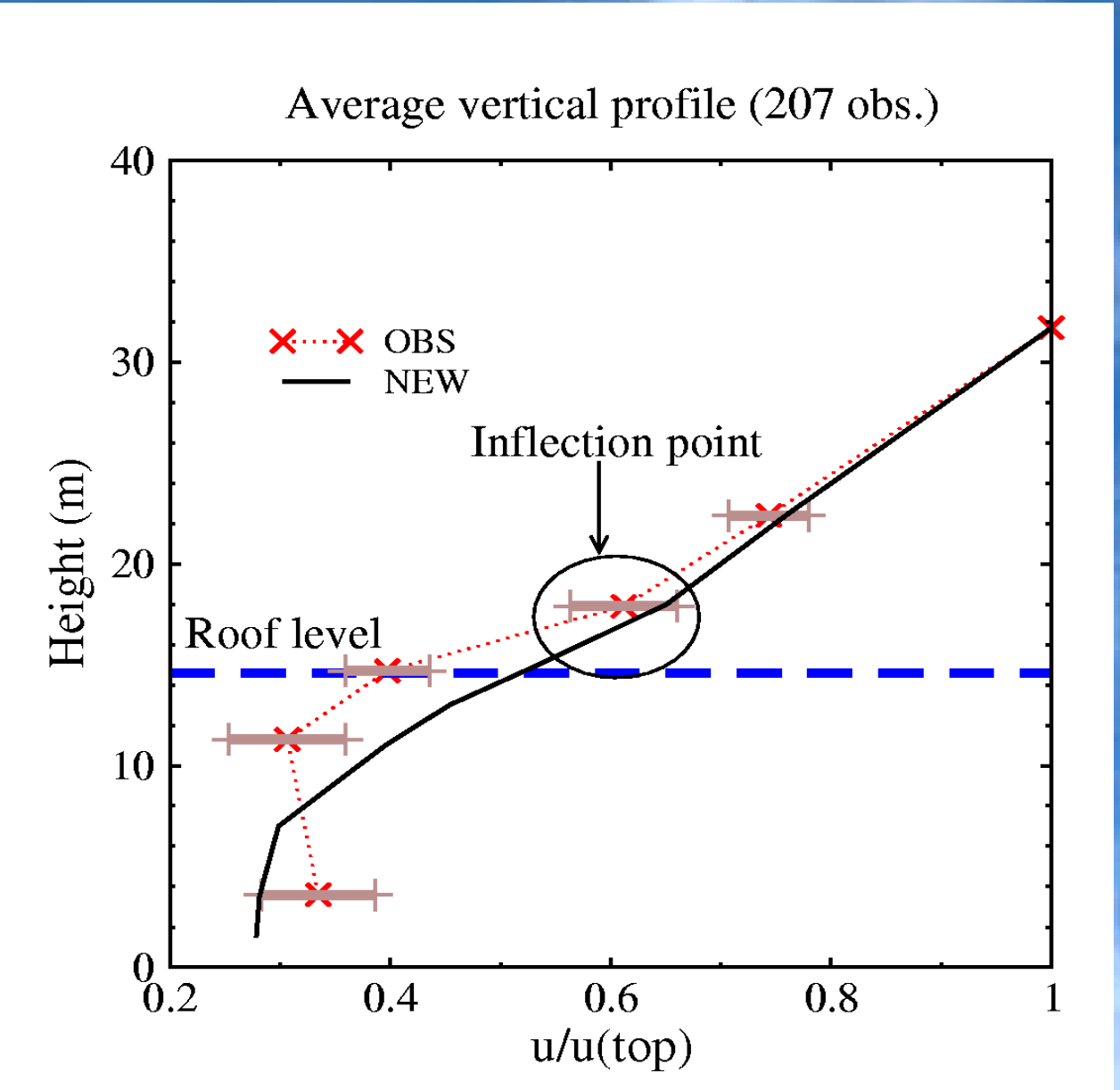


Two simulations:

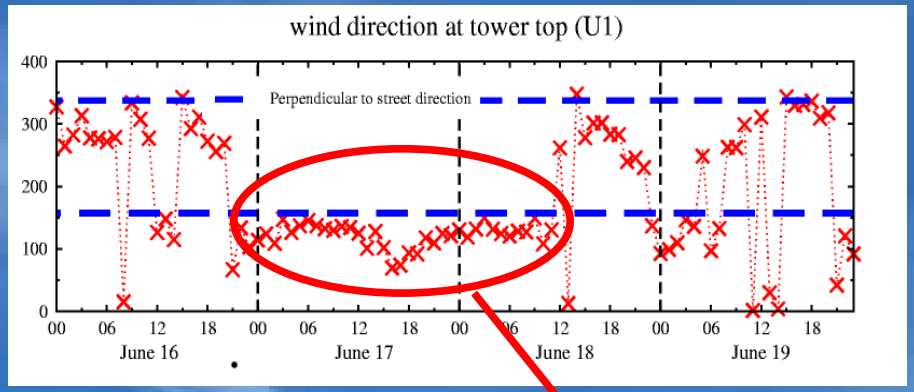
"NEW" with the prognostic version of SURFEX

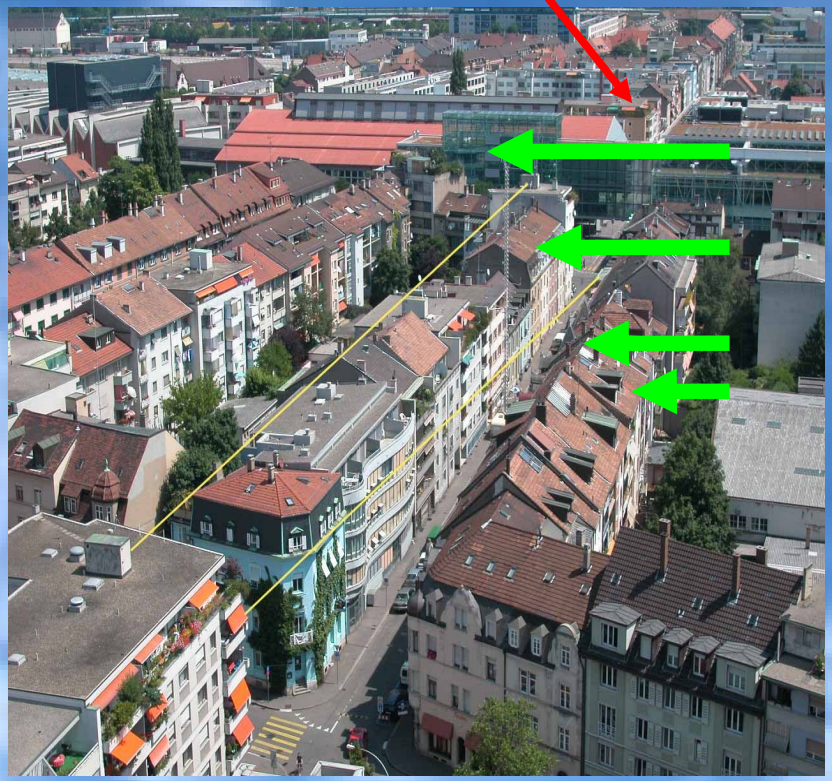
"ORI" with the diagnostic version of SURFEX.

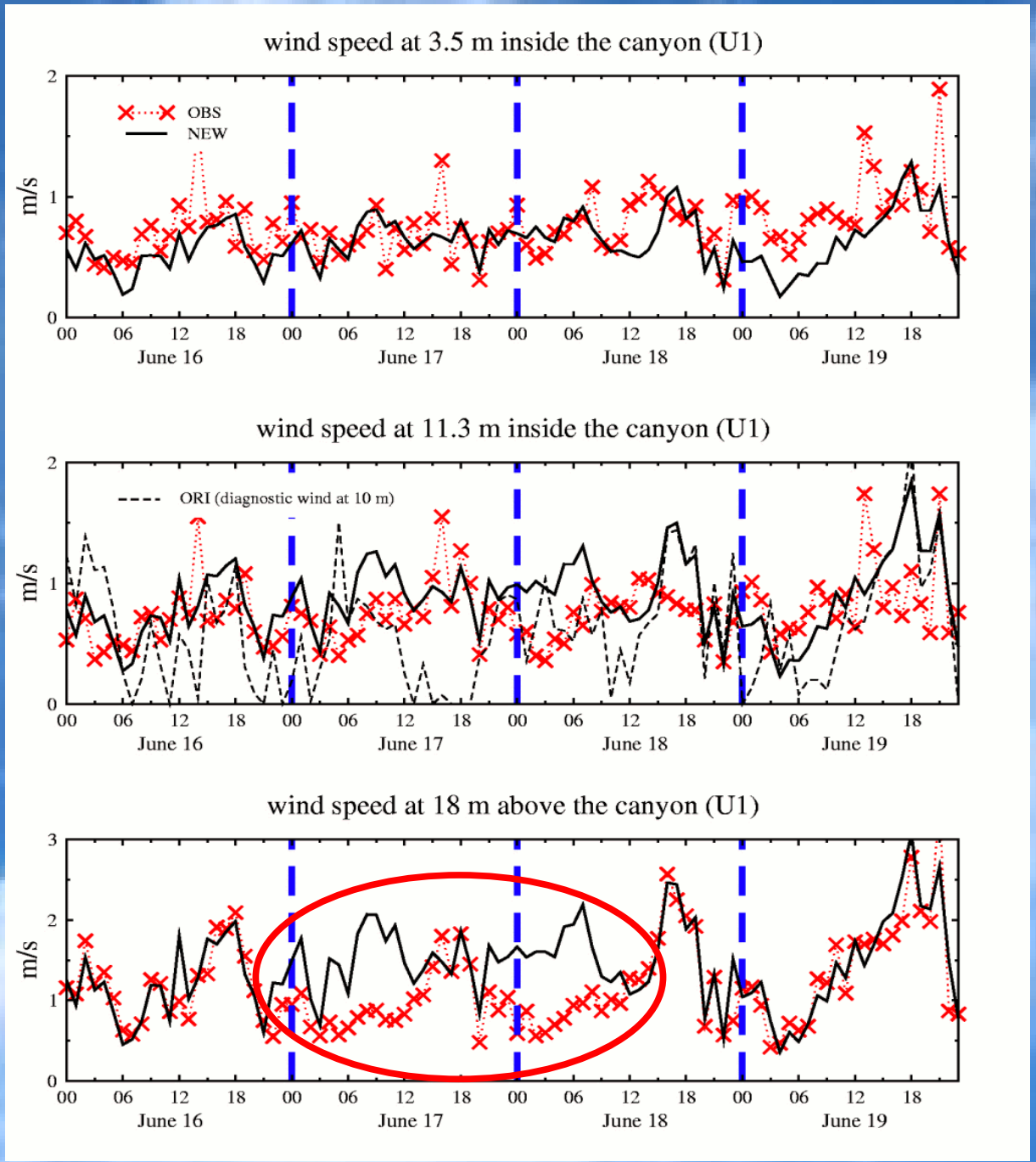
Results: wind speed



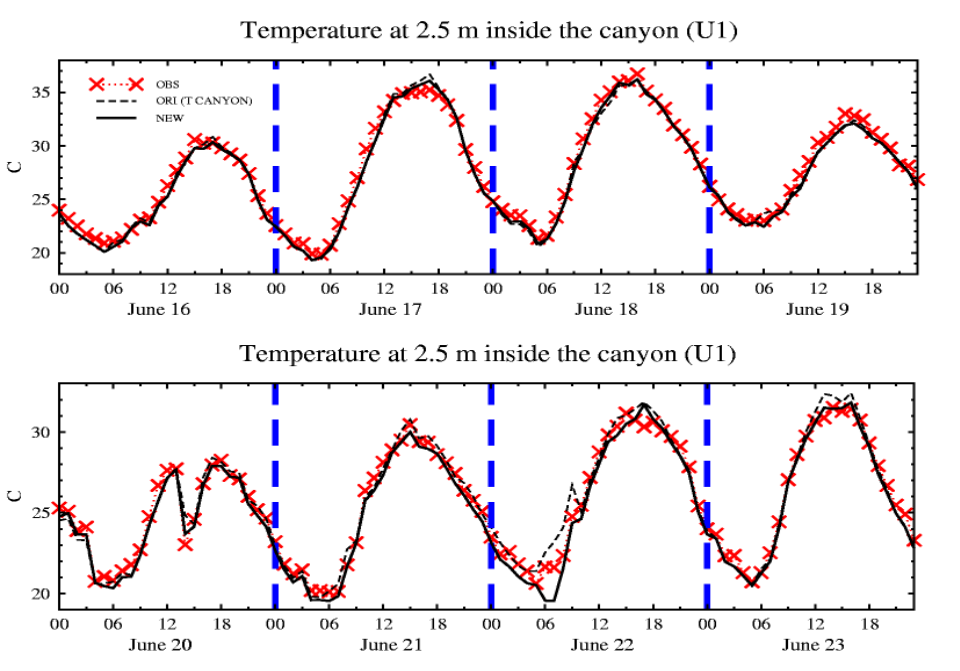
Results: wind speed

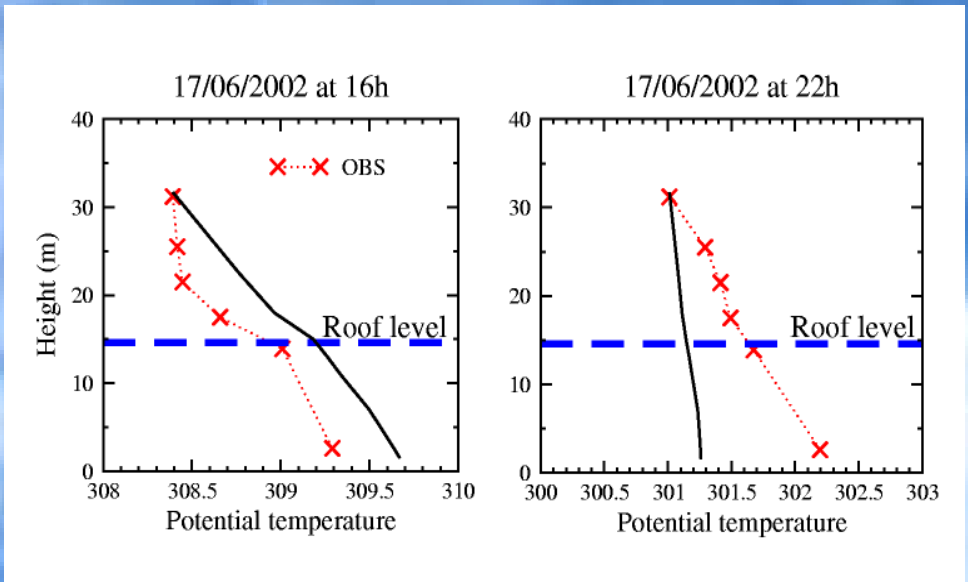


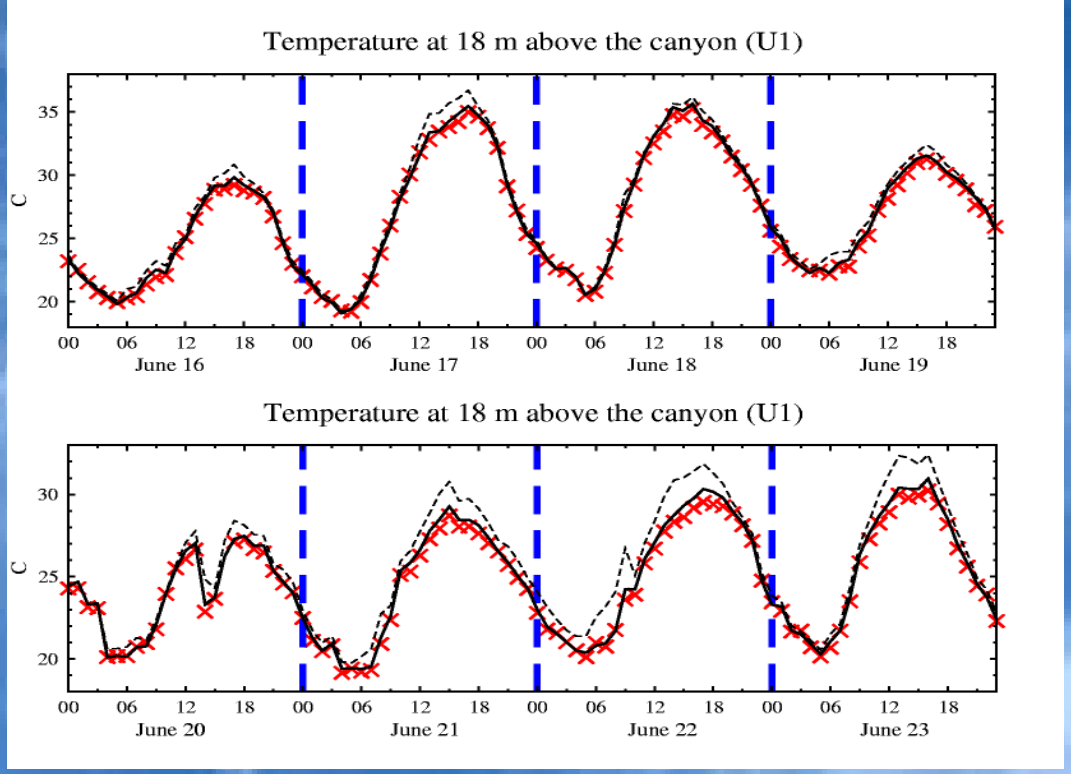


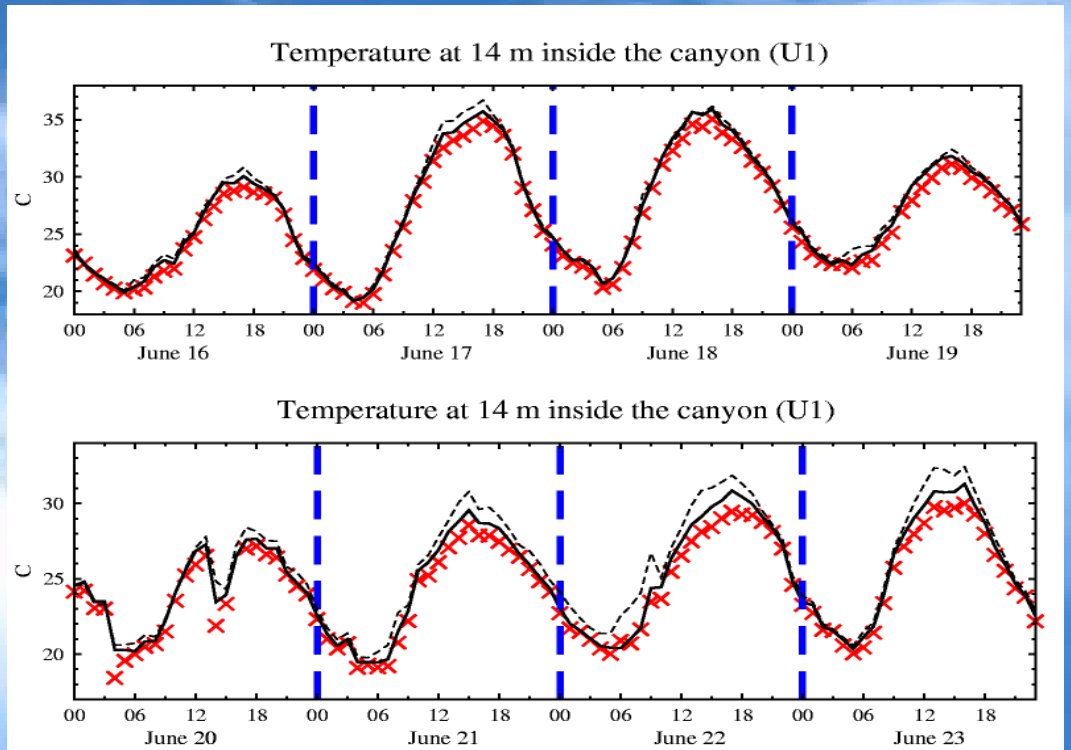


Results: temperature



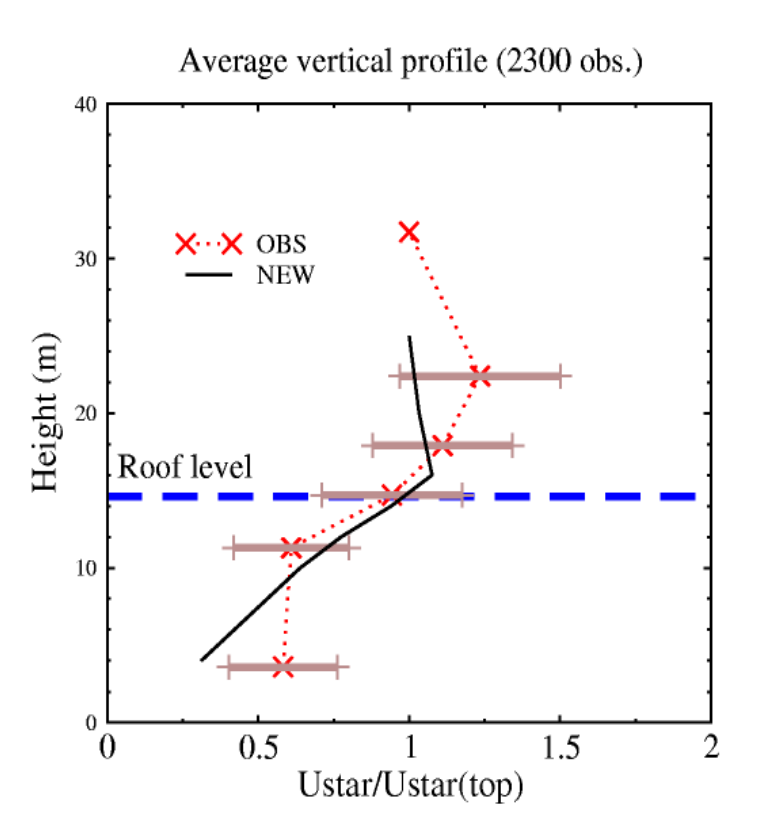


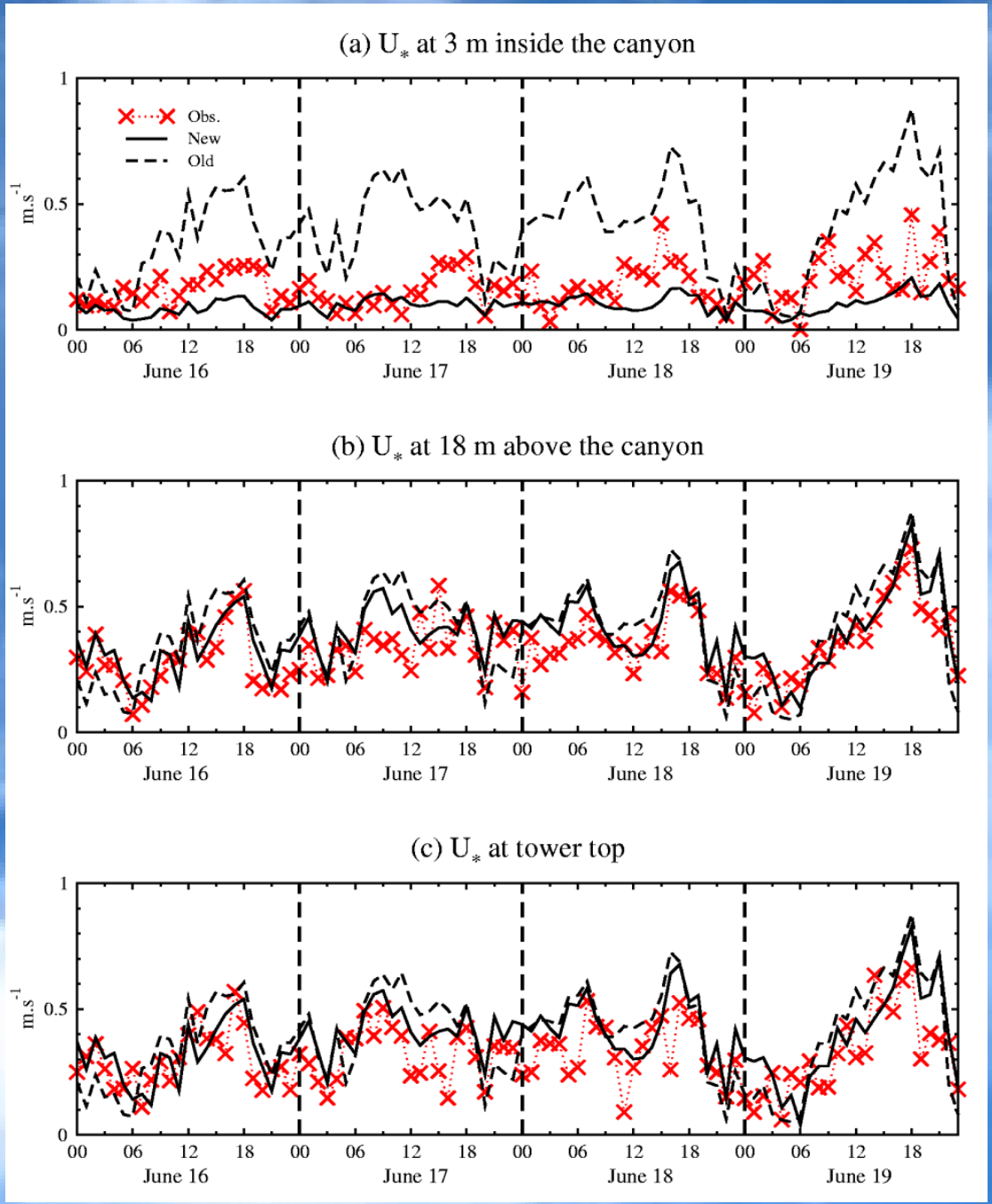




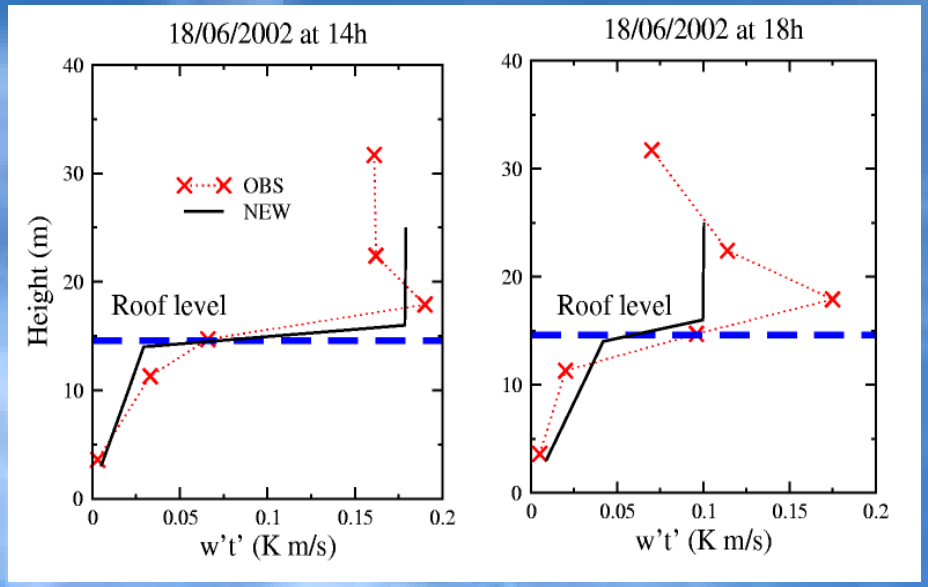
Results: momentum exchange

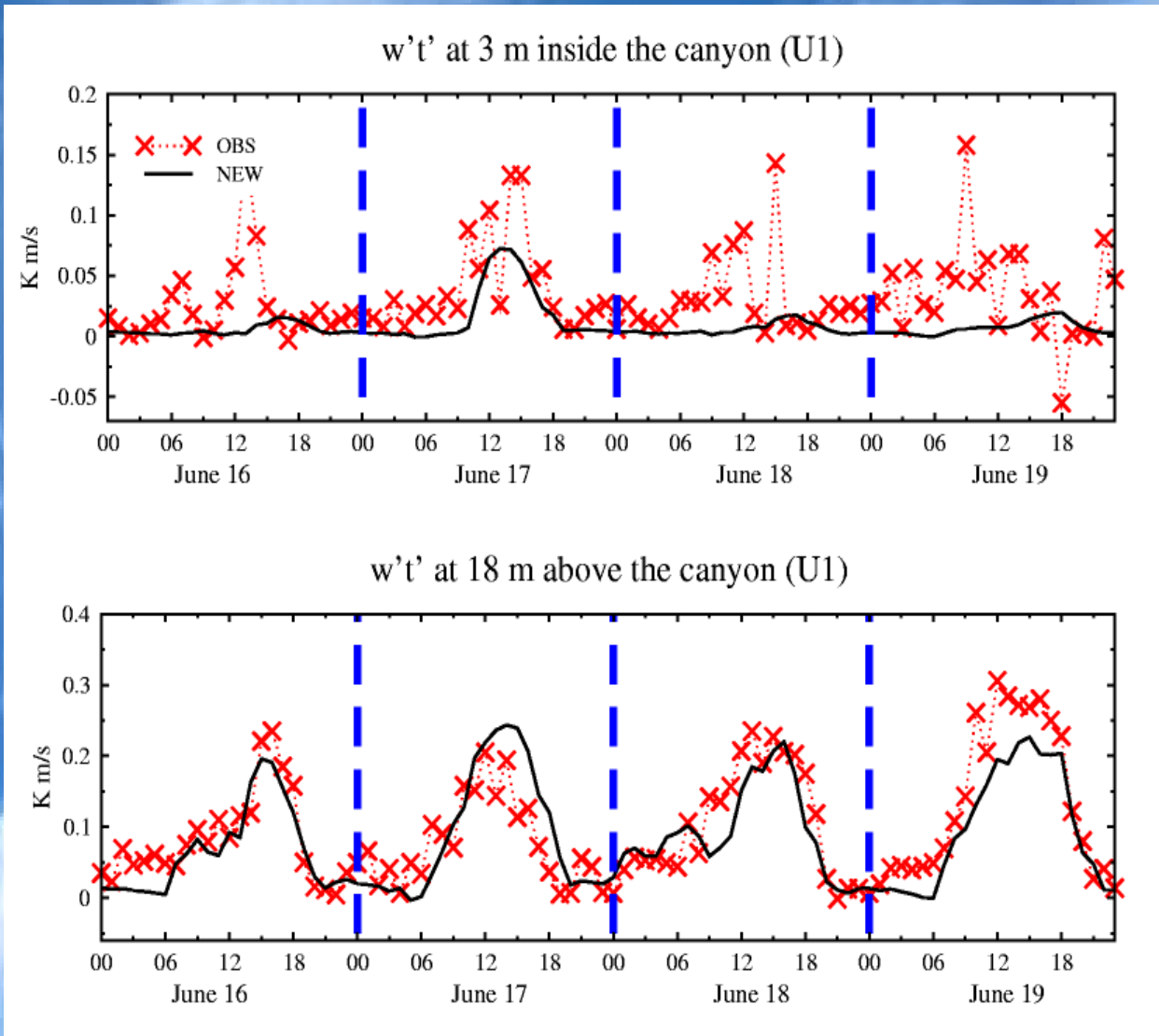
$$U_* = \left(\overline{w'u'}^2 + \overline{w'v'}^2\right)^{\frac{1}{4}}$$



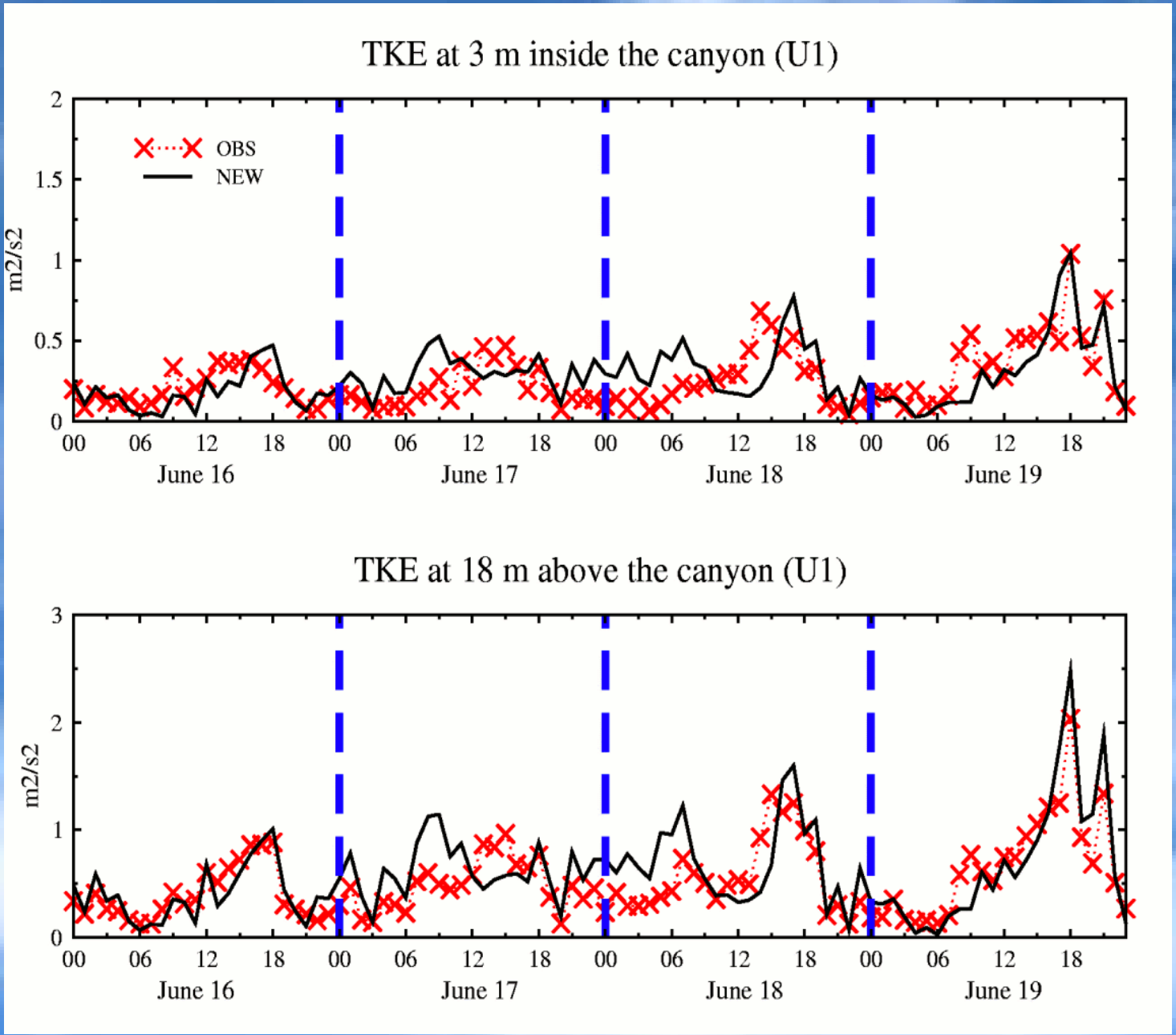


Results: turbulent exchange of heat

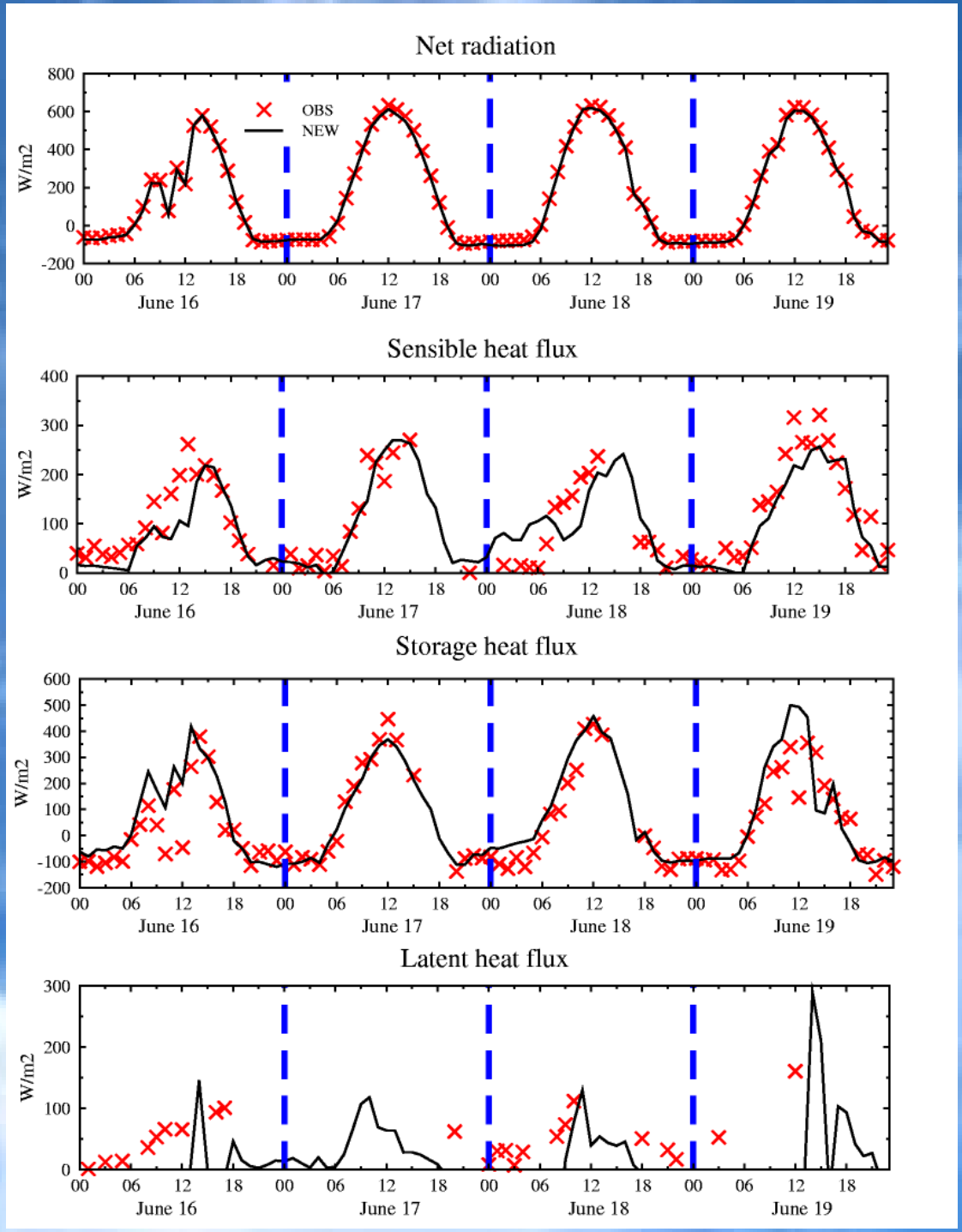




Results: turbulent kinetic energy



Results: energy balance at the top of the canyon



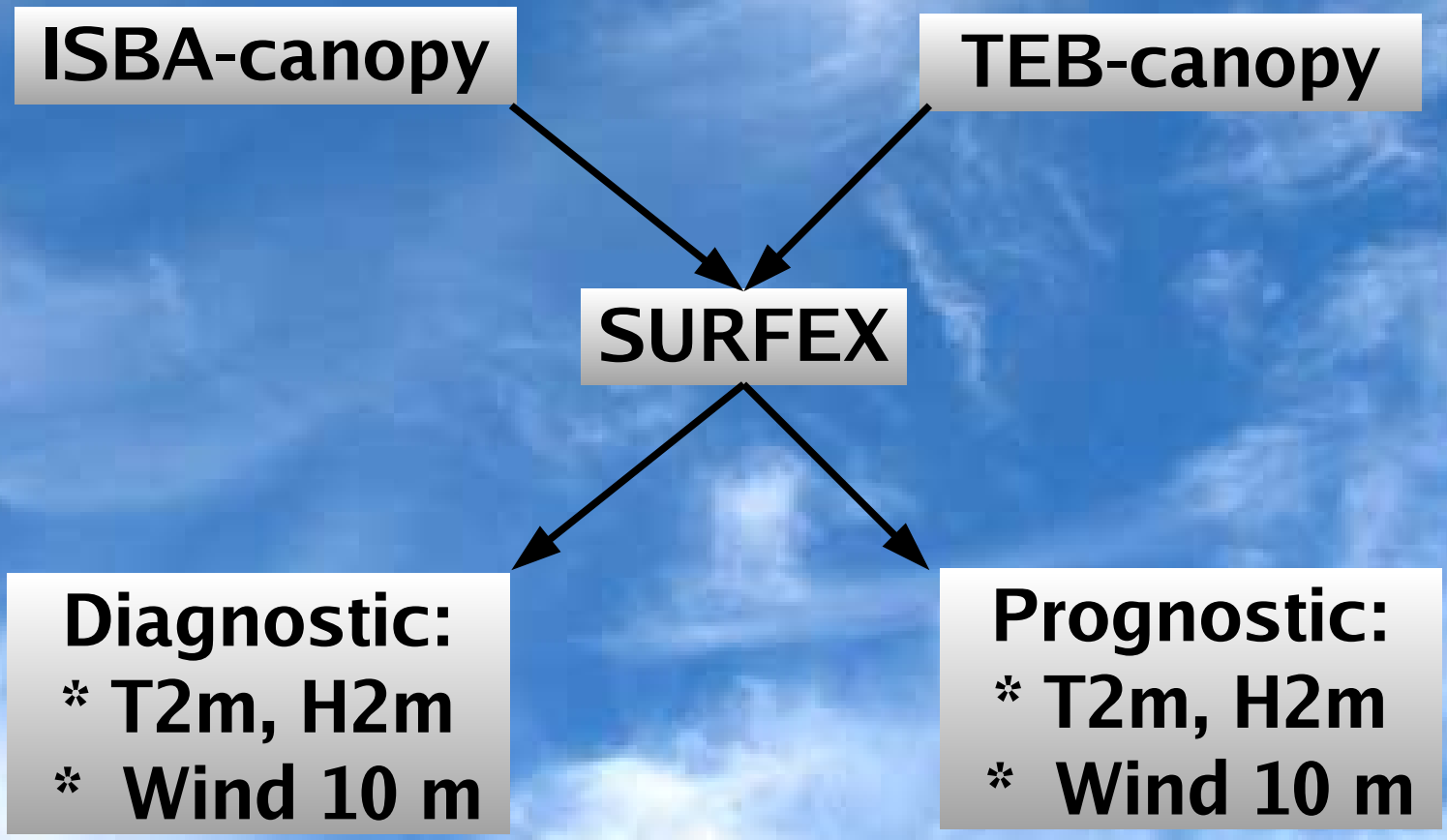
Conclusion

Bias = New(Ori)-Obs ; RMSE is the root-mean-square error.

	U($m.s^{-1}$)			T (°C)			U_* ($m.s^{-1}$)			Q_H ($W.m^{-2}$)
Level (m)	3	11.3	18	2.5	14	18	3	18	31.5	31.7
Obs	0.83	0.80	1.31	27.14	26.01	26.18	0.16	0.33	0.33	86.18
New	0.63	0.87	1.42	26.73	26.52	26.35	0.10	0.39	0.39	78.00
Ori	---	0.74	---	26.70	26.70	---	0.39	0.39	0.39	122.8
Bias-New	-0.20	0.08	0.11	-0.40	0.50	0.17	-0.06	0.06	0.06	**-8.00**
Bias-Ori	---	-0.06	---	-0.43	0.68	---	0.23	0.06	0.06	**36.60**
RMSE-New	0.35	**0.40**	0.48	**0.55**	**0.58**	0.28	**0.09**	0.10	0.12	**47.56**
RMSE-Ori	---	**0.56**	---	**0.73**	**0.90**	---	**0.27**	0.13	0.16	**60.00**

Perspectives

* Validation over a long period (1 year) and for others urban sites.



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ADAPTATION

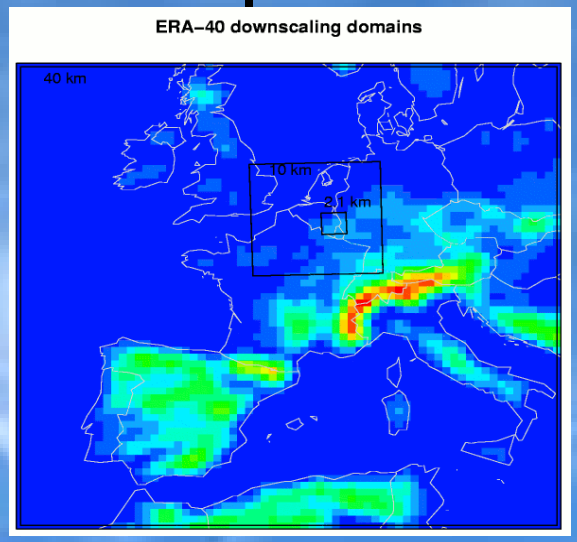
DOWNSCALING

FULLPOS

ECOCLIMAP

ERA40 → 10 km resolution over Belgium → Atmospheric forcing at 50 m T, P, Hu, Wind, Precipitation, downward Radiation → SURFEX (off-line)

SURFEX (off-line) → T2m, H2m wind10m

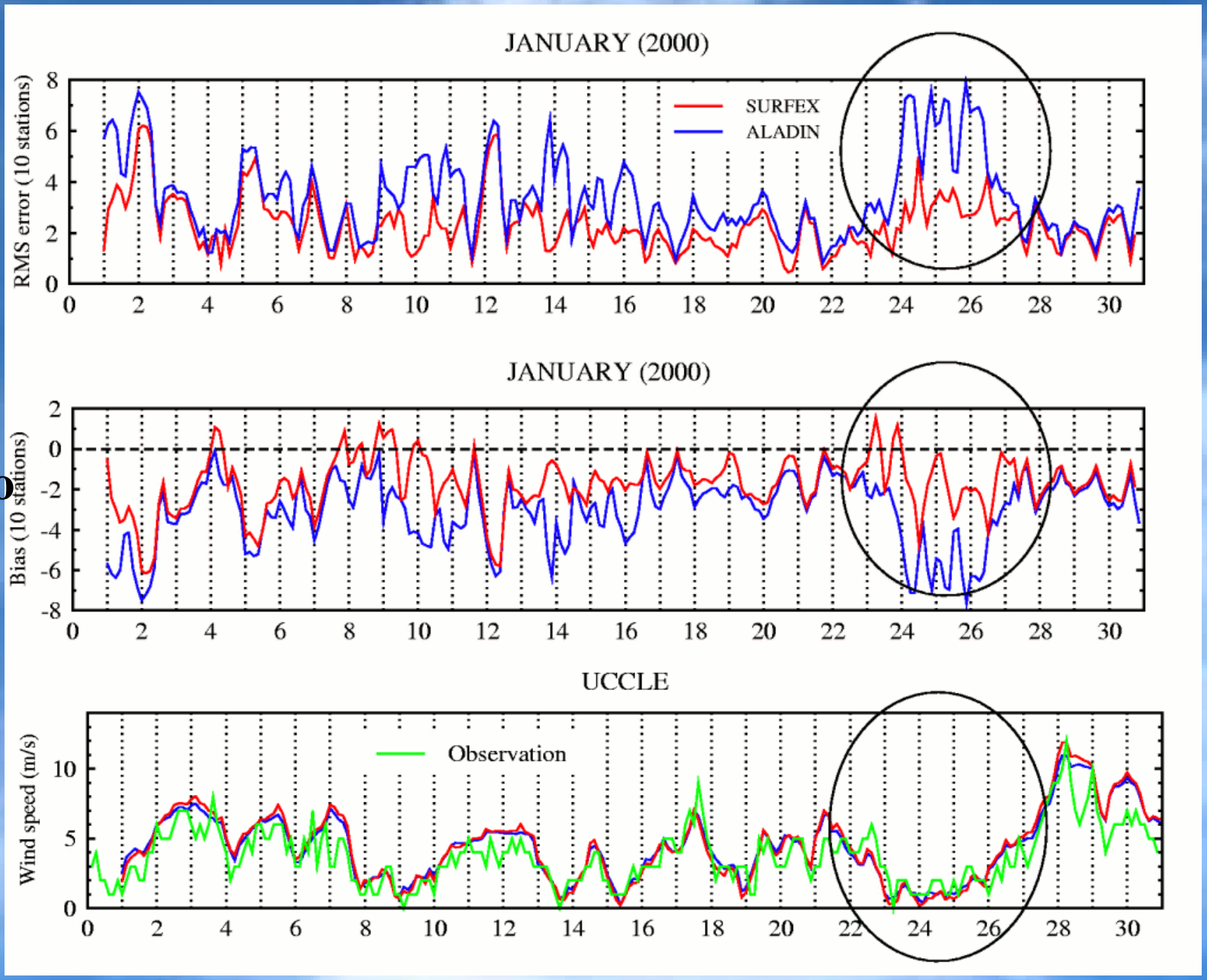


T2m

SURFEX decreases the RMS-error

ALADIN 2m T are too low

Anticyclonic situation with very weak wind



The same result is found for winter 2001