EVALUATION OF RAMS6.0 BOUNDARY-LAYER SIMULATION OVER SOFIA (BULGARIA) ON VERTICAL PROFILES OF THE ABL

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Configurations of RAMS6.0 used:

Case 1: 3 nested domains with grid size 25, 5 and 1 km
62, 132 and 202 grid points correspondingly,
42 vertical levels starting at 50 m and increase factor of 1.15 for the vertical resolution,
Time step of 30 seconds on the first domain and ratio 1, 5, 3,
The centre of the domain - in the plains about 250 km east of Sofia,
Simulation for 6 days in a row was performed.

Case 2: 3 nested domains with grid size 25, 5 and 1 km
42, 132 and 252 grid points correspondingly,
56 vertical levels starting at 10 m and increase factor of 1.15 for the vertical resolution,
Time step of 10 seconds for the outer domain and ratio 1, 5, 4 for the inner domains.
The centre of the domain was Sofia.
At this configuration the model was getting unstable after simulation of one or two days.

THE EXPERIMENTAL DATA

The Sofia Experiment of 2003 (Batchvarova et al, 2007) was a boundary layer experiment comprising:

•turbulence measurements at 20 and 40 m above ground on a meteorological tower (METEK sonic anemometers) and

•consecutive (every 2 hours) high resolution radio soundings performed with VAISALA equipment for standard aerological observations, but keeping much lower ascend velocity (about 3 m s^{-1}).

The radiosonde measurements were performed between 27 September and 3 October 2003. During most of those days clear convective boundary layers have formed and the measurements allowed following the convective boundary layer growth.

EVALUATION METHOD

Sreenivasan et al. (1978) suggest an applied method for estimation of the standard deviation of the wind speed and the sensible heat flux for a given averaging time, T:

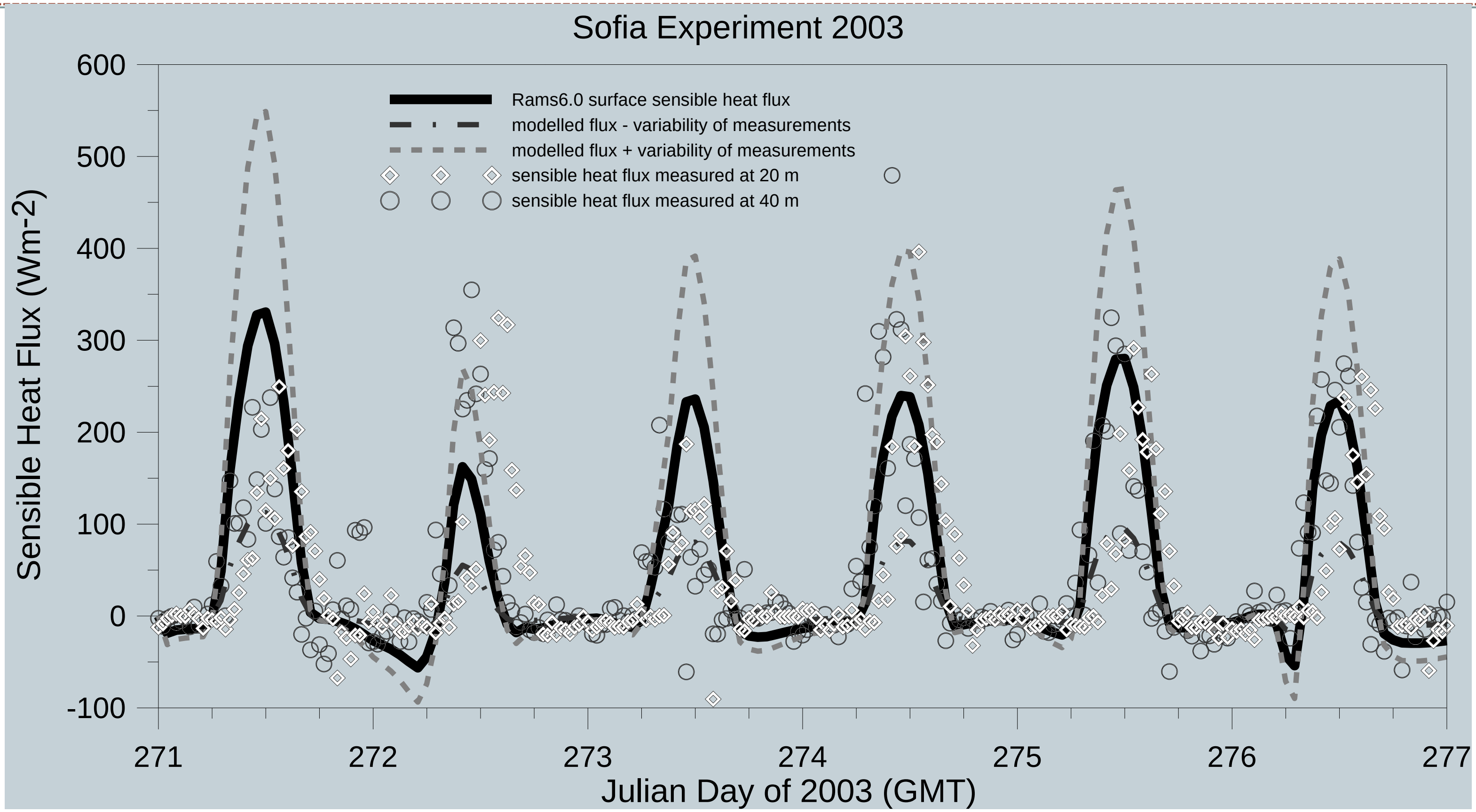
$$\sigma_{u,T} = \sqrt{12}\ \sqrt{\frac{z}{T\,u}}\ u \qquad (1)$$

and

$$\sigma_{\overline{w'\theta'},T} = 8\ \sqrt{\frac{z}{T\,u}}\ \overline{w'\theta'}\,. \qquad (2)$$

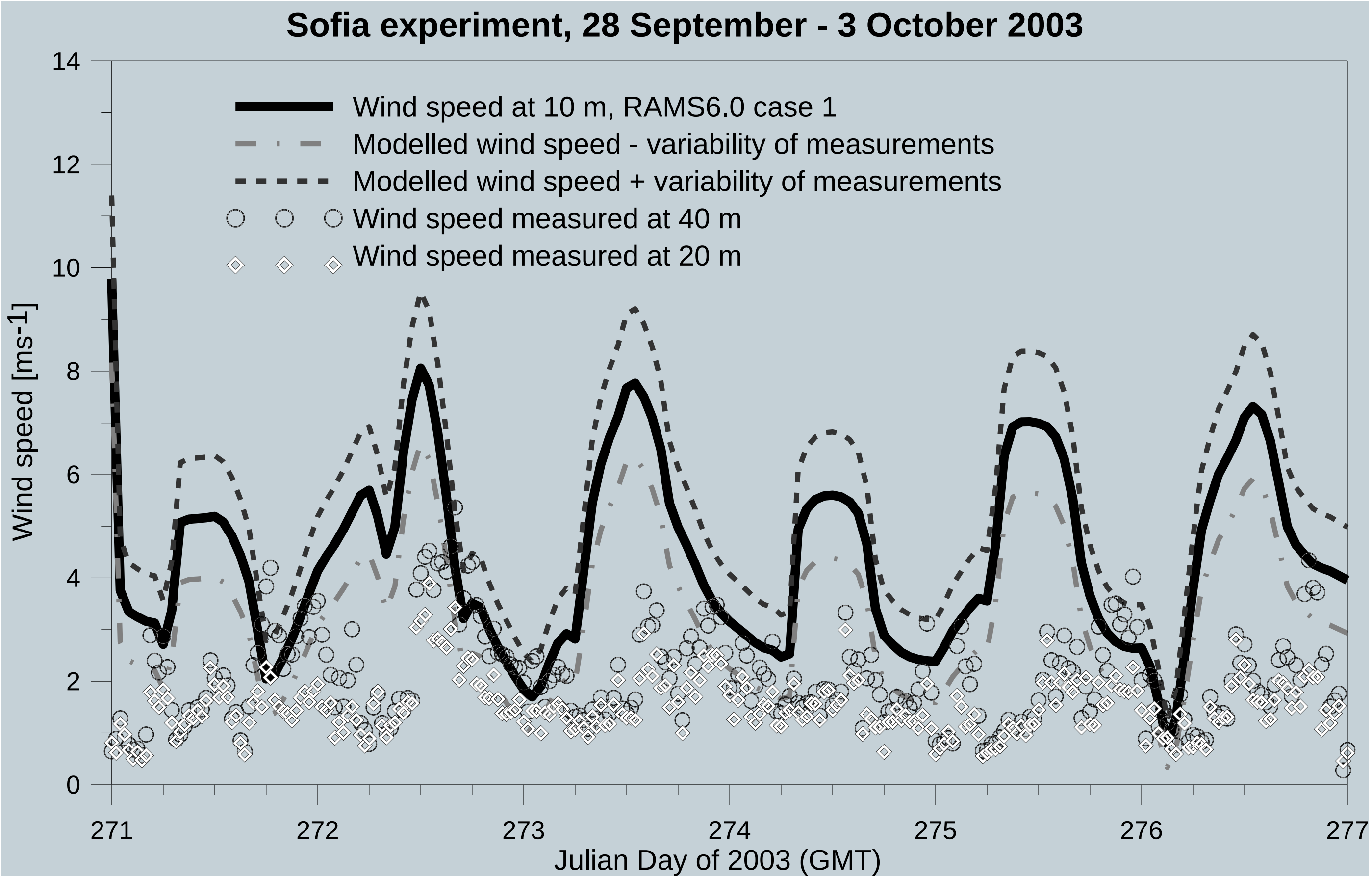
The standard deviation $\sigma_{u,T}$ increases with height, z, and wind speed, u, and decreases with averaging time. The standard deviation $\sigma_{\overline{w'\theta'},T}$ increases with height and sensible heat flux, $\overline{w'\theta'}$, and decreases with averaging time and wind speed, (Batchvarova and Gryning, 2009).

When the standard deviations $\sigma_{u,T}$ and $\sigma_{\overline{w'\theta'},T}$ are calculated using the actual averaging time for measurements and an interval is applied correspondingly around the model results, a range of possible values is defined. When measured values fall within the interval, we may conclude that the model prediction is successful.



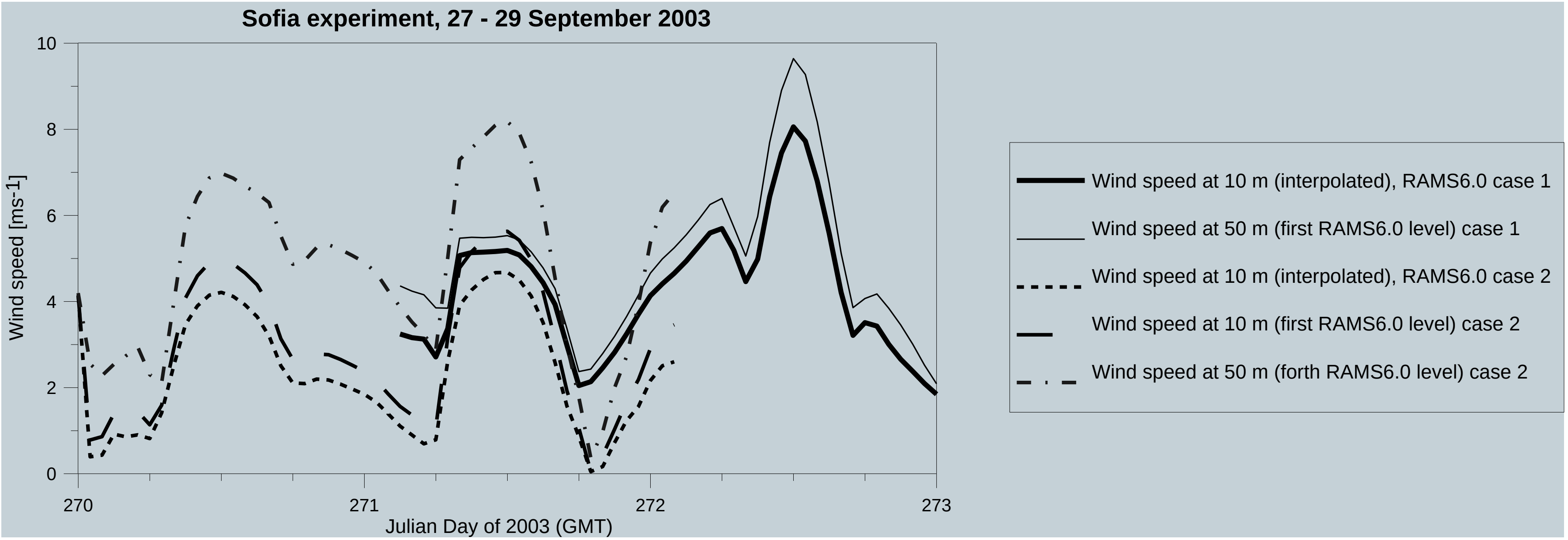
Surface sensible heat flux for the period 28 September – 3 October 2003 of Sofia Experiment. RAMS6.0 case 1 results for 5 km horizontal resolution (thick black line), variability of measurements according Equation 2 between dash-dotted and dashed lines, eddy correlation measurements at 20 m (diamonds) and 40 m (circles) height.

In Case 1 RAMS6.0 simulation of the surface sensible heat flux can hardly be improved.



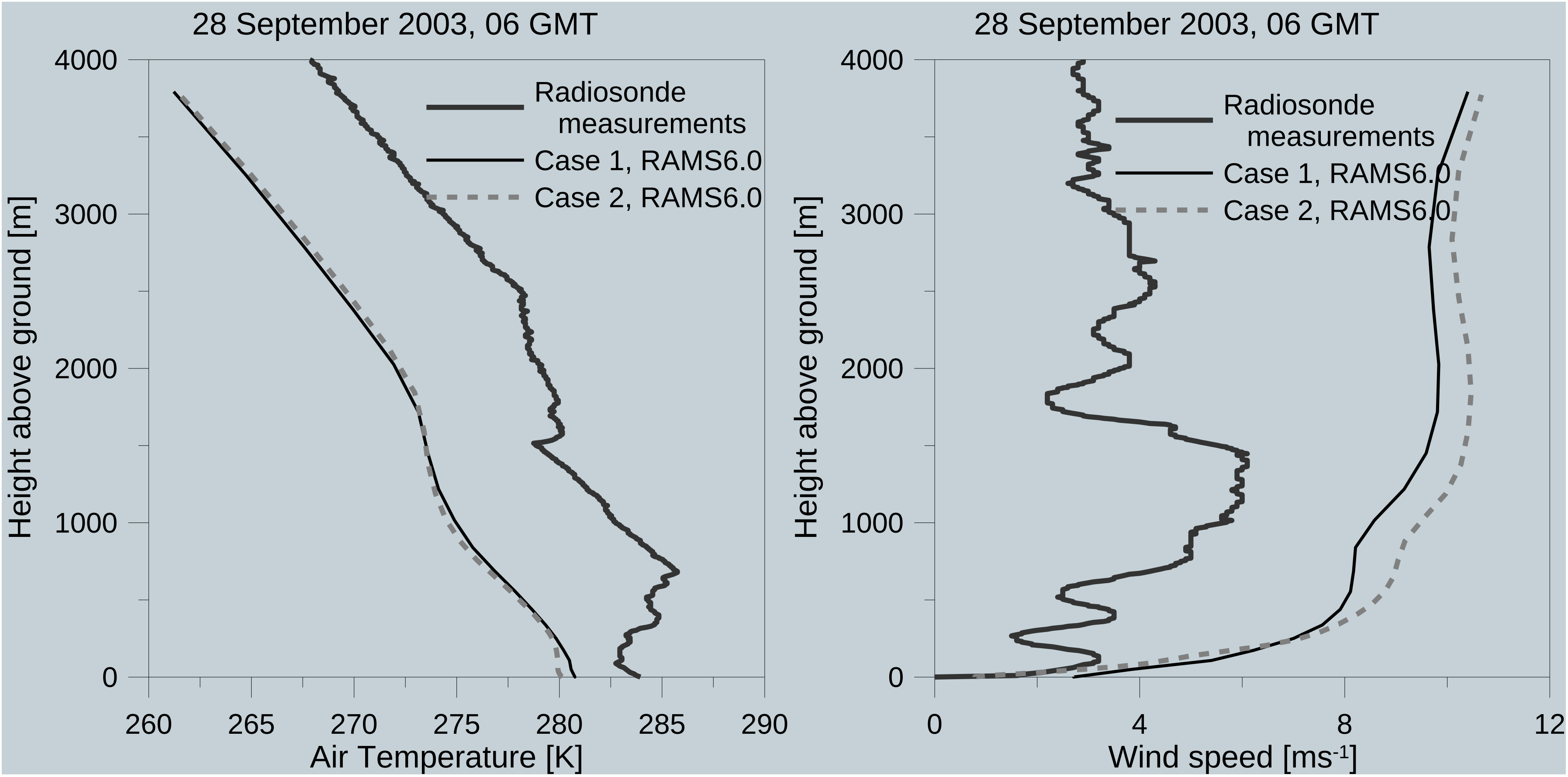
Wind speed for the period 28 September – 3 October 2003 of Sofia Experiment. Wind speed interpolation to 10 m from RAMS6.0 case 1 (thick black line). Variability of measurements (according Equation 1) between grey dash-dotted and dashed lines. Wind speed from eddy correlation measurements at heights of 20 m (diamonds) and 40 m (circles).

RAMS6.0 over predicts surface the 10 m wind speed.

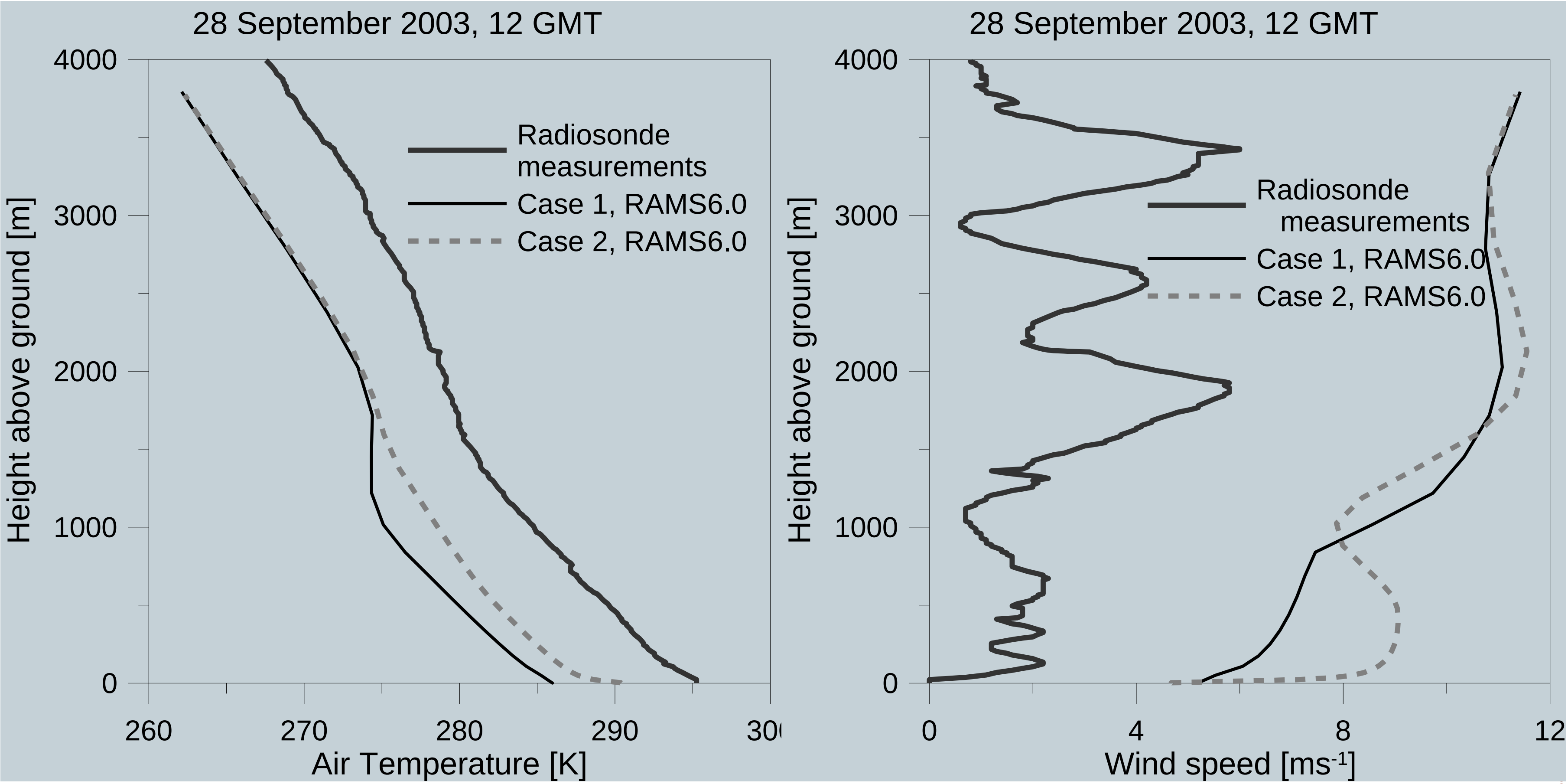


Wind speed for the period 27 – 29 September 2003 of Sofia Experiment. Wind speed interpolation at 10 m from RAMS6.0 case 1 (thick black line) and case 2 (short dashed line) for 5 km horizontal resolution. First model level wind speed in case 2 (10 m, long dashed line). Wind speed at 50 m from direct model outputs for case 1 (thin black line) and case 2 (dash dotted line).

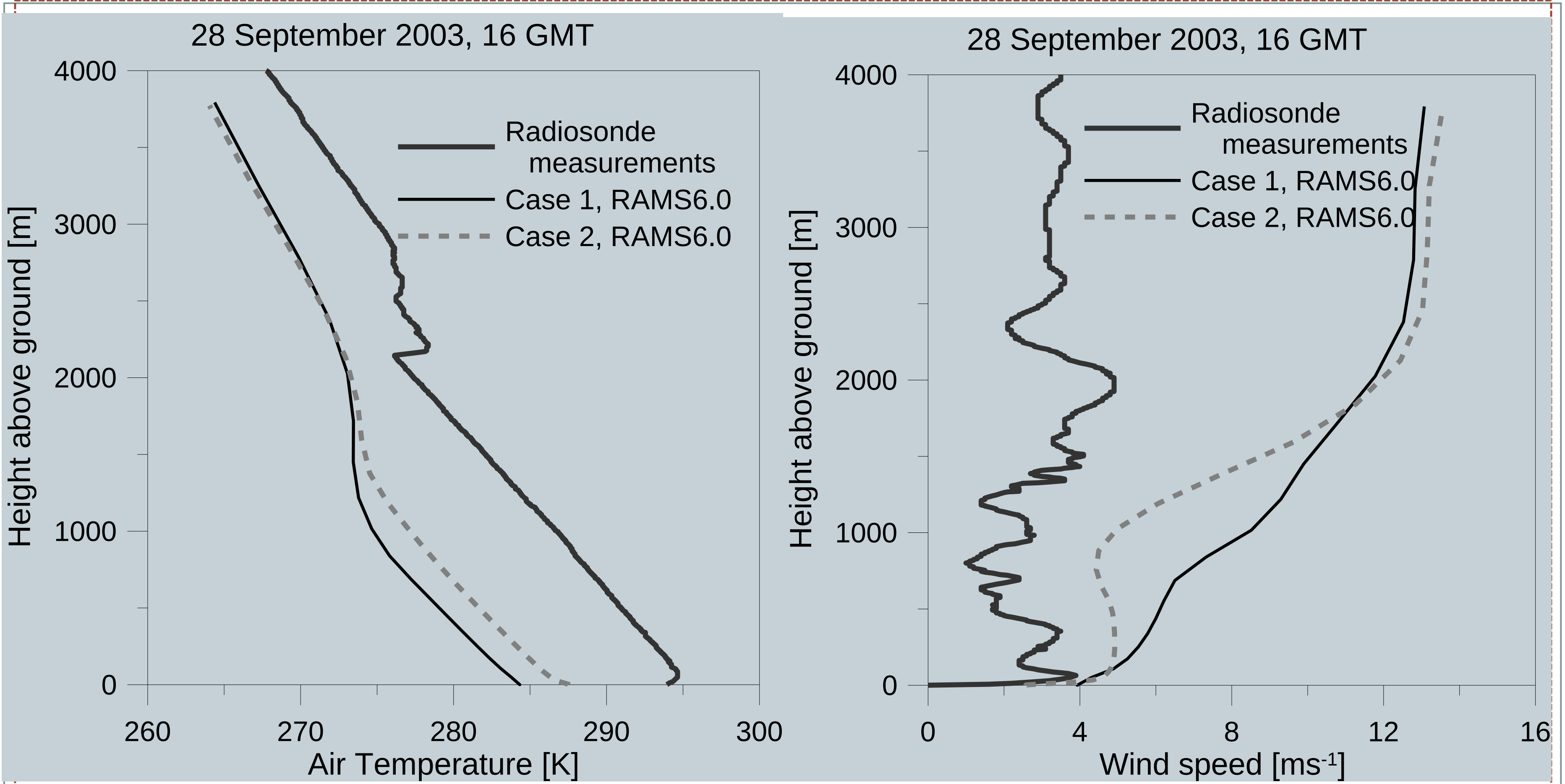
Comparing only model predictions in Figure 3, shows that the first model level (50 m) wind speed is slightly higher than the estimated by RAMS6.0 values of the 10-m wind (case 1). Setting the first model level very low (10 m) forces bigger differences between 10 m and 50 m wind speed (case 2).



Air Temperature and Wind speed profile at 6 GMT (9 local summer time) on 28 September 2003. High resolution (about 3-4 ms^{-1} ascend velocity) radiosonde measurements are represented with thick line, RAMS case 1 with thin black line and RAMS case 2 with grey dashed line.



Air Temperature and Wind speed profile at 12 GMT (15 local summer time) on 28 September 2003. High resolution (about 3-4 ms^{-1} ascend velocity) radiosonde measurements are represented with thick line, RAMS case 1 with thin black line and RAMS case 2 with grey dashed line.



Air Temperature and Wind speed profile at 16 GMT (19 local summer time) on 28 September 2003. High resolution (about 3-4 ms^{-1} ascend velocity) radiosonde measurements are represented with thick line, RAMS case 1 with thin black line and RAMS case 2 with grey dashed line.

CONCLUDING REMARKS

•The predictions of RAMS6.0 for the surface heat flux are in good agreement with measurements during the Sofia 2003 Experiment, while the wind speed near the surface is largely over predicted and temperature under predicted. Such performance for wind speed is typical in regions with complex terrain.

•The wind and temperature profiles are not satisfactory modelled which results in difficulties of estimation the atmospheric boundary layer height and mixing parameters.

•The results show also that even well validated over complex terrain models when applied for "new" complex terrain conditions, do not ensure a success.

•Measurements for model initial conditions, data assimilation and model validation are needed for all applications of mesoscale models.

•Regular profile measurements are needed for all meteorological parameters (and possibly air pollution) in order to meet the increased requirements of society for more reliable forecasts of weather and air pollution, and all types of assessment studies.

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Thank you for your attention!