Atmos. Chem. Phys. Discuss., 11, C8114–C8119, 2011
www.atmos-chem-phys-discuss.net/11/C8114/2011/

Atmospheric Chemistry and Physics Discussions

Interactive comment on "On the segregation of chemical species in a clear boundary layer over heterogeneous land surfaces" *by* H. G. Ouwersloot et al.

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Received and published: 23 August 2011

We thank Referee #1 for his/her interesting comments. The referee recommends including observational evidence to support some of the numerical findings. We agree that this would be desirable, but to our knowledge no observational data is available that could be directly compared to our results. Obtaining observational evidence is complicated by the requirements for observing the treated effects and relating them to the surface conditions. For example, if the length scale of surface heterogeneity is longer than 16 times the boundary layer height, the boundary layers over the forest and savannah will be decoupled and the transport of air between the regions is reduced.

In observations, also external influences play a role that make it hard to identify the effects. Therefore, we base our research strategy on numerical experiments with a Large Eddy Simulation model to study the processes driving the intensity of segregation. As such, the findings presented in the paper can be used in the future to help in the analysis of observations and to define field measurement campaigns. Even though no direct validation was possible, there are some indications that support our results. Below, we provide a short summary.

Referee #1 mentioned the high concentrations of isoprene above the savannah landscape for $2 < \frac{\lambda}{h_{BL}} < 16$. We find a first indication in Figure 4a of Garcia-Carreras et al. (JGR, 2010). To better visualize this relatively high isoprene, note that the shift in isoprene concentrations in optimal conditions (no wind blowing across the borders between land types) only occurs for length scales less than 16 times the boundary layer height. This corresponds to approximately 25 km or 0.25°. Near 9.75° latitude a sequence is visible with relatively high – lower – high forest cover that has a corresponding length scale. In the same region where the forest cover is lower, the isoprene concentration is higher and characterized by a local maximum. We emphasize that these measurements are performed at a height of 190 m. As shown in Figure 1 of this response, at this height the differences between forest and savannah in the LES results are very small, even though at greater heights the isoprene concentration over the savannah is higher than over the forest. The numerical experiments show that a description of the boundary layer average concentrations requires observations at higher heights.

Secondly, independent research with a different Large Eddy Simulation model has shown the same kind of transport from long lived species that are emitted at the surface. For example, Auger and Legras (Atmos. Environ., 2007) note that "*slowly varying species like VOC which are emitted at ground level are concentrated in the updrafts and more diluted elsewhere.*"

A recommendation will be added in the manuscript to obtain new observational evidence that can verify the results obtained from numerical experiments.

More specific comments

We agree with the referee's comment on the abstract. The Large Eddy Simulation model will be introduced at the beginning of the abstract to clarify our method and research strategy. Also the specification of the applied surface heterogeneity will be given before listing the obtained values of I_S.

A visualization of the boundary layer for larger length scales will be included to show the formation of separated boundary layers (Fig. 2 of this response). To limit the amount of figures, we will show 4 panels with cross sections and vertical profiles of respectively the potential temperature, the specific humidity, the isoprene concentration and the hydroxyl radical concentration for the case with $\lambda \approx 32\ h_{BL}$.

In relation to the comment on the role of the atmospheric surface layer, we mention that this study focuses on the properties of the bulk of the boundary layer, though we recognize that the effects on the surface layer are of great importance. Therefore, to present a more complete overview of the concentrations at different heights, we will include a new figure which shows the concentration of isoprene as a function of $\frac{x}{\lambda}$ at different heights (Fig. 1 of this response). The figure includes the cases HOM and HET.

Technical corrections

The use of $1 + I_S$ at line 11 on page 18944 is deliberately. Equation (10) shows how the average chemical reaction rate is related to the concentrations and this term.

The difference between the total intensity of segregation and the horizontal intensity of segregation in the bulk of the boundary layer is indeed not striking by looking at Figure 5. However, in the bulk of the boundary layer the blue dotted line is positioned left from the line representing the horizontal segregation, especially in panel (b). The main message is that these values for I_S are not interchangeable. Since we are only interested in boundary layer averaged values and not in horizontal segregation, the

exact difference is irrelevant.

The confusion about the location of the shallower boundary layer in Figure 2 is likely caused by the two different methods to determine the boundary layer height. The red line represents the boundary layer height as determined by the original maximum gradient method. This method leads to noise over the forest due to the problems discussed in Section 2.3.1. The blue line is a more 'stable' determination of the boundary layer height and shows that also during the first hour the boundary layer is shallower over the forest than over the savannah. Therefore, no changes are made to Figure 2.

The wind vectors in Figure 3 (a) are indeed hard to distinguish, because there is relatively low wind in this case and certainly no organized circulations. The (irregular) wind vectors could be presented more clearly, but in that case the scale of the vectors in panel (a) and (b) would differ. This would hinder the intent of the vectors: showing the mesoscale circulations for case HET and the lack of induced flow for case HOM. Therefore, we intend to maintain this figure.

All other technical corrections have been applied as proposed by Referee #1.

Interactive comment on Atmos. Chem. Phys. Discuss., 11, 18927, 2011.

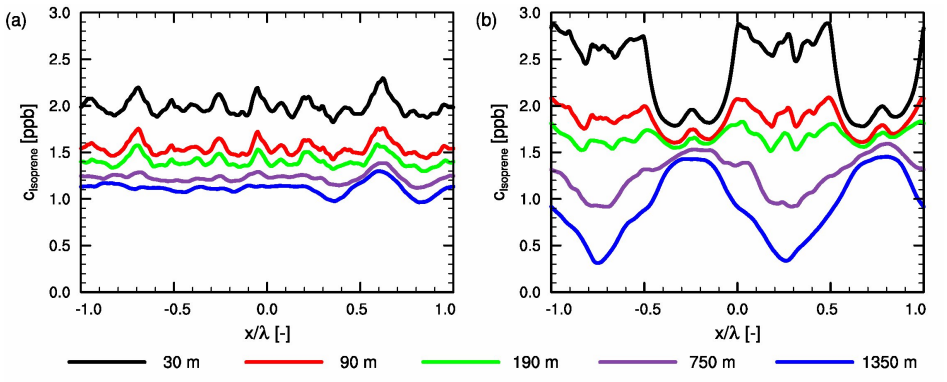

Fig. 1. Isoprene concentrations for the homogeneous case (a) and the heterogeneous case (b) at different heights. The x-coordinate is scaled by the length scale of heterogeneity, ...

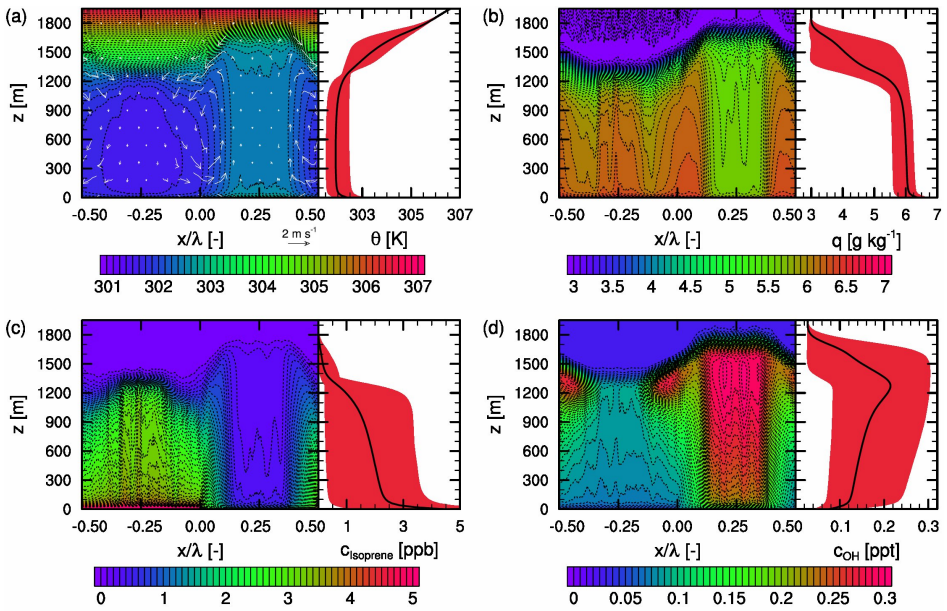

Fig. 2. The potential temperature (a), specific humidity (b), isoprene concentration (c) and OH concentration (d) for the fourth hour of numerical experiment LSB2. The length scale ...