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Atmospheric Chemistry and Physics Discussions

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Interactive Comment

Interactive comment on "The von Kármán constant retrieved from CASE-97 dataset using a variational method" *by* Y. Zhang et al.

Y. Zhang et al.

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First of all, we would like to thank the reviewer for his / her comments and suggestions. In response to the reviewer's comments, we have made relevant revisions on the manuscript. Listed below are answers and changes made to the manuscript according to the questions and suggestions given by the reviewer. The original comments and questions from the reviewer are listed on the first follow by our responses.

Could it be possible that after all k is in fact constant, and the variation stems from the measurement inaccuracies or the incomplete theory/model, where the variation of some other variables or some “unknown”, generally minor phenomena, are not taken into account?; I am not sceptical that k would be a changing variable but I would like to see the authors’ more strong statement on this; the possible invalidity of M-O theory under highly stable and unstable conditions is discussed but could it be possible that there is still even something else or if we had a corrected M-O theory the k would be constant? - l. 159: LE was computed from the energy budget method; how accurate is this concerning that there exists generally the known mismatch between net radiation and turbulent fluxes in a way that often the sum of fluxes are only 80% - 90% of the net radiation, over long averaging periods when storages should be negligible; may this affect somehow on the analysis in the paper? - How sensitive are the results for the mathematical form of Eqs. 5a – 6b; these forms are quite standard ones but sometimes a bit different formulas are also used - I would omit Table 1 and give the information only in the main text: different min and max limits of used weights of constraints and report the variation/max-min limits of the resulting k values - I would omit Fig. 3

The von Kármán constant was firstly introduced and defined in scaling wind profiles in the neutral boundary-layer as a constant. Our study did confirm the constant value of k = 0.4 under the neutral condition. While the flux-gradient relationship is extended to non-neutral stratifications, k value would vary in M-O theory. Changes in k value with stability has been also detected in Andreas et al.'s evaluations of the von Kármán constant using the measured data over Arctic sea ice (see ref.). Though these data were collected under much more neutral conditions, their results are quite similar to our figure 2, showing the decreasing of k values from stable to unstable conditions. As a response to the reviser's question, following Andreas et al (2006), a stratification correction is made to the variational calculated k values. This yields a mean value of the von Kármán constant at 0.401. This value is the same as the k value in the neutral stability. This point has been added in the revised paper.

The measurement errors were considered in the variational computation by introducing the dimensionless weights for wind, air temperature and humidity profiles in the cost function Eq. (1), defined to be inversely proportional to their respective observation error variances. This is one of advantages of the variational technique. After relaxing the constraint $0.35 <= k <= 0.45$ imposed to the variational calculation, we obtain a k

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value at 0.384. Thus the variational computed k value with and without the constraint ranges from 0.384 to 0.390, just within the error range of Andreas et al's (2006) value at 0.387 +- 0.003. This point has been added to the revised paper

There are likely other factors that affect the determination of the von Kármán constant, e.g., the mismatch between net radiation and turbulent fluxes, as the reviewer indicated. In the present study, the physical constraints in the cost function (Eq. (1)) are expressed by the Monin-Obukhov similarity relationships from which the von Kármán constant is retrieved. Therefore, uncertainties in the MOST in estimation of profiles of wind, air temperature and humidity as well as momentum and heat fluxes, especially under very stable and strong convection conditions, would inevitably yield errors in the evaluation of the von Kármán constant. On the other hand, given that the advantage of the variational method is that it is able to fully take into account information of the existing MOST and measured meteorological conditions over an underlying surface, the variational method has led to substantial improvements over the conventional MOST-based flux-gradient method (Cao and Ma, 2005, Cao et al., 2006, see Ref). We would expect that the variational estimated  values would be more accurate than that derived from the conventional method. These statements have been added in the revised manuscript. We further estimated the statistical difference between variational computed  values and the  value at 0.4, which is determined using a t-test. Based on the calculation, the statistic t under the null hypothesis Ho,is equal to 6.27 (> t0.005/2 = 2.6) with the statistically significant level of 99.5%. This suggests that the statistical difference between  values at 0.39 and 0.4 is significant. These statements have been added to the revised manuscript.

We still keep Table 1 in the revised manuscript. The von Kármán constant was introduced in early time as a scaling factor to scale the logarithmic law of mean wind profile, and subsequently extended to scale the mean temperature and humidity profile. The results listed in table 1 confirm that the scaling factor k can be applied in all logarithmic laws for u, T and q. Fig. 3 in the original version of the paper in ACPD is omitted

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following the reviewe's suggestion. A new figure 3 has been added as a response to other reviewers.

Minor/Technical - l. 152: I think 2.95 m is too accurate, it should be 3.0 m; also 1 and 2 m should 1.0 and 2.0 m

Done!

- l. 158: 1-D sonic anemometer?; I guess it should be 3-D

It is CSI 1-D sonic anemometer as described by Dr. Russell J. Qualls at http://data.eol.ucar.edu/datafile/nph-get/20.05/qualls_readme

- l. 347: how were sensible heat fluxes computed?

The way to calculated sensible heat flux has been defined and described in the revised paper.

Table 1 and Fig. 1: why Fig. 1a gives 0.42 for k while Table 1 gives 0.41?

K values shown in Fig. 1 used the constraint of $0.35 <= k <= 0.45$, whereas Table 1 used a constraint of $0.35 <= k <= 0.42$. To be consistent with Fig. 1, revision was made. The revised table 1 used the same constraint as that in Fig. 1.

- Fig. 4: what is the fundamental reason that two quarters (upper right and lower left) are empty? Can it be seen easily for example from theory?

The results presented in Fig. 4b are, in fact, consistent with Fig. 2 and the finding described in the manuscript. Namely, k is greater than 0.4 under stable conditions and smaller than 0.4 under unstable conditions. This point has been added to the revised manuscript.

Interactive comment on Atmos. Chem. Phys. Discuss., 8, 13667, 2008.

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