Atmos. Chem. Phys. Discuss., 8, S6655–S6659, 2008
www.atmos-chem-phys-discuss.net/8/S6655/2008/

Atmospheric Chemistry and Physics Discussions

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

T. Foken

thomas.foken@uni-bayreuth.de

Received and published: 3 September 2008

The flux-gradient similarity according to the Monin-Obukhov similarity theory depends on parameters which must be determined experimentally. These are the von-Kármán-constant and the coefficients of the universal function and, in the case of the sensible and latent heat flux, the turbulent Prandtl and Schmidt numbers, respectively. The normal way to determine these parameters is firstly to use near neutral cases of the momentum flux to determine the von-Kármán-constant, and secondly to use near neutral cases of the sensible and latent heat flux to determine the turbulent Prandtl and Schmidt numbers. The third step is to use data of all stratifications to determine the coefficients of the universal function. The authors have done this the opposite way. They assumed correct coefficients of the universal function and determined errors in the

von-Kármán-constant. The turbulent Prandtl and Schmidt numbers are ignored, while Businger et al. (1971) determined a turbulent Prandtl number of 0.74 (Foken, 2006). This can be done when the numbers are included in the universal function (Högström, 1988), but this was not done.

It is not understandable why the authors used, from the large amount of universal functions (Foken, 2008b; Högström, 1988) available, the universal function by Businger et al. (1971) with a von-Kármán-constant of 0.35, which was determined under non-ideal measuring conditions (Wieringa, 1980; Wyngaard et al., 1982) and was corrected by Högström (1988). The authors incorrectly tested their method with an independent universal function by Wieringa (1980), because this is the same function but re-determined with another von-Kármán-constant of 0.41.

The CASES-97 (Poulos et al., 2002) data set is, of course, one of the best of the last decade, but to use only two levels is not adequate. The ratio of the measuring heights (2 and 1 m) is much too low to determine gradients in the surface layer with a high accuracy (Foken, 2008b). Furthermore the lowest level can always be influenced by the roughness sublayer. This can only be checked if one has a profile with at least 4-5 levels. Furthermore any information about the canopy, the zero-plane displacement and the roughness height are missing. Therefore systematic errors can be assumed.

It is not possible to determine the latent heat flux from an energy balance calculation, because of the "unclosed" energy balance at the surface (Foken, 2008a). Furthermore the radiation sensors used are probably not of a high accuracy (Kohsiek et al., 2007). The input data for the latent heat flux have an error of at least 20 %.

Measurements under stable stratification need a very carefully conducted data analysis because of, for example, intermittencies or decoupling. Often a local Obukhov length must be used, and not the Obukhov length. For details about the determination of universal functions under these conditions see Handorf et al. (1999), Andreas et al. (2006; 2005) and others. Generally nothing is said about a data selection according to

the fulfilment of turbulent conditions (Foken and Wichura, 1996).

Högström (1996) found, after an very careful analysis of universal functions, that their accuracy for a given von-Kármán-constant of about 0.40 is, in a range of not very strong stable and unstable stratification, about 10-20 %. The authors found, for the opposite method of calculations for more neutral conditions, the same error. Therefore the results are absolutly not new, are based only on the Kansas experiment (Izumi, 1971) and ignore many other experiments, and the method of calculation has many weaknesses. It may be interesting to use the variational method for different examples, which you have already done, but the determination of the von-Kármán-constant is probably not the best example.

Minor remarks: What the authors call a universal function is the integrated form. This integration of the Dyer-Businger-type of universal functions was firstly done by Paulson (1970).

References:

Andreas, E.L., Claffey, K.J., Jordan, A., Fairall, C.W., Guest, P.S., Persson, P.O.G., and Grachev, A.A.: Evaluation of the von Kármán constant in the atmospheric surface layer. Journal of Fluid Mechanics, 559: 117-149, 2006.

Andreas, E.L., Jordan, R.E., and Makshtas, A.P.: Parametrizing turbulent exchange over sea ice: The ice station Weddell results. Boundary-Layer Meteorology, 114: 439-460, 2005.

Businger, J.A., Wyngaard, J.C., Izumi, Y., and Bradley, E.F.: Flux-profile relationships in the atmospheric surface layer. Journal of Atmospheric Sciences, 28: 181-189, 1971.

Foken, T.: 50 years of the Monin-Obukhov similarity theory. Boundary-Layer Meteorology, 119: 431-447, 2006.

Foken, T.: The energy balance closure problem - An overview. Ecological Applications, 18: 1351-1367, 2008a.

Foken, T.: Micrometeorology. Springer, Berlin, Heidelberg, 308 pp, 2008b.

Foken, T., and Wichura, B.: Tools for quality assessment of surface-based flux measurements. Agricultural and Forest Meteorology, 78: 83-105, 1996.

Handorf, D., Foken, T., and Kottmeier, C.: The stable atmospheric boundary layer over an Antarctic ice sheet. Boundary-Layer Meteorology, 91: 165-186, 1999.

Högström, U.: Non-dimensional wind and temperature profiles in the atmospheric surface layer: A re-evaluation. Boundary-Layer Meteorology, 42: 55-78, 1988.

Högström, U.: Review of some basic characteristics of the atmospheric surface layer. Boundary-Layer Meteorology, 78: 215-246, 1996.

Izumi, Y.: Kansas 1968 field program data report. Air Force Cambridge Research Papers, No. 379, Air Force Cambridge Research Laboratory, Bedford, MA, 1971.

Kohsiek, W., Liebethal, C., Foken, T., Vogt, R., Oncley, S.P., Bernhofer, C., and DeBruin, H.A.R.: The Energy Balance Experiment EBEX-2000. Part III: Behaviour and quality of radiation measurements. Boundary-Layer Meteorology, 123: 55-75, 2007.

Paulson, C.A.: The mathematical representation of wind speed and temperature profiles in the unstable atmospheric surface layer. Journal of Climate and Applied Meteorology, 9: 857-861, 1970.

Poulos, G.S., Blumen, W., Fritts, D.C., Lundquist, J.K., Sun, J., Burns, S.P., Nappo, C., Banta, R., Newsom, R., Cuxart, J., Terradellas, E., Balsley, B., and Jensen, M.: CASES-99: A comprehensive investigation of the stable nocturnal boundary layer. Bulletin of the American Meteorological Society, 83: 55-581, 2002.

Wieringa, J.: A revaluation of the Kansas mast influence on measurements of stress and cup anemometer overspeeding. Boundary-Layer Meteorology, 18: 411-430, 1980.

Wyngaard, J.C., Businger, J.A., Kaimal, J.C., and Larsen, S.E.: Comments on 'A revaluation of the Kansas mast influence on measurements of stress and cup anemometer

overspeeding'. Boundary-Layer Meteorology, 22: 245-250, 1982.

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