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Interactive comment on "An improved non-iterative surface layer flux scheme for atmospheric stable stratification condition" *by* Y. Li et al.

Anonymous Referee #2

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REVIEW

Title: An improved Non-Iterative Surface Layer Flux Scheme for Atmospheric Stable Stratification Condition; Authors: Y. Li, Z. Gao, D. Li, L. Wang, and H. Wang; Manuscript ID: GMD-2013-154; Journal: Geoscientific Model Development (GMD)

Summary:

In the study by Y. Li et al. an improved non-iterative parametrization for transfer coefficients for momentum and heat in the stable boundary layer (SBL) is presented. It is applicable for a wide range of aerodynamic and scalar roughness lengths including the effect of the roughness sublayer based on De Ridder (2010) approach. Authors use

universal profile functions derived for SBL by Cheng and Brutsaert (2005). This paper further develops Wouters et al. (2012) approach and proposes a group of equations instead only one equation used in Wouters et al. (2012). I think that the study has the right to life and it is potentially a useful complementary to the literature in boundary-layer parametrizations.

Recommendation:

The study proposed an updated parametrization scheme and manuscript is suitable for publication in the Geoscientific Model Development after some revision. My specific comments are listed below.

General comments:

(i) Authors have preferred universal profile functions for SBL proposed by Cheng and Brutsaert (2005) derived from CASES-99 data. Although this choice is not in doubt, more discussion on the recent approaches in this field is needed in the paper than is currently provided. A number of important references on the profile functions in the SBL highly relevant to the current study were missed. First, detailed review of the different non-linear similarity functions based on data collected in a variety of conditions can be found in Sharan and Kumar (2011). In particular, Grachev et al. (2007) and Sanz Rodrigo and Anderson (2013) proposed flux-profile relationships based on the measurements in Arctic and Antarctic (over more flat surfaces than Kansas in CASES-99). Moreover, Sorbjan (2010) and Sorbjan and Grachev (2010) discussed an alternative local scaling for the SBL when different universal functions plotted versus the gradient Richardson number instead of the Monin-Obukhov stability parameter (gradient-based scaling).

(ii) Authors wrote on p. 6460 "However, the BD equation suppresses fluxes under stable condition too quickly and is not applicable when the Richardson number exceeds a critical value (Louis, 1979)." Businger-Dyer (BD) relationships for the SBL are consequence of MOST and they have the same limits of applicability as MOST. The applicability of the local MOST in the SBL is limited by inequalities, when both gradient and flux Richardson numbers are below their "critical values" about 0.20-0.25 (e.g. Grachev et al. 2013). Cheng and Brutsaert (2005), Grachev et al. (2007) among others derived their parameterizations extending Monin-Obukhov formalism beyond the limits of the MOST applicability. Although their parameterizations work for z/L » 1, they don't follow the classical Monin-Obukhov local z-less predictions (but BD relationships follow). I think that this point should be clarified in the paper. In any case, parameterizations similar to Cheng and Brutsaert (2005) and Grachev et al. (2007) are not a final solution for the SBL.

Minor comments:

Page 6460, lines 21-22: use identical notation for Businger-Dyer equation in both cases, B-D or BD.

Page 6461, lines 4-5: "Under unstable condition, the iteration normally converges within 5 steps (Fairall et al., 1996)". Actually COARE 2.5 model (Fairall et al., 1996) was improved and in the next version, COARE 3.0 bulk algorithm (Fairall et al., 2003), "the stability iteration loop has been reduced from 20 to 3 by taking advantage of a bulk Richardson number parameterization for an improved first guess (Grachev and Fairall 1997)." - see Fairall et al. (2003, p. 575).

Page 6462, line 22. Reference Sarkar and De Ridder (2010) is missed.

Page 6468, Eq. (27). Sign minus is missed in the exponent (cf. Eqs. (6) and (27)).

Literature, not mentioned in the manuscript:

Fairall, C. W., E. F. Bradley, J. E. Hare, A. A. Grachev, and J. B. Edson. 2003. Bulk parameterization of air-sea fluxes: updates and verification for the COARE algorithm, J. Clim., 16(4), 571–591.

Grachev A.A., Andreas E.L, Fairall C.W., Guest P.S., Persson P.O.G. 2007. SHEBA flux-profile relationships in the stable atmospheric boundary layer. Boundary-Layer

Meteorol. 124(3): 315–333. DOI 10.1007/s10546-007-9177-6

Grachev A. A., Andreas E. L, Fairall C. W., Guest P. S., Persson P. O. G. 2013. The critical Richardson number and limits of applicability of local similarity theory in the stable boundary layer. Boundary-Layer Meteorol., 147(1), 51-82, doi: 10.1007/s10546-012-9771-0

Sanz Rodrigo J, Anderson P.S. 2013. Investigation of the stable atmospheric boundary layer at Halley Antarctica. Boundary-Layer Meteorol. 148(3): 517-539. DOI: 10.1007/s10546-013-9831-0

Sharan M. and Kumar P. 2011. Estimation of upper bounds for the applicability of non-linear similarity functions for non-dimensional wind and temperature profiles in the surface layer in very stable conditions. Proc. R. Soc. A. 467(2126): 473–494. DOI:10.1098/rspa.2010.0220

Sorbjan Z. 2010. Gradient-based scales and similarity laws in the stable boundary layer. Q. J. R. Meteorol. Soc. 136(650A): 1243–1254. DOI:10.1002/qj.638

Sorbjan, Z., Grachev A.A. 2010. An evaluation of the flux-gradient relationship in the stable boundary layer. Boundary-Layer Meteorol. 135(3): 385–405. DOI 10.1007/s10546-010-9482-3

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