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Influence of entrainment and countergradient on the ABL diurnal development

M.A. Hernández-Ceballos (1,2) and the G. J. Steeneveld (3), J. Vilá-Guerau de Arellano (3), J. Schröter (3), C.C. van Heerwaarden (3), J. A. Adame (1), M. Martinez (4), R. Sander (4), M. Jacob (4), D. Domínguez (2), J. Lelieveld (4), A.A.M. Holtslag (3), B. A. de la Morena (1) and J. P. Bolívar (2) Team

(1) National Institute for Aerospace Technology (INTA). Atmospheric Research and Instrumentation Branch. Atmospheric Sounding Station "El Arenosillo", Crta. Huelva-Matalascañas km 34. 21130, Mazagón – Huelva, Spain, (2) Department of Applied Physics. Facultad de Ciencias Experimentales, Universidad de Huelva, Campus de El Carmen, 21071, Huelva, Spain, (3) Meteorology and Air Quality Section, Wageningen University, Wageningen, Netherlands, (4) Max-Planck Institute, Atmospheric Chemistry, Mainz, Germany

The representation of the diurnal evolution of the boundary layer (ABL) by NCAR-Penn State Mesoscale Model (MM5) and by the mesoscale model Weather Research Forecast (WRF) is compared. Special attention is paid to determine the role of processes that occur near and below the inversion zone: the positive correlation between the heat flux and the gradient (countergradient) and the role of entrainment of heat originating from the free troposphere. Both processes play a key role in the modelling of the diurnal variability of temperature, moisture and atmospheric compounds.

A number of 13 simulations are carried out to determine the sensitivity of the model results to the formulation of the ABL height and countergradient heat flux in the Medium Range Forecast (MRF) ABL scheme. Model results are compared with experimental data obtained from the DOMINO (Diel Oxidant Mechanisms in relation to Nitrogen oxides) campaign. It was organized by Max Planck Institute for Atmospheric Chemistry (Germany) in collaboration with the National Institute for Aerospace Technology (Spain). The DOMINO campaign took place at the "Atmospheric Sounding Station - El Arenosillo", a platform dedicated to atmospheric measurements in the Southwest of Spain.

All numerical experiments are grouped in four clusters, each focussing on the sensitivity of different relevant aspects. The following aspects of the formulation are analyzed: surface moisture availability (M), the countergradient term (γ_c) and the ABL height (h). This is done by modifying both the bulk critical Richardson number (Ri_c) at the inversion zone, and a coefficient of proportionality (b) that determines the excess temperature and countergradient. The importance of b is due to its direct relation in the definition of both, γ_c and h.

The results got with MM5 model show that temperature and specific moisture temporal evolution is not very sensitive to changes in the soil moisture availability (M value from 0.6 to 0.1). Using the MRF parameterization, the ABL profile is more sensitive to changes in Ri_c than in b, indicating a larger dependence of h on Ri_c. Moreover, taking different combinations of b values (0.0 and 7.8) in the γ_c and h formulation a larger influence of the first term in ABL profile is found.

For the same experimental period, the WRF model results with MRF will be compared with both results: MM5 with MRF and WRF results from the successor of MRF, i.e. YSU.