LAND SURFACE-ATMOSPHERE EXCHANGE IN THE NATURAL LANDSCAPES

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In the last years the investigation of the processes of heat and mass exchange between different types of natural underlying surfaces and atmosphere has received considerable attention. The effect of turbulent processes in a rather thin atmospheric boundary layer on the formation of meteorological fields is especially notable in continental areas. Sensitivity analyses of forecasts produced by commonly used models show discrepancies or inaccuracies in the definition of initial and boundary conditions. The quality of parameterizations has shown to produce an essential part of the error of the short term forecast and even of the long-term forecast. This caused by errors in the initial conditions and the quality of the parameterization of heat and mass exchange [*Sellers et al*., 1992]. This is in particular the case in the atmospheric boundary layer above land, where the physical, biochemical and biophysical processes are characterised, as a rule, by variability depending on geographic conditions, relief, vegetation etc. It is related to the fact that the energy-mass exchange between the complex (horizontally inhomogeneous) land surface and the atmosphere is determined by applying theories that are based on the hypothesis of stationarity and horizontal homogeneity (SHH) (for example the Monin-Obukhov theory of similarity). In SHH conditions the cospectral form derived by *Kaimal et al* [1972], *Kaimal and Finnigan* [1994] have been taken as the archetype of surface-layer turbulence spectra.

Often flux measurements may be obtained in non-stationary conditions, usually in complex topography. One of the consequences of surface inhomogeneities (roughness, albedo, LAI, soil moisture, temperature etc.) is the existence of a complex internal boundary layer, others may be coherent fluxes escaping covariance flux measurements. In these conditions we can expect spectral and cospectral forms departures from classic *Kaimal forms*. The surface climatology, canopy structure and topography all influence the spectra and cospectra. Most of the problems will be concentrated in the low frequency part of the covariance spectrum. The low frequency content of the cospectrum in complex terrain is usually much greater than over flat, homogeneous land. It is possible to envisage that above an aerodynamically homogeneous underlying surface there is imbalance of heat, but in this case it will be connected to soil moisture or temperature (albedo) heterogeneities of a surface. Such situations are common in nature. Measurements of the surface energy fluxes showed imbalances of the surface energy budget $\Delta = 50 - 200 Wm^{-2}$ during daytime conditions. The sum of fluxes of heat $lE + H = STF$ which is going into the atmosphere is less than $R_n - G$. The main cause of this systematic imbalance is not the experimental methodology but a conceptual deficiency. It is related to the fact that the energy-mass exchange between the complex (horizontally inhomogeneous) land surface and the atmosphere is determined by applying theories that are based on the hypothesis of stationarity and horizontal homogeneity (SHH).

Using the experimental results, it was detected that the underestimation of the turbulent fluxes is related to the terrain inhomogeneity. To systematize the correction for this effect a parameterization is suggested which empirically makes use of the involved inhomogenity scale in the surrounding of a site. This parameterization incorporates seasonal and wind direction effects. For parameterization of the energy imbalance the coefficient $k_f(z_0^{eff} / L^{eff})$ is used. This coefficient can be interpreted as a measure of inhomogeneity and supposedly compromises the low frequency range of the covariance spectrum and possibly other coherent fluxes escaping covariance flux measurements, and serves as an expression of inhomogeneity and nonstationarity.

A special definition of L^{eff} was designed. This technique was encompass by the calculation of reference values by spectral analysis of surface heterogeneities at various wind directions. The scale of heterogeneities of an underlying surface is determined as the position of the spectral maximum of surface inhomogeneity. This definition of a surface inhomogeneity scale L^{eff} and coefficient $k_f(z_0^{eff} / L^{eff})$ allows to take into account the effect of imbalance (and can in turn be used as output for compensation of imbalance) in the atmosphere boundary layer for natural surfaces.

The paper aims to serve as a contribution to the ongoing discussion on how to account for different types and scales of land surface inhomogeneities inside cells of models such as global climate models, as well as mesoscale models.