Ecosystem Contrasts in Interaction with the Planetary Boundary Layer 1)

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Abstract: In many climatic regions the interface between the earth and the atmosphere consists of a mosaic of ecosystems, each possessing specific properties of absorbing and storing energy and matter. Large contrasts in these properties create differences in interface temperature and moisture, which, in combination with contrasts in roughness, produce differences in sensible and latent heat fluxes injected into the atmosphere, so that the boundary layer experiences rapid alterations to its structure and transport of energy and matter. In consequence, good data on fluxes from individual ecosystems and their contrasts are essential both to understanding the functioning of the boundary layer and energy/mass accounting at source and sink ecosystems.

Ecosystem analysis, which has proved of general value in natural science and can be applied to determine energy and mass transports into the planetary boundary layer (PBL) must be modified in many regions of the earth where ecosystems display marked contrast one from the other. Accordingly, there is need to quantify the properties that determine heat and mass transfers, the actual fluxes of energy and mass, and the contrasts in properties and fluxes among the ecosystems that together comprise a landscape mosaic.

The meteorologically significant properties of ecosystems, or small sectors of the earth-atmosphere interface, display a range of values of absorption of radiant energy, of water, and of other substances, and a range of capacities to store energy and water in readily retrievable form in their immediate substrates, and in the shelter and roughness that determine their closeness of coupling with the PBL. As a result there are significant contrasts in the rates of energy and mass fluxes contributed by ecosystems to the PBL or extracted by them from it, and hence in the transport of energy and mass by the PBL and the eventual receipts by other ecosystems.

These properties depend on such shape factors as diameter, perimeter, elongation and lineation, distance from ridge crests, and indeed the general dissection of the terrain in which ecosystems are located, their access to solar energy, illustrated by Lee and Baumgartner (1966) for a mountainous part of Bavaria, and the shelter that the terrain affords from wind energy, advected heat, cold, and hydrometeors. Conditions of lithology, geologic structure, and fluvial or glacial erosion or deposition produce ecosystems of a particular range of sizes and properties, some of which have been investigated by quantitative geomorphologists; such terrain factors as slope convexity and length have obvious meteorological meaning (Mahrt and Heald 1983). Geologic and geomorphic conditions bring about contrasts in soil depths and water-holding capacity, which in turn bring about contrasts in vegetation, particularly rooting depths, leaf density, depth and canopy thickness. Existing contrasts in the forest landscape of western Europe were greatly sharpened six thousand years ago, when human activity

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Fig 1 Snow cover revealing intricate dissection of a drainage network on the Sevier Plateau in Utah (February)

Fig 2 Plucked granite on divide between Castle Creek and Donner Creek, Central Sierra Snow Laboratory. (Photo by K.R. Knoerr, US Forest Service)

Fig 3 Tree clusters and interspersed glades, from ski tram at Snowbird, Utah (April)

Fig 4 Jack oak on low sand ridge among Crex Meadows wetlands, Wisconsin.

Fig 5 Ski runs and parking lot cut into northern hardwood forest on east face of Mount Mansfield, Vermont, generating vertical motion being utilized by hang-gliders (June).

Fig 6 Strip-cut forest harvesting, near Panguitch, Utah.