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Impact of landscape variability on atmospheric flows – Theory

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We show that landscape variability decreases the temperature in the surface layer when, through mesoscale flow, cool air intrudes over warm patches lifting warm air and weakening the static stability of the upper part of the planetary boundary layer.

This mechanism generates regions of upward vertical motion and a sizable amount of available potential energy, and can make the environment of the lower troposphere more favorable to cloud formation. This process is enhanced by light ambient wind through the generation of trapped propagating waves, which penetrate into the mid-tropospheric levels, transporting upward the thermal perturbations and weakening the static stability around the top of the boundary layer.

At moderate ambient wind speeds, the presence of surface roughness changes strengthens the wave activity, further favoring the vertical transport of the thermal perturbations. When the intensity of the ambient wind is larger than 5 m/s, the vertical velocities induced by the surface roughness changes prevail over those induced by the diabatic flux changes.

Our analysis is performed using a linear theory where the mesoscale dynamics are forced by the diurnal diabatic sensible heat flux and by the surface stress. Results are shown as a function of ambient flow intensity and of the wavelength of a sinusoidal landscape variability.