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Control of boundary layer cloud onset by surface humidity.

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We investigate the onset of moist convection over land using an idealised approach: a slab boundary layer model. This study provides new intuition and predictive capacity on the mechanism controlling its occurrence.

We study the essential factors for the onset of boundary layer clouds over land and their relative importance: 1) the ratio of the temperature to the moisture lapse rates of the free troposphere (i.e. the inversion Bowen ratio), 2) the mean-daily surface temperature, 3) the relative humidity of the free troposphere and 4) the surface evaporative fraction.

A transition is observed between two regimes of tendency to clouds, defined by the relative humidity tendency at the boundary layer top. In the first, the wet soil advantage regime, the moistening results from the increase of the mixed-layer specific humidity, which linearly depends on the surface evaporative fraction and inversion Bowen ratio through a dynamic boundary layer factor. In the second, the dry soil advantage regime, the relative humidity tendency at the boundary layer top is controlled by the thermodynamics and changes in the moist adiabatic induced by the decreased temperature at the boundary layer top and consequent reduction in saturation water vapor pressure. This is a regime of very deep boundary layers, under weakly stratified free troposphere conditions and over a hot surface.

In order to test and validate the theoretical approach above, wisely chosen measurements are used. Moreover, analysis of long regional model integrations allows to assess the sensitivity to soil moisture change. In the specific case of summer heatwaves, a dry soil advantage regime is found in the model.