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OBSERVATIONS OF THE MORNING TRANSITION OF THE CONVECTIVE BOUNDARY LAYER

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1. Introduction

The morning transition between the stable nocturnal boundary layer and the convective daytime boundary layer over land is generally thought to be well understood. We have published a detailed observational study (Angevine, Klein Baltink, and Bosveld, 2001) which we hope will provide a framework for more detailed understanding of this important transition period, and for improved modeling and parameterizations. We urge the interested reader to read the complete paper; only a very brief summary is provided here.

Our study was based on measurements from both in-situ and remote sensing instruments. The tower at Cabauw, The Netherlands, provided in-situ measurements of mean and turbulent quantities. These were used to verify measurements of the onset of turbulence by a radar wind profiler at Cabauw. Having established the usability of these measurements, similar profiler measurements were used to study the onset of turbulence at the Flatland Atmospheric Observatory in Illinois, USA. Near-surface flux measurements from sonic anemometers completed the dataset at both sites.

The conceptual framework of the study was the relative timing of three events: 1) Sunrise; 2) The crossover of the surface virtual temperature flux from negative to positive (defining a positive flux as away from the surface); and 3) The onset of turbulence at 200 m above ground level.

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2. Key findings

Perhaps the most interesting finding of our study was that the morning transition is largely driven by entrainment rather than by the surface heat flux. That is, the heat that warms the layer between the surface and 200 m, eroding the surface inversion, comes almost entirely from above rather than from the surface. The small positive surface heat flux appears to act primarily to relax the stability, allowing entrainment from above to proceed. Wyngaard (1983) also mentioned that only a small surface heat flux is required to initiate the morning transition.

We have gained some other physical insight into the transition process from the results of our study. The two transition phases (sunrise to crossover and crossover to onset) have different dependencies on the fluxes and variances (stability parameters) and surface variables. Stronger winds during the transitions add mechanical mixing that reduces the amount of heat flux required to mix out the nocturnal inversion and thus shorten the time from heat flux crossover to CBL onset. Wind during the night also reduces the pre-transition stability, again reducing the amount of accumulated heat flux and therefore the time required to reach onset. The morning transition appears to happen more slowly at higher latitude, at least in the sunrise to crossover phase.

References

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