RESEARCH INTEREST STATEMENT

I am interested in studying features of the convective boundary layer (CBL), both in terms of entrainment, and in terms of its effects on deep convection.

I am currently studying the effects of wind shear on the dynamics of convective entrainment in the CBL. The shear can either be surface wind shear, which is relatively straightforward to measure, or wind shear across the top of the CBL, which is more difficult to quantify with standard observations. The entrainment problem has been rather well-formulated for CBLs growing in conditions, in which wind shear does not play a significant role in the turbulence production in the CBL, and this particular regime is valid for conditions of light winds (in anticyclones), or strong surface heat flux (during the summer in middle and low-latitudes). However, in the presence of relatively weak surface heat flux and stronger winds, shear can play a significant role in CBL growth, and as the surface heat flux goes to zero, any equation formulated for boundary layer growth should revert to a mechanical-only growth rate. An important regulator of mechanical entrainment is the portion of any mechanically produced turbulence that is dissipated versus used for entrainment.

Shear not only has an effect on the CBL entrainment rate but also on turbulence structure and wind profiles within the CBL. This, in turn, can affect the general low-level inflow environment of thunderstorms, dispersion of air pollutants within the CBL, and wind loading on high-rise buildings and wind-power generation facilities, among other things.

The turbulence and wind structures within the CBL are believed to play a significant role in the initiation of deep convection that is rooted in the boundary layer. Cloud models and non-hydrostatic models of thunderstorms are commonly initiated with a “warm bubble” in order to generate a thunderstorm and thereby do not take into account realistic CBL structure involved in the development of deep, moist convection. Greater computer power nowadays is just beginning to allow simulations of thunderstorm initiation with realistic boundary layer structure. It is my hope that such simulations can be used to provide us a better understanding of the processes involved in the initiation of deep convection. Field experiments will also be crucial for this understanding.

Initiation is likely more sensitive to the presence of deep, sustained vertical motion in the atmosphere. In environments with plenty of convective available potential energy (CAPE) and little or no capping inversion at the top of the CBL, commonly understood to be sufficient for the development of deep, moist convection, thunderstorms often do not form, and likewise, storms may also become prevalent in situations where a strong capping inversion is initially present but deep, organized vertical motion, such as that resulting from quasigeostrophic forcing (among other forcing mechanisms), overcomes the effects of the capping inversion. It is my goal to achieve a deeper understanding of the respective roles of boundary layer processes and larger scale forcing for lift in the development of deep, moist convection.