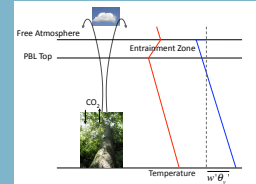


# EFFECTS OF PBL TOP ENTRAINMENT ON ECOSYSTEM FUNCTION AND CO<sub>2</sub>

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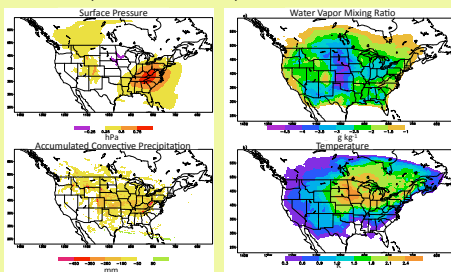
## Introduction

- Some mesoscale models treat stable layers in the atmosphere as lids to turbulence
- Low critical Richardson numbers, such as Mellor and Yamada's (1982) value of 0.19 can inhibit turbulent mixing between the PBL and the free troposphere
- This hinders PBL growth and the warming and drying of the PBL
- Carbon flux at the land-atmosphere interface is diluted by the volume of air in the PBL thus forming a dependence of CO<sub>2</sub> concentration on PBL depth and turbulent mixing
- The modified PBL conditions alter the canopy air space (CAS) thus creating different stomatal conditions to which the vegetation respond
- An enhanced entrainment parameterization representing additional unresolved turbulence was added to SiB-RAMS and is based on the assumption  $\overline{w'\theta_1'l_1} = -\alpha w'\theta_1'l_1$
- Plots show the effect of the parameterization by subtracting the control, standard RAMS from the enhanced entrainment case



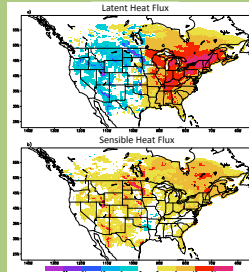
## Weather Impacts

- Enhanced entrainment produced higher surface pressure in the eastern United States and lower pressure in the Midwest
- Precipitation changes were a result of a drier boundary layer and reduced cloud cover
- Average mixing ratio decreased 18% and temperature increased 4%
- Changes were not homogeneous, but varied with the land surface and regional climate
- Modified state represents changes in wind velocity, cloud cover, frontal locations, etc.



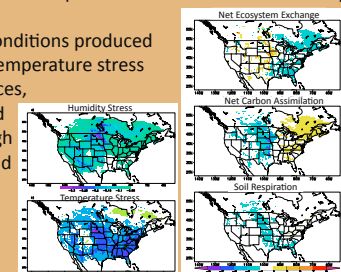
## Heat Flux Impacts

- Latent heat flux increased 12% in the enhanced entrainment case
- Sensible heat flux also increased in the average
- Decreased cloud cover produced an increase in total radiation and therefore in the heat fluxes
- Drier PBL conditions produced a greater humidity gradient between the CAS and PBL
- Produced more transpiration from vegetation and a shift in the Bowen ratio



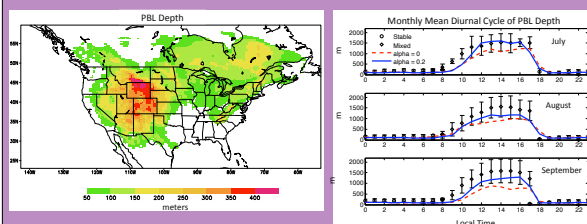
## Ecosystem Impacts

- Net ecosystem exchange (NEE) modified by enhanced entrainment
- NEE increased when assimilation decreased and vice versa
- Changes due to increased solar radiation, a drier CAS and a reduced low temperature inhibition
- Decreased soil moisture led to decreased respiration
- Vegetative stress factors indicate at what fraction of optimal the plants are photosynthesizing with 1 indicating ideal conditions
- Drier conditions produce an increased humidity stress
- Warmer conditions produced increased temperature stress in most places, but reduced stress at high latitudes and elevations



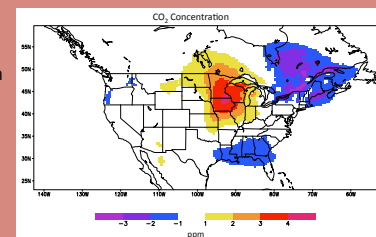
## PBL Impacts

- PBL depth increased an average of 11%
- Impact was greatest where the Bowen ratio is large
- CBL depth was observed by a 915 MHz Doppler profiler during clear sky conditions
- Profiler was positioned 8 km from a 450 m tall tower in northern Wisconsin, USA where CO<sub>2</sub> measurements are made
- Calculated nighttime BL depths using the CO<sub>2</sub> concentration gradient measured by the tower
- Error bars represent the standard deviation of the measurements
- Standard RAMS calculated too shallow a PBL
- Enhanced entrainment produced a deeper PBL with steeper morning growth that better matches the observations



## Carbon Impacts

- Deeper PBLs diluted carbon assimilation producing higher CO<sub>2</sub> concentrations in the Midwest
- Increased photosynthesis led to lower CO<sub>2</sub> concentrations in the northeastern USA, southeastern Canada and along the Gulf Coast
- No net change, but the CO<sub>2</sub> was redistributed
- Redistribution led to 7 ppm gradient from Minnesota in the Midwest to New York, a distance of about 1000 miles (1600 km)
- To put this in perspective, the observed interhemispheric gradient is only about 3 or 4 ppm!



## Conclusions

- Unresolved PBL top entrainment affects vegetative response, PBL depth, the weather, and CO<sub>2</sub> concentration through nonlinear interactions
- Produces inhomogeneous response depending on land surface and regional climate
- Produces a 7 ppm CO<sub>2</sub> concentration gradient across 1000 miles
- Understanding of PBL top entrainment is important for determining PBL depth and CO<sub>2</sub> concentration