A Higher-order Turbulence Closure with a prognostic PBL top Height

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Prognostic PBL Height

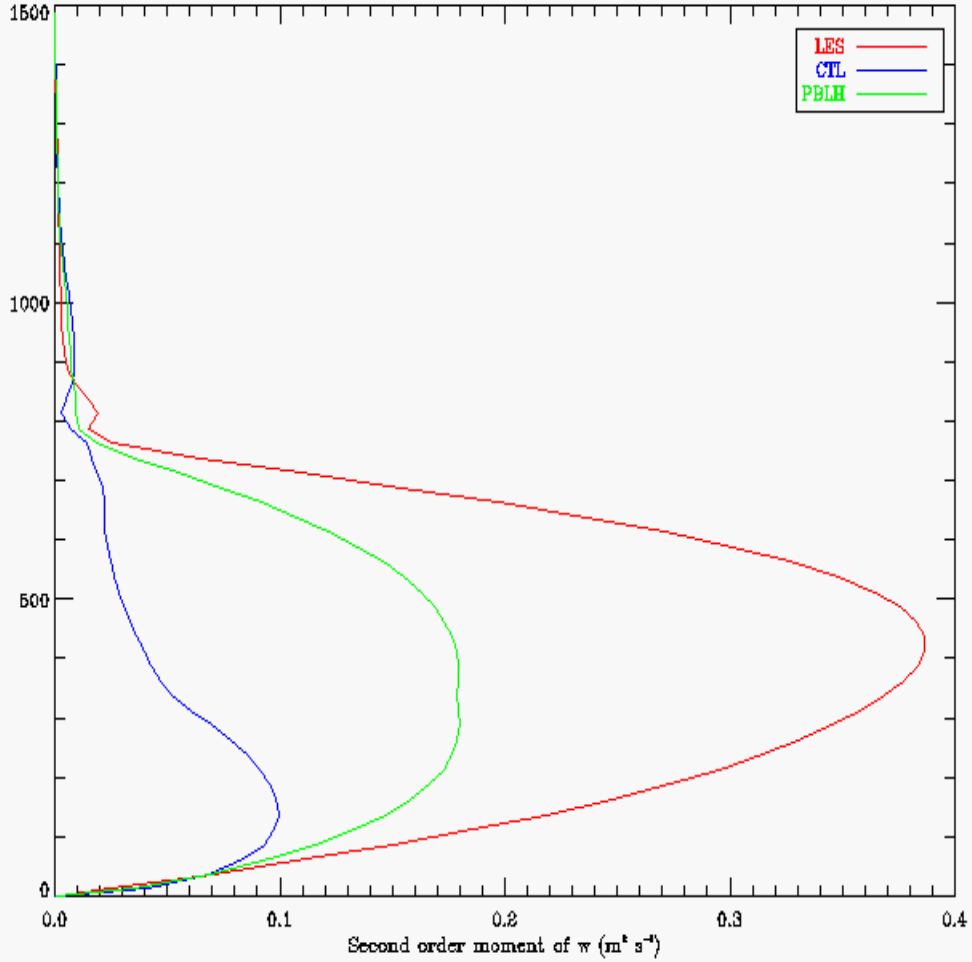
$$\frac{dh}{dt} = E + w$$

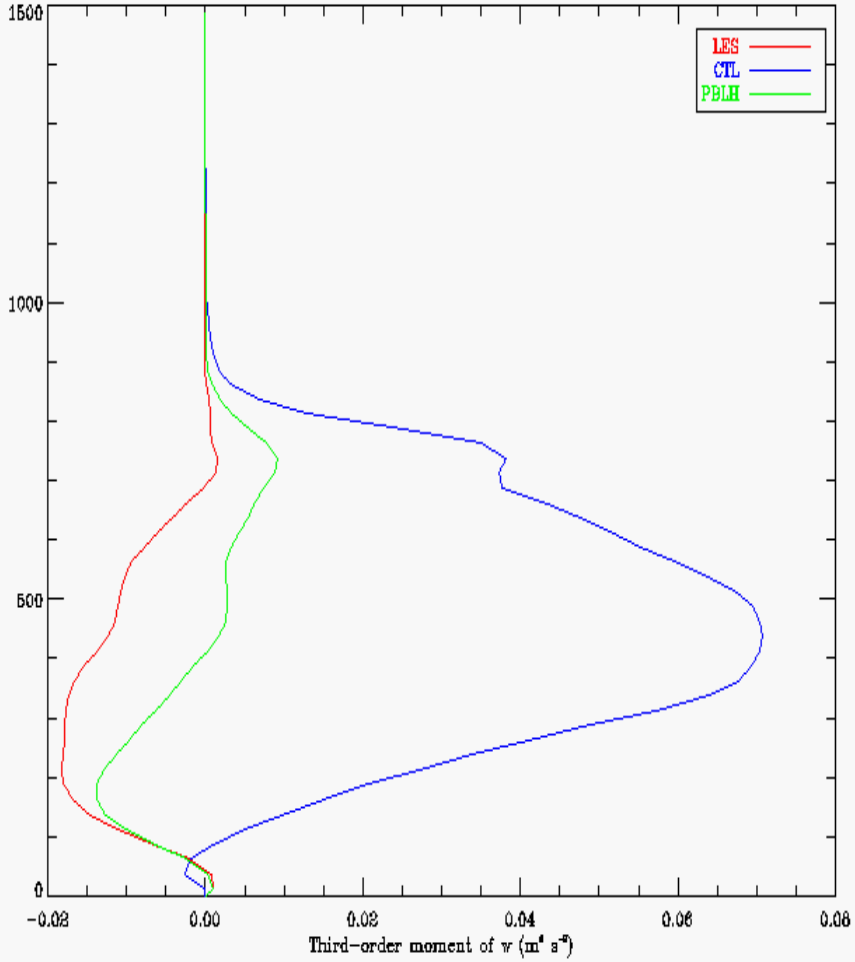
$$E = \frac{\overline{\rho w' w' w'_T} + \frac{2g\delta z}{c_p T} C_r \Delta R}{\overline{w' w'_T} + \frac{2g\delta z}{c_p T} \Delta \tau}$$

Apply to ASTEX (stratocumulus clouds)

Stronger TKE represented by second-order moment due to radiation cooling

Negative third-order moment of w means stronger downdrafts produced by the cloud top cooling

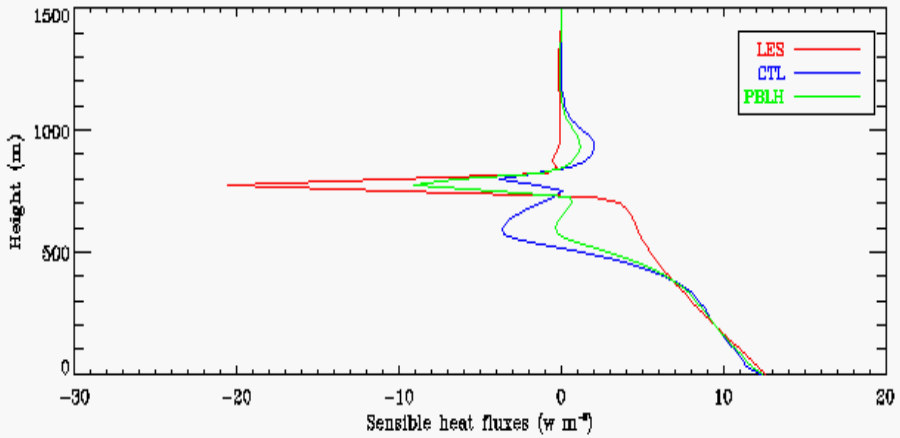


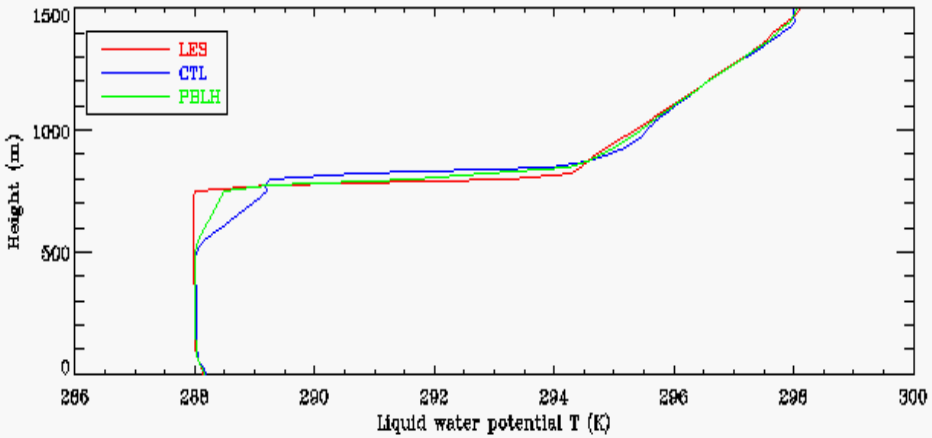


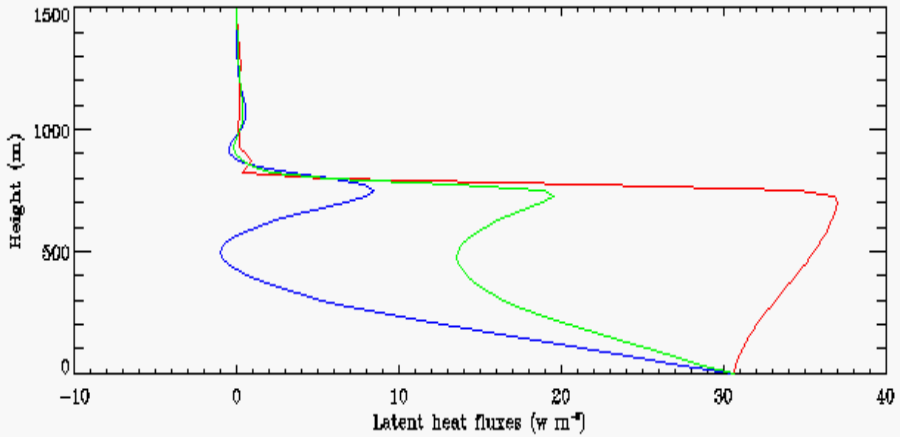
Apply to ASTEX (stratocumulus clouds)

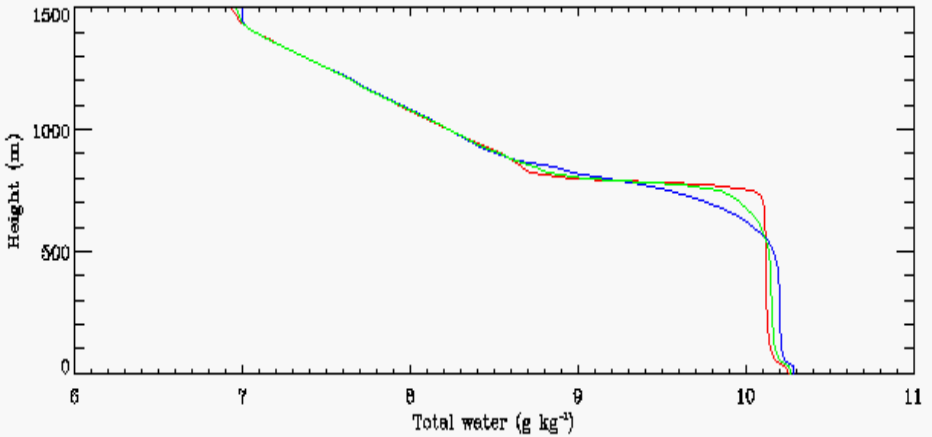
Stronger latent and sensible heat transport

More realistic and stronger inversions









Summary

- Realistic forecasts of PBL height lead to improved simulation of mean profile, turbulence kinetic energy, skewness, and vertical transport of temperature and moisture in a higher-order turbulence closure model.
- Cloud top entrainment is the most important factor to influence the growth of the PBL height, which is determined by the radiative cooling and buoyancy near cloud top.
- More observational data are needed to evaluate and improve the approach for various cases.