Convective Atmospheric Boundary Layer (ABL) forced by mesoscale surface heat flux variation

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Atmospheric Boundary Layer (ABL)

- The ABL is a lowest 10% of the troposphere where weather phenomena occur.
- The ABL is directly influenced by the earth’s surface.
- The earth's surface is heterogeneous on various spatial and temporal scales.
- The surface heterogeneity on a scale of the order of 10 - 100 km is increasing due to anthropogenic factors (e.g., urbanization, cultivation).

/www.esrl.noaa.gov/research/themes/pbl/
Horizontally homogeneous CBL
Horizontally homogeneous CBL

\[ \phi' = \phi'' \]

Wyngaard (2004)
Horizontally homogeneous CBL

\[ \phi' = \phi'' \]

Lenschow et al. (1980)
ABL variability on a scale of tens of kilometers

Inland Breeze Circulation

Surface Energy Budget (SEB) constraint

LeMone et al. (2002)

Mahrt (1991)

R_{net}-G=SH+LE
Horizontally heterogeneous CBL

\[ \phi' = \phi^M + \phi'' \]
Horizontally heterogeneous CBL

$\phi^M$
Downscale Energy Cascade

In a quasi-stationary state

Not in a quasi-stationary state

No significant energy cascade

Significant energy cascade
Normalized $\theta$, $v$, and $w$ turbulence variances

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<th>No significant energy cascade</th>
<th>Significant energy cascade</th>
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<td>$&lt;\theta''&gt;/\theta'$</td>
<td>![Image of $\theta$]</td>
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<td>$&lt;w''&gt;/w'$</td>
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Does the mixed-layer similarity work?

Lenschow et al. (1980)
Ongoing and future works

- More large eddy simulations (LES) with more realistic surface forcing and atmosphere conditions (e.g., diurnal change of surface fluxes, multiple scale surface forcing, heterogeneous background weather conditions)
- Mesoscale model (MM) simulations with the same conditions
  - To know the regime where mesoscale modeling fails
  - To suggest a better strategy to deal with the ABL turbulence in a mesoscale model