THE IMPACT OF SENSOR RESPONSE ON THE REPRESENTATION OF ATMOSPHERIC BOUNDARY LAYER PHENOMENA BY AIRBORNE INSTRUMENTS

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Objectives

Determine UAS system capabilities required to accurately represent thermodynamic properties of,

- The CBL
- Airmass boundaries

Specific focus on sensor response and aircraft speed
Methods

Synthetic data from large-eddy simulation

Cloud Model 1 (CM1) release 18.3

Grid spacing: 50 m (isotropic)
Methods

CBL simulations:

- **Domain**: 24 km x 24 km x 5 km
- **Insolation**: Mid-day, April 15, 40°N
- **Rotary-wing aircraft**
  - Up-sounding fixed x, y
  - Constant ascent rate
    [0.5 – 50 m/s]
Methods

Airmass boundary simulations:

- **Domain**: 244 km x 5 km (2D x-z)
- **Insolation**: Mid-day, April 15, 40°N
- **Initial cold block**: -15 K
- **Fixed-wing aircraft**
  - Transect at constant altitude (500 m)
  - Constant air-speed [2-100 m/s]
Results: CBL-Rotary Wing

**Ascent rate: 2 m/s**

τ: 10 s (blue), 20 s (red)

**Ascent rate: 5 m/s**

τ: 10 s (blue), 20 s (red)
Results: CBL-Rotary Wing

Ascent rate: 2 m/s
τ: 1 s (blue), 2 s (green), 5 s (red)

Ascent rate: 5 m/s
τ: 1 s (blue), 2 s (green), 5 s (red)
Results: CBL-Rotary Wing

Ascent rate: 2 m/s
τ: 1 s (blue), 2 s (green), 5 s (red)

Ascent rate: 5 m/s
τ: 1 s (blue), 2 s (green), 5 s (red)
Results: CBL-Rotary Wing

Maximum Temperature Error

Response Time (s)

Ascent Rate (m/s)
Results: CBL-Rotary Wing

RMSE Temperature

Response Time (s) vs. Ascent Rate (m/s)
Results: CBL-Rotary Wing

Maximum Relative Humidity Error

Response Time (s)

Ascent Rate (m/s)
Results: CBL-Rotary Wing

RMSE Relative Humidity

Response Time (s)

Ascent Rate (m/s)
Results: Boundary-Fixed-Wing

**Transect speed:** 10 m/s
\( \tau: 10 \text{ s (blue), } 20 \text{ s (red)} \)

**Transect speed:** 30 m/s
\( \tau: 10 \text{ s (blue), } 20 \text{ s (red)} \)
Results: Boundary-Fixed-Wing

**Transect speed: 10 m/s**
\[ \tau: 1 \text{ s (blue)}, 2 \text{ s (green)}, 5 \text{ s (red)} \]

**Transect speed: 30 m/s**
\[ \tau: 1 \text{ s (blue)}, 2 \text{ s (green)}, 5 \text{ s (red)} \]
Results: Boundary-Fixed-Wing

Maximum Temperature Error

Response Time (s)

Airspeed (m/s)
Results: Boundary-Fixed-Wing
Results: Boundary-Fixed-Wing

RMSE Temperature Error Relative to 2D State

- Response Time (s)
- Airspeed (m/s)
Results: Boundary-Fixed-Wing

RMSE Temperature Error

2D State

1D State

Airspeed (m/s)

Response Time (s)

Airspeed (m/s)

Response Time (s)
Summary

- Sensor response-driven errors in the CBL are generally dominated by the well-mixed lapse rate.
- Slow ascents through the CBL are likely preferable.*
- Airmass boundaries pose a significant challenge for even “decent” time constants.
- Slow transects improve representation of the 1D state but…
- Slow transects yield poor representation of the 2D state.

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