The impact of sensor response on the representation of atmospheric boundary layer phenomena by airborne instruments

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Oban, Scotland

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Acknowledgements

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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

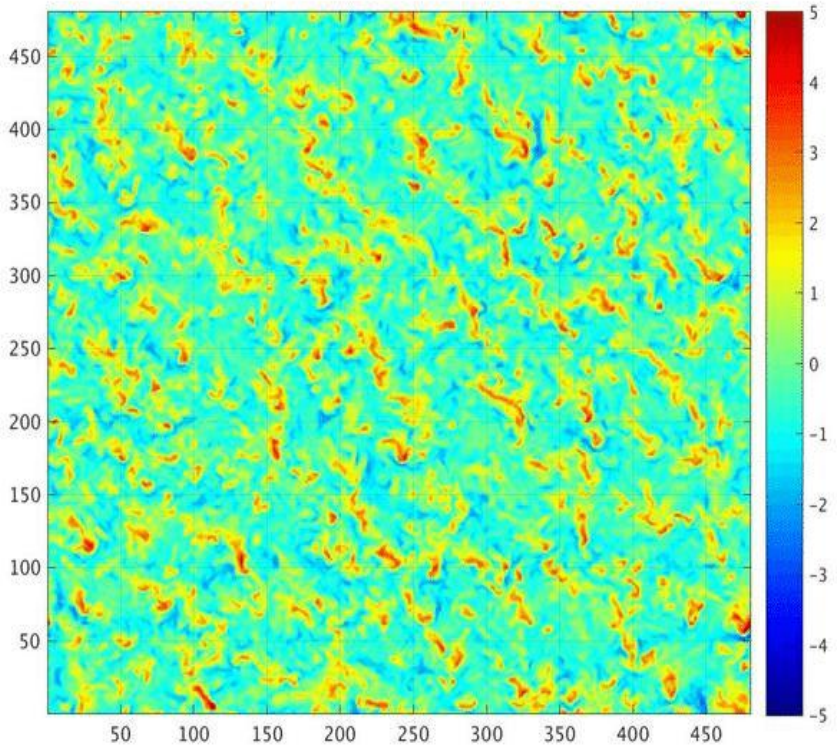
Cloud Model 1 (CM1) release 18.3

Grid spacing: 50 m (isotropic)

Methods

CBL simulations:

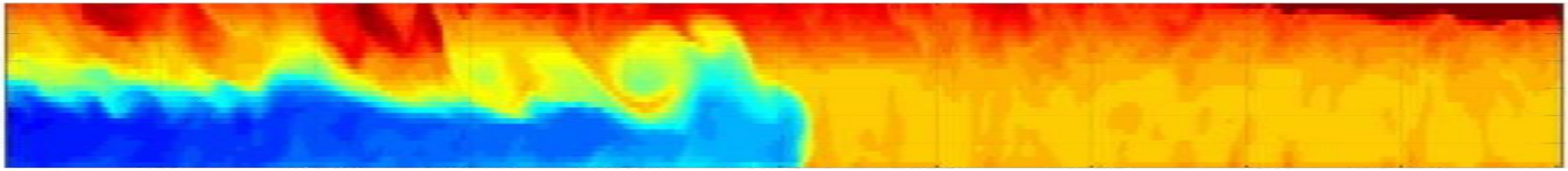
- Domain: 24 km x 24 km x 5 km
- Insolation: Mid-day, April 15, 40°N
- Rotary-wing aircraft
  - Up-sounding fixed x, y
  - Constant ascent rate [0.5 – 50 m/s]



Methods

Airmass boundary simulations:

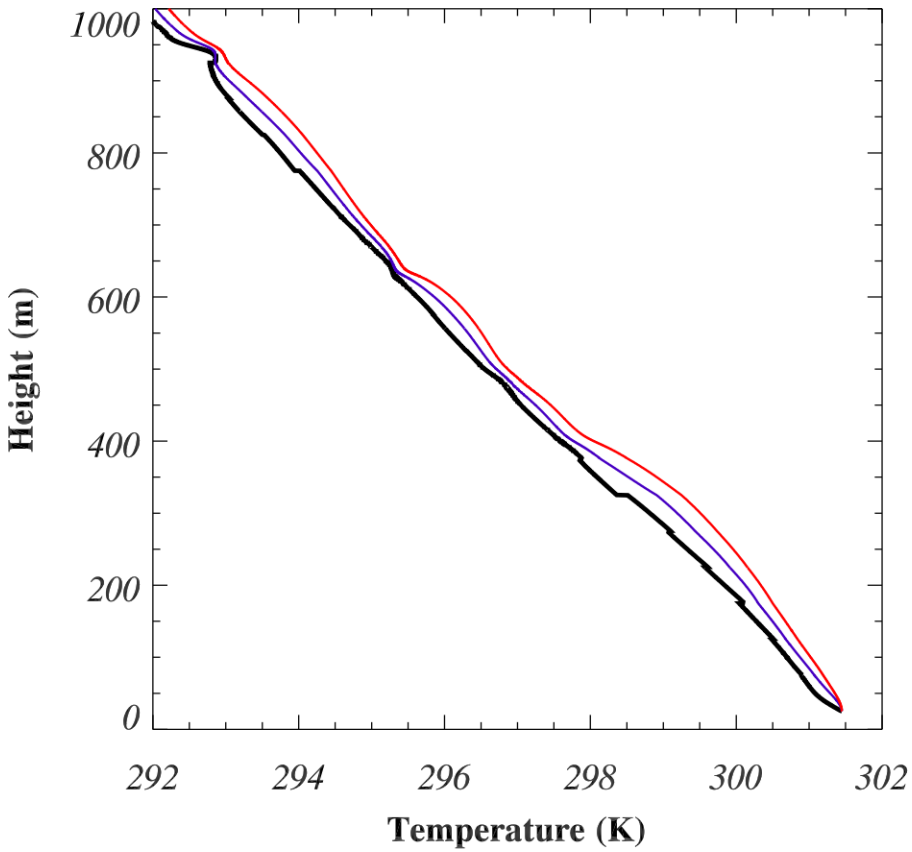
- Domain: 244 km x 5 km (2D x-z)
- Insolation: Mid-day, April 15, 40°N
- Initial cold block: -15 K
- Fixed-wing aircraft
  - Transect at constant altitude (500 m)
  - Constant air-speed [2-100 m/s]



Results: CBL-Rotary Wing

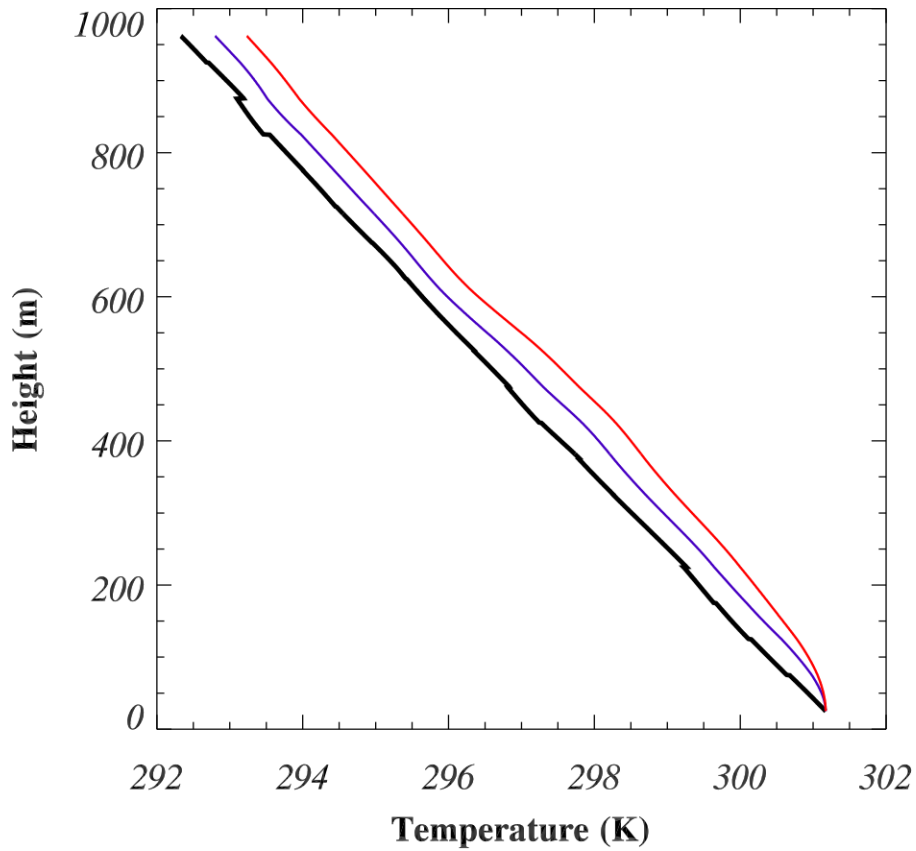
Ascent rate: 2 m/s

τ: 10 s (blue), 20 s (red)



Ascent rate: 5 m/s

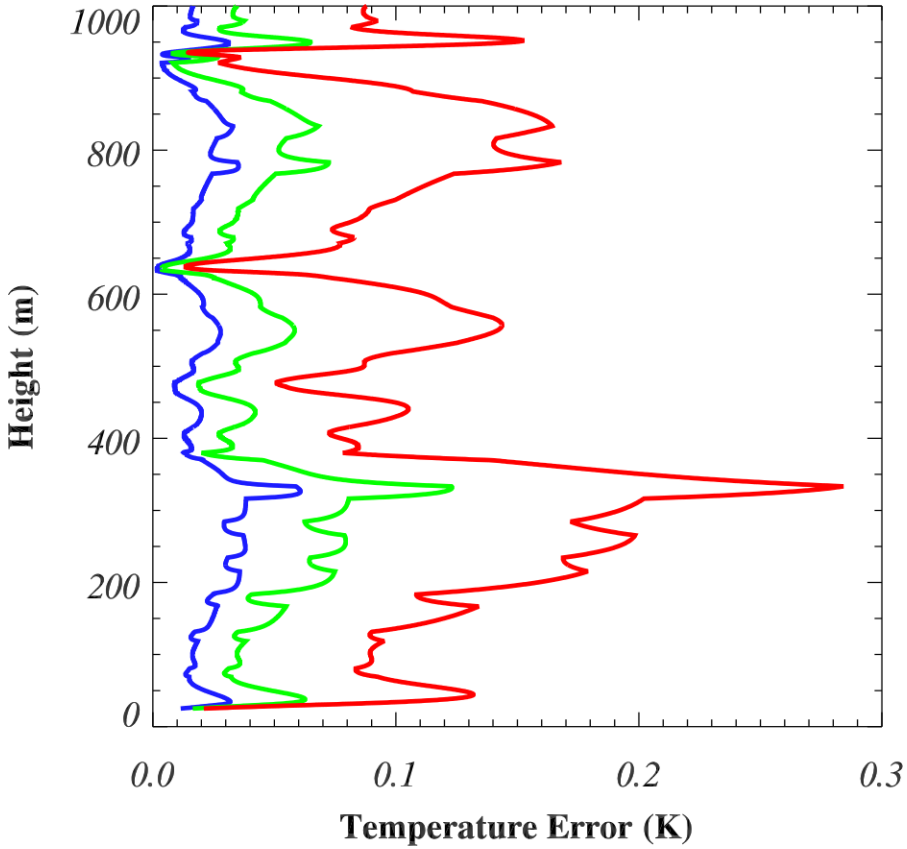
τ: 10 s (blue), 20 s (red)



Results: CBL-Rotary Wing

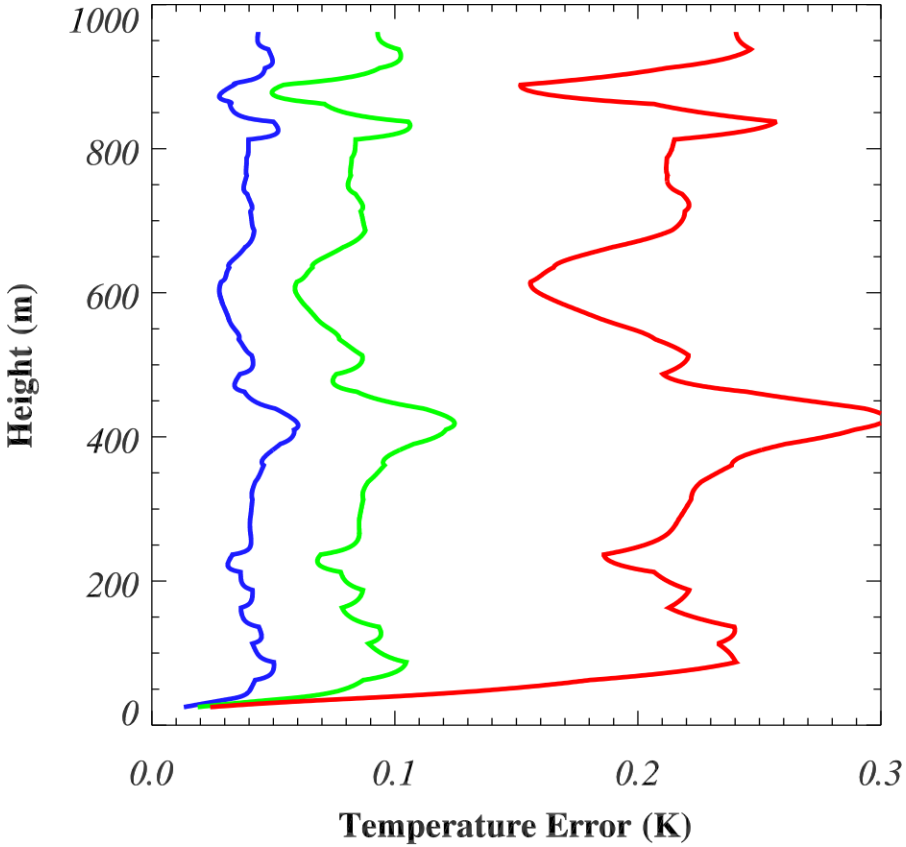
Ascent rate: 2 m/s

τ: 1 s (blue), 2 s (green), 5 s (red)



Ascent rate: 5 m/s

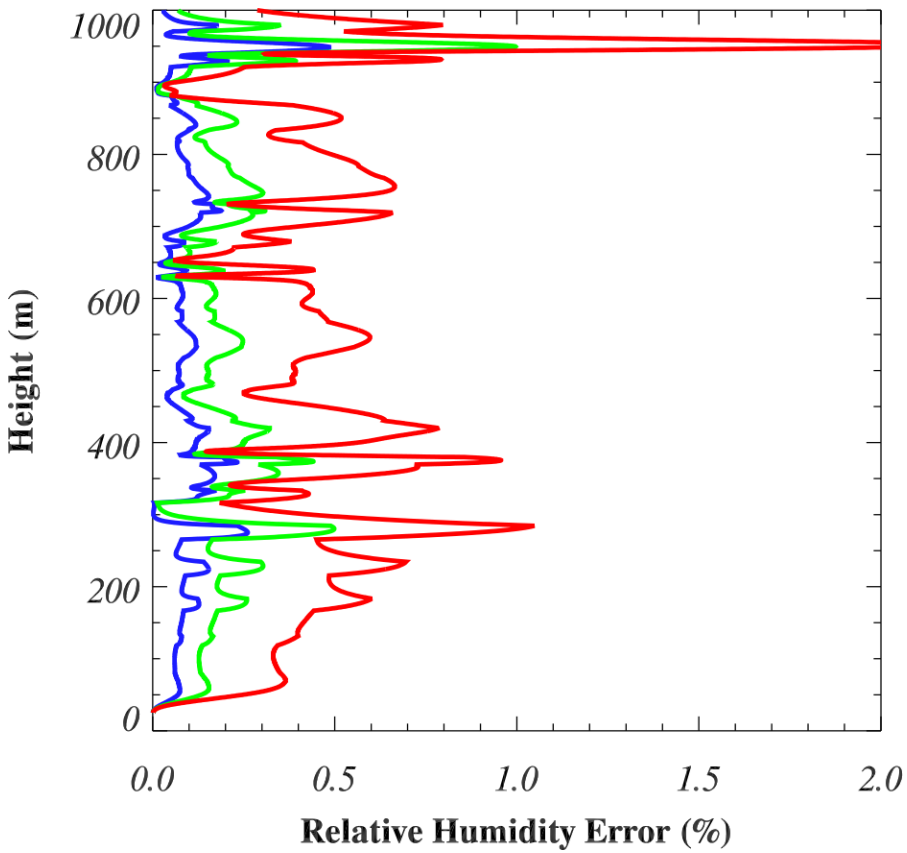
τ: 1 s (blue), 2 s (green), 5 s (red)



Results: CBL-Rotary Wing

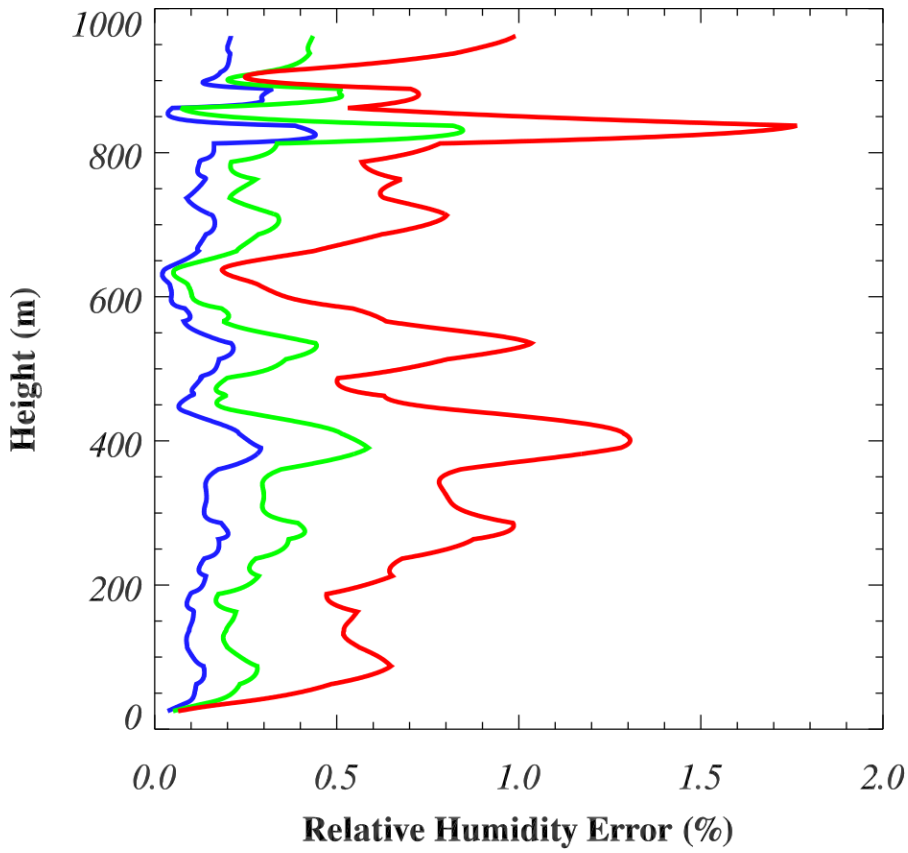
Ascent rate: 2 m/s

τ: 1 s (blue), 2 s (green), 5 s (red)

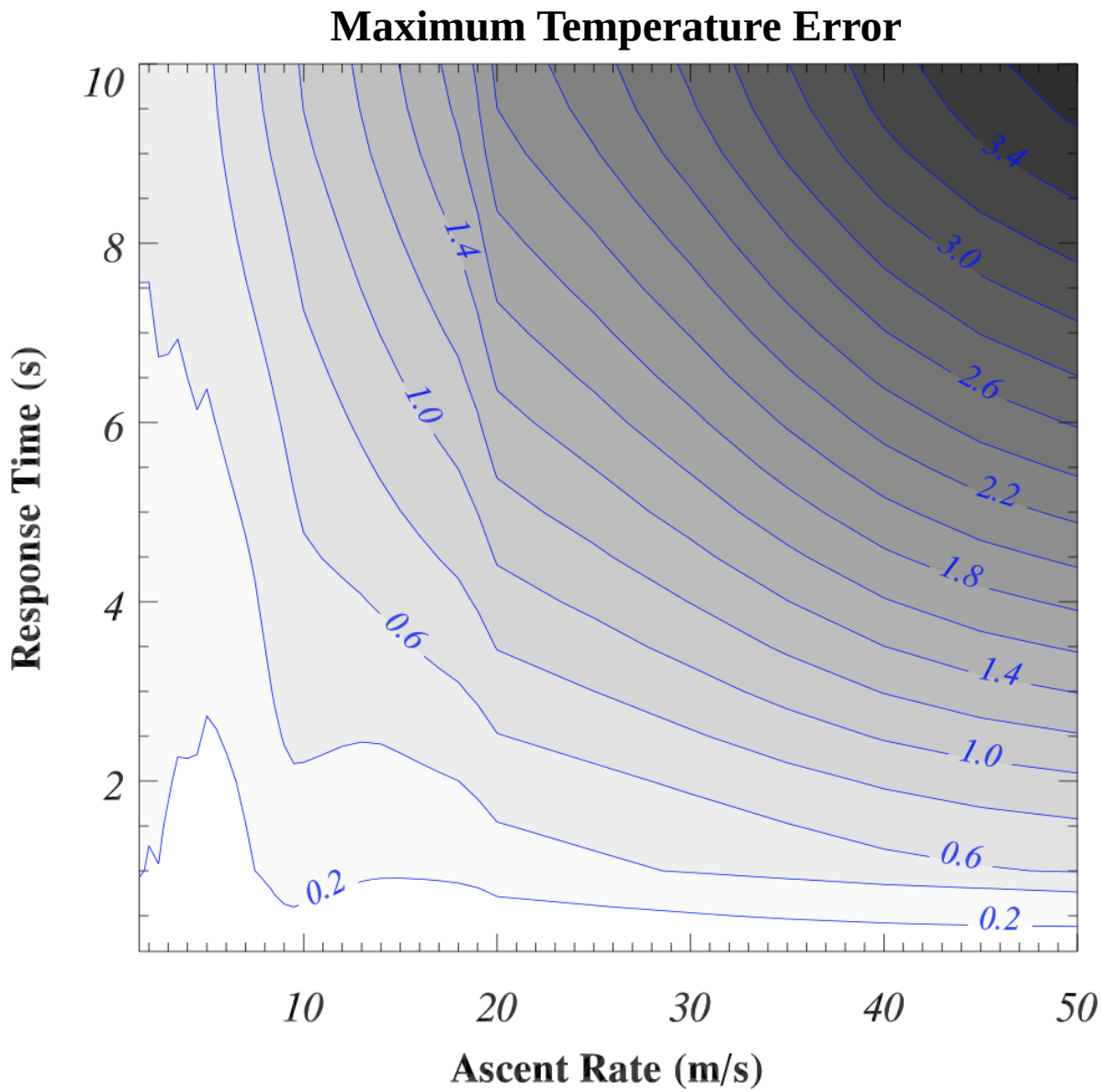


Ascent rate: 5 m/s

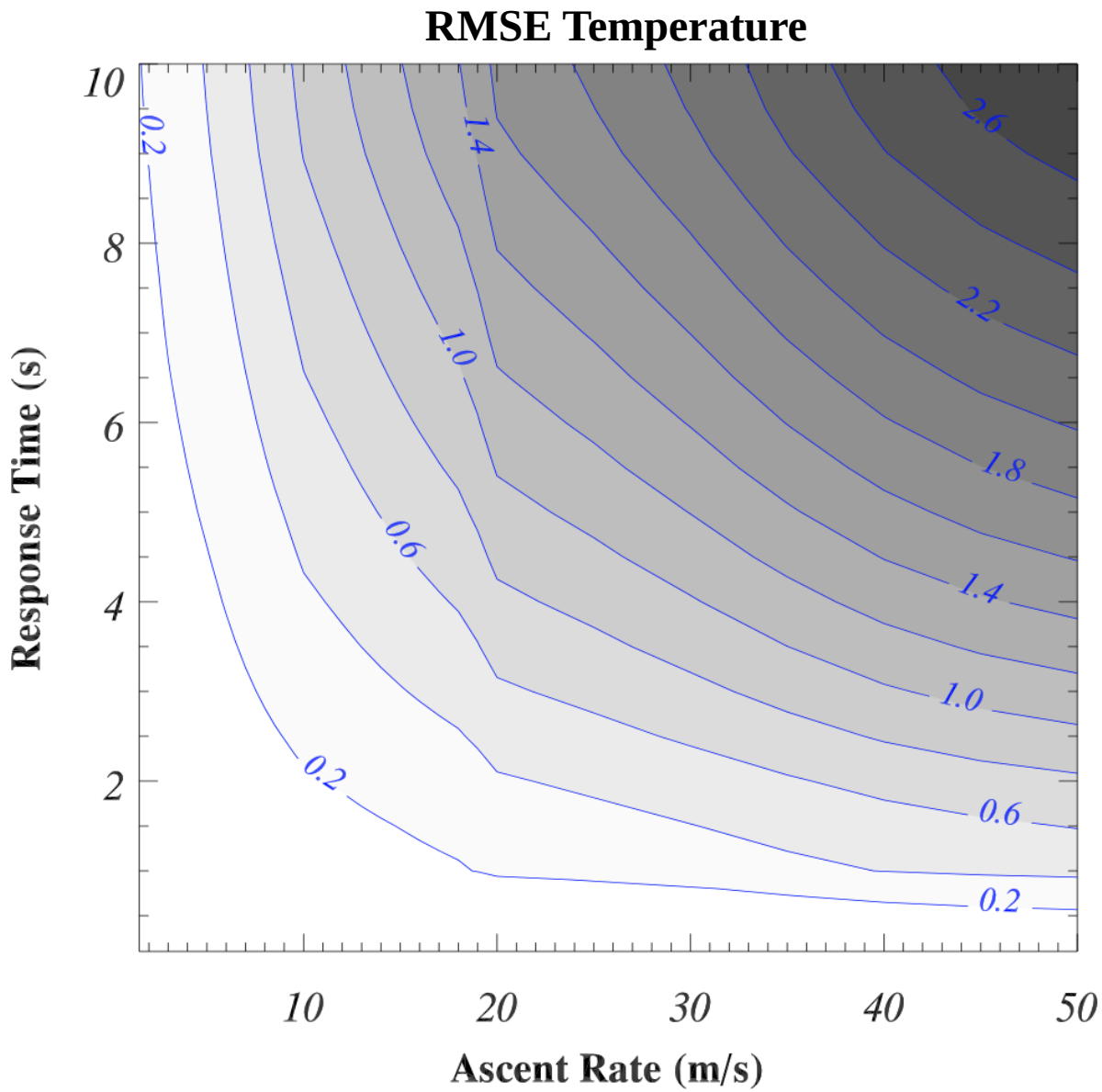
τ: 1 s (blue), 2 s (green), 5 s (red)



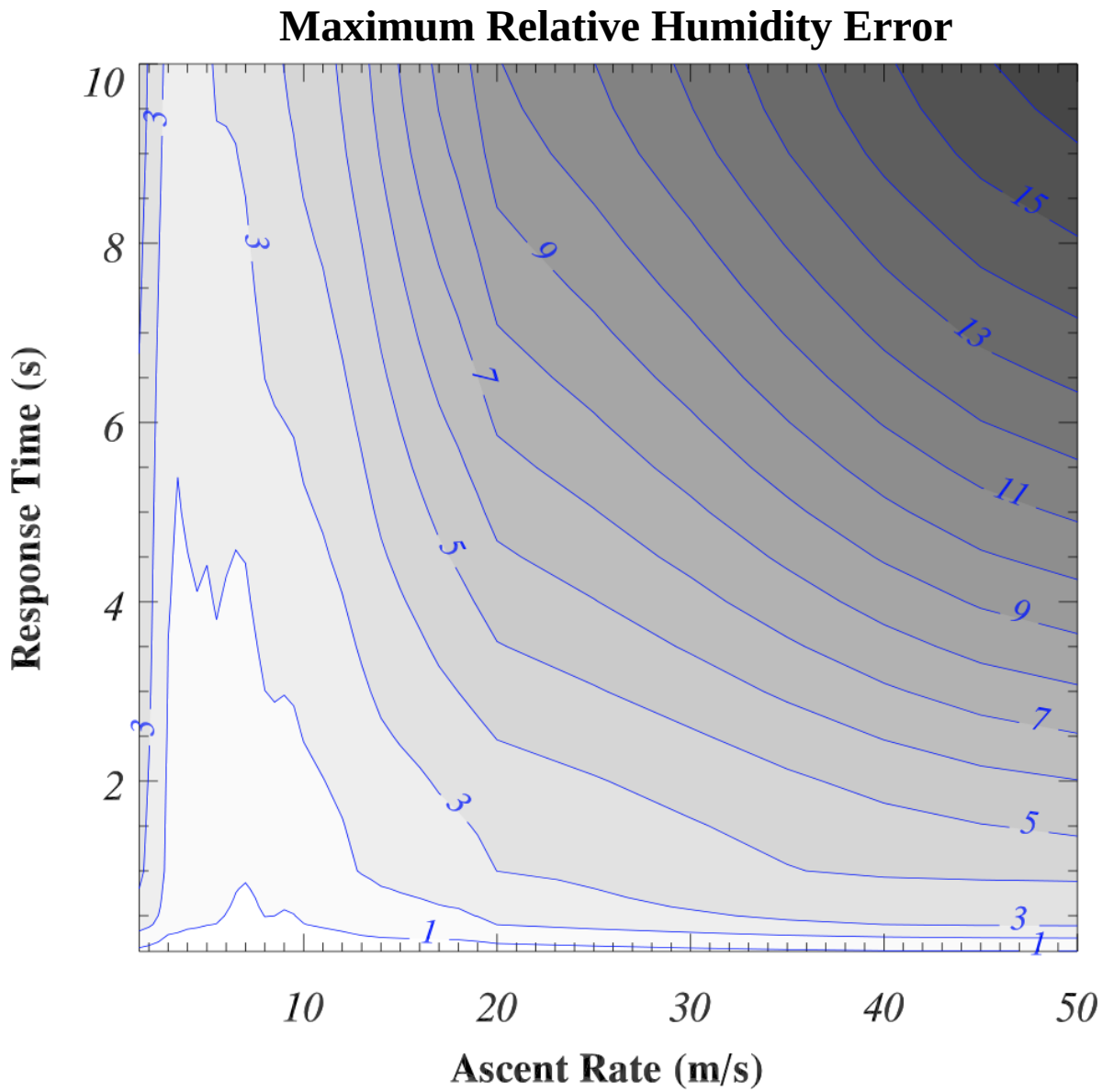
Results: CBL-Rotary Wing



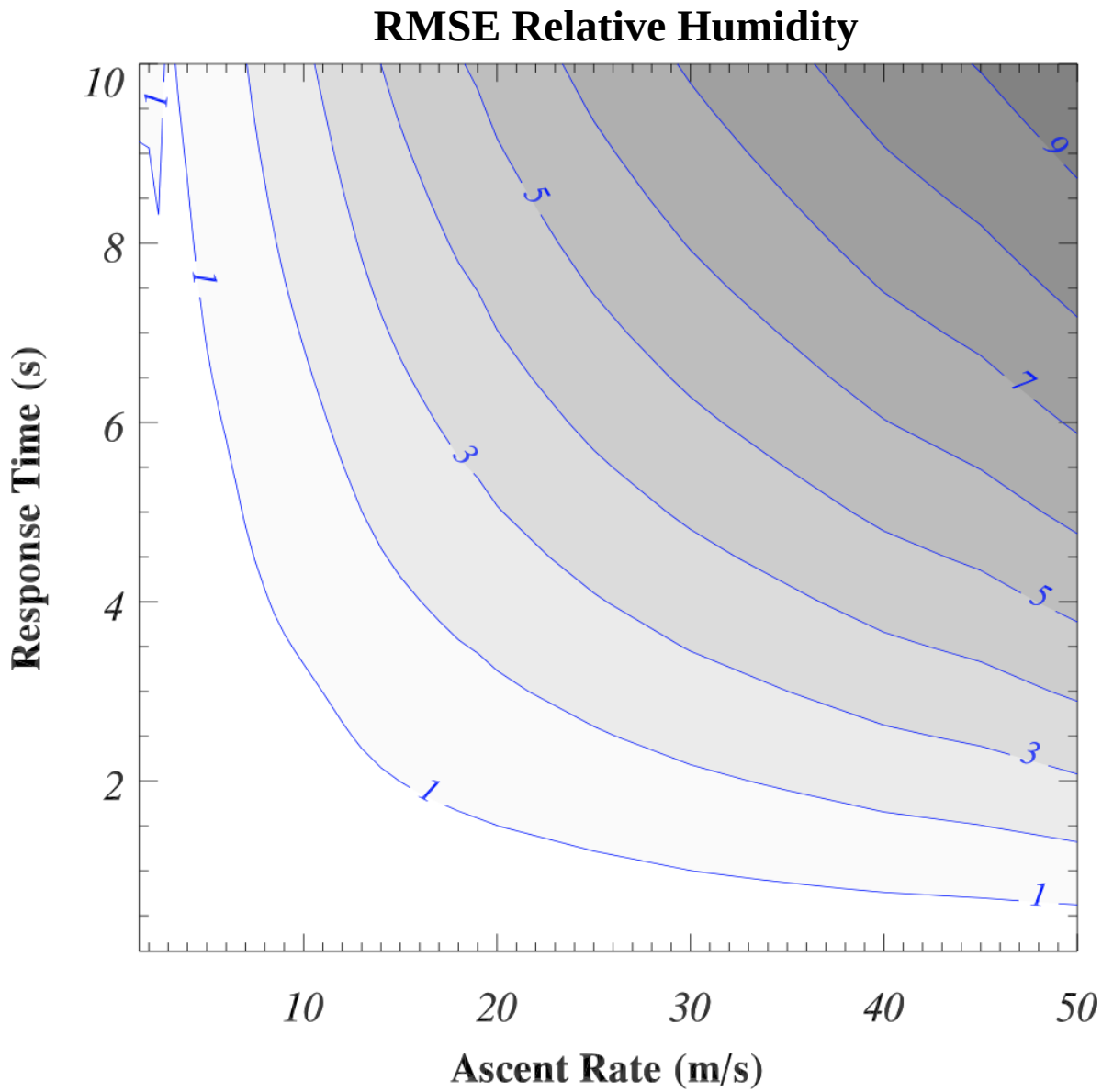
Results: CBL-Rotary Wing



Results: CBL-Rotary Wing



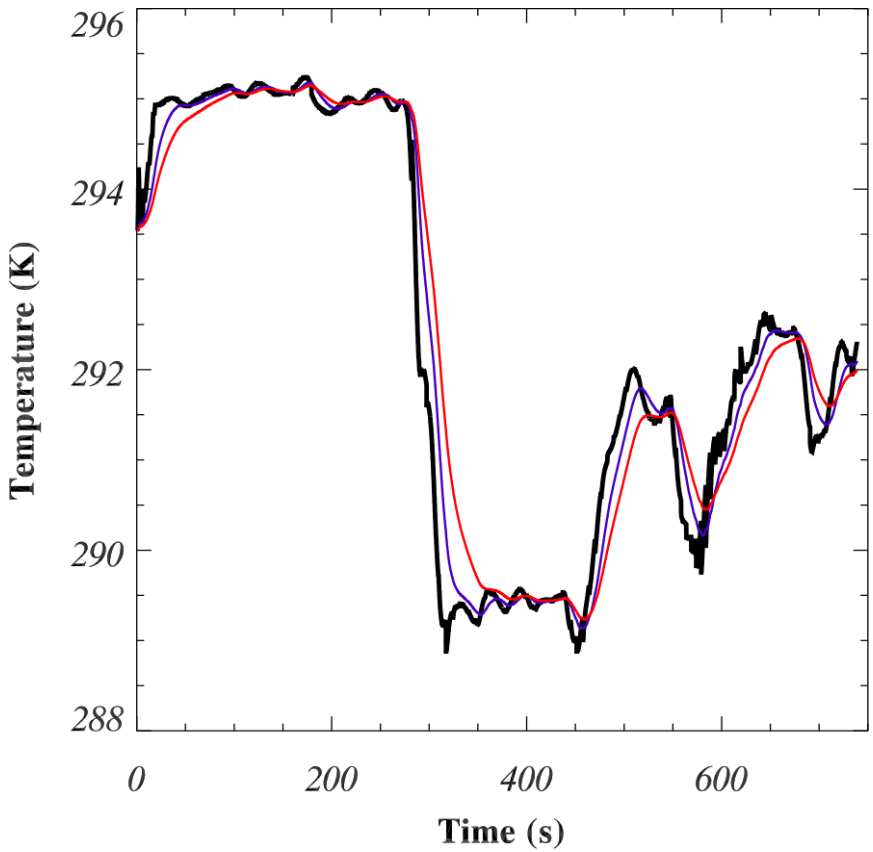
Results: CBL-Rotary Wing



Results: Boundary-Fixed-Wing

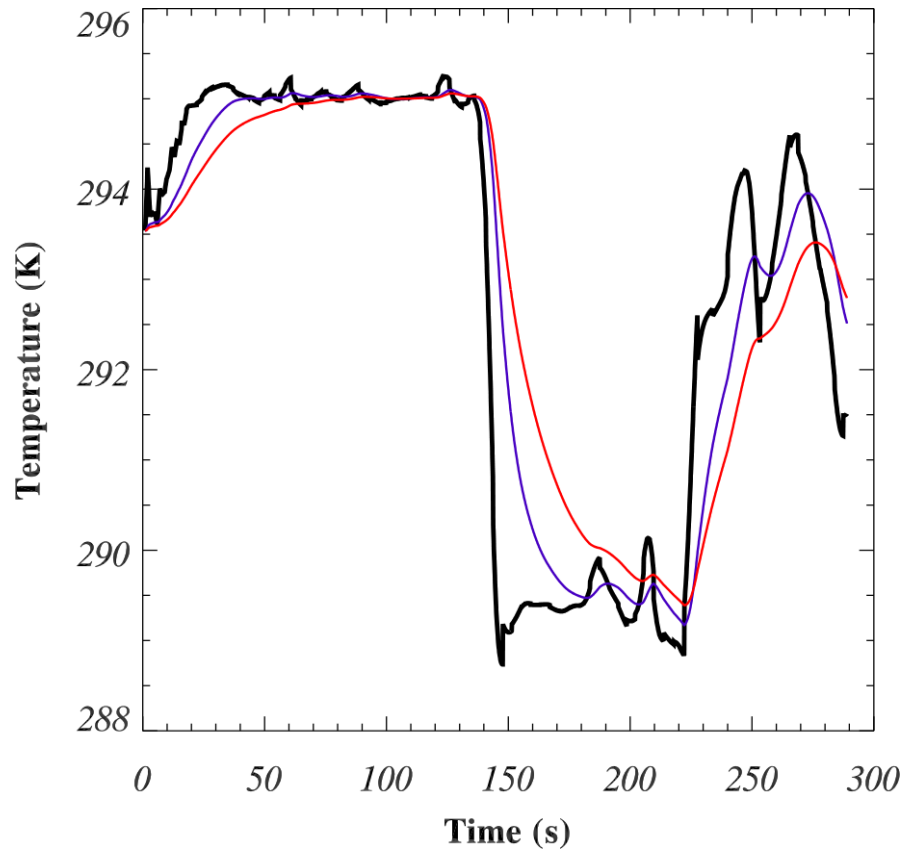
Transect speed: 10 m/s

τ: 10 s (blue), 20 s (red)



Transect speed: 30 m/s

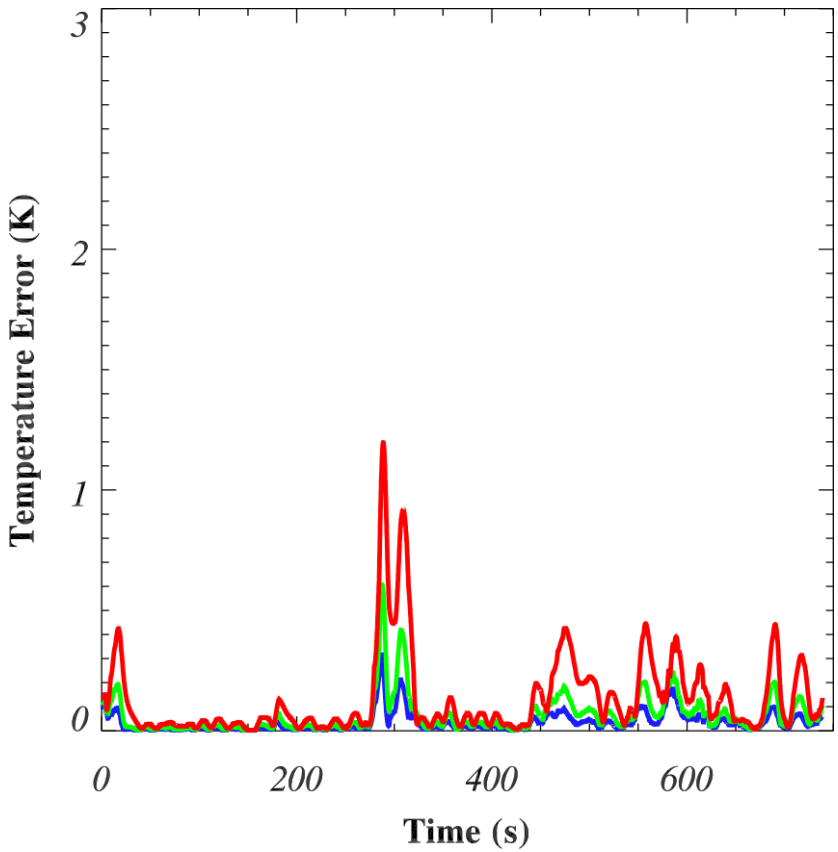
τ: 10 s (blue), 20 s (red)



Results: Boundary-Fixed-Wing

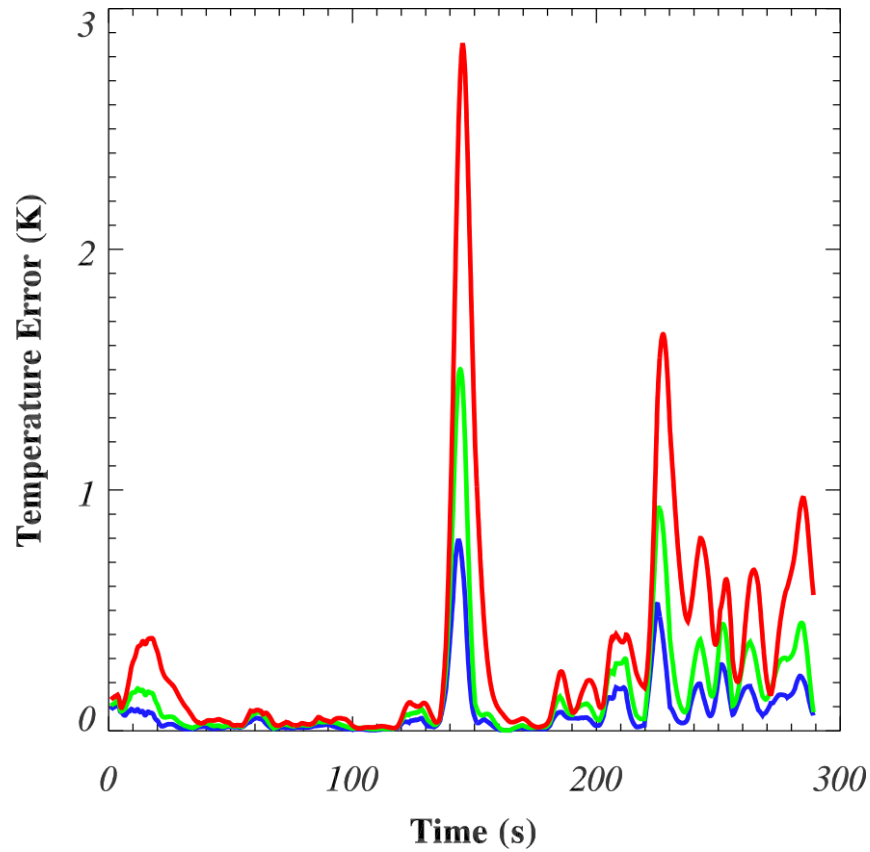
Transect speed: 10 m/s

τ: 1 s (blue), 2 s (green), 5 s (red)



Transect speed: 30 m/s

τ: 1 s (blue), 2 s (green), 5 s (red)



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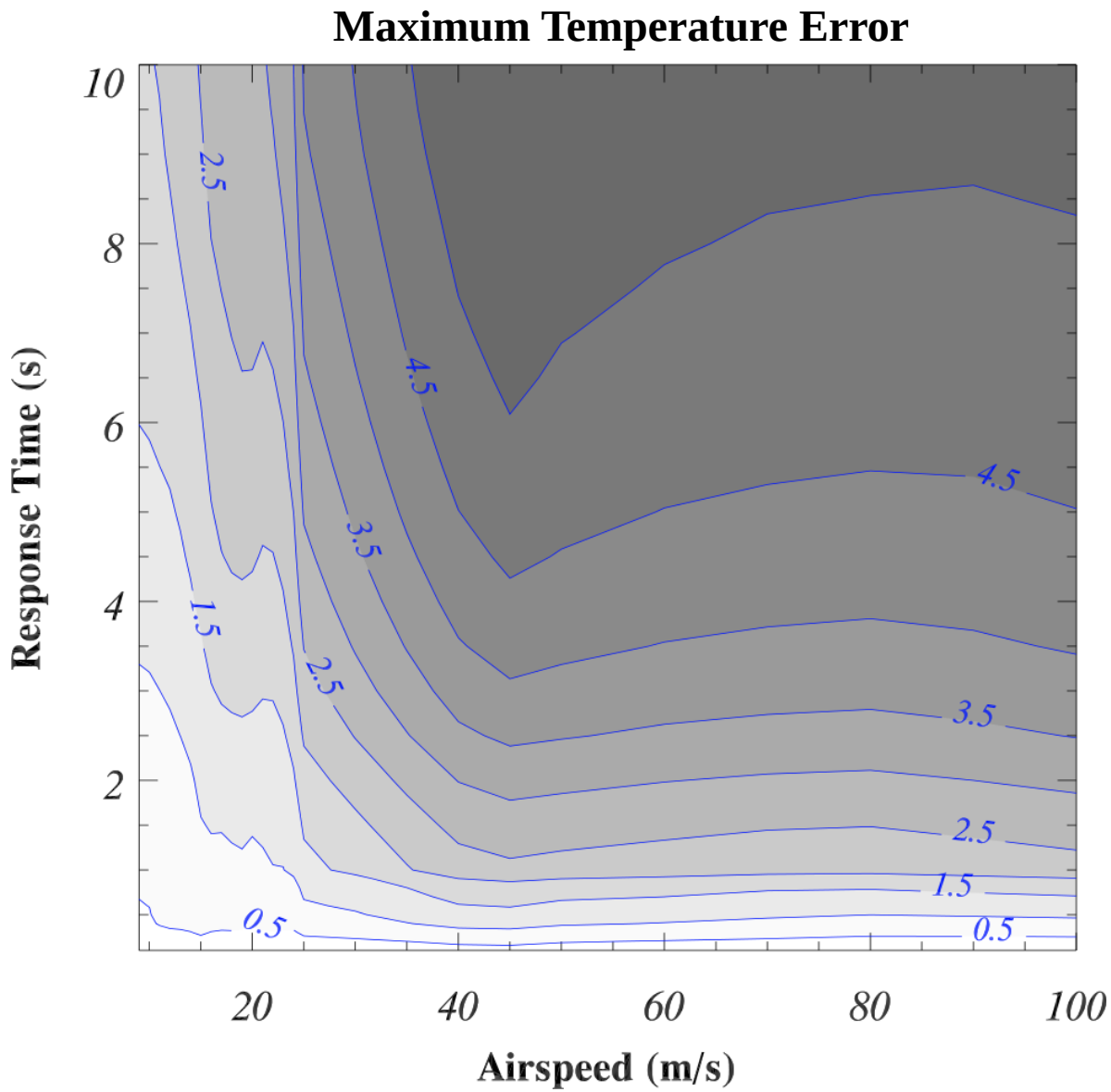
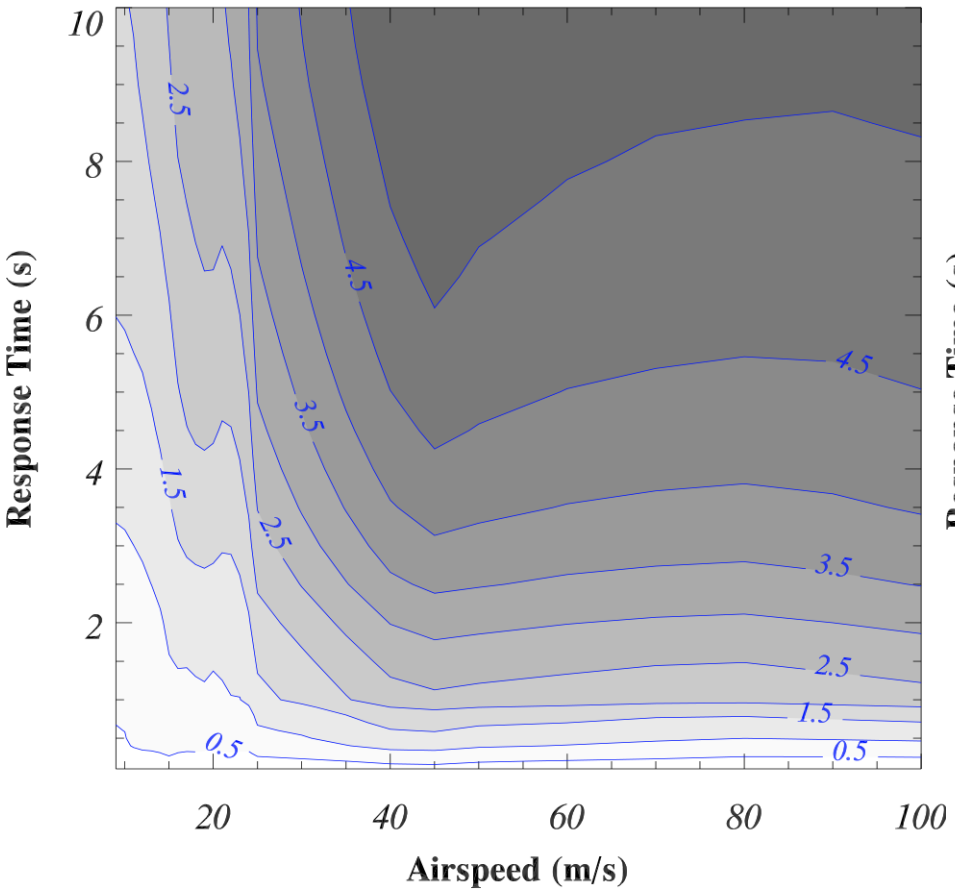


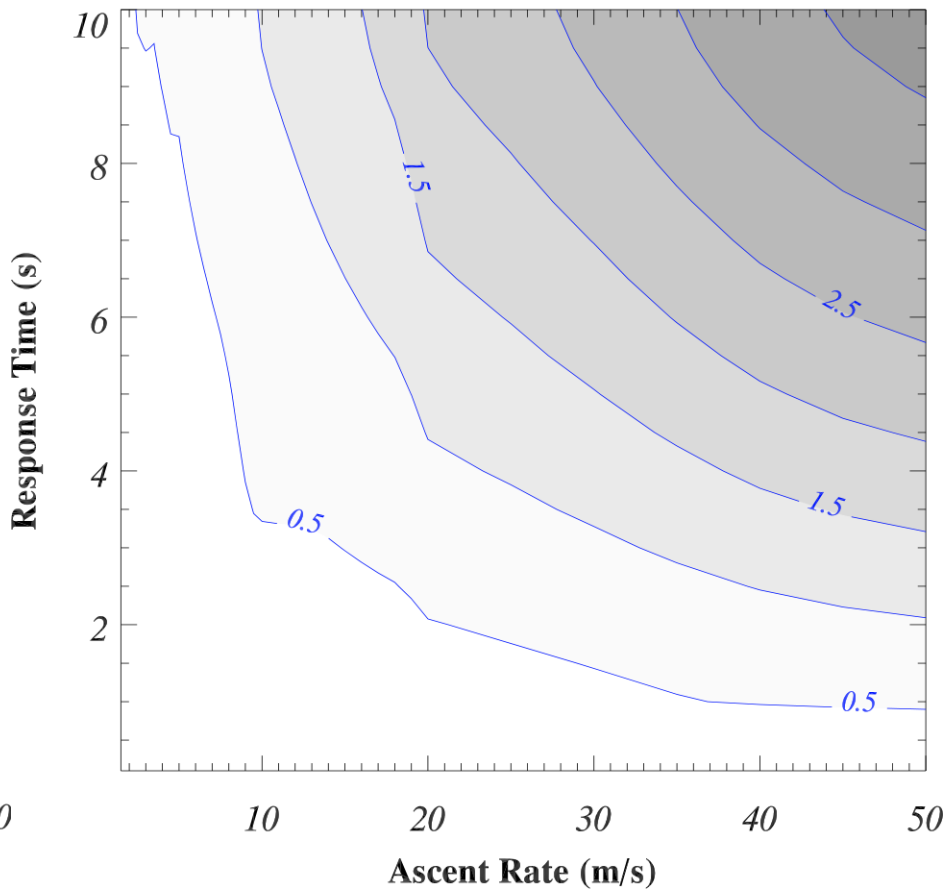
Results: Boundary-Fixed-Wing

Maximum Temperature Error

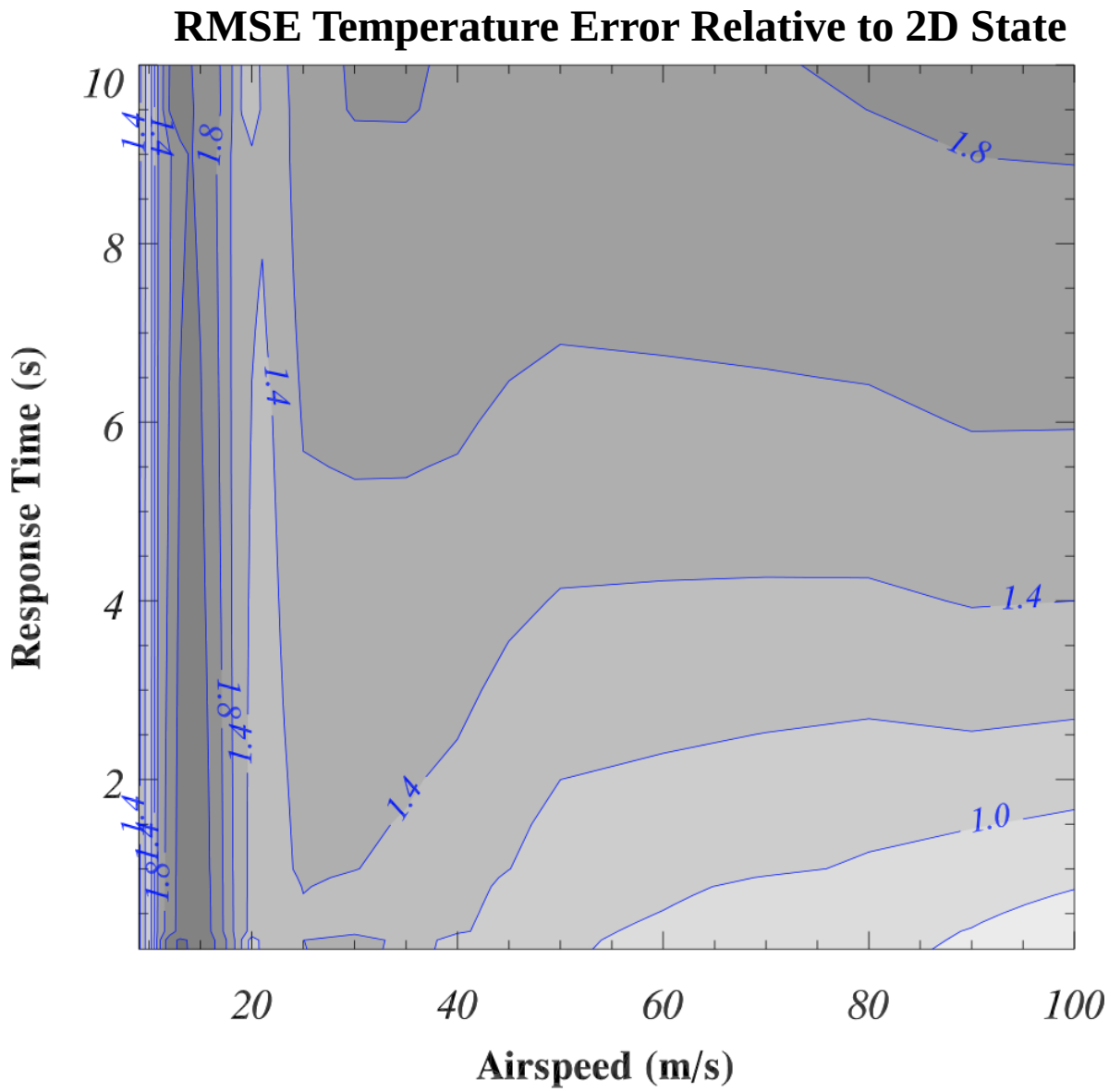
Boundary



CBL



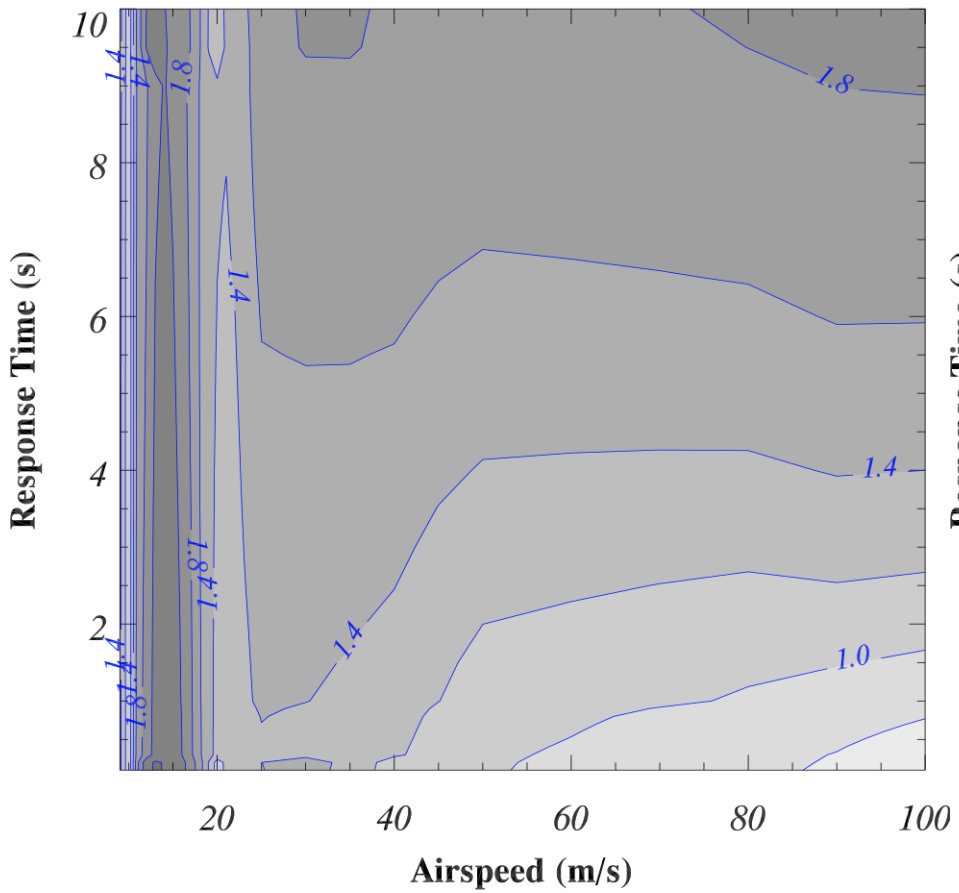
Results: Boundary-Fixed-Wing



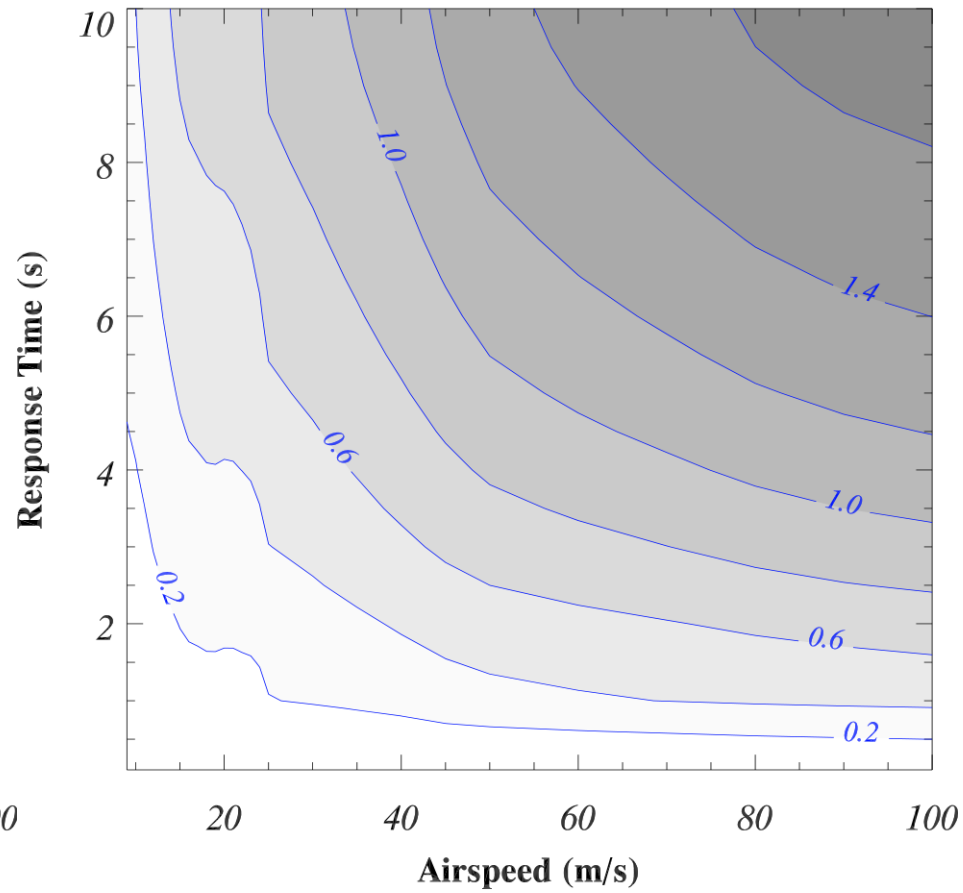
Results: Boundary-Fixed-Wing

RMSE Temperature Error

2D State



1D State



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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