Using Small Unmanned Aircraft Systems to Improve Boundary Layer Sampling: Insights from Recent Field Studies

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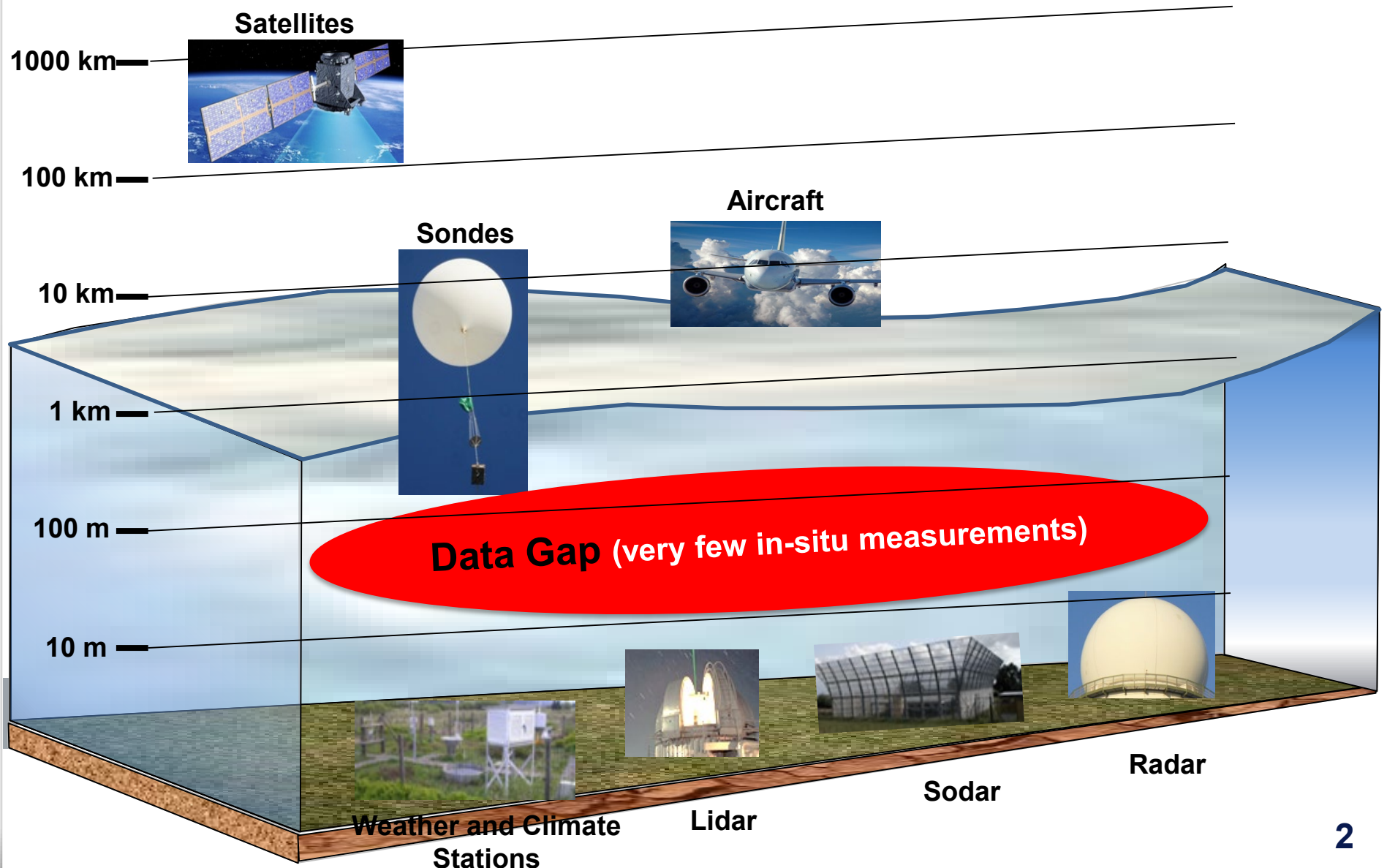
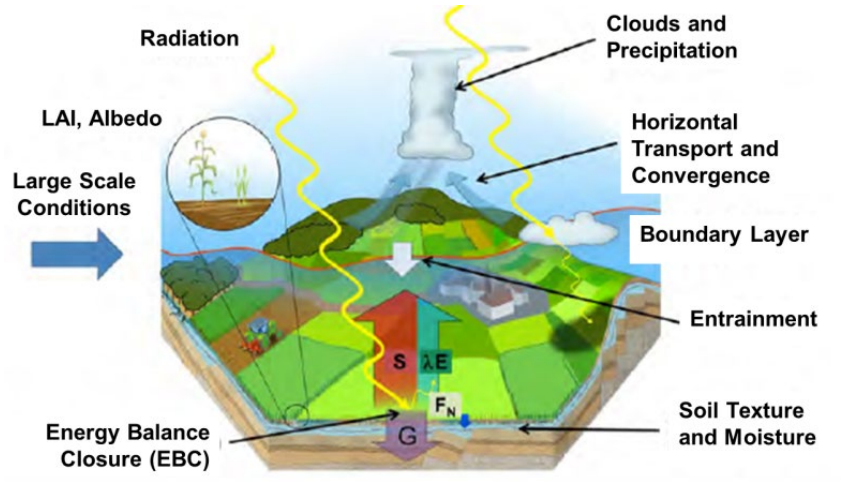
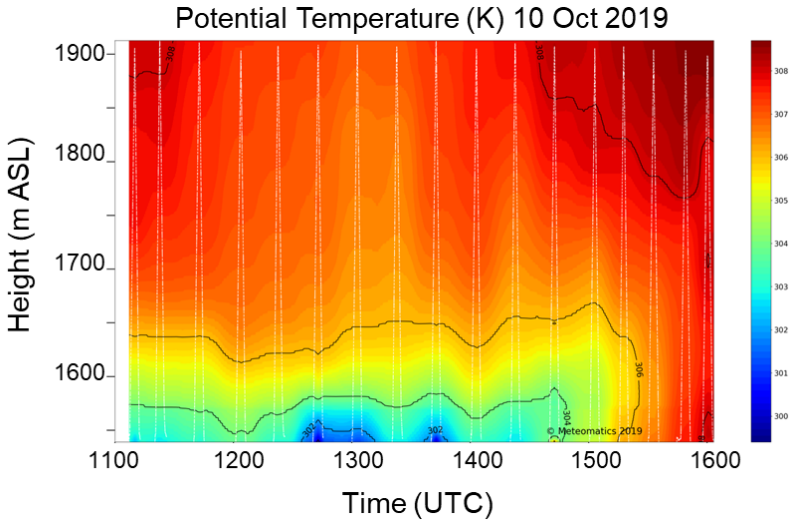
Importance of sUAS



Goal: Use sUAS to better sample the ABL and improve weather forecasts



Better scientific understanding of atmospheric processes through targeted field studies on land-atmosphere interactions



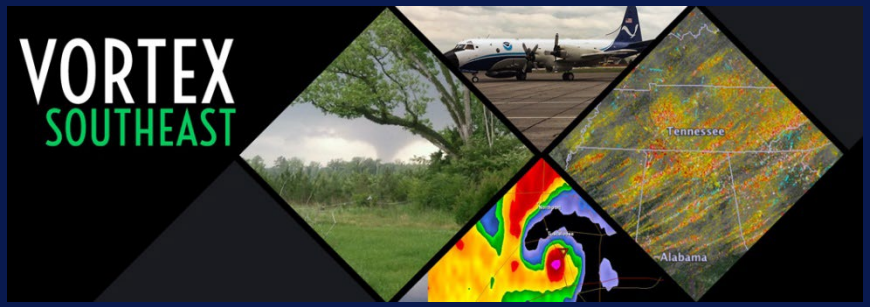
Routine ABL profiles to assist forecasters at NWS WFOs and assimilated into NWPs

NOAA / ARL / ATDD sUAS Operations

Model	DJI S-1000	MD4-1000	Meteodrone SSE	BlackSwift S2
				
Variables Sampled	*T*, *q*, *LST*	*T*, *q*	*T*, *q*, *u*, *v*	*T*, *q*, *u*, *v*, *w*
Manufacturer	DJI	Microdrone	Meteodrone	BlackSwift Technologies
Units in Fleet	1	1	2	2
Vehicle Type	Multi-rotor	Multi-rotor	Multi-rotor	Fixed-wing
Gross Weight	11 kg	3.85 kg	0.7 kg	6.6 kg
Wing Span	1.0 m	1.0 m	0.6 m	3.0 m
Length	1.0 m	1.0 m	0.6 m	2.0 m
Payload Capacity	4.5 kg	1.2 kg	--	2.3 kg
Engine Type	8 electric motors	4 electric motors	6 electric motors	1 electric motor
Autopilot	DJI A2 with iOSD Mk II	Microdrone	Meteodrone	SwiftPilot
Max Speed	10 m s^{-1}	10 m s^{-1}	19 m s^{-1}	24.7 m/s
Loiter Speed	0 m s^{-1}	0 m s^{-1}	0 m s^{-1}	15 m/s
Endurance	15 min	25 min	20 min	80 min
Ceiling	365 m	500 m	3000 m	3000 m

Since Oct 2015: 447 Flights, 74.8 Flight Hours

Recent Campaigns



Mar-Apr 2016, 2017

Land Atmosphere Feedback Experiment

Aug 2017

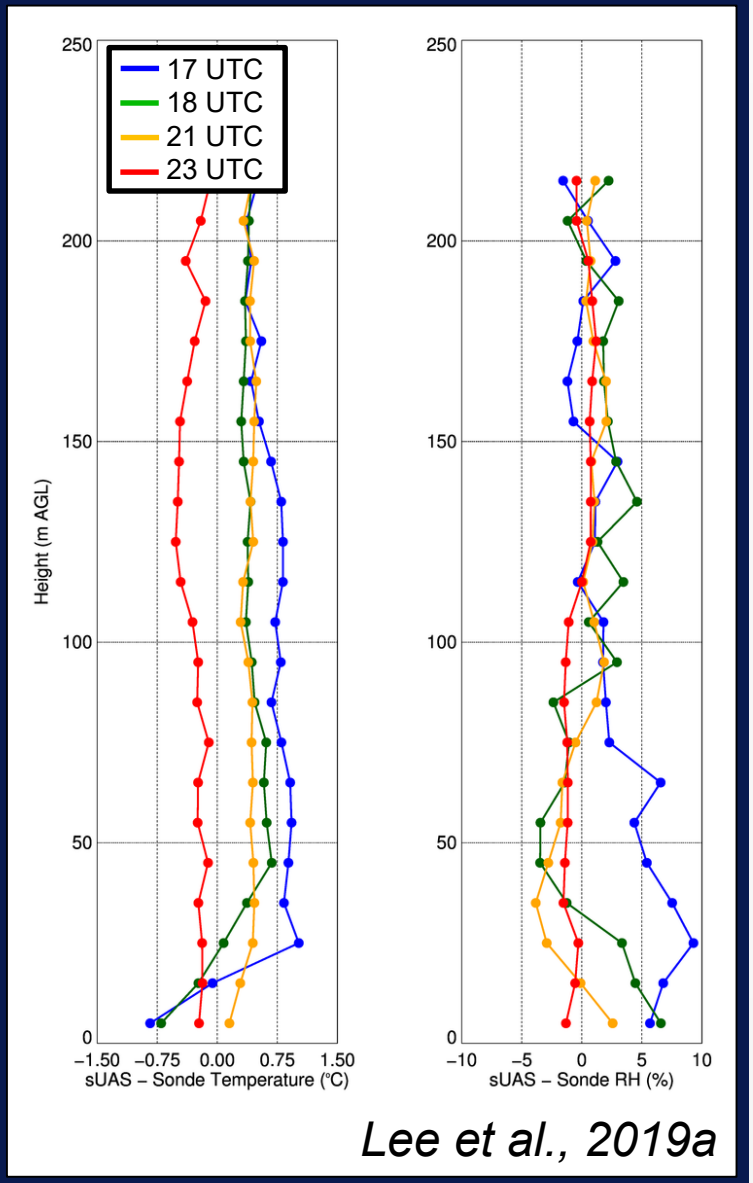
21 Aug 2017

Jul-Sep 2019

ALBUQUERQUE INTERNATIONAL BALLOON FIESTA®
The World's Premier Balloon Event

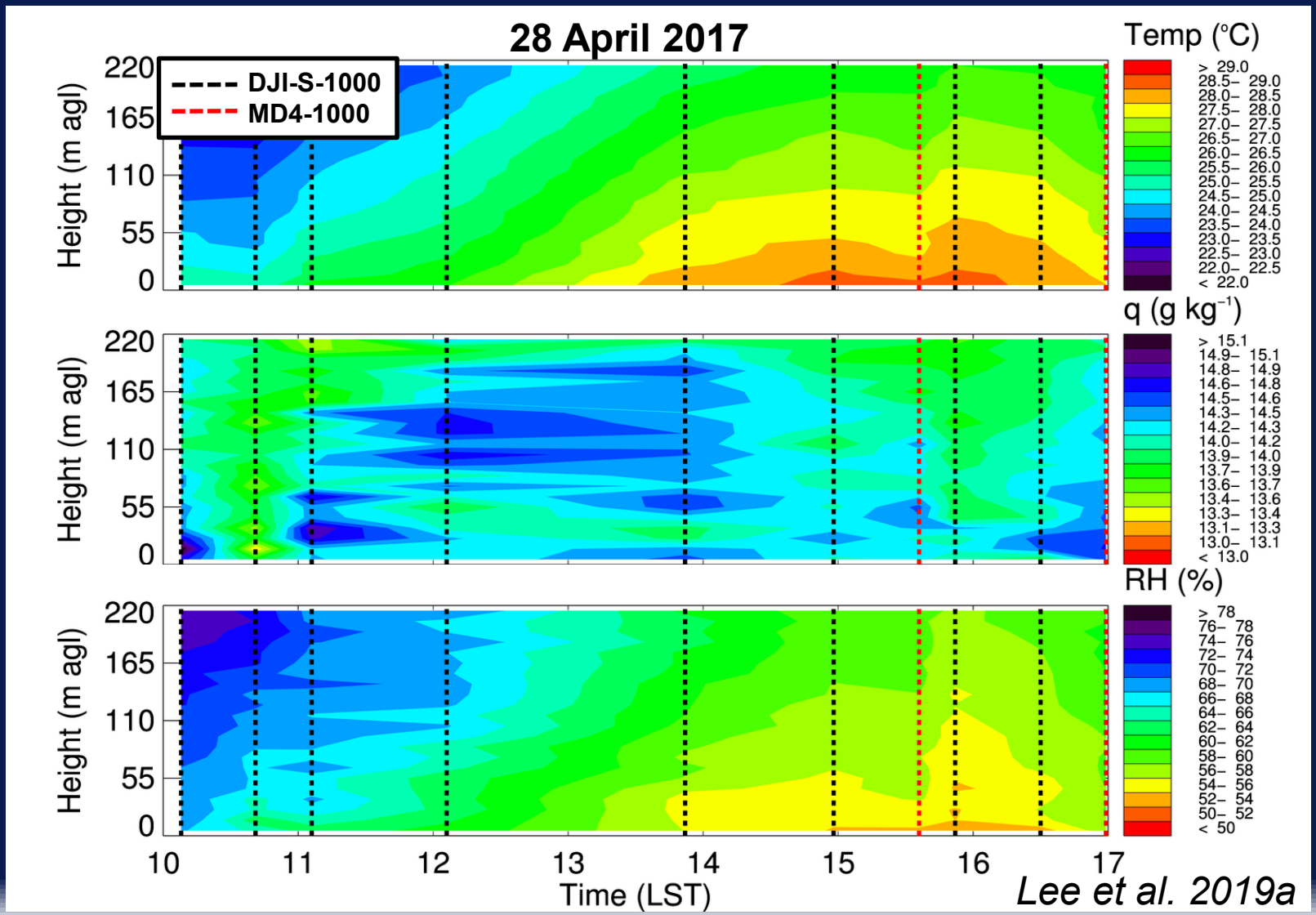
Oct 2019

VORTEX-SE

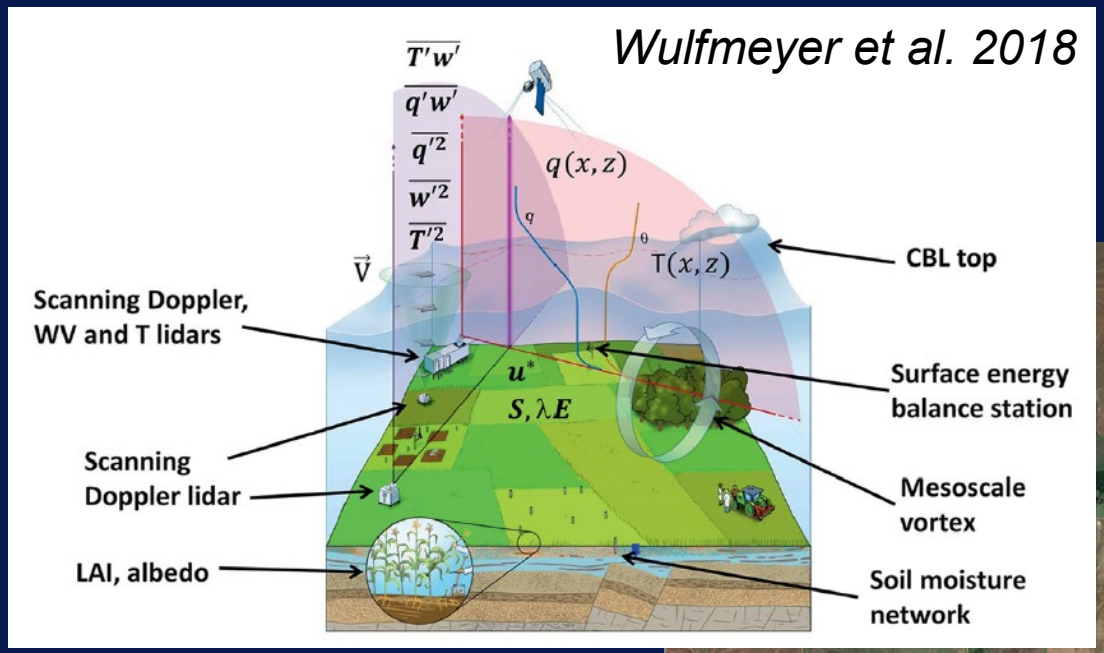


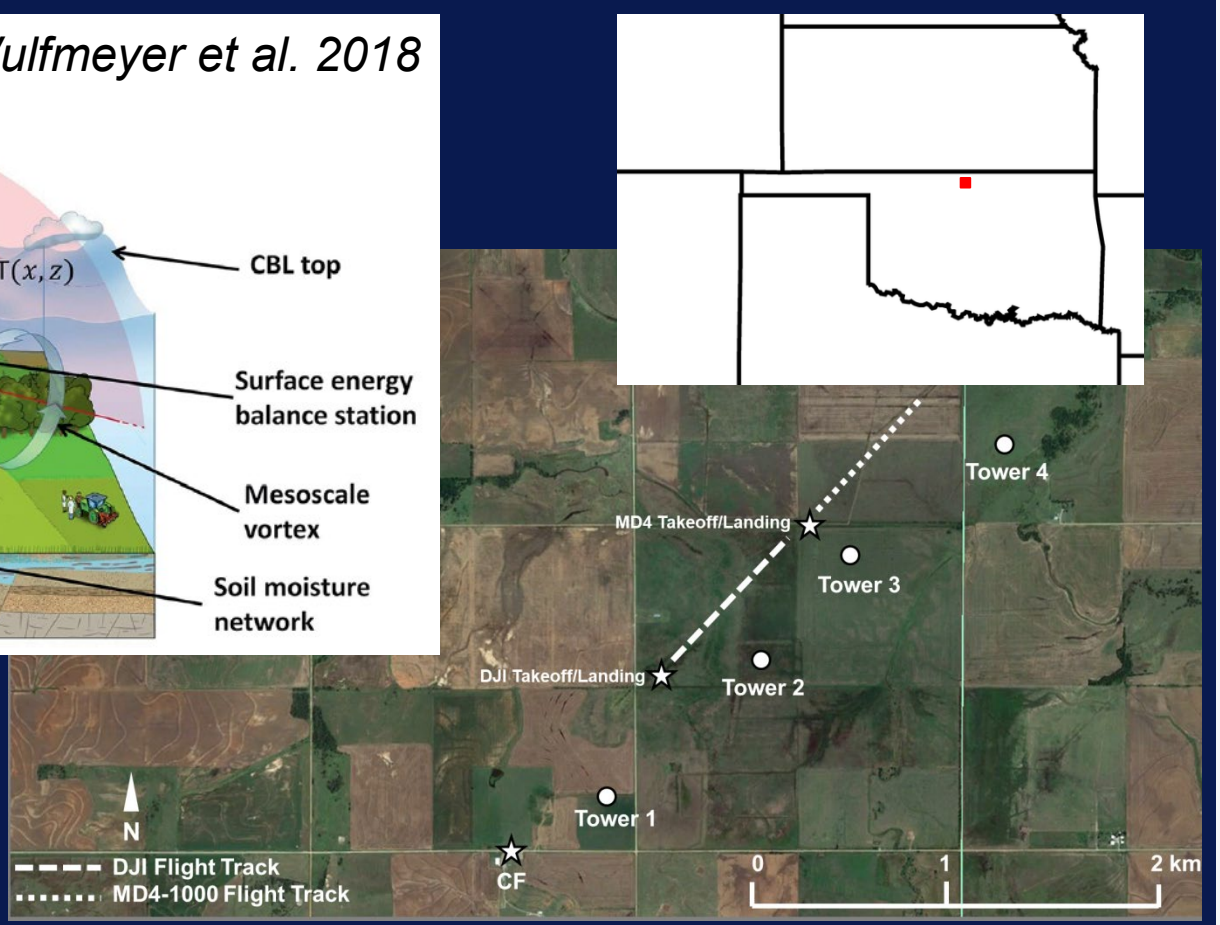
Lee et al., 2019a

Vertical profiles from sUAS provided critical information on the evolution of near-surface temperature and moisture prior to severe weather events during VORTEX-SE



Land Atmosphere Feedback Experiment (LAFE)

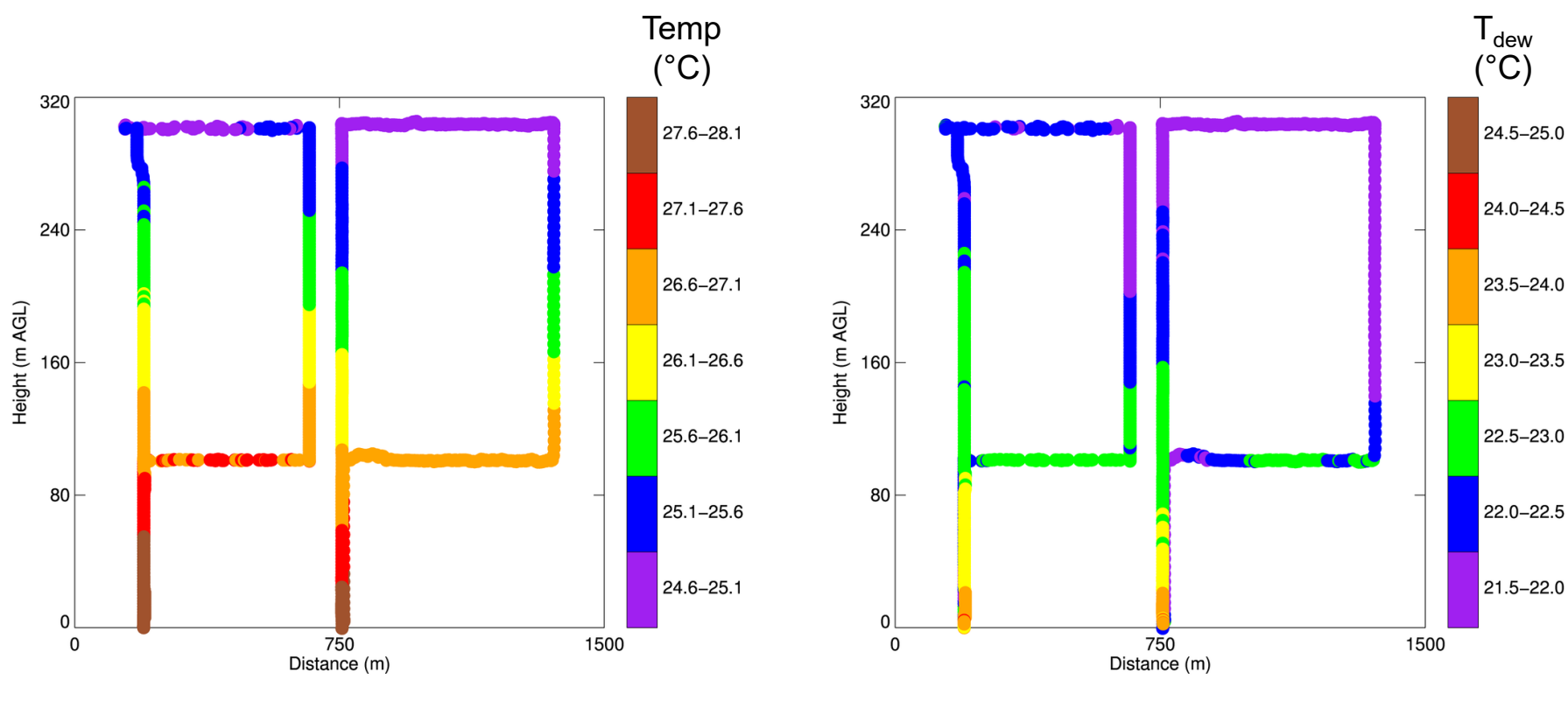




Array of sfc. weather instruments and ABL profilers to study interactions between the land surface and overlying atmosphere

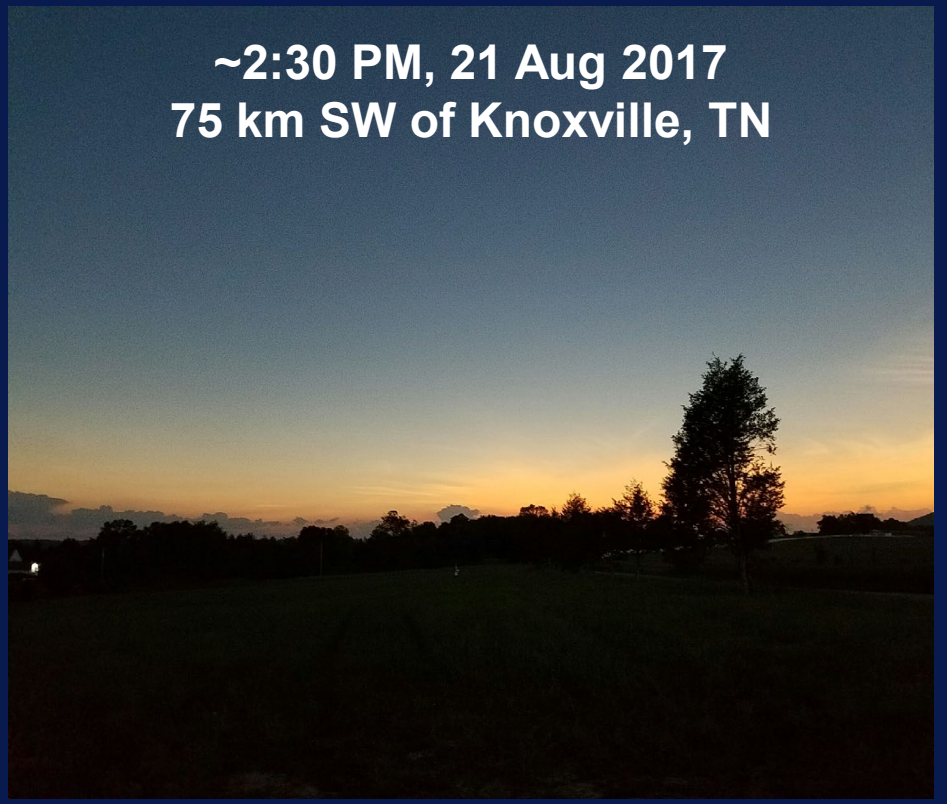
ABL profilers unable to sample in the lowest ~ 50 m; sUAS used to fill in this gap and measure differences in near-surface temp. and moisture

1710 UTC 15 Aug 2017

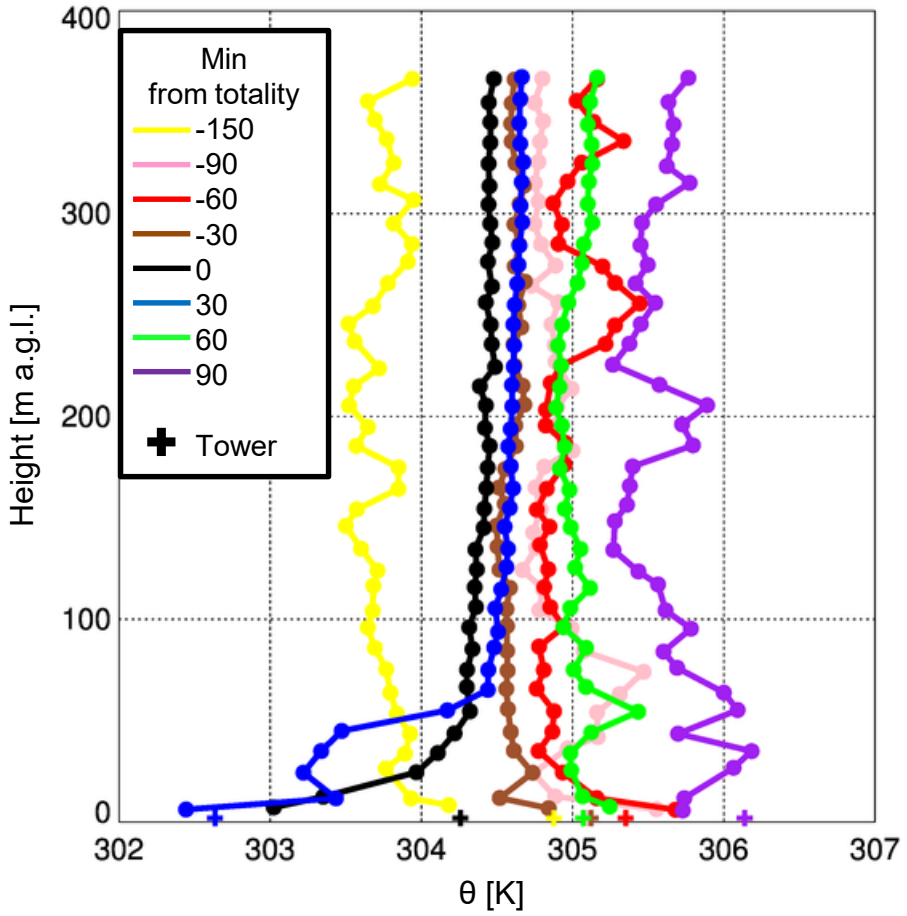


Great American Eclipse

…as observed by us

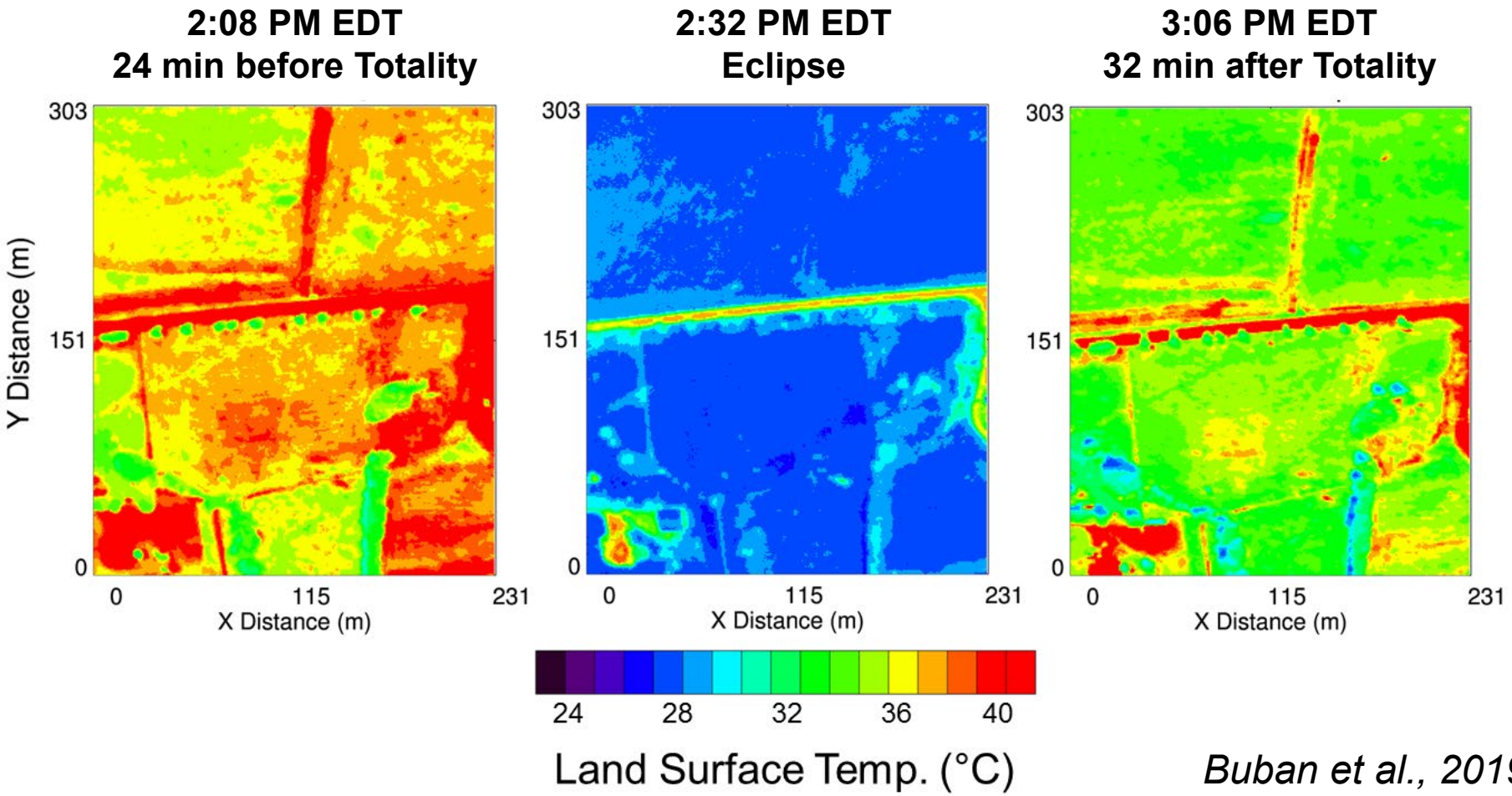


…and as observed by our sUAS



Buban et al., 2019

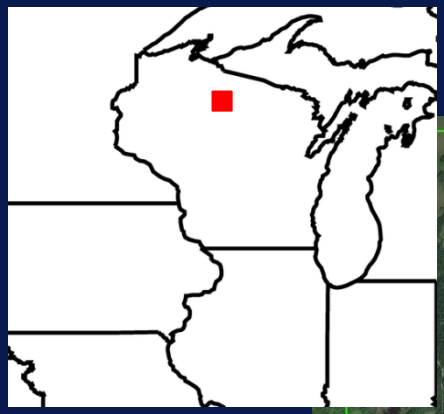
sUAS Surface Temp. Before, During and After Eclipse

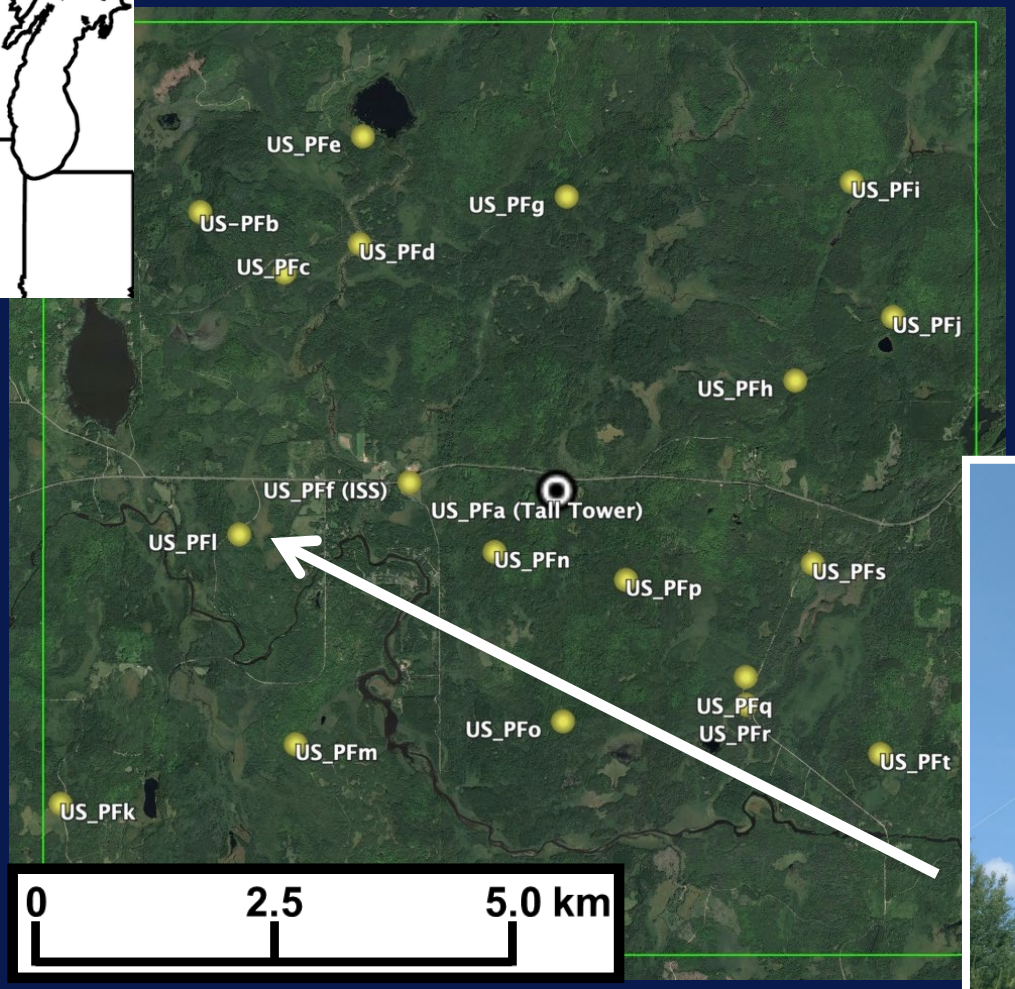


Buban et al., 2019

Rapid cooling and re-heating of the land surface during the afternoon of the eclipse

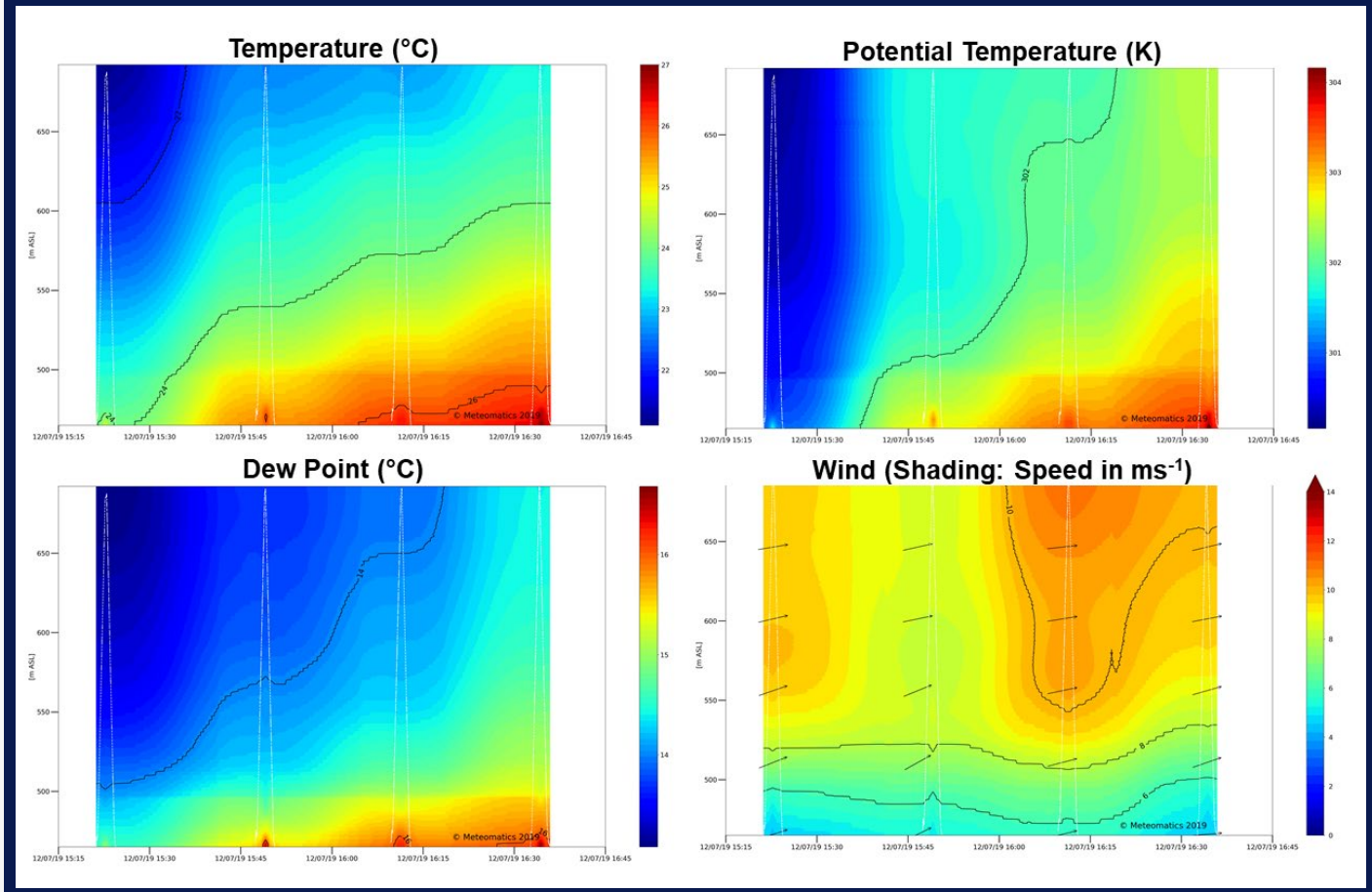
CHEESEHEAD



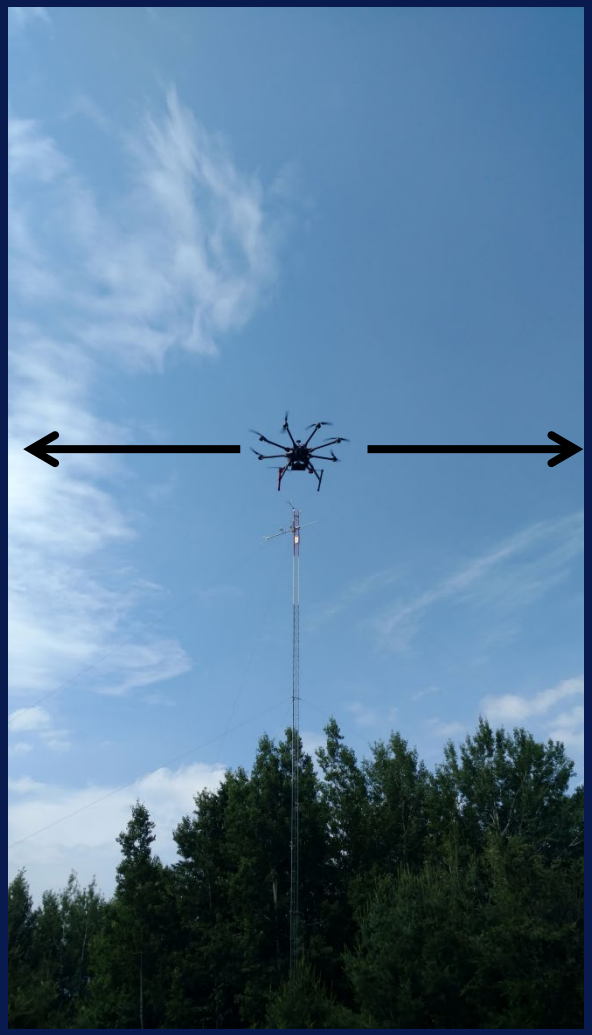


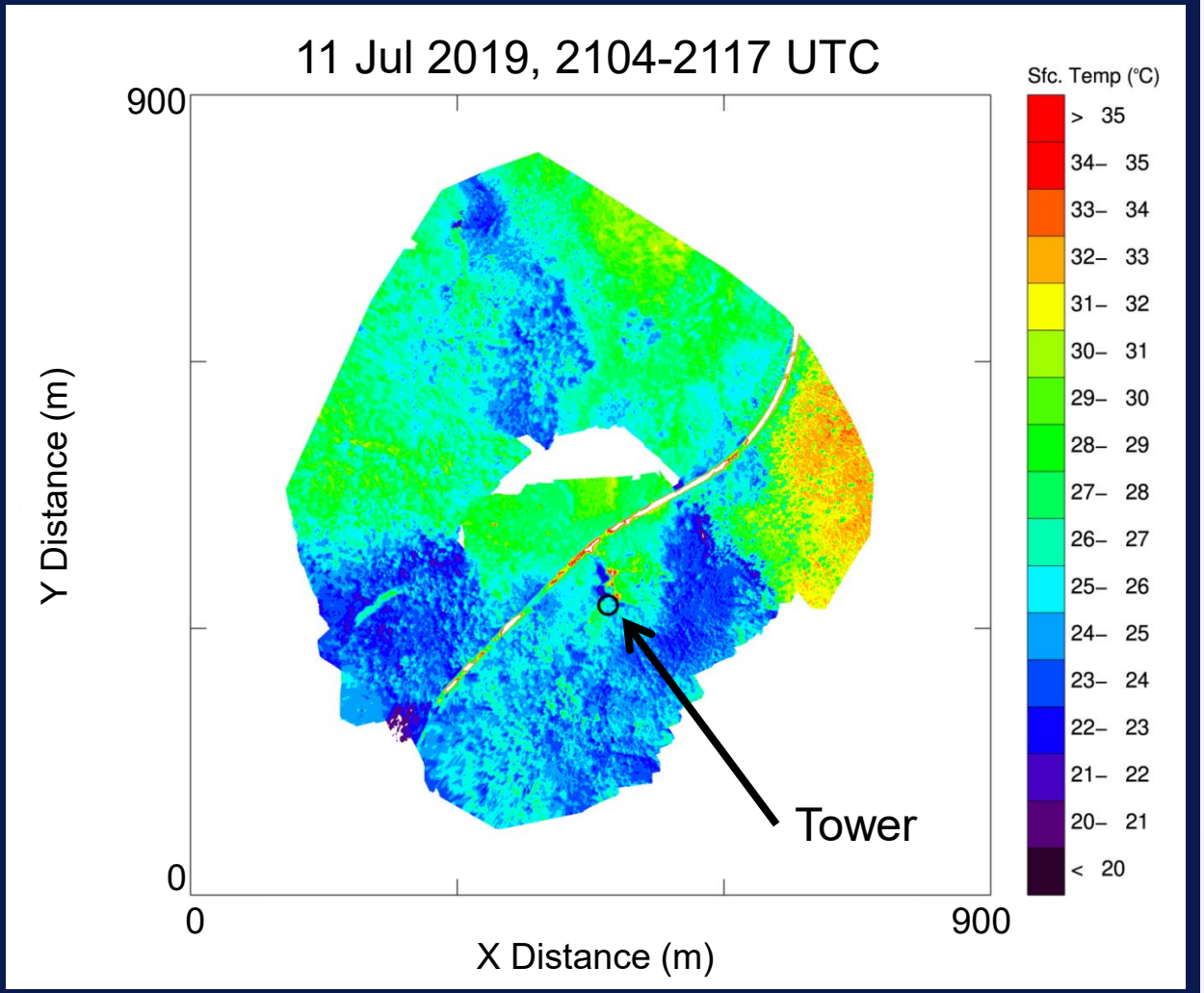
sUAS used to help scale point observations

During CHEESEHEAD, sUAS provided information not only above met. towers…



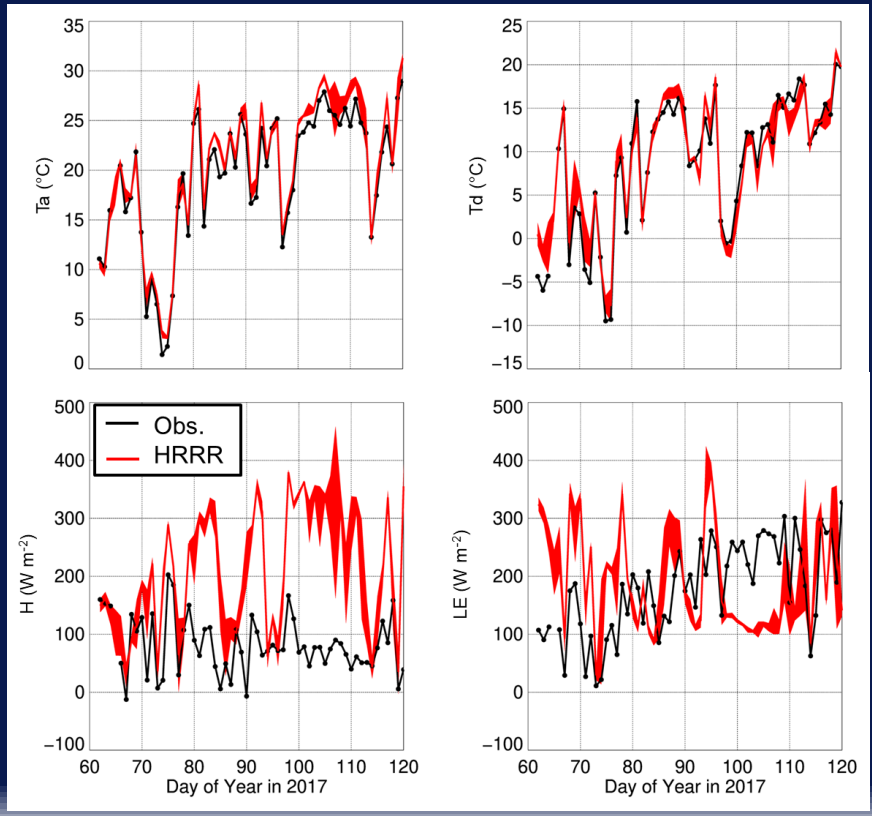
…but also provided information on the horizontal variability in temp. and moisture surrounding the towers.





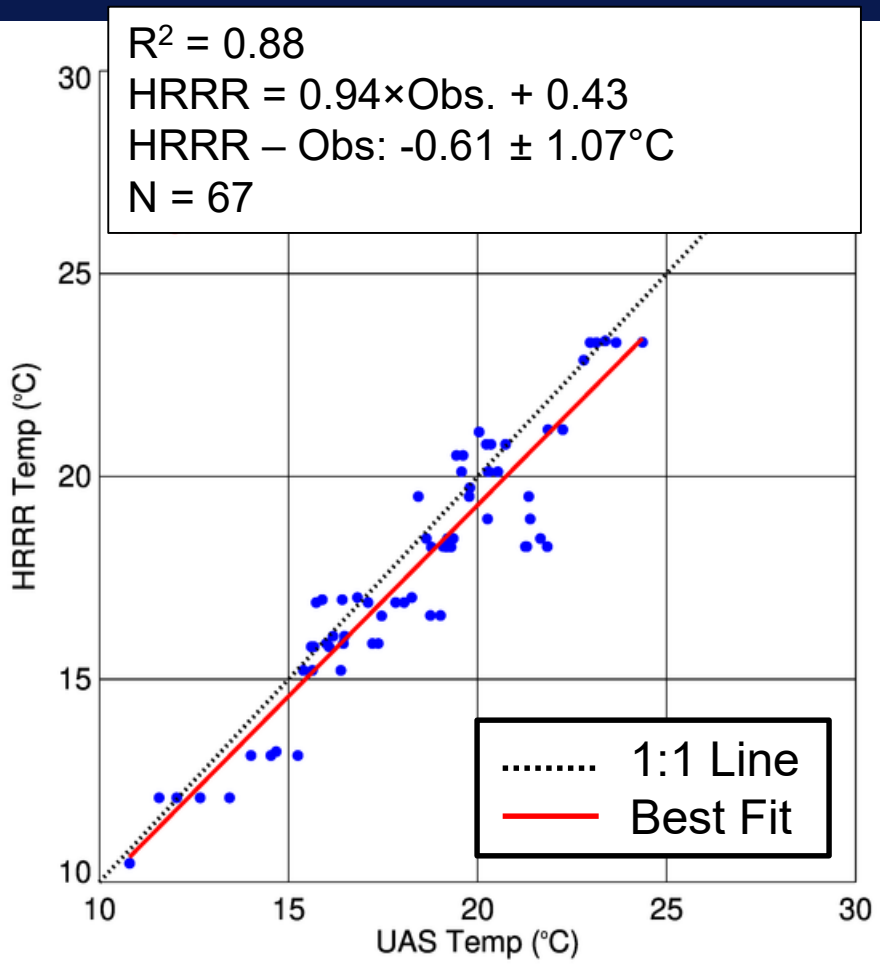
sUAS observations used to help evaluate HRRRv3

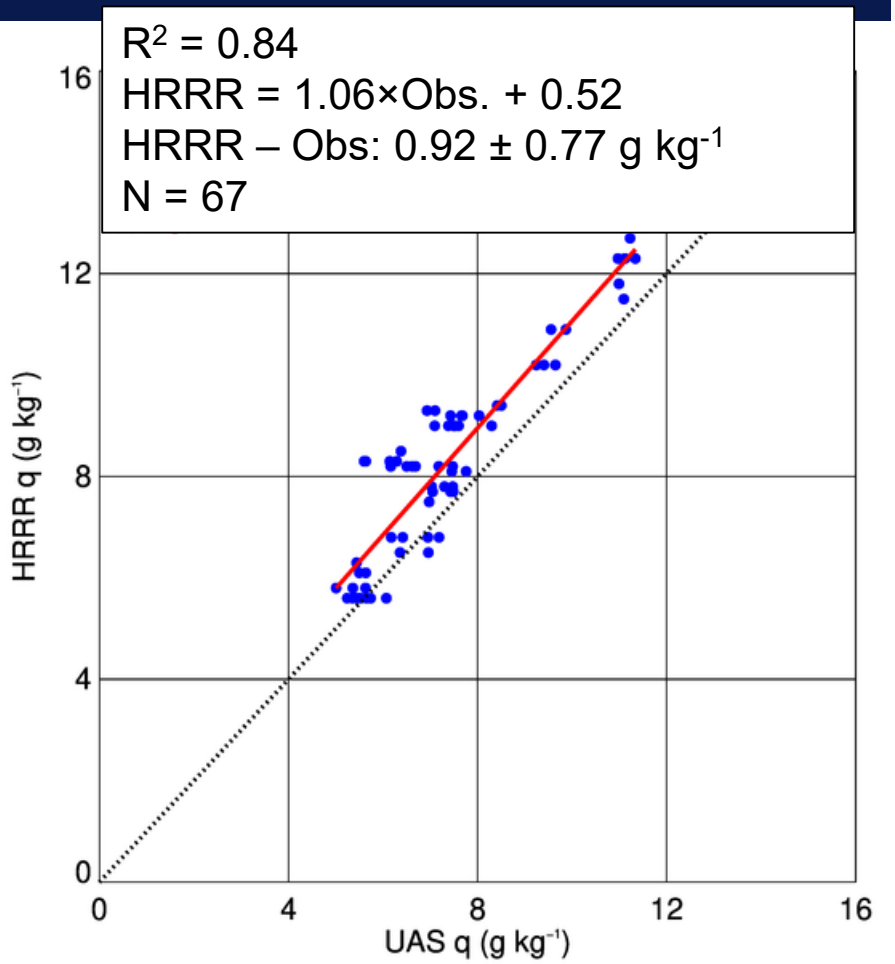
- 3 km hourly-updating cloud-resolving model
- HRRRv3 released July 2018 (HRRRv4 to be released ~July 2020)
- Surface values from HRRRv3 1-hr forecast compared against:
  - sUAS observations
  - NCAR flux towers
- Good agreement in surface met. fields from HRRRv2 but significant differences in fluxes



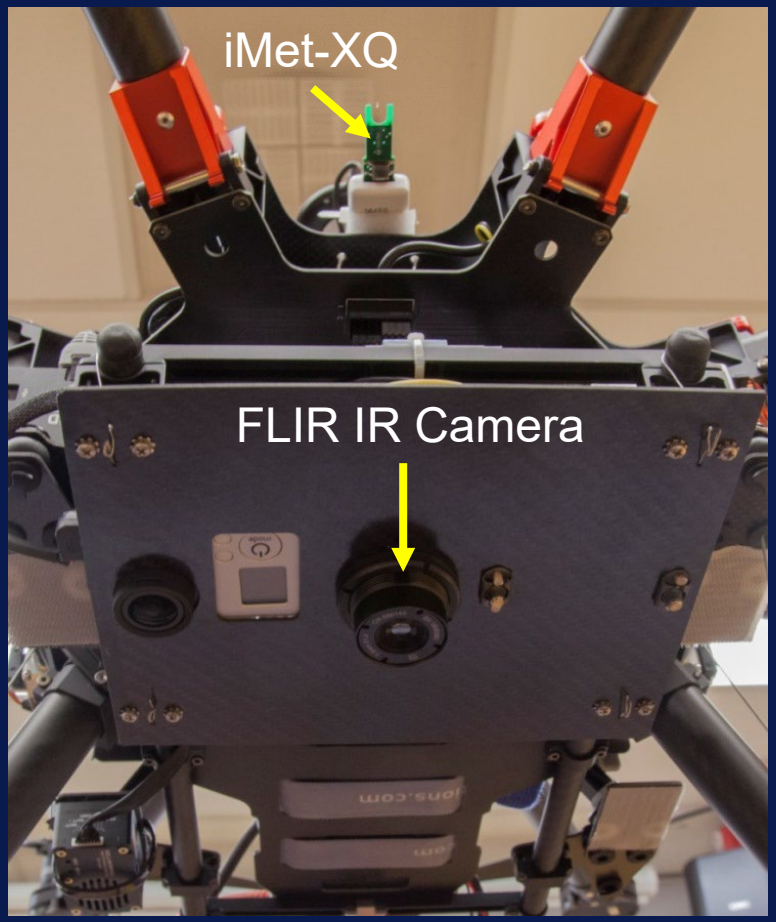
Lee et al. 2019b

sUAS vs. HRRRv3
T, *q*



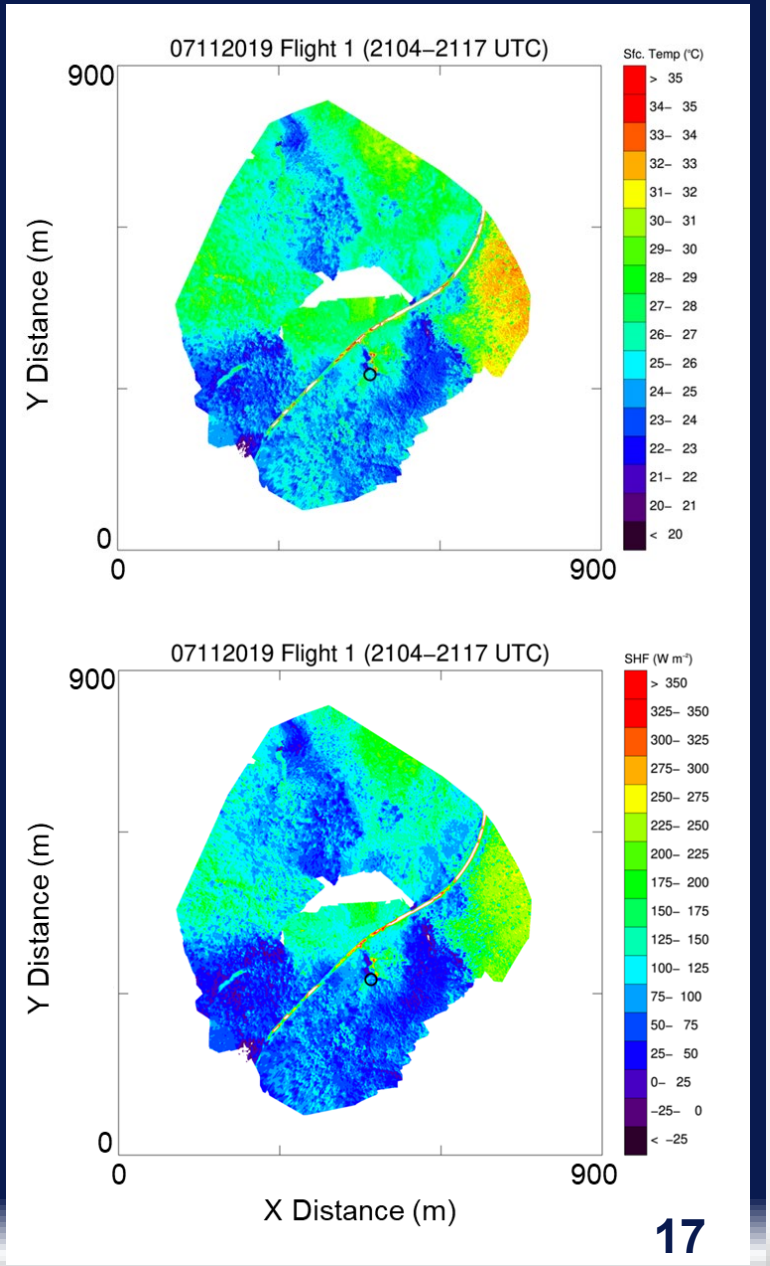


sUAS measurements to estimate *H*

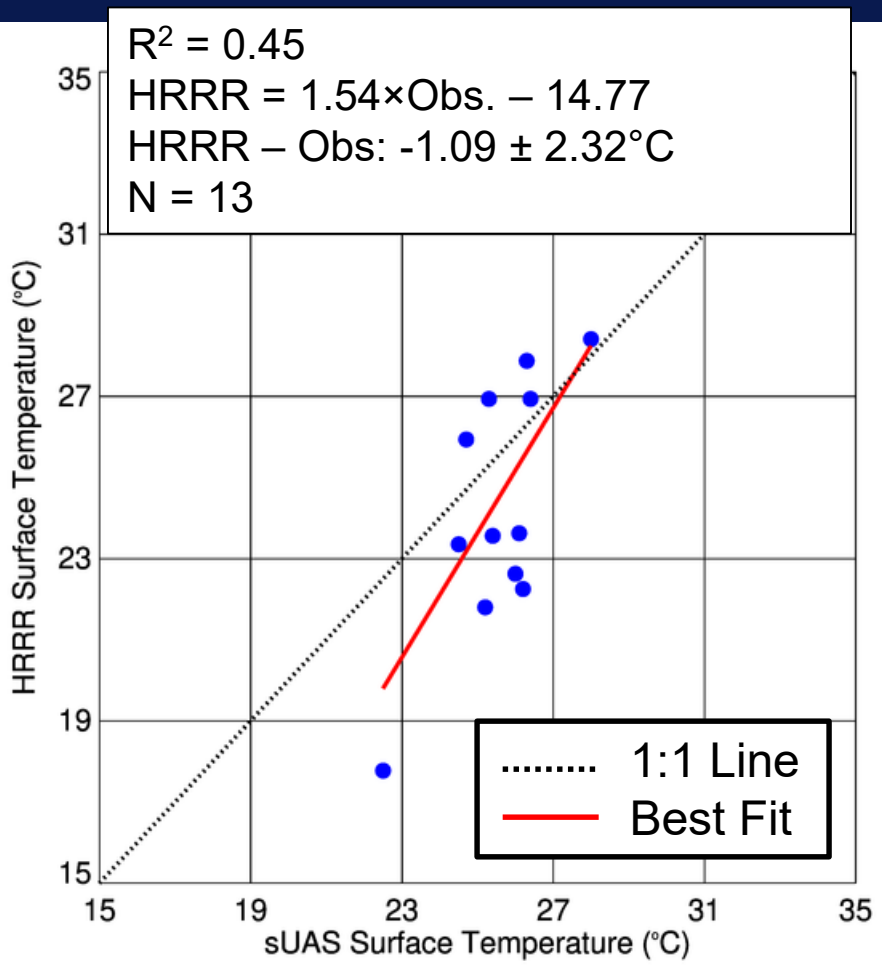


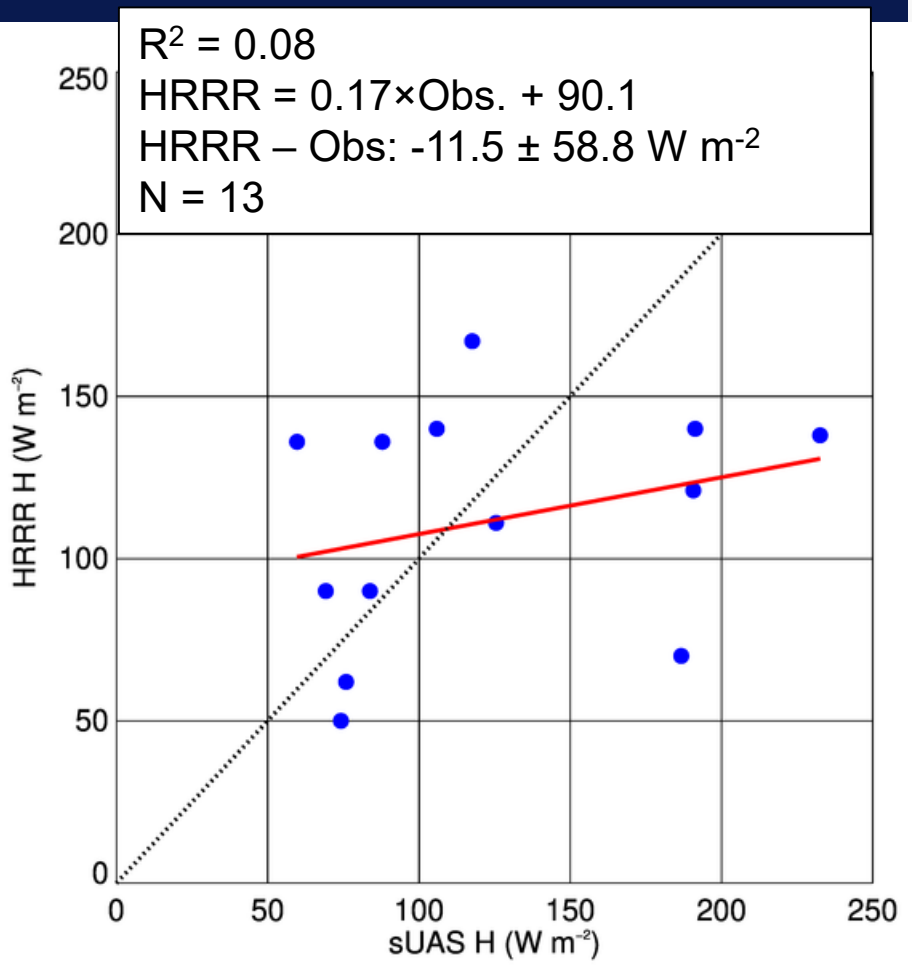
Underside of
DJI S-1000 sUAS

$$H(x,y) \approx \beta\left(T_{s_{UAS}}(x,y) - T_{a_{UAS}}(x,y)\right)$$



sUAS vs. HRRRv3
LST, H





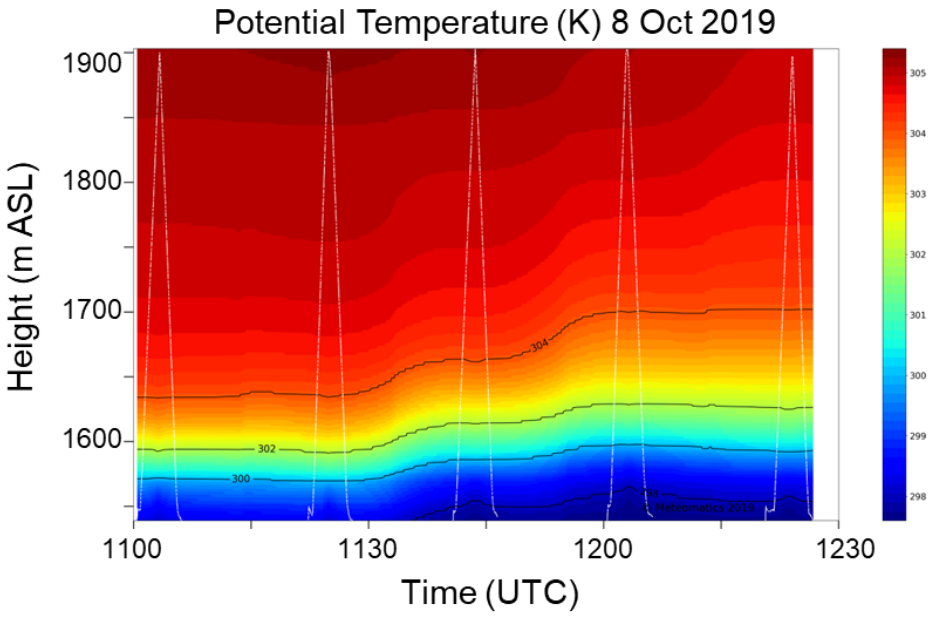
Albuquerque International Balloon Fiesta

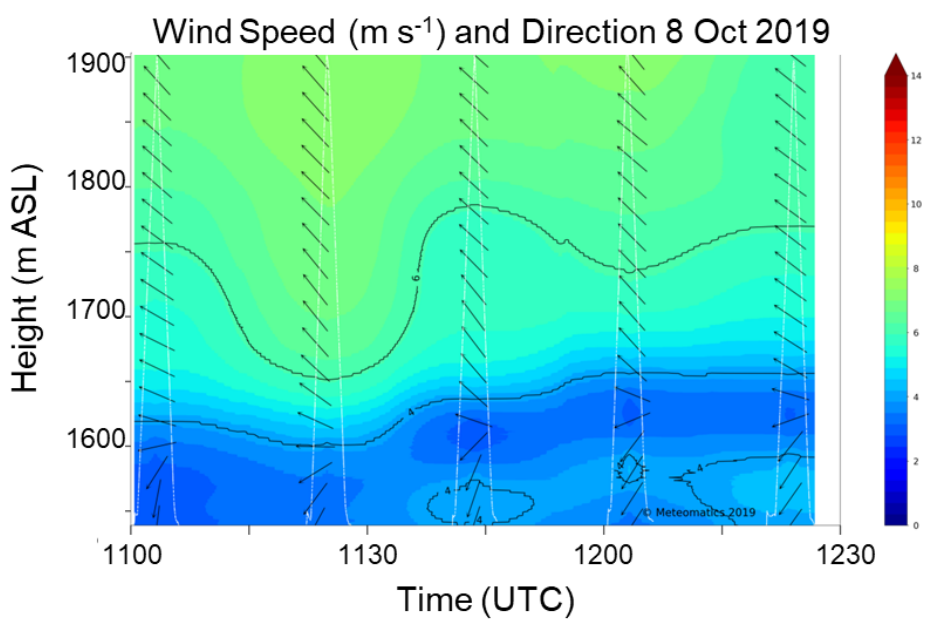
POSTCARD FROM THE FIELD

NOAA Team Keeps Balloons Flying High

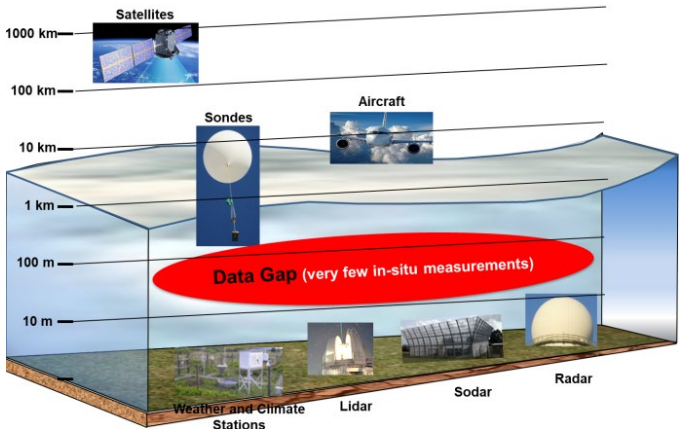
With a small drone, a NOAA team helped keep more than 500 hot air balloons aloft during Albuquerque's recent International Balloon Fiesta. Collecting meteorological data up to 1,200 feet above ground every 20 minutes throughout the nine-day festival supported accurate forecasts critical to safely and efficiently piloting the huge balloons. Credit NOAA's Air Resources Lab, Unmanned Aircraft Systems Program, Aircraft Operations Center, and National Weather Service for the collaborative effort.

sUAS played a critical role resolving sfc.-based inversion, NE drainage flows, and winds above inversion

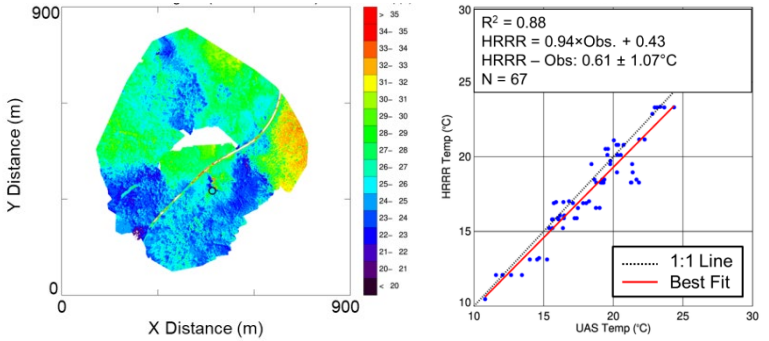




Summary

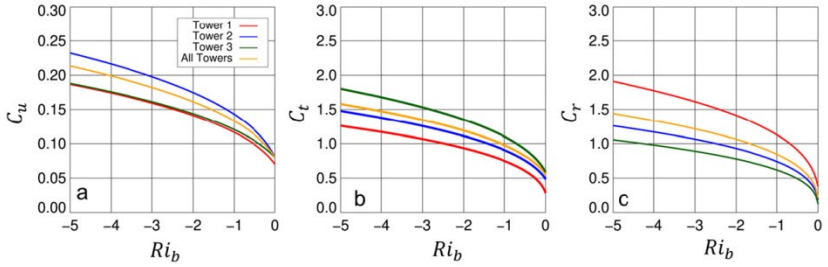


sUAS help to close a significant observation gap in Earth's atmosphere

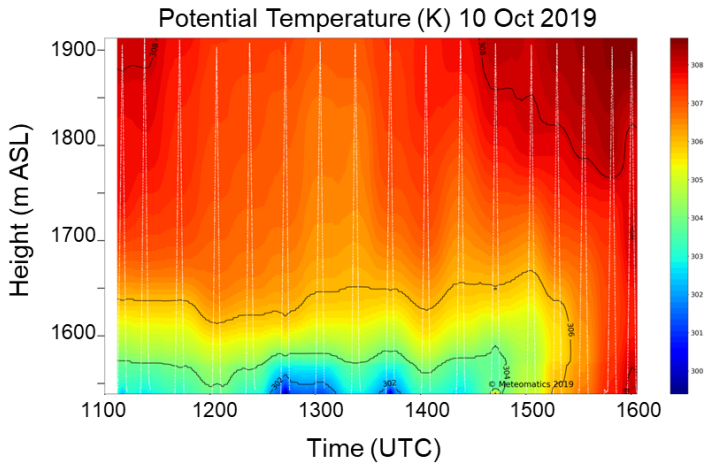


sUAS used to study interactions between the surface and atmosphere and improve how these are represented in forecast models

Outlook



sUAS to help evaluate / refine newly-suggested surface-layer parameterizations
(Lee and Buban, 2020)



Routine sUAS profiles provided to NWS WFOs, assimilated into the HRRR