Boundary Layer Technologies

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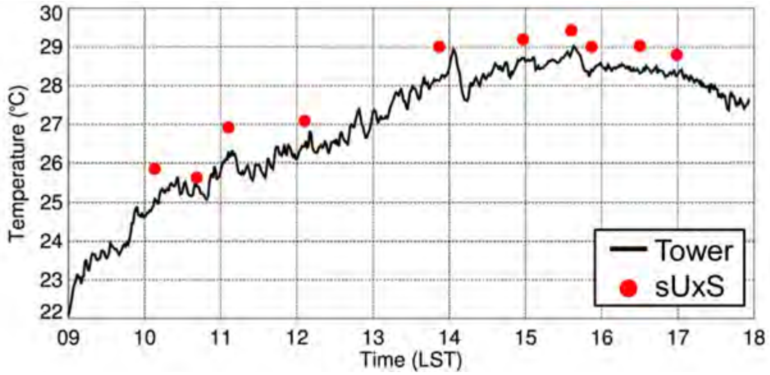
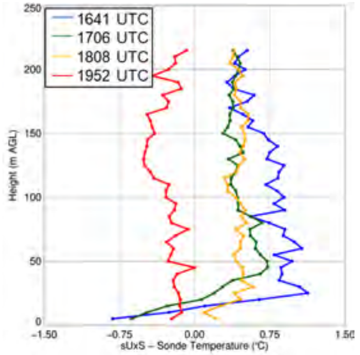
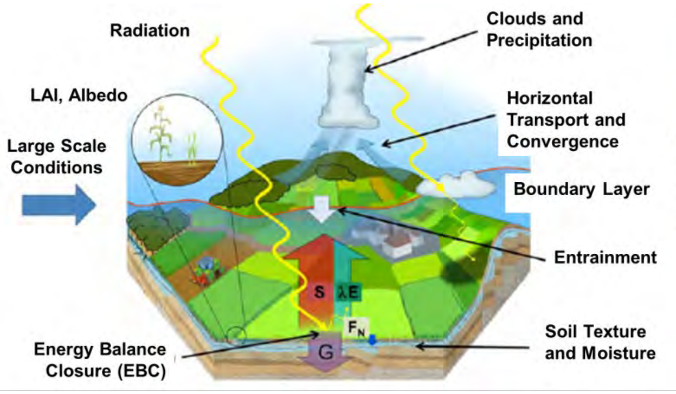
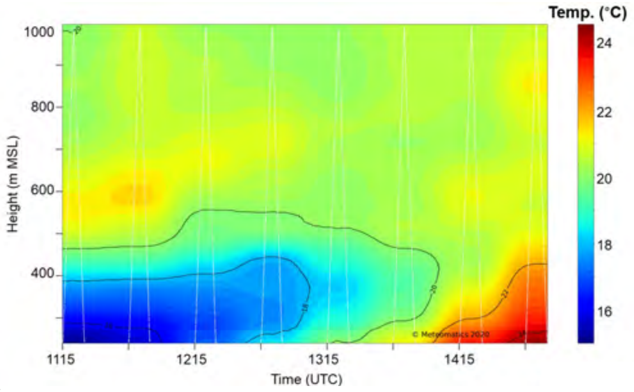
Using New Boundary Layer Technologies to Help Improve Weather Forecasts

Testing of new technologies for ABL sampling requires thorough in-lab calibration and comparisons against known standards (e.g., meteorological towers, rawinsondes, etc.)



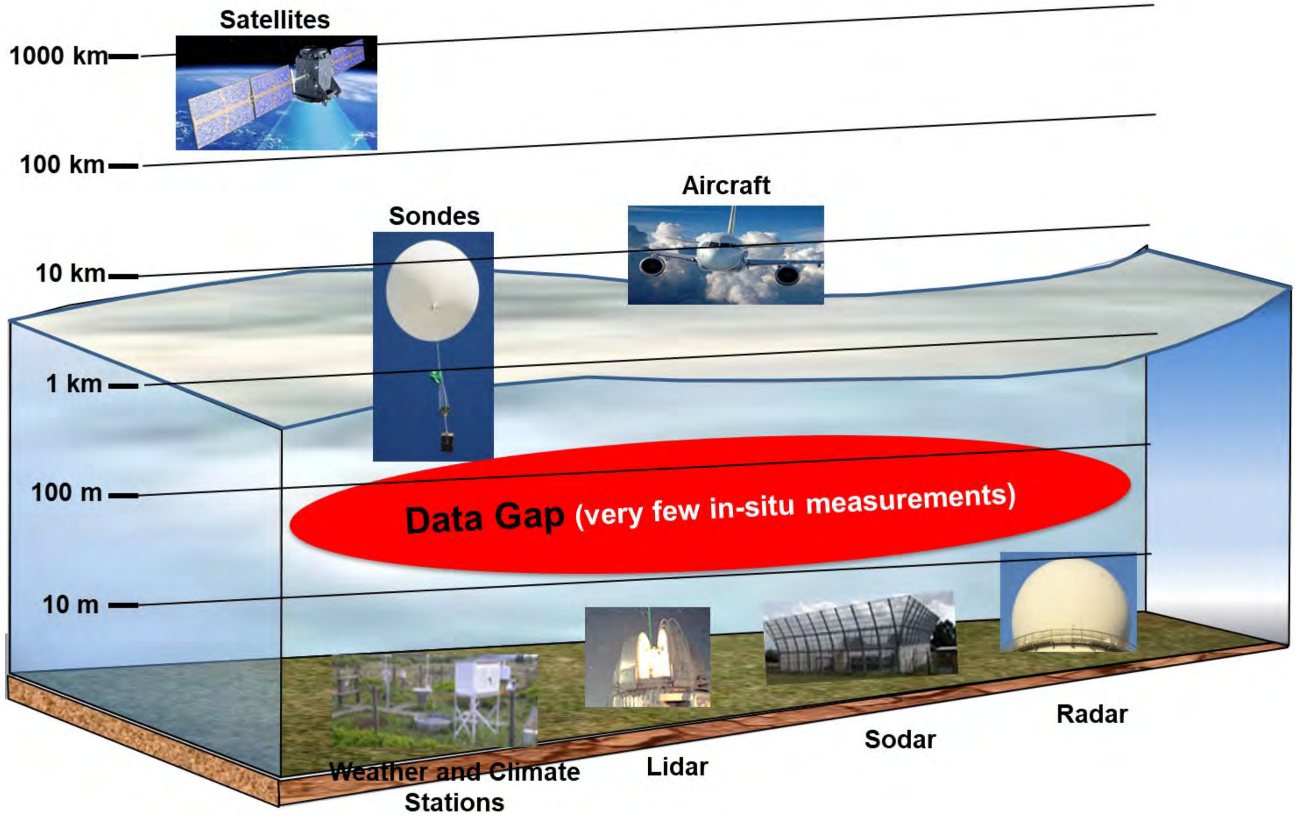






Coupling new ABL observing systems with other platforms through targeted field studies and routine ABL sampling yields a better understanding of ABL processes

Relevance to NOAA's Mission



Detect Changes in the Ocean and Atmosphere

"Identify and address gaps in observation requirements needed to understand causes of variability and change"
--OAR Strategy 2020-2026

Make Forecasts Better

"Design tools and processes to forecast high-impact weather, water, climate, ocean, and ecosystem events"
--OAR Strategy 2020-2026

"Improve weather & climate predictions by increasing our understanding of PBL processes"
--OAR Implementation Plan 2021-2026

ARL’s Fleet of sUxS

Model	APH-28	MD4-1000	Meteodrone SSE	BlackSwift S2
				
Variables Sampled	*T*, *q*, *LST*	*T*, *q*	*T*, *q*, *u*, *v*	*T*, *q*, *u*, *v*, *w*
Manufacturer	Aerial Imaging Solutions	Microdrone	Meteodrone	BlackSwift Technologies
Units in Fleet	1	1	2	2
Vehicle Type	Multi-rotor	Multi-rotor	Multi-rotor	Fixed-wing
Gross Weight	5 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	1.8 kg	1.2 kg	--	2.3 kg
Engine Type	6 electric motors	4 electric motors	6 electric motors	1 electric motor
Autopilot	APH	Microdrone	Meteodrone	SwiftPilot
Max Speed	13 m s^{-1}	10 m s^{-1}	19 m s^{-1}	24.7 m s^{-1}
Loiter Speed	0 m s^{-1}	0 m s^{-1}	0 m s^{-1}	15 m s^{-1}
Endurance	35 min	25 min	20 min	80 min
Ceiling	4300 m	500 m	3000 m	3000 m

Sensors on ARL's sUxS

Meteodrone

Meteomatics

Self-contained (temperature, moisture, pressure, wind)

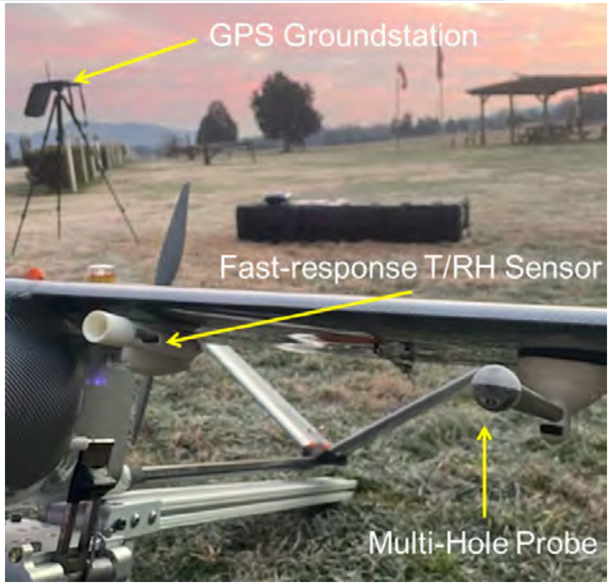
BST S2

iMet XQ2 (temperature, moisture, pressure)

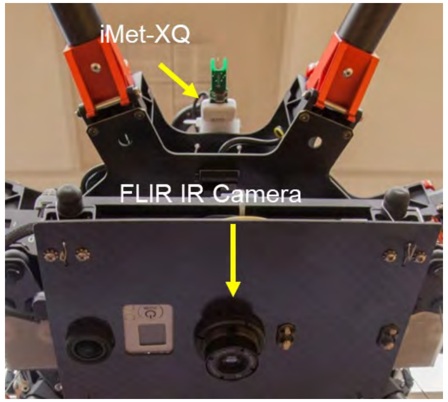
Multi-hole probe (3D wind components)

Fast-response temperature / humidity sensor

MapIR camera (NDVI, veg. characteristics)



One of ARL's BST S2's



Underside of APH-28

APH-28

iMet XQ (temperature, moisture, pressure)

FLIR Tau 2 infrared camera (surface temperature)

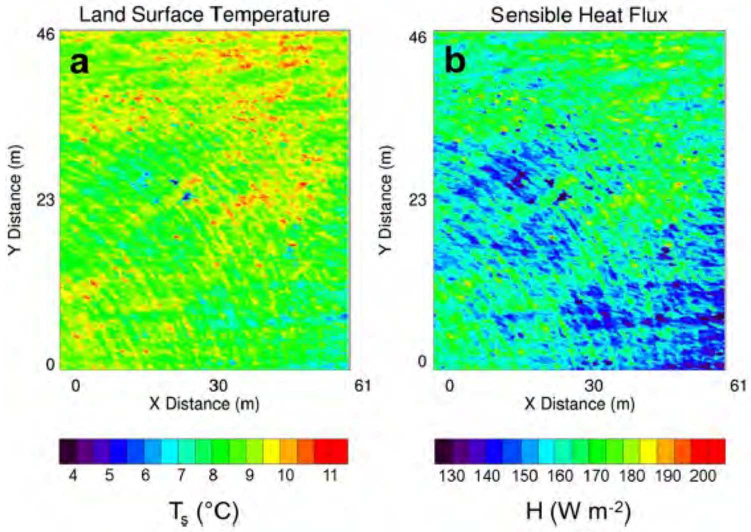
MD4-1000

iMet XQ

mdLidar1000 (surface roughness)

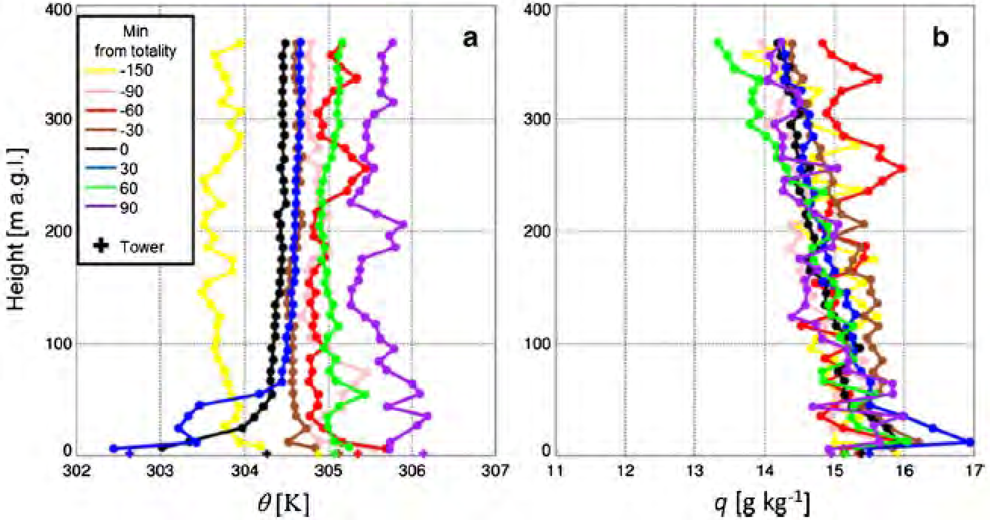
MD4-1000

Research Results using sUxS (1/2)



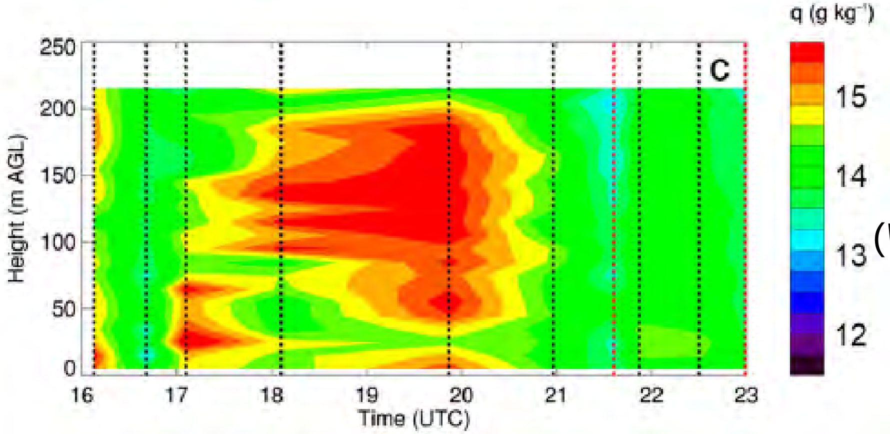
Surface sensible heat fluxes derived from sUxS

(*Lee et al. 2017 J. Atmos. Ocean Technol.*)



Evolution of near-surface θ and q during 2017 eclipse

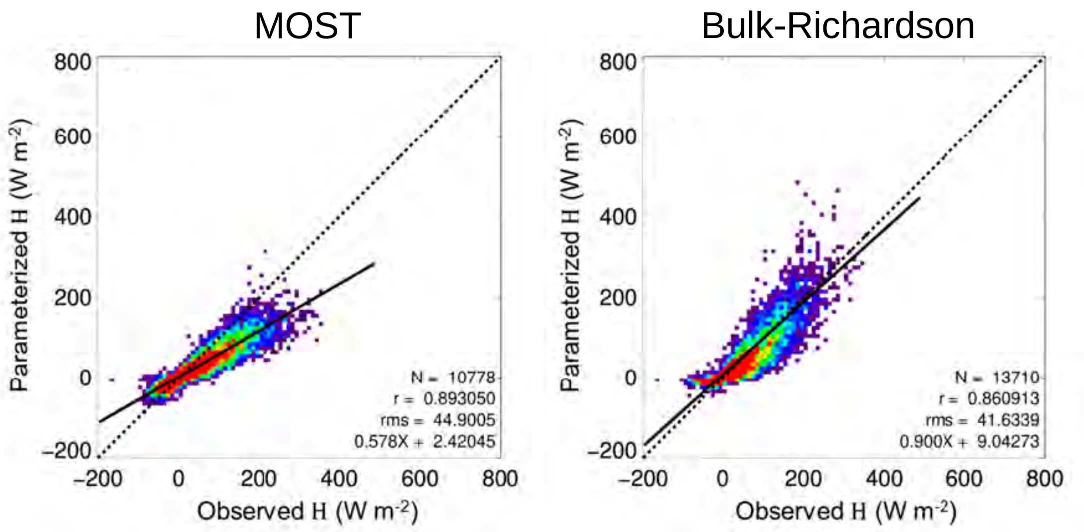
(*Lee et al. 2018 Eos*, *Buban et al. 2019 Bound.-Layer Meteor.*)



Evolution of near-surface T, q below remote-sensing instruments

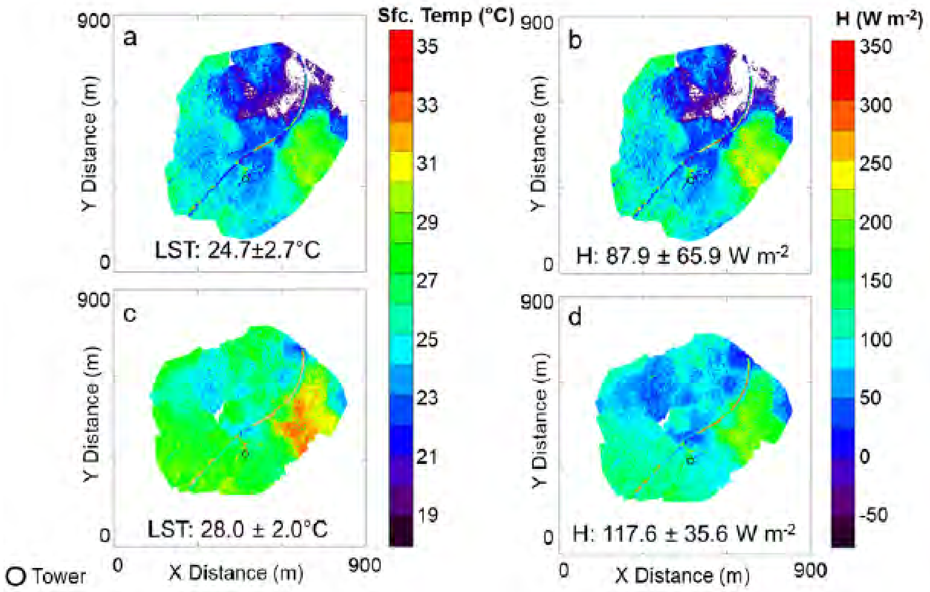
(*Wulfmeyer et al. 2018 Bull. Amer. Meteor. Soc.*, *Lee et al 2019 Sensors*, *Lee et al. 2019 Wea. Forecast.*)

Research Results using sUxS (2/2)



New bulk-Richardson similarity relationships for momentum, heat, moisture, and near-surface fluxes are shown to work better than classical relationships derived from Monin-Obukhov Similarity Theory

(*Lee and Buban 2020 J. Appl. Meteor. Climatol., Lee et al. 2021 Mon. Weather Rev.*)



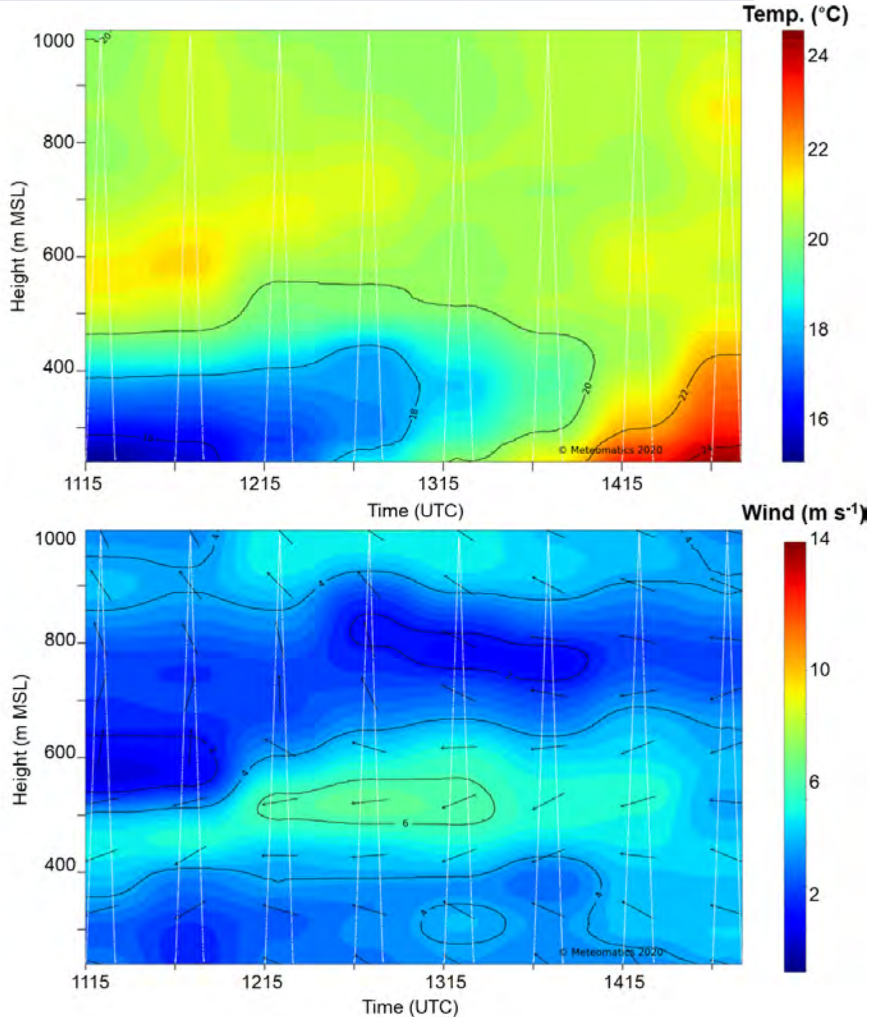
sUxS used to help upscale point measurements from surface meteorological towers and to evaluate downscaling approaches for satellite-derived surface temperature

(*Butterworth et al. 2020 Bull. Amer. Meteor. Soc., Desai et al. 2021 Earth Space Sci.*)

Routine sUxS Profiling to Support Operational Weather Forecasting at Morristown, TN NWS WFO

Nearest rawinsonde location ~ 300 km from Morristown (MRX) in Nashville (BNA)

- 8x per day profiling with Meteodrone up to ~800 m AGL at OSI to sample temp., humidity, pressure, and wind
- Data provided to MRX in real-time for use in AWIPS



Sample temp. and wind from 8 Sep 2020 provided to MRX

sUxS Data Assimilation

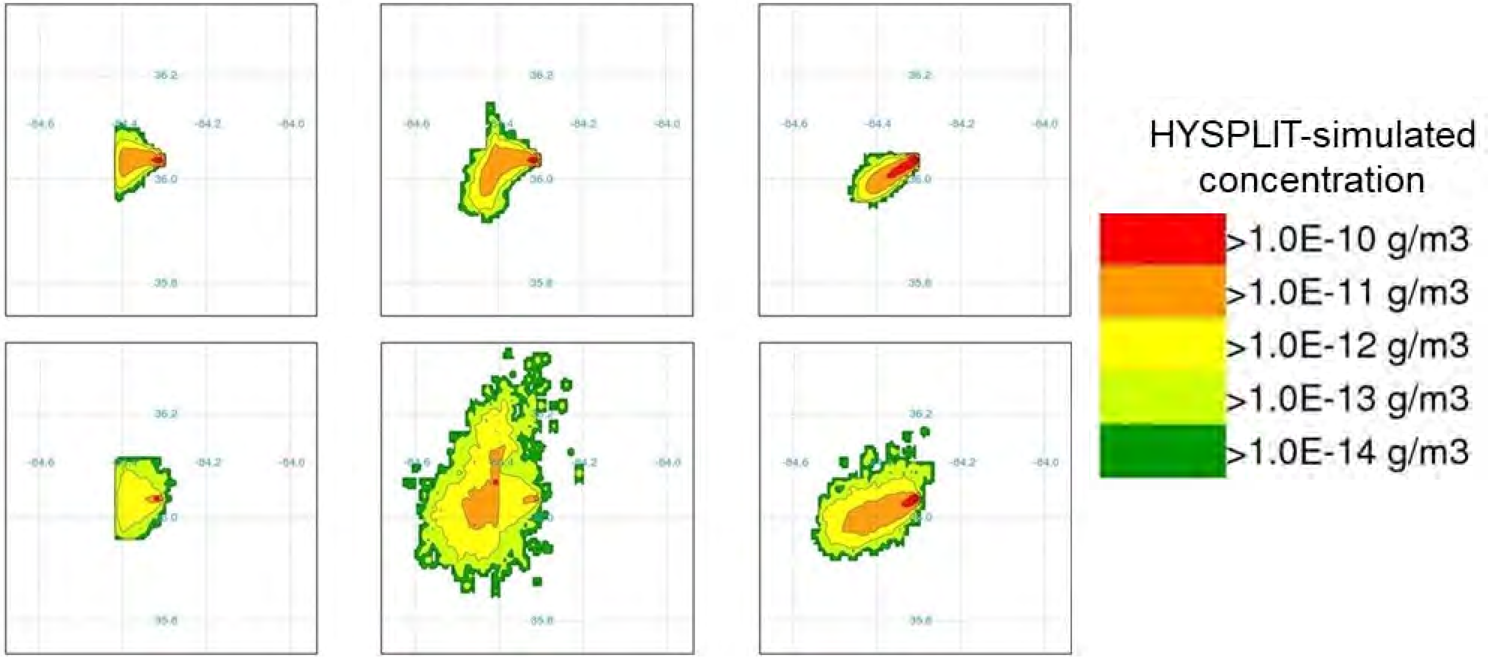
HYSPLIT = Hybrid Single Particle Lagrangian Integrated Trajectory

sUxS observations are being used to help improve HYSPLIT-based air pollutant dispersion forecasts

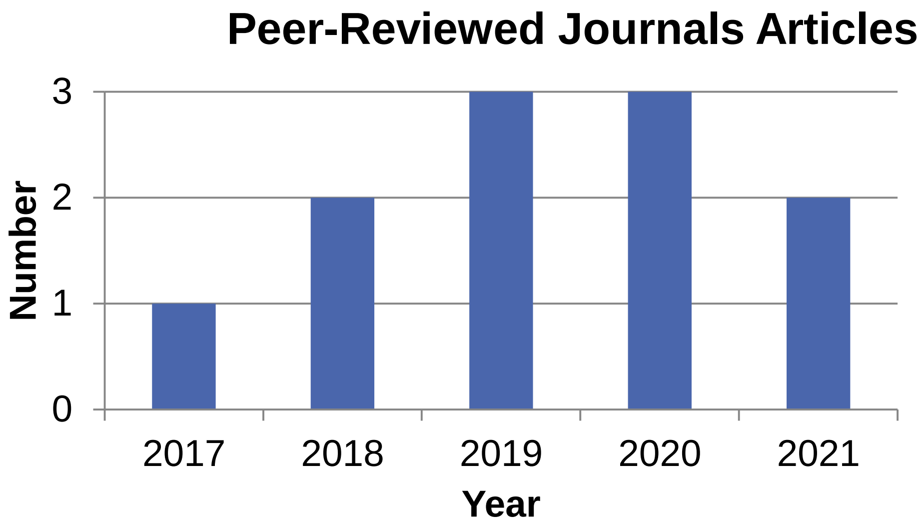
sUxS | sUxS + HRRR | HRRR

1 hr after release

2 hr after release



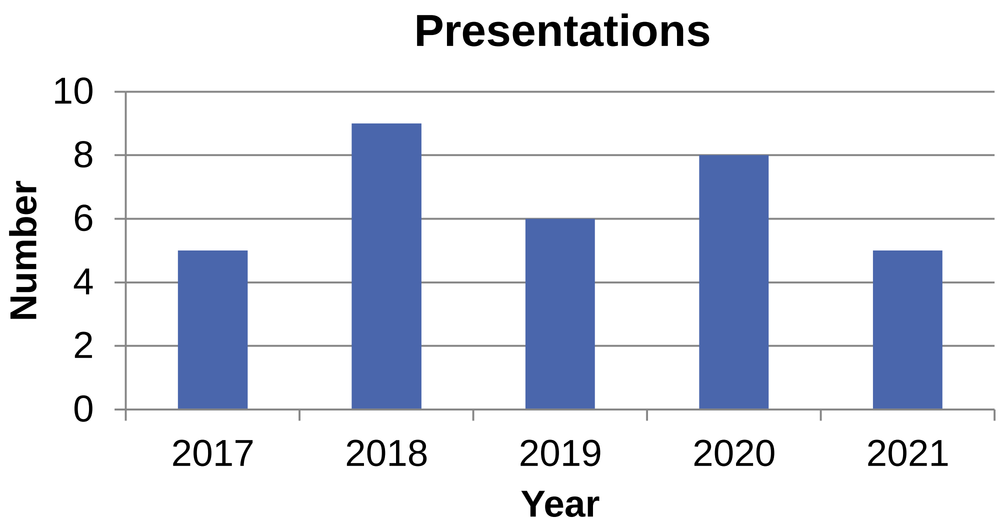
Quality and Performance



Total: 11

Number of citations (Google Scholar): 154

h-index (Google Scholar): 6



Total: 33

Includes presentations at national (AMS, AGU) and international (ISARRA) meetings and **10 invited presentations**

Future Plans

Short-term (1-2 years)

- Continue to evaluate the sensitivity of NWP models to sUxS observations over complex terrain and impacts on dispersion forecasts
- Develop techniques to obtain more reliable winds and fluxes from sUxS
- Use sUxS to scale point observations to model-relevant scales

Long-term (2+ years)

- Couple sUxS with other observing systems to expand newly-suggested similarity relationships to other landuse types and above surface monitoring stations
- Evaluate technologies for sampling trace gases and aerosols using sUxS; deploy technologies during upcoming campaigns through collaboration with other NOAA labs
  - Study the role of ABL mixing processes on the horizontal and vertical variability in trace gases and aerosols
  - Use sUxS to study NH_3 emissions during wildfires

Flight with BST S2 sUxS near Corryton, TN