A compact, flexible, and mobile micro pulsed Doppler Lidar

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Funding

Introduction

- Group focused on field measurements of the troposphere

- Understand tropospheric dynamics using various lidars, specifically Doppler
  - Boundary layer height/mixing (convection) [1]
  - Transport [2]
  - Stable conditions [3-4]

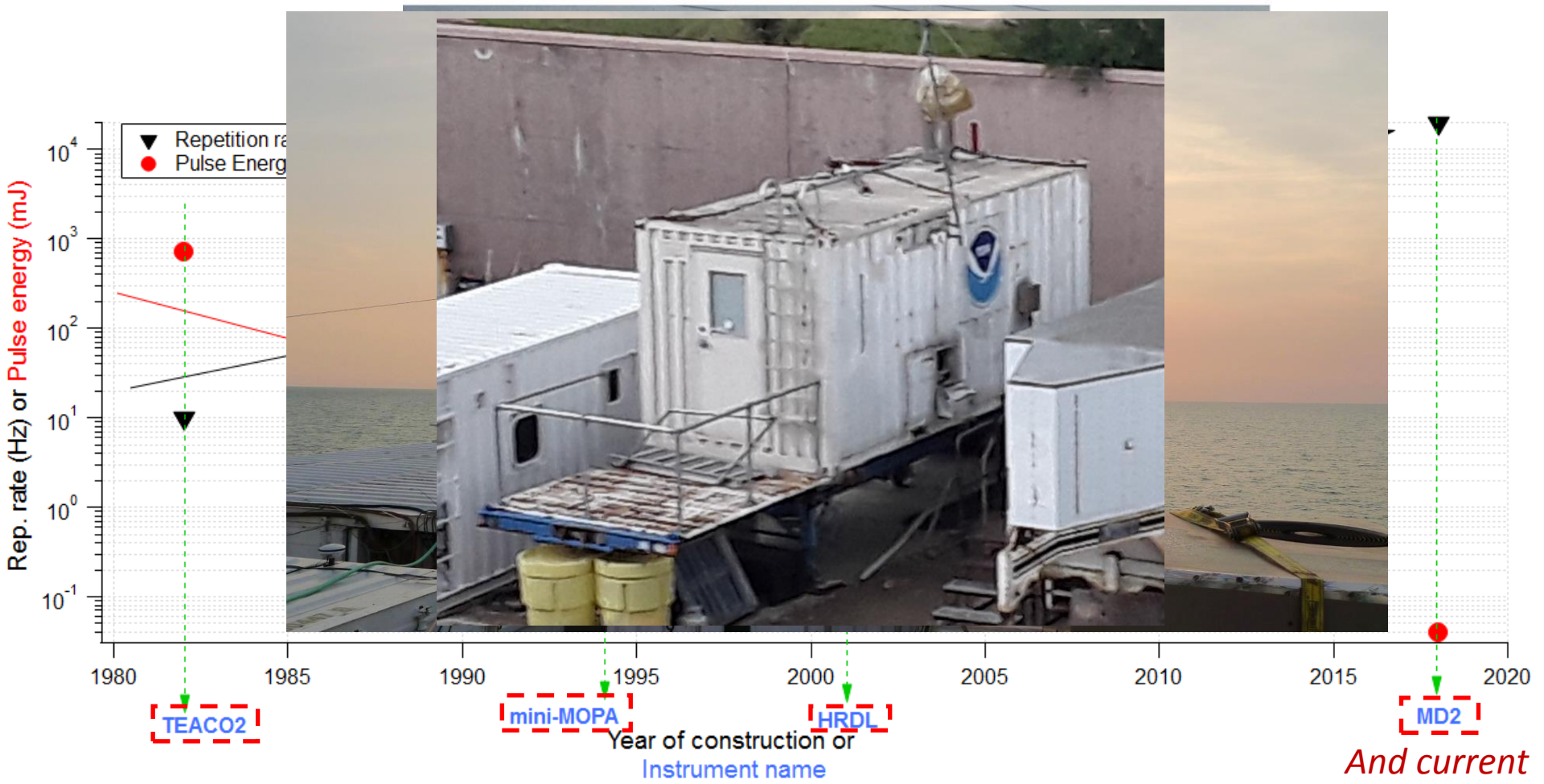
- Want to make measurements on smaller, mobile platforms
  - Cheaper, faster, flexible
  - Unique location access

- New type of measurement obtainable with smaller platforms
  - Twin Otter: small aircraft, low altitude, slow, maneuverable. Wildfires, city flows, down-wind tracking
  - Ship deployments: ease of measurement, access to variety of ships. Marine BL, hold station, meso-scale features
  - Pickup truck. Lower and slower than Twin Otter. City flows, transport away from sources, etc.

- Commercial and past research systems often one, large unit

1. J. R. Garratt, "Review: the atmospheric boundary layer," *Earth-Sci. Rev.*, vol. 37, no. 1, pp. 89–134, Oct. 1994.
2. C. J. Senff, R. J. Alvarez, R. M. Hardesty, R. M. Banta, and A. O. Langford, "Airborne lidar measurements of ozone flux downwind of Houston and Dallas," *J. Geophys. Res.*, Oct. 2010.
3. R. M. Banta, R. K. Newsom, J. K. Lundquist, Y. L. Pichugina, R. L. Coulter, and L. Mahrt, "Nocturnal low-level jet characteristics over Kansas during CASES-99," *Bound.-Layer Meteorol.*, 2002.
4. D. J. Stensrud, "Importance of Low-Level Jets to Climate: A Review," *J. Clim.*, vol. 9, no. 8, pp. 1698–1711, Aug. 1996.

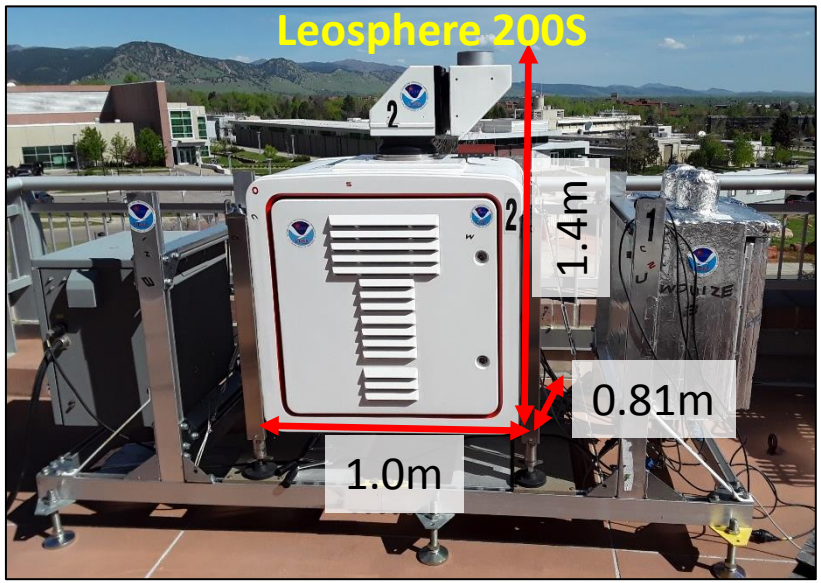
Past group instrument development

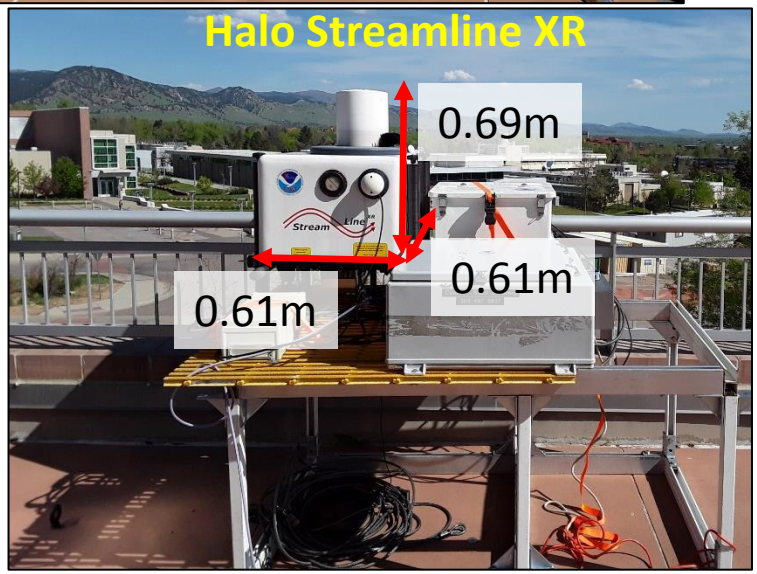


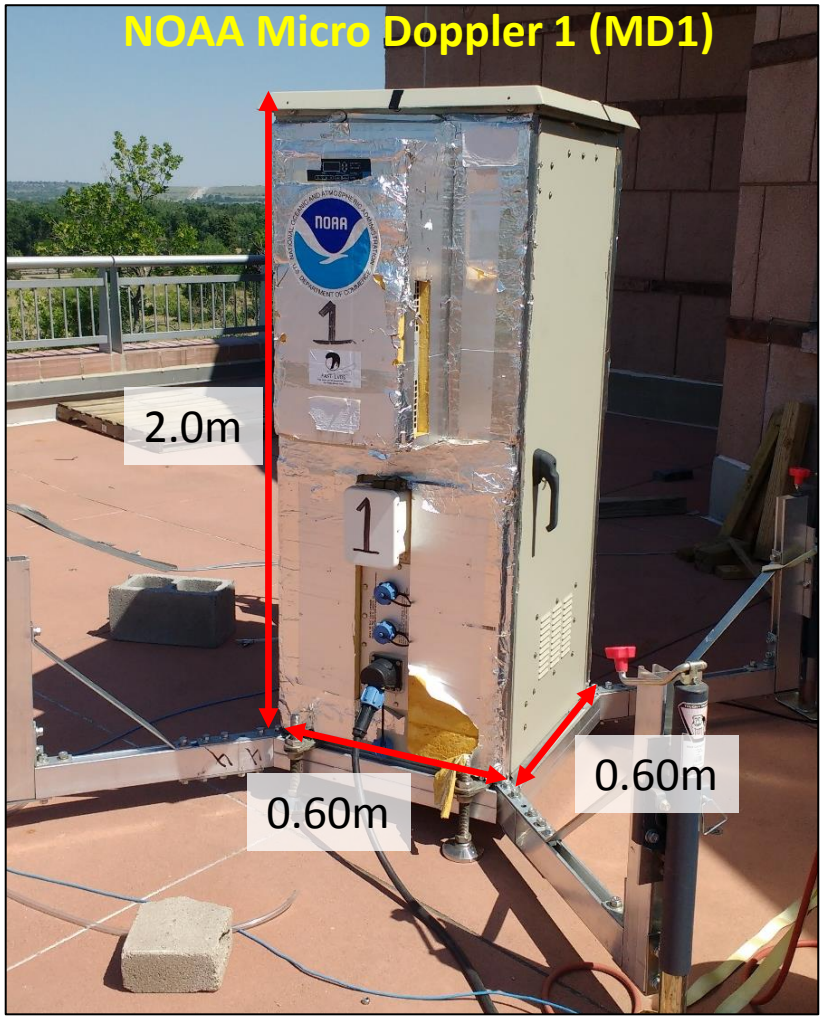
And current commercial systems

-TEACO2: M. J. Post and R. E. Cupp, "Optimizing a pulsed Doppler lidar," *Appl. Opt.*, vol. 29, no. 28, pp. 4145–4158, Oct. 1990.
-Mini-MOPA: W. A. Brewer and R. M. Hardesty, "Development of a dual-wavelength CO2 mini-MOPA Doppler lidar," *Coherent Laser Radar*, pp. 293–296, 1995.
-HRDL: C. J. Grund *et al.*, "High-Resolution Doppler Lidar for Boundary Layer and Cloud Research," *J. Atmospheric Ocean. Technol.*, vol. 18, no. 3, pp. 376–393, Mar. 2001.
-MD2: -Schroeder et al. "A compact, flexible, and robust micro pulsed Doppler Lidar" In prep.

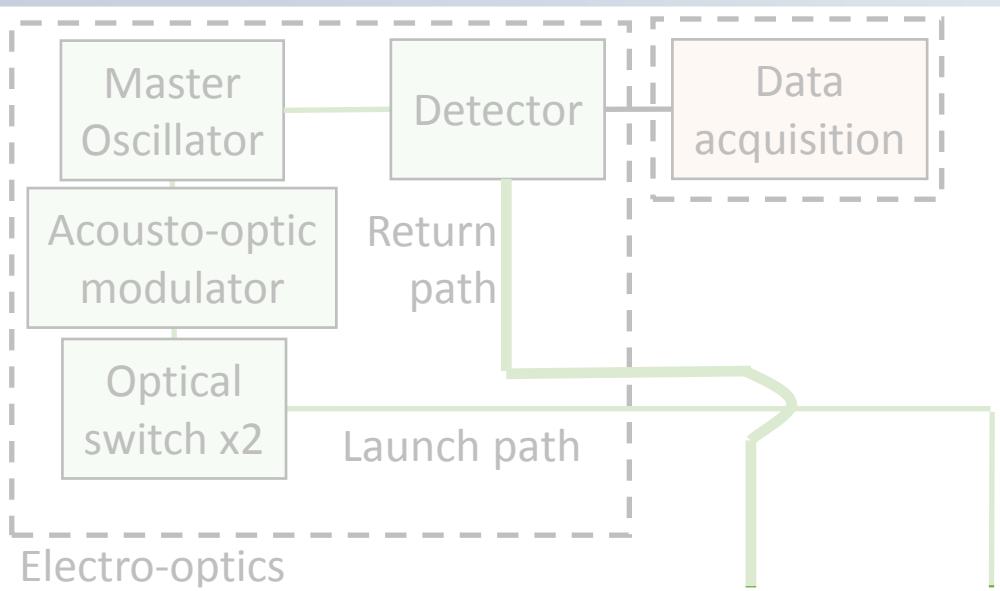
Current lidars too large for some platforms

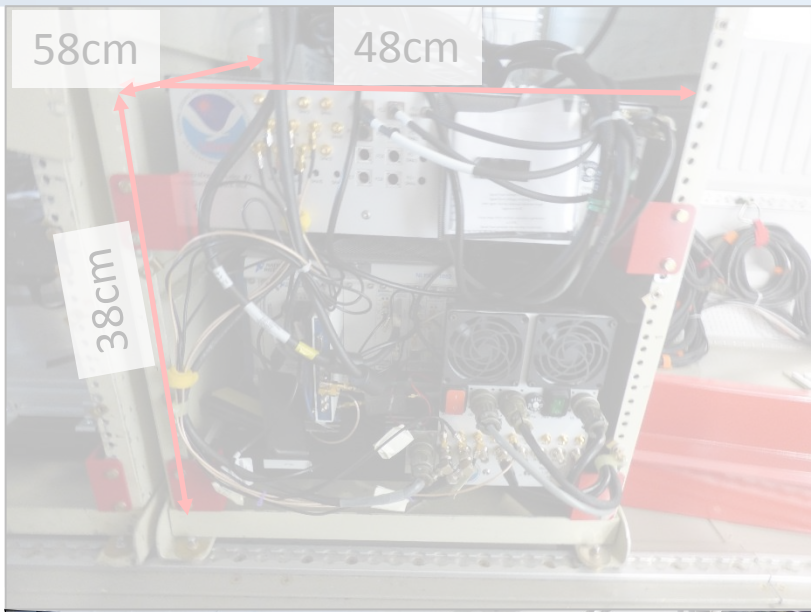


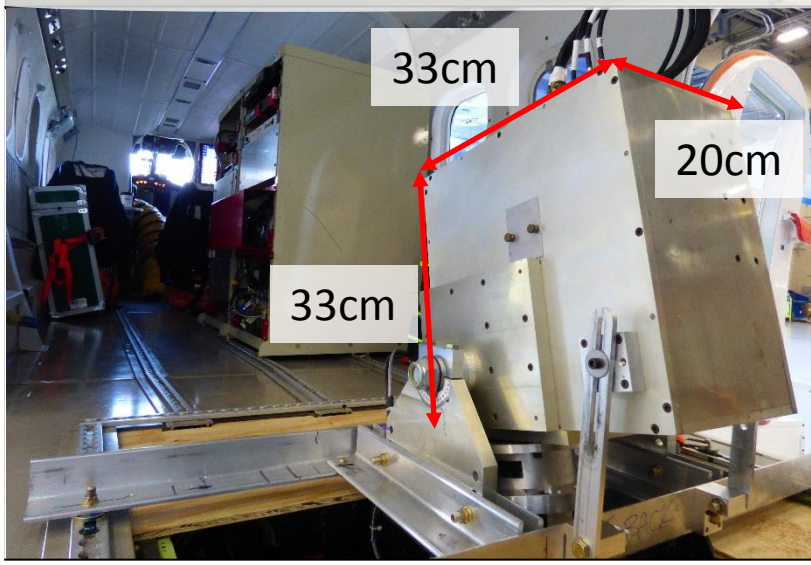




Micro Doppler 2: Fiber based Master Oscillator Power Amplifier (MOPA)







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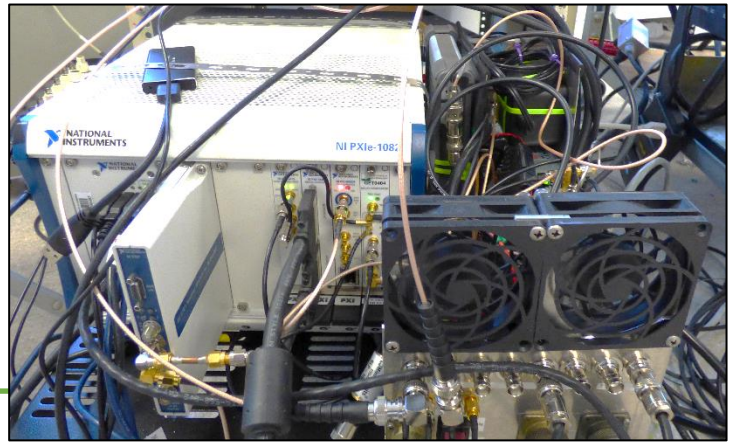
Micro Doppler 2

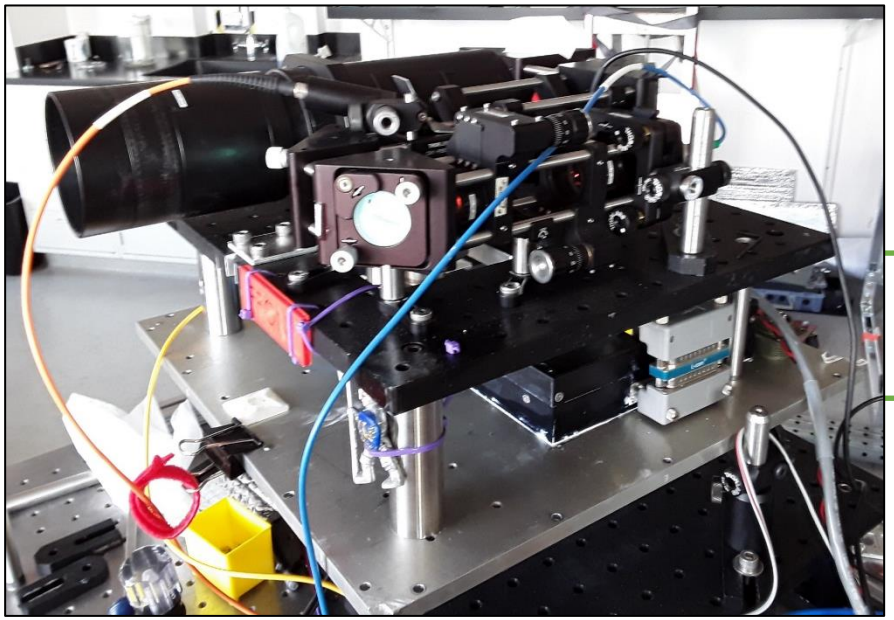
Data acquisition

20kg



10m

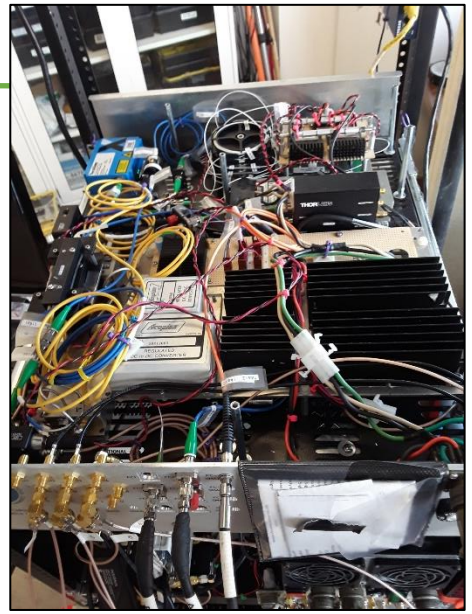
10m



Lidar head

14kg

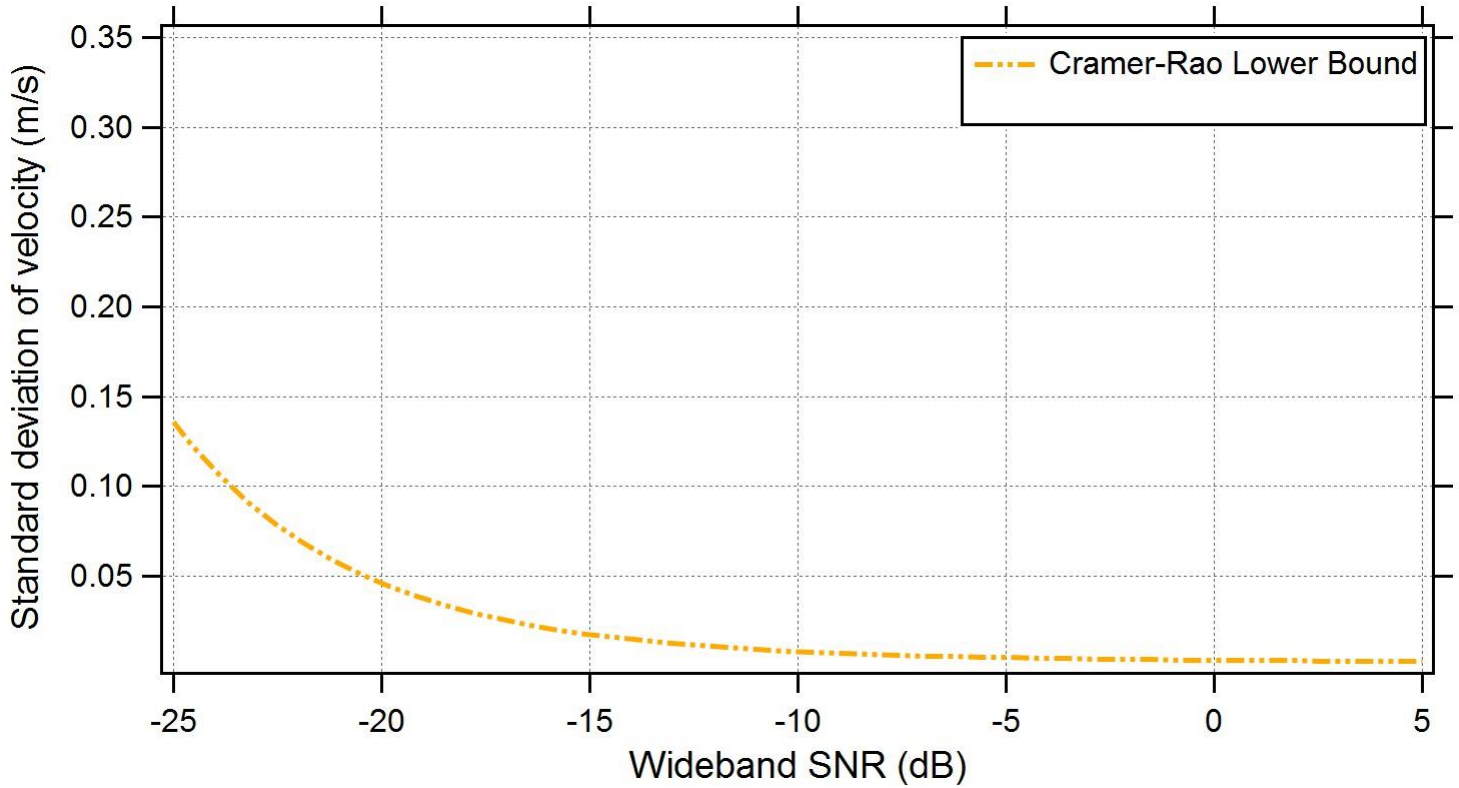
Electro-optics



10kg

System power~300W
System weight~44kg

Velocity uncertainty measurements



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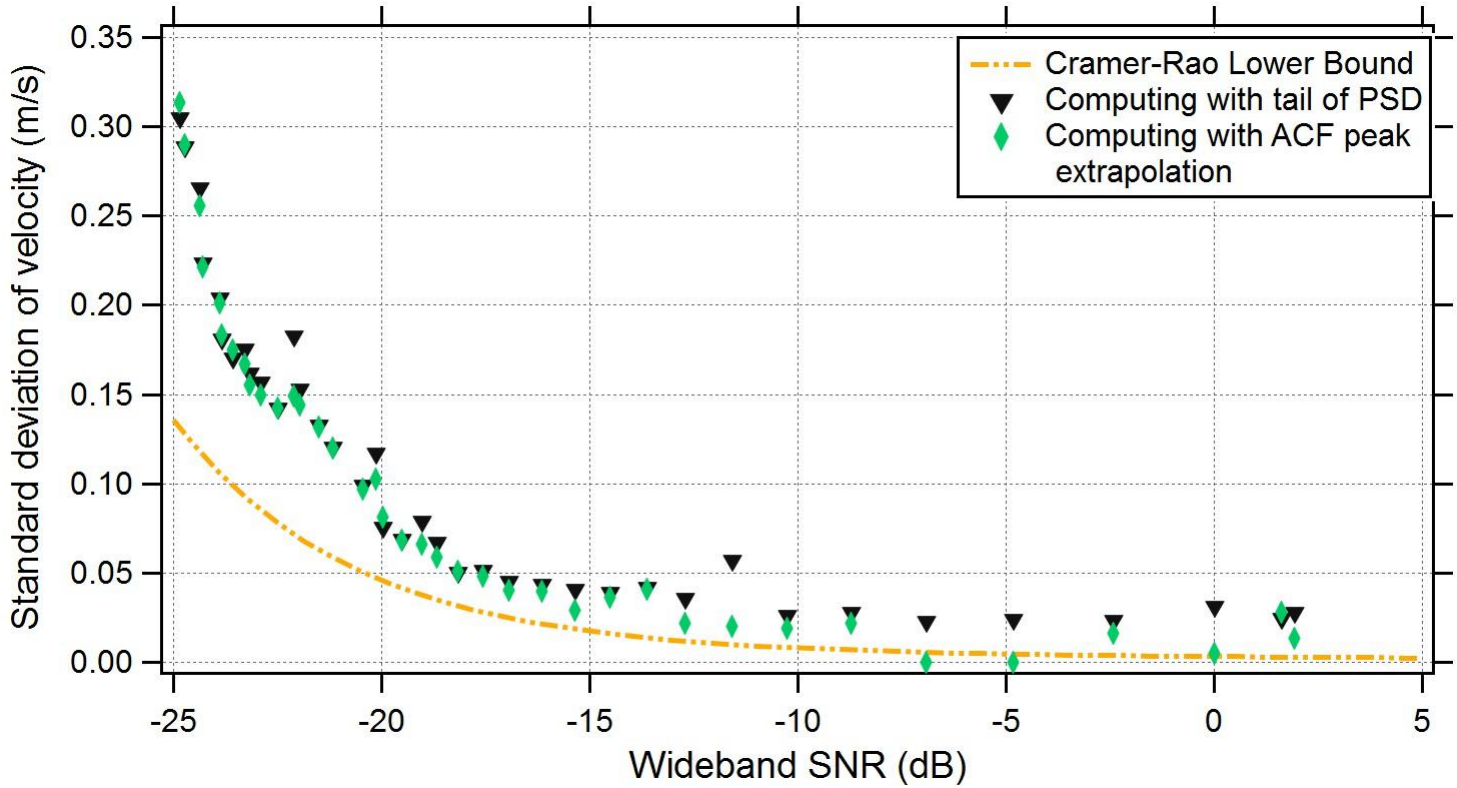
Velocity uncertainty measurements



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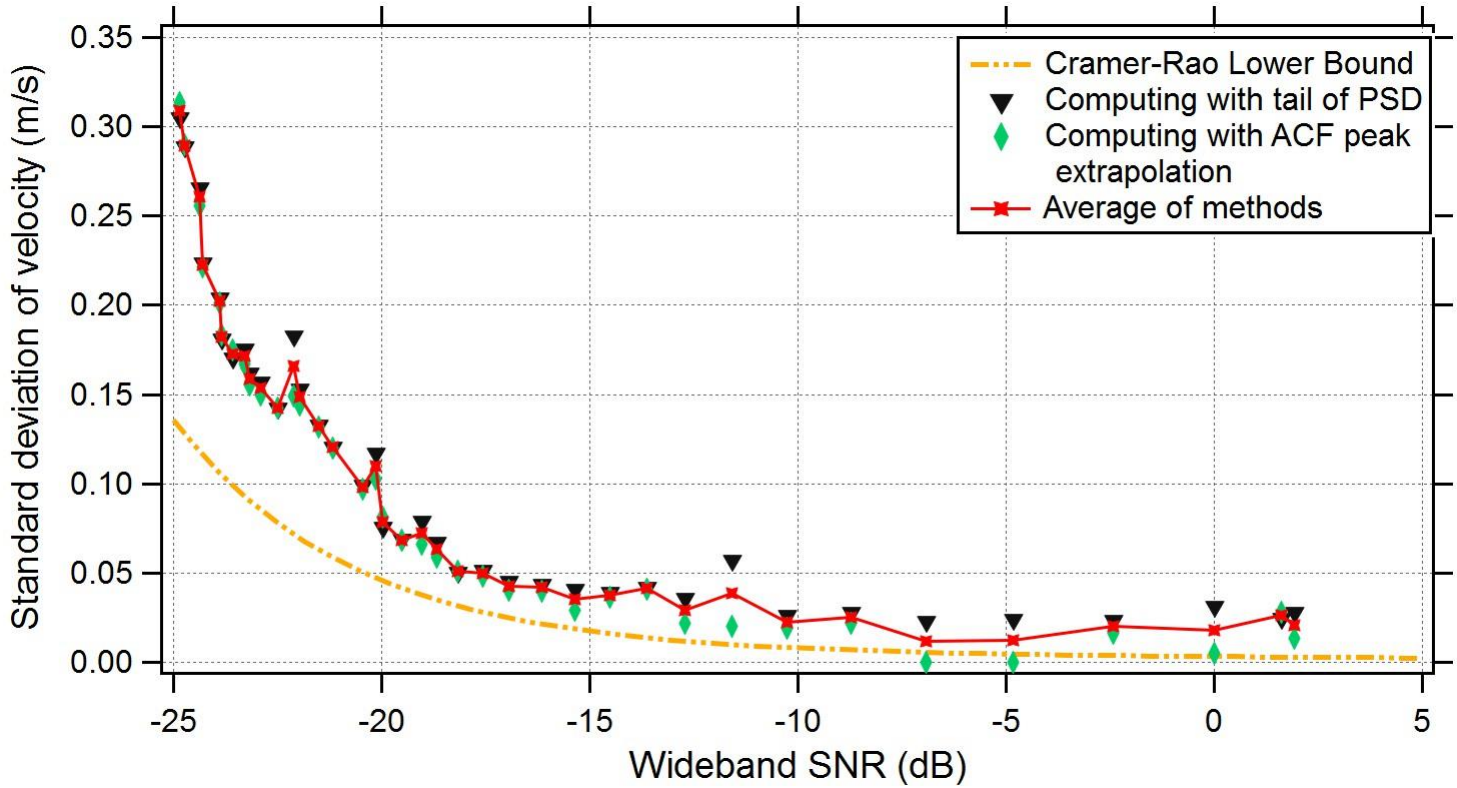
Velocity uncertainty measurements



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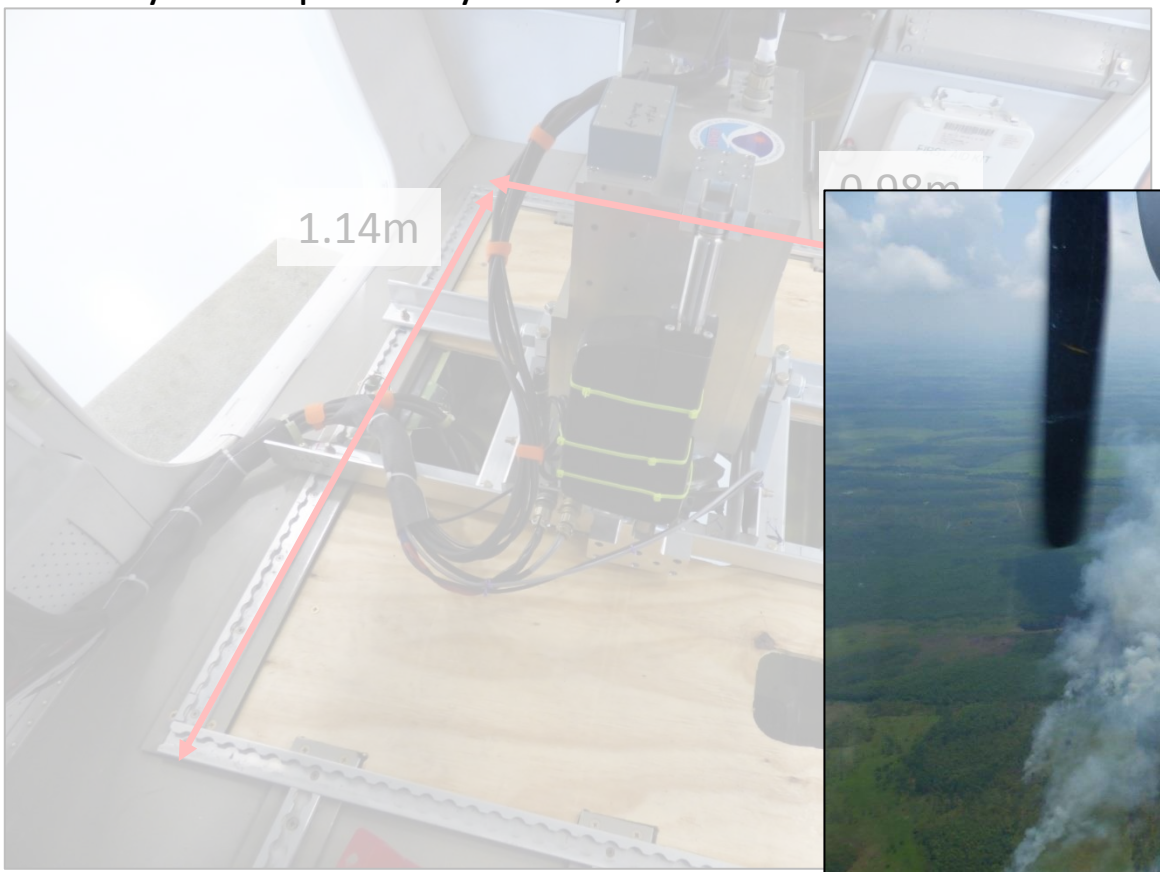
NOAA Twin Otter

Deployed on Twin Otter for wildfires

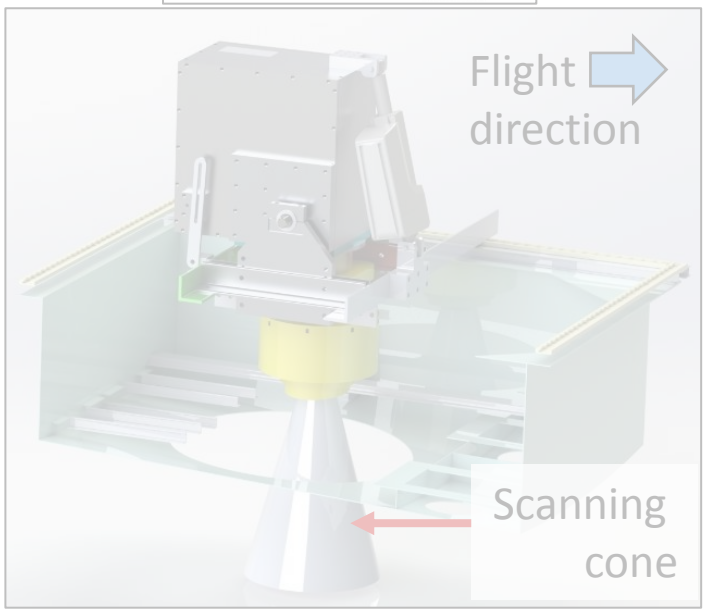
- Wildfire flow dynamics are difficult to access, Twin Otter enables direct interrogation
- Measure self-driven fire weather, plume size and height, inflow winds
- Study atmospheric dynamics, *in situ* Twin Otter chemical measurements, wildfire models



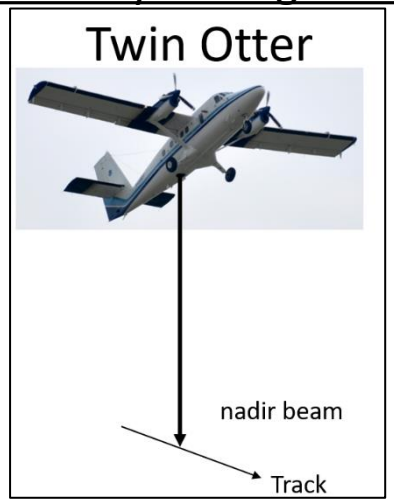
Actuator allows lidar
to rotate in flight

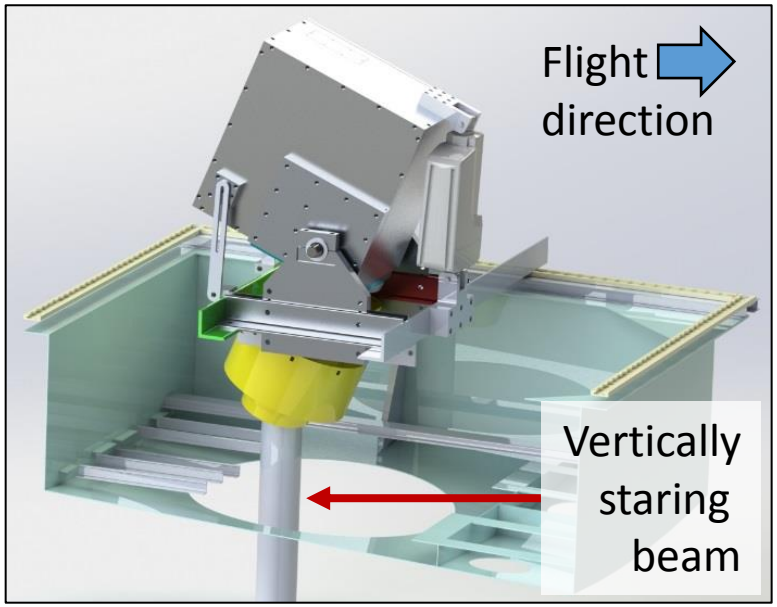
Lidar airborne scanning modalities

Scanning Mode



Vertically Staring Mode





Horizontal velocity profiles

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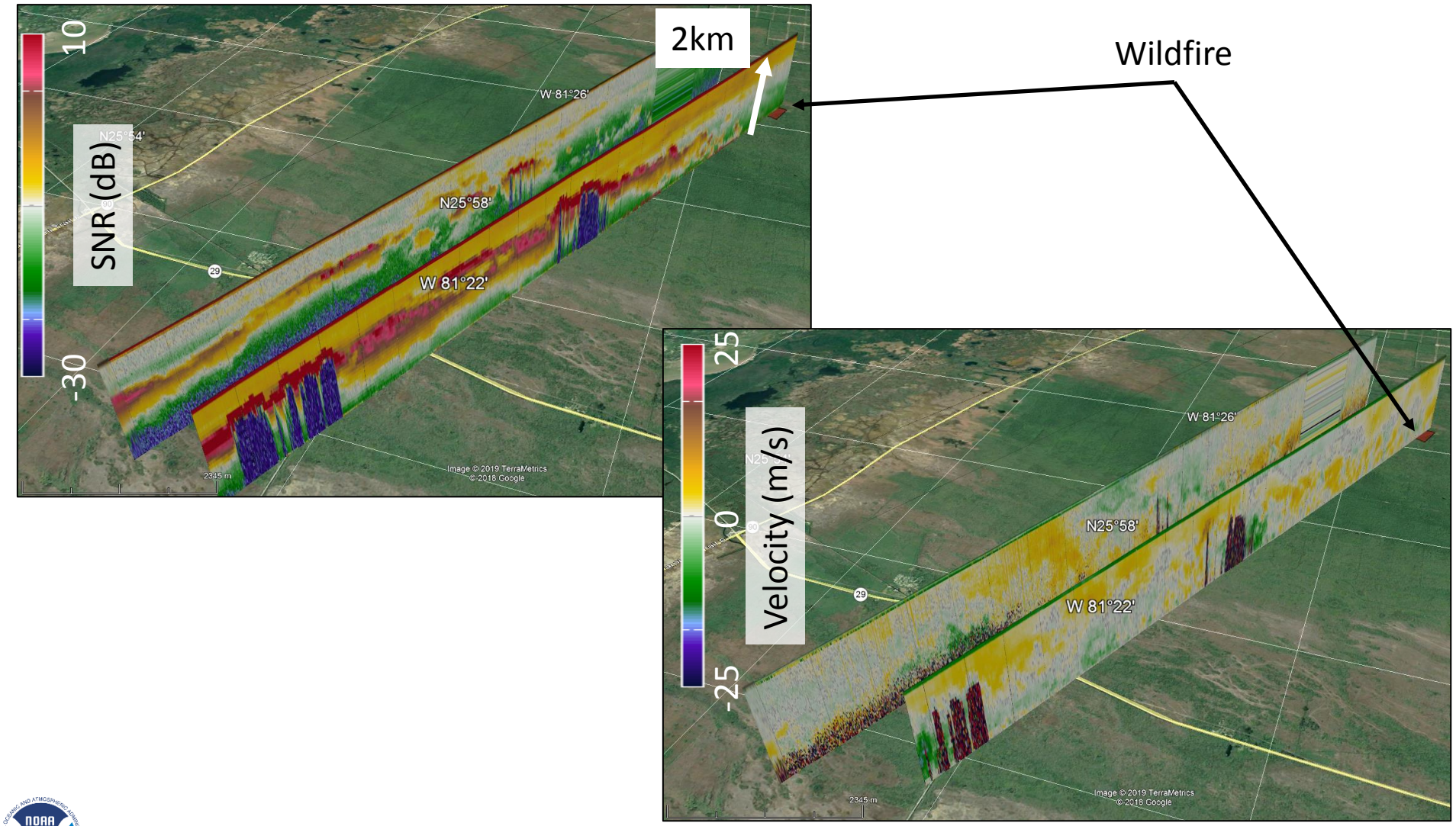
Vertical velocity profiles



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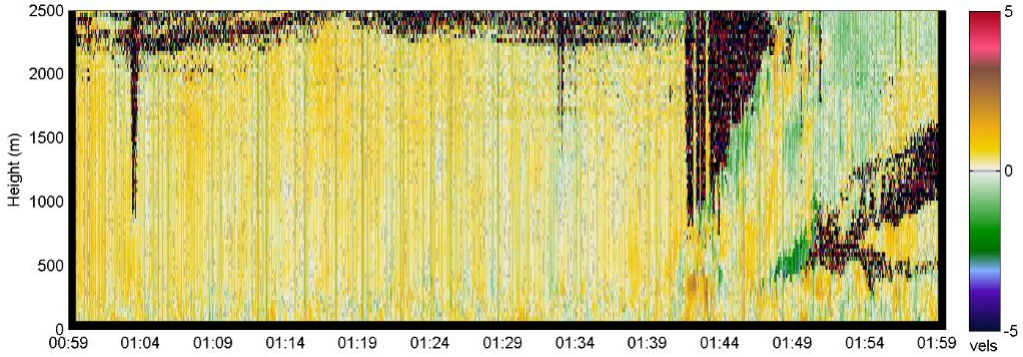
Propagation of Intra-Seasonal Tropical Oscillations (PISTON). On R/V Thomas Thompson

- Station keeping ~1200km east of Philippines for two, 1 month legs
- Staring vertically to monitor BL heights as large-scale convection system pass over
- MD2 mounted on corner of, rather than housed inside entire, seatainer

Photo courtesy of University of Washington

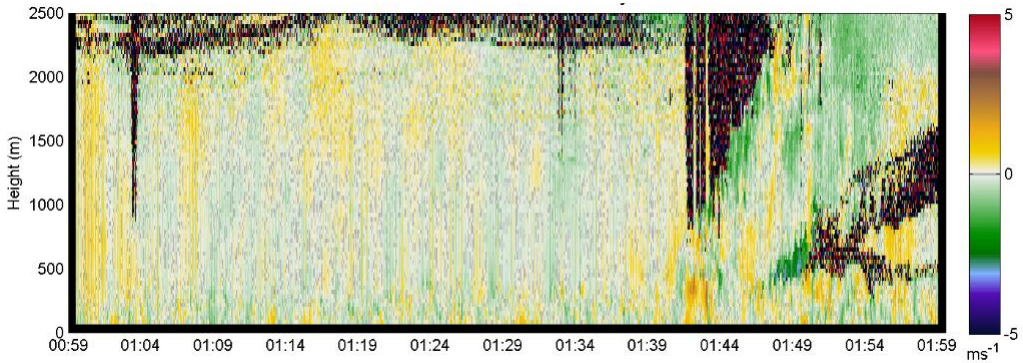
One hour of preliminary PISTON data

Lidar data without heave corrected



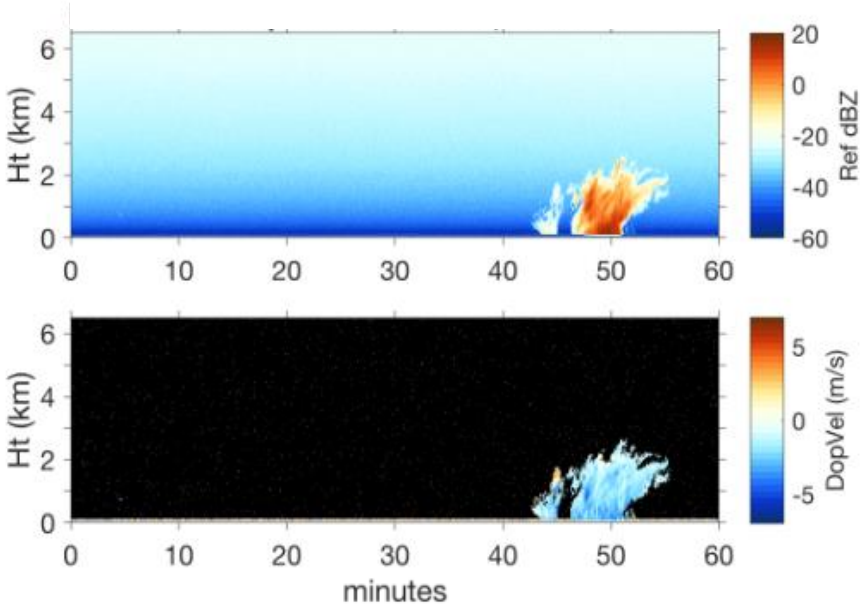
Time (HH:MM) UTC

Lidar data with heave corrected



Time (HH:MM) UTC

Co-located W-Band radar



W-Band plot courtesy of C. Fairall group

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Summary

- Built compact micro-pulse Doppler lidar, maintained sensitivity like other systems but in a smaller package
- Just have to mount optical head; connect via umbilical cable
- Allows motion compensation and opens up new measurement platforms, small aircraft, passenger trucks, seatainer not required on ships
- New platforms lead to new types of measurements
- Have deployed MD2 on two campaigns so far, aircraft and ship, with useful scientific results

Acknowledgements

- Atmospheric Remote Sensing group NOAA
  - Boulder, CO, US
- Aircraft Operations Command
  - Lakeland, Florida, US
- Crew of R/V Thomas Thompson
  - University of Washington, US