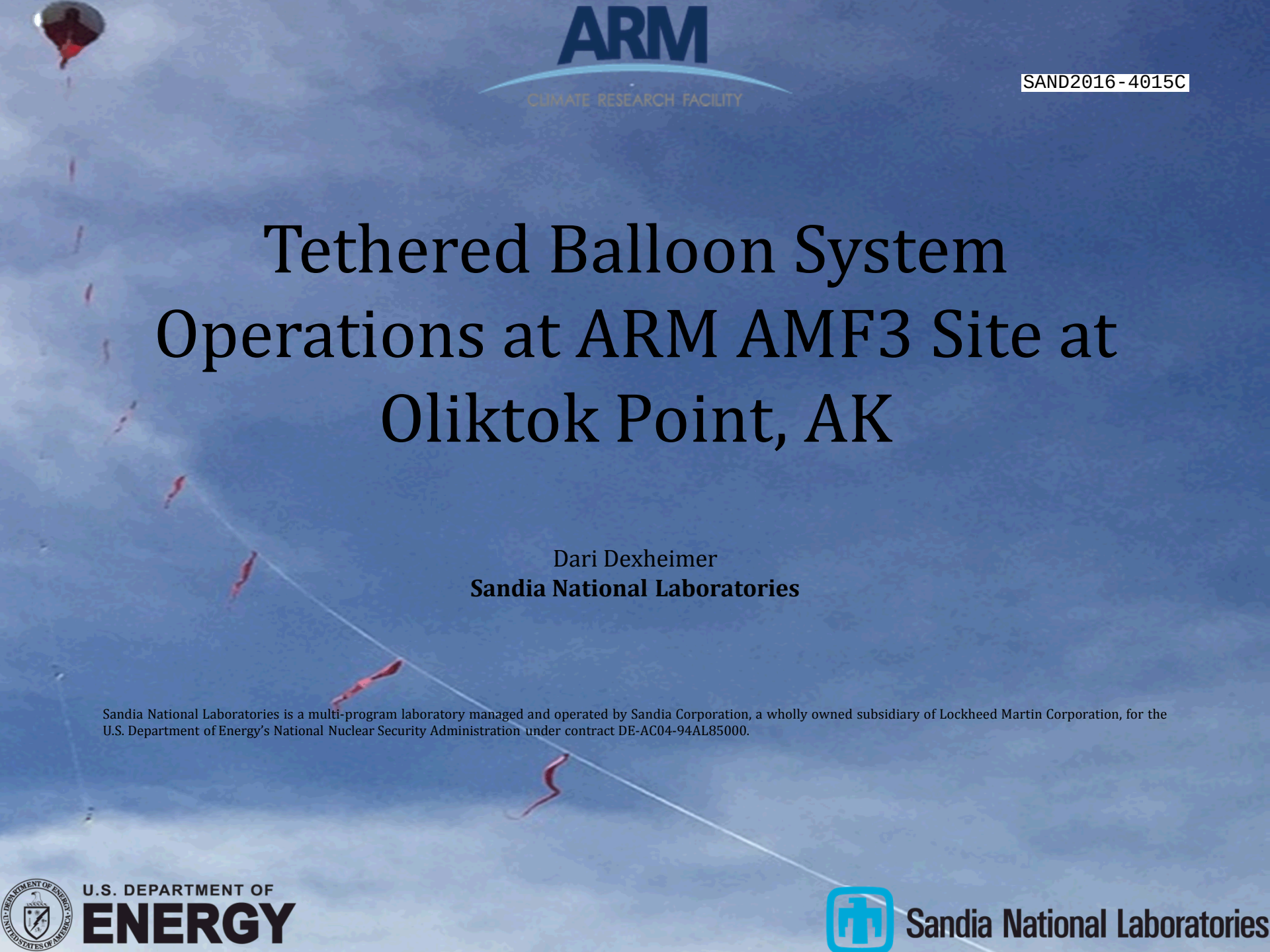

ARM CLIMATE RESEARCH FACILITY

SAND2016-4015C

Tethered Balloon System Operations at ARM AMF3 Site at Oliktok Point, AK

Dari Dexheimer
Sandia National Laboratories

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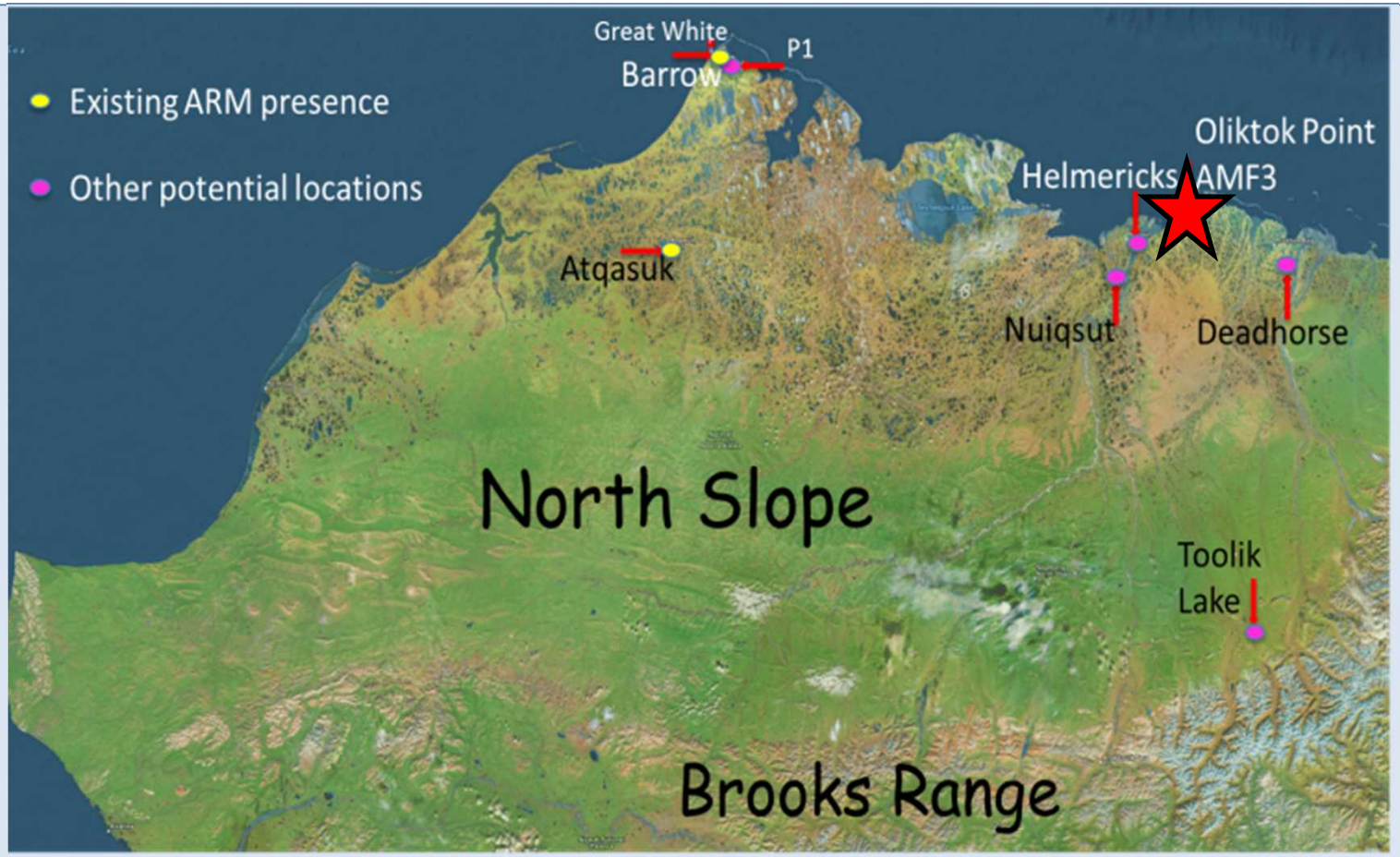
U.S. DEPARTMENT OF ENERGY

Sandia National Laboratories

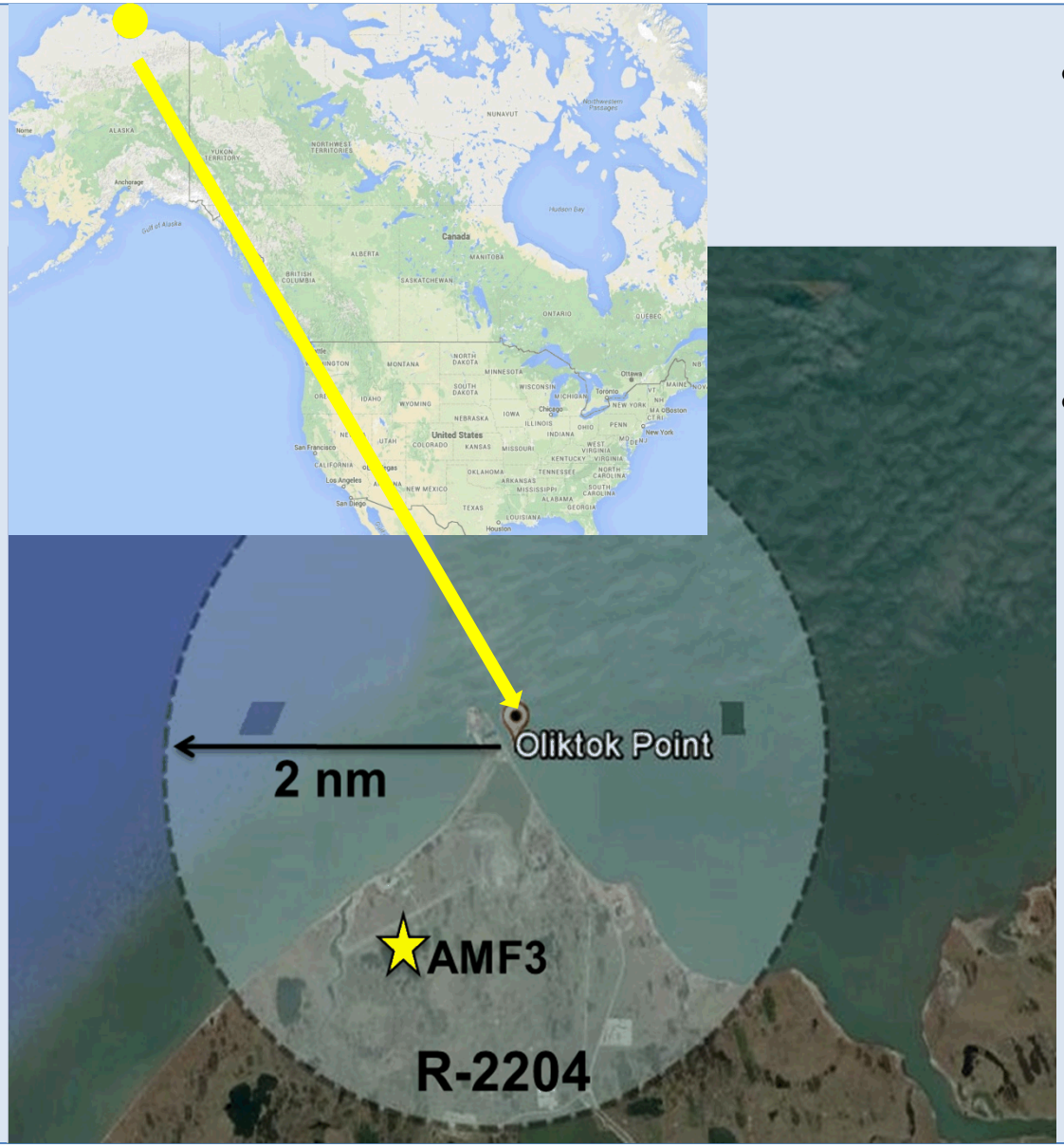
ARM & Sandia National Laboratories in AK



Sandia National Laboratories (SNL) has operated on behalf of ARM:

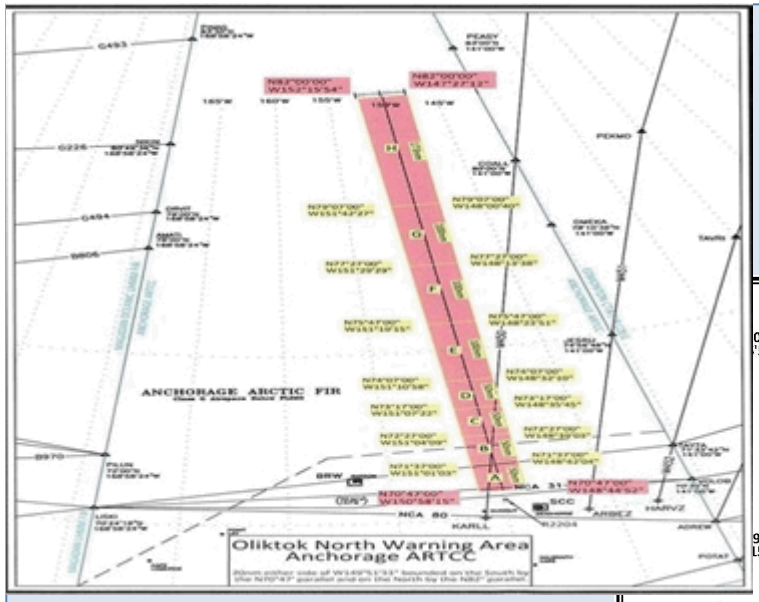
- Barrow installation since 1997
- Atqasuk facility from 1999-2010
- ★ ARM Mobile Facility #3 (AMF3) at Oliktok Point since 2013

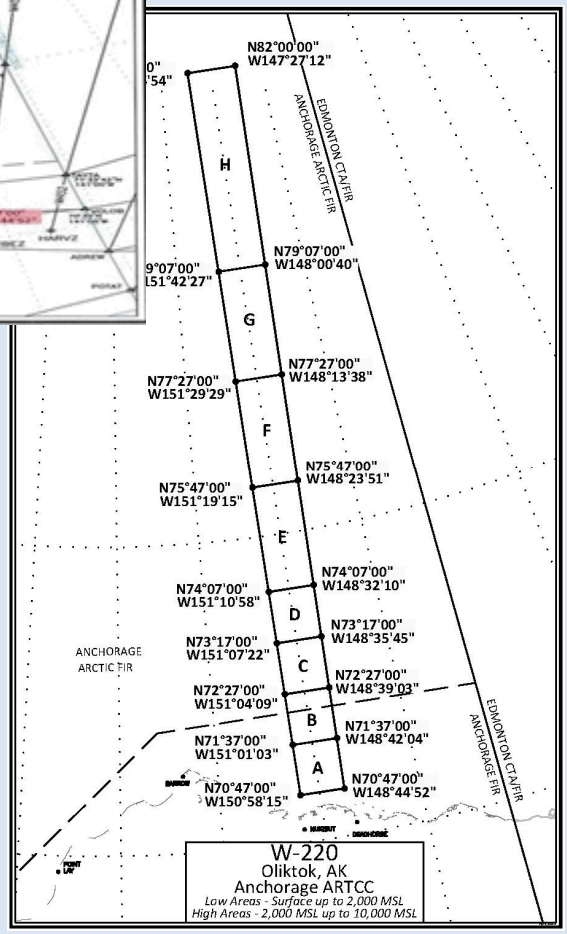
Restricted Airspace R-2204 at ARM's AMF3



- SNL operates R-2204 at AMF3, the only ARM site with restricted airspace.
- The restricted airspace encompasses a two nautical mile radius centered on Oliktok Point and is segmented by altitude into R-2204 Low (0-1,500' MSL) and R-2204 High (1,500-7,000' MSL).

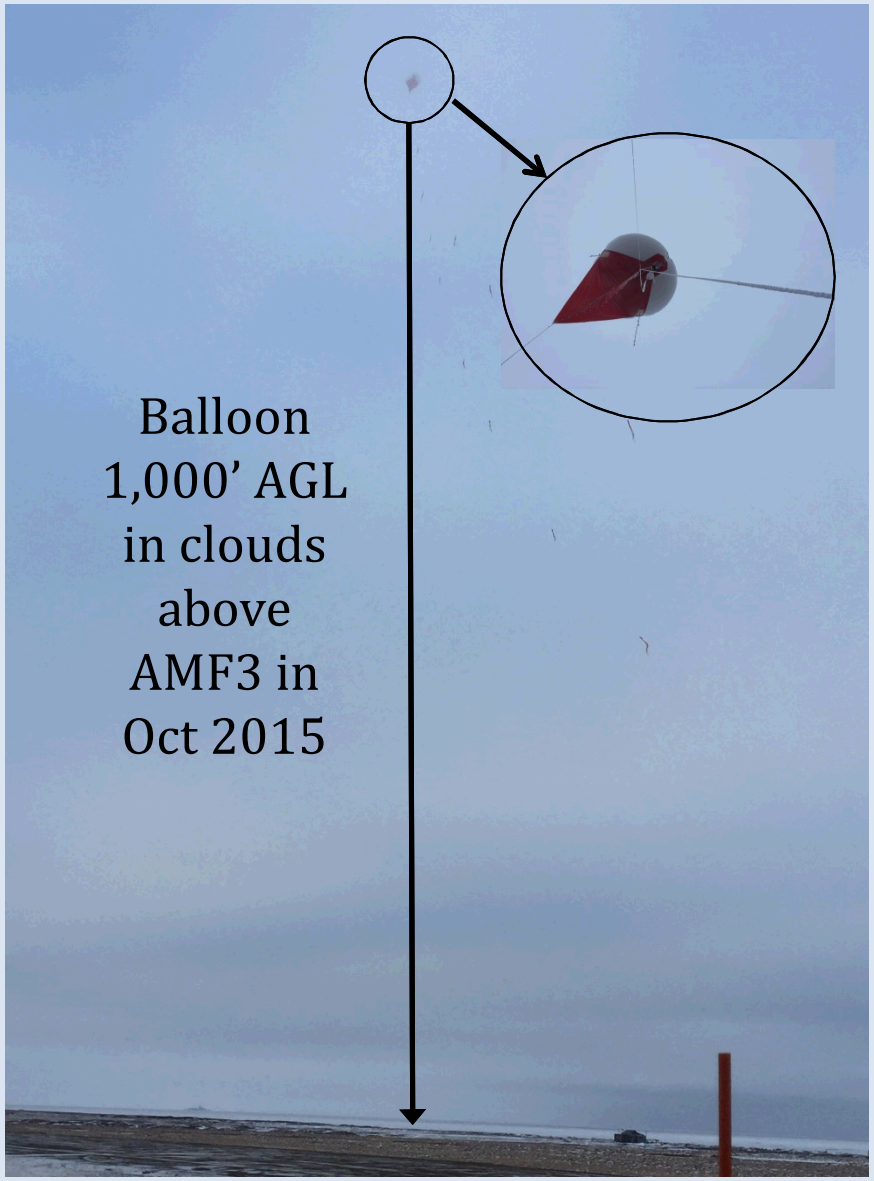
Warning Area W-220 at ARM's AMF3





- SNL also operates W-220 at AMF3
- W-220 extends ~700 nm into international airspace starting at the 12 nm limit and is ~40 nm wide
- W220 composed of eight segments, each segment has a low and high division:
  - Low = 0 – <2,000' MSL
  - High = 2,000' – 10,000' MSL

Objectives of TBS



- ARM is developing a tethered balloon system (**TBS**) capable of operating at AMF3 up to 6,000' AGL within DOE's R-2204 restricted area.
- The TBS operates within clouds and collects high vertical resolution atmospheric data that will improve process understanding.
- Primary science objectives are improved understanding of arctic cloud, aerosol, and precipitation properties.

Current Equipment & Capabilities

Enclosed winch and 35 m^3 helikites used for Sep & Oct 2015, April 2016 flights

Balloon launcher #28 Skydoc aerostat planned for May 2016 flights

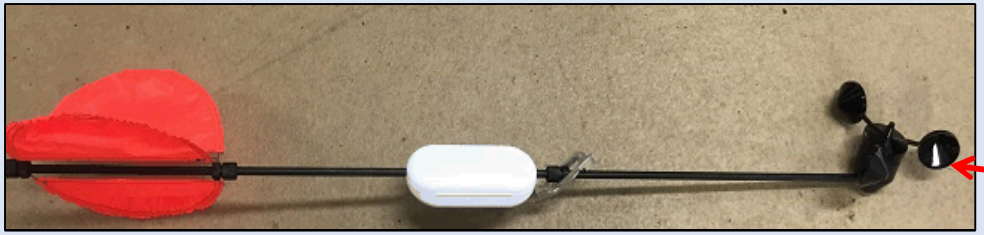
Current Equipment & Capabilities

- 35,000 ft^3 helium trailer at AMF3

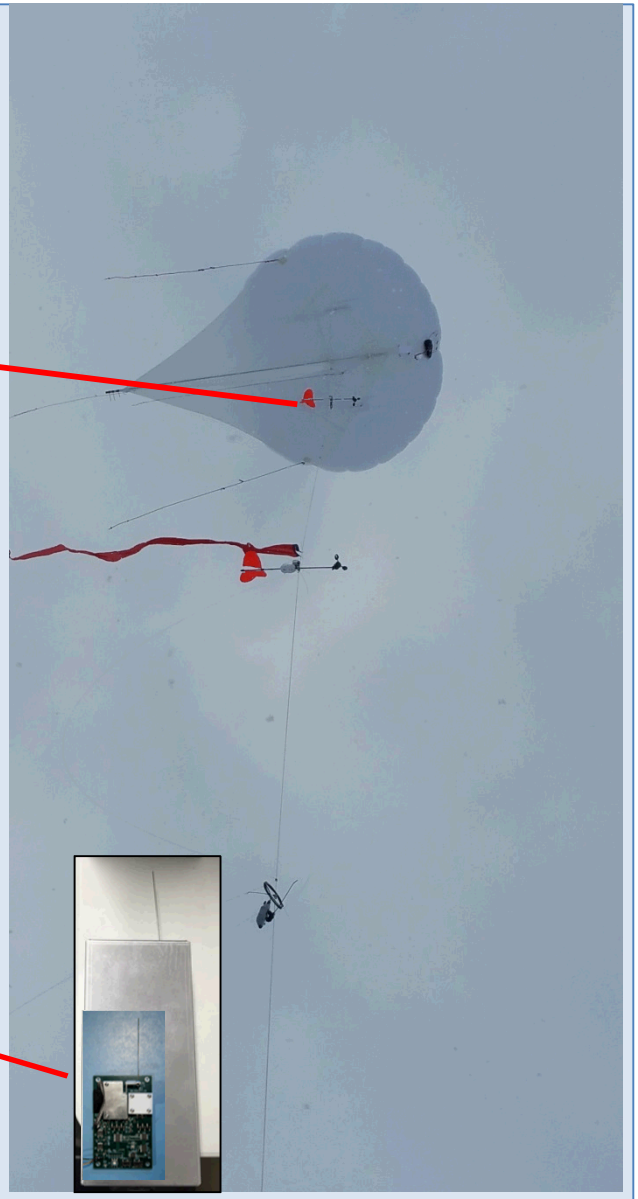
- Limiting factors to TBS flight time:
  - Crew availability
  - Sensor battery life in cold
  - Launch/retrieval wind limit of sustained winds > 30 mph at surface
  - Ice loading
  - Helium diffusion

TBS Sensors: Tethersondes & SLWCs

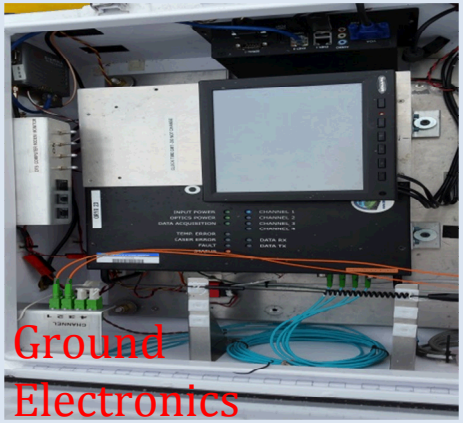
12 **tethersondes** provide a vertical profile of temperature, pressure, relative humidity, wind speed, wind direction, and altitude.

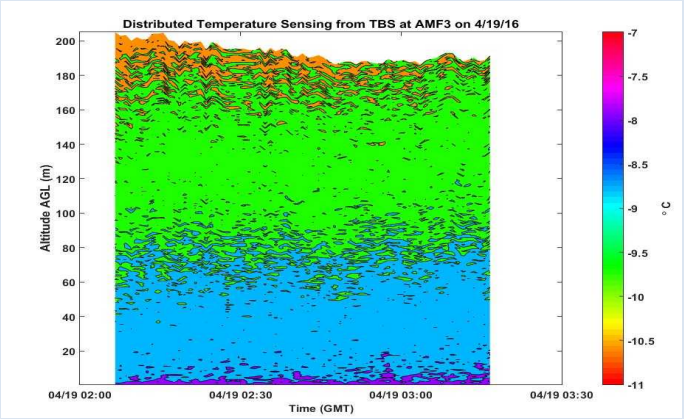


6 **Supercooled Liquid Water Content (SLWC) sensors** collect supercooled liquid water droplets on a vibrating wire. The frequency change of the wire's vibration is related to SLWC. Ice content (IWC) and liquid water content (LWC) sondes expected to be deployed in fall 2016.



TBS Sensors: DTS



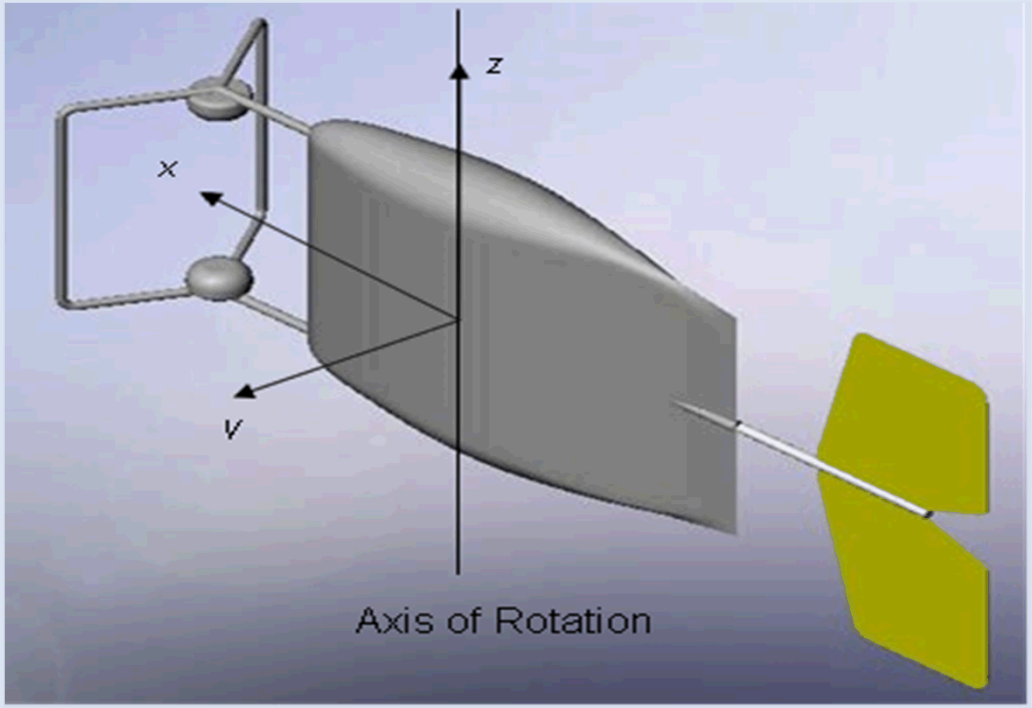


Distributed Temperature Sensing (DTS) system composed of **1.5 km** of fiber optic cable. The fiber optic cable serves as the thermometer, with a laser serving as the illumination source. Provides measurements of temperature every 2 meters every 30 seconds with temperature resolution of < 0.1°C. First flown on TBS at Oliktok on 4/18/16.

TBS Sensors: LWS & Turbulence Pod

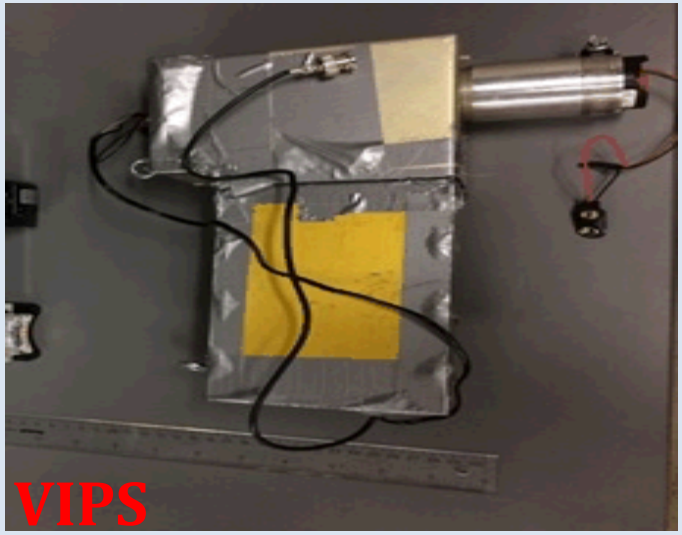
3 **LWS**s (**Leaf Wetness Sensors**) estimate wetness by measuring the dielectric constant of the sensor's upper surface. The sensor detects the presence of miniscule amounts of water, ice, or frost.

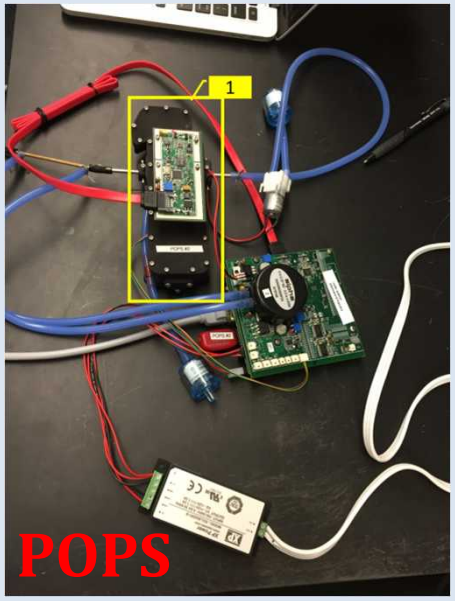
Turbulence Pod provides turbulence measurements from 3D sonic anemometer that are motion-corrected in order to calculate turbulent momentum fluxes. Expected to be deployed on TBS in October 2016.



TBS Sensors: VIPS, POPS, miniSASP

VIPS **(Video Ice Particle Sampler)** collects high-resolution imagery of ice particles for the purpose of obtaining size distributions and habit (shape) information for particles that range in size up to 1 mm. Expected to fly on TBS in October 2016.





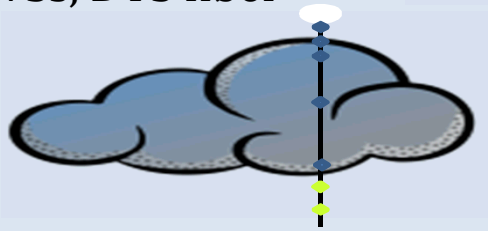
POPS (**Printed Optical Particle Spectrometer**) measures dry aerosol number density and size distribution; derives dry AOD profiles & humidification effect

MiniSASP (Mini Scanning Aerosol Solar Photometer) measures AOD profiles.

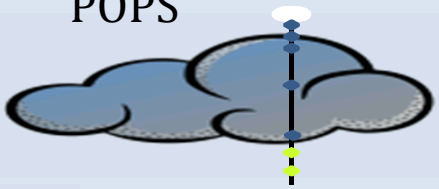
Currently being packaged to fly on TBS in late July 2016.

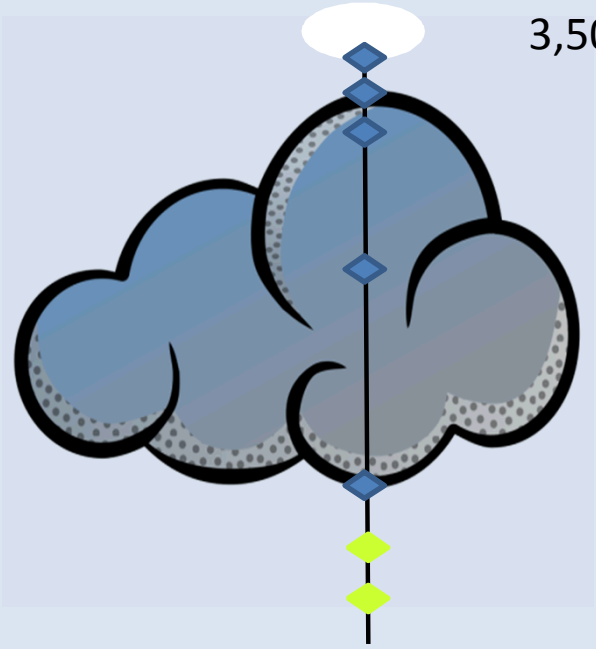
2016 TBS Flight Plans

May 2016:
Begin flights with payloads > 35 lbs and to altitudes > 2,000' AGL using tethersondes, SLWCs, LWSs, DTS fiber



June – early September 2016:
Continue to increase altitude with addition of prototype LWC, POPS





Late September - October 2016:
Test flights with prototype IWC sondes, VIPS, miniSASP, Turbulence Pod, SLWC with deicing mechanism

3,500'

AGL

1,500'

May

August