ARM
CLIMATE RESEARCH FACILITY

SAND2016-4034C

Oliktok Point, AK Tethered Balloon Capabilities Update

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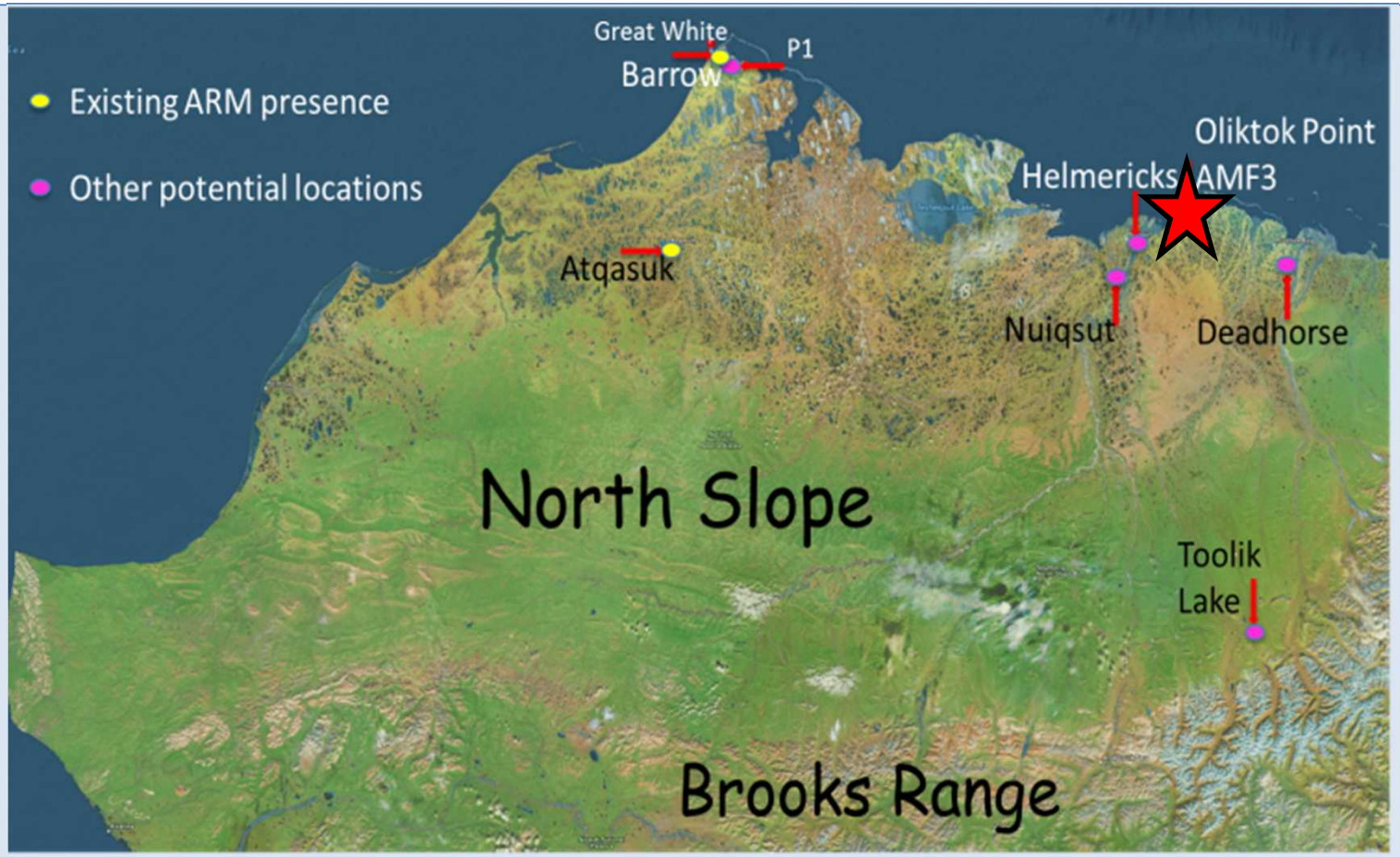
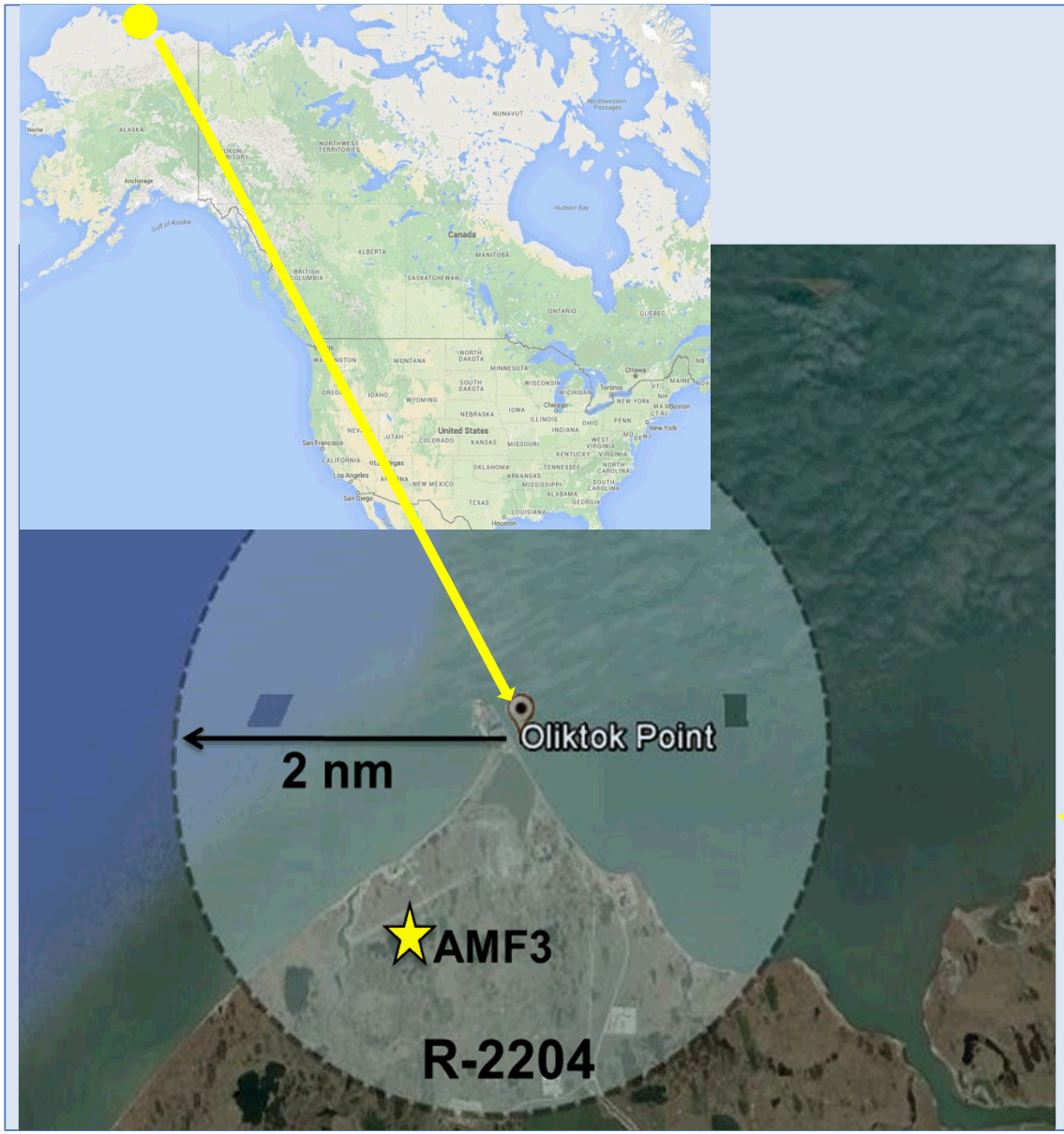


Sandia National Laboratories (SNL) has operated on behalf of ARM:

- 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 & NSA?



- 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).
- ★ Pursuing TBS operations at NSA in Barrow in late July 2016

Objectives of TBS

Balloon above AMF3 in Apr 2016

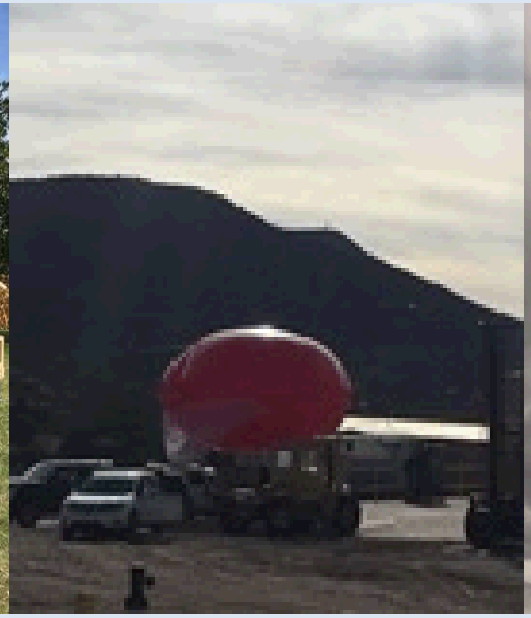
- ARM is developing a tethered balloon system (**TBS**) capable of operating at AMF3 up to 6,000' AGL within DOE's R-2204 restricted area.
- The TBS operates within clouds and collects high vertical resolution atmospheric data that will improve process understanding.
- Primary science objectives are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

Launcher expected to arrive in Oliktok on 5/13/16



Current Equipment & Capabilities

- Limiting factors to TBS operations:
  - Crew availability
  - Sensor battery life in cold
  - Launch/retrieval wind limit of sustained winds > 30 mph at surface
  - Ice loading
  - Helium diffusion
  - Have experienced some EMI with TBS sensors at Oliktok

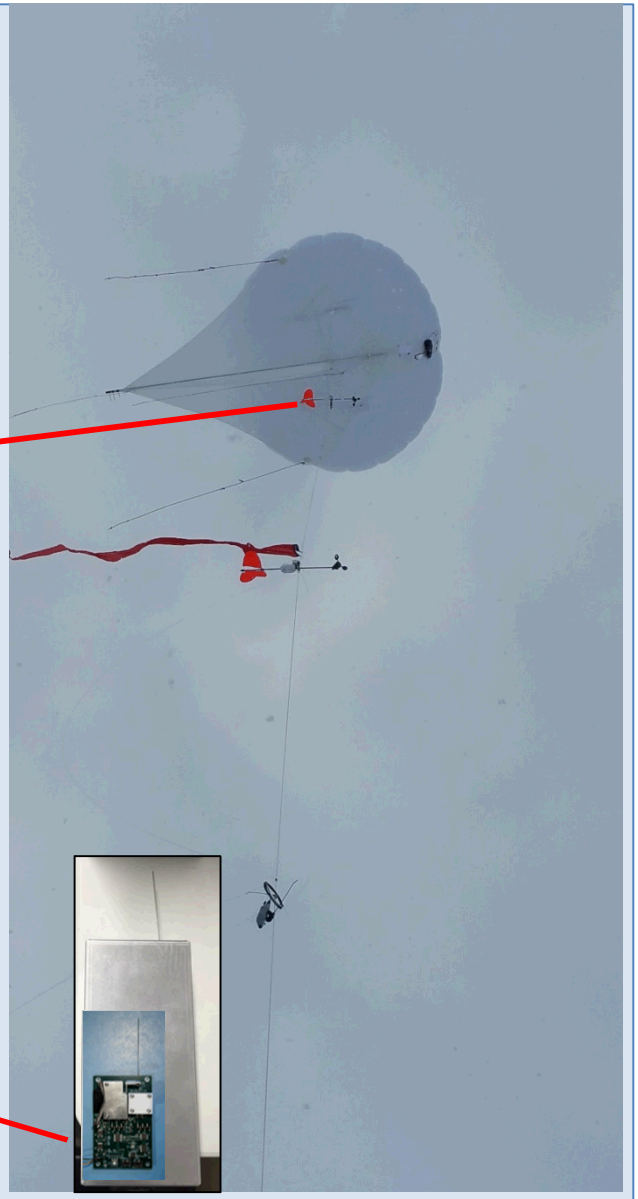
- Need Restricted Airspace or FAA Waiver to operate TBS > 150' AGL

- Must have emergency deflation device on balloon

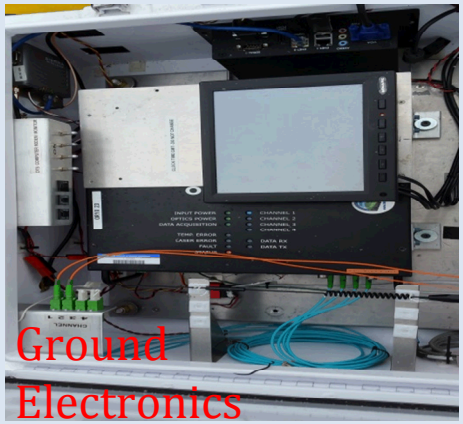
TBS Sensors: Tethersondes & SLWCs

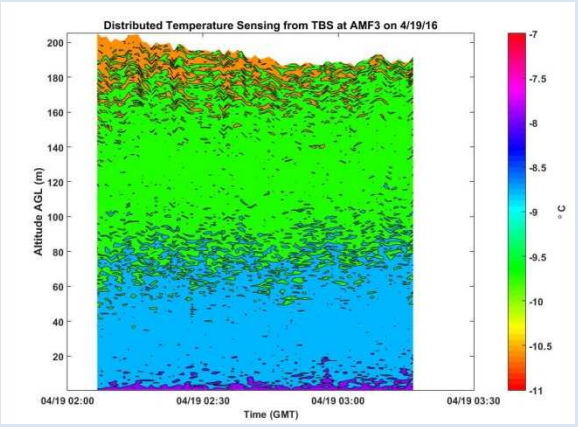
12 **tethersondes** provide a vertical profile of temperature, pressure, relative humidity, wind speed, wind direction, and altitude. Suspect SACR at Oliktok is interfering with compass (bad wind direction). Further testing is planned in May.

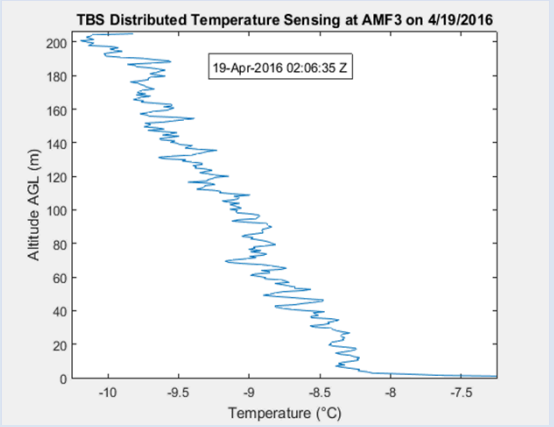
6 **Supercooled Liquid Water Content (SLWC) sensors** collect supercooled liquid water droplets on a vibrating wire. The frequency change of the wire's vibration is related to SLWC. Ice content (IWC) and liquid water content (LWC) sondes expected to be deployed in fall 2016.



TBS Sensors: DTS





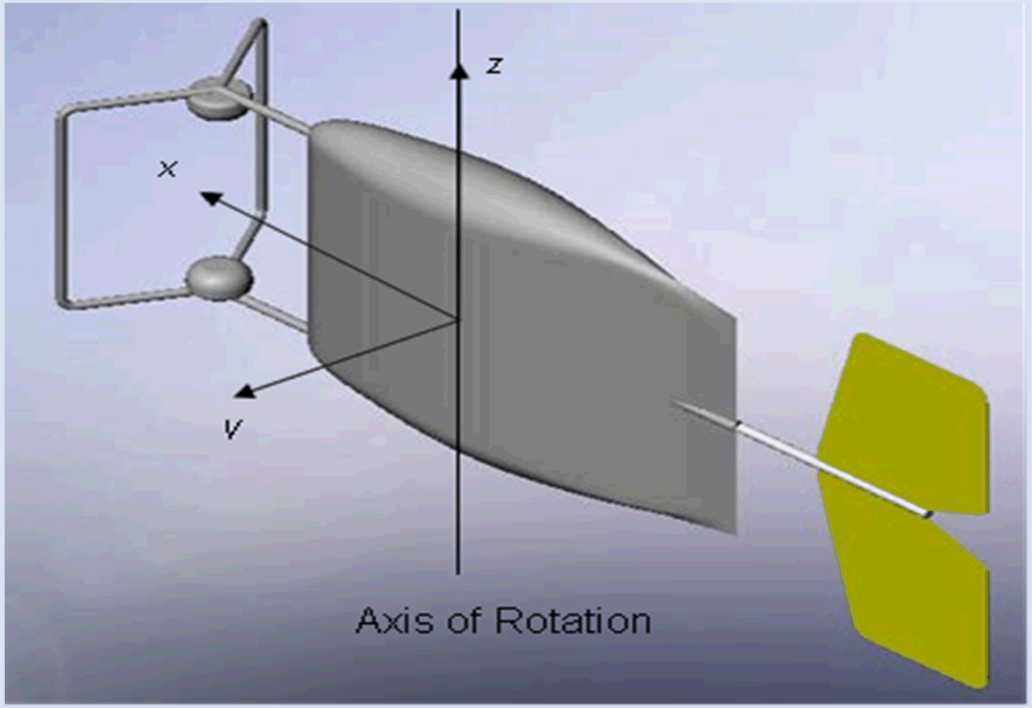


Distributed Temperature Sensing (DTS) system composed of **1.5 km** of fiber optic cable. The fiber optic cable serves as the thermometer, with a laser serving as the illumination source. Provides measurements of temperature every 2 meters every 30 seconds with temperature resolution of < 0.1°C. First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

TBS Sensors: LWS & Turbulence Pod

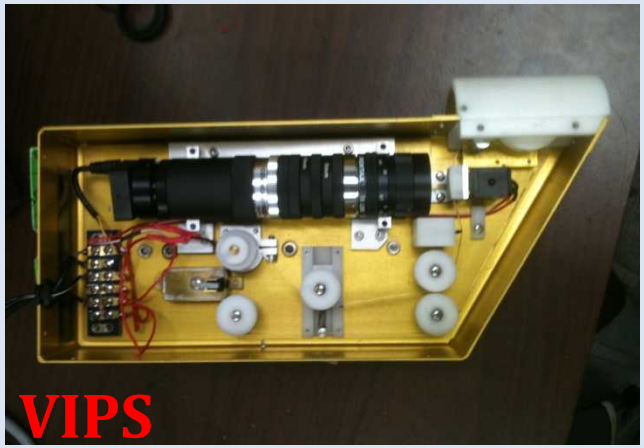
3 **LWS**s (**Leaf Wetness Sensors**) estimate wetness by measuring the dielectric constant of the sensor's upper surface. The sensor detects the presence of miniscule amounts of water, ice, or frost.

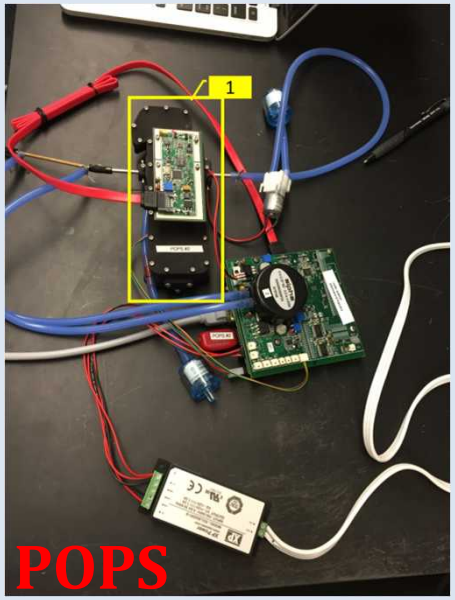
Turbulence Pod provides turbulence measurements from 3D sonic anemometer that are motion-corrected in order to calculate turbulent momentum fluxes. Expected to be deployed on TBS in October 2016.



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.

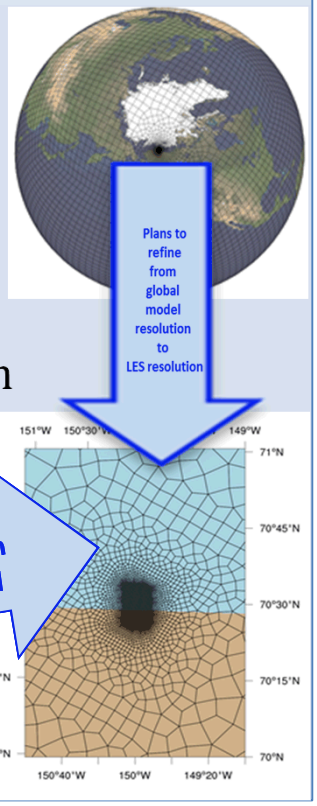
Currently being packaged to fly on TBS in late July 2016.

(AALCO) Aerial Assessment of Liquid in Clouds at Oliktok

- Proposed IOP at AMF3; PI: Erika Roesler of Sandia National Laboratory
- If approved operations expected in July 2016

- Laboratory Directed Research & Development (LDRD) funds to reduce uncertainty in regional climate change from Sandia National Laboratory cover equipment, labor, and analysis

- Studies performed with high-resolution and global models have uncertainties in understanding many properties of Arctic clouds.
- Goal is to reduce the number of unknowns in high-resolution Arctic cloud modeling by testing liquid water sensors on tethered balloons.



(AALCO) Aerial Assessment of Liquid in Clouds at Oliktok

- Planned operations include a smaller balloon (compared to the TBS) on an auto-reeler system. The auto-reeler will carry super-cooled liquid water content (SLWC) sensors and i-Met radiosondes into arctic clouds.

- SLWCs flown on TBS at AMF3 in October 2015 were compared against the LES
- System for Atmospheric Modeling (SAMv6.10.8), an LES, simulated 26-29 October 2015 with $\Delta x = 100$ m, $\Delta z = 40$ m initialized by ARM's ECMWF reanalysis data product
- Temperature, humidity, winds nudged to ARM's ECMWF reanalysis data