ARM, ASR, AND UAF ACTIVITIES AT THE NORTH SLOPE OF ALASKA

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2: Argonne National Laboratories

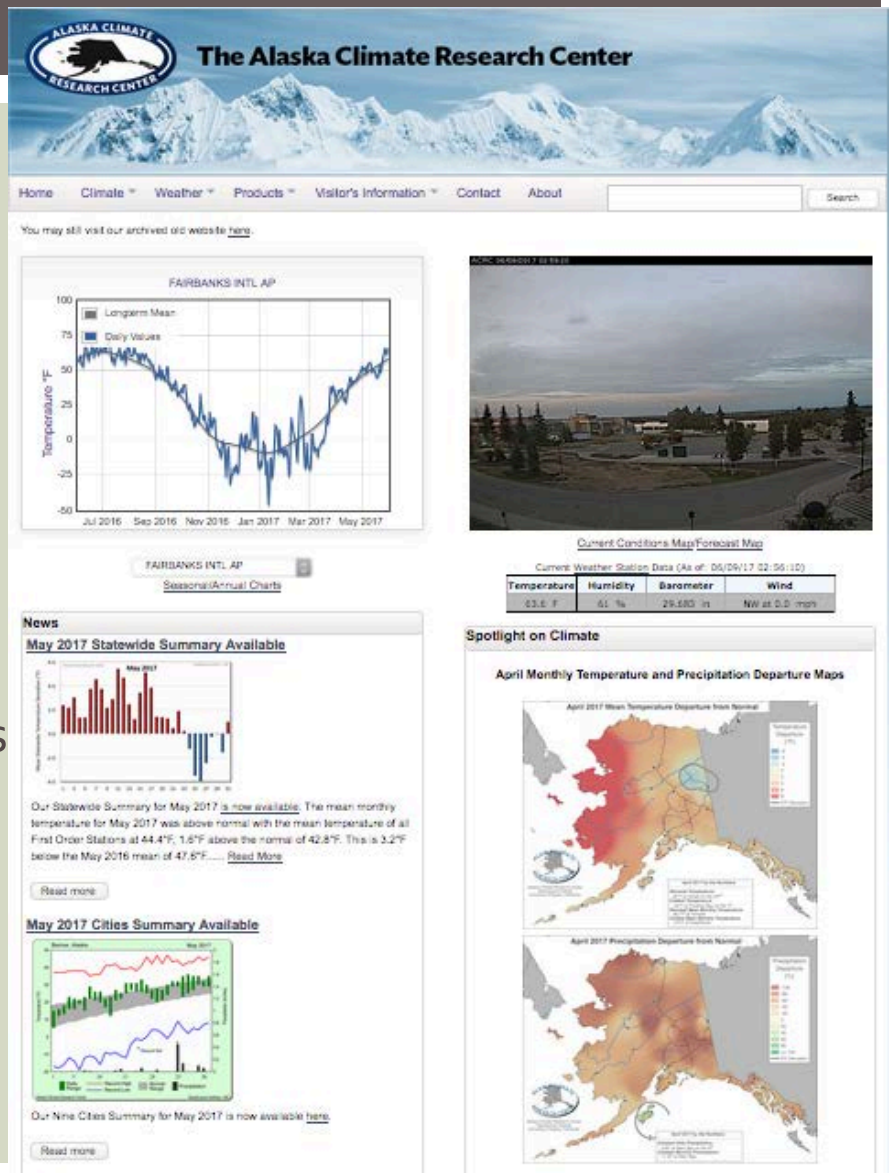
9th GRUAN Implementation and Coordination Meeting in Helsinki, June 2017

ALASKA CLIMATE RESEARCH CENTER

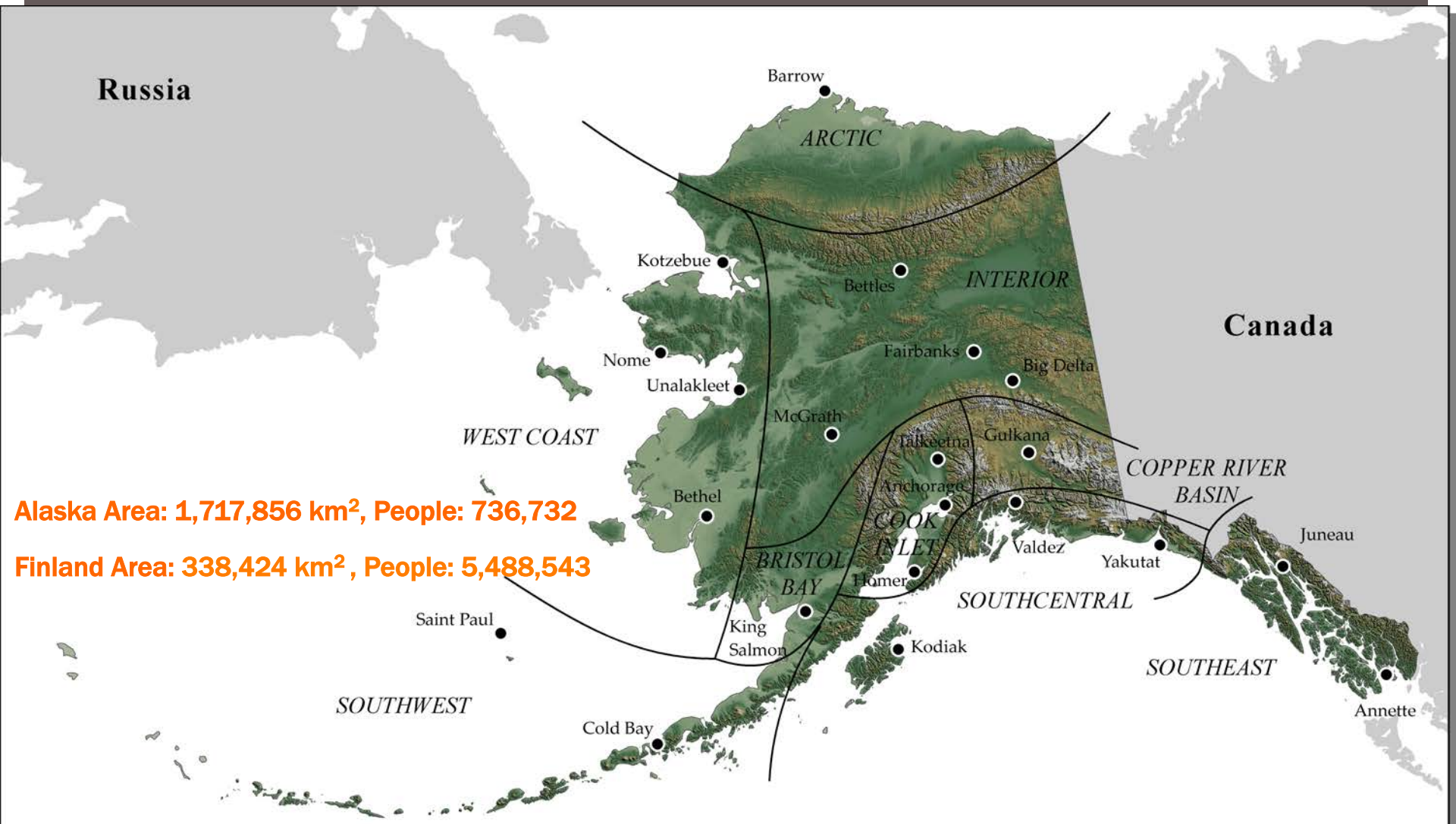
- ✓ Part of the Geophysical Institute at the University of Alaska Fairbanks
- ✓ Purpose of the Center
  - Dissemination of climatological data
  - Research on climate and climate variation in Alaska and Polar Regions
  - Education
- ✓ Only nationally recognized Climate Office for Alaska by Recognized State Climate Office; Established by the State of Alaska by Title 14, Chapter 40, Section 085

DISSEMINATION

- Climatological Data sets
- Weather, climate, environmental resources to the public, research organizations, and interested industries, free of charge
- We inform about
  - ✓Current Weather
  - ✓Monthly Summaries
  - ✓Numerical Weather Model Development and Real Time Runs
  - ✓On-campus weather station
  - ✓Webcam
- http://akclimate.org



ALASKA OBSERVATIONS

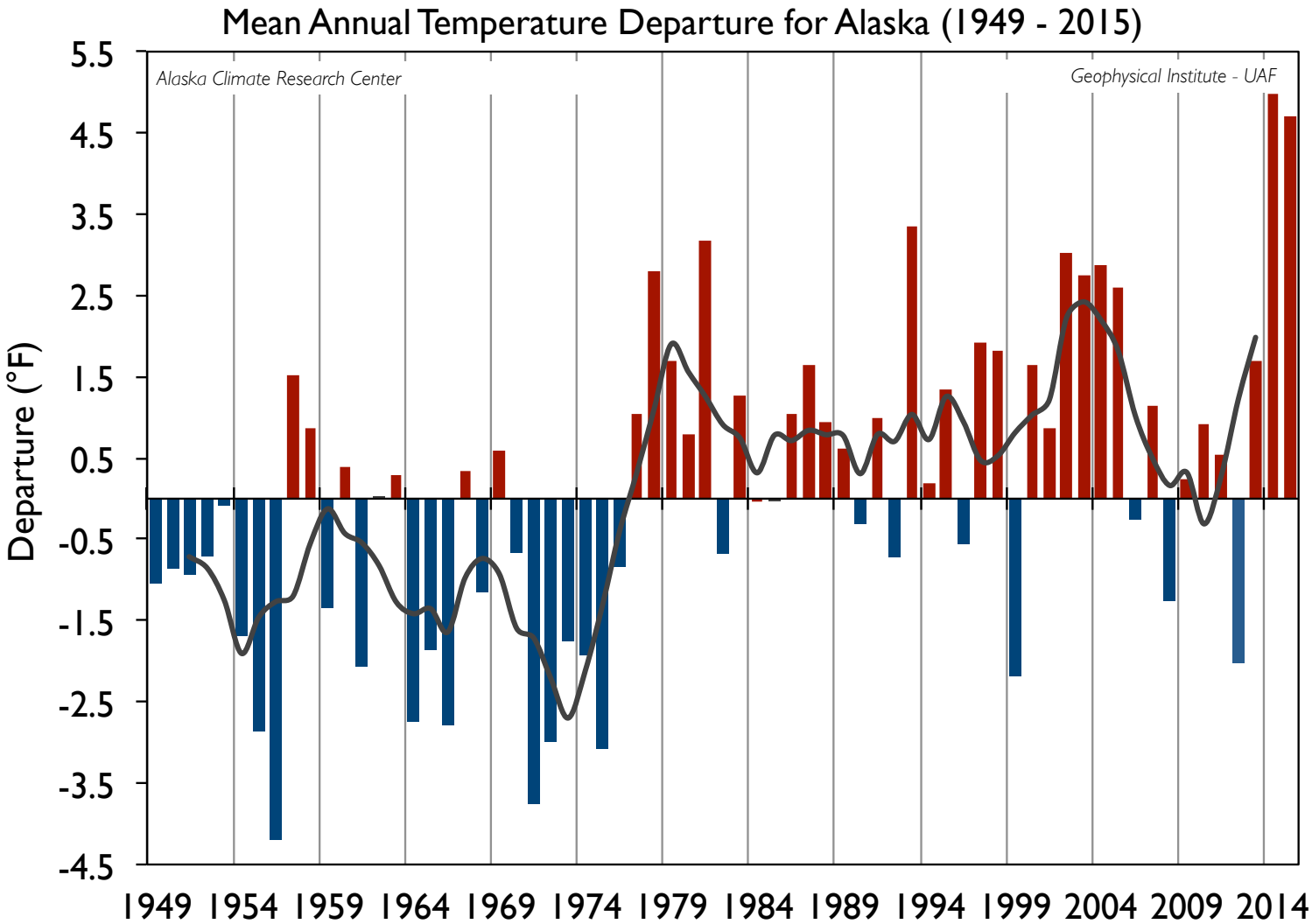


Alaska Area: 1,717,856 km², People: 736,732

Finland Area: 338,424 km² , People: 5,488,543

20 first order stations, 4 different climate zones

TEMPERATURE CHANGE IN ALASKA



TEMPERATURE CHANGE IN ALASKA

Total Change in Mean Seasonal and Annual Temperature (°F), 1949 - 2015

Region	Location	Winter	Spring	Summer	Autumn	Annual
Arctic	Barrow	7.6	5.6	3.6	6.3	5.8
Interior	Bettles	7.1	4.2	1.5	2.0	3.7
	Fairbanks	7.2	3.6	2.0	1.0	3.4
	Delta Junction	8.9	3.5	0.7	1.0	3.5
	McGrath	8.1	4.5	2.4	2.7	4.4
West Coast	Kotzebue	7.4	1.8	2.9	3.2	3.8
	Nome	4.9	2.6	2.2	1.6	2.8
	Bethel	7.2	3.7	1.9	1.1	3.5
	King Salmon	8.9	4.1	1.5	1.8	4.1
	St Paul	0.6	1.2	2.5	1.4	1.5
	Cold Bay	2.1	1.3	2.0	1.2	1.6
Southcentral	Talkeetna	9.1	5.0	2.7	3.4	5.0
	Gulkana	7.9	2.5	0.6	0.5	2.8
	Anchorage	6.0	3.5	1.5	1.8	3.2
	Homer	6.6	3.7	3.1	2.4	4.0
	Kodiak	1.5	2.0	1.5	0.2	1.3
Southeast	Yakutat	5.4	2.8	2.1	1.1	2.8
	Juneau	6.6	3.0	1.9	1.6	3.2
	Annette	3.6	2.4	1.7	0.8	2.1
	Average	6.1	3.2	2.0	1.8	3.3

Alaska Climate Research Center *Geophysical Institute, University of Alaska Fairbanks*

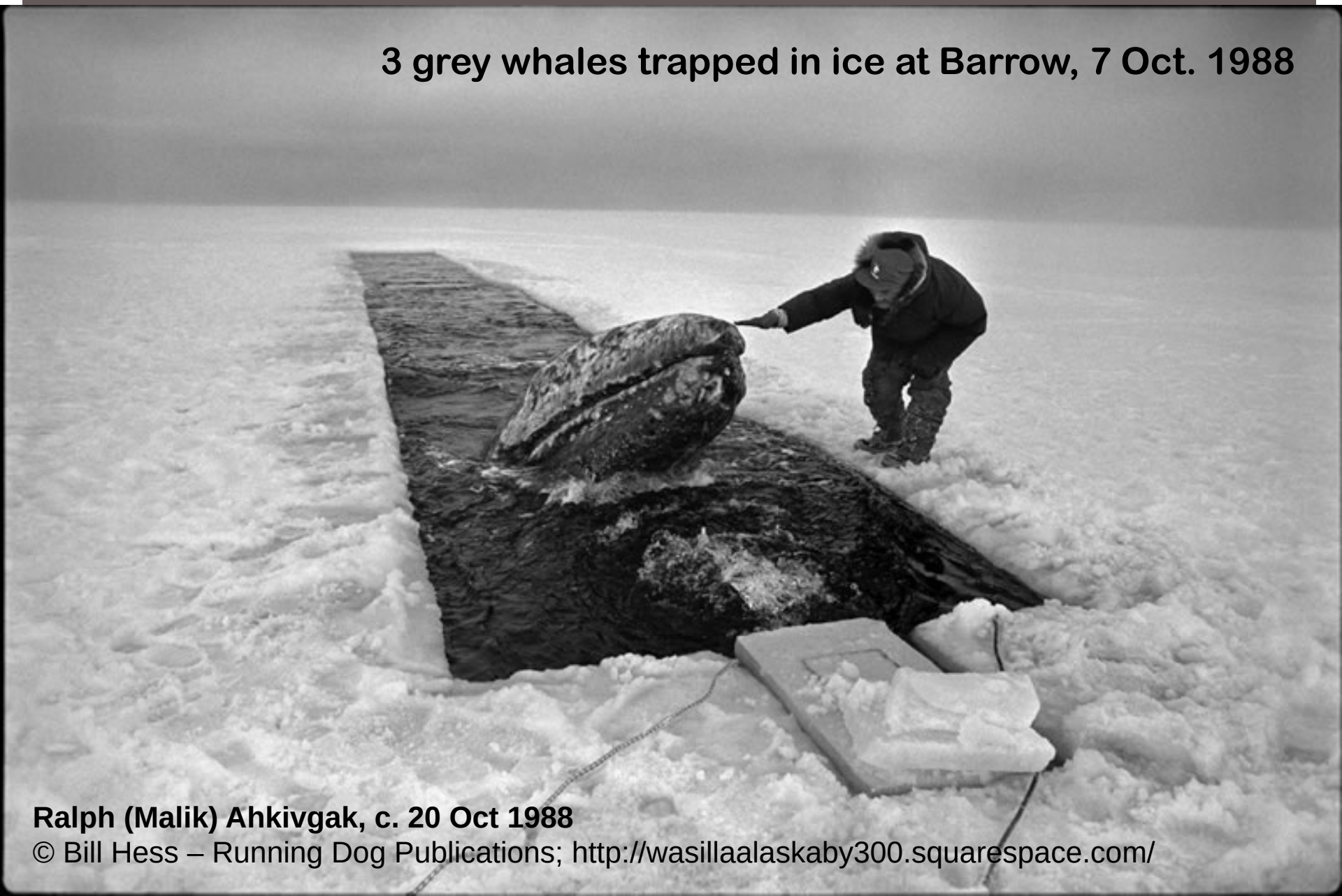
TEMPERATURE CHANGE 1977-2014

Total Change in Mean Seasonal and Annual Temperature (°F), 1977 - 2014

Region	Location	Winter	Spring	Summer	Autumn	Annual
Arctic	Barrow	3.0	4.8	2.5	10.2	5.0
Interior	Bettles	-1.5	-1.3	-0.5	1.6	-0.3
	Fairbanks	-3.4	-2.4	0.9	0.0	-1.1
	Big Delta	0.1	-2.3	0.0	0.3	-0.3
	McGrath	-0.1	0.3	1.7	2.5	1.3
West Coast	Kotzebue	-1.7	0.5	0.3	2.6	0.4
	Nome	-3.7	-2.1	-1.0	0.6	-1.5
	Bethel	-1.4	-2.0	1.3	0.7	-0.3
	King Salmon	-1.9	-2.7	0.3	1.0	-0.6
	St Paul	-3.7	-3.7	-0.6	0.0	-2.0
	Cold Bay	-1.0	-2.7	0.0	0.0	-0.9
Southcentral	Talkeetna	1.3	0.7	1.8	2.5	1.8
	Gulkana	-0.9	-1.5	0.6	-1.5	-0.6
	Anchorage	-1.6	-1.4	-0.4	0.4	-0.6
	Homer	-1.4	-1.6	0.5	0.8	-0.2
	Kodiak	-2.9	-2.9	-0.6	-1.6	-1.9
Southeast	Yakutat	0.3	-2.3	0.7	0.2	-0.2
	Juneau	1.4	-2.2	-0.2	-0.7	-0.3
	Annette	-0.2	-0.8	0.5	0.4	0.1
	Average	-1.0	-1.3	0.4	1.1	-0.1

Alaska Climate Research Center *Geophysical Institute, University of Alaska Fairbanks*

CHANGING SEA ICE



Ralph (Malik) Ahkivgak, c. 20 Oct 1988

© Bill Hess – Running Dog Publications; http://wasillaalaskaby300.squarespace.com/

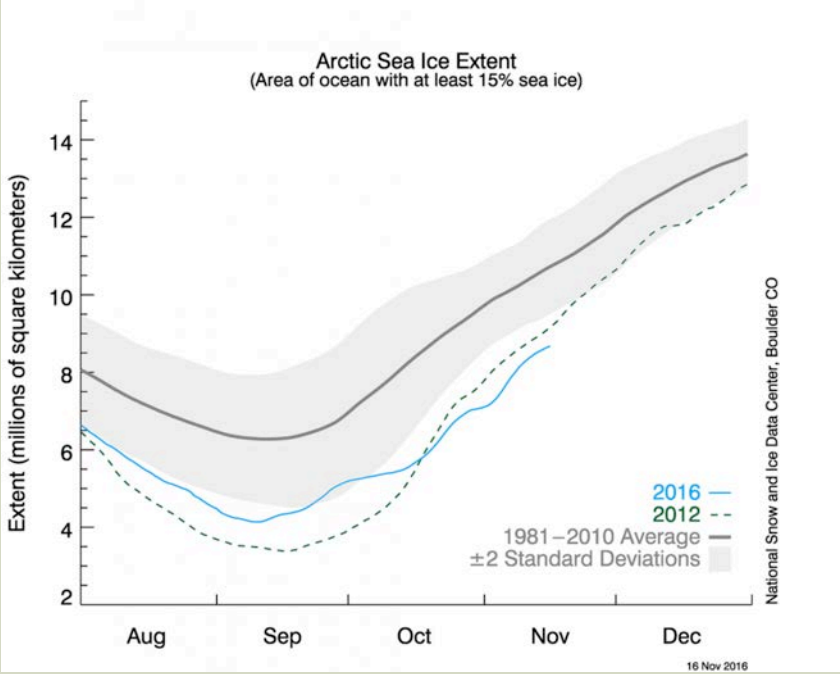
3 GREY WHALES TRAPPED IN ICE AT BARROW, 7 OCT. 1988

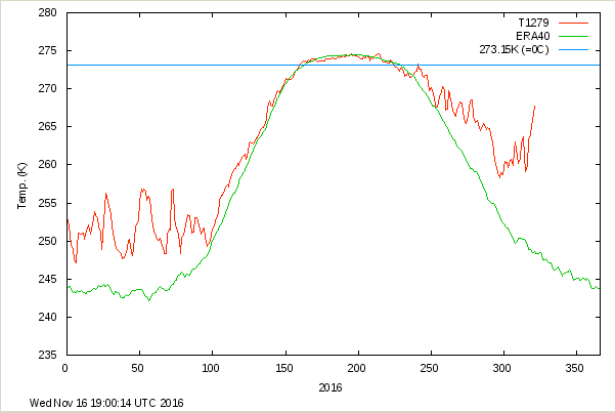
Ralph (Malik) Ahkivgak, c. 20 Oct 1988

© Anchorage Daily News

More recently (October 2011)
Barrow Sea Ice Cam 2011-10-20 11:32:22

2016





Temperatures north of 80 latitude were around -5 degrees Celsius — instead of the normal of around -25 degrees C.

Energy and Environment

The North Pole is an insane 36 degrees warmer than normal as winter descends

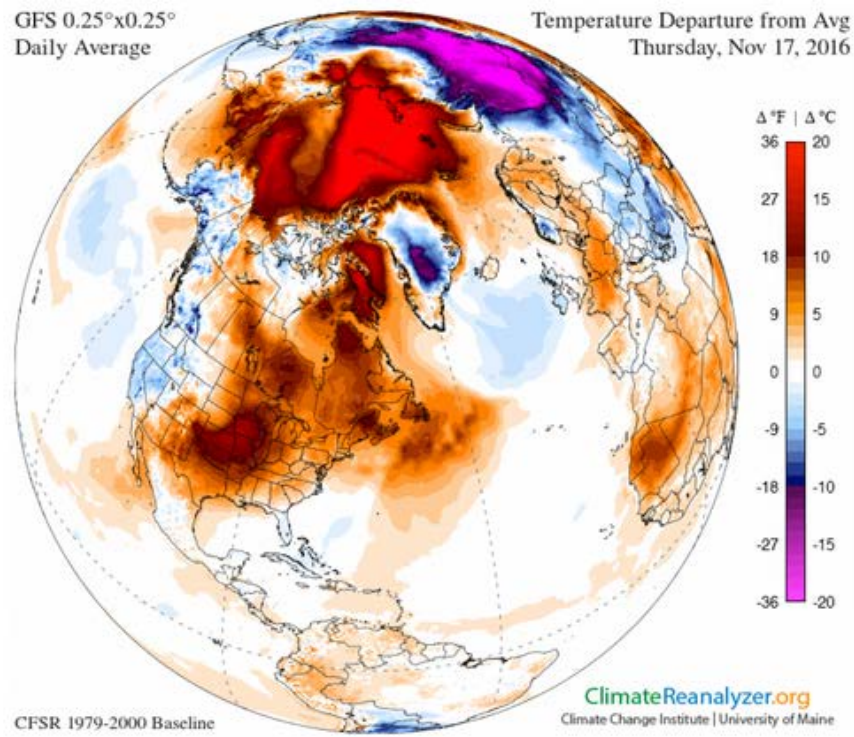
By Chris Mooney and Jason Samenow November 17

This story has been updated.

Political people in the United States are watching the chaos in Washington in the moment. But some people in the science community are watching the chaos somewhere else — the Arctic.

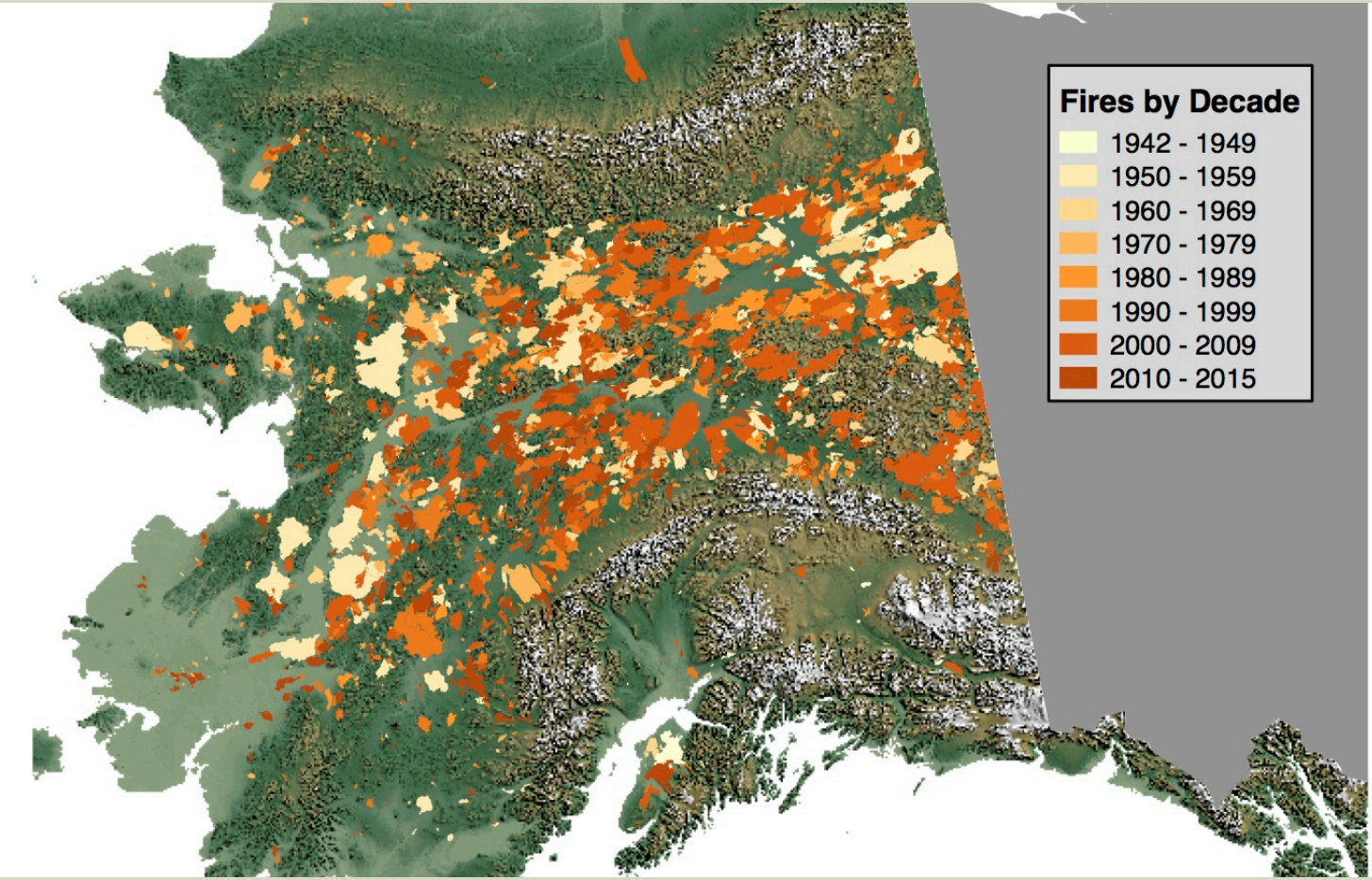
It's polar night there now — the sun isn't rising in much of the Arctic. That's when the Arctic is supposed to get super-cold, when the sea ice that covers the vast Arctic Ocean is supposed to grow and thicken.

But in fall of 2016 — which has been a zany year for the region, with multiple records set for low levels of monthly sea ice — something is totally off. The Arctic is super-hot, even as a vast area of cold polar air has been displaced over Siberia.

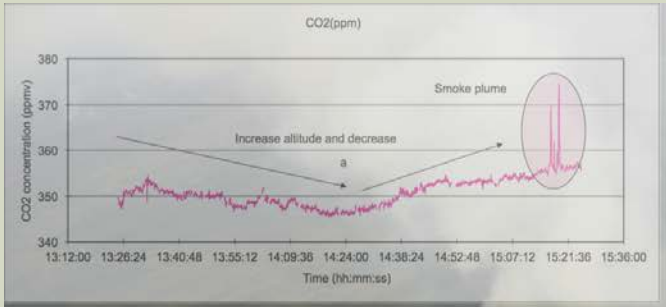


World	Northern Hemisphere	Arctic
+ 0.55 °C	+ 0.94 °C	+ 6.42 °C
Tropics	Southern Hemisphere	Antarctic
+ 0.31 °C	+ 0.15 °C	+ 0.92 °C

AEROSOL: FIRES, VOLCANOES



AIRBORNE AEROSOL MEASUREMENTS



M. Stuefer, S. R. Freitas, G. Grell, P. Webley, S. Peckham, S.A. McKeen and S. D. Egan, 2013: Inclusion of ash and SO2 emissions from volcanic eruptions in WRF-Chem: development and some applications, Geosci. Model Dev., 6, 457-468, doi:10.5194/gmd-6-457-2013, 2013.

Grell, S. Freitas, M. Stuefer, J. Fast, 2011: Inclusion of Biomass Burning in WRF-Chem: Impact of Wildfires on Weather Forecasts. Journal of Atmos. Chem. Phys., 11, 5289–5303, 2011.

ATMOSPHERIC RADIATION MEASUREMENT (ARM) PROGRAM AND RESEARCH FACILITIES

OBSERVATORY LOCATIONS AT-A-GLANCE

MARKER DEFINITIONS

- ARM site
- ARM site – inactive
- Mobile site
- Mobile site – inactive

USING THE MAP

- Pan and zoom using buttons in bottom right corner.
- Mouse over a marker to view observatory name.
- Click on a map marker to zoom in on an observatory and view more information.
- Double-click anywhere on map to return to global view.

ARM
CLIMATE RESEARCH FACILITY

U.S. DEPARTMENT OF ENERGY | Office of Science

ARM SITES IN ALASKA

CAPABILITIES > ATMOSPHERIC OBSERVATORIES

NORTH SLOPE OF ALASKA

The North Slope of Alaska (NSA) atmospheric observatory is providing data about cloud and radiative processes at high latitudes. The observatory, known as a megasite, includes a central facility at Barrow and the third ARM Mobile Facility to the east at Oliktok Point.

The NSA is a focal point for atmospheric and ecological research activity in the Arctic. Scientists use data from the NSA to improve the representation of high-latitude cloud and radiation processes in earth system models.

SCIENCE IN THE ALASKAN HIGH ARCTIC

The NSA facilities consist of two active measurement sites, the central facility at Barrow and the ARM Mobile Facility 3 at Oliktok Point.

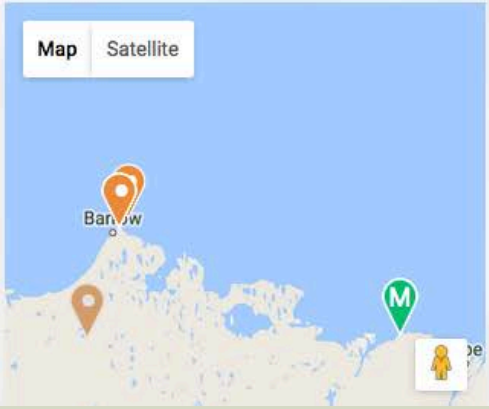
BARROW

Known as the "top of the world," Barrow hosts the NSA's main research site near the coast of the Arctic Ocean, where ARM collects data about cloud and radiative processes at high latitudes.

NORTH SLOPE OF ALASKA

Central location:
71° 19′ 22.8″ N, 156° 36′ 32.4″ W

Start year: 1996



BARROW NSAC1 INSTRUMENTS

Categories:

- ✓ **Aerosols**
- ✓ **Airborne Observations**
- ✓ **Atmospheric Carbon**
- ✓ **Atmospheric Profiling**
- ✓ **Cloud Properties**
- ✓ **Derived Quantities and Models**
- ✓ **Ocean Observations**
- ✓ **Radiometric**
- ✓ **Satellite Observations**
- ✓ **Surface Meteorology**
- ✓ **Surface/Subsurface Properties**
- ✓ **Other**

Currently 41 Instrument Groups
Visit https://www.arm.gov/ for details

AERI	Atmospheric Emitted Radiance Interferometer
AETH	Aethalometer
AMC	Ameriflux Measurement Component
AOS	Aerosol Observing System
CCN	Cloud Condensation Nuclei Particle Counter
CEIL	Ceilometer
CLAP	Continuous Light Absorption Photometer
CPC	Condensation Particle Counter
CSPHOT	Cimel Sunphotometer
DL	Doppler Lidar
ECOR	Eddy Correlation Flux Measurement System
GNDRAD	Ground Radiometers on Stand for Upwelling Radiation
GVRP	G-band (183 GHz) Vapor Radiometer Profiler
HSRL	High Spectral Resolution Lidar
IRT	Infrared Thermometer
KASACR	Ka-Band Scanning ARM Cloud Radar
KAZR	Ka ARM Zenith Radar
MET	Surface Meteorological Instrumentation
METTWR	Surface and Tower Meteorological Instrumentation at NSA
MFR	Multifilter Radiometer
MFRSR	Multifilter Rotating Shadowband Radiometer
MMCR	Millimeter Wavelength Cloud Radar
MPL	Micropulse Lidar
MWR	Microwave Radiometer
MWRHF	Microwave Radiometer - High Frequency
MWRP	Microwave Radiometer Profiler
NEPH	Nephelometer
NIMFR	Normal Incidence Multifilter Radiometer
ORG	Optical Rain Gauge
PSAP	Particle Soot Absorption Photometer
RWP	Radar Wind Profiler
SEBS	Surface Energy Balance System
SKYRAD	Sky Radiometers on Stand for Downwelling Radiation
SONDE	Balloon-Borne Sounding System
SONIC	Ultrasonic wind sensor
TSI	Total Sky Imager
TWR	Facility-specific multi-level Meteorological Instrumentation
TWRCAM	Tower Camera
WSACR	W-band Scanning ARM Cloud Radar
XSAPR	X-Band Scanning ARM Precipitation Radar

ARM MOBILE FACILITY 3 (AMF3)

OLIKTOK POINT

Located on the coast of the Arctic Ocean, Oliktok Point is the current home of the third, and newest, ARM Mobile Facility, or AMF3. From this remote spot, researchers have access to important data about Arctic climate processes at the intersection of land and sea ice, aided by DOE-controlled air spaces for manned and unmanned flight systems.

CONTROLLED AIRSPACES

The AMF3 at Oliktok Point is the only ARM facility that includes controlled airspace, with two designated areas. These controlled airspaces give the NSA observatory more freedom in using aerial systems to study the atmosphere.

ARM's Restricted Airspace consists of a 4 nautical mile (nm) radius, centered at Oliktok Point and extending 7,000 feet above ground level. ARM also operates a Warning Area north of Oliktok Point that is roughly 40 nm wide and extends approximately 700 nm into international airspace over the Arctic Ocean toward the North Pole.

Instruments:

- **Almost as NSA-C1 site of Barrow**
- **Tethered Balloon System**
- **UAS activities**
- **No Autosonde**

The DOE ARM Mobile Facility (AMF3) at Oliktok Point, AK

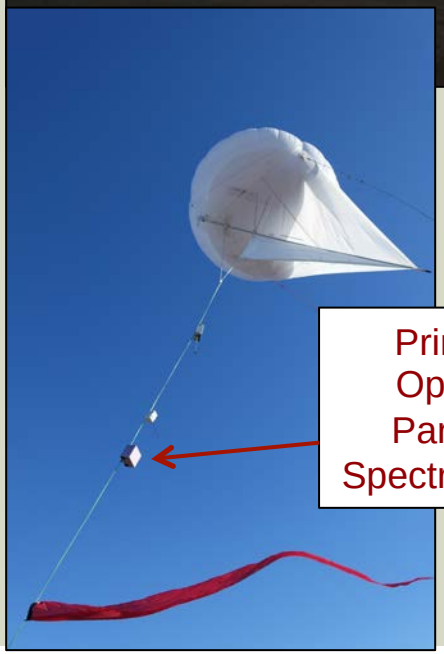
Exciting new opportunities for Arctic science

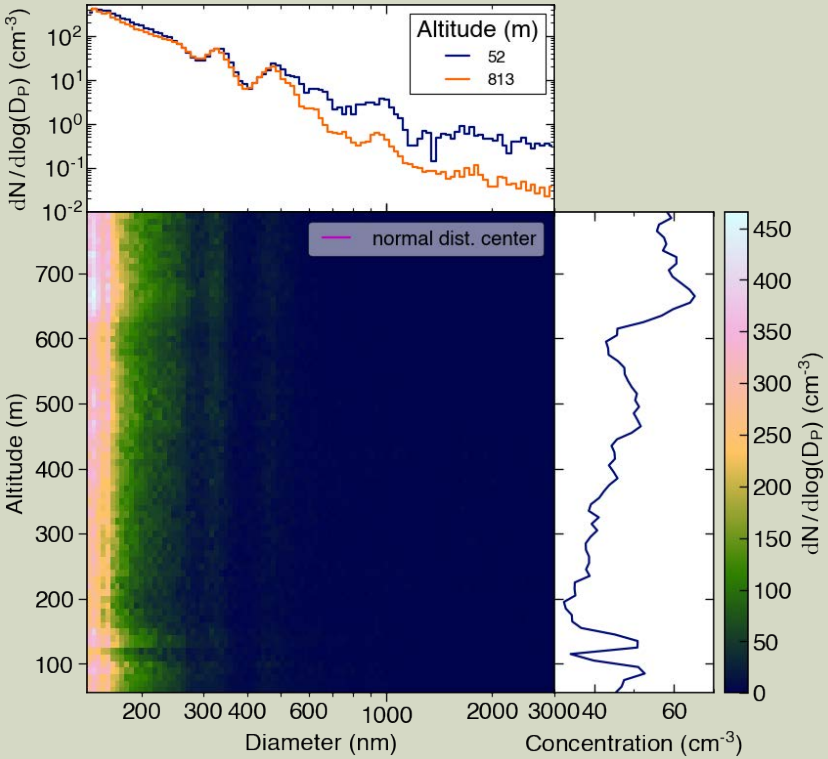
- Investigation of the synoptic scale environment at Oliktok Point (on Prudhoe Bay) and comparison to the long-term record at Barrow
- UAS campaigns, radar Calibration and Grooming Activity and the ACME-V airborne campaign for aerosol and trace gases
- Integration of an additional measurement point from Oliktok Point with information from other sources (e.g. satellites, reanalyses, other observatories)

Areas of focus for the Oliktok Point Site Science team:

- high latitude precipitation, including retrieval of habit and precipitation rate
- transitions between radiatively clear and cloudy states in the Arctic
- Arctic aerosol-cloud interactions
- Arctic/Oliktok Point aerosol properties
- Arctic/Oliktok Point cloud properties and the climatic relevance of Arctic cloud

DOE ARM tethered balloon program carrying aerosol instrumentation during testing at OLI in the summer of 2016





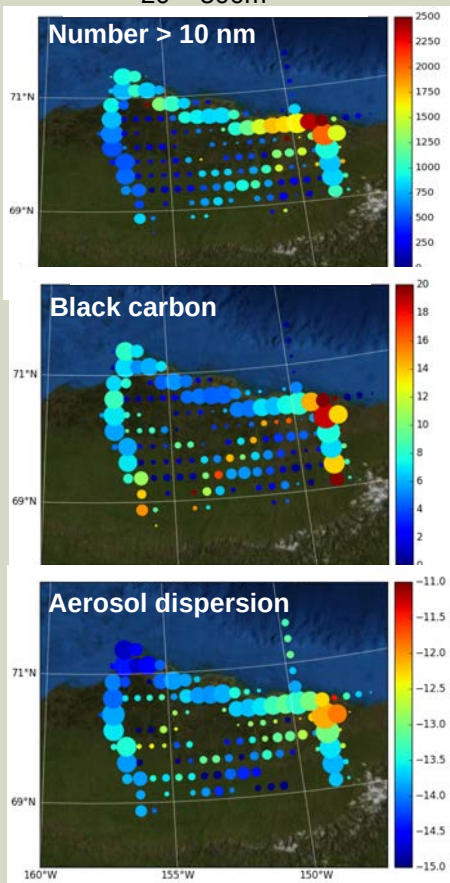
Measurements of aerosol size distribution and number concentration from the Printed Optical Particle Spectrometer (POPS) mounted on the ARM Tethered Balloon System for 26 July 2016 are shown at left. Consistent with the ground-based and aircraft data presented here, aerosol loading is enhanced at higher altitudes in a layer distinct from the surface layer.

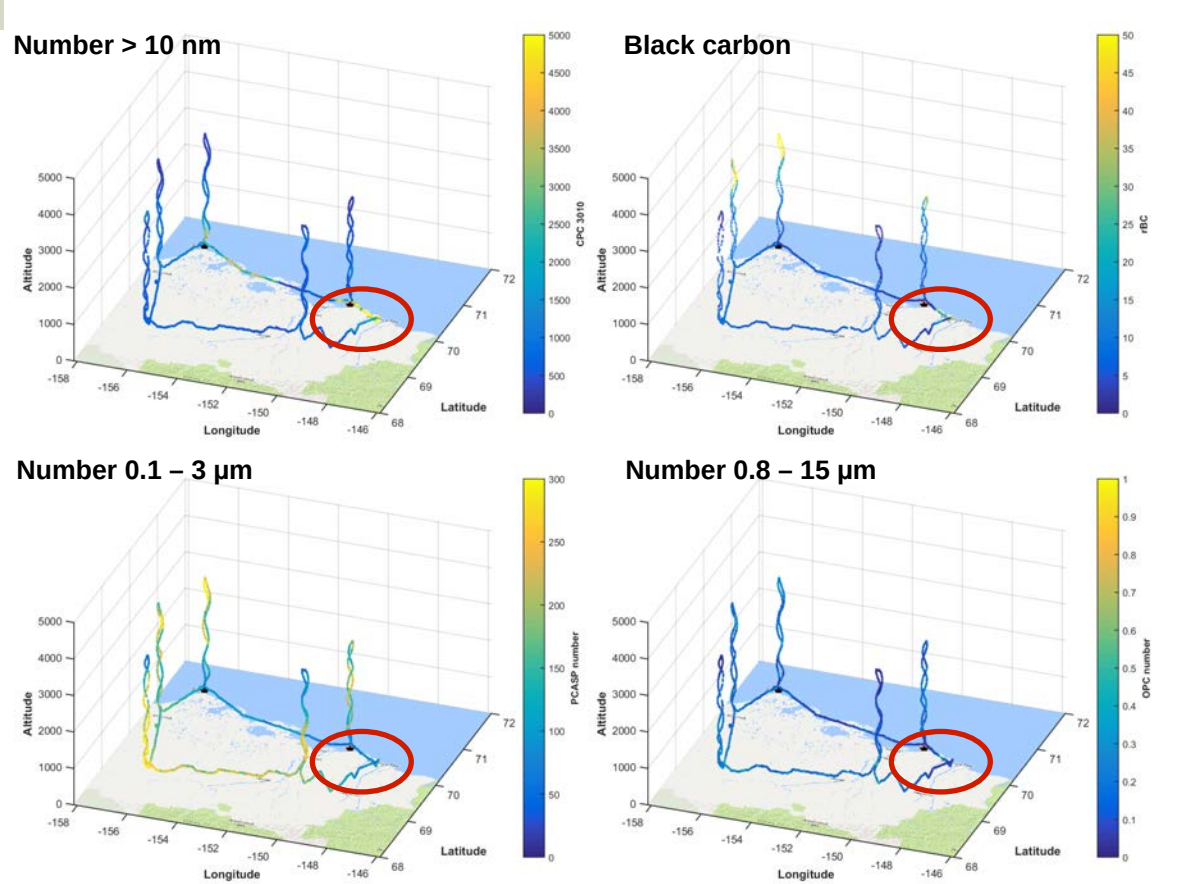
ARM Fifth Airborne Carbon Measurements Experiment (ACME-V): Prudhoe Bay as a source of small and numerous aerosol

Aerosol emissions persistent, localized, high in concentration, and relatively small in size

- High numbers near Prudhoe, particularly near ground below boundary layer, likely from local-regional oil extraction activities.
- Prudhoe Bay is also source of black carbon.
- Simulations from HYSPLIT show spatial dispersion of particles from Prudhoe Bay over the North Slope.
- Prudhoe Bay aerosol emissions were persistent, localized, high in concentration, and relatively small in size.

20 – 500m





Creamean et al, 2017, in prep.

Understanding clear/cloudy transitions:

- To what extent are transitions between radiatively clear and radiatively cloudy states governed by large-scale dynamics?
- How do local and distant sources of moisture vary by season or region, and do they lead to distinct cloud properties or longevity?
- What is the role of radiation in the initiation of the radiatively cloudy state?
- What processes determine cloud phase partitioning and the occurrence of liquid water?
- What mechanisms control the turbulence state of the sub-cloud environment?

Characterization of high-latitude precipitation processes:

- What relationships exist between ice crystal habit and the cloud-base precipitation rate?
- To what extent does precipitation intensity correspond with cloud liquid water path?
- Are precipitation processes responsible for the decoupling of clouds from the near-surface atmosphere?

Arctic aerosol-cloud interactions:

- To what extent can we use surface-based aerosol measurements as a proxy for in-cloud aerosol in the Arctic atmosphere?
- How do aerosol particles impact precipitation susceptibility in high-latitude, liquid-containing clouds?
- What role does the ice phase play in modulating the radiative impact of aerosol-cloud interactions?

Arctic/Oliktok Point aerosol properties:

- What is the climatological seasonal cycle of aerosol properties and their radiative effects over the
- North Slope of Alaska?
- How are aerosol properties such as hygroscopicity, particle size and CCN activity interrelated in this
- high latitude environment?
- Are there significant differences between aerosols observed within the Prudhoe Bay oilfields and those
- observed at the more pristine Barrow facility?

Arctic/Oliktok Point cloud properties and the climatic relevance of Arctic clouds:

- How representative is the long-term cloud climatology obtained at Barrow for estimating cloud radiative forcing over the North Slope of Alaska?
- How do these cloud-related processes, and their resulting impacts, relate to the changing Arctic climate system that is embodied by a declining cryosphere?
- Why is liquid water formation favored in environments as cold as -30 C?

ARM IOP (INTENSE OPERATING PERIODS), RESEARCH CAMPAIGNS

RESEARCH > RESEARCH HIGHLIGHTS

TWO PERSPECTIVES ON ARCTIC CLOUDS: BLENDING OBSERVATIONS FROM THE SURFACE AND SPACE

SUBMITTER:

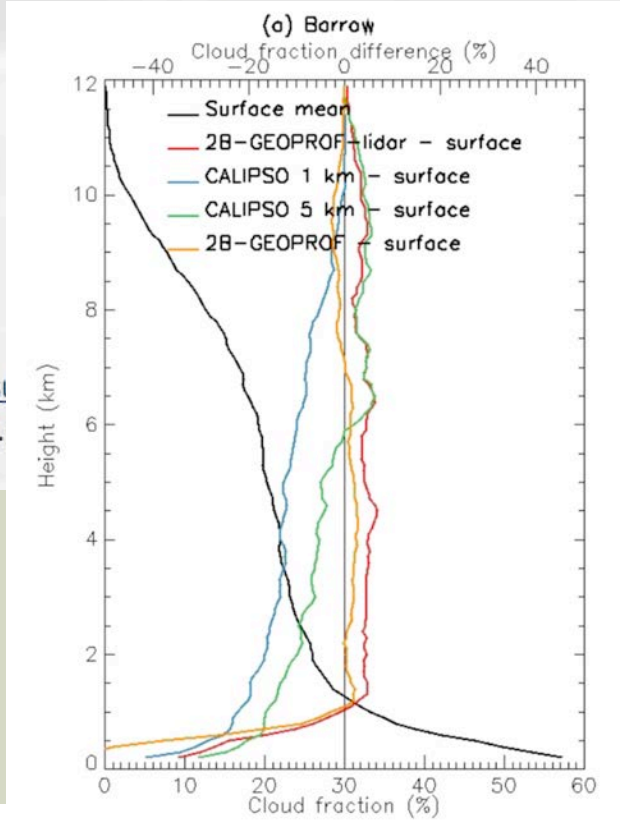
liu, yinghui - CIMSS/AOS UW-Madison
Shupe, Matthew - University of Colorado

AREA OF RESEARCH:

Cloud Distributions/Characterizations

JOURNAL REFERENCE:

Liu Y, M Shupe, Z Wang, and G Mace. 2017. "Cloud vertical distribution from combined s
two Arctic atmospheric observatories." *Atmospheric Chemistry and Physics*, 17(9), doi:10.



ARM IOP (INTENSE OPERATING PERIODS), RESEARCH CAMPAIGNS

RESEARCH > CAMPAIGNS

GFZ GNSS GROUND STATION NETWORK EXPANDS TO ARM NSA-C1 BARROW (Utqiaġvik)

GNSS Ground Station approved by DOE and the ARM Infrastructure Management Board.
Approved Time Period: Juli, 2017 – April , 2020

GNSS ground station will be established at NSA-C1 site of Barrow by colleagues from the Helmholtz-Centre Potsdam, GFZ German Research Centre for Geosciences Potsdam:

Dr. Markus Ramatschi
M. Eng. Markus Bradke
Dr. Galina Dick

GFZ
Helmholtz Centre
POTSDAM

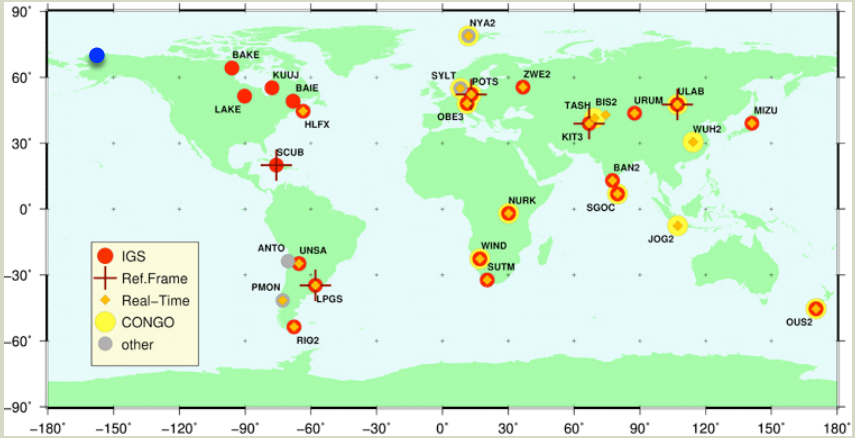


Image Courtesy: Uhlemann, M.; Ramatschi, M.; Gendt, G. (2012)