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Real-Time Ice Nuclei Measurements at Oliktok Point Field Campaign Report

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ARM

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Acronyms and Abbreviations

ARM	Atmospheric Radiation Measurement
DOE	U.S. Department of Energy
HYSPLIT	Hybrid Single-Particle Lagrangian Integrated Trajectory model
IN	ice nuclei
INP	ice nucleating particle
NOAA	National Oceanic and Atmospheric Administration
NSA	North Slope of Alaska
UTC	Coordinated Universal Time

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1.0 Summary

The ability of atmospheric particles (aerosols) to serve as heterogeneous ice nuclei (IN) for formation of ice and mixed-phase clouds is one of the least understood microphysical processes resulting in large uncertainties in climate modeling. As stated in the Intergovernmental Panel on Climate Change 2007 report, “The effects of aerosol particles on heterogeneous ice formation are currently insufficiently understood and present another level of challenge for both observations and modeling.” IN can strongly affect cloud radiative properties and precipitation formation. Only a small fraction (often less than 1%) of all aerosol particles act as atmospheric IN. Therefore, it becomes important to identify the active fraction of aerosol particles under a variety of environmental conditions. Proposed IN measurement techniques provide IN concentrations as a function of temperature and humidity conditions, and this unique data set can be analyzed to develop or constrain IN parameterizations that models rely on to calculate primary ice formation. Currently, the processes of ice formation within models are poorly represented, such that climate models often inaccurately partition cloud water between liquid and solid ice. Model studies have shown that uncertainties in cloud phase partitioning induce large uncertainties in the impact of mixed-phase clouds on climate change.

Arctic clouds composed of ice particles and supercooled liquid droplets at temperatures warmer than -37°C are important for the Arctic’s climate because of their extensive horizontal coverage over long periods, and their impact on the surface radiative balance and thus ice sheet coverage. The complexity of microphysical processes within these clouds and the sensitivity of precipitation to the details of microphysics are not fully understood. In addition, representation of these processes in a variety of cloud models continues to be challenging. Arctic clouds provide unique conditions to understand heterogeneous ice nucleation mechanisms, particularly immersion freezing, and will be the initial focus of the ice nucleation group. The U.S. Department of Energy Atmospheric Radiation Measurement (ARM)-North Slope of Alaska (NSA) site is well equipped with other aerosol measurement (number concentration, size) instruments, and a relationship among long-term IN measurements and aerosol physical and chemical properties under different environmental conditions can be identified and established. The long-term IN measurements will be critical for understanding the ice nucleation process in response to the seasonal variations of aerosol and developing robust ice nucleation parameterizations for cloud and climate models. In the future, IN measurements could also be made at other ARM-NSA sites, specifically, Oliktok Point.

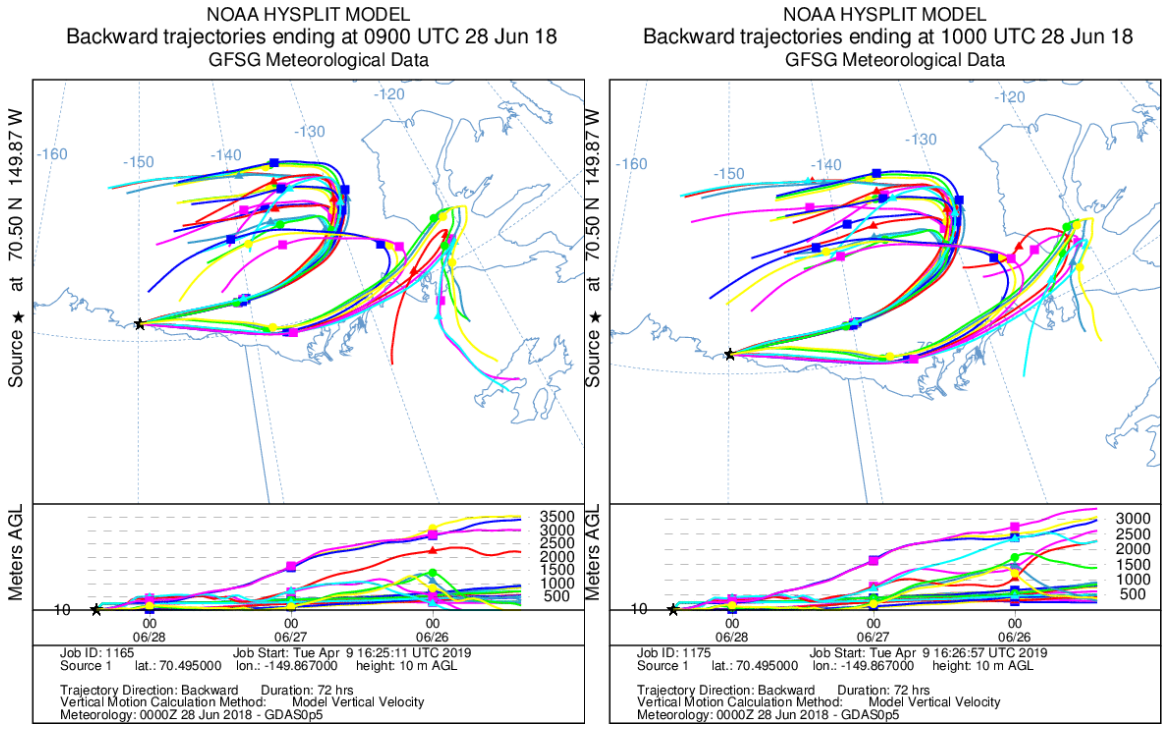
To achieve these objectives, surface soil samples (0-5 cm depth) were taken from within a 2.5-m radial area near the likely origin of the airborne particulates. More details are tabulated in Table 1. A total of six samples were collected.

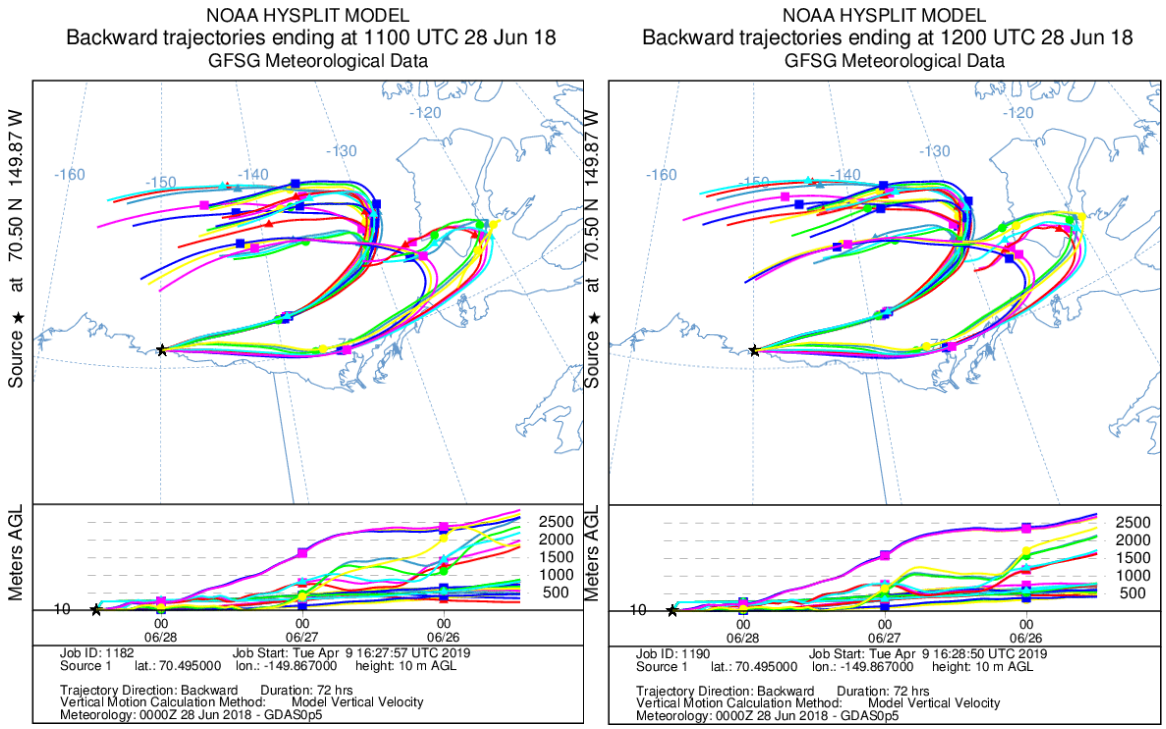
Table 1. Surface soil sample details.

Sample #	Date	Time (UTC)	Location	
1	6/28/2018	17:42	70.495N	149.867W
2	6/28/2018	17:55	70.495N	149.888W
3	6/28/2018	18:00	70.496N	149.888W
4	6/28/2018	18:04	70.475N	149.886W
5	6/29/2018	15:11	70.506N	149.886W
6	6/29/2018	15:15	70.500N	149.886W

2.0 Results

During the week of the campaign, the observed air masses arrived at site were mostly northeasterly, as indicated by back trajectories (Figure 1). The trajectories show the path of infinitesimally small particles of air traced backward in time and space. These back trajectories were calculated using a Hybrid Single-Particle Lagrangian Integrated trajectory (HYSPLIT) model that can be run interactively for various climatological conditions.


NOAA HYSPLIT MODEL
Backward trajectories ending at 0900 UTC 28 Jun 18
GFSG Meteorological Data
Source ★ at 70.50 N 149.87 W
Meters AGL
Job ID: 1165 Job Start: Tue Apr 9 16:25:11 UTC 2019
Source 1 lat.: 70.495000 lon.: -149.867000 height: 10 m AGL
Trajectory Direction: Backward Duration: 72 hrs
Vertical Motion Calculation Method: Model Vertical Velocity
Meteorology: 0000Z 28 Jun 2018 - GDAS0p5
NOAA HYSPLIT MODEL
Backward trajectories ending at 1000 UTC 28 Jun 18
GFSG Meteorological Data
Source ★ at 70.50 N 149.87 W
Meters AGL
Job ID: 1175 Job Start: Tue Apr 9 16:26:57 UTC 2019
Source 1 lat.: 70.495000 lon.: -149.867000 height: 10 m AGL
Trajectory Direction: Backward Duration: 72 hrs
Vertical Motion Calculation Method: Model Vertical Velocity
Meteorology: 0000Z 28 Jun 2018 - GDAS0p5


NOAA HYSPLIT MODEL
Backward trajectories ending at 1100 UTC 28 Jun 18
GFSG Meteorological Data
Source ★ at 70.50 N 149.87 W
Meters AGL
Job ID: 1182 Job Start: Tue Apr 9 16:27:57 UTC 2019
Source 1 lat.: 70.495000 lon.: -149.867000 height: 10 m AGL
Trajectory Direction: Backward Duration: 72 hrs
Vertical Motion Calculation Method: Model Vertical Velocity
Meteorology: 0000Z 28 Jun 2018 - GDAS0p5
NOAA HYSPLIT MODEL
Backward trajectories ending at 1200 UTC 28 Jun 18
GFSG Meteorological Data
Source ★ at 70.50 N 149.87 W
Meters AGL
Job ID: 1190 Job Start: Tue Apr 9 16:28:50 UTC 2019
Source 1 lat.: 70.495000 lon.: -149.867000 height: 10 m AGL
Trajectory Direction: Backward Duration: 72 hrs
Vertical Motion Calculation Method: Model Vertical Velocity
Meteorology: 0000Z 28 Jun 2018 - GDAS0p5

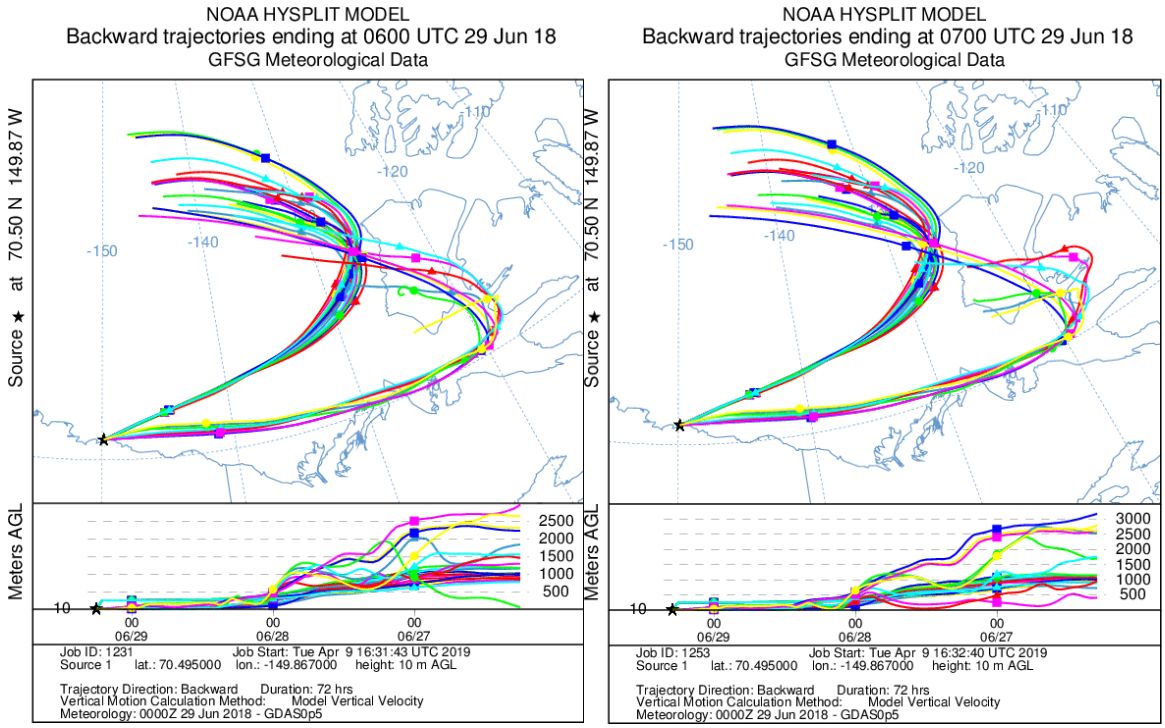


Figure 1. Calculated ensemble backward trajectories using GFSG meteorological data.

The soil samples will be analyzed for ice nucleation efficiency by dry dispersing the size-selected particles into the ice nucleation chamber. Ice nucleation efficiency of these particles will be investigated at different temperature and humidity conditions. The plan is to also analyze the morphological and composition properties using various microscopy techniques. In addition, analysis of physiochemical and ice nucleating properties of soils will be carried out to develop the INP parameterizations. In general, we attempt to relate particulates sampled in ambient air to with soils sampled at an arable site, the ARM Oliktok Point-site in Alaska.

3.0 Publications and References

No publications at this time.

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