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Impacts of Atmospheric Microbiomes Field Campaign Report

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Impacts of Atmospheric Microbiomes Field Campaign Report

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Acronyms and Abbreviations

ARM	Atmospheric Radiation Measurement
DNA	deoxyribonucleic acid
DOE	U.S. Department of Energy
EMSL	Environmental Molecular Sciences Laboratory
FICUS	Facilities Integrating Collaborations for User Science
HYSPLIT	Hybrid Single-Particle Lagrangian Integrated Trajectory
JGI	Joint Genome Institute
LDRD	Laboratory Directed Research and Development
MinT	Microbiomes in Transition
MOUDI	Micro-Orifice Uniform Deposit Impactor
NAM	North American Mesoscale Forecast System
NOAA	National Oceanic and Atmospheric Administration
PNNL	Pacific Northwest National Laboratory
PTFE	polytetrafluoroethylene
SGP	Southern Great Plains

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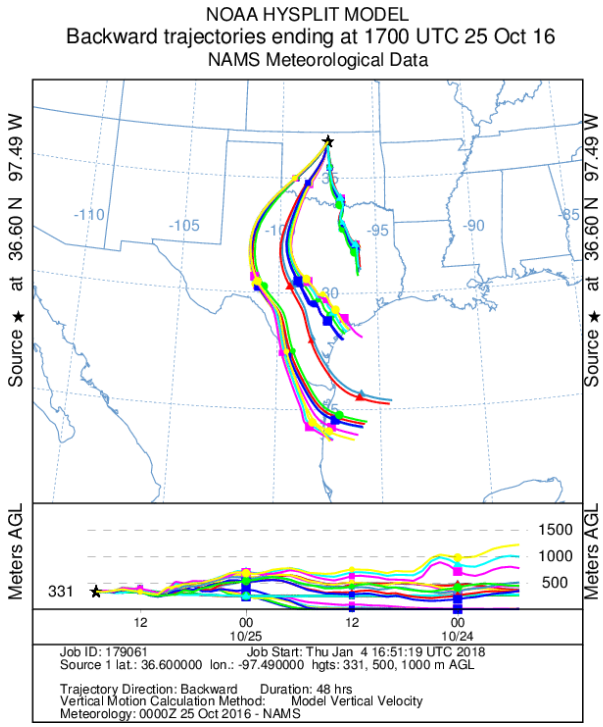
1.0 Summary

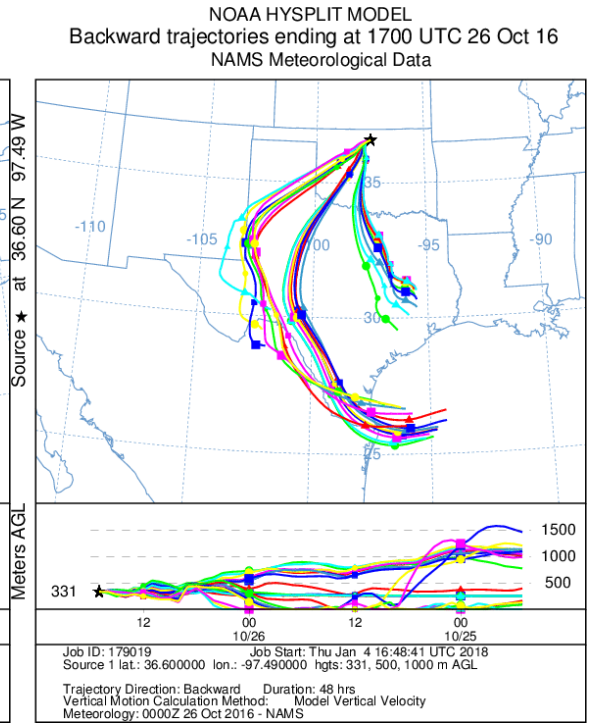
Aerosols of microbial origin (e.g., bacteria, fungi, etc.; also known as "atmospheric microbiome") are ubiquitous in the atmosphere where they can remain suspended for several days to weeks and be transported over long ranges across continents. There is growing recognition that a significant fraction of total particulates suspended in the atmosphere may host microorganisms. Studies indicate that atmospheric microbial transport can play a significant role in processes associated with climate change and atmospheric chemistry. Furthermore, microbe-bearing particles are continually exchanged between ecosystems through global atmospheric transport pathways with the potential to influence the dispersion, composition, and dynamics of microbial communities across diverse ecosystems, including land managed, modified, and used by humans. The impacts of these atmospheric microbiomes on climate are poorly understood. The goal of this work is to establish fundamental new capabilities that enable prediction of atmospheric microbiome dynamics and interactions from source to final deposition.

To achieve these objectives, surface soils (0-5 cm depth) were taken from within a 2.5-m radial area near the likely origin of the airborne particulates. In addition, we collected bulk and size-resolved airborne samples from a sampling line located ~4 m above the central U.S. Department of Energy (DOE) Atmospheric Radiation Measurement (ARM) Southern Great Plains (SGP) site from 25/10 to 31/10 in 2016. The SGP site is located in north-central Oklahoma and experiences a broad range of air mass, cloud, and atmospheric state disturbances. The site is surrounded by various agricultural crops and pasture fields. In total, 20 samples were collected over one week in October 2016, and each sample collection period was again approximately 12 hours. At both locations, the samples were collected on PTFE laminated membrane 0.45-µm filters (Sterlitech Corp.) mounted inside a 90-mm single-stage filter assembly (Savillex Inc.). The air was sampled from the sampling inlet located ~4 m height from the ground at total ~0.23 m^3/min, which allowed us to sample total ~166 m^3 of air per filter. The filter holder assembly and membrane filter holder tips were cleaned with isopropyl alcohol before a new filter was loaded. Blank filters were also collected to understand the background bacterial loading and composition but without operating the filter assembly. Both ambient air collected and blank filters were stored and shipped frozen at ~-20 °C to avoid the contamination and growth of unwanted bacterial communities. In parallel, we also collected the samples using a Micro-Orifice Uniform Deposit Impactor (MOUDI) for microscopy analysis.

2.0 Results

During the week of the campaign, the observed air masses that arrived at site were mostly southerly, but towards the end of the campaign the observed air mass arrived from the north, 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 the National Oceanic and Atmospheric Administration (NOAA) Hybrid Single-Particle Lagrangian Integrated Trajectory (HYSPLIT) model that can be run interactively for various climatological conditions. Microscopy images were analyzed to understand the size distribution and morphology of particles (Figure 2). We observed dust particles along with organic particles with inclusion of sulfates.


NOAA HYSPLIT MODEL
Backward trajectories ending at 1700 UTC 25 Oct 16
NAMS Meteorological Data
Source ★ at 36.60 N 97.49 W
Meters AGL
Job ID: 179061 Job Start: Thu Jan 4 16:51:19 UTC 2018
Source 1 lat.: 36.600000 lon.: -97.490000 hgts: 331, 500, 1000 m AGL
Trajectory Direction: Backward Duration: 48 hrs
Vertical Motion Calculation Method: Model Vertical Velocity
Meteorology: 0000Z 25 Oct 2016 - NAMS


NOAA HYSPLIT MODEL
Backward trajectories ending at 1700 UTC 26 Oct 16
NAMS Meteorological Data
Source ★ at 36.60 N 97.49 W
Meters AGL
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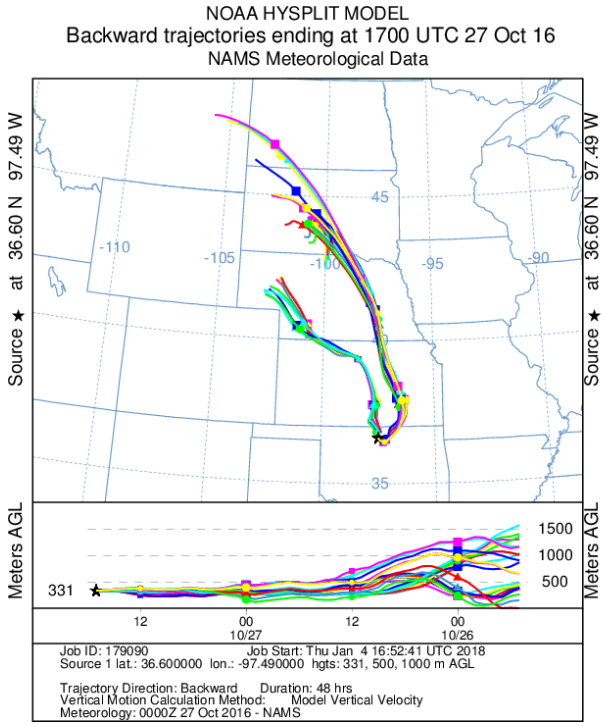
Vertical Motion Calculation Method: Model Vertical Velocity
Meteorology: 0000Z 26 Oct 2016 - NAMS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Backward trajectories ending at 1700 UTC 27 Oct 16
NAMS Meteorological Data
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Meters AGL
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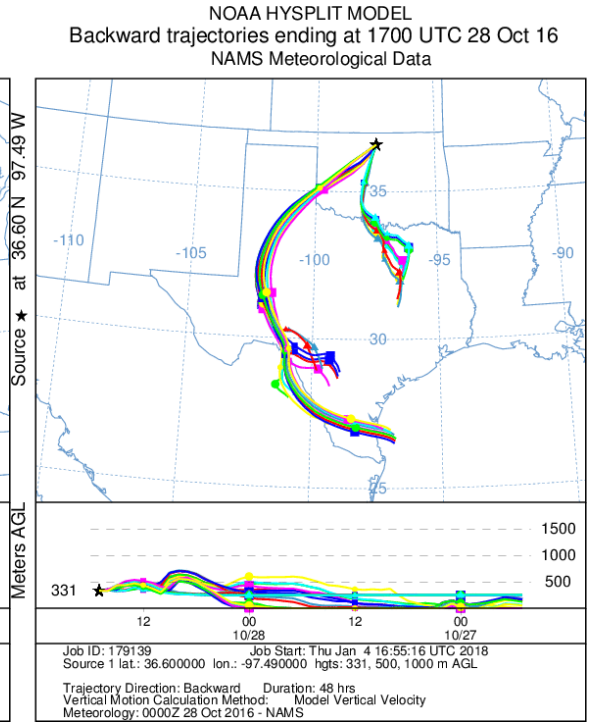
Vertical Motion Calculation Method: Model Vertical Velocity
Meteorology: 0000Z 27 Oct 2016 - NAMS


NOAA HYSPLIT MODEL
Backward trajectories ending at 1700 UTC 28 Oct 16
NAMS Meteorological Data
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Meters AGL
Job ID: 179139 Job Start: Thu Jan 4 16:55:16 UTC 2018
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Vertical Motion Calculation Method: Model Vertical Velocity
Meteorology: 0000Z 28 Oct 2016 - NAMS

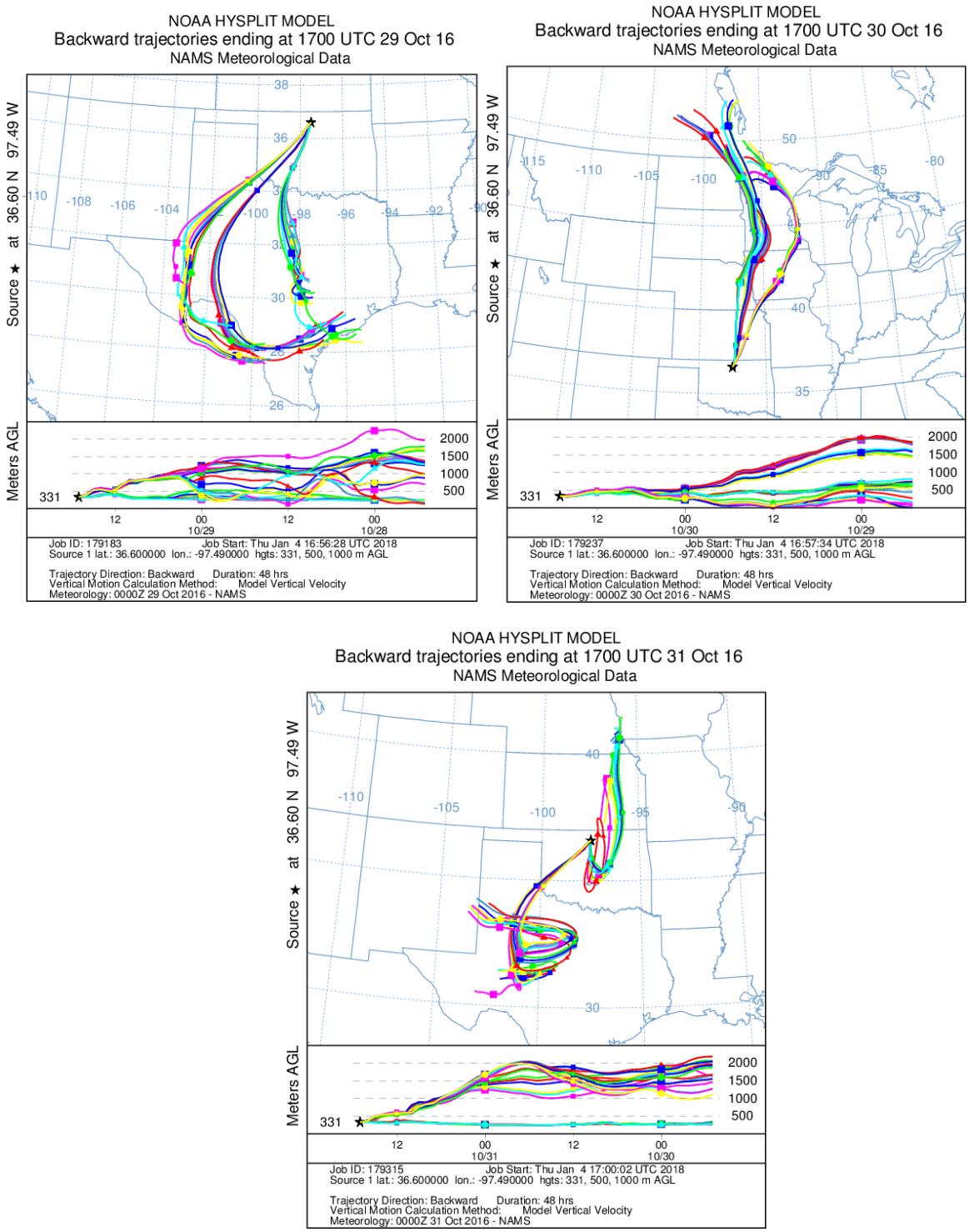

Figure 1. Calculated ensemble backward trajectories using NAM meteorological data.

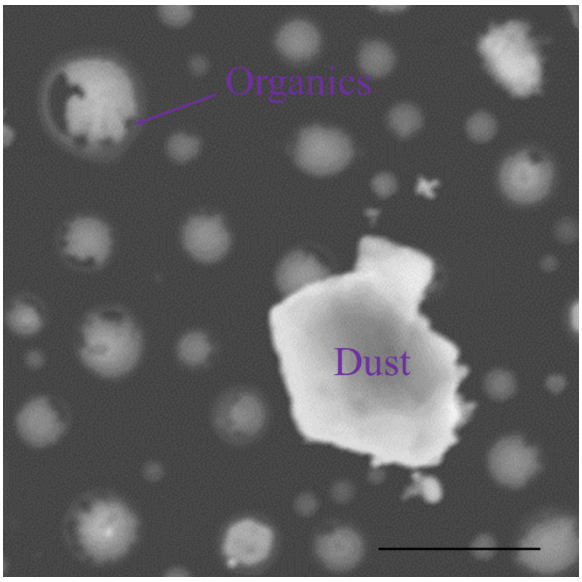

Figure 2. High-resolution microscopy images of atmospheric particles collected at the SGP site. We hypothesize that atmospheric microbiomes may be attached to these particles. Scale shown is 2 micrometers.

These trajectory and microscopy results will be further used to interpret the sequencing results. The biomass from the filter collected will be used for total DNA extractions. The composition and diversity of both bacterial and fungal communities collected will be analyzed using MiSeq (16S) sequencing and bioinformatics capabilities developed under Pacific Northwest National Laboratory (PNNL)'s Microbiomes in Transition (MinT) Initiative. We also plan to analyze these filter samples under our recent successful Facilities Integrating Collaborations for User Science (FICUS) proposal (joint proposal between Environmental Molecular Science Laboratory [EMSL]-Joint Genome Institute [JGI] DOE user facilities) and PNNL Laboratory Directed Research and Development (LDRD) proposal to characterize the microbiota. In addition, physiochemical and ice nucleating properties of soils will be also carried out. In general, we attempt to relate particulates sampled in ambient air to with soils sampled at an arable site, the ARM SGP site in Oklahoma.

3.0 Publications and References

No publications have been completed yet, but, we are preparing one manuscript.

S Burrows, et al. "Characterization of atmospheric microbiome in eastern Washington and Oklahoma" (in preparation).

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