ARM

Cold-Air Outbreaks in the Marine Boundary Layer Experiment

Boreal and Arctic regions have experienced warming faster than the rest of the planet, and the ice cover in the Arctic has declined faster than predicted by most earth system models. When cold air from the Arctic flows over the warmer open ocean, large surface fluxes result and a cloud-topped convective boundary layer forms, deepening with distance from the ice edge. Such clouds may produce heavy snowfall, and impact the Earth's energy balance. However, little is known about the cloud properties associated with cold-air outbreaks or how they vary with surface, environmental, and aerosol conditions. The role of cold-air outbreaks in the global atmospheric and ocean circulation is also uncertain.

The Atmospheric Radiation Measurement (ARM) user facility, a U.S. Department of Energy scientific user facility, plans to support the **Cold-Air Outbreaks in the Marine Boundary Layer Experiment (COMBLE)** from January to May 2020 around the Norwegian Sea. COMBLE will aim to shed light on the dynamics and microphysical properties of clouds and precipitation in the high-latitude marine boundary layer during cold-air outbreaks.

To help fill in observational gaps, ARM will deploy its first mobile facility near Andenes, Norway—a town on an island in the northeastern part of the country—and a smaller set of instruments on Bear Island, located approximately midway between the Norway mainland and Svalbard. This field deployment will help researchers learn more about the properties of clouds associated with boundary layer convection, as well as air-mass transformation in cold-air outbreaks over open water.

Science Objectives

COMBLE will be guided by six science themes. The first five themes deal with boundary layer convection in cold-air outbreaks. They are:

1. mesoscale organization of clouds and precipitation, including linear and cellular convection
2. surface heat and momentum fluxes, and vertical profiles of temperature, humidity, wind, and turbulence
3. vertical structure of clouds and precipitation
4. sources and sinks of aerosols, including ice nucleating particles, and the role of cloud-active aerosols on cloud processes and radiative fluxes
5. influence of the above four themes on polar cyclogenesis (the development and strengthening of low-pressure areas) and the vertical structure of polar lows, which are small-scale, short-lived low-pressure systems over polar seas.

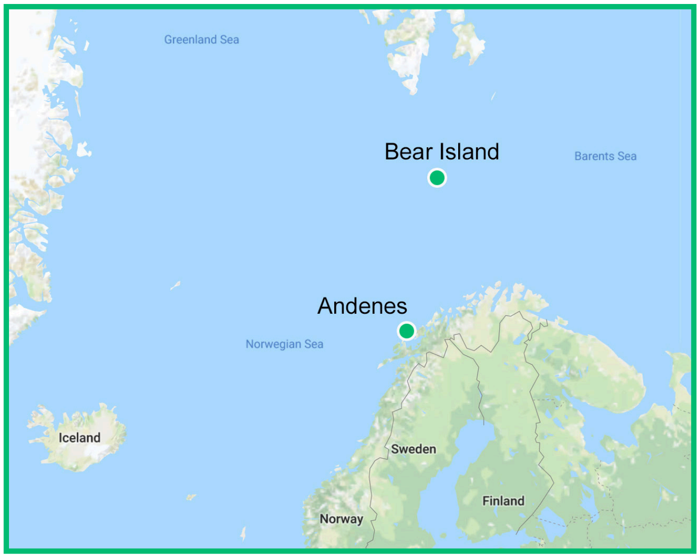
The overarching sixth theme is that COMBLE will provide integrated data sets of dynamical, thermodynamic, and cloud microphysical characteristics of marine boundary layer convection in cold-air outbreaks, including cloud and aerosol properties. These data sets will enable constraining high-resolution numerical simulations, developing process-level understanding, and, subsequently, evaluating and improving representations of shallow convection in earth system models.

Research Instrumentation

This campaign will use the observatory known as the first ARM Mobile Facility (AMF1), operating 24 hours a day, seven days a week. Onsite technicians monitor and maintain approximately 50 instruments to ensure that the best and most complete data set is acquired.

Key AMF1 instruments include a vertically pointing Ka-band radar and a scanning dual-frequency W- and Ka-band radar to measure properties of cloud and precipitation particles. An atmospheric emitted radiance interferometer and a microwave radiometer will provide temperature and humidity profiles. A profiling micropulse lidar will measure backscatter power, while a total sky imager will measure cloud fraction. A disdrometer will provide information on precipitation (size distribution and fall speed), while an eddy correlation system will measure surface radiative and turbulent heat fluxes. Radiosondes (weather balloons) will measure wind profiles. A suite of aerosol instrumentation will be used to collect measurements of aerosol radiative properties, composition, size distribution, and cloud activity, as well as information on key trace gases.

Instrumentation on Bear Island are expected to include a microwave radiometer; a profiling micropulse lidar and a ceilometer to measure backscatter power, aerosol layers, and cloud base; a disdrometer; a multifilter rotating shadowband radiometer to measure components of solar irradiance; a sunphotometer to measure direct solar irradiance and sky radiance at the Earth's surface; a broadband radiometer to measure the shortwave and longwave surface radiation budget; and radiosondes.



To help fill in observational gaps, ARM will deploy its first mobile facility near Andenes, Norway, and a smaller set of instruments on Bear Island to support the Cold-Air Outbreaks in the Marine Boundary Layer Experiment (COMBLE) from January to May 2020.

The first ARM Mobile Facility, pictured here in Germany's Black Forest, consists of instruments, operations shelters, and data and communication systems.

Collaborations

COMBLE involves researchers from more than 15 institutions in the United States and Europe. COMBLE will collaborate with several international campaigns, notably the Multidisciplinary Drifting Observatory for the Study of Arctic Climate (MOSAiC) and ArctiC Amplification: Climate Relevant Atmospheric and SurfaCe Processes and Feedback Mechanisms, otherwise known as $(AC)^3$.

From September 2019 to October 2020, the second ARM Mobile Facility will be deployed as part of MOSAiC, which will characterize source air masses of cold-air outbreaks over arctic ice. Meanwhile, $(AC)^3$—a project studying the increased near-surface temperatures in the Arctic in recent decades—will operate several aircraft between northern Scandinavia and the MOSAiC deployment in March and April 2020 to document how the air masses evolve.

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