Environment and Climate Change Canada | Environnement et Changement climatique Canada

Canada

Arctic POlar Night EXperiment (PONEX) aircraft campaign

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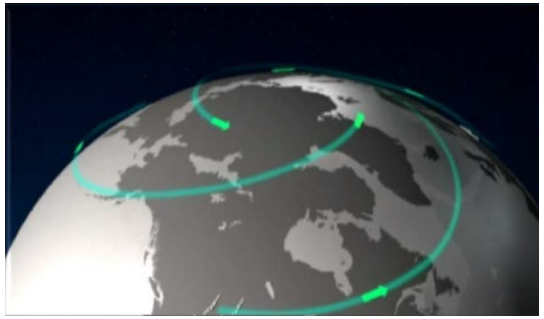
Background

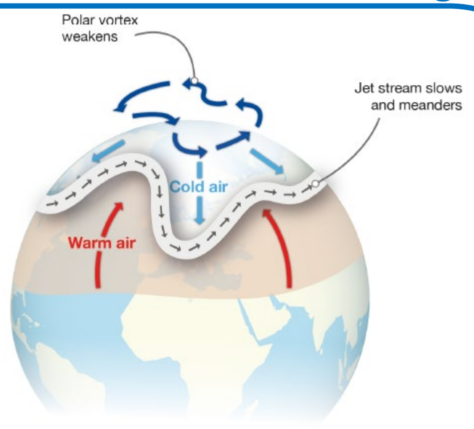
- ➢ The Polar regions are an integral part of Earth's energy budget and climate.
- ➢ Arctic clouds formation during winter is poorly understood due to lack of observations and remoteness.

Long-Range Transport



- Arctic cloud formation are strongly related to aerosol-cloud interaction processes.
- Long-range transport of aerosols from the mid-latitudes to Polar region during winter time
- Sulfuric acid (lowering freezing point, deactivation of ice nucleation) → impact on the formation of ice clouds, affecting ice particle sizes and concentration

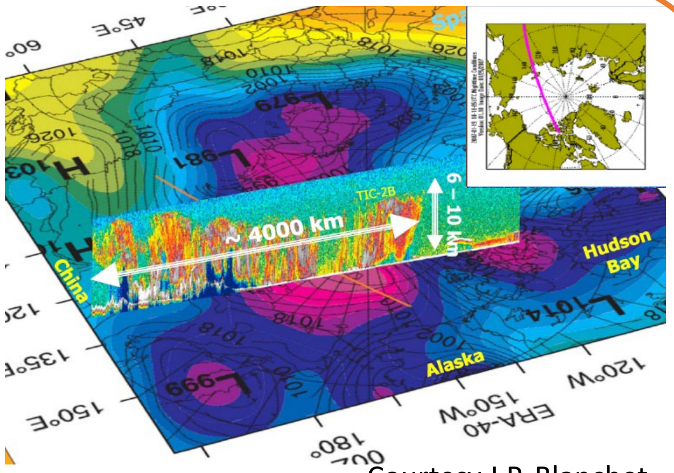
Polar Vortex Weakening



Screen (Weather, 2021)

- Arctic warms much faster
- Polar vortex & jet stream weakening
- Cold Arctic air to spill south
- Warm air to move north

Optically Thin Ice Clouds (OTIC)



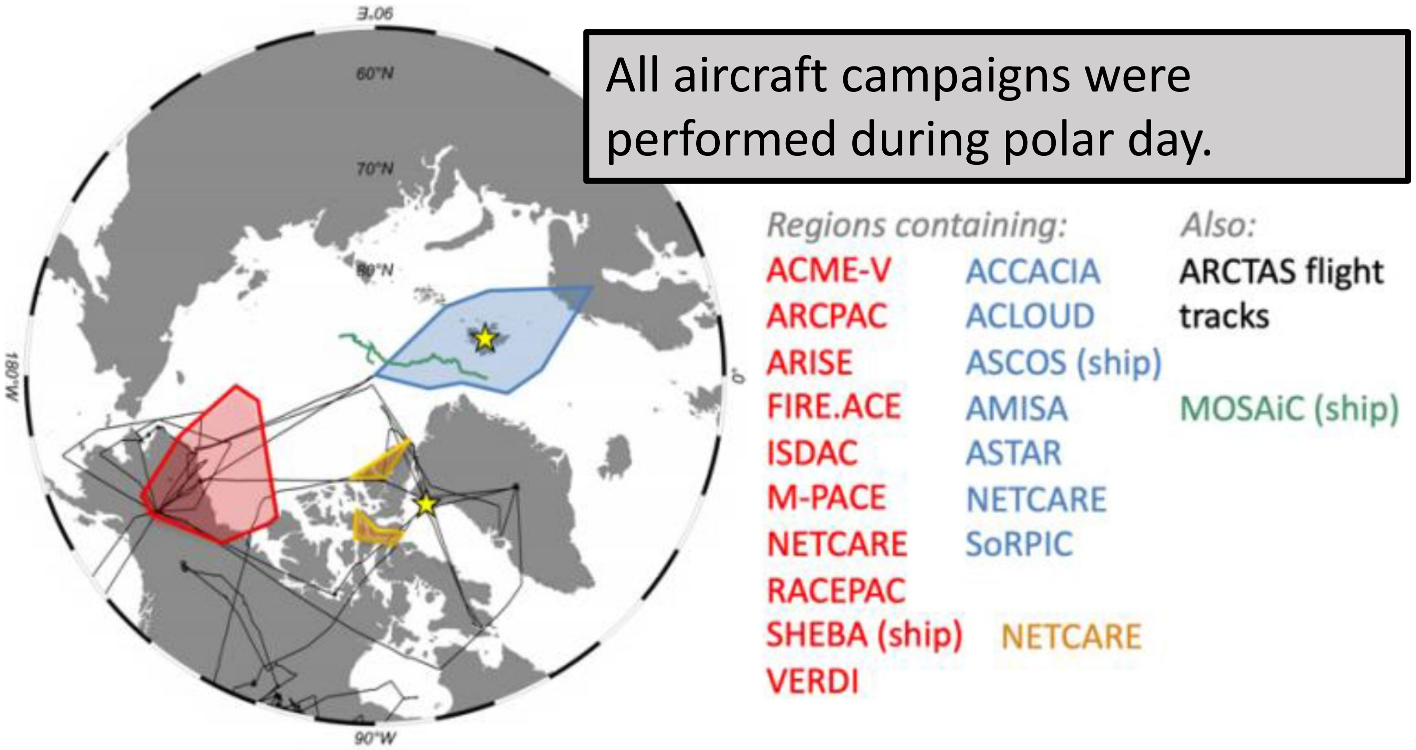
Courtesy J.P. Blanchet

- Vast Arctic areas are covered by vertically extended optically thin ice clouds (OTIC).
- Mechanisms of OTIC formation are not well understood.
- OTICs may play important role in the invigoration of polar night storms

Background

Airborne campaigns to study Arctic during last 20 years

All aircraft campaigns were performed during polar day.



Cloud genesis, radiation transfer and chemical processes in Arctic during polar nights dramatically differ from those during polar days. Despite of numerous field campaigns in Arctic regions, most of them were conducted during polar days or during polar sunrise or sunset. Until now Arctic environment during nighttime remains poorly explored.

It is proposed to conduct the first Arctic polar night airborne field campaign.

Arctic Polar Night Experiment (PONEX)

Overarching goal:

Improving weather and climate forecast in the polar regions, through a better understanding of key physical processes and improved representations of those processes within numerical weather and climate prediction systems.

Objectives:

Sub-orbital component

- Characterize cal/val of AOS-HAWC observations during its preparatory phase and EarthCARE observations during its post-launch phase via an aircraft field campaign
- Address the cal/val science objectives for both satellite missions' sub-orbital components, leveraging the two opportunities into a single field campaign

Science component

- Obtain novel observations of the Arctic surface emissivity and thermal profiles over snow and sea ice, cloud microphysics and aerosols, boundary layer during the polar night.
- Obtain new knowledge on the formation mechanism of optically thin ice clouds (OTIC). Explore feedback between OTICs and radiation processes in Arctic region. Explore the effect of OTICs on initiation of Arctic storms during polar night.
- Explore transport of air pollutants in Arctic regions during the polar night.
- Use these observations to develop new parameterizations suitable for numerical weather and climate prediction models.

Potential locations and flight operations for the NRC Convair580 during PONEX (radial return flight)

NRC/ECCC Arctic airborne field campaigns:

1. BASE, Inuvik, 1994
2. FIRE-ACE, Inuvik, 1998
3. STAR. Iqaluit, 2007
4. ISDAC, Barrow, Alaska, 2008 (DOE)
5. RadSnowExp, Iqaluit, 2018 (ESA)

NRC Convair-580, ISDAC, Barrow (Utqiagvik), Alaska, April 2008

Experimental Design

Location: Inuvik (NWT), warm hangar (absolutely critical), instrumentation and meeting rooms, hotel accommodation, restaurants

Timeframe:
- 2025: two 3-week windows with a three week pause in-between. This will enable observations during polar night (1st stage) and polar sunrise to enable operations of ALI (2nd stage).
- Stage 1: three weeks in January 2025 followed by a three week pause
- Stage 2: three weeks in late February 2025
- Flight operations: 15-20 flights (~60-80h) over 40-45 days

Research flight objectives:
- **Weather flights** aiming to study mechanisms of ice initiation in polar night OTICs, modulation of radiative fluxes by OTICs, spatio-temporal variability of polar night clouds, role of dynamics in formation of OTICs, mixed-phase clouds during polar nights, INP/CCN concentrations, effect of pollutants of ice initiation.
- **Clear sky flights** aiming to study aerosol size distributions, aerosol composition, identification of natural and anthropogenic aerosols, vertical and horizontal variability of aerosols, clear-sky radiative fluxes, trace gases (O3, NOx, SO2, CO2, H2O etc.) horizontal and vertical variability, INP/CCN measurements.
- **Suborbital flights** provide cal/val for HAWC-AOS & EarthCARE mission

Aircraft instrumentation (TBD):
- FIRR-2 (ground-based version of **TICFIRE**) and **ALI** (HAWC-AOS instruments)
- Radars: X, W, Ka-band
- Elastic cloud lidar (zenith, 355 nm)
- HiSRAMS (microwave sounder for temperature and water vapour)
- Aerosol mass spectrometer, aerosol size spectrometers, INP spectrometer, CCN, trace gases
- Cloud microphysical instrumentation (2DS, HVPS, CDP, CIP, HSI, Extinction, hot-wires, RID)
- Aircraft data and atmospheric state probes

Benefits for ESA’s EarthCARE mission