OBSERVATIONS OF WAVES AND COUPLING AT THE POLAR ENVIRONMENT ATMOSPHERIC RESEARCH LABORATORY (PEARL) IN EUREKA, CANADA

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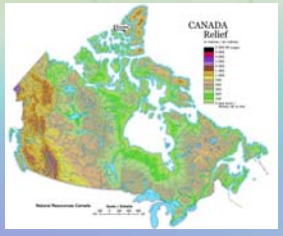
The PEARL facility at Eureka



The Polar Environment Atmospheric Research Laboratory (PEARL) is a sophisticated observatory in the Canadian Arctic at Eureka (80N, 86W). It houses a suite of instruments including radars, lidars, spectrometers, radiometers and imagers which allow measurements of Arctic conditions from the ground to the lower thermosphere. One scientific theme being investigated at the observatory is the wave environment in this region and the coupling of the dynamics between atmospheric layers and locations. Instrumentation pertinent to these investigations include the E-Region Wind Interferometer, the meteor radar, the Spectral Airglow Temperature Imager, the PEARL All-Sky Imager, the ozone and Rayleigh/Mie/Raman lidar, the VHF and cloud radar, the Fourier Transform Spectrometer and the Atmospheric Emitted Radiance Interferometer. Together these instruments provide the means to determine the mean fields, and wave signatures associated with tides, planetary waves and gravity waves from the stratosphere to the mesopause region. Interpretation of these results will be supported with satellite observations, model results and analyses from data assimilation. Collaborations are being developed with other polar observatories so that a global view of these processes in the Arctic middle atmosphere can be developed. This effort will peak during International Polar Year. In this paper the capabilities of the observatory will be described and some early results presented.

Funding and in-kind Support

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Instrumentation Relevant to the Waves and Coupling Theme

Rayleigh/Mie/Raman Lidar (RMR) (Mentor: T. Duck) will measure profiles of tropospheric aerosols, clouds, diamond dust, temperatures, and water vapour. Two wavelengths will be used by this system, and are needed to produce the full variety of data products: 355 nm and 532 nm.

Ozone Lidars (Mentor: J. Whiteway) Two ozone lidars will provide measurements of the ozone distribution with height (ozone profile) from ground level up to the lower stratosphere (height of 20 km), and from the lower stratosphere to 80 km. The height resolution will be 30 m near the ground and 1 km in the lower stratosphere.

Meteor Radar) (Mentors: A. Manson, S. Argall). This provides measurements of the horizontal and vertical components of winds in the range 0.5-16 km altitude; also time and height resolved turbulence, atmospheric anisotropy at the height of the tropopause. In meteor-detection mode horizontal winds (80-100km) are available, effectively continuously in time, with data resolution of 3 km and 1 hour.

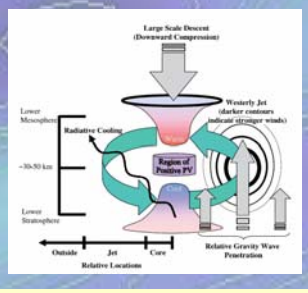
Spectral Airglow Temperature Imager (SATI) (Mentor: M. Shepherd) is a two-channel, Fabry-Perot interferometer. It monitors the dynamics and temperature in the upper mesosphere by alternate observations of the O2 atmospheric (0-1) nightglow emission layer at 94 km and the OH Meinel (6-2) layer at 87 km.

All-Sky Imager (Mentor: W. Ward) The all-sky imager is an instrument designed to image airglow emissions within 10 degrees of the horizon at a spatial resolution of 1 km at an elevation angle of 60 degrees. This instrument will provide images of the airglow and auroral emissions to aid in the interpretation of the other optical instruments and provide a capability for determining gravity wave parameters from the fine scale structure in the airglow emissions.

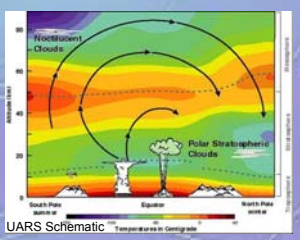
Michelson Wind Interferometer (E-region wind interferometer - ERWIN) (Mentor: W. Ward) is an interferometer for measuring mesospheric winds through a measurement of airglow emission, specifically OH, O2 and OI. This combination yields wind speed and radial direction for 3 altitudes in the range of 87-97 km.

Fourier Transform Spectrometer (FTS) (Mentor: K. Strong) Using the Sun or Moon as a source, the FTS scans result in absorption spectra that will yield the amount of an atmospheric constituent (column amount) and some information about its distribution (profile information).

UV-Visible Grating Spectrometer (UV-VIS) (Mentor: K. Strong) will be used to record UV-visible absorption spectra of the light scattered from the zenith sky. These will be analyzed using the technique of differential optical absorption spectroscopy (DOAS) to retrieve vertical columns of O3, NO2, NO3, BrO, and OClO.



Schematic of the overall configuration of the Arctic polar vortex as diagnosed from a hypothetical positive region of potential vorticity (i.e., a high potential vorticity anomaly). Redder (bluer) colors depict warmer (cooler) temperatures. The positive columnar region of PV is at the center of the vortex. Note the strong jet surrounding the region of PV, which weakens as one goes into the quasistationary core or outside of the vortex altogether. Transparent, upward arrows conceptualize relative gravity wave activity. Gerrard et al., 2002.



The global mean circulation in the mesosphere during solstice is thought to be associated with gravity wave dissipation. The polar regions are unique as they are regions of convergence and divergence (downward/upward motion) and exhibit particular wave structures. PEARL will allow the transport and dynamics in this region to be observed. Collaborations with other polar observatories, incorporation of satellite observations and assimilated data are a necessary and essential part of PEARL science.

Science Questions

•What are the dominant coupling processes in the polar winter vortex (0-100km) and summer circulation (0-100km) above Eureka, which link the lower, middle and upper atmospheres?

•What are the characteristics of gravity waves, tides and planetary waves near the arctic pole and how are these characteristics correlated with season, in altitude and with large-scale dynamical events? The suite of instruments at PEARL allows for extensive examination of wave properties of the various types of waves over Eureka.

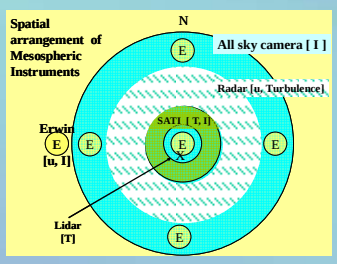
•What are the roles of planetary waves and tides in constituent variations and mixing in the polar stratosphere and mesosphere?

•What are the sources of the gravity waves observed at Eureka? How do these waves evolve with height and dissipate and what role do they play in constituent variability and transport in polar regions?

•What are the effects of Sudden Stratospheric (winter) Warmings upon the dynamical and chemical (e.g. ozone loss) characteristics of the lower and middle/upper atmospheres, and how do they differ from other Polar locations e.g. Europe-Scandinavia?

•What are the relative roles of waves, and solar and magnetospheric processes, in providing coupling and variability in the Arctic atmospheric circulation (10-100km) above Eureka? What is the related evidence for "Solar Influences upon Climate"?

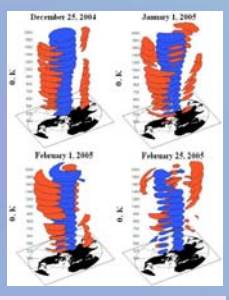
•What are the processes involved in the coupling between major equatorial processes (QBO and El Nino) and the variability of the Arctic atmospheric circulation above Eureka?



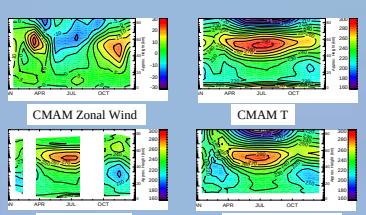
Viewing Location in Sky

The figure to the left shows the sampling of the various instruments observing the mesopause region in an all-sky view. This schematic shows the instrument sampling location relative to the horizon. These instruments will provide information on the background wind, temperature and airglow fields, the wave amplitudes and long and short term variability in these fields. Correlations with PEARL observations and satellite/assimilated fields at lower altitudes will provide information on the coupling from below.

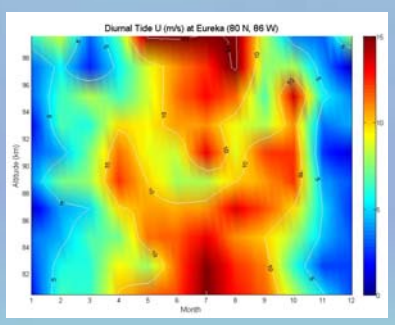
Initial Results and Analyses



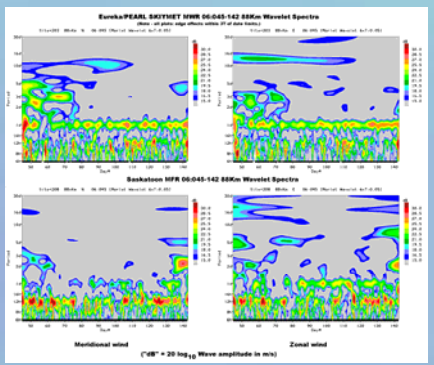
Representation of the polar vortex (blue) and anticyclones (orange) from θ=500 to 2000 K (~20-50 km) isentropic surface on December 25th, 2004; January 1st, February 1st, and February 25th, 2005. (T. Chshyolkova)



Annual cycle of zonal wind and temperature over Eureka from various sources (extended CMAM, MIPAS and AURA MLS). Data collected and plotted by D.Y. Wang.



Annual cycle of the diurnal tide over Eureka as reconstructed from CMAM amplitudes and phases. (J. Du)



Wavelet spectra comparing meteor wind signatures over Eureka to those observed over Saskatoon. Note the strong diurnal signature in the Eureka analyses and the absence of this signature in the Saskatoon analyses (C. Meek).