Projects in Atmospheric and Environmental Physics

One of the major difficulties in producing reliable climate predictions using models is the lack of data on the way in which the atmosphere couples energy, dynamics and composition within the Earth’s climate system. The upper atmosphere is where the major solar influences are felt, and there is a growing body of evidence that these effects propagate downward into the climate system in the troposphere. Over the last few years we have built up a suite of instruments at the Dragvoll observatory to study the variability of the Earth’s upper atmosphere. The following projects examine key parameters in the Earth system that will provide the observational constraints that will ultimately yield more accurate climate predictions.

Mountain waves over Norway

Wind flow over mountains creates waves that propagate up into the atmosphere. These waves, which can create hazards for air traffic, are frequently identified by the “flying saucer” clouds that they create near the mountains. However, farther up in the atmosphere, the cold pockets of the waves create polar stratospheric clouds that influence ozone destruction. Higher still, they may be observable far from the mountains using the advanced NTNU meteor radar at Dragvoll. Using data from this radar, algorithms will be developed to extract these mountain waves, and a comparison with the meteorological data will be done. The ultimate goal will be to assess whether their appearance in the mesosphere could be used as an advance warning of dangerous flight conditions or ozone loss in the stratosphere.

Large-scale waves in the mesosphere

NTNU operates a near infrared imaging spectrometer capable of remotely sensing the atmospheric temperature at 87 km using naturally occurring hydroxyl emissions. In addition to the temperature, the emission intensity also gives information on the density perturbations associated with wave activity in the mesosphere. Recently we have discovered that these intensity variations display a strong correlation with those observed with an identical instrument at the Andøya rocket range, nearly 700 km away. Using data from these spectrometers, a systematic investigation as to the extent of such correlations and the atmospheric conditions under which they occur will be done.

Relationship between temperature and winds at the edge of space over Antarctica

There is a global wind pattern at the edge of space (~80 km altitude) that causes the air to circulate upward from the summer polar stratosphere, across the globe and downward in into the winter polar regions. Since the air is dry, this circulation is adiabatic and causes the summer polar mesosphere to be the coldest place on earth (-140°C). On the other hand, the converging flow over Antarctica during the winter can create temperatures in the mesosphere that are much warmer than at the surface of the continent. This project will look at the relationship in the mesosphere between the horizontal and vertical winds during the Antarctic winter and compare these with temperatures measured by satellites and ground-based remote sensing instruments.

The goal will be to understand how the energy is partitioned between the wind and temperature fields.

Vertical winds from meteor ionisation trails

The long term measurement of vertical winds in the upper atmosphere is a notoriously difficult observation to make. Previous attempts to measure vertical winds have attempted to trace inert chemical species as they are transported in the atmosphere, or to measure very small Doppler shifts in spectral lines using very high resolution spectroscopic observations. We aim in this project to use the meteor trail drift velocities recorded with the NTNU meteor radar at Dragvoll to separate out the contribution from (large) horizontal winds and (small) vertical winds in the line of sight velocities measured by the radar. Data from this analysis can then be used to calculate adiabatic heating and cooling rates for comparison with spectroscopically-derived upper atmosphere temperatures above Dragvoll.

Planetary waves during sudden stratospheric warmings

During the winter of 2012-13 the northern hemisphere stratosphere underwent a so-called sudden stratospheric warming. During this process stratospheric planetary waves disrupt and reverse the usually strong eastward winds in the high latitude stratosphere and the temperature of the polar stratosphere is increased dramatically compared to the climatological mean. These disturbances are relatively common in the northern hemisphere winters, but much less so in the southern hemisphere due to the relative strength of the stratospheric polar vortex in the two hemispheres. The NTNU meteor radar recorded the influence of this stratospheric disturbance on the upper atmosphere showing strong periodic motions in the atmosphere before, during and after the stratospheric warming. The aim of this project is to quantify the nature of these mesospheric planetary waves during the stratospheric warming and to compare the results to mesospheric wind data recorded during a stratospheric warming event observed in the southern hemisphere during the winter of 2002.

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