

# Upper Air Measurements over Sodankylä, Finland

## Long-term Records and Recent Activities

*The Global Climate Observing System (GCOS) Reference Upper Air Network (GRUAN) was established in 2008 to meet climate requirements and to fill a major void in the current global observing system. Sodankylä in northern Finland is one of the first GRUAN stations.*



*Automatic sounding system in Sodankylä in March 2010 (Photo by Rigel Kivi, FMI).*

Upper air observations within the GRUAN network are expected to provide long-term high-quality climate records. They will also be used to obtain and validate data from space-based remote sensors, and provide accurate data for the study of atmospheric processes.

One of the initial stations in the GRUAN network is Sodankylä in northern Finland, operated by the

Finnish Meteorological Institute's Arctic Research Centre (FMI-ARC). The site is located at 67.4 °N, 26.6 °E, 179 m above mean sea level.

The site is representative of high latitude conditions in northern Europe. During winter and spring the upper air soundings are frequently sampling air inside the stratospheric vortex. Several measurement programs are running on a long term

basis and are thus producing valuable data for climate research.

### Long Records Of Upper Air Measurements

Sodankylä has one of the longest records of upper air measurements of temperature and ozone in the European sector of the Arctic. Temperature, air pressure, relative humidity, and wind speed and direction have been measured continuously by radiosondes since 1949, and ozone concentration by ECC sondes since 1988.

*Location of Sodankylä site.*





Balloon launch in Sodankylä in March 2010. This measurement is part of the LAPBIAT Atmospheric Sounding Campaign (Photo by Pauli Heikkinen, FMI).

Regular upper air measurements are performed daily at 00 UT and 12 UT. The measurements are performed by Vaisala DigiCORA® Sounding System MW31 and Vaisala Radiosonde RS92-SGPs. The Sodankylä station has performed soundings with Vaisala-manufactured equipment ever since the upper air measurements began, building up a six decade long time series of continuous observations.

The long-term data of upper air soundings have been used to study trends in stratospheric and tropospheric temperature and tropospheric humidity. Trend studies using the long-term record of ozonesonde measurements have also been carried out.

### LAPBIAT Atmospheric Sounding Campaign

In early 2010, FMI hosted a large international atmospheric sounding campaign in Sodankylä. The first phase of the campaign included radiosonde intercomparisons that took place in January-February. Different operational and research grade in situ instruments were launched with a focus on the comparison of humidity and temperature measurements in the troposphere and stratosphere.

The campaign included the most accurate light weight balloon

borne water vapor instruments such as the Fluorescent Lyman-alpha Stratospheric Hygrometer for Balloons (FLASH-B) and the Cryogenic Frostpoint Hygrometer (CFH). The prototype of Vaisala's new Reference Radiosonde RR01 was flown in the same payload with the cryogenic frost point hygrometer and the fluorescence hygrometer.

The remote sensing instruments participating in the campaign included MIAWARA-C, the new microwave radiometer for water vapor measurements developed by the University of Bern. Partners from Germany (DWD), Switzerland (ETHZ), Russia (CAO) and Finland (FMI, Vaisala) also participated in the in situ measurements.

Stratospheric measurements were made under very low temperatures in the Arctic vortex in January 2010. Thus polar stratospheric clouds were frequently measured by aerosol backscatter sondes during the campaign. Simultaneous measurements of water vapor indicated dehydration in the vortex in January 2010 related to the formation of the clouds.

The campaign measurements will be used in process studies, e.g. a study of polar stratospheric clouds and water vapor in the lower stratosphere, and for the purposes of intercomparison of water vapor, temperature and aerosol profiling instruments participating in the campaign. Several new or recently updated instruments participated in the campaign, and it is expected that the campaign intercomparisons will help to improve the instruments. One of the aims of the campaign was to characterize measurement uncertainties, which directly relates to the GRUAN activities.

### Research Activities on Multiple Fronts

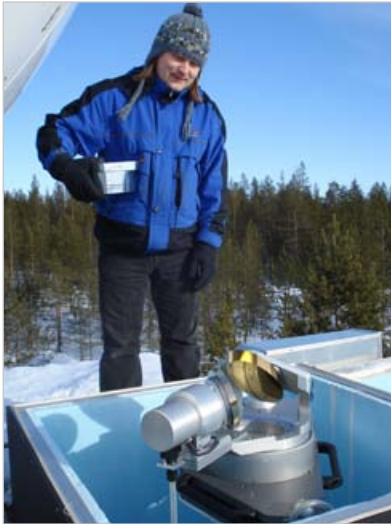
In addition to the operational soundings, Sodankylä has flown research grade hygrometers (CFH and FLASH-B) primarily during the winter

### Vaisala's Reference Radiosonde Program

In early 2009, Vaisala launched a program to develop an operational reference-grade radiosonde that could be used in GRUAN and other applications where enhanced radiosonde sensor performance is required. The program is being implemented in close collaboration with the meteorological research community, and the benefits will be shared equally with all countries.

A prototype of the reference radiosonde has undergone several testing rounds (including test campaigns in Sodankylä in 2007, late 2009 and early 2010), which have all yielded very encouraging results. The measurement accuracy has been verified against other high performance instruments. Field testing continues in cooperation with partners.

[www.vaisala.com/weather/applications/referencerasiosondeprogram.html](http://www.vaisala.com/weather/applications/referencerasiosondeprogram.html)



*FMI employee Pauli Heikkinen is inspecting the solar tracker recently installed in Sodankylä as a part of the new FTIR instrument. This instrument is designed for long-term measurements of greenhouse gases in the Earth atmosphere (Photo by Rigel Kivi, FMI).*

months since 2002. The observations have been used to study water vapor distribution in the upper troposphere and lower stratosphere (UTLS) at the vicinity of the polar vortex, and to provide accurate measurements of UTLS water vapor for satellite validation.

Recently new monitoring programs have also been started. An FTIR radiometer was installed in 2009 with the primary objective to measure CO<sub>2</sub> and methane columns on regular basis. The site has also been active in instrument comparison campaigns (e.g. LAUTLOS-WAV-VAP in 2004) and satellite validation campaigns (e.g. ESA ENVISAT, NASA Aura, and EUMETSAT MetOp).

**Further information:**

[fmiarc.fmi.fi](http://fmiarc.fmi.fi)  
[www.gruan.org](http://www.gruan.org)

**Regular observations at FMI-ARC, Sodankylä.**

Observation type	Starting year	Description
<b>Ground weather observations</b>		
Temperature, air pressure, air relative humidity, wind speed and direction, precipitation, visibility, soil temperature, snow cover	1908	Ground
Air chemistry: radon-222 (aerosol beta activity, alpha counting)	1996	Ground
<b>Solar radiation observations</b>		
Global-, reflected-, diffuse- and direct component of solar radiation, sunshine hours radiation	1957	16 m tower
Aerosol optical depth	2004	16 m tower
<b>Ground based UV- and ozone observations</b>		
Global UV-radiation, spectral UV-radiation, sotal column ozone	1990	Ground
Total column ozone, total column nitrogen dioxide	1990	Whole atmospheric pillar
<b>Balloon borne observations</b>		
Temperature, air pressure, air relative humidity, wind speed and direction from radiosondes	1949	Ground to 30 km
Ozone concentration from ECC sonde	1988	Ground to 30 km
Water vapor concentration from a frost point hygrometer	2002	Ground to 30 km
Aerosol backscatter coefficient ratio from backscatter sondes	1994	Ground to 30 km
<b>Meteorological Mast Experiment</b>		
Soil temperature and moisture profiles, RH% at 10 cm, leaf (needle) wetness, heat flux	1999	Ground
Snow depth, snow temperature profile, air temperature and relative humidity 10 cm above soil or snow	1999	Ground
Sonic wind speed, direction, temperature, friction velocity, heat vertical flux at 3,8,32 and 47 m	1999	48 m high meteorological mast
Temperature, relative humidity, wind 3,8,18,25,38,47 m, water vapour vertical flux	1999	48 m high meteorological mast
Global-, reflected-, diffuse- component of solar radiation, net radiation, photo-synthetically active radiation	1999	48 m high meteorological mast
Long-wave radiation, outgoing long-wave radiation, radiation temperature of canopy	1999	48 m high meteorological mast
<b>Other observations</b>		
Snow observations along a 4 km snow course		Ground