FMI Infrastructure for CryoNet at Sodankylä-Pallas, Finland

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Finnish Meteorological Institute
Arctic Research
FMI Arctic Research

- **Study of atmospheric phenomena and their interaction with biosphere and cryosphere including remote sensing methodology development** (around 55 employees)
- **Operations at Sodankylä and Helsinki (Finland), 4 groups**
- **Satellite data centre and observations**
  - Operation of the satellite data centre at Sodankylä.
  - Regular atmospheric observations, research campaigns, Cal-Val campaigns
- **Arctic Climate Change**
  - Study of atmospheric and cryospheric phenomena in polar and boreal regions
- **Satellite services/methodology development**
  - Development of satellite data processing, services and related research
- **Technical Services group**
  - Technical personnel for maintenance of observation and processing infrastructure in Sodankylä.
Stable operation since 1908

SYNOP and radio/ozone sonde climatologies:

- Surface temperature increase since mid-1980s,
- Stratospheric cooling since early 1990s

Annual 2m temperature at Sodankylä from 1908 until 2011 (from Kivi et al., 2012).

Temperature from radio-soundings over Sodankylä since 1950 (from Kivi et al., 2011).
Pallas-Sodankylä GAW Station, northern Finland
Sodankylä-Pallas GAW Twin Site

ACTIVITIES AT SODANKYLÄ

- Sounding and measuring campaigns
- Snow, soil, and vegetation studies & Field surveying
- Air chemistry
- Radiometric observations ranging from UV to MW
- Long term data records of various quantities
- Satellite Cal/Val activities
- A candidate “1-tier” site for WMO Global Cryosphere Watch

PALLAS CONCENTRATES ON

- Air chemistry
- Atmosphere-biosphere interactions
- Climatological research
- Hydrological activities
The measurements at Pallas include

- reactive gases (ozone, sulphur dioxide and nitrogen oxides)
- greenhouse gas concentrations (carbon dioxide, methane, nitrous oxide and sulphur hexafluoride)
- aerosol particle number concentration and size distribution
- volatile organic compounds (ethane, propane etc.)
- stable isotopes
- black carbon
- aerosol scattering coefficient
- PM$_{10}$ particle mass concentration
- radon-222
- meteorological parameters
High performance reference site network for upper air measurements. A selected subset of the whole WMO global network (GCOS). Sodankylä GRUAN site is operated by the Finnish Meteorological Institute Arctic Research Centre (FMI-ARC).
Total Carbon Column Observing Network

A world wide network of ground based Fourier Transform Spectrometers recording direct solar spectra in near infrared region.

RETRIEVED GASES INCLUDE:

- Carbon dioxide, CO2
- Methane, CH4
- Nitrous oxide, N2O
- Hydrogen flouride, HF
- Carbon Monoxide, CO
- Water, H2O and HDO

Column averaged (dry air) abundances of atmospheric constituents are retrieved.

Provide reliable and accurate CAL-VAL data for remote sensing instruments of greenhouse gases.

Website:
http://www.tccon.caltech.edu/

05.03.12
Monitoring of cryosphere and other terrestrial applications
Sodankylä-Pallas CAL-VAL activities:

• Reference instrumentation combined with extensive in-situ measurements for various EO missions:
  • SnowScat of ESA: Reference for the planned CoReH2O SWE mapping SAR mission
    • Dual frequency SAR for global mapping of cryosphere
  • SodRad: Reference for SSMI/I and AMSR-E
  • Mast-based spectrometer: Reference for MODIS, MERIS etc.
  • ELBARA-II of ESA: Reference for SMOS
ESA CoReH2O Phase-A activities at FMI

Providing data for CoReH20 studies:

- CoReH2O geophysical algorithm development & mission concept demonstration

Means:

1) Tower based X-/Ku-band scatterometer time series since 2009
   - Three -year campaign of experimental observations for CoReH2O geophysical algorithm development
   - Extensive microwave and ancillary instrumentation, including L, C, X, Ka, W-band radiometers

2) Airborne campaigns in 2011 and 2012
   - 5-7 airborne campaign periods in 2011 – 2012 (ongoing)
   - Continuous time series of airborne & space-borne SAR (TerraSAR-X) acquisitions

3) Ground based in-situ campaigns
   - Extensive measurements carried out by European and North American experts: FMI, SYKE, FGI, EC, SLF, GAMMA, NASA/JPL
   - ~40 people & 30 measurement days during winter 2011-2012
Tower-based measurements @ in-situ field

Passive microwave:
- October, 2009 – ongoing (L-band)
- December, 2009 – ongoing (C, X, Ka, W-bands)

Active microwave:
- October, 2009 – ongoing

Optical Spectrometer:
Three-winter time-series: ELBARA-II and frost/snow

[Graph showing brightness temperature and frost/snow depth over three years.]
Current Elbara-II setup: Soil frost and CH4 emissions from wetlands
CO₂ concentration and daily fluxes at Pallas (north boreal spruce forest)
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<td>CO\textsubscript{2} forest flux / CH\textsubscript{4} forest and wetland fluxes</td>
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<td>FTIR station; SWIR-NIR-MIR spectral region</td>
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<td>SodRad2 radiometer: 21, 150 GHz</td>
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<td>Global, Diffused, Reflected, Direct, Radiation balance, PAR, Sunshine duration, Global and Spectral UV, Albedo at several wavelengths</td>
<td>Pyranometers, pyrheliometers, pyrgeometers, albedometers, SL501, NILU-UV, Brewer, PFR- and Cimel sun-photometers</td>
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<td><strong>Surface reflectance, Reflected radiance</strong></td>
<td>UV to NIR Spectrometer: 350-2500 nm</td>
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Manual *in situ* snow measurements on a regular basis

### Three snow pit sites
- IOA (bi-weekly)
- Bog (1 km distance, bi-weekly)
- Lake ice (once/month)

### Parameters
- Stratigraphy
- Density profile (snow fork and snow scale)
- Grain size/SSA profile
- Temperature profile
- Snow moisture
- Bulk values for SD, SWE, density

### In addition, detailed campaign activities
- Snow depth/SWE distribution
- SSA measurements/ NIR photography
- High resolution penetrometry
- Daily snow pit measurements
- Instruments in continuous observation mode (diurnal change observation)
Automated soil and snow measurements from a distributed network including forest, wetland and tundra sites

- Snow depth and snow water equivalent (acoustic and gamma ray measurements)
- Soil moisture (permittivity) vertical profiles
- Soil temperature profiles and frost depth
- Snow temperature profile
- Weather (AWS) and radiation measurements (including albedo)
Sodankylä Satellite Data Centre

• Satellite Data Reception and Processing
  - NASA EOS Aura/OMI from 2004
  - NASA EOS Terra/MODIS and Aqua/MODIS from 2003
  - NOAA/NASA NPP Suomi from 2012

• Part of ESA ground segment
  - FIN-COPAC: Envisat GOMOS ozone data processing for International use
  - ESA GlobSnow processing

• EUMETSAT Activities
  - EUMETSAT O3-SAF, H-SAF/Snow products

• The Centre is being developed into a national satellite service centre providing Finnish and international customers with extensive satellite data services
Sodankylä Satellite Data Centre

• X-band reception systems:
  - 7.3 m antenna, data rate 320 (640) Mbps
  - 2.4 m antenna, data rate 20.8 Mbps

• ESA MMFI Ground Segment in operational use

• 24/7 operations capability:
  - New up-to-date computing facility
  - 10 Gbps data link to outside world

• Current operational NRT-processing lines:
  - MODIS data and products for FMI, SYKE, NOAA
  - EOS-Aura OMI products for FMI, KNMI and NASA
  - NPP/NPOESS (Suomi) data processing
  - ENVISAT GOMOS processing for ESA

• Potential international co-operation including:
  - GMES Sentinels
  - PCW/Canada, CMA-FY/China
  - Radarsat-C/Canada, COSMO-SkyMed/Italy
Summary

• Large scale facility with versatile instrumentation for atmospheric and terrestrial cal-val needs in Boreal and Arctic remote sensing

• Easily reachable location. Affordable guest rooms for visitors

• Long experience for hosting the campaigns. Experienced and highly qualified local staff.

• Long, stable operation; good prospect for the future (expanding)

• Operational data archiving and distribution systems, including real-time data delivery
Thank you for your attention!