

# Overview of the available ground-based data resources useful for the integration with the Earth Observation snow products

Jyri Heilimo Arctic Space Centre, Finnish Meteorological Institure Sodankylä, 19.4.2018

WP 3: Integrating in-situ and satellite components

Task 3.1 Streamlining satellite remote sensing data flows for new multi-sensor, multi-dimensional products, Milestone M3.1.1

Document version 1

## Introduction

This document gives the overview description of available ground-based measurements and resources that are available for integration and already used in many Earth Observation data products and are available in LitDB database. This document is part of iCUPE projects work package 3.1 Streamlining satellite remote sensing data flows for new multi-sensor, multi-dimensional products.

## Arctic Space Centre - High quality research infrastructure in the boreal zone

The location of Finnish Meteorological Institute's Sodankylä site at Finnish Lapland is ideal for the atmospheric and environmental research of boreal and sub-arctic zone. The principal observation infrastructure of Finnish Meteorological Institute (FMI) is deployed to two main areas: Arctic Research Centre at Sodankylä (67°22 'N, 26°39 'E) and Pallas clean air research station (67° 58'N, 24°07 'E). The Sodankylä facility hosts programs addressing upper air chemistry and physics, atmospheric column measurements, snow/soil hydrology, biosphere-atmosphere interaction and satellite calibration-validation studies. The Pallas station focuses to the monitoring the near-surface air chemistry and physics as well as greenhouse gas exchange.

Observations collected at Sodankylä and Pallas stations support several international research networks and projects concerning arctic and boreal environment such as:

- WMO GAW: Global Atmospheric Watch
- WMO GRUAN: GCOS Reference Upper Air Network. Sodankylä is among the initial stations of the reference network established in 2008.



- GEWEX: Global Energy and Water Cycle Experiment
- NDACC: Network for the Detection of Atmospheric Composition Change
- EU-ICOS: International Carbon Observation System
- TCCON (Total Carbon Column Observing Network): A network of ground-based Fourier Transform Spectrometers recording direct solar spectra in the near-infrared spectral region.
- ESA GlobSnow and EUMETSAT H-SAF: Climate databases and and near-real-time services for hemispheric snow mapping

Development of satellite systems for the monitoring of cryospheric processes and arctic atmosphere: Reference systems and measurements e.g. for ESA SMOS, ESA CoReH2O, NASA AURA, NASA/Jaxa AMSR-E, NASA MODIS, ESA AATSR.



Figure 1 The Sodankylä Pallas area is located in Finnish Lapland just poleward of the Arctic Circle. The distance between the Pallas and Sodankylä sites is ~130 km.

## Versatile calibration and validation facilities supporting remote sensing missions

The Sodankylä calibration and validation (cal-val) services are used in numerous remote sensing missions. The Sodankylä support for cal-val activities include



- Long-term measurements of geo-physical variables related to surface, atmosphere and near-Earth space.
- Balloon sounding launch facility for meteorology and atmospheric chemistry.
- Measurements towers, masts and platforms with versatile instrumentation.
- High-resolution information on surface characteristics of the Sodankylä-Pallas area (land use and land cover).
- Observation time-series with ground-based reference systems of satellite instruments (UV, VIS, IR, μW).



Figure 2 Meteorological observations from Sodankylä extend to over 100 years.



#### Daily total ozone at Sodankylä 1988-2010

Figure 3 Sodankylä ozone observations: Long-term behavior of the atmospheric ozone column (reference for space-based ozone measurements).





Figure 4 Snow cover and soil processes studies: Observation towers equipped with satellite instrument reference systems (Photo: Kimmo Rautiainen).

Snow cover and soil processes studies: Observation towers equipped with satellite instrument reference systems (Photo: Kimmo Rautiainen).

Table 1. Observations at Sodankylä.

Ground weather observations	Comments
Temperature 2m, Temperature ground, Dew point temperature, Air pressure, Air relative humidity, Wind speed, Wind direction, Precipitation, Cloud height, Amount of clouds, Visibility, Snow depth, Prevailing weather code	First measurements since 1908 Automatic weather station 2006
Soundings	
Temperature, Air pressure, Air relative humidity, Wind vertical profile	Measured since 1949
Ozone vertical profile	Measured since 1988
Stratospheric water vapour vertical profile	Campain measurements since 2002
Aerosol backscatter vertical profile	Campain measurements since 1994





Solar radiation observations	
Global, diffused, reflected, direct and net radiation, PAR up and down, Radiation balance, Sunshine duration, Aerosol optical depth, UVA and UVB radiation, UV index, Spectral UVB, Albedo	First measurements since 1957
Surface reflectance, Reflected radiance	Spectrometer: 350-2500 nm. Measured since 2006

Mast observations	
Temperature profile	Heights: 3, 8, 18, 32, 45, 48m. Measured since 2000
Humidity profile	Heights: 3, 8, 18, 32, 48m. Measured since 2000
Wind speed profile	Heights: 18, 32, 38, 48m. Measured since 2000
Wind and turbulence	Heights: 25, 48m

Soil and snow observations	
Soil temperature profile, Soil moisture profile, Soil heat flux, Soil respiration	First measurements since 2000
Snow temperature profile, Snow moisture profile	First measurements since 2000
Manual snow observations	Snowpack layering and snow grain size on snow bits, SWE and snow depth on snow pits, Dirstibuted snow observations on a 4 km-long snow course

Microwave observations	
Brightness temperature (surface / atmosphere)	SodRad radiometer: 10.65, 18.7, 36.5, 90 GHz SodRad2 radiometer: 21, 150 GHz Elbara L-band radiometer: 1.4 GHz Measured since 2009. (On loan from ESA)
Backscattering (surface)	Snow Scatterometer: 9-18 GHz Measured since 2009. (On loan from ESA)

Air chemistry observations	
Ozone column, SO <sub>2</sub> column, NO <sub>2</sub> column	First measurements since 1988
Total water vapor	Radiosondes, FTS, GPS, MW radiometer
CO <sub>2</sub> flux	Mast and ground measurements
Greenhouse gas columns: CO <sub>2</sub> , CH <sub>4</sub> , N <sub>2</sub> O, HF, CO, H <sub>2</sub> O, O <sub>2</sub>	FTS in the near IR region. Measured since 2009

\_\_\_\_\_

Other observations	
Radioactivity, Aerosols, Cloud camera	
Satellite reception	2.4 m system and 7.3 m system





# VISITING INSTRUMENTS SATELLITE RECEPTION RADIATION FIELD FOURIER TRANSFORM SPECTROMETER FACILITY RADIATION TOWER SOUNDING STATION AUTOMATIC SOUNDING STATION SNOW DEPTH FIELD EO REFERENCE INSTRUMENT

- FIELD AND TOWERS
- MAST FIELD

# Overview of Litdb database

The ground based measurement data sets are stored in LitDB database. All data presented at LITDB available for download. Datasets are checked annually and inserted into the database after checking. Data format for downloaded data files is a comma separated text file with two header lines. The measurement data stored in the LitDB database is free and open for use, but by using the data the user shall agree the general data disclaimer:

# **"GENERAL DATA DISCLAIMER**

The data sets are freely available for scientific and educational use. However, it is requested that when data is used for a publication either (1) appropriate referencing to data provider is provided, or (2) co-authorship to data provider (or to principal investigator responsible for the data) is offered and, additionally, that possible specific disclaimers attached to different data sets are respected. In case of some data sets contacting the principal investigator responsible for the data is required prior to obtaining the actual data."



## Data description

Each measurement data set has unique identifier and respective meta-data describing essential information of the data set. The types of data sets are different, so also the meta-data contents vary accordingly, but in general the meta-data contains at least following information.

- Data ID
- Data name
- Site desription
- Location coordinates
- Measurement type
- Textual description of measurement site
- Sensor type and description
- Contact person maintaining data set

#### For example:

#### DATA FROM SAA0001 STATION AT SAARISELKÄ

**Description**: Station is located to the eastern slope of Niilanpää in UKK national park near Saariselkä, Finland. Bald, infertile fell slope with juniper, heather, lichen and crowberry. Station includes a Mobotix M24 camera. Measurements are snow depth, air temperature, air relative humidity, wind speed, prevailing wind direction, incoming and outgoing SW- and LW-radiation (Spot 1) and soil temperature and dielectric constant profile in three different spots: Spot 1: -5, -10, -20, -40, -80 cm (Installed 2011-09-09) Spot 2: -5, -10 cm (Installed 2011-09-09) Spot 3: -5, -10, -20, -40, -63 cm (Installed 2017-10-15)

Altitude above sea level: 440 m

#### Coordinates:

Spot 1: N68.33019, E27.55062 Spot 2: N68.33025, E27.55076 Spot 3: N68.33013, E27.55083

Soil type Spot 1 and 2: organic/sand for sensors at -5cm, sand for sensors at -10
to -80 cm
Soil type Spot 3: organic for -5cm, organic/sand for -10cm, sand for sensors at -20
to -63 cm

Sensor for soil measurements Spot 1 and 2: Decagon Devices 5TE Soil Moisture Sensor Sensor for soil measurements Spot 3: Decagon Devices GS3 Sensor for snow depth: Campbell Scientific SR50A Sensor for radiation: Kipp&Zonen CNR4 Sensor for air temperature and relative humidity: Campbell Scientific CS215 <="" b="" style="color: rgb(0, 0, 0); font-family: Arial, Helvetica, sans-serif; font-size: 13px; font-style: normal; font-variant-



ligatures: normal; font-variant-caps: normal; font-weight: 400; letter-spacing: normal; orphans: 2; text-align: start; text-indent: Opx; text-transform: none; white-space: normal; widows: 2; wordspacing: Opx; -webkit-text-stroke-width: Opx; background-color: rgb(255, 255, 255); text-decoration-style: initial; text-decorationcolor: initial;">R.M. Young 05103 Wind Monitor

For more information contact NN.

GENERAL DATA DISCLAIMER



# List of data stored in LitDB

AIR TEMPER	RATURE DATA:
LUO0015	Operative automatic weather station
LUO0016	Manual SYNOP observations daily values
LU00017	Manual observations monthly values
LUO0018	Manual SYNOP observations
SU00003	Automatic weather station at the peatland
IOA0003	Station at the Intensive Observation Area
SU00003	Automatic weather station at the peatland
<u>SUO0010</u>	Station at the peatland methane flux station
MET0002	Station at the Micrometeorological mast
VU00001	Station at the CO2 flux mast field
VU00002	Station at the CO2 flux mast
KAI0002	Station at forest
RWS0001	Station at the Road Weather Station
RWS0003	Station at the Road Weather Station
DIS0001	Station at forest
DIS0002	Station at forest
SAA0001	Station at the Saariselkä
SAA0002	Station at the Saariselkä
SAA0003	Station at the Saariselkä
AIR RELATI	VE HUMIDITY DATA:
LUO0015	Operative automatic weather station
LUO0018	Manual SYNOP observations
IOA0003	Station at the Intensive Observation Area
<u>SUO0003</u>	Automatic weather station at the peatland
<u>SUO0010</u>	Station at the peatland methane flux station
MET0002	Station at the Micrometeorological mast
VUO0001	Station at the CO2 flux mast field
VUO0002	Station at the CO2 flux mast
RWS0001	Station at the Road Weather Station
RWS0003	Station at the Road Weather Station
SAA0001	Station at the Saariselkä
SAA0003	Station at the Saariselkä
AIR PRESSU	JRE DATA:
AIR PRESSU	JRE DATA: Operative automatic weather station



SAA0003	Station at the Saariselkä
SOIL TEMPE	ERATURE DATA:
IOA0002	Station at the Intensive Observation Area
IOA0003	Station at the Intensive Observation Area
<u>IOA0007</u>	Station at the Intensive Observation Area
IOA0009	Station at the Intensive Observation Area
LUO0008	Station at the Sounding station area (open area)
LUO0009	Station at the Sounding station area (forest)
LUO0013	Manual measurement at the Sounding station area
SU00001	Station at the peatland
SU00004	Station at the peatland
SUO0005	Station at the peatland
<u>SUO0007</u>	Station at the peatland
SU00008	Station at the peatland
<u>SUO0009</u>	Station at the peatland methane flux station
SU00010	Station at the peatland methane flux station
<u>SUO0011</u>	Station at the peatland
JAK0001	Station at the Lichen fence
LEN0001	Station at forest near airport
KAI0001	Station at forest
KAI0002	Station at forest
MET0001	Station at the Micrometeorological mast field
MET0003	Station at the Micrometeorological mast field
VUO0001	Station at the CO2 flux mast field
RWS0001	Station at the Road Weather Station
RWS0003	Station at the Road Weather Station
RWS0005	Station at the Road Weather Station
DIS0001	Station at forest
DIS0002	Station at forest
DIS0003	Station at forest
DIS0004	Station at forest
SAA0001	Station at the Saariselkä
SAA0002	Station at the Saariselkä
SAA0003	Station at the Saariselkä
-	
SOIL MOIST	URE DATA:
<u>IOA0002</u>	Station at the Intensive Observation Area
<u>IOA0003</u>	Station at the Intensive Observation Area
IOA0007	Station at the Intensive Observation Area



Overview of the available ground-based data resources useful for the integration	with	the	Earth
Observation snow products			
		1	

	Observation snow products
SUO0004	Station at the peatland
SUO0005	Station at the peatland
SUO0007	Station at the peatland
LEN0001	Station at forest near airport
KAI0001	Station at forest
KAI0002	Station at forest
MET0001	Station at the Micrometeorological mast field
MET0003	Station at the Micrometeorological mast field
VU00001	Station at the CO2 flux mast field
RWS0001	Station at the Road Weather Station
DIS0001	Station at forest
DIS0002	Station at forest
DIS0003	Station at forest
DIS0004	Station at forest
SAA0001	Station at the Saariselkä
SAA0002	Station at the Saariselkä
SAA0003	Station at the Saariselkä
SNOW DEP	TH DATA:
LUO0015	Operative automatic weather station
LUO0016	Manual SYNOP observations daily values
IOA0003	Station at the Intensive Observation Area
SU00003	Automatic weather station at the peatland
MET0002	Station at the Micrometeorological mast field
SAA0001	Station at the Saariselkä
SAA0002	Station at the Saariselkä
SAA0003	Station at the Saariselkä
SNOW TEM	PERATURE DATA:
SU00004	Station at the peatland
IOA0007	Station at the Intensive Observation Area
MET0004	Station at the Micrometeorological mast field
SNOW WAT	
IOA0011	
	Station at the Intensive Observation Area
LUO0015	Operative automatic weather station
LUO0018	Manual SYNOP observations



MET0002	Station at the Micrometeorological mast
RWS0001	Station at the Road Weather Station
RWS0003	Station at the Road Weather Station
<u>SAA0001</u>	Station at the Saariselkä
SAA0003	Station at the Saariselkä
	DATA:
IOA0006	Station at the Intensive Observation Area
LUO0015	Operative automatic weather station
LU00018	Manual SYNOP observations
RWS0002	Station at the Road Weather Station
RWS0003	Station at the Road Weather Station
RWS0004	Station at the Road Weather Station
PRECIPITAT	TION DATA:
IOA0006	Station at the Intensive Observation Area
LU00015	Operative automatic weather station
LU00016	Manual SYNOP observations daily values
LU00017	Manual observations monthly values
RWS0002	Station at the Road Weather Station
RWS0003	Station at the Road Weather Station
RADIATION	DATA:
IOA0001	Spectral radiance measurement at the Intensive Observation Area
IOA0008	SW radiation at the Intensive Observation Area
MET0002	SW, LW, PPFD, and net radiation at the Micrometeorological mast
MET0005	SW and LW radiation at the Micrometeorological mast
VU00002	SW, PPFD and net radiation at the CO2 flux mast
SU00006	SW radiation at the peatland
SUO0009	SW and PPFD radiation at the peatland methane flux station
SU00010	SW, PPFD, and net radiation at the peatland methane flux station
JAK0002	SW and LW radiation inside the Lichen fence
JAK0003	SW and LW radiation outside the Lichen fence
SAA0001	SW and LW radiation at the Saariselkä
SAA0002	SW radiation at the Saariselkä
SAA0003	SW and LW radiation at the Saariselkä
UV DATA:	·
LU00002	Brewer #037 Spectrophotometer
LU00010	Brewer #214 Spectrophotometer
	· · ·



OZONE DATA:	
LUO0002	Brewer #037 Spectrophotometer
LUO0010	Brewer #214 Spectrophotometer
EVAPORATION DATA:	
LUO0012	Manual measurement at the Sounding station area
-	
ROAD SURFACE DATA:	
RWS0003	Station at the Road Weather Station
RWS0004	Station at the Road Weather Station
CAMERA IMAGES FROM SODANKYLÄ:	
	Cloud camera images
	Intensive Observation area images
	Automatic weather station images

## Future Plans for iCUPE WP 3.1

The LitDB data, at the moment, is available in comma separated data format with two header lines. In the iCUPE project, the LitDB data interface will be renewed and Open Data datasets will be published using open standard web service interfaces for geospatial data defined by the Open Geospatial Consortium (OGC). The data opening is part of the growing global trend of publishing environmental information as Open Data, and is part of the implementation of the open data policy of the Finnish Government and the EU INSPIRE directive.

FMI-ARC's Open Data Services will be divided into three categories following the categorization used by the INSPIRE directive:

- 1. Discovery Service (a.k.a. Catalog service) provides metadata about the available datasets and services, implemented using the OGC Catalog Service for Web (CSW),
- 2. View Services give a visual preview of the available datasets, implemented using OGC Web Map Service (WMS), and
- 3. Download Services provide a continuous online access to the most up-to-date data, implemented using OGC Web Feature Service (WFS).

All these services are intended to be machine-accessible: in most cases the data users interact with these services only through applications provided by FMI-ARC, the data users themselves or third parties. In other words, FMI-ARC is providing APIs for accessing the data.



Using open standard interfaces makes it easier for developers to build re-usable software being able to access many datasets from different data providers and combine them together to create new interesting and technologically advanced applications. FMI encourages both small and large developer individuals and organizations to experiment with the provided datasets and publish their creations either as free or commercial products. The data users must agree to the FMI Open Data License and register to get access to the services.