Evolution of ESA DUE GlobSnow products and CAL-VAL Opportunities for Sentinels (+ other EO-missions) at the Sodankylä Supersite, Northern Finland


29 January 2014
Outline

- Evolution of ESA DUE GlobSnow products
- CAL-VAL Opportunities at the Sodankylä Supersite
- Examples of recent campaign activities
  - Studies in support of EE7 candidate CoReH2O
  - Monitoring of boreal forest/taiga seasonal albedo variations
  - Monitoring of soil freeze/thaw processes with L-band radiometry
ESA DUE GlobSnow

• ESA DUE GlobSnow project: Production of novel hemispherical snow extent (SE) and snow water equivalent (SWE) climate data records.

• Generation of long time-series employing FMI supercomputing facilities at Helsinki (daily, weekly and monthly maps of SE and SWE for northern hemisphere) + NRT processing

• Consortium members: Finnish Meteorological Institute (FMI) with ENVEO IT GmbH (Austria), GAMMA Remote Sensing (Switzerland), Norwegian Computing Center, Finnish Environment Institute (SYKE), and Environment Canada (EC). + Univ. Bern, MeteoSwiss, ZAMG & Norut

• GlobSnow-1 (3.5 years): 11/2008 – 11/2011 (36 months)
• GlobSnow-2 (2 years): 05/2012 – 05/2014 (24 months)

• Details and products available at www.globsnow.info
30 year-long CDR time-series on snow conditions of Northern Hemisphere

- First time reliable daily spatial information on SWE (snow cover):
  - Snow Water Equivalent (SWE)
  - Snow Extent and melt (+grain size)
  - 25 km resolution (EASE-grid)
  - Time-series for 1979-2012
- Passive microwave radiometer data combined with ground-based synoptic snow observations
  - Variational data-assimilation
- Available at open data archive (www.globsnow.info)
- Demonstration of NRT processing since October 2010
- Greenland, glaciers & mountains masked out

GlobSnow Snow Extent (SE) dataset

- 17 years SE data record has been produced using optical imagery from ESA ATSR-2 (1995-) and AATSR (2002-) on a hemispherical scale.
- SYKE’s SCAmod method for fractional snow cover mapping implemented for Northern hemisphere covering all non-mountainous terrain
- Cloud detection algorithm developed by SYKE (+ contributed by ENVEO, FMI & NR)

- Methodology developed especially for forested regions – basically a tough challenge for optical SE retrieval
- Operational data production at the Finnish Meteorological Institute (FMI)

Enhancing SE & SWE retrieval methods within GlobSnow-2

SWE:

• Homogenizing & augmenting weather station dataset
• Improved multi-layer HUT snow emission model
• Regional treatment of observation uncertainty for WS data
  • (Climatological based spatially & temporally varying snow density)

SE:

• Single algorithm (SCAmobd) throughout the NH
• Improved forest transmissivity mask
• Variable bare ground reflectance
• Uncertainty estimates
  • + VIIRS SE production, AVHRR comparison, additional validation data,
ESA GlobSnow-2 summary

- Improved retrieval methodologies for SWE & SE (v2.0 algorithms)
- SE & SWE CDR v2.0 processed & released 12/2013, data access:
  
  http://www.globsnow.info/se/   &   http://www.globsnow.info/swe/

- Combining PMW SWE product with medium resolution SE data
CAL-VAL Opportunities for future EO-missions at the Sodankylä-Pallas Supersite, Northern Finland
Sodankylä Pallas *in-situ* monitoring programme relevant to terrestrial cryosphere, vegetation & atmosphere

- Meteorological observations including radiation measurements (incoming and reflected)
- Snow cover measurements (depth, SWE) with automatic sensors accompanied by a manual sampling programme
- Soil frost, soil moisture (dielectric constant) and temperature profile measurements with a distributed automatic sensor network
  - Boreal forest-site, wetlands-site, tundra-site
- Absolute concentrations of CO2 and CH4 (Pallas GAW station)
- CO2 and CH4 fluxes between different ecosystems and atmosphere
  - CO2 in spruce and pine forests (mineral soil sites) & CH4 in wetland ecosystems
- Columnar CO2 and CH4 measurements through ground-based IR Fourier-spectrometry
- Coinciding observations with reference systems of EO instruments Microwave (active/passive) and optical wavelengths
Sodankylä-Pallas site as a Satellite CAL/VAL ”satellite pixel”

- Reference site for several ESA and NASA missions including
  - ESA SMOS and NASA SMAP (microwave radars and radiometers): soil moisture and cryospheric processes
  - SSM/I(S), AMSR-2 (snow processes including SWE)
  - Optical instruments including MODIS, NPP-VIIRS, FY-3 und upcoming Sentinels (2 and 3)
  - Planned (but not selected for ESA Earth Explorer) ESA CoReH2O (SAR radar): global SWE mapping at high spatial resolution (terrestrial areas and sea ice regions)

- Satellite data accompanied with extensive monitoring of soil, vegetation and atmospheric processes (distributed measurements)
  - Primary station in WMO Global Atmosphere Watch (CO2, aerosols etc.)
  - Primary (Integrated) station in the WMO Global Cryosphere Watch
  - Participation in WMO GRUAN network, TCCON network, EU-ICOS, NDACC, GEWEX
The westernmost part of the Eurasian taiga belt
Fragmented land cover including forests on mineral soil, wetlands, open water and open rock surface
Average maximum snow depth: 80 cm
Easy access and technical support
Sodankylä satellite CAL/VAL infrastructure 1/4

Ku to W-band radiometer systems

SodRad

• Commercial dual pol radiometers in two systems
  • 10.65, 18.7, 21, 37 GHz
  • 90 & 150 GHz
• Manufacturer Radiometer Physics GmbH
• Main applications
  • Cal/val activities of SSM/I, AMSR-E, AMSR2 observations and products
  • Development of applications for snow cover, soil and atmosphere
• Systems operational since 2009 (low frequency) and 2012 (high frequency)
Elbara – II

- L-band (1.435 GHz), dual polarization
- Manufactured by Gamma RS AG (Switzerland), currently on lease from European Space Agency
- Reference radiometer of SMOS mission

Main applications
- SMOS observation and soil moisture product cal/cal
- Investigations of soil freeze/thaw detection

Collected time series:
- Mineral soil site: 2009-2012
- Organic soil (wetland) site: 2012 ->
Sodankylä satellite CAL/VAL infrastructure 3/4
Mast-borne VIS/IR spectrometer
Sodankylä satellite CAL/VAL infrastructure 4/4
Spectrometer, scatterometer, GHG column

- Tower-based reference spectrometer for NASA MODIS, NPP- VIIRS, Sentinels-2 & 3
- ESA Snowscat X to Ku-band scatterometer, acted as reference for the planned CoReH₂O Earth Explorer 7 Phase A activities
  - Dual frequency SAR for the global investigation of snow cover
- Reference instruments for Jaxa GOSAT and NASA OCO
  - CO2 and CH4 columns
Model development including data at different scales

- Field spectrometry
- Mast-borne time-series
- Airborne campaigns
- Satellite observations
Airborne spectrometer campaigns for support of optical RS-method development
Sodankylä passive MW monitoring program:
SodRad and Elbara-II radiometers at Sodankylä (L to W bands)
Reference radiometers for AMSR-E, AMSR2, SSM/I and SMOS

Airborne campaign support
interpretation of in situ reference to satellite scale
• HUT2D (SMOS reference radiometer)
• HUTRAD system (AMSR frequencies)
Studies supporting CoReH2O

Collection of data for CoReH2O Phase A studies:

(1) Monitor seasonal backscatter signature of snow covered terrain at X/Ku bands: ESA NoSREx campaign 2009-2012 → support CoReH2O retrieval algorithm development

(2) Spatial variability of backscatter signal: SnowSAR airborne campaigns in 2011, 2012 → perform CoReH2O mission concept demonstration
Collected in situ data for airborne campaigns of the winter 2011-2012 (SnowSAR/CoReH20)

Summary

• ~30 measurement days
• ~30 people involved (8 – 20 per flight)
• Teams from FMI, SLF, EC, ENVEO, NASA, GAMMA
• 4-12 transects covered per flight
  • 6-10 SWE measurements per transect (500 m separation)
  • Repetition of 2 baseline transects for each flight (North -South & East West)
• 25 – 50 snow depth samples per transect (100 m separation)
• 1-3 transects per flight covered with high sampling density (500 – 1500 SD samples)
• Intensive sampling also for Sea Ice and tundra sites
In situ data - manual

Snow depth with MagnaProbe

Finnish Meteorological Institute
Main site track #5 for SnowSAR (CoReH20 studies)

Coniferous forests and mineral soil terrain

Wetlands (open bogs)
Thank You for Your Attention!