A multi-satellite concept in support of high latitude permafrost modeling and monitoring: The ESA DUE Permafrost Project

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www.ipf.tuwien.ac.at/permafrost
User Groups: National & sub-national public authorities, European institutions, International organizations, NGOs

User requirements consolidation → Ground truthing

Ground truthing In-situ data access → Products validation

Products validation Service assessment → Service Demonstration

EO data → Service Development

Service Development Products → Service Demonstration
To initiate a project, ESA requests to participating user organizations:

- a Letter of Commitment;
- a User Requirements Document (URD);

**Letter of Commitment**

I will commit X men/month of work to:

- Coordinate the work of local agencies;
- Consolidate the User Requirements;
- Provide access to data and information useful for the project;
- Organize dedicated ground data collection campaigns for the project;
- Support the validation of the results;
- Assess the final service from a user perspective;

*The User*

**User Requirement Document**

The Service required include the provision of the following geo-information products:

- XXX
- XXX

The area of interest is the following: ....
The timeframe of interest in the following: ....
The format of the products should be the following: ....
The National User Network is made of...
For more Information:
http://www.esa.int/due/

Ionia
an internet gateway for easy access to DUE demonstration products.
http://www.esa.int/due/ionia/
- Permafrost is an environmental indicator on climate change
- Thawing permafrost is a carbon source
- Transport in boreal areas (roads, railways, pipelines) is affected by permafrost degradation
- Thawing of permafrost in alpine areas raises the risks of landslides
- ...
ESA DUE Permafrost project

- DUE – Data User Element

- The objective is to establish a monitoring system based on mostly existing satellite data products

- Supporting
  - The GCOS implementation plan
  - National and intergovernmental bodies
  - Scientific groups involved in climate change research

- Multiscale concept
  - Pan-boreal/arctic (> 50° N): 25 km
    - Regional (1.5 mio km²) 150m-1km
    - Local (> 20,000 km²)
DUE Permafrost project

- User organizations
  - IPA – International Permafrost Association
  - Alfred-Wegener Institute of Polar and Marine Research
  - Perm. Laboratory, University of Alaska Fairbanks
  - IARC University of Alaska Fairbanks
  - Lomonossov Moscow State University, Russia
  - Permafrost Institute Yakutsk
  - State Hydrological Institute St Petersburg, Russia
  - Geological Survey of Canada
  - University of Hokkaido, Japan
  - MPI Jena, Germany

- + currently > 10 associated users
Permafrost is defined as ground (soil or rock and included ice or organic material) that remains at or below 0°C for at least two consecutive years.
Changing Permafrost

- Ground thermal regime changes due to
  - Changes in air temperature and/or precipitation
  - Surface disturbances
    - Clearing of vegetation
    - Removal of insulating organic layer
    - Forest fires
    - River channel migration
    - Shoreline erosion

- Response to climate change depends on variations in local seasonal factors
  - Snow cover
  - Vegetation
  - Surficial material
  - Moisture content
  - Drainage
Circumpolar ground networks

www.gtnp.org
Parameters for modelling

Example: GIPL

Structure of the GIPL 2 model
Remote Sensing

- Cannot directly see below the soil surface,
- but
  - Monitoring of indicators
    - Lake dynamics
    - Terrain changes
    - vegetation
  - Monitoring of parameters used in models
Parameters for modelling from Remote Sensing – pan-boreal/arctic scale

- Land Surface Temperature
- Landcover
- Disturbances
- Snow properties
- Soil moisture
- Terrain
Pan-boreal/arctic scale

- Land Surface Temperature
  - Available from
    - MODIS
    - ENVISAT AATSR
    - Passive microwave

- Aim: Creation of a combined product for optimal coverage
- Pan-boreal/arctic: monthly, 25 km
- Regional: weekly, 1 km

MODIS-AATSR-Temp

LST DAYTIME TERRA MODIS (DAY 179 – 2008)

AMSRE (DAY 179 – 2008)
Pan-boreal/arctic scale

- Land cover
  - ESA Glob-Projects
  - MODIS, AVHRR products
  - CAVM – Circum Arctic Vegetation Map
  - National maps

1. Harmonization of available maps
2. Adaption to Permafrost model needs
   -> information on organic layer?
Pan-boreal/arctic scale

- Snow properties
  - From Globsnow (Snow extent - 1km & Snow Water equivalent) – 25 km
  - Other products: MODIS, NSIDC

- SWE Thematic accuracy
  - Current alternative algorithms
    - Global scale 40mm – 200mm
    - Regional scale 20mm – 50mm
  - Globsnow algorithm:
    RMSE of 43.2 mm for Eurasia
    RMSE of 33.5 mm for Eurasia (SWE < 150mm)
Soil Moisture (incl. freeze/thaw)
- From microwave sensors
- Near surface soil moisture
- Incl. Freeze/thaw status

MetOp ASCAT NRT - 25 km

ESA WACMOS project
- Combination of passive and active soil moisture products for a 30 year record

Soil Moisture – Microwave sensors

Polar view of soil moisture anomalies from METOP ASCAT data of July 2007. 1-day composite (July 30th)
Soil Moisture (incl. freeze/thaw)
- From microwave sensors
- Near surface soil moisture
- Incl. Freeze/thaw status

MetOp ASCAT NRT - 25 km

ESA WACMOS project
- Combination of passive and active soil moisture products for a 30 year record

Ground data comparison: Central Yakutia

Comparison with summer discharge
Example: Lena basin
Regional scale

- Soil moisture (incl. Freeze/thaw) from ENVISAT ASAR GM (1km)
  - Has been already implemented within the ESA DUE Tiger project SHARE for Africa and entire Australia (www.ipf.tuwien.ac.at/radar/share)

Lena Delta – Schneider et al. 2009

Type: Wet Tundra
ENVISAT ASAR GM surface wetness 2005 (TU Wien method)
Heim et al. 2010
Regional scale

- Water bodies

- Identification with ENVISAT ASAR WS (150m)
  - Has been developed within the FP5 Project Siberia II
  - Allows for operational monitoring
    - Annual maps
  - Provides more detailed information than global land cover maps (MODIS – 500m, MERIS 300m) and the Global lakes and wetland database

Bartsch et al. (2008) Hydrology Research
Bartsch et al. (2007) J. Aquatic Conservation
Local scale monitoring

- **Terrain**
  - Incl. Subsidence

- **Landcover**
  - Lake dynamics
  - Vegetation

ERS2/ENVISAT interferogram (Mackenzie)

Rapid Eye – Lena Delta
Panboreal/-arctic, regional, local

- Scaling
  - Lakes
  - Land Surface Temperature
  - Land cover
  - Soil moisture
  - And freeze/thaw

ASAR WS 150m
PALSAR FB 25m
Mackenzie Delta

AWI SPARC
Lena delta Observatory
Langer et al. 2010

Regional soil moisture map
Yakustia

CRSS 2010
Information system - PEO

Multiple scales

Land cover, Scaling, LST, snow, soil moisture (incl. freeze/thaw status), water surfaces, terrain, methane

Database

Permfree Model (external)

WebGIS

MERIS MODIS AVHRR
ASAR PALSAR TerraSAR-X PRISM Corona Landsat RapdEye ...

ENVISAT AATSR ENVISAT MERIS ENVISAT ASAR MODIS MetOp ASCAT AMSR-E

CRSS 2010
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Database

Permafrost Models (external)

WebGIS

IPA Permafrost Information System

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Database

Permafrost Models (external)

WebGIS

IPA Permafrost Information System

ENVI...
Data portal – beta version
Aim is to establish a EO based monitoring service for climate change research over permafrost

First test dataset for Yamal/Ob-Estuary 2007 released in April 2010

Test datasets for all scales due in January 2011 (GeoTIFF, NetCDF)

Full service demonstration due end of 2011

More information:
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