Vienna University of Technology
Institute of Photogrammetry and Remote Sensing

DUE PERMAFROST

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

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EOEP-2 DUE (Data user element)
a user driven approach

User Groups: National & sub-national public authorities, European institutions, International organizations, NGOs

User requirements consolidation

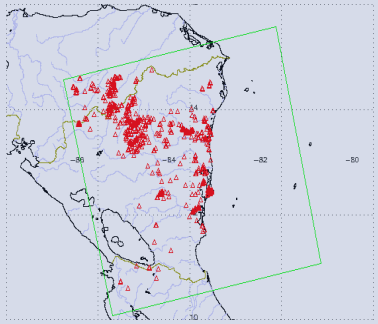
Ground truthing
In-situ data access

Products validation

Service assessment

EO data

Service Development



Products

Service Demonstration

EOEP-2 DUE:
the user commitment

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: ….

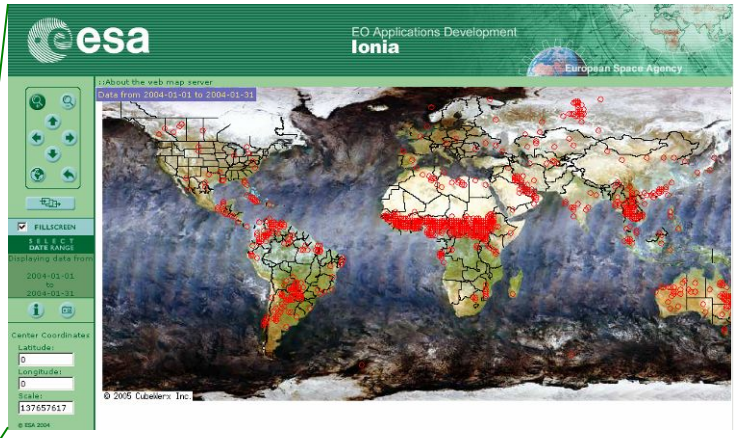
The National User Network is made of…

The User

DUE Web Portal and IONIA gateway

For more Information:

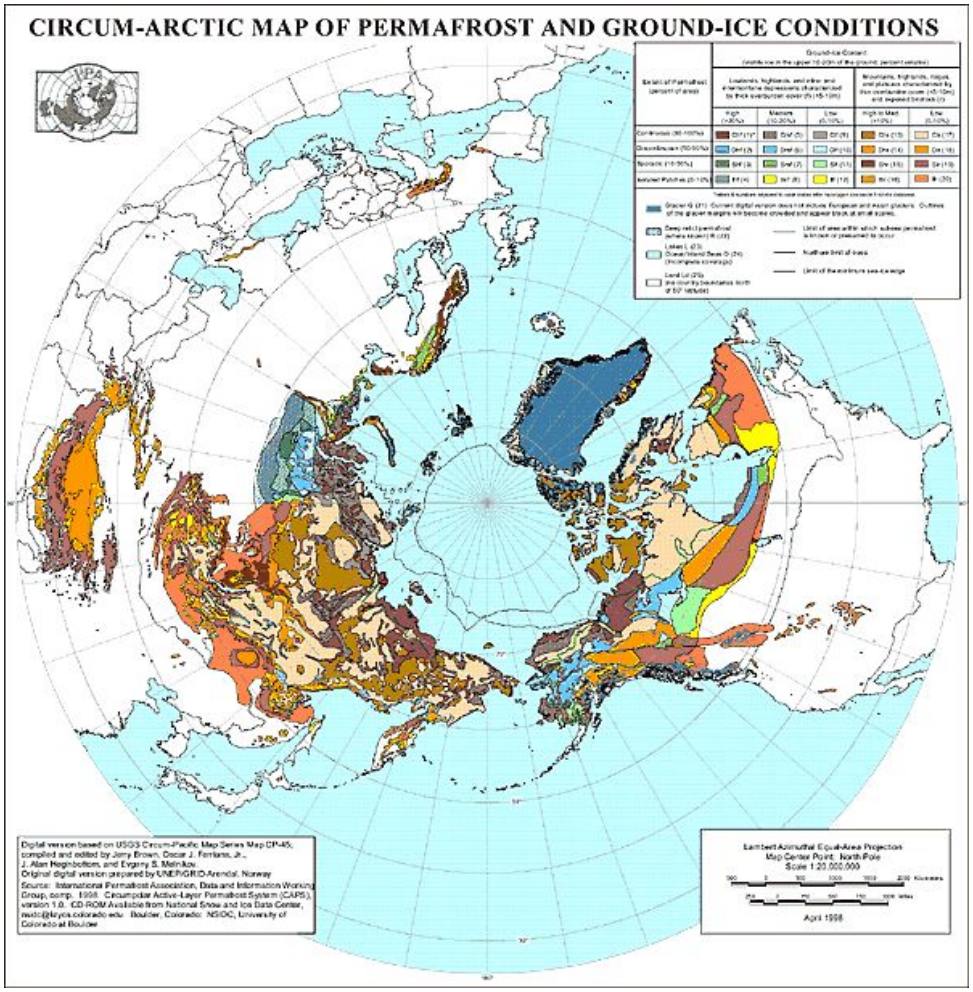
http://www.esa.int/due/



Ionia
an internet gateway for easy access
to DUE demonstration products.
http://www.esa.int/due/ionia/

Why Permafrost in DUE?

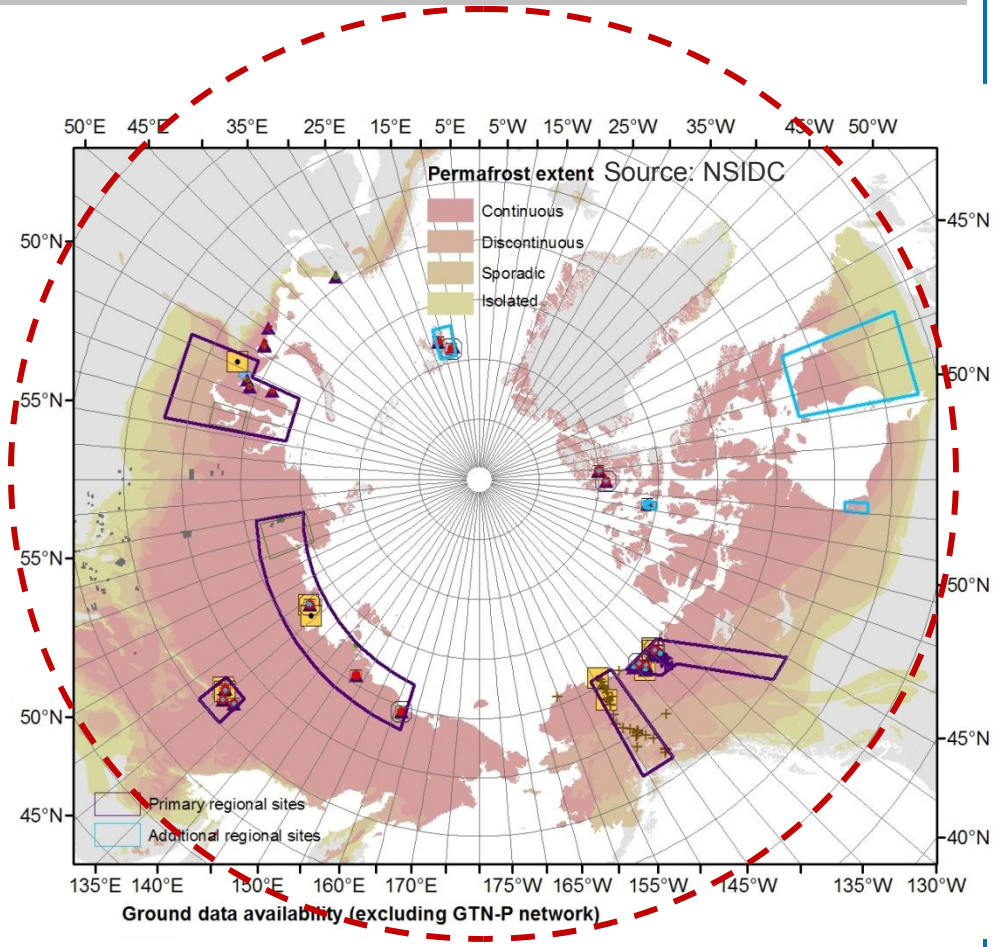
- Permafrost is an environmental indicator on climate change
- Thawing permafrost is a carbon source
- Transport in boreal areas (roads, railways, pipelines) is affected by permafrost degradation
- Thawing of permafrost in alpine areas raises the risks of landslides
- …



Courtesy International Permafrost Association

ESA DUE Permafrost project

- DUE – Data User Element
- The objective is to establish a monitoring system <u>based on mostly existing satellite data products</u>
- 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

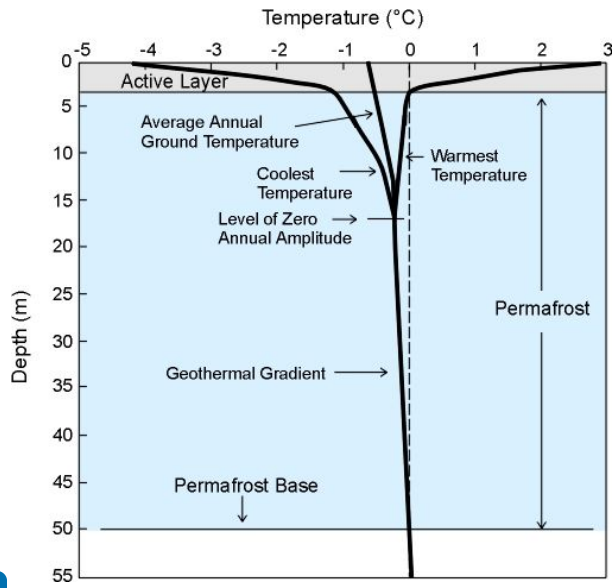
  - + currently > 10 associated users

TU WIEN

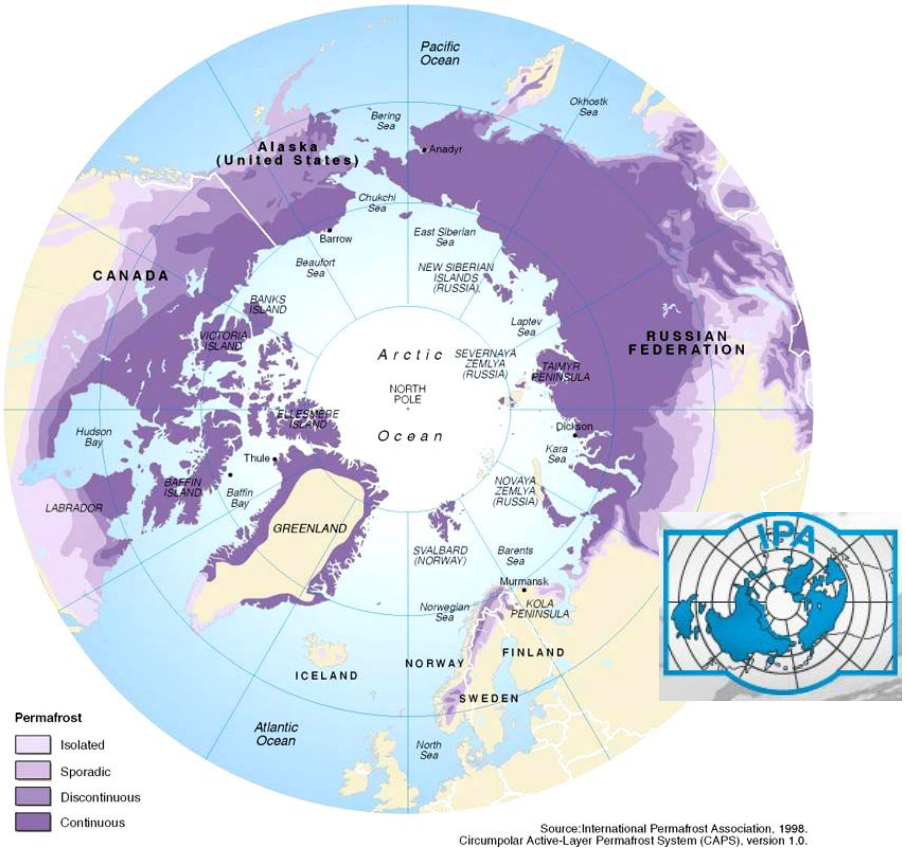
DUE PERMAFROST

Permafrost

- 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.



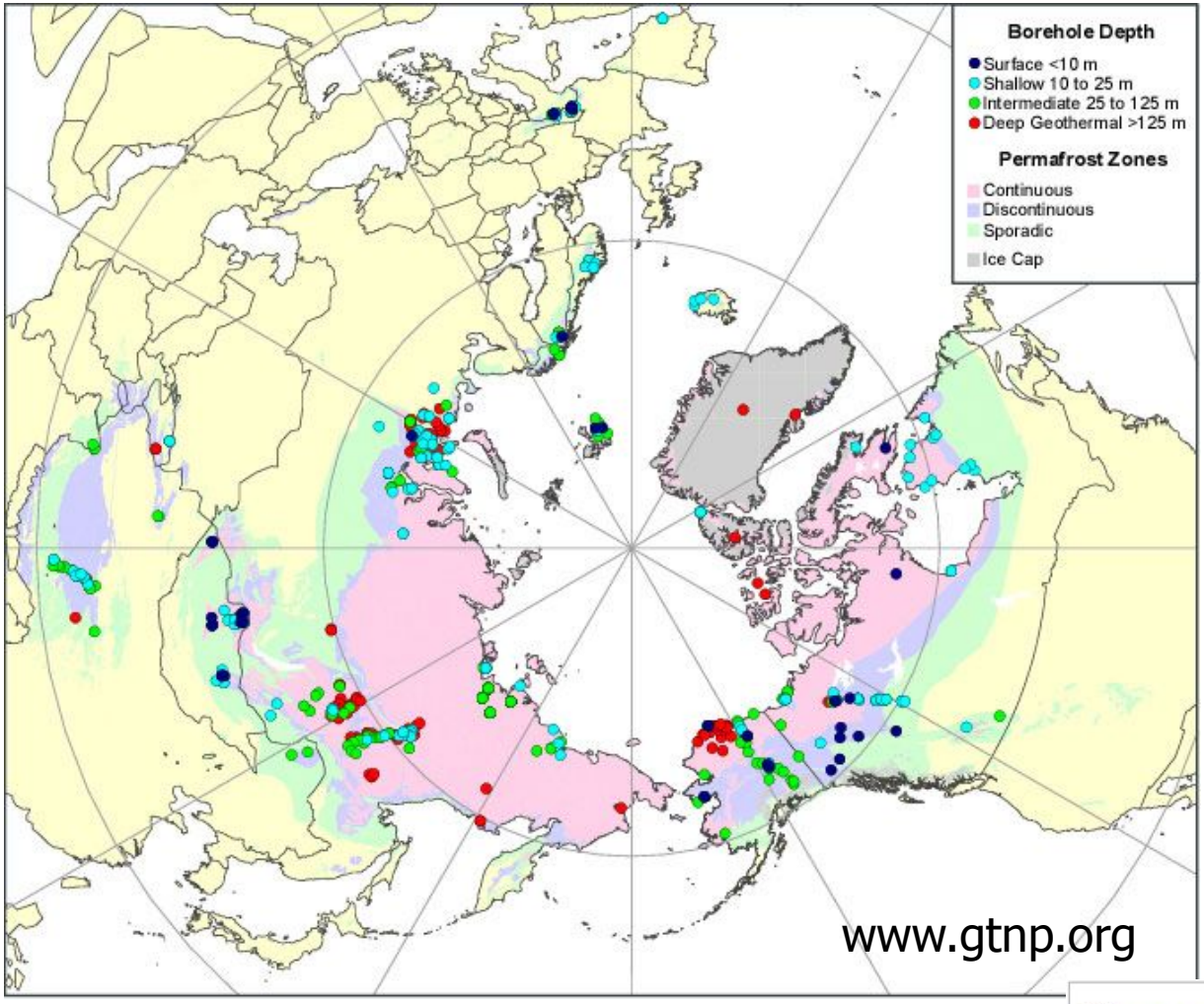
Permafrost extent



Changing Permafrost

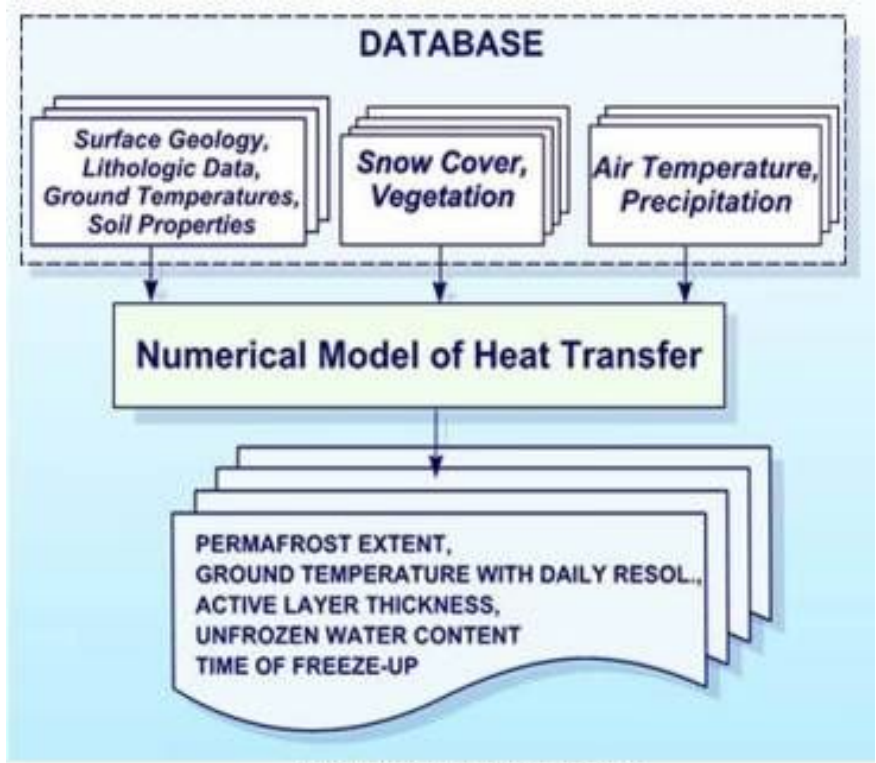
- Ground thermal regime changes due to
  - Changes in air temperature and/or precipitation
  - Surface disturbances
    - Clearing of vegetation
    - Removal of insulating organic layer
    - Forest fires
    - River channel migration
    - Shoreline erosion
- Response to climate change depends on variations in local seasonal factors
  - Snow cover
  - Vegetation
  - Surficial material
  - Moisture content
  - Drainage

Circumpolar ground networks



Parameters for modelling

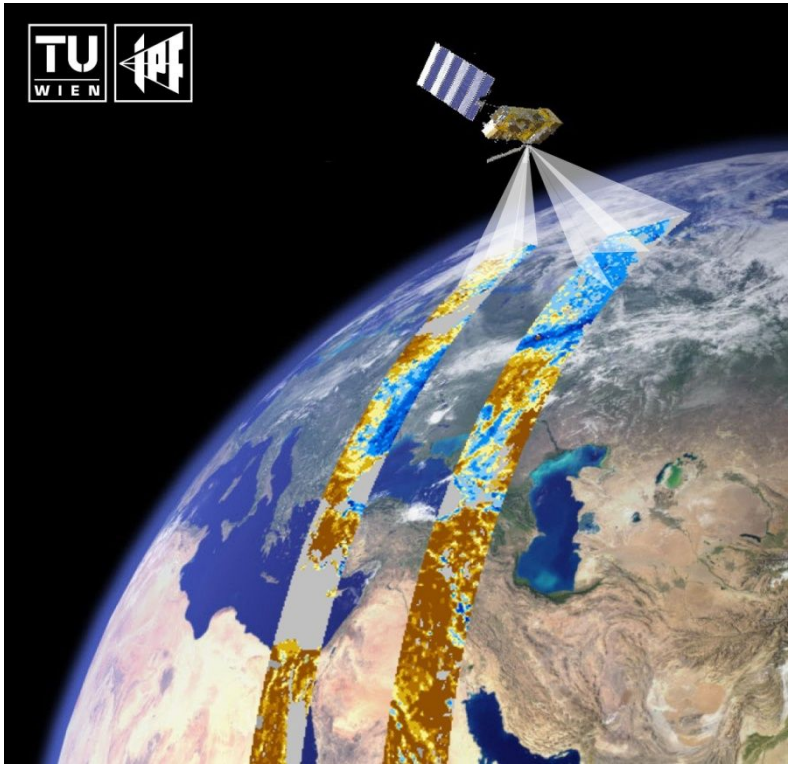
Example: GIPL



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



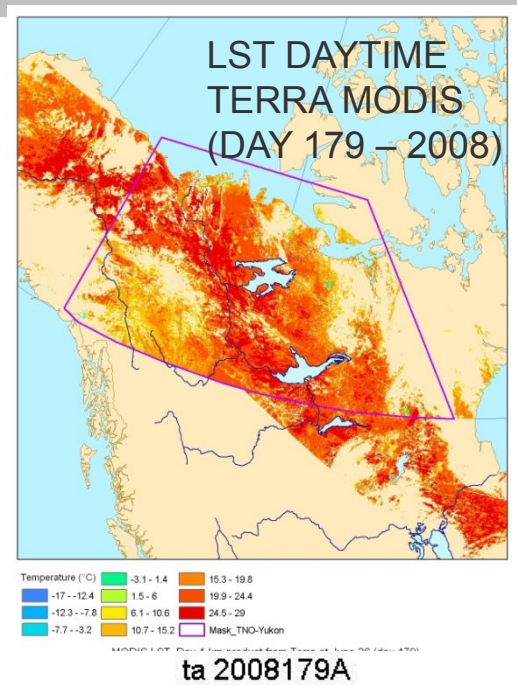
Parameters for modelling from Remote Sensing – pan-boreal/arctic scale

- 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, 1km



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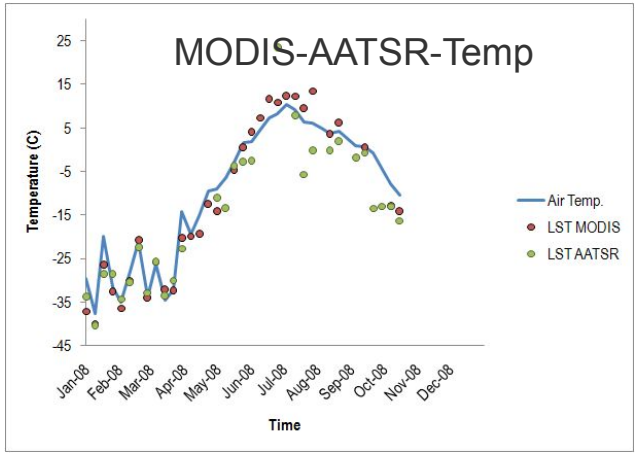
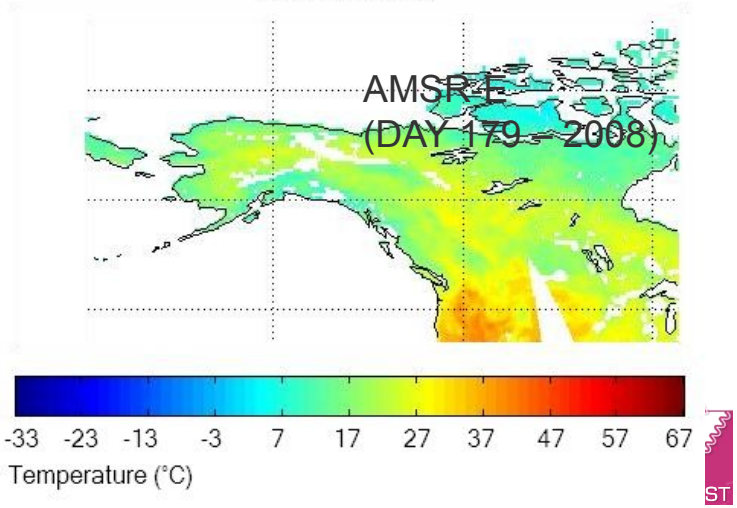


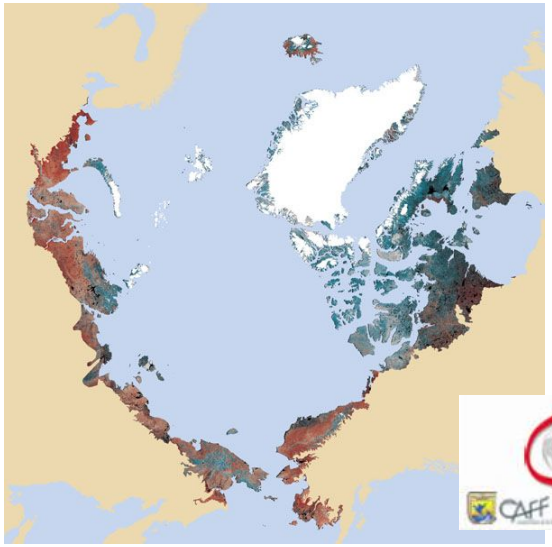


Pan-boreal/arctic scale

- 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?



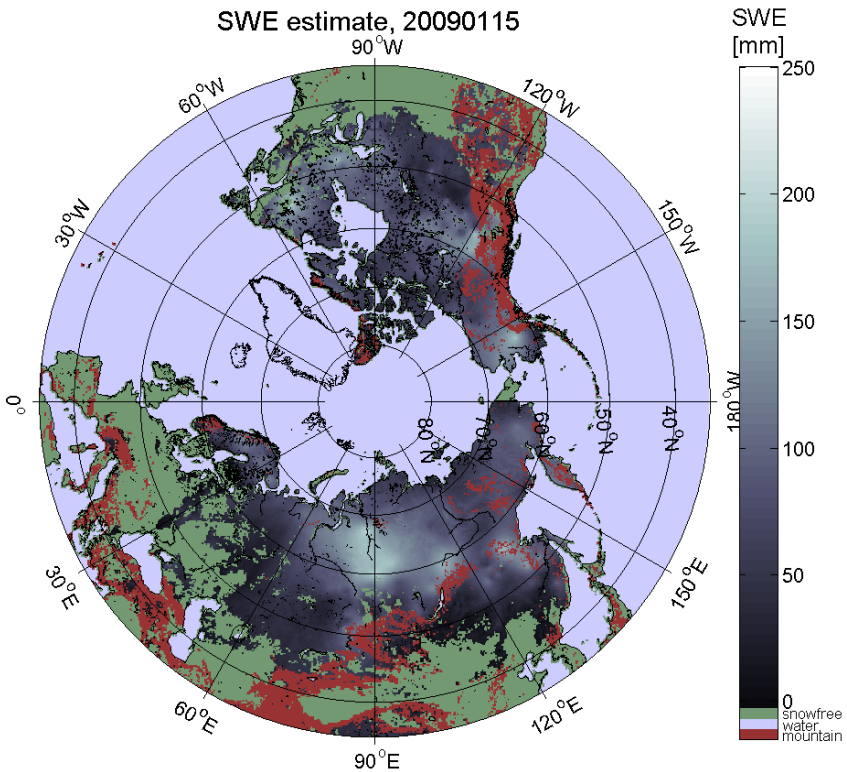
Pan-boreal/arctic scale

- 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:

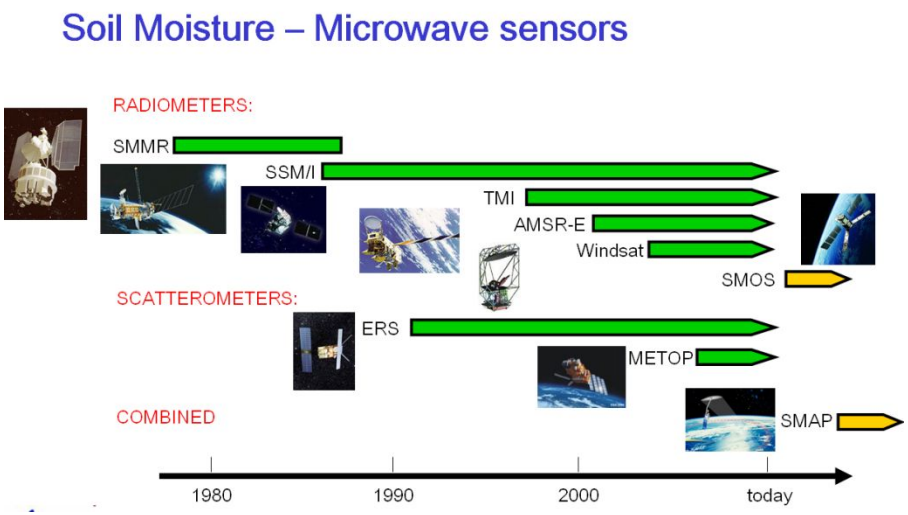
RMSE of 43.2 mm for Eurasia

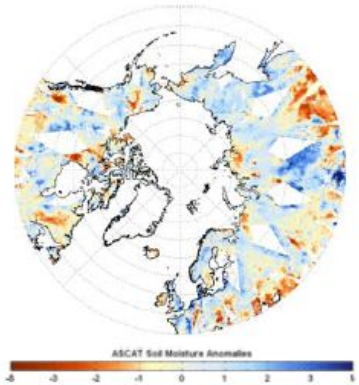
RMSE of 33.5 mm for Eurasia (SWE < 150mm)



Pan-boreal/arctic scale

- 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





Polar view of soil moisture anomalies from METOP ASCAT data of July 2007. 1-day composite (July 30th)

Pan-boreal/arctic scale

- Soil Moisture (incl. freeze/thaw)
  - From microwave sensors
  - Near surface soil moisture
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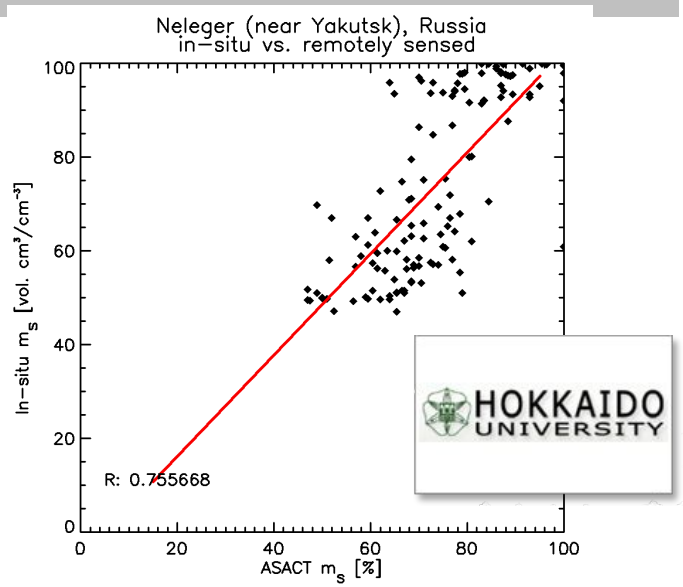
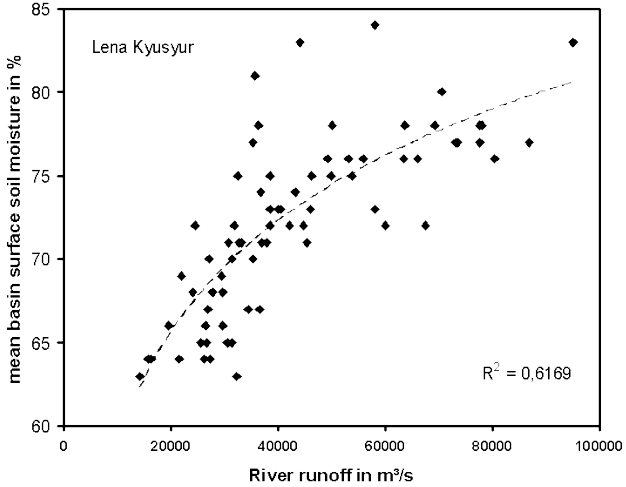
  - Combination of passive and active soil moisture products for a 30 year record

Ground data comparison: Central Yakutia

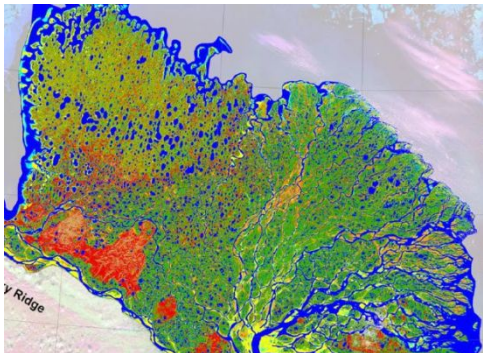




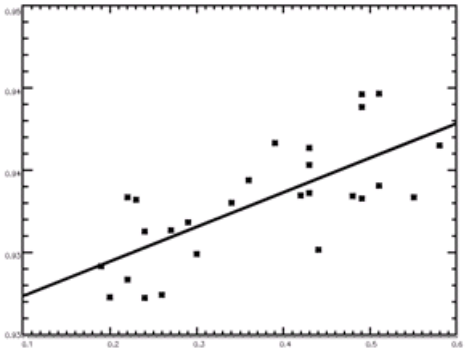
Comparison with summer discharge
Example: Lena basin

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



ENVISAT ASAR GM
Soil moisture in %

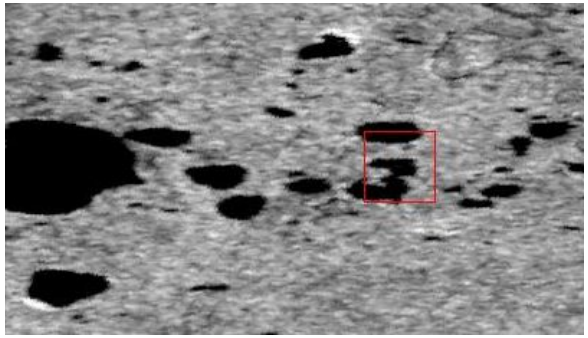
Type: Wet Tundra
ENVISAT ASAR GM
surface wetness 2005
(TU Wien method)
Heim et al. 2010

Regional scale

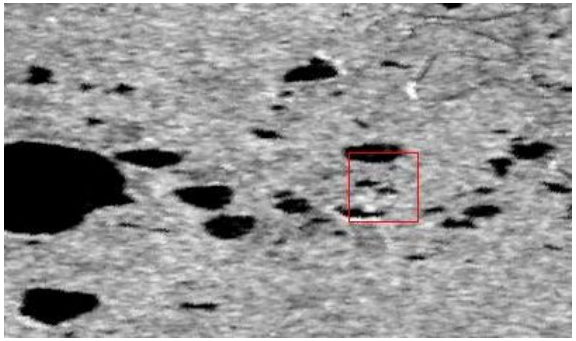
- Water bodies

- 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 then 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



25.07.2007

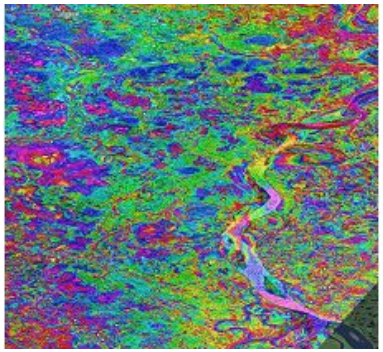


28.08.2007

5km

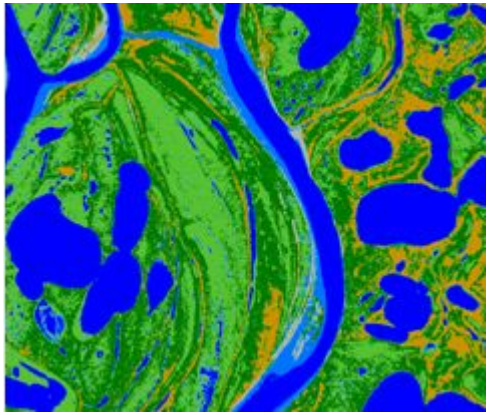
Local scale monitoring

- Terrain
  - Incl. Subsidence

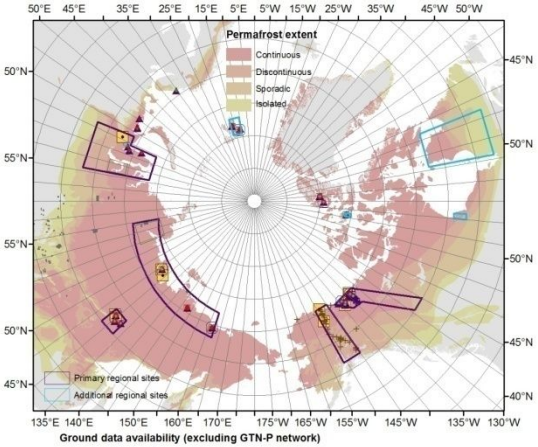


ERS2/ENVISAT interferogram (Mackenzie)

- Landcover
  - Lake dynamics
  - vegetation

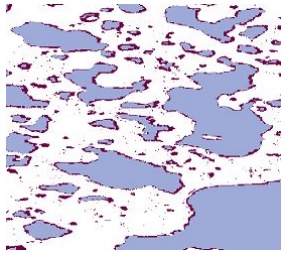


Rapid Eye – Lena Delta



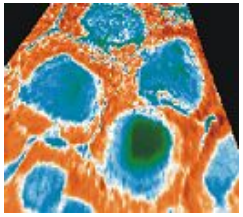
Panboreal/-arctic, regional, local

- Scaling
  - Lakes



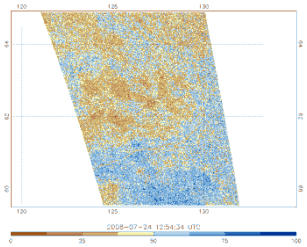
ASAR WS 150m
PALSAR FB 25m
Mackenzie Delta

  - Land Surface Temperature



AWI SPARC
Lena delta Observatory
Langer et al. 2010

  - Land cover
  - Soil moisture
  - And freeze/thaw

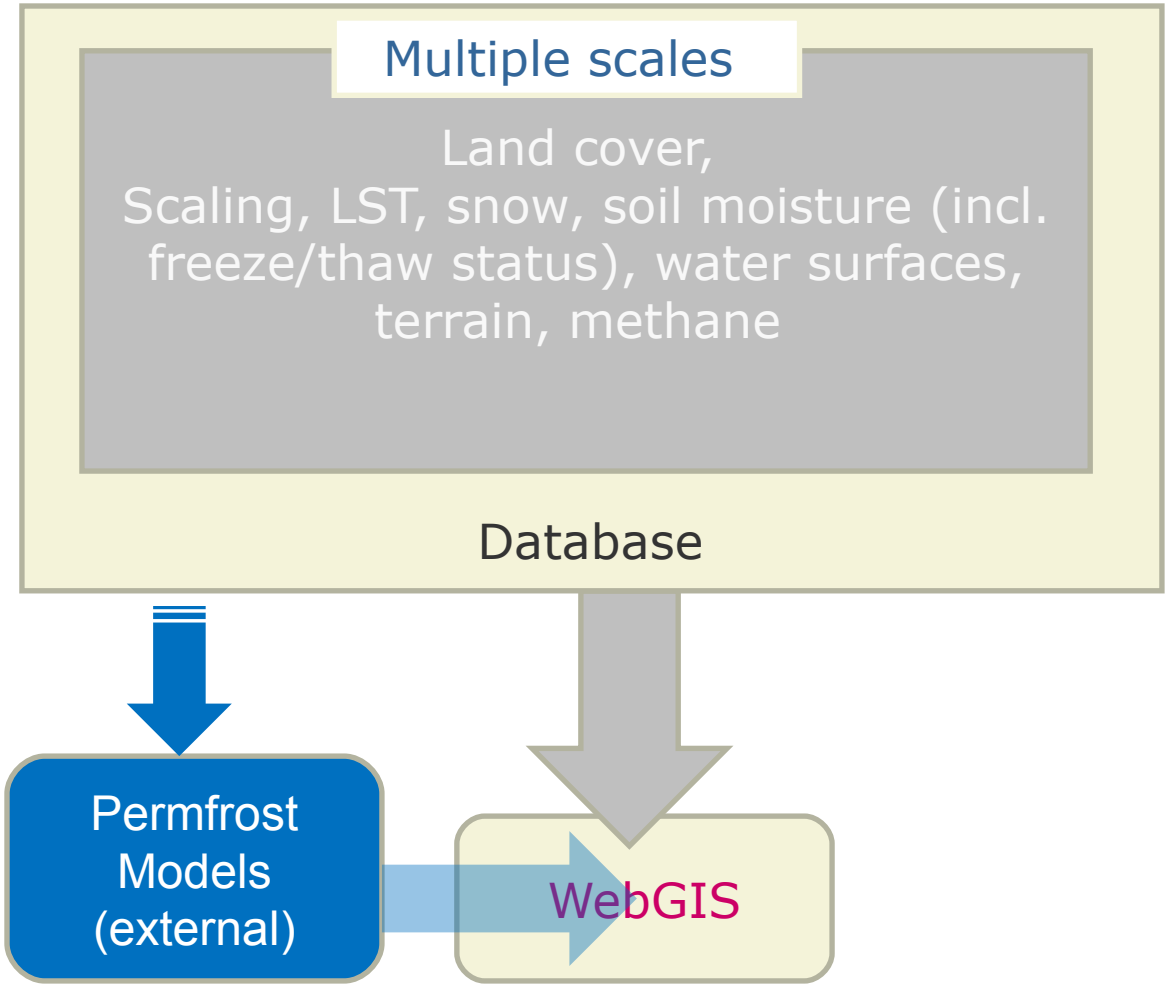


Regional soil moisture map
Yakustia

Information system - PEO

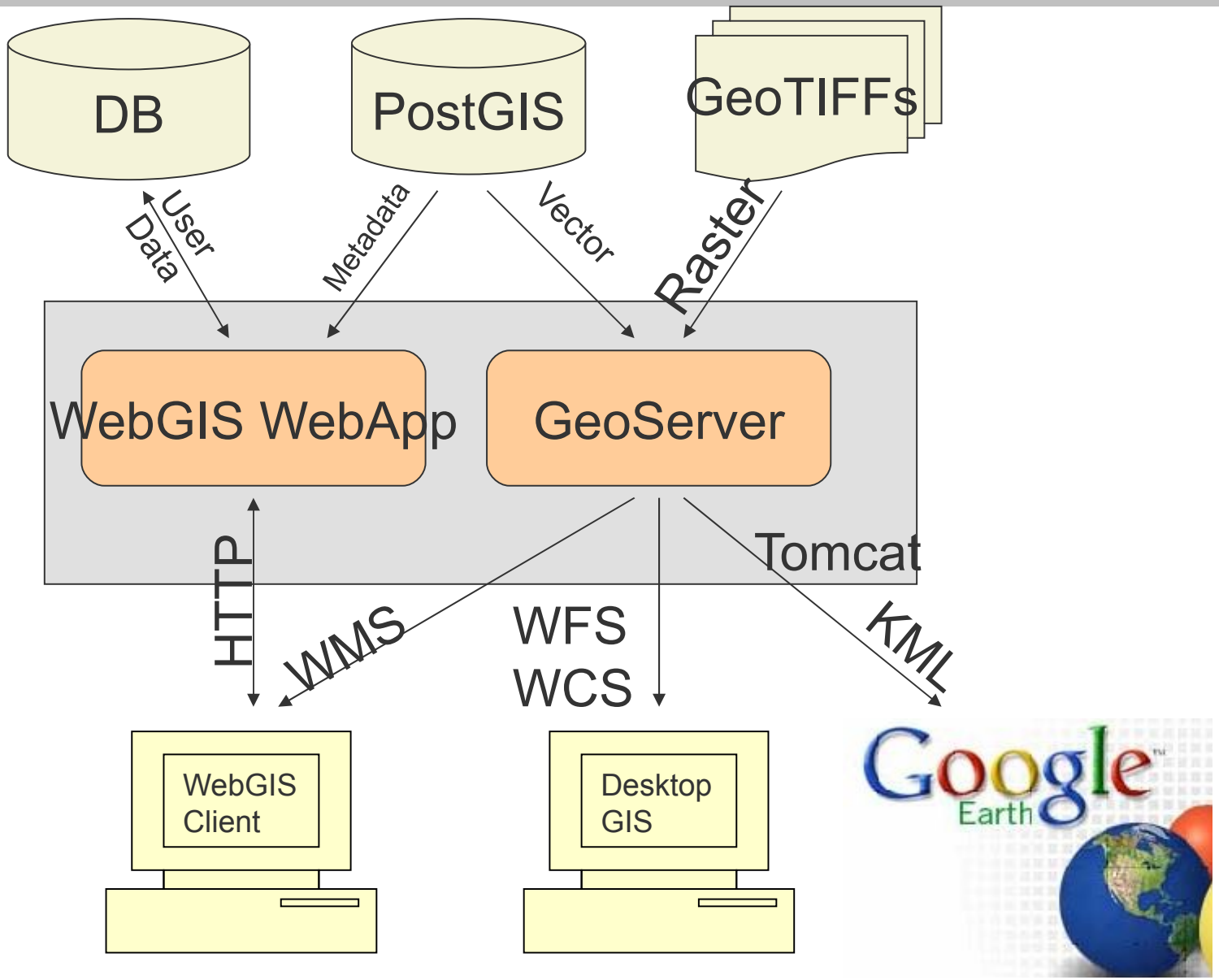
MERIS
MODIS
AVHRR

ASAR
PALSAR
TerraSAR-X
PRISM
Corona
Landsat
RapdEye
...



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

Web interface - Architecture



Information system

MERIS
MODIS
AVHRR

ASAR
PALSAR
TerraSAR-X
PRISM
Corona
Landsat
RapdEye
...

Multiple scales

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

Database

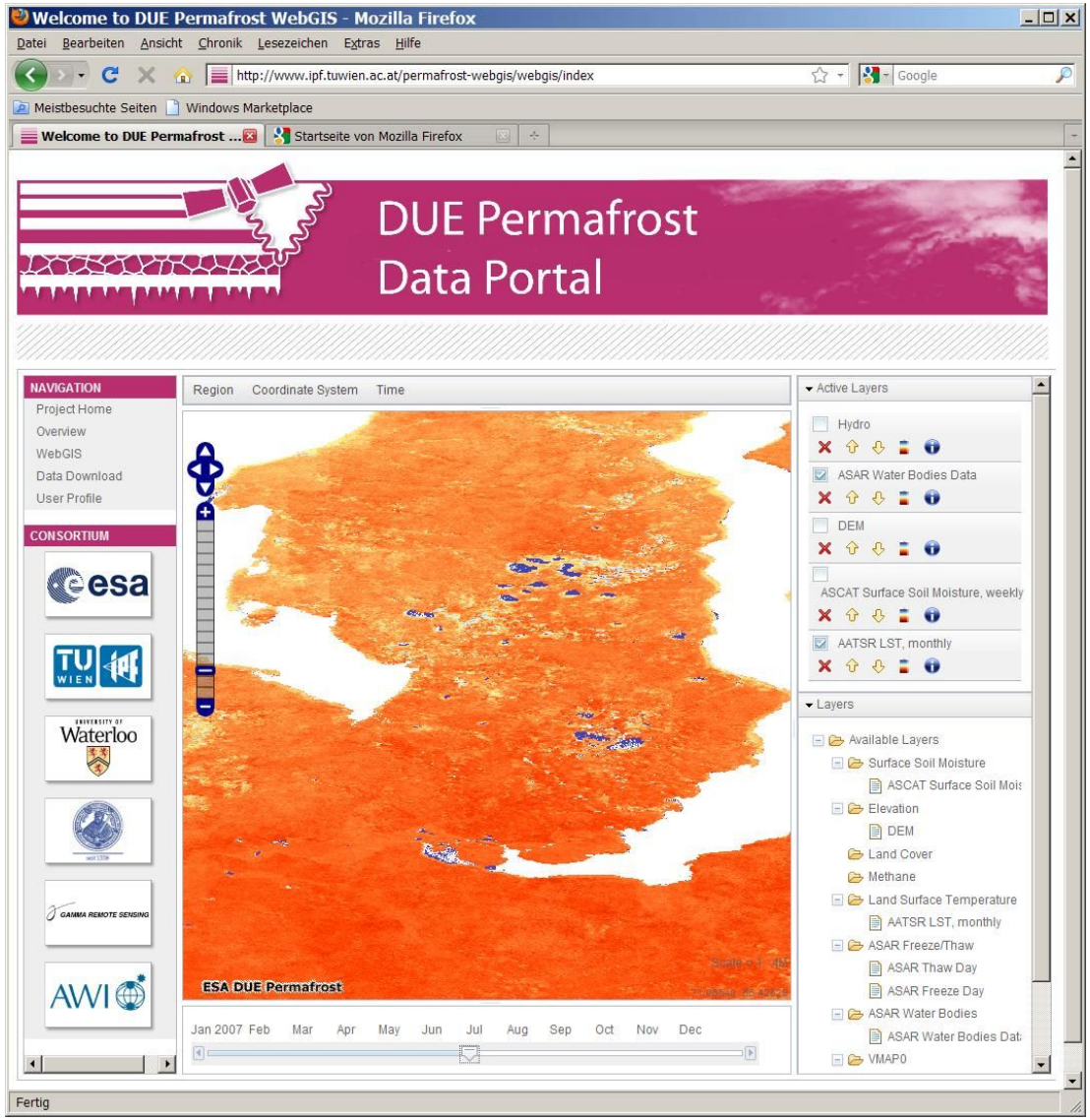
ENVISAT AATSR
ENVISAT MERIS
ENVISAT ASAR
MODIS
MetOp ASCAT
AMSR-E

Permafrost Models (external)

WebGIS

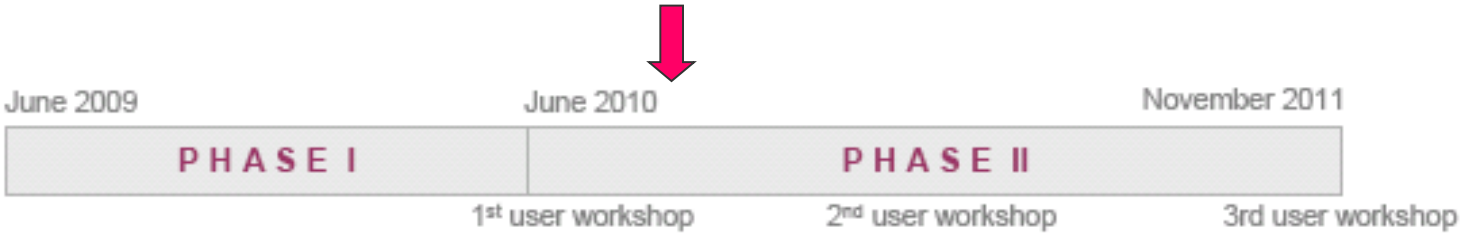
IPA Permafrost Information System

Data portal – beta version



Current status

- 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:
  - www.ipf.tuwien.ac.at/permafrost
  - annett.bartsch@ipf.tuwien.ac.at

Hertha Firnberg Program
Elise Richter Program
Austrian Science Fund