VIENNA UNIVERSITY OF TECHNOLOGY
INSTITUTE OF PHOTOGRAMMETRY AND REMOTE SENSING

MISAR
Multi-incidence ScanSAR data for biomass retrieval and soil moisture monitoring

SIBERIA - II
Multi-Sensor Concepts for Greenhouse Gas Accounting of Northern Eurasia

Monitoring of Siberian wetlands with satellite radar data – potential and limitations

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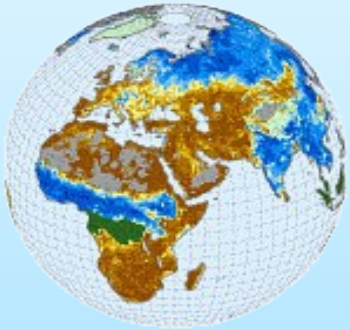
W3M Conference 22-25 September 2005

Microwave Remote Sensing Research at TU Vienna

http://www.ipf.tuwien.ac.at/radar

- Soil moisture



first global remotely sensed soil moisture data set

- Freeze/thawing conditions of soil surface
- Forest biomass
- Snow cover properties

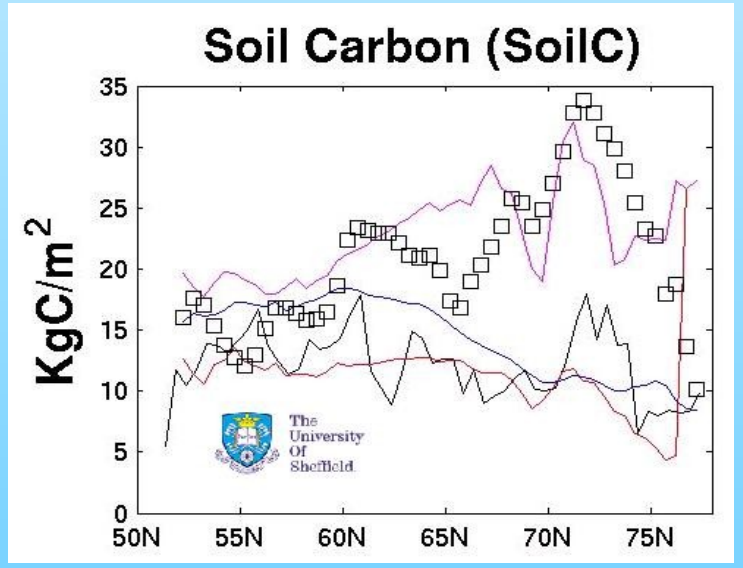
- Inundation and wetland mapping

Siberia II Project

http://www.siberia2.uni-jena.de

Multi-Sensor Concepts for Greenhouse Gas Accounting in Northern Eurasia

(5th Framework Program of the European Commission)



Wetlands & Water bodies within Siberia II
Objectives

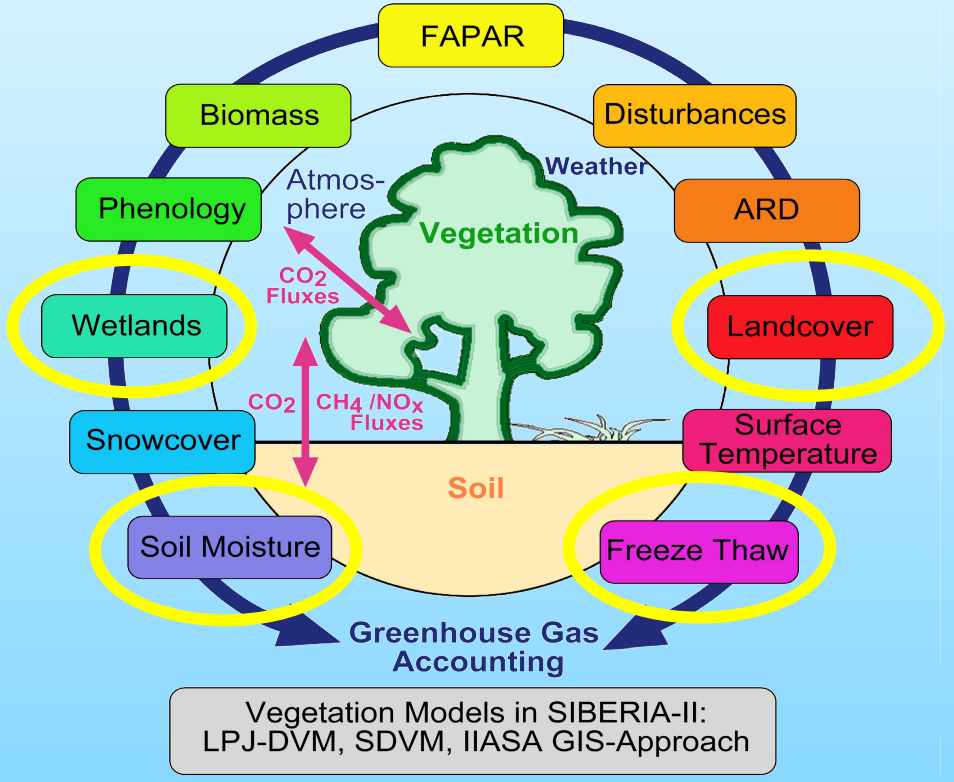
demonstrate the capabilities of radar remote sensing for the

extraction of natural inland wetlands

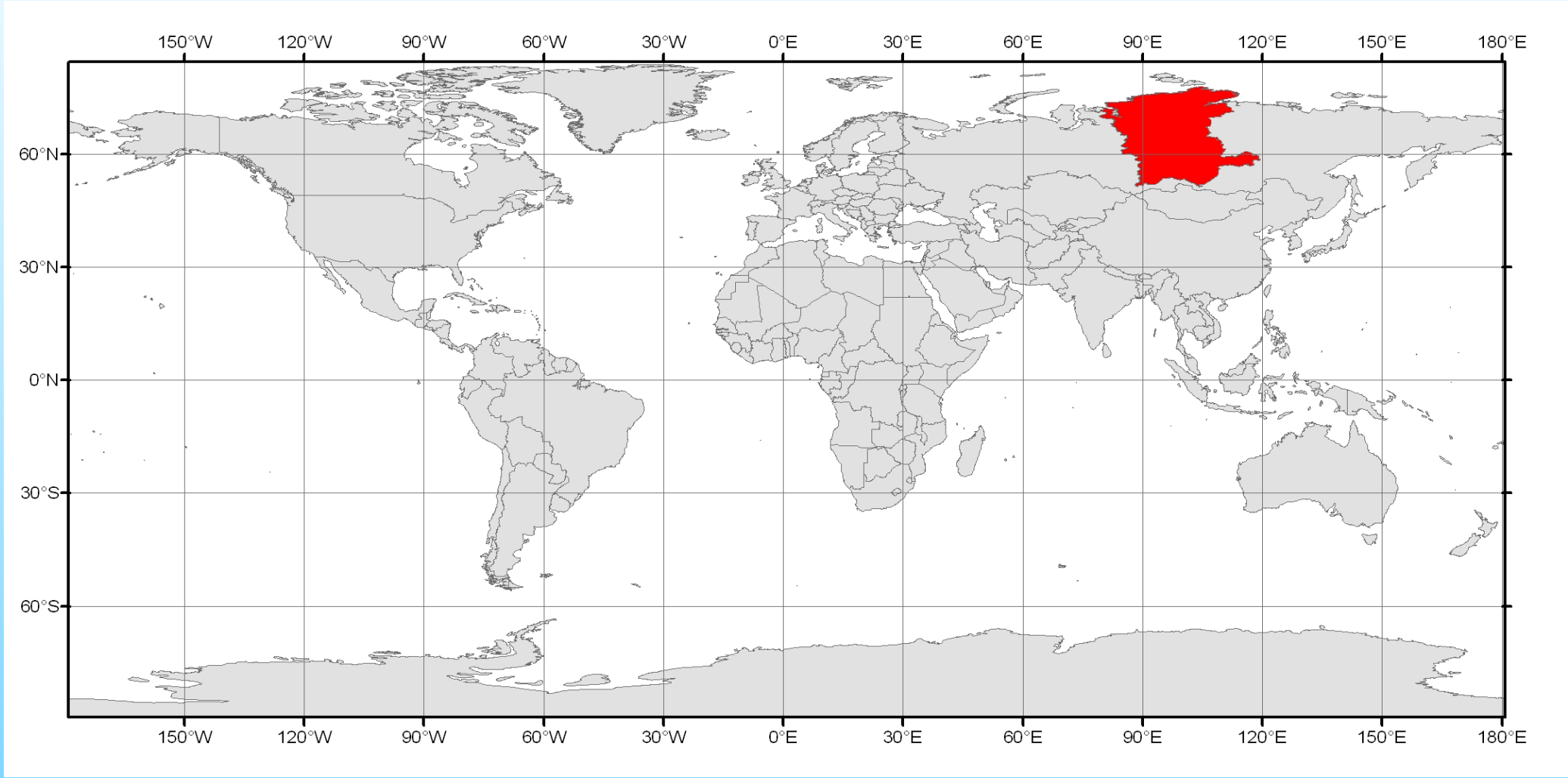
and to provide database

input for GHG accounting

in the Siberia II area

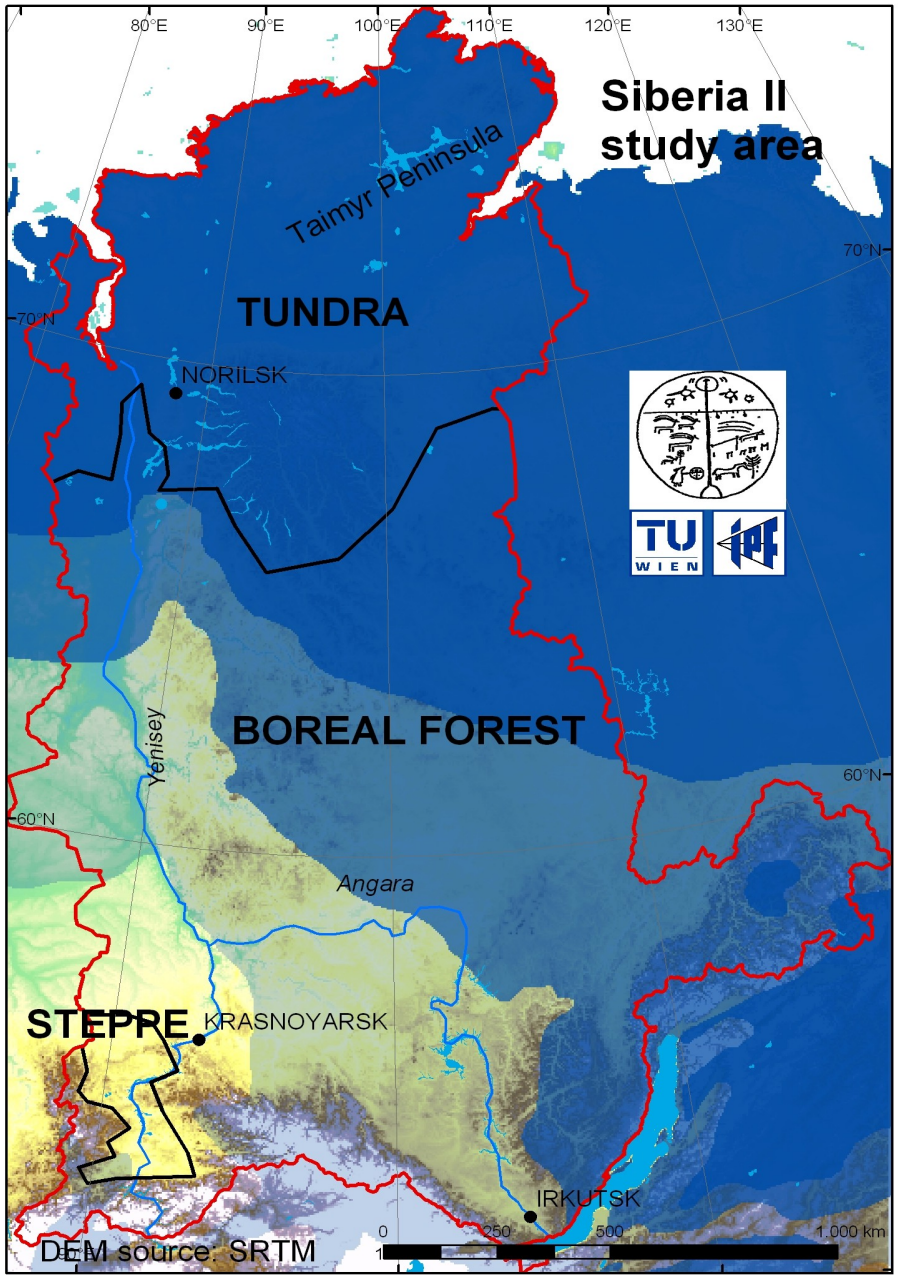


Siberia II study area



3 Mio km² (Poland 0.31 Mio km²)

Siberia II study area and wetland distribution



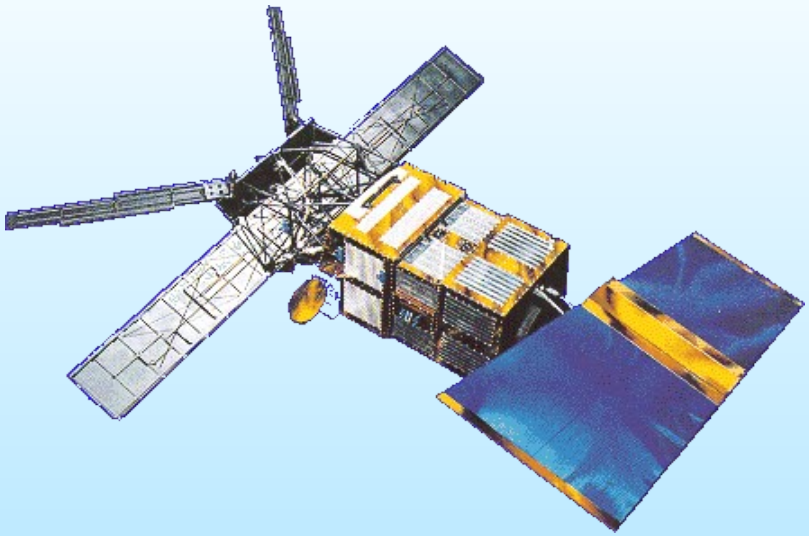
Permafrost

- 25
- 75
- 95

Investigated wetland types

Russian wetland classification scheme	*Ramsar* *code*	*description*	*trophic condition*
(sub-) arctic mineral sedge mires	Vt	tundra wetlands	mesotrophic
bogs of southern tundra and northern taiga	U	non-forested peatlands & fens	minerotrophic-oligotrophic
bogs with pools and ridges of northern and middle taiga	U	non-forested peatlands	ombro-oligotrophic
permanent lakes	O/Q	permanent freshwater and saline lakes (> 8 ha)	

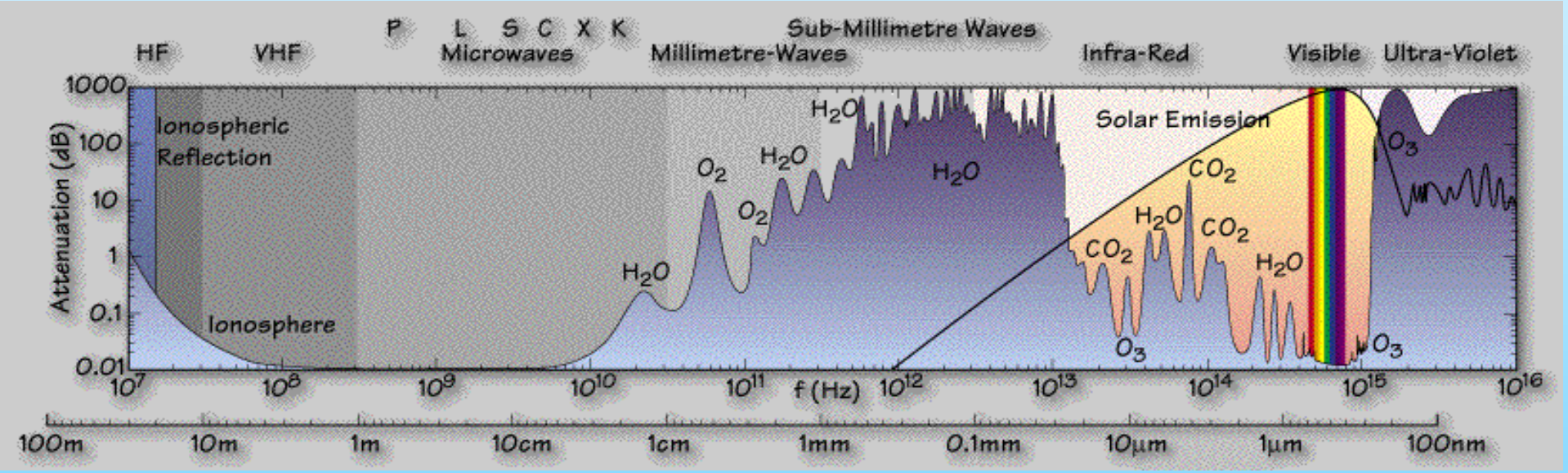
Challenges



- large area
- heterogeneous land cover
- diverse spatial & temporal wetland patterns
- capturing details + generalization

Sensor features

- Spatial resolution (large areas – single objects, patterns)
- Temporal resolution (monitoring capabilities, processes)
- Spectral features (range, number of bands)



Electromagnetic Spectrum

- Sensor life time


2005
2006
2007
2008
2009
2010
2011
2012
2013
2014
2015
2016
2017
2018
2019
CRYOSAT
Monitor-E
CALIPSO
CloudSat
TopSat
Resurs DK
ALOS
TerraSAR-X
METOP-1-3
Baumanets
BelKA
BISSAT
FY-3A-G
IGPM
Kanopus-Vulkan
TerraSAR-L
GOCE
RISAT-1
NMP EO-3 GIFTS
NPP
Elektro-L
HJ-1A-C
HY-1B
COSMO - SkyMed
OCEANSAT-2
RapidEye
SMOS
THEOS
OCO
SAOCOM 1A, 1B
ADM-Aeolus
SAC-F, E
Glory
SSR-1,2
DSCOVR
ESA Future Missions
PICARD
GOSAT
Pleiades 1, 2
GCOM-W, C
Hyperspectral Mission
MEGHA-TROPIQUES
Swarm
GPM
NPOESS-1-6
HYDROS
SAOCOM-2B 1,2
CURRENT/APPROVED
PLANNED/CONSIDERED

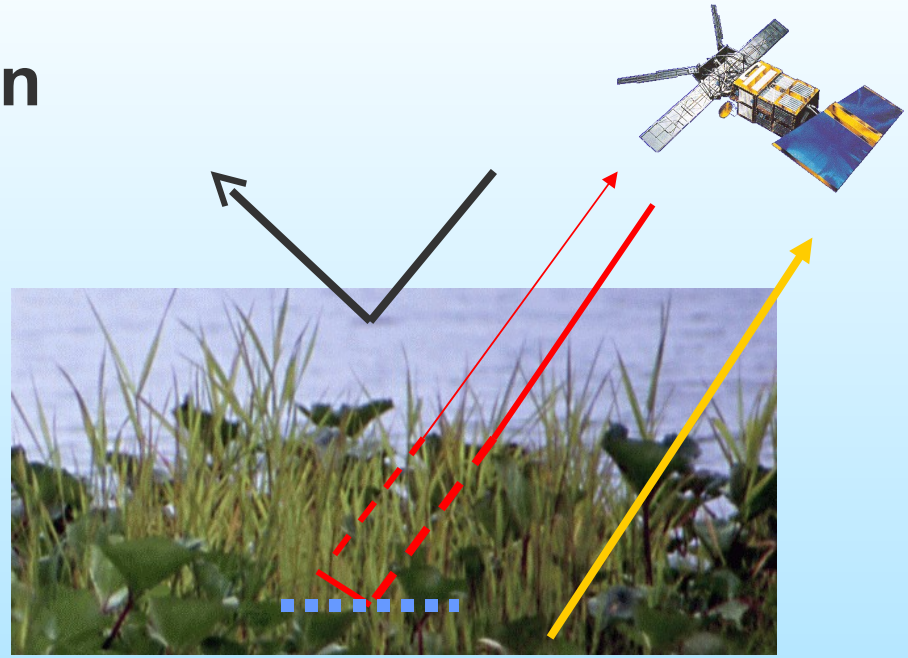
Sensor types

- Optical
  – straight forward processing, high spatial resolution, but impacted by weather and high detail requires high storage and processing capacities

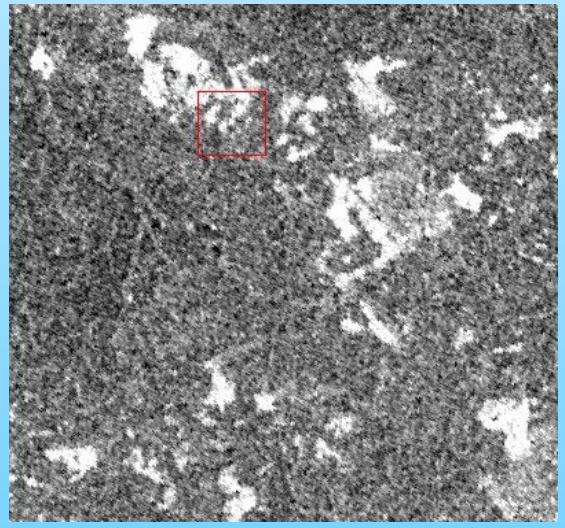
- Microwave
  – weather independent
  Important for wetland detection: sensitive to dielectric properties, vegetation structure and surface roughness

Radar signal & surface interaction

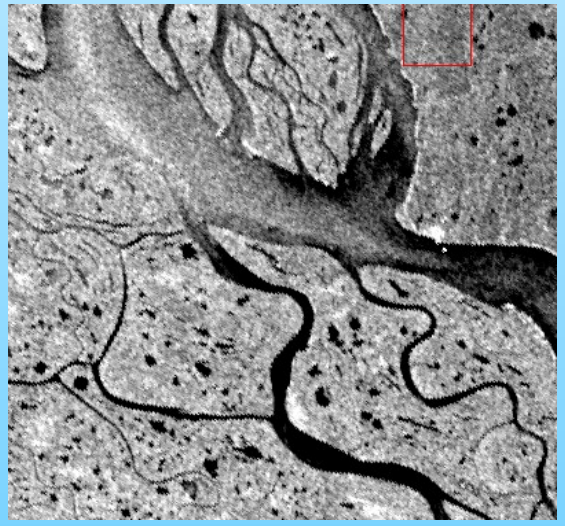
- hydrological conditions
- surface roughness
- vegetation structure

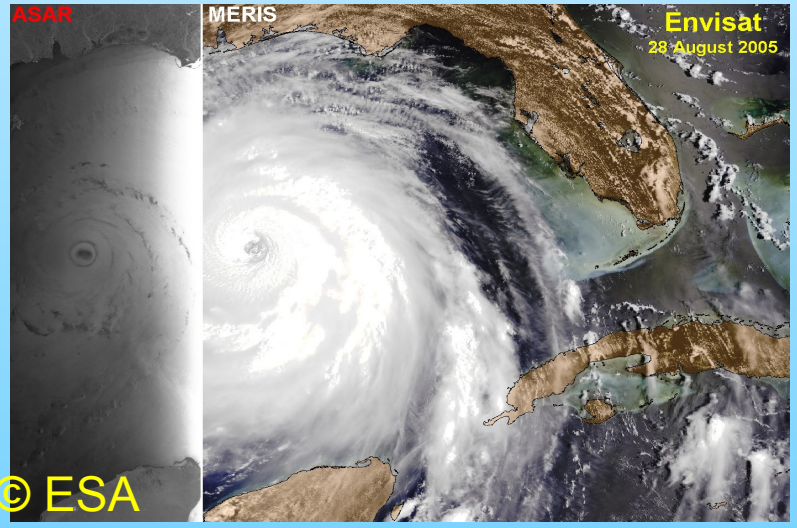


Boreal peatlands



Yenisey estuary





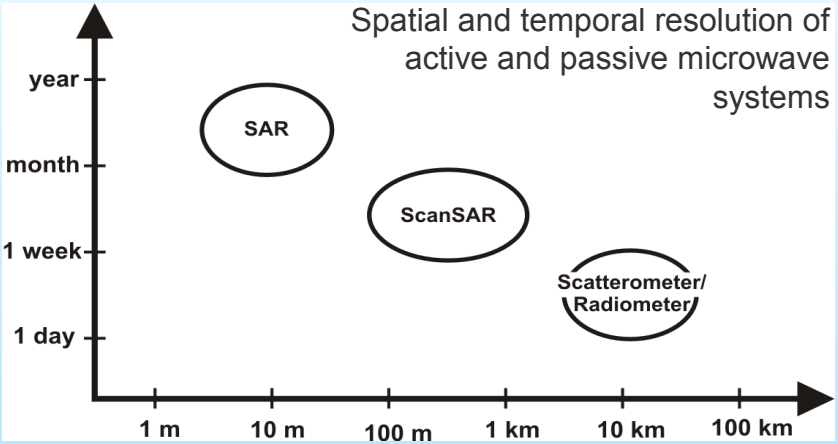
Past and current spaceborne active microwave missions

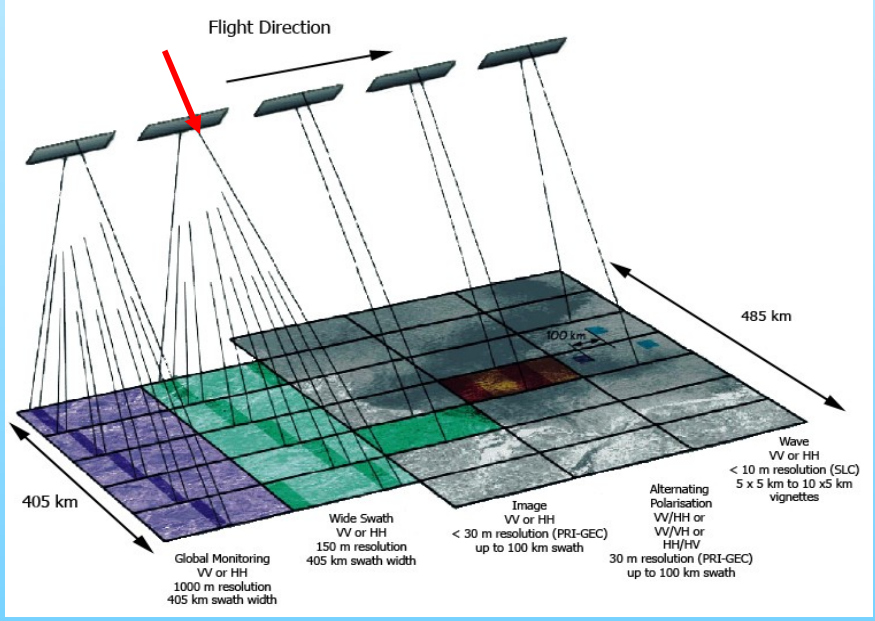
	Seasat 1978	SIR-A 1981	SIR-B 1984	SIR-C 1990	ERS-1/2 1991-99 1995-*	JERS-1 1992-1998	Radarsat I 1995-2005	ENVISAT 2002-*
Frequency (GHz) Band	1.275 L	1.278 L	1.282 L	1.25, 5.3, 9.6 L, C, X	5.3 C	1.275 L	5.3 C	5.3 C
Polarisation	HH	HH	HH	quad L+C, XVV	VV	HH	HH	VV+HH
Incidence Angle	23°	50°	15° - 55°	15° - 55°	23°	35°	20° - 59°	20° - 50°
Spatial Resolution (m)	25	40	17 – 58	10 – 60	30	18	10 – 100	30/150/1000
Repeat Cycle (days)	3/17	nil	nil	nil	3/35/176	44	24	17/35

* still in operation

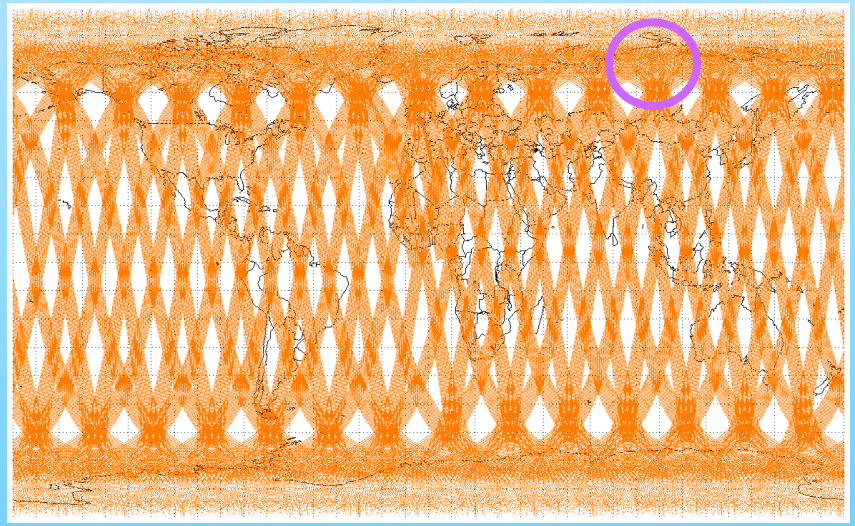
ENVISAT ASAR wide swath

- ScanSAR system
- C- Band (~ 5.6 cm)
- 150 m resolution in WS mode
- revisit intervals 3 - 5 days
- incidence angles 15 – 45 °

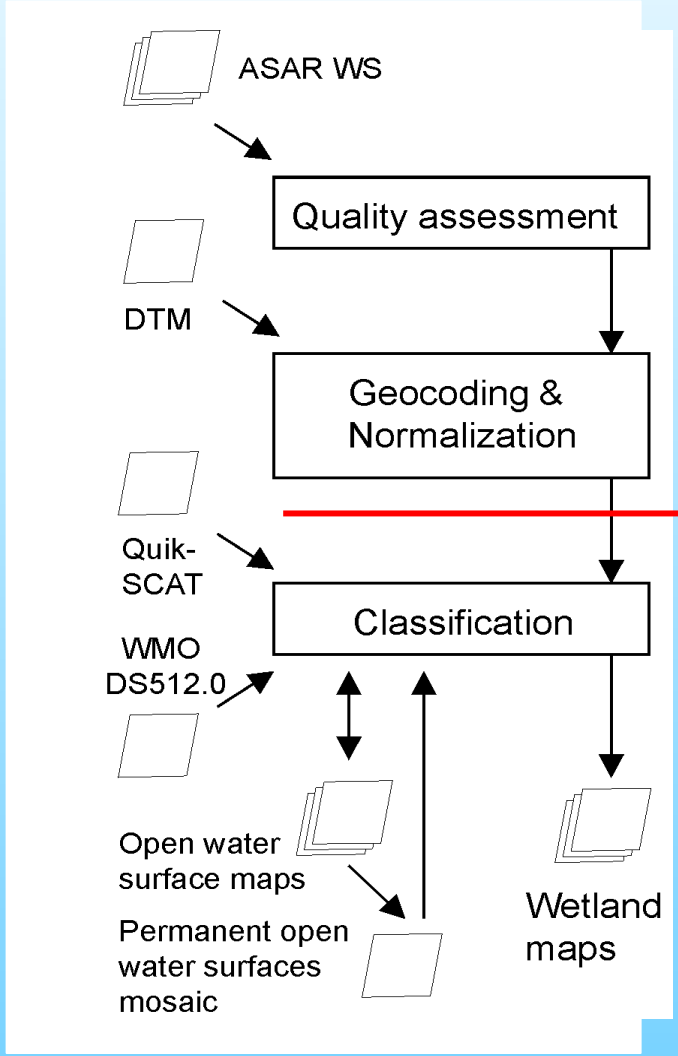




Daily Global Coverage



Methodology – ASAR WS processing



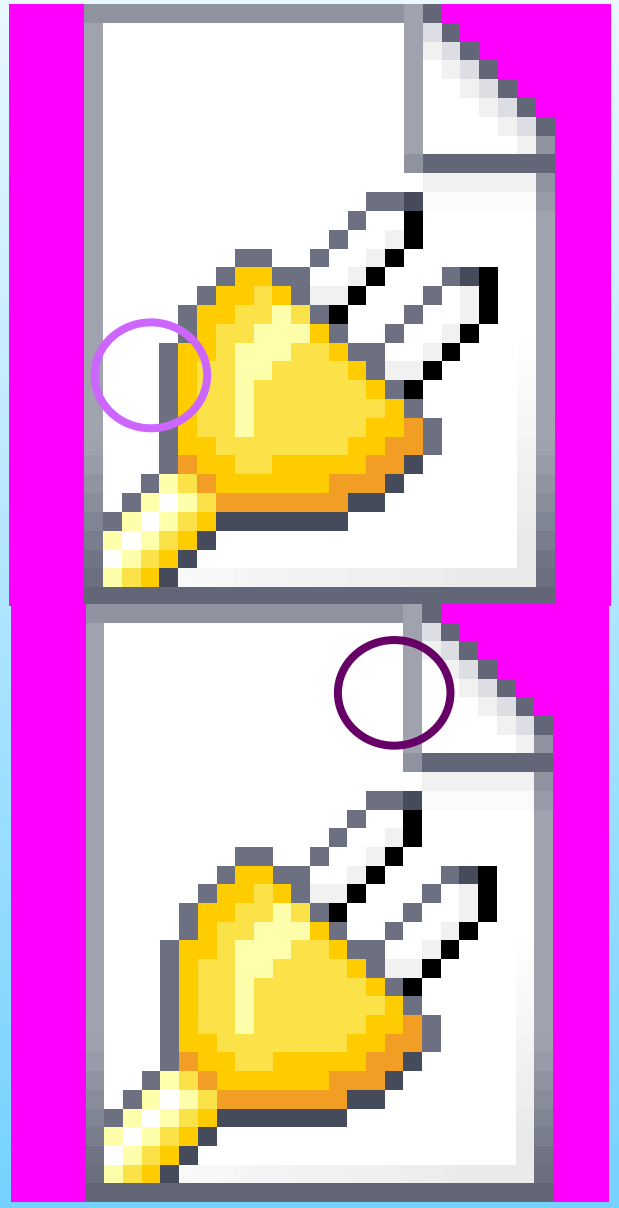
Input – ca. 500 scenes for 2 years

Geocoding/Normalization based on SRTM data for region below 60° latitude, all other on ellipsoid

Pre-classification of data for hydro-period using results from

- QuikSCAT: start of snowmelt and duration
- WMO (World Meteorological Organisation) data

ASAR WS time series



Subarctic

70 -72° N

Boreal

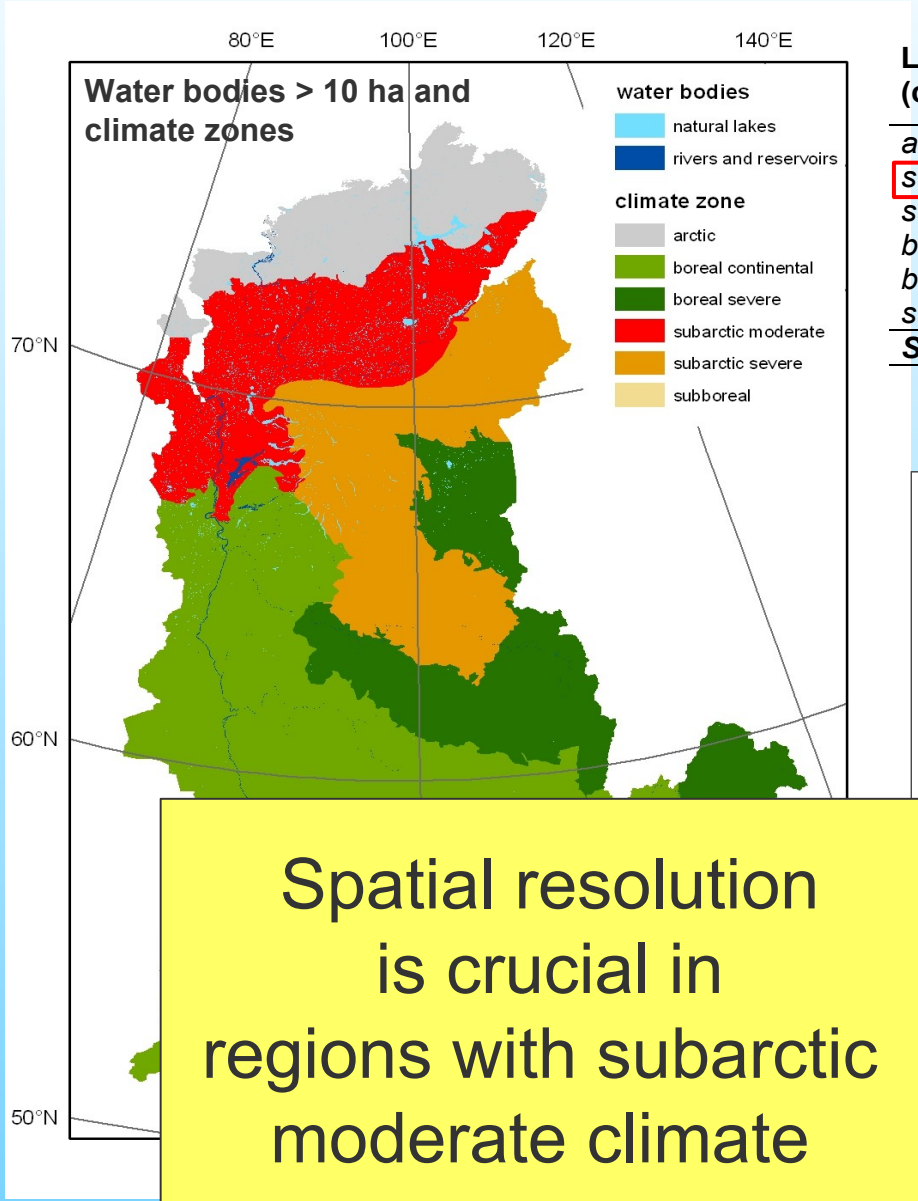
60 -62° N

Average monthly backscatter

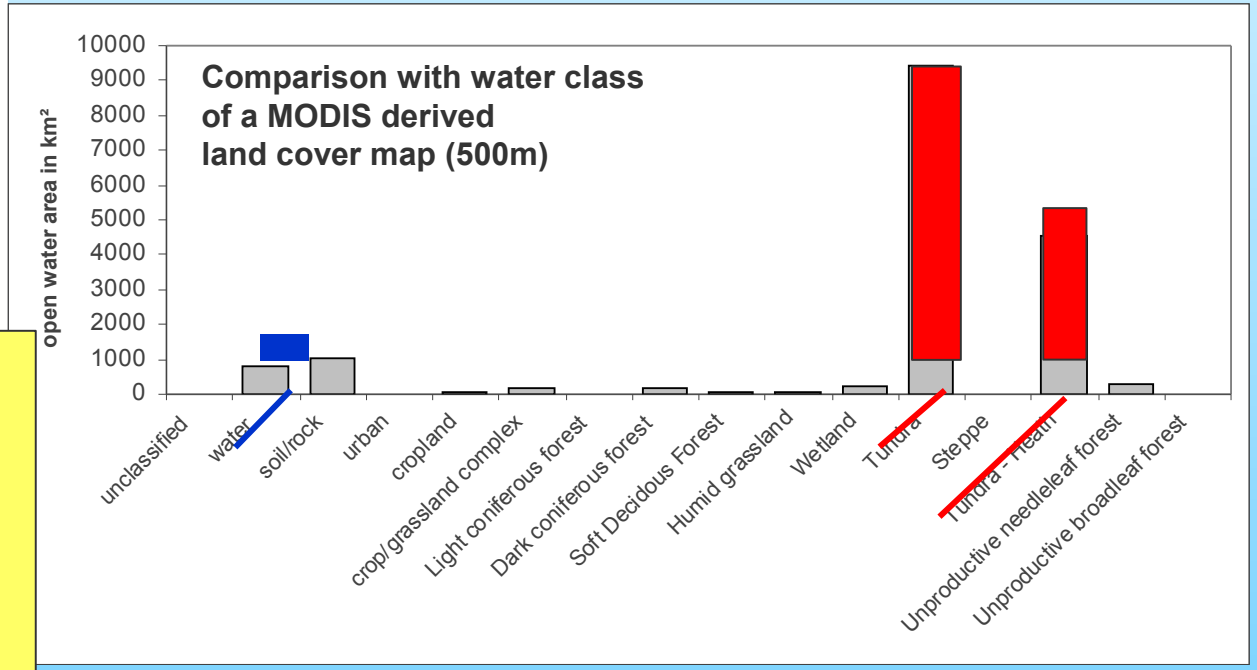
Peatlands show similar backscatter like forest except for events of

- flooding
- increased soil moisture

Permanent open water surfaces



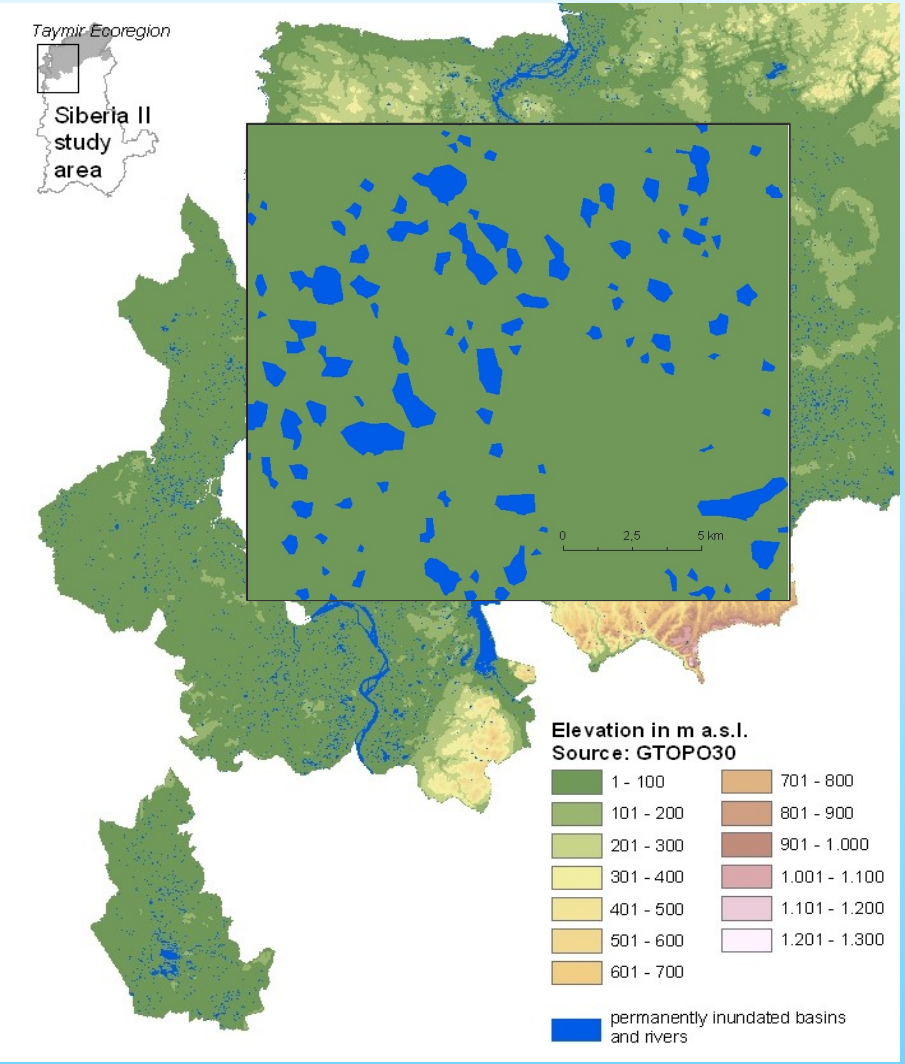
Landscape group (climatic zone)	water bodies amount in %	natural lakes		
		amount in %	sum area km²	number
arctic	3.95	2.33	5254	3921
subarctic moderate	8.44	5.16	20383	35900
subarctic severe	1.05	0.44	1989	2376
boreal continental	1.37	0.16	2469	4383
boreal severe	0.37	0.22	1010	1901
subboreal (steppe)	4.30	0.71	413	437
Sum	19.00	9.00	31518	48918

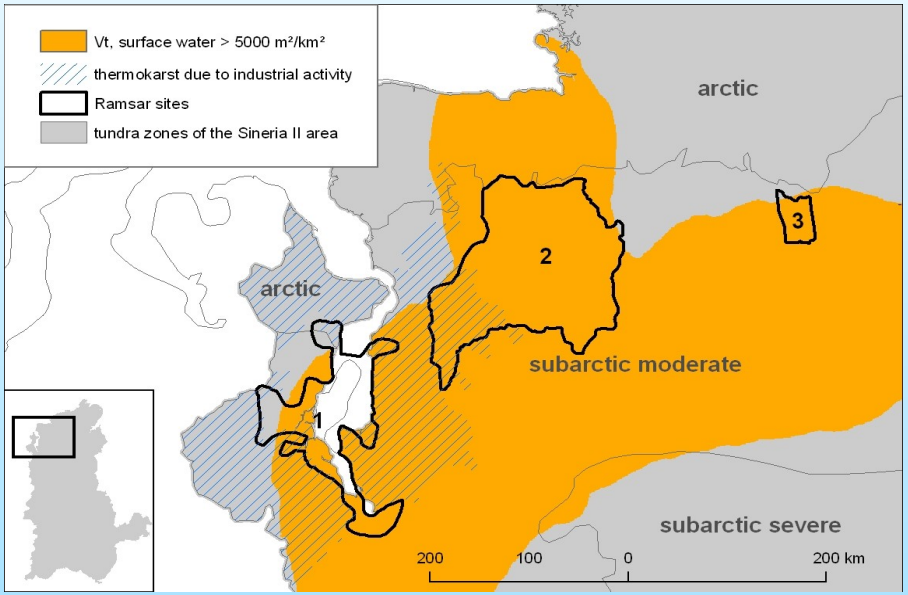


Spatial resolution is crucial in regions with subarctic moderate climate

Tundra wetlands from permanent features

Western Taymir Lowlands, tundra biome



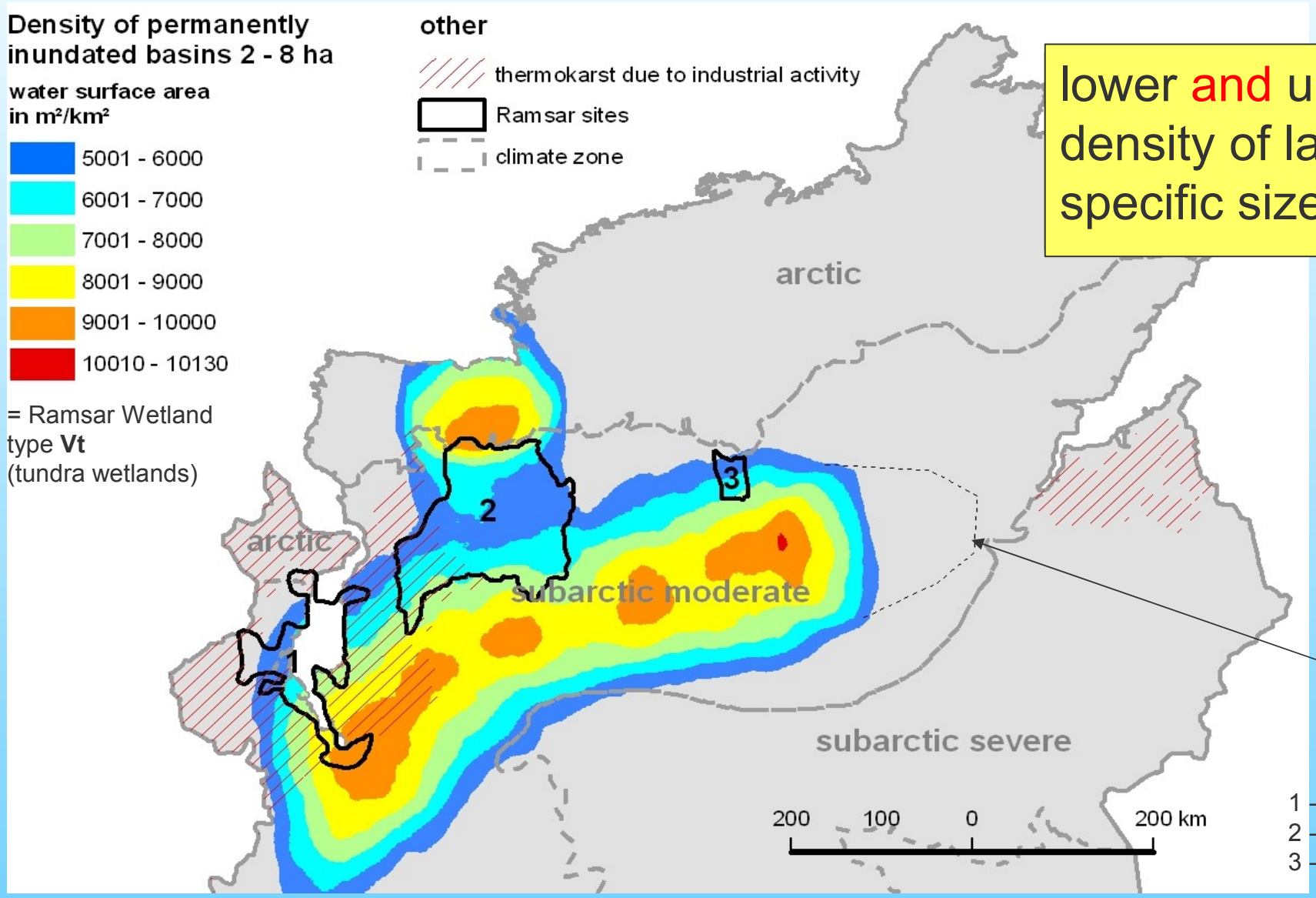


400,000 km² (7% of study area) are covered by **tundra wetlands** and not identified by previous land cover classifications (such as MODIS with 500 m resolution)

Approximately 45,000 t/day of CH_4 are emitted from the Taymir tundra wetlands during the growing season

(estimate is based on values from Zelenev (1996) for moist tundra, Gal'chenko *et al*. (2001) and Zimov *et al.* (1997) for tundra lakes)

Tundra wetlands – Ramsar sites



lower and upper limit of density of lakes with specific size

approximated extent where no ASAR WS data are available

1 - Brekhovsky islands
2 - Pura and Moritto river
3 - Gorbita

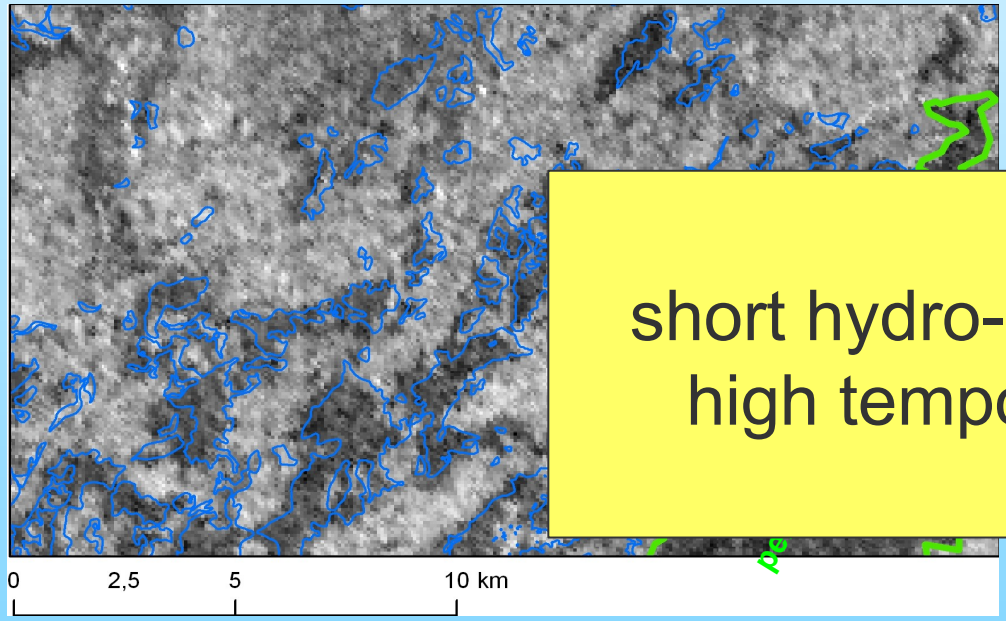
Inundation and soil moisture dynamics

JAN — permanent water bodies — DEC

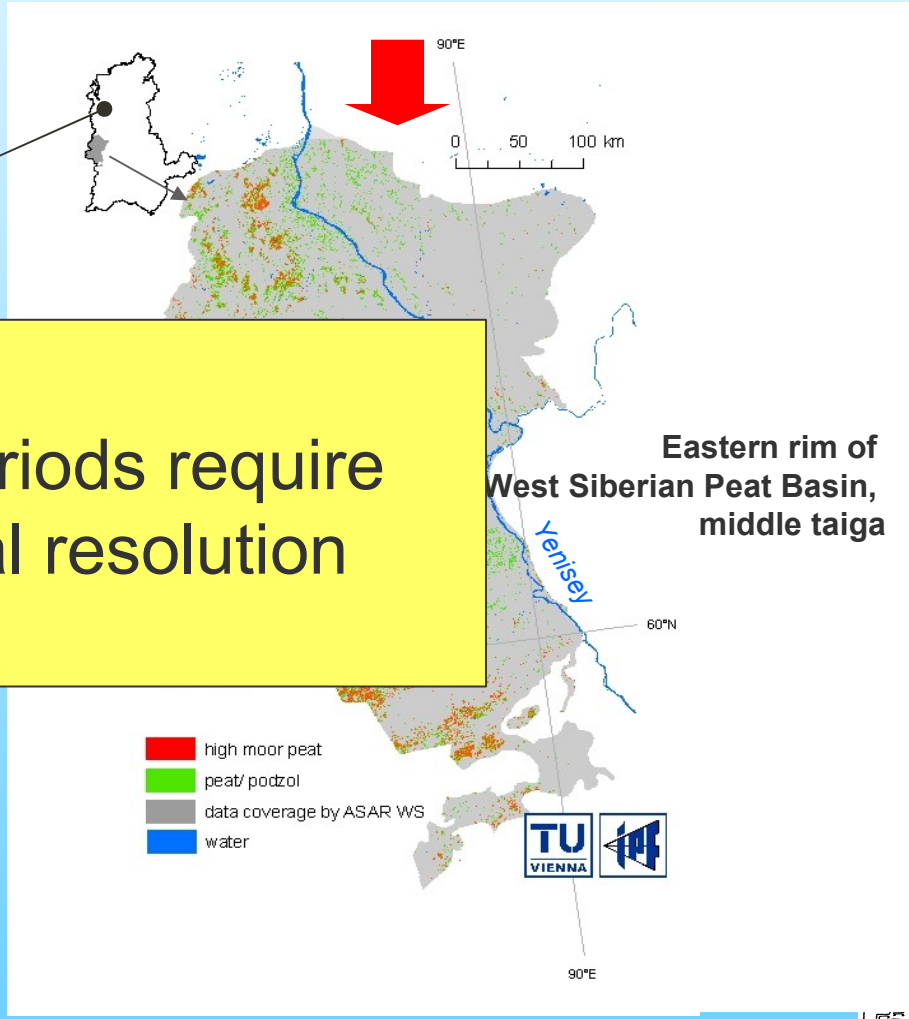
snow melt & inundation

stable summer conditions

change of dielectric properties



short hydro-periods require high temporal resolution



Eastern rim of West Siberian Peat Basin, middle taiga

Inventory site Norilsk: background: ASAR WS image from 6th of June 2003 – *dark areas indicate inundation.* Blue outlined area are open bogs from inventory data, green outline corresponds to a reservoir shoreline

Discussion & Summary

ENVISAT ASAR Wide Swath mode:

- ✓ can capture features down to 2 ha
  - ? Is this sufficient for other applications?
- ✓ offers good temporal resolution
  - ! Only when wide swath mode is given priority over global mode
- ✓ sensitive to wetland relevant parameters
  - ! still poorly understood because of lack of in situ measurements
- ✓ acquires data since 2003 and until 2007
  - 😐 Not much, but better than average

Can be used in subarctic and boreal environments to

- ✓ map tundra wetlands and their properties
- ✓ identify open peatlands and distinguish different types
- ✓ analyze seasonal inundation patterns
- ✓ monitor intra-annual changes

Acknowledgements

- Siberia II project: shared-cost action financed through the 5th Framework Program of the European Commission, Generic Activity 7.2: Development of generic Earth Observation Technologies (EVG1-CT-2001-00048).
- MISAR project: financed by the Austrian Science Fund (FWF; P16515-N10).
- ASAR WSM data are available by courtesy of ESA.

Radar remote sensing special issue in 2006

"Satellite-based radar – developing tools for wetlands management"
Aquatic Conservation: Marine and Freshwater Ecosystems.

Editors: M Finlayson[1], A Rosenqvist[2] & J Lowry[3]

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(from special session at INTECOL 2004)