Landscape-level remote sensing for upscaling of land cover, AGB and above ground carbon fluxes in the Lena River Delta (RU)

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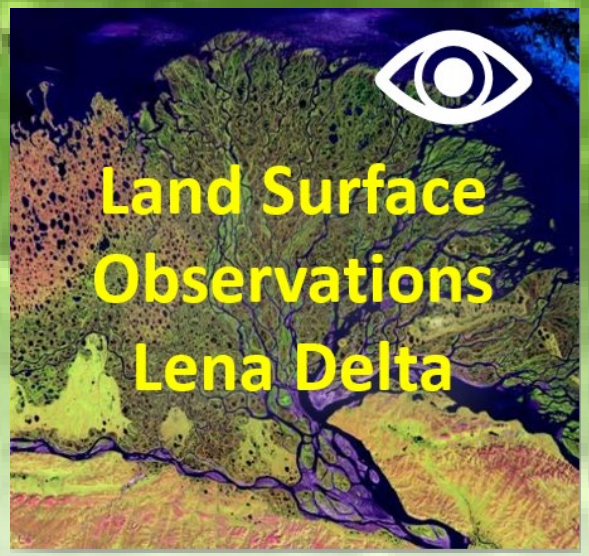
[3]*B.Geos, Korneuburg, Austria,* [4]*Austrian Polar Research Institute, Austria*



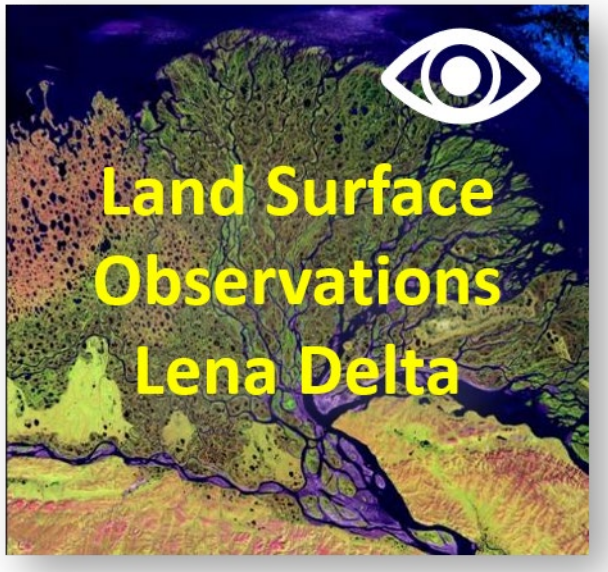
Birgit Heim

ALFRED-WEGENER-INSTITUT
HELMHOLTZ-ZENTRUM FÜR POLAR- UND MEERESFORSCHUNG

EGU21-13497 CR7.2
Wed, 28 Apr,
15:30–17:00 (CEST)

Land Surface Observations for Siberian tundra landscapes

Land surface observations are highly important to develop algorithms, assess and improve the quality of Earth Observation (EO) products.



- Long-term Russian-German Cooperation in the Lena Delta, Siberia
- Time-Lapse Camera monitoring
- Elementary Sampling Units ESUs for Land Cover applications
- Supportive ecological data on vegetation

Validity of EO products at high latitudes ?

Unknown accuracy of Earth Observation (EO) Landcover for Arctic and Siberian tundra landscapes

ESA CCI Land Cover products @ Lena Delta

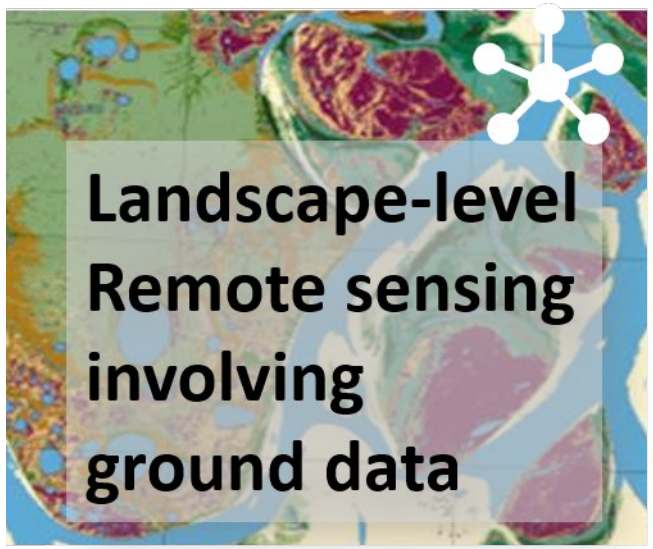
MODIS EO products @ Lena Delta

ESA GlobPermafrost regional @ Lena Delta

Elementary Sampling Unit Principle

Landscape-level EO applications

Experimental applications of Earth Observation (EO) Landcover for Arctic and Siberian tundra landscapes



- MODIS vegetation indices
- 'Seeing' Snow melt from MODIS Earth Observation
- Landcover from Sentinel-2 Earth Observation
- Upscaling AGB and C-pool ages from S2 Earth Observation

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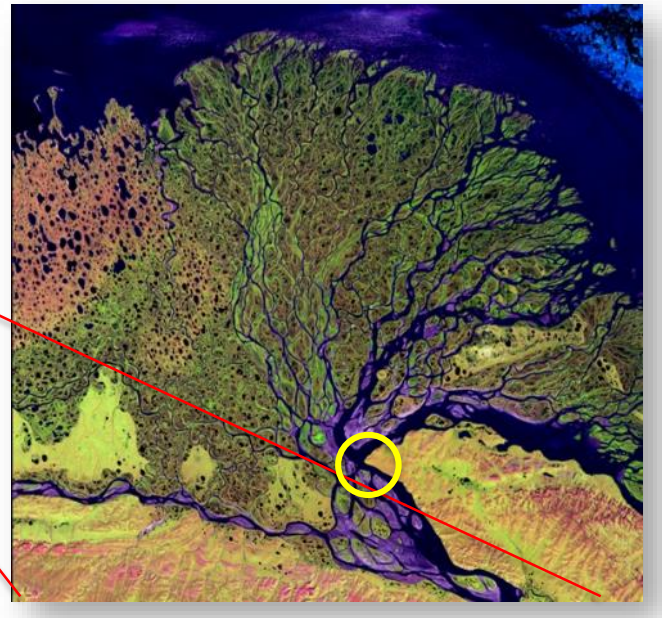
Long-term Russian-German Land Surface Observations, Lena Delta, Siberia

Lena-Delta 20 Jahre Russisch-Deutsche Forschung

Дельта Лены 20 лет Российско-Германских Исследований

a long-term cooperation enables our Russian-German terrestrial and marine research activities in the Laptev Sea region.



‘Seeing’ snow, snow melt and vegetation from the ground

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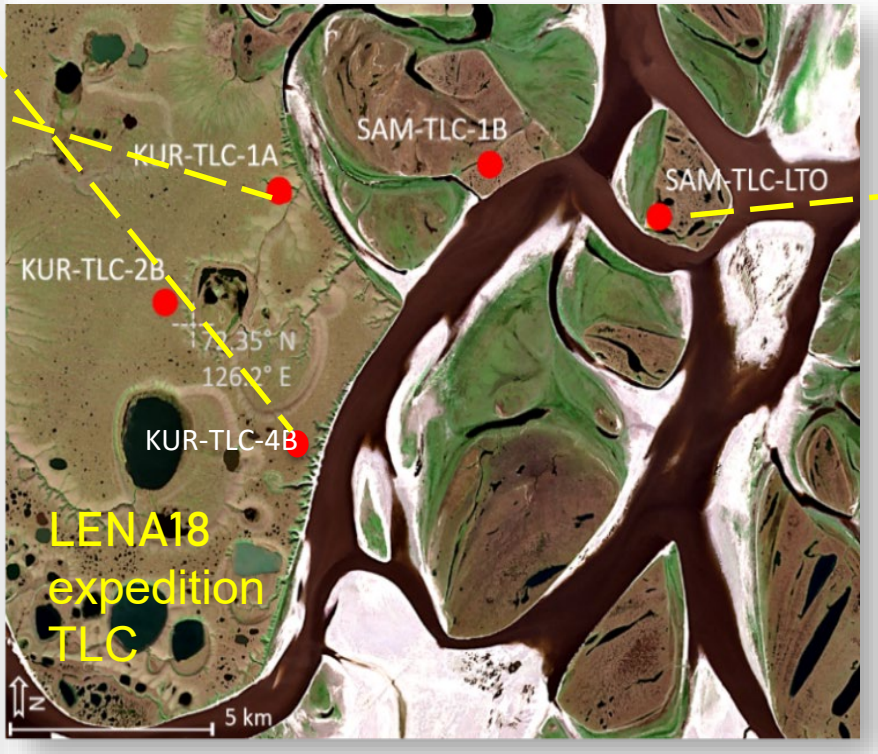
Time Lapse Camera Monitoring Lena River Delta – set up

Monitoring and ground truthing
using time lapse cameras TLC



Time Lapse Cameras TLC

Long Term Observation LTO-Samoylov

‘Seeing’ snow, snow melt and vegetation from the ground

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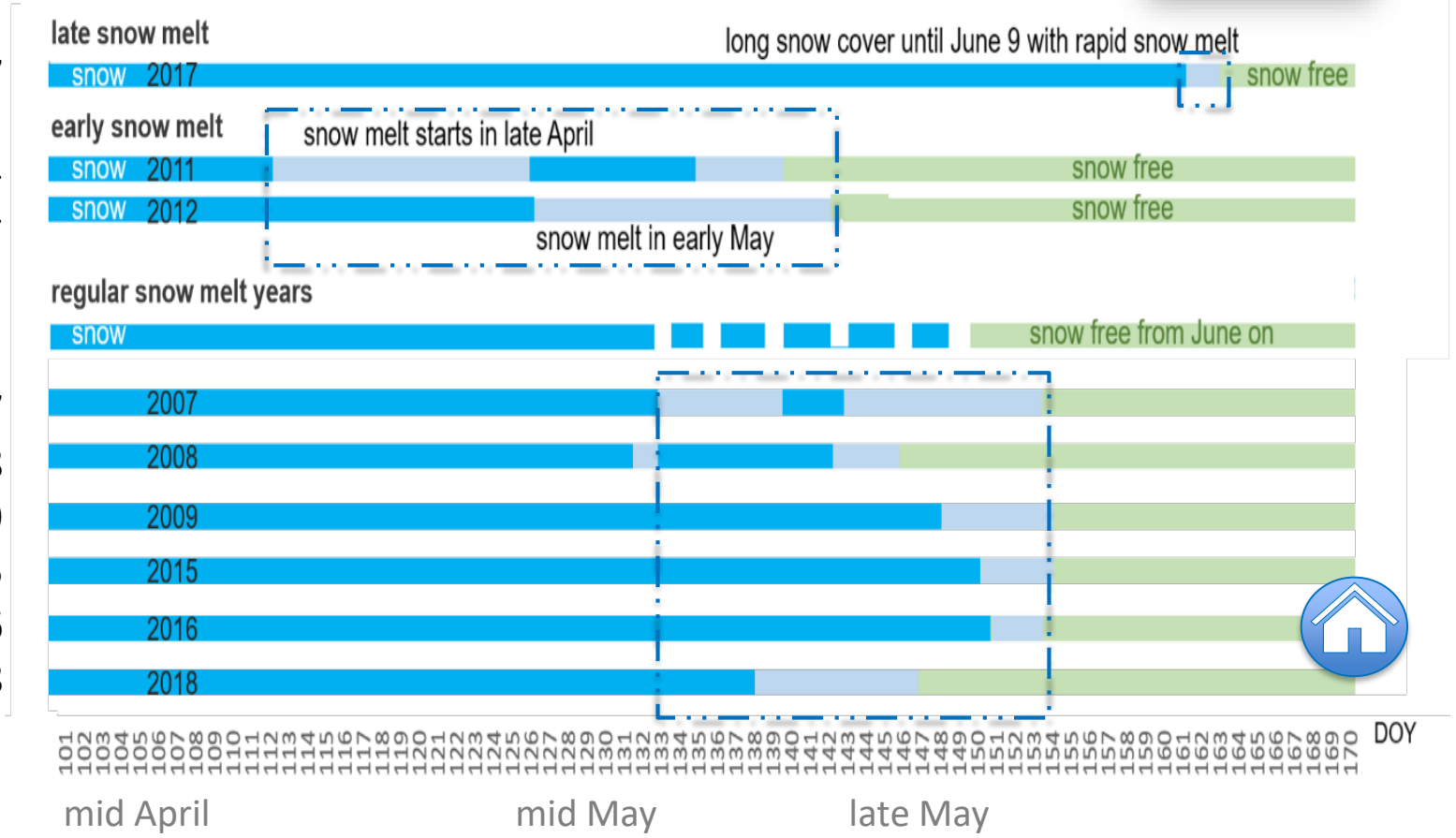
Time Lapse Camera Monitoring Lena River Delta – snow melt

bright snow cover
wet snow, snow patches
snow free

LTO TLC Samoylov, central delta

- *1 late snow melt year*
  LSY 2017
- *2 early snow melt years*
  ESY 2011, 2012
- *‚regular‘ years,*
  snow free from June on

no continuous record due to power outage



Set-up of Elementary Sampling Units ESUs for Land Cover

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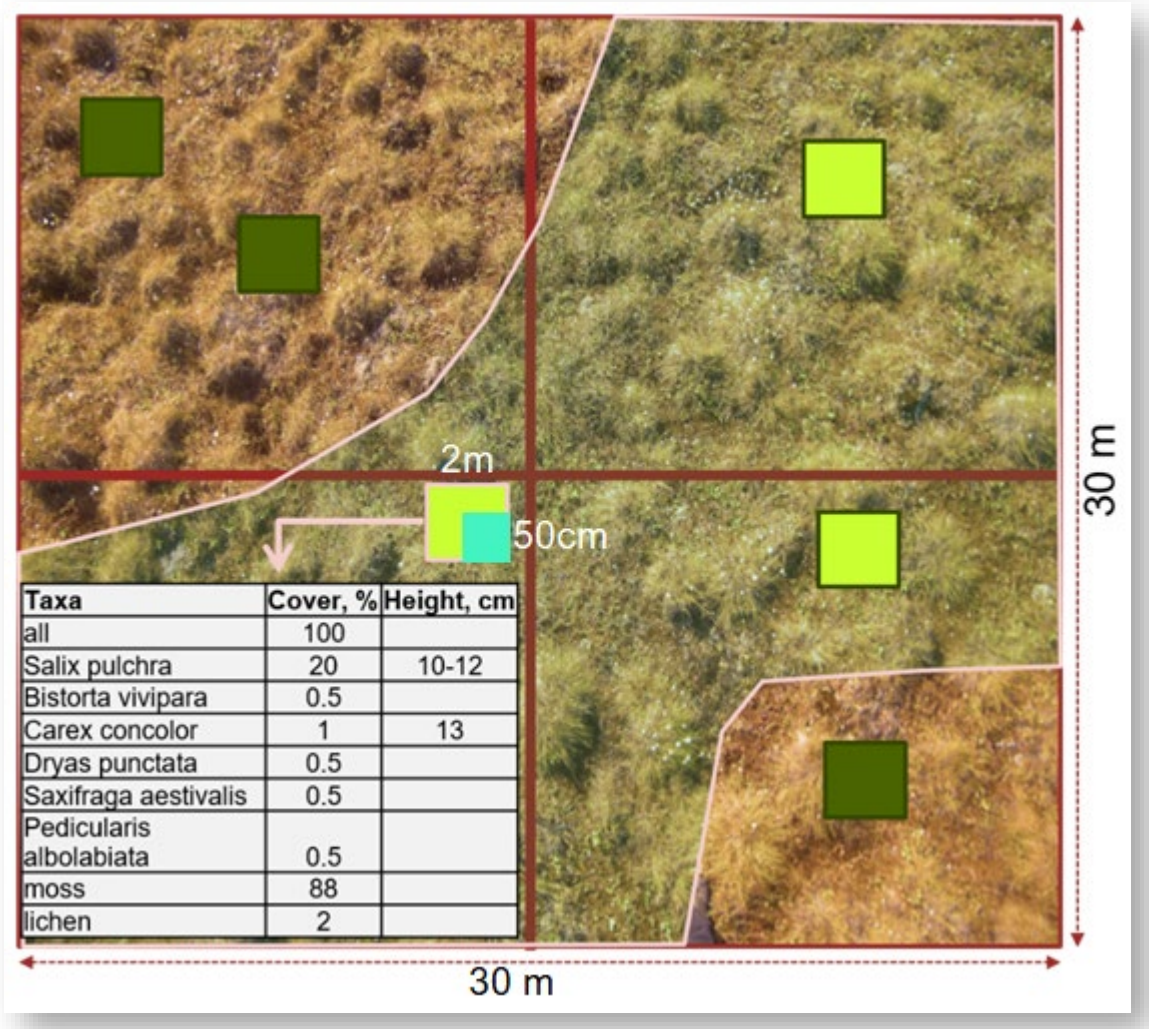
Elementary Sampling Units (ESUs)

"…an ESU represents a contiguous spatial region over which the expected value … can be estimated through in situ measurement …

ESU varies with surface properties, … and spatial sampling design…"

CEOS WGCV Land Product Validation LPV



We established several ESUs for different tundra types in the Lena Delta and measured and sampled vegetation cover, height and biomass.

Use of Elementary Sampling Units ESUs for Land Cover

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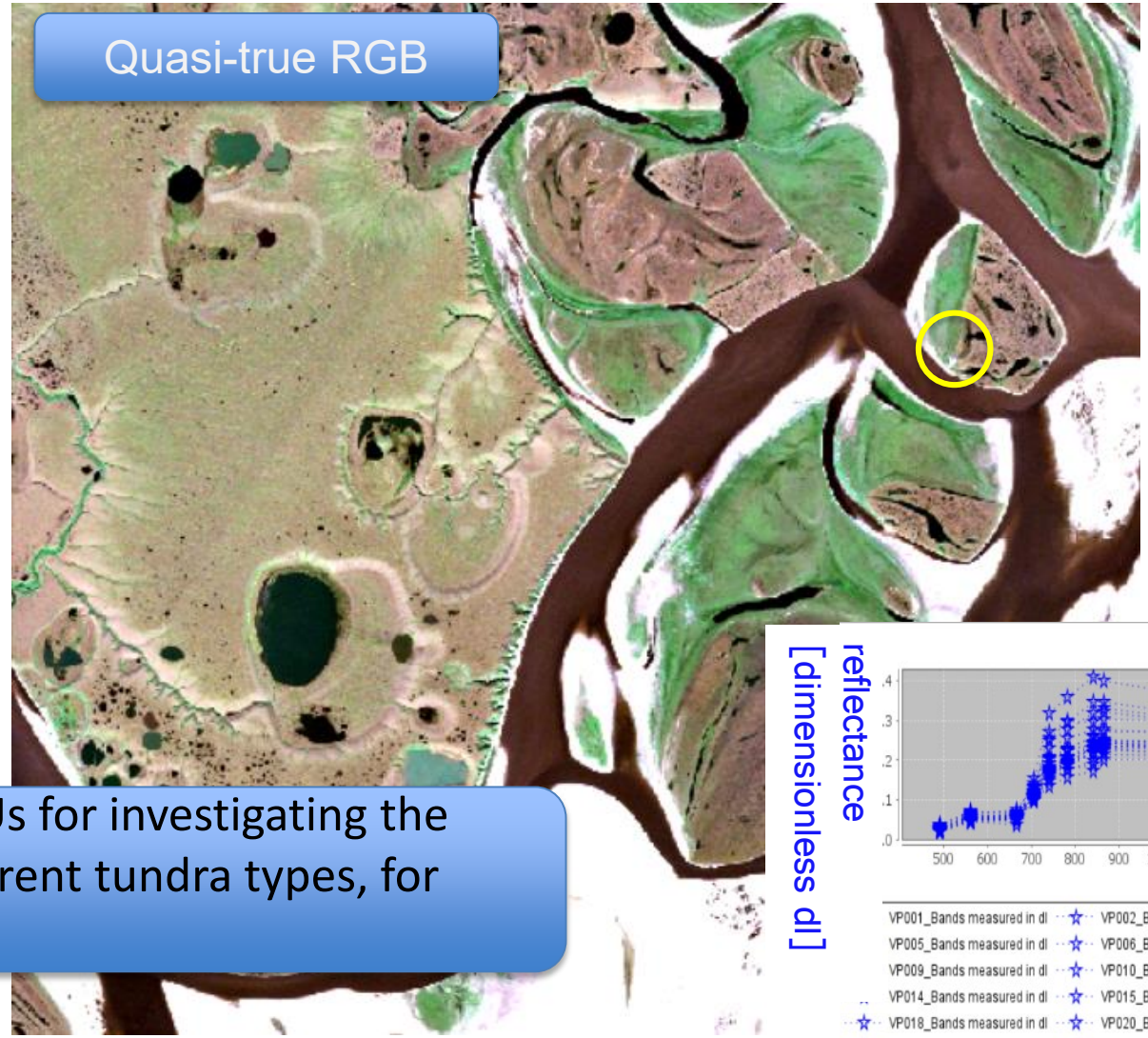
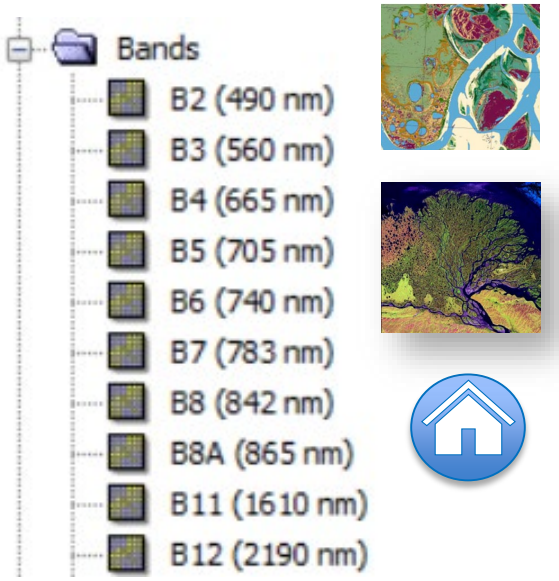
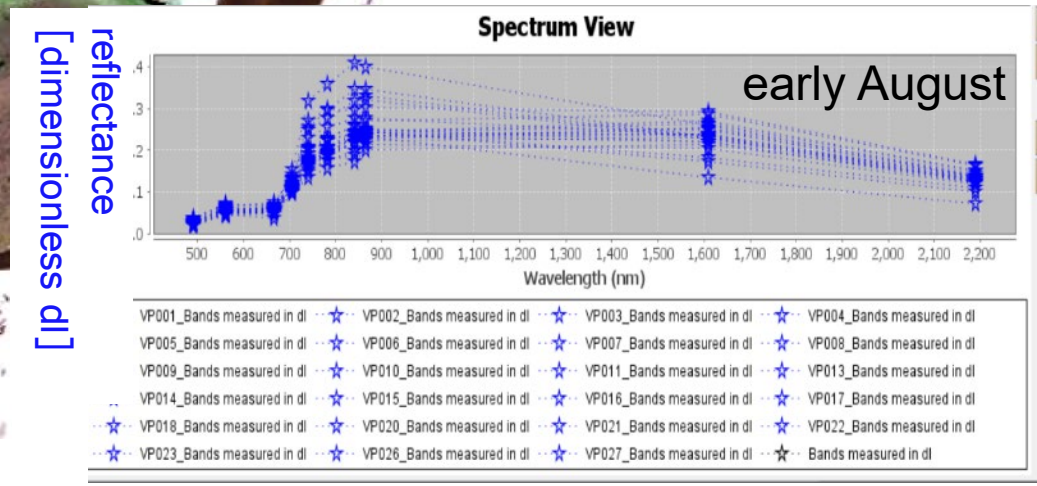
Sentinel-2
10 m VIS & NIR:
B2 Blue, B3 Green,
B4 Red, B8 NIR
20 m Red Edge B6-B8a
20 m SWIR B11-B12

Lena Delta ESUs
30x30 m plots VP
polygonal tundra, tussock tundra, herbs tundra,…



S-2 VNIR bands (10-20m)





We can use the Lena Delta ESUs for investigating the spectral properties of the different tundra types, for developing algorithms

German Space Agency DLR Sentinel-2 team processed atmospherical correction

Supportive ecological data

central Lena Delta, shrub ages (EU-INTERACT DENDRO-5, 2018)

Agata Buchwal, Grzegorz Rachlewicz, Adam Mickiewiz University, Poznan, PL

Overview of shrub genus sampling location performed in the central Lena Delta in August 2018

In Kruse et al. (2019) 'Polar Expeditions to Siberia 2018' Berichte zu Polar- und Meeresforschung

ESA CCI Landcover

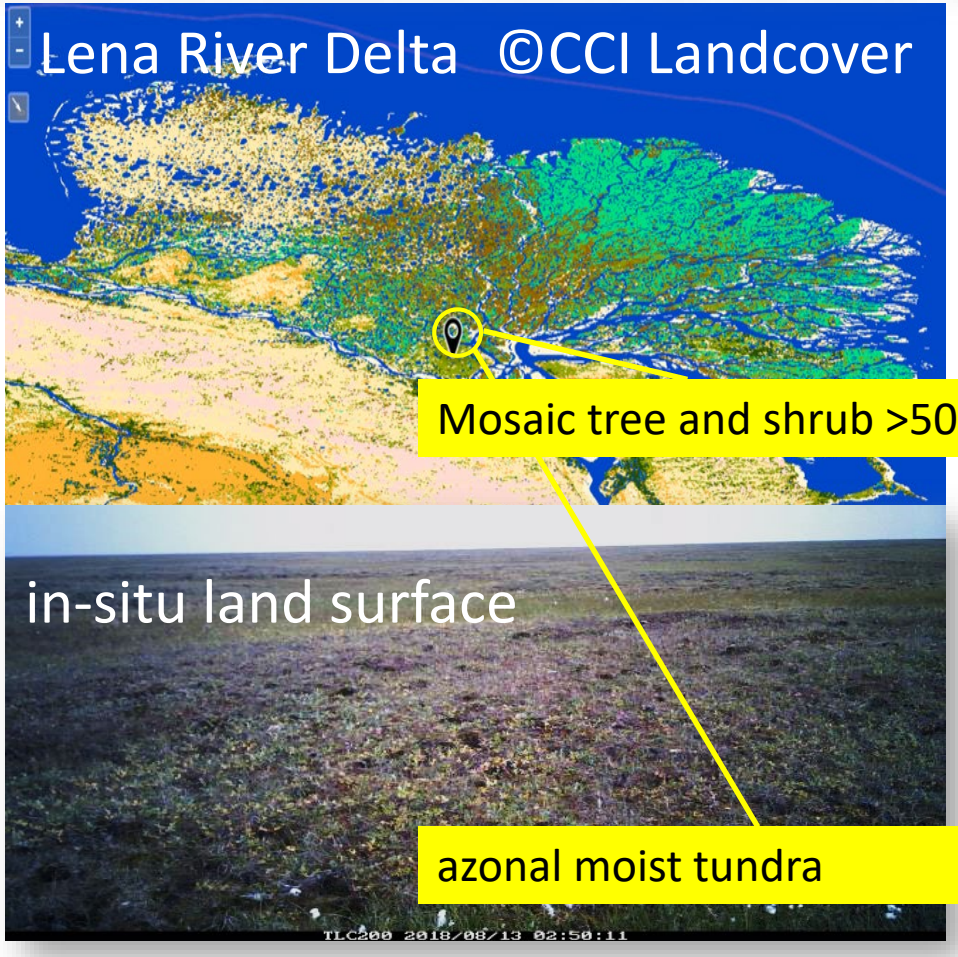
Birgit Heim

Lena Delta: North of tree line, mostly moist and azonal tundra types

- CCI Landcover shows high reliability spatial pattern
- CCI Landcover class attributions show an allover contributions of trees

- Tree cover, needleleaved, deciduous, closed (>40%)
- Tree cover, needleleaved, deciduous, open (15-40%)
- Tree cover, mixed leaf type (broadleaved and needleleaved)
- Mosaic T and shrub (>50%) / herbaceous cover (<50%)
- Mosaic herbaceous cover (>50%) / T and shrub (<50%)
- Shrubland
- - Shrubland evergreen
- - Shrubland deciduous
- Grassland
- Lichens and mosses
- Sparse vegetation (tree, shrub, herbaceous cover) (<15%)
- - Sparse tree (<15%)
- - Sparse shrub (<15%)
- - Sparse herbaceous cover (<15%)

ESA ©CCI Landcover classes for Lena Delta, Siberia



≠

good performance
spatial land cover pattern

low performance
landcover attribution

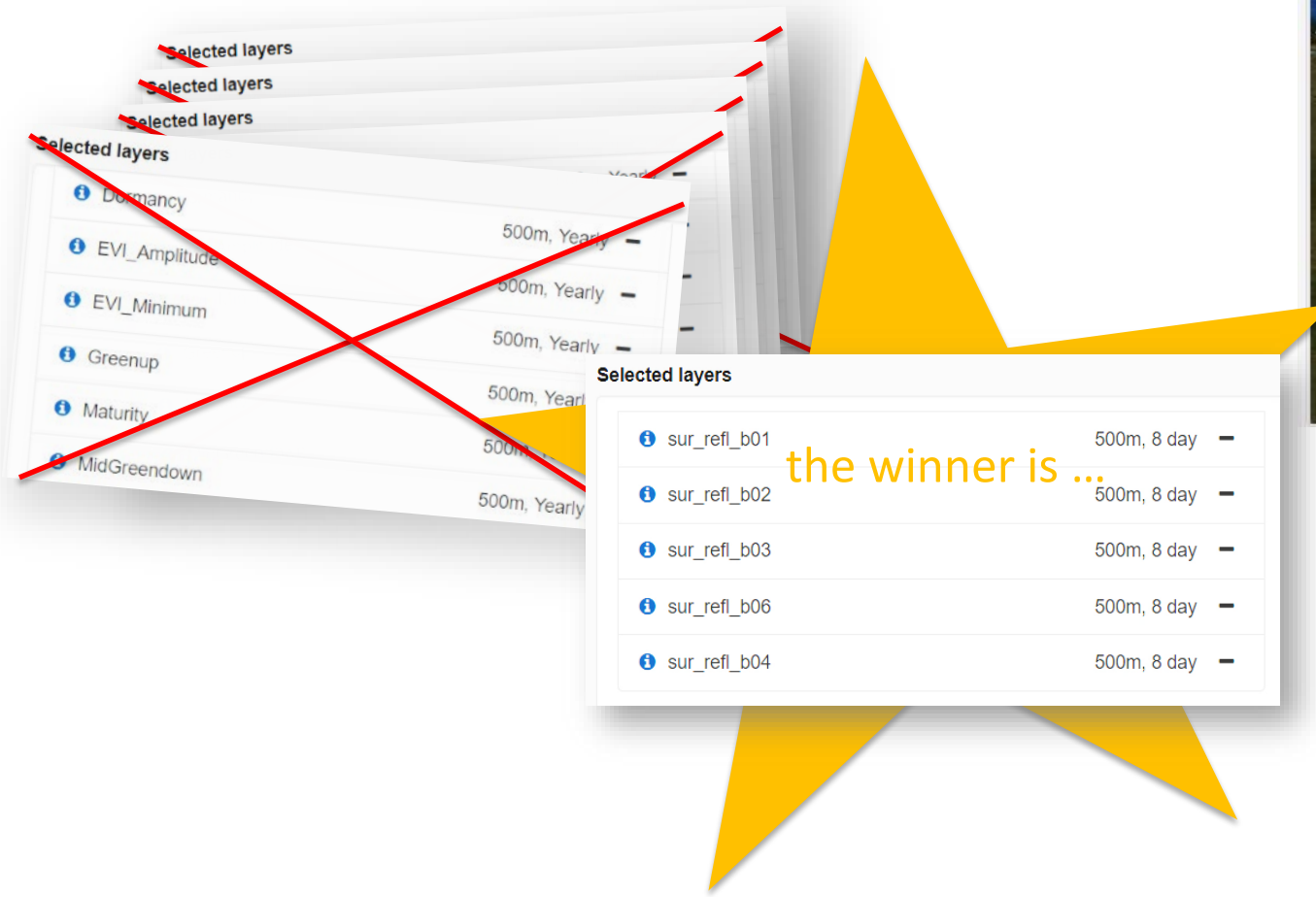
MODIS Landcover

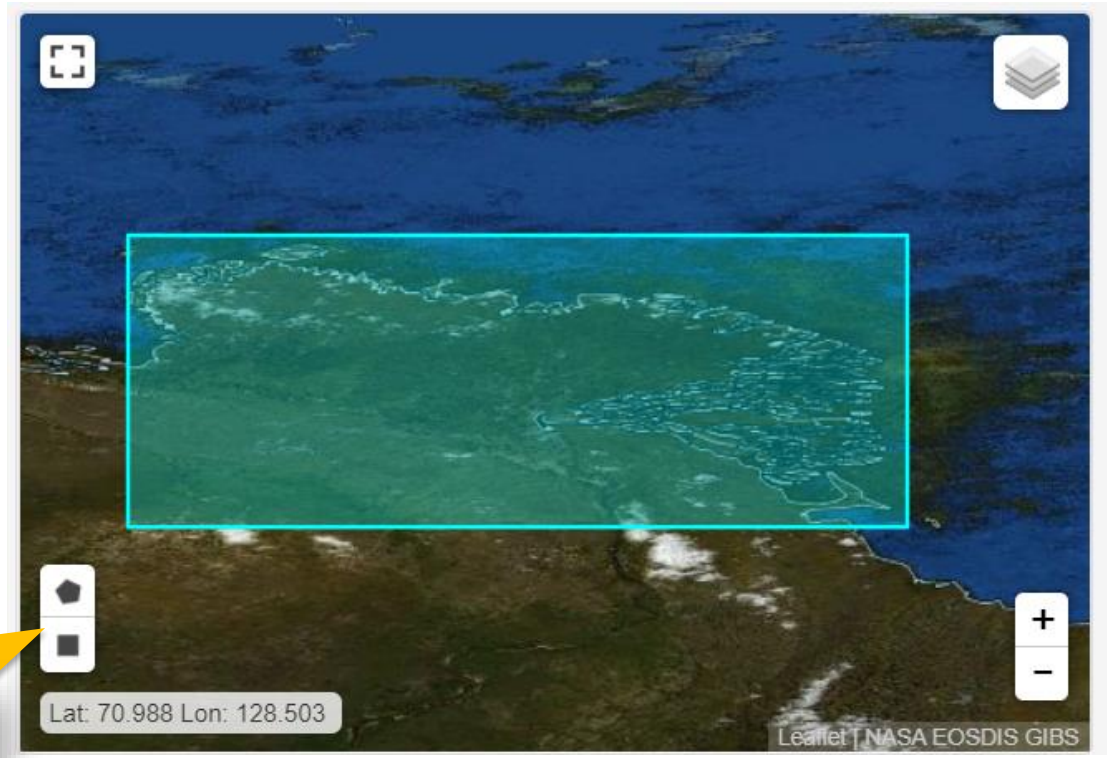
Birgit Heim

MODIS EO products

due to high cloud coverage too many artefacts in all weekly, bi-weekly, monthly, yearly products

throughout all investigated years 2000-2019





8-day Surface Reflectance:

- no averaged product
- optimum pixel per 8 day

ESA GlobPermafrost Vegetation – regional products

Birgit Heim

ESA GlobPermafrost Vegetation regional

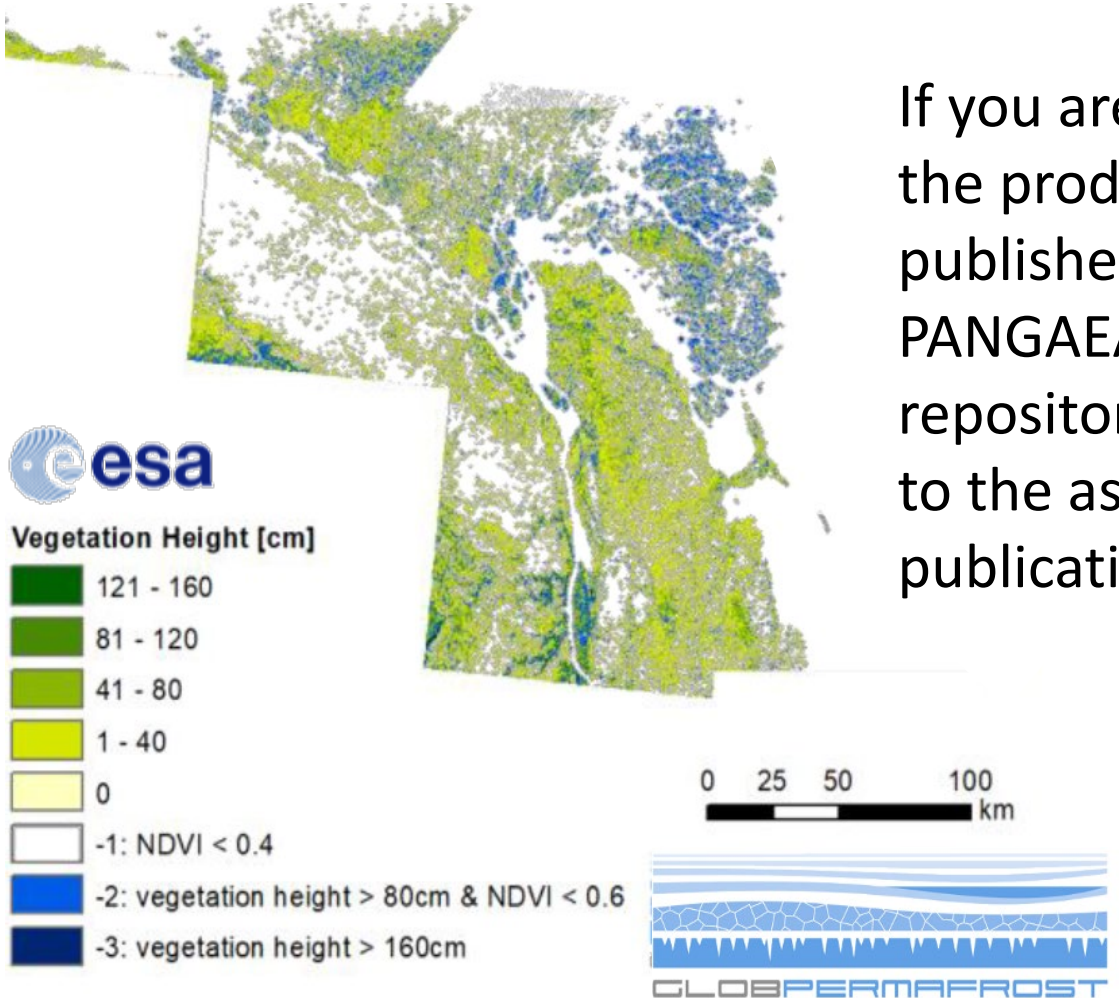
Land Cover optimized for different moisture and low-structure vegetation regimes

Sentinel-1 VV mode (radar) & Sentinel-2 (optical)

Vegetation Height optimized on tundra shrub layers

Sentinel-1 VV mode (radar) & Sentinel-2 (optical) for thresholds

GlobPermafrost Vegetation Height (Annett Bartsch & team)



If you are interested, the products are published in the PANGAEA data repository with links to the associated publications.

*Bartsch et al., 2019 https://doi.**org**/10.1594/PANGAEA.897045*

ESA GlobPermafrost Vegetation – regional products

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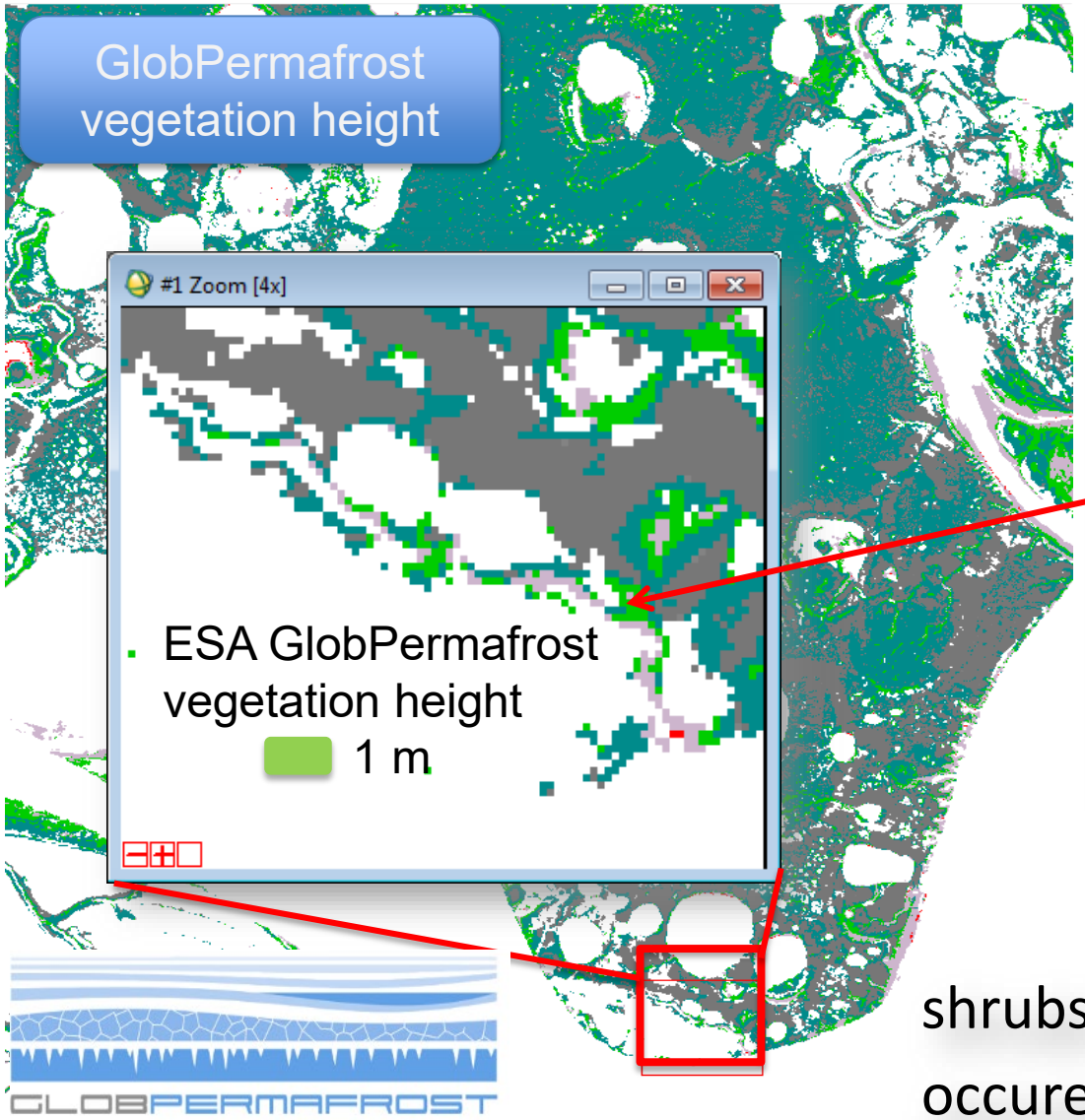
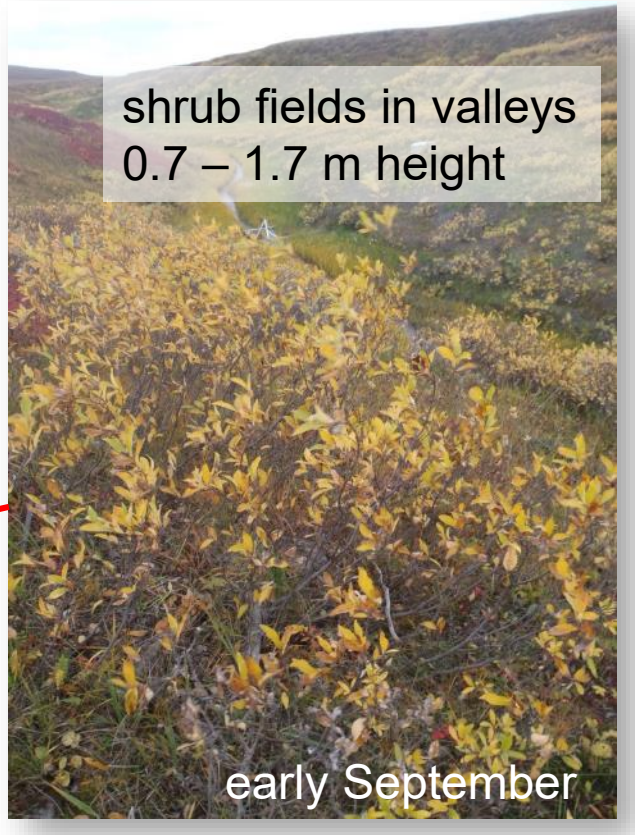




example: Lena Delta
shrub height valdiation

shrubs are landscape anomalies,

occurence in small patches, non-ESU size

Principle of Elementary Sampling Units ESUs for Land Cover

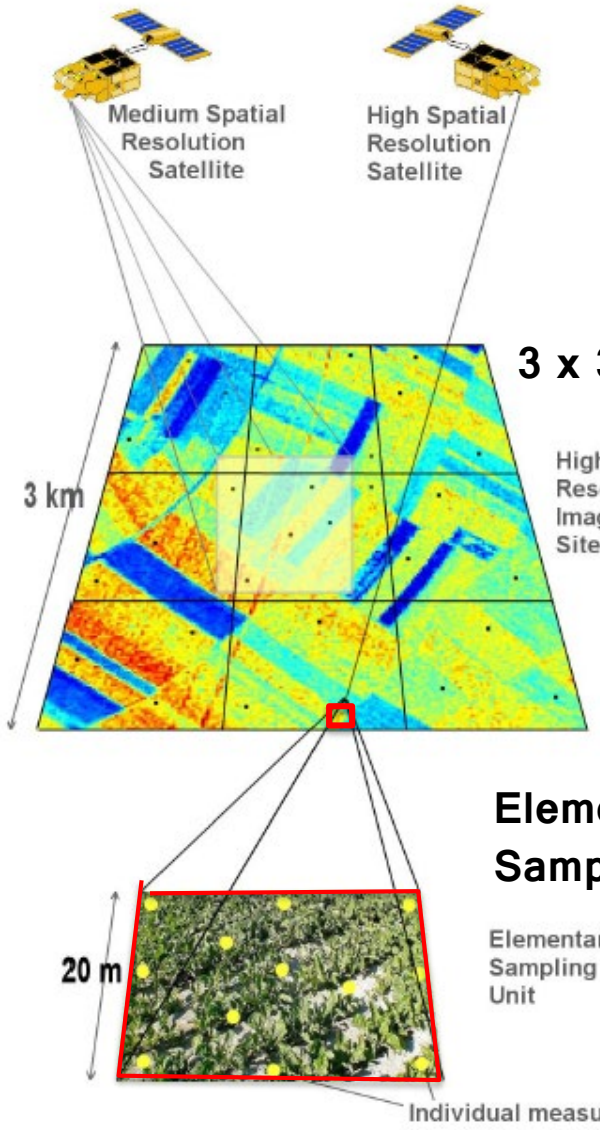
Birgit Heim

Elementary Sampling Units (ESUs)

"…an ESU represents a contiguous spatial region over which the expected value … can be estimated through in situ measurement ...

ESU varies with surface properties, … and spatial sampling design…"

CEOS WGCV Land Product Validation LPV



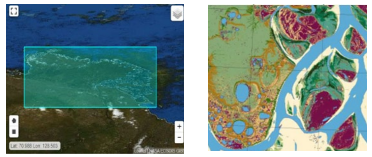
MODIS
~500 m to 1 km pixel length

homogenous at scales of ~20 to 30m length

Elementary Sampling Unit ESU

ground data
VHR satellite data
airborne data

Homogenitey at scales of 20 to 30 m can be also heterogenitey reguarly repeated in specific patterns, such as it is often the case for agricultural ESUs with barren soils and vegetation alternation within a single ESU.



MODIS Vegetation Indices

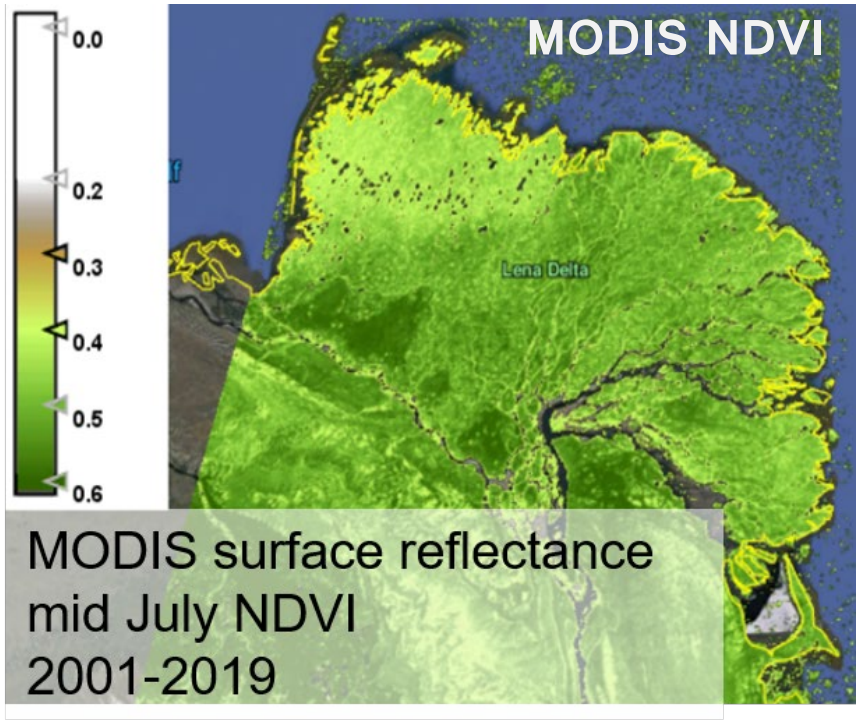
Birgit Heim

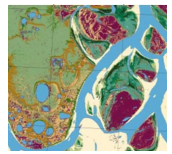
we proceed with MODIS surface reflectance calculated indices

several processing steps
involving thresholds
removing of artefacts

Lena Delta terraces:
different nutrient, soil and moisture constraints
⟹ **different spatio-temporal NDVI dynamics**

MODIS surface reflectance calculated vegetation indices NDVI



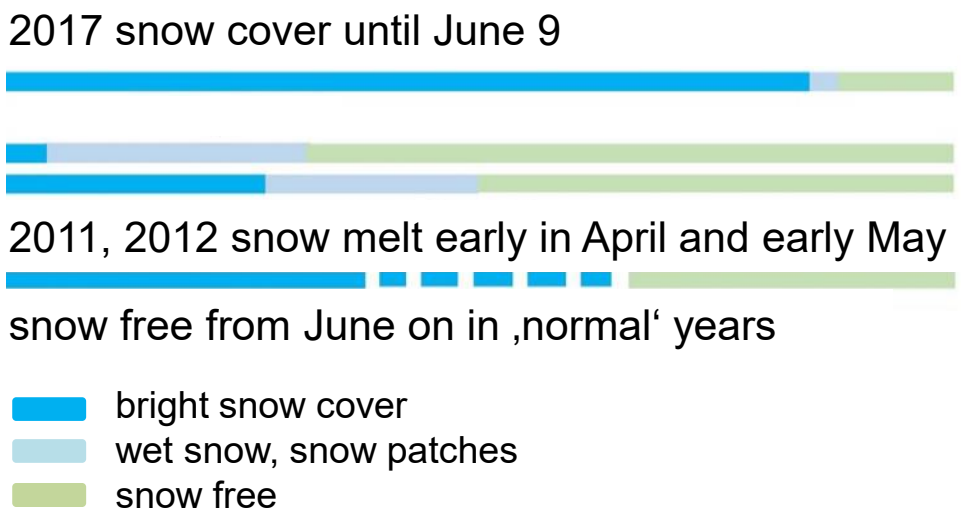


‘Seeing’ snow melt from Earth Observation

Birgit Heim

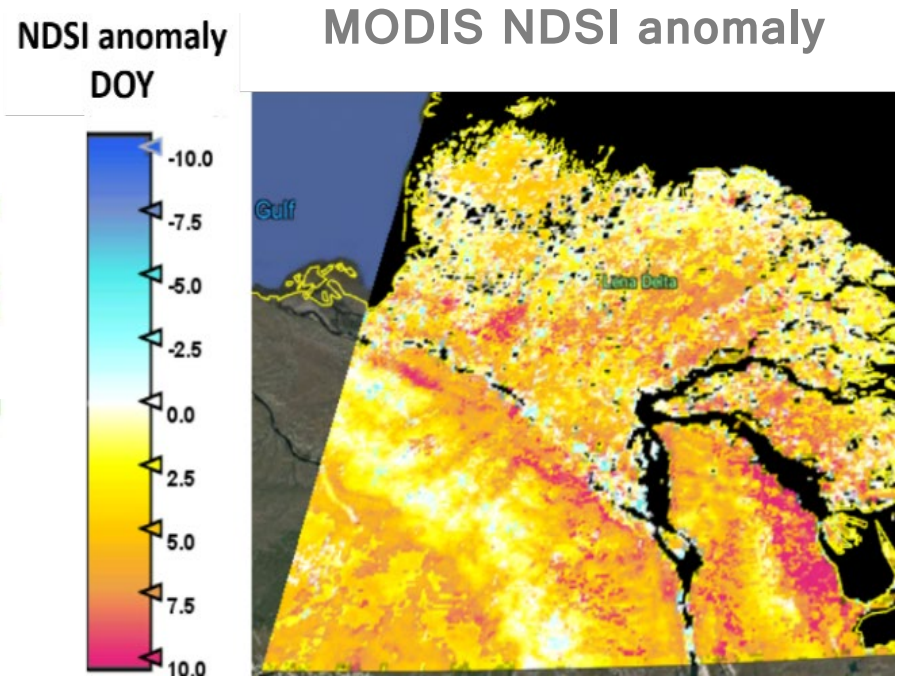
Time Lapse Camera TLC

Boike et al., 2018
https://doi.org/10.1594/PANGAEA.891129



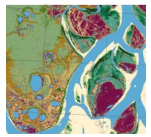
Lena Delta, snow cover on Samoylov
TLC positive deviation in 2017
longest snow cover

MODIS surface reflectance snow index NDSI



Lena Delta snow cover 2001-2019
strong positive deviation in 2017
longest snow cover

The long-term Time Lapse Camera monitoring on Samoylov confirmed the same years of long and short snow cover duration as we detected in the MODIS record.



Lena Delta Landcover from Earth Observation

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DSH dry low shrub communities

DT dry tundra communities

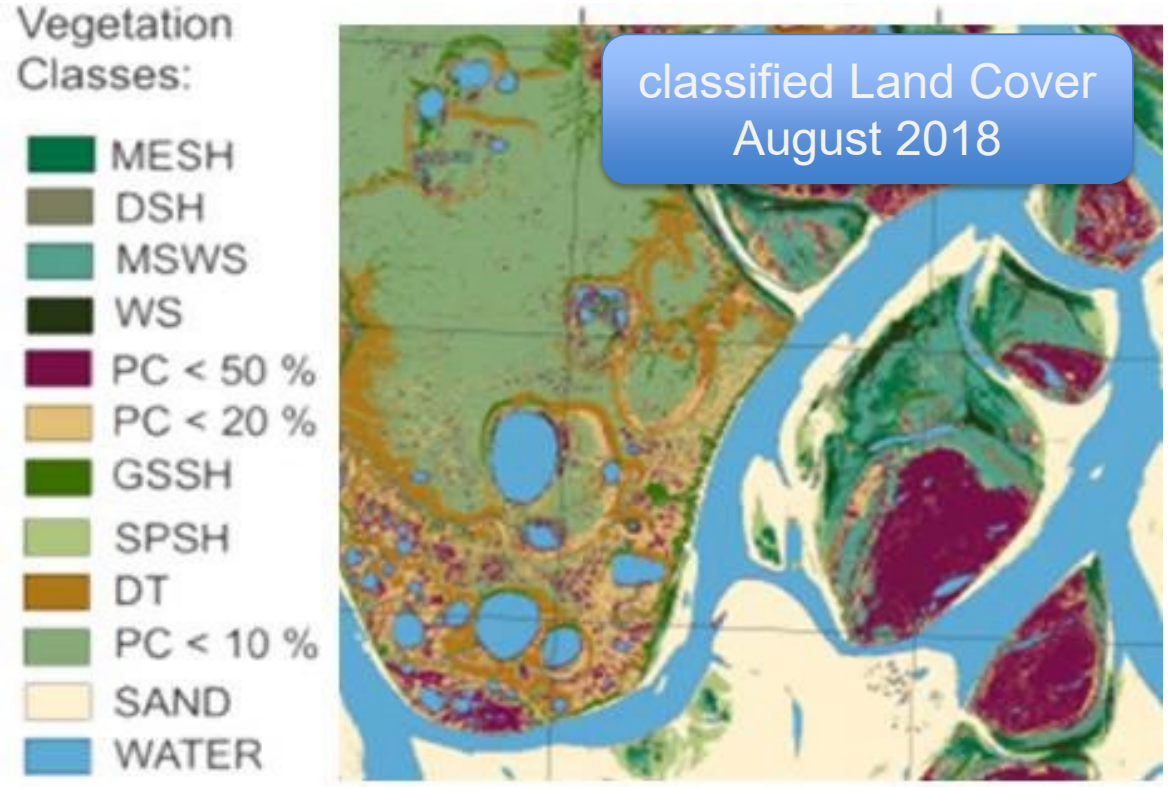
GSSH dry grass to wet sedge complexes

MESH moist-equisetum and high shrub communities

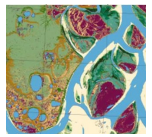
PC polygonal tundra complex with <10%, <20%, <50% surface water contribution

SPSH sparsely vegetated

WS wet-sedge complex with permanent wet sites



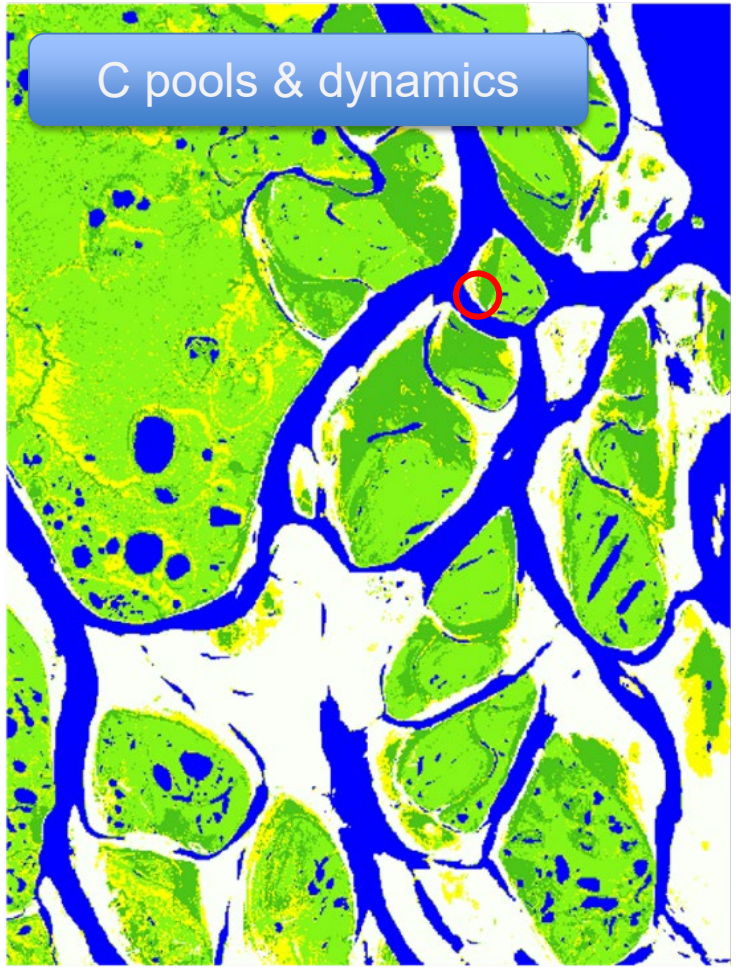
Lena Delta ESU + pseudo-ESU (set with expert knowledge) **trained Landcover classification** brings out **vegetation & moisture-related classes** applicable for wide range of ecological applications



Nele Landgraf, BSc @University Leipzig, AWI: Sentinel-2 classification, C&N in soil

Upscaling AGB and C-pool ages from Earth Observation

Birgit Heim



high-disturbance regimes
large & fast C fluxes
low C/N ratio

in soils

$AGB_{withoutmoss}$
> 0.5 kg/m²
fast regrowth
offsetting C loss

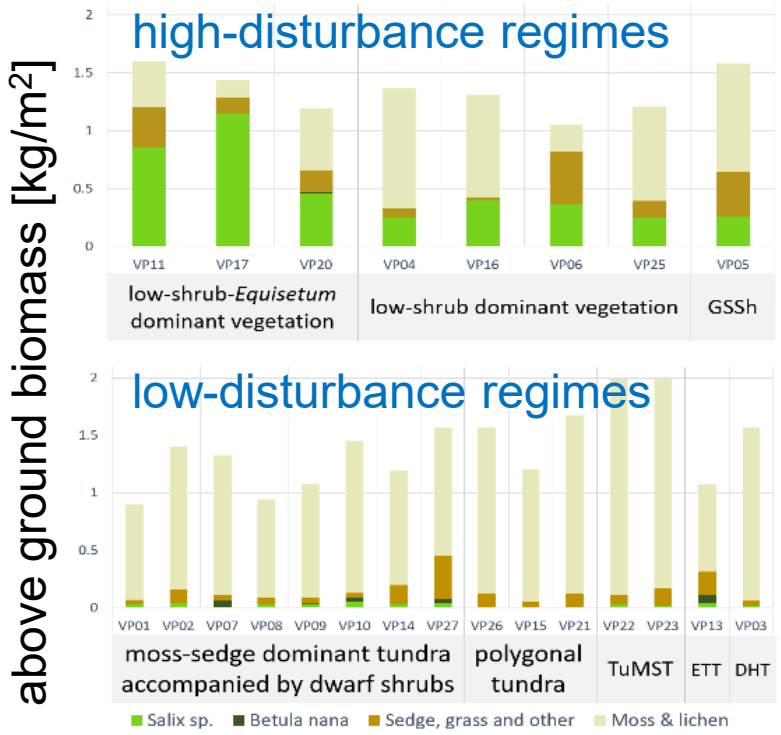
low-disturbance regimes
mosses largest AGB
slower C fluxes
medium to high C/N ratio

$AGB_{withoutmoss}$
< 0.5 kg/m²
slow C loss

transitional AGB

sand banks

water



young shrubs
annual to decadal
time-scale
C-pools

mature shrubs
decadal
time-scale
C-pools

GSSh moss-sedge dominant+low shrubs
TuMST tussock-forming moss-sedge tundra
ETT *Eriophorum vaginatum* tussock
DHT *Dryas sp.* herbs tundra

Upscaled AGB and C-pool ages based on S-2 classification

high disturbances regimes with annual to decadal pool ages of vascular plants trigger faster C fluxes than low disturbance regimes with pool ages of half a century for shrubs

Lena Delta ESU biomass
vs. disturbance