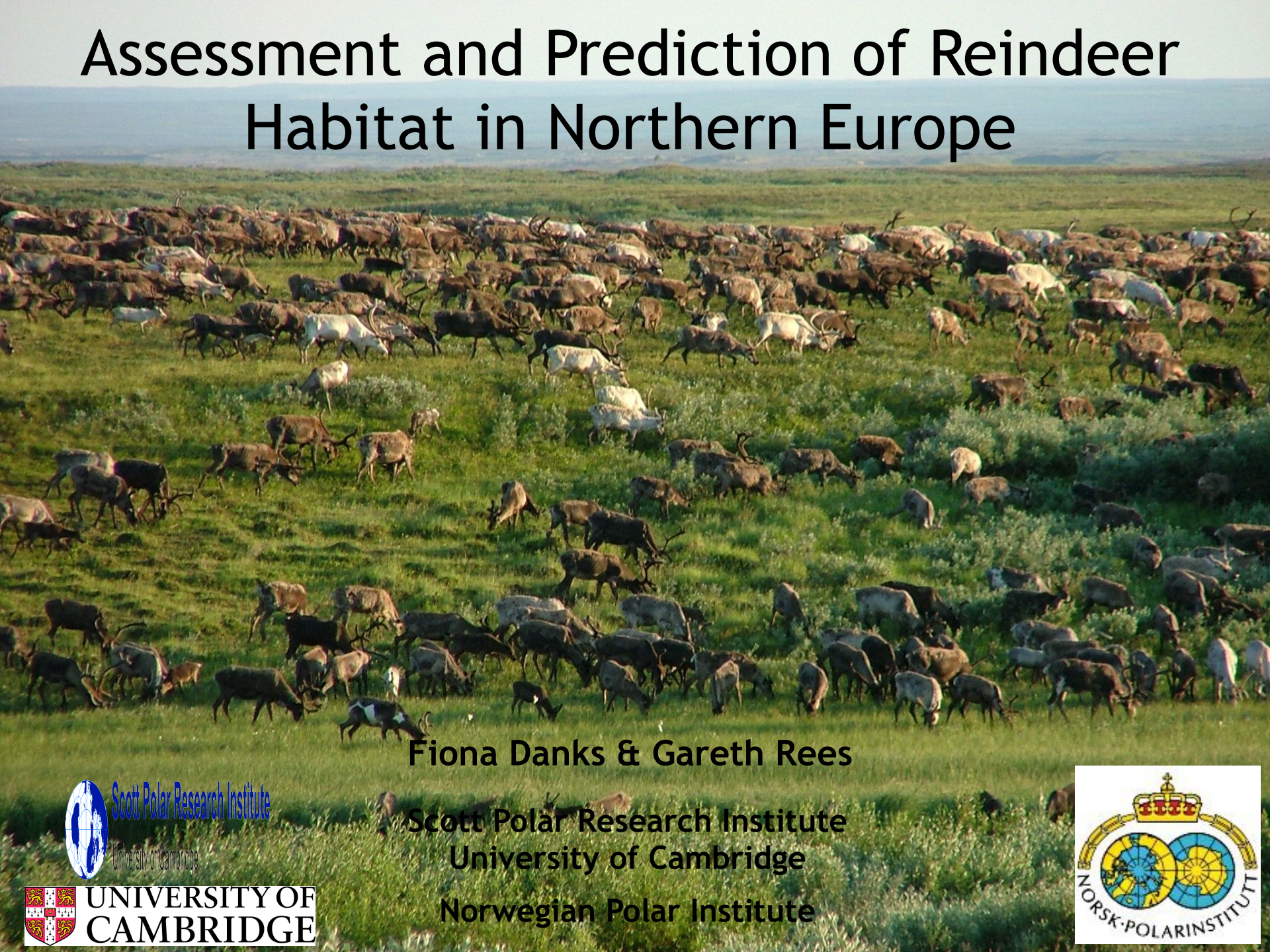
Assessment and Prediction of Reindeer Habitat in Northern Europe



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Outline

- Ideas of scale with remote sensing analyses and applications, particularly as they relate to reindeer and climate change

- Landsat-based 30m resolution vegetation map, tailored to reindeer habitat

- Future, modeled habitat scenarios output on a 0.5-degree grid

- What is necessary, what is best and is the best good enough?

The *BALANCE* project

Global Change Vulnerabilities in the Barents Region:
Linking Arctic Natural Resources, Climate Change and Economies.

BALANCE was an EU funded project (2002-2005(6)) that followed on from BASIS (1997-1999). Its aim was to assess the vulnerabilities of the Barents Sea system to climate change based on a common modelling framework for major environmental and societal components and on combining them through an Integrated Assessment Model (IAM).

Partners:

Germany - Inst. for Geophysics, Univ of Münster; Inst. for Geoinformatics, Univ of Münster, MPI Meteorology, Hamburg

Finland - Dept Biology, Univ of Turku; Dept Social Studies, Univ of Lapland; Dept of Social Sciences, Univ of Kuopio

Norway - SINTEF Fisheries & Aquaculture, Trondheim; Inst of Marine Research, Bergen; Fishery Science, Univ of Tromsø

Sweden - Abisko Scientific Research Station, KVA; Dept Social & Economic Geography, Umeå Univ

Netherlands - Dept Physical Geography, Univ of Utrecht

UK - Scott Polar Research Inst, Univ of Cambridge; Centre for Ecology & Hydrology; World Conservation Monitoring Centre

Research supported by EU under contract EVK2-2002-00169 ('BALANCE')

Why should we be interested in reindeer?

climate ⟷ vegetation

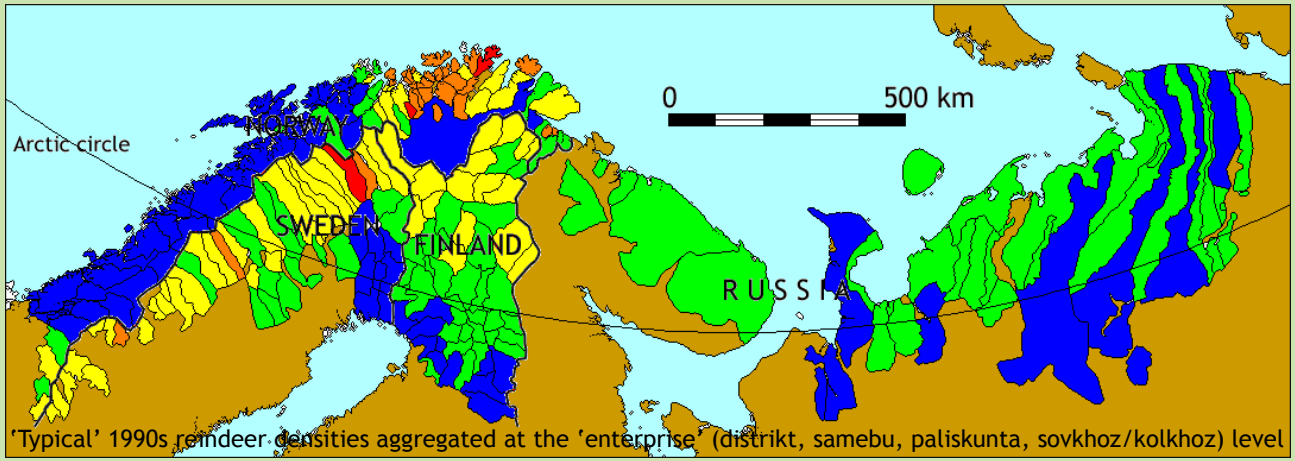
reindeer

~ 106 reindeer, ~ 106 km2,

~ 109 kg dry biomass consumed p.a.

Profound changes already occurring, though not spatially uniformly

- overgrazing, trampling and manuring by reindeer
- general shift away from lichen-dominance (and increase in graminoids)
- shrub encroachment



'Typical' 1990s reindeer densities aggregated at the 'enterprise' (distrikt, samebu, paliskunta, sovkhoz/kolkhoz) level

Climate change effects

- Vegetation shifts
- Ice and Snow Events
- Change in temperature trends, timing of melting and thawing, insect harassment, etc.

Perceptions of climate change

- Herders notice change, often overlapping with 'scientific' data, but sometimes priorities differ
- Timescales are different looking back (decades) and forward (days)
- Timescale for IK is long, so there is potential confusion between change and fluctuation
- Global change is more of an issue for herders in N, S, F (tend to be very 'news-aware') than in Russia (economic survival more of an issue)
- Factors that emerge consistently:

spatial variability, e.g. in refreezing of snow

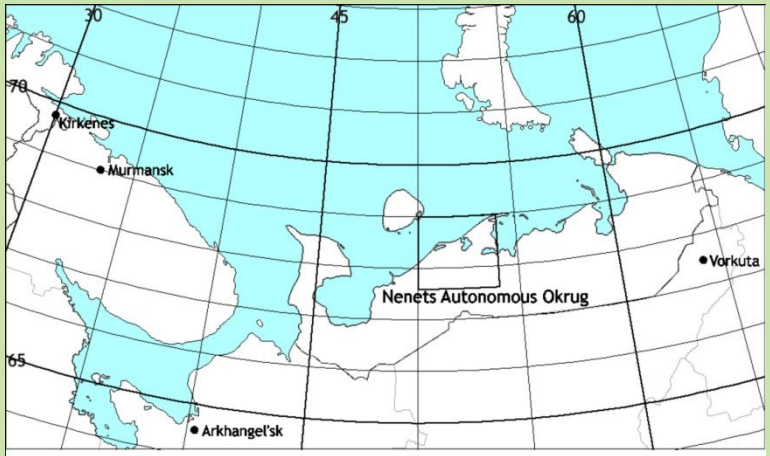
on less predictable

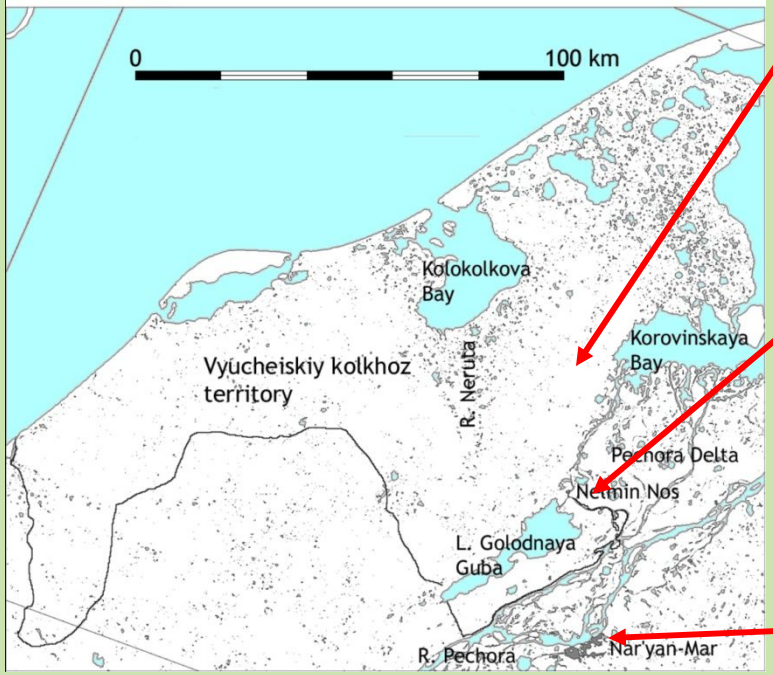
ying out

achment *denies* pastures (rather than enhancing)

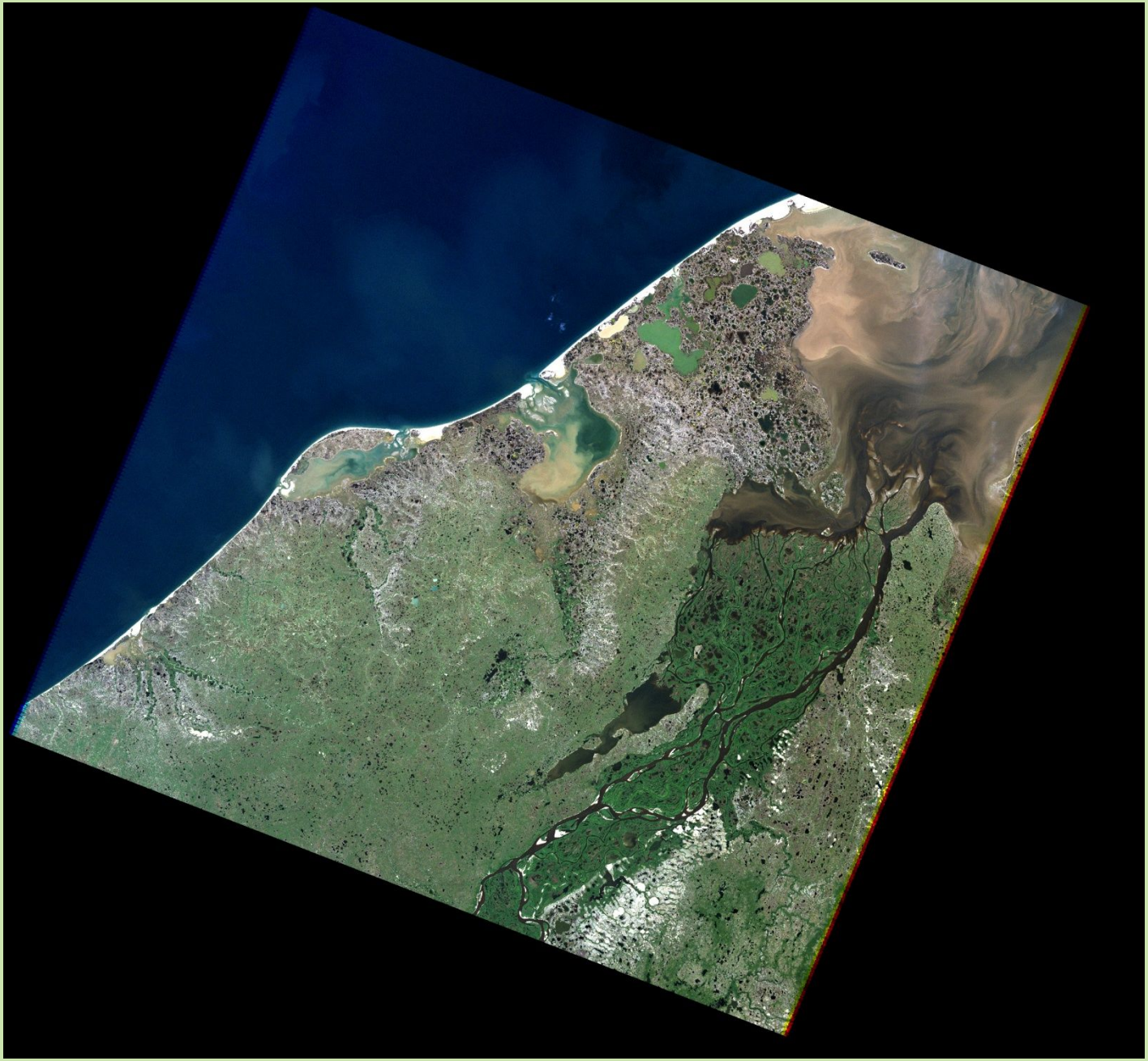
Vegetation Mapping

Field-based training of satellite image classification
- study area in Vyucheiskiy kolkhoz, Nenets Autonomous Okrug, Russia.





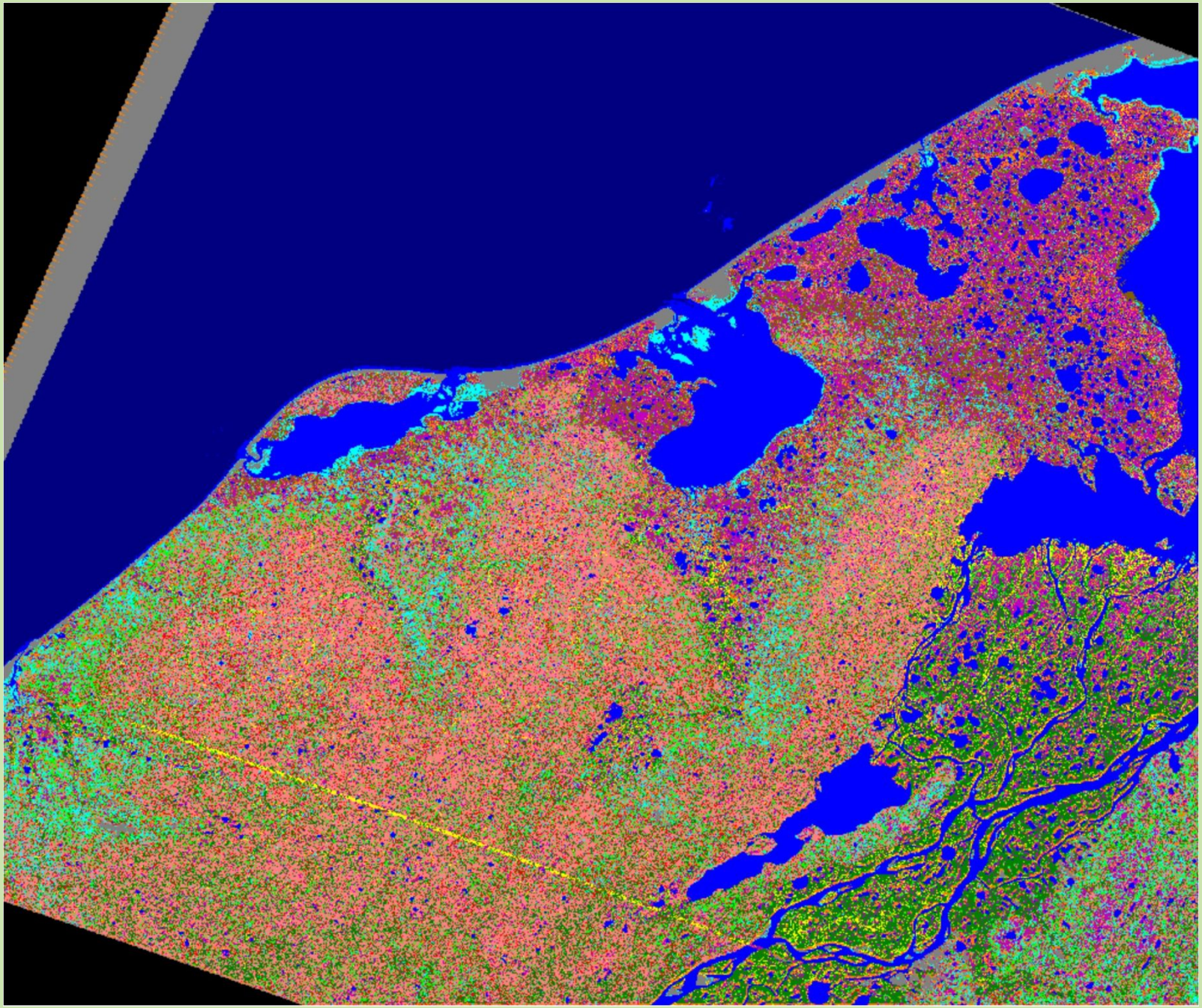
Landsat-7 ETM+ image, June 2000



Fieldwork

Characterisation of different vegetation units

Classified satellite image (land cover map)

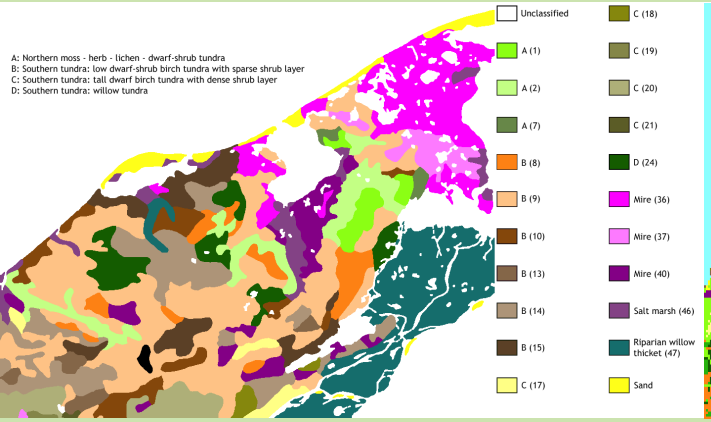


How do we scale up from Landsat to the Barents Region?

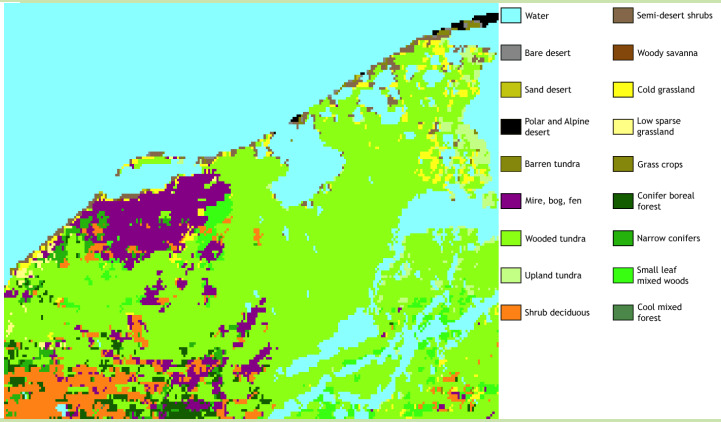
Investigation of similarities between maps at different scales and with different compilation methodologies

Regional or global vegetation maps (Olson, GLC2000, CAVM…) are inadequate (degree of generalisation, lack of accuracy)

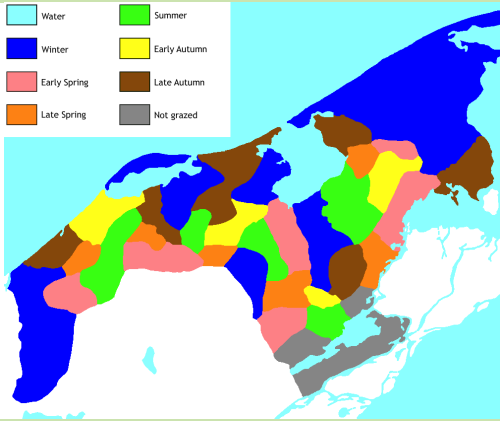
Vegetation map from fieldwork, 1974



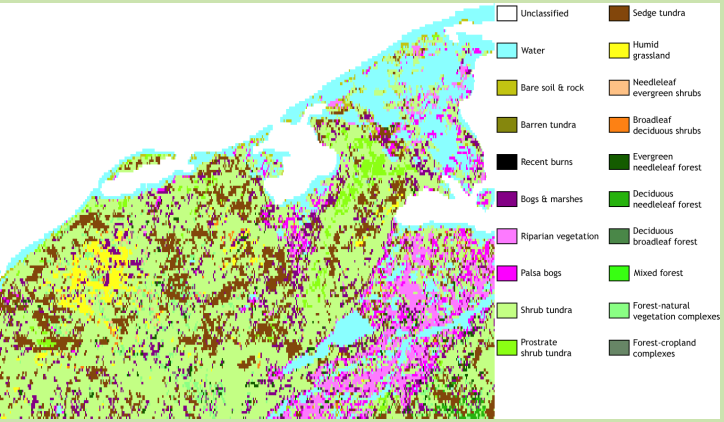
Olson classification



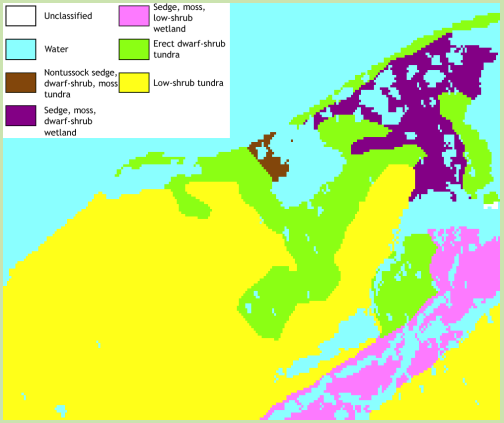
Official grazing map



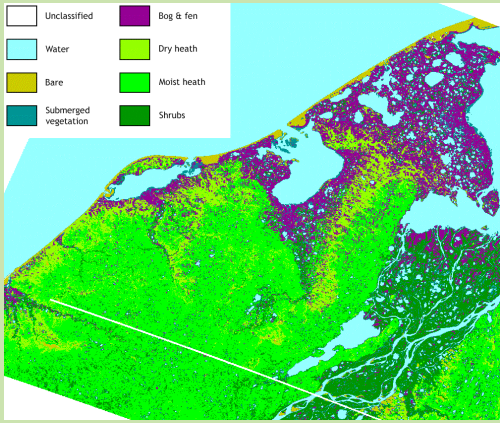
JRC GLC2000 land cover



CAVM



Landsat classification



Climate Modelling for the Barents Region

- Primary climate variables calculated by MPI für Meteorologie, Hamburg

- Use ECHAM4/OPYC3 IPCC-SRES B2 climate change scenario coupled to BALANCE vegetation model

- Output on REMO 0.5-degree grid for all of Barents region

Vegetation biomass

- LPJ GUESS Dynamic Ecosystem Model (Annett Wolf, KVA Sweden)
- Predicts biomass in different plant functional types (PFTs)
- Based on climatic parameters so can be used to **predict** future distributions
- Highly generalised

<-- Boreal needle-leaved evergreen trees (BNE) e.g. Scots Pine

<-- Shade-intolerant broadleaved deciduous trees (IBS) e.g. Mountain Birch

Shade-tolerant broadleaved deciduous trees (TBS) e.g. Ash -->

<-- Evergreen shrubs 1-5 m (S5W) e.g. Juniper

<-- Evergreen shrubs <1 m (S1W) e.g. Crowberry

Deciduous shrubs 1-5 m (S5S) e.g. Willow -->

<-- Deciduous shrubs <1 m (S1S) e.g. Bilberry

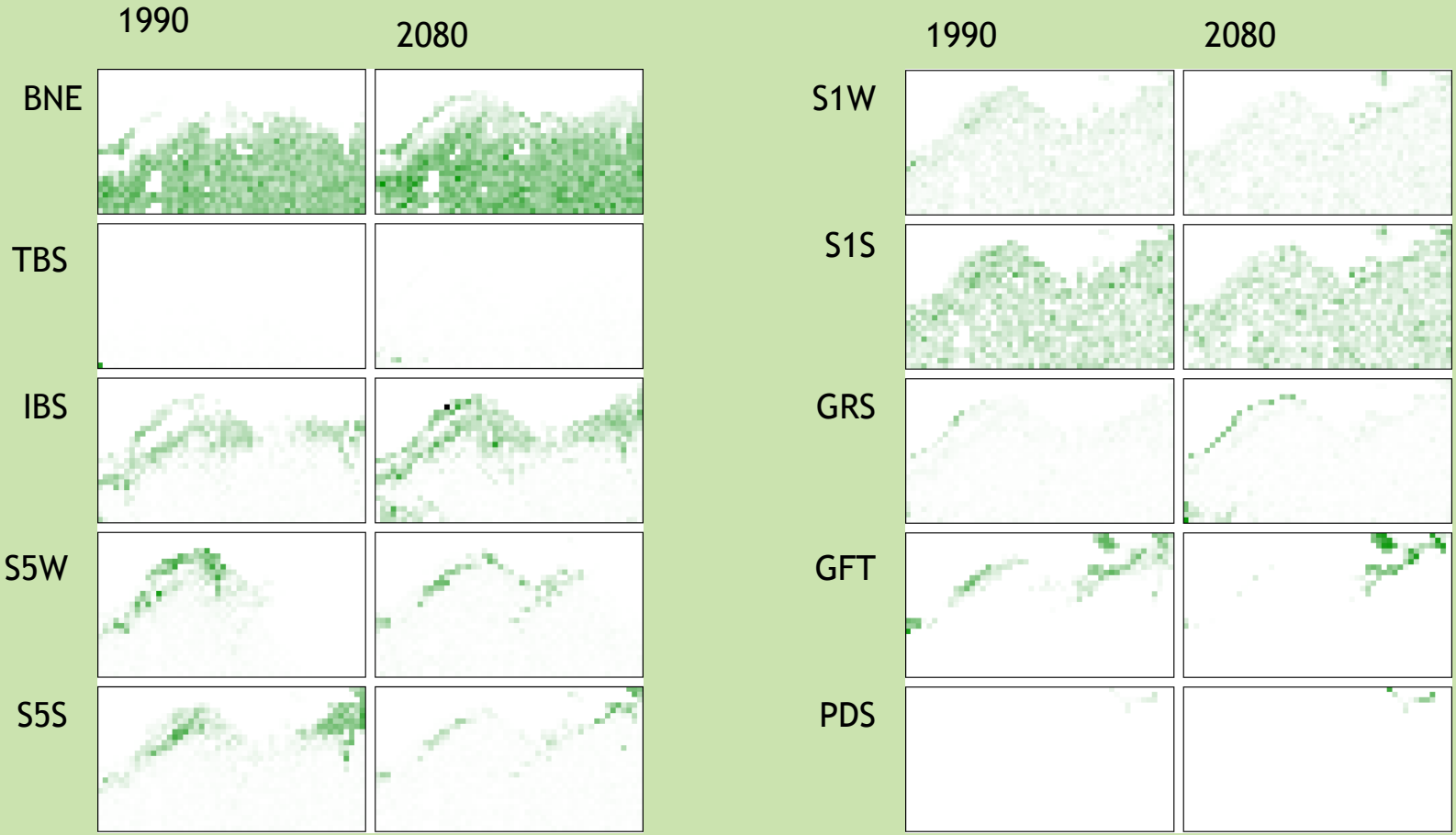
Grassland (GRS) -->

<-- Graminoid forb tundra (GFT)

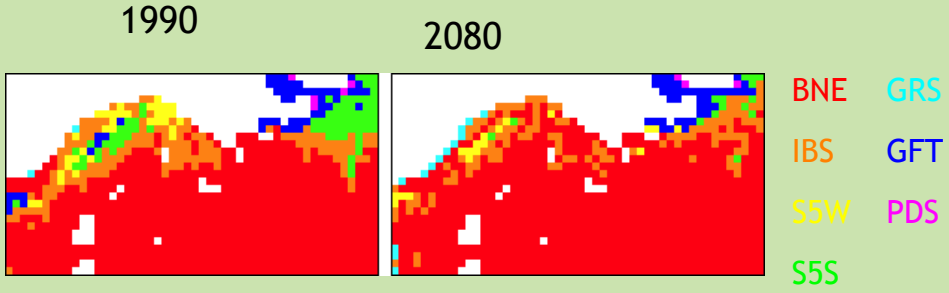
<-- Prostrate dwarf shrub tundra (PDS) e.g. Arctostaphylos spp.

<-- Cushion forb, lichen, moss tundra (CLM)

Modelled distributions of biomass by PFT



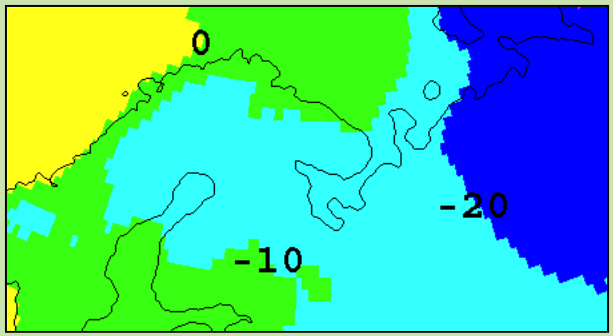
Dominant PFT

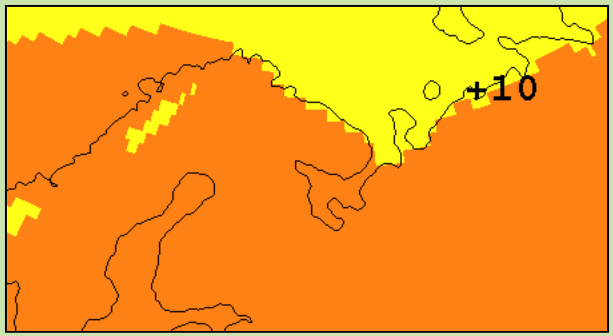


Temperature

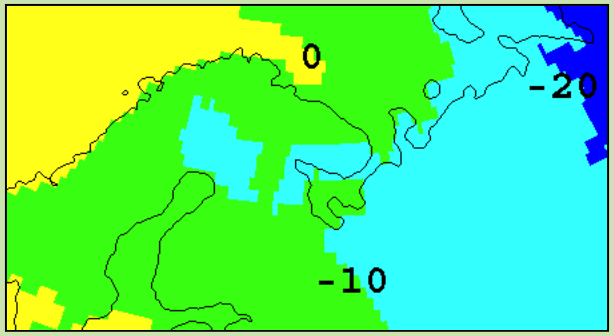
Winter minimum

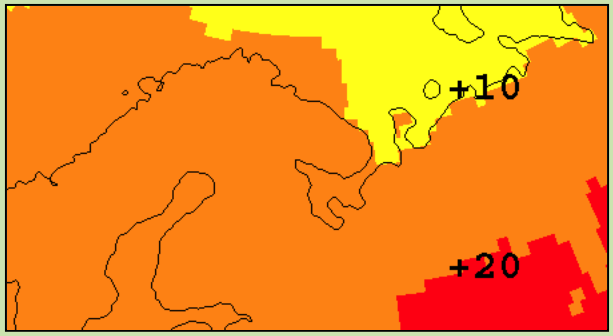
Summer maximum



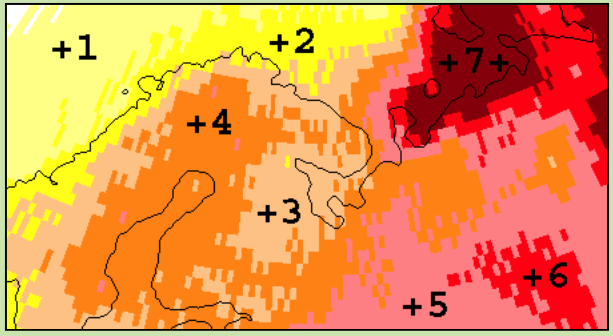


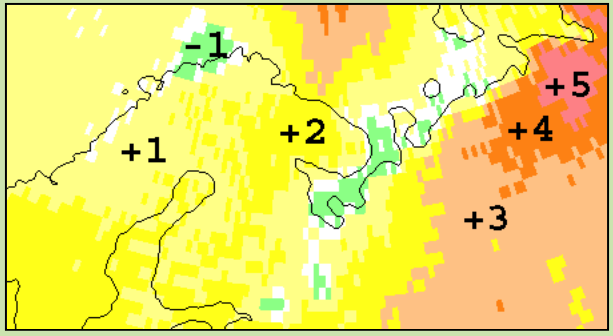
1990-1999





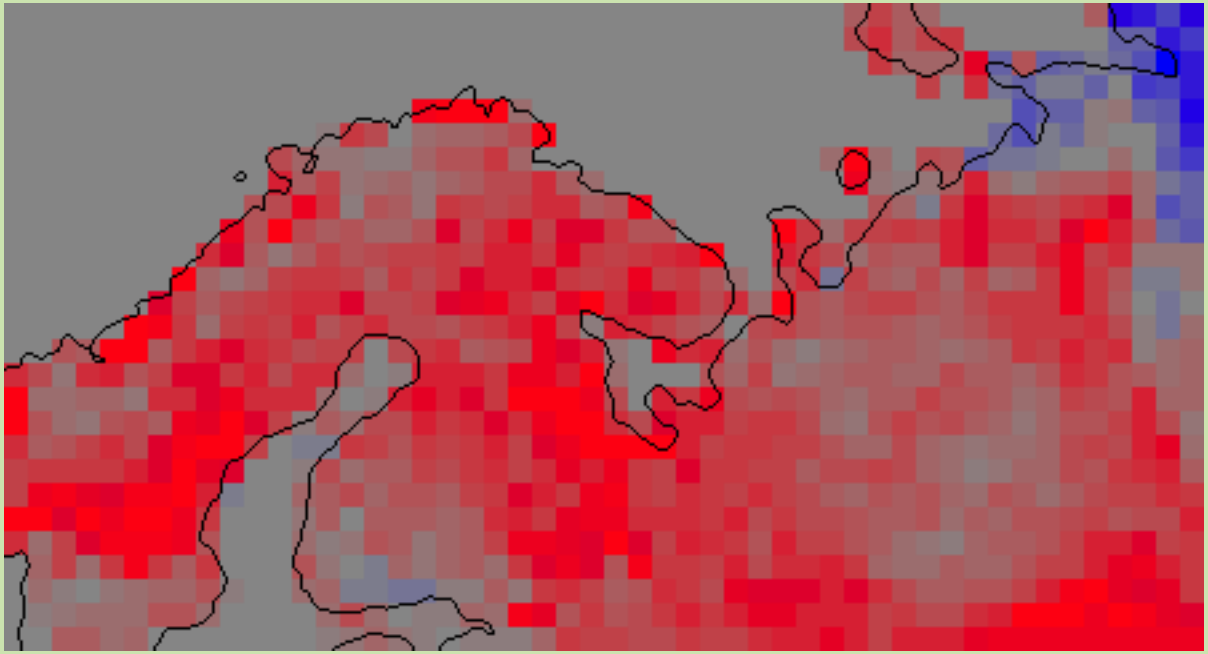
2070-2079





difference

Change in frequency of deep-snow (>60 cm) events from 1990s to 2070s



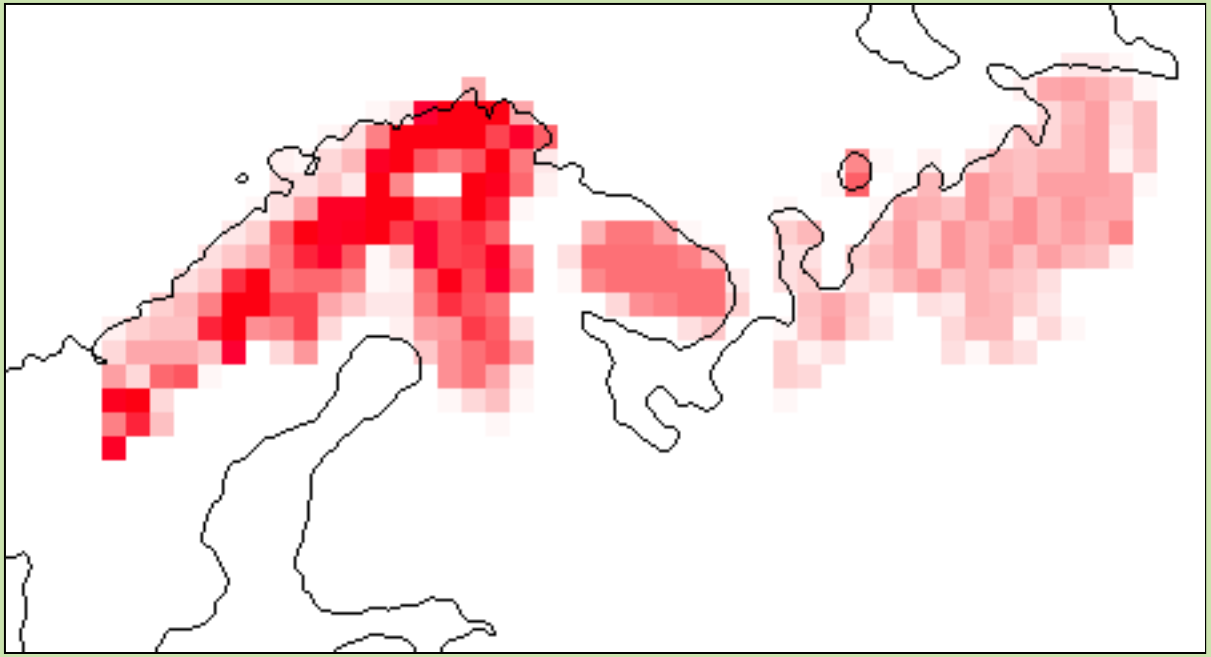
Snow refreezing

Partial thaw followed by refreezing produces hard crust of ice that is impenetrable by reindeer - extremely dangerous.

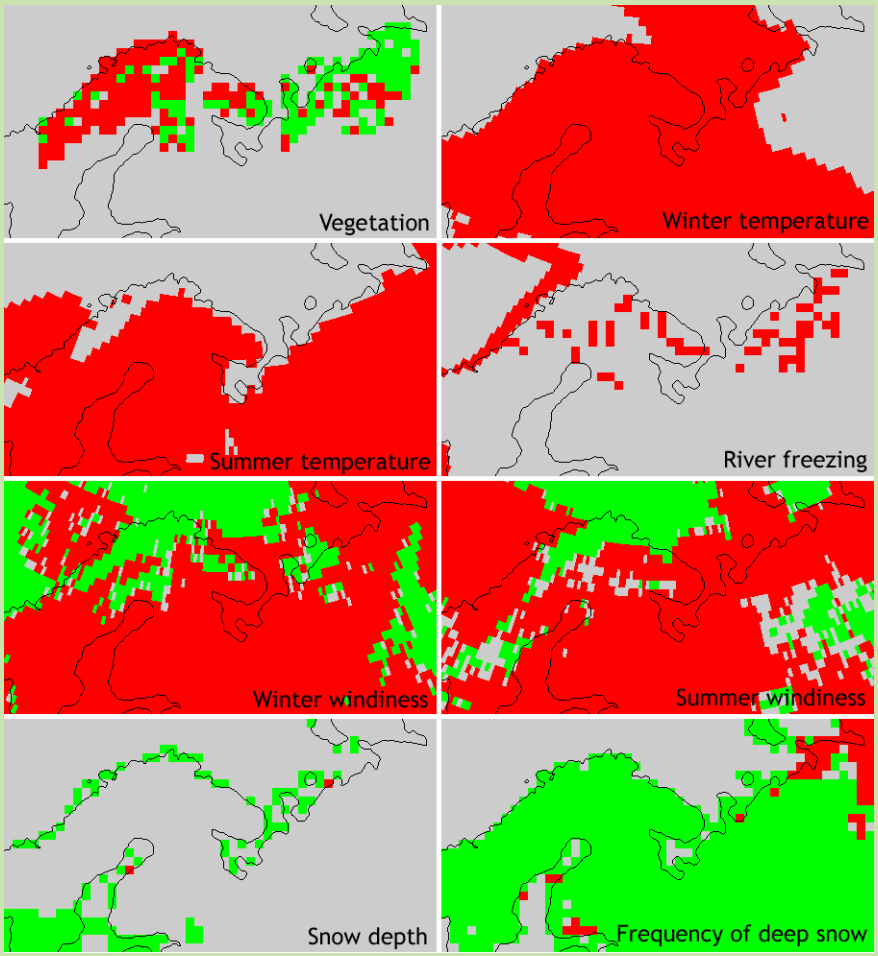
Estimated through Rutger Dankers' *refreezing index* which calculates quantity of rainwater or meltwater that penetrates into a snowpack and then freezes.

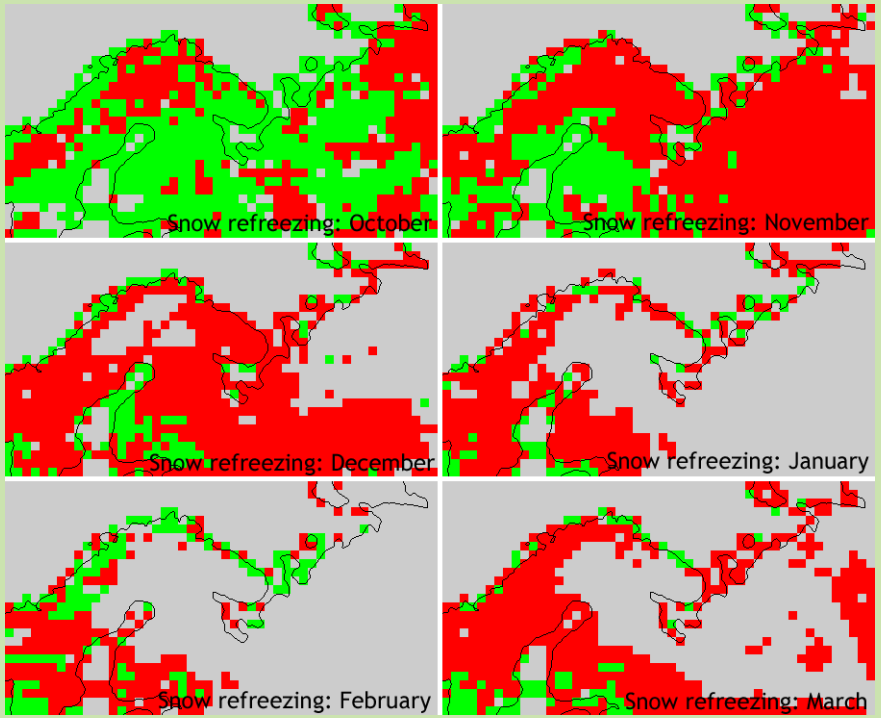
Calculated from October to March

Reindeer density on BALANCE project REMO grid (Plate Carrée, centred 72 ˚N, 35 ˚E, grid size 0.5˚ ≈ 55 km)

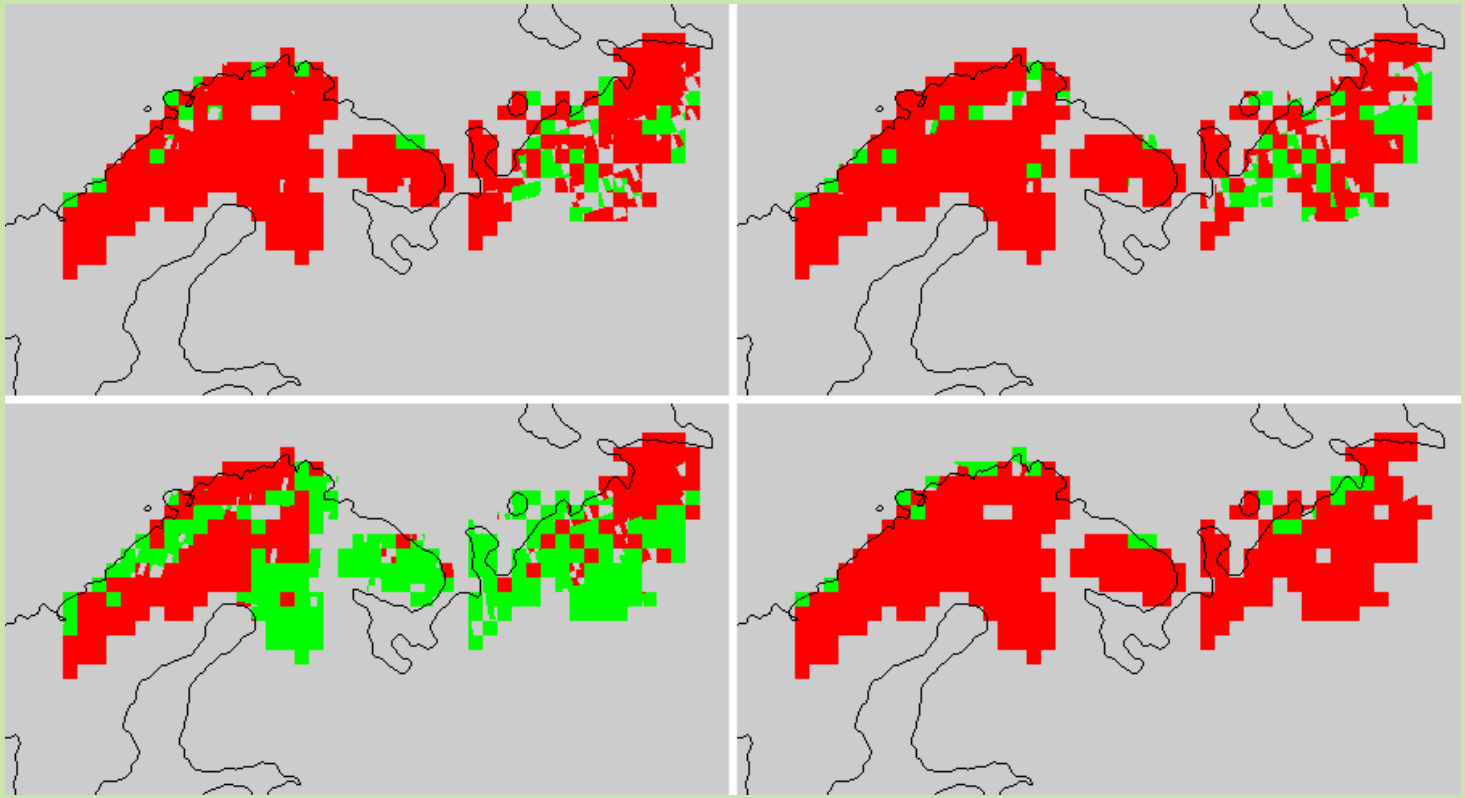


Changes in suitability, 1990s to 2070s





Combination of impacts: 4 different sets of weights



Most negative: Sweden, Finnmark, Lappi, NE Nenets Okrug

Positive trend: Some, mainly coastal, parts of Russia

Unclear: Other areas

Changes in reindeer density from vegetation regression alone:

Norway: –60%

Sweden: –50%

Finland: –5%

Russia: +10%

BARENTS: –25%

Numbers are probably uncertain to within a factor of 2.

Trends are probably correct

BUT: have considered environmental potential impacts alone, without consideration of adaptive capacity or non-environmental influences

So… how vulnerable *is* reindeer husbandry to climate change?

- probably, most important environmental factor is the change in vegetation distribution
- this is modelled rather crudely at present but suggests a gentle decline in reindeer numbers as (if) shrubs and forest move north
- but… a change in institutional or subsidy regime could achieve in 1-2 years what climate change could achieve in 80 years

and if herders' comparatively low priority accorded to climate change *per se* is reasonable, what *are* they worrying about?

loss of pasture through

- industry
- pollution
- farming and forestry

… and these may be modified by climatic factors

Conclusions

- environmental pressures on reindeer husbandry in the European North, driven by climate change to 2080, are predicted to be generally negative in Scandinavia, neutral in Finland, positive in Russia
- main effective variables are vegetation distribution, winter temperature and wind regime
- predicted effects of these pressures are **relatively small**, with considerable scope for mitigation, and largely within the range of experience of herders
- potential effects of change in subsidy regime or loss of pasture are **large and rapid**
- socioeconomic change can act in **synergy** with environmental change
- adaptive capacity varies considerably across Barents region

What is needed for understanding?

• There is a need for greater understanding of the Arctic environment and its components, such as reindeer, in particular due to potential climate change implications.

· Understanding dynamics and details of our complex natural environment is valuable

  - Understanding effects of perturbations and shifts is even more so as we begin to comprehend the potential for and extent of global change.

·Therefore, development of relevant data that can aid in this process is of critical value

What is needed for understanding?

·What are relevant data?

·Factors to consider are 1) requirements of scale

- 2) requirements of coverage – extent and flexibility
- 3) minimum and maximum levels of required detail
- 4) potential error and its effects in limiting the value of an assessment

What is optimal?

• As scale increases from fine to coarse (and detail generally decreases) information is lost. However, as coverage broadens, patterns and trends that were otherwise hidden by detail may emerge

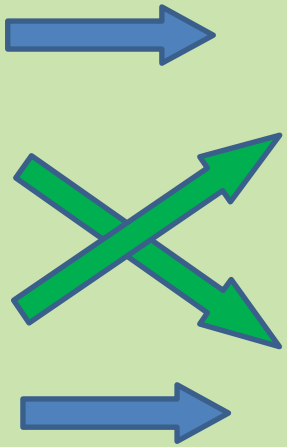
· What details do different analysis levels elucidate?

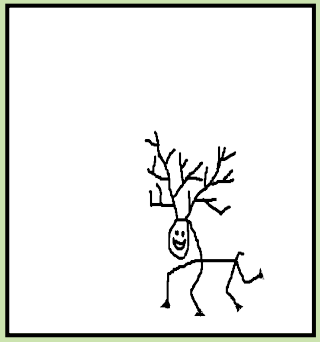
· What assessments may provide, or obscure, the most critical information?

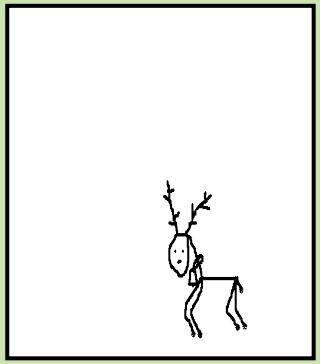
·Shifts may be quick or slow, small-scale or more expansive, obvious or obscure, but change needs to be detected regardless

- How is this best achieved?

What is optimal?







What is optimal?

None?!

·None is universally applicable given specific needs of ecological assessments and the inability of spatial assessments to easily translate between explicit detail and extensive coverage

· However, with continued improvements in computing power, satellite data choices, efforts to analyse and compile data, etc., there is an increased likelihood of compatibility between interests and needs

And so the future is bright!