Human Dimensions in the Arctic Tundra under Changing Climate Conditions

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LCLUC Science Team Meeting

May 1, 2008

Photo Courtesy of Svein D. Mathiesen

Outline of Talk

- **Purpose of Study**
- **What is "EALAT: Reindeer Pastoralism in a Changing Climate"?**
- **What is EALAT/"Reindeer Mapper"?**
- **Who are the Partners?**
- **Background**
  - **Impacts – climate, development**
  - **Reindeer**
- **Study Area**
- **Data –** *A Work in Progress*
  - **Indigenous Observations**
  - **Remote Sensing**
  - **Snow & Thermochron Study**
- **Status of Study**

Overall Purpose of Study

"…to promote a new kind of science where traditional knowledge is integrated into the management of the natural environment in the Arctic."[1]

Photo Courtesy of Svein D. Mathiesen

[1] **Johan Mathis Turi, President, Association of World Reindeer Herders 2002**

What is IPY *"EALAT: Reindeer Pastoralism in a Changing Climate"*?

EALAT is <u>an interdisciplinary intercultural study</u> to assess the *vulnerability* of coupled human-ecological systems in the Arctic to increasingly significant impacts of *global warming and climate change* (& development) on reindeer, reindeer herding, and herding society – especially, snow change

<u>Leadership</u> = Sami Reindeer Herders

Reindeer Herder-Scientist Teams

- <u>EALAT was initiated by</u>
  - **Association of World Reindeer Herders**
  - **Reindeer Herders' Union of Russia,**
  - **Sami Reindeer Herders Association of Norway**
  - **Sami University College**
  - **U. Tromso & others**

What is *EALAT/"Reindeer Mapper" – This Study?*
Reindeer Herders-NASA-University

EALAT/"Reindeer Mapper" is a unique partnership *within the EALAT project* between Sami Reindeer Herders & NASA and other Scientists
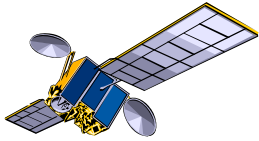
To Co-produce Findings

To Decrease Vulnerability
&
Increase Resilience

- **Partners Collecting Data:**
  - *Reindeer Herders (GPS):*
    - **Weather, snow conditions, herd behavior**
  - *NASA & University*
    - **Satellites, LCLUC, GIS Data Layers, Met Data**

EALAT/"Reindeer Mapper" Sami Reindeer Herder-Remote Sensing Team

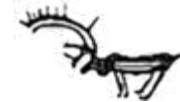**NASA Goddard Space Flight Center**
• Nancy Maynard

Florida International University
• Jennifer Gebelein

Sami University College
• Inger Marie Gaup Eira
• Svein D. Mathiesen

International Centre for Reindeer Husbandry
• Anders Oskal

True-color image of Earth's surface using Moderate Resolution Imaging Spectroradiometer (MODIS)
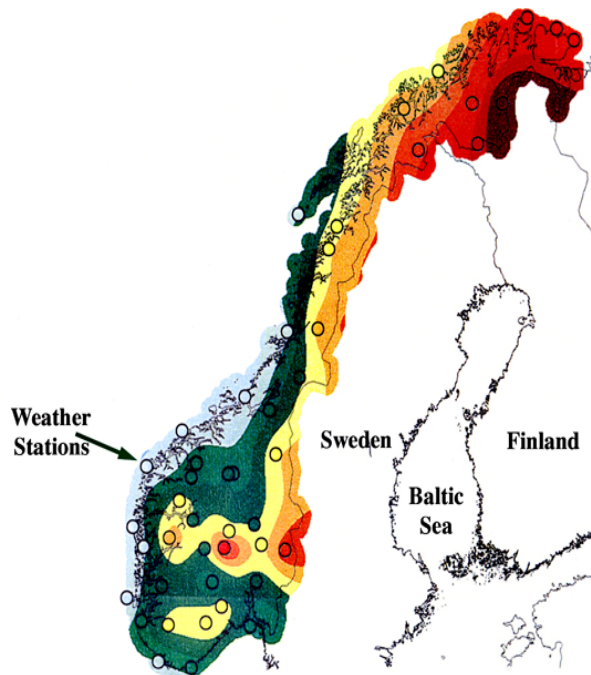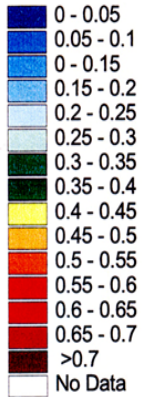
EALAT/"Reindeer Mapper": Background/Issues

Drastic changes in the economy and environment are creating critical situation in reindeer husbandry

The health, well-being, & culture of indigenous peoples (reindeer herders) of the Eurasian North are directly dependent upon the state of reindeer husbandry

The Climate/Environment Impacts – Reindeer and Herders:

- *Warmer temperatures create problems for herds*
  - **Changes in snow/ice cover/permafrost**
  - **Freeze-thaw – ice layers**
  - **Changes in availability & quality of forage**
  - **Increased insect harassment**
- *Interrupted migration routes* – **infrastructure**, pipelines; melting rivers
- *Contamination* (mining, pollution)
- *Increasing number of predators -* increased vulnerability (soft footing)

Background

Changes in Degrees/Decade in Centigrade

	0 - 0.05
	0.05 - 0.1
	0 - 0.15
	0.15 - 0.2
	0.2 - 0.25
	0.25 - 0.3
	0.3 - 0.35
	0.35 - 0.4
	0.4 - 0.45
	0.45 - 0.5
	0.5 - 0.55
	0.55 - 0.6
	0.6 - 0.65
	0.65 - 0.7
	>0.7
	No Data

Svalbard

Projected increases in Norwegian Winter Temps

Norway Study Area:

Next 20-30 years

0.5-0.7 ºC per decade

Weather Stations

Sweden

Finland

Baltic Sea

Projected increases in Norwegian winter temperatures per decade from base period of 1961-1990 to 2020-2049 using mid-scenario GCM outputs and NMI downscaling modeling methodologies

Source: Norwegian Metoerological Institute

Projected Human Impact on Northern Norway

1600-2052

Source:
Hugo Ahlenius, UNEP/GRID-Arendal)
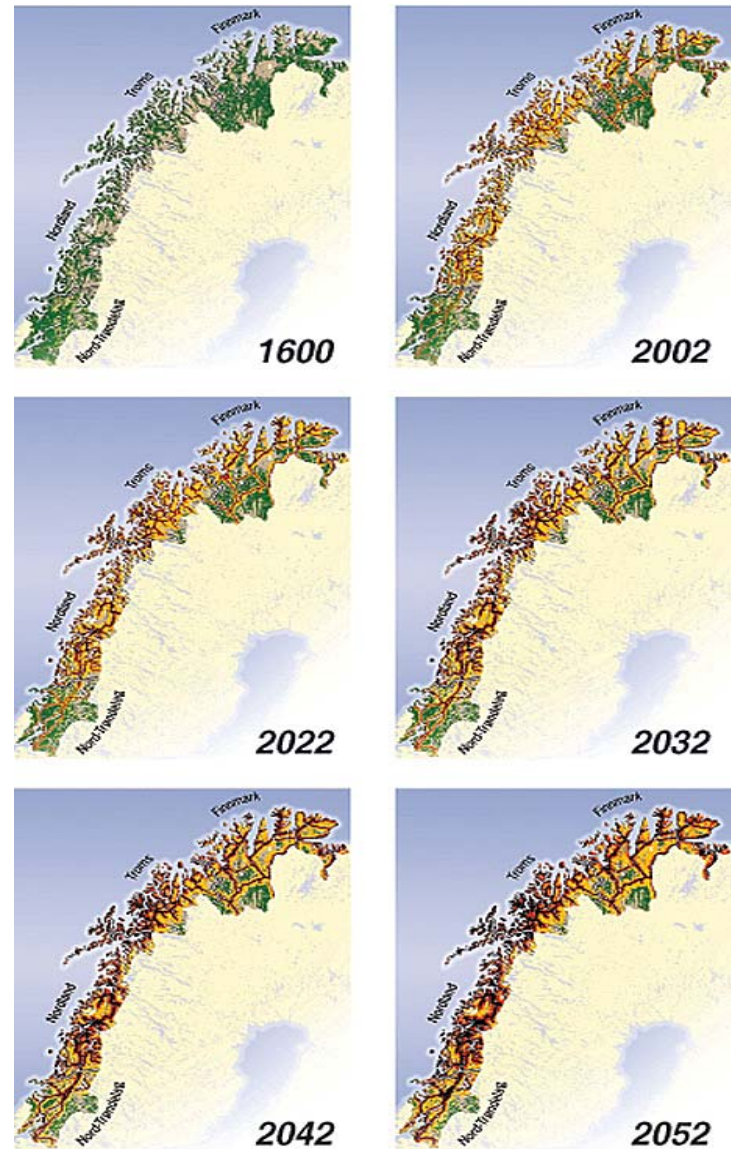
■	High Impact
■	Medium - High Impact
■	Low - Medium Impact
■	Forests
■	Tundra
■	Wetlands
□	Barren, Glaciers

Background
Rangifer tarandus = Reindeer or Caribou

Rangifer tarandus = most common land mammal of Arctic/subArctic

- *Large herds of 10s to 1000s*

- *~100,000 herders, Eurasia*

- *~2.5 M Reindeer Eurasia*

- **Reindeer must constantly forage for food – winter and summer – any changes to food can threaten herds**

  e.g., *Warming in Arctic causing decline in reindeer by changing amounts and type of snowfall and ice – changing ability of animal to find and dig through snow for winter forage*

General Pattern of Migration of Semi-domesticated Reindeer in Finnmark

- ***2 migrations per year***, moving between summer and winter pastures

  - ***Spring (April, May)*** move to the **mountainous coastal region**
    - Reindeer left on peninsulas or are swum or ferried across to islands
    - Feed on highly nutritious parts of dwarf shrubs, birch, willows, sedges, grasses
  - ***September*** - gathered, taken inland to **winter pastures**
    - Characterized by open, upland plains of tundra and taiga birch scrub

Seasonal Reindeer Husbandry Activities

Reindeer on Winter Grazing Grounds

January- March

Autumn Migration (mating)

September - December

Spring Migration (calving)

April - June

Reindeer on Summer Grazing Grounds

June - September
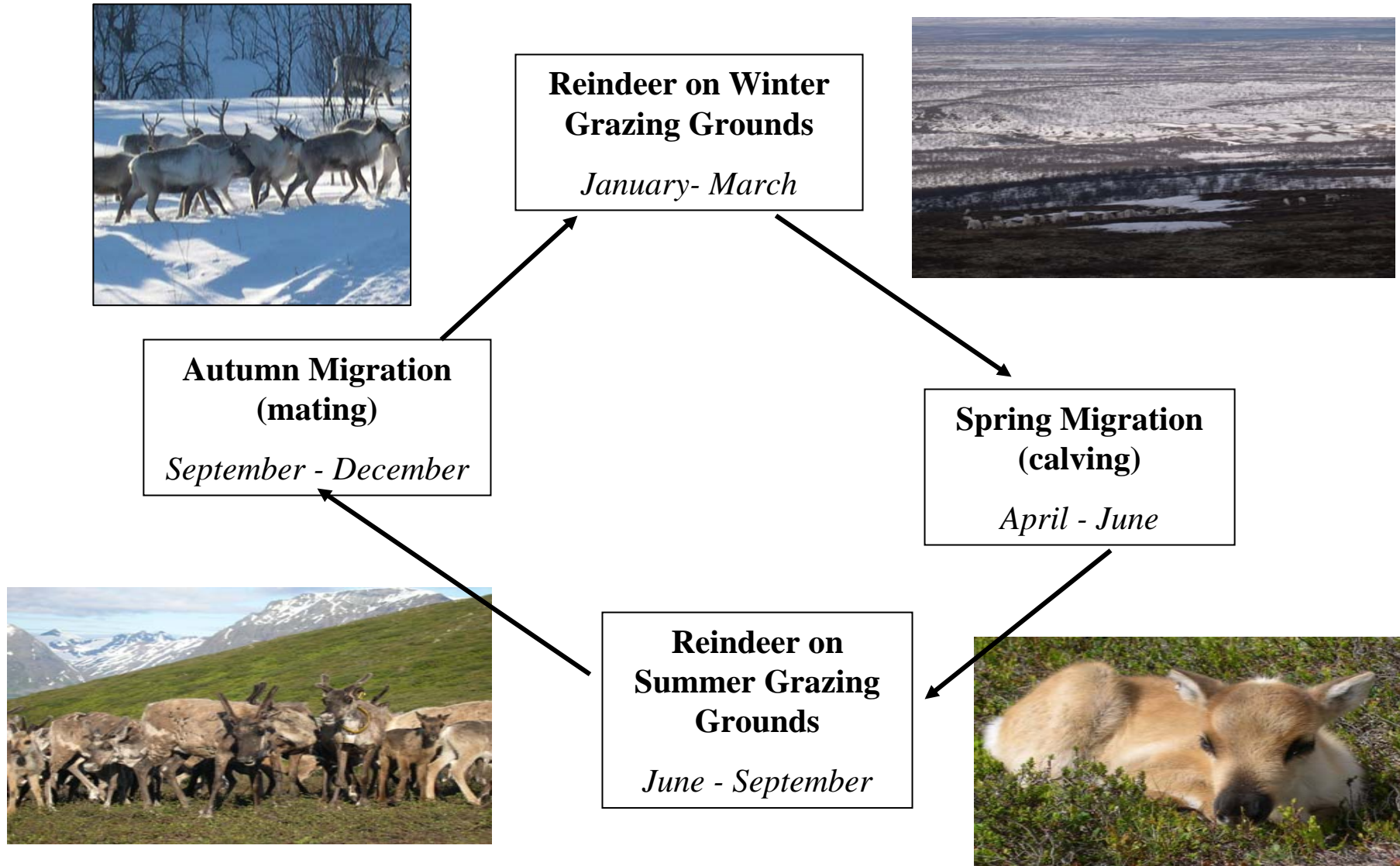
EALAT/"Reindeer Mapper" Study Sites

(1) ***Climate Change/Global Warming***
(Emphasis on Norway)

Reindeer Herders

6 migration routes in Northern Norway

PI = Inger Marie Gaup Eira

Norway

(2) ***Infrastructure (oil & gas) Development***
(Emphasis on Russia)

Reindeer Herders –

Pastures & migration routes in Nenets

PI = Anders Oskal

Russia

Russia Study Site
2007-2009

Data Collection Plan for Russia Site
Comparing Herder Observations with NASA-University
Emphasis of Study = Infrastructure Development

- *Sami Reindeer Herder Data Collection (A. Oskal)*
  - **Analysis of Historical Changes in Migration Routes**
    - Recent Years
    - Historical
  - **In situ Observations – Changes in:**
    - Snow
    - Weather
    - Infrastructure**
    - Interference with Migration/Forage**
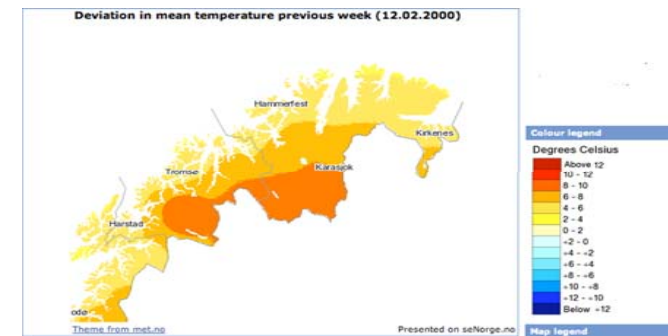
- *NASA-University Remote Sensing, Snow studies, & GIS Data Collection*
    - **Landsat and other Satellite Imagery**
      - Inventory search underway
      - Decadal comparison – images: 1970s to 2000s
    - **GIS Data bases**
      - Roads, urban, infrastructure, oil and gas

Norway Study Site
2007-2009

PI: Inger Marie Eira
Sami University College

Reindeer Herders
(GPS):

6 Herders'
Migration Routes

NASA & University

Satellites, data

Approximate Reindeer Migration trails

Seiland, Norway

Kuatokeino, Norway

Legend

Migration Trails

• Kuatokeino, Norway

• Seiland, Norway

N
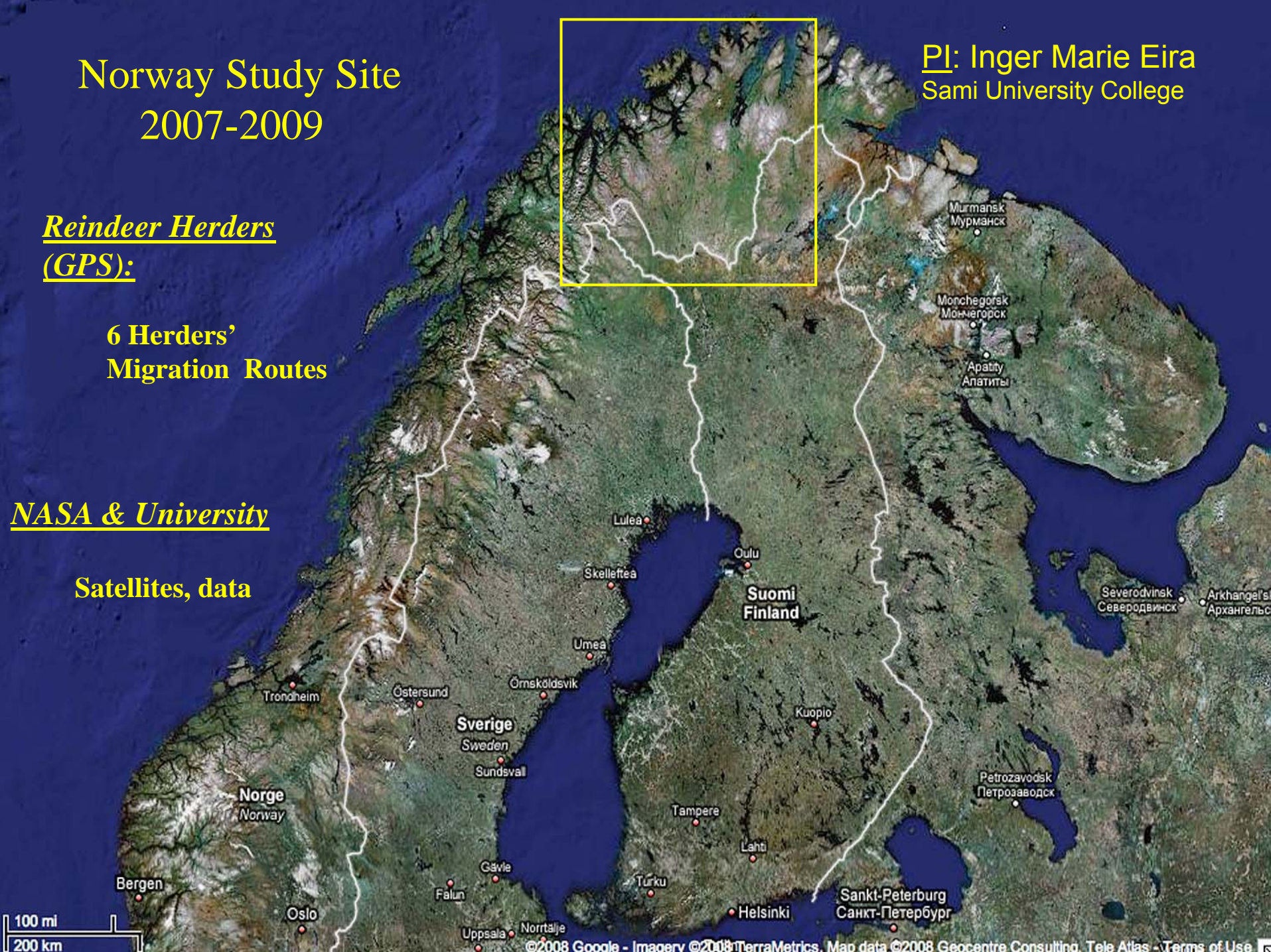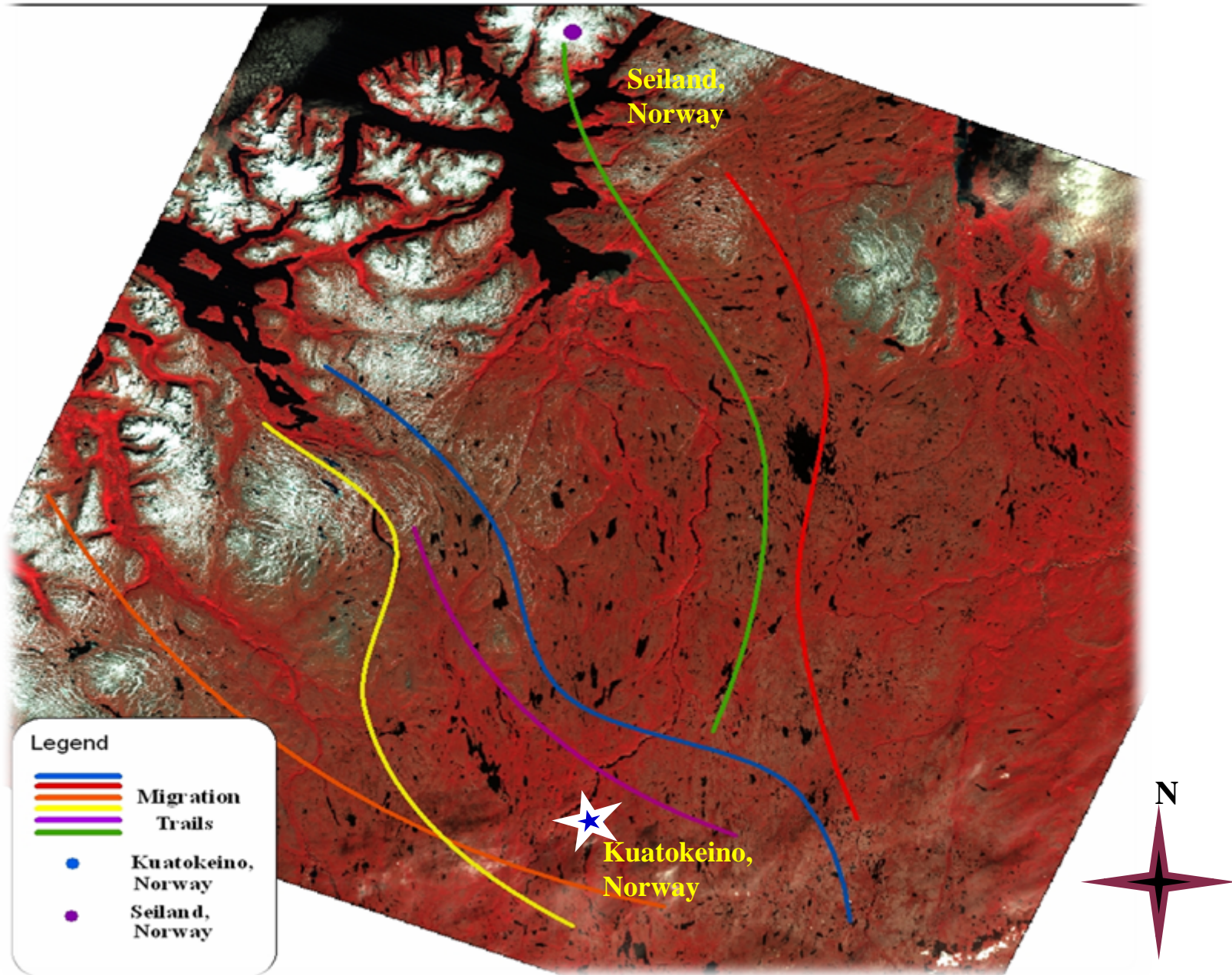
Indigenous Observations Norway Study Sites
Daily Observations Being Made by 6 Norwegian Sami Reindeer Herders 2007-2008

PI = Reindeer Herder, Inger Marie G. Eira - Sami University College

Daily Herder Data Logs:

- **Time/Date, GPS Location**
- **11 Specific Weather Obs – e.g.,**
  - **Wind, cloud cover, precip, T**
- **Sami snow terms**
- **Snow**
  - **Depth, description, measurements**
- **Herd Behavior**
- **Snow conditions**
  - **as they pertain to reindeer ability to get to lichens**
- **Thermochrons**

Day

Weather

Daily Data Logs of Reindeer Herders

Snow words

by *Inger Marie Gaup Eira*, PI

Wind, air and snow depth

Herds behavior

Karakt. av beiteforhold
GIS pkt/place

Njukčamánu 5. beaivi

Dii	⬅ Biegga	Ruvaš	Láfu biegga	Jeala-has	○ šearadat Beaivvá-dát	Obba-dálki	⚲ Balva-dálki	☁ Borga muohtti	guoldu	☂ Savda šlahtti Arvi	🌡 Temp
	4			X							−15°

Muohta ja guohtun

Áidnen-áinnahas		Doavdnji		Šalka - čiegar	
Bearta		Earbmut		Saŋas	
Bievlan		Gaikon-veađahat		Sarti	
- bovdnaoaivvit					
- muorramaddagat		Gaskageardi		Seakŋut	
- ramat		Geardni	X	Seaŋaš	
- vađat		Girrat		Sievlla	
Bievllus		Goahpálat		Skártabodni	
Čađgi		Joavggahat		Skávvi - skáva	
Časttas - časttasat	X	Luotkkus - luotko		Skoavdi-skovdai	
Čearga - čeargan	X	Moarri			
Ceavvi		Muovllahat		Soavli-soavllas	
Činus	X	Njuohpa		Spotna-spoanas	
Cuoŋu		Oppas		Skoalddas	
Dobádat		Ridni-rinadat		Vahca-vazadat	

Biegga,		áibmu		muohta	
Goalki	X	Bivval/bivvalat		Seaggi (unnan) muohta	
Spiella		Galbmas/galbma		Gaskamearalaš	
(Čavges) Biegga		Čoaskis/čoaskimat		Garas/garradan	X
Garra (ramadat) biegga		Ruvaš/ruvvašat		Gassat(ollu) muohta	X

Movt eallu lea?

Lodji/ Guohtu	Čoahkkit	Biđgista Vistta	Vázzálas Manni	Ruvggahallá	Viggá	Jállu	Normal	Árgi
X								X

Makkár guohtun lea?: ☐ buorre, ☐ oalle buorre, ☒ oalle heitot, ☐ heitot

Makkar baikkis? (GPS: jus lea)	
Namma/namat	

Sami reindeer herders use more than 300 words on snow and snow change.

Reindeer herders' traditional knowledge should be used to decrease vulnerability to change.

joavggahat

sievlla

lavki

bohkolat

čearga

Fieski

Skarti

muovllahat

moarri

skoarádat

girrat

OPPAS

časttas

ČIEGAR

rodda

fáska

činus

Sámi boazodoalus leat s. 300 iešguđege analyhtalaš muohtasáni.

Čierga

gálja

Pictures by ICR

EALAT Snow Change Studies:
Snow is governing factor on ability for reindeer to find and dig through snow for winter food or to travel across the tundra

Cuonu (Sami) =strong crust on snow (this snow is very bad for reindeer)

Sami-NASA Snow Change Study– Thermochrons
Combining Traditional Knowledge & Science to Solve Problems

<u>Serious Snow Problem for Herders in Finnmark</u>:

- Over-wintering pastures which provide lichens for forage are more frequently getting "locked out" due to *ice layers in snow pack or over lichens*
- Due to *"free-thaw" cycles* from changes in weather
- Impossible for reindeer to *access primary food source*
- Result = *starvation & illness*

<u>EALAT Goal to Solve Snow Problem:</u>

- To better *predict* when and where adverse winter grazing conditions might occur
- So a *service* could be set up to help herders know where winter pastures with bad grazing conditions so they can avoid them

Sami-NASA Snow Change Study-Thermochrons

EALAT Snow Study

To combine traditional indigenous knowledge with science to increase herder information base for better adaptation strategies for dealing with adverse weather conditions & climate changes

- **Sami University College (I. Eira)**
  - **October 2007**
  - Team put down thermochrons (from NASA) all over Finnmark at various depths between ground and top of snow pack
  - **May 2008.**
    - Team to take out and compare Ts with predictions from NMS model
- **Norwegian Met Service (NMS):**
  - Models to predict snow conditions by looking at T gradients in snow pack (2007)
- **NASA "Global Snowflake Network" Team**
  - Thermochron technology
  - Other NASA/NOAA temperature, precip data

Remote Sensing & Science Data Observations
(for Integration with Reindeer Herder Observations)

- *NASA-University Remote Sensing, Snow Studies, & GIS Data Collection*
  - *Landsat*
    - **Inventory search continuing**
    - **Series of cloud-free scenes located, ordered, processing**
      - **Seasonal vegetation change study: 1-year time series**
      - **Decadal vegetation/infrastructure change study:**
        - » **1970s through 2007**
      - **Applying Digital Elevation Model (DEM) for topographic perspective**
  - *GIS Data Bases* – **Collecting for Integration**
    - **Roads, Infrastructure, urban, oil & gas**
- *Other Data Sets to be Included*
  - *Snow Studies* **w/ NASA "Snowflake" Project (Wasilewski, Foster)**
  - **NASA/NOAA Climate Data (Temp, Precip)**
  - **MODIS & NDVI for** *Annual/Seasonal vegetation/snow changes*
  - **Land Surface** *Temperature Patterns & Sea Ice* **Trends (Comiso)**
  - **Ikonos & other** *high-resolution imagery*

Approximate Reindeer Migration trails
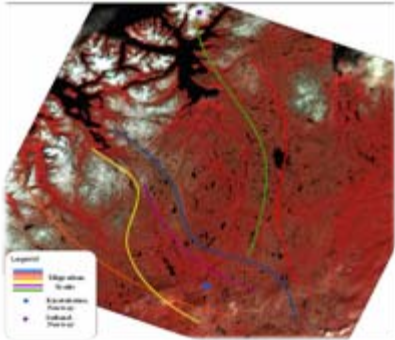
Unsupervised Classification Landsat 2000 Data, Norway (195/11)
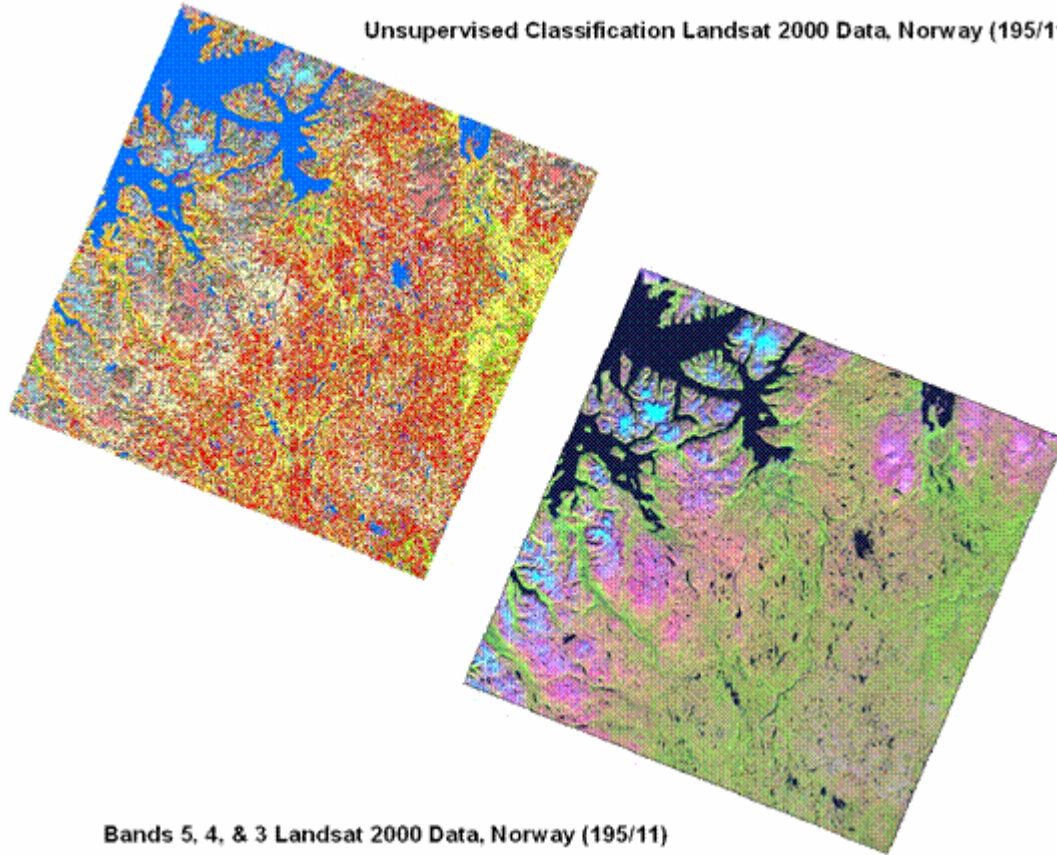
Bands 5, 4, & 3 Landsat 2000 Data, Norway (195/11)
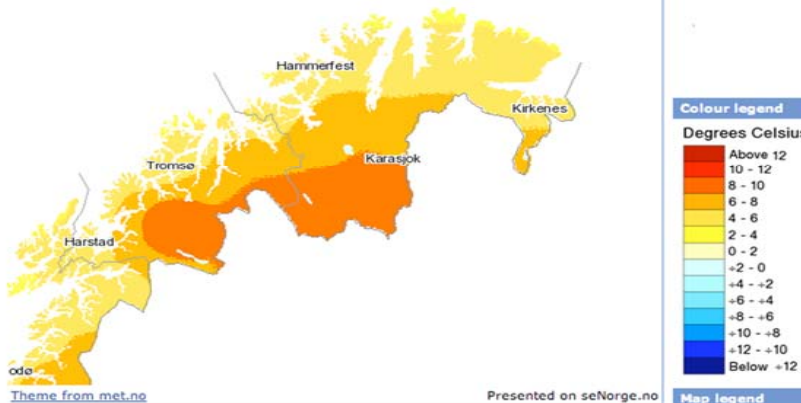
Example data set being compared with Reindeer Herder Observations
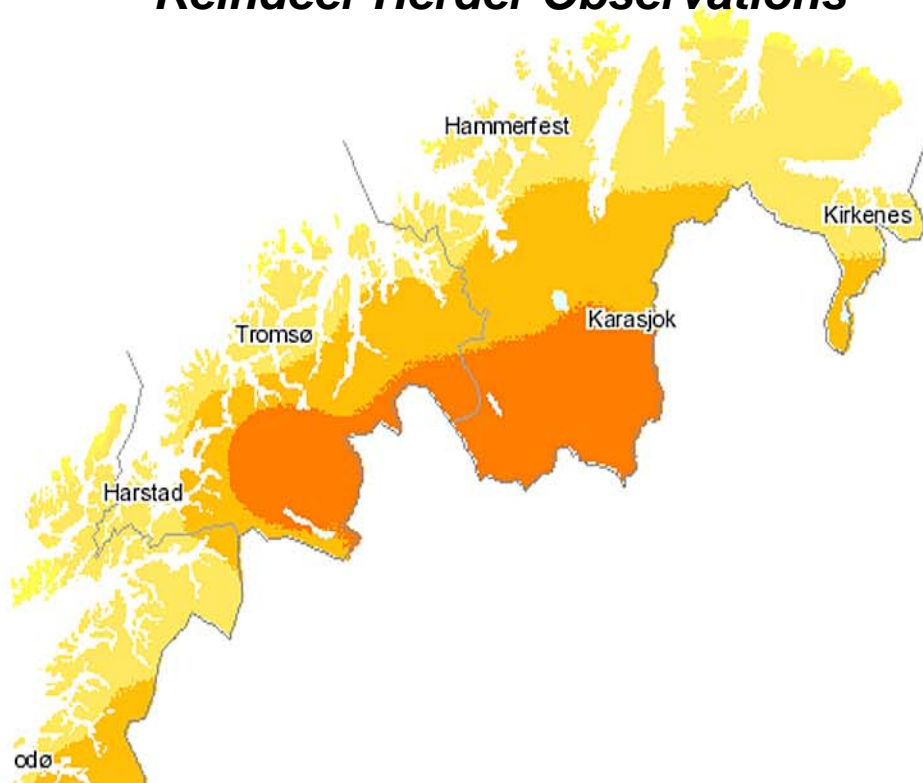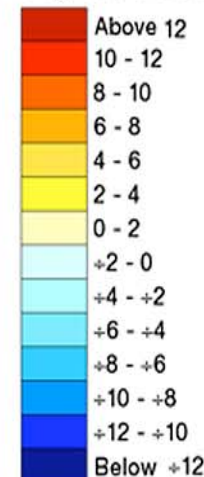
Example of data sets being compared with Reindeer Herder Observations (especially important for freeze-thaw conditions)
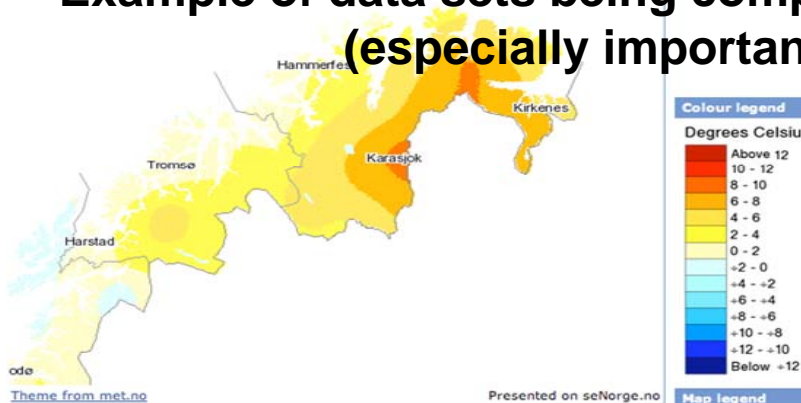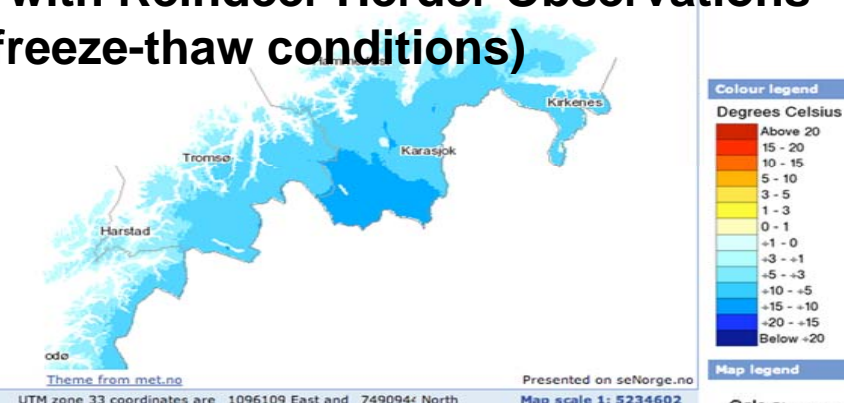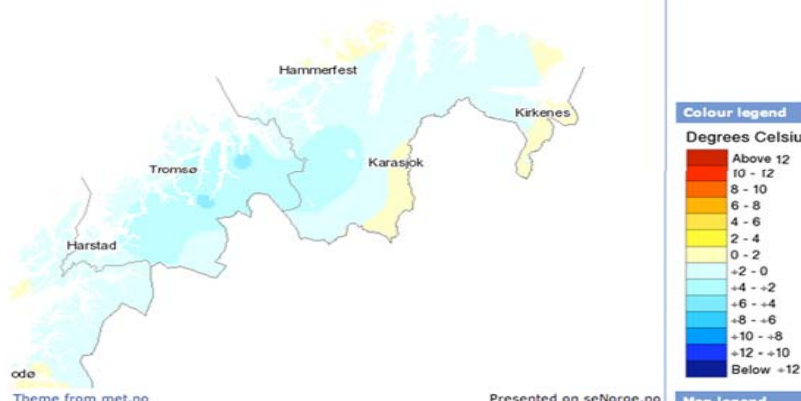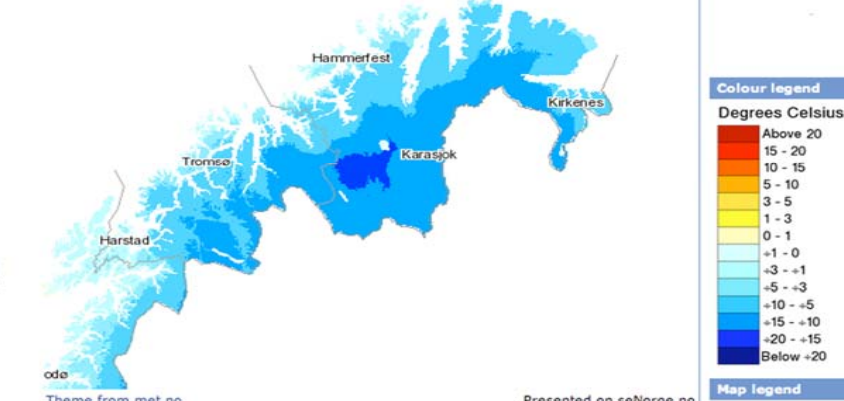
EALAT Snow Freeze-Thaw Study
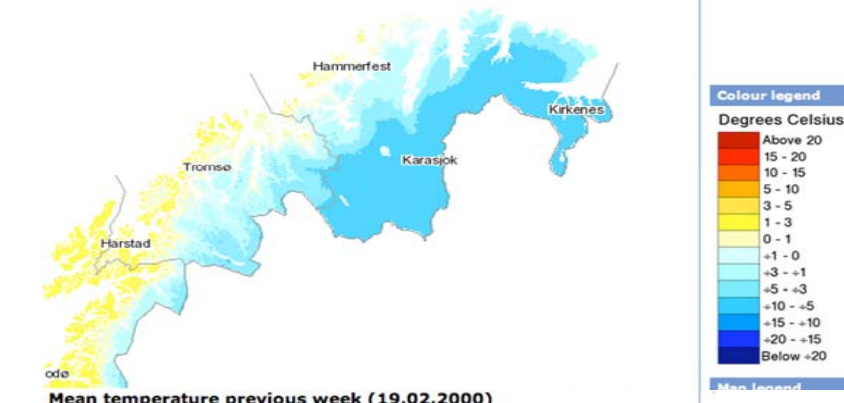## *Temperature Data Kautokeino: <u>Last 365 Days</u>*

<u>Kautokeino Temperatures</u>: One year (365 days)

– **Actual vs. Normal Temps**

– **Maximum/Minimum**

• **<u>Red</u> = Above-Normal Temps**

• **<u>Blue</u> = Below-Normal Temps**

(1) **Daily Average & Normal T**

(2) **Daily T Departures**

(3) **Daily Max (red), Min (Blue)**

*Green line = departure for the period: +1.98 C

KAUTOKEINO, NORWAY
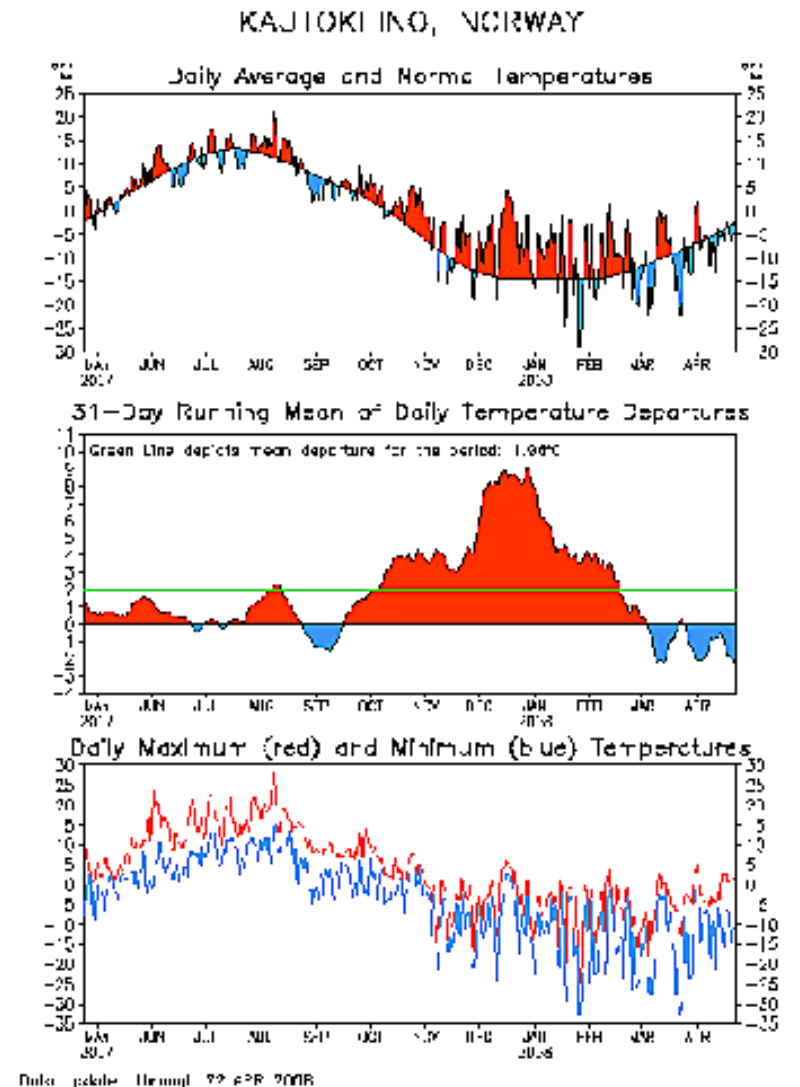
EALAT Snow Freeze-Thaw Study
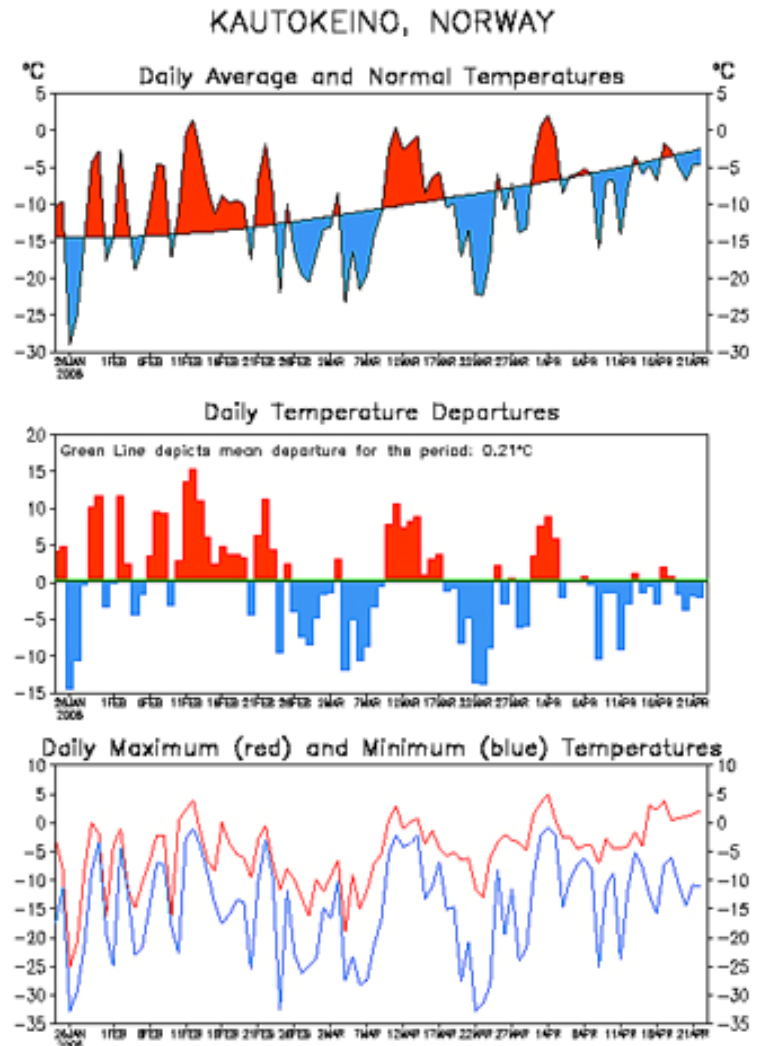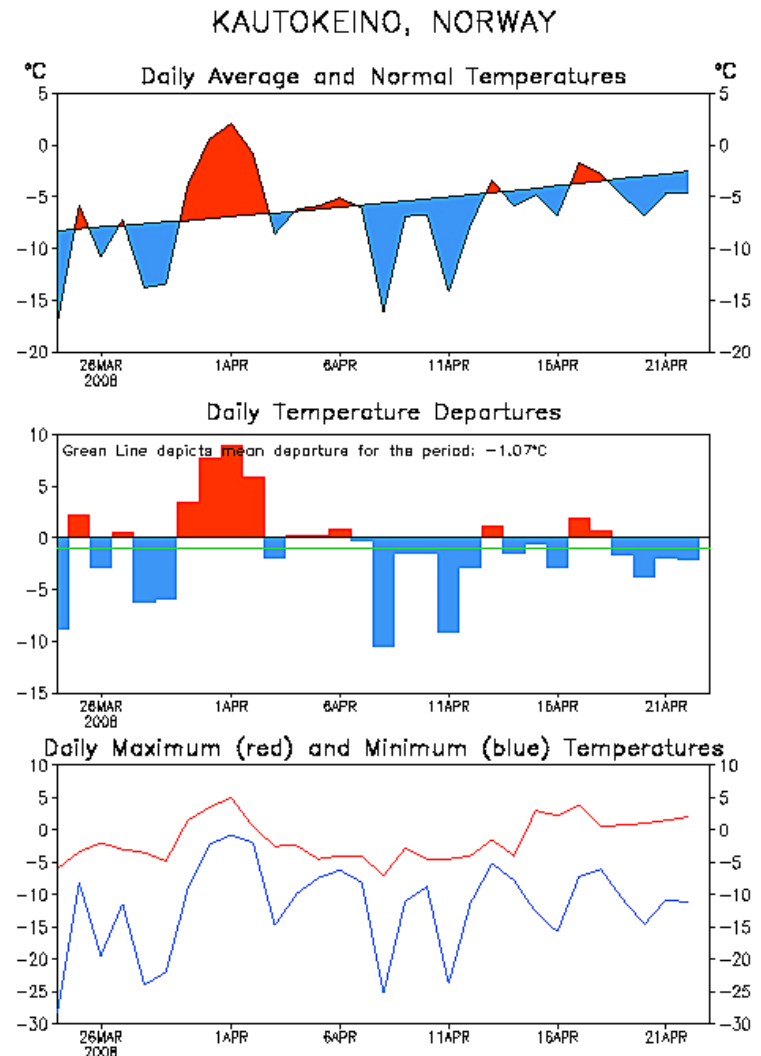## *Temperature Data Kautokeino: <u>Last 90 Days</u>*

<u>Kautokeino Temperatures</u>: 90 days
- **Actual vs. Normal Temps**
- **Maximum/Minimum**

- **<u>Red</u> = Above-Normal Temps**
- **<u>Blue</u> = Below-Normal Temps**

(1) **Daily Average & Normal T**
(2) **Daily T Departures**
(3) **Daily Max (red), Min (Blue)**

*Green line = mean departure for period:
    +0.21 C

KAUTOKEINO, NORWAY

Daily Average and Normal Temperatures

Daily Temperature Departures

Green Line depicts mean departure for the period: 0.21°C

Daily Maximum (red) and Minimum (blue) Temperatures

Data updated through 22 APR 2008

CLIMATE PREDICTION CENTER/NCEP

EALAT Snow Freeze-Thaw Study
Temperature Data Kautokeino: <u>Last 30 Days</u>

<u>Kautokeino Temperatures</u>: 30 days
- – **Actual vs. Normal Temps**
- – **Maximum/Minimum**
- **<u>Red</u> = Above-Normal Temps**
- **<u>Blue</u> = Below-Normal Temps**

(1) **Daily Average & Normal T**
(2) **Daily T Departures**
(3) **Daily Max (red), Min (Blue)**

*Green line = mean departure for period:
-1.07 C

KAUTOKEINO, NORWAY

Daily Average and Normal Temperatures

Daily Temperature Departures

Green Line depicts mean departure for the period: −1.07°C

Daily Maximum (red) and Minimum (blue) Temperatures

Data updated through 22 APR 2008

CLIMATE PREDICTION CENTER/NCEP

EALAT Snow Freeze-Thaw Study
PRECIPITATION Data Kautokeino: Time Series

(1) Last 30 days

(2) Last 365 days
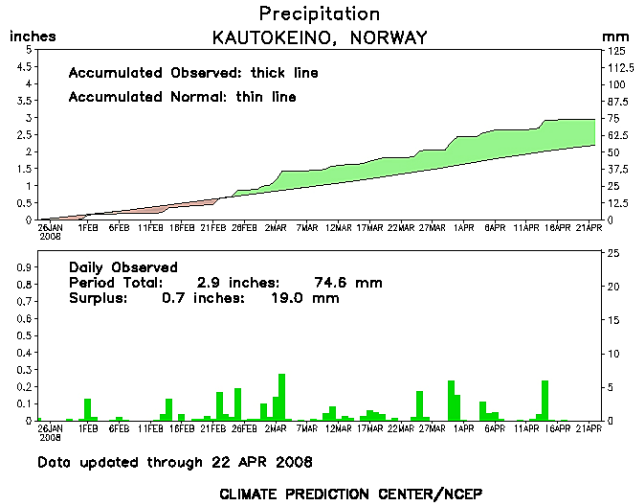
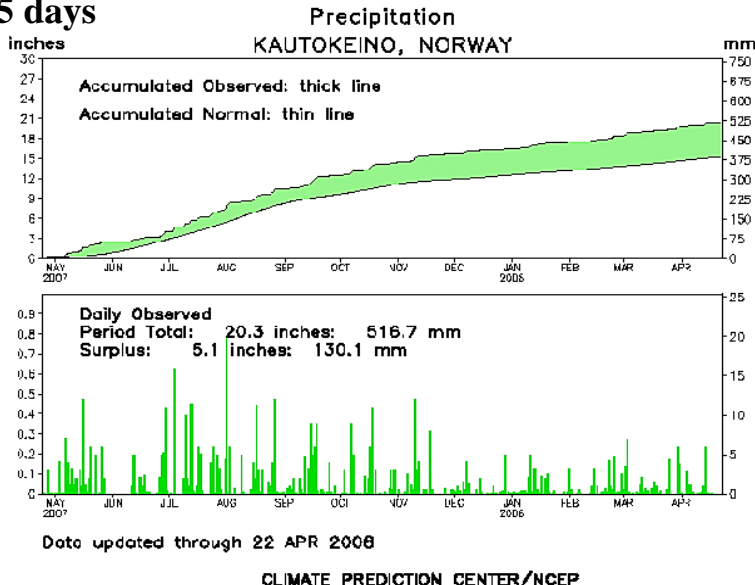**Kautokeino Precipitation:Time Series**

- **Actual vs. Normal Precip**
- **Accumulated Precip**
- **Actual vs. Normal**

- **Green** = Precip surpluses
- **Brown** = Precip deficits

- **Accumulated Observed & Accumulated Normal**
- **Daily Observed (mm)**

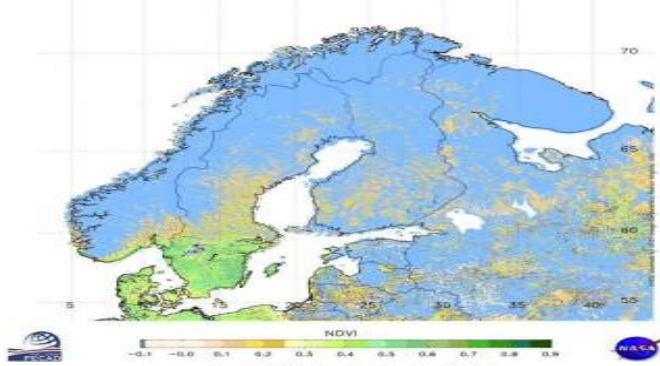*2 Example Data Sets*:
  (1) Last 30 days
  (2) Last 365 days

NDVI = a land's "greenness" measure - photosynthetically active vegetation

March-April 2002

NDVI=Normalized Difference Vegetation Index
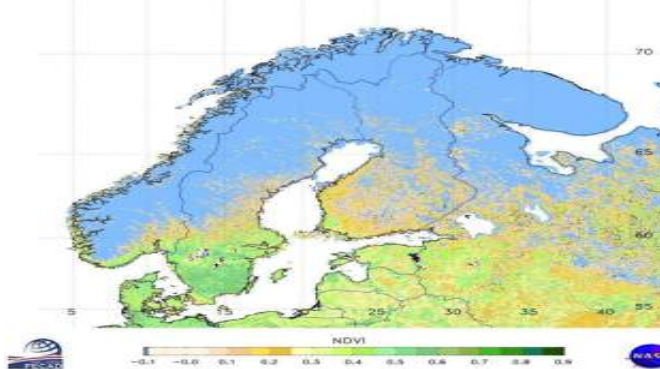*(Example data set)*
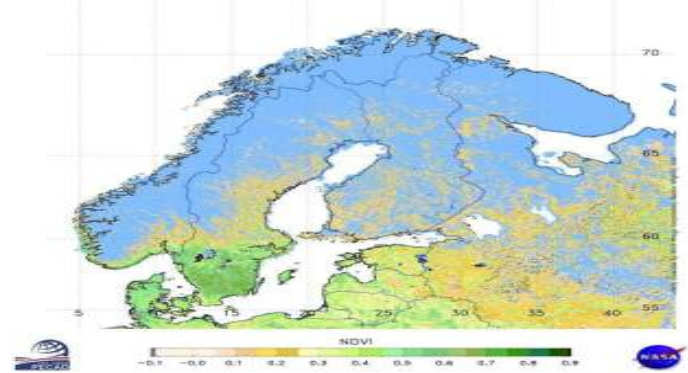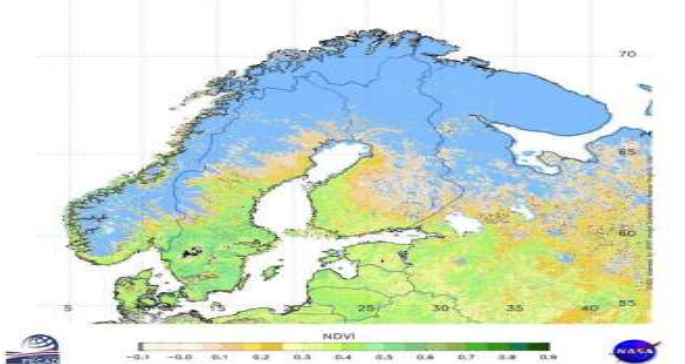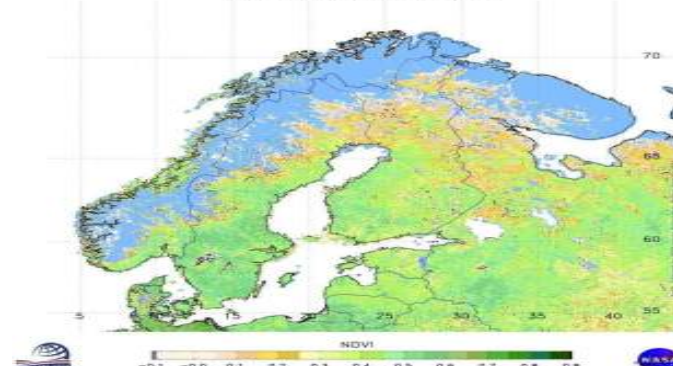
Status & Future Plans
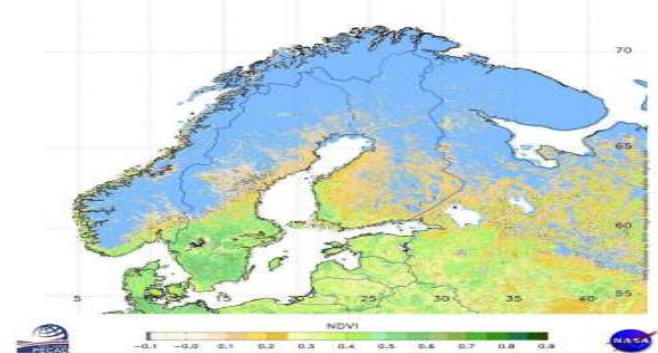
<u>Summer 2008</u> First Data Comparisons: Herders-Satellites

- **Meanwhile…….**

<u>Sami Reindeer Herder Data Collection Continues</u> (I. Eira/Norway)
Analysis of *Historical* Changes in 6 Migration Routes
  – **2007-2008 *Real Time* Observations – Changes in:**
    - Snow, Weather, Forage Conditions, Infrastructure, Interference with Migration/Forage

<u>NASA-University Remote Sensing, Snow Studies, & GIS/other Data Collection Continues</u>
  - **Landsat and other Satellite Imagery**
    – Seasonal & Decadal comparison – images: 1970s to 2000s
  - **GIS Data bases**
    – Roads, urban, infrastructure, oil and gas
  - **Snow Studies** – Global Snowflake Network, Satellites (MODIS)
    – NCEP/NMI Temperature/Precip
  - **NDVI -** Annual/Seasonal vegetation/snow changes

Thank you…………………

Source: www.arcticphoto.co.uk