

An Introduction to Selected Aspects of Remote Sensing

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Based on

CCRS Remote Sensing Tutorial
Canada Centre for Remote Sensing
www.ccrs.nrcan.gc.ca

and work at IMM/DTU
www.imm.dtu.dk



Definitions

- Remote sensing is the science (and to some extent, art) of acquiring information about the Earth's surface without actually being in contact with it. This is done by sensing and recording reflected or emitted energy and processing, analyzing, and applying that information.
- Remote sensing consists of collection, analysis and interpretation of data from a study area obtained without tangible, physical contact. Data collection is often based on electromagnetic energy (light, heat or radar). Data analysis is often carried out by means of geographical information systems (GIS) or is based on methods from multivariate and/or spatial statistics. Interpretation is often carried out in an interdisciplinary group consisting of subject-matter applications experts and data analysts.



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1. Fundamentals of Remote Sensing
2. Satellites and Sensors
3. Microwave Remote Sensing
4. Image Interpretation and Analysis
5. Remote Sensing Applications



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Contents

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4. Geology
 - 1. Structural Mapping and Terrain Analysis
 - 2. Geologic Unit Mapping
5. Hydrology
 - 1. Flood Delineation and Mapping
 - 2. Soil Moisture



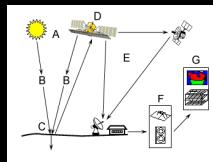
Contents

5. Remote Sensing Applications (cont'd)

6. Sea Ice
 - 1. Ice Type and Concentration
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7. Land Cover and Land Use
 - 1. Land Use Change (Rural / Urban)
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8. Mapping
 - 1. Planimetry
 - 2. Digital Elevation Models
 - 3. Topographic and Baseline Thematic Mapping
9. Oceans and Coastal Monitoring
 - 1. Ocean Features
 - 2. Ocean Colour and Phytoplankton Concentration
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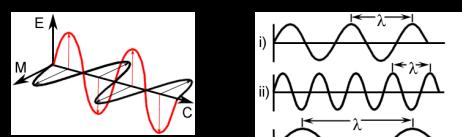
Remote Sensing



1. Energy Source or Illumination (A)
2. Radiation and the Atmosphere (B)
3. Interaction with the Target (C)
4. Recording of Energy by the Sensor (D)
5. Transmission, Reception, and Processing (E)
6. Interpretation and Analysis (F)
7. Application (G)



EM, wavelength and frequency

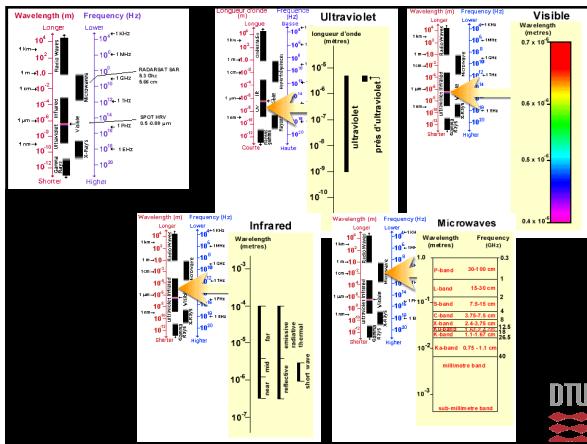


$$c = \lambda v$$

where:

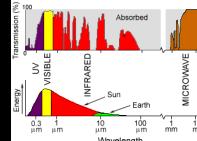
$$\begin{aligned} \lambda &= \text{wavelength (m)} \\ v &= \text{frequency (cycles per second, Hz)} \\ c &= \text{speed of light } (3 \times 10^8 \text{ m/s}) \end{aligned}$$





Atmosphere

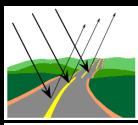
- Rayleigh scattering (small particles or gas molecules)
- Mie scattering (particles size of wavelength)
- Nonselective scattering (large particles)
- Absorption (ozone, carbon dioxide, and water vapour)
- Above leads to "atmospheric windows"



Target Interactions



- Specular reflection

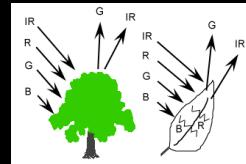


- Diffuse reflection

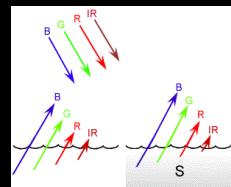


Target Interactions

- Leaves (chlorophyll, internal leave structure)

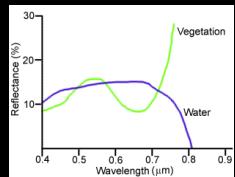


- Water (chlorophyll, suspended sediment, CDOM)

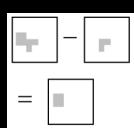
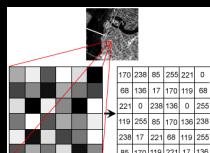


Spectral Response

- Use several wavelengths to distinguish (or discriminate) between targets



Digital Images

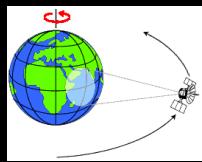


Ground, Air, Space



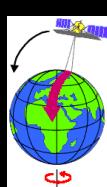
Orbits and Swaths

Geostationary orbits

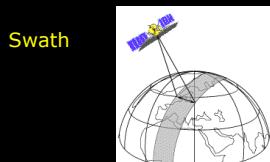


Near-polar orbits

(many sun-synchronous,
local sun time,
ascending-descending)



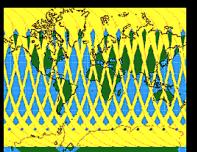
Orbits and Swaths



New area with
consecutive swaths



Overlap



Digital Images

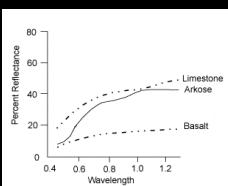
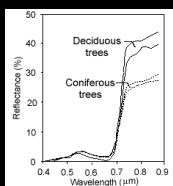
Spatial resolution



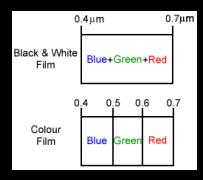
Coarse/low
resolution

Fine/high
resolution

Digital Images



Spectral resolution



Digital Images

Radiometric resolution



2 bit
(4 DNs)



8 bit
(256 DNs)



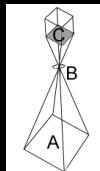
Digital Images

Temporal resolution



DTU

Cameras, Aerial Photography



Normal colour

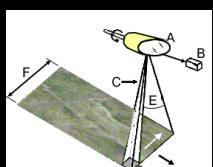


False colour

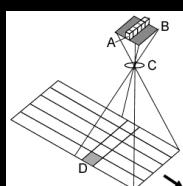


DTU

Multispectral Scanning



Across-track
(rotating mirror)



Along-track
(pushbroom)

DTU

Digital Images

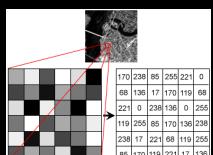
Contrast enhancement

Contrast stretch or
spatial filtering or ...



DTU

Digital Images



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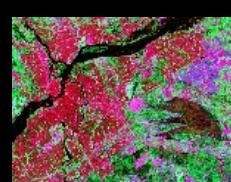
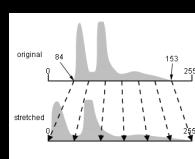


DTU

Digital Images

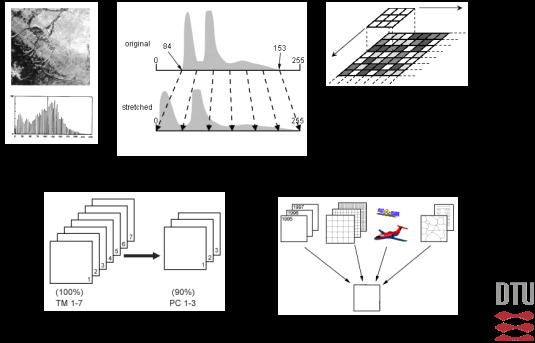
Contrast enhancement

Contrast stretch or
spatial filtering or ...



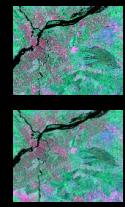
DTU

Digital Images

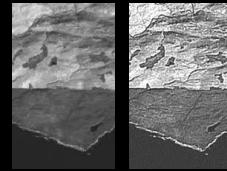


Digital Images

Low-pass filter

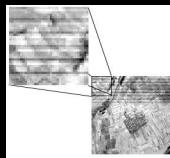


Directional filter
Edge detection

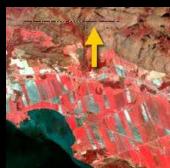


Striping, Drop-Outs

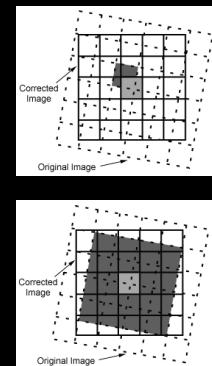
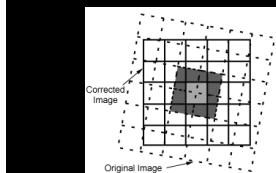
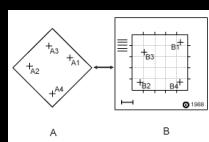
Striping



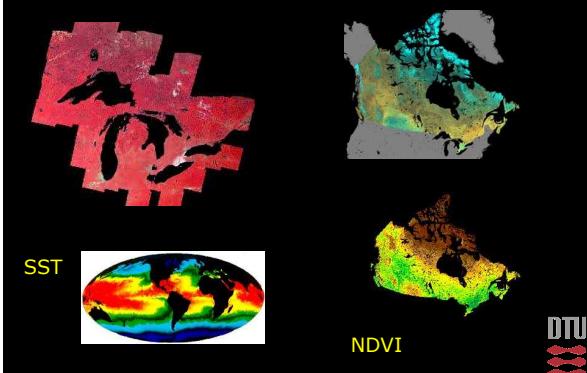
Dropped line



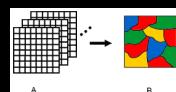
Geometric Registration



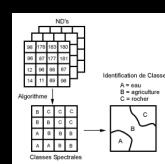
Mosaic (SST, NDVI)



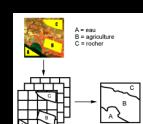
Classification



Unsupervised (clustering)

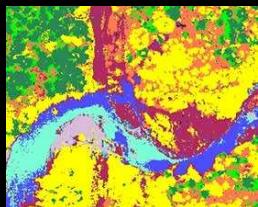


Supervised



Classification, casi

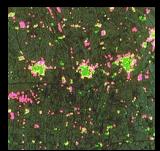
First commercial imaging spectrometer
Up to 288 spectral bands
400-900 nm (18 nm)
Spectral 'fingerprint'



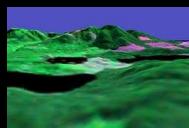
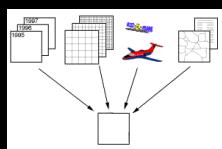
Compact Airborne Spectrographic Imager, casi



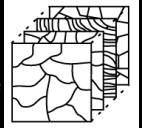
Change Detection



Data Integration



DEM/DTM
Perspective

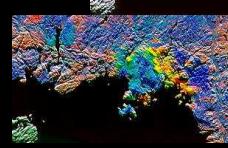
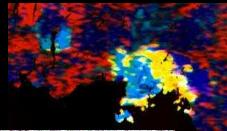


GIS



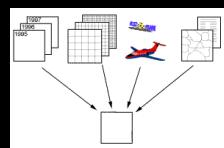
Data Integration

- Airborne gamma survey
- Airborne SAR image
- Integration

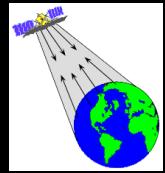
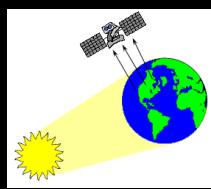


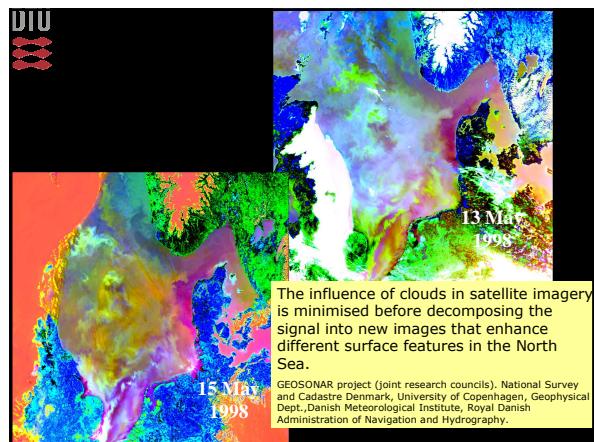
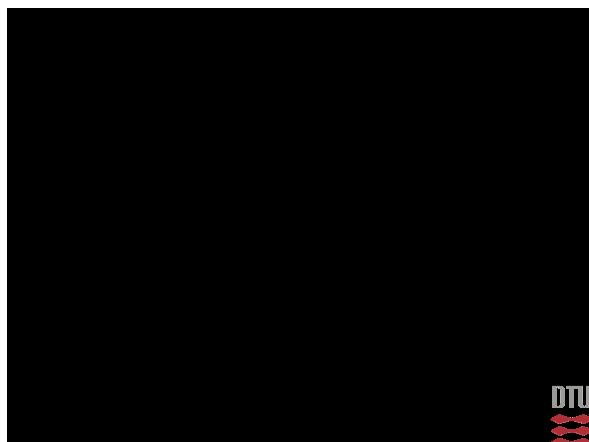
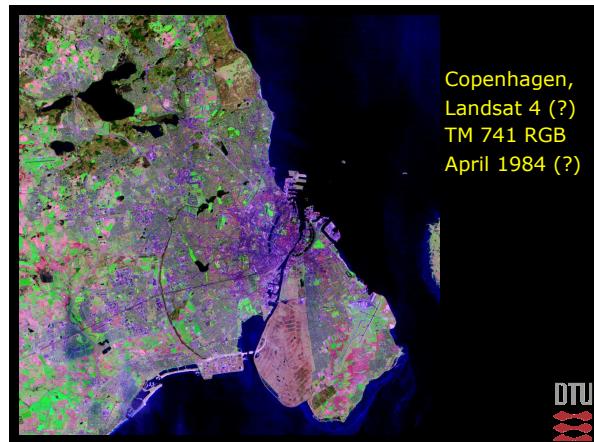
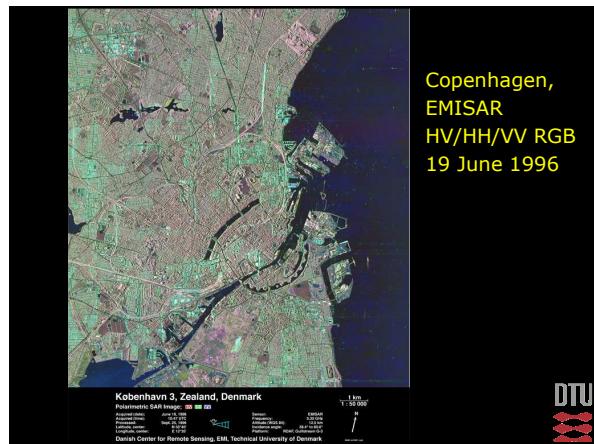
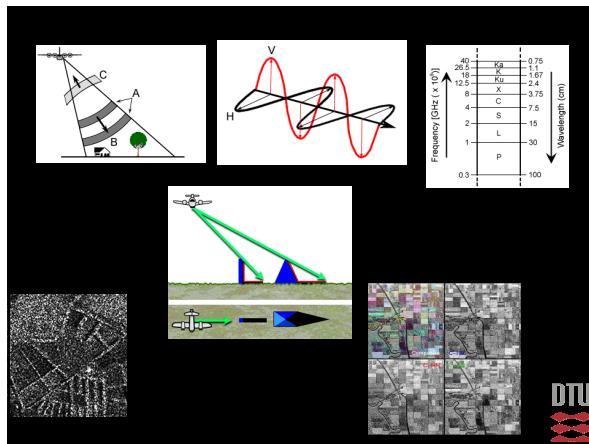
Data Integration

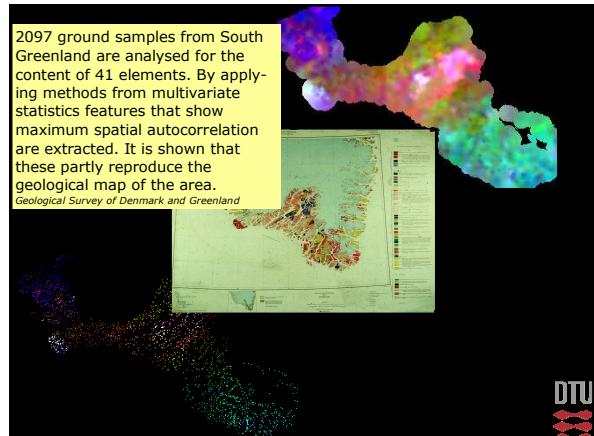
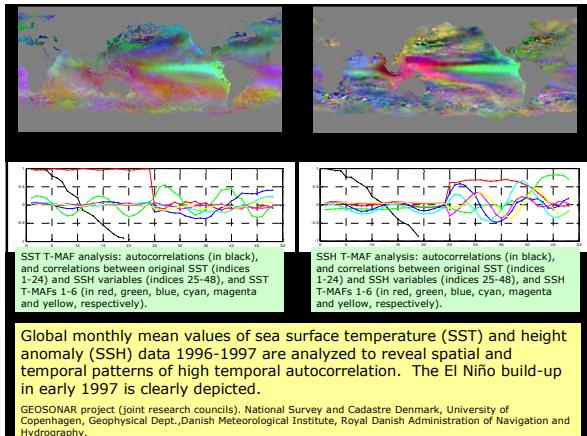
- Multi-/Hyper-spectral
- Multi-source
 - Optical
 - Radar
 - Lidar
 - Geophysics
 - Geochemistry
 - In-situ
- Multi-sensor
 - Space-borne (Landsat, SeaWiFS, ERS, ...)
 - Airborne (casi, AVIRIS, DAIS, HyMap, ...)
- Multi-temporal

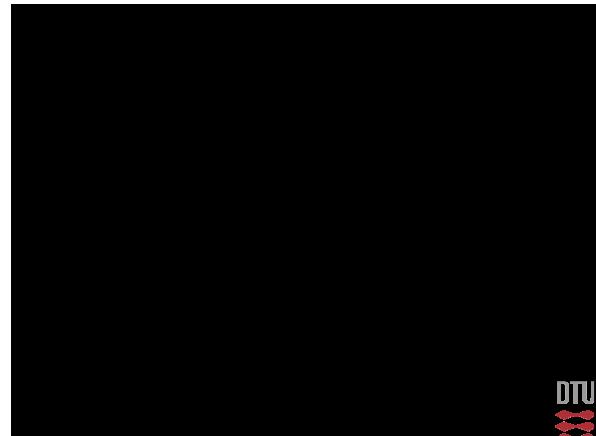
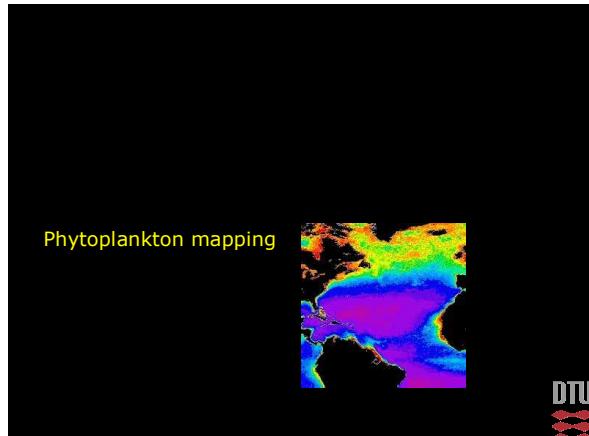


Passive vs. Active









Land Use Applications

- Natural resource management
 - Wildlife habitat protection
 - Baseline mapping for GIS input
 - Urban expansion / encroachment
 - Routing and logistics planning for seismic / exploration / resource extraction activities
 - Damage delineation (tornadoes, flooding, volcanic, seismic, fire)
 - Legal boundaries for tax and property evaluation
 - Target detection - identification of landing strips, roads, clearings, bridges, land / water interface
- DTU

Ocean Applications

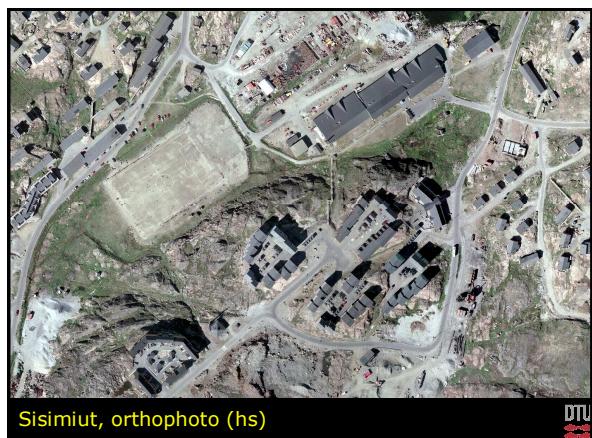
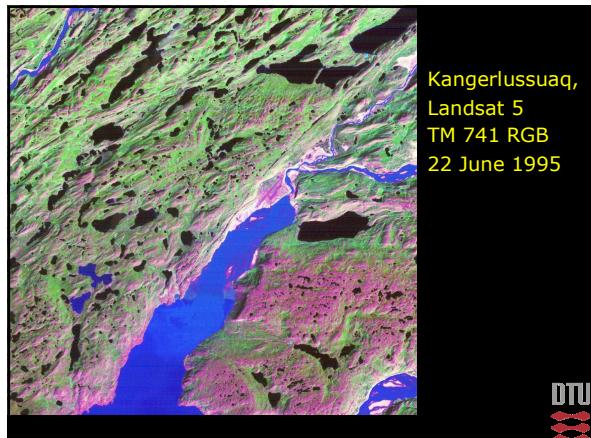
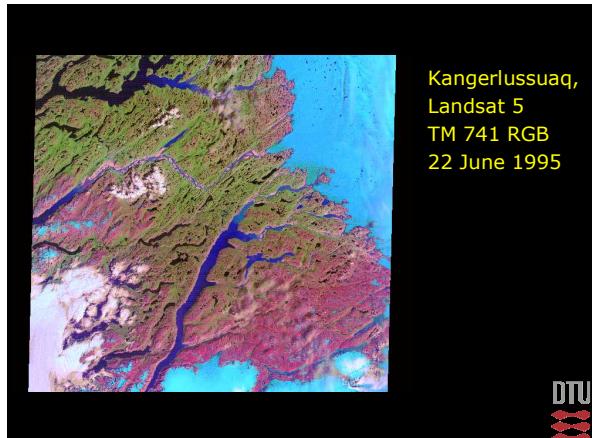
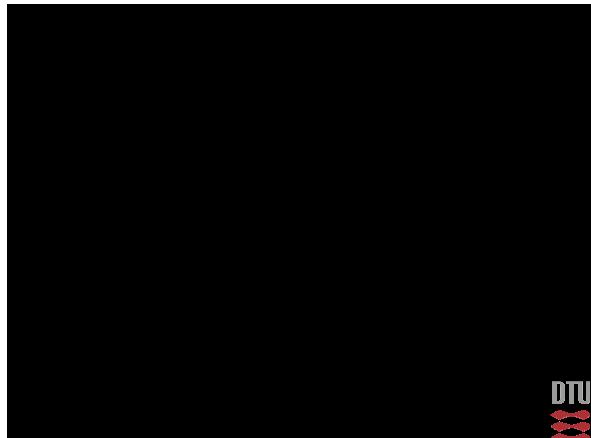
- Ocean pattern identification:
 - currents, regional circulation patterns, shears
 - frontal zones, internal waves, gravity waves, eddies, upwelling zones, shallow water bathymetry,
 - Storm forecasting
 - wind and wave retrieval
 - Fish stock and marine mammal assessment
 - water temperature monitoring
 - water quality
 - ocean productivity, phytoplankton concentration and drift
 - aquaculture inventory and monitoring
- DTU

Ocean Applications (cont'd)

- Oil spill
 - mapping and predicting oilspill extent and drift
 - strategic support for oil spill emergency response decisions
 - identification of natural oil seepage areas for exploration
 - Shipping
 - navigation routing
 - traffic density studies
 - operational fisheries surveillance
 - near-shore bathymetry mapping
 - Intertidal zone
 - tidal and storm effects
 - delineation of the land /water interface
 - mapping shoreline features / beach dynamics
 - coastal vegetation mapping
 - human activity / impact
- DTU

Sea Ice Applications

- Ice concentration
 - Ice type / age / motion
 - Iceberg detection and tracking
 - Surface topography
 - Tactical identification of leads: navigation: safe shipping routes / rescue
 - Ice condition (state of decay)
 - Historical ice and iceberg conditions and dynamics for planning purposes
 - Wildlife habitat
 - Pollution monitoring
 - Meteorological / (global) change research
- DTU





Sisimiut, orthophoto (be22)



Sisimiut, PC1 (98.9 %)



Sisimiut, PC2 (0.7 %)



Sisimiut, PC3 (0.4 %)