EO operational data provision for modeling purposes

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METIER course 6:
“Remote Sensing of the Hydrosphere”,
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Remote sensing at SYKE

Research

Operative near-real time monitoring:
- Sea surface temperature (SST)
- Algae blooms
- Water quality: turbidity, chlorophyll-a (Baltic Sea, lakes)
- Snow melt

Land cover monitoring

Vegetation monitoring

Oil spill monitoring (EMSA)
Corine Land Cover 2000 + IMAGE2000

Orig.images - LANDSAT ETM
Cal.mosaic
National lc 25m
EU lc 25 ha
Preprocessing of IMAGE2000

Objectives of calibration

- Detection
- Interpretation by vegetation zones -> minimizing the need of ground truth data
- Homogenous satellite image map for various purposes
- Enable more automated change

- Detection of clouds
- Atmospheric correction (SMAC & estimation of aerosol optical depth using in-image data)
- Topographic correction in Lapland
- Mosaicing
National CLC2000 – 25m raster

Data integration:
- Wetlands
- Water bodies
- Artificial surfaces
- Agricultural areas
- Forests and semi-natural areas
Production of CLC2000 in Finland

Preparation of Satellite Data
- detection of clouds
- atmospheric correction
- mosaicing

Preparation of Input Map Data
- rasterizing, mosaicing, re-classification etc

Interpretation of Satellite Data
- automated
- semi-automated / visual

Crown cover
Tree height
Tree species
Veget. cover

Updated Land use data
Soil data

Data Integration
Generalisation
Conversion from raster to vector

LC data for national use
(25 m raster)

LC data for EU
Automated generalization

A fully automated generalization tool developed

25 m raster -> 25 ha polygons

- ArcInfo macro (raster procedures)
- Development work 4 –6 months; run time 80 km * 80 km ~ 3 h (UNIX ArcInfo/SUN )

- Data dependent (Finnish Land Cover)
The effect of generalization

FinCLC2000, 25m

EU CLC2000, 25ha
Procesing steps for CLC2006

Landcover 2000 ja 2006

- CLC2000 25m
  - Lc Change 1 – Type

Satellite images 2000 ja 2006

- CLC2006 25m
  - Lc Change 1 – Type

- IMAGE2000
  - Lc changes 2– Delineation, type and degree

- IMAGE2006

Lc changes(25m) – working version

Lc changes for EU (mmu 5 ha)

CLC2006 for EU (25 ha)

National data set
GMES Services Element

GSE Land

Products

- Time series of vegetation coverage in agricultural areas (EO based)
- Nutrient loads within drainage basins (model output)
- Lake water quality (EO based turbidity)

Data

- TERRA/AQUA MODIS, ENVISAT MERIS
- In-situ observations

Contacts

- SYKE contact: Pekka Härmä, Markus Törmä
- TKK (Research Partner)
Fenology for drainage base modelling: Dates of change

M=in-situ veg. cover %; S=NDVI; SM=estimated veg cover %
Models and remote sensing

Can the modelling system really take the RS data as input?

- Support of data formats?
- Access to source code?
- Algorithm & system structure?
Sea Ice Services by FIMR
- Baltic Sea node manager: Ari Seinä
- Sea Ice Services (9 national)
- VTT (System partner)

Snow Services by SYKE
- Fractional Snow Covered Area (SCA) maps
- Covering Baltic Sea drainage area
- SYKE contacts: Sari Metsämäki & Miia Eskelinen

Snow Services by FMI
- Snow Water Equivalent (SWE)
- Snow Depth (SD)
- Covering Northern Eurasia
- TKK (Research Partner)
Snow Covered Area (SCA)

- Daily basis covering Baltic Sea Drainage basin
- March – May
- Terra/MODIS and RADARSAT
- sub drainage basins, 5x5 km² grid,
- End-users
  - In Hydrological modeling (flood prediction, water resource management)
  - Hydro-Power industry
  - Climate change studies

Demo: SCA 15.3.-25.5. 2005

May 23-25
Map-interface

- EO-information is combined with other GIS-data using SYKE’s map interface
- On the right, major river basing and largest settlements are displayed on an SCA-map
- Largest possible view at the moment: Finland
GMES Services Element

MarCoast

Coastal water quality by SYKE:

- Parameters:
  - Chl-a
  - Turbidity
  - Sea surface temperature
  - Floating algae
- Satellite data:
  - MODIS, AVHRR, MERIS
- In-situ observations used for validation

Contacts

- SYKE contact: Timo Pyhälahti
- TKK (Research Partner)
- Future extension partners: FMI, FIMR

MERIS DATA provided by ESA within ENVISAT-AO project © SYKE
Sea surface temperature (SST)

- NOAA AVHRR, resolution 1 km
- Upwelling detection
- Results are published in WWW daily

Sea Surface Temperature
weekly products
May-September 2006
Turbidity on 9 May 2006
Envisat MERIS (FR 300m)
Chlorophyll-a
Envisat MERIS FR

8.5.2006

12.5.2006
Surface floating algae bloom intensity

July and August are typical periods of occurrence

Floating cyanobacterial blooms
Water quality of lakes

Turbidity derived from MODIS (250 m)

Water quality observed in the field (1994-97)
Problems in practical application to lakes and coastal sea with archipelago

- Large variation in lake and coastal water optical properties
  - In Finland
  - In Europe / globally
  - Not known well
  - Differences of water quality within lakes are visible

- Lake size - instrument resolution
  - 250 m (MODIS) and 300 m (MERIS) data daily
  - Turbidity operational
  - Clouds are a problem, prevent observations

- Complex and dense archipelago area near coast has similar problems
  - Interesting for EU Water Framework Directive monitoring

← 150 km →
Example of current service Turbidity: Helsinki and Loviisa

8th May

31st May
Turbidity (FNU) in the Helsinki sea area during
the flood in 2004 and in normal summer 2002
Landsat images (=not a near-real-time service in SYKE)
TM 5.8.2004
ETM 9.9.2002

5 km

Users get higher expectations
on resolution …
Oil Spill Surveillance in Finland

Finnish Environment Institute (SYKE) is the national competent pollution control authority

- Responsible also for surveillance of illegal oil discharges

Surveillance in close co-operation with Finnish Border Guard

- Two surveillance aircrafts, Dornier 228
  - Aircraft equipped with SLAR, IR/UV scanner
    - FLIR, LLTV and 360° surveillance radar
- Border Guard Helicopters
- Every flight, the crew is also monitoring the environmental situation
Satellite monitoring of oil spills in Baltic Sea area

- Finland has used oil spill satellite surveillance since 2002
  - First experiences 1996 ->
- Until 2007 national or bilateral use of satellite images in ‘operational’ oil spill surveillance
- EMSA satellite surveillance service started 04/2007
  - Baltic Sea states have defined, that operational need is 840 scenes annually
  - Regional co-operation is needed to verify satellite detections and to cover spatially and temporally the surrounding sea areas
BORIS - Baltic Oil Response Information System

Tools for oil slick detection and combatting:
- Automated processing of radar images in NIR
- Semi-Automated oil slick detection (confirmed by operator)
- Detected slicks into Drifting model
- Results visible in browser based map interface
- The BORIS system is used in planning and allocation of oil combatting activities by different authorities

Service evolution: From remote sensing service provision tool to a GIS interface
Production chain for satellite EO data in SYKE

EO-data acquisition and distribution (FMI; additionally KSAT, ESA…)

Common automated processing system (AKO & NAPS)

Image processing:
1. Unpacking
2. Radiometric calibration and atmospheric correction
3. Geometric correction

Data in usable form for the algorithms

Dedicated product calculation & data delivery (snow)

End users
- citizens
- runoff forecasts
- climate change research
- water protection
- forest industry
- watershed research
- tourism
- hydropower industry

End-product

Algorithm & Cloud masking

Data delivery
- WWW
- Map user interface
- numerical data
The SYKE processing chain

- Automated processing chain for near-real-time AND batch processing of satellite data for various applications (water, snow, …)
  - AKO: Web browser interface for controlling the processing flow
  - NAPS: Software & software library (Python) for executing the processing steps
  - Command-line programs for performing the processing

- 'Operator tools’ software for product finalisation, cloud masking, quality control etc of single images

- Rapid system modifications & sustainable processing
  - Addition of new instruments and processing methods; algorithm modification
  - No unnecessary separate systems for land, water, snow or different instruments; no re-inventing the wheel
NAPS: A modifiable processing execution program for data

* Generic
* data/processing type specific software modules
Processing definitions: .ini and .xml files

[Logging]
textnumber_logginglevel = 9
filename_logging = C:\cvs\runexecutable\runexecutable\testdata\loki.log

[runparallel]
edittxt_progress_checktime = 1.0
edittxt_process_definitionfile = C:\cvs\runexecutable\runexecutable\runparallel.ini
edittxt_temporary_unsuccessful_process_log = C:\cvs\runexecutable\runexecutable\testdata\temp_error_parameters.txt
edittxt_executable_definitionsection = runexecutable
edittxt_maxprocessduration = 10.0
filename_parameterfile = C:\cvs\runexecutable\runexecutable\testdata\parameters.txt
edittxt_maxtotalduration = 100.0
edittxt_unsuccessful_processes_parameterfile = C:\cvs\runexecutable\runexecutable\testdata\error_parameters.txt
textnumber_parallel_number = 3
AKO process control for a single NAPS chain of processing

→ Automatic generation from .ini (and optionally .xml) files

→ Not necessarily SATELLITE data
AKO processor control for different processing servers
Information on Sea Surface Temperature Maps

The sea surface temperature in the Baltic Sea is monitored from May to September using NOAA/AVHRR satellite images. Finnish Environment Institute receives 3-4 satellite images daily, but cloud cover often prevents the monitoring at least in some parts of the Baltic Sea. During sufficiently clear days the sea surface temperature values are presented in thematic maps with a continuous color scale. Clouds are shown as white and land areas are gray.

The AVHRR satellite images are received by the Finnish Meteorological Institute. SYKE processes the sea surface temperature maps. The resolution for the satellite images used is 1-2 km depending on the measurement angle.

You can browse the sea surface temperature maps by clicking the dates on the calendar on the left marked with grey background. Days which have a brilliant map are marked with green background. Click the map to enlarge. In addition to daily temperature maps, weekly average value maps are also calculated. In order to show the maps, you can click the corresponding week number in the "wk" column.

Sea Surface Temperature covering the Gulf of Finland and the Gulf of Bothnia is one of the MarCoast products at the Finnish Environment Institute (SYKE). The target of the MarCoast project (2005-2008) is to establish sustainable service networks to deliver EO-based products. Other water quality products at SYKE within MarCoast are turbidity, chi-a and Algal Blooms.
Sea Surface Temperature Map of the Baltic Sea

Instrument: NOAA-AVHRR
Time: 22.08.2008 04:09
Processed: 22.08.2008
Metadata

Back to SST pages
Close Window
Operator involvement required!

- Control of input data stream & archiving
- Control & improvement of cloud detection
- Control of provided service quality
- Communication with end users
MarCoast validation measurements (2007)

<table>
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<th>No.</th>
<th>Product / Parameter</th>
<th>Number of data pairs used for correlation</th>
<th>Correlation coefficient ($r^2$)</th>
<th>Significance level [%]</th>
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<td>163</td>
<td>0.948</td>
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<td>2</td>
<td>Chl-a</td>
<td>88</td>
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<td>Turbidity</td>
<td>75</td>
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</table>

- Surface floating algae blooms are validated against airplane qualitative visual observations
- Other products compared against standard water quality monitoring
- User – service provider interaction IS important!
Thank you for your attention!

Questions?
Discussion!