The development of a dynamic web mapping service for vegetation productivity using remote sensing and in situ sensors in a sensor web based approach

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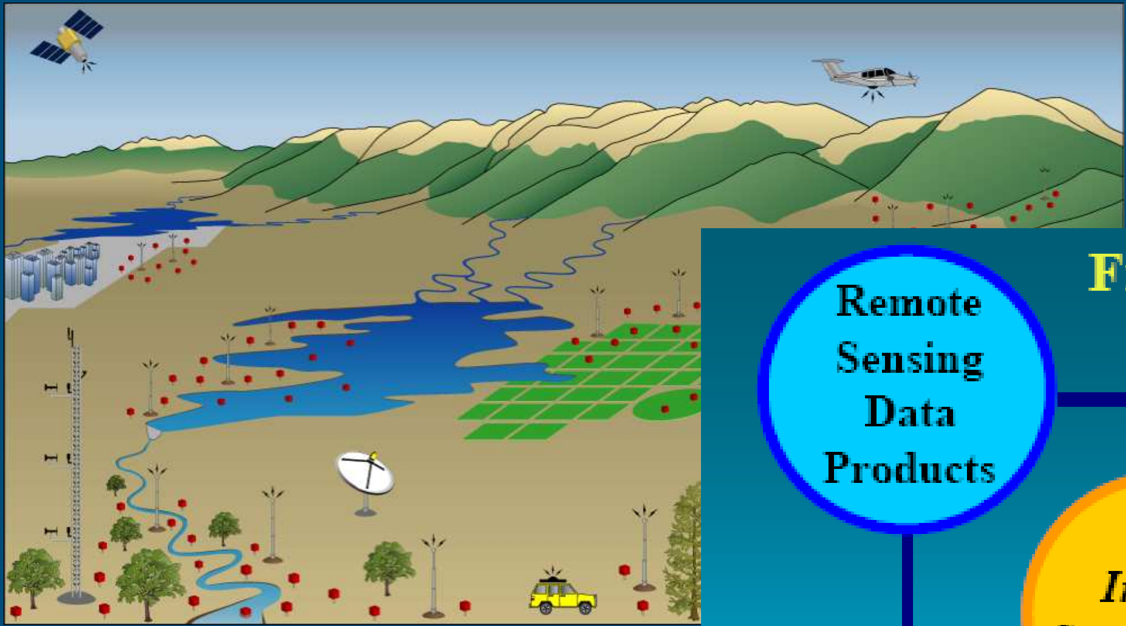
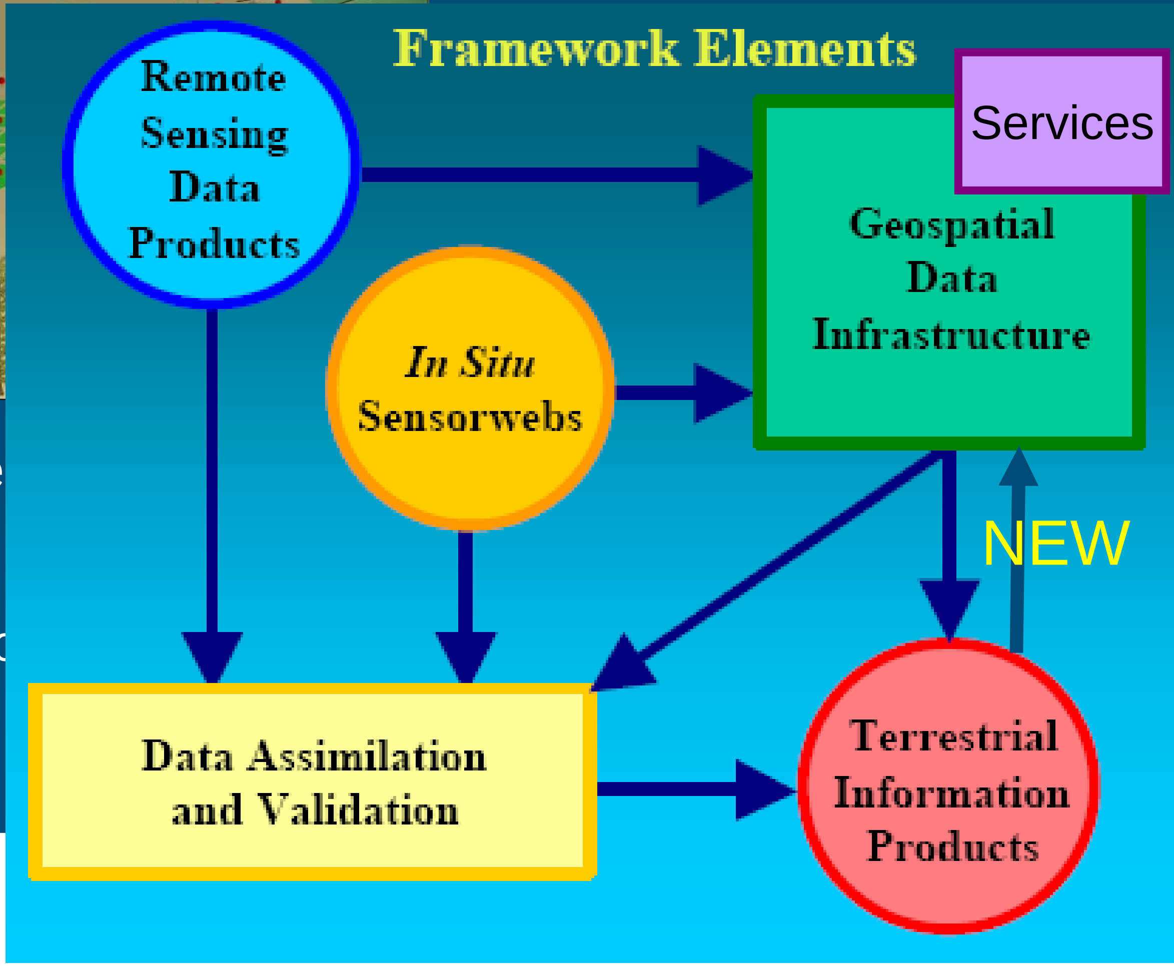
Why combine in situ and remote sensing sensors?



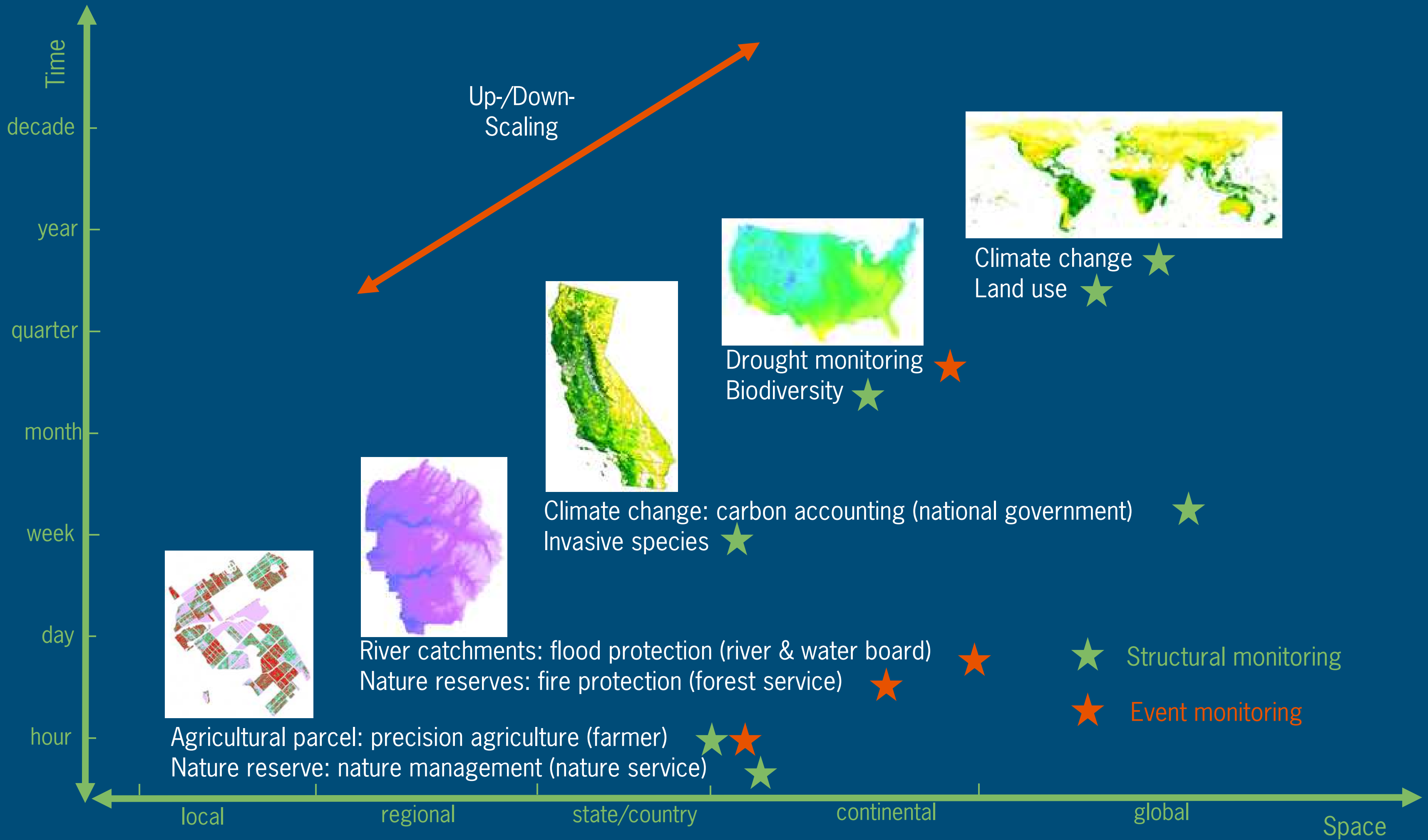
***In Situ* Sensor Measurement Assimilation Program (ISSMAP) (Teillet, 2002)**



Opportunities for sensor web base

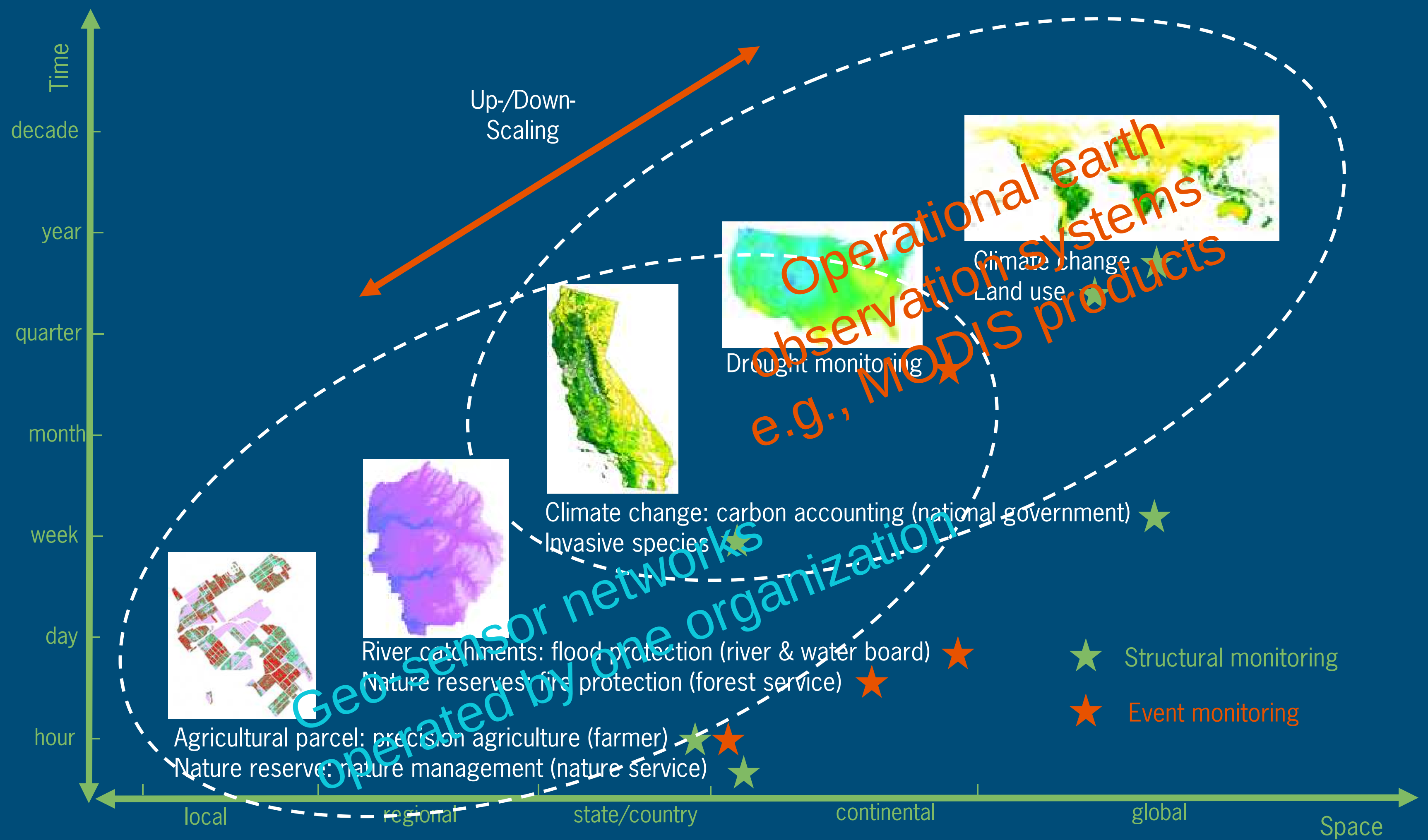
- multi-sensor
- Interoperability
- Requirement for scaling in spac
- Autonomy

Scaling between user requirements



Source images: ecocast.arc.nasa.gov

Scaling between user requirements



Source images: ecocast.arc.nasa.gov

Objectives of activities in RGI-project

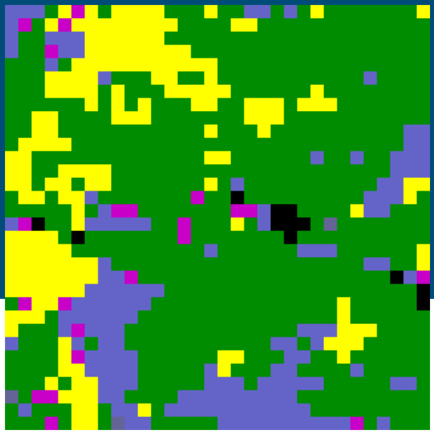
- Develop a sensor web based approach which combines earth observation and *in situ* sensor data to derive daily maps of vegetation productivity for regional to national scale

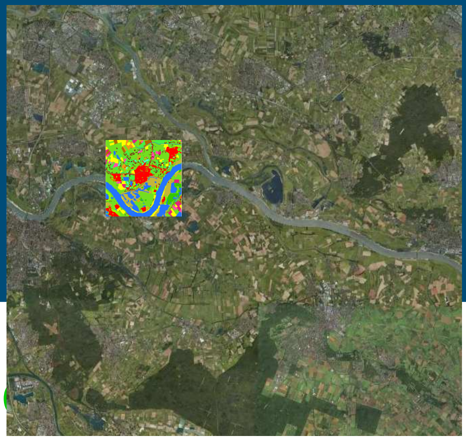
- Implementation in dynamic Web Mapping Service

- Evaluate current limitations and future research requirements

Background

- At the global scale, terrestrial plant productivity (GPP, NPP) is one of the most-modeled ecological parameters
- 8-day MODIS product (MOD17A2) is available which models GPP at a 1 km resolution
- for regional applications (e.g., monitoring crop productivity) both spatial and temporal resolution are too coarse
- products developed for a global scale; not taking into account the regional heterogeneity of land use and meteorological parameters





MODIS land use schematization (left) and high resolution image (right) with detail of LGN database of area around Gendt

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Requirements for service

- Real time information provision
- Easy access to broad range of end-users: from farmers to river managers to scientists
- Automated processing
- Opportunities for scaling
- Use available OGC standards and protocols

Calculation of vegetation productivity

- GPP = ↓PAR x FPAR x ($\varepsilon_{g\text{-}max}$ x S_{Tmin} x S_{VPD})

- GPP = gross primary production (g C m^{-2} day^{-1})
- ↓PAR = incoming photosynthetically active radiation
- FPAR = fraction of ↓PAR absorbed by the plant canopy
- $\varepsilon_{g\text{-}max}$ = maximum light use efficiency (land use specific)
- S_{Tmin} = minimum temperature scalar
- S_{VPD} = vapor pressure deficit scalar

Calculation of vegetation productivity

☻ meteo data
☻ remote sensing

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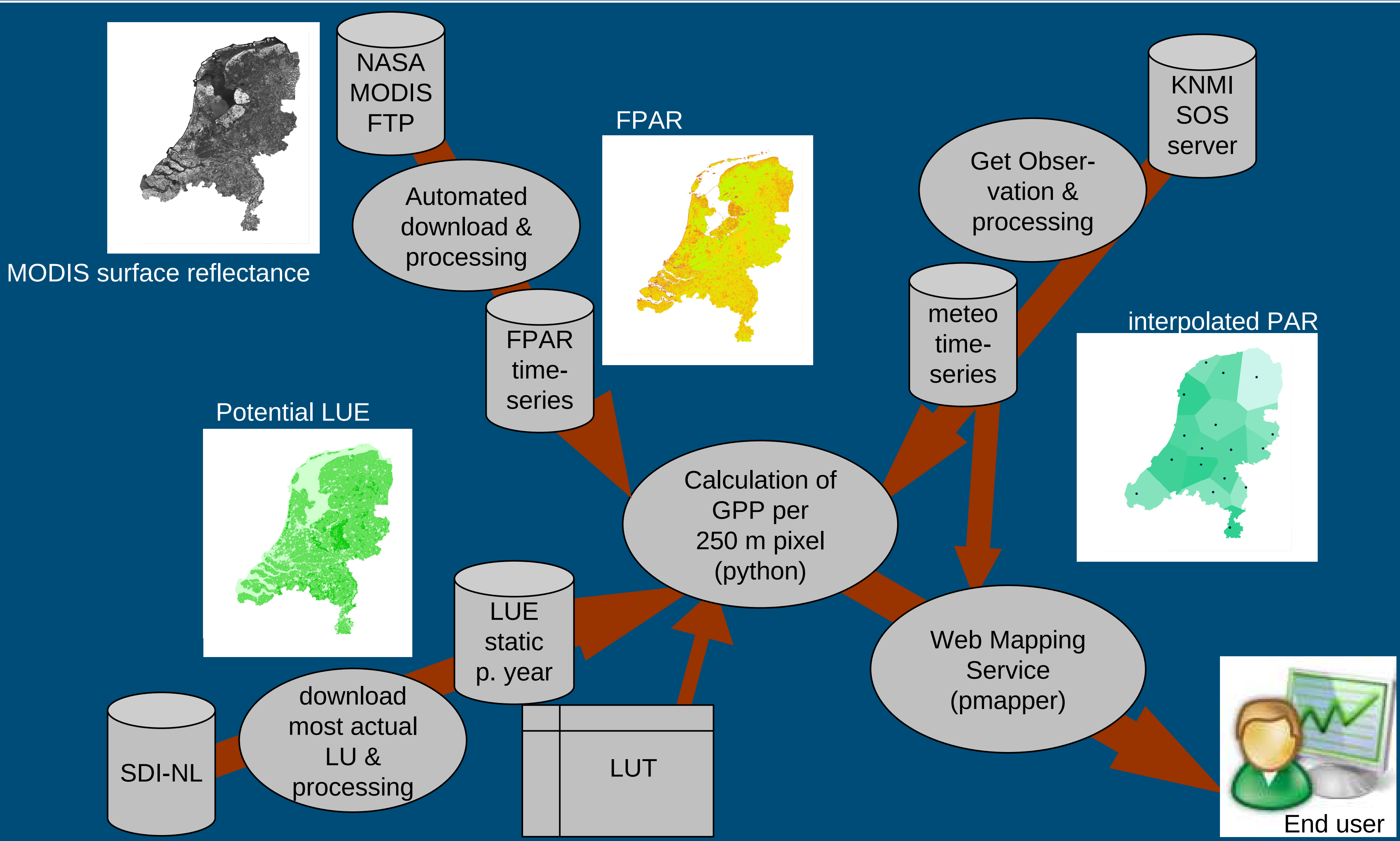
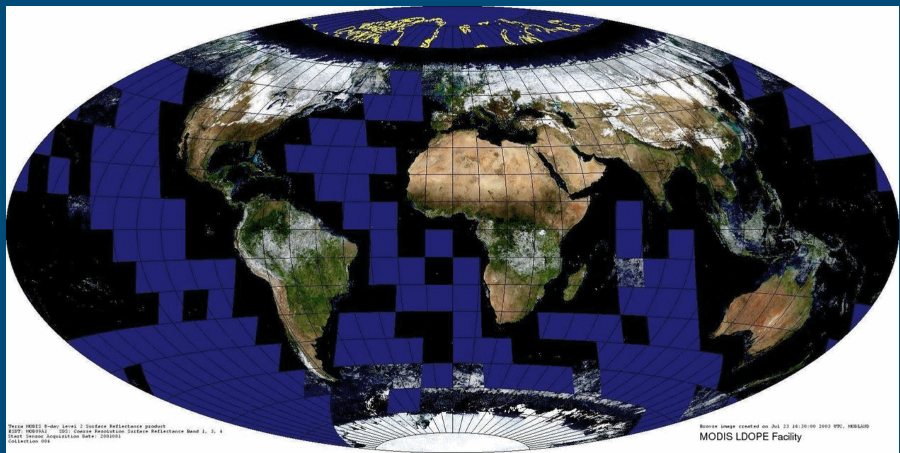
Implementation: automated processing chain

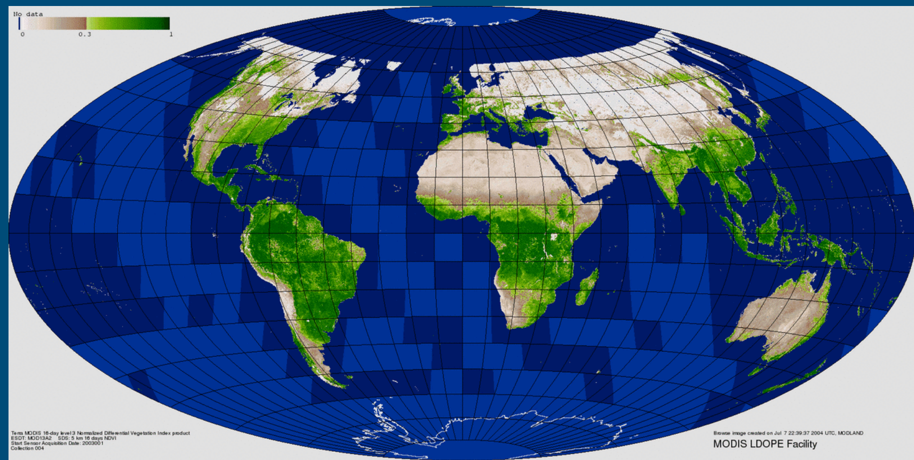


RS data - MODIS sensor

- Operated by NASA (start 2000)
- Daily over-flight; spatial res.: 250–1000 m; 36 bands
- Completely automated pre-processing chain
- Daily download MODIS surface reflectance product (MOD09) from MODIS ftp download facility[1]
- Simple cloud screening algorithm
- Calculation of FPAR (≈ NDVI = (NIR-RED)/(NIR+RED))



MODIS surface reflectance

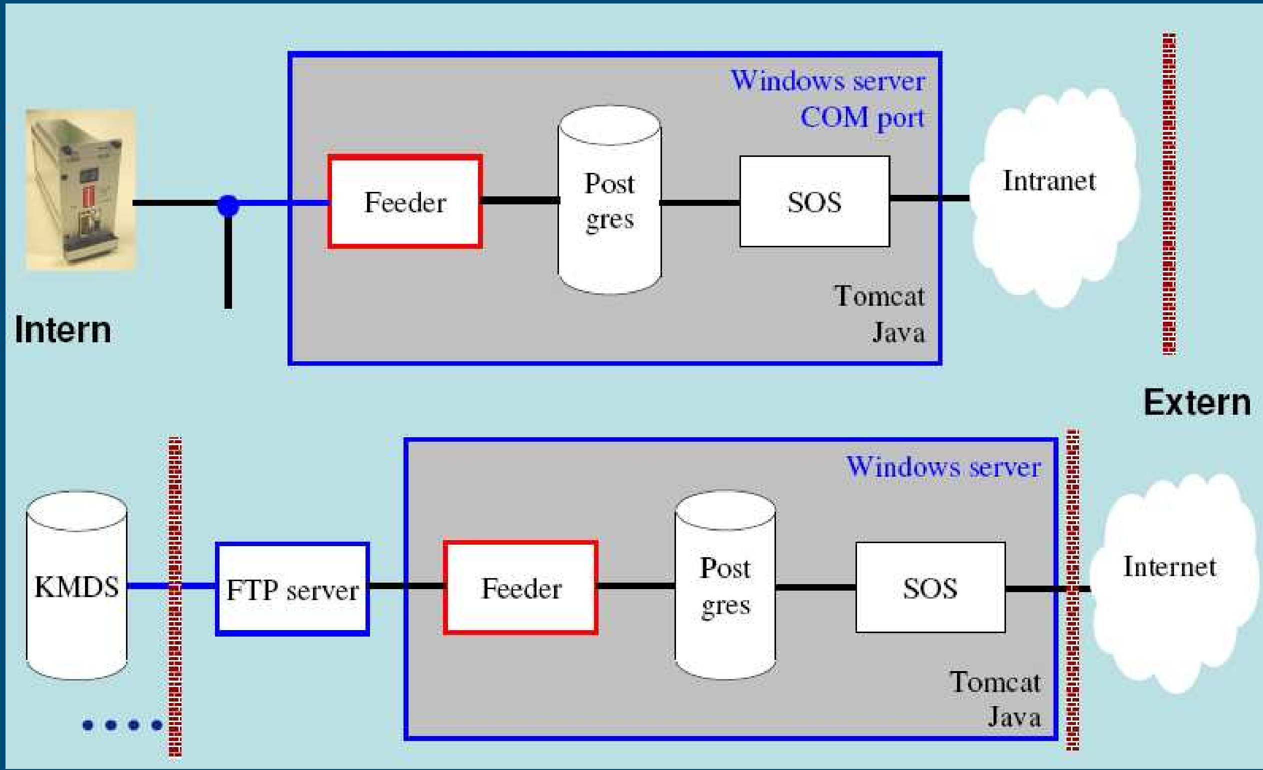


MODIS NDVI

[1] Source: http://edcdaac.usgs.gov/modis/mod09gqv5.asp

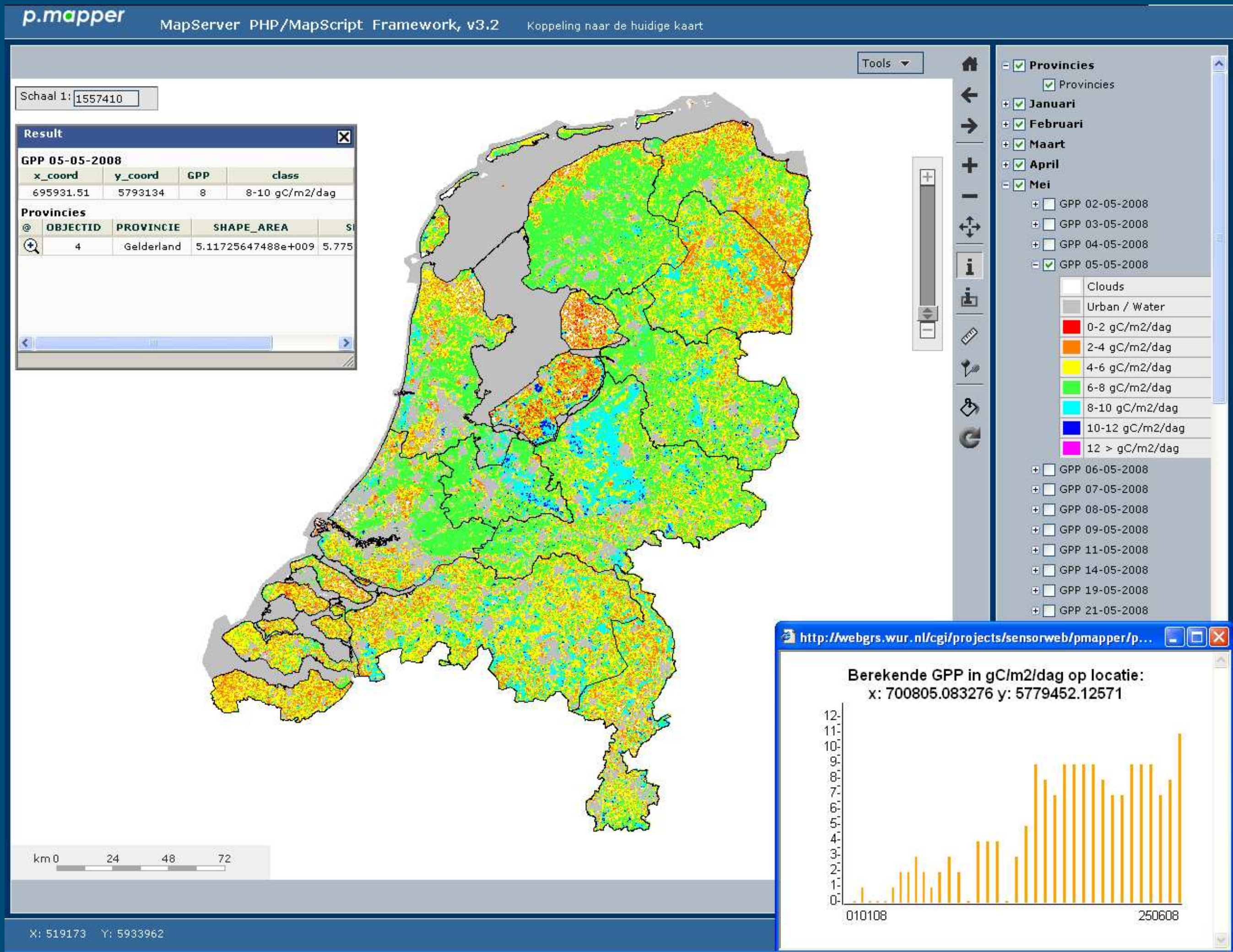
SWE – KNMI set-up

- 16 stations (KMDS)
- WMO set-up
- Prec; temp; rel hum; glob sol rad; wind dir & speed;
- 10 minute data
- OGC-SWE implementation
- Calculation of daily mean



Source: KNMI, Wiel Wauben

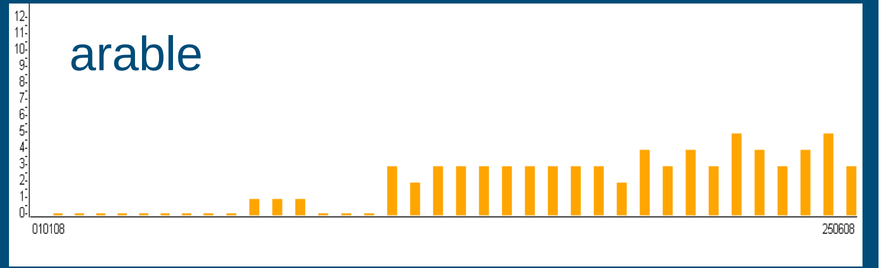
Web Mapping Service Vegetation Productivity

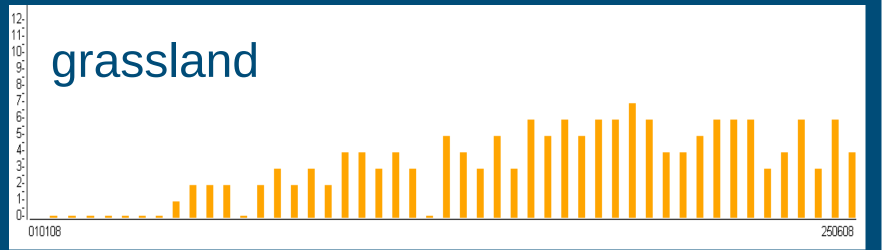


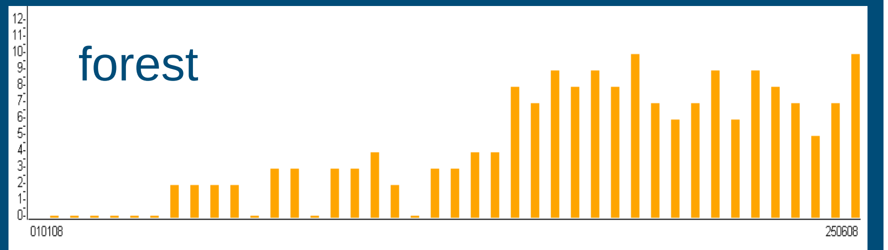
Source: http://webgrs.wur.nl/cgi/projects/sensorweb/pmapper/pmapper_gpp/map.phtml

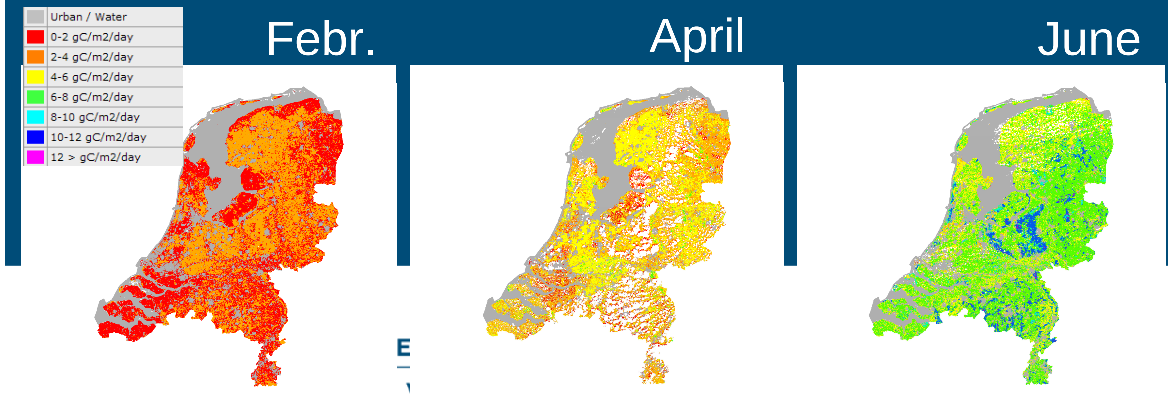
Functionality WMS Vegetation Productivity

- Standard: panning, zooming, selection of layers, download as geotiff etc.
- Information on most recent vegetation productivity
- Time-series of vegetation productivity

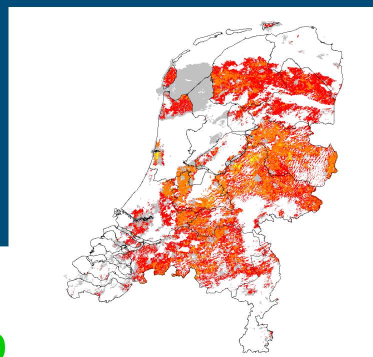








October 2, 2008



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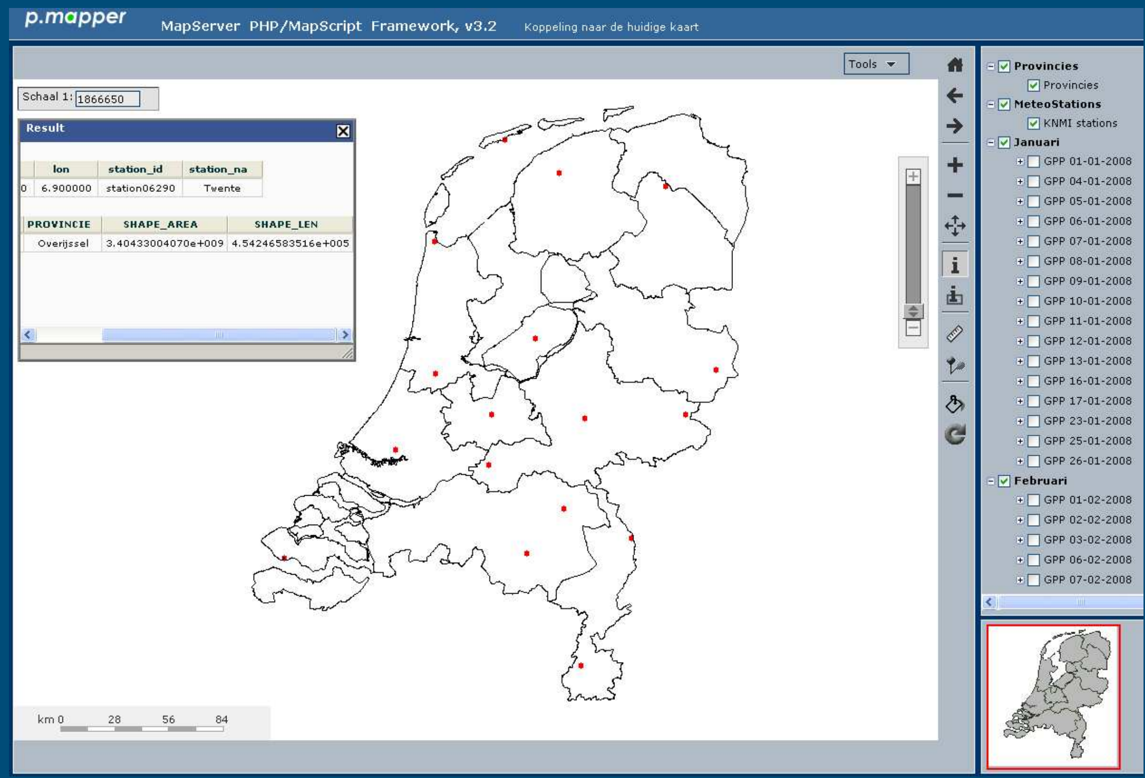
Functionality WMS KNMI Meteo Data

- Query most recent meteo data using KNMI SOS server using GetObservation request
- Example:

  Tuesday October 14
  14:00:
  Leeuwarden (13:30):
  14.1 ˚C
  Maastricht (13:30):
  16.0 ˚C



- Additional functionality:
  - trajectories
  - other parameters
  - geographic selection
  - Etc.

Source: http://webgrs.wur.nl/cgi/projects/sensorweb/pmapper/pmapper_gpp/map.phtml

Limitations and opportunities

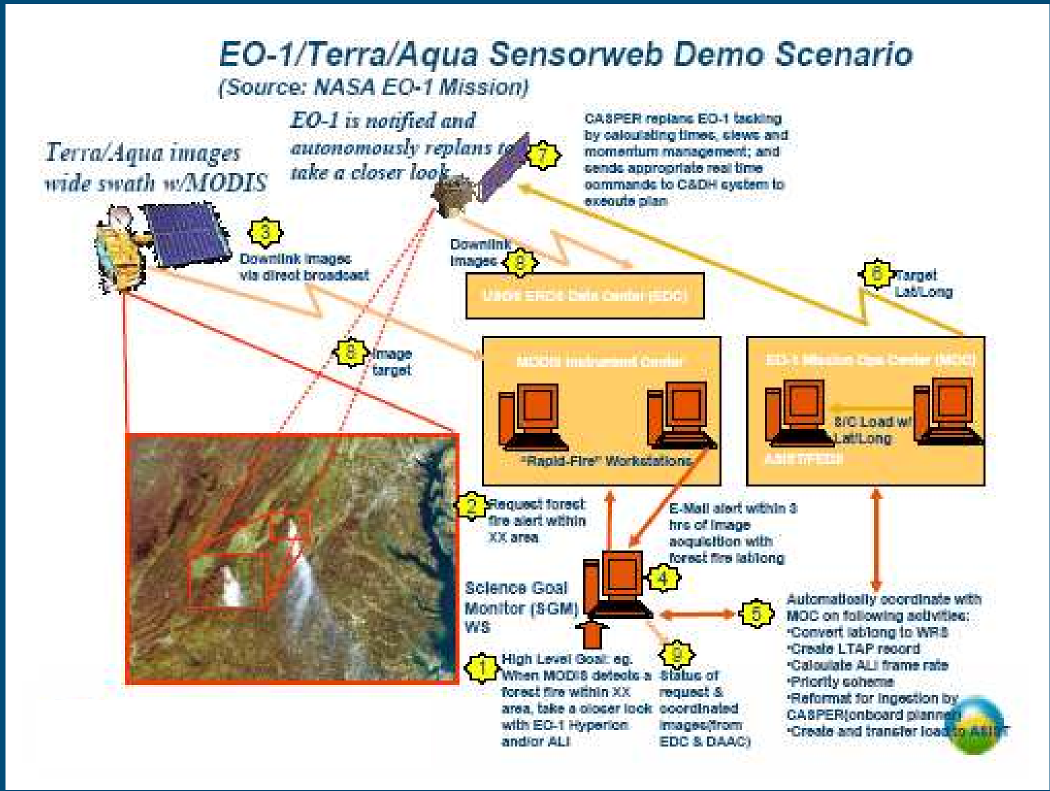
- Time delay remote sensing data (5-10 days)
  - Direct broadcast (including facility for processing: NL organization)
  - SWE standards not used yet
- Limited revisit frequency of RS data (incl. clouds)
  - Multi-sensor approach: specific tasking
- Limited spatial resolution of RS data
  - Sensor data fusion: combine high (25 m) and low (250 m) resolution sources: e.g., Landsat and MODIS
  - Multi-sensor approach: specific tasking
- Limited number of point stations available as SOS
  - Plug and play services required to include other stations
  - However, KNMI evaluation shows not yet the case: incomplete, redundant information, security, tools for exploration and finding data

- Interoperability will be key to combine (multi-source) sensors in space and time: use of common standards and protocols

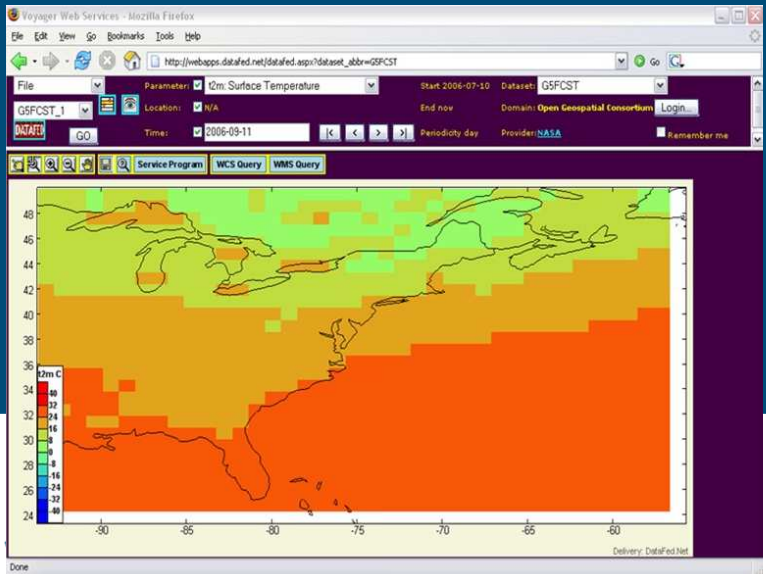
Developments in field of Earth Observation

- OGC - Open Web Service phase 4 - Demonstration
  - Service discovery
  - EO1 tasking (NASA)
  - SPOT Tasking (ESA)
  - Web processing:
    - threshold filter
    - workflow

Example 2: Wildfire monitoring through EO sensor tasking



Example 1: Datafed online EO processing



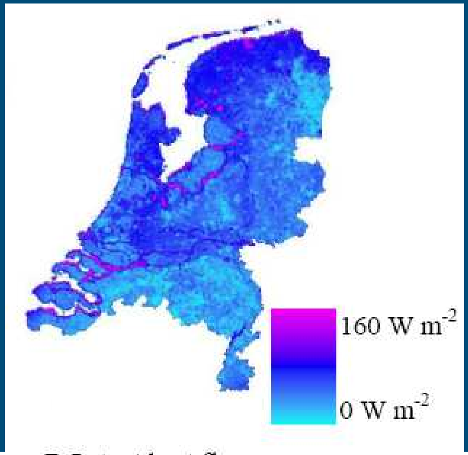
Source: http://www.opengeospatial.org/pub/www/ows4/demo.html

Conclusions and outlook

- Proof of concept shown
- Combined use of in situ sensor and remote sensing data: dynamic continuous maps (as input for SDI)
- Multi-sensor data: extent use of (OGC) standards
- Further research & implementation to reduce limitations

Outlook

- Extent to other products and applications: e.g., actual evapotranspiration



D Latent heat flux