Remote Sensing in Europe: Status analysis and trends focusing on Environment and Agriculture

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Researcher

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Informatics & Telematics Institute

…acknowledgement

My special thanks for the invitation and the chance to introduce and discuss my ideas and experiences with you to

Prof Maria Petrou,

Director, CERTH-ITI

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…from space to place

ioannis Manakos, Dr.

how decisions here may be supported by activities up there
or
how geoinformation may support environmental & agricultural management

int.@ EARSeL, Secretary General
[www.earsel.org]

loc.@ CERTH-ITI, Researcher
[www.iti.gr]

…a few words about the speaker

ioannis Manakos, Dr.

BSc Geology (RS - GIS - Physical Geography)

MSc Agriculture (RS - GIS - ES - Erosion)

PhD Forestry (RS - GIS - Precision Agriculture)

ARISTOTLE UNIVERSITY OF THESSALONIKI

TECHNISCHE UNIVERSITÄT MÜNCHEN

…acting within Europe

EARSeL

int.@ EARSeL, Secretary General
[www.earsel.org]

A scientific networking platform fostering the exchange of ideas and experiences while utilizing remote sensing products and methods for tackling contemporary challenges in the following fields:

3D RS	Land Ice & Snow	Forestry
Coastal Zones	Education & Training	Forest Fires
Developing Countries	Radar RS	Geological Applications
Land Use & Land Cover	Archaeology	Imaging Spectroscopy
Temporal Analysis	Cultural Heritage	Urban RS
		Thermal RS

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…topics in sequence

1. Considerations
2. Policy making in Europe
3. Remote Sensing challenges
4. Remote Sensing in practice
5. Remote Sensing platforms/ sensors
6. Examples – Projects
7. Trends and Outlook

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...considerations

http://fathersdaypictures.blogspot.com/2011/03/keeping-family-happy.html

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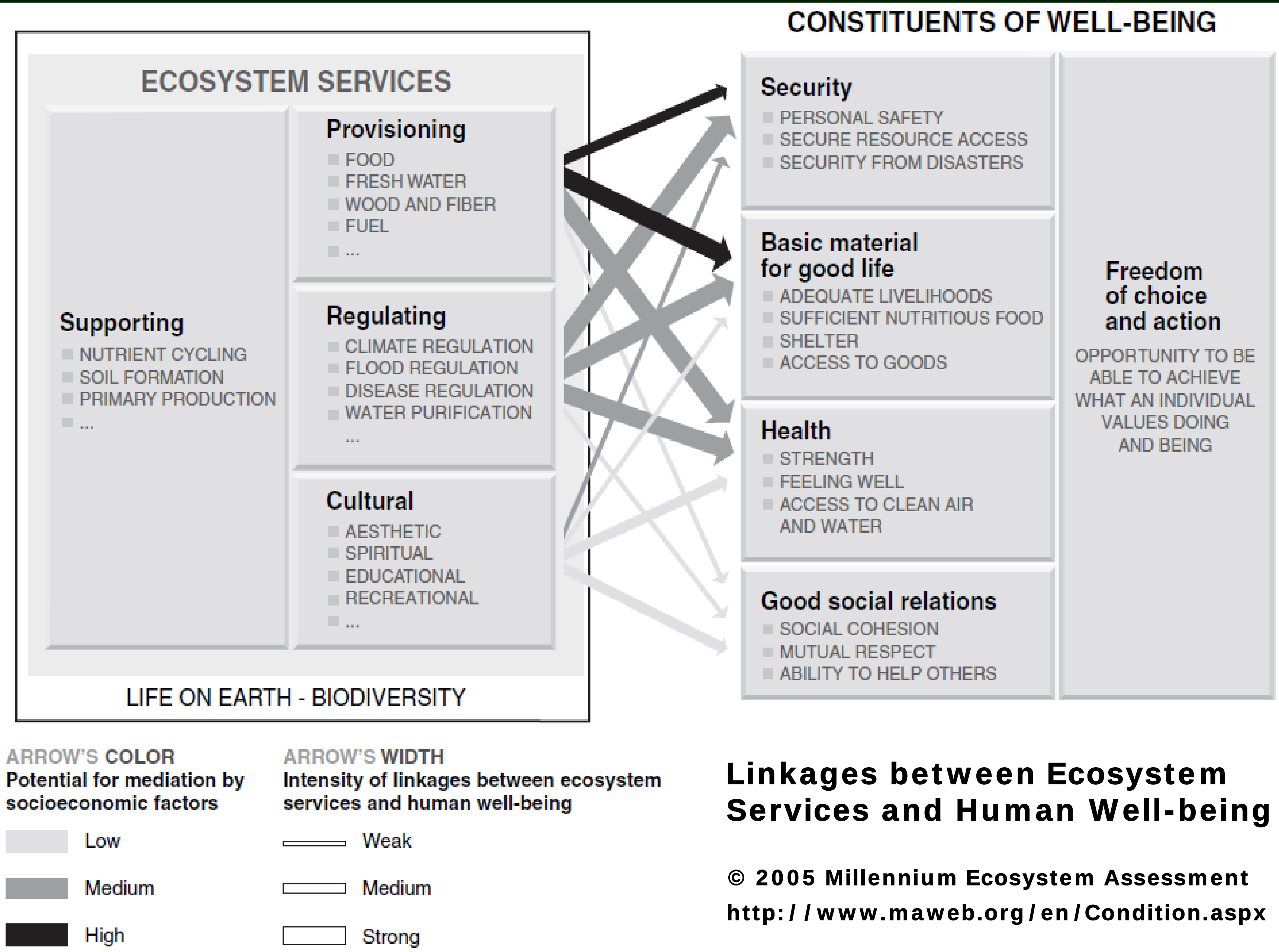
...considerations



Linkages between Ecosystem Services and Human Well-being

http://www.maweb.org/en/Condition.aspx

…objectives

Major: Quality of life

Supportive:
- Food security
- Conservation of the natural resources
- Reduction of risks & threats
- Sustainable Rural and Urban development

Challenge:

Special adjustment for the human – environment interaction surface

in 4D: x,y,z, space and t, time

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...drivers

Indirect:

- Demographic
- Economic
- Sociopolitical
- Science & Technology
- Cultural & Religious

Direct:

- Changes in Local Land Use & Land Cover
- Species introduction or removal
- Technology adaptation & use
- External inputs
- Harvest & resource consumption
- Climate change
- Natural, physical and biological drivers

NEED for Spatial Information

After © 2005 Millennium Ecosystem Assessment, http://www.maweb.org/en/Condition.aspx

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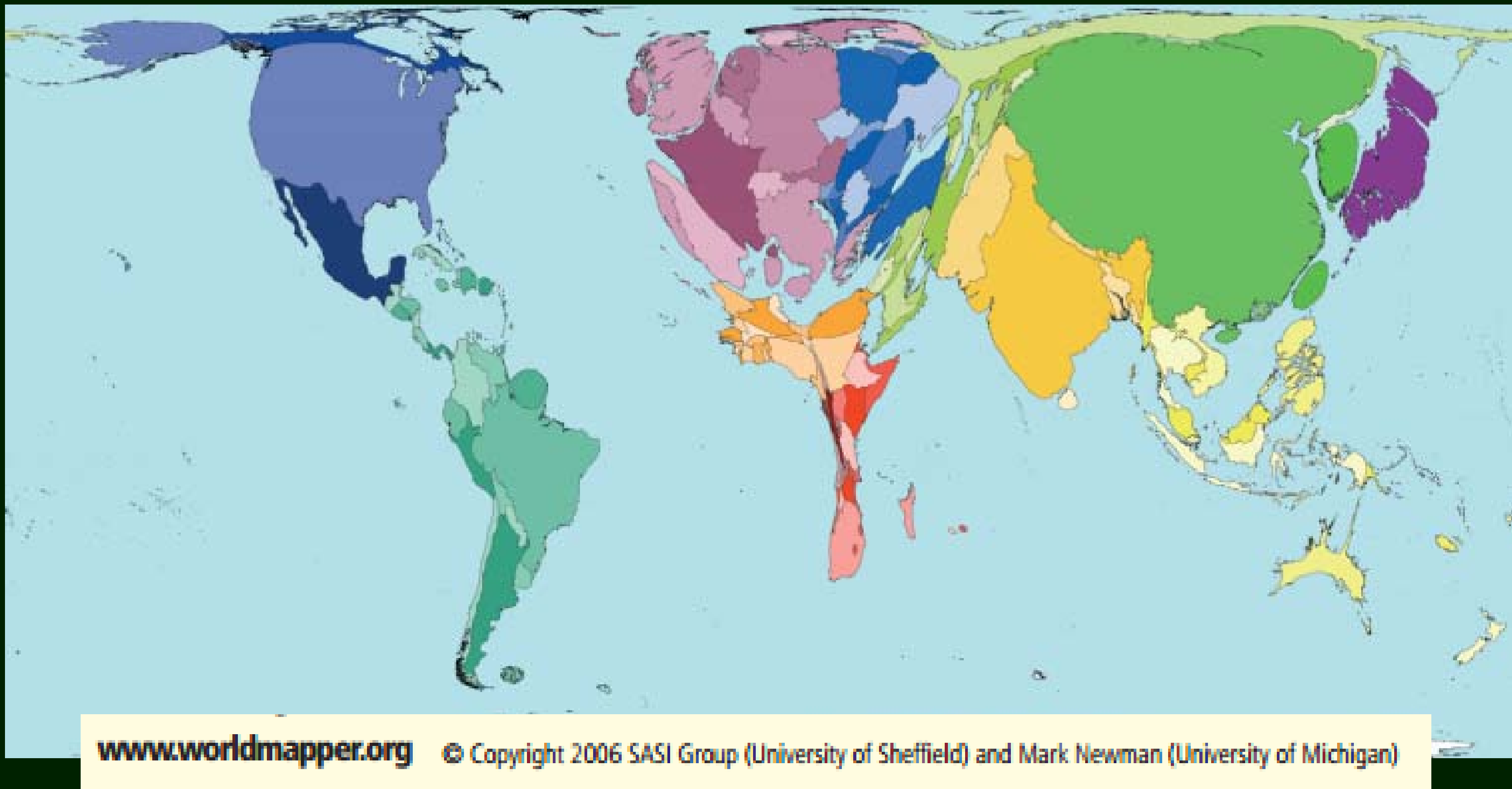
…socio-economic dimensions and drivers of LUCC

The human footprint – The earth from another perspective

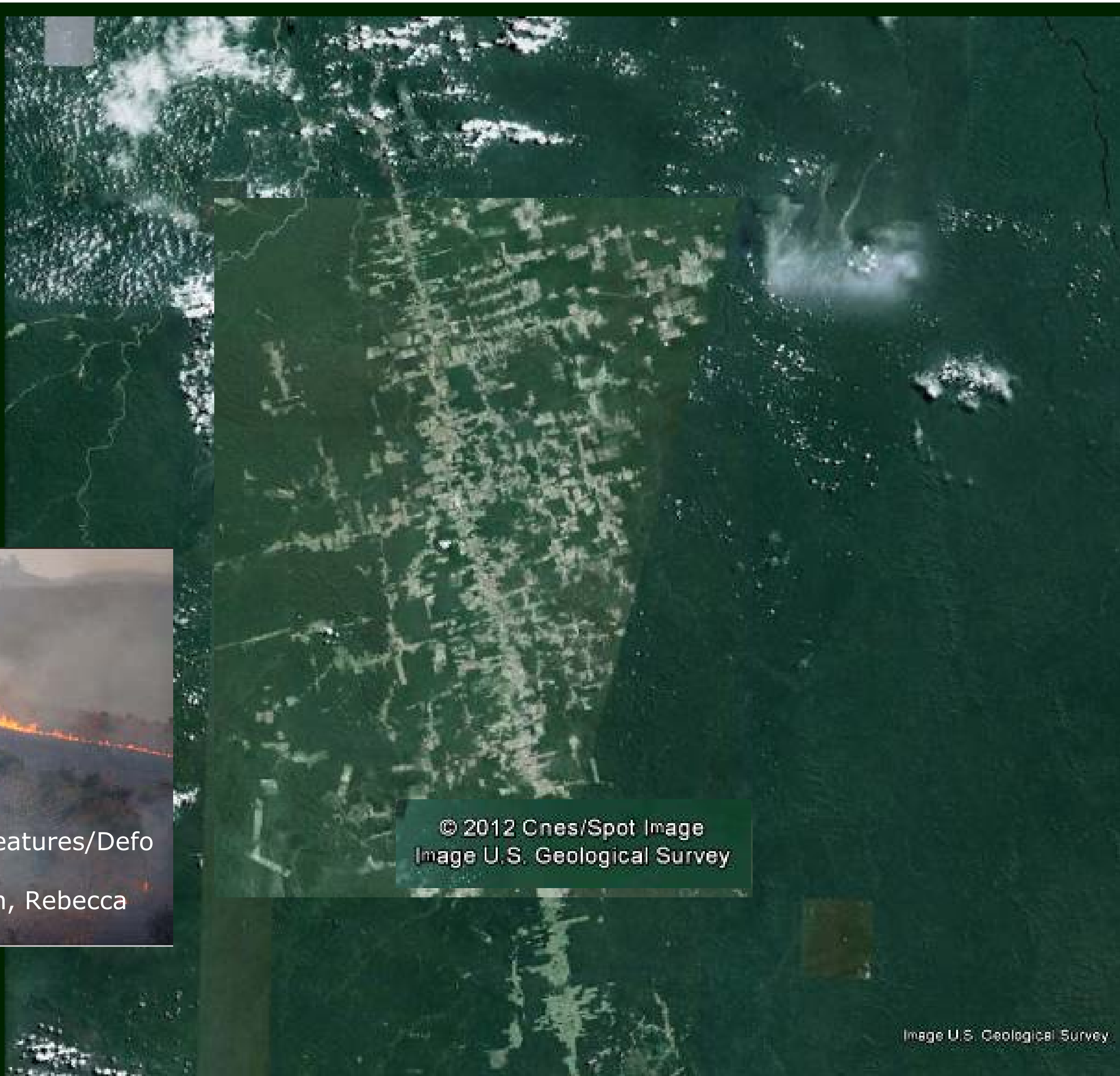


Meat consumed per person and day, 2005 (www.worldmapper.org)

…socio-economic dimensions and drivers of LUCC

The human footprint

Brazil, Amazon basin, viewed from Google Earth at two different snapshots in time



http://earthobservatory.nasa.gov/Features/Deforestation/printall.php [NASA - Earth Observatory – Tropical Deforestation, Rebecca Lindsey]

…socio-economic dimensions and drivers of LUCC

The human footprint

http://visibleearth.nasa.gov/images/1438/earth_lights.jpg

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…socio-economic dimensions and drivers of LUCC

The human footprint

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…wide area coverage & real time data required

Information Services for Decision Making and Implementation Support are particularly based on

a) the near real time registration of the surface status

b) harmonized geo-information products

c) the combination, analysis and modeling of data received from Earth Observation satellites as well as ground-based networks

Target is to

a) monitor changes [location, magnitude, reason]

b) support and test scenaria by projecting the validated trends in the present and past to delineate possible situations in the future

…office to nature in the EU

POLICY ADAPTATION & FEEDBACK

EU POLICY

FUNDING FRAMEWORKS

RESEARCH

OPERATIONALIZATION

CAPACITY BUILDING

DISSEMINATION & AWARENESS RAISING

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… EU Policy consultants/ supporters

European Environment Agency

The European Environment Agency (EEA) is an agency of the European Union.

EEA's task is to provide sound, independent information on the environment.

The European environment information and observation network (EIONET) aims to provide timely and quality-assured data, information and expertise for assessing the state of the environment in Europe and the pressures acting upon it.

… EU Policy consultants/ supporters

European Environment Agency

Role of the European Environmental Agency:

- Continuing to support implementation of Europe's environmental legislation through analyses and assessments of Europe's environment;

- Ensuring continuous access to high quality environmental data, information and services;

- Producing integrated environmental assessments and forward studies for Europe increasingly in the global context;

- Addressing critical environmental priorities as they arise on the policy agenda;

- Improving communications and dissemination to decision-makers and citizens via multi-media, user-friendly, multilingual information.

(from the EEA presentation at the 4th EARSeL SIG WS on LU/LC in Prague, 2011)

… EU Policy consultants/ supporters

Global Monitoring for Environment and Security:

-An independent Earth Observation system for Europe

- The largest fleet of satellites and atmosphere/earth-based monitoring instruments in the world

- An end user-focused programme of services for environment and security

- Joined-up information for policymakers, scientists, businesses and the public

- Europe’s response to the global need for environment and climate monitoring

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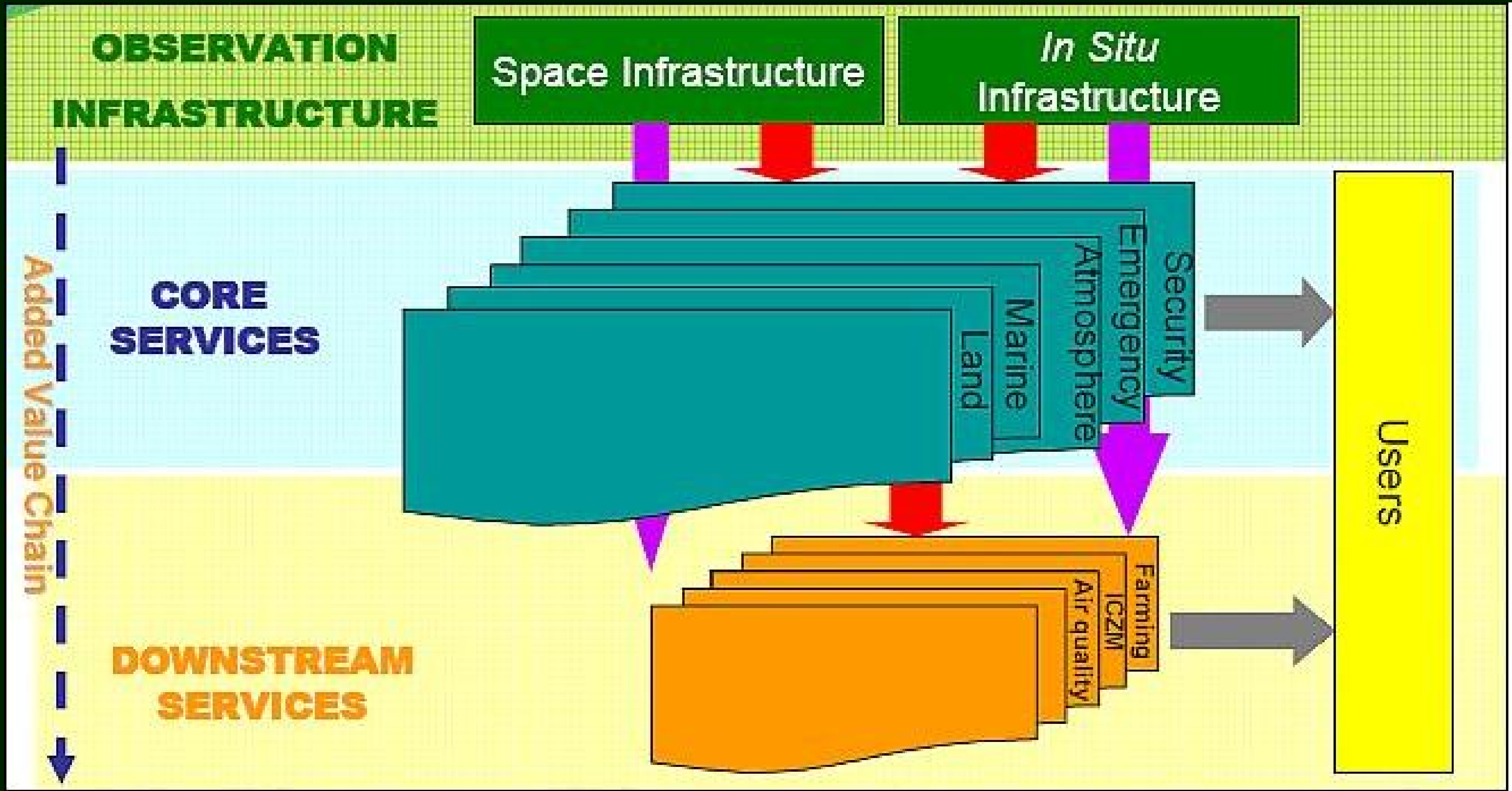
… EU Policy consultants/ supporters



High-level view of the GMES architecture (image credit: EC, ESA)

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… strategic areas

1 Environmental themes
- 1.1 Air quality
- 1.2 Air pollutant emissions
- 1.3 Biodiversity
- 1.4 Greenhouse gas emissions
- 1.5 Freshwater
- 1.6 Marine

2 Cross-cutting themes
- 2.1 Climate change impacts
- 2.2 Vulnerability and adaptation
- 2.3 Ecosystems
- 2.4 Environment and health
- 2.5 Maritime
- 2.6 Sustainable consumption and production and waste
- 2.7 Land use
- 2.8 Agriculture and forestry
- 2.9 Energy
- 2.10 Transport

3 Integrated environmental assessment
- 3.1 Integrated environmental assessment
- 3.2 Regional and global assessment
- 3.3 Decision support
- 3.4 Economics
- 3.5 Strategic futures

4 Information services and communications
- 4.1 Shared Environmental Information System
- 4.2 Communications

(from the EEA presentation at the 4th EARSeL SIG WS on LU/LC in Prague, 2011)

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… need and use of land cover/use data

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(from the EEA presentation at the 4th EARSeL SIG WS on LU/LC in Prague, 2011)

Remote Sensing Working Groups in Europe

...++++...

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Land cover changes – are the scientists aware? Active?

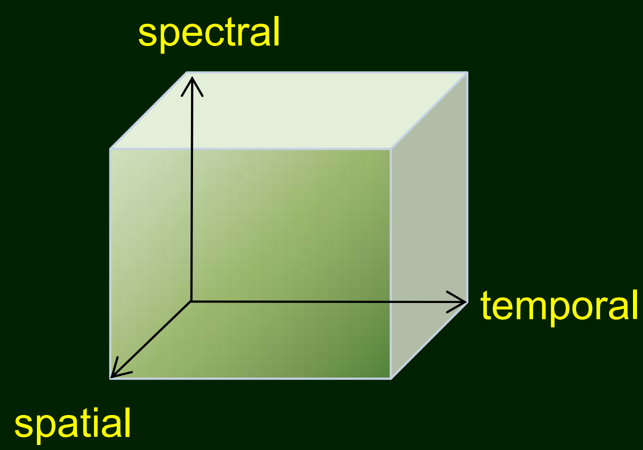
- About 14 % of all papers in major journals address CD during last decade

- Land-use & land-cover and forest are the dominant categories, followed by agriculture, urban, ocean and cryosphere

- CD methods based on „ALGEBRA“ have been and still are the most used ones. „CLASSIFICATION“ and „TRANSFRORMATION“ approaches – so far – play a minor roll

- CD methods based on optical data sets are dominant. Significantly less use SAR data or a combination of both

- CD is a robust approach, very promising, especially for high resolution optical data sets.



(after the University of Bonn presentation at the 4th EARSeL SIG WS on LU/LC in Prague, 2011 / Prof Gunter Menz)

Detect land cover changes – using?

Algebra: -> results are change magnitudes for individual channels or ~ combinations; limited use for change labeling

Transformation: -> results contain information about changes, often difficult to interpret, postprocessing for change labeling necessary

Classification: -> result is a final change map, no further labeling necessary, disadvantage: supervised training of change classes is necessary

(after the University of Bonn presentation at the 4th EARSeL SIG WS on LU/LC in Prague, 2011 / Prof Gunter Menz)

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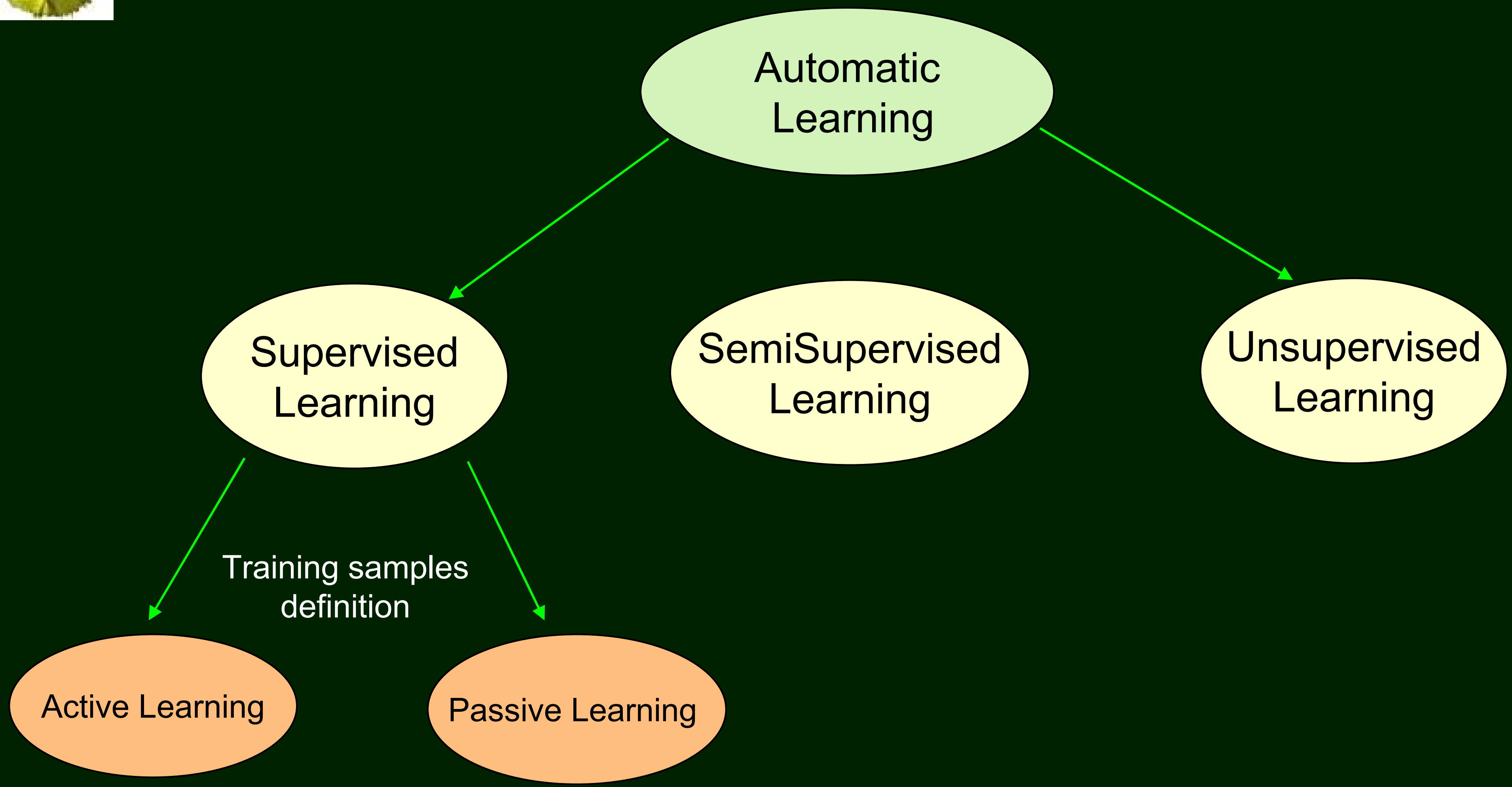
Image analysis approaches/ information extraction



[1] L. Bruzzone, M. Marconcini, “Domain Adaptation Problems: a DASVM Classification Technique and a Circular Validation Strategy”, *IEEE Transactions on Pattern Analysis and Machine Intelligence*, Vol. 32, No. 5, pp. 770-787, 2010

[2] L. Bruzzone, M. Marconcini, “Toward an Automatic Updating of Land-Cover Maps by a Domain Adapatation SVM Classifier and a Circular Validation Strategy,” *IEEE Transactions on Geoscience and Remote Sensing*, Vol. 47, No. 4, 2009, pp. 1108-1122.

Image analysis approaches/ information extraction

Most promising approaches nowadays:

- Supervised classification methods + Active learning methods: active learning is an effective method for transforming an initially unrepresentative training set in a representative and optimized training set [requires: Supervised classifier; Query function; Supervisor (user); Training set; pool of unlabeled samples]

- Semisupervised approaches: jointly exploits labeled (training) and unlabeled samples in the learning of the classifier

- Kernel methods (e.g. Support Vector Machines) that are robust to the problem of the small ratio between training samples and feature space

Land cover changes challenges

- Preprocessing issues (geometry & radiometry)

- Systematic investigations about…
  …the influence of CD algorithm, segmentation approach and threshold selection
  …the accuracy of the change mask,
  …the influence of number and type of sensors
  …the influence of features

- Towards automation?
  Selection of training areas
  Selection of threshold
  Selection of segmentation level
  Development of Automated processing chains for CD

(after the University of Bonn presentation at the 4th EARSeL SIG WS on LU/LC in Prague, 2011 / Prof Gunter Menz)

Accuracy assessment

Why is the accuracy low?

Genuine difficulty in discriminating classes (definition)

Technical problems such as mis-registration, pre-processing, ++

Use of inappropriate reference targets

spatial autocorrelation that violates the assumption of sample independence &

spatial variability of spectral signatures of land-covers

Use of misleading measures of accuracy

Use of a biased approach to accuracy assessment – not all errors seen to be in the remote sensing

(Inspired by Prof Giles Foody, University of Nottingham & Prof Bruzzone, University of Trento)

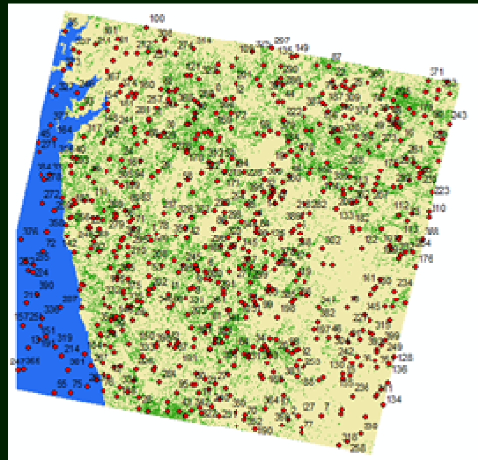
Accuracy assessment

One poorly understood sources of error and uncertainty is the impact of error in ground data

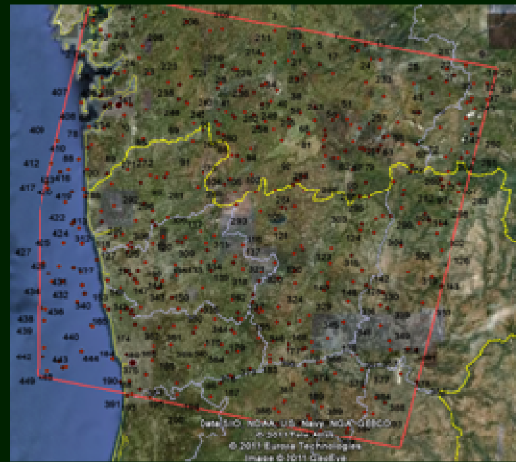
Ground data are not a gold standard reference – contain error and are not 'truth'

Ground data 'quality' is of major importance on estimating the accuracy of land cover change detection and land cover change extent

Impacts vary with nature of errors and often with prevalence

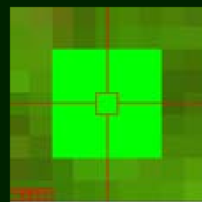


JRC Cover Map 2006



Google Earth

Select ROI on Landsat Image



TRAINING SET AND VALIDATION SET SELECTION

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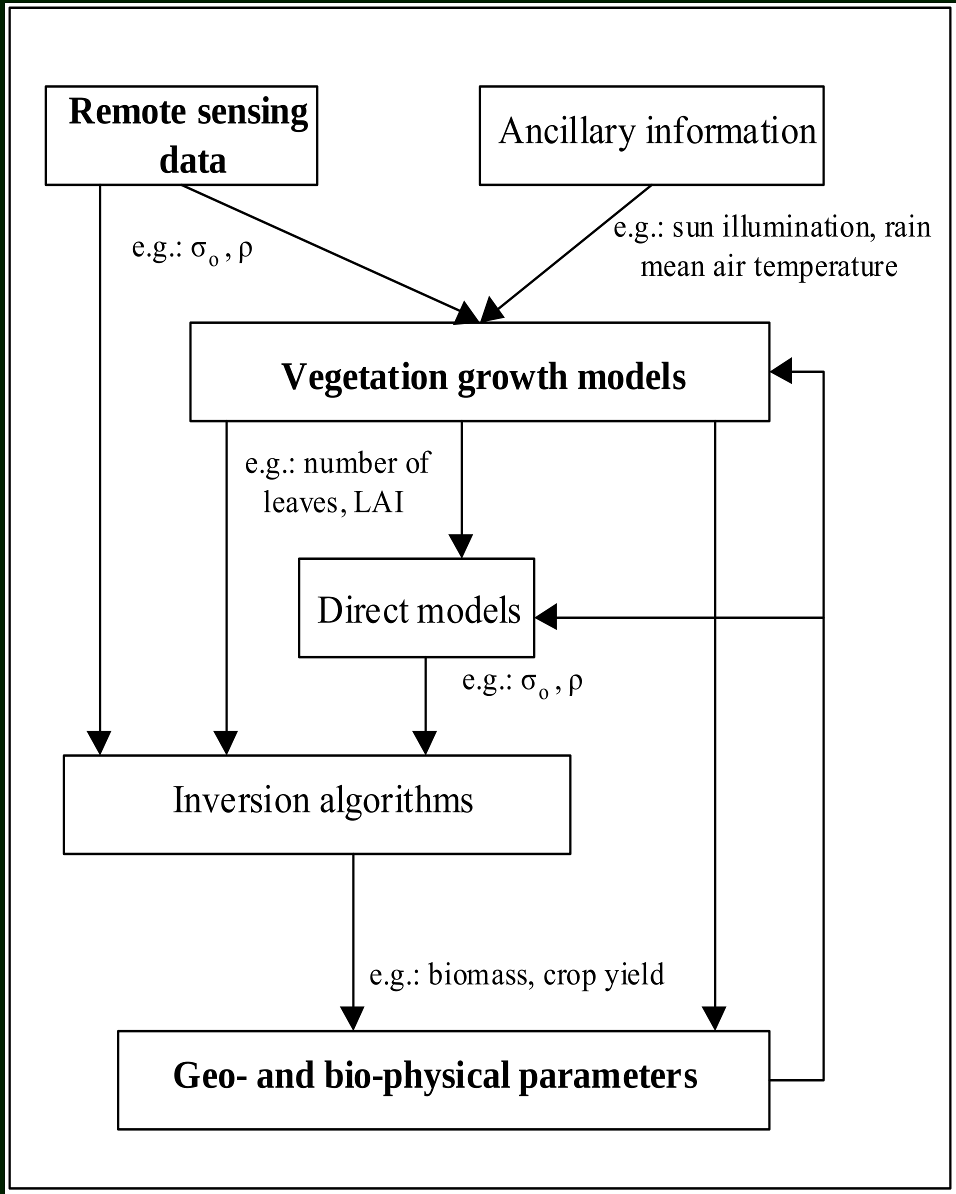
…let us start with the Ground data

Ground data provide reference data for:

- classifications
- atmospheric corrections
- modeling

especially in agriculture…

Remote sensing's role is the normalization of the relative signal registered with the remote sensing sensor in a typical physical measurement value for the growth stage

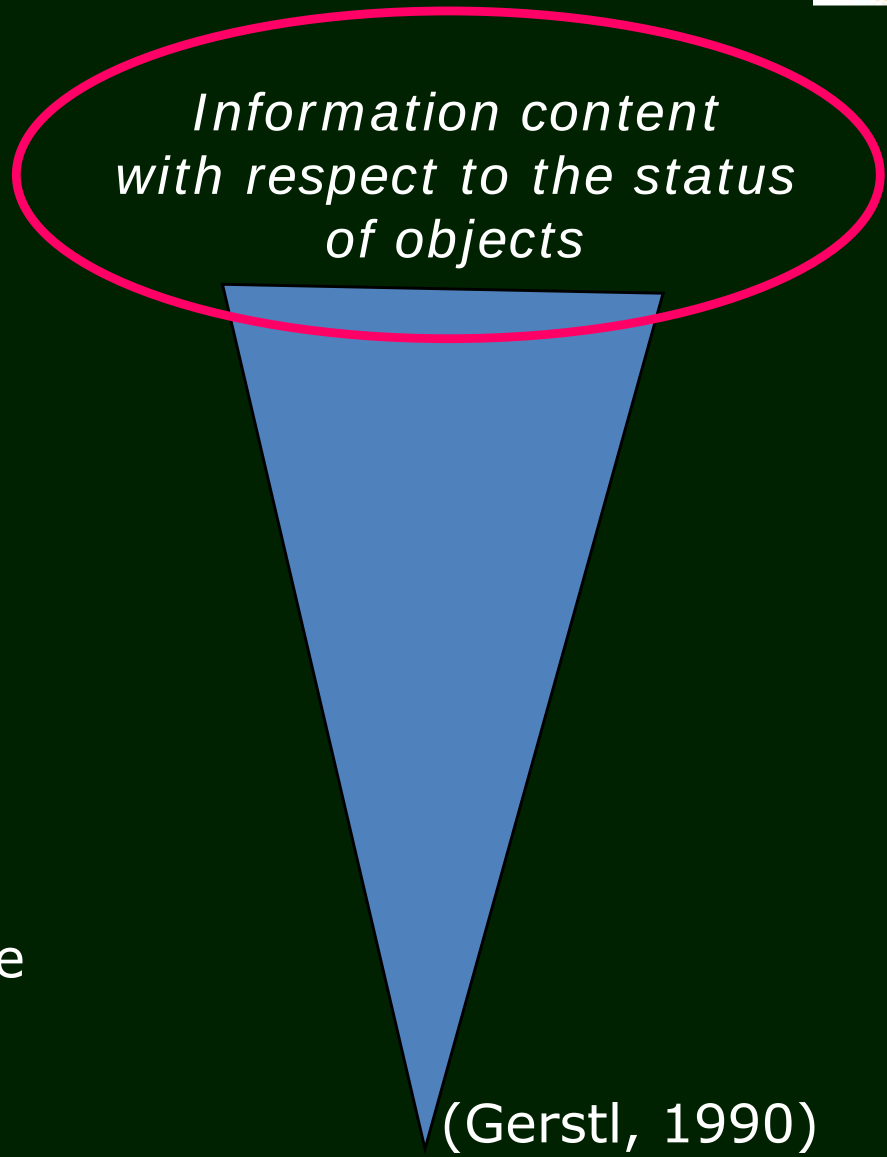


ESA, 1998

…type of incoming information

5 Signature types are known in RS:

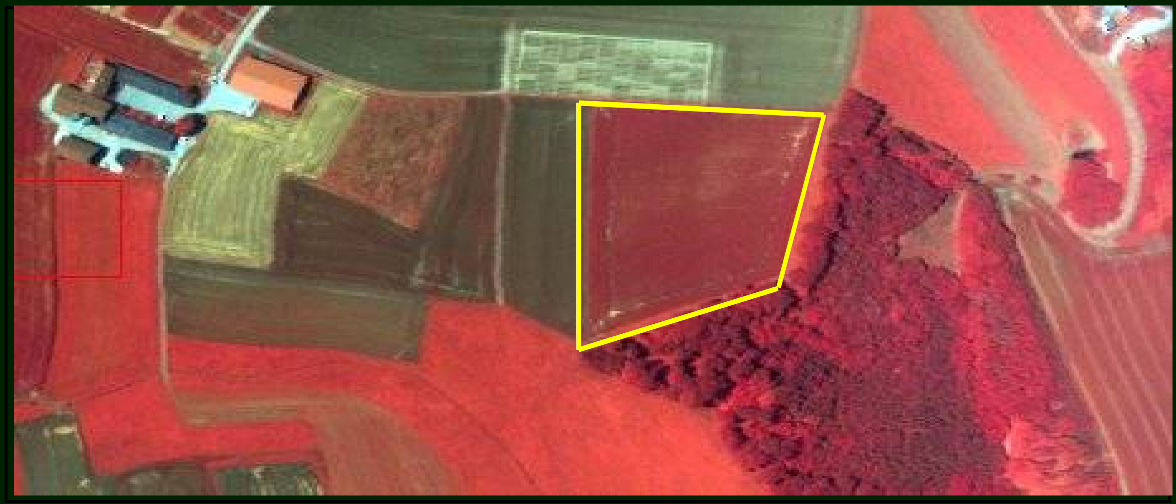
- spectral:
  bio-geo-chemical parameter: pigment- and water status, cell structure, mineral composition, etc.
- angular:
  plant architecture, canopy structure
- textural:
  pattern of similar frequency inside a structure
- polarisation
  not sufficient explored, low experience
- temporal
  change of signatures between two or more observations



Coupling of Ground with Spaceborne data

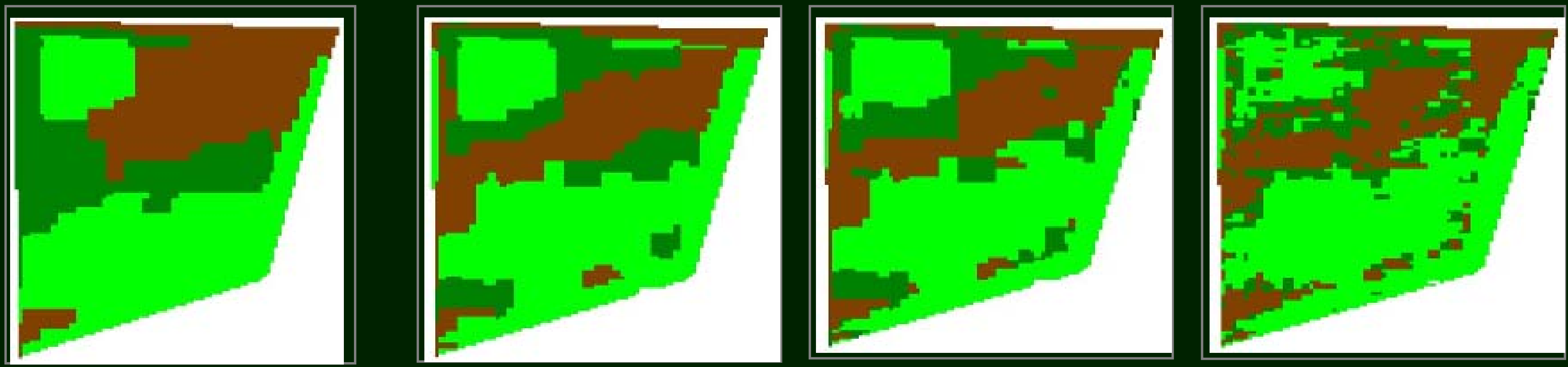
Final identification & classification result

Airborne support for agricultural management



Air photo DAEDALUS ATM
Spatial resolution 5m
RGB presentation: NIR,R,G

Vegetation Index NDVI : four segmentation levels



Vitality & Biomass : High Average Low

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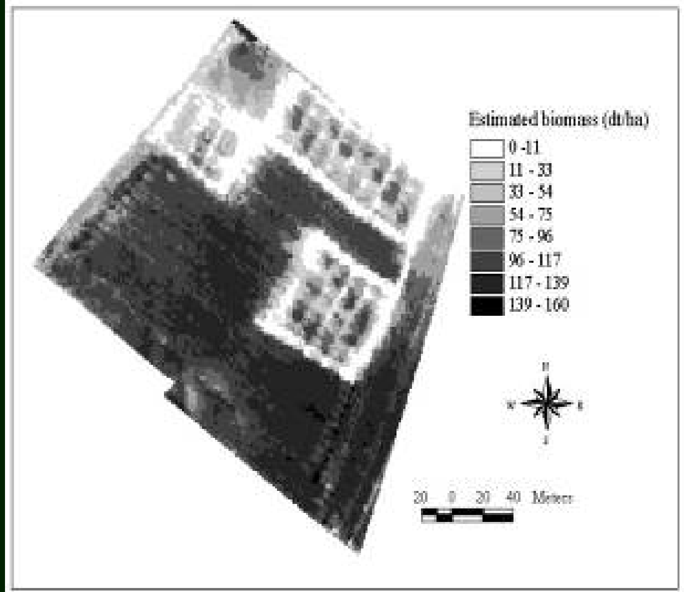
Vicarious calibration of Airborne Data



Example methodology – steps to follow:

- Simulation of the airborne sensor's channels
- Calculation of the indices (NDVI, IR/G, G/R)
- Regression analysis with the biomas and yield data
- Evaluation of the findings
- Fusion of the empirical functions

R(in situ) = a1[biomas or yield] +b1*

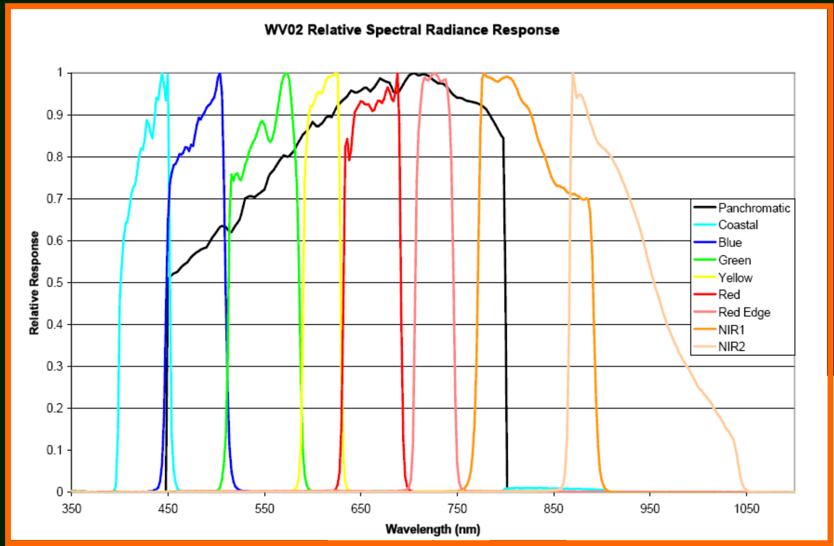
R(in situ) = a2[airborne image data] + b2*

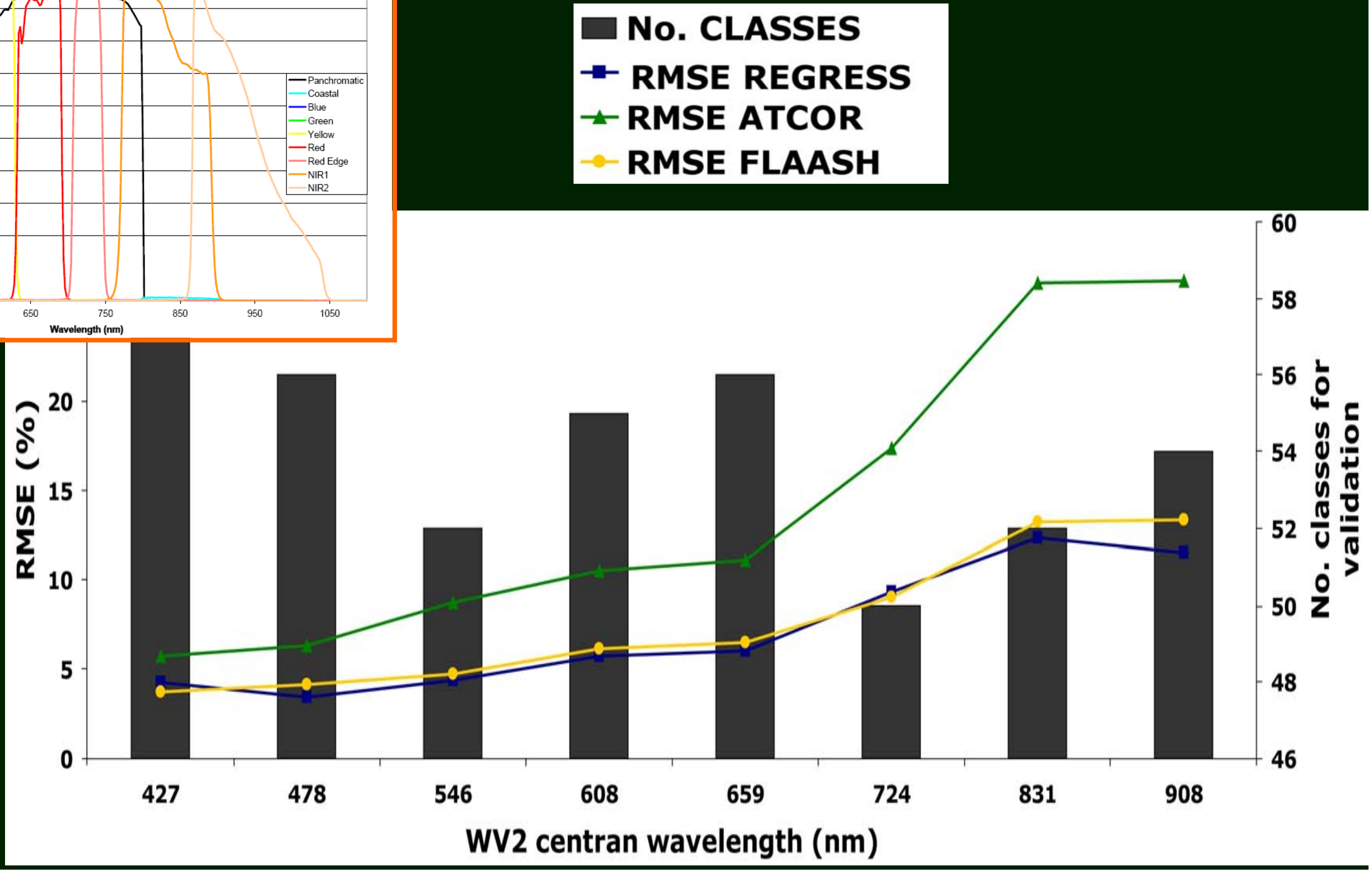
for the extrapolation of the findings from the parcels to the whole plot and correction of the atmospherical interference (conversion of the reflection to a value of a physical feature of the canopy)

[biomas or yield estimation] =

*{[a2 * (airborne image data) + b2] - b1} / a1*

Atmpospheric correction using Ground Data for WV-2





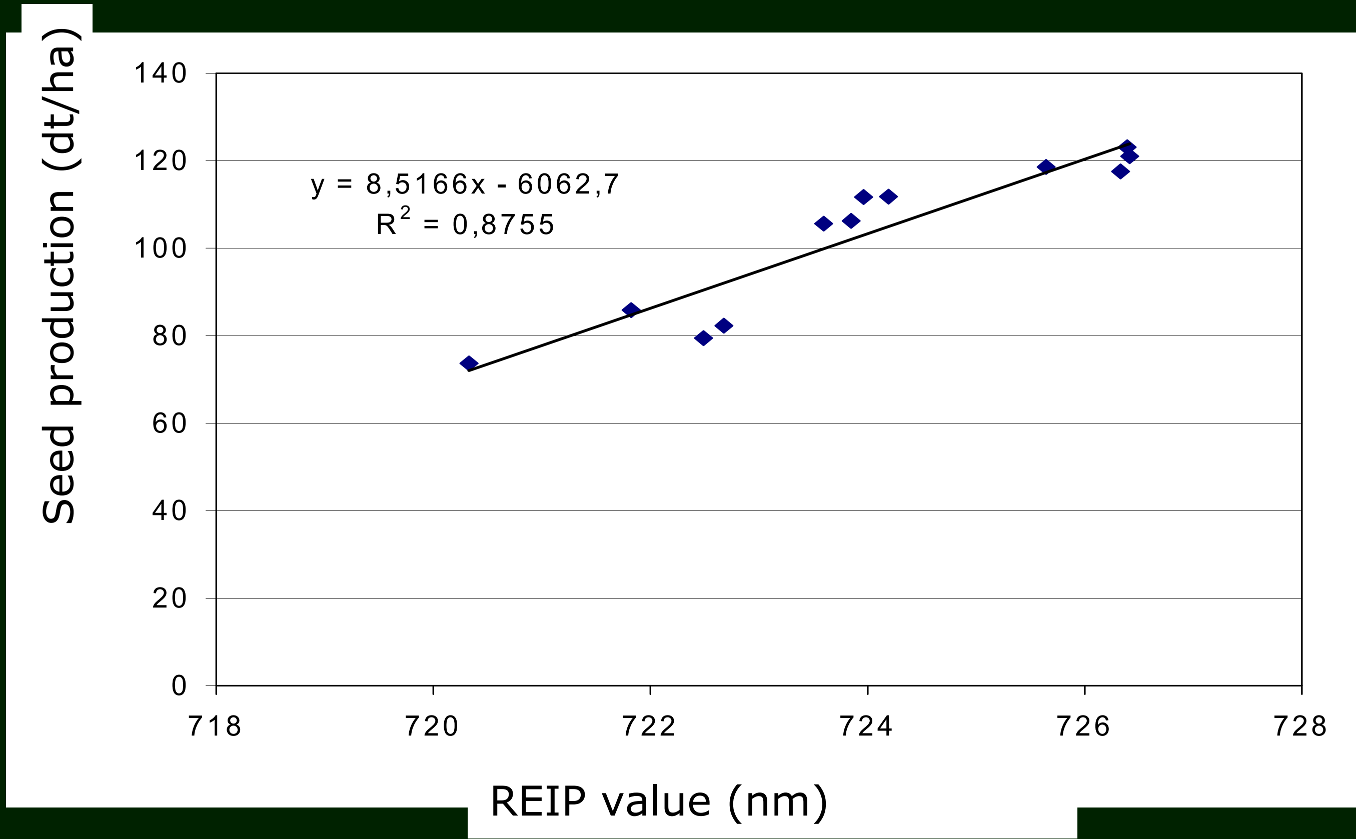
Modeling

Reflection models may be distinguished into

1. *empirical formulas*
   based on the approximation of the reflectance behaviour by mathematical functions

Red Edge Inflection Point (REIP) vegetation index at the flowering growth stage Versus seed production (wheat sort Flair) –

After Dr J. Liebler, TUM



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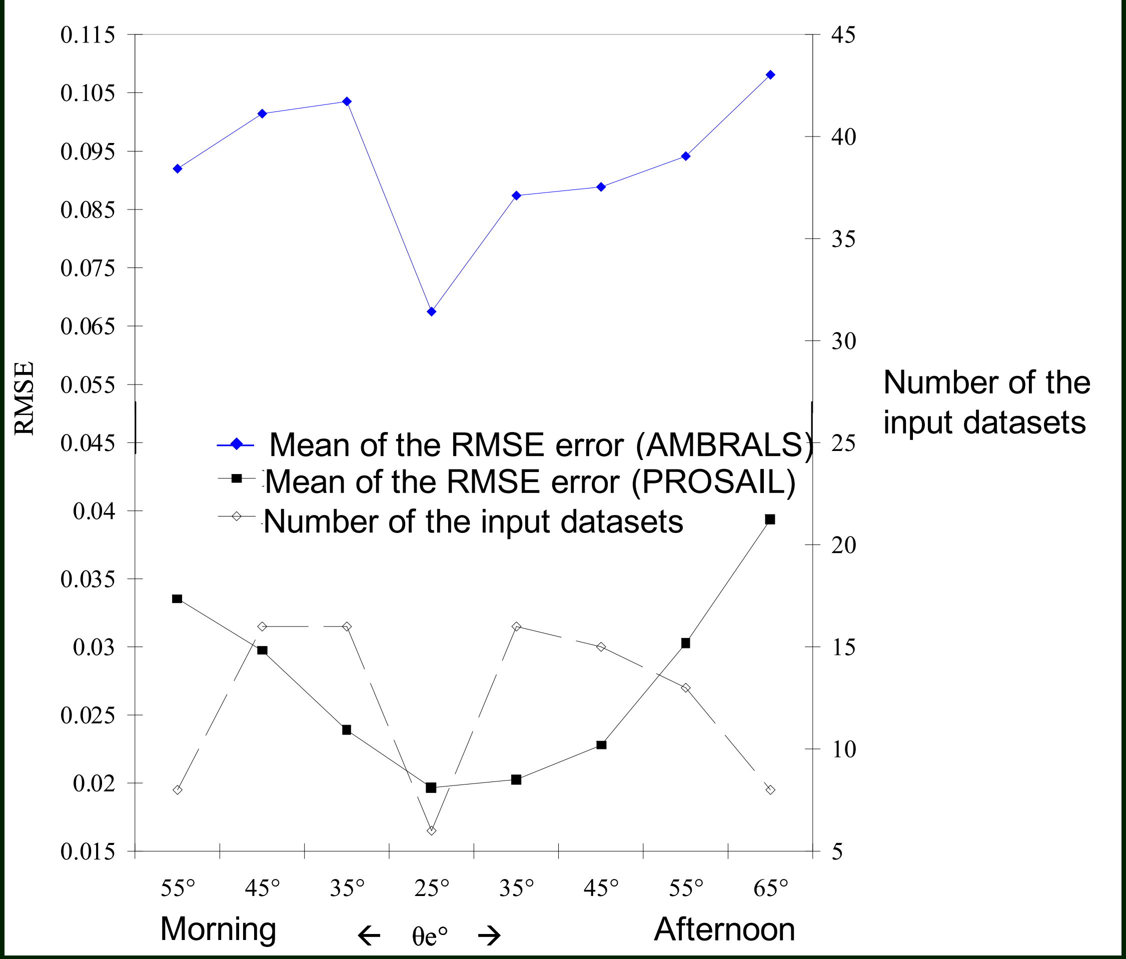
Modeling

2. *semiempirical models*

based on approximated consideration of physical processes and the use of complementary empirical parameters

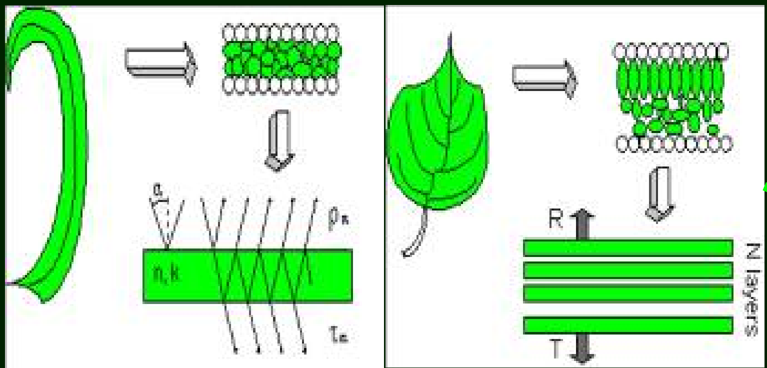


Modeling

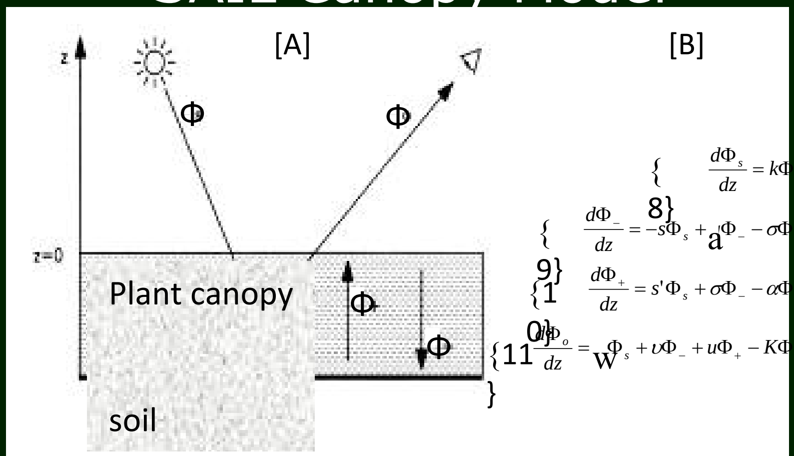
3. *physical models*

based on a psysical theory, the radiation path and its interaction with every chemical compoment and physical structure of the plant and canopy elements is simulated

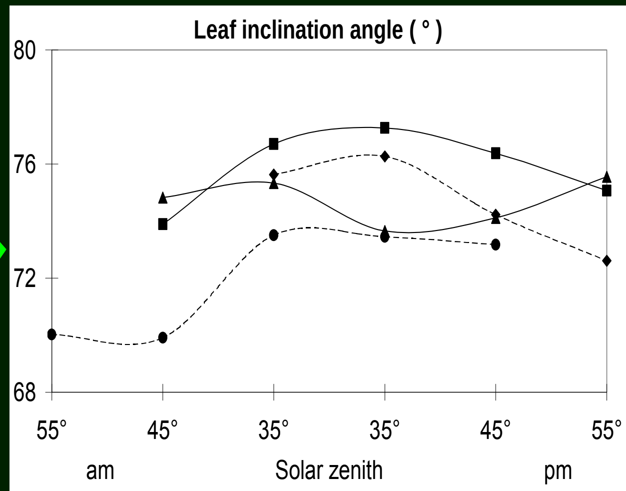
Prospect Leaf Model



SAIL Canopy Model



PROSAIL Model



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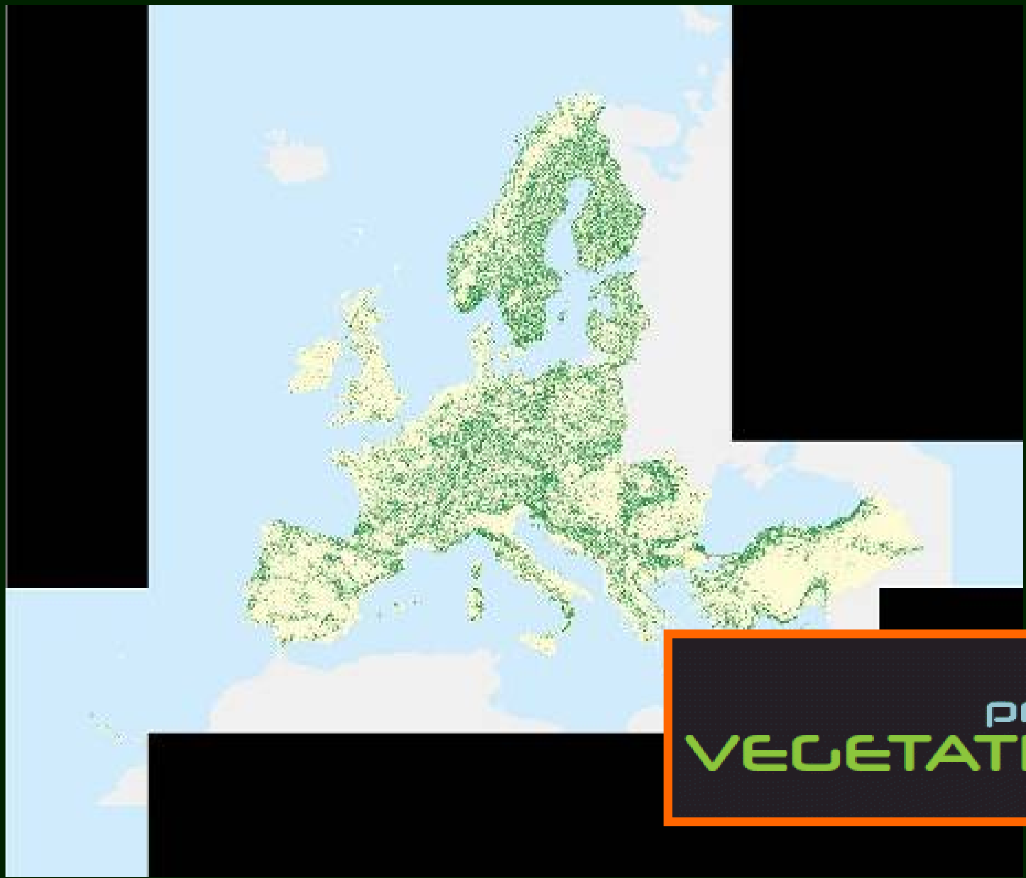
Forest Cover Monitoring over Europe



Study sites within the bio-geographical regions

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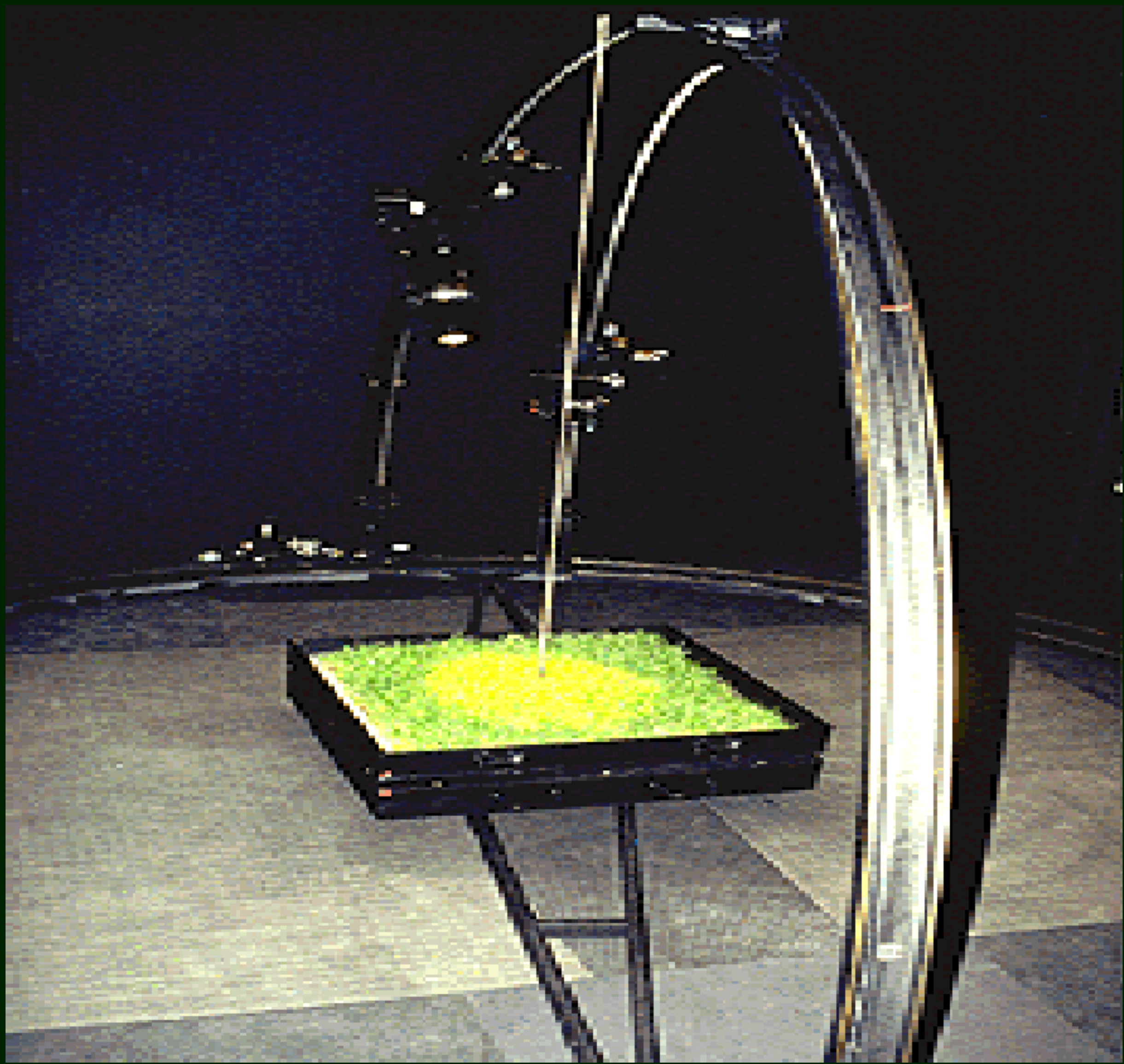
In situ

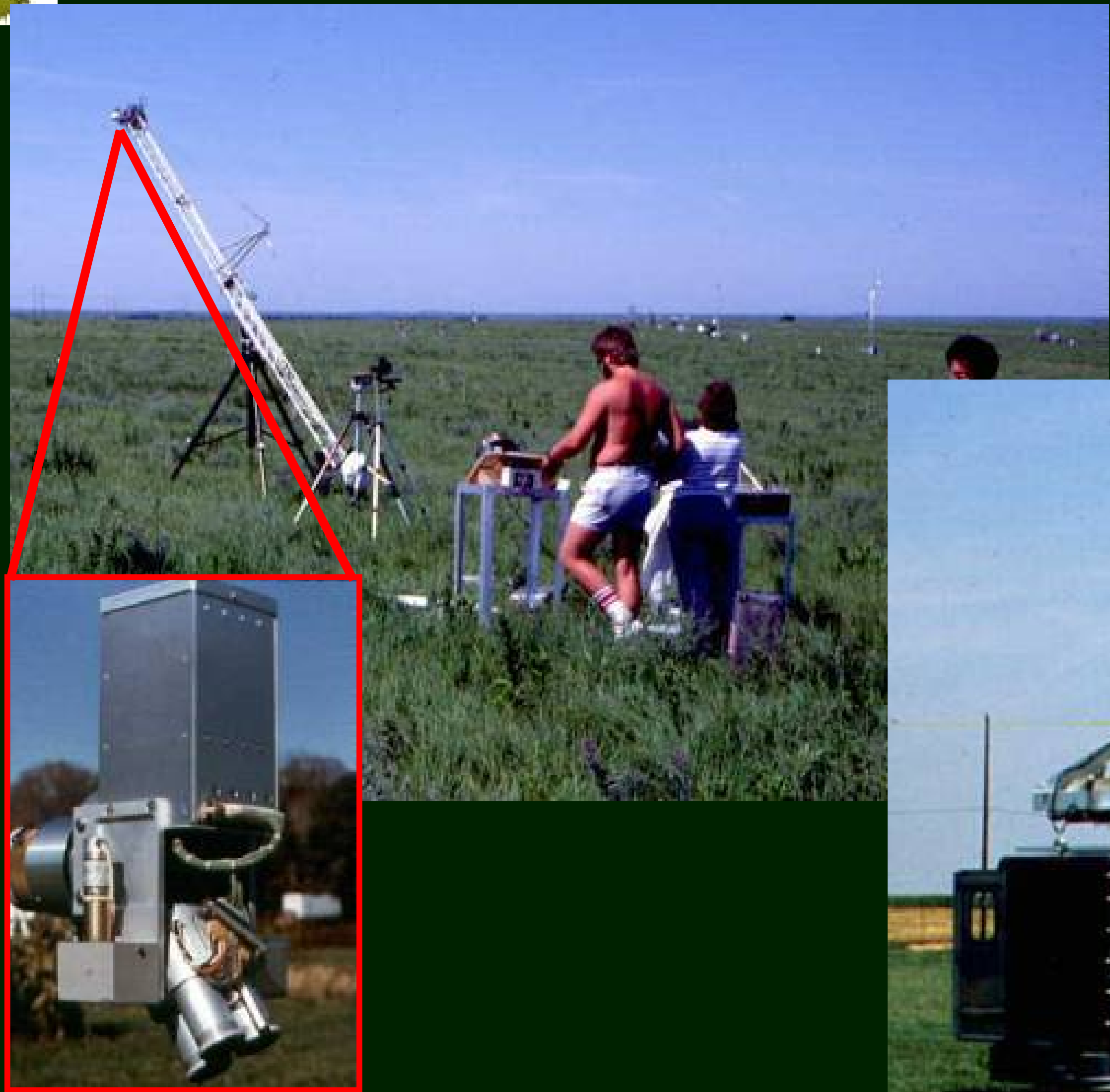
FIGOS, Zurich

In situ



EGO, JRC, Ispra

In situ



PARABOLA, NASA

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In situ

MUFSPEM - Mobile Unit for Field SPEctroradiometric Measurements

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In situ

MUFSPEM@MED –
Mobile Unit for Field SPEctroradiometric Measurements
at the Mediterranean [www.gi-eastmed.net]

In situ

Airborne – Example: DLR Germany

Credit: M. Gottwald, DLR-IMF
IPY Space Task Group, Geneva, 17-19 January 2007

Falcon aircraft

Airborne Reflective Emissive Spectrometer

DO228 Aircraft – Sensors

High Altitude and Long Range research aircraft

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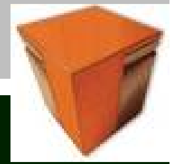
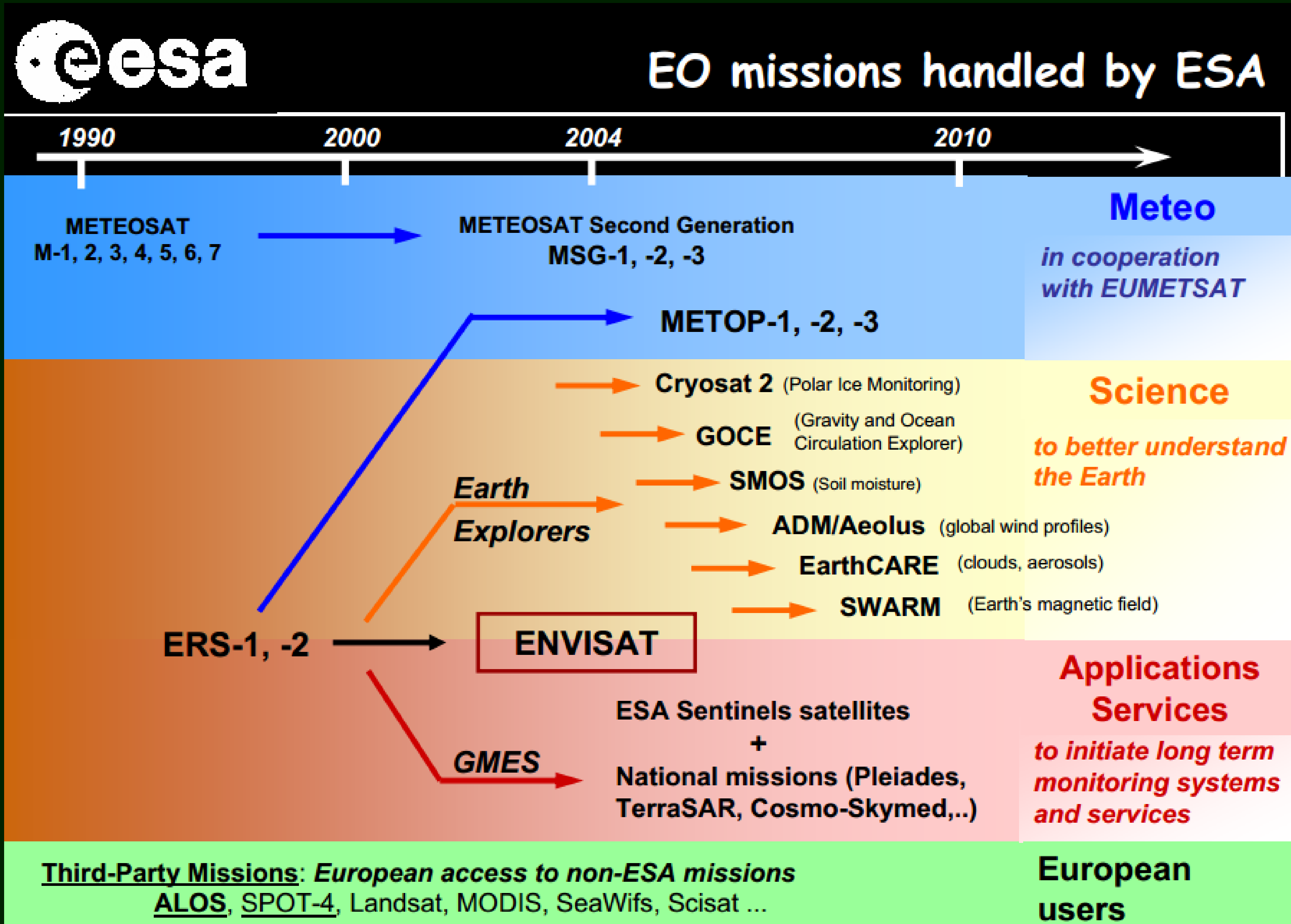
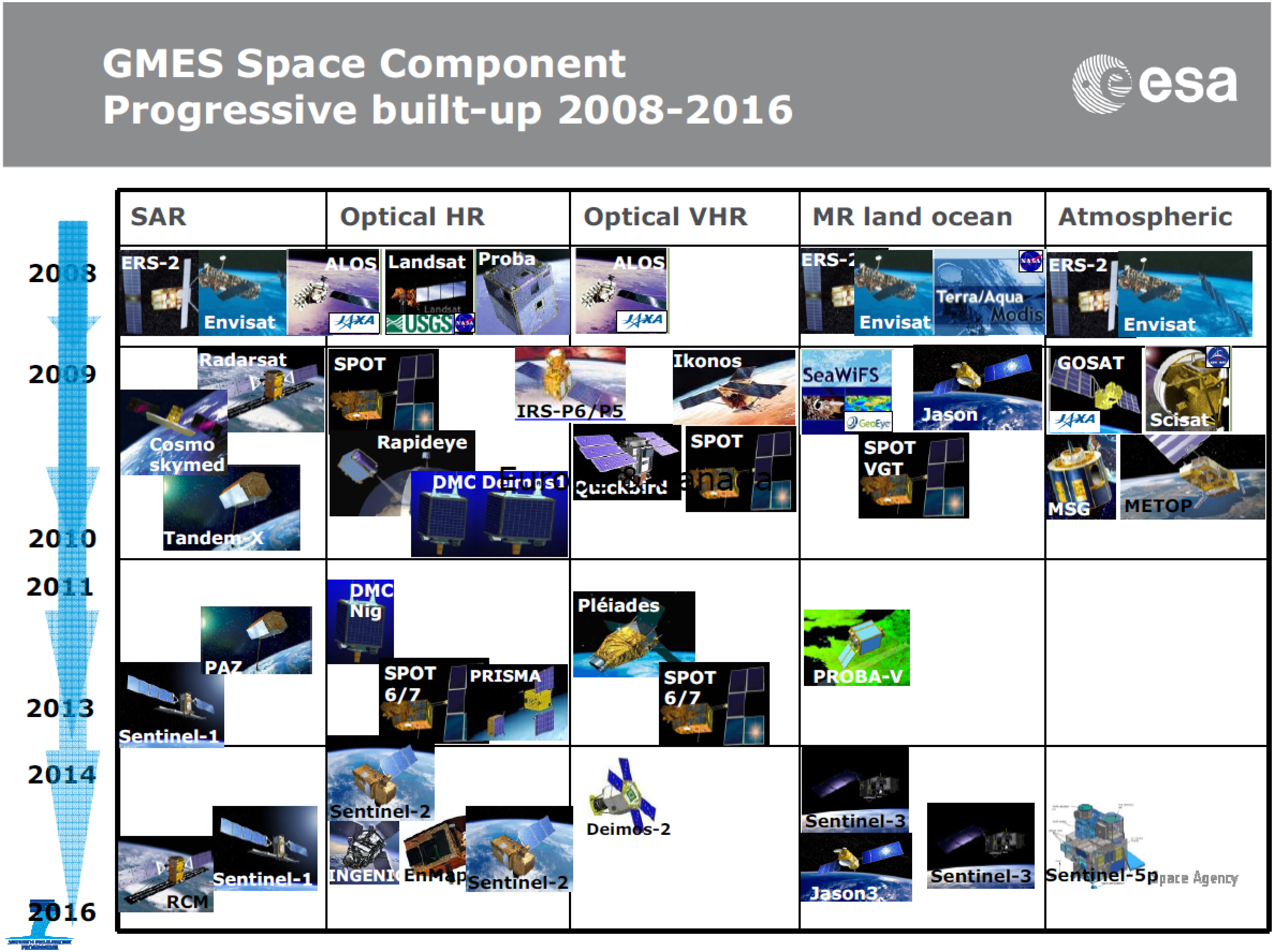
Spaceborne platforms/ sensors





Spaceborne platforms/ sensors



Spaceborne platforms/ sensors

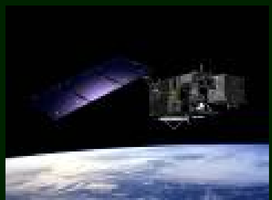
possible launch dates

Sentinel 1 – SAR imaging
All weather, day/night applications, interferometry
x 2 satellites, 693 km, Dawn dusk orbit

2013 / 2015

Sentinel 2 – Multi-spectral imaging
Land applications: urban, forest, agriculture,..
Continuity of Landsat, SPOT
x 2 satellites, 786 km, LTDN 10:30 am

2013 / 2016

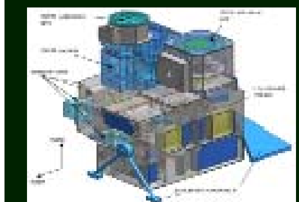


Sentinel 3 – Ocean and global land monitoring
Wide-swath ocean color, vegetation, sea/land surface temperature, altimetry
x 2 satellites, 814 km, LTDN 10:00 am

2013 / 2017

Sentinel 4 – Geostationary atmospheric
Atmospheric composition monitoring, trans-boundary pollution

2019



Sentinel 5 – Low-orbit atmospheric
Atmospheric composition monitoring
(S5 Precursor launch in 2014)

2020+

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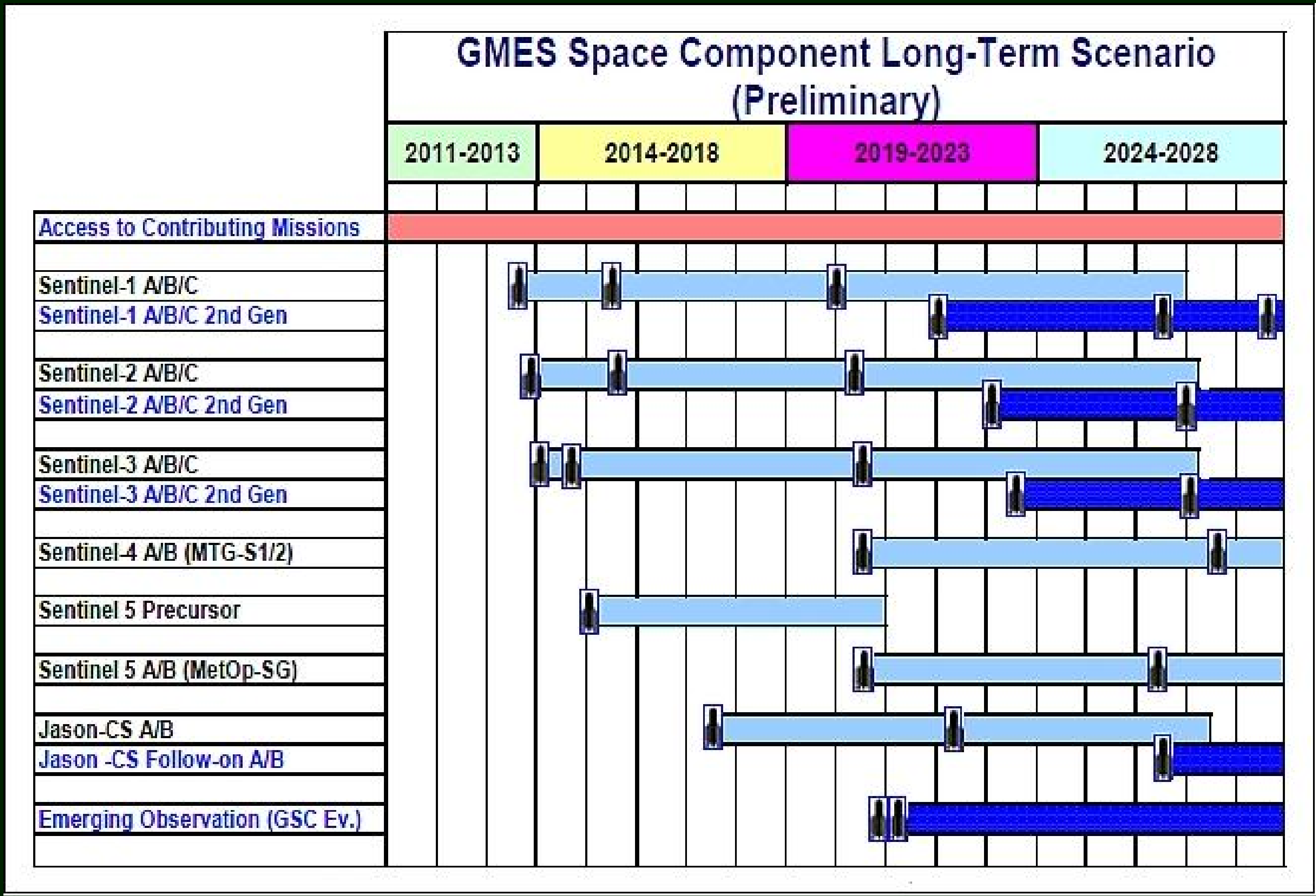
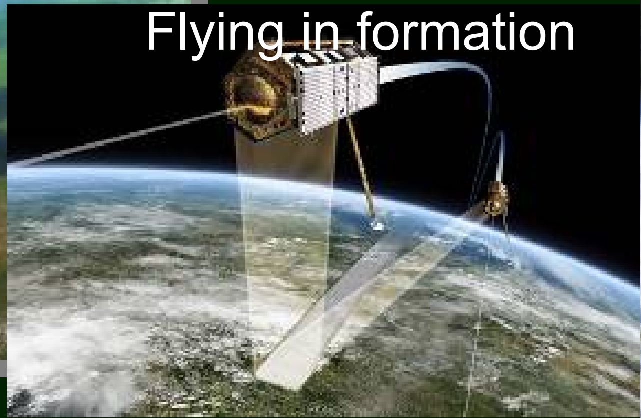
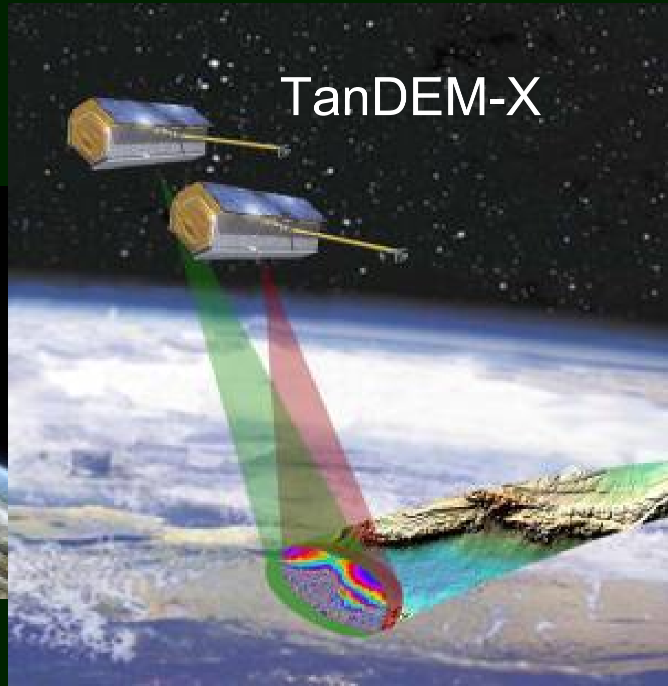
Spaceborne platforms/ sensors



GMES Space Component Long term scenario (launch dates of Sentinels are indicative), image credit: ESA, J. Aschbacher, M. P. Milagro-Pérez, A. Ciccolella, E. Paliouras, G. Filippazzo, T. Beer, "GMES Space Component: Programme overview," Proceedings of IAC 2011 (62nd International Astronautical Congress), Cape Town, South Africa, Oct. 3-7, 2011, paper: IAC-11-B1.1.9

Spaceborne platforms/ sensors





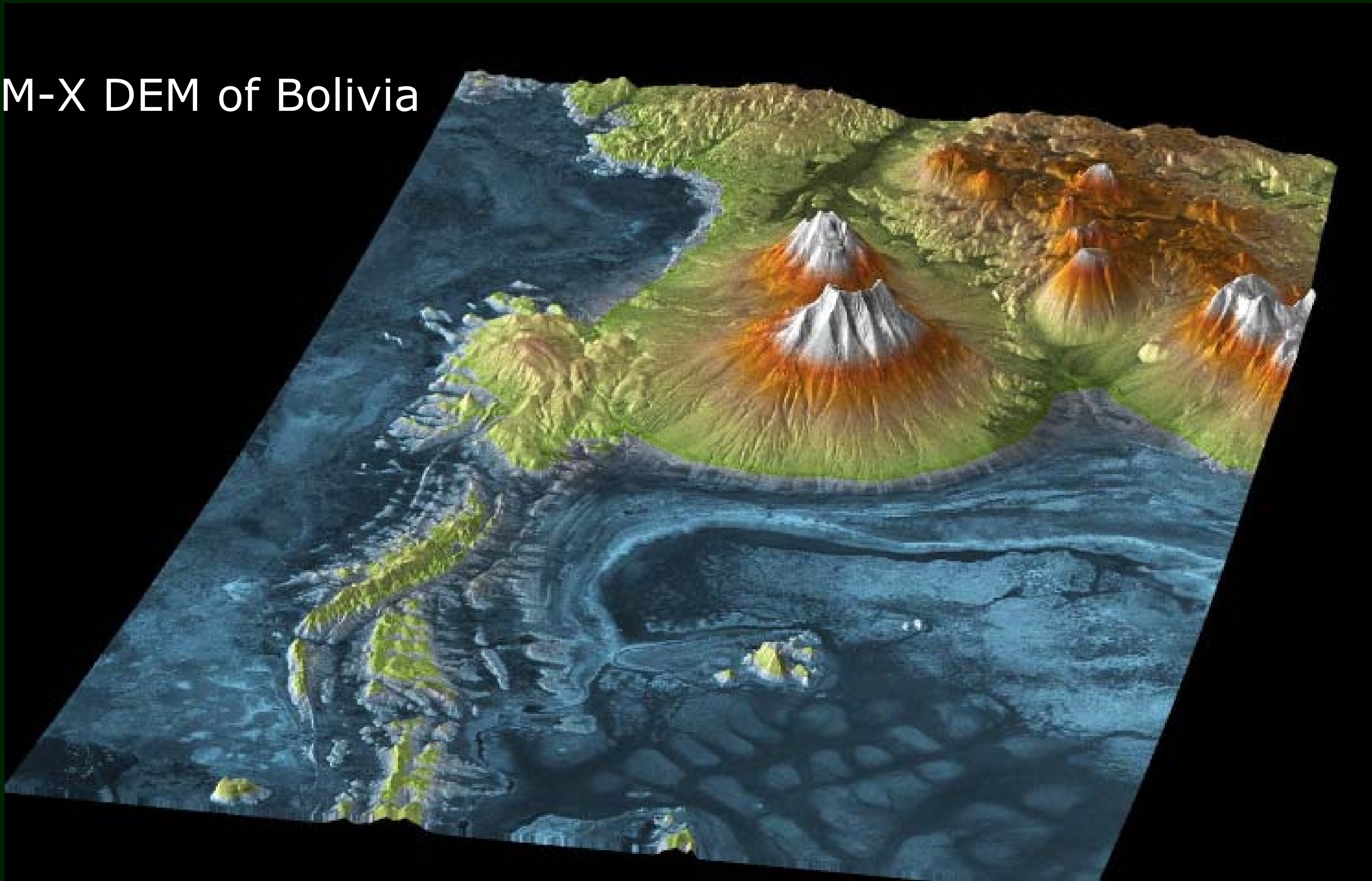
MISSION:
provision provide value-added SAR (Synthetic Aperture Radar) data in the X-band, for research and development purposes as well as scientific and commercial applications

MISSION:
Create global DEM in 3 years
12 m resolution, <2 m vertical accuracy
1.5 petabytes expected
1,000,000,000,000,000 B (at 8bits/B)

Credit: DLR and M. Gottwald, DLR-IMF
IPY Space Task Group, Geneva, 17-19 January 2007

Spaceborne platforms/ sensors

TanDEM-X DEM of Bolivia



http://www.terrasar.de/image-gallery

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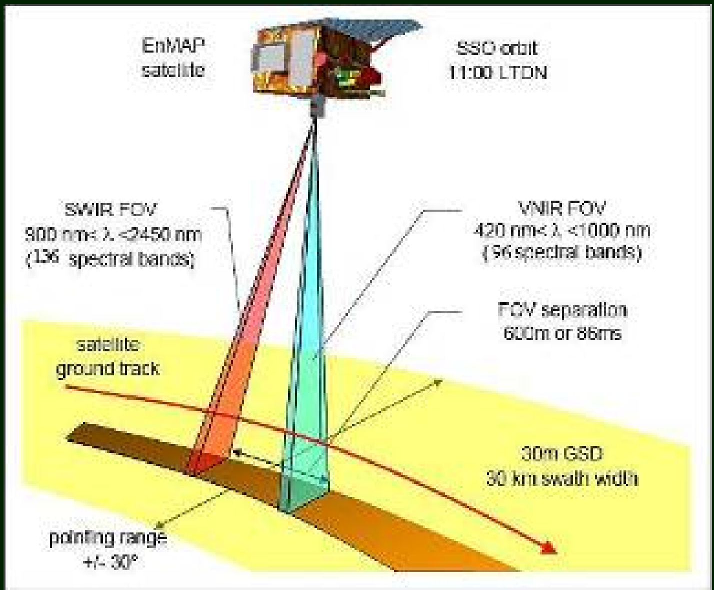
Spaceborne platforms/ sensors

EnMap mission (launch: 2015)



Schematic view of the delay observation technique of the HSI instrument
(image credit: OHB, Kayser Threde)

Spectral coverage	420 nm - 2450 nm VNIR (420-1000 nm) SWIR I (900-1390 nm) SWIR II (1480- 1760 nm) SWIR III (1950-2450 nm)
NEΔR (Noise Equivalent Delta Radiance) $[mW/cm^2\ sr\ \mu m]$	VNIR: 0.005 SWIR I: 0.003 SWIR II: 0.003 SWIR III: 0.001
Spectral sampling	VNIR: 5-10 nm (6.5 nm average) SWIR: 10 nm (average)
Spectral stability (VNIR-SWIR)	0.5 nm
Radiometric stability	± 2.5 % between calibrations
GSD (Ground Sampling Distance)	30 m x 30 m nadir
Frame readout rate	230 MHz (4.3 ms integration time)
MTF (Modulation Transfer Function)	> 25% at 16.6 cycles/km (Nyquist) for all wavelengths across track > 16% at 16.6 cycles/km (Nyquist) for all wavelengths along track
Swath width	30 km
FOR (Field of Regard)	± 390 km
Smile and smile effects	≤ 0.2 pixel
Band-to-band registration (VNIR/SWIR detectors)	≤ 0.2 pixel (co-registration)
Local equator crossing time	11:00 hours

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…topics in sequence

1. Considerations
2. Policy making in Europe
3. Remote Sensing challenges
4. Remote Sensing in practice
5. Remote Sensing platforms/ sensors
6. Examples - Projects
7. Trends and Outlook

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GMES on-going projects

geoland2 — www.gmes-geoland.info (preoperational GMES Land Monitoring Service)

myOcean — www.MyOcean.eu (preoperational GMES Marine Monitoring Service)

macc — Monitoring atmospheric composition & climate — www.gmes-atmosphere.eu (preoperational GMES Atmosphere Monitoring Service)

Safer — Services and Applications For Emergency Response — www.emergencyresponse.eu (preoperational GMES Emergency Response Service)

Gmosaic — GMES Pilot Services for Security — www.gmes-gmosaic.eu (preoperational GMES Security Service)

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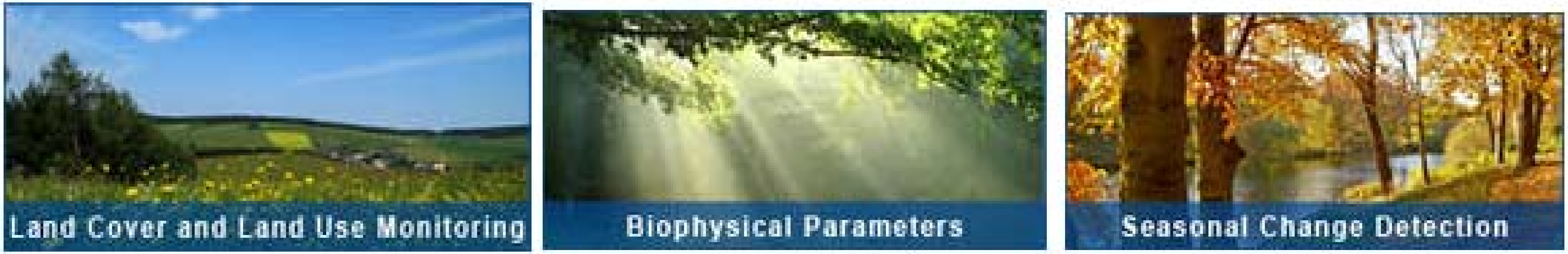
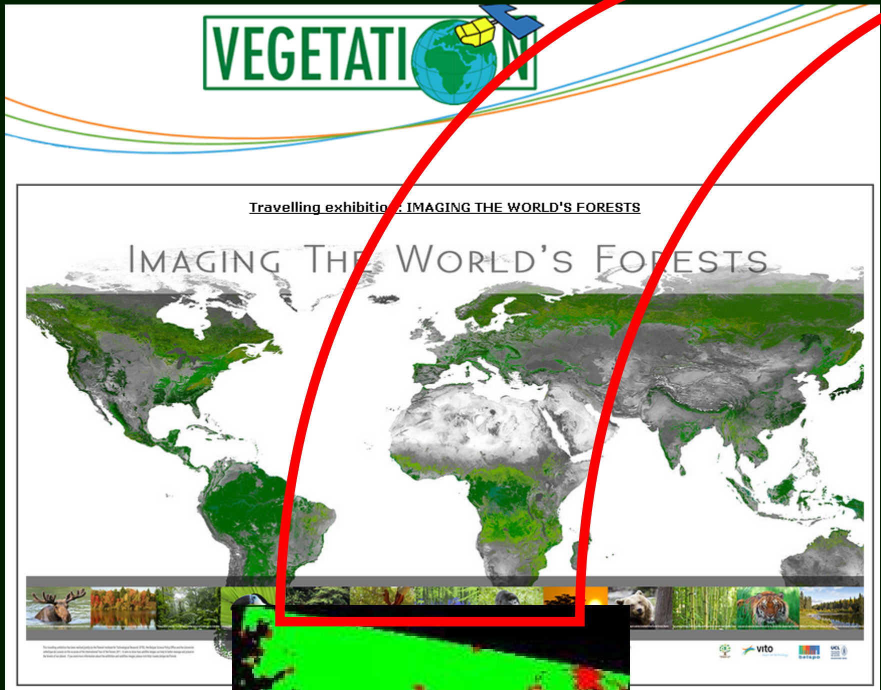
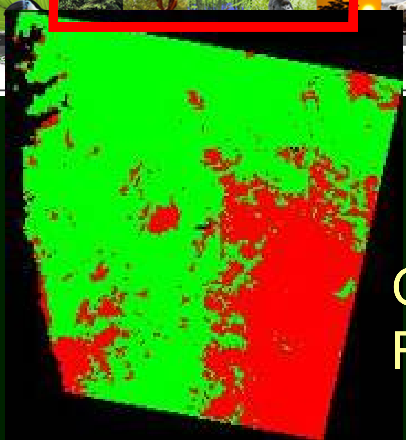
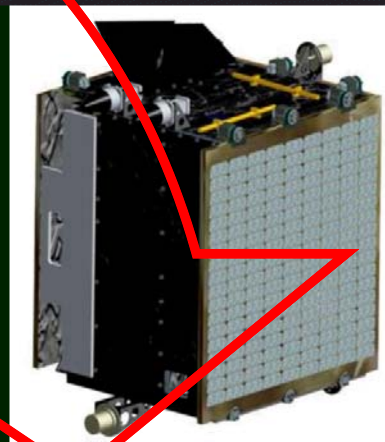
…on-going projects

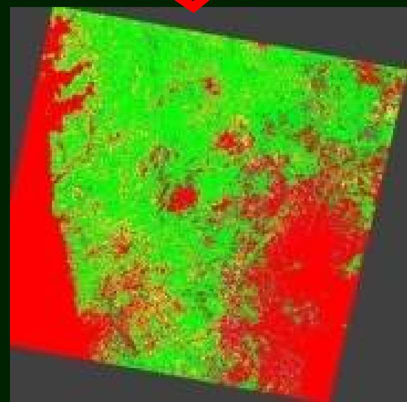


…on-going projects









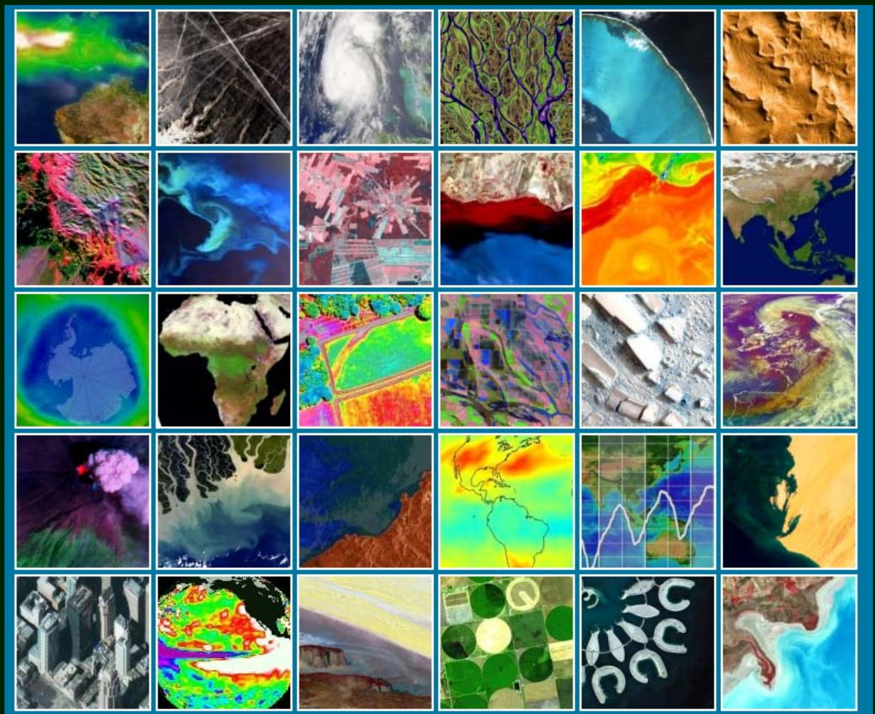
Green: Stocked
Red: Non stocked areas

…recent supportive projects

SEOS

Science Education through Earth Observation for High Schools (and GMES Users)

Languages
English
German
French
Dutch
Spanish
Greek
Arabic
Turkish



- World of Images
- Introduction to Remote Sensing
- Conservation of Natural and Cultural Heritages
- Coral Reefs
- Land Use and Land Use Change
- Remote Sensing and Geo-information Technologies in Agriculture
- Natural Resources Management
- Ocean Colour in the Coastal Zone
- Understanding Spectra from the Earth
- Remote Sensing Using Lasers
- Ocean Currents
- Marine Pollution
- Time Series Analysis
- Modelling of Environmental Processes
- 3D Models Based upon Stereoscopic Satellite Data
- Classification Algorithms and Methods
- Satellite Navigation with GPS

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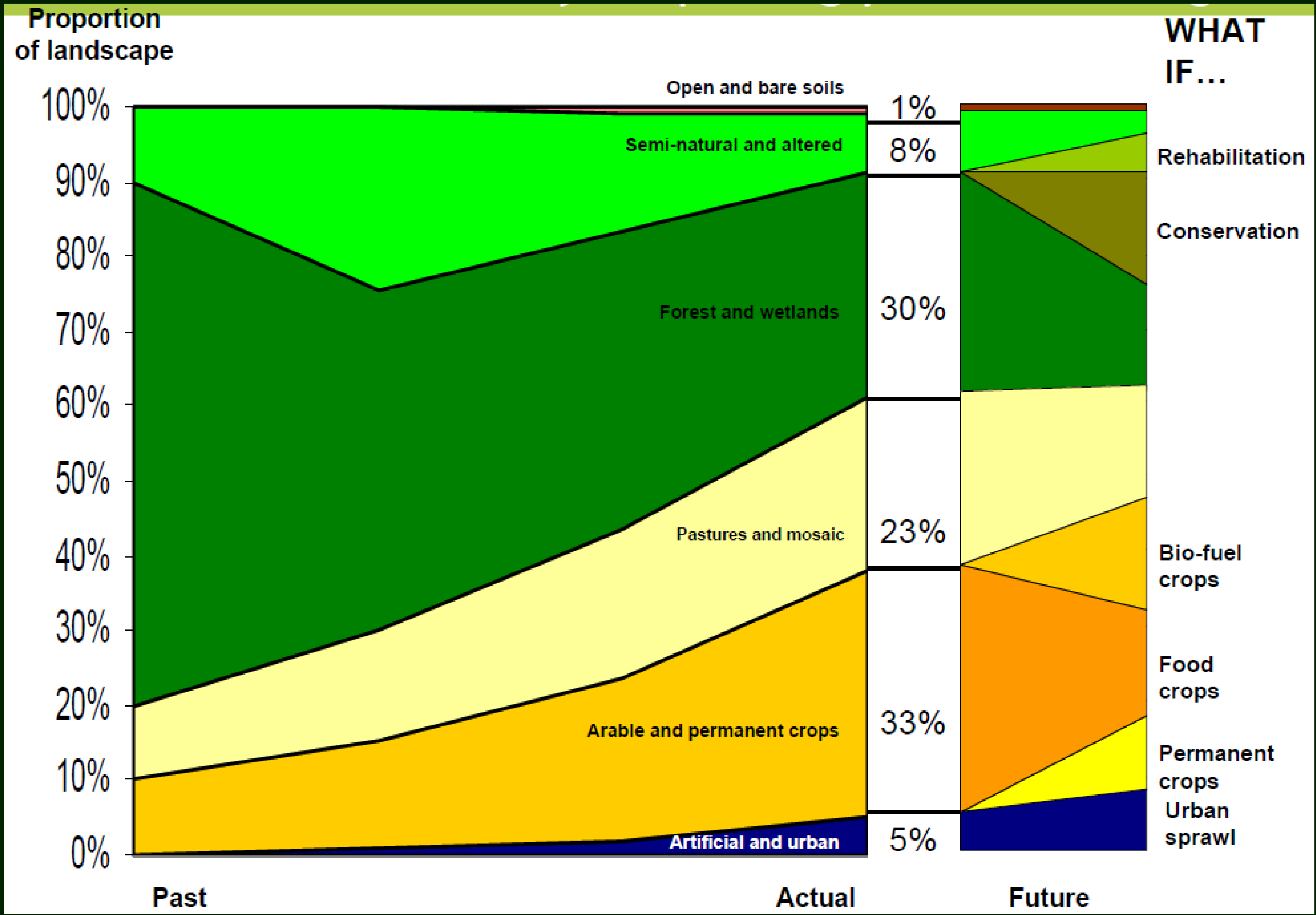
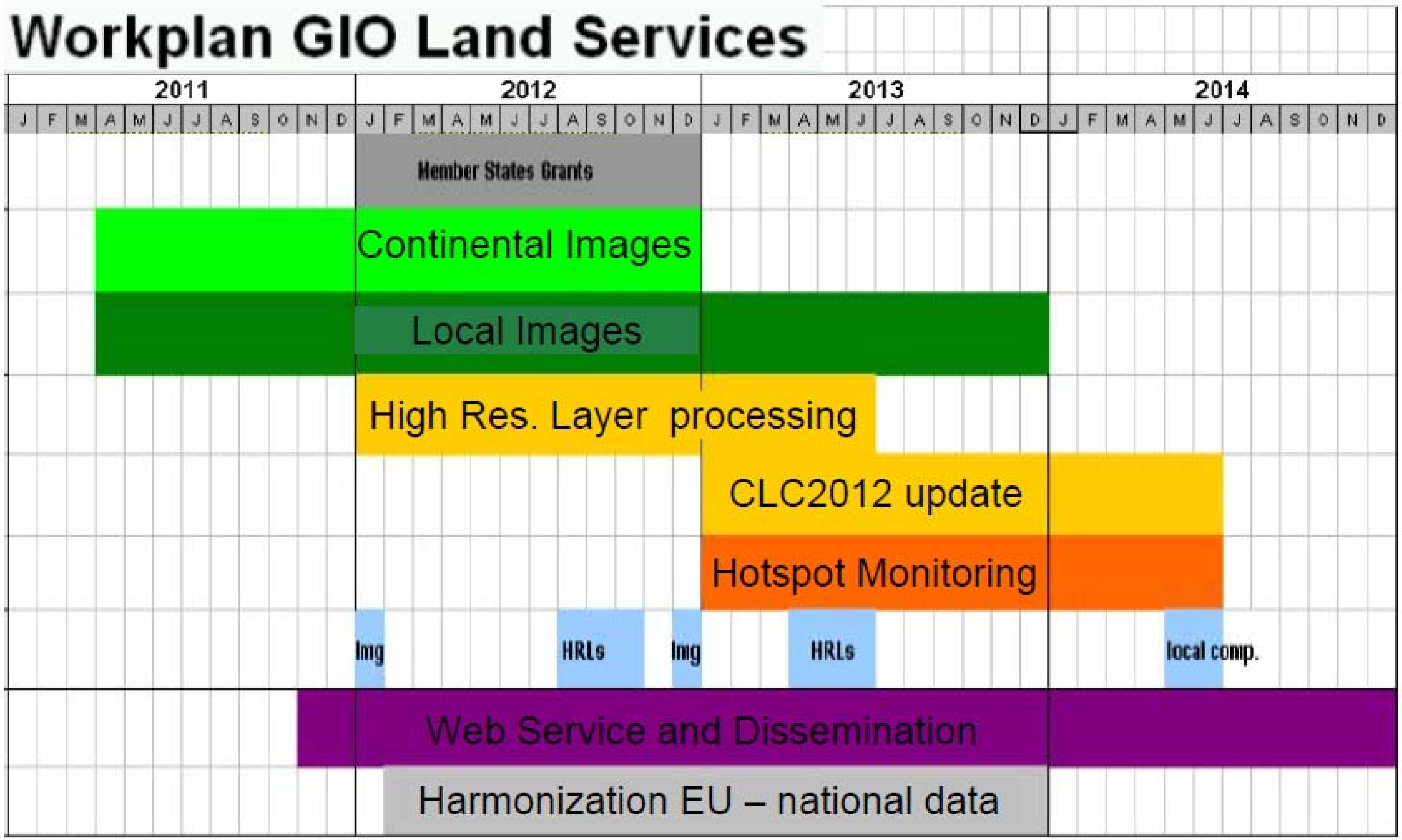
...outlook



Credit: Markus Erhard Hans Dufourmont, EEA, Warsaw, Geoland2 Forum, 14-15.09.2011

...outlook

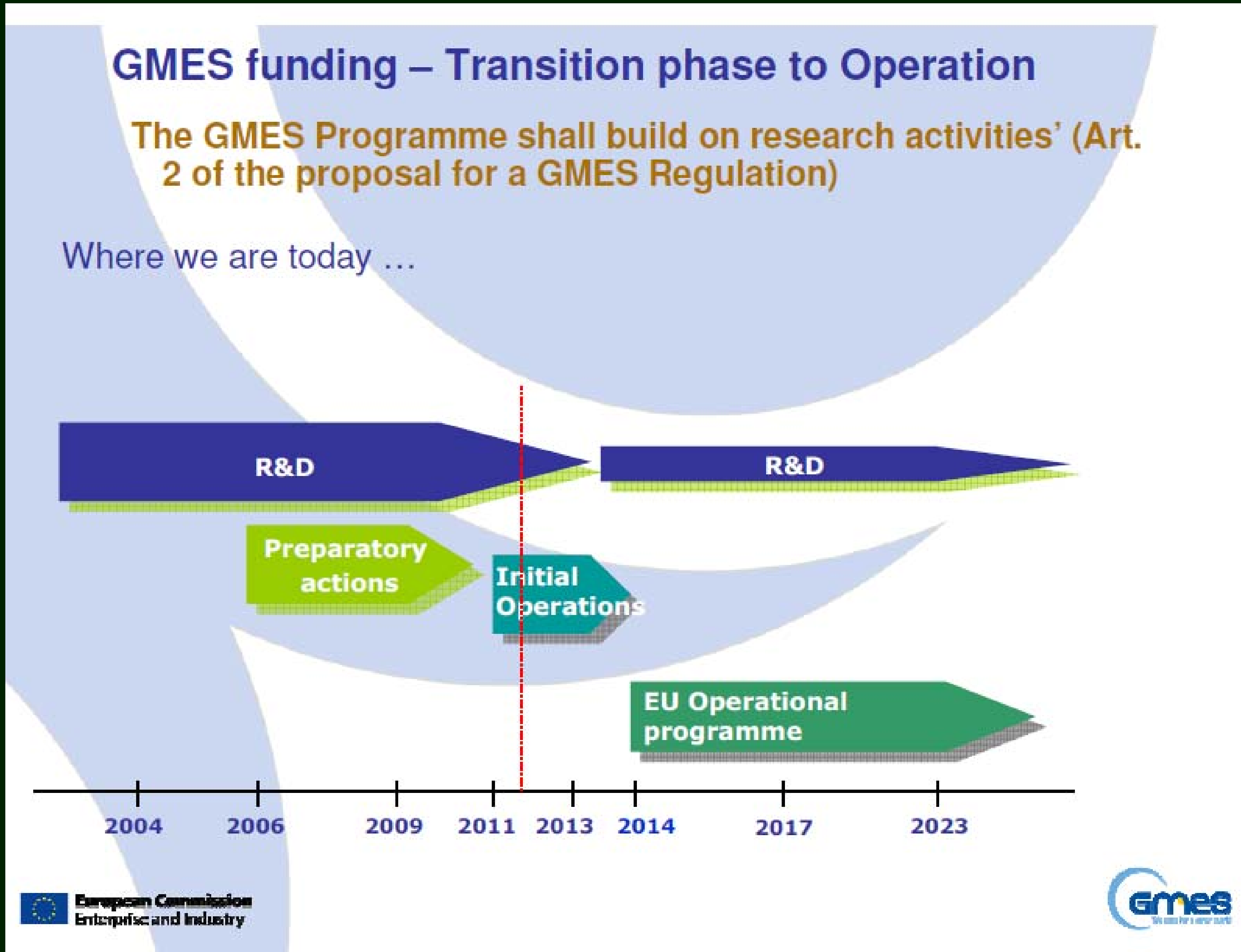
Perspectives and Planning EC / EEA



Extract from GMES Initial Operations (GIO) timetable

Credit: Stephan Arnold, German Federal Agency for Cartography and Geodesy geoland2 Forum 7 14. - 15. September 2011, Warsaw

…outlook: fostering Remote Sensing incorporation in the Decision Support and Policy Implementation chain.



…outlook & suggestions

Services are being implemented through GIO 2011- 2013 (High Resolution layers)

Launch of satellites delayed, due to budget issues

EU policy is being realigned towards a new strategy regarding GMES funding

Keywords:

Research	Budget	Harmonization	Engagement
Documentation	Quality	Usability	Members states

…with smile & vision

Thank you for your attention

At your disposal

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