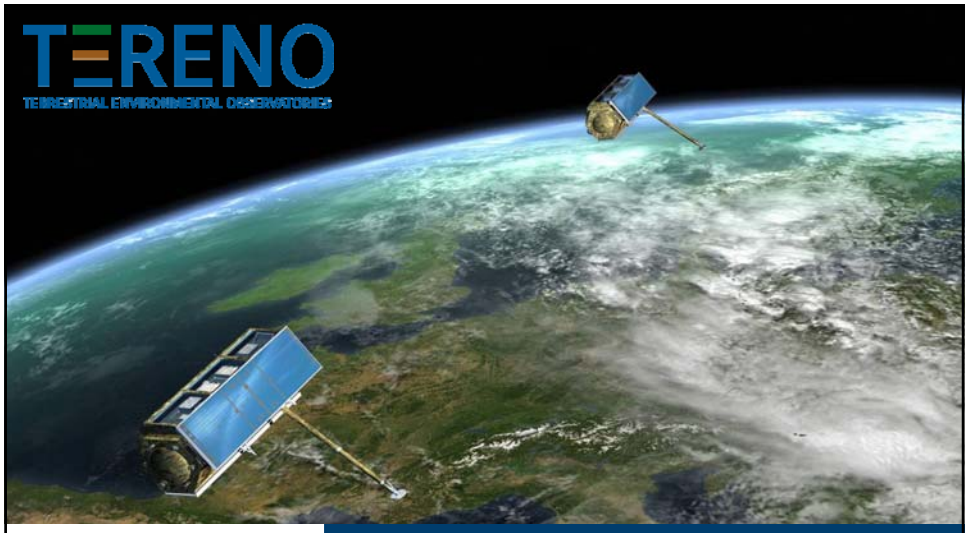

Remote sensing for environmental applications

Irena Hajnsek & TERENO Members

German Aerospace Center, Microwaves and Radar Institute

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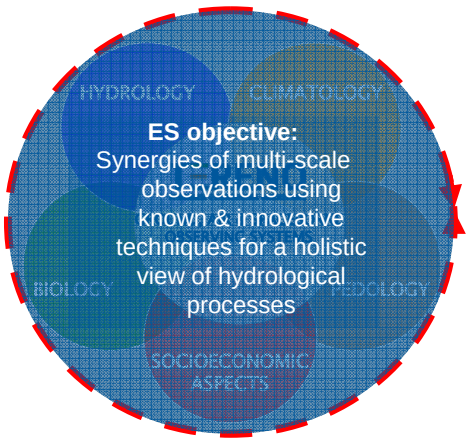
Motivation for environmental sensing (ES)

Information availability
- local
- regional
- global

Information delivery
- high resolution (1-10 m)
- large scale coverage (swath 15-100 km)
- area-wide
- regular
- day & night (radar)
- weather independent (radar)

Information product derivation
- mapping (cartographic)
- observation in time
- change detection & dynamic observation
- bio-/geophysical & chemical parameter estimation



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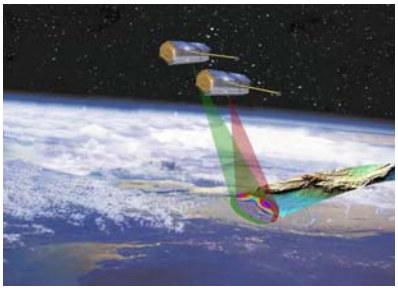
Environmental sensing from air and space

Airborne measurements

- Highly flexible operation
- Coverage of dedicated areas
- Experimental configuration
- Sensor specific data formats
- Short re-visit times

Spaceborne measurements

- Highly regular observation
- Wide area coverage
- Highly operational & reliable
- Standard product delivery
- Long term observations



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Why do we need airborne campaigns?

Innovation

- Specifications needed for future satellite sensors
- Test new sensor technologies/ combinations, advanced modes (Pol-InSAR, digital beamforming, etc.)

Development

- Provide data for development of algorithms for quantitative parameter estimation
- Development of new application products
- Calibrate or validate satellite retrievals

Data Availability

- Detailed informations in critical (conflict or inaccessible) areas
- Key information that cannot currently be measured from space
- Young researcher education & preparation to satellite sensors

DLR's aircraft

Requirements to an airborne system

- Flexible & modular sensor system
- System availability
- Complete operational processing chain
- Fast data delivery
- High data quality

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Contribution & interest from different research centers

Research Institution	Optic	SAR	Radiometry
German Aerospace Center Microwaves and Radar Inst.; Remote Sensing Technology Inst.	Hyperspectral ARES (>2009)	E-SAR F-SAR (> 2010)	---
UFZ Helmholtz Center for Environmental Research	Hyperspectral Sensors	---	---
Forschungszentrum Jülich GmbH Agrosphere Institute (ICG 4)	---	E-SAR (DLR)	PLMR EMIRAD-2 HUT-2D (ELBARA)
Forschungszentrum Karlsruhe	Thermal Infrared Camera	---	---
German Research Center for Geociences	Hyperspectral ARES (>2009); MAMap	---	---

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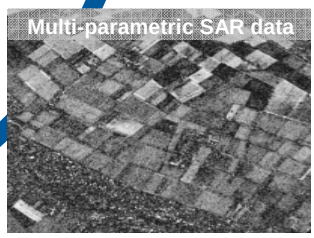
DLR (HR) – Derivation of physical parameters from SAR

Forest Vegetation		•Forest Height •Forest Biomass •Canopy Extinction •Forest Structure •Underlying Topography	•Forest Ecology •Forest Management •Ecosystem Change •Carbon Cycle
Agricultural Vegetation		•Soil Moisture Content •Soil Roughness •Height of Vegetation Layer •Moisture of Vegetation Layer	•Farming Management •Water Cycle •Desertification
Ice and Snow		•Topography •Penetration Depth •Depth of Snow-Ice Layer •Density of Ice Bodies	•Ecosystem Change •Water Cycle •Water Management
Urban Areas		•Geometric Properties •Dielectric Properties	•Urban Monitoring

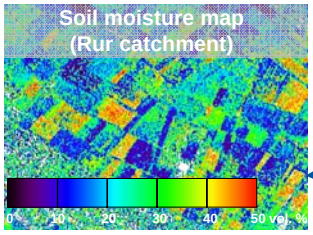
DLR (HR) - Soil moisture from SAR

- Mapping/monitoring surface soil moisture dynamic
  - sesonally observation (min 3x a year)
  - continously > 5 years
- Mapping/monitoring regional differences
  - Rur catchment
  - Ammer catchment
  - Bode catchement
  - Ucker catchement (optional)
- Research potential
  - devlopment of algorithm for surface soil moisture estimaton under the vegetation

SAR data processing



Modelling & Inversion



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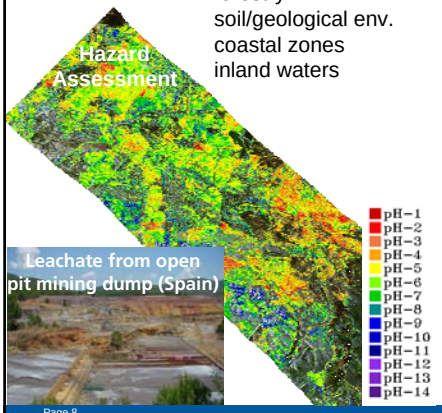
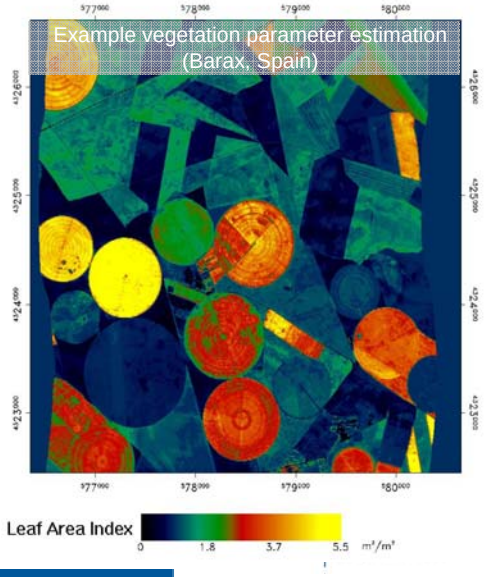
DLR (IMF) – Parameter derivation from hyperspectral

Hyperspectral data products :

- Biophysical, biochemical, geochemical variables
- Ecosystem parameters encompassing
  - agriculture
  - forestry
  - soil/geological env.
  - coastal zones
  - inland waters





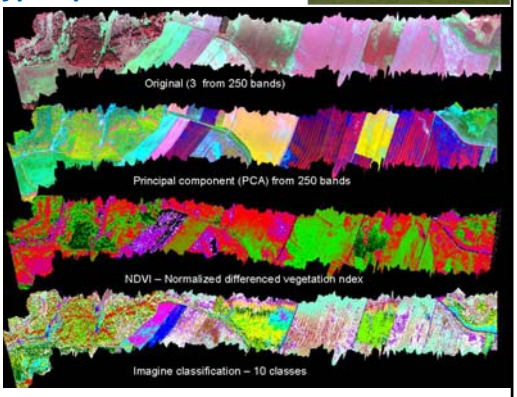
UFZ – Parameter derivation from hyperspectral

Standing and flowing water

- Qualitative, quantitative & temporal assessment of spectral signatures from suspended matters (phytopigments)
- Assessment of plant & vegetation vitality
- Spatio-temporal assessment, classification & monitoring of water body conditions
- Water quality (trophic conditions)

Soil

- Quantitative assessment & derivation of important biophysical/ biochemical soil parameters (corg, ferric oxide, water content, soil texture, structure, heterogeneities)
- Temporal assessment, classification & monitoring of soil structure
- Temporal variability of soil moisture



Terrestrial vegetation

- Assessment of physiological & structurel parameters (biomass, water content, vitality, nutrient stress, heavy metal contents …)

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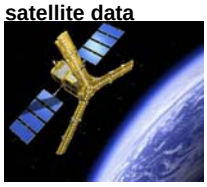
FZJ – Soil moisture derivation with radiometry

Agrosphere (ICG 4)

Calibration and validation of the ESA *Soil Moisture and Ocean Salinity* (SMOS) mission (2009)

global
regional
local

satellite data



SMOS with MIRAS
⇒ long time measurements

airborne campaigns

e.g. Skyvan with EMIRAD
⇒ momentary imaging

test sites

radiometer and sensor networks
for soil moisture and temperature
⇒ long time measurements

regionalisation by modelling approaches
⇒SMOS CAL/VAL

SMOS

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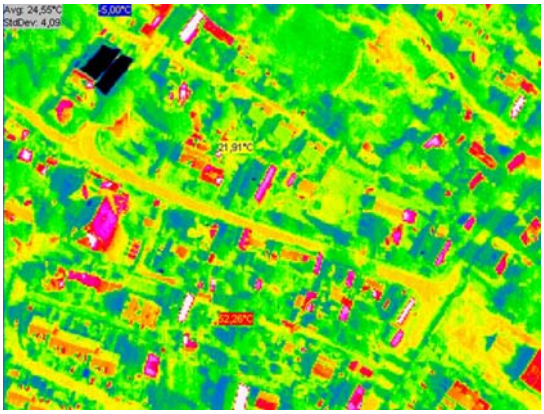
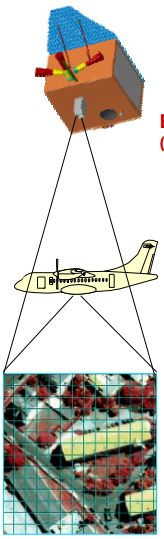
FZK – Product derivation with thermal infrared

Thermal infrared imaging products

- Soil temperature maps and derived products



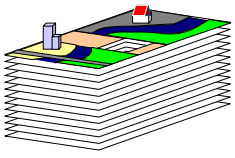
GFZ- Hyperspectral for monitoring environmental dynamics

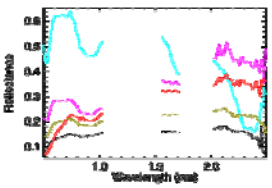


EnMAP
(launch 2011)

ARES

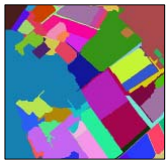
Airborne (ARES) and future satellite (ENMAP) remote sensing based data acquisition with high number of spectral bands - a spectrum per pixel

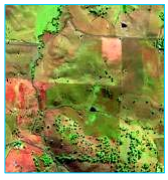


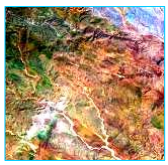


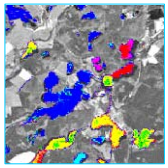
Research focus on development of methods for monitoring of environmental parameters

Agricultural and forest ecosystems









Desertification - Dryland degradation

Bioproductivity - Inland waters

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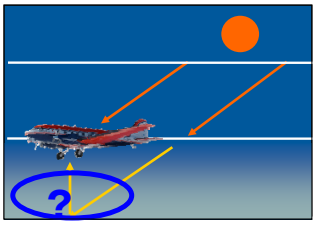
GFZ - Airborne mapping of soil-plant-atmosphere fluxes of CH_4 und CO_2 for monitoring of environmental dynamics (MAMap)

Motivation:

Enormous uncertainties in global CH_4 und CO_2 sources (rates of emissions, spatial heterogeneity, temporal variability), for example:

2006: new findings on natural CH_4 sources surprise modelling groups; models are under discussion, global and landscape models have been modified



What is MAMap?

Spectrometer system for detecting atmospheric CH_4 and CO_2 concentrations

Sun as source of light

accuracy: ±2% of background atmos. Concentration

First device world wide !

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Derived data products from environmental sensing

Research Institution	Optic	SAR	Passive Radar
German Aerospace Center *Microwaves and Radar Inst.;* *Remote Sensing Technology Inst.*	***LAI (leaf area index),*** ***Cab (Chlorophyll a,b),*** ***PAR (photosynthetic active radiation)*** ***Cw (water content)*** ***Cdm (Dry matter content)*** ***...***	***Soil moisture map (fully polarimetric)*** ***...***	---
UFZ Helmholtz Center for Environmental Research	***LAI (leaf area index)*** ***Vitality parameters*** ***Plant water content*** ***...***	---	---
Forschungszentrum Jülich GmbH *Agrosphere Institute (ICG 4)*	---	***Soil moisture map (radar backscatter)***	***Soil moisture map (brigthnees temperature)***
Forschungszentrum Karlsruhe	***Soil temperature maps***	---	---
German Research Center for Geociences	***Greenhouse gas fluxes (GHG), Soil minerals, soil organic matter,*** ***(see DLR)***	---	---

Requierements on spaceborne sensors & products

Research Institution	Optic		SAR		Passive Radar	
	Sensor	Data Product	Sensor	Data Product	Sensor	Data Product
German Aerospace Center *Microwaves and Radar Inst.; Remote Sensing Technology Inst.*	EnMAP (2011)	biophysical, biochemical, geochemical variables	TerraSAR-X TanDEM-X (>2009) PALSAR	land class map; change detection; soil moisture; DEM	---	
UFZ Helmholtz Center for Environmental Research	SPOT	land class map; vegetation cover	TerraSAR-X Envisat	land class map; …	---	
Forschungszentrum Jülich GmbH *Agrosphere Institute (ICG 4)*	ASTER SPOT (LANDSAT)	land cover NDVI, DTM impervious-ness	ERS-2 RADARSAT-2 ALOS	soil moisture (roughness)	SMOS (2009)	soil moisture
Forschungszentrum Karlsruhe	---					
German Research Center for Geosciencs	EnMAP (2011)	biophysical, biochemical, geochemical variables	---	---	---	

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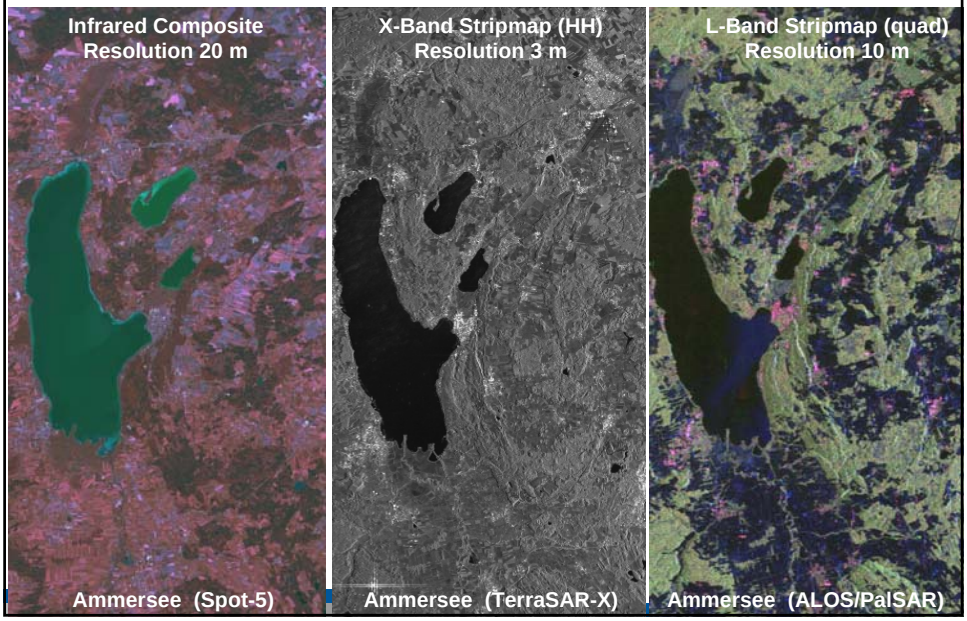
Spaceborne sensors: Optic and SAR



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Prediction of hydrological processes with sensing information