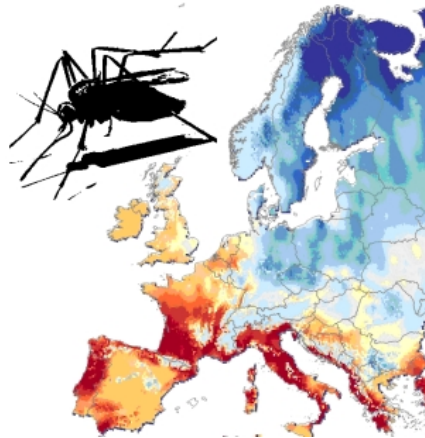


Mapping habitats for vectors of infectious disease: VECMAP



Integrated Applications Promotion
European Space Agency

Mapping habitats for vectors of infectious disease: VECMAP

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IAP Projects

	Earth Observation	Navigation	SatCom	Human Space Flight techn.
HEWS (pre-IAP)				
SAFE (pre-IAP)				
Water quality monitoring in Egypt				
AMAZON				
PREDICT – Senegal				
Portable Telemedicine Workstation				
eHealth in Subsaharan Africa				
VECMAP				



Disease vector mapping

- **Outbreaks of Chikungunya**
 - Reunion 2005-2006
 - Ravenna (Italy) 2007
- **Global introductions of disease vectors**
 - International trade (e.g. eggs in tyres)
 - Tourism
 - Global warming
- **Need for surveillance, early warning systems & control**
 - Vectors survive only in particular ecosystems
 - Need for **spatial prediction maps**



Asian Tiger Mosquito

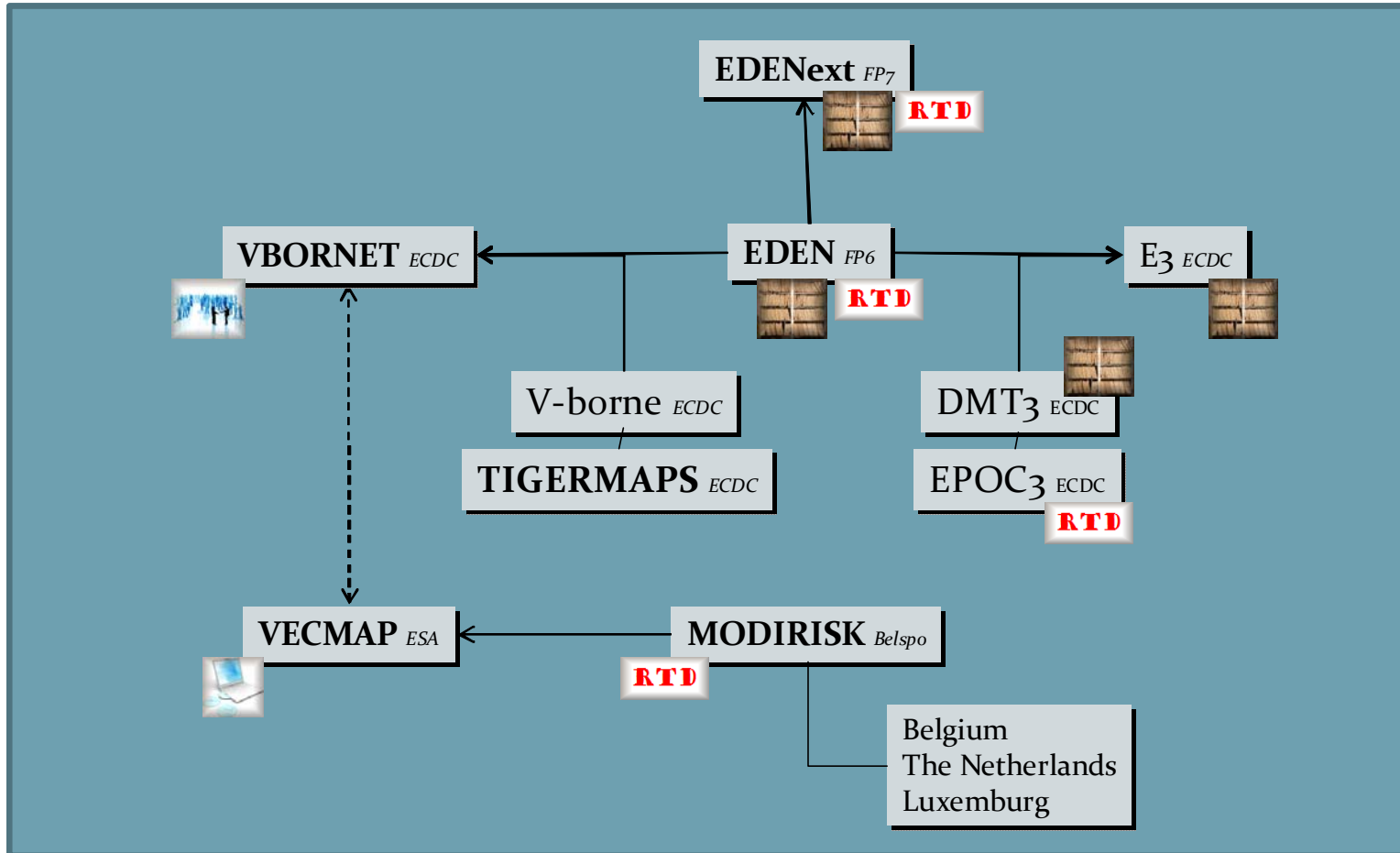
A. Albopictus, vector for:

- West-Nile
- Dengue
- Chikungunya
- Yellow fever
- St. Louis Encephalitis





Project origin and context





Users & their needs

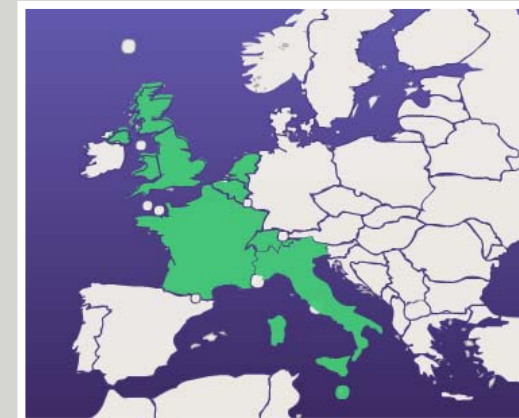
1. Academic users

- Reduce field work, more focus on analysis of data
- More standardized results



Academic Users

- PhD students
- ITM (B)
- UZH (CH)
- CEH (UK)





Users & their needs

1. Academic users

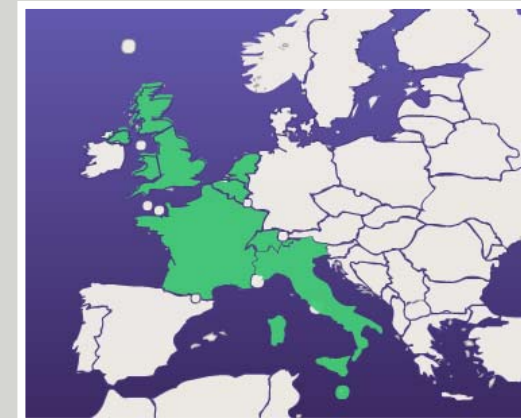
2. Public Health (decision makers)

- Early warning vector presence
- Critical species
- Where are they now
- Where will they be in future
- National coverage



Public Health

- RIVM (NL)
- IPH (B)
- PH Malta
- PH French Polynesia





Users & their needs

1. Academic users

2. Public Health (decision makers)

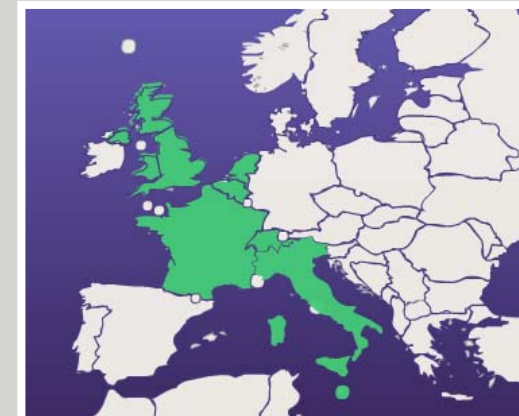
3. Control agencies

- Critical & nuisance species
- Where are they (mosquitoes, larvae, eggs), high resolution
- When will eggs hatch & population peak
- Cover a greater area with the same budget
- Use less pesticides



Control agencies

- EID Mediterranee (F)
- CAA (I)
- CMV (NL)



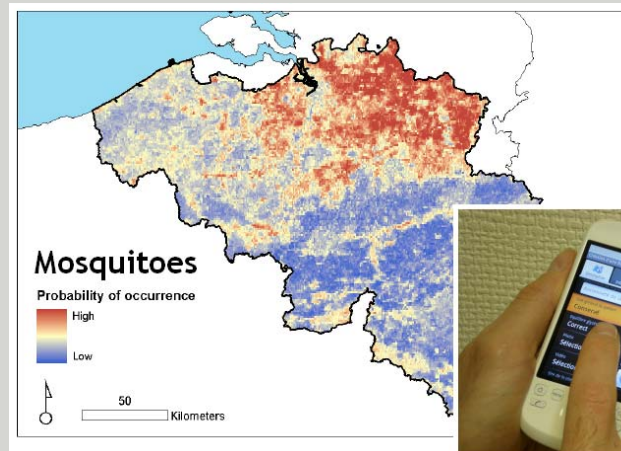


The use case

- **Cross-sectional baseline study**

Cross-sectional baseline study

- Extensive in-situ sampling (CO₂ traps)
- Randomly selected locations
- Taking into account land use distribution & seasonal effects
- Register location & conditions
- Collect field reports





The use case

- Cross-sectional baseline study
- Laboratory analysis

Laboratory analysis

- Species count
- Male/female
- LIMS reports



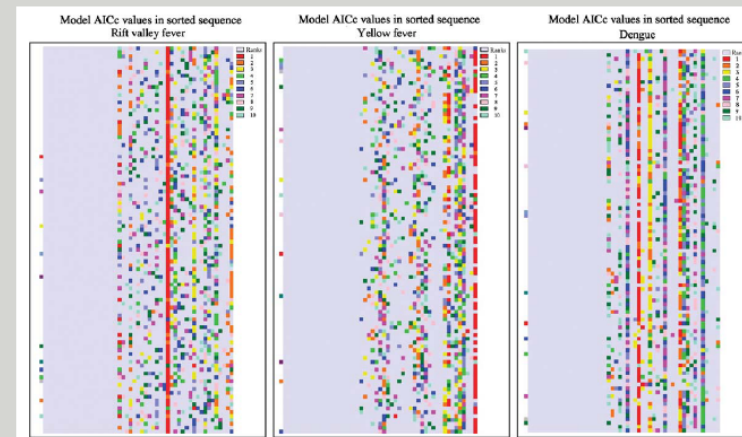


The use case

- Cross-sectional baseline study
- Laboratory analysis
- **Spatial modeling**

Spatial modeling

- Collect & resample spatial data (elevation, vegetation, temperature, demographics etc.)
- Fourier analysis (seasonal effects)
- Bootstrap in-situ datasets
- E.g. non-linear discriminant analysis
- Identify correlations with physical parameters

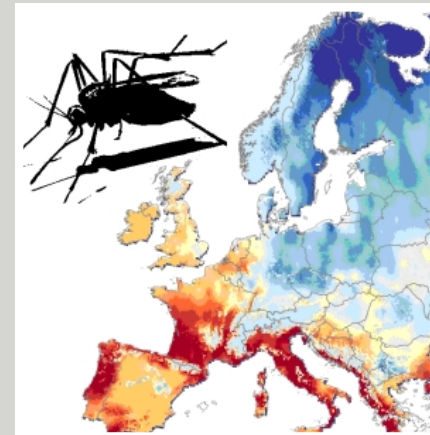


The use case

- Cross-sectional baseline study
- Laboratory analysis
- Spatial modeling
- **Risk maps**

Risk maps

- Suitability of environment
- For each stage of vector life cycle
- Available at 1 km and 30 m resolution
- Raster functions for trend and impact analysis





The use case

- Cross-sectional baseline study
- Laboratory analysis
- Spatial modeling
- Risk maps
- **Longitudinal study**

Longitudinal study

- Continued sampling in high-probability locations
- Register local conditions
- Collect field reports



The VEC MAP project



Data of Interest for Vector Mapping

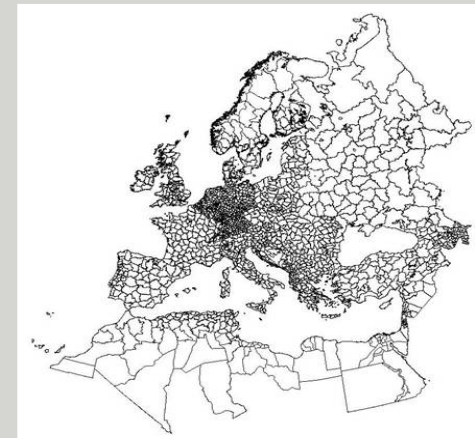
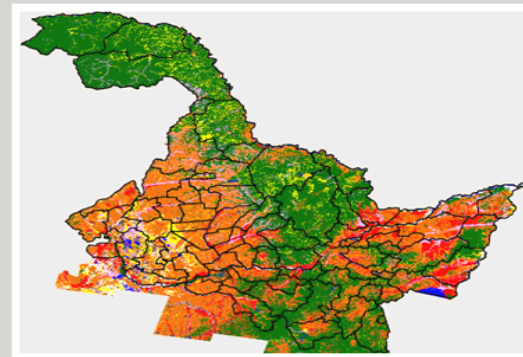


Data of Interest for Vector Mapping

- **Static data**

Static data

- Digital Terrain Maps (GTOPO30)
- Land use maps (GLC2000, Corine)
- Administrative regions (NUTS 1,2,3)



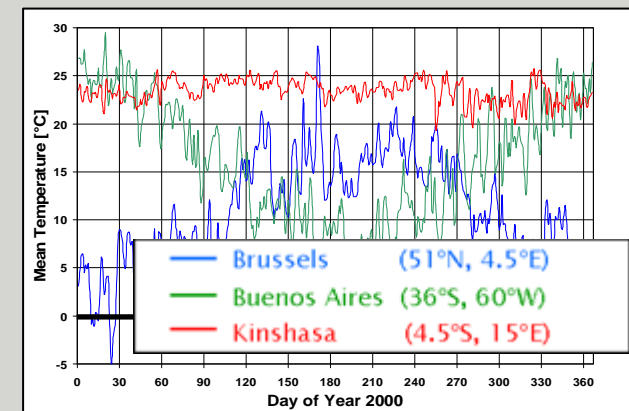


Data of Interest for Vector Mapping

- Static data
- **Meteo data from ground stations**

Meteo data from ground stations

- Daily AGROMET-data (Tmin, Tmax, Rad, Pluvio)
- Atmospheric data, water vapour etc.



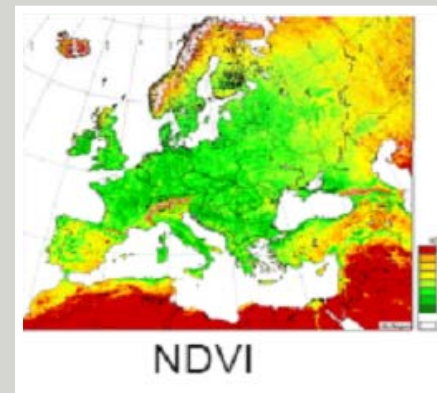


Data of Interest for Vector Mapping

- Static data
- Meteo data from ground stations
- **Satellite band combi's**

Satellite band combi's

- Proxy's from spectral band ratio's
- Normalised Difference Vegetation Index
- SAVI, NDWI
- Visual and Infrared
- Envisat, Terra/Aqua, Spot



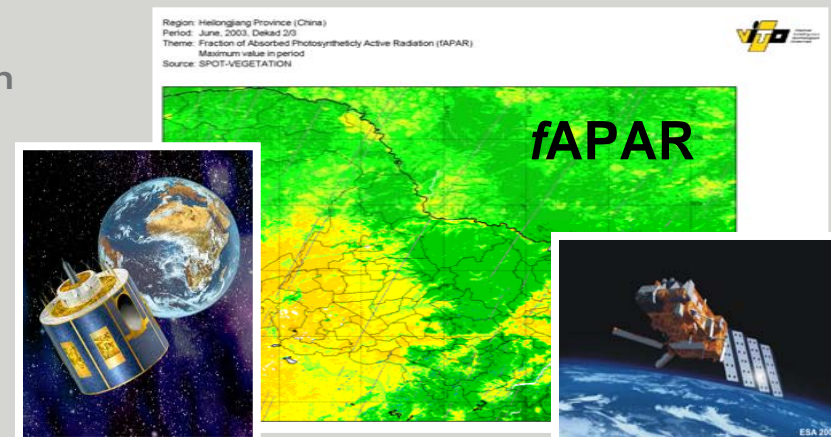


Data of Interest for Vector Mapping

- Static data
- Meteo data from ground stations
- Satellite band combi's
- **Satellite model-based data**

Satellite model-based data

- fAPAR Fraction of Absorbed Photosynthetically Active Radiation
- Dry Matter Productivity (DMP)
- Leaf Area Index (LAI)
- Evapotranspiration, Precipitation: VIR/TIR, MSG
- Land Surface Temperature (LST): TIR
Terra/Aqua, NOAA/METOP





Data of Interest for Vector Mapping

- Static data
- Meteo data from ground stations
- Satellite band combi's
- Satellite model-based data
- **Satellite navigation data**

Satellite navigation data

- Currently: GPS, 15 m
- Since 2008, EGNOS Augmentation: 5 m + integrity
- From 2013: Galileo: integrity + guarantee
- Galileo + GPS: increased availability (urban)

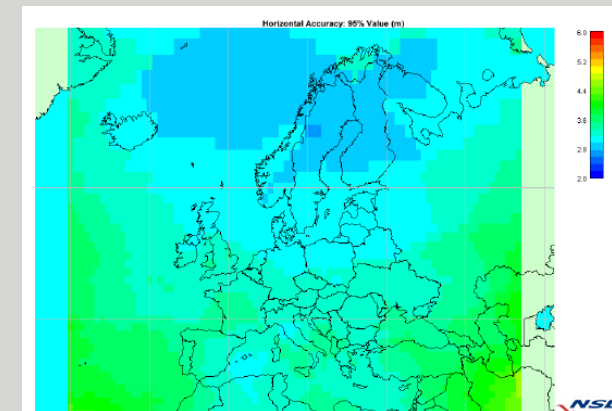


Figure 19 EGNOS performance



Consortium

- **Avia-GIS (B)**
 - Team leader & service provider
- **ERGO (UK)**
 - Geospatial modelling based on in-situ and Earth Observation data
- **MEDES (F)**
 - In-situ measurements and field reporting
- **EARS (NL) and VITO (B)**
 - Analysis of Earth Observation data
- **RIVM (NL)**
 - Key public health user



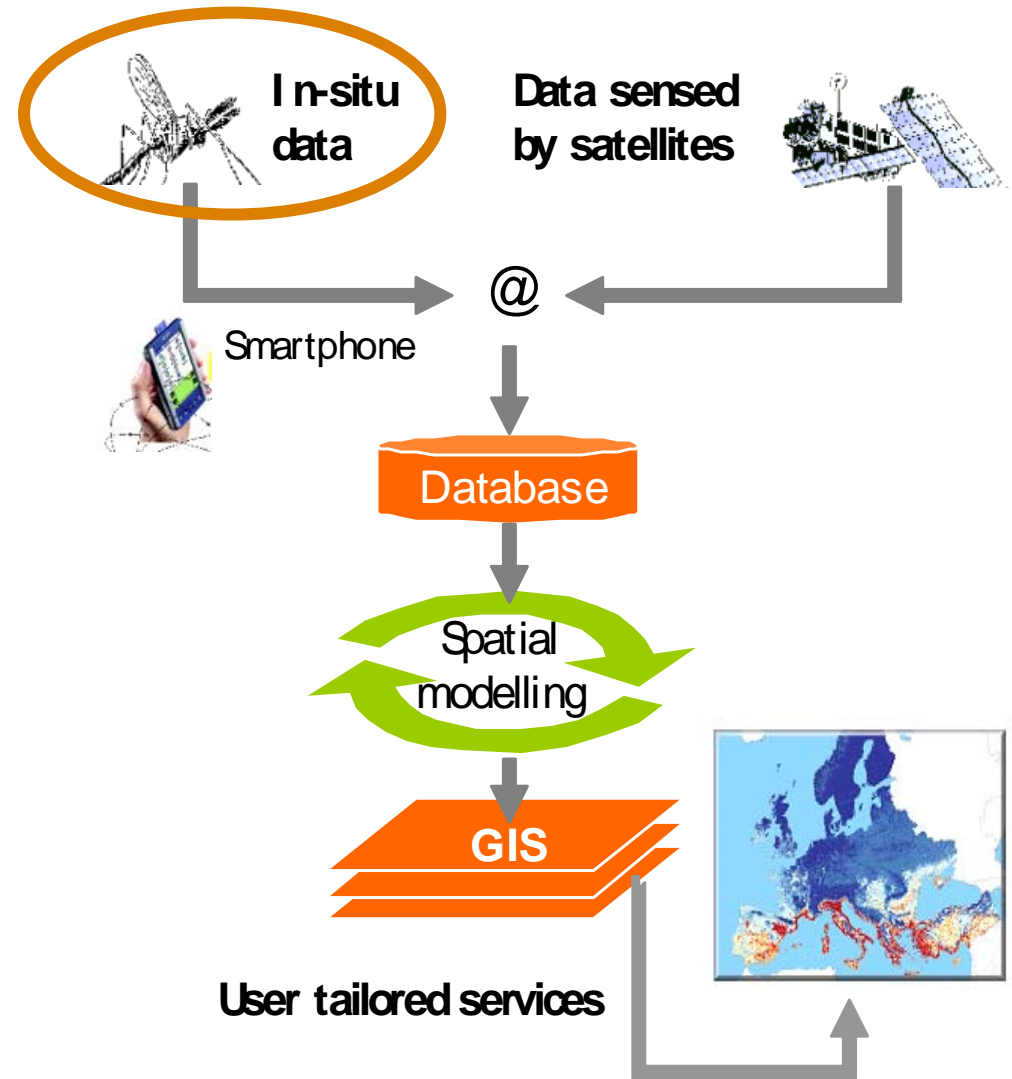
VECMAP team at EID user in Montpellier





VECMAP Services

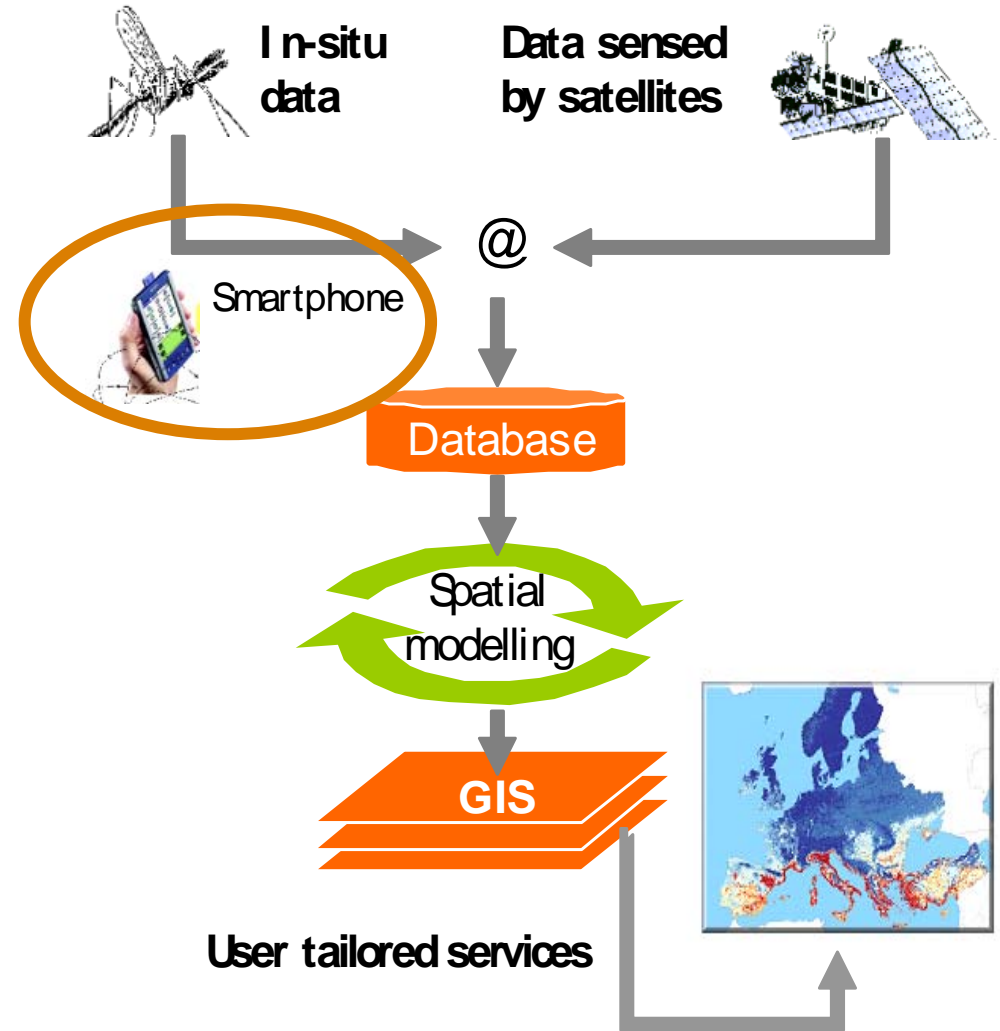
- Sampling strategy & routing service





VECMAP Services

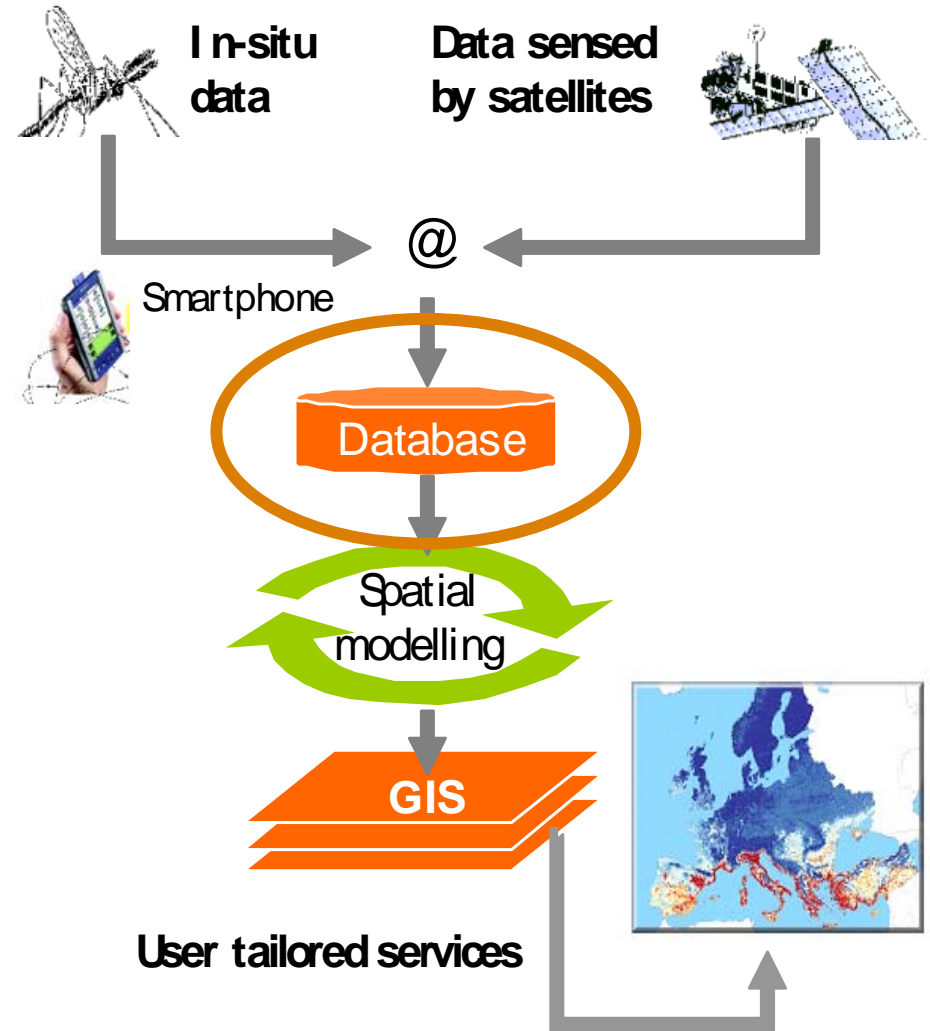
- Sampling strategy & routing service
- **Field-data synchronization with dBase incl. GNSS position**





VECMAP Services

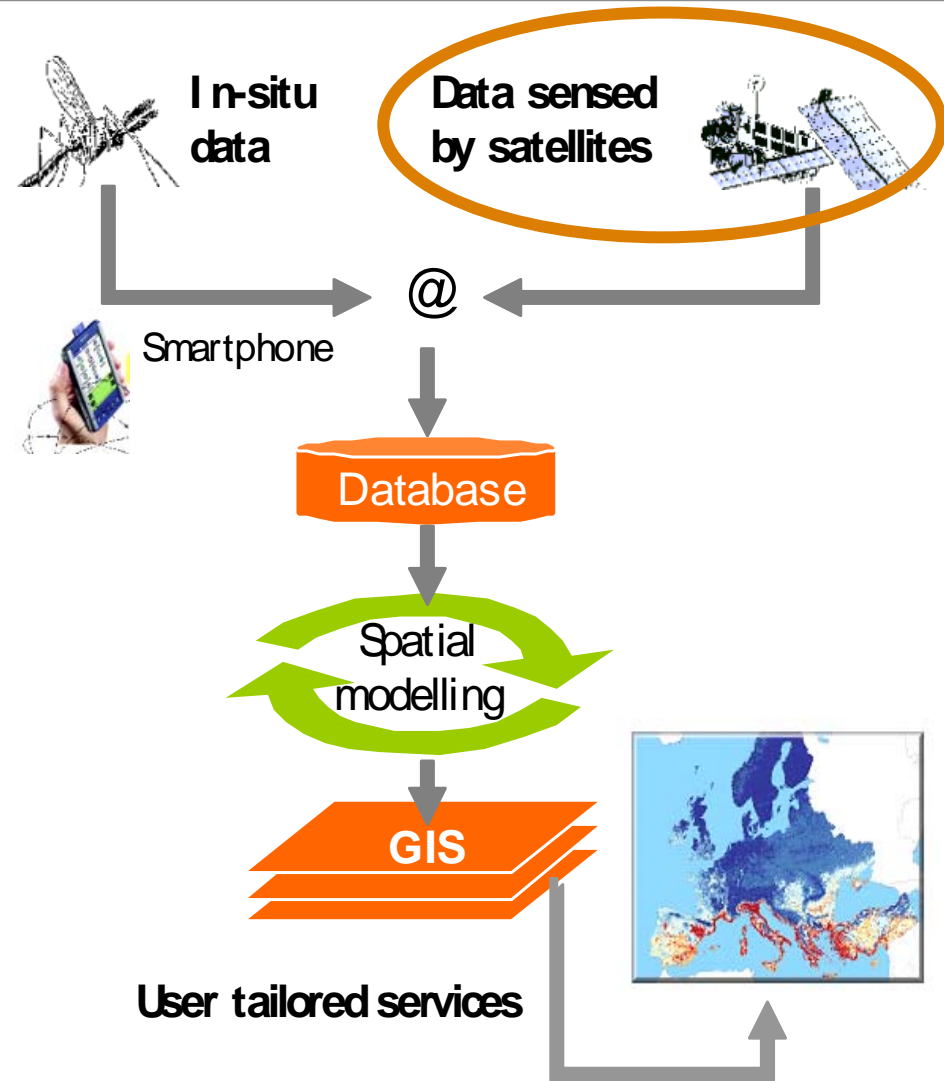
- Sampling strategy & routing service
- Field-data synchronization with dBase incl. GNSS position
- **Synchronization of laboratory data**





VECMAP Services

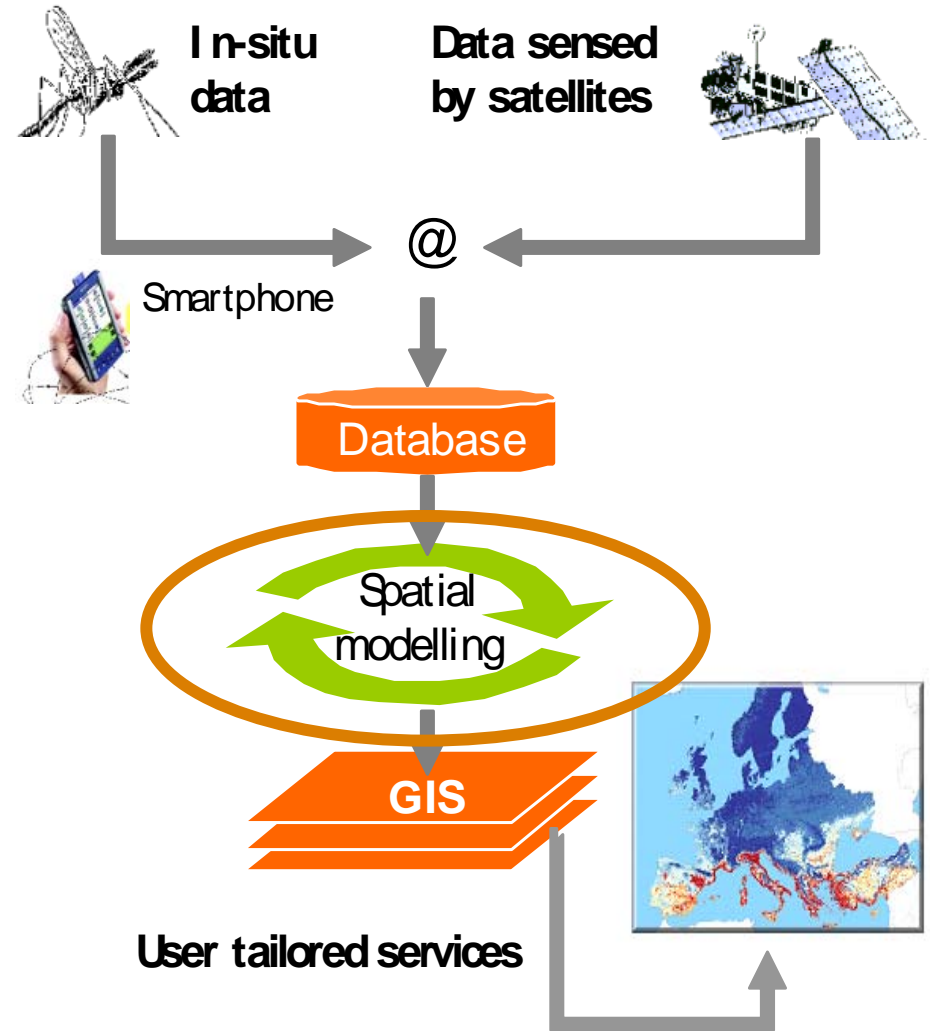
- Sampling strategy & routing service
- Field-data synchronization with dBase incl. GNSS position
- Synchronization of laboratory data
- **Continuous set of processed EO data**





VECMAP Services

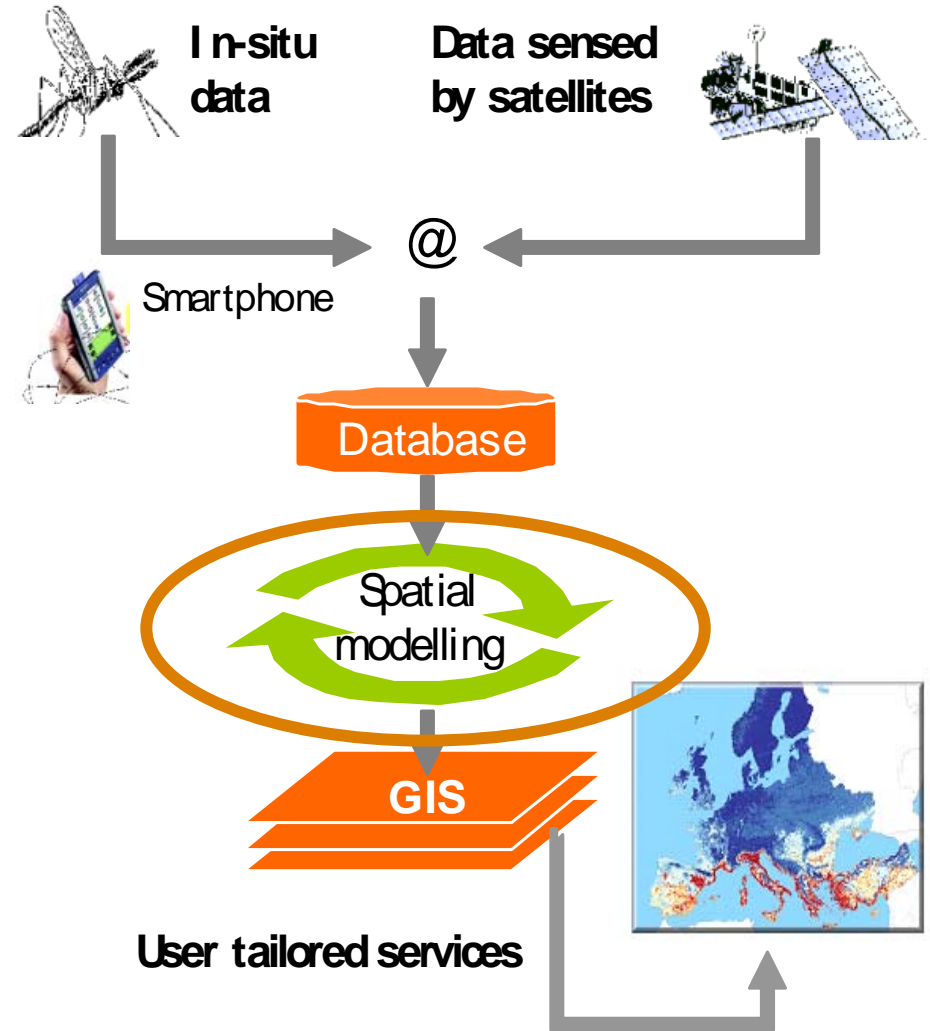
- Sampling strategy & routing service
- Field-data synchronization with dBase incl. GNSS position
- Synchronization of laboratory data
- Continuous set of processed EO data
- **Habitat suitability mapping service**





VECMAP Services

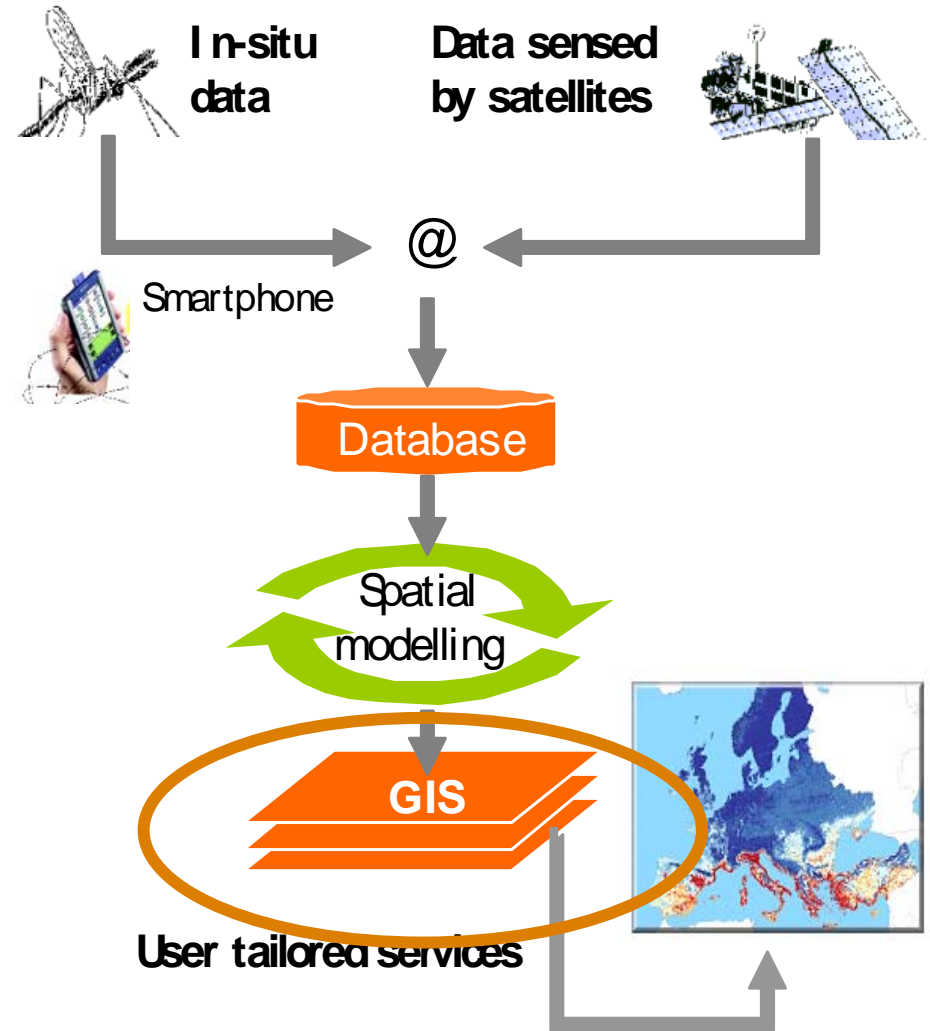
- Sampling strategy & routing service
- Field-data synchronization with dBase incl. GNSS position
- Synchronization of laboratory data
- Continuous set of processed EO data
- Habitat suitability mapping service
- **Landscape suitability mapping service**





VECMAP Services

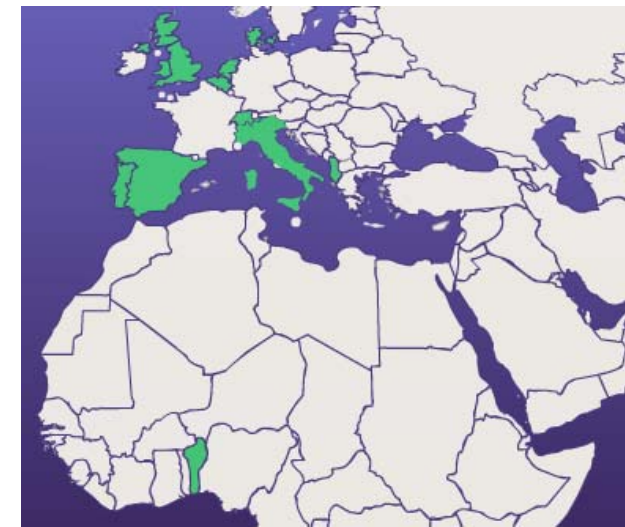
- Sampling strategy & routing service
- Field-data synchronization with dBase incl. GNSS position
- Synchronization of laboratory data
- Continuous set of processed EO data
- Habitat suitability mapping service
- Landscape suitability mapping service
- **GIS & raster functions by web interface**





VECMAP Demonstration Project (2011-2013)

- Following successful feasibility study and system demonstration
- Mosquitoes, ticks, midges, mammals
- Demo services in 12 countries



THANK YOU!

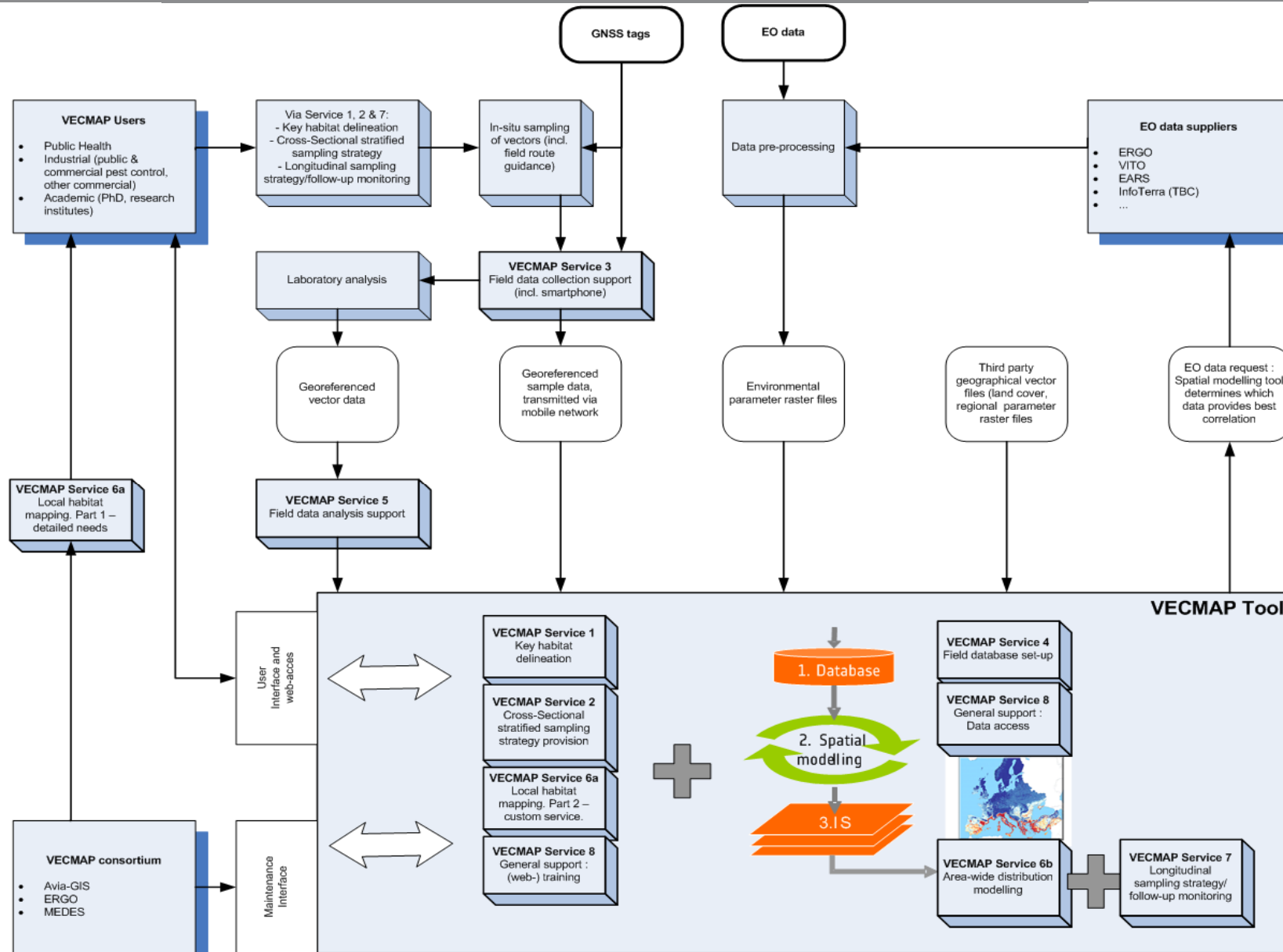
Michiel Kruijff

Michiel.Kruijff@esa.int

Integrated Applications Promotion

Satellite/Sensor	Environmental data time series	Spatial resolution	Time Series Period
METEOSAT SEVIRI	Precipitation	3km	2004 onwards
	Net Radiation	3km	2004 onwards
	Sensible Heat Flux	3km	2004 onwards
	Actual Evapotranspiration	3km	2004 onwards
	Relative Evapotranspiration	3km	2004 onwards
MODIS TERRA AQUA	Day-time Land Surface Temperature	1km	2001 onwards
	Night-time Land Surface Temperature	1km	2001 onwards
	Middle Infrared	1km	2001 onwards
	Normalised Difference Vegetation Index	1km	2001 onwards
	Enhanced Vegetation Index	1km	2001 onwards
SPOT-VGT	fAPAR	1km	1998 onwards
	Normalised Difference Vegetation Index	1km	1998 onwards
ENVISAT MERIS	fAPAR	1km	2003 onwards
	LAI	1km	2003 onwards
	fCOVER	1km	2003 onwards
	MTCI	1km	2003 onwards
	Normalised Difference Vegetation Index	1km	2003 onwards

Platform	NOAA	METOP	SPOT	TERRA	MSG
Country / Organisation	USA NOAA	ESA EuMetSat	France (Bel, Ital, Swe)	USA NASA	ESA EuMetSat
Launch date (YYYY/MM)	N17: 2002/06 N18: 2005/05	2006/10	SPOT4: 1998/03 SPOT5: 2002/05	1999/12	2002/08
Orbit	Near-Polar	Near-Polar	Near-Polar	Near-Polar	Geostationary
Equatorial Crossing time	N17: 10h24' N18: 13h55'	9h30'	10h30'	10h30'	NA
Sensor	AVHRR	AVHRR	VEGETATION	MODIS	SEVIRI
Swath (km)	2926	2926	2250	2330	12000
Glob. Cover in	1 day	1 day	1 day	1 day	15 minutes
Nadir pixel size (km)	1.1 (LAC) 4.4 (GAC)	1.1 (LAC) 4.4 (GAC)	1.15	1.00 (29 bands) 0.50 (5 bands) 0.25 (2 bands)	3.0
Spectral Bands	5	5	4	36	11
VIS: 0.40 – 0.75	1	1	2	11	1
NIR: 0.75 – 1.10	1	1	1	5	1
SIR: 1.10 – 3.00			1	4	1
MIR: 3.00 – 7.00	1	1		7	2
TIR: 7.00 - 14.00	2	2		9	6
Simultan. HiRes images	No	No	HRVIR (30/10m)	ASTER (15/30/90m)	No
Processing & Distribution	No centralized facilities	Local reception EuMetCast	CTIV-VITO	NASA	EuMetSat LandSAF

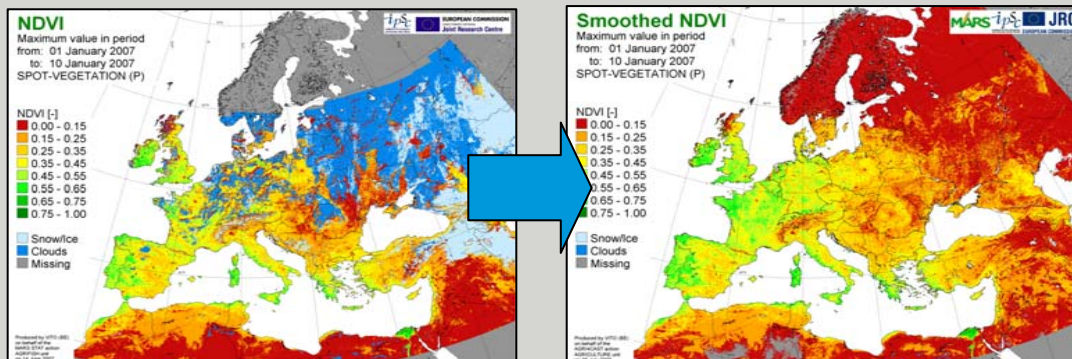




Data processing steps

1. Raw imagery
2. Georectification
3. Calibration (yielding physical parameters)
4. Atmospheric correction
5. Generate layers (NDVI, LST etc.)
6. Cloud cleaning
7. Standardization for VECMAP : Resampling, Framing, Fourier Analysis
8. Raster functions.

E.g. One year : extract phenologies, Multiyear : extract calamities, changes



Cloud cleaning



One year phenology

What space assets can bring you

Satellite navigation

- **GPS constellation**
 - 15 m, no integrity, no guarantee
- **SBAS/EGNOS**
 - Satellite based augmentation system
 - 5 m + integrity
- **Galileo**
 - European constellation (2013)
 - Integrity + guarantee of service
- **Galileo + GPS**
 - 2 m + improved availability



Figure 21 High Sensitivity GPS performance



Figure 22 High Sensitivity GPS + Galileo performance

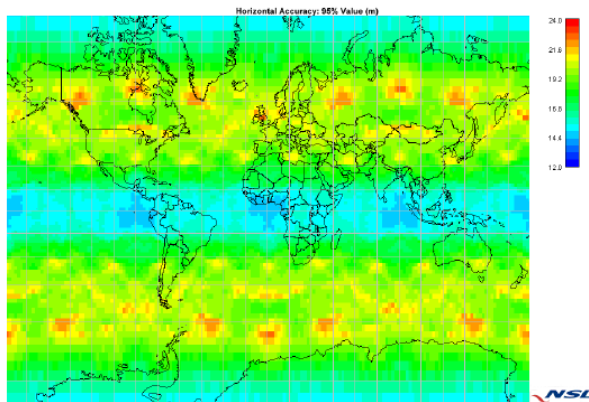


Figure 15 GPS performance

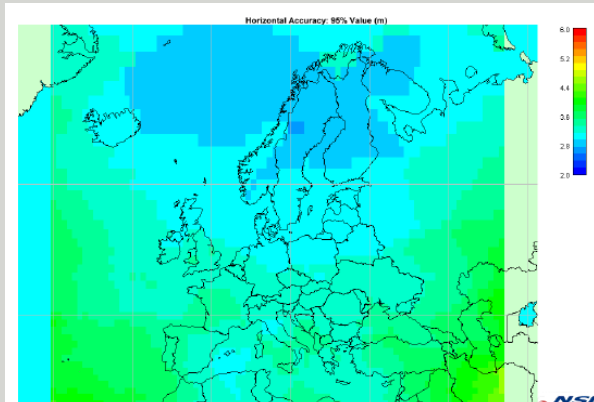


Figure 19 EGNOS performance

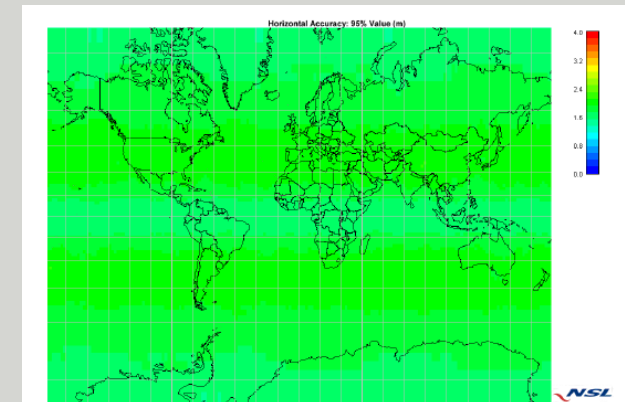


Figure 16 GPS + Galileo performance

What space assets can bring you



Satellite Communication

What space assets can bring you

Satellite Communication

- **Applications**
 - Remote locations
 - Infrastructure breakdown
 - Broadcasting



What space assets can bring you



Satellite Communication

- **Applications**
 - Remote locations
 - Infrastructure breakdown
 - Secure link
 - Broadcasting
- **Services**

Services

- Voice, data, video
- Messaging
- Broadband internet
- Broadcast



What space assets can bring you

Satellite Communication

- Applications
 - Remote locations
 - Infrastructure breakdown
 - Secure link
 - Broadcasting
- Services
- Typical systems
 - **VSAT**

VSAT (Very Small Aperture Terminal)

- Small dish antenna, ~1 m
- Eutelsat, Astra (geostationary)
- Broad band, Ku band, 0.5 MB/s
- Telephony, transactions, internet, maritime communications, video



What space assets can bring you



Satellite Communication

- **Applications**
 - Remote locations
 - Infrastructure breakdown
 - Broadcasting
 - Secure link
- **Services**
- **Typical systems**
 - VSAT
 - **BGAN**

BGAN (Broadband Global Aera Network)

- Portable terminals
- Internet modem
- Up to 400 Mbit/s
- E.g. Inmarsat



What space assets can bring you

Satellite Communication

- Applications
 - Remote locations
 - Infrastructure breakdown
 - Broadcasting
 - Secure link
- Services
- Typical systems
 - VSAT
 - BGAN
 - **Satellite phones & modems**

Satellite phones and modems

- Iridium (Low Earth Orbit constellation)
- Thuraya (Geostationary)
- Inmarsat (Geostationary)
- 1 to 144 kbit/s
- voice, data



What space assets can bring you



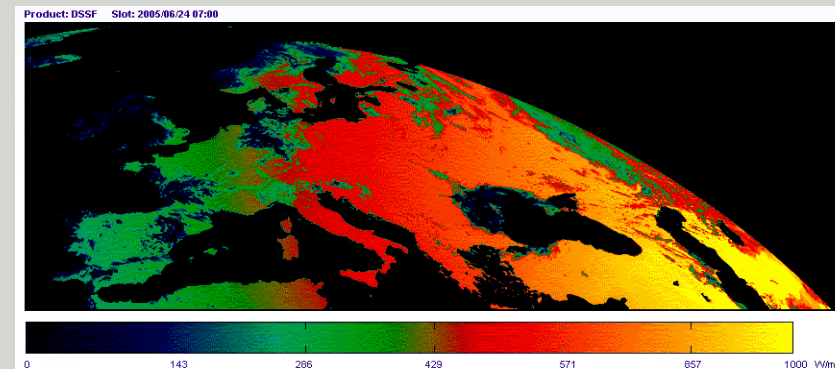
Earth Observation sensors

Earth Observation sensors

- **Geostationary passive sensors**

Geostationary passive sensors

- Altitude 36000 km, fixed position over Earth equator
- Each satellite covers about 1/3rd of Earth
- Visual/Infrared
- High temporal resolution (minutes/hours)
- Low spatial resolution (3-10 km)
- Meteosat/MSG, GOES

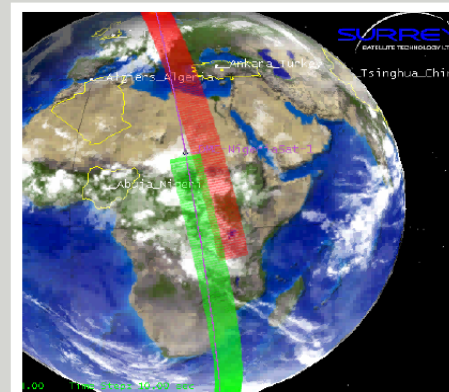


Earth Observation sensors

- Geostationary passive sensors
- Low Earth Orbit passive sensors

Low Earth Orbit passive sensors

- Altitude ~800 km, polar orbit
- Usually providing wide and narrow swath
- Visual/Infrared, L-band (moisture)
- Low temporal resolution (day(s))
- High spatial resolution (0.5 -1000 m)
- Envisat (MERIS), Aqua/Terra (Modis)
DMC, SPOT-VGT, METOP/NOAA (AVHRR)

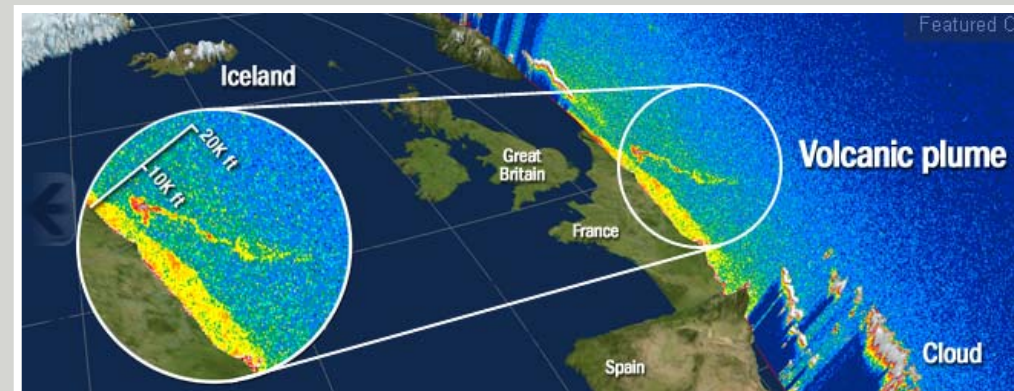


Earth Observation sensors

- Geostationary passive sensors
- Low Earth Orbit passive sensors
- **Low Earth Orbit active sensors**

Low Earth Orbit active sensors

- Altitude ~800 km, polar orbit
- Radar (X, C band), Lidar, Scatterometer
- Cloud penetration, sea wind, altimetry
- Resolution 1-1000 m
- Low temporal resolution (days/weeks)
- Envisat (ASAR), TerraSAR-X, CosmoSkyMed, Calipso



What space assets can bring you



Earth Observation data

Precipitation/Radiation/Flux

fAPAR, NDVI

Land Surface Temperature

Spatial Resolution	Temporal Resolution	Past	Present	Future

What space assets can bring you



Earth Observation data

Precipitation/Radiation/Flux

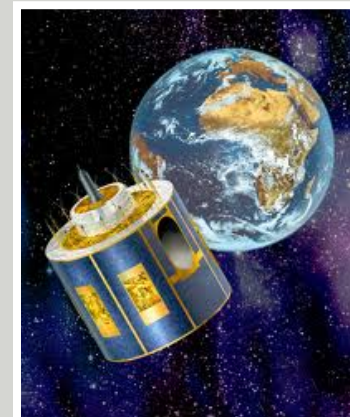
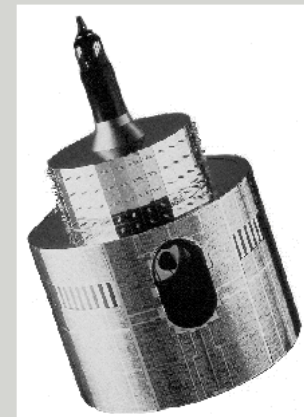
fAPAR, NDVI

Land Surface Temperature

Spatial Resolution	Temporal Resolution	Past	Present	Future
LOW	HIGH			

Precipitation/Radiation/Heat flux, Evapotranspiration

- Requires VIS, NIR and also (rare) Thermal IR
- High temporal resolution, to remove clouds -> GEO sats.
- 1977 : Meteosat (MVIRI)
- 2004 : Meteosat Second Generation (SEVIRI, 3 km)
- 2013 : Meteosat Third Generation (1 km)



What space assets can bring you



Earth Observation data

Precipitation/Radiation/Flux

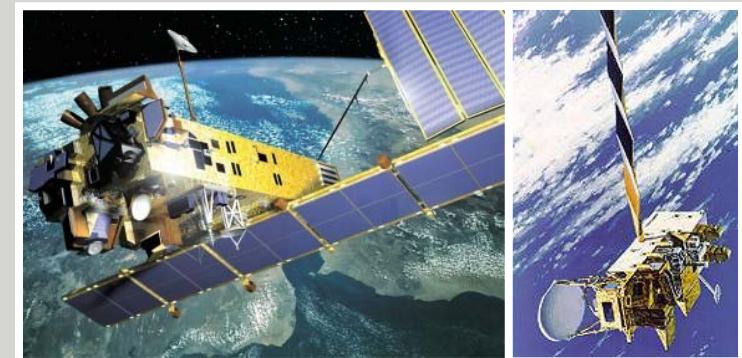
fAPAR, NDVI

Land Surface Temperature

Spatial Resolution	Temporal Resolution	Past	Present	Future
LOW	HIGH			
HIGH	LOW			

fAPAR, NDVI

- Requires only VIS & NIR
- High spatial resolution required (30 m – 1 km)
- Terra/Aqua (MODIS)
- SPOT (VGT)
- Envisat (MERIS, 250 m), until 2013
- Sentinel 3 (OLCI), after 2013



Earth Observation data

Precipitation/Radiation/Flux

fAPAR, NDVI

Land Surface Temperature

Spatial Resolution	Temporal Resolution	Past	Present	Future
LOW	HIGH			
HIGH	LOW			
HIGH	LOW			

Land Surface Temperature

- Requires Thermal IR, day and night data
- High spatial resolution
- Terra/Aqua (MODIS), may go out of operation
- Since 1981 : NOAA/METOP (AVHRR), at least until 2020



What space assets can bring you

Earth Observation data

Precipitation/Radiation/Flux

fAPAR, NDVI

Land Surface Temperature

Spatial Resolution	Temporal Resolution	Past	Present	Future
LOW	HIGH			
HIGH	LOW			
HIGH	LOW			

