European Hyperspectral Explorer: HYPEX-2

Monitoring anthropogenic influences in critical zones

PI Briottet Xavier

From critical zone .... to biodiversity

Critical interface from shallow water up to vegetation canopy where stands terrestrial life (@National Research Council, USA 2001)

Understanding the functioning of critical zones requires a multidisciplinary approach

Anthropogenic activity causes accelerating erosion of biodiversity

Main drivers contributing to this loss: invasions, pollution, resource (over-) utilization, climate, and land use (cf Millennium Ecosystem Assessment)

Pollution & mining  Habitat loss  Climate change  Coral bleaching  Urban sprawl

Image courtesy of R. Vevers, XL Catlin Seaview Survey
Knowledge and information gaps:
- Knowledge on spatial distribution of biodiversity
- Understanding of complex interaction between biodiversity, environment & human activities

Essential Biodiversity Variables (EBV) defined by GEO BON
Used to report and manage biodiversity changes at global scale, inform about species distribution, plant traits, community composition, ecosystem structure and function

Remote Sensing
Appropriate source of information for monitoring EBVs (Rose et al., 2013)
Biodiversity...from remote sensing

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Existing or scheduled space missions can contribute (Sentinel-2, Landsat, Hyperion, EnMAP) but no individual mission is combining:

• Imaging spectroscopy species discrimination, morphological and physiological traits, leaf chemistry
• High temporal revisit biodiversity monitoring, sources of degradation
• High spatial resolution fragmented & heterogeneous ecosystems, gradients of biodiversity
Objective: **fine-scale monitoring** of surface including natural and anthropogenized systems, in order to track the influence of environmental changes induced by human activity on the spatial and temporal evolution of **species assemblages**, including their traits and composition.

Four scientific questions:

SQ1 - How does **functional diversity of vegetation** respond to anthropogenic and climatic influence?

SQ2 - What is the biodiversity, water quality and bathymetry of selected shallow water test areas? How much anthropogenic activities impact **coastal and inland waters biodiversity**?

SQ3 - What is the **impact of management practices on environmental processes** such as soil infiltration, surface retention, runoff and erosion?

SQ4 - How do **urban materials and industrial pollution** impact on vulnerable surroundings?

**HYPEX-2 focuses on specific hot spots (fragmented / with a high gradient)**
SQ1 - How does vegetation functional diversity respond to anthropogenic influence?

Science Team: FERET J.-B.. (Irstea, Fr), JACQUEMOUD S. (IPGP, Fr), ASNER G. (Carnegie Institution for Science, USA), CHAVE J (CNRS, Fr), LUQUE S. (Irstea, Fr), LELONG C. (Cirad, Fr), ROCCHINI D. (University of Trento, It), SCHAEPMAN M. (Univ. of Zurich, Remote Sensing Laboratories, CH), SHEEREN D. (ENSAT, Fr), SANTOS M.-J. (Utrecht Univ., Nl), SKIDMORE A. (ITC, Nl), SOMERS B. (KULeuven, Be)

Main variables to be estimated: Taxonomic & functional diversity, spatial distribution of species assemblages, phenological metrics

- High spectral resolution: 10 nm in VIS-NIR-SWIR, → discrimination of canopy traits and individual species, leaf chemistry (pigments/water)
- High spatial resolution: < 10 m → Tree crown for dominant individuals, groups of individuals
- High temporal resolution: < 10 days → Seasonal and annual variations of vegetation properties (phenology, stress); change in species composition

Ecosystem types: Tropical forest, temperate forest, temperate grassland, alpine forest, savanna, cropland, tundra, shrub land and agriculture, urban vegetation

Additional variables: indicators of ecosystem functioning, assimilation product

Optimal detection of invasive species (Ustin & Gamon, 2008)

- 174 bands, 4m → $K = 0.7$
- 6 bands, 4m → $K = 0.3$

Coupling leaf, canopy and atmosphere models (Schaepman et al., RSE 2009)
Main variable to be estimated: Species identification, spatial distribution of species assemblages, monitoring

- High spectral resolution: 10 nm in VIS-NIR, → Species discrimination
- High spatial resolution: < 10 m → Spatial heterogeneity of sea floor composition and vegetation coverage (e.g. Marine Protected Area)
- High temporal resolution: < 10 days → Habitats monitoring: seasonal and annual cycles

Ecosystem types: shallow coral reef, seagrass meadow, estuaries, lake

Additional variables: Water composition, depth of shallow water
SQ3 - What is the impact of management practices on environmental processes such as soil infiltration, surface retention, runoff and erosion?

Science Team: GOMEZ C. (IRD, Fr), CHABRILLAT S. (GFZ, Ge), SCHMID T. (CIEMAT, Sp), STENBERG B. (Swedish Univ. of Agricultural Sciences, Sw), MARION R. (CEA, Fr), CARRERE V. (LPGN, Fr), E. VAUDOUR(AgroParisTech, Fr)

Main variables to be estimated: top soil properties (Clay, soil organic carbon, CaCO₃, iron), dry vegetation coverage, soil moisture

- High spectral resolution: 10 nm in VIS-NIR-SWIR, Texture, mineralogy,
- High spatial resolution: < 10 m
→ Dry vegetation coverage, soil properties
- High temporal resolution: < 10 days
→ Humidity, vegetation coverage

Ecosystem types: arid and semi-arid environment, natural areas and agricultural fields

Additional variables: mineralogy for exploration and resources mapping, mining and industrial waste pollution

Gomez et al., 2012

Clay map

SOC map

Selige et al., 2008

Marion et al., 2016
SQ4 - How do urban materials and industrial pollution impact on vulnerable surrounding?

Science Team: GAMBA P. (Univ. of Pavia, It), WEBER C. (CNRS, Univ. of Strasbourg, Fr), SHIMONI M. (RMA, Be), BRIOTTET X. (ONERA, Fr), MARION R. (CEA, Fr), FOUCHER P.-Y. (ONERA, Fr)

Main variable to be estimated: Surface material composition (biological and artificial materials) and abundances.

- High spectral resolution: 10 nm in VIS-NIR-SWIR, Soil properties discrimination, species group
- High spatial resolution: 5-10 m → Geometric discrimination of man-made materials
- High temporal resolution: < 10 days → Urban sprawl, urban vegetation monitoring

Ecosystem types: urban/rural gradient, industrial brownfields

Additional variables: gases/aerosols of industrial plants, urban local climate zone, litter/debris mapping (such as HC-bearing plastics)
### HYPEX-2 Main Characteristics

| **Satellite** | **Mass:** ~400 kg  
**Helio-synchronous orbit:** 500km |
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<td><strong>Launch compatibility</strong></td>
<td><strong>Vega</strong></td>
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<td><strong>Payload</strong></td>
<td><strong>Mass:</strong> 70-100 kg / <strong>Power:</strong> 150W</td>
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| **Spectral channel** | **GSD:** 8 m / **Swath:** 8 km / **typical SNR VIS:** > 250, **NIR:** > 200, **SWIR:** > 100  
**Spectral resolution / spectral range:** <14 nm / 0.4 – 2.5 µm |
| **Panchromatic channel** | **GSD:** about 2 m / **Swath:** 8 km |
| **Revisit period (±60° in latitude)** | ± 20° across-track imaging: 5 days  
**Global coverage** |
| **Accessibility** | **Permanent acquisition over ~100 hot spot areas** |
| **Link to Ground** | **X-Band link at 160 Mbps (with ground or mobile stations)** |
| **Lifetime** | **3 to 5 years** |

**TRL > 5**  
**Estimated cost:** ~ 150 Meuros  
**On going studies with TAS, ADS**  
**Supported by CNES**
HYPEX-2 science questions

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THANK YOU FOR YOUR ATTENTION