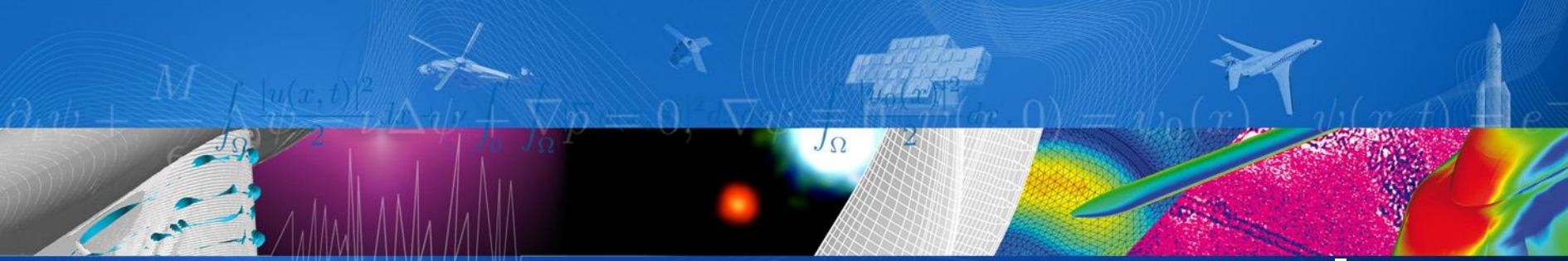
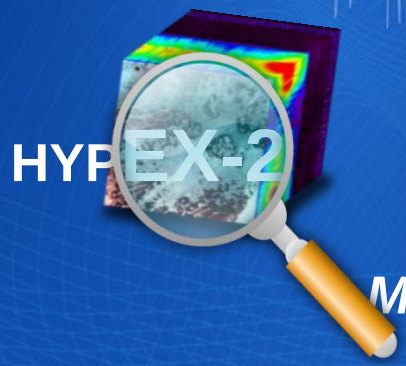


European Hyperspectral Explorer: HYPEX-2



Monitoring anthropogenic influences in critical zones

PI Briottet Xavier

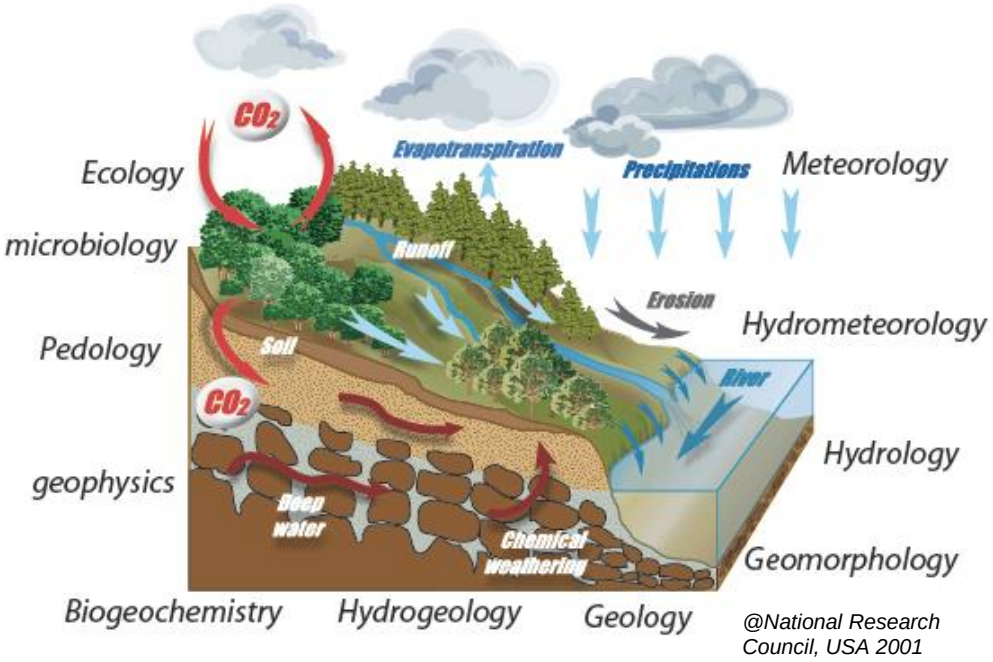
ASNER G. (Carnegie Institution for Science, USA, SQ1), BAJJOUK T. (IFREMER, France, SQ3), CARRERE V. (Univ. of Nantes, France, SQ2-4), CHABRILLAT S. (GFZ, Germany, SQ2), CHAMI M. (Univ. Pierre et Marie Curie, France, SQ3), CHANUSSOT J., (GIPSA-Lab, Fr), DEKKER A. (Univ. of Queensland, Australia, SQ3), DELACOURT C. (Univ. of Bretagne Occidentale, France, SQ3), FERET J.-B. (Irstea, France, SQ1), FOUCHER P.-Y. (ONERA, France, SQ4), SANTOS M. J. (Utrecht Uni., Nl), GAMBA P. (Univ. of Pavia, Italy, SQ4), GEGE P. (DLR, Germany, SQ3-4), GOMEZ C. (IRD, France, SQ2), JACQUEMOUD S. (Univ. Paris Diderot, France, SQ1-2), LEFEVRE M.J. (CNES), LELONG C. (Cirad, France, SQ1), LOPEZ S. (Univ. of Las Palmas de Gran Canaria, Spain) , MARION R. (CEA, France, SQ2-4), McKEE D. (Univ. of Strathclyde, Scotland, SQ3), MINGHELLI A. (Univ. of Toulon, France, SQ3), ROCCHINI D. (University of Trento, Italy, SQ1), SANTOS M.-J. (Utrecht Univ., Netherlands, SQ1), SCHAEPMAN M. (Univ. of Zurich, Switzerland, SQ1), SCHMID T. (CIEMAT, Spain, SQ2), SHEEREN D. (ENSAT, France, SQ1), SHIMONI M. (RMA, Belgium, SQ4), SKIDMORE A. (ITC, Netherlands, SQ1), SOMERS B. (KU Leuven, Belgium, SQ1), STENBERG B. (Swedish Univ. of Agricultural Sciences, Sweden, SQ2), E. Vaudour (AgroParitech, Fr), WEBER C. (TETIS, France, SQ4)

ONERA

THE FRENCH AEROSPACE LAB

return on innovation

From critical zone …. to biodiversity



@National Research Council, USA 2001

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

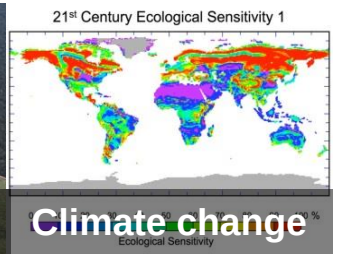
Understanding the functioning of critical zones requires a **multidisciplinary approach**

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)

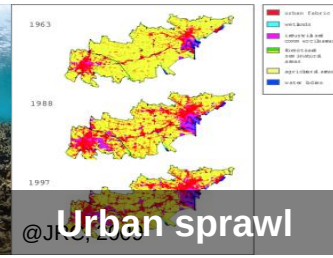

Pollution & mining


Habitat loss



Climate change

Coral bleaching



Urban sprawl

@JHC, 2015

image courtesy of R. Vevers, XL Catlin Seaview Survey

Biodiversity…from remote sensing

Knowledge and information gaps:

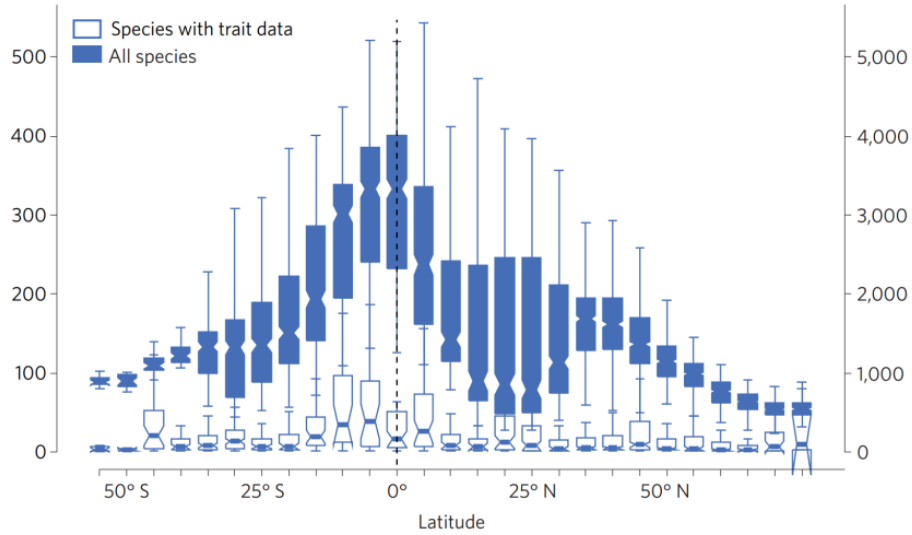
- Knowledge on spatial distribution of biodiversity
- Understanding of complex interaction between biodiversity, environment & human activities

Essential Biodiversity Variables (EBV) defined by GEO BON

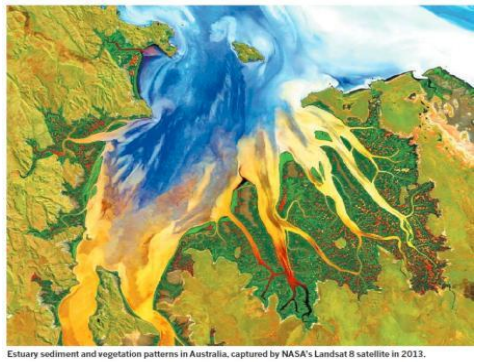
Used to report and manage biodiversity changes at global scale, inform about species distribution, plant traits, community composition, ecosystem structure and function

Remote Sensing

Appropriate source of information for monitoring EBVs (Rose et al., 2013)



Jetz et al. (2016) "Monitoring plant functional diversity from space" Nature Plants



Estuary sediment and vegetation patterns in Australia, captured by NASA's Landsat 8 satellite in 2013.

Agree on biodiversity metrics to track from space

Ecologists and space agencies must forge a global monitoring strategy, say **Andrew K. Skidmore, Nathalie Pettorelli** and colleagues.

Skidmore *et al.*, *Nature*, 2015.

Biodiversity…from remote sensing

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

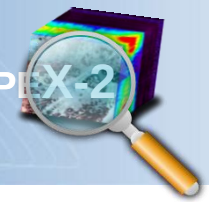
Remote Sensing

Appropriate source of information for monitoring EBVs (Rose et al., 2013)

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**

….HYPEX-2 answer



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**?

Main drivers for mission specifications

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

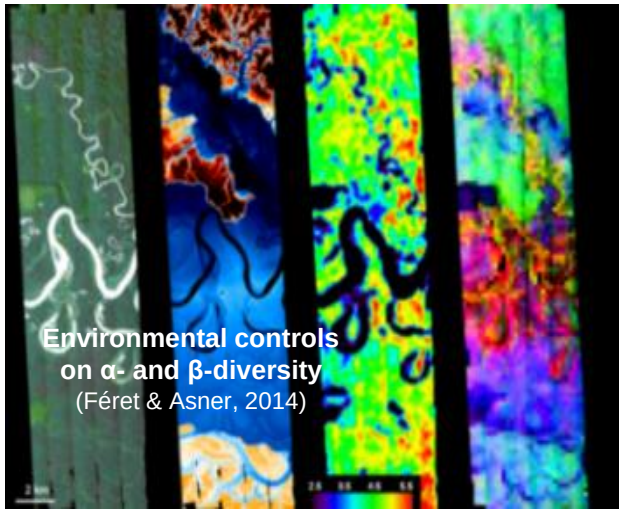
SQ4 - How do **urban materials and industrial pollution** impact on vulnerable surroundings?

HYPEX-2 only focuses on specific hot spots (fragmented / with a high gradient)

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

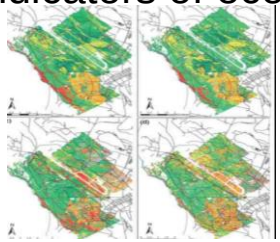
Ecosystem types: Tropical forest, temperate forest, temperate grassland, alpine forest, savanna, cropland, tundra, shrub land and agriculture, urban vegetation

Additional variables: indicators of ecosystem functioning, assimilation product

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

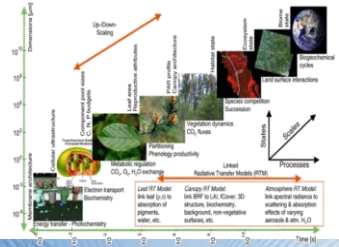
174 bands, 4m
→ K = 0,7

6 bands, 4m
→ K = 0,3



174 bands, 30m
→ K = 0,5

6 bands, 30m
→ K = 0,3

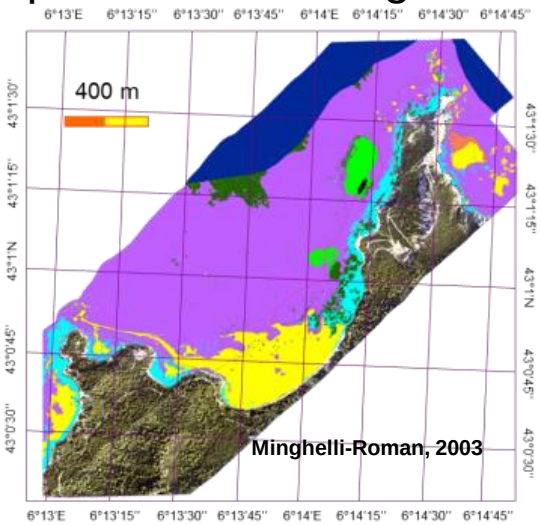


Coupling leaf, canopy and atmosphere models (Schaepman et al., RSE 2009)

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

Science Team: DELACOURT C. (Institut Universitaire Européen de la Mer Univ. Brest, Fr), CHAMI M. (Laboratoire d'Océanographie de Villefranche, Fr), McKEE D. (Univ. of Strathclyde, Sc), BAJJOUK T. (IFREMER, Fr), GEGE P. (DLR, Ge), MINGHELLI A. (LSIS, Univ. Toulon, Fr), A. DEKKER (CSIRO, Au)

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)

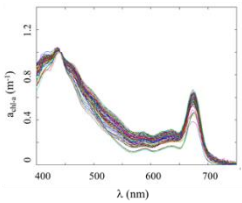
- High temporal resolution: < 10 days

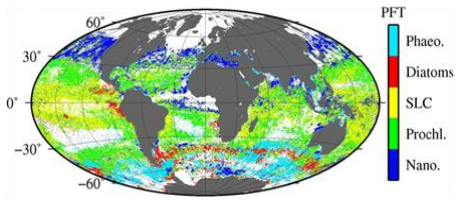
→Habitats monitoring: seasonal and annual cycles

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

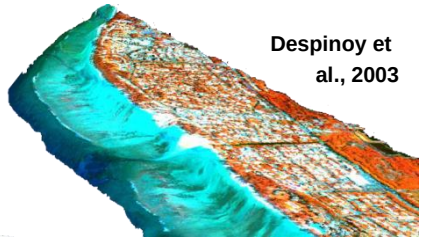
Additional variables: Water composition, depth of shallow water

Database of MERIS reference spectra, ESA





Alvain et al. (2008)

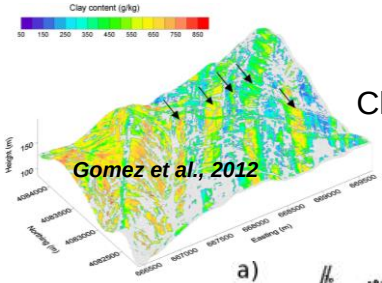


Despinoy et al., 2003

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, $CaCO_3$, iron), dry vegetation coverage, soil moisture



Clay map

SOC map

- High spectral resolution: 10 nm in VIS-NIR-SWIR, Texture, mineralogy,
- High spatial resolution: < 10 m

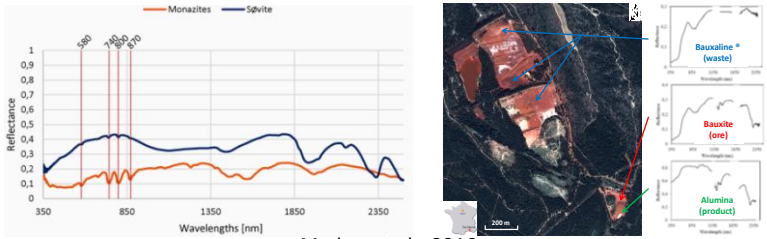
→Dry vegetation coverage, soil properties

- 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



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.

(a) (b)

- High spectral resolution: 10 nm in VIS-NIR-SWIR,
  Soil properties discrimination, species group
- High spatial resolution: 5-10 m

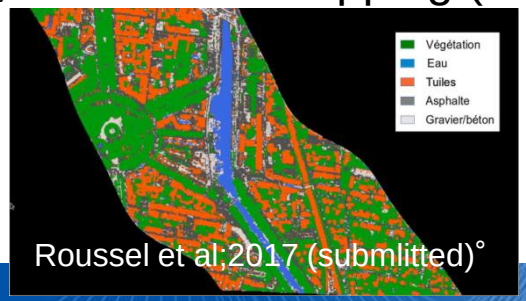
→ Geometric discrimination of man-made materials

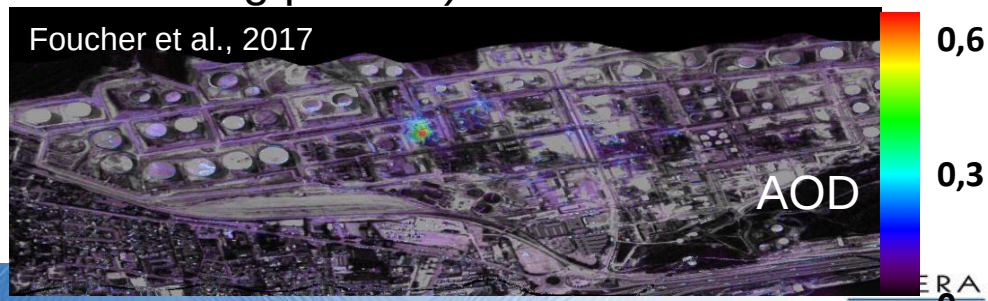
- High temporal resolution: < 10 days

→ Urban sprawl, urban vegetation monitoring

Ecosystem types: urban/rural gradient, industrial brownfields

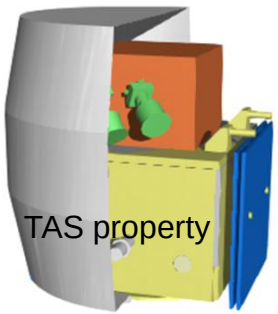
Additional variables: gases/aerosols of industrial plants, urban local climate zone, litter/debris mapping (such as HC-bearing plastics)





HYPEX-2 Main Characteristics

Satellite	Mass: ~400 kg Helio-synchronous orbit: 500km
Launch compatibility	Vega
Payload	Mass: 70-100 kg / Power: 150W
Spectral channel **Spectral resolution / spectral range**	GSD: 8 m / Swath: 8 km / typical SNR VIS > 250, NIR > 200, SWIR > 100 <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

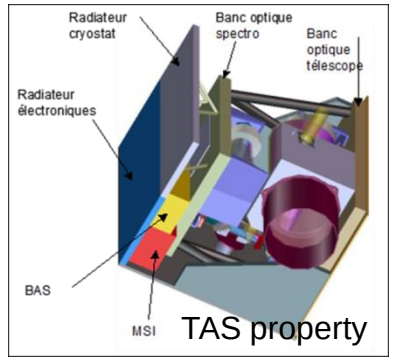

TAS property

TRL > 5

Estimated cost: ~ 150 Meuros

On going studies with TAS, ADS

Supported by CNES



TAS property

HYPEX-2 science 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**?

THANK YOU FOR YOUR ATTENTION

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?