Space Observations for Agriculture and Food Support

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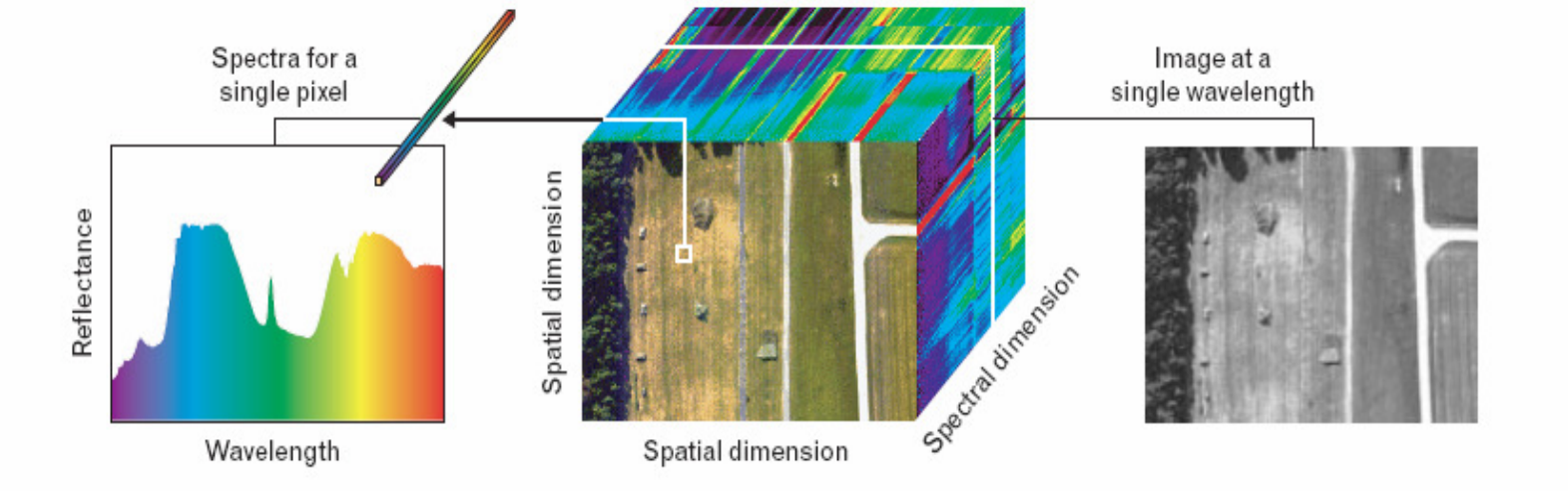
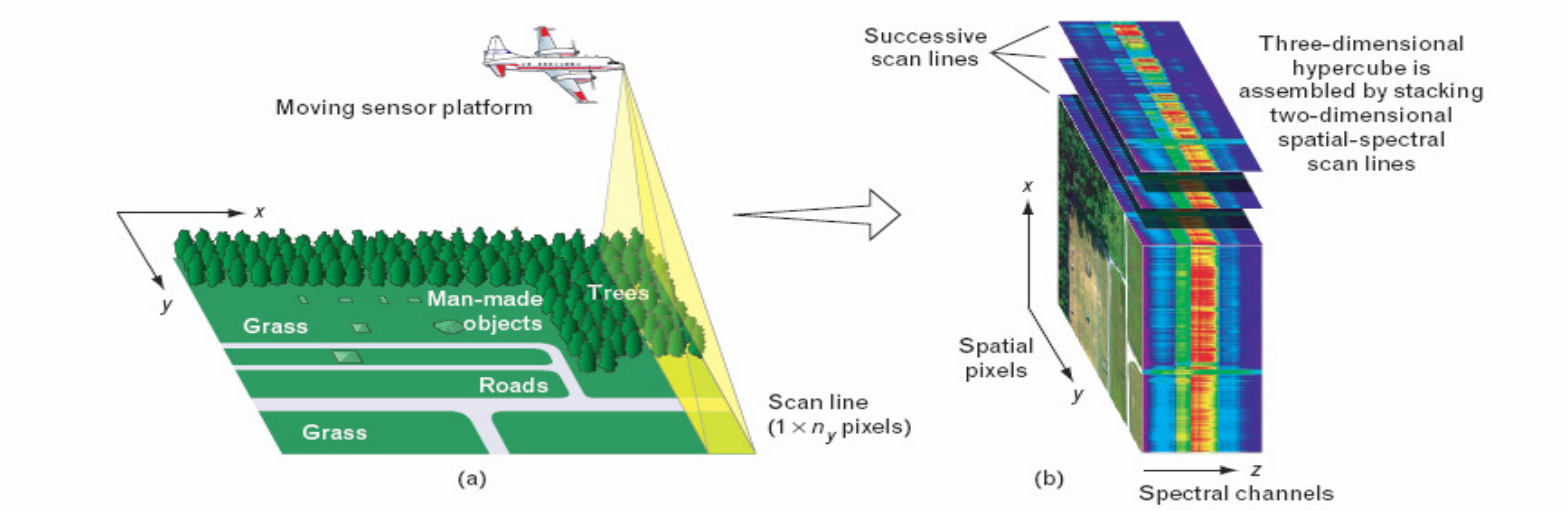
Hyperspectral

- The Earth System is a complex Physical Structure
- To understand it more and more sophisticated sensors with better spatial, temporal, radiometric and spectral resolution are required.
- The imaging spectroscopy is a very powerful tool suitable for this purpose. This technique provides not only the geometrical information but also the spectral information of the scenario under observation (i.e. chemical and physical properties).



Hyperspectral

- A complete knowledge of the “spectral signature” of a pixel in many cases can be more useful than the knowledge of its very detailed geometrical property.
- Typical tools able to perform imaging spectroscopy are the Hyper-Spectral instruments installed aboard satellites or aircrafts
- The advantage of a hyper-spectral over broad-band sensors (Landsat Thematic Mapper , SPOT etc.) is its fine spectral resolution and the contiguity and continuity of the spectral channels.

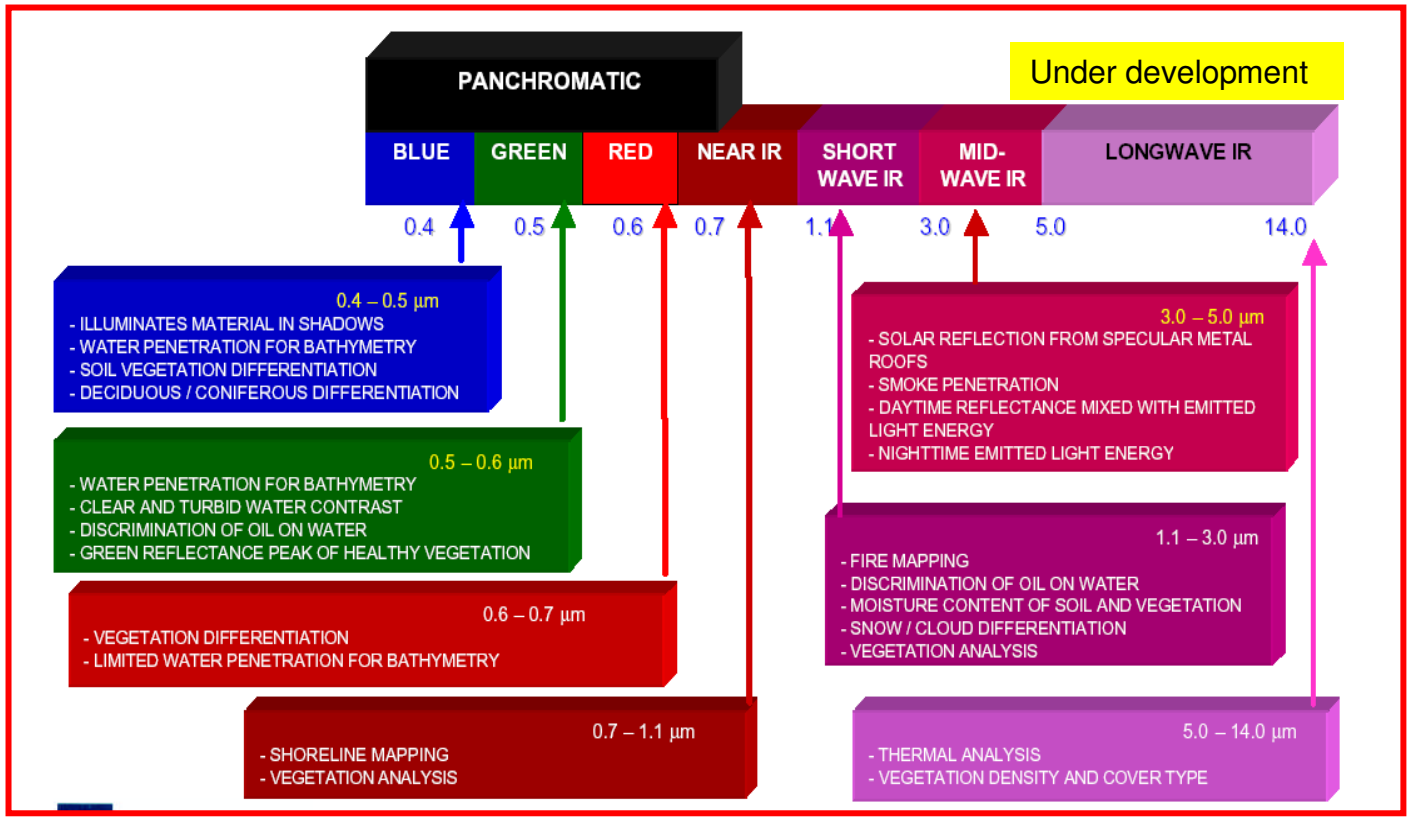


Hyperspectral

The high spectral resolution allows the detection of the physical and chemical properties of the surface materials, their abundances, as well as inferences of biological and chemical processes.

The spectral capability of this kind of instruments allows to address national/regional issues on sustainability and environment by means of numerous applications .

So far hyper-spectral instruments cover the range 0.4-2,5 microns



Hyper-spectral Applications for Renewable Resources

Parameters	Specific Applications
Relative abundance of species Leaf water content Leaf area index (LAI) Leaf chlorophyll content FAPAR (Fraction of Active Photosint.Radiation) NPP (Net Primary Production) Red edge spectral position	Land cover mapping Flood & drought monitoring, Soil quality and erosion, Precision Farming, Crop stress mitigation , Crop productivity, Agro-Environmental health monitoring and forecasting Wetlands and substrate mapping Land degradation Desertification Forestry management, Precision forestry,

Hyper-spectral applications for renewable resources

- Land cover discrimination improvement,

  at hierarchical level on urban, agronomic and natural levels, at regional scale (national agronomic data bases, e.g LPIS- Land Parcel Identification Systems by Agriculture Agencies)

- Agro-environmental analysis support and bio-diversity indicators extraction,

  also considering the new agro policies to maintain and valorise natural and semi-natural landscape features (agro-environment layers Research Institutes, Rural Development addressing and funding by local authorities)

- Inland water conditions monitoring

  for irrigation/aquaculture and carbon stock sink classification (agronomic agencies, national authorities, International Organizations)

- Agronomic vegetation/crops stress and growing rates detection

  monitoring and analysis support (Research and innovation Departments)

- Forestry health status detection and monitoring

  both in countryside and in urban areas (timber production estimation, forestry management in protected areas, Enterprises, Forestry Guards and services, Municipalities)

Hyperspectral Activity in Italy

Space missions of the Italian Space Agency (ASI)

- PRISMA
- SHALOM (in co-operation with Israel)

Aircraft instruments of AGEA/TELAER

- SIMGA

telaer
Consorzio Telespazio - Selex Galileo
per il telerilevamento aereo avanzato

PRISMA

PRecursore IperSpettrale della Missione Applicativa

- Program Highlights:

  National program

  Fully funded by ASI

  B2/C/D/E1 contract running

- Mission Objectives:

  Pre-operational and technology demonstrator

  Focus on

  - Space qualification of Hyperspectral (HYP) and panchromatic (PAN) payloads
  - Development and production of PAN/HYP products/ applications

- Expected Launch date: end of 2013

Main Applications:

Vegetation monitoring

Geological mapping

Agricultural diagnostics, agricultural indicators

Land cover maps and crop inventories

Urban and functional areas mapping and monitoring

Coastal and inland productivity assessment of aquatic ecosystems

Monitoring of carbon sources and sinks on land (Kyoto Protocol)

Land surface hydrology and water management,

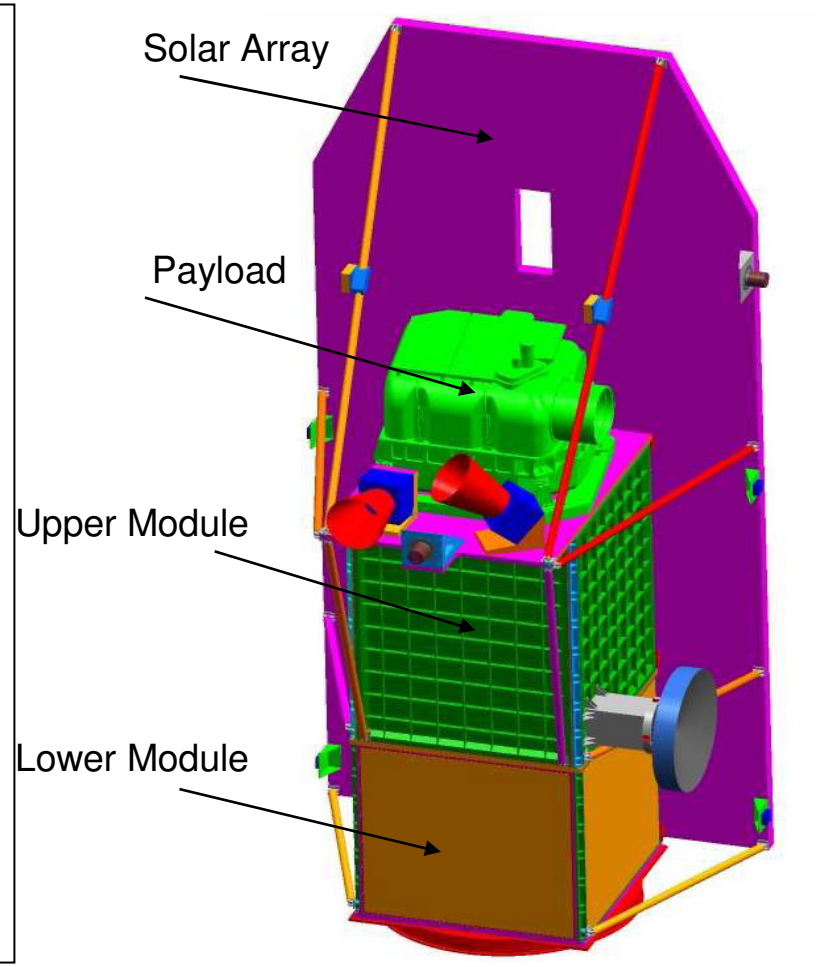
Risk Management Support (fires, landslides, volcanic and seismic hazard).

Atmosphere characterization

PRISMA

- Orbit and lifetime:
  - LEO SSO, 620km, 10.30 LTDN
  - 5 years lifetime
- Coverage:
  - World-wide
- System Latencies

  (inside the Area of Interest):
  - Re-look time < 7 days,
  - Response time < 14 days
- The Satellite
  - Mass: ≈600kg
  - Power: (generated) ≈1000 W



SHALOM

SHALOM is a cooperation between the Italian Space Agency ASI and the Israeli Space Agency ISA based on a satellite carrying a Hyper-spectral Imaging Spectrometer (0,4-2.5 microns), an advanced PRISMA type, and a satellite carrying an infrared camera (8-12 microns).

Panchromatic

- Swath: 30 km
- Spatial GSD: <2.5 m
- Spectral ranges: 400-700 nm
- SNR = 240

Hyperspectral

- Swath: 30 km
- Spatial GSD: <\0 m
- Spectral ranges (contiguous spectrum):
  - VNIR: 400-1010 nm
  - SWIR: 920-2500 nm
- Spectral resolution: 10 nm
- SNR

  VNIR: 200 (400-1000 nm)
  600 (@650nm)

  SWIR: 200 (1000-1750 nm)
  400 (@1550nm)
  100 (1950-2350 nm)
  200 (@2100nm)

telaer
Consorzio Telespazio - Selex Galileo
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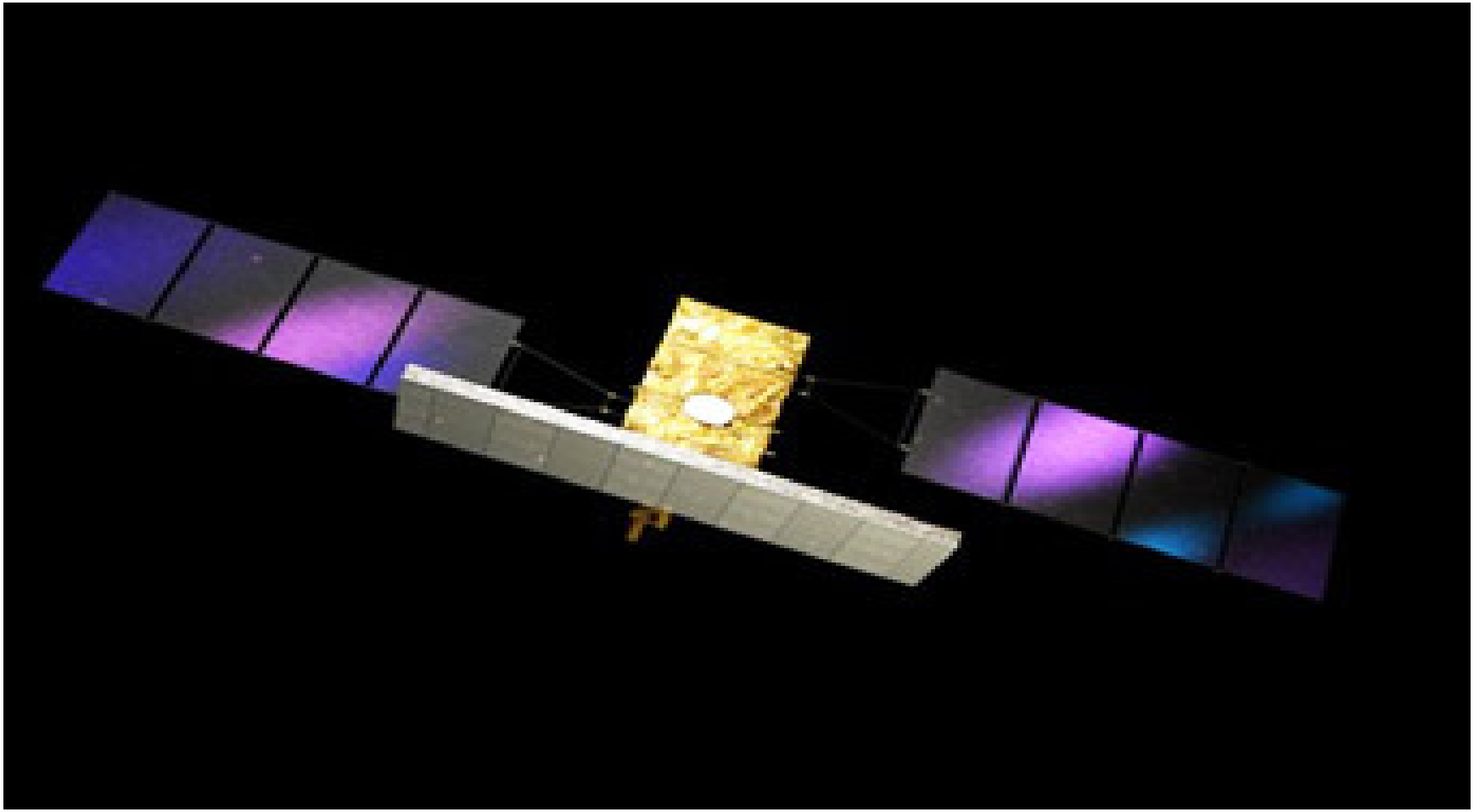
SIM_GA

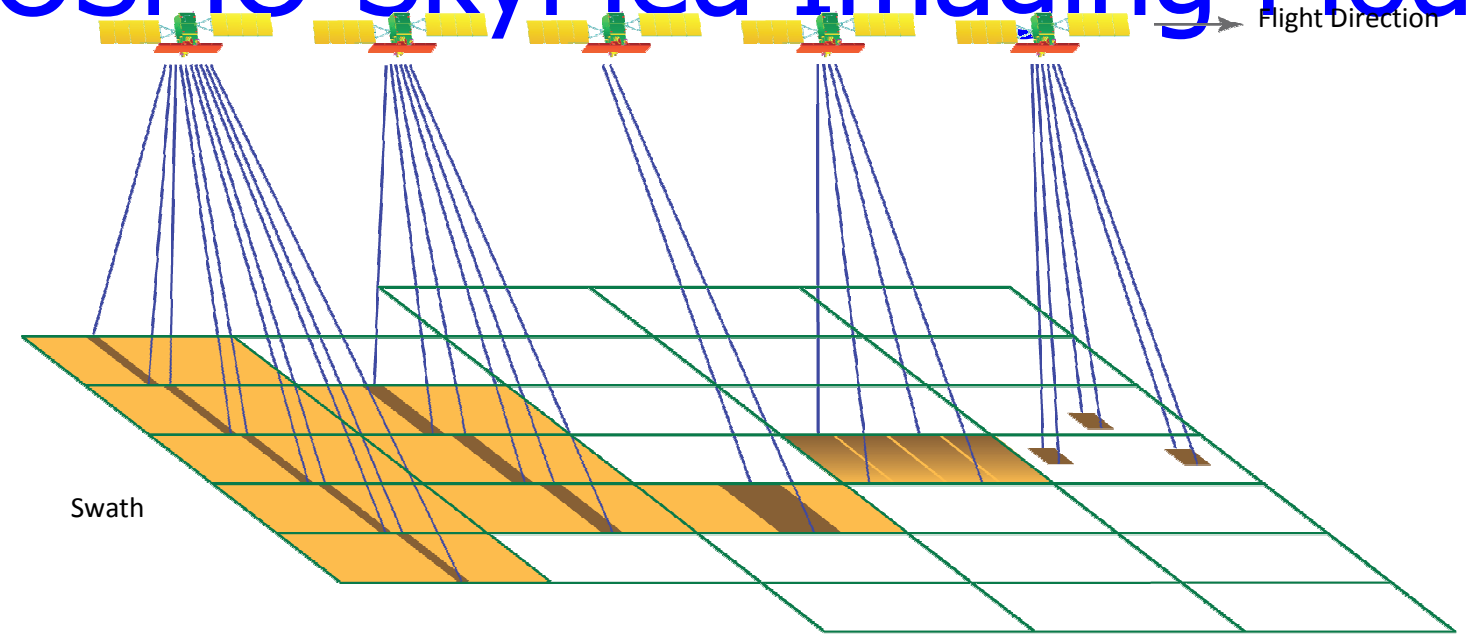
SIMGA is an avionic Hyperspectral instrument with very demanding performance.

	VNIR	SWIR	PAN
Spectral Range	400-1000 nm	1000 –2450 nm	450 –900 nm
Spectral Sampling	1.2 nm	5.8 nm	-
Spectral bands	512	256	-
Spatial pixels	1024	320	4096
IFOV	0.73 mrad	1.3 mrad	0.14 mrad
FOV	±19.8°	±12.04°	±16°
GSD @H=1000m	0.73 m	1.3 m	0.14 m
SWATH @H=1000m	700 m	425m	570 m
Focal Length	17 mm	23 mm	50 mm
Digital resolution	12 bit	14 bit	8 bit
Operating Frame Rate	54 Hz	27 Hz (VNIR FR./2)	2160 Hz (VNIR F.R.x40)
Data Rate	55.2 MB/s	4.32 MB/s	8.64 MB/s
Total Data Rate	68.3MB/s		
Storage Capacity	640 GB		
Max acquisition time	2h 40min		
	The spectral range VNIR and SWIR have an overlapping region like PRISMA		

COSMO-SkyMed



COSMO-SkyMed Imaging Modes

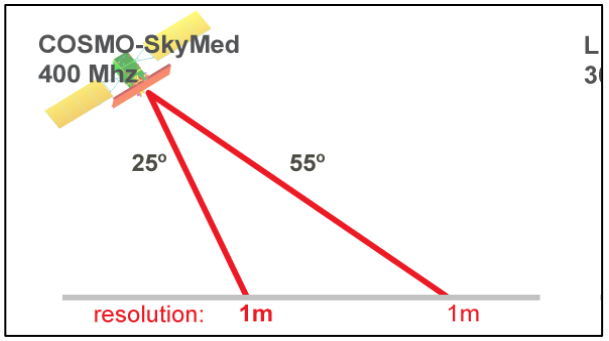


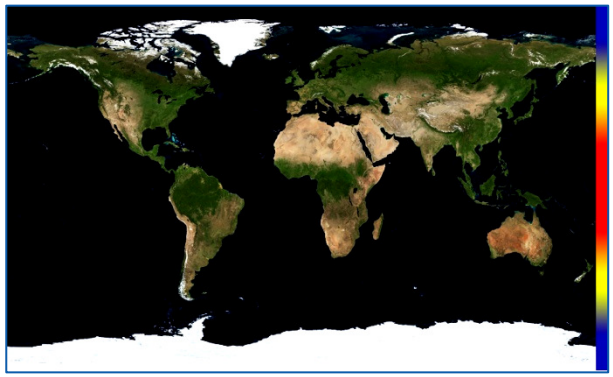
	HUGEREGION	WIDEREGION	HIMAGE	PINGPONG	MODE-2
Resolution – standard	100 m	30 m	3 m	15 m	1 m
Swath	200 km	100 km	40 km	30 km	10 x 10 km

SCANSAR STRIPMAP SPOTLIGHT

COSMO-SkyMed Superior Performance

- Extended Very High Resolution
  - 10 x 10 Km at 1m resolution
  - 1m also at low incidence angles





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- Unmatched revisit capability
  - 4-8 images per day depending on latitude

Rice paddies Monitoring

bare soil,
ploughed

High SAR signal

ponding

Low SAR signal

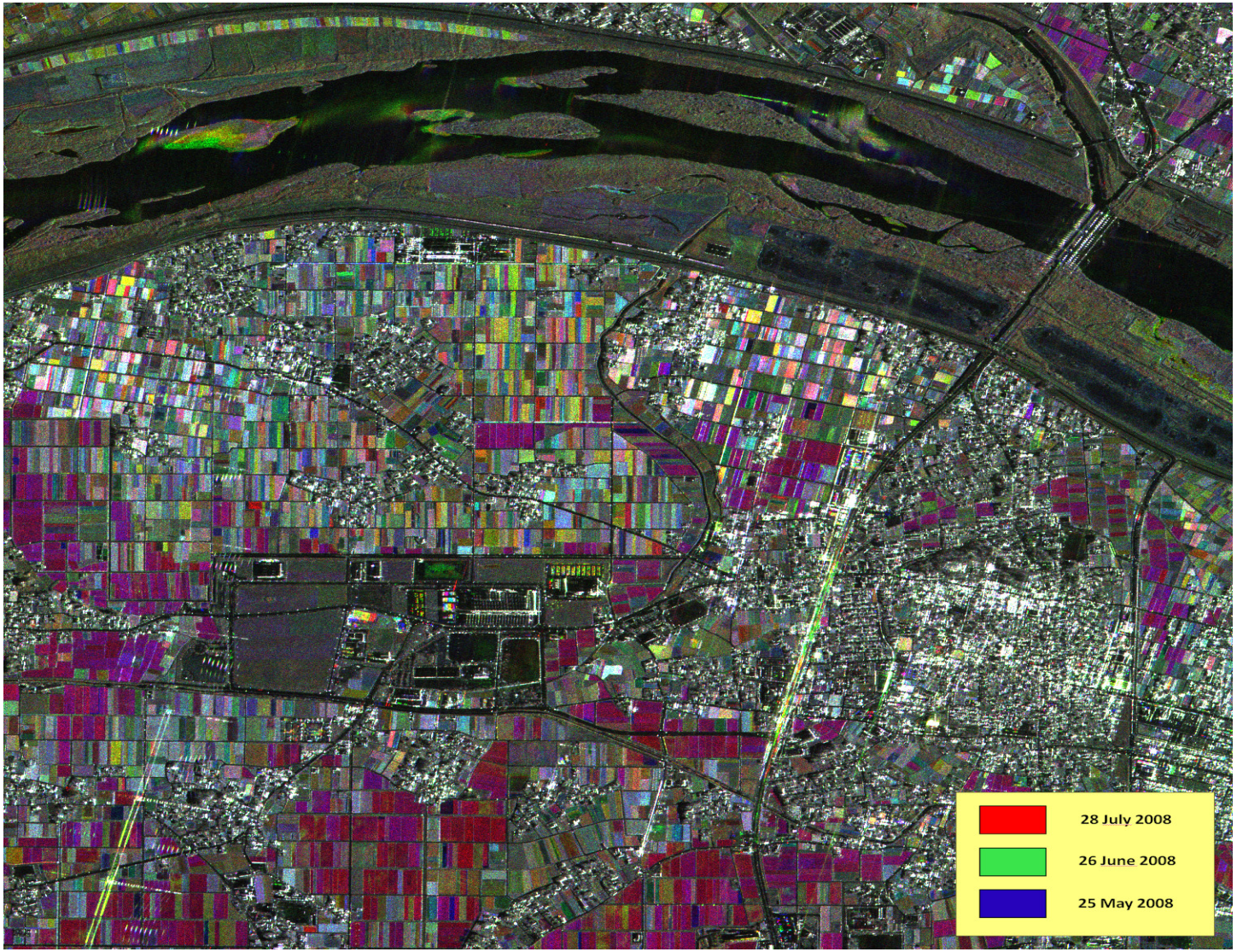
rice plants transplantation

Medium SAR signal

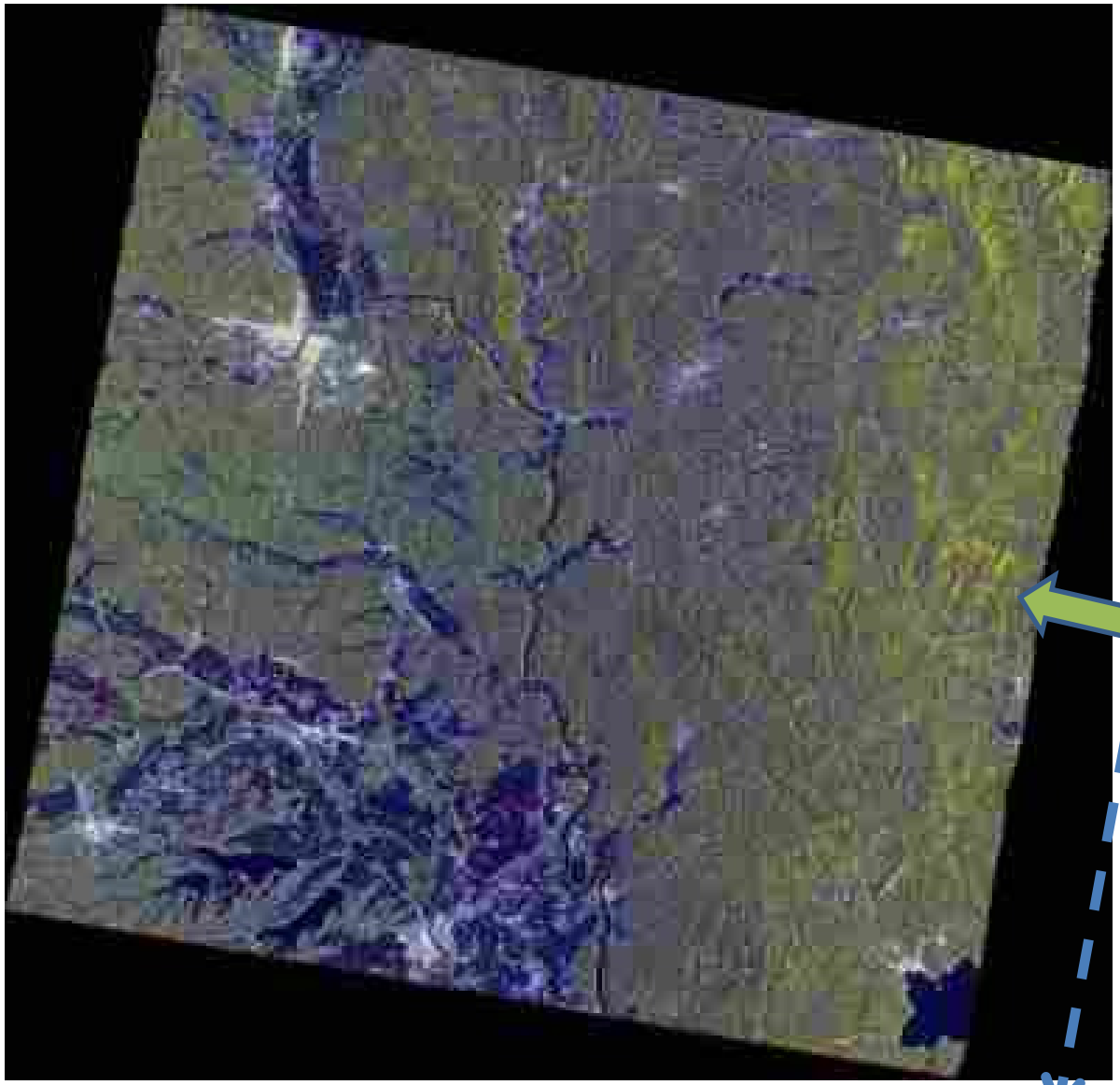
rice plants growing

High SAR signal

Kunegawa rice fields



Agriculture



COSMO-SkyMed for Rice Monitoring

Acquisition of CSK data interferometric pair

Type of data:
HIMAGE- Stripmap mode
Incidence angle 35.53°
Right looking
Descending pass
Polarization:HH

Satellites & acquisition dates:

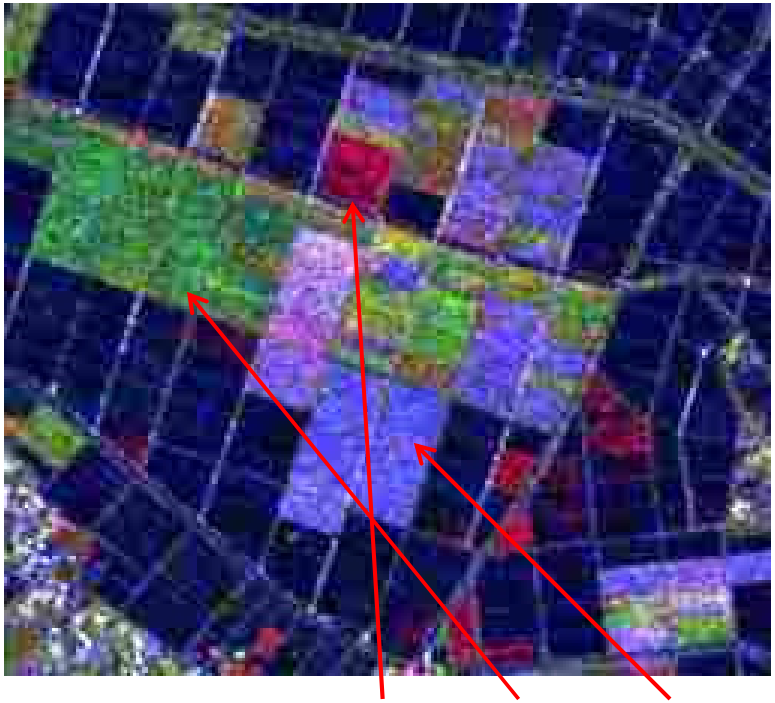
CSKS 2: May 17, 2010
CSKS 2: June 02, 2010

SHORT TERM MONITORING

Plant growing

CSK single scene

CSK Multitemporal Coherence product generated using the 2 acquired CSK images (May 16 – Jun 01, 2010)



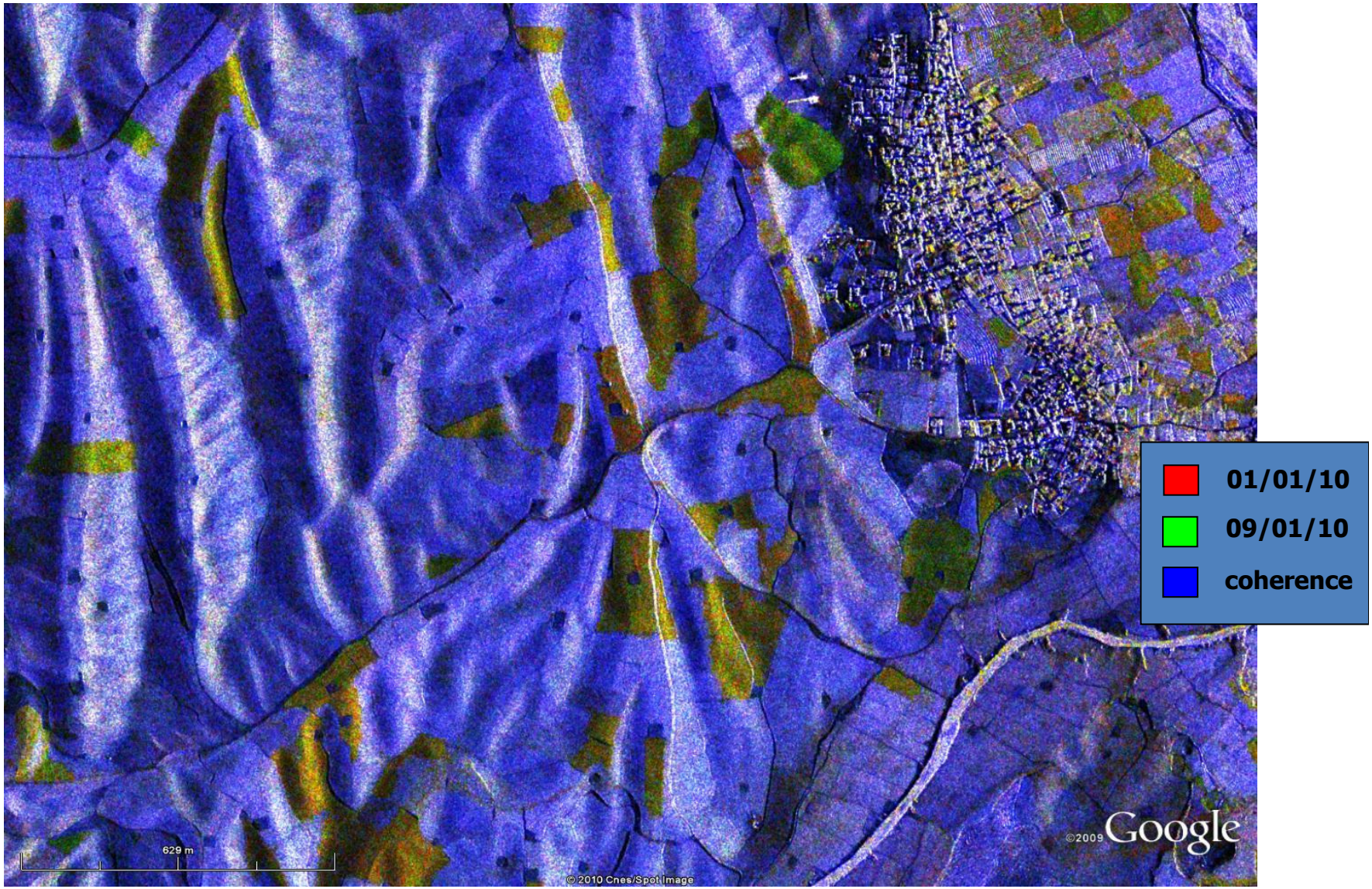
Green color (low coherence and increase of brightness between the first and the second image) indicates plant growing
(to be monitored up to harvesting)

Green: Fastly growing vegetation or ploughing activities (depending on season)

Red: Changes in surface roughness (flattening) or ponding activity

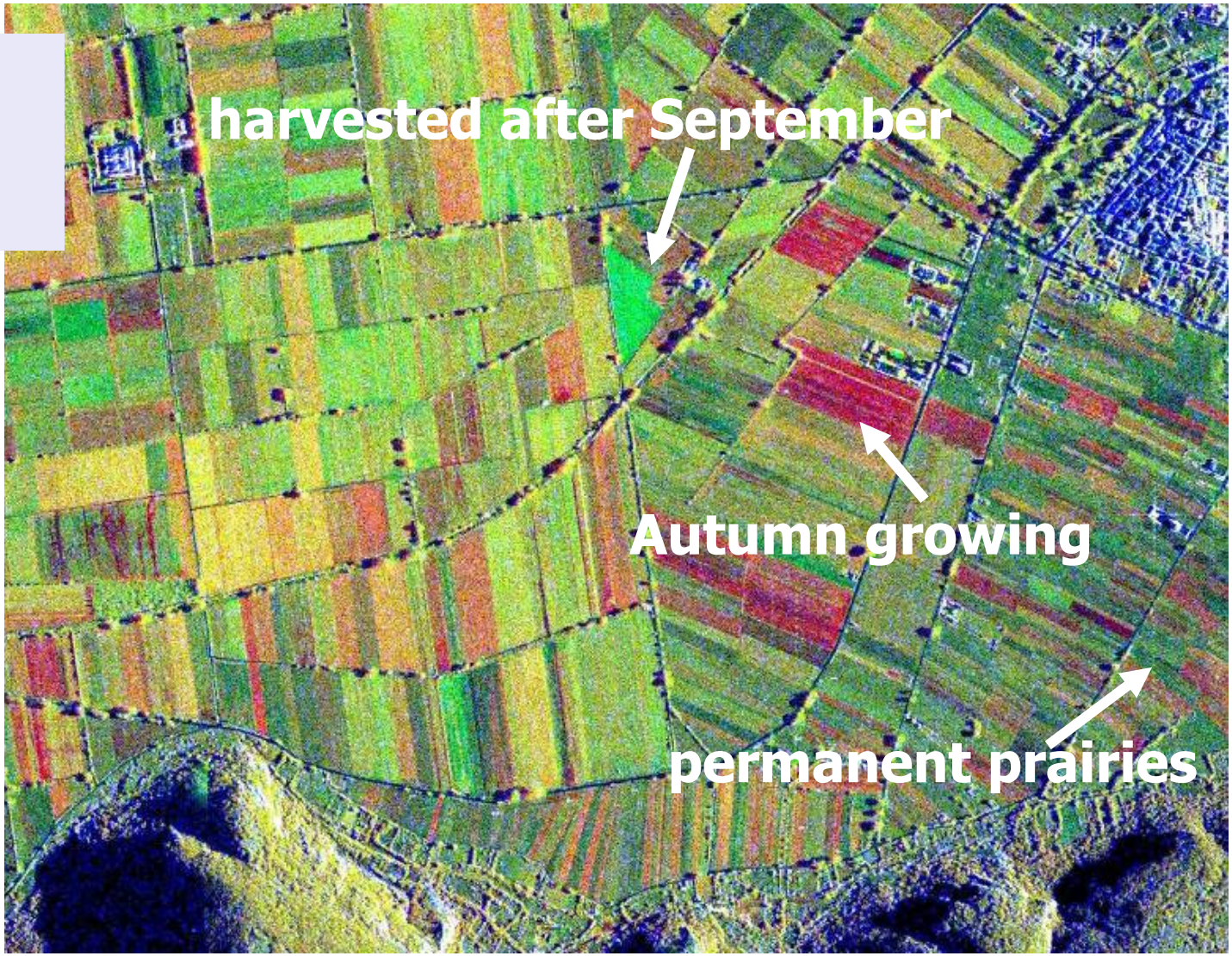
Blu: Unchanged bare soil

8 days coherence analysis



Agronomic Pattern Detection

November
September
Coherence



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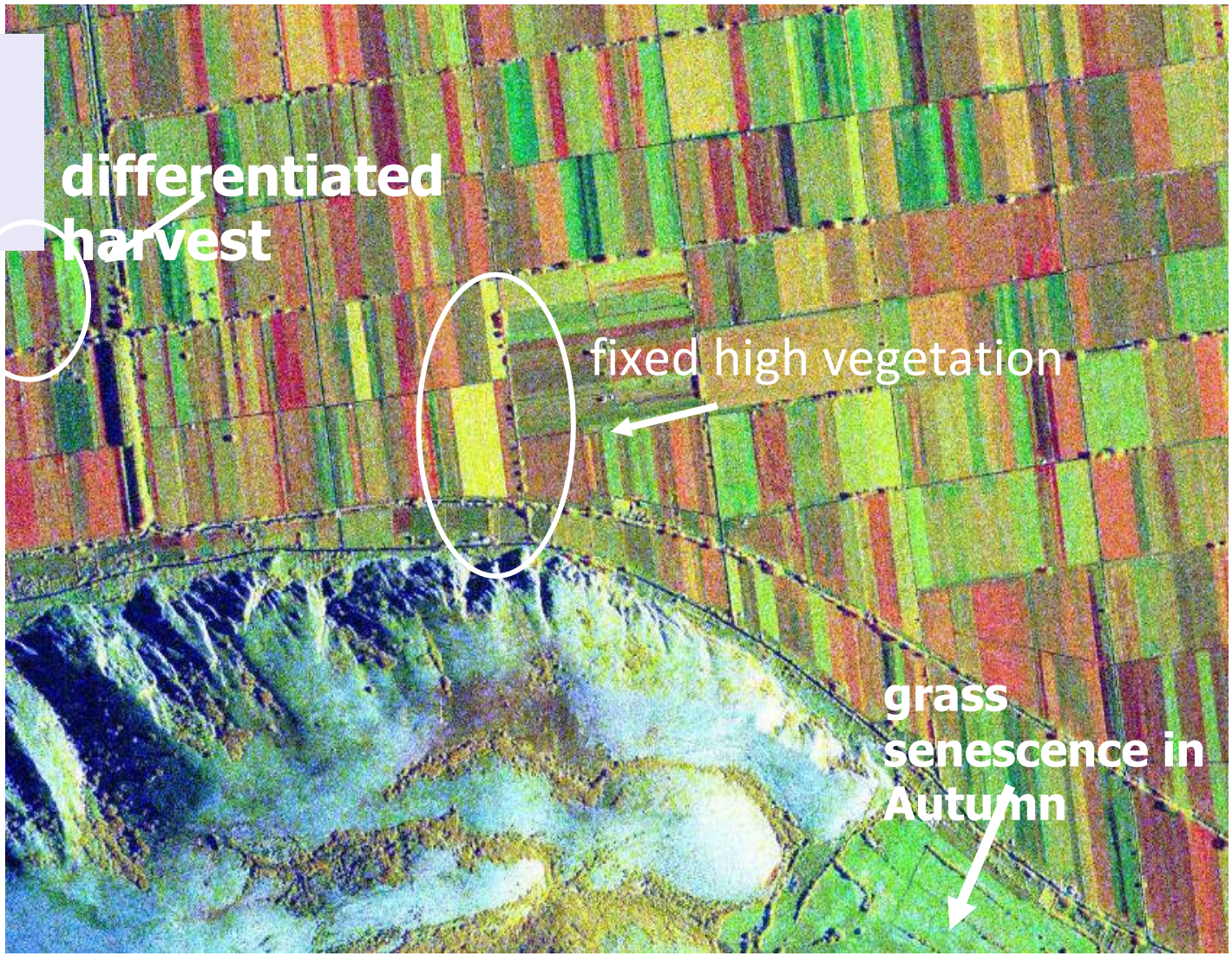

Humidity information

- EUFOR Road Condition Mapping (Chad)
  - Road surface extraction from COSMO images acquired at the beginning of the wet season
  - Classification of humidity of the surface to indicate zones at risk of road flooding