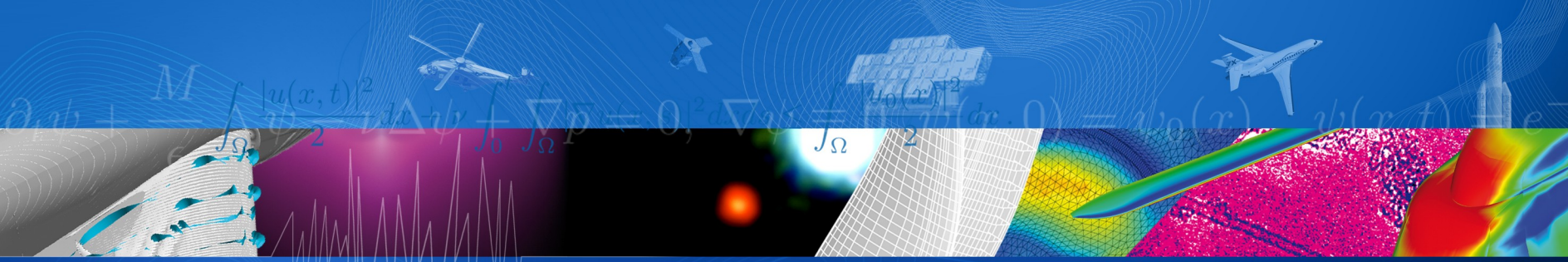

Fusion of hyperspectral and panchromatic data, extension to the thermal infra-red range

Yohann CONSTANS[1,2]

1st year PhD student

Thesis directors: Xavier Briottet[1], Yannick Deville[2]
Thesis supervisor: Sophie Fabre[1]
Industrial supervisors: Vincent Crombez[3], Michael Seymour[3]
Co-funding: ONERA-ADS

[1]ONERA/DOTA, [2]IRAP/SISU, [3]Airbus/ADS

AIRBUS
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Context, issue, objectives

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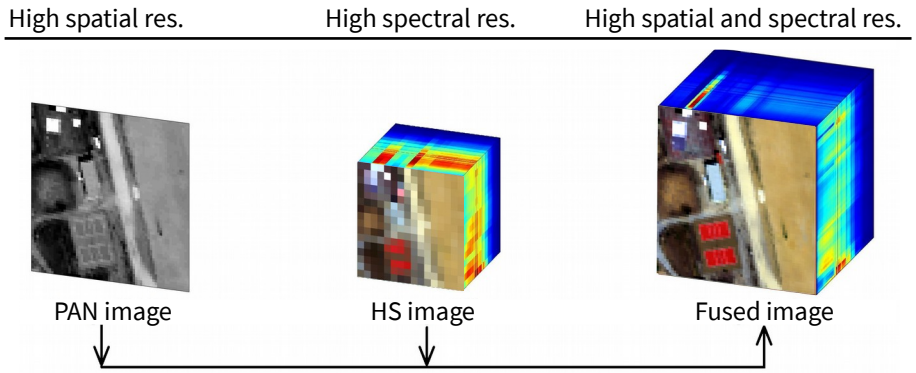
- Both high **spatial** and **spectral** resolutions needed for Earth observation.
  Problem: sensors cannot provide *simultaneously* such characteristics.
- Solution: Pan sharpening ⇒ Fusion of panchromatic [PAN] (spatial info) and hyperspectral [HS] (spectral info) images



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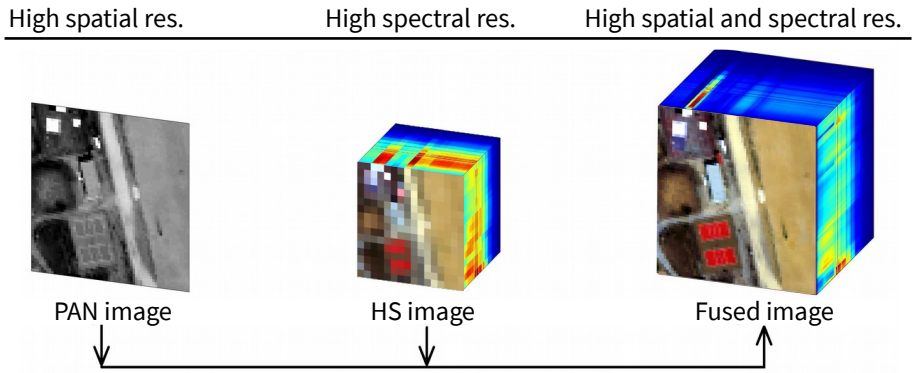
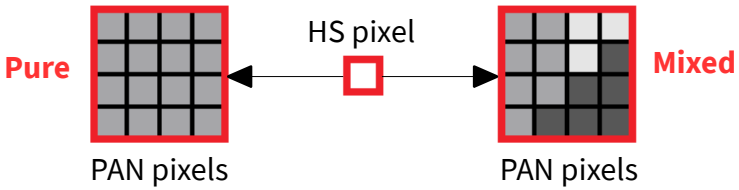


Limits of existing methods:

- limited spatial resolution ratios (4),
- strong spatial variability (*mixed pixels*),
- non-uniform irradiance (shadow),
- limitation to the reflective spectral range [0,4-2,5 µm].



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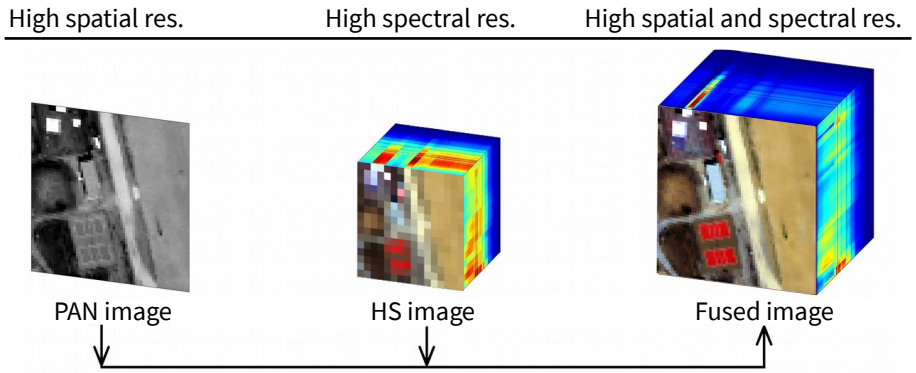

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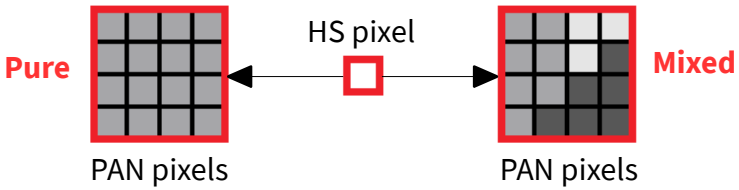


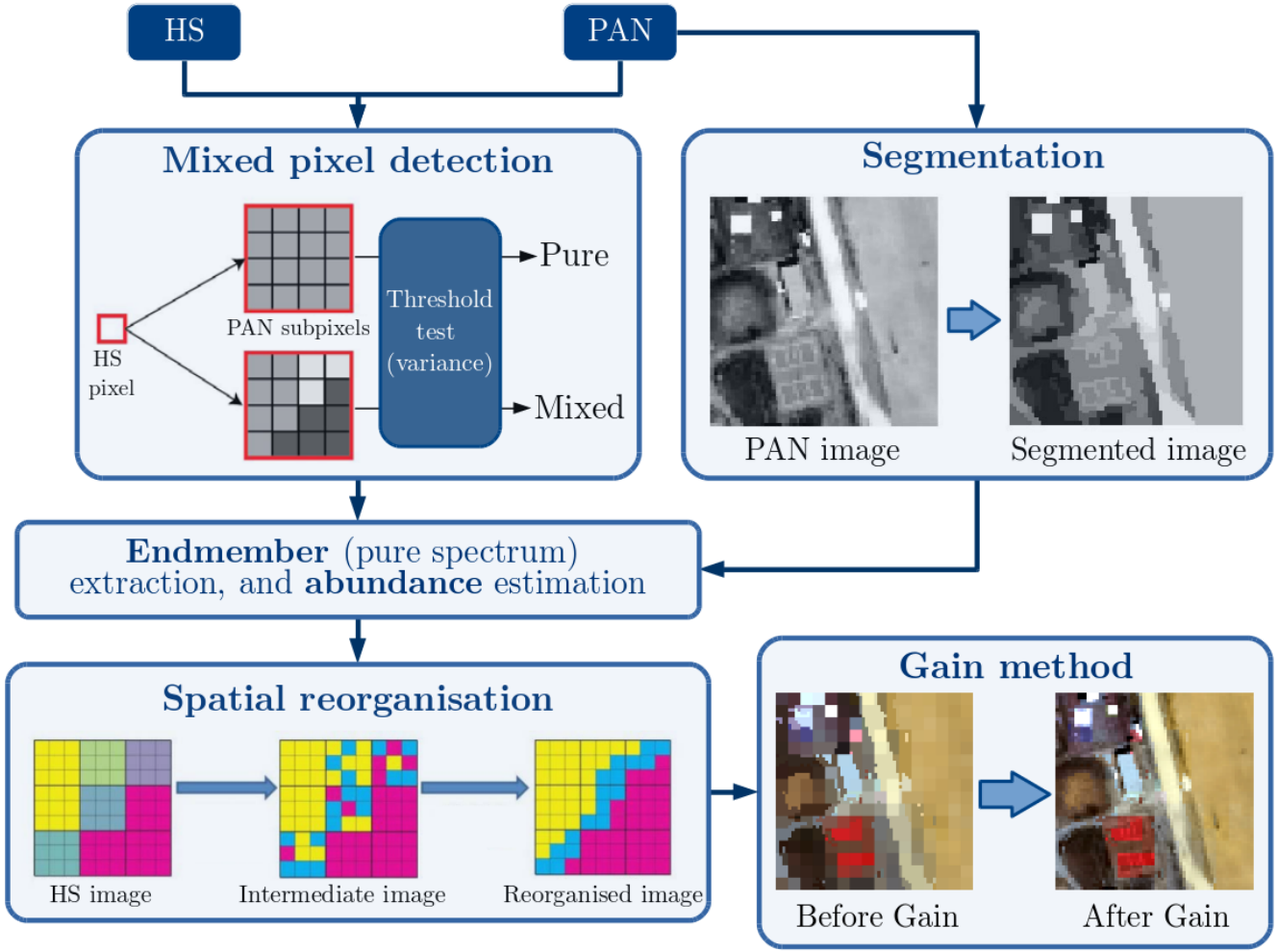
Reference method: Gain

Scale factor derived from PAN image and applied to all bands of the oversampled HS image *(see poster!).*

Objective: Development and validation of a fusion method for HS-PAN images, in the whole optical domain, with mixed pixel unmixing and shadow processing.

SOSU method

Current method : SOSU *(Spatially Organized Spectral Unmixing)* **= Unmixing + Gain**



Data set and protocol

Data set

Stadium – SYSIPHE : HS simulated image (RGB representation), 64 x 64:

Spatial resolution: *1.5 m*

PAN/HS resolution ratio: *4*

Spectral range: *[0,4 µm – 2,5 µm]*

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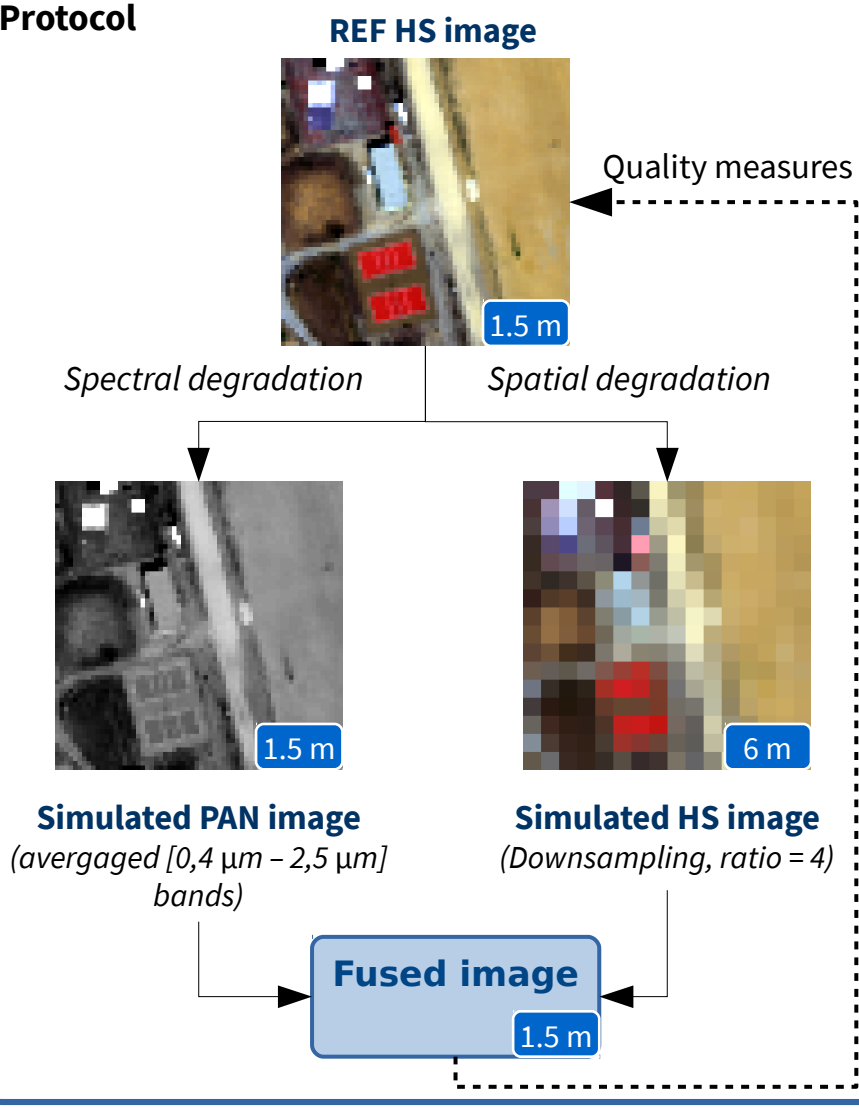

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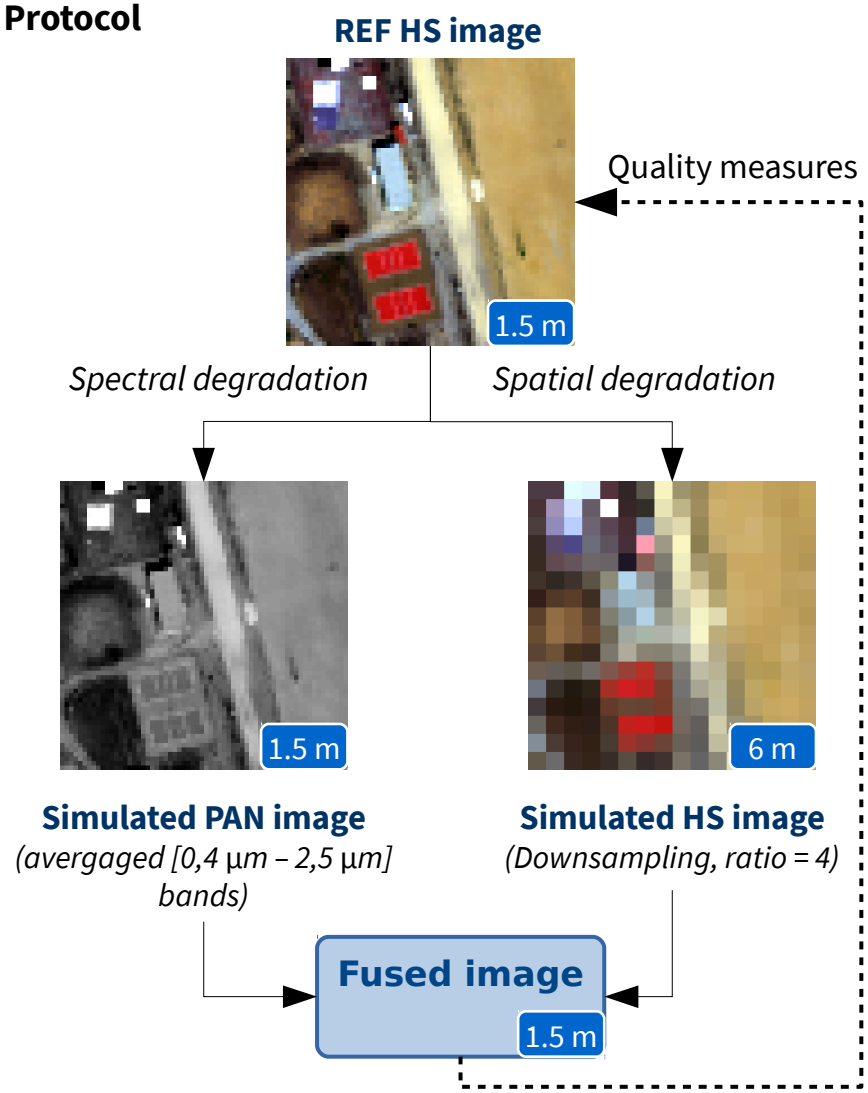
Quality measures

- Compare quality of fused images (against reference image): **spatial** (RMSE), **spectral** (SAM) and **global** (ERGAS, UIQI) criteria.

- Criteria can be applied pixel-wise:
  ⇒ Error maps
  ⇒ Improved/degraded pixel count: Percentage of pixel for which tested method is more/less effective than the other ones.

Protocol



Visual results

REF

PAN image

HS image

Visual results

REF

PAN image

HS image

Segmented image

(EDISON method)

Visual results

REF

PAN image

HS image

SOSU unmixing

Segmented image

Visual results

REF

PAN image

HS image

SOSU unmixing

Segmented image

Gain fusion

SOSU fusion

Visual results

REF

PAN image

HS image

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Segmented image

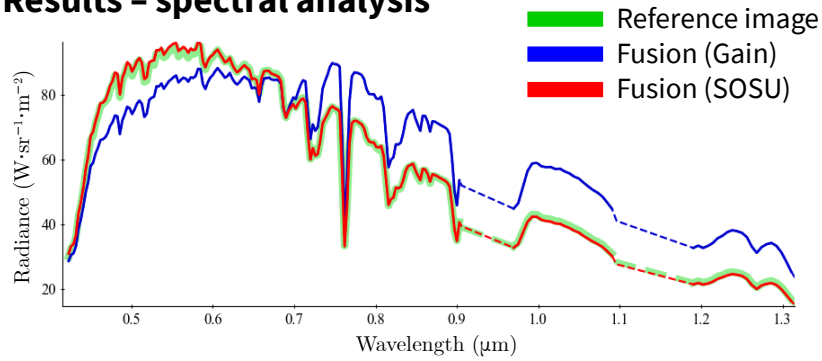
Gain fusion

SOSU fusion

	RMSE	UIQI	ERGAS	SAM
Gain/ref	3.98	1.00	$3{,}67.10^4$	0.09
SOSU/ref	3.95	0.99	$3{,}81.10^4$	0.09

Results : spectra and measures

Results – spectral analysis



✔ SOSU > Gain

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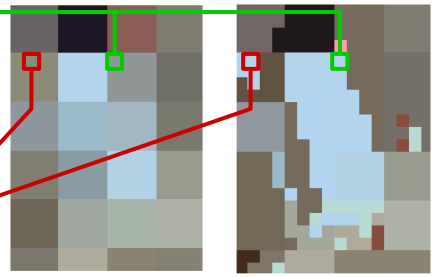
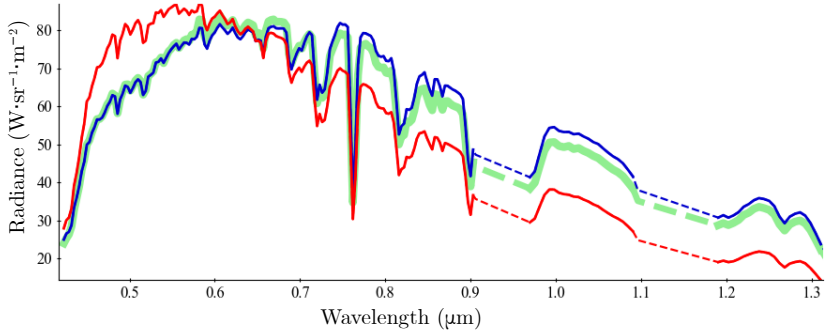


HS Unmixed



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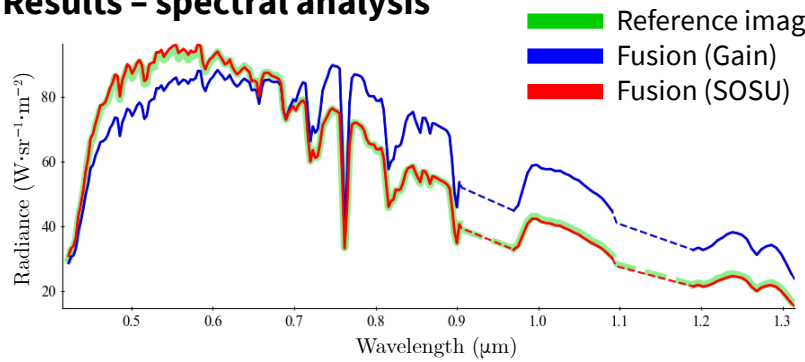

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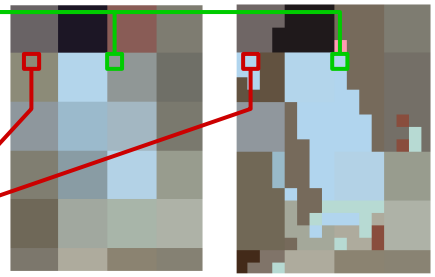

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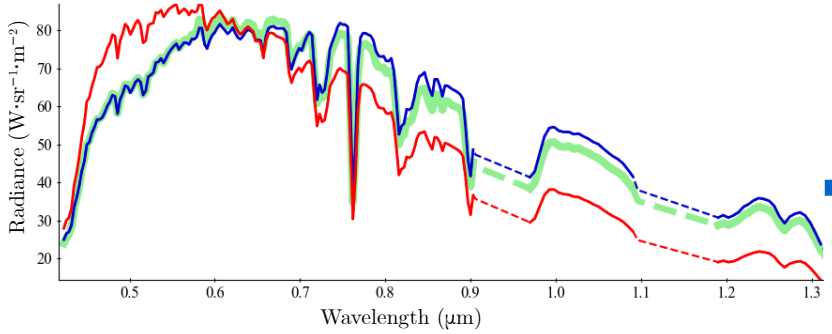


Results (mean gaps)

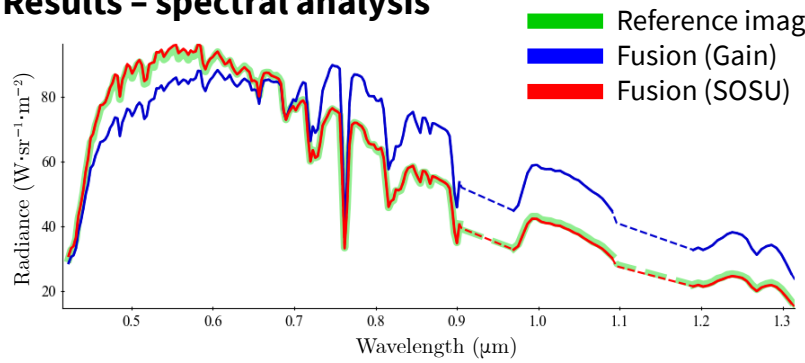
Range	SOSU/ref	Gain/ref
VNIR	0,8 %	15,2 %
SWIR	3,1 %	40,2 %

Results (mean gaps)

Range	SOSU/ref	Gain/ref
VNIR	13,7 %	3,0 %
SWIR	34,7 %	6,4%

Results : spectra and measures

Results – spectral analysis



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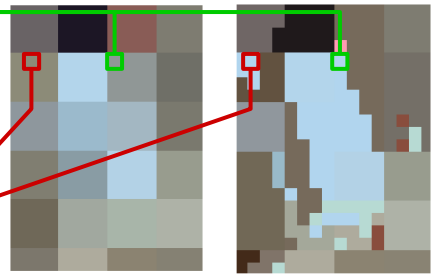

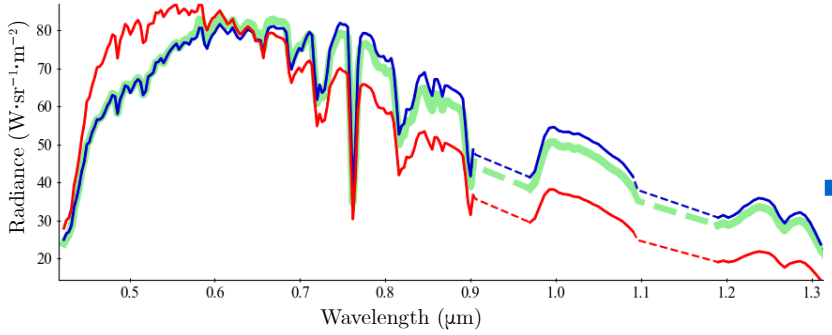

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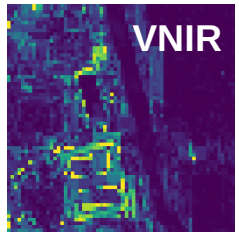
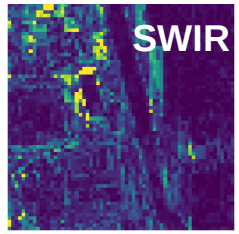
Pixel counts





- SOSU error maps using « gap » criteria
- Comparison of pixel-wise errors (entire reflective range) → Counts of pixels such that:

SOSU > Gain: 23.0 %
SOSU < Gain: 25.0 %

- Interest of SOSU confirmed
- However: enhancements are needed

Results (mean gaps)

Range	SOSU/ref	Gain/ref
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Thank you for your attention!

Selected bibliography:

[1] L. Loncan et al., "Hyperspectral Pansharpening: A Review," in *IEEE Geoscience and Remote Sensing Magazine*, vol. 3, no. 3, pp. 27-46, Sept. 2015.

[2] L. Loncan, *Fusion of hyperspectral and panchromatic images with very high spatial resolution*, Diss., Université Grenoble Alpes, 2016.

[3] C. Chisense, J. Engels, M. Hahn, et al., "Pansharpening of hyperspectral images in urban areas," in International Archives of the Photogrammetry, Remote Sensing and Spatial Information Sciences, vol. 39-B7, XXII ISPRS Congress, Melbourne, Australia, pp. 387-392, Aug. 2012.

SOSU method

Endmember extraction

- For each mixed HS pixel, 2 ways of extracting endmembers:
  - Pure neighbour pixel spectra (configurable neighbourhood)
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- Once the list of possible endmember has been set:
  - Endmember reduction via correlation (threshold test)
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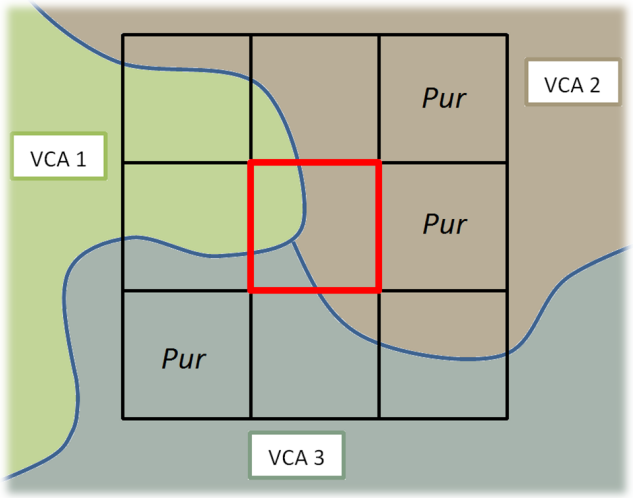

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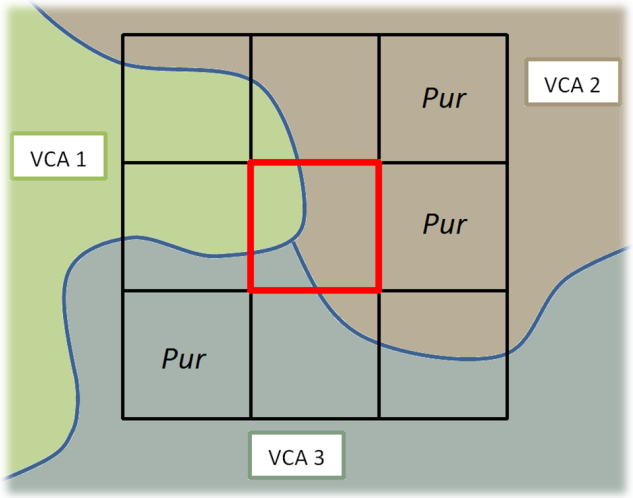
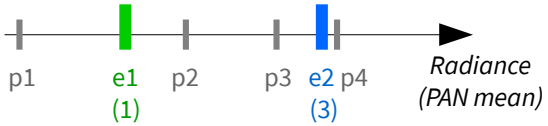


Spatial reorganisation within HS coarse pixel

Several possible methods:

1) Distances only (without considering abundances)



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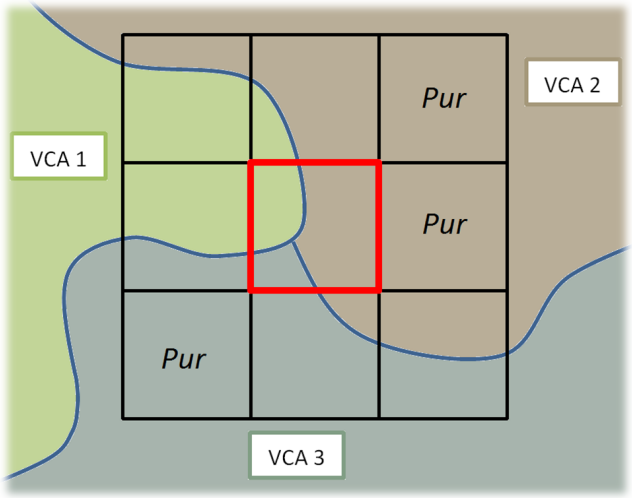

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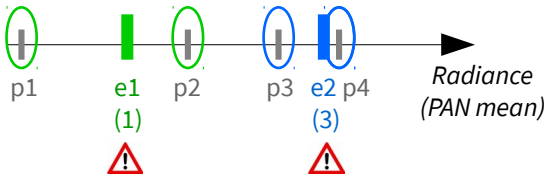

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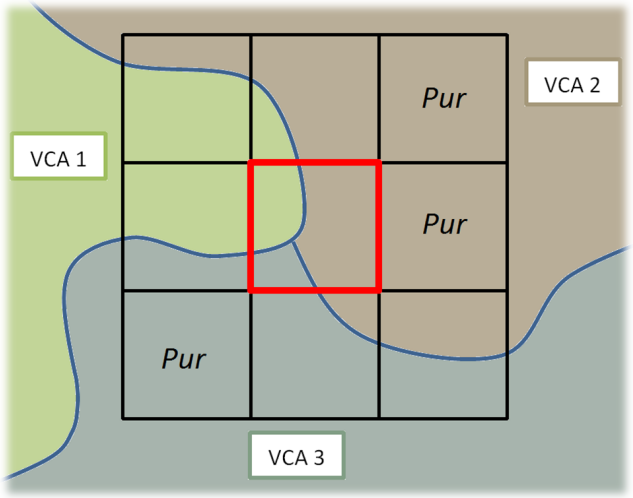

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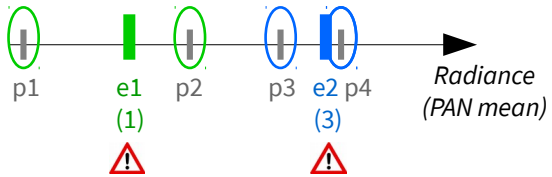

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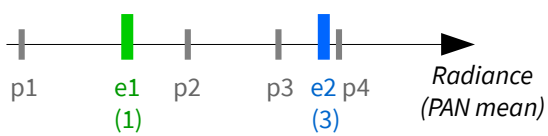

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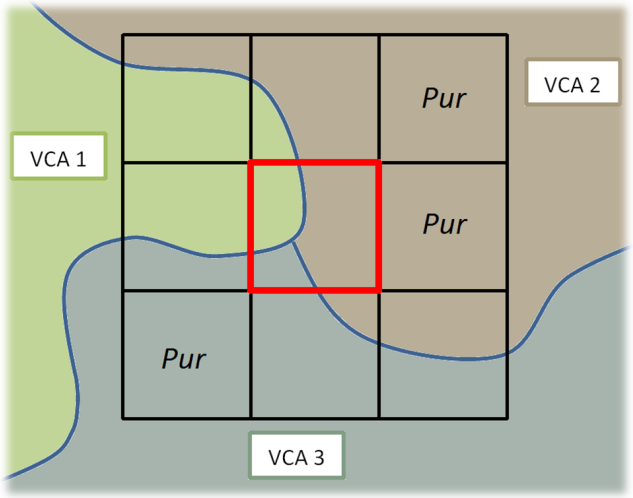

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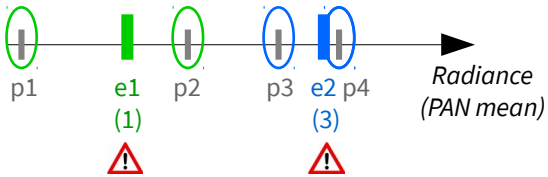

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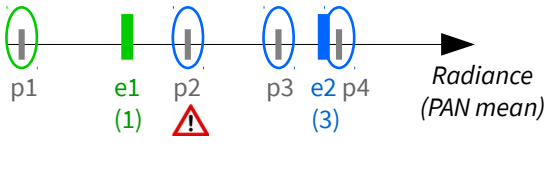

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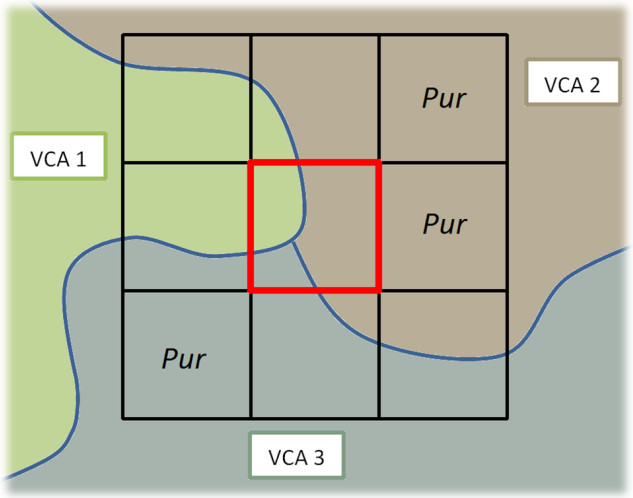

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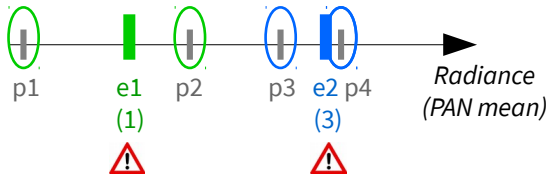

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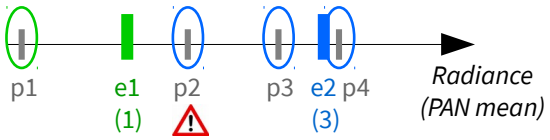
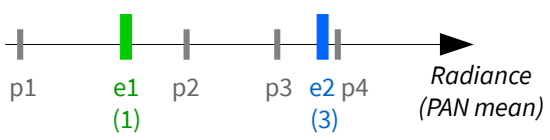


3) Distances + abundances



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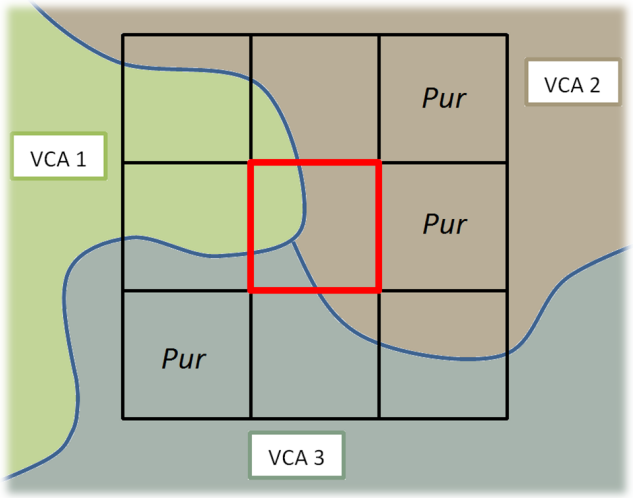

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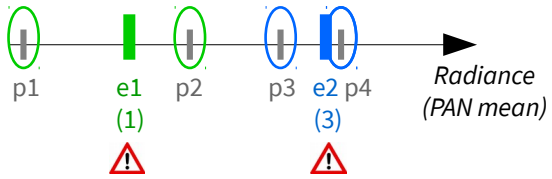

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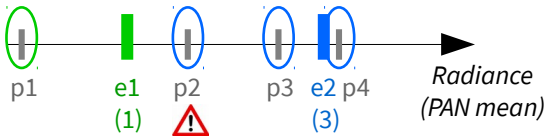

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