Limits and Potentials of Sentinel-2 for Large Scale Near-Real-Time Land-Cover Map Production

J. Inglada, O. Hagolle, G. Dedieu, J-F. Dejoux

April 2012

Outline

What S2 brings for LSNRTLCMP

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  - 13 spectral bands
  - Nadir view

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  - 13 spectral bands
  - Nadir view
- Will allow the production of very accurate land-cover maps.
  - higher spatial resolutions than MODIS, SPOT and Landsat;
  - higher number of spectral bands, shorter revisit time and a wider swath than Landsat and SPOT.

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  - the **improved spatial resolution** will allow to operate with smaller mapping units
  - the **spectral richness** will allow to assess and detect certain types of changes in the vegetation.

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  - Stress the importance of the **temporal dimension**
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- Work done in the framework of the **French Land Thematic Data Centre**
  - Poster presentation by S. Cherchali et al.
- Funded by CNES under the TOSCA Program

New applications . . .

. . . which require to closely monitor the temporal trajectory of the characteristics of land surfaces.

- real time classification
- evolving nomenclatures for the land-cover maps

Challenges

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- Expectations for land cover change monitoring
- Real-time: update the land-cover maps for every new acquisition
- Going from this vision towards operationality, needs a closer look at the constraints which are induced by
  - the quality requirements of the final products
  - the huge amount of image data to deal with.

Example

Soil work

- Main goal: improve real-time crop classification; soil work can give hints on the type of crop
- Soil map: is also interesting in itself as a product

Inter-crop	Stubble disking	Deep ploughing
		
Harrowing	**Sowing preparation**	**Emergence**
		

What is "large scale"

Examples

Southern France coverage

- Landsat-5 and Landsat-7 (30 m., 7 bands)
- All available images: 8-12 dates/year/pixel, 2 years
- Evolution of forests, croplands and grasslands

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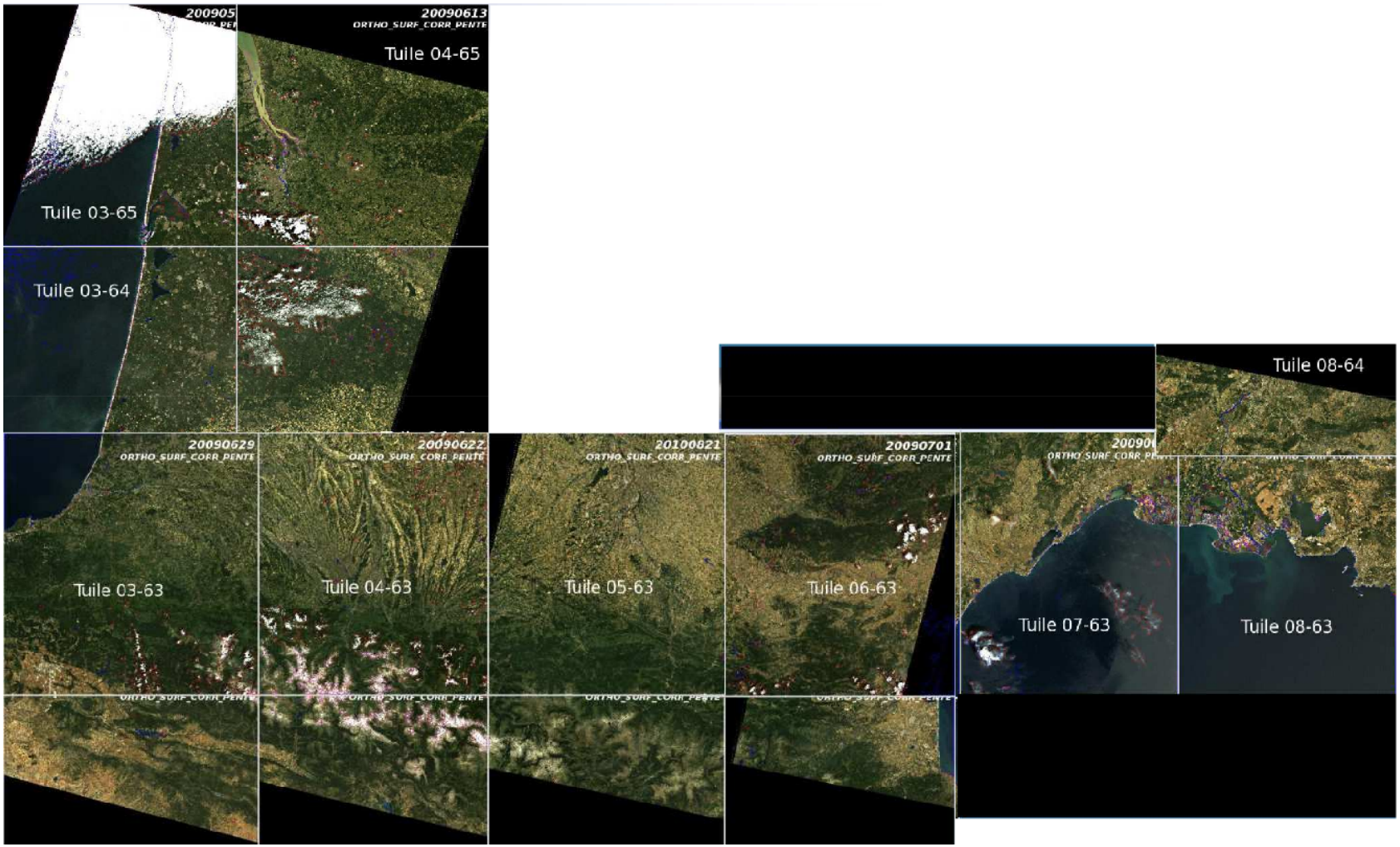
Midi-Pyrénées Region

- 45300 km^2
- Rapid-Eye
  - 5 m., 5 bands, 1 date per pixel
- SPOT
  - 10-20 m., 4 bands, 4 dates per pixel, 91 scenes
- Land-cover classes
  1. Forest, Grassland, Cropland, Urban, Water
  2. More detailed forest and cropland classes

Landsat


Tuile 03-65
Tuile 04-65
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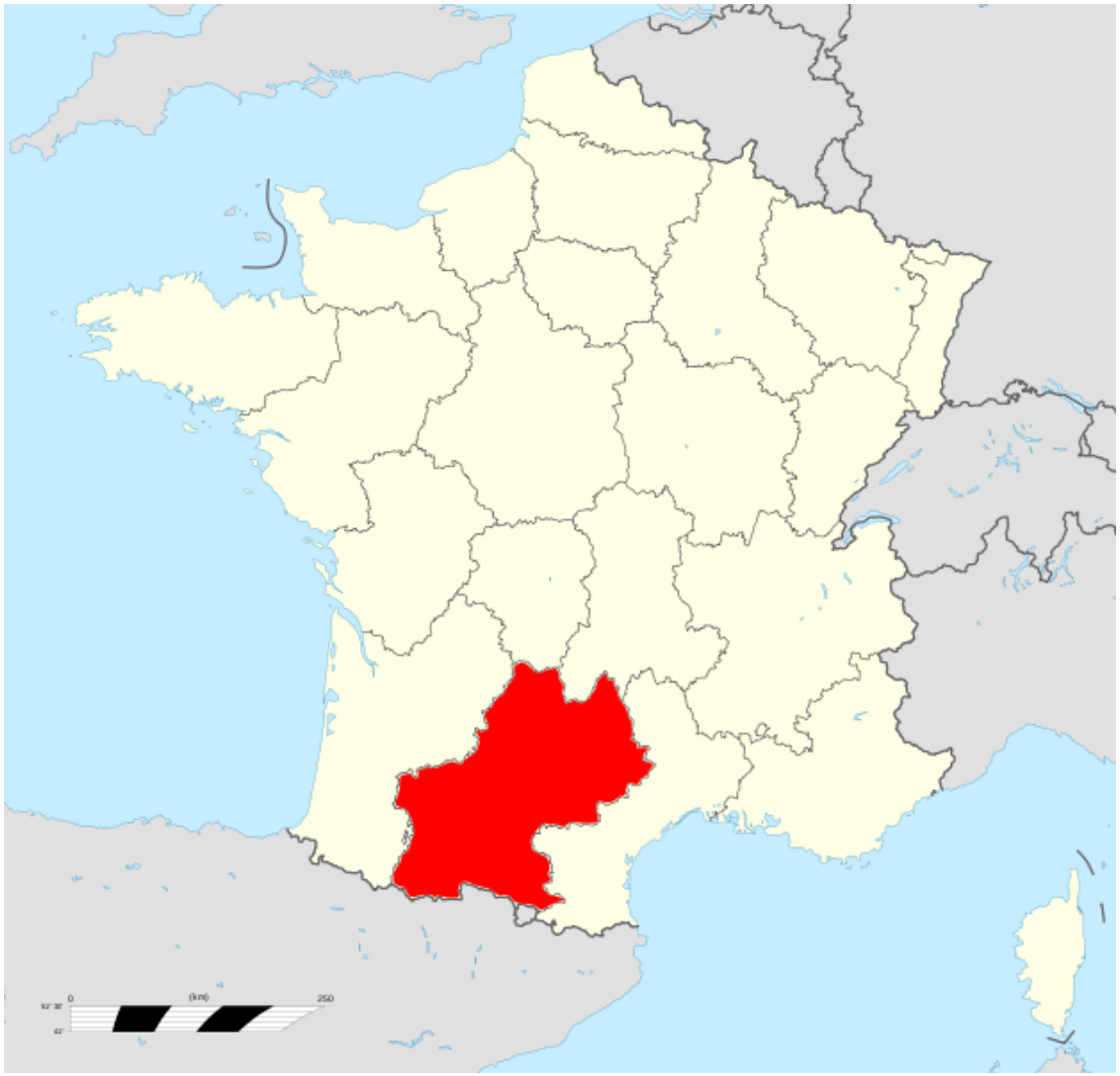
Midi-Pyrenées region

Rapid Eye



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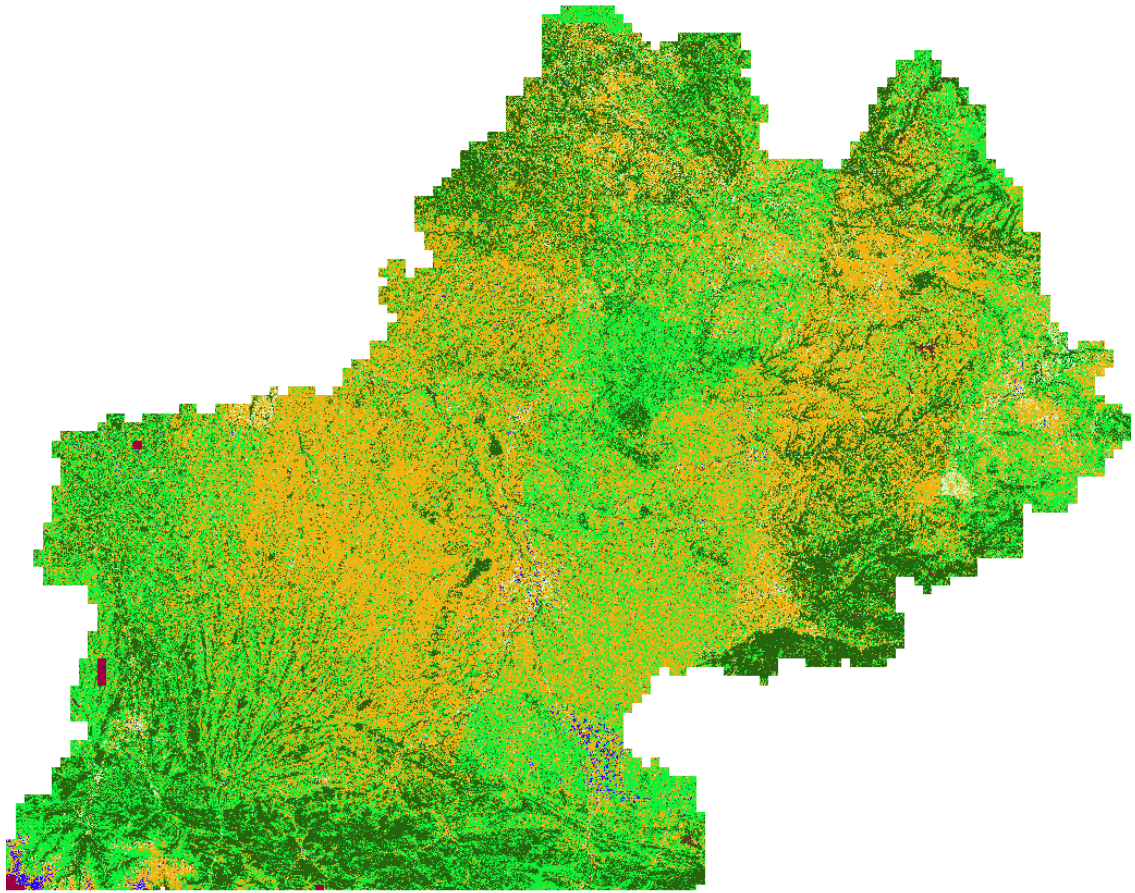

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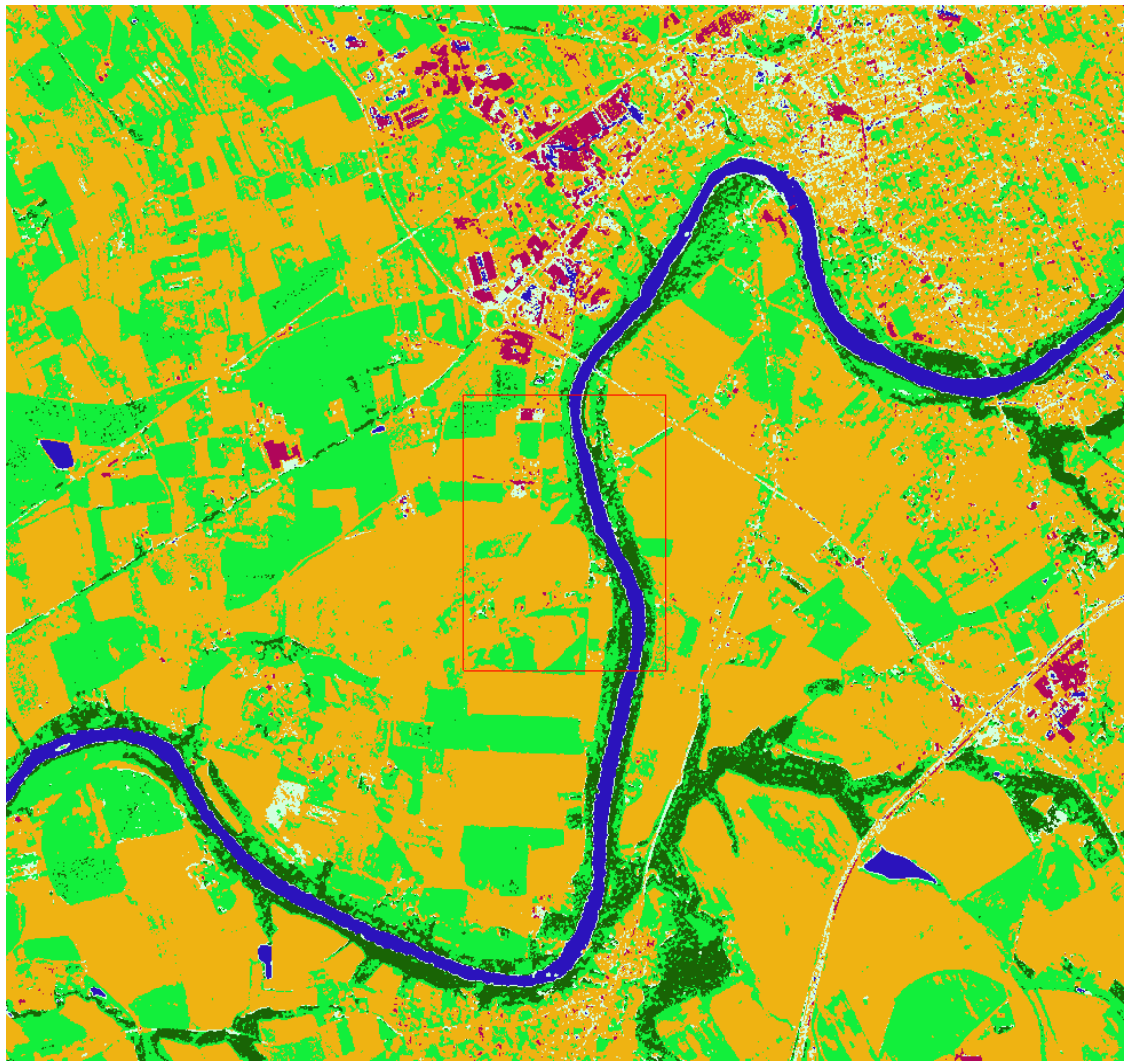

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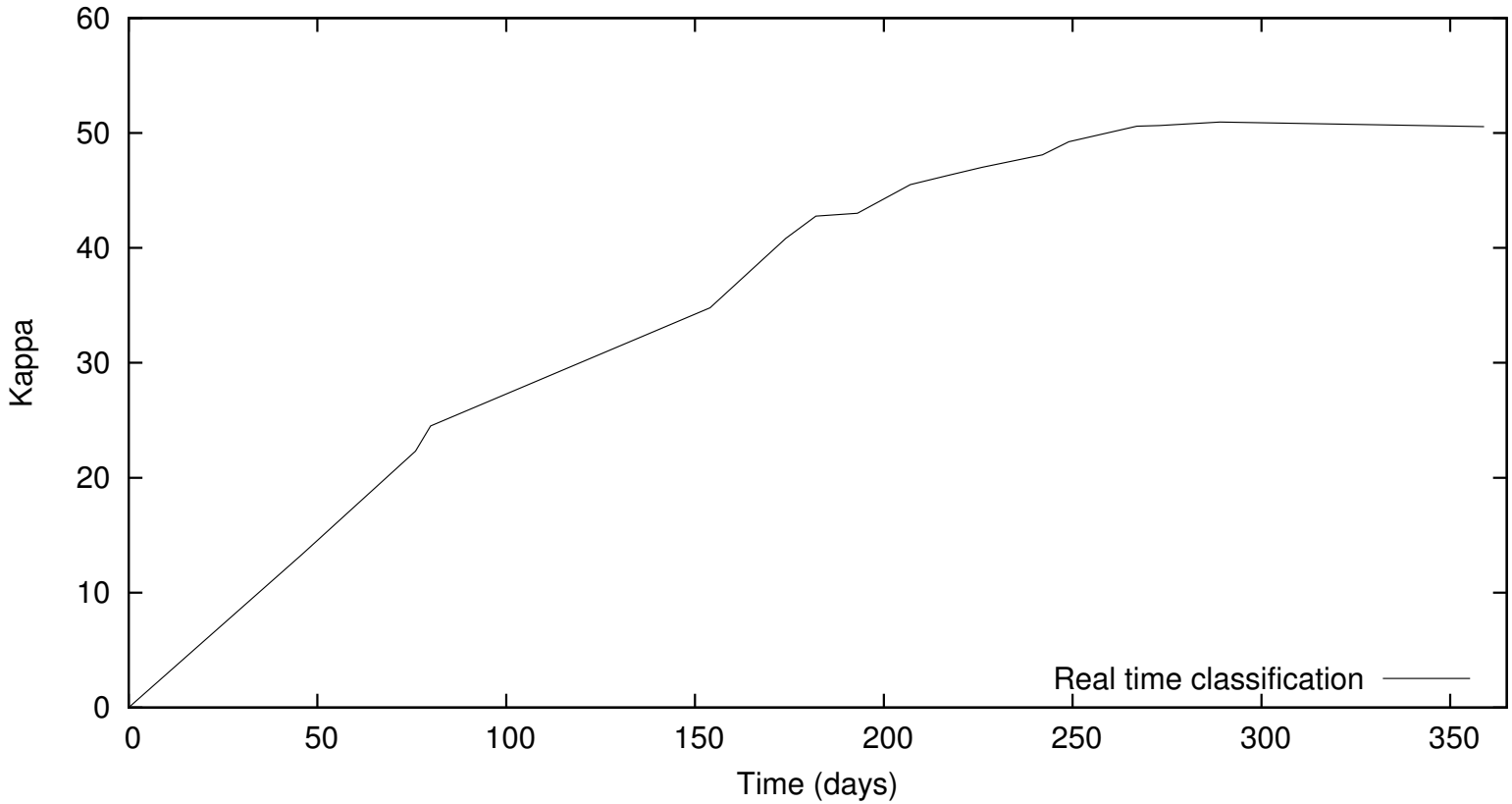
Real-time land-cover maps

Example

- Classification accuracy increases with new available images



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- In this context, being able to exploit **prior knowledge** as well as **ancillary data** will be crucial

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  - Same thematic class can have different behaviors in different areas
    - altitude, aspect, etc.
    - agricultural practices

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- Possible limitations to data access:
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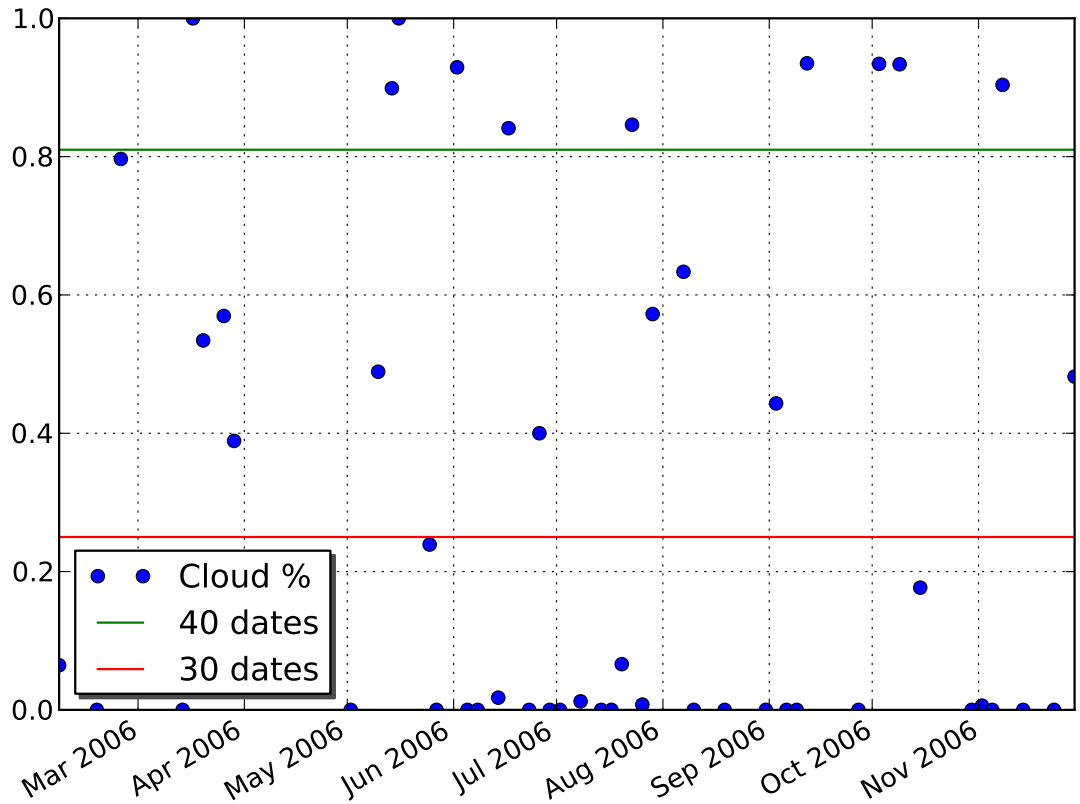
- Land-cover map production system will have to be robust to spatially localized temporal data gaps.

Cloud cover


1.0
0.8
0.6
0.4
0.2
0.0
Cloud %
40 dates
30 dates
Mar 2006
Apr 2006
May 2006
Jun 2006
Jul 2006
Aug 2006
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?	?	?	0.740	?	?	?	0.789	?	?	?	?
?	?	0.777	?	?	?	0.885	?	?	?	?	?
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?	0.738	0.755	?	?	?	0.681	?	0.583	?	0.800	0.681
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?	0.858	0.856	0.807	?	?	0.546	?	0.226	?	0.771	0.866
?	0.463	0.554	?	0.567	?	?	?	0.695	?	?	0.581

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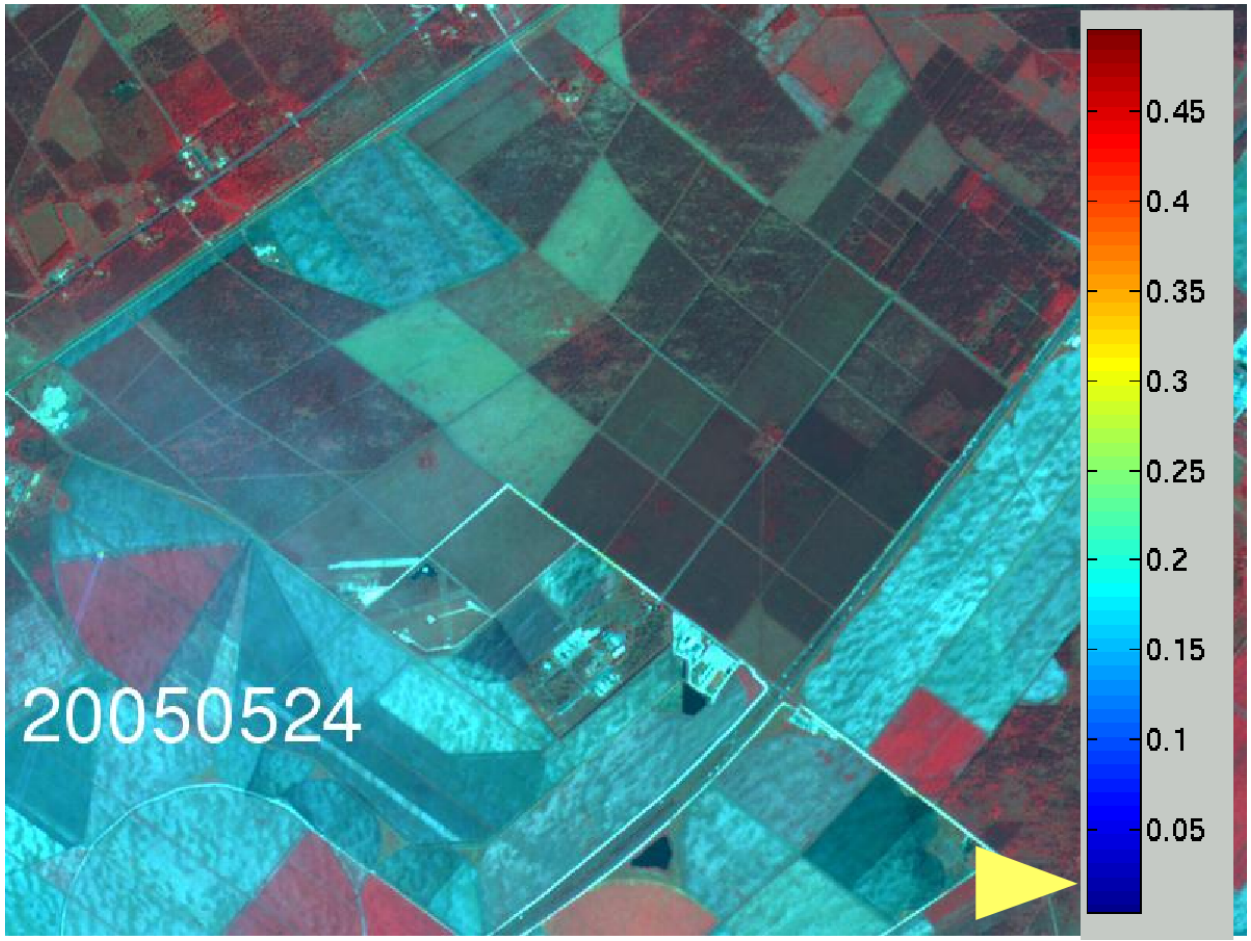
Importance of atmospheric corrections



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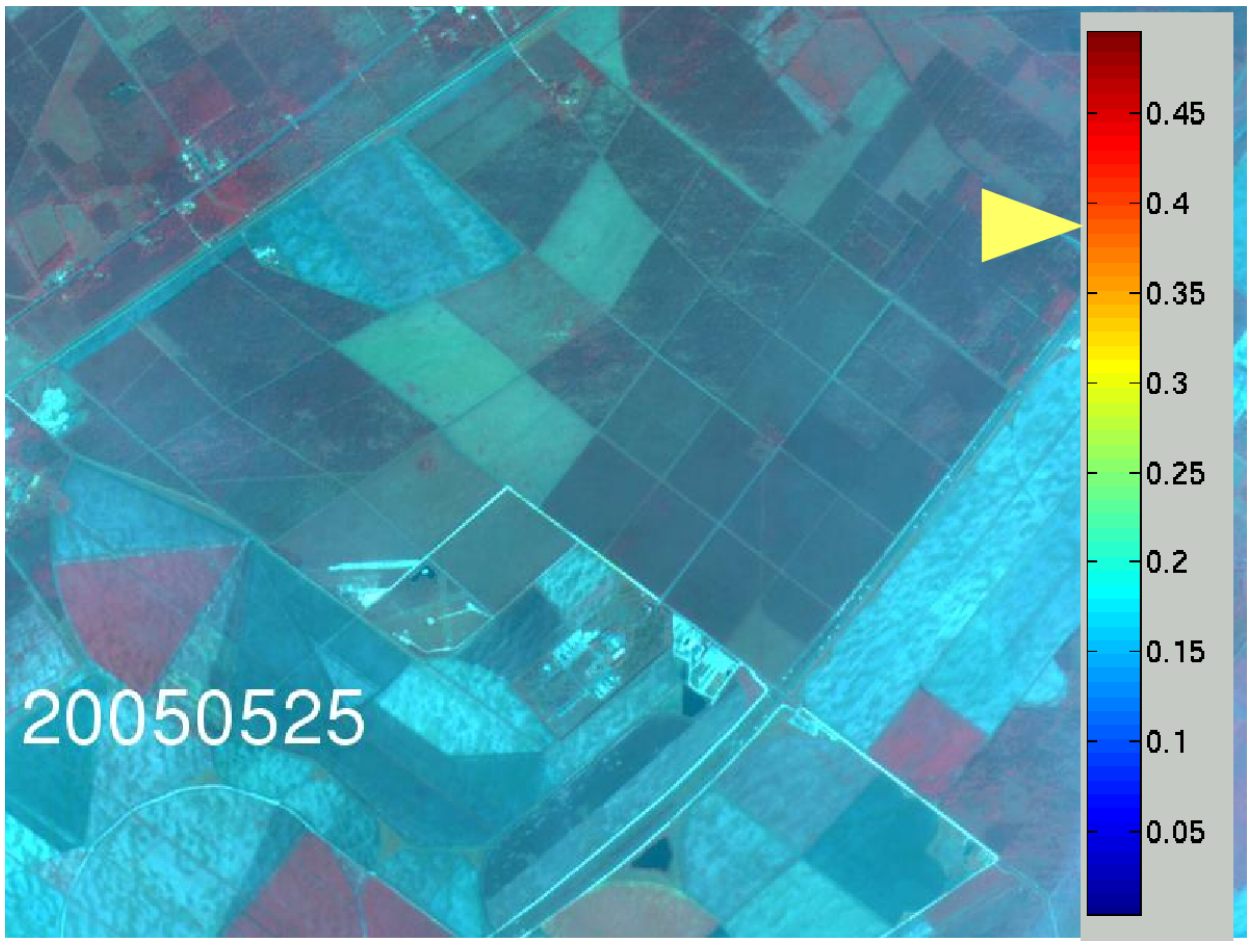

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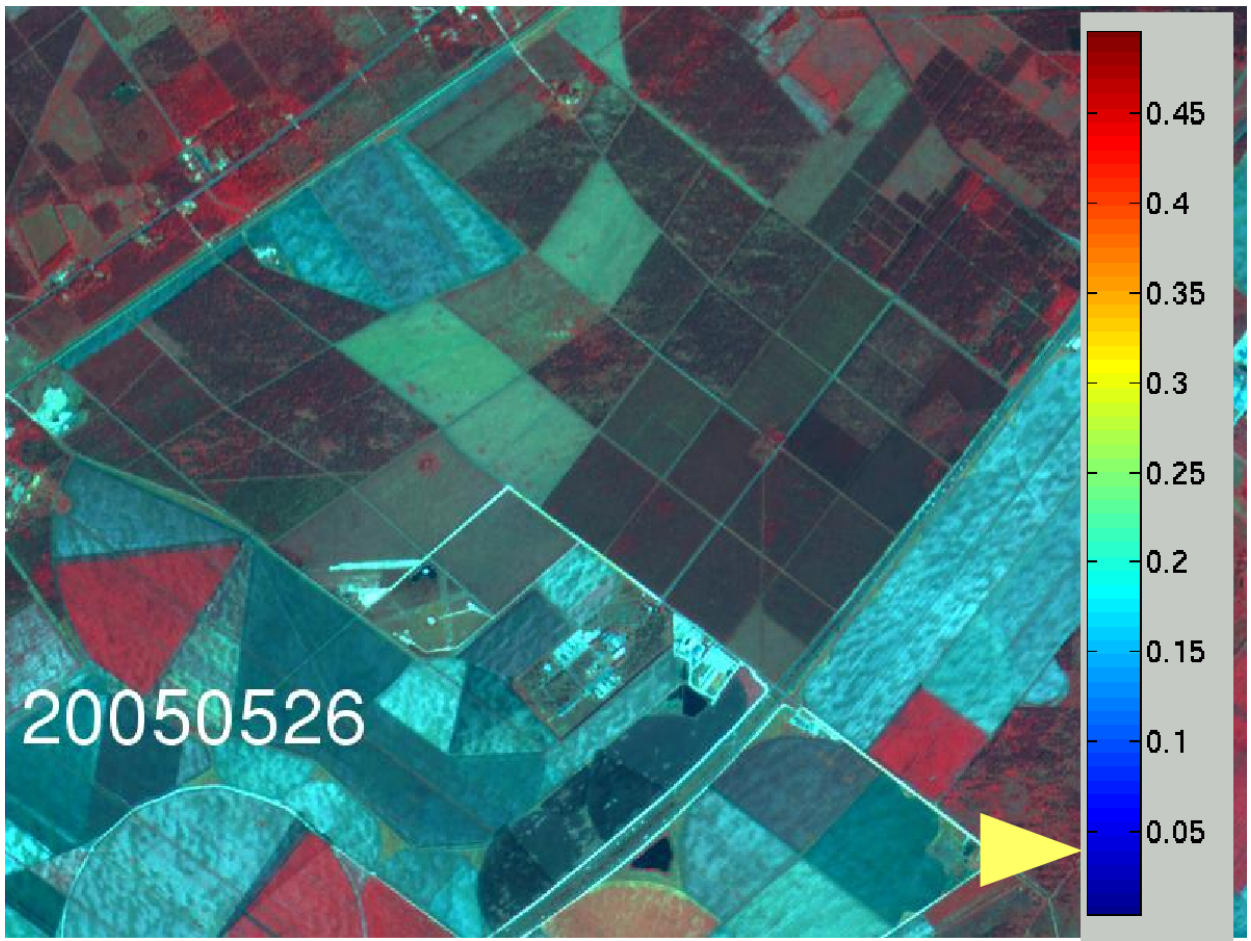

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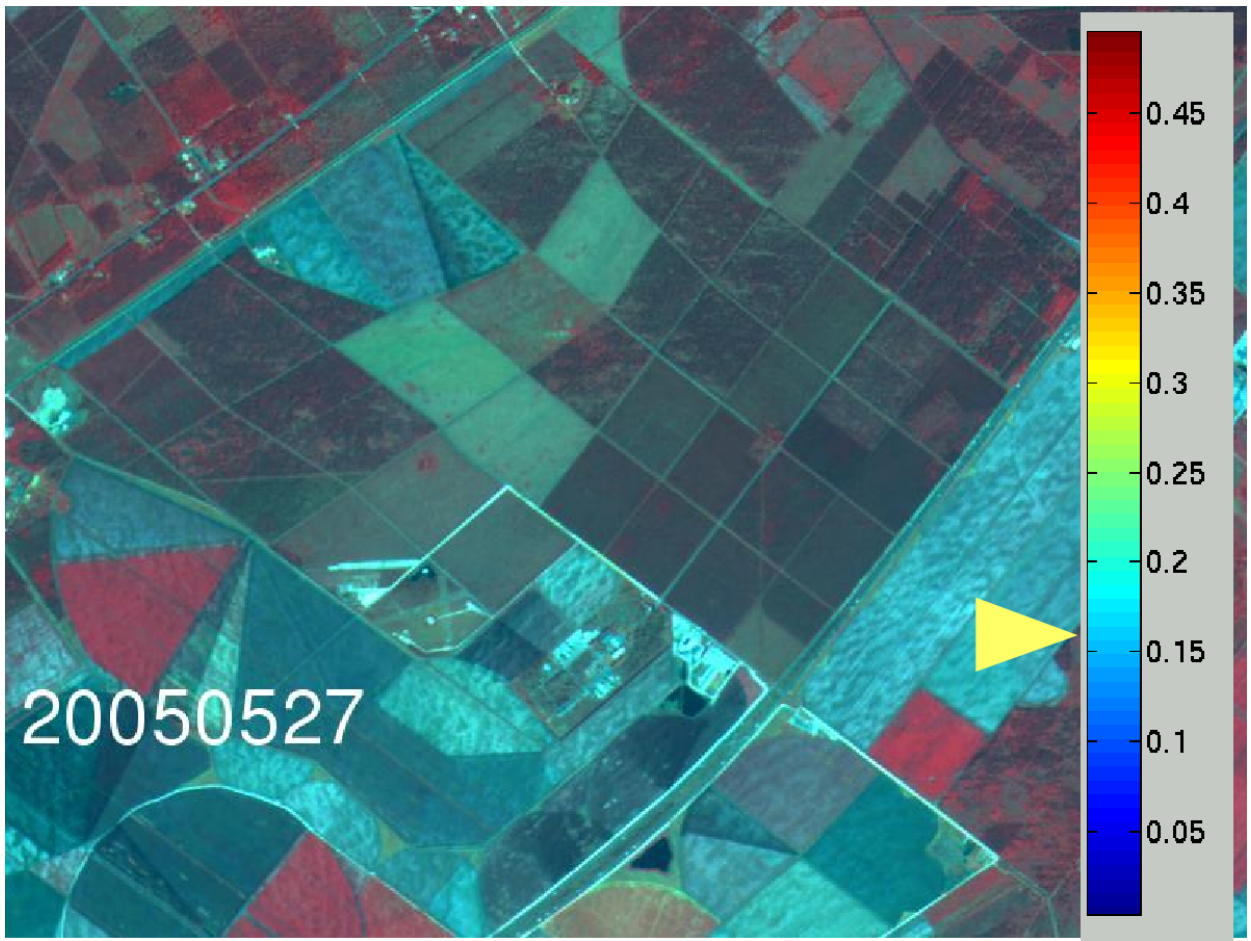

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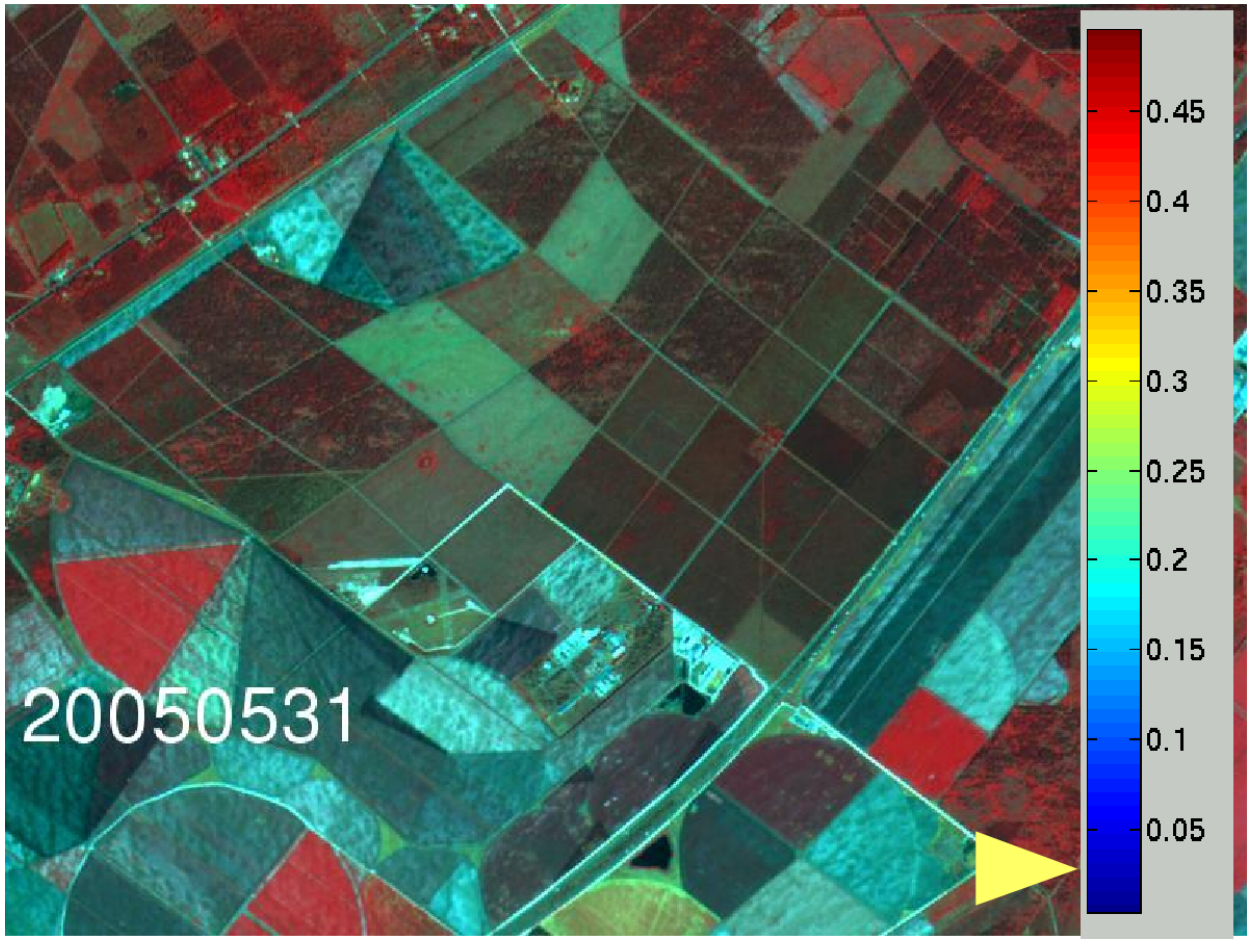

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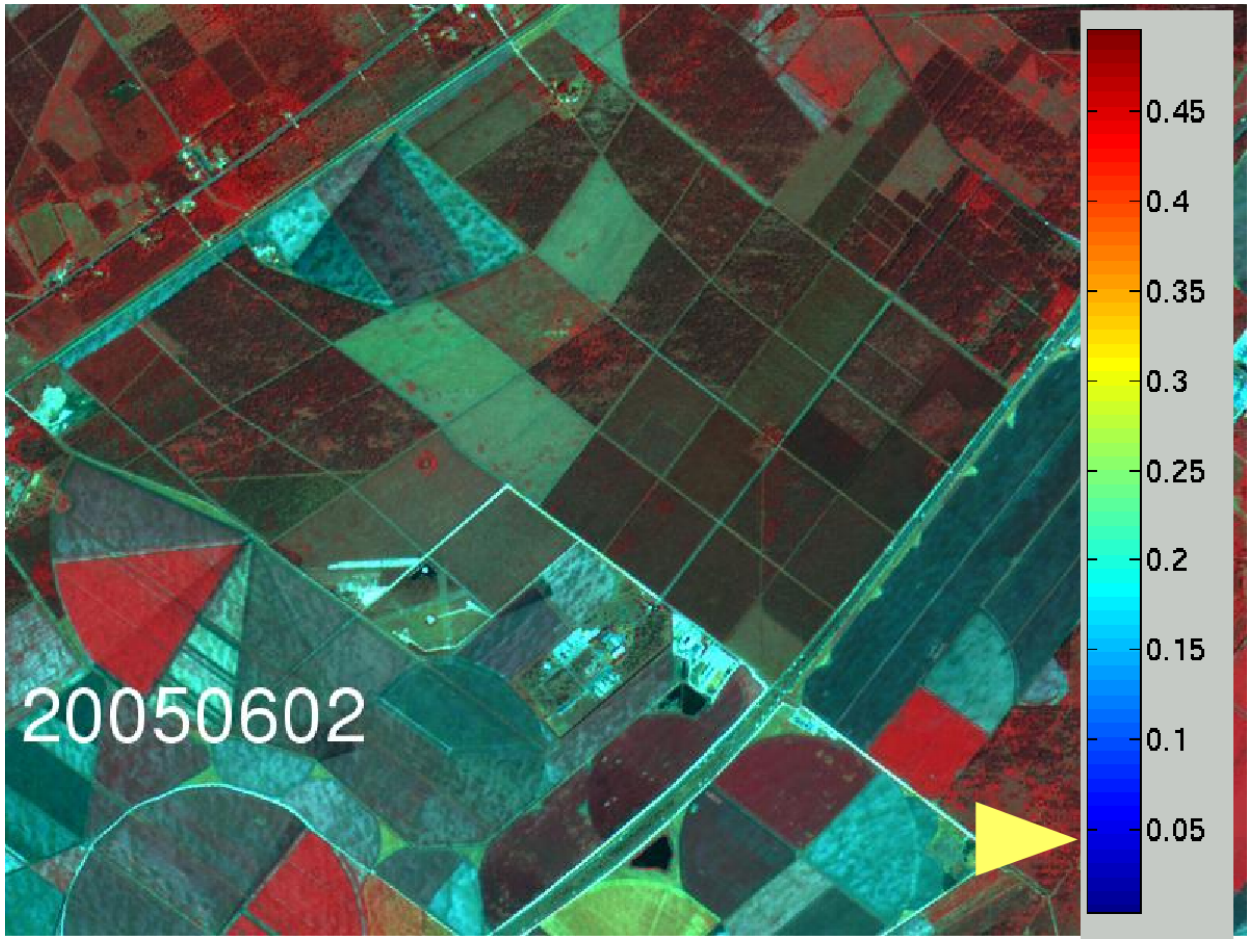

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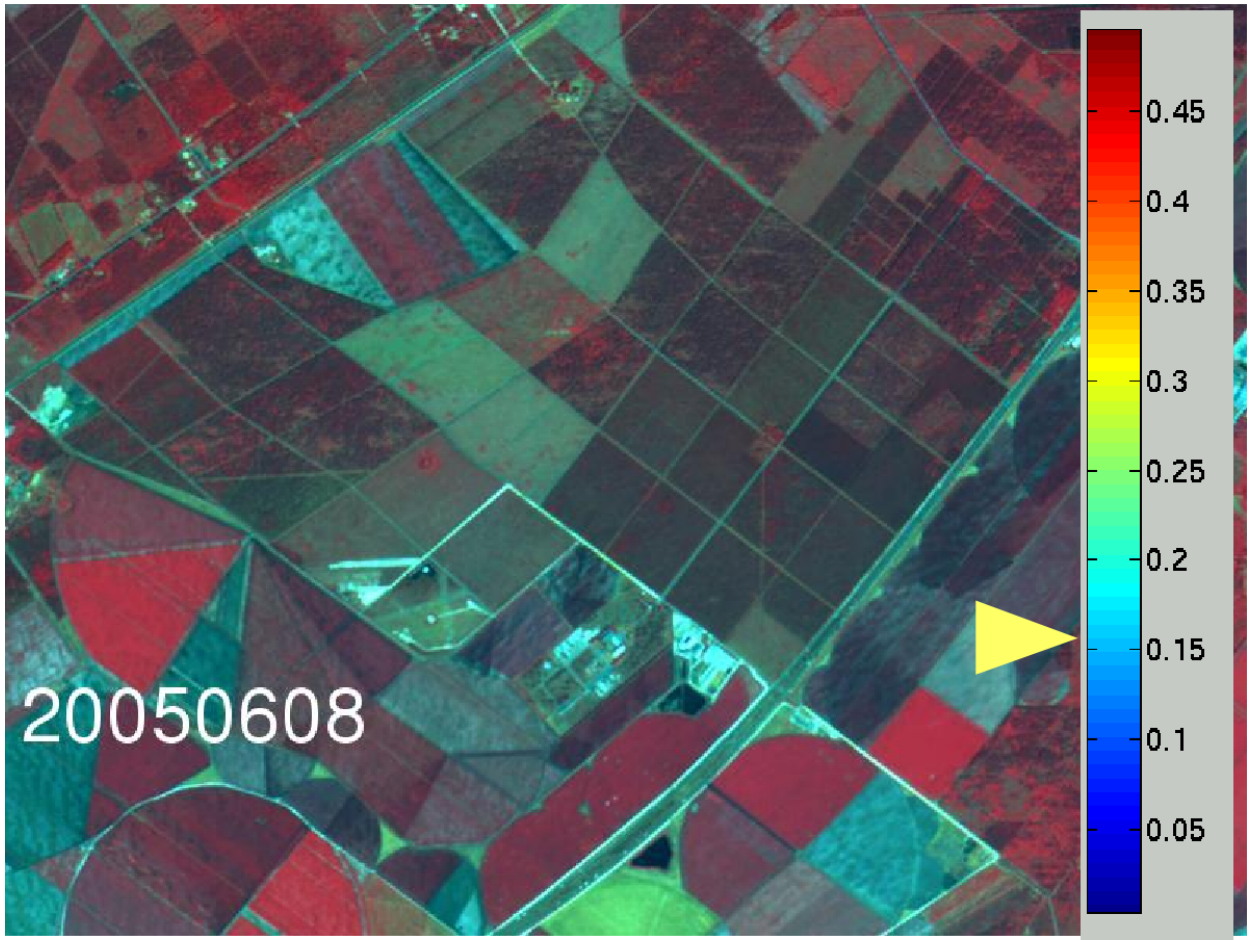

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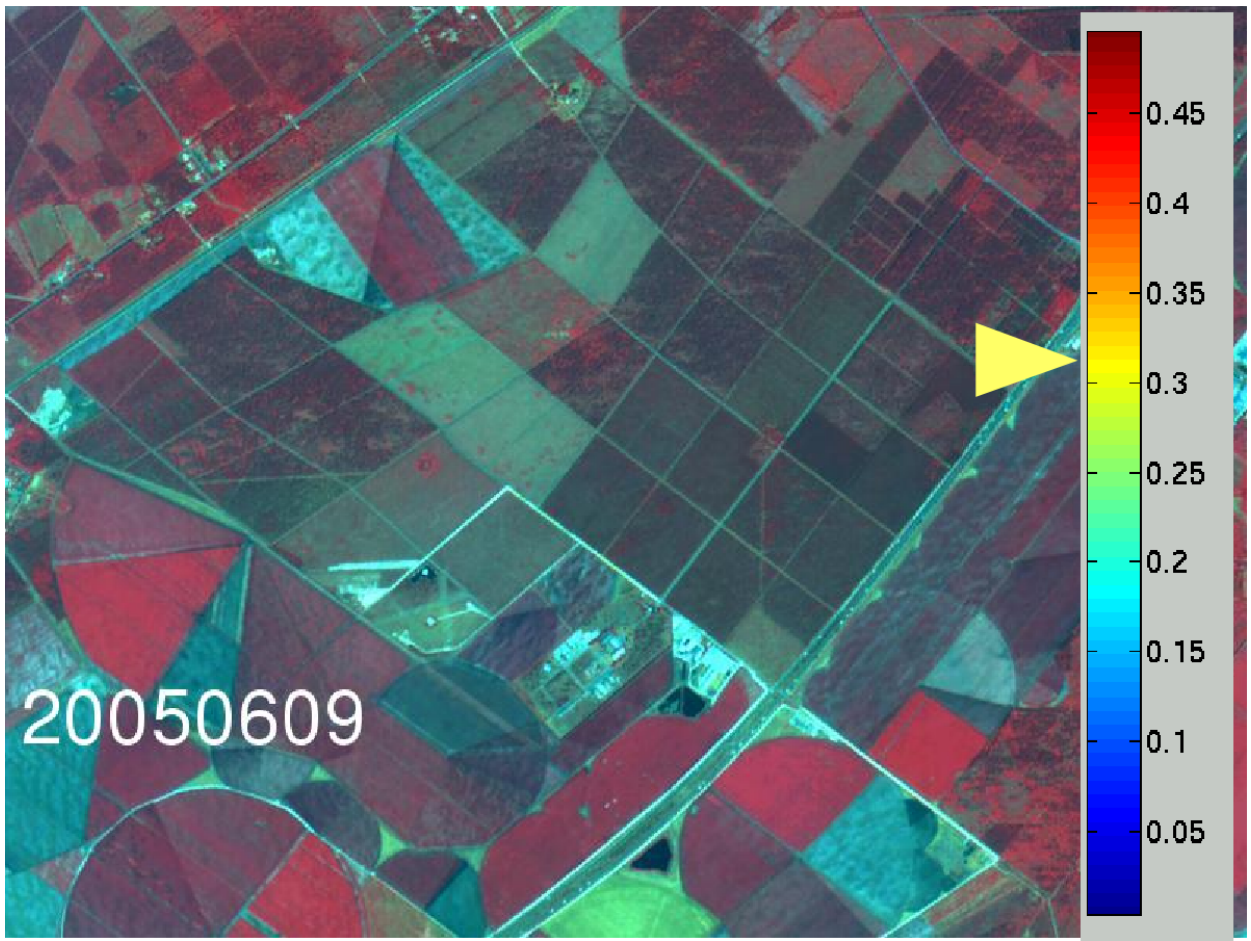

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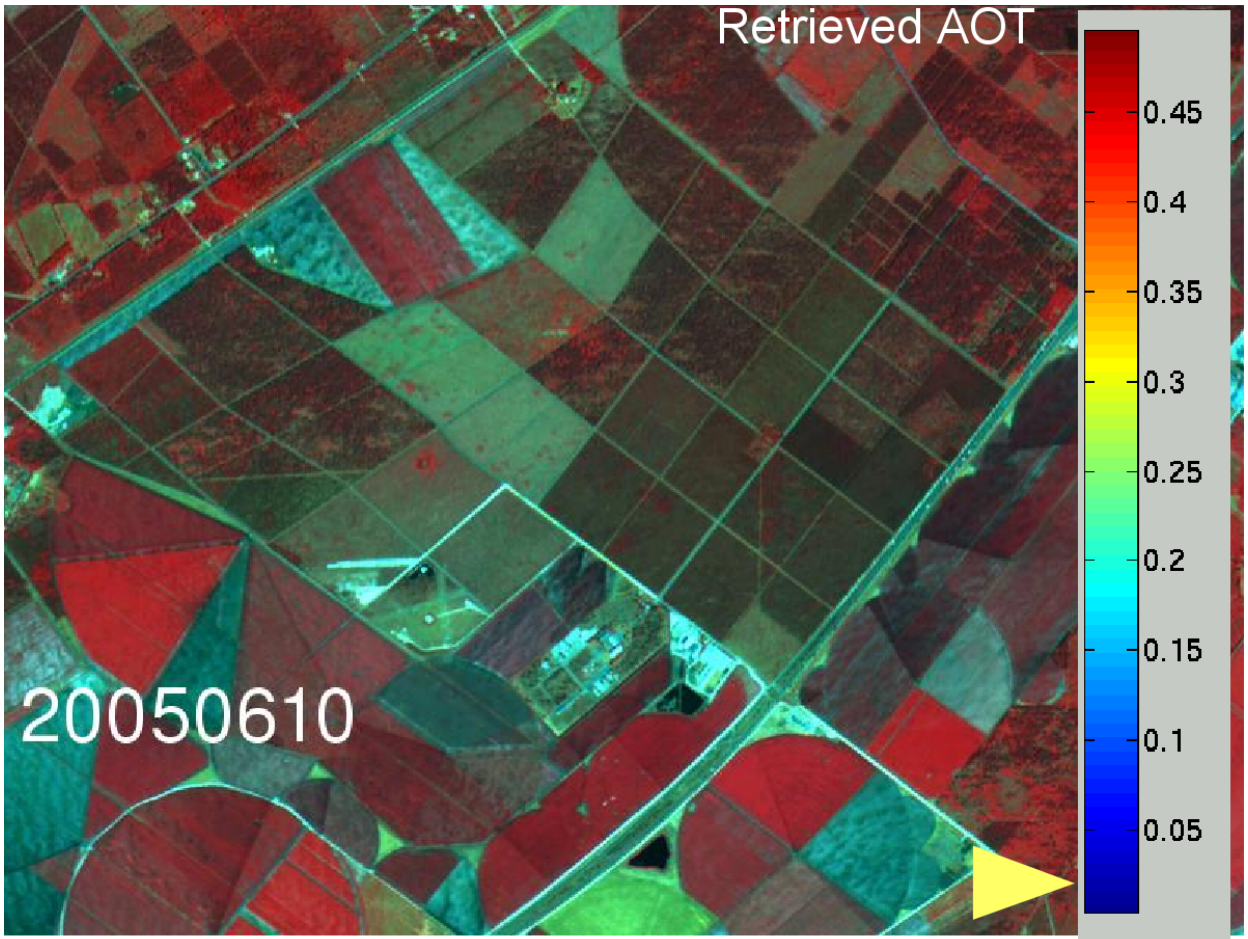

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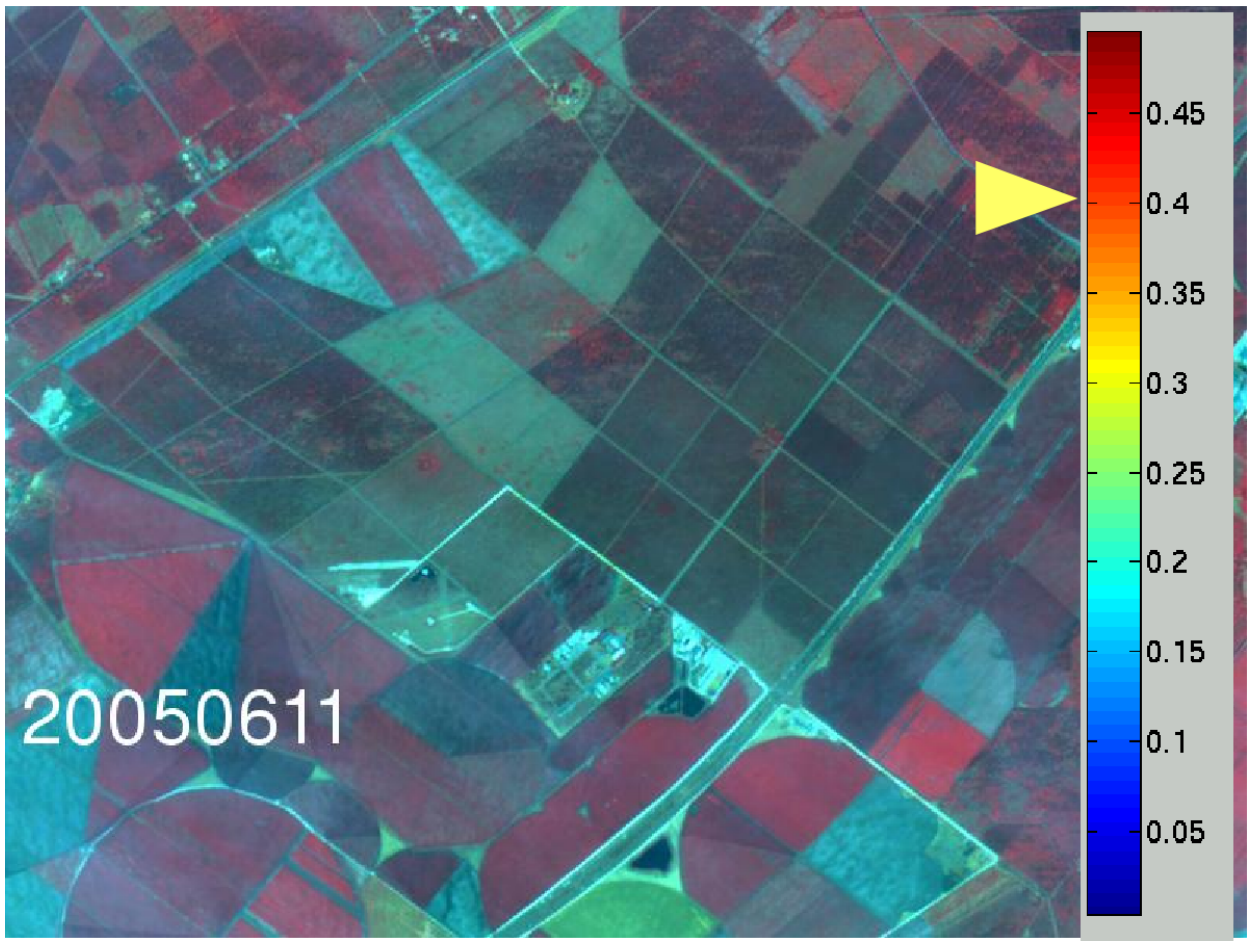

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4. How to take into account existing **prior knowledge**, as for instance the crop rotation practices in agricultural areas?

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Spectral descriptors

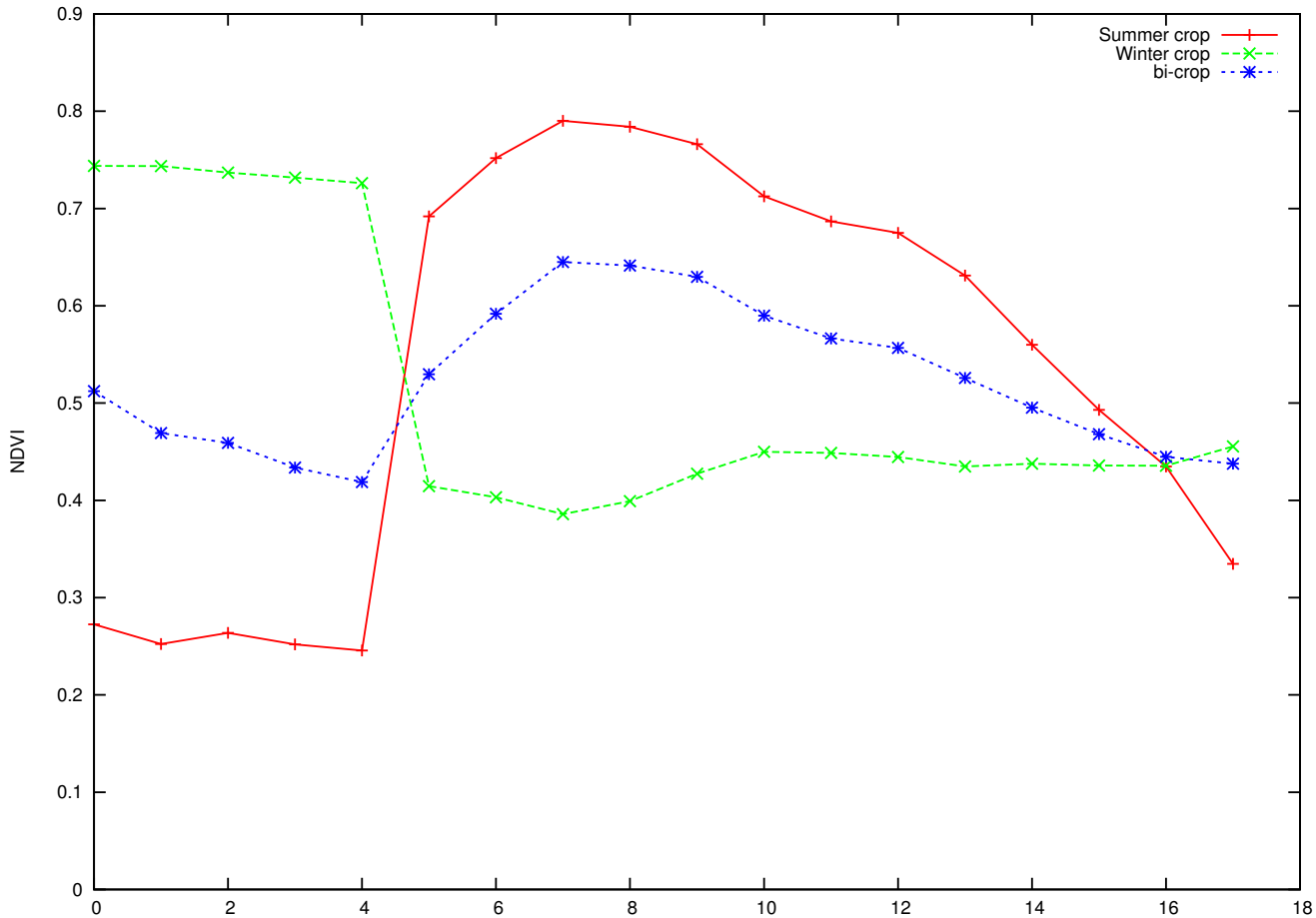
Can be used for preliminary classification:

- Brightness $= \frac{1}{8}(TM1 + TM2 + 2 * TM3 + 2 * TM4 + TM5 + TM7)$
- Visible $= \frac{1}{3}(TM1 + TM2 + TM3)$
- NDVI
- NDBSI $= \frac{(TM5 - TM4)}{(TM5 + TM4)}$ for bare soils
- BIO $= \frac{((TM5 + TM3) - (TM4 + TM1))}{((TM5 + TM3) + (TM4 + TM1))}$ for forests
- NDSI $= \frac{(TM2 - TM5)}{(TM2 + TM5)}$ for snow
- NDBBBI $= \frac{(TM1 - TM5)}{(TM1 + TM5)}$ for bare soil and built up

Baraldi, A.; Puzzolo, V.; Blonda, P.; Bruzzone, L.; Tarantino, C.; , "Automatic Spectral Rule-Based Preliminary Mapping of Calibrated Landsat TM and ETM+ Images," Geoscience and Remote Sensing, IEEE Transactions on , vol.44, no.9, pp.2563-2586, Sept. 2006

Temporal descriptors

NDVI time profiles



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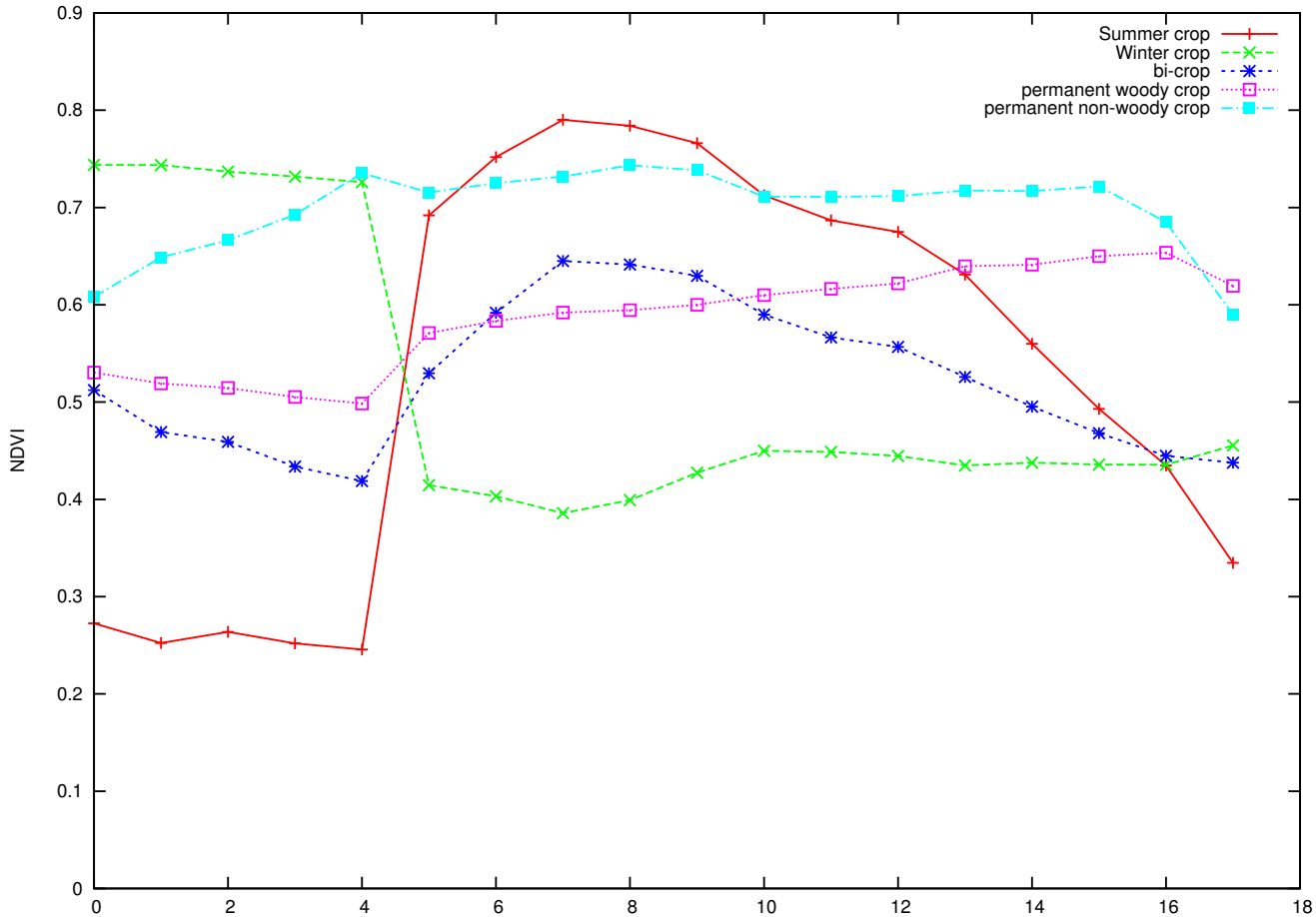

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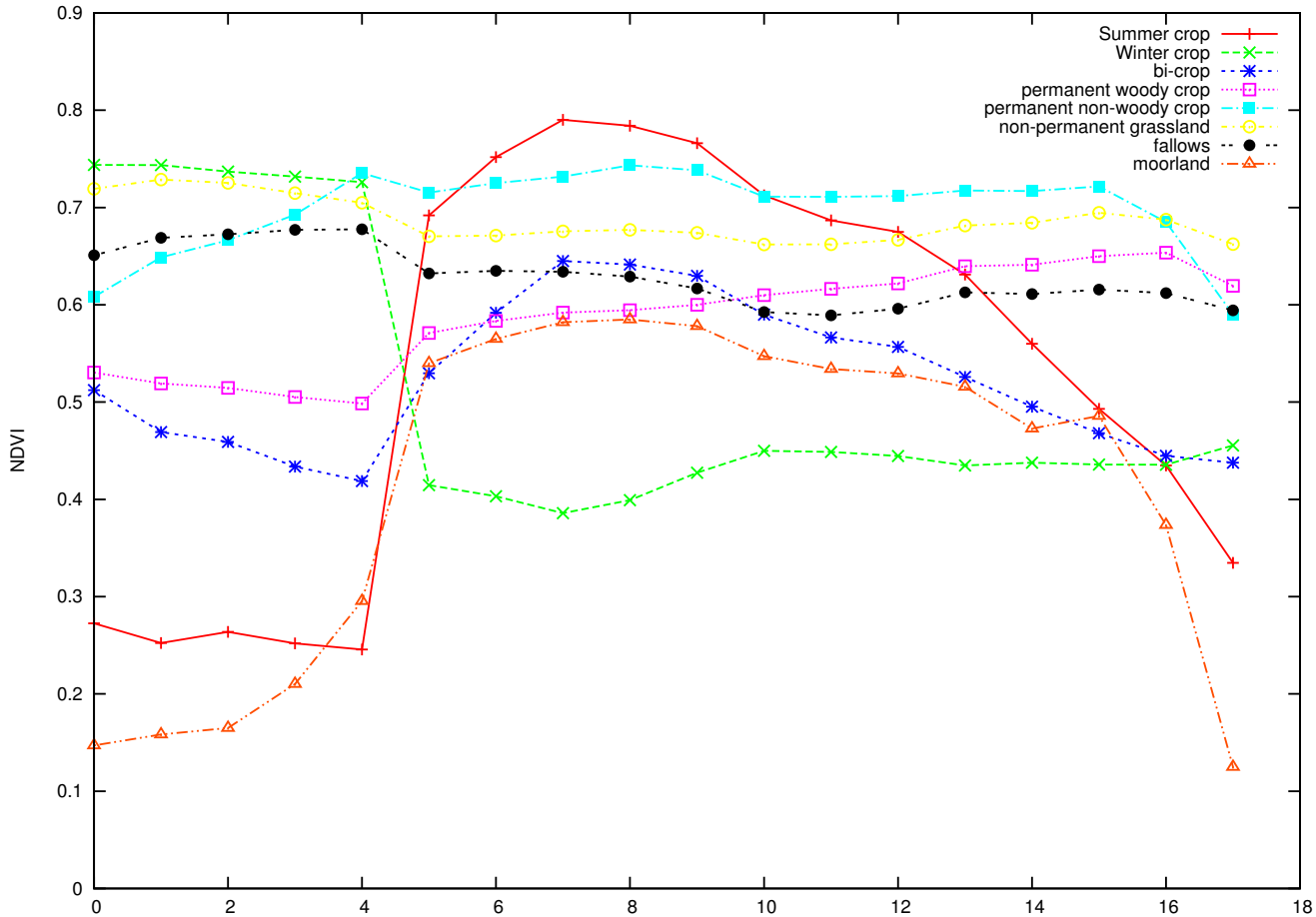

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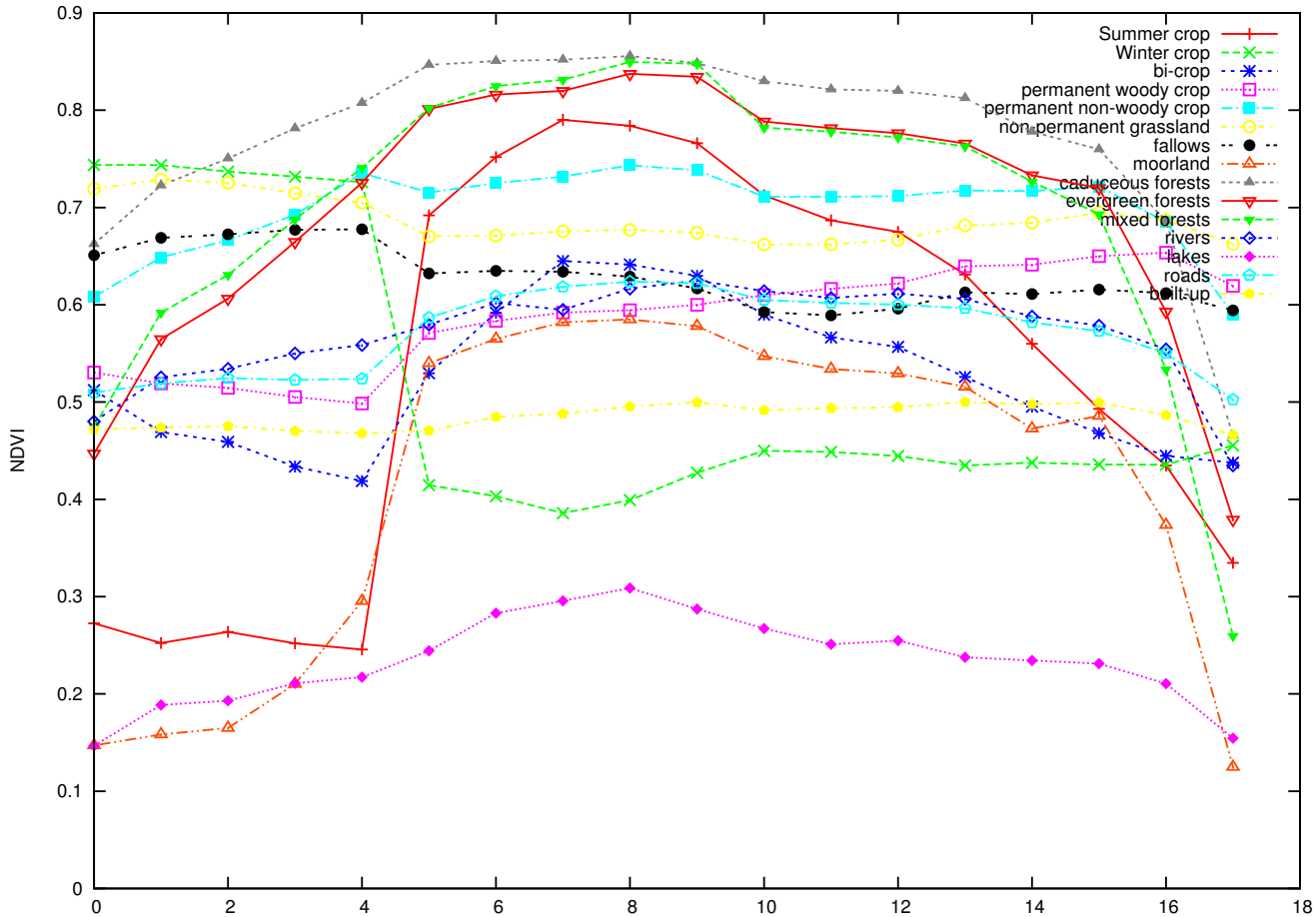

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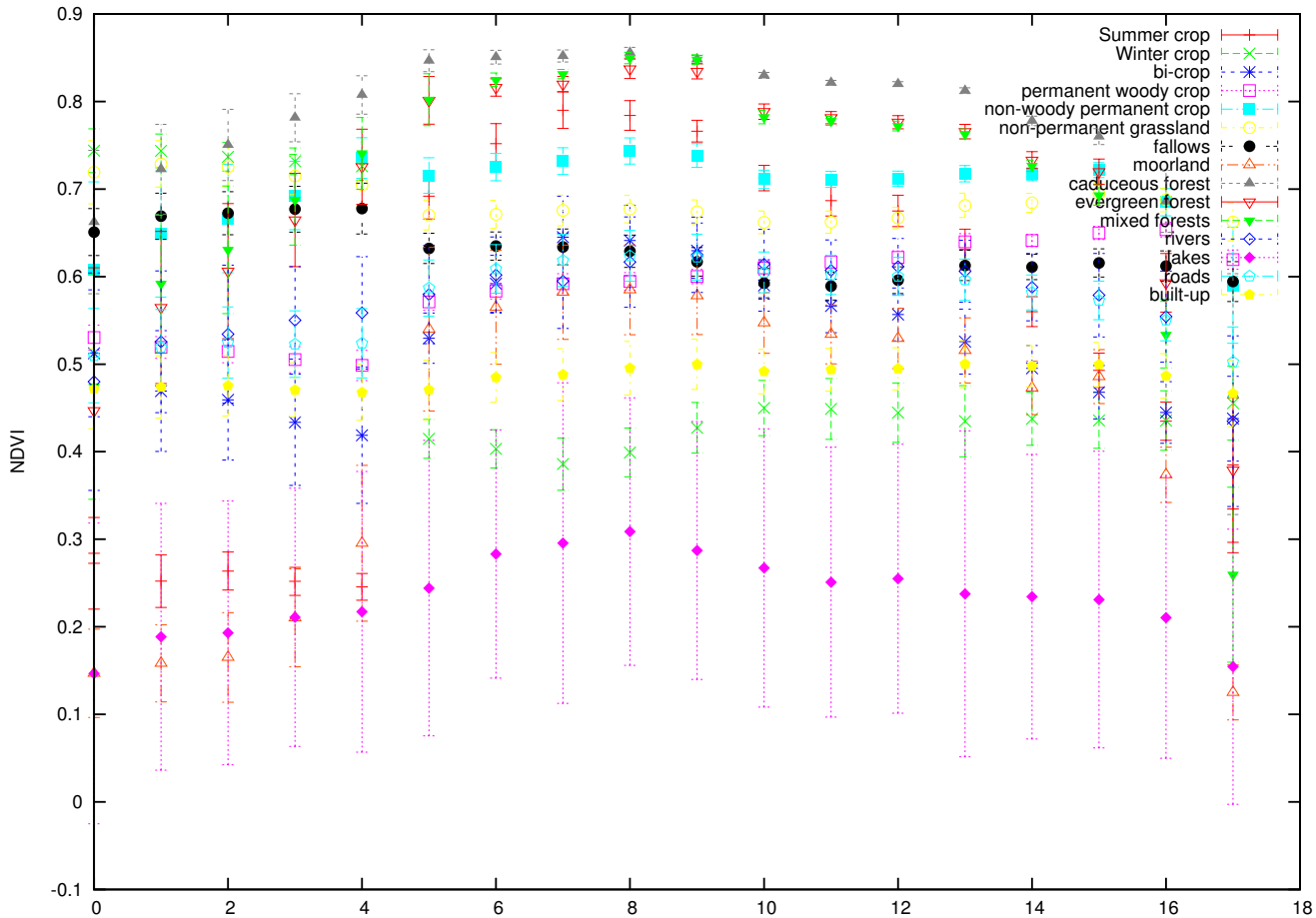

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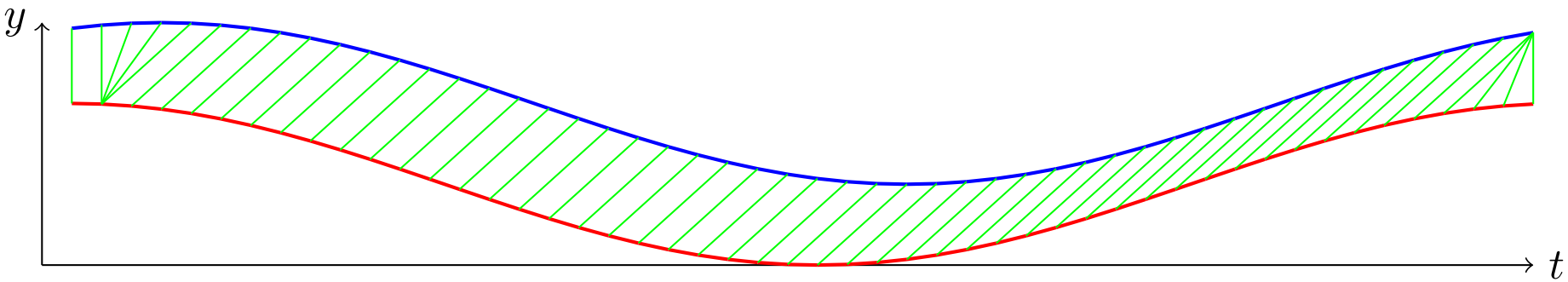
- Generic descriptors which can be compared across geographical areas and temporal periods

Multi-annual comparisons



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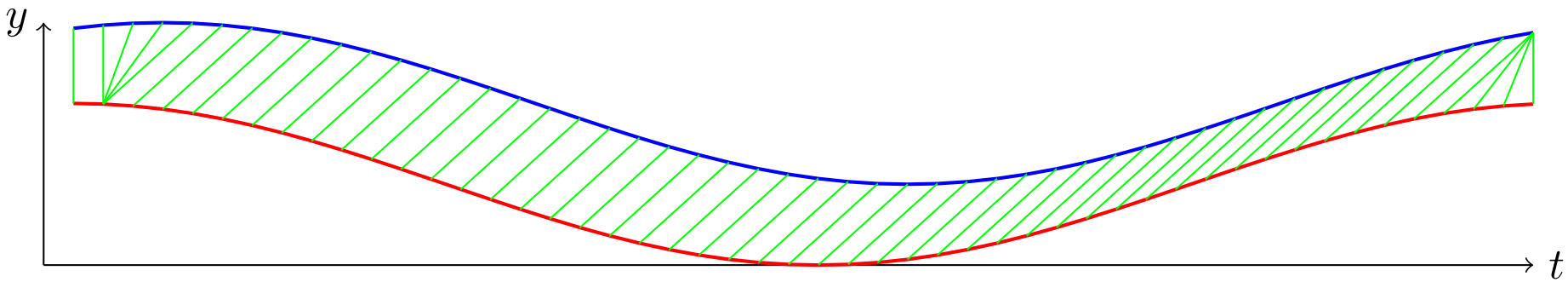

$$D(A_i, B_j) = \delta(a_i, b_j) + \min \begin{cases} D(A_{i-1}, B_{j-1}), \\ D(A_i, B_{j-1}), \\ D(A_{i-1}, B_j) \end{cases}$$

Petitjean, F.; Inglada, J.; Gançarski, P.; , "Satellite Image Time Series Analysis Under Time Warping," Geoscience and Remote Sensing, IEEE Transactions on , in press. doi: 10.1109/TGRS.2011.2179050 URL: http://ieeexplore.ieee.org/stamp/stamp.jsp?tp=arnumber=6144005isnumber=4358825

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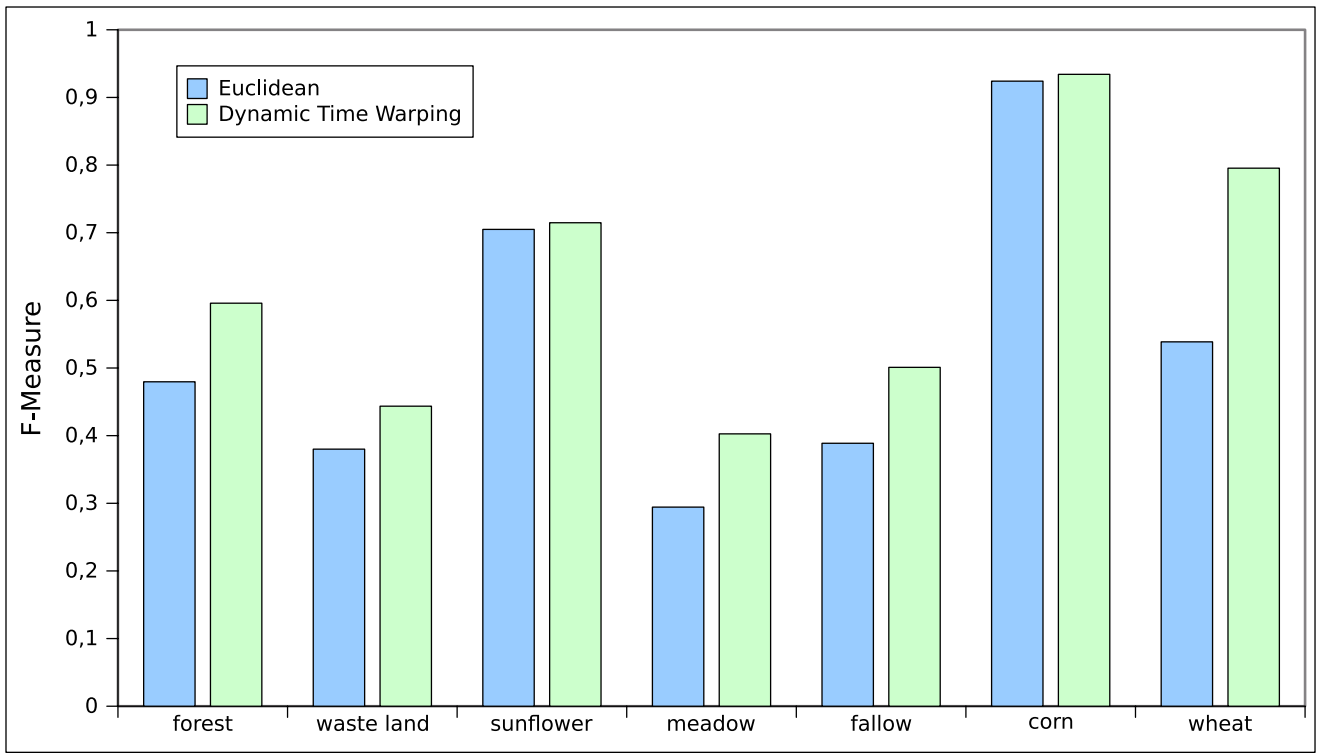

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- Use ancillary data for stratified sampling

'SAMPLING STRATEGIES FOR UNSUPERVISED CLASSIFICATION OF MULTITEMPORAL HIGH RESOLUTION OPTICAL IMAGES OVER VERY LARGE AREAS'. Isabel Rodes, Jordi Inglada, Jean-François Dejoux, Olivier Hagolle, Gérard Dedieu. To be presented at IGARSS 2012.

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Qualitative knowledge

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  - crop rotations
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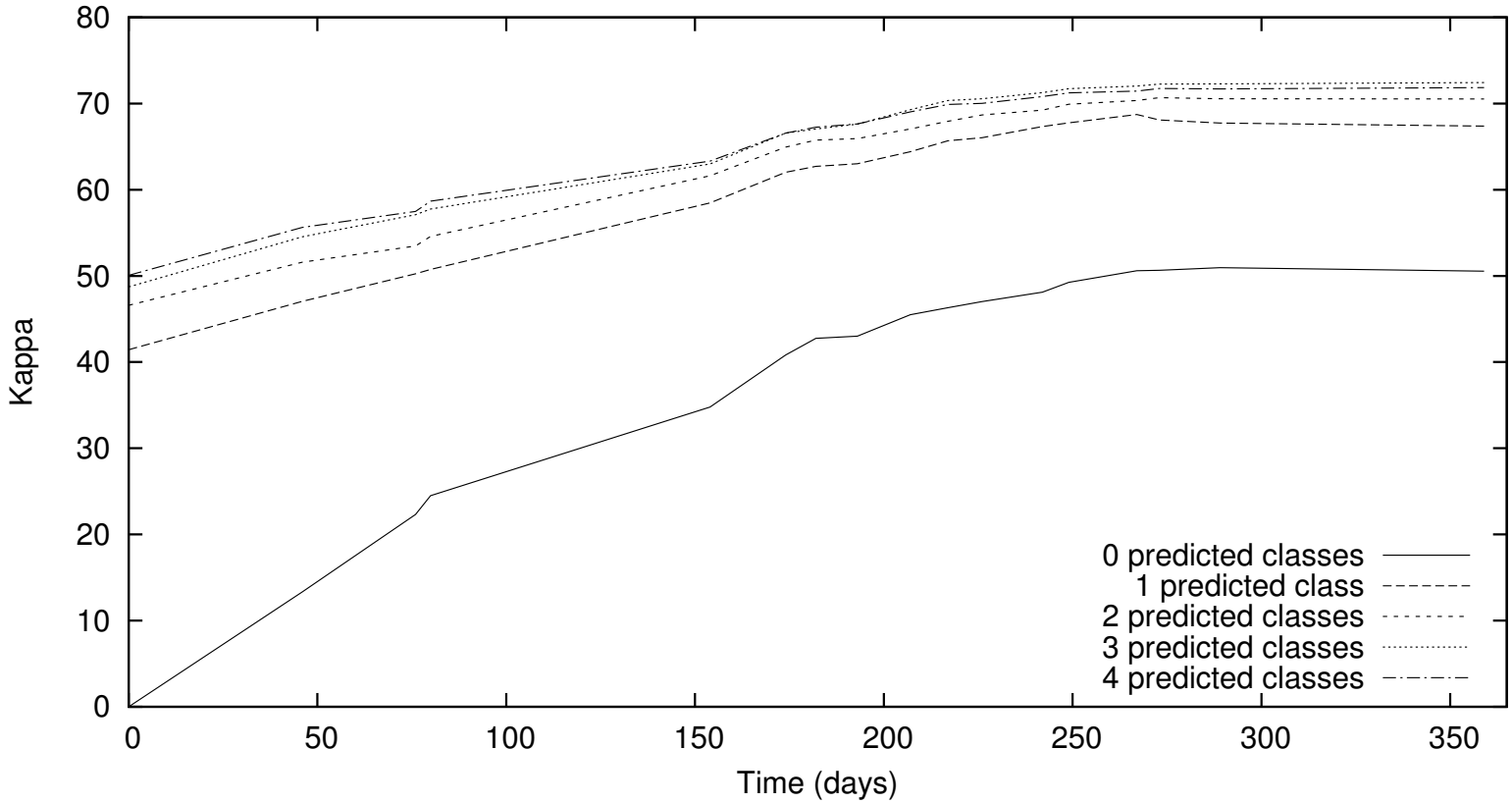
  - crop rotations
  - irrigation
- Legal and economic constraints:
  - inter-crops (nitrate directive),
  - forest fire prevention practices

Quantitative knowledge

- Physical models: Hydro, météo, agri, SVAT, forest, popdyn
- Ancillary data
  - DEM, soil maps,
  - Historical land-cover maps
  - Specific data-bases: crop declarations,

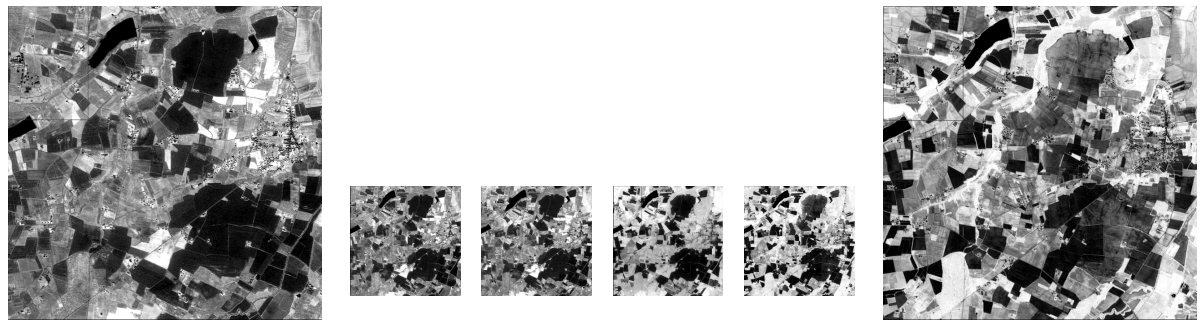
Example: Crop rotations

- Using the knowledge about past seasons in order to predict the most likely crop classes.



Outline

Naive fusion



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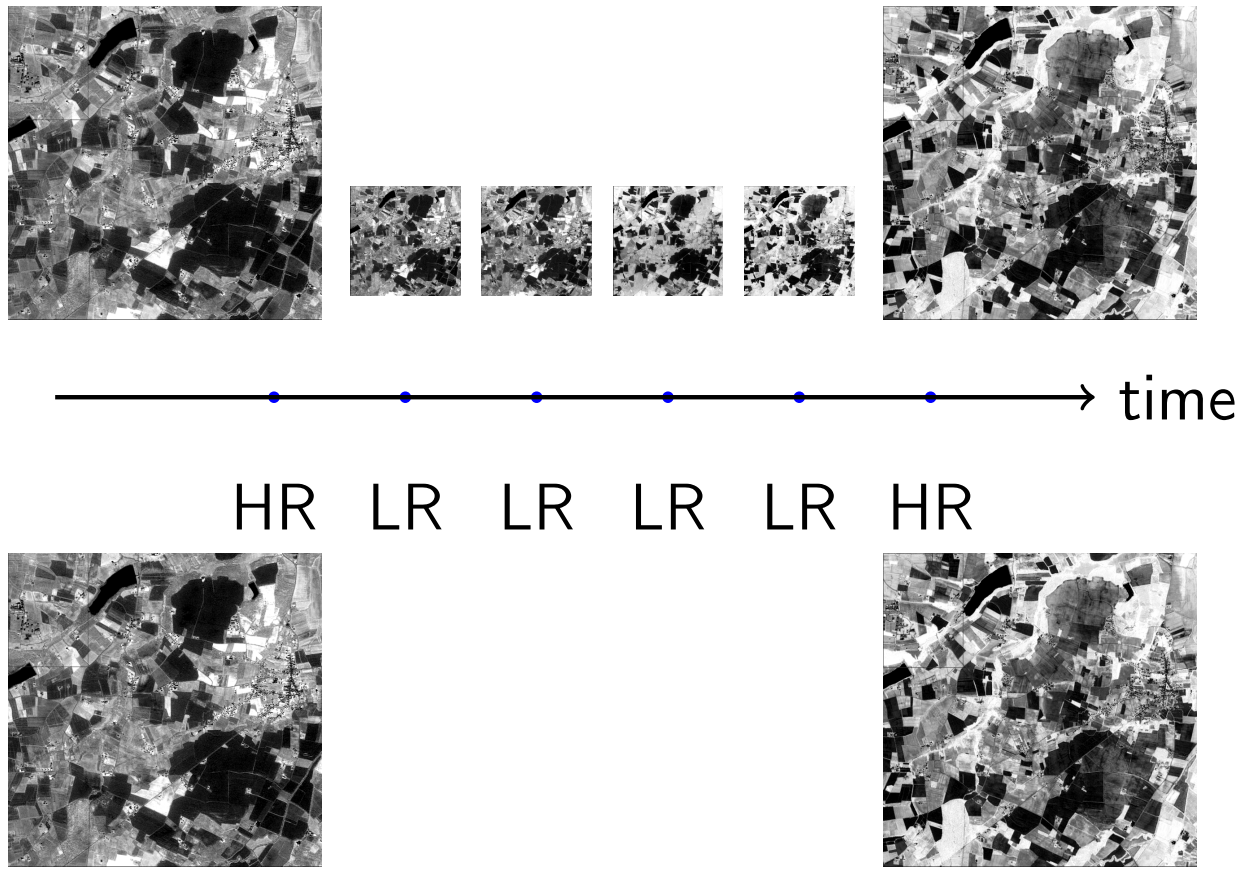
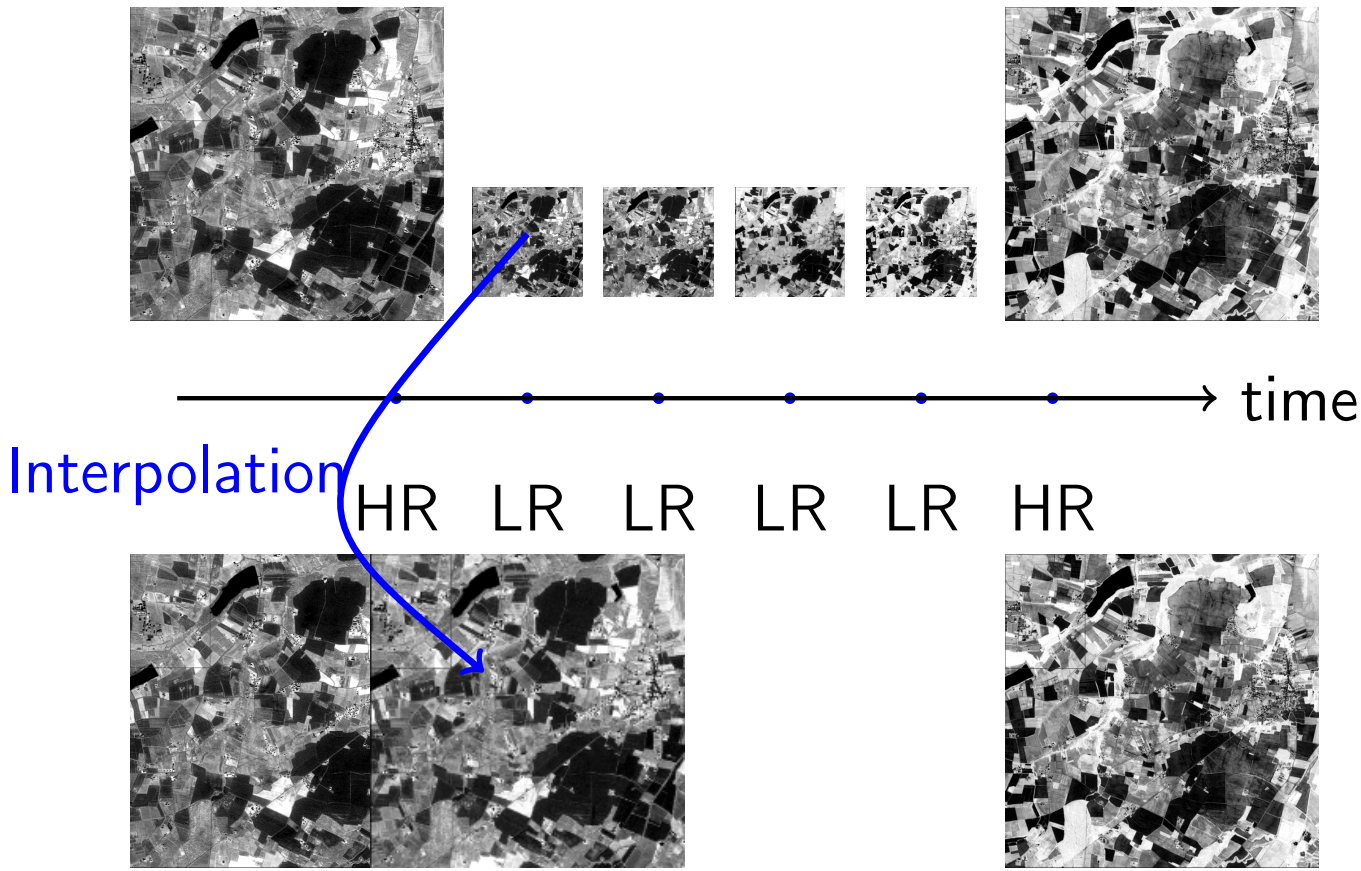


Naive fusion



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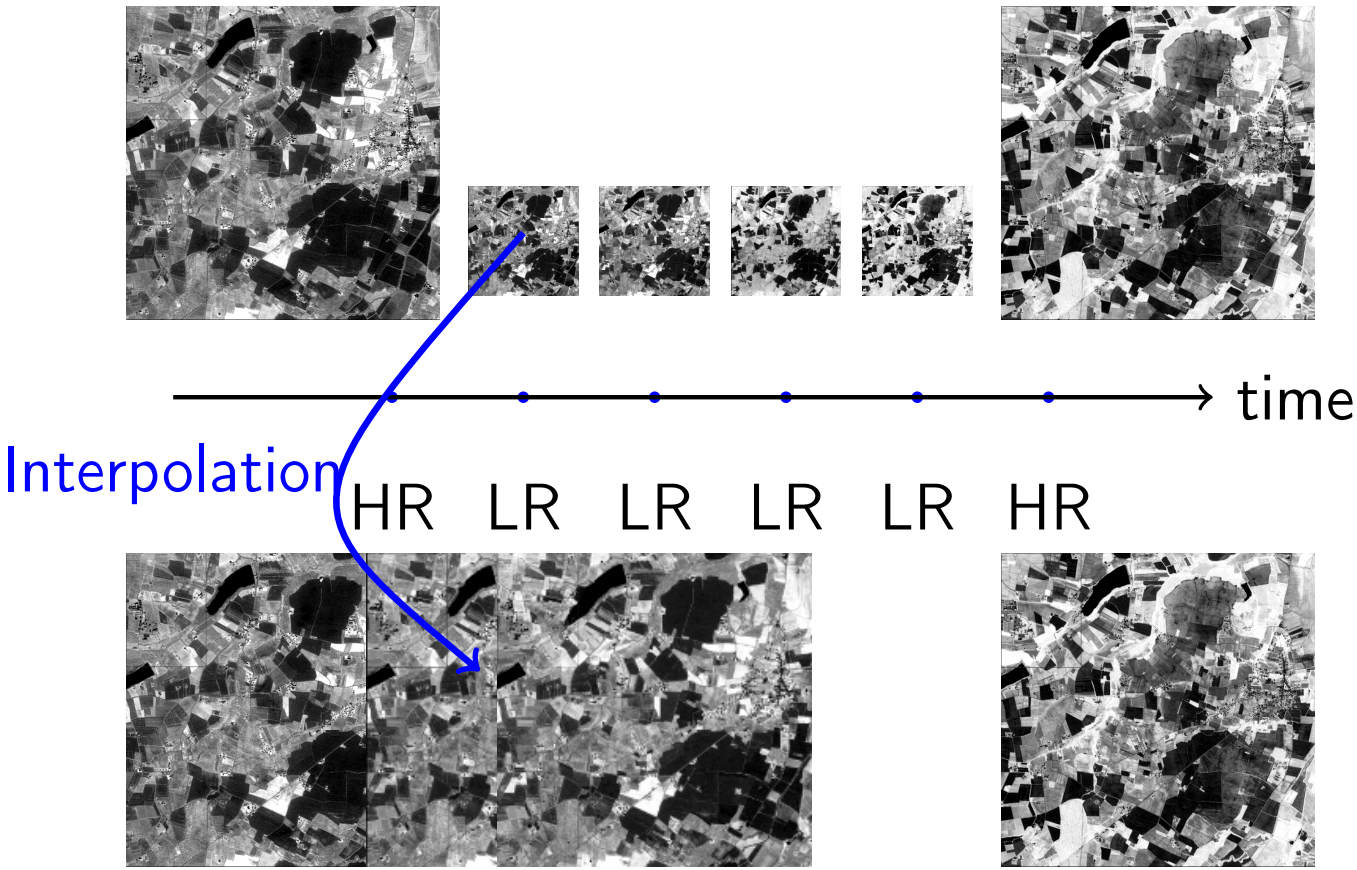

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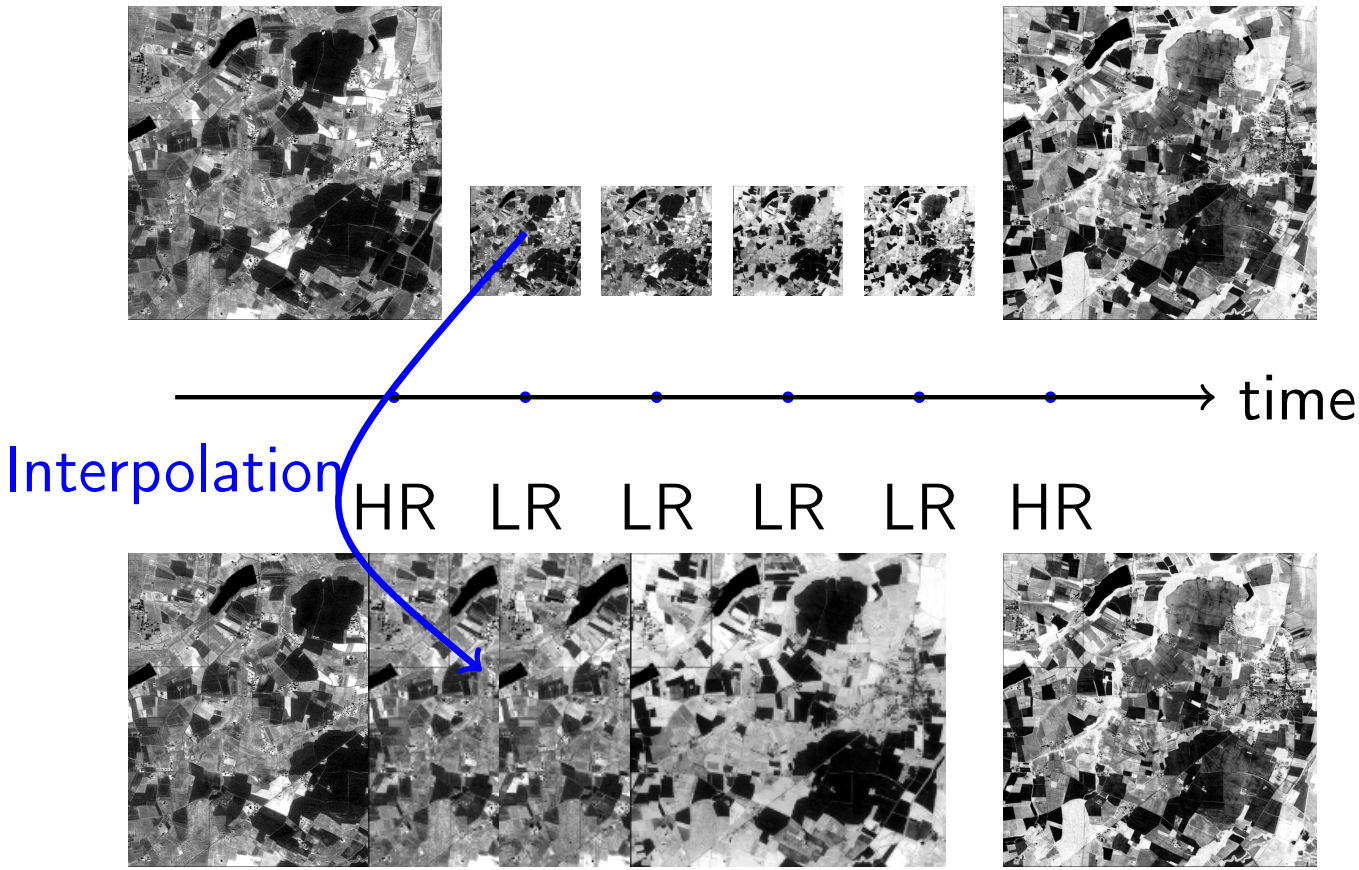

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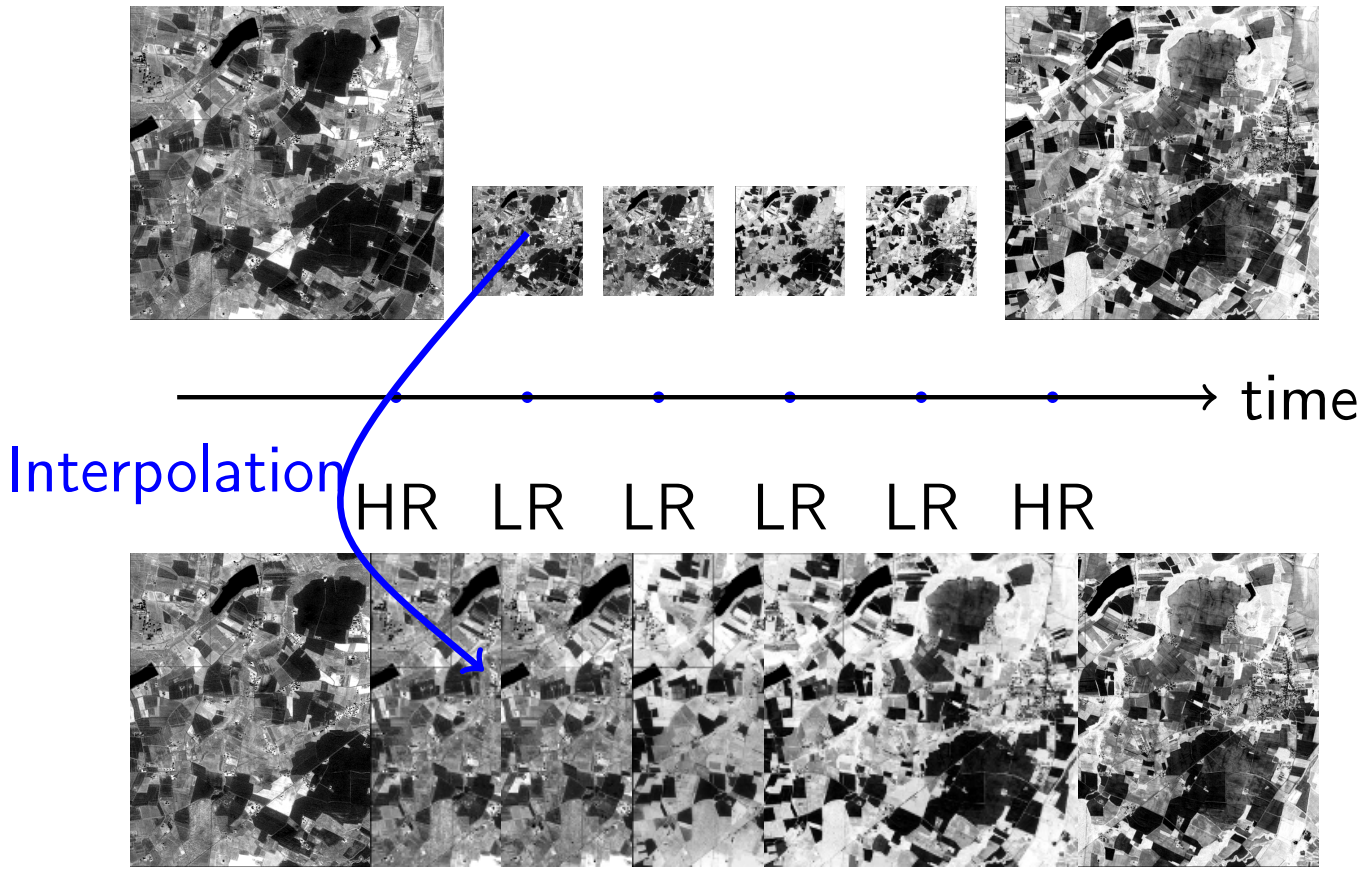
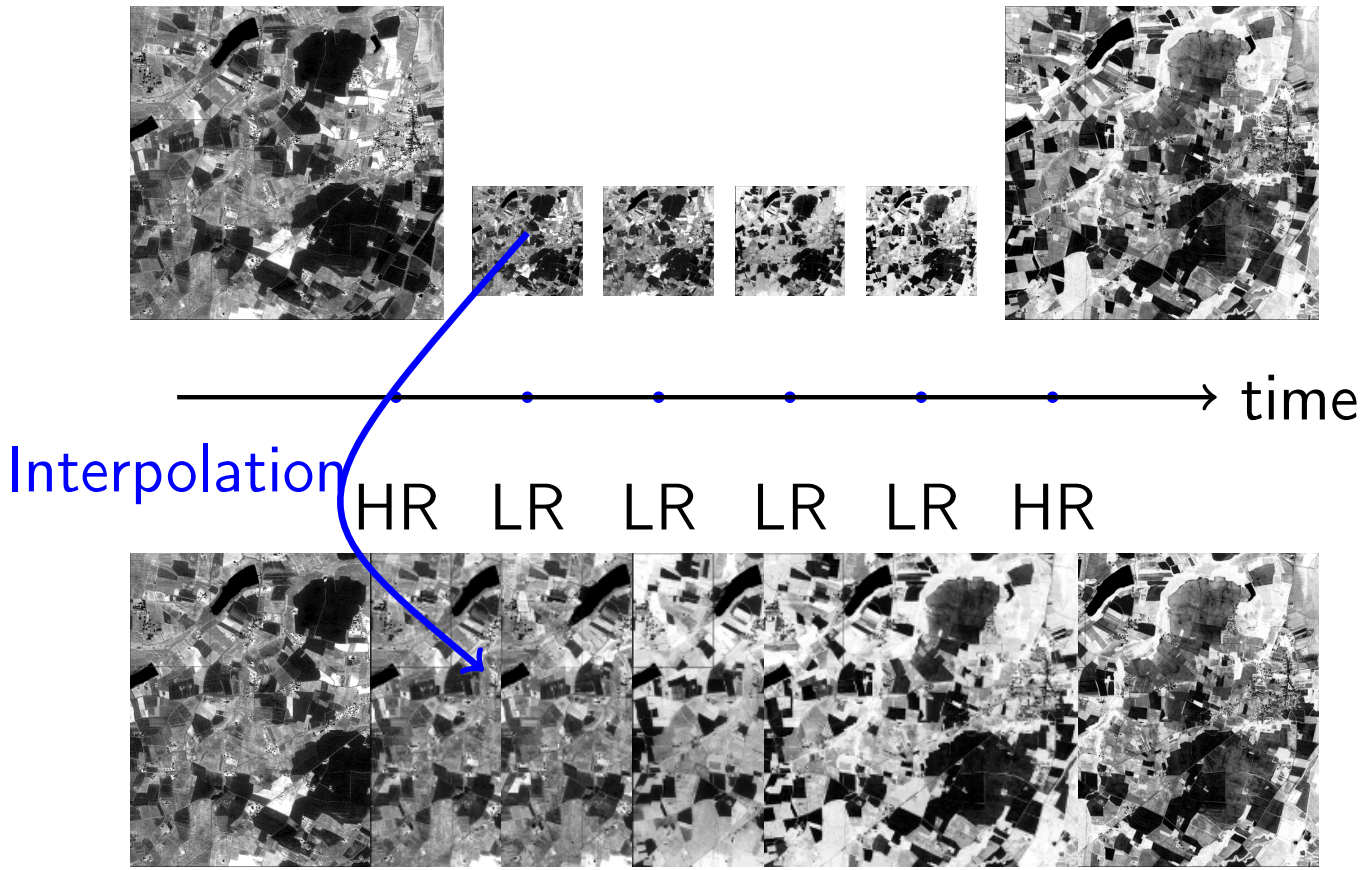


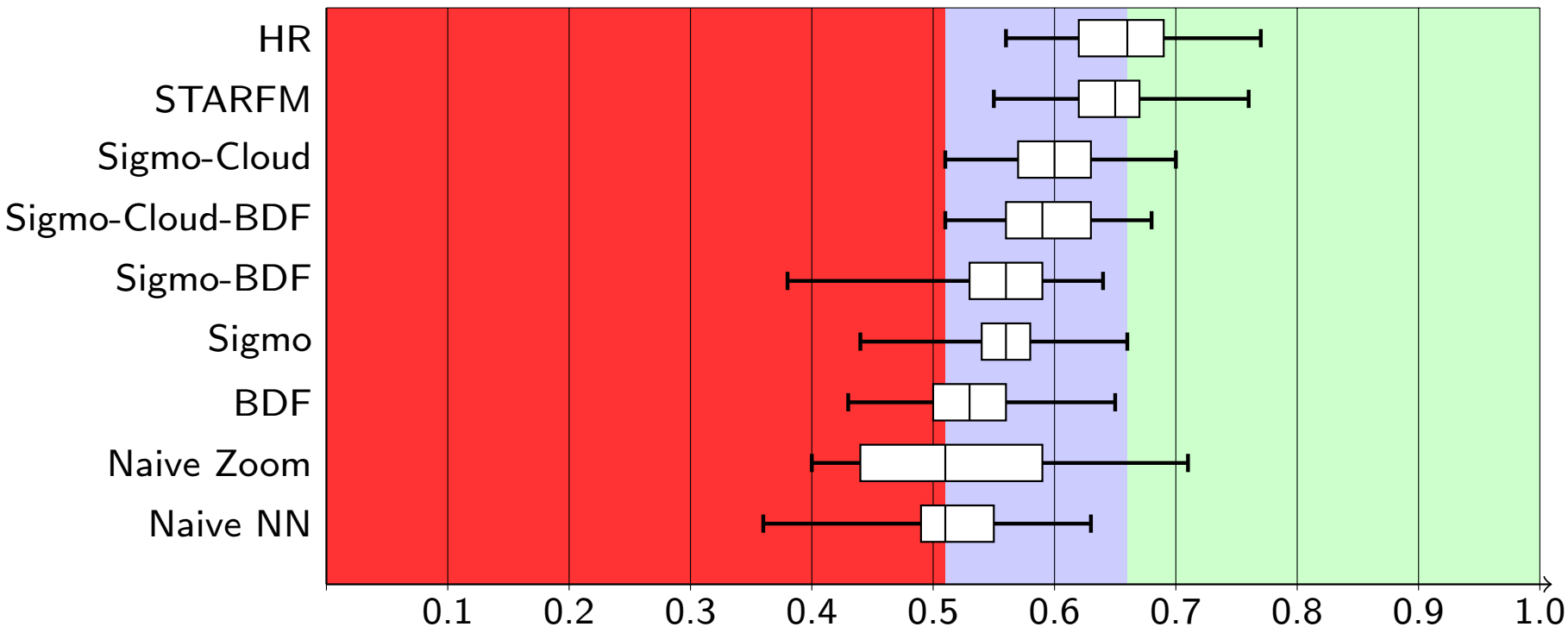
Naive fusion



- Nearest neighbor vs. bi-cubic interpolation

Algorithm comparison

Comparison of the different algorithms using synthetic Sentinel2 (10m) and PROBA-V (330m) images.

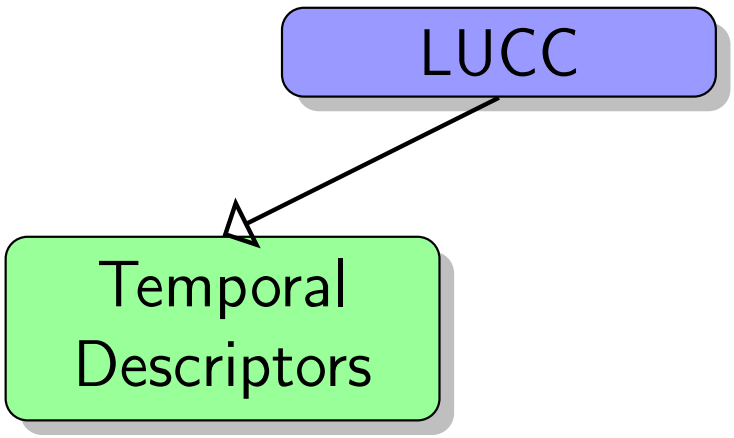


Outline

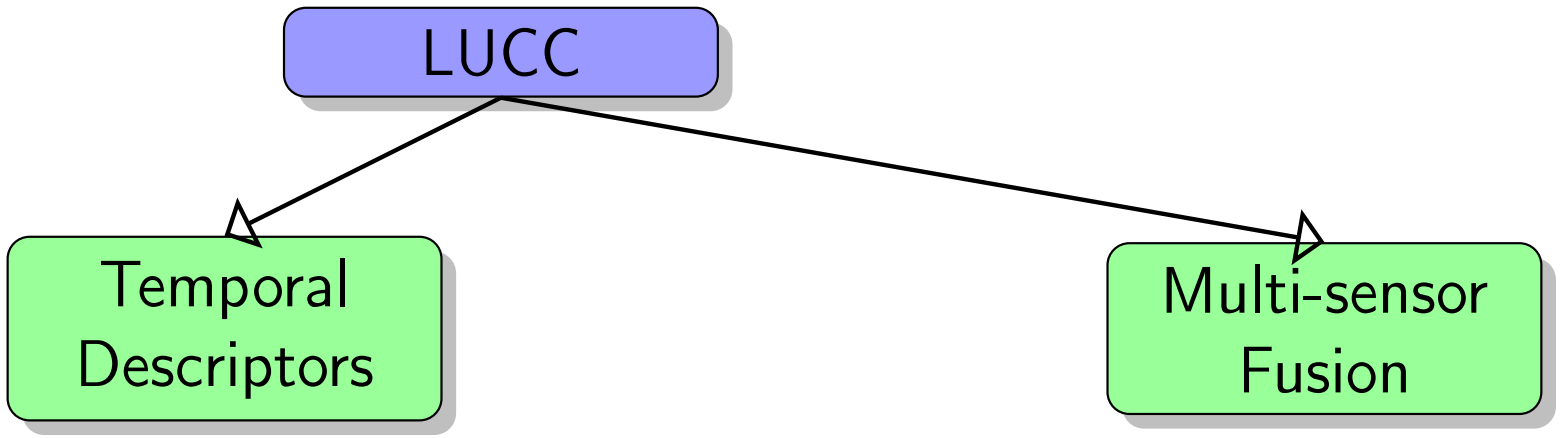
A research program

LUCC

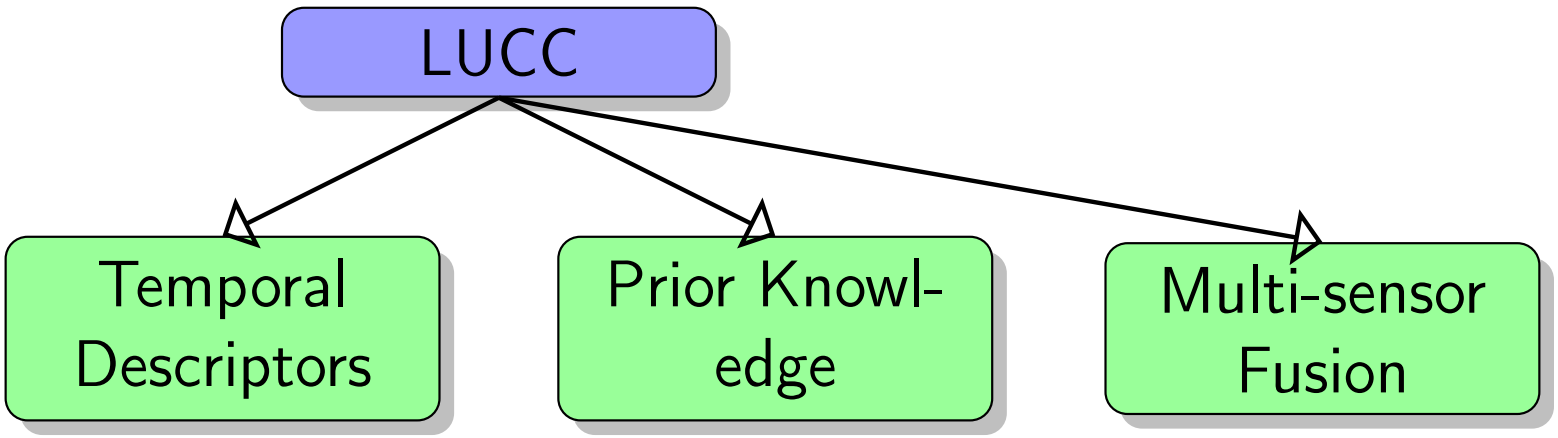
A research program



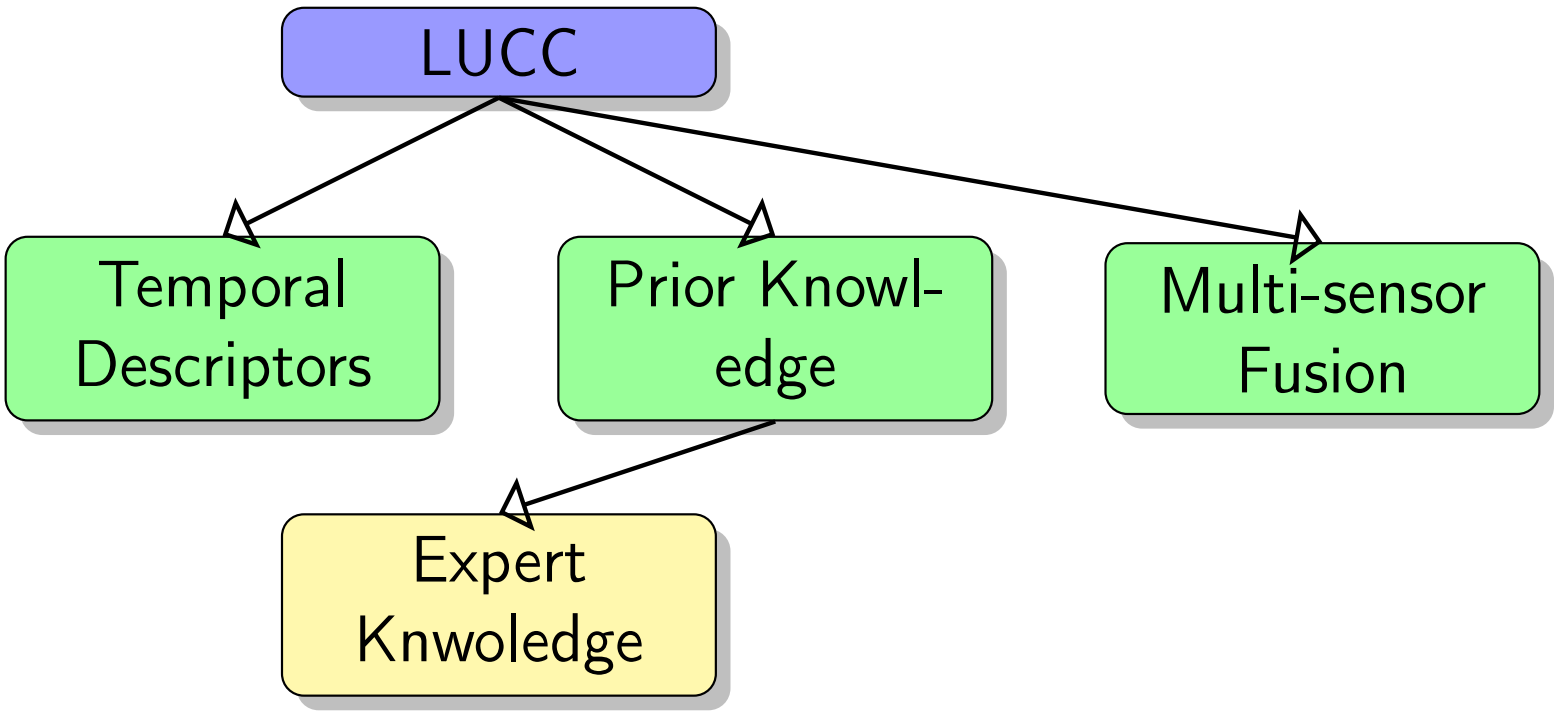
A research program



A research program



A research program



A research program