

Spatial Unmixing of Pixels for More Accurate Displacement Time-Series Obtained with a Small Baseline Strategy: A Case Study in France

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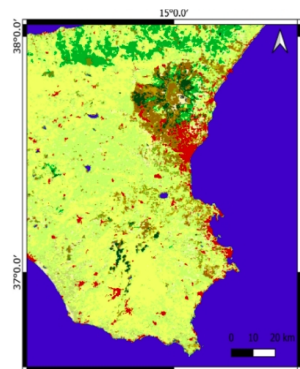
September 12, 2023

FRINGE 2023



Bias on vegetated terrains with SBAS time series

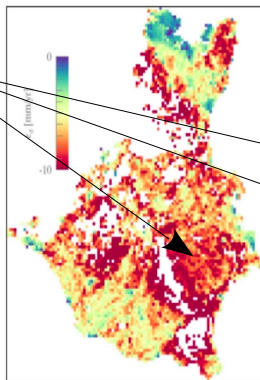
Sicily, Italy



- Rainfed croplands
- Mosaic vegetation/cropland
- Broadleaved deciduous forest
- Needleleaved evergreen forest
- Mosaic grassland/forest or shrubland
- Broadband or needleleaved shrubland
- Herbaceous vegetation
- Sparse vegetation
- Urban areas
- Water bodies

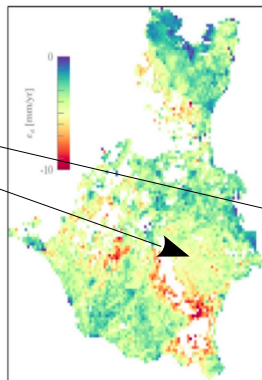
Fading signal

bw=5



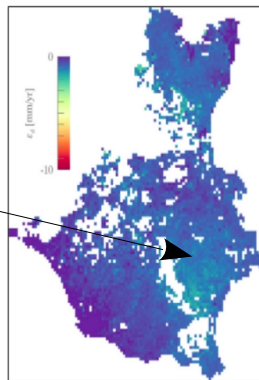
(a)

bw=10



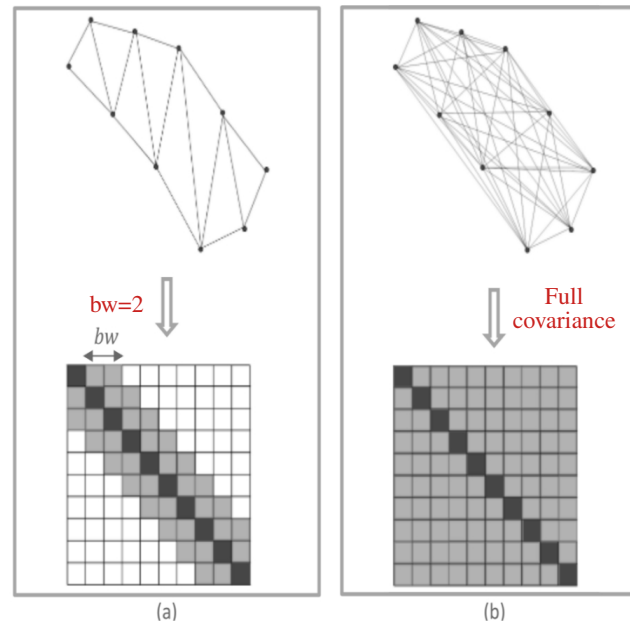
(b)

Full covariance



(c)

Ansari et al., 2021



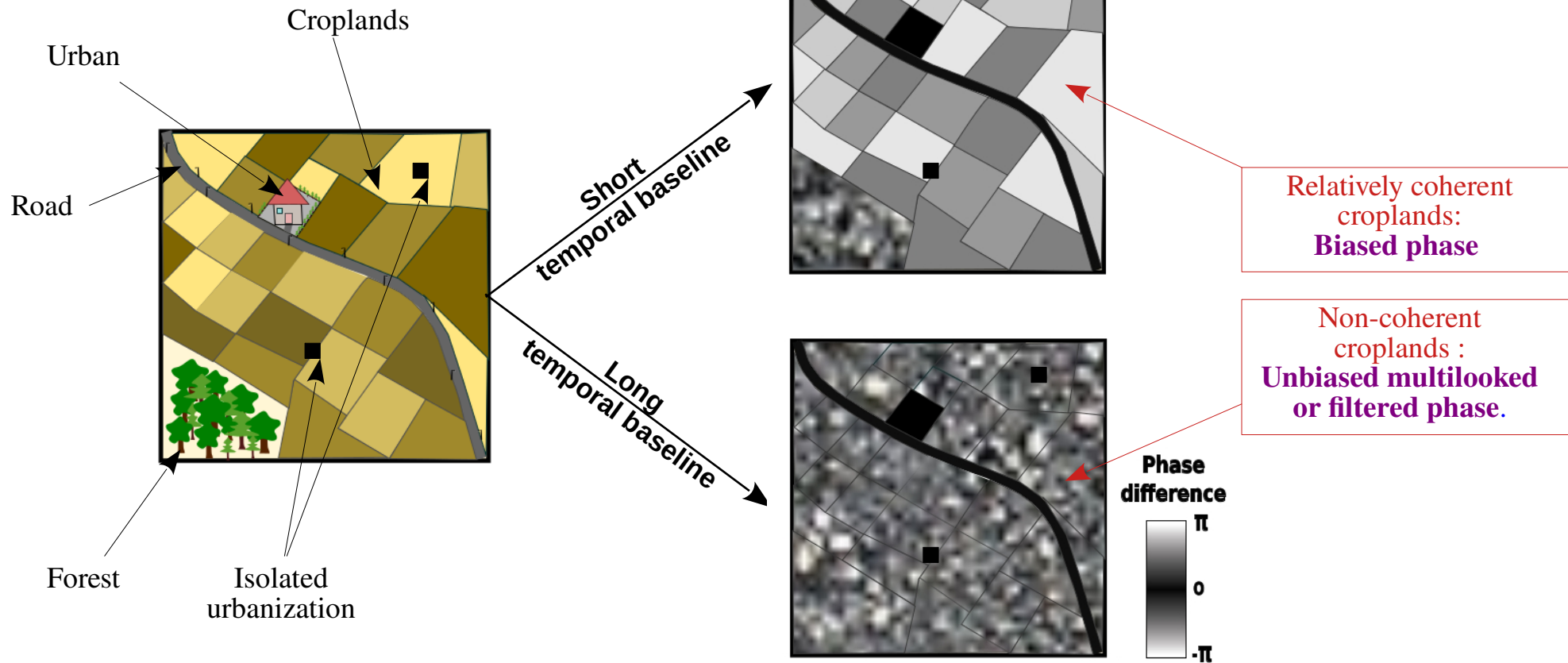
(a)

(b)

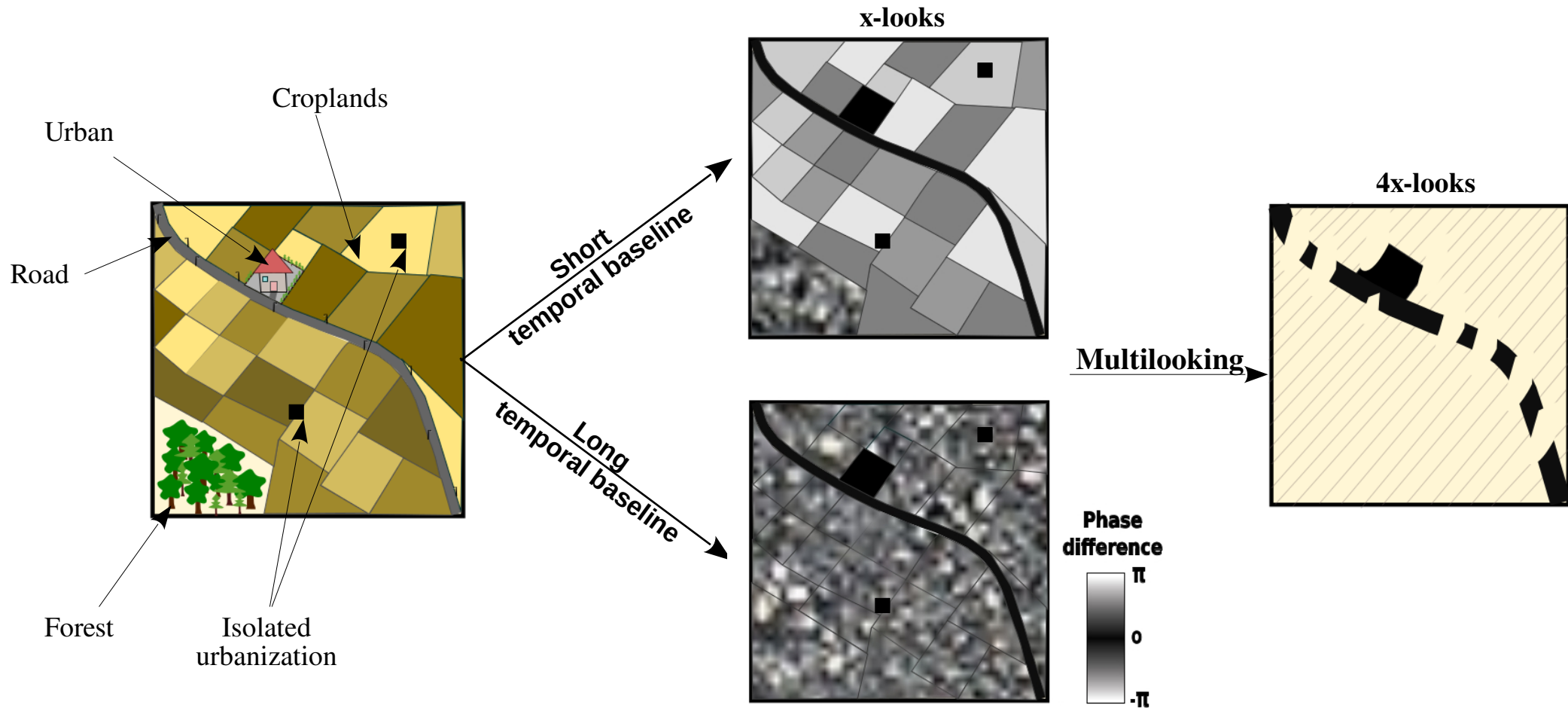
Ansari et al., 2021

- Additional bias not related to other known effects (topography, atmosphere, ..)
- Bias accumulated from short term interferograms

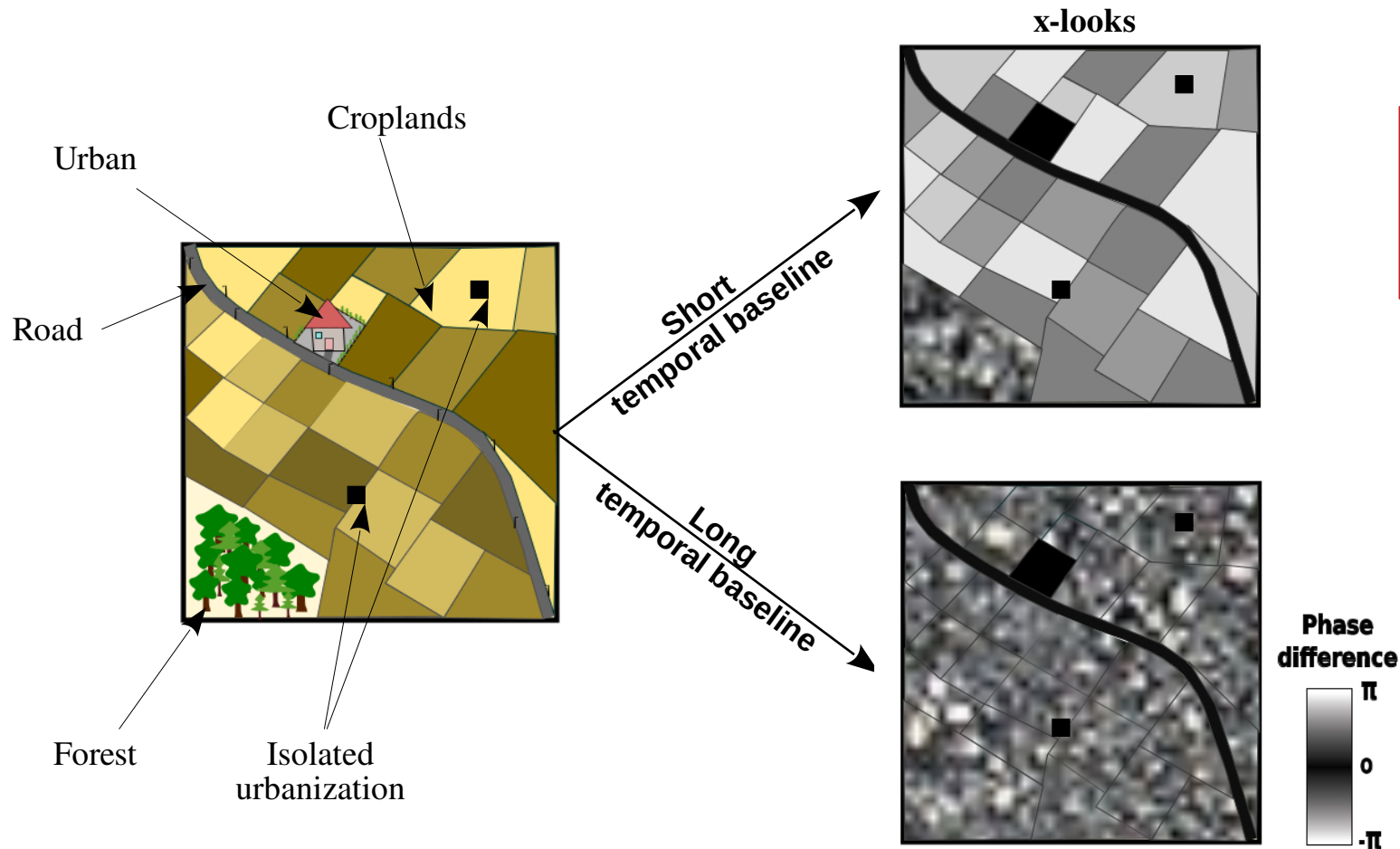
Very simplified sketch of bias acquisition principle



Mixing of pixels with spatial averaging



Mixing of pixels with spatial averaging



How can we limit the impact of the biased pixels on the other pixels ?

1- Identify the biased pixels

2- Integrate their characteristics to weight them down

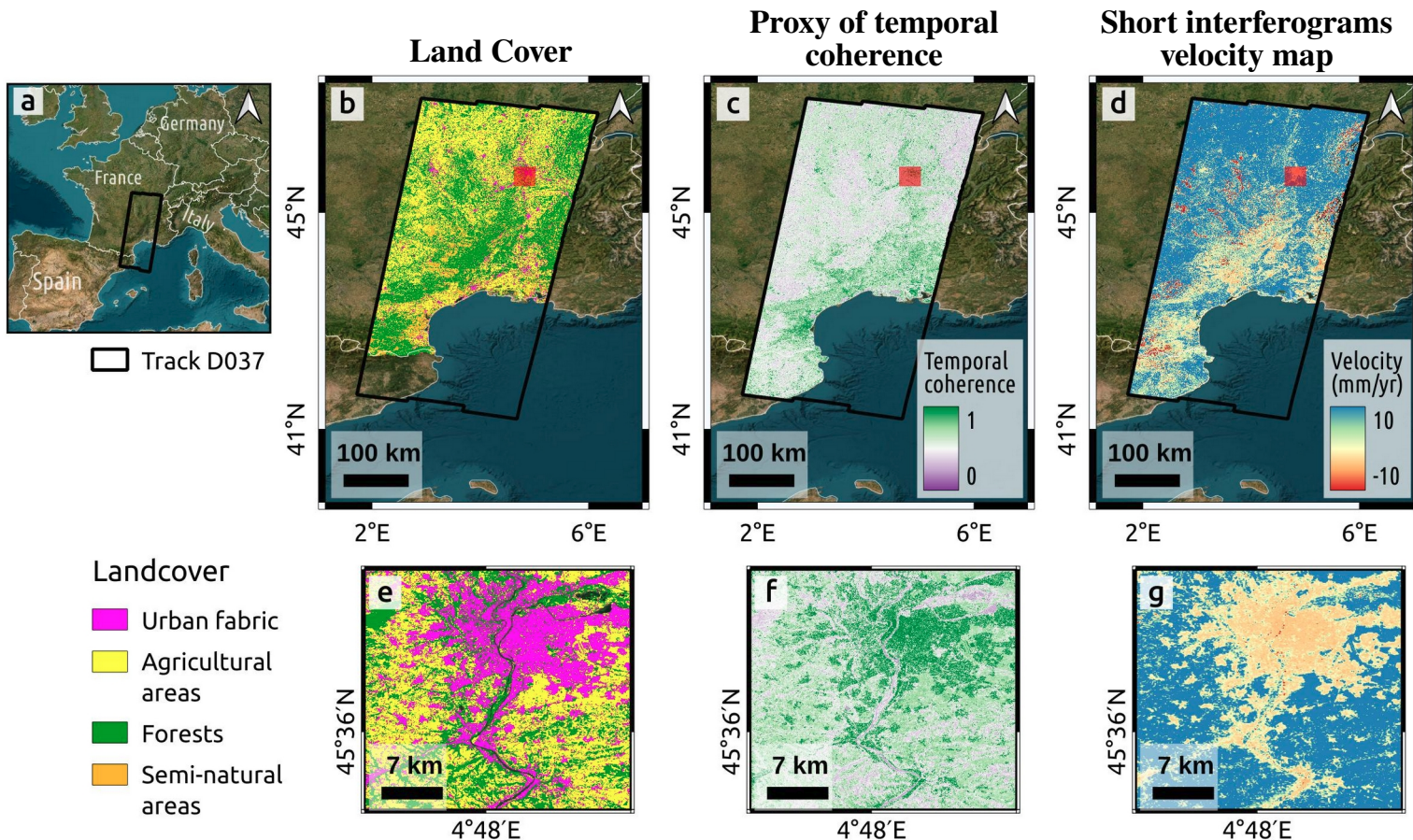
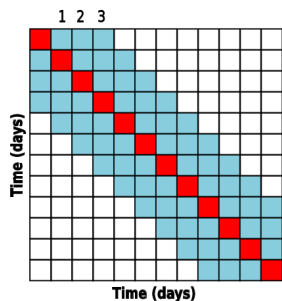
Data: Sentinel-1 time series processed with NSBAS

Track D037 from Sentinel-1 data:

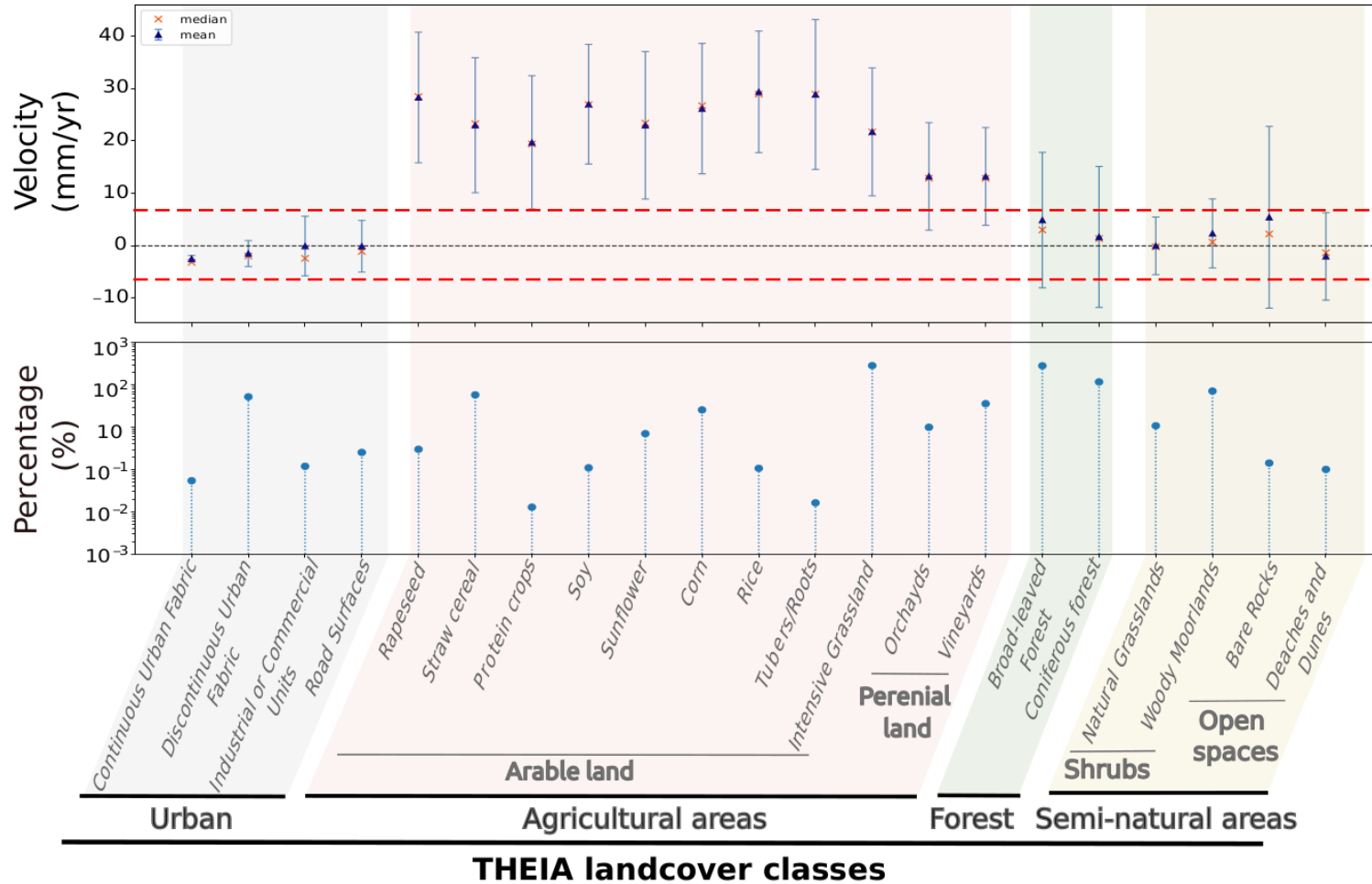
- August 2016 to April 2021
- 306 dates
- ~900 2-looks interferograms

Time series inversion:

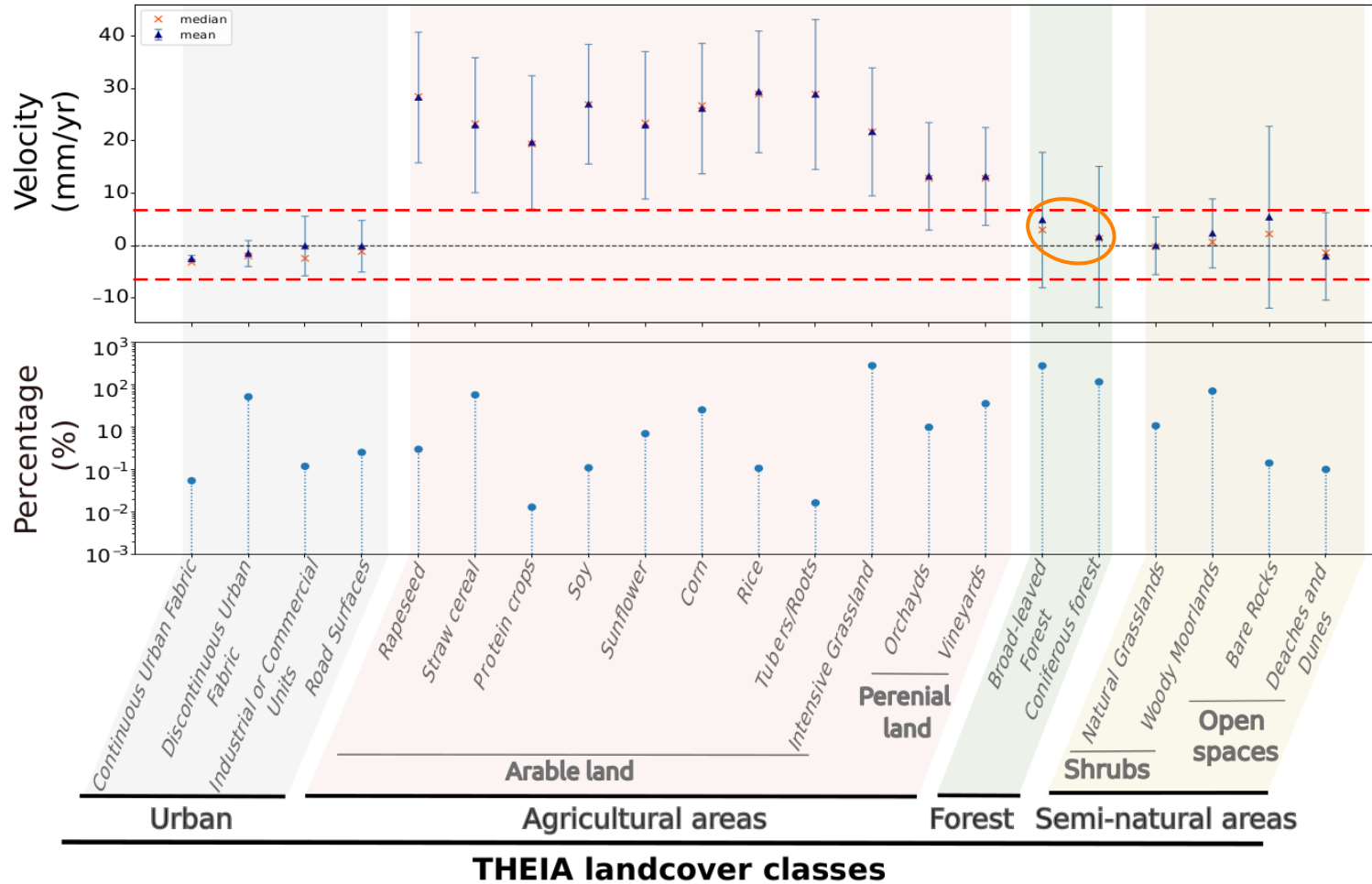
- Non-filtered 8-looks interferograms
8x4 in range
8x1 in azimuth
- Only interferograms at date+1, 2, 3 were used



Relate biased pixel with landcover type

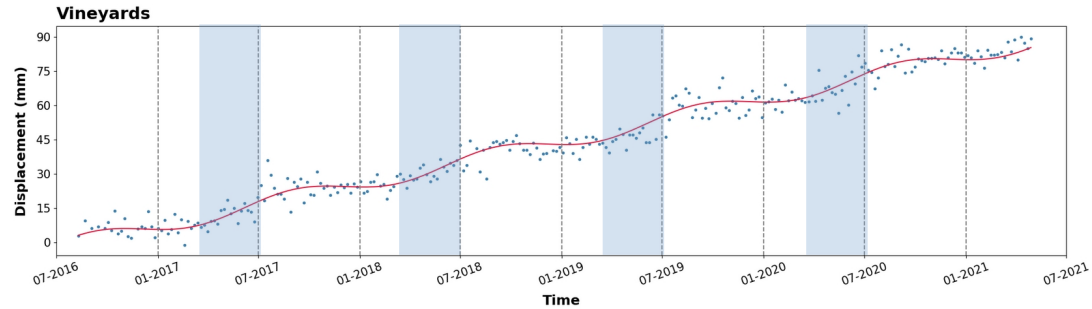
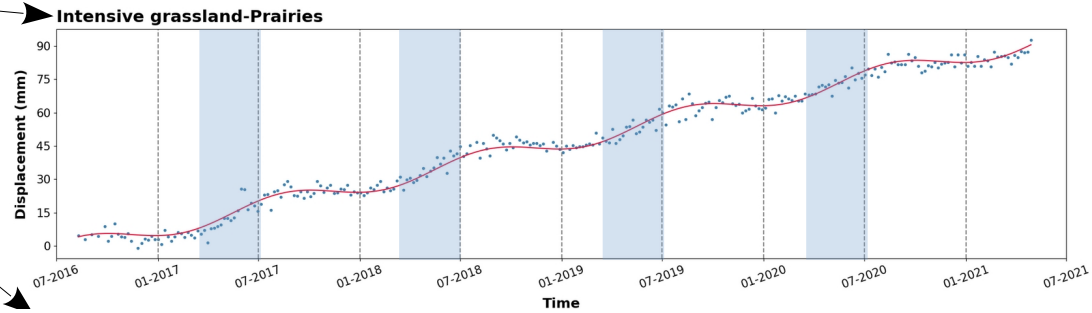
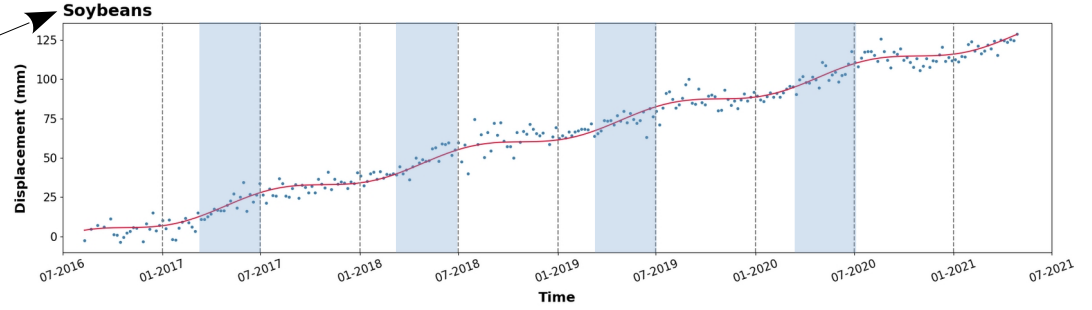
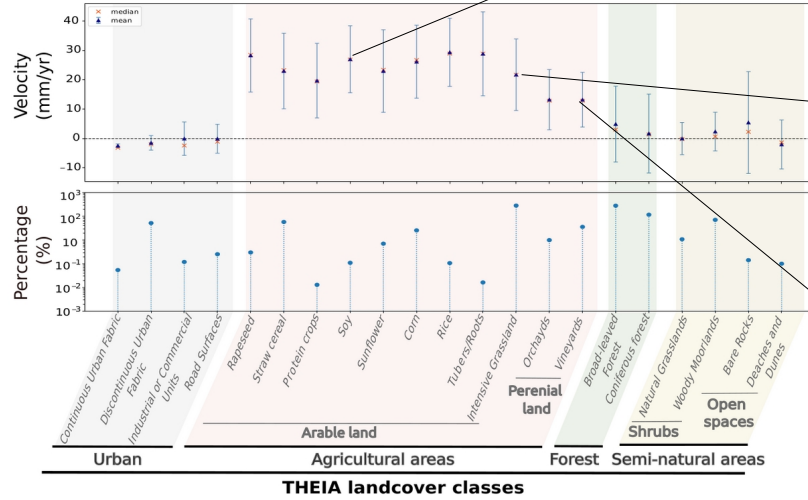


Relate biased pixel with landcover type



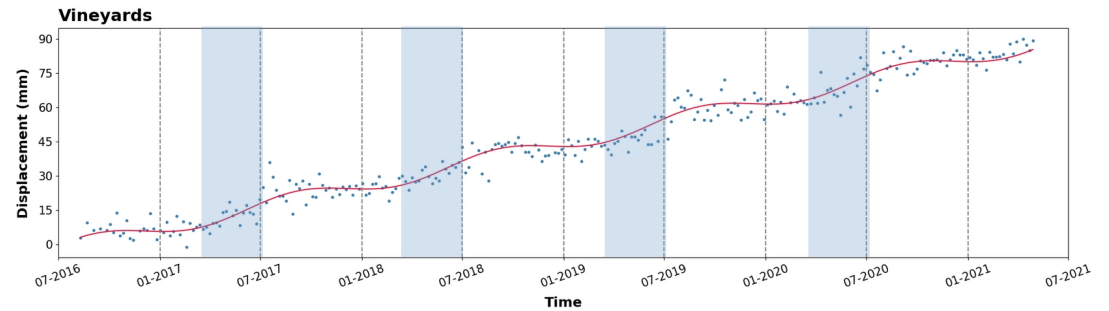
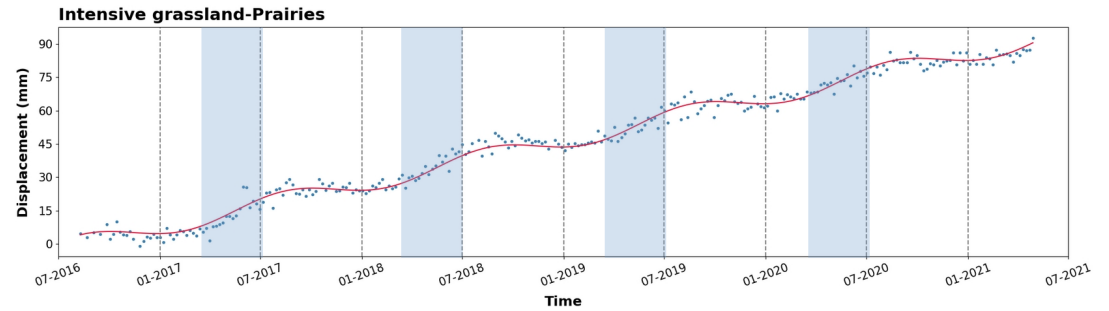
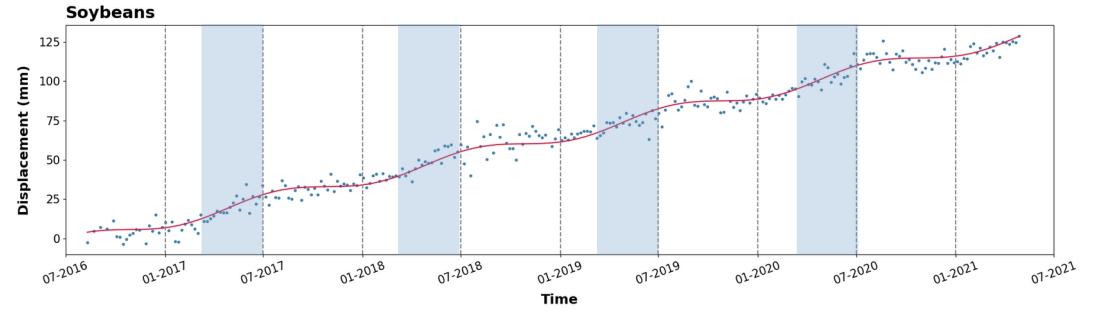
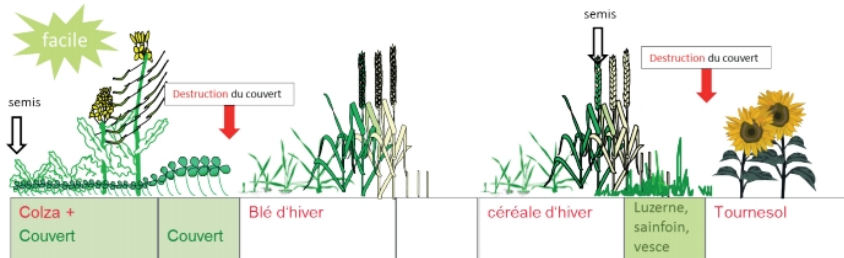
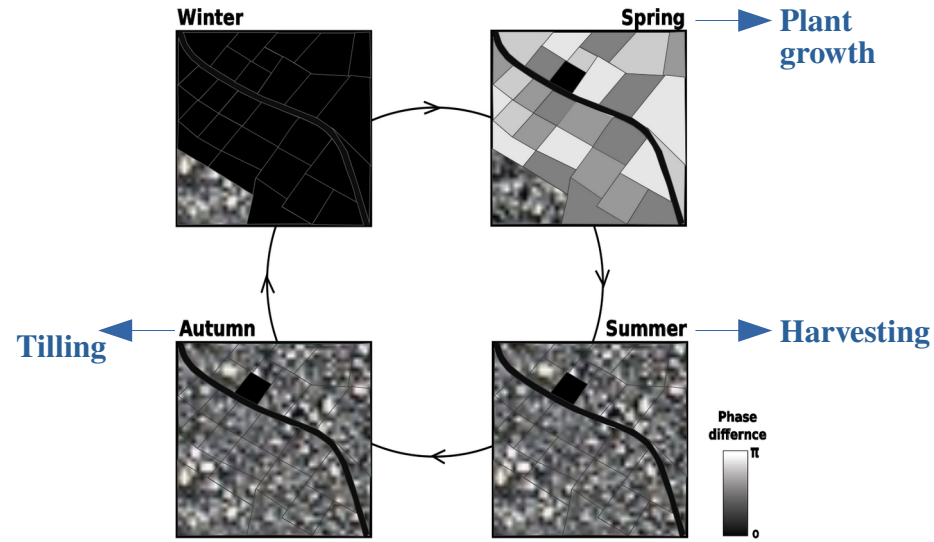
Relate biased pixel with landcover type: Croplands

1- Identification of biased pixels

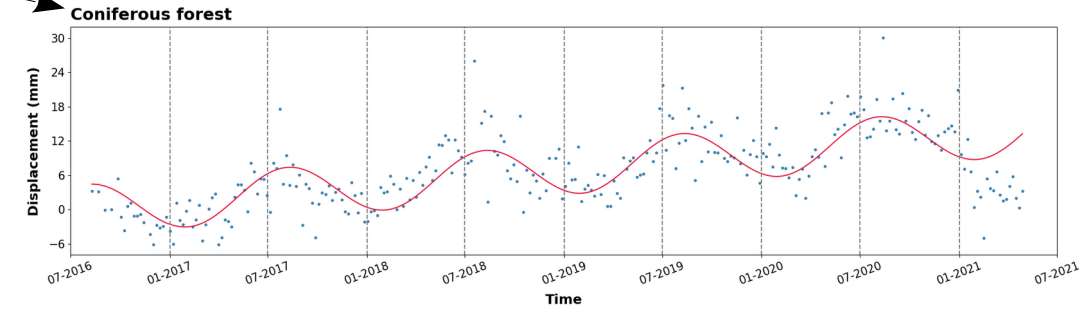
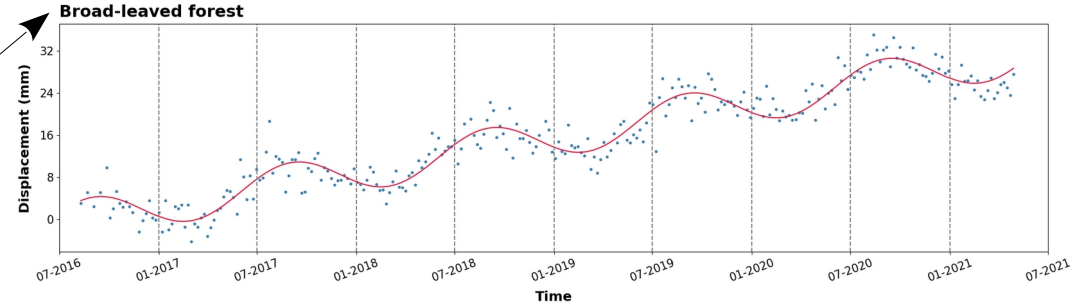
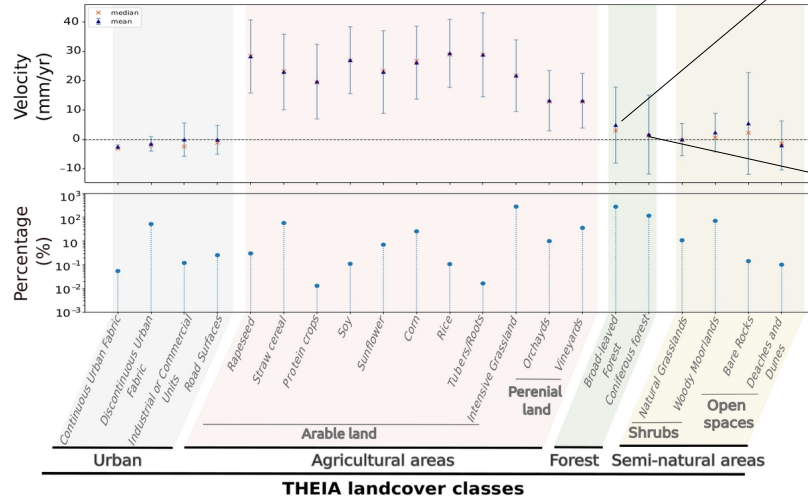


Assymmetric vegetation cycle

1- Identification of biased pixels

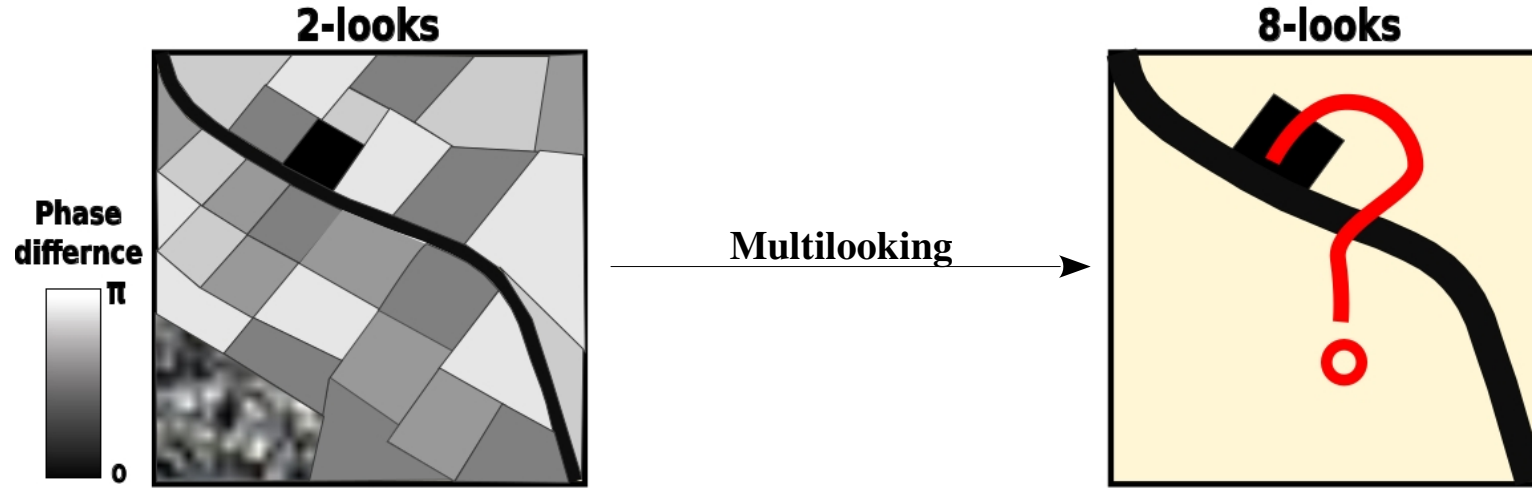


Relate biased pixel with landcover type: Forests



The process that triggers the phase increase during the spring period is partly reversible

How to go from 2rlks to 8rlks wisely ?

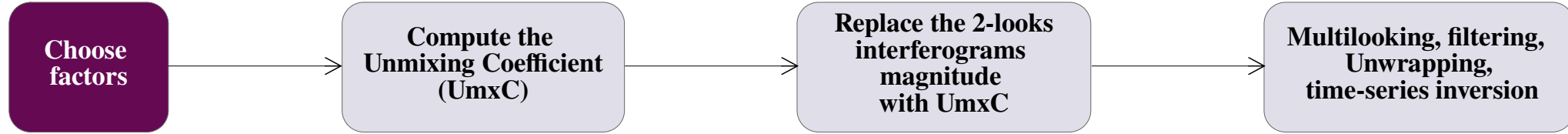


Identify the unbiased pixels
And
Isolate them during
multilooking



Weighted multilooking

Quantitative proxy for bias: unmixing coefficient



$$(1) TCoh = \frac{\sum e^{arg(T_{ijk})}}{Nt_{ijk}}$$

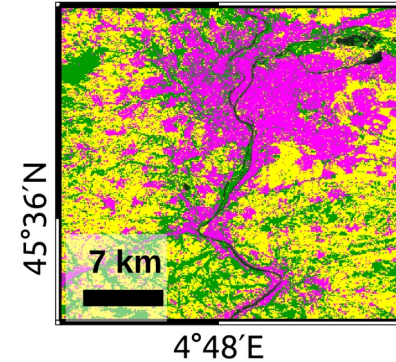
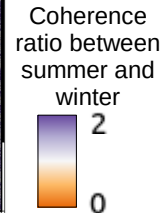
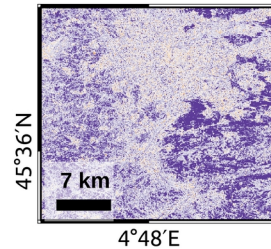
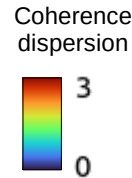
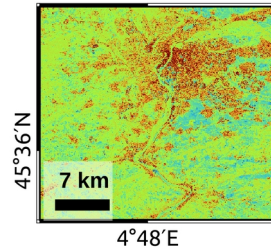
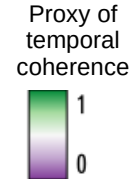
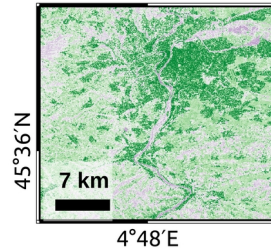
With $j=i+1$
 $k=i+2$

$$(2) CohDisp = \frac{\bar{A}_{(Iij)}}{\sigma_{A(Iij)}}$$

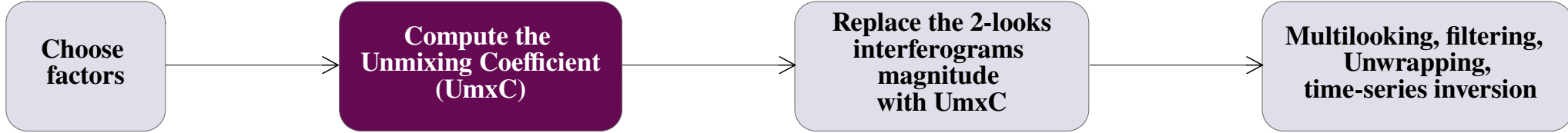
With $j-i < 1$ month

$$(3) CohRatio = \frac{\sum \bar{I}_{ij(Aug-Sep)}/N1}{\sum \bar{I}_{ij(Jan)}/N2}$$

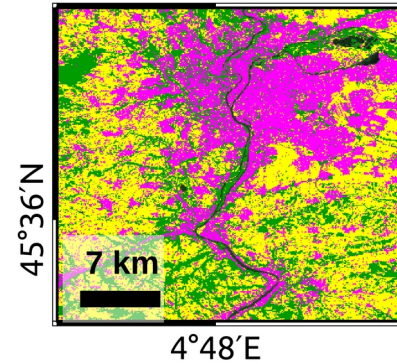
With $j=i+2$



Quantitative proxy for bias: unmixing coefficient

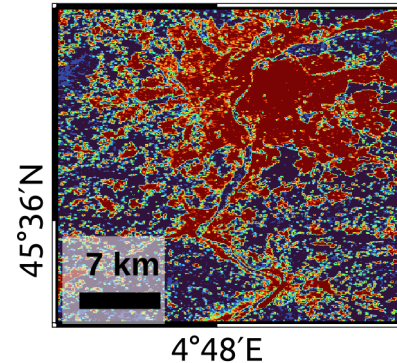
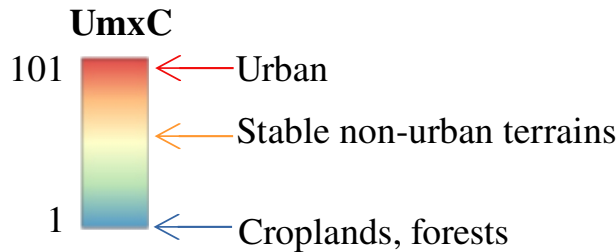


$$\begin{aligned}
 UmxC = 100 \times \exp & \left(-0.75 \times \text{Min} \left(\sqrt{\frac{0.9 - \text{Min}(TCoh, 0.9)}{0.9 - 0.7}}, 1 \right) \right. \\
 & \times \text{Min} \left(\sqrt{\frac{2 - \text{Min}(CohDisp, 2)}{2 - 1}}, 1 \right) \\
 & \left. \times \text{Min} \left(1 - \sqrt{\frac{2 - \text{Min}(CohRatio, 2)}{2 - (-0.5)}}, 1 \right) \times 20 \right) + 1
 \end{aligned}$$



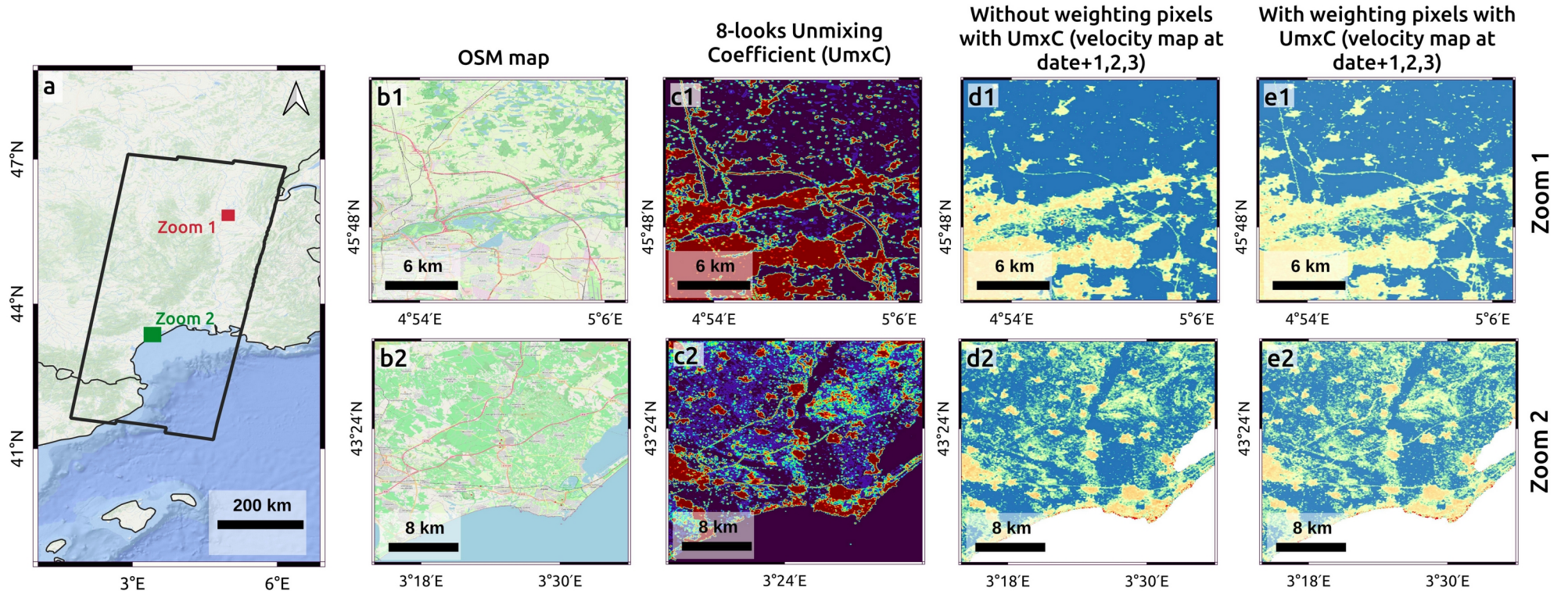
- Landcover**
- Urban fabric
 - Agricultural areas
 - Forests
 - Semi-natural areas

➔ **Continuous UmxC classes differentiating land cover**

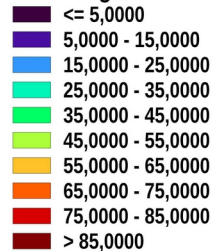


- Unmixing coefficient**
- < 5,000
 - 5,000 - 15,000
 - 15,000 - 25,000
 - 25,000 - 35,000
 - 35,000 - 45,000
 - 45,000 - 55,000
 - 55,000 - 65,000
 - 65,000 - 75,000
 - 75,000 - 85,000
 - > 85,000

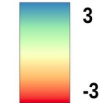
Improving velocity maps with pixels unmixing



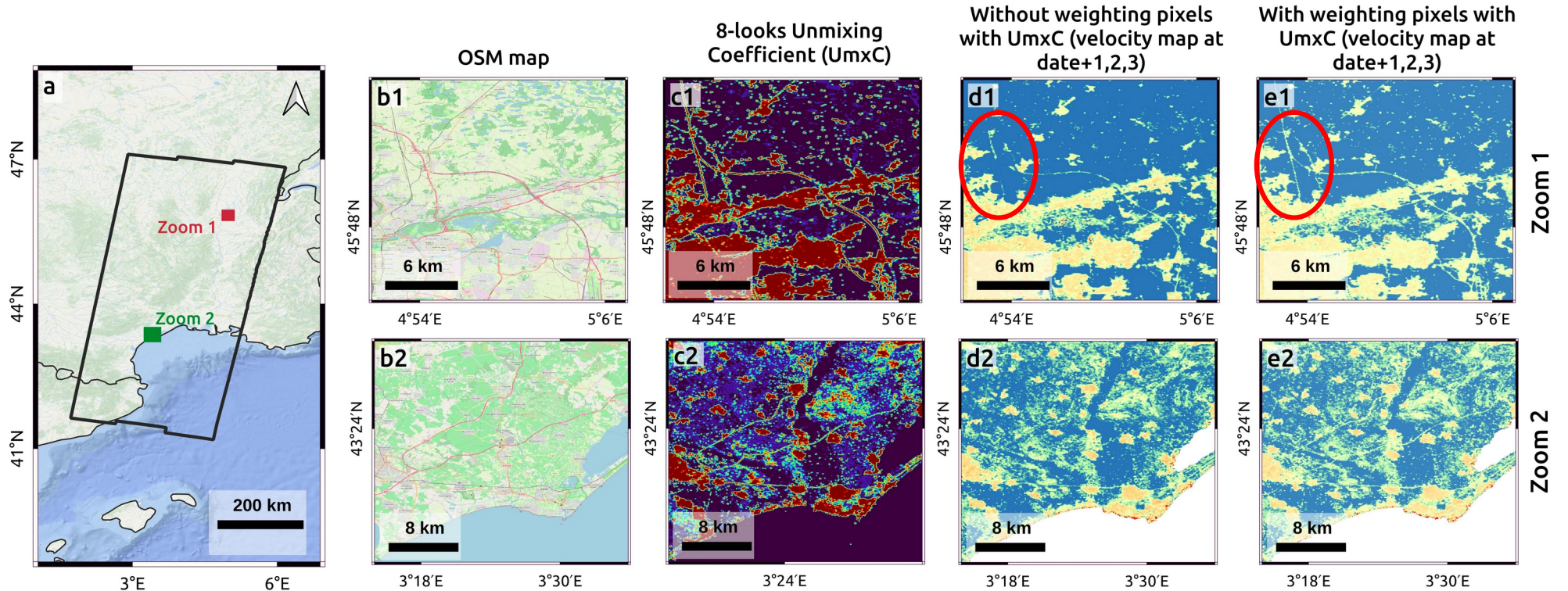
Unmixing coefficient



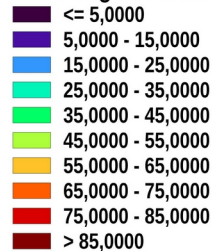
Velocity (rad/yr)



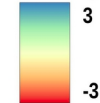
Improving velocity maps with pixels unmixing



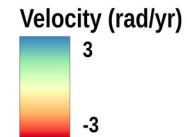
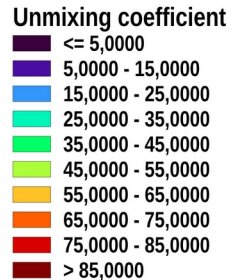
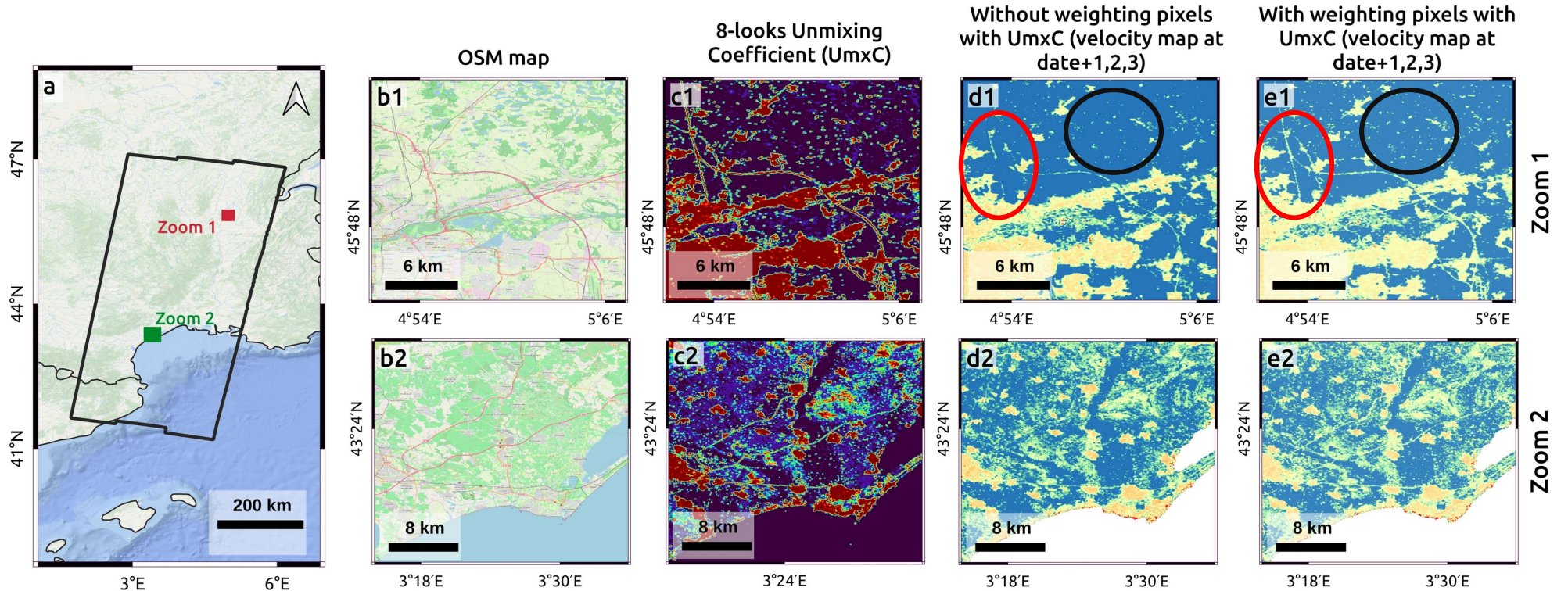
Unmixing coefficient



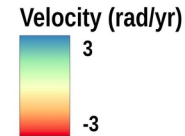
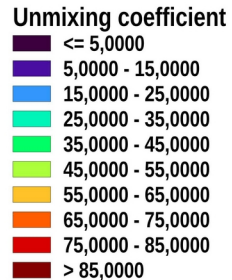
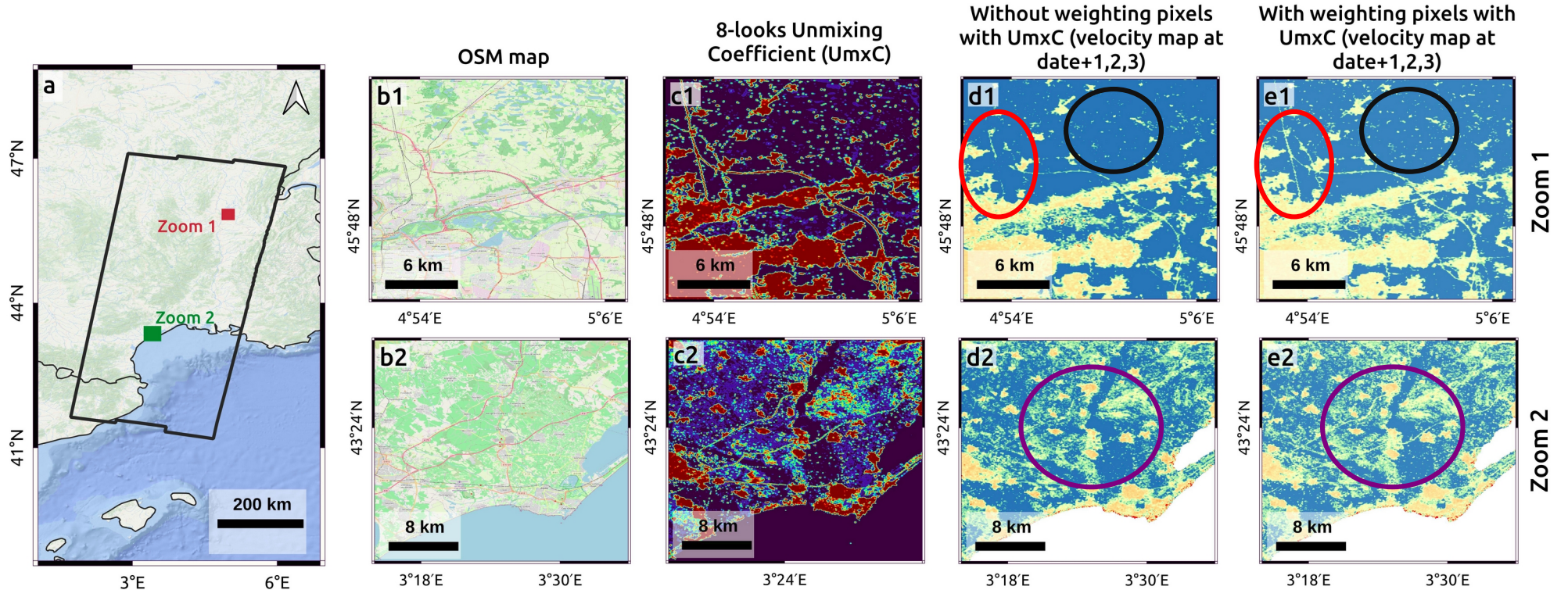
Velocity (rad/yr)



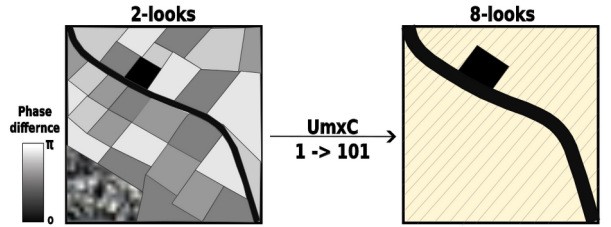
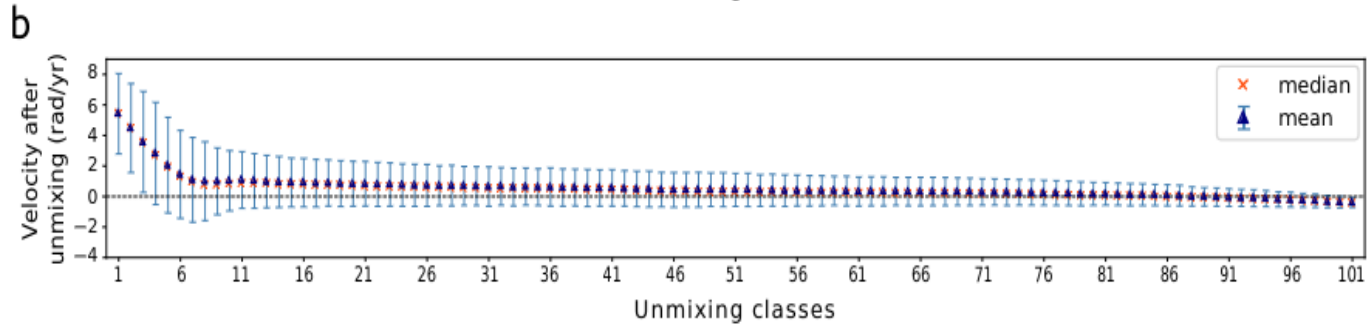
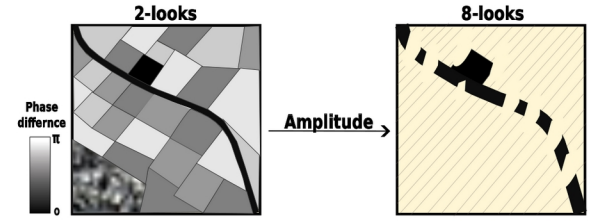
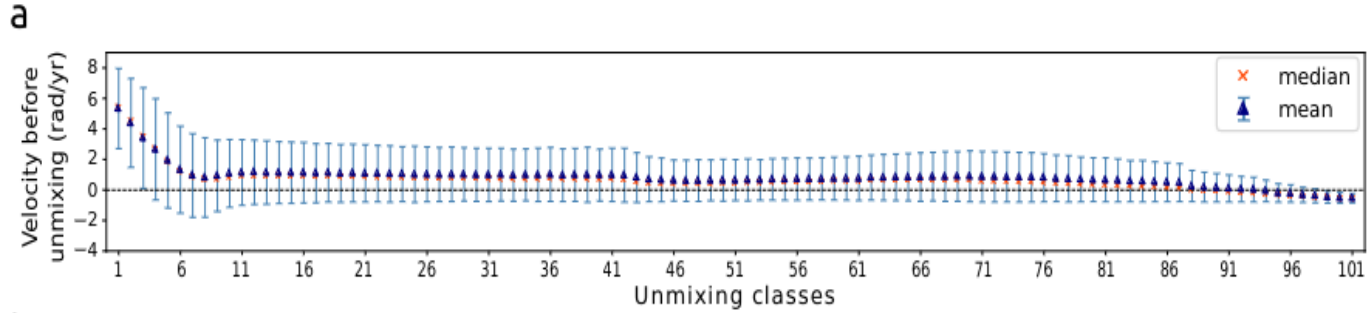
Improving velocity maps with pixels unmixing



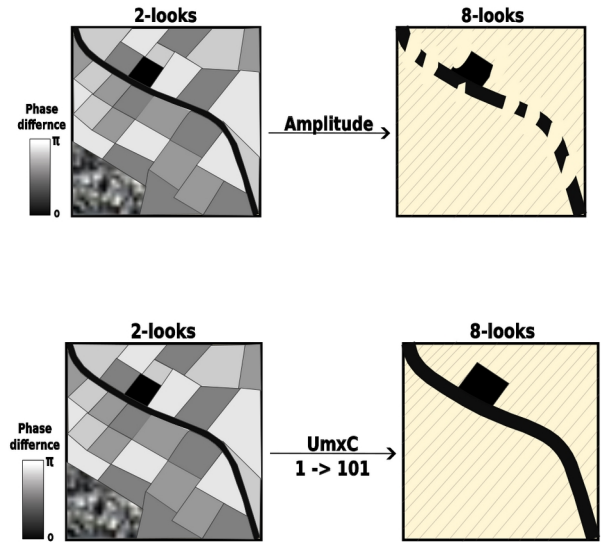
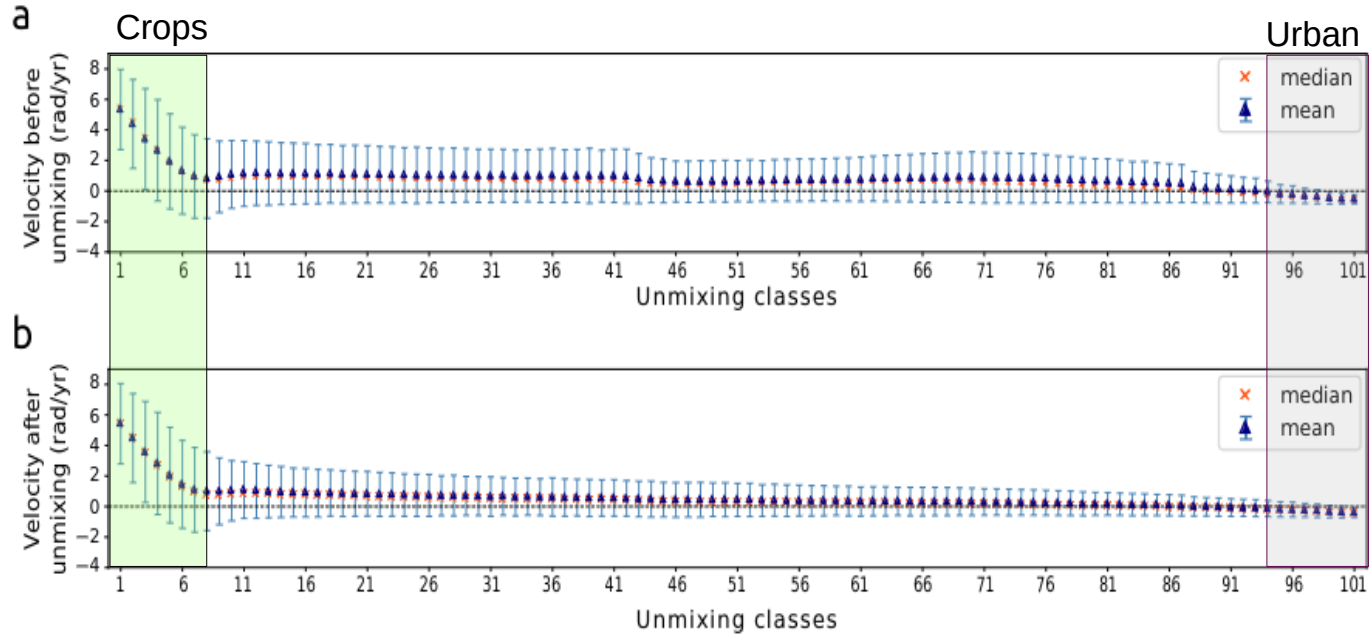
Improving velocity maps with pixels unmixing



Improving velocity maps with pixels unmixing

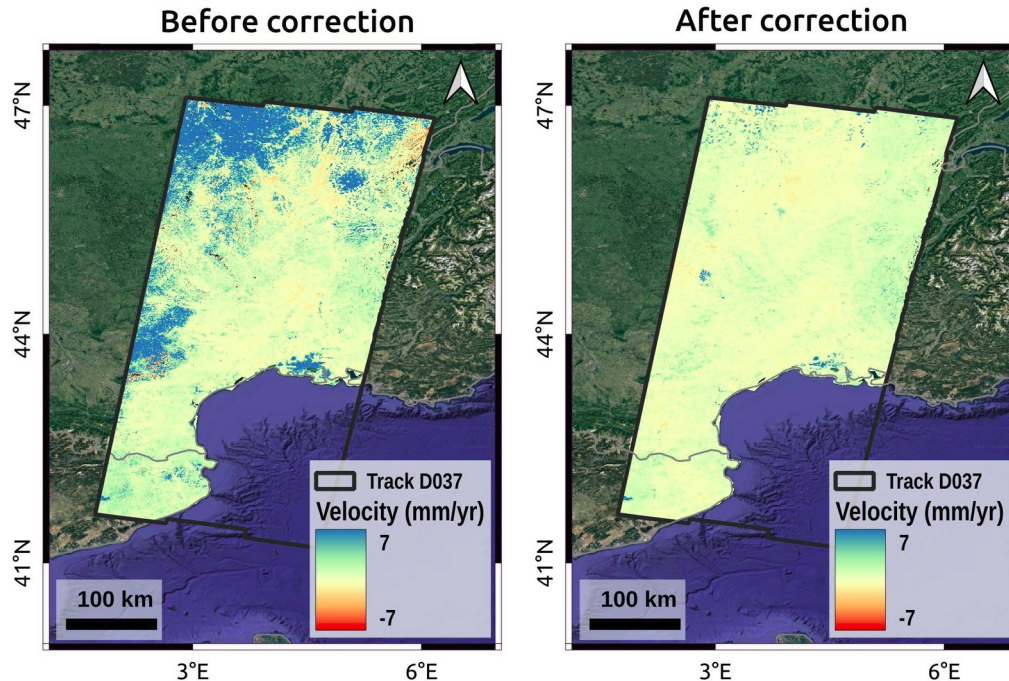


Improving velocity maps with pixels unmixing



Conclusions and perspectives

- It is important to characterize pixels in a country like France (strongly vegetated areas with small roads, isolated farms, small villages) before multi-looking in a SBAS processing workflow
- Bias (up to 2-3 cm/yr) is acquired during the period of vegetation growth on croplands
- Forests present small, partly reversible, bias
- This work was a **first step in a larger project aimed at mitigating the cumulative bias on cropland for velocity maps produced using NSBAS** ([poster by Doin et al., this afternoon](#)).



Time series inversion:

- Non-filtered 8-looks interferograms
8x4 in range
8x1 in azimuth
- Interferograms at date+6, 12, 18, 60, 365 days were used

