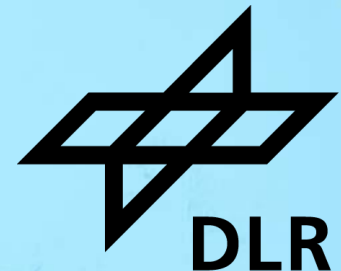


SEASONAL AND LONG-TERM VEGETATION EFFECTS ON SENTINEL-1 RANGE COREGISTRATION SHIFTS

Giorgio Gomba¹, Francesco De Zan², Simon Sing Hee¹

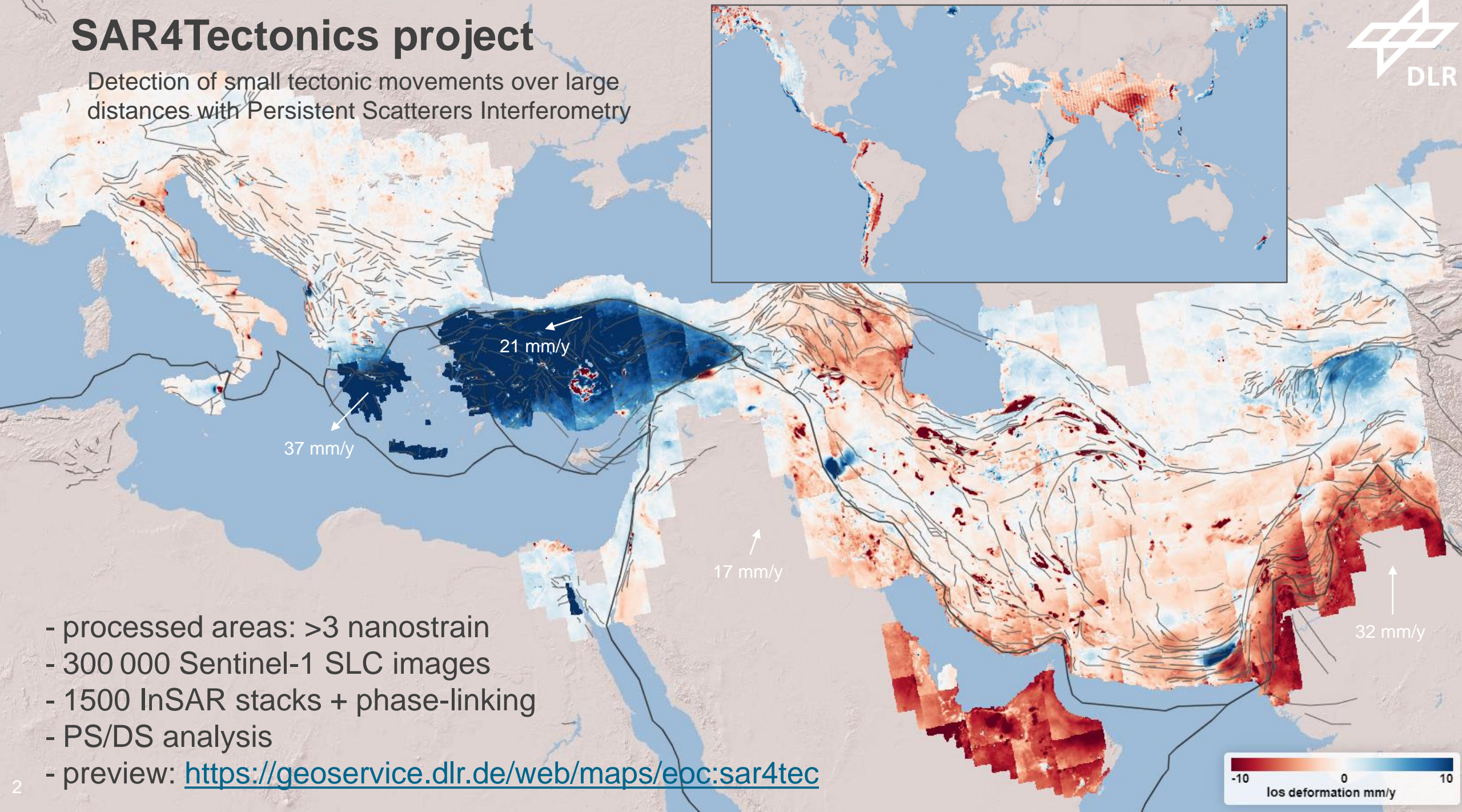
1 German Aerospace Center

2 delta phi remote sensing GmbH



SAR4Tectonics project

Detection of small tectonic movements over large distances with Persistent Scatterers Interferometry



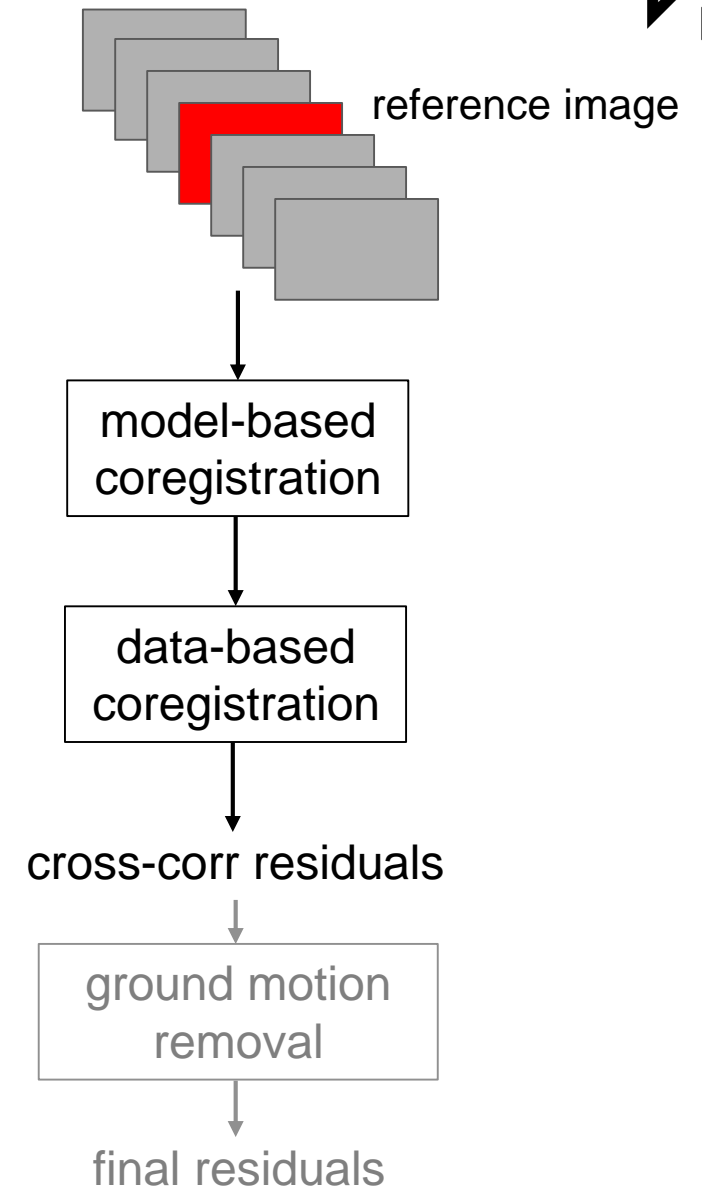
- processed areas: >3 nanostrain
- 300 000 Sentinel-1 SLC images
- 1500 InSAR stacks + phase-linking
- PS/DS analysis
- preview: <https://geoservice.dlr.de/web/maps/eoc:sar4tec>



Processing details



- Custom slices
- InSAR stack (one reference image)
 - Model-based coregistration
 - Orbit, DEM
 - Troposphere (ERA5)
 - Ionosphere (CODE)
 - Solid-Earth tides
 - Data-based coregistration
 - **Range: Incoherent patch-based cross-correlation**
 - Azimuth: Enhanced Spectral Diversity
 - Phase estimation
 - Phase linking
- PS/DS parameters estimation
- Ground motion (tectonic) removal from X-Corr residuals

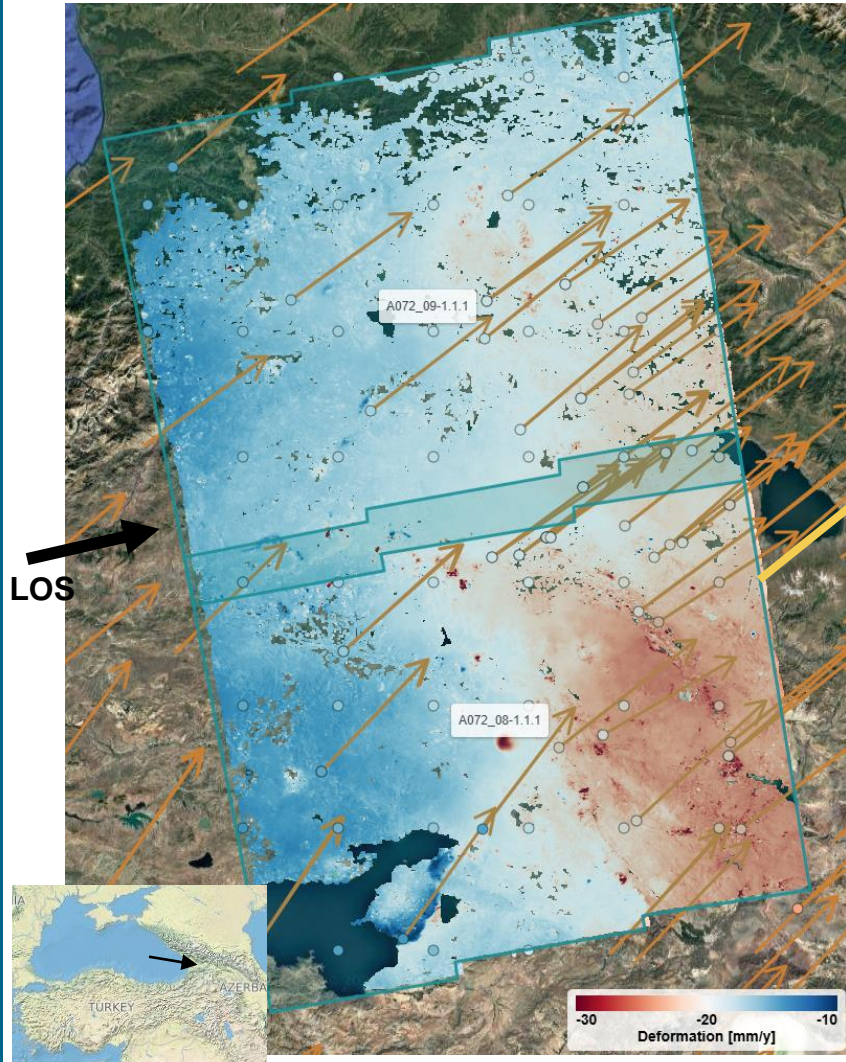


Range coregistration residuals example

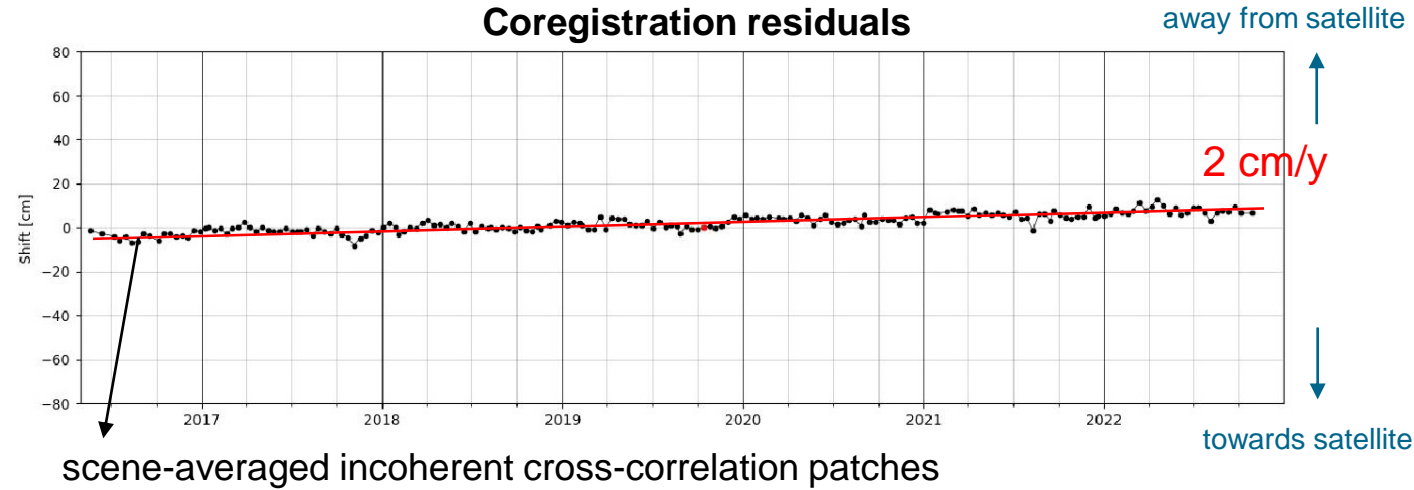


Tectonic plate LOS motion (towards satellite): -20 mm/y

PS/DS results



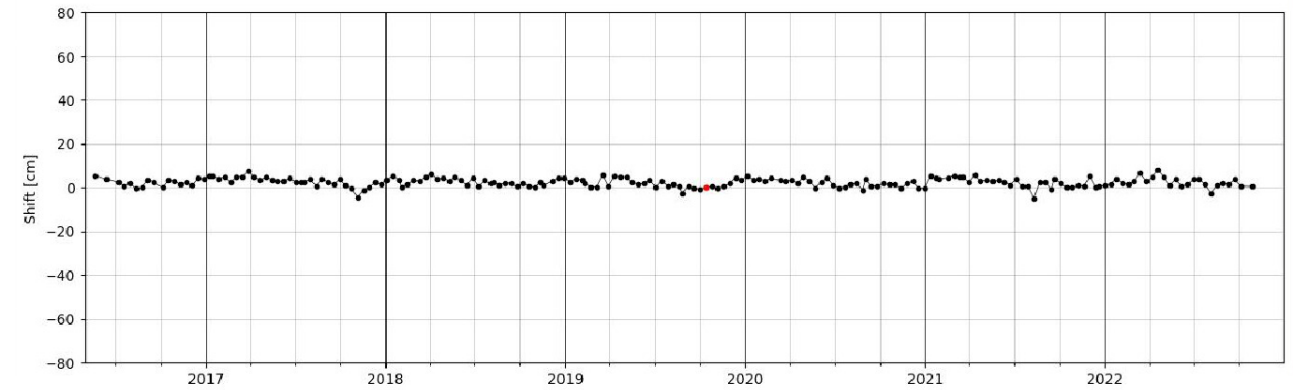
Coregistration residuals



scene-averaged incoherent cross-correlation patches

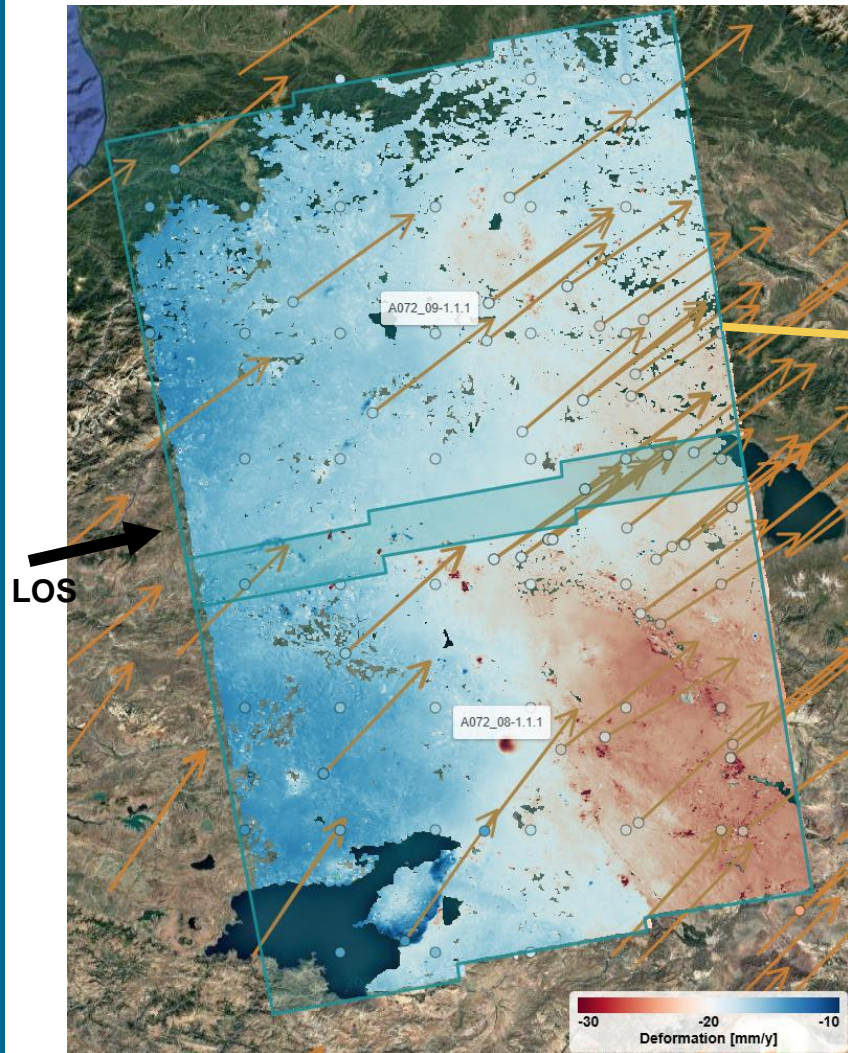


Final residuals: tectonic motion removed

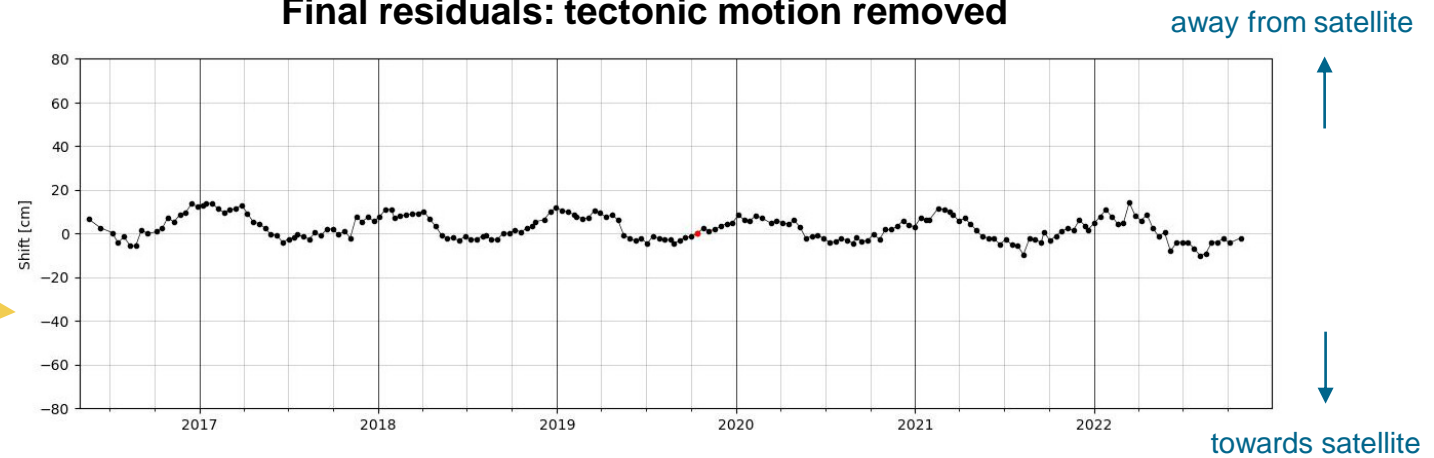


Unexpected anomalies

PS/DS results



Final residuals: tectonic motion removed

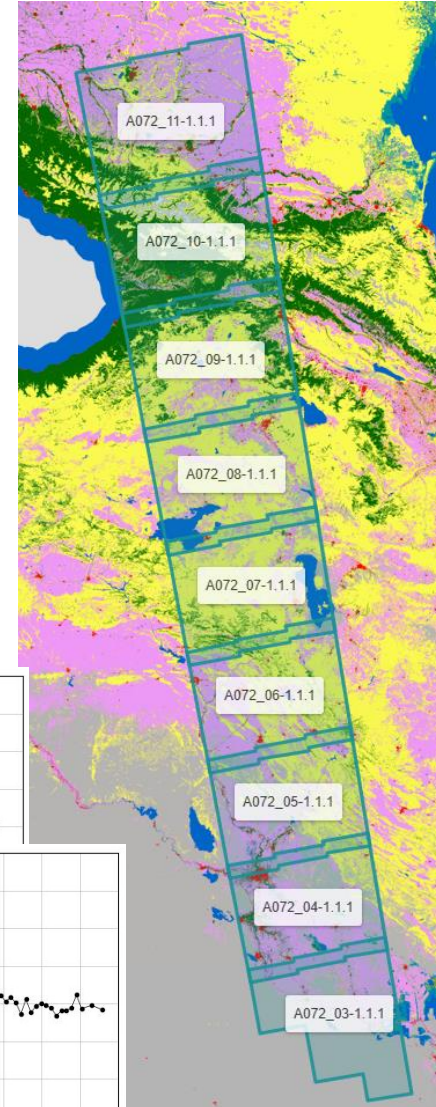
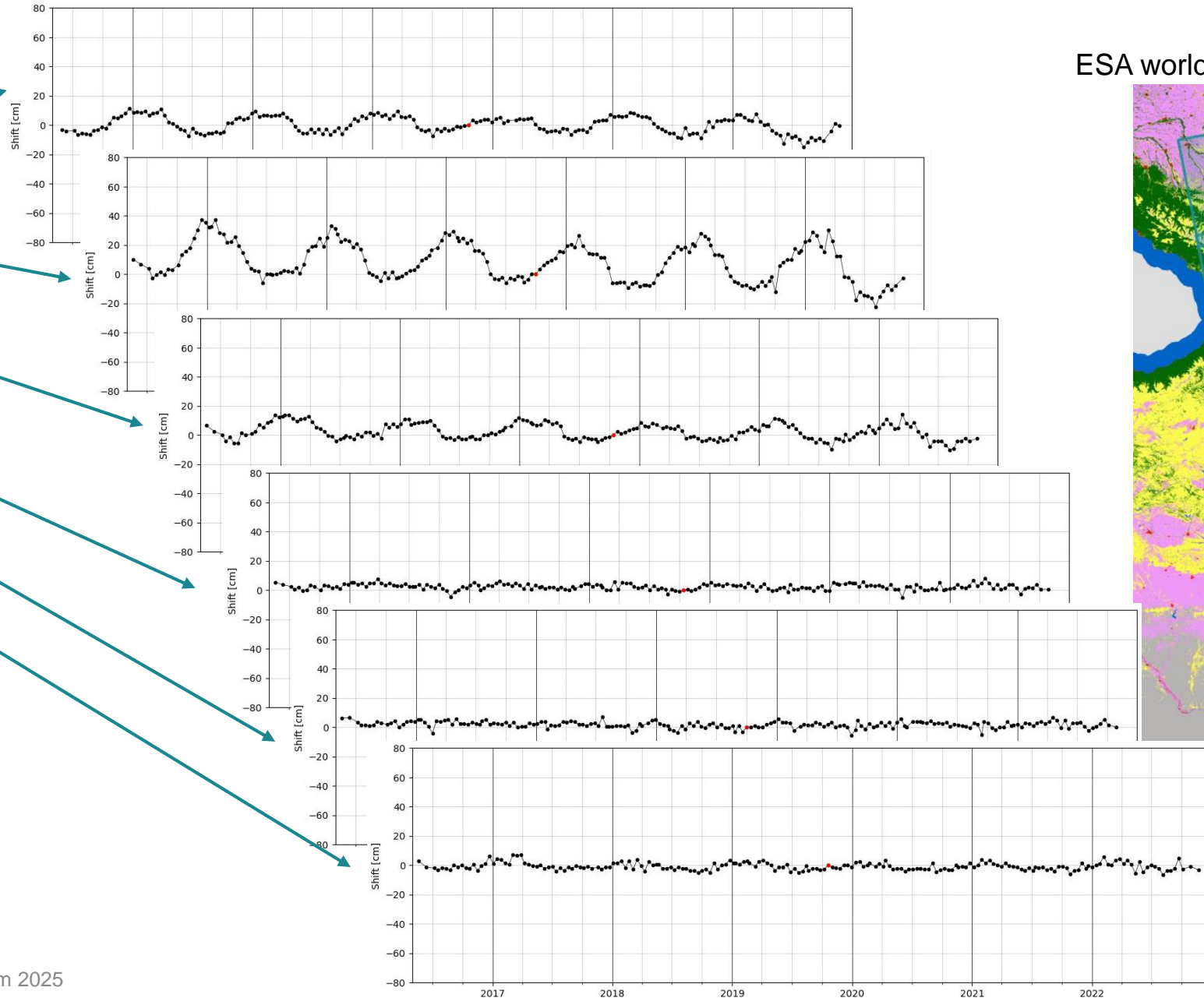
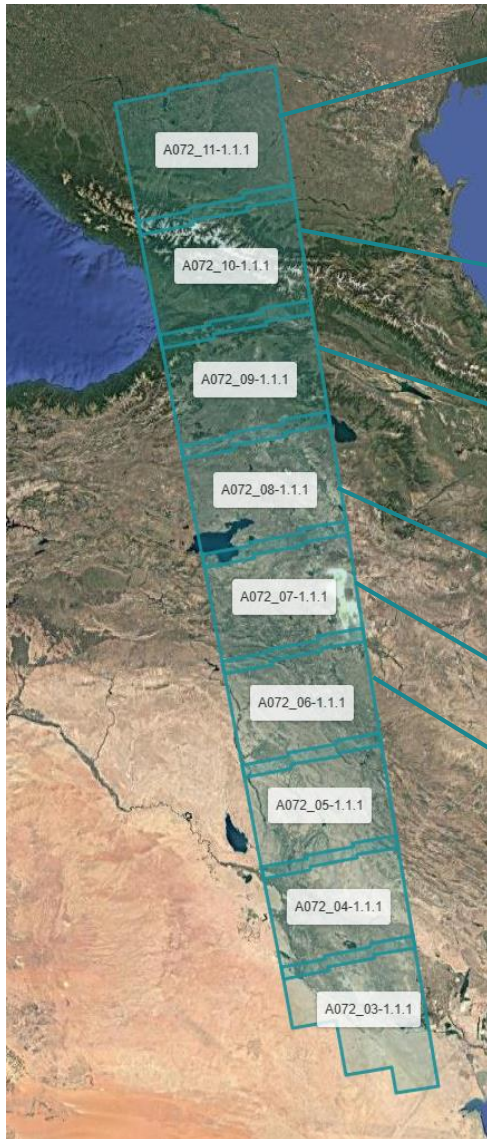


➔ Unexpected seasonal oscillations + trend

More examples: vegetation dependency

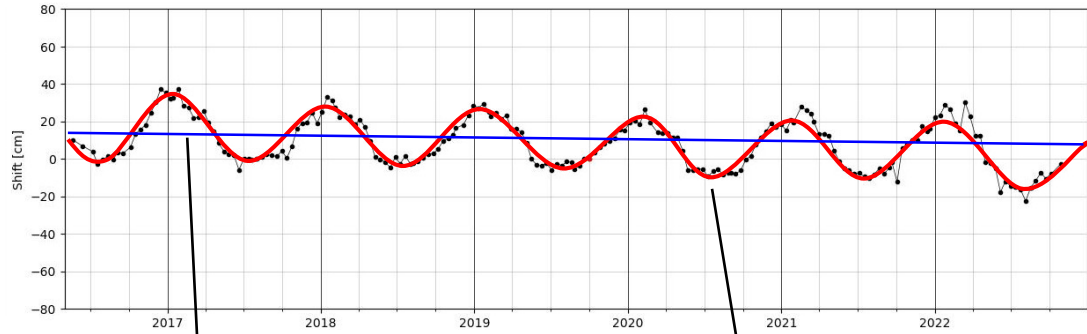


ESA world cover



Fitting of residuals

Fit: sinusoid + trend



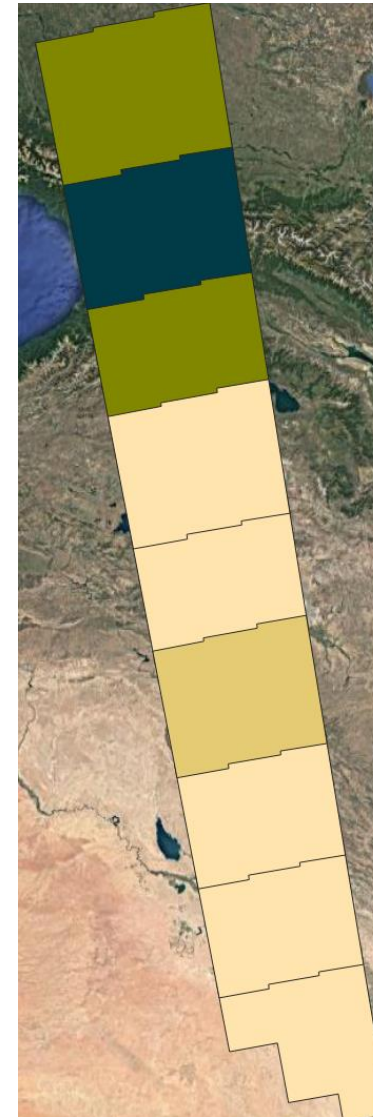
Trend towards the satellite

Summer peaks towards the satellite

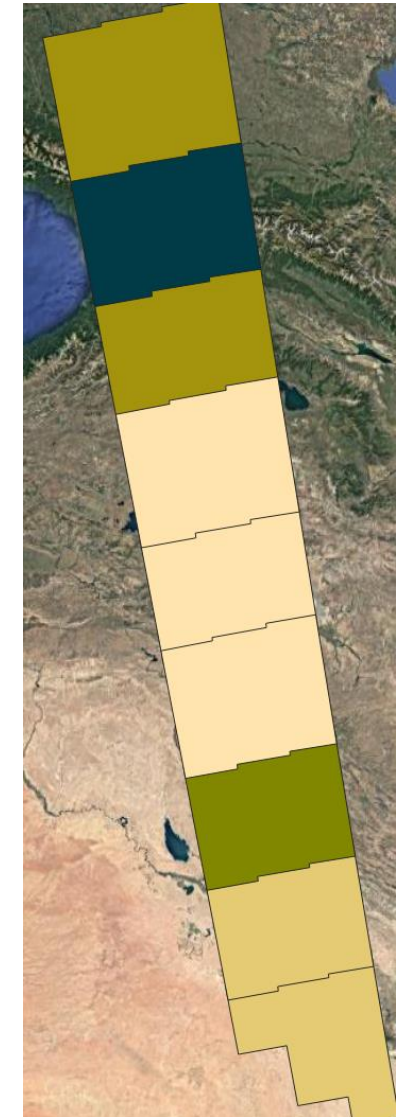
Results for scene-average shift

Oscillation amplitude

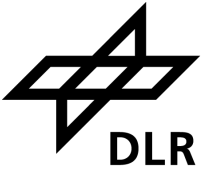
Trend



0 [cm] 16



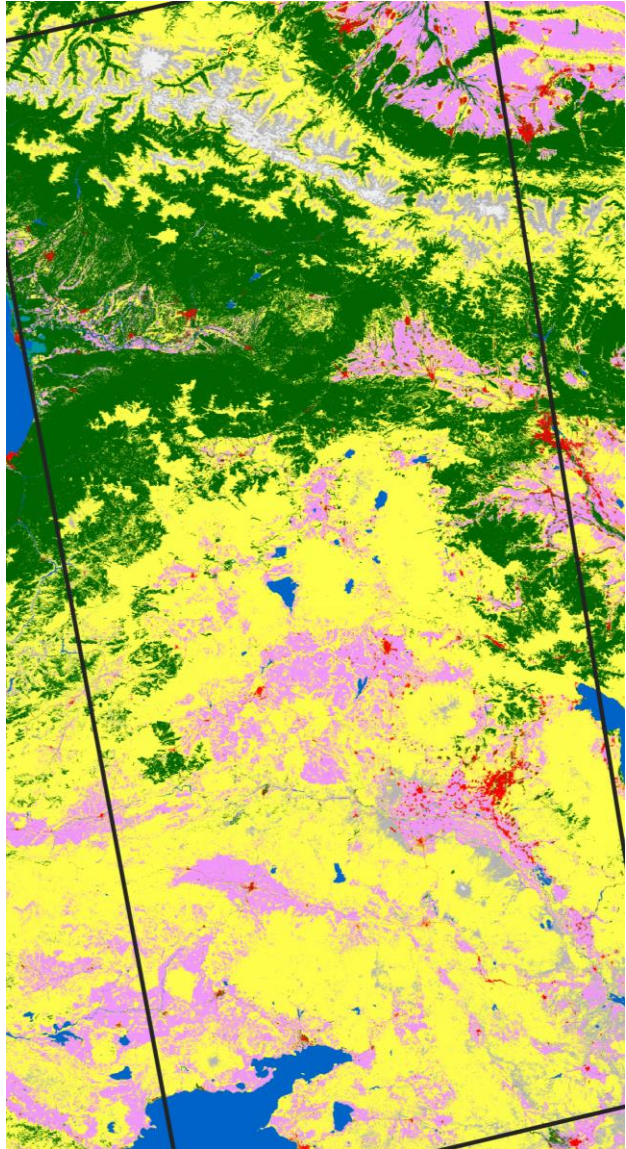
0 [cm/y] -2



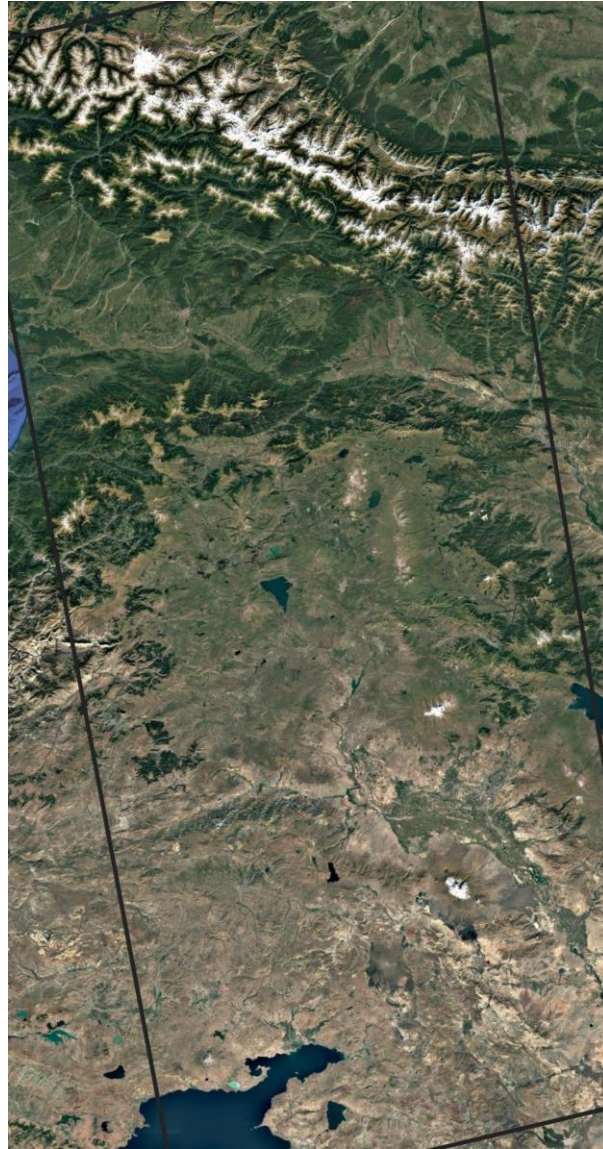
Fitting of residuals

Results for shift patches

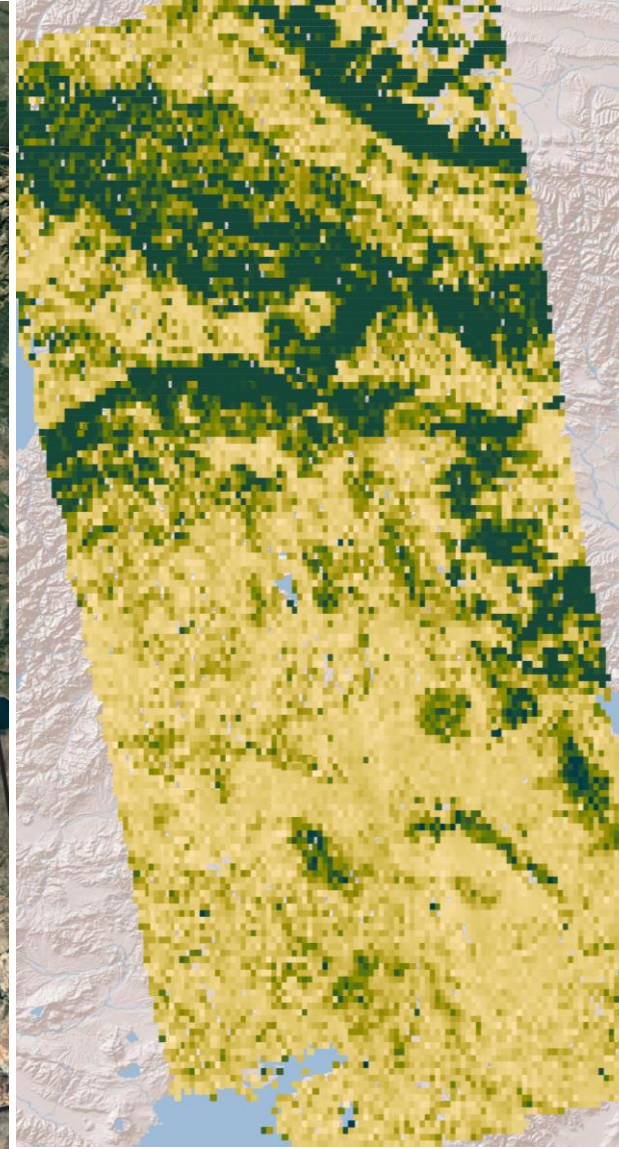
ESA world cover



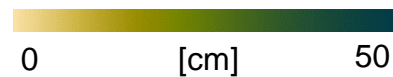
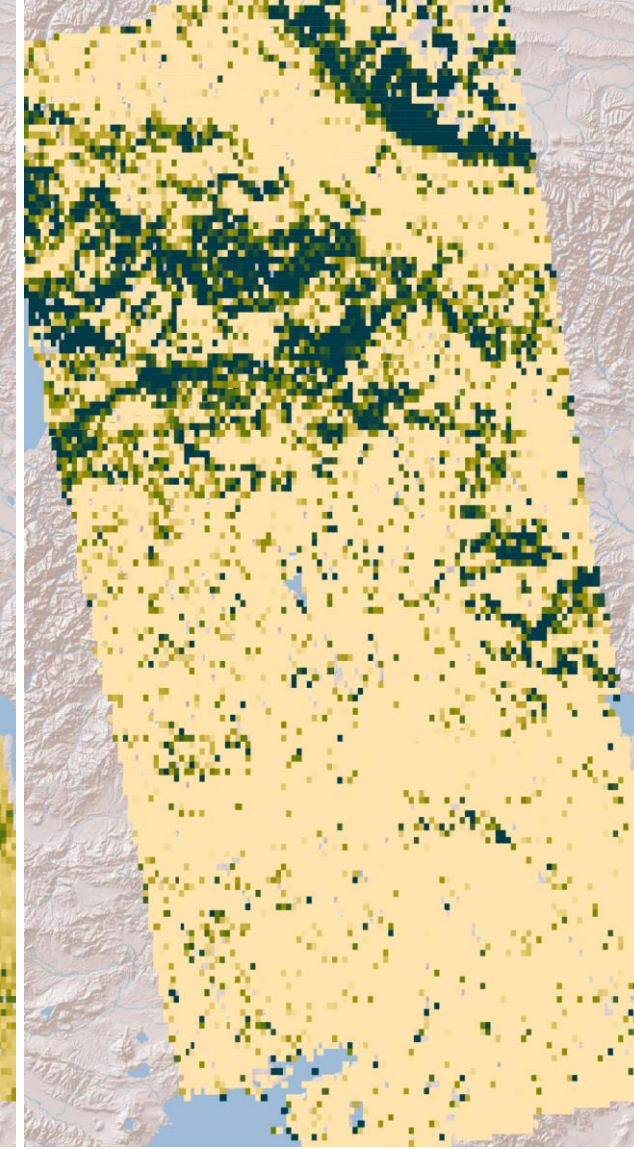
Google optical



Oscillation amplitude

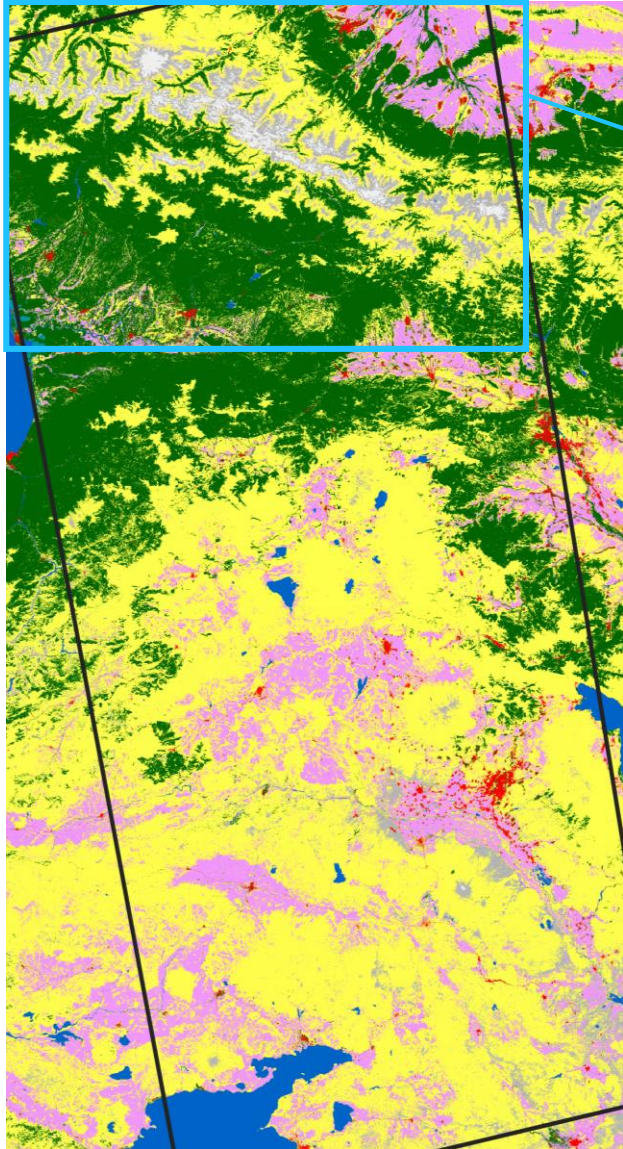


Trend

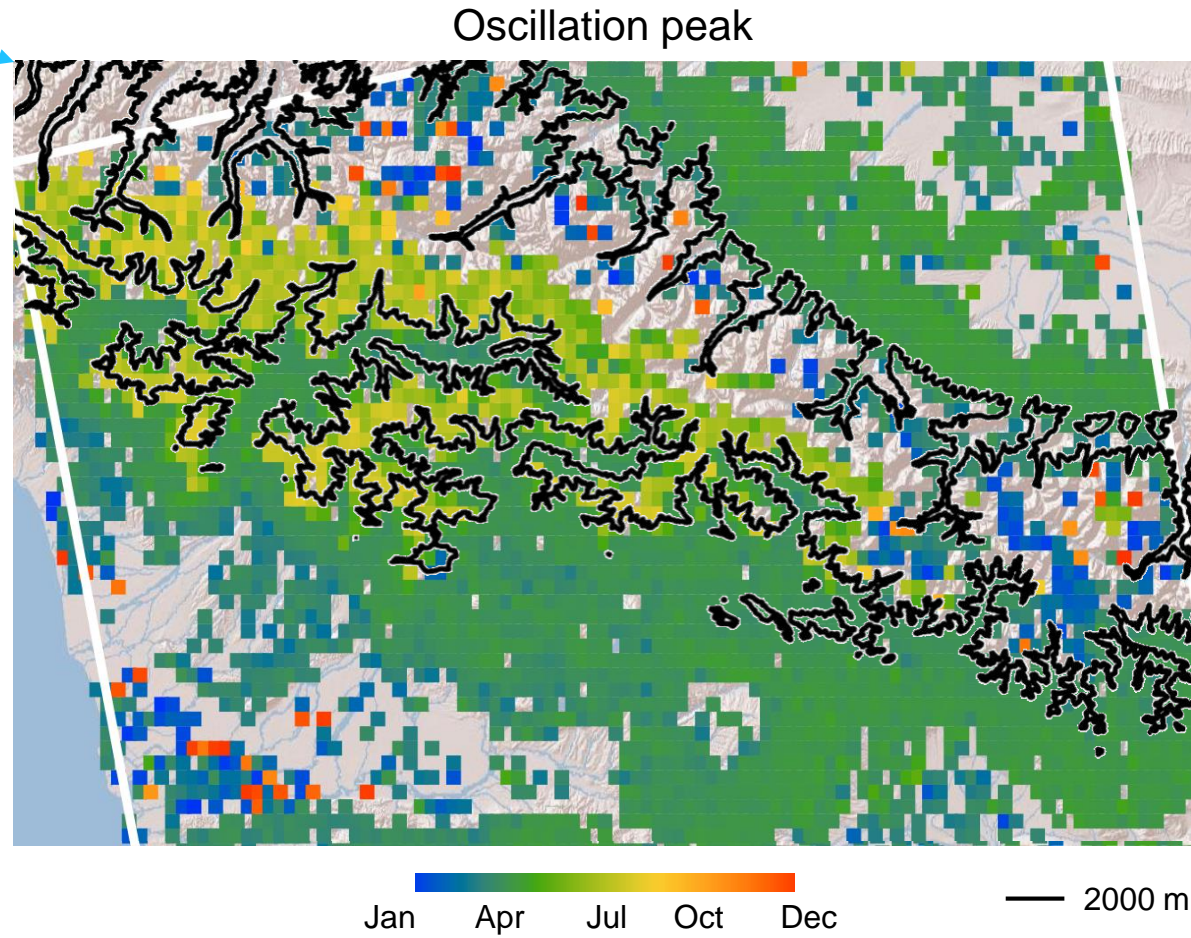


Fitting of residuals

ESA world cover



Results for shift patches

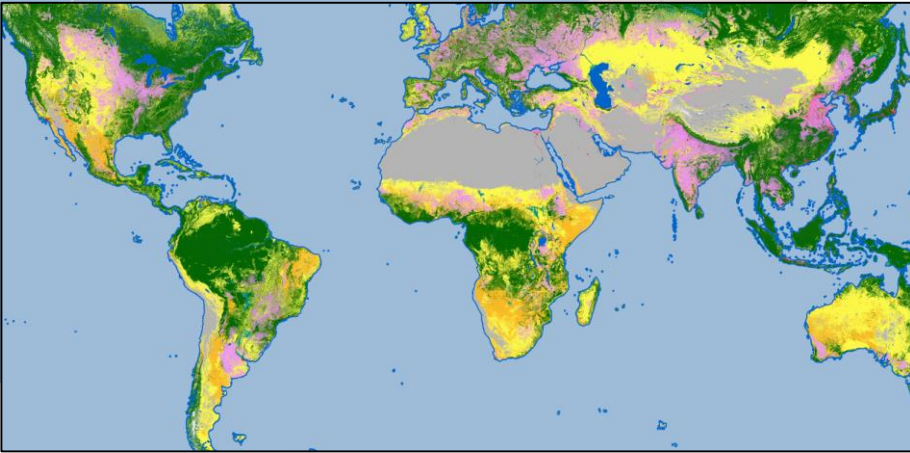
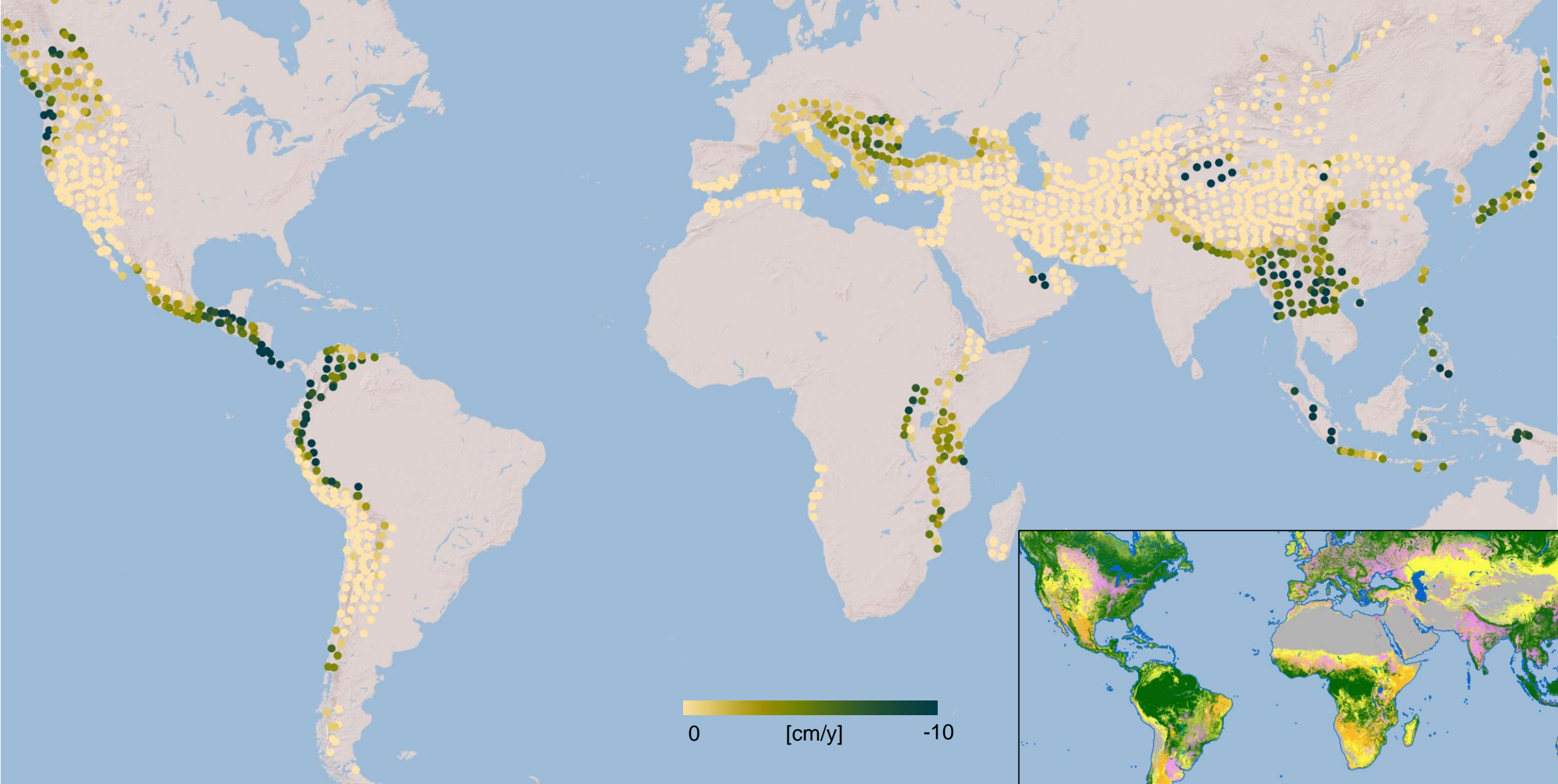


Global results - Trend

Each dot is an ascending or descending stack



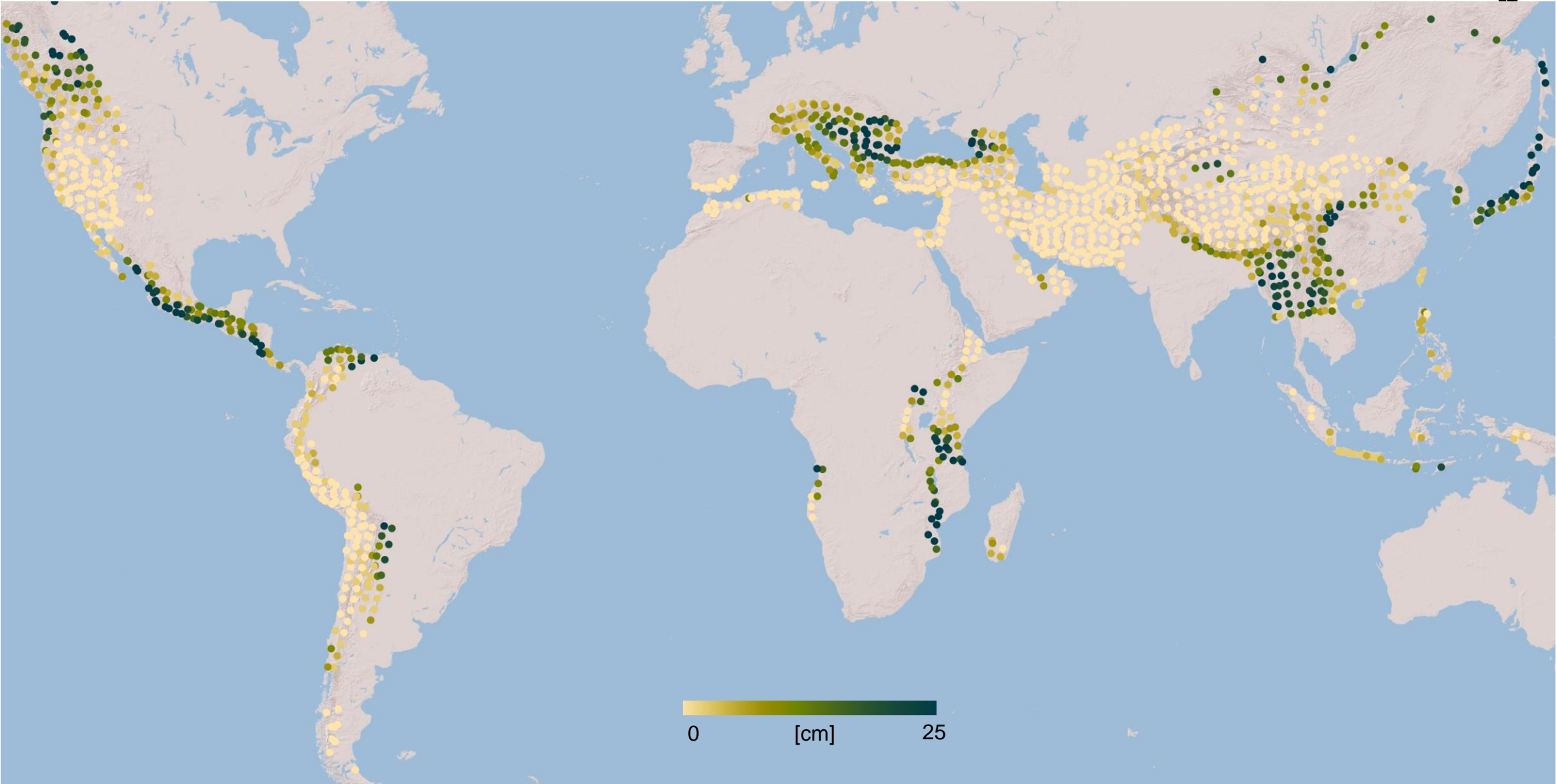
LR



Global results – Oscillation amplitude



LR

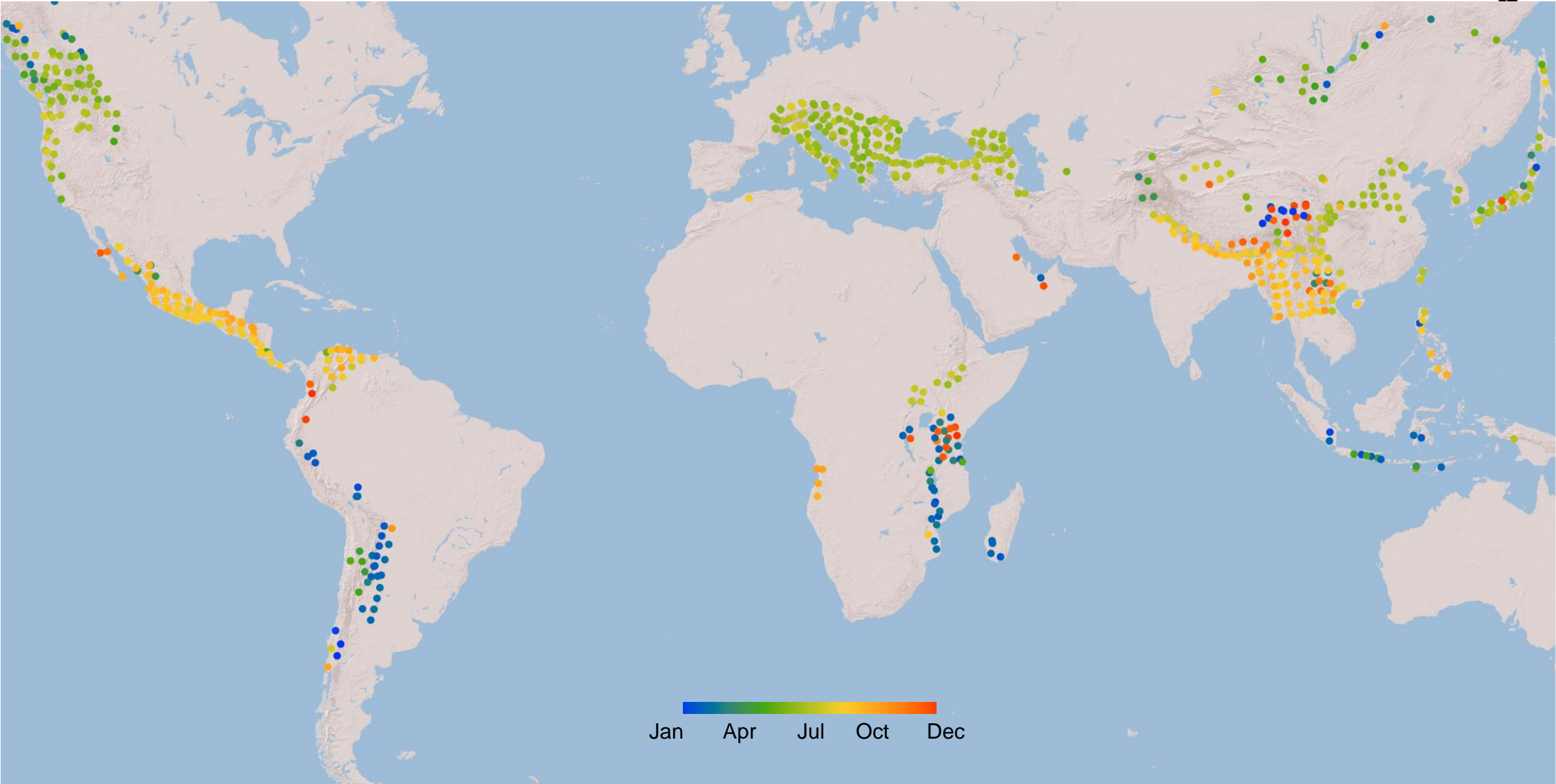


0 [cm] 25

Global results – Oscillation peak

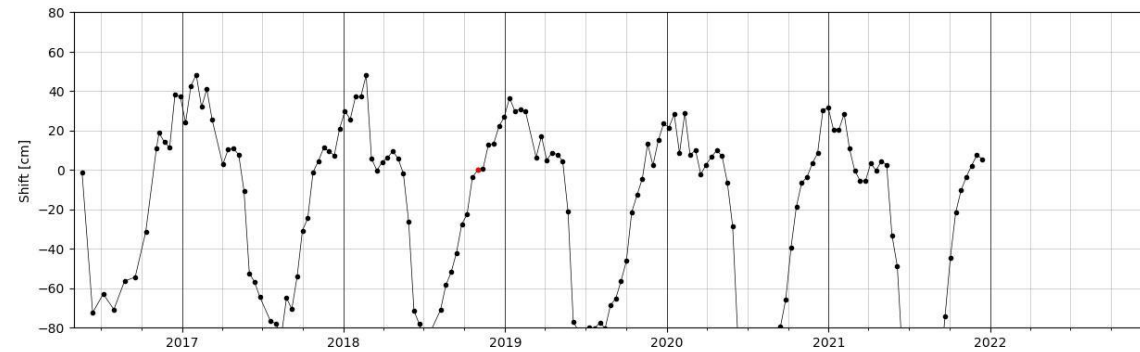
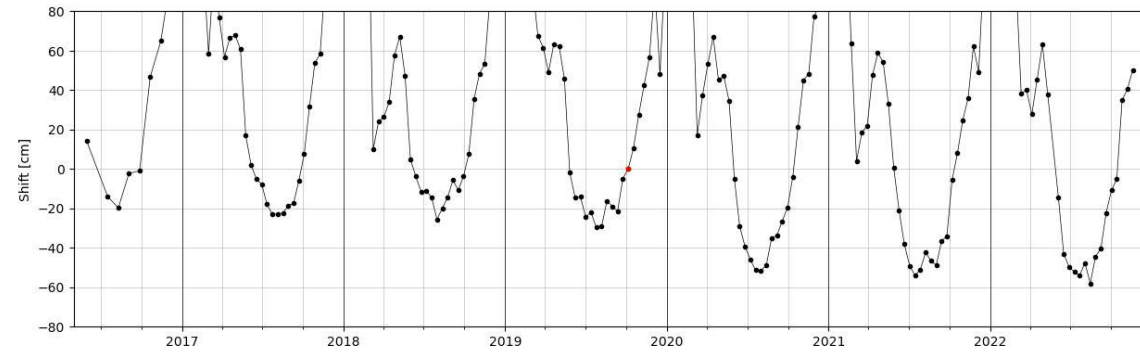
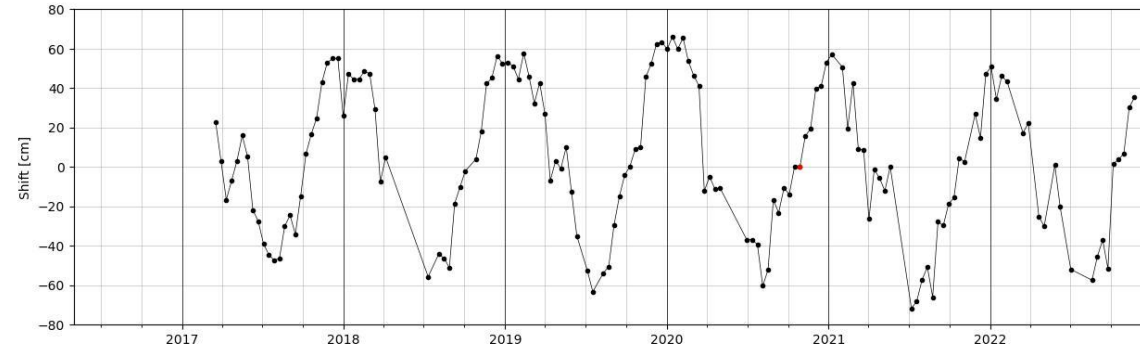
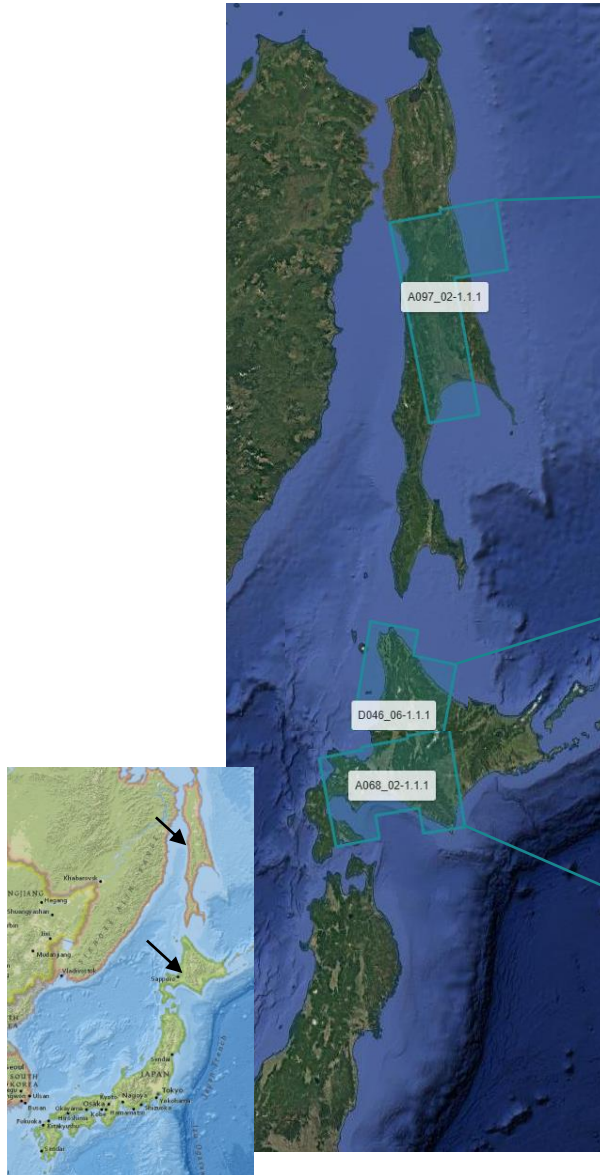


LR

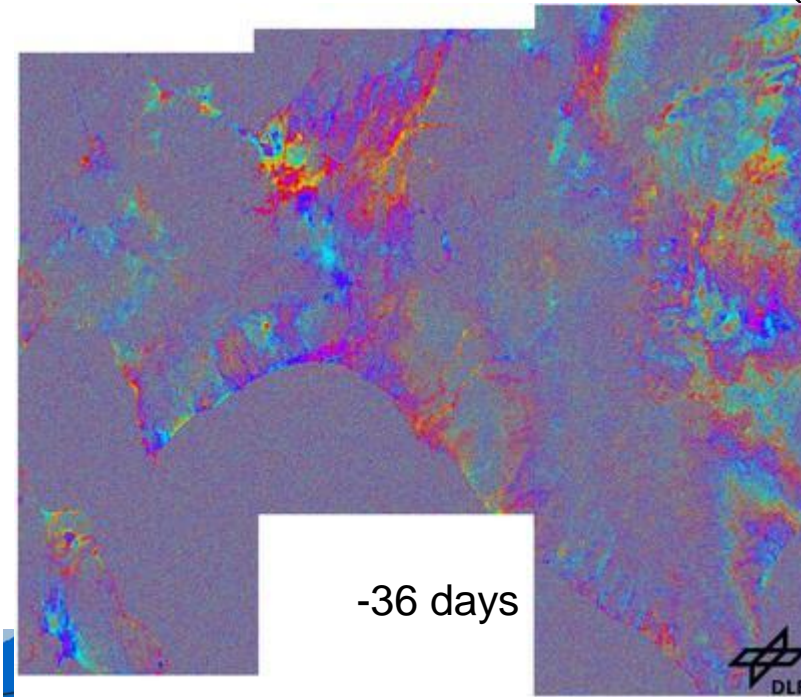
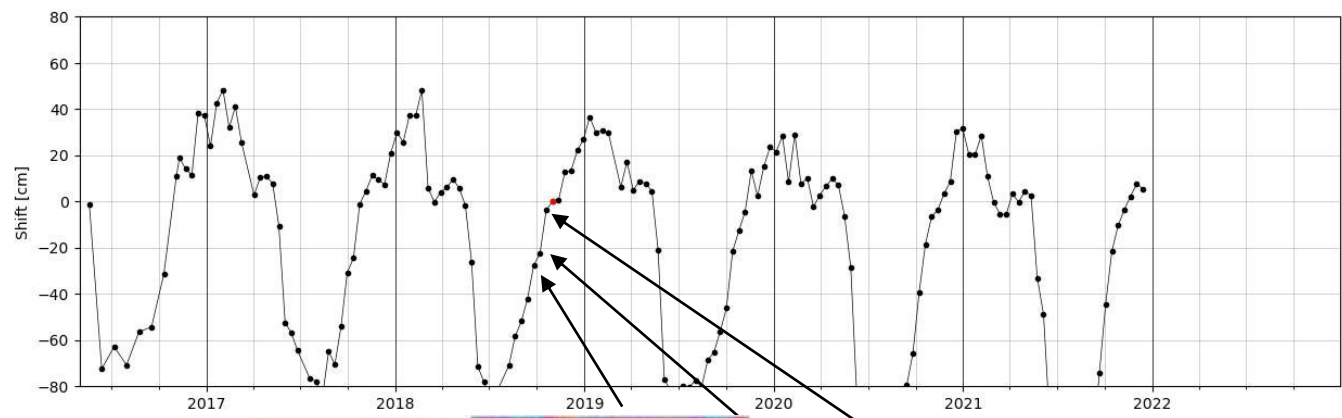
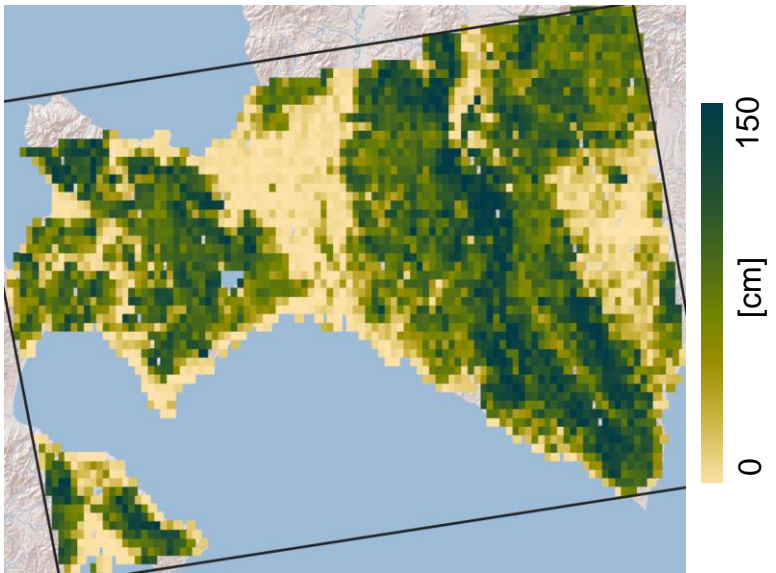
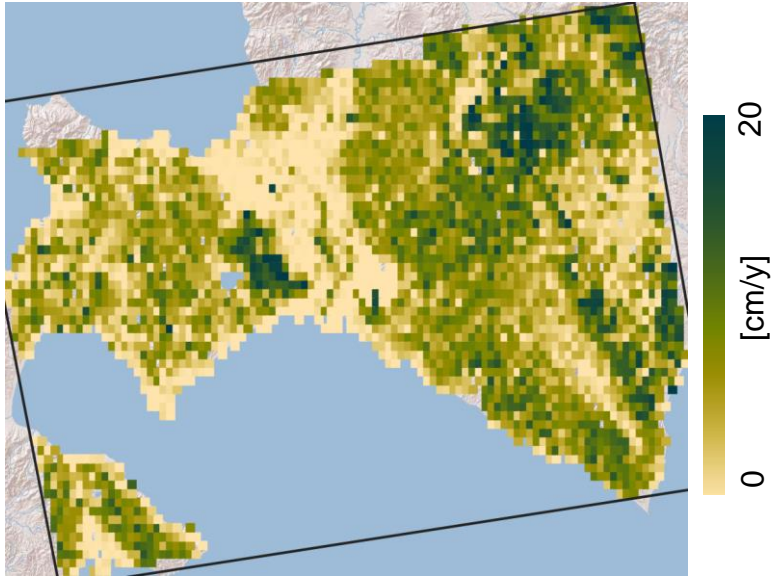
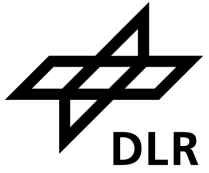


Jan Apr Jul Oct Dec

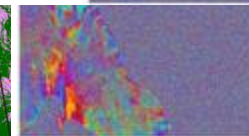
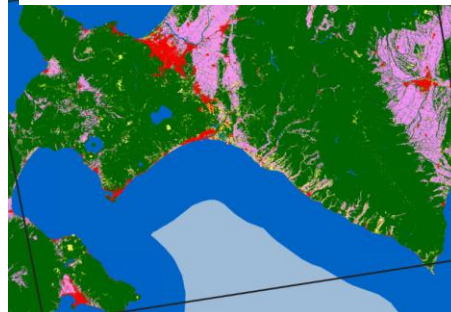
More examples: extreme oscillations



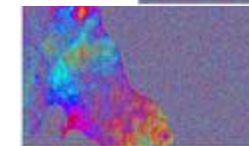
Effect on the phase



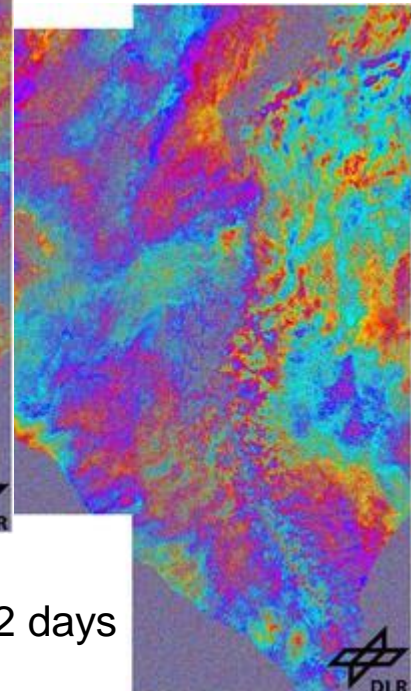
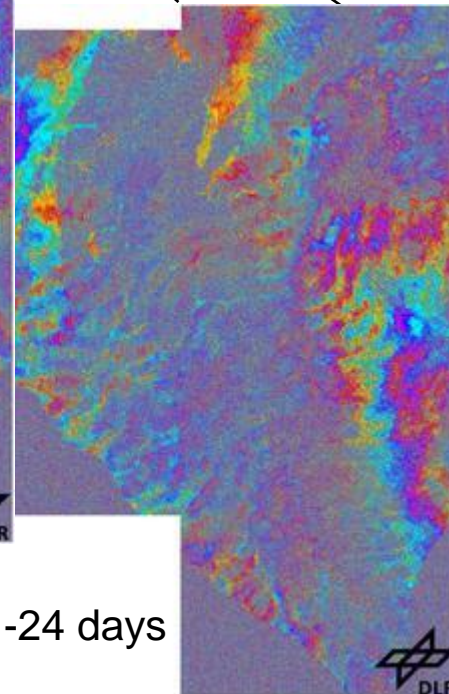
-36 days



-24 days



-12 days



Conclusion



- Seasonal oscillations and multi-year trend observed in range incoherent cross-correlation
- Strong forests dependency
- No equivalent signal in phase and PS/DS results

- (Not) Possible explanations
 - Additional delay in propagation through tree crown due to water content increase: does not explain the smaller delay in the growth season
 - Volume/ground ratio change: if two scatterer populations are uncorrelated a ratio change does not explain the shift, but since we are using incoherent cross-correlation, correlated amplitude features could explain the shift

- Future work
 - Check dependency on reference image, polarization, carrier frequency, ...
 - Applications?