

# A Proposal for **Interferometric Time Series Product** with Reduced Stochastic and Systematic **Phase Errors**

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Knowledge for Tomorrow

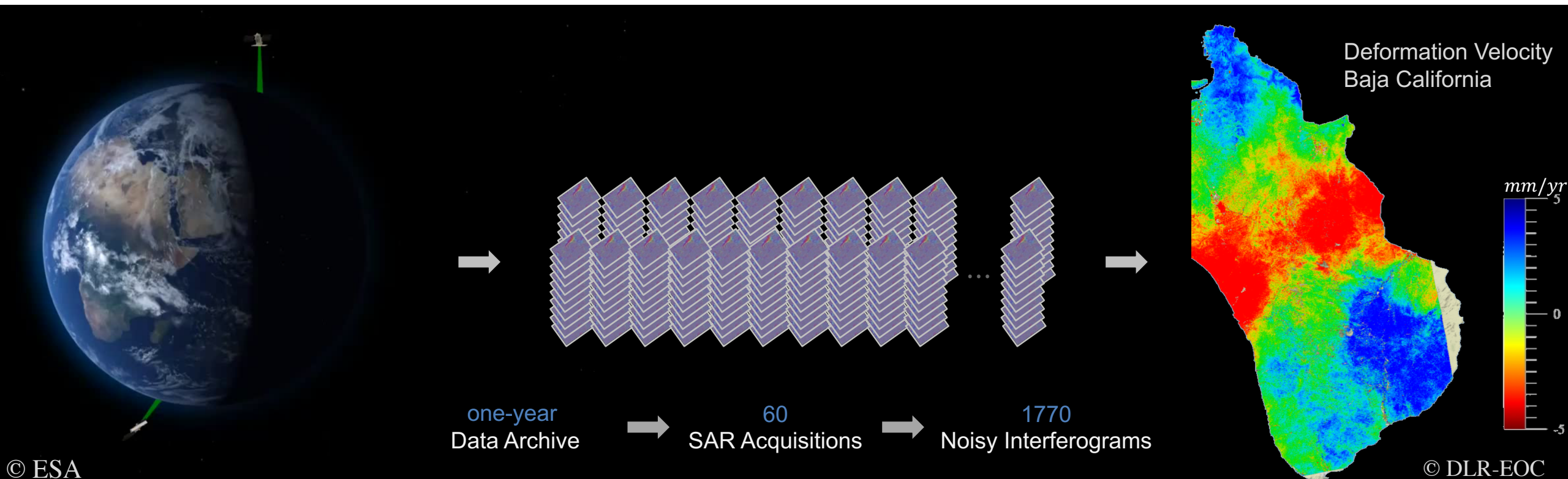


# Big Data from Sentinel-1

Unique Capability : high-precision **deformation** monitoring (mm/yr)

Challenge : **preserving** accuracy in Big Data processing

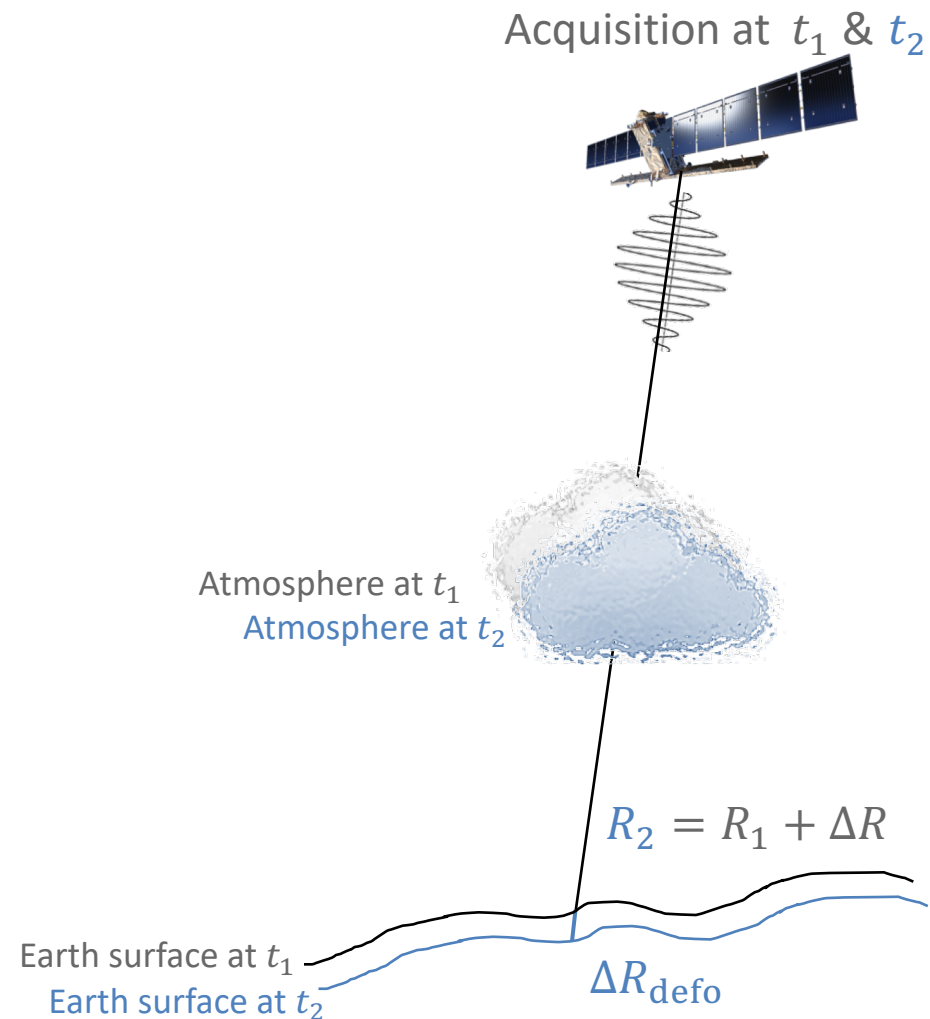
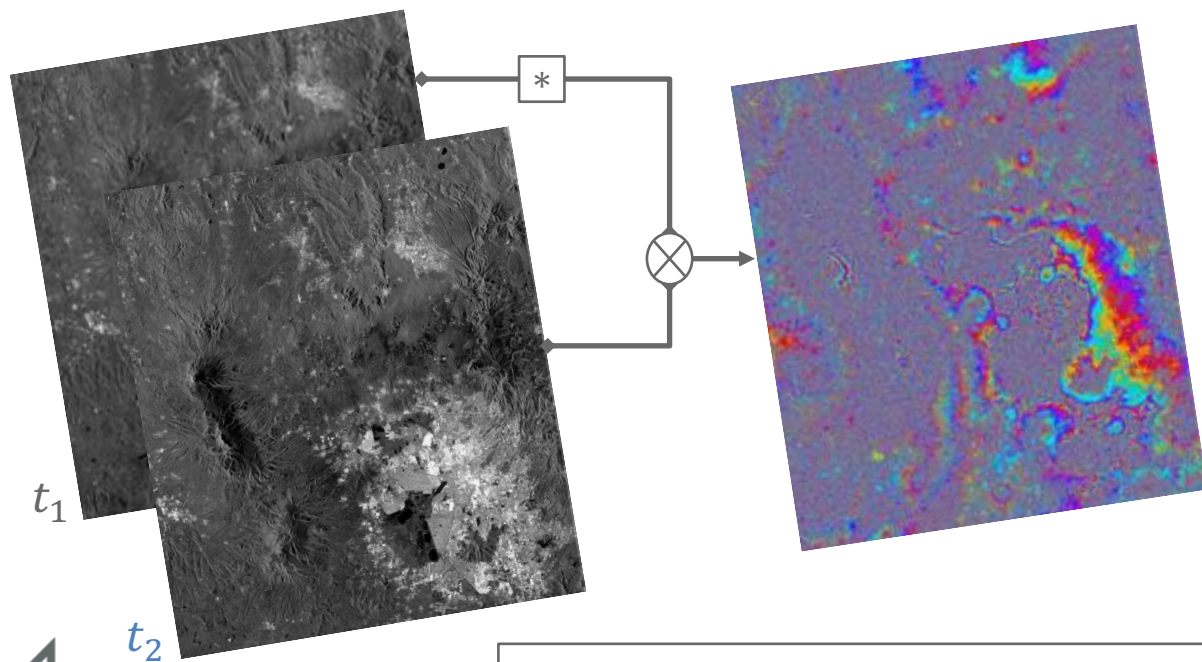
Our Solution : proposal of **an analysis-ready phase product** to overcome the challenge



# Systematic Error Sources in Interferograms

$$\Delta R = \frac{\lambda}{4\pi} \Delta\phi = \Delta\phi_{\text{atmo}} + \Delta\phi_{\text{defo}} + \Delta\phi_{\text{sct}} + \Delta\phi_{\text{system noise}}$$

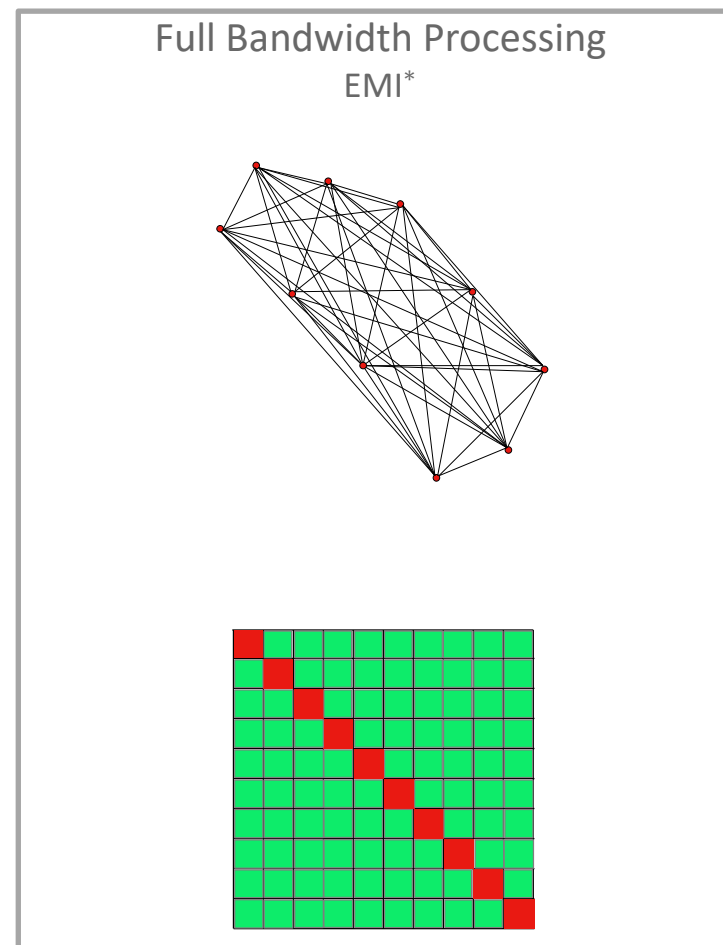
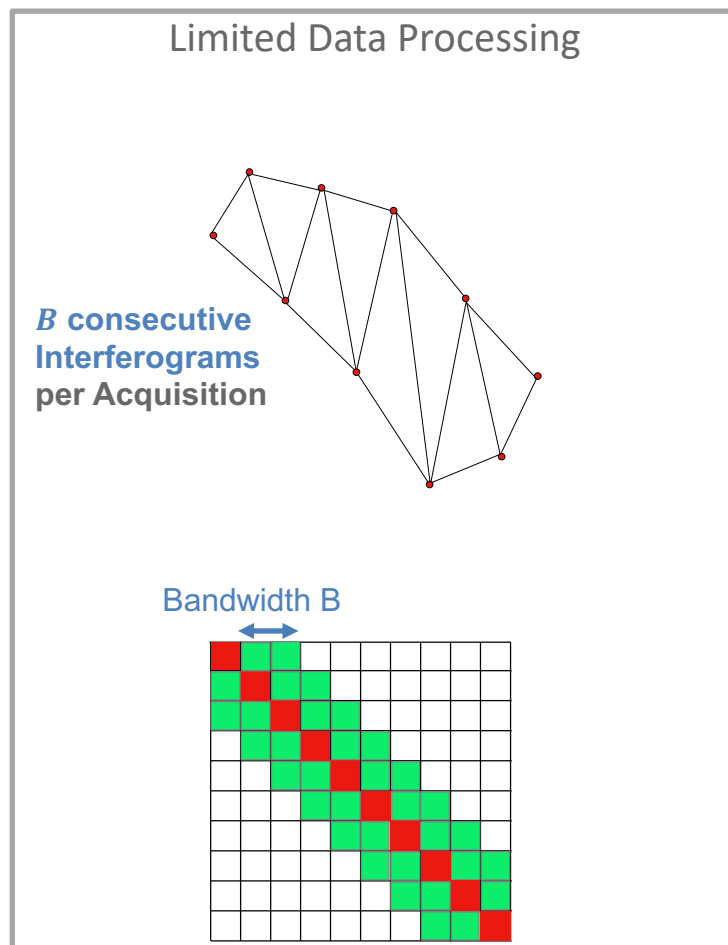
$\Delta\phi_{\text{sct}} \rightarrow$  decorrelation noise  
 $\rightarrow$  systematic signal/error



# Verification of Deformation Velocity of Big Data Processing Schemes



# Different Schemes in Big Data Processing



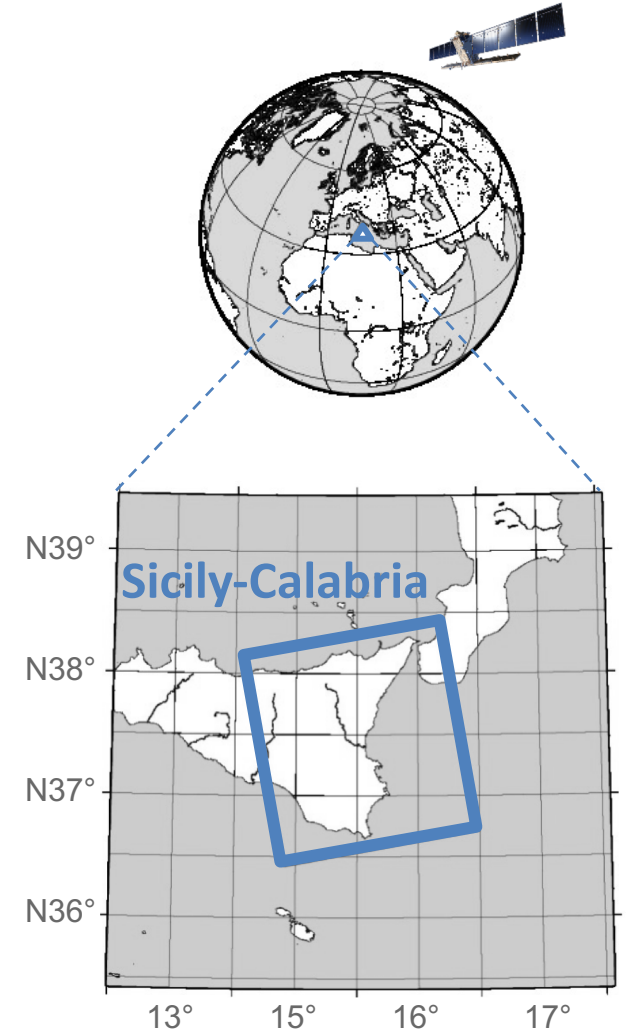
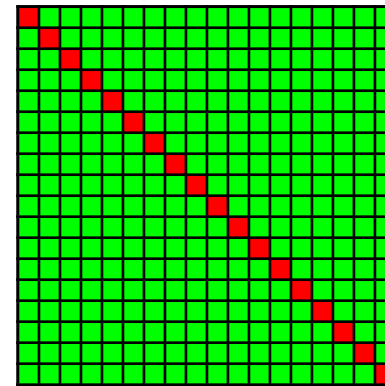
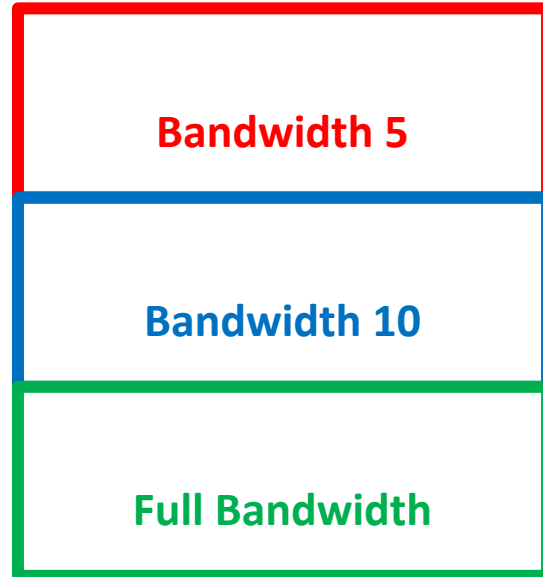
# Verification Scheme

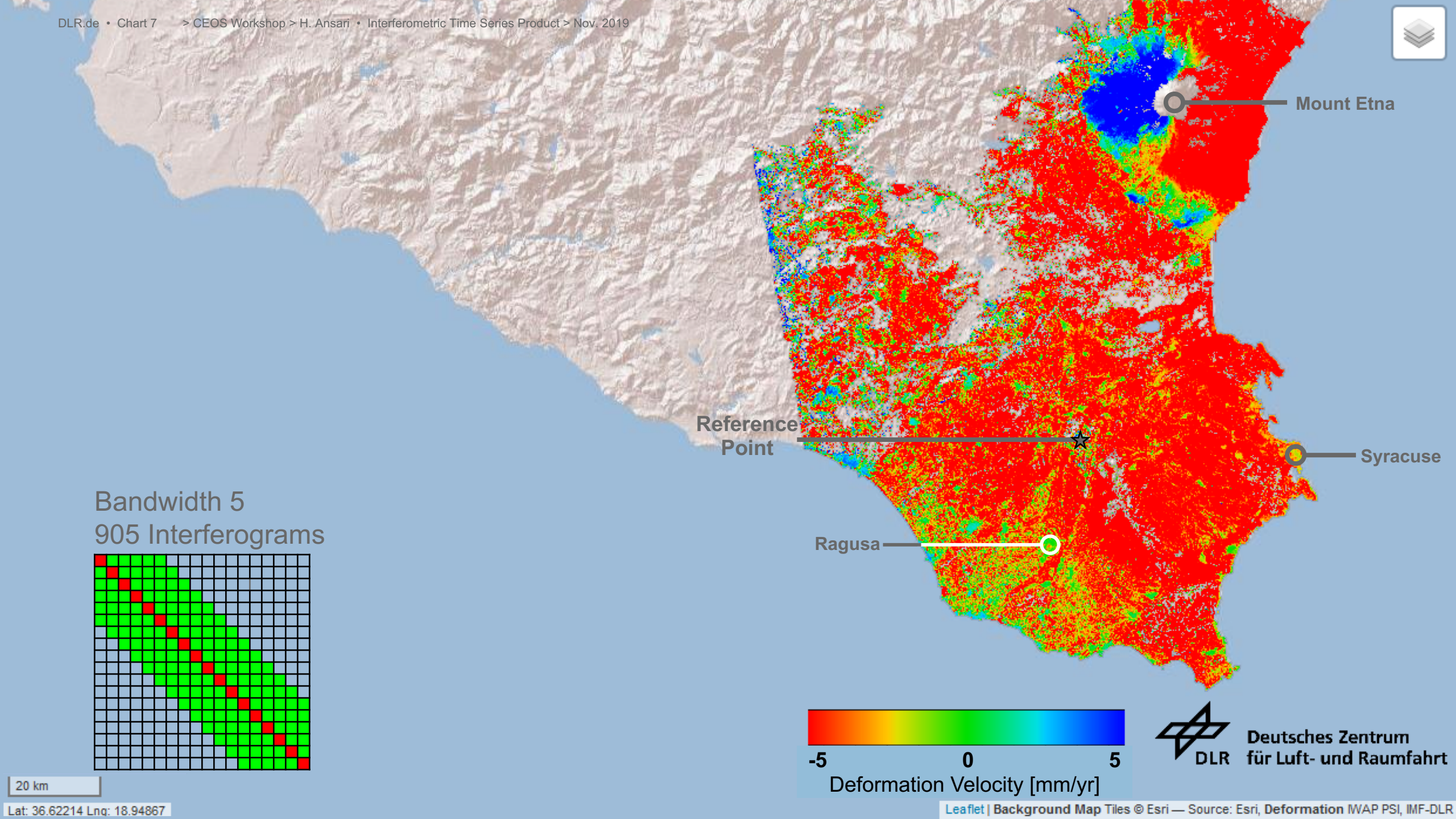
## Sentinel-1 A/B time series:

acquisition time span : 4 years (Oct. 2014-Sep. 2018)  
size of the time series : 184 SLCs  
extent of the chosen area  $\approx 30000 \text{ km}^2$   
number of processed bursts : 19

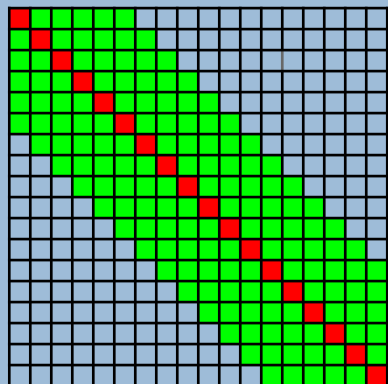
PSI

versus



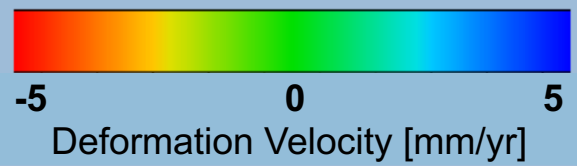



Bandwidth 5  
905 Interferograms

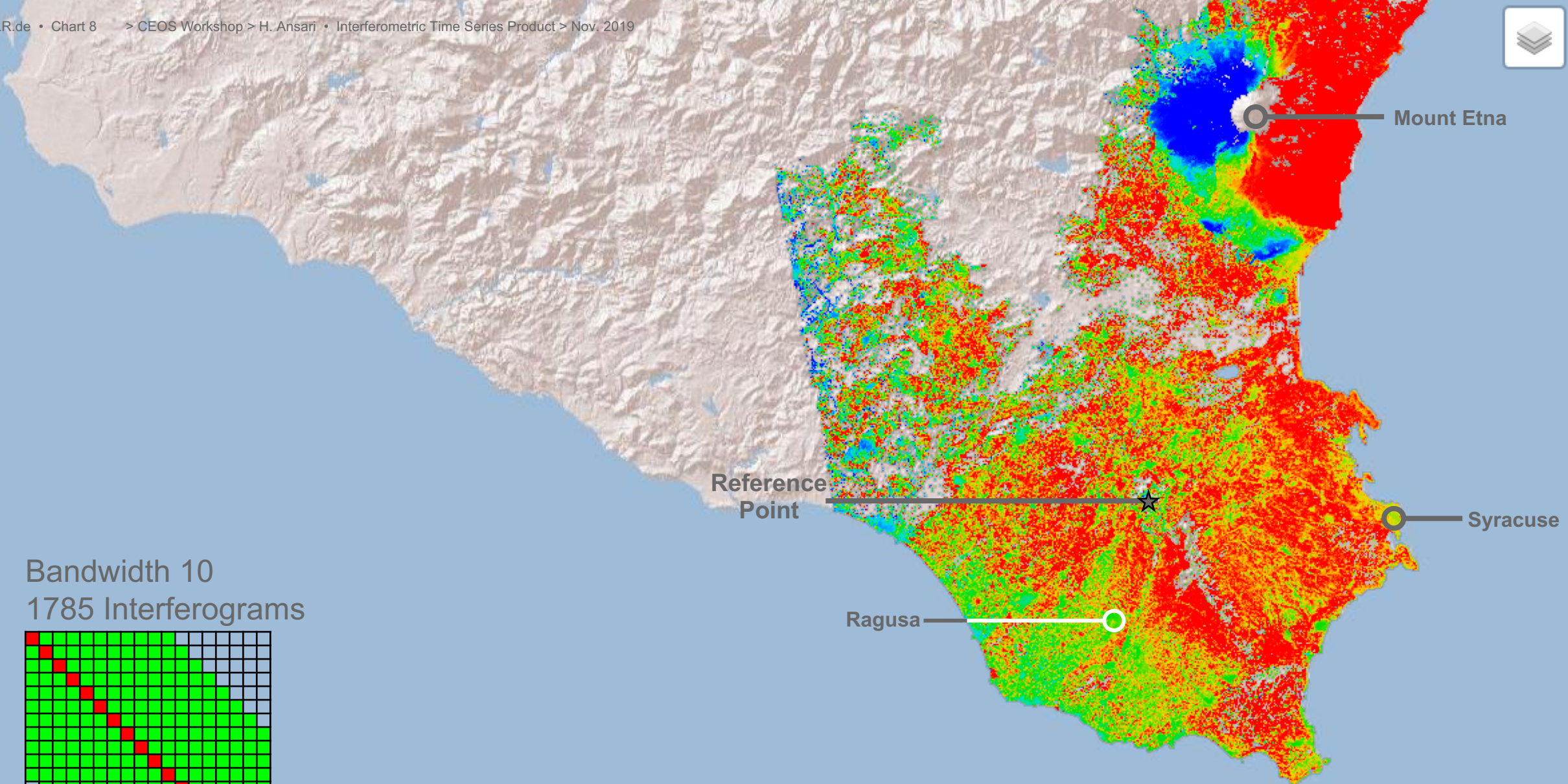


20 km

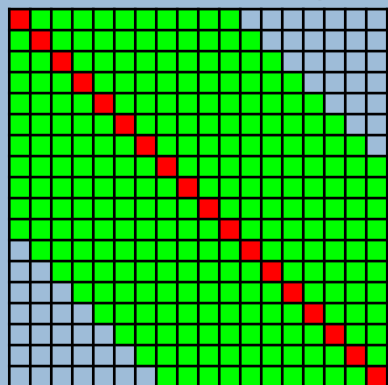
Lat: 36.62214 Lng: 18.94867



 Deutsches Zentrum  
für Luft- und Raumfahrt

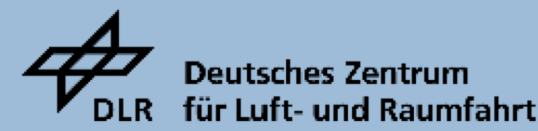
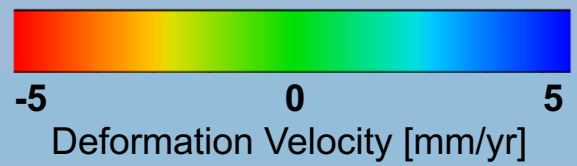


Bandwidth 10  
1785 Interferograms

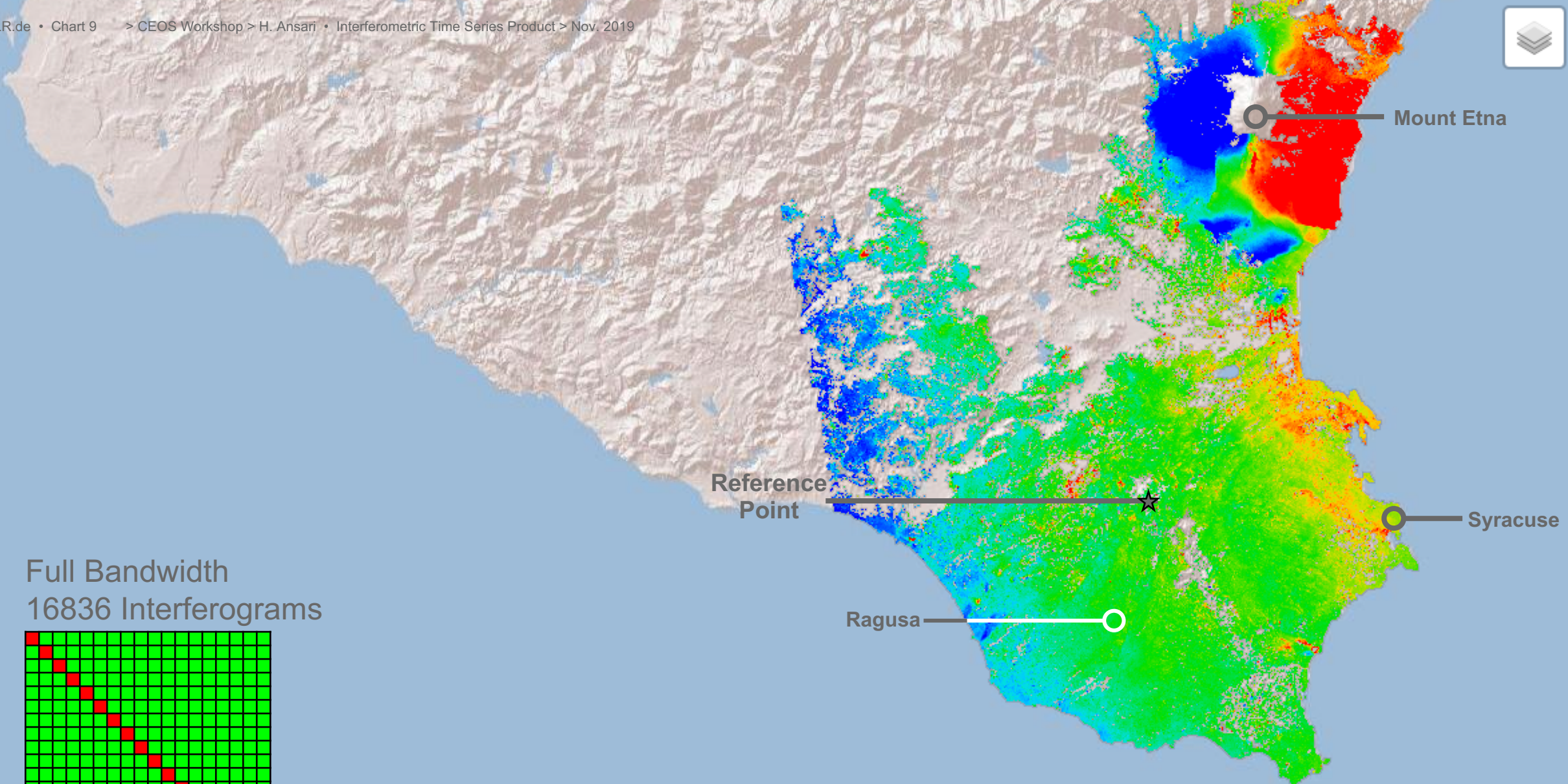


20 km

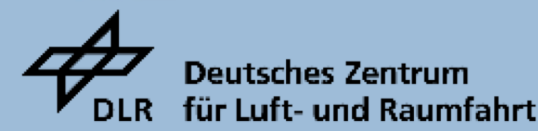
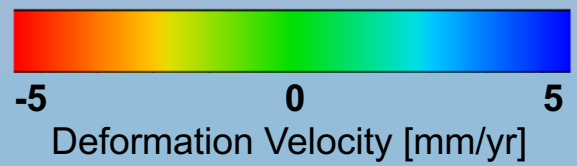
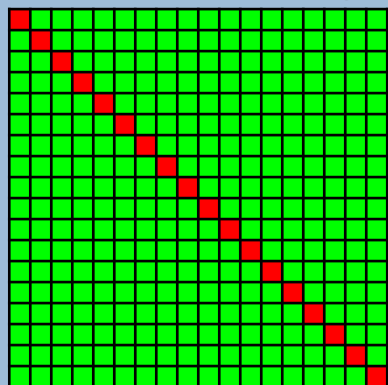
Lat: 36.62214 Lng: 18.94867







Full Bandwidth  
16836 Interferograms



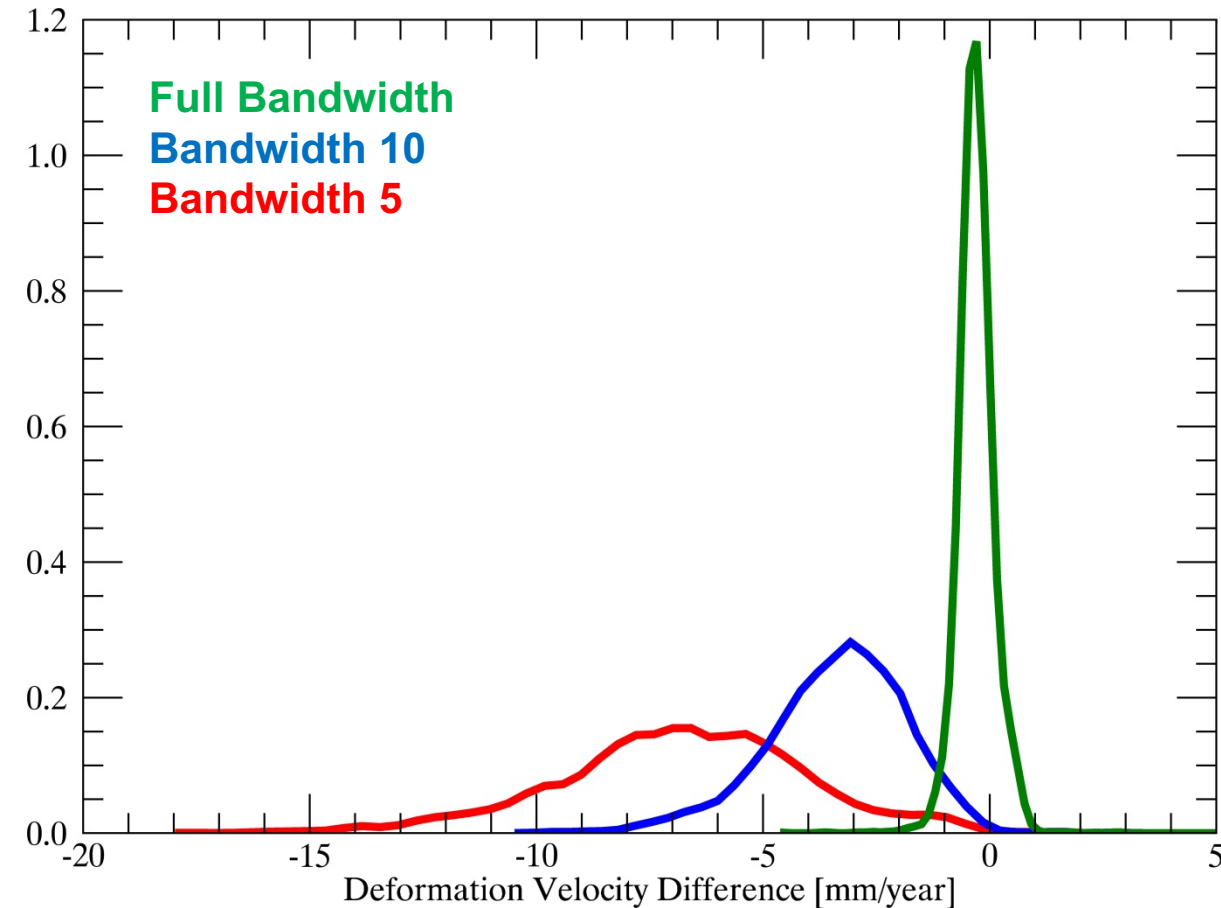
20 km

Lat: 36.62214 Lng: 18.94867

# Accuracy of Deformation Velocity Maps

- Comparison with PSI
- Persistent Scatterers (PS): free from systematic phase error

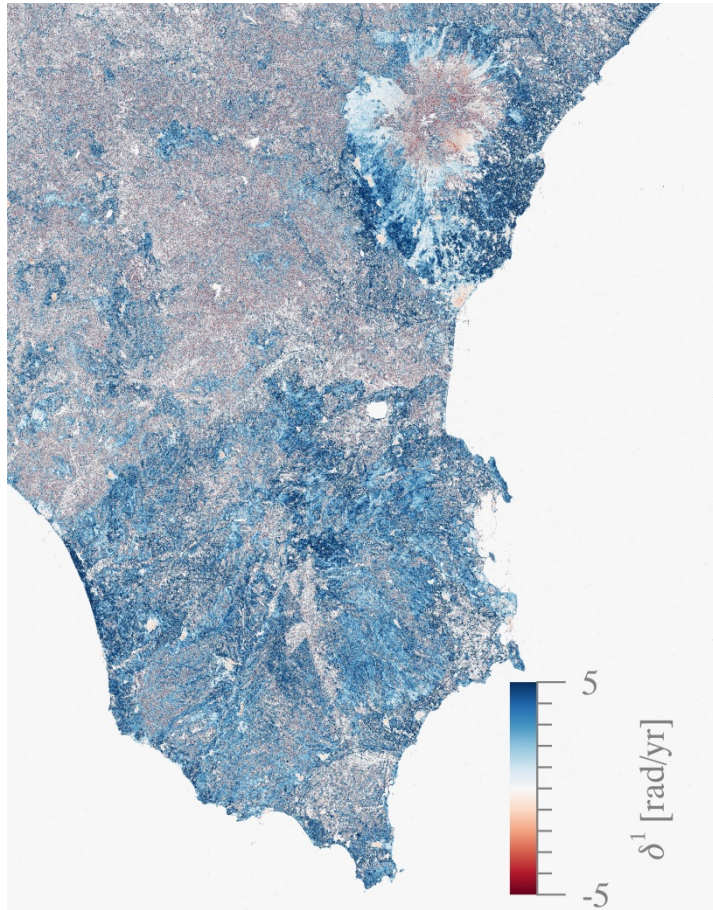
	Bias [mm/year]	Std. Deviation [mm/year]
Bandwidth 5	-6.50	2.58
Bandwidth 10	-3.05	1.55
Full Bandwidth	-0.24	0.70



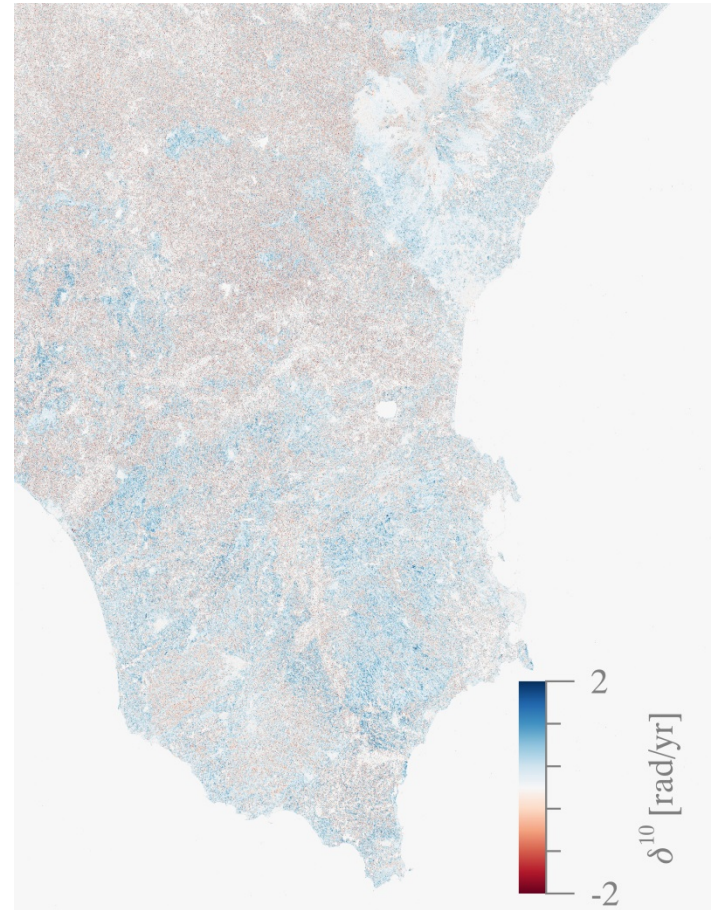
## The Origin of Deformation Error



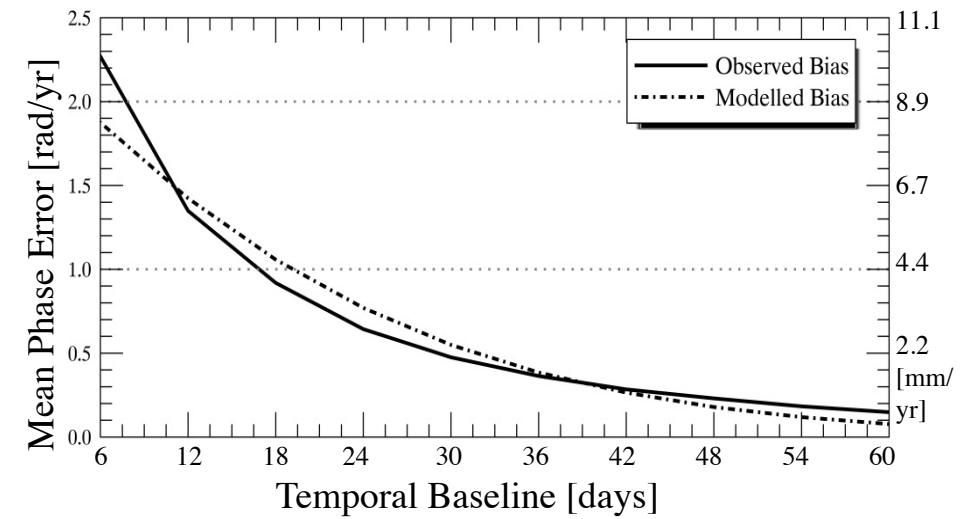
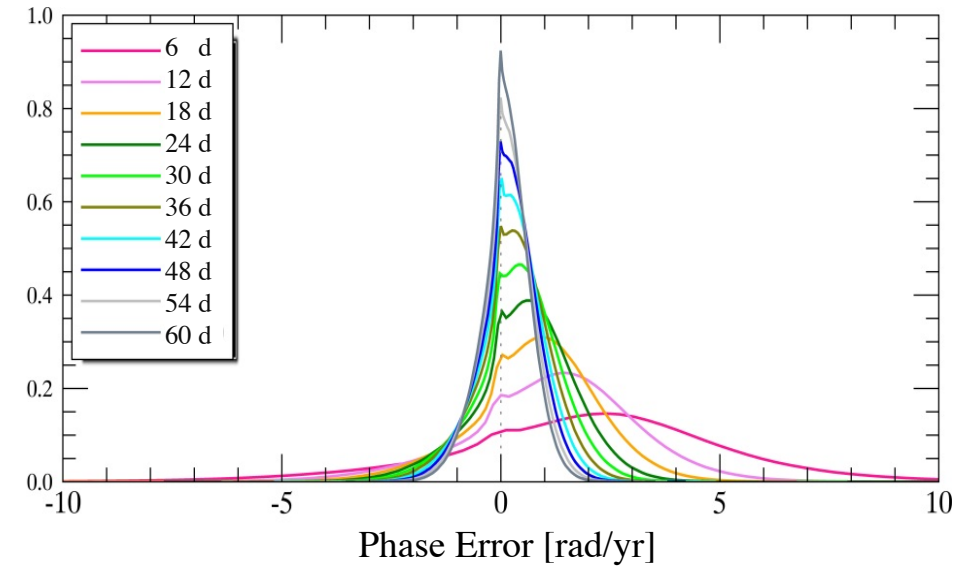
# Evaluation of Phase Error



**Error of 6-day Interferograms**

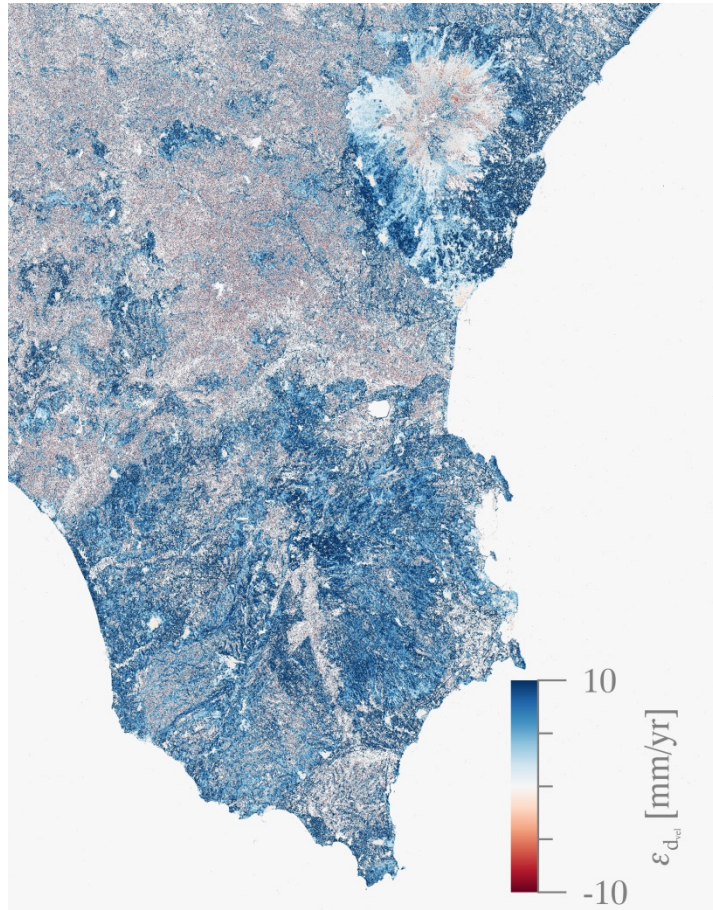


**Error of 60-day Interferograms**

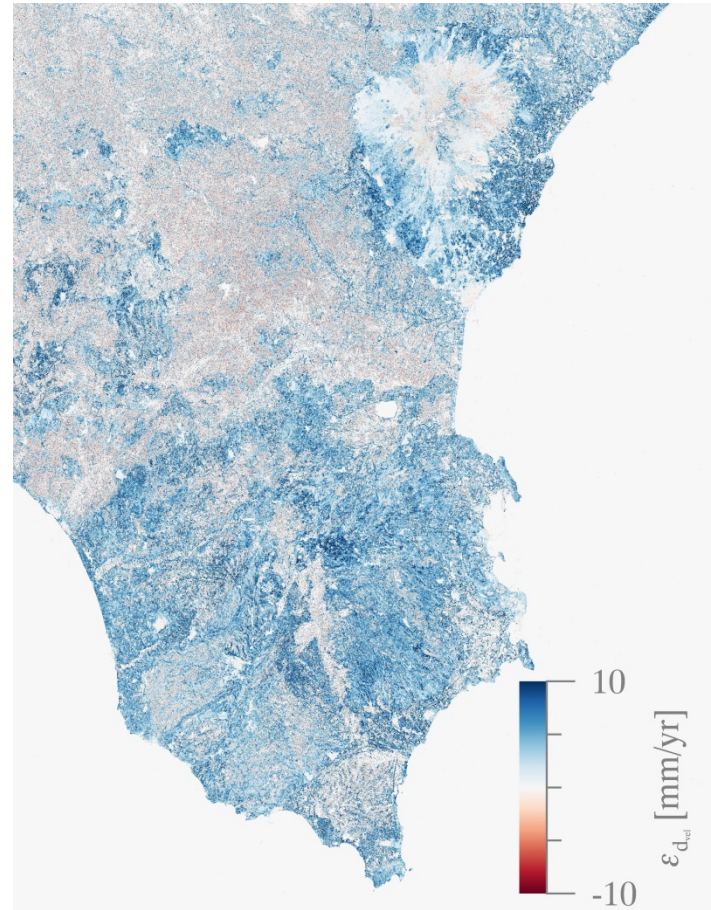


# Prediction of Deformation Error

propagation of phase errors to deformation velocity estimates

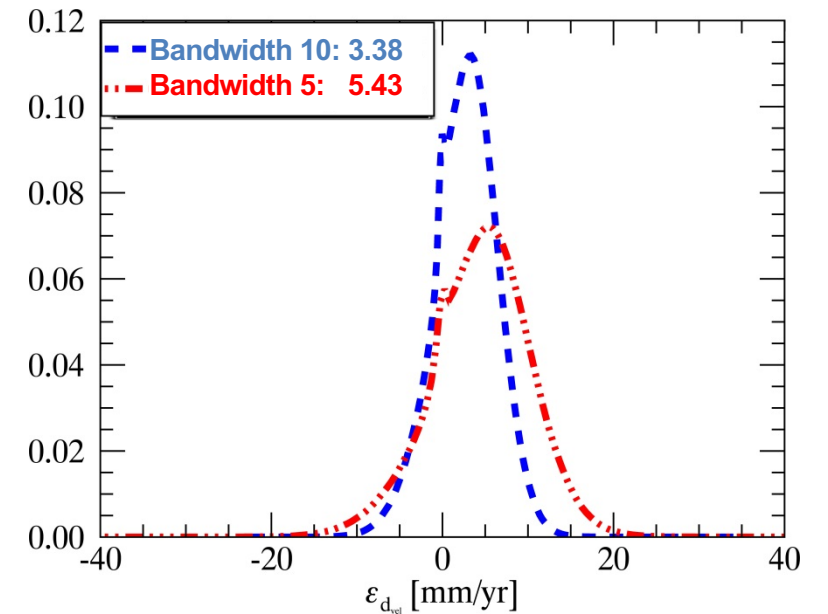


**Bandwidth 5 processing**



**Bandwidth 10 processing**

Empirical Deformation Error from Data:  
Bandwidth 10 : 3.05 mm/yr  
Bandwidth 5 : 6.5 mm/yr

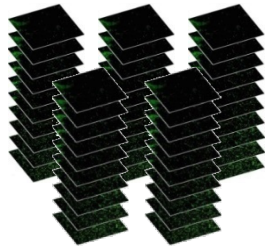


# An Analysis-ready InSAR Product with Reduced Phase Errors

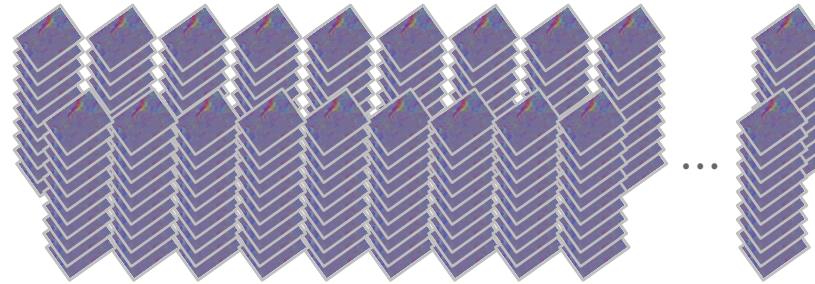


# Current Approach in Processing Big Data

Coregistration  
 $N$  SLCs

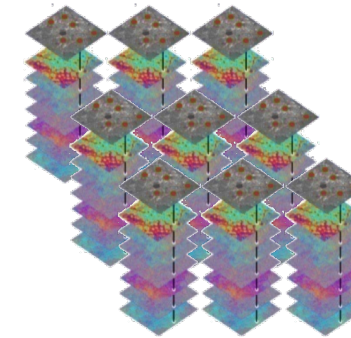


Choosing a subset of  
 $K$  interferograms  
 $K > N - 1$



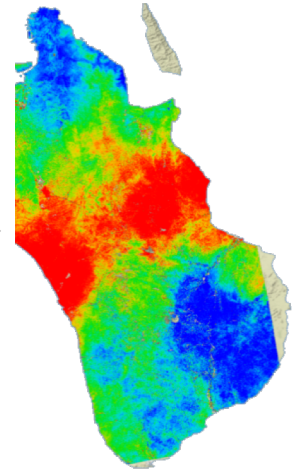
Subjective &  
Prone to Systematic Phase Error

Unwrapping the  
 $K$  interferograms

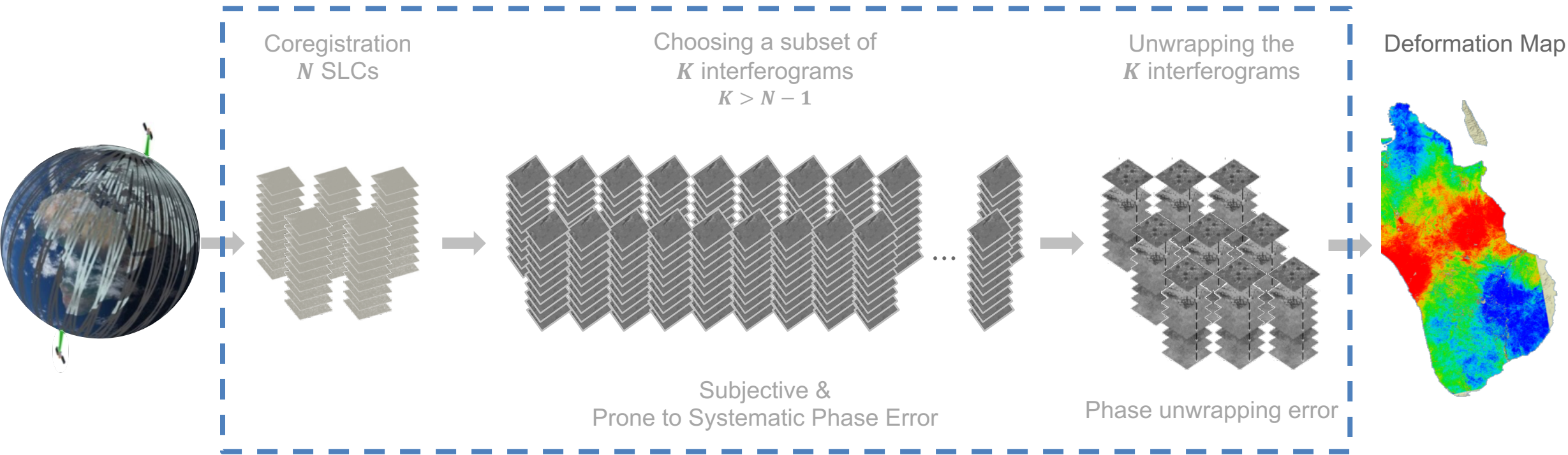


Phase unwrapping error

Deformation Map



# Current Approach in Processing Big Data



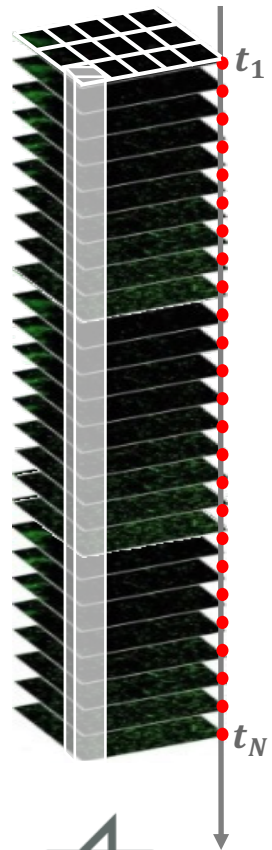
Substitution with an analysis-ready InSAR product



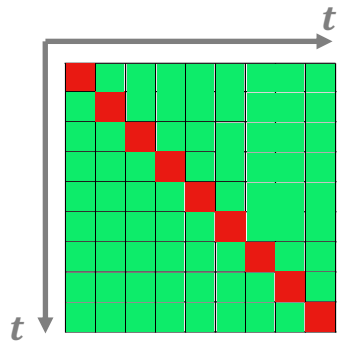


# Analysis-Ready InSAR Product

Accurate Coregistration



Spatial Multilooking via covariance matrix



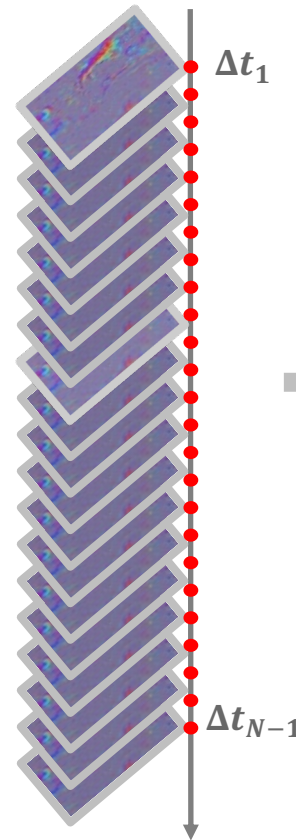
Accurate phase estimation



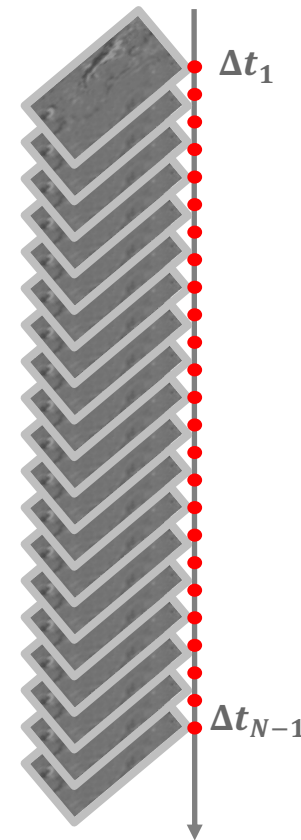
Efficient Full Bandwidth Processing

Significant  
Temporal and Spatial  
Data Reduction

$N - 1$   
Analysis-Ready  
Interferograms



Optional  
SAR Geodetic Correction \*  
Layers



Merits of the product:

- “Compressed”
- Reduced Error
- Wrapped
- Geocoded
- Optional correction layers



\* Towards Operational SAR Imaging Geodesy (Talk By Christoph Gisinger at 11:50)

# In Summary

- **Verification** of differential interferograms and deformation products is a **necessity**
- Big Data **processing** schemes can **compromise** mission capabilities
- An **analysis-ready accurate interferometric product** is a potential solution
- Computational complexity is not a concern. **Stream processing** is possible as well ...



# Our recipe for Big Data:

# Sequential Estimator: Toward Efficient InSAR Time Series Analysis

