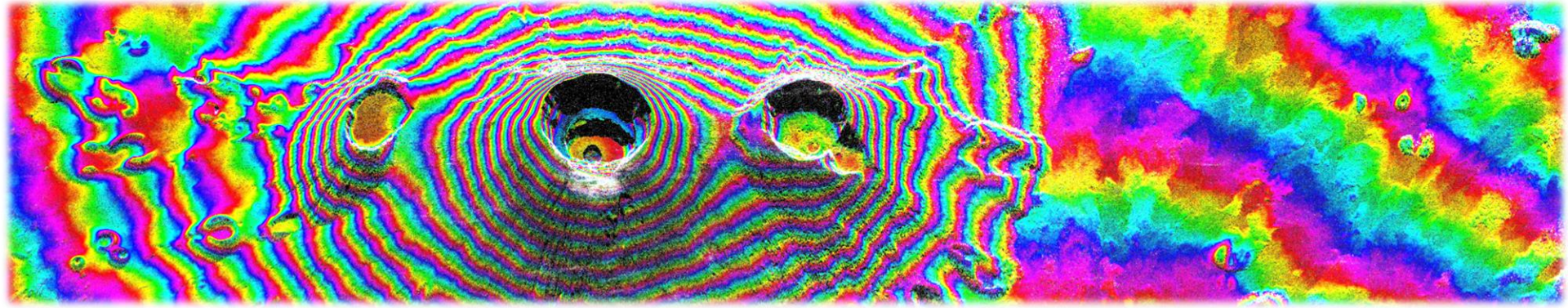

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Optimum Split-Band Parameters for Phase-Offset Retrieval

L. Libert, D. Derauw, and C. Barbier

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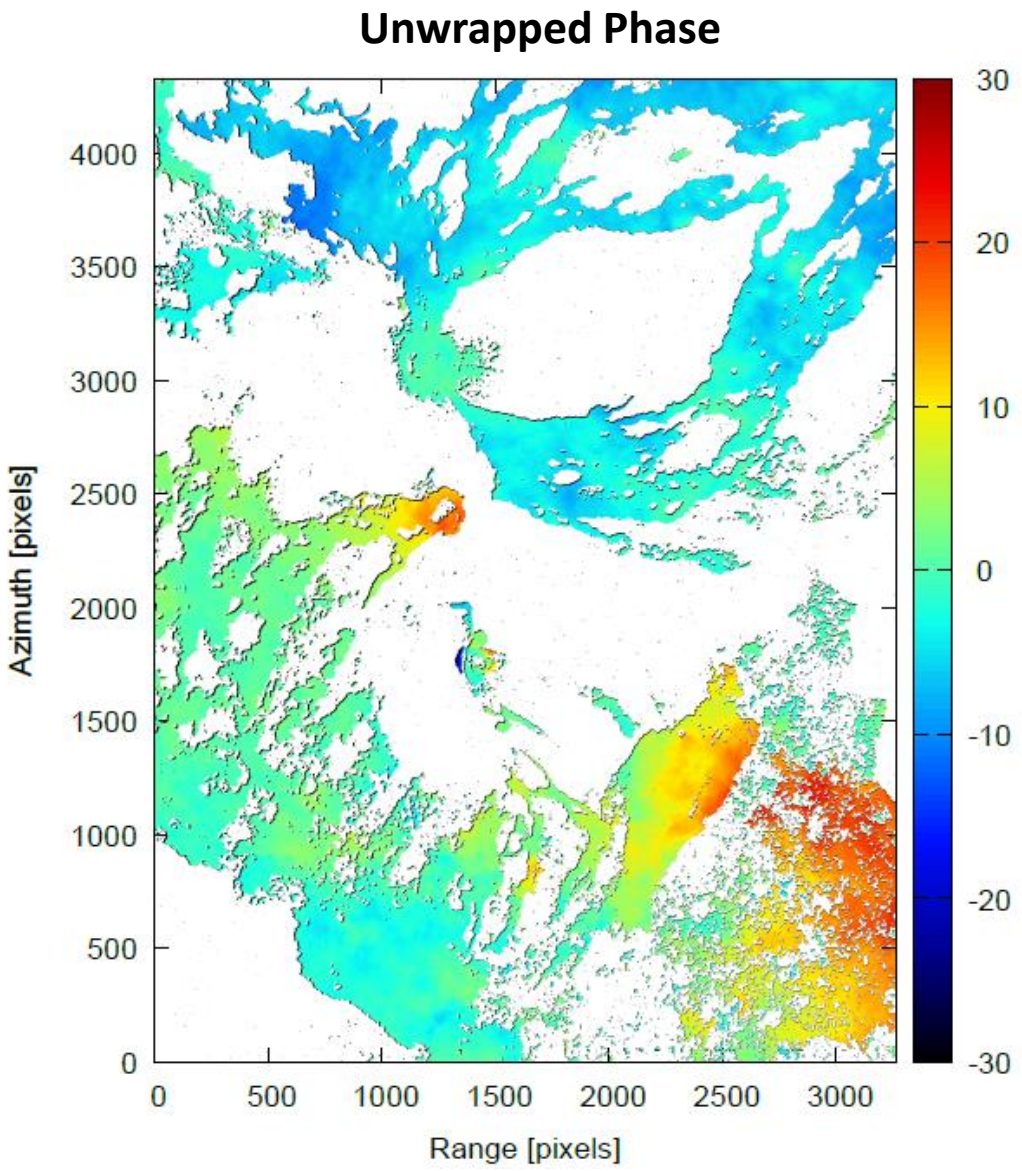
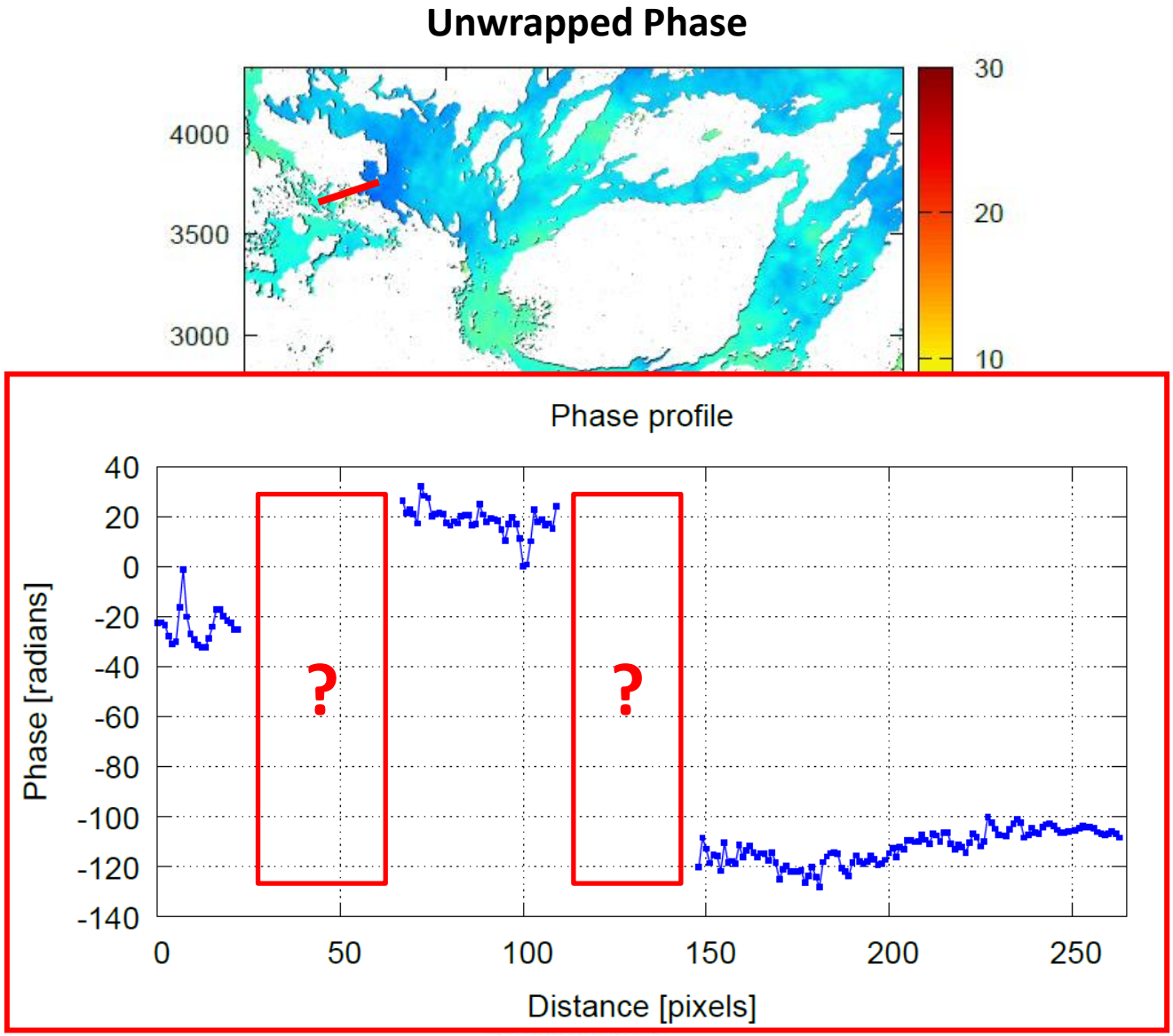
Phase-Offset Issue

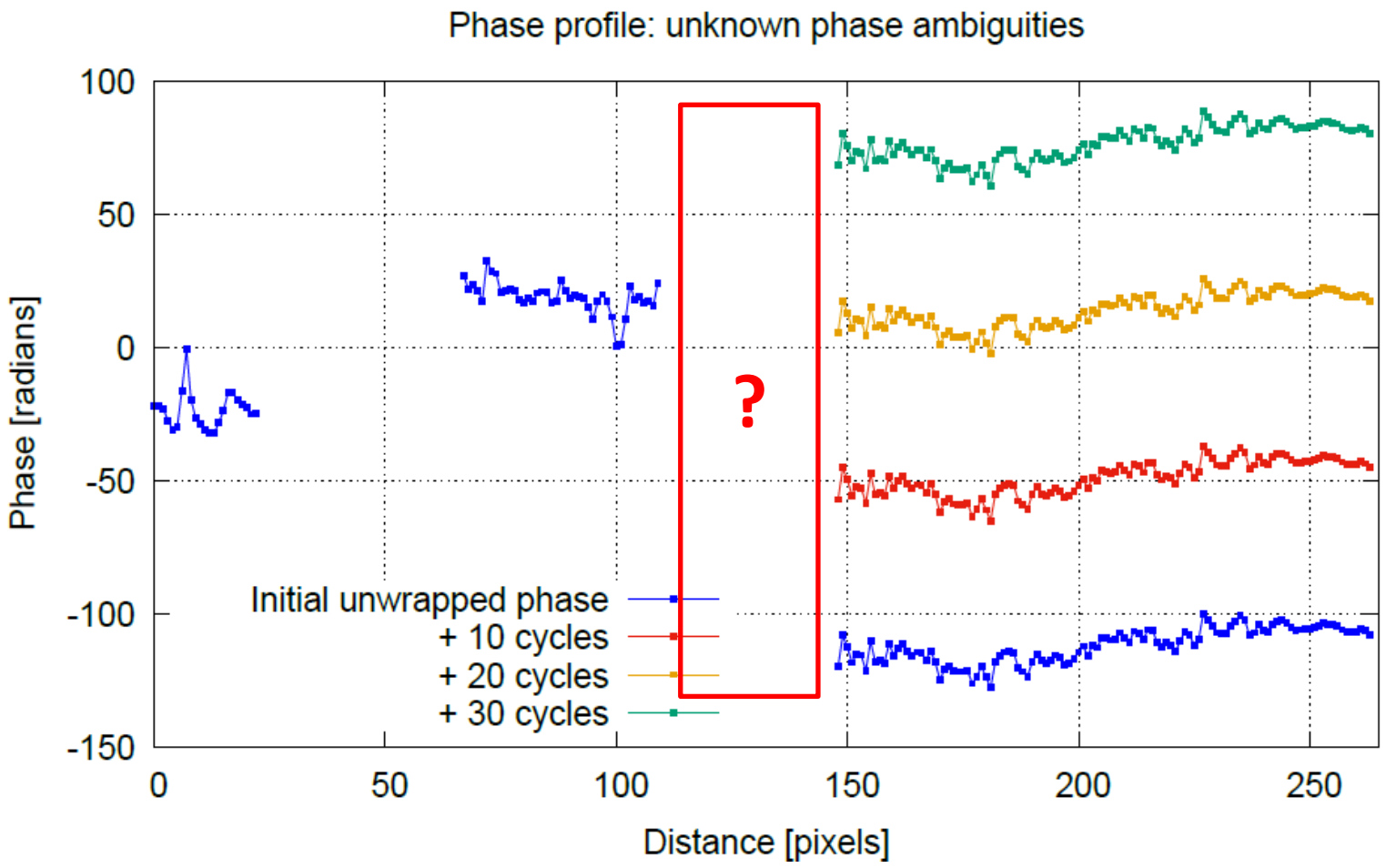


Virunga (DRC) – TerraSAR-X
22/06/2008 and 03/07/2008

Phase-Offset Issue



Phase-Offset Issue



Offset constraint:

$$\phi_{abs} = \phi_{unw} + 2\pi n$$

Split-Band Interferometry (SBInSAR)

- Also known as MCA
- Exploits the spectral information of wideband SAR images
- Absolute phase computation for frequency-persistent scatterers (PS_f)

SBInSAR Rationale

Let us consider an interferometric pair of coregistered images with :

- bandwidth B
- central carrier frequency ν_0

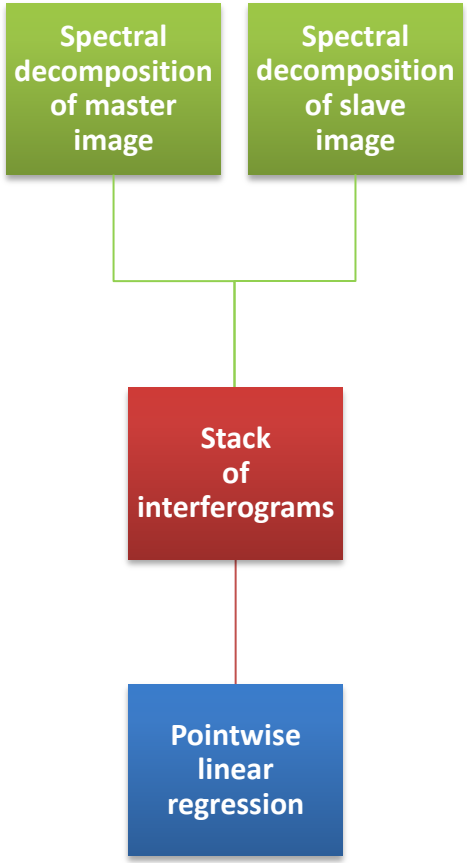
The images are spectrally decomposed into N subbands of :

- partial bandwidth B_N
- central frequencies ν_i

The phase in i[th] partial interferogram is given by :

$$\Delta\phi_i = \frac{4\pi}{c}(r_s - r_m - e_c)\,\nu_0 + \frac{4\pi}{c}e_c\,\nu_i$$

- master and slave range r_m , r_s
- error of coregistration e_c



SBInSAR Rationale

The phase in i[th] partial interferogram is given by :

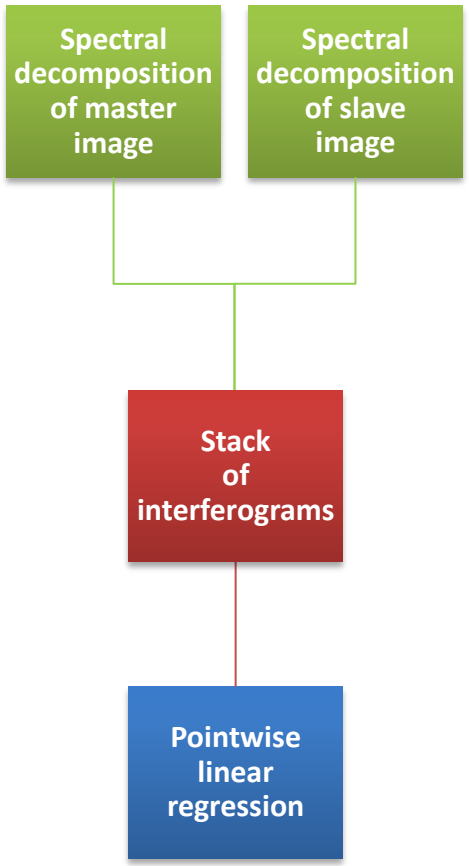
$$\Delta\phi_i = \frac{4\pi}{c}(r_s - r_m - e_c)\,\nu_0 + \frac{4\pi}{c} e_c\,\nu_i$$

- master and slave ranges r_m , r_s
- error of coregistration e_c

The phase behaviour of a point across the N subbands is fitted by a linear function.

The split-band phase is computed as :

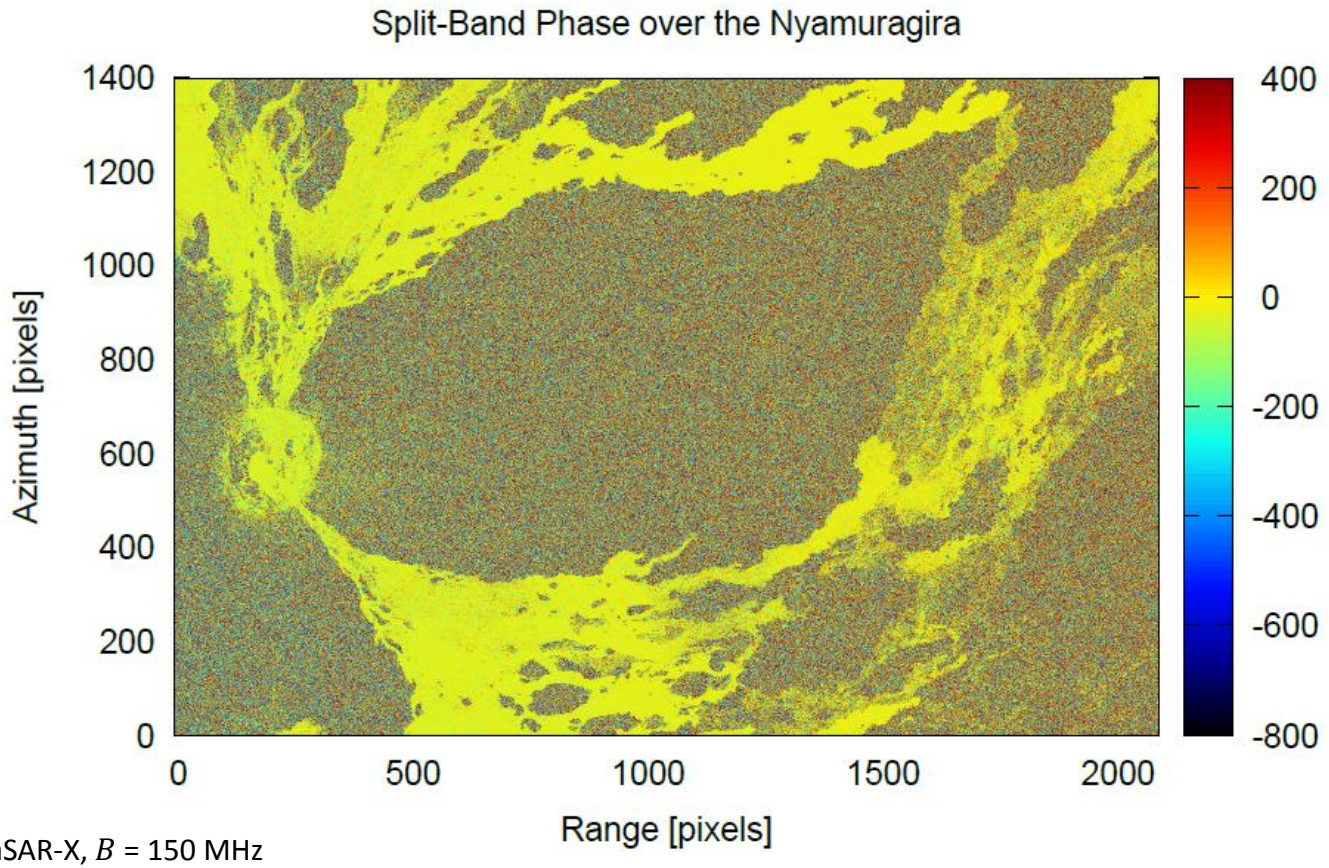
$$\begin{aligned} \Delta\varphi &= \Delta\varphi_{reg} + \Delta\varphi_{e_c} \\ &= \frac{4\pi}{c}\,\nu_0\,\Delta r + \frac{4\pi}{c}\,\nu_0\,e_c \end{aligned}$$



Which set of parameters is optimum to determine phase-offsets ?

Frequency-Persistent Scatterers (PS_f)

Frequency-persistent scatterers (PS_f) are targets with a stable response across the spectral domain, i.e. targets on which Split-Band Interferometry can be performed to obtain **absolute phase measurements**.



TerraSAR-X, B = 150 MHz
N = 5, B_i = 30 MHz

Frequency-Persistent Scatterers (PS_f)

How to detect PS_f ?

Standard deviation of the slope σ_s :

Error propagation : $\sigma_{\Delta\varphi} = \nu_0 \, \sigma_s$

One-cycle accuracy: $\sigma_s < \frac{2\pi}{\nu_0}$

Chi-square linear fitting:

$$\sigma_s = \frac{N-1}{B-B_N} \sqrt{\frac{\sum_{i=1}^{N} \frac{1}{\sigma_{\phi_i}^2}}{\sum_{i=1}^{N} \frac{1}{\sigma_{\phi_i}^2} \sum_{i=1}^{N} \frac{x_i^2}{\sigma_{\phi_i}^2} - \left(\sum_{i=1}^{N} \frac{x_i}{\sigma_{\phi_i}^2} \right)^2}}$$

+ correlation terms

Other criteria:

- multifrequency phase error
- phase variance stability
- spectral coherence
- …

subband index $x_i = -\frac{N-1}{2}, \ldots, \frac{N-1}{2}$

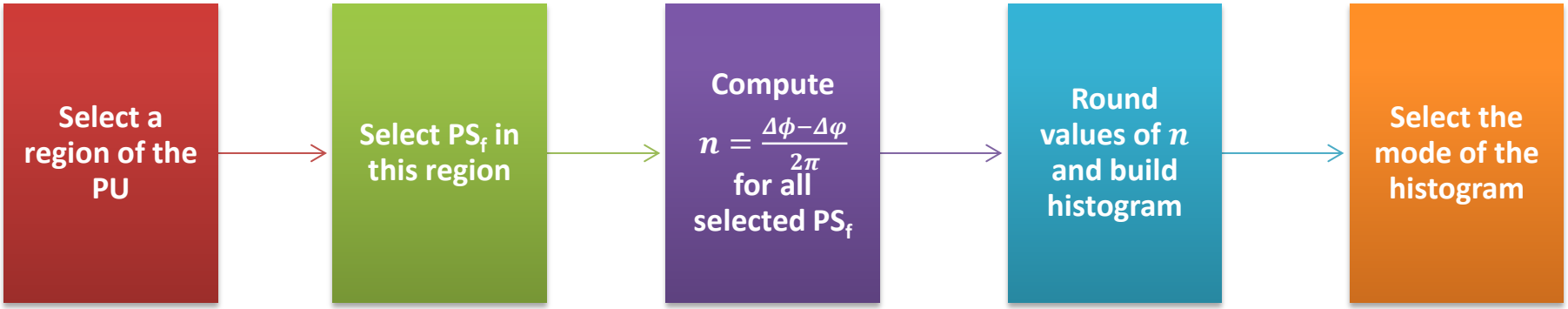
partial phase variance $\sigma_{\phi_i}^2$

L. Libert et al., « Split-Band Interferometry-Assisted Phase Unwrapping for the Phase Ambiguities Correction », Remote Sensing (submitted)

SBInSAR-Assisted Phase Unwrapping

The proposed approach is based on the joint use of InSAR and SBInSAR :

- InSAR unwrapped phase $\Delta\phi$
- Split-band phase $\Delta\varphi$
- Phase-offset in cycles n



Validation based on relative phase-offsets of artificially disconnected regions

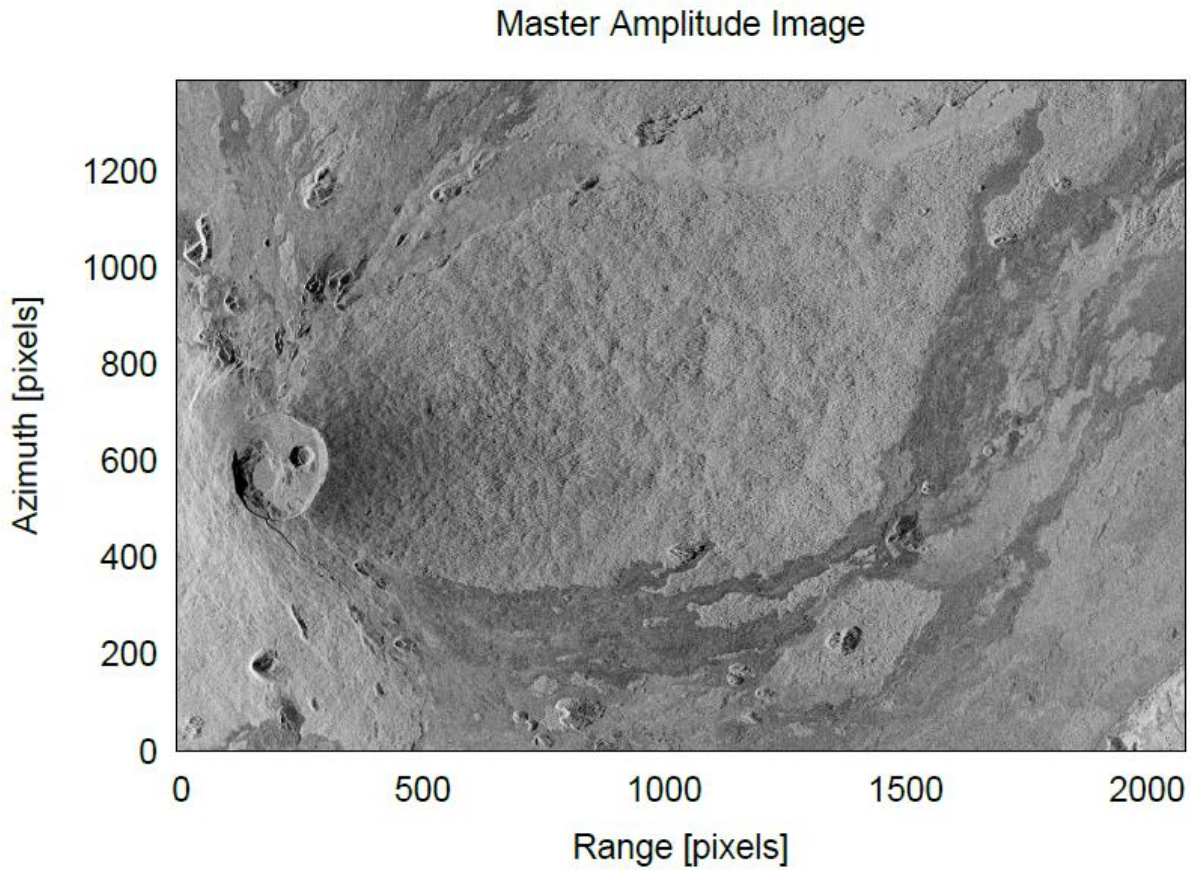
Test site : Nyamuragira volcano

Nyamuragira volcano (Democratic Republic of Congo)

TerraSAR-X Stripmap images 22/06/2008 – 03/07/2008

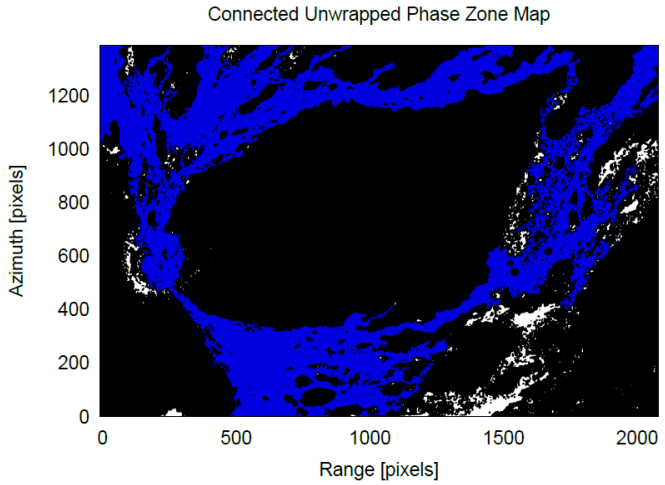
B_i = 150 MHz

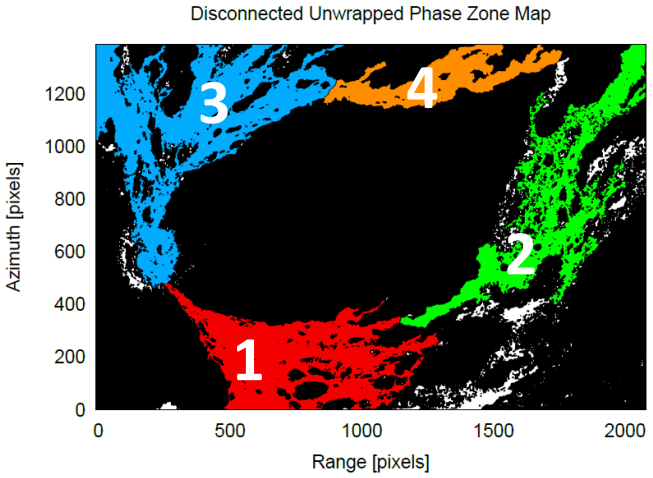
ν_0 = 9.65 GHz

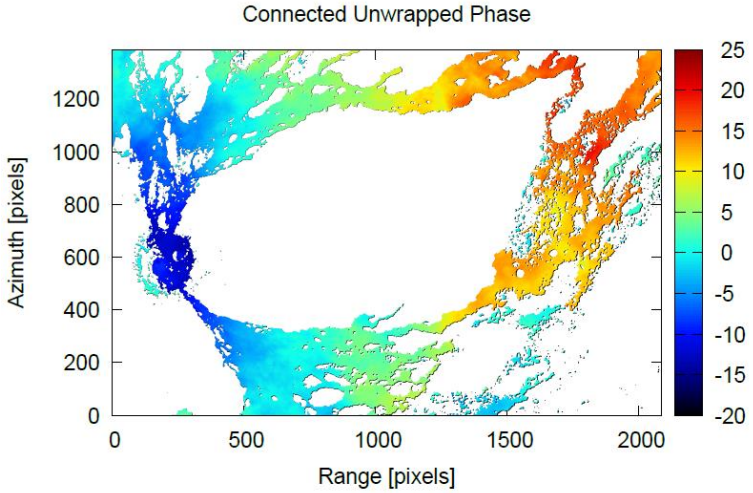


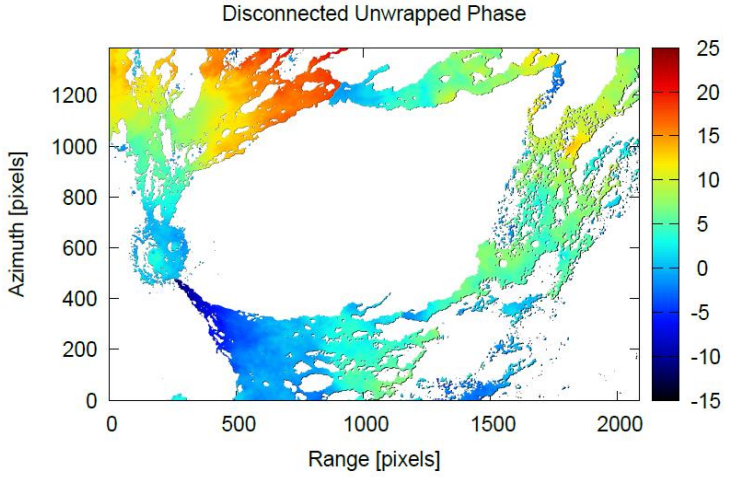
Approach for the phase-offset retrieval

Manual disconnection of a continuously unwrapped area into 4 regions.

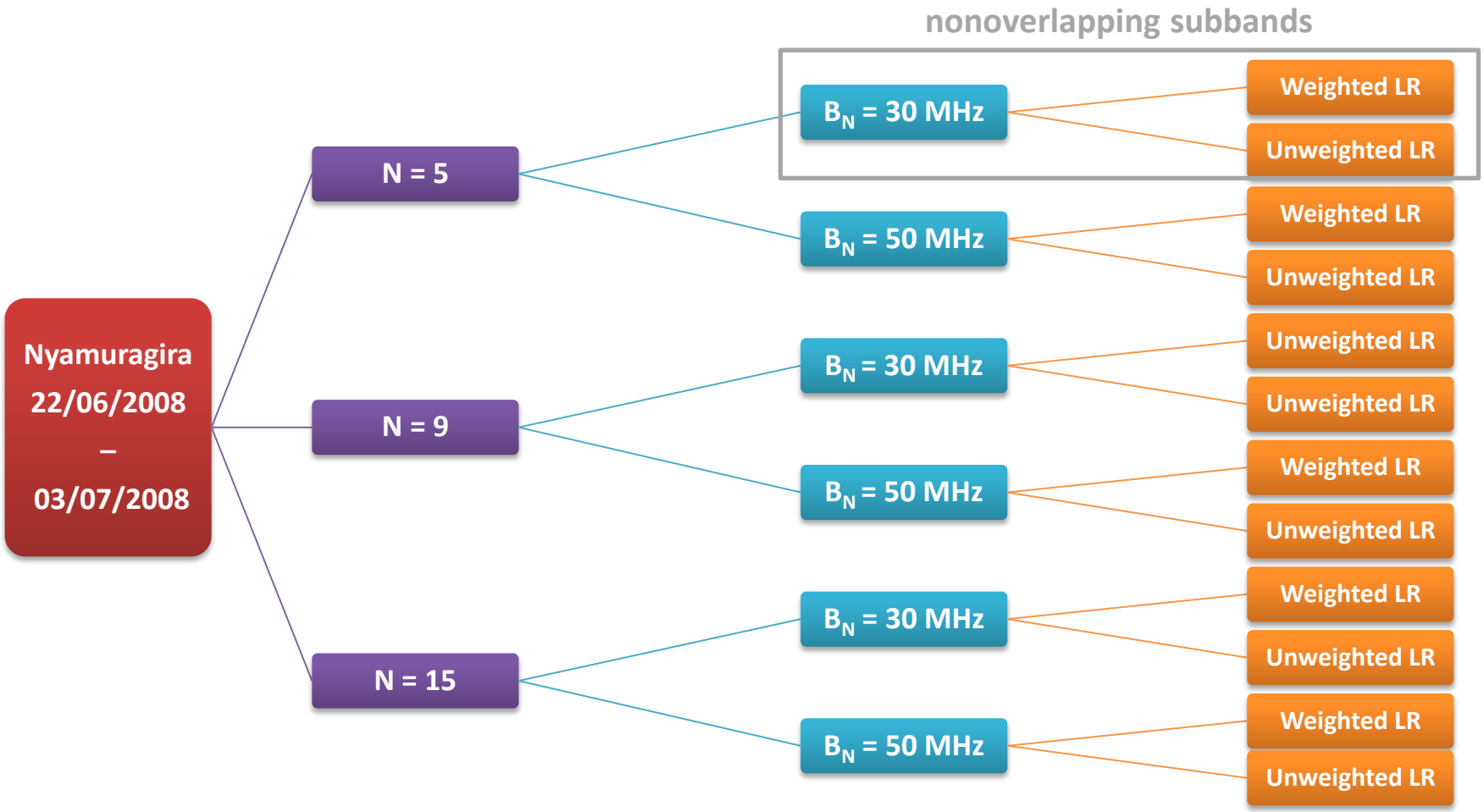




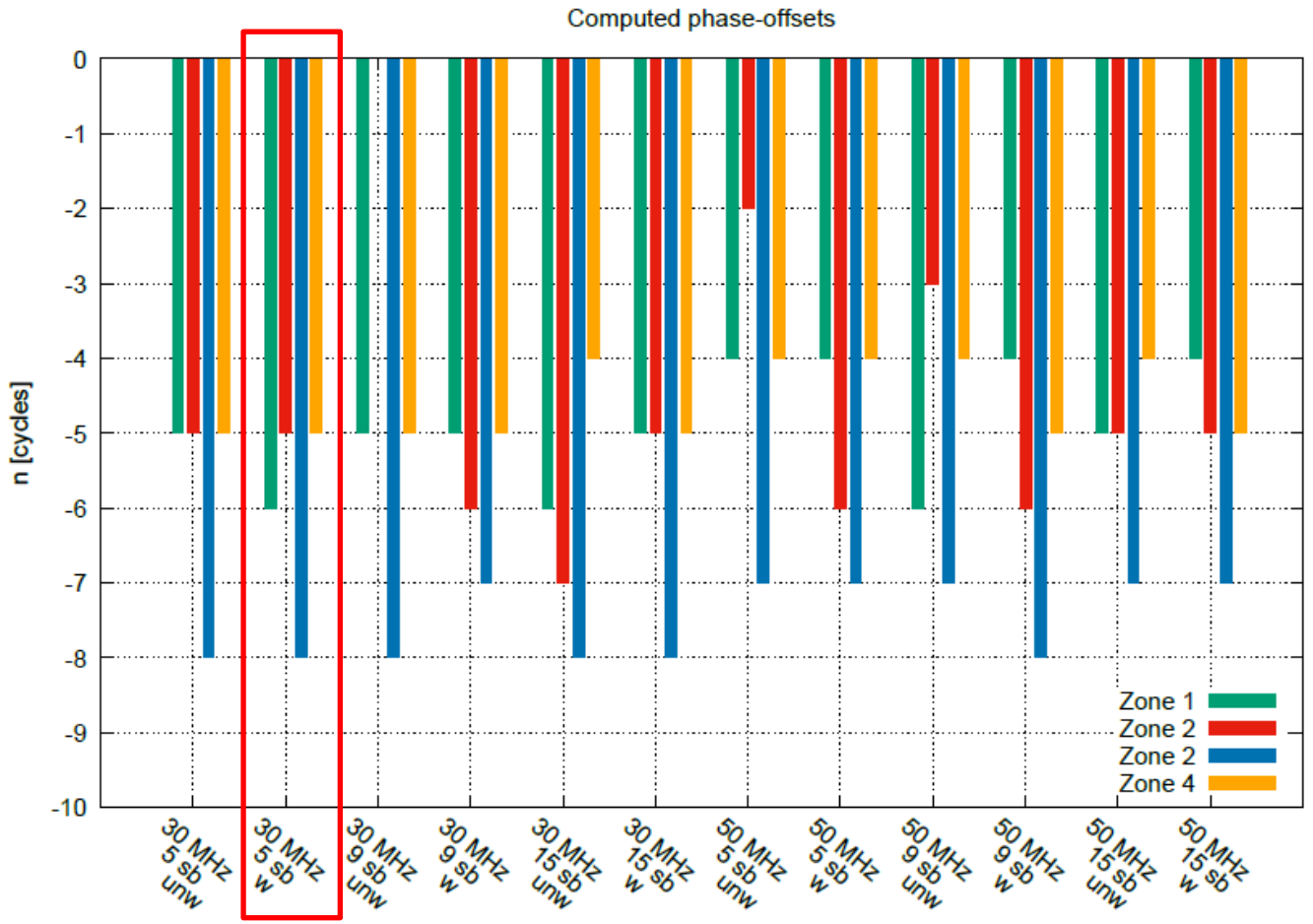




Optimum set of parameters ?



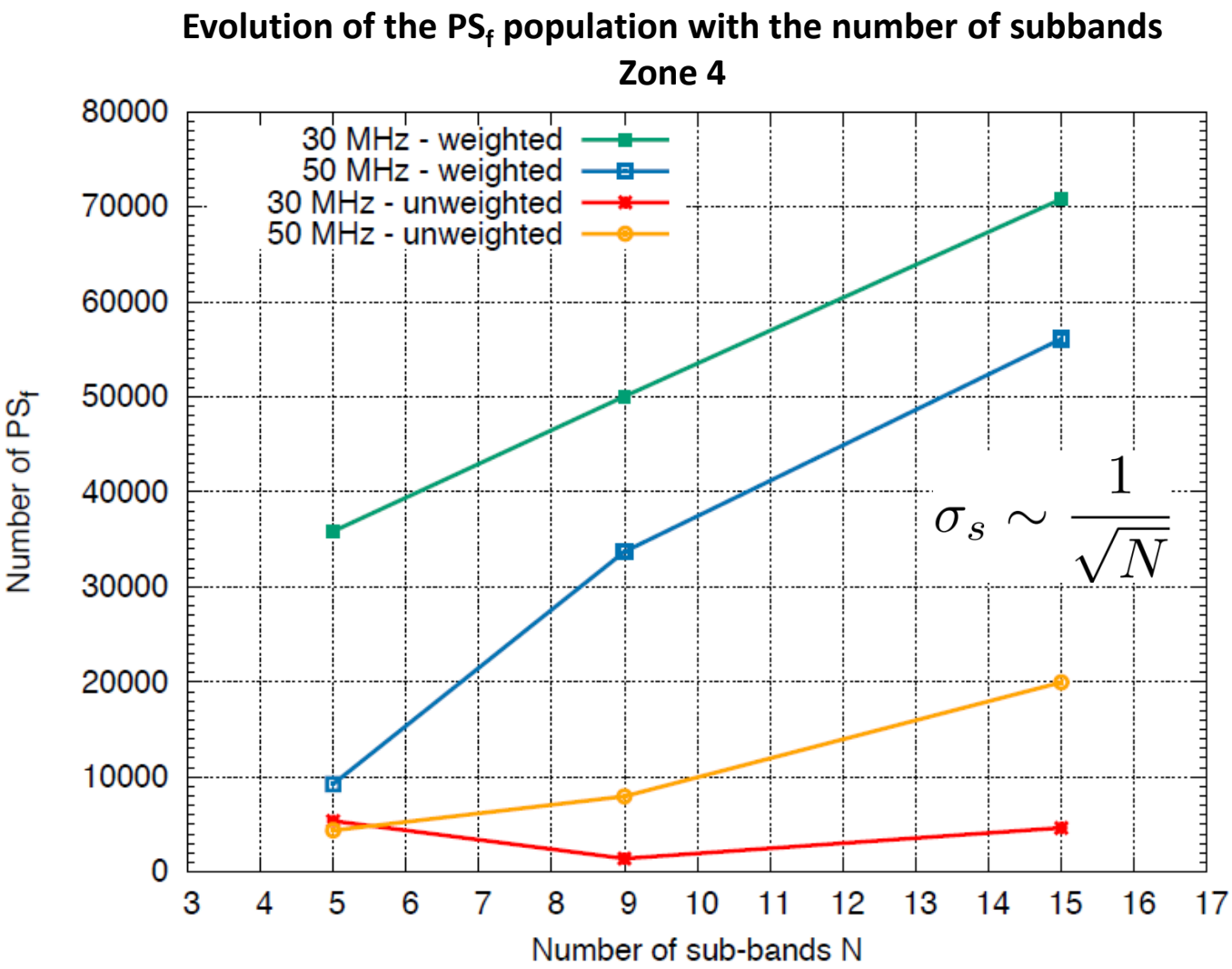
Phase-Offset Retrieval



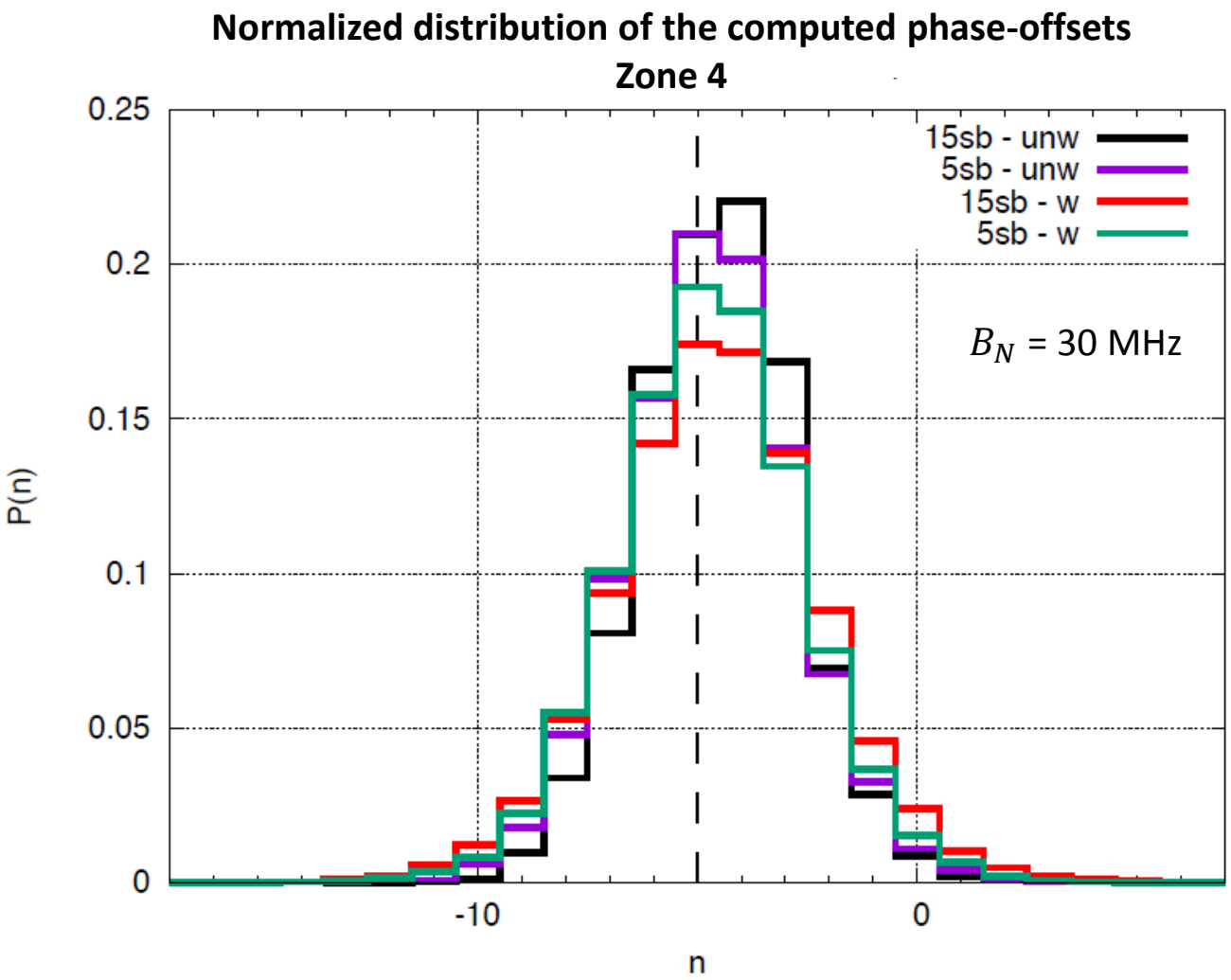
Expected relative offsets :

$n_1 - n_2$	$n_1 - n_3$	$n_1 - n_4$	$n_2 - n_3$	$n_2 - n_4$	$n_3 - n_4$
-1	2	-1	3	0	-3

Frequency-Persistent Scatterers Population

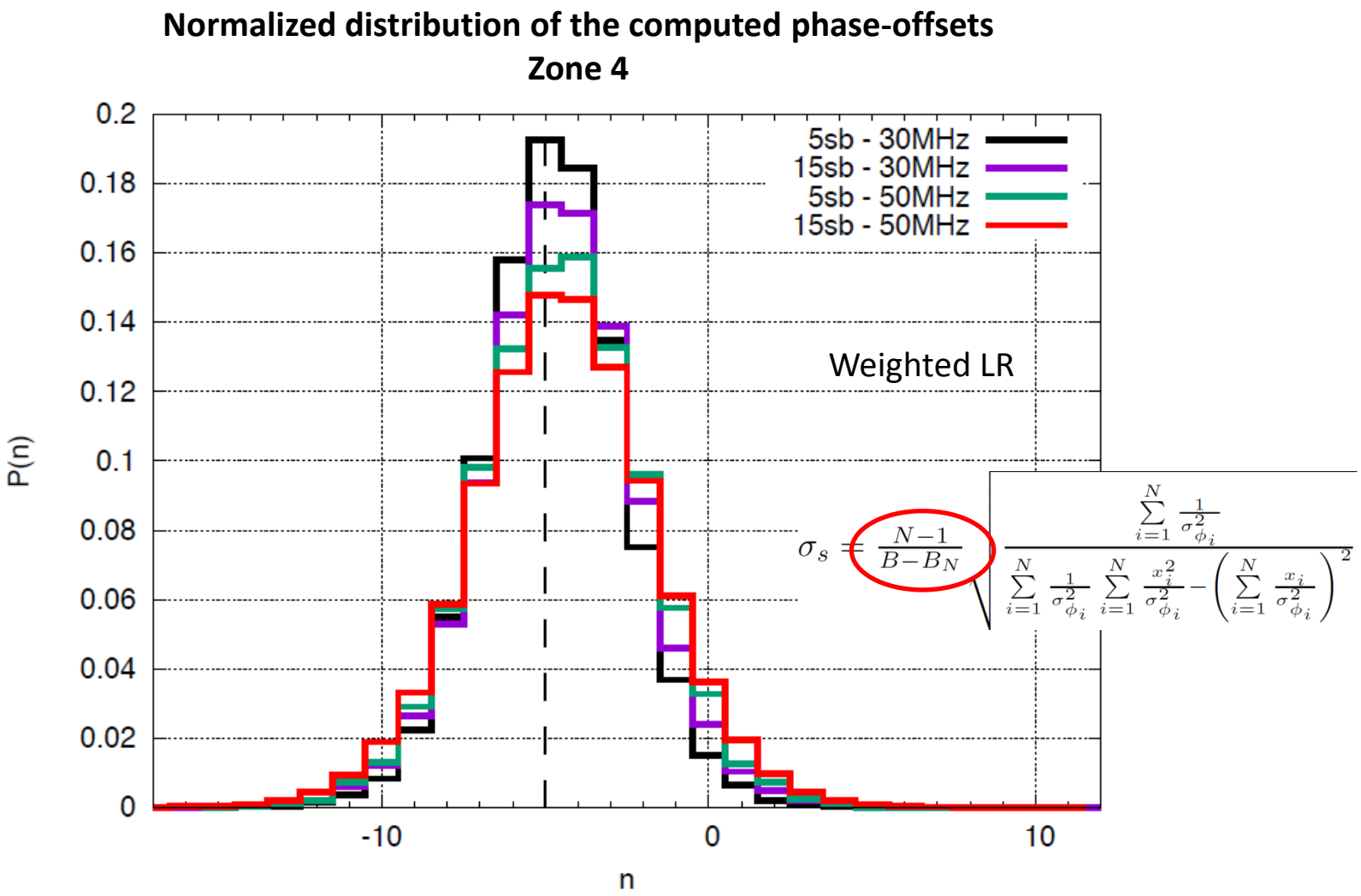


Parameters Analysis



Correct offset computed in the case of a weighted LR, even though with lower probability.

Parameters Analysis



Smaller partial bandwidth B_N reduces the standard deviation on the split-band phase measurements

Conclusions

- SBInSAR-assisted phase unwrapping is **valid** providing that a correct set a parameters is chosen.

- **Nonoverlapping subbands with a weighted linear regression** is the only combination that provides the expected values of phase ambiguities. Other combinations of parameters lead generally to an error of +-1 cycle.

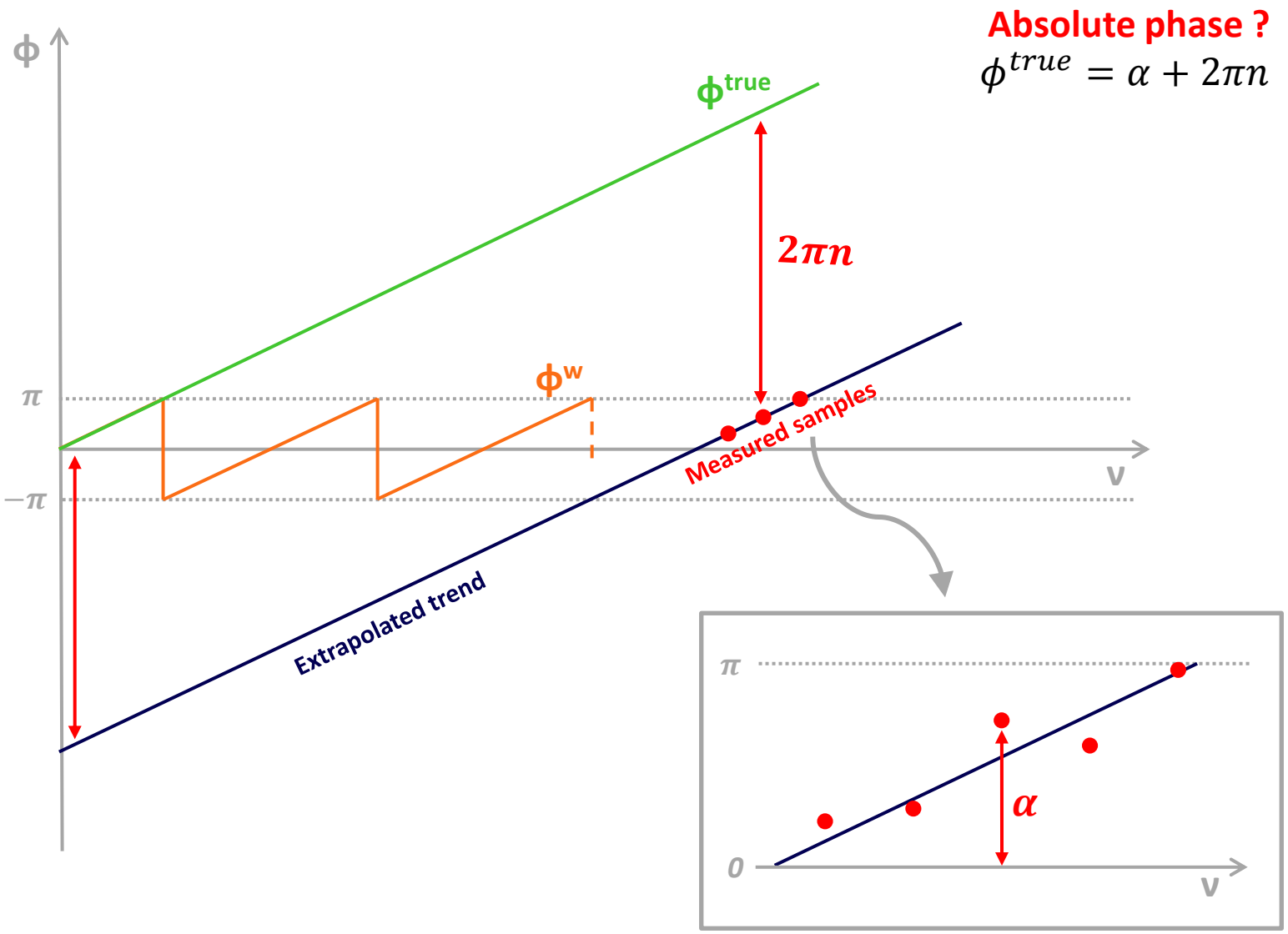
- **Weighted linear regression** shows more dispersion, but is more efficient to determine the phase-offset.

- In agreement with the theoretical calculation, we showed that:
  - **Small partial bandwidth** should be preferred.
  - The **larger the number of subbands**, the better.
  - **Trade-off** has to be found between accuracy and loss of resolution

Thank you for your attention

Back Up Slides

SBInSAR Rationale



Phase-Offset Validation : Procedure