# FIRST VALIDATION EXPERIMENT FOR A MULTI-CHROMATIC ANALYSIS (MCA) OF SAR DATA STARTING FROM SLC IMAGES[1]

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## 1. BACKGROUND

The Multi-Chromatic Analysis, as introduced in [1], uses interferometric pairs of SAR images processed at range sub-bands and explores the phase trend of each pixel as a function of the different central carrier frequencies. The phase of suitable "frequency-coherent" scatterers evolves linearly with the sub-band central wavelength, the slope being proportional to the absolute optical path difference. This potentially solves the problem of phase unwrapping, since the frequency sampling can be chosen by the user in order to have unaliased measurements and thus deterministically unwrap the phase on each pixel independently. Unlike the conventional "monochromatic" InSAR approach, this new multi-chromatic technique allows performing spatially independent and absolute topographic measurements, if the attention is focused on single targets exhibiting stable phase behaviour across the frequency domain. These can be used to retrieve unambiguous height information, without the need for a spatial phase unwrapping process.

What is true for interferograms is also true for single acquisitions. If we consider several "chromatic looks" obtained by focusing range sub-bands of equal width, we obtain a set of images of reduced but constant resolution, imaging the same ground pixels, and thus the same scatterer distribution. Therefore, the phase of each pixel in a single SAR image will also vary linearly with wavelength, the slope being proportional to the whole absolute optical path for the scattering center under concern. Preliminary investigations indicate that, if all contributions are modeled with sufficient accuracy, the whole path delay due to the atmosphere, including ionospheric anomalies, can be investigated with unprecedented spatial resolution.

Potential applications for the study of frequency-stable targets include topographic measurement, atmospheric research, and urban monitoring.

In [1], the use of different combinations of spectral separations and bandwidths is investigated through their effect on the quality of the phase samples in the spectral domain. The method has been then applied to arrays of multiple-band interferograms ([2], [3]), to study the inter-frequency phase behaviour, isolating coherently scattering pixels as those having a more linear dependence of phase vs. frequency. In [4], the first experiment of MCA application to single SAR images is described concerning the localization of point-wise reflectors or extended scatterers exhibiting a stable phase center, according to the same criterion on the regularity of the reflectivity values along frequencies.

## 2. MCA ADVANCEMENTS

The previous work on the subject has started demonstrating the practical feasibility of the technique by using a set of SAR data collected by the airborne AES-1 radar-interferometer and by focusing the sensor raw data in order to generate the sub-band images at different central frequencies. The system was operated at X-band by a multi-channel electronics, which provided a total radar bandwidth of 400 MHz on both antennas, resulting from four non-overlapping LFM pulses, each 100 MHz wide, with central frequencies equally spaced in the microwave spectrum. The dataset we used is acquired on an area of gently rolling topography, sited in the west-central part of Switzerland close to the village of Langnau. The area is characterized by the presence of small urban centres and farms scattered within an environment of woods and grassland.

Although the above-mentioned experiments have been based on an airborne SAR sensor and starting from raw data, the technique appears optimally suited for the new generation of satellite sensors, which operate with larger bandwidths than those of previously available instruments, generally limited to about 20 MHz. SAR sensors such as those mounted on

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TerraSAR-X or COSMO-SkyMed spacecrafts, all pose great expectations on the potential use of multi-chromatic methods. However, data policies of these missions do not foresee the delivery of Level 0 (raw) data thus imposing to perform the MCA starting from SLC images.

This paper presents the results of application of MCA starting from both Level 0 and Level 1 data of the AES-1 airborne sensor as well as by Level 1 TerraSAR-X data. In fact, a pair of InSAR images has been obtained from the TerraSAR-X archive (beam configuration ID: strip_009; processed range bandwidth: 100 MHz), which include the same area around Langnau as the AES-1 dataset.

The experiments have been aimed to:

- test the robustness of MCA methods with respect to total processed bandwidth, through comparison of results from datasets with 400 and 100 MHz available bandwidth, respectively;
- verify the reliability of MCA procedures starting from SLC images, by comparing its performances with those obtained directly from the raw data;
- compare the results obtained from airborne and satellite sensors, by using the same bandwidth and radar carrier frequency (9.65 GHz), but different incidence angles.

The cross validation of the mentioned techniques is performed through comparison of the distribution on the ground of detected phase-coherent targets, as well as by comparing the agreement of the interferometric fringe classifications based on the integer number of phase cycles.

An assessment of the absolute height retrieval performances is also presented, through comparison of retrieved spot heights with two high-resolution digital elevation models, which have been provided by Swiss geographic authorities. The models are derived from an airborne, high-precision laser-scanner, and represent the earth surface with and without vegetation and buildings, respectively.

## REFERENCES


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