Nodal sampling: removing tails and ripples from SMOS Brightness Temperatures

Since the beginning of SMOS mission, one of the problems that has strongly affected the quality of the retrieval of SSS from SMOS Brightness Temperatures (BT) is the presence of large human-generated Radio Frequency Interference (RFI) sources, as shown in the following figure:

Image acquired over a coastal area in Europe; several strong RFI sources and the associated tails are very noticeable

The figure shows the effect of several strong RFIs on a SMOS BT. There are six tails spawning from each RFI in three directions (vertical and two diagonal) which are very noticeable, but there is also a ripple effect (like a grid of light and darker blue on sea, yellow and orange on land) contaminating all the snapshot.

BEC team has developed a new technique, called Nodal Sampling, to reduce the impact of tails and ripples on SMOS BT snapshots. The first step of this technique is to oversample snapshots by zero-padding the unknown high frequencies in Fourier space.

Image resulting after oversampling the previous snapshot with a oversampling factor of 9

When oversampling an image, it becomes evident that tails and ripples have a definite structure of valleys and peaks, which are quite homogeneously distributed but not with an uniform frequency. Nodal sampling consists of subsampling the greater image by exactly the same number of points of the original image but at those points where the oscillation cancels, that

is, when the oscillatory perturbations pass through zero. We have verified that those zero-crossings can be characterized as local minima of the Laplacian operator, so we have defined our nodal sampling as the local minima of the Laplacian of the oversampled image.

Detail on oversampled image. White dots represent the positions at which the oversampled image takes exactly the same value as the original one.

Same as above, but now white points are the nodal points, that is, the points at which Laplacian attain a local minimum.

By choosing nodal points we incur in a small representativity error (as the value of the geophysical signal at that point does not correspond to exactly with that of the attributed position) but the gain in the signal-to-noise more than compensates this deviation.

Nodal sampling leads to dramatic reduction of tails; for instance, when applied to a heavily contaminated snapshot on open sea,

A strong RFI generated by a ship in open sea

nodal sampling leads to a significant reduction not only of tails, but also of ripples:

Same image after having applied nodal sampling on it.

In fact, even non-contaminated snapshots have some degree of rippling (probably induced by the Earth-sky transition at the horizon);

even in the absence of a RFI, nodal sampling leads to a reduction of ripples.

Same as above, after applying nodal sampling

In average, applying nodal sampling leads to a reduction of noise of 0.7 K on clean open sea scenes, both in Tx and Ty polarizations.

Distribution of the standard deviations of the difference between measured BT and modeled BT (derived from geophysical priors). 9 days of data all over Earth's oceans were used. Red histogram is for standard processing, blue is for nodal sampling. Histograms are for Tx polarization; similar results are obtained for Ty.

In summary: nodal sampling supposes a significant improvement in quality for SMOS BTs, by playing down one of the most embarrassing problems with SMOS: RFI's. We plan to use nodal sampled snapshots directly as feedstock for the production of higher quality SSS products, but also for the development of new products and the introduction of refined techniques for correcting know biases. Keep tuned!

The BEC Team