CFOSAT Scatterometer Doppler processing and Data Product Development

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Introduction

The Rotating fan-beam scatterometer (RFSCAT) produces large overlaps on the observation regions within the total swath by successive sweeps and provides a large number of sigma0 acquisitions with diverse azimuth and elevation angles for a single surface resolution cell. The scatterometer onboard on CFOSAT is a Ku-band RFSCAT which is expected to acquire frequent global coverage and high quality wind acquisitions.

The Doppler effects of CFOSAT scatterometer introduced by relative motion between the scatterometer and the earth and the rotation of the earth are kind of 3-D coupling distributions in latitude, antenna azimuth and elevation directions, which should be compensated carefully.

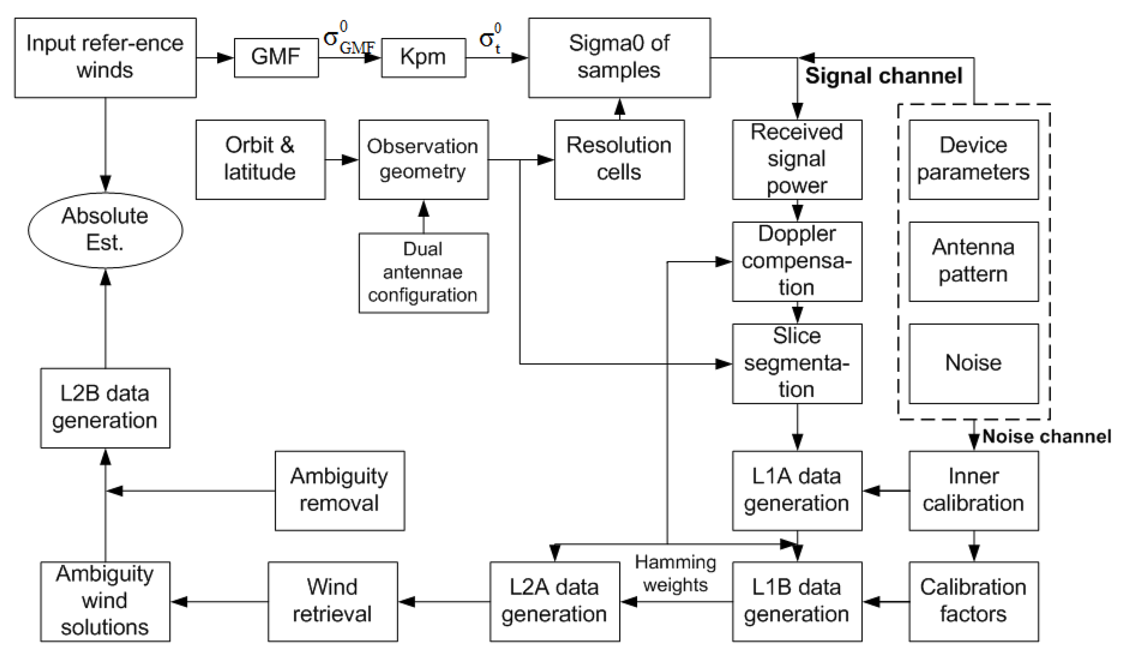

Figure 1: The complete signal simulation and processing system diagram

In order to investigate and process the received signals in different channel phases, a complete signal simulation and processing system have been established(Fig.1). Based on this system, the Doppler is analyzed and a compensation solution is provided. Pre-compensation by shifting central frequency of transmitting signal before transmitting is used for compensating the mean Doppler w.r.t antenna azimuth direction. The residual Doppler frequency compensation and slice segmentation processing onboard are combined to implement via a well-designed look-up table. On the other hand, the processing algorithms for CFOSAT scatterometer data product development are considered (Fig.2). Table 1 lists the main CFOSAT parameters.

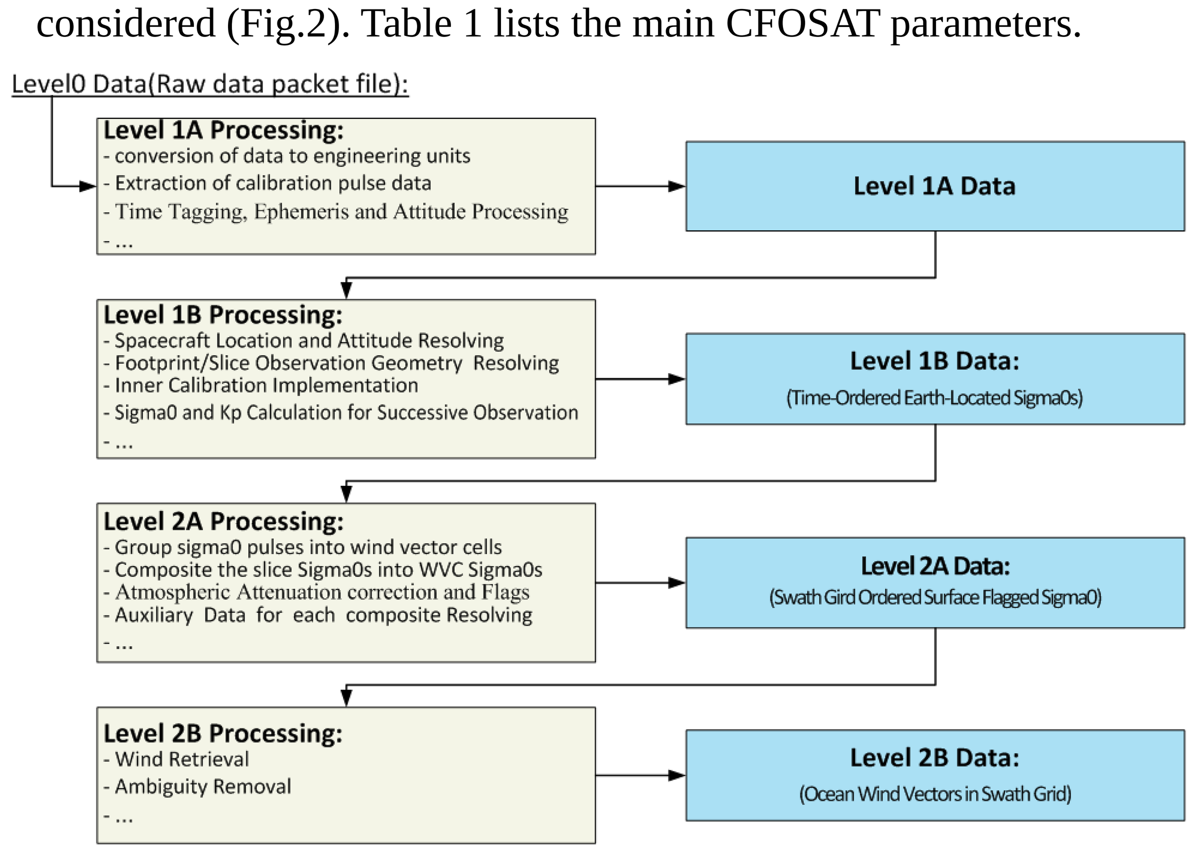

Figure 2: The data product development of CFOSAT Scatterometer

Table 1: The orbit parameters and main CFOSAT scatterometer parameters

CFOSAT Orbit Parameters		CFOSAT Scatterometer System Parameters	
Semi major(km)	6891.984	Transmit power (W)	120
Eccentricity	0.001075	Carrier frequency (GHz)	13.256
Inclination(deg.)	97.4779	Pulse width (ms)	1.35
Argument of perigee (deg.)	90	Pulse repeat frequency (Hz)	75
Descending time	7:00 AM	Transmit bandwidth (MHz)	0.5

Results

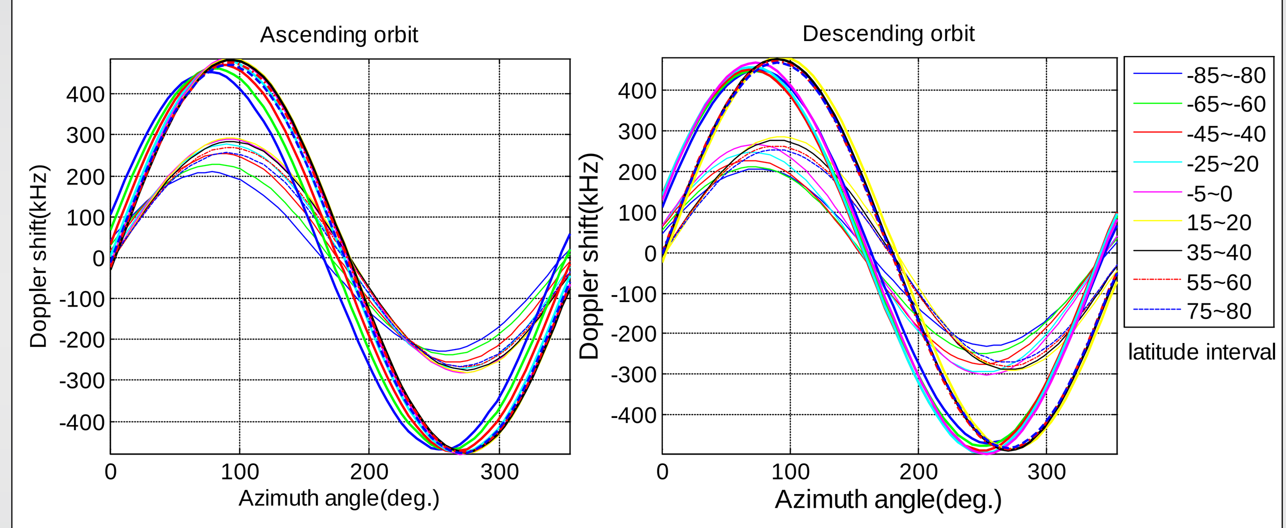

Figure 3: The Doppler shifts of CFOSAT scatterometer in different latitudes (left) Ascending orbit. (right) Descending orbit

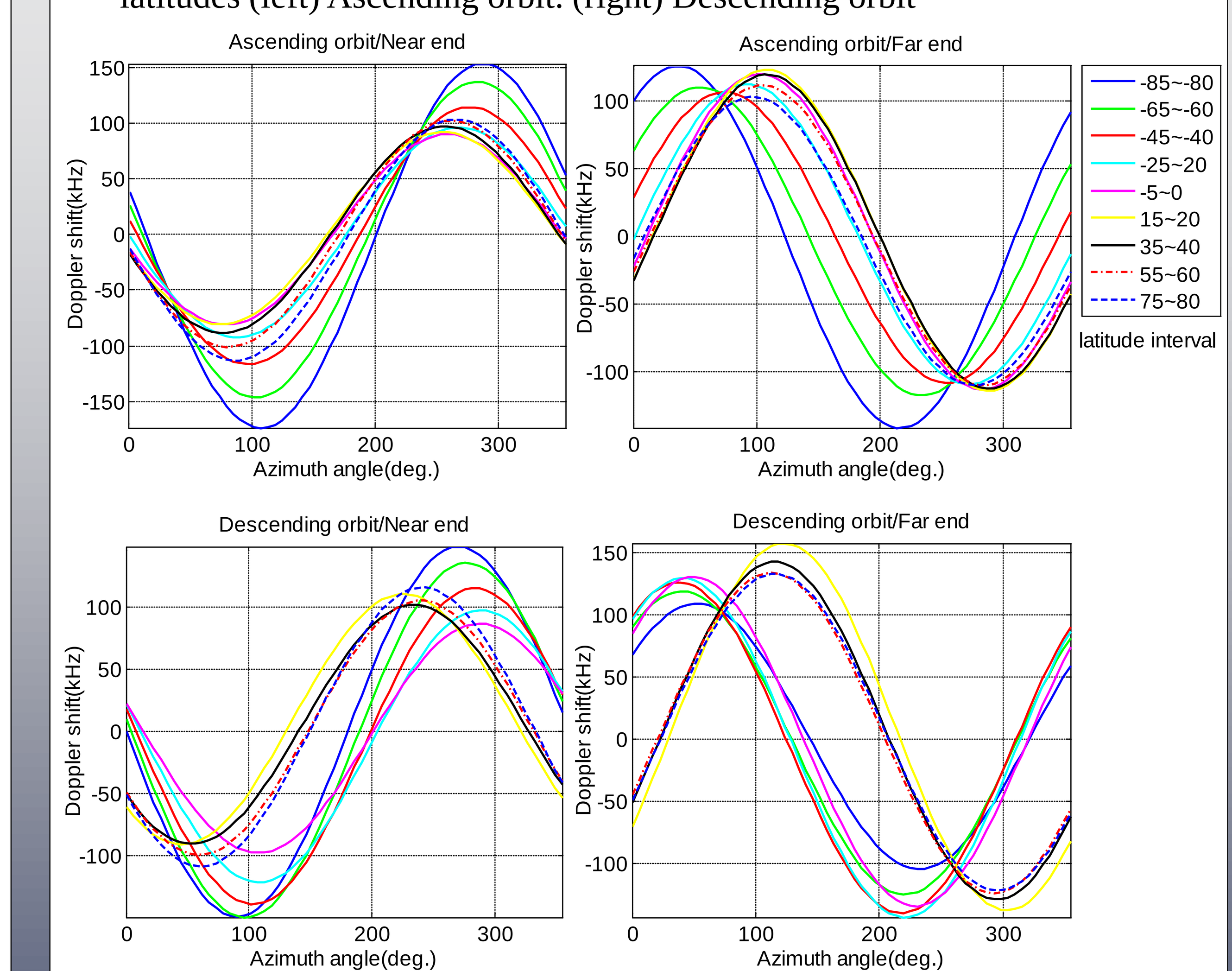

Figure 4: Residual Doppler in different latitudes after pre-compensation

In fig.3, the two curves in the same color denote the far/near end of the fan beam respectively. From fig.3, we can conclude that the Doppler shifts are significant determined jointly by azimuth angle, latitude and elevation direction. In elevation direction, the minimum values in near end are about ±200kHz, and the maximum values in far end are about ±500kHz.

The pre-compensation values are the averaged Doppler in elevation and latitude dimensions(64 azimuth angle bins are adopted).Fig.4 is the residual Doppler after pre-compensation. From the figure , we can see that the residual Doppler are reduced to about [-150, 150]kHz.

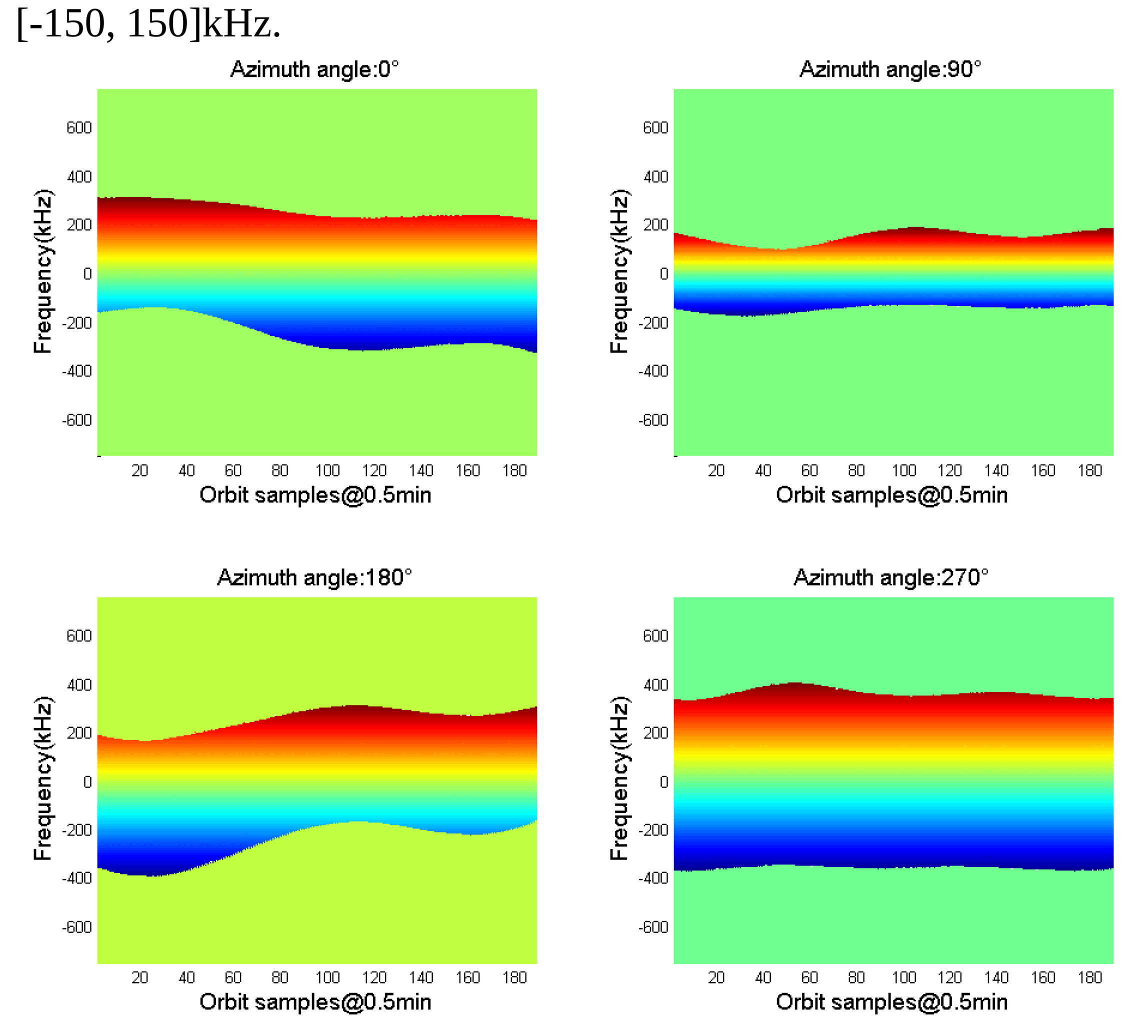

Figure 5: The echo frequencies in different orbit positions and antenna azimuth angles

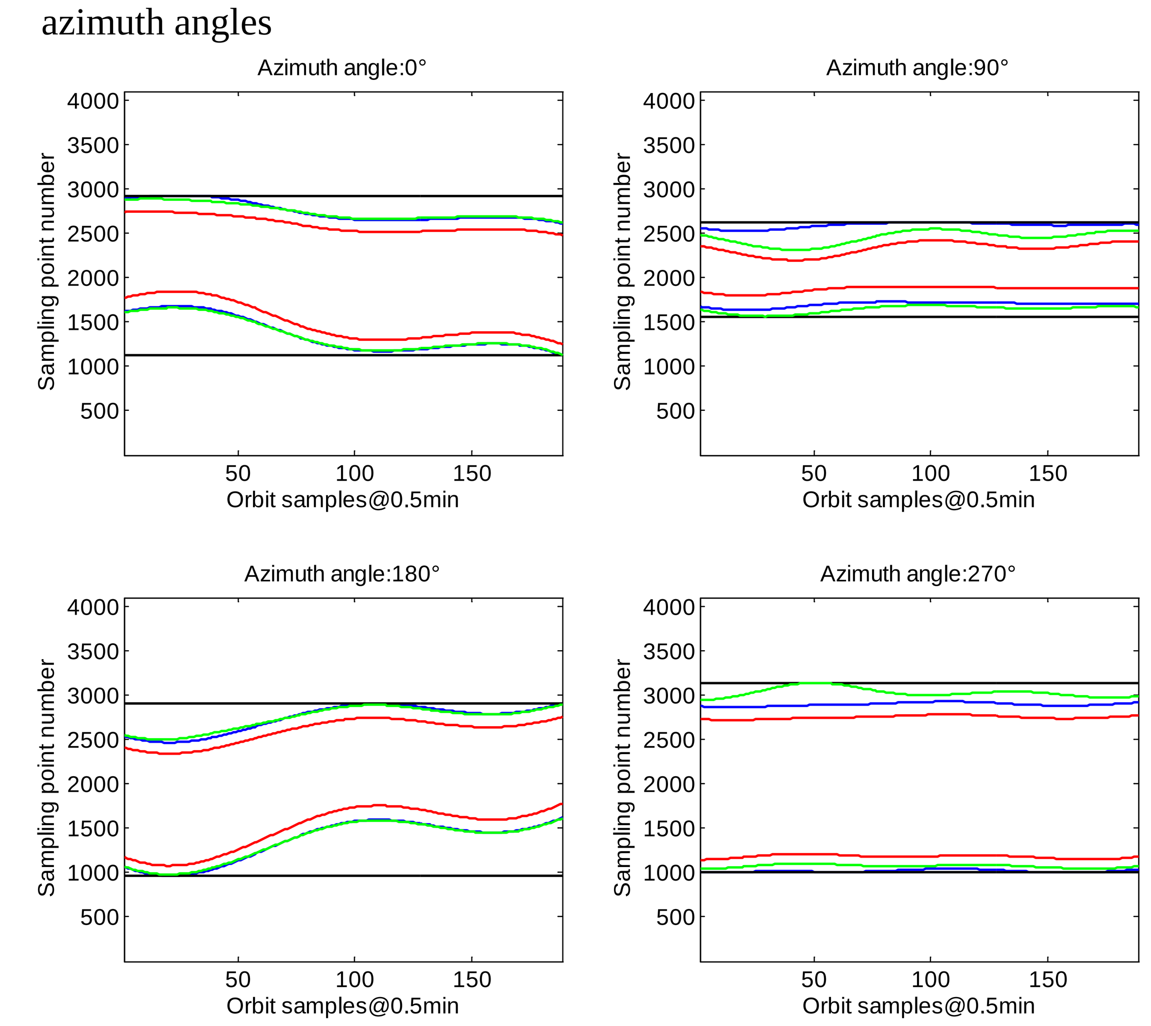

Figure 6: The effective sampling point intervals in different orbit positions and azimuth angles after receiver resampling. (green) received window; (blue) antenna main-lobe; (black) used for residual Doppler compensation and slice segmentation;(red) selected data used in product development.

From fig.5, the echo frequency bandwidths are changed with different orbit positions(latitudes) and azimuth angles, ranged from nearly 400kHz to 800kHz.

After frequency down-conversion and resampling by receiver, the number of echo pulse sampling points are reduced to 4096. In order to simplify the processing onboard reasonably, the residual Doppler compensation and slice segmentation are integrated to one step, and only the azimuth dimension is reserved for an optimum LUT design. In fig.6, the pulse sampling points region between two black lines are all collected and processed onboard based on the LUT even if some redundant points are involved. The ultimate selected slices(as the red line showed) for specific pulse are determined according to the received window and the antenna pattern main-lobe in elevation direction.

Fig.7 shows the slice width after the Doppler processing described above. In some cases, the slice width is large up to 18km; but the averaged slice width is nearly 10~12km.

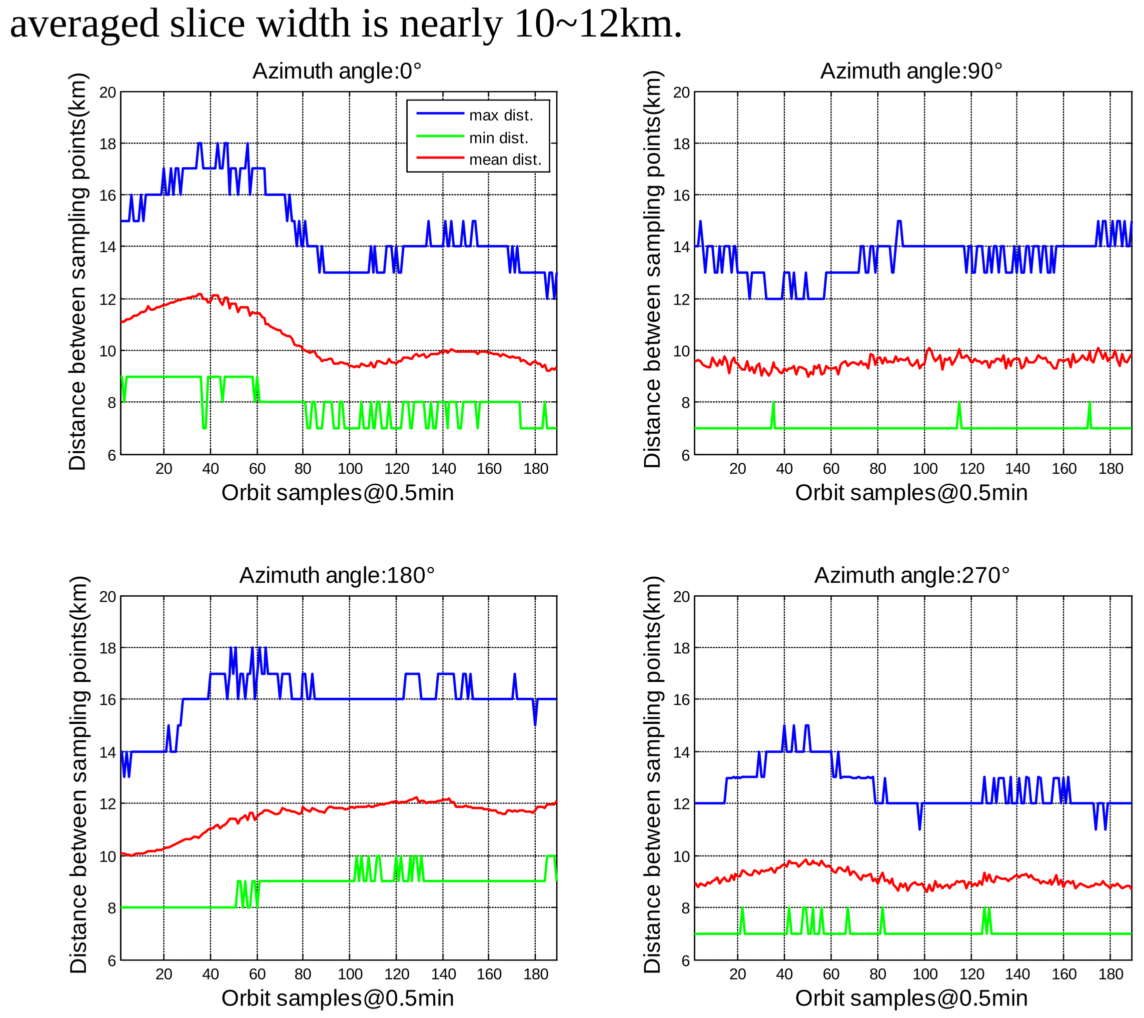

Figure 7: The slice width distributions on the ground

Summary

1. A complete signal simulation and processing system for CFOSAT scatterometer is established for investigating and processing the signals in different received phases. Meanwhile, the data product development are deploying deeply.
2. The Doppler shifts are analyzed detailedly and a feasible solution for Doppler compensation and slice segmentation is proposed; some of the results about Doppler processing onboard are proposed.
3. The signal and data processing for CFOSAT are relatively complicated, some improvement and optimization are ongoing.

References:

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