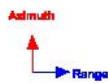
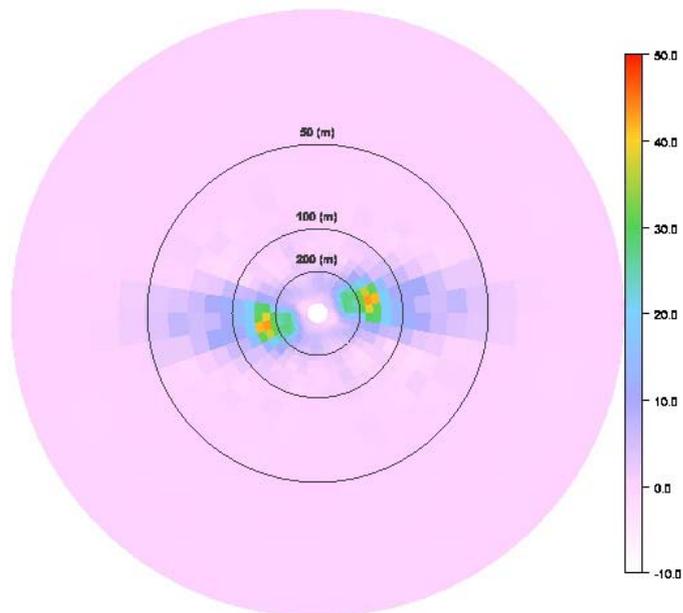

ENVISAT ASAR Wave Mode Product Description and Reconstruction Procedure



Record : 7
Radius : Wavelength (m)
RealSpectrum
01-JUN-1997 13:43:03.038606

Peak at : 160.42827 (m), 275.0 (deg)
CROSS SPECTRA MODE
ABA_WVB_1/PTPD19970801_134002_00000600A015_00260_07274_0018.N1

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Abstract/Summary The purpose of this note is to provide the user community with information on how to reconstruct and interpret the ocean wave spectral information within the ASAR WM products.			

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1. Introduction

The ASAR Wave Mode provides three products of importance for ocean wind/wave application. These are the Level 1 Single-Look-Complex imagette (ASA_WVI), the Level 1 cross-spectra (ASA_WVS), and the Level 2 SAR ocean wave spectra (ASA_WWW). The Level 1 cross-spectra product provides an estimate of the imagette cross-spectra, and is thus an engineering product. The Level 2 products provide estimates of the SAR ocean wave spectra and the local wind speed. In this note we will describe the procedure for reconstruction and interpretation of the wave spectral information within the ASA_WVS and the ASA_WWW products.

2. The Level 2 – ASA_WWW Product

2.1 Product Parameters

Below is given key parameters and procedure for reconstructing the SAR ocean wave spectra from the Level 2 product of the Envisat ASAR Wave Mode. The note also gives some quality check parameters that should be used to remove corrupted products.

2.1.1 Spectral parameters

- $S_{n,m}$ = SAR ocean wave spectrum (byte scaled) on polar grid (2D ocean_spectra in MDS)
 n = index over wavenumbers ($n \in [0, N_k - 1]$)
 N_k = number of wavenumbers (nominal value of 24) (*num_wl_bins* in SPH)
 m = index over directions ($m \in [0, N_\phi - 1]$)
 N_ϕ = number of directions (nominal value of 36) (*num_dir_bins* in SPH)
 λ_o = first wavelength (nominal value of 800m) (*first_wl_bin* in SPH)
 λ_{N_k-1} = last wavelength (nominal value of 30m) (*last_wl_bin* in SPH)
 ϕ_o = first directional bin (nominal value of 0) (*first_dir_bin* in SPH)
 $\Delta\phi$ = directional bin step (nominal value of 10deg) (*dir_bin_step* in SPH)
 S^{\max} = maximum value (float) of SAR ocean wave spectrum (*max_spectrum* in MDS)
 S^{\min} = minimum value (float) of SAR ocean wave spectrum (*min_spectrum* in MDS)
 ψ = satellite track heading (deg.) from north (*heading* in Geolocation ADS)

The orientation of the SAR spectra is clockwise from North. This means that 0 degree means north and 90 degrees means East.

2.1.2 Confidence parameters

- λ_{cut} = azimuth cut-off wavelength (m) (*az_cutoff* in Ocean Wave Spectra MDS)
 σ_I = image variance (*image_variance* in Ocean Wave Spectra MDS)
 i_{conf} = confidence measure of swell inversion (0 or 1) (*confidence.swell* in MDS)
landFlag = land flag (0 over ocean, 1 over land) (*land_Flag* in SQ ADS)

2.2 Reconstruction

Below is described how the SAR ocean wave spectra can be recovered from the product and transformed into frequency-directional space. The procedure for reconstruction of wavelengths is also specified.

2.2.1 Wave Spectra

The SAR ocean wave spectrum, S is byte scaled and must be converted to float values using the S^{\max} and S^{\min} values according to the formula:

$$\tilde{S}_{n,m} = S_{n,m} \frac{(S^{\max} - S^{\min})}{255} + S^{\min} \quad n, m \in [0, N_k - 1] \times [0, N_\phi - 1]$$

The spectrum, $\tilde{S}_{n,m}$ is now given in units of m^4 and is the Cartesian spectral density sampled on a wavenumber, directional (k, ϕ) polar grid. So in order to convert it to frequency-direction space, it needs to be multiplied by the factor:

$$k \frac{dk}{df} = 4\pi k_n \sqrt{\frac{k_n}{g}}$$

where k_n is the wavenumber domain (see also Chapter 2.2.3). Examples of $\tilde{S}(k, \phi)$ and $\tilde{S}(f, \phi)$ are shown in Figure 1.

2.2.2 Spectral Domain

The wavenumbers, k_n are given in logarithmic scale and the directions, ϕ_m are equidistantly. The wavenumbers (in rad/m) can be computed from the formula (see also <http://envisat.esa.int/dataproducts/asar/> (Chapter 6.6.18).

$$\alpha = \left(\frac{\lambda_o}{\lambda_{N_k-1}} \right)^{1/N_k-1}$$

$$k_n = \frac{2\pi}{\lambda_o} \alpha^n \quad n \in [0, N_k - 1]$$

The spacing in wavenumber and frequency domain can be written as:

$$dk_n = \frac{1}{2} \left(\alpha - \frac{1}{\alpha} \right) k_n \quad n \in [0, N_k - 1]$$
$$df_n = \frac{1}{2} \left(\sqrt{\alpha} - \frac{1}{\sqrt{\alpha}} \right) f_n \quad n \in [0, N_k - 1]$$

where $f_n = \frac{1}{2\pi} \sqrt{gk_n}$ is the dispersion relation at deep water.

The directions (in degrees clockwise from North) are given as:

$$\phi_m = \phi_0 + m\Delta\phi \quad m \in [0, N_\phi - 1]$$

The discrete values computed using these formulas is in the center of the bin. See the figure and description given at <http://envisat.esa.int/dataproducts/asar/> (Figure 2.65 in Chapter 2.7.2).

2.2.3 Conversion to frequency-directional grid

The Level 2 SAR spectrum $\tilde{S}_{n,m}$ can be converted to WAM like format i.e. given as a frequency-directional spectrum by multiplying it with the factor $k \frac{dk}{df} = 4\pi k_n \sqrt{\frac{k_n}{g}}$ followed by a resampling into the desired (f_n, ϕ_m) grid size of the WAM spectrum (if WAM has different size):

$$\hat{S}_{n,m} = \tilde{S}_{n,m} 4\pi k_n \sqrt{\frac{k_n}{g}} \quad n, m \in [0, N_k - 1] \times [0, N_\phi - 1]$$

Here $\hat{S}_{n,m}$ is the spectra, now in units of $\left[\frac{m^2}{Hz} \right]$, to be resampled into your WAM (f_n, ϕ_m) grid dimension.

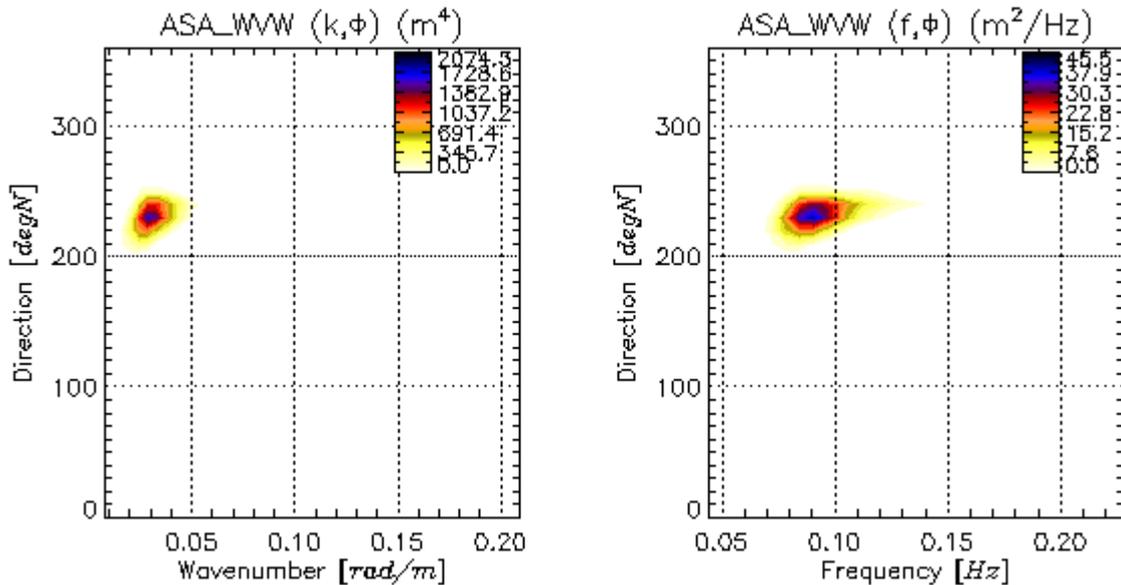


Figure 1: Left: Example of ASA_WWV spectra on (k, ϕ) grid as read from the product and converted to float values. Right: Same spectra converted to (f, ϕ) grid.

2.2.4 Some Wave Spectral Parameters

The SAR significant waveheight (in meters) can thus be computed as:

$$H_s = 4 \left(\sum_{n=0}^{N_k-1} \sum_{m=0}^{N_\phi-1} \hat{S}_{n,m} df_n d\phi_m \right)^{1/2}$$

The SAR heave spectrum can be computed as:

$$F_n = \sum_{m=0}^{N_\phi-1} \hat{S}_{n,m} d\phi_m \quad n \in [0, N_k - 1]$$

and the directional spectrum as:

$$\Phi_m = \sum_{n=0}^{N_k-1} \hat{S}_{n,m} df_n \quad m \in [0, N_\phi - 1]$$

2.3 Product Quality

The product quality and the azimuth cut-off effect will be varying depending on the SNR and the sea-state, respectively. Below is given approaches to deal properly with these effects from product to product, in order to avoid corrupted spectra.

2.3.1 Azimuth Cut-Off

The SAR wave spectra are always affected by the azimuth cut-off, which rolls off (Gaussian) the spectra in the azimuth direction. The width of the Gaussian function is related to the parameter λ_{cut} . The main effect of the azimuth cut-off is that the SAR imaging domain is a narrow band region centered around the range axis (radar look direction), as illustrated in Figure 2.

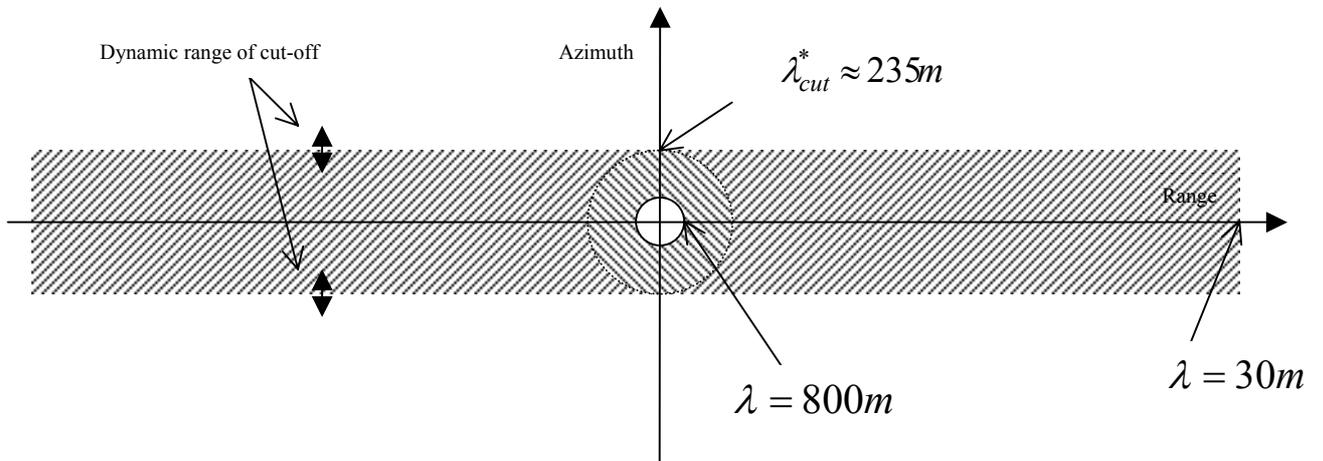


Figure 2: The shaded areas illustrate the SAR imaging spectral domain (in Cartesian wavenumbers). Inside this area, the SAR detects wave spectral information. Outside this area is mainly noise. Azimuth is the spectral domain along the satellite flight direction, while the range is along the radar look direction. The inner shaded circle ring illustrate the imaging domain left after using the Gaussian filtering function given below. The dynamic range illustrate the variations in the azimuth cut-off (see Figure 4) (i.e. the imaging region) that typically can occur from observation to observation.

The consequence of this is that the wind sea part of the spectrum is mostly not visible by the SAR, and when it appears in the spectrum it is often heavily distorted, and aligned along the range axis. This can be well illustrated by plotting the ASA_WVW spectra on Cartesian grid in SAR coordinates. A typical example is shown in Figure 3. We clearly see the alignment of the spectrum along the range axis. We thus plan to filter out the part of the ASA_WVW spectra outside the cut-off region before using it. For this we need an estimate of the cut-off wavelength, and the λ_{cut} given in the Level 2 product can be used for this. However, **for the current version of the Level 2 product** the azimuth cut-off given in the Level 2 product must be scaled according to the formula (in order to be applicable with a Gaussian roll-off function):

$$\lambda_{cut}^* = 0.5\lambda_{cut} + 90$$

to give a more correct estimate of the cut-off wavelength to be applied for filtering out the distorted part of the SAR wave spectrum. The computed cut-off value should typically be in the range $\lambda_{cut}^* \in [100m, 400m]$, with a global average value around 235m (see Figure 4). **In future**

versions of the Level 2 product (higher than PF-ASAR, 4.0), this scaling operation on the azimuth cut-off value will not be necessary.

The simplest way of filtering out the distorted part is to apply a roll-off function on the entire spectrum (all directions), given as:

$$h_n = \exp\left\{-\left(\frac{\lambda_{cut}^*}{\lambda_n}\right)^2\right\} \quad n \in [0, N_k - 1]$$

where $\lambda_n = 2\pi/k_n$ is the wavelengths of the spectrum. To simply cut the spectrum for wavelengths above λ_{cut}^* could also be considered.

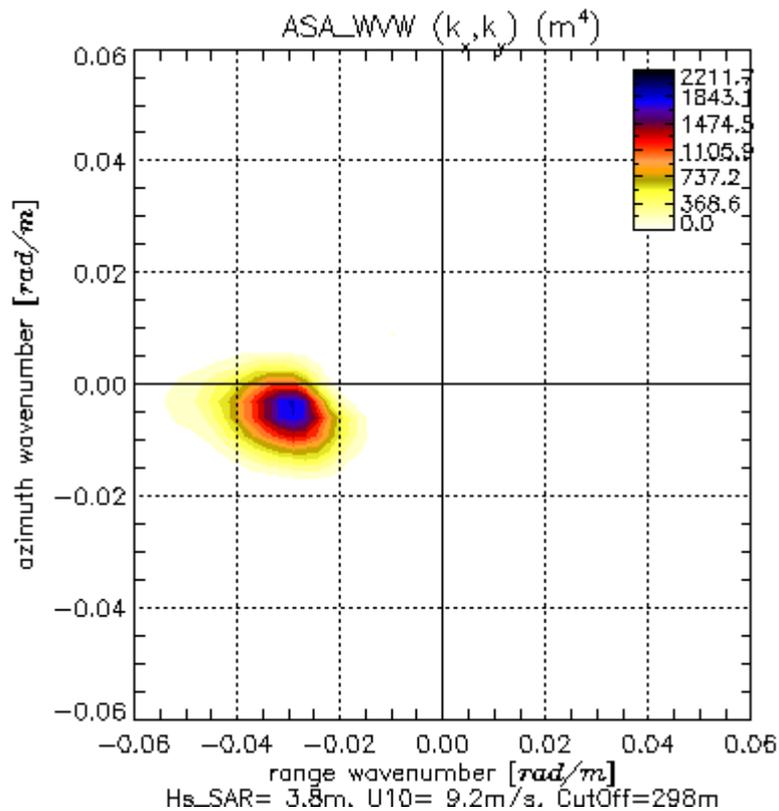


Figure 3: ASA_WVW spectra converted into Cartesian wavenumber domain and in SAR coordinates. Note the alignment of the spectral information along the range axis. The azimuth cut-off length is here 298m. Only the part of the spectral domain with wave information is plotted here (wavelengths above 104.7m).

Some statistics and dependency of λ_{cut}^* on local wind speed are shown in the Figure 4 and Figure 5, respectively.

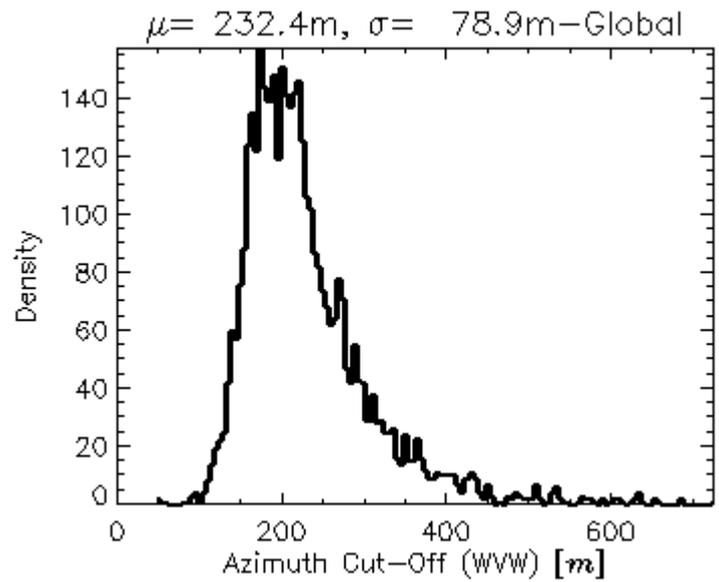


Figure 4: Histogram of ASA_WWW cut-off value, λ_{cut}^* globally collected.

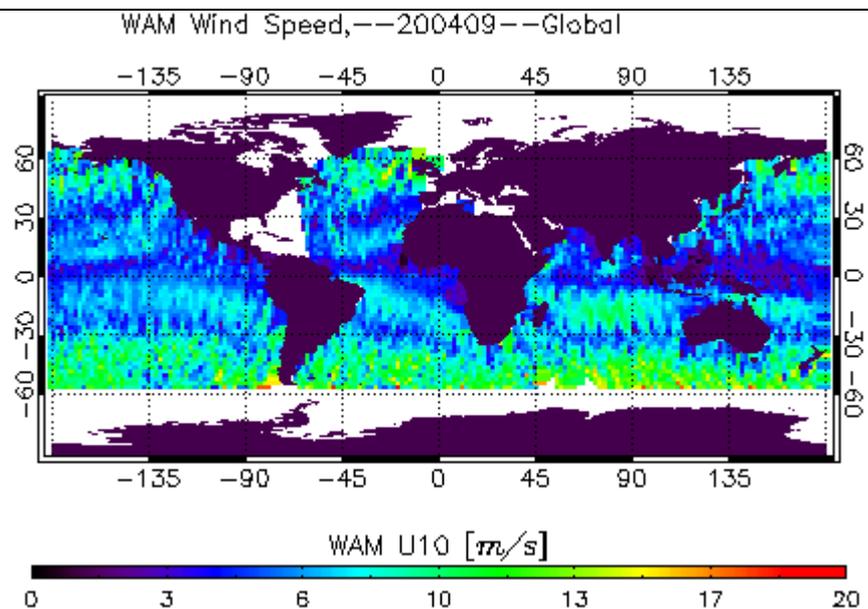
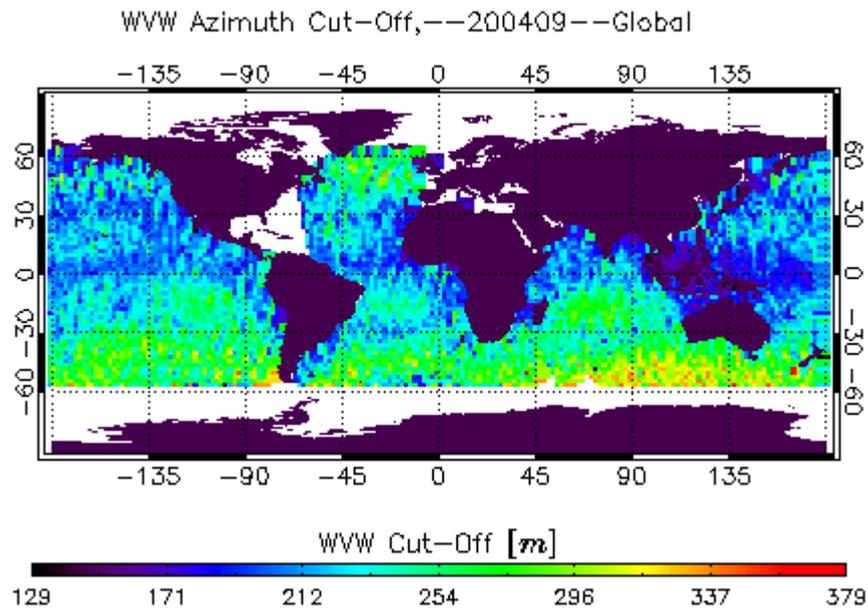


Figure 5: Upper plot: ASA_WV azimuth cut-off values, λ_{cut}^* for September 2004. Lower plot: Wind field from ECMWF co-located with the ASAR Wave Mode measurements.

Figure 5 shows how the azimuth cut-off value varies globally and how it is correlated with the local wind speed (or more correctly the local wind sea).

More sophisticated weighting function (directional dependency) can be developed in order to take into account wind sea information that sometimes is imaged along the range axis. Then you must take into account the satellite track heading as well since the spectrum is geographic oriented. This is however not given here, but can easily be implemented since the satellite track angle is given in the Level 2 product.

2.3.2 Confidence

If the modulation is weak in the image, the SNR can be too low to gain any meaningful information from the data, although some sort of spectrum is generated. In such case the normalized variance should theoretically be $\sigma_I = 1.0$ i.e. only speckle noise is detected. On the other hand, if the image is corrupted with signatures from land, islands, sea surface slicks, current shears, atmospheric fronts etc., the normalized variance takes values larger than expected from pure wave modulation only. The variance measure, σ_I can therefore be a parameter to use to reject low SNR data and data with large inhomogenities (see Figure 6). Data with variance in the range:

$$\sigma_I \in [1.05, 1.4]$$

is usually of good quality, and covers most of the histogram taken over ocean areas (see Figure 6) (landFlag = 0).

In addition to this, the use of the confidence measure within the Level 2 can be implemented. In order to reject ambiguity from non-ambiguity data use of the confidence parameters can be helpful. The confidence parameter i_{conf} is set to 0 when an ambiguity free spectrum is produced, and to 1 when a spectrum with 180 degree ambiguity is produced.

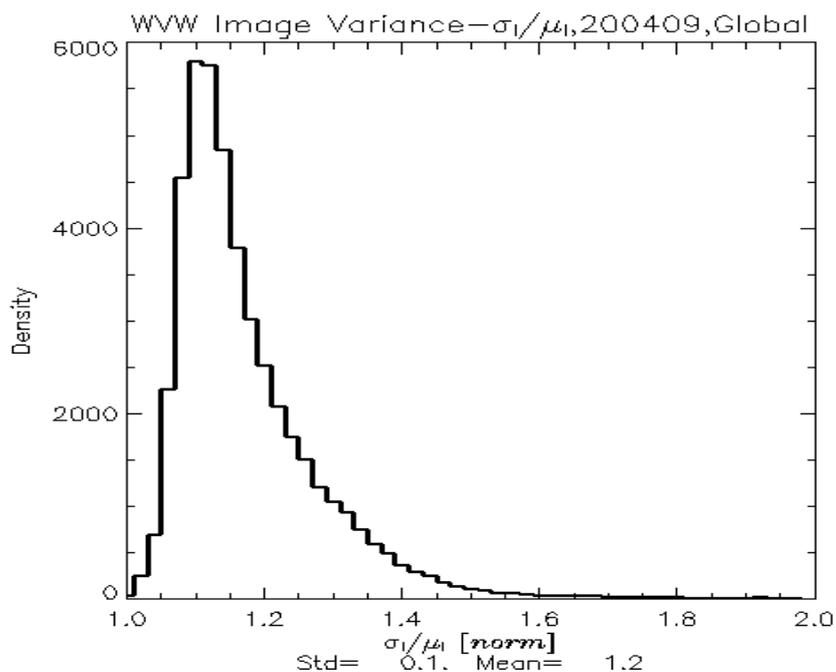


Figure 6: Histogram of ASA_WVW normalized image variance for September 2004.

2.4 Error Budget

For assimilation purposes the knowledge of the error (bias and RMS) in the observation space is of importance. In the following plots we show the RMS error and bias between ECMWF WAM and ASA_WWV spectra on the 2 dim ASAR observation grid for data acquired between 2004-01-01 and 2004-03-01. The corresponding average energy of the WAM and ASAR WM are also given on the same grid. The data are for plotted for both northern (Figure 7) and southern (Figure 8) hemisphere.

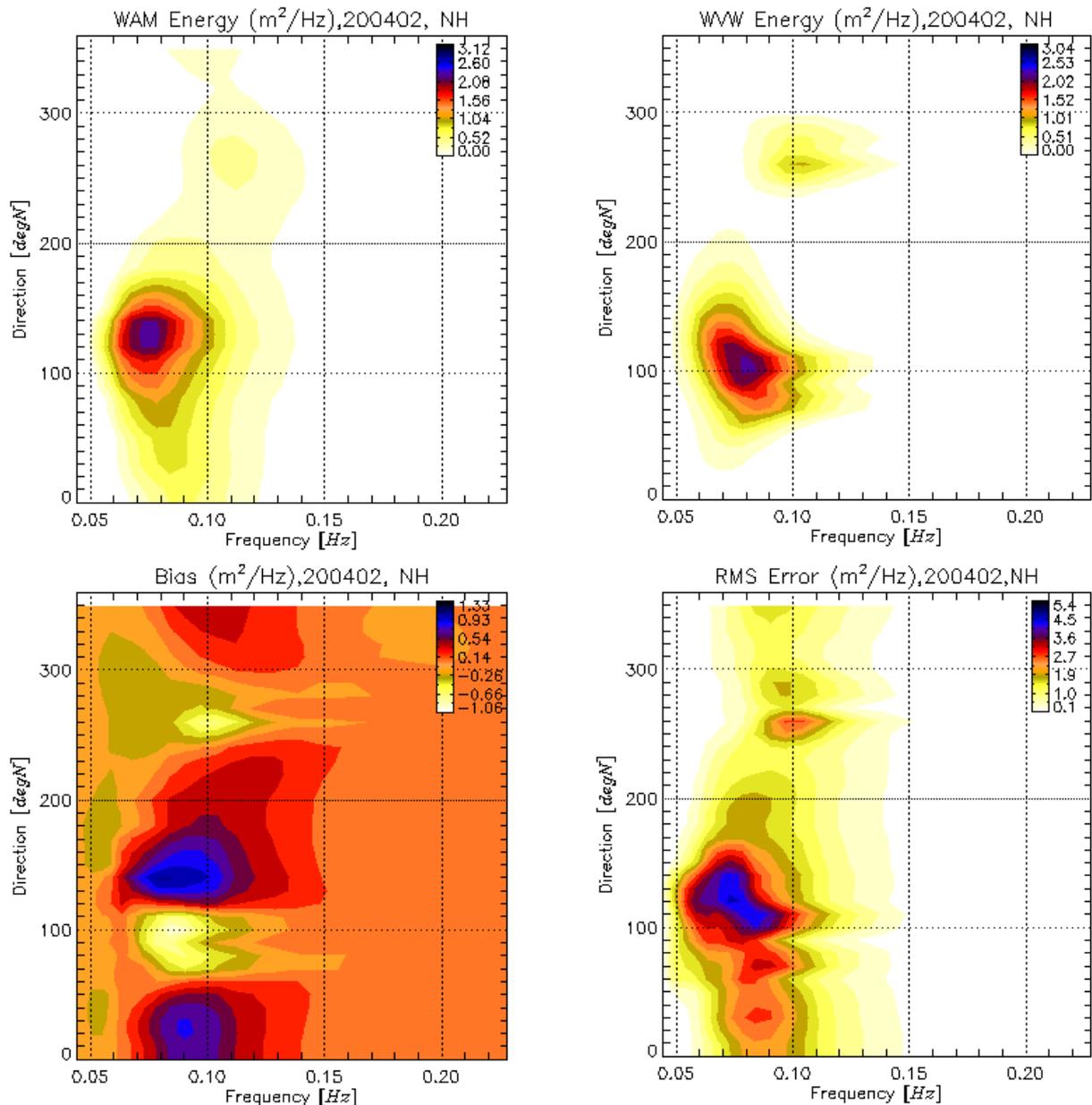


Figure 7: WAM and ASAR WM Level 2 error budget for the northern hemisphere for the period 200401-200403. Direction here is clockwise from North. Upper plot are the corresponding WAM and ASAR WWV energy, while the lower plot are the bias and RMS values.

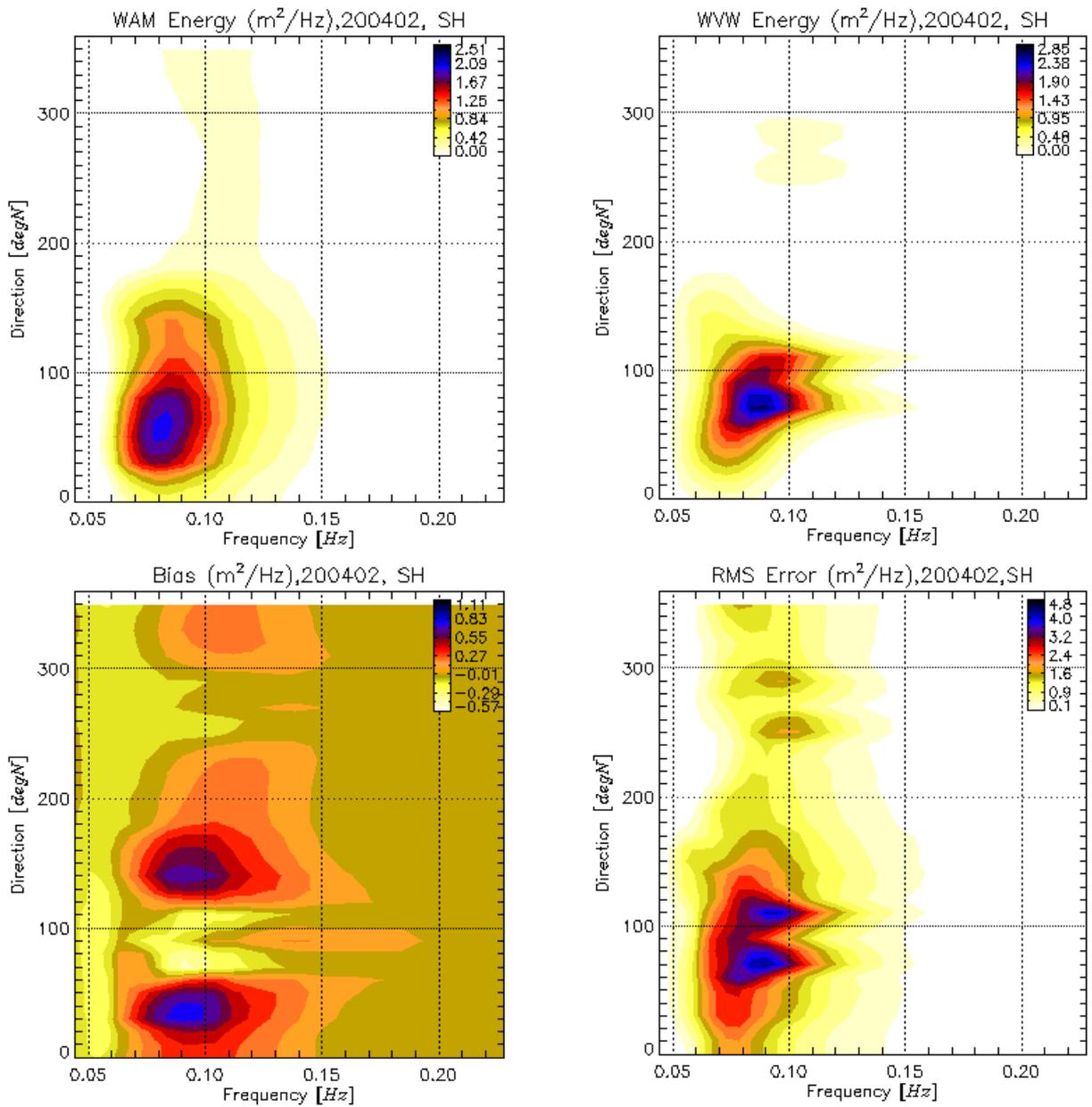


Figure 8: WAM and ASAR WM Level 2 error budget for the southern hemisphere for the period 200401-200403. Direction here is clockwise from North. Upper plots are the corresponding WAM and ASA_WVV energy, while the lower plots are the bias and RMS values.

3. The Level 1 – ASA_WVS Product

3.1 Product Parameters

Below is given key parameters and procedure for reconstructing the SAR image cross spectra from the Level 1 product of the Envisat ASAR Wave Mode. The note also gives some quality check parameters that should be used to remove corrupted products.

3.1.1 Spectral parameters

$\text{Re } P_{n,m}$ = Real part of SAR cross spectrum (byte scaled) on log-polar grid (*real_spectra* in MDS)

$\text{Im } P_{n,m}$ = Imaginary part of SAR cross spectrum (byte scaled) on log-polar grid (*imag_spectra* in MDS)

n = index over wavenumbers ($n \in [0, N_k - 1]$)

N_k = number of wavenumbers (nominal value of 24) (*num_wl_bins* in SPH)

m = index over directions ($m \in \left[0, \frac{N_\phi}{2} - 1\right]$)

N_ϕ = number of directions (nominal value of 36) (*num_dir_bins* in SPH)

λ_o = first wavelength (nominal value of 800m) (*first_wl_bin* in SPH)

λ_{N_k-1} = last wavelength (nominal value of 30m) (*last_wl_bin* in SPH)

ϕ_o = first directional bin (nominal value of 0) (*first_dir_bin* in SPH)

$\Delta\phi$ = directional bin step (nominal value of 10deg) (*dir_bin_step* in SPH)

$\text{Re } P^{\max}$ = maximum value (float) of real part of SAR ocean wave spectrum stored in the product (*max_real* in MDS)

$\text{Re } P^{\min}$ = minimum value (float) of real part of SAR ocean wave spectrum stored in the product (*min_real* in MDS)

$\text{Im } P^{\max}$ = maximum value (float) of imaginary part of SAR ocean wave spectrum stored in the product (*max_imag* in MDS)

$\text{Im } P^{\min}$ = minimum value (float) of imaginary part of SAR ocean wave spectrum (*min_imag* in MDS) stored in the product

ψ = satellite track heading (deg.) from north (*heading* in Geolocation ADS)

The orientation of the SAR cross spectra is counter clockwise from satellite heading (azimuth). This means that 0 degree means along the satellite track heading, 270 degree means along the radar look direction (range). **Note that only half plane of the real and imaginary parts are stored in the product.** However, the whole spectra can be reconstructed using the symmetry properties of the cross spectra (see Chapter 3.2.1).

3.1.2 Confidence parameters

λ_{cut} = azimuth cut-off wavelength (m) (*az_cutoff* in Cross Spectra MDS)

μ_I = image mean (float array dim 2) (*sublook_means* in Cross Spectra MDS)

σ_I = image variance (float array dim 2) (*sublook_variance* in Cross Spectra MDS)

β_1 = image skewness (float array dim 2) (squared) (*sublook_skewness* in Cross Spectra MDS)

β_2 = image curtosis (float array dim 2) (*sublook_curtosis* in Cross Spectra MDS)
landFlag = land flag (0 over ocean, 1 over land) (*land_Flag* in SQ ADS)
 ϕ_{\max} = direction of spectral maximum counter clockwise from satellite heading (deg)
 (*spec_max_dir* in MDS)
 Γ_{\max} = wavelength of spectral maximum (m) (*spec_max_wl* in MDS)
 E_{tot} = total spectral energy of cross spectra (*spec_tot_energy* in MDS)

3.2 Reconstruction

Below is described how the SAR image cross spectra can be recovered from the product. The procedure for reconstruction of wavelengths and directions are also specified (see also <http://envisat.esa.int/dataproducts/asar/> (Chapter 6.6.18)).

3.2.1 Image Cross Spectra

The complex SAR image cross spectra (real and imaginary parts) is stored in the product on the grid (N_k, N_ϕ) where the first half space $\left(0 : N_k - 1, 0 : \frac{N_\phi}{2} - 1\right)$ is assigned to the first half plane of real part of the cross spectrum, while the second half space $\left(0 : N_k - 1, \frac{N_\phi}{2} : N_\phi - 1\right)$ is assigned to the first half plane of the imaginary part of the cross spectra. **So only one half of the real and the imaginary parts are stored in the product, but the whole spectra can be reconstructed using the symmetry properties of the cross spectra.** This is done as follows:

First read from product the byte scaled real, $\text{Re } P$ and imaginary, $\text{Im } P$ half plane parts of the cross spectra, and store the values, respectively in a complex array, \hat{P} of dimensions $\left(N_k, \frac{N_\phi}{2}\right)$. The spectral values of the complex SAR image cross spectra, \hat{P} is byte scaled and must be converted to float values using the $\text{Re } P^{\max}$, $\text{Re } P^{\min}$ and the $\text{Im } P^{\max}$, $\text{Im } P^{\min}$ values, separately for the real and the imaginary parts using the formula:

$$\begin{aligned}
 \text{Re } \hat{P}_{n,m} &= \text{Re } \hat{P}_{n,m} \frac{(\text{Re } P^{\max} - \text{Re } P^{\min})}{255} + \text{Re } P^{\min} & n, m \in [0, N_k - 1] \times \left[0, \frac{N_\phi}{2} - 1\right] \\
 \text{Im } \hat{P}_{n,m} &= \text{Im } \hat{P}_{n,m} \frac{(\text{Im } P^{\max} - \text{Im } P^{\min})}{255} + \text{Im } P^{\min} & n, m \in [0, N_k - 1] \times \left[0, \frac{N_\phi}{2} - 1\right]
 \end{aligned}$$

Now the cross spectra, \hat{P} must be expanded to dimension $N_k \times N_\phi$ and the symmetry properties must be used to recover the whole spectra. Define a complex array, \tilde{P} of dimension $N_k \times N_\phi$ and assign its values using the values of \hat{P} as follows:

$$\tilde{P}(0 : N_k - 1, 0 : \frac{N_\phi}{2} - 1) = \hat{P}(0 : N_k - 1, 0 : \frac{N_\phi}{2} - 1)$$

$$\tilde{P}(0 : N_k - 1, \frac{N_\phi}{2} : N_\phi - 1) = \text{conj}\left\{\hat{P}(0 : N_k - 1, 0 : \frac{N_\phi}{2} - 1)\right\}$$

The spectrum, $\tilde{P}_{n,m}$ is now given in units of m^2 and is the Cartesian image cross spectral density sampled on a log-polar grid (see Fig. 9). If you want to convert it to frequency-direction space, see Chapter 3.2.4. The computation of the wavenumbers is given in Chapter 3.2.2.

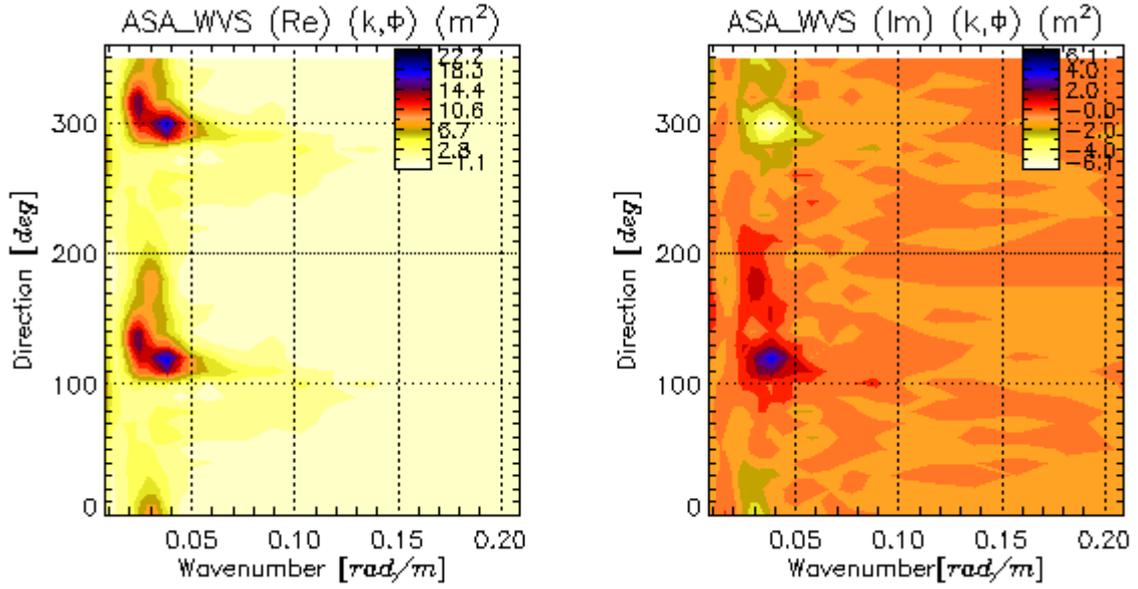


Figure 9: Example of cross spectra, \tilde{P} on (k, ϕ) grid as reconstructed from the ASA_WVS product using the procedure described above. Note the symmetry and anti-symmetry of the real and imaginary parts, respectively. Left: Real Part, Right: Imaginary part.

3.2.2 Spectral Domain

The wavenumbers, k_n are given in logarithmic scale and the directions, ϕ_m are equidistantly. The reconstruction procedure is similar to that of the ASA_WVW product, **except that for the ASA_WVS product the grid is generated on double density and then resampled by picking only one every second samples**. The wavenumbers (in rad/m) can be computed from the formulas below. First compute the wavenumbers and directions on double density grid, and then pick only one every second samples.

The wavenumbers, \hat{k}_n on double density grid ($2N_k$) are computed as:

$$\alpha = \left(\frac{\lambda_o}{\lambda_{N_k-1}} \right)^{1/2N_k-1}$$

$$\hat{k}_n = \frac{2\pi}{\lambda_o} \alpha^n \quad n \in [0, 2N_k - 1]$$

The double density spacing in wavenumber and frequency domain can be written as:

$$\begin{aligned} dk_n &= \frac{1}{2} \left(\alpha - \frac{1}{\alpha} \right) \hat{k}_n & n \in [0, 2N_k - 1] \\ df_n &= \frac{1}{2} \left(\sqrt{\alpha} - \frac{1}{\sqrt{\alpha}} \right) \hat{f}_n & n \in [0, 2N_k - 1] \end{aligned}$$

where $\hat{f}_n = \frac{1}{2\pi} \sqrt{g\hat{k}_n}$ is the dispersion relation at deep water.

The directions (in degrees clockwise from North) are given as:

$$\hat{\phi}_m = \phi_0 + m\Delta\phi \quad m \in [0, 2N_\phi - 1]$$

Then pick only one every second of the wavenumber and direction samples:

$$\begin{aligned} k_n &= \hat{k}_{2n} & n \in [0, N_k - 1] \\ \phi_m &= \hat{\phi}_{2m} & m \in [0, N_\phi - 1] \\ dk_n &= \frac{1}{2} \left(\alpha - \frac{1}{\alpha} \right) \hat{k}_{2n} & n \in [0, N_k - 1] \\ df_n &= \frac{1}{2} \left(\sqrt{\alpha} - \frac{1}{\sqrt{\alpha}} \right) \hat{f}_{2n} & n \in [0, N_k - 1] \end{aligned}$$

The discrete values computed using these formulas are in the center of the bin. See the figure and description given at <http://envisat.esa.int/dataproducts/asar/> (Figure 2.65 in Chapter 2.7.2).

3.2.3 Conversion of spectra to North-East orientation

The cross spectra is given in the SAR imaging domain, where the directions are counter clockwise and relative to the satellite track direction. If we want to convert the cross spectra into clockwise relative to North we can use the following approach:

$$\hat{\phi}_m = 360. - (\phi_m - \psi) \text{ MOD } 360.$$

The same equation can be used to convert the cross spectral peak direction stored in the product MDS (*spec_max_dir*) relative to clockwise from North.

The 2dim cross spectra can converted to clockwise from north, by a rotation (with the satellite track angle value) followed by a shift operation of the directional indexes.

3.2.4 Conversion to frequency-directional grid

The SAR image cross spectrum $\tilde{P}_{n,m}$ can be converted to WAM like format i.e. given as a frequency-directional cross spectrum by multiplying it with the factor

$k \frac{dk}{df} = 4\pi k_n \sqrt{\frac{k_n}{g}}$ followed by a resampling into the desired (f_n, ϕ_m) grid size of the WAM spectrum (if WAM has different size):

$$\tilde{P}_{n,m} = \tilde{P}_{n,m} 4\pi k_n \sqrt{\frac{k_n}{g}} \quad n, m \in [0, N_k - 1] \times [0, N_\phi - 1]$$

Here $\tilde{P}_{n,m}$ is the cross spectra, now in units of $[1/Hz]$, to be resampled into your WAM (f_n, ϕ_m) grid dimension.

3.3 Product Quality

The product quality and the azimuth cut-off effect will be varying depending on the SNR and the sea-state, respectively. Below are given approaches to deal properly with these effects from product to product.

3.3.1 Azimuth Cut-Off

A similar approach as described for the ASA_WVW product (see Chapter 2.3.1) can be used for the ASA_WVS product, but for this product **we do not need to scale the azimuth cut-off value from the product for generating the Gaussian roll-off function**. We can simply use the cut-off value read from the product:

$$h_n = \exp\left\{-\left(\frac{\lambda_{cut}}{\lambda_n}\right)^2\right\} \quad n \in [0, N_k - 1]$$

where $\lambda_n = 2\pi/k_n$ is the wavelengths of the spectrum.

In Figure 10 we show the ASA_WVS cross spectra on Cartesian grid and in SAR coordinates to illustrate the alignment of the spectral information along the range axis due to the azimuth cut-off effect.

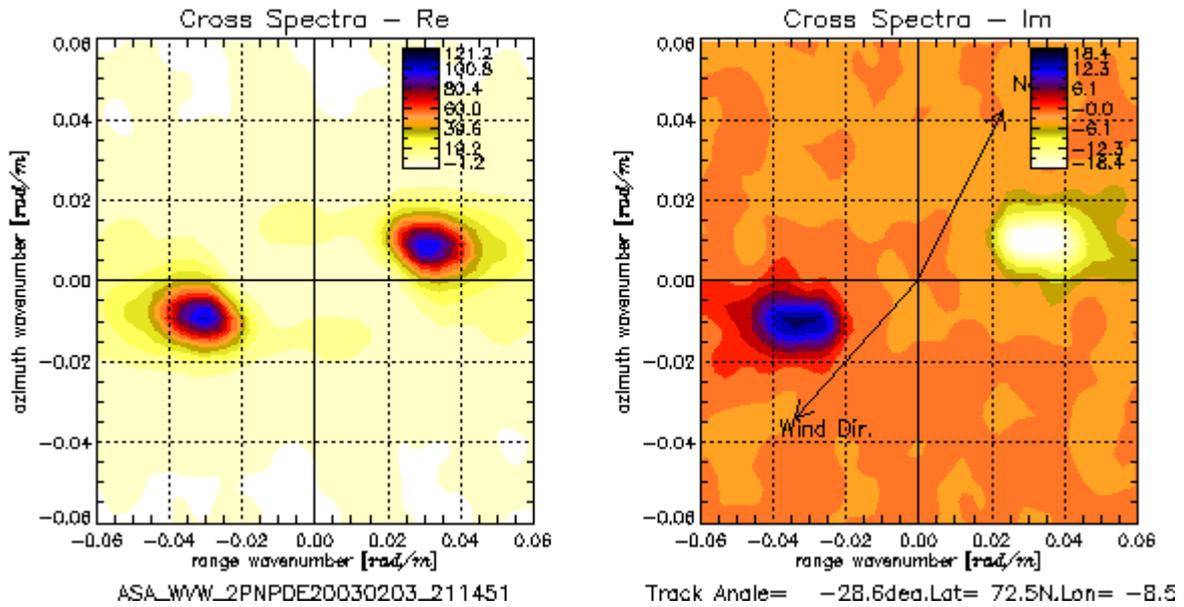
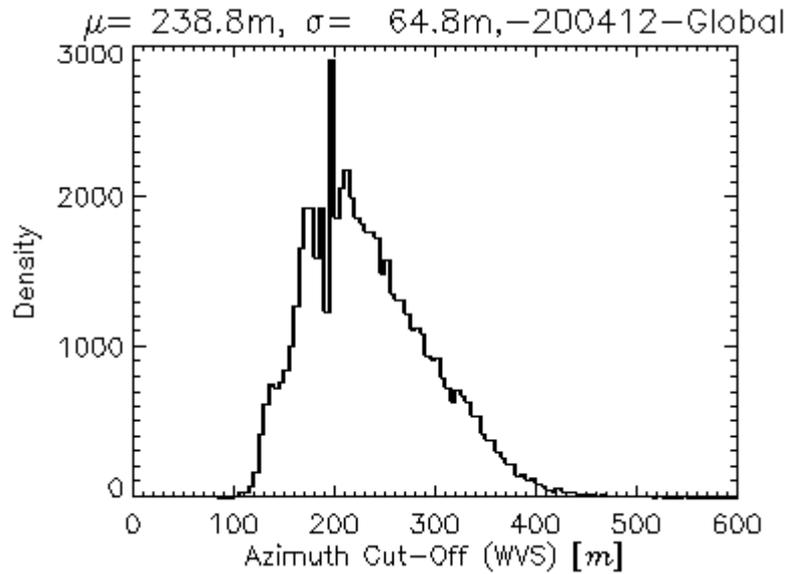


Figure 10: ASA_WVS cross spectra converted into Cartesian wavenumber domain and in SAR coordinates. Note the alignment of the spectral information along the range axis. The azimuth cut-off length is here 298m. Only the part of the spectral domain with wave information is plotted here (wavelengths above 104.7m). Direction of North and local wind are shown with the arrows.

In Figure 11 we show the typical histogram and global distribution of azimuth cut-off values from the ASA_WVS product for the period 2004-12-01 to 2004-12-31.



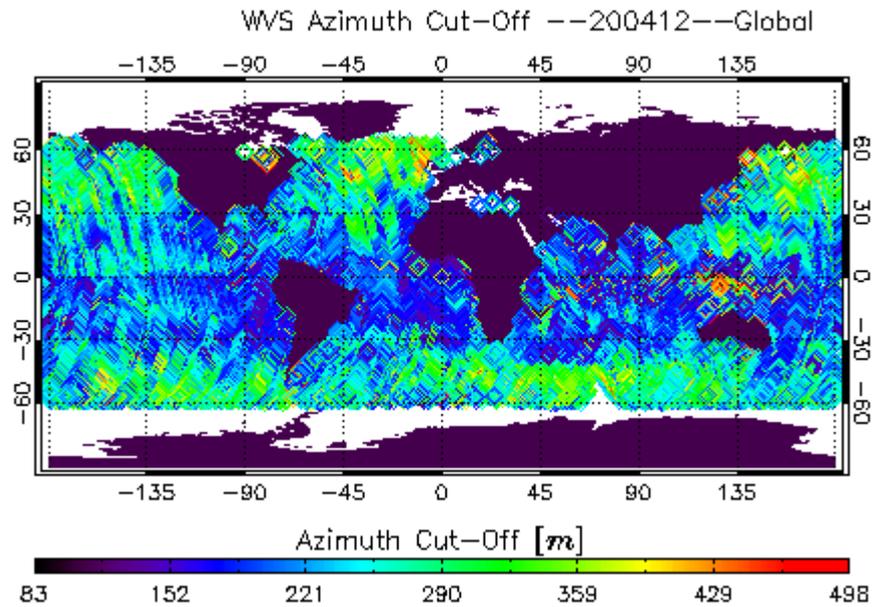


Figure 11: Histogram (upper) and global monthly average (lower) azimuth cut-off from ASA_WVS product.

3.3.2 Confidence

The confidence of the product can be checked by excluding land data using the landFlag parameter (similar as for the ASA_WVW product), as well as by the cross comparison of sub-look statistics given by the mean, variance, skewness and curtosis values. They should not deviate much from one look to the other look. Example is shown below for the intensity.

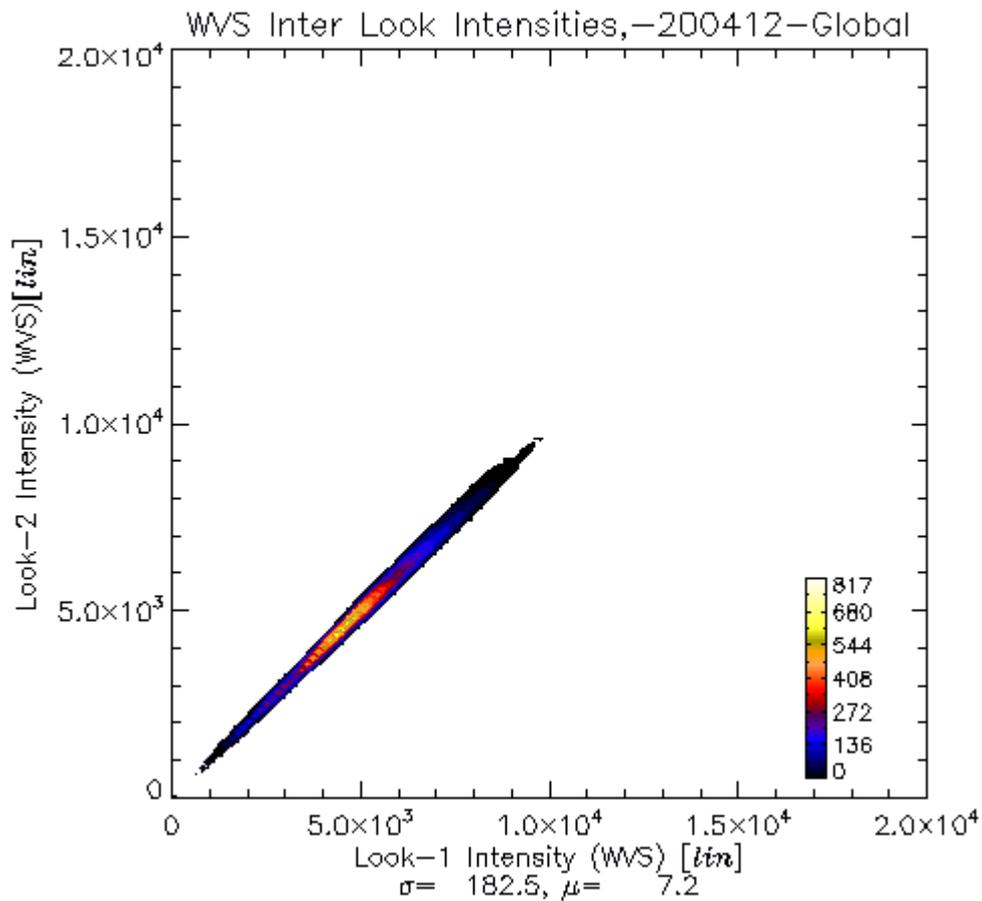


Figure 12: Sub-look intensity of look 1 versus look 2 extracted from the ASA_WVS product (MDS).

3.4 Error Budget

The ASA_WVS is not a geophysical product and can thus not directly be validated against in-situ or model data. However, some parameters stored in the ASA_WVS product (ϕ_{\max} , Γ_{\max} and E_{tot}) can be plotted against corresponding WAM parameters to quickly assess the quality of the product.

Below we show histograms of difference between ASA_WVS and WAM for ϕ_{\max} and Γ_{\max} , and a scatterplot of E_{tot} against WAM significant waveheight, H_s .

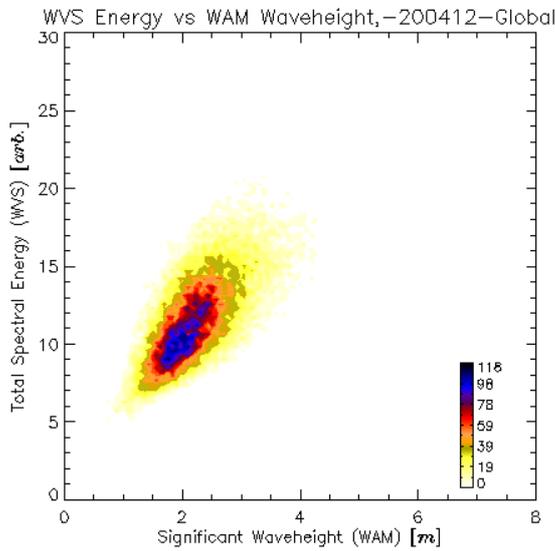
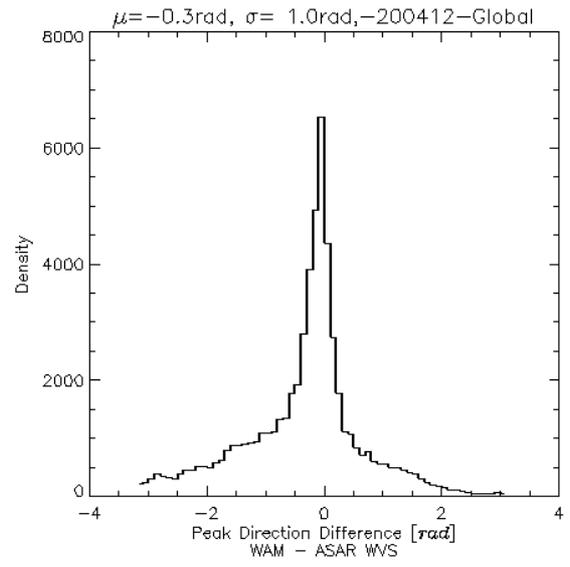
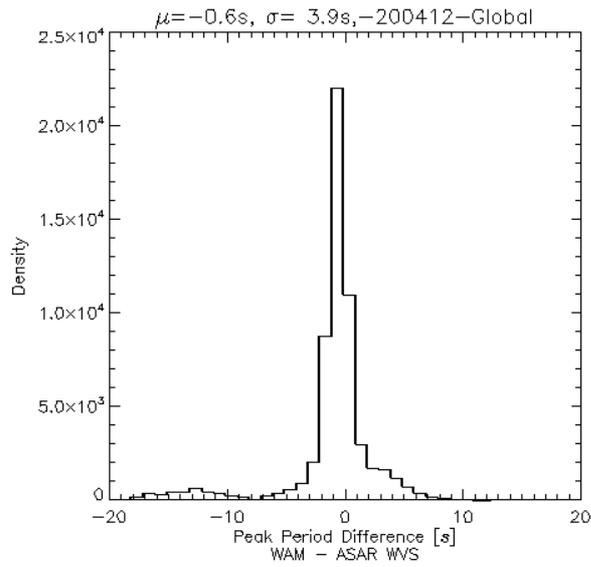


Figure 13: Upper left: Histogram of difference between ASA_WVS and WAM peak period (derived from Γ_{max}). Upper right: Histogram of difference between ASA_WVS and WAM peak wave direction. Lower: Scatterplot of WAM H_s versus ASA_WVS E_{tot} .

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