KOMPSAT-5 support within GAMMA Software

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1. INTRODUCTION

In this document the support provided in the GAMMA Software for the processing of data of the Korean X-band SAR on-board KOMPSAT-5 is summarized. The basic approach followed is that SLC and higher level products, i.e. detected data in ground or in map coordinates, can be imported into the formats used in the GAMMA Software, so that a broad functionality including SAR interferometry and terrain corrected geocoding can then be used.

In the following the importing of the data and a geocoding and differential interferometry example are described.

2. IMPORTING KOMPSAT-5 DATA

2.1. Importing SLC data

The KOMPSAT-5 SLC sample data (*SCS*.h5) are provided in a "h5-file" K5_20140323051755_000000_03197_A_HR02_HH_SCS_B_L1A.h5. In addition an XML file with auxiliary information and jpgs with quick looks of the image are provided.

To read the SLC data and generate the corresponding SLC parameter file the ISP program par_KS_SLC is used:

par_KS_SLC K5_20140323051755_000000_03197_A_HR02_HH_SCS_B_L1A.h5 20140323

Apart from the KOMPSAT-5 "h5-file" an identifier for the output files (in this case the acquisition date 20140323 is used) is provided. As output the program generates the SLC file 20140323_HH_02.slc and the SLC parameter file 20140323_HH_02.slc.par.

The SLC generated is in SCOMPLEX (pair of short integers) format. Displaying the SLC

disSLC 20140323_HH_02.slc 3765 1 7364 1. .35 1

shows that the scaling is such that the short integer values for the real and imaginary parts are almost all very small (0,1,2,3,…) with many short integer values equal to 0. To avoid possible problems with the interpretation as (0,0) as "no data" and severe quality reduction when resampling the data we modify the data from SCOMPLEX to FCOMPLEX and replace the 0.0 values with a very small non-zero value (1.18e-38)

SLC_copy 20140323_HH_02.slc 20140323_HH_02.slc.par 20140323.slc.tmp 20140323.slc.par 3 0.1

replace_values 20140323.slc.tmp 0.0 1.18e-38 20140323.slc 3765 0 2

/bin/rm 20140323.slc.tmp

As a result the imported SLC data in FCOMPLEX format (*20140323.slc*) and the corresponding SLC parameter file *20140323.slc.par* are available for further processing.

2.1.1. Investigate point target characteristics of KOMPSAT-5 High Resolution data

Within the sample data there is a very strong scatterer at pixel coordinate (324,3094) that we can use to study the point target characteristics of the high resolution KOMPSAT-5 data. For this we use the MSP program *ptarg*:

ptarg 20140323.slc 3765 324 3094 20140323.slc.ptr_image_324_3094 20140323.slc.r_plot_324_3094 20140323.slc.az_plot_324_3094 0 3 1

Figures 1 and 2 shows the point target reponses in range and azimuth.
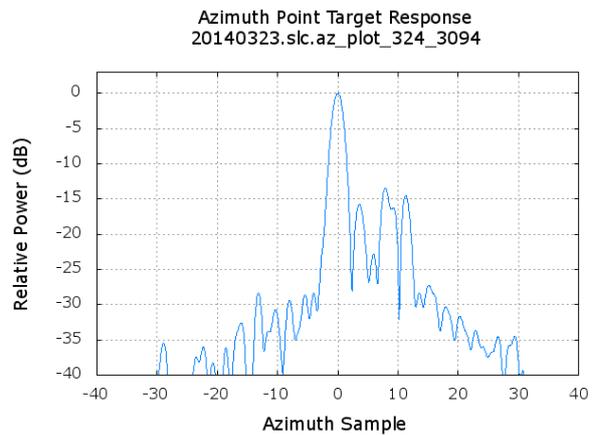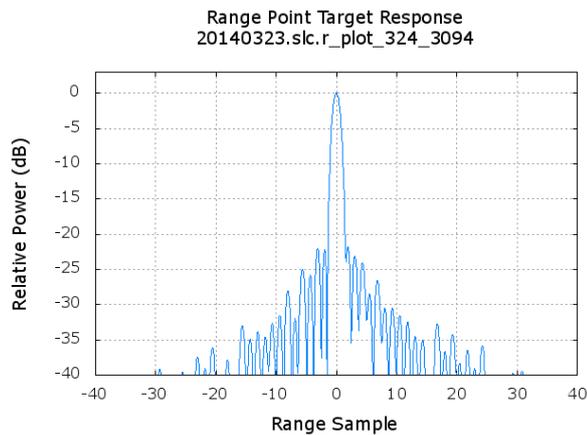
Figure 1 Point target responds in range.   Figure 2 Point target responds in azimuth.

Relevant related parameters are found in the screen output:

```
SLC range_peak_position:   324.41510  value:  5.50284e+03
SLC azimuth_peak_position: 3094.05777  value:  5.49846e+03
SLC interpolated_peak_power_value:  5.50065e+03
SLC interpolated peak phase (no phase gradients) (rad):     1.4534
SLC interpolated peak phase (with phase gradients (rad):   -7.8956
range -3 dB width (samples):      1.228
range -10 dB width (samples):      2.143
range PSLR (dB):           -21.715
range ISLR (dB):           -17.297
azimuth -3 dB width  (samples):     1.706
azimuth -10 dB width (samples):     3.034
azimuth PSLR (dB):          -13.465
azimuth ISLR (dB):   -10.095
```

2.1.2. Multi-looking and geocoding

Multi-looking and terrain corrected geocoding, using an oversampled section of the SRTM DEM, of the SLC data was done using the commands:

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multi_look 20140323.slc 20140323.slc.par 20140323.mli 20140323.mli.par 2 5 0 - 1.0

gc_map 20140323.mli.par - EQA.area2.dem_par EQA.area2.dem EQA.area2.dem_seg_par EQA.area2.dem_seg 20140323.lt 1 1 EQA.20140323.sim_sar - - EQA.20140323.inc - - EQA.20140323.ls_map 8 2

geocode_back 20140323.mli 1882 20140323.lt_fine EQA.20140323.mli 2880 2760 2 0

No refinement was done to the geocoding. For visualization purposes and to check the quality of the geocoding done we generate kmz file for visualization in Google Earth:

First we generate a SUN raster file

raspwr EQA.20140323.mli 2880 1 0 1 1 1. .35

convert it then to jpg

convert EQA.20140323.mli.ras EQA.20140323.mli.jpg

and generate the kmz file using the program kml_map that combines the jpg (in geographic coordinates) with the corresponding meta data

kml_map EQA.20140323.mli.slc.jpg EQA.area2.dem_seg_par EQA.20140323.mli.slc.kml

zip EQA.20140323.mli.slc.kmz EQA.20140323.mli.slc.jpg EQA.20140323.mli.slc.kml

Figures 3 and 4 show the KOMPSAR-5 SAR backscatter and the corresponding section in Google Earth. The geometric correspondence of the geocoded backscatter data with the optical data in Google Earth is excellent, indicating that the state vectors are of high quality and that the geometric information of the KOMSAT-5 data was correctly interpreted.

Figure 3 Detected, multi-looked and geocoded KOMPSAT-5 HR SLC data visualized in Google Earth.

Figure 4 Optical imagery in Google Earth for the section of the backscatter data shown in Figure 3.

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2.2. Importing DGM (ground-range) data

KOMPSAT-5 DGM data is detected data that was converted to ground-range azimuth geometry. The values correspond to amplitudes (corresponding to the PRI products of other SAR sensors) and not to intensities.

To read in the KOMPSAT-5 DGM data (*DGM*.h5) the program par_KS_DGM is used:

par_KS_DGM K5_20140323051755_000000_03197_A_HR02_HH_DGM_B_L1B.h5 20140323.DGM

Apart from the KOMPSAT-5 "h5-file" an identifier for the output files (in this case the acquisition date 20140323.DGM is used) is provided. As output the program generates the PRI file 20140323.DGM_HH_02.pri and the corresponding parameter file 20140323.DGM_HH_02.pri.par.

To convert the amplitude data (*.pri) to intensity data (*.grd) the program radcal_PRI can be used. We are at present not sure about the correct reference incidence angle and calibration gain to use to get radiometrically calibrated intensities. Using 90 dB for the calibration gain and 90 deg for the reference angle brings the values of the sample data in the correct order of magnitude.

The data can be displayed using dispwr

dispwr 20140323.DGM_HH_02.grd 6046

To convert the ground range data into slant range geometry the program *GRD_to_SR* can be used. To calculate a geocoding lookup table for the ground range data the program *gc_map_grd* can be used.

We recommend not to work with DGM data but to start from SLC data.

2.3. Importing geocoded data

For KOMPSAT-5 there is also a geocoded data product (GEC). In this product the data is geocoded under the assumption that the scattering surface is the WGS84 ellipsoid. As a consequence of the deviation of the true terrain height from the WGS84 ellipsoid the map positions obtained are offset (by definition). This offset increases with the deviation of the true terrain height from the WGS84 ellipsoid and it is larger for small incidence angles (as the 21.5 deg. of the sample data).

The program par_KS_geo supports importing KOMSAT-5 *GEC*.h5 data

par_KS_geo K5_20140323051755_000000_03197_A_HR02_HH_GEC_B_L1C.h5 20140323.GEC

it generates as outputs the 3 files *20140323.GEC_HH_02.dem_par* (DEM/MAP parameter file with relevant map parameters), *20140323.GEC_HH_02.geo* (image file in UTM map coordinates), and *20140323.GEC_HH_02.mli.par* (parameter file for related SAR image parameters).

Apart from the offset mentioned above the image geometry is affected by not considering terrain effects on the geocoding. Therefore, we recommend not to work with GEC data but to start from SLC data.

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3. SAR INTERFEROMETRY USING KOMPSAT-5 DATA

3.1. Preparation of co-registered SLCs

As sample data for interferometry a pair of High Resolution (HR) KOMPSAT-5 SLC data acquired on 20131211 and 20140106 with a long interferometric baseline (Bperp = 2060 m) over a quite flat arid area (Gobi desert) are provided.

As described above in Section 2.1. we import the SLC data using par_KS_SLC, convert it to FCOMPLEX format (replacing also 0.0 with a very small value). For the interferometry we will use a multi-looking with 4 range and 6 azimuth looks. Using this multi-looking we generate the multi-look intensity image (MLI) for the reference scene (selected to be the first one, acquired on 20131211) and we perform a terrain corrected geocoding (using SRTM DEM heights, without refinement) for the reference scene, so that we get the geocoding lookup table as well as SRTM heights in SAR geometry (using program geocoded) for use in the SLC co-registration and simulation of the topographic phase.

The SLC co-registration is done using the approach considering the terrain height (i.e. using the program rdc_trans and applying refinements first based on the MLI and then based on the SLC). The offset statistics indicate a very high co-registration quality (in SLC pixels):

final model fit std. dev. (samples) range: 0.0125 azimuth: 0.0133

3.2. Calculate differential interferogram

The interferogram is then calculated using the orbit based phase model (program *phase_sim_orb*) and applying a terrain slope adaptive common band filtering (program *SLC_diff_intf*). Common band filtering in range is very important for this pair with a long baseline (Bperp = 2060 m) and common band filtering in azimuth is also recommended, considering the relatively high and spatially varying Doppler Centroid and of the data

create_offset 20131209.rslc.par 20140106.rslc.par 20131209_20140106.off 1 4 6 0

phase_sim_orb   20131209.rslc.par   20140106.rslc.par   20131209_20140106.off   20131209.hgt 20131209_20140106.ph_sim_orb 20140106.rslc.par - - 1 1

SLC_diff_intf   20131209.rslc   20140106.rslc   20131209.rslc.par   20140106.rslc.par 20131209_20140106.off 20131209_20140106.ph_sim_orb 20131209_20140106.diff0 4 6 0 0 0.1

rasmph_pwr24   20131209_20140106.diff0   20131209.rmli   1481   1   1   0   1   1   1.   .35   1 20131209_20140106.diff0.ras

The resulting differential interferogram is shown in Figure 5. The incomplete coverage with phase information relates to the fact that a part of the area is only covered by the first image, but not by the second one. Overall the phase coherence looks quite good. Using *mcf* it was possible to unwrap the differential phase without particular problems.

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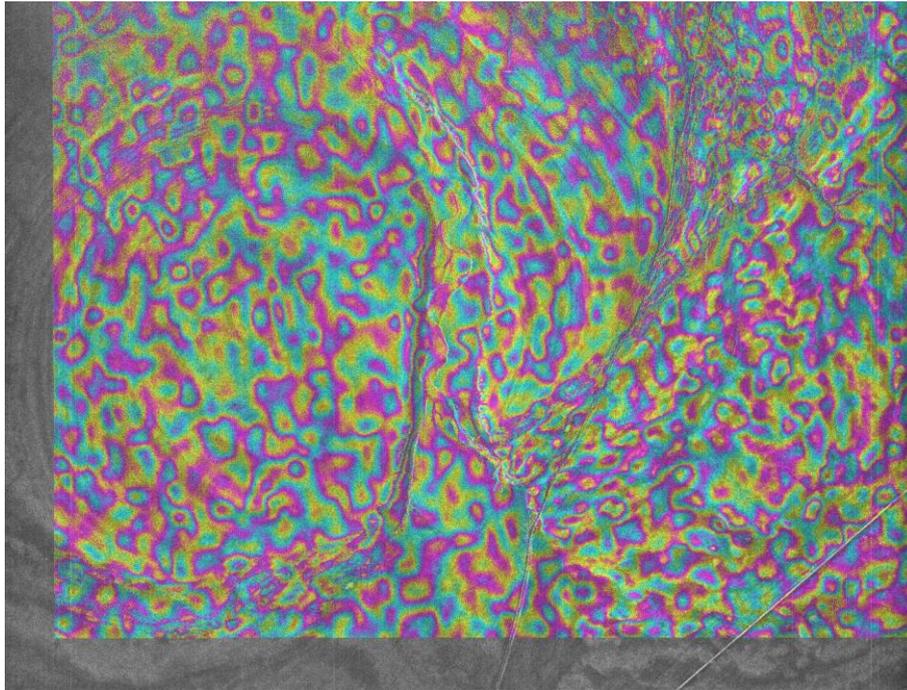
Figure 5   KOMPSAT-5 differential interferogram. A color cycle corresponds to a phase cycle. The time interval is 28 days, the perpendicular baseline component -2060m.

3.3. Results

The phase in the differential interferogram looks quite "wild" with spatial variations larger than one phase cycle in spite of a relatively flat area and a probably very dry atmosphere (arid site, cold winter time). Considering the long perpendicular baseline component (-2060m) this is not surprising though, as this corresponds to a ambiguity height of only 2.75 m per phase cycle. Consequently, topographic effects and modulations in the SRTM heights used both result in such phase variations.

Unwrapping the phase (program *mcf*) and converting the differential phase to a height correction (program *dh_map_orb*) results in a height correction that can be added to the SRTM height used in the simulation. We observe a small range trend of about 3m per 100 MLI pixel) in the height correction relative to the SRTM DEM that we remove using the DIFF programs *quad_fit* (using 3-parameter model) and *quad_sub*. The updated DEM (after one iteration step on the lookup table calculate to consider in this the high resolution KOMPSAT-5 based heights and not the SRTM heights) the final heights in map geometry are obtained. Thanks to the very long baseline the quality of this KOMPSAT-5 based DEM should be excellent over this arid area.

The resulting DEM is shown in Figure 6. Furthermore we also generated a KOMPSAT-5 "coherence product" (see Figure 9), i.e. an RGB composite of the interferometric coherence (in red, using linear scale), the average backscattering intensity (in green, using log scale) and the backscatter change between the two dates (in blue, using log scale). Comparing these products with Google Earth shows an excellent geometric correspondence (Figures 8 and 9).

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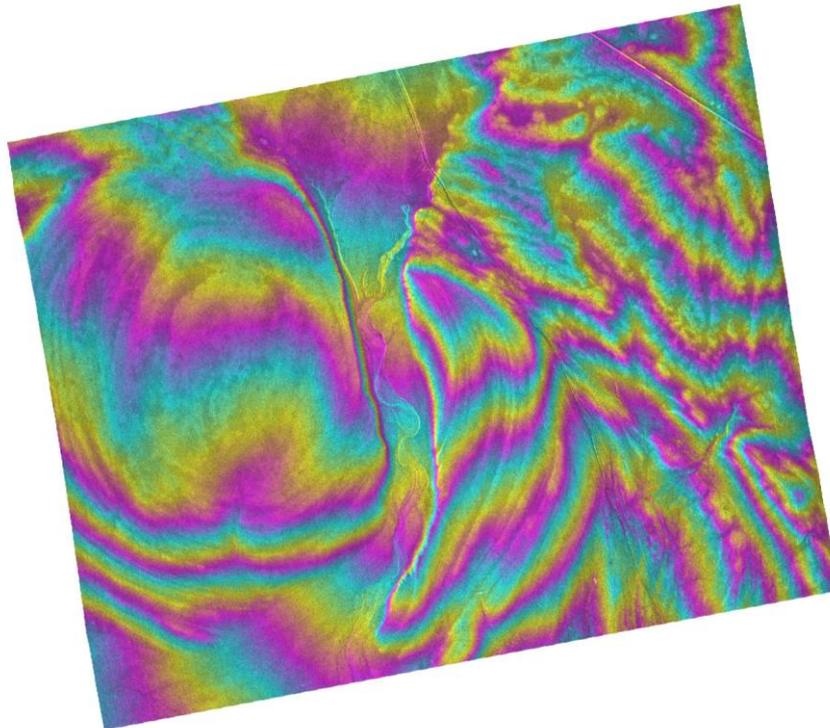
Figure 6   Height map generated with KOMPSAT-5 differential interferogram. A fine color scale with 10 meter height per color cycle is used. The time interval of the interferogram used is 28 days, the perpendicular baseline component -2060m.
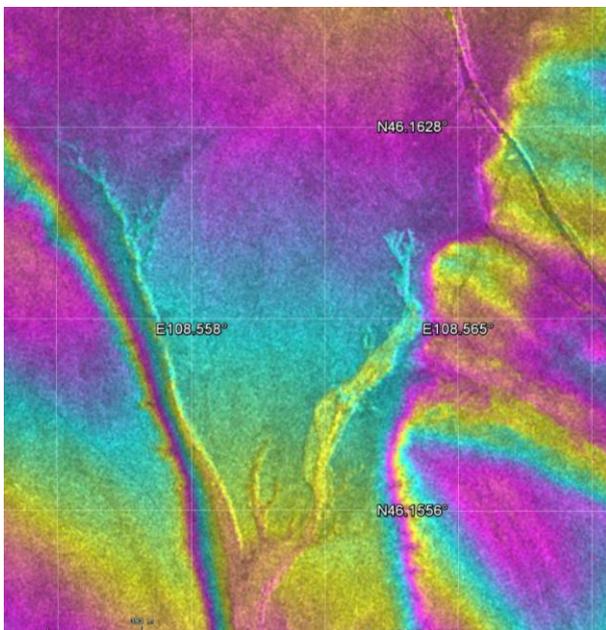
Figure 7 Detected, multi-looked and geocoded KOMPSAT-5 HR SLC data visualized in Google Earth.

Figure 8 Optical imagery in Google Earth for the section shown in Figure 7.

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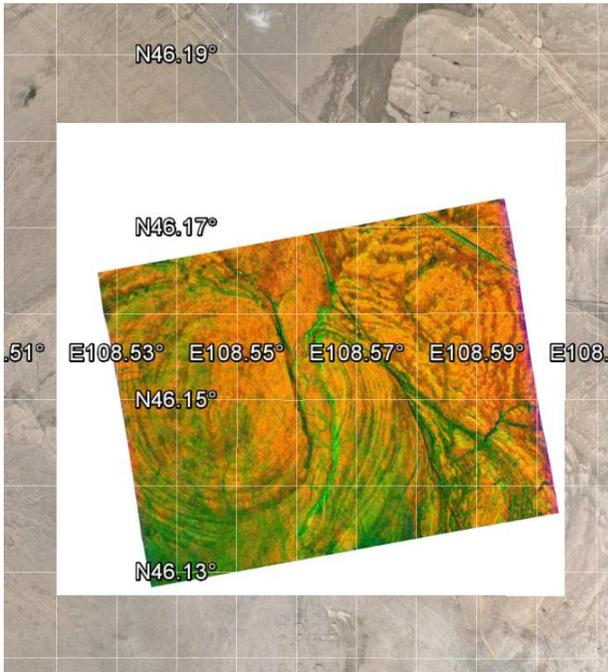
Figure 9 KOMPSAT-5 "coherence product" for HR pair of 20131209, 20140106 (dtime = 28 days, Bperp = -2060m) visualized in Google Earth.
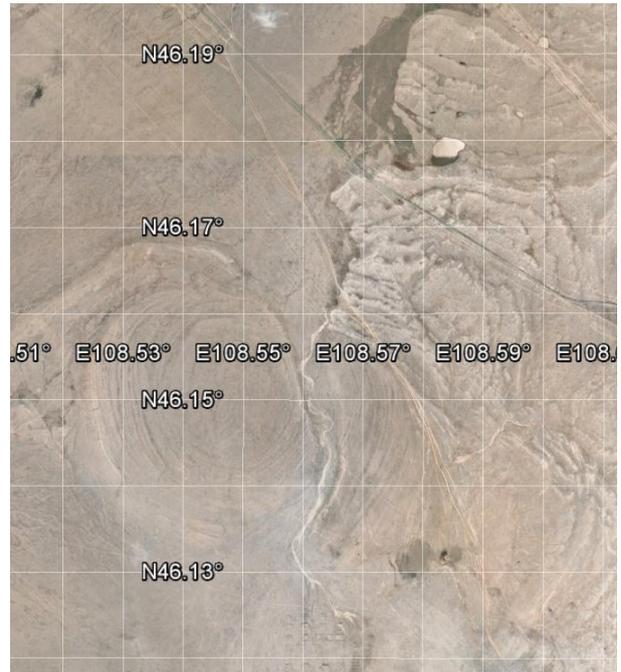
Figure 10 Optical imagery in Google Earth for the section of the backscatter data shown in Figure 9.

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