# Tabulated response to suggestions arising from the review of the CARD4L specifications provided by the UK-Catapult team, August 2017.

# Surface Reflectance

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|  | **Input** | **Discussion** | **Proposed Action**  | **Anticipated lead in CEOS** | **Status** |
|  | **General comments** |  |  |  |  |
| 1 | Why a limit on spatial resolution? | Conceptually, as you point out, there is no reason to limit the spatial resolution. The LSI-VC tends to work in the 10-100m resolution range, which some call ‘moderate resolution’. Setting ‘boundaries’ like this may exclude others (private sector, marine) from ‘buying in’ to the conversation and adopting the concept of ARD. This would be a loss.  | Propose to remove or qualify initial references to spatial resolution. | LSI-VC drafting teams | Closed |
| 2 | Is there scope to expand beyond land?  | Yes. This is a very timely comment given that CEOS is considering a parth to take CARD4L beyond land. | This question will inform discussions of CEOS at SIT-33in Sept 2017 | SIT – to consider a mechanism for taking ARD forward beyond land products. | Closed (process in-train) |
| 3 | Licensing terms are needed in general metadata. | The metadata elements indicated in the PFS are not intended to be comprehensive. It is expected that licence metadata would be included with any dataset, but this is beyond the current scope of CARD4L. | No change planned | NA | -- |
| 4 | The adoption of CEOS standards would improve user experience and help to grow the market. | Agreed. Further input to how this could be monitored and reported is welcome | Methods to capture the benefit of CARD4L to be discussed in the LSI-VC-4 meeting in Frascati, Sept 5-7 2017. | LSI-VC – Strategy discussion | Open |
|  | **General metadata** |  |  |  |  |
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| 5 | Is there compatibility with ISO and INSPIRE standards that will enable machine-level interoperability of meta data | An important point. The implementation of CARD4L is early days and this has not been examined in detail | Future work in the implementation and review of Specifications and CARD4L should examine this question.  | WGISS to be approached for advice on how this could be included in the PFS’ | Open |
| 6 | Metadata in products is, so far, not well advanced toward machine-readability  | Implementation of CARD4L will progress over time. It will be important that the implementation incudes the metadata as well as the data! | As above | WGISS to be approached for advice on the best approach to ensuring machine-readable metadata in CARD4L | Open |
| 7 | Increased specification of approaches to metadata is needed and geojson should be considered as the preferred technical implementation |  | CEOS WGISS will be asked to examine and advise on this question as one of several activities that LSI-VC will ask of them to support the implementation of CARD4L. | WGISS to be approached for advice on if / how the PFS’ could offer more specific advice on machine readable metadata. | Open |
| 8 | Should the file format be included? | The metadata elements indicated in the PFS are not intended to be comprehensive. It is expected that licence metadata would be included with any dataset, but this is beyond the current scope of CARD4L. | Discuss at LSI-VC-4 including drawing on the experience of agencies such as USGS and CSA and ESA so far. | na | -- |
|  | **Pixel-level metadata** |  |  |  |  |
| 9 | ‘*Un-tested*’ does not equal ‘*not successfully completed*’. There is ambiguity in the phrasing. | We’ve struggled a bit with this nuancing and clearly don’t have it right yet. | Revisit wording | LSI-VC | Closed |
| 10 | “Aerosol optical depth parameters are required for most algorithms for atmospheric corrections, therefore a target should be determined” | We don’t have a target level at this point and future work should address that | This question needs further expert input and consideration.  | LSI-VC drafting team | Open |
| 11 | Worth considering directional scattering in the atmosphere too. | Agreed; the relative contributions of atmospheric v. target directional scattering seems to be an open question. Current PFS notes that this is ‘to be determined’. | This question needs further expert input and consideration.  | WGCV to be approached by LSI-VC for advice on this question. | Open |
| 12 | In the context of geometric corrections – When considering different sources need to make reference to spatial resolution. Spatial resolution is not mentioned anywhere in the document. | Further discussion is needed to clarify the point being made here. At present, we don’t require ANY information on the geometric accuracy to reach the threshold level. This seems too low a bar (1.7, 1.8) as the user is missing important information. | Revisit threshold level fro 1.8, Geometric accuracy. | LSI-VC drafting team | Open |

# Normalised Radar Backscatter

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| 1 | The document seems tailored (at least for certain processing steps) towards Sentinel-1, more than other SAR missions. | Not the intention, but the main ‘exemplar’ given is Sentinel-1. Sentinel-1 is clearly of great importance however ALOS PALSAR products are similarly covered. | Increased input to be sought from CSA and other radar providers and users. | LSI-VC sub-group. | Open |
| 2 | The proposed standard should take into account requirements for operational implementation of ARD generation. | More background on this point would be helpful. The threshold level of CARD4L is the minimum processing deemed necessary but does not place unreasonable burdon on data providers. | Follow up to get a better understanding of the concern being put here.  | LSI-VC | Open |
| 3 | The proposed standard should not be restricted to any given software (proprietary or not), as this may limit scalability etc. | Agreed. References to specific methods to achieve ARD are intended to be demonstrative and helpful but not exclusive | Review wording to avoid ambiguity | LSI-VC | Closed |
| 4 | The proposed validation process for CARD4L, seems sensible and the UK would be happy to contribute to the peer review process. | Noted with thanks. UK experts are invited to engage with the LSI-VC to help in the development of the ‘assessment framework’ (and with a view to increased participation in LSI-VC if this is feasible). | No specific action required. | NA | Closed |
| 5 | Metadata should consider: look direction (L, R or both) polarization resolution (range x azimuth) pixel spacing (range x azimuth) number of looks and equivalent number of looks layover and shadow flags | The technical specifics of the general metadata do need to be comprehensive and meaningful. Layover and Shadow masks are a refinement to the No-data flags requird in pixel-level metadata. | Revise the PFS draft to include these data  | LSI-VC | Closed |
|  | **Radiometric Corrections** |  |  |  |  |
| 6 | A more general description should be considered as the information presented appears oriented around Sentinel-1 requirements. | The intention is to be general, not specific to Sentinel-1.  | For noting | NA | -- |
| 7 | The reader assumes that the starting product is a GRD (Ground Range Detected) product. If this is the case it should be more clearly stated. | Ok. The aim of the PFS is to describe and ‘end state’ that is ready for a non-radar specialist to be able to use the data.  |  |  | -- |
| 8 | A GRD product has a pixel size which is usually half of the actual resolution, creating confusion among users. In this proposed processing chain, the Multilook process (2x2) has not been considered, which could be used to restore the actual resolution of the data. |  | Revise to address | LSI-VC drafting team | Open |
| 9 | With regards to envisaged resolution, some users may find a coarser resolution is required for (i) reduced noise; (ii) bandwidth restrictions for download. Consideration of multiple output products is therefore proposed to meet ranging user requirements. | The PFS does not specify a resolution. It is assumed that providers will settle on resolutions that generally serve well.  | No action required. | NA | -- |
| 10 | There is no mention of the inclusion of Sigma0, which should be considered. The subsequent use of Gamma0 or Sigma0 will depend on the application. | The proposal of CARD4L is that Gamma-0 is the minimum level of correction required for a non-specialist user to work with backscatter data. | No action proposed. | NA | -- |
| 11 | With regards to thermal noise removal and GRD border noise removal, certain SAR Missions may already have applied these corrections (e.g. TS-X, Cosmo-SkyMed). | Noted.  | No action required, the PFS is in principle indifferent to when or how a correction is applied. | NA | -- |
| 12 | Regarding transformation to the logarithm decibel scale, it should be clarified that all corrections should be made using the original dimensionless values. An equation for conversion could also be provided. | This clarification can be added.An equation could also be added in the Guidance section, however the lack of an equation does not detract from the Specification per se. | Suggest that the UK ‘team’ recommend specific amendments to the guidance to include the relevant equation. | LSI-VC | Open |
| 13 | With regards to terrain correction, the generation of absolute calibrated Gamma0/Sigma0 does not require any DEM since it models the earth with an ellipsoid. After generation of absolute Gamma0/Sigma0 terrain correction can be applied. It is suggested to separate and rename this section into the followingAbsolute calibration; Radiometric normalisation/slope normalisation where the radiometry can be improved with the caveat of (i) Correction for the local incidence angle (e.g. Kellndorfer et al., TGRS, Sept, 1998) are valuable when a DEM is available with post size matching or higher than the ground resolution of SAR final derived output; (ii) The availability of a DEM with resolution equal or higher than the final SAR derived output should be a mandatory element for generating a meaningful product especially for areas where high topography variation are present. Where a suitable DEM is not available (i) This step should not be mandated; (ii) The user may wish to undertake these corrections. | The proposition that CARD4L is putting is that the “absolute calibrated” is not analysis ready for the non-specialist user due to the other factors (terrain) that need to be accounted for (in general). The threshold level is that the local incidence angle is allowed for, and the target level is that the cross sectional incidence area is allowed for. (In principle these could be negligible, e.g., in flat terrain so no correction would be required). CARD4L aims to enable the ‘non-specialist user’, who is not in a position to undertake further corrections. | Consider in future revisions of the PFS.  | LSI-VC | Open |
| 14 | Agreed that speckle filtering should be optionally applied beyond ARD. | Noted | N/A | N/A | --  |
|  | **Geometric Corrections** |  |  |  |  |
| 15 | The geometric corrections should include the Terrain Correction/Ortho-rectification process. In particular the Range-Doppler approach should be considered. | Given the importance of this for Radar data I tend to agree.  | Revise the PFS. | LSI-VC drafting team | Closed |
| 16 | Layover and Shadow masks (GIM masks) should be also provided as further outputs. | As masks provide individual information for each pixel, they form part of pixel-level metadata. | Include layover and shadow masks as pixel-level metadata at the target level | LSI-VC drafting team | Closed |
| 17 | With regards to sub-pixel accuracy, which is taken to be less than or equal to 0.5 pixel, this requirement is thought to be insufficient to allow the creation of a time series from the same SAR mission. It is suggested to increase to 0.2 pixel, as all recent SAR missions (TS-X, Sentinel-1, Alos-2) by means of precise restituted ephemerides allow such precision. | Happy to take that advice. | Revise the PFS to specify 0.2 pixel precision | LSI-VC drafting team | Closed |
| 18 | The use of precise orbits should be mandated as a first processing step. Quality of the orbit is of paramount importance and can affect all steps of the processing where geometry is required, for instance, Sentinel-1 AUX\_RESORB are available only a few hours after the acquisition. | Agree with the intent; this makes sense if it is practical for the majority of applications which is the target zone of CARD4L. (Time critical applications may use less precise orbit determination however these are likely to be for a specialist audience rather than the ‘CARD4L’ users.) | Revise the PFS *Guidance* to make clear that the *methods* needed to achieve geometric correction will require precise orbit ephemeris. Revise the body of the PFS to ensure that any reference to methods is consistent with the Guidance.  | LSI-VC drafting team | Closed |

# Surface Temperature

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|  | **General** |  |  |  |  |
| 1 | We support the concept of defining analysis-ready data for the infrared. We believe the infra-red development should be broadly consistent with that for surface reflectance. | Noted with thanks | Nil | NA | -- |
| 2 | The “measurement” should … in principle .. be surface brightness temperature as a level 1 product rather than kinetic land surface temperature (LST) which is a level 2 product for many sensors. We would suggest that the two quantities have to be clearly identified if in the same file as this would likely be confusing to non-expert users. | This is significant food for thought. Given that LST requires in general additional information it may well be the ‘right thing’ to specify SBT as the product family, however the counter –argument is that a non-specialists may not be comfortable to use SBT. | LSI-VC-3 to discuss with input from agencies (e.g., USGS and others) working to provide or produce SBT and / or LST. | LSI-VC sub-team | Open |
| 3 | We think … per-pixel metadata … is better presented as data or flags rather than metadata. The data aspects could be auxiliary fields, other information could be quality or other flags. Overall, this section could be entitled “Quality indicators” ... | This is a terminology question. In the CARD4L framework the purpose is to provide the user with sufficient information about the quality of the *individual* observations (pixels) to inform use. They would take the form of flags or data fields. Generically, however, this is ‘per pixel’, and by intent it is ‘meta-data’, which is why CARD4L has gone that way. | Consider adding words such as ‘quality indicators’ in the relevant section / heading. | LSI-VC drafting team | Closed |
| 4 | We would suggest it could be useful to distinguish more between product level metadata (data that doesn’t change over time) from granule level. | Noted | Consider in future revision of all PFS | LSI-VC  | Open |
| 5 | There are other metadata standards (CF, ACDD) that should be adhered to, as well as ISO 19115-2 | Noted | Consider in future revision of the PFS | LSI-VC  | Open |
| 6 | It would be useful to cross-reference the ARD definitions with QA4ECV approaches. Within this framework uncertainty is a core field and not an optional field. | Agreed. Also, if QA4EVC is ahead on this then we should not drag our feet. | Future revision work to cross-reference with EVC and QA4EVC teams.Consider including uncertainty for SBT as a threshold requirement | LSI-VC  | Open |
| 7 | Where there are threshold requirements then such fields could be described as core fields whereas those with no threshold then requirements could be described as auxiliary or experimental fields. It may make more sense to group core fields together and auxiliary or experimental fields together. | Noted, however these considerations, which are essentially questions of presentation rather than content, are probably best left for awhile until the content is more bedded down. | NA | NA | -- |
| 8 | Common data types are helpful for users as well as common specifications. This might not be possible within CEOS but the ILSTE group are defining harmonised formats for medium resolution (1 km-type) LST data products.A very useful way to really examine this is to produce a couple of example files for a given instrument and circulate with reading tools to interested CEOS experts to examine whether the standard works practically. | An important point. File formats are likely to be the ‘next step’, i.e., the next barrier to use, but are outside of the CARD4L framework per se.  | Refer this consideration to WGISSS | WGISS | -- |
| 9 | Units are K (not degrees K) or degrees C. | Thanks! | Correct this | LSI-VC Drafting teams | Closed |
| 10 | 1.8 Geodetic accuracy. The threshold requirement could be a global estimate of the likely accuracy. | This would be an increase in expectations  | LSI-VC to consider | LSI-VC drafting team | Closed |
| 11 | 1.9 Instrument should be higher up the list? Perhaps at 1.5 | Probably agree but don’t want to confuse the numbering at this point. | Consider re-ordering for the next revision | LSI-VC drafting teams | Open |
| 12 | Spectral bands should be specified by central wavelength and FWHM as threshold. Breakthrough = provision of spectral response data in metadata or else location of data identified. | Seems consistent with current view | For consideration | LSI-VC drafting teams | Open |
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| 13 | 1.12 Threshold requirement = global estimate of the likely accuracy | Is this realistic? | Revise accordingly | LSI-VC drafting teams | Open |
| 14 | 1.13 The breakthrough requirements for an algorithm that is implemented in the processing chain suggest it should be from a peer-reviewed journal but will there be any requirement for the algorithm to be validated or to indicate its validation status? | This would be out of scope for the PFS. We have to rely on the scientific process and user feedback to drive quality. | No action | -- | -- |
| 15 | 1.14 The inclusion in the metadata of the ancillary data used in product development and its download location is very useful. We are a bit unclear about the requirement to indicate the location of the data in the metadata unless they are designed to be retrieved separately which may not be the case. Perhaps this should not be a threshold requirement. | A reasonable point. | To be considered | LSI-VC drafting teams | Closed |
| 16 | 1.17 May well be better removed as may be hard to define.Information should include location co-ordinates for data, sun angles and view angles as these all affect interpretation of the measured temperature. Information on viewing and illumination geometry is important. | Good advice | To be considered | LSI-VC drafting teams | Closed |
| 17 | Per-pixel metadata• As in the general comments above, these should really be flags or data fields. | Noted – hopefully the terminology is not a show-stopper | Revised heading to make clear that the pixel-level metadata is seen to include quality flags. | LSI-VC drafting teams | Closed |
| 18 | 2.8 Uncertainty should really be placed after the measurement 3.1 as in currently 3.3. | Noted | Consider reorganisation in Revision 2, | LSI-VC drafting teams | Open |
| 19 | 2.8 …. The threshold should be a global estimate of the uncertainty, e.g. from NEdT. However we are not clear if something else is meant here. | Agreed, 2.8 is very unclear and seems to be metadata for experts, rather than for users. | Revise this section for Target level metadata – it is not clear what is meant or if that is appropriate for non-specialist users. | LSI-VC drafting teams | Open |
| 20 | Also the breakthrough requirements for pixel uncertainty mention the atmospheric transmission but it’s not clear if this will be included on a per-pixel basis. Again we may just be confused by the fields proposed here. | Each pixel would need to be corrected for atmospheric transmission.  | As for 19. | LSI-VC drafting teams | Open |
| 21 | Radiometric corrections and Geometric correctionsThese sections could be better organised as:3. The Measurement, its Uncertainty4. CorrectionsThe measurement needs to be discussed as it sets the other fields. | Noted | For consideration in Revision 2. | LSI-VC drafting teams | Open |
| 22 | If it is surface brightness temperature then it is atmosphere corrected but not emissivity corrected so that the user can determine these themselves or use as is. However there could be a correction or an estimate for the emissivity angular effect. | Noted, comes back to the question of LST or SBT | For discussion / decision at LSI-VC-4 | LSI-VC drafting teams | Open |
| 23 | If it is LST then the assumed emissivity and the atmospheric correction (could be an implied correction depending on the LST retrieval) need to be given along with uncertainties. | Tend to agree, but would the non-specialist user need this? | Revise pixel-level metadata to identify that emissivity layers or correction factors applied may need to be included.  | LSI-VC drafting teams | Open |
| 24 | Will the measurement uncertainty be provided independently for both the surface brightness temperature and the surface temperature, in this case that the latter is the product being described in the metadata? | If both SBT and LST are provided, then each would need an uncertainty estimate. Which comes back to the earlier question of which should it be, or do we have two PFS  | For decision at LSI-VC-4 | LSI-VC drafting teams | Open |
| 25 | If surface brightness temperature is being provided for a multi-channel instrument, e.g. ASTER, then the measurement is produced per channel per pixel and the atmospheric/emissivity corrections are per channel per pixel also.Corrections would include atmosphere, emissivity, geometric depending on how they are applied. | This comes back to ‘what would be most useful to the non-specialist user?’  | For decision at LSI-VC-4 | LSI-VC  | Open |