SMOS

LEVEL 2 PROCESSOR

HIGH LEVEL REQUIREMENTS

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Version 2

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1.a	02/09/2003			
1.b	09/09/2003	all	Land and ocean separated, more specific data included as per PM request, comments by Jordi Font added	
2.a	09/10/2003	all	Comments from the SAG included (PV,JB, MB)	
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REFERENCES

1	System Requirement Document	2.1	Feb 2000
2	SMOS Proposal (COP16)		Nov 1998
3	Mission Requirement Definition	5.0	Mar 2001
4	S0-TN-CBSA-GS-0001	1.b	Mar 2003
5	Achim Hahne's FAX		27/08/2003

ACRONYMS

ASC	Ascending (pass)
CESBIO	Centre d'Etudes Spatiales de la BIOsphère
DESC	Descending (pass)
ECMWF	European Centre for Medium-range Weather Forecasting
ESA	European Space Agency
LST	Land Surface Temperature
NWC	National Weather Centres
PSU	Practical Salinity Unit
OS	Ocean salinity
Req	Required
SA	Service d'Aéronomie
SAG	Science advisory Group
SM	Soil Moisture
SMOS	Soil Moisture and Ocean Salinity Mission
SRD	System Requirement Document
SSS	Sea Surface Salinity
SST	Sea Surface Temperature
TB	Brightness temperature
TBC	To be confirmed
TBD	To Be Determined
TOA	Top Of Atmosphere
TX, TY	Polarised brightness temperature at antenna level and in antenna ref. frame
WS	Wind Speed
WSC	Wind Scatterometer

TABLE OF CONTENTS

1. INTRODUCTION

The aim of this document is to give the high level requirements for the level 2 processor.

It is based on a template and some indications given by the PM in his August 27 2003 FAX.

The document is separated into chapters related to the main types of pixels (i.e., land, water and mixed) and each chapter is divided in subsections related to the different steps of the processing.

2. HIGH LEVEL REQUIREMENTS FOR LAND

2.1 PROCESSING GRID

R-1-001-1: The processor shall process all level 1C data on a half orbit basis (Pole to pole)

R-1-001-2: the processing shall be performed on a fixed grid and TBD projection (s) at the level 1C spatial resolution

2.2 COVER CLASSIFICATION

R-1-002-1: the processor shall process differently the three main types of pixels (i.e., land, sea/water, mixed).

R-1-002-2: land surfaces shall be classified into 12 categories, namely:

1. Dry sand/deserts
2. Bare soils (i.e. barren)
3. Natural low vegetation (steppe like)
4. Cropland, temperate
5. Dense Forests
6. Moderately dense forests
7. Snow covered area
8. Marshes, swamps, wetlands
9. Rocky terrain
10. Mountains
11. Ice
12. Urban

2.3 AUXILIARY DATA

R-1-003-1: the processor shall use auxiliary data of static characteristics (TBC)

- Land sea mask (spatial resolution)
- Rivers (spatial resolution ideally 400 m, Fall back 1 km)
- Urban areas (spatial resolution of 1 km or better)

- DEM (either high resolution better than 100m over topography so as to identify the pixels to be flagged or 1 to 4 km for atmospheric corrections or first order topography flagging))
- Soil texture (FAO data set (5' x 5') ideal would be 1 km)
- Surface roughness (1 km) (TBC)

R-1-003-2 The processor shall use auxiliary data that evolve with time

• **From external sources**	**baseline**	**fall back**
Land use map (?)	med res sat classifications	Existing maps
Snow cover extent	NWC info + sat data	NWC
Freezing	SMOS data +NWC	NWC
Land surface temperature	Interpolated SAT data	NWC
Atmospheric characteristics	NWC	alt and climatology
TEC	Observatories	climatologies
Sun	Observatories	
• **From the sensor's previous passes**		
Vegetation optical thickness		n-1 pass, LAI (?)

R-1-003-3: Should any of these data sets be missing and the fall back not be available neither, the processor shall use climatology data.

R-1-003-4: all the above options shall be clearly flagged in the level 2 data

R-1-003-5: the auxiliary data shall be processed so as to be compatible with SMOS acquisition characteristics (spatial and temporal sampling/ interpolation) and whenever necessary upscaled to the fixed grid. Whenever necessary, information for each of the land classes present in the fixed grid should be retained.

2.4 PROCESSING

R-1-004-1: the processor shall then process the level 1C data as per surface type (land, sea, mixed,) as a function of the coverage (i.e. according to thresholds for the cover ratio)

R-1-004-2: soil moisture shall be retrieved with an accuracy of 4% for low vegetation cover (less than 5 Kgm-2) over fairly flat and homogeneous areas (typically US southern great plains, French Bassin Parisien etc…, no slopes higher than a few percent, no major water bodies or towns, uniform vegetation type).

R-1-004-3: depending on the quality of the retrieval the pixel shall be flagged accordingly

R-1-004-5: the output of level 2 shall be the geophysical value (SM, tau, LST) whenever available, the characteristics of the auxiliary data used and possibly the values, the fraction cover, for mixed pixels, the full set of flags, the retrieval error estimate, the average pixel characteristics…

2.5 POSSIBLE DATA SOURCES

Below are identified possible data sources for the level 2 processor over land. One should be aware that these sources are not requirements what so ever but simply hints about potential sources knowing that they do not necessarily fill the need and that they will be most probably obsolete at the time of launch for SMOS.

- **Land sea mask** (spatial resolution 1 km or better (req 400 m)
- **Rivers** (req spatial resolution of 400m or better)
- **Urban areas** (req. spatial resolution of 1 km or better)

1. For these three items, traditionally, one may either use a mask embedded in another product (land use, LAI,…) or a land water mask specifically developed from satellite data.
2. Potential sources can be found at the EDC DAAC (http://edcdaac.usgs.gov/glcc/globdoc1_2.html)
3. Another source of data is with the MODIS land DAAC and possibly with the MERIS ground segment (see below with land use maps)
4. Lakes and rivers may be obtained from the Olson classification (see same web page)

- **DEM** (either high resolution better than 100m /10m over topography so as to identify the pixels to be flagged or 1 to 4 km/100 m for atmospheric corrections or first order topography flagging))

1. The best current source for DEM is the GLOBE or GETOPO30 but many much better products are currently been assembled from different space missions (see for instance ACE, a global data set at 1 km resolution [(Berry, Pinnock et al.)], plus higher resolution data sets being assembled (SPOT, ASTER, …).

- **Soil texture** (5'X5' ideally 1 km)

2. Currently the most adequate seems to be available on http://www.ngdc.noaa.gov/seg/eco/cdroms:reynolds/reynolds/reynolds.htm. This data set gives texture and bulk density

- **Soil roughness** (req. 1 km, 0.01cm)

    1. No data has been found. Several studies [(Magagi and Kerr 2001)]-[(Magagi and Kerr 1997)] showed some potentialities over arid land , while others studied the possibilities using altimeter data. Currently thus, the best approach would be to establish a correspondence between land use and soil type and potential surface roughness.

R-1-003-2 The processor shall use auxiliary data that evolve with time

- **From external sources** **baseline** **fall back**

Land use map (?) med res sat classifications Existing maps

Req.: 1 km weekly

Land use maps are numerous and usually not adequate for our purposes as they are much detailed (17 to hundreds of classes) but it is usually straightforward to reduce the number of classes. It should also be noted that these maps often also contain information on makes rivers and urban areas. The target resolution should be 1 km. These maps should be "dynamic" but a fall back solution in case of problem could be a standard land use maps such as the one described above.

Identified sources are:

Fall back

http://edcdaac.usgs.gov/glcc/globdoc1_2.html

Corine Landcover map (CEC 1993)

Base line

Ecoclimap (Masson, Chauvin et al. 2003) this data base also includes information on soil texture and depth and monthly estimates of LAI!

Another solution would be to use products from other satellites:

http://edcdaac.usgs.gov/modis/product_set.html

http://redhook.gsfc.nasa.gov

http://modis-land.gsfc.nasa.gov/

as well as products from VEGETATION or MERIS

For vegetation optical thickness, LAI maps (after modifications eventually) could be used. Sources are always the same (MODIS DAAC, VEGETATION GS, MODIS GS etc.) see for instance http://edc.usgsμ.gov/programs/sddm/modisdist/index./html

Snow cover extent and sate NWC info + sat data NWC

Req. 1 km daily for snow cover (MODIS-MERIS), snow state and thickness (25 km (NWP)-10 cm) TBC

The base line here is to use data from weather centres such as ECMWF. The forecast could be usefully complemented with satellite data (SSM/I or AVHRR, AMSR, MODIS retrievals) as done routinely in such centres. Currently some information can be found on

http://eosdata.gsfc.nasa.gov/CAMPAIGN_DOCS/FTP_SITE/INT_DIS/readmes/smmr_snow.html
or on the ftp site:
ftp://daac.gsfc.nasa.gov/data/inter_disc/hydrology/smmr_snow
Traditionally the NSIDC is a very efficient contact point for up to date snow algorithms and data sets. The MODIS DAAC is also currently implementing snow data sets (see http://nsidc.org/PROJECTS/HDFEDS/MS2GT.

Freezing NWC NWC

Req. 1 km, time of overpass
Here the best source will most probably be obtained from weather centres.

Land surface temperature Interpolated SAT data NWC

Req.: 5-10 km, 2 K, time of overpass
Several satellites are delivering daily LST maps (knowing that the requested accuracy for SMOS is not drastic. One may think of the AVHRR but also MODIS (ftp://modis.gsfc.nadsa.gov/pub/Data_Sets/CDROM/LAND/HDF/SURFACE_TEMPERATURE/read.me) or ENVISAT AATSR (gridded surface temperature products, or average surface temperature products could be used, provided they are sufficiently validated. The main issue here might be the temporal interpolation.

Atmospheric characteristics NWC altitude and climatology

Req.: 12-25 km time of overpass
2.5 gcm2 for integrated water content, presence of rain possibly, cloud thickness and Integrated liquid water?
Over land the information is not crucial even though necessary. Weather centres should be able to deliver the information that should be added to the elevation eventually. Note that more and more satellites deliver useful information on cloud cover etc.. See for instance http://daac.gsfc.nasa.gov/MODIS/software.html and http://modis-atmos.gsfc.nasa.gov/.

Misc

The TEC is available on several servers with different accuracies. Sufficient for land retrievals
The Galactic background should probably be known as well as obviously sun and moon position and temperature at L band (Sun).

3. HIGH LEVEL REQUIREMENTS FOR OCEAN SURFACES

3.1 PROCESSING GRID

R-2-001-1: The processor shall process all level 1C data on a half orbit basis (Pole to pole)

R-2-001-2: the processing shall be performed on a fixed grid and TBD projection at the level 1C spatial resolution

3.2 COVER CLASSIFICATION

R-2-002-1: the processor shall process differently the three main types of pixels (i.e., land, sea/water, mixed)

R-2-002-2: water surfaces shall be classified into 4 categories (all necessary?)

1. salted
2. sea ice

3.3 AUXILIARY DATA

R-2-003-1: the processor shall use auxiliary data of static characteristics

- Land sea mask (300 –400 m resolution see land part)
- Islands (or High resolution Land sea Mask)
- Galactic background maps

R-2-003-2 the processor shall use auxiliary data that evolve with time

• **From external sources**	**baseline**	**fall back**
Sea surface temperature	interpolated SST	NWC Forecasts
Sea state proxy (SWH)	MWC Forecast	climatology
Roughness[1] (through WS)	NWC analysis	WSC
Wind direction (TBC)	NWC analysis	WSC
Sea ice fraction	NWC analysis	SSM/I

[1] The idea is eventually to use directly information on sea surface characteristics rather than using wind information

Clouds	NWC analysis	climatologies
Rain	NWC analysis	climatologies
TEC	Observatories	climatologies
Sun	Observatories	

- **From satellite derived information**

  Sun glint and other perturbations such as aliases (angles)

R-2-003-3 Should any of these data sets be missing and the fall back not available neither, the processor shall use climatology data.

R-2-003-4: all the above options shall be clearly flagged in the level 2 data

R-2-00 3-5: the auxiliary data shall be processed so as to be compatible with SMOS acquisition characteristics (spatial and temporal sampling/ interpolation) and whenever necessary the parameters/variable shall be computed for the fixed grid with eventually the corresponding ratios.

3.4 PROCESSING

R-2-004-1: the processor shall then process the level 1C data as per surface type (land, sea, mixed,) as a function of the coverage (i.e. according to thresholds for the cover ratio)

R-2-004-2: Sea surface salinity shall be retrieved, with an accuracy better than 1 psu for a SST of 298 K (after averaging along dwell lines and this value being the mean value obtained over the whole FOV), when WS is know with an accuracy of 1.5 m/s and SST is known with an accuracy of 1 K and when no land is within 1 pixel around the considered pixel

Otherwise the retrieval accuracy should be better than 3 psu all together [(Boutin, Waldteufel et al. 2003)].

R-2-004-3: depending on the quality of the retrieval the pixel shall be flagged accordingly

R-2-004-4: the output of level 2 shall be the geophysical value (OS) whenever available, the characteristics of the auxiliary data used and possibly the values, the fraction cover for mixed pixels, the full set of flags (including all flags present in level 1), the retrieval error estimate, the average pixel characteristics…

R-2-004-5: Pixels with rain shall be flagged.

3.5 DATA SOURCES

Identified data sources are either those depicted in 2.5 or:

Sea surface temperature: required 1K accuracy, 10 km resolution

AVHRR MODIS, ATSR SST products

See for example: http://modis-ocean.gsfc.nasa.gov or ftp://daac.gsfc.nasa.gov/data/inter_disc/surf_temp_press/ncep_sst/sst/

ECMWF fields or ghrsst-pp/uk met office

SEA State (wind speed and direction significant wave height):

Required 25 km, 1.5 m/s, 15° (all TBC)

Sources ECMWF (including the WAM model), ERS WSC or ASCAT field, windscatt data, altimeter data…

Galactic background:

Req. 1°, 1K?

Existing maps such as Reich and Reich

Clouds NWC forecasts climatologies

Req. 25 km TBC
Sources satellite (MODIS/MERIS etc see land) and NWC

Rain NWC forecasts climatologies
Req. 10 km (TBC)
Sources: NWC,

Sun Observatories
Req. XXX
Source observatories

4. MIXED PIXELS (LAND AND WATER)

R-3-001-1: Mixed pixels shall be processed using both land and sea processors.

R-3-001-2: all the above shall *a priori* apply to mixed pixels

R-3-001-3: Mixed pixels shall be treated with all the care (i.e. all the classes for each surrounding surface type.

R-3-001-4: According to thresholds TBD the mixed pixels shall be processed of discarded (flagged).

5. REFERENCES

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