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Project : **ESA CCI Phase 1 (SST)**

Title : **MMD Content Specification**

Abstract : This Technical Note contains the content specification for producing MMD files

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AMENDMENT RECORD

This document shall be amended by releasing a new edition of the document in its entirety. The Amendment Record Sheet below records the history and issue status of this document.

AMENDMENT RECORD SHEET

ISSUE	DATE	REASON FOR CHANGE
A	2 June 2011	Initial draft
B	21 June 2011	Updated with feedback from UoE and BC
C	22 July 2011	Minor updates for agreed final MMD specification
1	04 May 2012	First release

TABLE OF CONTENTS

1. INTRODUCTION

The SST_CCI project is part of the ESA Climate Change Initiative, which aims to produce and validate sea surface temperature (SST) SST essential climate variable (ECV) data products. In order to identify the best performing algorithm or combination of algorithms, the SST_CCI project is holding an open Round Robin (RR) algorithm intercomparison and product validation exercise. In support of the RR the project team will be carrying out a number of studies to improve the clear-sky masking and retrieval algorithms.

Traditional SST algorithm development has used a single sensor match-up dataset, where the retrieved SST from one satellite instrument is matched to a single in situ measurement. To support the development and validation activities in the SST_CCI project, we require a multi-sensor match-up dataset (MMD) of temporal and spatial coincidences between multiple satellite datasets and a time series of SST from an in situ sensor (such as a drifting buoy).

The MMD approach offers improved information for interpretation of the diurnal cycle and time difference between the various satellite measurements, as well as a partition of the uncertainty budget into components for individual sensors (including in situ). Each multi-sensor match-up (MM) is supplemented with auxiliary data describing estimates of the atmospheric and surface state at the time of the satellite observation.

1.1 Purpose and Scope

This document provides the specification for creating the SST_CCI MMD. It defines the inputs and the output file content and format. It also identifies which fields can be queried to produce MMD outputs.

1.2 Structure of the Document

After this introductory section, the document is divided into a number of major sections. Section 2 provides details of the dimensions of the various MMD fields. Sections 3 to 12 inclusive list each MMD variable, a brief description, field format and dimension sizes, whether the record is to be queryable, the input data source and ingestion operations

1.3 Definitions of Terms

The following terms have been used in this report with the meanings shown.

Term	**Definition**
AAI	Aerosol Absorbing Index
AN	Analysis
AMSR-E	Advanced Microwave Scanning Radiometer - EOS
ATSR	Along Track Scanning Radiometer
AVHRR	Advanced Very High Resolution Radiometer

BT	Brightness Temperature
dBT	Delta BT
dSST	Delta SST
ECMWF	European Centre for Medium Range Weather Forecasting
FC	Forecast
FFM	Fast Forward Model
GAC	Global Area Coverage
GHRSST	Group for High Resolution SST
GOME	Global Ozone Monitoring Experiment
GRIB	Gridded Binary file format
HDF	Hierarchical Data Format
METOP	Meteorological Operational Satellite
MMD	Multi-sensor Match-up Dataset
NetCDF	Network Common Data Form
NOAA	National Oceanic and Atmospheric Administration
NWP	Numerical Weather Prediction
OMI	Ozone Monitoring Instrument
SEVIRI	Spinning Enhanced Visible and Infrared Imager
SST	Sea Surface Temperature
SST_CCI	SST Climate Change Initiative
TCWV	Total Column Water Vapour
TMI	TRMM Microwave Imager
TOMS	Total Ozone Mapping Spectrometer
TRMM	Tropical Rainfall Measuring Mission

1.4 Input data

The following input datasets are required to produce MMD files.

DS1: ATSR MD files – single sensor match-ups in monthly NetCDF files

DS2: METOP MD files – single sensor match-ups in daily NetCDF files

DS3: SEVIRI MD files – single sensor match-ups in daily NetCDF files

DS4: AVHRR MD files – single sensor match-ups in monthly NetCDF files

DS5: ATSR Level 1b files – single orbit files in Envisat format

DS6: AVHRR GAC Level 1b files – single orbit files in NOAA KLM format

DS7: AMSR-E Level 2 files – single orbit files in GHRSST L2P format (NetCDF)

DS8: TMI Level 2 files – single orbit files in GHRSST L2P format (NetCDF)

DS9: Drifter files – history of drifting buoy measurements in NetCDF

DS10: Sea Ice files – daily files of sea ice concentration (one for each hemisphere) in OSI-SAF HDF and Net CDF format

DS11: TOMS-type aerosol – daily files of TOMS/GOME-1/OMI/GOME-2 aerosol absorbing index (AAI) in NetCDF

DS12: ECMWF ERA-interim reanalysis forecast and analysis fields in GRIB and NetCDF

1.5 MMD output format

The SST_CCI MMD files will be output in NetCDF format.

1.6 Match-up rules

The SST_CCI MMD shall be built using the following spatial and temporal match-up rules:

- Spatial. Each MM record shall have a central reference location using the priority of ATSR > METOP > AVHRR GAC. The centre of each additional satellite data added to the MM record shall overlap the central reference location.
- All match-ups shall use a maximum time window of 12 hours.

1.7 From concept to reality

The MMD approach described in this document uses as its basis pre-existing MD datasets for ATSR, AVHRR GAC, METOP Full Resolution Area Coverage (FRAC) and SEVIRI. The reason for using these files is that long-term archives of METOP FRAC and SEVIRI data were not available at the start of the project. A future operational system would not use the exact approach described in this document; instead it would ideally have the capability to create multi-sensor match-ups from scratch. This sub-section summarises the main differences between the two methods. We start by considering the ideal case.

As noted earlier, the traditional way of creating single sensor MDs for algorithm development and validation compares a single satellite measurement to a single in situ measurement. In this approach the in situ data are assumed to be the reference dataset and the nearest-in-space-and-time (using predefined criteria) match-up pair between the in situ measurement and the satellite dataset is selected in each case. The current predefined criterion recommended by the GHRSST ST-VAL group for satellite SST validation is that the in situ measurement should be located within the satellite pixel within 2 hours of the satellite overpass (https://www.ghrsst.org/ghrsst-science/science-team-groups/stval-wg/sses-common-principles/) based on previous work of Minnett (1991; RD.234). Validation match-up criteria is an active area of research and the limits will be reviewed prior to the product validation work which does not start until February 2014.

In developing our MMD a slightly different approach is required in that a satellite dataset is chosen as the primary reference for a particular multi-sensor match, to which all other datasets (including in situ) are matched. For the non-primary matches, the match-up rule on temporal coincidence between satellite datasets is relaxed to within 12 hours, to allow for the multiple overpass times of the various satellites. The strict criterion on spatial overlap is retained, but in this case the centre of the second satellite pixel must reside within the boundary of the first satellite pixel. This process is somewhat simplified if a priority is assigned to each satellite dataset in order to define the primary sensor.

To define the priority for each sensor we use the best available knowledge of the estimated performance of each sensor relative to each other sensor. We also need to consider the full list of sensors being evaluated within the project. The SST_CCI project will create two categories of data products:

1. A long-term record that combines the ATSR and AVHRR series

2. A short-term demonstration product that combines ATSR, METOP, SEVIRI, AMSR-E and TMI.

Within both categories the ATSR series is to be used to bias correct the other infrared sensors. Consequently in any multi-sensor match-up the ATSR will always be the primary sensor. Subsequently one would add METOP FRAC, AVHRR GAC, followed by SEVIRI and then the PMW sensors.

To support the many activities proposed within the SST_CCI the MMD will not contain information on a single satellite pixel but will contain image extracts from each sensor covering roughly the same spatial area in total. In addition, each MMD record will have an in situ history covering the match-up window where available (e.g. a drifting buoy record covering 12 hours each side of the primary satellite sensor overpass time), and will also contain auxiliary information on the atmospheric and surface state from NWP models, aerosol forecasts and sea-ice analyses.

2. DIMENSIONS

Number	Name	Size
0	matchup	Unlimited
1	callsign.length	16
2	filename.length	80
3	matchup.nwp.an.time	13
4	matchup.nwp.fc.time	25
5	matchup.nwp.ny	1
6	matchup.nwp.nx	1
7	metop.ny	11
8	metop.nx	11
9	metop.nwp.nz	60
10	metop.nwp.ny	1
11	metop.nwp.nx	1
12	seviri.ny	3
13	seviri.nx	3
14	atsr.ny	11
15	atsr.nx	11
16	atsr.nwp.nz	60
17	atsr.nwp.ny	1
18	atsr.nwp.nx	1
19	avhrr.ny	5
20	avhrr.nx	3
21	avhrr.nwp.nz	60
22	avhrr.nwp.ny	1
23	avhrr.nwp.nx	1
24	amsre.ny	1
25	amsre.nx	1
26	tmi.ny	1
27	tmi.nx	1
28	seaice.ny	1
29	seaice.nx	1
30	aai.ny	1
31	aai.nx	1
32	insitu.time	48

Table 1: Dimensions of data to be stored in MMS

3. MATCH-UP CENTRE PIXEL

Variable	Contains	Format	Dimensions	Query	Where to find	Notes
matchup.id	Unique ID for each match-up in the MMS	Long	0	Yes	Create on ingestion	**Ingestion operation [1]**
matchup.time	Time for primary match-up location	Long	0	Yes	ATSR MD file: atsr.time METOP_MD file: msr_time & dtime SEVIRI_MD file: msr_time & dtime	Only include for primary sensor. ATSR time in MD file is in Julian time. Time is provided for each row of METOP and SEVIRI extracts as a delta (dtime) from the time of the insitu measurement (msr_time); the time of the in situ measurement in the MD files is stored as seconds from 01/01/1981 00:00:00, which needs to be changed to the SST_CCI Epoch. **Ingestion operation [2]**
matchup.latitude	Latitude for primary match-up location	Float	0	Yes	ATSR MD file: atsr.latitude METOP_MD file: lat[10,10] SEVIRI_MD file: lat[2,2]	Only include for primary sensor ATSR stored as float METOP and SEVIRI stored as scaled short **Ingestion operation [3]**
matchup.longitude	Longitude for primary match-up location	Float	0	Yes	ATSR MD file: atsr.longitude METOP_MD file: lon[10,10] SEVIRI_MD file: lon[2,2]	Only include for primary sensor ATSR stored as float METOP and SEVIRI stored as scaled short **Ingestion operation [3]**

matchup.insitu_callsign	In situ callsign for primary match-up	String	1, 0	Yes Any field value	ATSR MD file insitu.callsign METOP_MD file msr_id SEVIRI_MD file msr_id	Only include for primary sensor Gives WMO ID of in situ measurement
matchup.insitu_dataset	In situ data type for primary match-up	Byte	0	Yes Select single or multiple	ATSR MD file: insitu.dataset METOP_MD file: msr_type SEVIRI_MD file: msr_type	Only include for primary sensor For ATSR: 0 = drifter 1 = mooring (non-GTMBA) 2 = ship 3 = GTMBA 4 = radiometer 5 = Argo 6 = dummy sea-ice 7 = dummy diurnal variability For METOP & SEVIRI: 0 = moored 1 = drifter 2 = ship **Ingestion operation [4]**
matchup.reference_flag	Flag to indicate if match-up contains reference data	Byte	0	Yes Select single or multiple		Only include for primary sensor 0 = Training 1 = Test 2 = Selection 3 = Validation 4 = Undefined 5 = Duplicate **Created by UoL**
matchup.valid	Flag to indicate if match-up is valid or invalid	Byte	0	Yes Select single or multiple	Create on ingestion	0 = valid 1 = invalid **Ingestion operation [5]**

matchup.primary_sensor	Flag to indicates ID of primary match-up sensor	Byte	0	Yes Select single or multiple	Create on ingestion	Only include for primary sensor 0 = ATSR_MD 1 = METOP_MD 2 = SEVIRI_MD 3 = AVHRR_MD **Ingestion operation [6]**
matchup.primary_filename	Name of MD file providing primary reference	Char	2,0	No	Create on ingestion	Only include for primary sensor **Ingestion operation [7]**
matchup.primary_md_record_number	MD file record number of primary reference	Long	0	No	Create on ingestion	**Ingestion operation [7]**
matchup.sensor_list	List of sensors included in MMS record	Long	0	Yes Select single or multiple	Create on ingestion	Bit 0 = ATSR_MD Bit 1 = METOP_MD Bit 2 = SEVIRI_MD Bit 3 = ATSR-1 Bit 4 = ATSR-2 Bit 5 = ATSR-3 (AATSR) Bit 6 = NOAA-TN (TIROS-N) Bit 7 = NOAA-6 (NOAA-A) Bit 8 = NOAA-7 (NOAA-C) Bit 9 = NOAA-8 (NOAA-E) Bit 10 = NOAA-9 (NOAA-F) Bit 11 = NOAA-10 (NOAA-G) Bit 12 = NOAA-11 (NOAA-H) Bit 13 = NOAA-12 (NOAA-D) Bit 14 = NOAA-13 (NOAA-I) Bit 15 = NOAA-14 (NOAA-J) Bit 16 = NOAA-15 (NOAA-K) Bit 17 = NOAA-16 (NOAA-L) Bit 18 = NOAA-17 (NOAA-M) Bit 19 = NOAA-18 (NOAA-N) Bit 20 = NOAA-19 (NOAA-P) Bit 21 = METOP-A (METOP-2) Bit 22 = AMSR-E Bit 23 = TMI In future add new sensors to end of current list; 4-bytes allows for 32 unique 'sensors' for demonstration system. **Ingestion operation [8]**

matchup.nwp.an.sea_ice_fraction	ECMWF ERA-interim sea-ice concentration interpolated to match-up location keeping synoptic time	Float	0,3,5,6	No	GGAS CI	Interpolation to NWP coordinates using CDO tools
matchup.nwp.an.sea_surface_temperature	ECMWF ERA-interim sea surface temperature interpolated to match-up location keeping synoptic time	Float	0,3,5,6	No	GGAS SSTK	Interpolation to NWP coordinates using CDO tools
matchup.nwp.an.10m_east_wind_component	ECMWF ERA-interim 10 m east wind component interpolated to match-up location keeping synoptic time	Float	0,3,5,6	No	GGAS U10	Interpolation to NWP coordinates using CDO tools
matchup.nwp.an. 10m_north_wind_component	ECMWF ERA-interim 10 m north wind component interpolated to match-up location keeping synoptic time	Float	0,3,5,6	No	GGAS V10	Interpolation to NWP coordinates using CDO tools
matchup.nwp.fc.sea_surface_temperature	ECMWF ERA-interim sea surface temperature interpolated to match-up location keeping synoptic time	Float	0,4,5,6	No	GGFS SSTK	Interpolation to NWP coordinates using CDO tools
matchup.nwp.fc.surface_sensible_heat_flux	ECMWF ERA-interim surface sensible heat flux interpolated to match-up location keeping synoptic time	Float	0,4,5,6	No	GAFS SSHF	Interpolation to NWP coordinates using CDO tools
matchup.nwp.fc.surface_latent_heat_flux	ECMWF ERA-interim surface latent heat flux interpolated to match-up location keeping synoptic time	Float	0,4,5,6	No	GAFS SLHF	Interpolation to NWP coordinates using CDO tools
matchup.nwp.fc.mean_sea_level_pressure	ECMWF ERA-interim mean sea level pressure interpolated to match-up location keeping synoptic time	Float	0,4,5,6	No	GGFS MSL	Interpolation to NWP coordinates using CDO tools

matchup.nwp.fc.boundary_layer_height	ECMWF ERA-interim boundary layer height interpolated to match-up location keeping synoptic time	Float	0,4,5,6	No	GGFS BLH	Interpolation to NWP coordinates using CDO tools
matchup.nwp.fc.10m_east_wind_component	ECMWF ERA-interim 10 m east wind component interpolated to match-up location keeping synoptic time	Float	0,4,5,6	No	GGFS U10	Interpolation to NWP coordinates using CDO tools
matchup.nwp.fc.10m_north_wind_component	ECMWF ERA-interim 10 m north wind component interpolated to match-up location keeping synoptic time	Float	0,4,5,6	No	GGFS V10	Interpolation to NWP coordinates using CDO tools
matchup.nwp.fc.2m_temperature	ECMWF ERA-interim 2 m temperature interpolated to match-up location keeping synoptic time	Float	0,4,5,6	No	GGFS T2	Interpolation to NWP coordinates using CDO tools
matchup.nwp.fc.2m_dew_point	ECMWF ERA-interim 2 m dew point interpolated to match-up location keeping synoptic time	Float	0,4,5,6	No	GGFS D2	Interpolation to NWP coordinates using CDO tools
matchup.nwp.fc.downward_surface_solar_radiation	ECMWF ERA-interim downward surface solar radiation interpolated to match-up location keeping synoptic time	Float	0,4,5,6	No	GAFS SSRD	Interpolation to NWP coordinates using CDO tools
matchup.nwp.fc. downward_surface_thermal_radiation	ECMWF ERA-interim downward surface thermal radiation interpolated to match-up location keeping synoptic time	Float	0,4,5,6	No	GAFS STRD	Interpolation to NWP coordinates using CDO tools
matchup.nwp.fc.surface_solar_radiation	ECMWF ERA-interim surface solar radiation interpolated to match-up location keeping synoptic time	Float	0,4,5,6	No	GAFS SSR	Interpolation to NWP coordinates using CDO tools

matchup.nwp.fc.surface_thermal_radiation	ECMWF ERA-interim surface thermal radiation interpolated to match-up location keeping synoptic time	Float	0,4,5,6	No	GAFS STR	Interpolation to NWP coordinates using CDO tools
matchup.nwp.fc.turbulent_stress_east_component	ECMWF ERA-interim turbulent stress east interpolated to match-up location keeping synoptic time	Float	0,4,5,6	No	GAFS EWSS	Interpolation to NWP coordinates using CDO tools
matchup.nwp.fc. turbulent_stress_north_component	ECMWF ERA-interim turbulent stress north interpolated to match-up location keeping synoptic time	Float	0,4,5,6	No	GAFS NSSS	Interpolation to NWP coordinates using CDO tools
matchup.nwp.fc.evaporation	ECMWF ERA-interim evaporation interpolated to match-up location keeping synoptic time	Float	0,4,5,6	No	GAFS E	Interpolation to NWP coordinates using CDO tools
matchup.nwp.fc.total_precipitation	ECMWF ERA-interim total precipitation interpolated to match-up location keeping synoptic time	Float	0,4,5,6	No	GAFS TP	Interpolation to NWP coordinates using CDO tools

3.1 Note on match-up NWP fields

1. For the match-up, the NWP analysis and forecast fields are to be interpolated spatially to the match-up location defined by matchup.longitude and matchup.latitude but not in time.

2. For the time dimension the following rule shall be used to keep the model synoptic time:

   - For forecast (FC) fields: Find t0 equal to the nearest forecast time (every 3 hours) to matchup.time, and then select forecast fields from (t0 – 48 hr.) to (t0 + 24 hr.), which is 25 samples at 3 hr. resolution.

   - For analysis (AN) fields: Find t0 equal to the nearest analysis time (every 6 hours) to matchup.time, and then select analysis fields from (t0 – 48 hr.) to (t0 + 24 hr.), which is 13 samples at 6 hr. resolution

4. METOP_MD

Variable	Contains	Format	Dimensions	Query	Where to find	Note
metop.time	Time of observation at centre of METOP extract in seconds from SST_CCI Epoch	Long	0	No	METOP_MD file msr_time & dtime	Time is provided for each row of METOP extract as a delta (dtime) from the primary time of the insitu measurement (msr_time) **Ingestion operation [2]**
metop.dtime	Time of each METOP image extract row as milliseconds from metop.time	Short	0,7	No	METOP_MD file msr_time & dtime	Time is provided for each row of METOP extract as a delta (dtime) from the primary time of the insitu measurement (msr_time) **Ingestion operation [2]**
metop.longitude	Longitude of METOP image extract	Float	0,7,8	No	METOP_MD file lon	
metop.latitude	Latitude of METOP image extract	Float	0,7,8	No	METOP_MD file lat	
metop.reflectance_006	0.6 micron percent reflectance of METOP image extract	Short	0,7,8	No	METOP_MD file VIS006	
metop.reflectance_009	0.9 micron percent reflectance of METOP image extract	Short	0,7,8	No	METOP_MD file VIS009	
metop.reflectance_016	1.6 micron percent reflectance of METOP image extract	Short	0,7,8	No	METOP_MD file VIS012 **Note: Field is stored in MD file as 1.2 micron, which is incorrect**	
metop.brightness_temperature_037	3.7 micron BT of METOP image extract	Short	0,7,8	No	METOP_MD file IR037	

Variable	Contains	Format	Dimensions	Query	Where to find	Note
metop.brightness_temperature_108	10.8 micron BT of METOP image extract	Short	0,7,8	No	METOP_MD file IR108	
metop.brightness_temperature_120	12.0 micron BT of METOP image extract	Short	0,7,8	No	METOP_MD file IR120	
metop.solar_zenith_angle	Solar zenith angles of METOP image extract	Short	0,7,8	No	METOP_MD file solzen	
metop.satellite_zenith_angle	Satellite zenith angles of METOP image extract	Short	0,7,8	No	METOP_MD file satzen	
metop.relative_azimuth_angle	Relative azimuth angles of METOP image extract	Short	0,7,8	No	METOP_MD file relazi	
metop.sea_surface_temperature	Sea surface temperature of METOP image extract	Short	0,7,8	No	METOP_MD file sst	
metop.sst_confidence_level	Confidence Level of METOP image extract	Byte	0,7,8	No	METOP_MD file sst_confidence_level	
metop.sst_mask_indicator	Classification mask for METOP image extract	Byte	0,7,8	No	METOP_MD file sst_mask_indicator	
metop.sst_missing_reason	Indication of reason for missing SST in METOP image extract	Byte	0,7,8	No	METOP_MD file sst_missing_season	
metop.aerosol_optical_depth	Estimate of aerosol optical depth for METOP image extract	Short	0,7,8	No	METOP_MD file x_aod	
metop.saharan_dust_index	Estimate of SEVIEI Saharan dust index for METOP image extract	Short	0,7,8	No	METOP_MD file x_sdi	

Variable	Contains	Format	Dimensions	Query	Where to find	Note
metop.sea_ice_concentration	Estimate of sea-ice concentration for METOP image extract	Byte	0,7,8	No	METOP_MD file x_ice_conc	
metop.land_sea_mask	Land/sea mask for METOP extract	Byte	0,7,8	No		**Ingestion operation [9]**
metop.l1b_filename	Source (metagranule) filename	Char	2,0	No	METOP_MD file box_filename	
metop.matchup.elem	Match-up across-track position in source file	Short	0	No		
metop.matchup.line	Match-up along-track position in source file	Short	0	No		
metop.md_filename	Filename of parent METOP_MD file	Char	2,0	No	METOP_MD file	
metop.md_record_number	Record ID from parent METOP_MD file	Long	0	No	METOP_MD file	

4.1 Note on METOP_MD NWP fields

NWP single level and model level analysis fields are to be interpolated spatially and temporally to the coordinates and time defining the centre of the METOP extract

5. SEVIRI_MD

Variable	**Contains**	**Format**	**Dimensions**	**Query**	**Where to find**	**Note**
seviri.time	Time of observation at centre of SEVIRI image extract in seconds from SST_CCI Epoch	Long	0	No	SEVIRI _MD file msr_time & dtime	Time is provided for each row of SEVIRI extract as a delta (dtime) from the primary time of the insitu measurement (msr_time) **Ingestion operation [2]**
seviri.dtime	Time of each SEVIRI image extract row as milliseconds from seviri.time	Short	0,12	No	SEVIRI_MD file msr_time & dtime	Time is provided for each row of SEVIRI extract as a delta (dtime) from the primary time of the insitu measurement (msr_time) **Ingestion operation [2]**
seviri.latitude	Latitude of SEVIRI image extract	Float	0,12,13	No	SEVIRI _MD file lat	
seviri.longitude	Longitude of SEVIRI image extract	Float	0,12,13	No	SEVIRI _MD file lon	
seviri.reflectance_006	0.6 micron reflectance factor of SEVIRI image extract	Short	0,12,13	No	SEVIRI _MD file VIS006	
seviri.reflectance_008	0.8 micron reflectance factor of SEVIRI image extract	Short	0,12,13	No	SEVIRI _MD file VIS008	
seviri.reflectance_016	1.6 micron reflectance factor of SEVIRI image extract	Short	0,12,13	No	SEVIRI _MD file IR_016	
seviri.brightness_temperature_039	3.9 micron BT of SEVIRI image extract	Short	0,12,13	No	SEVIRI _MD file IR_039	
seviri.brightness_temperature_087	8.7 micron BT of SEVIRI image extract	Short	0,12,13	No	SEVIRI _MD file IR_087	

Variable	Contains	Format	Dimensions	Query	Where to find	Note
seviri.brightness_temperature_097	9.7 micron BT of SEVIRI image extract	Short	0,12,13	No	SEVIRI _MD file IR_097	
seviri.brightness_temperature_108	10.8 micron BT of SEVIRI image extract	Short	0,12,13	No	SEVIRI _MD file IR_108	
seviri.brightness_temperature_120	12.0 micron BT of SEVIRI image extract	Short	0,12,13	No	SEVIRI _MD file IR_120	
seviri.brightness_temperature_134	13.4 micron BT of SEVIRI image extract	Short	0,12,13	No	SEVIRI _MD file IR_134	
seviri.solar_zenith_angle	Solar zenith angles of SEVIRI image extract	Short	0,12,13	No	SEVIRI _MD file solzen	
seviri.satellite_zenith_angle	Satellite zenith angles of SEVIRI image extract	Short	0,12,13	No	SEVIRI _MD file satzen	
seviri.relative_azimuth_angle	Relative azimuth angles of SEVIRI image extract	Short	0,12,13	No	SEVIRI _MD file relazi	
seviri.sea_surface_temperature	Sea surface temperature of SEVIRI image extract	Short	0,12,13	No	SEVIRI_MD file sst	
seviri.sst_confidence_level	Confidence Level of SEVIRI image extract	Short	0,12,13	No	SEVIRI_MD file sst_confidence_level	
seviri.sst_mask_indicator	Classification mask for SEVIRI image extract	Short	0,12,13	No	SEVIRI_MD file sst_mask_indicator	
seviri.sst_missing_reason	Indication of reason for missing SST in SEVIRI image extract	Short	0,12,13	No	SEVIRI_MD file sst_missing_season	

Variable	Contains	Format	Dimensions	Query	Where to find	Note
seviri.aerosol_optical_depth	Estimate of aerosol optical depth for SEVIRI image extract	Short	0,12,13	No	SEVIRI_MD file x_aod	
seviri.saharan_dust_index	Estimate of Saharan dust index for SEVIRI image extract	Short	0,12,13	No	SEVIRI_MD file x_sdi	
seviri.land_sea_mask	Land/sea mask for SEVIRI extract	Byte	0,12,13	No		**Ingestion operation [9]**
seviri.prd_filename	Source PRD filename	Char	2,0	No	SEVIRI_MD file box_prd_filename	
seviri.sat_filename	Source SAT filename	Char	2,0	No	SEVIRI_MD file box_sat_filename	
seviri.matchup.elem	Match-up across-track position in source file	Short	0	No		
seviri.matchup.line	Match-up along-track position in source file	Short	0	No		
seviri.md_filename	Filename of parent SEVIRI_MD file	Char	2,0	No	SEVIRI_MD file	
seviri.md_record_number	Record ID from parent SEVIRI_MD file	Long	0	No	SEVIRI_MD file	

6. ATSR LEVEL 1B

Variable	Contains	Format	Dimensions	Query	Where to find	Note
atsr.<sen_id>.time	Time of observation at centre of ATSR extract in seconds from SST_CCI Epoch	Long	0	No	ATS_TOA_1P file AT2_TOA_1P file AT1_TOA_1P file	Time in ATSR file stored in modified Julian date format. **Ingestion operation [2]**
atsr.<sen_id>.dtime	Time of each ATSR image extract row as milliseconds from atsr.<sen_id>.time	Short	0,14	No	ATS_TOA_1P file AT2_TOA_1P file AT1_TOA_1P file	Time in ATSR file stored in modified Julian date format. **Ingestion operation [2]**
atsr.<sen_id>.latitude	Latitudes of ATSR image extract	Short	0,14,15	No	ATS_TOA_1P file AT2_TOA_1P file AT1_TOA_1P file	
atsr.<sen_id>.longitude	Longitudes of ATSR image extract	Short	0,14,15	No	ATS_TOA_1P file AT2_TOA_1P file AT1_TOA_1P file	
atsr.<sen_id>.reflectance_55_nadir	Nadir view 0.55 micron reflectance for ATSR image extract	Short	0,14,15	No	ATS_TOA_1P file AT2_TOA_1P file AT1_TOA_1P file	**Ingestion operation [10]**
atsr.<sen_id>.reflectance_55_forward	Forward view 0.55 micron reflectance for ATSR image extract	Short	0,14,15	No	ATS_TOA_1P file AT2_TOA_1P file AT1_TOA_1P file	**Ingestion operation [10]**
atsr.<sen_id>.reflectance_66_nadir	Nadir view 0.66 micron reflectance for ATSR image extract	Short	0,14,15	No	ATS_TOA_1P file AT2_TOA_1P file AT1_TOA_1P file	**Ingestion operation [10]**
atsr.<sen_id>.reflectance_66_forward	Forward view 0.66 micron reflectance for ATSR image extract	Short	0,14,15	No	ATS_TOA_1P file AT2_TOA_1P file AT1_TOA_1P file	**Ingestion operation [10]**
atsr.<sen_id>.reflectance_87_nadir	Nadir view 0.87 micron reflectance for ATSR image extract	Short	0,14,15	No	ATS_TOA_1P file AT2_TOA_1P file AT1_TOA_1P file	**Ingestion operation [10]**
atsr.<sen_id>.reflectance_87_forward	Forward view 0.87 micron reflectance for ATSR image extract	Short	0,14,15	No	ATS_TOA_1P file AT2_TOA_1P file AT1_TOA_1P file	**Ingestion operation [10]**

Variable	Contains	Format	Dimensions	Query	Where to find	Note
atsr.<sen_id>.reflectance_16_nadir	Nadir view 1.6 micron reflectance for ATSR image extract	Short	0,14,15	No	ATS_TOA_1P file AT2_TOA_1P file AT1_TOA_1P file	**Ingestion operation [10]**
atsr.<sen_id>.reflectance_16_forward	Forward view 1.6 micron reflectance for ATSR image extract	Short	0,14,15	No	ATS_TOA_1P file AT2_TOA_1P file AT1_TOA_1P file	**Ingestion operation [10]**
atsr.<sen_id>.brightness_temperature_37_nadir	Nadir view 3.7 micron reflectance for ATSR image extract	Short	0,14,15	No	ATS_TOA_1P file AT2_TOA_1P file AT1_TOA_1P file	**Ingestion operation [10]**
atsr.<sen_id>.brightness_temperature_37_forward	Forward view 3.7 micron reflectance for ATSR image extract	Short	0,14,15	No	ATS_TOA_1P file AT2_TOA_1P file AT1_TOA_1P file	**Ingestion operation [10]**
atsr.<sen_id>.brightness_temperature_11_nadir	Nadir view 10.8 micron reflectance for ATSR image extract	Short	0,14,15	No	ATS_TOA_1P file AT2_TOA_1P file AT1_TOA_1P file	**Ingestion operation [10]**
atsr.<sen_id>.brightness_temperature_11_forward	Forward view 10.8 micron reflectance for ATSR image extract	Short	0,14,15	No	ATS_TOA_1P file AT2_TOA_1P file AT1_TOA_1P file	**Ingestion operation [10]**
atsr.<sen_id>.brightness_temperature_12_nadir	Nadir view 12.0 micron reflectance for ATSR image extract	Short	0,14,15	No	ATS_TOA_1P file AT2_TOA_1P file AT1_TOA_1P file	**Ingestion operation [10]** **Ingestion operation [11]**
atsr.<sen_id>.brightness_temperature_12_forward	Forward view 12.0 micron reflectance for ATSR image extract	Short	0,14,15	No	ATS_TOA_1P file AT2_TOA_1P file AT1_TOA_1P file	**Ingestion operation [10]** **Ingestion operation [11]**
atsr.<sen_id>.detector_tempertaure_12	12 micron channel detector temperature	Short	0	No	Detector T file	**Ingestion operation [12]** **Only required for ATSR-1**
atsr.<sen_id>.confidence_word_nadir	Nadir view confidence word for ATSR image extract	Short	0,14,15	No	ATS_TOA_1P file AT2_TOA_1P file AT1_TOA_1P file	**Ingestion operation [10]**
atsr.<sen_id>.confidence_word_forward	Forward view confidence word for ATSR image extract	Short	0,14,15	No	ATS_TOA_1P file AT2_TOA_1P file AT1_TOA_1P file	**Ingestion operation [10]**

Variable	Contains	Format	Dimensions	Query	Where to find	Note
atsr.<sen_id>.cloud_flags_nadir	Nadir view cloud flags for ATSR image extract	Short	0,14,15	No	ATS_TOA_1P file AT2_TOA_1P file AT1_TOA_1P file	**Ingestion operation [10]**
atsr.<sen_id>.cloud_flags_forward	Forward view cloud flags for ATSR image extract	Short	0,14,15	No	ATS_TOA_1P file AT2_TOA_1P file AT1_TOA_1P file	**Ingestion operation [10]**
atsr.<sen_id>.solar_zenith_angle_nadir	Nadir view solar zenith angles of ATSR image extract	Short	0,14,15	No	ATS_TOA_1P file AT2_TOA_1P file AT1_TOA_1P file	**Ingestion operation [13]**
atsr.<sen_id>.solar_zenith_angle_forward	Forward view solar zenith angles of ATSR image extract	Short	0,14,15	No	ATS_TOA_1P file AT2_TOA_1P file AT1_TOA_1P file	**Ingestion operation [13]**
atsr.<sen_id>.satellite_zenith_angle_nadir	Nadir view satellite zenith angles of ATSR image extract	Short	0,14,15	No	ATS_TOA_1P file AT2_TOA_1P file AT1_TOA_1P file	**Ingestion operation [13]**
atsr.<sen_id>.satellite_zenith_angle_forward	Forward view satellite zenith angles of ATSR image extract	Short	0,14,15	No	ATS_TOA_1P file AT2_TOA_1P file AT1_TOA_1P file	**Ingestion operation [13]**
atsr.<sen_id>.solar._azimuth_angle_nadir	Nadir view solar azimuth angles of ATSR image extract	Short	0,14,15	No	ATS_TOA_1P file AT2_TOA_1P file AT1_TOA_1P file	
atsr.<sen_id>.solar_azimuth_angle_forward	Forward view solar azimuth angles of ATSR image extract	Short	0,14,15	No	ATS_TOA_1P file AT2_TOA_1P file AT1_TOA_1P file	
atsr.<sen_id>.satellite_azimuth_angle_nadir	Nadir view solar azimuth angles of ATSR image extract	Short	0,14,15	No	ATS_TOA_1P file AT2_TOA_1P file AT1_TOA_1P file	
atsr.<sen_id>.satellite_azimuth_angle_forward	Forward view solar azimuth angles of ATSR image extract	Short	0,14,15	No	ATS_TOA_1P file AT2_TOA_1P file AT1_TOA_1P file	
atsr.<sen_id>.l1b_filename	Source ATSR Level 1b filename	Char	2,0	No	ATS_TOA_1P file AT2_TOA_1P file AT1_TOA_1P file	

Variable	Contains	Format	Dimensions	Query	Where to find	Note
atsr.<sen_id>.VC1_filename	Source ATSR visible channel calibration filename	Char	2,0	No	ATS_TOA_1P file AT2_TOA_1P file AT1_TOA_1P file	
atsr.<sen_id>.GC1_filename	Source ATSR general calibration filename	Char	2,0	No	ATS_TOA_1P file AT2_TOA_1P file AT1_TOA_1P file	
atsr.<sen_id>.matchup.elem	Match-up across-track position in source file	Short	0	No	ATS_TOA_1P file AT2_TOA_1P file AT1_TOA_1P file	
atsr.<sen_id>.matchup.line	Match-up along-track position in source file	Long	0	No	ATS_TOA_1P file AT2_TOA_1P file AT1_TOA_1P file	
atsr.<sen_id>.land_sea_mask	Land/sea mask for ATSR image extract	Byte	0,14,15	No		**Ingestion operation [9]**
atsr.<sen_id>. nwp.sea_ice_fraction	ECMWF ERA-interim sea ice fraction interpolated to image extract	Float	0,17,18	No	ECMWF files GGAS CI	Interpolation to NWP coordinates using CDO tools
atsr.<sen_id>.nwp.snow_albedo	ECMWF ERA-interim snow albedo interpolated to image extract	Float	0,17,18	No	ECMWF files GGAS ASN	Interpolation to NWP coordinates using CDO tools
atsr.<sen_id>.nwp.sea_surface_temperature	ECMWF ERA-interim sea surface temperature interpolated to image extract	Float	0,17,18	No	ECMWF files GGAS SSTK	Interpolation to NWP coordinates using CDO tools
atsr.<sen_id>.nwp.total_column_water_vapour	ECMWF ERA-interim total column water vapour interpolated to image extract	Float	0,17,18	No	ECMWF files GGAS TCWV	Interpolation to NWP coordinates using CDO tools
atsr.<sen_id>.nwp.mean_sea_level_pressure	ECMWF ERA-interim surface pressure interpolated to image extract	Float	0,17,18	No	ECMWF files GGAS MSL	Interpolation to NWP coordinates using CDO tools
atsr.<sen_id>.nwp.total_cloud_cover	ECMWF ERA-interim total cloud cover interpolated to image extract	Float	0,17,18	No	ECMWF files GGAS TCC	Interpolation to NWP coordinates using CDO tools

Variable	Contains	Format	Dimensions	Query	Where to find	Note
atsr.<sen_id>.nwp.10m_east_wind_component	ECMWF ERA-interim 10 m wind speed east component interpolated to image extract	Float	0,17,18	No	ECMWF files GGAS U10	Interpolation to NWP coordinates using CDO tools
atsr.<sen_id>.nwp.10m_north_wind_component	ECMWF ERA-interim 10 m wind speed north component interpolated to image extract	Float	0,17,18	No	ECMWF files GGAS V10	Interpolation to NWP coordinates using CDO tools
atsr.<sen_id>.nwp.2m_temperature	ECMWF ERA-interim 2m temperature interpolated to image extract	Float	0,17,18	No	ECMWF files GGAS T2	Interpolation to NWP coordinates using CDO tools
atsr.<sen_id>.nwp.2m_dew_point	ECMWF ERA-interim 2m dew point interpolated to image extract	Float	0,17,18	No	ECMWF files GGAS D2	Interpolation to NWP coordinates using CDO tools
atsr.<sen_id>.nwp.albedo	ECMWF ERA-interim albedo interpolated to image extract	Float	0,17,18	No	ECMWF files GGAS AL	Interpolation to NWP coordinates using CDO tools
atsr.<sen_id>.nwp.skin_temperature	ECMWF ERA-interim skin temperature speed interpolated to image extract	Float	0,17,18	No	ECMWF files GGAS SKT	Interpolation to NWP coordinates using CDO tools
atsr.<sen_id>.nwp.log_surface_pressure	ECMWF ERA-interim log surface pressure interpolated to image extract	Float	0,17,18	No	ECMWF files SPAM LNSP	Interpolation to NWP coordinates using CDO tools
atsr.<sen_id>.nwp.temperature_profile	ECMWF ERA-interim temperature profile interpolated to image extract	Float	0,16,17,18	No	ECMWF files SPAM T	Interpolation to NWP coordinates using CDO tools
atsr.<sen_id>.nwp.water_vapour_profile	ECMWF ERA-interim water vapour profile interpolated to image extract	Float	0,16,17,18	No	ECMWF files GGAM Q	Interpolation to NWP coordinates using CDO tools
atsr.<sen_id>.nwp.ozone_profile	ECMWF ERA-interim ozone profile interpolated to image extract	Float	0,16,17,18	No	ECMWF files GGAM O3	Interpolation to NWP coordinates using CDO tools
atsr.<sen_id>.cloud_mask_bayes_max_nadir	ATSR nadir view Bayesian maximum channel cloud mask for image extract	Short	0,14,15	No	Output from ARC3 processor	

Variable	Contains	Format	Dimensions	Query	Where to find	Note
atsr.<sen_id>.cloud_mask_bayes_max_dual	ATSR dual view Bayesian maximum channel cloud mask for image extract	Short	0,14,15	No	Output from ARC3 processor	
atsr.<sen_id>.cloud_mask_bayes_min_nadir	ATSR nadir view Bayesian minimum channel cloud mask for image extract	Short	0,14,15	No	Output from ARC3 processor	
atsr.<sen_id>.cloud_mask_bayes_min_dual	ATSR dual view Bayesian minimum channel cloud mask for image extract	Short	0,14,15	No	Output from ARC3 processor	
atsr.<sen_id>.saharan_dust_index_2	ATSR Saharan Dust Index (SDI) mask from 2-channel algorithm	Short	0,14,15	No	Output from ARC3 processor	
atsr.<sen_id>.saharan_dust_index_3	ATSR Saharan Dust Index (SDI) mask from 3-channel algorithm	Short	0,14,15	No	Output from ARC3 processor	
atsr.<sen_id>.ffm.brightness_temperature_37_nadir	RTTOV modelled nadir 3.7 BT	Float	0, 17, 18	No	Output from ARC3 processor	Scale as per channel BT
atsr.<sen_id>.ffm.brightness_temperature_37_forward	RTTOV modelled forward 3.7 BT	Float	0, 17, 18	No	Output from ARC3 processor	Scale as per channel BT
atsr.<sen_id>.ffm.brightness_temperature_11_nadir	RTTOV modelled nadir 11 BT	Float	0, 17, 18	No	Output from ARC3 processor	Scale as per channel BT
atsr.<sen_id>.ffm.brightness_temperature_11_forward	RTTOV modelled forward 11 BT	Float	0, 17, 18	No	Output from ARC3 processor	Scale as per channel BT
atsr.<sen_id>.ffm.brightness_temperature_12_nadir	RTTOV modelled nadir 12 BT	Float	0, 17, 18	No	Output from ARC3 processor	Scale as per channel BT
atsr.<sen_id>.ffm.brightness_temperature_12_forward	RTTOV modelled forward 12 BT	Float	0, 17, 18	No	Output from ARC3 processor	Scale as per channel BT

Variable	Contains	Format	Dimensions	Query	Where to find	Note
atsr.<sen_id>.ffm.dbt_dsst_37_nadir	RTTOV nadir 3.7 BT tangent linear w.r.t SST	Float	0, 17, 18	No	Output from ARC3 processor	
atsr.<sen_id>.ffm.dbt_dsst_37_forward	RTTOV forward 3.7 BT tangent linear w.r.t SST	Float	0, 17, 18	No	Output from ARC3 processor	
atsr.<sen_id>.ffm.dbt_dsst_11_nadir	RTTOV nadir 11 BT tangent linear w.r.t SST	Float	0, 17, 18	No	Output from ARC3 processor	
atsr.<sen_id>.ffm.dbt_dsst_11_forward	RTTOV forward 11 BT tangent linear w.r.t SST	Float	0, 17, 18	No	Output from ARC3 processor	
atsr.<sen_id>.ffm.dbt_dsst_12_nadir	RTTOV nadir 12 BT tangent linear w.r.t SST	Float	0, 17, 18	No	Output from ARC3 processor	
atsr.<sen_id>.ffm.dbt_dsst_12_forward	RTTOV forward 12 BT tangent linear w.r.t SST	Float	0, 17, 18	No	Output from ARC3 processor	
atsr.<sen_id>.ffm.dbt_dtcwv_37_nadir	RTTOV nadir 3.7 BT tangent linear w.r.t TCWV	Float	0, 17, 18	No	Output from ARC3 processor	
atsr.<sen_id>.ffm.dbt_dtcwv_37_nadir	RTTOV forward 3.7 BT tangent linear w.r.t TCWV	Float	0, 17, 18	No	Output from ARC3 processor	
atsr.<sen_id>.ffm.dbt_dtcwv_11_nadir	RTTOV nadir 11 BT tangent linear w.r.t TCWV	Float	0, 17, 18	No	Output from ARC3 processor	
atsr.<sen_id>.ffm.dbt_dtcwv_11_nadir	RTTOV forward 11 BT tangent linear w.r.t TCWV	Float	0, 17, 18	No	Output from ARC3 processor	
atsr.<sen_id>.ffm.dbt_dtcwv_12_nadir	RTTOV nadir 12 BT tangent linear w.r.t TCWV	Float	0, 17, 18	No	Output from ARC3 processor	

Variable	Contains	Format	Dimensions	Query	Where to find	Note
atsr.<sen_id>.ffm.dbt_dtcwv_12_nadir	RTTOV forward 12 BT tangent linear w.r.t TCWV	Float	0, 17, 18	No	Output from ARC3 processor	

6.1 Notes on ATSR Level 1b

<sen_id> = ‘1’ for ATSR-1

<sen_id> = ‘2’ for ATSR-2

<sen_id> = ‘3’ for AATSR

NWP single level and model level analysis fields are to be interpolated spatially and temporally to the coordinates and time defining the centre of the ATSR extract

A single MMS record can have multiple ATSR Level 1b image extracts, for example, during the overlap of ATSR-2 and AATSR.

7. AVHRR GAC

Variable	Contains	Format	Dimensions	Query	Where to find	Note
avhrr.<sen_id>.time	Time at centre of AVHRR image extract as seconds from SST_CCI Epoch	Long	0	No	Output from ARC2 processor	**Ingestion operation [2]**
avhrr.<sen_id>.dtime	Time of AVHRR image row as milliseconds from avhhr.<sen_id>.time	Short	0,19	No	Output from ARC2 processor	**Ingestion operation [2]**
avhrr.<sen_id>.latitude	Latitudes of AVHRR image extract	Float	0,19,20	No	Output from ARC2 processor	
avhrr.<sen_id>.longitude	Longitudes of AVHRR image extract	Float	0,19,20	No	Output from ARC2 processor	
avhrr.<sen_id>.reflectance_1	Channel 1 reflectance for AVHRR image extract	Short	0,19,20	No	Output from ARC2 processor	
avhrr.<sen_id>.reflectance_2	Channel 2 reflectance for AVHRR image extract	Short	0,19,20	No	Output from ARC2 processor	
avhrr.<sen_id>.reflectance_3a	Channel 3a reflectance for AVHRR image extract	Short	0,19,20	No	Output from ARC2 processor	
avhrr.<sen_id>.brightness_temperature_3b	Channel 3b brightness temperature for AVHRR image extract	Short	0,19,20	No	Output from ARC2 processor	
avhrr.<sen_id>.brightness_temperature_4	Channel 4 brightness temperature for AVHRR image extract	Short	0,19,20	No	Output from ARC2 processor	
avhrr.<sen_id>.brightness_temperature_5	Channel 5 brightness temperature for AVHRR image extract	Short	0,19,20	No	Output from ARC2 processor	

Variable	Contains	Format	Dimensions	Query	Where to find	Note
avhrr.<sen_id>.solar_zenith_angle	Solar zenith angles for AVHRR image extract	Short	0,19,20	No	Output from ARC2 processor	
avhrr.<sen_id>.satellite_ zenith_angle	Satellite zenith angles for AVHRR image extract	Short	0,19,20	No	Output from ARC2 processor	
avhrr.<sen_id>.relative_azimuth_angle	Difference between solar and satellite azimuth angles	Short	0,19,20	No	Output from ARC2 processor	
avhrr.<sen_id>.ict_temperature	Temperature of internal calibration target	Short	0,19	No	Output from ARC2 processor	
avhrr.<sen_id>.reflectance_to_radiance_1	Reflectance to radiance conversion factor for channel 1	Float	0	No	Output from ARC2 processor	
avhrr.<sen_id>. reflectance_to_radiance_2	Reflectance to radiance conversion factor for channel 2	Float	0	No	Output from ARC2 processor	
avhrr.<sen_id>. reflectance_to_radiance_3a	Reflectance to radiance conversion factor for channel 3a	Float	0	No	Output from ARC2 processor	
avhrr.<sen_id>.bad_data	AVHRR image data quality flag	Byte	0,19,20	No	Output from ARC2 processor	
avhrr.<sen_id>.cloud_flag	CLAVR-x cloud mask	Byte	0,19,20	No	Output from ARC2 processor	
avhrr.<sen_id>.cloud_probability	CLAVR-x cloud probability	Byte	0,19,20	No	Output from ARC2 processor	
avhrr.<sen_id>.land_sea_mask	Land/sea mask for AVHRR image extract	Byte	0,19,20	No		**Ingestion operation [9]**

Variable	Contains	Format	Dimensions	Query	Where to find	Note
avhrr.<sen_id>.l1b_filename	Source AVHRR Level 1b product	Char	2,0	No	Output from ARC2 processor	GAC files are termed Level 1B according to NOAA definition; by ESA definition they are actually Level 1A files.
avhrr.<sen_id>.matchup.elem	Across-track location of match-up in source file	Short	0	No	Output from ARC2 processor	
avhrr.<sen_id>.matchup.line	Along-track location of match-up in source file	Short	0	No	Output from ARC2 processor	
avhrr.<sen_id>.l1b_record_number	Record number of AVHRR scan-line from parent L1B file	Short	0,19	No	Output from ARC2 processor	
avhrr.<sen_id>. nwp.sea_ice_fraction	ECMWF ERA-interim sea ice fraction interpolated to image extract	Float	0,22,23	No	ECMWF files GGAS CI	Interpolation to NWP coordinates using CDO tools
avhrr.<sen_id>.nwp.snow_albedo	ECMWF ERA-interim snow albedo interpolated to image extract	Float	0,22,23	No	ECMWF files GGAS ASN	Interpolation to NWP coordinates using CDO tools
avhrr.<sen_id>.nwp.sea_surface_temperature	ECMWF ERA-interim sea surface temperature interpolated to image extract	Float	0,22,23	No	ECMWF files GGAS SSTK	Interpolation to NWP coordinates using CDO tools
avhrr.<sen_id>.nwp.total_column_water_vapour	ECMWF ERA-interim total column water vapour interpolated to image extract	Float	0,22,23	No	ECMWF files GGAS TCWV	Interpolation to NWP coordinates using CDO tools
avhrr.<sen_id>.nwp.mean_sea_level_pressure	ECMWF ERA-interim surface pressure interpolated to image extract	Float	0,22,23	No	ECMWF files GGAS MSL	Interpolation to NWP coordinates using CDO tools
avhrr.<sen_id>.nwp.total_cloud_cover	ECMWF ERA-interim total cloud cover interpolated to image extract	Float	0,22,23	No	ECMWF files GGAS TCC	Interpolation to NWP coordinates using CDO tools
avhrr.<sen_id>.nwp.10m_east_wind_component	ECMWF ERA-interim 10 m wind speed east component interpolated to image extract	Float	0,22,23	No	ECMWF files GGAS U10	Interpolation to NWP coordinates using CDO tools

Variable	Contains	Format	Dimensions	Query	Where to find	Note
avhrr.<sen_id>.nwp.10m_north_wind_component	ECMWF ERA-interim 10 m wind speed north component interpolated to image extract	Float	0,22,23	No	ECMWF files GGAS V10	Interpolation to NWP coordinates using CDO tools
avhrr.<sen_id>.nwp.2m_temperature	ECMWF ERA-interim 2m temperature interpolated to image extract	Float	0,22,23	No	ECMWF files GGAS T2	Interpolation to NWP coordinates using CDO tools
avhrr.<sen_id>.nwp.2m_dew_point	ECMWF ERA-interim 2m dew point interpolated to image extract	Float	0,22,23	No	ECMWF files GGAS D2	Interpolation to NWP coordinates using CDO tools
avhrr.<sen_id>.nwp.albedo	ECMWF ERA-interim albedo interpolated to image extract	Float	0,22,23	No	ECMWF files GGAS AL	Interpolation to NWP coordinates using CDO tools
avhrr.<sen_id>.nwp.skin_temperature	ECMWF ERA-interim skin temperature speed interpolated to image extract	Float	0,22,23	No	ECMWF files GGAS SKT	Interpolation to NWP coordinates using CDO tools
avhrr.<sen_id>.nwp.log_surface_pressure	ECMWF ERA-interim log surface pressure interpolated to image extract	Float	0,22,23	No	ECMWF files SPAM LNSP	Interpolation to NWP coordinates using CDO tools
avhrr.<sen_id>.nwp.temperature_profile	ECMWF ERA-interim temperature profile interpolated to image extract	Float	0,21,22,23	No	ECMWF files SPAM T	Interpolation to NWP coordinates using CDO tools
avhrr.<sen_id>.nwp.water_vapour_profile	ECMWF ERA-interim water vapour profile interpolated to image extract	Float	0,21,22,23	No	ECMWF files GGAM Q	Interpolation to NWP coordinates using CDO tools
avhrr.<sen_id>.nwp.ozone_profile	ECMWF ERA-interim ozone profile interpolated to image extract	Float	0,21,22,23	No	ECMWF files GGAM O3	Interpolation to NWP coordinates using CDO tools
avhrr.<sen_id>.ffm.brightness_temperature_3b	RTTOV modelled channel 3b BT	Short	0, 22, 23	No	Output from ARC3 processor	Scale as per channel BT
avhrr.<sen_id>.ffm.brightness_temperature_4	RTTOV modelled channel 4 BT	Short	0, 22, 23	No	Output from ARC3 processor	Scale as per channel BT

Variable	Contains	Format	Dimensions	Query	Where to find	Note
avhrr.<sen_id>.ffm.brightness_temperature_5	RTTOV modelled channel 5 BT	Short	0, 22, 23	No	Output from ARC3 processor	Scale as per channel BT
avhrr.<sen_id>.ffm.dbt_dsst_3b	RTTOV channel 3b BT tangent linear w.r.t SST	Float	0, 22, 23	No	Output from ARC3 processor	
avhrr.<sen_id>.ffm.dbt_dsst_4	RTTOV channel 4 BT tangent linear w.r.t SST	Float	0, 22, 23	No	Output from ARC3 processor	
avhrr.<sen_id>.ffm.dbt_dsst_5	RTTOV channel 5 BT tangent linear w.r.t SST	Float	0, 22, 23	No	Output from ARC3 processor	
avhrr.<sen_id>.ffm.dbt_dtcwv_3b	RTTOV channel 3b BT tangent linear w.r.t TCWV	Float	0, 22, 23	No	Output from ARC3 processor	
avhrr.<sen_id>.ffm.dbt_dtcwv_4	RTTOV channel 4 BT tangent linear w.r.t TCWV	Float	0, 22, 23	No	Output from ARC3 processor	
avhrr.<sen_id>.ffm.dbt_dtcwv_5	RTTOV channel 5 BT tangent linear w.r.t TCWV	Float	0, 22, 23	No	Output from ARC3 processor	

7.1 Notes on AVHRR GAC

<sen_id> = ‘TN’ for AVHRR TIROS-N

<sen_id> = ‘6’ for AVHRR NOAA-6

<sen_id> = ‘7’ for AVHRR NOAA-7

<sen_id> = ‘8’ for AVHRR NOAA-8

<sen_id> = ‘9’ for AVHRR NOAA-9

<sen_id> = ‘10’ for AVHRR NOAA-10

<sen_id> = ‘11’ for AVHRR NOAA-11

<sen_id> = ‘12’ for AVHRR NOAA-12

<sen_id> = ‘13’ for AVHRR NOAA-13

<sen_id> = ‘14’ for AVHRR NOAA-14

<sen_id> = ‘15’ for AVHRR NOAA-15

<sen_id> = ‘16’ for AVHRR NOAA-16

<sen_id> = ‘17’ for AVHRR NOAA-17

<sen_id> = ‘18’ for AVHRR NOAA-18

<sen_id> = ‘19’ for AVHRR NOAA-19

<sen_id> = ‘M2’ for AVHRR METOP-A

NWP single level and model level analysis fields are to be interpolated spatially and temporally to the coordinates and time defining the centre of the AVHRR extract

A single MMS record can have multiple AVHRR GAC image extracts, for example, in 2010 where there is data from NOAA 15, 16, 17, 18 & 19.

8. AMSR-E L2P

Variable	Contains	Format	Dimensions	Query	Where to find	Note
amsre.time	Time at centre of AMSR-E L2P extract in seconds from SST_CCI Epoch	Long	0	No	AMSR-E L2P file time & sst_dtime	Time per row (sst_dtime) stored in seconds from reference time (time). **Ingestion operation [2]**
amsre.dtime	Time of each AMSR-E image row in milliseconds from amsre.time	Short	0,24	No	AMSR-E L2P file time & sst_dtime	Time per row (sst_dtime) stored in seconds from reference time (time). **Ingestion operation [2]**
amsre.latitude	Latitude of AMSR-E L2P extract	Float	0,24,25	No	AMSR-E L2P file lat	
amsre.longitude	Longitude of AMSR-E L2P extract	Float	0,24,25	No	AMSR-E L2P file lon	
amsre.sea_surface_temperature	SST of AMSR-E extract	Short	0,24,25	No	AMSR-E L2P file sea_surface_temperature	
amsre.SSES_bias_error	SSES bias field for AMSR-E extract	byte	0,24,25	No	AMSR-E L2P file SSES_bias_error	
amsre.SSES_standard_deviation_error	SSES SD field for AMSR-E extract	Byte	0,24,25	No	AMSR-E L2P file SSES_standard_deviation_error	
amsre.proximity_confidence	Proximity confidence level for AMSR-E extract	Byte	0,24,25	No	AMSR-E L2P file proximity_confidence	
amsre.rejection_flag	Rejection flag for AMSR-E extract	Byte	0,24,25	No	AMSR-E L2P file rejection_flag	

Variable	Contains	Format	Dimensions	Query	Where to find	Note
amsre.confidence_flag	Confidence flag for AMSR-E extract	Byte	0,24,25	No	AMSR-E L2P file confidence_flag	
amsre.cool_skin	Estimate of cool skin for AMSR-E extract	Byte	0,24,25	No	AMSR-E L2P file cool_skin	
amsre.diurnal_amplitude	Diurnal warming amplitude	Byte	0,24,25	No	AMSR-E L2P file diurnal_amplitude	
amsre.wind_speed	Wind speed for AMSR-E extract	Byte	0,24,25	No	AMSR-E L2P file wind_speed	
amsre.land_sea_mask	Land sea mask for AMSR-E extract	Byte	0,24,25	No		**Ingestion operation [9]**
amsre.l2p_filename	AMSR-E source L2P filename	Char	2,0	No	AMSR-E L2P filename	
amsre.matchup.elem	Match-up across-track position in source file	Long	0	No	AMSR-E L2P file	
amsre.matchup.line	Match-up along-track position in source file	Long	0	No	AMSR-E L2P file	

9. TMI L2P

Variable	Contains	Format	Dimensions	Query	Where to find	Note
tmi.observation_time	Time of TMI L2P extract in seconds from SST_CCI Epoch	Long	0	No	TMI L2P file time & sst_dtime	Time per row (sst_dtime) stored in seconds from reference time (time). **Ingestion operation [2]**
tmi.dtime	Time of each TMI image row in milliseconds from tmi.time	Short	0,26	No	TMI L2P file time & sst_dtime	Time per row (sst_dtime) stored in seconds from reference time (time). **Ingestion operation [2]**
tmi.latitude	Latitude of TMI L2P extract	Float	0,26,27	No	TMI L2P file lat	
tmi.longitude	Longitude of TMI L2P extract	Float	0,26,27	No	TMI L2P file lon	
tmi.sea_surface_temperature	SST of TMI extract	Short	0,26,27	No	TMI L2P file sea_surface_temperature	
tmi.sses_bias_error	SSES bias field for TMI extract	Byte	0,26,27	No	TMI L2P file SSES_bias_error	
tmi.sses_standard_deviation_error	SSES SD field for TMI extract	Byte	0,26,27	No	TMI L2P file SSES_standard_deviation_error	
tmi.proximity_confidence	Proximity confidence level for TMI extract	Byte	0,26,27	No	TMI L2P file proximity_confidence	
tmi.rejection_flag	Rejection flag for TMI extract	Byte	0,26,27	No	TMI L2P file rejection_flag	

Variable	Contains	Format	Dimensions	Query	Where to find	Note
tmi.confidence_flag	Confidence flag for TMI extract	Byte	0,26,27	No	TMI L2P file confidence_flag	
tmi.cool_skin	Estimate of cool skin for TMI extract	Byte	0,26,27	No	TMI L2P file cool_skin	
tmi.diurnal_amplitude	Diurnal warming amplitude	Byte	0,26,27	No	TMI L2P file diurnal_amplitude	
tmi.wind_speed	Wind speed for TMI extract	Byte	0,26,27	No	TMI L2P file wind_speed	
tmi.land_sea_mask	Land sea mask for TMI extract	byte	0,26,27	No		**Ingestion operation [9]**
tmi.l2p_filename	TMI source L2P filename	Char	2,0	No	TMI L2P filename	
tmi.matchup.elem	Match-up across-track position in source file	Long	0	No	TMI L2P file	
tmi.matchup.line	Match-up along-track position in source file	Long	0	No	TMI L2P file	

10. SEA ICE CONCENTRATION

Variable	Contains	Format	Dimensions	Query	Where to find	Notes
seaice.latitude	Latitude of sea-ice extract	Float	0,28,29	No	Sea-ice concentration file	For HDF files (2008) onwards the values are provided in a separate file. For NetCDF files (up to end 2007) the values are provided in the file (field 'lat'). Modified polar stereographic EASE grid used (~ 10 km)
seaice.longitude	Longitude of sea-ice extract	Float	0,28,29	No	Sea-ice concentration file	For HDF files (2008) onwards the values are provided in a separate file. For NetCDF files (up to end 2007) the values are provided in the file (field 'lon'). Modified polar stereographic EASE grid used (~ 10 km)
seaice.concentration	Sea-ice concentration	Short	0,28,29	No	Sea-ice concentration file	For HDF files (2008) onwards the values are in field 'DATA'. For NetCDF files (up to end 2007) the values are in field 'ice_conc'. Modified polar stereographic EASE grid used (~ 10 km)
seaice.land_sea_mask	Land sea mask for sea-ice extract	Byte	0,28,29	No		**Ingestion operation [9]**
seaice.filename	Sea ice source filename	Char	2,0	No	Sea-ice concentration file	
seaice.matchup.elem	Match-up across-track position in source file	Long	0	No	Sea-ice concentration file	
seaice.matchup.line	Match-up along-track position in source file	Long	0	No	Sea-ice concentration file	

11. AEROSOL ABSORBING INDEX

Variable	Contains	Type	Dimensions	Query	Where to find	Notes
aai.latitude	Latitude of AAI pixel	Float	0,30,31	No	AAI files	
aai.longitude	Longitude of AAI pixel	Float	0,30,31	No	AAI files	
aai.absorbing_aerosol_index	Absorbing aerosol index for centre of match-up	Float	0,30,31	No	AAI files	
aai.land_sea_mask	Land sea mask for AAI position	Byte	0,30,31	No		**Ingestion operation [9]**
aai.filename	AAI source filename	Char	2,0	No	AAI files	
aai.matchup.elem	Match-up across-track position in source file	Long	0	No	AAI files	
aai.matchup.line	Match-up along-track position in source file	Long	0	No	AAI files	

12. IN SITU DATA

Variable	Contains	Format	Dimensions	Query	Where to find	Note
insitu.time	Observation time of in situ data time series in seconds from matchup.time	Long	0, 32	No	ATSR_MD insitu.time.julian METOP_MD msr_time SEVIRI_MD msr_time In situ history insitu.time	**Ingestion operation [2]**
insitu.longitude	Longitude of in situ data time series	Float	0, 32	No	ATSR_MD insitu.longitude METOP_MD msr_lon SEVIRI_MD msr_lon In situ history insitu.longitude	
insitu.latitude	Latitude of in situ data time series	Float	0, 32	No	ATSR_MD insitu.latitude METOP_MD msr_lat SEVIRI_MD msr_lat In situ history insitu.latitude	
insitu.sea_surface_temperature	In situ sea surface temperature series	Short	0, 32	No	ATSR_MD insitu.sea_surface_temperature METOP_MD msr_sst SEVIRI_MD msr_sst In situ history insitu.sea_surface_temperature	

13. INGESTION OPERATIONS:

[1]. ID. Each match-up in the MMS shall have a unique ID to ensure future updates are added to the correct match-up record.

[2]. Time. All times in the MMD output files shall be stored using two fields, 'time' and 'dtime'. 'time' is the observation time at the centre of the sensor scene stored as seconds from the SST_CCI Epoch, which is 01/01/1978 00:00:00. 'dtime' is the observation time of each image row (nj, along-track direction) stored as milliseconds from image 'time'.

[3]. Lat/lon. All latitude and longitude values shall be stored in the MMS as floats.

[4]. Insitu dataset. All in situ dataset codes shall be stored according to ATSR nomenclature. Therefore, the MMS shall change the value of the METOP_MD and SEVIRI_MD codes on ingestion to agree with ATSR_MD codes.

[5]. Match-up valid. Each MMS record shall contain a single flag to validate/invalidate any MMS record. This flag shall be created on ingestion and shall initially be set such that all values are 0 to indicate all MMS records are valid.

[6]. Primary sensor. Each MMS record shall contain a flag to indicate which MD file is the primary sensor for the MMS record. This flag shall be created on ingestion.

[7]. Primary filename and record. Each MMS record shall store the filename of the MD file contributing the primary sensor for the MMS record, as well as the record number of primary matchup location from the parent MD file.

[8]. Sensor list. Each MMS record shall contain a multi-bit flag to identify all sensors (MD files plus image data) that contribute to the MMS record. This flag shall be created on ingestion.

[9]. Land/sea mask. Each MMS image extract shall have a land/sea mask created on ingestion from a common high resolution mask.

[10]. Shift ATSR imagery. All ATSRs have a small systematic offset between the optimal alignment of the forward view with the nadir view. Consequently, the MMS shall shift the ATSR forward view BTs should be shifted relative to the nadir view BTs on ingestion. The shifts required (relative to the normal ATSR image grid where pixels are numbered from 0 to 511 left to right across-track in the along-track direction are:

- ATSR-1: +3 pixel across-track (xi)
- ATSR-2: +1 pixel across-track (xi) and -1 pixels along-track (xj)
- AATSR: -1 pixel across-track (xi) and -2 pixels along-track (xj)

[11]. AATSR 12 micron BTs. It is believed that there is a calibration error in the AATSR 12 micron channel spectral response function. Consequently, all ATSR 12 µm BTs (both nadir and forward) shall have 0.2 K added to them.

[12]. ATSR-1 detector temperature. 12 micron detector temperatures are required for ATSR-1. These shall be added according for the centre of the ATSR-1 extract by linear interpolation from the ATSR-1 Detector T file provided by Owen Embury.

[13]. Convert ATSR elevation angles. Solar and satellite elevation angles are provided in the ATSR Level 1b files. These shall be converted to zenith angles for the MMS using zenith angle = 90-elevation angle.

14. CREATION OF REFERENCE FLAG

Each MMS record shall be assigned a 'matchup.reference_flag' field to distinguish the various uses of the MMD records as the SST_CCI project progresses. This field can have the values:

- '0' – indicates 'training' data
- '1' – indicates 'test' data
- '2' – indicates ''selection' data
- '3' – indicates 'validation' data
- '4' – indicates 'unassigned' data
- '5' – indicates 'duplicate' data

Initially, this flag shall be set to either '4' or '5' to indicate the data is either unassigned or a duplicate record (see Section 16).

The proportioning of the data into other categories will be done by the University of Leicester as the lead institute for the RRDP exercise. For this process, a subset of the matchup fields (Section 3) is required:

- Time
- Latitude
- Longitude
- Dataset
- Primary sensor

All drifting buoy match-ups within the MMD are split into four categories for use within the project. This segregation is done once using a random number generator on one year's worth of match-ups at a time for each of the three reference sensors (ATSR; METOP; AVHRR GAC).

For data between and 1991 and 2007 the data is split:

- Training – 40%; test – 20%; selection – 40%

For data between and 2008 and 2010 the data is split:

- Training – 40%; test – 10%; selection – 40%; validation – 10%

The segregation ratios were chosen based on the previous experience of the SST_CCI project team to ensure sufficient match-ups are available throughout the time series for training and selection. The limited amount of buoy matchups for validation is not seen as an issue as the SST_CCI project will provide uncertainties with each product and will not rely on validation for uncertainty estimates merely for confirmation that the uncertainties are realistic. However, some of the drifting buoy match-ups used for training, test and selection will be used as pseudo-independent data as part of the validation (see Section 7.8 for further details).

15. CREATION OF DUMMY MATCH-UPS

In order to support classification activities a sample of <1000 cases are required where there is a good mix of clear water, marginal sea ice and cloud, over a range of illumination conditions and seasons etc., for a wider area and time interval than will be standard in the MMD.

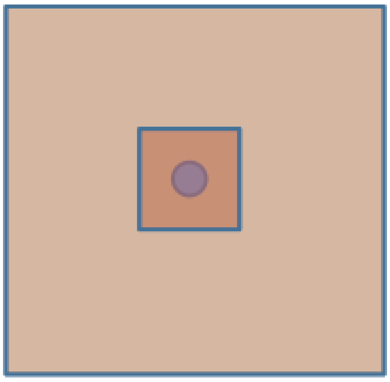
The match-up locations shall be based on the random sample strategy of 50 samples along the 30% ice concentration boundary; this will give of order ~20000 multi sensor matches over the 20 years for the ATSRs (and also therefore the AVHRRs) from which a carefully selected sub-set will be extracted.

Further, add dummy matches for high latitude diurnal warming events and of extreme anomalous SSTs, that otherwise may not be sampled by the random strategy, are required. The match-up locations will be provided by Met.NO and CMS.

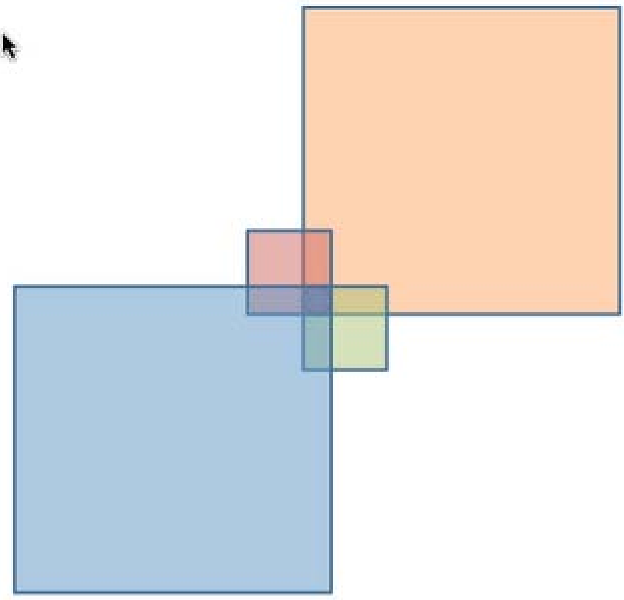
The MMD shall provide such extracts for locations defined in the ATSR MD where matchup.insitu_dataset = 6 for high latitudes and matchup.insitu_dataset = 7 for diurnal warming events.

16. CO-REGISTRATION AND REMOVAL OF DUPLICATE MATCH-UPS

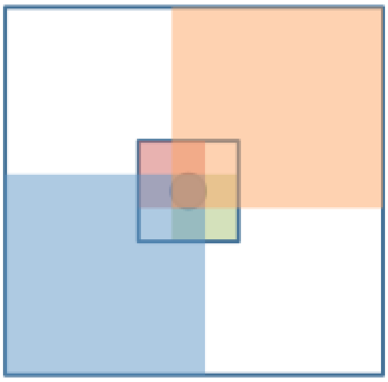
Image collection is based on a fixed number of pixels for different sorts of sensor. For the most part, these extract sizes are designed to ensure coverage of the 101 x 101 pixel image from ATSR (main reference sensor), which is matched at its centre to an in situ observation. Ideally, the overlaps would look like the following:



However, where one of more additional sensors cannot fully cover the 101 x 101, there are two options available. The first option is to simply extract the full number of pixels as in the following example:



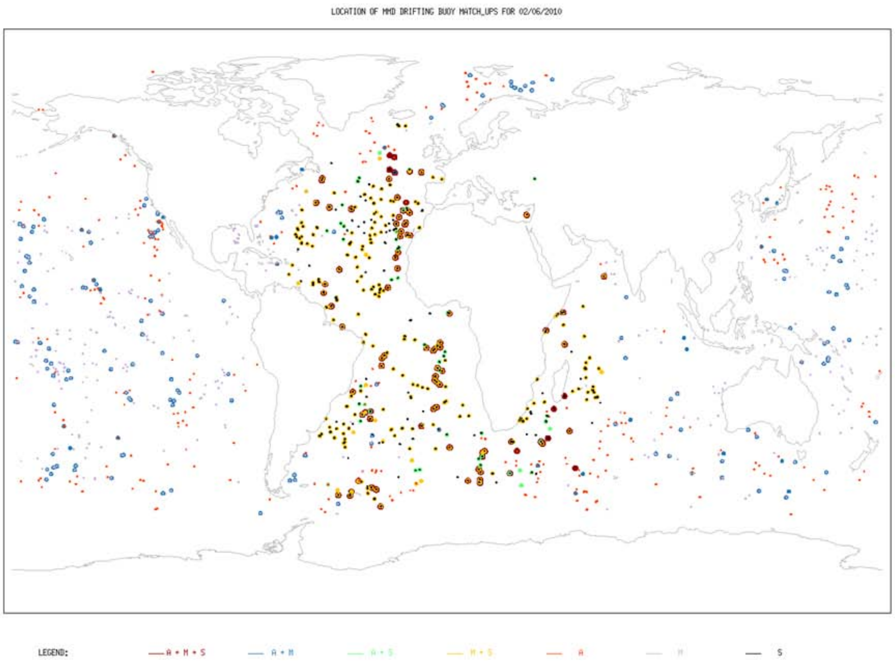
The second option is to populate the uncaptured areas with fill values as in the following example:



The MMD shall ingest all satellite imagery using the second option. This means that the centre pixel of any extract is always the one nearest in location to the reference point.

Due to the use of pre-matched data in the ATSR, AVHRR, METOP and SEVIRI MDs, some match-up dataset instances can be filtered out because they are essentially duplicates or overly-numerous for our purposes.

An example of all inputs for one month is show in the figure below:



The above figure contains single sensor and multi-sensor match-ups for:

- A = from the ATSR MD
- M = from the METOP MD
- S = from the SEVIRI MD

- G = from the Pathfinder MDs for AVHRR GAC (up to 2003)

Within each UTC day the MMD shall:

1. Keep all A+M+S, with A as the primary
2. Keep A+M only if there are no similar A+M+S, with A as the primary
3. Keep A+S only if there are no similar A+M+S, with A as the primary
4. Keep M+S only if there are no similar A+M+S, with M as the primary
5. Keep A (singles) only if no similar A+M+S, A+M or A+S
6. Keep M (singles) only if no similar A+M+S, A+M or M+S
7. Keep no S singles (unnecessary for adequate S coverage)
8. Keep G unless similar to an A (since GAC imagery will be found for all instances in a later step)

"Similar" means a match to the same in situ callsign within 3 hours.

17. EXTRACTS FROM THE MMS

Two extracts from the MMS are foreseen:

1. Extract 1. The initial MMD extract is required for the RRDP. For this we only need to extract MMS records matched to drifting buoys, i.e. matchup.insitu_dataset =0 (assuming METOP and SEVIRI records are converted in ingestion).

   The RRDP extract will be in two data files.

   - The first data file will contain all training, testing match-ups, i.e. where matchup.insitu_dataset =0 and matchup.reference_flag = 0 or 1.

   - The second data file will be the algorithm selection dataset, i.e. where matchup.insitu_dataset =0 and matchup.reference_flag = 2; **it is important that insitu.sea_surface_temperature field and other fields describing the drifter data are not extracted for this second data file**.

2. Extract 2. The second extract will be the large area match-ups for the high-latitude classification work, i.e. where matchup.insitu_dataset = 6.

18. RRDP EXTRACT

An extraction of the MMD is required to run through the ARC3 processor to create the ASDI, cloud mask and forward model fields for ATSR and forward model fields for AVHRR. These ARC3 output fields are then to be ingested into the MMS so that complete MMD extracts for the RRDP can be produced. [Note: The RRDP extract also relies on having the correct matchup.reference_flag setting, which needs to be done externally by UoL].

For the RRDP MMD extracts from the MMS the following dimensions shall be used instead of those given in Table 1 in Section 2:

Number	Name	Size
7	metop.nj	1
8	metop.ni	1
12	seviri.nj	1
13	seviri.ni	1
14	atsr.nj	1
15	atsr.ni	1
19	avhrr.nj	1
20	avhrr.ni	1

In addition, the RRDP MMD extracts shall only contain match-ups to drifting buoys and shall adhere to the matchup.reference_flag rules defined in Section 18.

19. HIGH LATITUDE EXTRACTS

For classification work within the project imagery will need to be extracted for a larger area than the extract for the RRDP. The locations for these larger extracts are indicated by matchup.insitu_dataset =6.

For these larger extracts the following dimensions shall be used instead of those given in Table 1 in Section 2:

Number	Name	Size
14	atsr.nj	201
15	atsr.ni	201
16	atsr.nwp.nz	60
17	atsr.nwp.nj	5
18	atsr.nwp.ni	5
19	avhrr.nj	61
20	avhrr.ni	49
21	avhrr.nwp.nz	60
22	avhrr.nwp.nj	5
23	avhrr.nwp.ni	17
28	seaice.nj	31
29	seaice.ni	31

Note:

- atsr.nwp.nj and atsr.nwp.ni are sampled evenly across the ATSR grid such that atsr.nwp.nj[0] = atsr.nj[0], atsr.nwp.nj[1] = atsr.nj[50], atsr.nwp.nj[2] = atsr.nj[100] etc.

- avhrr.nwp.nj and avhrr.nwp.ni are sampled evenly across the AVHRR grid such that avhrr.nwp.nj[0] = avhrr.nj[0], avhrr.nwp.nj[1] = avhrr.nj[15], avhrr.nwp.nj[2] = avhrr.nj[30], avhrr.nwp.ni[0] = avhrr.ni[0], avhrr.nwp.ni[1] = avhrr.ni[3], avhrr.nwp.ni[2] = avhrr.nj[6] etc.

20. UNIVERSAL SCALING FACTORS

The following universal scaling factors are used to store variables as scaled shorts for all instances of each parameter:

Parameter (units)	add_offset	scale_factor	_FillValue	Valid Range
SST (K)	293.15	0.001	-32768	271.15, 325.0
BT (K)	260.0	0.002	-32768	195.0, 325.0
Reflectance factor (% or unitless)	0.00	0.0001	-32768	0.0, (no max)
zenith angle (°)	90.0	0.01	-32768	0.0, 180.0
azimuth angle (°)	0.0	0.01	-32768	-180.0, 180.0