Customer	:	**ESRIN**	**Document Ref**	:	**SST_CCI-DPM-BC-001**
WP No	:		**Issue Date**	:	**21 June 2013**
			Issue	:	**2.1**

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

Title : **CCI-SST Detailed Processing Model**

Abstract : This document contains the detailed processing model (DPM) for the ESA SST_CCI project

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CONTRACT REPORT

The work described in this report was done under ESA contract. Responsibility for the contents resides in the author or organisation that prepared it.

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
1.0	04 Oct 2012	Initial version
2.0	20 Mar 2013	Minor updates
2.1	21 June 2013	Add details of OSTIA sub-sampling

TABLE OF CONTENTS

1. INTRODUCTION

1.1 Purpose and scope

This Sea Surface Temperature (SST) Detailed Processing Model (DPM) identifies and describes the data processors of the SST system for the European Space Agency (ESA) Climate Change Initiative (CCI). SST is one of 13 Essential Climate Variables (ECV) currently studied by CCI. The SST system will be used to generate and continuously update the SST part of the CCI climate data record (CDR).

Each data processor of the SST CCI system is described in terms of its function, data interface and call interface. Data types are described in the Sea Surface Temperature Input Output Data Definition (IODD) Document [RD 5].

1.2 References

The following documents are applicable to this document:

ID	Title	Issue	Date
[AD 1]	ESA Climate Change Initiative Phase I - Scientific User Consultation and Detailed Specification Statement of Work (SoW), including Annex G: Sea Surface Temperature ECV	1.4	09.11.2009
[AD 2]	Sea Surface Temperature ECV Proposal		16.07.2010
[AD 3]	Sea Surface Temperature CCI User Requirements Document, SST_CCI-URD-UKMO-001 (URD)	2	30.11.2010
[AD 4]	Sea Surface Temperature Data Access Requirements Document, SST_CCI-DARD-UOL-001 (DARD)	1.0	27.01.2012
[AD 5]	Sea Surface Temperature Product Specification Document, SST_CCI-PSD-UKMO-002 (PSD)	2	11.11.2011
[AD 6]	MMD Content Specification, SST_CCI-REP-UOL-001	C	22.07.2011
[AD 7]	Sea Surface Temperature Input Output Data Definition Document, SST_CCI-IODD-BC-001 (IODD)	1.0	03.09.2012

The following documents are referenced in this document (see Reference Documents List, SST_CCI-REP-UOE-001):

ID	Title
[RD 181]	GBCS Users guide and ATBD
[RD 262]	Horrocks, L. A., B. Candy, T. J. Nightingale, R. W. Saunders, A. O'Carroll, and A. R. Harris (2003), Parameterizations of the ocean skin effect and implications for satellite-based measurement of sea-surface temperature, *J. Geophys. Res.*, 108, 3096, doi:10.1029/2002JC001503
[RD 285]	European Committee for Space Standardisation - Software, ECSS-E40
[RD 289]	WMO publication No 306 - Manual on Codes
[RD 290]	CDO User's Guide
[RD 291]	A User's Guide for SCRIP: a Spherical Coordinate Remapping and Interpolation Package
[RD 292]	MSG Ground Segment LRIT/HRIT Mission Specific Implementation, Doc.no. EUM/MSG/SPE/05
[RD 293]	AVHRR/3 Level 1 Product Format Specification, Doc.no. EPS.MIS.SPE.97231

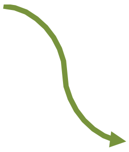
1.3 Acronyms

The following SST-specific acronyms are used in this report (also see Acronyms List, SST_CCI-REP-UOE-002):

Acronym	Definition
ARC	ATSR Reprocessing for Climate
(A)ATSR	(Advanced) Along-Track Scanning Radiometer
AVHRR	Advanced Very High Resolution Radiometer
BADC	British Atmospheric Data Centre
BEAM	Earth observation toolbox and development platform
CCI	Climate Change Initiative
CF	Climate Forecast
CMIP5	Coupled Model Intercomparison Project Phase 5
DARD	Data Access Requirements Document
DPM	Detailed Processing Model
ECDF	Edinburgh Compute and Data Facility
ECMWF	European Centre for Medium-Range Weather Forecasts
ECSS	European Cooperation for Space Standardisation
ECV	Essential Climate Variable
ESA	European Space Agency
GBCS	Generalised Bayesian Cloud Screening
GDS	GHRSST Data Processing Specification
GHRSST	Group for High-Resolution SST
GMPE	GHRSST Multi Product Ensemble
IR	Infrared
MetOp	Meteorological Operational (EUMETSAT)
MD	Match-up Dataset (single-sensor)
MMD	Multi-sensor Match-up Dataset
MMS	Multi-sensor Match-up System
NOAA	National Oceanic and Atmospheric Administration
NEODC	NERC Earth Observation Data Centre
NERC	Natural Environment Research Council
NWP	Numerical weather prediction
OSI-SAF	Ocean & Sea Ice Satellite Application Facility (EUMETSAT)
OSTIA	Operational Sea Surface Temperature and Sea Ice Analysis
PMW	Passive Microwave
SDI	Saharan Dust Index
SEVIRI	Spinning Enhanced Visible and Infrared Imager
SGE	Sun Grid Engine
SoW	Statement of Work
SST	Sea Surface Temperature
UoE	University of Edinburgh

1.4 Symbols

The meaning of symbols used in flow diagrams is explained below.

Symbol	Meaning
	A process
	Data
	Connector indicating the direction of flow

1.5 Document structure

After this formal introduction,

section 2 provides an overview of the SST CCI processing chain, its components, and the data required for input and produced as output

section 3 describes the components of the SST CCI Level-2 processing carried out at ECDF

section 4 describes the components of the SST CCI Level-3 processing for carried out at CMS (MetOp/AVHRR and SEVIRI) and ECDF (ATSR variants, PWM satellites, and collations)

section 5 describes the components of the SST CCI Level-4 processing carried out by the OSTIA system at UK MetOffice

2. THE SST PROCESSING CHAIN AND ITS COMPONENTS

The SST CCI processing chain is depicted in Figure 2-1. The figure illustrates the two variants of the processing chain: the demonstrator (also referred to as short-term) and the long-term SST processing systems. Both variants share several common components.

The processing occurs at different locations: ECDF carries out the Level-2 and Level-3 processing of NOAA AVHRR GAC, (A)ATSR and passive microwave (PMW) satellite data, CMS produces Level-3 SST from MetOp AVHRR and SEVIRI satellite data, and MetOffice produces Level-4 SST from Level-2 and Level-3 data produced by ECDF. A list of the processing chain's major components is compiled in Table 2-1. An overview of the input and output product data used for the SST CCI processing are compiled in Table 2-2.

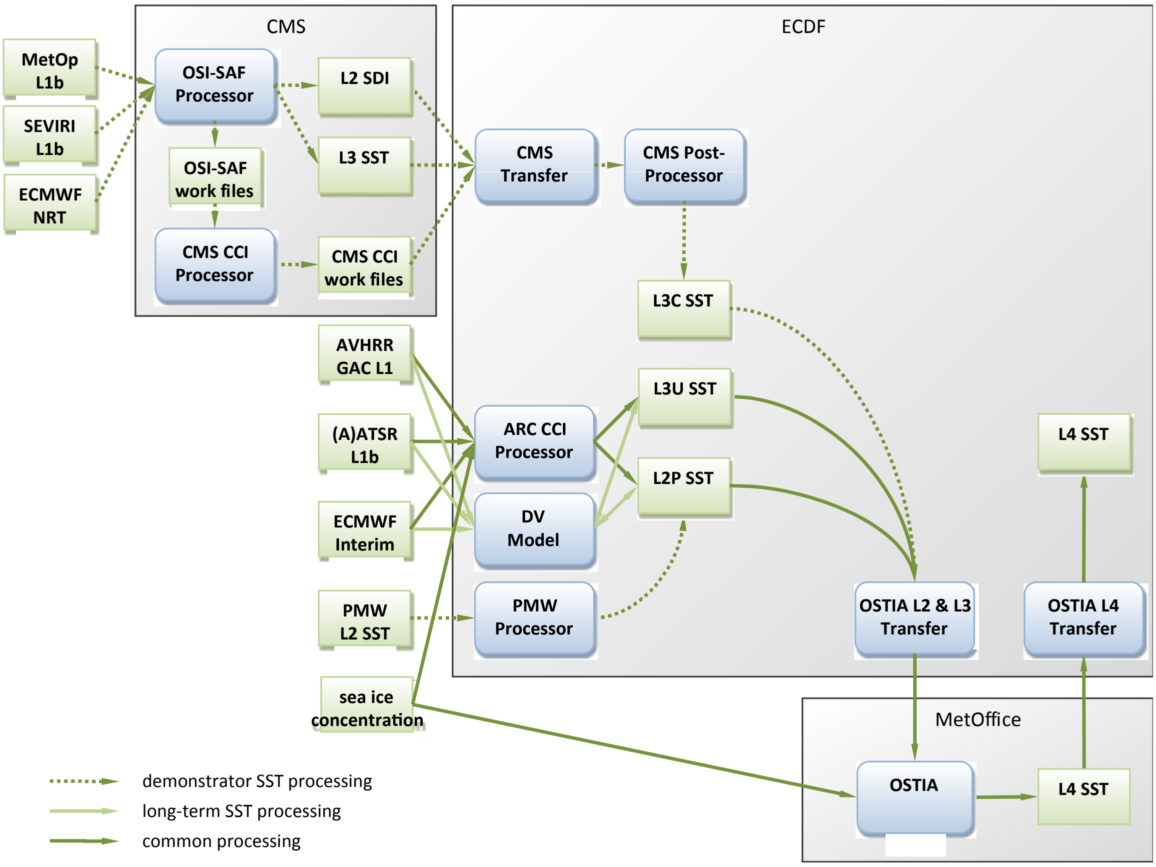


Figure 2-1: SST CCI processing chain

2.1 ECDF

The processing at ECDF mainly consists of the ARC CCI processor, the diurnal variability (DV) model, and the PMW processor. AVHRR GAC Level-1 and (A)ATSR Level 1b satellite data are the main input of the ARC CCI processor, with ECMWF Interim and sea ice concentration auxiliary data. The outputs of the ARC CCI processor are SST CCI L2P and L3U SST. The DV model uses the same inputs as the ARC CCI processor in order to modify the L2P produced by the ARC CCI. It also produces L3U SST. The PMW processor converts PMW Level-2 SST data into SST CCI L2P SST format. All inputs required for the processing are hosted in high performance fibre channel disk storage at ECDF.

Minor components in the ECDF processing for converting outputs fetched from CMS into SST CCI L3U SST and for the transfer of inputs to and outputs from MetOffice.

2.2 CMS

The processing at CMS consists of the OSI-SAF and CMS CCI processors. MetOp AVHRR and SEVIRI L1b satellite data are the main input of the OSI-SAF processor, with ECMWF NRT auxiliary data. The OSI-SAF processor produces Level-2 SDI and Level-3 SST. The CMS CCI processor interfaces with the OSI-SAF processor and produces MetOp work files. All inputs required for the processing are available at CMS.

2.3 MetOffice

The processing at MetOffice essentially consists of the OSTIA processor, which receives SST CCI L2P and L3U SST from ECDF and produces SST CCI L4 SST. Sea ice concentration auxiliary data are used.

Table 2-1: Components of the SST CCI processing chain

Name	Description	Location
ARC CCI processor	Produces SST CCI L2P and L3U from satellite L2 data	ECDF
DV model	Diurnal variability model for SST CCI	ECDF
PMW processor	Converts PMW L2 SST products into SST CCI L2P format	ECDF
CMS post-processor	Converts Level-3 products obtained from CMS into SST CCI L3U format	ECDF
OSI-SAF processor	Produces operational near-real-time OSI-SAF MSG/SEVIRI and METOP/AVHRR SST products from L1 data disseminated by EUMETSAT	CMS
CMS CCI processor	Produces SST CCI AVHRR MetOp internal L1 products from OSI-SAF AVHRR MetOp internal work files	CMS
OSTIA	Produces SST CCI L4 products from SST CCI L2P and L3U	UK MetOffice

Table 2-2: Data products and their roles in the SST CCI processing chain

Name	Coverage	Input for	Output from
(A)ATSR L1b	1991 to 2010	ARC CCI processor, DV model	External source (ESA)
AVHRR GAC L1	1991 to 2010	ARC CCI processor, DV model	External source (NOAA)
MetOp L1b	2007 to now	OSI-SAF processor	External source (EUMETSAT)
SEVIRI L1b	2004 to now	OSI-SAF processor	External source (EUMETSAT)
ECMWF NRT	1999 to now	OSI-SAF processor	External source (ECMWF)
ECMWF-interim	1991 to 2010	ARC CCI processor, DV model	External source (ECMWF)

Name	Coverage	Input for	Output from
SSM/I sea ice concentration maps	2005 to 2010	OSTIA	External source (OSI SAF HL processing centre)
Global sea ice concentration reprocessing dataset	Oct 1978 to Oct 2009	OSTIA	External source (OSI SAF HL processing centre)
SST CCI L2P SST	1991 to 2010	OSTIA	ARC CCI processor, DV model
SST CCI L3U SST	1991 to 2010	OSTIA	ARC CCI processor, DV model, CMS post-processor
SST CCI L3C SST	1991 to 2010		CMS post-processor
SST CCI L4 SST	1991 to 2010		OSTIA

3. LEVEL 2 PROCESSING

3.1 ARC CCI Processor

The ARC CCI processor is based on the ARC processor developed for the ARC and NOAA's ARC projects. It generates SST CCI L2P and L3U outputs from ATSR L1b and AVHRR GAC L1 inputs. It takes auxiliary inputs in the form of ECMWF-interim NWP fields and (when processing AVHRR GAC) the AVHRR CLAVR-X cloud mask. When processing ATSR inputs it performs both cloud detection and SST retrieval. When processing AVHRR GAC inputs it only performs SST retrieval, and uses the CLAVR-X cloud mask.

The ARC CCI process can be split into three main tasks as shown in Figure 3-1. These tasks are described in detail in the following sections.

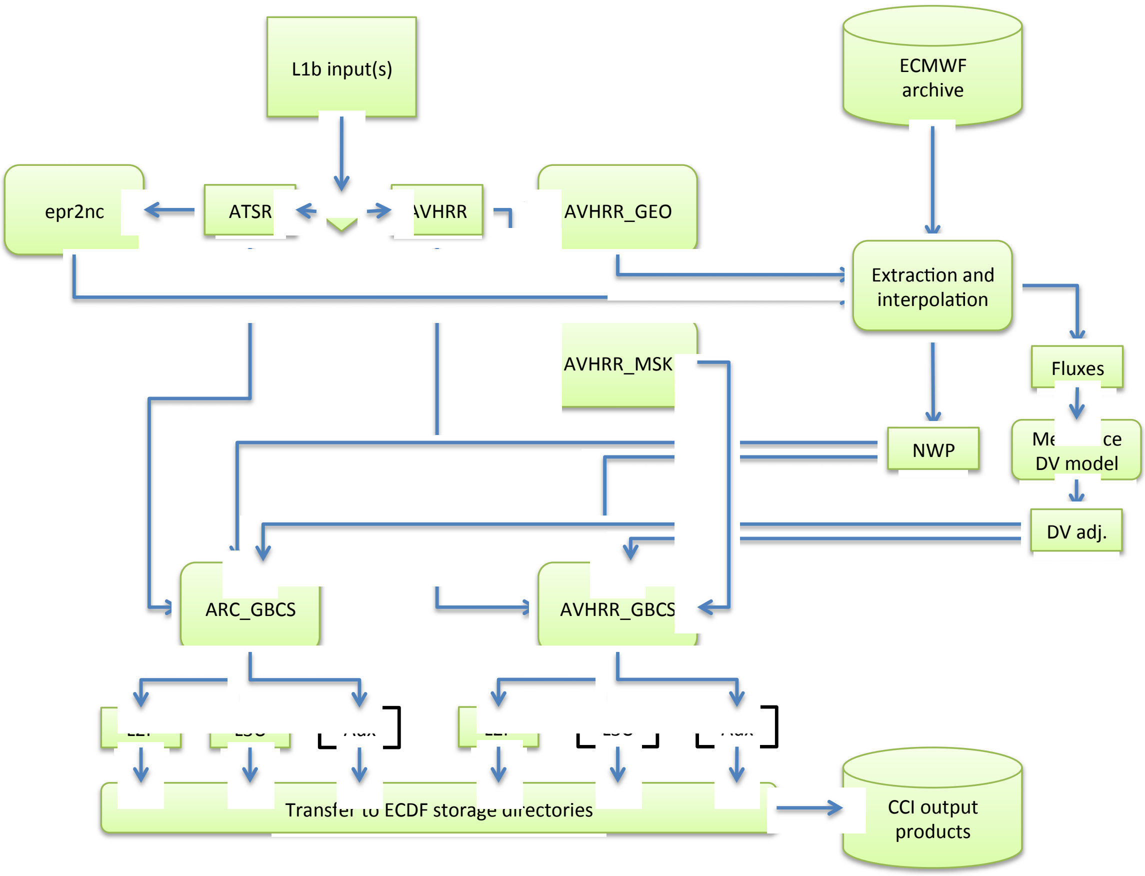


Figure 3-1: ARC CCI processor

3.1.1 Extracting geo-location

Geo-location information must be extracted from the input L1 ATSR and AVHRR files and converted into a format, which the NWP interpolation tool recognises.

3.1.1.1 Function

Extraction of geo-location information is done with a command line tool, which reads the input L1 files and writes the geo-location information to a netCDF complying with the Spherical Coordinate Remapping and Interpolation Package (SCRIP) grid conventions [RD-291, section 2.2].

3.1.1.2 Data interface

Input: An ATSR L1b [AD-7, section 3.1] or AVHRR GAC L1 [AD-7, section 3.2]

Output: Geo-location information in netCDF format complying with SCRIP grid conventions.

3.1.1.3 Call interface

The geo-location extraction is called from the command line with:

```
extract_geolocation [options] file
```

The command line parameters are:

Option	Description
`-V, --version`	Show program version number and exit
`-?, --gelp`	Show this help message and exit
`-v, --verbose`	Produce verbose output
`-q, --quiet`	Suppress all warning messages
`-o, --output=FILE`	Specify output filename (default = geo.nc)

3.1.2 Interpolating NWP data

Interpolation of NWP data is carried out by means of the Climate Data Operators (CDO) software [RD-290], which is developed by the Max Planck Institute for Meteorology.

3.1.2.1 Function

For any (A)ATSR or AVHRR GAC input file, corresponding ECMWF ERA interim [AD-7, section 7.1] data are extracted and interpolated. A chain of calls to the CDO software performs extraction and interpolation, taking the geo-locations of the relevant pixels as input.

Extraction and interpolation is done for NWP analysis and forecast data sets separately. But for both types of data the CDO operations carried out are basically identical.

For the analysis data, all relevant time steps in the GGAS, GGAM and SPAM data sets are merged into separate time series, containing the subset of actually needed analysis fields only. In a second step the GGAS, GGAM and SPAM time series are remapped (interpolated) to the input geo-locations. Finally the separate time series are merged into a single time series.

For the forecast data, all relevant time steps in the GAFS and GGFS data sets are merged into separate time series, containing the subset of actually needed forecast fields only. In a second step the GAFS and GAFS time series are remapped (interpolated) to the input geo-locations. Finally the separate time series are merged into a single time series.

3.1.2.2 Data interface

Input: Besides ECMWT ERA Interim data [AD-7, section 7.1], the input data consists of a netCDF data set of geo-location complying with the Spherical Coordinate Remapping and Interpolation Package (SCRIP) grid conventions [RD-291, section 2.2] produced by extraction step in section 3.1.1.

Output: The output data consists of time series stored in netCDF data sets also complying with SCRIP grid conventions.

3.1.2.3 Call interface

The calls to the CDO software for the extraction and interpolation of NWP analysis and forecast data are explicitly listed below. The call interface of the CDO software is described in [RD-290].

```
1.  cdo ${CDO_OPTS} -f nc mergetime ${GGAS_TIMESTEPS} ${GGAS_TIME_SERIES}
2.  cdo ${CDO_OPTS} -f grb mergetime ${GGAM_TIMESTEPS} ${GGAM_TIME_SERIES}
3.  cdo ${CDO_OPTS} -f grb mergetime ${SPAM_TIMESTEPS} ${SPAM_TIME_SERIES}
4.  cdo ${CDO_OPTS} -f nc -R -t ecmwf setreftime,${REFTIME} -remapbil,${GEO} -
    selname,Q,O3 ${GGAM_TIME_SERIES} ${GGAM_TIME_SERIES_REMAPPED}
5.  cdo ${CDO_OPTS} -f nc -t ecmwf setreftime,${REFTIME} -remapbil,${GEO} -
    sp2gp -selname,LNSP,T ${SPAM_TIME_SERIES} ${SPAM_TIME_SERIES_REMAPPED}
```

```
6.  cdo ${CDO_OPTS} -f nc merge -setreftime,${REFTIME} -remapbil,${GEO} -
    selname,CI,ASN,SSTK,TCWV,MSL,TCC,U10,V10,T2,D2,AL,SKT ${GGAS_TIME_SERIES}
    ${GGAM_TIME_SERIES_REMAPPED} ${SPAM_TIME_SERIES_REMAPPED}
    ${AN_TIME_SERIES}
7.  cdo ${CDO_OPTS} -f nc mergetime ${GAFS_TIMESTEPS} ${GAFS_TIME_SERIES}
8.  cdo ${CDO_OPTS} -f nc mergetime ${GGFS_TIMESTEPS} ${GGFS_TIME_SERIES}
9.  cdo ${CDO_OPTS} -f nc setreftime,${REFTIME} -remapbil,${GEO} -
    selname,SSTK,MSL,BLH,U10,V10,T2,D2 ${GGFS_TIME_SERIES}
    ${GGFS_TIME_SERIES_REMAPPED}
10. cdo ${CDO_OPTS} -f nc merge -setreftime,${REFTIME} -remapbil,${GEO} -
    selname,SSHF,SLHF,SSRD,STRD,SSR,STR,EWSS,NSSS,E,TP ${GAFS_TIME_SERIES}
    ${GGFS_TIME_SERIES_REMAPPED} ${FC_TIME_SERIES}
```

The calls are parameterised with the following parameters; all parameters are strings.

Name	Value
AN_TIME_SERIES	The file path of the output analysis time series
CDO_OPTS	"-M"
FC_TIME_SERIES	The file path of the output forecast time series
GAFS_TIME_STEPS	Space-separated list of GAFS input file paths, selected by time
GAFS_TIME_SERIES	The file path of the GAFS time series
GEO	The file path of the input geo-location data set
GGAM_TIMESTEPS	Space-separated list of GGAM input file paths, selected by time
GGAM_TIME_SERIES	The file path of the GGAM time series
GGAM_TIME_SERIES_REMAPPED	The file path of the remapped GGAM time series
GGAS_TIMESTEPS	Space-separated list of GGAS input file paths, selected by time
GGAS_TIME_SERIES	The file path of the GGAS time series
GGFS_TIME_STEPS	Space-separated list of GGFS input file paths, selected by time
GGFS_TIME_SERIES	The file path of the GGFS time series
GGFS_TIME_SERIES_REMAPPED	The file path of the remapped GGFS time series
REFTIME	"1978-01-01,00:00:00,seconds"
SPAM_TIMESTEPS	Space-separated list of SPAM input file paths, selected by time
SPAM_TIME_SERIES	The file path of the SPAM time series
SPAM_TIME_SERIES_REMAPPED	The file path of the remapped SPAM time series

3.1.3 Cloud screening and SST retrieval

Cloud detection (for ATSR only) and SST retrieval (for both ATSR and AVHRR) is performed by the ARC GBCS software developed at the University of Edinburgh [RD-181]

3.1.3.1 Function

The ARC GBCS software performs the following functions:

- Read input L1b satellite data
- Read input NWP data
- Generate RTTOV simulations using input NWP and satellite id.
- Perform SST retrieval (ARC or OE)
- Perform Bayesian Cloud detection
- Calculate spatial averages
- Write SST CCI L2P and L3U output files

3.1.3.2 Data interface

Input: An ATSR L1b [AD-7, section 3.1] or AVHRR GAC L1 [AD-7, section 3.2) product file, and interpolated NWP in a SCRIP-compliant netCDF file generated in section 3.1.2

Output: SST CCI L2P and L3U [AD-7, section 4.1 and section 5.1]

3.1.3.3 Call interface

The ARC GBCS software is a command line program with the following call interface

```
{ARC|AVHRR}_Gbcs_Linux gbcs.inp l1-file nwp-file l2p-file l3u-file skn-file
```

There are two versions of the command line program; one is used for ATSR L1b input data, while the other is used for AVHRR GAC. The command line arguments are:

Name	Description
`gbcs.inp`	GBCS configuration file (described in GBCS User Manual)
`l1-file`	Name of input L1 data file
`nwp-file`	Name of input NWP data file
`l2p-file`	Name of output SST CCI L2P file
`l3u-file`	Name of output SST CCI L3U file
`skn-file`	Name of input diurnal variability adjustment file

3.2 DV model (long-term only)

The diurnal variability model is used to calculate adjustments for differences in both measurement depth and measurement time between the various datasets. It was originally developed at the Met Office and is described in [RD 262] and the Met Office Forecasting Research Technical Report 418. The software was adapted to its current form by Karsten Fenning and Sarah Millington as part of the ARC project.

3.2.1 Function

For a specified day, the DV program will read all available interpolated NWP files. The Fairall-Kantha-Clayson model will be run using the input NWP data to generate corresponding skin, depth, and diurnal adjustments, which will be written to a netCDF output, file.

3.2.2 Data interface

Input: Interpolated NWP (section 3.1.2)

Output: DV model adjustment file

3.2.3 Call interface

The DV software is a command line program with the following call interface:

```
arc_skin2bulk.exe --date=YYYY-MM-DD --verbose=1 --noclobber=0 --
instrument=ATS --overpass_correction=30
```

The command line arguments are:

Name	Description
`--date=YYYY-MM-DD`	Date to process
`--verbose`	Log detail level (use 1 or 2)
`--noclobber`	Do not overwrite existing output files
`--instrument`	Satellite instrument to process (AT1, AT2, ATS)
`--overpass_correction`	Satellite overpass time correction to use

3.3 PMW Processor (demonstrator only)

The PMW processor is used to read in L2 PMW files from AMSR-E and TMI and convert them to SST CCI L2P format adding appropriate auxiliary fields where necessary.

3.3.1 Function

The PMW processor is a format conversion tool. It performs the following steps:

- Read an input L2P (GDS 1.6 format) product file
- Write SST CCI L2P product file

3.3.2 Data interface

Input: GHRSST L2P (GDS 1.6)

Output: SST CCI L2P [RD 5, section 4.1]

3.3.3 Call interface

The PMW processor is a command line executable with the following call interface:

```
nc2cci_linux pmw gbcs.inp pmw-file nwp-file l2p-file l3u-file skn-file
```

The command line arguments are:

Name	Description
`gbcs.inp`	GBCS configuration file (described in GBCS User Manual)
`pmw-file`	Name of input PMW data file
`nwp-file`	Ignored, best practice is set to 'None'
`l2p-file`	Name of output SST CCI L2P file
`l3u-file`	Ignored, best practice is set to 'None'
`skn-file`	Ignored, best practice is set to 'None'

3.4 CMS Transfer (demonstrator only)

CMS pulling is the step of transferring files from the CMS system to ECDF

3.4.1 Function

Files generated by CMS are made available on an FTP server. These files are downloaded to ECDF through the use of a shell script, which calls GNU Wget.

3.4.2 Data interface

Input: All CMS outputs

Output: All CMS outputs

3.4.3 Call interface

The shell script used to download CMS files is included below:

```
#!/bin/bash

# Get routine files from CMS Meteo-France

years='2011 2012'
metops='02'
```

```
meteosats='09'

# /exports/nas/exports/cse/geos/scratch/gc/sst-cci/metop
# /exports/nas/exports/cse/geos/scratch/gc/sst-cci/meteosat

dir=/exports/nas/exports/cse/geos/scratch/gc/sst-cci/metop
for number in $metops; do
    subDir=$dir/metop-$number
    mkdir -p $subDir
    chmod --quiet g+rwxs,o= $subDir
    for year in $years; do
   mkdir -p $subDir/$year
   chmod --quiet g+rwxs,o= $subDir/$year
   cd $subDir/$year
        # get
   wget -nv -m -nd ftp://meteo-spatiale.fr//home/agrocampus/CCI/routine/btsglb_metop${number}_${year}????_??????.nc.gz
#  chmod --quiet ug=r,o= btsglb_metop${number}_${year}????_??????.nc.gz
    done
done
dir=/exports/nas/exports/cse/geos/scratch/gc/sst-cci/meteosat
for number in $meteosats; do
    subDir=$dir/meteosat-$number
    mkdir -p $subDir
    chmod --quiet g+rwxs,o= $subDir
    for year in $years; do
   mkdir -p $subDir/$year
   chmod --quiet g+rwxs,o= $subDir/$year
   cd $subDir/$year
        # get
   wget -nv -m -nd ftp://meteo-spatiale.fr//home/agrocampus/CCI/routine/*prd_meteosat${number}_${year}????.tar
#  chmod --quiet ug=r,o= *prd_meteosat${number}_${year}????.tar
    done
done
```

It is called using a daily crontab:

```
SHELL=/bin/bash
MAILTO='oembury@staffmail.ed.ac.uk'

11 5 * * * $HOME/CCI/routine_ops/getRoutineCMS.bash
```

4. LEVEL 3 PROCESSING

4.1 OSI-SAF Processor (demonstrator only)

The components described in this section already exist; they are routinely running at CMS and are not specific to the SST CCI project.

4.1.1 OSI-SAF MSG/SEVIRI Processor

The OSI-SAF MSG/SEVIRI processor is a pre-existing component not specifically used for SST CCI.

4.1.1.1 Function

Ingest every 15-minute SEVIRI L1 data and cloud mask from the NWC-SAF Processor

Control cloud mask

Compute SST using multi-spectral algorithm

Apply SST correction derived from NWP outputs and RTTOV simulations

Build composite hourly SST field

Re-map and format final hourly OSI-SAF SEVIRI SST products (L3C)

Compute SST using Optimal Estimation (every 3 hour only)

Re-map and format 3-hourly Optimal Estimation SEVIRI SST products for SST CCI (L3C)

4.1.1.2 Data interface

Input: SEVIRI L1 data in HRIT format [RD 292]; ECMWF NRT in GRIB format [RD 289]

Output: MSG/SEVIRI L3C file [RD 5, section 5.3]

4.1.1.3 Call interface

CMS-internal (managed by operational CMS task manager)

4.1.2 OSI-SAF METOP/AVHRR Processor

The OSI-SAF MSG/SEVIRI processor is a pre-existing component not specifically used for SST CCI.

4.1.2.1 Function

Ingest AVHRR L1 data and cloud mask from the MAIA Processor

Control cloud mask

Compute SST using multi-spectral algorithm

Determine confidence level

Build and format OSI-SAF AVHRR internal work files used by CMS CCI processor (see section 4.2)

Build and format final OSI-SAF AVHRR SST products (L2P, L3C)

4.1.2.2 Data interface

Input: AVHRR L1 data in PFS format [RD 293]; ECMWF NRT in GRIB format [RD 289]

Output: OSI-SAF MetOp internal work file [RD 5, section 3.3]

4.1.2.3 Call interface

CMS-internal (managed by operational CMS task manager)

4.2 CMS CCI Processor (demonstrator only)

The CMS CCI processor is specifically used for SST CCI. Its processing steps are illustrated in Figure 4-1.

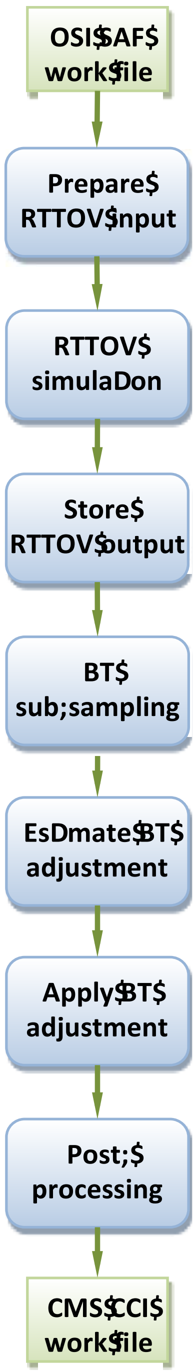


Figure 4-1: CMS CCI processing

4.2.1 Prepare RTTOV input

4.2.1.1 Function

Read a twice daily global METOP/AVHRR work file at 0.05° horizontal resolution, produced by the EUMETSAT OSI SAF operational processing chain at M-F/CMS, to extract satellite zenith angle and time information.

At each grid box where non missing values are present, interpolate atmospheric parameters from the closest ECMWF forecast in time to the grid box centre location, compute the total water vapour content and extract the corresponding analysed sea surface temperature from the last OSTIA analysis.

Write all these data into a formatted ASCII file for the next step (RTTOV computation).

4.2.1.2 Data interface

Input: OSI SAF MetOp internal work file [RD 5, section 3.3], OSTIA sea surface temperature analysis file [RD 5, section 6.1], ECMWF short-range forecasts [RD 5, section 7.1] for surface fields defined in an internal file yyyymmddHH00.TTT_PARAM.nc, with TTT = 006, 009, 012, 015, 018 hour forecast range, PARAM = PRES (surface pressure), TMP_SFC (skin temperature), TMP_2M (air temperature at 2m), RH_2M (air relative humidity at 2m), UGRD (W-E wind component at 10m), VGRD (S-N wind component at 10m) and pressure level fields defined in an internal file yyyymmddHH00.TTT_PARAM_LEVEL.nc, with TTT = 006, 009, 012, 015, 018 hour forecast range, PARAM = TMP (air temperature), RH (air relative humidity), LEVEL = 1000, 950, 925, 900, 850, 800, 700, 600, 500, 400, 300, 250, 200, 150, 100 hPa. All input files are selected by data and time.

Output: Column-formatted ASCII files yyyymmddHHMM.TTT.txt, with TTT = 006, 009, 012, 015, 018 hour forecast range. The columns listed in Table 4-1 define the contents of the ASCII files.

Table 4-1: Columns of RTTOV input file (ASCII)

Column	Description	Unit
k	Number of vertical pressure levels	
lon lat	Grid point latitude and longitude	degrees east degrees north
model_pres model_sst model_t2m model_q2m model_w	Surface pressure, skin surface temperature, 2m air temperature and specific humidity and total water vapour content from near real-time ECMWF model outputs	Pa K K kg / kg g / cm²
satzen	Satellite zenith angle	degree
landmask	Land mask associated with the grid	
guess_sst errstd_sst	Analysed sea surface temperature and associated analysis error standard deviation from near real-time OSTIA analysis	K K
wind	10m wind speed from near real-time ECMWF model outputs	m / s
k times :		
pres_lev	ECMWF model output pressure level	Pa
model_t model_q	air temperature and specific humidity at pres_lev Pa from near real-time ECMWF model outputs	K kg / kg

4.2.1.3 Call interface

The component is executed by calling the `int_champ_modele_metop_OSTIA` executable from the command line:

```
int_champ_modele_metop_OSTIA yyyymmddHH00 TTT yyyymmdd yyyymmddHH00
```

The command line arguments of the executable, in order of appearance on the command line, are explained in the list below.

1. *yyyymmddHH*00: date and time of the initial state which the ECMWF forecast is starting from, e.g. `201204301200` for 30th of April 2012 at 12:00 UTC
2. *TTT*: ECMWF forecast range, e.g. `006` for 6 hours
3. *yymmdd*: date of the OSTIA analysis to be used, e.g. `20120430` for 30th of April 2012
4. *yyyymmddHH*00: central date and time of the OSI SAF METOP/AVHRR work file to process, e.g. `201205010000` for 1st of May 2012 at 00:00 UTC

4.2.2 Perform RTTOV simulations

4.2.2.1 Function

Read a batch of grid points from the ASCII file.

Apply a –0.2 K bulk-to-skin correction to OSTIA analysed sea surface temperature

Call RTTOV to compute METOP/AVHRR simulated brightness temperatures at 3.7, 10.8 and 12.0 microns, and their partial derivatives against surface temperature and specific humidity at each pressure level.

Compute partial derivatives of simulated brightness temperatures against total water vapour content from the ones against specific humidity at each pressure level.

Write simulated brightness temperatures and their partial derivatives against surface temperature and total water vapour content into two formatted ASCII files for the next step.

4.2.2.2 Data interface

Input: Column-formatted ASCII files yyyymmddHHMM.TTT.txt (section 4.2.1.2), with TTT = 006, 009, 012, 015, 018 hour forecast range, read from fort.3, file logical unit 3.

Output: A column-formatted ASCII file (fort.20, file logical unit 20) for simulated brightness temperature, and a column-formatted ASCII file (fort.21, file logical unit 21) for the partial derivatives of simulated brightness temperatures against surface temperature and total water vapour content. The columns listed in Table 4-2 and Table 4-3 define the contents of the output files.

Table 4-2: Columns of simulated brightness temperature file (ASCII)

Column	Description	Unit
lon lat	Grid point latitude and longitude	degrees east degrees north
simut37 simut108 simut120	Simulated brightness temperatures at 3.7, 10.8 and 12.0 micron	K K K
model_sst model_w	Skin surface temperature and total water vapour content from near real-time ECMWF model outputs	K g / cm²
satzen	Satellite zenith angle	degrees
landmask	Land mask associated with the grid	-
guess_sst errstd_sst	Analysed sea surface temperature and associated analysis error standard deviation from near real-time OSTIA analysis	K K
wind	10m wind speed from near real-time ECMWF model outputs	m / s

Table 4-3: Columns of partial derivative file (ASCII)

Column	Description	Unit
lon lat	Grid point latitude and longitude	degree degree
dt_dt_37 dt_dt_108 dt_dt_120	Partial derivatives: brightness temperature versus surface temperature at 3.7, 10.8 and 12.0 micron	K / K K / K K / K
dt_dw_37 dt_dw_108 dt_dw_120	Partial derivatives: brightness temperature versus total water vapour content at 3.7, 10.8 and 12.0 micron	K / (g / cm²) K / (g / cm²) K / (g / cm²)

4.2.2.3 Call interface

The component is executed by calling the test_herve_rttov_k_005_metop_lot.exe executable from the command line

```
test_herve_rttov_k_005_metop_lot.exe
```

There are no parameters, input is read from logical file unit 3, and outputs are written to logical file units 20 and 21.

4.2.3 Store RTTOV output

4.2.3.1 Function

Create a global METOP/AVHRR internal L1B file in netCDF format.

Fill it with the data from the RTTOV output files.

Fill it with the relevant fields extracted from the original EUMETSAT OSI SAF work file.

4.2.3.2 Data interface

Input: Two column-formatted ASCII files (output fort.20 and fort.21 from section 4.2.2) and an OSI SAF AVHRR MetOp internal work file, selected by date and time [RD 5, section 3.3].

Output: An AVHRR MetOp internal L1b file [RD 5, section 3.3] for the date and time selected.

4.2.3.3 Call interface

Two executable programs have to be called from the command line

```
ecri_tempe_jacobien_OSTIA yyyymmdd HH00

ecri_tempe_observation_OSTIA yyyymmdd HH00
```

Here *yyyymmdd* denotes the date selected and *HH* is either `00` or `12`, e.g. `20120430 1200` for 30th of April 2012 at 12:00 UTC.

4.2.4 Sub-sampling of brightness temperatures

4.2.4.1 Function

Read a global METOP/AVHRR internal L1B file.

Sub-sample (one every 20 in longitude and latitude) observed and simulated brightness temperatures entering the estimation of the simulated brightness temperature correction.

Write sub-sampled observed and simulated brightness temperatures into a formatted ASCII file for the next step (estimation of the simulated brightness temperature correction).

4.2.4.2 Data interface

Input: An AVHRR MetOp internal L1b file selected by date and time [RD 5, section 3.3]

Output: A column-formatted ASCII file (btsglb_metopNN_ech_*yyyymmdd_HHMMSS*.txt). The columns listed in Table 4-4 define the contents of the output file.

Table 4-4: Columns of sub-sampled brightness temperatures file (ASCII)

Column	Description	Unit
date time	Date and time of observation	yyyymmdd HHMMSS
lat lon	Grid point latitude and longitude	degrees north degree east
satzen solzen	Satellite and solar zenith angles	degrees degrees
model_w	Total water vapour content from near real-time ECMWF model outputs	g / cm²
guess_sst	Analysed sea surface from near real-time OSTIA analysis	K
ope_sst	OSI-SAF operational METOP/AVHRR sea surface temperature	K
obst37 obst108 obst120	Observed brightness temperatures at 3.7, 10.8 and 12.0 micron	K K K
simut37 simut108 simut120	Simulated brightness temperatures at 3.7, 10.8 and 12.0 micron	K K K

4.2.4.3 Call interface

The component is executed by calling the `echant_bts.pro` PV-Wave program from the command line

```
echant_bts.pro, yyyymmdd, HH0000
```

Here *yyyymmdd* denotes the date selected and *HH* is either `00` or `12`, e.g. `20120430 120000` for 30th of April 2012 at 12:00:00 UTC.

4.2.5 Estimate brightness temperature adjustment

4.2.5.1 Function

Read sub-sampled observed and simulated brightness temperatures from ASCII files over *P* days (*P* = 10) and apply selection thresholds.

Compute for each channel over *P* days the regression coefficients of the simulated minus observed brightness temperature differences against satellite zenith angle secant (quadratic polynomial).

Correct for each channel the simulated minus observed brightness temperature differences for the estimated satellite zenith angle dependent error.

Compute for each channel over *P* days the averaged field of simulated minus observed brightness temperature differences, and smooth it using an *L* x *L* point window filter (*L* = 10).

Interpolate for each channel at 0.05° horizontal resolution the averaged and smoothed field of simulated minus observed brightness temperature differences, and smooth it again using a 20 x 20 point window filter.

Write for each channel the smoothed simulated minus observed brightness temperature difference field at 0.05° horizontal resolution into a netCDF file.

4.2.5.2 Data interface

Input: Column-formatted ASCII files for *D* days obtained as output from the component described in section 4.2.4.

Output: Simulated brightness temperature corrections at 0.05° horizontal resolution stored in a single netCDF file (moy_data_over_*P*_till_*yyyymmdd*.nc, where *yyyymmdd* denotes the date of the last day of the *P* day input period. The variables listed in Table 4-5 define the contents of the output file.

Table 4-5: Contents of the smoothed brightness temperature adjustment file (netCDF)

Variable	Description	Unit
lat	Grid point latitude	degrees north
lon	Grid point longitude	degrees east
simu_obst37 simu_obst108 simu_obst120	Smoothed simulated minus observed brightness temperature differences at 3.7, 10.8 and 12.0 micron	K K K

4.2.5.3 Call interface

The component is executed by calling the `ajustements_empir_rout_bts.pro` PV-Wave program from the command line

```
ajustements_empir_rout_bts.pro, yyyy, mm, dd, P, limsst, limt108, limsol, L
```

Here `yyyy`, `mm`, and `dd` denote the date of the final day in the smoothing period, `P` denotes the length of the smoothing period in days, and `L` is the size of the window filter. The parameters `limsst` and `limt108`, respectively, are the absolute limits of the operational minus guessed SST and observed minus simulated brightness temperature differences to be taken into account for a pixel in the brightness temperature adjustment estimation. `limsol` is the limit of solar zenith angle for a pixel to be taken into account in the brightness temperature estimation.

4.2.6 Apply brightness temperature adjustment

4.2.6.1 Function

Read for each channel a smoothed correction field at 0.05° horizontal resolution.

Read for each channel the simulated brightness temperatures from a global AVHRR MetOp internal L1b file.

Apply for each channel to the simulated brightness temperatures the satellite zenith angle correction using the regression coefficients (quadratic polynomial), and the smoothed correction field at 0.05° horizontal resolution.

Write for each channel the corrected simulated brightness temperatures into the global AVHRR MetOp internal L1b file.

4.2.6.2 Data interface

Input: A smoothed simulated brightness temperature adjustment file obtained as output from the previous component, an AVHRR MetOp internal L1b file [RD 5 section 3.3]. Inputs are selected by date and time.

Output: A CMS CCI work file [RD 5 section 3.4] with adjusted brightness temperature.

4.2.6.3 Call interface

The component is executed by calling the `applic_ajust.pro` PV-Wave program from the command line

```
applic_ajust.pro, yyyymmdd, HH, P, limsst, limt108, limsol, L
```

Here *yyyymmdd* denotes the date selected, *HH* denotes the time of day (either 00 or 12), *P* denotes the length of the smoothing period in days, and *L* is the size of the window filter. Other parameters are the same as in section 4.2.5.3.

4.3 CMS Post-Processor (demonstrator only)

The CMS post-processor is used to read CMS outputs and convert them to SST CCI L3U format adding appropriate auxiliary fields where necessary.

4.3.1 Function

The L3U processor is a format conversion tool. It performs the following steps:

- Read product files from CMS
- Write SST CCI L3U product files

4.3.2 Data interface

Input: Product files fetched from CMS (see section 3.4)

Output: SST CCI L3U [RD 5, section 5.1]

4.3.3 Call interface

The L3U processor is a command line executable with the following call interface:

```
cmspost file-in file-out
```

The command line arguments are:

Name	Description
`file-in`	Name of the input file
`file-out`	Name of the output file

5. LEVEL 4 PROCESSING

5.1 OSTIA

The SST CCI Level-4 product is created using the Operational SST and Sea Ice Analysis (OSTIA) system. OSTIA was developed at the Met Office where it is run operationally every day. The system produces daily global SST fields on a 1/20° grid (~6 km resolution). The operational OSTIA system is fully described in [RD.213]. The OSTIA reanalysis system (as documented in [RD.275]) is based largely on the operational system and has previously been used to create a reanalysis product for 1985 to 2007 (OSTIA reanalysis v1.0, [RD.239]). It is the reanalysis system that will be used for the level 4 processing in this project.

5.1.1 Pre-processing sea ice observations (long term ECV only)

Some pre-processing of the sea ice observational data is carried out prior to use in the level 4 processing system. There are gaps in the daily Global Sea Ice Concentration Reprocessing Dataset [AD-7 section 8.2] owing to lack of available data, or rejection of poor quality data during inhouse quality control procedures. These missing days are filled using a simple linear scheme to ensure there are no gaps in the data series. Currently, this is only done for the long term ECV.

5.1.1.1 Function

The dates of files present at the beginning and end of gaps are passed to an IDL script. The ice concentration, standard error and date information are read in for both files, and the number of days in the gap is calculated. Any missing error information in the files at either end of the gap is set to the maximum, 18%. For each day in the gap, the new ice concentration at each grid point is calculated. This is based on a linear interpolation of the concentration at the start and end of the gap, weighted by the position of the day in the gap and the errors in the data. This procedure is performed separately for each hemisphere.

Error information in the new files is set to the maximum error estimate of 18%, and status flags are set to 100 for land, 12 for sea and 13 for interpolated ice concentration data, following the OSI-SAF convention for this dataset.

5.1.1.2 Data interface

The input sea ice data format is specified in [AD-7, section 8.2]. The output files containing the filled data are in the same format.

5.1.1.3 Call interface

A shell script passes pairs of start and end days of each gap to an IDL script, which produces the interpolated files for each missing day.

5.1.2 The OSTIA system

The OSTIA reanalysis system consists of a series of shell scripts, which are controlled and run by the Met Office Suite Control System. The details of the key scripts used in OSTIA are detailed below and their calling sequence is illustrated in Figure 5-1.

In order to run the OSTIA reanalysis system efficiently, it is run in a ‘leap-frog’ fashion in which the observation pre-processing is run in parallel with the analysis and error estimation procedures. This means the observations are pre-processed 2 days ahead of the SST analysis day as explained in [RD.275].

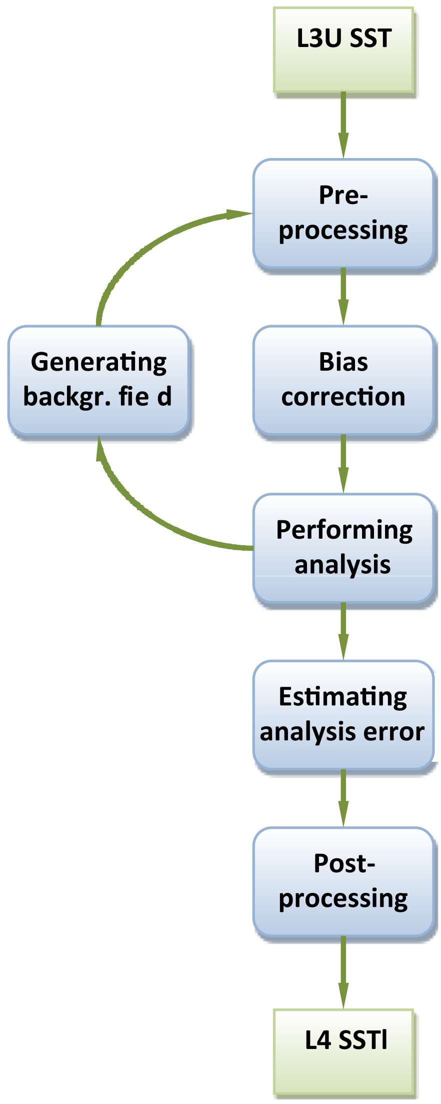


Figure 5-1: Schematic diagram of the OSTIA L4 processor

5.1.3 Pre-processing observations

The OSTIA reanalysis system uses a rolling observation window of 72 hours centred on 1200 UTC on the analysis day, thus giving an overlap period of plus and minus one day. Scripts from the Met Office Observational Processing System are used to quality check the observations in the required time window.

5.1.3.1 Function

For each L2 or L3 input data source, the system extracts the observational data from the relevant files for the 72-hour assimilation window. For the long-term ECV and the first demonstration ECV (June-August 2007), the depth-corrected *SSTdepth* field is used for the (A)ATSR and AVHRR inputs. For the passive microwave data used in the first demonstration ECV, the SST*subskin* field is used. For the second demonstration ECV (early 2012), it is the *SSTskin* field. The observations then undergo a quality control check consisting of a Bayesian background check (as described in [RD.275]). Observations that fail the background check are flagged as bad and not used in the assimilation. Data is also flagged: a) if it is over land in the OSTIA land mask; or b) if the SST is below a minimum SST (currently set to -2°C).

The quality checked observations, which are now stored in a 1-D array, are then sub-sampled to reduce data volumes (with the exception of the (A)ATSR long-term L3 data) as detailed in Table

5-1. (Note, in the case of the 2nd demonstration ECV, the (A)ATSR L2 data is sub-sampled prior to the quality control check as it is necessary to reduce large data volume before the quality control testing.) The L4 analysis for the 2nd demonstration ECV is for the foundation SST (*SSTfnd*) and only night-time input data is used; this ensures there is no diurnal warming signal and further lowers the data volume thus reducing the need to spatially sub-sample the input data in this demonstration product. Following the sub-sampling process, the sub-sampled quality checked observations are then written out to a single file for each data source. Note that the input data will not be masked over lakes, and therefore lake temperatures based on the L2 and L3 SST input data will be included in the L4 product.

Table 5-1: Sub-sampling of input data used in the L4 processing

L4 processing	Input data type	Spatial sub-sampling
Long-term (LT)	L3 (A)ATSR	None
	L2 MetOp AVHRR	1 in 4
	L2 NOAA AVHRR	1 in 4
Demo 1: Jun-Aug 2007 (As in the LT plus)	L2 AMSRE	1 in 2
	L2 TMI	1 in 2
Demo 2: Jan-Mar 2012	L2 (A)ATSR	1 in 4* (pre-QC)
	L3 MetOp AVHRR	None*
	L3 SEVIRI	None*

* Night time data only is used

Additional quality control procedures will be required for the passive microwave data in the first demonstration ECV (June-Aug 2007) to limit any SST*subskin*-SST*depth* differences; the passive microwave data will be rejected if the wind speed is less than 6 ms^{-1} and the sun is above the horizon.

The input *SSTskin* fields in the second demonstration ECV will also be adjusted to account for a skin temperature bias above a wind speed of 6 ms^{-1} by adding 0.17K to the SST measurement for the foundation SST analysis (as is done for the operational system [RD.213]).

If the L2 or L3 input data have SSES bias fields of non-zero, this bias field will be subtracted from the SST field in the pre-processing.

The sea ice concentration data (AD-7, section 8) is extracted for the analysis day for each hemisphere and interpolated on to the OSTIA global 0.05° grid. Missing data over the North Pole and along coasts are also in-filled. Sea ice concentration data failing the OSI-SAF 2m air temperature check (where air temperature is greater than 10°C) are set to zero. Lake ice concentration will also be set to zero.

The sea ice concentration total error estimate data is also extracted with the concentration data and interpolated on to the OSTIA grid. The error is set to the maximum error value of 18% in missing data areas, which have been in-filled. The error estimate data is not available from October 2009 onwards (when the operation OSI-SAF data is used, AD-7, section 8.1), so the error fields are set to missing data for this period. The error is set to zero over open ocean.

5.1.3.2 Data interface

Input: The main input data are the L2 and L3 data (AD-7, sections 4 and 5) and the sea ice concentration and error estimate data (AD-7, section 8). Other input files are: the background error variances (one file for each season containing both mesoscale and synoptic scales in an internal Met Office ‘ancillary’ format); and the background field (in an internal netCDF format).

Output: The output data are single files for each L2 and L3 data source (in an internal format) and the sea ice concentration and error estimate on the OSTIA grid in a single file (in an internal netCDF format).

5.1.3.3 Call interface

The Suite Control System runs the script `scs_run_subsuite` for each data source. The following environment variables are required to be set:

Environment variable	Description
WDIR_OB	Working directory for observation extraction
OPS_OCEAN_NETCDF_DIR	Location of L2 and L3 files
DTF_YEAR	Reference time from suite (year)
DTF_MONTH	Reference time from suite (month)
DTF_DAY	Reference time from suite (day)
DTF_HOUR	Reference time from suite (hour)
DTF_MINUTE	Reference time from suite (minute)

5.1.4 Generating the background field

The method used to generate the background field for the analysis procedure is described in [RD.213, section 4.5]. The SST daily climatology used in this calculation is the OSTIA reanalysis v1.0 [RD.239].

5.1.4.1 Function

The background field for the analysis day is calculated based on the 2 day's previous SST analysis with a relaxation to climatology. Areas under sea ice (with concentration greater than 50%) are relaxed to the freezing temperature of -1.8°C. The background field is output ready for use in the analysis procedure.

5.1.4.2 Data interface

Input: The input files are the previous day's analysis field (in an internal netCDF format), the processed sea ice concentration data (in an internal netCDF format) and the OSTIA reanalysis v1.0 climatology (in an internal netCDF format).

Output: The output is the background SST field in an internal netCDF file.

5.1.4.3 Call interface

The script `Ostia_run_bgupdate` is run from the System Control Suite to calculate the background field.. The following environment variables must be set prior to running the script:

Environment variable	Description
OST_DATA	Working directory
OST_NML	Location of namelists
OST_DATAR	Location of climatologies.
DTF_YEAR	Reference time from suite (year)
DTF_MONTH	Reference time from suite (month)
DTF_DAY	Reference time from suite (day)

DTF_HOUR	Reference time from suite (hour)
DTF_MINUTE	Reference time from suite (minute)
OST_SEC_OFFSET_REF (optional)	Offset in seconds from DTF_ time to input file time

5.1.5 Bias correction

The non-(A)ATSR data is bias corrected using the method described in [RD.213] with the exceptions that only (A)ATSR data is used as a reference, and that a single bias correction field is calculated for all relevant satellite observations of each specific type within the assimilation time window of 72 hours as described in [RD.275].

5.1.5.1 Function

Daily bias correction fields are calculated for each non-(A)ATSR satellite by combining the satellite-reference match-ups using a large scale optimal interpolation type scheme. During periods when (A)ATSR data is not available, the previous day's bias field is persisted with a 10% reduction.

5.1.5.2 Data interface

Input: The input files are the processed L2 and L3 files which are output from the pre-processing function (5.1.3). Other input files required are: the background error variance file in the internal Met Office 'ancillary' format; and the previous day's bias correction fields.

Output: The output file is the daily bias field on the OSTIA grid in an internal netCDF format.

5.1.5.3 Call interface

The script `Ostia_run_assim` is run from the System Control Suite to calculate the bias field. (Note the same script also contains the analysis process described next.) The following environment variables must be set prior to running the script:

Environment variable	Description
OST_DATA	Working directory

5.1.6 Performing the analysis

The analysis procedure is as described in [RD.213, section 4.5], with the following exceptions.

1. The background error covariance used in the analysis is a summation of a mesoscale and synoptic component, and in contrast to [RD.213], these have been calculated from AATSR observations minus background fields from the OSTIA reanalysis v1.0 [RD.239]. Seasonally and spatially varying error variances for each length-scale component are input to the analysis system. Error correlation length scales are also input to the system through name list settings. These are anisotropic (N/S and E/W directions) and a function of latitude.
2. The observation error covariance for all the input data sources is set to the SSES standard deviation field (plus the adjustment uncertainty field for the *SSTdepth* analysis) given in each L2 or L3 file [AD-7 sections 4 and 5].
3. A 72-hour assimilation window is used in the OSTIA reanalysis system whereas a 36 hour window is used in the operational system. In order to give a higher weighting to observations closest to 12Z on the analysis day, the observational errors are scaled as described in [RD.275, section 3.5].

5.1.6.1 Function

The non-(A)ATSR observations are bias-corrected by subtracting the bias field from the L2 data. The analysis is then performed by combining the background field with the pre-processed bias-corrected L2 and L3 observations for the analysis day using a multi-scale optimal interpolation type scheme as described in [RD.213]. The output is the SST analysis on the OSTIA 0.05° grid.

5.1.6.2 Data interface

Input: The primary input files are the processed L2 and L3 files which are output from the pre-processing function (5.1.3). Other input files that are required are: the bias correction fields from the bias correction function (5.1.5); the background field calculated from the background creation function (5.1.4); and the background error variance files (one file for each season which contains both the mesoscale and synoptic scale fields in the internal Met Office 'ancillary' format).

Output: The output file is the daily analysis on the OSTIA grid in an internal netCDF format.

5.1.6.3 Call interface

The script `Ostia_run_assim` is run from the System Control Suite to calculate the background field. The following environment variable must be set prior to running the script:

Environment Variable	Description
OST_DATA	Working directory

5.1.7 Estimating the analysis error

The error analysis procedure is described in [RD.213, section 4.5].

5.1.7.1 Function

A second optimal interpolation is performed to generate the analysis error field for the analysis day. The error field is output with the SST analysis fields to create the final L4 product.

5.1.7.2 Data interface

Input: The input files required are the processed L2 and L3 files (which contain the observational errors needed in this function, in an internal format) together with the background error variance files (one file for each season which contains both the mesoscale and synoptic scale fields in the internal Met Office 'ancillary' format).

Output: The error estimates are output to an internal format netCDF file.

5.1.7.3 Call interface

The script `Ostia_run_errest` is run from the System Control Suite to calculate the background field. The following environment variable must be set prior to running the script:

Environment Variable	Description
OST_DATA	Working directory

5.1.8 Post-processing output files

Output files from the different analysis stages are combined to a single file in the required format. The SST analysis, sea ice and SST analysis error estimate output files are combined into a single L4 output file. A land/sea/ice/lake composite mask is also generated and included in the Level-4 analysis file.

5.1.8.1 Data interface

Input: The three input files are: the SST analysis file from the analysis procedure (5.1.5), the sea ice concentration and error estimate files from the pre-processing procedure (5.1.3); and the analysis error estimate file from the error estimation procedure (5.1.6).

Output: The final output is a single netCDF file in GHRSST GDS2.0 format [RD 5, section 6.1].

5.1.8.2 Call interface

The script `Ostia_Run_post_proc` is run from the System Control Suite to post process the output files. The following environment variables must be set prior to running the script:

Environment Variable	Description
OST_DATA	Working directory
OST_AN_DATE	Date of analysis day

5.2 OSTIA L2 & L3 Transfer

5.2.1 Function

This step covers the transfer of L2P and L3U files generated at ECDF to the Met Office where they are used as input to the OSTIA system. The transfer is performed using the rsync utility over an SSH connection from the Met Office to ECDF, via a staging server.

Rsync is a file transfer tool, which can operate over a secure shell (SSH) connection without the need for an FTP server or similar.

5.2.2 Data interface

The rsync utility copies any files contained in a given input path to the given output path.

Input: L2P and L3U generated at ECDF [RD 5, section 4.1 and 5.1]

Output: L2P and L3U generated at ECDF [RD 5, section 4.1 and 5.1]

5.2.3 Call interface

The call interface is that of the rsync utility:

```
rsync -az eddie.ecdf.ed.ac.uk:/exports/nas/exports/cse/geos/scratch/gc/sst-
cci/to-ukmo/ /metoffice/local/path
```

5.3 OSTIA L4 Transfer

ECDF will obtain the L4 files directly from the data server holding the SST CCI Climate Data Records Package.