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	3/12/2013	

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1. INTRODUCTION

1.1 Purpose and scope

This Input Output Data Description (IODD) identifies and describes the sets of data which are inputs to or outputs from the ATSR Re-analysis for Climate (ARC) processor when used for purposes of accessing the cloud detection algorithm. The ARC processor cloud detection originally applied to ATSR-series instruments (hence its name), but is now adapted for other implementations. In the project under which this IODD was prepared, the ARC processor was adapted and applied to MetOp-A AVHRR L1b input data as a demonstration.

This IODD also describes the format for an output file containing the *a posteriori* probabilities of clear sky across the image.

Some of the data files and formats defined in this document have already been described in detail elsewhere. Therefore these data sets are described briefly, with references to the original defining document. Input or output data sets not described elsewhere are given a detailed description herein.

1.2 References

The following documents are referenced in this document:

ID	Title
[1]	AVHRR Level 1b Product Guide, EUM/OPS-EPS/MAN/04/0029
[2]	U-MARF LEO Format Descriptions, EUM/OPS/USR/06/1855
[3]	WMO publication No 306, Manual on Codes
[4]	RTTOV v11 Users Guide, NWPSAF-MO-UD-028 `http://research.metoffice.gov.uk/research/interproj/nwpsaf/rtm/docs_rttov11/users_guide_11_v1.2.pdf`
[5]	Sea Surface Temperature Product Specification Document, SST_CCI-PSD-UKMO-002

1.3 Acronyms

The following acronyms are used in this document:

Acronym	Definition
ARC	ATSR Reprocessing for Climate
(A)ATSR	(Advanced) Along-Track Scanning Radiometer
AVHRR	Advanced Very High Resolution Radiometer
CCI	Climate Change Initiative
ECMWF	European Centre for Medium-Range Weather Forecasts
ESA	European Space Agency
GBCS	Generalised Bayesian Cloud Screening
GDS	GHRSST Data Processing Specification
GHRSST	Group for High-Resolution SST
MetOp	Meteorological Operational (EUMETSAT)
NWP	Numerical weather prediction
SST	Sea Surface Temperature

1.4 Processing Overview

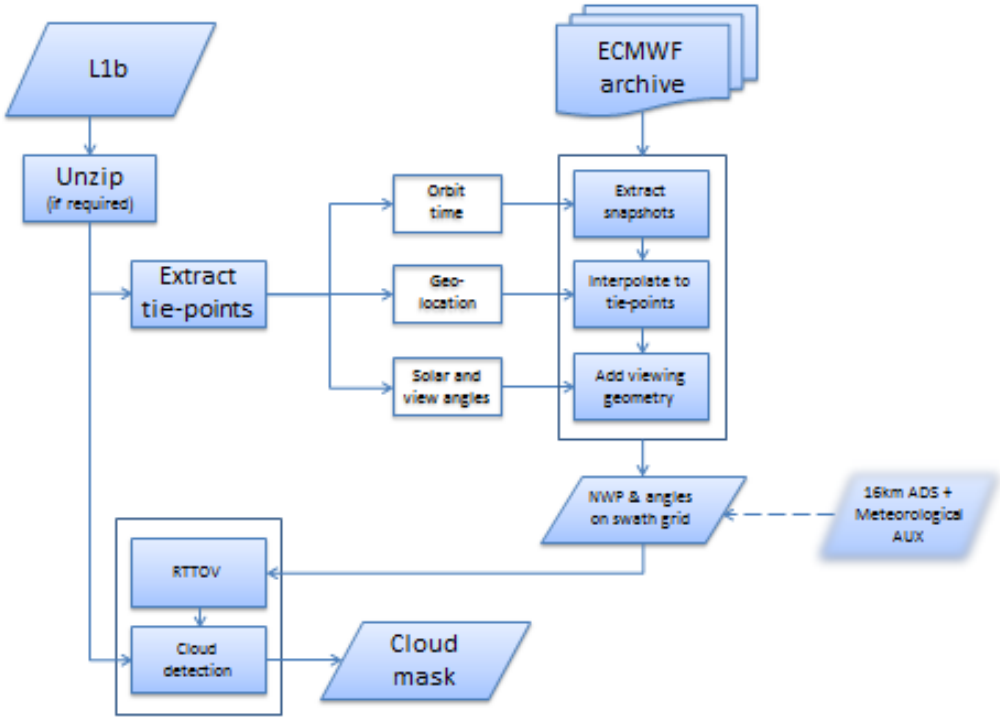

Figure 1 Overview of the data flows for the processor

The principal data flows around the processor are summarised in Figure 1. Level 1b data are acquired and unzipped if necessary. From these, the time of the relevant orbit, pixel locations and solar and satellite geometry information are extracted. These are combined with auxiliary information from ECMWF ERA-Interim analyses to create intermediate meteorological files that contain the required meteorological quantities and the geometry information for each pixel on the satellite swath. In future applications, these intermediate files could potentially be generated from suitable satellite products such as, in the case of SLSTR, the 16 km geometry annotation dataset (ADS) and meteorological parameters auxiliary dataset (AUX) files. The intermediate meteorological files are fed to the Bayesian cloud detection algorithm where they are used by the RTTOV radiative transfer code as part of the forward model. The final output from the detection scheme is a file containing the probability of clear sky for each input pixel in the satellite swath.

2. INPUT FILES

In the following sections the AVHRR-A data that are required as inputs for the ARC processor are described briefly. More detailed descriptions are provided by the documents referenced. Any future adaptation to other L1b data streams will involve identification of equivalent variables. Equivalents are likely to be readily identifiable for the variables Earth Location and Angular Relationships. The observations may be represented differently from the AVHRR-A fields of scene radiances in geophysical units e.g. as sensor data and calibration coefficients.

2.1 AVHRR-A L1b Data

AVHRR-A L1b data are used as input for the cloud detection algorithm in the demonstration adaptation. The file contents and format are described in the *AVHRR Level 1b Product Guide* [1].

2.1.1 File naming convention

The product files follow the EPS file naming convention:
`<INSTRUMENT_ID>_<PRODUCT_TYPE>_<PROCESSING_LEVEL>_<SPACECRAFT_ID>_`
`_<SENSING_START>_<SENSING_END>_<PROCESSING_MODE>_<DISPOSITION_MODE>_`
`_<PROCESSING_ TIME>`

which for AVHRR-A takes the form:

`AVHR_xxx_1B_Mnn_< ...>`

2.1.2 Product data format

The AVHRR-A L1 product files are produced in EPS and HDF5 formats. The ARC processor uses the EPS format files with a detailed description in *U-MARF LEO Format Descriptions* [2]. The particular product fields and variables used by the processor are compiled in Table 2-1.

Table 2-1: Variables in AVHRR-A L1 products used by the ARC processor

Variable name	Description	Reference
Earth_Locations	Latitude and longitude	[1] section 11
Angular_Relations	Solar zenith angle, satellite zenith angle, relative azimuth angle	[1] section 11
Scene_Radiances	Scene radiances for channels 1 to 5 in geophysical units	[1] section 11

3. AUXILIARY INPUT DATA

Additional data are required by the processor to provide background prior information on the meteorological state. If the necessary variables are not available at the same time and on the same grid as the image data, they can be ingested from ECMWF ERA-Interim datasets. These are described in Section 3.1. This data is interpolated in space to the image grid and in time to the midpoint of the orbit relevant to the observations. An intermediate data file is then created. The meteorological information can alternatively be supplied directly in this intermediate form. This format is described in Section 3.2.

Further information regarding the conditional probabilities of observations in clear and cloudy conditions is required in the form of look-up tables described in Section 3.3. An auxiliary file is also required to effect the adjustment from the original (A)ATSR scheme to other sensors. The format for this parameter file is given in Section 3.4.

3.1 ECMWF ERA-Interim

ECMWF ERA-Interim data can be used to provide background prior information on the meteorological state. These can be supplied in either WMO GRIB format (see [3]) or netCDF format. The processor currently assumes that these will be spaced at 6-hourly intervals and extracts instantaneous fields bracketing the observations for interpolation.

3.1.1 File naming convention

The ECMWF-interim files use the following naming convention

`<AA><B><C><yyyymmddHH><step>.<fmt>`

Example:

`spam200902021200.grb`

The filename elements are explained in Table 3-1.

Table 3-1: Elements of ECMWF ERA-interim file names

Pattern Element	Example	Title	Description
AA	Gg	Grid type	Two characters indicating the gridding type: gg – Gaussian gridded data sp – Spectral harmonic data ga – accumulated data on Gaussian grid
B	A	Data type	One character indicating the data type: a – Analyses data f – forecast data
C	m	Level type	One character indicating the level type: s – Surface data m – model level data
yyyymmddHH	2005040300	Analyses time	Date and time of the NWP analyses
step	03	Forecast step	Forecast time step (offset from analyses time)
fmt	nc	File format	nc – netCDF format grb – GRIB format

3.1.2 Product data format

There are three file groups used by the processor for cloud detection purposes. These are summarised in Table 3-2 with full format details given in the subsequent subsections.

Table 3-2: ECMWF-interim file groups used

File stem	Description	Reference
spam	Atmospheric data on spectral harmonic grid (analyses)	Section 3.1.2.1
ggam	Atmospheric data on Gaussian grid (analyses)	Section 3.1.2.2
ggas	Surface data on Gaussian grid (analyses)	Section 3.1.2.3

3.1.2.1 Spectral harmonic analyses on model levels (spam)

The spam files are in GRIB format and contain the parameters in Table 3-3. Those used for cloud screening are indicated.

Table 3-3: Parameters in ECMWF-interim "spam" files

Parameter	Description	Used
129.128	Geopotential	No
130.128	Temperature	Yes
135.128	Vertical velocity	No
138.128	Vorticity (relative)	No
155.128	Divergence	No
152.128	Logarithm of surface pressure	Yes

3.1.2.2 Gaussian gridded analyses on model levels (ggam)

The ggam files are in GRIB format containing the parameters in Table 3-4. Those used for cloud screening are indicated.

Table 3-4: Parameters in ECMWF-interim "ggam" files

Parameter	Description	Used
133.128	Specific humidity	Yes
203.128	Ozone mass mixing ratio	No
246.128	Cloud liquid water content	No
247.128	Cloud ice water content	No
248.128	Cloud cover	No

3.1.2.3 Gaussian gridded analyses on surface (ggas)

The ggas files are in netCDF format (version 3) containing the parameters in Table 3-5**.** Those used for cloud screening are indicated.

Table 3-5: Parameters in ECMWF-interim "ggas" files

Parameter	Description	Used
31.128	Sea-ice cover	Yes
32.128	Snow albedo	No
33.128	Snow density	No
34.128	Sea surface temperature	Yes
35.128	Ice surface temperature layer 1	No
36.128	Ice surface temperature layer 2	No
37.128	Ice surface temperature layer 3	No
38.128	Ice surface temperature layer 4	No
39.128	Volumetric soil water layer 1	No
40.128	Volumetric soil water layer 2	No
41.128	Volumetric soil water layer 3	No
42.128	Volumetric soil water layer 4	No
134.128	Surface pressure	No
136.128	Total column water	No
137.128	Total column water vapour	Yes
139.128	Soil temperature level 1	No
141.128	Snow depth	No
148.128	Charnock parameter	No
151.128	Mean sea level pressure	Yes
164.128	Total cloud cover	No
165.128	10 metre wind u-component	Yes
166.128	10 metre wind v-component	Yes
167.128	2 metre temperature	No
168.128	2 metre dewpoint temperature	No
170.128	Soil temperature level 2	No
173.128	Surface roughness	No
174.128	Albedo	No
183.128	Soil temperature level 3	No
186.128	Low cloud cover	No
187.128	Medium cloud cover	No
188.128	High cloud cover	No
198.128	Skin reservoir content	No
206.128	Total column ozone	No

234.128	Logarithm of surface roughness length for heat	No
235.128	Skin temperature	Yes
236.128	Soil temperature level 4	No
238.128	Temperature of snow layer	No

The ggas files have the structure given below. It should be noted that some of the variables have incorrect attributes associated with them (eg. CI:standard name) and so the processor ignores these attributes when accessing the data.

```
netcdf ggas200902020000 {
dimensions:
       longitude = 512 ;
       latitude = 256 ;
       surface = 1 ;
       t = UNLIMITED ; // (1 currently)
       depth = 1 ;
       depth_1 = 1 ;
       depth_2 = 1 ;
       depth_3 = 1 ;
variables:
       float longitude(longitude) ;
              longitude:long_name = "longitude" ;
              longitude:units = "degrees_east" ;
              longitude:point_spacing = "even" ;
              longitude:modulo = " " ;
       float latitude(latitude) ;
              latitude:long_name = "latitude" ;
              latitude:units = "degrees_north" ;
       float surface(surface) ;
              surface:long_name = "surface" ;
              surface:units = "level" ;
              surface:positive = "up" ;
       float t(t) ;
              t:long_name = "t" ;
              t:units = "days since 2009-02-02 00:00:00" ;
              t:time_origin = "02-FEB-2009:00:00:00" ;
       float CI(t, surface, latitude, longitude) ;
              CI:source = "GRIB data" ;
              CI:name = "CI" ;
              CI:title = "Sea-ice cover" ;
              CI:date = "02/02/09" ;
              CI:time = "00:00" ;
              CI:long_name = "Sea-ice cover" ;
              CI:standard_name = "wind_from_direction" ;
              CI:units = "(0 - 1)" ;
              CI:missing_value = 2.e+20f ;
              CI:_FillValue = 2.e+20f ;
              CI:valid_min = 0.f ;
              CI:valid_max = 1.f ;
```

```
float ASN(t, surface, latitude, longitude) ;
       ASN:source = "GRIB data" ;
       ASN:name = "ASN" ;
       ASN:title = "Snow albedo" ;
       ASN:date = "02/02/09" ;
       ASN:time = "00:00" ;
       ASN:long_name = "Snow albedo" ;
       ASN:standard_name = "wind_speed" ;
       ASN:units = "(0 - 1)" ;
       ASN:missing_value = 2.e+20f ;
       ASN:_FillValue = 2.e+20f ;
       ASN:valid_min = 0.5f ;
       ASN:valid_max = 0.8499985f ;
float RSN(t, surface, latitude, longitude) ;
       RSN:source = "GRIB data" ;
       RSN:name = "RSN" ;
       RSN:title = "Snow density" ;
       RSN:date = "02/02/09" ;
       RSN:time = "00:00" ;
       RSN:long_name = "Snow density" ;
       RSN:standard_name = "eastward_wind" ;
       RSN:units = "kg**-3" ;
       RSN:missing_value = 2.e+20f ;
       RSN:_FillValue = 2.e+20f ;
       RSN:valid_min = 100.f ;
       RSN:valid_max = 300.f ;
float SSTK(t, surface, latitude, longitude) ;
       SSTK:source = "GRIB data" ;
       SSTK:name = "SSTK" ;
       SSTK:title = "Sea surface temperature" ;
       SSTK:date = "02/02/09" ;
       SSTK:time = "00:00" ;
       SSTK:long_name = "Sea surface temperature" ;
       SSTK:standard_name = "northward_wind" ;
       SSTK:units = "K" ;
       SSTK:missing_value = 2.e+20f ;
       SSTK:_FillValue = 2.e+20f ;
       SSTK:valid_min = 269.8706f ;
       SSTK:valid_max = 304.1411f ;
float depth(depth) ;
       depth:long_name = "depth" ;
       depth:units = "cm" ;
       depth:positive = "down" ;
float ISTL1(t, depth, latitude, longitude) ;
       ISTL1:source = "GRIB data" ;
       ISTL1:name = "ISTL1" ;
       ISTL1:title = "Ice surface temperature layer 1" ;
       ISTL1:date = "02/02/09" ;
       ISTL1:time = "00:00" ;
       ISTL1:long_name = "Ice surface temperature layer 1" ;
       ISTL1:standard_name = "atmosphere_horizontal_streamfunction" ;
```

```
              ISTL1:units = "K" ;
              ISTL1:missing_value = 2.e+20f ;
              ISTL1:_FillValue = 2.e+20f ;
              ISTL1:valid_min = 236.6075f ;
              ISTL1:valid_max = 273.1602f ;
       float depth_1(depth_1) ;
              depth_1:long_name = "depth" ;
              depth_1:units = "cm" ;
              depth_1:positive = "down" ;
       float ISTL2(t, depth_1, latitude, longitude) ;
              ISTL2:source = "GRIB data" ;
              ISTL2:name = "ISTL2" ;
              ISTL2:title = "Ice surface temperature layer 2" ;
              ISTL2:date = "02/02/09" ;
              ISTL2:time = "00:00" ;
              ISTL2:long_name = "Ice surface temperature layer 2" ;
              ISTL2:standard_name = "atmosphere_horizontal_velocity_potential" ;
              ISTL2:units = "K" ;
              ISTL2:missing_value = 2.e+20f ;
              ISTL2:_FillValue = 2.e+20f ;
              ISTL2:valid_min = 239.9525f ;
              ISTL2:valid_max = 273.1595f ;
       float depth_2(depth_2) ;
              depth_2:long_name = "depth" ;
              depth_2:units = "cm" ;
              depth_2:positive = "down" ;
       float ISTL3(t, depth_2, latitude, longitude) ;
              ISTL3:source = "GRIB data" ;
              ISTL3:name = "ISTL3" ;
              ISTL3:title = "Ice surface temperature layer 3" ;
              ISTL3:date = "02/02/09" ;
              ISTL3:time = "00:00" ;
              ISTL3:long_name = "Ice surface temperature layer 3" ;
              ISTL3:units = "K" ;
              ISTL3:missing_value = 2.e+20f ;
              ISTL3:_FillValue = 2.e+20f ;
              ISTL3:valid_min = 250.3956f ;
              ISTL3:valid_max = 272.3633f ;
       float depth_3(depth_3) ;
              depth_3:long_name = "depth" ;
              depth_3:units = "cm" ;
              depth_3:positive = "down" ;
       float ISTL4(t, depth_3, latitude, longitude) ;
              ISTL4:source = "GRIB data" ;
              ISTL4:name = "ISTL4" ;
              ISTL4:title = "Ice surface temperature layer 4" ;
              ISTL4:date = "02/02/09" ;
              ISTL4:time = "00:00" ;
              ISTL4:long_name = "Ice surface temperature layer 4" ;
              ISTL4:standard_name =
"vertical_air_velocity_expressed_as_tendency_of_sigma" ;
```

```
              ISTL4:units = "K" ;
              ISTL4:missing_value = 2.e+20f ;
              ISTL4:_FillValue = 2.e+20f ;
              ISTL4:valid_min = 262.1167f ;
              ISTL4:valid_max = 271.8987f ;
       float SWVL1(t, depth, latitude, longitude) ;
              SWVL1:source = "GRIB data" ;
              SWVL1:name = "SWVL1" ;
              SWVL1:title = "Volumetric soil water layer 1" ;
              SWVL1:date = "02/02/09" ;
              SWVL1:time = "00:00" ;
              SWVL1:long_name = "Volumetric soil water layer 1" ;
              SWVL1:standard_name =
"vertical_air_velocity_expressed_as_tendency_of_pressure" ;
              SWVL1:units = "m**3 m**-3" ;
              SWVL1:missing_value = 2.e+20f ;
              SWVL1:_FillValue = 2.e+20f ;
              SWVL1:valid_min = -1.e-38f ;
              SWVL1:valid_max = 0.471054f ;
       float SWVL2(t, depth_1, latitude, longitude) ;
              SWVL2:source = "GRIB data" ;
              SWVL2:name = "SWVL2" ;
              SWVL2:title = "Volumetric soil water layer 2" ;
              SWVL2:date = "02/02/09" ;
              SWVL2:time = "00:00" ;
              SWVL2:long_name = "Volumetric soil water layer 2" ;
              SWVL2:standard_name = "upward_air_velocity" ;
              SWVL2:units = "m**3 m**-3" ;
              SWVL2:missing_value = 2.e+20f ;
              SWVL2:_FillValue = 2.e+20f ;
              SWVL2:valid_min = -1.e-38f ;
              SWVL2:valid_max = 0.4699368f ;
       float SWVL3(t, depth_2, latitude, longitude) ;
              SWVL3:source = "GRIB data" ;
              SWVL3:name = "SWVL3" ;
              SWVL3:title = "Volumetric soil water layer 3" ;
              SWVL3:date = "02/02/09" ;
              SWVL3:time = "00:00" ;
              SWVL3:long_name = "Volumetric soil water layer 3" ;
              SWVL3:standard_name = "atmosphere_absolute_vorticity" ;
              SWVL3:units = "m**3 m**-3" ;
              SWVL3:missing_value = 2.e+20f ;
              SWVL3:_FillValue = 2.e+20f ;
              SWVL3:valid_min = -1.e-38f ;
              SWVL3:valid_max = 0.4672639f ;
       float SWVL4(t, depth_3, latitude, longitude) ;
              SWVL4:source = "GRIB data" ;
              SWVL4:name = "SWVL4" ;
              SWVL4:title = "Volumetric soil water layer 4" ;
              SWVL4:date = "02/02/09" ;
              SWVL4:time = "00:00" ;
```

```
            SWVL4:long_name = "Volumetric soil water layer 4" ;
            SWVL4:units = "m**3 m**-3" ;
            SWVL4:missing_value = 2.e+20f ;
            SWVL4:_FillValue = 2.e+20f ;
            SWVL4:valid_min = -1.e-38f ;
            SWVL4:valid_max = 0.4682949f ;
      float SP(t, surface, latitude, longitude) ;
            SP:source = "GRIB data" ;
            SP:name = "SP" ;
            SP:title = "Surface pressure" ;
            SP:date = "02/02/09" ;
            SP:time = "00:00" ;
            SP:long_name = "Surface pressure" ;
            SP:standard_name = "surface_air_pressure" ;
            SP:units = "Pa" ;
            SP:missing_value = 2.e+20f ;
            SP:_FillValue = 2.e+20f ;
            SP:valid_min = 51821.57f ;
            SP:valid_max = 104616.7f ;
      float TCW(t, surface, latitude, longitude) ;
            TCW:source = "GRIB data" ;
            TCW:name = "TCW" ;
            TCW:title = "Total column water" ;
            TCW:date = "02/02/09" ;
            TCW:time = "00:00" ;
            TCW:long_name = "Total column water" ;
            TCW:units = "kg m**-2" ;
            TCW:missing_value = 2.e+20f ;
            TCW:_FillValue = 2.e+20f ;
            TCW:valid_min = 0.3206847f ;
            TCW:valid_max = 73.40427f ;
      float TCWV(t, surface, latitude, longitude) ;
            TCWV:source = "GRIB data" ;
            TCWV:name = "TCWV" ;
            TCWV:title = "Total column water vapour" ;
            TCWV:date = "02/02/09" ;
            TCWV:time = "00:00" ;
            TCWV:long_name = "Total column water vapour" ;
            TCWV:standard_name =
"lwe_thickness_of_atmosphere_water_vapour_content" ;
            TCWV:units = "kg m**-2" ;
            TCWV:missing_value = 2.e+20f ;
            TCWV:_FillValue = 2.e+20f ;
            TCWV:valid_min = 0.3206847f ;
            TCWV:valid_max = 72.5156f ;
      float STL1(t, depth, latitude, longitude) ;
            STL1:source = "GRIB data" ;
            STL1:name = "STL1" ;
            STL1:title = "Soil temperature level 1" ;
            STL1:date = "02/02/09" ;
            STL1:time = "00:00" ;
```

```
        STL1:long_name = "Soil temperature level 1" ;
        STL1:standard_name = "surface_temperature" ;
        STL1:units = "K" ;
        STL1:missing_value = 2.e+20f ;
        STL1:_FillValue = 2.e+20f ;
        STL1:valid_min = 203.6484f ;
        STL1:valid_max = 313.447f ;
    float SD(t, surface, latitude, longitude) ;
        SD:source = "GRIB data" ;
        SD:name = "SD" ;
        SD:title = "Snow depth" ;
        SD:date = "02/02/09" ;
        SD:time = "00:00" ;
        SD:long_name = "Snow depth" ;
        SD:standard_name = "lwe_thickness_of_surface_snow_amount" ;
        SD:units = "m of water equivalent" ;
        SD:missing_value = 2.e+20f ;
        SD:_FillValue = 2.e+20f ;
        SD:valid_min = 0.f ;
        SD:valid_max = 10.f ;
    float CHNK(t, surface, latitude, longitude) ;
        CHNK:source = "GRIB data" ;
        CHNK:name = "CHNK" ;
        CHNK:title = "Charnock" ;
        CHNK:date = "02/02/09" ;
        CHNK:time = "00:00" ;
        CHNK:long_name = "Charnock" ;
        CHNK:units = " " ;
        CHNK:missing_value = 2.e+20f ;
        CHNK:_FillValue = 2.e+20f ;
        CHNK:valid_min = 0.009527728f ;
        CHNK:valid_max = 0.08831505f ;
    float MSL(t, surface, latitude, longitude) ;
        MSL:source = "GRIB data" ;
        MSL:name = "MSL" ;
        MSL:title = "Mean sea-level pressure" ;
        MSL:date = "02/02/09" ;
        MSL:time = "00:00" ;
        MSL:long_name = "Mean sea-level pressure" ;
        MSL:standard_name = "air_pressure_at_sea_level" ;
        MSL:units = "Pa" ;
        MSL:missing_value = 2.e+20f ;
        MSL:_FillValue = 2.e+20f ;
        MSL:valid_min = 95195.62f ;
        MSL:valid_max = 104612.7f ;
    float TCC(t, surface, latitude, longitude) ;
        TCC:source = "GRIB data" ;
        TCC:name = "TCC" ;
        TCC:title = "Total cloud cover" ;
        TCC:date = "02/02/09" ;
        TCC:time = "00:00" ;
```

```
        TCC:long_name = "Total cloud cover" ;
        TCC:standard_name = "cloud_area_fraction" ;
        TCC:units = "(0 - 1)" ;
        TCC:missing_value = 2.e+20f ;
        TCC:_FillValue = 2.e+20f ;
        TCC:valid_min = 9.999779e-13f ;
        TCC:valid_max = 1.f ;
    float U10(t, surface, latitude, longitude) ;
        U10:source = "GRIB data" ;
        U10:name = "U10" ;
        U10:title = "10 metre U wind component" ;
        U10:date = "02/02/09" ;
        U10:time = "00:00" ;
        U10:long_name = "10 metre U wind component" ;
        U10:standard_name = "eastward_wind" ;
        U10:units = "m s**-1" ;
        U10:missing_value = 2.e+20f ;
        U10:_FillValue = 2.e+20f ;
        U10:valid_min = -39.05307f ;
        U10:valid_max = 26.71087f ;
    float V10(t, surface, latitude, longitude) ;
        V10:source = "GRIB data" ;
        V10:name = "V10" ;
        V10:title = "10 metre V wind component" ;
        V10:date = "02/02/09" ;
        V10:time = "00:00" ;
        V10:long_name = "10 metre V wind component" ;
        V10:standard_name = "northward_wind" ;
        V10:units = "m s**-1" ;
        V10:missing_value = 2.e+20f ;
        V10:_FillValue = 2.e+20f ;
        V10:valid_min = -27.75667f ;
        V10:valid_max = 21.1101f ;
    float T2(t, surface, latitude, longitude) ;
        T2:source = "GRIB data" ;
        T2:name = "T2" ;
        T2:title = "2 metre temperature" ;
        T2:date = "02/02/09" ;
        T2:time = "00:00" ;
        T2:long_name = "2 metre temperature" ;
        T2:standard_name = "air_temperature" ;
        T2:units = "K" ;
        T2:missing_value = 2.e+20f ;
        T2:_FillValue = 2.e+20f ;
        T2:valid_min = 217.2299f ;
        T2:valid_max = 312.3011f ;
    float D2(t, surface, latitude, longitude) ;
        D2:source = "GRIB data" ;
        D2:name = "D2" ;
        D2:title = "2 metre dewpoint temperature" ;
        D2:date = "02/02/09" ;
```

```
        D2:time = "00:00" ;
        D2:long_name = "2 metre dewpoint temperature" ;
        D2:standard_name = "dew_point_temperature" ;
        D2:units = "K" ;
        D2:missing_value = 2.e+20f ;
        D2:_FillValue = 2.e+20f ;
        D2:valid_min = 213.3904f ;
        D2:valid_max = 300.2801f ;
    float STL2(t, depth_1, latitude, longitude) ;
        STL2:source = "GRIB data" ;
        STL2:name = "STL2" ;
        STL2:title = "Soil temperature level 2" ;
        STL2:date = "02/02/09" ;
        STL2:time = "00:00" ;
        STL2:long_name = "Soil temperature level 2" ;
        STL2:units = "K" ;
        STL2:missing_value = 2.e+20f ;
        STL2:_FillValue = 2.e+20f ;
        STL2:valid_min = 207.0131f ;
        STL2:valid_max = 311.7494f ;
    float SR(t, surface, latitude, longitude) ;
        SR:source = "GRIB data" ;
        SR:name = "SR" ;
        SR:title = "Surface roughness" ;
        SR:date = "02/02/09" ;
        SR:time = "00:00" ;
        SR:long_name = "Surface roughness" ;
        SR:standard_name = "surface_roughness_length" ;
        SR:units = "m" ;
        SR:missing_value = 2.e+20f ;
        SR:_FillValue = 2.e+20f ;
        SR:valid_min = 0.0009999999f ;
        SR:valid_max = 99.99905f ;
    float AL(t, surface, latitude, longitude) ;
        AL:source = "GRIB data" ;
        AL:name = "AL" ;
        AL:title = "Albedo" ;
        AL:date = "02/02/09" ;
        AL:time = "00:00" ;
        AL:long_name = "Albedo" ;
        AL:standard_name = "surface_albedo" ;
        AL:units = "(0 - 1)" ;
        AL:missing_value = 2.e+20f ;
        AL:_FillValue = 2.e+20f ;
        AL:valid_min = 0.06999999f ;
        AL:valid_max = 0.4899707f ;
    float STL3(t, depth_2, latitude, longitude) ;
        STL3:source = "GRIB data" ;
        STL3:name = "STL3" ;
        STL3:title = "Soil temperature level 3" ;
        STL3:date = "02/02/09" ;
```

```
        STL3:time = "00:00" ;
        STL3:long_name = "Soil temperature level 3" ;
        STL3:units = "K" ;
        STL3:missing_value = 2.e+20f ;
        STL3:_FillValue = 2.e+20f ;
        STL3:valid_min = 208.1016f ;
        STL3:valid_max = 311.5642f ;
    float LCC(t, surface, latitude, longitude) ;
        LCC:source = "GRIB data" ;
        LCC:name = "LCC" ;
        LCC:title = "Low cloud cover" ;
        LCC:date = "02/02/09" ;
        LCC:time = "00:00" ;
        LCC:long_name = "Low cloud cover" ;
        LCC:units = "(0 - 1)" ;
        LCC:missing_value = 2.e+20f ;
        LCC:_FillValue = 2.e+20f ;
        LCC:valid_min = 0.f ;
        LCC:valid_max = 1.f ;
    float MCC(t, surface, latitude, longitude) ;
        MCC:source = "GRIB data" ;
        MCC:name = "MCC" ;
        MCC:title = "Medium cloud cover" ;
        MCC:date = "02/02/09" ;
        MCC:time = "00:00" ;
        MCC:long_name = "Medium cloud cover" ;
        MCC:units = "(0 - 1)" ;
        MCC:missing_value = 2.e+20f ;
        MCC:_FillValue = 2.e+20f ;
        MCC:valid_min = 0.f ;
        MCC:valid_max = 1.f ;
    float HCC(t, surface, latitude, longitude) ;
        HCC:source = "GRIB data" ;
        HCC:name = "HCC" ;
        HCC:title = "High cloud cover" ;
        HCC:date = "02/02/09" ;
        HCC:time = "00:00" ;
        HCC:long_name = "High cloud cover" ;
        HCC:units = "(0 - 1)" ;
        HCC:missing_value = 2.e+20f ;
        HCC:_FillValue = 2.e+20f ;
        HCC:valid_min = 9.999779e-13f ;
        HCC:valid_max = 1.f ;
    float SRC(t, surface, latitude, longitude) ;
        SRC:source = "GRIB data" ;
        SRC:name = "SRC" ;
        SRC:title = "Skin reservoir content" ;
        SRC:date = "02/02/09" ;
        SRC:time = "00:00" ;
        SRC:long_name = "Skin reservoir content" ;
        SRC:units = "m of water" ;
```

```
            SRC:missing_value = 2.e+20f ;
            SRC:_FillValue = 2.e+20f ;
            SRC:valid_min = 0.f ;
            SRC:valid_max = 0.001190007f ;
      float TCO3(t, surface, latitude, longitude) ;
            TCO3:source = "GRIB data" ;
            TCO3:name = "TCO3" ;
            TCO3:title = "Total column ozone" ;
            TCO3:date = "02/02/09" ;
            TCO3:time = "00:00" ;
            TCO3:long_name = "Total column ozone" ;
            TCO3:units = "kg m**-2" ;
            TCO3:missing_value = 2.e+20f ;
            TCO3:_FillValue = 2.e+20f ;
            TCO3:valid_min = 0.004478014f ;
            TCO3:valid_max = 0.01183951f ;
      float LSRH(t, surface, latitude, longitude) ;
            LSRH:source = "GRIB data" ;
            LSRH:name = "LSRH" ;
            LSRH:title = "Logarithm of surface roughness length for heat" ;
            LSRH:date = "02/02/09" ;
            LSRH:time = "00:00" ;
            LSRH:long_name = "Logarithm of surface roughness length for heat"
;
            LSRH:units = " " ;
            LSRH:missing_value = 2.e+20f ;
            LSRH:_FillValue = 2.e+20f ;
            LSRH:valid_min = -20.f ;
            LSRH:valid_max = -1.386719f ;
      float SKT(t, surface, latitude, longitude) ;
            SKT:source = "GRIB data" ;
            SKT:name = "SKT" ;
            SKT:title = "Skin temperature" ;
            SKT:date = "02/02/09" ;
            SKT:time = "00:00" ;
            SKT:long_name = "Skin temperature" ;
            SKT:units = "K" ;
            SKT:missing_value = 2.e+20f ;
            SKT:_FillValue = 2.e+20f ;
            SKT:valid_min = 197.185f ;
            SKT:valid_max = 323.6345f ;
      float STL4(t, depth_3, latitude, longitude) ;
            STL4:source = "GRIB data" ;
            STL4:name = "STL4" ;
            STL4:title = "Soil temperature level 4" ;
            STL4:date = "02/02/09" ;
            STL4:time = "00:00" ;
            STL4:long_name = "Soil temperature level 4" ;
            STL4:units = "K" ;
            STL4:missing_value = 2.e+20f ;
            STL4:_FillValue = 2.e+20f ;
```

```
            STL4:valid_min = 210.4828f ;
            STL4:valid_max = 309.5672f ;
      float TSN(t, surface, latitude, longitude) ;
            TSN:source = "GRIB data" ;
            TSN:name = "TSN" ;
            TSN:title = "Temperature of snow layer" ;
            TSN:date = "02/02/09" ;
            TSN:time = "00:00" ;
            TSN:long_name = "Temperature of snow layer" ;
            TSN:standard_name = "snow_temperature" ;
            TSN:units = "K" ;
            TSN:missing_value = 2.e+20f ;
            TSN:_FillValue = 2.e+20f ;
            TSN:valid_min = 191.6718f ;
            TSN:valid_max = 311.9511f ;

// global attributes:
            :history = "Fri Oct 23 15:55:49 BST 2009 - CONVSH V1.92 16-
February-2006" ;
}
```

3.2 Intermediate Meteorological Files

The required meteorological information can be supplied directly to the cloud detection algorithm if it is available on the image grid and at a time corresponding to the middle of the orbit containing the L1b observation data.

3.2.1 File naming convention

The intermediate meterological files use the following naming convention

nwp_<*yyyymmddHHMM*>*.nc*

Example:

nwp_201201010430.nc

3.2.2 Data format

The contents of the intermediate meteorological files are listed in Table 3-6. The forward-view angle information (elements beginning ‘fwd_’) is only required for dual view instruments.

Table 3-6: Parameters in Intermediate Meteorological Files

Name	Type	Description
lon	Float array	Longitude of pixel
lat	Float array	Latitude of pixel
lev	Double vector	Model level height (hybrid pressure-sigma units)
hyam	Double vector	Height conversion coefficient
hybm	Double vector	Height conversion coefficient
lev_2	Double vector	Single-level model height (hybrid pressure-sigma units)
surface	Double vector	Single-level height axis
time	Double vector	Time axis
T	Float array	Temperature

LNSP	Float array	Logarithm of surface pressure
Q	Float array	Specfic humidity
CI	Float array	Sea-ice cover
SSTK	Float array	Sea-surface temperature
TCWV	Float array	Total column water vapour
MSL	Float array	Mean sea-level pressure
U10	Float array	Eastward component of wind at 10m height
V10	Float array	Northward component of wind at 10m height
T2	Float array	Temperature at 2m height
D2	Float array	Dew point temperature at 2m height
SKT	Float array	Skin temperature
sat_zen	Float array	Pixel location to satellite zenith angle (nadir view)
sat_azim	Float array	Pixel location to satellite azimuth angle (nadir view)
sol_zen	Float array	Pixel location to sun zenith angle (nadir view)
sol_azim	Float array	Pixel location to sun azimuth angle (nadir view)
fwd_sat_zen	Float array	Pixel location to satellite zenith angle (forward view)
fwd_sat_azim	Float array	Pixel location to satellite azimuth angle (forward view)
fwd_sol_zen	Float array	Pixel location to sun zenith angle (forward view)
fwd_sol_azim	Float array	Pixel location to sun zenith angle (forward view)
sat_dtime	Float array	Offset for observation of each pixel from the nominal time
x	Float vector	Pixel number across scan axis
y	Float vector	Pixel number along scan axis

The intermediate files are in netCDF format with the specification given below.

```
netcdf nwp_201105010328 {
dimensions:
       x = 103 ;
       y = 612 ;
       x_2 = 2 ;
       lev = 60 ;
       nhym = 60 ;
       lev_2 = 1 ;
       surface = 1 ;
       time = UNLIMITED ; // (1 currently)
variables:
       float lon(y, x) ;
              lon:standard_name = "longitude" ;
              lon:long_name = "longitude" ;
              lon:units = "degrees_east" ;
              lon:_CoordinateAxisType = "Lon" ;
       float lat(y, x) ;
```

```
        lat:standard_name = "latitude" ;
        lat:long_name = "latitude" ;
        lat:units = "degrees_north" ;
        lat:_CoordinateAxisType = "Lat" ;
    double lev(lev) ;
        lev:standard_name = "hybrid_sigma_pressure" ;
        lev:long_name = "hybrid level at layer midpoints" ;
        lev:units = "level" ;
        lev:positive = "down" ;
        lev:formula = "hyam hybm (mlev=hyam+hybm*aps)" ;
        lev:formula_terms = "ap: hyam b: hybm ps: aps" ;
    double hyam(nhym) ;
        hyam:long_name = "hybrid A coefficient at layer midpoints" ;
        hyam:units = "Pa" ;
    double hybm(nhym) ;
        hybm:long_name = "hybrid B coefficient at layer midpoints" ;
        hybm:units = "1" ;
    double lev_2(lev_2) ;
        lev_2:standard_name = "hybrid_sigma_pressure" ;
        lev_2:long_name = "hybrid level at layer midpoints" ;
        lev_2:units = "level" ;
        lev_2:positive = "down" ;
        lev_2:formula = "hyam hybm (mlev=hyam+hybm*aps)" ;
        lev_2:formula_terms = "ap: hyam b: hybm ps: aps" ;
    float surface(surface) ;
        surface:long_name = "surface" ;
        surface:units = "level" ;
        surface:axis = "Z" ;
    double time(time) ;
        time:standard_name = "time" ;
        time:units = "hours since 2011-05-01 00:00:00" ;
        time:calendar = "proleptic_gregorian" ;
    float T(time, lev, y, x) ;
        T:long_name = "Temperature" ;
        T:units = "K" ;
        T:code = 130 ;
        T:table = 128 ;
        T:coordinates = "lon lat" ;
    float LNSP(time, lev_2, y, x) ;
        LNSP:long_name = "Logarithm of surface pressure" ;
        LNSP:code = 152 ;
        LNSP:table = 128 ;
        LNSP:coordinates = "lon lat" ;
    float Q(time, lev, y, x) ;
        Q:long_name = "Specific humidity" ;
        Q:units = "kg kg**-1" ;
        Q:code = 133 ;
        Q:table = 128 ;
        Q:coordinates = "lon lat" ;
    float CI(time, y, x) ;
        CI:standard_name = "wind_from_direction" ;
```

```
              CI:long_name = "Sea-ice cover" ;
              CI:units = "(0 - 1)" ;
              CI:coordinates = "lon lat" ;
              CI:_FillValue = 2.e+20f ;
              CI:missing_value = 2.e+20f ;
              CI:source = "GRIB data" ;
              CI:name = "CI" ;
              CI:title = "Sea-ice cover" ;
              CI:date = "01/05/11" ;
              CI:time = "00:00" ;
       float SSTK(time, y, x) ;
              SSTK:standard_name = "northward_wind" ;
              SSTK:long_name = "Sea surface temperature" ;
              SSTK:units = "K" ;
              SSTK:coordinates = "lon lat" ;
              SSTK:_FillValue = 2.e+20f ;
              SSTK:missing_value = 2.e+20f ;
              SSTK:source = "GRIB data" ;
              SSTK:name = "SSTK" ;
              SSTK:title = "Sea surface temperature" ;
              SSTK:date = "01/05/11" ;
              SSTK:time = "00:00" ;
       float TCWV(time, y, x) ;
              TCWV:standard_name =
"lwe_thickness_of_atmosphere_water_vapour_content" ;
              TCWV:long_name = "Total column water vapour" ;
              TCWV:units = "kg m**-2" ;
              TCWV:coordinates = "lon lat" ;
              TCWV:_FillValue = 2.e+20f ;
              TCWV:missing_value = 2.e+20f ;
              TCWV:source = "GRIB data" ;
              TCWV:name = "TCWV" ;
              TCWV:title = "Total column water vapour" ;
              TCWV:date = "01/05/11" ;
              TCWV:time = "00:00" ;
       float MSL(time, y, x) ;
              MSL:standard_name = "air_pressure_at_sea_level" ;
              MSL:long_name = "Mean sea-level pressure" ;
              MSL:units = "Pa" ;
              MSL:coordinates = "lon lat" ;
              MSL:_FillValue = 2.e+20f ;
              MSL:missing_value = 2.e+20f ;
              MSL:source = "GRIB data" ;
              MSL:name = "MSL" ;
              MSL:title = "Mean sea-level pressure" ;
              MSL:date = "01/05/11" ;
              MSL:time = "00:00" ;
       float U10(time, y, x) ;
              U10:standard_name = "eastward_wind" ;
              U10:long_name = "10 metre U wind component" ;
              U10:units = "m s**-1" ;
```

```
        U10:coordinates = "lon lat" ;
        U10:_FillValue = 2.e+20f ;
        U10:missing_value = 2.e+20f ;
        U10:source = "GRIB data" ;
        U10:name = "U10" ;
        U10:title = "10 metre U wind component" ;
        U10:date = "01/05/11" ;
        U10:time = "00:00" ;
    float V10(time, y, x) ;
        V10:standard_name = "northward_wind" ;
        V10:long_name = "10 metre V wind component" ;
        V10:units = "m s**-1" ;
        V10:coordinates = "lon lat" ;
        V10:_FillValue = 2.e+20f ;
        V10:missing_value = 2.e+20f ;
        V10:source = "GRIB data" ;
        V10:name = "V10" ;
        V10:title = "10 metre V wind component" ;
        V10:date = "01/05/11" ;
        V10:time = "00:00" ;
    float T2(time, y, x) ;
        T2:standard_name = "air_temperature" ;
        T2:long_name = "2 metre temperature" ;
        T2:units = "K" ;
        T2:coordinates = "lon lat" ;
        T2:_FillValue = 2.e+20f ;
        T2:missing_value = 2.e+20f ;
        T2:source = "GRIB data" ;
        T2:name = "T2" ;
        T2:title = "2 metre temperature" ;
        T2:date = "01/05/11" ;
        T2:time = "00:00" ;
    float D2(time, y, x) ;
        D2:standard_name = "dew_point_temperature" ;
        D2:long_name = "2 metre dewpoint temperature" ;
        D2:units = "K" ;
        D2:coordinates = "lon lat" ;
        D2:_FillValue = 2.e+20f ;
        D2:missing_value = 2.e+20f ;
        D2:source = "GRIB data" ;
        D2:name = "D2" ;
        D2:title = "2 metre dewpoint temperature" ;
        D2:date = "01/05/11" ;
        D2:time = "00:00" ;
    float SKT(time, y, x) ;
        SKT:long_name = "Skin temperature" ;
        SKT:units = "K" ;
        SKT:coordinates = "lon lat" ;
        SKT:_FillValue = 2.e+20f ;
        SKT:missing_value = 2.e+20f ;
        SKT:source = "GRIB data" ;
```

```
            SKT:name = "SKT" ;
            SKT:title = "Skin temperature" ;
            SKT:date = "01/05/11" ;
            SKT:time = "00:00" ;
      float sat_zen(time, surface, y, x) ;
            sat_zen:standard_name = "platform_zenith_angle" ;
            sat_zen:units = "degree" ;
            sat_zen:coordinates = "lon lat" ;
      float sat_azim(time, surface, y, x) ;
            sat_azim:standard_name = "platform_azimuth_angle" ;
            sat_azim:units = "degree" ;
            sat_azim:coordinates = "lon lat" ;
      float sol_zen(time, surface, y, x) ;
            sol_zen:standard_name = "solar_zenith_angle" ;
            sol_zen:units = "degree" ;
            sol_zen:coordinates = "lon lat" ;
      float sol_azim(time, surface, y, x) ;
            sol_azim:standard_name = "solar_azimuth_angle" ;
            sol_azim:units = "degree" ;
            sol_azim:coordinates = "lon lat" ;
      float fwd_sat_zen(time, surface, y, x) ;
            fwd_sat_zen:standard_name = "platform_zenith_angle" ;
            fwd_sat_zen:units = "degree" ;
            fwd_sat_zen:coordinates = "lon lat" ;
      float fwd_sat_azim(time, surface, y, x) ;
            fwd_sat_azim:standard_name = "platform_azimuth_angle" ;
            fwd_sat_azim:units = "degree" ;
            fwd_sat_azim:coordinates = "lon lat" ;
      float fwd_sol_zen(time, surface, y, x) ;
            fwd_sol_zen:standard_name = "solar_zenith_angle" ;
            fwd_sol_zen:units = "degree" ;
            fwd_sol_zen:coordinates = "lon lat" ;
      float fwd_sol_azim(time, surface, y, x) ;
            fwd_sol_azim:standard_name = "solar_azimuth_angle" ;
            fwd_sol_azim:units = "degree" ;
            fwd_sol_azim:coordinates = "lon lat" ;
      float sat_dtime(time, surface, y, x) ;
            sat_dtime:long_name = "time difference from reference time" ;
            sat_dtime:units = "second" ;
            sat_dtime:coordinates = "lon lat" ;
      int grid_dims(x_2) ;
      float x(x) ;
            x:long_name = "across track pixel" ;
            x:units = "pixel" ;
            x:axis = "X" ;
      float y(y) ;
            y:long_name = "along track pixel" ;
            y:units = "pixel" ;
            y:axis = "Y" ;

// global attributes:
```

```
            :CDI = "Climate Data Interface version 1.6.1
(http://code.zmaw.de/projects/cdi)" ;
            :Conventions = "CF-1.4" ;
            :history = "Thu Oct 31 14:03:58 2013: cdo -O merge -
remapdis,geo_20110501023703.nc -inttime,2011-05-01,03:28:03
nwp_2011050100_2011050106.nc geo_20110501023703.nc nwp_201105010328.nc\n",
                  "Created using GBCS library $Rev: 1821 $" ;
            :CDO = "Climate Data Operators version 1.6.1
(http://code.zmaw.de/projects/cdo)" ;
}
```

3.3 Probability Look-Up Tables

The algorithm uses look-up tables for the conditional probability of particular observations both given cloudy conditions and given clear conditions and also the prior probability of clear sky. The tables are identical to the those for (A)ATSR and the algorithm carries out required adaptations for other sensors internally using the parameters described in Section 3.4.

3.3.1 Conditional probability look-up tables – cloudy conditions

The conditional probability density look-up tables for given observations assuming cloudy conditions are supplied for the three situations: thermal daytime (11μm, 12μm), joint daytime (1.6μm, 11μm, 12μm) and thermal night-time (3.7μm, 11μm, 12μm). The local standard deviation (LSD) of a 3x3 array about a given pixel is also used. The conditional probability density of LSD assuming cloudy conditions is supplied in two situations: day-time reflectance texture (LSD 1.6μm) and night-time thermal texture (LSD 11μm). These are provided in a netCDF format file 'AATSR_cloud.nc' with the following specification

```
netcdf AATSR_cloud {
dimensions:
        d110sst = 30 ;
        d110120 = 50 ;
        sst = 33 ;
        satz = 2 ;
        dayn = 2 ;
        d110sst_1 = 15 ;
        d037110 = 80 ;
        sst_1 = 14 ;
        c016 = 100 ;
        solz = 30 ;
        t110 = 400 ;
        t016 = 400 ;
        solz_1 = 15 ;
        d110F110 = 20 ;
        dF110F120 = 20 ;
        d110120_1 = 20 ;
        tF110 = 400 ;
        cF016 = 100 ;
        solz_2 = 28 ;
variables:
        float d110sst(d110sst) ;
                d110sst:gbcs_chan = 8 ;
                d110sst:diff_chan = -1 ;
                d110sst:lower_bound = -20.f ;
                d110sst:upper_bound = 10.f ;
```

```
        d110sst:bin_width = 1.f ;
        d110sst:num_bins = 30 ;
        d110sst:padded = 0 ;
    float d110120(d110120) ;
        d110120:gbcs_chan = 8 ;
        d110120:diff_chan = 9 ;
        d110120:lower_bound = -1.f ;
        d110120:upper_bound = 9.f ;
        d110120:bin_width = 0.2f ;
        d110120:num_bins = 50 ;
        d110120:padded = 0 ;
    float sst(sst) ;
        sst:nwp_var = 1 ;
        sst:lower_bound = 271.f ;
        sst:upper_bound = 304.f ;
        sst:bin_width = 1.f ;
        sst:num_bins = 33 ;
        sst:padded = 0 ;
    float satz(satz) ;
        satz:gbcs_state = 5 ;
        satz:lower_bound = 0.f ;
        satz:upper_bound = 60.f ;
        satz:bin_width = 30.f ;
        satz:num_bins = 2 ;
        satz:padded = 0 ;
    float dayn(dayn) ;
        dayn:gbcs_state = 6 ;
        dayn:lower_bound = 0.f ;
        dayn:upper_bound = 180.f ;
        dayn:bin_width = 90.f ;
        dayn:num_bins = 2 ;
        dayn:padded = 0 ;
    float d110sst_1(d110sst_1) ;
        d110sst_1:gbcs_chan = 8 ;
        d110sst_1:diff_chan = -1 ;
        d110sst_1:lower_bound = -20.f ;
        d110sst_1:upper_bound = 10.f ;
        d110sst_1:bin_width = 2.f ;
        d110sst_1:num_bins = 15 ;
        d110sst_1:padded = 0 ;
    float d037110(d037110) ;
        d037110:gbcs_chan = 6 ;
        d037110:diff_chan = 8 ;
        d037110:lower_bound = -6.f ;
        d037110:upper_bound = 10.f ;
        d037110:bin_width = 0.2f ;
        d037110:num_bins = 80 ;
        d037110:padded = 0 ;
    float sst_1(sst_1) ;
        sst_1:nwp_var = 1 ;
        sst_1:lower_bound = 270.f ;
```

```
        sst_1:upper_bound = 305.f ;
        sst_1:bin_width = 2.5f ;
        sst_1:num_bins = 14 ;
        sst_1:padded = 0 ;
    float c016(c016) ;
        c016:gbcs_chan = 5 ;
        c016:lower_bound = 0.f ;
        c016:upper_bound = 1.f ;
        c016:bin_width = 0.01f ;
        c016:num_bins = 100 ;
        c016:padded = 0 ;
    float solz(solz) ;
        solz:gbcs_state = 6 ;
        solz:lower_bound = 20.f ;
        solz:upper_bound = 95.f ;
        solz:bin_width = 2.5f ;
        solz:num_bins = 30 ;
        solz:padded = 0 ;
    float t110(t110) ;
        t110:text_chan = 8 ;
        t110:lower_bound = 0.f ;
        t110:upper_bound = 2.f ;
        t110:bin_width = 0.005f ;
        t110:num_bins = 400 ;
        t110:padded = 0 ;
    float t016(t016) ;
        t016:text_chan = 5 ;
        t016:lower_bound = 0.f ;
        t016:upper_bound = 2.f ;
        t016:bin_width = 0.005f ;
        t016:num_bins = 400 ;
        t016:padded = 0 ;
    float solz_1(solz_1) ;
        solz_1:gbcs_state = 6 ;
        solz_1:lower_bound = 20.f ;
        solz_1:upper_bound = 95.f ;
        solz_1:bin_width = 5.f ;
        solz_1:num_bins = 15 ;
        solz_1:padded = 0 ;
    float d110F110(d110F110) ;
        d110F110:gbcs_chan = 8 ;
        d110F110:diff_chan = 23 ;
        d110F110:lower_bound = -1.f ;
        d110F110:upper_bound = 7.f ;
        d110F110:bin_width = 0.4f ;
        d110F110:num_bins = 20 ;
        d110F110:padded = 0 ;
    float dF110F120(dF110F120) ;
        dF110F120:gbcs_chan = 23 ;
        dF110F120:diff_chan = 24 ;
        dF110F120:lower_bound = -1.f ;
```

```
                dF110F120:upper_bound = 7.f ;
                dF110F120:bin_width = 0.4f ;
                dF110F120:num_bins = 20 ;
                dF110F120:padded = 0 ;
        float d110120_1(d110120_1) ;
                d110120_1:gbcs_chan = 8 ;
                d110120_1:diff_chan = 9 ;
                d110120_1:lower_bound = -1.f ;
                d110120_1:upper_bound = 7.f ;
                d110120_1:bin_width = 0.4f ;
                d110120_1:num_bins = 20 ;
                d110120_1:padded = 0 ;
        float tF110(tF110) ;
                tF110:text_chan = 23 ;
                tF110:lower_bound = 0.f ;
                tF110:upper_bound = 2.f ;
                tF110:bin_width = 0.005f ;
                tF110:num_bins = 400 ;
                tF110:padded = 0 ;
        float cF016(cF016) ;
                cF016:gbcs_chan = 20 ;
                cF016:lower_bound = 0.f ;
                cF016:upper_bound = 1.f ;
                cF016:bin_width = 0.01f ;
                cF016:num_bins = 100 ;
                cF016:padded = 0 ;
        float solz_2(solz_2) ;
                solz_2:gbcs_state = 6 ;
                solz_2:lower_bound = 20.f ;
                solz_2:upper_bound = 90.f ;
                solz_2:bin_width = 2.5f ;
                solz_2:num_bins = 28 ;
                solz_2:padded = 0 ;
        float tir_110_120(dayn, satz, sst, d110120, d110sst) ;
                tir_110_120:gbcs_pdf = 1 ;
        float tir_037_110_120(satz, sst_1, d037110, d110120, d110sst_1) ;
                tir_037_110_120:gbcs_pdf = 1 ;
        float vis_016(satz, solz, c016) ;
                vis_016:gbcs_pdf = 1 ;
        float txt_110(satz, t110) ;
                txt_110:gbcs_pdf = 1 ;
        float txt_016(solz_1, satz, t016) ;
                txt_016:gbcs_pdf = 1 ;
        float dual_110_120(sst_1, d110sst_1, d110120_1, dF110F120, d110F110) ;
                dual_110_120:gbcs_pdf = 1 ;
        float dtxt_110(tF110, t110) ;
                dtxt_110:gbcs_pdf = 1 ;
        float dual_016(solz_2, cF016, c016) ;
                dual_016:gbcs_pdf = 1 ;

// global attributes:
```

```
                :title = "Gbcs PDF lookup tables" ;
                :institution = "University of Edinburgh" ;
                :contact = "Owen Embury, owen.embury@ed.ac.uk" ;
                :creation_date = "Mon Aug 17 18:57:06 2009" ;
                :ARC_source_id = "ARC_Jul09" ;
                :ARC_config_id = "001" ;
                :ARC_version_id = "1.0" ;
                :comment = "Final (RC1) PDFs for AATSR" ;
}
```

3.3.2 Conditional probability look-up tables – clear conditions

The conditional probability of LSD assuming clear conditions is supplied in two situations: day-time reflectance texture (LSD 1.6μm) and night-time thermal texture (LSD 11μm). They are provided in a netCDF format file 'AATSR_clear.nc' with the following specification

```
netcdf AATSR_clear {
dimensions:
        t110 = 400 ;
        satz = 2 ;
        dayn = 2 ;
        t016 = 400 ;
        solz = 15 ;
        tF110 = 400 ;
variables:
        float t110(t110) ;
                t110:text_chan = 8 ;
                t110:lower_bound = 0.f ;
                t110:upper_bound = 2.f ;
                t110:bin_width = 0.005f ;
                t110:num_bins = 400 ;
                t110:padded = 0 ;
        float satz(satz) ;
                satz:gbcs_state = 5 ;
                satz:lower_bound = 0.f ;
                satz:upper_bound = 60.f ;
                satz:bin_width = 30.f ;
                satz:num_bins = 2 ;
                satz:padded = 0 ;
        float dayn(dayn) ;
                dayn:gbcs_state = 6 ;
                dayn:lower_bound = 0.f ;
                dayn:upper_bound = 180.f ;
                dayn:bin_width = 90.f ;
                dayn:num_bins = 2 ;
                dayn:padded = 0 ;
        float t016(t016) ;
                t016:text_chan = 5 ;
                t016:lower_bound = 0.f ;
                t016:upper_bound = 2.f ;
                t016:bin_width = 0.005f ;
                t016:num_bins = 400 ;
```

```
                t016:padded = 0 ;
        float solz(solz) ;
                solz:gbcs_state = 6 ;
                solz:lower_bound = 20.f ;
                solz:upper_bound = 95.f ;
                solz:bin_width = 5.f ;
                solz:num_bins = 15 ;
                solz:padded = 0 ;
        float tF110(tF110) ;
                tF110:text_chan = 23 ;
                tF110:lower_bound = 0.f ;
                tF110:upper_bound = 2.f ;
                tF110:bin_width = 0.005f ;
                tF110:num_bins = 400 ;
                tF110:padded = 0 ;
        float txt_110(satz, t110) ;
                txt_110:gbcs_pdf = 1 ;
        float txt_016(solz, satz, t016) ;
                txt_016:gbcs_pdf = 1 ;
        float dtxt_110(tF110, t110) ;
                dtxt_110:gbcs_pdf = 1 ;

// global attributes:
                :title = "Gbcs PDF lookup tables" ;
                :institution = "University of Edinburgh" ;
                :contact = "Owen Embury, owen.embury@ed.ac.uk" ;
                :creation_date = "Mon Aug 17 18:57:06 2009" ;
                :ARC_source_id = "ARC_Jul09" ;
                :ARC_config_id = "001" ;
                :ARC_version_id = "1.0" ;
                :comment = "Final (RC1) PDFs for AATSR" ;
}
```

3.3.3 Prior probability look-up table

The overall probability of clear-sky occurring at a given location without any further information is provided in a netCDF format file ‘AATSR_prior.nc’ with the following specification

```
netcdf AATSR_prior {
dimensions:
        lon = 360 ;
        lat = 180 ;
variables:
        float lon(lon) ;
                lon:gbcs_state = 2 ;
                lon:lower_bound = -180.f ;
                lon:upper_bound = 180.f ;
                lon:bin_width = 1.f ;
                lon:num_bins = 360 ;
                lon:padded = 0 ;
        float lat(lat) ;
                lat:gbcs_state = 1 ;
```

```
                lat:lower_bound = -90.f ;
                lat:upper_bound = 90.f ;
                lat:bin_width = 1.f ;
                lat:num_bins = 180 ;
                lat:padded = 0 ;
        float clr_prior(lat, lon) ;
                clr_prior:gbcs_pdf = 1 ;

// global attributes:
                :title = "qwerty" ;
                :institution = "University of Edinburgh" ;
                :contact = "Owen Embury, owen.embury@ed.ac.uk" ;
                :creation_date = "Thu Feb 19 16:49:26 2009" ;
                :gbcs_pdf_ver = 0 ;
                :comment = "Clear-sky prior probability generated from (A)RC
output of 22-Dec-2008" ;
}
```

3.4 Adjustment Parameters

The probability look-up tables derived from (A)ATSR described in Section 3.2 are adjusted to account for differences with the AVHRR-A sensor using parameters contained in a file 'shift_lut.txt'. This is an ASCII text file with contents:

$N_{channels}$
$ID1 \quad a_1 \quad b_1 \quad c_1$
$ID2 \quad a_2 \quad b_2 \quad c_2$
$ID3 \quad a_3 \quad b_3 \quad c_3$

where $N_{channels}$ is the total number of channels to be corrected, *IDn* is the internal index number of the channel in question (6=3.7µm, 8=11µm and 9=12µm) and a_n, b_n and c_n are the coefficients appropriate to the channel.

3.5 RTTOV Coefficient Files

The algorithm makes use of radiative transfer calculations that are undertaken by the RTTOV fast radiative transfer model v11. This accesses coefficient files specified in the *RTTOV11 User Guide* [4].

4. OUTPUT FILES

4.1 Clear Sky Probability

The probability of clear sky is output as a data product from the algorithm, with a Bayesian probability generated corresponding to each image pixel.

4.1.1 File naming convention

The product files use a variable length file name pattern that is modelled on specifications in the Group for High Resolution SST Data Specification (GDS), as follows:

yyyymmddHHMMSS-BAYES-Pclear-<*Product String*>- v*nn.n*-fv*xx.x*.nc

Example:

20100701000000-BAYES-Pclear-AVHRRMTA-v02.0-fv01.0.nc

The filename elements are explained in Table 4-1. It should be noted that, despite the naming convection, since these files do not contain SST fields they are not actually GDS compliant.

Table 4-1: Elements of Clear Sky Probability file names

Pattern Element	Example	Title	Description
yyyymmdd	20100701	Indicative date	The identifying date for this data set. yyyy is the four-digit year, mm is the two-digit month from 01 to 12, and dd is the two-digit day of month from 01 to 31. The date used is the best representation of the observation date for the dataset.
HHMMSS	125400	Indicative time	The indicative time of the data set, i.e. *start time of granule*. HH is the two-digit hour from 00 to 23, MM is the two- digit minute from 00 to 59, and SS is the two- digit second from 00 to 59. All times in UTC. Chosen to best represent the observation time for this dataset.
Product String	ATSR1 ATSR2 AATSR AVHRR<*X*>	A character string identifying the SST product set.	If the satellite hosting the AVHRR is a NOAA platform, <*X*> is the satellite number, if the AVHRR is on MetOp-A, <*X*> is 'MTA'
nn.n	02.0	GDS format version	Set to '02.0'
xx.x	01.0	Version number of the file	

4.1.2 Product data format

The probability of clear sky output files are generated in netCDF-4 classic format based on the L2P file format as defined in [5] section 4.3 and B.1. The file has the following contents:

```
netcdf \20110501023703-BAYES-Pclear-AVHRRMTA-v02.0-fv01.0 {
dimensions:
```

```
	ni = 2048 ;
	nj = 36720 ;
	time = 1 ;
variables:
	float lat(time, nj, ni) ;
		lat:long_name = "Latitude coordinates" ;
		lat:standard_name = "latitude" ;
		lat:units = "degrees_north" ;
		lat:valid_min = -90.f ;
		lat:valid_max = 90.f ;
		lat:reference_datum = "geographical coordinates, WGS84 projection"
;
	float lon(time, nj, ni) ;
		lon:long_name = "Longitude coordinates" ;
		lon:standard_name = "longitude" ;
		lon:units = "degrees_east" ;
		lon:valid_min = -180.f ;
		lon:valid_max = 180.f ;
		lon:reference_datum = "geographical coordinates, WGS84 projection"
;
	int time(time) ;
		time:long_name = "reference time of sst file" ;
		time:standard_name = "time" ;
		time:units = "seconds since 1981-01-01 00:00:00" ;
		time:calendar = "gregorian" ;
	byte probability_clear(time, nj, ni) ;
		probability_clear:_FillValue = -128b ;
		probability_clear:long_name = "Probability of pixel being clear" ;
		probability_clear:units = "" ;
		probability_clear:add_offset = 0.f ;
		probability_clear:scale_factor = 0.01f ;
		probability_clear:valid_min = 0b ;
		probability_clear:valid_max = 100b ;
		probability_clear:coordinates = "lon lat" ;
		probability_clear:comment = "Probability of pixel being clear as
estimated by Bayesian cloud detection" ;
	short sst_dtime(time, nj, ni) ;
		sst_dtime:_FillValue = -32768s ;
		sst_dtime:long_name = "time difference from reference time" ;
		sst_dtime:units = "seconds" ;
		sst_dtime:add_offset = 0.f ;
		sst_dtime:scale_factor = 1.f ;
		sst_dtime:valid_min = -32767s ;
		sst_dtime:valid_max = 32767s ;
		sst_dtime:comment = "time plus sst_dtime gives seconds after 1981-
01-01 00:00:00" ;
		sst_dtime:coordinates = "lon lat" ;
	byte solar_zenith_angle(time, nj, ni) ;
		solar_zenith_angle:_FillValue = -128b ;
		solar_zenith_angle:long_name = "solar zenith angle" ;
		solar_zenith_angle:standard_name = "zenith_angle" ;
		solar_zenith_angle:units = "angular_degree" ;
```

```
            solar_zenith_angle:add_offset = 90.f ;
            solar_zenith_angle:scale_factor = 1.f ;
            solar_zenith_angle:valid_min = -90b ;
            solar_zenith_angle:valid_max = 90b ;
            solar_zenith_angle:coordinates = "lon lat" ;
            solar_zenith_angle:comment = "The solar zenith angle at time of
the observations" ;
      short l2p_flags(time, nj, ni) ;
            l2p_flags:long_name = "L2P flags" ;
            l2p_flags:valid_min = 0s ;
            l2p_flags:valid_max = 255s ;
            l2p_flags:flag_meanings = "microwave land ice lake river spare
views channels" ;
            l2p_flags:flag_masks = 1s, 2s, 4s, 8s, 16s, 32s, 64s, 128s ;
            l2p_flags:comment = "These flags are important to properly use the
data" ;
            l2p_flags:coordinates = "lon lat" ;

// global attributes:
            :Conventions = "CF-1.5" ;
            :title = "Bayesian clear sky probabilities for AVHRRMTA" ;
            :summary = "This netCDF file contains clear sky probabilities es-
timated using the Generalised Bayesian Cloud Screening (Gbcs) library. These
data are generated using techniques developed within the ATSR Reprocessing for
Climate project." ;
            :references = "This netCDF file contains clear sky probabilities
estimated using the Generalised Bayesian Cloud Screening (Gbcs) library. These
data are generated using techniques developed within the ATSR Reprocessing for
Climate project." ;
            :institution = "EUMETSAT" ;
            :history = "Created using GBCS library $Rev: 1821 $" ;
            :comment = "These data were produced at the EUMETSAT using soft-
ware developed at The University of Edinburgh within the ATSR Reprocessing for
Climate project and the University of Reading." ;
            :license = "" ;
            :id = "ARC-BAYES-Pclear-AVHRRMTA-v2" ;
            :naming_authority = "" ;
            :product_version = "1.0" ;
            :uuid = "fd0f7330-416a-11e3-8d66-1fec013047b4" ;
            :netcdf_version_id = "4.3.0 of Aug 19 2013 13:21:46 $" ;
            :date_created = "2013-10-30 13:55:51Z" ;
            :spatial_resolution = "1 km at nadir" ;
            :start_time = "2011-05-01 02:37:03Z" ;
            :time_coverage_start = "2011-05-01 02:37:03Z" ;
            :stop_time = "2011-05-01 04:19:03Z" ;
            :time_coverage_end = "2011-05-01 04:19:03Z" ;
            :time_coverage_duration = "PT1H42M00S" ;
            :time_coverage_resolution = "PT1S" ;
            :northernmost_latitude = 90. ;
            :southernmost_latitude = -90. ;
            :easternmost_longitude = 180. ;
            :westernmost_longitude = -180. ;
            :source = "AVHRRMTA-EUMETSAT-L1-v1" ;
            :platform = "MetOpA" ;
```

```
            :sensor = "AVHRR" ;
            :Metadata_Conventions = "Unidata Dataset Discovery v1.0" ;
            :metadata_link = "" ;
            :keywords = "Atmosphere > Clouds" ;
            :keywords_vocabulary = "NASA Global change Master Directory (GCMD)
Science Keywords" ;
            :standard_name_vocabulary = "NetCDF Climate and Forecast (CF)
Metadata Convention" ;
            :geospatial_lat_units = "degrees_north" ;
            :geospatial_lat_resolution = 0.01f ;
            :geospatial_lon_units = "degrees_east" ;
            :geospatial_lon_resolution = 0.01f ;
            :acknowledgment = "" ;
            :creator_name = "" ;
            :creator_email = "" ;
            :creator_url = "" ;
            :project = "" ;
            :publisher_name = "" ;
            :publisher_url = "" ;
            :publisher_email = "" ;
            :processing_level = "L1" ;
            :cdm_data_type = "swath" ;
}
```