Environmental Satellite Processing Center (ESPC)



NOAA Unique CrlS/ATMS Product System (NUCAPS)

External Users Manual (EUM)

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Environmental Satellite Processing Center (ESPC)



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The NOAA Unique CrIS/ATMS Product System

External Users Manual

Approval Page

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# PRODUCTS

This is an external user’s manual document describing the NOAA Unique CrIS/ATMS Product System (NUCAPS) products and output files. The NUCAPS product system was developed at the Center for Satellite Applications and Research (STAR). It will be delivered to the NPOESS Data Exploitation (NDE) team and integrated into the NDE Data Handling System (DHS) where it will be run in a pre-operational manner. The NDE DHS will also run several other product systems developed at STAR. After a preliminary testing period, the NDE DHS will, in turn, be delivered to the Office of Satellite and Product Operations (OSPO) to be run operationally.

The intended users of the External Users Manual (EUM) are end users of the output products and files, and the product verification and validation (V&V) teams. The purpose of the EUM is to provide product users and product testers with information that will enable them to acquire the product, understand its features, and use the data. External users are defined as those users who do not have direct access to the processing system (those outside of the OSPO and NDE). The output files are defined as those leaving the NDE DHS (running within ESPC) as opposed to those that are output by the NUCAPS processing, but available only internally within the NDE. NUCAPS does output some files for tailoring into BUFR within NDE. Those tailored files are described in a separate EUM.

## Product Overview

### Product Requirements

All NUCAPS basic and derived requirements are available in the NUCAPS Requirements Allocation Document (RAD). These requirements identify the users and their needs with respect to file content, format, latency, and quality.

### Product Team

The NUCAPS Development product team consists of members from STAR and OSPO. The roles and contact information for the different product team members are identified in .

Table ‑ Product Team Members

|  |  |  |  |
| --- | --- | --- | --- |
| Team Member | Organization | Role | Contact Information |
| Walter Wolf | STAR | STAR Product Lead | 5830 University Research CourtCollege Park, MD. 20740 Phone: 301-683-1314Email: Walter.Wolf@noaa.gov |
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| Tony Reale | STAR | STAR Scientist | NSOF4231 Suitland RdSuitland MD 20746Email: tony.reale@noaa.gov |
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### Product Description

The NOAA Unique CrIS/ATMS Processing System (NUCAPS) was developed to generate (1) spectrally and spatially thinned radiances, (2) retrieved products such as profiles of temperature, moisture, trace gases and cloud-cleared radiances, and (3) global validation products such globally gridded OLR and EDR products. The thinned radiance products are not external outputs of NDE. After they are produced in the NUCAPS system they are tailored into BUFR by the N4RT system that also runs within NDE. Therefore, the only external outputs are the retrieved and the validation products. Details on the content of all NUCAPS external output files are shown in section 1.3.

##  Product History

NUCAPS is a new product system was made operational in several phases. Phase 1 went operational in April 2012 with thinned radiances, principal components, and SDR validation products.  Phase 2 went operational in October 2013 adding temperature, moisture, and trace gases profiles along with global EDR validation products (grids).  Phase 3 was made operational in October 2015.  It included VIIRS/CrIS collocation to include VIIRS cloud products for the CrIS SDR BUFR, updates and bug fixes to the preprocessor and retrieval codes, ILS correction, and a port from IBM to Linux GNU compilers. Phase 4 is planned to be operational by summer of 2016 and will include modifications to the preprocessor and retrieval the use of CrIS full spectrum data.

## Product Access

All NUCAPS output data files will be made available by the NDE DHS on the NDE data distribution server at ESPC in a near real time manner. For access to this server, information about data files, and associated documentation, the NUCAPS PAL should be contacted (see Table 1‑1).

The NESDIS' Policy on Access and Distribution of Environmental Data and Products is provided at: <http://www.ospo.noaa.gov/Organization/About/access.html>.

Users need to fill out the Data Access Request Form located on this site and submit to the PAL with a copy to nesdis.data.access@noaa.gov. This address provides the OSPO Data Access Team a copy of the correspondence. The process is defined in the following diagram. Once the request is approved by the OSPO management the data will be delivered by the Data Distribution System (DDSProd) currently distributing the ESPC data products and later by the Product Distribution and Access (PDA) system. The ESPC Data Distribution Manager, Donna McNamara (donna.mcnamara@noaa.gov) should be contacted for any data accessibility and data distribution problems.



Figure ‑ NDE Data Access Process

The data format is defined in Table 1.2

In order to obtain the near real time data, the user needs to fill out the Data Access Request Form located on <http://www.ospo.noaa.gov/Organization/About/access.html> and submit it to the PAL with a copy to nesdis.data.access@noaa.gov. CLASS will be archiving the NUCAPS data products for distributing to the non-real time users. NDE pushes the data to CLASS with the associated metadata in the standard formats. CLASS will archive the NUCAPS EDR (trace gases) products in netCDF4 format with associated metadata and the Cloud Clear Radiance (CCR) product for the full channel set (1305) in netCDF4 with associated CCR granule metadata compliant with ISO metadata and CF 1.5 version standards. The thinned radiances will not be archived as they can be generated from the archived full SDR data.

Table 1‑2 lists all NUCAPS files distributed outside of the NDE system to external users. The BUFR and AWIPS files are not produced inside the NUCAPS software, but are produced elsewhere downstream within the NDE system. Each global grid includes two binary data files, which are ascending orbital data file (ASC) and descending orbital data file (DSC). Table 1‑3 ~ Table 1‑6 shows the detailed content of each output files listed in Table 1‑2.

Table ‑ NUCAPS Output Files

|  |  |  |  |
| --- | --- | --- | --- |
| File | Description | Format | Size/file |
| NUCAPS-EDR\_v1r0\_npp\_s???????????????\_e???????????????\_c??????????????.nc | This is the granule output file containing all the retrieval (profile) products. | netCDF4 | 3.1 MB/file2700 files/day |
| NUCAPS-CCR-AR\_v1r0\_npp\_s???????????????\_e???????????????\_c??????????????.nc | This is the granule output file containing cloud-cleared radiance product data. | netCDF4 | 0.7 MB/file2700 files/day |
| NUCAPS-OLR\_v1r0\_npp\_s???????????????\_e???????????????\_c???????????????.nc | This is the granule output file containing the outgoing longwave radiance product data. | netCDF4 | 0.6 MB/file 2700 files/day |
| NUCAPS-GG-EDR-GRIDS-?SC\_v1r0\_npp\_s???????????????\_e???????????????\_c??????????????.bin | CrIS/ATMS retrievals on a daily global grid at 0.5X2 degree resolution. | Gridded direct-access binary | 726 MB/file2 files/day |
| NUCAPS-GG-OLR-GRIDS-?SC\_v1r0\_npp\_s??????????????\_e??????????????\_c??????????????.bin | Outgoing Longwave Range CrIS radiances on a daily global grid at  | Gridded direct-access binary | 5.8 MB/file 2 files/day |
| NUCAPS-PCS-MONITORING\_v1r0\_npp\_s???????????????\_e???????????????\_c??????????????.txt | This is the PCS statistics monitoring file. This is to be distributed for SDR monitoring at OSPO. | Text file | 0.0015 MB/file2700 files/day |
| NUCAPS-EDR-MONITORING\_ v1r0\_npp\_s???????????????\_e???????????????\_c??????????????.txt | This is the retrieval monitoring output file. | Text file | 0.078 MB/file2700 files/day |
| NUCAPS\_EDR\_IUTN06\_KNES\_npp\_$.nc.wmo | NUCAPS EDR for AWIPS for 9 sectors | netCDF4 | 0.215 MB/file 1648 files/day |
| C0399\_v1r0\_npp\_s???????????????\_e???????????????\_c???????????????.bufr | The output CrIS 399-channel full spatial resolution BUFR file converted from NUCAPS netCDF4. | BUFR | 0.8 MB/file2700 files/day |
| C1305\_v1r0\_npp\_s???????????????\_e???????????????\_c???????????????.bufr | The output CrIS 1305-channel full spatial resolution BUFR file converted from NUCAPS netCDF4. | BUFR | 2.8 MB/file2700 files/day |

Table ‑ NUCAPS EDR File

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| Variable | Type | Description | Dim | Units | Range |
| CrIS\_FORs | Long | CrIS Fields of Regard per granule | 120 | None | 1 to 120 |
| Time | Double | UTC Milliseconds since Jan 1, 1970 | 120 | Milliseconds | 950000000000 to 2500000000000 |
| Latitude | Float | Latitude of the center of the FOR | 120 | Degrees | -90 to 90 |
| Longitude | Float | Longitude of the center of the FOR | 120 | Degrees | -180 to 180 |
| View\_Angle | Float | Viewing angle of the sensor from the satellite | 120 | Degrees | -60 to 60 |
| Satellite\_Height | Float | Satellite height above the FOR | 120 | km | 800 to 900 |
| Mean\_CO2 | Float | Column averaged CO2 of the FOR | 120 | ppm | 0 to 1000 |
| Solar\_Zenith | Float | Solar zenith angle | 120 | Degrees | 0 to 180 |
| Ascending\_Descending | Short | Orbital status | 120 | None | 0 to 1 |
| Topography | Float | Surface height | 120 | Meters | 0 to 10000 |
| Land\_Fraction | Float | Land fraction | 120 | None | 0 to 1 |
| Surface\_Pressure | Float | Surface air pressure | 120 | mb | 0 to 10000 |
| Skin\_Temperature | Float | Surface temperature | 120 | Kelvin | 0 to 1000 |
| MIT\_Skin\_Temperature | Float | Surface temperature from MIT retrieval | 120 | Kelvin | 0 to 1000 |
| FG\_Skin\_Temperature | Float | Surface temperature from the first guess | 120 | Kelvin | 0 to 1000 |
| MW\_Surface\_Class | Short | Microwave surface class | 120 | None | 0 to 10 |
| MW\_Surface\_Emis | Float | Microwave surface emissivity | 120 | None | 0 to 1 |
| N\_Smw\_Per\_FOV | Long | Number of MW spectral points | 120 | None | 1 to 16 |
| nemis\_Per\_FOV | Long | Number of surface emis hinge points | 120 | None | 1 to 100 |
| ncemis\_Per\_FOV | Long | Number of cloud emis hinge points | 120 | None | 1 to 100 |
| ncld\_Per\_FOV | Long | Number of cloud layers | 120 | None | 1 to 8 |
| Quality\_Flag | Long | Quality flags for retrieval | 120 | None | 0 to 31 |
| Ispare\_Field | Long | Ispare diagnostics array from retrieval | 129X120 | None | N/A, see NUCAPS SMM |
| Rspare\_Field | Float | Rspare diagnostics array from retrieval | 258X120 | None | N/A, see NUCAPS SMM |
| Cloud\_Top\_Pressure | Float | Cloud top air pressure | 8X120 | mb | 0 to 10000 |
| Cloud\_Top\_Fraction | Float | Cloud top fractional coverage | 8X120 | None | 0 to 1 |
| Pressure | Float | Air pressure | 100X120 | mb | 0 to 2000 |
| Effective\_Pressure | Float | Effective Air pressure | 100X120 | mb | 0 to 2000 |
| Temperature | Float | Air temperature | 100X120 | Kelvin | 0 to 1000 |
| MIT\_Temperature | Float | Air temperature from MIT retrieval | 100X120 | Kelvin | 0 to 1000 |
| FG\_Temperature | Float | Air temperature from the first guess | 100X120 | Kelvin | 0 to 1000 |
| H2O | Float | Water vapor layer column density | 100X120 | molecules/cm2 | 0 to 100000000 |
| MIT\_H2O | Float | Water vapor layer column density from MIT retrieval | 100X120 | molecules/cm2 | 0 to 100000000 |
| FG\_H2O | Float | Water vapor layer column density from the first guess | 100X120 | molecules/cm2 | 0 to 100000000 |
| H2O\_MR | Float | Water vapor mixing ratio | 100X120 | g/g | 0 to 100000000 |
| MIT\_H2O\_MR | Float | Water vapor mixing ratio from MIT retrieval | 100X120 | g/g | 0 to 100000000 |
| FG\_H2O\_MR | Float | Water vapor mixing ratio from the first guess | 100X120 | g/g | 0 to 100000000 |
| O3 | Float | Ozone layer column density | 100X120 | molecules/cm2 | 0 to 100000000 |
| FG\_O3 | Float | Ozone layer column density from first guess | 100X120 | molecules/cm2 | 0 to 100000000 |
| O3\_MR | Float | Ozone mixing ratio | 100X120 | ppb | 0 to 100000000 |
| FG\_O3\_MR | Float | Ozone mixing ratio from first guess | 100X120 | ppb | 0 to 100000000 |
| Liquid\_H2O | Float | Liquid water layer column density | 100X120 | molecules/cm2 | 0 to 100000000 |
| Liquid\_H2O\_MR | Float | Liquid water mixing ratio | 100X120 | g/g | 0 to 100000000 |
| Ice\_Liquid\_Flag | Short | Ice liquid flag | 100X120 | None | 0 to 1 |
| CO | Float | Carbon monoxide layer column density | 100X120 | molecules/cm2 | 0 to 100000000 |
| CO\_MR | Float | Carbon monoxide mixing ratio | 100X120 | ppb | 0 to 100000000 |
| CH4 | Float | Methane layer column density | 100X120 | molecules/cm2 | 0 to 100000000 |
| CH4\_MR | Float | Methane mixing ratio | 100X120 | ppb | 0 to 100000000 |
| CO2 | Float | Carbon dioxide dry mixing ratio | 100X120 | ppm | 0 to 1000 |
| HNO3 | Float | Nitric Acid layer column density | 100X120 | molecules/cm2 | 0 to 100000000 |
| HNO3\_MR | Float | Nitric Acid mixing ratio | 100X120 | ppb | 0 to 100000000 |
| N2O | Float | Nitrous Oxide layer column density | 100X120 | molecules/cm2 | 0 to 100000000 |
| N2O\_MR | Float | Nitrous Oxide mixing ratio | 100X120 | ppb | 0 to 100000000 |
| SO2 | Float | Sulfur Dioxide layer column density | 100X120 | molecules/cm2 | 0 to 100000000 |
| SO2\_MR | Float | Sulfur Dioxide mixing ratio | 100X120 | ppb | 0 to 100000000 |
| MW\_Frequency | Float | Microwave frequency | 16X120 | cm-1 | 0 to 10000 |
| MW\_Emis | Float | Microwave emissivity | 16X120 | None | 0 to 1 |
| MIT\_MW\_Emis | Float | Microwave emissivity from MIT retrieval | 16X120 | None | 0 to 1 |
| IR\_Emis\_Freq | Float | IR emissivity hinge point frequencies | 100X120 | cm-1 | 0 to 10000 |
| FG\_IR\_Emis\_Freq | Float | IR emissivity hinge point frequencies from the first guess | 100X120 | cm-1 | 0 to 10000 |
| IR\_Surface\_Emis | Float | IR surface emissivity | 100X120 | None | 0 to 1 |
| FG\_IR\_Surface\_Emis | Float | IR surface emissivity from the first guess | 100X120 | None | 0 to 1 |
| IR\_Surface\_Refl | Float | IR surface reflectance | 100X120 | percent | 0 to 100 |
| Stability | Float | Stability parameters | 16X120 | Varying | 0 to 1000000 |
| Cloud\_Freq | Float | Cloud IR frequencies | 100X8X120 | cm-1 | 0 to 10000 |
| Cloud\_Emis | Float | Cloud IR emissivity | 100X8X120 | None | 0 to 1 |
| Cloud\_Refl | Float | Cloud IR reflectivity | 100X8X120 | percent | 0 to 100 |
| quality\_information | Char | Empty variable, containing a collection of attributes describing quality information metadata | 0 | N/A | N/A |

Table ‑ NUCAPS CCR Archive File

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| Variable | Type | Description | Dim | Units | Range |
| CrIS\_Channels | Long | Channel number for the CrIS radiance data | 1317 | None | 1 to 1317 |
| CrIS\_Frequencies | Float | Frequency at which the CrIS radiances are observed | 1317 | cm-1 | 1 to 10000 |
| Subset\_CrIS\_FORs | Long | The index of the CrIS fields of regard to subset | 120 | None | 1 to 120 |
| Subset\_CrIS\_FOVs | Long | The index of the CrIS fields of view to subset | 1 | None | 1 to 9 |
| Scan\_Line | Long | The number of the current scan line in the granule | 120 | None | 1 to 4 |
| CrIS\_FORs | Long | CrIS Fields of Regard per granule | 120 | None | 1 to 120 |
| CrIS\_FOVs | Long | CrIS Fields of View per FOR | 120 | None | 1 to 9 |
| Quality\_Flag | Byte | CrIS quality flag | 120 | None | 0 to 31 |
| Time | Double | UTC Milliseconds since Jan 1, 1970 | 120 | Milliseconds | 950000000000 to 2500000000000 |
| CrIS\_Latitude | Float | CrIS Latitude values for each FOV | 120 | Degrees | -90 to 90 |
| CrIS\_Longitude | Float | CrIS Longitude values for each FOV | 120 | Degrees | -180 to 180 |
| CrIS\_Radiances | Float | CrIS Cloud-Cleared Radiances (CCR) for each FOV | 1317X120 | mW/(m2 sr cm-1) | -5 to 150 |
| CrIS\_View\_Angle | Float | CrIS View Angles for each FOV | 120 | Degrees | -60 to 60 |
| Satellite\_Height | Float | Satellite height above each FOV | 120 | km | 800 to 900 |
| Solar\_Zenith | Float | Solar zenith angles for each FOV | 120 | Degrees | 0 to 180 |
| Ascending\_Descending | Short | Orbital status for each FOV | 120 | None | 0 to 1 |
| quality\_information | Char | Empty variable, containing a collection of attributes describing quality information metadata | 0 | N/A | N/A |

Table 1‑5 NUCAPS OLR File

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| Variable | Type | Description | Dim | Units | Range |
| LAT | Float | CrIS Latitude values for each FOV | 4x30x9 | Degrees | -90 to 90 |
| LON | Float | CrIS Longitude values for each FOV | 4x30x9 | Degrees | -180 to 180 |
| TIME | Double | UTC time as milliseconds from 01/01/1970 | 4x30x9 | msec |  |
| SATZEN | Float | Solar zenith angles for each FOV | 4x30x9 | Degrees | 0 to 180 |
| SATHEIGHT | Float | SATELLITE HEIGHT for each FOV | 4x30x9 | km | 0 to 180 |
| VIEWANG | Float | CrIS View Angles for each FOV | 4x30x9 | Degrees | -49 to 49 |
| FLUX | Float | CrIS OLR at top-of-atmosphere | 4x30x9 | Wm-2 | 0 to 500 |
| QA | Short | CrIS level1c radiance quality flag | 4x30x9 | None | 0 to 1 |
| AD | Short | CrIS level1c AD flag | 4x30x9 | None | 0 to 1 |

Table ‑ NUCAPS EDR 0.5X2 Global Grids File

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| Variable | Type | Description | Dim | Units | Range |
| YearMonthDay | Float | Calendar date | 720X91 | MMDDYY | 010100 to 123199 |
| Time | Float | Hours.Fractional\_Minutes | 720X91 | Hours | 0 to 24 |
| Grid\_Latitude | Float | Latitude locations of the grid points | 720X91 | Degrees | -90 to 90 |
| Grid\_Longitude | Float | Longitude locations of the grid points | 720X91 | Degrees | -180 to 180 |
| Instrument\_Latitude | Float | Latitude of the actual observations | 720X91 | Degrees | -90 to 90 |
| Instrument\_Longitude | Float | Longitude of the actual observations | 720X91 | Degrees | -180 to 180 |
| View\_Angle | Float | Viewing angle of the sensor from the satellite | 720X91 | Degrees | -60 to 60 |
| Satellite\_Height | Float | Satellite height | 720X91 | km | 800 to 900 |
| Mean\_CO2 | Float | Column averaged CO2 of the FOR | 720X91 | ppm | 0 to 1000 |
| Solar\_Zenith | Float | Solar zenith angle | 720X91 | Degrees | 0 to 180 |
| Topography | Float | Surface height | 720X91 | Meters | 0 to 10000 |
| Land\_Fraction | Float | Land fraction | 720X91 | None | 0 to 1 |
| Surface\_Pressure | Float | Surface air pressure | 720X91 | mb | 0 to 10000 |
| Skin\_Temperature | Float | Surface temperature | 720X91 | Kelvin | 0 to 1000 |
| MW\_Surface\_Class | Float | Microwave surface class | 720X91 | None | 0 to 10 |
| MW\_Surface\_Emis | Float | Microwave surface emissivity | 720X91 | None | 0 to 1 |
| N\_Smw\_Per\_FOV | Float | Number of MW spectral points | 720X91 | None | 1 to 16 |
| nemis\_Per\_FOV | Float | Number of surface emis hinge points | 720X91 | None | 1 to 100 |
| ncemis\_Per\_FOV | Float | Number of cloud emis hinge points | 720X91 | None | 1 to 100 |
| ncld\_Per\_FOV | Float | Number of cloud layers | 720X91 | None | 1 to 8 |
| Quality\_Flag | Float | Quality flags for retrieval | 720X91 | None | 0 to 31 |
| Cloud\_Top\_Pressure | Float | Cloud top air pressure | 720X91X8 | mb | 0 to 10000 |
| Cloud\_Top\_Fraction | Float | Cloud top fractional coverage | 720X91X8 | None | 0 to 1 |
| Pressure | Float | Air pressure | 720X91X100 | mb | 0 to 2000 |
| Effective\_Pressure | Float | Effective aire pressure | 720X91X100 | mb | 0 to 2000 |
| Temperature | Float | Air temperature | 720X91X100 | Kelvin | 0 to 1000 |
| H2O | Float | Water vapor layer column density | 720X91X100 | molecules/cm2 | 0 to 100000000 |
| H2O\_MR | Float | Water vapor mixing ratio | 720X91X100 | g/g | 0 to 100000000 |
| O3 | Float | Ozone layer column density | 720X91X100 | molecules/cm2 | 0 to 100000000 |
| O3\_MR | Float | Ozone mixing ratio | 720X91X100 | ppb | 0 to 100000000 |
| Liquid\_H2O | Float | Liquid water layer column density | 720X91X100 | molecules/cm2 | 0 to 100000000 |
| Liquid\_H2O\_MR | Float | Liquid water mixing ratio | 720X91X100 | g/g | 0 to 100000000 |
| Ice\_Liquid\_Flag | Float | Ice liquid flag | 720X91X100 | None | 0 to 1 |
| CO | Float | Carbon monoxide layer column density | 720X91X100 | molecules/cm2 | 0 to 100000000 |
| CO\_MR | Float | Carbon monoxide mixing ratio | 720X91X100 | ppb | 0 to 100000000 |
| CH4 | Float | Methane layer column density | 720X91X100 | molecules/cm2 | 0 to 100000000 |
| CH4\_MR | Float | Methane mixing ratio | 720X91X100 | ppb | 0 to 100000000 |
| CO2 | Float | Carbon dioxide dry mixing ratio | 720X91X100 | ppm | 0 to 1000 |
| N2O | Float | Nitrous Oxide layer column density | 720X91X100 | molecules/cm2 | 0 to 100000000 |
| N2O\_MR | Float | Nitrous Oxide mixing ratio | 720X91X100 | ppb | 0 to 100000000 |
| SO2 | Float | Sulfur Dioxide layer column density | 720X91X100 | molecules/cm2 | 0 to 100000000 |
| SO2\_MR | Float | Sulfur Dioxide mixing ratio | 720X91X100 | ppb | 0 to 100000000 |
| HNO3 | Float | Nitric Acid layer column density | 720X91X100 | molecules/cm2 | 0 to 100000000 |
| HNO3\_MR | Float | Nitric Acid mixing ratio | 720X91X100 | ppb | 0 to 100000000 |
| MW\_Frequency | Float | Microwave frequency | 720X91X16 | cm-1 | 0 to 10000 |
| MW\_Emis | Float | Microwave emissivity | 720X91X16 | None | 0 to 1 |
| IR\_Emis\_Freq | Float | IR emissivity hinge point frequencies | 720X91X100 | cm-1 | 0 to 10000 |
| IR\_Surface\_Emis | Float | IR surface emissivity | 720X91X100 | None | 0 to 1 |
| IR\_Surface\_Refl | Float | IR surface reflectance | 720X91X100 | percent | 0 to 100 |
| CrIS\_FORs | Float | CrIS Fields of Regard | 720X91 | None | 1 to 120 |
| FG\_Temperature | Float | Air temperature from the first guess | 720X91X100 | Kelvin | 0 to 1000 |
| FG\_H2O\_MR | Float | Water vapor mixing ratio from the first guess | 720X91X100 | g/g | 0 to 100000000 |
| FG\_O3\_MR | Float | Ozone mixing ratio from the first guess | 720X91X100 | ppb | 0 to 100000000 |

Table 1‑7 NUCAPS OLR 0.5X2 Global Grids File

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| Variable | Type | Description | Dim | Units | Range |
| YearMonthDay | Real | Year/Month/Day string given as YYYYMMDD. | 720X91 | MMDDYY | 010100 to 123199 |
| Time | Real | Hours.Fractional\_Minutes | 720X91 | Hours | 0 to 24 |
| Grid\_Latitude | Real | Lat locations of the grid points (± 90 degrees) | 720X91 | Degrees | -90 to 90 |
| Grid\_Longitude | Real | Lon locations of the grid points (± 90 degrees) | 720X91 | Degrees | -180 to 180 |
| Instrument\_Latitude | Real | Lat locations of the actual observations (± 90 degrees) | 720X91 | Degrees | -90 to 90 |
| Instrument\_Longitude | Real | Lon locations of the actual observations (± 90 degrees) | 720X91 | Degrees | -180 to 180 |
| View\_Angle | Real | The view angle of the current CrIS FOV (± 90 degrees)  | 720X91 | Degrees | -60 to 60 |
| Satellite\_Zenith | Real | The satellite zenith of each matched CrIS FOV (0 - 90 degrees). | 720X91 | Degrees | 0 to 70 |
| Satellite\_Height | Real | The satellite height of each matched CrIS FOV (km). | 720X91 | km | 800 to 900 |
| Flux | Real | Outgoing Longwave Radiation Flux | 720X91 | Wm-2 | 0 to 500 |
| Quality\_Flag | Real | OLR quality flag | 720X91 | None | 0 to 1 |

# ALGORITHM

## Algorithm Overview

The NUCAPS profile products and cloud-cleared radiances are generated using a retrieval algorithm whereas the thinned radiances and global products do not require a science algorithm and can be conceived of as a reorganization of the data. The Outgoing Longwave Radiances are generated using a separate code. The retrieval algorithm runs inside a system of supporting software. This system was developed during the Aqua mission to use data from the AIRS/AMSU/MODIS instruments, but was designed to be flexible to use IASI/AMSU-A/MHS/AVHRR and CrIS/ATMS/VIIRS. Therefore, even though it is referred to in this document as the NUCAPS algorithm, it is in fact identical to that used for AIRS and IASI. The NUCAPS retrieval algorithm has a flexible modular design that allows the types of instruments, the amount of diagnostics, and the activation of various retrieval process steps to be turned on or off via a set of input name-lists. This flexibility allows the system to be used for research or in a faster and more efficient operational manner. For information about the NUCAPS algorithm, see the NUCAP Algorithm Theoretical Basis Document (NESDIS/STAR, 2009). The output files are described earlier in section 1.3. This section describes the input files.

## Input Satellite Data

### Satellite Instruments

NUCAPS is a product system operated within the NDE DHS by OSPO. NUCAPS uses data from the Cross-track Infrared Sounder (CrIS) and the Advanced Technology Microwave Sounder (ATMS) instruments on the NPOESS Preparatory Project (NPP) platform. NPP launched on October 28, 2011. It is in a sun synchronous circular orbit with a 10:30am descending-node orbit at an altitude of 824 km.

CrIS is a Michelson Interferometer with 1305 channels measuring in the Infrared (IR) portion of the spectrum. It has the following spectral characteristics:

Spectral bands:

LWIR Band 650-1095 cm-1

MWIR Band 1210-1750 cm-1

SWIR Band 2155-2550 cm-1

Spectral Resolution:

LWIR Band <0.625cm-1

MWIR Band <1.25cm-1

SWIR Band <2.50cm-1

The CrIS instrument starts a new Earth scan every 8 seconds. Each scans contains 30 Fields of Regard (FOR) viewed on the Earth’s surface with a scan width of ±50˚. Each FOR contains a simultaneously measured 3X3 set of Fields of View (FOVs). The CrIS FOVs are circular and have a diameter of 14 km at nadir.

ATMS is a cross-track scanning 22-channel passive microwave radiometer. The channels are bands from 23 GHz through 183 GHz making its measurement capabilities similar to that of the Advanced Microwave Sound Unit (AMSU) and the Microwave Humidity Sounder (MHS). ATMS makes three scans (a scan set) every eight seconds. Each scan contains a single row of 96 FOVs. The FOV coverage sizes vary for each ATMS channel. ATMS scan sets are synchronized with those of the CrIS instrument. With each scan, the ATMS FOV coverage extends over each end of the associated CrIS scans. This is done to allow for footprint resampling of the smaller ATMS FOVs into larger AMSU-A like footprints (~40km at nadir). The resampled ATMS radiances can be used as input into existing retrieval algorithms like that in NUCAPS.

Both the CrIS and ATMS instruments are scheduled to fly on the JPSS J1 and J3 platforms as well. Additional details about these instruments can be found at:

<http://jointmission.gsfc.nasa.gov/cris.html>

### Pre-Processing Steps

The Raw Data Records (RDR) CrIS and ATMS instrument packet data are transmitted from the satellite to the ground stations and are then sent to the Internal Data Processing Segment (IDPS) at the NOAA Satellite Operations Facility (NSOF). The IDPS applies the instrument calibration and geolocation to generate the Science Data Records (SDR) and Temperature Data Record (TDR) files required by NUCAPS. The SDR and TDR are distributed from the IDPS and made available to NDE as 32 second granule files in HDF5 format. When NDE has the inputs required to process a CrIS and ATMS granule set (based on the NUCAPS production rules), it executes the job to produce the output file described in this document.

Format information on the CrIS and ATMS SDR and TDR files is described in the NPOESS Common Data Format Control Book – External, Volume III – SDR/TDR Formats. The most recent versions of all the CDFCB documents can be obtained from the JPSS Program Office or from the NASA NPP site:

http://npp.gsfc.nasa.gov/documents.html

http://www.nasa.gov/mission\_pages/NPP/main/index.html

Information about the GFS forecast files can be found at: <http://www.nco.ncep.noaa.gov/pmb/products/gfs/>

Within NUCAPS, there is additional pre-processing required to get the CrIS, ATMS, and GFS data into an input format that can be directly read by the retrieval code. That internal NUCAPS preprocessing is disc**u**ssed in the NUCAPS SMM (NESDIS/STAR, 2011).

NDE Data Handling System (DHS) ingests the CrIS and ATMS SDR data from IDPS. The NUCAPS software units generate the products running within NDE system and the output products are distributed by the NDE distribution system. The IDPS produces the CriS and ATMS SDR using the algorithms described in the Algorithm Theoretical Basis Document (ATBD) that is available at

http://ntrs.nasa.gov/archive/nasa/casi.ntrs.nasa.gov/20120014588.pdf

CrIS is a Michelson interferometer based on the principle of Fourier Transform and designed to measure with high resolution and high spectral accuracy the emission of infrared radiation from the atmosphere in three bands in the spectral range from 3.9 to 15.4 µm (650 – 2550 cm–1). The core of the instrument is a Fourier transform spectrometer which measures in one sweep the spectral features of the atmosphere with high spectral resolution and throughput. The spectrometer transforms the incoming spectral radiance, i.e. the spectrum, into a modulated signal, the interferogram, where all infrared wavenumbers in the band of interest are present simultaneously. The output from the spectrometer consists of one such interferogram for each observed scene.

Level 1B ground segment algorithms are required to transform raw instrument records (RDR) into sensor data records (SDR), which are essentially calibrated spectra. Auxiliary data will also be used in conjunction with several indicators to address the accuracy of the data. The SDR Algorithm system mathematically retransforms the scene interferograms from the CrIS instrument into spectral information useful for retrieving the atmospheric parameters,

The incoming data may be acquired during deep space, internal calibration blackbody, and scene atmospheric measurements of the CrIS sensor. Each of these three types of incoming data therefore needs to be processed differently. Once combined together they will ultimately generate calibrated spectra with small residual errors.

The main objectives of the SDR Algorithms are:

Pre-process incoming data packets

Load and sort data

Convert interferograms to spectra

Convert scene measurements into calibrated spectra

Compute *spectral calibration*, using metrology wavelength measurements

» Characterize metrology using neon lamp reference measurements

» Monitor metrology drift using laser diode parameters measurements

» Perform alias unfolding and spectral labeling

» Map spectral channels to a fixed wavenumber grid

Compute *radiometric calibration*, using reference calibration measurements

» Average warm calibration target data, average cold calibration target data

» Subtract sensor background radiance

» Remove sensor induced phase dispersion

» Correct for fringe count errors

» Perform non-linearity correction

» Correct for off-axis self-apodization on each FOV

» Correct for polarization errors

» Remove orthogonal noise components

Compute *geometric calibration*, using LOS position and ephemeris data

Evaluate the associated error

Check for data quality and maintain quality controls

Compute NEdN estimates

## Input Ancillary Data

### Digital Elevation Model

There is one Digital Elevation Model (DEM) file: *Global\_DEM.bin*

It contains the following fields: latitude, longitude, topography (elevation in meters), land fraction, and land/sea mask. The values in the file apply to the center of a grid cell. The DEM is a global file with a resolution of 21600 latitude points X 43200 longitude points. This provides a grid resolution of 0.0083° X 0.0083°. This file is static and is delivered as part of the system which is why the DEM resides in the system file directory. The file is used in the L1C Subsetter and L1B Processing units. In these units, the preprocessing for level2 adds the DEM information. The downstream Level 2 Processing unit code requires this surface information for the retrieval.

### Retrieval System Files

There are a number of static retrieval system files. These are inputs to the NUCAPS retrieval, but unlike data files, they are static and are only updated with a delivery of the system.

Table 2‑1 contains the file name in the first column and the second column contains a brief description of the file.

Table ‑ Retrieval System Files

|  |
| --- |
| RTA files |
| airs\_olr.dat  | Rapid transmittance coefficients to compute Outgoing Longwave Radiation |
| atms.v5a | Most recent version of ATMS transmittance coefficients  |
| binary.trcoef.cris.v7b | post-flight CrIS RTA coefficients |
| hsb.v7a | HSB RTA coefficients |
| Cloud Averaging Table |
| cris\_v7b.t1 | CrIS cloud averaging table |
| Ensemble Error Estimate File |
| jpl\_100c.inp | Ensemble error estimate of climatology |
| MIT Retrieval Files |
| L2.M.cov100av.v1.0.0.anc | MW retrieval error covariance file |
| L2.M.ecof\_705.v1.0.0.anc | MW retrieval error covariance file |
| L2.M.weight.hsb.v1.0.0.anc | HSB weighting file |
| L2.uars\_clim.v1.0.3.anc | L2 UARS climatology file for upper atmosphere |
| ncep\_clim.bin | Binary NCEP climatology file for T(p) and q(p) |
| Name List Files for the Main Retrieval Program |
| clouds\_cris.nl | Cloud files name list |
| io\_cris.nl | Input/Output name list |
| microw\_cris.nl | Microwave file name list |
| ozone\_cris.nl | Ozone file name list |
| pro\_cris.nl | Profile file name list |
| temp\_cris.nl | Temperature file name list |
| water\_cris.nl | Water vapor file name list |
| Noise Files |
| cris\_0404a.dat | Noise file for CrIS |
| atms\_2.dat | Noise files for ATMS |
| Solar Irradiance Files |
| cris\_solar\_v7a.txt | Solar irradiance file for the radiance calculation |
| Coefficient Files to Compute Surface Emissivity |
| L2.masuda.v2.0.0.anc | Coefficients for the Masuda surface emissivity model for ocean |
| Clear Flag Coefficient Files |
| L2.I.cleartest\_coef.v2.0.2.day.anc | Day time coefficients |
| L2.I.cleartest\_coef.v2.0.2.night.anc | Night time coefficients |
| Regression Coefficient Files |
| rt\_noaa/cris\_v03.eig | NOAA IR regression radiance eigenvector file |
| rt\_noaa /cris\_v03.frq | NOAA IR regression frequency file |
| rt\_noaa / cris\_v03.reg | NOAA IR regression coefficient file |

### GFS Forecast Files

These are forecast files generated by NCEP and pushed (by NCEP) to the ESPC/DDS. These files are needed for the NUCAPS EDR generation.

The files have the following name structure:

gfs.t${Hour}z.pgrbf${Forecast}

where:

*${Hour}* = the time for which the forecast is run (00Z, 06Z, 12Z, and 18Z)

*${Forecast}* = the forecast projection time (in hours = 00, 03, 06, 09, and 12)

00, 03, 06, 09, and 12 hour forecasts are run every six hours. The files are GRIB2 format files and are read with the *wgrib2* reader which is freely available from NCEP. The header content of any GRIB2 file can viewed by running *wgrib2* and supplying the file name as an argument to the command.

The forecast file preprocessor in the EDR Processing unit uses these files to extract only the surface pressure. The retrieval uses the surface pressure to anchor its solution to the surface. The following forecast variables are extracted from 91 levels and used by this processing:

Run Hour

Forecast Hour

Forecast Latitude

Forecast Longitude

Pressure

Temperature

Water Vapor

Ozone

2 meter Dew Point

2 meter Temperature

Skin Temperature

Surface Pressure

Precipitable Water Content

Total Column Ozone

Sea Surface Temperature

Land Fraction

Temperature of the 30 mb to 0 mb layer

### Eigenvector Files

There are four of these files, one for each of the three bands, and one for the entire band. These are binary big-endian files. They are not external inputs to the system, but are in fact part of the system. As such, they come with the system delivery and are automatically installed with the system by the system installation script. Any update to these files will be part of an update to the system in general.

They all have the same name structure as described below:

eigvec\_${Year}${Month}${Day}\_${Band}\_ascii\_real

where:

*${Year}* = 2-digit year

*${Month}* = 2-digit month

*${Day}* = 2-digit day

*${Band}* = the band option (full, band1, band2, and band3)

The date string indicates when the file was generated. This file contains the eigenvector coefficients required for principal component radiance reconstructions. It is a file that will need to be updated about once every six months or if there are major changes to the calibration of the instrument.

### OLR Boxcar files

The OLR code uses a number of boxcar static files that are provided with the system. These files are called:

airs\_17boxcar\_01.txt

airs\_17boxcar\_02.txt

airs\_17boxcar\_03.txt

airs\_17boxcar\_04.txt

airs\_17boxcar\_05.txt

airs\_17boxcar\_06.txt

airs\_17boxcar\_07.txt

airs\_17boxcar\_08.txt

airs\_17boxcar\_09.txt

airs\_17boxcar\_10.txt

airs\_17boxcar\_11.txt

airs\_17boxcar\_12.txt

airs\_17boxcar\_13.txt

airs\_17boxcar\_14.txt

airs\_17boxcar\_15.txt

airs\_17boxcar\_16.txt

airs\_17boxcar\_17.txt

airs\_17boxcar.txt

cris\_17boxcar\_01.txt

cris\_17boxcar\_02.txt

cris\_17boxcar\_03.txt

cris\_17boxcar\_04.txt

cris\_17boxcar\_05.txt

cris\_17boxcar\_06.txt

cris\_17boxcar\_07.txt

cris\_17boxcar\_08.txt

cris\_17boxcar\_09.txt

cris\_17boxcar\_10.txt

cris\_17boxcar\_11.txt

cris\_17boxcar\_12.txt

cris\_17boxcar\_13.txt

cris\_17boxcar\_14.txt

cris\_17boxcar\_15.txt

cris\_17boxcar\_16.txt

cris\_17boxcar\_17.txt

cris\_17boxcar.txt

olr\_reg\_coef\_cv005\_17boxcar\_2.asc

rad\_corr\_reg\_coef\_17boxcar\_airsv10ab\_2.asc

### VIIRS collocation LUT Files

The CrIS-VIIRS collocation code uses a set of look up tables to more quickly collocate the two instruments. These files are called:

CrIS\_VIIRS\_MOD.dat

CrIS\_VIIRS\_MOD\_HEI.dat

CrIS\_VIIRS\_WGT.dat

CrIS\_VIIRS\_WGT\_HEI.dat

### Template Files

The system uses a number of template files. These are all static files that will only change with a new delivery of the system. They are never modified by the scripts and programs that use them. Scripts will only copy these files to a local directory or create soft links to them

#### CDL Template Files

These are template parameter files used for generating the NUCAPS SDR and NUCAPS EDR granule subsets. These files contain the lists of channels and footprints to be extracted for each type of subset. They also contain the variable lists, array sizes and array dimensions for each NetCDF output file. Each file can be converted into a NetCDF file using the *ncgen* NetCDF4 library utility. This file will have a complete header based on that of the CDL template, but contains no instrument data values, only fill (missing) values. These files are then populated with instrument data values by the subsetter code. There is a different template file for each type of subset.

The following NUCAPS CDL template files shown in Table 2‑2 are present in the current build:

Table ‑ NUCAPS CDL Files

|  |  |
| --- | --- |
| CDL Template Name | Description |
| nucaps\_all.cdl | A template for all fovs, 1317 channels (4 scans) |
| nucaps\_c0300\_allfovs.cdl | A template for all fovs, 399 channels (4 scans) |
| nucaps\_c0300\_allfovs\_pcs1b.cdl | A template for all fovs, 399 channels of RR, 1 band (4 scans) |
| nucaps\_c0300\_allfovs\_pcs3b.cdl | A template for all fovs, 399 channels of RR, 3 band (4 scans) |
| nucaps\_c0300\_centerfov.cdl  | A template for center fov, 399 channels (4 scans) |
| nucaps\_c0300\_centerfov\_pcs1b.cdl  | A template for center fov, 399 channels of RR, 1 band (4 scans) |
| nucaps\_c0300\_centerfov\_pcs3b.cdl | A template for center fov, 399 channels of RR, 3 band (4 scans) |
| nucaps\_c1317\_1scan.cdl | A template for all fovs, 1317 channels, 1 scans/granule (4 scans) |
| nucaps\_ccr.cdll  | A template for 1 fov, 1317 channels (4 scans) |
| nucaps\_ccr\_archive.cdl | A template for 1 fov, 1317 channels (4 scans). Unused variable names are deleted and current ones are standardized for archive. Also contains static metadata. |
| nucaps\_l2.cdl | A template for 1 fov for level 2 EDR profile data (4 scans) Also contains static metadata. |
| All files contain radiances unless otherwise indicated with an RR which stands for Reconstructed Radiances from principal components. |

# PERFORMANCE

## Product Testing

### Test Data

Description of all NUCAPS test data (input, output, and intermediate) used in unit and system tests is provided in the NUCAPS Test Readiness Document (NESDIS/STAR, 2010). These are available by contacting the NUCAPS Product Area Lead (PAL) at OSPO. This document will be updated in 2012 prior to delivery of the Phase 2 NUCAPS system which will contain the operationally ready retrieval code.

### Test Plans

Description of all NUCAPS test plans used in unit and system tests is provided in the NUCAPS Test Readiness Document (NESDIS/STAR, 2010). These are available by contacting the NUCAPS Product Area Lead (PAL) at OSPO. This document will be updated in 2012 prior to delivery of the Phase 2 NUCAPS system which will contain the operationally ready retrieval code.

## Product Accuracy

### Test Results

Description of all NUCAPS test results from the unit and system tests is provided in the NUCAPS Test Readiness Document (NESDIS/STAR 2010). These are available by contacting the NUCAPS Product Area Lead (PAL) at OSPO. This document will be updated in 2012 prior to delivery of the Phase 2 NUCAPS system which will contain the operationally ready retrieval code.

### Product Accuracy

The Retrieval algorithm product accuracy validation has not yet been conducted at the current phase of this project. This work is scheduled to be done prior to the delivery of the operational retrieval code which will occur in phase 2 scheduled for January 2013. When this occurs, all testing documents will be updated and made available through the NUCAPS PAL.

There are no accuracy requirements for the thinned radiance products or validation products. Validation products are for validation and quality monitoring and therefore do not have any accuracy requirements.

## Product Quality

All the CrIS and ATMS thinned radiance and validation output data files contain the following 6 CrIS quality flags and 2 ATMS quality flags.

CrIS\_QF1 = QF1\_SCAN\_CRISSDR of the CrIS SDR input data.

CrIS\_QF2 = QF2\_CRISSDR of the CrIS SDR input data.

CrIS\_QF3 = QF3\_CRISSDR of the CrIS SDR input data.

CrIS\_QF4 = QF4\_CRISSDR of the CrIS SDR input data.

CrIS\_QF5 = QF1\_CRISSDRGEO of the CrIS SDR Geolocation input data.

CrIS\_QF6 = NUCAPS Aggregate quality flag

ATMS\_QF1 = ATMS Aggregate quality flag (0 = good, 1 = bad if any relative quality flags in the ATMS TDR and Geolocation input data are not equal to zero)

ATMS\_QF2 = ATMS Aggregation qulatiy flag (0 = good, 1 = bad if there is an error occurred during the ATMS resampling process)

The CrIS flags, except for CrIS\_QF6 are bit fields. CrIS\_QF1 – CrIS\_QF5 are defined in the JPSS Common Data Format Control Books Volume III. CrIS\_QF6 is created by the NUCAPS code and is a summary of all the bit field flags. A CrIS\_QF6 = 0 indicates all the other bit fields within all the other quality flags are indicating good data. A non-zero flag indicates a problem and therefore the user should interrogate the other flags for details.

The NUCAPS CrIS OLR Quality\_Flag is defined at:

0 – good

1 – rejected

-9999 – missing

The NUCAPS retrieval output data files (CCR archive and EDR) contain Quality\_Flag with following value settings:

0 – good

1 – rejected by physical

2 – rejected by MIT file

4 – rejected by NOAA (regression) file

8 – rejected by internal MIT

9 – rejected by physical and internal MIT

16 – rejected by internal NOAA

17 – rejected by physical and internal NOAA

24 – rejected by internal MIT and internal NOAA

25 – rejected by physical, internal MIT, and internal NOAA

-9999 – missing

## Analysis Tools

No external product tools are supplied. The NUCAPS output files are plain text files, binary files, or netCDF4 files. External users can choose their own tools to display and analyze these output files.

# PRODUCT STATUS

## Operations Documentation

Operational logs contain the information regarding the changes made to science, instruments, and systems. Basically the Configuration Management system will have the detailed information about these changes, but operational logs keep the high level description of these changes.

NESDIS/STAR (2009), NUCAPS Algorithm Theoretical Basis Document, Version 1.0.

NESDIS/STAR (2011), NUCAPS System Maintenance Manual, Version 1.0.

NESDIS/STAR (2010), [NUCAPS Test Readiness Document (TRD)](http://www.star.nesdis.noaa.gov/smcd/spb/iosspdt/qadocs/NUCAPS_TRR/NUCAPS_TRD_Final.pptx)

http://www.star.nesdis.noaa.gov/star/documents/meetings/2014JPSSAnnual/dayThree/11\_Session5d\_Nalli\_NUCAPS\_validation.pdf

## Maintenance History

The System Maintenance Manual (SMM) will be updated to reflect the changes that will be required to maintain the NUCAPS system within the ESPC environment. Information regarding the changes to the products is tracked by the Operational logs and will be available to users on request. Product metadata will be updated as per the changes required in the product including the version number, quality flags etc.

END OF DOCUMENT