Instrument Earth Scans (IES)

The IES data product contains one hour of data from a single CERES scanner. The data records are ordered in time with a separate index that sorts the records by an along-track angle relating each footprint position to the spacecraft's suborbital point at the start of the hour. The spatial ordering of records using this index will ease the comparison of CERES data with cloud imager data in Subsystem 4. The footprint record is the basic data structure for this data product. This record contains the following kinds of information:

1) Time of Observation
2) Geolocation data (at both the Top-of-Atmosphere (TOA) and the Earth's surface)
3) Filtered radiances (at satellite altitude), with associated quality measures
4) Spacecraft orbital data
5) Footprint viewing geometric data

The IES data product contain only Earth-viewing measurements. For the Tropical Rainfall Measuring Mission (TRMM) mission, there are approximately 225 Earth-viewing footprints (records) that are stored on an IES from each 3.3-second half-scan. The IES product size is derived by using the number of 3.3-second half-scans per hour (approximately 1091) times the number of Earth-viewing measurements per half-scan (approximately 225 for TRMM and 195 for Terra). This yields approximately 245475 and 212745 measurements per TRMM and Terra IES data products, respectively. The product size used within this catalog is determined using the TRMM numbers. The summary of HDF structures is shown in Table 1. The metadata are listed in Appendix B, Table 2, and Table 3. The complete listing of science parameters for this data product can be found in Table 4 and Table 5.

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**Level:** 1B  
**Frequency:** 1/Hour  
**Configuration Code:** 009001 and greater  
**Time Interval Covered**  
**File:** 1 Hour  
**Record:** 1/100-Second  
**Portion of Globe Covered**  
**File:** Satellite Swath  
**Record:** 1 CERES Footprint  

**Portion of Atmosphere Covered**  
**File:** Satellite Altitude
Instrument Earth Scans (IES) Definition

Table 1 summarizes the contents and estimated product size of each data structure type contained within an IES file. Each IES product contains three metadata structures and three Vdata structures.

Table 1. IES HDF Structure Summary

<table>
<thead>
<tr>
<th>Name</th>
<th>Description Table</th>
<th>Records</th>
<th>Number of Fields</th>
<th>Nominal Size (Bytes)</th>
</tr>
</thead>
<tbody>
<tr>
<td>CERES Baseline Header Metadata</td>
<td>Table B-1</td>
<td>1</td>
<td>36</td>
<td>~25907</td>
</tr>
<tr>
<td>CERES_metadata Vdata</td>
<td>Table B-2</td>
<td>1</td>
<td>14</td>
<td>~1024</td>
</tr>
<tr>
<td>IES Product-specific Metadata</td>
<td>Table 2</td>
<td>1</td>
<td>11</td>
<td>~66</td>
</tr>
<tr>
<td>IES Header Vdata</td>
<td>Table 3</td>
<td>1</td>
<td>22</td>
<td>132</td>
</tr>
<tr>
<td>Along Track Sort Index</td>
<td>Table 4</td>
<td>n: 1..245,475</td>
<td>2</td>
<td>1,963,800</td>
</tr>
<tr>
<td>IES Data Record</td>
<td>Table 5</td>
<td>n: 1..245,475</td>
<td>30</td>
<td>33,384,600</td>
</tr>
<tr>
<td><strong>Total Size (Bytes):</strong></td>
<td></td>
<td></td>
<td></td>
<td><strong>35,375,529</strong></td>
</tr>
<tr>
<td><strong>Total Size (MBytes, including ~0.2% HDF overhead; 1MByte = 1024²Bytes):</strong></td>
<td></td>
<td></td>
<td></td>
<td><strong>33.8</strong></td>
</tr>
</tbody>
</table>

IES Metadata

The IES product includes three metadata structures. These include the CERES Baseline Header Metadata and the CERES_metadata Vdata Metadata, which are listed in Appendix B. The IES-specific metadata parameters are listed in Table 2. An IES Header Vdata is also included as part of the IES metadata and the parameters are listed in Table 3.

Table 2. IES Product-Specific Metadata

<table>
<thead>
<tr>
<th>Item</th>
<th>Parameter Name</th>
<th>Units</th>
<th>Range</th>
<th>Data Type</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>ScanMode</td>
<td>N/A</td>
<td>XtrkOnly, RapsOnly, FapsOnly, Raps/Faps, Xtrk/Raps, Xtrk/Faps, Xtrk/Raps/Faps</td>
<td>s(14)</td>
</tr>
<tr>
<td>2</td>
<td>Second Time Constant Mode</td>
<td>N/A</td>
<td>Off, On</td>
<td>s(3)</td>
</tr>
<tr>
<td>3</td>
<td>Ephemeris Data Used</td>
<td>N/A</td>
<td>Real, Pred, Sim</td>
<td>s(4)</td>
</tr>
<tr>
<td>4</td>
<td>Attitude Data Used</td>
<td>N/A</td>
<td>Real, Sim</td>
<td>s(4)</td>
</tr>
<tr>
<td>5</td>
<td>Percent Total Channel Bad</td>
<td>N/A</td>
<td>0.0 .. 100.0</td>
<td>F11.6</td>
</tr>
<tr>
<td>6†</td>
<td>Percent Window Channel Bad (PFM, FM1 thru FM5)</td>
<td>N/A</td>
<td>0.0 .. 100.0</td>
<td>F11.6</td>
</tr>
<tr>
<td>6†</td>
<td>Percent Longwave Channel Bad (FM6 only)</td>
<td>N/A</td>
<td>0.0 .. 100.0</td>
<td>F11.6</td>
</tr>
<tr>
<td>7</td>
<td>Percent Short Wave Channel Bad</td>
<td>N/A</td>
<td>0.0 .. 100.0</td>
<td>F11.6</td>
</tr>
<tr>
<td>8</td>
<td>Percent FAPS</td>
<td>N/A</td>
<td>0.0 .. 100.0</td>
<td>F11.6</td>
</tr>
<tr>
<td>9</td>
<td>Percent RAPS</td>
<td>N/A</td>
<td>0.0 .. 100.0</td>
<td>F11.6</td>
</tr>
<tr>
<td>10</td>
<td>Percent Transitional</td>
<td>N/A</td>
<td>0.0 .. 100.0</td>
<td>F11.6</td>
</tr>
<tr>
<td>11</td>
<td>Percent Crosstrack</td>
<td>N/A</td>
<td>0.0 .. 100.0</td>
<td>F11.6</td>
</tr>
</tbody>
</table>
Table 2. IES Product-Specific Metadata

<table>
<thead>
<tr>
<th>Item</th>
<th>Parameter Name</th>
<th>Units</th>
<th>Range</th>
<th>Data Type</th>
</tr>
</thead>
<tbody>
<tr>
<td>12</td>
<td>TOA_Model_Used</td>
<td>N/A</td>
<td>CERES-TOA or WGS 84</td>
<td>s(9)</td>
</tr>
<tr>
<td>13</td>
<td>Number Input Files</td>
<td>N/A</td>
<td>1 .. n</td>
<td>uint32</td>
</tr>
</tbody>
</table>

Note: 1 – Window Percent bad was replaced with Longwave Percent bad for J01-FM6. For the FM6 instrument, the Window channel was replaced with a Longwave channel. All other instruments (PFM, FM1 – FM5) have the Window channel.

IES Vdata

The IES product contains three Vdata structures: the IES Header Vdata (Table 3), the Along-track Sort Index Vdata (Table 4), and the IES Data Record (Table 5). These data structures are listed below, where each list contains the field number, the field or parameter name, the data type, the units, and the range. The fields are listed in the order they are written to an IES. Data types are referenced by their HDF classification (e.g. Char8, Float32, Float64, Int8, UInt8, Int16, UInt16, Int32, UInt32, Int64, UInt64).

Table 3. IES Header Vdata

<table>
<thead>
<tr>
<th>Field No.</th>
<th>Field Name</th>
<th>Data Type</th>
<th>Units</th>
<th>Range</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Whole Julian Day</td>
<td>float64</td>
<td>day</td>
<td>2449353 .. 2458500</td>
</tr>
<tr>
<td>2</td>
<td>Fractional Julian Day</td>
<td>float64</td>
<td>day</td>
<td>-0.01 .. 1.01</td>
</tr>
<tr>
<td>3</td>
<td>Hour Number</td>
<td>uint32</td>
<td>N/A</td>
<td>0 .. 23</td>
</tr>
<tr>
<td>4</td>
<td>Colatitude of Subsatellite Point at Surface at Hour Start</td>
<td>float32</td>
<td>deg</td>
<td>0.0 .. 180.0</td>
</tr>
<tr>
<td>5</td>
<td>Longitude of Subsatellite Point at Surface at Hour Start</td>
<td>float32</td>
<td>deg</td>
<td>0.0 .. 360.0</td>
</tr>
<tr>
<td>6</td>
<td>Colatitude of Subsatellite Point at Surface at Hour End</td>
<td>float32</td>
<td>deg</td>
<td>0.0 .. 180.0</td>
</tr>
<tr>
<td>7</td>
<td>Longitude of Subsatellite Point at Surface at Hour End</td>
<td>float32</td>
<td>deg</td>
<td>0.0 .. 360.0</td>
</tr>
<tr>
<td>8</td>
<td>Along-track Angle of Satellite at Hour End</td>
<td>float32</td>
<td>deg</td>
<td>0.0 .. 360.0</td>
</tr>
<tr>
<td>9</td>
<td>Number of Footprints</td>
<td>uint32</td>
<td>N/A</td>
<td>0 .. 245475</td>
</tr>
<tr>
<td>10</td>
<td>Earth-Sun Distance at Hour Start</td>
<td>float32</td>
<td>AU</td>
<td>0.98 .. 1.02</td>
</tr>
<tr>
<td>11</td>
<td>Satellite Position X</td>
<td>float64</td>
<td>km</td>
<td>-8000.0 .. 8000.0</td>
</tr>
<tr>
<td>12</td>
<td>Satellite Position Y</td>
<td>float64</td>
<td>km</td>
<td>-8000.0 .. 8000.0</td>
</tr>
<tr>
<td>13</td>
<td>Satellite Position Z</td>
<td>float64</td>
<td>km</td>
<td>-8000.0 .. 8000.0</td>
</tr>
<tr>
<td>14</td>
<td>Satellite Velocity X</td>
<td>float64</td>
<td>km sec^{-1}</td>
<td>-10.0 .. 10.0</td>
</tr>
<tr>
<td>15</td>
<td>Satellite Velocity Y</td>
<td>float64</td>
<td>km sec^{-1}</td>
<td>-10.0 .. 10.0</td>
</tr>
<tr>
<td>16</td>
<td>Satellite Velocity Z</td>
<td>float64</td>
<td>km sec^{-1}</td>
<td>-10.0 .. 10.0</td>
</tr>
<tr>
<td>17</td>
<td>N Vector X</td>
<td>float64</td>
<td>N/A</td>
<td>0.0 .. 1.0</td>
</tr>
<tr>
<td>18</td>
<td>N Vector Y</td>
<td>float64</td>
<td>N/A</td>
<td>0.0 .. 1.0</td>
</tr>
</tbody>
</table>
# Table 3. IES Header Vdata

<table>
<thead>
<tr>
<th>Field No.</th>
<th>Field Name</th>
<th>Data Type</th>
<th>Units</th>
<th>Range</th>
</tr>
</thead>
<tbody>
<tr>
<td>19</td>
<td>N Vector Z</td>
<td>float64</td>
<td>N/A</td>
<td>0. 0 .. 1.0</td>
</tr>
<tr>
<td>20</td>
<td>Satellite Type</td>
<td>uint32</td>
<td>N/A</td>
<td>0 = TRMM, 1 = Terra, 4 = Aqua, 6 = SNPP, 7 = J01</td>
</tr>
<tr>
<td>21</td>
<td>Instrument Type</td>
<td>uint32</td>
<td>N/A</td>
<td>0 = Fore (FM1, FM3) 1 = Aft (FM2, FM4) 2 = Single (PFM, FM5, FM6)</td>
</tr>
<tr>
<td>22</td>
<td>Instrument Scan Mode</td>
<td>uint32</td>
<td>N/A</td>
<td>0 = Crosstrack, 1 = RAPS, 2 = FAPS, 3 =Transitional</td>
</tr>
</tbody>
</table>

Number of bytes per Vdata record: 132

# Table 4. Along-track Sort Index

<table>
<thead>
<tr>
<th>Field No.</th>
<th>Field Name</th>
<th>Data Type</th>
<th>Units</th>
<th>Range</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Footprint_index</td>
<td>uint32</td>
<td>N/A</td>
<td>1 .. n</td>
</tr>
<tr>
<td>2</td>
<td>Along_Track_Angle</td>
<td>float32</td>
<td>N/A</td>
<td>-20.0 .. 360.0</td>
</tr>
</tbody>
</table>

Number of bytes per Vdata record: 8

# Table 5. IES Data Record

<table>
<thead>
<tr>
<th>Field No.</th>
<th>Field Name / Parameter</th>
<th>Data Type</th>
<th>Units</th>
<th>Range</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Colatitude of CERES FOV at TOA</td>
<td>float32</td>
<td>deg</td>
<td>0.0 .. 180.0</td>
</tr>
<tr>
<td>2</td>
<td>Longitude of CERES FOV at TOA</td>
<td>float32</td>
<td>deg</td>
<td>0.0 .. 360.0</td>
</tr>
<tr>
<td>3</td>
<td>Colatitude of CERES FOV at Surface</td>
<td>float32</td>
<td>deg</td>
<td>0.0 .. 180.0</td>
</tr>
<tr>
<td>4</td>
<td>Longitude of CERES FOV at Surface</td>
<td>float32</td>
<td>deg</td>
<td>0.0 .. 360.0</td>
</tr>
<tr>
<td>5</td>
<td>CERES Viewing Zenith at Surface</td>
<td>float32</td>
<td>deg</td>
<td>0.0 .. 90.0</td>
</tr>
<tr>
<td>6</td>
<td>CERES Solar Zenith at Surface</td>
<td>float32</td>
<td>deg</td>
<td>0.0 .. 180.0</td>
</tr>
<tr>
<td>7</td>
<td>CERES Relative Azimuth at Surface</td>
<td>float32</td>
<td>deg</td>
<td>0.0 .. 360.0</td>
</tr>
<tr>
<td>8</td>
<td>CERES Viewing Azimuth at Surface wrt North</td>
<td>float32</td>
<td>deg</td>
<td>0.0 .. 360.0</td>
</tr>
<tr>
<td>9</td>
<td>Cross-track Angle of CERES FOV at Surface</td>
<td>float32</td>
<td>deg</td>
<td>-90.0 .. 90.0</td>
</tr>
<tr>
<td>10</td>
<td>Along-track Angle of CERES FOV at Surface</td>
<td>float32</td>
<td>deg</td>
<td>-20.0 .. 360.0</td>
</tr>
</tbody>
</table>
### Table 5. IES Data Record

<table>
<thead>
<tr>
<th>Field No.</th>
<th>Field Name / Parameter</th>
<th>Data Type</th>
<th>Units</th>
<th>Range</th>
</tr>
</thead>
<tbody>
<tr>
<td>11</td>
<td>Cone Angle of CERES FOV at Satellite</td>
<td>float32</td>
<td>deg</td>
<td>0.0 .. 90.0</td>
</tr>
<tr>
<td>12</td>
<td>Clock Angle of CERES FOV at Satellite wrt Inertial Velocity</td>
<td>float32</td>
<td>deg</td>
<td>0.0 .. 360.0</td>
</tr>
<tr>
<td>13</td>
<td>Rate of Change of Cone Angle</td>
<td>float32</td>
<td>deg sec⁻¹</td>
<td>-100.0 .. 100.0</td>
</tr>
<tr>
<td>14</td>
<td>Rate of Change of Clock Angle</td>
<td>float32</td>
<td>deg sec⁻¹</td>
<td>-10.0 .. 10.0</td>
</tr>
<tr>
<td>15</td>
<td>X Component of Satellite Inertial Velocity</td>
<td>float64</td>
<td>km sec⁻¹</td>
<td>-10.0 .. 10.0</td>
</tr>
<tr>
<td>16</td>
<td>Y Component of Satellite Inertial Velocity</td>
<td>float64</td>
<td>km sec⁻¹</td>
<td>-10.0 .. 10.0</td>
</tr>
<tr>
<td>17</td>
<td>Z Component of Satellite Inertial Velocity</td>
<td>float64</td>
<td>km sec⁻¹</td>
<td>-10.0 .. 10.0</td>
</tr>
<tr>
<td>18</td>
<td>Radius of Satellite from Center of Earth at Observation</td>
<td>float64</td>
<td>km</td>
<td>6000.0 .. 8000.0</td>
</tr>
<tr>
<td>19</td>
<td>CERES TOT Filtered Radiance, Upwards</td>
<td>float32</td>
<td>W m⁻²sr⁻¹</td>
<td>0.0 .. 700.0</td>
</tr>
<tr>
<td>20</td>
<td>CERES SW Filtered Radiance, Upwards</td>
<td>float32</td>
<td>W m⁻²sr⁻¹</td>
<td>-10.0 .. 510.0</td>
</tr>
<tr>
<td>21¹</td>
<td>CERES WN Filtered Radiance, Upwards (FM1 - FM5)</td>
<td>float32</td>
<td>W m⁻²sr⁻¹ μm⁻¹</td>
<td>0.0 .. 50.0</td>
</tr>
<tr>
<td>21¹</td>
<td>CERES LW Filtered Radiance, Upwards (FM6)</td>
<td>float32</td>
<td>W m⁻²sr⁻¹</td>
<td>0.0 .. 180.0</td>
</tr>
<tr>
<td>22</td>
<td>Colatitude of Subsatellite Point at Surface at Observation</td>
<td>float32</td>
<td>deg</td>
<td>0.0 .. 180.0</td>
</tr>
<tr>
<td>23</td>
<td>Longitude of Subsatellite Point at Surface at Observation</td>
<td>float32</td>
<td>deg</td>
<td>0.0 .. 360.0</td>
</tr>
<tr>
<td>24</td>
<td>Colatitude of Subsolar Point at Surface at Observation</td>
<td>float32</td>
<td>deg</td>
<td>0.0 .. 180.0</td>
</tr>
<tr>
<td>25</td>
<td>Longitude of Subsolar Point at Surface at Observation</td>
<td>float32</td>
<td>deg</td>
<td>0.0 .. 360.0</td>
</tr>
<tr>
<td>26</td>
<td>Scan Sample Number</td>
<td>uint16</td>
<td>N/A</td>
<td>1 .. 660</td>
</tr>
<tr>
<td>27</td>
<td>Packet Number</td>
<td>uint16</td>
<td>N/A</td>
<td>0 .. 32767</td>
</tr>
<tr>
<td>28</td>
<td>Time of Observation</td>
<td>float64</td>
<td>day</td>
<td>2449353.0 .. 2458500.0</td>
</tr>
<tr>
<td>29</td>
<td>Radiance and mode flags</td>
<td>uint32</td>
<td>N/A</td>
<td>0 .. (2**31)-1</td>
</tr>
<tr>
<td>30</td>
<td>Absolute Packet Number</td>
<td>uint32</td>
<td>N/A</td>
<td>0 .. 65535</td>
</tr>
</tbody>
</table>

**Number of bytes per Vdata record:** 136

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1. For the FM-6 instrument, the “LW” channel substitutes for the “WN” channel
IES Revision Record

The product Revision Record contains information pertaining to approved section changes. The table lists the date the Software Configuration Change Request (SCCR) was approved, the Release and Version Number, the SCCR number, a short description of the revision, and the revised sections. The authors are listed on the document cover.

### IES Revision Record

<table>
<thead>
<tr>
<th>SCCR Approval Date</th>
<th>Release/Version Number</th>
<th>SCCR Number</th>
<th>Description of Revision</th>
<th>Section(s) Affected</th>
</tr>
</thead>
</table>
| N/A                | R3V1                   | N/A         | • Updated format to comply with standards.  
|                    |                        |             | • The EOSDIS Product Code line was removed from the document. (6/17/2008)  
|                    |                        |             | • Some links were not working. They have now been modified. (12/09/2010)  
|                    |                        |             | • The ASDC footer was added to the bottom of the document. (06/06/2013)  
|                    |                        |             | • Eliminated section numbers from the Data Products Catalog. Specifically, in this document, section number 3.2 was removed. (12/17/2013)  
|                    |                        |             | • Updated some links to refer to the .pdf file instead of the .doc file. (06/20/2014)  
| N/A                | R6V1                   | N/A         | • Updated Satellite_Type to contain only instruments being used. Added J01 for upcoming FM6 launch in 2016.  
|                    |                        |             | • Updated Instrument_Type to be the correct values being used in production. Added FM6, which will launch in 2016.  
| N/A                | R7V1                   | N/A         | • Updated tables to include Longwave values for FM6 which replace the Window values used by all other instruments. Added a note at the bottom of the table to explain duplicate parameter numbers in the table.  
| N/A                | R7V2                   | N/A         | • Updated to fix the issue with WN-channel radiance missing the per micron in the units.  

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IES-6