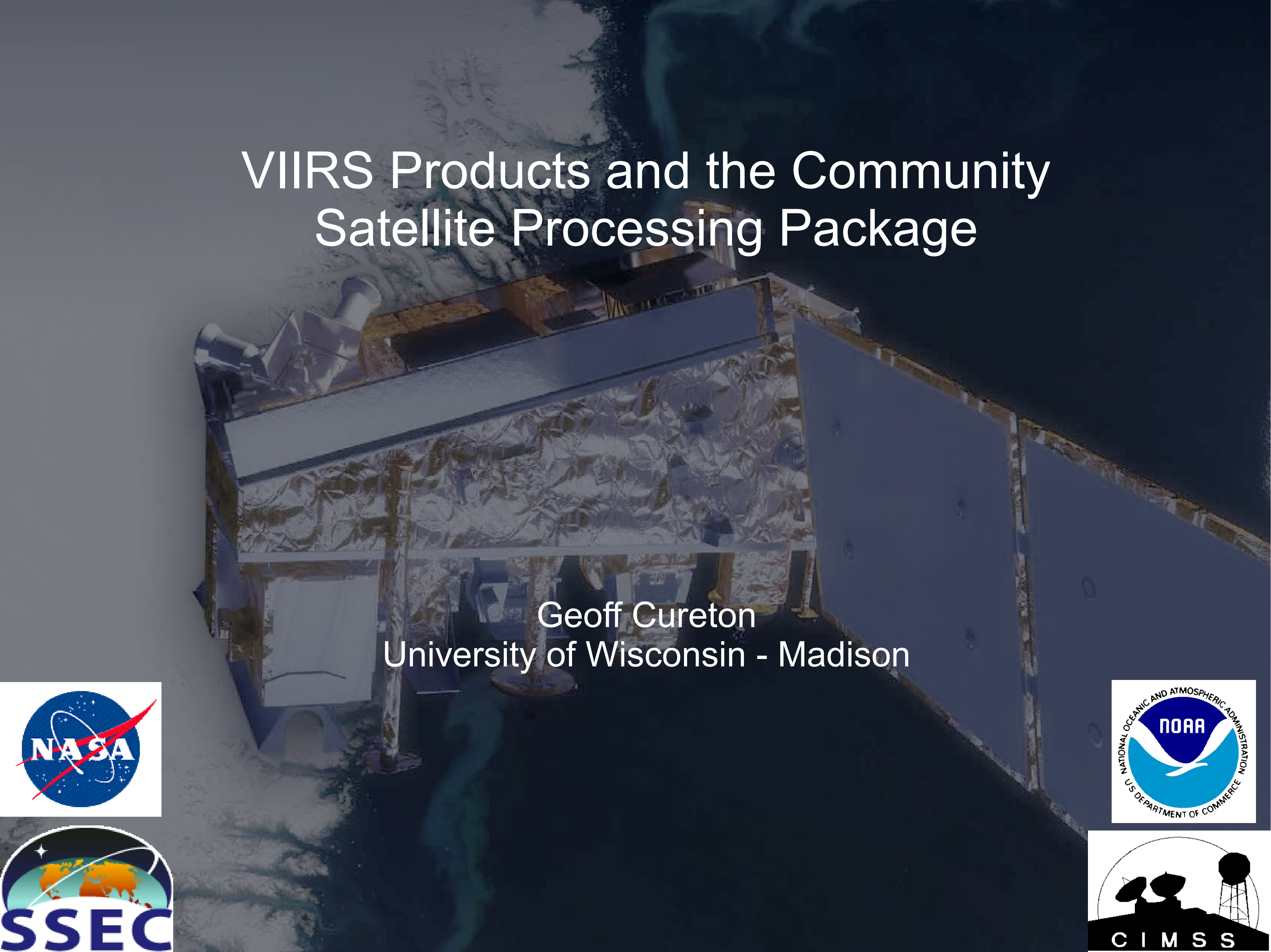
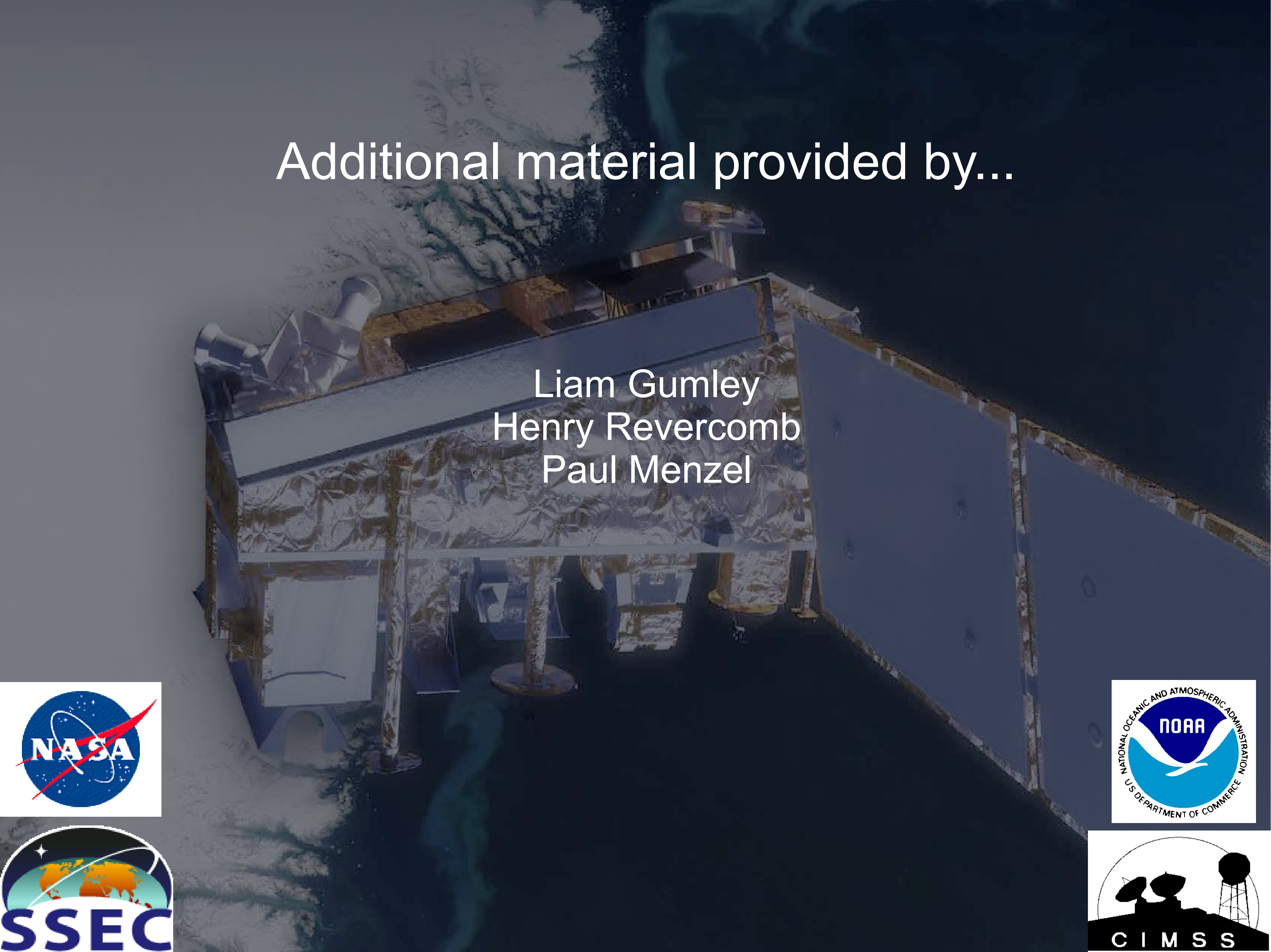
VIIRS Products and the Community Satellite Processing Package



Geoff Cureton
University of Wisconsin - Madison



Additional material provided by...

Liam Gumley
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Overview

- VIIRS Product Types
- Interrogation of VIIRS product files
- NPP/NPOESS data model
- Community Satellite Processing Package (CSPP)

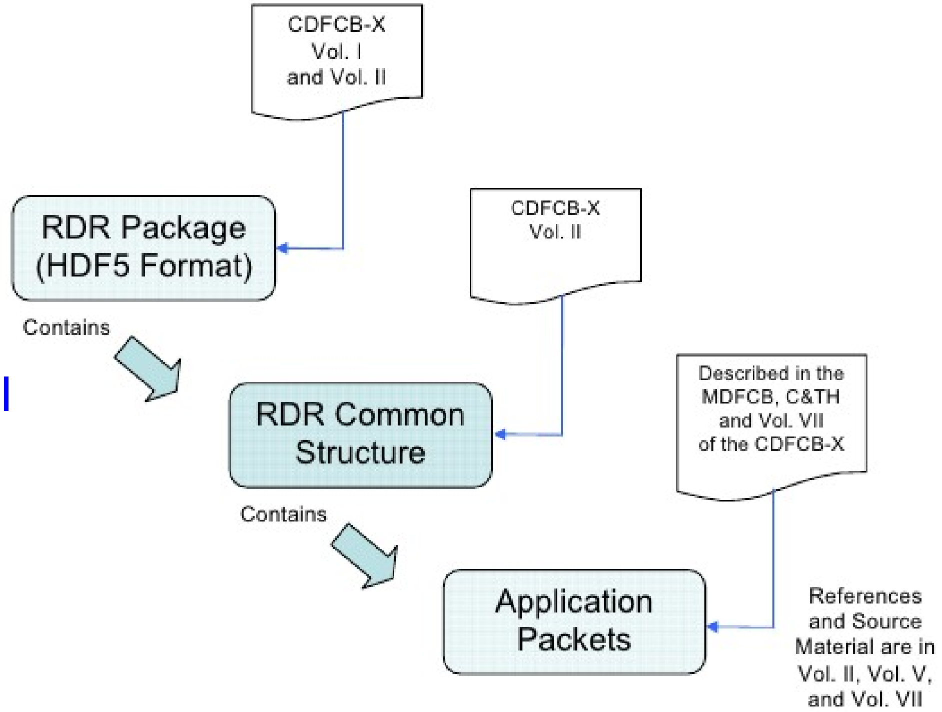
VIIRS Product Types

- Raw Data Record (RDR)
- Sensor Data Record (SDR)
- Intermediate Product (IP)
- Environmental Data Record (EDR)
- Climate Data Record (CDR)

Raw Data Record (RDR)

- The RDR is an accumulation of binary data generated by sensors on board the NPP spacecraft and assembled into groups called application packets (APs).
- The ground software collects one or more groups of related APs together into granules which are then assembled into common RDR structures and combined with metadata to create the delivered HDF5 file.
- Similar to MODIS Level 0
- CDFCB-X documents at right can be obtained from...

http://jointmission.gsfc.nasa.gov/science/documents.html



Sensor Data Record (SDR)

- The SDR is an accumulation of binary data generated by sensors on board the NPP spacecraft and assembled into groups called application packets (APs).

- Processing an RDR into an SDR involves unpacking and decommutating the Application Packet (AP) data, as necessary, applying calibration (radiometric, geometric, engineering), and finally geo-locating, as needed, using ephemeris and attitude information and earth model information.

- An SDR contains the following:

  - Calibrated sensor data
  - Geolocation data (where applicable)
  - Quality flags
  - Metadata at the granule and aggregation level

- Similar to MODIS Level 1b

- Have file prefixes GMODO, GMTCO, GIMGO, GITCO, SVM[01-16], SVI[01-05]

Intermediate Product (IP)

- IPs are defined as a data subset or retrieval by-product that is required within another primary data product's generation sequence or is used as an input to secondary processing or analysis.
- Generally are pixel-level products like the SDRs (750m resolution).
- Certain IPs (Cloud Mask, Quarterly Surface Type) are packaged and delivered to the end-user, and are used to create further IPs (Cloud Optical Properties, Cloud Top Parameters, Aerosol etc...).
- Other IPs (Quarterly Surface Type/Land Water Mask [QSTLWM IP] are generated during the creation of IPs and EDRs but are not delivered.
- Similar to MODIS Level 2
- Have file prefixes...
  - IICMO (Cloud Mask)
  - IVAOT (Aerosol Optical Thickness)
  - IVCOP (Cloud Optical Properties [COT, EPS])
  - IVCTP (Cloud Top Parameters [CTP, CTT, CTH])

Environmental Data Records (EDR)

- Environmental Data Records (EDRs) are data records that contain the environmental parameters or imagery generated by the NPOESS system as products deliverable to the user. The NPOESS and NPP required set of EDRs are defined in the NPOESS System Specification.
- EDRs provide stable measurements useful for long-term trends. An EDR contains the following:
  - EDR specific data
  - Appropriate geolocation values
  - Quality Flags
  - Metadata represented as Attributes in the HDF5 file that are provided at the granule and aggregation level
- Similar to MODIS Level 2
- Have file prefixes VAOOO (AOT), VCEPO (EPS), VCOTO (COT), VCTPO (CTP), VCTTO(CTT), VCTHO (CTH)...

Climate Data Records (CDR)

- Climate quality data records, known as Climate Data Records (CDRs), will be developed by the NPP science team.
- Based primarily upon the EDRs, but incorporating such refinements as can be made taking advantage of reduced requirements for data latency (EDRs must be produced no more than 90 minutes after acquisition).
- Can take advantage of re-processing of time series with retrospective calibration and ancillary data sets.
- Similar to MODIS Level 2

VIIRS Products

MISSION AREAS

🟨	Atmosphere	🟩	Climate
🟫	Land	🟦	Ocean
◼	Space Env.	□	RDR/SDR Only

- 🟫🟩🟨 Albedo (Surface)
- 🟩🟨 Cloud Base Height
- 🟩🟨 Cloud Cover/Layers
- 🟩🟨 Cloud Effective Part Size
- 🟩🟨 Cloud Optical Thickness
- 🟩🟨 Cloud Top Height
- 🟩🟨 Cloud Top Pressure
- 🟩🟨 Cloud Top Temperature
- 🟫🟩 Land Surface Temp 1
- 🟫🟩 Surface Type

- 🟩🟦 Ocean Color/Chlorophyll 2
- 🟩🟨🟦 Suspended Matter
- 🟫🟩 Vegetation Index
- 🟩🟨 Aerosol Optical Thickness
- 🟩🟨 Aerosol Particle Size
- 🟩🟦 Ice Surface Temperature 3
- 🟫🟨🟦 Imagery 3
- 🟩🟦 Sea Ice Characterization 3
- 🟫🟩 Snow Cover/Depth 3
- 🟩🟦 Sea Surface Temperature 3

Interrogation of VIIRS product files

- VIIIRS RDR, SDR, EDR, CDR and IP files are in HDF5 format
- HDF5 format is hierarchical in nature, and HDF5 data structure shares a similarity with a UNIX file system. We can dump the basic file structure using "h5dump -n "...

```
h5dump -n SVM16_npp_d20120120_t0534262_e0535504_b01189_c20120120120117709679_noaa_ops.h5

HDF5 "SVM16_npp_d20120120_t0534262_e0535504_b01189_c20120120120117709679_noaa_ops.h5" {
FILE_CONTENTS {
 group      /
 group      /All_Data
 group      /All_Data/VIIRS-M16-SDR_All
 dataset    /All_Data/VIIRS-M16-SDR_All/BrightnessTemperature
 dataset    /All_Data/VIIRS-M16-SDR_All/BrightnessTemperatureFactors
 dataset    /All_Data/VIIRS-M16-SDR_All/ModeGran
 dataset    /All_Data/VIIRS-M16-SDR_All/ModeScan
 dataset    /All_Data/VIIRS-M16-SDR_All/NumberOfBadChecksums
 dataset    /All_Data/VIIRS-M16-SDR_All/NumberOfDiscardedPkts
 dataset    /All_Data/VIIRS-M16-SDR_All/NumberOfMissingPkts
 dataset    /All_Data/VIIRS-M16-SDR_All/NumberOfScans
 dataset    /All_Data/VIIRS-M16-SDR_All/PadByte1
 dataset    /All_Data/VIIRS-M16-SDR_All/QF1_VIIRSMBANDSDR
 dataset    /All_Data/VIIRS-M16-SDR_All/QF2_SCAN_SDR
 dataset    /All_Data/VIIRS-M16-SDR_All/QF3_SCAN_RDR
 dataset    /All_Data/VIIRS-M16-SDR_All/QF4_SCAN_SDR
 dataset    /All_Data/VIIRS-M16-SDR_All/QF5_GRAN_BADDETECTOR
 dataset    /All_Data/VIIRS-M16-SDR_All/Radiance
 dataset    /All_Data/VIIRS-M16-SDR_All/RadianceFactors
 group      /Data_Products
 group      /Data_Products/VIIRS-M16-SDR
 dataset    /Data_Products/VIIRS-M16-SDR/VIIRS-M16-SDR_Aggr
 dataset    /Data_Products/VIIRS-M16-SDR/VIIRS-M16-SDR_Gran_0
 }
}
```

Interrogation of VIIRS product files

- If we want to examine the details about a particular dataset, say the M16 radiance...

```
h5dump -H -d  /All_Data/VIIRS-M16-SDR_All/Radiance
      SVM16_npp_d20120120_t0534262_e0535504_b01189_c20120120120117709679_noaa_ops.h5

HDF5 "SVM16_npp_d20120120_t0534262_e0535504_b01189_c20120120120117709679_noaa_ops.h5" {
DATASET "/All_Data/VIIRS-M16-SDR_All/Radiance" {
DATATYPE  H5T_STD_U16BE
DATASPACE  SIMPLE { ( 768, 3200 ) / ( 768, 3200 ) }
}
}
```

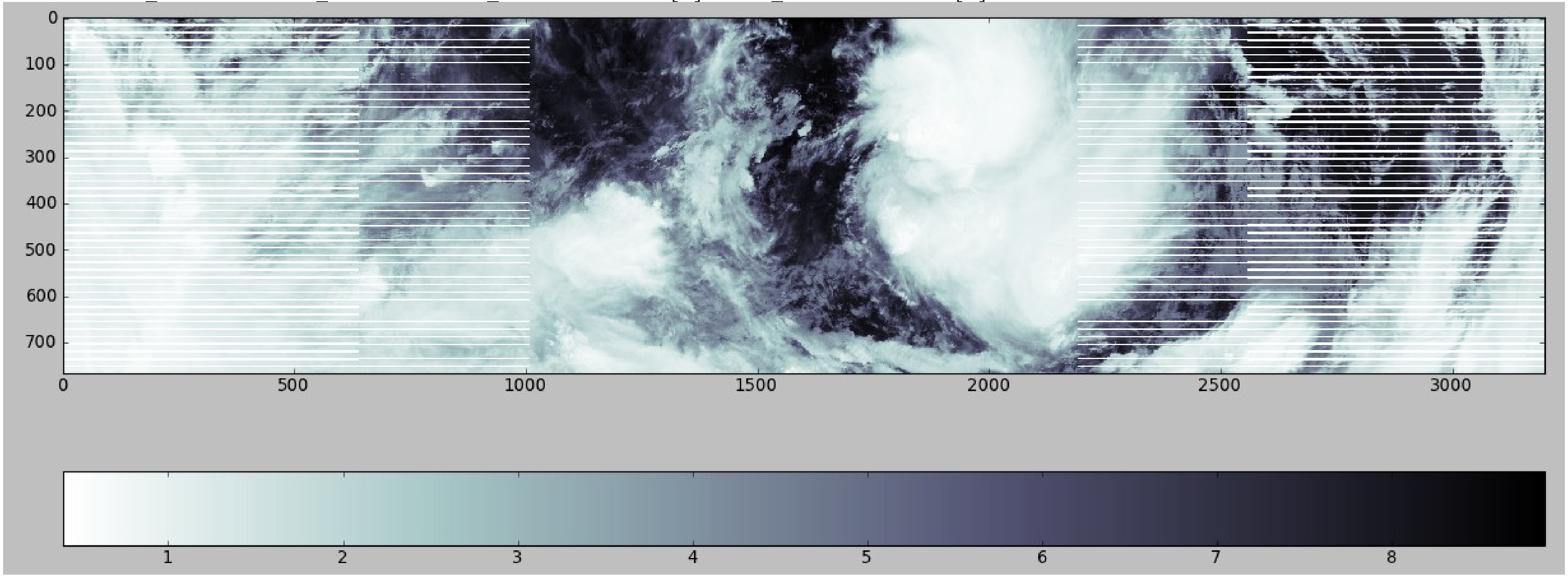
- Examining the actual data values in the radiance dataset...

```
h5dump -d  /All_Data/VIIRS-M16-SDR_All/Radiance
      SVM16_npp_d20120120_t0534262_e0535504_b01189_c20120120120117709679_noaa_ops.h5

HDF5 "SVM16_npp_d20120120_t0534262_e0535504_b01189_c20120120120117709679_noaa_ops.h5" {
DATASET "/All_Data/VIIRS-M16-SDR_All/Radiance" {
DATATYPE  H5T_STD_U16BE
DATASPACE  SIMPLE { ( 768, 3200 ) / ( 768, 3200 ) }
DATA {
(0,0): 65533, 65533, 65533, 65533, 65533, 65533, 65533, 65533, 65533,
(0,9): 65533, 65533, 65533, 65533, 65533, 65533, 65533, 65533, 65533,
(0,18): 65533, 65533, 65533, 65533, 65533, 65533, 65533, 65533, 65533,
(0,27): 65533, 65533, 65533, 65533, 65533, 65533, 65533, 65533, 65533,
(0,36): 65533, 65533, 65533, 65533, 65533, 65533, 65533, 65533, 65533
...
...
```

Interrogation of VIIRS product files

- For a scripting approach, we can use python (for M15 this time)...

```
#!/usr/bin/env python
import numpy as np
from numpy import ma as ma
import tables as pytables

h5File = "SVM15_npp_d20120124_t0601110_e0602351_b01246_c20120124153245027569_noaa_ops.h5"
M15Obj = pytables.openFile(h5File)
M15_radiance = M15Obj.getNode('/All_Data/VIIRS-M15-SDR_All/Radiance')[:,:]
M15_radianceFactors = M15Obj.getNode('/All_Data/VIIRS-M15-SDR_All/RadianceFactors')[:]
M15Obj.close()
M15_radiance = M15_radiance * M15_radianceFactors[0] + M15_radianceFactors[1]
```

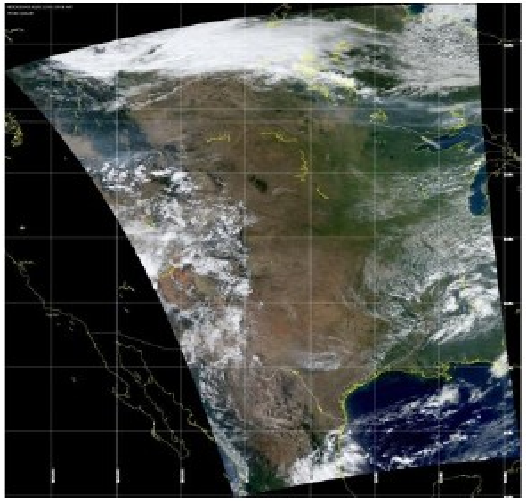


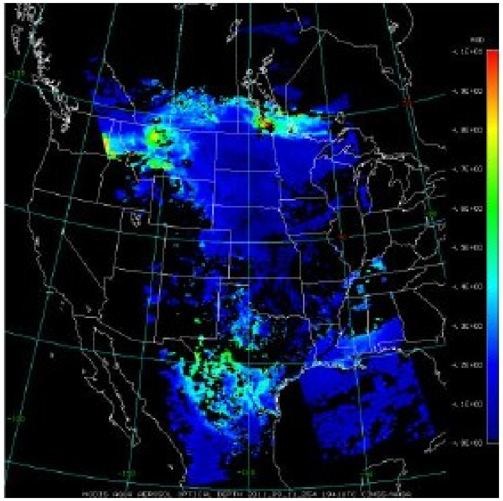
New Dual X-Band L-Band Antenna Installed on Engineering Research

New X/L-Band Antenna

Liam Gumley, Fred Best, Will Robus, Dave Jones, Allen Huang

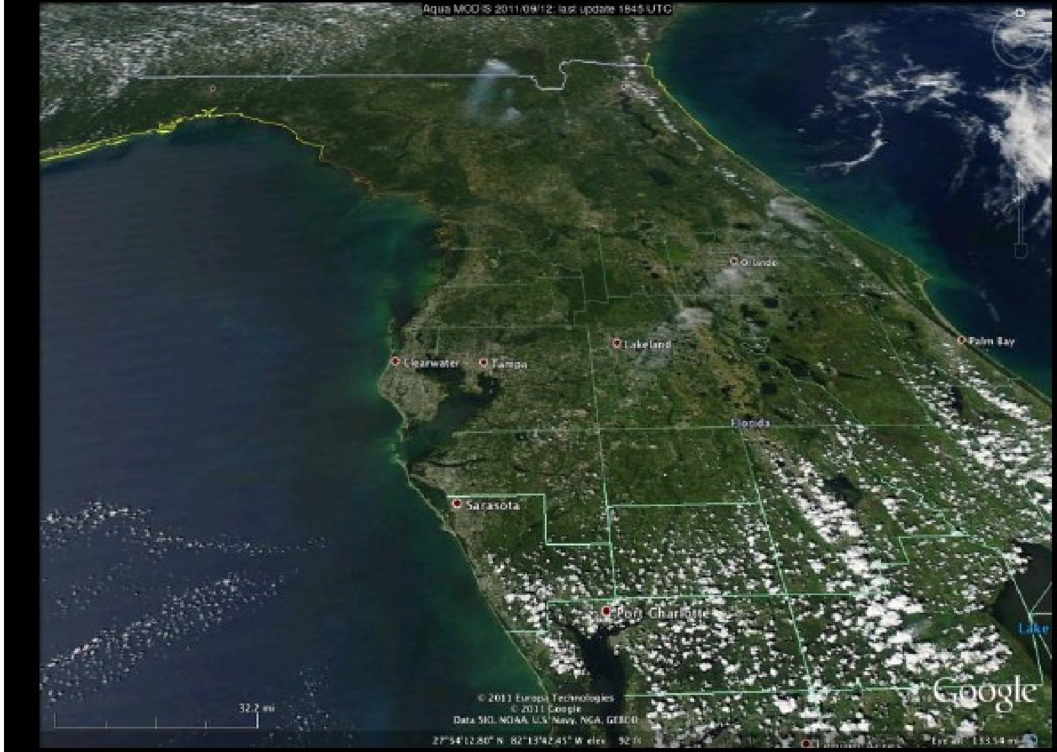
- 2.4 meter dual X/L-Band antenna system was acquired from Orbital Systems.
- Installation started at 8 am on Sep 11, 2011, and was finished by 2 pm.
- At 2:40 pm on Sep 11, Aqua direct broadcast was acquired (images at right).
- Supports NPP, Terra, Aqua, POES, Metop, FY-1, and FY-3.

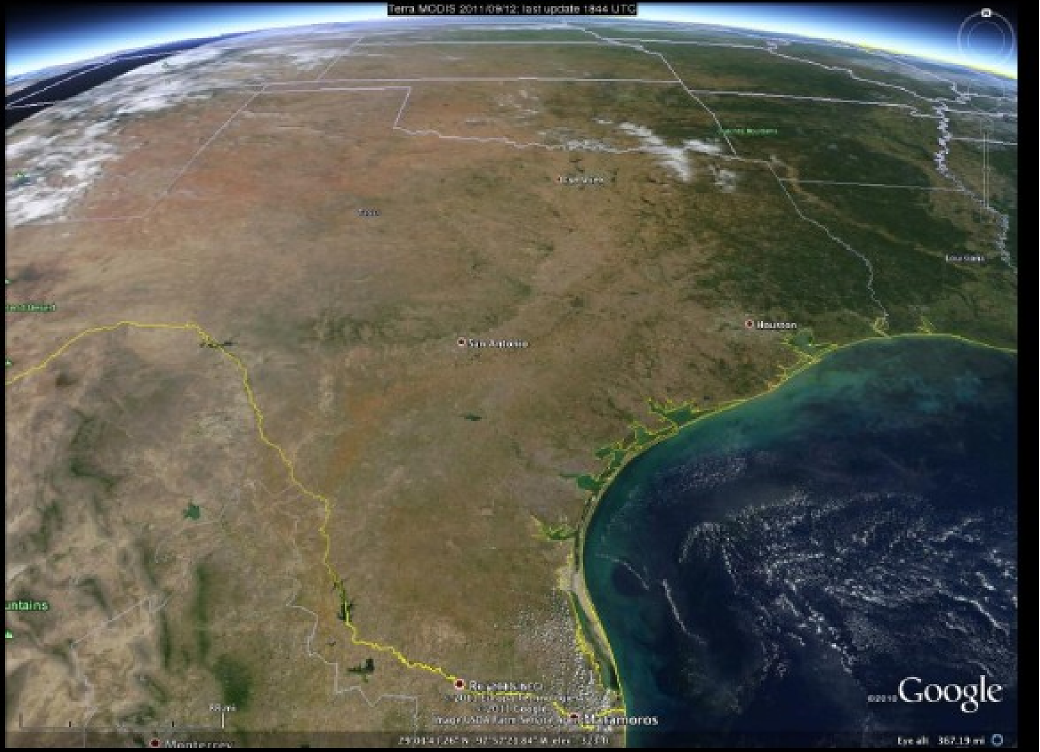




Sunday September 11

Monday September 12





These MODIS images were acquired the day after SSEC's new Orbital Systems 2.4 meter X/L-band system was installed.

Community Satellite Processing Package (CSPP)

- Based on Algorithm Development Environment (ADL).
- ADL is a cut down version of the IDPS, to allow for community algorithm development for eventual use in the IDPS.
- Internal data format is BLOBs (Binary Large Objects) and XML files.
- While CSPP input and output will eventually be in HDF5, internal look-up tables, configuration files etc... will be BLOBs, so we need to read and manipulate them.
- Python to the rescue again...

Reading and Writing BLOB Files

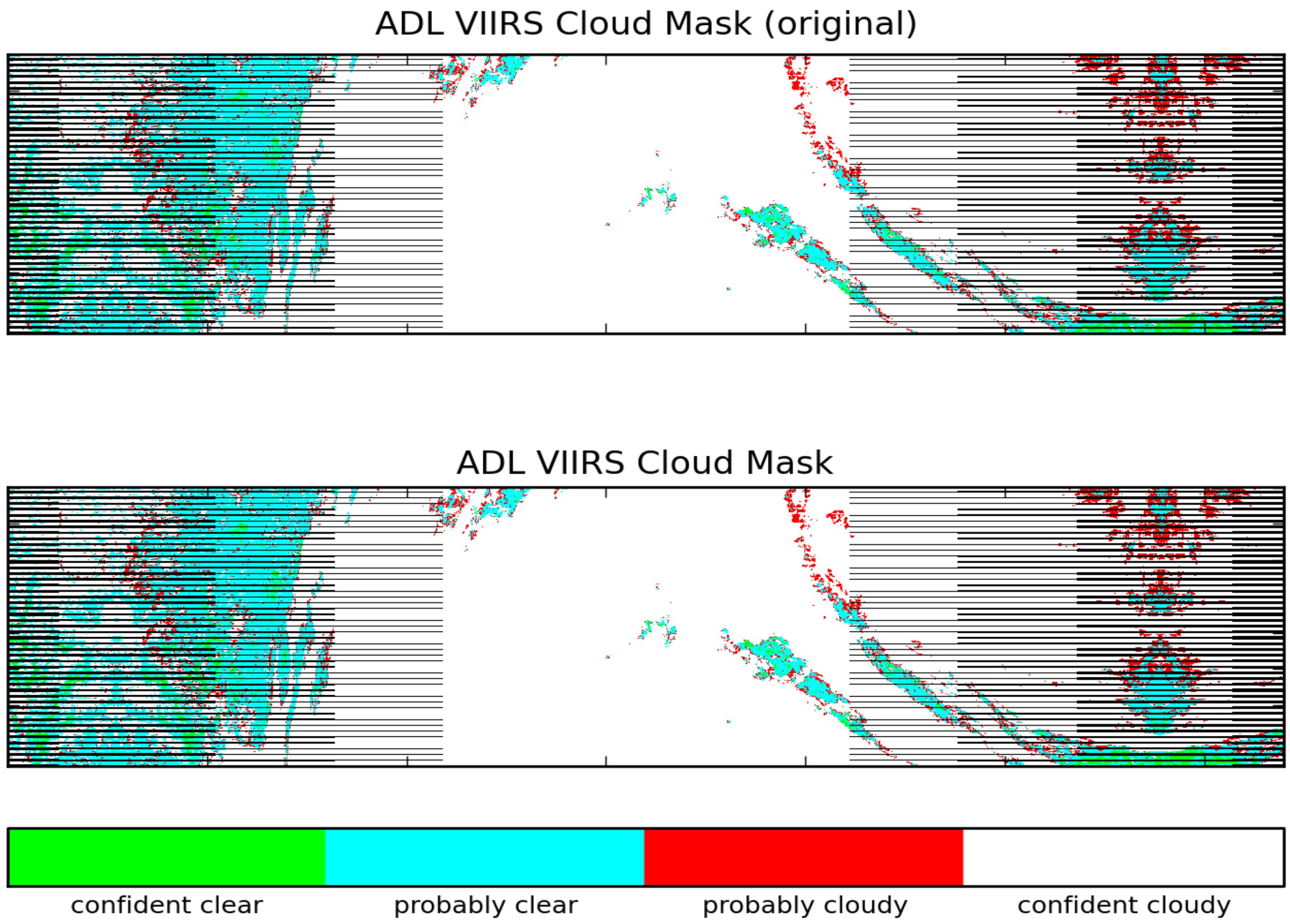
- Ray Garcia (SSEC) created adl_blob.py, which uses the XML file defining the contents of a BLOB file to create a python structure of the BLOB contents https://forums.ssec.wisc.edu/viewtopic.php?f=32&t=81#p155
- Geoff Cureton (SSEC) used the VIIRS Cloud Mask XML and BLOB files (VIIRS_CM_IP.xml, VIIRS-CM-IP) and VIIRS Aerosol Optical Thickness XML and BLOB files (VIIRS_AEROS_OPT_THICK_IP.xml, VIIRS-Aeros-Opt-Thick-IP) to ingest BLOB contents into a python structure.
- VIIRS Cloud Mask, for example...

```
import adl_blob as adl
vcmObj = adl.map(xmlFile,BlobFile,endian=adl.LITTLE_ENDIAN)
vcm = reshape(vcmObj.vcm0[:],(768,3200))
```

https://forums.ssec.wisc.edu/viewtopic.php?f=32&t=81#p161

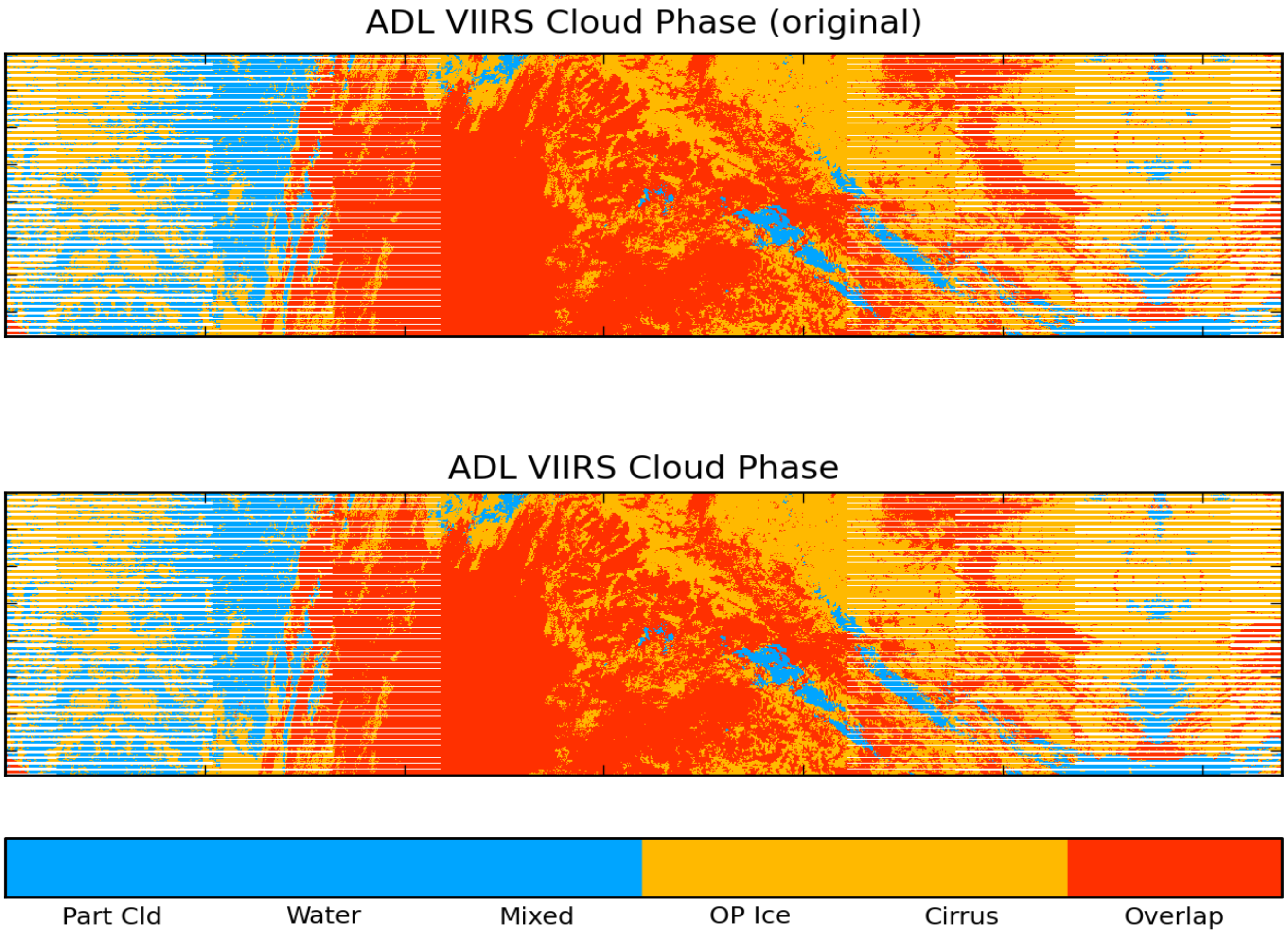
- Now for some pictures...

Reading and Writing BLOB Files

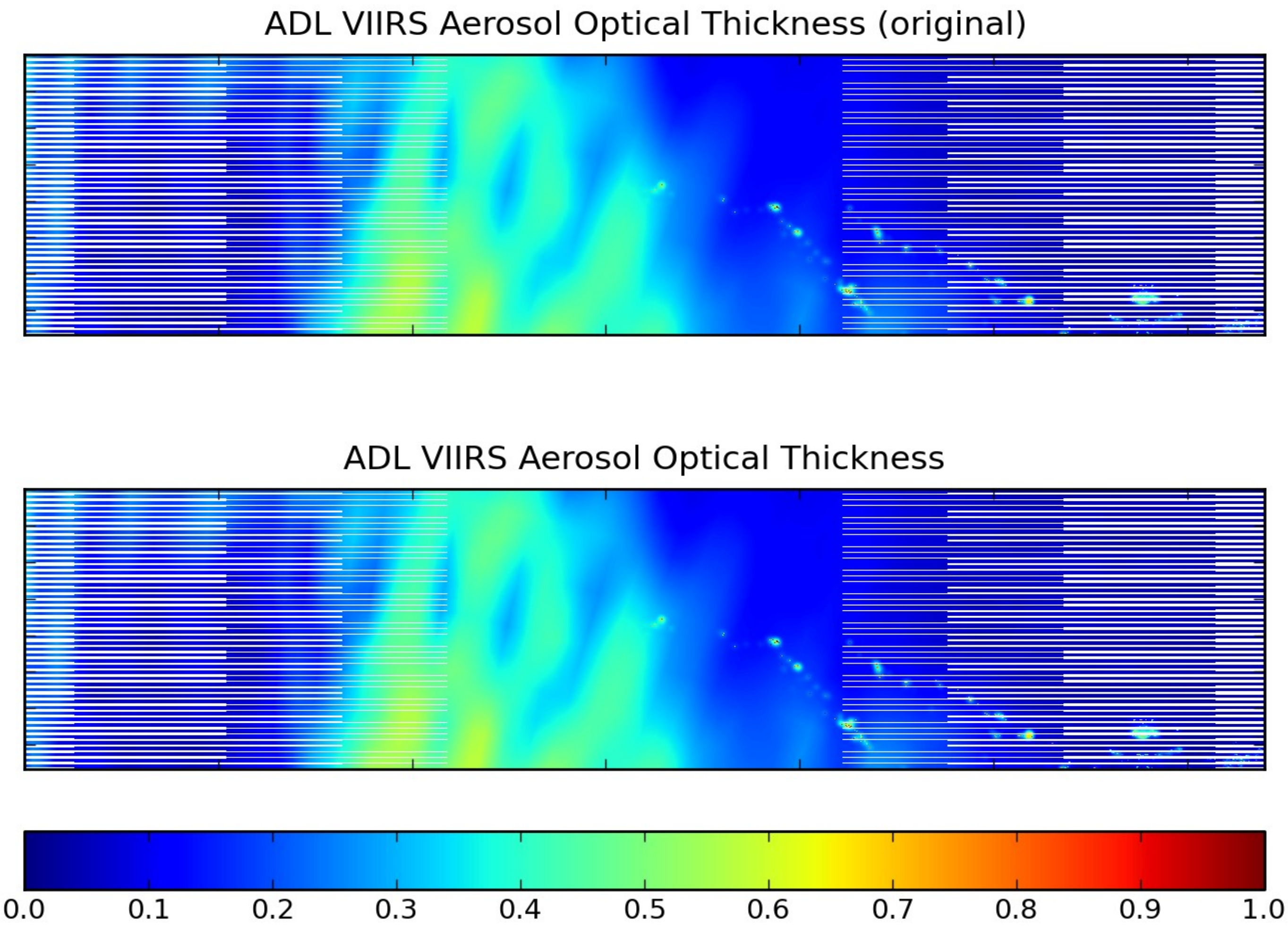

ADL VIIRS Cloud Mask (original)

ADL VIIRS Cloud Mask

Reading and Writing BLOB Files

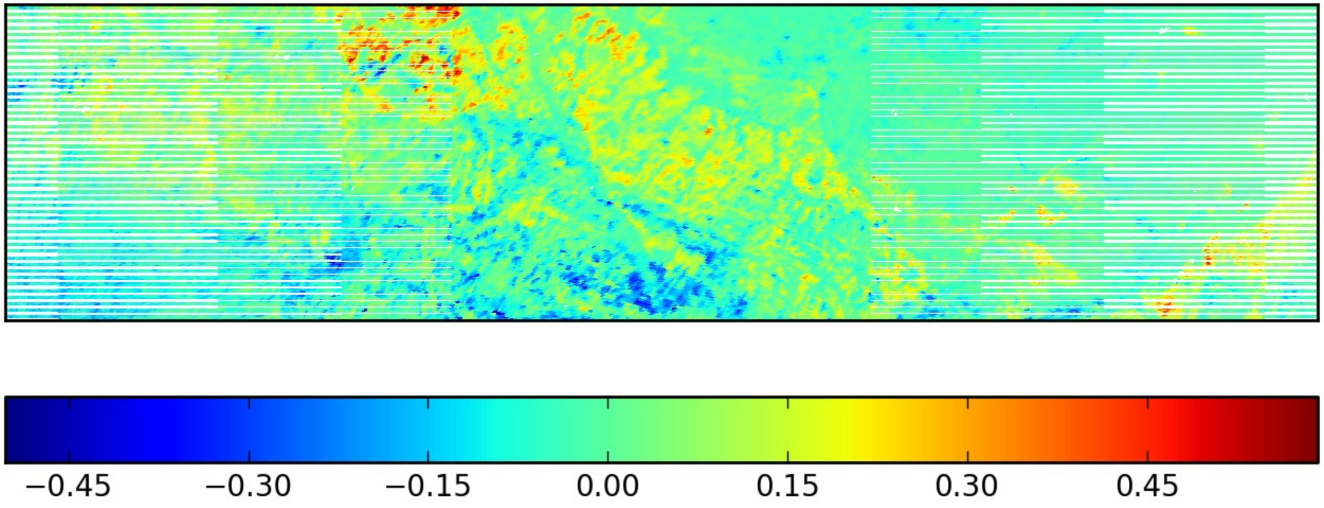


Reading and Writing BLOB Files

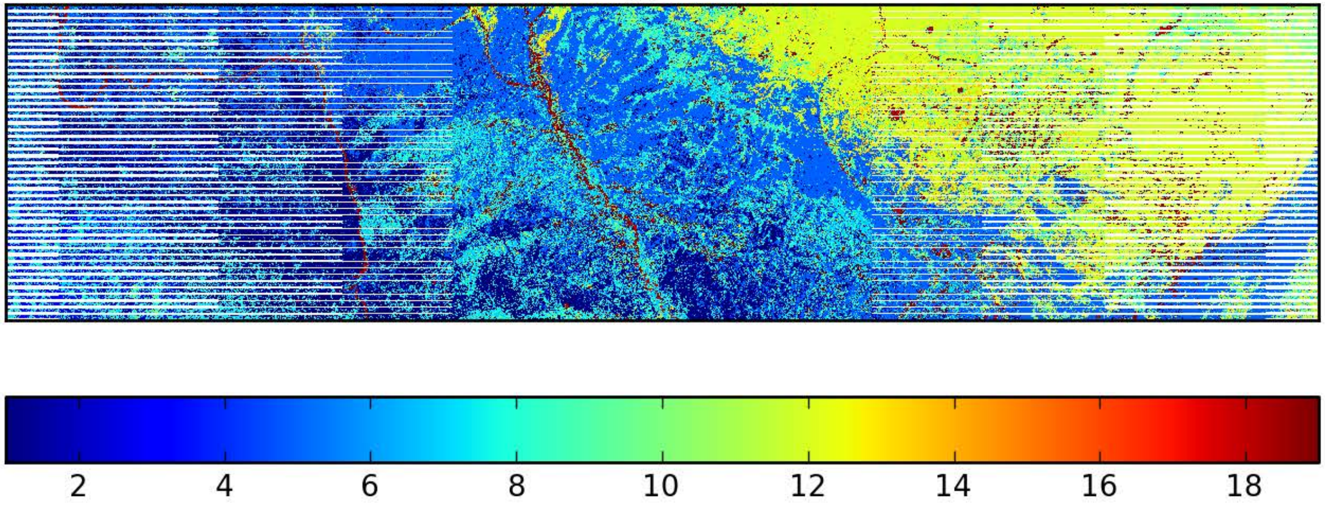


Reading and Writing BLOB Files

ADL VIIRS Normalized Vegetation Index (NDVI)



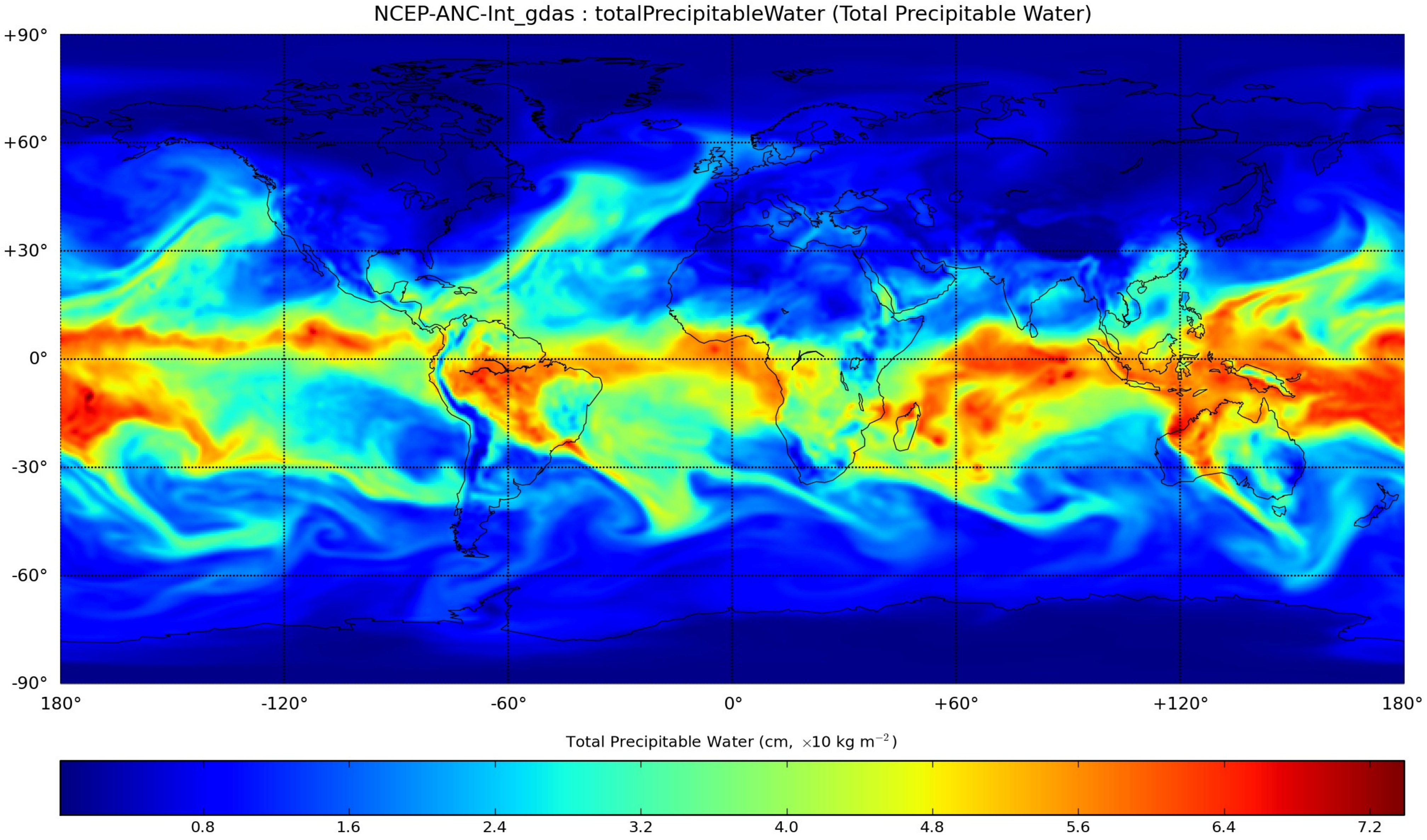
ADL VIIRS Quarterly Surface Type / Land Water Mask (QSTLWM)



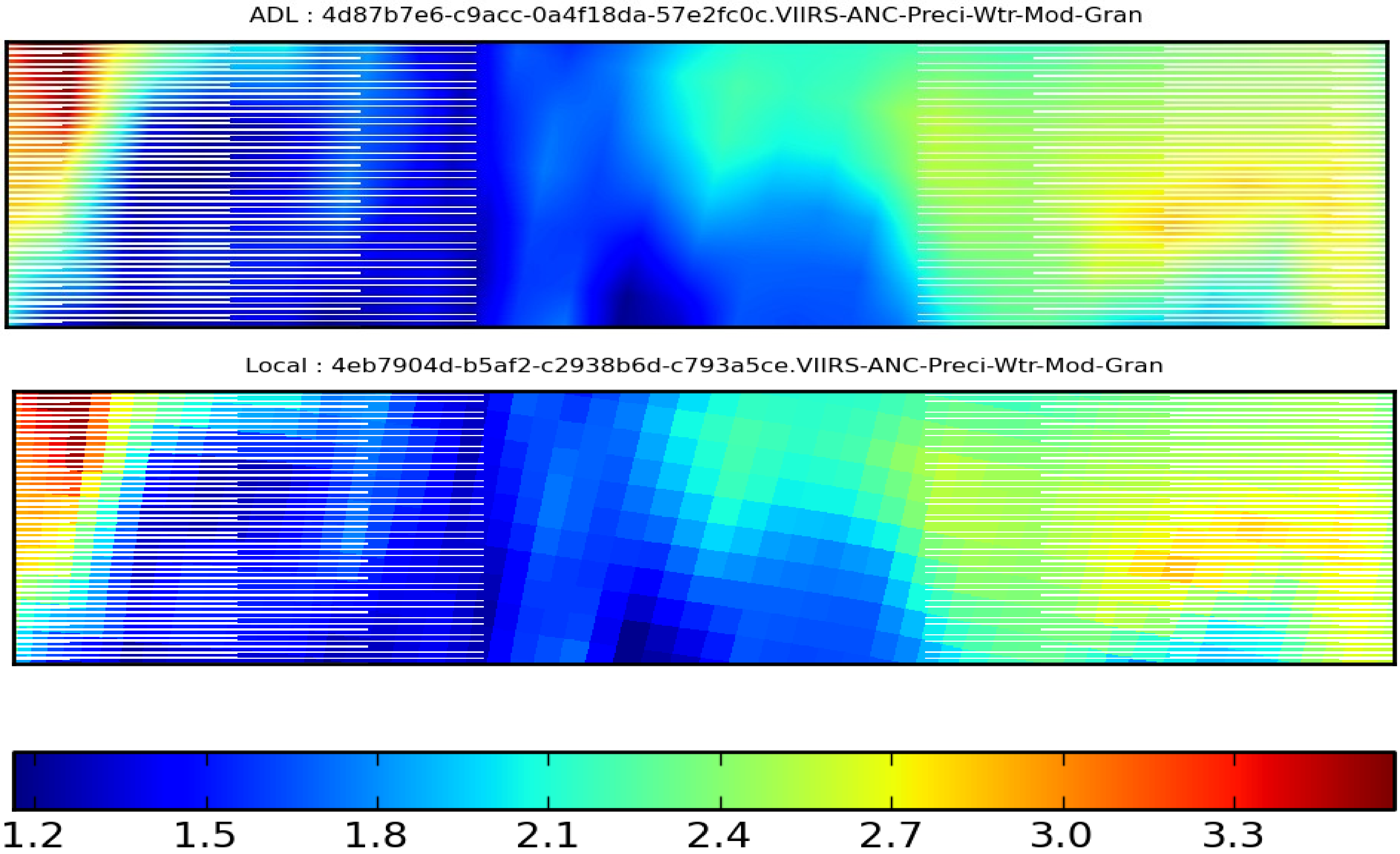
So we can read BLOB files, what now...

- Reading ADL generated BLOB files using adl_blob.py gives us a python structure with familiar arrays which we can manipulate, plot, analyze etc...
- We would like to go in the other direction, i.e.: populate such structures with data of our choosing and write back to a BLOB file, which can be ingested by ADL.
- In this way we could generate our own ancillary and SDR data in BLOB format, relatively painlessly
- BLOB files can be read, the contents of the resulting python structure overwritten (using contents of a HDF5 file), and flushed back to the BLOB file. This provides the mechanism we need to ingest our own data into ADL.

Creating Ancillary BLOB Files


NCEP-ANC-Int_gdas : totalPrecipitableWater (Total Precipitable Water)
+90°
+60°
+30°
0°
-30°
-60°
-90°
180°
-120°
-60°
0°
+60°
+120°
180°
Total Precipitable Water (cm, ×10 kg m^{-2})
0.8
1.6
2.4
3.2
4.0
4.8
5.6
6.4
7.2

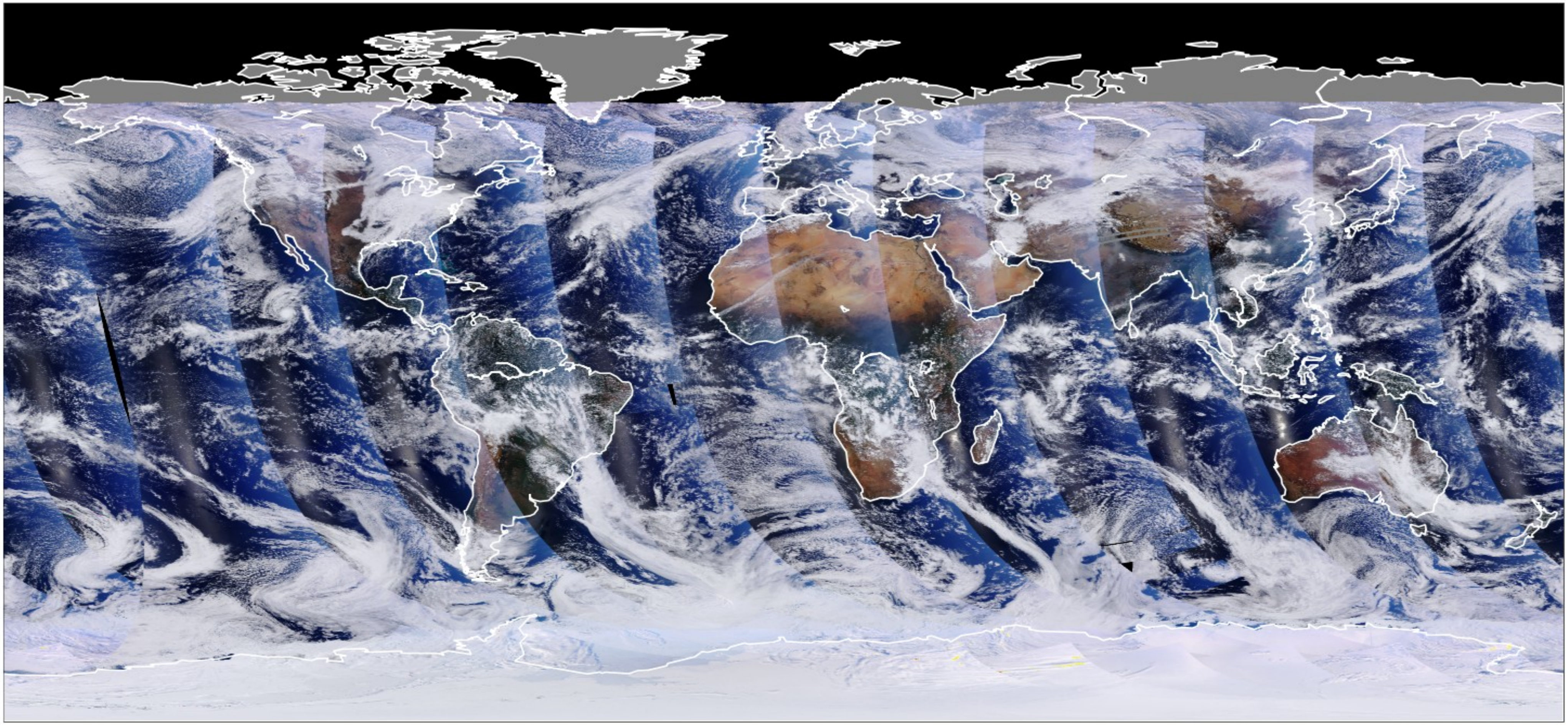
Creating Ancillary BLOB Files



ADL : 4d87b7e6-c9acc-0a4f18da-57e2fc0c.VIIRS-ANC-Preci-Wtr-Mod-Gran

Local : 4eb7904d-b5af2-c2938b6d-c793a5ce.VIIRS-ANC-Preci-Wtr-Mod-Gran

Global Mosaics -RGB

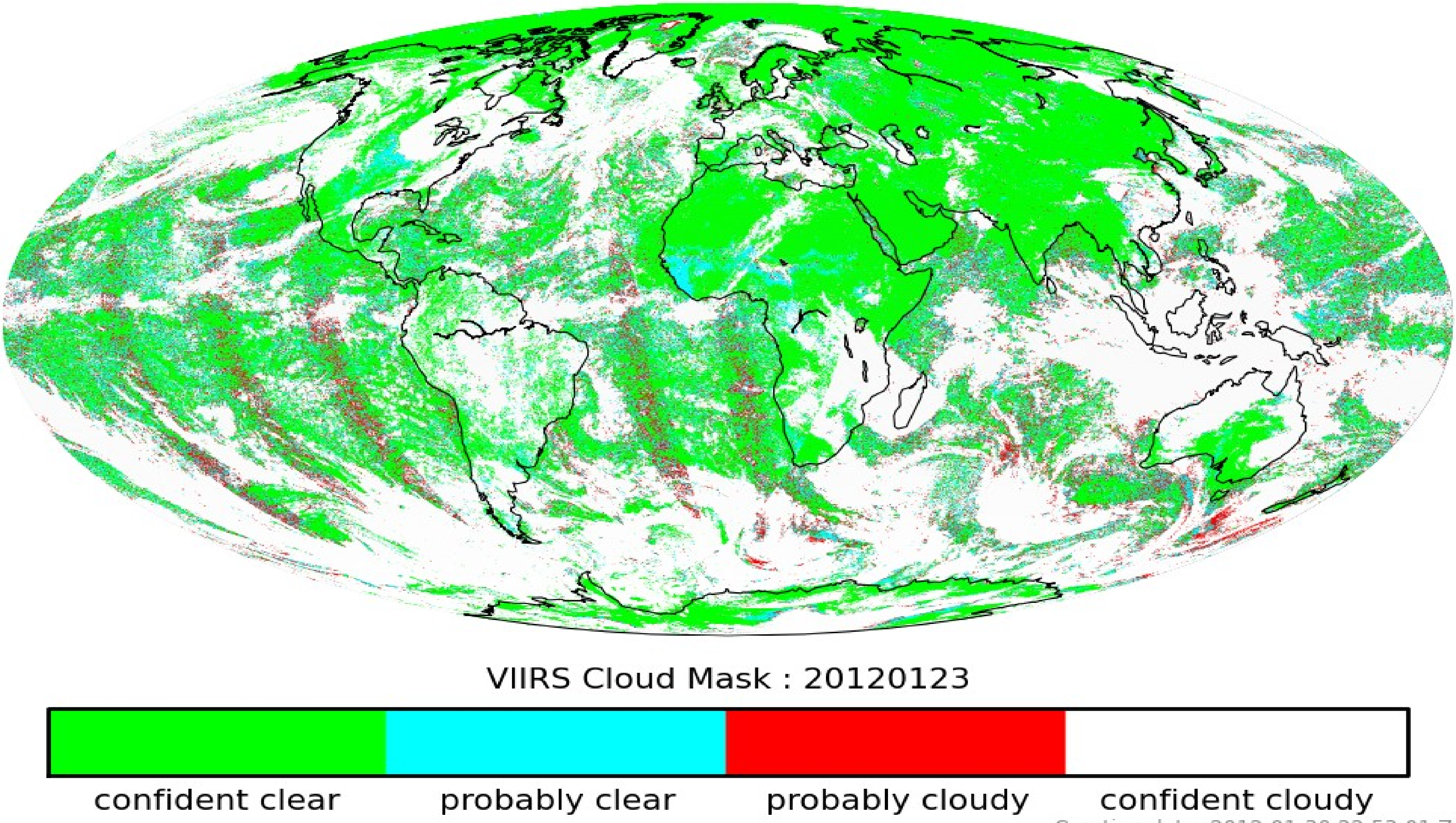


VIIRS RGB (True Color), 20111122

R : M05 (0.672 μm); G : M04 (0.555 μm); B : M02 (0.445 μm)

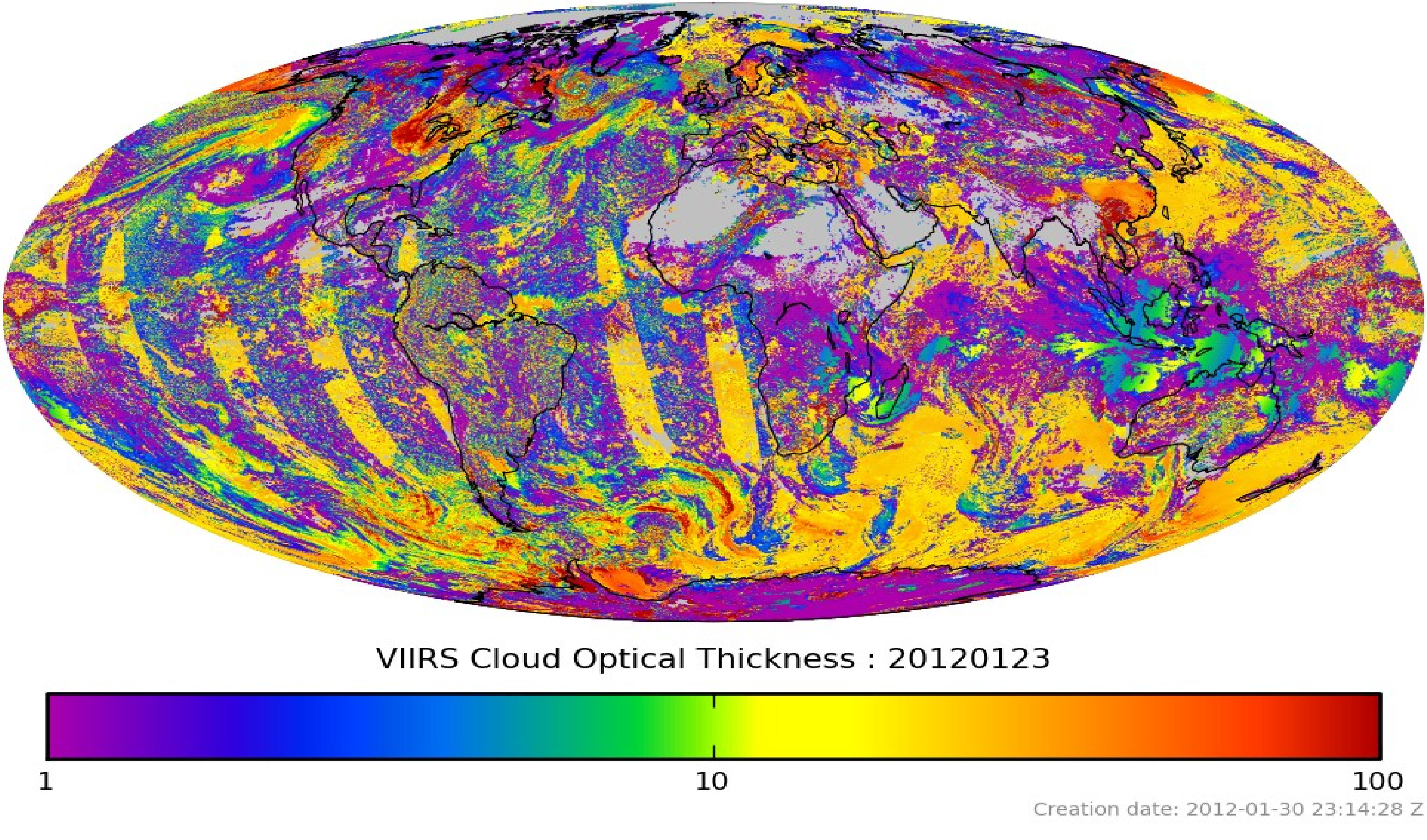
Creation date: 2011-11-26 07:19:26 Z

Global Mosaics – Cloud Mask

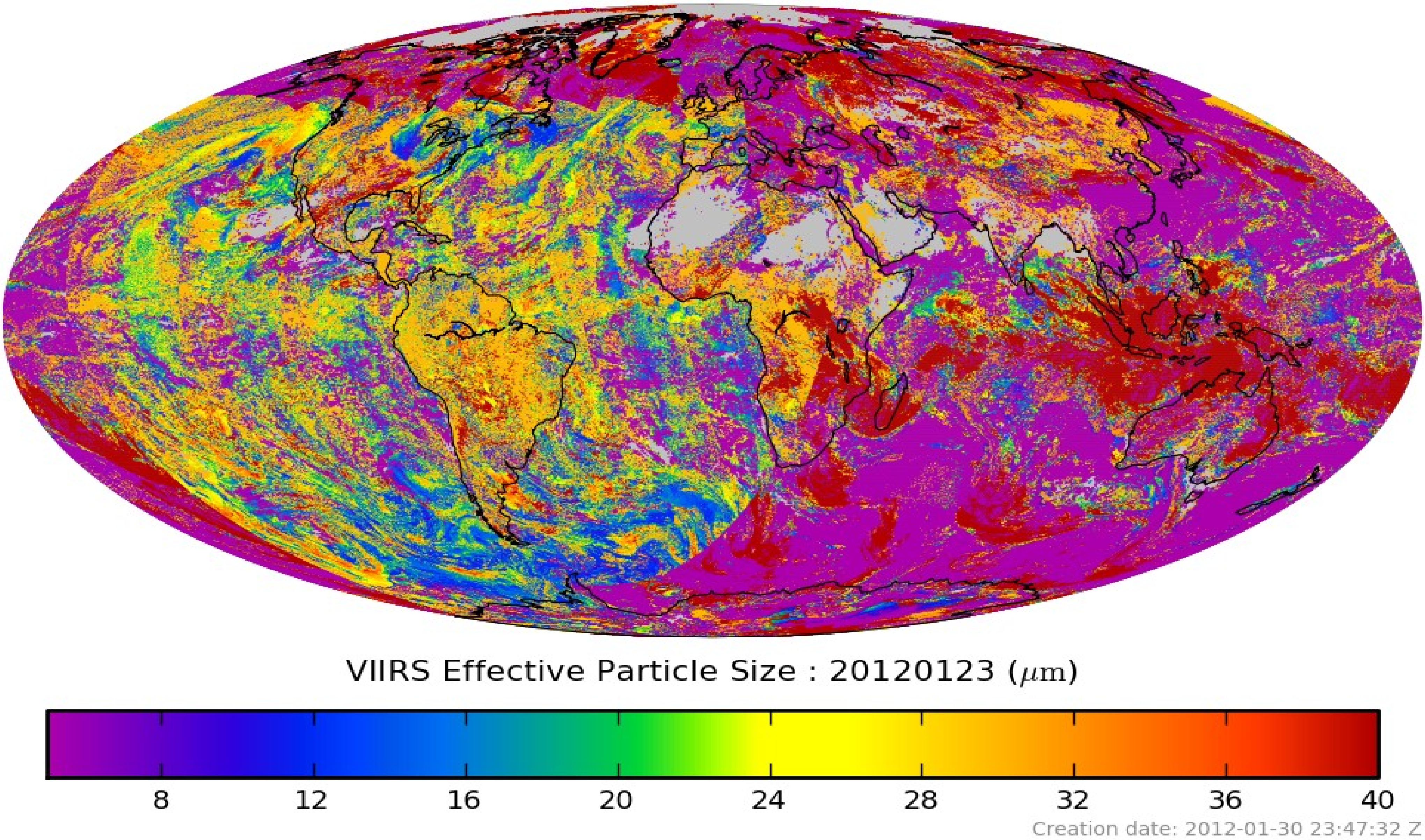


Creation date: 2012-01-30 22:53:01 Z

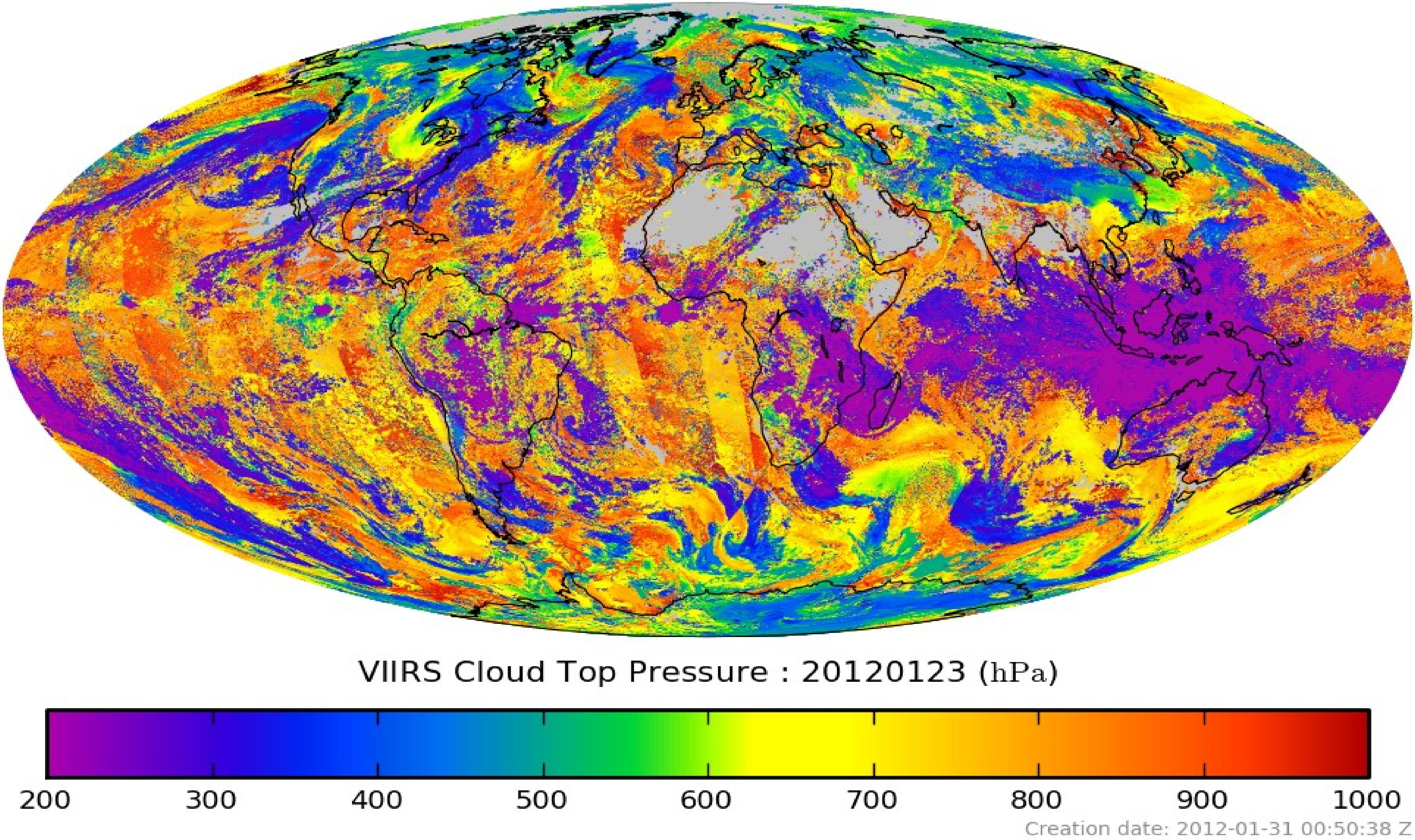
Global Mosaics – Cloud Optical Thickness


VIIRS Cloud Optical Thickness : 20120123
1
10
100
Creation date: 2012-01-30 23:14:28 Z

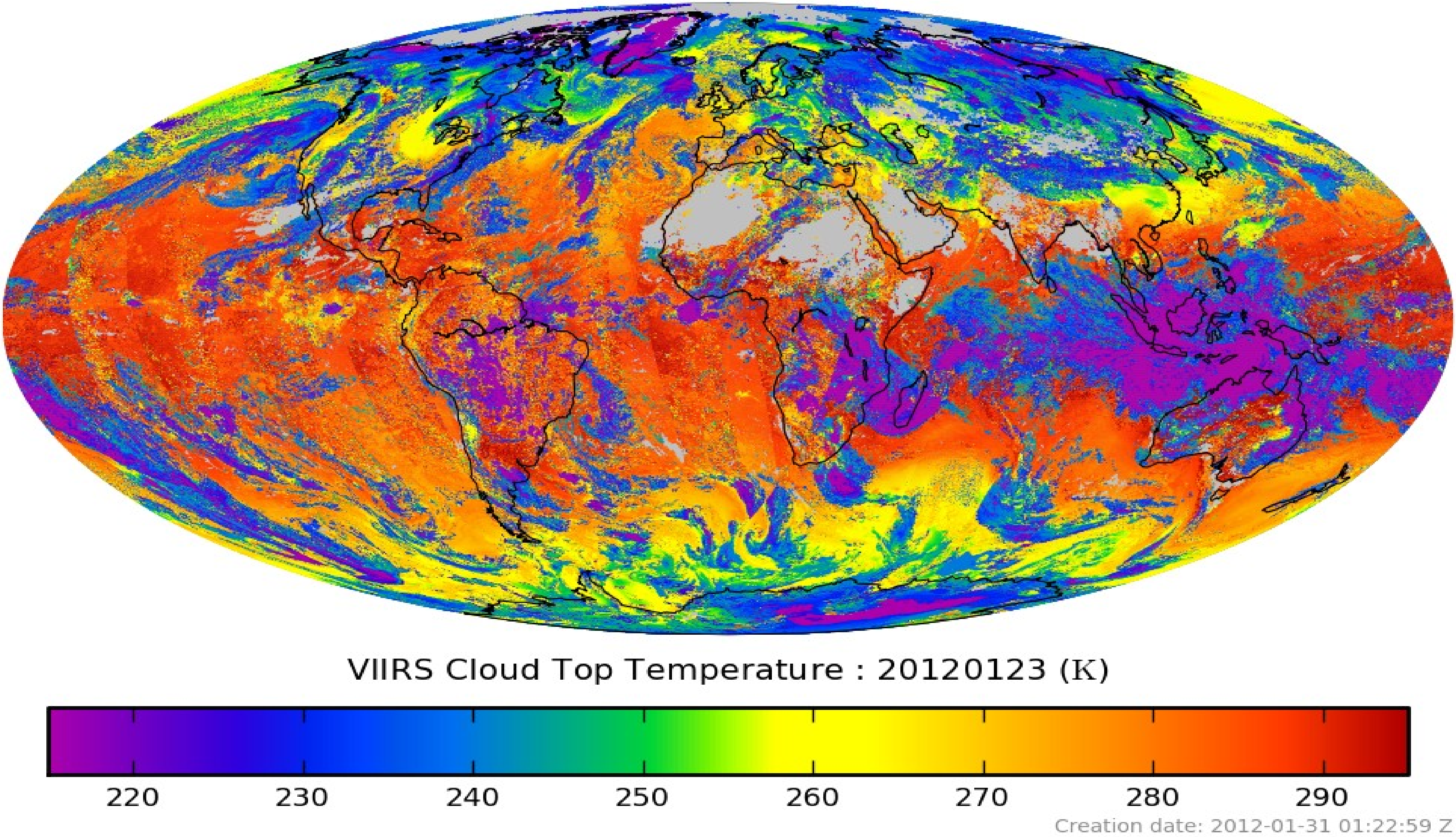
Global Mosaics – Effective Particle Size


VIIRS Effective Particle Size : 20120123 (μm)
8
12
16
20
24
28
32
36
40
Creation date: 2012-01-30 23:47:32 Z

Global Mosaics – Cloud Top Pressure

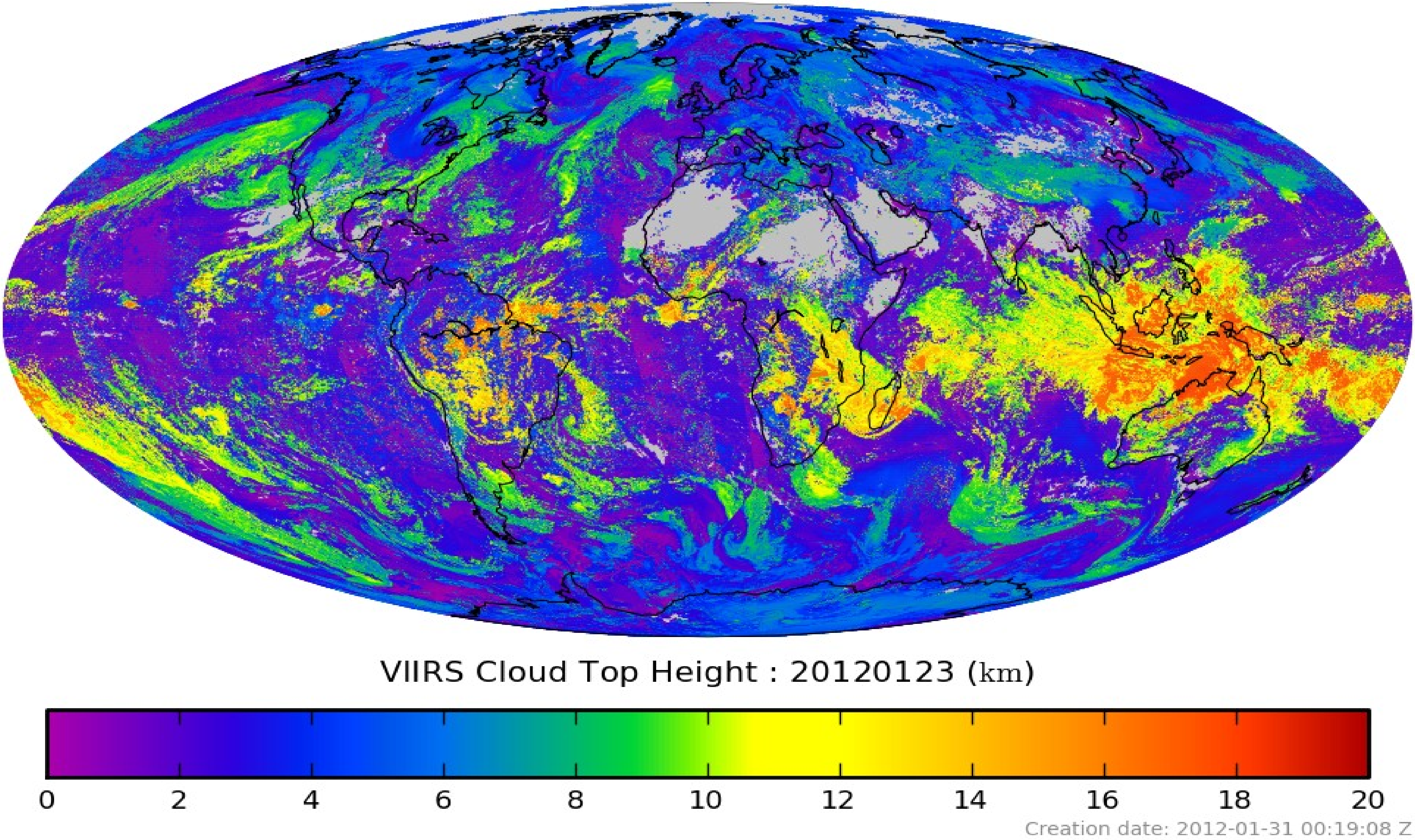

VIIRS Cloud Top Pressure : 20120123 (hPa)
200
300
400
500
600
700
800
900
1000
Creation date: 2012-01-31 00:50:38 Z

Global Mosaics – Cloud Top Temperature


VIIRS Cloud Top Temperature : 20120123 (K)
220
230
240
250
260
270
280
290
Creation date: 2012-01-31 01:22:59 Z

Space Science and Engineering Center
University of Wisconsin-Madison

Global Mosaics – Cloud Top Height


VIIRS Cloud Top Height : 20120123 (km)
0
2
4
6
8
10
12
14
16
18
20
Creation date: 2012-01-31 00:19:08 Z