Mapping CrIS Spectral Radiances of CO2 and Water Vapor Bands to VIIRS

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CERES Science Team Meeting

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Outline

- Why is this work needed?
  - the issue with SNPP-VIIRS
  - Possible solution
- Methodology
- Data involved in the mapping
- Results: pixel level images, global maps, scatterplots…
- Summary & Future Plans

The Issue with SNPP-VIIRS

- Terra & Aqua MODIS contain Water Vapor (WV) and CO_2 bands:

  6.72 μm
  13.34 μm
  13.64 μm
  13.94 μm
  14.23 μm

- Unfortunately, SNPP-VIIRS lacks of WV and CO_2 bands.

  Inconsistency in CERES data between CERES-MODIS & CERES-VIIRS

Possible Solution

- Cross-track Infrared Sounder (CrIS):

  CrIS & VIIRS two independent instruments, but on the same S-NPP platform

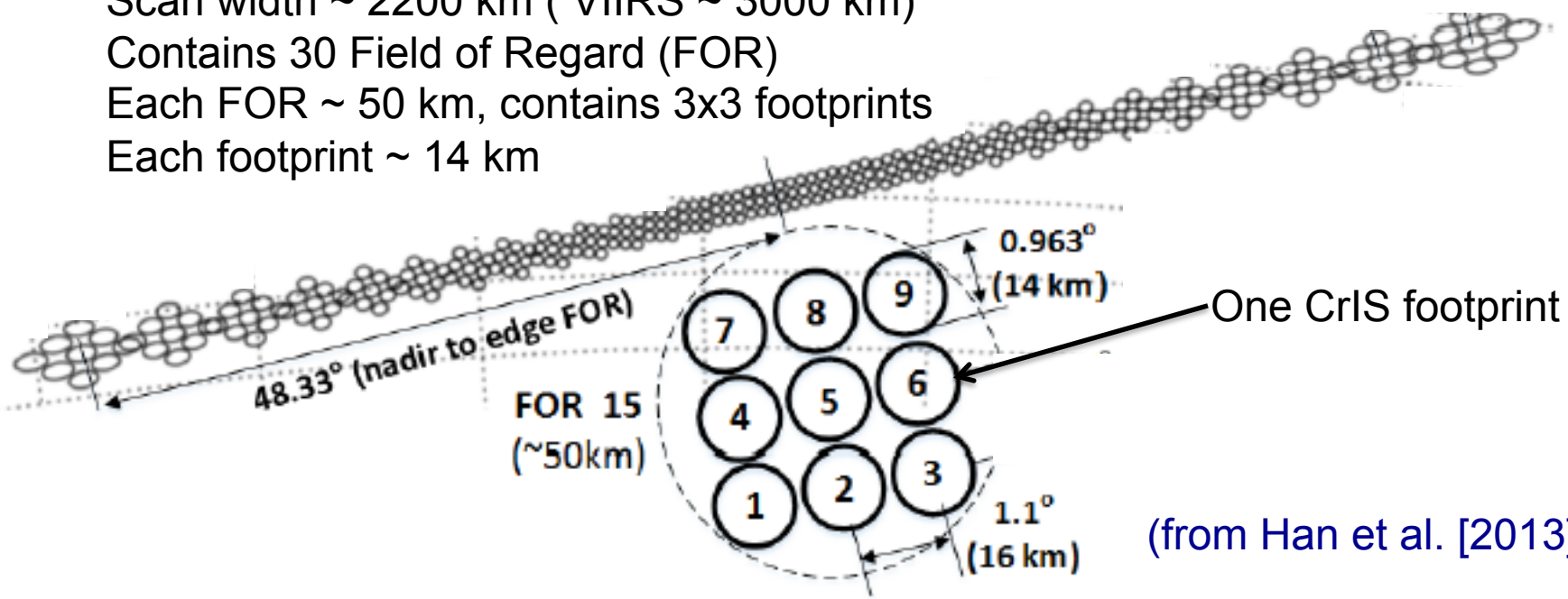
- CrIS, hyperspectral instrument, contains 3 spectral band ranges covering:

  650 – 1096 cm^{-1} (713 channels, sampling 0.625 cm^{-1}) ← CO2
  1210 – 1750 cm^{-1} (433 channels, sampling 1.25 cm^{-1}) ← WV
  2155 – 2550 cm^{-1} (159 channels, sampling 2.5 cm^{-1})

- Use CrIS to produce MODIS-like WV & CO2 radiances

One CrIS Scan

Scan width ~ 2200 km (VIIRS ~ 3000 km)
Contains 30 Field of Regard (FOR)
Each FOR ~ 50 km, contains 3x3 footprints
Each footprint ~ 14 km



(from Han et al. [2013])

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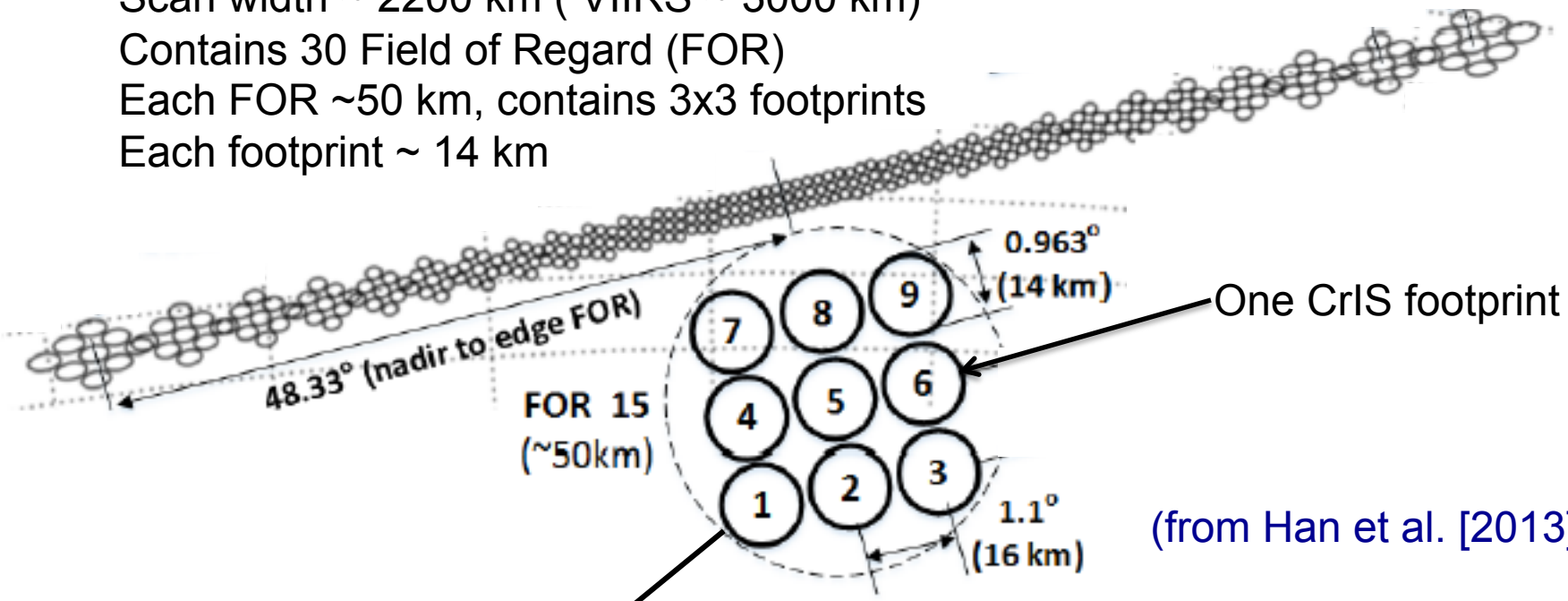
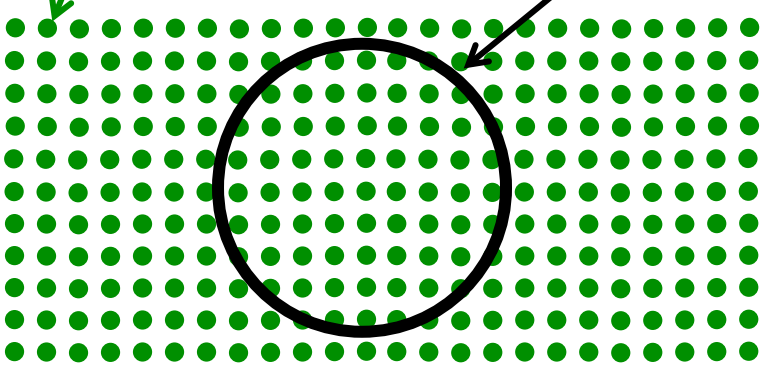


One CrIS footprint

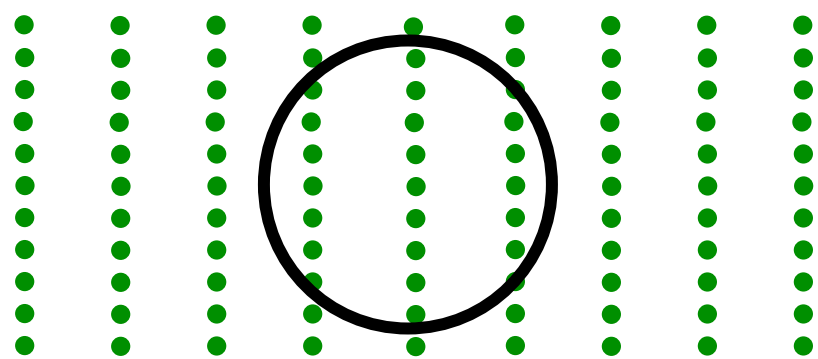
(from Han et al. [2013])

VIIRS Pixel

VIIRS at ASDC
2 x 2



CERES VIIRS Ed1 Processing
2 x 8



Methodology

- Mapping software (NWP-SAF AAPP)

  ATOVS and AVHRR Pre-processing (AAPP) package provided by Satellite Application Facilities for Numerical Weather Prediction (NWP SAF). Mapping VIIRS to CrIS.

- Modified AAPP package so that it would map CrIS to VIIRS, instead of VIIRS to CrIS.

Methodology - Conti

- MODIS-like WV and CO2 radiance can be calculated as:

CrIS hyper-spectral radiance at the channel i

$$L_\lambda = \sum_i I_i R_i / \sum_i R_i$$

MODIS relative spectral response (RSR)

MODIS-like WV & CO2 radiances

- Use trapezoidal approximation to optimize the accuracy of the radiance calculation

Methodology - Conti

- Due to the coarse CrIS spatial resolution, some VIIRS pixels do not have CrIS mapped values. Therefore a regional average filling method was applied to those VIIRS pixels

- Append the 6 calculated MODIS-like radiances of CO2 and WV bands to the VIIRS Level 1B files.

6.72 μm
7.33 μm
13.34 μm
13.64 μm
13.94 μm
14.23 μm

Data

- Test Data: September 19, 2015
- S-NPP VIIRS NetCDF4 Product from NASA GSFC Land SIPS (with the subsetter provided by CERES):
  VNP0203IMD_SS
- CrIS SDR products from NOAA CLASS (~1.5 GB/month)
  GCRSO: Geolocation
  SCRIS: Radiances
- Relative Spectral Response (RSR) from MODIS Characterization Support Team:
  https://mcst.gsfc.nasa.gov/calibration/parameters

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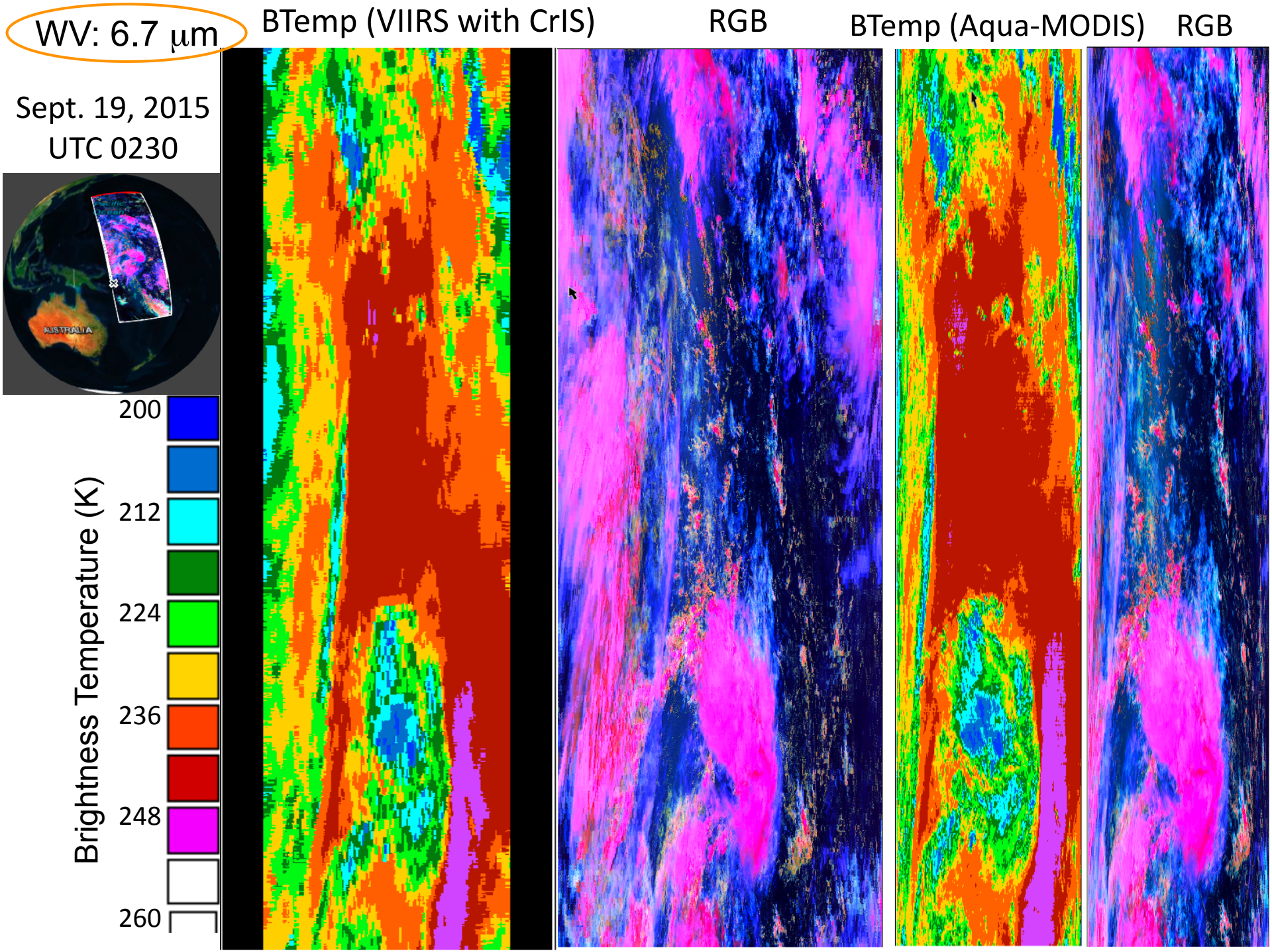
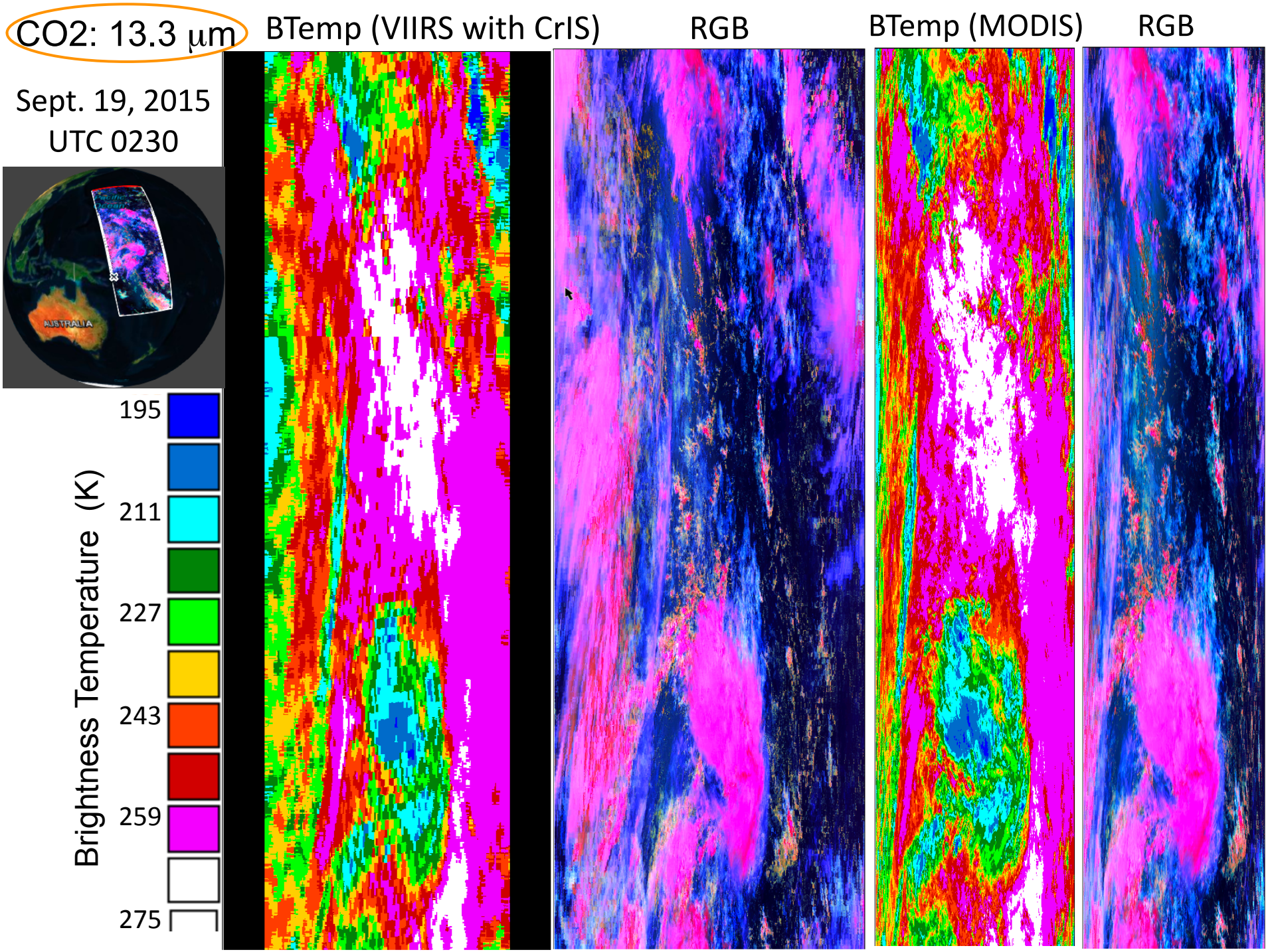
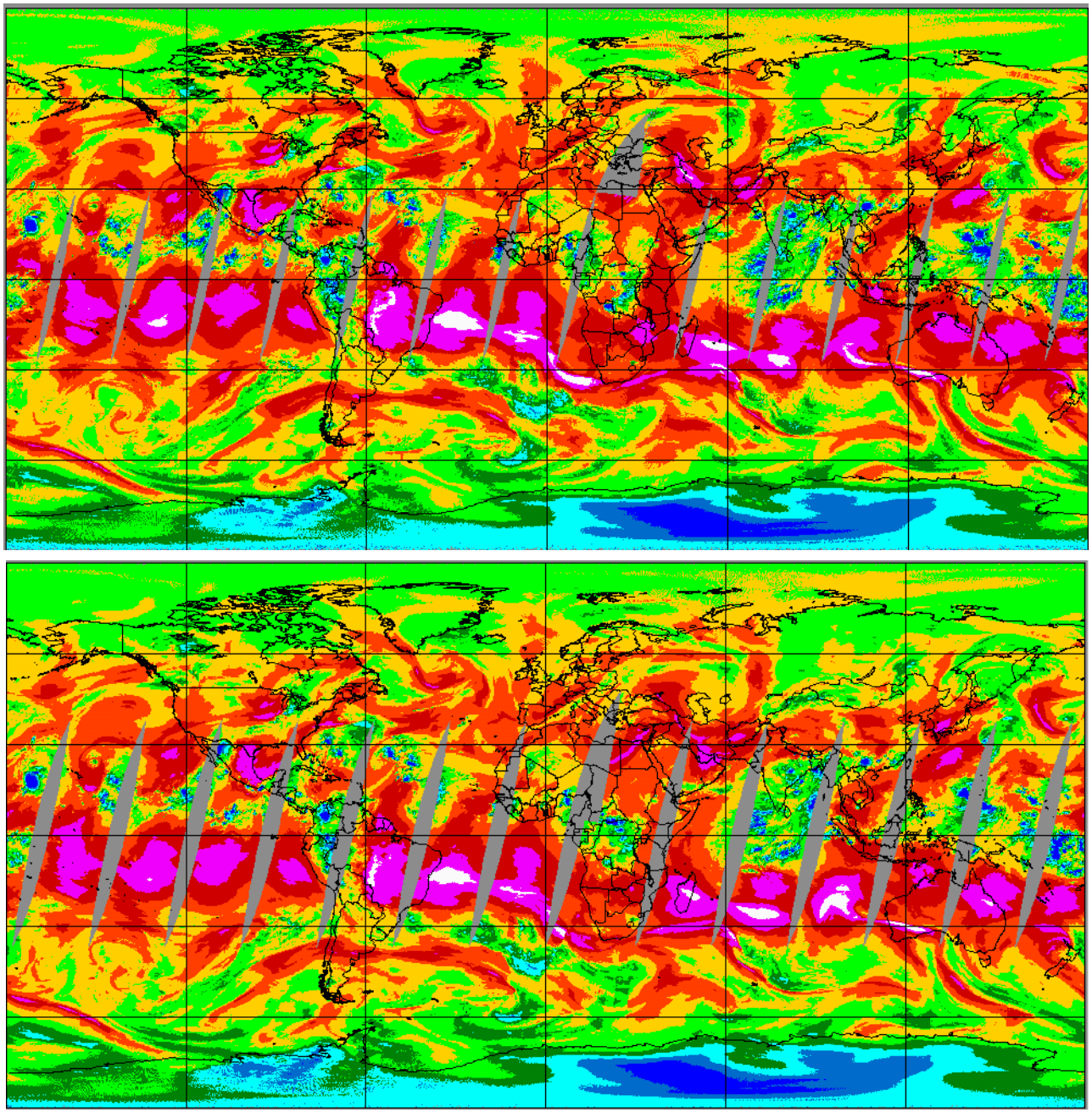

WV: 6.7 μm
BTemp (VIIRS with CrIS)
RGB
BTemp (Aqua-MODIS)
RGB
Sept. 19, 2015
UTC 0230
AUSTRALIA
Brightness Temperature (K)
200
212
224
236
248
260


CO2: 13.3 μm
BTemp (VIIRS with CrIS)
RGB
BTemp (MODIS)
RGB
Sept. 19, 2015
UTC 0230
AUSTRALIA
Brightness Temperature (K)
195
211
227
243
259
275

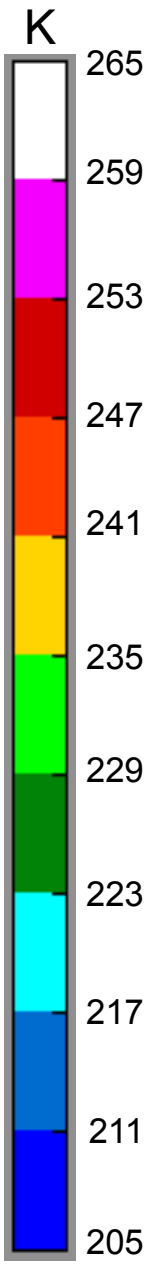
WV: 6.7 μm

Brightness Temperature, September 19, 2015, Night Time



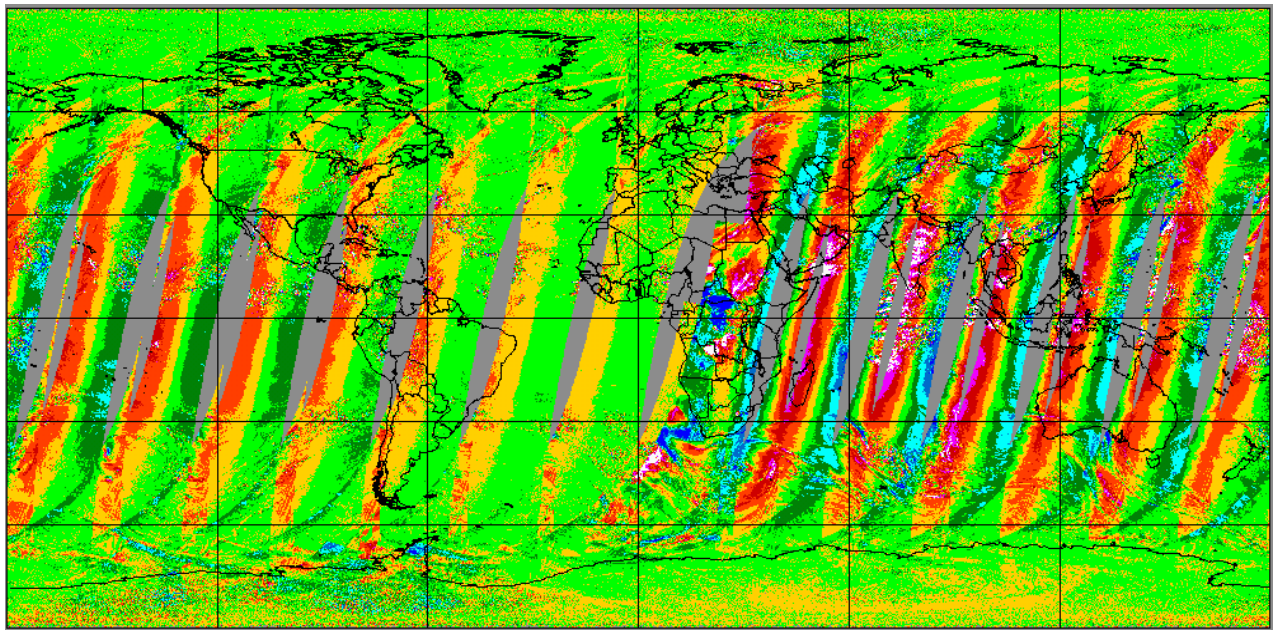
Aqua-MODIS

VIIRS with CrIS

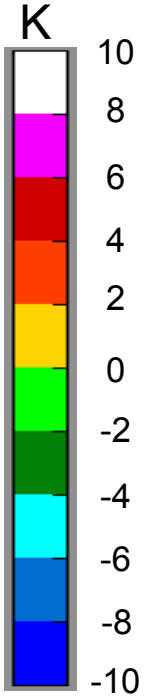


WV: 6.7 μm

BTemp Difference, September 19, 2015, **Nigh Time**

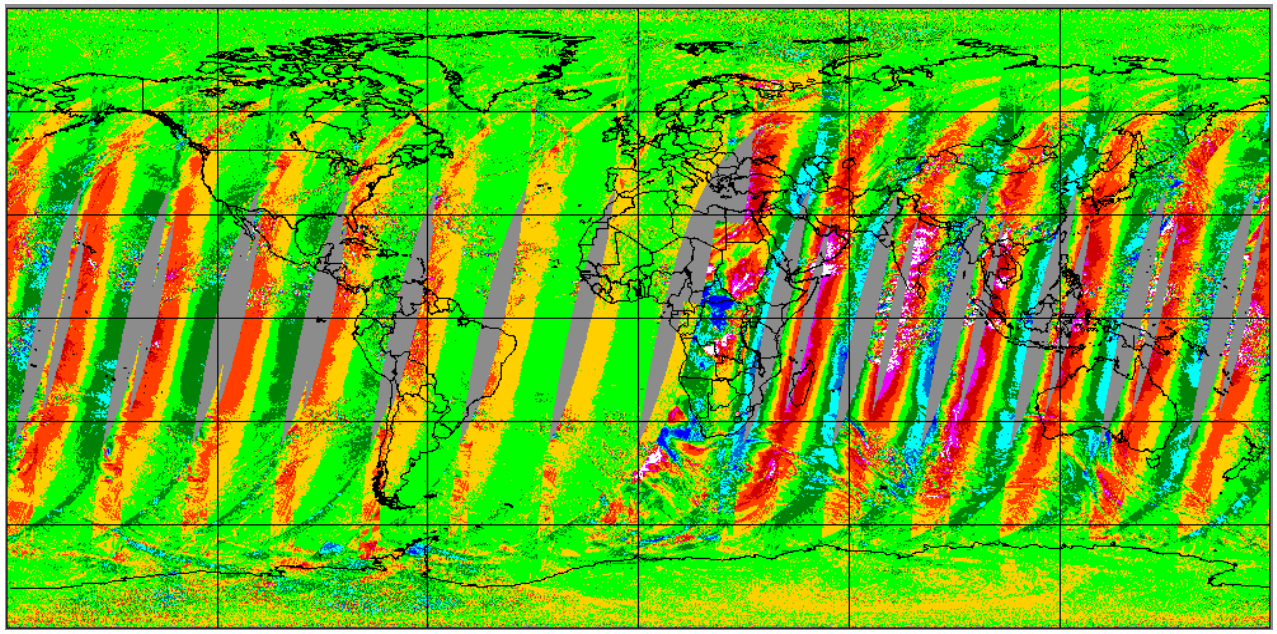


VIIRS with CrIS
minus
Aqua-MODIS

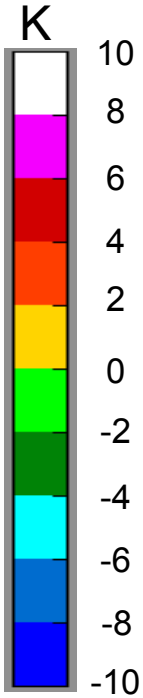


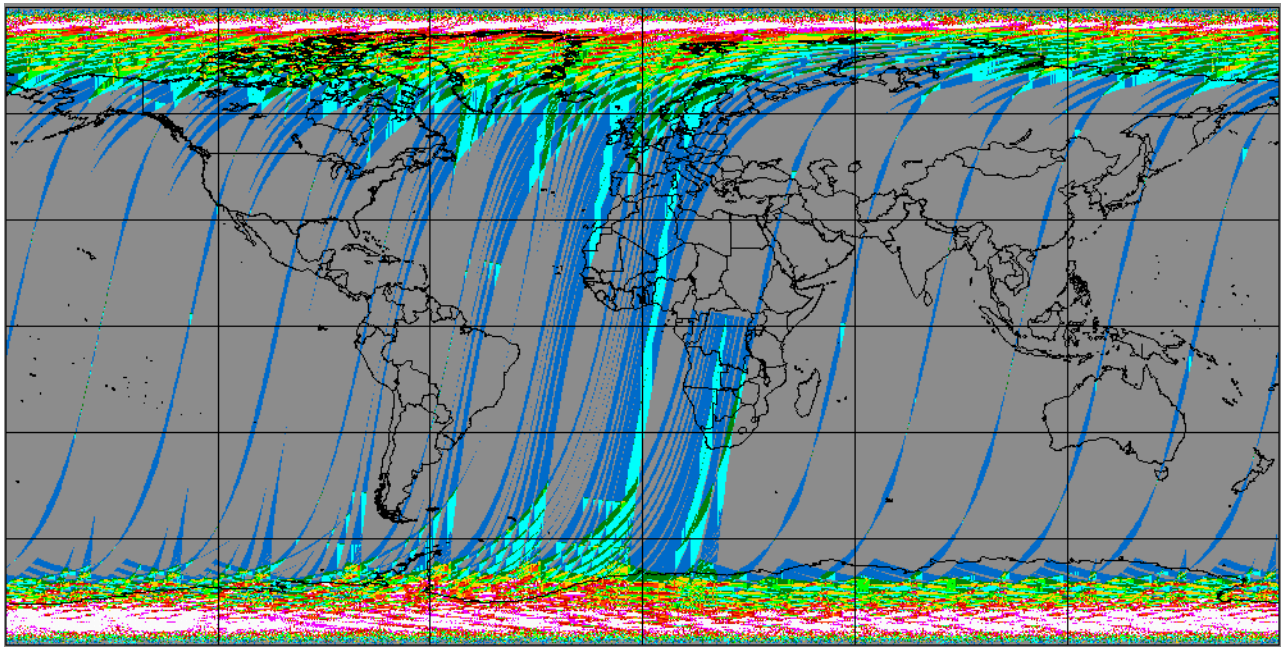
WV: 6.7 μm

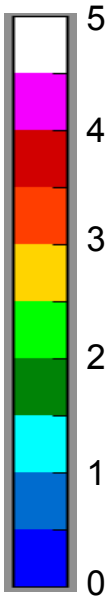
BTemp Difference, September 19, 2015, **Nigh Time**



VIIRS with CrIS minus Aqua-MODIS



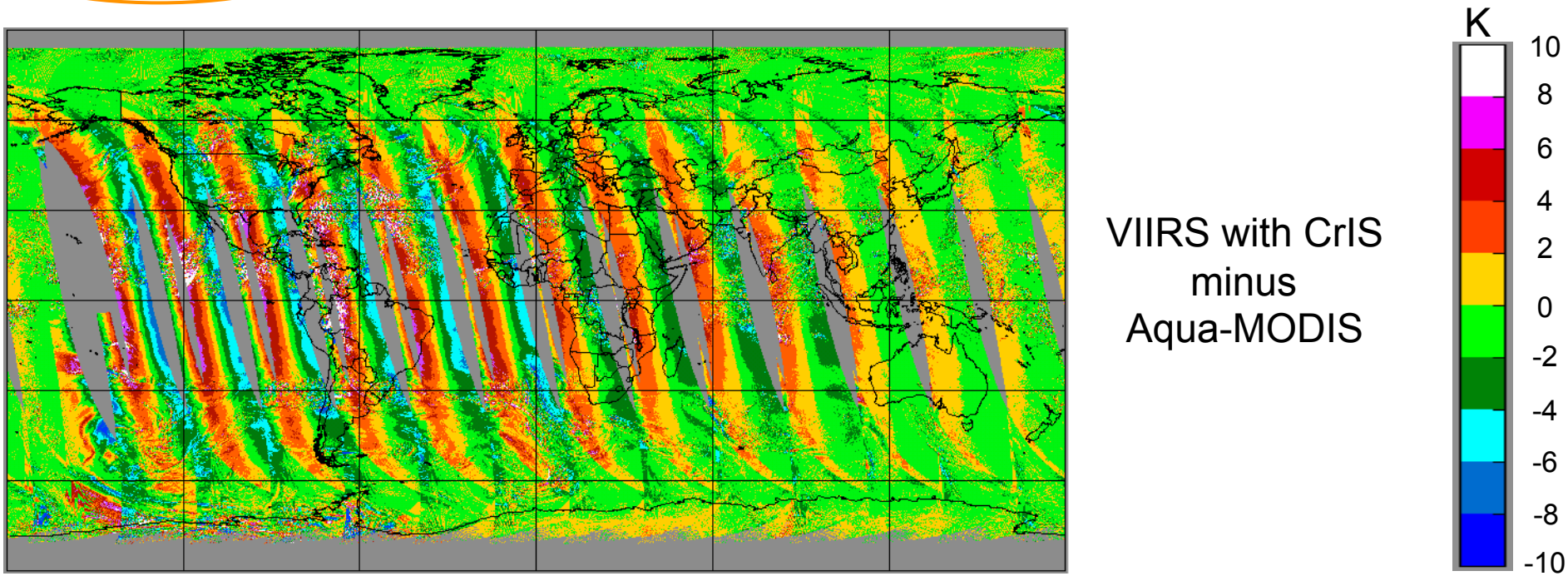




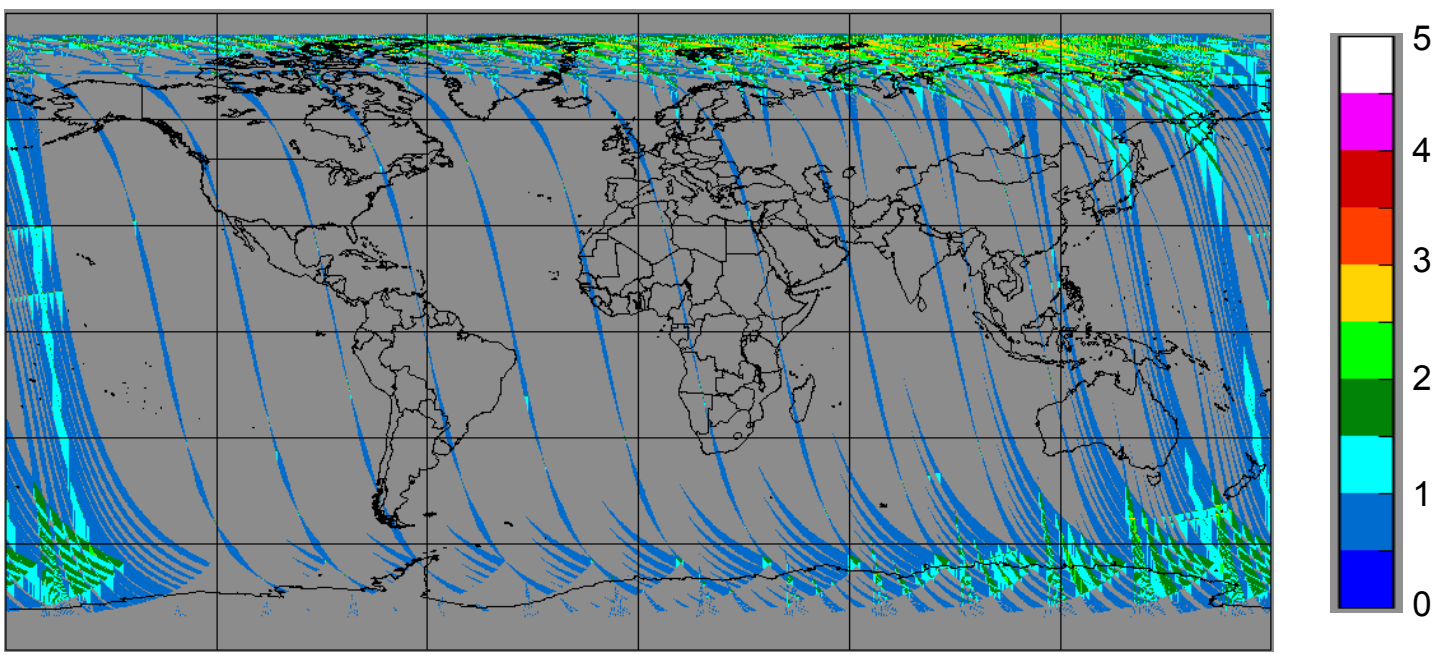
Frequency (number of counts) that VIIRS and Aqua-MODIS having the same colocated overpass

WV: 6.7 μm

BTemp Difference, September 19, 2015, **Day Time**



VIIRS with CrIS minus Aqua-MODIS



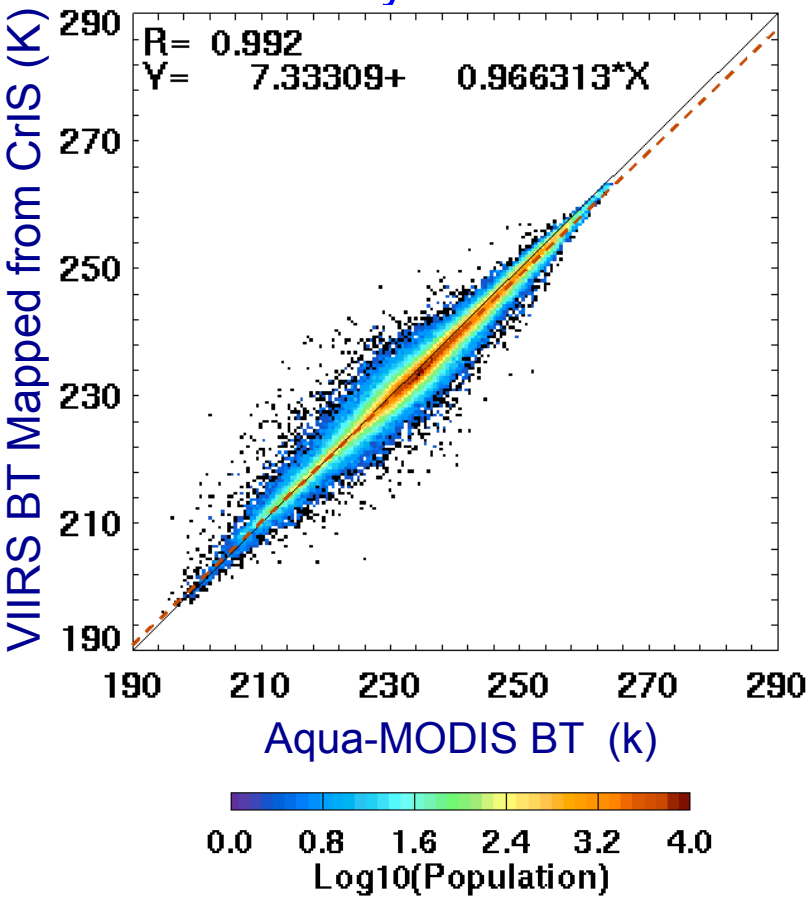
Frequency (number of counts) that VIIRS and Aqua-MODIS having the same colocated overpass

WV: 6.7 μm

Comparison of Brightness Temperature at 6.7 μm between VIIRS with CrIS and Aqua-MODIS

September 19, 2015, Co-located overpasses between Aqua-MODIS &VIIRS

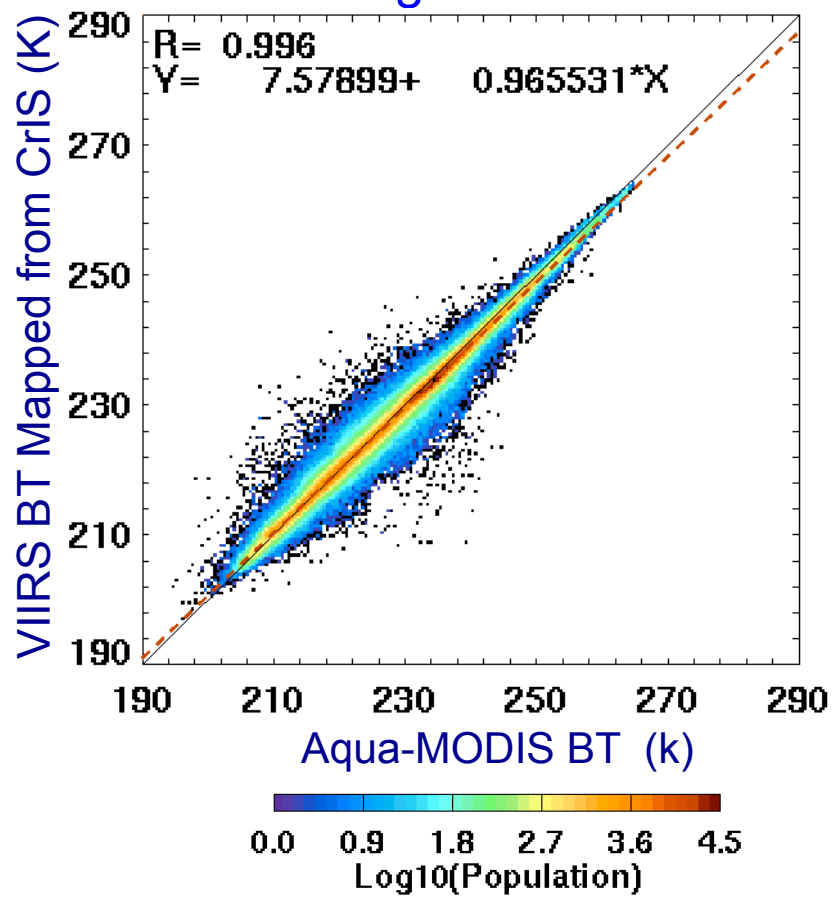
Day Time



N= 628219.

	Mean	(StdDev)
Aqua	236.4	(7.68)
VIIRSwithCrIS	235.8	(7.51)
Y-X	-0.631	(0.993)
RMS	(1.18)	.....

Night Time



N= 1837247.

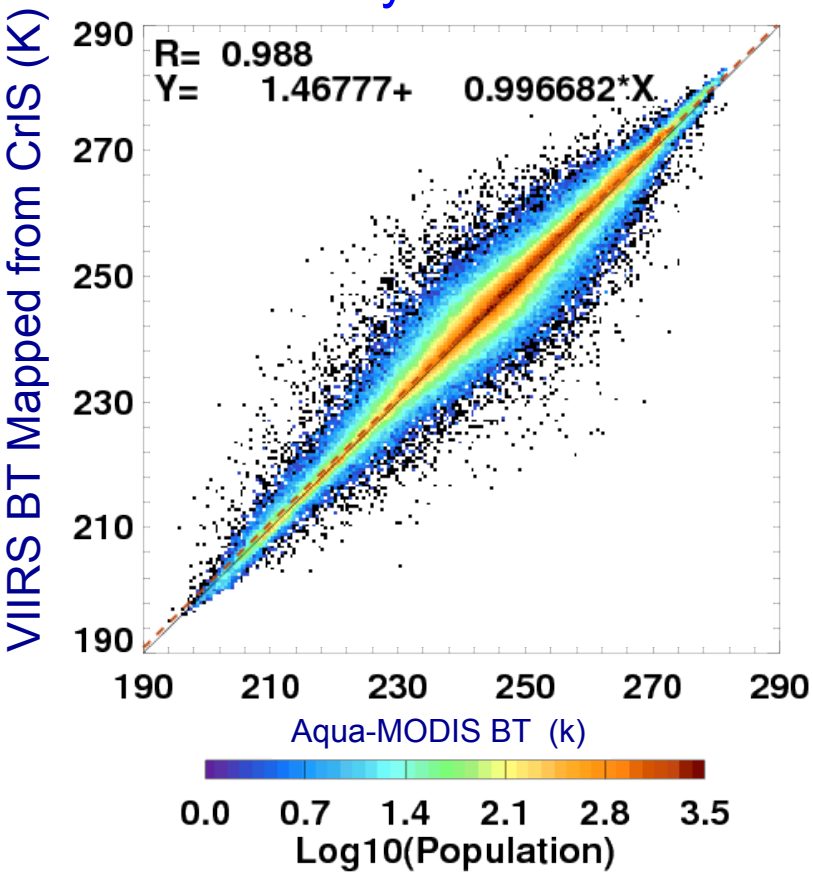
	Mean	(StdDev)
Aqua	230.1	(9.72)
VIIRSwithCrIS	229.8	(9.42)
Y-X	-0.349	(0.937)
RMS	(1.00)	.....

CO2: 13.3 μm

Comparison of Brightness Temperature at 13.3 μm between VIIRS with CrIS and Aqua-MODIS

September 19, 2015, Co-located overpasses between Aqua-MODIS & VIIRS

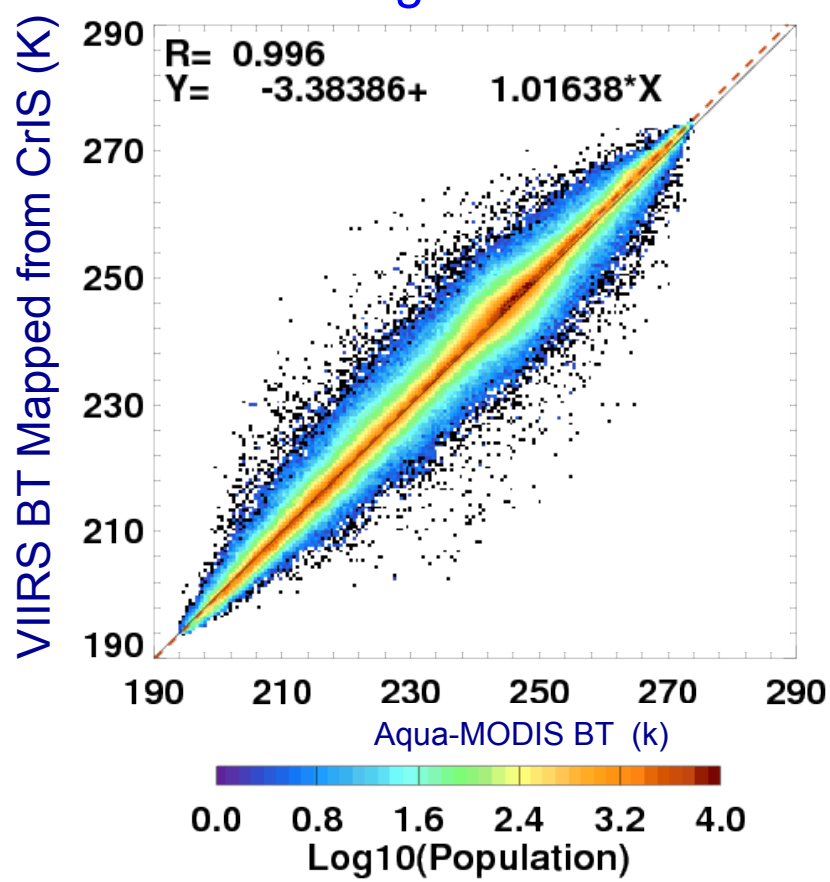
Day Time



N= 628219.

	Mean	(StdDev)
Aqua	247.5(	12.92)
VIIRS	248.2(	13.03)
Y-X	0.646(	2.00)
RMS(	2.10).....	

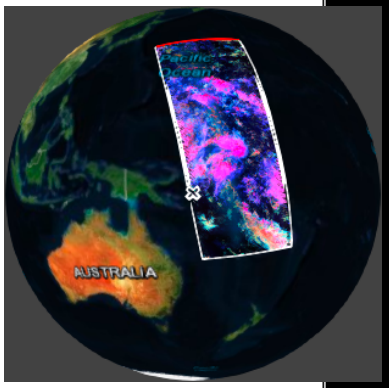
Night Time

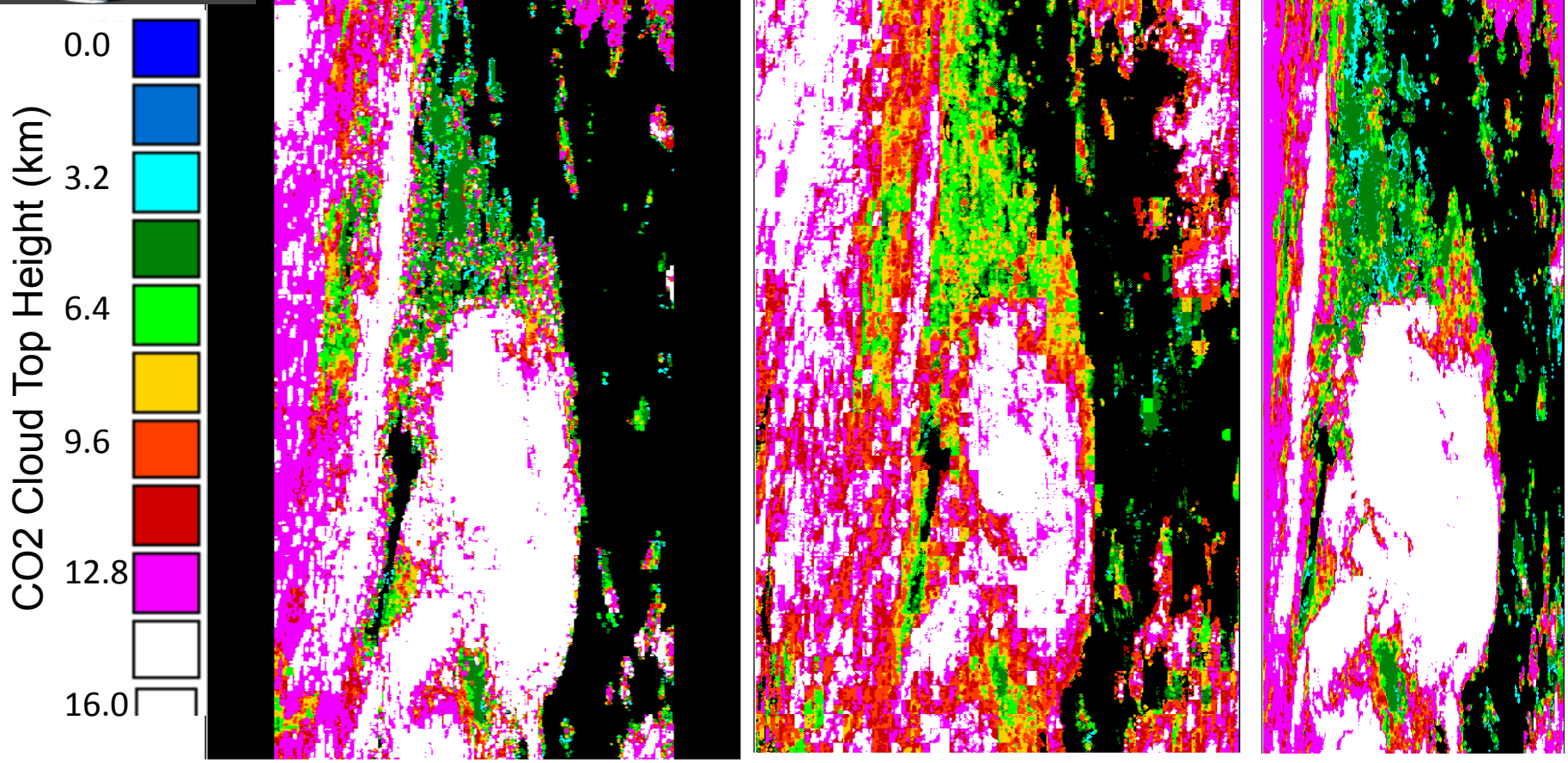


N= 1837247.

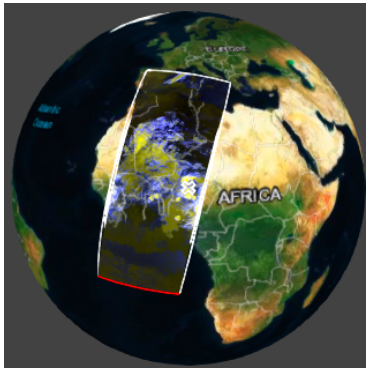
	Mean	(StdDev)
Aqua	235.4(	17.53)
VIIRS	235.8(	17.86)
Y-X	0.470(	1.67)
RMS(	1.74).....	

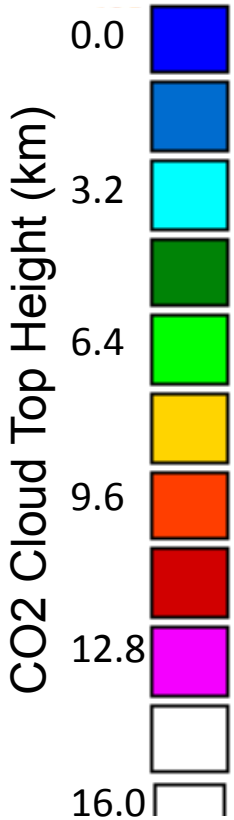
Sept. 19, 2015
UTC 0230



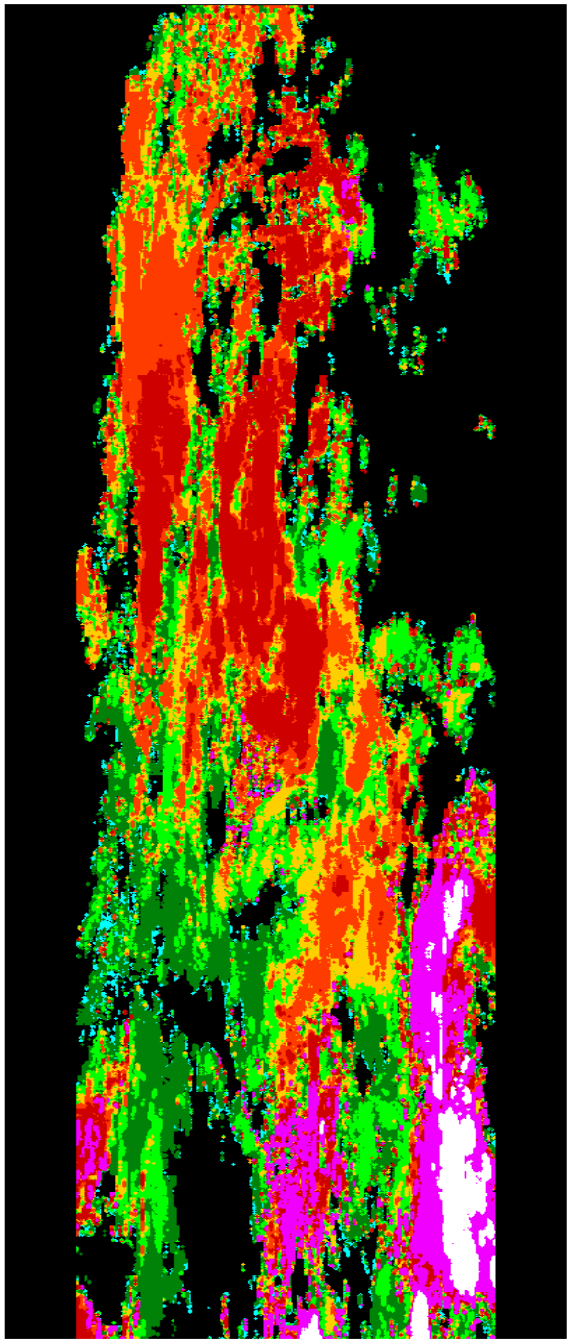


Sept. 19, 2015
UTC 0140

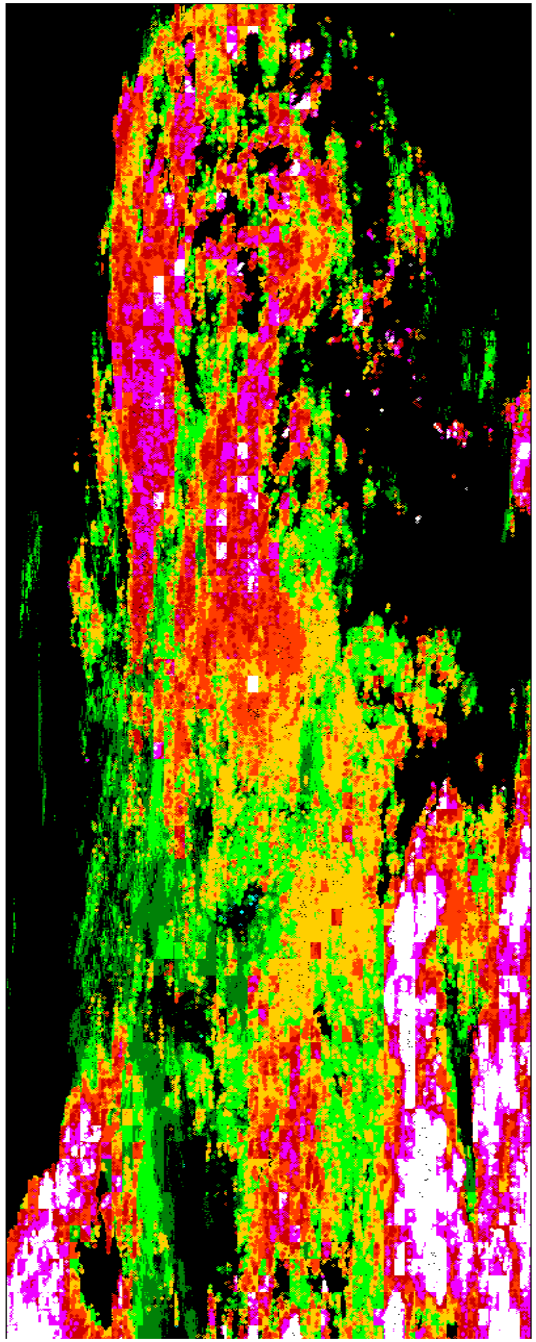




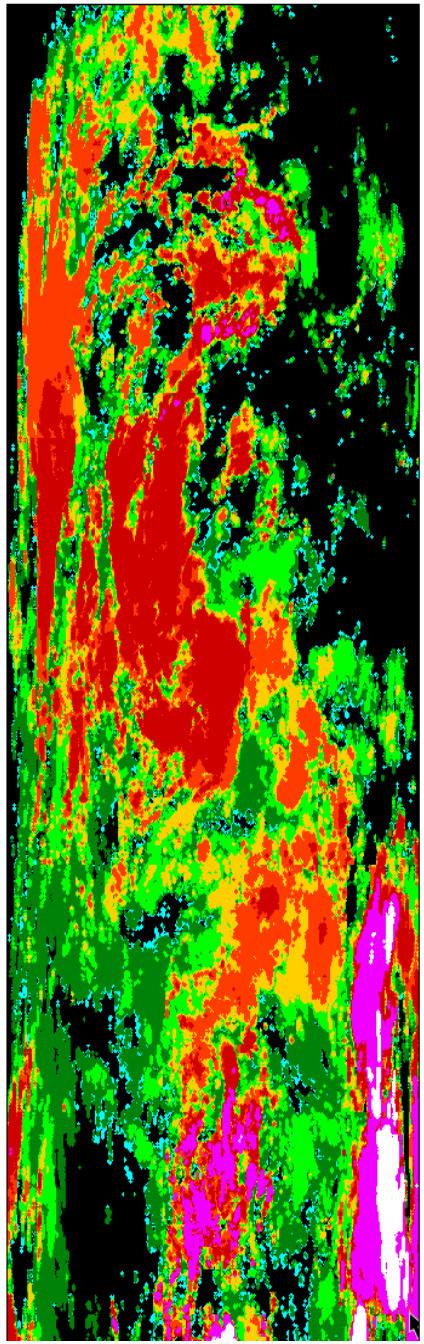
VIIRS CO2 Height (with CrIS)



VIIRS Height (without CrIS)

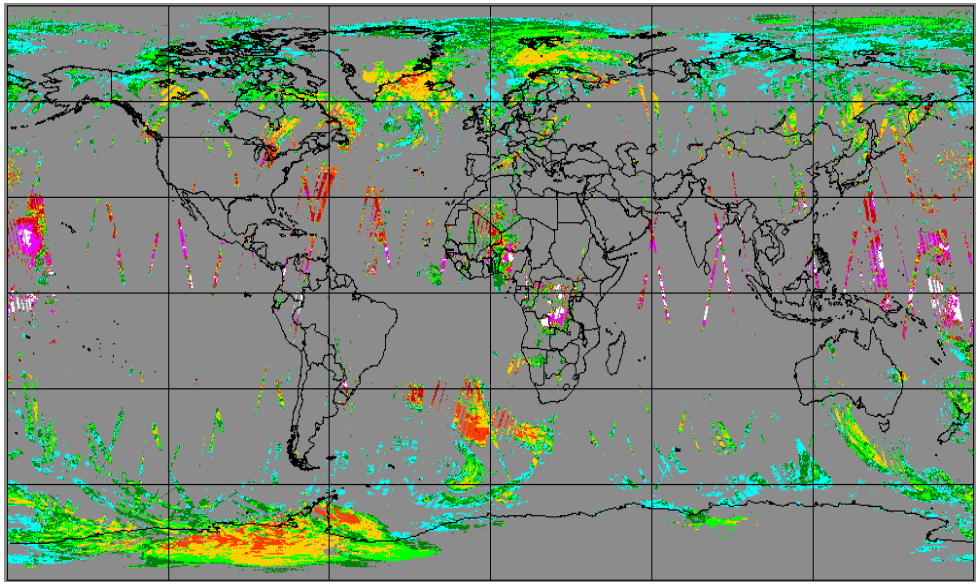


Aqua CO2 Height

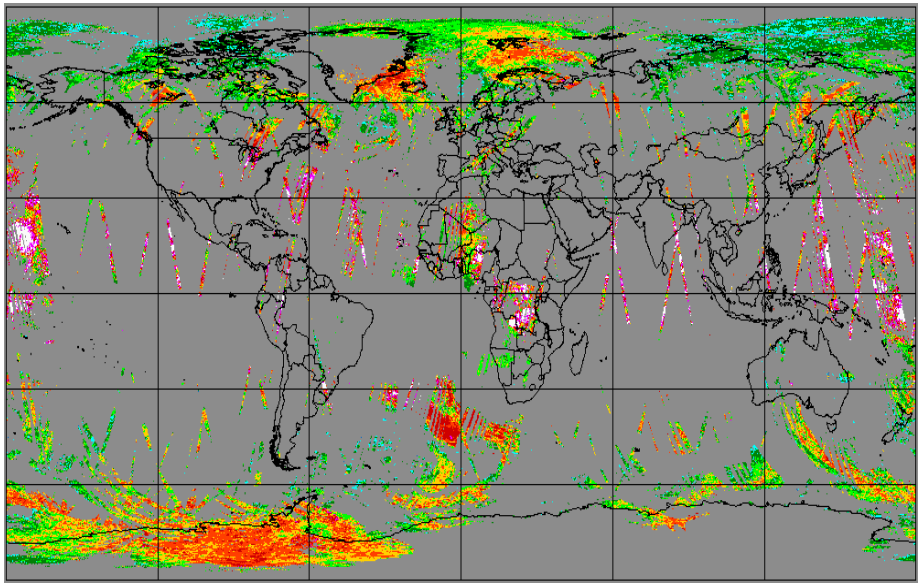


CO2 Cloud Top Height, 20150919, day + night, co-located overpasses

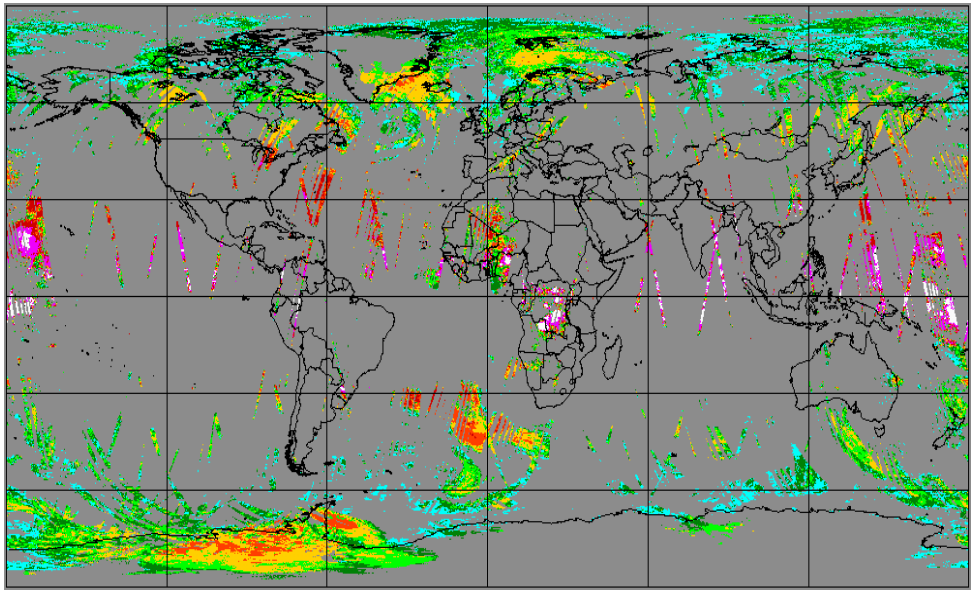
Aqua-MODIS

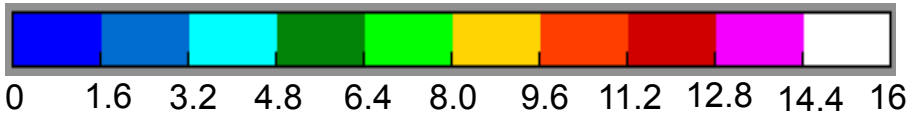


VIIRS without CrIS (using 11/12 um)

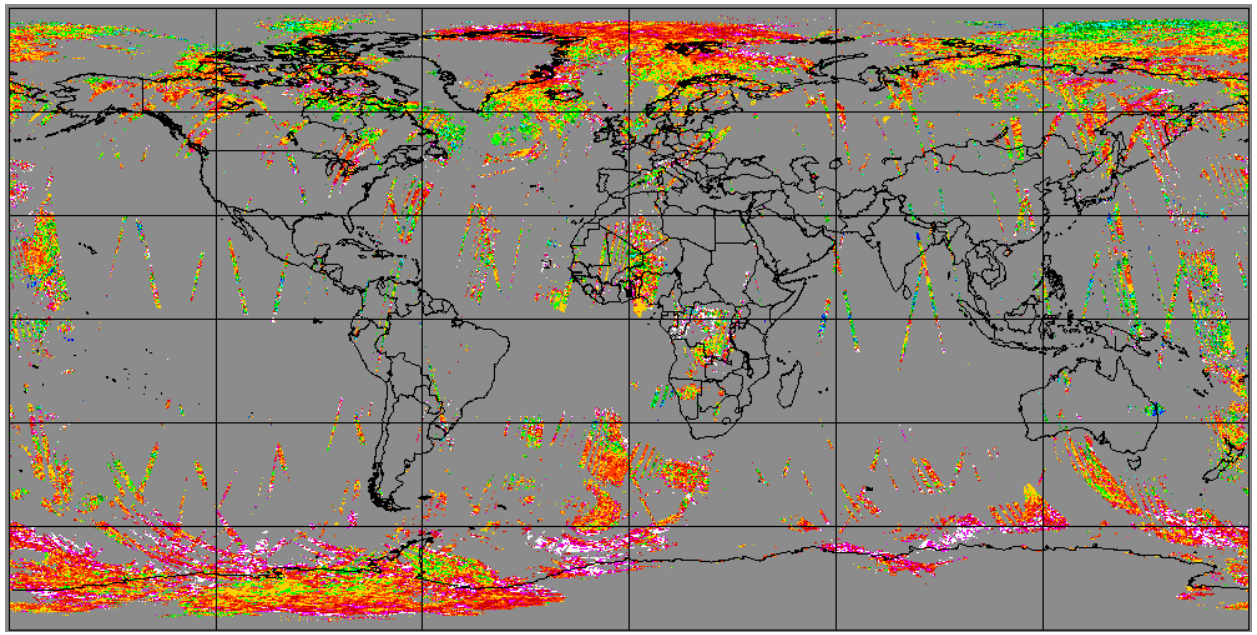


VIIRS with CrIS

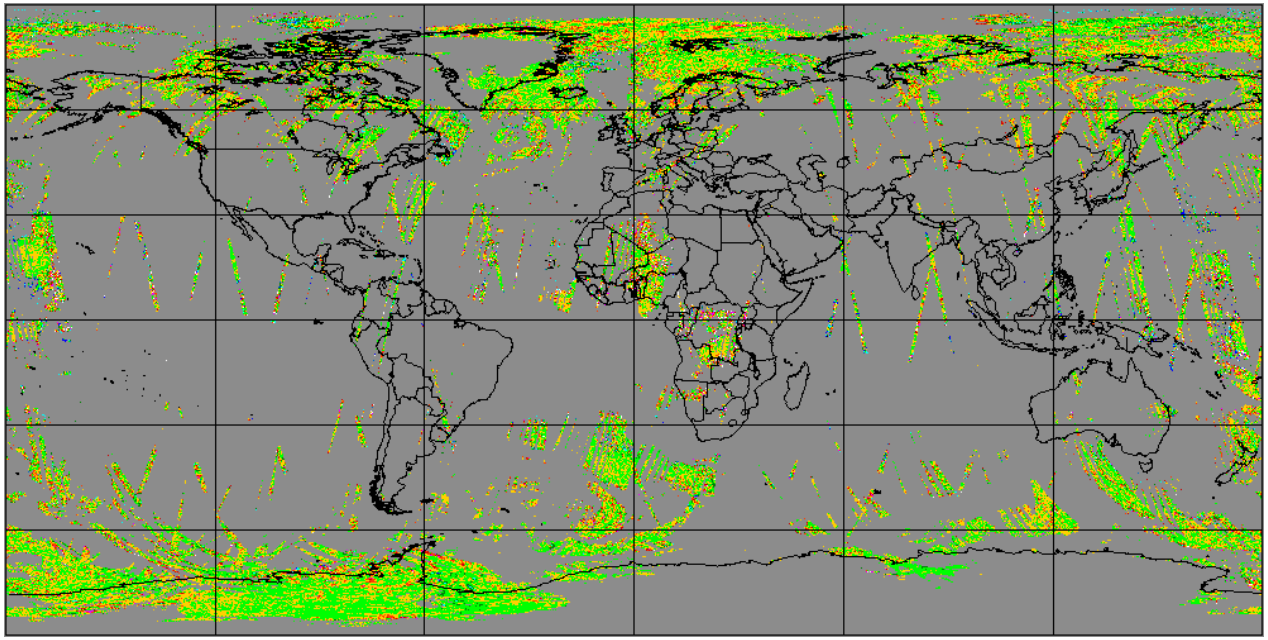




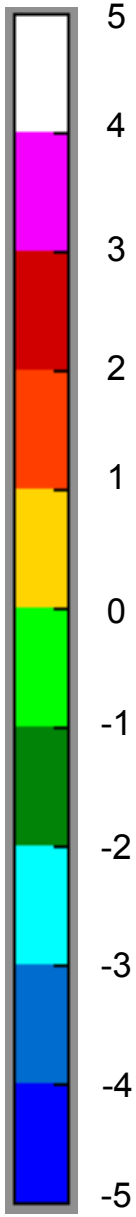
VIIRS without CrIS (11/12 μm) minus Aqua-MODIS



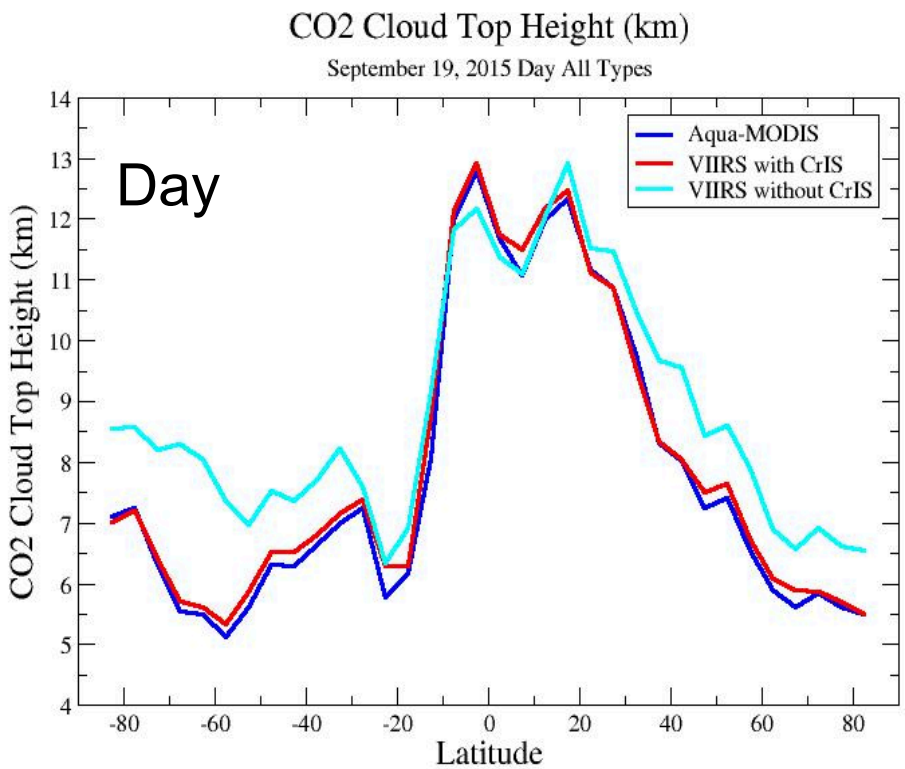
VIIRS with CrIS minus Aqua-MODIS

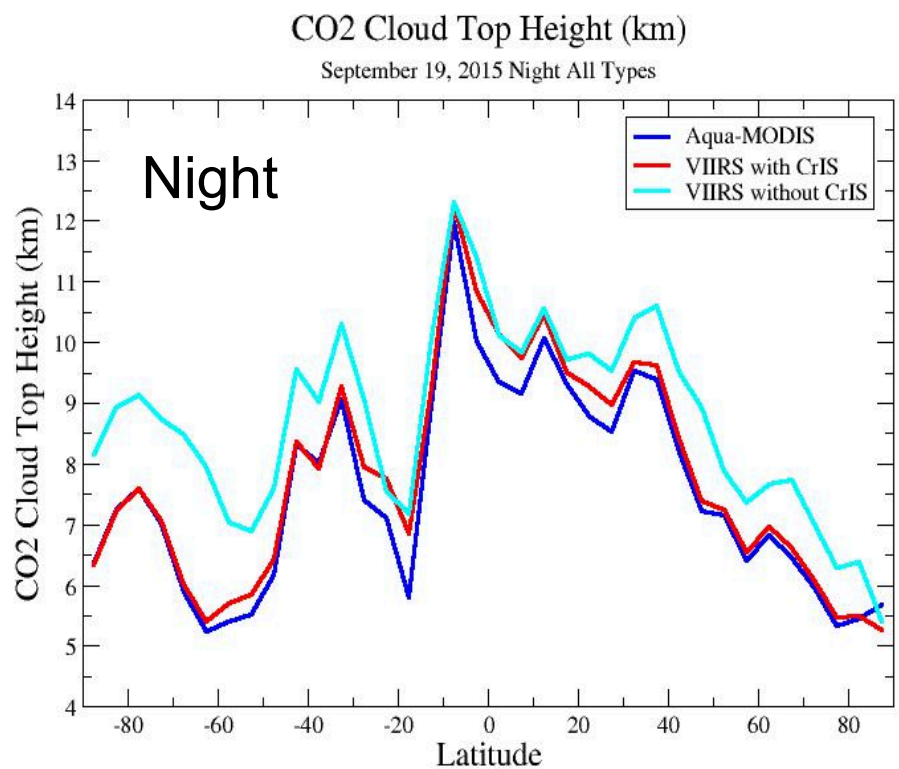


CO2 Cloud Top Height Difference 20150919 day + night



Zonal CO2 Cloud Top Height
September 19, 2015, Co-located Aqua and NPP



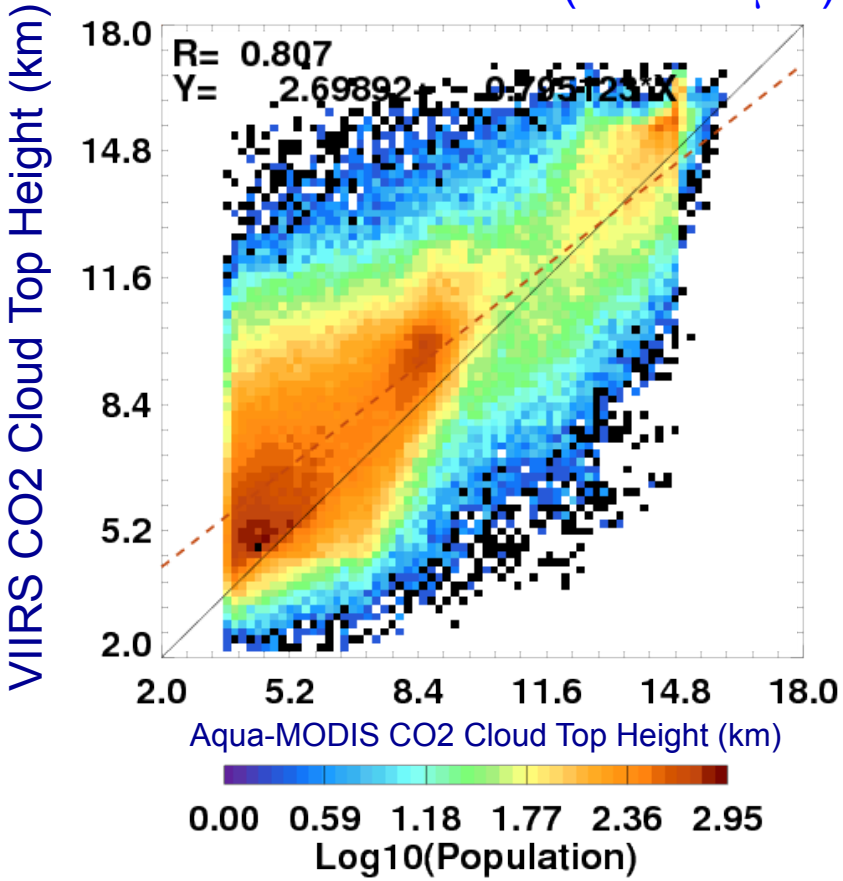


Day Time

Comparison of CO2 Cloud Top Height

September 19, 2015, co-located overpasses

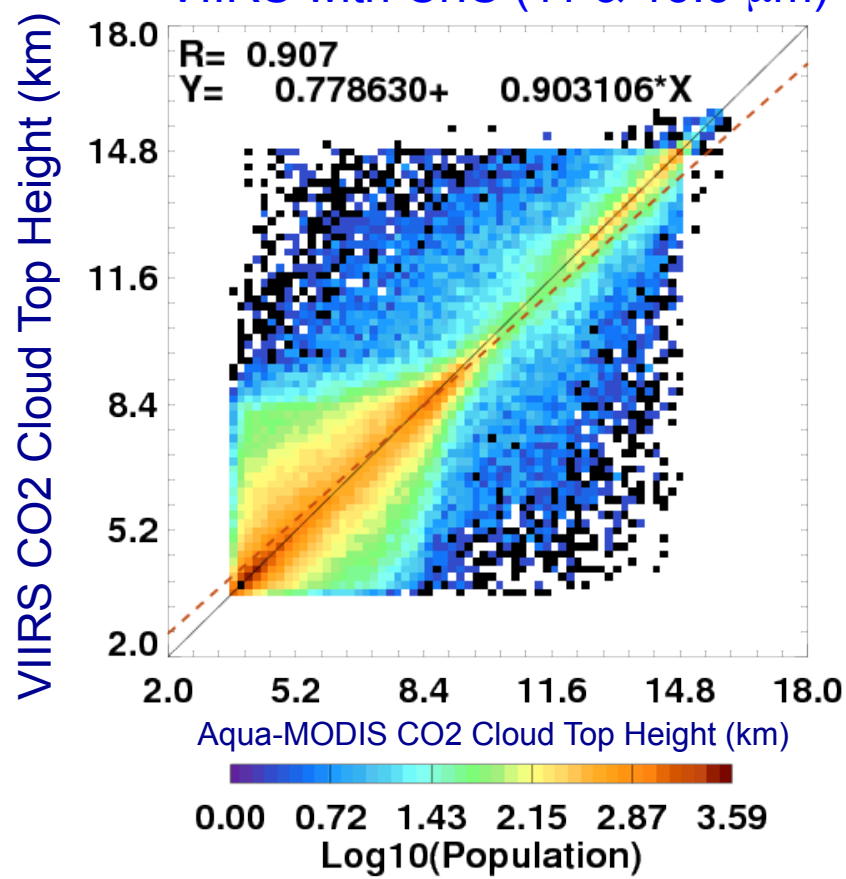
VIIRS without CrIS (11 & 12 μm)



N= 254845.

	Mean	(StdDev)
Aqua	7.01(	2.88)
VIIRSEd1A	8.27(	2.84)
Y-X	1.26(	1.78)
RMS(	2.18).....	

VIIRS with CrIS (11 & 13.3 μm)



N= 207246.

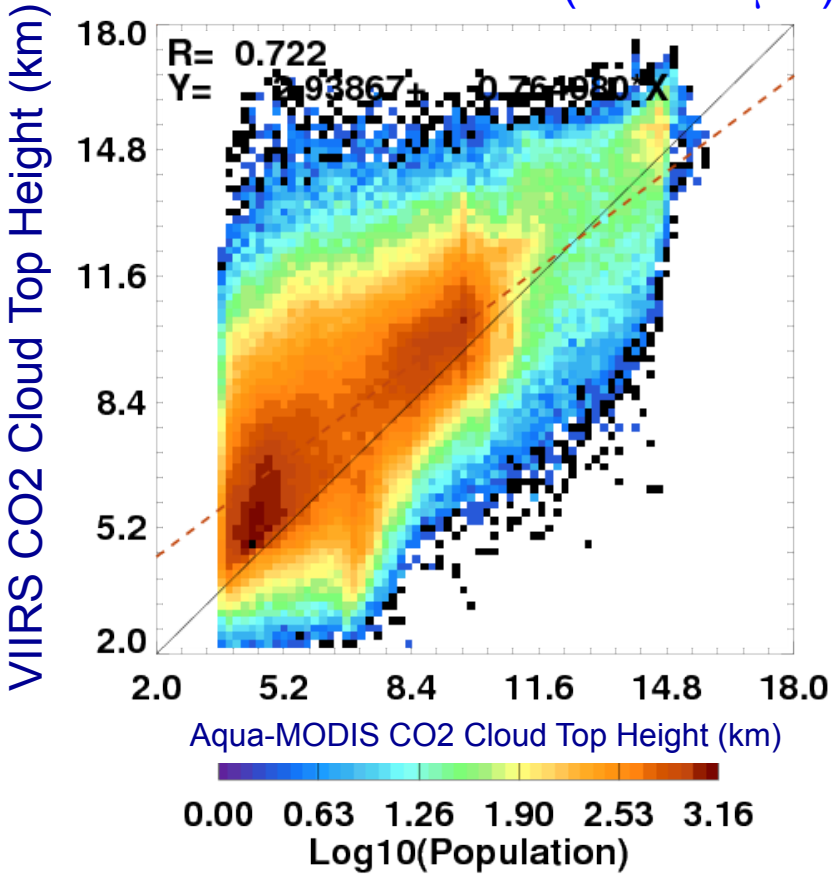
	Mean	(StdDev)
Aqua	6.75(	2.78)
VIIRS	6.87(	2.77)
Y-X	0.125(	1.20)
RMS(	1.21).....	

Night Time

Comparison of CO2 Cloud Top Height

September 19, 2015, co-located overpasses

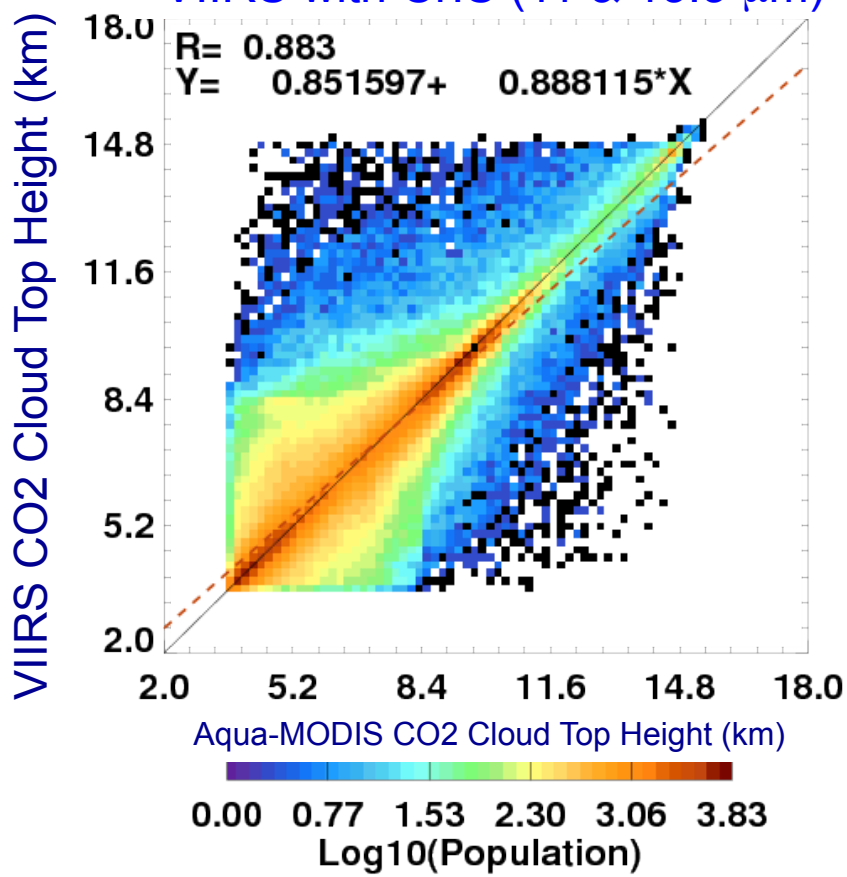
VIIRS without CrIS (11 & 12 μm)



N= 538320.

	Mean	(StdDev)
Aqua	6.84(	2.28)
VIIRSEd1A	8.16(	2.42)
Y-X	1.33(	1.76)
RMS(	2.20).....	

VIIRS with CrIS (11 & 13.3 μm)



N= 453835.

	Mean	(StdDev)
Aqua	6.83(	2.23)
VIIRS	6.92(	2.24)
Y-X	0.087(	1.08)
RMS(	1.08).....	

Summary

- Initial mapping of CrIS to VIIRS for MODIS-like CO2 and WV bands looks promising

- Brightness temperatures:
  VIIRS mapped from CrIS agree with Aqua-MODIS within ~ 0.5 K for both CO2 and WV bands.

- CO2 slicing cloud top height:
  VIIRS with CrIS agrees with Aqua-MODIS within ~0.1 km
  VIIRS without CrIS (VIIRS-Ed1) ~ 1.3 km higher than Aqua-MODIS

- By mapping CrIS to VIIRS, CERES-VIIRS is much more consistent with CERES-MODIS

Future Plan

- If we decide to bring CrIS to VIIRS,

  - Will map CrIS to VIIRS edges (~300 km on each side of VIIRS swath), probably at the reduced accuracy

  - Either, subscribe 2 CrIS data to Langley ASDC:
    GCRSO (Geolocation) and SCRIS (Radiances)

  - Or, if Land SIPS has access to CrIS data, CERES could deliver mapping software to LSIPS to be part of CERES subsetter