Provisional Maturity Science Review For NOAA-20 VIIRS Surface Reflectance Algorithm

Presented by Ivan Csiszar

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Provisional Maturity Review - Entry Criteria

- Product Requirements
- Pre-launch Performance Matrix/Waivers
- Provisional Maturity Performance Validation
  - On-orbit instrument performance assessment
    - Identify all of the instrument and product characteristics you have verified/validated as individual bullets
    - Identify pre-launch concerns/waivers, mitigation and evaluation attempts with on-orbit data
- Users/EDRs feedback
- Risks, Actions, Mitigations
  - Potential issues, concerns
- Path forward to Validated Maturity
- Summary

Provisional Maturity Review - Exit Criteria

- Provisional Maturity Performance is well characterized and meets/exceeds the requirements:
  - On-orbit instrument performance assessment
    - Provide summary for each identified instrument and product characteristic you have validated/verified as part of the entry criteria
    - Provide summary of pre-launch concerns/waivers mitigations/evaluation and address whether any of them are still a concern that raises any risk.
- Updated Provisional Maturity Slide Package addressing review committee's comments for:
  - Cal/Val Plan and Schedules
  - Product Requirements
  - Provisional Maturity Performance
  - Risks, Actions, Mitigations
  - Path forward to Validated Maturity

PROVISIONAL MATURITY REVIEW MATERIAL

Top of atmosphere I3-I2-I1 RGB

Feb 6, 2019 over Eastern India

Surface reflectance I3-I2-I1 RGB

Feb 6, 2019 over Eastern India

Outline

- Algorithm Cal/Val Team Members
- Product Overview/Requirements
- Evaluation of algorithm performance to specification requirements
  - Algorithm version, processing environment
  - Evaluation of the effect of required algorithm inputs
  - Quality flag analysis/validation
  - Error Budget
- User Feedback
- Downstream Product Feedback
- Risks, Actions, and Mitigations
- Documentation (Science Maturity Check List)
- Conclusion
- Path Forward

NOAA-20 Surface Reflectance Algorithm Cal/Val Team

Algorithm Cal/Val Team Members and key stakeholders

Name	Organization	Major Task
Ivan Csiszar	NESDIS/STAR	Surface Reflectance product managerial lead
Eric Vermote et al.	NASA GSFC	Algorithm development, validation
Mike Wilson	IMSG@STAR	STAR ASSIST integration
Yunyue Yu	STAR	STAR VI team lead
Feng Zhao	IMSG@STAR	STAR JPSS VI team liaison
Zhangyan Jiang	IMSG@STAR	STAR JPSS VI team liaison
Valerie Mikles	IMSG@STAR	STAR ASSIST liaison
Hanjun Ding	OSPO	OSPO PAL, transition to operations
Jonathan Hansford	NDE	NDE integration
Yufeng Zhu	OSPO	NDE integration
Xiwu (Jerry) Zhan et al.	STAR, UMD	STAR Surface Type team
Veronica Lance et al.	STAR	CoastWatch

Requirements

- JERD-2441 The algorithm shall produce a surface reflectance product with a horizontal cell size of 0.80 km for radiometric and 0.40 km for imagery bands.

- JERD-2529 The algorithm shall produce a surface reflectance product with a mapping uncertainty, 3 Sigma, of the VIIRS SDR pixel geolocation uncertainty.

- JERD-2530 The algorithm shall produce a surface reflectance product with a measurement range of 0-1. (Note 1)

- JERD-2531 The algorithm shall produce a surface reflectance product with a measurement Accuracy 0.005+0.05ρ. (Note 2)

- JERD-2532 The algorithm shall produce a surface reflectance product with a measurement Precision of 0.005+0.05ρ. (Note 2)

Notes:

1. The actual retrieved range of Surface Reflectances is -0.01 to 1.6 .
2. The symbol ρ denotes the retrieved surface reflectance. The APU metrics are applicable in conditions of low-to-moderate atmospheric turbidity (AOT (0.55μm) x m <1) where m is the air mass. The performance is degraded for the SR at wavelengths lower than 0.55μm by at least a factor 2. The SR errors may also be higher under partly cloudy and snow conditions.

JPSS Data Products Maturity Definition

JPSS/GOES-R Data Product Validation Maturity Stages – COMMON DEFINITIONS (Nominal Mission)

1. Beta

- Product is minimally validated, and may still contain significant identified and unidentified errors.
- Information/data from validation efforts can be used to make initial qualitative or very limited quantitative assessments regarding product fitness-for-purpose.
- Documentation of product performance and identified product performance anomalies, including recommended remediation strategies, exists.

2. Provisional

- Product performance has been demonstrated through analysis of a large, but still limited (i.e., not necessarily globally or seasonally representative) number of independent measurements obtained from selected locations, time periods, or field campaign efforts.
- Product analyses are sufficient for qualitative, and limited quantitative, determination of product fitness-for-purpose.
- Documentation of product performance, testing involving product fixes, identified product performance anomalies, including recommended remediation strategies, exists.
- Product is recommended for potential operational use (user decision) and in scientific publications after consulting product status documents.

3. Validated

- Product performance has been demonstrated over a large and wide range of representative conditions (i.e., global, seasonal).
- Comprehensive documentation of product performance exists that includes all known product anomalies and their recommended remediation strategies for a full range of retrieval conditions and severity level.
- Product analyses are sufficient for full qualitative and quantitative determination of product fitness-for-purpose.
- Product is ready for operational use based on documented validation findings and user feedback.
- Product validation, quality assurance, and algorithm stewardship continue through the lifetime of the instrument.

Evaluation of algorithm performance to specification requirements (3-5 slides)

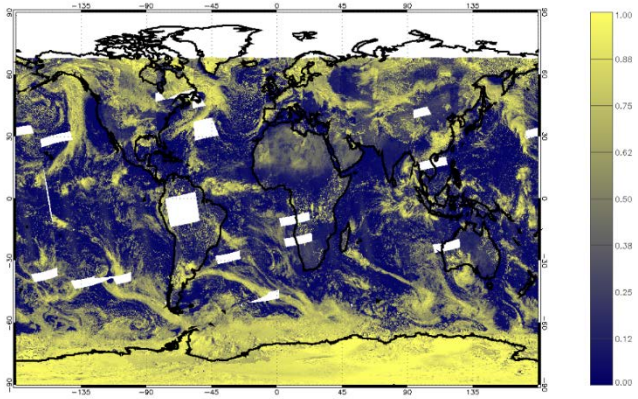
- Findings/Issues from Beta Review
  - Missing granule problem (in the JRR framework)
  - QF updates to support Vegetation products (This one will take some work)
  - Mitch notes the need for a detailed plan for reaching provisional in November
- Improvements since Beta Review
  - Correction of LUT band mismatch for select bands
  - Patch to address missing granule problem
  - Add missing metadata to meet DAP standards
- Algorithm performance evaluation
  - Test data
    - NDE I&T and STAR processing environments
  - Validation strategies / methods
    - Accuracy - precision – uncertainty (APU) against AERONET data
  - Validation results
    - See upcoming slides

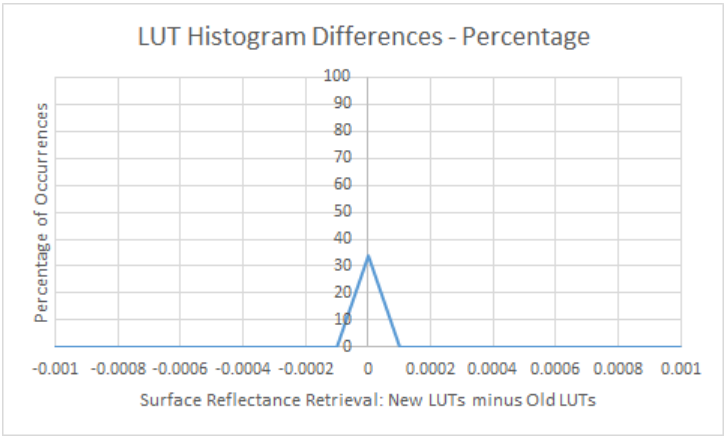
Improvements since beta: fix LUT band mismatch

- LUT band mismatch
  - Issue was in the Enterprise_Aerosol_Lut.hdf lookup table:
    - original order of values in lookup tables were:
      - M1, M2, M3, M4, M5, M6, M7, M8, M10, M11
    - The order should have been:
      - M1, M2, M3, M4, M5, M7, M8, M10, M11, I1
    - (Note: LUT values for I2 and I3 are the same as M7 and M10 respectively due to spectral band placement)
- Impact demonstrated by test runs, issue fixed
  - See next slides
- Only bands impacting Vegetation Index products are shown

I1 Band Analysis

Surface Reflectance Plot Using New LUTs



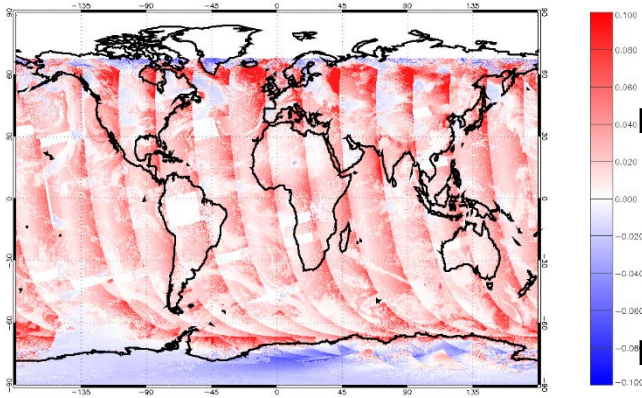


Regular Statistics

Mean Difference:
0.0064

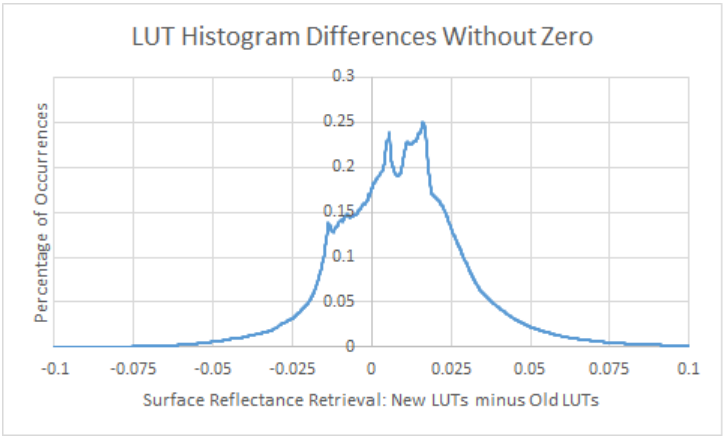
Mean Standard Deviation:
0.019

Difference Due to New LUT



Old LUTs Brighter

New LUTs Brighter



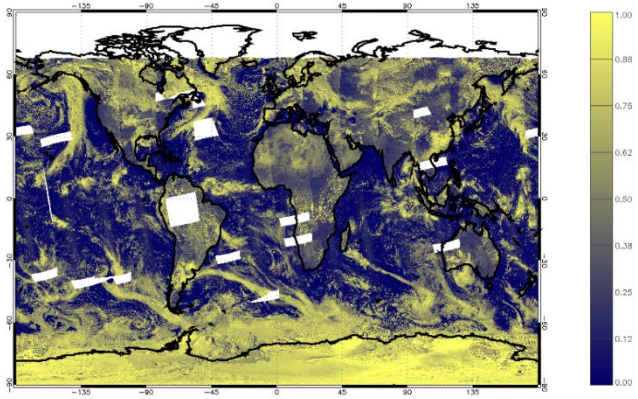
Statistics Without Including Zeroes

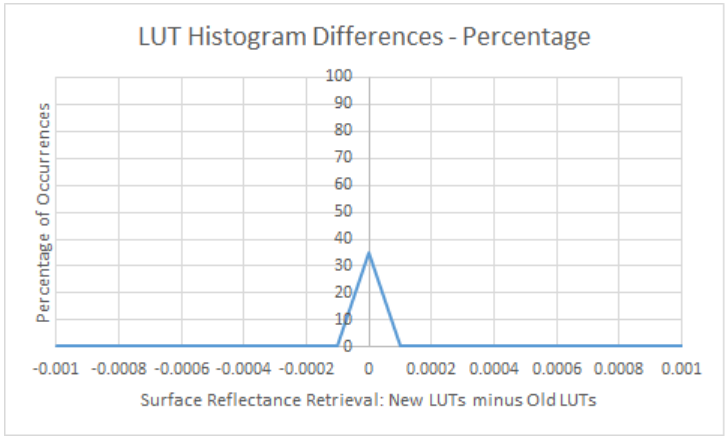
Mean Difference:
0.0096

Mean Standard Deviation:
0.023

I2 Band Analysis

Surface Reflectance Plot Using New LUTs



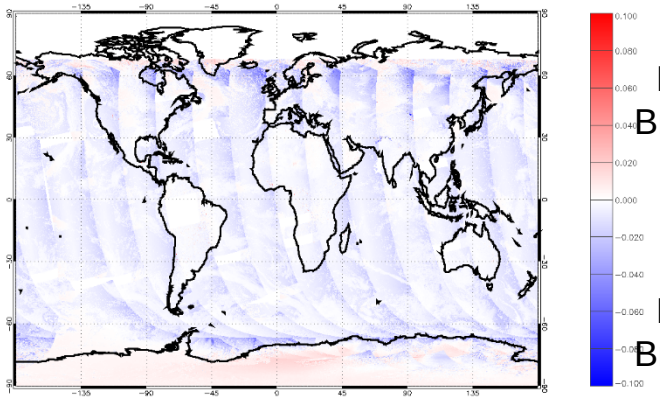


Regular Statistics

Mean Difference:
-0.0015

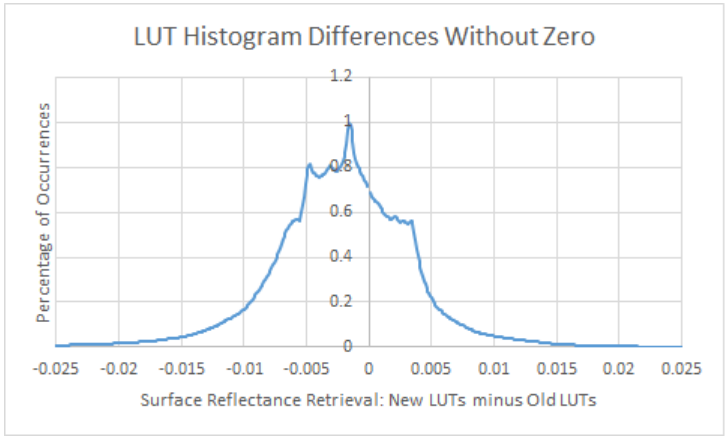
Mean Standard Deviation:
0.0050

Difference Due to New LUT



Old LUTs Brighter

New LUTs Brighter



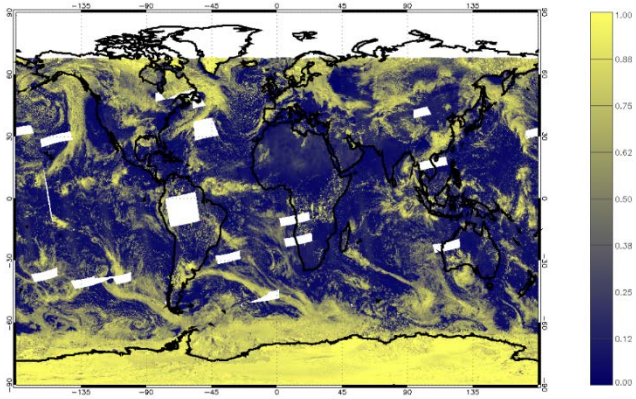
Statistics Without Including Zeroes

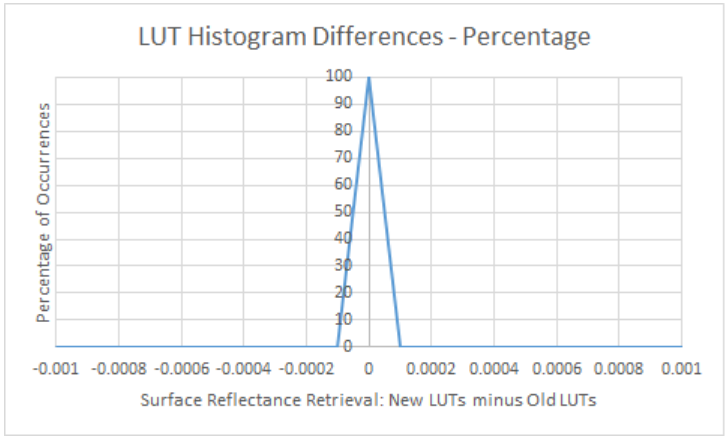
Mean Difference:
-0.0023

Mean Standard Deviation:
0.0061

M3 Band Analysis

Surface Reflectance Plot Using New LUTs



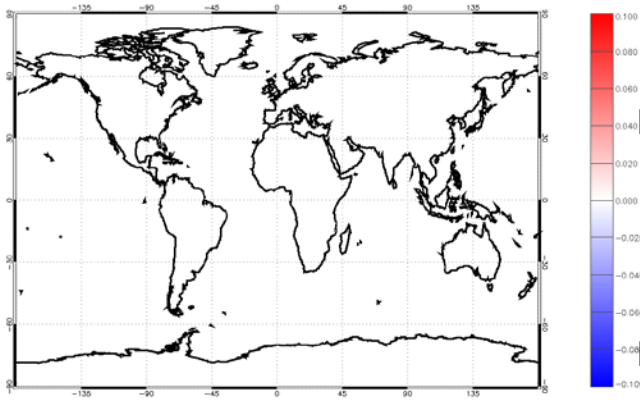


Regular Statistics

Mean Difference:
0.0

Mean Standard Deviation:
0.0

Difference Due to New LUT



Old LUTs Brighter

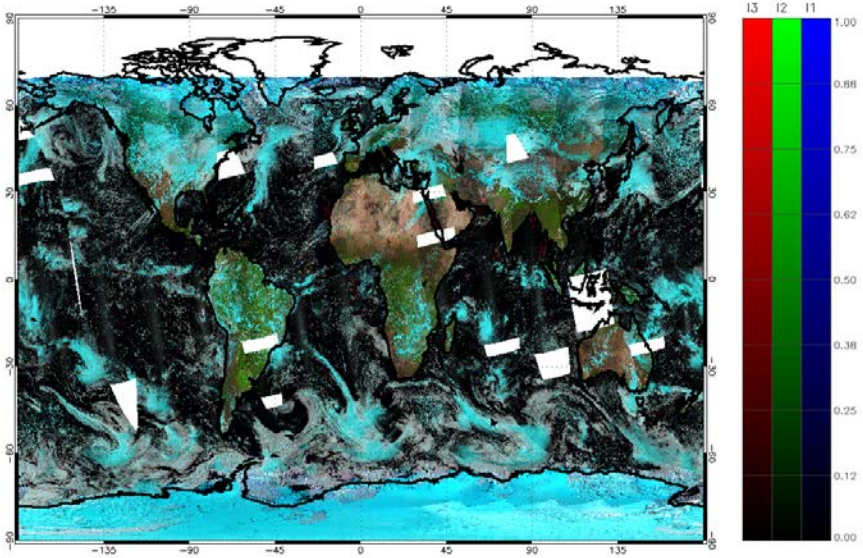
New LUTs Brighter

Nothing to Report:
All Differences Are Zero

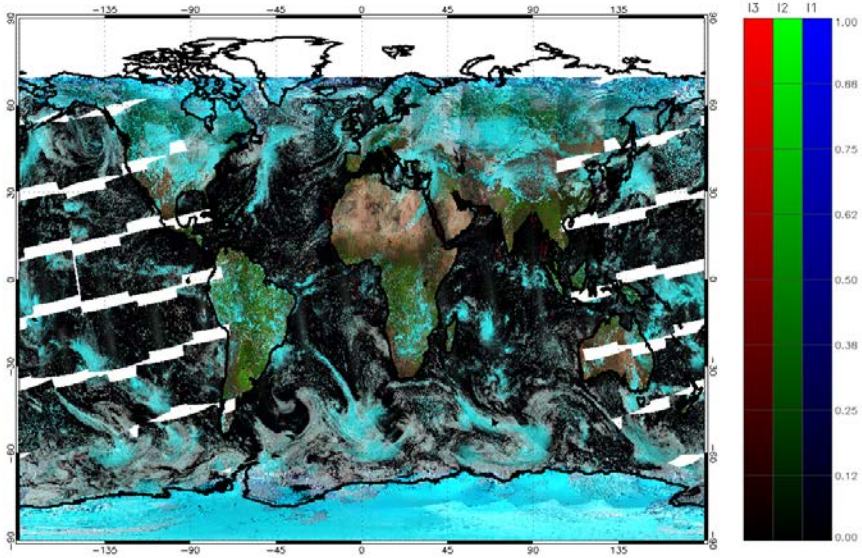
Improvements since beta: missing granules

- Data all taken from NOAA-20 satellite for February 6, 2019.
- Plotted with red – Band I3; green – Band I2; blue – Band I1
- STAR (in-house) data:
  - SDRs, Geolocation pulled from IDPS – scdr-files command.
  - Cloud Mask, Cloud Height, Aerosol pulled from I&T subscription – scdr060
  - GFS pulled from I&T subscription – scdr050
  - Surface Reflectance generated in-house from above products.
- I&T data: pulled from I&T subscription – scdr060

STAR



NDE I&T



Patch delivered to NDE to exclude missing lat/lon data in last scanline for global attributes

Evaluation of the effect of required algorithm inputs

- Required Algorithm Inputs
  - Primary Sensor Data
    - VIIRS bands I1, I2, I3, M1, M2, M3, M4, M5,M7, M8, M10, M11, geolocation
  - Ancillary Data
    - GFS (surface pressure, total column ozone, total precipitable water) through cloud mask
  - Upstream algorithms
    - Enterprise Cloud Mask, Cloud Height, Aerosol Optical Thickness
  - LUTs / PCTs
    - See next slide
- Evaluation of the effect of required algorithm inputs
  - VIIRS SDR performance monitoring through ICVS and maturity reviews

Enterprise Surface Reflectance LUTs

File Name	File Description
Aot	Binary lookup table of 20 aerosol optical thicknesses
Vzen	Binary lookup table of 40 viewing zenith angles
Szen	Binary lookup table of 38 solar zenith angles
VIIRS-SR-IncScatAngles-LUT_v1.5.06.02_LP	Binary lookup table containing the scattering angle increment
VIIRS-SR-ScatAngDims-LUT_v1.5.06.02_LP	Binary lookup table containing the location of the maximum scattering angle corresponding to 105 different pairs of solar and sensor zenith angles
VIIRS-SR-IP-AC-INT_v1.5.06.02_LP	Binary lookup table containing a variety of ancillary information including max/min boundaries of retrieved surface reflectance, max/min for aerosol optical depth, max/min for GFS fields (water vapor, ozone, surface pressure), aerosol model limits, Rayleigh optical depth coefficients, and transmittance coefficients for ozone (1 value), water vapor (3 values), and other gasses (6 values)
Reflect	Binary lookup table of reflectivities. This is a four-dimensional table with dimensions of aerosol model (4), aot (20), M-band channel (9), and scattering angle (5527).
Trans	Binary lookup table of transmittances. This is a four-dimensional table with dimensions of aerosol model (4), aot (20), M-band channel (9), and solar zenith angle (15).
Albedo	Binary lookup table of albedos. This is a three-dimensional table with dimensions of aerosol model (4), aot (20), and M-band channel (9).

Quality flag analysis/validation (2-5 slides)

- Defined Quality Flags
  - Variable
  - Description
  - Value
- Quality flag analysis/validation
  - Test / example / ground truth data sets
  - Analysis / validation results
  - Analysis / validation plan

Quality Flags (3/1)

QF1

Bit #	Meaning
7	Spare
6	Sun Glint: 0: no sun glint detected 1: sun glint detected
5	Low Sun Mask 0: high 1: low
4	Day/Night Flag 0: day 1: night
2-3	Cloud Detection and Confidence 00: confident clear 01: probably clear 10: probably cloudy 11: confidence cloudy
0-1	Cloud Mask Quality 00: poor 01: low 10: medium 11: high

QF2

Bit #	Meaning
7	Thin Cirrus Detected – Emissive Test 0: no cloud 1: cloud
6	Thin Cirrus Detected – Reflective Test 0: no cloud 1: cloud
5	Snow/Ice Flag 0: no snow/ice 1: snow or ice
4	Heavy Aerosol Mask 0: no heavy aerosol 1: heavy aerosol
3	Cloud Shadow Mask 0: no cloud shadow 1: shadow
0-2	Land/Water Background 001: deep ocean 010: shallow water 011: land 100: snow 101: arctic 110: Antarctic and Greenland 111: desert

Quality Flags (3/2)

QF3

Bit #	Meaning
7	Bad M10 SDR data 0: no 1: yes
6	Bad M8 SDR data 0: no 1: yes
5	Bad M7 SDR data 0: no 1: yes
4	Bad M5 SDR data 0: no 1: yes
3	Bad M4 SDR data 0: no 1: yes
2	Bad M3 SDR data 0: no 1: yes
1	Bad M2 SDR data 0: no 1: yes
0	Bad M1 SDR data 0: no 1: yes

QF4

Bit #	Meaning
7	Missing Precipitable Water data 0: no 1: yes
6	Invalid Land AM input data 0: valid 1: invalid or over ocean
5	Missing AOT input data 0: no 1: yes
4	Overall Quality of AOT 0: good 1: bad
3	Bad I3 SDR data 0: no 1: yes
2	Bad I2 SDR data 0: no 1: yes
1	Bad I1 SDR data 0: no 1: yes
0	Bad M11 SDR data 0: no 1: yes

QF5

Bit #	Meaning
7	Overall Quality of M7 Surface Reflectance Data 0: good 1: bad
6	Overall Quality of M5 Surface Reflectance Data 0: good 1: bad
5	Overall Quality of M4 Surface Reflectance Data 0: good 1: bad
4	Overall Quality of M3 Surface Reflectance Data 0: good 1: bad
3	Overall Quality of M2 Surface Reflectance Data 0: good 1: bad
2	Overall Quality of M1 Surface Reflectance Data 0: good 1: bad
1	Missing Surface Pressure input data 0: no 1: yes
0	Missing total column ozone input data 0: no 1: yes

Quality Flags (3/3)

QF6

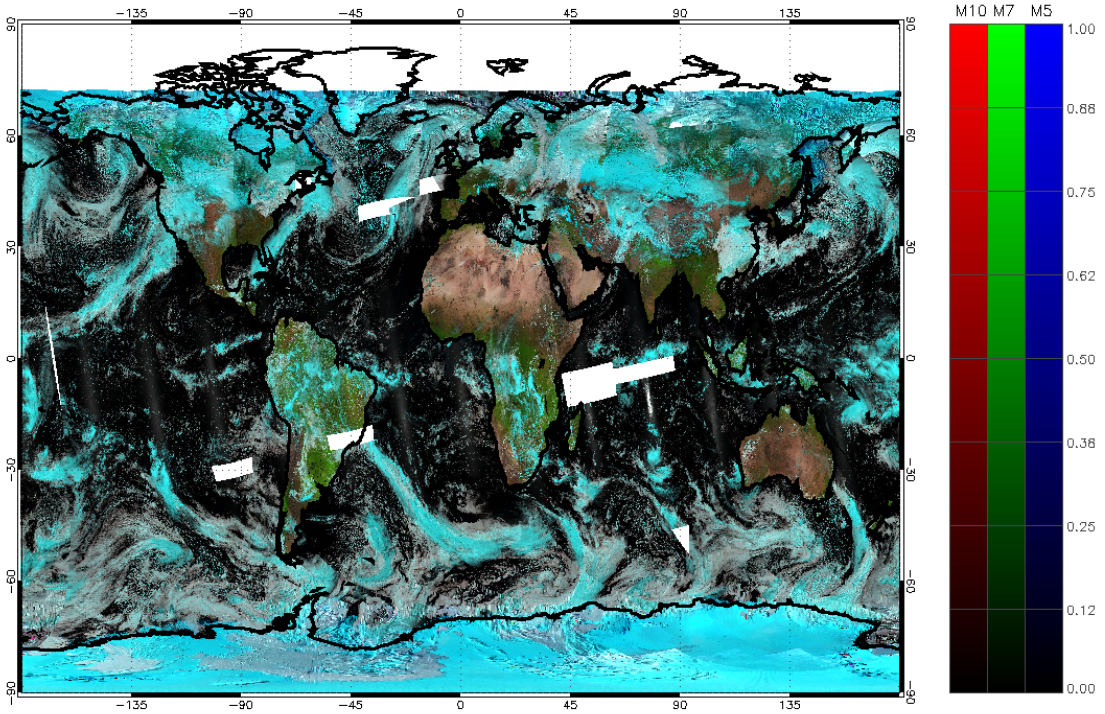
Bit #	Meaning
7	Unused
6	Unused
5	Overall Quality of I3 Surface Reflectance Data 0: good 1: bad
4	Overall Quality of I2 Surface Reflectance Data 0: good 1: bad
3	Overall Quality of I1 Surface Reflectance Data 0: good 1: bad
2	Overall Quality of M11 Surface Reflectance Data 0: good 1: bad
1	Overall Quality of M10 Surface Reflectance Data 0: good 1: bad
0	Overall Quality of M8 Surface Reflectance Data 0: good 1: bad

QF7

Bit #	Meaning
7	Unused
6	Unused
5	Unused
4	Thin Cirrus Flag 0: no 1: yes
2-3	Aerosol Quantity 00: climatology 01: low 10: average 11: high
1	Adjacent to Cloud (disabled) 0: no 1: yes
0	Snow Present 0: no 1: yes

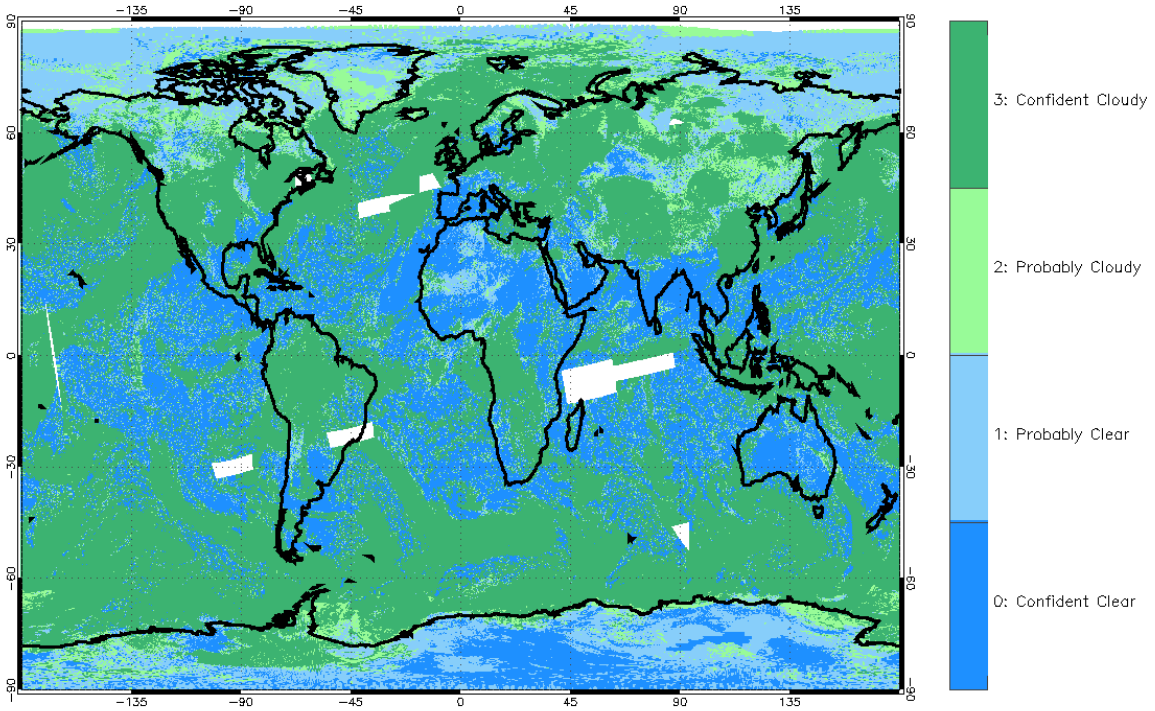
False Color Image

February 13, 2019



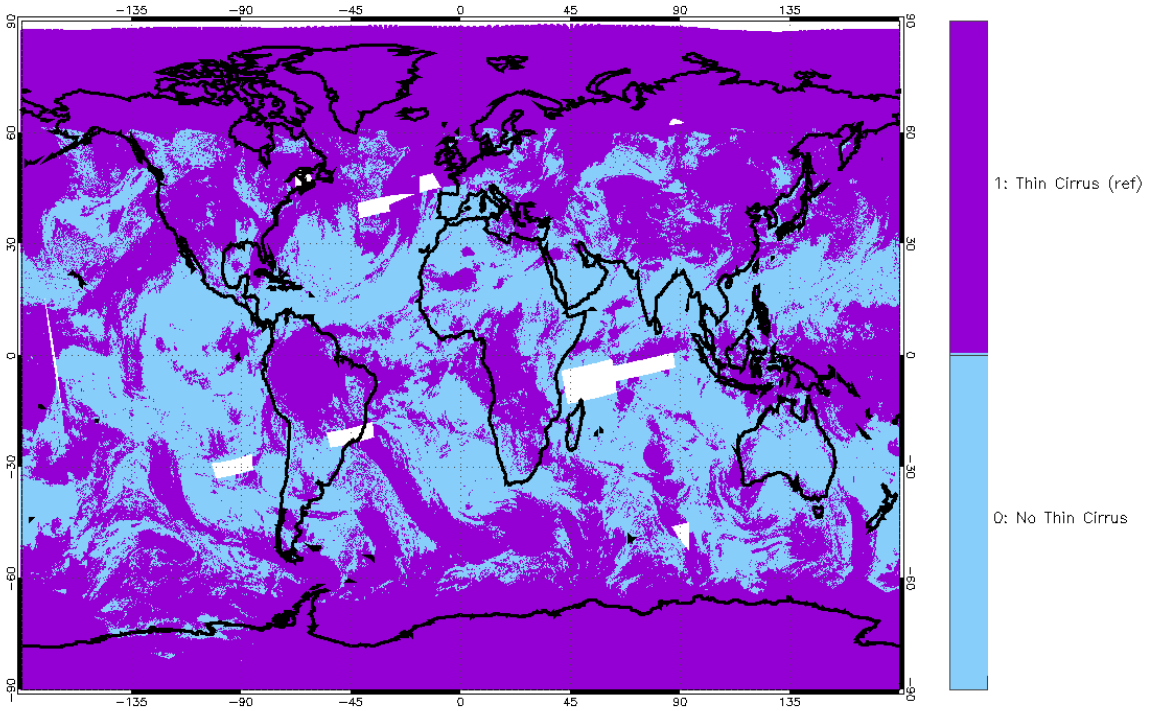
Cloud Detection Confidence: QF1, Bits 2-3

February 13, 2019



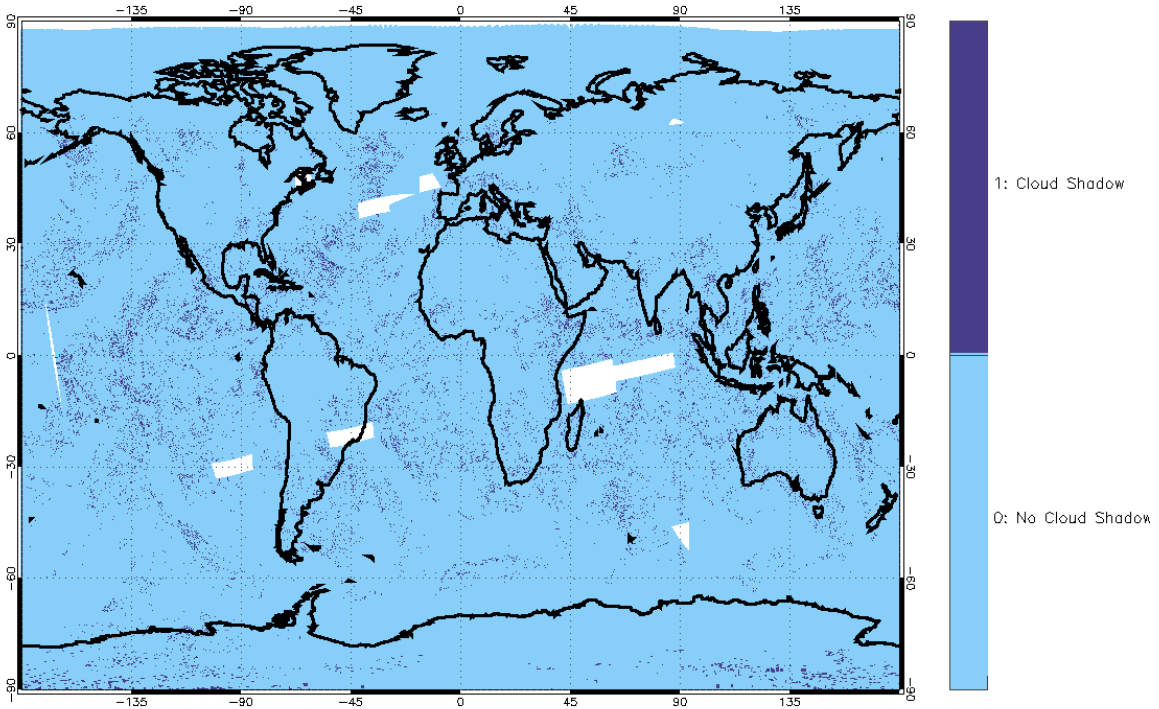
Thin Cirrus Mask – Reflective: QF2, Bit 6

February 13, 2019



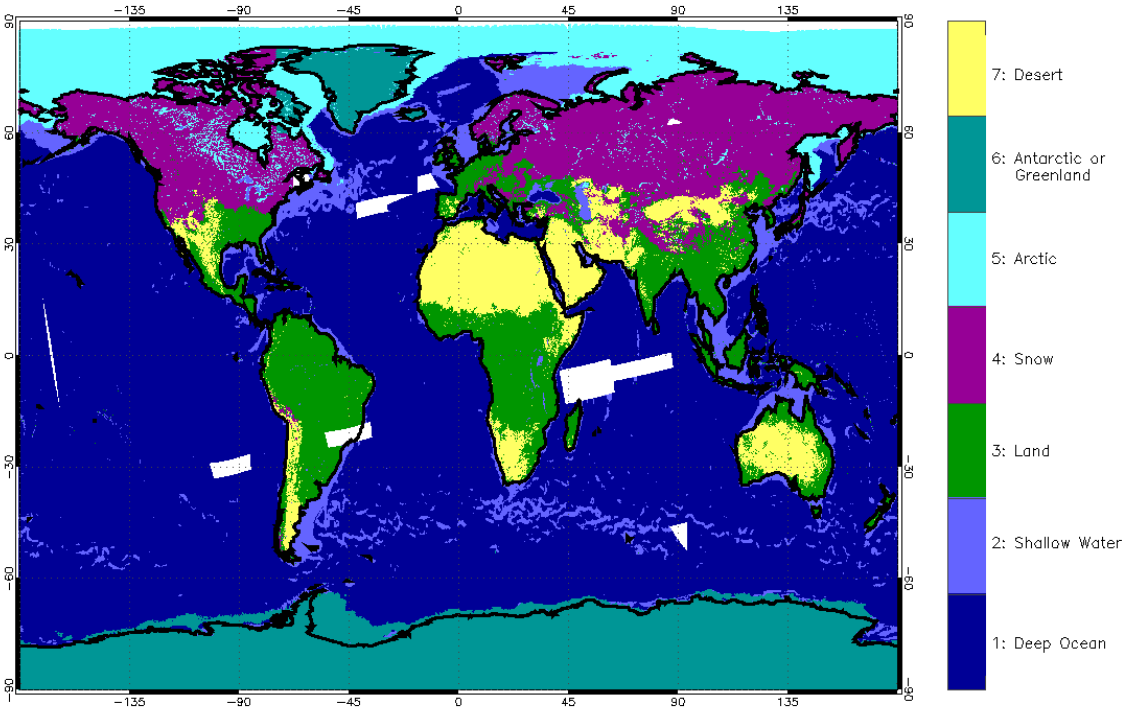
Cloud Shadow Mask: QF2, Bit 3

February 13, 2019



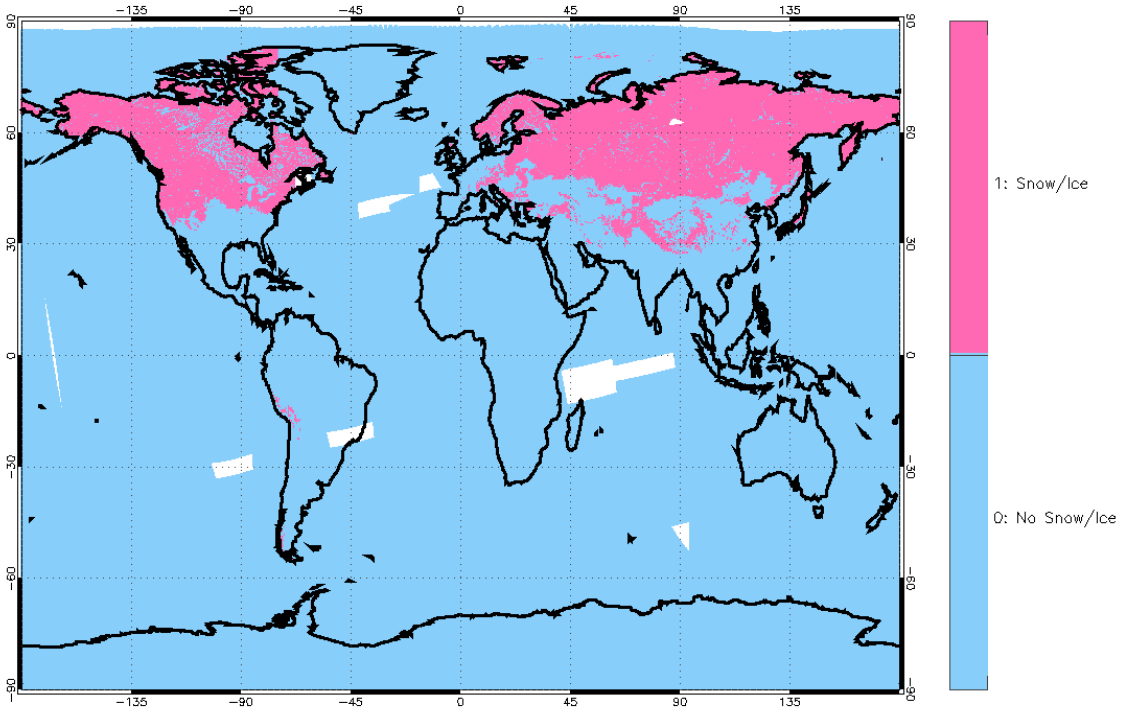
Land-Water Mask: QF2, Bits 0-2

February 13, 2019



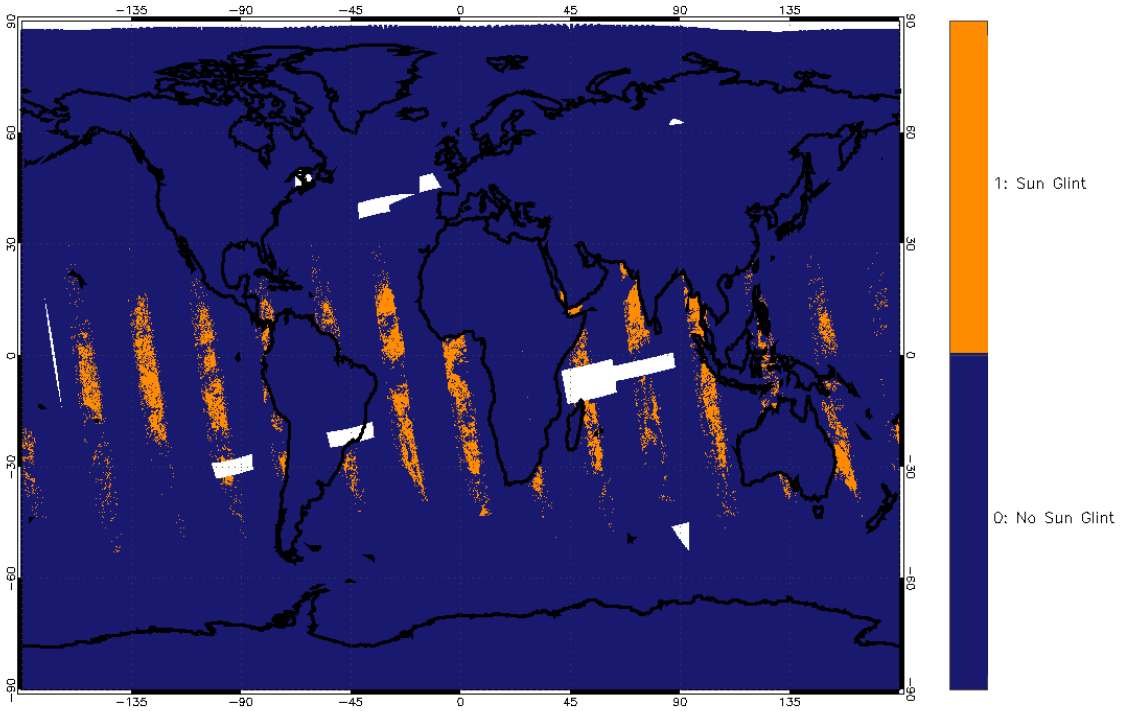
Snow-Ice Mask: QF2, Bit 5

February 13, 2019



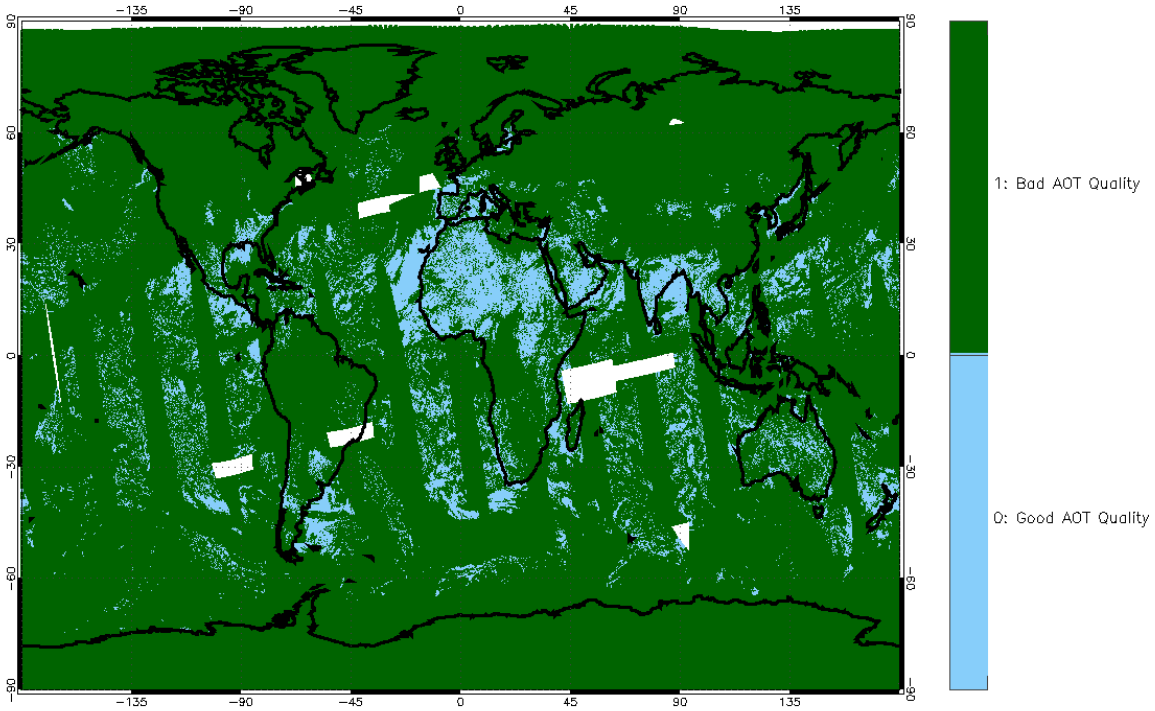
Sun Glint Flag: QF1, Bit 6

February 13, 2019



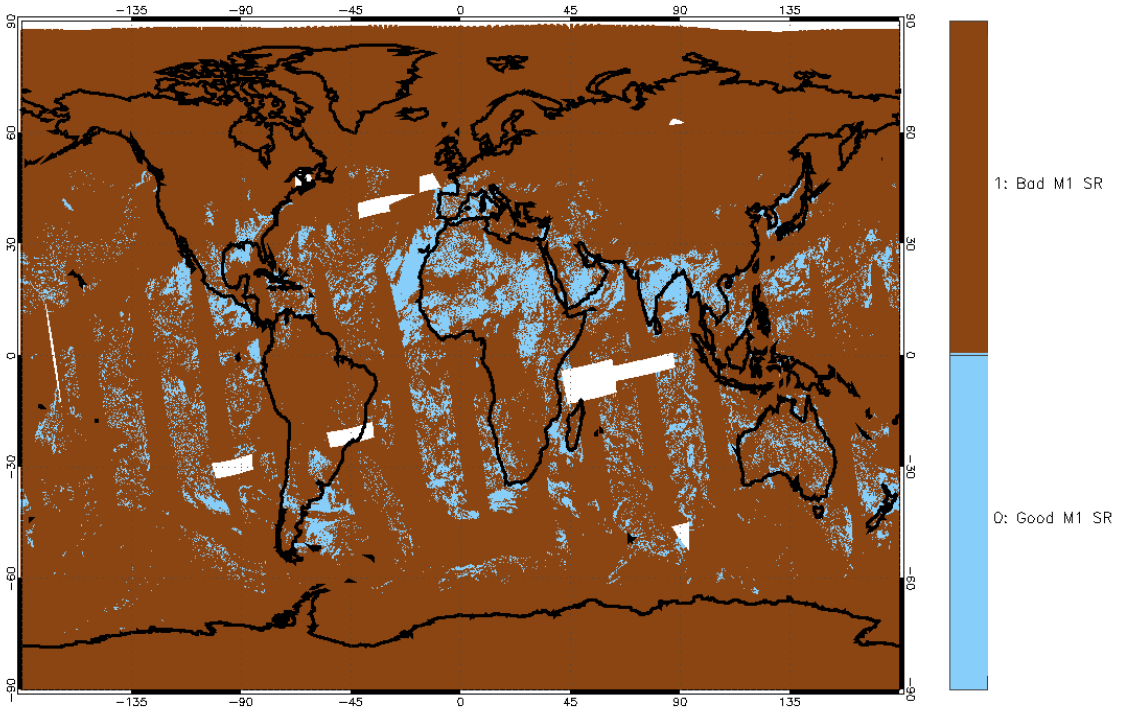
AOT Quality Flag: QF4, Bit 4

February 13, 2019



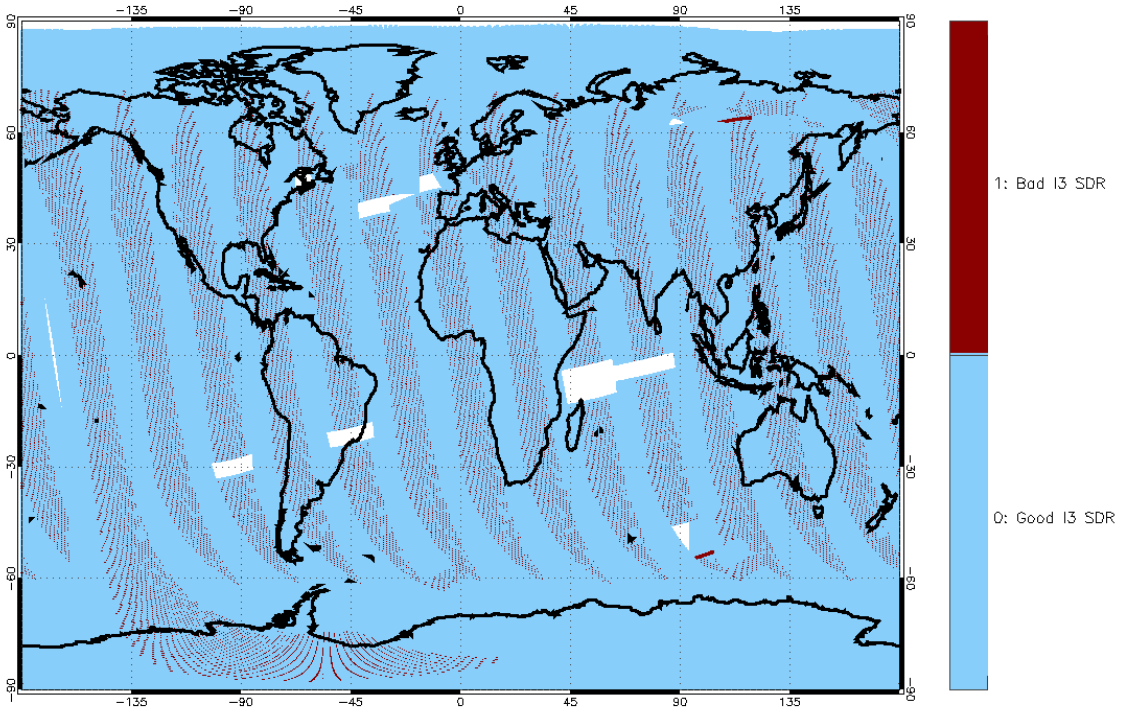
Overall M1 Surface Reflectance: QF5, Bit 2

February 13, 2019



Bad I3 SDR Data: QF4, Bit 3

February 13, 2019

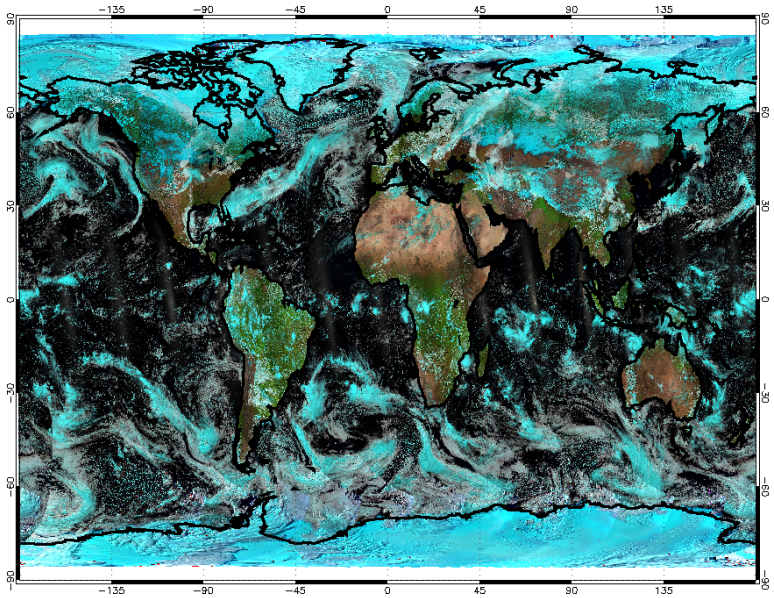


Comparison of Suomi NPP and NOAA-20 retrievals

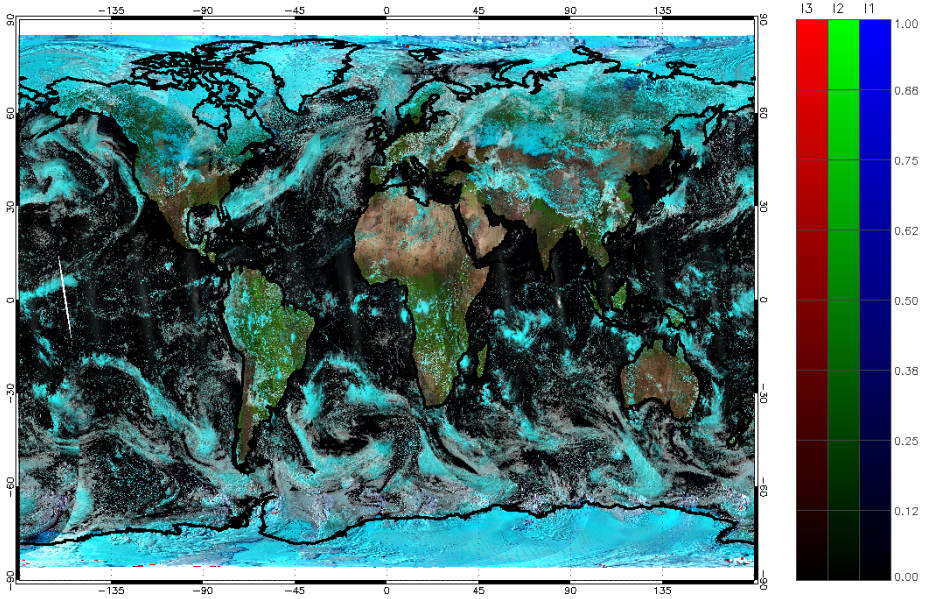
- All plots are based on the I&T Data Stream from March 19, 2019.
  - S-NPP: /data/scdr060/PDA_IT/SurfRefl/NPP/20190319
  - NOAA-20: /data/scdr060/PDA_IT/SurfRefl/J01/20190319
- Both datasets were derived using the same code and set of LUTs
- Global maps and scatterplots are presented
  - Maps of quality flags are included in the back-up section
- The half-orbit / half-swath difference allows only for semi-quantitative comparisons due to solar and viewing geometry effects
- Robust statistical comparison can be done through averaging ~1 month of data

I-Band False Color Composite (I3/I2/I1)
March 19, 2019

S-NPP

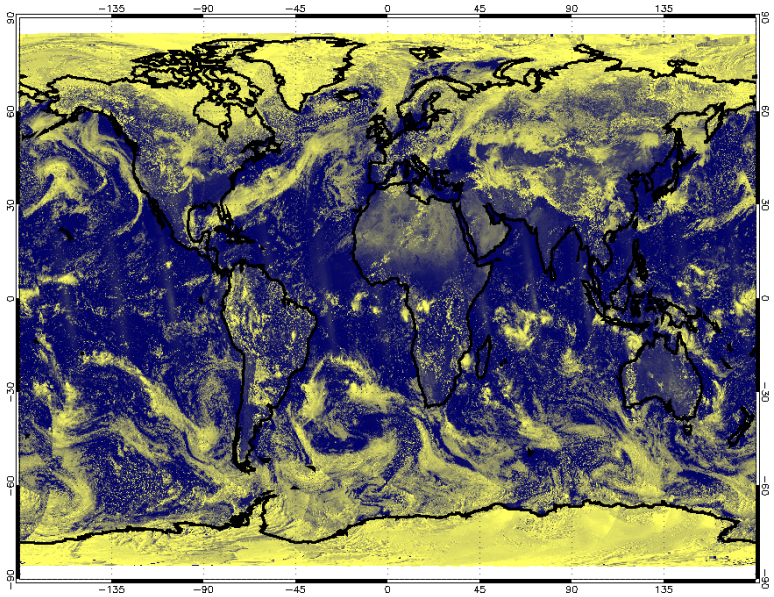


NOAA-20

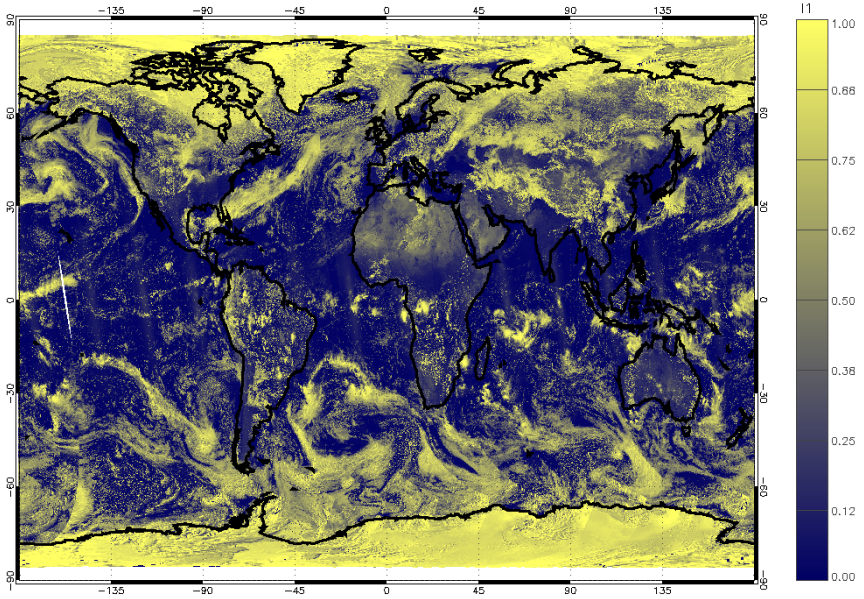


I1 Band Surface Reflectance
March 19, 2019

S-NPP

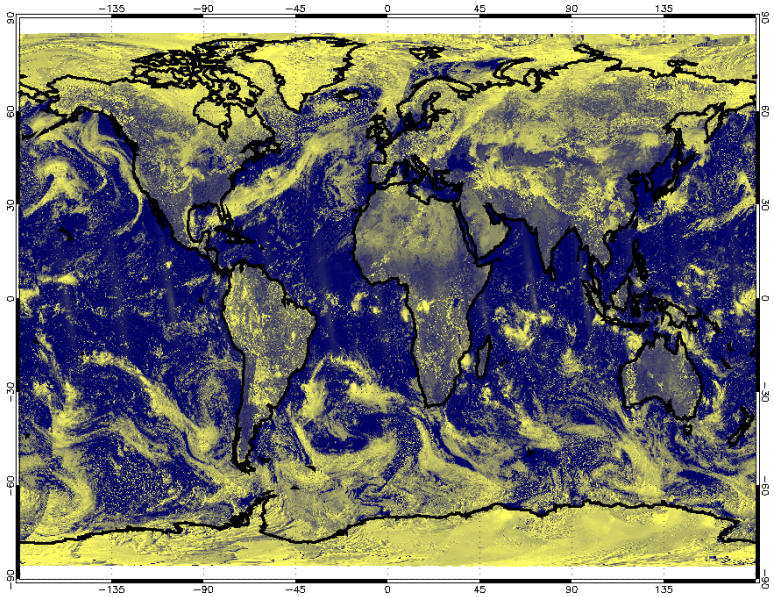


NOAA-20

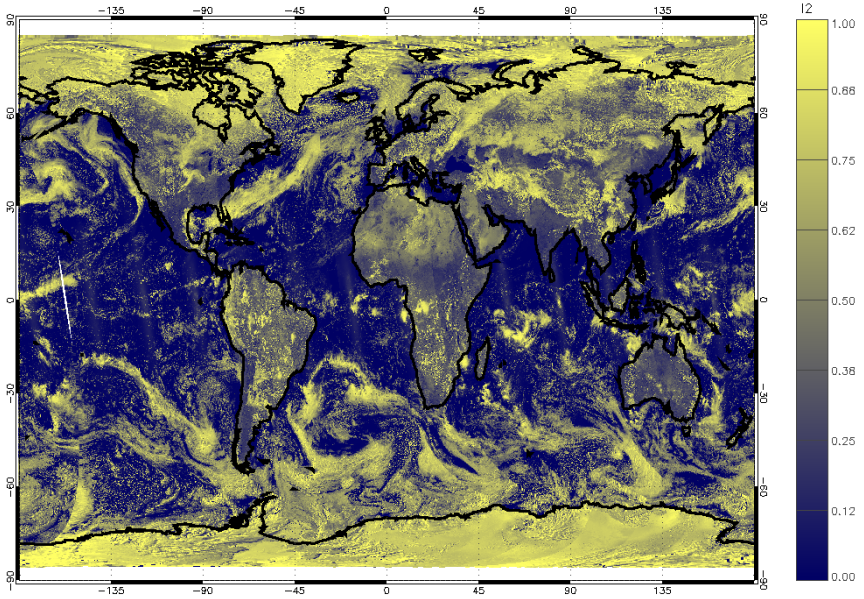


I2 Band Surface Reflectance
March 19, 2019

S-NPP

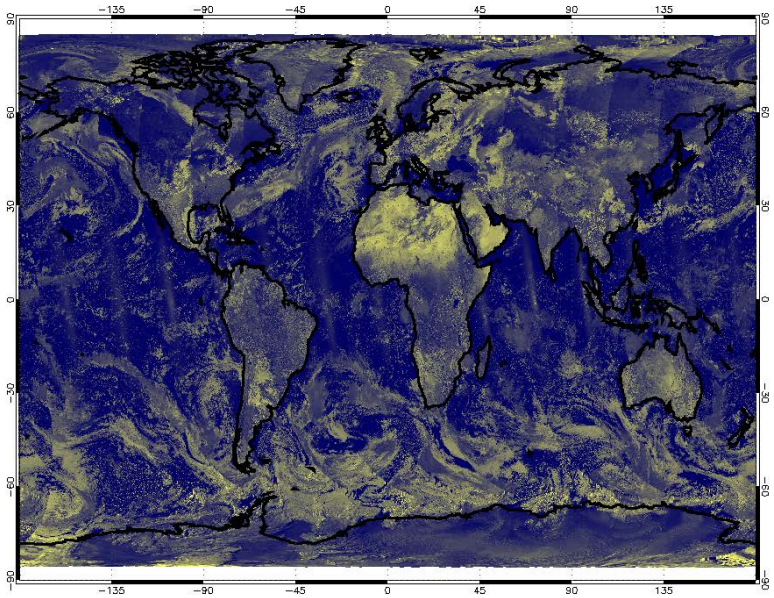


NOAA-20



I3 Band Surface Reflectance
March 19, 2019

S-NPP



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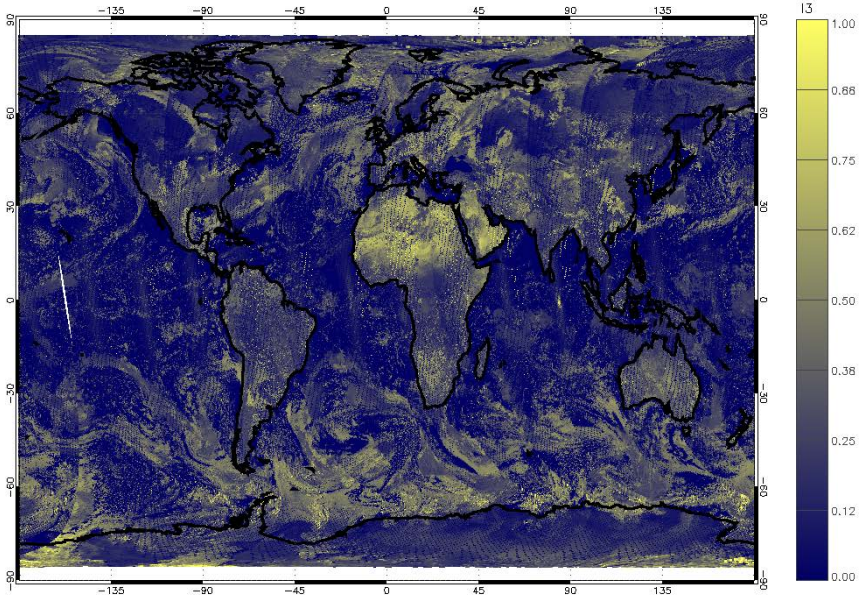
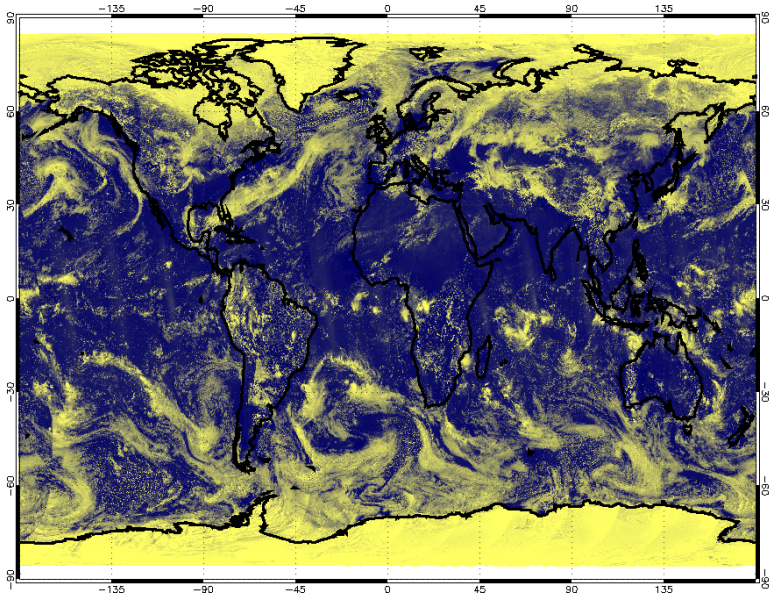


M1 Band Surface Reflectance
March 19, 2019

S-NPP



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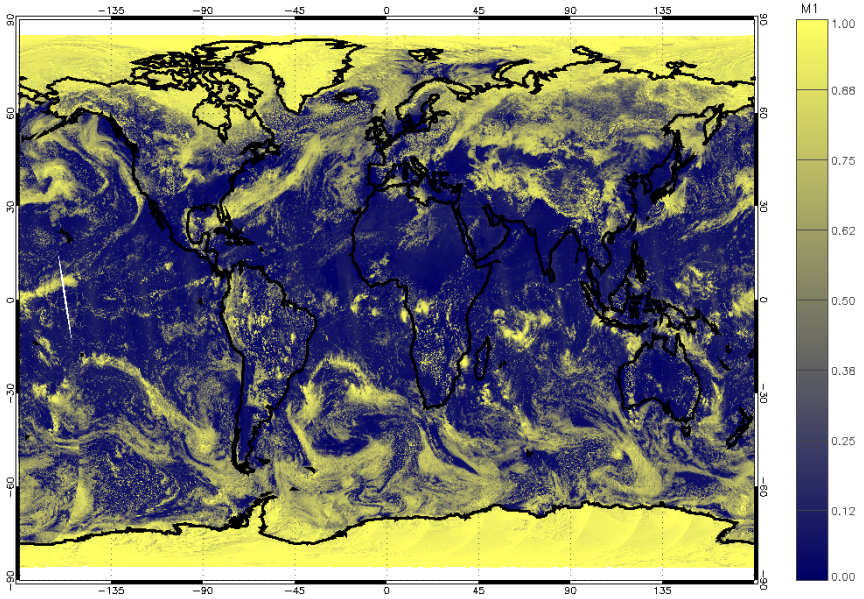
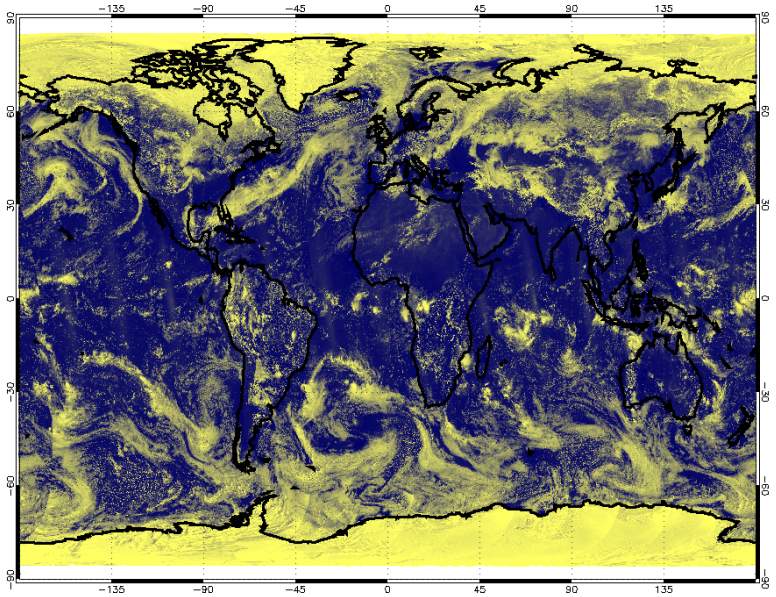


M2 Band Surface Reflectance
March 19, 2019

S-NPP



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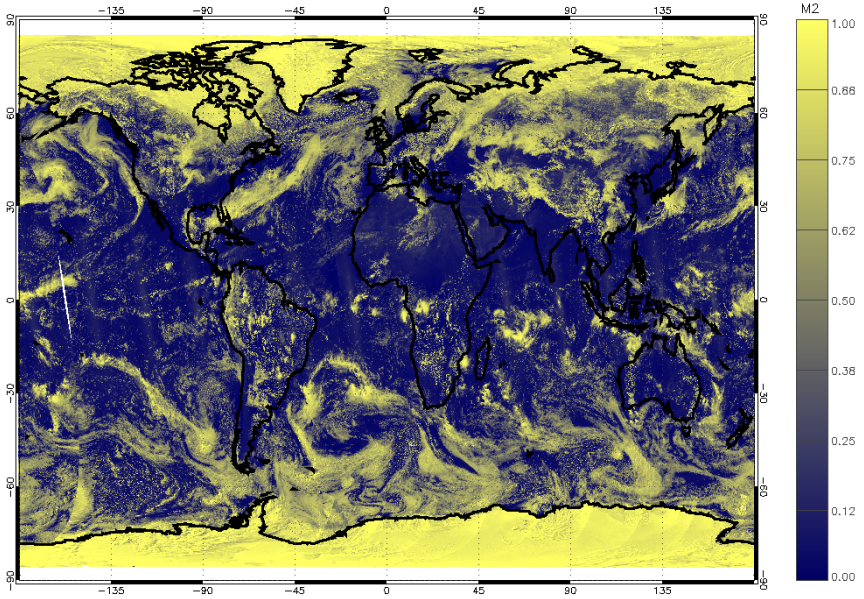
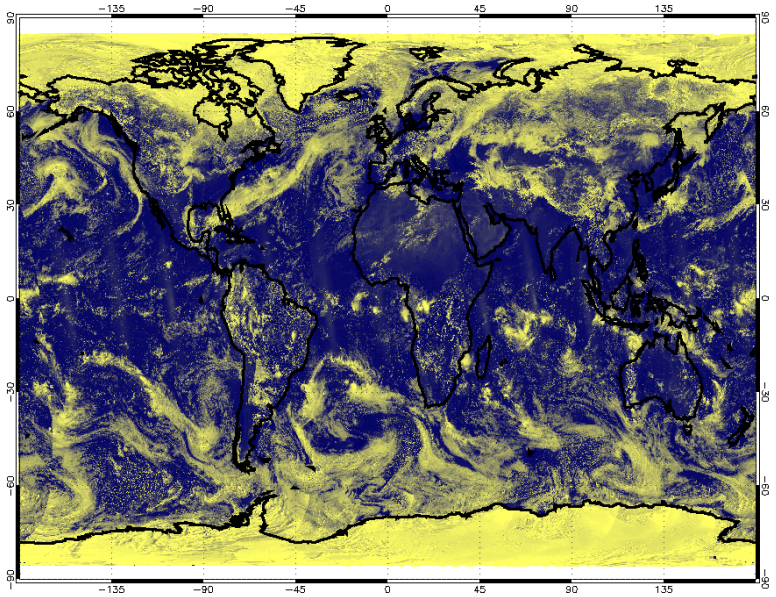


M3 Band Surface Reflectance
March 19, 2019

S-NPP



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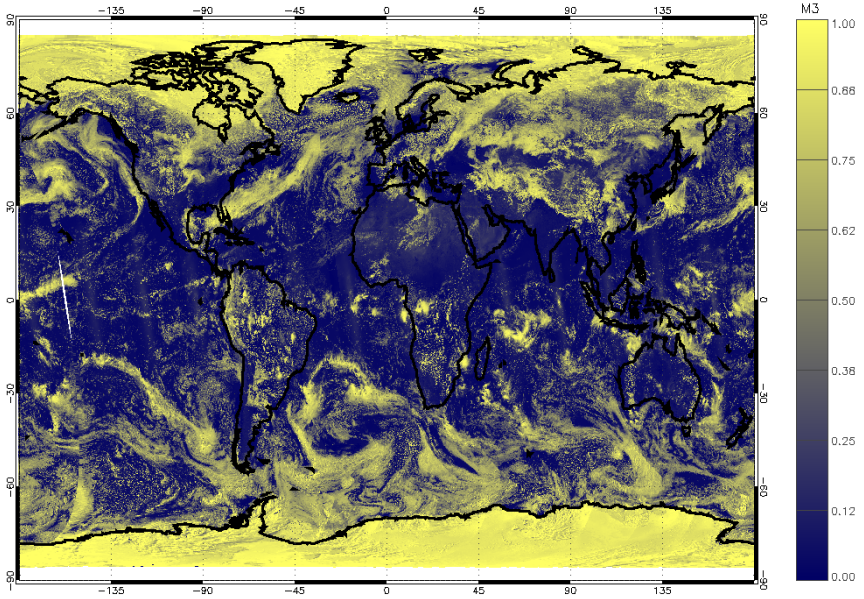
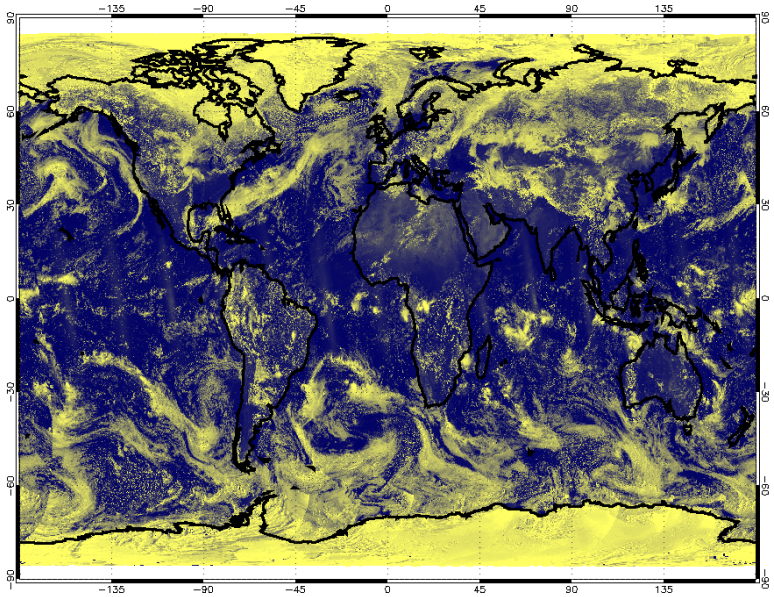


M4 Band Surface Reflectance
March 19, 2019

S-NPP



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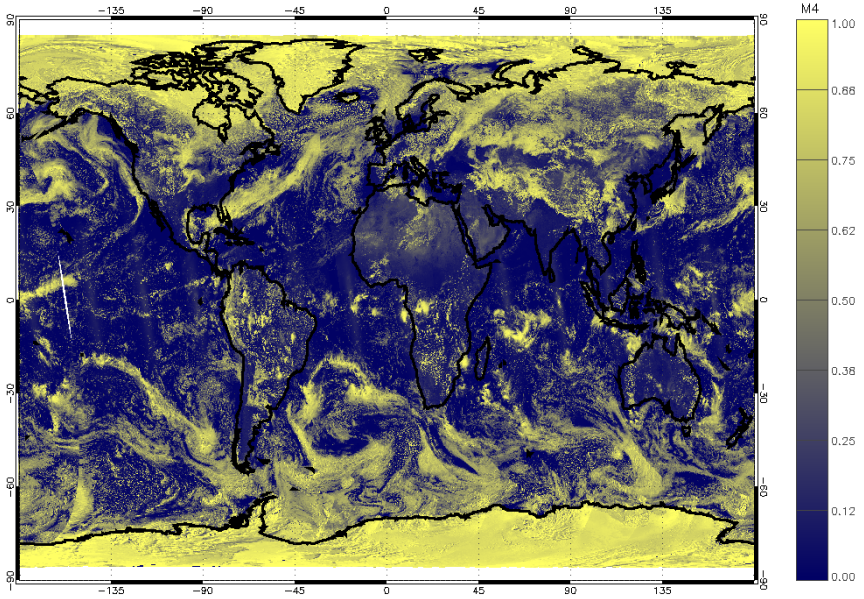

M5 Band Surface Reflectance
March 19, 2019

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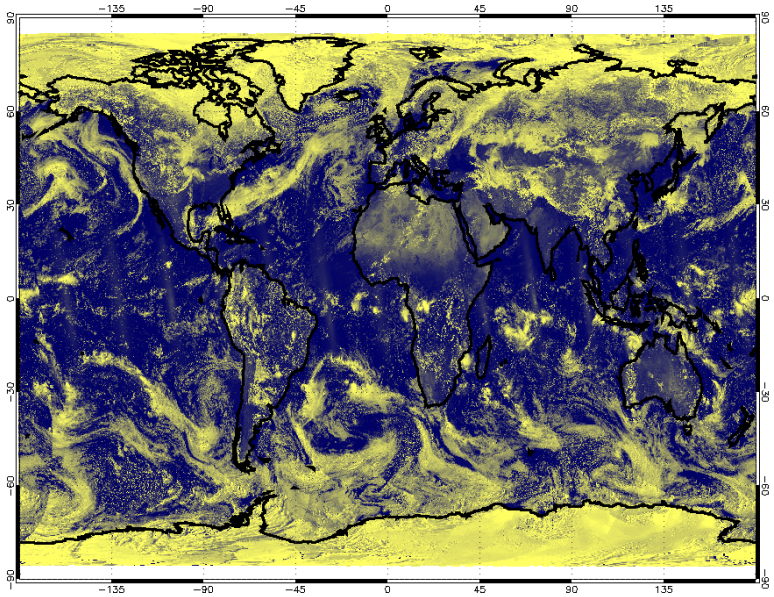

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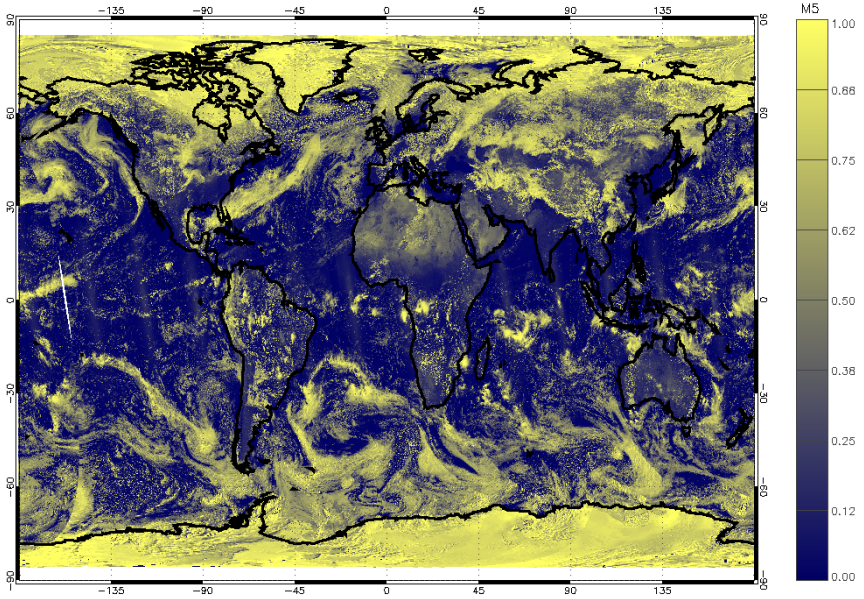
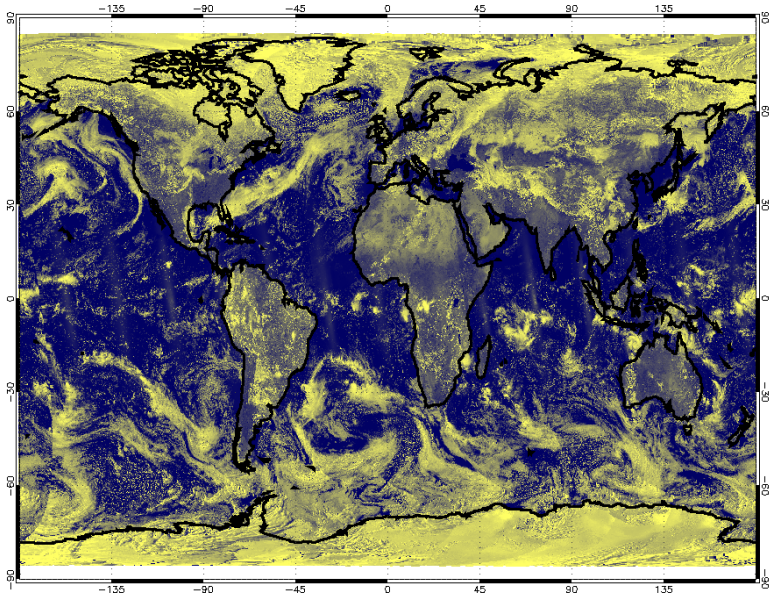


M7 Band Surface Reflectance
March 19, 2019

S-NPP



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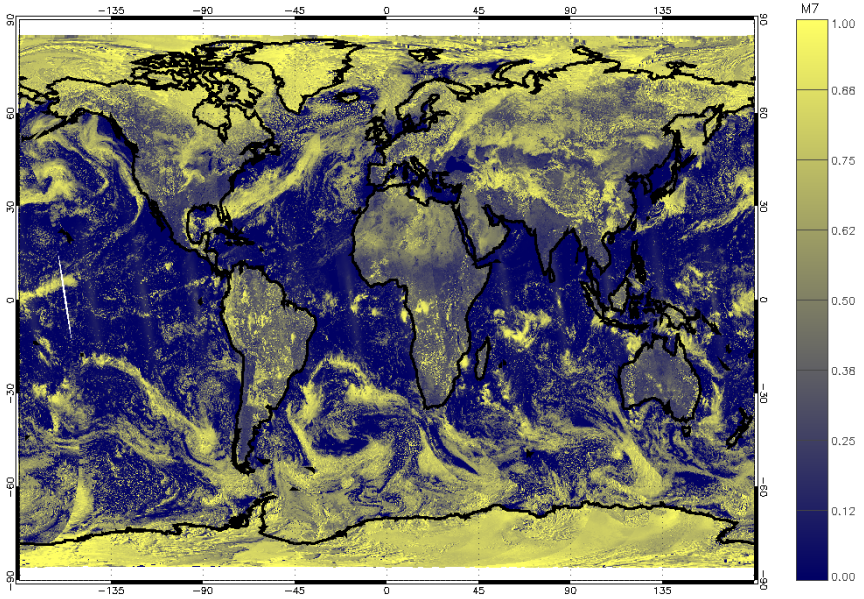
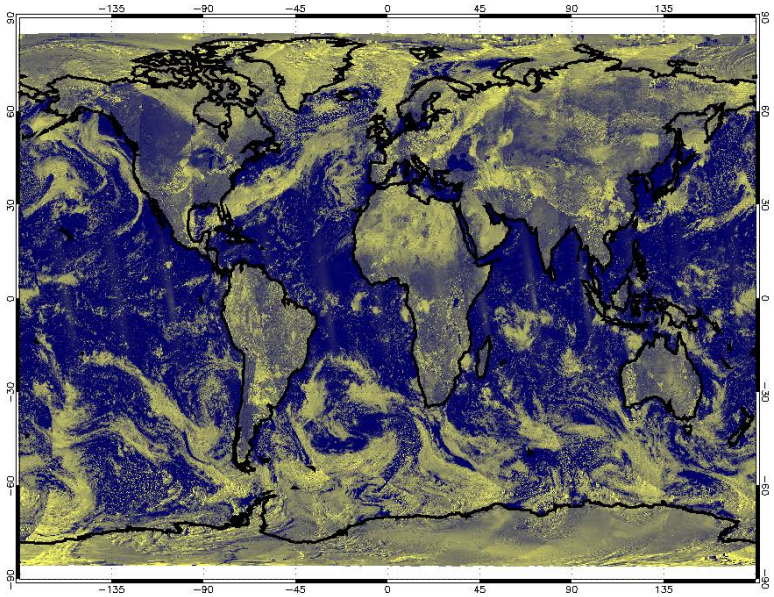
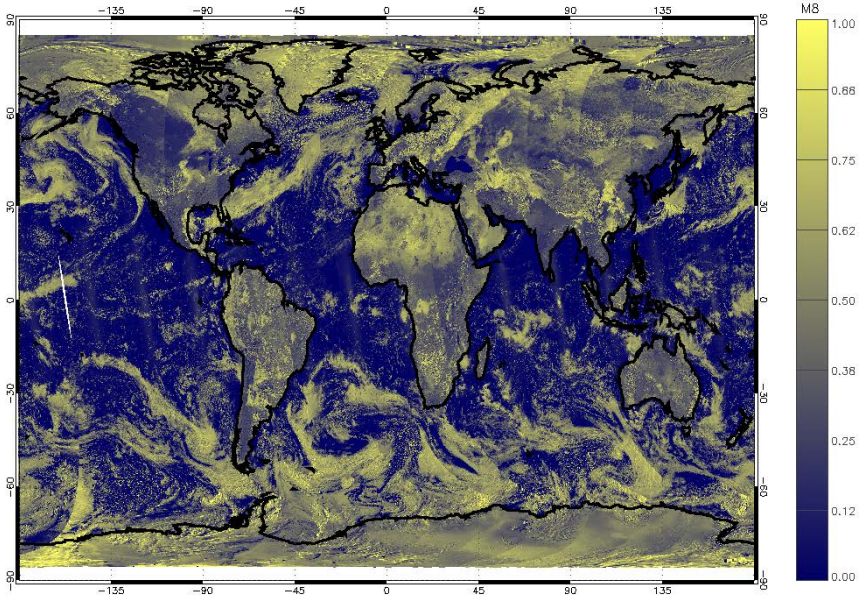


M8 Band Surface Reflectance
March 19, 2019

S-NPP

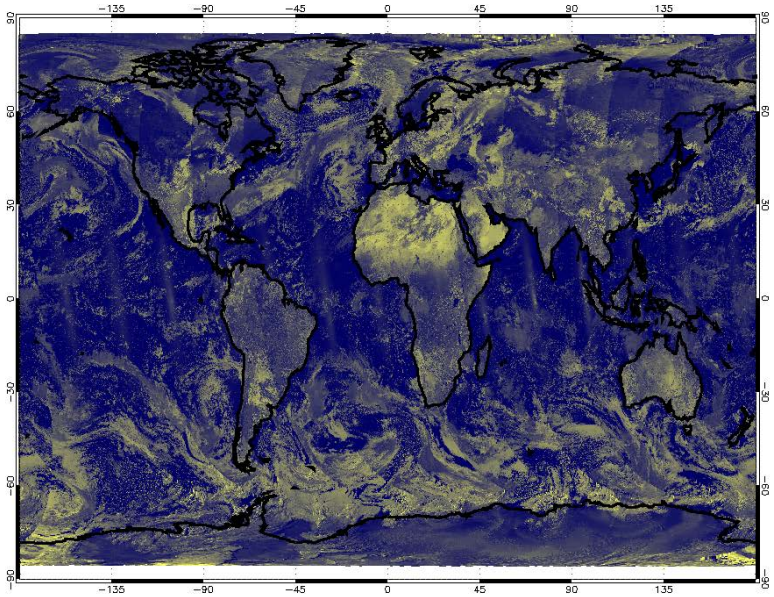


NOAA-20

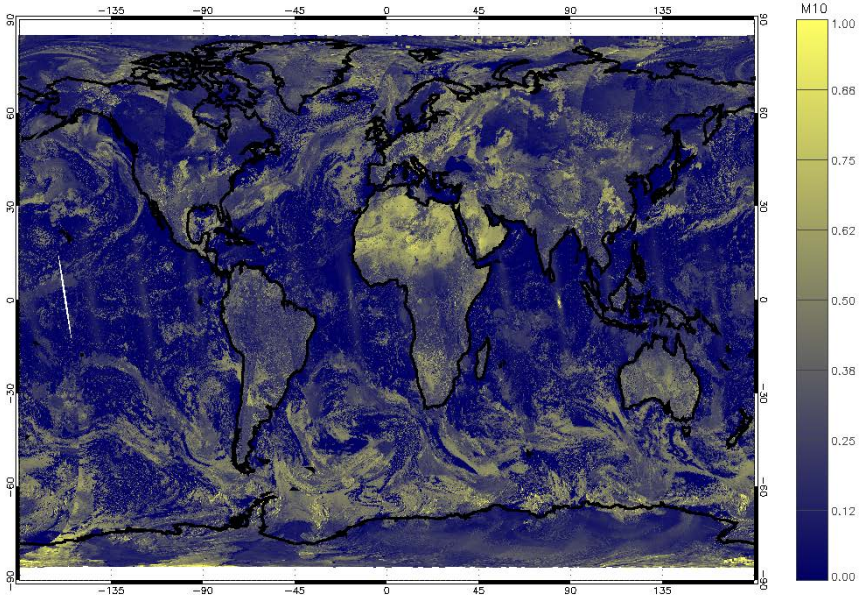


M10 Band Surface Reflectance
March 19, 2019

S-NPP

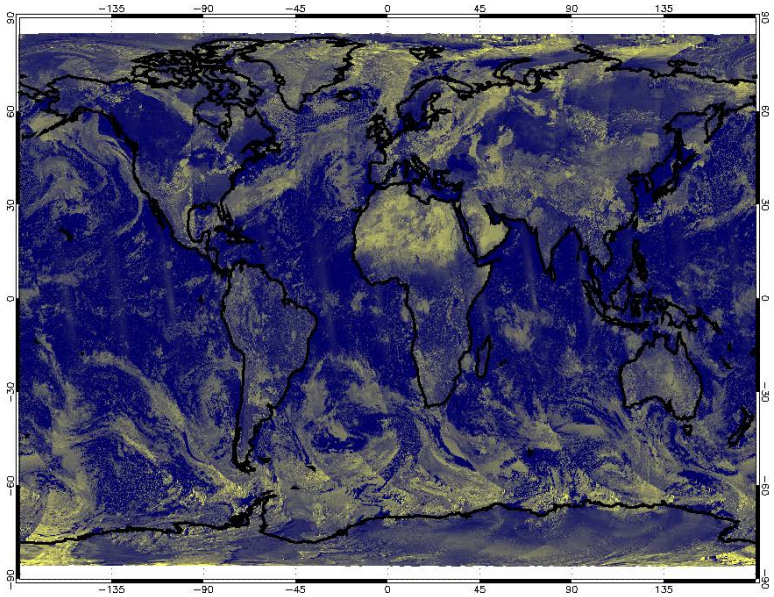


NOAA-20

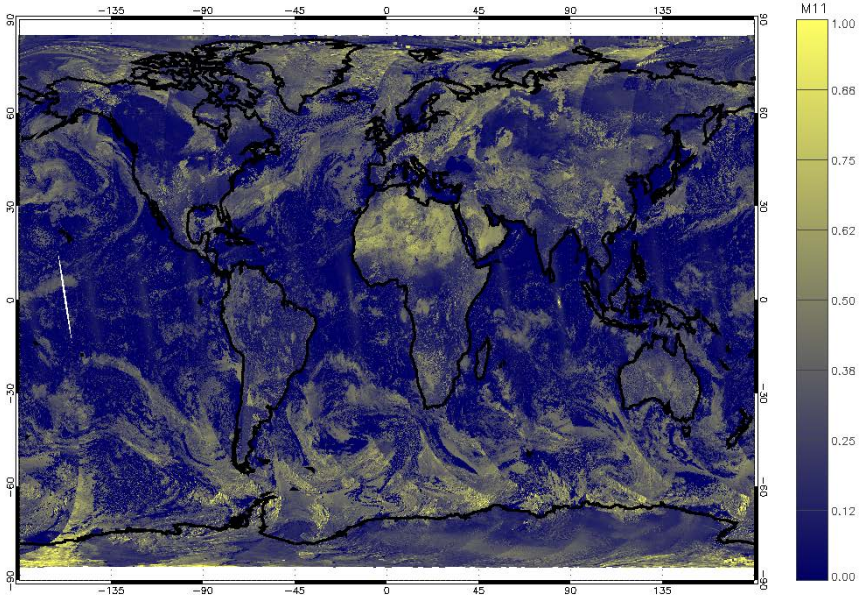


M11 Band Surface Reflectance
March 19, 2019

S-NPP

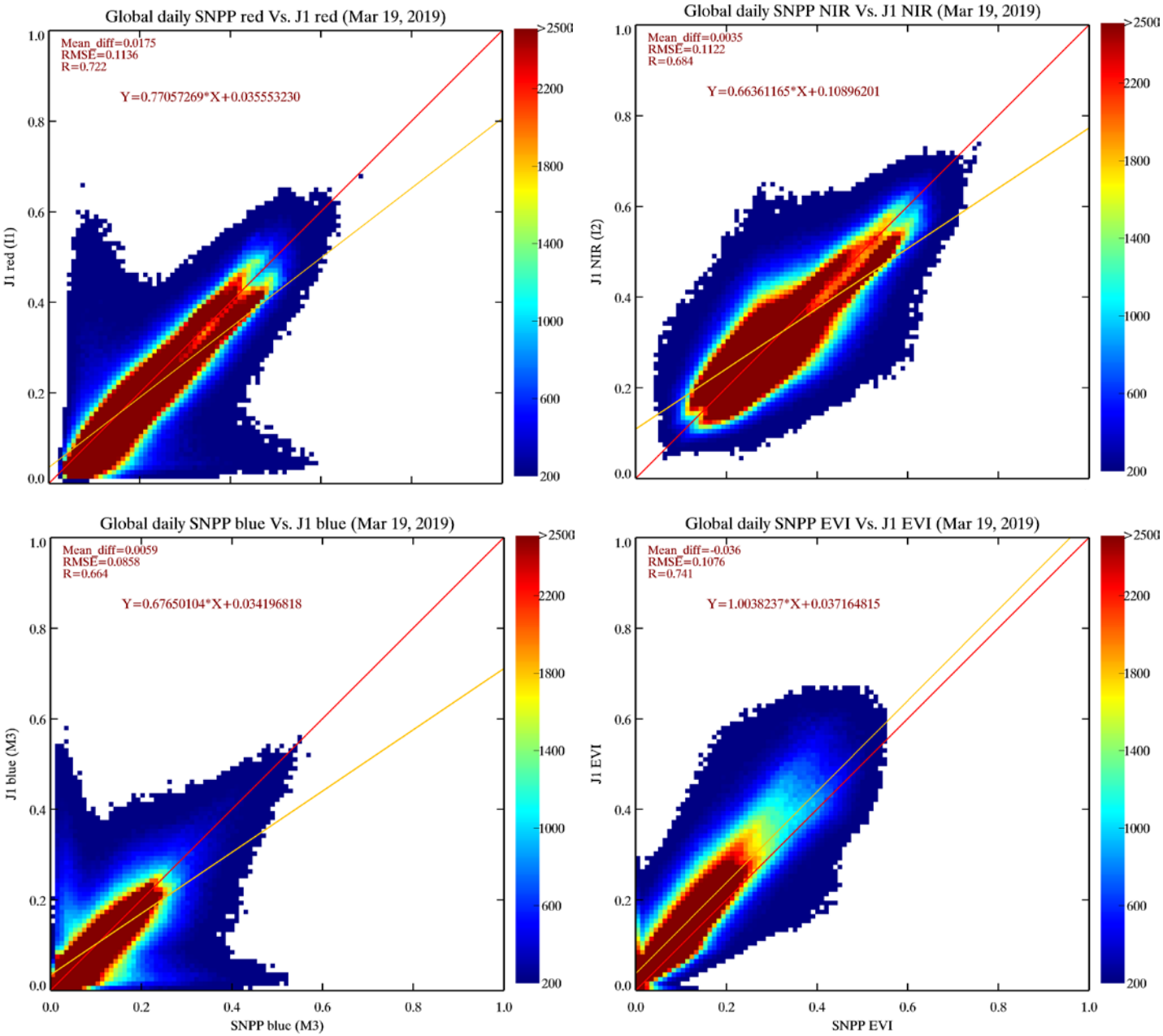


NOAA-20



Suomi NPP vs. NOAA-20 scatterplots

- Comparisons of data from different solar and viewing geometries and cloud contamination
- Good quantitative agreement
- Regression lines are skewed by data densities
- At least one month of data should be averaged for robust statistical comparison



Accuracy assessment

- Validation is performed by comparing the VIIRS surface reflectance products to a reference obtained from correcting the TOA reflectance using the 6SV radiative transfer code and the AERONET data (optical thicknesses, size distribution, indices of refraction and water vapor)
  - Very accurate atmospheric correction around the AERONET sites (9km x 9km)
  - Accuracy, Precision and Uncertainty (APU) values are derived from this comparison
- For the current validation exercise
  - APU statistics were derived from ~1 month of NOAA data from November 2018 – January 2019
  - Statistics were compared to APU results of the NASA Land SIPS product
  - *Note: the NASA product is based on different L1B and ancillary data*

Validation Metrics

- Accuracy (A) = the bias

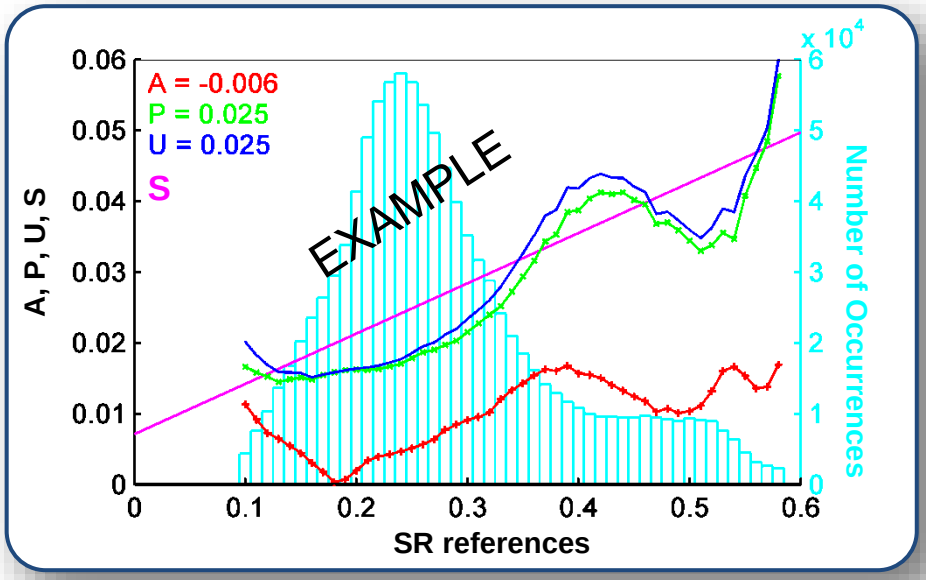
$$A = \frac{1}{N} \times \sum_{i=1}^{N} \varepsilon_i$$

- Precision (P) = the repeatability

$$P = \sqrt{\frac{1}{N-1} \times \sum_{i=1}^{N} (\varepsilon_i - A)^2}$$

- Uncertainty (U) = the actual statistical deviation

$$U = \sqrt{\frac{1}{N} \times \sum_{i=1}^{N} \varepsilon_i^{\,2}}$$

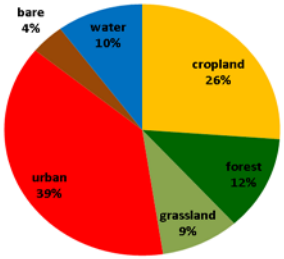


- Specification (S) = A and P requirement (per JERD)

From Vermote and Kotchenova, 2008
(modified for JERD requirements)

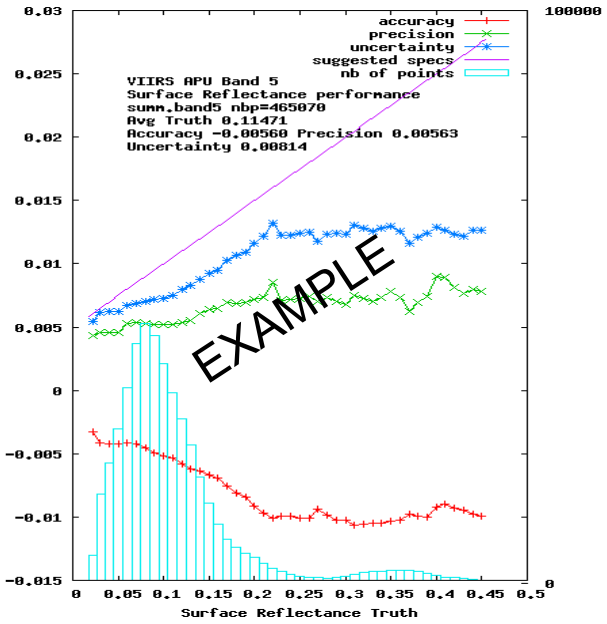
Accuracy assessment: AERONET validation

- AERONET data
  - Very accurate atmospheric correction around the AERONET site (9km x 9km)



AERONET Sites (left) and the associated Land cover distribution (right) used for SR validation.

Estimates of BRDF corrected surface reflectance for VIIRS band M5



Atmospherically corrected TOA reflectances derived from Level 1 subsets

Reference data set

comparison

Subsets of Level 1 data processed using the standard surface reflectance algorithm

Vector 6S

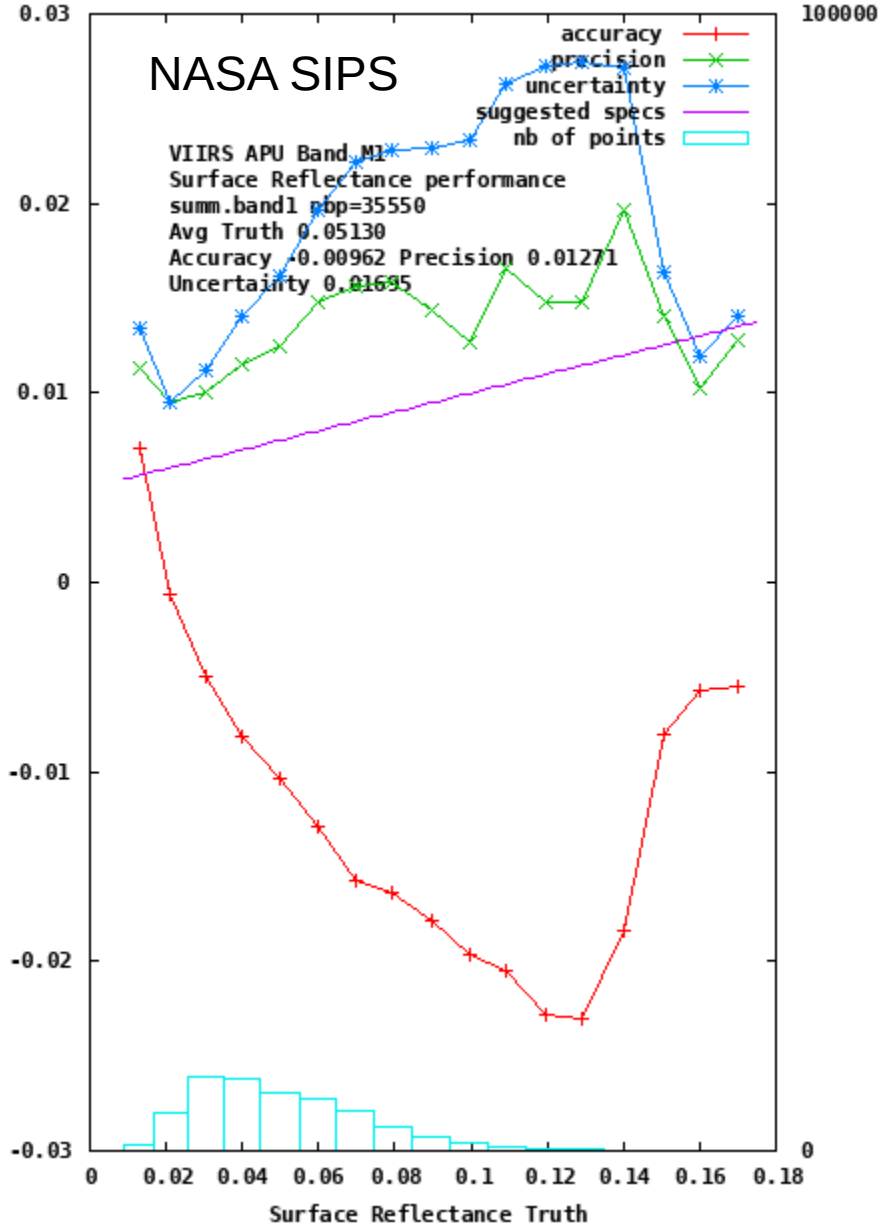
AERONET measurements (τ_{aer}, H_2O, particle distribution Refractive indices, sphericity)

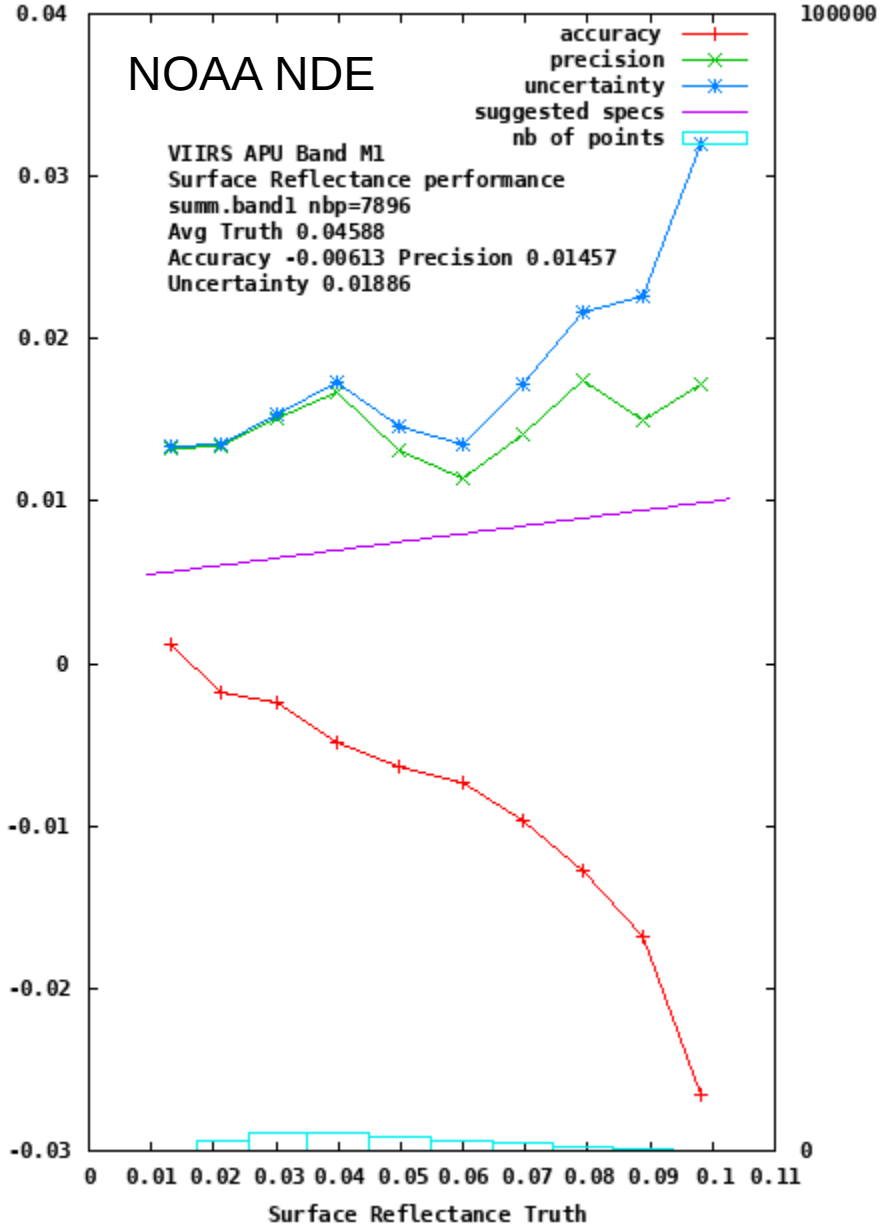
AERONET sites included in the validation of the NDE surface reflectance product (39 sites)

https://aeronet.gsfc.nasa.gov

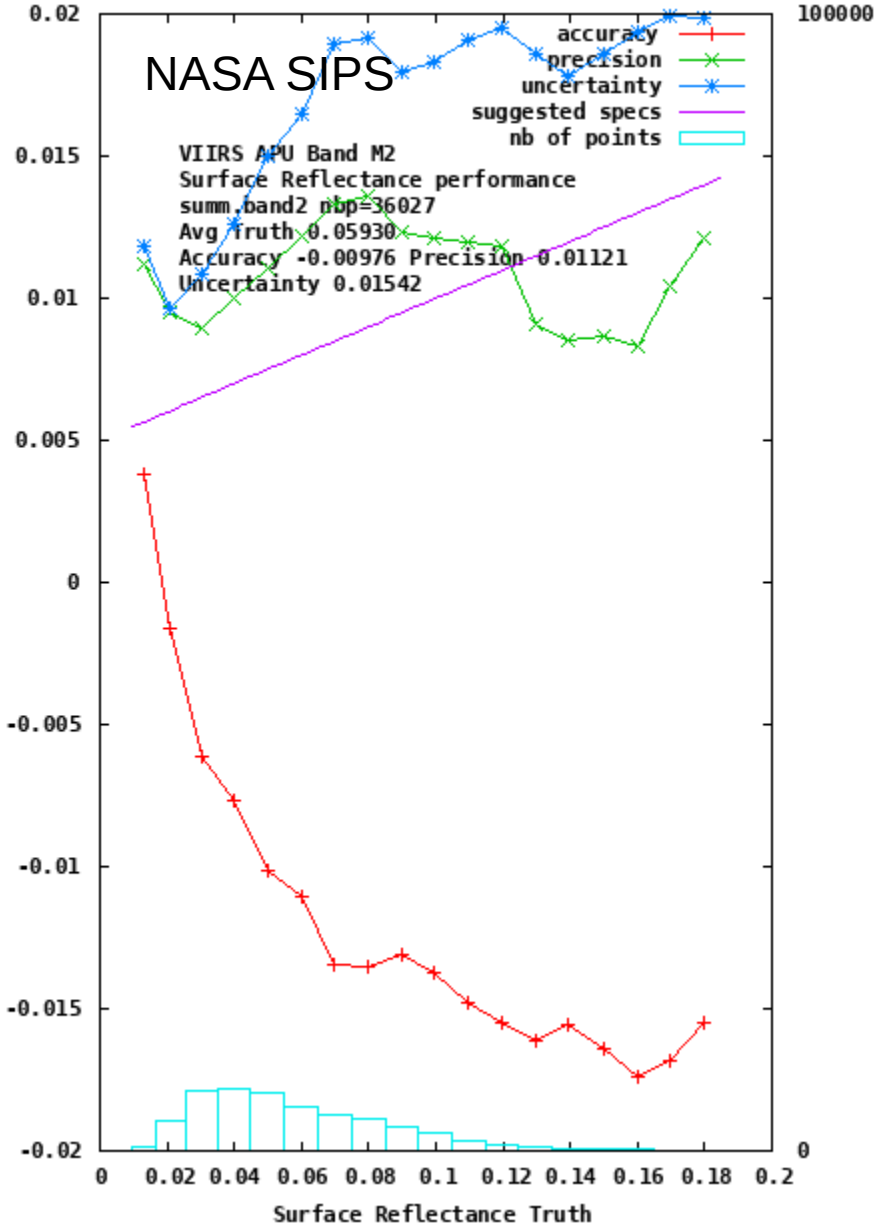
Site	lat,lon	Site	lat,lon	Site	lat,lon	Site	lat,lon
Arica, Chile	18S,70W	Dakar, Senegal	14N,16W	Kanpur, India	26N,80E	Santa Cruz, Tenerife	28N,16W
Ascension Island	7S,14W	El Arenosillo, Spain	37N,6W	Lake Argyle, Australia	16S,128E	Sede Boker, Israel	30N,34E
Banizoumbou, Niger	13N,2E	Evora, Portugal	38N,7W	Lecce, Italy	40N,18E	Sevilleta, New Mexico	34N,106W
Barcelona, Spain	41N,2E	Granada, Spain	37N,3W	Lille, France	50N,3E	Table Mountain, CA	34N,117W
Beijing, China	39N,116E	GSFC, Greenbelt	38N,76W	MD Science Center, Baltimore	39N,76W	Toulon, France	43N,6E
Billerica, Massachusetts	42N,71W	IER-Cinzana, MALI	13N,5W	Messina, Italy	38N,15E	Tucson, Arizona	32N,110W
Brookhaven National Lab, Upton, NY	40N,72W	Ilorin, Nigeria	8N,4E	Monterey, California	36N,121W	Santa Barbara, California	34N,119W
Cabo da Roca, Portugal	38N,9W	IMS-METU-ERDEMLI, Turkey	36N,34E	OHP Observatoire, France	43N,5E	Ussuriisk, Russia	43N,132E
CCNY, New York	40N,73W	Ispra, Italy	45N,8E	Rimrock, Idaho	46N,116W	Wallops Island, Virginia	37N,75W
CEILAP-BA, Argentina	34S,58W	Izana, Spain	28N,16W	Rome-Tor Vergata, Italy	41N,12E		

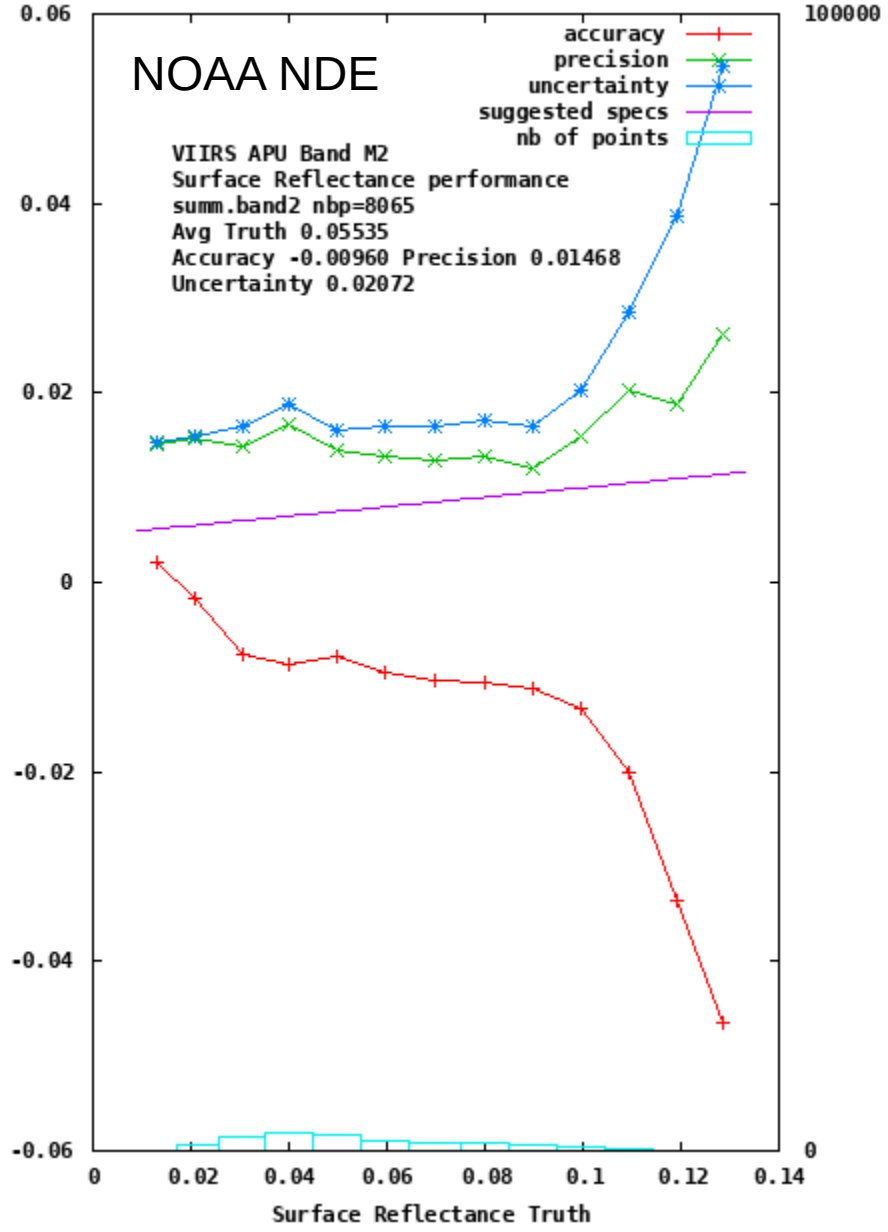
Accuracy assessment



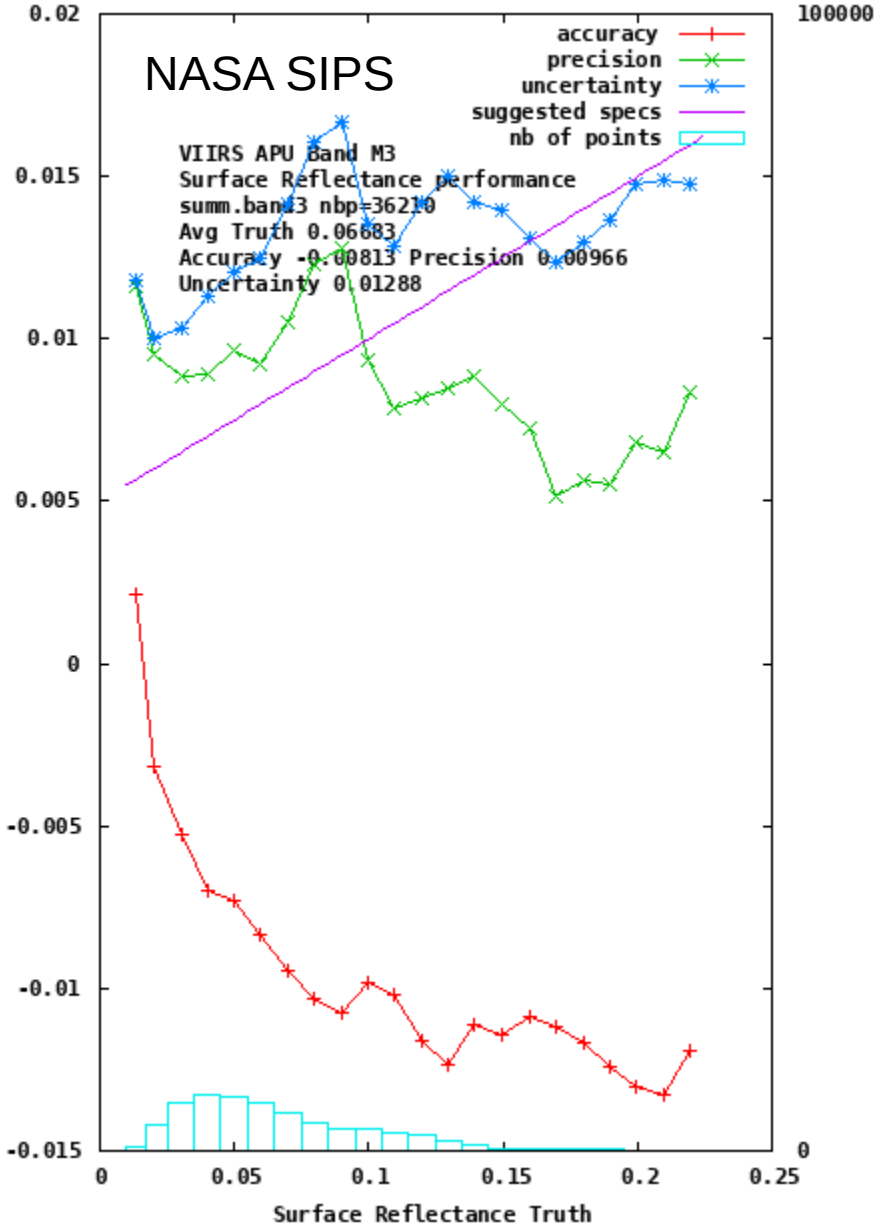


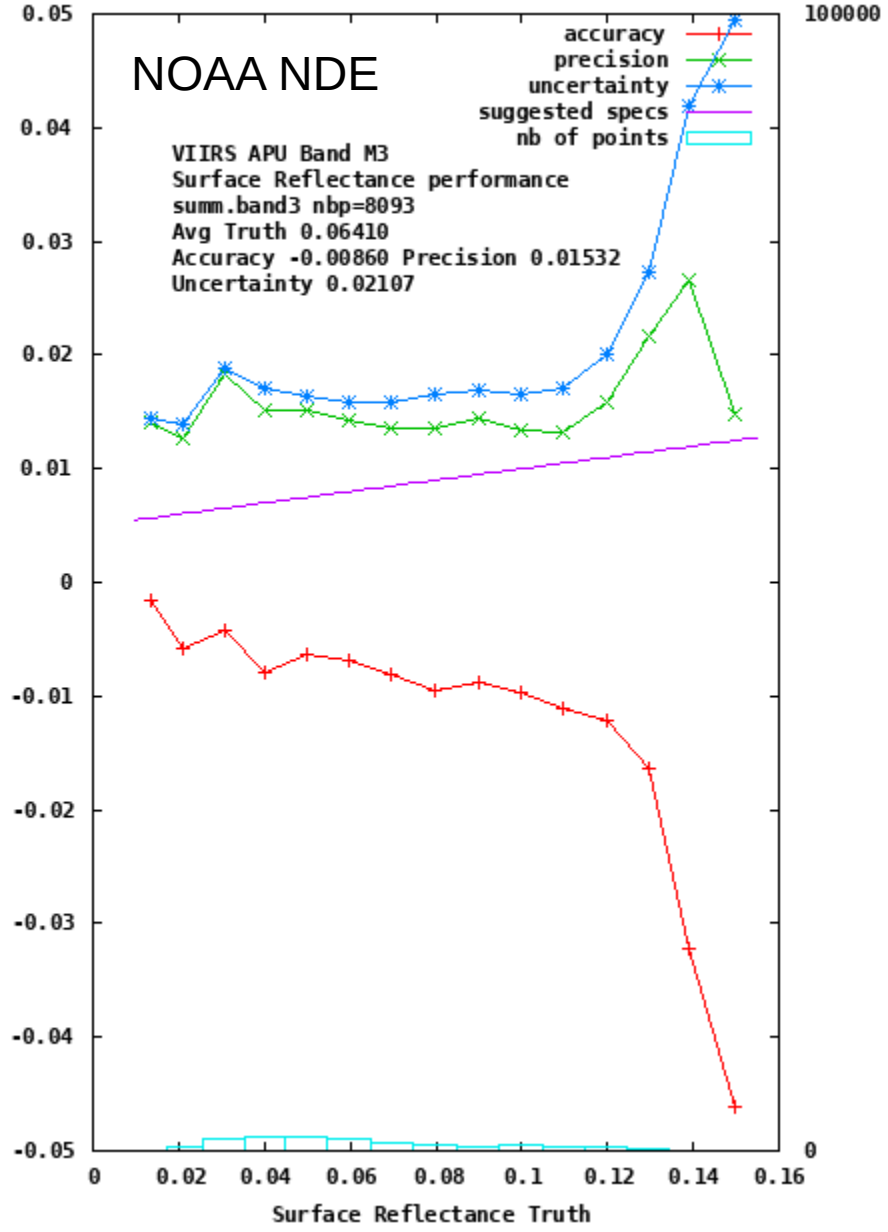
Accuracy assessment



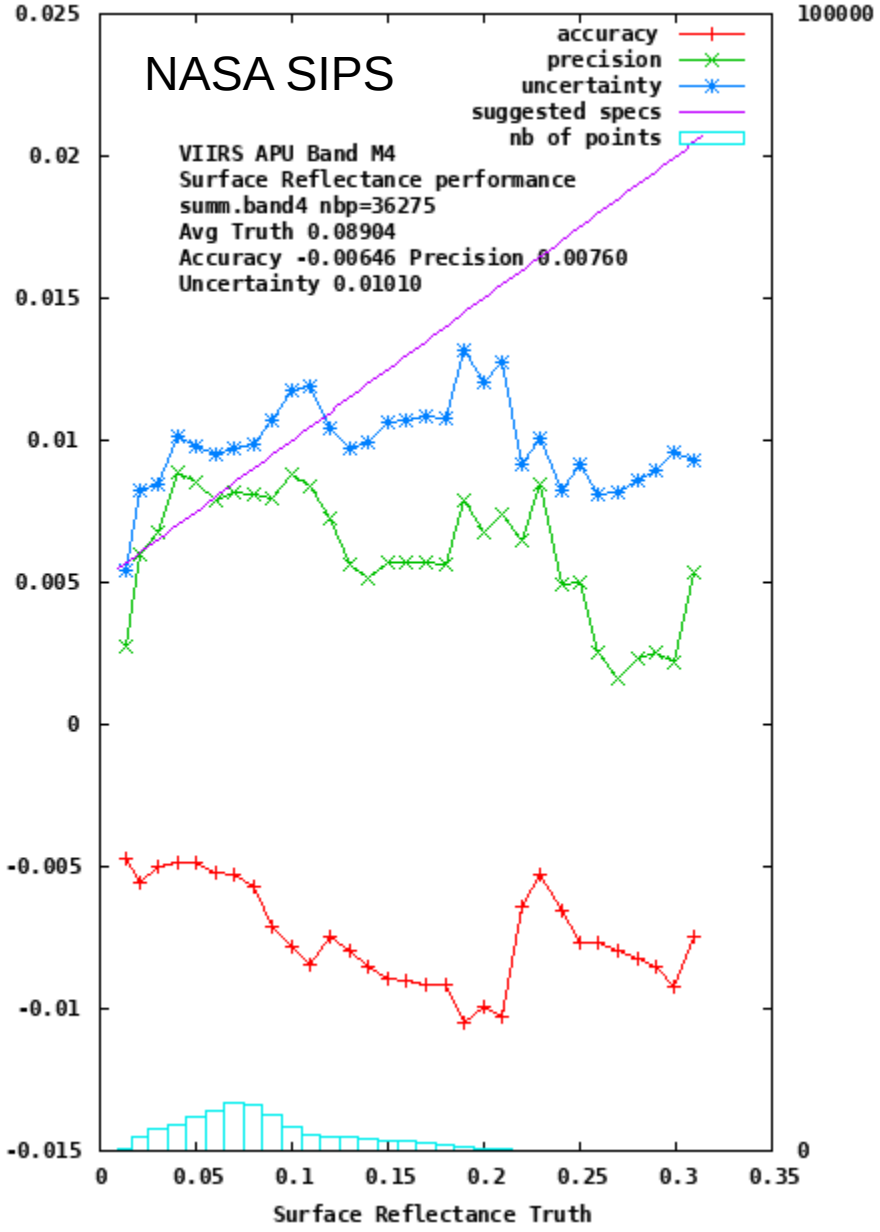


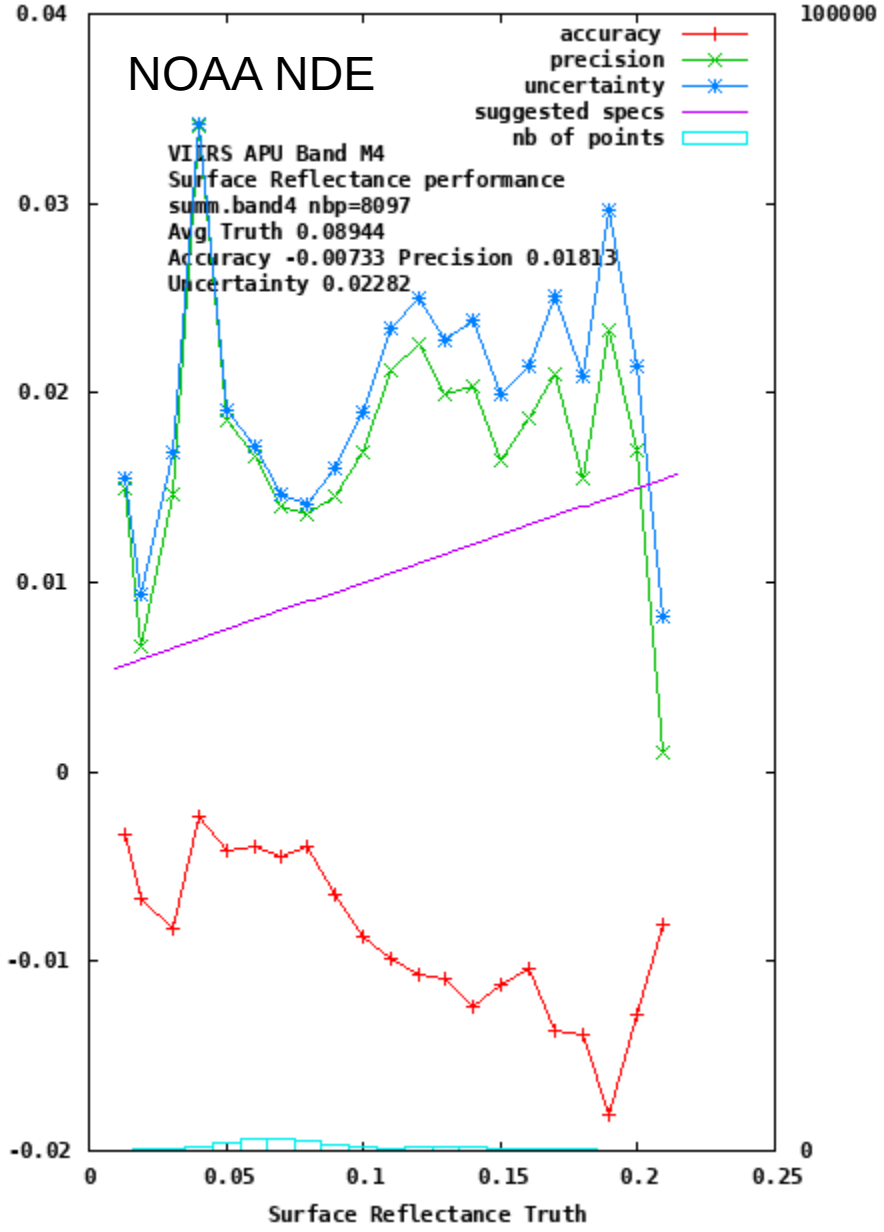
Accuracy assessment



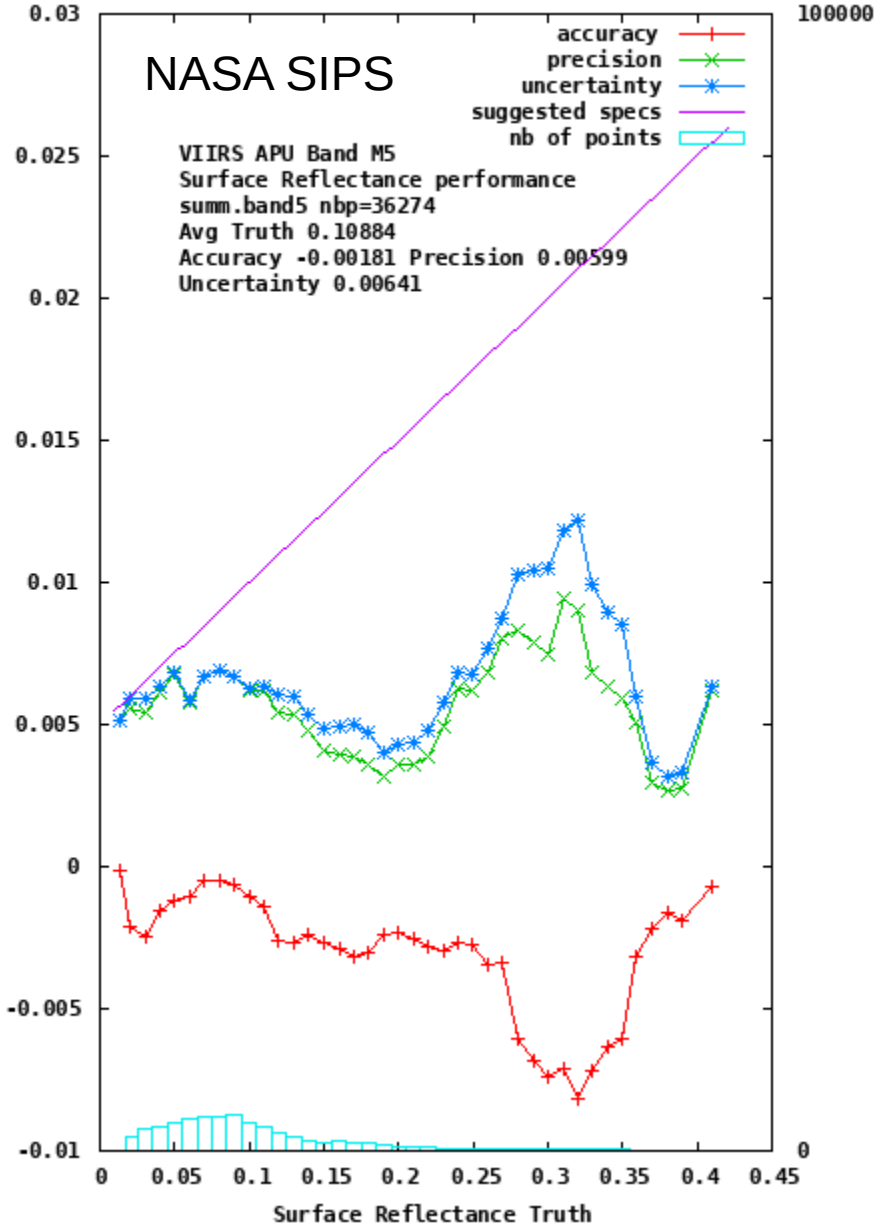


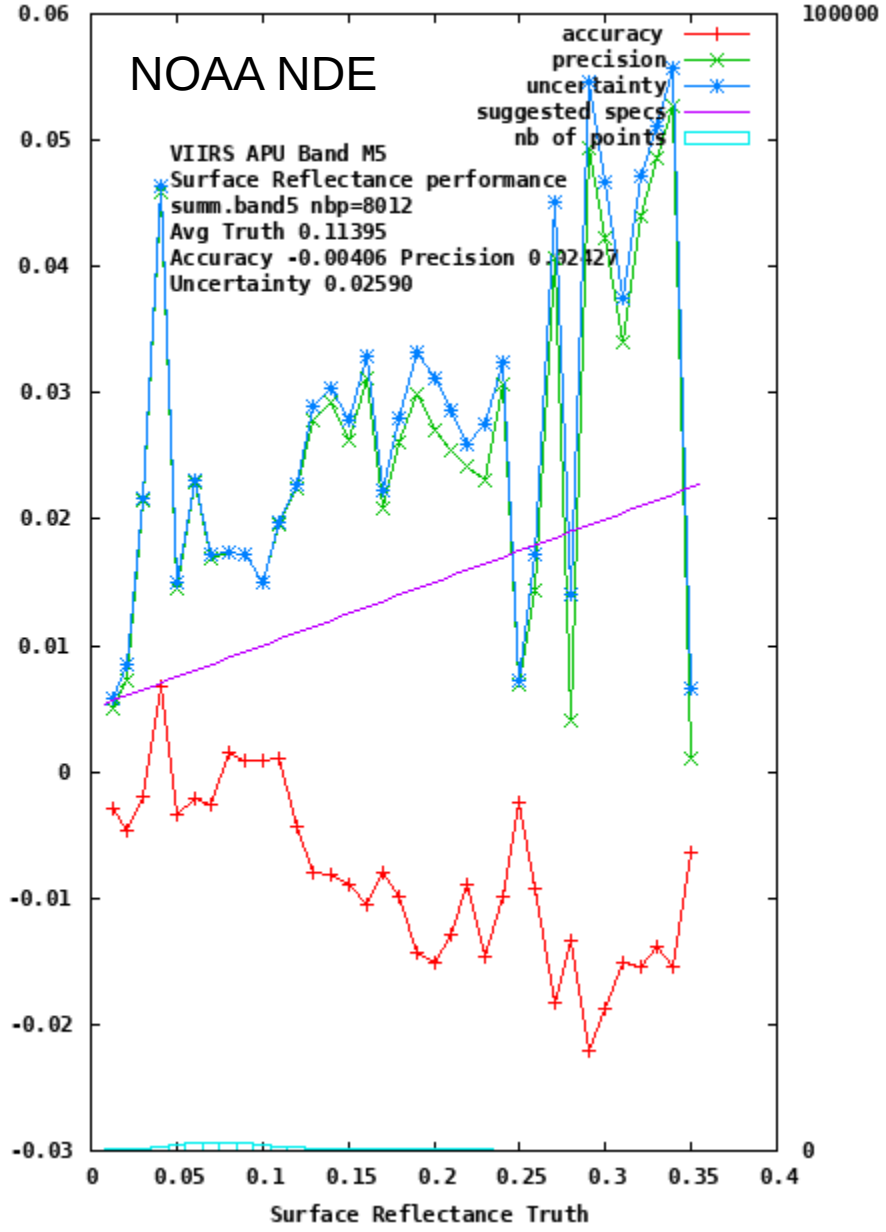
Accuracy assessment



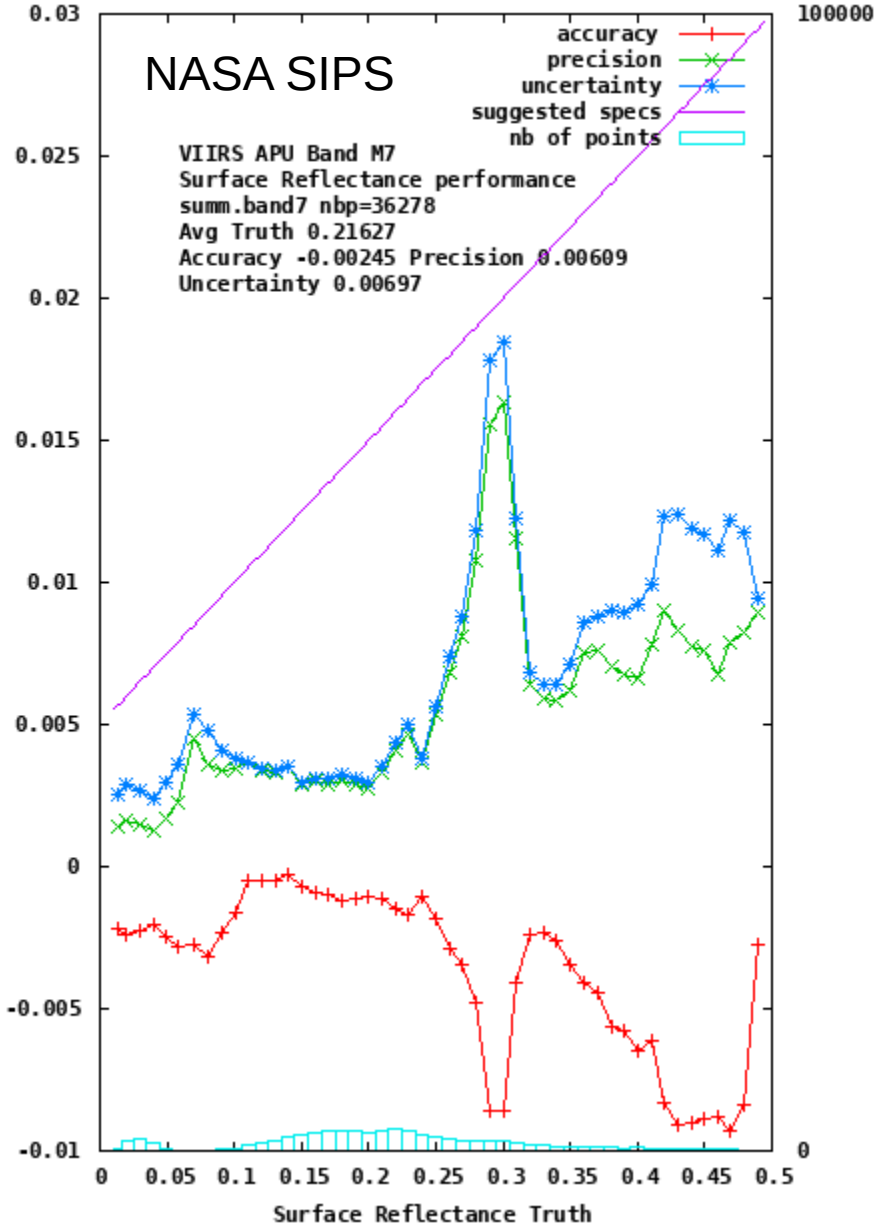


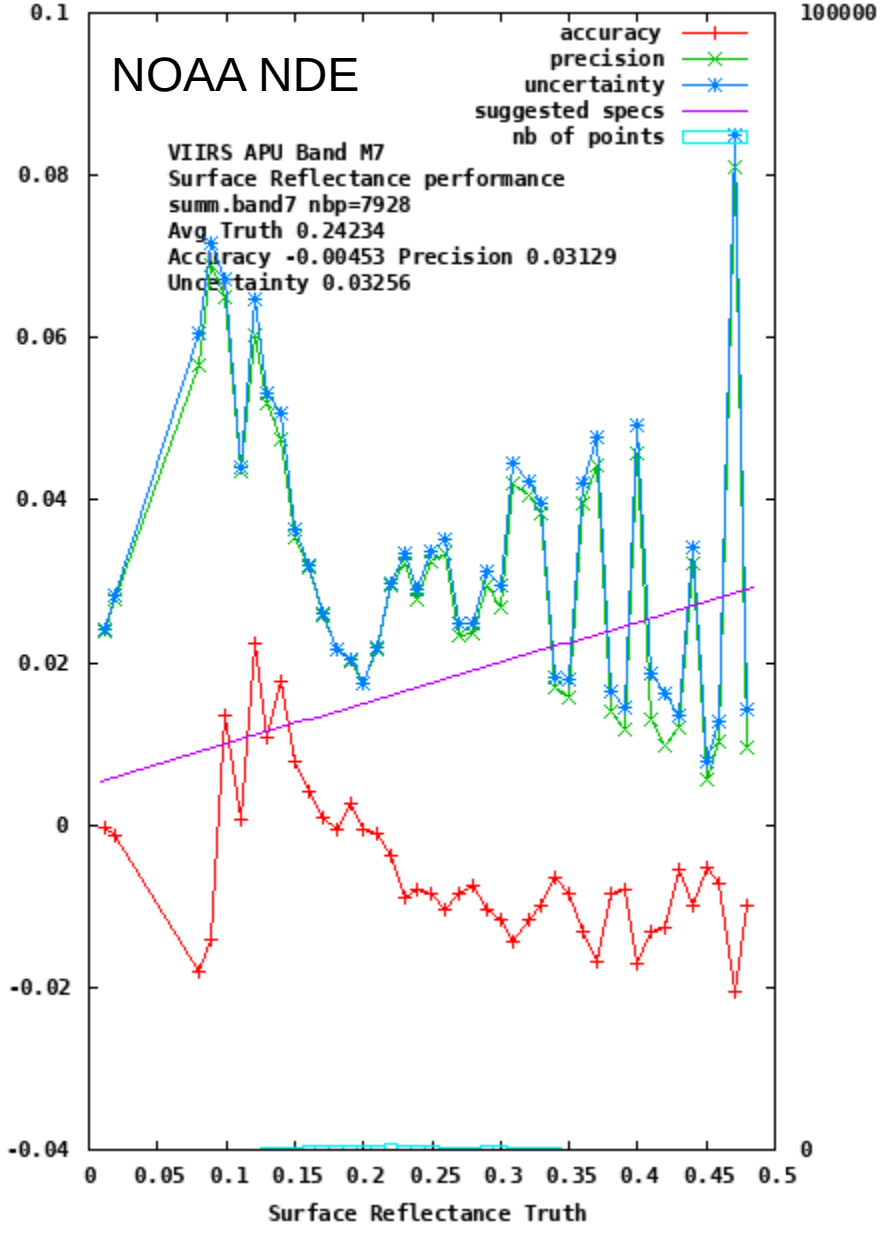
Accuracy assessment



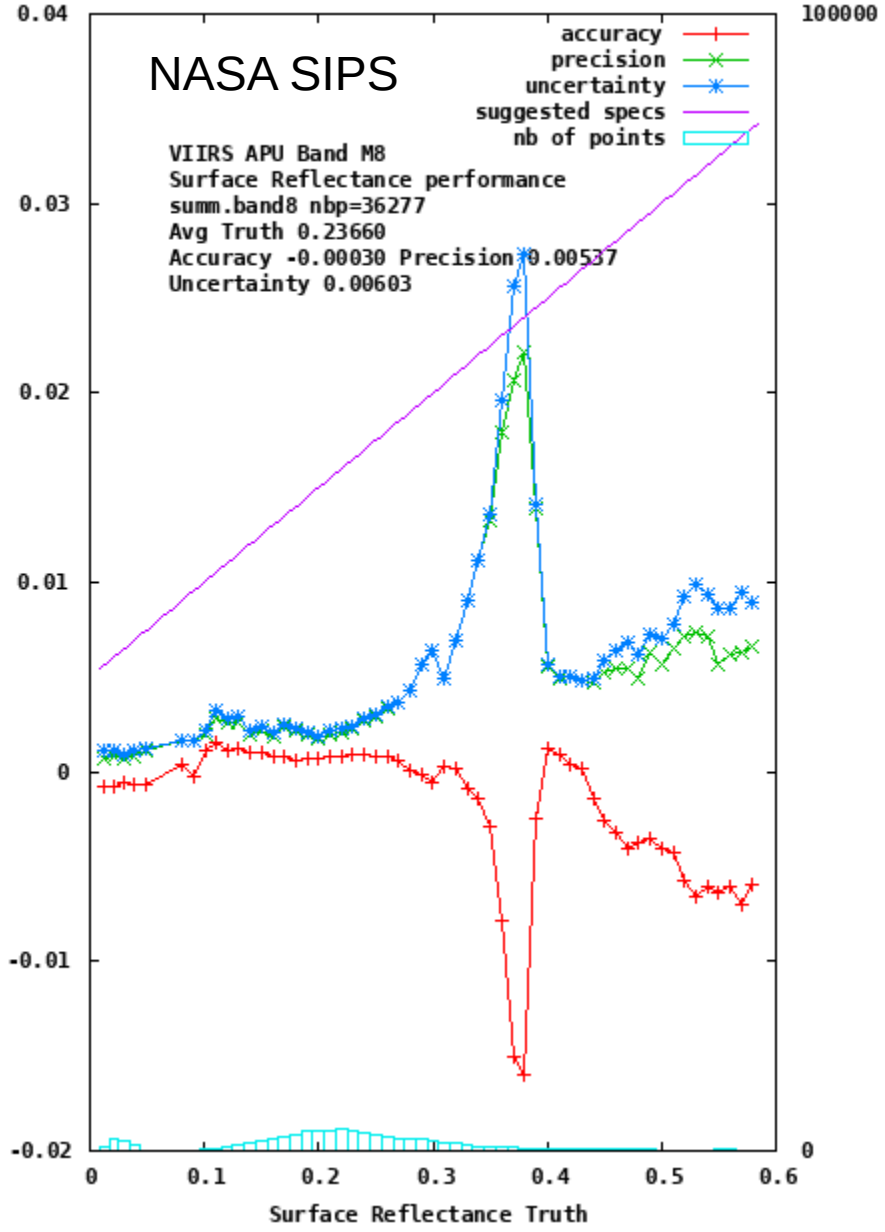


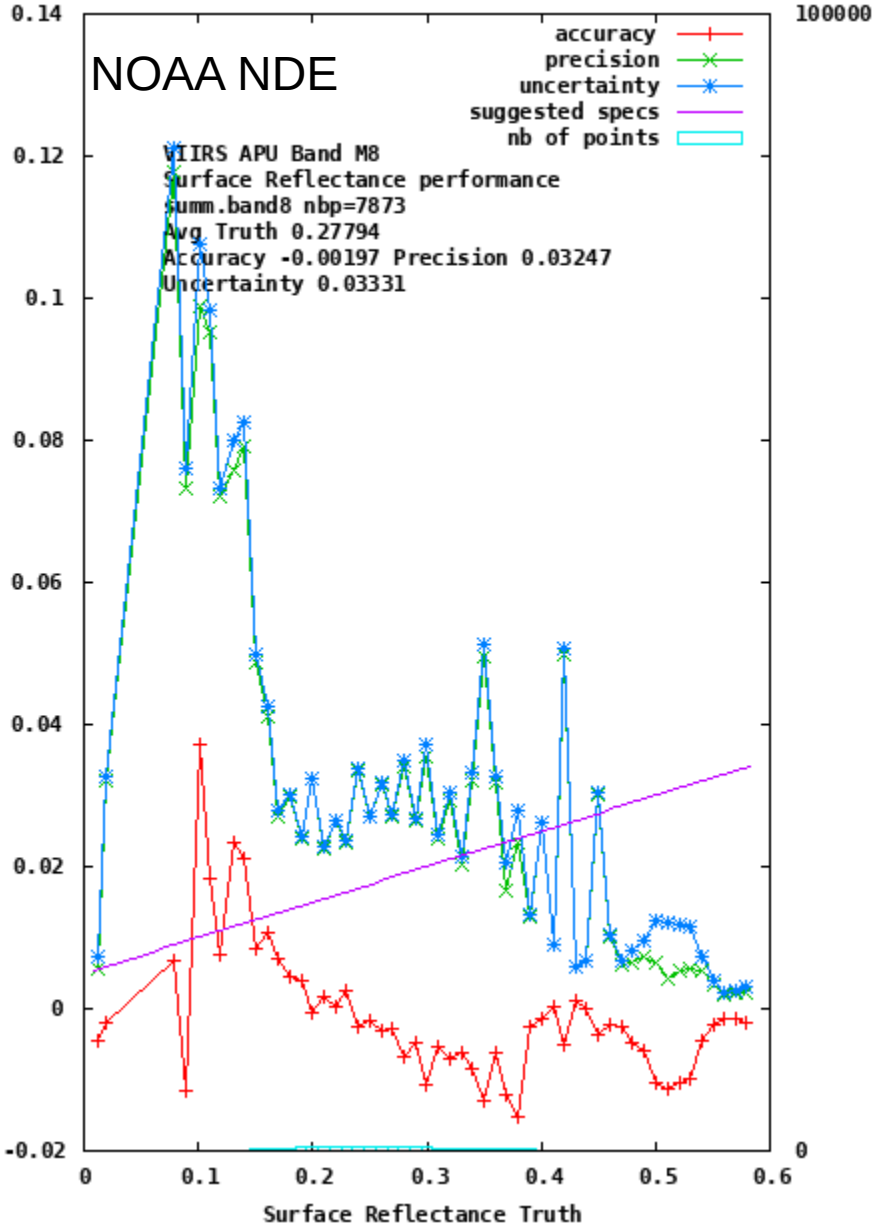
Accuracy assessment



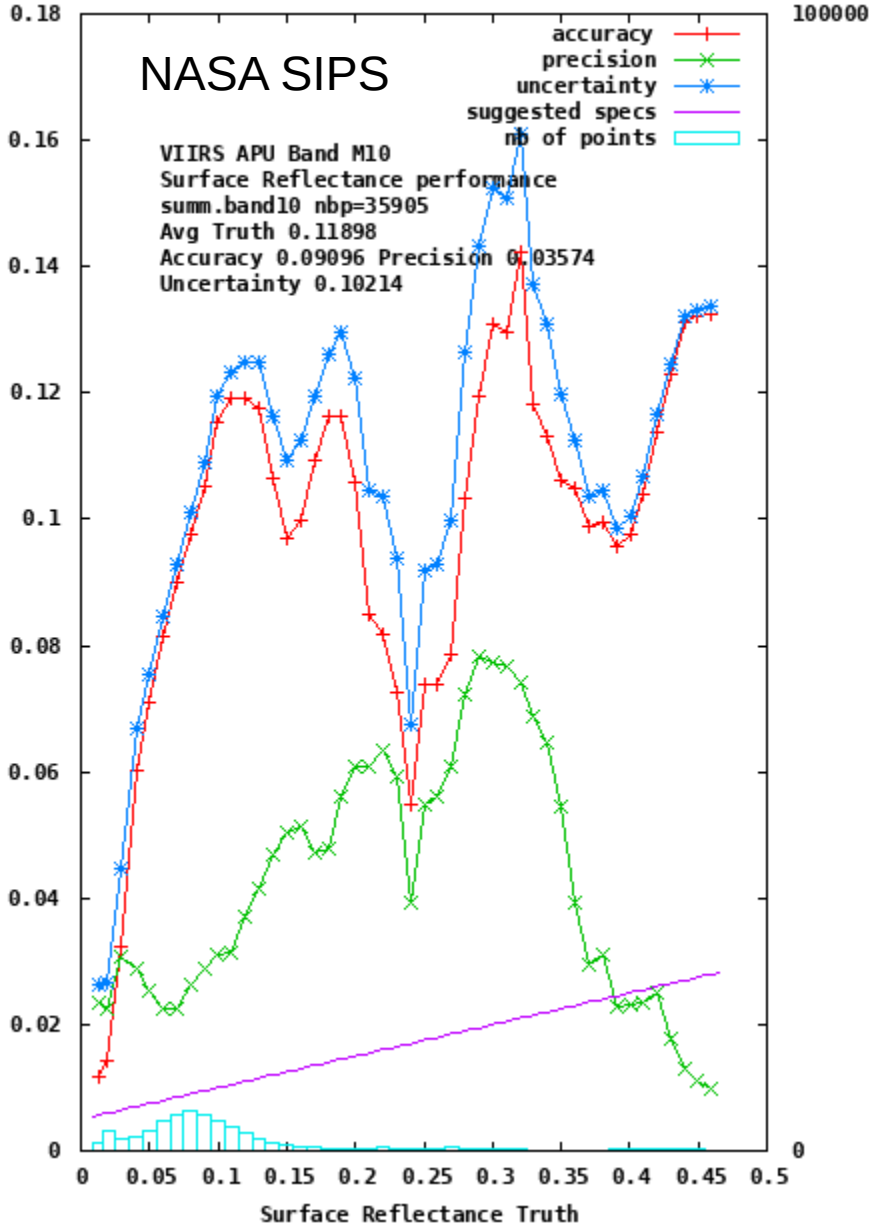


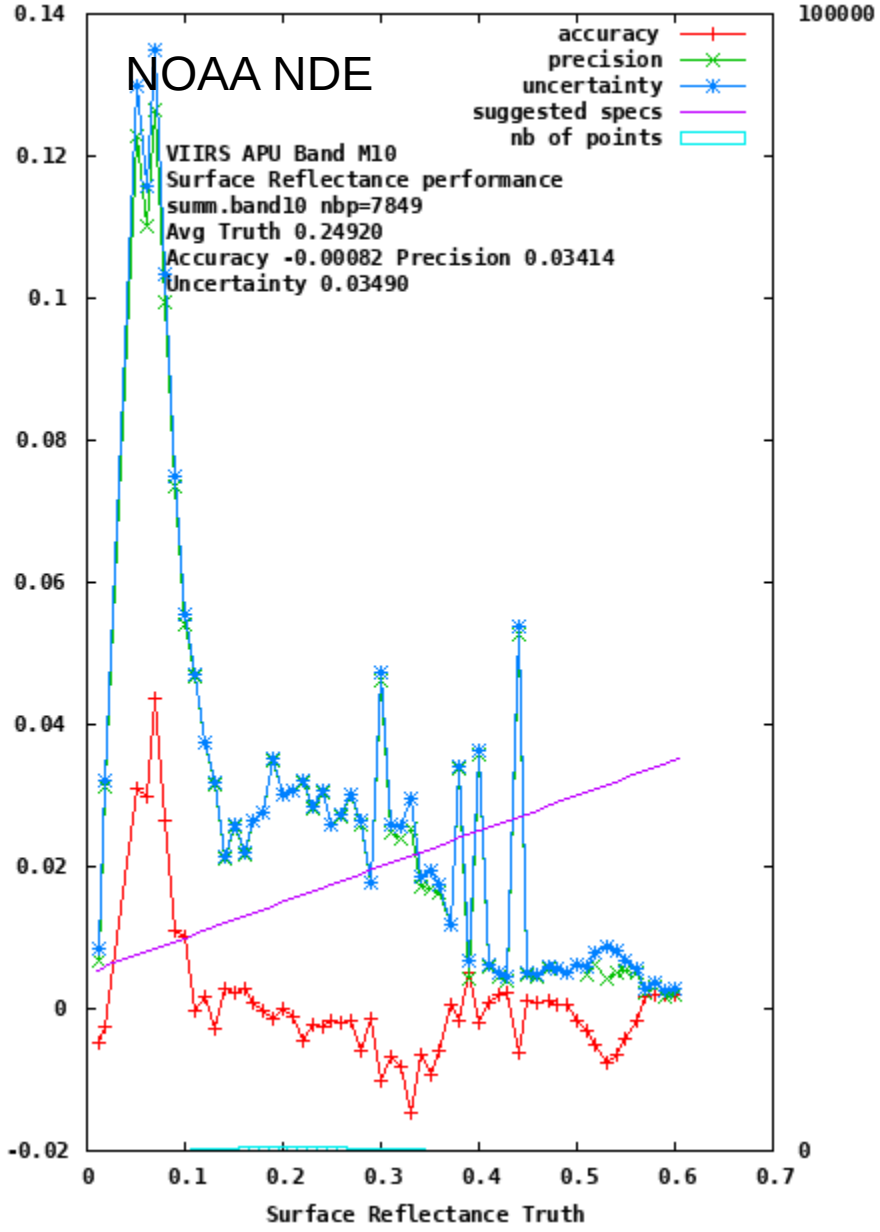
Accuracy assessment



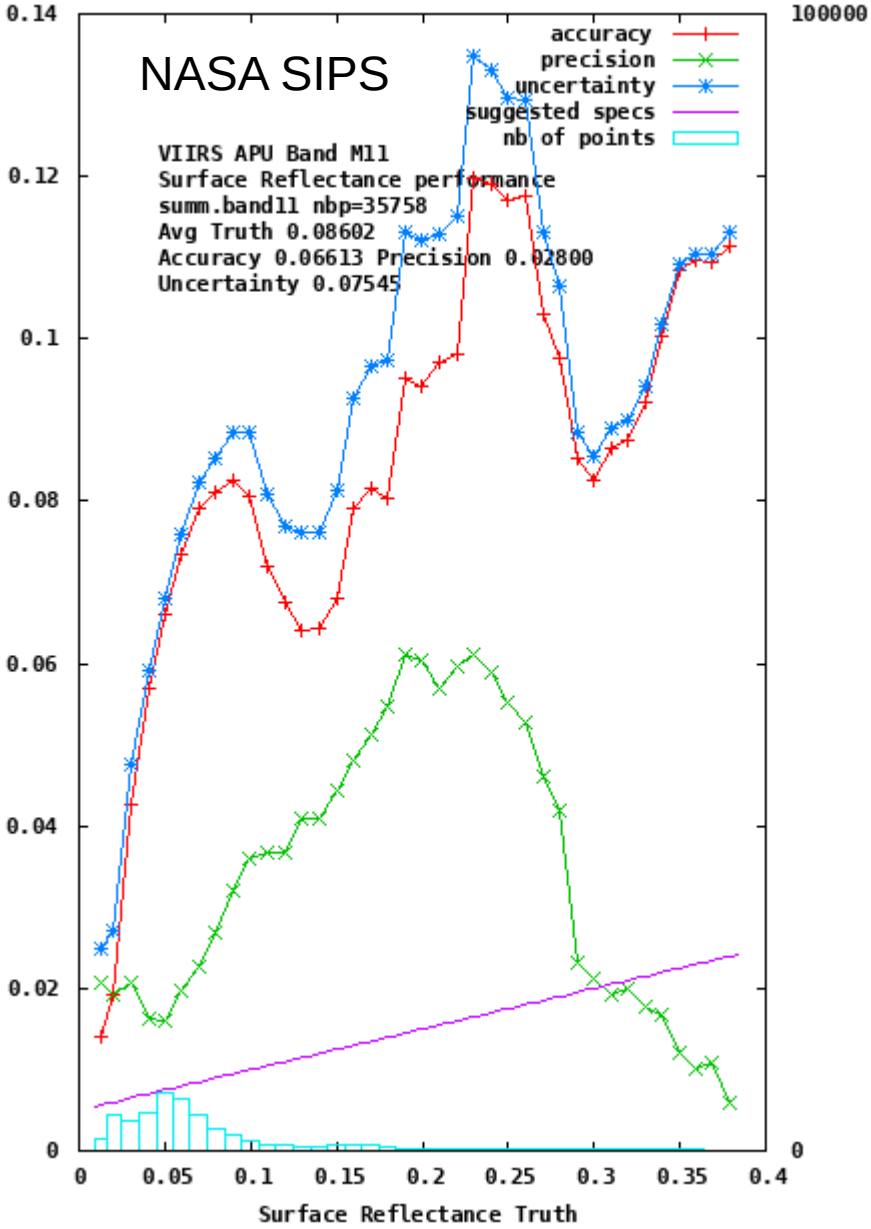


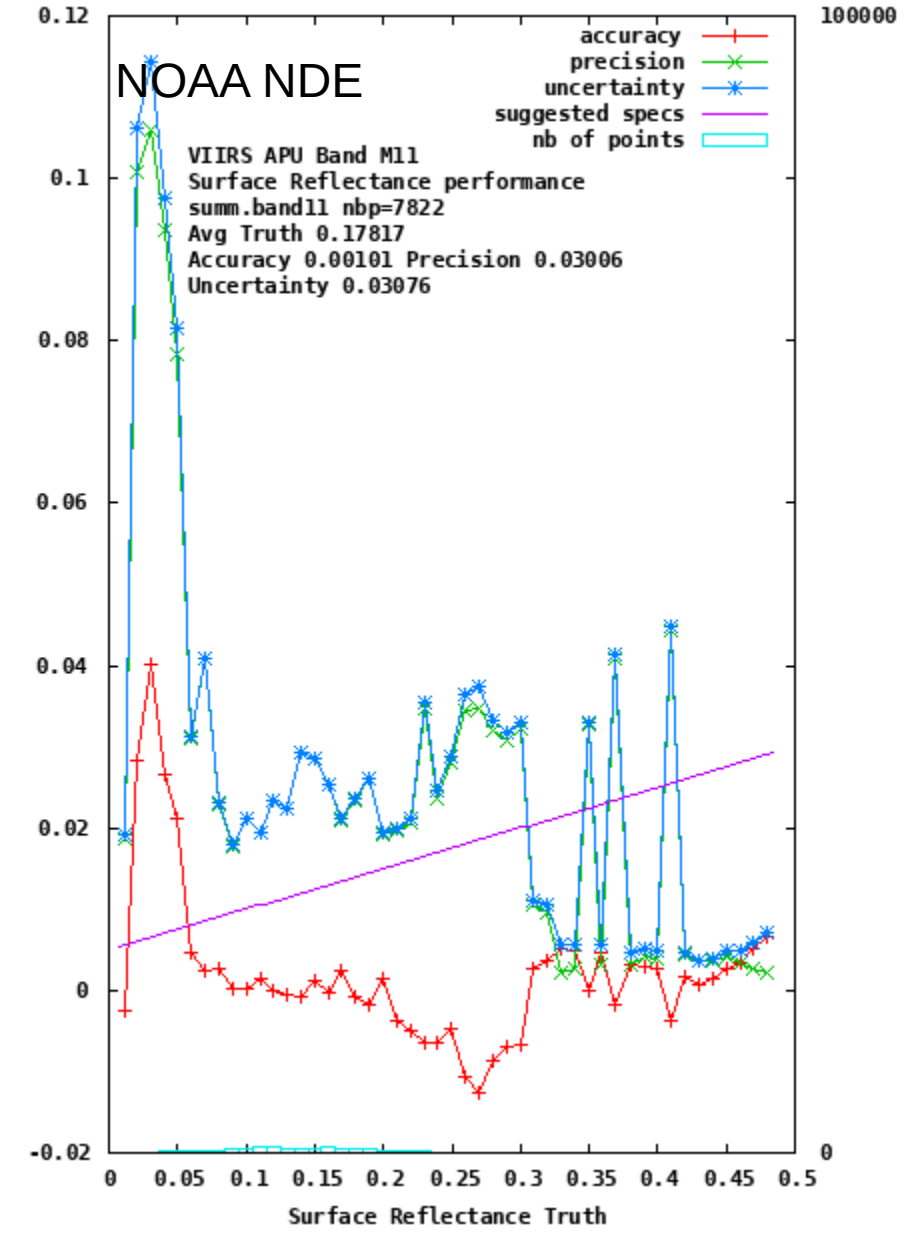
Accuracy assessment



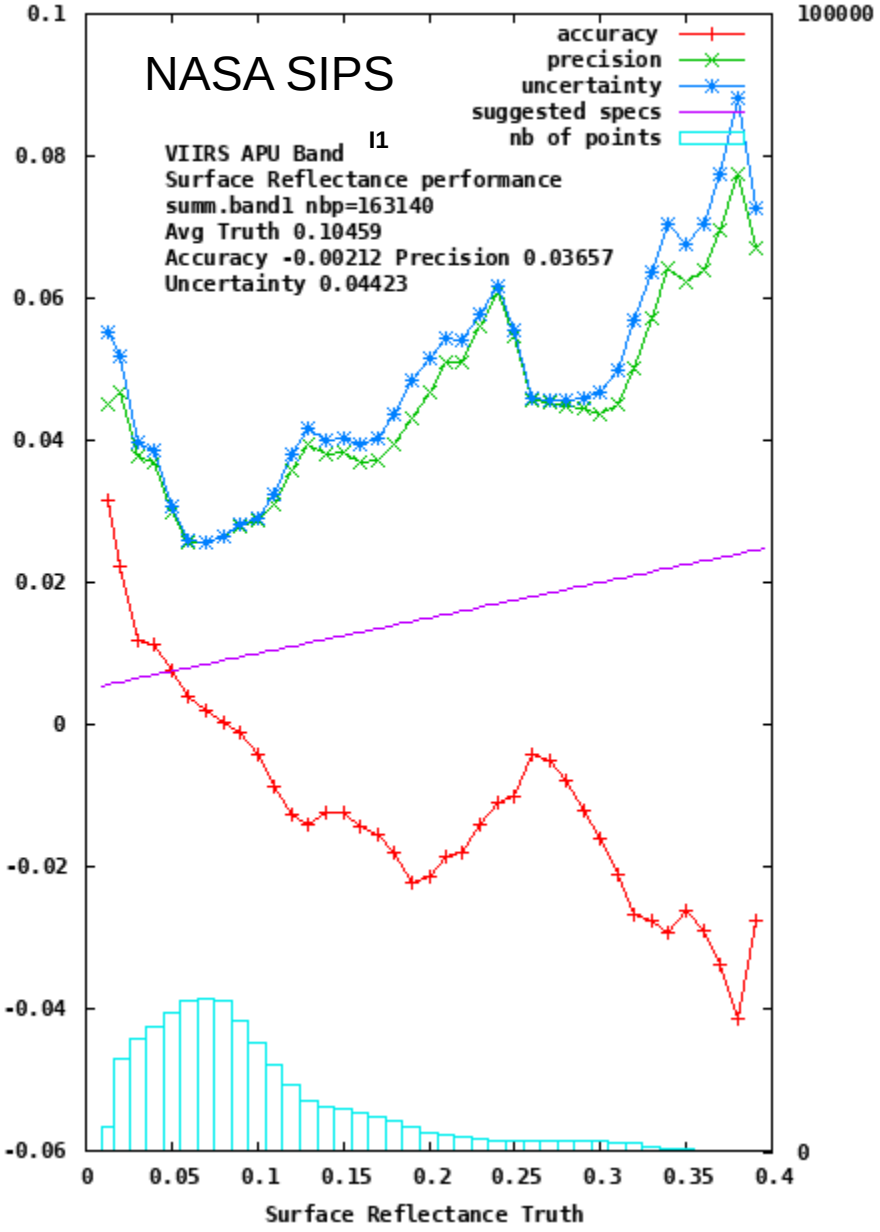


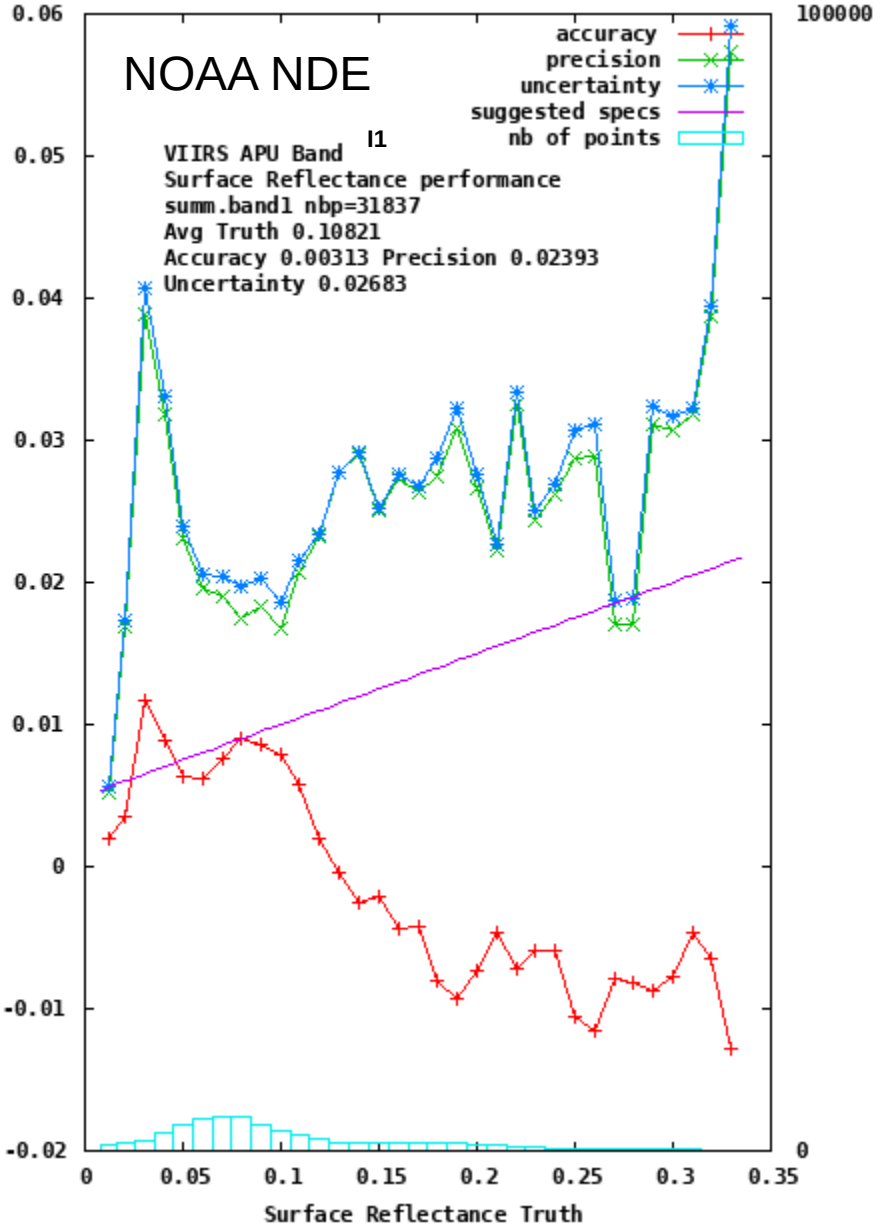
Accuracy assessment



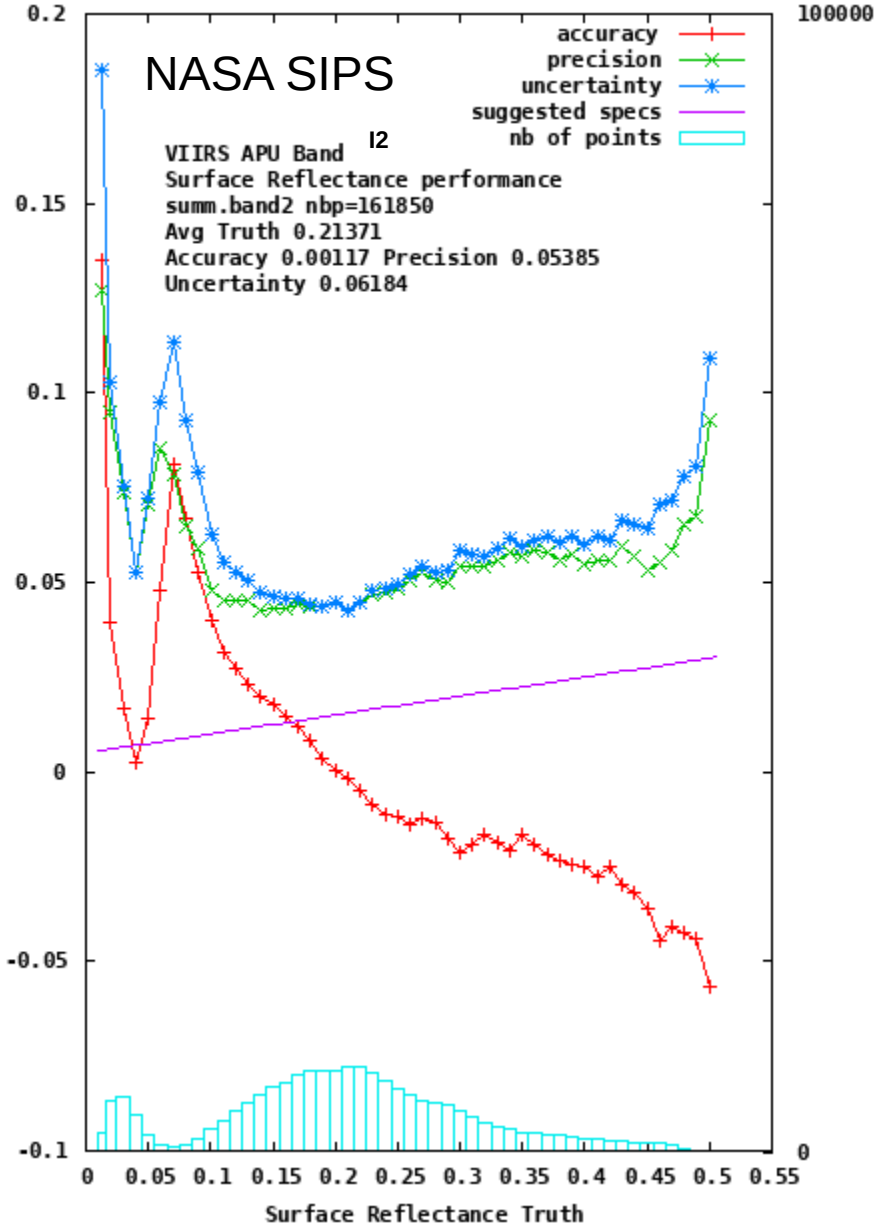


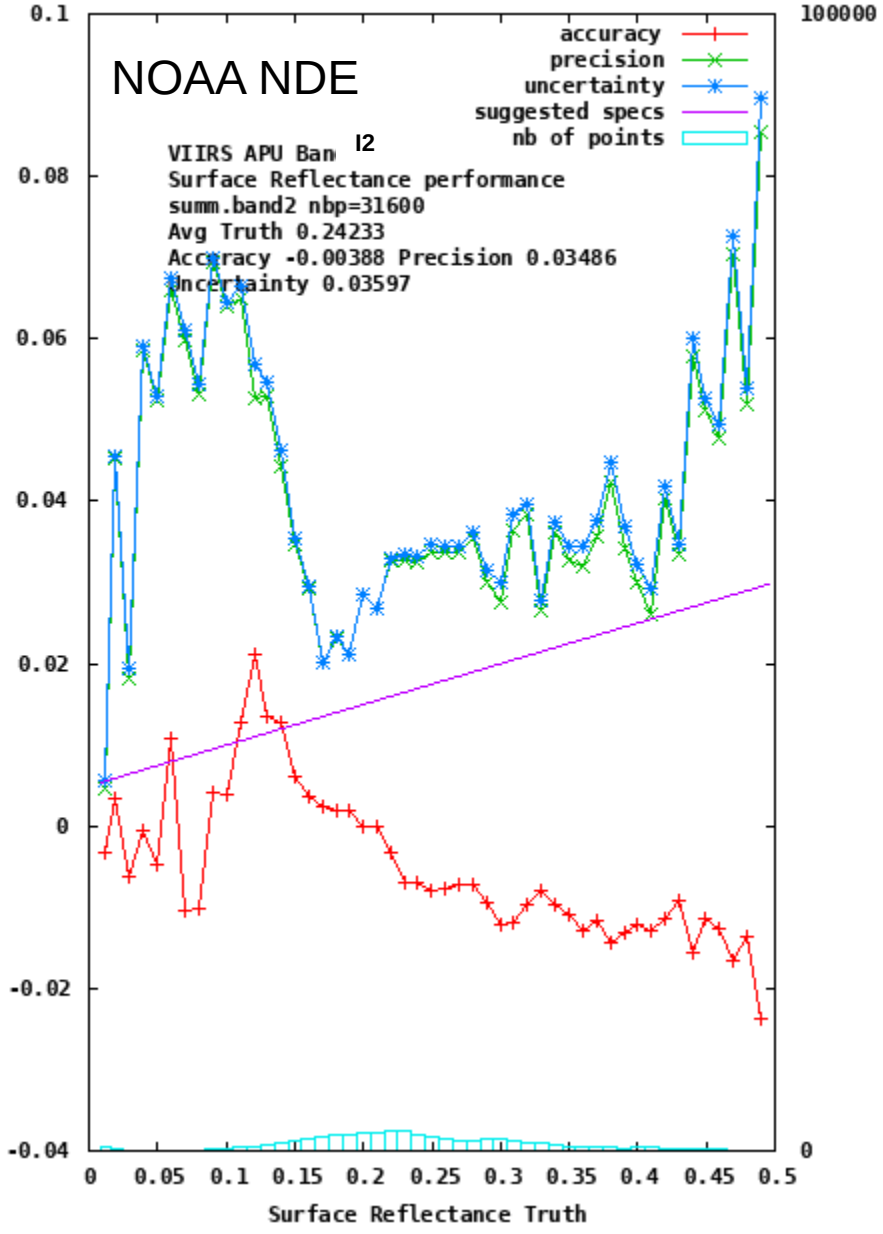
Accuracy assessment



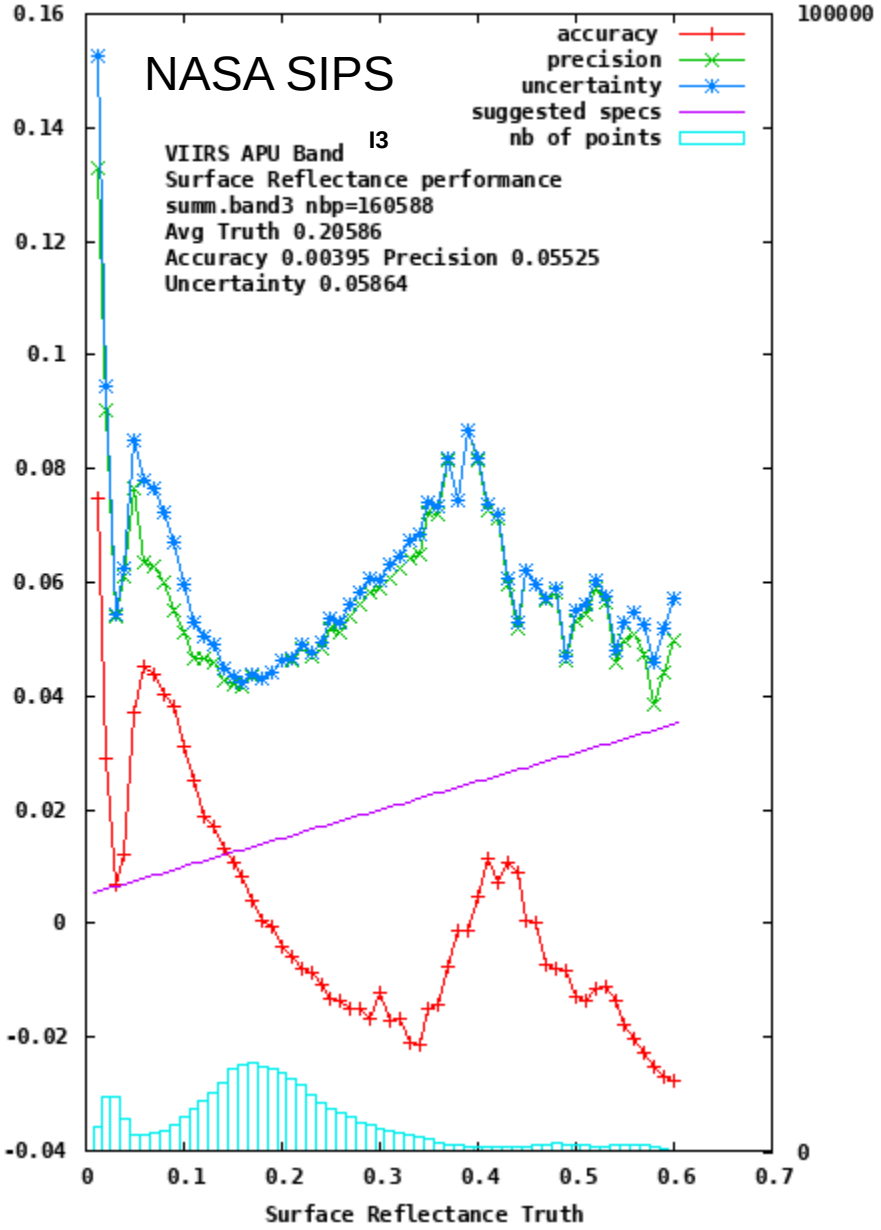


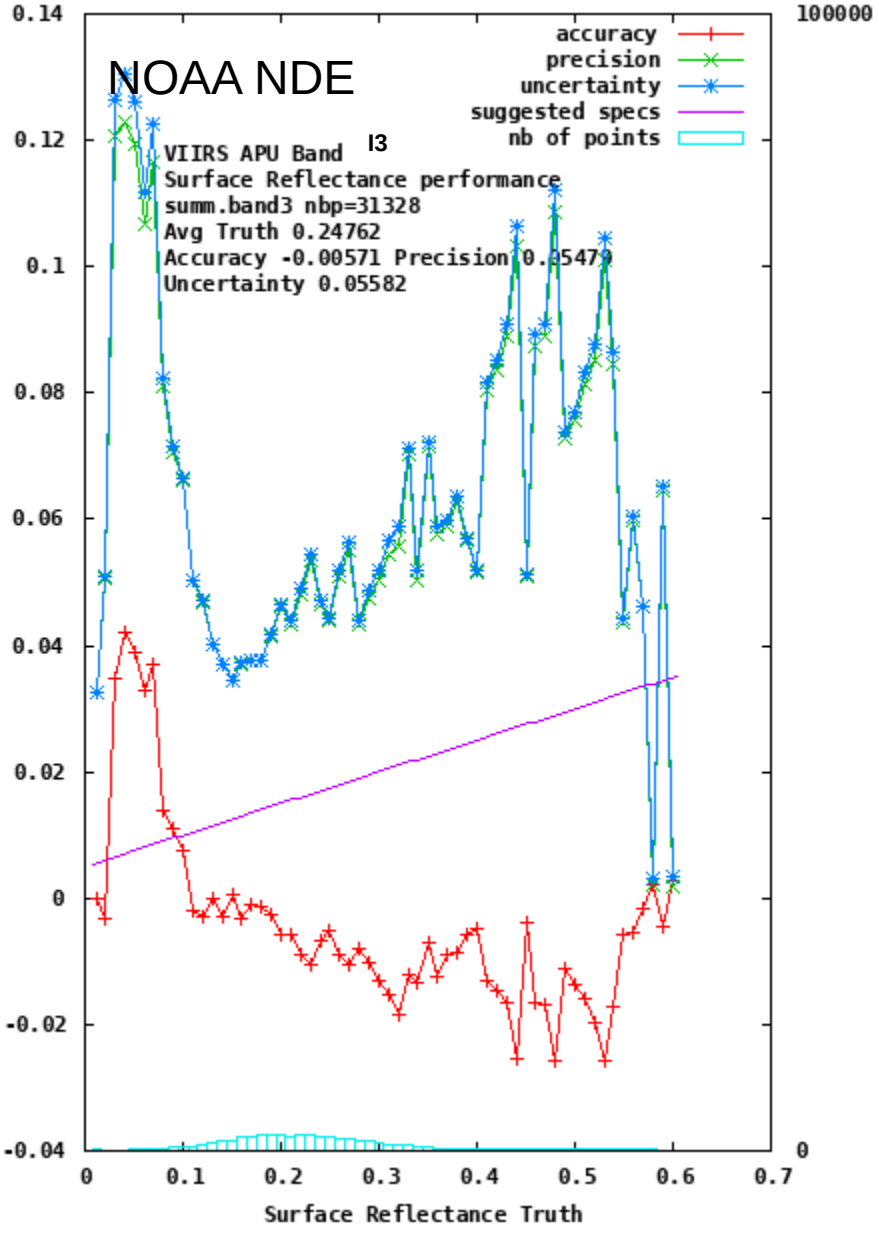
Accuracy assessment





Accuracy assessment





Error Budget (1 slide)

Compare analysis/validation results against requirements, present as a table. Error budget limitations should be explained. Describe prospects for overcoming error budget limitations with future improvements of the algorithm, test data, and error analysis methodology. A: accuracy; P: precision (Note: Y/N denote overall patterns)

Attribute Analyzed	JERD Threshold	Pre-Launch Performance	On-orbit Performance	Meet Requirement?	Additional Comments
M1	0.005+0.05ρ	N/A	-0.00613/0.01457	Y/N	A/P
M2	0.005+0.05ρ	N/A	-0.00960/0.02072	Y/N	A/P
M3	0.005+0.05ρ	N/A	-0.00860/0.01532	Y/N	A/P
M4	0.005+0.05ρ	N/A	-0.00733/0.01813	Y/N	A/P
M5	0.005+0.05ρ	N/A	-0.00406/0.02427	Y/N	A/P
M7	0.005+0.05ρ	N/A	-0.00453/0.03129	Y/N	A/P
M8	0.005+0.05ρ	N/A	-0.00197/0.03247	Y/N	A/P
M10	0.005+0.05ρ	N/A	-0.00082/0.03414	Y/N	A/P
M11	0.005+0.05ρ	N/A	0.00101/0.03006	Y/N	A/P
I1	0.005+0.05ρ	N/A	0.00313/0.02393	Y/N	A/P
I2	0.005+0.05ρ	N/A	-0.00571/0.05479	Y/N	A/P
I3	0.005+0.05ρ	N/A	-0.03231/0.13494	Y/N	A/P

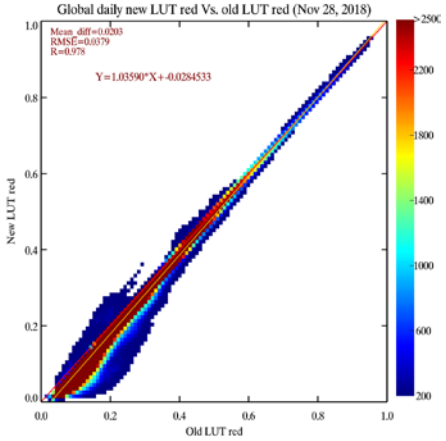
Identification of Processing Environment

- ESPC NDE version
  - 2.0.14
- Algorithm version
  - SR v1.1 + LUT Patch
- Version of LUTs used
  - V1.5.06.02
- Version of PCTs used
  - SR V1.0
- Description of environment used to achieve provisional maturity stage
  - STAR computing environment
  - NDE I&A
  - NASA Land SIPS and associated R&D systems

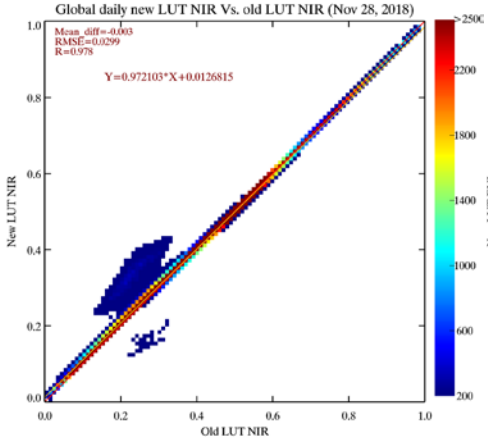
Downstream Product Feedback

Algorithm	Product	Downstream Product Feedback - Reports from downstream product teams on the dependencies and impacts
Vegetation Index	TOC NDVI	LUT fix impacting I1 and I2 resulted in changes in NDVI, EVI and GVF consistent with expectations.
Vegetation Index	TOC EVI	
Vegetation Index	Green Vegetation Fraction	

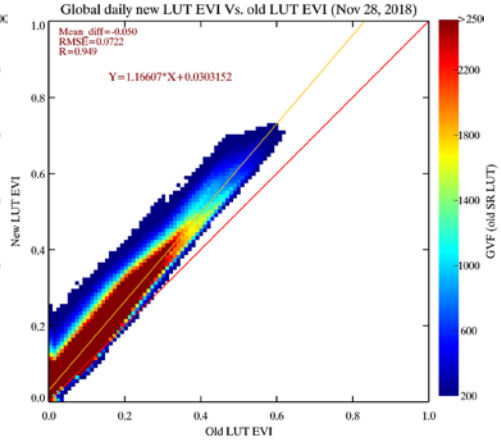
I1



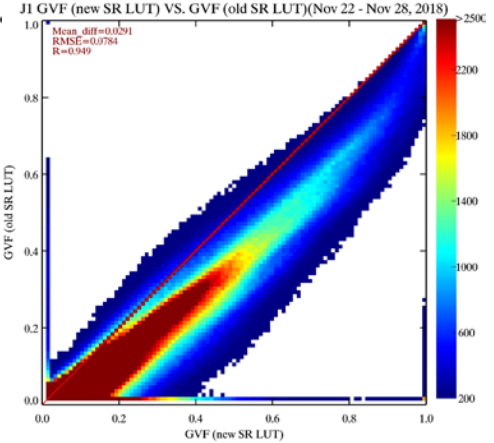
I2



EVI

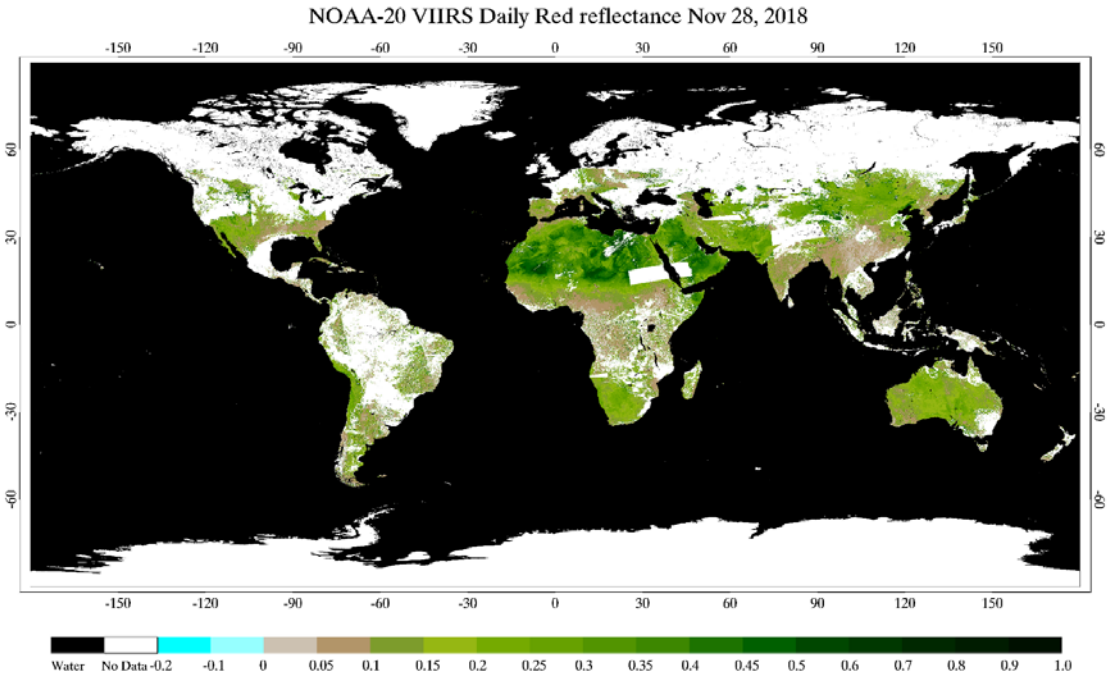


GVF

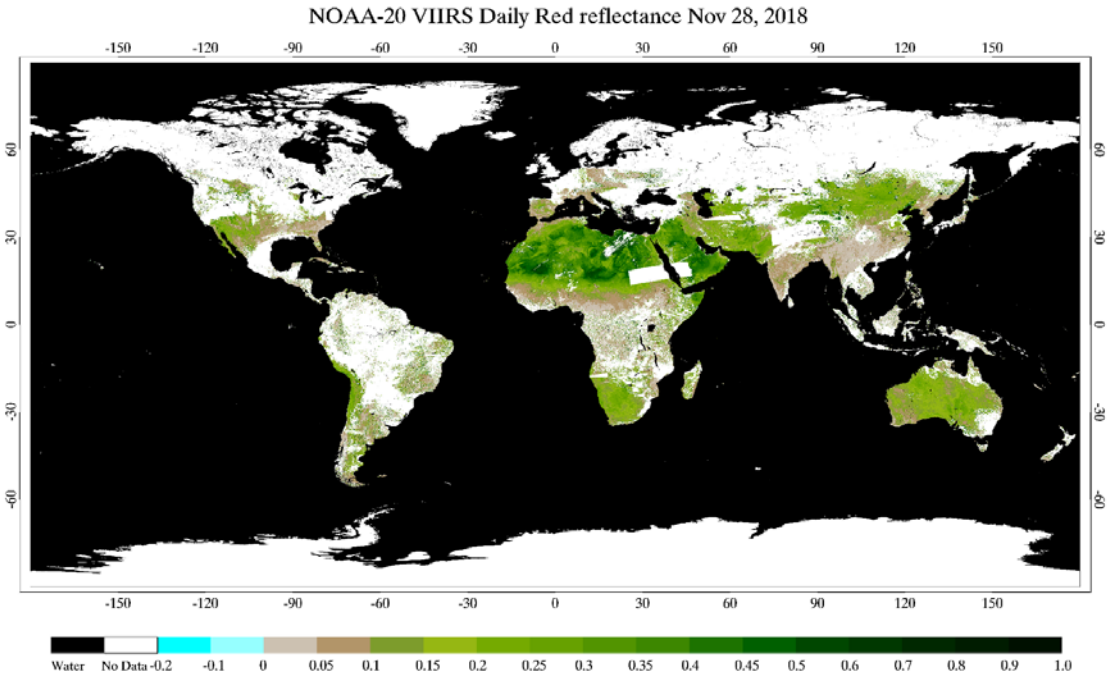


Note: band M3 (included in EVI) is unaffected by the LUT update

NOAA-20 I1 reflectance (old LUT)

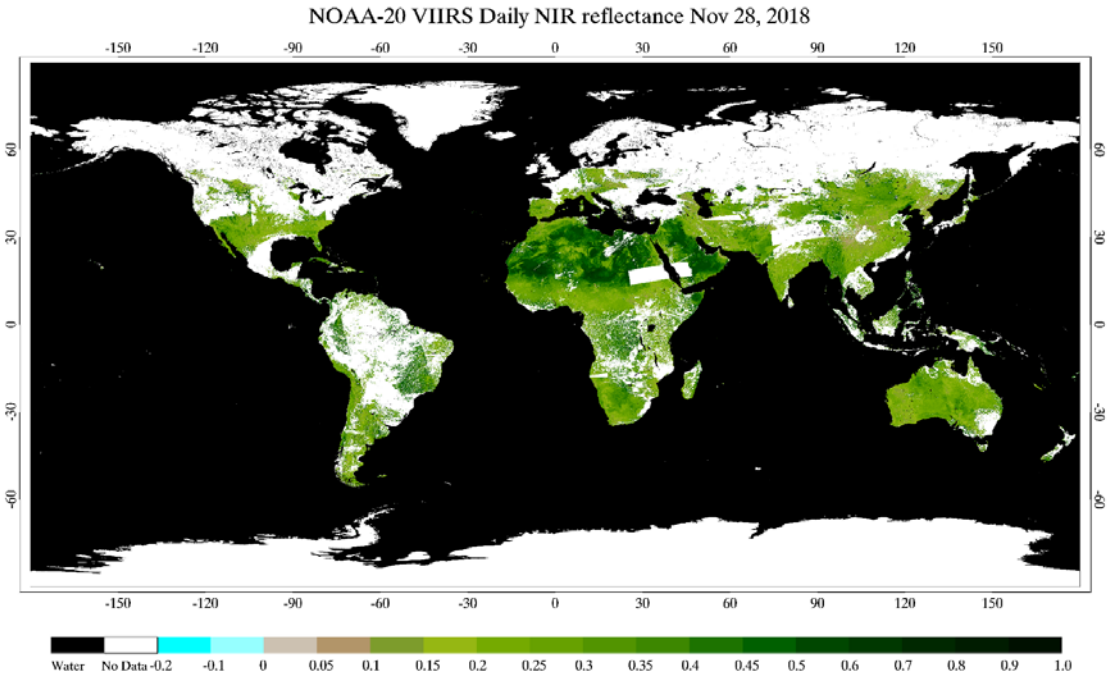


NOAA-20 I1 reflectance (new LUT)

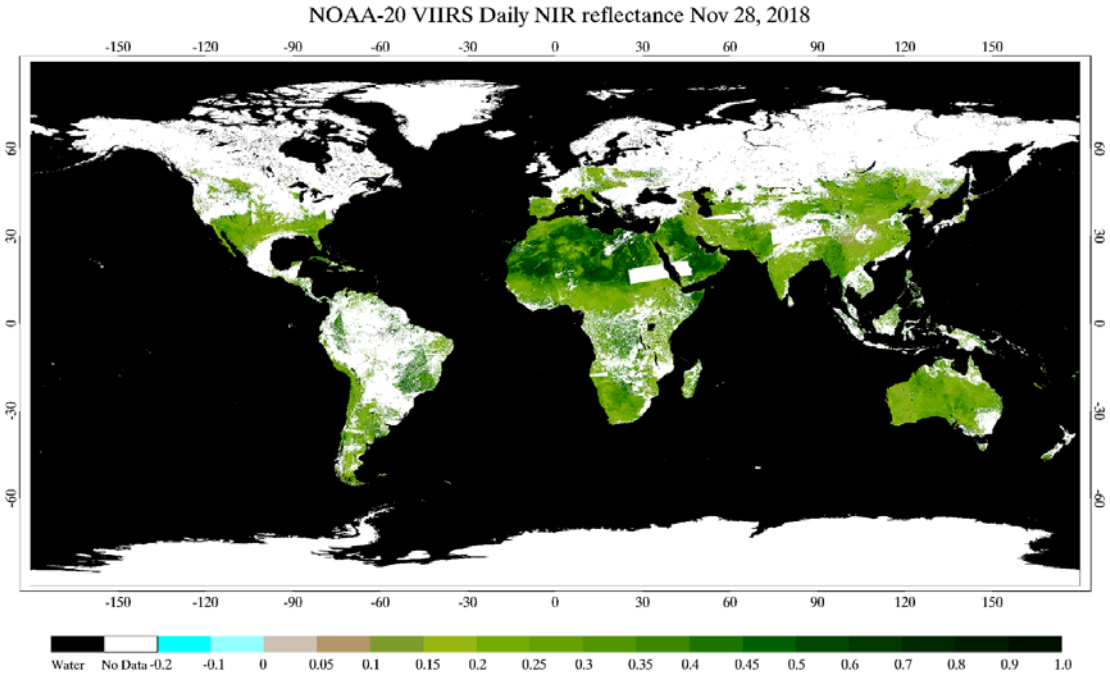


New LUT results in lower red reflectance

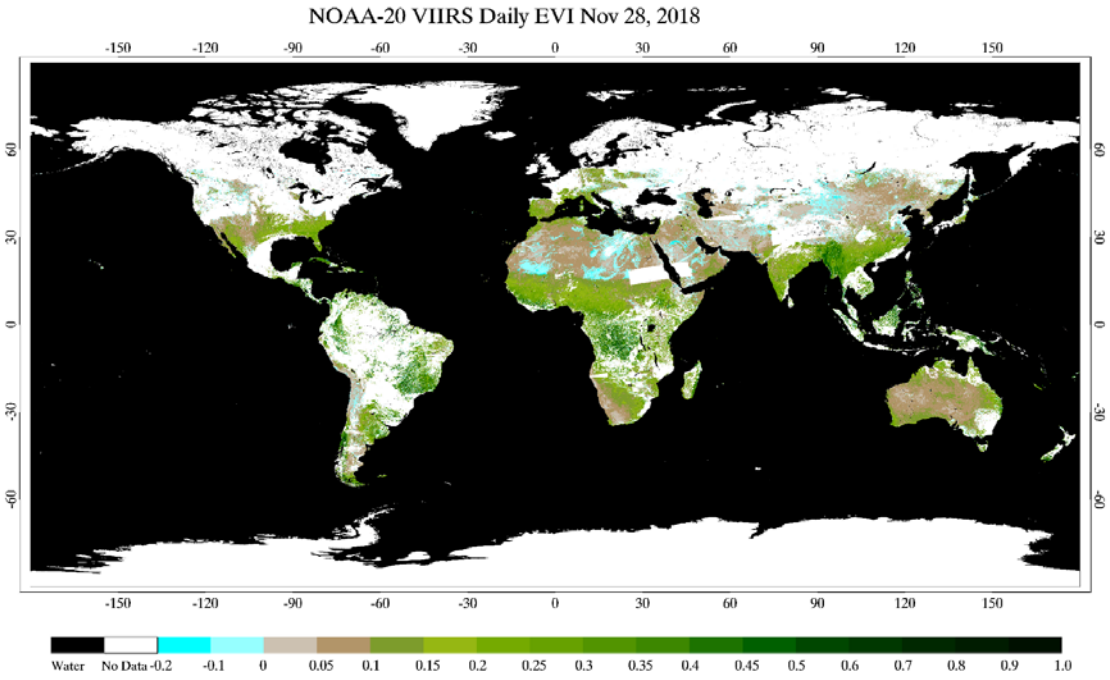
NOAA-20 I2 reflectance (old LUT)



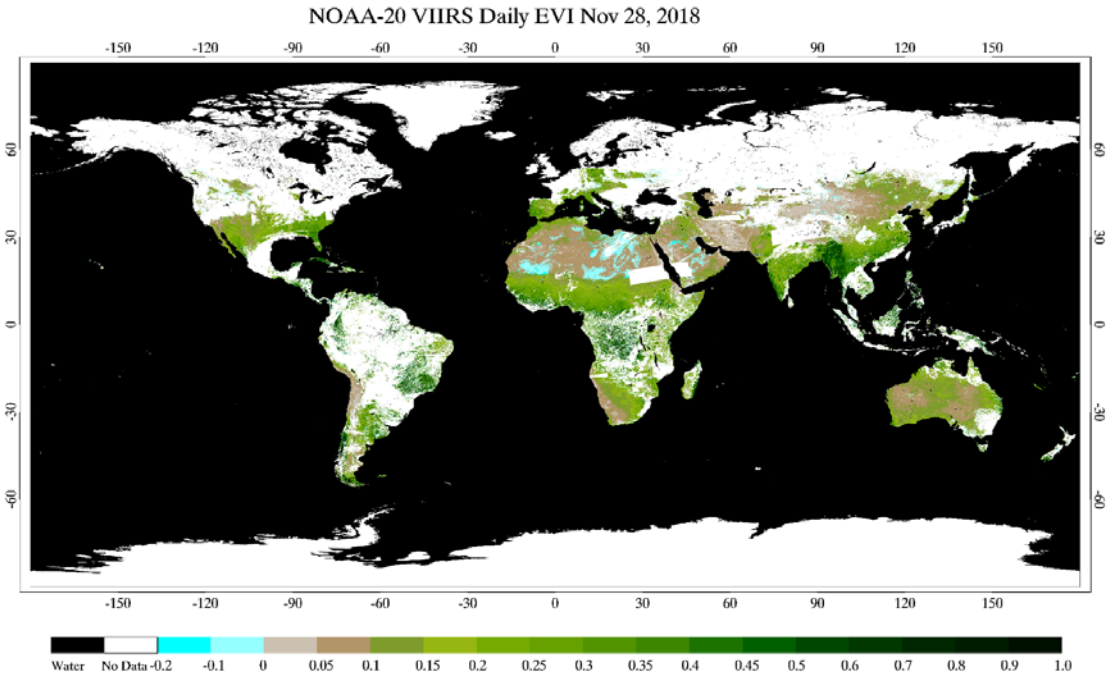
NOAA-20 I2 reflectance (new LUT)



NOAA-20 EVI (old SR LUT)

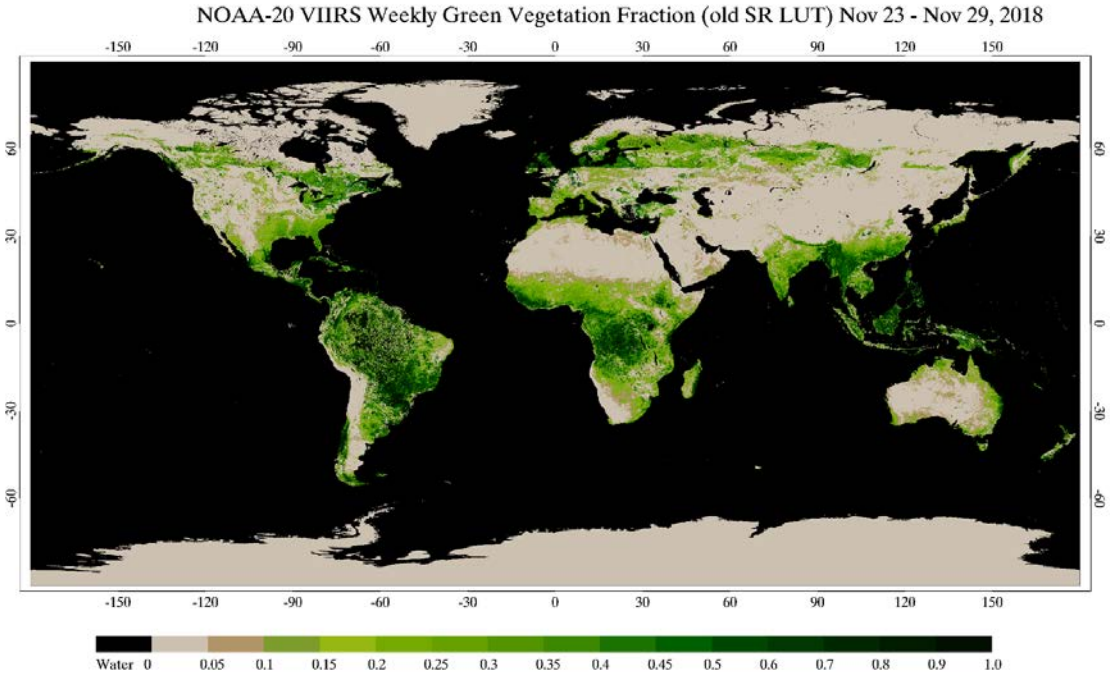


NOAA-20 EVI (new SR LUT)

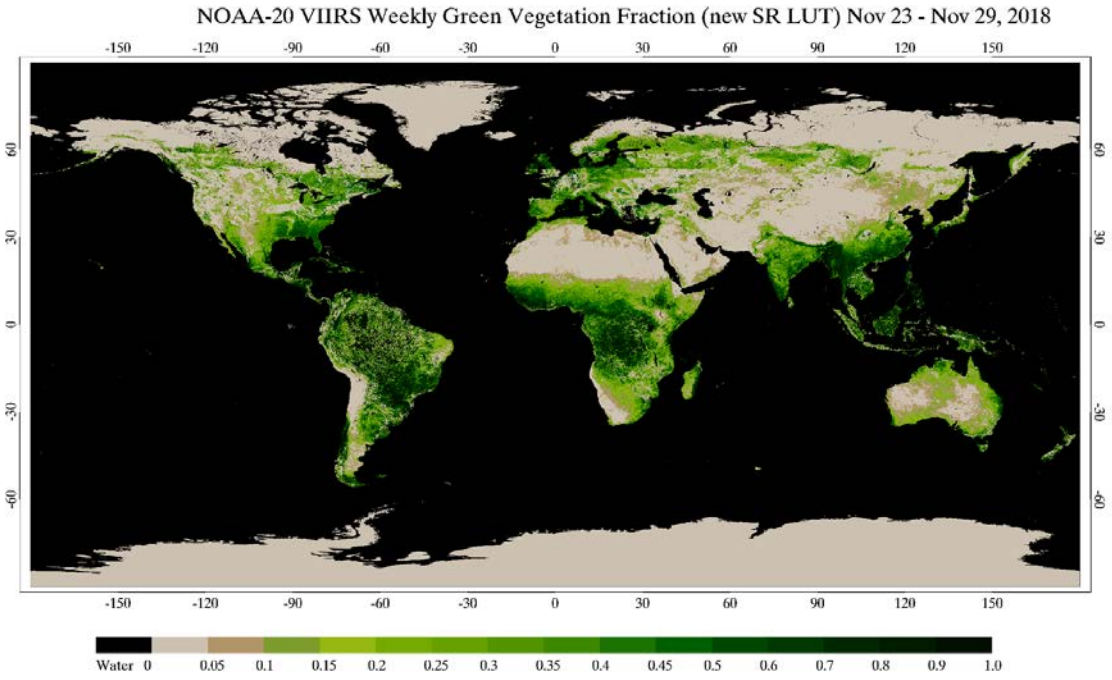


New LUT results in higher EVI

NOAA-20 GVF (old SR LUT)



NOAA-20 GVF (new SR LUT)



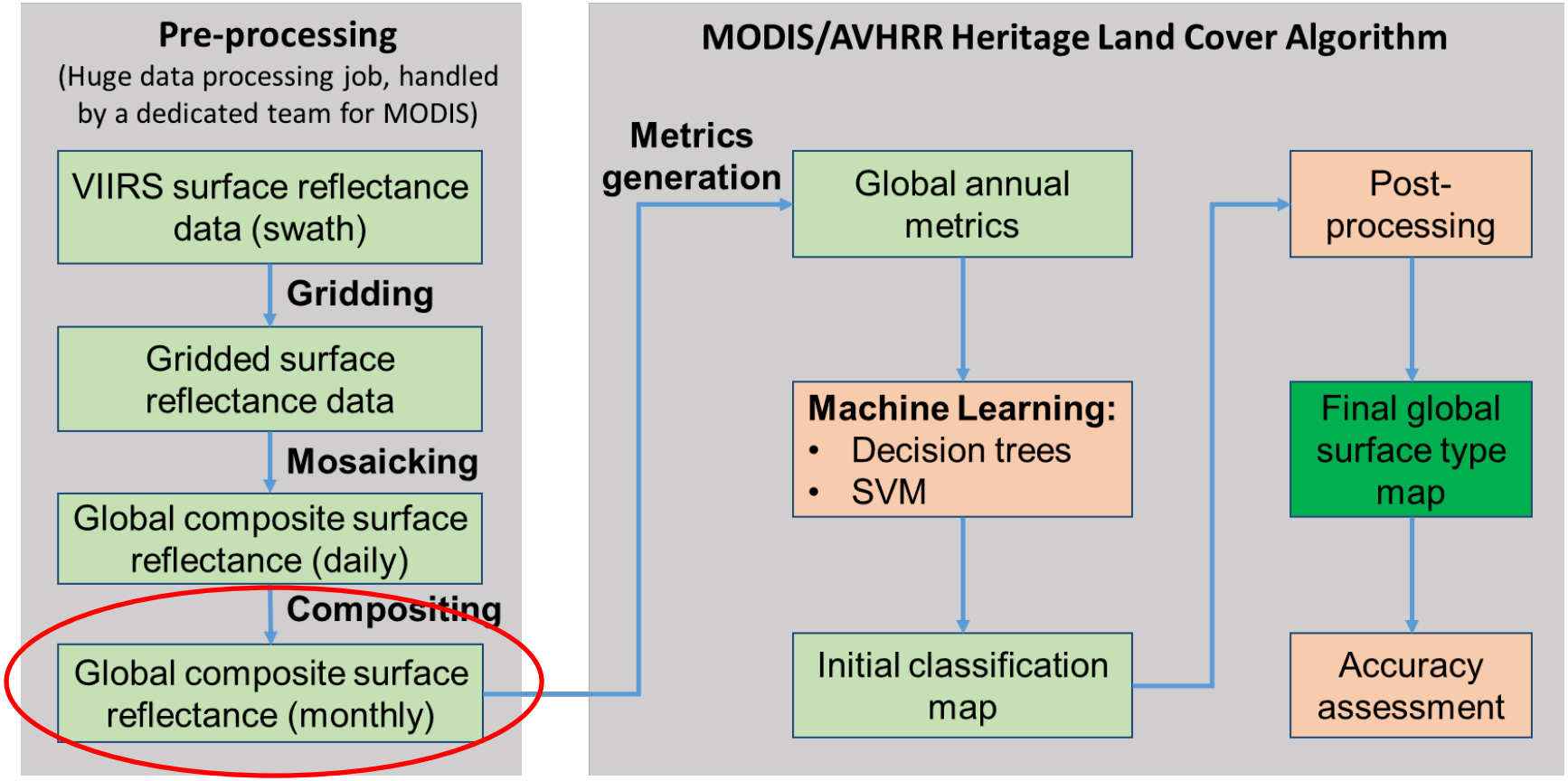
New LUT results in higher GVF

Downstream product / user feedback

- Surface Type (Jerry Zhan)
  - “We have been able to process the NetCDF files of your NDE surface reflectance product for developing the VIIRS Annual Global Surface Type Map. Surface reflectance and the associated geolocation data in granule files are the primary input for compositing monthly surface reflectance of all VIIRS land relevant channels and generating monthly classification metrics that are required for the surface type classification algorithm as well as the surface type training and validation data sets. Previously the surface reflectance data are downloaded from CLASS which were generated by the IDPS. We plan to transition the data downlink from CLASS to NDE surface reflectance products once the resources become available.”

VIIRS Annual Surface Type 2017

- Improve compositing algorithm
- Generate AST product with 2017 VIIRS Data



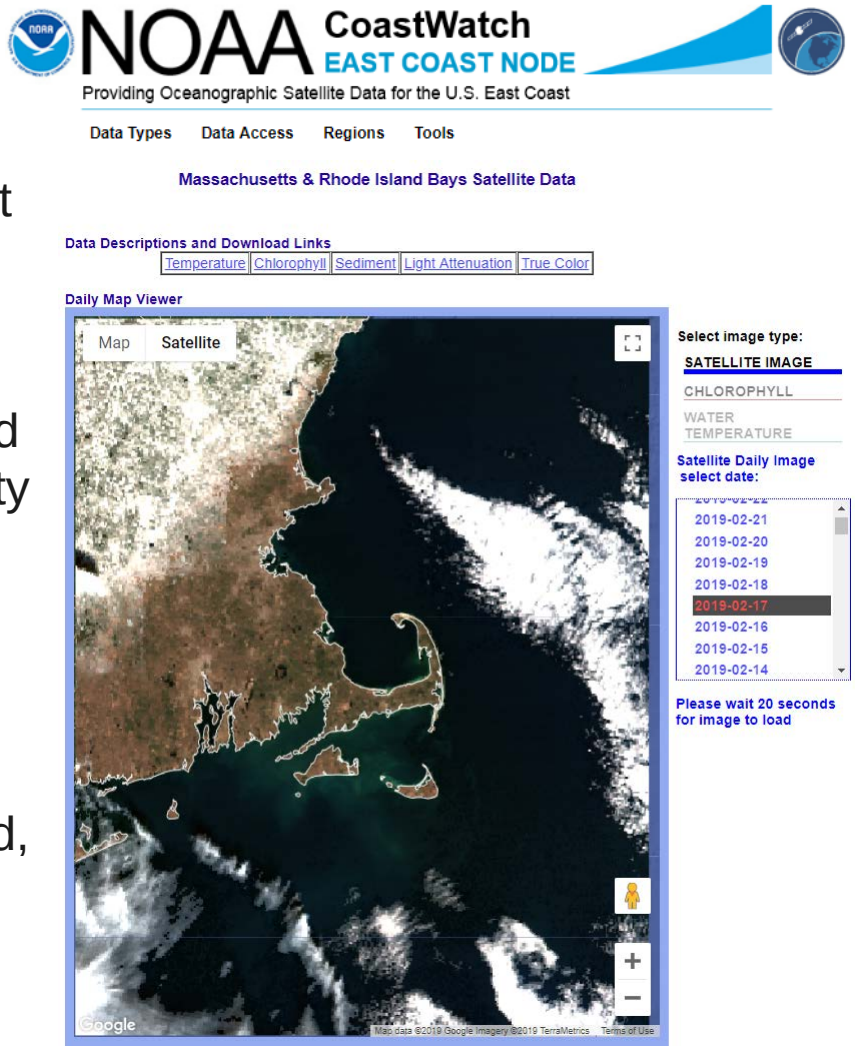
NOAACoastWatch/OceanWatch/PolarWatch as a user of VIIRS Land Surface Reflectance

- NOAA CoastWatch Central (the central processing team housed in STAR) is generating true color images using the VIIRS Land Surface Reflectance product

- Currently for 3 CW regions: East Coast, West Coast and Great Lakes.. Additional regions may be added..

- CoastWatch East Coast Node established and runs the Satellite Near Real-time Water Quality Monitor to monitor water quality conditions along the U.S. east coast on a daily basis. In addition to such water quality products from satellite such as chlorophyll, turbidity and temperature, true color imagery from VIIRS surface reflectance provides views to see land, water and cloud features which help in interpreting the various satellite water quality parameters.

CoastWatch.NOAA.gov



Risks, Actions, and Mitigations

Identified Risk	Action/Mitigation
I3 QF issue	Check implementation of previously delivered fix.
Precision not meeting specifications	Check possible upstream product impacts
Incomplete validation spatially	Extend validation to well-defined set of locations and conditions
Incomplete validation temporally	Extend validation to all seasons

Documentation

Science Maturity Check List	Yes ?
ReadMe for Data Product Users	Yes
Algorithm Theoretical Basis Document (ATBD)	Yes (Suomi NPP)
Algorithm Calibration/Validation Plan	Yes
(External/Internal) Users Manual	Yes (Suomi NPP)
System Maintenance Manual (for ESPC products)	Yes (Suomi NPP)
Peer Reviewed Publications (Demonstrates algorithm is independently reviewed)	Yes
Regular Validation Reports (at least. annually) (Demonstrates long-term performance of the algorithm)	

Check List - Provisional Maturity

Provisional Maturity End State	Assessment
Product performance has been demonstrated through analysis of a large, but still limited (i.e., not necessarily globally or seasonally representative) number of independent measurements obtained from select locations, periods, and associated ground truth or field campaign efforts.	Yes. About one month of data have been analyzed and performance was shown to meet requirements.
Product analysis is sufficient to communicate product performance to users relative to expectations (Performance Baseline).	Yes. APU statistics were derived from reliable reference data, using a traceable and documented methodology.
Documentation of product performance exists that includes recommended remediation strategies for all anomalies and weaknesses. Any algorithm changes associated with severe anomalies have been documented, implemented, tested, and shared with the user community.	Yes.
Product is ready for operational use and for use in comprehensive cal/val activities and product optimization.	Yes.

Conclusions

- Cal/Val results summary:
  - Team recommends algorithm Provisional maturity based on direct validation using AERONET data
  - Larger sample (~1 month of global data) analyzed
- Prelaunch waiver impacts
  - No impact of pre-launch waivers foreseen and seen with in-orbit data
- Caveats
  - Evaluation still done over a limited sample of data during the Northern Hemisphere winter
  - I3 QF issue remains

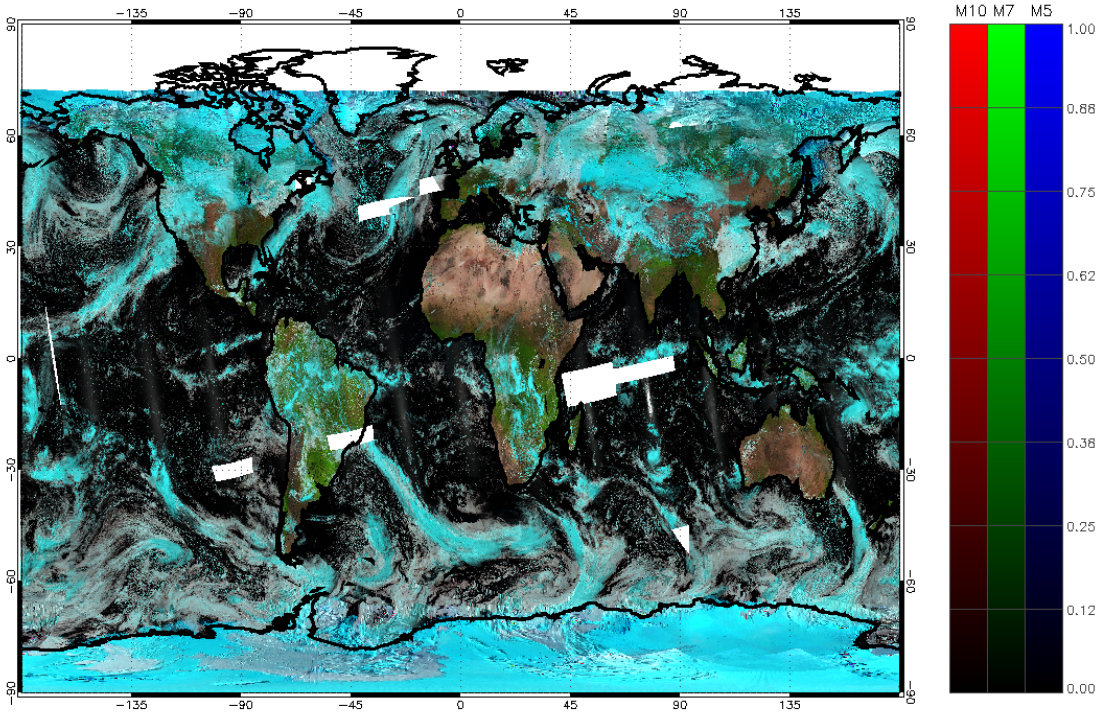
Path Forward

- Expand user base and applications
  - Work with imagery team to demonstrate SR-based imagery products
  - STAR visualization systems
- Streamline production system
  - Adjust internal processing code
    - No impact on performance
  - Adjust quality flag algorithms and output
    - Needs further R&D
  - Make compatible with CEOS requirements
    - CARD4L-OSR: CEOS Analysis Ready Data for Land
- Future Cal/Val activities / milestones
  - Formal transition to operations
    - NDE I&T vs. STAR regression test done – no issues
  - Validated maturity
    - System in place for direct validation using AERONET

Backup Slides: Quality Flags

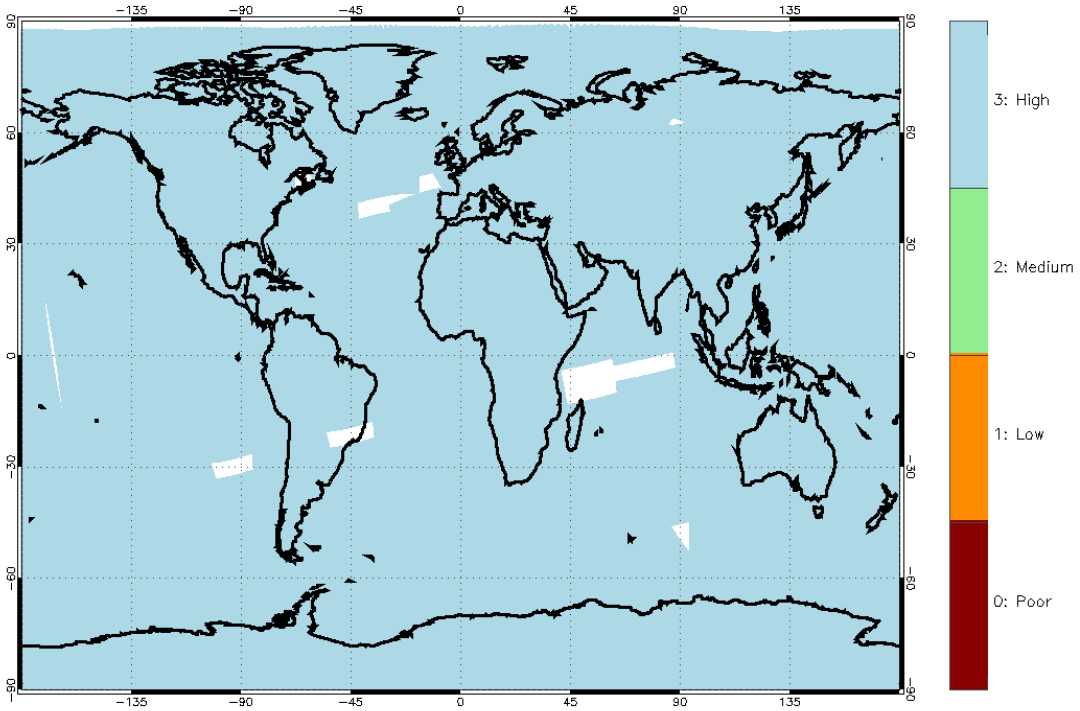
False Color Image

February 13, 2019



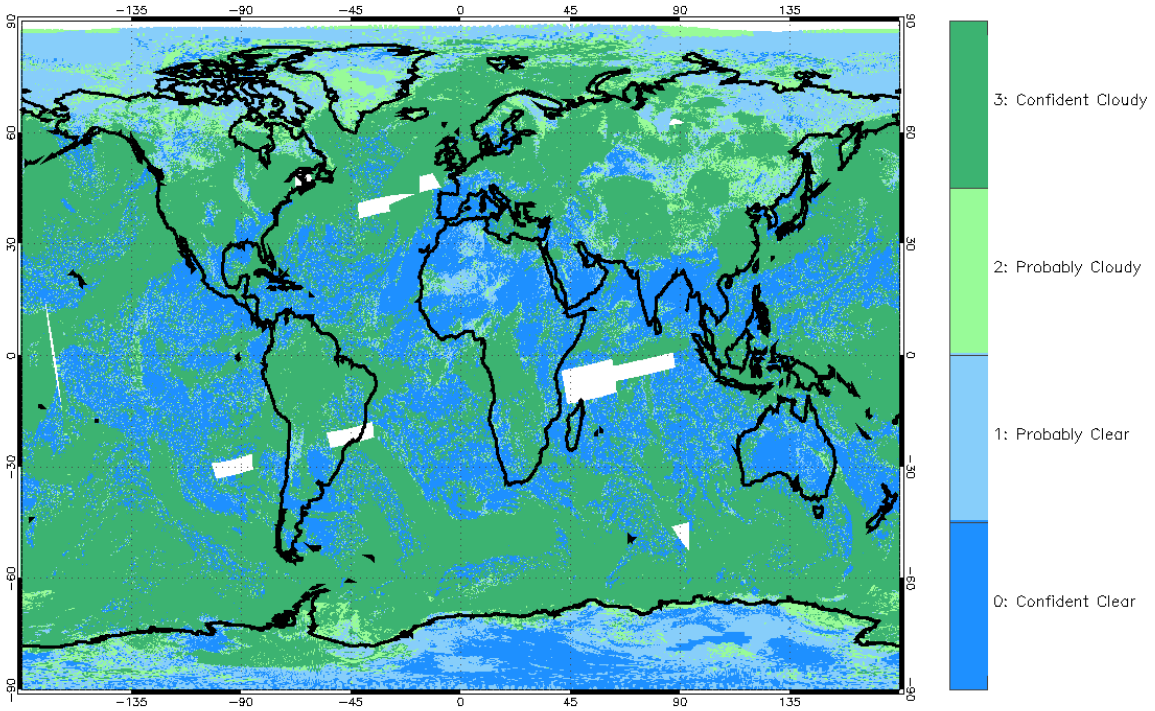
Cloud Mask Quality: QF1, Bits 0-1

February 13, 2019



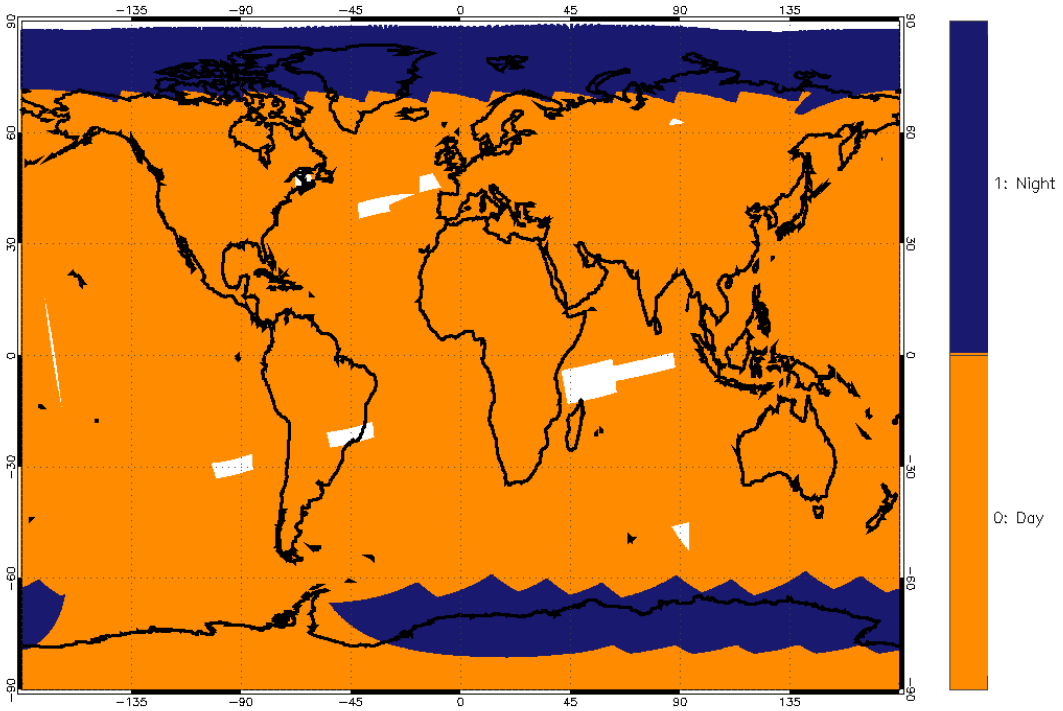
Cloud Detection Confidence: QF1, Bits 2-3

February 13, 2019



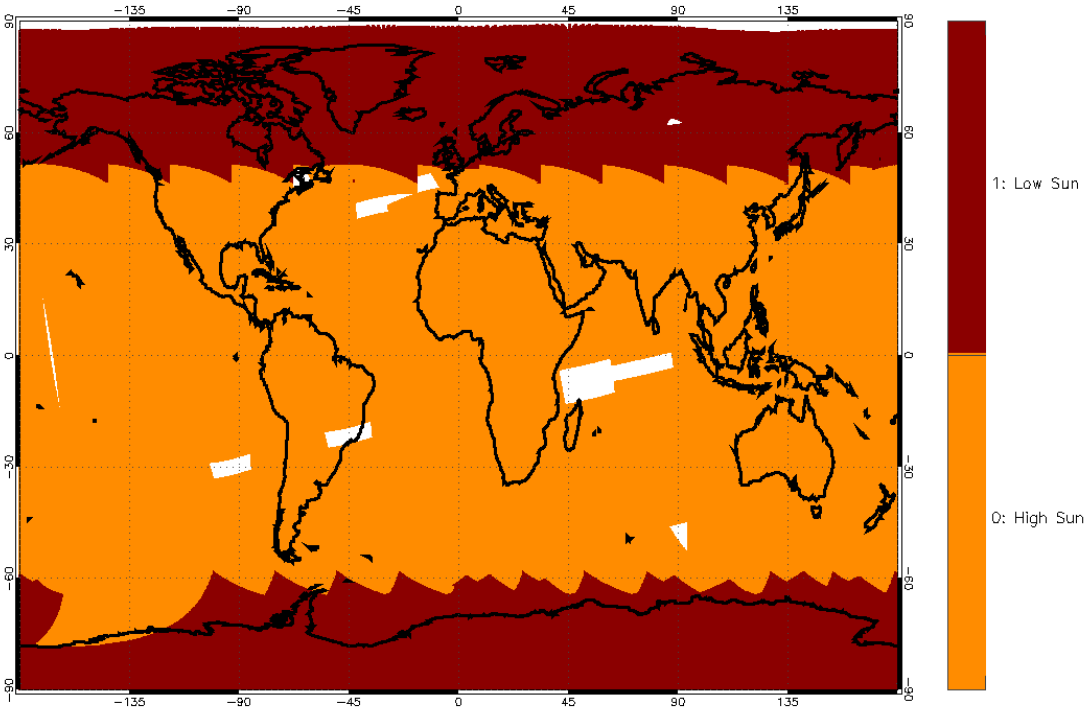
Day-Night Flag: QF1, Bit 4

February 13, 2019



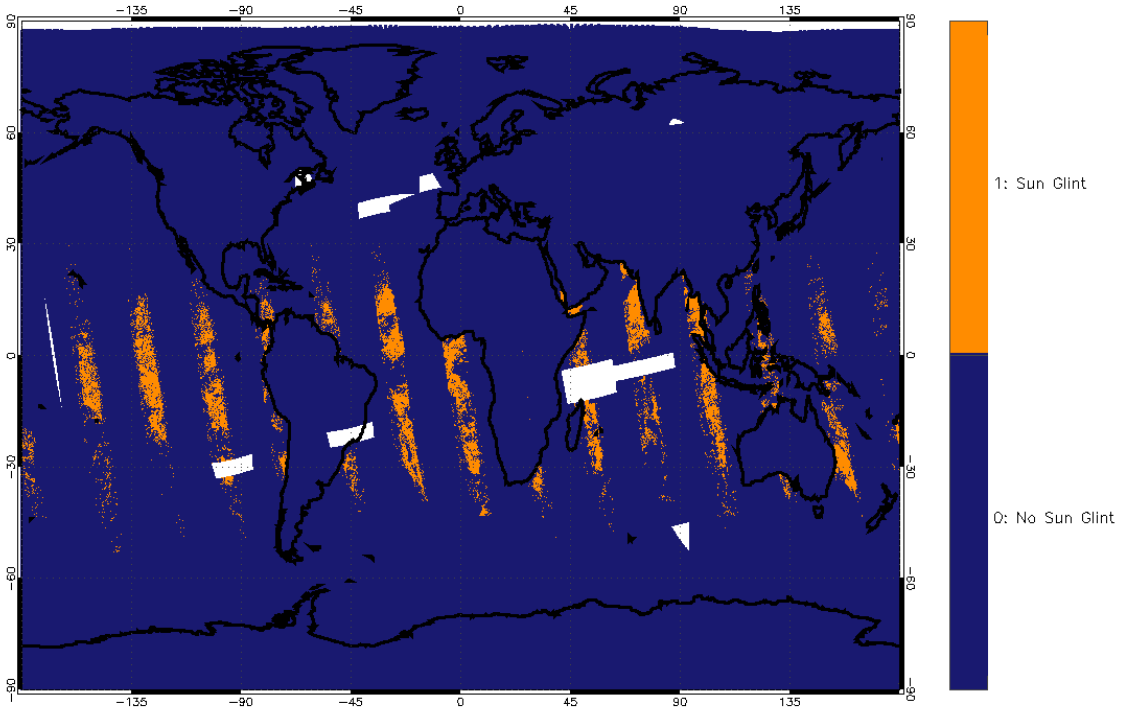
Low Sun Flag: QF1, Bit 5

February 13, 2019



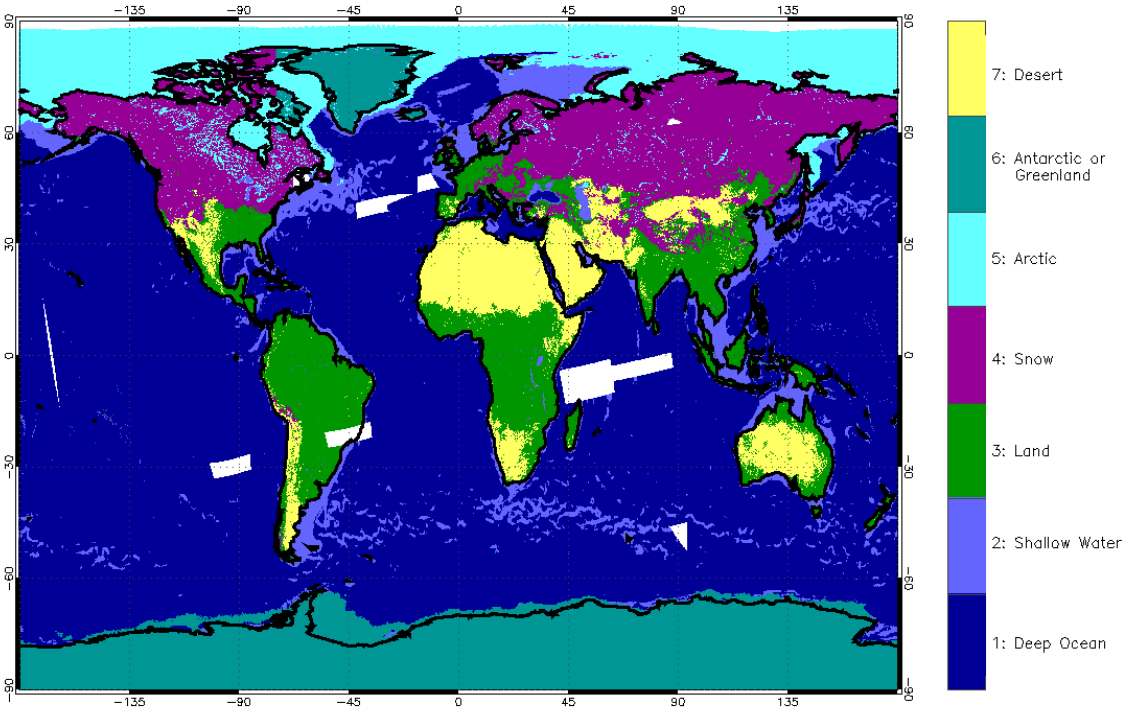
Sun Glint Flag: QF1, Bit 6

February 13, 2019



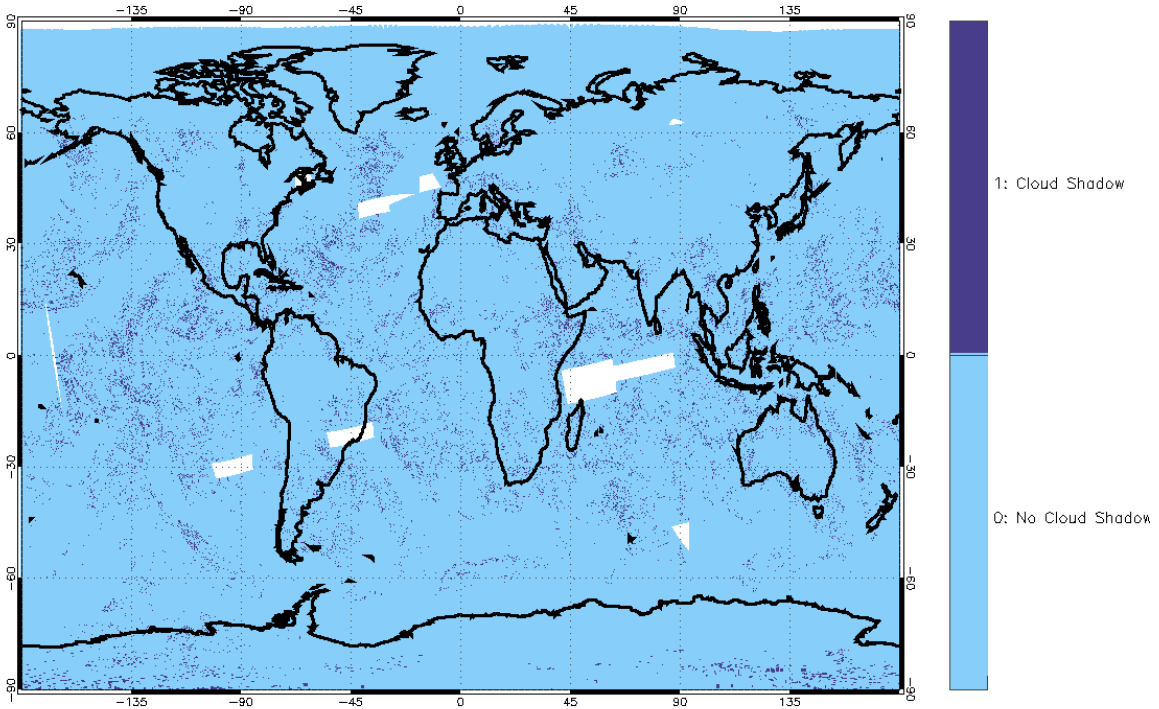
Land-Water Mask: QF2, Bits 0-2

February 13, 2019



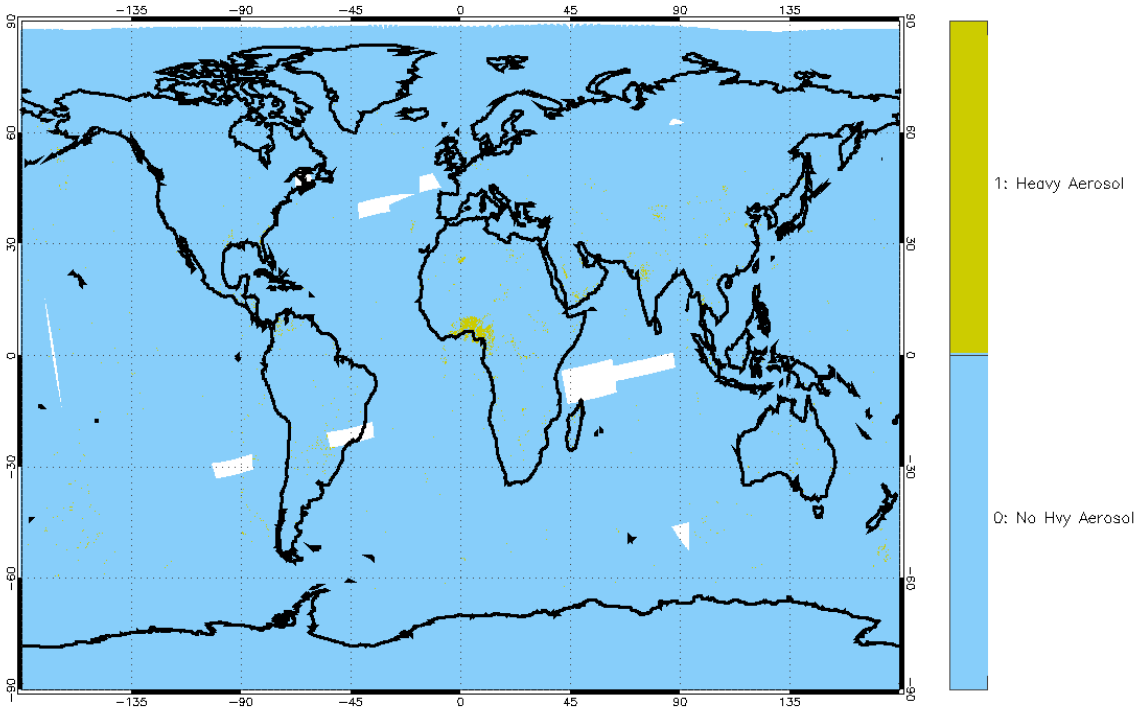
Cloud Shadow Mask: QF2, Bit 3

February 13, 2019



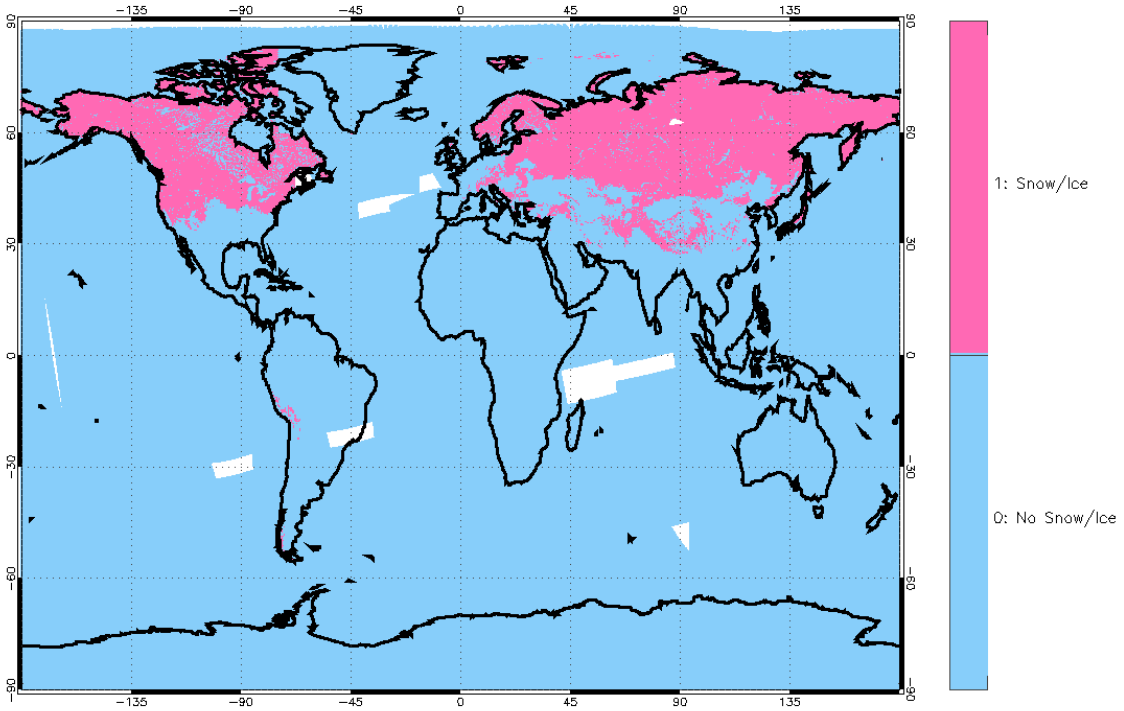
Heavy Aerosol Mask: QF2, Bit 4

February 13, 2019



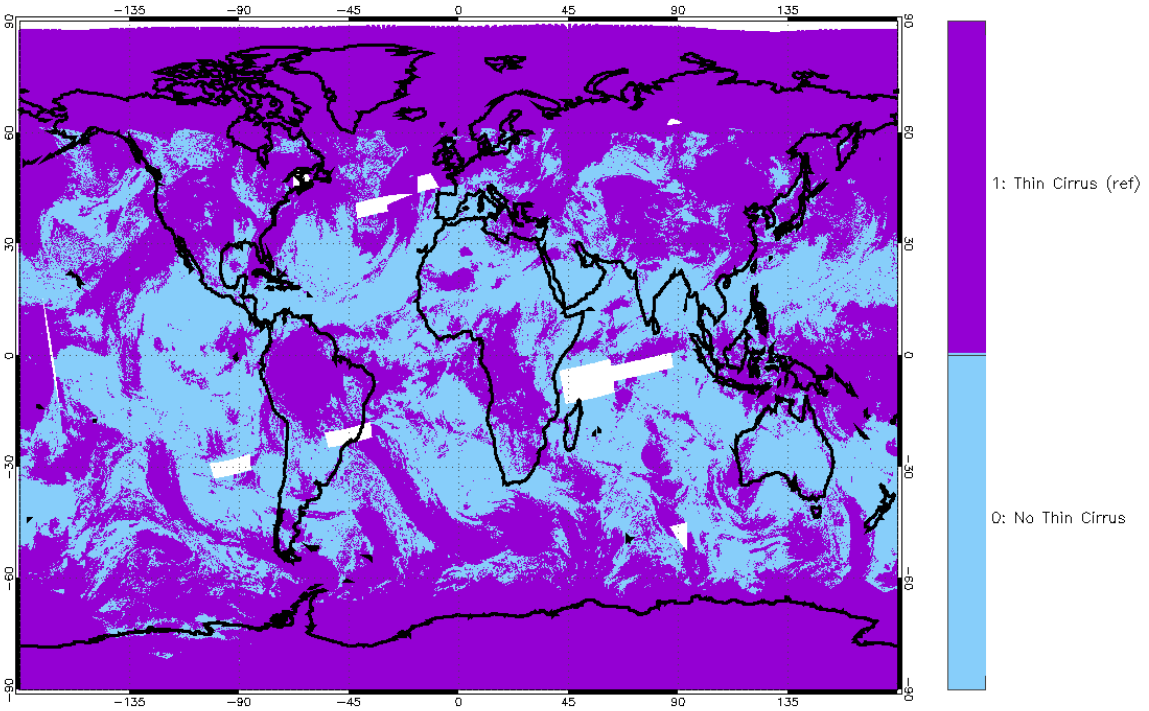
Snow-Ice Mask: QF2, Bit 5

February 13, 2019



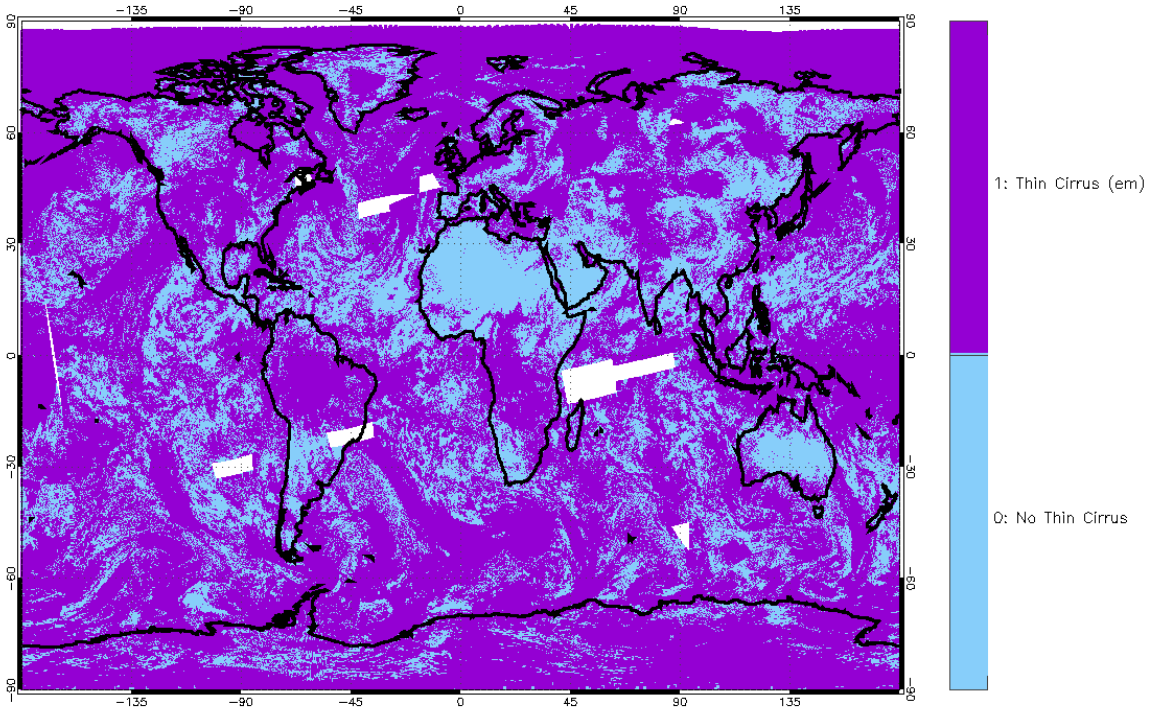
Thin Cirrus Mask – Reflective: QF2, Bit 6

February 13, 2019



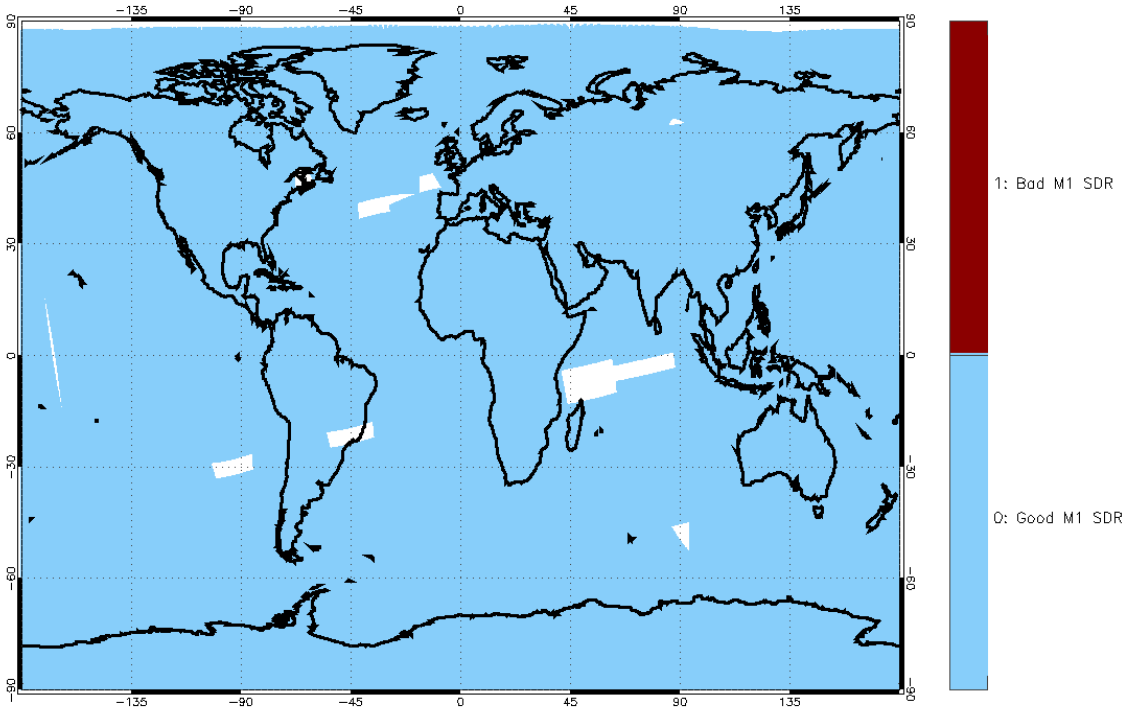
Thin Cirrus Mask – Emissive: QF2, Bit 7

February 13, 2019



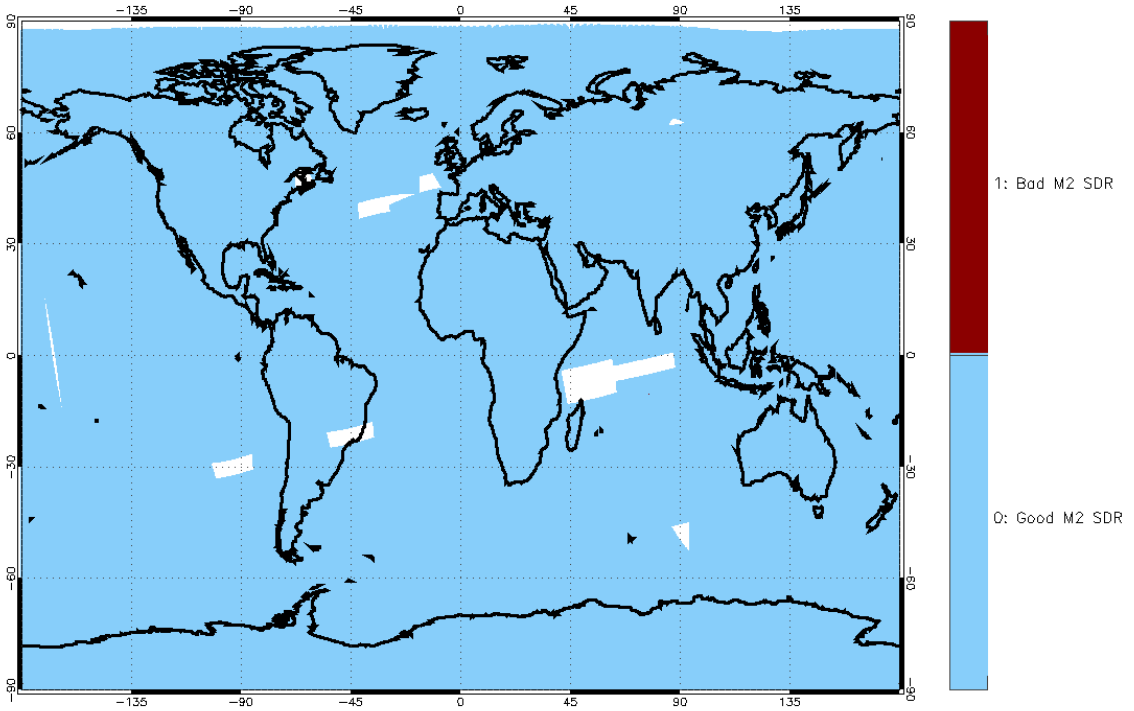
Bad M1 SDR Data: QF3, Bit 0

February 13, 2019



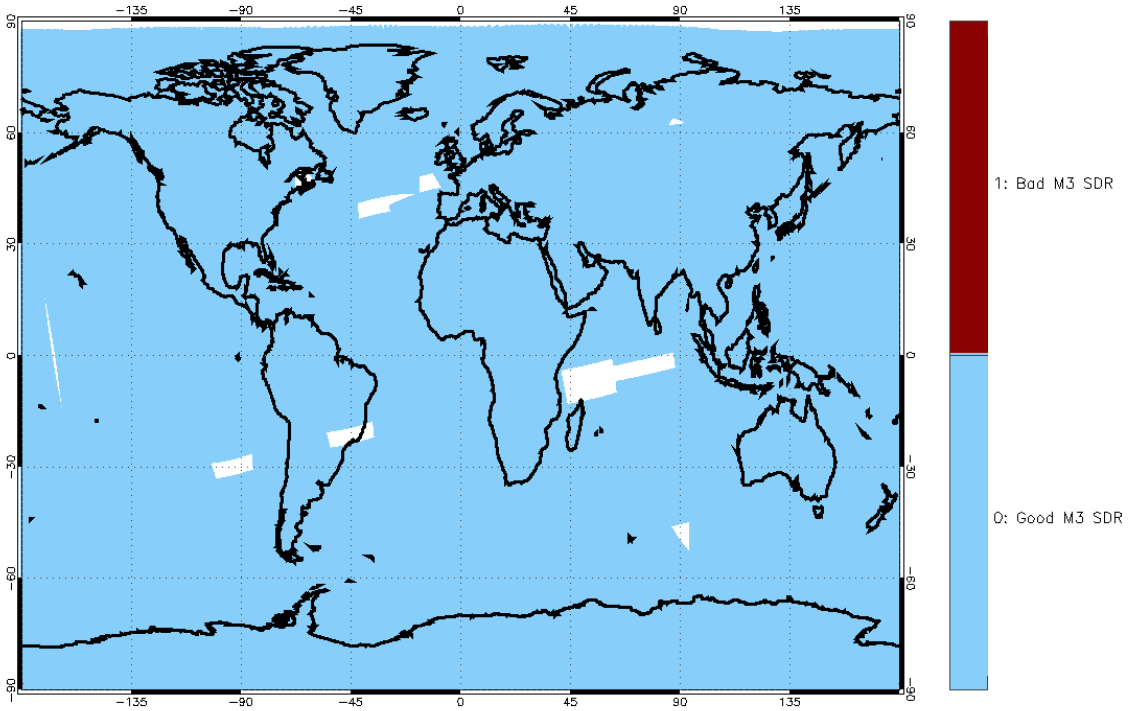
Bad M2 SDR Data: QF3, Bit 1

February 13, 2019



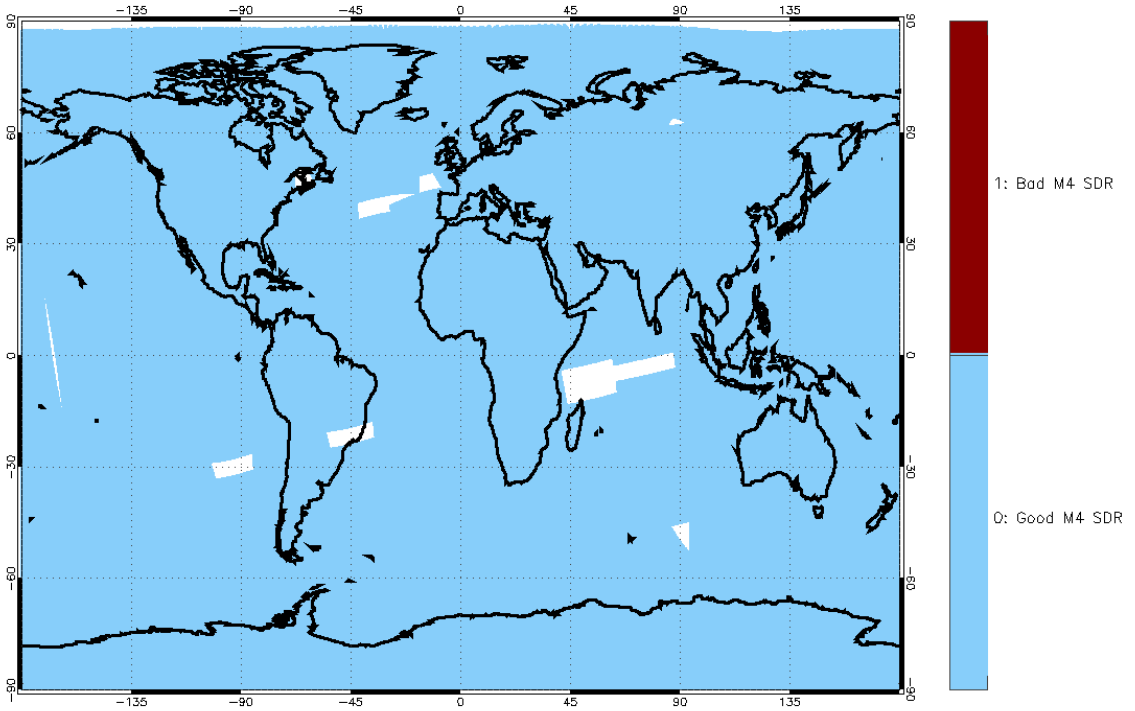
Bad M3 SDR Data: QF3, Bit 2

February 13, 2019



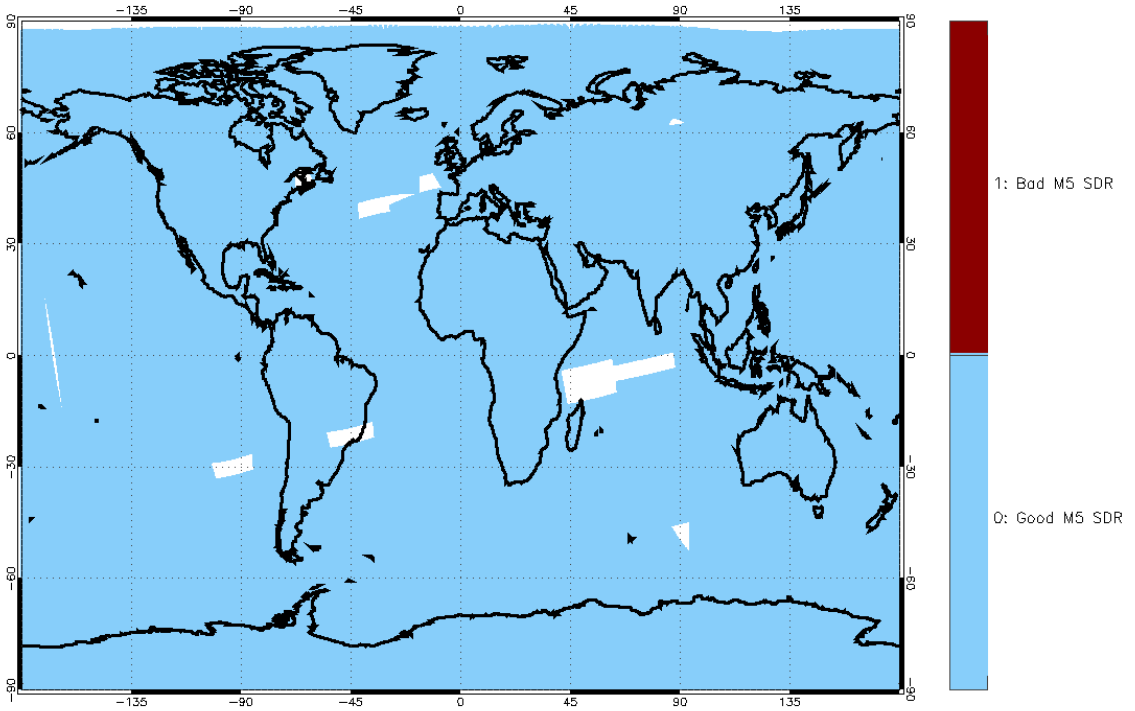
Bad M4 SDR Data: QF3, Bit 3

February 13, 2019



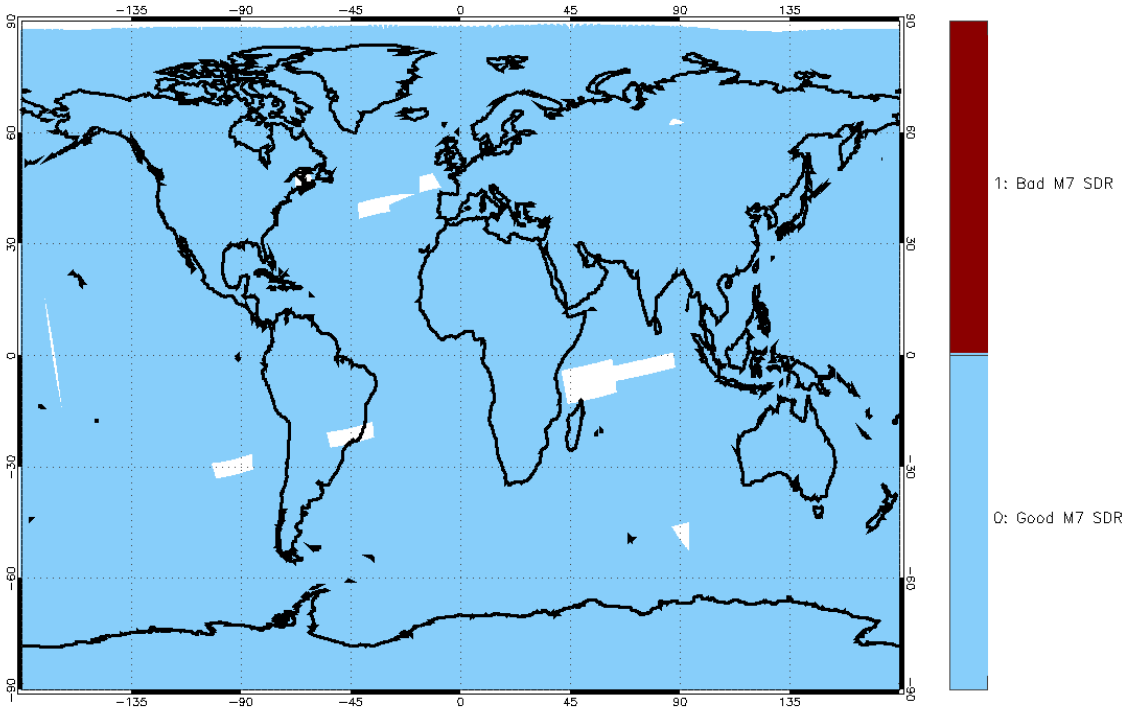
Bad M5 SDR Data: QF3, Bit 4

February 13, 2019



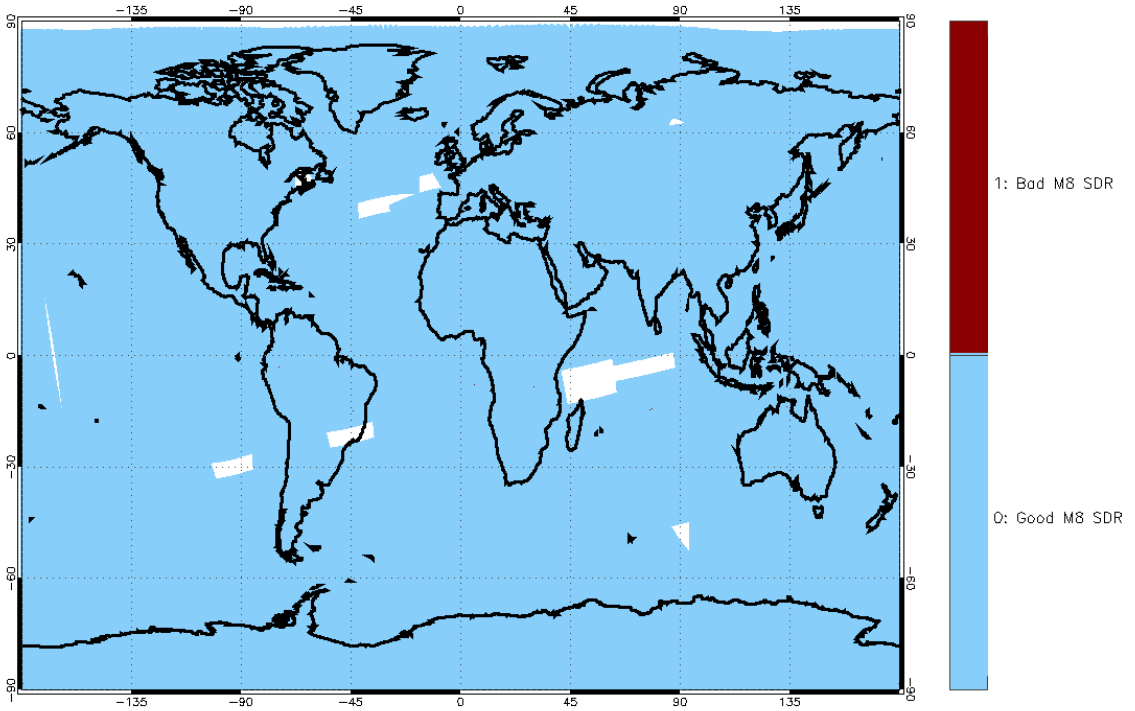
Bad M7 SDR Data: QF3, Bit 5

February 13, 2019



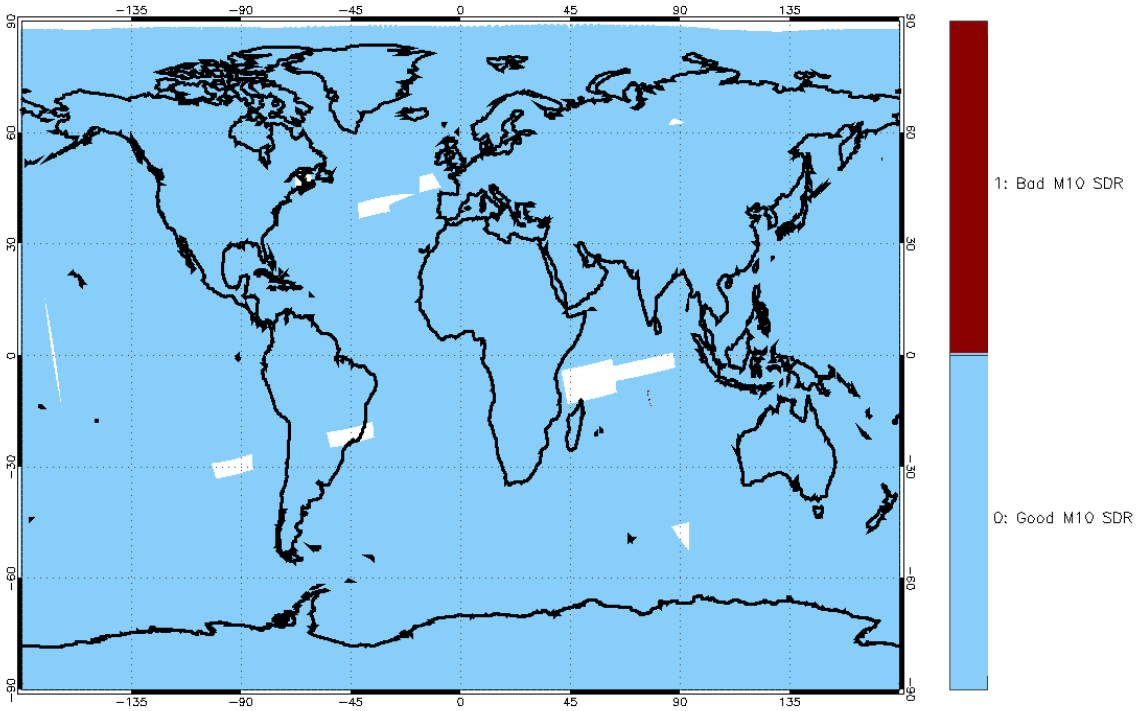
Bad M8 SDR Data: QF3, Bit 6

February 13, 2019



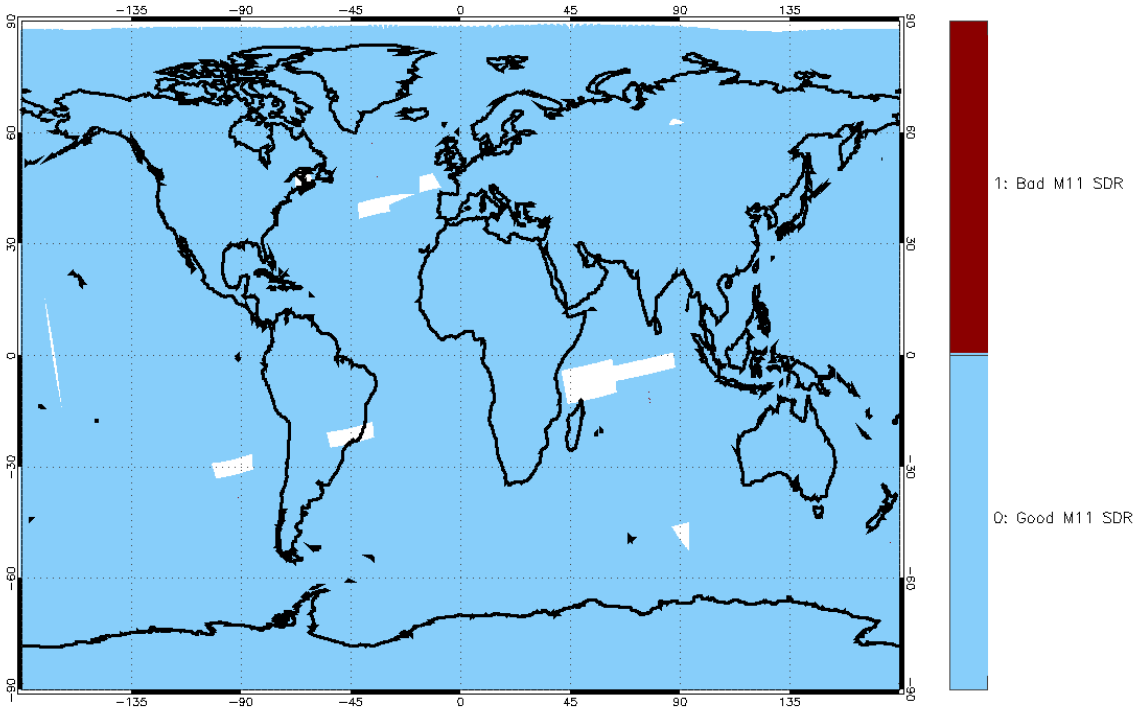
Bad M10 SDR Data: QF3, Bit 7

February 13, 2019



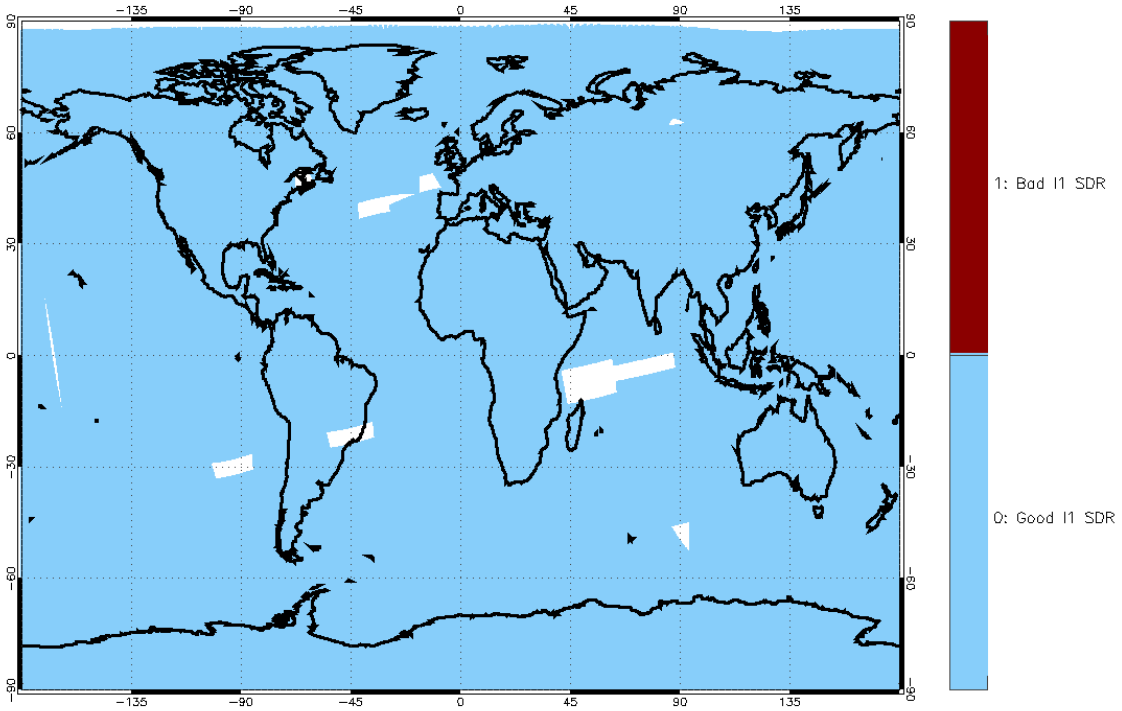
Bad M11 SDR Data: QF4, Bit 0

February 13, 2019



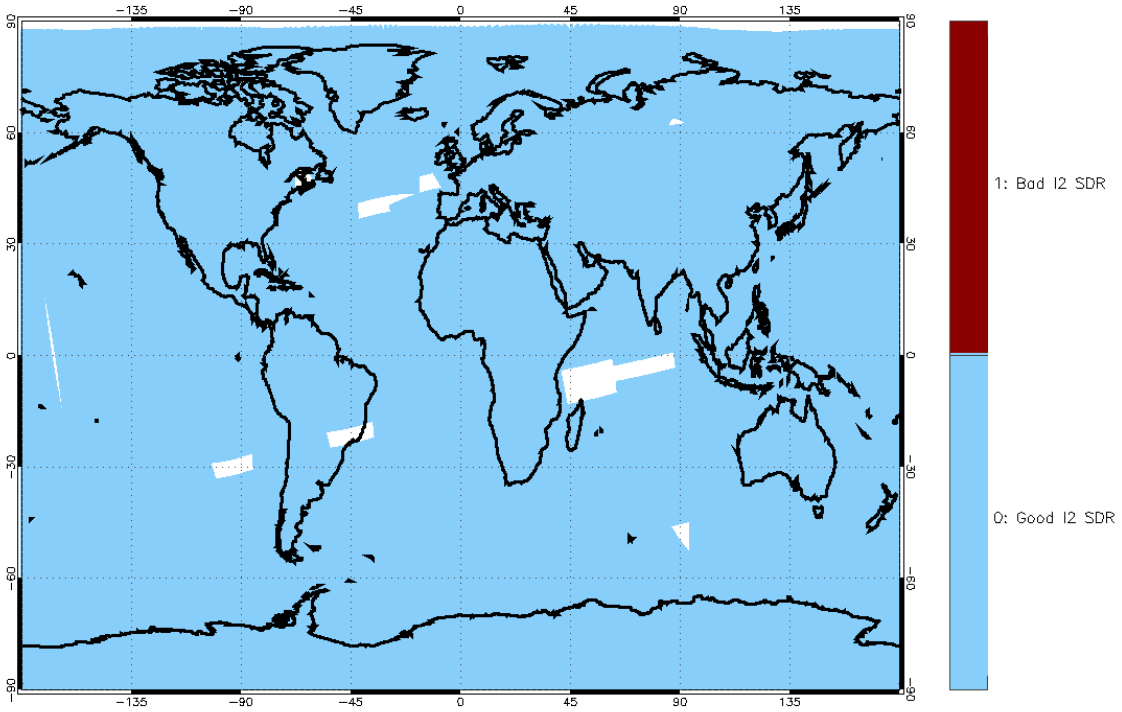
Bad I1 SDR Data: QF4, Bit 1

February 13, 2019



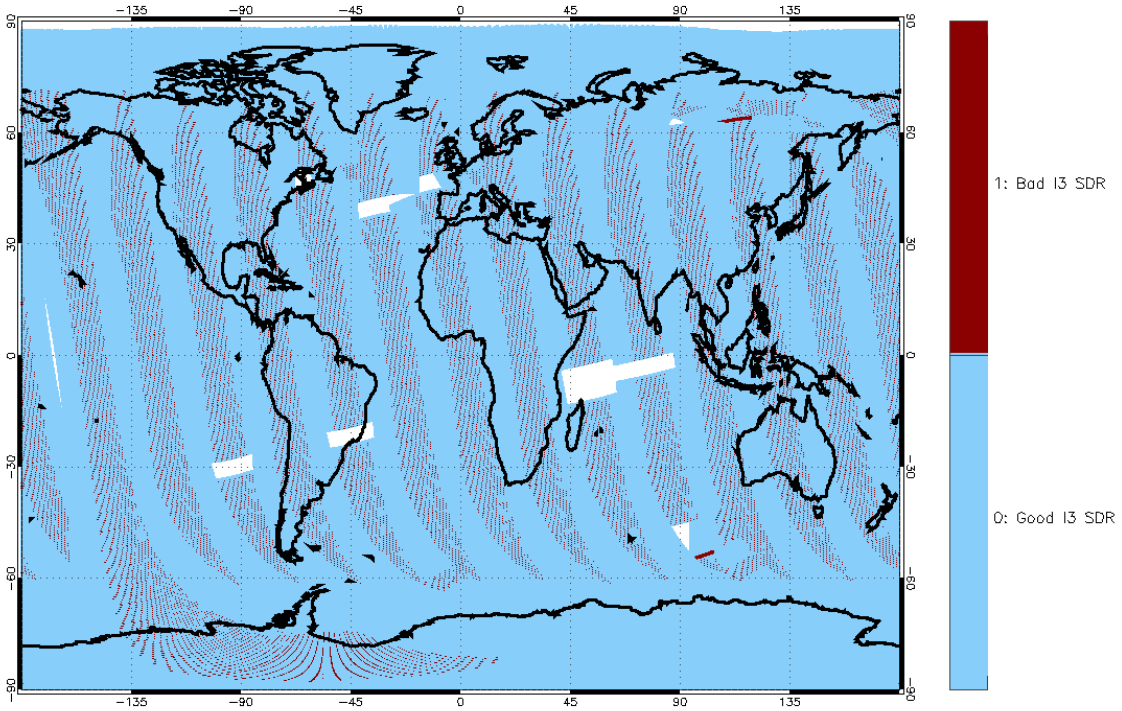
Bad I2 SDR Data: QF4, Bit 2

February 13, 2019



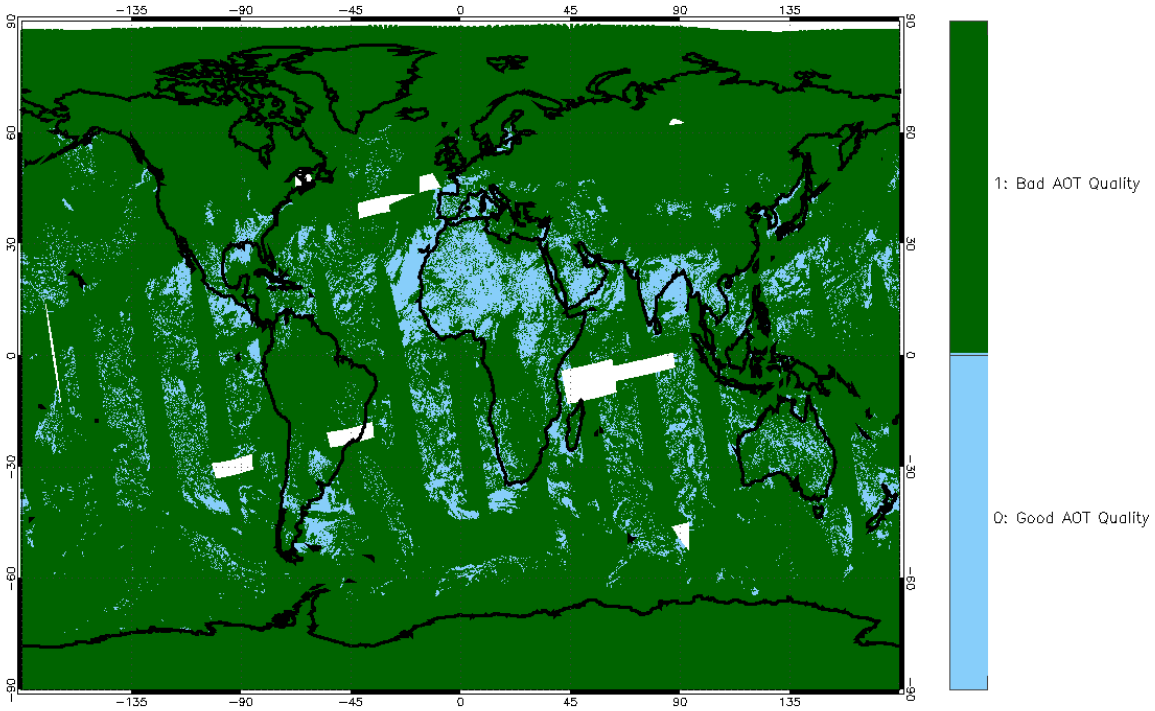
Bad I3 SDR Data: QF4, Bit 3

February 13, 2019



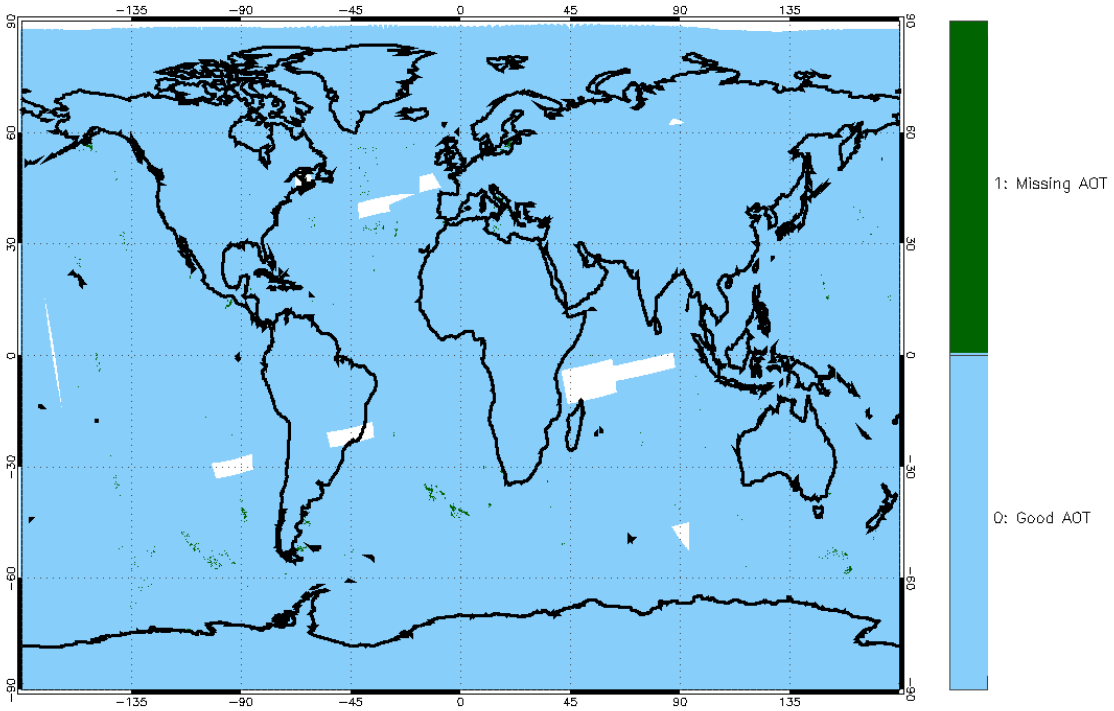
AOT Quality Flag: QF4, Bit 4

February 13, 2019



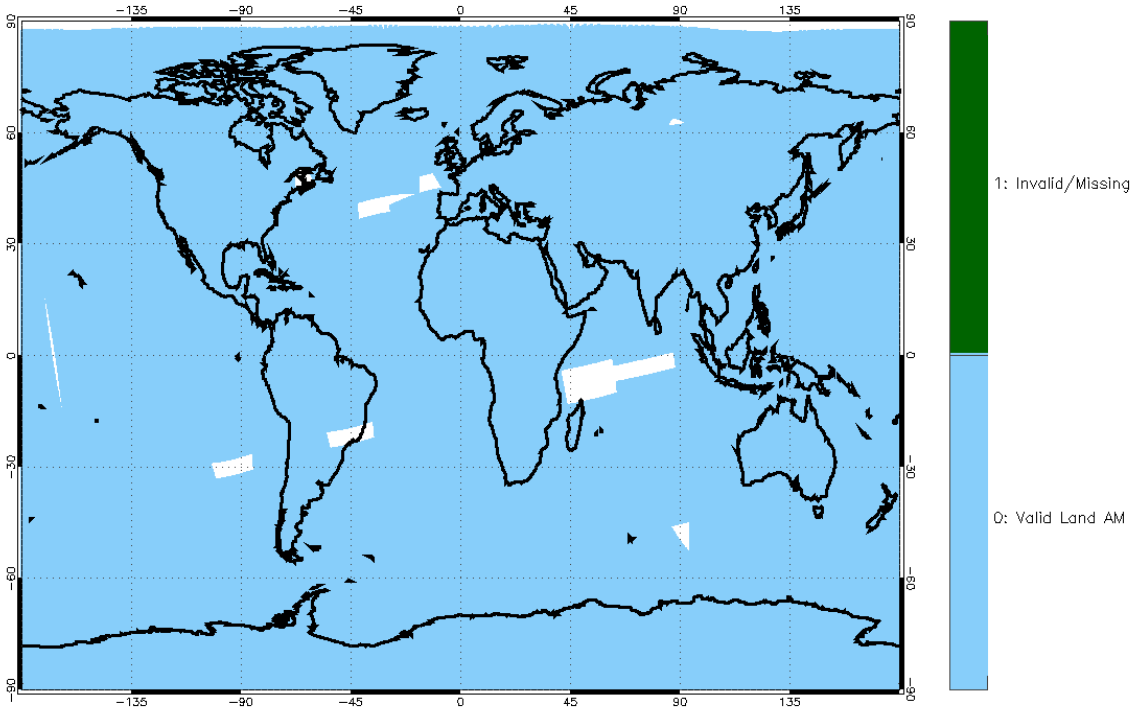
Missing AOT Flag: QF4, Bit 5

February 13, 2019



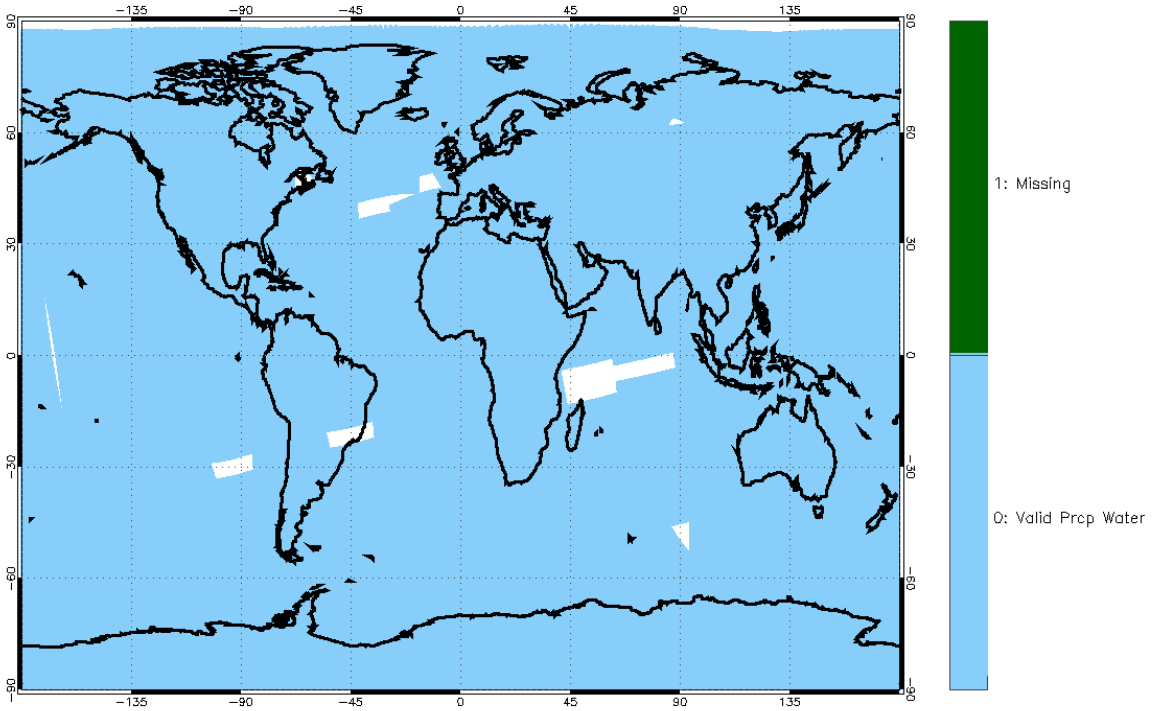
Invalid Land AM Flag: QF4, Bit 6

February 13, 2019



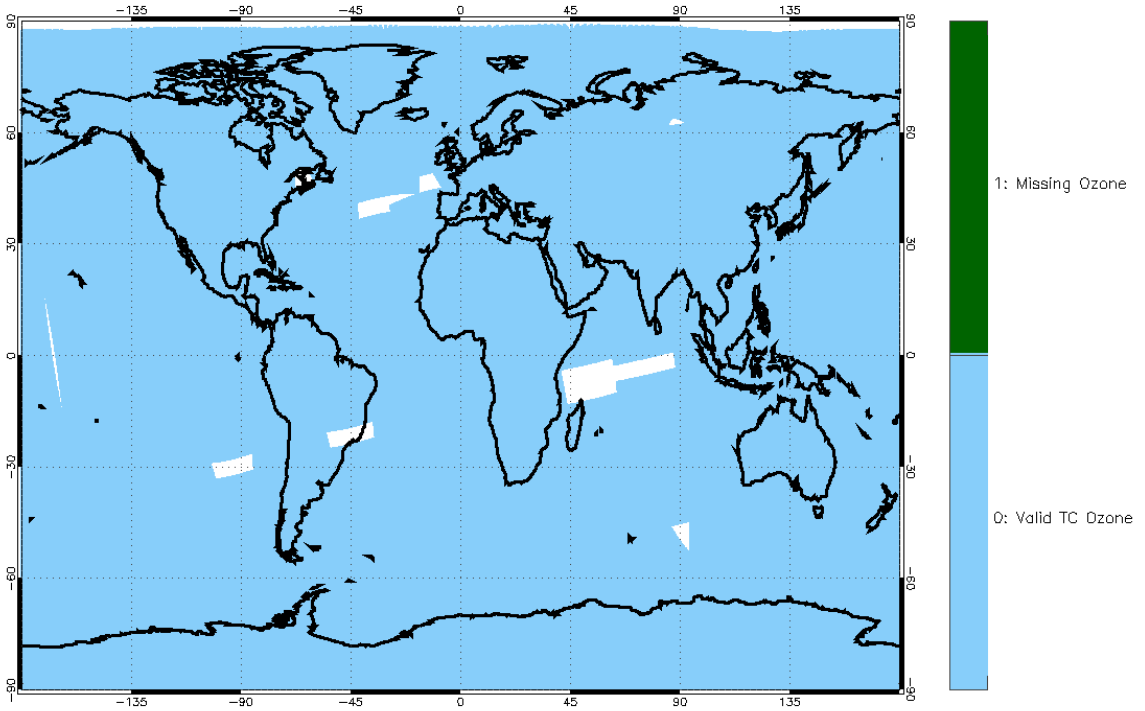
Missing Precipitation Flag: QF4, Bit 7

February 13, 2019



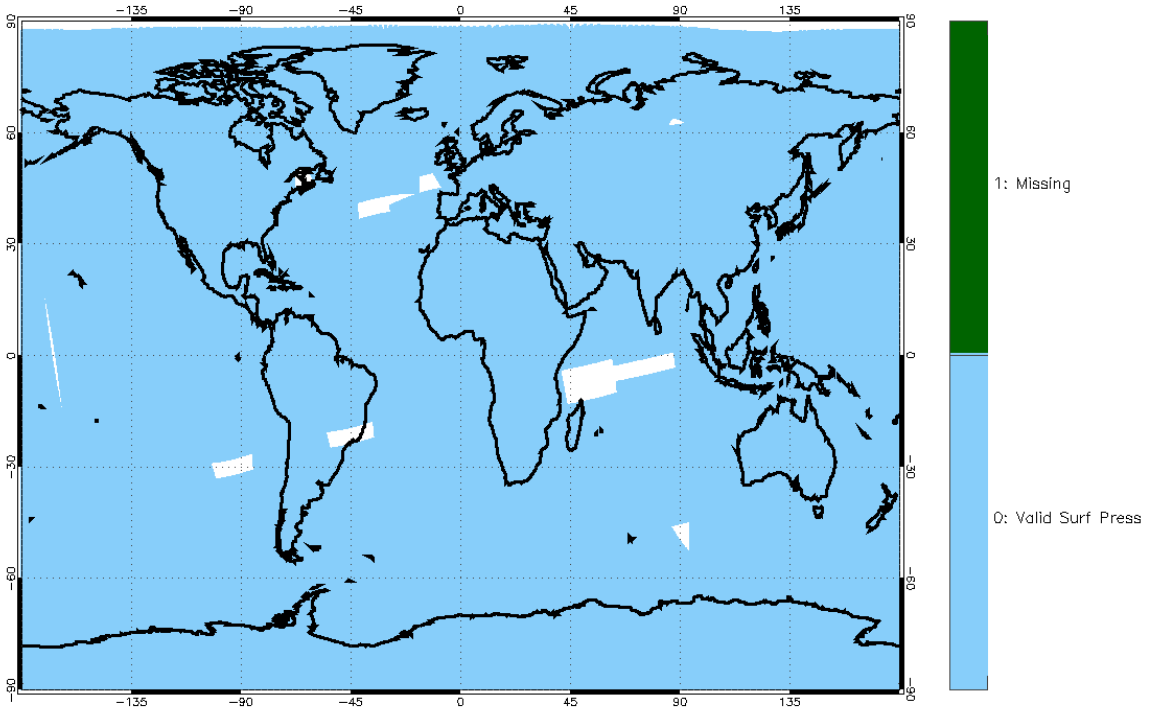
Missing Total Column Ozone Flag: QF5, Bit 0

February 13, 2019



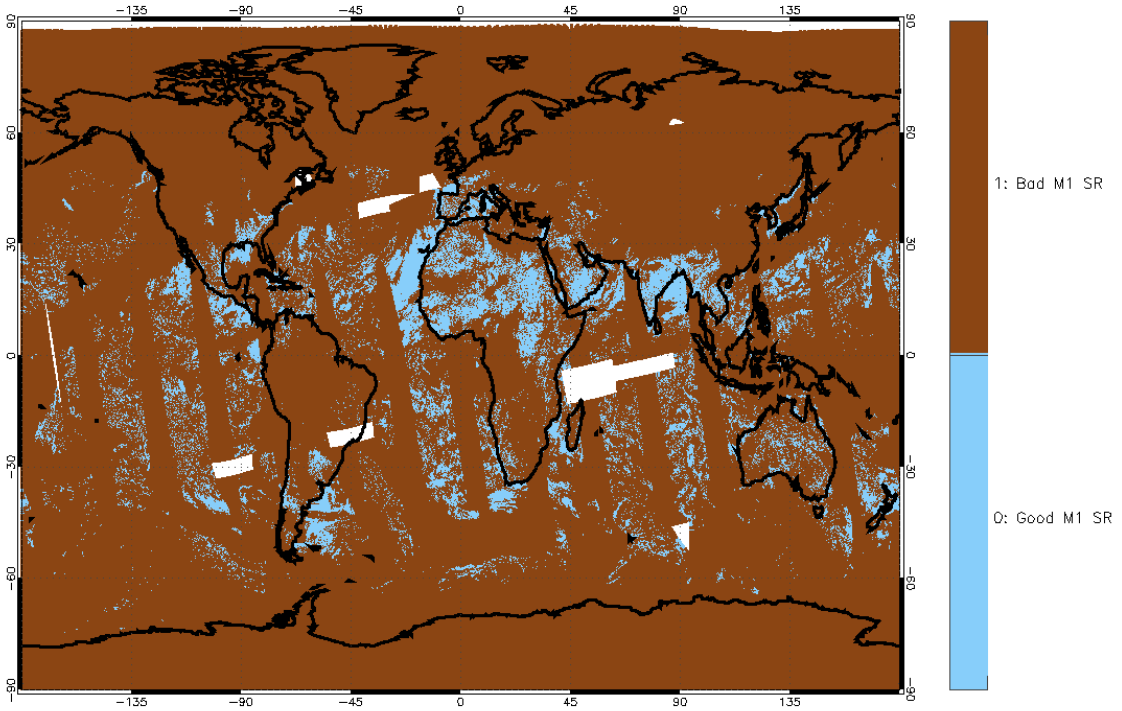
Missing Surface Pressure Flag: QF5, Bit 1

February 13, 2019



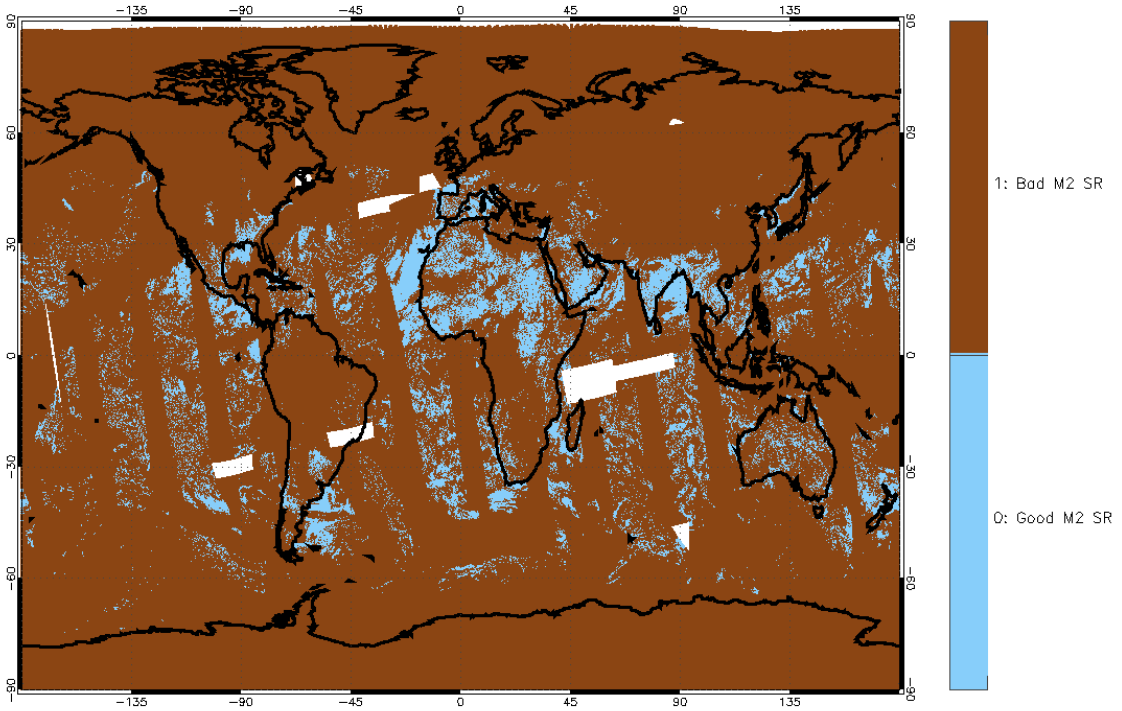
Overall M1 Surface Reflectance: QF5, Bit 2

February 13, 2019



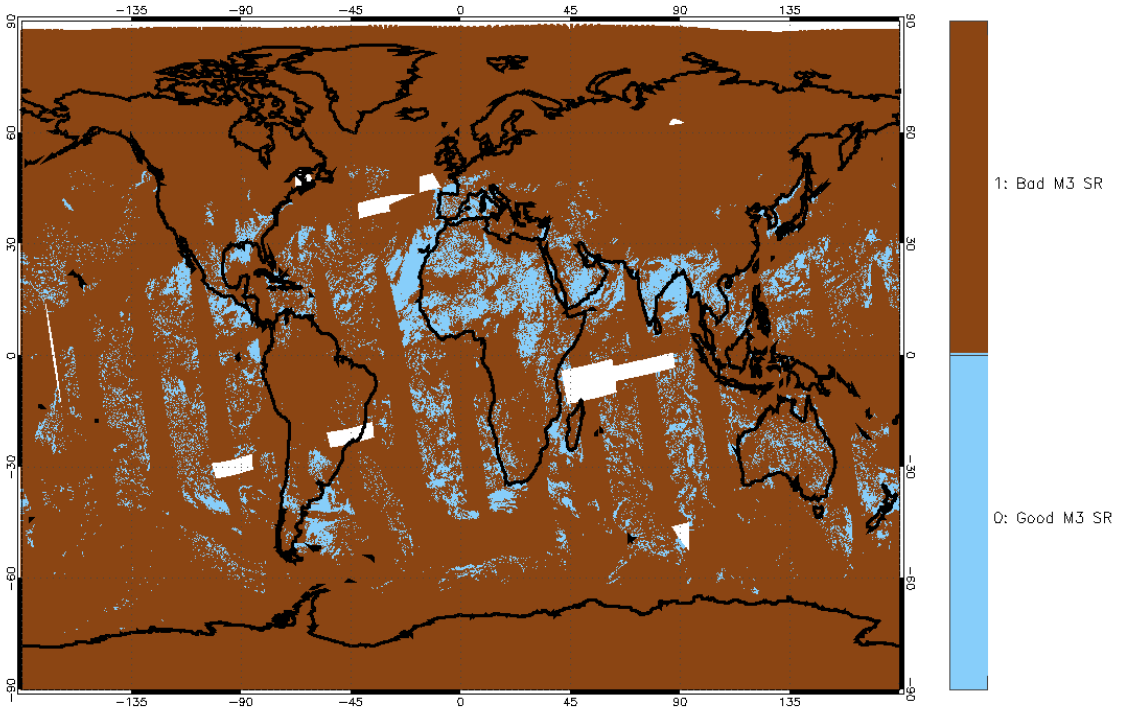
Overall M2 Surface Reflectance: QF5, Bit 3

February 13, 2019



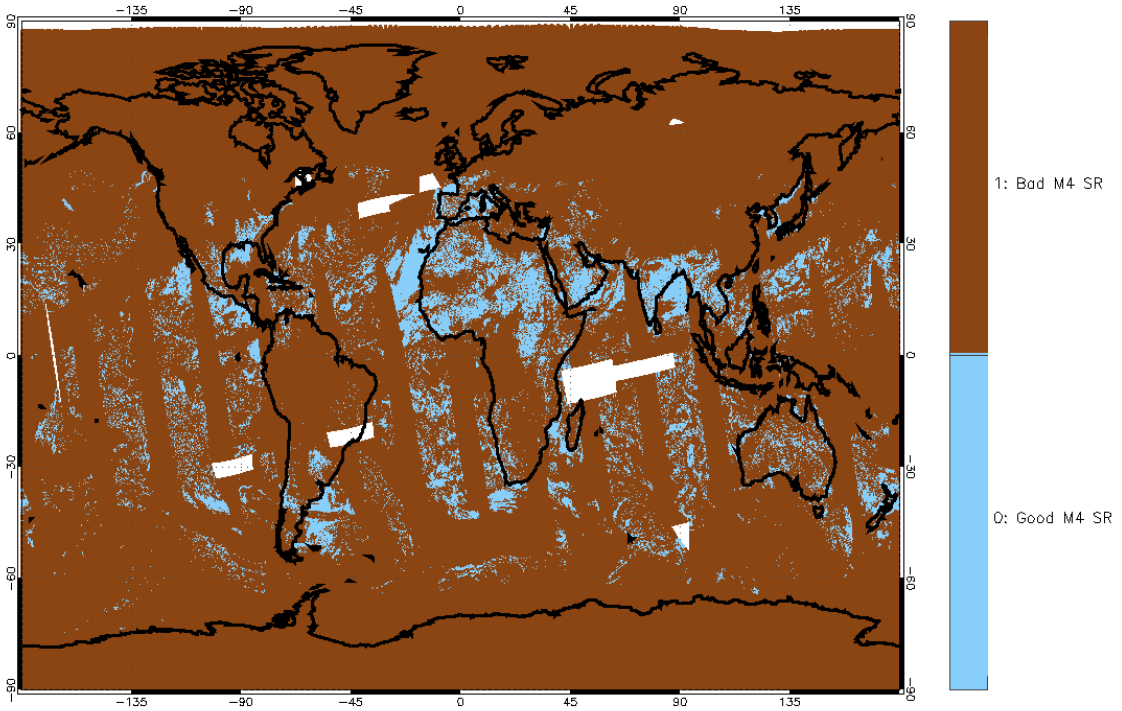
Overall M3 Surface Reflectance: QF5, Bit 4

February 13, 2019



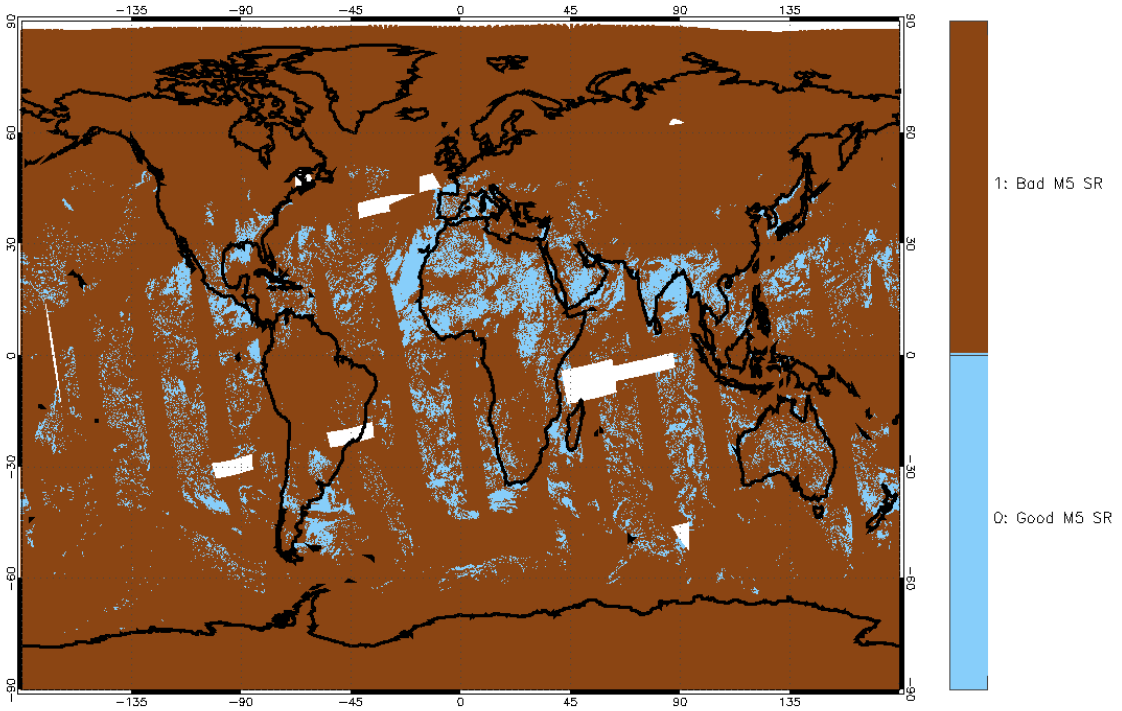
Overall M4 Surface Reflectance: QF5, Bit 5

February 13, 2019



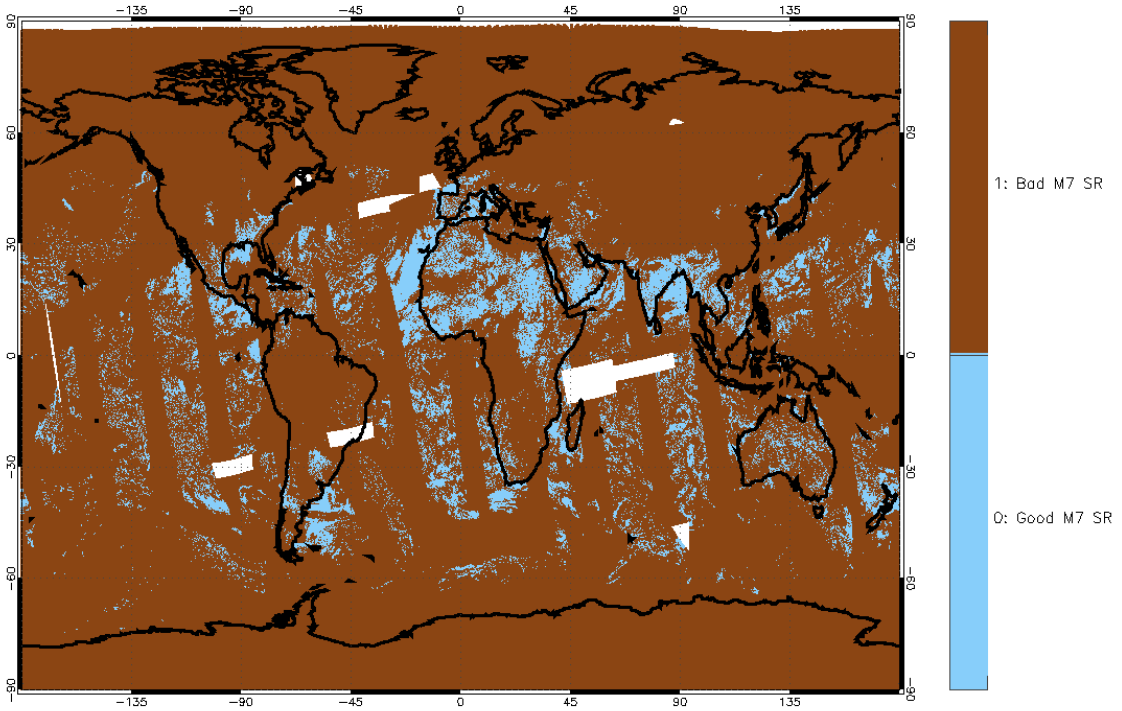
Overall M5 Surface Reflectance: QF5, Bit 6

February 13, 2019



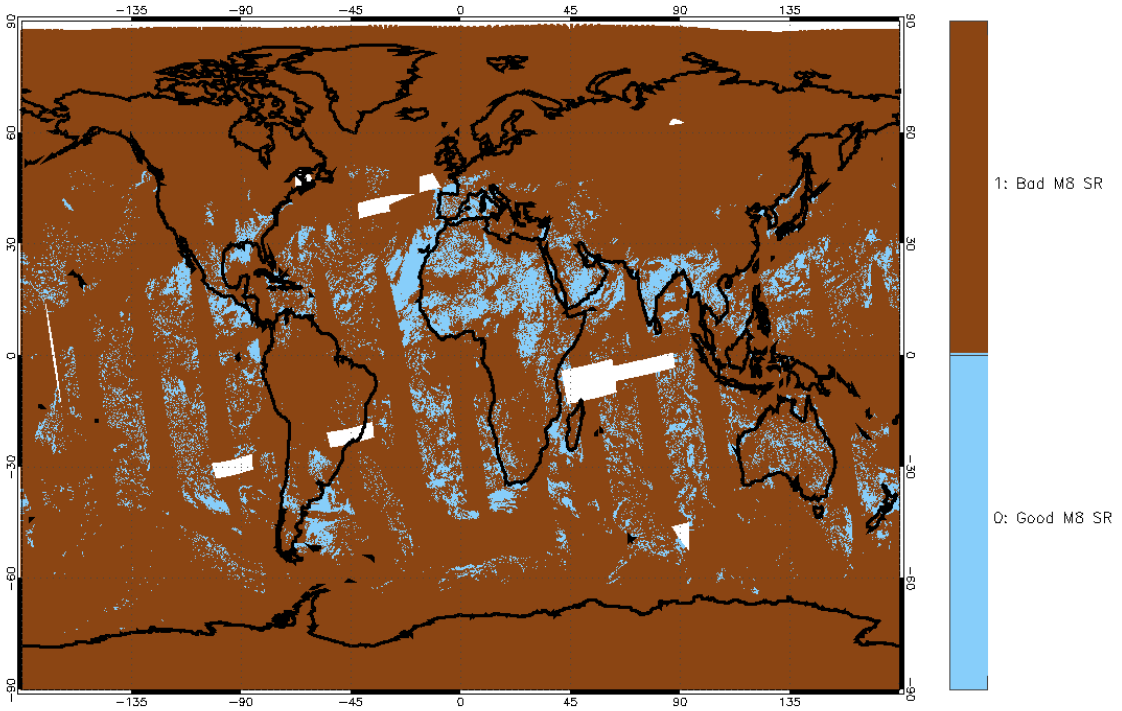
Overall M7 Surface Reflectance: QF5, Bit 7

February 13, 2019



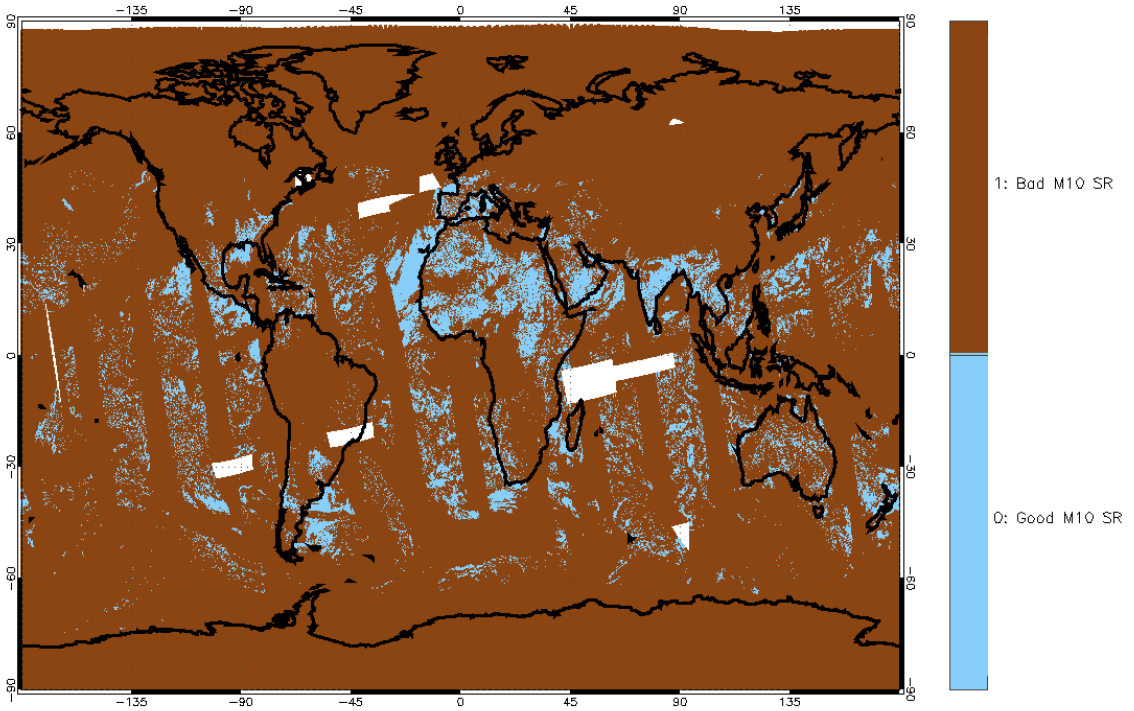
Overall M8 Surface Reflectance: QF6, Bit 0

February 13, 2019



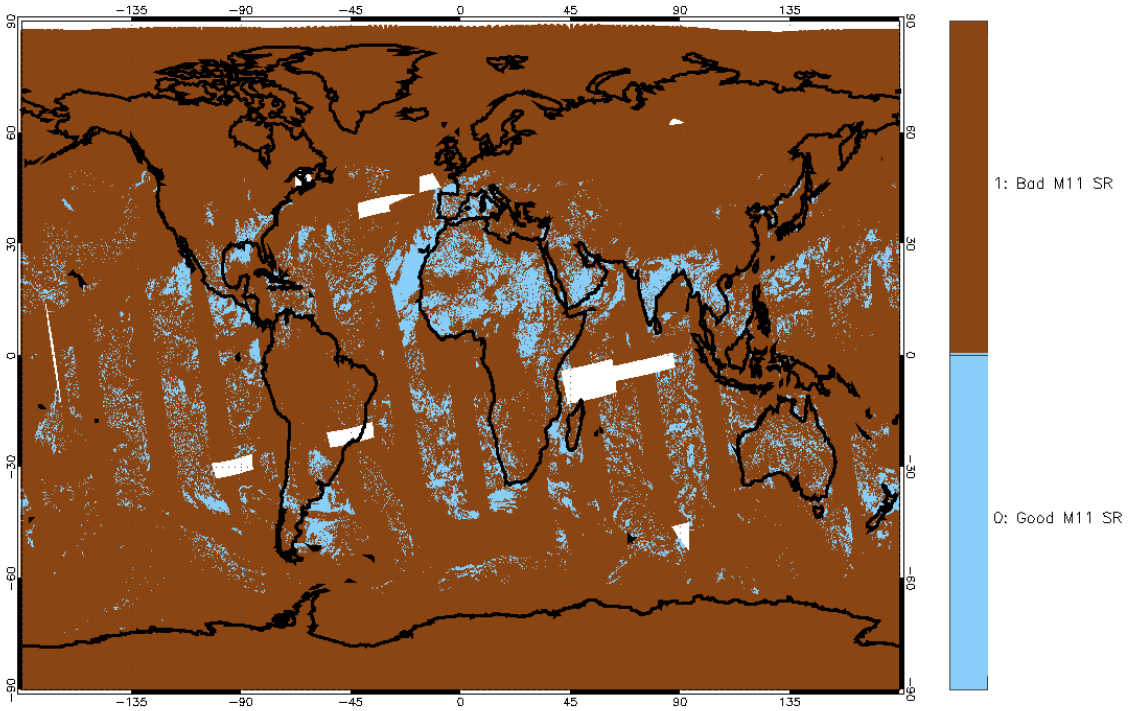
Overall M10 Surface Reflectance: QF6, Bit 1

February 13, 2019



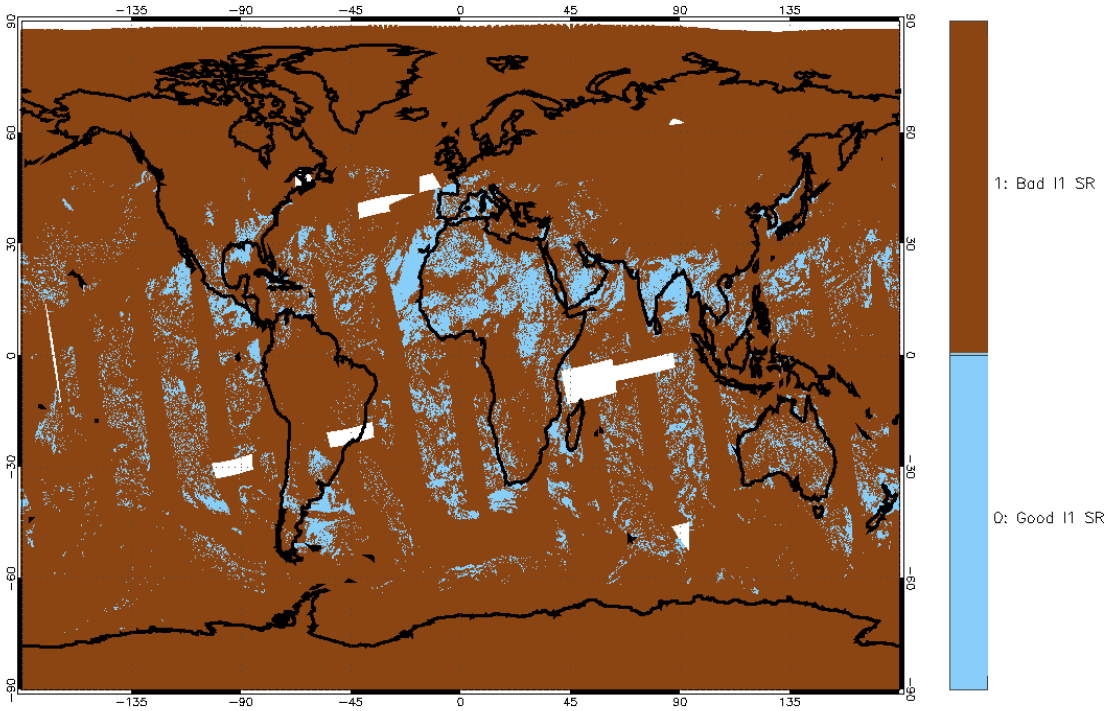
Overall M11 Surface Reflectance: QF6, Bit 2

February 13, 2019



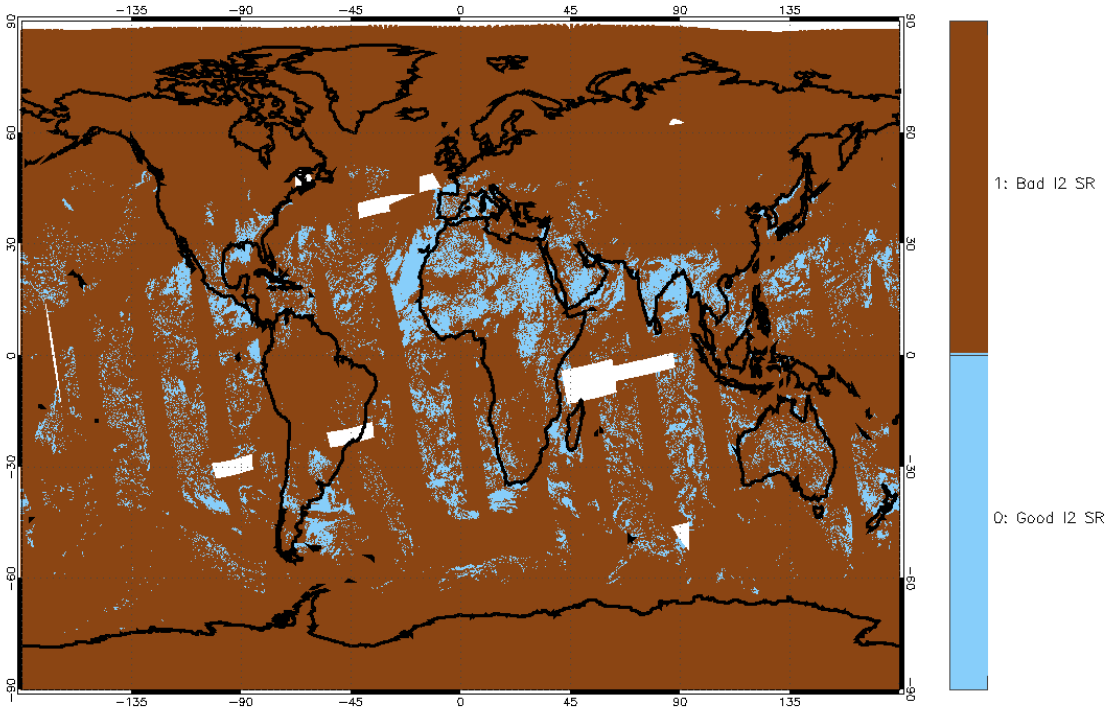
Overall I1 Surface Reflectance: QF6, Bit 3

February 13, 2019



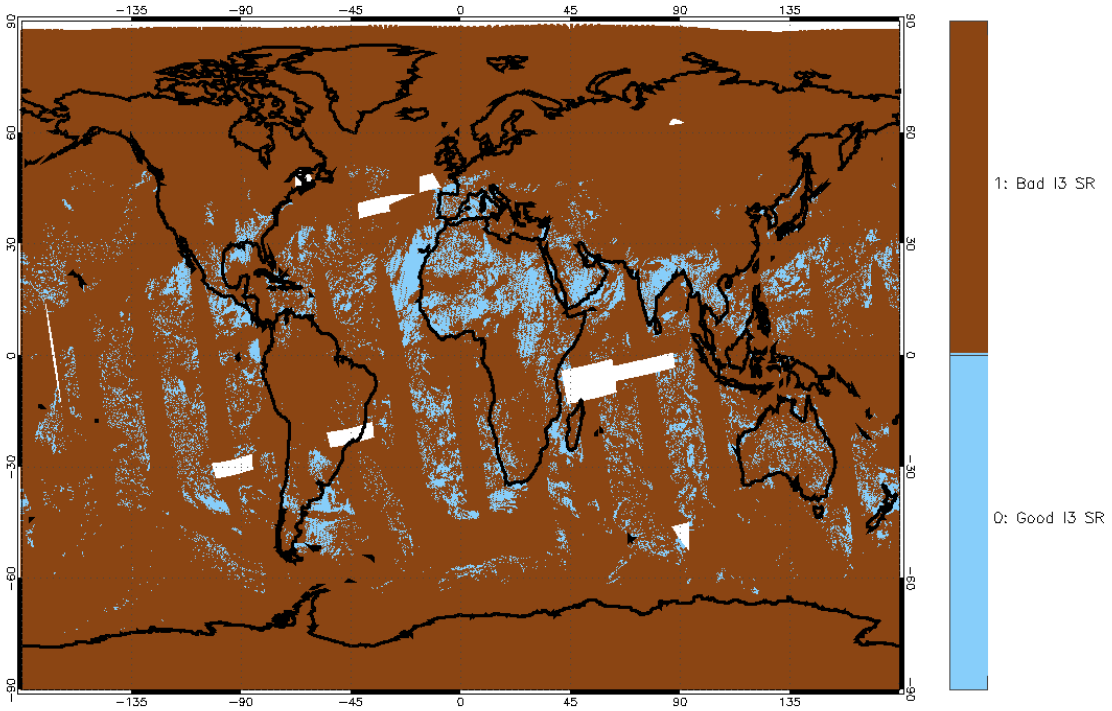
Overall I2 Surface Reflectance: QF6, Bit 4

February 13, 2019



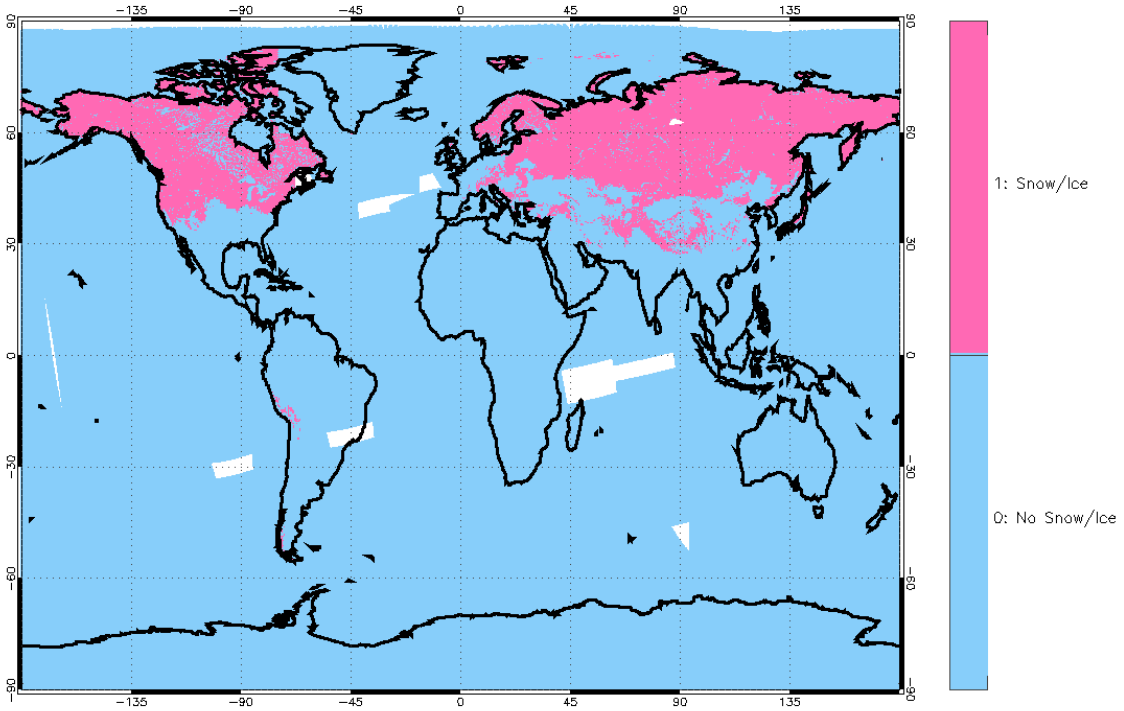
Overall I3 Surface Reflectance: QF6, Bit 5

February 13, 2019



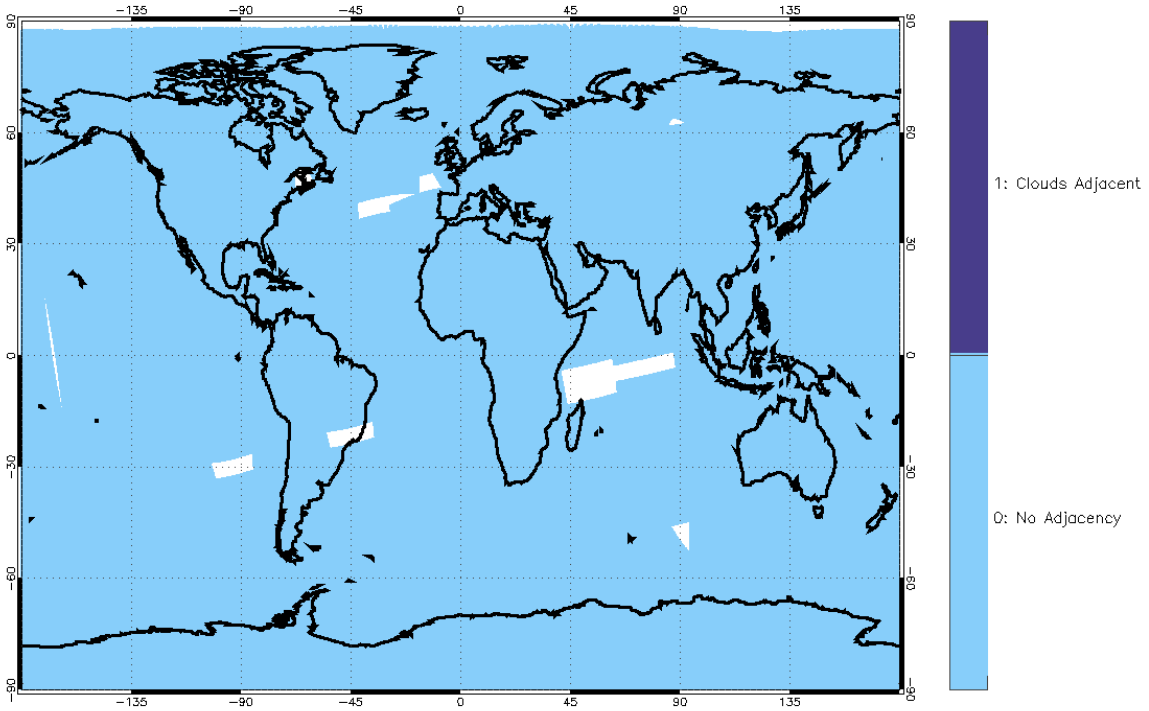
Snow Present Flag: QF7, Bit 0

February 13, 2019



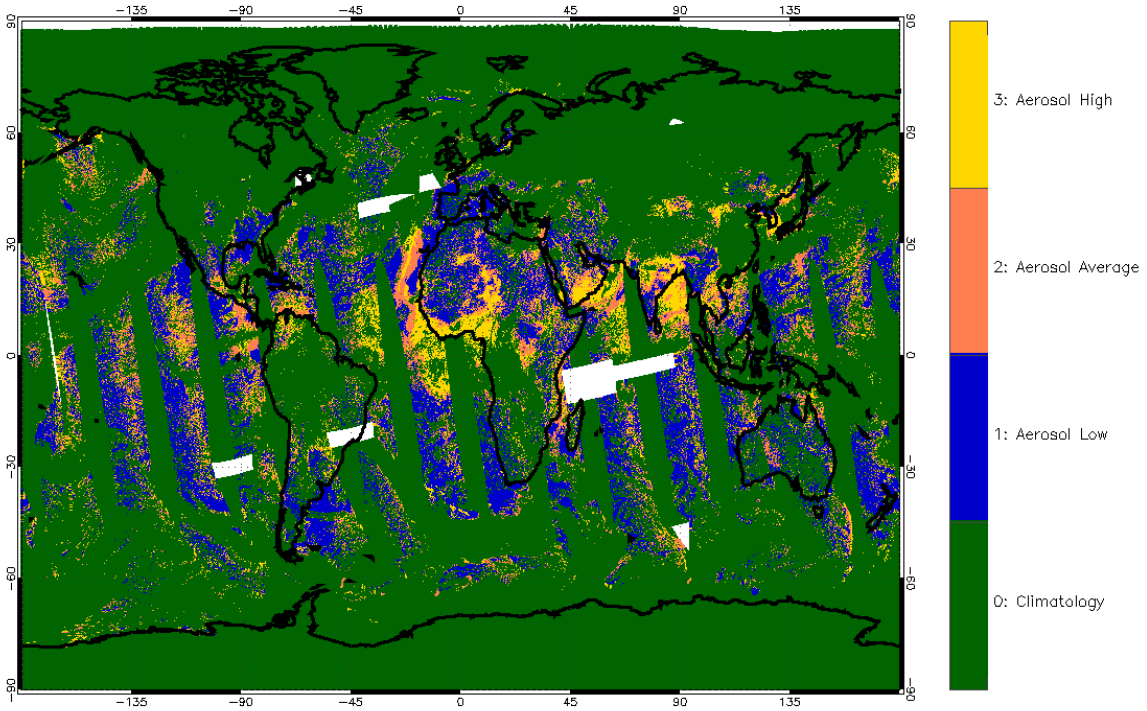
Cloud Adjacency Flag: QF7, Bit 1

February 13, 2019



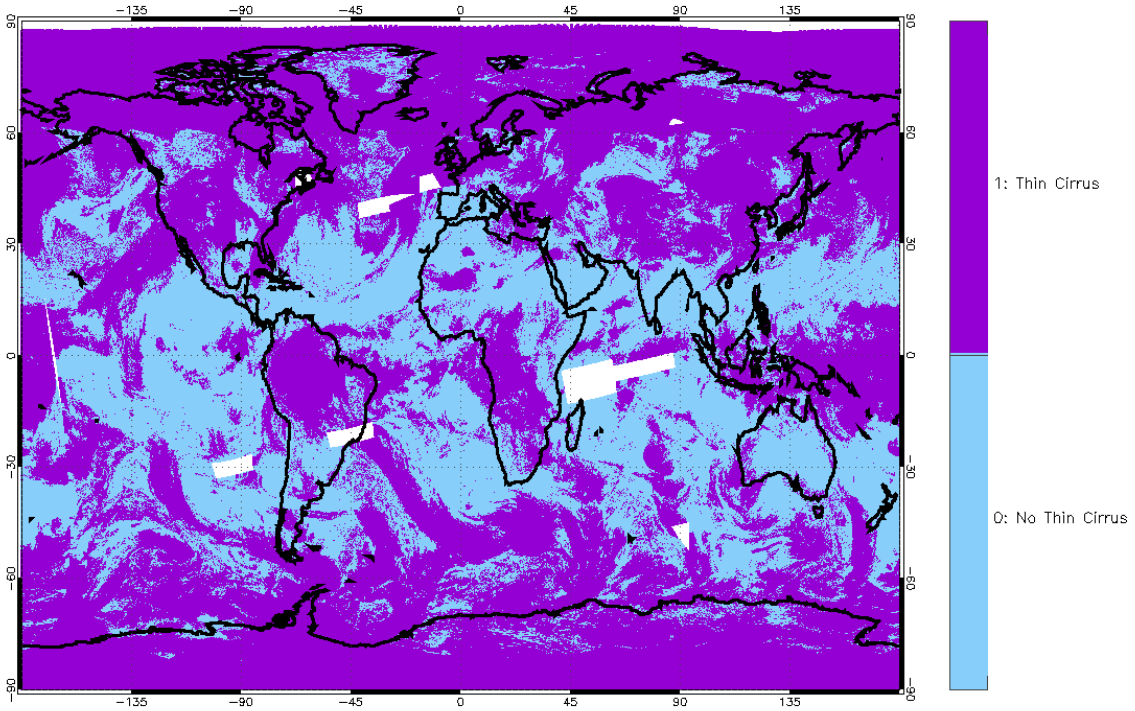
Aerosol Quantity: QF7, Bits 2-3

February 13, 2019



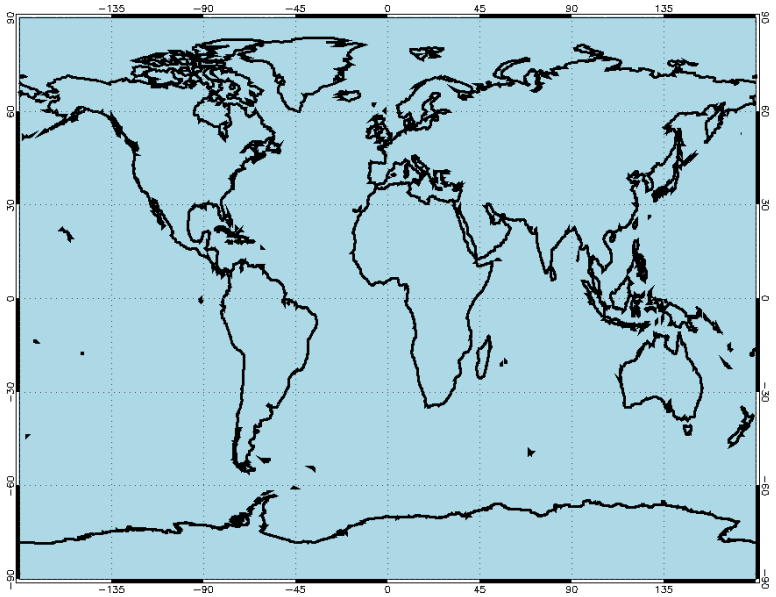
Thin Cirrus Flag: QF7, Bit 4

February 13, 2019

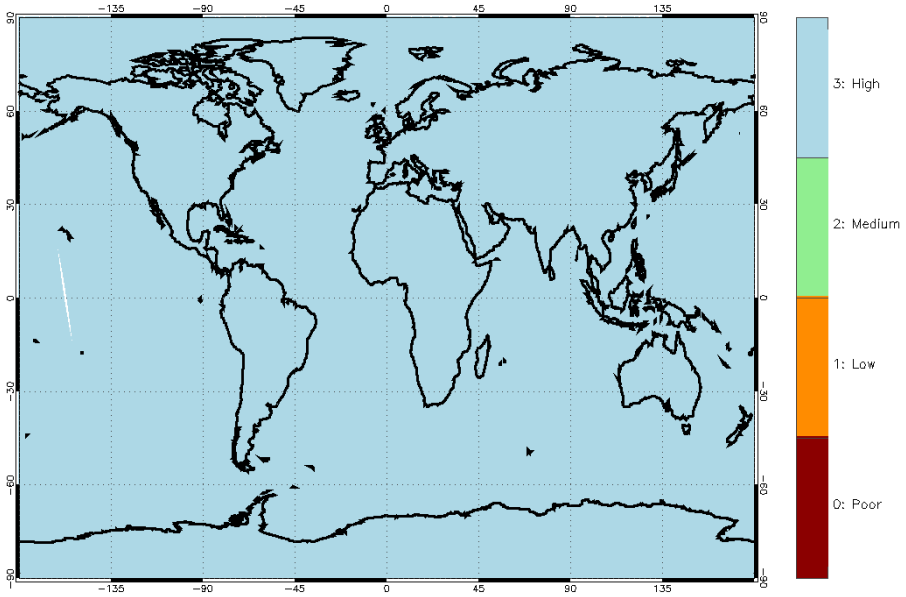


Cloud Mask Quality Flag: QF1, Bits 0-1
March 19, 2019

S-NPP

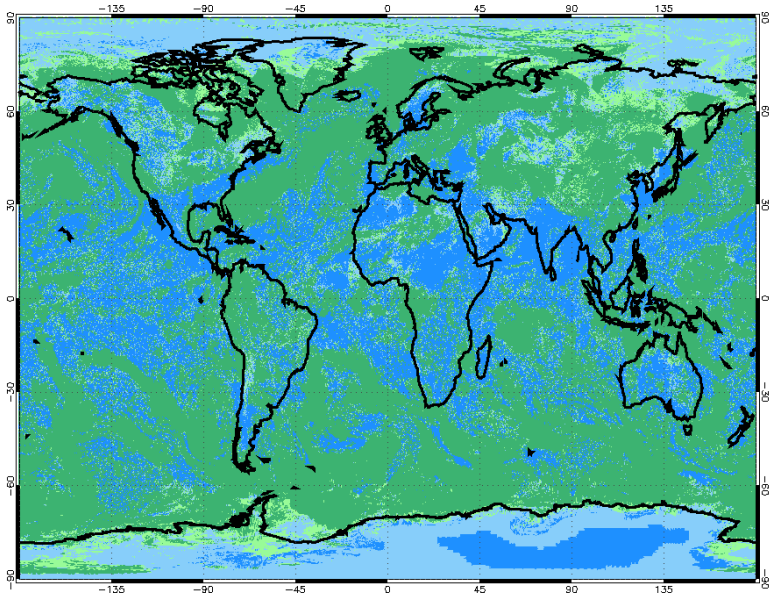


NOAA-20



Cloud Confidence Flag: QF1, Bits 2-3
March 19, 2019

S-NPP



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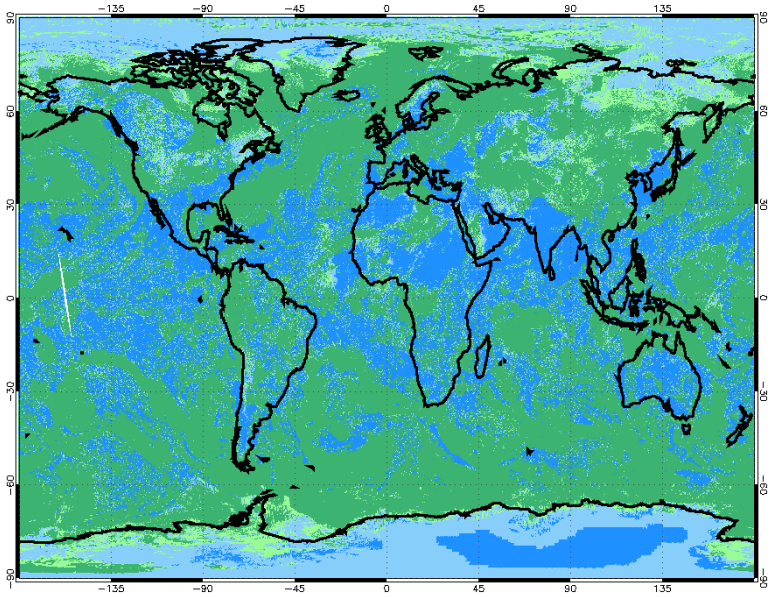
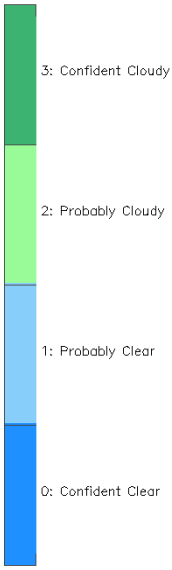
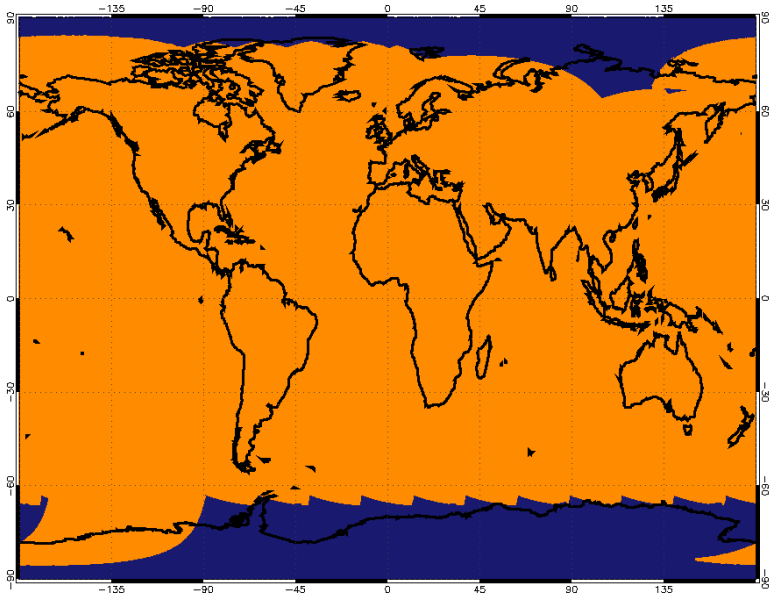




Day/Night Flag: QF1, Bit 4
March 19, 2019

S-NPP



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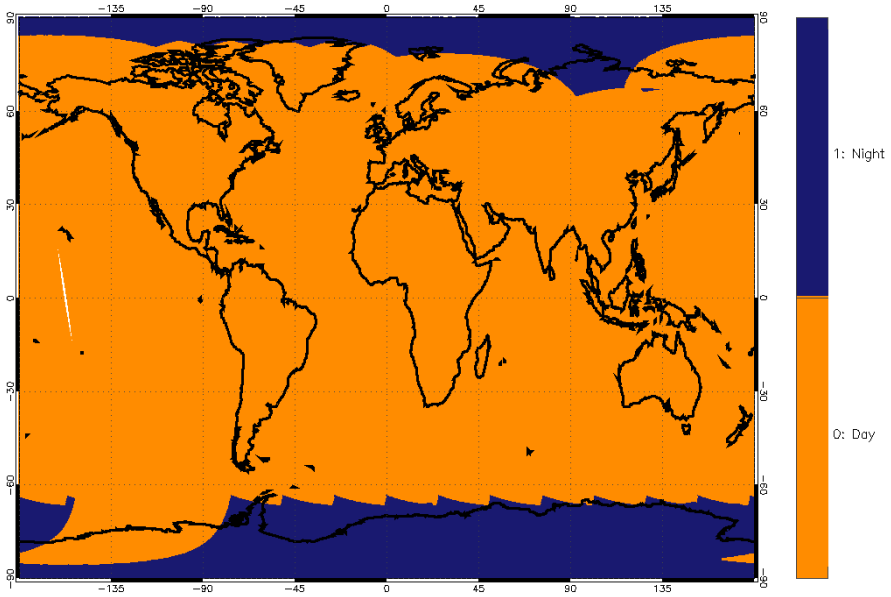
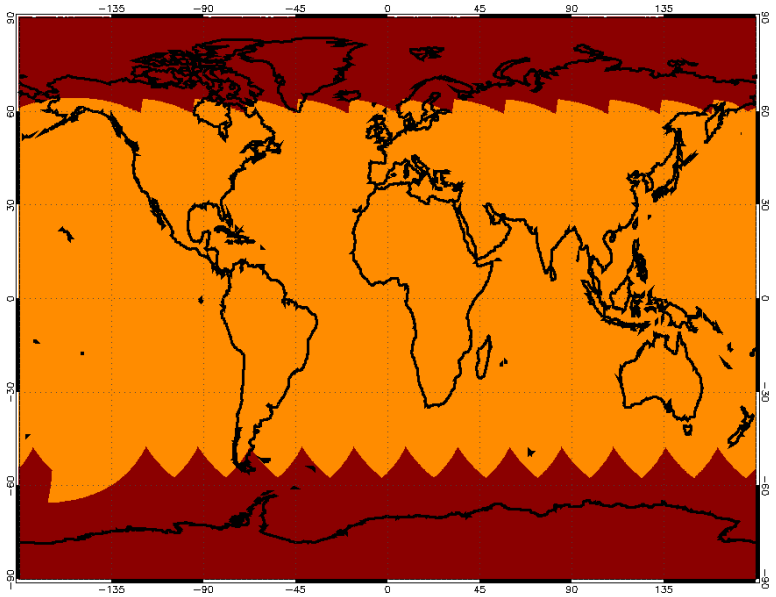


Low Sun Flag: QF1, Bit 5
March 19, 2019

S-NPP



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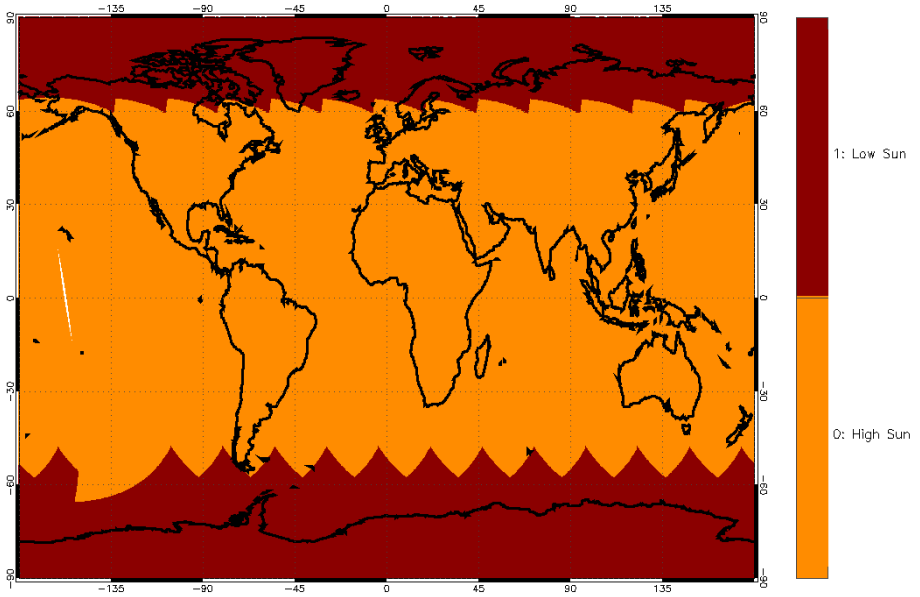
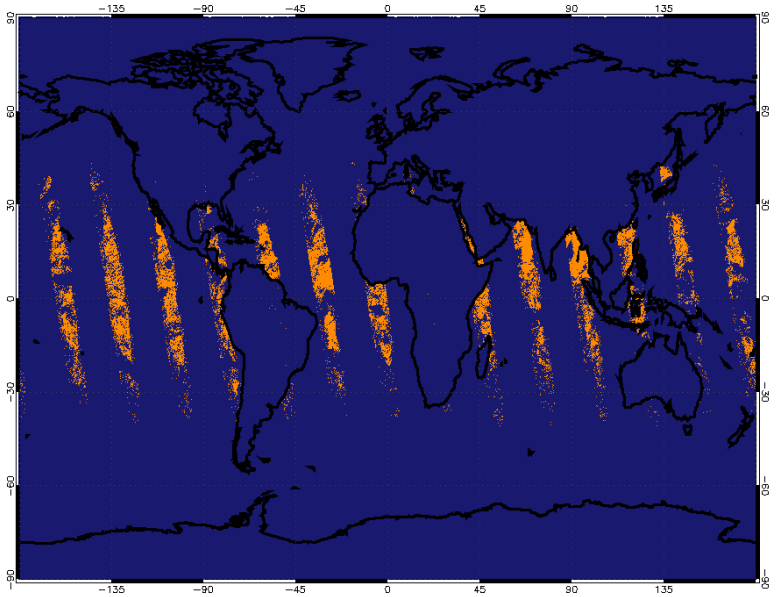


Sun Glint Flag: QF1, Bit 6
March 19, 2019

S-NPP



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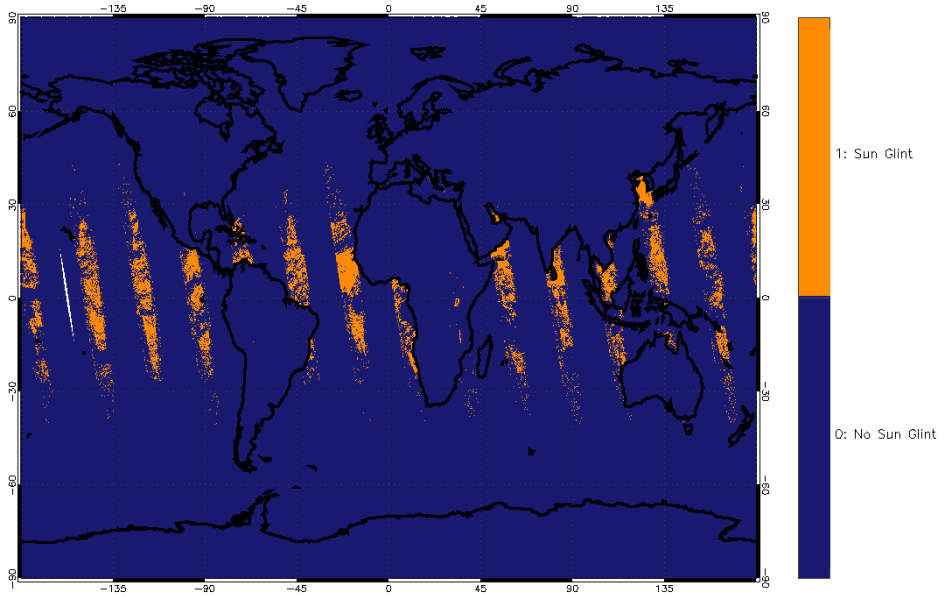
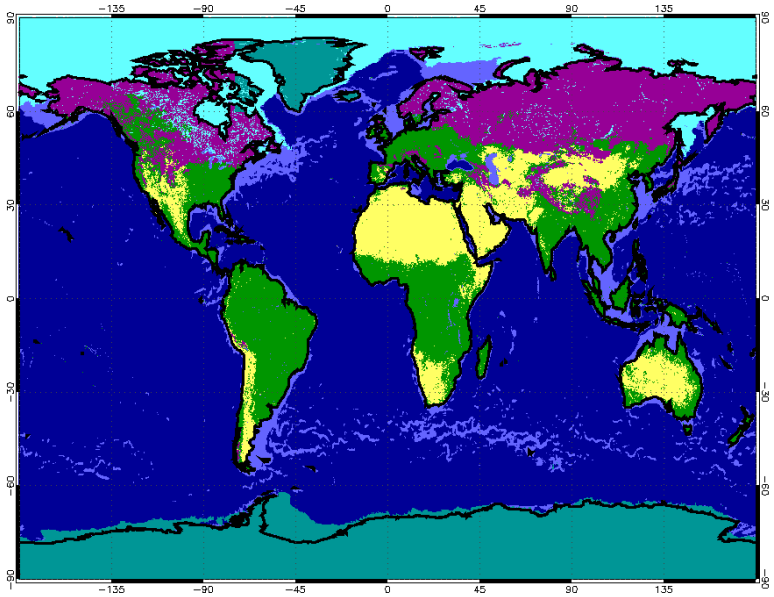


Land Water Background: QF2, Bits 0-2
March 19, 2019

S-NPP



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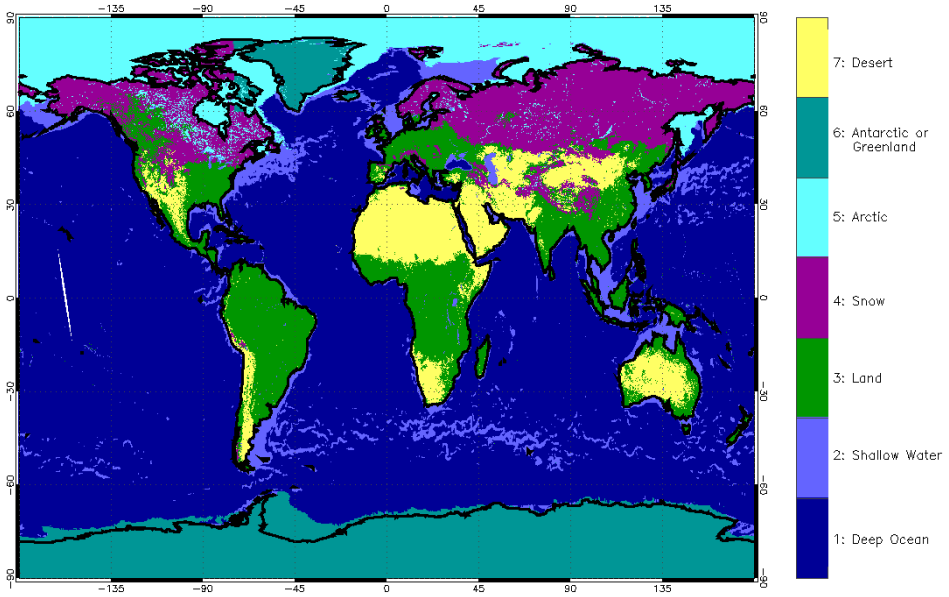
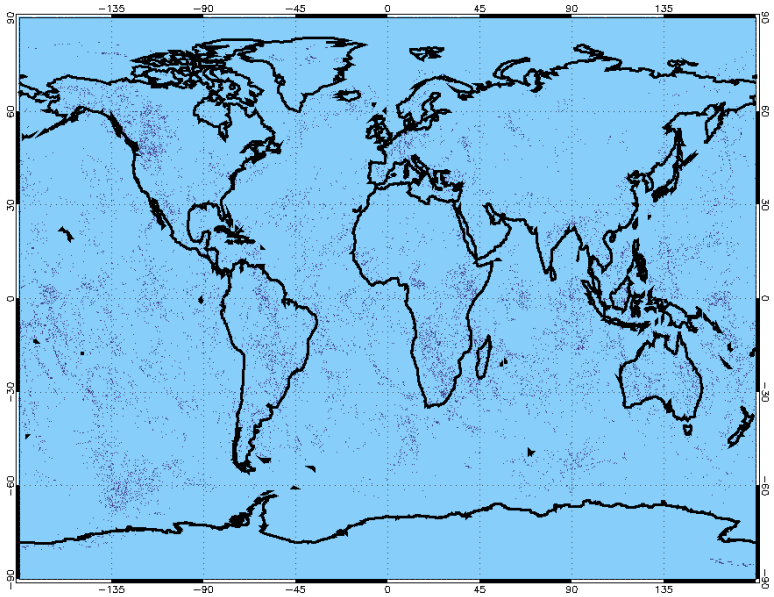


Cloud Shadow Mask: QF2, Bit 3
March 19, 2019

S-NPP



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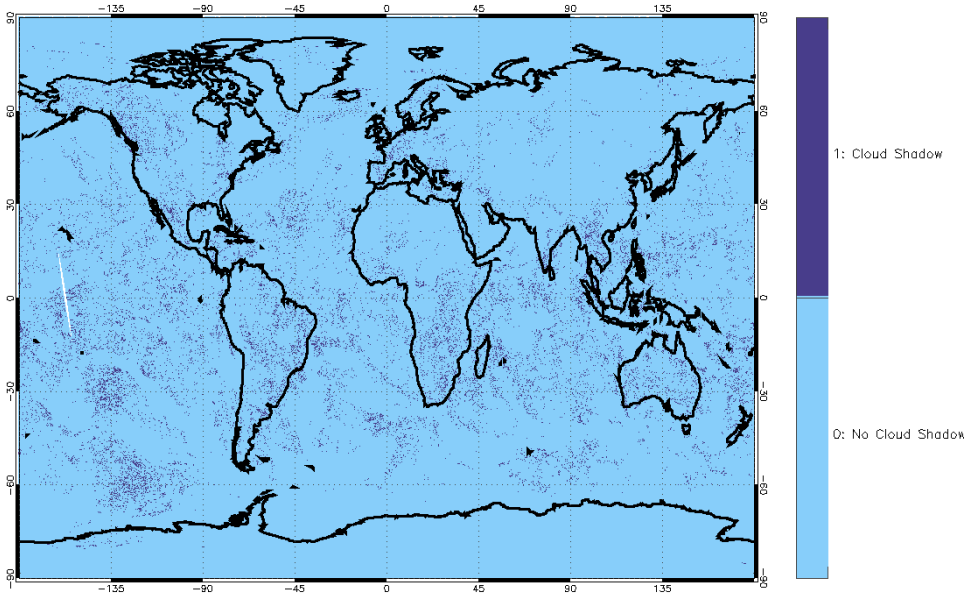
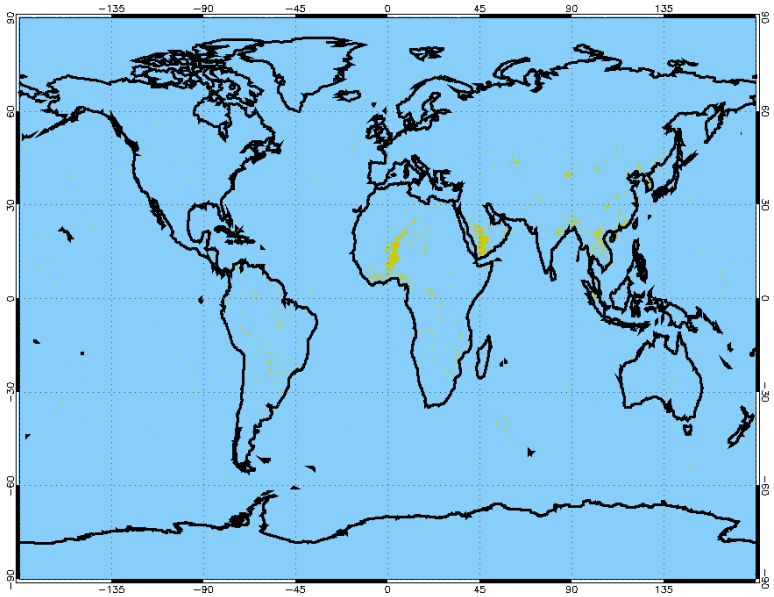


Heavy Aerosol Mask: QF2, Bit 4
March 19, 2019

S-NPP



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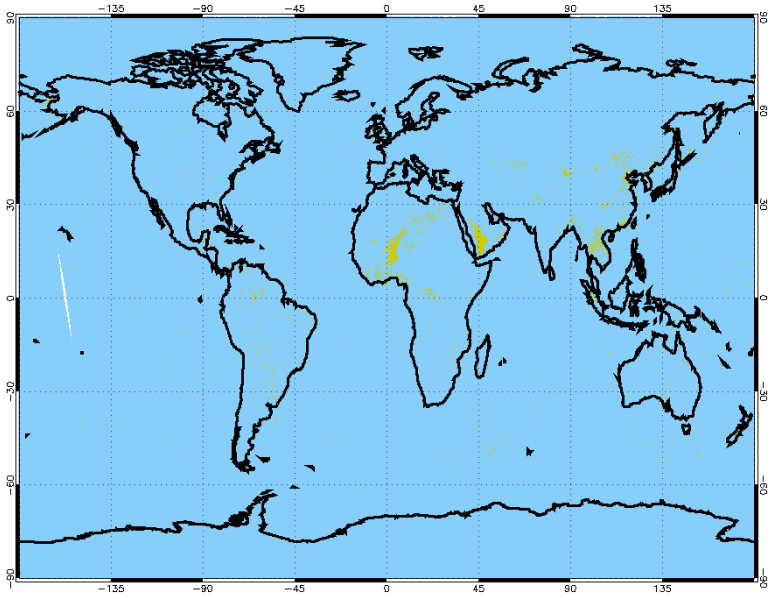
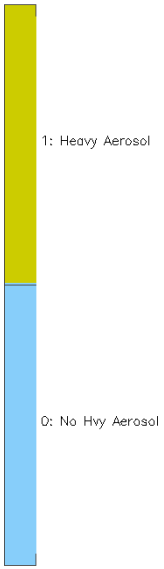
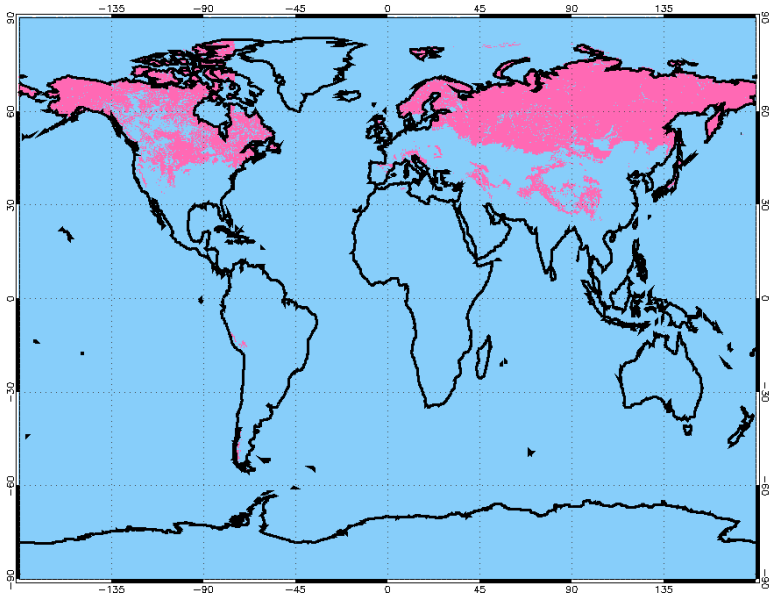




Snow/Ice Flag: QF2, Bit 5
March 19, 2019

S-NPP



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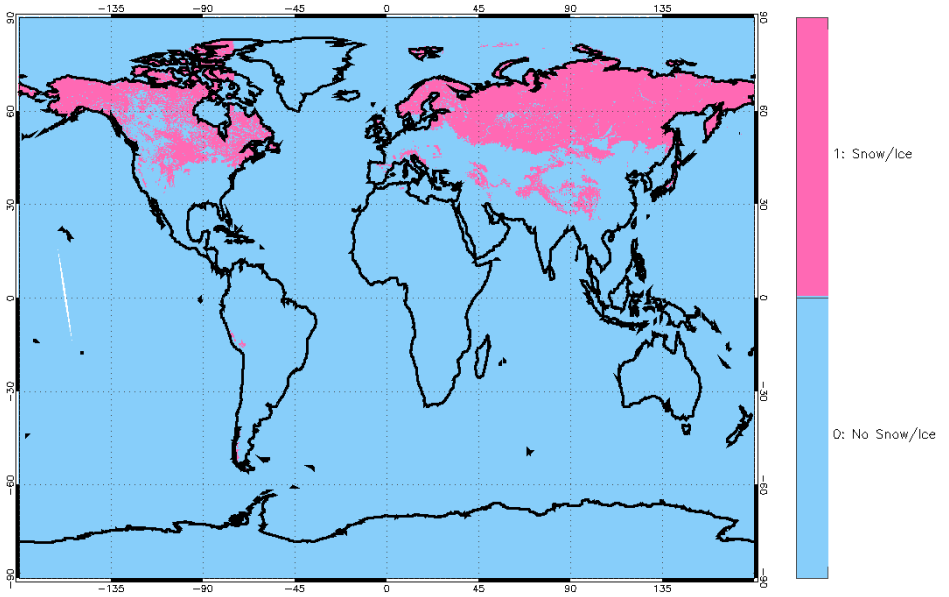
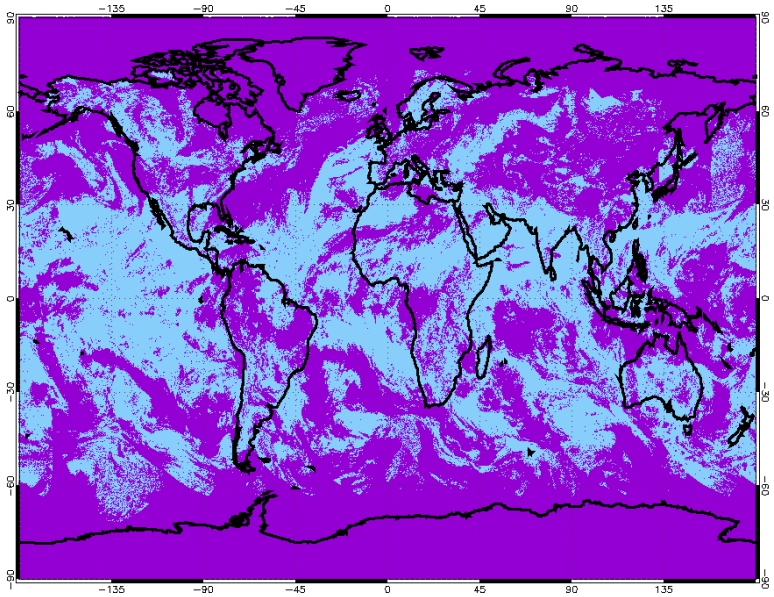


Thin Cirrus Reflective Test: QF2, Bit 6
March 19, 2019

S-NPP



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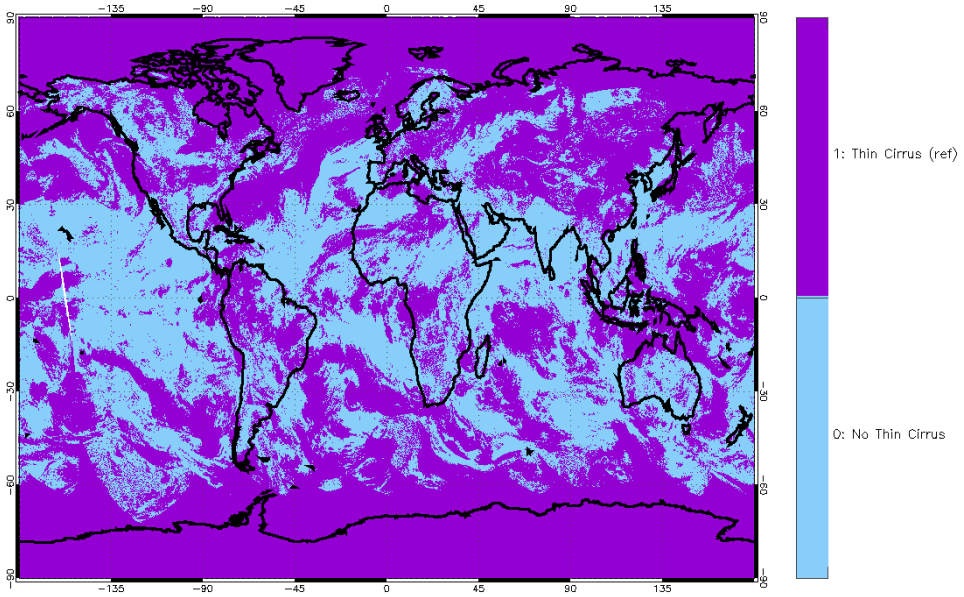
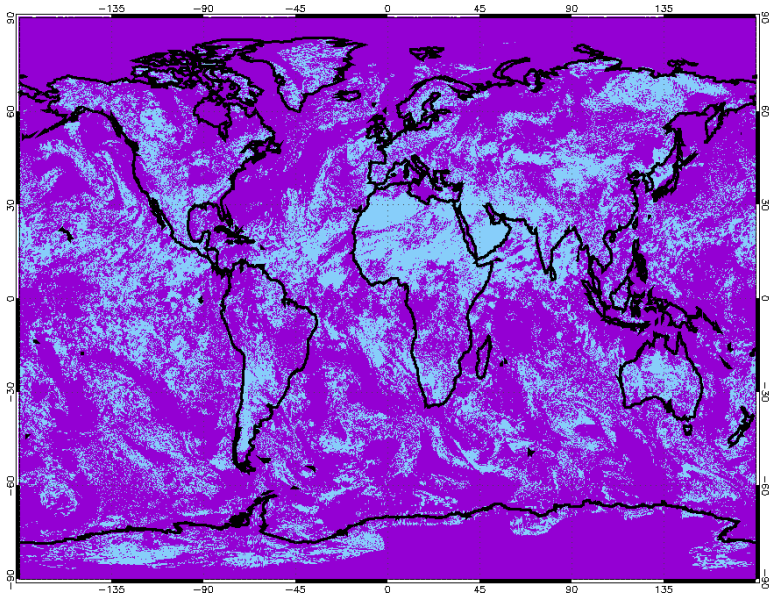


Thin Cirrus Emissive Test: QF2, Bit 7
March 19, 2019

S-NPP



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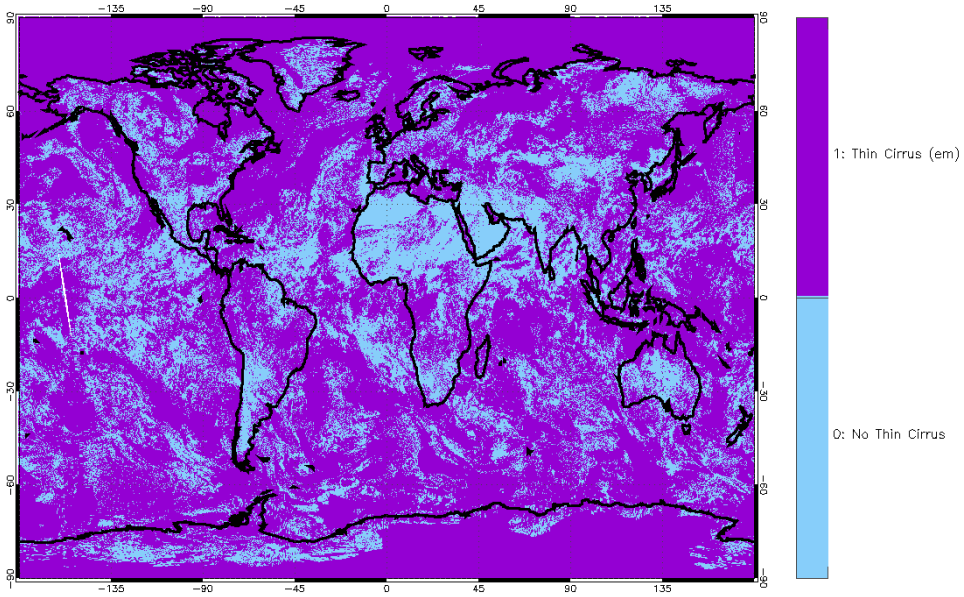
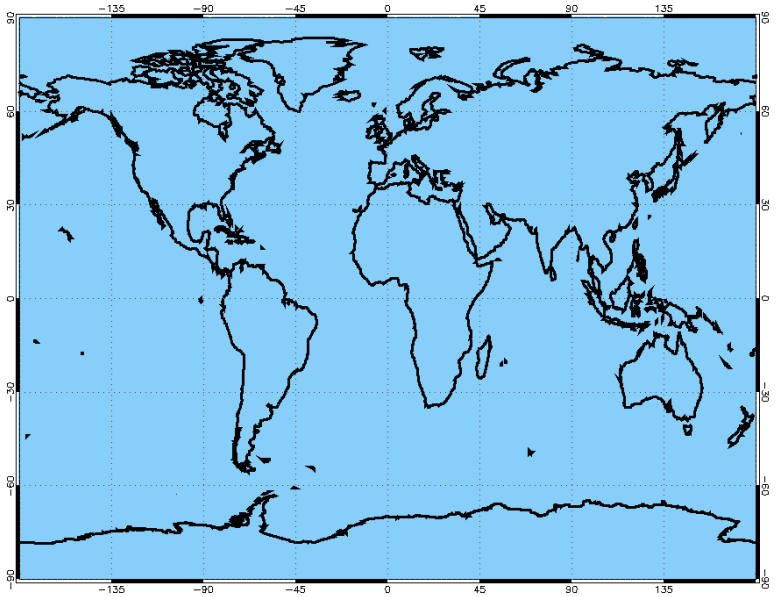


Bad M1 SDR Data: QF3, Bit 0
March 19, 2019

S-NPP



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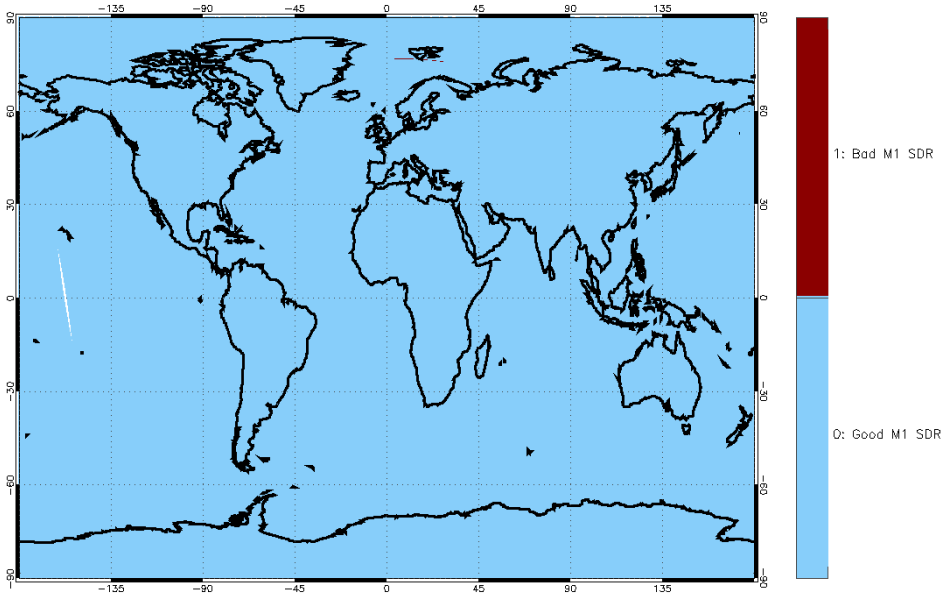
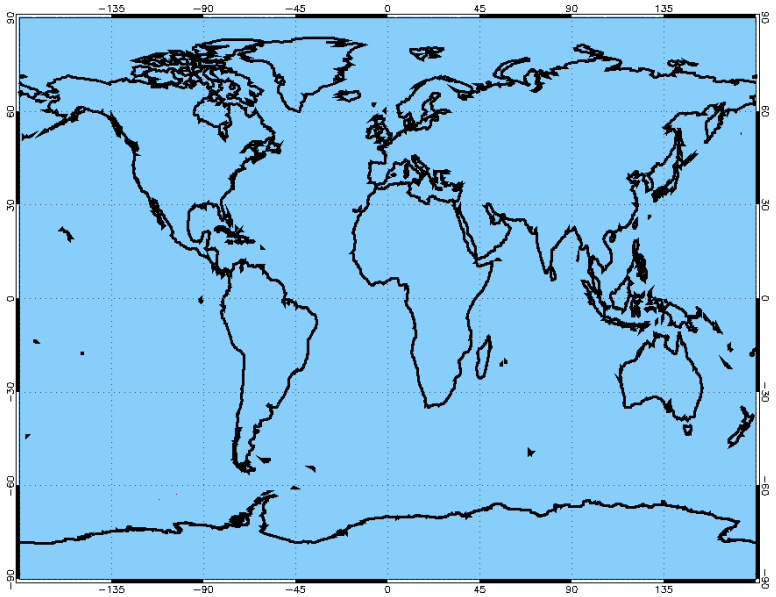


Bad M2 SDR Data: QF3, Bit 1
March 19, 2019

S-NPP



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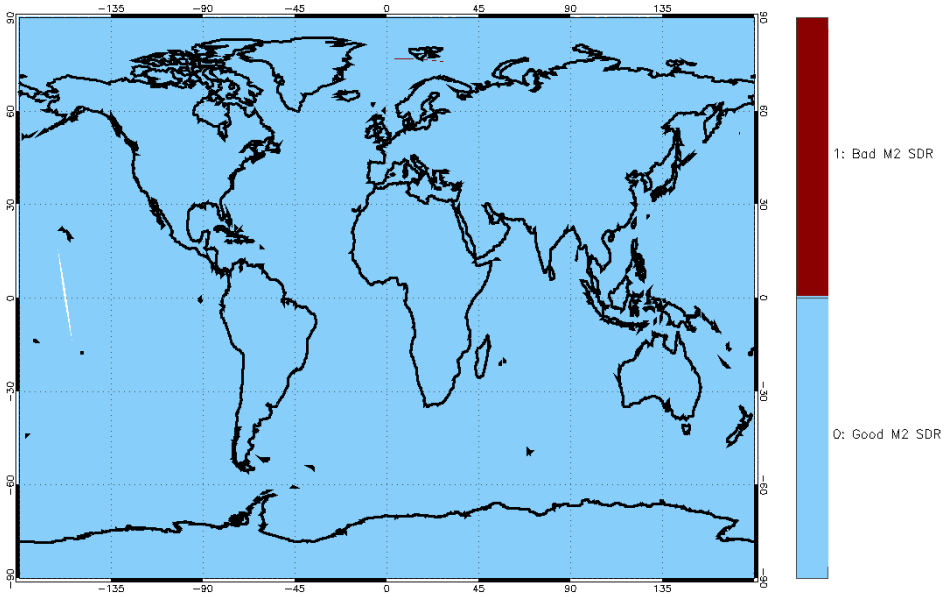
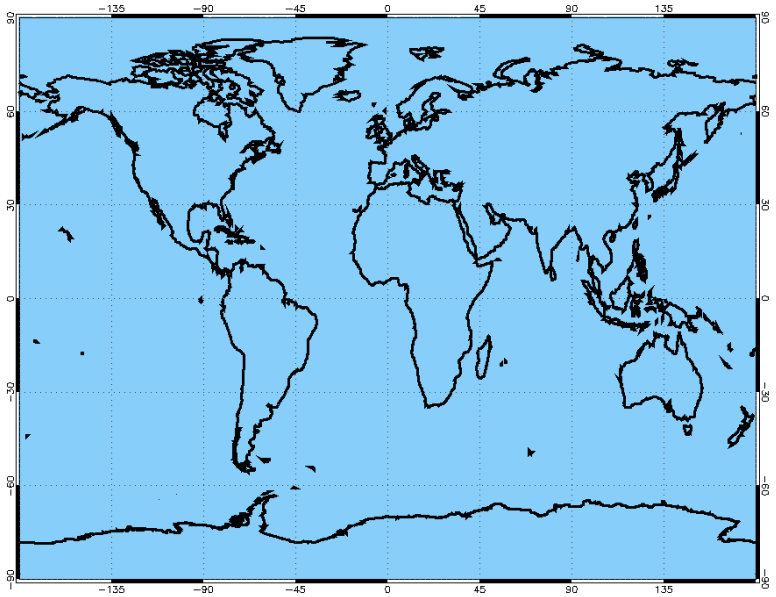


Bad M3 SDR Data: QF3, Bit 2
March 19, 2019

S-NPP



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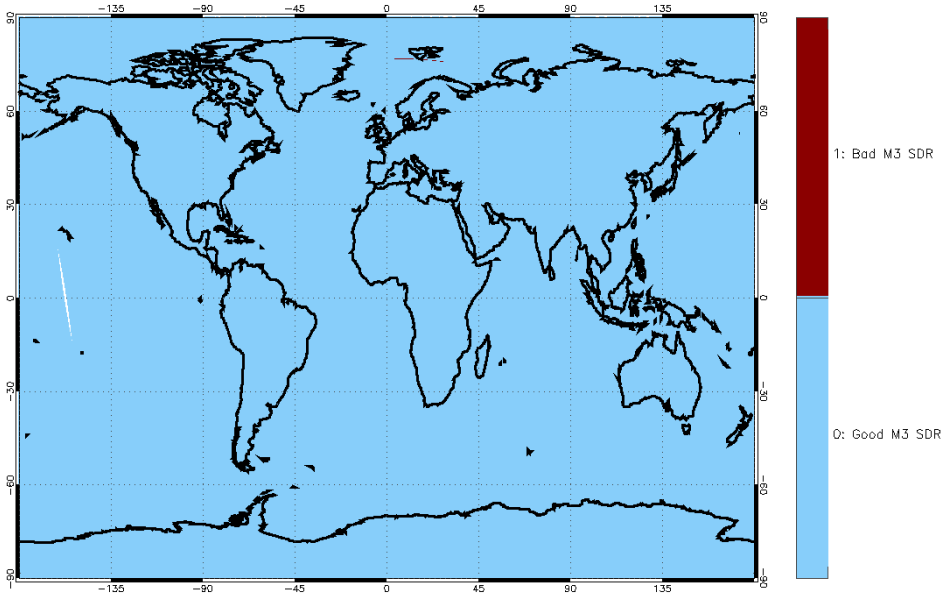
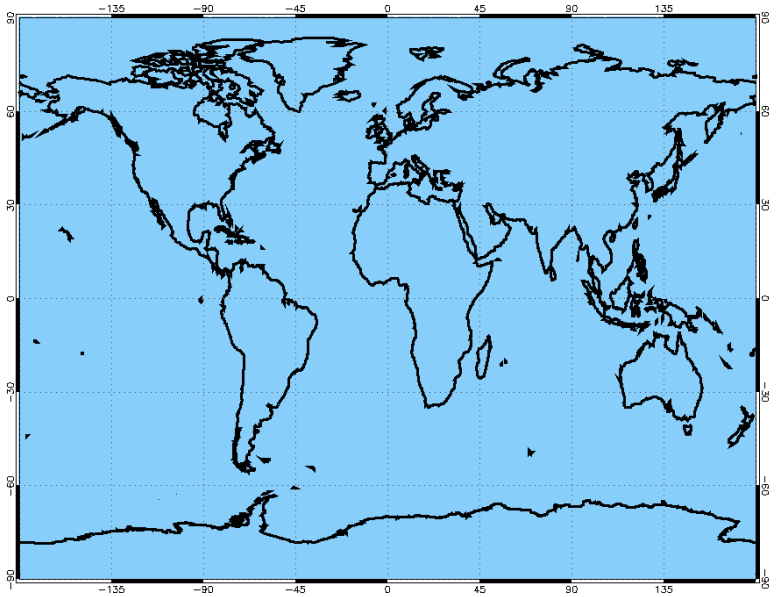
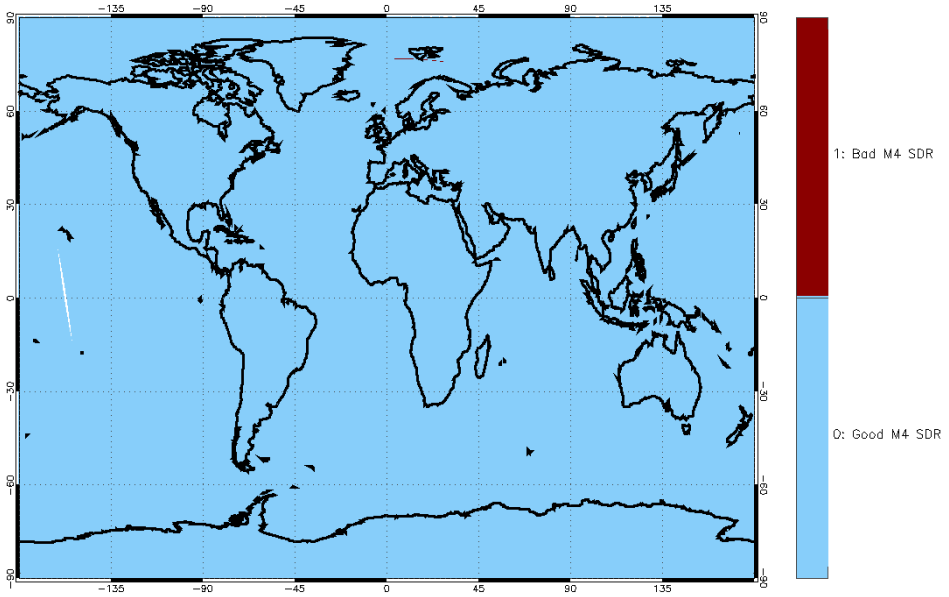


Bad M4 SDR Data: QF3, Bit 3
March 19, 2019

S-NPP

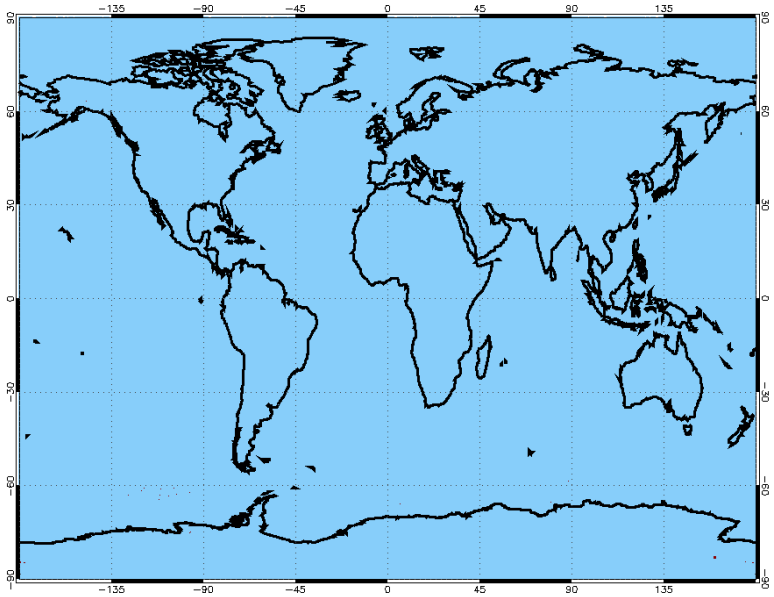


NOAA-20



Bad M5 SDR Data: QF3, Bit 4
March 19, 2019

S-NPP



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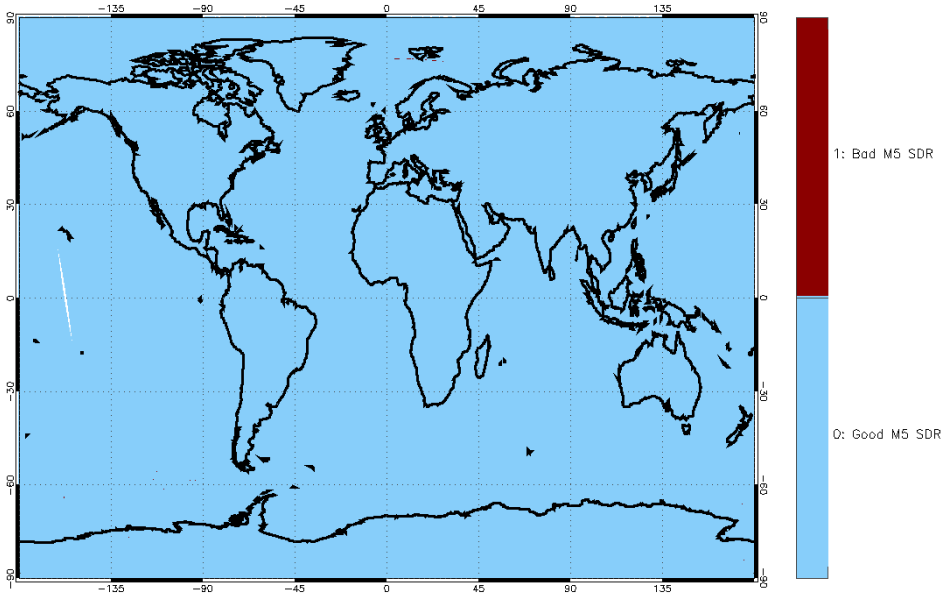
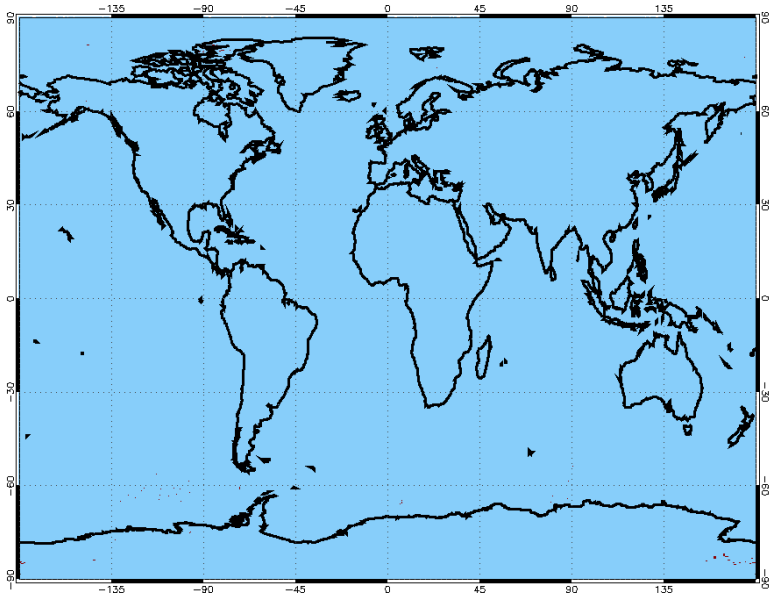


Bad M7 SDR Data: QF3, Bit 5
March 19, 2019

S-NPP



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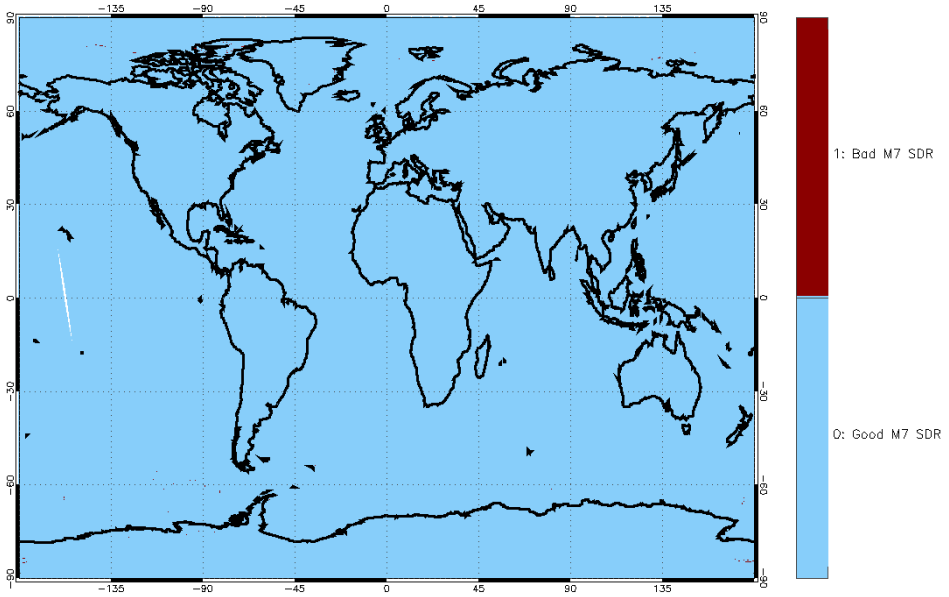
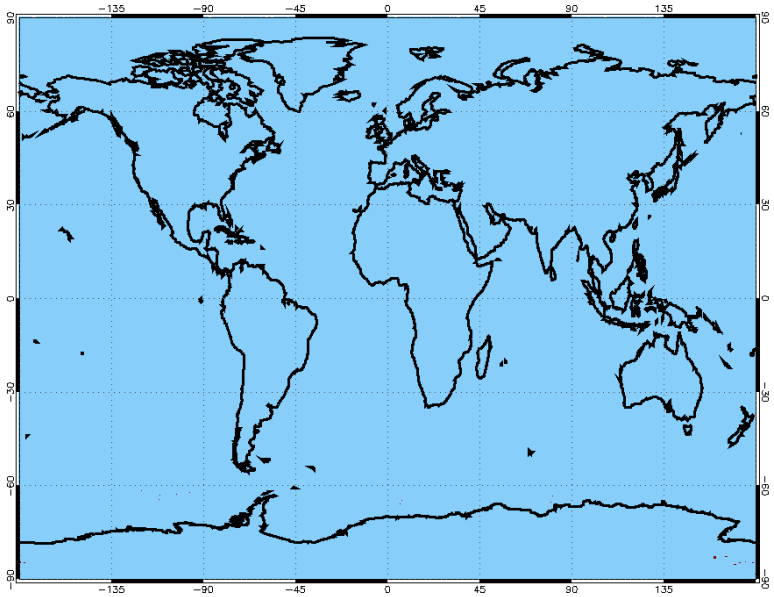
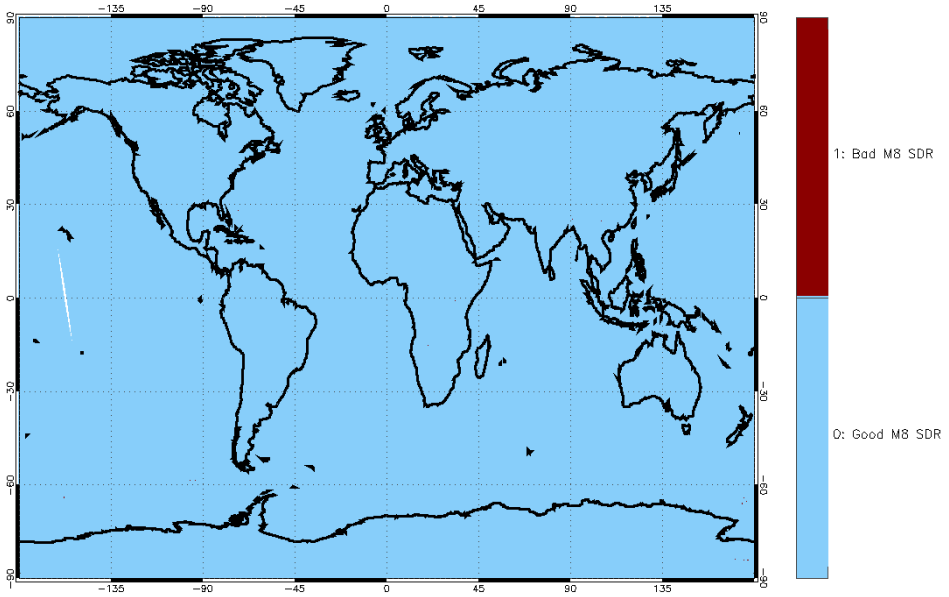


Bad M8 SDR Data: QF3, Bit 6
March 19, 2019

S-NPP

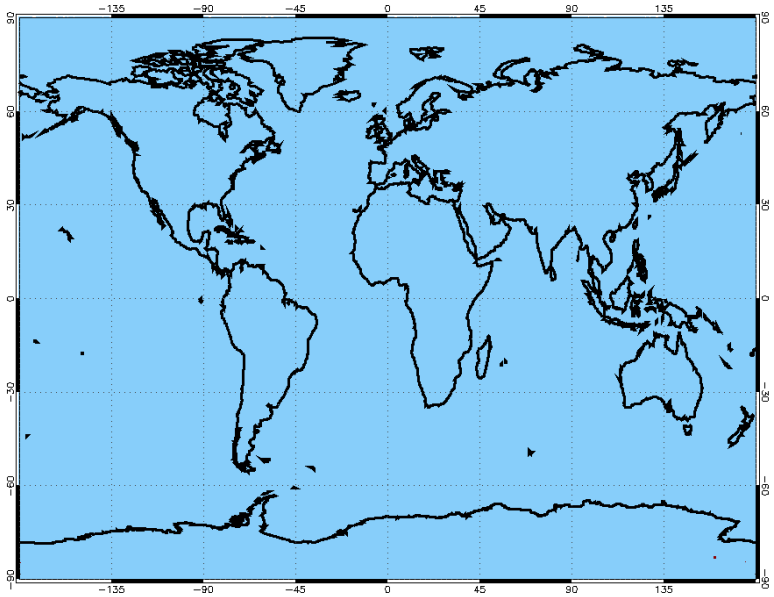


NOAA-20



Bad M10 SDR Data: QF3, Bit 7
March 19, 2019

S-NPP



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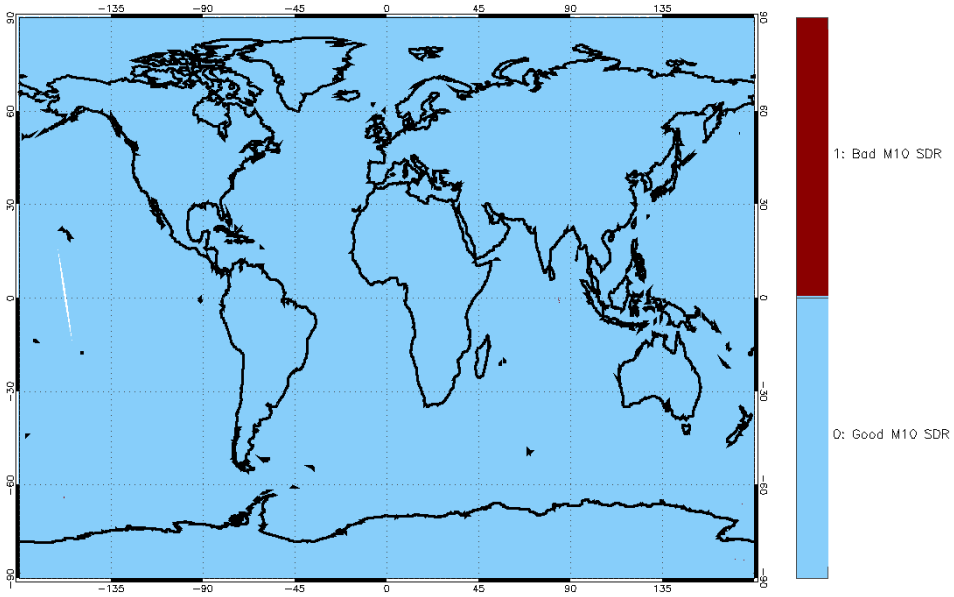
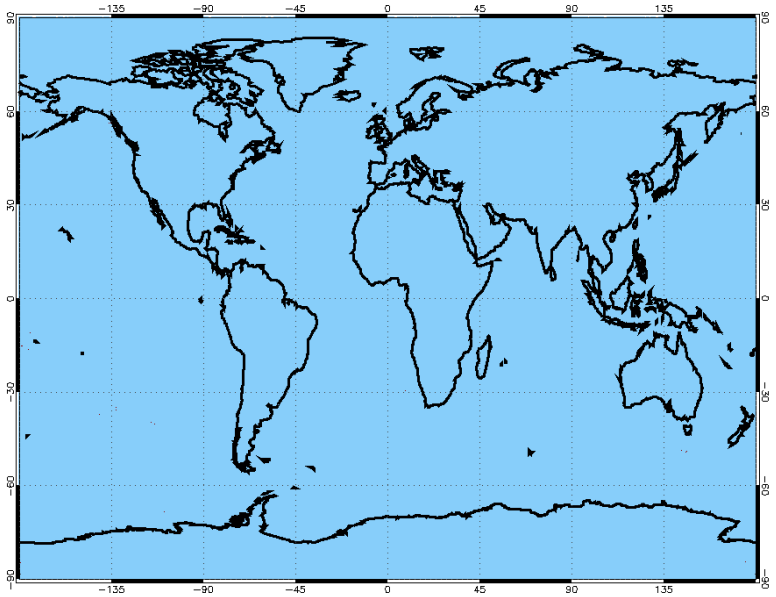


Bad M11 SDR Data: QF4, Bit 0
March 19, 2019

S-NPP



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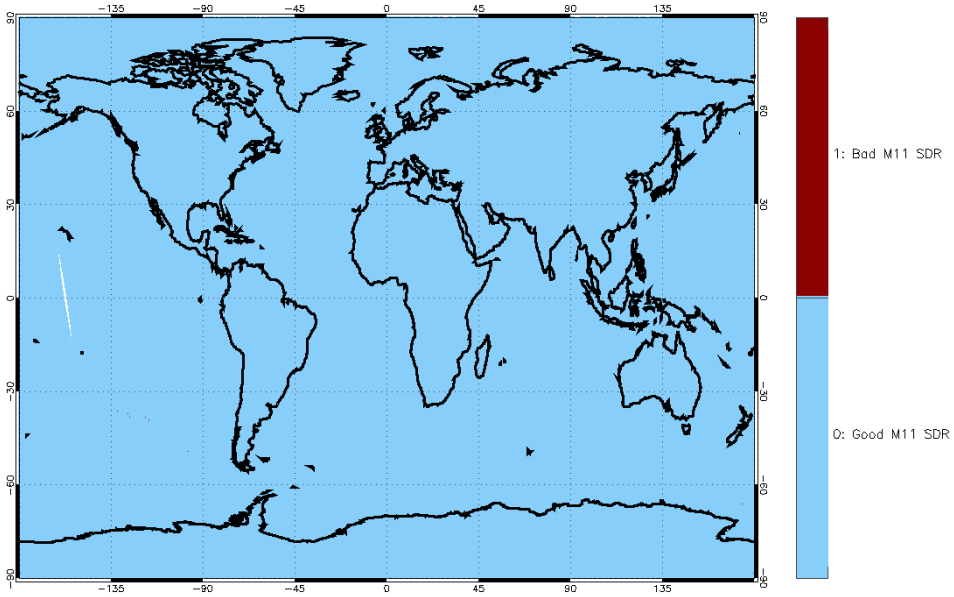
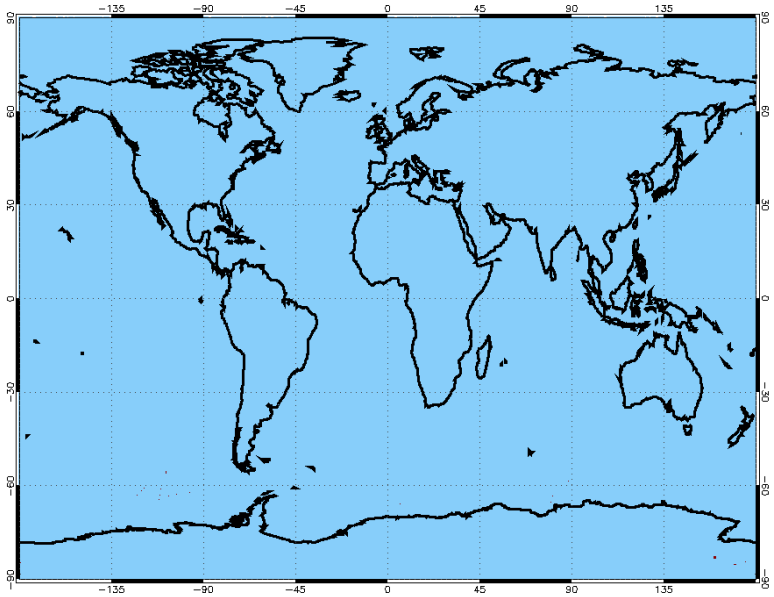


Bad I1 SDR Data: QF4, Bit 1
March 19, 2019

S-NPP



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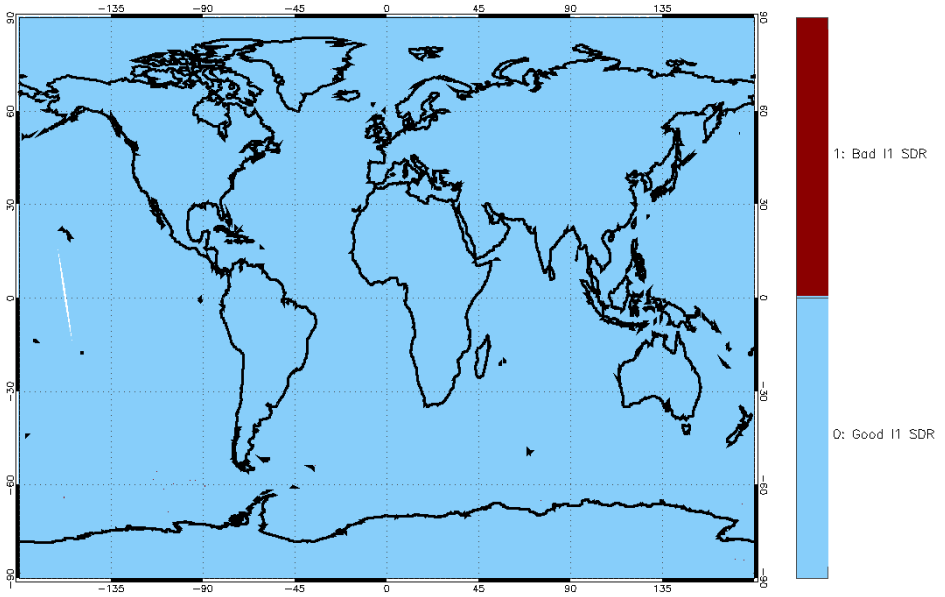
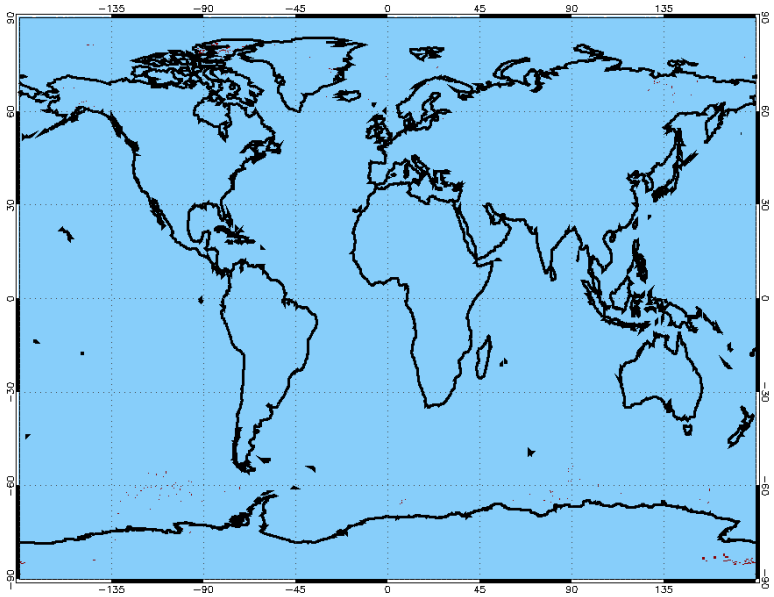


Bad I2 SDR Data: QF4, Bit 2
March 19, 2019

S-NPP



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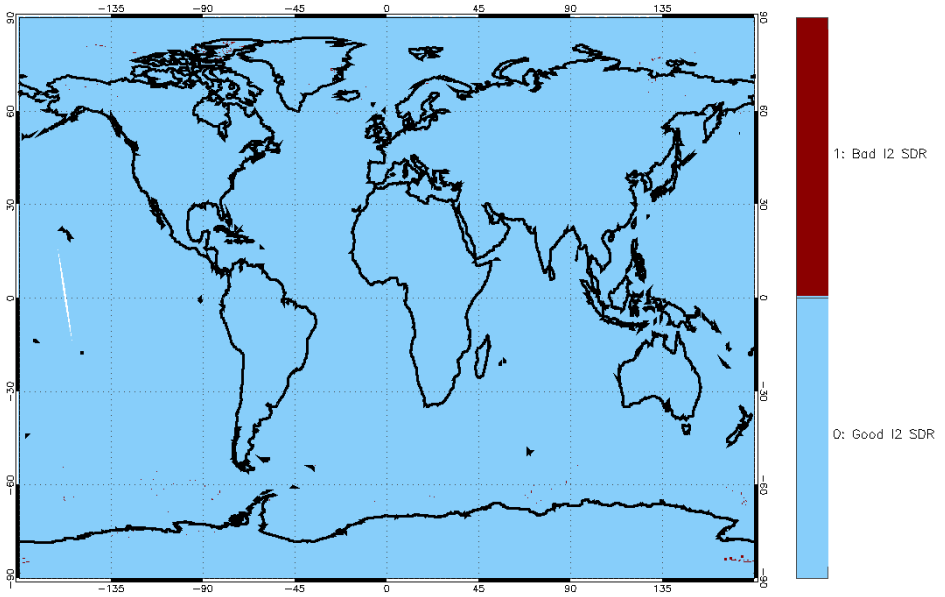
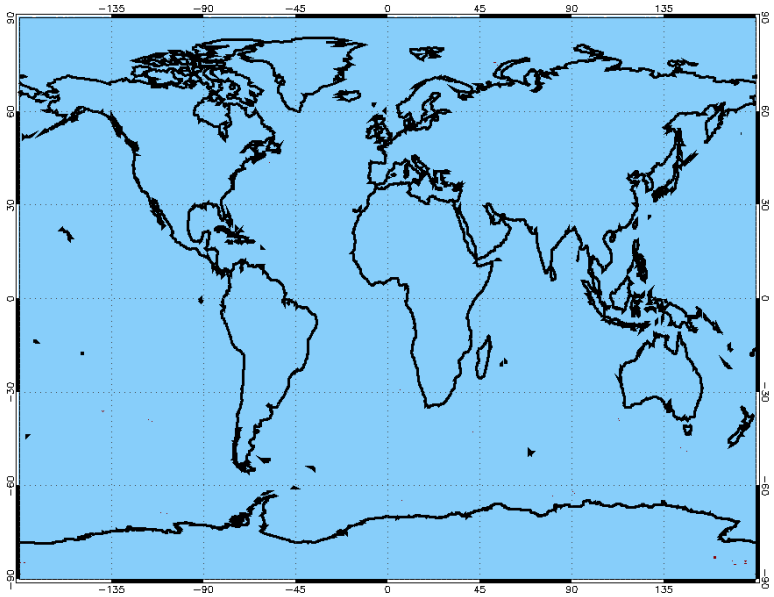


Bad I3 SDR Data: QF4, Bit 3
March 19, 2019

S-NPP



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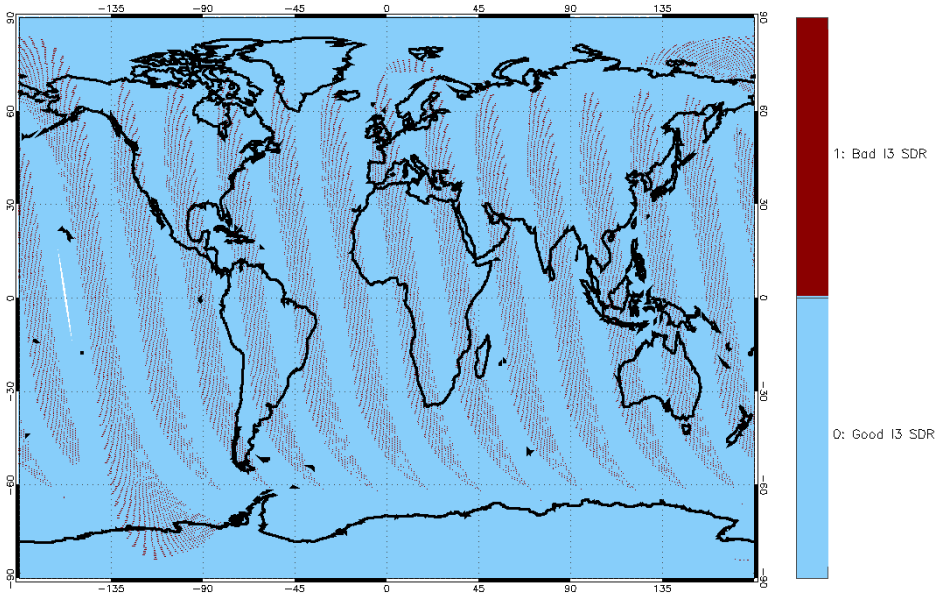
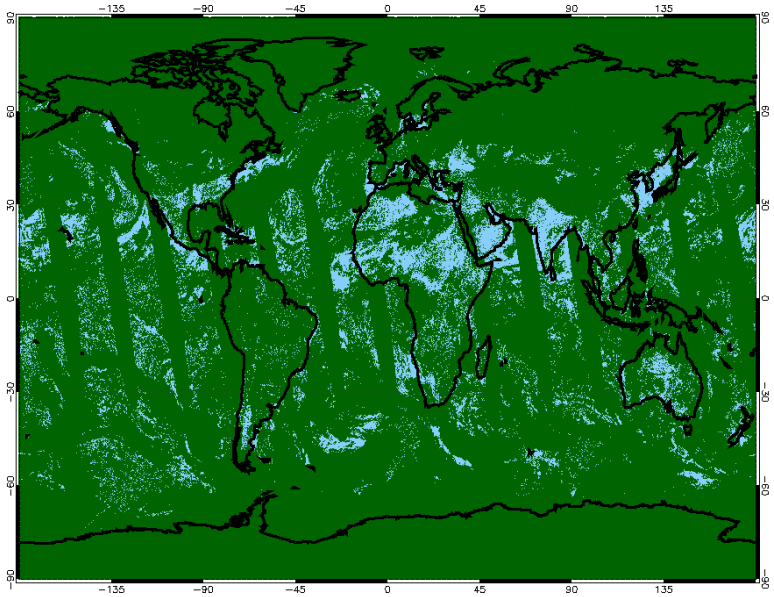


AOT Quality Flag: QF4, Bit 4
March 19, 2019

S-NPP



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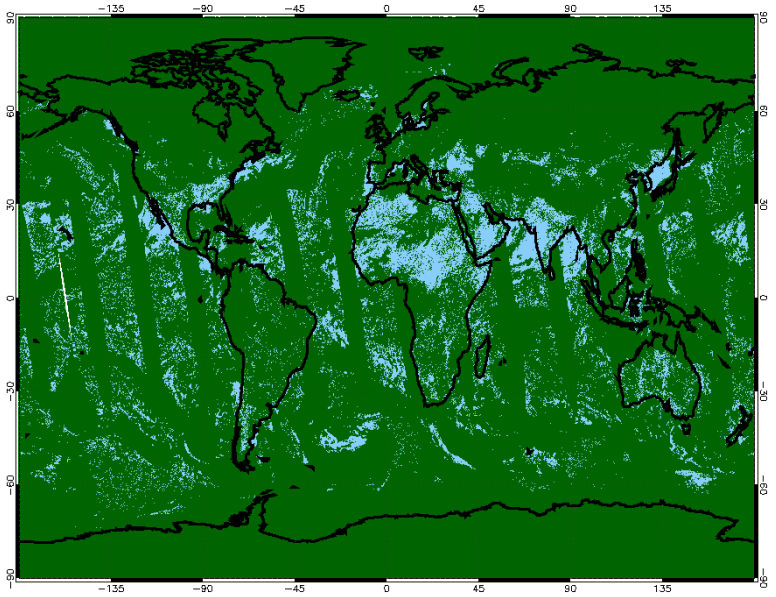
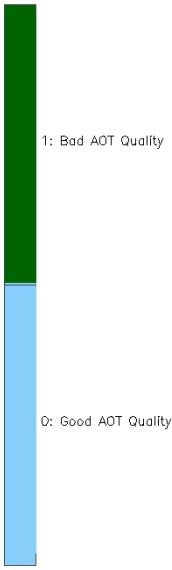
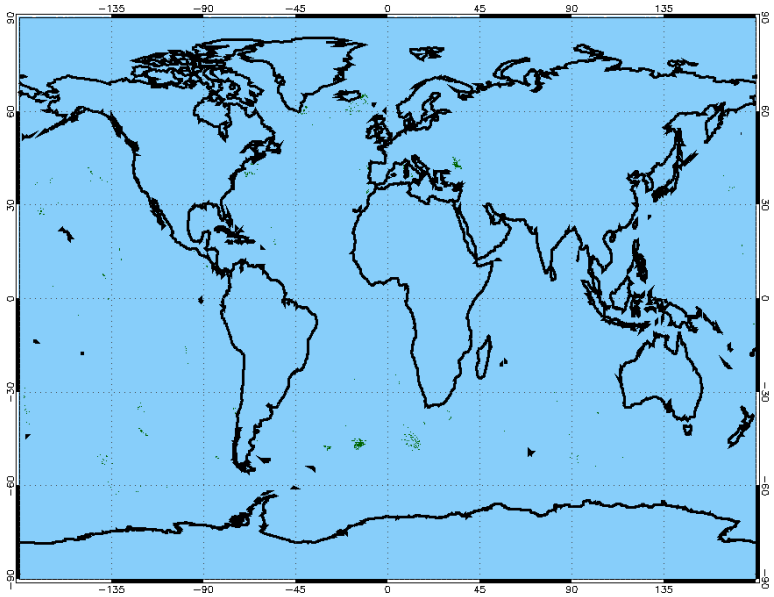


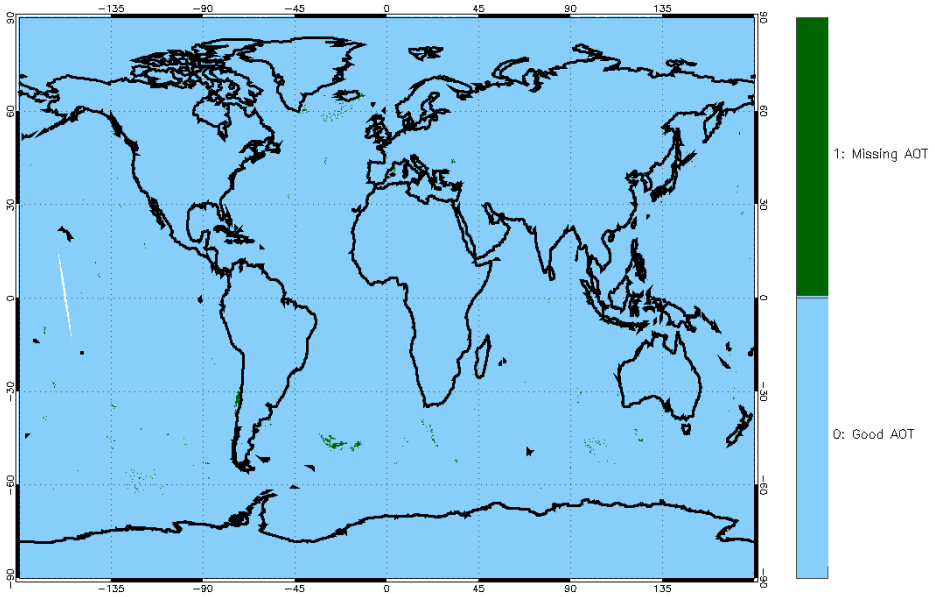


Missing AOT Flag: QF4, Bit 5
March 19, 2019

S-NPP

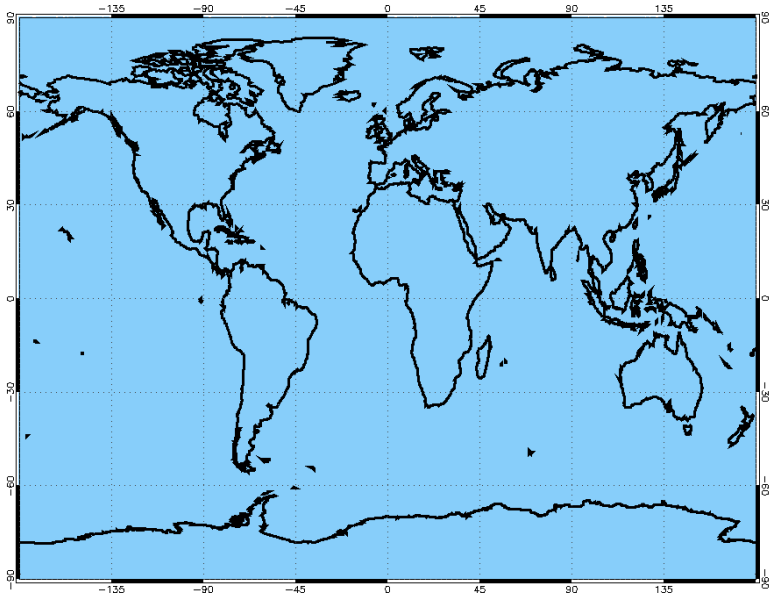


NOAA-20



Invalid Land AM: QF4, Bit 6
March 19, 2019

S-NPP



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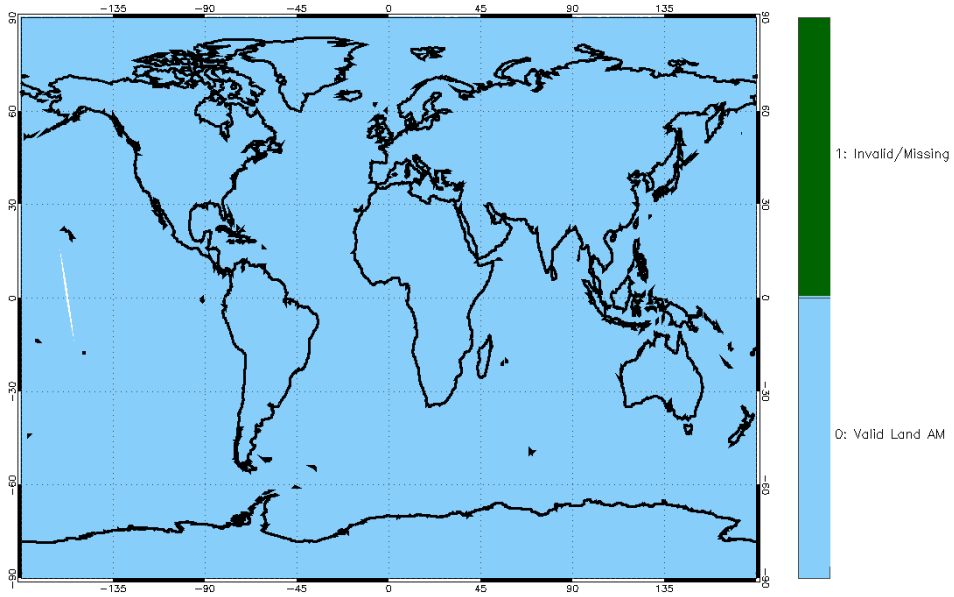
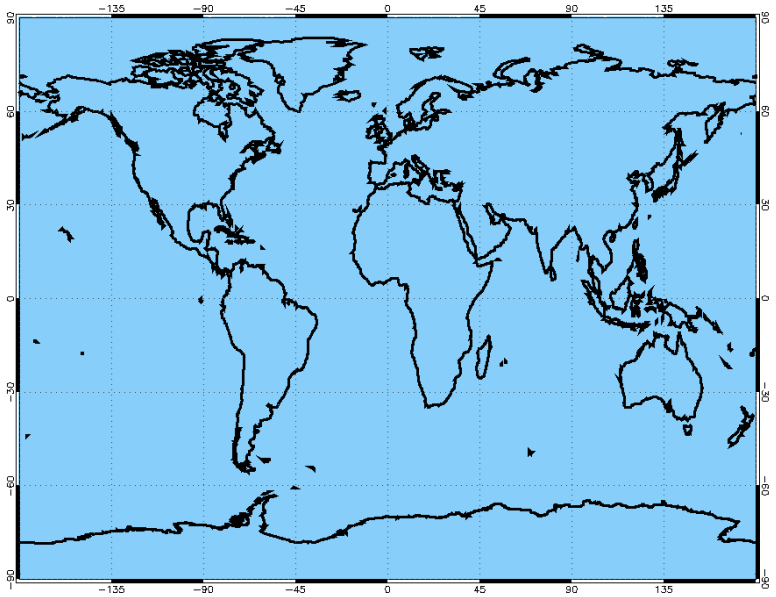


Missing Precipitation Flag: QF4, Bit 7
March 19, 2019

S-NPP



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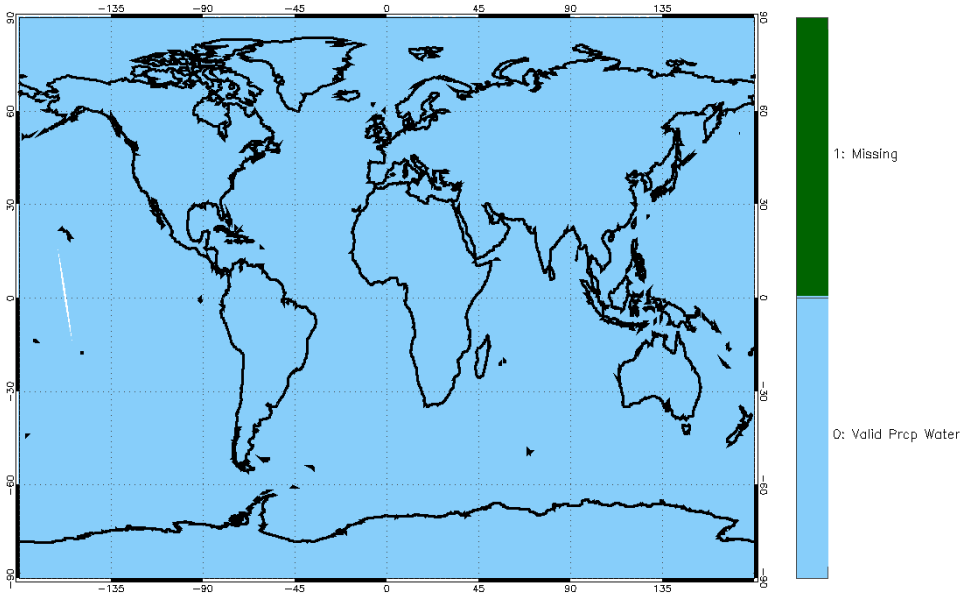
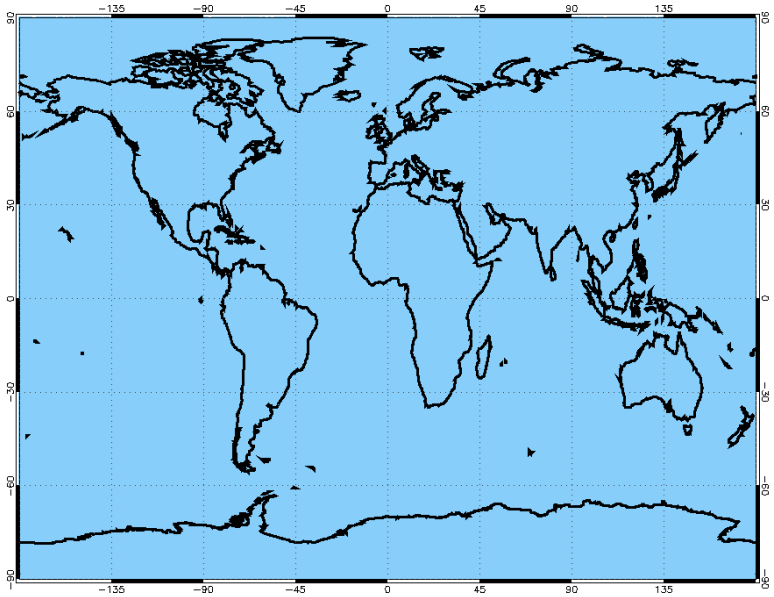


Missing Total Ozone Flag: QF5, Bit 0
March 19, 2019

S-NPP



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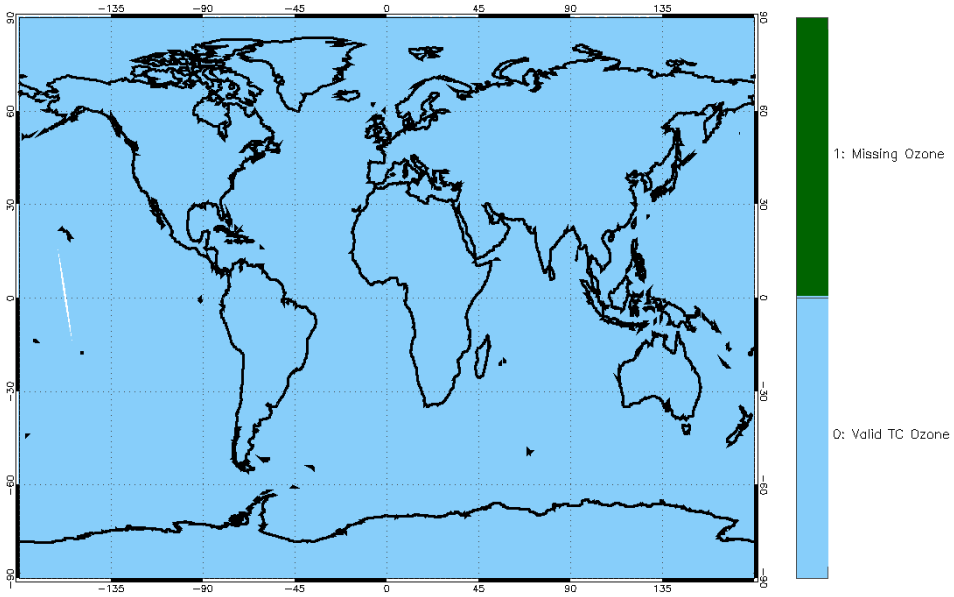
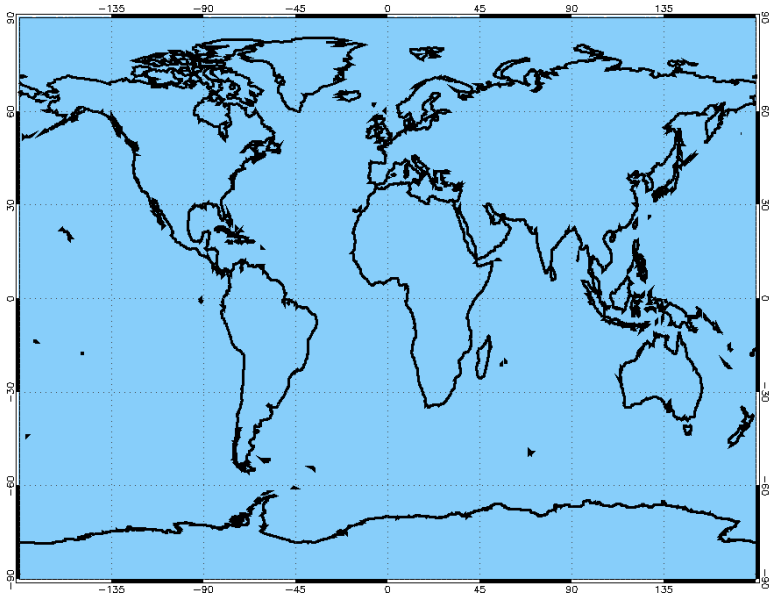


Missing Surface Pressure Flag: QF5, Bit 1
March 19, 2019

S-NPP



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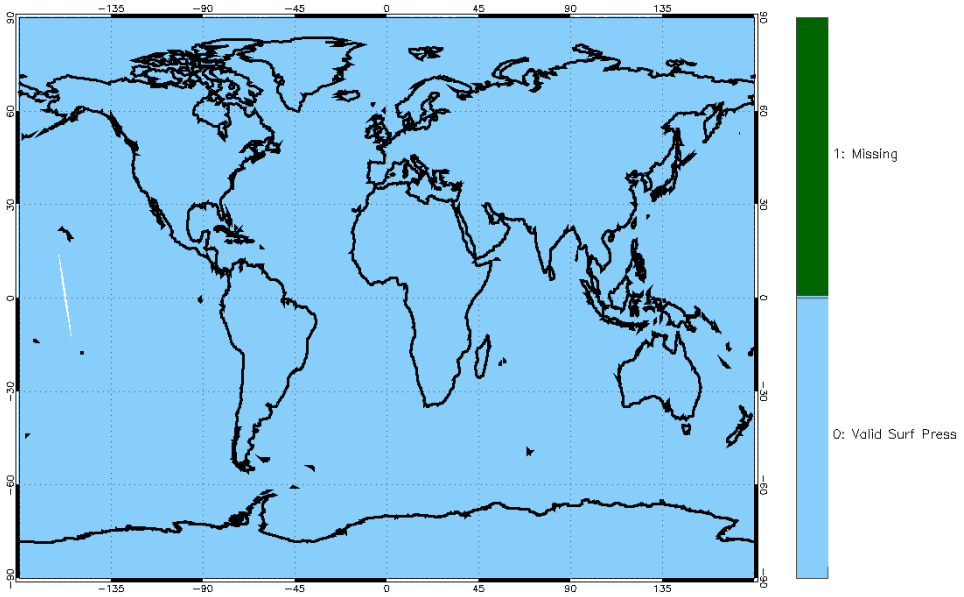
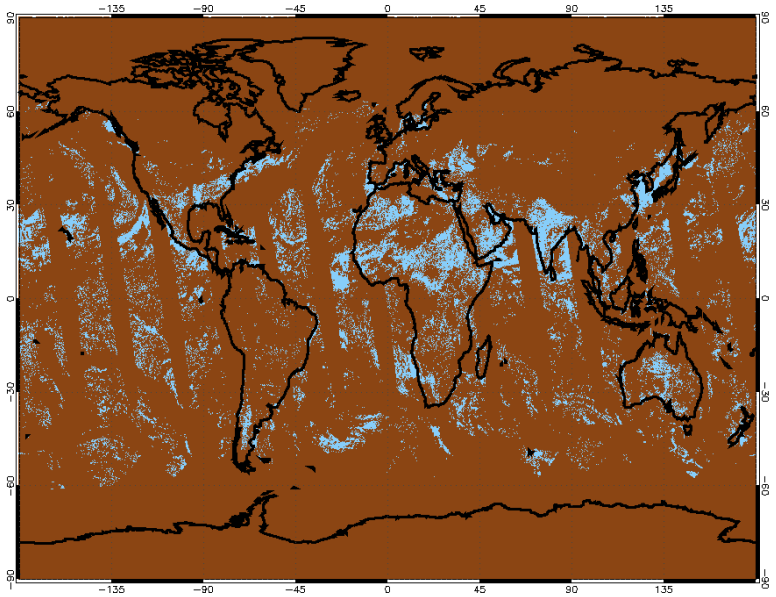


Overall Quality of M1 SR: QF5, Bit 2
March 19, 2019

S-NPP



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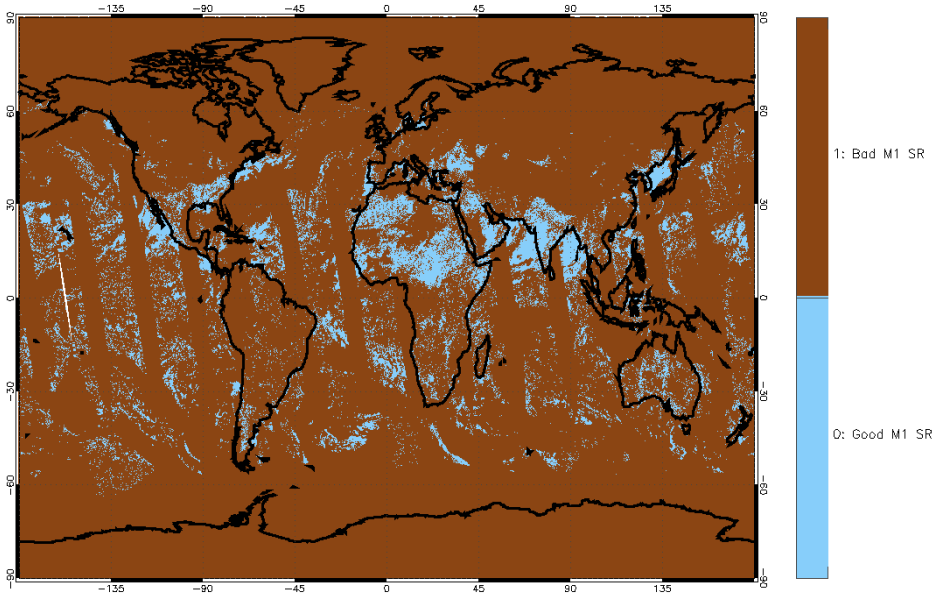
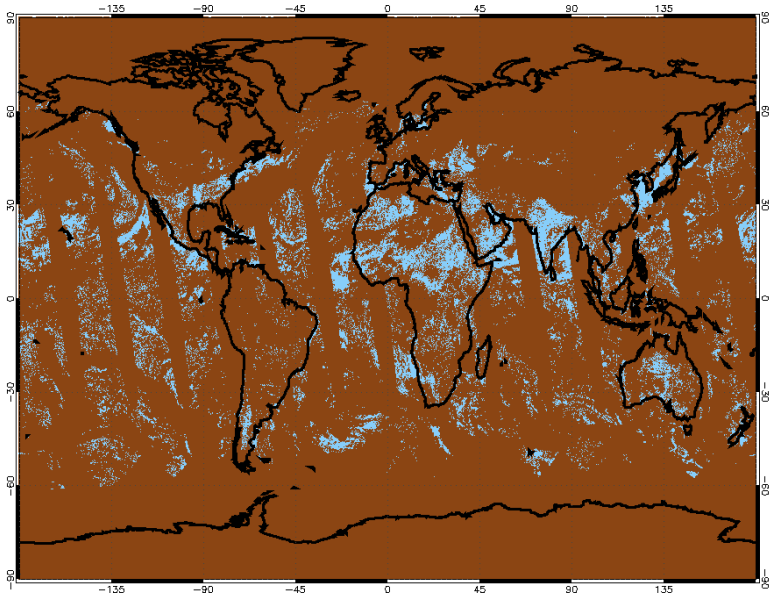


Overall Quality of M2 SR: QF5, Bit 3
March 19, 2019

S-NPP



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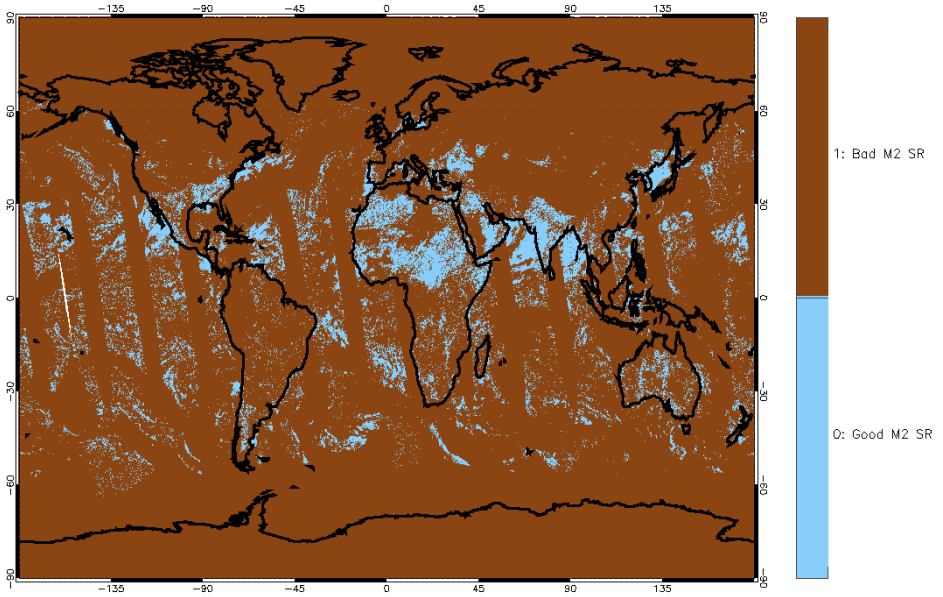
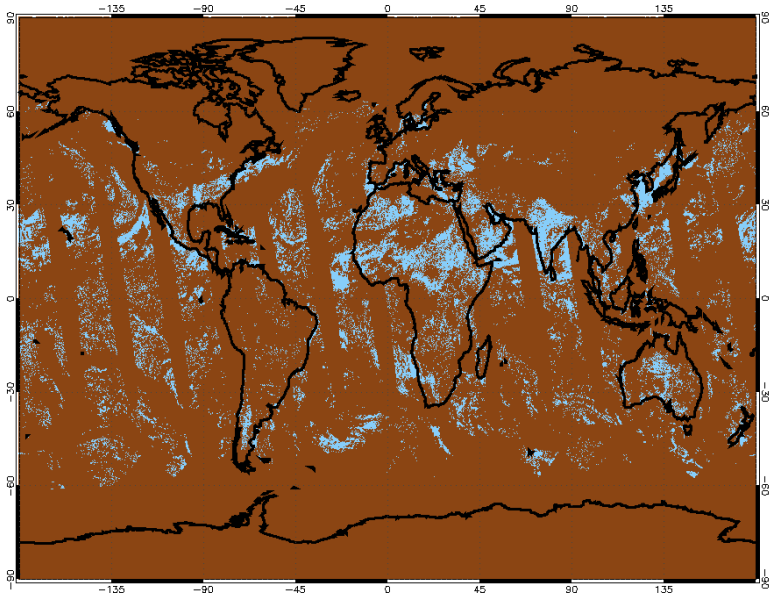
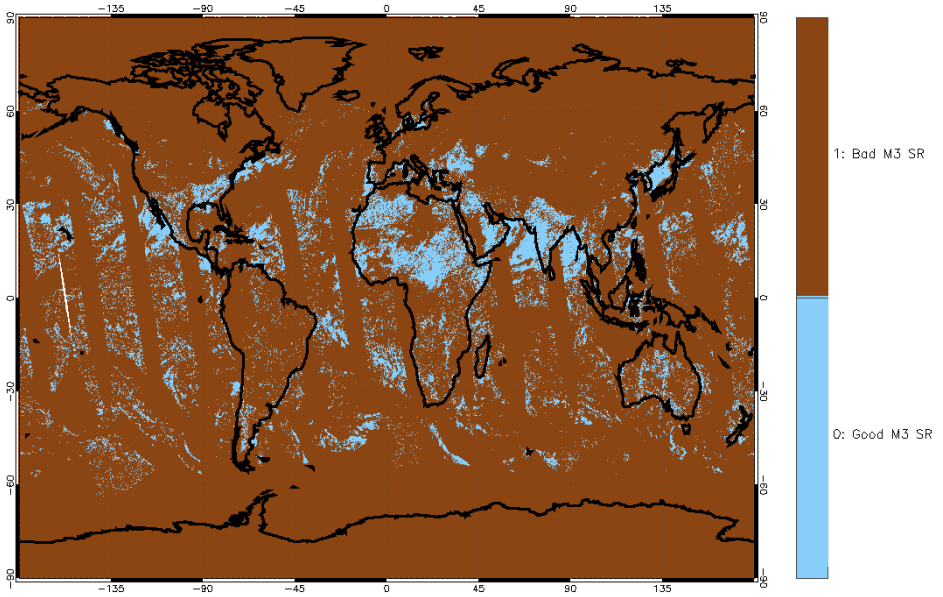


Overall Quality of M3 SR: QF5, Bit 4
March 19, 2019

S-NPP

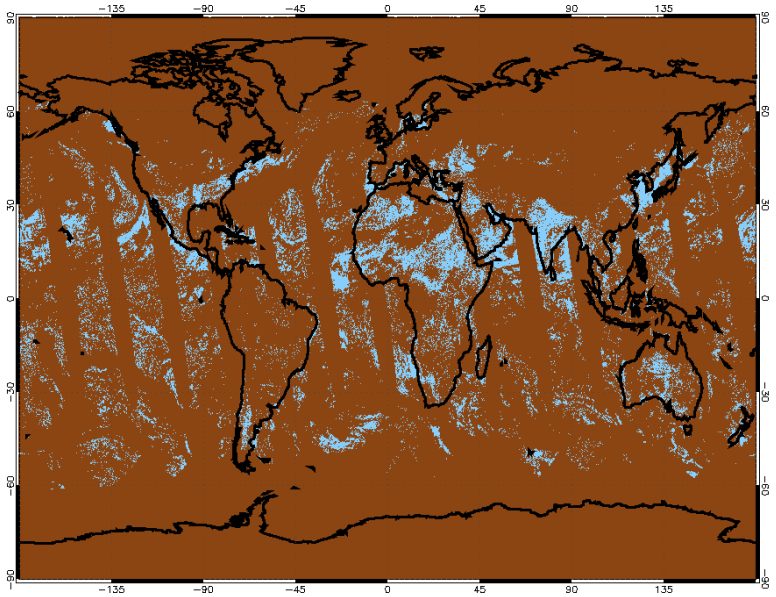


NOAA-20

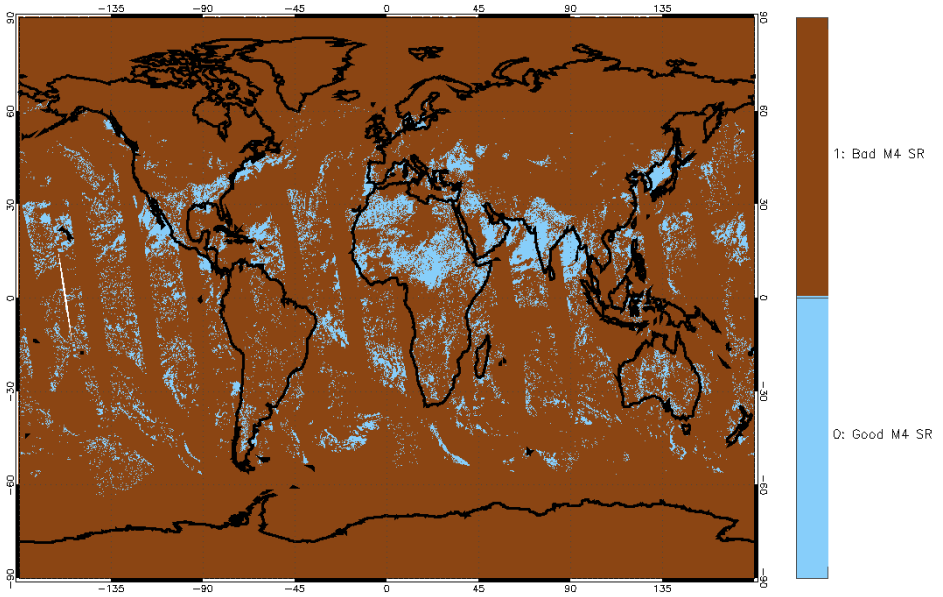


Overall Quality of M4 SR: QF5, Bit 5
March 19, 2019

S-NPP

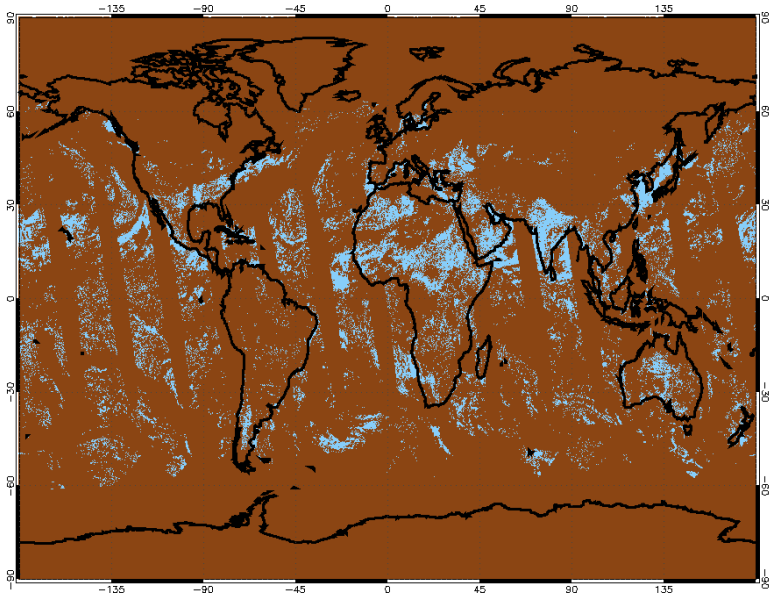


NOAA-20

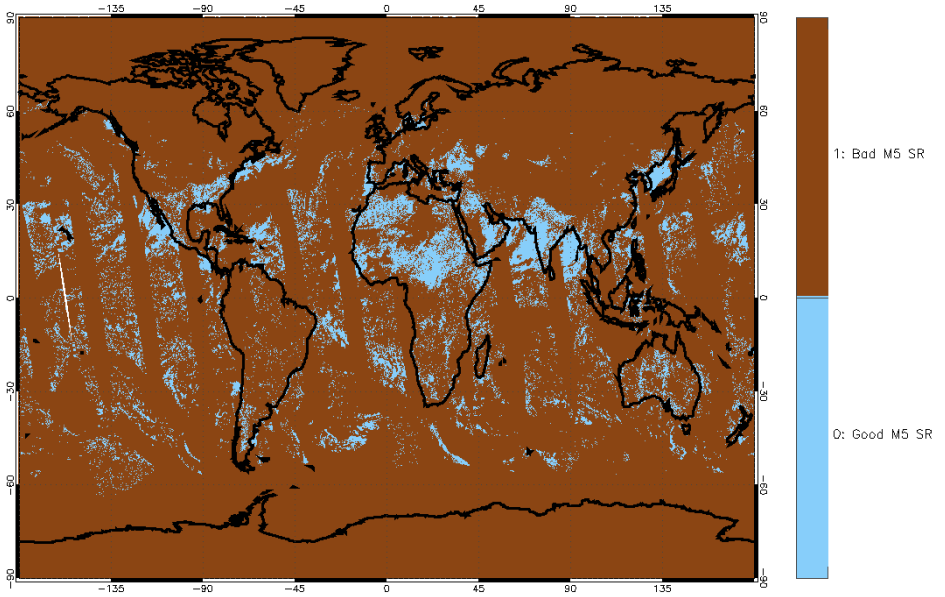


Overall Quality of M5 SR: QF5, Bit 6
March 19, 2019

S-NPP

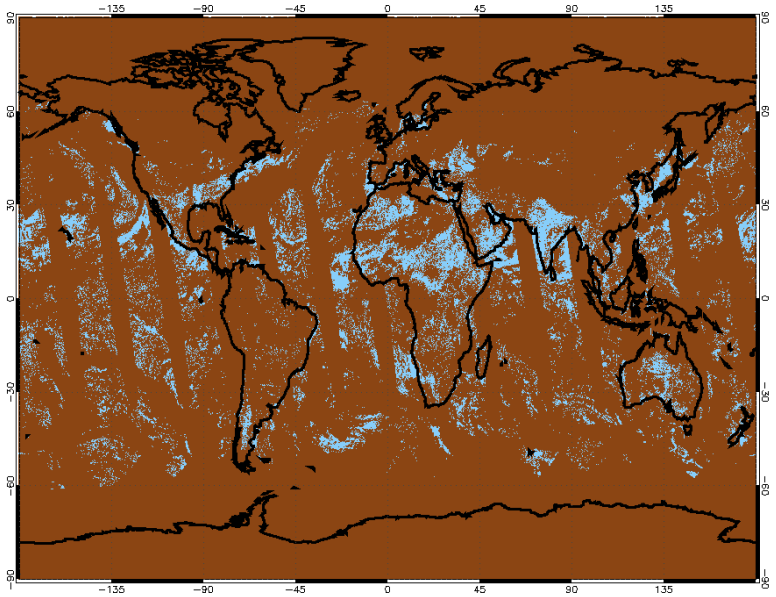


NOAA-20



Overall Quality of M7 SR: QF5, Bit 7
March 19, 2019

S-NPP



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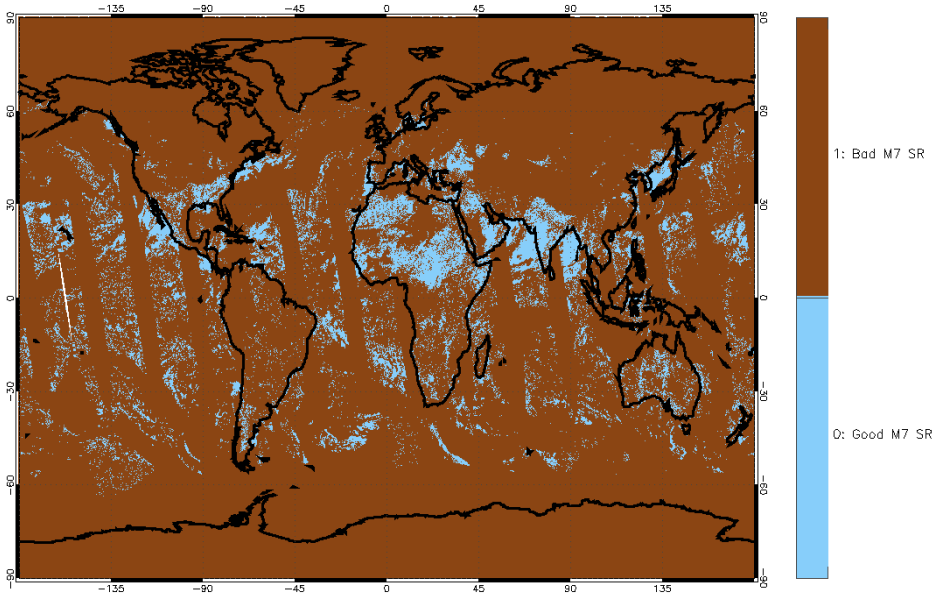
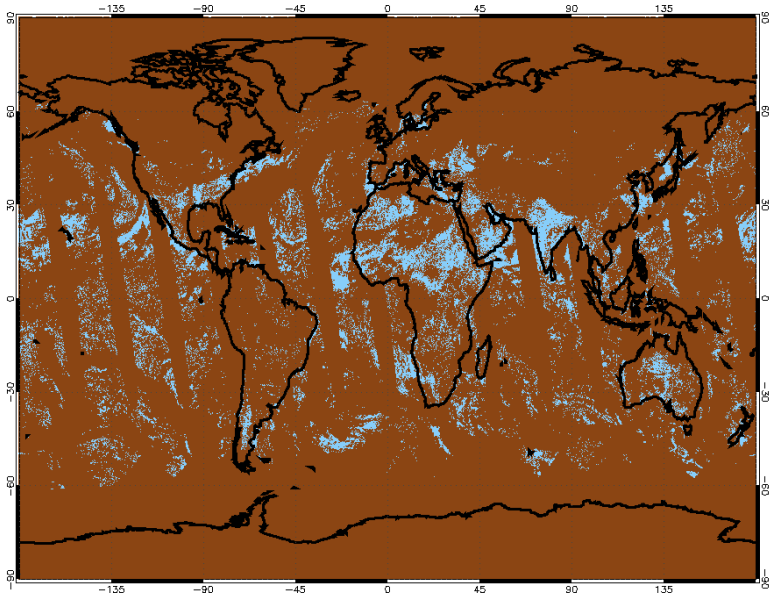


Overall Quality of M8 SR: QF6, Bit 0
March 19, 2019

S-NPP



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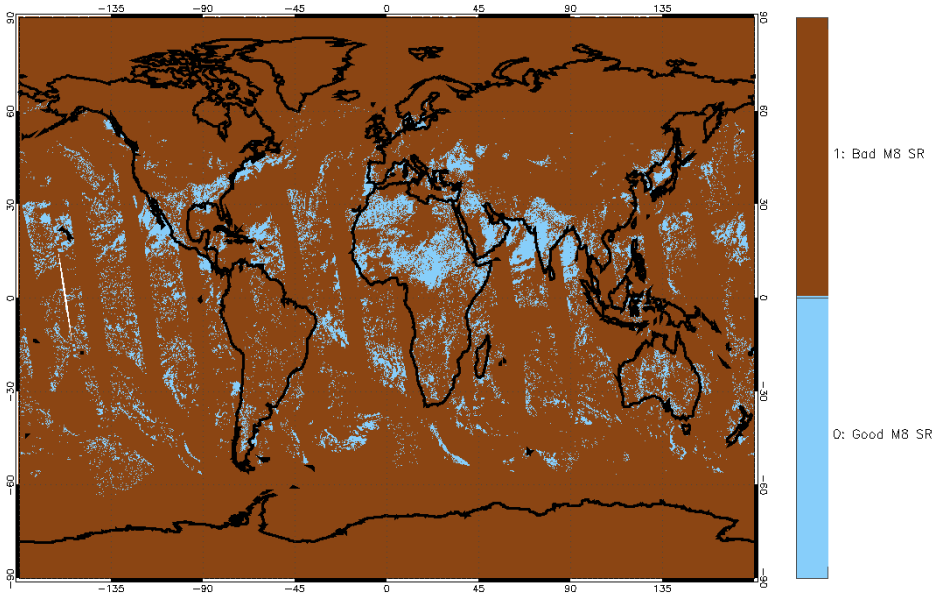
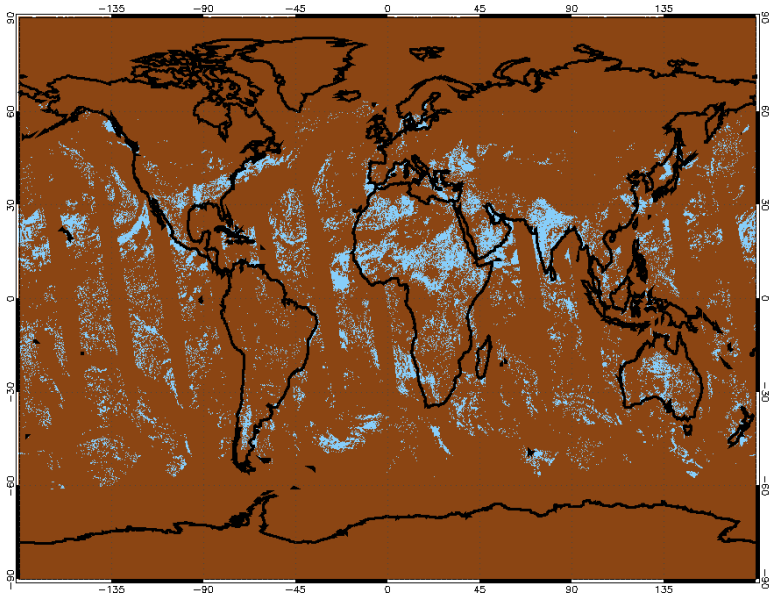


Overall Quality of M10 SR: QF6, Bit 1
March 19, 2019

S-NPP



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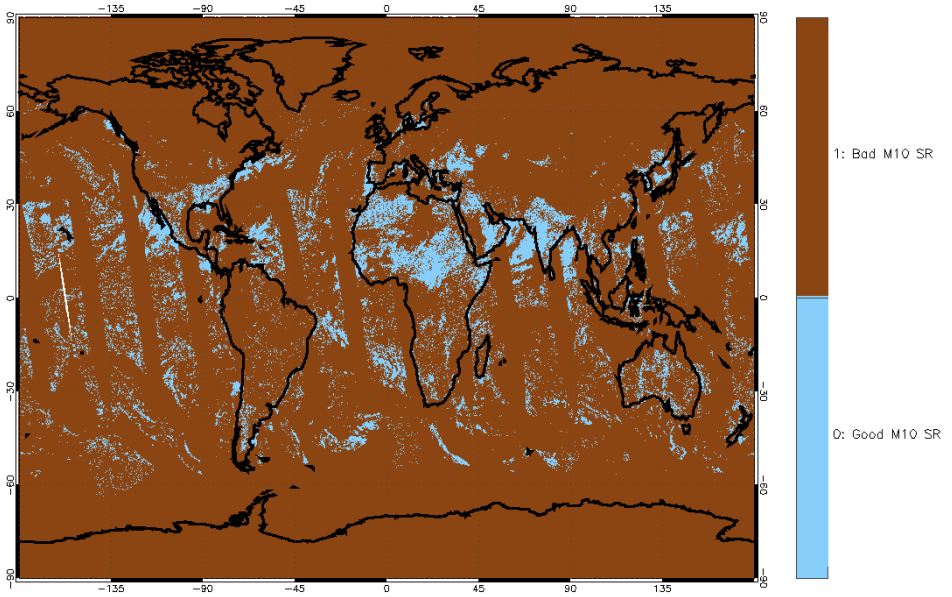
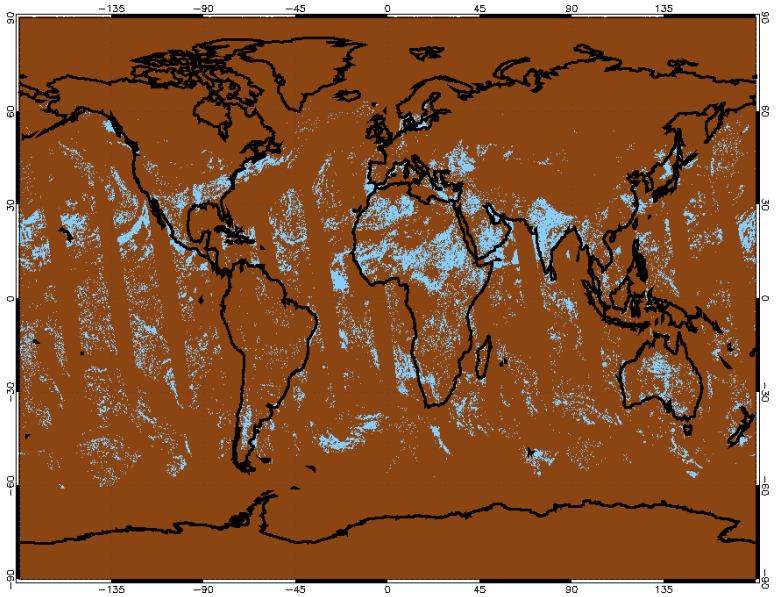
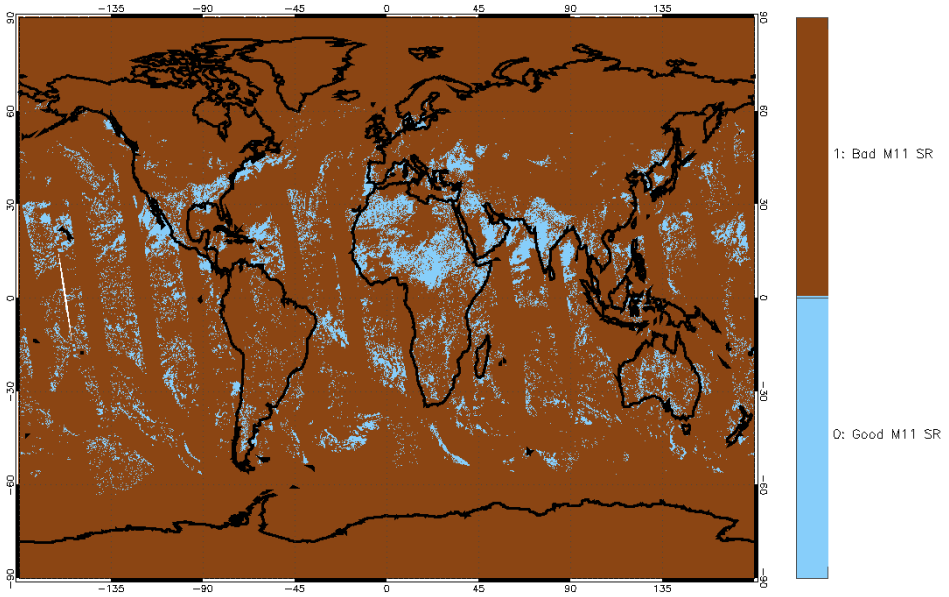


Overall Quality of M11 SR: QF6, Bit 2
March 19, 2019

S-NPP

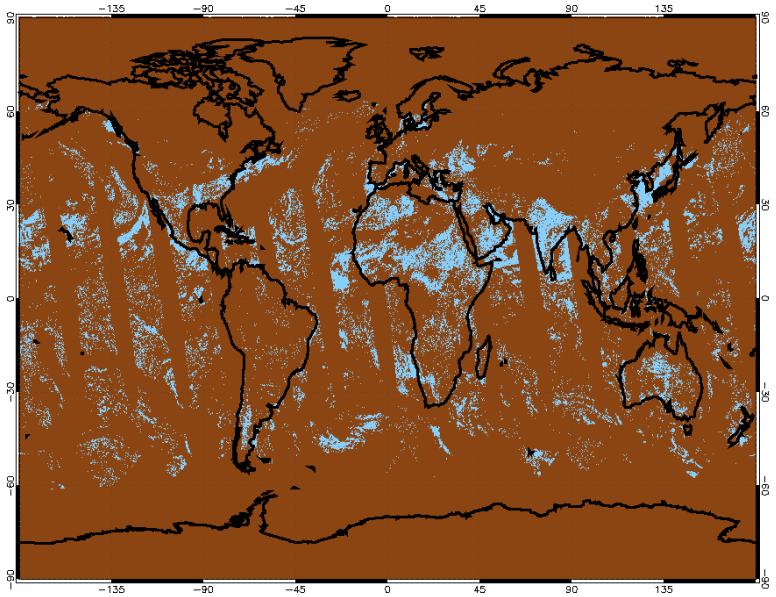


NOAA-20

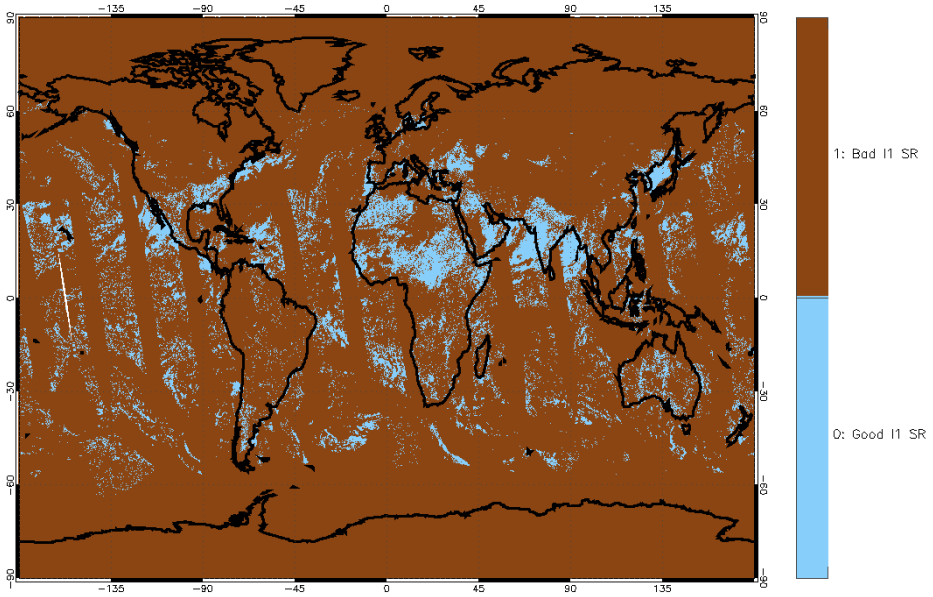


Overall Quality of I1 SR: QF6, Bit 3
March 19, 2019

S-NPP

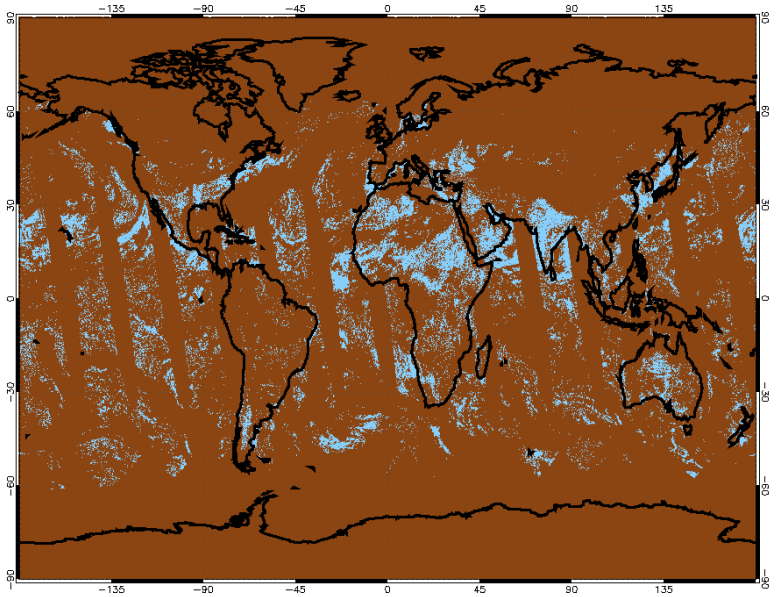


NOAA-20

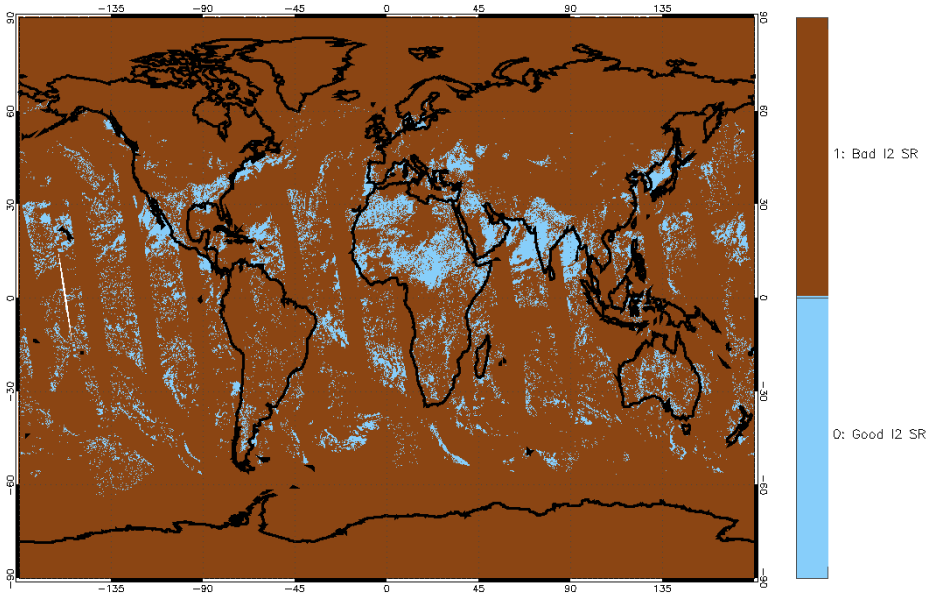


Overall Quality of I2 SR: QF6, Bit 4
March 19, 2019

S-NPP

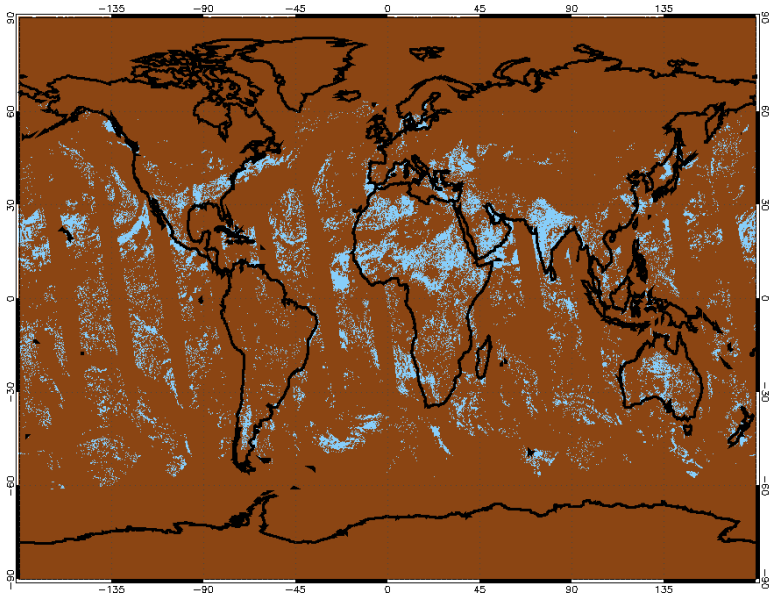


NOAA-20

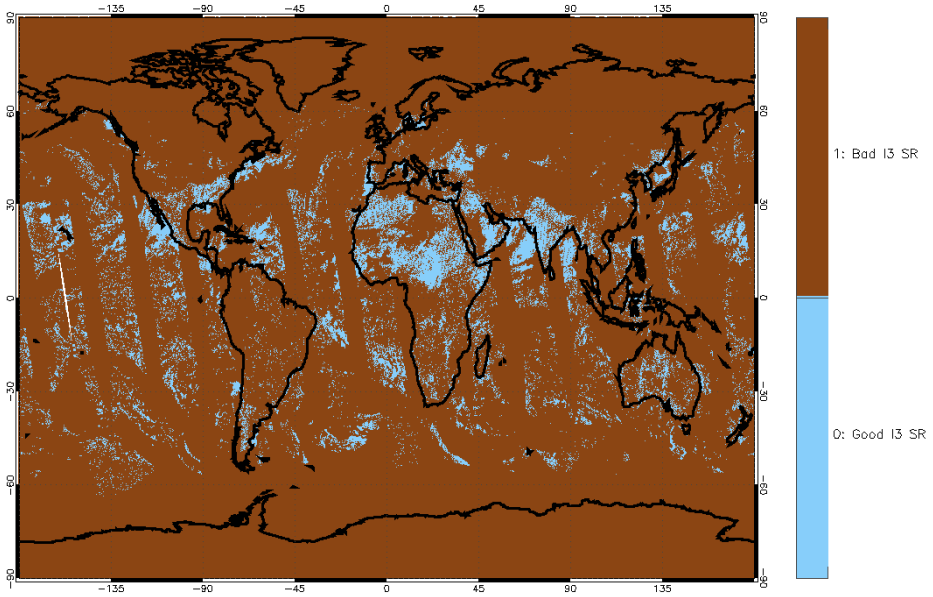


Overall Quality of I3 SR: QF6, Bit 5
March 19, 2019

S-NPP

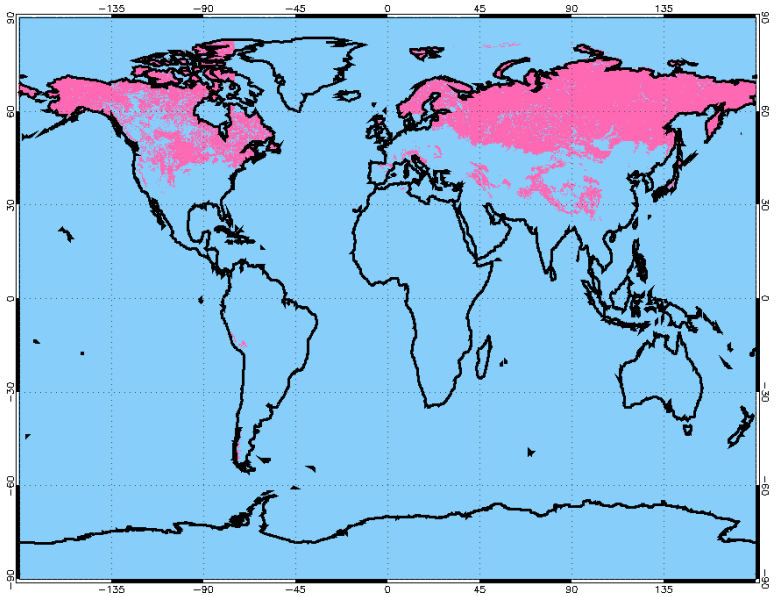


NOAA-20

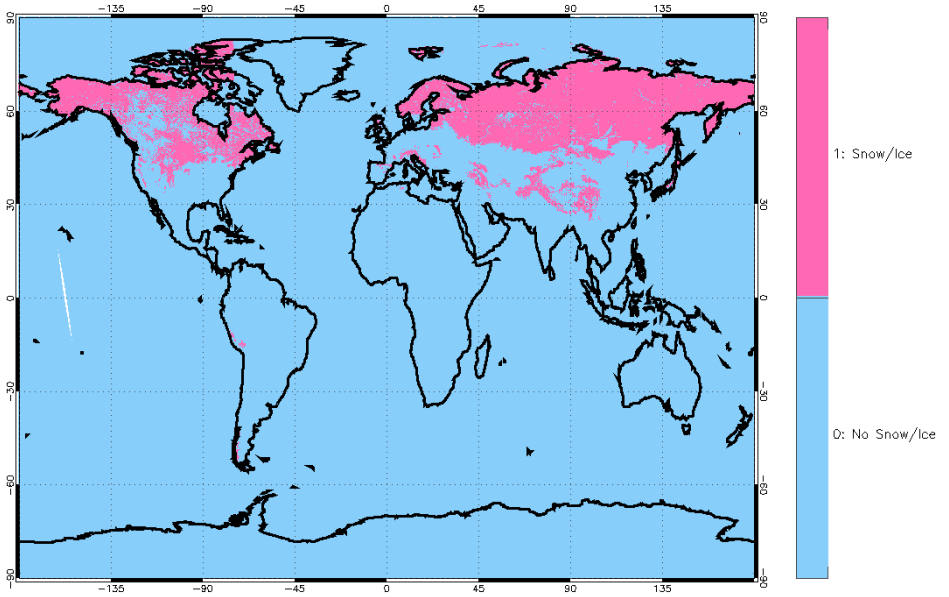


Snow Present Flag: QF7, Bit 0
March 19, 2019

S-NPP

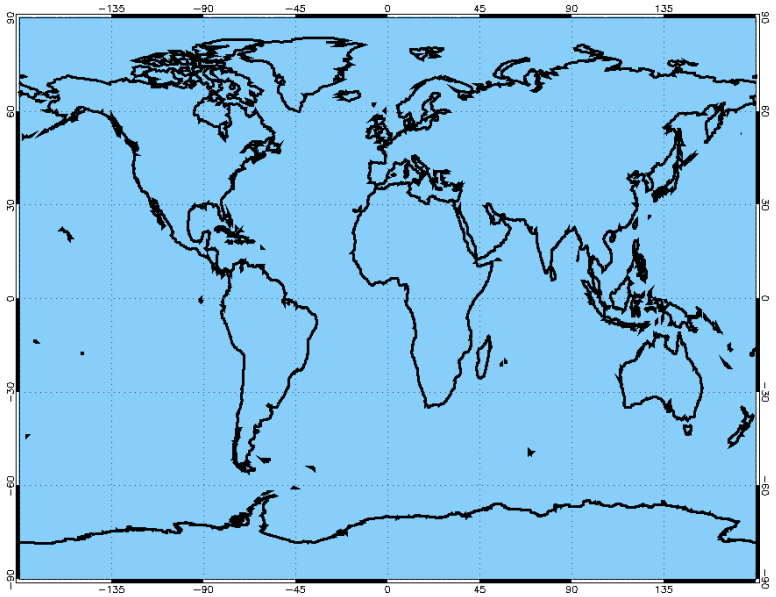


NOAA-20

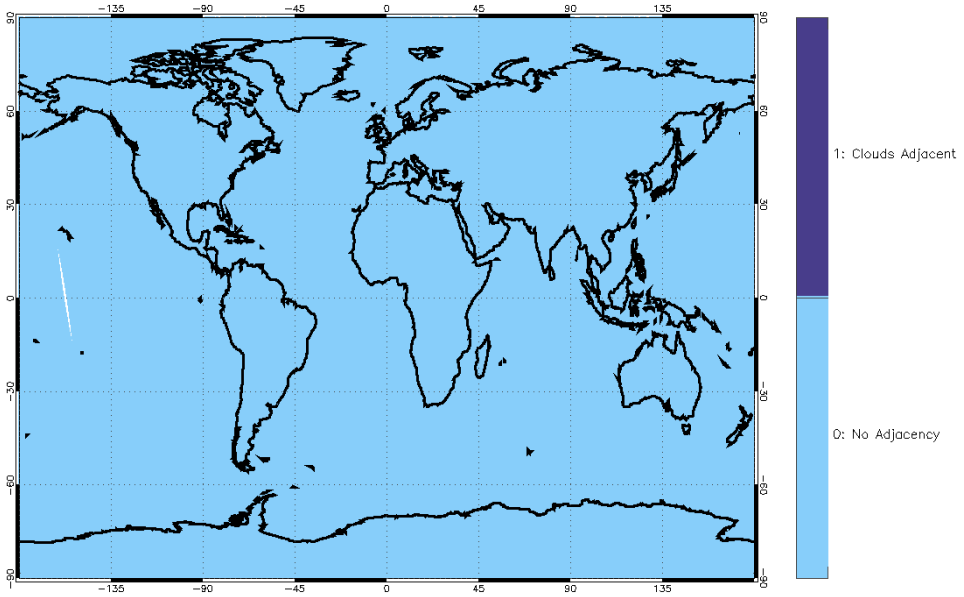


Cloud Adjacency Flag (not used): QF7, Bit 1
March 19, 2019

S-NPP

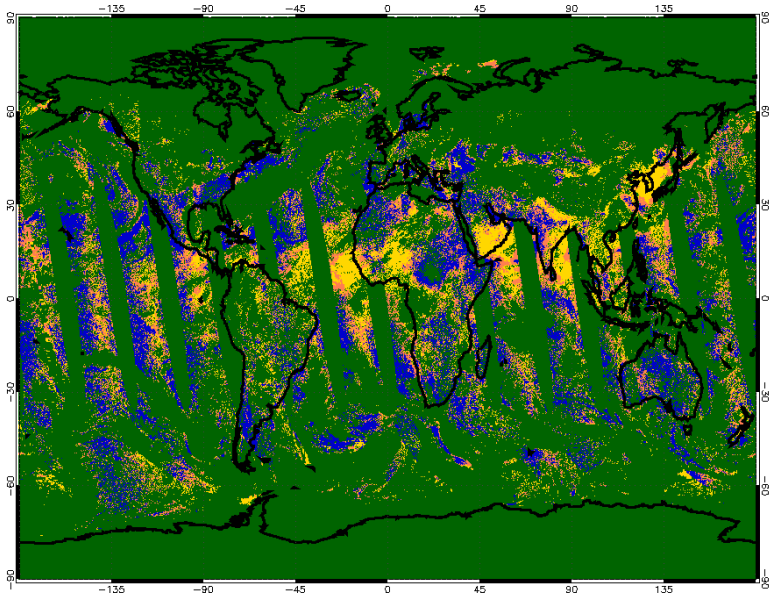


NOAA-20

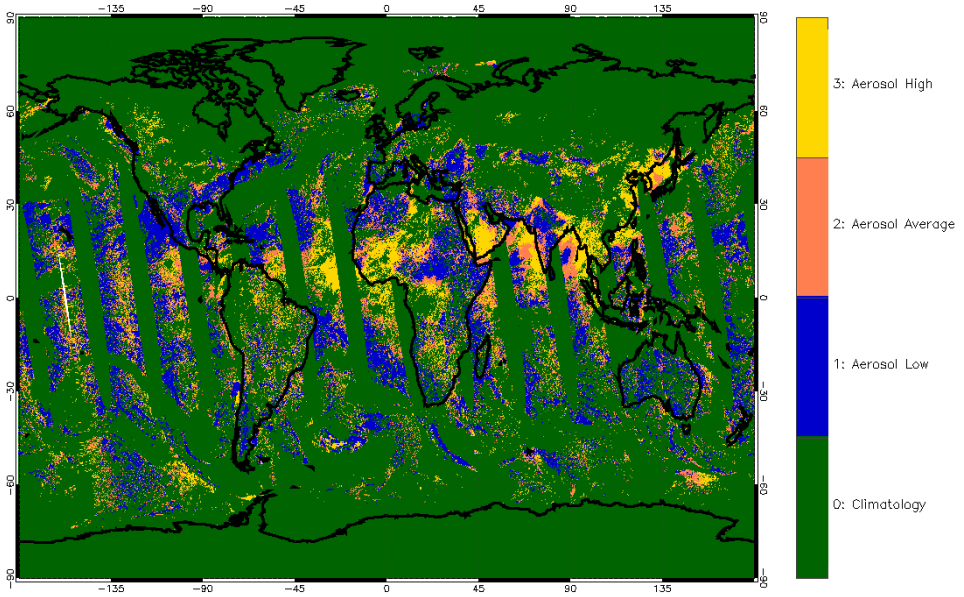


Aerosol Quantity Flag: QF7, Bits 2-3
March 19, 2019

S-NPP

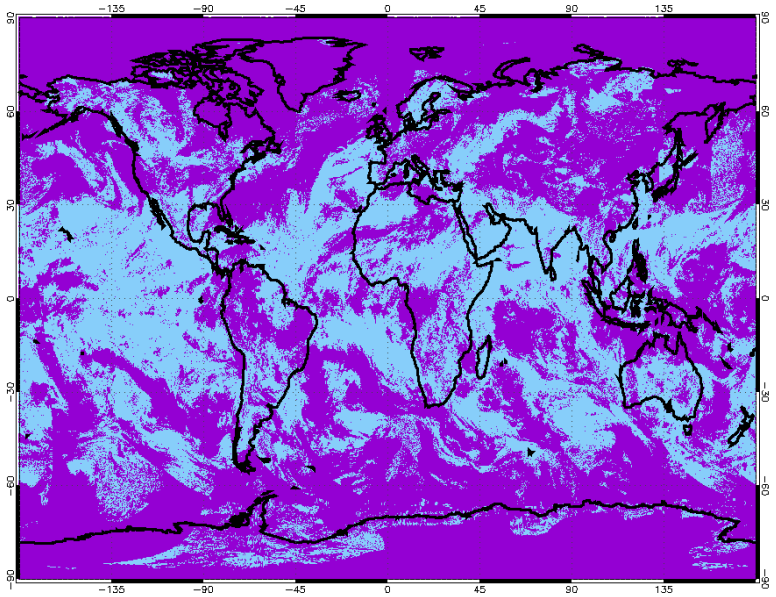


NOAA-20



Overall Thin Cirrus Flag: QF7, Bit 4
March 19, 2019

S-NPP



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