# JAXA Optical Sensors

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JAXA/EORC

CEOS IVOS Mar. 2018

# 0. JAXA Earth observation satellite missions

| Targets (JFY: Apr-Mar) | 2012 | 2013 | 2014 | 2015 | 2016 | 2017 | 2018 | 2019 | 2020 | 2021 | 2022 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **Disasters & Resources**<br>JERS1/OPS, SAR (1992-1998)<br>ADEOS-I/AVNIR<br>ALOS/AVNIR2, PALSAR (2006-2011) | | | [Land and disaster monitoring] | | | | | | | | |
| | | | **ALOS-2 / PALSAR-2** | | | | | | **ALOS-4** | | |
| | | | ALOS-2CIRC | | | | | | | | |
| | | | ISS/CIRC | | | | | | **ALOS-3** | | |
| **Climate System** | | | | | | | | | | | |
| •**Water Cycle**<br>ADEOS-I/AMSR (1996-1997)<br>Aqua/AMSR-E (2002-2010) | TRMM / PR 2013~ | | [Precipitation 3D structure] | | | | | | | Feasibility study | |
| | *with NASA* | | GPM / **DPR** | | | | | | | | |
| | | | *with NASA* | | | | | | | | |
| | [Wind, SST , water vapor, precipitation] | | | | | | | | | | |
| | **GCOM-W / AMSR2** | | | | | | | | | | **AMSR 2-F/O** |
| •**Climate change**<br>ADEOS-I/**OCTS** (1996-1997)<br>ADEOS-II/**GLI** (2003) | | | | | | | [Vegetation, aerosol, cloud, SST, ocean color] | | | | |
| | | | | | | | **GCOM-C / SGLI** | | | | |
| | **GCOM-C has been launched on 23 Dec 2017** | | | | | | | [Cloud and aerosol 3D structure] | | | |
| | | | | | | | | EarthCARE / **CPR** | | | |
| | | | | | | | *with ESA* | | | | |
| •**Greenhouse gases** | [$CO_2$, Methane] | | | | | | | [$CO_2$, Methane, CO] | | | **GOSAT 2-F/O** |
| | **GOSAT / FTS, CAI 2009~** | | | | | | *with MOE* | **GOSAT-2** | | | |

**(ref.) JMA meteorological satellites**

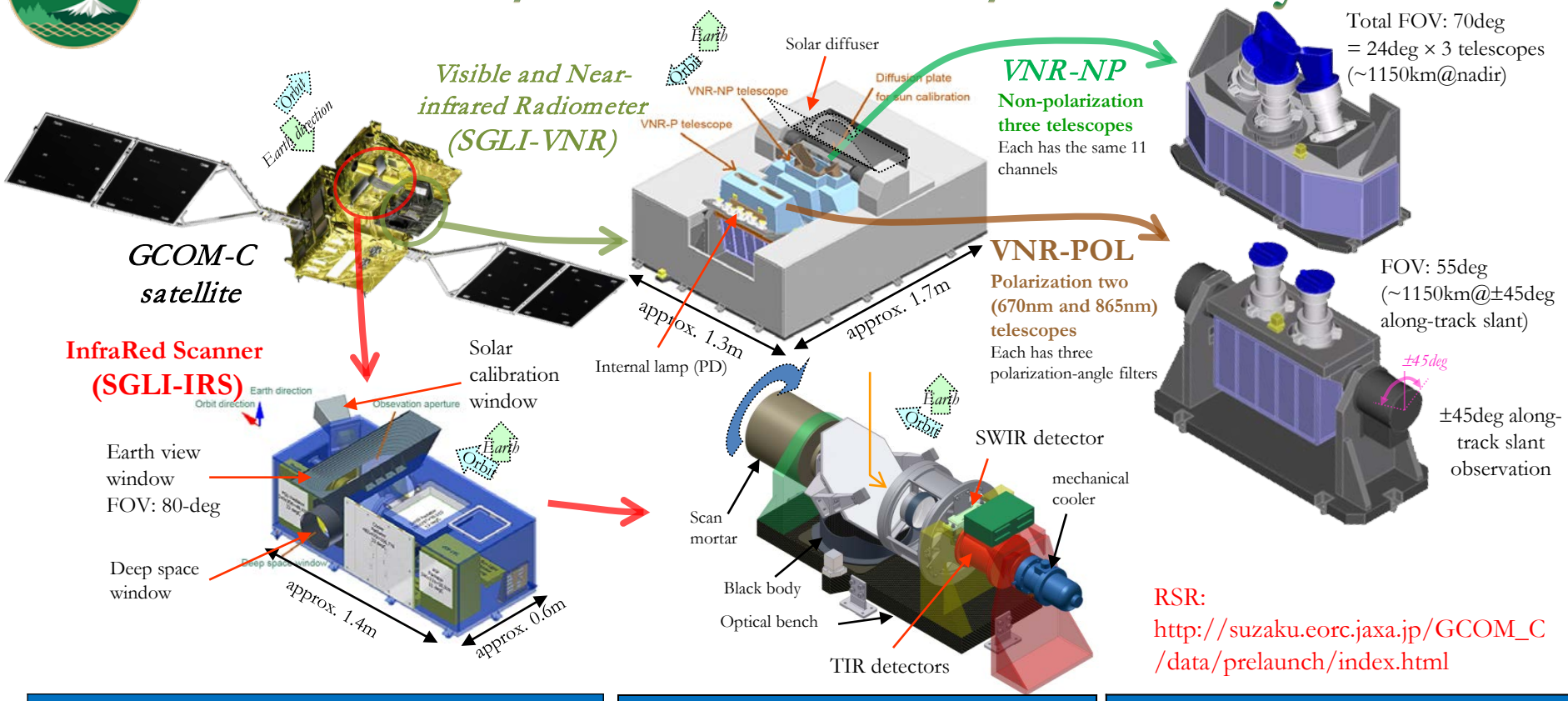
| | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | **MTSAT-1R (Himawari-6)** | | | | | | | | | | |
| | **MTSAT-2 (Himawari-7)** | | | | | | | [Cloud, aerosol, SST] | | | |
| | [Cloud, SST] | | | | | | | **Himawari-8/AHI** | | | |
| | | | | | | | | **Himawari-9 (standby)** | | | |

Mission status: On orbit | Development | Study | Pre-phase-A

# 1. GCOM-C/SGLI:

- GCOM-C/SGLI has been launched on 23 December 2017.
- The SGLI observation and calibration functions have been confirmed in the Initial Check-Out until 28, March 2018.
- The first observation images of VNR-SWIR and TIR have been acquired successfully on 1 Jan. 2018 and 22 Jan 2018 respectively. The first internal-lamp calibration and moon calibration was on 10 Jan 2018 and 31 Jan 2018, respectively.
- Sensor calibration model including detector offset, gain, geometries, and their temperature dependency will be confirmed and revised by the lamp, solar, moon, and earth observation data (vicarious calibration).
- GCOM-C Level-1 and geophysical data products (Level-2 and -3 data) will be evaluated by comparing in-situ observation data and other satellite products, and be released one-year after the launch.

# 1. GCOM-C/SGLI: Satellite/Sensor system




RSR:
http://suzaku.eorc.jaxa.jp/GCOM_C/data/prelaunch/index.html

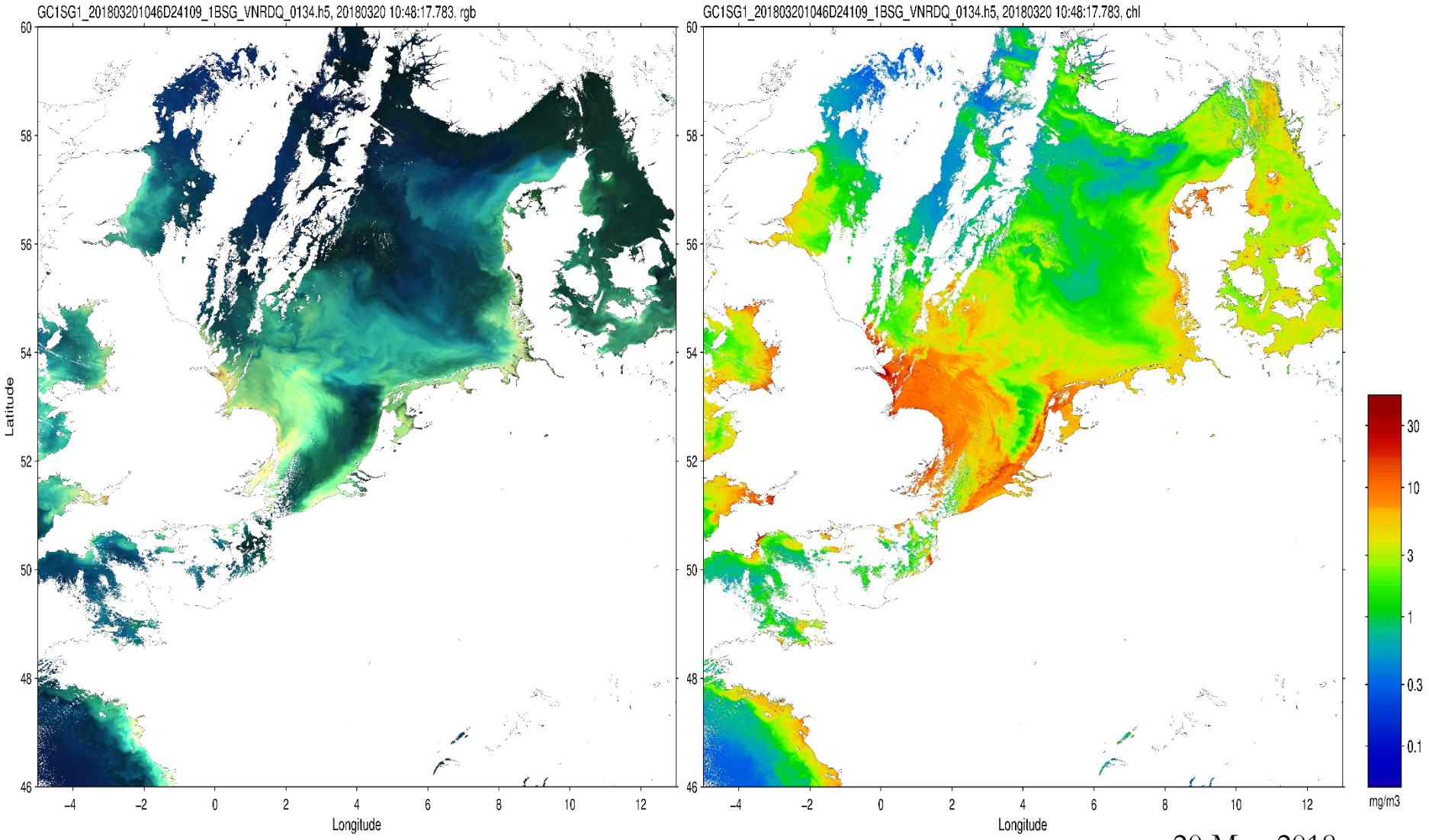
| GCOM-C SGLI characteristics | |
|---|---|
| Launch Date | **23 Dec. 2017** |
| Weight | **2,000kg** |
| Orbit | Sun-synchronous (descending local time: 10:30), Altitude: 798km, Inclination: 98.6deg |
| Mission Life | 5 years (3 satellites; total 13 years) |
| Scan | Push-broom electric scan (VNR: VN & P)<br>Wisk-broom mechanical scan (IRS: SW & T) |
| Scan width | **1150km** cross track (VNR: NP & POL)<br>**1400km** cross track (IRS: SWIR & TIR) |
| IFOV | **250m, 500m, 1km** |
| Polarization | **3 polarization angles for POL** |
| Along track tilt | +/-45 deg for POL |

| Specification of SGLI spectral bands | | | | | | |
|---|---|---|---|---|---|---|
| CH | λ | Δλ | $L_{std}$ | $L_{max}$ | SNR@$L_{std}$ | IFOV |
| | nm | | W/m²/sr/μm | | - | m |
| VN1 | 380 | 10 | 60 | 210 | 250 | **250** /1000 |
| VN2 | 412 | 10 | 75 | 250 | 400 | **250** /1000 |
| VN3 | 443 | 10 | 64 | 400 | 300 | **250** /1000 |
| VN4 | 490 | 10 | 53 | 120 | 400 | **250** /1000 |
| VN5 | 530 | 20 | 41 | 350 | 250 | **250** /1000 |
| VN6 | 565 | 20 | 33 | 90 | 400 | **250** /1000 |
| VN7 | 673.5 | 20 | 23 | 62 | 400 | **250** /1000 |
| VN8 | 673.5 | 20 | 25 | 210 | 250 | **250** /1000 |
| VN9 | 763 | 12 | 40 | 350 | 1200* | 250 /**1000*** |
| VN10 | 868.5 | 20 | 8 | 30 | 400 | **250** /1000 |
| VN11 | 868.5 | 20 | 30 | 300 | 200 | **250** /1000 |

| Specification of SGLI spectral bands | | | | | | |
|---|---|---|---|---|---|---|
| CH | λ | Δλ | $L_{std}$ | $L_{max}$ | SNR@$L_{std}$ | IFOV |
| | nm | | W/m²/sr/μm<br>K: Kelvin | | -<br>K: NEΔT | m |
| POL1 | 673.5 | 20 | 25 | 250 | 250 | **1000** |
| POL2 | 868.5 | 20 | 30 | 300 | 250 | **1000** |
| SW1 | 1050 | 20 | 57 | 248 | 500 | **1000** |
| SW2 | 1380 | 20 | 8 | 103 | 150 | **1000** |
| SW3 | 1630 | 200 | 3 | 50 | 57 | **250** /1000 |
| SW4 | 2210 | 50 | 1.9 | 20 | 211 | **1000** |
| TIR1 | 10800 | 700 | 300K | 340K | 0.2K | 250/**500**/1000 |
| TIR2 | 12000 | 700 | 300K | 340K | 0.2K | 250/**500**/1000 |

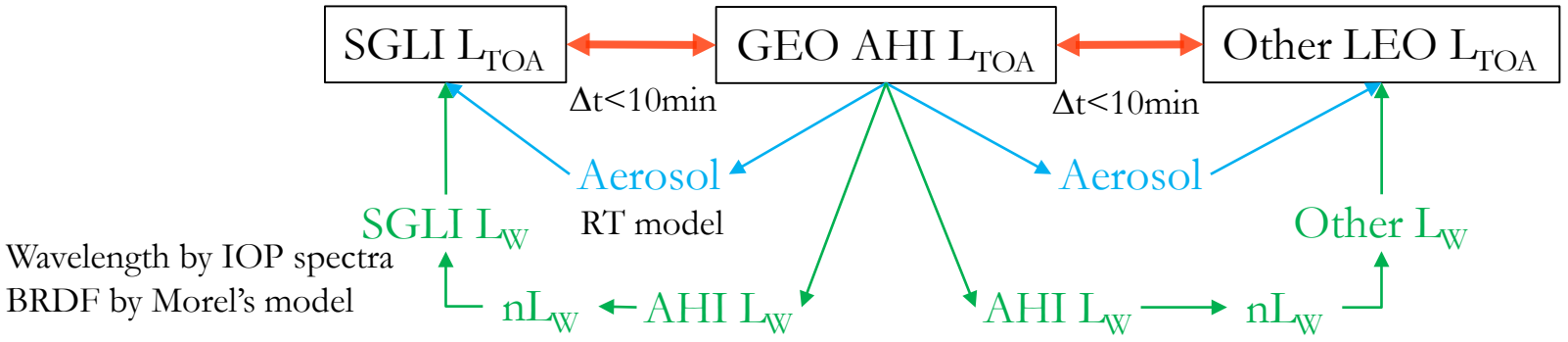
# 1. GCOM-C/SGLI: acquired images

## An example of $\rho_w$ RGB and Chlorophyll-a concentration




20 Mar. 2018

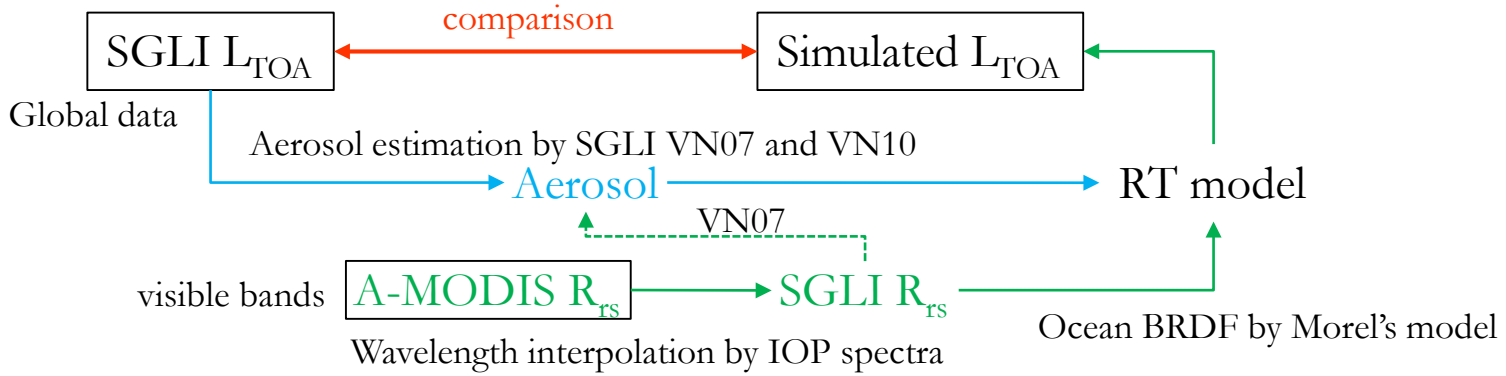
# 1. GCOM-C/SGLI:
## Cross-cal of SGLI and AHI (Ocean area)

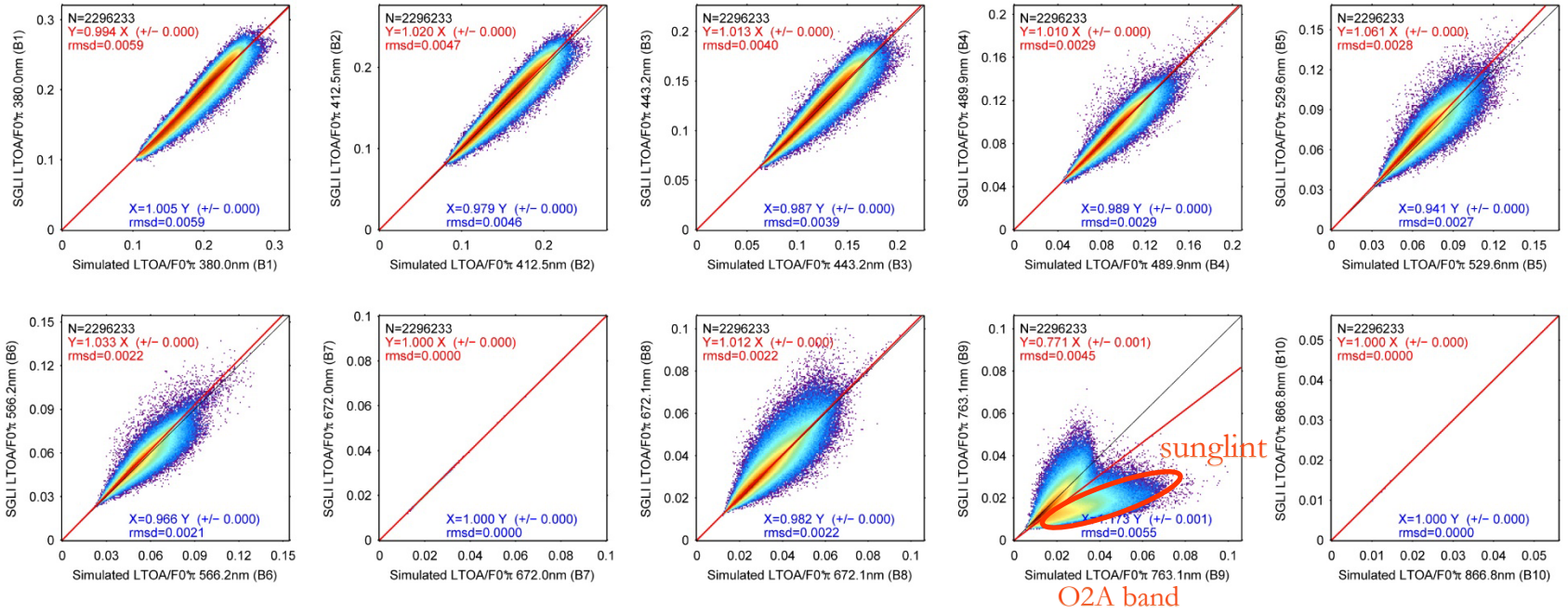



Wavelength by IOP spectra
BRDF by Morel's model

| | nm | 380 | 412 | 443 | 490 | 530 | 565 | 673 | 673 |
|---|---|---|---|---|---|---|---|---|---|
| SGLI /AHI | avg | **0.988** | **1.000** | **0.995** | **1.004** | **1.031** | **0.972** | **0.935** | **0.948** |
| | 95% | 0.002 | 0.003 | 0.004 | 0.005 | 0.006 | 0.007 | 0.009 | 0.009 |
| VIIRS /AHI | avg | | **1.030** | **0.973** | **0.989** | **0.969** (550nm) | | **0.979** | |
| | 95% | | 0.004 | 0.004 | 0.005 | 0.008 | | 0.011 | |
| A-MODIS /AHI | avg | | **0.989** | **1.011** | **1.007** | **0.983** | **0.972** | **0.939** | |
| | 95% | | 0.006 | 0.007 | 0.009 | 0.011 | 0.012 | 0.017 | |
| SGLI /VIIRS | avg | | **0.971** | **1.023** | **1.015** | **1.064** | **1.003** | **0.955** | **0.968** |
| | 95% | | 0.005 | 0.006 | 0.007 | 0.011 | 0.011 | 0.014 | 0.014 |
| SGLI /A-MODIS | avg | | **1.011** | **0.984** | **0.997** | **1.049** | **1.000** | **0.996** | **1.010** |
| | 95% | | 0.007 | 0.008 | 0.010 | 0.013 | 0.014 | 0.019 | 0.020 |

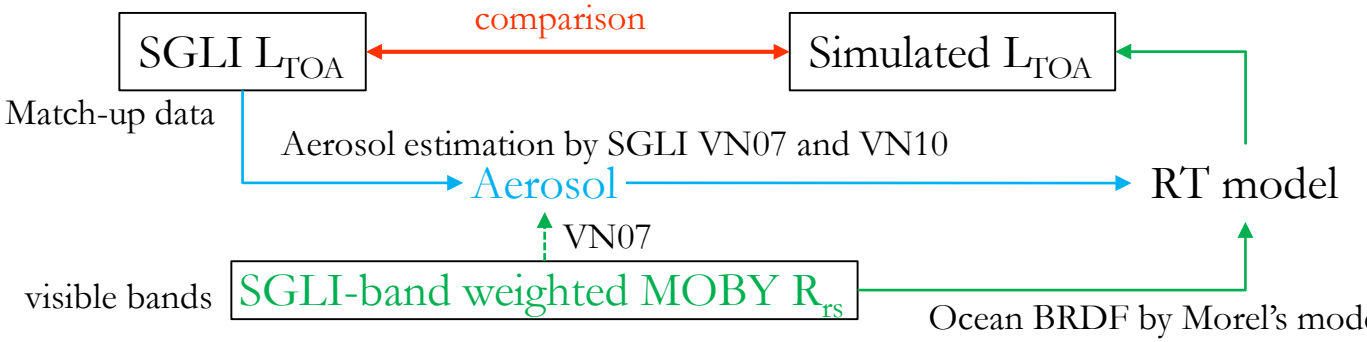
# Ocean color cross-cal by MODIS $R_{rs}$ in Jan-Feb 2018

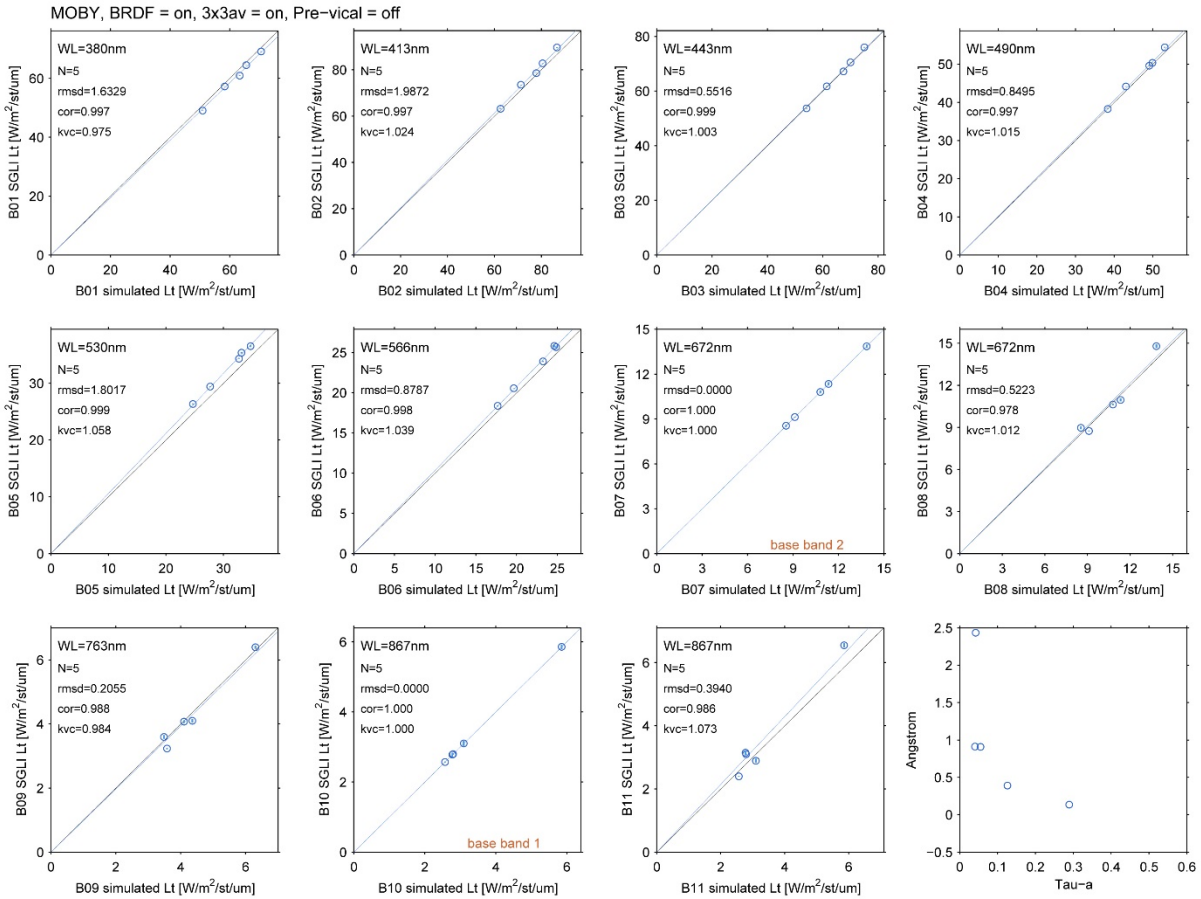



| OC vcal | 380 | 412 | 443 | 490 | 530 | 565 | 673 | 673 | 763 | 868 | 868 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| SGLI/sim | 0.994 | 1.020 | 1.013 | 1.010 | 1.061 | 1.033 | *1.000* | 1.012 | NA | *1.000* | (1.031) |

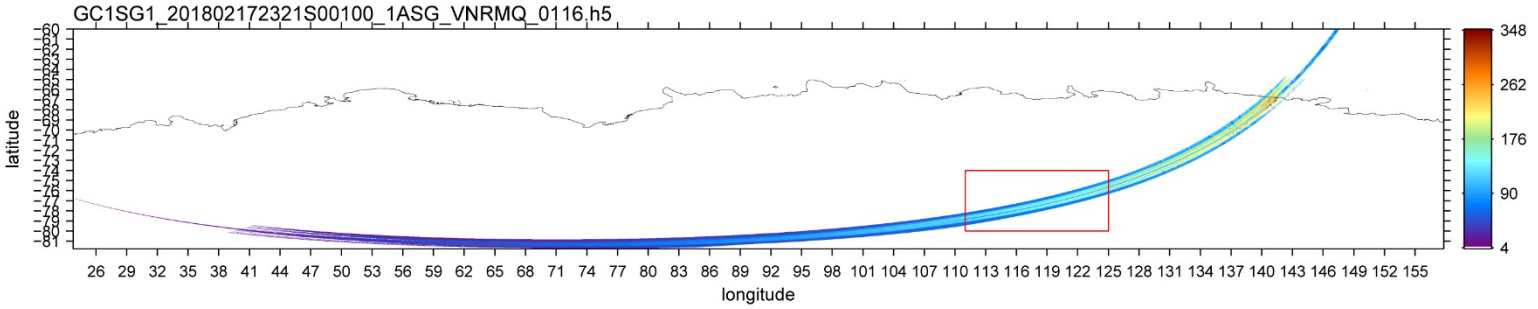
# Ocean color vi-cal by MOBY (Jan-Mar 2018)

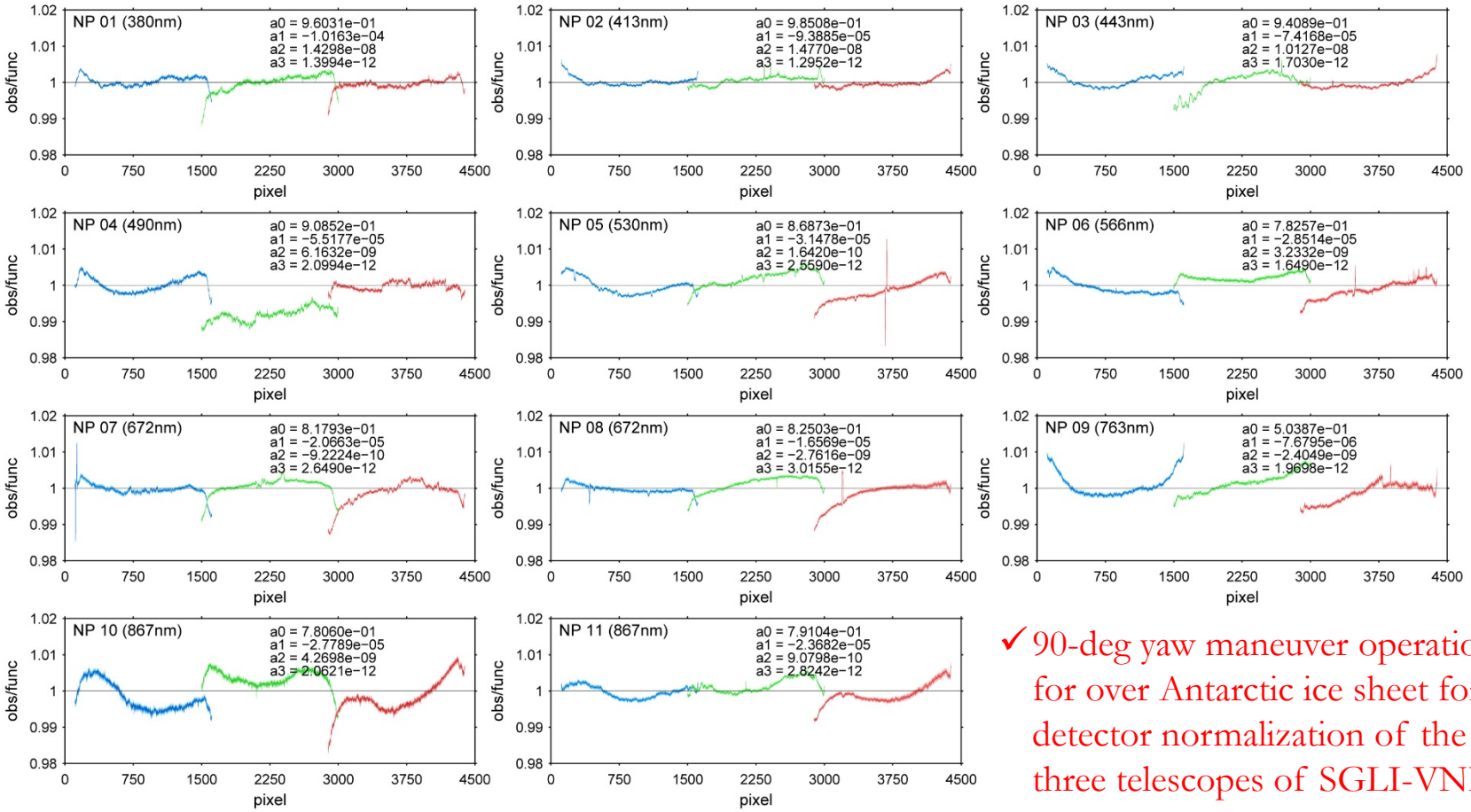



- ✓ SGLI band-weighted MOBY data are provided by NOAA

# Maneuver for SGLI detector normalization 2018/02/17

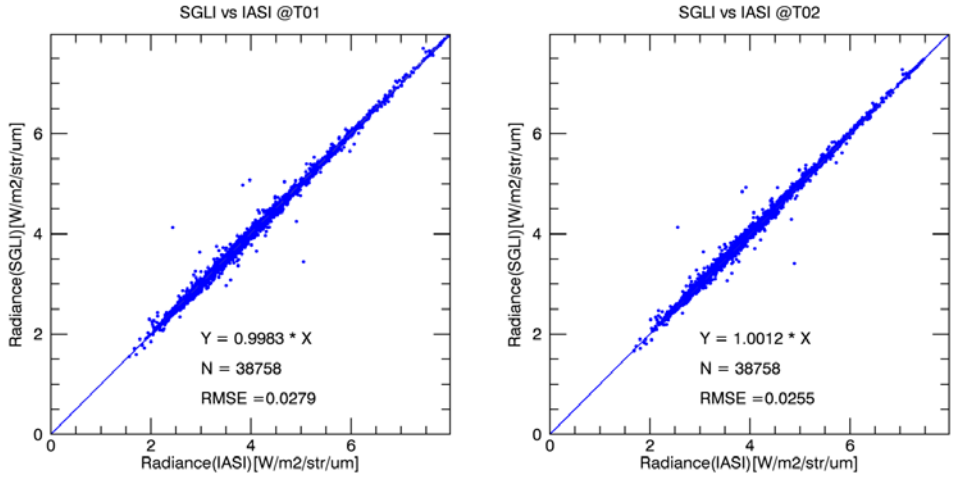



✓90-deg yaw maneuver operation for over Antarctic ice sheet for detector normalization of the three telescopes of SGLI-VNR

# Cross calibration of SGLI thermal infrared bands with satellite sounders

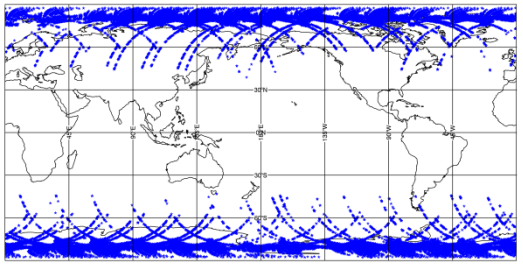
MetOp-A/IASI and SGLI TIR01, TIR02



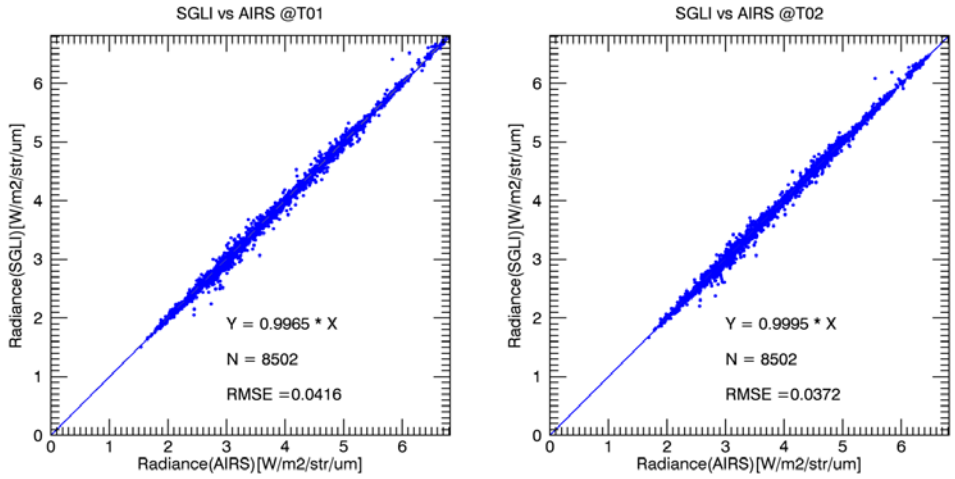




Match-ups in 29-31 Jan 2018



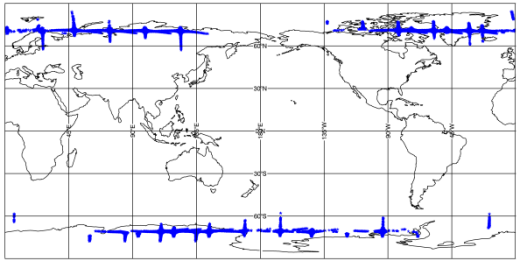
Aqua/AIRS and SGLI TIR01, TIR02







Match-ups in 31 Jan - 10 Feb 2018



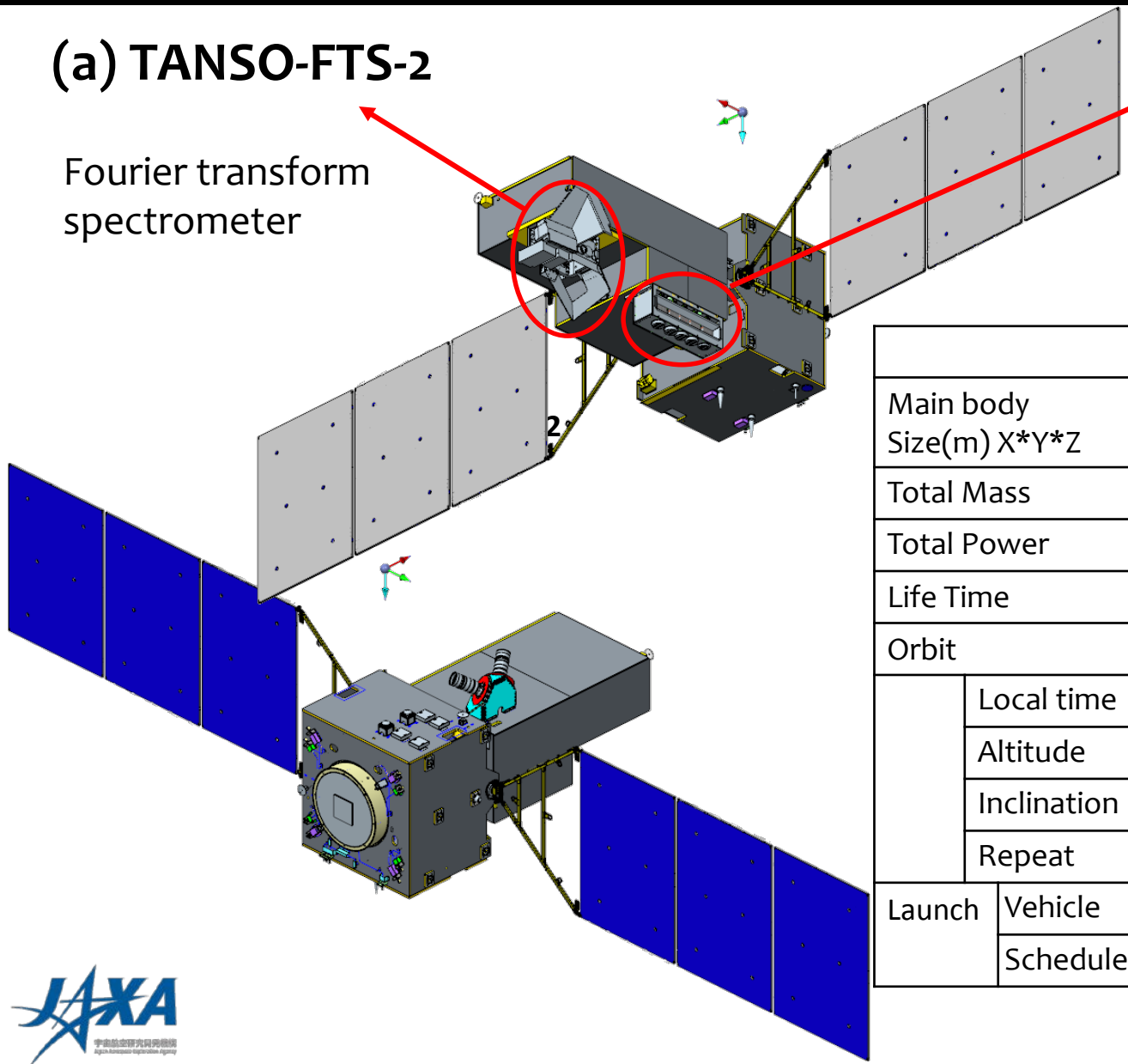
# 2. GOSAT-2

## (a) TANSO-FTS-2

Fourier transform spectrometer

## (b) TANSO-CAI-2

Push-broom imager



| | | GOSAT-2 | GOSAT |
|---|---|---|---|
| Main body Size(m) X*Y*Z | | 5.8 x 2.0 x 2.1 (Wing Span 16.5m) | 3.7 x 1.8 x 2.0 (Wing Span 13.7m) |
| Total Mass | | 1800kg | 1750kg |
| Total Power | | 5.0 kW(EOL) | 3.8 kW (EOL) |
| Life Time | | 5 years | 5 years |
| Orbit | | sun synchronous | sun synchronous |
| | Local time | 13:00+/-0:15 | 13:00+/-0:15 |
| | Altitude | 613km | 666km |
| | Inclination | 98deg | 98deg |
| | Repeat | 6 days (89 revol.) | 3 days (44 revol.) |
| Launch | Vehicle | H-IIA | H-IIA |
| | Schedule | JFY2018 | 23 Jan., 2009 |

# 2-a. TANSO-FTS-2 Specifications

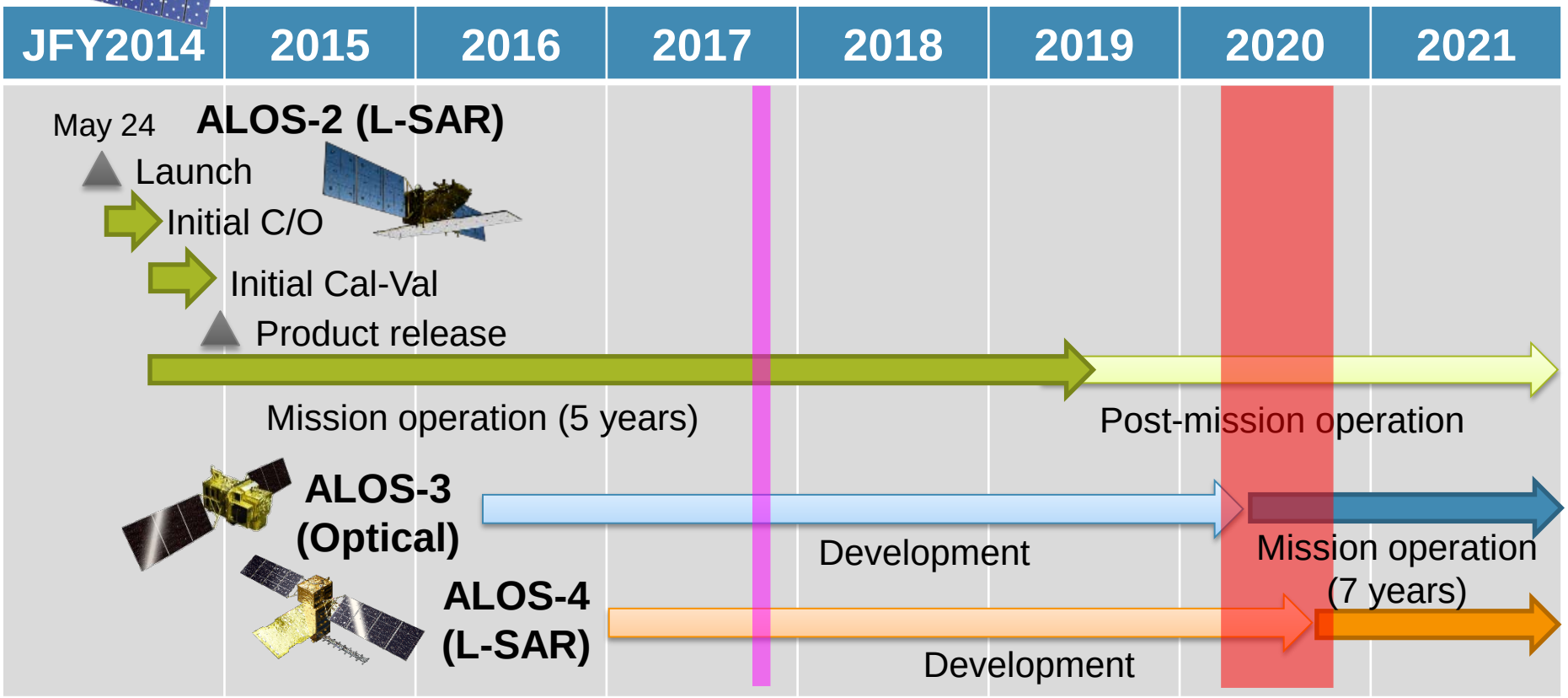
| Items | GOSAT-2/FTS-2 | GOSAT/FTS |
|---|---|---|
| Measurement Gases | CO2, CH4, O3, H2O, **CO** | CO2, CH4, O3, H2O |
| Footprint size (FOV) | **9.7 kmϕ** (15.8mrad) | 10.5 kmϕ (15.8mrad) |
| Spectral Ranges (μm)(cm-1) | band 1 : 0.75-0.77 (**12,950-13,250**)<br>band 2: 1.56-**1.69** (**5,900**-6,400)<br>band 3: 1.92-**2.33** (**4,200**-5,200)<br>band 4: 5.5-**8.4 (1,188-1,800)**<br>band 5: **8.4**-14.3 **(700-1,188)** | band 1: 0.75-0.77 (12,900-13,200)<br>band 2: 1.56-1.72 (5,800-6,400)<br>band 3: 1.92-2.08 (4,800-5,200)<br>band 4: 5.5-14.3 (700-1,800) |
| SNR | band 1: **>400** (S@13,050$cm^{-1}$)<br>band 2: **>**300 (S@6,200$cm^{-1}$)<br>band 3: **>**300 (S@5,000$cm^{-1}$)<br>**>**250 (S@4,250$cm^{-1}$)<br>band 4: **>**300 (@1,300$cm^{-1}$)<br>band 5: **>**300 (@700$cm^{-1}$) | band 1: >300 (345)<br>band 2: >300 (322)<br>band 3: >300 (412)<br>band 4: >300 (304) |
| Observation Mesh | 160km (5 points in the CT direction) | 160km (5 points in the CT direction) |
| Scan duration | **4 seconds / interferogram** | 4, 2, 1.1 seconds / interferogram |
| Sampling resolution | 0.2$cm^{-1}$ | 0.2$cm^{-1}$ |
| Effective Aperture size | **Φ73mm** | Φ64mm |
| Gain steps | **16** | 2 |
| Avoidance of the cloud | **Intelligent pointing** | ------- |

# 2-b. TANSO-CAI-2 Specifications

| Items | GOSAT-2/CAI-2 | | GOSAT/CAI |
|---|---|---|---|
| Spectral Ranges (nm) | Forward Viewing (+20 deg) | Backward Viewing (-20deg) | Nadir Viewing |
| | b 1 : 333-353 | b 6 : 370-390 | band 1 : 370-390 |
| | b 2 : 433-453 | b 7 : 540-560 | |
| | b 3 : 664-684 | b 8 : 664-684 | band 2 : 664-684 |
| | b 4 : 859-879 | b 9 : 859-879 | band 3 : 860-880 |
| | b 5 : 1585-1675 | b 10: 1555-1645 | band 4 : 1555-1645 |
| Spatial Resolution | except band 5, 10 | band 5, 10 | Band 1-3 / Band 4 |
| nadir | 460m (700μrad) | 920m(1,400μrad) | 500m(750μrad) / 1,500m(2,250μrad) |
| swath/FOV | every points on the earth to be observed at least twice a recurrent cycle | | Band 1-3 / Band 4 |
| | | | 1,002 km / 72 deg / 786km / 60 deg |
| SNR (@spectral-radiance/albedo) (W/m²/sr/μm) | b 1 : >200 (45/0.158) | b 6 : >200 (48/0.152) | b 1 : >200 (47/0.149) |
| | b 2 : >200 (79/0.144) | b 7 : >200 (65/0.125) | |
| | b 3 : >200 (46/0.106) | b 8 : >200 (46/0.106) | b 2 : >200 (45/0.104) |
| | b 4 : >200 (30/0.112) | b 9 : >200 (30/0.112) | b 3 : >200 (29/0.108) |
| | b 5 : >200 (7/0.101) | b 10 : >200 (7/0.101) | b 4 : >200 (7/0.101) |

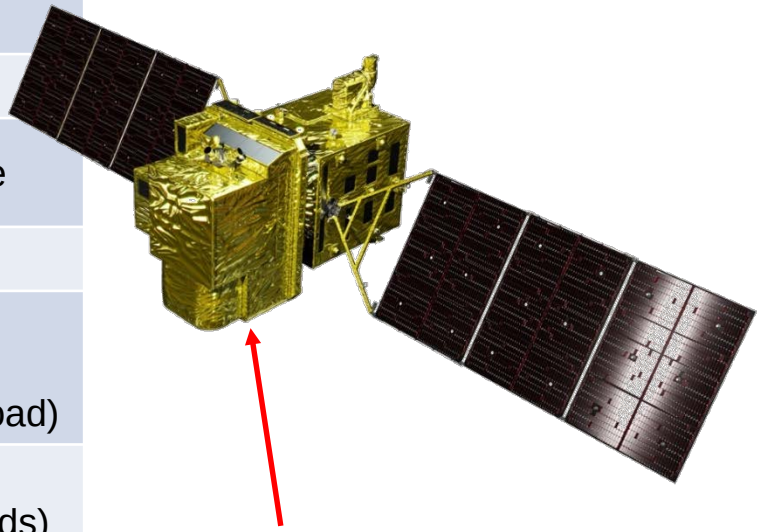
# 3. ALOS F/O Missions

- Continuous observations successor *"Daichi" (ALOS)* from 2006 to 2011
  - Contribute to ensure the safety and security of citizens, *i.e.* disasters monitoring and management, land deformation monitoring, national developing management, foods and natural resources, environmental issues in global etc. as common issues.
  - Contribute to industrial development based on Earth observation data *i.e.* National Spatial Data infrastructure (NSDI) and new applications.



# 3-a. ALOS-3 Overview

| Items | | Specifications |
|---|---|---|
| Orbit | Type | Sun-synchronous sub-recurrent |
| | Altitude | 669 km at the equator |
| | Local Sun Time | 10:30 am +/- 15 minutes at the descending node |
| | Revisit | 35 days (Sub-cycle 3 days) |
| Instruments | | - Wide-swath and high-resolution optical imager (WISH, as a tentative)<br>- Dual-frequencies Infrared sensor (hosted payload) |
| Ground Sampling Distance (GSD) | | - Panchromatic band of WISH (Pa): 0.8 m<br>- Multispectral band of WISH (Mu): 3.2 m (6 bands) |
| Quantization | | 11 bit / pixel |
| Swath width | | 70 km at nadir |
| Mission data rate | | Approx. 4 Gbps (after onboard data compression: 1/4 (Pa) and 1/3 (Mu)) |
| Mission data downlink | | - Direct Transmission: Ka and X-band<br>- *via.* the Optical Data Relay Satellite |
| Mass | | Approx. 3 tons at launch |
| Size | | 5 m × 16 m × 3.5 m on orbit |
| Duty | | 10 mins / recurrent |
| Design life time | | Over 7 years |

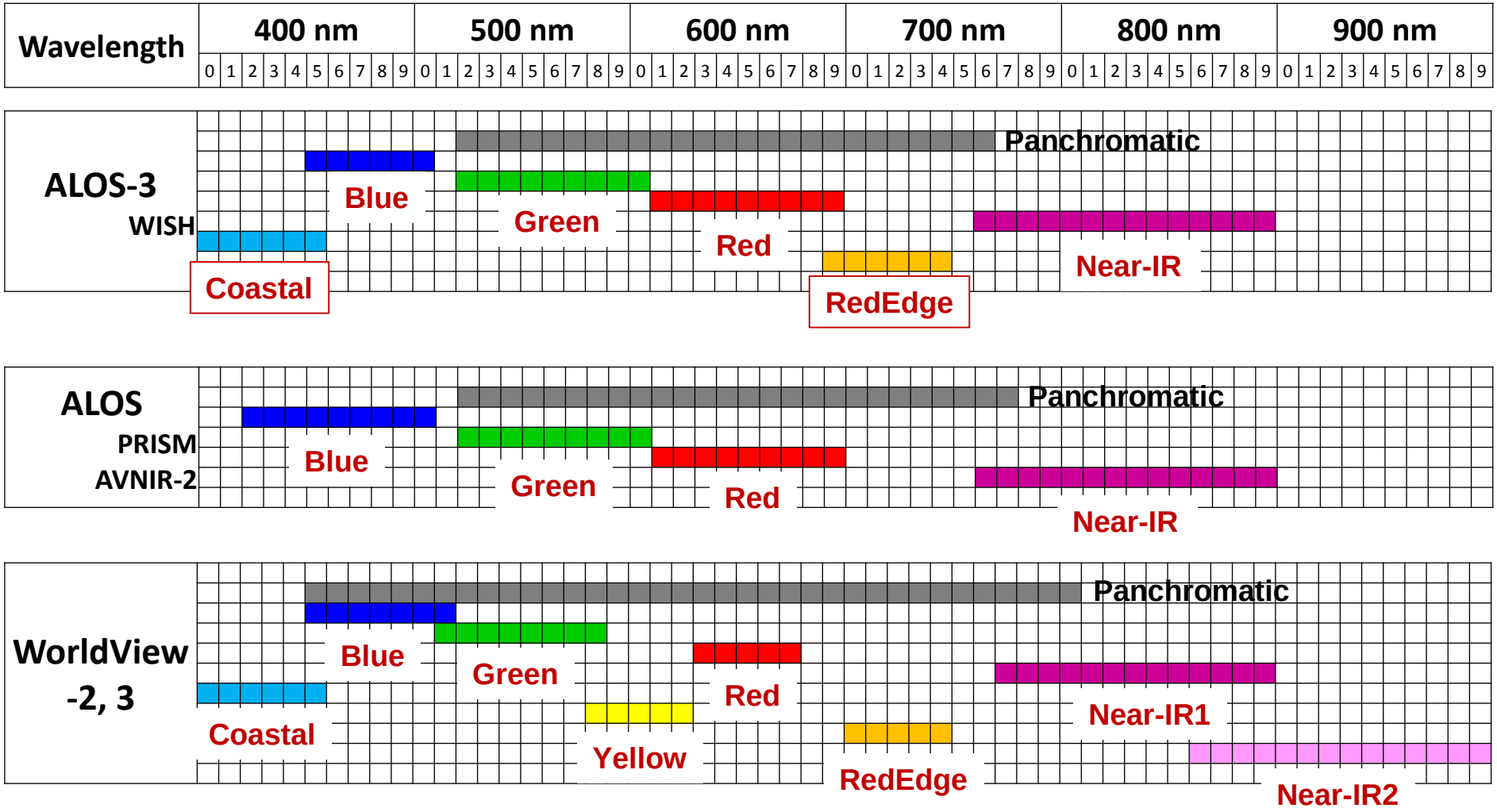


Wide-swath and high-resolution optical imager (WISH)

In-orbit configuration

# Wide-Swath and High-Resolution Optical Imager

Observation channel band allocations among optical satellites (visible to near-infrared).



# 4. PICSCAR

Procedure:

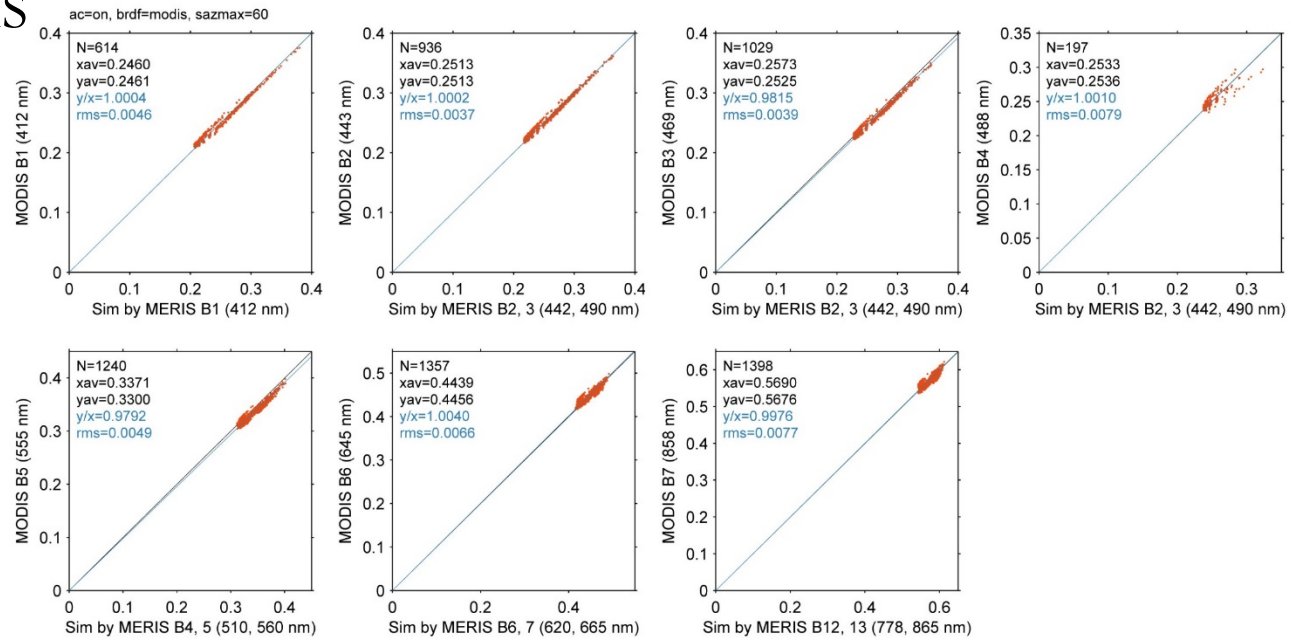
TOA reflectance observed by the reference sensor, Rt0_obs
-> Calculate surface reflectance by PSTAR4 and ancillary -> Rs0
-> Fitting to the BRDF kernel model -> BRDF
-> Calculate for the target sensor geometry -> Rs1
-> Calculate TOA reflectance by PSTAR4 and ancillary -> Rt1
-> Comparison with TOA reflectance observed by the target sensor, Rt1_obs

- Rt is approximated by Rt/tg=Ra+Rs*Tr/(1-sa*Rs') assuming Rs'=Rs, and no aerosols.
- tg (transmittance correction for absorptive gases), Tr (molecule transmittance), and sa (spherical albedo) are calculated by PSTAR4 with sensor RSR,
  (PSTAR: radiative transfer code, http://157.82.240.167/~clastr/index.html)
- Ancillary data: NCEP (TPW and Prs), and TOMS/OMI (ozone)
- BRDF kernels are

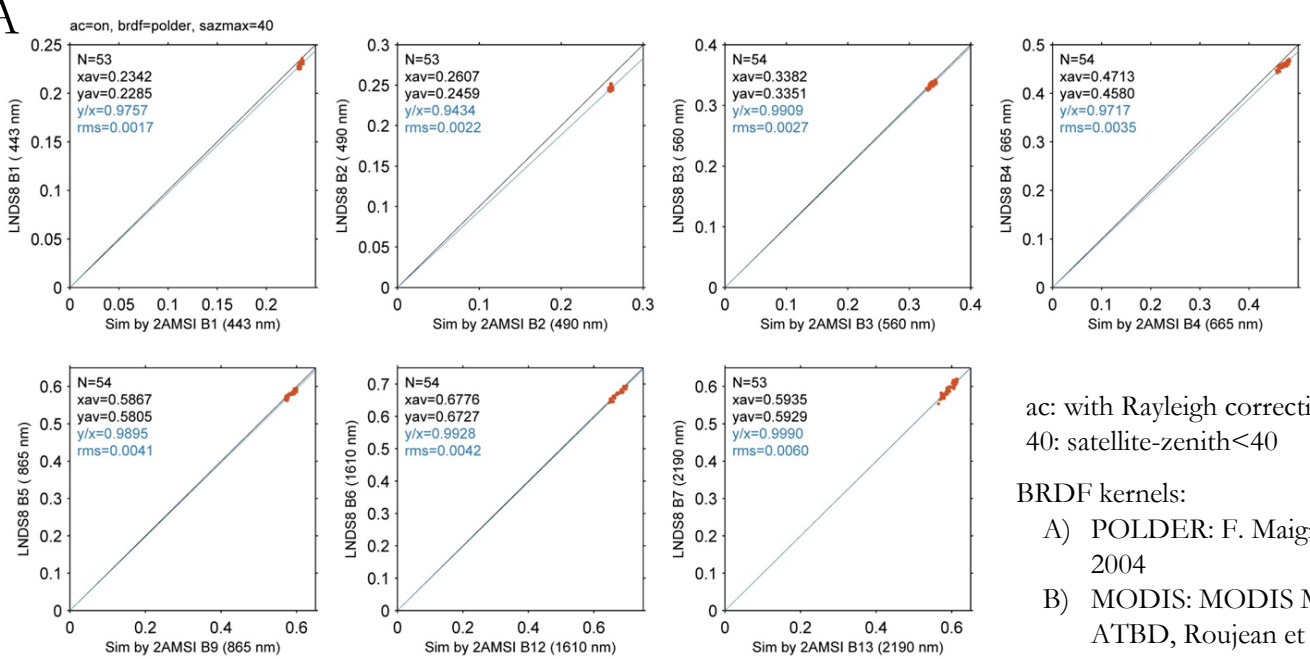
A) POLDER: F. Maignan et al., 2004
B) MODIS: MOD08 ATBD, Roujean et al., 1992
C) 2-nd order regression on sat-zenith (each 5-deg sol-zenith bin)

| | G | R | N |
|---|---|---|---|
| MODIS/MERIS | 0.9762 | 1.0028 | 0.9963 |
| LS8/S2A | 0.9909 | 0.9717 | 0.9895 |

# A-MODIS/MERIS




# LANDSAT-8/S2A




ac: with Rayleigh correction
40: satellite-zenith<40

BRDF kernels:

A) POLDER: F. Maignan et al., 2004
B) MODIS: MODIS MOD08 ATBD, Roujean et al., 1992