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Calibration Plan for the Ocean Color Instrument (OCI) Engineering Test Unit

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ABSTRACT

The Plankton, Aerosol, Cloud, ocean Ecosystem (PACE) mission will launch no earlier than summer 2022. The primary payload is the Ocean Color Instrument (OCI). OCI is a hyperspectral imaging radiometer that will measure top-of-atmosphere radiances from 340nm to 2260nm at approximately 1km spatial resolution. The spectral resolution will be 5nm from 340nm to 890nm to enable the production of innovative ocean color products on a global scale (OCI will provide global coverage every 2 days). There are 7 different multispectral bands in the shortwave infrared to support atmospheric correction for ocean color and aerosol and cloud studies. Ocean color applications require state of the art radiometric accuracy (approximately 0.5%, excluding the absolute calibration uncertainty). Considerable effort has been invested in the planning of the prelaunch calibration campaign and the on-orbit calibration capabilities. This paper describes the current plans for the prelaunch calibration and characterization campaign of the OCI Engineering Test Unit (ETU), which is scheduled to begin towards the end of 2019. The prelaunch calibration campaign will characterize all sensor characteristics that are expected to influence radiometric sensitivity: absolute calibration (i.e. radiometric gains), signal to noise ratio, nonlinearity, response versus scan angle, dynamic range, signal to noise ratio, and sensitivities to polarization and temperature. In addition to these one-time characterization tests, two types of tests have been developed that monitor the evolution of several OCI radiometric characteristics: a Limited Performance Test (LPT, expected duration about 8 hours), and a Comprehensive Performance Test (CPT, expected duration about 2 days).

Keywords: PACE, OCI, calibration, hyperspectral

1. INTRODUCTION

The PACE (Werdell at al., 2019) mission's primary payload is OCI, NASA's latest ocean color radiometer to acquire global ocean color products from a low earth orbit. The instrument has been described by Gorman et al., 2019, in the same conference as this paper, so we refer the reader to that paper for an in-depth description of OCI. The radiometric performance requirements for OCI were derived following the guidance provided in Meister et al., 2011.

Two OCI units are currently being built at NASA's Goddard Space Flight Center: an ETU and a Flight Unit. ETU testing will begin towards the end of 2019 and conclude in April 2020. The Flight Unit testing is expected to begin during the summer of 2020. This document describes the system level calibration and characterization plan for the ETU. Lessons learned from the ETU test campaign will influence the design of the test campaign for the Flight Unit.

The ETU does not have the full capabilities of the Flight Unit. The most important differences regarding the calibration of the instrument are:

- 1) The ETU does not have the spectrograph that contains the hyperspectral channels below 600nm.
- 2) The aft-optics box containing the SWIR channels will be attached to the ETU after thermal vacuum (TVAC) testing, due to schedule constraints. This means that some of the SWIR channels can only be tested at room temperature, some not at all (because they do not perform adequately at room temperature). Also, the ETU aft-optics box contains only a limited number of detectors (all wavelengths are available, but at reduced SNR (signal-to-noise-ratio) levels).
- 3) The instrument mechanical structure is not flight-like (and there are no radiators in the ETU), potentially modifying the thermal distortions of the instrument during TVAC testing.
- 4) The ETU does not contain the solar diffuser assembly.
- 5) After the analysis of the ETU system level test results, the OCI team may decide to replace certain components of OCI with similar components that promise better performance (e.g. depolarizer, lenses, etc.).

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In the following, this document describes the OCI calibration approach and the following ETU tests: absolute calibration, polarization sensitivity, response versus scan angle, relative spectral response, linearity, temperature sensitivity, signal to noise ratio, LPT and CPT. The calibration plans for high contrast resolution (straylight) and crosstalk were still in flux at the time of this writing, so they are not included here. This document focuses on radiometric tests, environmental tests (e.g. vibration, TVAC) are only mentioned as they relate to radiometric characterizations.

2. OCI CALIBRATION APPROACH

OCI data will be calibrated using the following **calibration equation**:

$$L_t = K_1 * K_2(t) * (1- K_3 * (T- T_{ref}) * K_4(\theta) * K_5(dn, T) * dn$$

L_t = radiance measured by OCI in a hyperspectral or SWIR band
K_1 = absolute gain factor
$K_2(t)$ = relative gain factor as a function of time t (trended on-orbit with solar diffuser and lunar measurements)
K_3 = temperature correction factor
T = Instrument temperature measured at relevant location
T_{ref} = Reference Temperature (used during TVAC prelaunch characterization, close to expected on-orbit temperature)
K_4 = response versus scan
θ = scan angle (can be replaced by science pixel number per scan)
K_5 = nonlinearity factor
DN = digital number measured at a certain θ
DN_0 = average of the digital numbers measured during dark current collection (average of ~40 numbers, once per scan)
dn = DN – DN_0

Note: other radiometric characteristics such as out-of-band, polarization and straylight/crosstalk correction are handled later in the processing stage (need ancillary information, such as surrounding radiances for straylight, amount of rayleigh/aerosol/glint for polarization), and are therefore not part of the calibration equation.

All the above K factors will be derived from (or verified with) system level testing. During pre-launch testing, some or all of the corrections coefficients K_i will not yet be available, so that Lt cannot be calculated. In this case, the quantity Lmeas will be used to estimate the radiance measured by OCI. Lmeas will be calculated like Lt, but with estimates or default values for any K_i not yet determined.

The total systematic uncertainty of L_t is calculated by error propagation of the individual components. The uncertainty requirements for OCI are separated into different dynamic ranges: very demanding requirements from Llow to Lhigh/Lbright (Llow and Lhigh bracket the expected radiance levels for ocean color measurements), and less demanding requirements up to Lmax (the radiance reflected off a white cloud). See Meister et al. 2011 for tables of Llow, Lhigh, Ltyp (radiance typical for ocean scenes), and Lmax. Lbright is defined as the maximum radiance reflected from the solar diffuser during on-orbit measurements.

3. ABSOLUTE CALIBRATION

The absolute calibration is applied in the calibration equation by K_1. The absolute uncertainty requirements for the OCI bands are much less demanding than the requirements for the other radiometric characteristics. The reason is that on-orbit, a vicarious calibration coefficient will be applied that essentially overwrites K_1. Therefore, this section will provide few details. Note that the atmospheric correction bands do not benefit from the vicarious calibration (with the possible exception of the 748nm band), so these bands drive the absolute calibration uncertainty requirement. On-orbit, K_1 can be measured with solar diffuser measurements.

K_1 is measured using monochromatic illumination, stepping through the whole wavelength range of interest (e.g. in 1nm steps from 600nm to 900nm). The system providing the illumination is called GLAMR (Goddard Laser for Absolute Measurement of Radiance) and described by Barsi et al., 2018. GLAMR allows the measurement of the absolute spectral response (ASR), which is the ratio of the dn measured by OCI when viewing the integrating sphere illuminated by the monochromatic laser light, and the radiance exiting the sphere (see also section 6).

Using the ASR, the gain K_1 at each wavelength can be determined (Barnes et al, 2010):
$K_1 = \sum \mathrm{ASR}(\lambda) * \Delta\lambda$

where $\Delta\lambda$ is the wavelength spacing between the ASR measurements (e.g. 1nm for 600nm to 900nm).

4. POLARIZATION SENSITIVITY

a. Background and OCI polarization requirement

Polarization sensitivity of the instrument is undesirable, therefore its magnitude is limited by the OCI requirements to 1.0% for all wavelengths below 900nm, and 2% above 900nm. In addition, the OCI sensitivity to polarization will be characterized with an uncertainty of 0.2% for wavelengths below 900nm. TOA (top-of-atmosphere) radiances are not circularly polarized, therefore only linear polarization is relevant here.

a. Basic Characterization Approach

The sensitivity of any optical system to linear polarization can be described in the following way:
$\mathrm{Lmeas}(\beta) = \mathrm{A0} * + \mathrm{A2}*\sin(2*\beta) + \mathrm{B2}*\cos(2*\beta)$

where β (angle in radians) is the direction of the electric field vector of the linearly polarized light (Lmeas is the measured radiance before the polarization correction). The magnitude of the polarization sensitivity (or polarization amplitude, PA) is given by
$\mathrm{PA} = \mathrm{sqrt}(\mathrm{A2}^2+\mathrm{B2}^2)$

The basic approach to characterizing the polarization sensitivity of OCI is to expose OCI to linearly polarized light at various polarization angles β. Ideally, Lmeas will follow exactly the form of the equation above. In practice, there will be deviations. A Fourier analysis will be used to extract the measured coefficients A2m and B2m:
$\mathrm{Lmeas}(\beta) = \sum_i (\mathrm{Aim}*\sin(i*\beta) + \mathrm{Bim}*\cos(i*\beta))$

The linearly polarized light will be created by putting a linear polarizer between a source of unpolarized light (e.g. an integrating sphere) and OCI. The variation of the angle β will be accomplished by rotating the linear polarizer. Note that the polarizer needs to be large enough to fully illuminate the OCI telescope aperture. The polarization sensitivity is expected to vary with scan angle θ, so this test needs to be repeated for several scan angles (by rotating OCI relative to the integrating sphere).

a. Implementation Details

- 1) The polarizer angles will be varied over one full rotation (0^o to 360^o), even though only 0^o to 180^o is needed for a full characterization. The step size will be 15^o (MODIS/VIIRS heritage), yielding 25 measurements for one full rotation.
- 2) The linear polarizer will not provide 100% linearly polarized light. The polarizer efficiency PE needs to be measured. This is accomplished by placing two identical polarizers between the light source and OCI and rotating one of the polarizers. The minimum radiance allows the calculation of the PE. The coefficients A2 and B2 need to be corrected for the polarizer efficiency:
  A2corr = A2m/PE
  B2corr = B2m/PE

This test also allows to verify the orientation of the polarizer relative to the angle theta. It should be known with an accuracy of 1°. Note that the uncertainty of PE fully impacts the error of the polarization amplitude.

- 3) The light source may not be stable during the test. This stability will be corrected by normalizing the radiances Lmeas(β) with the trends as measured by a sphere stability monitor. Note that an uncorrected trend in the light source will only marginally effect the accuracy. E.g., an uncorrected, linear change of 1% in the light stability will only introduce errors of the polarization amplitude of 0.04% (calculated for measurements for a system with 1% polarization amplitude and 25 measurements at varying polarizer angles from 0^o to 360^o).
- 4) The polarization of the light exiting the integrating sphere (before it hits the polarizer) needs to be measured. The measurement requires a polarization insensitive radiometer and a polarizer. The polarizer is rotated by 360^o, and the two cycle component of the measurements describes the polarization of the sphere. This two cycle component must be subtracted from Lmeas(β) as measured by OCI. The polarization of the sphere is not expected to have sharp spectral features, so linear interpolation from the wavelengths of the polarization insensitive radiometer to the OCI wavelengths is appropriate.
- 5) Straylight must be reduced to a reasonable minimum for the polarization sensitivity measurements. The straylight will be either estimated or measured with a 'lollipop' device put between the polarizer and OCI. If straylight is larger than 0.1% of A0, straylight will be measured and subtracted from Lmeas(β).

5. RESPONSE VERSUS SCAN ANGLE

a. Background and Requirement

OCI measures the TOA radiance at different scan angles θ_{scan}, from $+56.5^o$ to -56.5^o, and at the solar diffuser scan angle ($\theta_{scanSD}=90^o$). The absolute calibration is determined from measurements at θ_{scanSD}, so all other scan angles must be related to θ_{scanSD}. This is accomplished by K4(θ_{scan}) in the calibration equation, which describes how the measured dn of a constant radiance source vary as a function of θ_{scan} . By definition, K4($\theta_{scan} = \theta_{scanSD}$)=1.0. The requirements state that K4 must vary by less than 0.05, and the uncertainty of K4 must be 0.1% or less for the VIS/NIR wavelengths.

a. Basic Characterization Approach

OCI will look into a SIS (spherical integrating sphere). The SIS will provide a homogeneous, unpolarized light field. OCI will look into the SIS at different scan angles and measure the radiance Lmeas(θ_{scan}). Practically, this is easier to accomplish by rotating OCI (rather than moving the SIS). Therefore, a rotating table for OCI is needed for this test. The most difficult aspect of this test is to know the radiance produced by the SIS. Although a constant radiance is ideal, this is not required, as long as the radiance changes between OCI measurements are known. Radiance monitors (internal to the sphere or external) will be used to measure the radiance of the sphere and correct for any intensity variations. The radiance readings of these radiance monitors at time t are called RM(t).

The measurement of Lmeas(θ_{scan}) at $\theta_{scan}= \theta_{scanSD}$ will be made at time t_{SD}, and the measurement at any other scan angle at time t_{THSC}. For a constant light source, the measured K4m(θ_{scan}) can then be calculated as
$K4m(\theta_{scan}) = Lmeas(\theta_{scan}) / Lmeas(\theta_{scanSD})$

For a light source with varying intensity, the K4m(θ_{scan}) can be calculated as
$K4m(\theta_{scan}) = Lmeas(\theta_{scan})/RM(t=t_{THSC}) / (Lmeas(\theta_{scanSD}))/RM(t=t_{SD})$

It is expected that the dependence of K4 on scan angle can be described by a 2nd order polynomial (to be confirmed by the OCI optical model):
$K4(\theta_{scan}) = a0 +a1* \theta_{scan} + a2* \theta_{scan}^2$

The coefficients a0, a1, and a2 of this polynomial will be fitted to the measurements.

K4 is the function that will be used in science data processing. Therefore, the uncertainty requirement (0.1% for VIS/NIR) is on the fitted polynomial. K4 will be derived for each mirror side separately.

The angle θ_{scan} denotes the angle at which the science pixel is recorded. The actual scan angle of the light path in the instrument will cover a range of 16 science pixels close to θ_{scan} because of TDI. This may have to be considered when comparing instrument model predictions to actual system level measurements, but the effect does not impact the accuracy for science data processing.

6. RELATIVE SPECTRAL RESPONSE

This section describes the approach to verify OCI requirements using the relative spectral response measurements, focusing on center wavelength, bandwidth and out-of-band. Acquiring data with a monochromatic source (one monochromatic line for each the blue and red spectrograph) with each of the different modes is sufficient. To maximize the information content acquired with these tests, we will acquire all data with 1/8th of the nominal (5nm) spectral resolution setting of OCI, and bin the data using post-acquisition software processing.

There are two important uses of the relative spectral response (RSR) in ocean color processing: the out-of-band (OOB) correction of the measured top-of-atmosphere (TOA) radiance, and the convolution of the in-band RSR with modelled TOA radiances. Note that although the requirement defines OOB as those regions beyond the 1% points, for the correction, the range needed for the TOA correction is everything except for the in-band (IB), i.e. the region beyond the 50% points. In this document, we will focus on OOB50P defined with the 50% points, the OOB defined with the 1% threshold will be referred to as OOB1P.

The absolute spectral response (ASR) of band i is the response of the band (expressed as background subtracted dn) to stimulation by monochromatic light of wavelength λ, normalized by the radiance of the illumination source L_s:
$ASR^i(\lambda) = dn(\lambda)^i / L_s(\lambda)$. Once correction functions are available, the dn should be corrected for linearity, temperature, etc.

The relative spectral response is the ASR normalized to its maximum:
$RSR^i(\lambda) = ASR^i(\lambda) / \max[ASR^i(\lambda)]$

The radiance measured by band i is influenced by radiances from all wavelengths, weighted by the RSR:
$L_m^i = \int L_t(\lambda) * RSR^i(\lambda)\, d\lambda / \int RSR^i(\lambda)\, d\lambda$

where $L_t(\lambda)$ is the true radiance. Ocean color processing needs only the TOA radiance of the in-band region:
$L_c^i = \int_{[\lambda_{IB})]} L_t(\lambda) * RSR^i(\lambda)\, d\lambda / \int_{[\lambda_{IB})]} RSR^i(\lambda)\, d\lambda$

L_c^i can be calculated from
$L_c^i = L_m^i - \int_{[\lambda_{OOB}]} L_t(\lambda) * RSR^i(\lambda)\, d\lambda / \int_{[\lambda_{OOB}]} RSR^i(\lambda)\, d\lambda$

The equation above is the OOB correction.

Approximating L_t by the measured L_m^j $(j \neq i)$ from the other bands allows to solve this equation. This approximation will be avoided by using a matrix inversion technique as described in Zong et al, 2006.

Since the OOB effects have been corrected, the center wavelength λ_c should be calculated only for the IB wavelengths:
$\lambda_c = \int_{[\lambda_{IB}]} \lambda * RSR^i(\lambda)\, d\lambda / \int_{[\lambda_{IB}]} RSR^i(\lambda)\, d\lambda$

7. LINEARITY

GLAMR will be used to provide the illumination for OCI linearity testing. The GLAMR team will monitor the radiance exiting the sphere and provide the radiance values to OCI. GLAMR will provide different intensities by modifying the laser power.

For each tap, the wavelength will be selected where GLAMR can provide the maximum radiance. A maximum radiance of Lmax is ideal. GLAMR will provide the following radiance levels:

- 5 equidistant radiances levels from Lmin to Lbright
- 3 equidistant radiance levels from Lbright to Lmax or the highest radiance GLAMR can provide (whichever is smaller; Lbright will not be included)
- 3 equidistant radiance levels from 0 to Lmin (excluding 0 and Lmin)

OCI will make its measurements in regular science mode and scanning in TVAC (TVAC is critical for SWIR bands). The number of scans should be sufficient to achieve an accuracy of 0.01% after averaging (at least for the radiance levels higher than Lbright). E.g., if the SNR for a certain wavelength is 1000, each measurement has an uncertainty of 0.1%, and 10 scans with 10 useable science pixels each will provide a factor of sqrt(100)=10 reduction in uncertainty, i.e. 0.1%/10=0.01%. Note that for the low light levels, the OCI SNR will decrease substantially (presumably the GLAMR SNR as well), and the measurement time may need to be extended. The nonlinearity coefficient K_5 will be fitted to the measurements via polynomials. For each CCD, one wavelength per tab will be evaluated (K_5 is not expected to vary within a tap). This means for the ETU red spectrograph, linearity will be evaluated at 15 different wavelengths.

8. TEMPERATURE SENSITIVITY

Determining the K_3 term (as a function of various temperatures) in the radiance calibration requires correlation of OCI throughput with changes in temperature(s) from their nominal operating value(s) within the OCI optical system. The radiance L_m of the system is related to the K3 term as

$$L_m \boxed{\propto} [1 - \mathbf{K_3} \{T_1, T_2, T_3, \ldots, T_n, T_{1ref}, T_{2ref}, T_{3ref}, \ldots, T_{nref}\}]$$

K_3 is 0 at the reference temperature, correction of the gain is applied only when the system temperature state is changed from the nominal operating value.

T_n represents the temperature of the nth optical element that shows temperature dependent throughput sensitivity, and T_{nref} is the reference temperature for the nth component. ETU testing (in a thermal vacuum chamber, varying the OCI temperatures in a controlled way, preferably independent of each other) and STOP (Structural, Thermal and Optical Performance)analyses will help determine how many components are likely to be temperature sensitive and hence how many sensors will actually be required for flight calibration and where they should be placed. Prior to testing and STOP analyses the elements perceived to be most likely to affect system throughput as a function of temperature are the collimating mirror, the dielectric beamsplitters, the gratings, the focusing lens arrays and the rear imaging optic (RIO).

The precise optimal (most sensitive) location for a sensor on any given element will be advised by STOP analyses. In some cases it might be better to measure at more than one location on an element, however we do have a limit on the total number of sensors, presently set at 8 total dedicated for K_3 correction, and we will have access to many more spread throughout the OCI that are used for thermal monitoring and control of the instrument.

a. Nominal Sensor Locations

The FPA/FEE electronics have temperature sensors embedded within them and these temperatures will be used to correct the detector gain independent of any temperature-induced changes in the optics. Sub-system testing of the detector system will provide the appropriate correction curves.

8 sensors will be dedicated for optical component calibration and temperature correction in flight. Some sensors may ultimately prove to be unnecessary pending test results. Correlation between OCI throughput and sensors used for thermal control will also be examined to see if those sensors provide additional information, or can be used in place of those specifically planned for optical calibration. This potentially frees some sensors for other uses.

a. Test measurements

Since the changes in temperature are small, it is likely that any effects on the system throughput due to temperature changes of the components will be linear with temperature. Thus correction terms are essentially related to just the slope of an apparent gain vs. temperature line, and only two temperatures need be measured for each component. We are planning to measure system throughput at five system temperatures (determined by a control temperature TBD), four in addition to the reference temperature. The reference temperature will be near the midpoint of the nominal extremes for orbital operating range (10 and 25 °C). The system temperature will also be set and held at values near the extremes, and at values approximately halfway between each extreme and the reference. Using multiple temperatures in the test will provide some chance to detect any non-linear behavior in the gain vs. temperature curves. OCI does not provide control of the temperatures of individual components on the optical bench, so the temperatures of all components may vary in different ways. All will be recorded with temperature sensitivity +/- 0.5 °C or better.

a. Analyses

Correlations between apparent system gain and temperature will be examined for each component, and correlation of temperatures between components will also be determined. It is possible there will be no detectable gain changes as the system temperature is varied, in such case K_3 is simply 0. If significant gain effects are noted, they may be either 1) limited to a single component or 2) be some combination of temperature changes in multiple components. Correction will depend upon the degree of correlation and the number of elements involved. Five measurements will allow inclusion of up to 4 component temperatures in the correction (assuming all individual component effects are linear).

9. SIGNAL TO NOISE RATIO

The signal to noise ratio (SNR) is defined as

$$SNR = mean(L_i)/stdev(L_i)$$

where L_i is a set of measurements of OCI looking at a homogeneous light field, typically an spherical integrating sphere (SIS). The index 'i' identifies the number of the radiance measurement. Although the data could be acquired with a stationary telescope (to increase the number of samples per measurement time), image acquisition with a rotating telescope will give a more realistic estimate, because it allows the subtraction of dark current in a flight like mode. L_i can be calculated with the calibration equation provided in section 2.

There are two ways of evaluating SNR from an image analysis point of view: the index i could be proportional to the scan angle, and an SNR value would be calculated for every scan line. Or the radiance measurements could be taken at a certain within-scan sample number (corresponding to a fixed scan angle), and the mean and standard deviation would be calculated over scan lines. For OCI, both methods will be used. For the first case, spatial inhomogeneities of the radiance field in the exit aperture of the SIS need to be considered as an error source, whereas for the second case, the temporal stability of the light source becomes more critical. Since the uncertainties from neither method can bias the measured SNR too low, it is reasonable to use the method that produces the higher SNR for threshold evaluation.

In theory, correcting the measured radiances for a drift in the light source should increase the accuracy of the SNR measurement. In practice, especially in the shorter wavelengths, the noise of the monitoring GSE radiometers is similar to the OCI noise. Therefore, the GSE radiometers will only be used to validate that the light source was stable within the measurement period, not to actually correct the data.

The stability of the light source over short time periods is of critical importance for the SNR measurements. As of July 2018, the OCI team has identified that the EQ-400 provides stability at least an order of magnitude better than needed for the bands up to 900nm, whereas a halogen lamp provided sufficient accuracy for higher wavelengths. Both light sources have the advantage of covering a large spectral range. Monochromatic GLAMR measurements will also be used for SNR evaluations, but only for validation (only for those wavelengths where the noise of the GLAMR radiances is sufficiently low).

Ideally, SNR measurements will be acquired in thermal vacuum and at radiance levels covering all radiances from Llow to Lmax for every band.

10. LPT AND CPT

The characterization tests described so far will only be performed once during a test campaign. In order to monitor the performance of the unit under test throughout the campaign, two tests have been designed: the Limited Performance Test (LPT) and the Comprehensive Performance Test (CPT).

The LPT is a sequence of tests lasting about 8 hours. OCI is cycled through various data acquisition modes, acquiring data with zero illumination. This data is used for noise analysis. Then, a 12 inch integrating sphere is placed in front of OCI, illuminated by a 10W lamp inside the sphere. Two radiometers are connected to the sphere via fiber cables to monitor the light level in the sphere, one for wavelengths up to about 950nm, the other for wavelengths above, up to 2400nm. OCI makes measurements of the light exiting the exit aperture of the sphere, while the lamp is cycled through 3 power levels: 100%, 95%, and 90%. These measurements allow gain and linearity checks of OCI. Next, the light of several monochromatic lasers is fiber fed into the sphere, to test the wavelength calibration of OCI. Lastly, collimated light corresponding to much less than a science pixel is projected into OCI, to check for spatial responsivity variations of OCI.

The LPT test is designed such that for the Flight Unit, the ground support equipment for the test can travel with OCI, allowing OCI to be monitored even outside of its main characterization laboratory, e.g. after the integration of OCI onto the spacecraft.

In July 2019, a successful dry run of the LPT was completed (without OCI). In addition to exercising the ground support equipment (radiometers, light sources, environmental monitors, etc.), the data flow was exercised for the first time (using simulated OCI data), demonstrating the ability of the OCI team to monitor OCI data in real time.

The CPT is a sequence of tests lasting about 2 to 3 days. It includes an LPT test, and several of the tests described in the previous sections, but in abbreviated form. The CPT allows a much more thorough evaluation of OCI performance than the LPT. The CPT can only be performed in the OCI test laboratory, and is executed e.g. before and after environmental tests.

11. CONCLUDING REMARKS

The OCI ETU is on schedule to enter an extensive characterization campaign at NASA’s Goddard Space Flight Center towards the end of 2019. The campaign is similar to the test campaigns performed for previous NASA sensors that provided global ocean color products, such as SeaWiFS, MODIS, and VIIRS. The main purpose of the ETU test campaign is not the characterization of the ETU itself, but to optimize the test procedures for the Flight Unit, which is scheduled to be characterized in the summer of 2020.

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