Impact Of Ozone Concentration On Ocean Colour Retrievals For OCM-2

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ABSTRACT:

Ozone being an absorbing gas have a significant impact on OCM-2 bands 510 nm, 555 nm and 620 nm which are using for retrieval of major geophysical parameters like Chlorophyll and suspended sediment concentrations. A study has been carried out to analyse the impact of Ozone concentration by ingesting near real time from OMI (Ozone Monitoring Instrument) on Aura instead of Climatology V2013(2004 - 13) with a resolution of 1x1 deg for ocean colour retrievals from OCM-2 sensor using SeaWiFS Data Analysis System (SeaDAS). The spectral behaviour of Ozone transmittance has been studied for various bands of OCM-2 by using both Climatology and near real time inputs. We could observe maximum relative error percentage about 12 % from Climatology to NRT in Ozone concentration and 0.28 %, 0.66 % and 0.72 % of maximum mean relative error in ozone transmittance at 512 nm, 557 nm and 620 nm. We calculated error budgets induced by ozone in remote sensing reflectance(/sr) where in we could observe mean relative error percentage of 0.52 % in 491 nm, 1.12 % in 512 nm and 4.28 % 557 nm a bands respectively.

1. INTRODUCTION

Improvement in the retrieval of geophysical products from Ocean Color Monitor-2 is objective of this study. To achieve this, one approach is to ingest near real time Meteorological and Ozone data. Radiance from the sea surface reaching to any ocean color sensor undergoes gaseous absorption. It affects the magnitude of radiance. Ocean color processing involves removal of atmospheric components from sensor measured top of the atmosphere radiance (Lt). Lt can be written as (Franz et al., 2007, Eq. 1)*

$$Lt(\lambda) = (Lr(\lambda) + [La(\lambda) + Lra(\lambda)] + tdvLwc(\lambda) + tdv\ Lw(\lambda))tgvtgsfp \quad (1)$$

Lr(λ) is the Rayleigh radiance due to molecular scattering, La(λ) is the aerosol radiance, Lra(λ) is the interaction term between aerosol and molecular scattering, Lwc(λ) is the whitecap radiance, Lw(λ) is the water leaving radiance, tdv is the diffuse transmittance along the sensor viewing path, tgv is the gaseous transmittance in surface to sensor path, tgs is the gaseous transmittance in sun to surface path and fp polarization correction factor. In the process of atmospheric correction gases absorption removes at first. As of now, Gaseous transmittance is computing for eight gases namely Ozone(O3), Oxygen(O2), CO2, CO, H2O, CH4, N2O, NO2 in sun to surface direction and surface to sensor direction. It is a component quantifying the total losses due to eight gases based on its impact. In the above gases CO, N2O, CO2 and CH4 have negligible absorption in the Visible and NIR wavelengths (Mobley et al., 2016). Ozone transmittance is a function of Ozone concentration and air mass of the atmosphere , it decreases with increasing concentration and air mass.

$$\text{Ozone transmittance } tO3 = \exp[-\tau O3 M] \quad (2)$$

$M = 1/\cos\theta_s + 1/\cos\theta_v$ is the air mass to account for atmospheric path length, θ_s is the solar zenith angle, θ_v is the sensor zenith angle.

$$\tau O3(\lambda) = [O3]\ kO3(\lambda) \quad (3)$$

[O3] Ozone concentration in cm (1000 DU = 1 atm-cm), τO3(λ) is the optical thickness of the ozone for a vertical path through the atmosphere, kO3(λ) is the ozone absorption in /cm.

Sensor Specifications	**OCM-2**	**OMI**
IGFOV at nominal altitude (m)	360 x 236 m	3 km, binned to 13 x 24 km
Inclination	98.28 °	98.7 °
Swath width	1420 km	2600 km
Altitude	724 km	705 km
Spectral bands	Band 1: 404 - 424 nm Band 2: 431 - 451 nm Band 3: 476 - 496 nm Band 4: 500 - 520 nm Band 5: 546 - 566 nm Band 6: 610 - 630 nm Band 7: 725 - 755 nm Band 8: 845 - 885 nm	Visible: 350–500 nm UV–1: 270–314 nm UV–2: 306–380 nm
Equatorial crossing time	12 ± 10 minutes	13.45
Launch date	September 2009	July 15, 2004
Repeat cycle	2 Days	16 days

Tabel 1: Specifications of the sensors Ocean Color Monitor-2 (OCM-2) and Ozone Monitoring Instrument (OMI) used in the present study

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2. Methodology

In operational ocean color processing using SeaWiFs Data Analysis System, Ozone transmittance computed by using Ozone daily climatology data of 2004 to 2013 from OMI-Aura about 1 x 1 deg resolution. Here we examined the impact of Ozone concentration by computing relative error percentage in Ozone transmittance by using daily climatology and NRT data for 16 scenes of OCM-2 for the month of January 2017 (path: 009 and row: 013) by assuming the parameter generated using climatology data is a true value.

$$Relative\ error\ perentage = \left| \frac{Climatology\ parameter - near\ rael\ time\ paramater}{climatology\ parameter} \right| X100\%$$

Generated histograms for the open ocean region in Arabian sea of North 21.50 ° South 17.52 ° East 72.39 ° and West 63.93 °. Binwidth used for computing the histogram for the relative error percentage in remote sensing reflectance is 0.1. Wavelengths 491 nm, 512 nm, 557 nm and 620 nm are central wavelengths of OCM-2 channels have significant influence by Ozone transmittance. Remote sensing reflectance Rrs(/sr) is a fundamental geo-physical quantity to retrieve Chlorophyll-a concentration. It’s a ratio of Normalized water leaving radiance nLw(W/m2/µm/sr) to the extra terrestrial solar irradiance F0(W/m2/µm). nLw is the radiance emerging from water, normalized to the geometry of sensor and F0 is the extra terrestrial solar irradiance at mean Earth - sun distance.

2.1 Quality flags

In ocean color processing quality flags are assigned to each pixel to explain the quality of a pixel, one pixel can have more than one flag. Few quality flags analyzed in this study are ATMWARN, COCCOLITH, COASTZ and TURBIDW. ATMWARN flag is a condition for a pixel having epsilon values 0.85 > epsilon > 1.35, COASTZ flag is set when depth < 30 m, TURBIDW flag is a condition for a pixel having Rrs(670 nm) > 0.0012 (/sr).

3. Results and Discussions

Gaseous transmittance is the total transmittance of atmospheric column due to eight gases. Ozone gas only have considered in the present study due to its significant attenuation in visible wavelengths. The dates having relative error percentage with significant high frequency in Ozone transmittance is also showing significant percentage of relative error remote sensing reflectance(/sr).

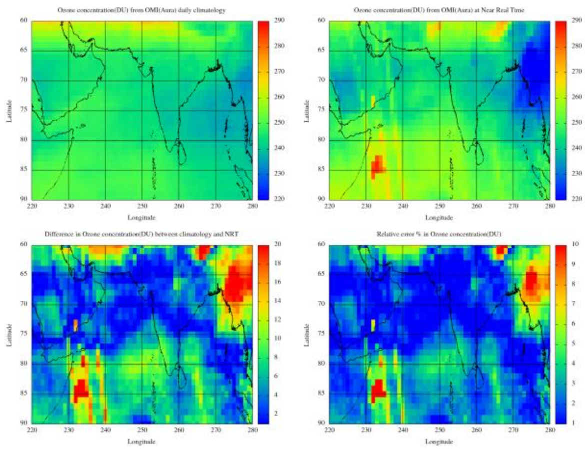

Figure 1: Ozone concentration (DU) from OMI (Aura) of daily climatology (top left) and near real time (top right) difference between climatology and NRT (bottom left) and relative error percentage wrt climatology (bottom right) about 1 x 1 deg spatial resolution for North Indian Ocean East: 40° West: 100° North: 0° South: 30° on 03 JAN 2017.

Figure plotted using daily climatology ozone data of 1 x 1 deg (180 x 360) from SeaDAS ancillary support files and NRT downloaded from OCEAN COLOR WEB on 03 JAN 2017 and coastline overlaid on ozone file. Latitude represented by 0 ° to 180 ° and longitude represented by 0 ° to 360 °.

Ozone concentration (DU) of daily climatology on 03 JAN 2017 for North Indian Ocean is showing consistent behaviour about∼240 to 260 DU, but details of greater than 290 DU and less than 220 DU could not seen in daily climatology. For the specific day on 03 JAN maximum observed difference is 20 DU and 10 to 12 DU difference can be seen in 0 ° N (Equator) to 10 ° N latitude of water surface.

Relative error percentage in Ozone concentration have computed using daily climatology and NRT concentration. Minimum relative error percentage of 0.50 % and 0.54 % have observed on 01 JAN, 03 JAN and maximum relative error percentage observed is 10.39 % on 23 JAN , 8.92 % on 25 JAN respectively.

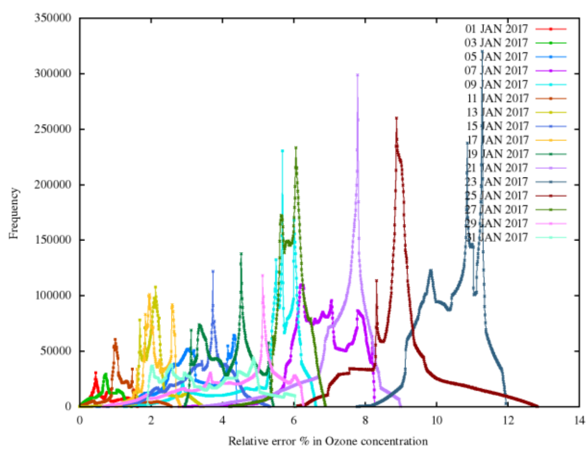

Figure 2: Histograms of Relative error percentage in ozone concentration between daily climatology and near real time for January 2017

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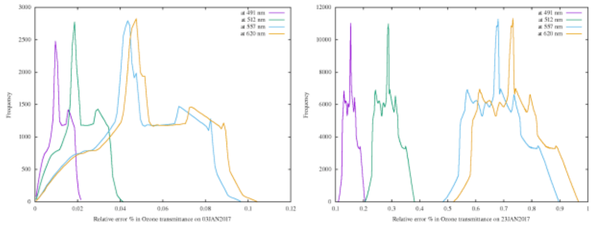

Figure 3: Histograms of Relative error percentage in Ozone transmittance (dimensional less) at 491, 512, 557 and 620 nm for OCM-2 on 03 January and 23 January 2017.

The spectral behaviour of Ozone transmittance can be seen in figure 3 between 491 nm, 512 nm, 557 nm and 620 nm wavelength for January 2017. Relative error percentage is showing high values with increasing wavelength. Among 16 days low and high mean relative error percentage only presented here. For the specific day histogram pattern needs to be analysed further.

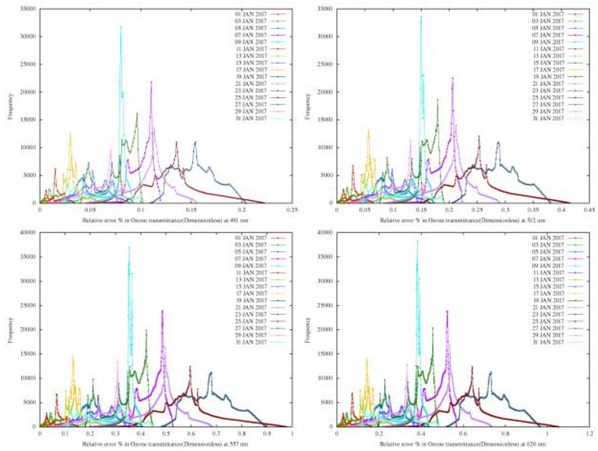

Figure 4: Histograms of Relative error percentage in Ozone transmittance (dimensionless) at 491 nm , 512 nm, 557 nm and 620 nm wavelength for the month of January 2017

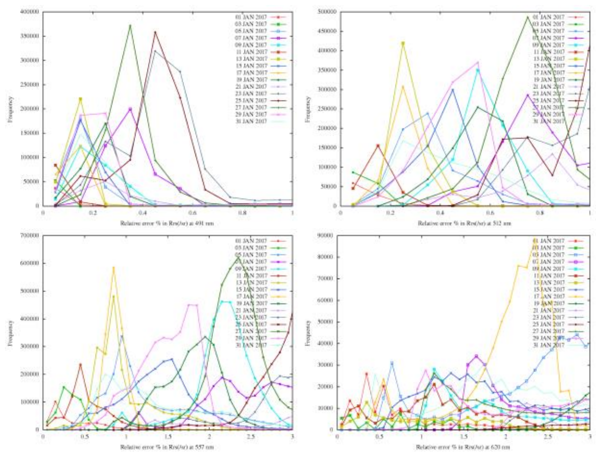

Figure 5: Histograms of Relative error percentage in Rrs (/sr) at 491 nm , 512 nm, 557 nm and 620 nm wavelength for the month of January 2017

Initially, magnitude of deviation computed between retrieved remote sensing reflectance (/sr) when daily climatology and near real time Ozone concentration have used. And computed relative error percentage w.r.t daily climatology. The relative error about 2 % can be positive or negative value. Minimum relative error percentage in Rrs (/sr) is 0.02, most of the days ranging to 0.6 at 491 nm, at 512 nm its ranging to 1 %, at 557 nm its showing 8 % of relative error. We are focussing on wavelength of 557 nm which is using as base band in retrieval of chlorophyll-a (OC2 & OC4) concentration (O’Reilly et al., 1998). Rrs (/sr) showing minimum on 03 JAN and maximum relative error is 8 % on 23 JAN. The mean relative error 8 % in rrs means retrieved rrs from climatology is having 0.00008 (/sr) if we taken the maximum possible rrs (/sr) (for eg 0.01 /sr) at 557 nm wavelength. Further analysis required to see the impact of ozone on chlorophyll concentration(mg/m3). The days 21 JAN, 23 JAN showing maximum mean relative error percentage having high relative error percentage 7.16 % and 10.39 % in Ozone concentration (DU) respectively. And minimum relative error percentage in rrs (/sr) have observed on 03 JAN having 0.54 % percentage of deviation in Ozone concentration.

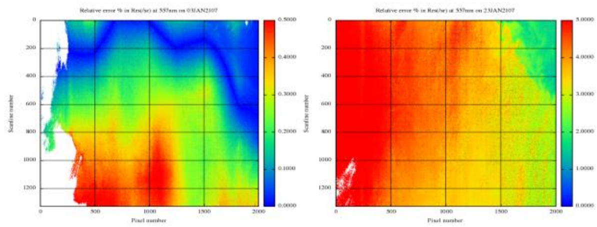

Figure 6: Spatial distribution of relative error percentage in Rrs (/sr) on 03 JAN 2017 and 23JAN2017 having low mean relative error percentage and high mean relative percentage.

SeaDAS quality flags allows examine the pixels which are sensitive to change in ozone concentration. Pixels with 2 % of deviation have flagged as TURBIDW on 23 JAN 2017 scene can be seen in figure 6.

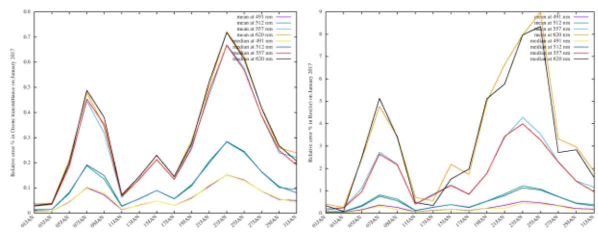

Figure 7: Mean and median of relative error percentage in Ozone transmittance (dimensionless) and Remote sensing reflectance (/sr) at 491 nm, 512 nm, 557 nm and 620 nm for January 2017

Due to vast number of pixels, plotted mean and median for individual days to see the consistency in relative error percentage. From this figure, we can observe the days having minimum and maximum relative error percentage in Ozone transmittance and remote sensing reflectance (/sr). 01 JAN, 03 JAN, 11 JAN are showing minimum and 23 and 25 JAN are showing maximum relative error percentage in Ozone transmittance at four bands.

4. Conclusions

At present OCM-2 operational ocean color processing uses climatology ancillary data for Ozone concentration to retrieve geophysical products. Near Real Time Ozone concentration is the alternative source to reduce the uncertainties. Based on the observation of 4 % relative error in remote sensing reflectance (/sr) further analysis is required to see the impact of Ozone concentration on remote sensing reflectance in different seasons. 4 % of deviation in rrs(/sr) may reduce the quality of chlorophyll concentration to be analyzed extensively in future. There is a need to process the ocean color data with available Near Real Time parameters to represent current weather / atmospheric conditions.

5. Acknowledgements

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