High resolution Sentinel-3B OLCI data during the tandem phase: a novel dataset towards the FLEX/S-3 mission

Introduction

In Summer 2018, during the Sentinel-3A / Sentinel-3B tandem phase, thanks to a joint effort of the S-3 team and the EE-8 Fluorescence Explorer (FLEX) team, OLCI (on the B unit) was operated for selected orbits in a special sequence acquiring 45 individual bands, and maximising the spectral resolution in the oxygen absorption bands. In this way, it was possible to acquire a set of real measurements to test at first the future FLEX Level-2A processing (i.e., geometric, radiometric and spectral co-registration), and the Level-2B processing (i.e., atmospheric characterisation using OLCI A and subsequent atmospheric correction for OLCI B in different spectral channels).

In total, 24 acquisitions were taken in this mode during the time window 14th June 2018 – 14th August 2018. Each acquisition covered more than 1500km along track, and the pattern was optimized in order to collect data over several ground sites instrumented with continuously operating systems and regularly overpassed with airborne systems within the ATMO-FLEX and FLEXSense ESA projects.

In order to process the raw data to Level-1B calibrated top-of-atmosphere radiances, the original 45-bands products were split in three spectral subsets, each containing a subset of 21 bands (i.e., FX1, FX2 and FX3).

Data structure

This dataset contains 72 standardly formatted OLCI “FLEX mode” L-1B products (24 acquisitions x 3 spectral subsets; Table 1). The products follow the standard naming convention for OLCI L-1B products, but the code of each spectral subset (i.e., FX1-3) was included in the product name (last three digits) in order to be unequivocally identified by the end-user. In conformity with the S-3 standard format, each folder includes 29 netCDF files (netCDF 4 format; Figure 1), in particular:

OaXX_radiance.nc 21 files corresponding to the 21 spectral bands (i.e., with “XX” being the band number);

geo_coordinates.nc annotation file containing DEM corrected longitude and latitude, and surface elevation above reference ellipsoid;

instrument_data.nc annotation file containing the instrument characteristics: detector index, re-sampling along-track frame offset, OLCI pixels characterized central wavelength, OLCI bandwidths (Full Widths at Half Maximum), in-band solar irradiance (seasonally corrected), relative spectral covariance matrix;

tie_geo_coordinates.nc annotation file containing longitude and geodetic latitude at tie points;

tie_geometries.nc annotation file containing Sun and viewing zenith and azimuth angles at tie points;

tie_meteo.nc annotation file containing several meteo information at tie points: horizontal wind vector at 10m altitude, mean sea level pressure, total columnar ozone, relative humidity, reference pressure levels, atmospheric temperature profile, total column water vapor;

time_coordinates.nc annotation file containing the measurement time stamp for each line of the product;

quality_flags.nc annotation file containing classification and quality flags for each pixel. It comprises the following flags:

- Land \ saline water mask (based on a priori knowledge)
- Fresh inland water mask (based on a priori knowledge)
- Tidal regions mask (based on a priori knowledge)
- Coastline mask (based on a priori knowledge)
- Preliminary Cloud mask (bright pixels)
- Identification of pixels not corrected for the straylight
- Identification of invalid pixels
- Identification of pixels where sun glint might occurs (computed in function of the viewing and sun geometries as well as the wind conditions at water surface
- Identification of saturated samples
- Identification of “dubious” samples or pixels of potentially lower quality
- Identification of cosmetic pixels (containing at least one sample filled with cosmetic data)
- Identification of duplicated pixels (as a consequence of the re-sampling process on an even product grid)

removed_pixels.nc annotation file containing index of the pixels removed during the processing

Moreover, a manifest file (“xfdumanifest.xml”) with all information on the logical view of the data product, the associated metadata and all the physical information needed to get the location of each file composing the product. A thorough description of the structure of the manifest file can be found in the Product Data Format Specification - Product Structures document (https://sentinel.esa.int/documents/247904/1848151/Sentinel-3_Product_Format_Specification_Product_Structures).

The L-1B products can be read with SNAP (https://step.esa.int/main/toolboxes/snap/), ENVI (https://www.l3harrisgeospatial.com/Software-Technology/ENVI) or any other software capable of reading standard S-3 OLCI L-1B data. Moreover, the netCDF 4 files can be explored with any netCDF compatible software (e.g., Panoply https://www.giss.nasa.gov/tools/panoply/) or programming language (e.g., MATLAB https://mathworks.com/, R https://www.r-project.org/, Python https://www.python.org/).

Table 1: List of the 72 Sentinel-3 OLCI "FLEX mode" products contained in this dataset.

Product name

Product name

S3B_OL_1_EFR____20180614T094159_20180614T094647_20200205T143540_0287_009_193_____LR1_D_NT_FX1.SEN3
S3B_OL_1_EFR____20180614T094159_20180614T094647_20200205T151723_0287_009_193_____LR1_D_NT_FX2.SEN3
S3B_OL_1_EFR____20180614T094159_20180614T094647_20200205T153538_0287_009_193_____LR1_D_NT_FX3.SEN3
S3B_OL_1_EFR____20180619T105407_20180619T105855_20191022T113046_0287_009_265_____LR1_D_NT_FX1.SEN3
S3B_OL_1_EFR____20180619T105407_20180619T105855_20191022T123655_0287_009_265_____LR1_D_NT_FX2.SEN3
S3B_OL_1_EFR____20180619T105407_20180619T105855_20191022T125833_0287_009_265_____LR1_D_NT_FX3.SEN3
S3B_OL_1_EFR____20180621T095946_20180621T100433_20191022T133751_0287_009_293_____LR1_D_NT_FX1.SEN3
S3B_OL_1_EFR____20180621T095946_20180621T100433_20191022T140454_0287_009_293_____LR1_D_NT_FX2.SEN3
S3B_OL_1_EFR____20180621T095946_20180621T100433_20191022T142537_0287_009_293_____LR1_D_NT_FX3.SEN3
S3B_OL_1_EFR____20180624T102312_20180624T102800_20191023T163436_0287_009_336_____LR1_D_NT_FX1.SEN3
S3B_OL_1_EFR____20180624T102312_20180624T102800_20191023T165353_0287_009_336_____LR1_D_NT_FX2.SEN3
S3B_OL_1_EFR____20180624T102312_20180624T102800_20191023T172301_0287_009_336_____LR1_D_NT_FX3.SEN3
S3B_OL_1_EFR____20180627T104659_20180627T105146_20191023T174127_0287_009_379_____LR1_D_NT_FX1.SEN3
S3B_OL_1_EFR____20180627T104659_20180627T105146_20191023T180018_0287_009_379_____LR1_D_NT_FX2.SEN3
S3B_OL_1_EFR____20180627T104659_20180627T105146_20191023T181848_0287_009_379_____LR1_D_NT_FX3.SEN3
S3B_OL_1_EFR____20180628T101928_20180628T102415_20191024T101401_0287_010_008_____LR1_D_NT_FX1.SEN3
S3B_OL_1_EFR____20180628T101928_20180628T102415_20191024T103806_0287_010_008_____LR1_D_NT_FX2.SEN3
S3B_OL_1_EFR____20180628T101928_20180628T102415_20191024T110618_0287_010_008_____LR1_D_NT_FX3.SEN3
S3B_OL_1_EFR____20180702T101353_20180702T101841_20191024T140239_0287_010_065_____LR1_D_NT_FX1.SEN3
S3B_OL_1_EFR____20180702T101353_20180702T101841_20191024T143530_0287_010_065_____LR1_D_NT_FX2.SEN3
S3B_OL_1_EFR____20180702T101353_20180702T101841_20191024T150927_0287_010_065_____LR1_D_NT_FX3.SEN3
S3B_OL_1_EFR____20180703T094952_20180703T095440_20191024T154445_0287_010_079_____LR1_D_NT_FX1.SEN3
S3B_OL_1_EFR____20180703T094952_20180703T095440_20191024T162142_0287_010_079_____LR1_D_NT_FX2.SEN3
S3B_OL_1_EFR____20180703T094952_20180703T095440_20191024T165809_0287_010_079_____LR1_D_NT_FX3.SEN3
S3B_OL_1_EFR____20180707T094618_20180707T095105_20191024T210546_0287_010_136_____LR1_D_NT_FX1.SEN3
S3B_OL_1_EFR____20180707T094618_20180707T095105_20191025T091145_0287_010_136_____LR1_D_NT_FX2.SEN3
S3B_OL_1_EFR____20180707T094618_20180707T095105_20191025T093024_0287_010_136_____LR1_D_NT_FX3.SEN3
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S3B_OL_1_EFR____20180710T100822_20180710T101310_20191025T074802_0287_010_179_____LR1_D_NT_FX2.SEN3
S3B_OL_1_EFR____20180710T100822_20180710T101310_20191025T080633_0287_010_179_____LR1_D_NT_FX3.SEN3
S3B_OL_1_EFR____20180711T094233_20180711T094721_20191025T094937_0287_010_193_____LR1_D_NT_FX1.SEN3
S3B_OL_1_EFR____20180711T094233_20180711T094721_20191025T100904_0287_010_193_____LR1_D_NT_FX2.SEN3
S3B_OL_1_EFR____20180711T094233_20180711T094721_20191025T102810_0287_010_193_____LR1_D_NT_FX3.SEN3
S3B_OL_1_EFR____20180714T100335_20180714T100823_20191025T133047_0287_010_236_____LR1_D_NT_FX1.SEN3
S3B_OL_1_EFR____20180714T100335_20180714T100823_20191025T134958_0287_010_236_____LR1_D_NT_FX2.SEN3
S3B_OL_1_EFR____20180714T100335_20180714T100823_20191025T140940_0287_010_236_____LR1_D_NT_FX3.SEN3
S3B_OL_1_EFR____20180716T105420_20180716T105907_20191025T151315_0287_010_265_____LR1_D_NT_FX1.SEN3
S3B_OL_1_EFR____20180716T105420_20180716T105907_20191025T153239_0287_010_265_____LR1_D_NT_FX2.SEN3
S3B_OL_1_EFR____20180716T105420_20180716T105907_20191025T155215_0287_010_265_____LR1_D_NT_FX3.SEN3
S3B_OL_1_EFR____20180718T095954_20180718T100441_20191004T151811_0287_010_293_____LR1_D_NT_FX1.SEN3
S3B_OL_1_EFR____20180718T095954_20180718T100441_20191007T112006_0287_010_293_____LR1_D_NT_FX3.SEN3
S3B_OL_1_EFR____20180718T095954_20180718T100441_20191016T135009_0287_010_293_____LR1_D_NT_FX2.SEN3
S3B_OL_1_EFR____20180721T170751_20180721T171238_20191025T161148_0287_010_340_____LR1_D_NT_FX1.SEN3
S3B_OL_1_EFR____20180721T170751_20180721T171238_20191025T163138_0287_010_340_____LR1_D_NT_FX2.SEN3
S3B_OL_1_EFR____20180721T170751_20180721T171238_20191025T165114_0287_010_340_____LR1_D_NT_FX3.SEN3
S3B_OL_1_EFR____20180724T104656_20180724T105143_20191025T171102_0287_010_379_____LR1_D_NT_FX1.SEN3
S3B_OL_1_EFR____20180724T104656_20180724T105143_20191025T173127_0287_010_379_____LR1_D_NT_FX2.SEN3
S3B_OL_1_EFR____20180724T104656_20180724T105143_20191025T175104_0287_010_379_____LR1_D_NT_FX3.SEN3
S3B_OL_1_EFR____20180725T101732_20180725T102219_20200206T061121_0287_011_008_____LR1_D_NT_FX1.SEN3
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S3B_OL_1_EFR____20180725T101732_20180725T102219_20200206T070337_0287_011_008_____LR1_D_NT_FX3.SEN3
S3B_OL_1_EFR____20180729T101350_20180729T101838_20200602T143132_0287_011_065_____LR1_D_NT_FX1.SEN3
S3B_OL_1_EFR____20180729T101350_20180729T101838_20200602T145245_0287_011_065_____LR1_D_NT_FX2.SEN3
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S3B_OL_1_EFR____20180730T094954_20180730T095441_20191007T113731_0287_011_079_____LR1_D_NT_FX1.SEN3

Product name

S3B_OL_1_EFR____20180730T094954_20180730T095441_20191007T123408_0287_011_079_____LR1_D_NT_FX2.SEN3
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S3B_OL_1_EFR____20180802T101008_20180802T101456_20191112T110358_0287_011_122_____LR1_D_NT_FX1.SEN3
S3B_OL_1_EFR____20180802T101008_20180802T101456_20191112T112809_0287_011_122_____LR1_D_NT_FX2.SEN3
S3B_OL_1_EFR____20180802T101008_20180802T101456_20191112T114832_0287_011_122_____LR1_D_NT_FX3.SEN3
S3B_OL_1_EFR____20180802T165646_20180802T170133_20191112T120955_0287_011_126_____LR1_D_NT_FX1.SEN3
S3B_OL_1_EFR____20180802T165646_20180802T170133_20191112T123042_0287_011_126_____LR1_D_NT_FX2.SEN3
S3B_OL_1_EFR____20180802T165646_20180802T170133_20191112T125120_0287_011_126_____LR1_D_NT_FX3.SEN3
S3B_OL_1_EFR____20180806T100714_20180806T101201_20191105T134832_0287_011_179_____LR1_D_NT_FX1.SEN3
S3B_OL_1_EFR____20180806T100714_20180806T101201_20191105T140635_0287_011_179_____LR1_D_NT_FX2.SEN3
S3B_OL_1_EFR____20180806T100714_20180806T101201_20191105T142504_0287_011_179_____LR1_D_NT_FX3.SEN3
S3B_OL_1_EFR____20180810T100332_20180810T100819_20191112T131045_0287_011_236_____LR1_D_NT_FX1.SEN3
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S3B_OL_1_EFR____20180814T095950_20180814T100437_20200206T105840_0287_011_293_____LR1_D_NT_FX2.SEN3
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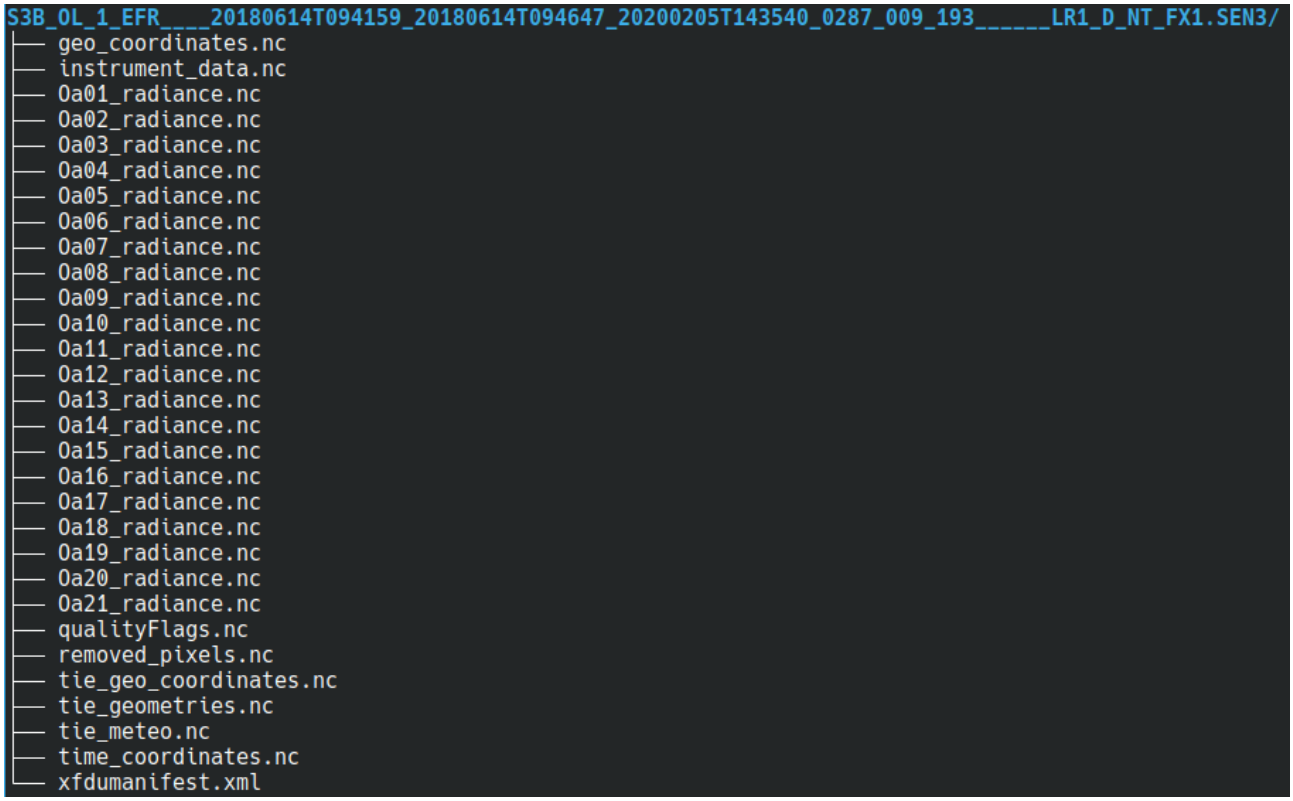

Figure 1: folder structure for one of the 72 S-3 OLCI "FLEX mode" L-1B products contained in this dataset.

Example code for reading

```
function [out] = READ_S3_OLCI_L1B(fname)
%READ_S3_OLCI_L1B function to load Sentinel-3 OLCI L-1B standard data into a MATLAB
%structure
%   README INFO
%
%   c - number of columns
%   r - number of rows
%   b - number of bands
%   i - detector index
%
%   INPUT
%
%               fname - full path to OLCI L-1B product folder (e.g.,
'/home/user/S3A_OL_1_EFR____20180103T094257_20180103T094557_20180104T144307_017
9_026_193_2160_LN1_O_NT_002.SEN3/')
%
%   OUTPUT
%
%   out - a structure containing the spectral information as well as key ancillary data, in particular:
%
%      out.altitude       - [c x r] DEM corrected altitude in meters
%      out.latitude       - [c x r] DEM corrected latitude in degrees North
%      out.longitude      - [c x r] DEM corrected longitude in degrees East
%      out.detector_index  - [c x r] Index of the detector in the spatial grid
%      out.frame_offset    - [c x 1] Re-sampling along-track frame offset
%      out.lambda0        - [i x b] OLCI characterised central wavelength in nm
%      out.FWHM           - [i x b] OLCI bandwidth (Full Widths at Half Maximum) in nm
%      out.solar_flux     - [i x b] In-band solar irradiance, seasonally corrected in mW.m-2.nm-1
%        out.Oa_radiance      - [c x r x b] TOA radiance for OLCI acquisition bands in mW.m-2.sr-
1.nm-1
%
%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
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%
%   20201015 - first version
%
```

```
%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%


%%  Initialization
out = struct;

%%  Data read

%   Latitude / Longitude / Altitude
out.altitude     = ncread(fullfile(fname,'geo_coordinates.nc'),'altitude'); [c,r] = size(out.altitude);
out.latitude     = ncread(fullfile(fname,'geo_coordinates.nc'),'latitude');
out.longitude    = ncread(fullfile(fname,'geo_coordinates.nc'),'longitude');

%   Instrument characteristics

out.detector_index  = ncread(fullfile(fname,'instrument_data.nc'),'detector_index');
out.frame_offset    = ncread(fullfile(fname,'instrument_data.nc'),'frame_offset');
out.lambda0         = ncread(fullfile(fname,'instrument_data.nc'),'lambda0'); b = size(out.lambda0,2);
out.FWHM            = ncread(fullfile(fname,'instrument_data.nc'),'FWHM');
out.solar_flux      = ncread(fullfile(fname,'instrument_data.nc'),'solar_flux');

%   TOA radÃ¬ance
out.Oa_radiance = nan(c,r,b);

for b_ = 1:b
    eval(['out.Oa_radiance(:,:,' num2str(b_) ') = ncread(fullfile(fname,''Oa' sprintf('%02u',b_) '_radiance.nc''),''Oa' sprintf('%02u',b_) '_radiance'');']);
end

end
```