Characterization and Correction of OMPS Nadir Mapper L1B measurements for Ozone Profile Retrievals

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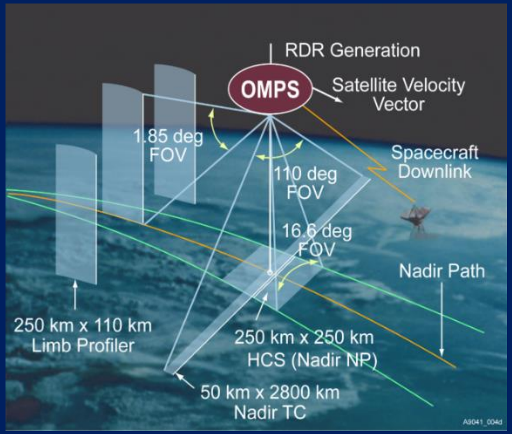
- OMPS is the next generation of BUV radiation sensors.
- Flying onboard the Suomi NPP spacecraft launched in 2011.
- Continue the nearly 40 year NASA ozone record.
- Composed of three difference sensors, followings.



Nadir Mapper	**nadir viewing, 300–380 nm (@1.0 nm), 110°, total column O_3 and other trace gases**	OMI/TOMS
Nadir Profiler	250–310 nm (@1.0 nm) , continue heritage of SBUV, Stratospheric Ozone Profile (15-60km)	SBUV2
Limb Profiler	limb viewing, 280–1000 nm (@0.8-25 nm nm), 16°, O_3 profiles	MLS

- No OMPS ozone profile product including troposphere, like OMI/GOME

SAO Ozone Profile Algorithm

- Optimal Estimation
- Heritage: GOME (Liu et al., 2005), OMI (Liu et al., 2010), GOME2(Cai et al., 2012), adapted for GEMS and TEMPO.
- RTM : VLIDORT v2.6

  ➔ BDM O3 cross section

  ➔ Slit Function : OMPS preflight slit function

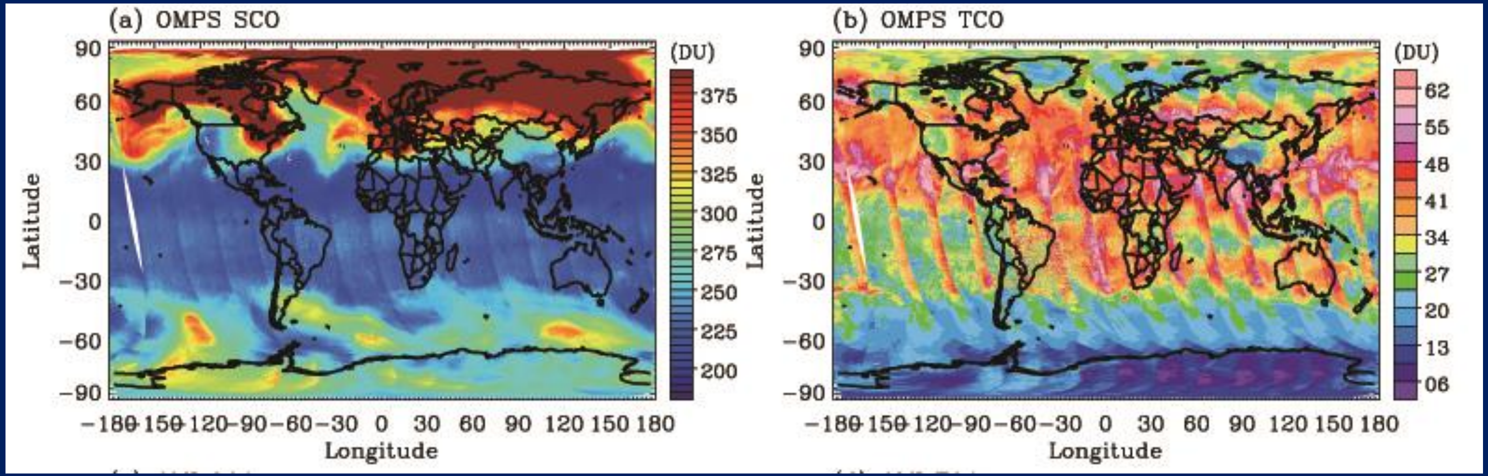
  ➔ OMPS Raman cloud product, OMI surface albedo climatology

  ➔ NCEP FNL temperature, surface pressure (1x1 deg, 26 levels)
- A priori : Tropopause-based ozone profile climatology (Bak et al. 2013)
- OMPS v2.0 L1B data : OMPS radiance with 1) soft calibration and 2) common mode correction for 302.5-340 nm.
- Measurement Error : 3) OMPS Floor Noise Error

Initial OMPS retrievals (2013m0314)

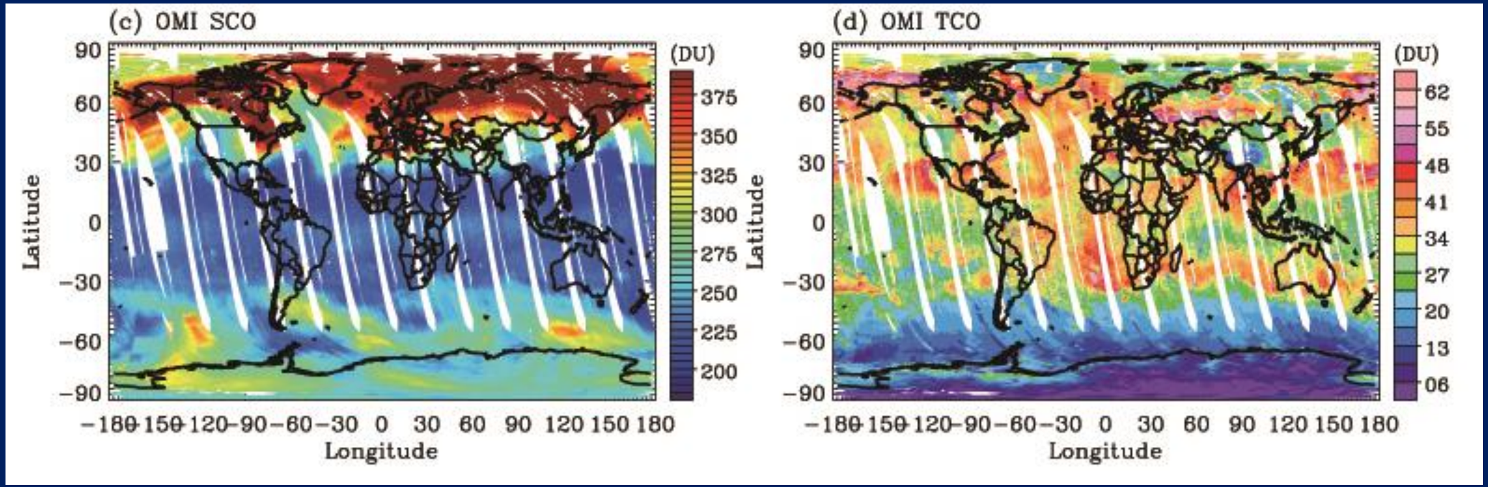
OMPS SCO

OMPS TCO



OMI SCO

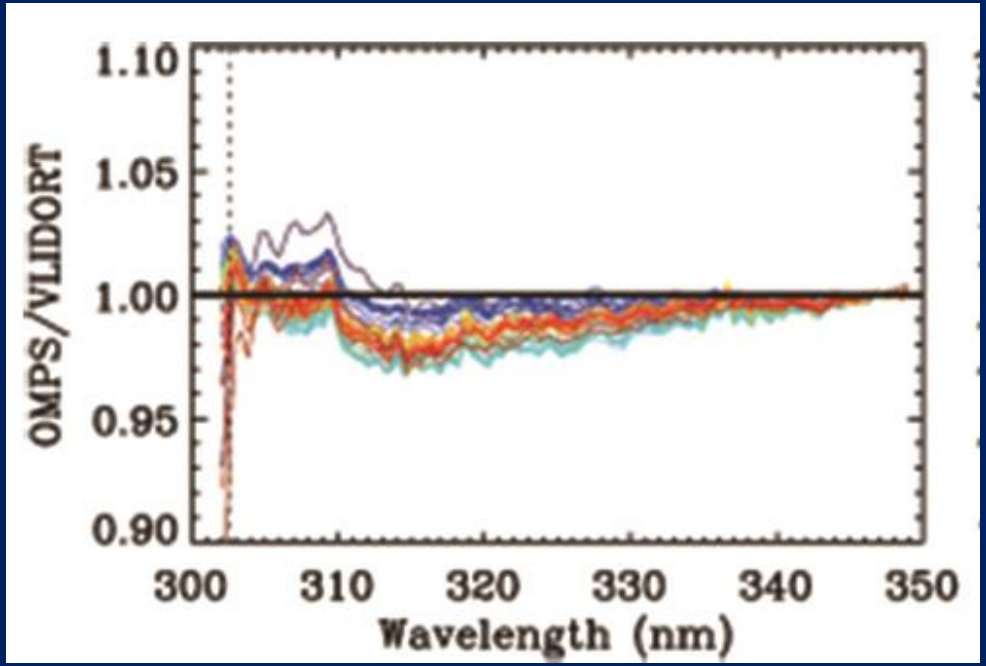
OMI TCO



- Excellent consistency between OMPS and OMI SCO even though OMPS does not cover much of the Hartley O3 absorption wavelengths where strat. O3 comes mostly from.
- Significant positive biases of OMPS TCO relative to OMI, which is largely dependent on the cross-track position.
- 2D CCD could be susceptible to artificial cross-track errors.

Soft Calibration

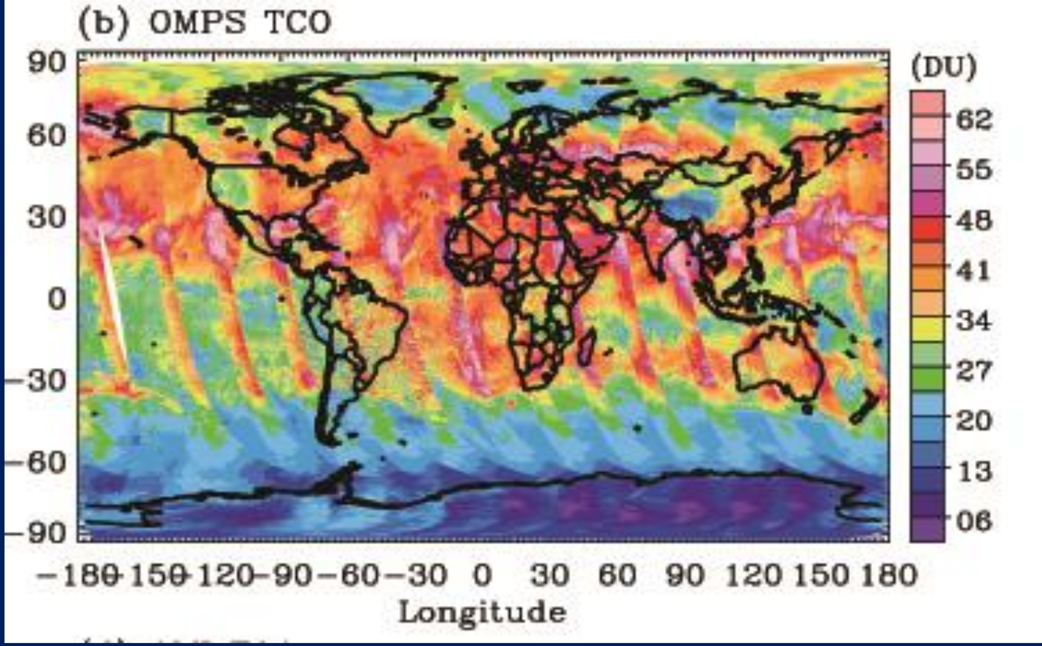
❖Characterize Systematic Component of $Y - R(X)$ under tropical sky condition



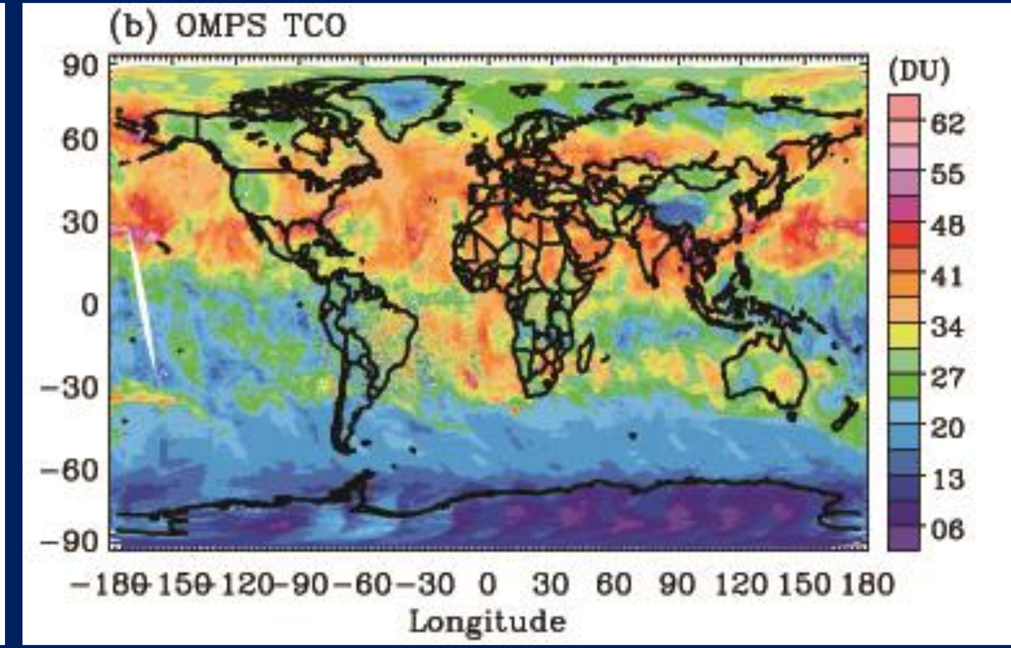
- Scenes where we could assume that all parameters are known; tropical clear-sky conditions
- OMPS radiances for 25 days (1-25th MAR 2013) and VLIDORT simulations with collocated OMI O3 profiles.
- Residuals are mostly at ± 2 %, except at λ <~ 302.5 nm where systematic biases increase sharply due to the overcorrection of straylight in OMPS v2.0 processing.

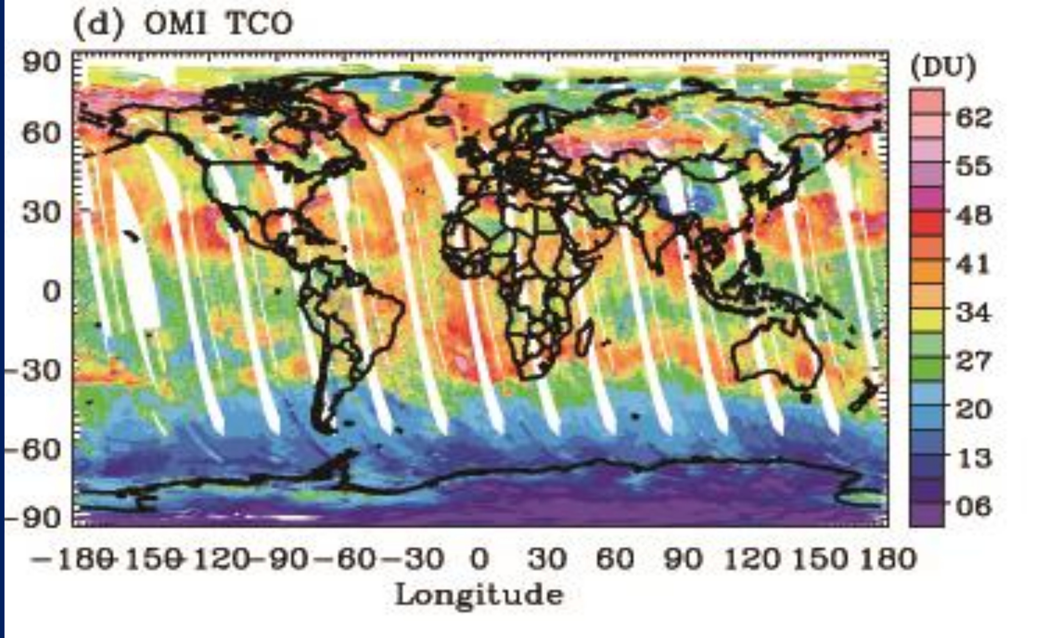
❖Apply Y = Y/Csoft

- OMPS w/o soft



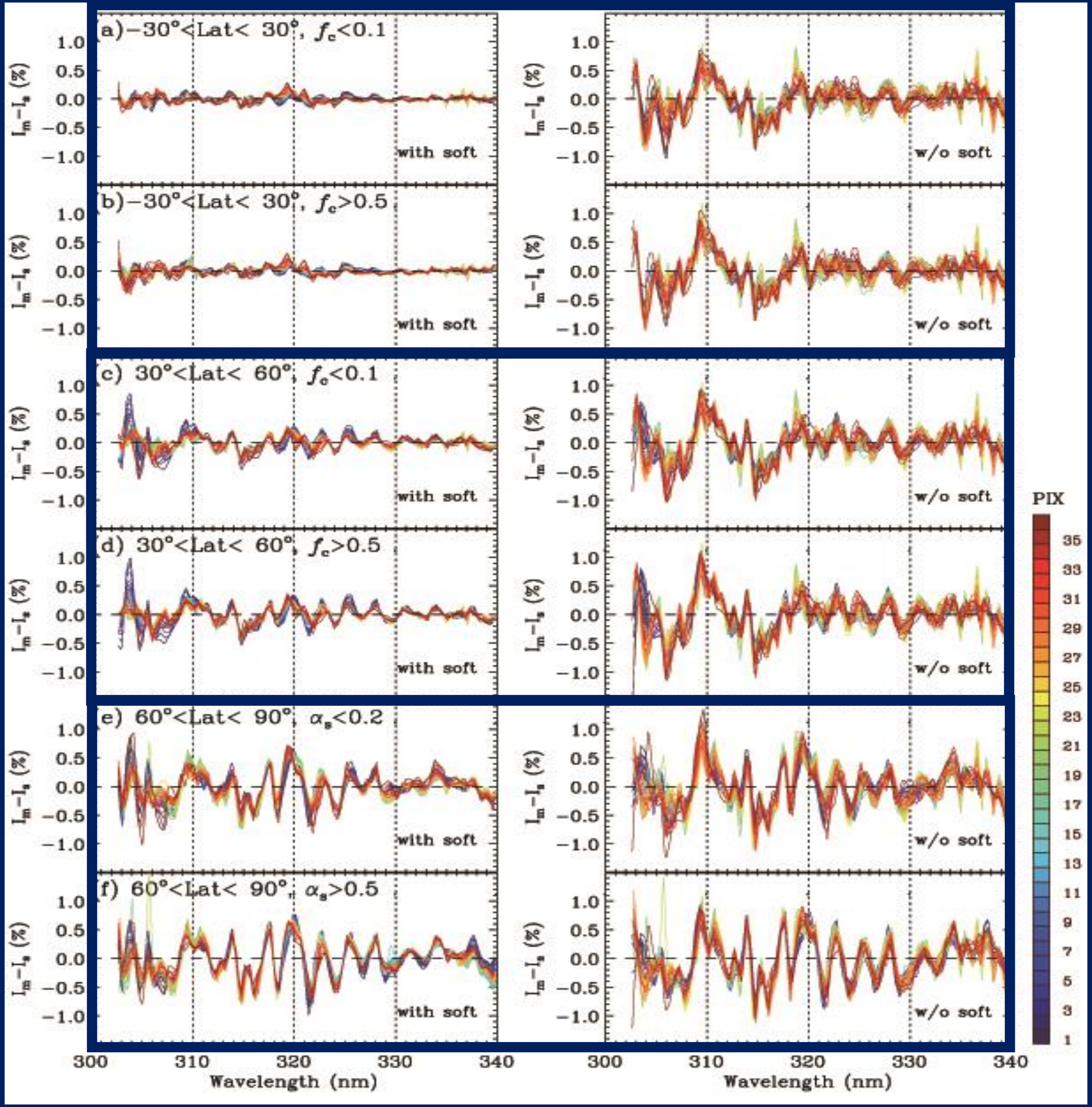
- OMPS with soft





➔ remove cross-track striping errors in tropospheric column ozone retrievals so consistency with OMI retrievals are greatly improved.

■ OMPS with soft ■ OMPS w/o soft



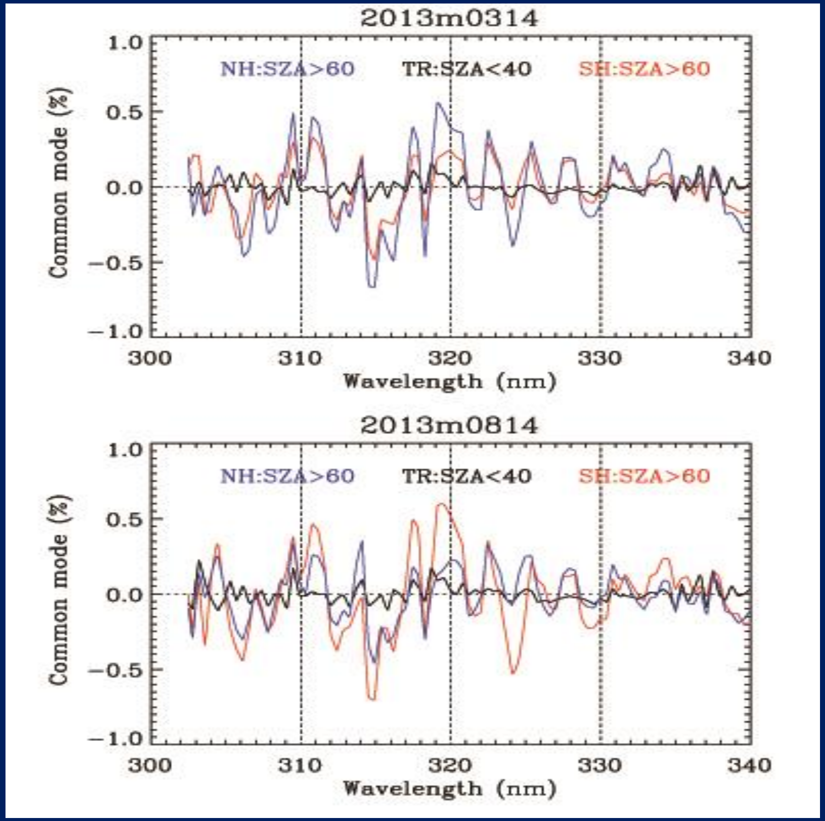
- Effect of soft calibration on fitting residual spectrum, over low, mid, high latitude bands for cloud/clear sky, low/high albedo surfaces.

- 1 % for short UV and 0.3 to 0.5 % for longer UV without soft calibration
- Improve the fitting accuracy for both clear and cloudy pixels, especially over tropics and mid latitude region.

  ➔ 0.2 % at longer wavelength

- In high latitudes, improvements can be identified, but large remaining systematic biases can still be found.

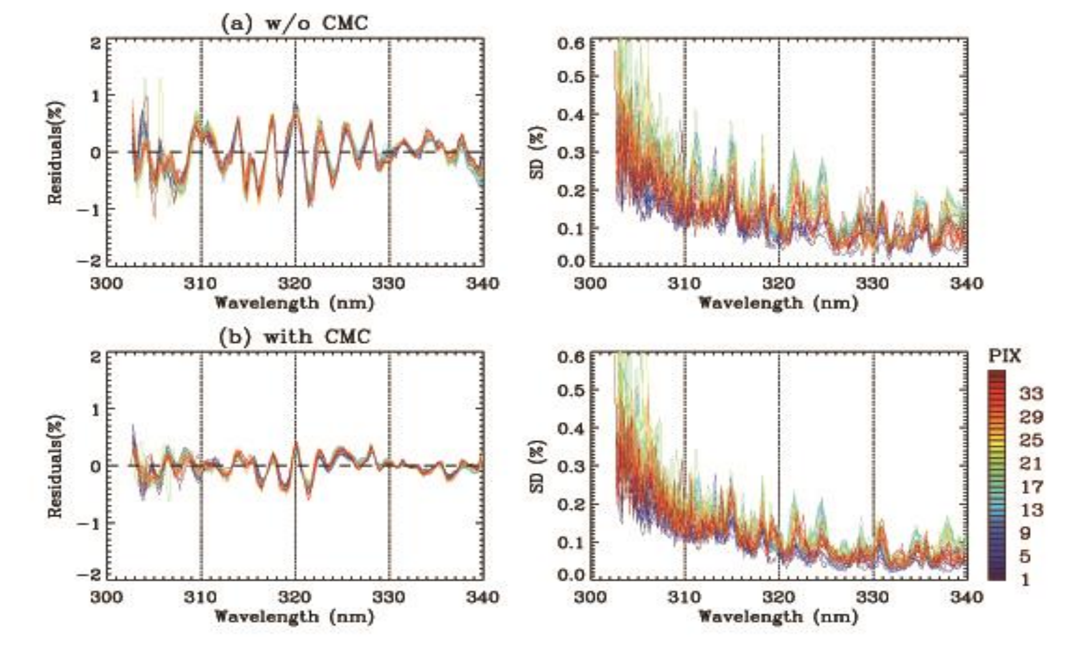
Common mode correction (CMC)



- Way to need : To correct systematic biases remaining after soft calibration, especially at high latitudes
- How to derive: characterize spectral fitting residuals at final iteration classified into 3 latitude/SZA regimes (SH polar region/SZA>60°, tropical region/ SZA<40°, NH polar region/ SZA>60°) for each cross-track position and for one day (14^{th} or 15^{th}) of each month.
- How to apply: : $\mathrm{I} = \mathrm{I} - S \cdot C_{cmc}$ at every iteration whose amplitude (S) is iteratively and simultaneously adjusted with the rest of other state vector components

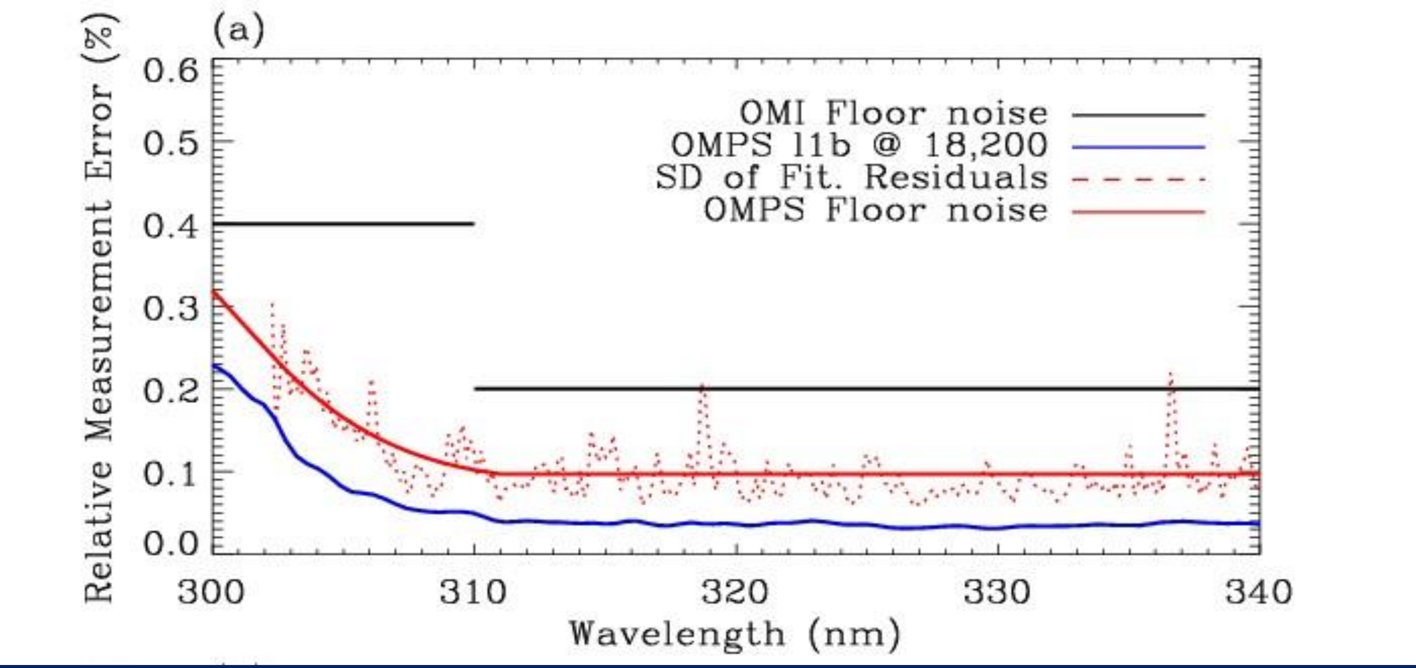
Impact of CMC on retrievals

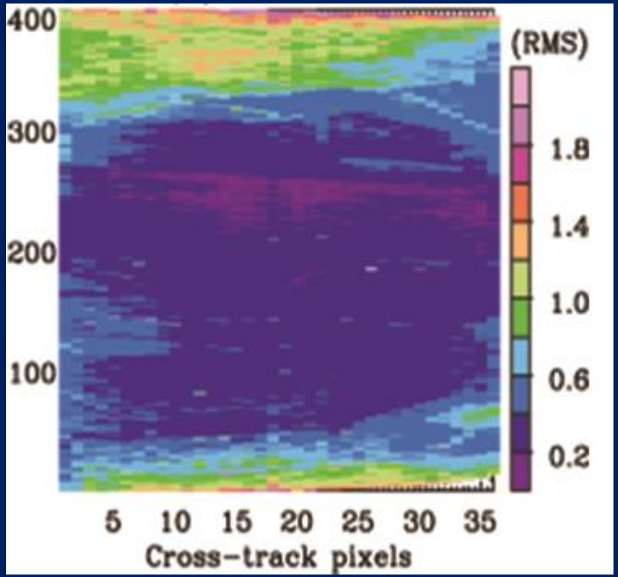
- **Fitting residual spectrum at high latitude**



- eliminate the wavelength dependent fitting errors , with reduced amplitude of them from 1% to 0.5 %.
- Reduce the standard deviations of residuals.

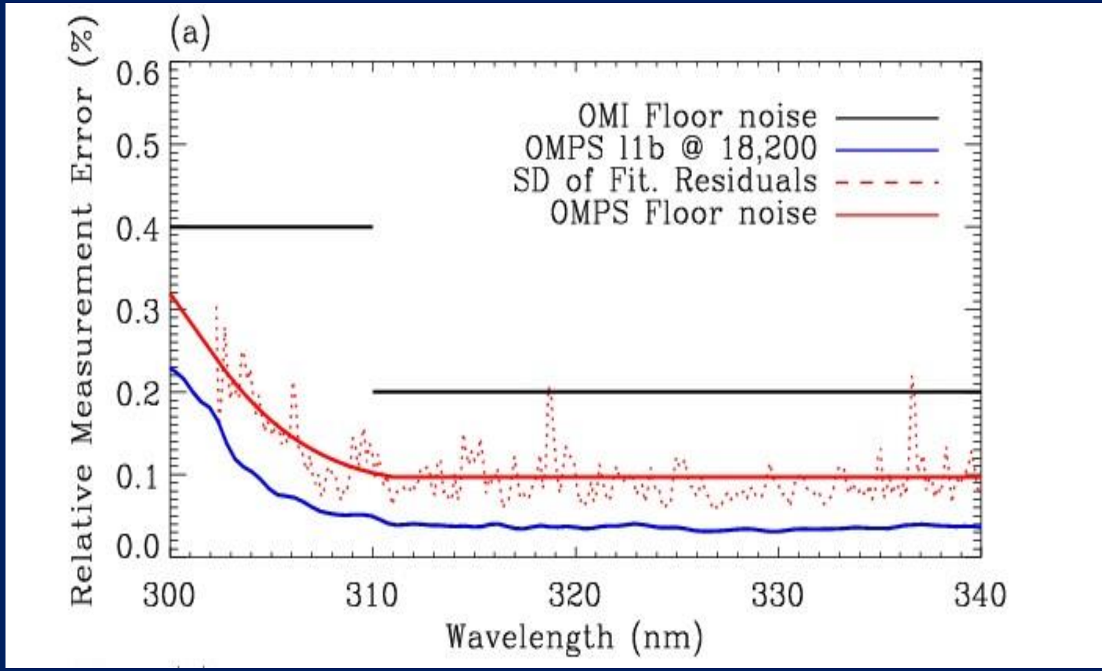
Measurement error correction

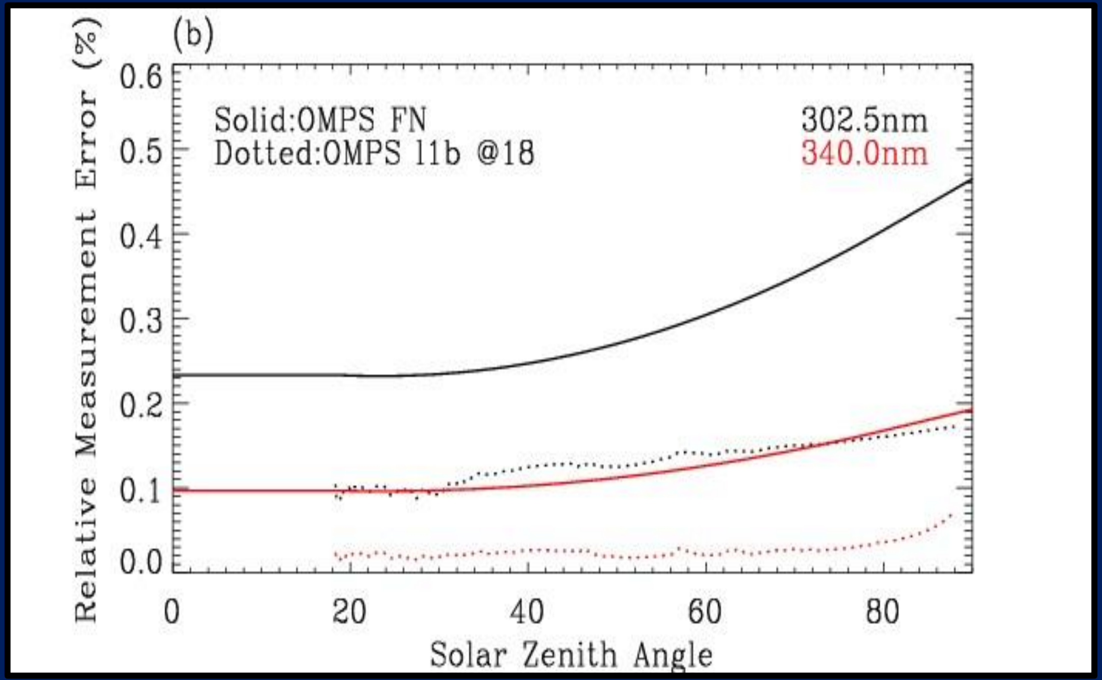




- OMPS L1B (~ 0.04 % @ 320 nm) : too small so many retrievals are failed due to overfitting.
- OMI FN (0.4 % <310 nm, 0.2%>310 nm) : our preliminary retrievals show a room for increasing DFS with a better measurement error constraints.
- OMPS SNR could be better than OMI, due to Its coarser spectral and spatial resolutions

- Gonzalez et al (2016): better detection limit of OMPS H2CO retrievals than OMI.





- (Red dashed) Characterize SD of fitting residuals in the tropical clear sky to define OMPS minimum random noise errors.
- (Red solid) Apply 4th order polynomial fit to define OMPS minimum FN error

1.5-4 times smaller than OMI FN below 310 nm, 2 times above 310 nm.

- Impose the minimum FN at SZA < 20 and multiply a SNR scaling factor to increase measurement error as a function of SZAs.

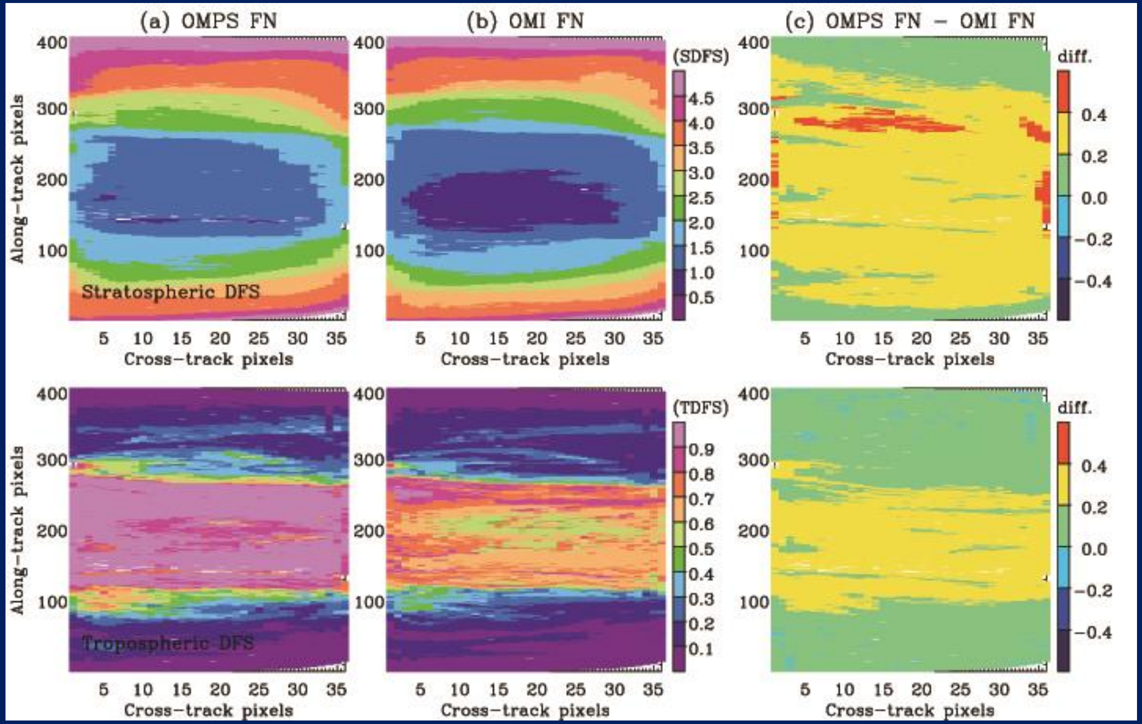
@ 302.5 nm from 0.24 % to 0.45 %

@ 340 nm from 0.097 to 0.19 %

Impact of measurement error correction on DFS (sensitivity)

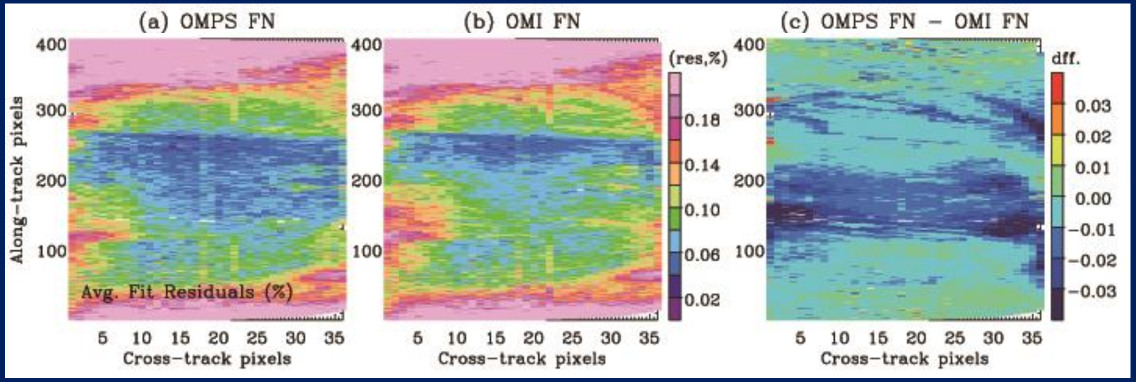
SCO DFS

TCO DFS



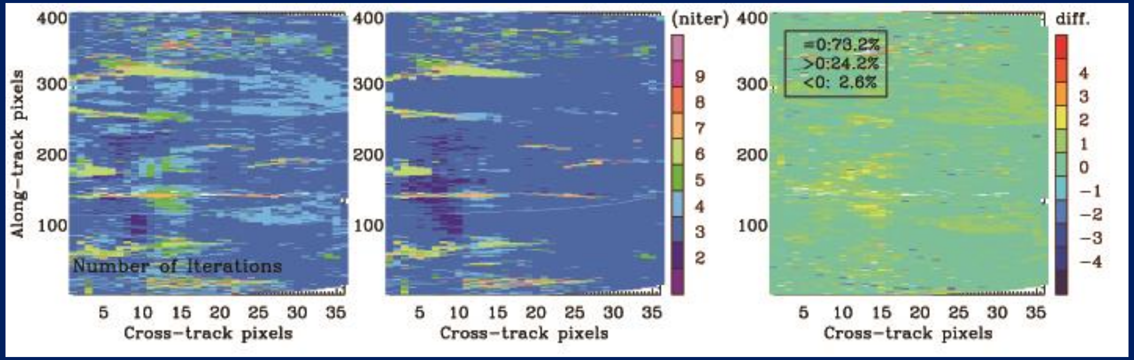
- stratospheric and tropospheric DFSs are improved by 0.2-0.4 under mild SZAs and by up to 0.2 under high SZAs.
- tropospheric ozone retrievals could have ~ 1 DFS in low/mid latitudes, which is similar to OMI retrievals

Fitting. Average (%)



- Slightly improve the fitting accuracy by 0.02 %, with OMPS noise error

Number of fitting iteration



- Require 1-2 more iterations to be conversed for 24 % of total pixels

Summary and Future plan

- demonstrated our ability of OMPS retrievals w.r.t Fitting accuracy, by radiometric and measurement error corrections.

- Evaluate OMPS NM ozone profile product against ozonesonde
- Combining OMPS NM (300-340 nm) with OMPS NP (260-310 nm) to compensate stratospheric ozone retrievals.
- Apply radiometric and measurement correction for improving OMI ozone profile retrievals.
- Create OMPS long-term ozone profile product.
  - ➔ will fill the gap between OMI and TropoOMI.
  - ➔ Will be a reference for validating GEMS and TEMPO.