Intercomparison of Total Column Ozone Observations From S-NPP OMPS and Ground-Based IR FTS During Summer and Fall of 2012

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Outline

- Suomi-NPP OMPS
- NDACC Ground-Based FTS
- Data Selection Criteria
- Comparison of Total Column Ozone
- Summary

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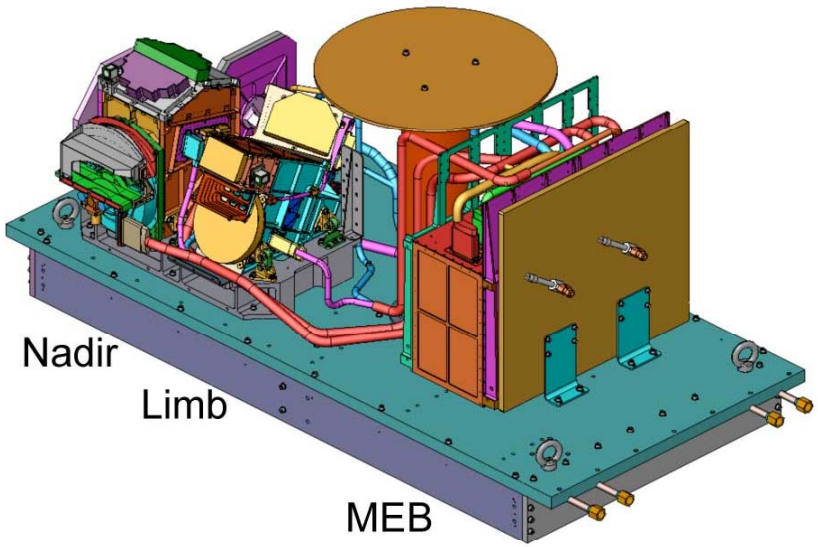
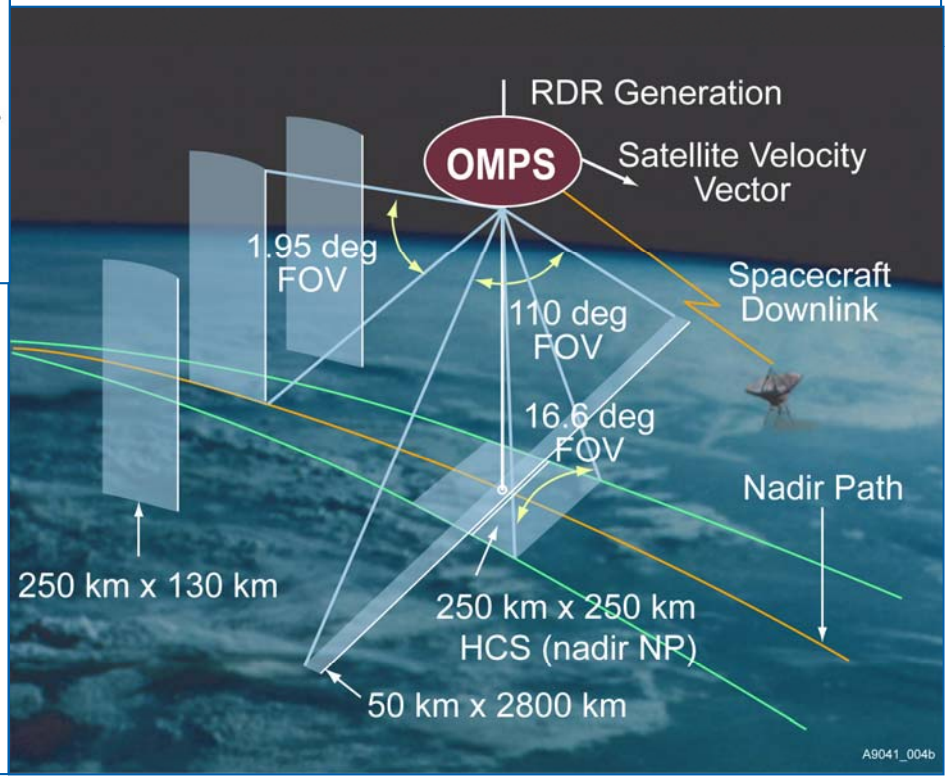
The Ozone Mapper and Profiler Suite (OMPS)



Global monitoring of three dimensional distribution of ozone every day



Total Column Mapper

Grating spectrometer, 2-D CCD
Nadir view, 110° cross track
50 km along track
300 to 380 nm spectral range
1.1nm FWHM bandpass

Profiler

Grating spectrometer, 2-D CCD
Nadir view, 250 km cross track
270 to 310 nm spectral range
1.1 nm FWHM bandpass

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OMPS Total Column Ozone Retrieval Methodology

- OMPS retrieval of ozone is based on a comparison between the measured normalized radiances (NRs) and NRs derived by RT calculations for different ozone amounts and the conditions of the measurement.

- Using an effective cloud fraction, derived from radiances for wavelengths insensitive to ozone, and the NRs measured at a pair of wavelengths (one strongly sensitive to ozone, one weakly sensitive or insensitive to ozone), an initial ozone estimate is derived by matching the measured NR value to NR values interpolated from the table using the viewing conditions of the measurement.

- The total column ozone is iteratively retrieved using multiple sets of wavelength triplets, which depend on the optical path length of the measurement:

$$\Omega = \Omega_0 + \frac{r_1(\lambda_2 - \lambda_R) - r_2(\lambda_1 - \lambda_R)}{\left(\frac{dN}{d\Omega}\right)_1(\lambda_2 - \lambda_R) - \left(\frac{dN}{d\Omega}\right)_2(\lambda_1 - \lambda_R)}$$

  - where Ω_0 is an initial estimate of ozone obtained using the pair of ozone-sensitive wavelengths 1 and 2, r is the NR residual and ($dN/d\Omega$) is the NR Jacobian with respect to layer ozone amount. Residuals and Jacobians are updated from RT tables each iteration.

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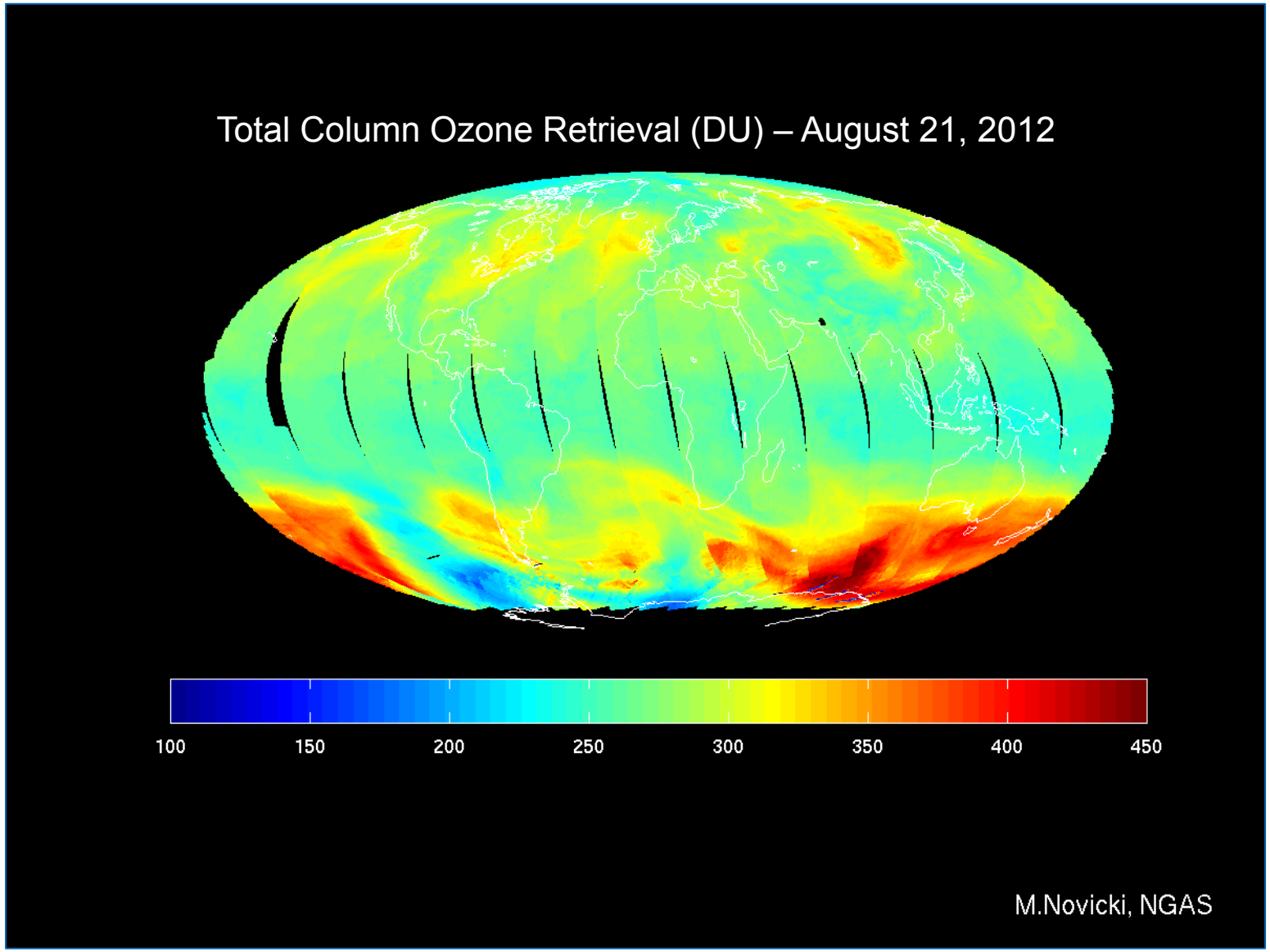
OMPS Total Column Ozone Global Distribution on August 21, 2012



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NDACC Ground-Based IR FTS

- The international Network for the Detection of Atmospheric Composition Change (NDACC) is composed of more than 70 remote-sensing research stations for observing and understanding the physical and chemical state of the stratosphere and upper troposphere.

- Ground-based total column ozone from three infrared Fourier-transform spectrometer stations, that are part of NDACC, are compared to OMPS measurements to understand the summertime variation of ozone.

NDACC FTIR Site	Location	Site Description
JPL, USA	34.2 N, 118.2 W 340 m asl	Vicinity of Los Angeles
Wollongong, Australia	34.4 N, 150.9 E 30 m asl	Coastal Plain in New South Wales, Australia
Ny Ãlesund, Norway	78.9 N, 11.9 E 21 m asl	Situated in Spitsbergen archipelago

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FTIR Total Column Ozone Retrieval Methodology

- The JPL FTIR spectra were analyzed using the non-linear least squares spectral fitting algorithm GFIT, developed in-house. Atmospheric absorption coefficients are calculated line-by-line for each gas in a chosen spectral window, and are used together with the assumed temperature, pressure, and VMR profile in the forward model to calculate the atmospheric transmittance spectrum. This is compared with the measured spectrum and the VMR profiles are iteratively and multiplicatively scaled to minimize the RMS differences between the calculated and measured spectra. Significant difference between the atmospheric VMR profile and that used in the FM can introduce a systematic bias.

- Ny Ãlesund and Wollongong FTIR spectra were analyzed using the non-linear least squares fitting algorithm sfit2 version 3.94 using the HITRAN2008 spectroscopic data base. Atmospheric absorption coefficients are calculated line-by-line from an altitude resolved atmospheric model containing temperature and up to 99 gases on a pressure grid. Using the optimal estimation method described by Rodgers (2000) the gas profiles are modified in order to obtain a calculated spectrum which is equal to the measured spectrum in a least square sense. Total column is calculated by integrating the final, fitted profile.

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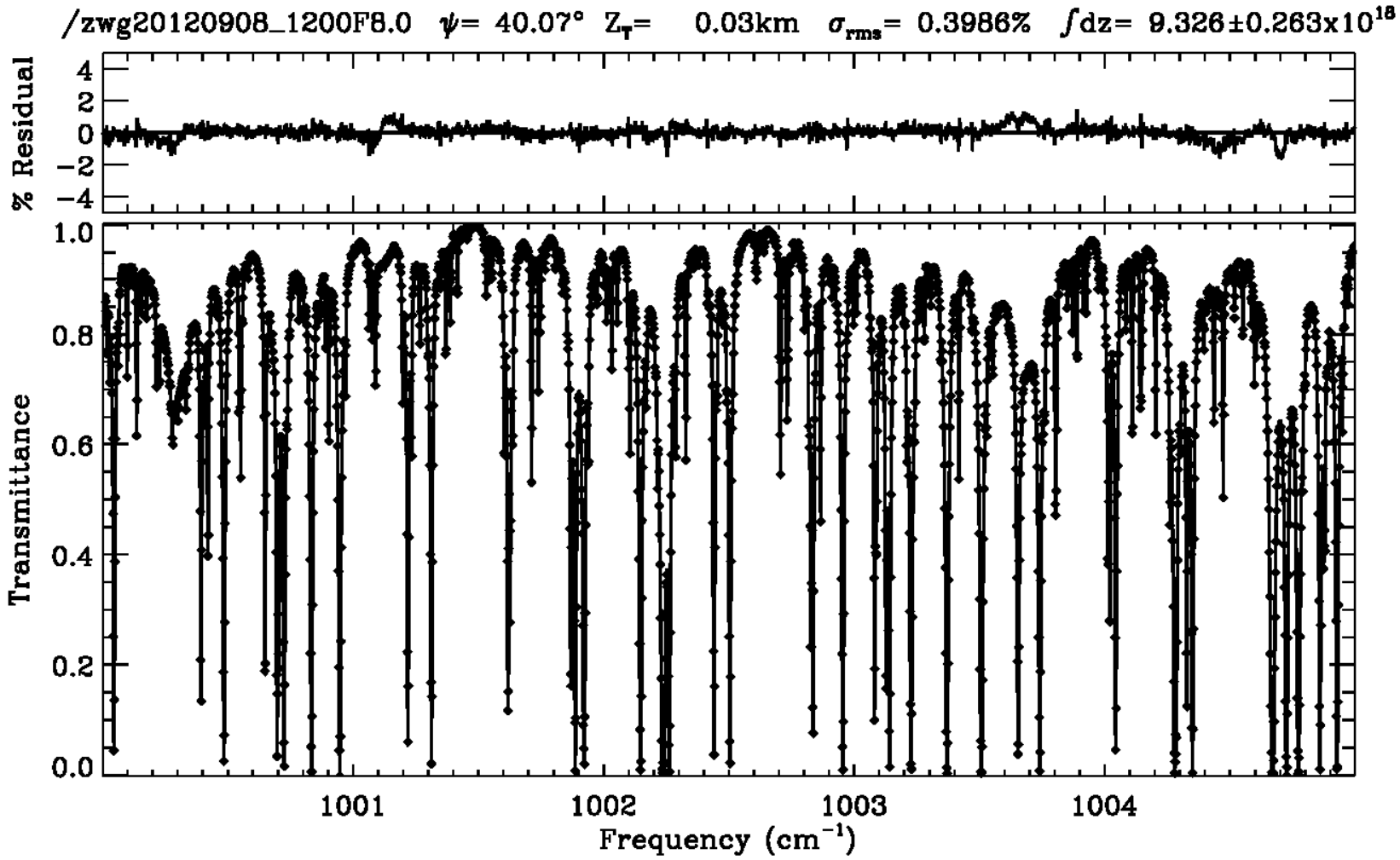
Spectral Fit and Residuals for Wollongong Ground-Based FTS Spectrum



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Total Column Ozone Observation Selection Criteria

- All OMPS retrievals with latitude and longitude within 0.3° were aggregated from the data sites independent of the FTIR observation time for the following sites and dates:
  - Ny Ãlesund – July 31, 2012 and August 24, 2012
  - Wollongong – July through October 2012
  - JPL – July through November 2012
- The OMPS First Guess Total Column Ozone was used for the comparison
  - Produced by the OMPS Total Column IP algorithm beta version for validation purposes
  - OMPS retrieval uses only climatology and NCEP forecast data
  - While the OMPS instrument was stable throughout the observation period, there were several changes to the operational algorithm during that time.
- The OMPS retrieval in the aggregated dataset closest in time to each FTIR retrieval (within 1 day) was used for the point-to-point comparison.
  - Any FTIR measurements without corresponding OMPS retrievals within 1 day are not used in the comparison
  - Relative difference (%) = {[OMPS – FTIR] / [OMPS + FTIR]/2} × 100

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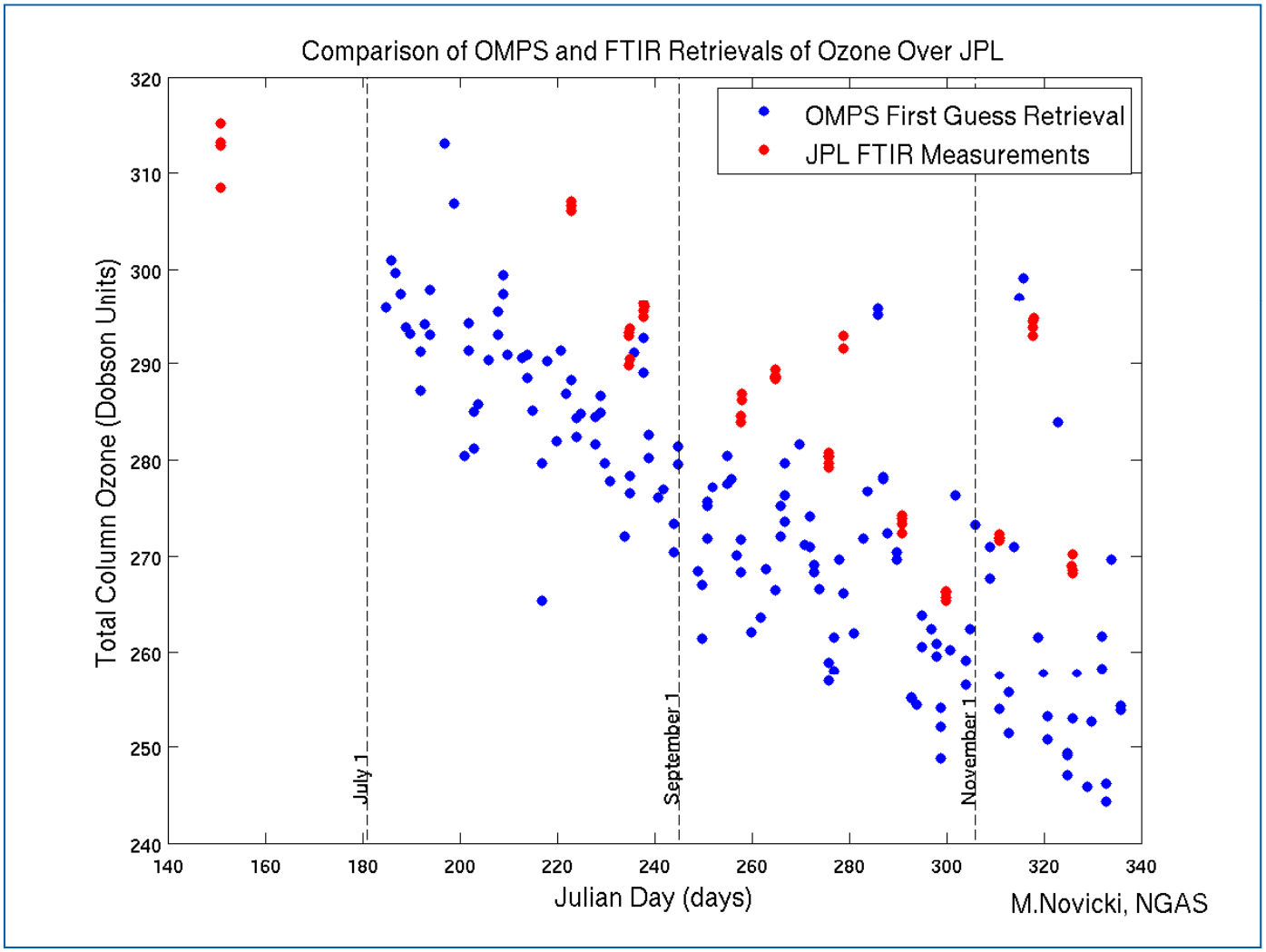
Time Series of JPL and OMPS Total Column Ozone Observations



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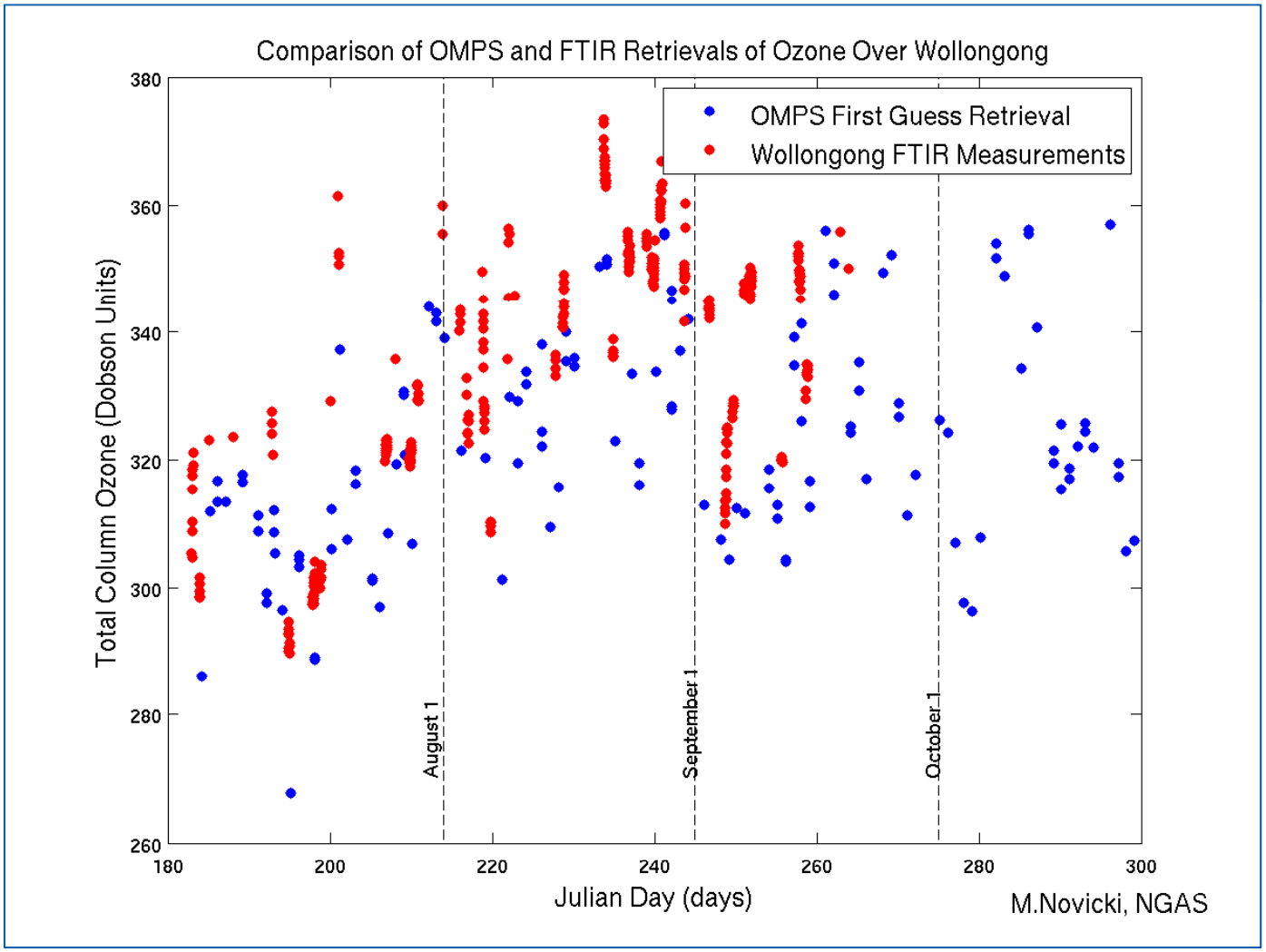
Time Series of Wollongong and OMPS Total Column Ozone Observations



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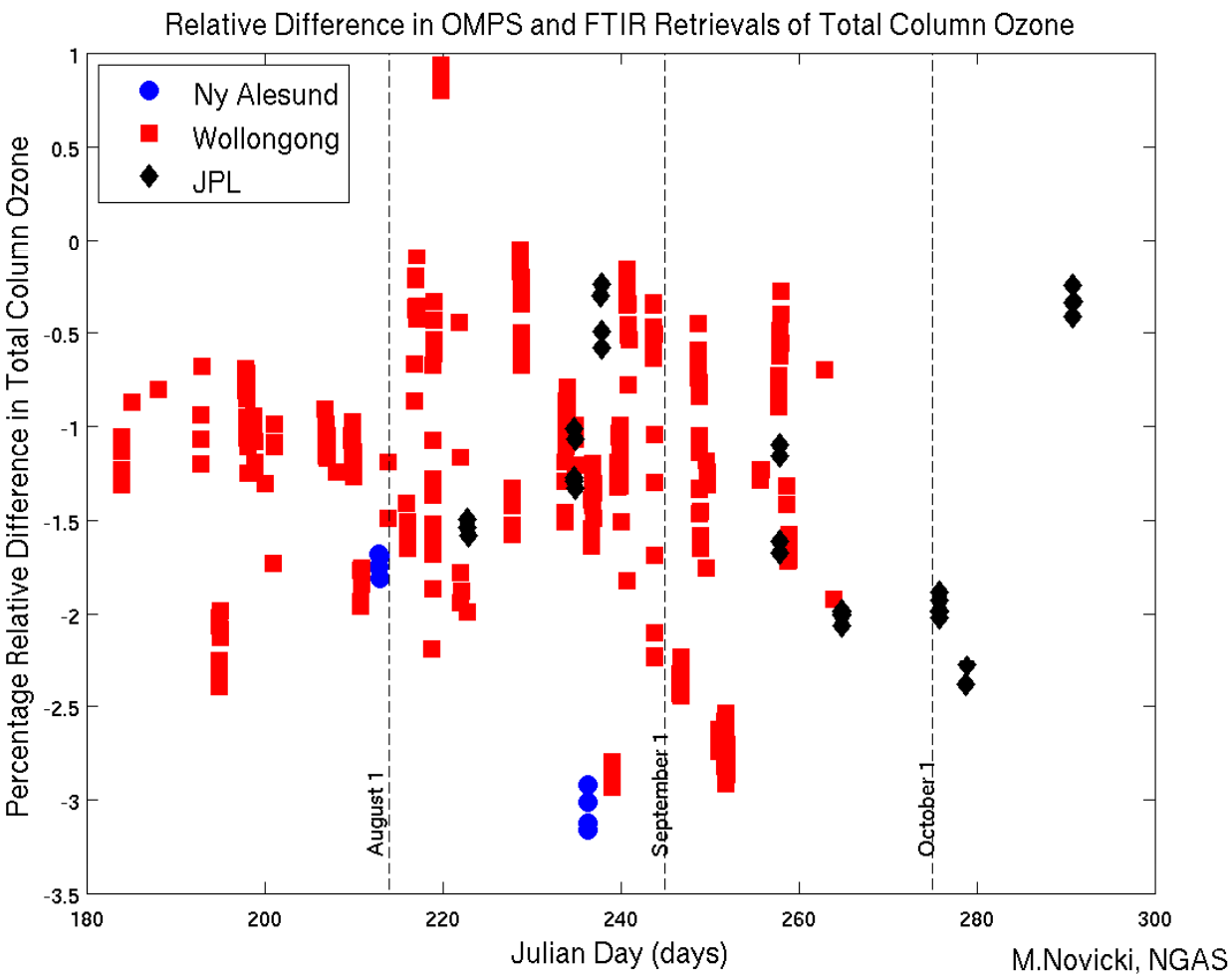
Relative Difference Between Ground-Based FTIR and OMPS Total Column Ozone Observations



The mean relative difference between the OMPS and FTIR measurements is -1.3 (± 0.7)%.

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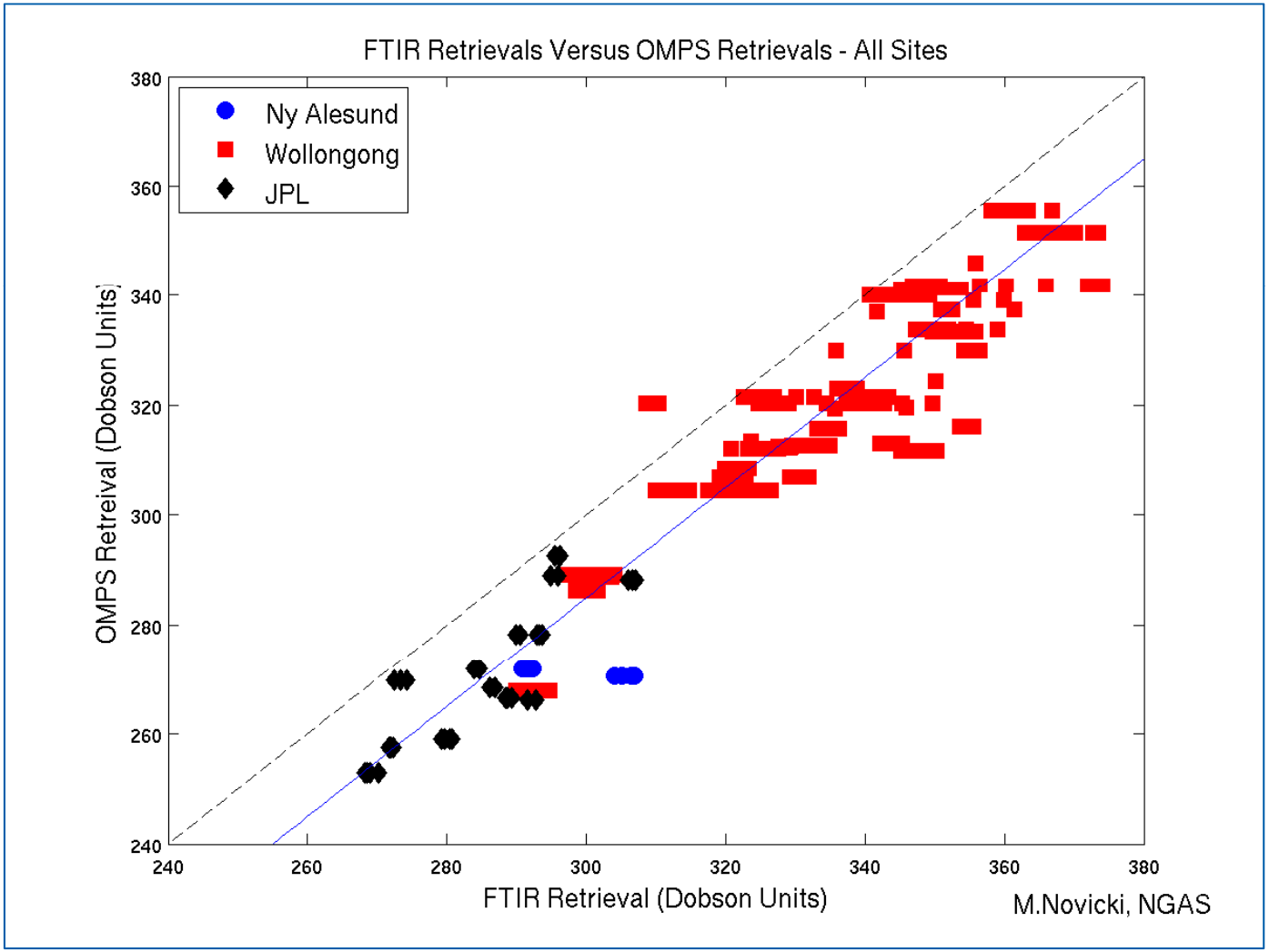
Scatter Plot of Ground-Based FTIR and OMPS Total Column Ozone Observations



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Comparison of Total Column Ozone Observations

- The seasonal trend in total column ozone observed at JPL and at Wollongong, opposite due to hemispheric location, is captured by the OMPS first guess ozone IP.

- At both mid-latitude sites, OMPS total column ozone observations are systematically biased low compared to FTIR observations.

- The overall mean relative difference between all FTIR and OMPS total column ozone is -1.3 (± 0.7)%.
  - The mean relative difference is much larger than previous comparisons of FTIR total column ozone from Izana and from GOME-2 and OMI (Viatte, 2011).
  - The relative difference is similar in magnitude to a previous comparison of MkIV and EP-TOMS total column ozone, however, opposite in sign (Lloyd, 1999).

- The mean bias between all FTIR and OMPS total column ozone observations is 15 DU.
  - The mean bias is much larger than previous comparisons of FTIR and BUV satellite observations.
  - The mean bias is nearly constant across a range in total column ozone, season and geographic location.

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Summary

- Three FTIR data sets of total column ozone are compared to OMPS over the summer and fall of 2012.
- The FTIR and OMPS observations show the summer to fall seasonal change in total column ozone for the respective hemisphere.
- The mean relative difference between OMPS and FTIR total column ozone are much larger than previous comparisons.
- A nearly constant, mean bias across a range in total column ozone, season and geographic location is indicative of an issue with the OMPS radiance calibration.
  - Since Wollongong and Ny Alesund are atmospherically clean NDACC sites, without significant temporal gradient in daily values of total column ozone, the nearly constant bias with OMPS requires further investigation.
  - FTIR and OMPS scene conditions need further investigation
  - Investigate cross-track and ozone triplet dependencies

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