Constructing an Ozone Long-Term Climate Data Set (1979 – 2010) from V8.6 SBUV/2 Profiles

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Introduction: Much of our understanding of ozone depletion issues is based on measurements and analyses of total ozone. However to fully understand the processes of ozone depletion, we must consider the effect throughout the ozone profile. Several high quality long-term ozone profile datasets exist including SAGE, AURA & UARS MLS, and ground-based measurements, but the SBUV and SBUV/2 offer a unique continuous long-term global coverage from 1979 until present. The full record is provided by a series of satellites which must yield consistent results in order to provide a trend quality dataset. The recent release of Version 8.6 provides improved calibrations to ensure inter-satellite agreement.

Version 8.6 Changes:

- Climatology changed from SAGE based to Ozonesonde in the troposphere and AURA MLS in the stratosphere
- Cross sections changed from Bass and Paur to Brion-Daumont-Malicet – to provide a better spectral resolution, extended wavelength range, and better characterization of temperature dependence
- Includes OMI-based cloud-height climatology
- Updated calibrations including "no local time" calibration technique to cross calibrate between satellites instead of the previous reliance on SSBUV

Time-of-day: Complicating the issue is the longevity of the NOAA satellites, which have a drifting equatorial crossing time (**Figure 1**). Profile ozone values change during the daylight hours at some levels producing a false trend in the long-term satellite record.

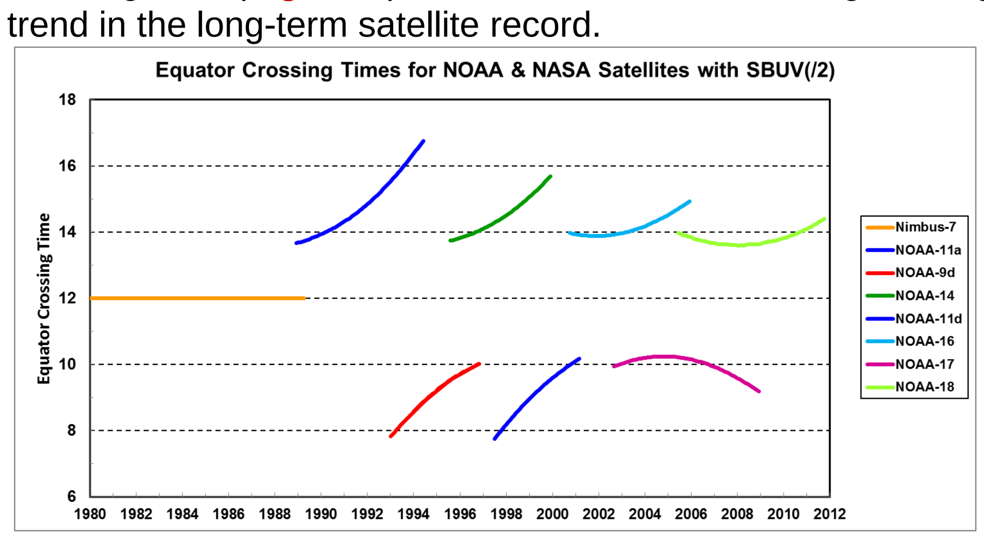


Figure 1: Equatorial crossing time of NOAA satellites. Note ascending and descending nodes have significantly differing measurements times

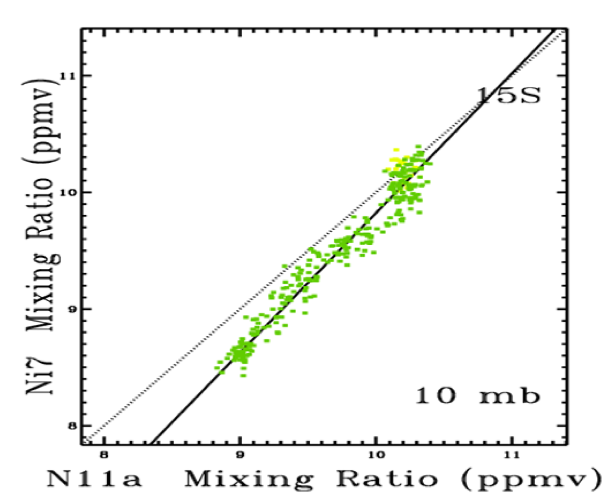


Figure 2: Correlation graph of Nimbus 7 and NOAA 11 at 10 hPa, 15S. Note the need beyond a simple bias correction.

Technique: For each level and zone, we create 5 degree daily zonal means and examine the data correlations of overlapping satellite records to examine the need for further adjustments (**Figure 2**). Overlap study periods are shown in **Table 1**. A least square fit with intercept 0 and slope 1 corresponds satellites that are measuring the same ozone values with no bias. Fits with a non-zero intercepts indicate a bias shift between the two satellites. Non-unit slopes indicate an ozone dependent variation, essentially a change in the amplitude of the annual oscillation of ozone. We use the results of fits to the correlation graphs to generate adjustments. An adjustment is created for **each zone** and **each level**. This method can be applied to mixing ratio data, as well as Dobson level data. This poster focuses on mixing ratio results.

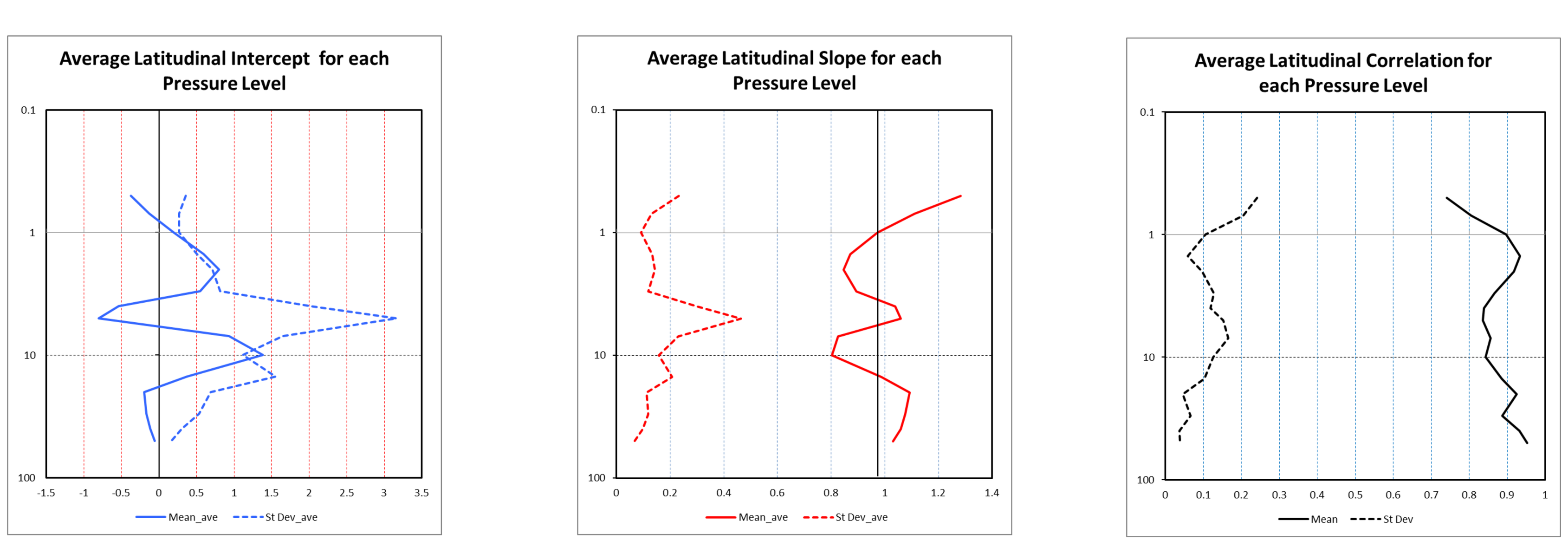
Note that the overlap period for N11d to N16 is very short in time, therefore a bias only calculation is used. Also we adjust both ascending and descending N11 to Nimbus 7, and then adjust N14 to the N11d leg. This avoids propagating the non-physical trends in the N9 data. The final combined dataset uses a single satellite in each time period as shown in **Table 2**.

Table 1: Satellite Comparison Dates

Satellite 1	Satellite 2	Overlap Dates
Nimbus 7	NOAA 11a,d	12/1/88 – 10/31/89
NOAA 11a	NOAA 09d	7/1/93 – 6/31/94
NOAA 09d	NOAA 14	9/222/95 – 5/21/96
NOAA 14	NOAA 11d	7/15/97 – 12/31/99
NOAA 11d	NOAA 16	10/3/00 – 3/27/01
NOAA 16	NOAA 17	7/11/02 – 12/31/05
NOAA 17	NOAA 18	6/5/05 – 12/31/08

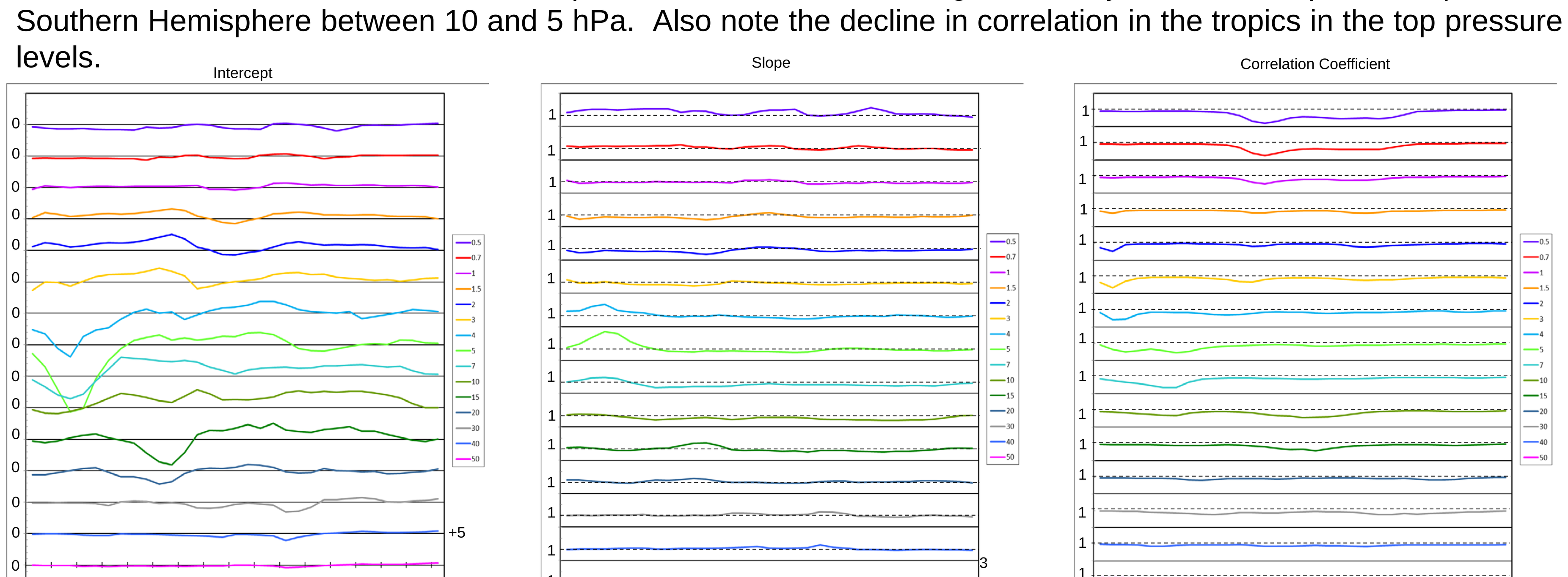
Table 2: Satellite Periods

Time	Satellite	Node
10/31/78 – 5/31/89	Nimbus7	Ascending
6/1/89 – 12/31/93	NOAA11	Ascending
1/1/94 – 7/14/95	NOAA 9	Descending
8/1/95 – 12/31/97	NOAA14	Ascending
1/1/98 – 12/31/00	NOAA11	Descending
1/1/01 – 12/31/03	NOAA16	Ascending
1/1/04 – 12/31/08	NOAA17	Descending
1/1/09 – 12/31/10	NOAA 18	Ascending



Figures 3: N14-N11d period mean and st. dev. of the intercept (*left*), slope (*center*), and correlation coefficient (*right*) of the zones between 80S and 80N for each SBUV(/2) pressure level between 50 hPa up to 0.5 hPa.

An examination of the means and standard deviation of each period intercepts, slopes, and correlation coefficients indicate that there is large variability in the vertical of how well the SBUV(/2) data sets agree with each other during the overlap periods. **Figure 3** shows these N14-N11 period statistics. Note that at 10 and 5 hPa there are large intercepts as well as deviations of slopes from unity. The correlations indicate that the best agreement occurs in the upper and lower parts of the profile and less agreement between 20 and 3 hPa. The standard deviations indicate that at some levels there is large variability with latitude. **Figure 4** shows the intercept, slope and correlation coefficient for each zone and pressure level. Note the large variability in the intercept and slope in the Southern Hemisphere between 10 and 5 hPa. Also note the decline in correlation in the tropics in the top pressure levels.



Figures 4: N14-N11d period intercepts (*left*), slopes (*center*), and correlation coefficient s(*right*) for each latitude zone between 80S and 80N for each SBUV(/2) pressure level between 50 hPa up to 0.5 hPa.

Sage II Comparisons: Comparisons are made to zonally averaged SAGE II data. **Figure 5** shows the average differences for the periods defined in **Table 2** for the V8.6 dataset before and after adjustments. There is moderate improvement in the intra-period consistency as compared to SAGE II in the equatorial and Northern Hemisphere regions. But at high-Southern latitudes the adjustment from N11 to N16 shows a large error in N16 and subsequently N17 as compared to SAGE II at 5 to 10 hPa.

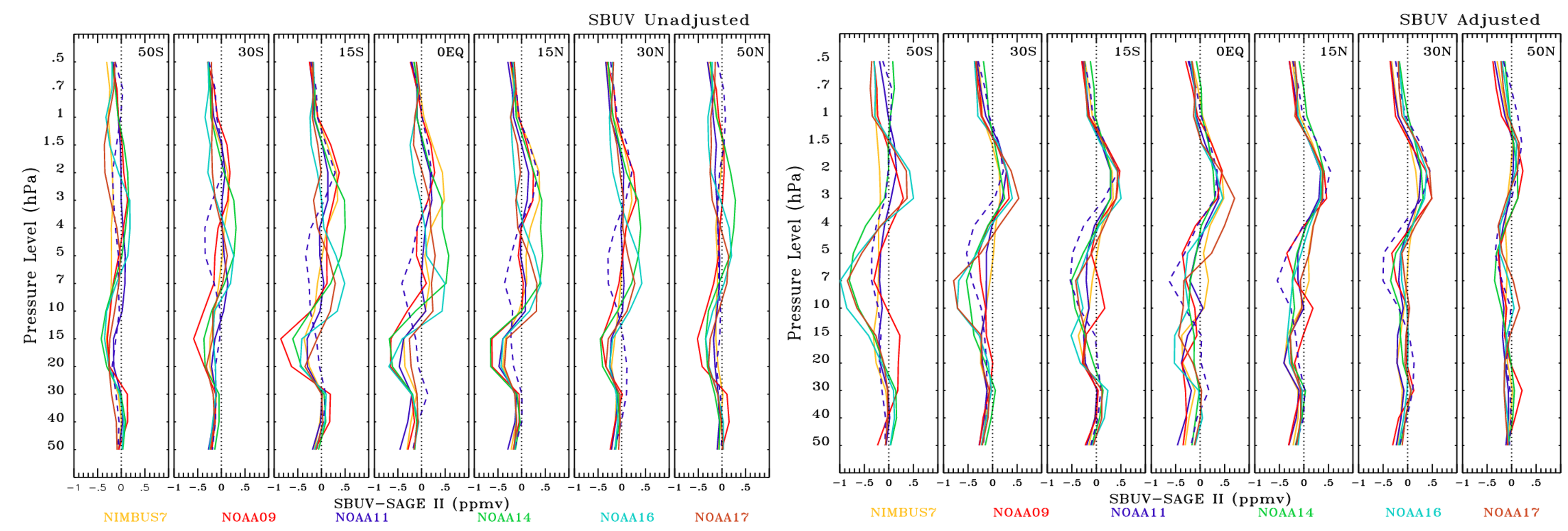


Figure 5: Average differences SAGE II – SBUV(/2) in relevant periods before (*left*) and after (*right*) adjustment.

Looking into the above successes and failures in more detail, we show in **Figure 6** two sets of time series of the combined SBUV(/2) product and SAGE II observations for the Eq at 2 hPa and 45S at 10 hPa. The adjustment at the former zone/pressure shows an improvement in the consistency of the SAGE II – SBUV/2 differences notably for the N16 and N17 periods. However, at the later zone/pressure the combination technique appears to fail for N14, N16 and N17. Also note that the differences are offset for the ascending and descending nodes of N11. This is likely a manifestation of the differing time of measurement of these two branches.

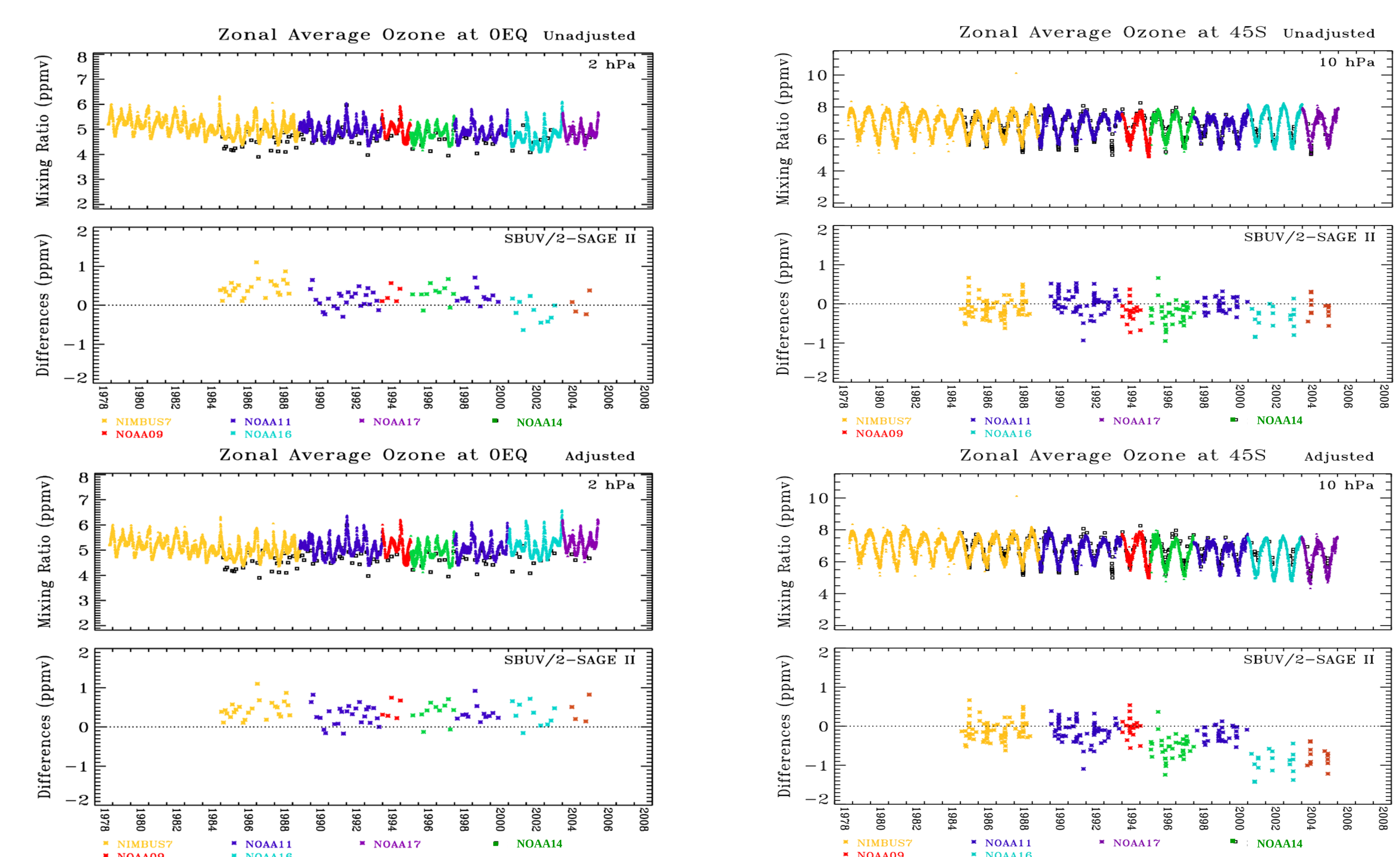


Figure 6: Presentation of cases where adjustments to the SBUV(/2) improved (*i.e. made the bias more similar)* the inter-satellite comparisons with SAGE II (Eq, 2 hPa) (*right*) and where the adjustments made comparisons with SAGE II worse (45S,10 hPa) (*left*). Unadjusted SBUV(/2) is on *top* and adjusted are on the *bottom*.

Ground instrument comparisons: A wealth of ozone profile data is available from the Network for the Detection of Atmospheric Composition Change (NDACC). **Figures 7** shows comparisons to lidar and microwave instruments at Lauder, NZ, 45°S, in the middle of the zone of concern. These comparisons are complicated in that we are now comparing zonal data with point data, and the station may see variability not exhibited in the zonal average. A better method would be to compare SBUV(/2) profiles near the site. We can apply the above derived adjustments for the zone to these profiles, but this has not yet been done. In lieu of that we compare the point measurement to the zonal average. For the microwave data at 10 hPa, N16 is slightly too high before adjustment, but perhaps slightly too low after. N17, however, seems about right after adjustment. As compared to lidar at Lauder, N16 at 10 hPa seems appropriately adjusted..

Also shown are comparisons before and after adjustment to lidar at Hohenpeissenberg. In this case N14 is clearly better at most levels after adjustment, but again N16 is problematic. N17 is reasonable. In general areas can be found where the adjustment is an improvement, and where it fails. In particular, the N16 tie on must be more carefully examined.

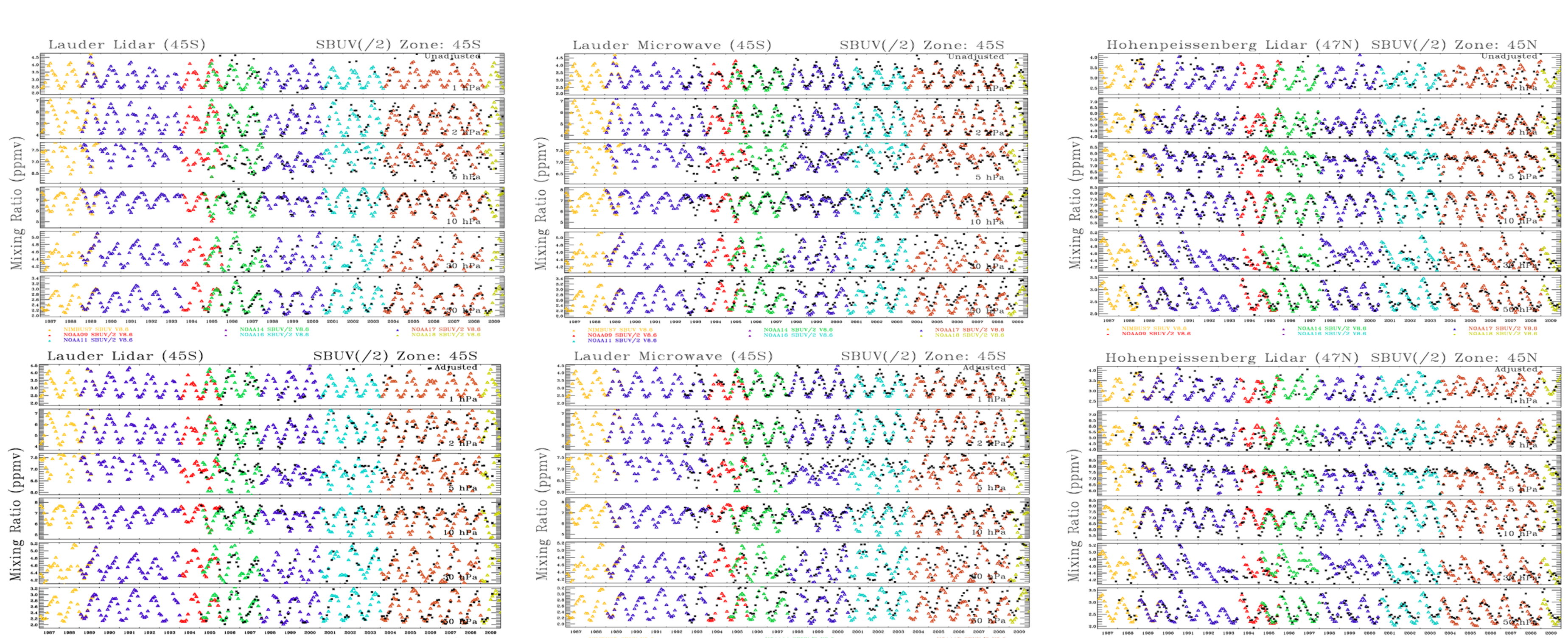


Figure 7: Comparisons of combined SBUV(/2) with NDACC ground instruments: Lauder Lidar (*left*), Lauder Microwave (*center*), and Hohenpeissenberg (*right*). Unadjusted are on the *top* and adjusted are on the *bottom*.

Conclusions: We have shown that the combination technique can improve comparisons to SAGE II especially in the Northern Hemisphere. **More work needs to be done** for the N16 tie on, perhaps by using N14 as an intermediary. Comparisons with ground data are plentiful with mixed results. More statistics need to be considered to get a complete picture. Time-of-day corrections need to be added to resolve the drifting satellite local time effects.

Acknowledgement: Some of the data used in this publication were obtained as part of the Network for the Detection of Atmospheric Composition Change (NDACC) and are publicly available (see http://www.ndacc.org).

References:

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