

APPENDIX A

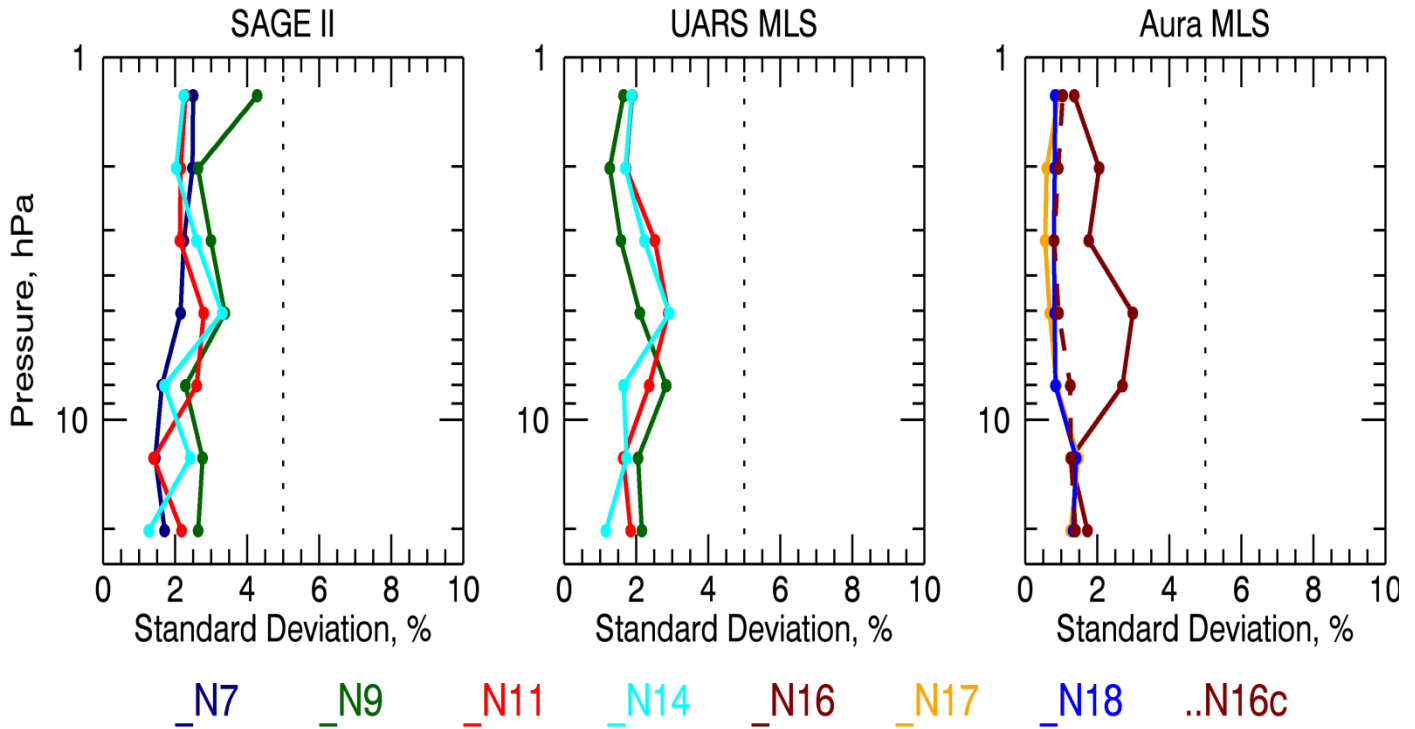


Figure A1. Vertical profiles of the standard deviations of mean biases for the latitude band 50S - 50N. Colors correspond to individual SBUV instruments. The standard deviations vary from 1-4%. Lower standard deviations are found for N17 and N18 relative to Aura MLS. We found a significant drift in the N16 ozone time series after mid-2007 due to orbital drift, when local equatorial time for N16 satellite passes 4 pm. As a result the standard deviation for the full N16 record are larger compared with N17 and N18. The dashed maroon line on the right panel shows the standard deviation for N16 for the period from October 2004 to mid-2007. The N16 standard deviations for this time period are the same order as those for N17 and N18. We do not recommend using N16 ozone data after mid-2007.

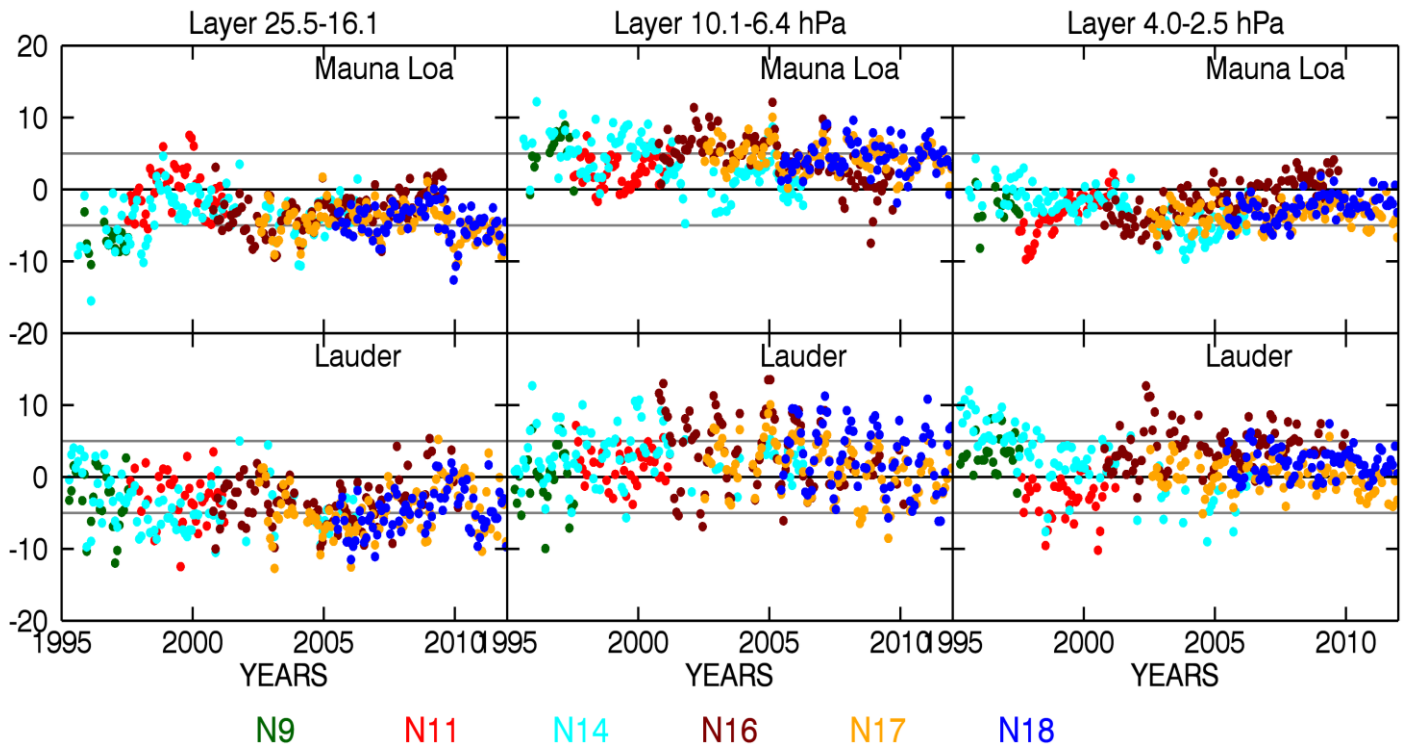


Figure A2. Time series of monthly mean differences for individual SBUV instruments relative to ground-based microwave spectrometers. Columns on the panel show different layers, while rows correspond to different stations (Mauna Loa (20N) and Lauder (45S)). Colors correspond to individual SBUV instruments. Despite the mean offsets between microwave and SBUV measurements, the dispersion of the differences is small (10-15%). This points on a good correspondence between the SBUV and microwave measurements.

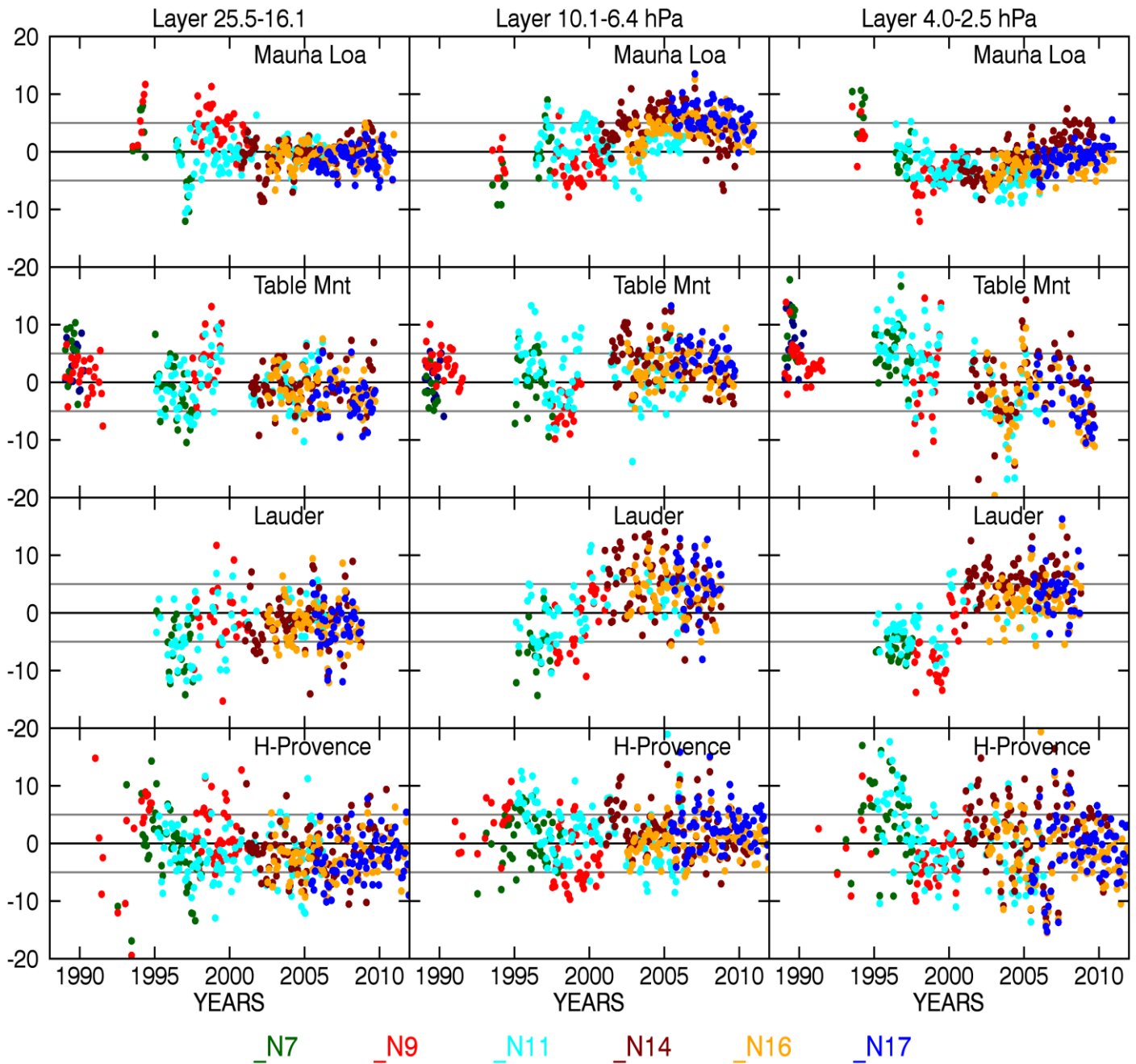


Figure A3. Same as figure A2 only relative to ground-based lidar instruments at four stations: Mauna Loa (20N), Table Mountain (34N), Lauder (45S) and Haute Provence (44N). The dispersion of differences is larger relative to lidar observations, and there are notable offsets in the long term data records at some layers and locations. At Table Mountain and Lauder we can see a transition around 2000, especially in the 4-2.5 hPa layer. At Mauna Loa the differences in the first half of the 1990s are slightly shifted relative to measurements after 1996. The time series of differences relative to lidar measurements at Haute-Provence do not show significant time dependence.

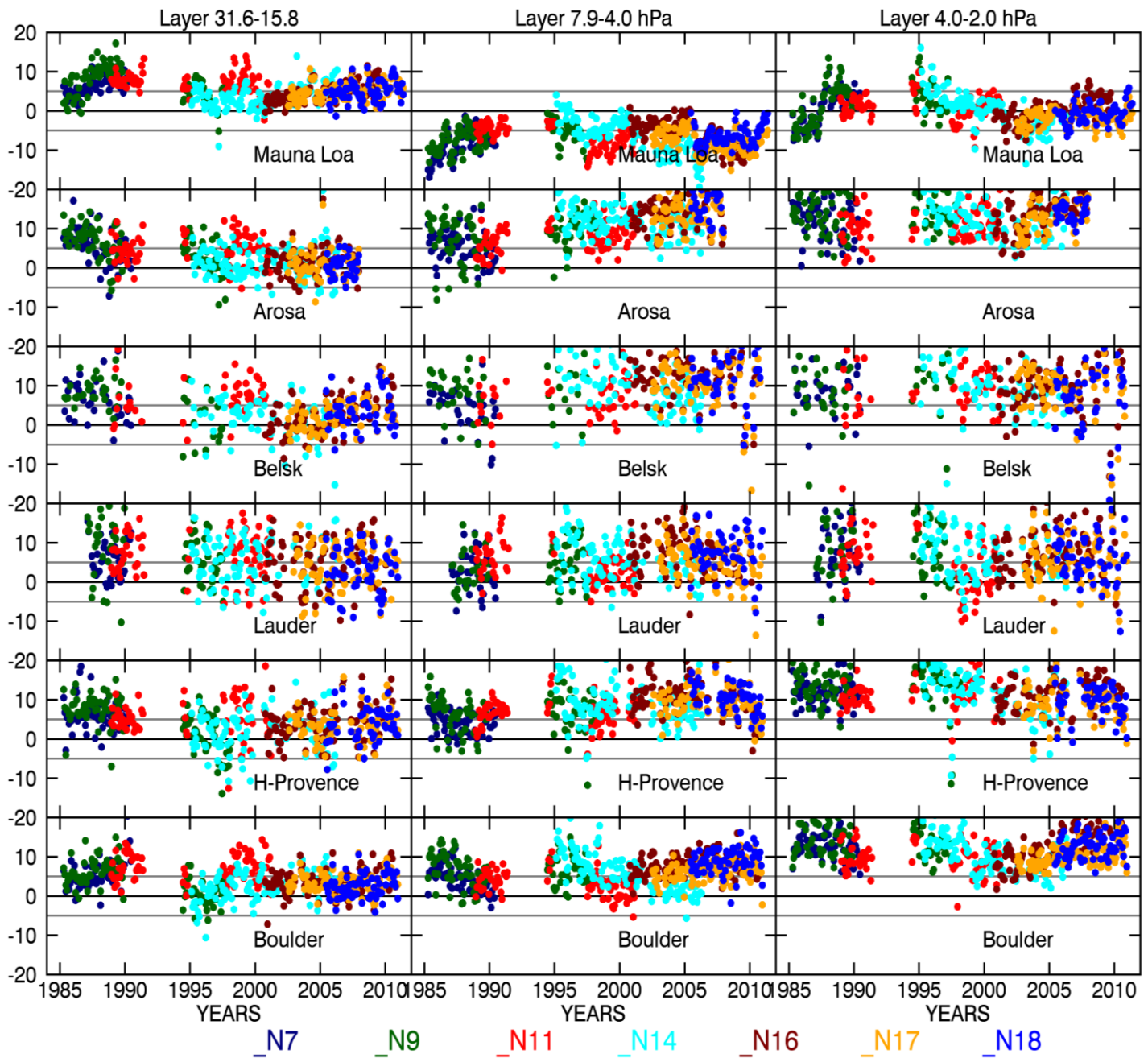


Figure A4. Same as figure A2 only relative to ground-based Umkehr instruments at six stations: Mauna Loa (20N), Arosa (47N), Belsk (52N), Lauder (45S), Haute Provence (44N) and Boulder (40N). Records from all stations demonstrate that Umkehr instruments underestimate ozone amount in the stratosphere above 31 hPa.

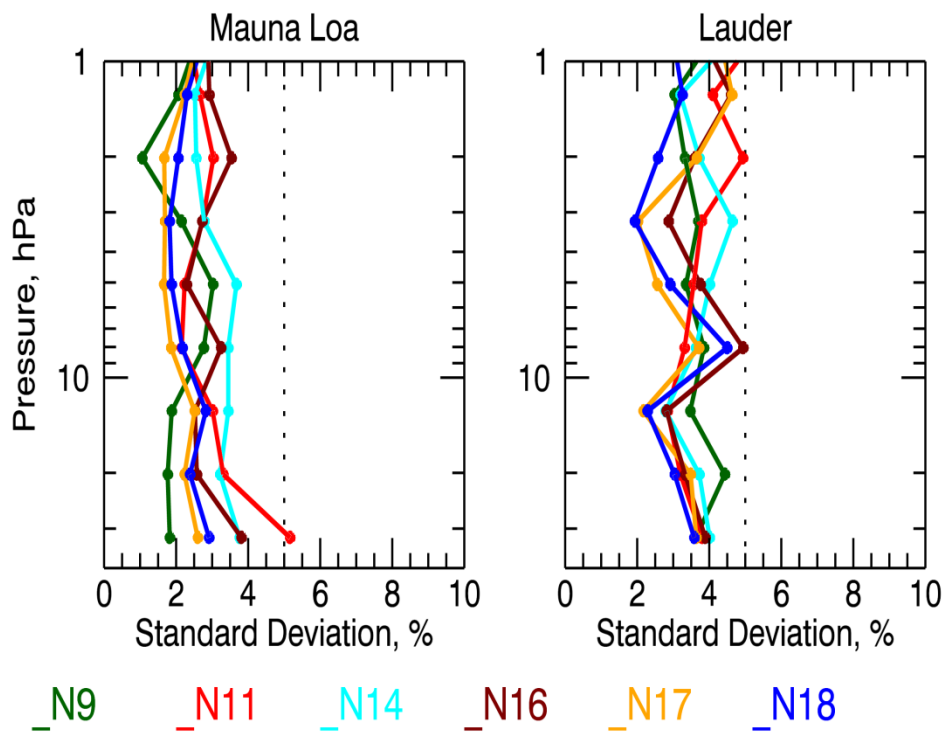


Figure A5. Vertical profiles of the standard deviations for individual SBUV instruments relative to coincident ground-based microwave measurements at Mauna Loa and Lauder. Colors correspond to individual SBUV instruments. Standard deviations vary between 1-5% with slightly larger deviations at Lauder.

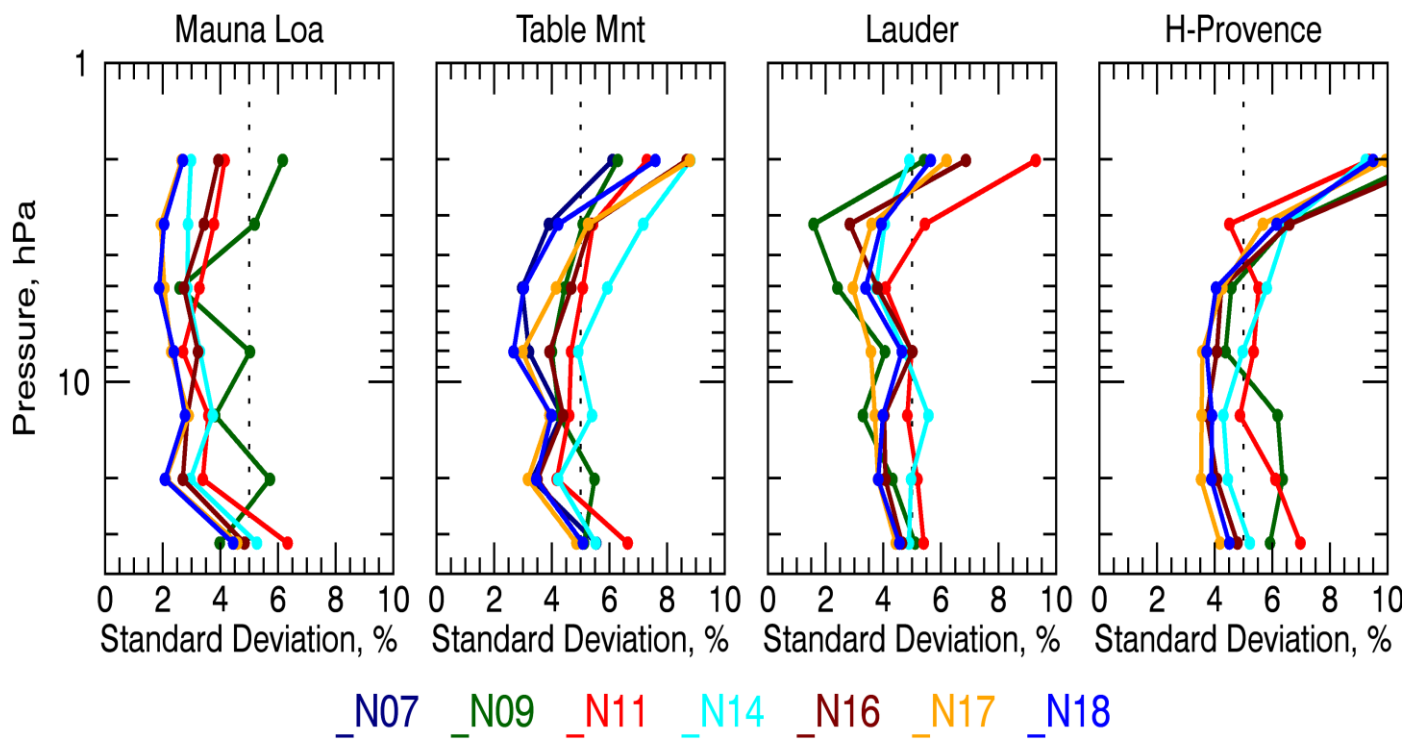


Figure A6. Same as figure A5 but relative to ground-based lidar measurements at four specified stations. Between 40 and 2 hPa standard deviations are within 2-6%, and significantly increase above 2 hPa up to 10-12%. Larger deviations were detected for the upper layer due to the reduced number of lidar observations.

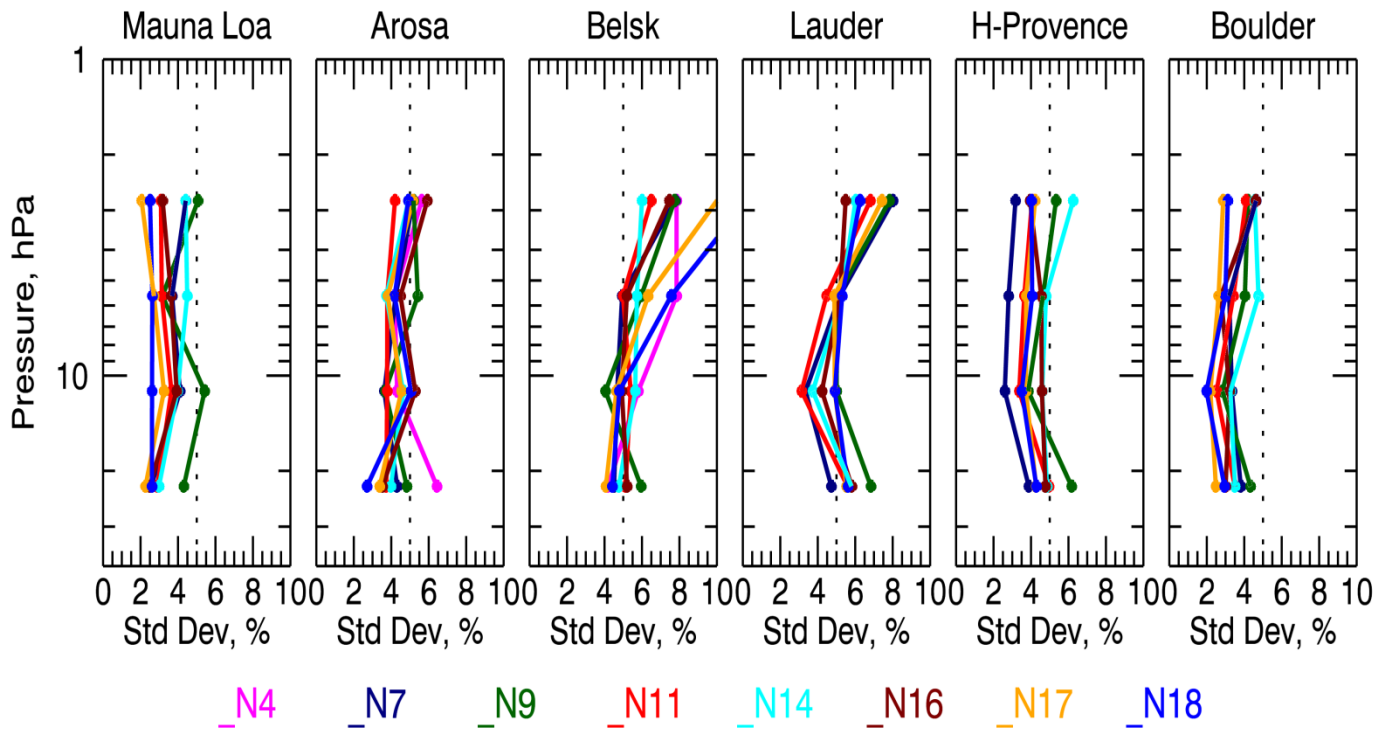


Figure A7. Same as figure A5, but relative to ground-based Umkehr measurements at six specified stations. Standard deviations for comparisons with Umkehr measurements are mostly within 2-6%. However, we find larger deviations relative to the instrument at Belsk (up to 10-14%) above 4 hPa. The lowest deviations are found at Mauna Loa and Boulder.

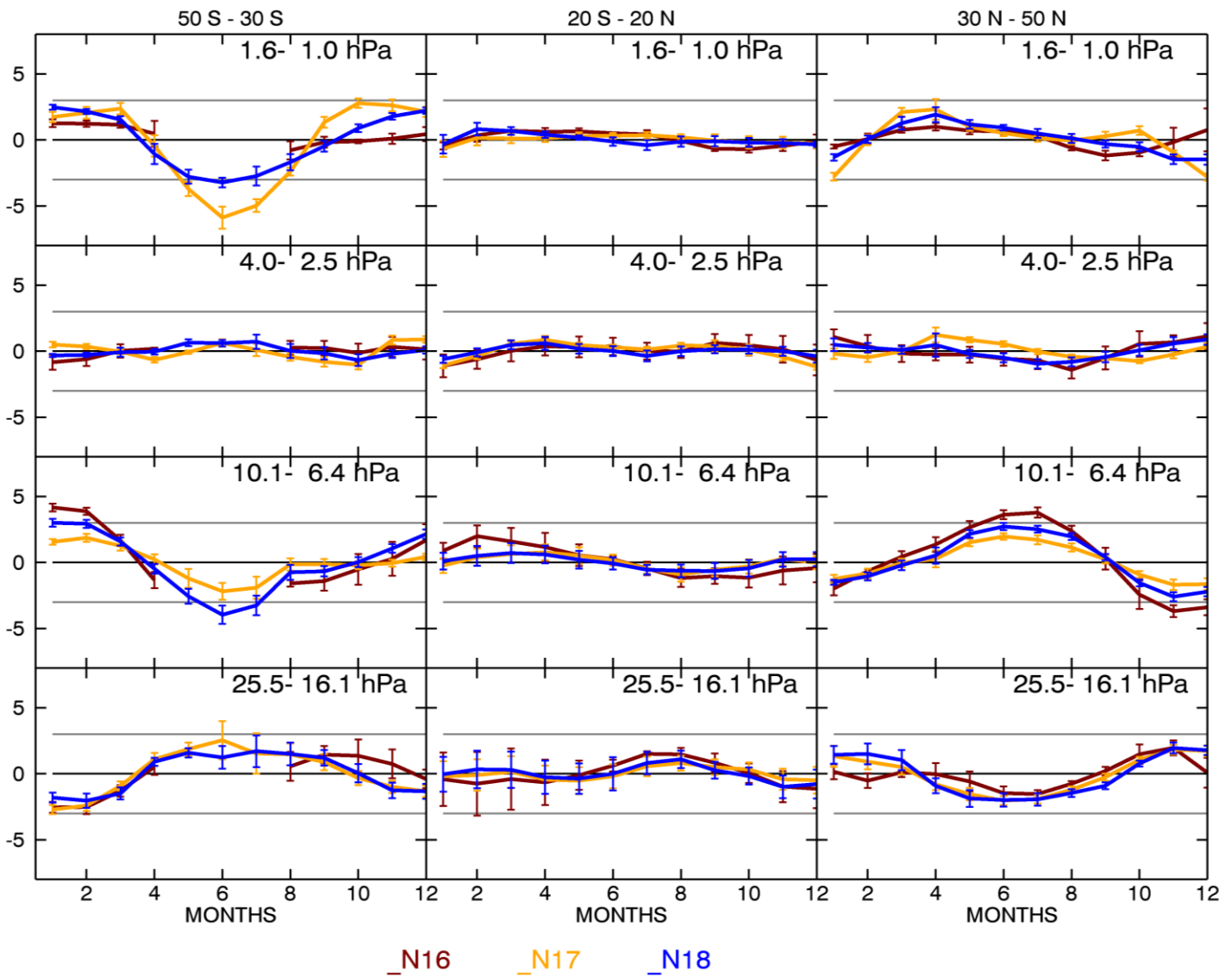


Figure A8. Seasonal biases for N16, N17 and N18 SBUV relative to AURA MLS for four layers and 3 latitude bands. The vertical lines define the standard error of the mean. We calculate seasonal biases as the differences between datasets at each month after removing the mean bias. We required at least two measurements from two different years in each specified month to calculate the seasonal bias. The seasonal biases are smaller over the tropics, where they are mostly insignificant and less than 2%. We found clear seasonal patterns in both extrotropics, with a 6-month lag between the two hemispheres. The seasonal biases are mostly within $\pm 2\text{-}3\%$, but at some layers the amplitude is as high as 5-6%. We find larger seasonal biases in the middle and lower stratosphere with the maximum in the 10-6 hPa layer.

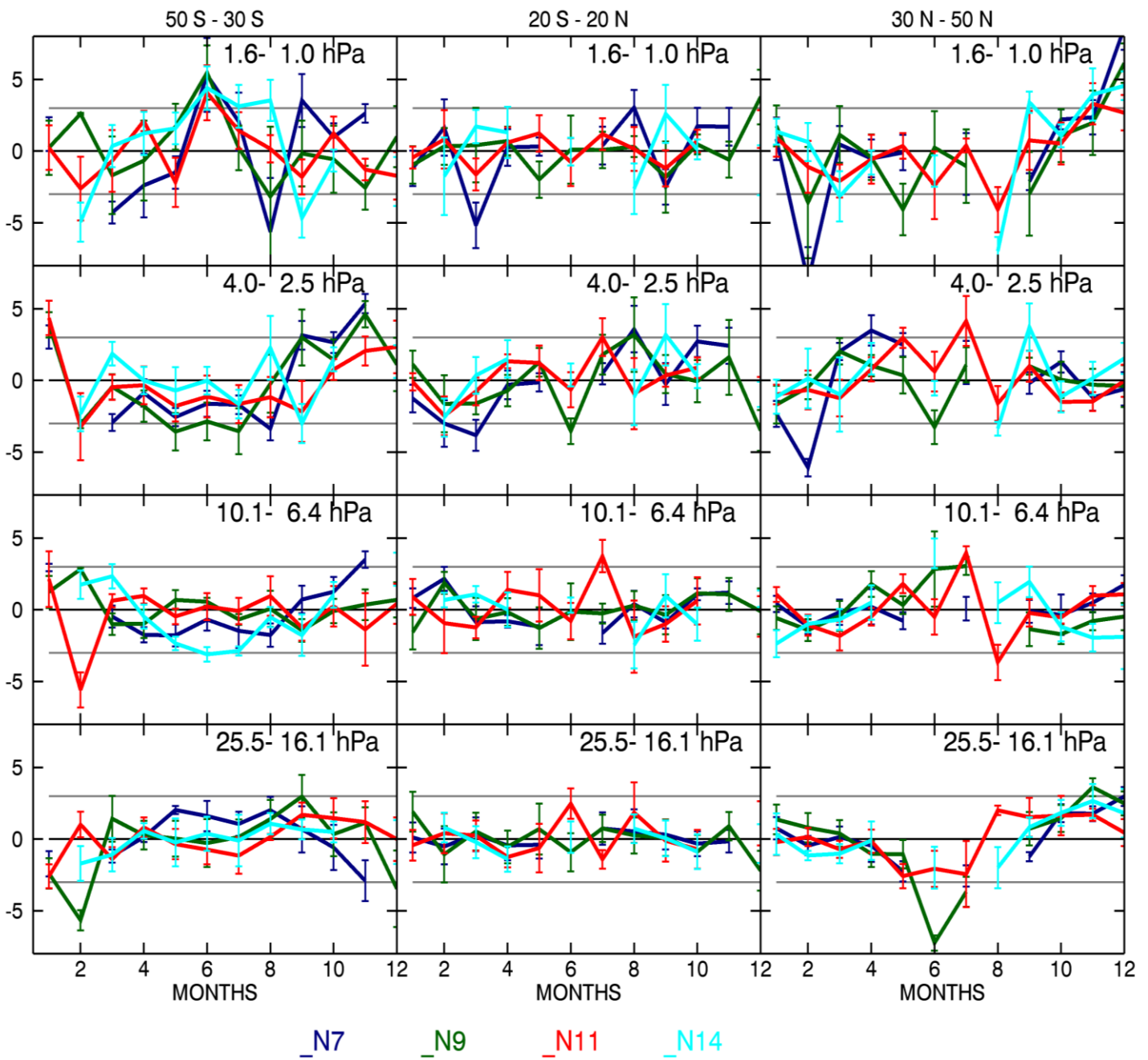


Figure A9. Same as figure A8 but for N7, N9, N11 and N14 SBUV relative to SAGE II. We did not find seasonal patterns from the comparisons with SAGE II. However, it is important to note that we have limited overlap time periods and sparse SAGE II sampling. These factors complicate the analysis of the seasonal biases.

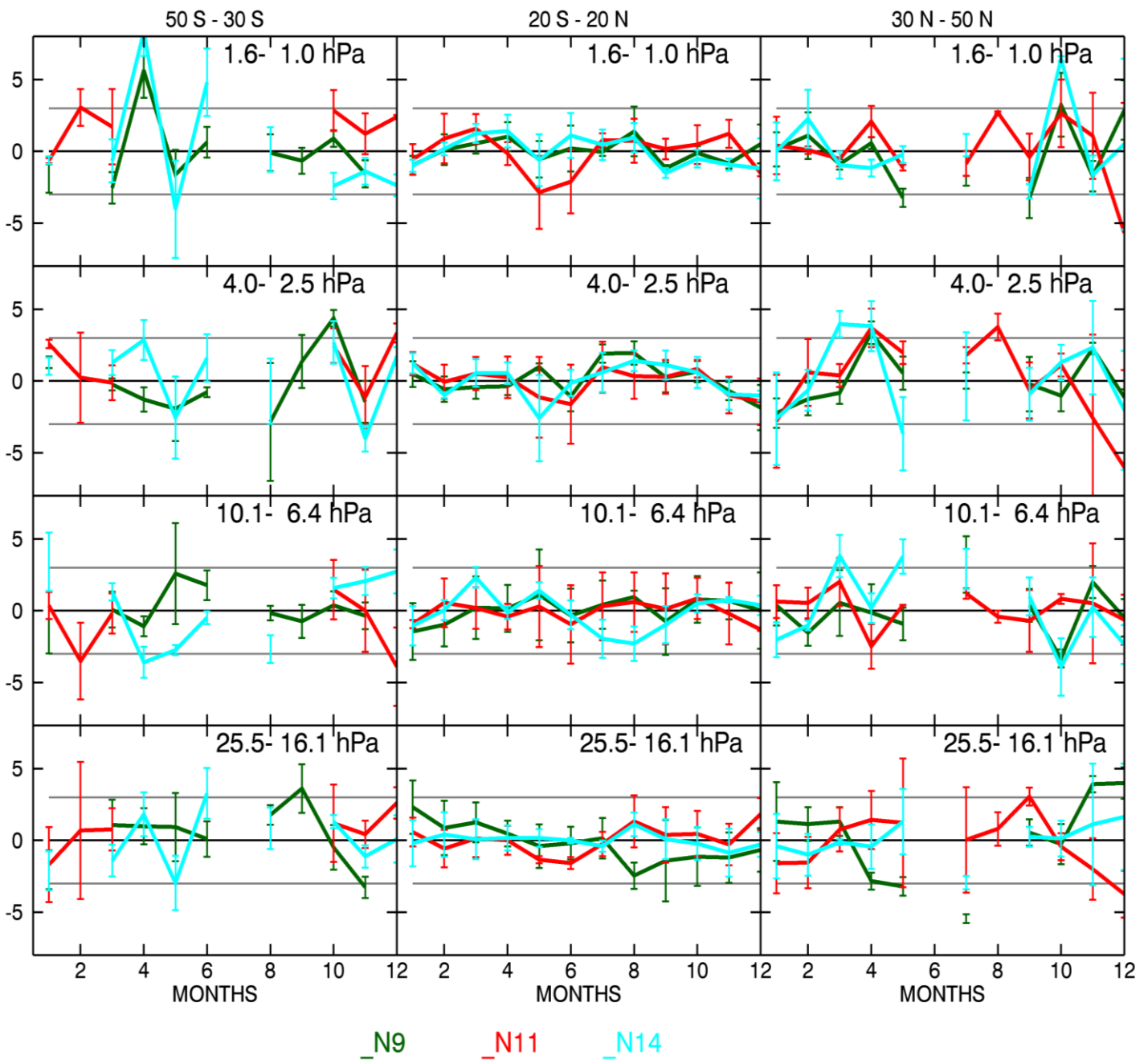


Figure A10. Same as figure A8 but for N9, N11 and N14 SBUV relative to UARS MLS. There are not enough coincident measurements in the extratropics to estimate biases for all months. Coincidences are limited by short overlap time periods between SBUV instruments and UARS MLS and by the specific orbital track of the UARS satellite, which scans middle and high latitudes of each hemisphere only every other month. The biases in the tropics are small and mostly less than 2-3%.

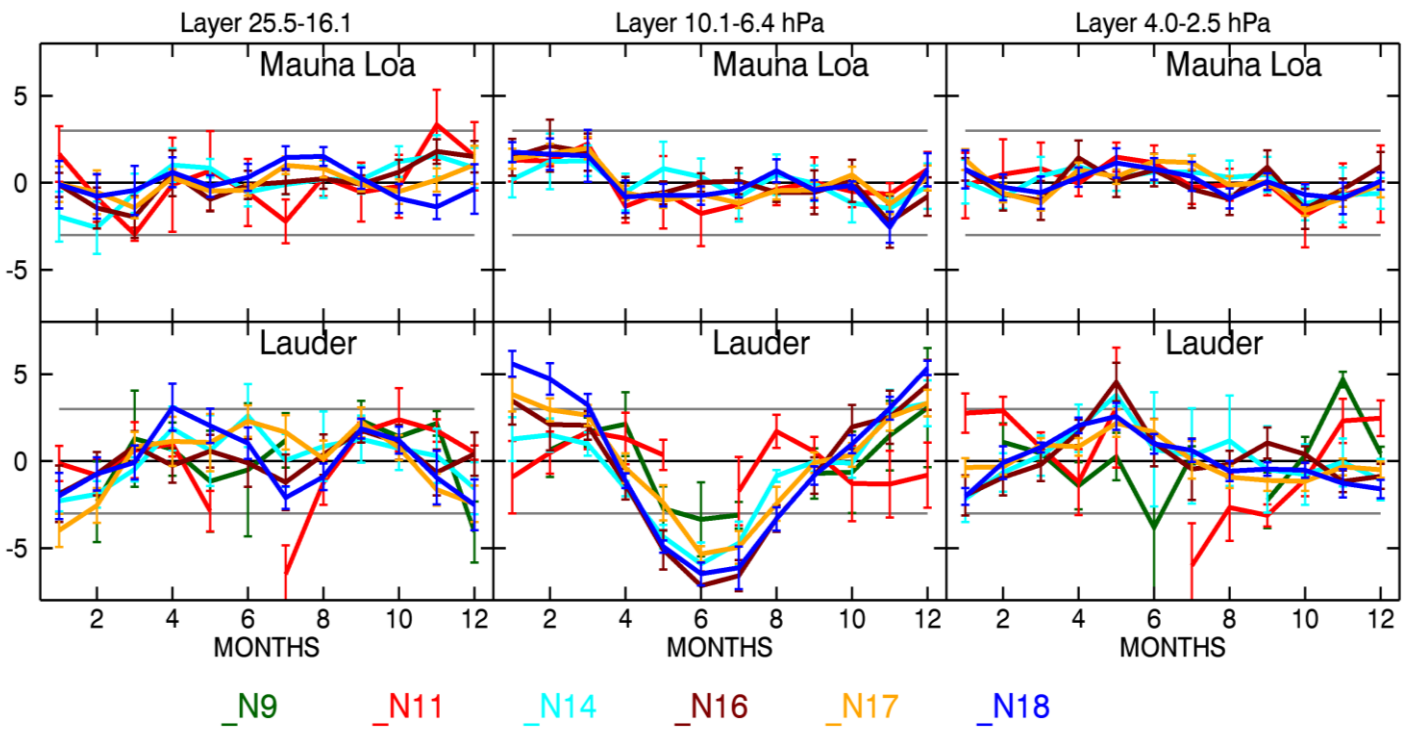


Figure A11. Seasonal biases for individual SBUV instruments relative to ground-based microwave spectrometers at Mauna Loa and Lauder. Colors correspond to individual SBUV instruments. Seasonal biases are very small at Mauna Loa and consistent with the satellite comparisons which also show smaller seasonal biases over the tropics. Biases are larger at Lauder with amplitudes up to 7% in the 10-6 hPa layer. The seasonal pattern found at Lauder is similar to the one detected from comparisons with Aura MLS (see Fig. A8).

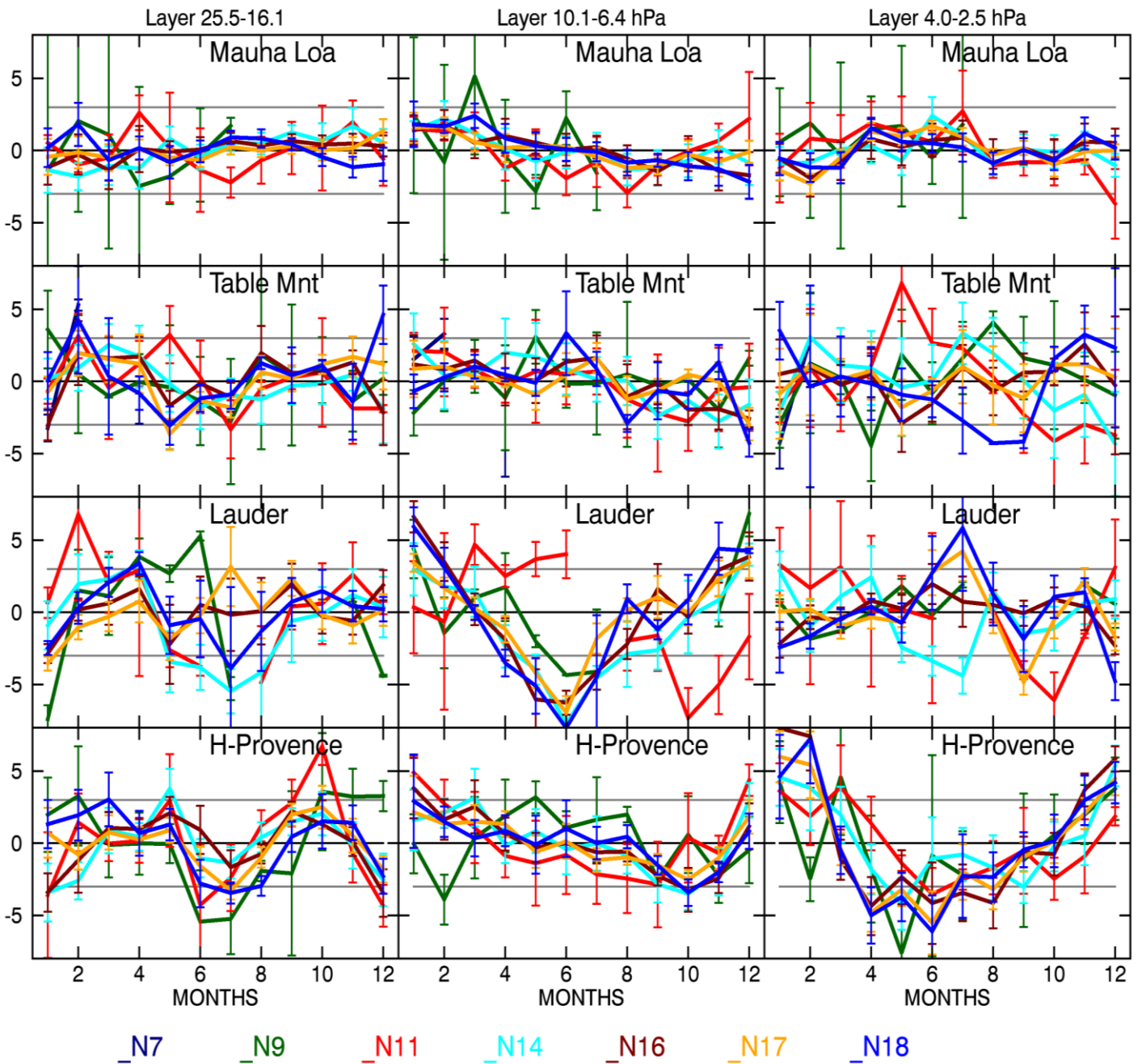


Figure A12. Same as figure A11 but relative to ground-based lidars at four stations. Seasonal biases for N9 and N11 are substantially greater with large error bars. Again seasonal biases are smaller in the tropics at Mauna Loa. In the layer 4-2.5 hPa, the seasonal pattern at Table Mountain shows inconsistent differences that are not seen in Mauna Loa and Haute Provence. At Lauder the seasonal pattern in the 10-6 hPa layer is consistent with that detected from comparisons with the Lauder microwave spectrometer and Aura MLS. Seasonal structures of biases relative to the Haute Provence lidar are not consistent with Aura MLS, for example, the 2-4 hPa layer the amplitude of the seasonal biases is about 8%, while comparisons with Aura MLS showed no sign of seasonal biases at that altitude.

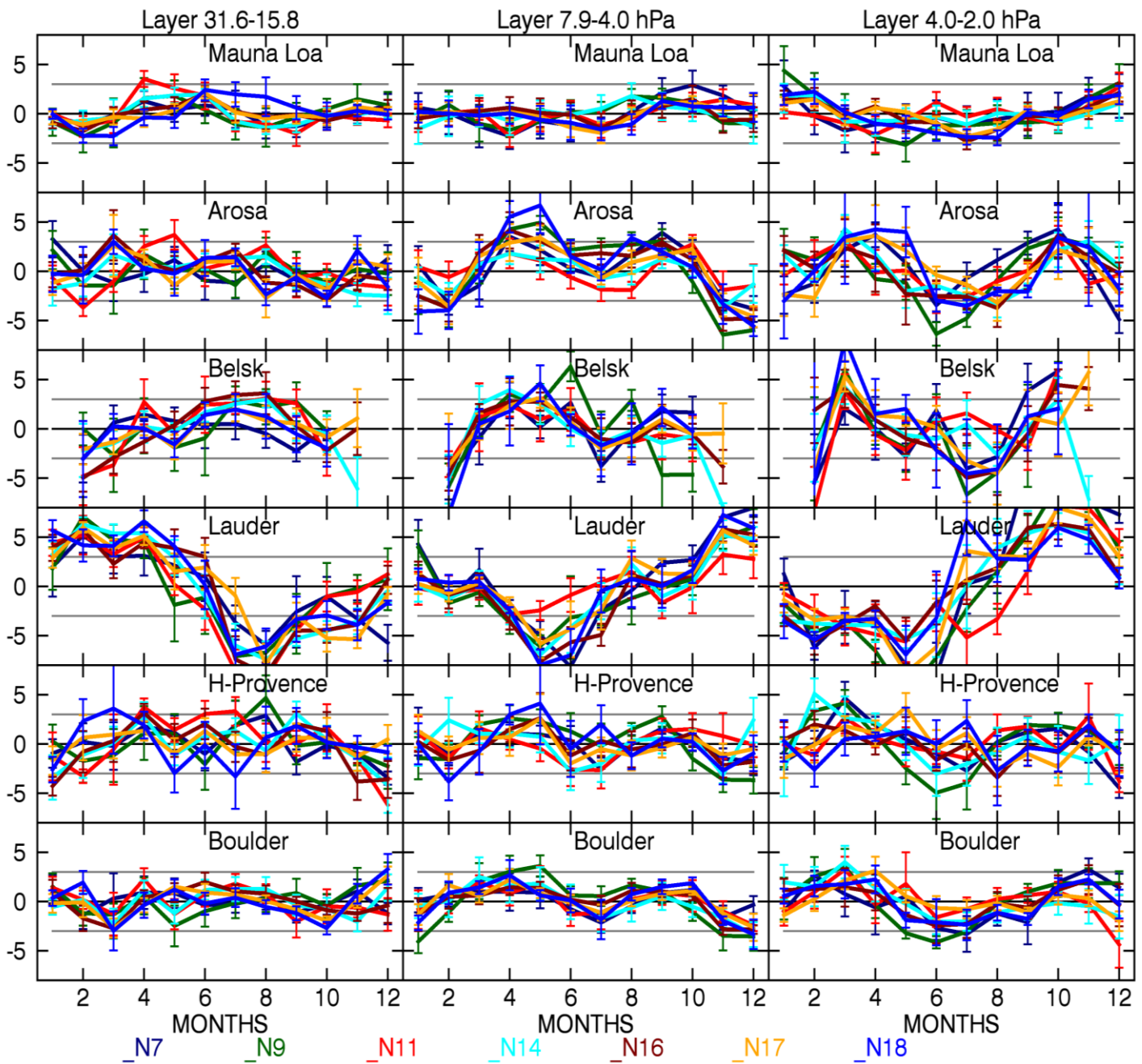


Figure A13. Same as figure A11 but relative to ground-based Umkehr instruments at six stations. Note, that the vertical scale for validation with Umkehr is different. Seasonal biases at Mauna Loa are less than 2-3%. Biases relative to two northern hemisphere instruments (Arosa and Belsk) have similar structures in the 8-4 hPa and 4-2 hPa layers. In 8-4 hPa layer the biases are positive in summer and negative in winter. These results are consistent with Aura MLS comparisons (see Fig. A8), but the two other northern hemisphere stations, Haute Provence and Boulder, show small seasonal biases within $\pm 5\%$ in all layers. At Lauder the seasonal pattern of biases in the 4-8 hPa layer is consistent with other comparisons (in the layer 10-6 hPa for the Lauder microwave (Fig. A11) and lidar (Fig. A12) comparisons), but large seasonal biases in other h layers are not consistent with other observations.

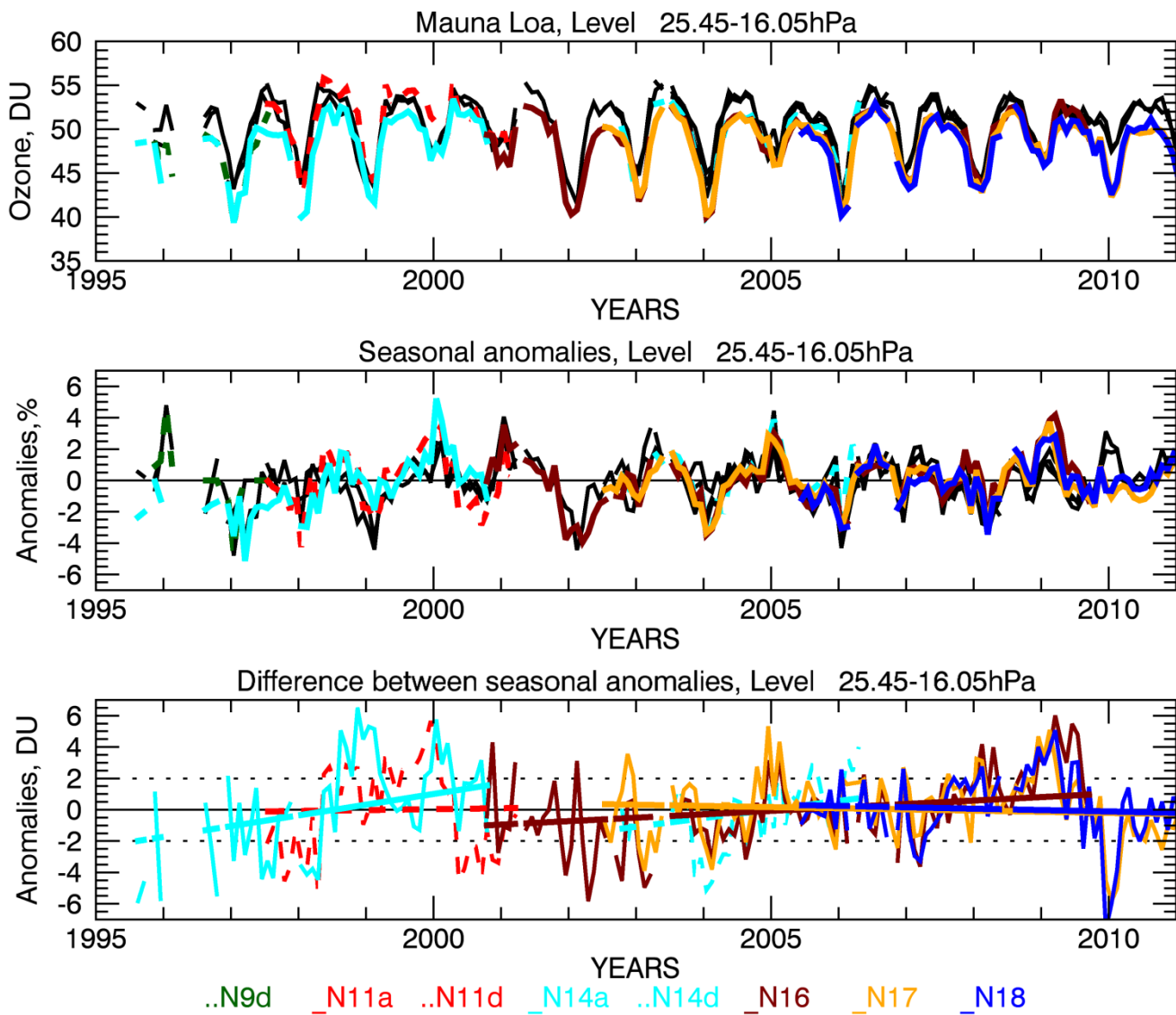


Figure A14. (top) Time series of the coincident microwave (black line) and SBUV measurements at 25-16 hPa layer. Different colors correspond to individual SBUV instruments, and dashed lines correspond to descending modes.

(middle) Time series of the deseasonalized ozone anomalies obtained from individual SBUV instruments (different colors) and microwave spectrometer (black line). Note the good correspondence between the deseasonalized time series.

(bottom) Time series of the differences between the deseasonalized microwave and SBUV anomalies (thin color lines) along with the linear drifts (thick color lines). This figure demonstrates a typical example of the differences time series and associated linear drifts.

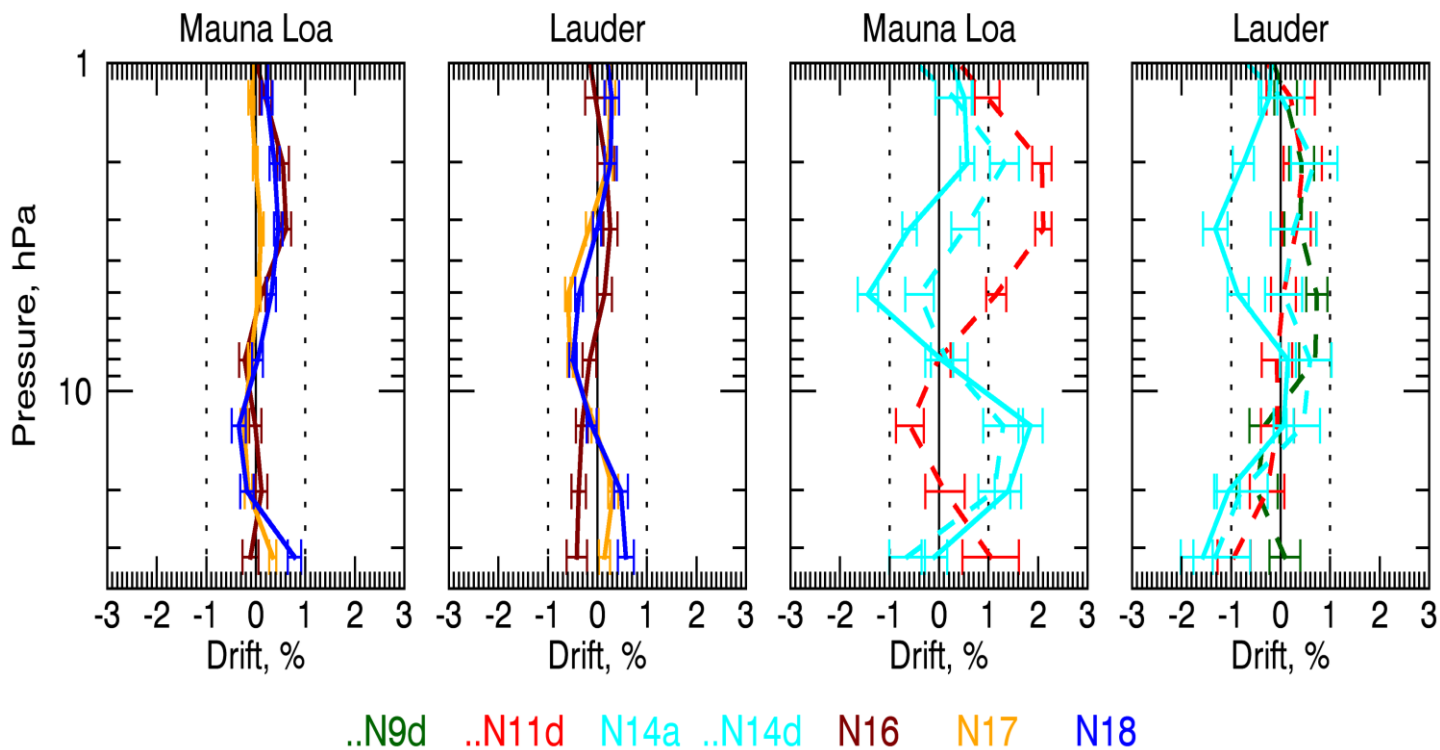


Figure A15. Vertical profiles of drifts for individual SBUV instruments relative to ground-based microwave instruments at Mauna Loa and Lauder. Drifts for ascending and descending orbit modes are calculated independently. The drifts for N16, N17 and N18 are small, reflecting the stability of the most recent instruments. Drifts are larger for previous SBUV instruments. The vertical pattern of drifts for N14 ascending is similar for both stations. This consistency will allow us to account for the N14 drift in the merged data set uncertainty analysis.

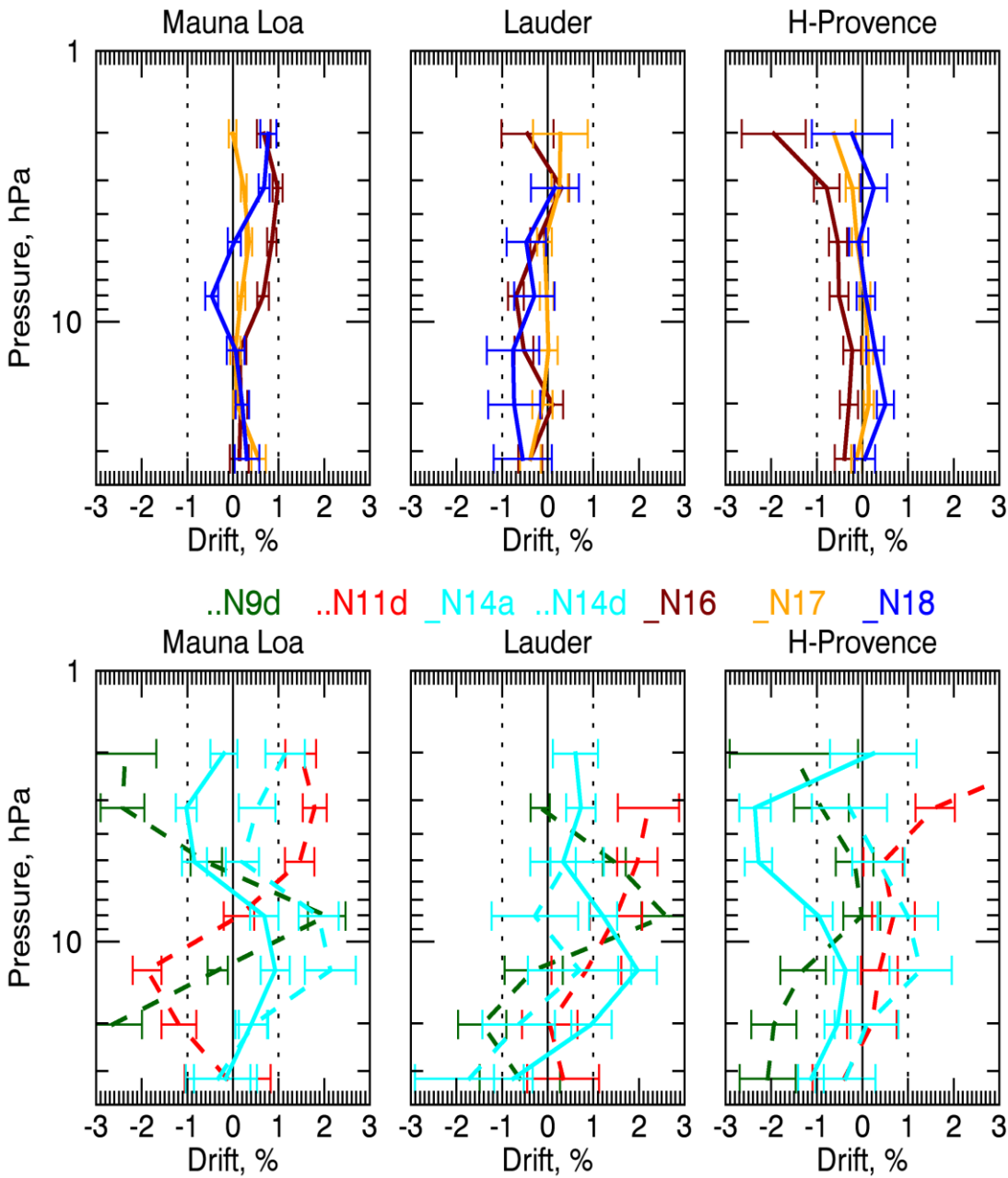


Figure A16. Same as figure A15 but relative to lidar instruments at Mauna Loa, Lauder and Haute Provence. Drifts for three recent instruments shown on the top panel are small (less than 0.5% per year) at all locations, with slightly larger drifts and corresponding uncertainties for the upper layer at Haute Provence. We found significantly larger drifts (1-3% per year) for earlier instruments.

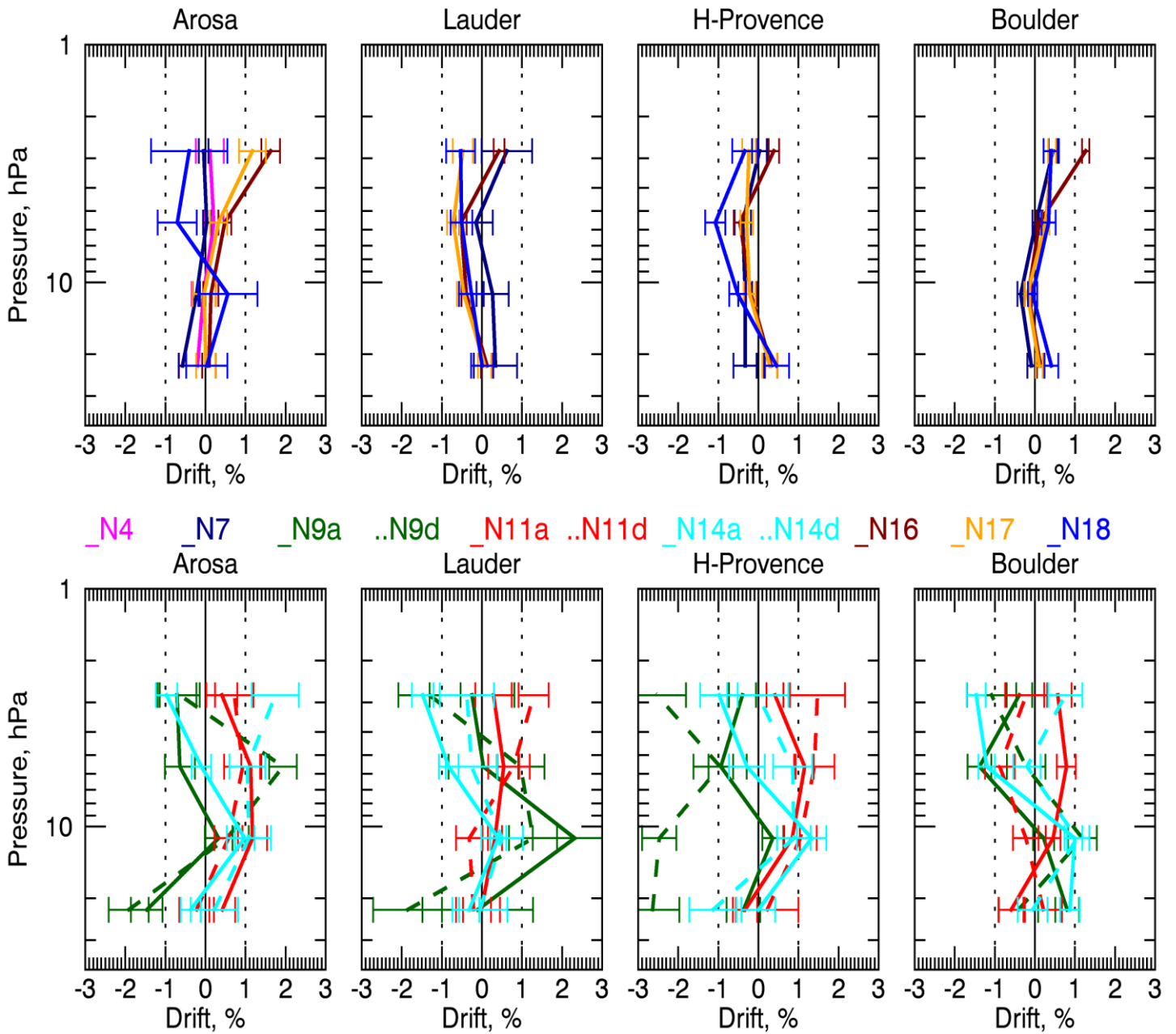


Figure A17. Same as figure A15 but relative to ground-based Umkehr observations at Arosa, Lauder, Haute Provence and Boulder. The top panel shows drifts for N4, N7, N16, N17 and N18 relative to Umkehr observations at four locations. Drifts are small and mostly less than 0.5% per year. However we found slightly larger drifts for N16, N17 and N18 relative to Arosa, most likely due to a shorter overlap time period. The bottom row shows drifts for ascending (solid lines) and descending (dashed lines) modes of N9, N11 and N14. Drifts are larger and vary within $\pm 3\%$. However, we should note a stable pattern of drifts at all stations for the ascending mode of N11 and the ascending mode of N14.