Mini-DOAS BrO Analysis Update

UCLA

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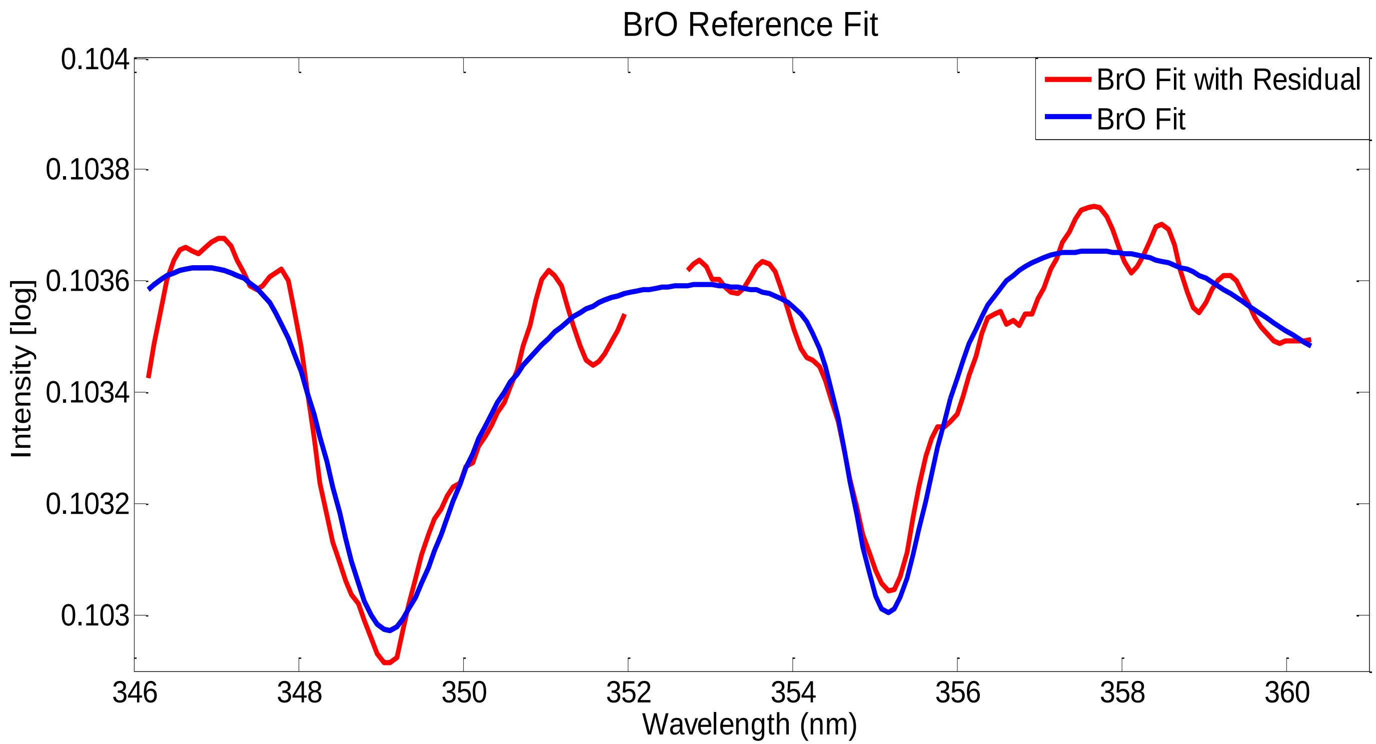
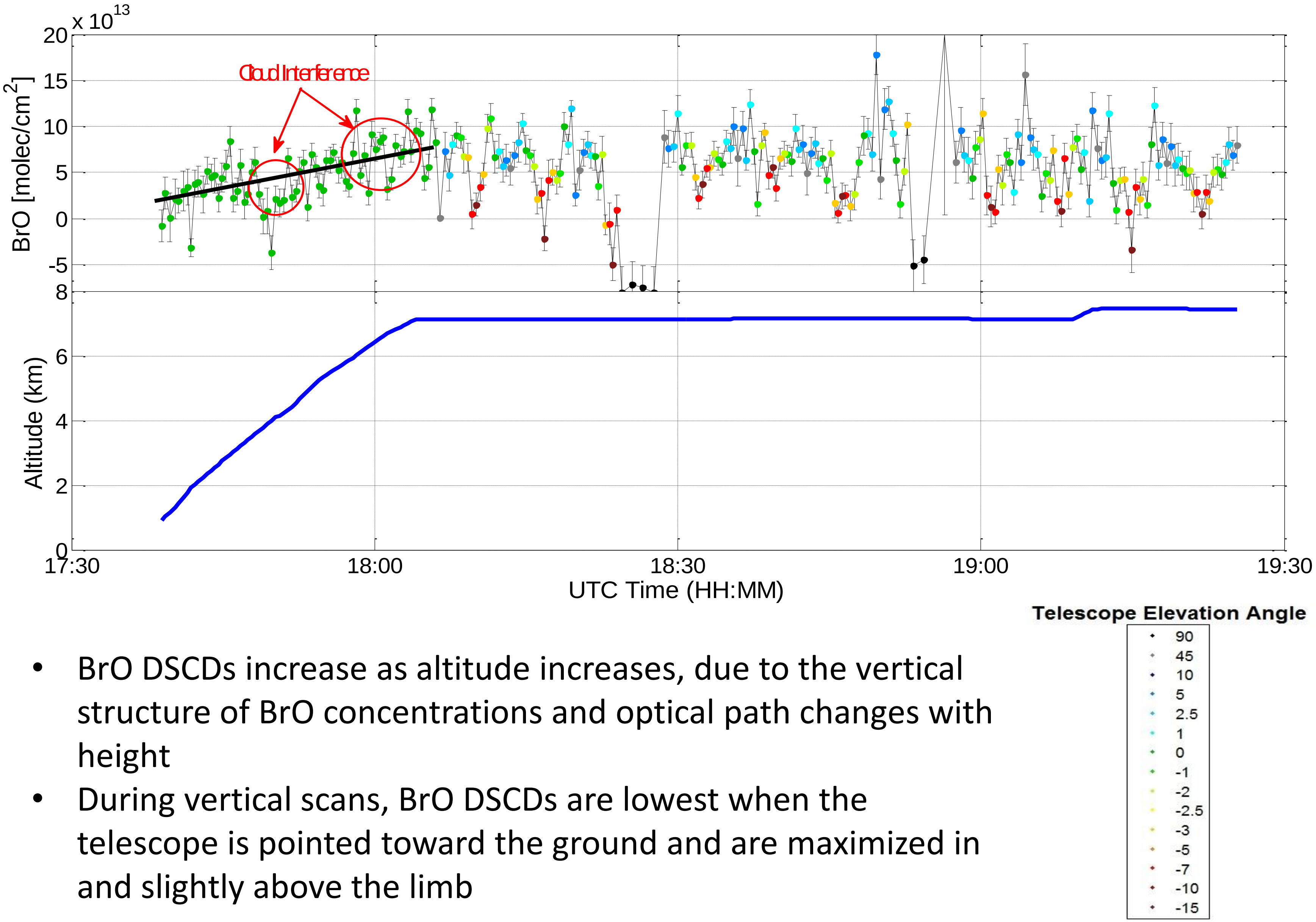
Example BrO Fit During SF6



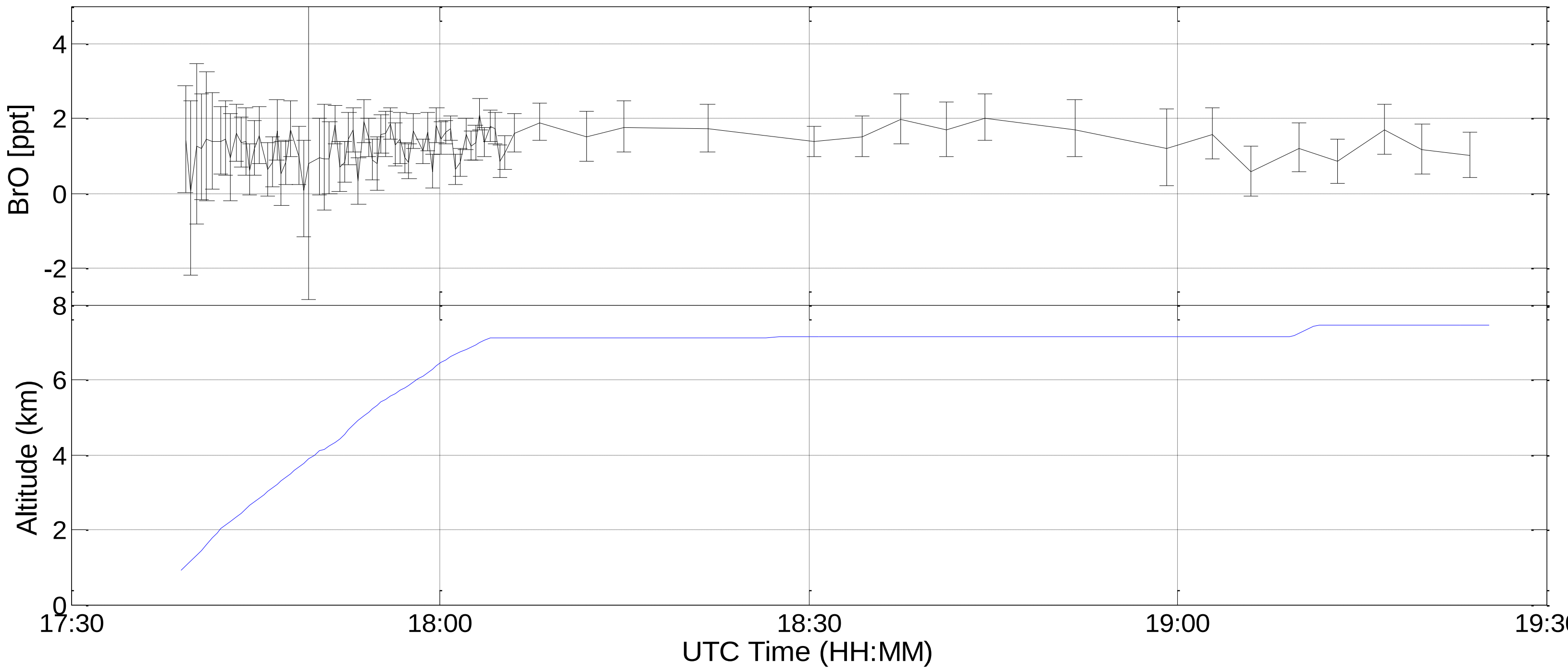
- This spectrum was measured during science flight 6 (06/19/2013) at 18:14:59 UTC
- The BrO reference comes from Fleischmann et al., 2004
- We see BrO!!!

BrO Altitude Dependence During SF6



- BrO DSCDs increase as altitude increases, due to the vertical structure of BrO concentrations and optical path changes with height
- During vertical scans, BrO DSCDs are lowest when the telescope is pointed toward the ground and are maximized in and slightly above the limb

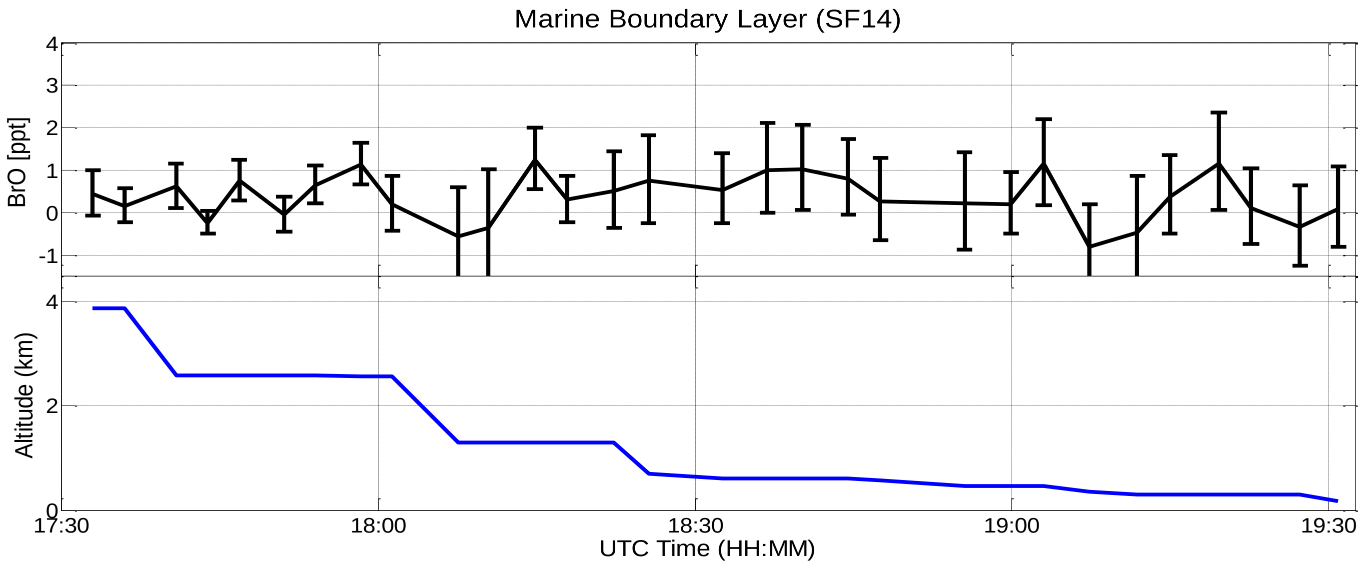
BrO Detection Limits for SF6

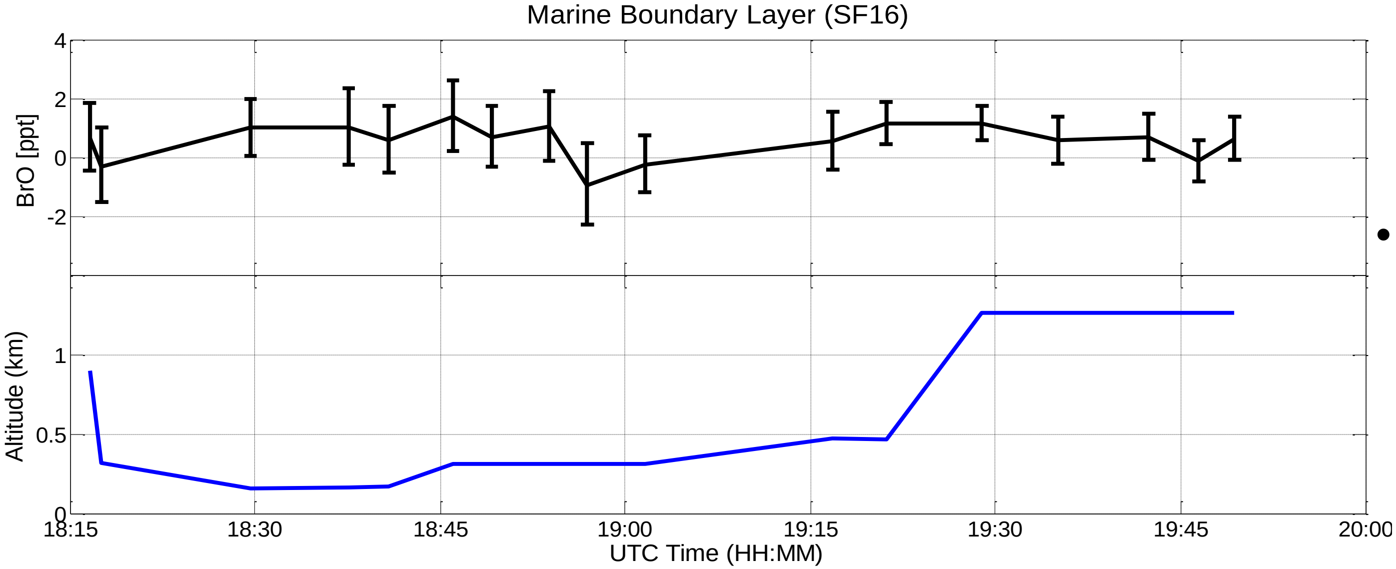


$$MR_{BrO} = \frac{DSCD_{BrO}}{DSCD_{O_4}} \cdot (MR_{O_2})^2 \cdot \frac{l^*_{O_4}}{l^*_{BrO}}$$

- The “scaling” method is not ideal for BrO, but it provides a quick estimate for concentrations and DOAS detection limits
- Detection limits generally range from 0.5 ppt to 1 ppt
- Only 0 degree scanning angles are included in this figure

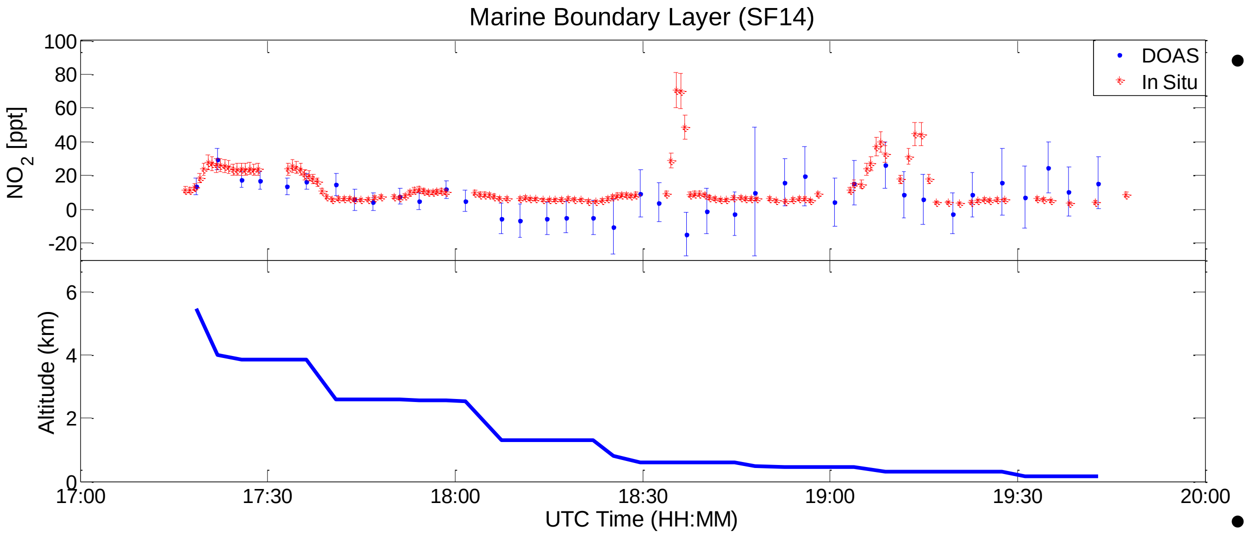
MBL BrO Detection Limits

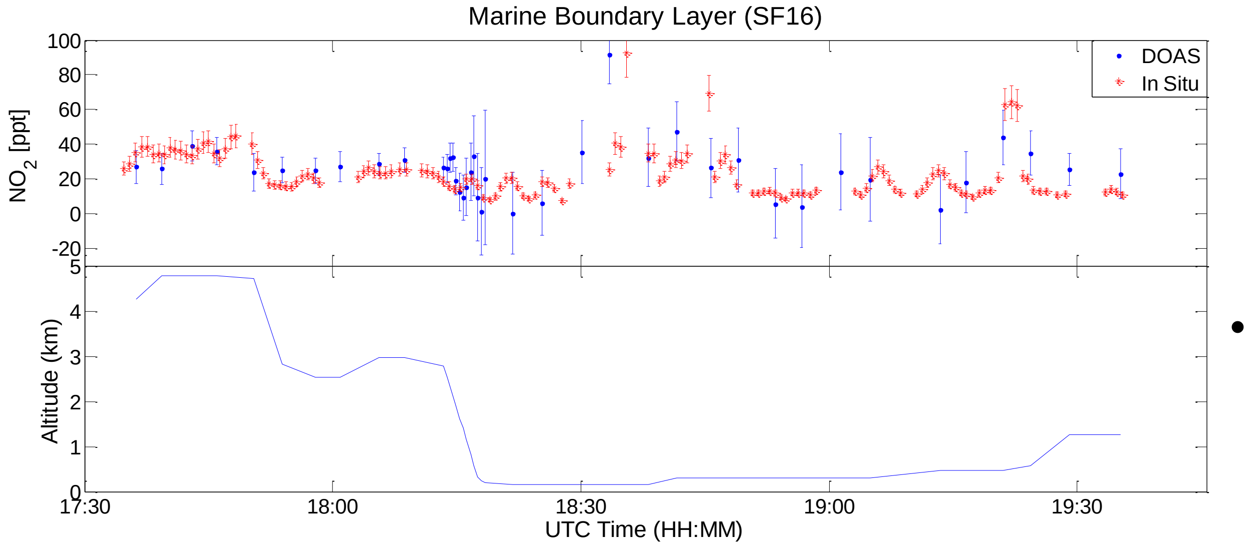




- The uncertainties in our analysis while flying at a low altitude over the ocean will improve in the future
  - It is likely that ocean surface Raman scattering effects need to be taken into account in our analysis
- That issue also applies for other chemical species we measured on these flights

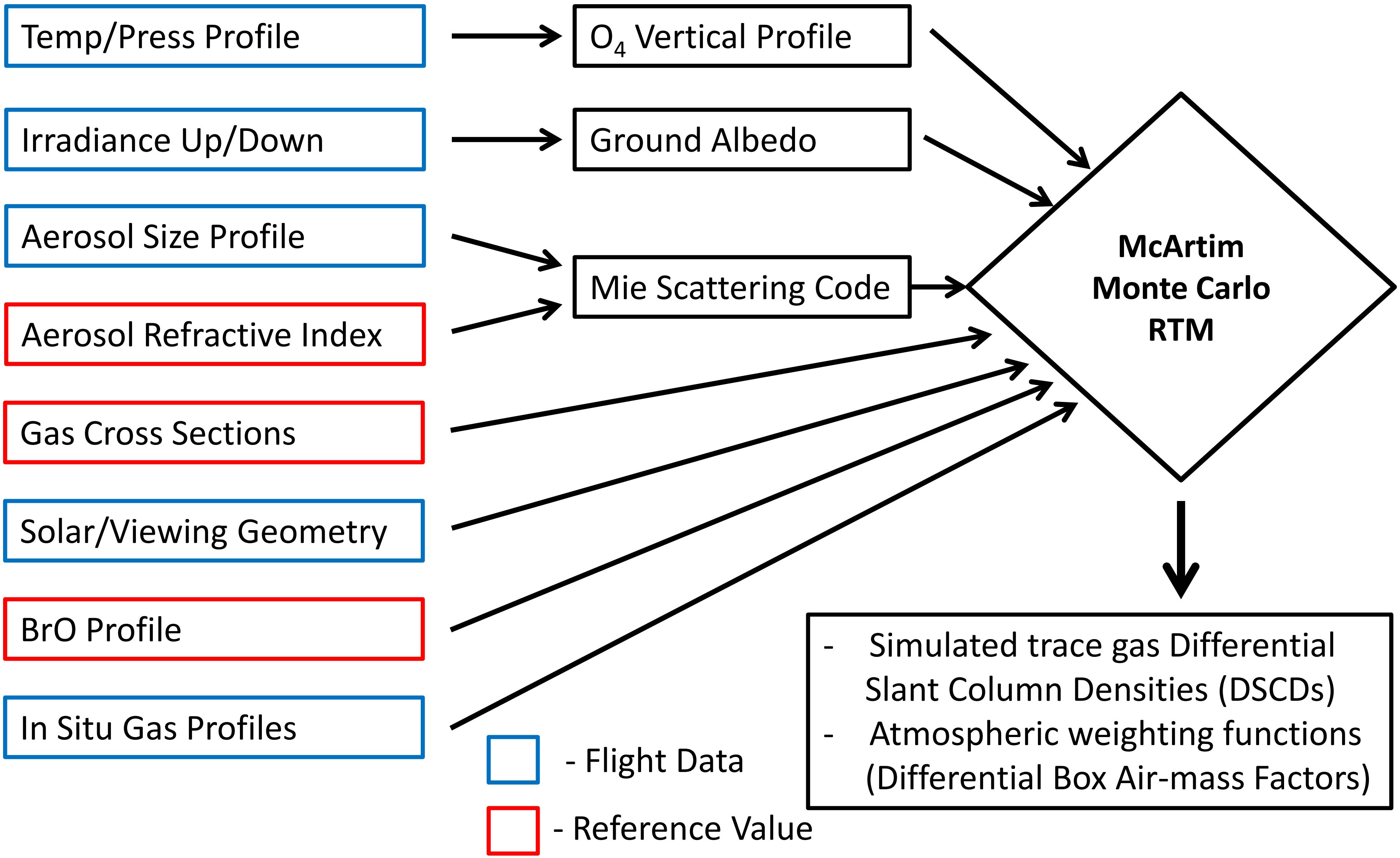
MBL NO_2 Comparison



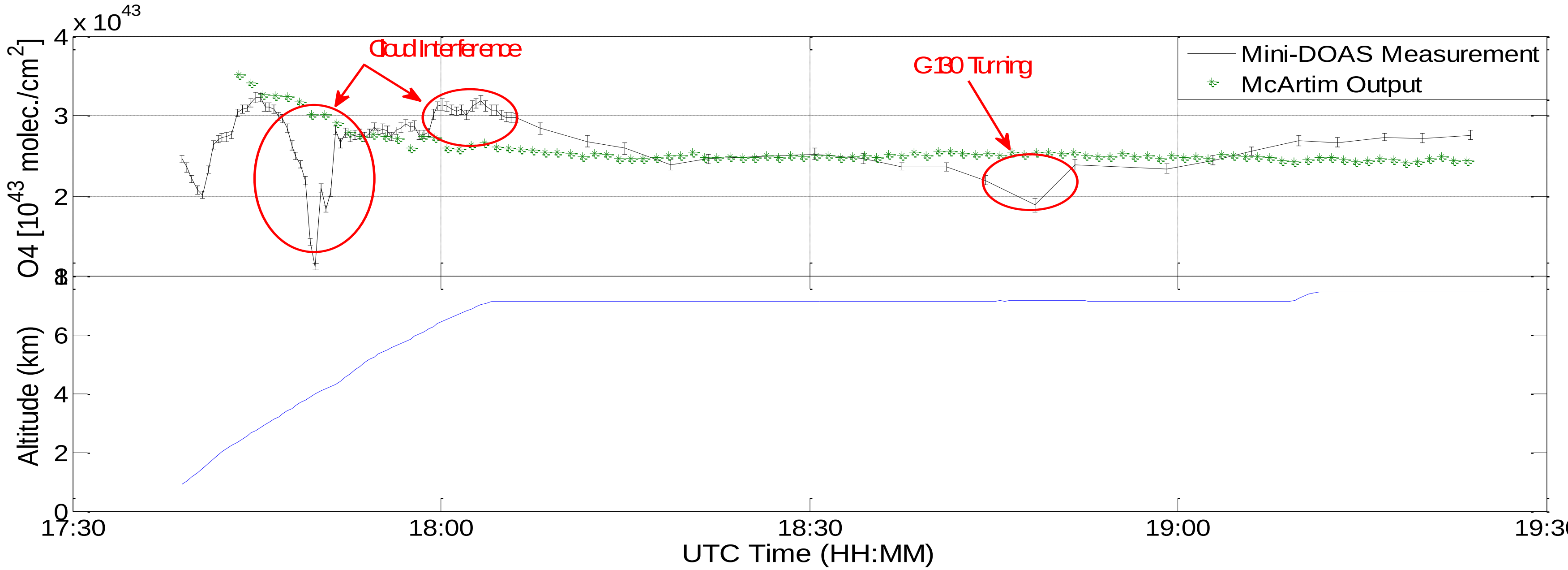


- Comparison between DOAS NO_2 analysis incorporating the O_4 scaling method and the NCAR In Situ Chemiluminescence instrument for a portion of SF14 and SF16
- A two minute running average of the in situ data was taken to account for the DOAS instrument sampling the average air mass ahead of the aircraft
- NO_2 mixing ratios are at or near the detection limit, but agreement is still quite good

McArtim Radiative Transfer Model

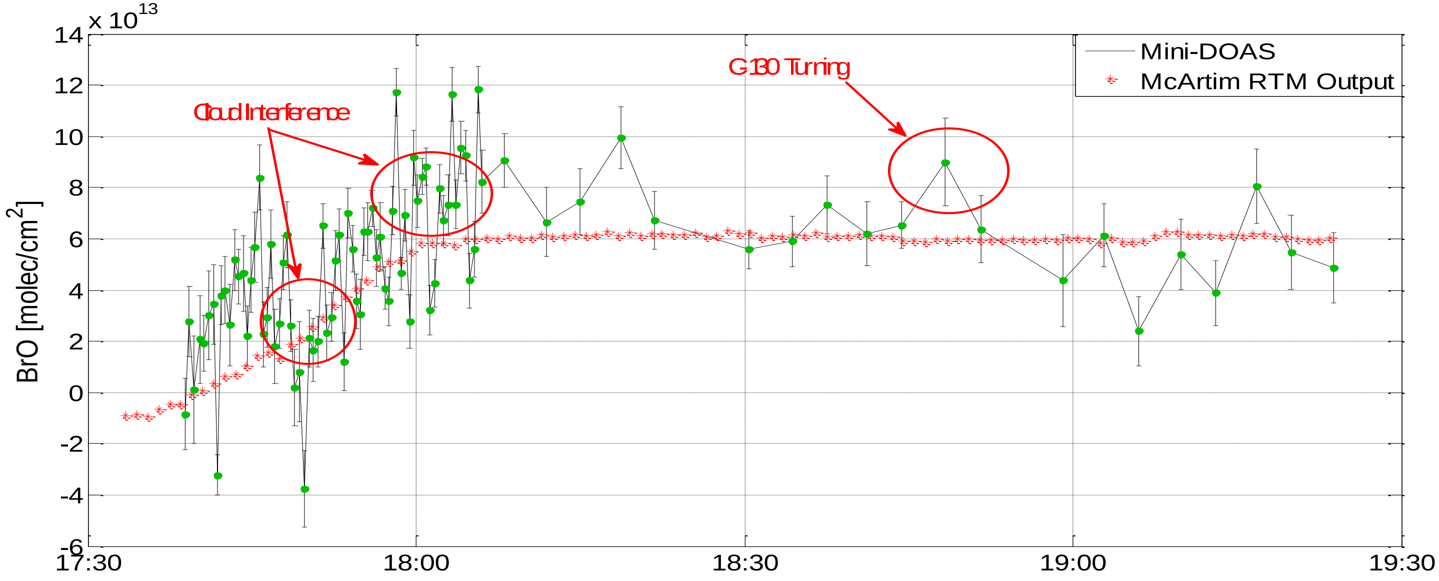


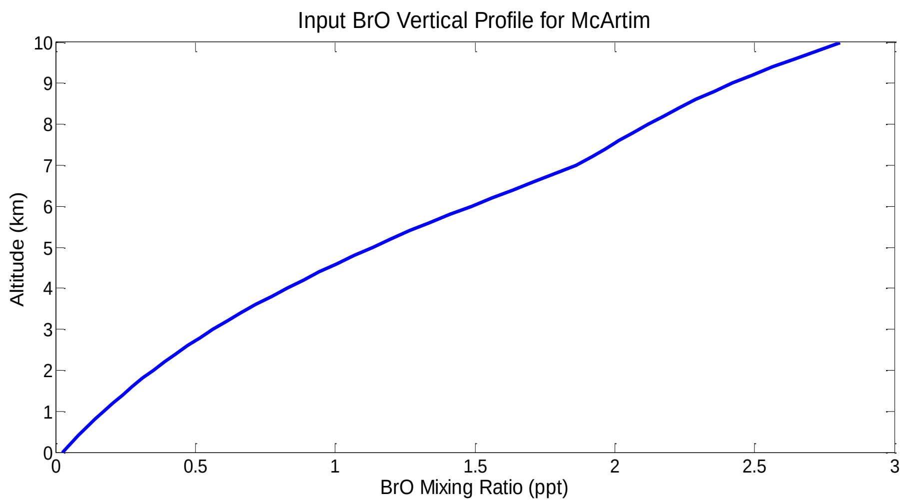
McArtim O_4 Comparison



- O_4 comparisons are required to determine how well aerosols are represented in the model, as they have a large influence on the optical path length
- When clouds are not present and the aircraft is steady, the agreement between modeled results and measurements of O_4 are quite good (within 20%)

McArtim BrO Comparison



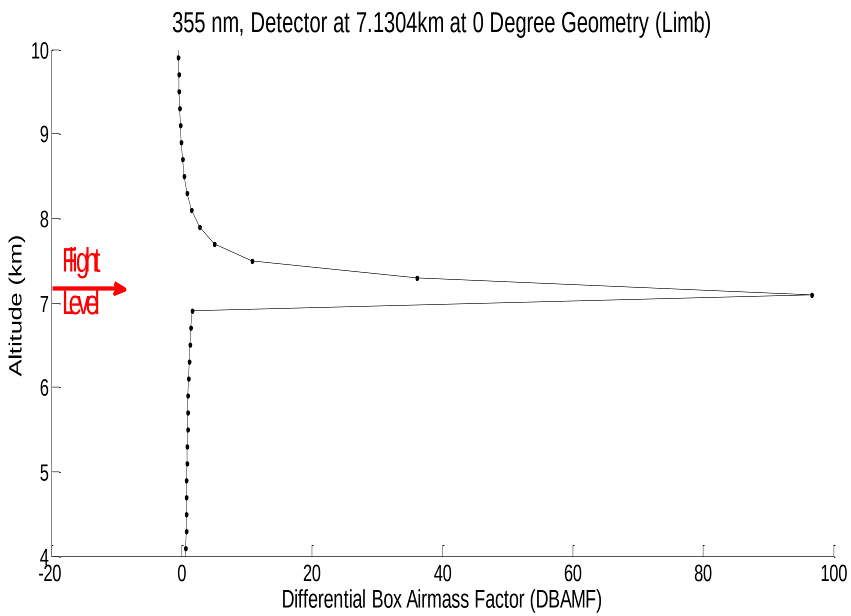


Initial BrO vertical profile based on Pundt et al., 2002

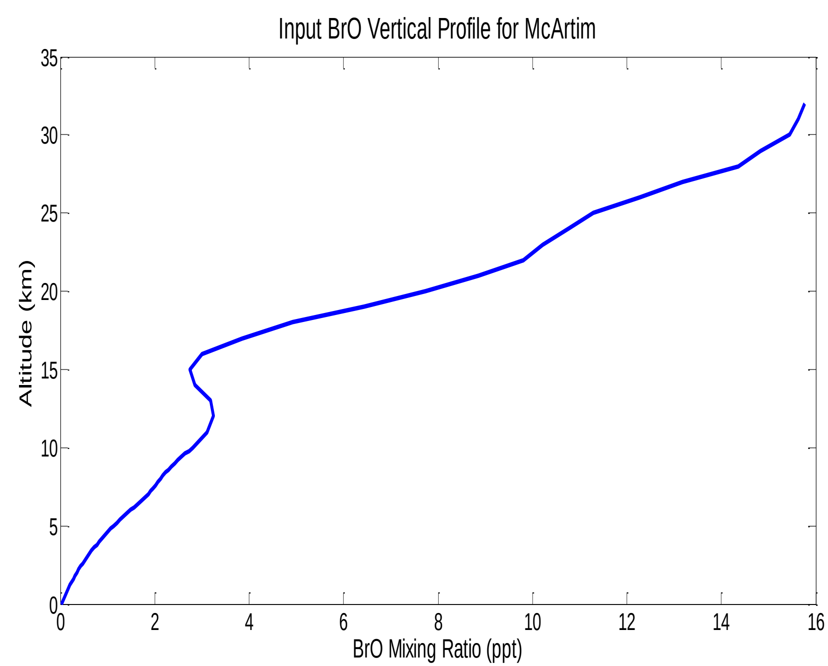
BrO mixing ratios at flight level (~7.2 km) are 1.9 ppt (±0.25ppt)

These are preliminary results but the agreement between the model output and DOAS measurements are quite good

McArtim BrO Sensitivity



- DOAS trace gas results do not only represent conditions at flight-level (even in the limb), radiation scattering causes the instrument to have decent trace gas sensitivity a few hundred meters above and below flight-level
  - Represented by the DBAMF



- Trace gas profiles also have a strong influence on sensitivity
- High or low trace gas concentrations away from flight-level are even represented in limb measurements
- The BrO profile was taken from Pundt et al., 2002.

Sensitivity Test Results (~7.2km)

BrO Sensitivity Test	**Percent (%)**
10% increase of BrO at flight altitude	10.02
Constant BrO Profile (0km-7km)	5.19
Telescope pointed up 0.2 degrees	1.82
Set Albedo at 10%	1.59
10% increase in stratospheric BrO	1.41
Telescope pointed down 0.2 degrees	1.4
Multiply temperature profile (K) by 1.005	0.55
10% increase in lower tropospheric BrO	0.52
Double aerosol concentration	0.31
0.2 decrease in phase function	0.06
Increase of 0.05 in real refractive index	0.06
Increase of 0.05 in imaginary refractive index	0.05
10% increase in aerosol diameter	0.03
Set SSA at 0.998	0.02

O_4 Sensitivity Test	**Percent (%)**
Change wavelength from 355nm to 361nm	4.31
Set Albedo at 10%	3.1
Telescope pointed up 0.2 degrees	1.42
Telescope pointed down 0.2 degrees	1.27
Multiply temperature profile (K) by 1.005	0.88
Set SSA at 0.998	0.23
Double aerosol concentration	0.21
Increase of 0.05 in imaginary refractive index	0.17
0.2 decrease in phase function	0.14
10% increase in aerosol diameter	0.09
Increase of 0.05 in real refractive index	0.08

- Altering aerosol parameters does not significantly contribute to uncertainty at a high flight altitude (relatively low aerosol concentration)
- Changes in the BrO profile (especially near flight-level) contribute to the greatest difference in RTM BrO output
- Wavelength and ground albedo changes contribute to the greatest change in O_4 output

Conclusions and Future Work

- BrO was detected and preliminarily quantified for the high altitude portion of SF6
- A constrained RTM comparison shows that 1.9 ppt (±0.25 ppt) of BrO at flight altitude explains the DSCDs of BrO we have measured
  - The model successfully took aerosols into account based on the comparison of O_4 DSCDs
- Similar work is planned for other flights
- Eventually, we plan to complete a full BrO retrieval (vertical profile) based on our data