Review for J. Su et al., Tropospheric NO2 Measurements Using a Three-wavelength Optical Parametric Oscillator Differential Absorption Lidar submitted to Atmospheric Measurement Techniques.

This paper provides a preliminary analysis of a three-wavelength (dual-DIAL) lidar technique applied to both a modeled lidar signal and to lidar signals from the OPO-based Hampton University NO_2 lidar. While multi-wavelength DIAL methods do exist, the wavelength flexibility of new laser transmitters permit novel optimizations to improve lidar measurements of chemical species in the atmosphere. The authors demonstrate that many of the errors in the NO_2 lidar profiles (due to uncertainties in the analysis parameters) are significantly reduced using this method, and they compare the lidar results to results from a well-established atmospheric composition model.

I believe that this paper would benefit from revision to provide more details/discussion of a few essential points and for several technical corrections.

In section 2 it would be useful to cite a few examples of prior works on three-wavelength (or dual-DIAL) lidar analysis. (There are many available, and previous work is suggested in lines 135ff, but that citation is missing/mislabeled in the references section.)

In equation 5, it would be helpful to label this term as NAD since it is described as this in the text. (e.g. "NAD = $\Delta\sigma_N$ = …")

In equation 7, it would be useful to include the term K that will be used later (e.g. "AED = … = $K\alpha_a(Z)$")

Since the three-wavelength results are compared against the two-wavelength results throughout this paper, it would be useful to readers to include the two-wavelength equations that correspond to equations 4 through 9.

In section 2a, it would be useful to note that DIAL systems for other atmospheric gases like ozone, it is only practical to use wavelength selection Method B because of the shape of the ozone absorption spectrum (lacking narrow peaks). The shape of the absorption spectrum of NO_2 allows for an especially favorable three-wavelength analysis using Method C because it is possible to choose the points spanning over the peak as shown in figures 1 and 2.

In sections 2 and 3, it is mentioned that the wavelengths are optimized according to the rules a. (maximize NAD) and b. (minimize AED), but this is a multivariate optimization. It would be useful to provide more detail of the optimization process and how the authors arrived at the final wavelengths.

There are two sections of text (lines 163ff and lines 223ff) that describe the lidar hardware and should be combined.

In section 4, Disregarding the uncertainty introduced by the lidar signals, U_s, should not be taken lightly. In particular, because this term is the result of taking a derivative of (logs of ratios of) signals, it can be very susceptible to noise in the raw signals. The modelled analysis in this paper uses relatively noise-free aerosol and ozone profiles (figure 4) which reduces this issue and facilitates evaluation of the optimizations presented. It is noted that the lidar signals in section 4 were integrated for 2 minutes to reduce the signal noise, and as a result, the resulting NO_2 profiles are relatively smooth. However, there should be some discussion of this noise source and its contribution to the resulting NO_2 profile uncertainty. This provides readers with an estimation of the relative contribution of signal noise which ultimately depends on lidar specifications (e.g. power and aperture) as well as on temporal and spatial resolution (i.e. averaging).

In section 4, the notation of "N_a" and "σ_a" for number density of air and Rayleigh (air) scattering cross section, respectively, might be less confusing as "N_m" and "σ_m" to be consistent with the rest of the text where "m" denotes molecular terms and "a" denotes aerosol terms.

In section 4 (line 272), a reference to Fernald's paper describing the lidar inversion procedure should be provided.

In section 5 (line326), the vertical resolution of the WRF-Chem results should be provided since the comparison with the lidar will be in this dimension.

Typographic errors:
Line 118 (equation 4), the numerator of the lidar signal term should be $X(\lambda_1,Z)X(\lambda_3,Z)$.
Lines 193-194, "…light blue lines are NAD." should be "…light blue lines are OAD."
Line 217 (figure 5 caption), Add "B" to the list of values described as shown on the graphs.
Line 228 "NO2" should be "NO_2"
Line 239, "NO" should be "NO_2"
Line 257 (equation 18), "*In*" should be "*ln*"
Lines 271ff, Font used for "α_a" is different than that used elsewhere (e.g. compare with line 109).
Line 309, "Fig. 8" should be "Fig. 12"

General review/editing for grammar would be helpful.