Abstract
Like other kind of grating spectrometers, scattering by the grating is the major source of stray light in Brewer Spectrophotometers. Presence of the stray light due to imperfection of Brewer as well as the large intensity gradient due to ozone absorption at large ozone paths result in a finite out-of-band rejection, which means that light of longer wavelengths contributes in measurement at short wavelengths. This results in underestimated ozone column especially when the ozone slant path becomes more than 1000 Dobson Unit (D.U.). The ozone column of 600 D.U. with an airmass factor of 3 (1800 D.U.) can be measured 8% lower than actual amount. In this work, a mathematical model of instrument response was developed for two versions of Brewer (Single-monochromator and Double-monochromator) to estimate the amount of stray light from the slit functions measured using a He-Cd laser. This model can be used to validate the methods of correcting the stray light effect.

Introduction
The Brewer spectrophotometer is designed to measure total ozone by examining the differential absorption of selected wavelengths in the UVB portion of the spectrum. It also has a UV diffuser which is used for measuring the solar UV irradiance. Brewer contains a modified Ebert spectrometer, utilizing a holographic diffraction grating. It has six exit slits through which the light coming from monochromator is guided to a photomultiplier. Due to the finite performance of the Brewer, light of other wavelengths than those specified by exit slits contributes in the measurements. The imperfection of the grating is the main source of the stray light. However, holographic gratings with higher line density have lower stray light so Brewer MkIII (3600 line/mm grating) has minimum stray light compare to other types. Also Brewer MkIIId contains two spectrometers which results to minimum stray light effect (Fig. 1.).

Methodology
There are four wavelengths which are used by Brewer spectrophotometer for calculating total ozone amount: F3 (303-310.0 nm), F4 (443-313.5 nm), F5 (459-316.8 nm) and F6 (1680-3200.0 nm). Ratios of weighted photon count rates of these wavelengths are calculated as:

\[ MS9 = 10^4 \times \log_{10} \left( \frac{F_2^2 \times F_4}{F_6} \right) \]

(1)

where MS9 is double ratio and F is the photon count rate that relate to spectral intensities of each wavelengths. The weighted factors are used to minimize the aerosol effects. The total ozone column can be determined using MS9 through equation:

\[ MS11 = MS9 - \text{ETC} \]

(2)

where ETC and \( \alpha \) are extra-terrestrial constant and absorption coefficient and \( \mu \) is an airmass factor [Sci-TEC Instruments Inc., 1999]. Absorption coefficient, \( \alpha \), is calculated from a known absorption cross section, Bass and Paur (1995), and ETC can be obtained from Langley plot or transferred from a calibrator/Brewer.

To characterize the stray light of the instruments a HeCd-laser at 325 nm was used as a source and all wavelengths starting from 290 nm with a single-monochromator brewer (Brewer # 009) and a double-monochromator Brewer (Brewer # 119) were measured. The photon count rate, F, measured by Brewer is the integral of spectral intensities on all wavelengths weighted by the slit function, \( S(\lambda) \):

\[ F(\lambda) = \int_{\lambda} S(\lambda - \lambda) I(\lambda) d(\lambda) \]

(3)

Where \( I(\lambda) \) is solar radiance and can be modeled using

\[ I(\lambda) = I_0 \exp(-\tau) \]

(4)

\( I_0 \) is solar spectrum at the top of atmosphere and T is the optical depth

\[ \tau = \sigma X_{\lambda} \mu \times 2.69 \times 10^{16} \]

(5)

In this equation \( \sigma \) is the cross section of ozone at 228 K, \( \mu \) is the airmass factor and \( X_{\lambda} \), is ozone amount in Dobson unit. In Brewer MKIV a solar blind filter made of NiSO4 crystal sandwiched between two UG-11 glasses has been employed which must be considered for single-monochromator model (Fig. 3.). The high resolution Kelly Chance’s solar spectrum [Kelly Chance, 2010] was used in this study as a source. Also, ozone absorption cross sections for the UV region measured by Bass and Paur [1995] were used. They measured ozone absorption at six different temperatures (K): 203, 223, 246, 273, 276 and 280.

Summary and Results
The slit function was defined by a straight line between 10% and 90% with a 0.6 nm FWHM and a flat top at 0.87 of the full triangular height. Wing regions were created by a Lorentzian function which were fitted to the measured slit function data. Outer regions are flat lines. Then it was interpolated to solar spectrum grid wavelengths and was normalized to one (Fig. 2.). Also, Bass Paur Cross Section at 228 K was interpolated to the solar spectrum grid wavelengths. Assuming 300 Dobson Ozone the intensities of different wavelengths were calculated by equation (4) and applied in the equation (3). Photon count rates for ozone wavelengths were obtained and finally the absorption function MS9 was determined versus airmass. The extraterrestrial constant (ETC) and absorption coefficient (\( \alpha \)) were calculated by doing the linear Langley plot calibration for modeled single and double monochromator Brewer (Fig. 4.).

References