Comparison of Aircraft Observed with Calculated Downwelling Solar Fluxes during ARESE

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August, 1998

Submitted to Dr. Robert Ellingson

as

Partial Fulfillment of the Degree of Master of Sciences
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Abstract

The objectives of the Atmospheric Radiation Measurement (ARM) Enhanced Shortwave Experiment (ARESE) are to directly measure clear and cloudy sky shortwave atmospheric absorption and to quantify any absorption found in excess of model predictions. We have the measurements made from collocated aircraft of the absorption of solar radiation within the atmospheric column between the two aircraft, Egrett and Twin-Otter. The focus of this study is to find the confidence intervals of these ARESE measurements. Egrett downwelling flux measurements on ten days in Fall 1995 are investigated and are compared to SBDART model calculations. The result shows that the model calculated fluxes have higher values than those observed, and the differences vary from 0.1 to 24.2 W/m$^2$. The average difference of the ensemble data set is about 11 W/m$^2$. Due to a good understanding of the radiative transfer process at the level of the Egrett, we assume that this discrepancy is mainly caused by a radiometer error on board of the aircraft. Because the same instruments were used also for downwelling flux measurement on the Egrett and both upward and downwelling flux measurements on the Twin-Otter, we assume the same magnitude of system error for the other three observations. With these assumptions, we conclude that the confidence intervals for the ARESE atmospheric absorption approximately fall into a \( \pm 22 \) W/m$^2$ range.
1. Introduction

The most fundamental quantity determining Earth’s climate is the amount of solar radiation absorbed by the climate system. This flux of energy is determined by the amount of short-wave radiation both reflected and absorbed by the system. A major component in determining the disposition of shortwave radiation in the atmosphere is the presence of clouds. Radiation models indicate that cloudy skies absorb about as much shortwave energy as clear skies. Observations of how much shortwave radiation is absorbed in clouds suggest discrepancies with these models. Recent studies by Cess et al. [1995], Ramanathan et al. [1995], Pilewskie and Valero [1995], and Waliser et al. [1996] indicate that clouds absorb considerably more shortwave radiation than current radiative transfer models suggest. Indeed, there is still a vigorous debate in the atmospheric radiation community on the cloud shortwave absorption. The disagreement in interpretation of atmospheric absorption prompted the Atmospheric Radiation Measurement (ARM) program to initiate a field experiment named the Enhanced Shortwave Experiment (ARESE) at the Southern Great Plains site in Oklahoma, which was carried out in 1995. The primary goals of ARESE were to obtain sets of measurements to determine accurately the absorption of solar radiation by the clear and cloudy atmospheric column at midlatitudes, and to investigate the spectral regions where the excess absorption occurs [Valero et al., 1997].

The ARESE data comprise a unique data set for testing our understanding of the absorption of solar radiation in both clear and cloudy atmospheres. The interest of this study is to find the confidence intervals for the accuracy of the Egrett measurements. The calculations from a radiative transfer model are used to compare with the observations. The uncertainty of the instrument measurement obtained from this study should be
incorporated in the comparison of absorption between model prediction and field measurements.

2. Model Description

The model description in this section is taken from an online paper that appears in SBDART’s homepage located at http://arm.mrcsb.com/sbdart/html/sbdart-intro.html.

SBDART (Santa Barbara DISORT Atmospheric Radiative Transfer) is a FORTRAN computer code designed for the analysis of a wide variety of radiative transfer problems encountered in satellite remote sensing and atmospheric energy budget studies. The program is based on a collection of highly developed and reliable, physical models which have been developed by the atmospheric science community over the past few decades.

SBDART relies on low resolution band models developed for the LOWTRAN 7 atmospheric transmission code (Pierluissi and Marogoudakis, 1986). These models provide the clear sky atmospheric transmission from 0 to 50000 cm\(^{-1}\) and include the effects of all radiatively active molecular species found in the earth's atmosphere. The models were derived from detailed line-by-line calculations that were degraded to 20 cm\(^{-1}\) resolution for use in LOWTRAN.

The radiative transfer equation is numerically integrated with the DISORT (DIScreet Ordinate Radiative Transfer, Stamnes et al., 1988). The discrete ordinate method provides a numerically stable algorithm to solve the equations of plane-parallel radiative transfer in a vertically inhomogeneous atmosphere. The intensity of both scattered and thermally emitted radiation can be computed at different heights and directions. SBDART is
configured to allow up to 40 atmospheric layers and 16 radiation streams (16 zenith angles and 16 azimuthal modes).

SBDART adopts six standard atmospheric profiles from the 5s (Tanre' et al., 1958) atmospheric radiation code which are intended to model the following typical climatic conditions: tropical, midlatitude summer, midlatitude winter, subarctic summer, subarctic winter and US62. These model atmospheres (McClatchey et al., 1971) have been widely used in the atmospheric research community and provide standard vertical profiles of pressure, temperature, water vapor and ozone density. In addition, the users can specify their own model atmosphere based on, for example, a series of radiosonde profiles. In this work, sounding data from the ARM SGP site are used to specify the atmospheric profile for input to the SBDART.

3. Aircraft Measurement and Data

The ARM Enhanced Shortwave Experiment (ARESE) was a joint effort by the DOE's Atmospheric Radiation Measurement Program and its Unmanned Aerospace Vehicle (UAV) Program. Field measurements, consisting of coordinated observations from three instrumented aircraft platforms, several operational satellites, and a variety of specialized ground-based instrument platforms, were made in the vicinity of the ARM Southern Great Plains Site (SGP) in north central Oklahoma from September 25 to November 1, 1995. The Central Facility for this site is located at longitude 97.48° W and latitude 36.59° N. The ARESE data are being used by many scientists to test and refine the understanding of how clear and cloudy skies interact with solar radiation.

Three kinds of aircraft were used in ARESE: the NASA ER-2 flying at an altitude of about 20 km, an Egrett flying at an altitude of about 14 km, and a Twin Otter flying at altitudes ranging from 0.5 to 2 km. Each aircraft was equipped with identical zenith and nadir pointing radiometers as follows: Total Solar Broadband Radiometers (TSBR) that
measure the total broadband solar irradiance (0.224 to 3.91 μm), Fractional Solar Broadband Radiometers (FSBR) that measure the broadband near-infrared solar irradiance (0.68 to 3.30 μm), and Total, Direct, Diffuse Radiometers (TDDR) that measure in 10 nm wide spectral bands centered at seven wavelengths. Table 1 lists the dates, observational platforms, and atmospheric conditions encountered during the ARESE radiometric observations. Figure 1 illustrates schematically the ARESE experiment for the measurements of atmospheric absorption. The absorption is defined as the difference between the net fluxes at each level in the atmosphere.

The flux measurement by the Egrett is the focus of this work. Ten days of measurements are investigated. The days studied in Fall 1995 are:
- Sept. 25, 29
- Oct. 11, 13, 17, 19, 24, 26, 30 and
- Nov. 1.

Aircraft navigational data are also available to determine the instrument platform's position throughout the flight. Figure 2a, 2b, 2c and 2d show the aircraft altitude, pitch, roll and heading respectively for October 11, 1995. When the aircraft ascends, descends or makes turns, the aircraft and the instruments on board cannot keep themselves horizontal. This will affect the measured downwelling flux by a factor of the cosine of the tilting angle. For refinement, Valero applied corrections to account for the aircraft pitch, roll and heading. However, the errors of these corrections when the pitch and roll angle is larger than 2 degrees is unknown. Thus our analysis only includes data with pitch and roll angles that are less then 2 degrees. Sections when the aircraft was ascending, descending or turning have been removed (i.e. when the pitch and/or roll exceed approximately ±2 degree from the zero pitch/roll during level flight). The effect of this refinement is shown in Figure 3, where Figure 3a shows the downwelling flux for all angles, and Figure 3b shows the one after the refinement. We can see that the flux is further smoothed, although
the change is not significant. We also notice some oscillation of the flux that is too large to be caused merely by the oscillation of the flight pitch and roll angles and the heading changes.

4. Model-Measurement Comparisons

The downwelling flux at any given level is composed of direct and diffuse components. However, at a flight level of the order of 13 km, the optical depths for wavelengths covered by the radiometers are very small. Thus, to a first order, the monochromatic downwelling flux at the flight level \( F_\lambda \) might be approximated as direct beam flux alone given as

\[
F_\lambda \downarrow = S_\lambda \mu e^{-\tau_\lambda}/\mu
\]

where \( S_\lambda \) is the monochromatic flux incident at the top of the atmosphere, \( \tau_\lambda \) is the optical depth above the aircraft, and \( \mu \) is the cosine of the solar zenith angle.

Since \( \tau_\lambda \) is small, Eq.(1) may be expanded in a first order Taylor’s series as

\[
F_\lambda \downarrow = S_\lambda \mu \left(1 - \frac{\tau_\lambda}{\mu}\right)
\]

Integrating over all wavelengths yields

\[
F \downarrow = S\mu - \int S_\lambda \tau_\lambda d\lambda
\]

where \( S \) is the spectrally integrated solar parameter. Eq.(3) is of the form

\[
F \downarrow = A + B\mu
\]

That is, for a given distribution of absorbers, \( F \downarrow \) should be linear in \( \mu \).

At the level of the flight at about 13 km, the atmosphere is very thin and the air pressure is as low as 150 mb. Figure 4 shows the SBDART-calculated downwelling fluxes versus the Greenwich Mean Time for the ten flights. The model-calculated downwelling fluxes as
the function of $\mu$ are shown in Figure 5a. As shown in Figure 5b, the linear regression for each flight is almost perfect (i.e., the explained variance is nearly 1). This result is what we expected beforehand because of the small optical depth above the aircraft.

Figure 6 shows the observed downwelling flux versus Greenwich Mean Time for the ten flights. The observed downwelling fluxes as the function of $\mu$ for the ten flights are shown in Figure 7a, and the linear regressions of the flux with $\mu$ for the individual days are given in figure 7b. We can see that the linear properties for the majority days are quite good except two days, Oct. 10 and Nov. 1. The reason for the large flux deviation for these two days is still not known. A possible reason is that there were unseen high level clouds above the Egrett aircraft during its flights. For the entire data set, even without the effect of two days’ large deviation, we still cannot get a good linear regression because the downwelling fluxes for each day do not fit very well to each other, though they may look fine themselves from day to day.

We can write the linear regressions of these two sets as

$$F_{\text{obs}} \downarrow = A_{\text{obs}} + B_{\text{obs}} \times \mu$$
$$F_{\text{cal}} \downarrow = A_{\text{cal}} + B_{\text{cal}} \times \mu$$

where $F_{\text{cal}}$ and $F_{\text{obs}}$ are the observed and calculated downwelling flux respectively. The mean difference between them for a given day can be written as

$$\epsilon \downarrow = F_{\text{obs}} \downarrow - F_{\text{cal}} \downarrow = \Delta A + \Delta B \times \bar{\mu}$$

where $\bar{\mu}$ is the average of the cosine of the solar zenith angle for a given day.

A comparison of the flight averaged flux differences is given in Table 2. The table shows that the differences range from 0.1 to 24.2 W/m$^2$. Although the difference between the observations and the calculations changes without any trend from day to day, the model-
calculated downwelling fluxes always have higher values than the observations. The linear average of the flux difference for the ensemble data set is about 11 W/m².

In the SBDART calculation, a user has freedom to set various parameters for the input to the model. Besides the atmospheric profile, the time, location, solar zenith angle, aerosol type, visibility and surface albedo are among the available choices. For the fluxes shown in Figure 4 and 5, the flight measured sounding and navigation data are used to determine the profile, the time, the location and the solar zenith angle to minimize the potential cause of the difference between the observation and the calculation. The only subjectively selected parameters for the input are aerosols type, surface albedo and ozone concentration. For the calculations shown, we use a rural aerosol with a visibility of 23 km, and the surface albedo is set to 0.22. At the height of the Egrett, the aerosol and the albedo are not the crucial factors for the model calculation. In order to ensure this assumption, we tested other combinations for these two parameters. The urban aerosol, no aerosol and vegetation surface albedo have been tried. In addition, we also tried the mid-latitude summer, mid-latitude winter and US62 atmospheric profile for the input to SBDART. The resulting changes to the original fluxes are no larger than 3 to 4 W/m², and this value cannot explain the large deficit of the observation compared to the calculation. The cause of this deficit is still unclear. But due to our good understanding of the radiative transfer at high altitudes, the consistency of the model calculations, and the drastic change of the observations from day to day, we are suspicious that there exist system errors in the radiometric instruments on board the Egrett, and the errors in the downwelling flux is primarily caused by the instrument error.

Due to our poor understanding of radiative transfer in presence of clouds, it is impossible to use the same technique to estimate the errors in the upward flux at Egrett levels and both the upward and downwelling fluxes at Otter levels. Because the same instruments are used for both upward and downwelling flux measurement, and since they are used on
both the Egrett and the Otter, we assume the same instrument system error holds for the other three comparisons.

Let $\mathcal{E}$ denote the instrument system error. Assuming random error, the net flux deviation for each level can be written as

$$\delta F_{\text{net}} = \left( \mathcal{E}_\downarrow^2 + \mathcal{E}_\uparrow^2 \right)^{1/2} = \sqrt{2\mathcal{E}}$$

(7)

Then the error in the net flux difference between the two levels $E(\Delta F_{\text{net}})$ is $2\mathcal{E}$, because

$$E(\Delta F_{\text{net}}) = \left( \delta F_{\text{netEgrett}}^2 + \delta F_{\text{netOtter}}^2 \right)^{1/2} = 2\mathcal{E}$$

(8)

i.e.

$$\Delta F_{\text{net}} = \Delta F_{\text{netObs}} \pm E(\Delta F_{\text{net}}) = \Delta F_{\text{netObs}} \pm 2\mathcal{E}$$

(9)

where $\Delta F_{\text{netObs}}$ and $\Delta F_{\text{net}}$ are the observed and the actual net flux difference between the two levels.

Thus the 95% confidence intervals on the net absorption of the atmosphere between the layer falls into $4\mathcal{E}$, which is about 44 W/m$^2$. This uncertainty should be incorporated in studies of the cloud absorption comparison between model prediction and field measurements.

5. Conclusion

One of the goals of the ARM ARESE experiment is to measure the atmospheric absorption of shortwave solar radiation in both clear and cloudy sky cases. By comparing the measurements with the model prediction, we can have better understanding of the shortwave absorption process, especially for the cloudy case. The absorption can be obtained by differencing the net fluxes measured by two collocated aircraft, Egrett and Otter, which flew above and below the cloud respectively.
The purpose of this study is to find the confidence intervals for the measurement by comparing the observed fluxes with the SBDART model calculations. A total of ten days’ Egrett downwelling flux measurements in Fall 1995 were compared to the SBDART model calculations. We find that the model calculated fluxes have higher values than the observations, and the differences vary from 0.1 to 24.2 \text{ W/m}^2. The average difference of the ensemble data set is about 11 \text{ W/m}^2. Due to our good understanding of the radiative transfer process at and above the level of the Egrett, we can assume that this discrepancy is mainly caused by an error in the radiometer system on board the aircraft. Because of our poor knowledge of the effects of the clouds between the two levels, similar comparisons between the observation and calculations the Egrett’s upward flux and both Otter’s upward and downwelling flux cannot be performed. The fact that the same instruments were also used for downwelling flux measurement on the Egrett and both upward and downwelling flux measurements on the Twin-Otter enable us to make the assumption that the same same magnitude of system error for the other three instruments. With these assumptions, we find that the confidence limits on the ARESE atmospheric absorption approximately falls into a $\pm$ 24 \text{ W/m}^2 range.

This uncertainty of the shortwave absorption should be incorporated in any study that interprets the comparison of ARESE shortwave observations with calculations. Further investigation is needed to find the cause of the discrepancy between the EGRETT observed and SBDART calculated downwelling fluxes.
References


SURFACE (97.48°W, 36.59°N)

Figure 1. ARESE measurements of cloud absorption.
Figure 2a. Flight altitude for 10/11/95.
Figure 2b. Flight Pitch Angle for 10/11/95
Figure 2c. Flight Roll Angle for 10/11/95
Figure 2d. Flight Heading Angle for 10/11/95
Figure 3a. Downwelling flux for 10/11/95 (for all pitch and roll angles)
Figure 3b. Downwelling flux for 10/11/95 (for pitch and roll angles within ±2 degrees of level flight).
Figure 4. Model Calculated Downfluxes as Function of Greenwich Mean Time.
Figure 5a. Model Calculated Downfluxes as Function of Cosine of Solar Zenith Angle
Figure 6. Observed Downwelling Fluxes as Function of Greenwich Mean Time
Figure 7a. Observed Downfluxes as Function of Cosine of Solar Zenith Angle
Figure 7b. Linear Regressions of observed downwelling fluxes with the cosine of the solar zenith angle. The dash line patterns correspond to the dates shown in Fig. 7a, and $R^2$ is the explained variance.
<table>
<thead>
<tr>
<th>Day</th>
<th>Date</th>
<th>Aircraft</th>
<th>Ground Stations</th>
<th>Conditions</th>
</tr>
</thead>
<tbody>
<tr>
<td>268</td>
<td>Sept. 25</td>
<td>ER-2, Egrett, Twin Otter</td>
<td></td>
<td>broken clouds</td>
</tr>
<tr>
<td>269</td>
<td>Sept. 26</td>
<td>ER-2</td>
<td></td>
<td>scattered clouds</td>
</tr>
<tr>
<td>270</td>
<td>Sept. 27</td>
<td>ER-2</td>
<td></td>
<td>(satellite calibration, Gulf of Mexico)</td>
</tr>
<tr>
<td>271</td>
<td>Sept. 28</td>
<td>ER-2</td>
<td></td>
<td>low clouds and cirrus</td>
</tr>
<tr>
<td>272</td>
<td>Sept. 29</td>
<td>ER-2, Egrett, Twin Otter</td>
<td></td>
<td>scattered clouds</td>
</tr>
<tr>
<td>276</td>
<td>Oct. 3</td>
<td>ER-2, Twin Otter</td>
<td></td>
<td>clear sky</td>
</tr>
<tr>
<td>279</td>
<td>Oct. 6</td>
<td>ER-2</td>
<td>L, R</td>
<td>(survey of hurricane-damaged areas)</td>
</tr>
<tr>
<td>284</td>
<td>Oct. 11</td>
<td>ER-2, Egrett, Twin Otter</td>
<td></td>
<td>clear sky</td>
</tr>
<tr>
<td>285</td>
<td>Oct. 12</td>
<td>ER-2</td>
<td></td>
<td>(satellite calibration, Gulf of Mexico)</td>
</tr>
<tr>
<td>286</td>
<td>Oct. 13</td>
<td>Egrett, Twin Otter</td>
<td>L, B</td>
<td>broken-to-solid clouds</td>
</tr>
<tr>
<td>287</td>
<td>Oct. 14</td>
<td>ER-2</td>
<td></td>
<td>(satellite calibration, south central United States)</td>
</tr>
<tr>
<td>288</td>
<td>Oct. 15</td>
<td>L, B</td>
<td></td>
<td>clear sky</td>
</tr>
<tr>
<td>290</td>
<td>Oct. 17</td>
<td>ER-2, Egrett, Twin Otter</td>
<td>L, B, R</td>
<td>clear sky</td>
</tr>
<tr>
<td>291</td>
<td>Oct. 18</td>
<td>L</td>
<td></td>
<td>clear sky</td>
</tr>
<tr>
<td>292</td>
<td>Oct. 19</td>
<td>ER-2, Egrett, Twin Otter</td>
<td>L, B, R</td>
<td>clear sky</td>
</tr>
<tr>
<td>294</td>
<td>Oct. 21</td>
<td>ER-2</td>
<td></td>
<td>(satellite calibration, south central United States)</td>
</tr>
<tr>
<td>295</td>
<td>Oct. 22</td>
<td>ER-2</td>
<td>B, R</td>
<td>clear sky</td>
</tr>
<tr>
<td>296</td>
<td>Oct. 23</td>
<td>ER-2</td>
<td></td>
<td>scattered clouds (transit across United States)</td>
</tr>
<tr>
<td>297</td>
<td>Oct. 24</td>
<td>Egrett, Twin Otter</td>
<td>L, B, R</td>
<td>thin cirrus</td>
</tr>
<tr>
<td>298</td>
<td>Oct. 25</td>
<td>...</td>
<td>L, B, R</td>
<td>scattered clouds</td>
</tr>
<tr>
<td>299</td>
<td>Oct. 26</td>
<td>Egrett, Twin Otter</td>
<td>L, B, R</td>
<td>solid cirrus deck: broken clouds</td>
</tr>
<tr>
<td>301</td>
<td>Oct. 28</td>
<td>Twin Otter</td>
<td>L, B, R</td>
<td>clear sky</td>
</tr>
<tr>
<td>303</td>
<td>Oct. 30</td>
<td>Egrett, Twin Otter</td>
<td>L, B, R</td>
<td>thick uniform stratus deck</td>
</tr>
<tr>
<td>304</td>
<td>Oct. 31</td>
<td>Egrett, Twin Otter</td>
<td>L, B, R</td>
<td>thick uniform stratus deck</td>
</tr>
<tr>
<td>305</td>
<td>Nov. 1</td>
<td>Egrett, Twin Otter</td>
<td>L, B, R</td>
<td>broken-to-solid stratocumulus</td>
</tr>
</tbody>
</table>

Ground station key: L, Lamont; B, Byron; R, Ringwood.

**Table 1.** ARESE operation list with related weather conditions.
<table>
<thead>
<tr>
<th>Date (Fall 95)</th>
<th>A_{obs}</th>
<th>A_{cal}</th>
<th>B_{obs}</th>
<th>B_{cal}</th>
<th>\mu_1</th>
<th>\mu_2</th>
<th>\Delta A</th>
<th>\Delta B</th>
<th>\mu</th>
<th>\Delta F \downarrow (F_{obs}-F_{cal}) (W/m^2)</th>
</tr>
</thead>
<tbody>
<tr>
<td>9/25</td>
<td>-30.024</td>
<td>-26.382</td>
<td>1316.50</td>
<td>1339.50</td>
<td>0.550</td>
<td>0.800</td>
<td>-3.642</td>
<td>-23.000</td>
<td>0.675</td>
<td>-19.167</td>
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<tr>
<td>9/29</td>
<td>-62.726</td>
<td>-25.514</td>
<td>1357.00</td>
<td>1329.00</td>
<td>0.670</td>
<td>0.780</td>
<td>-37.212</td>
<td>28.000</td>
<td>0.725</td>
<td>-16.912</td>
</tr>
<tr>
<td>10/11</td>
<td>-36.975</td>
<td>-24.694</td>
<td>1332.30</td>
<td>1344.60</td>
<td>0.480</td>
<td>0.730</td>
<td>-12.281</td>
<td>-12.300</td>
<td>0.605</td>
<td>-19.722</td>
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<tr>
<td>10/13</td>
<td>19.980</td>
<td>-16.796</td>
<td>1258.80</td>
<td>1331.00</td>
<td>0.520</td>
<td>0.710</td>
<td>36.776</td>
<td>-72.200</td>
<td>0.615</td>
<td>-7.627</td>
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<tr>
<td>10/17</td>
<td>-35.407</td>
<td>-16.796</td>
<td>1337.70</td>
<td>1331.00</td>
<td>0.470</td>
<td>0.710</td>
<td>-18.611</td>
<td>6.700</td>
<td>0.590</td>
<td>-14.658</td>
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<td>10/19</td>
<td>-20.777</td>
<td>-25.201</td>
<td>1313.60</td>
<td>1360.20</td>
<td>0.540</td>
<td>0.690</td>
<td>4.424</td>
<td>-46.600</td>
<td>0.615</td>
<td>-24.235</td>
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<td>10/24</td>
<td>17.758</td>
<td>-26.832</td>
<td>1270.30</td>
<td>1352.20</td>
<td>0.480</td>
<td>0.660</td>
<td>44.590</td>
<td>-81.900</td>
<td>0.570</td>
<td>-2.093</td>
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<tr>
<td>10/26</td>
<td>-4.044</td>
<td>-12.121</td>
<td>1315.20</td>
<td>1336.50</td>
<td>0.470</td>
<td>0.660</td>
<td>8.077</td>
<td>-21.300</td>
<td>0.565</td>
<td>-3.958</td>
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<tr>
<td>10/30</td>
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<td>-24.257</td>
<td>1079.60</td>
<td>1353.40</td>
<td>0.570</td>
<td>0.635</td>
<td>162.501</td>
<td>-273.800</td>
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<tr>
<td>11/1</td>
<td>44.430</td>
<td>-22.121</td>
<td>1240.70</td>
<td>1351.80</td>
<td>0.575</td>
<td>0.625</td>
<td>66.551</td>
<td>-111.100</td>
<td>0.600</td>
<td>-0.109</td>
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<tr>
<td><strong>Average</strong></td>
<td>3.046</td>
<td>-22.071</td>
<td>1282.17</td>
<td>1342.92</td>
<td></td>
<td></td>
<td>25.118</td>
<td>-60.750</td>
<td>0.616</td>
<td>-11.094</td>
</tr>
</tbody>
</table>

Table 2. Linear regression and flux differences between Egrett observed and model calculated downwelling fluxes.