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A GROUND TRUTH ANALYSIS OF DMSP WATER VAPOR RADIANCES.(U)

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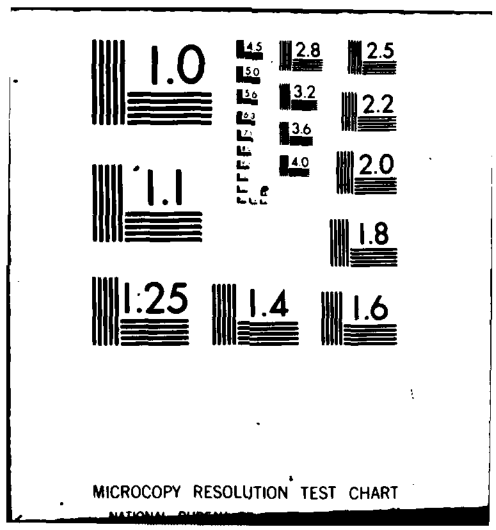
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# A Ground Truth Analysis of DMSP Water Vapor Radiances

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DR. ALVA T. STARR, Jr
Chief Scientist

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20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

SSH $H_2O$ data from the Defense Meteorological ... Program (DMSP) were received for analysis and evaluation. Approximately 70 measurements of upwelling radiation in the 8-sounder channels of the 18 to 30 μm rotational water vapor band have been compared with calculations for both clear and cloud contaminated conditions. The calculated radiances generally exceed the measured radiances in the clear column comparison. In the mean, the radiance comparison indicates a discrepancy less than 5 percent in the water vapor continuum band. This systematic discrepancy, by approximately a

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4:1 ratio, is found in all the DMSP SSH $H_2O$ channels. These results are in agreement with McClatchey's 1976 results in his analysis of the DMSP 15 μm $CO_2$ sounder channels.

The data sets comparison were divided into three latitude belts, that is, Tropical, Mid-latitude and Arctic. In turn, the discrepancies between calculated and measured radiances appear to be latitudinally dependent. Smaller discrepancies are found in the Tropics and the larger discrepancies are found in the Arctic latitude belt. Also, it appears that the DMSP SSH $H_2O$ channels cannot discriminate between low cloud contamination and clear column conditions.

# Preface

The author wishes to acknowledge the following organizations and individuals: the Air Force Global Weather Center for supplying the DMSP HPKG data; the USAF Environmental Technical Applications Center for supplying the ground truth data; Dr. Robert McClatchey for use of his computer programs; Dr. Jean I. F. King for reviewing the manuscript; Ed Lefebvre for his programming skills and Celeste Gannon for her typing the manuscript.

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## Contents



## Illustrations

## Illustrations



## Tables

# A Ground Truth Analysis of DMSP Water Vapor Radiances

## 1. INTRODUCTION

The Defense Meteorological Satellite Program (DMSP) Block 5D Satellite carries a Special Meteorological Sensor H (SSH) package. An excellent review of the optical subsystems and the spectral characteristics of this SSH package is provided by Nichols.[1] Infrared energy is measured in 16 spectral bands by the SSH package: six spectral channels are located in the 15 μm carbon dioxide bands, eight in the 18 to 30 μm rotational water vapor band, one in the 9.6 μm ozone band, and one in the atmospheric window near 12 μm. In this study, the emphasis is placed on the eight DMSP water vapor SSH channels. The various channel characteristics are listed in Table 1.

Originally, the purpose of this study was: (1) to evaluate the DMSP multi-channel water vapor radiances for informational content, and (2) to recommend some operational techniques whereby moisture parameters may be derived directly from DMSP water vapor radiance measurements. A preliminary evaluation of the DMSP water vapor radiances was made in a previous report[2] concerning the

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(Received for publication 2 November 1981)

1. Nichols, D. A. (1975) DMSP Block 5D special meteorological sensor H, optical subsystem, Opt. Eng. 14:284-288.
2. Valovcin, F. R. (1980) DMSP Water Vapor Radiances—A Preliminary Evaluation, AFGL-TR-80-0312, AD A099305.

informational content. Before a reliable operational technique on deriving moisture parameters could be recommended, the Forward Problem had to be investigated. By definition, the Forward Problem is the matching of satellite observed or measured and the classically-calculated radiances based on coincident in time and space radiosonde data. McClatchey[3] in studying the Forward Problem reported a systematic discrepancy, that is, calculations, in general, exceed the measured or observed radiances in the DMSP 15 $\mu$m carbon dioxide bands. As this study progressed, it became quite apparent that the purpose would change from recommending some operational techniques on deriving moisture parameters to conducting a Ground Truth Analysis of the DMSP water vapor radiances similar to McClatchey's study of the DMSP 15 $\mu$m carbon dioxide band. Thus in this report, a comparison program was carried out for approximately 70 sets of DMSP SSH water vapor measurements with calculated water vapor radiances. Both clear and cloud contaminated columns as a function of three latitude belts, that is, Tropical, Midlatitude and Arctic were used in this study. The DMSP water vapor radiance sets analyzed were from Flight II SSH aboard spacecraft WX 13536 and on a few occasions from Flight III SSH aboard spacecraft WX 14537. Flight II SSH and Flight III SSH were launched in July 1977 and April 1978 respectively.

Table 1. DMSP Water Vapor SSH Channel Characteristics*

| Band | Center $\mu$m | Center $cm^{-1}$ | Width $cm^{-1}$ | NESR** |
|---|---|---|---|---|
| F1 | 28.2 | 355.0 | 15.0 | 0.25 |
| F2 | 25.2 | 397.5 | 10.0 | 0.16 |
| F3 | 23.8 | 420.0 | 20.0 | 0.12 |
| F4 | 22.7 | 441.5 | 18.0 | 0.09 |
| F5 | 18.7 | 535.0 | 16.0 | 0.15 |
| F6 | 24.5 | 408.5 | 12.0 | 0.14 |
| F7 | 26.7 | 374.0 | 12.0 | 0.18 |
| F8 | 28.3 | 353.5 | 12.0 | 0.33 |

*After Nichols[1]

**NESR: Noise Equivalent Spectral Radiance in $mW/m^2$ sr $cm^{-1}$

3. McClatchey, R.A. (1976) Satellite Temperature Sounding of the Atmosphere: Ground Truth Analysis, AFGL-TR-76-0279, AD A038236.

## 2. DMSP WATER VAPOR RADIANCE DATA

The Air Force Global Weather Central (AFGWC) forwarded to the Air Force Geophysics Laboratory (AFGL) printouts of world-wide SSH spectral radiance data for the period 00Z 30 January 1979 to 12Z 18 October 1979. The printouts contained information on date-time, latitude and longitude of the scan spot, Zenith angle, 3D NEPH[4] and data base parameters along with the spectral radiance measurements for the 16 DMSP spectral channels. The scan spot is the first cloud-free radiance set available within a 3° × 3° area as selected by AFGWC's HPKG software (based on the 3D NEPH files). Only the eight water vapor channels and the one located in the atmospheric window near 12 μm were used in this study.

The DMSP SSH sounder scan pattern is accomplished in 25 4-degree incremental steps from -48° to +48° of nadir across the orbit track. The range of zenith angles for the 25 scan spots are +57° to -57°. Zenith angles are designated positive on the left and negative on the right of the scan swath. At nadir the scan spot on the earth's surface is approximately 21 nmi (39 km) and increase to approximately 35 by 25 nmi (65 × 46 km) at a zenith angle of +/-32°. The analysis was limited to zenith angles of +/-32° or approximately +/-245 nmi (454 km) from nadir.

## 3. GROUND TRUTH DATA

The USAF Environmental Technical Application Center (ETAC) provided the ground truth data for the various stations world-wide. A "ground truth" site is defined as a radiosonde observation being within +/-3 hrs and 100 nmi (185 km) of a DMSP satellite scan spot. Atmospheric conditions such as clear or cloud contaminated were determined through surface observations, AFGWC three-dimensional nephanalysis (3D NEPH) and the radiosonde observations. Imagery was not generally used because of the period involved (January-October 1979) and the final selection of the "ground truth" site world-wide. The radiosonde data were received in a LOWTRAN format with the following parameters: Height (km), Pressure (mb), Temperature (°C), Dewpoint Temperature (°C), Relative Humidity (%), and Absolute Humidity (g/m$^3$). The values of absolute or relative humidity above 300 mb are climatologically modeled by ETAC since the radiosonde usually does not report humidity above this level. An example of the detailed atmospheric profile of temperature, water vapor, and ozone as a function of height and pressure that is used in the transmittance calculations is shown in Table 2. The concentration

4. Coburn, A. R. (1970) Three Dimensional Analysis, AFGWC, Offut AFB, NE, AFGWC TM-70-9.

of water vapor was calculated as described by Selby and McClatchey.[5] The ozone data were introduced from climatological models of ozone distributions. The units of water vapor and ozone are in molecules/cm$^2$ and are integrated values from the top of the atmosphere to the surface.

Table 2. Atmospheric Profile and Composition Derived From Radiosonde Data—West Palm Beach, Florida, 72203-790403

| HT (km) | Pressure (mb) | Temp (K) | Water Vapor (Molecules/cm$^2$) | Ozone (Molecules/cm$^2$) |
|---|---|---|---|---|
| 31.3 | 10.0 | 237.9 | 1.067E+19 | 3.451E+16 |
| 29.2 | 13.5 | 232.5 | 1.155E+20 | 6.160E+17 |
| 28.7 | 14.5 | 235.3 | 1.372E+20 | 8.015E+17 |
| 26.6 | 20.0 | 228.1 | 2.106E+20 | 1.815E+18 |
| 25.6 | 23.0 | 223.1 | 2.230E+20 | 2.259E+18 |
| 23.9 | 30.0 | 221.7 | 2.377E+20 | 3.117E+18 |
| 20.7 | 50.0 | 211.9 | 2.496E+20 | 4.764E+18 |
| 19.4 | 62.0 | 200.3 | 2.517E+20 | 5.439E+18 |
| 18.7 | 70.0 | 200.9 | 2.529E+20 | 5.819E+18 |
| 17.8 | 81.0 | 200.3 | 2.544E+20 | 6.287E+18 |
| 17.7 | 82.0 | 198.1 | 2.545E+20 | 6.327E+18 |
| 16.9 | 95.0 | 203.9 | 2.561E+20 | 6.788E+18 |
| 16.6 | 100.0 | 201.9 | 2.569E+20 | 6.947E+18 |
| 16.4 | 102.0 | 201.3 | 2.571E+20 | 7.008E+18 |
| 14.6 | 138.0 | 202.3 | 2.661E+20 | 7.859E+18 |
| 14.1 | 150.0 | 203.9 | 2.625E+20 | 8.099E+18 |
| 13.6 | 165.0 | 205.9 | 2.646E+20 | 8.329E+18 |
| 12.4 | 200.0 | 215.7 | 2.764E+20 | 8.957E+18 |
| 10.9 | 250.0 | 227.9 | 3.396E+20 | 9.639E+18 |
| 10.2 | 278.0 | 236.3 | 4.905E+20 | 9.968E+18 |
| 9.7 | 300.0 | 237.9 | 6.983E+20 | 1.020E+19 |
| 7.6 | 400.0 | 254.7 | 1.266E+21 | 1.110E+19 |
| 5.9 | 500.0 | 266.3 | 1.949E+21 | 1.282E+19 |
| 4.7 | 581.0 | 275.6 | 3.294E+21 | 1.231E+19 |
| 3.2 | 760.0 | 284.0 | 6.999E+21 | 1.291E+19 |
| 2.2 | 791.0 | 289.6 | 1.125E+22 | 1.330E+19 |
| 1.9 | 811.0 | 289.6 | 1.233E+22 | 1.338E+19 |
| 1.9 | 819.0 | 283.0 | 1.336E+22 | 1.341E+19 |
| 1.5 | 850.0 | 285.8 | 2.164E+22 | 1.352E+19 |
| 1.3 | 876.0 | 287.0 | 2.877E+22 | 1.360E+19 |
| 0.7 | 944.0 | 290.4 | 5.222E+22 | 1.379E+19 |
| 0.2 | 1000.0 | 295.2 | 7.703E+22 | 1.393E+19 |
| 0.0 | 1018.0 | 295.4 | 8.475E+22 | 1.396E+19 |

These are integrated values

5. Selby, J.E.A., and McClatchey, R.A. (1975) Atmospheric Transmittance From 0.25 to 28.5 μm: Computer Code LOWTRAN 3, AFCRL-TR-75-0255, AD A017734.

## 4. ATMOSPHERIC WATER VAPOR TRANSMITTANCE

Atmospheric transmittance calculations for the DMSP SSH water vapor channels for the approximately 70 selected cases were computed using the McClatchey transmittance program developed at AFGL. In this program, line by line calculations are performed using the following equations from McClatchey.[3]

$$I_{\Delta\nu} = \left[ \int_{\Delta\nu} f(\nu) \int_{\tau g}^{1.0} B(\nu, T)\, d\tau\, d\nu + \int_{\Delta\nu} f(\nu)\, B(\nu, T_S)\, d\nu \right] \Big/ \int_{\Delta\nu} f(\nu)\, d\nu \qquad (1)$$

which is the solution of the radiative transfer equation, where

| | |
|---|---|
| $I_{\Delta\nu}$ | is the radiant intensity in $mW/m^2\ sr\ cm^{-1}$, |
| $B(\nu, T)$ | is the Planck blackbody function, |
| $T$ | is the atmospheric temperature and $T_s$ is the surface temperature, |
| $\tau$ | is the transmittance of the atmosphere from the altitude associated with the pressure level, p, to the top of the atmosphere, |
| $\nu$ | is the frequency (given here in $cm^{-1}$), and |
| $f(\nu)$ | is the DMSP SSH instrument filter function. |

McClatchey assumes that $B(\nu, T)$ is relatively constant over the width of a filter function (10 or 20 $cm^{-1}$ wide), and he writes $\ell\eta\,(p)$ as an independent variable instead of $\tau$, and obtains Eq. (2), where the quantity, $d\bar{\tau}/d\ell\eta\, p$, now becomes a weighting function that can be interpreted as defining the atmospheric layer primarily responsible for the upwelling emission in the spectral interval, $\Delta\nu$.

$$I_{\Delta\nu} \approx \int_{p_g}^{0} B(\bar{\nu}, \tau) \frac{d\bar{\tau}}{d(\ell\eta\, p)}\, d\ell\eta\, p + B(\bar{\nu}, T_s), \qquad (2)$$

$$\bar{\tau}_{\Delta} = \frac{f(\nu)\, \tau\,(\nu)\, d\nu)}{f(\nu)\, d\nu}. \qquad (3)$$

Monochromatic transmittances were computed over the various eight DMSP water vapor filter functions for the appropriate radiosonde observation taking temperature, water vapor and ozone distributions as a function of pressure and height as shown in Table 2. These monochromatic transmittances were then weighted by the appropriate filter function as indicated in Eq. (3) in order to generate the appropriate averaged transmittance. The AFCRL Atmospheric Absorption Line Parameters Compilation[6] was used for all water vapor absorption lines between

6. McClatchey, R.A., Benedict, W.S., Clough, S.A., Burch, D.E., Calfee, R.F., Fox, K., Rothman, L.S., and Garing, J.S. (1973) AFCRL Atmospheric Absorption Line Parameters Compilation, AFCRL-TR-73-0096, AD A762904.

320-600 $cm^{-1}$. The calculation was based on the April 1979 data tape. The Lorentz line shape was used throughout with a line-wing modification of the water continuum proposed by Burch and Gryvnak.[7] The simple Lorentz line shape is used for $|\nu - \nu_o| \le 20\ cm^{-1}$ and varies linearly from unity at $|\nu - \nu_o| = 20\ cm^{-1}$ to zero at $|\nu - \nu_o| = 30\ cm^{-1}$. Also from this same report by Burch and Gryvnak,[7] the appropriate values of the temperature coefficient for the water vapor continuum were used and are listed in Table 3.

Table 3. Temperature Coefficient for Empirical Water Vapor Continuum*

| $\nu$ ($cm^{-1}$) | b (K) | $\nu$ ($cm^{-1}$) | b (K) |
|---|---|---|---|
| 320. | 1197 | | |
| 330. | 1206 | | |
| 340. | 1214 | | |
| 350. | 1223 | 600. | 1442 |
| 360. | 1231 | 610. | 1454 |
| 370. | 1240 | 620. | 1467 |
| 380. | 1248 | 630. | 1481 |
| 390. | 1257 | 640. | 1495 |
| 400. | 1265 | 650. | 1510 |
| 410. | 1273 | 660. | 1525 |
| 420. | 1282 | 670. | 1542 |
| 430. | 1290 | 680. | 1560 |
| 440. | 1299 | 690. | 1579 |
| 450. | 1307 | 700. | 1597 |
| 460. | 1316 | 710. | 1615 |
| 470. | 1324 | 720. | 1633 |
| 480. | 1333 | 730. | 1652 |
| 490. | 1341 | 740. | 1670 |
| 500. | 1349 | 750. | 1688 |
| 510. | 1358 | 760. | 1706 |
| 520. | 1366 | 770. | 1725 |
| 530. | 1375 | 780. | 1743 |
| 540. | 1383 | 790. | 1761 |
| 550. | 1392 | 800. | 1779 |
| 560. | 1400 | 810. | 1798 |
| 570. | 1409 | 820. | 1816 |
| 580. | 1419 | | |
| 590. | 1430 | | |

$$a_{C_s^\circ}(\theta) = a_{C_s^\circ}(296\,K)\exp\left(\frac{b}{\theta} - \frac{b}{296}\right)$$

*After Burch and Gryvnak

7. Burch, D. E., and Gryvnak, D. A. (1979) Method of Calculating $H_2O$ Transmittance Between 333 and 633 $cm^{-1}$), Final Report AFGL-TR-79-0054, Aeronutronic Report U6503, AD A072850.

## 5. DMSP WATER VAPOR FILTER FUNCTIONS

In Appendix A, filter transmission curves and the digitized filter functions for the eight DMSP water vapor channels are provided. These curves and filter functions are valid for the Flight II SSH package aboard spacecraft WX 13536 launched in July 1977. The listed frequencies for each channel are normally the central frequency for each filter. The frequency steps for each channel were 0.5 $cm^{-1}$. These curves were used to calculate the water vapor transmittances and the resulting weighting functions according to Eqs. (2) and (3).

## 6. COMPARISONS BETWEEN DMSP WATER VAPOR MEASUREMENTS AND CALCULATED RADIANCES

The DMSP water vapor measurements were provided by AFGWC from their HPKG*RADISAVE HPKG files for the period February to October 1979. The radiances set of DMSP SSH data is the first cloud-free set available within a 3° X 3° area as selected by AFGWC's HPKG software (based on 3D NEPH files). As described in an earlier report,[2] this file also contained cloud contaminated scan spots. The radiosonde observation which was used as the "ground truth" site was obtained from ETAC in a LOWTRAN format. The transmittance calculations were based on the temperature and humidity profiles as a function of pressure from these radiosonde observations. The major criteria used in the colocated DMSP water vapor data and the "ground truth" site were as follows: (1) radiosonde station located within 100 nmi (185 km) of a DMSP scan spot, (2) radiosonde observations taken within +/-3 hr, and (3) zenith angle of the scan spot restricted to +/-32°.

The comparison between the DMSP water vapor measurements and the calculated radiances were divided into three latitude belts; that is, Tropical (26°S-26°N), Mid-latitude (26°-62°N) and Arctic (62°-90°N). In addition, the ground truth analysis considered both the clear and cloud contaminated scan spots. For illustration purposes, Figures 1, 2, and 3 depict the theoretical weighting function curves for the eight DMSP water vapor channels for a Tropical, Standard and Sub-arctic atmosphere respectively. The pressure, temperature and water vapor concentration for these three models are thosed used by McClatchey at al.[8] On the left side of these figures, the most opaque water vapor channels (F8-353,

8. McClatchey, R.A., Fenn, R.W., Selby, J.E.A., Voltz, F.E., and Garing, J.S. (1972) Optical Properties of the Atmosphere (Third Edition), AFCRL-72-0497, AD A753075.

F1-355, F7-374 and F2-397 $cm^{-1}$) are shown. The less opaque or more transparent water vapor channels (F3-420, F4-441, F6-408, and F5-535 $cm^{-1}$) are shown on the right. The most opaque DMSP water vapor channel is F8-353 $cm^{-1}$ and the most transparent is F5-535 $cm^{-1}$. The maximum value of the weighting function for each channel represents the approximate location in the atmosphere from which the major portion of the energy is received at the satellite sensor. Table 4 lists the location in mb of the maximum value of the weighting function for the three model atmospheres.

### 6.1 Clear Column Water Vapor Radiance Comparison

The colocated cases selected for comparison purposes designated clear are listed in Tables 5, 6, and 7 for Tropical, Mid-latitude, and Arctic latitude belts respectively. The 40 clear cases—Tropical (10), Mid-latitude (21), and Arctic (9) were selected based on surface reports, 3D NEPH and the radiosonde humidity profile. The tables list the stations, location, date, zenith angle, distance between the satellite scan spot and the radiosonde or "ground truth" station along with the satellite measured and the calculated water vapor radiances in $mW/m^2$ sr $cm^{-1}$ for the eight DMSP water vapor channels. The calculated radiances were computed from Eqs. (2) and (3) using the radiosonde of temperature and humidity observations coincident in space and time as "ground truth".

Figures 4, 5, and 6 show the results of the comparison in graphical form. As can be seen from both the tables and the figures, the calculated water vapor radiances are greater than those measured by the satellite in the majority of cases. The percentage deviations in the mean are listed in the tables and are defined as (measured - calculated) ÷ measured radiance in percent. A positive (negative) deviation indicates that the measured is greater (less) than the calculated radiance. In the mean, the smallest percentage deviations are found in the Tropics and the largest in the Arctic latitude belt. The range of mean percentage deviations for the eight DMSP channels are +0.2 percent to -4.5 percent for the three latitude belts in the clear column comparisons. The ratio of negative to positive percentage deviations for the various latitude belts are: Tropic 52:28, Mid-latitude 132:36, and Arctic 70:2 for a total of 253 negative vs 67 positive percentage deviations. Thus, the calculated as indicated by the negative deviation exceed the satellite measured water vapor radiances by almost a 4:1 ratio. In addition, the calculated exceed the measured water vapor radiances in excess of +/-2.0 $mW/m^2$ sr $cm^{-1}$ by almost a 3:1 ratio. The correlation between measured and calculated water vapor radiances are higher for the most transparent channels, that is, F5-535 and F6-408 $cm^{-1}$ and lower for the most opaque water vapor channels, that is, F8-353 and F1-355 $cm^{-1}$. The lower correlations for the most opaque channels may be due to the use of the climatological humidity values above 300 mb. Also, it should be noted the maximum percentage deviations for all three latitude belts are found in the DMSP water vapor channel F3-420 $cm^{-1}$.

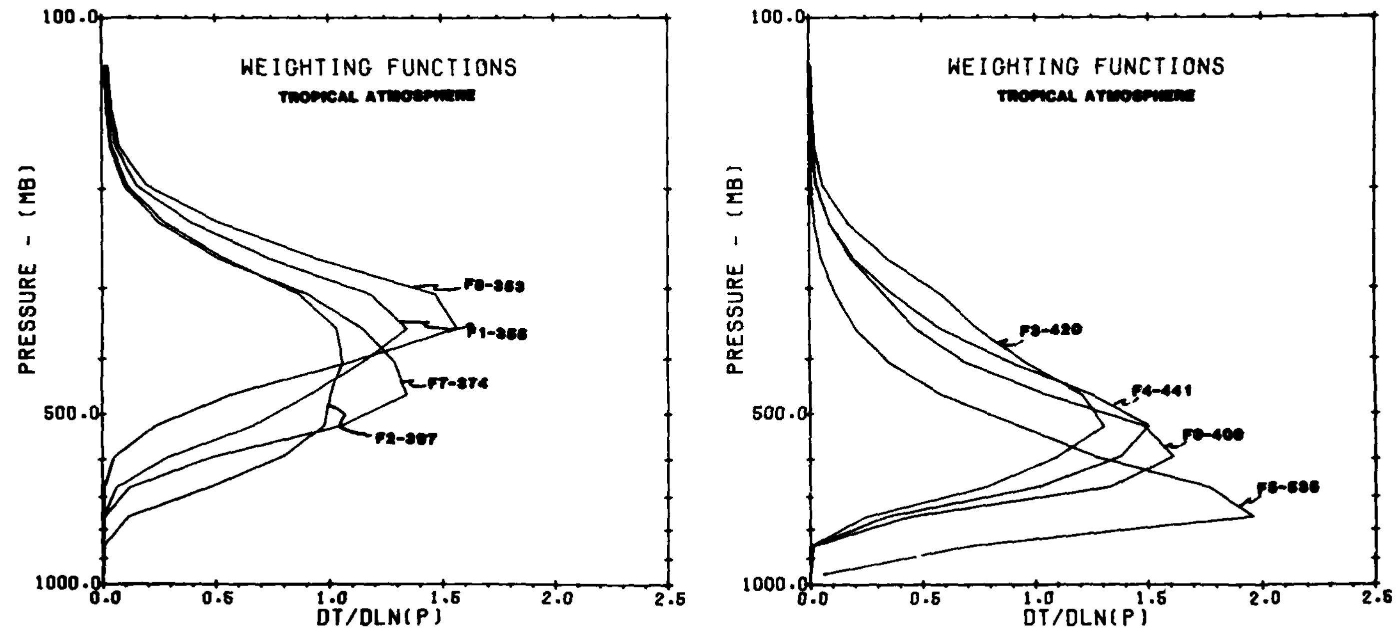


Figure 1. Weighting Functions for the DMSP SSH $H_2O$ Channels—Tropical Atmosphere

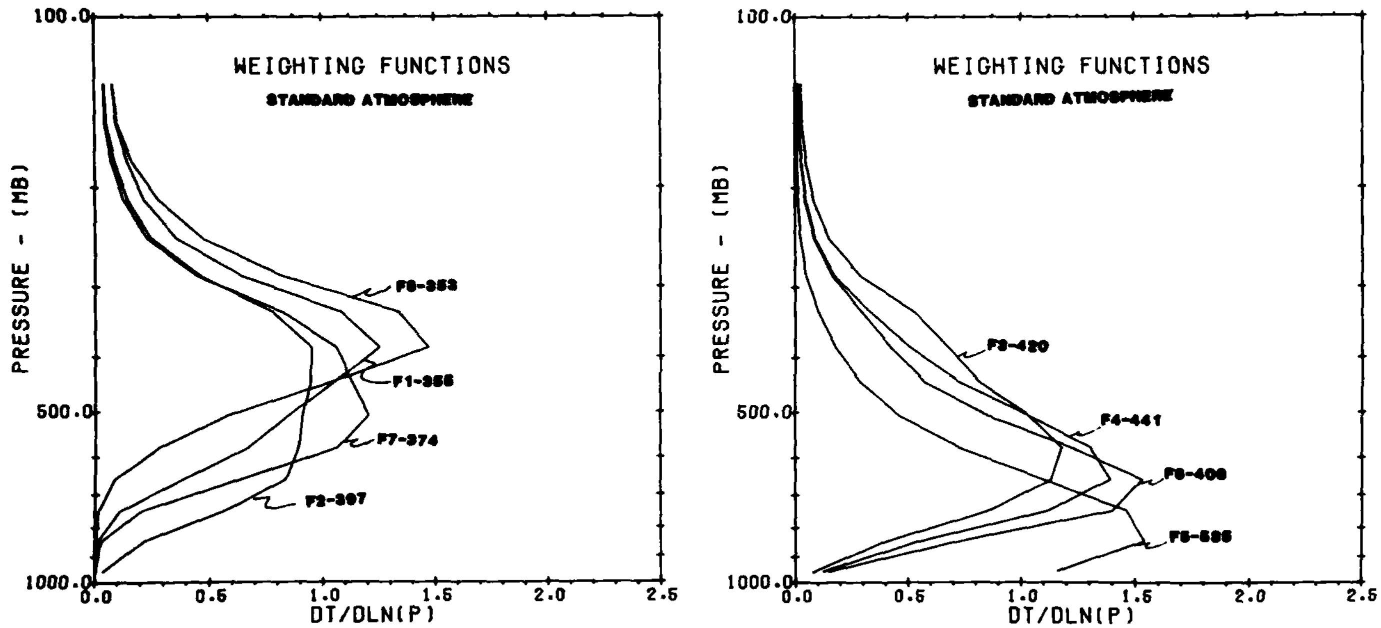


**Figure 2. Weighting Functions for the DMSP SSH $H_2O$ Channels—Standard Atmosphere**

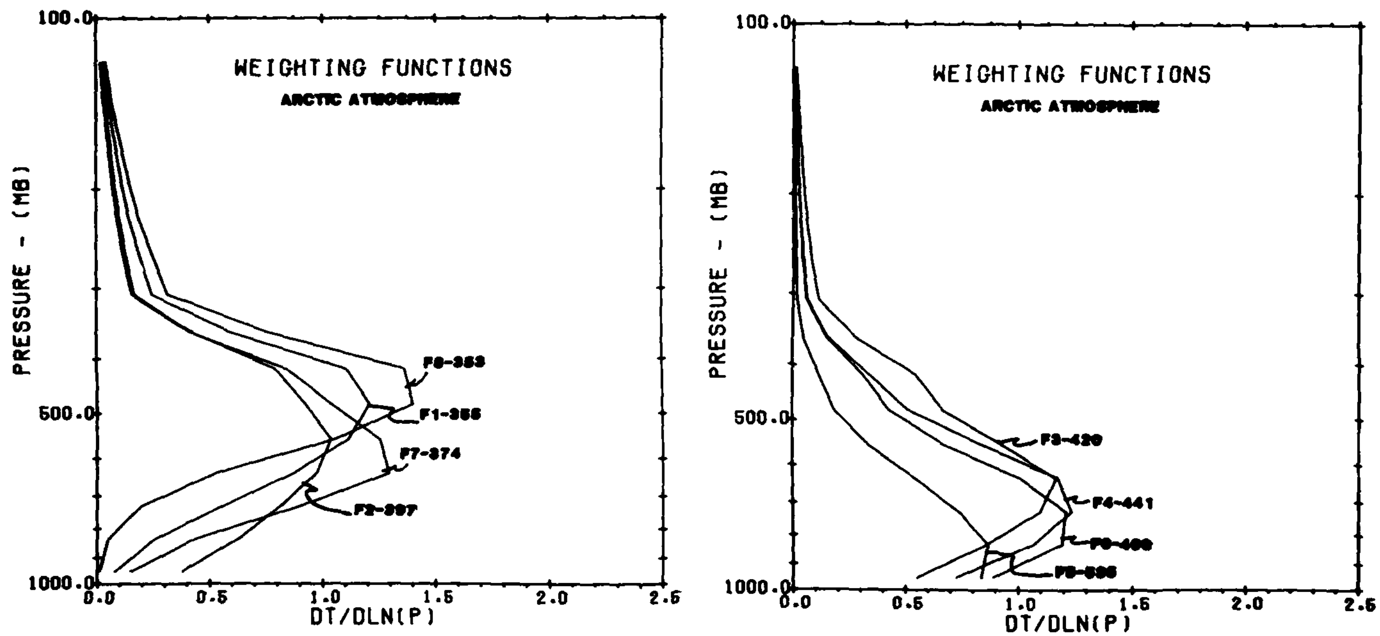


Figure 3. Weighting Functions for the DMSP SSH $H_2O$ Channels—Arctic Atmosphere

Table 4. Location of the Maximum Value of the Weighting Function for the DMSP Water Vapor Channels

| DMSP Channel | Tropical (mb) | Standard (mb) | Arctic (mb) |
|---|---|---|---|
| F1-355 $cm^{-1}$ | 355 | 385 | 480 |
| F2-397 | 405 | 580 | 555 |
| F3-420 | 525 | 580 | 635 |
| F4-441 | 525 | 660 | 730 |
| F5-535 | 760 | 845 | 835 |
| F6-408 | 595 | 660 | 835 |
| F7-374 | 460 | 505 | 635 |
| F8-535 | 355 | 385 | 480 |

Table 5. Comparison of Measured With Calculated Radiances—Tropical (26S-26N)—Clear

| | Location | Date | θ | Distance | F1 355 | F2 397 | F3 420 | F4 441 | F5 535 | F6 408 | F7 374 | F8 353 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Measured | Jiddah, SA | 790406 | 22.74 | 99 nmi | 79.0 | 92.9 | 100.0 | 107.5 | 130.1 | 105.6 | 86.6 | 74.8 |
| Calculated | 21.5N 39.2E | | | | 81.5 | 94.5 | 104.9 | 110.6 | 129.2 | 108.0 | 90.5 | 77.9 |
| Measured | Jiddah, SA | 790406 | 18.16 | 66 nmi | 79.0 | 92.4 | 100.0 | 107.6 | 129.4 | 105.6 | 86.5 | 74.5 |
| Calculated | 21.5N 39.2E | | | | 81.7 | 94.7 | 105.1 | 110.8 | 129.4 | 108.2 | 90.6 | 78.1 |
| Measured | Chiang Mai, TH | 790409 | 18.16 | 90 nmi | 75.1 | 88.3 | 94.6 | 101.8 | 120.1 | 100.6 | 82.3 | 71.4 |
| Calculated | 18.78N 98.98E | | | | 75.7 | 87.4 | 96.6 | 102.0 | 119.7 | 100.5 | 83.1 | 72.7 |
| Measured | Ascension Island | 790329 | 9.05 | 99 nmi | 82.7 | 94.3 | 102.0 | 108.4 | 124.4 | 105.5 | 89.1 | 78.6 |
| Calculated | 7.97S 14.4W | | | | 77.4 | 89.8 | 99.6 | 105.0 | 123.1 | 103.5 | 85.4 | 74.2 |
| Measured | Ascension Island | 790507 | 22.8 | 77 nmi | 82.1 | 94.6 | 100.9 | 107.7 | 122.1 | 105.0 | 89.1 | 82.8 |
| Calculated | 7.97S 14.4W | | | | 80.9 | 92.8 | 101.7 | 106.6 | 121.9 | 104.3 | 88.8 | 77.8 |
| Measured | Coolidge Field, AT | 790202 | -9.05 | 52 nmi | 84.7 | 95.4 | 103.8 | 110.9 | 126.7 | 107.6 | 92.2 | 79.6 |
| Calculated | 17.12N 61.78W | | | | 81.2 | 93.0 | 101.1 | 107.0 | 126.1 | 105.8 | 88.1 | 77.2 |
| Measured | TRUK KA | 790603 | -18.04 | 31 nmi | 76.0 | 88.5 | 94.5 | 101.3 | 119.1 | 99.3 | 82.9 | 73.5 |
| Calculated | 7.47N 151.8E | | | | 76.7 | 89.1 | 98.6 | 104.1 | 125.0 | 103.2 | 84.1 | 73.7 |
| Measured | MT ISA MO AU | 790328 | -22.86 | 92 nmi | 75.0 | 89.5 | 96.2 | 104.2 | 127.4 | 103.0 | 82.4 | 70.3 |
| Calculated | 20.67S 139.48E | | | | 78.5 | 90.5 | 100.1 | 105.3 | 124.2 | 103.4 | 86.5 | 75.4 |
| Measured | MT ISA MO AU | 790330 | 32.2 | 32 nmi | 76.3 | 88.5 | 94.6 | 101.2 | 119.2 | 99.5 | 82.8 | 72.0 |
| Calculated | 20.67S 139.48E | | | | 76.9 | 88.6 | 97.7 | 102.8 | 120.1 | 101.2 | 84.4 | 74.0 |
| Measured | Giles MO AU | 790401 | 4.52 | 91 nmi | 73.0 | 84.3 | 90.0 | 96.3 | 113.6 | 94.8 | 78.7 | 69.2 |
| Calculated | 25.03S 129.9E | | | | 75.8 | 86.8 | 95.4 | 100.3 | 119.1 | 98.9 | 82.8 | 73.2 |
| Measured Mean | | | | | 78.3 | 90.9 | 97.7 | 104.7 | 123.2 | 102.7 | 85.3 | 74.7 |
| STD DEV | | | | | 3.9 | 3.6 | 4.3 | 4.5 | 5.3 | 4.0 | 4.1 | 4.4 |
| Calculated Mean | | | | | 78.6 | 90.7 | 100.1 | 105.5 | 123.8 | 103.7 | 86.4 | 75.4 |
| STD DEV | | | | | 2.5 | 2.9 | 3.2 | 3.4 | 3.7 | 3.0 | 2.9 | 2.1 |
| $\frac{(Meas-Calc)}{Meas}$ % | | | | | -0.4 | +0.2 | -2.5 | -0.7 | -0.5 | -1.0 | -1.4 | -1.0 |
| Correlation | | | | | 0.662 | 0.780 | 0.724 | 0.784 | 0.850 | 0.833 | 0.657 | -0.594 |

Table 6. Comparison of Measured With Calculated Radiances—Mid-latitude (26-62N) and (26-62S)—Clear

| | Location | Date | θ | Distance | F1 355 | F2 397 | F3 420 | F4 441 | F5 535 | F6 408 | F7 374 | F8 353 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Measured | Lajes, Azores | 790711 | 8.99° | 63 nmi | 78.5 | 88.4 | 95.6 | 102.5 | 120.0 | 99.7 | 84.8 | 73.2 |
| Calculated | 38.73N 27.08W | | | | 83.4 | 95.8 | 105.2 | 110.4 | 125.7 | 107.8 | 91.6 | 80.3 |
| Measured | Griefswald, Denmark | 791001 | 9.05° | 18 nmi | 72.2 | 81.7 | 89.1 | 95.8 | 111.9 | 93.6 | 78.7 | 67.6 |
| Calculated | 54.10N 13.38E | | | | 71.7 | 82.4 | 90.3 | 95.0 | 108.8 | 94.2 | 78.2 | 69.2 |
| Measured | OMSK, USSR | 790314 | 0° | 59 nmi | 68.3 | 77.9 | 82.3 | 87.1 | 92.4 | 86.5 | 73.2 | 65.8 |
| Calculated | 54.93N 73.40E | | | | 70.7 | 80.0 | 86.5 | 90.3 | 97.8 | 89.1 | 75.6 | 68.5 |
| Measured | OMSK, USSR | 790505 | 27.27° | 45 nmi | 75.1 | 85.4 | 90.6 | 95.9 | 108.2 | 94.2 | 80.6 | 71.8 |
| Calculated | 54.93N 73.40E | | | | 72.7 | 82.5 | 89.7 | 93.9 | 105.5 | 92.5 | 79.0 | 70.3 |
| Measured | Churchill, Mon, CN | 790816 | 13.52° | 80 nmi | 73.1 | 84.2 | 89.5 | 95.5 | 110.7 | 94.4 | 78.6 | 70.0 |
| Calculated | 58.75N 94.07W | | | | 76.6 | 87.6 | 96.0 | 100.7 | 115.6 | 98.7 | 83.9 | 73.9 |
| Measured | W. Palm Beach, FL | 790322 | -13.63° | 63 nmi | 76.8 | 88.4 | 94.1 | 100.1 | 116.1 | 98.4 | 83.0 | 73.3 |
| Calculated | 26.68N 80.10W | | | | 81.0 | 92.2 | 100.6 | 105.4 | 120.6 | 103.3 | 88.2 | 78.3 |
| Measured | W. Palm Beach, FL | 790408 | -18.10° | 33 nmi | 74.0 | 86.3 | 92.0 | 98.9 | 118.3 | 98.1 | 80.1 | 70.6 |
| Calculated | 26.68N 80.10W | | | | 77.1 | 89.2 | 98.8 | 104.2 | 123.2 | 102.9 | 84.7 | 74.1 |
| Measured | Boothville, LA | 790618 | -32.08° | 92 nmi | 81.9 | 96.3 | 104.0 | 111.6 | 129.4 | 109.3 | 90.2 | 77.6 |
| Calculated | 29.33N 89.40W | | | | 83.9 | 95.8 | 105.7 | 111.1 | 130.6 | 108.9 | 91.3 | 80.0 |
| Measured | Wallops, VA | 790502 | -13.58° | 79 nmi | 76.7 | 89.1 | 95.4 | 101.7 | 117.0 | 100.0 | 83.4 | 72.8 |
| Calculated | 37.85N 75.48W | | | | 76.7 | 89.7 | 100.0 | 105.9 | 124.9 | 104.5 | 85.0 | 73.3 |
| Measured | Wallops, VA | 790518 | -4.52° | 92 nmi | 79.7 | 91.3 | 98.0 | 104.0 | 118.5 | 102.1 | 86.2 | 75.1 |
| Calculated | 37.85N 75.48W | | | | 75.0 | 86.9 | 96.2 | 101.5 | 117.0 | 99.8 | 82.8 | 71.9 |
| Measured | Sterling, VA | 790518 | -13.63° | 99 nmi | 74.1 | 86.3 | 92.4 | 98.8 | 115.3 | 98.0 | 80.0 | 69.9 |
| Calculated | 38.98N 77.47W | | | | 74.9 | 86.7 | 96.0 | 101.4 | 116.7 | 99.7 | 82.6 | 71.7 |
| Measured | Wallops, VA | 790916 | 31.91° | 23 nmi | 74.9 | 87.2 | 93.3 | 100.0 | 115.6 | 98.4 | 81.1 | 70.9 |
| Calculated | 37.85N 75.48W | | | | 78.5 | 90.9 | 100.8 | 106.2 | 121.0 | 104.0 | 87.1 | 75.1 |
| Measured | Wallops, VA | 790920 | -32.14 | 26 nmi | 77.2 | 89.6 | 96.2 | 102.9 | 120.1 | 101.1 | 84.3 | 74.1 |
| Calculated | 37.85N 75.48W | | | | 82.9 | 94.7 | 103.5 | 108.7 | 126.8 | 107.0 | 89.6 | 80.5 |
| Measured | Salem, IL | 790516 | -31.91° | 97 nmi | 75.2 | 87.6 | 93.1 | 99.8 | 118.0 | 98.4 | 81.4 | 73.1 |
| Calculated | 38.65N 88.97W | | | | 78.3 | 88.9 | 96.6 | 101.2 | 116.4 | 99.6 | 84.7 | 76.0 |
| Measured | Chatham, MA | 790503 | -22.74° | 87 nmi | 71.3 | 81.5 | 86.2 | 91.7 | 107.5 | 90.8 | 76.6 | 67.8 |
| Calculated | 41.67N 69.97W | | | | 73.6 | 85.3 | 94.3 | 99.5 | 115.0 | 98.1 | 81.2 | 70.6 |
| Measured | Chatham, MA | 790917 | 9.05° | 92 nmi | 76.6 | 90.7 | 96.6 | 103.5 | 119.0 | 104.3 | 85.7 | 74.4 |
| Calculated | 41.67N 69.98W | | | | 81.8 | 93.6 | 102.6 | 107.6 | 121.5 | 105.0 | 89.8 | 78.8 |
| Measured | Cape Canaveral, FL | 790130 | -4.52° | 47 nmi | 79.3 | 89.8 | 94.8 | 100.0 | 112.8 | 98.0 | 85.2 | 77.7 |
| Calculated | 28.47N 80.55W | | | | 74.6 | 84.6 | 92.3 | 96.7 | 110.4 | 95.1 | 81.1 | 72.1 |
| Measured | Porto Allegro, BZ | 790320 | 4.52° | 49 nmi | 77.7 | 91.7 | 98.1 | 104.9 | 121.3 | 102.9 | 84.8 | 75.0 |
| Calculated | 30.0S 51.18W | | | | 81.5 | 93.8 | 103.3 | 108.5 | 125.7 | 106.2 | 89.7 | 78.3 |
| Measured | Porto Allegro, BZ | 790505 | 27.33° | 71 nmi | 75.0 | 89.1 | 96.6 | 103.3 | 120.5 | 102.0 | 83.3 | 70.2 |
| Calculated | 30.0S 51.18W | | | | 78.5 | 90.8 | 100.3 | 105.6 | 120.6 | 103.7 | 86.7 | 75.3 |
| Measured | Ship Charlie | 790507 | -8.99° | 48 nmi | 70.3 | 81.1 | 85.9 | 91.7 | 105.1 | 90.9 | 76.0 | 67.0 |
| Calculated | 52.7N 35.5W | | | | 73.2 | 83.3 | 90.8 | 95.3 | 109.3 | 94.0 | 79.5 | 70.8 |
| Measured | Ship Charlie | 790628 | 9.05° | 93 nmi | 72.8 | 84.4 | 89.6 | 95.6 | 109.3 | 94.8 | 78.5 | 69.6 |
| Calculated | 52.7N 35.5W | | | | 72.7 | 82.8 | 90.3 | 94.8 | 109.6 | 93.8 | 78.7 | 70.3 |
| Measured Mean | | | | | 75.3 | 87.0 | 93.0 | 99.3 | 114.6 | 97.9 | 81.7 | 71.8 |
| STD DEV | | | | | 3.3 | 4.3 | 4.9 | 5.4 | 7.6 | 5.2 | 4.0 | 3.3 |
| Calculated Mean | | | | | 77.1 | 88.5 | 97.1 | 102.1 | 117.3 | 100.4 | 84.4 | 74.3 |
| STD DEV | | | | | 4.1 | 4.8 | 5.6 | 6.0 | 8.1 | 5.6 | 4.6 | 3.9 |
| $\frac{(\text{Meas-Calc})}{\text{Meas}}$ % | | | | | -2.4 | -1.6 | -4.4 | -2.8 | -2.3 | -2.5 | -3.3 | -3.4 |
| STD DEV | | | | | 3.7 | 3.4 | 3.5 | 3.3 | 3.1 | 3.1 | 3.6 | 3.9 |
| Correlation: | | | | | 0.697 | 0.779 | 0.807 | 0.834 | 0.902 | 0.835 | 0.758 | 0.653 |

Table 7. Comparison of Measured With Calculated Radiances—Arctic (62-90N)—Clear

| | Location | Date | θ | Distance | F1 355 | F2 397 | F3 420 | F4 441 | F5 535 | F6 408 | F7 374 | F8 353 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Measured | Thule AB, GL | 790205 | -9.0 | 18 nmi | 64.6 | 69.6 | 72.3 | 74.4 | 75.4 | 73.6 | 68.2 | 62.7 |
| Calculated | 76.52N 68.83W | | | | 68.3 | 73.5 | 76.2 | 77.9 | 77.7 | 76.6 | 71.8 | 66.8 |
| Measured | Thule AB, GL | 790205 | -4.5 | 36 nmi | 63.8 | 68.0 | 70.4 | 72.0 | 71.6 | 70.8 | 66.8 | 62.2 |
| Calculated | 76.52N 68.83W | | | | 68.3 | 73.5 | 76.2 | 77.9 | 77.7 | 76.6 | 71.8 | 66.8 |
| Measured | Thule AFB, GL | 790205 | -13.6 | 41 nmi | 64.9 | 69.3 | 71.4 | 72.6 | 73.5 | 72.1 | 67.8 | 61.9 |
| Calculated | 76.52N 68.83W | | | | 68.3 | 73.5 | 76.2 | 77.9 | 77.7 | 76.6 | 71.8 | 66.8 |
| Measured | Khatanga, USSR | 790418 | 18.0 | 75 nmi | 68.6 | 76.9 | 80.6 | 84.8 | 88.0 | 83.5 | 73.0 | 65.3 |
| Calculated | 71.98N 102.47E | | | | 70.9 | 78.7 | 83.9 | 86.6 | 88.5 | 85.0 | 76.2 | 68.9 |
| Measured | Khatanga, USSR | 790419 | 13.5 | 67 nmi | 68.7 | 75.7 | 78.9 | 82.0 | 84.3 | 81.1 | 72.9 | 65.9 |
| Calculated | 71.98N 102.47E | | | | 69.0 | 76.7 | 81.8 | 84.6 | 86.8 | 83.2 | 74.2 | 67.1 |
| Measured | Alert, NT, CN | 790314 | -27.4 | 23 nmi | 70 6 | 76.5 | 78.6 | 80.2 | 76.7 | 78.2 | 75.2 | 68.8 |
| Calculated | 82.5N 62.33W | | | | 70.4 | 77.2 | 81.4 | 83.2 | 81.8 | 81.8 | 75.8 | 68.4 |
| Measured | Alert, NT, CN | 790321 | -22.7 | 54 nmi | 66.2 | 70.9 | 73.2 | 74.6 | 72.0 | 73.6 | 69.7 | 64.3 |
| Calculated | | | | | 66.9 | 72.6 | 75.9 | 77.4 | 76.8 | 76.0 | 71.0 | 65.5 |
| Measured | Alert, NT, CN | 790326 | -27.3 | 64 nmi | 67.2 | 74.4 | 77.7 | 80.6 | 79.7 | 79.5 | 71.5 | 65.4 |
| Calculated | | | | | 68.7 | 75.7 | 80.0 | 82.3 | 81.5 | 80.8 | 73.6 | 67.0 |
| Measured | Alert, NT, CN | 790326 | -32.0 | 98 nmi | 67.4 | 74.7 | 78.0 | 80.7 | 80.6 | 79.6 | 71.3 | 65.8 |
| Calculated | | | | | 68.7 | 75.7 | 80.0 | 82.3 | 81.5 | 80.8 | 73.6 | 67.0 |
| Measured Mean: | | | | | 66.9 | 72.9 | 75.7 | 78.0 | 78.0 | 76.9 | 70.7 | 64.7 |
| STD DEV | | | | | 2.2 | 3.4 | 3.8 | 4.6 | 5.6 | 4.5 | 2.8 | 2.2 |
| Calculated Mean: | | | | | 68.8 | 75.2 | 79.1 | 81.1 | 81.1 | 79.6 | 73.3 | 67.1 |
| STD DEV | | | | | 1.2 | 2.1 | 3.0 | 3.4 | 4.2 | 3.3 | 1.9 | 1.0 |
| (Meas-Calc)/Meas % | | | | | -2.8 | -3.2 | -4.5 | -4.0 | -4.0 | -3.5 | -3.7 | -3.7 |
| Correlation: | | | | | 0.698 | 0.919 | 0.961 | 0.969 | 0.961 | 0.964 | 0.881· | 0.524 |

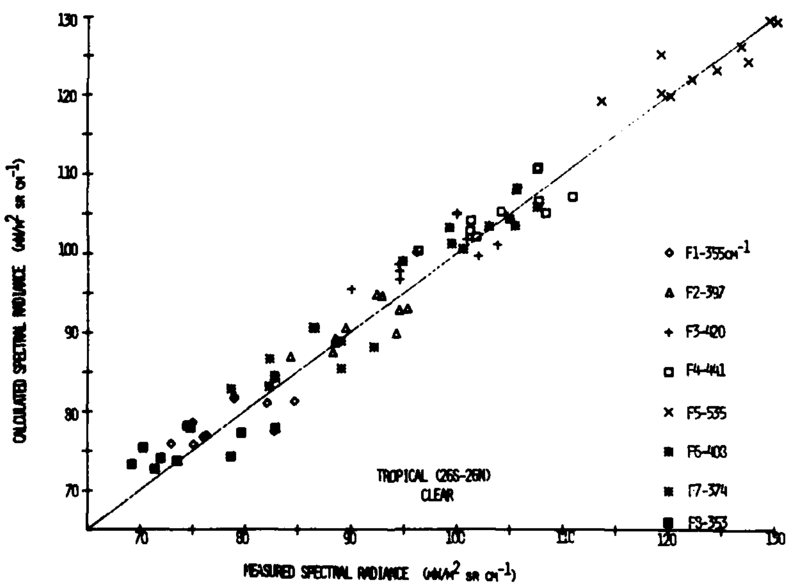


Figure 4. Measured and Calculated Clear Column Radiances for DMSP SSH $H_2O$ Channels—Tropical

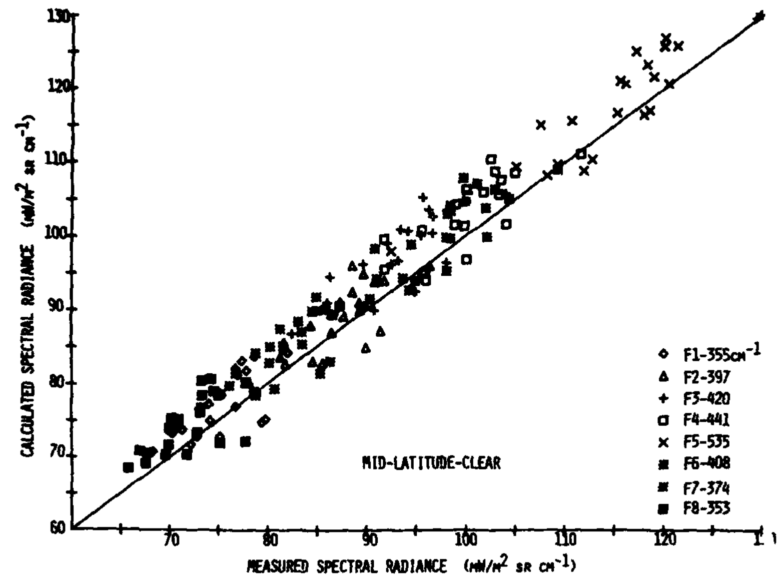


Figure 5. Measured and Calculated Clear Column Radiances for DMSP SSH $H_2O$ Channels—Mid-latitude

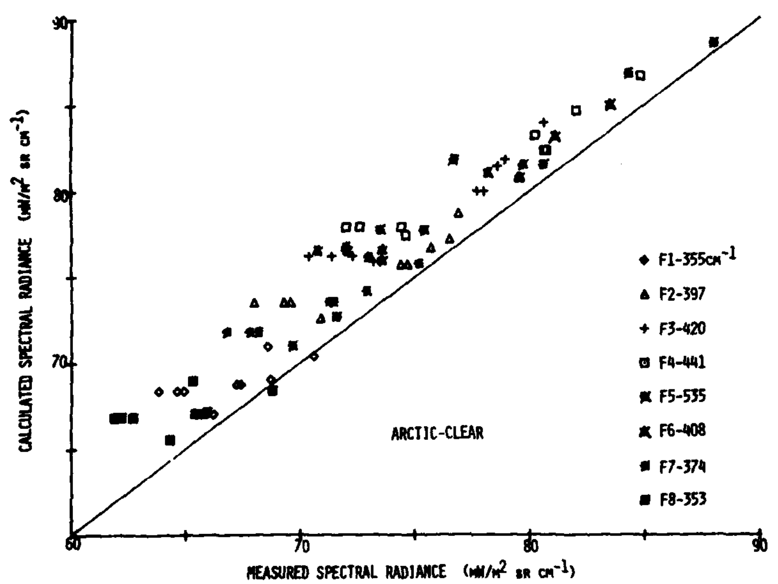


Figure 6. Measured and Calculated Clear Column Radiances for DMSP SSH $H_2O$ Channels—Arctic

### 6.2 Cloud Contaminated Water Vapor Radiance Comparison

The colocated cloud contaminated cases selected for comparison are listed in Table 8 (Tropical), Table 9 (Mid-latitude—Low Clouds), Table 10 (Mid-latitude—High overcast) and Table 11 (Arctic). The 29 cloud contaminated cases—Tropical (5), Mid-latitude–Low Clouds (11), Mid-latitude–High overcast (7), and Arctic (6) were selected based again on the surface reports and the 3D NEPH data. In a few cases cloud conditions from 3D NEPH data were not available but are listed. In these tables, the row designated calculated-clear means that the transmittance calculations were carried out as if there were no clouds present. In the case where the transmittance calculations were computed and an effective cloud layer was determined in the row designated calculated-cloud at some height, the following assumptions were made: (1) the cloud has an emissivity of 1.00 and is constant over the width of the filter function, (2) the cloud amount is 100 percent and fills the field of view of the instrument, (3) $T_s$, the surface temperature in Eq. (1) is replaced by $T_c$, the cloud top temperature, and (4) the radiance percentage deviation is minimized by iterations for DMSP channel F5-535 $cm^{-1}$ only, and (5) the effective cloud level found for F5-535 $cm^{-1}$ is valid for all the DMSP water vapor channels.

Figures 7, 8, 9, and 10 show the results of the comparison in graphical form for the calculated clear-cloud contaminated for Tropical, Mid-latitude-Low Clouds, Mid-latitude—High overcast and Arctic, respectively. As should be expected, in the majority of cases, the calculated exceeds the satellite measured water vapor radiances. The higher the effective cloud layer, the greater the deviation. This should be expected since the upwelling radiation is coming from a higher level in the atmosphere. However, it is surprising that even with the cloud contamination there are a few comparisons showing a slight positive percentage deviation. For example in Table 8 and Figure 9, the comparison radiance data for Bangkok would indicate a clear column condition but the 3D NEPH data showed a broken cirrus stratus condition 1.5 to 4.0 km thick. No effective cloud layer calculations were performed for Bangkok because the radiance data for F5-535 $cm^{-1}$ was already maximized with minimum percentage deviation. Also shown in Table 8, the greatest discrepancy found in this study was Ponope, Caroline Islands. The range of discrepancies range from -61 percent for F8-353 $cm^{-1}$, the most opaque channel, to -182 percent for F5-535 $cm^{-1}$, the most transparent channel. Although there are only five cases in the Tropics used for comparison, the cloud retrievals are disappointing when the effective cloud layer is compared directly to the cloud conditions reported in the 3D NEPH data. For example, in Table 8 see Bangkok on 790403 and either Truk or Ponape. The effective cloud layer calculations do not even come close to the actual cloud conditions being reported by the 3D NEPH data. However, the relationship between the measured and calculated radiances for an effective cloud layer in the Tropics is greatly improved as shown graphically in Figure 11.

Table 8. Comparison of Measured With Calculated Radiances—Tropical (0-26N)—Calculated Clear and Clouds

| | Location | Date | θ | Distance | F1 355 | F2 397 | F3 420 | F4 441 | F5 535 | F6 408 | F7 374 | F8 353 | Cloud Level | Conditions Amount |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Measured** | Bangkok, TH | 790329 | 27.44 | 68 nmi | 73.2 | 85.0 | 90.3 | 96.9 | 115.5 | 95.4 | 79.2 | 69.9 | 12.0 km | 0.55 |
| **Calc-Clear** | 13.73N 100.5E | | | | 74.2 | 85.0 | 93.2 | 98.0 | 115.4 | 96.7 | 81.0 | 81.0 | | |
| **Calc-Cloud at N/A** | | | | | ---- | ---- | ---- | ---- | ----- | ---- | ---- | ---- | | |
| **Measured** | Bangkok, TH | 790403 | 13.52 | 81 nmi | 81.6 | 94.9 | 101.9 | 109.3 | 125.2 | 107.0 | 89.1 | 76.6 | 12.0 | 0.75 |
| **Calc-Clear** | 13.73N 100.5E | | | | 81.0 | 93.2 | 102.8 | 108.1 | 127.5 | 106.0 | 89.0 | 78.0 | | |
| **Calc-Cloud at N/A** | | | | | ---- | ---- | ----- | ----- | ----- | ----- | ---- | ---- | | |
| **Measured** | Brownsville, T | 790206 | -9.05 | 69 nmi | 69.2 | 72.8 | 74.0 | 75.0 | 76.5 | 74.4 | 71.5 | 68.0 | 10.7 | 0.25 |
| **Calc-Clear** | 25.9N 92.43W | | | | 72.0 | 82.2 | 90.0 | 94.5 | 109.6 | 93.2 | 78.5 | 69.5 | 4.3 | 1.00 |
| **Calc-Cloud at 8.6 km** | | | | | 67.4 | 72.6 | 75.6 | 77.0 | 76.9 | 75.8 | 71.0 | 66.2 | | |
| **Measured** | TRUK, KA | 790317 | 27.50 | 42 nmi | 66.5 | 73.5 | 76.2 | 79.0 | 82.4 | 78.5 | 70.2 | 64.2 | 4.3 | 0.10 |
| **Calc-Clear** | 7.47N 151.8SE | | | | 73.5 | 83.3 | 90.4 | 94.6 | 109.5 | 93.3 | 79.4 | 71.2 | 1.5 | 0.90 |
| **Calc-Cloud at 9.5 km** | | | | | 70.7 | 76.9 | 80.4 | 82.2 | 83.2 | 80.6 | 74.9 | 69.4 | | |
| **Measured** | Ponape, KA | 790409 | -9.05 | 31 nmi | 46.6 | 46.2 | 45.3 | 44.5 | 40.3 | 45.8 | 46.4 | 46.3 | 12.2 | 0.65 |
| **Calc-Clear** | 6.97N 158.22E | | | | 77.2 | 87.7 | 95.6 | 101.4 | 113.5 | 98.3 | 84.0 | 74.6 | 7.9 | 1.00 |
| **Calc-Cloud at 15.0 km** | | | | | 45.4 | 46.0 | 45.8 | 45.3 | 40.4 | 46.0 | 45.8 | 45.3 | | |

Table 9. Comparison of Measured With Calculated Radiances—Mid-latitude (26-62N) Calculated Clear and Effective Cloud Layer Less Than 4 km

| | Location | Date | θ | Distance | F1 355 | F2 397 | F3 420 | F4 441 | F5 535 | F6 408 | F7 374 | F8 353 | Cloud Level | Conditions Amount |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Measured | Oslo, Norway | 790328 | 4.46° | 90 nmi | 71.5 | 80.4 | 84.8 | 89.4 | 96.8 | 88.0 | 76.6 | 68.5 | N/A | |
| Calc-Clear | 60.2N 11.1E | | | | 71.7 | 81.7 | 89.1 | 93.4 | 105.4 | 92.1 | 78.0 | 69.3 | | |
| Calc-Cloud at 2.0 km | | | | | 71.4 | 80.3 | 86.7 | 90.3 | 97.4 | 88.9 | 77.3 | 69.1 | | |
| Measured | Lerwick, UK | 790326 | -13.52° | 64 nmi | 77.7 | 87.1 | 91.4 | 95.1 | 100.1 | 92.7 | 83.5 | 75.1 | 1.1 | 0.80 |
| Calc-Clear | 60.13N 1.18W | | | | 74.2 | 85.0 | 93.2 | 97.7 | 109.0 | 95.9 | 81.7 | 71.2 | | |
| Calc-Cloud at 2.5 km | | | | | 73.8 | 83.8 | 91.0 | 94.8 | 101.5 | 92.8 | 80.9 | 71.0 | | |
| Measured | Lerwick, UK | 790406 | 4.46° | 31 nmi | 70.7 | 80.1 | 84.6 | 89.1 | 98.2 | 87.9 | 75.8 | 67.0 | 2.1 km | 0.30 |
| Calc-Clear | | | | | 71.8 | 81.4 | 88.3 | 92.5 | 106.0 | 91.3 | 77.7 | 69.6 | 1.1 | 0.95 |
| Calc-Cloud at 2.2 km | | | | | 71.7 | 80.7 | 86.9 | 90.5 | 98.2 | 89.1 | 77.5 | 69.6 | | |
| Measured | W. Palm Beach, FLA | 790403 | 0° | 86 nmi | 75.5 | 89.4 | 96.7 | 104.5 | 117.5 | 103.2 | 83.4 | 70.1 | 3.0 | 1.00 |
| Calc-Clear | 26.68N 80.1W | | | | 79.8 | 92.9 | 103.3 | 109.0 | 125.3 | 106.9 | 88.4 | 76.2 | | |
| Calc-Cloud at 4.0 km | | | | | 79.3 | 91.6 | 101.1 | 106.2 | 118.8 | 104.0 | 87.6 | 76.0 | | |
| Measured | Cape Hatteras, NC | 790623 | 13.52° | 92 nmi | 72.1 | 80.9 | 87.8 | 93.8 | 111.5 | 92.1 | 78.0 | 67.9 | 12.2 km | 0.40 |
| Calc-Clear | 35.27N 75.55W | | | | 74.2 | 86.0 | 95.2 | 100.5 | 118.0 | 99.3 | 81.5 | 71.2 | 1.1 | 0.15 |
| Calc-Cloud at 3.75 km | | | | | 74.1 | 85.5 | 94.2 | 99.2 | 111.4 | 97.8 | 81.4 | 71.2 | | |
| Measured | Cape Hatteras, NC | 790816 | 4.46° | 64 nmi | 73.6 | 84.6 | 90.3 | 96.6 | 113.4 | 95.7 | 79.0 | 70.7 | 6.7 km | 0.25 |
| Calc-Clear | | | | | 78.7 | 88.7 | 95.8 | 99.8 | 112.4 | 97.9 | 84.9 | 76.4 | | |
| Calc-Cloud at N/A | | | | | ---- | ---- | ----- | ----- | ----- | ----- | ---- | ---- | | |
| Measured | Wallops, VA | 790205 | 18.11° | 31 nmi | 74.5 | 83.2 | 89.1 | 94.3 | 106.0 | 92.3 | 80.1 | 71.1 | N/A | |
| Calc-Clear | 37.85N 75.48W | | | | 78.3 | 87.9 | 94.1 | 98.7 | 109.8 | 96.7 | 84.4 | 75.2 | | |
| Calc-Cloud at 1.4 km | | | | | 78.2 | 87.5 | 93.4 | 97.7 | 105.6 | 95.5 | 84.3 | 75.1 | | |
| Measured | Wallops, VA | 790205 | 4.53° | 36 nmi | 76.2 | 86.0 | 90.3 | 95.0 | 105.6 | 93.5 | 81.0 | 74.1 | N/A | |
| Calc-Clear | | | | | 78.0 | 87.9 | 95.0 | 99.0 | 109.8 | 96.9 | 84.5 | 75.7 | | |
| Calc-Cloud at 1.4 km | | | | | 78.0 | 87.5 | 94.2 | 97.9 | 105.6 | 95.6 | 84.4 | 75.7 | | |
| Measured | Wallops, VA | 790617 | 0° | 74 nmi | 78.2 | 89.9 | 95.3 | 101.5 | 117.6 | 99.3 | 84.3 | 75.2 | 7.9 | 0.25 |
| Calc-Clear | | | | | 82.7 | 93.6 | 101.5 | 106.0 | 121.9 | 103.7 | 89.4 | 80.3 | 1.5 | 0.85 |
| Calc-Cloud at 3.0 km | | | | | 82.7 | 93.4 | 101.0 | 105.3 | 117.6 | 102.9 | 89.4 | 80.3 | 0.3 | 0.95 |
| Measured | Chatham, MA | 790519 | 0° | 82 nmi | 70.5 | 81.9 | 87.1 | 93.3 | 108.7 | 92.6 | 76.1 | 68.0 | 12.2 km | 0.90 |
| Calc-Clear | 41.67N 69.9W | | | | 75.4 | 88.1 | 97.9 | 103.5 | 119.7 | 101.9 | 83.6 | 72.0 | | |
| Calc-Cloud at 3.5 km | | | | | 74.9 | 86.3 | 94.8 | 99.6 | 110.0 | 97.6 | 82.5 | 71.8 | | |
| Measured | Chatham, MA | 790703 | 0° | 91 nmi | 72.8 | 83.8 | 88.7 | 94.3 | 108.4 | 93.1 | 78.7 | 70.4 | 9.1 km | 0.20 |
| Calc-Clear | | | | | 78.5 | 88.6 | 96.0 | 100.1 | 113.6 | 97.8 | 85.1 | 76.1 | 4.3 | 0.20 |
| Calc-Cloud at 3.6 km | | | | | 78.5 | 88.4 | 95.6 | 99.6 | 109.4 | 97.3 | 85.1 | 76.1 | 1.1 | 0.20 |
| Mean-Measured | | | | | 73.9 | 84.3 | 89.6 | 95.2 | 107.6 | 93.7 | 79.7 | 70.7 | | |
| -Calc-Clear | | | | | 76.7 | 87.4 | 95.4 | 100.0 | 113.7 | 98.2 | 83.6 | 73.9 | | |
| -Calc-Cloud | | | | | 76.5 | 86.7 | 94.1 | 98.3 | 108.0 | 96.3 | 83.2 | 73.8 | | |
| (Meas-Calc)/Meas Clear % | | | | | -3.7 | -3.7 | -6.4 | -5.1 | -5.7 | -4.9 | -4.9 | -4.5 | | |
| (Meas-Calc)/Meas Cloudy % | | | | | -3.4 | -2.8 | -5.0 | -3.2 | -0.3 | -2.8 | -4.4 | -4.4 | | |

Table 10. Comparison of Measured With Calculated Radiances—Mid-latitude (26-62N) Calculated Clear and High Overcase

| | Location | Date | θ | Distance | F1 355 | F2 397 | F3 420 | F4 441 | F5 535 | F6 408 | F7 374 | F8 353 | Cloud Level | Conditions Amount |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Measured** | Lerwick, UK | 790207 | 9.05° | 75 nmi | 65.2 | 70.8 | 73.3 | 75.1 | 76.0 | 74.4 | 68.8 | 63.1 | 6.6 km | 1.00 |
| **Calc-Clear** | 60.13N 1.18W | | | | 66.8 | 76.6 | 83.8 | 88.2 | 101.4 | 87.4 | 73.0 | 64.3 | | |
| **Calc-Cloud at 5.6 km** | | | | | 64.5 | 70.6 | 74.3 | 76.1 | 76.7 | 75.1 | 68.9 | 63.0 | | |
| **Measured** | Lerwick, UK | 790302 | 18.16° | 68 nmi | 65.4 | 70.6 | 73.0 | 74.8 | 75.5 | 74.3 | 68.9 | 63.1 | 6.6 | 1.00 |
| **Calc-Clear** | 60.13N 1.18W | | | | 67.9 | 77.3 | 84.3 | 88.4 | 100.5 | 87.3 | 74.0 | 65.5 | | |
| **Calc-Cloud at 6.5 km** | | | | | 65.0 | 70.6 | 73.8 | 75.4 | 75.4 | 74.3 | 68.9 | 63.7 | | |
| **Measured** | Stanwell, UK | 790302 | 27.38° | 85 nmi | 64.4 | 68.7 | 70.4 | 71.6 | 72.1 | 71.2 | 66.9 | 62.3 | 7.8 | 1.00 |
| **Calc-Clear** | 56.43N 2.87W | | | | 69.0 | 78.8 | 86.0 | 90.3 | 103.1 | 89.3 | 75.2 | 66.5 | | |
| **Calc-Cloud at 8.1 km** | | | | | 64.5 | 69.3 | 71.8 | 73.0 | 72.1 | 72.1 | 67.8 | 63.5 | | |
| **Measured** | Marssarssuaq, GL | 790306 | 18.22° | 70 nmi | 56.8 | 56.0 | 54.7 | 53.4 | 51.4 | 55.1 | 57.1 | 56.1 | 10.5 | 0.65 |
| **Calc-Clear** | 61.18N 45.43W | | | | 67.1 | 76.1 | 82.6 | 86.5 | 96.7 | 85.7 | 72.7 | 64.9 | 7.8 | 1.00 |
| **Calc-Cloud at 9.1 km** | | | | | 54.4 | 55.8 | 55.9 | 55.7 | 51.5 | 55.8 | 55.1 | 54.3 | | |
| **Measured** | Griefswald, DEN | 790316 | -27.44° | 47 nmi | 58.9 | 62.0 | 62.7 | 63.2 | 62.0 | 64.7 | 60.7 | 58.7 | 12.0 | 0.65 |
| **Calc-Clear** | 54.1N 13.38E | | | | 70.7 | 80.3 | 87.4 | 91.6 | 103.4 | 90.2 | 76.9 | 68.3 | 7.8 | 1.00 |
| **Calc-Cloud at 8.5 km** | | | | | 60.1 | 62.6 | 63.1 | 63.8 | 60.9 | 63.4 | 61.4 | 60.0 | | |
| **Measured** | Huntington, W.VA | 790402 | -18.16° | 72 nmi | 57.0 | 58.7 | 58.5 | 58.1 | 55.7 | 59.2 | 58.4 | 56.8 | 10.5 | 0.75 |
| **Calc-Clear** | 38.37N 82.55W | | | | 71.8 | 81.1 | 87.9 | 92.0 | 106.0 | 90.8 | 77.5 | 69.6 | 6.6 | 0.95 |
| **Calc-Cloud at 11.0 km** | | | | | 56.8 | 56.8 | 59.3 | 59.3 | 55.7 | 59.2 | 58.0 | 56.5 | 5.4 | 1.00 |
| **Measured** | Salem, IL | 790401 | -13.58° | 36 nmi | 55.0 | 55.4 | 55.0 | 54.2 | 50.5 | 55.6 | 55.4 | 54.0 | 12.0 | 0.65 |
| **Calc-Clear** | 38.65N 88.97W | | | | 71.6 | 81.1 | 87.9 | 91.9 | 104.7 | 90.5 | 77.6 | 69.4 | 7.8 | 1.00 |
| **Calc-Cloud at 11.0 km** | | | | | 53.7 | 55.3 | 55.5 | 55.3 | 51.2 | 55.5 | 54.6 | 53.6 | | |
| **Mean-Measured** | | | | | 60.4 | 63.2 | 63.9 | 64.3 | 63.3 | 64.9 | 62.3 | 59.2 | | |
| **-Calc-Clear** | | | | | 69.3 | 78.8 | 85.7 | 89.8 | 102.3 | 88.7 | 75.3 | 66.9 | | |
| **-Calc-Clouds** | | | | | 59.9 | 63.3 | 64.8 | 65.5 | 63.4 | 65.1 | 62.1 | 59.2 | | |
| **(Meas-Calc)/Meas** Clear% | | | | | -14.7 | -24.7 | -34.1 | -39.7 | -61.6 | -36.7 | -20.9 | -13.0 | | |
| **(Meas-Calc)/Meas** Clouds% | | | | | 0.8 | -0.2 | -1.4 | -1.9 | -0.2 | -0.3 | +0.3 | 0 | | |

Table 11. Comparison of Measured With Calculated Radiances—Arctic (62-90N) Calculated Clear and Clouds

| | Location | Date | θ | Distance | F1 355 | F2 397 | F3 420 | F4 441 | F5 535 | F6 408 | F7 374 | F8 353 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Measured | Thule AB, GL | 790204 | 0° | 5 nmi | 61.6 | 63.4 | 63.2 | 62.2 | 60.6 | 63.2 | 62.8 | 60.6 |
| Calc-Clear | 76.52N 68.83W | (13536) | | | 66.8 | 72.6 | 75.9 | 78.2 | 79.3 | 77.0 | 70.6 | 64.9 |
| Calc-Cloud at 4.5 km | | | | | 60.7 | 63.3 | 64.0 | 64.2 | 61.1 | 63.7 | 62.1 | 60.5 |
| Measured | Thule AB, GL | 790294 | -4.5° | 27 nmi | 61.9 | 64.2 | 64.1 | 63.5 | 62.1 | 64.3 | 63.6 | 61.2 |
| Calc-Clear | | (13536) | | | 66.8 | 72.6 | 75.9 | 78.2 | 79.3 | 77.0 | 70.6 | 64.9 |
| Calc-Cloud at 4.0 km | | | | | 61.6 | 64.5 | 65.5 | 65.9 | 63.2 | 65.3 | 63.3 | 61.3 |
| Measured | Thule AB, GL | 790204 | +4.5° | 37 nmi | 63.0 | 66.2 | 66.9 | 67.6 | 67.1 | 67.3 | 64.7 | 62.6 |
| Calc-Clear | | (13536) | | | 66.8 | 72.6 | 75.9 | 78.2 | 79.3 | 77.0 | 70.6 | 64.9 |
| Calc-Cloud at 3.0 km | | | | | 63.3 | 66.8 | 68.4 | 69.2 | 67.3 | 68.4 | 65.5 | 62.7 |
| Measured | Thule AB, GL | 790204 | 0° | 16 nmi | 61.8 | 63.6 | 63.9 | 63.0 | 61.4 | 63.6 | 63.5 | 60.7 |
| Calc-Clear | | (14537) | | | 66.4 | 72.5 | 76.2 | 78.2 | 79.2 | 77.0 | 70.5 | 65.0 |
| Calc-Cloud at 4.25 km | | | | | 61.0 | 63.6 | 64.4 | 64.7 | 61.6 | 64.2 | 62.5 | 60.8 |
| Measured | Thule AB, GL | 792004 | +4.5° | 16 nmi | 63.2 | 66.6 | 67.5 | 67.6 | 67.1 | 67.2 | 65.4 | 62.5 |
| Calc-Clear | | (14537) | | | 66.4 | 72.5 | 76.2 | 78.2 | 79.2 | 77.0 | 70.5 | 65.0 |
| Calc-Cloud at 2.5 km | | | | | 63.5 | 67.2 | 68.9 | 69.6 | 67.6 | 68.9 | 69.8 | 62.9 |
| Measured | Thule AB, GL | 790204 | -4.5° | 50 nmi | 62.0 | 63.6 | 64.3 | 63.7 | 61.9 | 64.3 | 63.1 | 60.7 |
| Calc-Clear | | (14537) | | | 66.4 | 72.5 | 76.2 | 78.2 | 79.2 | 77.0 | 70.5 | 65.0 |
| Calc-Cloud at 4.25 km | | | | | 61.0 | 63.6 | 64.4 | 64.7 | 61.6 | 64.2 | 62.5 | 60.8 |
| Mean-Measured | | | | | 62.25 | 64.6 | 65.0 | 64.6 | 63.4 | 65.0 | 63.85 | 61.4 |
| -Calc-Clear | | | | | 66.6 | 72.55 | 76.05 | 78.2 | 79.25 | 77.0 | 70.55 | 64.95 |
| -Calc-Clouds | | | | | 61.85 | 64.8 | 65.9 | 66.4 | 63.7 | 65.8 | 63.6 | 61.5 |
| $\frac{(Meas-Calc)}{Meas}$ Clear % | | | | | -7.0 | -12.3 | -17.0 | -21.1 | -25.0 | -18.5 | -10.5 | -5.8 |
| $\frac{(Meas-Calc)}{Meas}$ Clouds % | | | | | +0.6 | -0.3 | -1.4 | -2.8 | -0.5 | -1.2 | +0.4 | -0.2 |

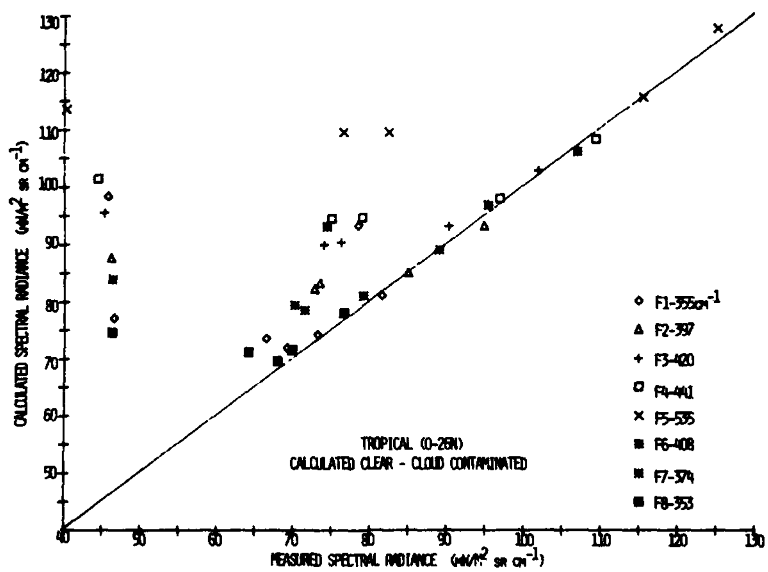


Figure 7. Measured and Calculated Clear Column—Cloud Contaminated Radiances for DMSP SSH $H_2O$ Channels—Tropical

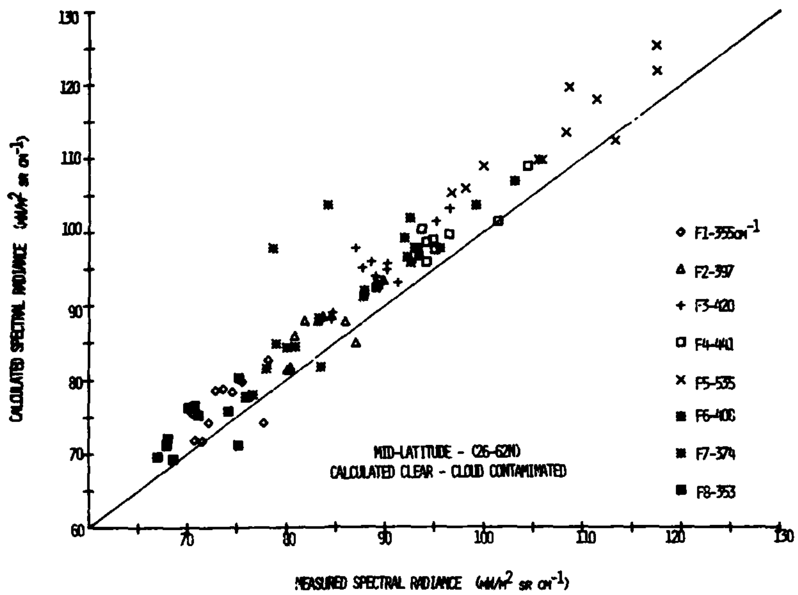


Figure 8. Measured and Calculated Clear Column—Cloud Contaminated Low Cloud Radiances for DMSP SSH $H_2O$ Channels—Mid-latitude

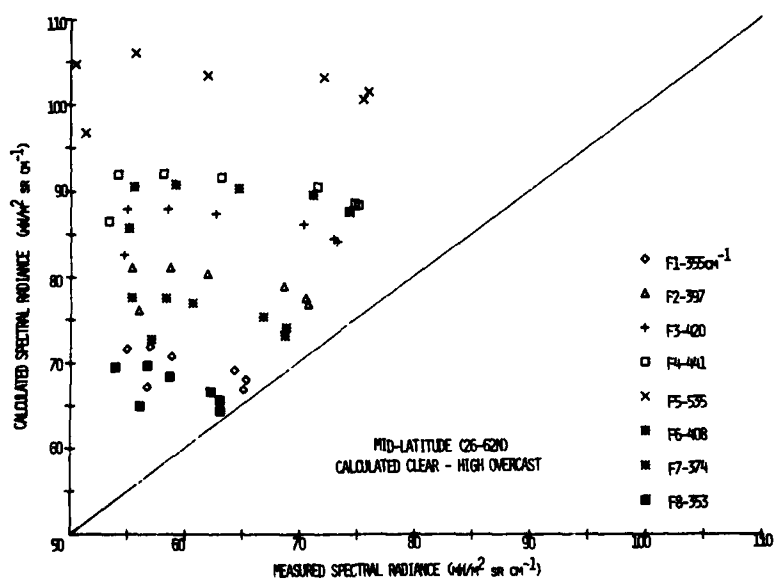


Figure 9. Measured and Calculated Clear Column—Cloud Contaminated High Overcast Radiances for DMSP SSH $H_2O$ Channels—Mid-latitude

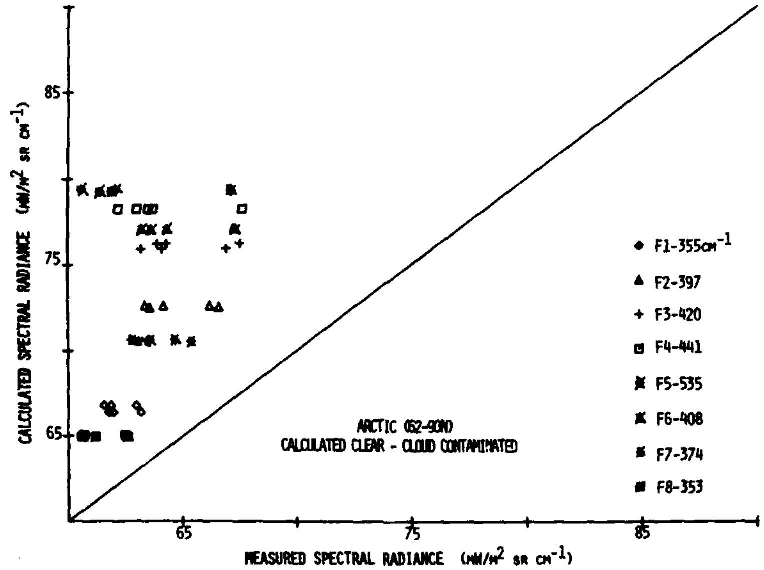


Figure 10. Measured and Calculated Clear Column—Cloud Contaminated Radiances for DMSP SSH $H_2O$ Channels—Arctic

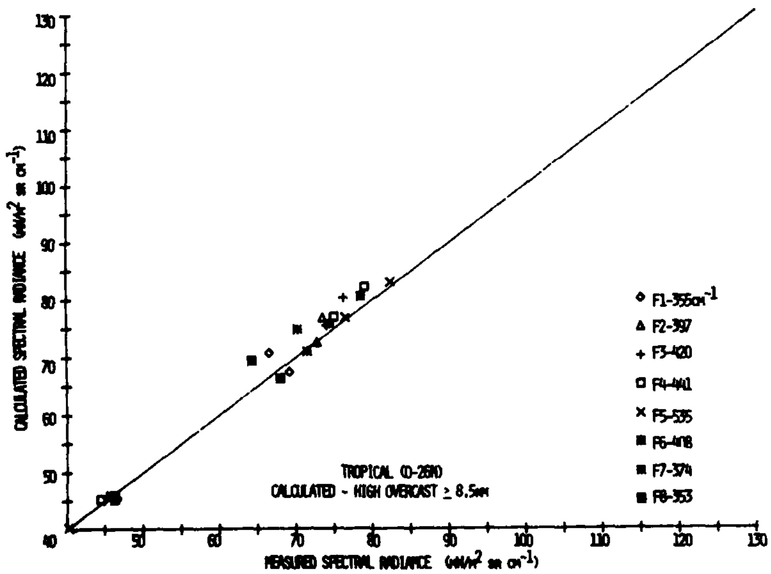


Figure 11. Measured and Calculated High Overcast Radiances for DMSP SSH $H_2O$ Channels—Tropical

The comparison of measured with calculated radiances in the cloud contaminated cases for the Mid-latitude belt was sub-divided into a low and high cloud atmospheric condition. The low cloud category was arbitrarily chosen based on the calculation of an effective cloud layer at or below 4 km or approximately the 600 mb level in the atmosphere. The actual cloud conditions both in amounts and levels as obtained from the 3D NEPH data are quite variable as can be seen in Table 9. The Mid-latitude—High overcast category shows a more uniform type of cloud conditions, as seen in Table 10.

The Mid-latitude—Low-effective cloud layer comparison is listed in Table 9 and shown graphically in Figure 8. The mean percentage deviations are negative for all DMSP channels. The range is -3.7 percent to -5.7 percent for the cloud contaminated cases which is very similar to the range of -1.6 percent to -4.4 percent for the clear column comparison shown in Table 6. Also, it would be very difficult to see any significant differences between Figure 5—Mid-latitude Clear and Figure 8—Mid-latitude Calculated Clear-Cloud contaminated. The cloud retrievals only show a slight improvement as shown in Table 9 and Figure 12. The maximum improvement is shown in DMSP channel F5-535 $cm^{-1}$, a reduction from -5.7 to -0.3 percent, and this improvement is due to the design of the cloud retrieval calculation. There is very little improvement in the more opaque water vapor channels, that is, F8-353 $cm^{-1}$ and F1-355 $cm^{-1}$. It appears from this analysis that the DMSP water vapor channels cannot distinguish between *clear and low cloud contamination.* Low cloud contamination being an overcast below 3 or 4 km or lower than the 600 to 700 mb atmospheric level.

On the other hand, the Mid-latitude—High overcast comparison listed in Table 10 and shown graphically in Figure 9 shows a definite negative discrepancy between the measured and calculated water vapor radiances. The range of negative deviations is -13.0 percent for F8-353 $cm^{-1}$ to -61.6 percent for F5-535 $cm^{-1}$. As should be expected, there is a definite negative discrepancy as shown both in Tables 10 and Figure 9. The cloud retrievals show an improvement in the comparison of effective cloud layer to the cloud conditions reported in the 3D NEPH data for the Mid-latitude—High overcast category. The cloud retrievals calculations in the measured and calculated radiance comparison show a large improvement as shown in Table 10 and Figure 13. The negative deviation for channel F5-535 $cm^{-1}$ is reduced from -61.6 percent to -0.2 percent and for channel F8-353 $cm^{-1}$ from -13.0 percent to 0 percent.

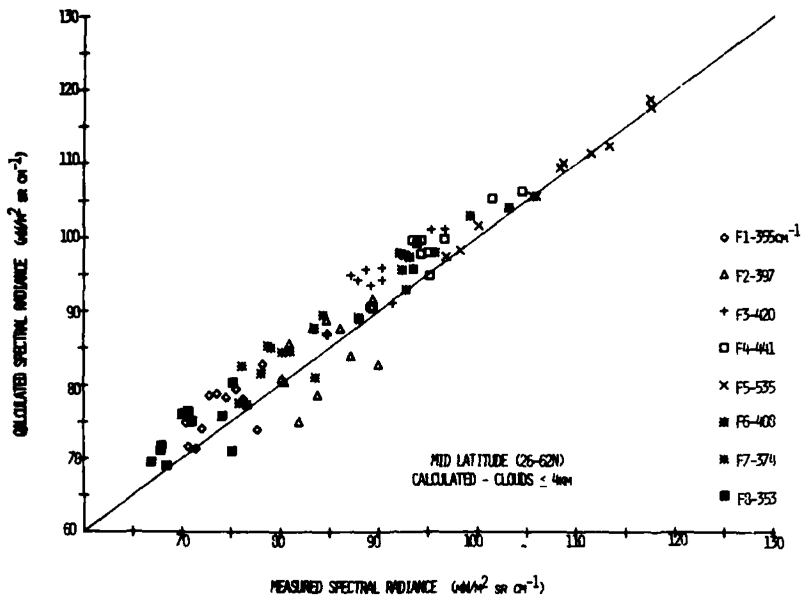


Figure 12. Measured and Calculated Low Overcast Radiances for DMSP SSH $H_2O$ Channels—Mid-latitude

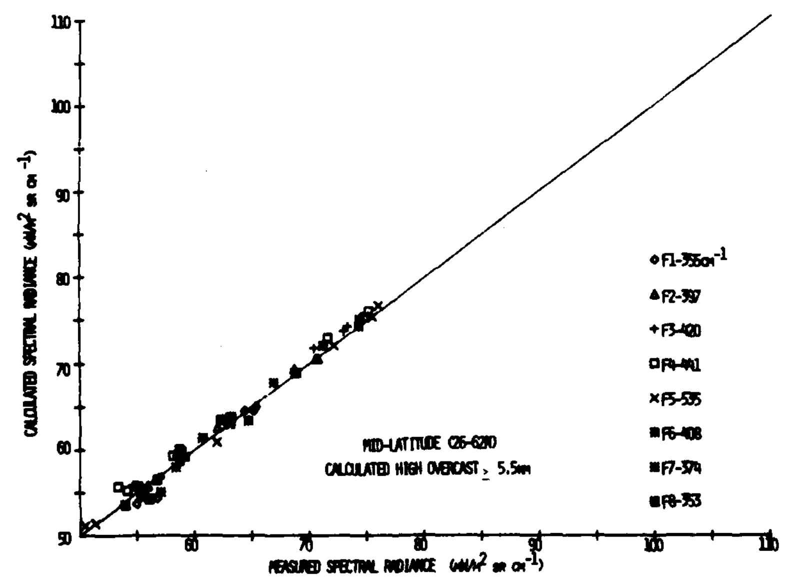


Figure 13. Measured and Calculated High Overcast Radiances for DMSP SSH $H_2O$ Channels—Mid-latitude

Finally, in Table 11 and Figure 10, the comparison of measured with calculated radiances for the Arctic latitude belt is shown. There was no cloud information available so no actual comparisons could be made between the calculated effective and the actual cloud layer. This is also the only time when the comparison used both DMSP satellites, that is, 13536 and 14537. Figure 10 shows quite graphically the cloud contamination because of the large negative deviations of calculated being greater than the measured water vapor radiances. The range of negative deviations are -5.8 percent for F8-353 $cm^{-1}$ and -25.0 percent for F5-535 $cm^{-1}$. The Arctic cloud retrievals are shown in Table 11 and Figure 14.

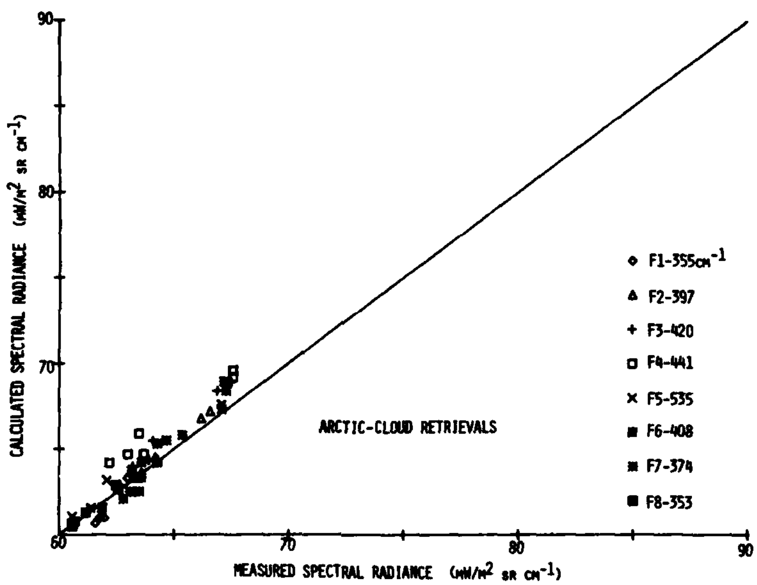


Figure 14. Measured and Calculated Overcast Radiances for DMSP SSH $H_2O$ Channels—Arctic

## 7. CONCLUSIONS

Comparisons have been made between DMSP SSH $H_2O$ measurements and classically-calculated water vapor radiances based on colocated in space and time radiosonde observations. Approximately 70 sets of radiance data were compared both in clear and cloud contaminated atmospheric conditions. In addition, the sets were divided into three latitude belts, that is, Tropical (26S-26N), Mid-latitude

(26-62N) and Arctic (62-90N). Systematic discrepancies, by approximately a 4:1 ratio, are shown for all of the DMSP SSH $H_2O$ channels in comparison to the calculated water vapor radiances. The calculated radiances generally exceed the measured radiances with DMSP SSH F3-420 $cm^{-1}$ channel showing the largest discrepancy. In the mean, the radiance comparison indicates a systematic discrepancy less than 5 percent for the clear column conditions. Results of this analysis, that is, calculated exceeds measured radiances, is in agreement with McClatchey's[3] results in his analysis of the 15 $\mu m$ carbon dioxide channels.

In the clear column comparisons, the discrepancies appear to be latitudinally dependent. Smaller discrepancies are found in the Tropics and the larger discrepancies are found in the Arctic latitude belt. This may be due to the moisture and temperature profiles representing the latitude belts, that is, Tropics—more moisture—higher atmospheric temperature and Arctic—less moisture and colder atmospheric temperature. As would be expected, the discrepancies are larger in the cloud contaminated cases because the upwelling radiation is coming from the cloud top level. However, in the low cloud contamination (less than 600 mb) the discrepancies are very similar to the clear column comparisons. Thus it appears that the DMSP SSH $H_2O$ channels cannot discriminate between low cloud contamination and clear column conditions. A cloud retrieval procedure was used to improve the relationship between the measured and calculated cloud contaminated water vapor radiances. However, when the calculated effective cloud level is compared to the 3D NEPH cloud conditions, the results are disappointing. In general, the effective cloud level is much higher than that given in the 3D NEPH data.

In view of these results, it appears that additional research should be done on the Forward Problem, that is, matching measurements with calculations. The single point or scan spot station comparison from Polar orbiting satellites has been disappointing. There is a definite need to delineate the Forward Problem discrepancy. Hopefully a study of spatial and temporal variations of the satellite radiance data and carefully selected "ground truth" sites will answer some of these discrepancies. It appears that a carefully designed research program using a geostationary satellite sounder such as the VISSR Atmospheric Sounder could provide some of the answers to the Forward Problem discrepancy.

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9. Barnes Engineering Co. (1976) Flight II—Supplementary Sensor H (SSH) Radiometric Performance, Report 2413-TA-012.

# Appendix A

## DMSP SSH $H_2O$ Filter Transmission Curves and Digitized Filter Functions

Filter transmission curves and digitized filter functions for the eight (8) DMSP SSH water vapor channels are provided in Appendix A. These curves and the digitized filter functions were obtained from a Barnes Engineering Company's Report[9] and are valid for Flight II SSH package aboard spacecraft WC 13536 launched in July 1977. These curves were used to calculate the water vapor transmittances and the resulting weighting functions.

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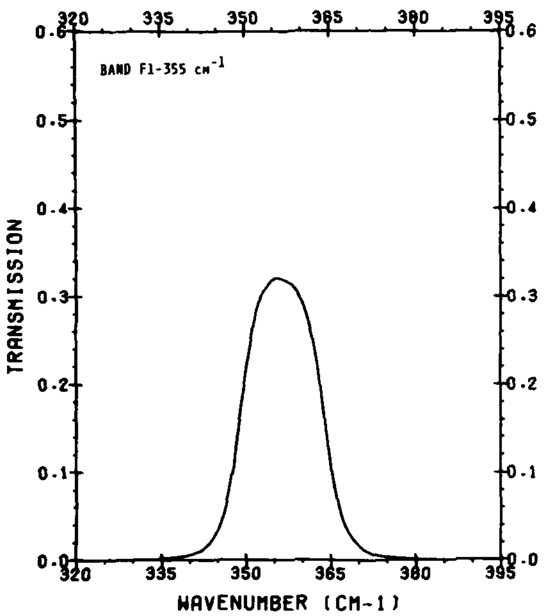
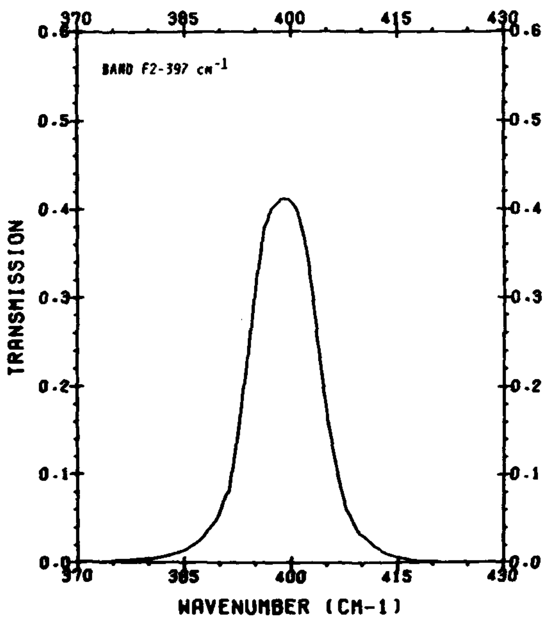
9. Barnes Engineering Co. (1976) Flight II-Supplementary Sensor H (SSH) Radiometric Performance, Report 2413-TA-012.




Band F1, 355 Wavenumber Channel

OMSP FILTER NO. 13536
355 WAVENUMBER CHANNEL
FREQUENCY STEP= .5 WAVENUMBERS

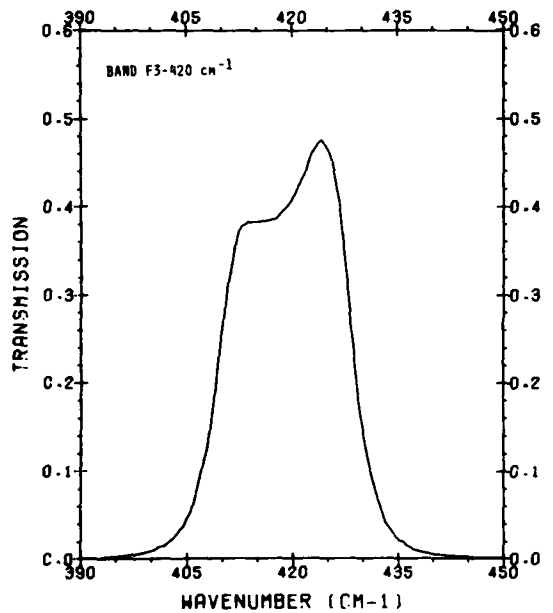
| FREQUENCY | FILTER TRANSMISSION | FREQUENCY | FILTER TRANSMISSION |
|---|---|---|---|
| 334.5 | .0011 | 358.5 | .3100 |
| 335.0 | .0012 | 359.0 | .3050 |
| 335.5 | .0015 | 359.5 | .2970 |
| 336.0 | .0017 | 360.0 | .2900 |
| 336.5 | .0020 | 360.5 | .2800 |
| 337.0 | .0024 | 361.0 | .2700 |
| 337.5 | .0028 | 361.5 | .2570 |
| 338.0 | .0033 | 362.0 | .2420 |
| 338.5 | .0039 | 362.5 | .2240 |
| 339.0 | .0045 | 363.0 | .2000 |
| 339.5 | .0053 | 363.5 | .1740 |
| 340.0 | .0063 | 364.0 | .1480 |
| 340.5 | .0074 | 364.5 | .1250 |
| 341.0 | .0087 | 365.0 | .1020 |
| 341.5 | .0100 | 365.5 | .0830 |
| 342.0 | .0120 | 366.0 | .0690 |
| 342.5 | .0150 | 366.5 | .0550 |
| 343.0 | .0180 | 367.0 | .0450 |
| 343.5 | .0220 | 367.5 | .0380 |
| 344.0 | .0270 | 368.0 | .0320 |
| 344.5 | .0320 | 368.5 | .0270 |
| 345.0 | .0390 | 369.0 | .0230 |
| 345.5 | .0490 | 369.5 | .0190 |
| 346.0 | .0610 | 370.0 | .0160 |
| 346.5 | .0770 | 370.5 | .0130 |
| 347.0 | .0950 | 371.0 | .0110 |
| 347.5 | .1020 | 371.5 | .0095 |
| 348.0 | .1320 | 372.0 | .0079 |
| 348.5 | .1500 | 372.5 | .0070 |
| 349.0 | .1820 | 373.0 | .0063 |
| 349.5 | .2030 | 373.5 | .0056 |
| 350.0 | .2260 | 374.0 | .0051 |
| 350.5 | .2440 | 374.5 | .0045 |
| 351.0 | .2650 | 375.0 | .0041 |
| 351.5 | .2820 | 375.5 | .0037 |
| 352.0 | .2930 | 376.0 | .0033 |
| 352.5 | .3000 | 376.5 | .0030 |
| 353.0 | .3060 | 377.0 | .0027 |
| 353.5 | .3100 | 377.5 | .0024 |
| 354.0 | .3150 | 378.0 | .0021 |
| 354.5 | .3180 | 378.5 | .0019 |
| 355.0 | .3200 | 379.0 | .0017 |
| 355.5 | .3210 | 379.5 | .0015 |
| 356.0 | .3200 | 380.0 | .0014 |
| 356.5 | .3190 | 380.5 | .0012 |
| 357.0 | .3180 | 381.0 | .0011 |
| 357.5 | .3160 | 381.5 | .0010 |
| 358.0 | .3140 | | |




Band F2, 397 Wavenumber Channel

DMSP FILTER NO. 13536
397 WAVENUMBER CHANNEL
FREQUENCY STEP= .5 WAVENUMBERS

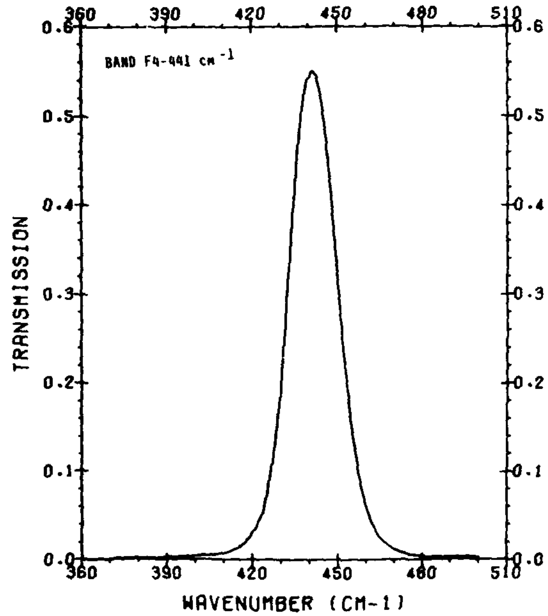
| FREQUENCY | FILTER TRANSMISSION | FREQUENCY | FILTER TRANSMISSION |
|---|---|---|---|
| 375.0 | .0010 | 398.5 | .4110 |
| 375.5 | .0012 | 399.0 | .4120 |
| 376.0 | .0014 | 399.5 | .4110 |
| 376.5 | .0016 | 400.0 | .4070 |
| 377.0 | .0018 | 400.5 | .4010 |
| 377.5 | .0020 | 401.0 | .3910 |
| 378.0 | .0023 | 401.5 | .3730 |
| 378.5 | .0027 | 402.0 | .3570 |
| 379.0 | .0030 | 402.5 | .3300 |
| 379.5 | .0035 | 403.0 | .2980 |
| 380.0 | .0040 | 403.5 | .2620 |
| 380.5 | .0046 | 404.0 | .2300 |
| 381.0 | .0052 | 404.5 | .1950 |
| 381.5 | .0060 | 405.0 | .1620 |
| 382.0 | .0068 | 405.5 | .1400 |
| 382.5 | .0078 | 406.0 | .1150 |
| 383.0 | .0089 | 406.5 | .0940 |
| 383.5 | .0100 | 407.0 | .0770 |
| 384.0 | .0120 | 407.5 | .0620 |
| 384.5 | .0130 | 408.0 | .0550 |
| 385.0 | .0150 | 408.5 | .0460 |
| 385.5 | .0180 | 409.0 | .0380 |
| 386.0 | .0200 | 409.5 | .0330 |
| 386.5 | .0230 | 410.0 | .0310 |
| 387.0 | .0260 | 410.5 | .0270 |
| 387.5 | .0300 | 411.0 | .0230 |
| 388.0 | .0370 | 411.5 | .0190 |
| 388.5 | .0420 | 412.0 | .0170 |
| 389.0 | .0460 | 412.5 | .0140 |
| 389.5 | .0530 | 413.0 | .0120 |
| 390.0 | .0630 | 413.5 | .0100 |
| 390.5 | .0750 | 414.0 | .0089 |
| 391.0 | .0880 | 414.5 | .0076 |
| 391.5 | .1050 | 415.0 | .0065 |
| 392.0 | .1200 | 415.5 | .0056 |
| 392.5 | .1560 | 416.0 | .0048 |
| 393.0 | .1890 | 416.5 | .0041 |
| 393.5 | .2150 | 417.0 | .0035 |
| 394.0 | .2480 | 417.5 | .0030 |
| 394.5 | .2890 | 418.0 | .0026 |
| 395.0 | .3220 | 418.5 | .0022 |
| 395.5 | .3480 | 419.0 | .0019 |
| 396.0 | .3700 | 419.5 | .0016 |
| 396.5 | .3950 | 420.0 | .0014 |
| 397.0 | .4000 | 420.5 | .0012 |
| 397.5 | .4030 | 421.0 | .0010 |
| 398.0 | .4070 | | |



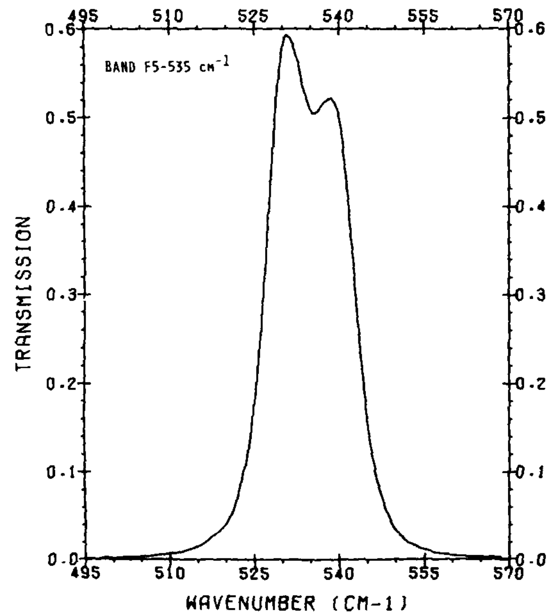

Band F3, 420 Wavenumber Channel

DMSP FILTER NO. 13536
420 WAVENUMBER CHANNEL
FREQUENCY STEP= .5 WAVENUMBERS

| FREQUENCY | FILTER TRANSMISSION | FREQUENCY | FILTER TRANSMISSION | FREQUENCY | FILTER TRANSMISSION |
|---|---|---|---|---|---|
| 393.0 | .0010 | 412.5 | .3770 | 432.0 | .0650 |
| 393.5 | .0012 | 413.0 | .3790 | 432.5 | .0550 |
| 394.0 | .0014 | 413.5 | .3820 | 433.0 | .0420 |
| 394.5 | .0017 | 414.0 | .3820 | 433.5 | .0360 |
| 395.0 | .0020 | 414.5 | .3820 | 434.0 | .0300 |
| 395.5 | .0023 | 415.0 | .3820 | 434.5 | .0250 |
| 396.0 | .0028 | 415.5 | .3830 | 435.0 | .0210 |
| 396.5 | .0034 | 416.0 | .3830 | 435.5 | .0200 |
| 397.0 | .0040 | 416.5 | .3840 | 436.0 | .0160 |
| 397.5 | .0045 | 417.0 | .3850 | 436.5 | .0140 |
| 398.0 | .0052 | 417.5 | .3860 | 437.0 | .0110 |
| 398.5 | .0060 | 418.0 | .3910 | 437.5 | .0100 |
| 399.0 | .0070 | 418.5 | .3950 | 438.0 | .0080 |
| 399.5 | .0082 | 419.0 | .4000 | 438.5 | .0078 |
| 400.0 | .0090 | 419.5 | .4050 | 439.0 | .0070 |
| 400.5 | .0120 | 420.0 | .4120 | 439.5 | .0062 |
| 401.0 | .0130 | 420.5 | .4200 | 440.0 | .0056 |
| 401.5 | .0140 | 421.0 | .4290 | 440.5 | .0050 |
| 402.0 | .0180 | 421.5 | .4360 | 441.0 | .0047 |
| 402.5 | .0220 | 422.0 | .4500 | 441.5 | .0042 |
| 403.0 | .0260 | 422.5 | .4600 | 442.0 | .0039 |
| 403.5 | .0320 | 423.0 | .4660 | 442.5 | .0035 |
| 404.0 | .0350 | 423.5 | .4720 | 443.0 | .0032 |
| 404.5 | .0440 | 424.0 | .4750 | 443.5 | .0030 |
| 405.0 | .0510 | 424.5 | .4700 | 444.0 | .0027 |
| 405.5 | .0630 | 425.0 | .4620 | 444.5 | .0025 |
| 406.0 | .0800 | 425.5 | .4500 | 445.0 | .0023 |
| 406.5 | .0950 | 426.0 | .4270 | 445.5 | .0021 |
| 407.0 | .1100 | 426.5 | .4030 | 446.0 | .0020 |
| 407.5 | .1250 | 427.0 | .3600 | 446.5 | .0018 |
| 408.0 | .1500 | 427.5 | .3200 | 447.0 | .0017 |
| 408.5 | .1800 | 428.0 | .2740 | 447.5 | .0016 |
| 409.0 | .2140 | 428.5 | .2400 | 448.0 | .0015 |
| 409.5 | .2500 | 429.0 | .1900 | 448.5 | .0014 |
| 410.0 | .2750 | 429.5 | .1600 | 449.0 | .0013 |
| 410.5 | .3100 | 430.0 | .1350 | 449.5 | .0012 |
| 411.0 | .3300 | 430.5 | .1120 | 450.0 | .0011 |
| 411.5 | .3520 | 431.0 | .0950 | 450.5 | .0010 |
| 412.0 | .3700 | 431.5 | .0800 | | |




Band F4, 441 Wavenumber Channel




Band F5, 535 Wavenumber Channel

EMSP FILTER NO. 13536
441 WAVENUMBER CHANNEL
FREQUENCY STEP= .5 WAVENUMBERS

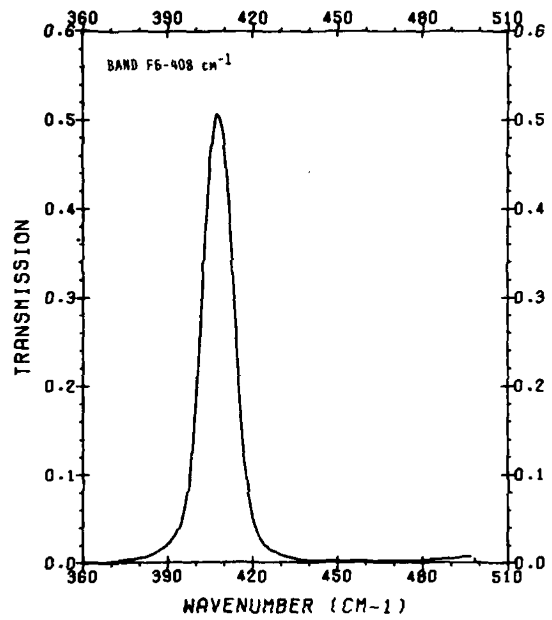
| FREQUENCY | FILTER TRANSMISSION | FREQUENCY | FILTER TRANSMISSION | FREQUENCY | FILTER TRANSMISSION | FREQUENCY | FILTER TRANSMISSION | FREQUENCY | FILTER TRANSMISSION |
|---|---|---|---|---|---|---|---|---|---|
| 371.0 | .0010 | 397.0 | .0030 | 423.0 | .0500 | 449.0 | .3660 | 475.0 | .0068 |
| 371.5 | .0010 | 397.5 | .0031 | 423.5 | .0550 | 449.5 | .3450 | 475.5 | .0064 |
| 372.0 | .0010 | 398.0 | .0032 | 424.0 | .0620 | 450.0 | .3260 | 476.0 | .0062 |
| 372.5 | .0011 | 398.5 | .0033 | 424.5 | .0680 | 450.5 | .3040 | 476.5 | .0059 |
| 373.0 | .0011 | 399.0 | .0034 | 425.0 | .0750 | 451.0 | .2800 | 477.0 | .0055 |
| 373.5 | .0011 | 399.5 | .0036 | 425.5 | .0850 | 451.5 | .2500 | 477.5 | .0052 |
| 374.0 | .0011 | 400.0 | .0037 | 426.0 | .0940 | 452.0 | .2410 | 478.0 | .0050 |
| 374.5 | .0012 | 400.5 | .0038 | 426.5 | .1030 | 452.5 | .2240 | 478.5 | .0048 |
| 375.0 | .0012 | 401.0 | .0039 | 427.0 | .1130 | 453.0 | .2070 | 479.0 | .0046 |
| 375.5 | .0012 | 401.5 | .0041 | 427.5 | .1240 | 453.5 | .1900 | 479.5 | .0043 |
| 376.0 | .0012 | 402.0 | .0042 | 428.0 | .1350 | 454.0 | .1750 | 480.0 | .0041 |
| 376.5 | .0012 | 402.5 | .0043 | 428.5 | .1400 | 454.5 | .1570 | 480.5 | .0039 |
| 377.0 | .0013 | 403.0 | .0044 | 429.0 | .1620 | 455.0 | .1440 | 481.0 | .0037 |
| 377.5 | .0013 | 403.5 | .0045 | 429.5 | .1750 | 455.5 | .1310 | 481.5 | .0036 |
| 378.0 | .0013 | 404.0 | .0046 | 430.0 | .1920 | 456.0 | .1220 | 482.0 | .0034 |
| 378.5 | .0014 | 404.5 | .0047 | 430.5 | .2120 | 456.5 | .1100 | 482.5 | .0033 |
| 379.0 | .0014 | 405.0 | .0048 | 431.0 | .2320 | 457.0 | .1000 | 483.0 | .0032 |
| 379.5 | .0015 | 405.5 | .0050 | 431.5 | .2510 | 457.5 | .0930 | 483.5 | .0031 |
| 380.0 | .0015 | 406.0 | .0052 | 432.0 | .2700 | 458.0 | .0840 | 484.0 | .0030 |
| 380.5 | .0015 | 406.5 | .0054 | 432.5 | .3030 | 458.5 | .0770 | 484.5 | .0030 |
| 381.0 | .0015 | 407.0 | .0055 | 433.0 | .3250 | 459.0 | .0700 | 485.0 | .0029 |
| 381.5 | .0015 | 407.5 | .0056 | 433.5 | .3450 | 459.5 | .0640 | 485.5 | .0029 |
| 382.0 | .0015 | 408.0 | .0058 | 434.0 | .3700 | 460.0 | .0580 | 486.0 | .0028 |
| 382.5 | .0015 | 408.5 | .0062 | 434.5 | .3950 | 460.5 | .0530 | 486.5 | .0028 |
| 383.0 | .0015 | 409.0 | .0064 | 435.0 | .4150 | 461.0 | .0480 | 487.0 | .0028 |
| 383.5 | .0016 | 409.5 | .0066 | 435.5 | .4360 | 461.5 | .0440 | 487.5 | .0027 |
| 384.0 | .0017 | 410.0 | .0070 | 436.0 | .4570 | 462.0 | .0400 | 488.0 | .0027 |
| 384.5 | .0017 | 410.5 | .0073 | 436.5 | .4740 | 462.5 | .0370 | 488.5 | .0027 |
| 385.0 | .0017 | 411.0 | .0076 | 437.0 | .4920 | 463.0 | .0340 | 489.0 | .0027 |
| 385.5 | .0018 | 411.5 | .0082 | 437.5 | .5050 | 463.5 | .0310 | 489.5 | .0027 |
| 386.0 | .0018 | 412.0 | .0088 | 438.0 | .5150 | 464.0 | .0290 | 490.0 | .0027 |
| 386.5 | .0018 | 412.5 | .0094 | 438.5 | .5260 | 464.5 | .0270 | 490.5 | .0026 |
| 387.0 | .0019 | 413.0 | .0100 | 439.0 | .5330 | 465.0 | .0250 | 491.0 | .0026 |
| 387.5 | .0019 | 413.5 | .0110 | 439.5 | .5400 | 465.5 | .0230 | 491.5 | .0026 |
| 388.0 | .0020 | 414.0 | .0115 | 440.0 | .5420 | 466.0 | .0210 | 492.0 | .0025 |
| 388.5 | .0020 | 414.5 | .0122 | 440.5 | .5470 | 466.5 | .0200 | 492.5 | .0025 |
| 389.0 | .0021 | 415.0 | .0130 | 441.0 | .5500 | 467.0 | .0190 | 493.0 | .0025 |
| 389.5 | .0021 | 415.5 | .0150 | 441.5 | .5490 | 467.5 | .0170 | 493.5 | .0025 |
| 390.0 | .0022 | 416.0 | .0160 | 442.0 | .5470 | 468.0 | .0160 | 494.0 | .0025 |
| 390.5 | .0023 | 416.5 | .0170 | 442.5 | .5450 | 468.5 | .0150 | 494.5 | .0025 |
| 391.0 | .0023 | 417.0 | .0180 | 443.0 | .5390 | 469.0 | .0140 | 495.0 | .0026 |
| 391.5 | .0024 | 417.5 | .0200 | 443.5 | .5330 | 469.5 | .0130 | 495.5 | .0026 |
| 392.0 | .0024 | 418.0 | .0220 | 444.0 | .5250 | 470.0 | .0120 | 496.0 | .0026 |
| 392.5 | .0024 | 418.5 | .0230 | 444.5 | .5160 | 470.5 | .0110 | 496.5 | .0026 |
| 393.0 | .0025 | 419.0 | .0250 | 445.0 | .5030 | 471.0 | .0110 | 497.0 | .0026 |
| 393.5 | .0025 | 419.5 | .0280 | 445.5 | .4880 | 471.5 | .0098 | 497.5 | .0027 |
| 394.0 | .0026 | 420.0 | .0310 | 446.0 | .4750 | 472.0 | .0093 | 498.0 | .0027 |
| 394.5 | .0026 | 420.5 | .0330 | 446.5 | .4600 | 472.5 | .0087 | 498.5 | .0027 |
| 395.0 | .0027 | 421.0 | .0360 | 447.0 | .4430 | 473.0 | .0082 | 499.0 | .0028 |
| 395.5 | .0027 | 421.5 | .0410 | 447.5 | .4220 | 473.5 | .0078 | 499.5 | .0028 |
| 396.0 | .0028 | 422.0 | .0440 | 448.0 | .4040 | 474.0 | .0074 | 500.0 | .0029 |
| 396.5 | .0029 | 422.5 | .0470 | 448.5 | .3850 | 474.5 | .0070 | | |

Band F4, 441 Wavenumber Channel

DMSP FILTER NO. 13536
535 WAVENUMBER CHANNEL
FREQUENCY STEP= .5 WAVENUMBERS

| FREQUENCY | FILTER TRANSMISSION | FREQUENCY | FILTER TRANSMISSION | FREQUENCY | FILTER TRANSMISSION |
|---|---|---|---|---|---|
| 497.5 | .0010 | 521.5 | .0670 | 545.5 | .1210 |
| 498.0 | .0011 | 522.0 | .0800 | 546.0 | .1050 |
| 498.5 | .0011 | 522.5 | .0930 | 546.5 | .0890 |
| 499.0 | .0012 | 523.0 | .1070 | 547.0 | .0780 |
| 499.5 | .0013 | 523.5 | .1220 | 547.5 | .0670 |
| 500.0 | .0014 | 524.0 | .1390 | 548.0 | .0570 |
| 500.5 | .0015 | 524.5 | .1700 | 548.5 | .0500 |
| 501.0 | .0016 | 525.0 | .1990 | 549.0 | .0420 |
| 501.5 | .0017 | 525.5 | .2340 | 549.5 | .0360 |
| 502.0 | .0018 | 526.0 | .2700 | 550.0 | .0320 |
| 502.5 | .0019 | 526.5 | .3240 | 550.5 | .0290 |
| 503.0 | .0021 | 527.0 | .3730 | 551.0 | .0270 |
| 503.5 | .0022 | 527.5 | .4240 | 551.5 | .0230 |
| 504.0 | .0024 | 528.0 | .4710 | 552.0 | .0200 |
| 504.5 | .0026 | 528.5 | .5180 | 552.5 | .0190 |
| 505.0 | .0028 | 529.0 | .5490 | 553.0 | .0170 |
| 505.5 | .0030 | 529.5 | .5760 | 553.5 | .0160 |
| 506.0 | .0032 | 530.0 | .5900 | 554.0 | .0140 |
| 506.5 | .0035 | 530.5 | .5930 | 554.5 | .0130 |
| 507.0 | .0038 | 531.0 | .5900 | 555.0 | .0120 |
| 507.5 | .0041 | 531.5 | .5830 | 555.5 | .0110 |
| 508.0 | .0044 | 532.0 | .5710 | 556.0 | .0100 |
| 508.5 | .0049 | 532.5 | .5620 | 556.5 | .0091 |
| 509.0 | .0054 | 533.0 | .5420 | 557.0 | .0086 |
| 509.5 | .0059 | 533.5 | .5310 | 557.5 | .0079 |
| 510.0 | .0064 | 534.0 | .5210 | 558.0 | .0074 |
| 510.5 | .0068 | 534.5 | .5110 | 558.5 | .0069 |
| 511.0 | .0076 | 535.0 | .5050 | 559.0 | .0065 |
| 511.5 | .0082 | 535.5 | .5050 | 559.5 | .0061 |
| 512.0 | .0090 | 536.0 | .5070 | 560.0 | .0058 |
| 512.5 | .0100 | 536.5 | .5120 | 560.5 | .0054 |
| 513.0 | .0110 | 537.0 | .5160 | 561.0 | .0052 |
| 513.5 | .0120 | 537.5 | .5180 | 561.5 | .0049 |
| 514.0 | .0130 | 538.0 | .5210 | 562.0 | .0046 |
| 514.5 | .0150 | 538.5 | .5220 | 562.5 | .0043 |
| 515.0 | .0160 | 539.0 | .5170 | 563.0 | .0041 |
| 515.5 | .0180 | 539.5 | .5000 | 563.5 | .0039 |
| 516.0 | .0200 | 540.0 | .4900 | 564.0 | .0037 |
| 516.5 | .0220 | 540.5 | .4620 | 564.5 | .0035 |
| 517.0 | .0250 | 541.0 | .4310 | 565.0 | .0034 |
| 517.5 | .0270 | 541.5 | .3990 | 565.5 | .0033 |
| 518.0 | .0300 | 542.0 | .3560 | 566.0 | .0032 |
| 518.5 | .0330 | 542.5 | .3190 | 566.5 | .0030 |
| 519.0 | .0360 | 543.0 | .2720 | 567.0 | .0029 |
| 519.5 | .0390 | 543.5 | .2370 | 567.5 | .0028 |
| 520.0 | .0440 | 544.0 | .2020 | 568.0 | .0026 |
| 520.5 | .0500 | 544.5 | .1690 | 568.5 | .0025 |
| 521.0 | .0580 | 545.0 | .1420 | | |

Band F5, 535 Wavenumber Channel

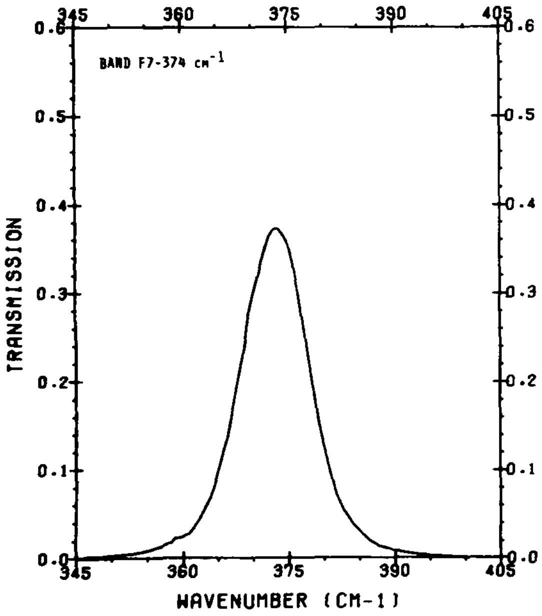



Band F6, 408 Wavenumber Channel

DMSP FILTER NO. 13536
408 WAVENUMBER CHANNEL
FREQUENCY STEP= .5 WAVENUMBERS

| FREQUENCY | FILTER TRANSMISSION | FREQUENCY | FILTER TRANSMISSION | FREQUENCY | FILTER TRANSMISSION | FREQUENCY | FILTER TRANSMISSION | FREQUENCY | FILTER TRANSMISSION |
|---|---|---|---|---|---|---|---|---|---|
| 368.0 | .0010 | 394.0 | .0410 | 420.0 | .0450 | 446.0 | .0017 | 472.0 | .0013 |
| 368.5 | .0011 | 394.5 | .0470 | 420.5 | .0400 | 446.5 | .0017 | 472.5 | .0014 |
| 369.0 | .0011 | 395.0 | .0530 | 421.0 | .0370 | 447.0 | .0017 | 473.0 | .0014 |
| 369.5 | .0012 | 395.5 | .0600 | 421.5 | .0340 | 447.5 | .0016 | 473.5 | .0015 |
| 370.0 | .0013 | 396.0 | .0700 | 422.0 | .0300 | 448.0 | .0016 | 474.0 | .0015 |
| 370.5 | .0014 | 396.5 | .0770 | 422.5 | .0270 | 448.5 | .0016 | 474.5 | .0016 |
| 371.0 | .0015 | 397.0 | .0880 | 423.0 | .0250 | 449.0 | .0015 | 475.0 | .0016 |
| 371.5 | .0016 | 397.5 | .1020 | 423.5 | .0220 | 449.5 | .0014 | 475.5 | .0017 |
| 372.0 | .0017 | 398.0 | .1230 | 424.0 | .0200 | 450.0 | .0014 | 476.0 | .0017 |
| 372.5 | .0018 | 398.5 | .1380 | 424.5 | .0190 | 450.5 | .0013 | 476.5 | .0017 |
| 373.0 | .0019 | 399.0 | .1600 | 425.0 | .0180 | 451.0 | .0012 | 477.0 | .0018 |
| 373.5 | .0020 | 399.5 | .1850 | 425.5 | .0160 | 451.5 | .0012 | 477.5 | .0018 |
| 374.0 | .0021 | 400.0 | .2090 | 426.0 | .0150 | 452.0 | .0011 | 478.0 | .0018 |
| 374.5 | .0023 | 400.5 | .2330 | 426.5 | .0140 | 452.5 | .0011 | 478.5 | .0018 |
| 375.0 | .0024 | 401.0 | .2660 | 427.0 | .0130 | 453.0 | .0010 | 479.0 | .0019 |
| 375.5 | .0026 | 401.5 | .2950 | 427.5 | .0130 | 453.5 | .0010 | 479.5 | .0019 |
| 376.0 | .0027 | 402.0 | .3250 | 428.0 | .0120 | 454.0 | .0010 | 480.0 | .0019 |
| 376.5 | .0029 | 402.5 | .3550 | 428.5 | .0110 | 454.5 | .0010 | 480.5 | .0020 |
| 377.0 | .0031 | 403.0 | .3830 | 429.0 | .0100 | 455.0 | .0011 | 481.0 | .0021 |
| 377.5 | .0033 | 403.5 | .4000 | 429.5 | .0095 | 455.5 | .0011 | 481.5 | .0022 |
| 378.0 | .0035 | 404.0 | .4320 | 430.0 | .0089 | 456.0 | .0011 | 482.0 | .0023 |
| 378.5 | .0038 | 404.5 | .4520 | 430.5 | .0083 | 456.5 | .0011 | 482.5 | .0025 |
| 379.0 | .0041 | 405.0 | .4690 | 431.0 | .0078 | 457.0 | .0011 | 483.0 | .0026 |
| 379.5 | .0044 | 405.5 | .4860 | 431.5 | .0073 | 457.5 | .0011 | 483.5 | .0028 |
| 380.0 | .0047 | 406.0 | .4950 | 432.0 | .0068 | 458.0 | .0011 | 484.0 | .0029 |
| 380.5 | .0051 | 406.5 | .5040 | 432.5 | .0064 | 458.5 | .0011 | 484.5 | .0030 |
| 381.0 | .0055 | 407.0 | .5060 | 433.0 | .0060 | 459.0 | .0011 | 485.0 | .0031 |
| 381.5 | .0059 | 407.5 | .5040 | 433.5 | .0056 | 459.5 | .0011 | 485.5 | .0032 |
| 382.0 | .0064 | 408.0 | .4990 | 434.0 | .0052 | 460.0 | .0011 | 486.0 | .0032 |
| 382.5 | .0069 | 408.5 | .4920 | 434.5 | .0049 | 460.5 | .0011 | 486.5 | .0033 |
| 383.0 | .0075 | 409.0 | .4820 | 435.0 | .0045 | 461.0 | .0012 | 487.0 | .0035 |
| 383.5 | .0080 | 409.5 | .4680 | 435.5 | .0043 | 461.5 | .0012 | 487.5 | .0036 |
| 384.0 | .0087 | 410.0 | .4500 | 436.0 | .0040 | 462.0 | .0012 | 488.0 | .0037 |
| 384.5 | .0093 | 410.5 | .4270 | 436.5 | .0038 | 462.5 | .0012 | 488.5 | .0038 |
| 385.0 | .0100 | 411.0 | .4070 | 437.0 | .0036 | 463.0 | .0012 | 489.0 | .0039 |
| 385.5 | .0110 | 411.5 | .3800 | 437.5 | .0034 | 463.5 | .0012 | 489.5 | .0040 |
| 386.0 | .0120 | 412.0 | .3510 | 438.0 | .0032 | 464.0 | .0012 | 490.0 | .0041 |
| 386.5 | .0130 | 412.5 | .3200 | 438.5 | .0030 | 464.5 | .0012 | 490.5 | .0043 |
| 387.0 | .0140 | 413.0 | .2950 | 439.0 | .0029 | 465.0 | .0012 | 491.0 | .0046 |
| 387.5 | .0150 | 413.5 | .2700 | 439.5 | .0027 | 465.5 | .0012 | 491.5 | .0048 |
| 388.0 | .0160 | 414.0 | .2300 | 440.0 | .0025 | 466.0 | .0012 | 492.0 | .0050 |
| 388.5 | .0170 | 414.5 | .2050 | 440.5 | .0024 | 466.5 | .0012 | 492.5 | .0053 |
| 389.0 | .0180 | 415.0 | .1760 | 441.0 | .0023 | 467.0 | .0013 | 493.0 | .0055 |
| 389.5 | .0200 | 415.5 | .1570 | 441.5 | .0022 | 467.5 | .0013 | 493.5 | .0058 |
| 390.0 | .0210 | 416.0 | .1300 | 442.0 | .0020 | 468.0 | .0013 | 494.0 | .0060 |
| 390.5 | .0230 | 416.5 | .1180 | 442.5 | .0020 | 468.5 | .0013 | 494.5 | .0062 |
| 391.0 | .0250 | 417.0 | .1050 | 443.0 | .0019 | 469.0 | .0013 | 495.0 | .0063 |
| 391.5 | .0270 | 417.5 | .0930 | 443.5 | .0019 | 469.5 | .0013 | 495.5 | .0065 |
| 392.0 | .0290 | 418.0 | .0800 | 444.0 | .0019 | 470.0 | .0013 | 496.0 | .0066 |
| 392.5 | .0320 | 418.5 | .0700 | 444.5 | .0019 | 470.5 | .0013 | 496.5 | .0068 |
| 393.0 | .0350 | 419.0 | .0610 | 445.0 | .0018 | 471.0 | .0013 | 497.0 | .0071 |
| 393.5 | .0370 | 419.5 | .0520 | 445.5 | .0018 | 471.5 | .0013 | 497.5 | .0073 |

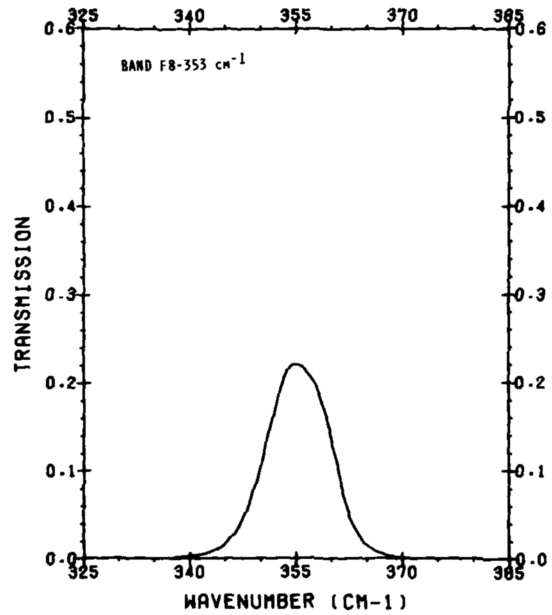
Band F6, 408 Wavenumber Channel




Band F7, 374 Wavenumber Channel

DMSP FILTER NO. 13536
374 WAVENUMBER CHANNEL
FREQUENCY STEP= .5 WAVENUMBERS

| FREQUENCY | FILTER TRANSMISSION | FREQUENCY | FILTER TRANSMISSION | FREQUENCY | FILTER TRANSMISSION |
|---|---|---|---|---|---|
| 346.0 | .0010 | 364.5 | .0920 | 382.5 | .0560 |
| 346.5 | .0011 | 365.0 | .1070 | 383.0 | .0500 |
| 347.0 | .0013 | 365.5 | .1230 | 383.5 | .0440 |
| 347.5 | .0014 | 366.0 | .1350 | 384.0 | .0380 |
| 348.0 | .0015 | 366.5 | .1550 | 384.5 | .0340 |
| 348.5 | .0017 | 367.0 | .1760 | 385.0 | .0300 |
| 349.0 | .0020 | 367.5 | .1980 | 385.5 | .0260 |
| 349.5 | .0022 | 368.0 | .2200 | 386.0 | .0220 |
| 350.0 | .0025 | 368.5 | .2390 | 386.5 | .0190 |
| 350.5 | .0028 | 369.0 | .2700 | 387.0 | .0170 |
| 351.0 | .0032 | 369.5 | .2880 | 387.5 | .0140 |
| 351.5 | .0036 | 370.0 | .3040 | 388.0 | .0130 |
| 352.0 | .0040 | 370.5 | .3180 | 388.5 | .0120 |
| 352.5 | .0045 | 371.0 | .3350 | 389.0 | .0110 |
| 353.0 | .0052 | 371.5 | .3490 | 389.5 | .0095 |
| 353.5 | .0058 | 372.0 | .3620 | 390.0 | .0086 |
| 354.0 | .0065 | 372.5 | .3690 | 390.5 | .0077 |
| 354.5 | .0074 | 373.0 | .3730 | 391.0 | .0069 |
| 355.0 | .0084 | 373.5 | .3720 | 391.5 | .0062 |
| 355.5 | .0094 | 374.0 | .3670 | 392.0 | .0056 |
| 356.0 | .0110 | 374.5 | .3600 | 392.5 | .0050 |
| 356.5 | .0120 | 375.0 | .3500 | 393.0 | .0045 |
| 357.0 | .0140 | 375.5 | .3320 | 393.5 | .0040 |
| 357.5 | .0160 | 376.0 | .3100 | 394.0 | .0036 |
| 358.0 | .0170 | 376.5 | .2870 | 394.5 | .0032 |
| 358.5 | .0220 | 377.0 | .2610 | 395.0 | .0024 |
| 359.0 | .0220 | 377.5 | .2340 | 395.5 | .0026 |
| 359.5 | .0230 | 378.0 | .2080 | 396.0 | .0023 |
| 360.0 | .0250 | 378.5 | .1850 | 396.5 | .0021 |
| 360.5 | .0270 | 379.0 | .1580 | 397.0 | .0019 |
| 361.0 | .0320 | 379.5 | .1380 | 397.5 | .0017 |
| 361.5 | .0380 | 380.0 | .1200 | 398.0 | .0015 |
| 362.0 | .0440 | 380.5 | .1030 | 398.5 | .0014 |
| 362.5 | .0520 | 381.0 | .0870 | 399.0 | .0012 |
| 363.0 | .0600 | 381.5 | .0730 | 399.5 | .0011 |
| 363.5 | .0670 | 382.0 | .0659 | 400.0 | .0010 |
| 364.0 | .0780 | | | | |




Band F8, 353 Wavenumber Channel

DWSP FILTER NO. 13536
353 WAVENUMBER CHANNEL
FREQUENCY STEP= .5 WAVENUMBERS

| FREQUENCY | FILTER TRANSMISSION | FREQUENCY | FILTER TRANSMISSION |
|---|---|---|---|
| 337.5 | .0009 | 354.5 | .2200 |
| 338.0 | .0011 | 355.0 | .2210 |
| 338.5 | .0013 | 355.5 | .2190 |
| 339.0 | .0016 | 356.0 | .2150 |
| 339.5 | .0020 | 356.5 | .2100 |
| 340.0 | .0025 | 357.0 | .2040 |
| 340.5 | .0030 | 357.5 | .1980 |
| 341.0 | .0037 | 358.0 | .1860 |
| 341.5 | .0045 | 358.5 | .1740 |
| 342.0 | .0054 | 359.0 | .1610 |
| 342.5 | .0067 | 359.5 | .1450 |
| 343.0 | .0082 | 360.0 | .1250 |
| 343.5 | .0100 | 360.5 | .1100 |
| 344.0 | .0120 | 361.0 | .0900 |
| 344.5 | .0150 | 361.5 | .0720 |
| 345.0 | .0190 | 362.0 | .0580 |
| 345.5 | .0240 | 362.5 | .0460 |
| 346.0 | .0280 | 363.0 | .0370 |
| 346.5 | .0340 | 363.5 | .0300 |
| 347.0 | .0420 | 364.0 | .0230 |
| 347.5 | .0510 | 364.5 | .0180 |
| 348.0 | .0610 | 365.0 | .0150 |
| 348.5 | .0750 | 365.5 | .0120 |
| 349.0 | .0860 | 366.0 | .0092 |
| 349.5 | .1000 | 366.5 | .0073 |
| 350.0 | .1150 | 367.0 | .0057 |
| 350.5 | .1340 | 367.5 | .0046 |
| 351.0 | .1500 | 368.0 | .0036 |
| 351.5 | .1630 | 368.5 | .0028 |
| 352.0 | .1790 | 369.0 | .0022 |
| 352.5 | .1930 | 369.5 | .0018 |
| 353.0 | .2050 | 370.0 | .0014 |
| 353.5 | .2130 | 370.5 | .0011 |
| 354.0 | .2180 | 371.0 | .0009 |

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