P5.31

A TEST OF THE PETTY AND KATSAROS (1994) INCIDENCE ANGLE CORRECTION IN A FORWARD MODEL

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1. INTRODUCTION

In microwave radiative transfer (RT) models, upwelling brightness temperatures (TB's) over an ocean background are generally computed by following the path of a single beam of radiation with specular reflection off a horizontal plane surface. While models generally allow for the variation of surface emissivity with surface roughness, another effect is often neglected. The upwelling radiation at zenith angle θ actually includes contributions from a range of incidence angles, due to the variation of surface slope within the field of view. Petty and Katsaros (1994) derived a parameterization (at Special Sensor Microwave Imager (SSM/I) frequencies and view angle) for an effective sky radiation angle θ' which could be used as the angle of a single beam of downwelling radiation in an RT model. This parameterized incidence angle is tested in this paper.

2. PROCEDURE

The Petty and Katsaros (PK) incidence angle correction was tested using simulations in the following manner. A set of 20 different atmospheres (together with surface temperature and wind speed) was compiled. These were taken from NOGAPS model atmospheres at various points around the globe. In nine of the cases, clouds were assigned (with total cloud liquid water ranging up to 0.2 mm) and the relevant levels were saturated. Simulated SSM/I TB's were calculated with the downwelling radiation angle set to 1) the upwelling radiation angle θ (simple reflection off a horizontal plane), and 2) the corrected sky radiation angle θ'. Table 1 gives values for the mean TB's for each channel with each computation method. In all cases the corrected TB is higher since the PK correction always gives a lower (less steep) incidence angle and hence a greater optical depth.

Table 1. Mean calculated brightness temperatures before and after the Petty and Katsaros correction.

Channel	Mean TB (Original)	Mean TB (Corrected)	Difference
19V	200.4 K	201.6 K	1.2 K
19H	140.8	143.9	3.0
22V	226.4	227.4	1.0
37V	217.8	218.8	1.0
37H	160.2	164.9	4.7
85V	257.7	257.9	0.2
85H	224.7	228.9	4.2

Next, for each atmosphere, simulated retrieved values of precipitable water (PW) and surface wind speed (SWS) were computed from the Environmental Data Record (EDR) algorithms of the SSM/I Algorithm Specification Document (Raytheon Systems Company, 2000). The SWS algorithm is more fully described by Goodberlet et al. (1990). The EDR algorithms were derived by regression with buoy-observed SWS and radiosonde-observed PW. Because these algorithms were empirically derived from relationships between TB and observed parameters in the real atmosphere, they provide a test for RT models. Inputting a more realistic set of TB's into the EDR algorithms is expected to more closely reproduce the model EDR values. Results from this experiment are shown in Table 2.

Table 2. Results from simulated retrievals for uncorrected and corrected brightness temperatures.

	Surface Wind Speed [m/s]	Precipitable Water [cm]
Mean	9.53	2.88
Bias(Original)	-2.54	-0.01
Bias(Corrected)	0.27	0.03
Standard Deviation of Error (Original)	0.85	0.25
Standard Deviation of Error (Corrected)	1.31	0.26
RMS Error (Original)	2.67	0.24
RMS Error (Corrected)	1.30	0.25

3. RESULTS AND ANALYSIS

The PK correction improved the RMS error for SWS from 2.67 m s^{-1} (40% of the mean) to 1.30 m s^{-1} (21% of the mean). The correction had very little effect on the retrieved PW. This can be explained because 1) proper retrieval of SWS is dependent on accurate modeling of surface effects, and 2) the PW EDR uses channels less affected by the incidence angle correction.

Most of the improvement in SWS is due to the reduction of a systematic bias in the uncorrected TB's, so it is possible that the correction is just compensating for another systematic error in the RT model. However, given the systematic TB correction and the fact that the EDR algorithm for SWS is a linear combination of Tb's, a systematic change in retrieved EDR values is

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expected. This experiment shows that the effective incidence angle correction given by Petty and Katsaros (1994) does introduce a significant improvement to simulated retrievals of SWS.

4. REFERENCES

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