Some Issues on the Microwave Remote Sensing of Clouds

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Abstract

Various techniques of microwave remote sensing of atmosphere have been developed and much improved in a last decade. The developed algorithms have been successfully applied to satellite microwave radiometer measurements, particularly to SSM/I. Some issues, however, have been pointed out regarding microwave remote sensing of cloud and precipitation. One of the most important but difficult issues is the beam filling error due to wide field of view. Another one is vertical profile of clouds although it has not been paid much attention. Physical retrieval methods using radiative transfer have become much popular in the microwave remote sensing. Since complex refractive index of water and ice strongly depend on the temperature in these spectral regions, radiative transfer calculation should take it into account. The vertical profile of cloud liquid water content, as well as water vapor, cannot be obtained in advance in the satellite data analysis. Therefore some errors occur from the uncertainties in atmospheric profiles.

In this study some results from simulation of satellite remote sensing of clouds are presented, focusing on the vertical profiles of clouds. Also reports will be presented for results from a microwave-infrared combined measurements from ground surface. Based on these results, the possibility and effectivity of the spaceborne lidar will be discussed for remote sensing of clouds.

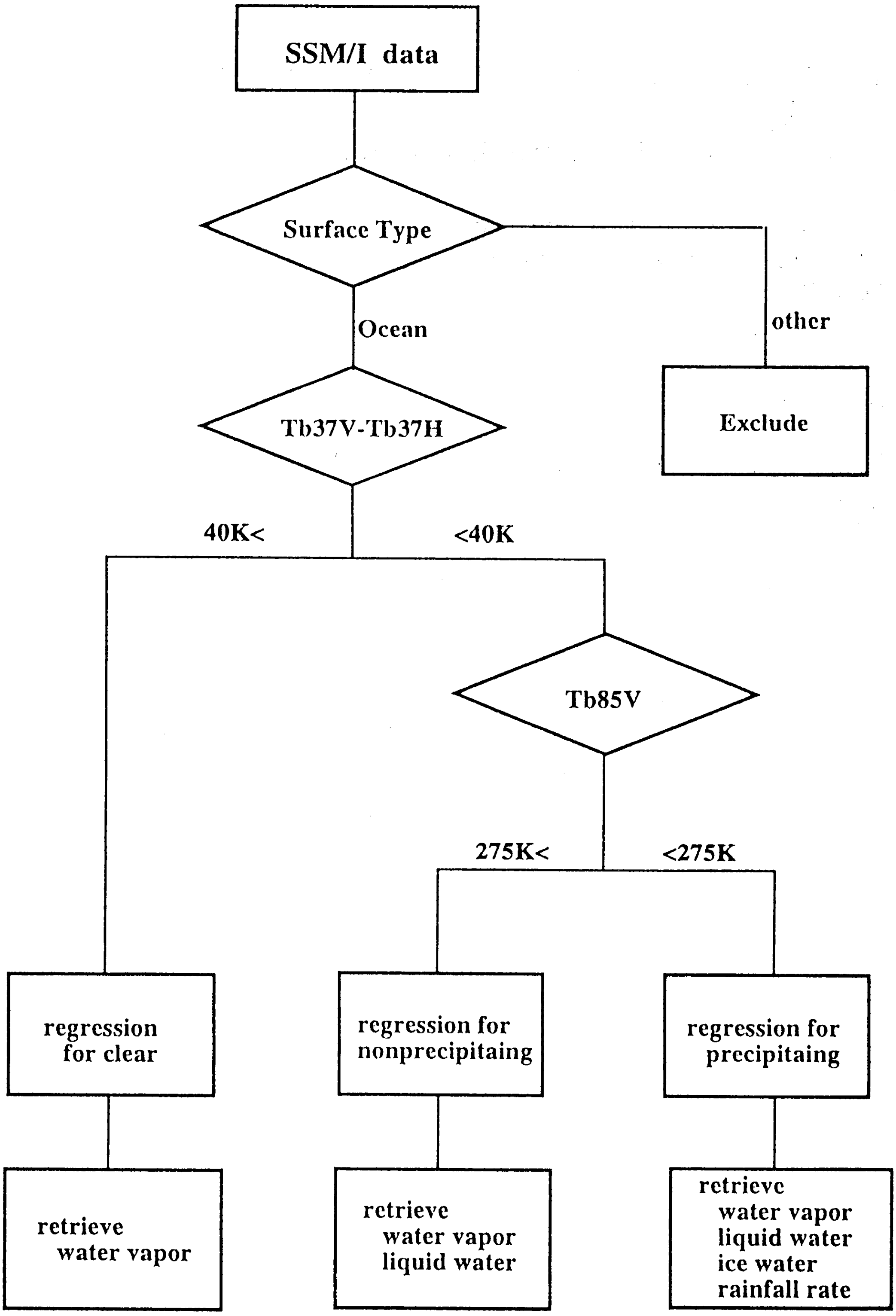

SSM/I data
Surface Type
Ocean
other
Exclude
Tb37V-Tb37H
40K<
<40K
Tb85V
275K<
<275K
regression for clear
regression for nonprecipitaing
regression for precipitaing
retrieve water vapor
retrieve water vapor liquid water
retrieve water vapor liquid water ice water rainfall rate

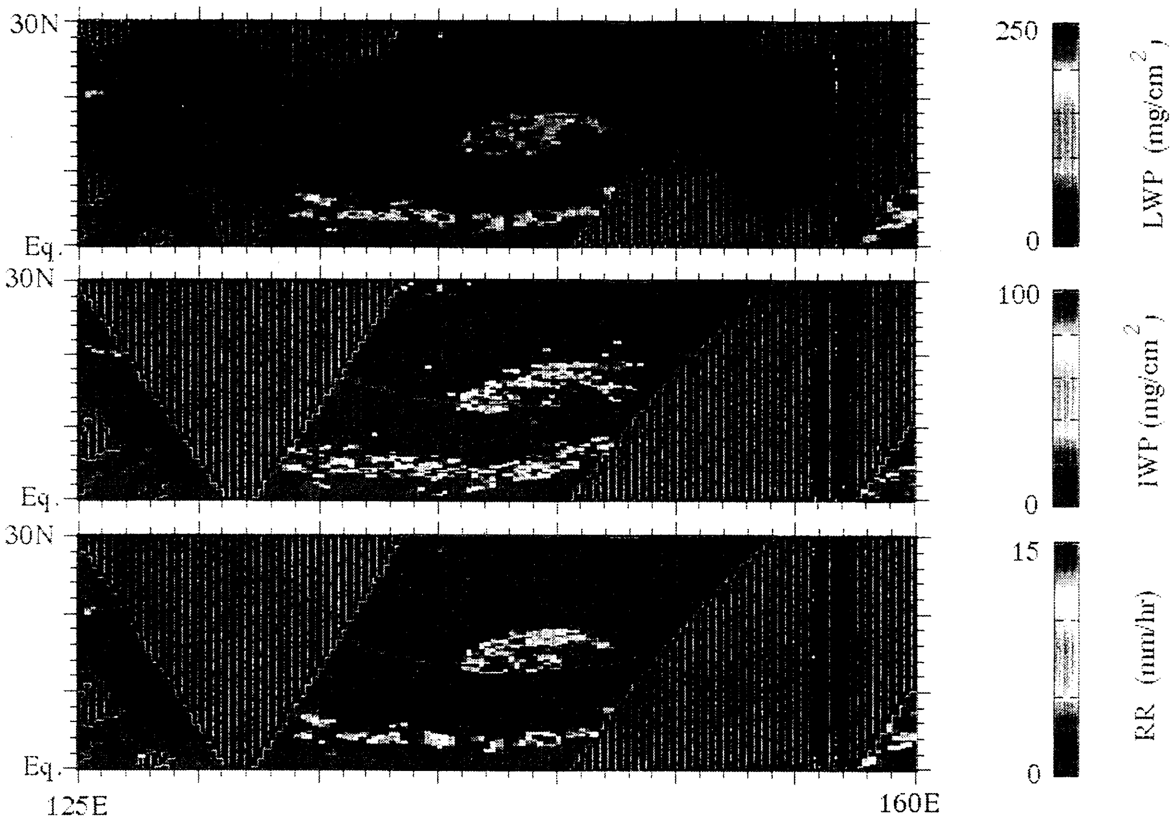
図. 3-1　解析の流れ

$$Q = a_0 + \Sigma\, a_i * T_{Bi}$$

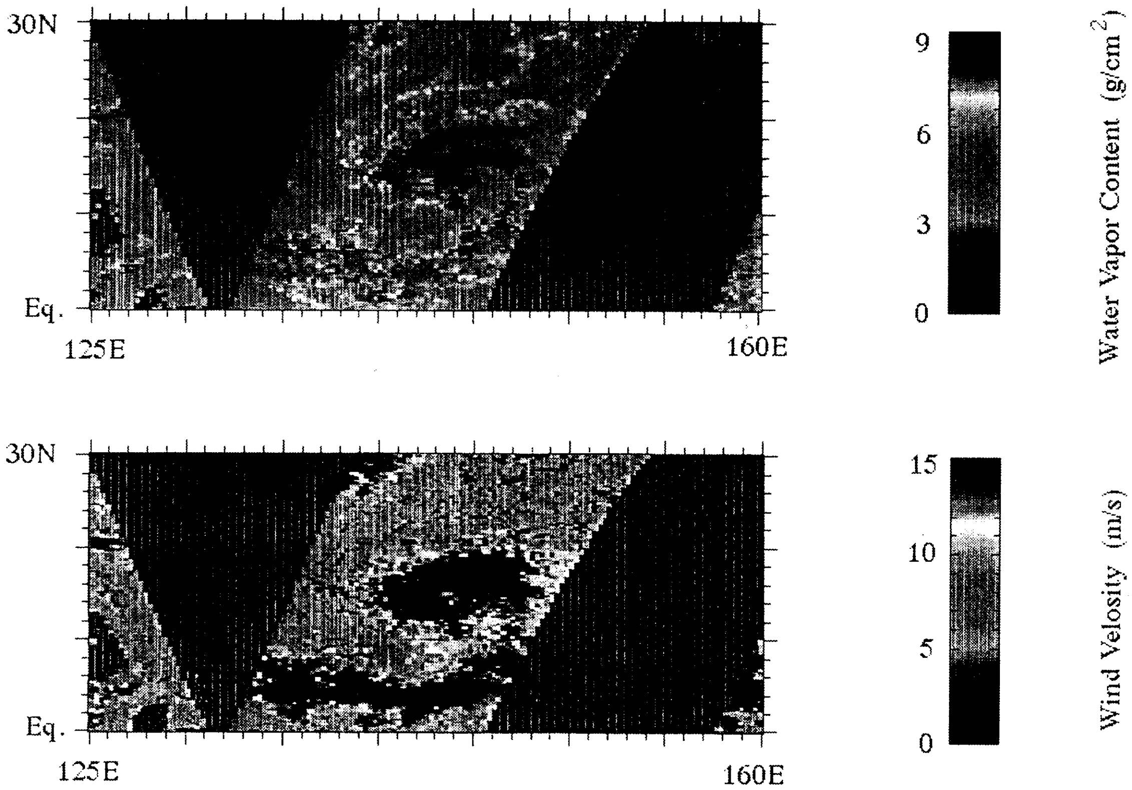
○ **Regression Coefficient**

	constant	19v	19H	22V	37V	37H	85V	85H
Clear *Water Vapor*	-31.4	-0.0181	-0.108		0.130	0.120		0.0269
Wind Velocity	220.	-0.241	1.56	0.177	-1.35	-0.364	0.194	-0.543
nonprecipitating *Water Vapor*	-18.1	-0.0105	0.0536	0.123		-0.0536	-0.0884	0.0764
Liquid Water	-0.392	0.00641	0.000313	-0.00859		0.00285	0.00888	-0.00700
Wind Velocity	110.	-2.17	1.09	0.453	0.0990		0.508	-0.345
precipitating *Water Vapor*	-35.6	-0.0517	-0.0126	0.283	-0.0878	0.023	-0.00448	
Liquid Water	1.24	0.0216	0.000747	-0.0239	-0.00143	-0.000513		0.00154
Ice Water	0.574	-0.00182	0.000554	0.000572	0.00181	-0.00128	-0.00531	0.00327
Rainfall Rate	52.1	1.26		-1.25	-0.194			0.133

○ **Correlation Coefficient**



1992 / 08 /03 (08:54 UTC)



1992/08/03 (08:54 UTC)

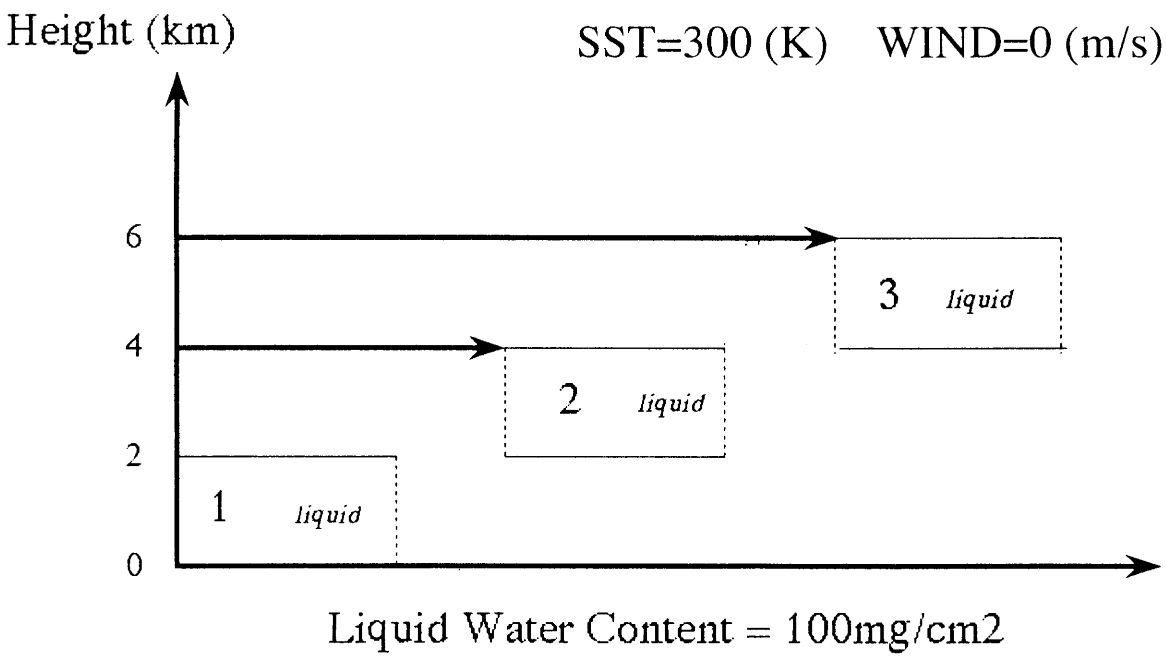
$Q = a_0 + \Sigma a_i * T_{bi}$ **Q : Liquid Water Path (g/cm^2)**

○ Regression Coefficient

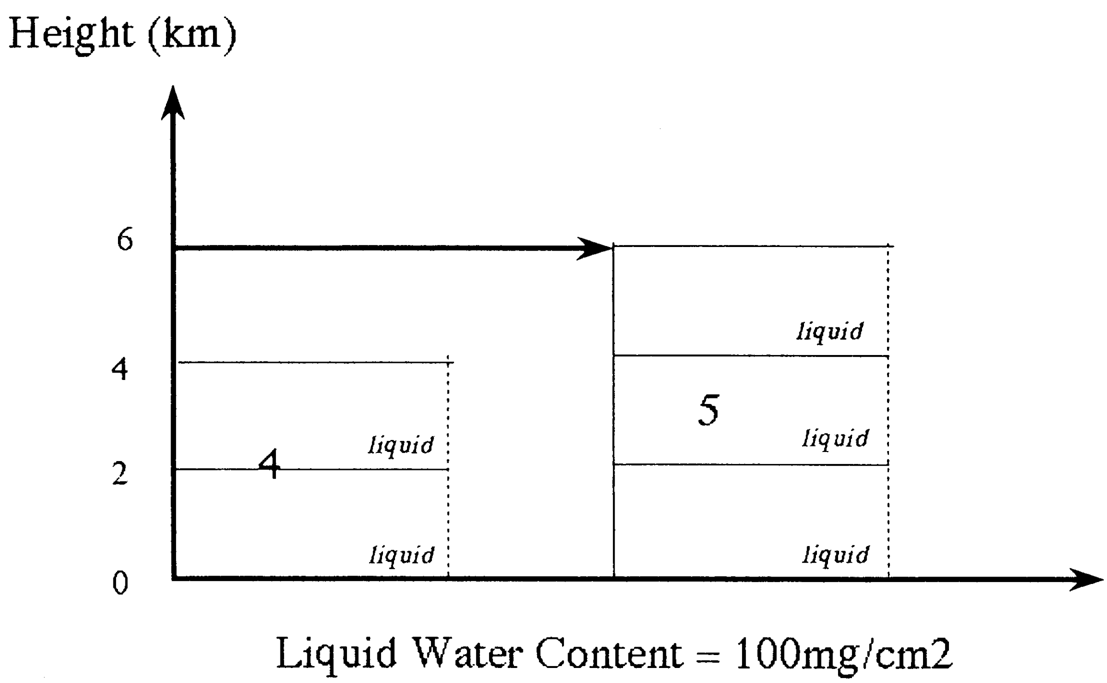
	constant	19V	19H	22V	37V	37H	85V	85H
low-level cloud	**-0.583**	**-0.0000934** -0.0778	**-0.00243** -0.944			**0.00402** 0.990	**0.00574** 0.866	**-0.00497** -0.872
mid-level cloud	**-0.0527**	**0.00403** 0.338	**-0.000829** -0.243	**-0.00403** -0.262		**0.00276** 0.647	**0.00467** 0.434	**-0.00549** -0.603
high-level cloud	**0.574**	**0.00643** 0.373	**-0.00127** -0.187	**-0.00350** -0.229	**-0.00152** -0.124	**0.00237** 0.239	**0.000144** 0.00655	**-0.00375** -0.239

○ Statistics

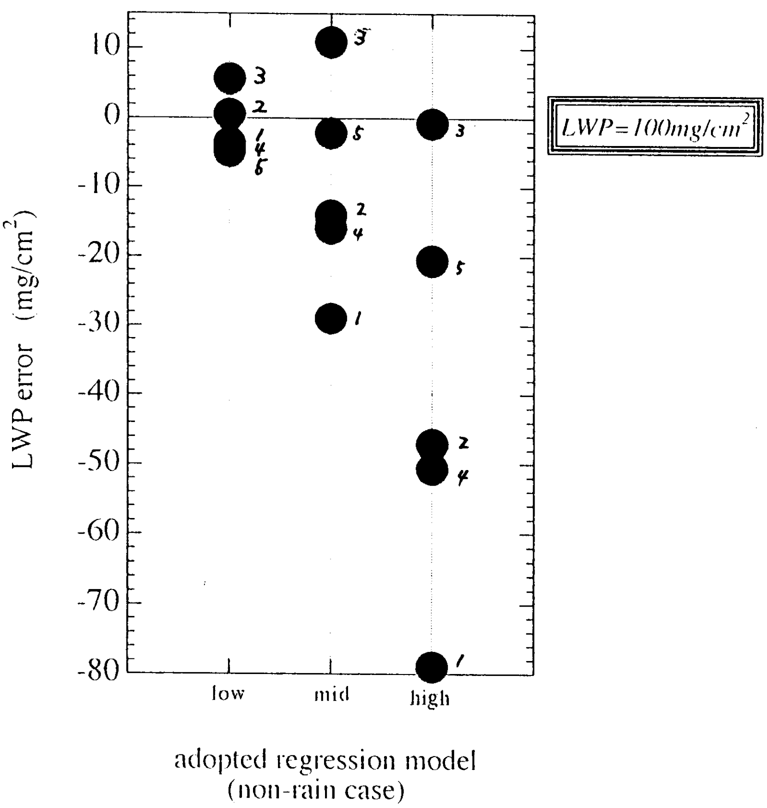
	R*	bias mg/cm2	(%)	RMSE mg/cm2	(%)
low-level cloud	0.997	-0.233	(-0.575)	2.16	(5.34)
mid-level cloud	0.995	-0.737	(-1.23)	4.49	(7.51)
high-level cloud	0.994	1.40	(1.75)	6.78	(8.47)



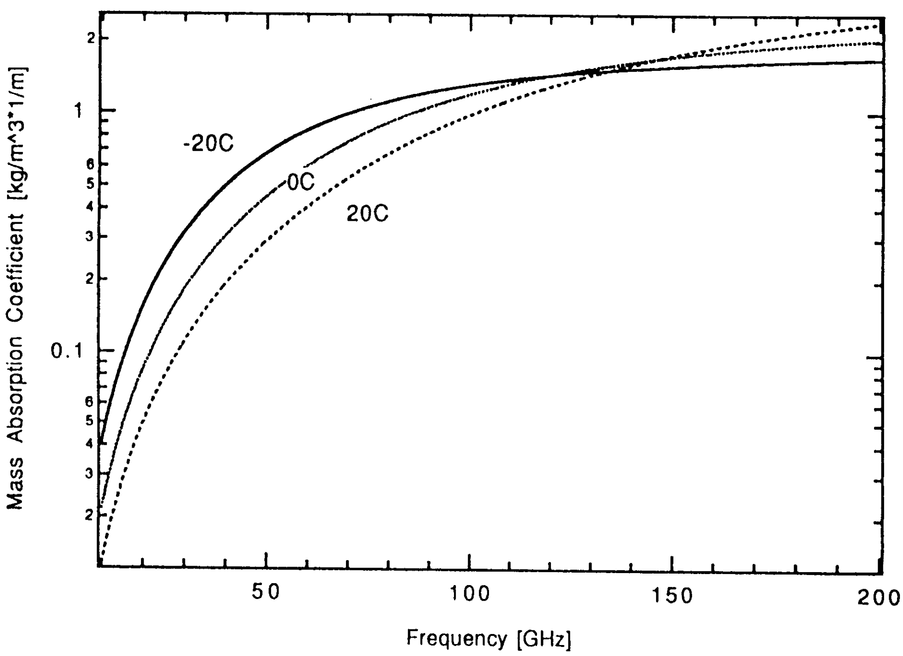
Low-level cloud (no.1 .2 .3)



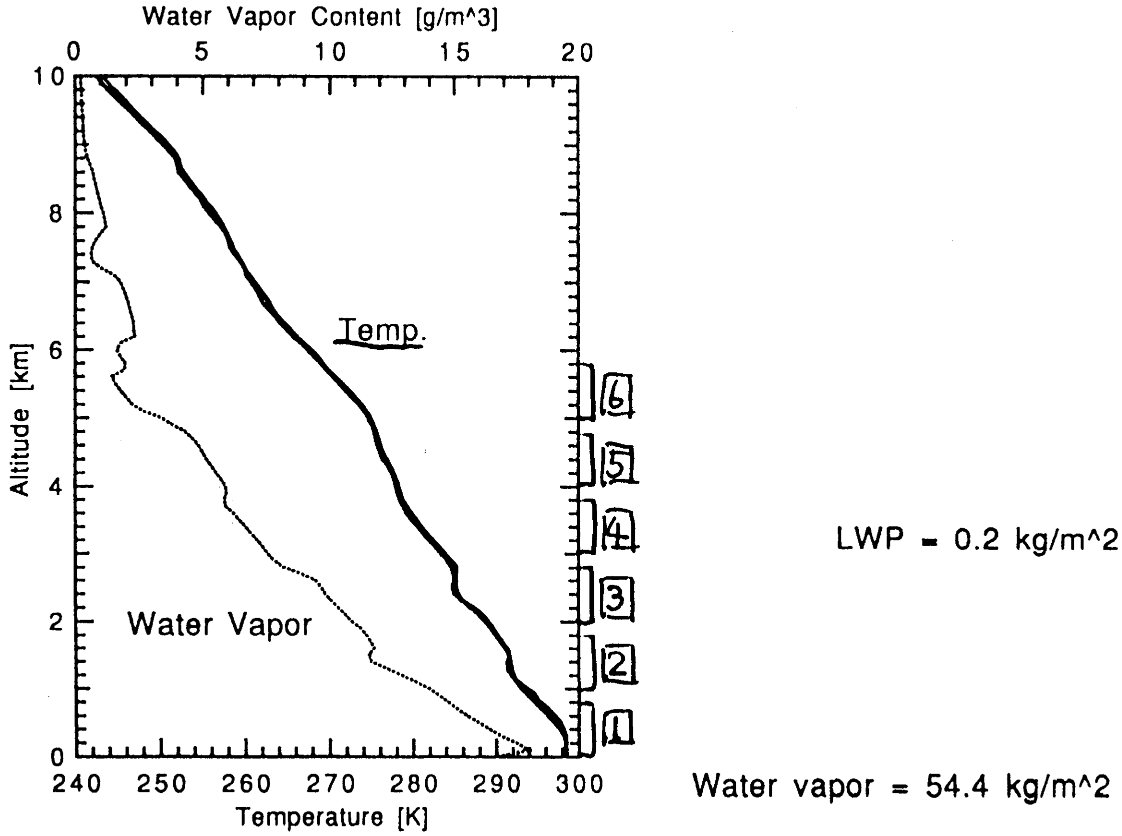
Low-level cloud (no.4 .5)



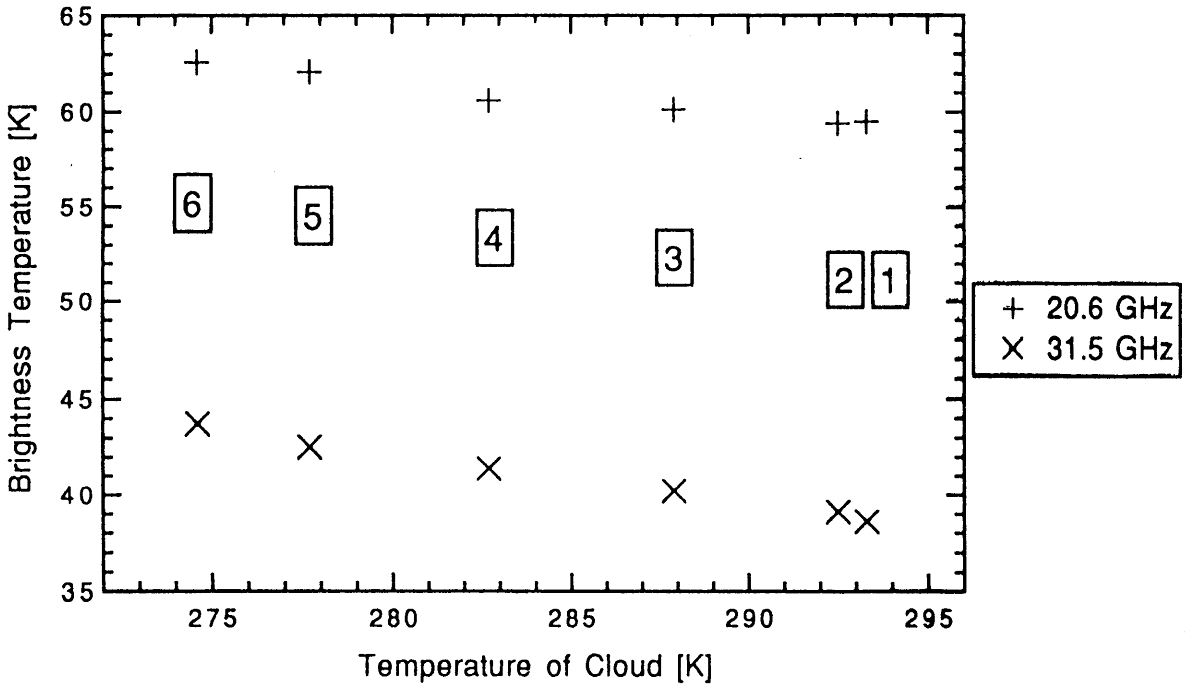
simulated data for low-level cloud
(non-rain case)

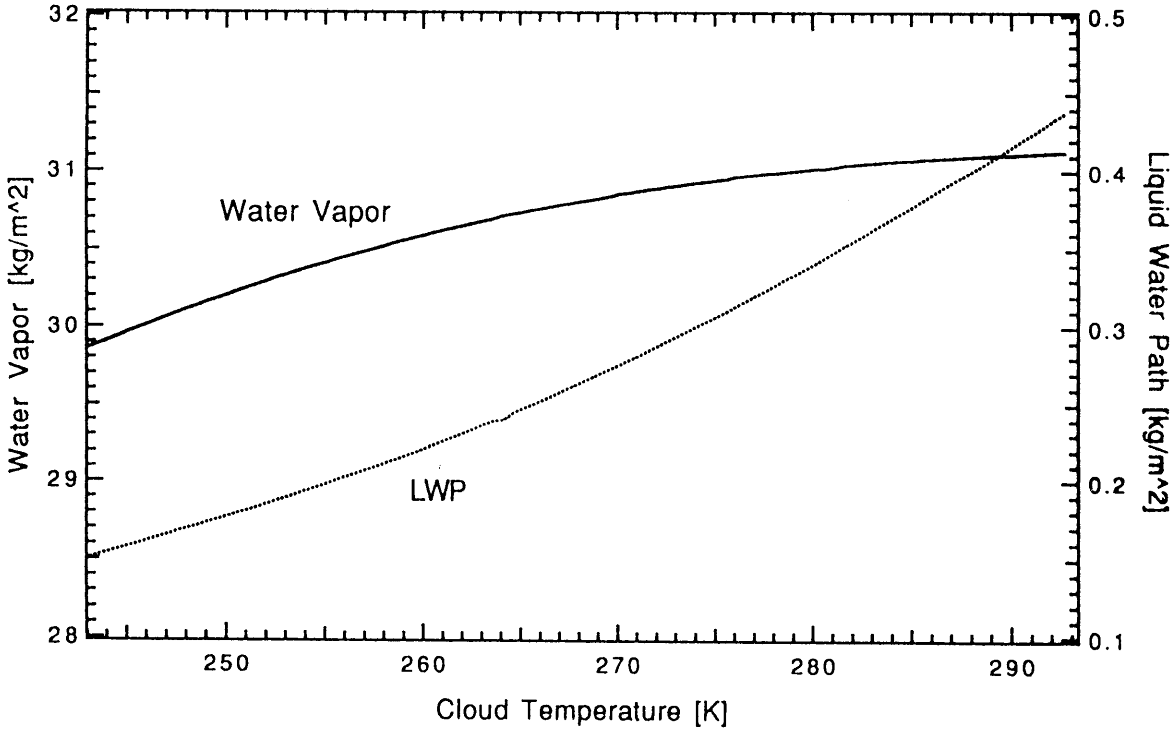


Mass Abworption Coefficient of Cloud Particle

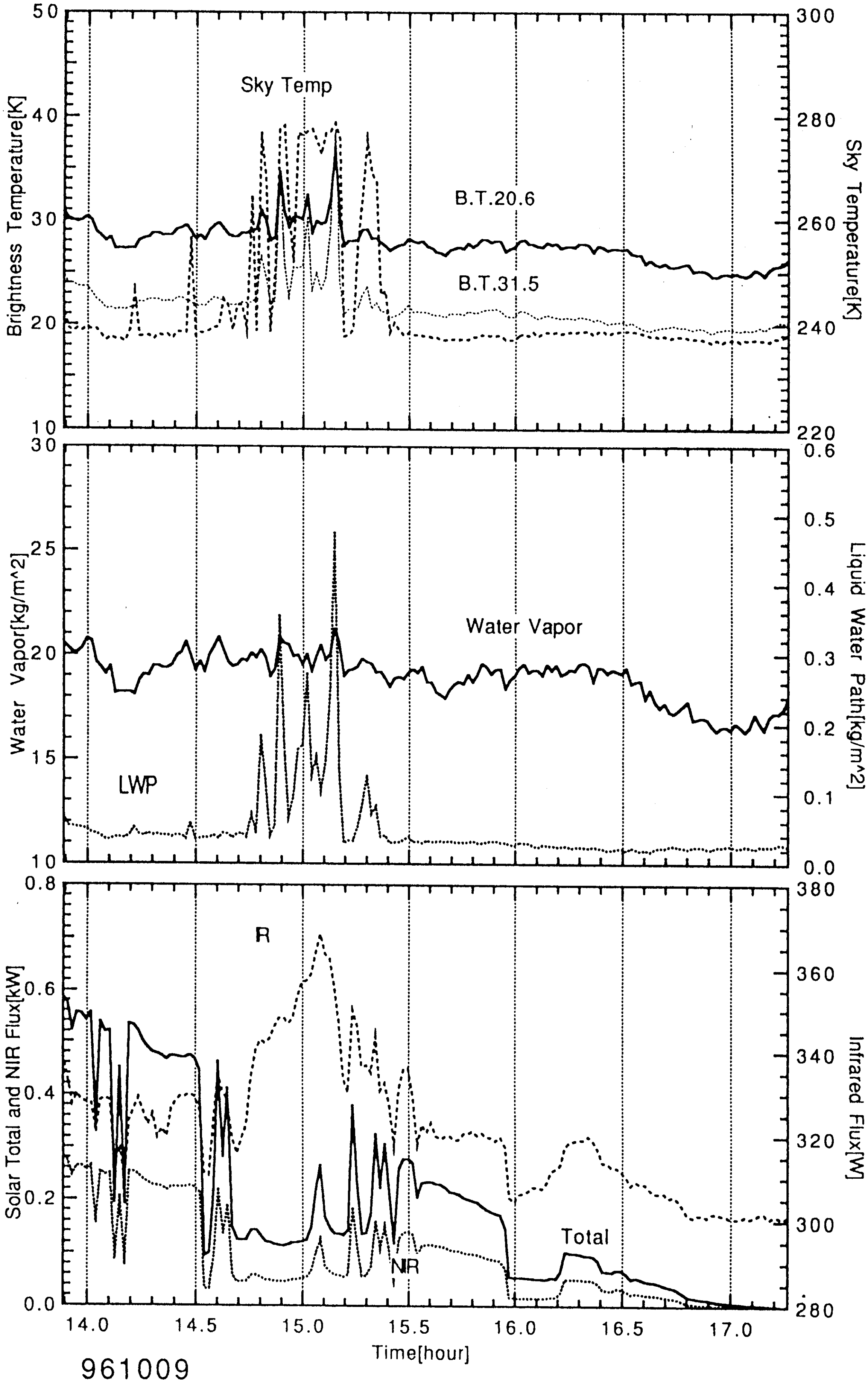


from Sondedata of 96/07/18, Sendai



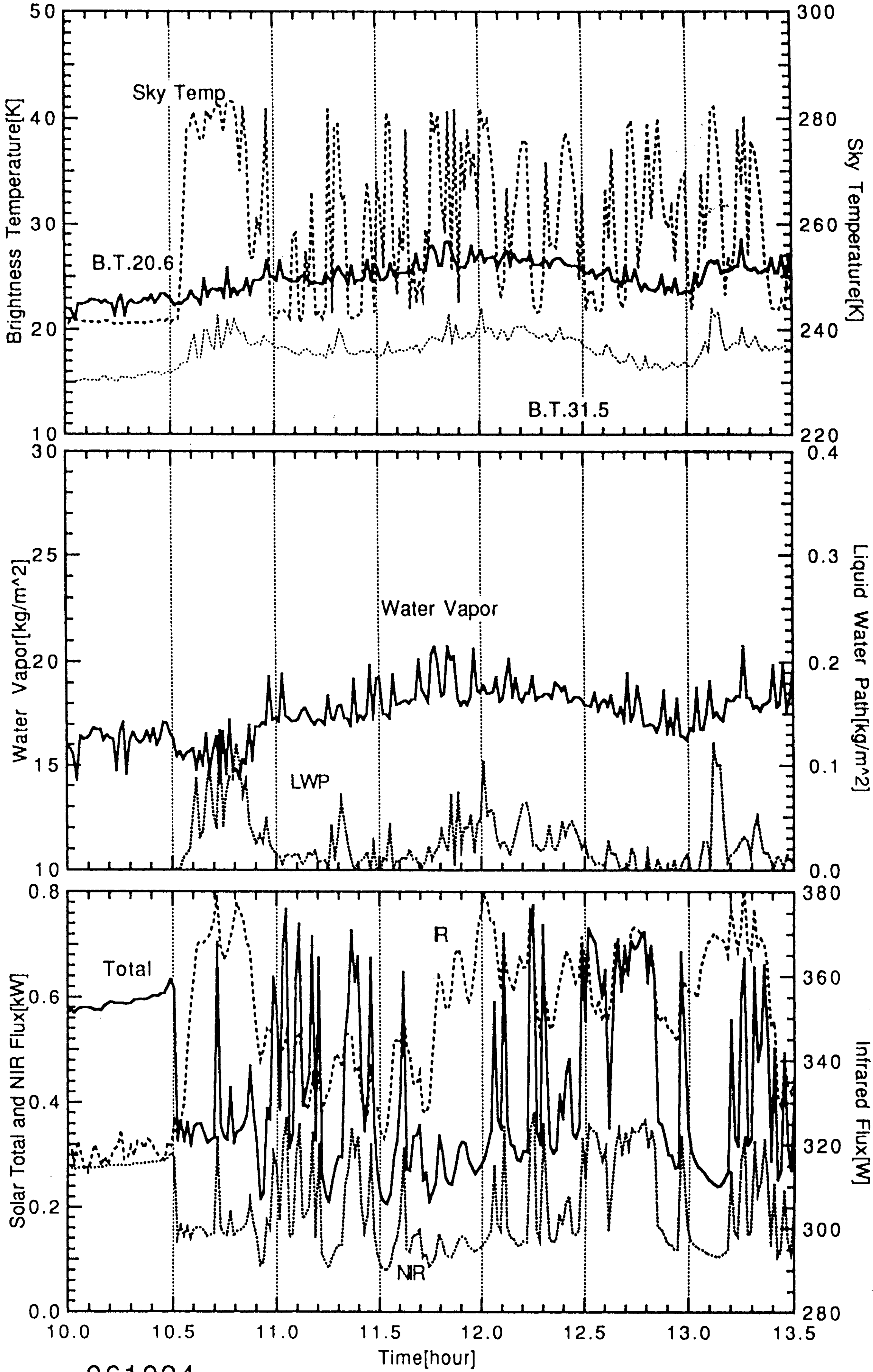


Tb20.6 = 44 K
Tb31.5=38 K
Surface Temperature = 293.15 K
Temperature Lapse Rate = 5.8 K/km



Sky Temp
B.T.20.6
B.T.31.5
Brightness Temperature[K]
Sky Temperature[K]
Water Vapor
LWP
Water Vapor[kg/m^2]
Liquid Water Path[kg/m^2]
R
Total
NIR
Solar Total and NIR Flux[kW]
Infrared Flux[W]
Time[hour]

961009



Sky Temp
B.T.20.6
B.T.31.5
Brightness Temperature[K]
Sky Temperature[K]
Water Vapor
LWP
Water Vapor[kg/m^2]
Liquid Water Path[kg/m^2]
Total
R
NIR
Solar Total and NIR Flux[kW]
Infrared Flux[W]
Time[hour]

961024

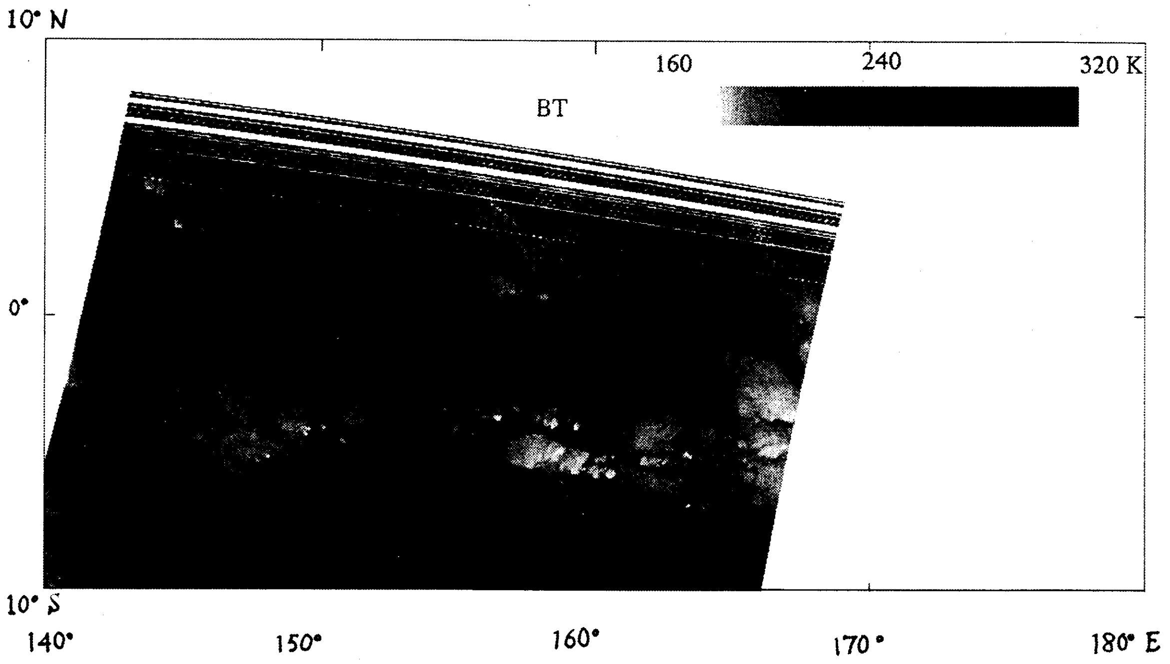


図　赤外画像（NOAA AVHRR 4channel 10.8μm）　1992.12.23. 21:12:27GMT

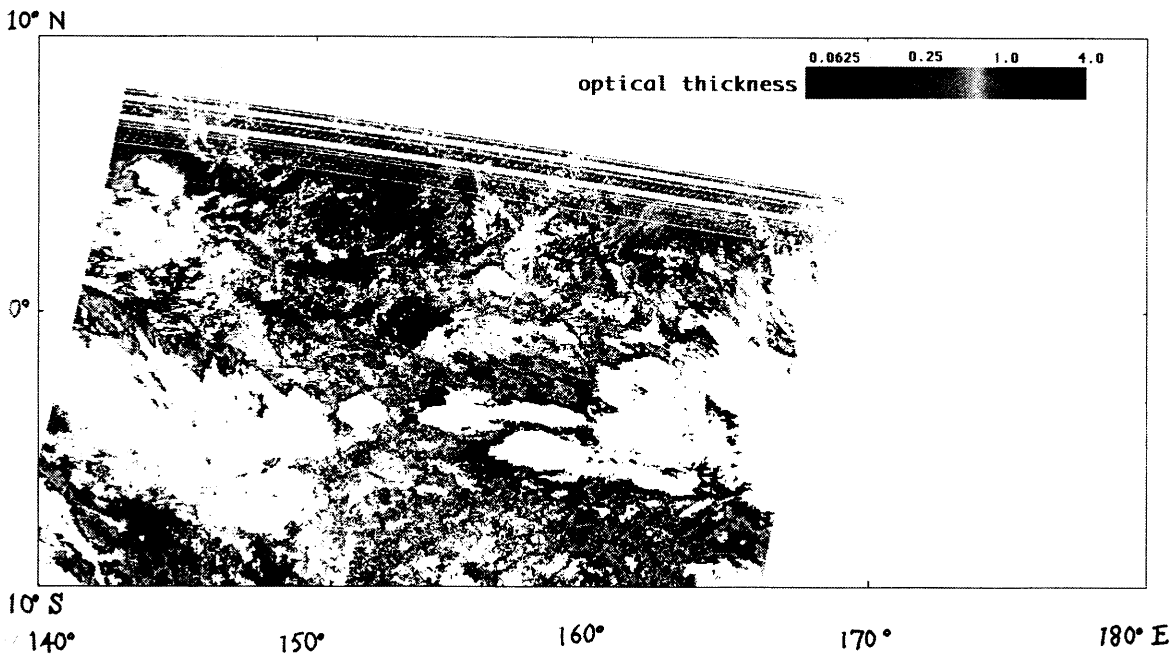


図　光学的厚さの分布図　1992.12.23. 21:12:27GMT

Summary

- Vertical cloud distribution is important for microwave remote sensing of clouds because of temperarure dependency on the complex refractive index of water.

- Lidar measurements may be useful and complementary to microwave remote sensing of clouds.