INFLUENCE OF DISTORTING FACTORS ON THE OUTGOING RADIANCE IN IR-CHANNELS OF HIRS/2

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Results of investigations into the influence of distorting factors such as surface and volcanic aerosols, overcast and cirrus cloudiness, and solar illumination on the outgoing radiance in channels of HIRS/2 are presented in the paper as functions of the geometry of observations. These data can be used to reconstruct the atmospheric meteorological parameters.

1. INTRODUCTION

A correct solution to the problem of reconstruction of the atmospheric meteorological parameters from the measurements in IR-channels of the HIRS/2 apparatus (the channel parameters are given in Table I) calls for a consideration of the distorting influence of some factors in the spectral range 4–15 μm among which are the thermal radiation of the underlying surface (US), solar and atmospheric radiance reflected from the US, and extinction and scattering of radiation by aerosol and cloud formations.

TABLE I. Channels of the HIRS/2 apparatus and their designation.

Serial number of channel	Radiation wavelength, μm	Designation
1–7	14.95–13.35	Temperature profiles
8	11.11	Surface temperature
9	9.71	Total ozone
10–12	8.16–6.72	Vertical profiles of the humidity
13–17	4.57–4.24	Vertical profiles of the temperature
18–19	4.00; 3.76	Surface temperature

This circumstance calls for an integrated study of the degree of influence of the above-enumerated distorting factors on the formation of upwelling thermal radiance in the range 4–15 μm. These investigations were carried out with the help of the code[1] LOWTRAN–7 for a wide range of variations of the optical-geometric parameters of observations. Results of numerical modeling allowed us to evaluate quantitatively the distorting effect on the upwelling thermal radiance in the IR-channels of the HIRS/2 apparatus of the following types of aerosol and cloud formations:

1) surface atmospheric aerosol;
2) stratospheric postvolcanic aerosol layers;
3) low overcast cloudiness;
4) cirrus cloudiness.

For each of the four above-enumerated types of atmospheric situations we estimated the relative contribution to the upwelling radiance of the following components: the thermal radiance of the underlying surface, atmospheric and solar radiances reflected from the US and scattered by the aerosol and clouds, and the net contribution of reflected and scattered solar radiation.

In addition, we estimated quantitatively the influence on the variability of the upwelling radiance of variations of the following parameters:

– underlying surface temperature (UST) and its albedo;
– characteristics of the surface aerosol;
– characteristics of the low cloudiness.

In fact, these data allow us to estimate the level of possible errors when solving the problems of reconstruction of the atmospheric meteorological parameters under conditions of the uncertainty in the above-indicated parameters.

2. OPTICAL-GEOMETRIC CONDITIONS OF MODELING

Optical-meteorological models of the atmosphere

1. Meteorological models. Modeling was executed for all four seasons. The vertical profiles of the meteorological parameters were assigned with the help of the standard models for the Arctic latitudes in winter (WAL, UST is 257 K) and the mid-latitudes in winter (WML, UST is 272 K) and summer (SML, UST is 294 K) included in the data block of the code LOWTRAN–7. These models were selected based on an analysis of the statistical data on seasonal variability of the vertical temperature and humidity profiles in Western Siberia (in Novosibirsk).

2. Aerosol models. Optical models of the atmospheric aerosol were selected from the data block of the code LOWTRAN–7.

The optical characteristics of the surface aerosol were chosen for two models of the rural and urban aerosol for four values of the meteorological visibility

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range S_m = 2, 5, 10, and 23 km. In these situations the background model was used for the stratospheric aerosol.

A postvolcanic situation in the stratosphere was modeled for two models with high and moderate content of the fresh volcanic aerosol in the stratosphere. The maximum of the aerosol extinction coefficient was at altitudes between 18–19 km for the first model. Its altitude decreased down to 15 km for the second model. At these altitudes the content of the volcanic aerosol differed 5 times for the SML model. This difference was almost 3.8 times for the winter models. In that cases the rural aerosol model for S_m = 23 km was chosen for the surface layer of the atmosphere.

3. Models of low cloudiness. The optical models of the low cloudiness were selected from the data block of the code LOWTRAN–7.

The parameters of low cloudiness were varied with the help of the following five models:

1) *Cumulus* (*Cu*) with a cloud base altitude (CBA) of 0.66 km and a cloud top altitude (CTA) of 3 km;

2) *Altostratus* (*As*) with a CBA of 2.4 km and a CTA of 3 km;

3) *Stratus* (*St*) with CBA = 0.33 km and CTA = 1 km;

4) *Stratus/Strato Cu* (*Sc*) with CBA = 0.66 km and CTA = 2 km;

5) *Nimbostratus* (*Ns*) with CBA = 0.16 km and CTA = 0.66 km.

4. Model of cirrus cloudiness. A standard model of cirrus cloudiness was selected from the data block of the code LOWTRAN–7 with the following characteristics:

1) a cloud thickness of 1 km;

2) a cloud optical thickness of 0.14 (independent of the wavelength);

3) the cloud altitude depending on the meteorological model was equal to

a) 10 km for the SML model,

b) 8 km for the WML model,

c) 5 km for the WAL model.

5. Albedo of the underlying surface. Numerical calculations were done with the values of the albedo A = 0–0.1.

Geometric parameters

1. Observation angles (θ). Numerical calculations were done for the observation angles θ = 0–50° corresponding to the scanning angles of the HIRS/2 apparatus.

2. Solar zenith angles (θ_s). In our numerical calculations the range of variations of the solar zenith angles was varied versus a season and was determined by the maximum solar elevation angle for the Tomsk latitude. In January, April, July, and October it was

a) θ_s = 20–0° (measured from the horizon) (winter model),

b) θ_s = 60–0° (summer model),

c) θ_s = 30–0° (fall model).

3. Azimuth observation angles (φ). This angle specifies the relative position of the apparatus axis and the direction of the solar radiation incidence. It was considered only for inclined observation angles θ > 0°. In those cases the numerical calculations were done for azimuth angles φ = 0, 45, 90, and 180°.

3. PARAMETERS OF NUMERICAL MODELING

1. Upwelling radiance. All the parameters required for our numerical study were computed from the code LOWTRAN–7. The upwelling radiance in the channels of HIRS/2 was represented as a sum of the terms that influence it

$$I_n = I_{atm} + I_{srf} + I_{rfl} + I_{sct},$$

$$I_{srf} = (1 - A) \int B_\lambda(T_s)\, P_\lambda\, d\lambda; \quad I_{rfl} = I^{atm}_{rfl} + I^{sun}_{rfl};$$

$$I_{sct} = I^{trm}_{sct} + I^{sun}_{sct} = (I^{trm}_{sst} + I^{trm}_{mst}) + (I^{sun}_{sst} + I^{sun}_{mst});$$

where I_{atm} is the atmospheric radiance, I_{srf} is the thermal radiance of the underlying surface, A is the albedo of the underlying surface, T_s is the underlying surface temperature; B_λ is the Planck function, P_λ is the atmospheric transmittance, $I^{atm}_{rfl} = AF^{\downarrow}_{atm}$ and $I^{sun}_{rfl} = AF^{\downarrow}_{sun}$ are the radiance produced by the incident atmospheric $F^{\downarrow}_{atm}$ and solar $F^{\downarrow}_{sun}$ radiances reflected from the underlying surface, I^{trm}_{scf} and I^{sun}_{sct} are the thermal and solar radiances scattered by the aerosol and clouds expressed as a sum of singly and multiply scattered components; in calculations of I^{trm}_{mst} and I^{sun}_{mst}, multiple scattering was considered in the two-flux approximation.

2. Influence of the aerosol or cloudiness. To estimate the effect of the aerosol or cloudiness on the upwelling radiance, the following relative characteristics were calculated:

1) in the case of the surface aerosol, $R = 1 - I_n(S_m)/I_n(\mathrm{mol})$, where $I_n(S_m)$ and $I_n(\mathrm{mol})$ are the outgoing radiances for (*a*) turbid (with the meteorological visibility range MVR – S_m) and (*b*) clear (cloudless, without aerosols) atmosphere, respectively;

2) in the case of the volcanic aerosol, $R = 1 - I_n(\mathrm{vlc})/I_n(S_m = 23)$, where $I_n(\mathrm{vlc})$ and $I_n(S_m = 23)$ are the upwelling radiances corresponding to (*a*) occurrence of the volcanic aerosol layer in the stratosphere and (*b*) background aerosol model in the surface layer of the atmosphere (MVR = 23 km) and in the stratosphere;

3) in the case of cloudiness, $R = 1 - I_n(\mathrm{cld})/I_n(S_m = 23)$, where $I_n(\mathrm{cld})$ and $I_n(S_m = 23)$ are the upwelling radiances for (*a*) cloudy atmosphere, and (*b*) background aerosol model in the surface layer of the atmosphere (rural aerosol for MVR = 23 km) and in the stratosphere.

3. Contribution of the factors contributing to the radiance. We calculated the relative contributions to the upwelling radiance I_n of the following components: thermal radiation of the US, I_{srf}; solar and atmospheric radiation reflected from the US, I_{rfl}; multiply scattered radiation, $(I^{trm}_{mst} + I^{sun}_{mst})$; solar radiation, $(I^{sun}_{rfl} + I^{sun}_{sct})$.

4. Influence of the UST variations. To estimate the effect of the surface temperature (T_s) variations on the variability of the upwelling radiance, the values of $I_n(T_s)$ and $I_n(T_s \pm dT_s)$ corresponding to the standard value of the UST for the examined meteorological model and to the UST changed by $dT_s = 5$ K were compared.

5. Influence of the albedo variations. To estimate the effect of variations of the albedo (A) of the underlying surface on the variability of the upwelling radiance, we compared the radiances $I_n(A = 0)$, $I_n(A = 0.05)$, and $I_n(A = 0.1)$.

6. Influence of the aerosol variations. To estimate the effect of variations of the surface aerosol parameters on the variability of the upwelling radiance, we calculated the following relative characteristic:

$$R = \frac{1}{N_{aer}} \sum_{S_m}^{N_{aer}} |1 - I_n(S_m)/I_n(avr)|,$$

$$I_n(avr) = \frac{1}{N_{aer}} \sum_{S_m}^{N_{aer}} I_n(S_m),$$

where $N_{aer} = 8$ is the number of examined aerosol situations (2 types of aerosol models ×4MVR).

7. Influence of the cloudiness variations. To estimate the effect of variations of the low cloudiness parameters on the variability of the upwelling radiance, we calculated the following relative characteristic:

$$R = \frac{1}{N_{cld}} \sum_{cld}^{N_{cld}} |1 - I_n(cld)/I_n(avr)|,$$

$$I_n(avr) = \frac{1}{N_{cld}} \sum_{cld}^{N_{cld}} I_n(cld),$$

where $N_{cld} = 5$ is the number of examined situations for cloudiness.

4. RESULTS OF CALCULATIONS

From the code LOWTRAN–7 the atmospheric transmittance and the upwelling radiance were computed with a spectral resolution of 20 cm^{-1} and a frequency step of 5 cm^{-1}. Thus, the spectral ranges corresponding to the HIRS/2 channels in our calculations could differ the true channels determined by their instrumental functions. Therefore, we first compared the results of computations of the outgoing radiance under conditions of clear atmosphere from the code LOWTRAN–7 and the code described in Ref. 3 and based on the spectroscopic database HITRAN–96 (see Ref. 2) and the direct line-by-line method of calculations with consideration of the real instrumental functions. The results of comparison are given in Table II.

Our analysis shows that, on the whole, the results of computations agree quite satisfactory and the difference does not exceed 10%. Only for the 1st and 16th channels the systematic errors exceed this level. However, even for these channels the difference does not exceed 15–20%. The bandwith of the 1st channel is 3 cm^{-1}, that is, significantly less than the spectral resolution of the code LOWTRAN–7. The 16th channel falls on the edge of the 4.3 μm band of CO_2 which is characterized by fast spectral variations of the atmospheric transmission function. Thus, in both cases the true instrumental function affects the results of computations stronger than in any other channels. Nevertheless, the spectral ranges selected for modeling describe fairly adequately the real IR-channels of the HIRS/2 radiometer and hence can be used to estimate the influence of the distorting factors on the outgoing radiance.

Results of investigations of the distorting factors on the outgoing radiance are given in Table III which provides a general idea of the influence of each distorting factor in channels of the HIRS/2 apparatus for the examined optical-geometric situations. The table comprises four different cases of the surface aerosol (*1*), volcanic aerosol (*2*), overcast cloudiness (*3*), and cirrus cloudiness (*4*). The absence of the channel in the table means that the influence of all distorting factors in it does not exceed 0.5%. Omissions in the table mean that the influence of this factor in the channel does not exceed 0.5%.

Our analysis of the errors of radiative models of the outgoing radiation (OR) used for determining the atmospheric meteorological parameters has demonstrated that the influence of the underlying surface and all atmospheric factors can be neglected in the first four channels of HIRS/2. This conclusion fully agrees with the physical concept on the formation of the OR in the atmospheric layers located at altitudes of 8 km and higher. The low cloud top boundary does not exceed 3 km and the cirrus clouds are observed between 8–10 km.

In the cloudless atmosphere channels 12 and 17 are not subject to the influence of the distorting factors in addition to channels 1–4. Channels 5, 11, and 16 in which the contribution of the distorting factors does not exceed 5% in most cases should be also mentioned (this circumstance suggests their simple consideration in the data interpretation). A conclusion about the insignificant influence of the aerosol on the outgoing radiance in the channels of HIRS/2 whose contribution does not exceed 1–3% is also important.

TABLE II. Results of computations of the outgoing radiance, in mW/($m^2 \cdot sr \cdot cm^{-1}$)*, from the code LOWTRAN-7 and by the direct method of computations using the database HITRAN-96.*

Serial number of channel	Central wavelength of channel, cm^{-1}	θ = 0° LOWTRAN	θ = 0° HITRAN	Relative difference, %	θ = 45° LOWTRAN	θ = 45° HITRAN	Relative difference, %
Meteorological model for the Arctic latitudes in winter							
1	669.0	42.9980	48.0316	11.06	43.4260	49.4001	12.87
2	680.0	41.7250	42.0348	0.74	41.0760	42.3390	0.86
3	690.0	41.2087	41.0182	0.46	41.0793	41.0421	0.09
4	703.0	43.2820	45.4435	4.87	41.2427	43.0086	4.19
5	716.0	47.5287	51.8191	8.64	43.8753	47.8484	8.66
6	733.0	56.2467	59.9983	6.45	51.5253	55.3623	7.18
7	749.0	61.6493	66.7676	7.97	57.5940	63.6006	9.91
8	900.0	56.8857	57.0164	0.23	56.7371	56.9880	0.44
9	1030.0	26.7152	26.5152	0.75	22.9304	23.5527	2.68
10	797.0	68.5950	69.7040	1.60	67.7800	69.1224	1.96
11	1365.0	10.3380	10.4345	0.93	9.3865	9.4691	0.88
12	1488.0	4.2527	4.2513	0.03	3.7665	3.7653	0.03
13	2190.0	0.4203	0.3997	5.02	0.3634	0.3455	5.05
14	2210.0	0.2718	0.2669	1.81	0.2083	0.2070	0.62
15	2240.0	0.1486	0.1567	5.29	0.1061	0.1160	8.89
16	2270.0	0.0653	0.0564	14.66	0.0521	0.0505	3.10
17	2420.0	0.1841	0.1888	2.51	0.1664	0.1700	2.10
18	2515.0	0.1428	0.1481	3.59	0.1396	0.1477	5.58
19	2660.0	0.0757	0.0810	6.77	0.0749	0.0806	7.42
Meteorological model for the mid-latitudes in winter							
1	669.0	45.4480	52.0120	13.47	46.3760	53.8159	14.85
2	680.0	43.9850	44.1232	0.32	44.6180	44.7579	0.31
3	690.0	43.3680	43.0250	0.79	43.3867	43.1645	0.51
4	703.0	46.3253	48.9445	5.50	43.7367	45.9426	4.92
5	716.0	51.9980	57.2128	9.55	47.3367	52.2521	9.87
6	733.0	64.1940	68.6601	6.72	57.7420	62.1902	7.42
7	749.0	72.4800	79.0353	8.65	66.5413	74.0451	10.67
8	900.0	74.6257	74.9850	0.48	74.1743	74.7110	0.72
9	1030.0	34.5792	34.2249	1.03	28.8748	29.6629	2.69
10	797.0	85.9600	87.3735	1.63	84.2500	85.8805	1.92
11	1365.0	12.3703	12.4686	0.79	11.0375	11.1043	0.60
12	1488.0	5.1156	5.0355	0.39	4.4755	4.4943	0.42
13	2190.0	0.7417	0.6982	6.05	0.6195	0.5814	6.34
14	2210.0	0.4470	0.4427	0.97	0.3260	0.3266	0.17
15	2240.0	0.2258	0.2406	6.35	0.1524	0.1695	10.57
16	2270.0	0.0878	0.0748	15.96	0.0667	0.0643	3.73
17	2420.0	0.3602	0.3692	2.47	0.3146	0.3191	1.44
18	2515.0	0.3040	0.3200	5.13	0.2940	0.3183	7.94
19	2660.0	0.1671	0.1803	7.62	0.1638	0.1780	8.34
Meteorological model for the mid-latitudes in summer							
1	669.0	54.4260	34.4358	16.84	57.3000	67.2363	15.96
2	680.0	52.0530	52.0896	0.07	54.4190	54.3736	0.08
3	690.0	50.4580	49.6130	1.69	51.6453	50.8340	1.58
4	703.0	53.6827	56.8962	5.81	50.4593	53.1150	5.13
5	716.0	61.5880	68.4444	10.55	55.2767	62.0562	11.56
6	733.0	78.9200	84.3878	6.70	69.7467	75.5451	7.98
7	749.0	78.9200	84.3878	6.70	69.7467	75.5451	7.98
8	900.0	103.9540	104.4199	0.45	101.9230	102.5959	0.66
9	1030.0	54.0040	53.0126	1.85	45.2040	45.8701	1.46
10	797.0	112.4900	113.2624	0.68	108.2400	109.1633	0.85
11	1365.0	15.5730	15.6269	0.35	13.6180	13.6819	0.47
12	1488.0	5.8789	5.9023	0.40	5.1855	5.2085	0.44
13	2190.0	1.6544	1.5201	8.46	1.3454	1.2293	9.02
14	2210.0	0.9724	0.9672	0.55	0.6801	0.6902	1.47
15	2240.0	0.4652	0.4951	6.21	0.2953	0.3343	12.36
16	2270.0	0.1612	0.1352	17.58	0.1174	0.1105	6.02
17	2420.0	0.9084	0.9373	3.13	0.7788	0.7978	2.41
18	2515.0	0.8099	0.8563	5.57	0.7771	0.8471	8.61
19	2660.0	0.4556	0.4937	8.03	0.4386	0.4787	8.73

TABLE III. Average contribution, in %, of different distorting factors to the upwelling radiance in the channels of HIRS/2 apparatus.

Situation: surface aerosol									
Channels	Time of the day	1	2	3	4	5	6	7	8
005	Day		1.5						
006	Day		10.6				0.7		
007	Day		22.4	0.9			1.7		
009	Day		48.4	1.1	2.7		4.8	1.4	
010	Day		54.6	1.3	1.2		6.6	1.4	
10=*	Day		56.1	1.2	1.9		4.5	1.7	
011	Day		2.1						
013	Day	0.7	44.7	1.9	2.6	0.9	9.5	0.5	
	Night	0.6	45.0	1.3	2.6		9.6	0.8	
014	Day		20.7	1.2	0.8		4.4		
	Night		20.7	1.1	0.8		4.4		
015	Day		7.3				1.4		
016	Day		0.6						
17=*	Day	1.0	52.6	3.6	5.5	3.5	12.3	2.2	0.5
	Night	0.8	54.4	1.3	5.4		12.7	1.5	
Channels of measuring the UST									
008	Day	0.5	73.6	0.8	4.2		6.5	3.0	
018	Day	3.8	65.3	9.3	9.7	14.4	15.9	9.0	2.5
	Night	1.1	76.1	0.7	9.4		18.6	3.4	0.7
019	Day	8.9	56.1	14.9	8.9	25.0	14.4	17.1	5.0
	Night	1.3	74.7	0.8	8.4		19.3	3.2	0.8

Situation: volcanic aerosol								
Channels	Time of the day	1	2	3	4	5	6	7
005	Day		1.6					
006	Day		11.4				0.8	
007	Day		24.3	0.9			1.9	
009	Day	1.4	53.2	1.1	0.6		5.3	1.7
010	Day		59.0	1.2	0.9		7.1	1.6
10=	Day		60.8	1.0	1.1		4.9	1.9
011	Day		2.3		0.7			
013	Day	0.9	47.0	2.0	2.9	2.2	10.0	0.5
	Night	0.8	48.0	1.3	2.9		1	0.9
014	Day	1.4	22.9	1.1	1.8	2.2	4.9	
	Night	1.4	23.4	1.0	1.7		5.0	
015	Day	2.4	8.0			3.2	1.6	
	Night	1.5	8.2				1.6	
016	Day	3.1	0.8			3.8		
	Night	1.3	0.8					
17=	Day	3.3	56.1	4.0	4.5	6.5	13.1	2.4
	Night		59.9	1.4	4.5		14.0	1.8
Channels for measuring the UST								
008	Day	1.0	79.5	0.6	2.1		7.1	3.5
018	Day	3.7	7	10.7	6.1	16.3	17.1	9.9
	Night		83.7	0.5	6.0		2	3.9
019	Day	6.3	59.8	17.2	6.2	26.9	15.4	19.2
	Night		82.0	0.7	5.9		21.3	3.7

N o t e . Here, the distorting factors are: the influence of the aerosol (1), the contribution of the radiation from the underlying surface (US) (2), the contribution of the solar and atmospheric radiation reflected from the US (3), the contribution of the multiply scattered solar and thermal radiation (4), the net contribution of the reflected and scattered solar radiation (5), the effect of the US temperature variations (6), the effect of the variations of the US albedo (7), and the effect of variations of the aerosol characteristics (8); the asterisks denote channels 10a (797 cm^{-1}) and 17= (2420 cm^{-1}) of NOAA-14; channels 10 (1225 cm^{-1}) and 17 (2360 cm^{-1}) are used in NOAA-12.

Continuation of Table III

Situation: overcast cloudiness

Channels	Time of the day	1	2	3	4
005	Day	0.5	2.2		
006	Day	2.1	9.7		1.6
007	Day	3.6	16.6		2.6
009	Day	6.4	42.7		4.7
010	Day	10.5	59.4		7.3
10=	Day	6.4	29.9		4.9
011	Day	1.9	11.2		1.5
013	Day	11.6	49.9	9.0	6.0
	Night	17.4	53.7		11.2
014	Day	9.1	34.2	3.1	5.3
	Night	11.5	35.1		7.5
015	Day	5.1	17.7	0.9	3.3
	Night	5.9	17.8		4.0
016	Day	1.9	4.0		0.9
017	Day	4.0			
17=	Day	21.2	54.4	28.8	10.9
	Night	23.5	66.8		15.0
Channels for measuring the UST					
008	Day	7.6	40.0		6.2
018	Day	64.5	54.2	56.6	2
	Night	29.3	81.4		18.4
019	Day	128.3	50.9	71.5	27.3
	Night	32.6	83.2		19.9

N o t e . Here, the distorting factors are: the influence of the cloudiness (1), the contribution of multiply scattered solar and thermal radiation (2); the net contribution of the reflected and scattered solar radiation (3), and the influence of the parameters of cloudiness (4).

Situation: cirrus cloudiness

Channels	Time of the day	1	2	3	4	5	6	7
004	Day	0.8						
005	Day	2.1	1.3					
006	Day	4.0	9.9		2.4		0.7	
007	Day	4.5	21.0	0.8	4.6		1.5	
009	Day	4.5	46.6	1.0	5.8		4.7	1.4
010	Day	5.3	51.5	1.2	9.6		6.2	1.4
10=	Day	4.1	52.2	1.1	1		4.2	1.6
011	Day	5.5	2.0		5.9			
012	Day	3.1						
013	Day	5.4	41.9	1.7	7.1	4.2	8.9	0.5
	Night	8.6	43.7	1.2	7.4		9.3	0.9
014	Day	6.3	21.1	1.0	4.0	3.6	4.5	
	Night	9.5	21.8	0.9	4.2		4.6	
015	Day	5.3	7.4		0.8	3.2	1.2	
	Night	8.2	7.6		0.8		1.3	
016	Day	3.8				1.8		
	Night	5.5						
017	Day	12.8						
17=	Day	5.1	48.6	3.1	8.9	12.9	11.3	1.9
	Night	8.0	55.5	1.3	9.9		13.0	1.6
Channels for measuring the UST								
008	Day	4.8	69.2	0.7	10.6		6.1	2.9
018	Day	9.5	58.3	7.7	10.7	24.6	14.1	7.5
	Night	7.4	77.0	0.5	12.3		18.8	3.6
019	Day	19.9	46.8	11.6	9.7	38.1	12.0	13.3
	Night	7.3	75.7	0.6	12.1		19.6	3.4

N o t e . Here, the distorting factors are: the influence of cloudiness (1), the contribution of radiation from the underlying surface (US) (2), the contribution of the solar and atmospheric radiation reflected from the US (3), the contribution of the multiply scattered solar and thermal radiation (4), the net contribution of the reflected and scattered solar radiation (5), the influence of the US temperature variations (6), and the influence of variations of the US albedo (7).

The contribution of the solar radiation to the outgoing radiance in channels 13–16 does not exceed 1–4% for the cloudless atmosphere. It is increased up to 2–9% in the presence of cloudiness. This factor is more noticeable in channel 17a. In the other channels the influence of the solar radiation on the outgoing radiance can be neglected.

The thermal radiation from the underlying surface affects most strongly the outgoing radiance in most channels of HIRS/2. Therefore, it is most important to consider this factor in the data interpretation. The results of our calculations vividly demonstrate significant sensitivity of the outgoing radiance model primarily to the US parameters and albedo. In addition to the underlying surface, the overcast cloudiness also plays an important role in the formation of the outgoing radiance. It is expedient to note that to take this factor into account, we should know the characteristics of the cloudiness.

The cirrus cloudiness affects the outgoing radiance practically in all channels of HIRS/2 (except for the first four channels). The contribution of this factor in the most informative channels is, on average, 3–5% and can reach 13% (channel 17). At night the contribution of this factor is 5–10% only in channels 13–16.

One more factor that restricts the application of the HIRS/2 data for the determination of the meteorological parameters in the daytime is the contribution of the multiply scattered solar and thermal radiation (especially in the presence of overcast cloudiness). In the cloudless atmosphere the contribution of this factor does not exceed 6%, in the presence of cirrus cloudiness it can reach 10%, whereas under conditions of overcast cloudiness it exceeds 10–20% in most channels.

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