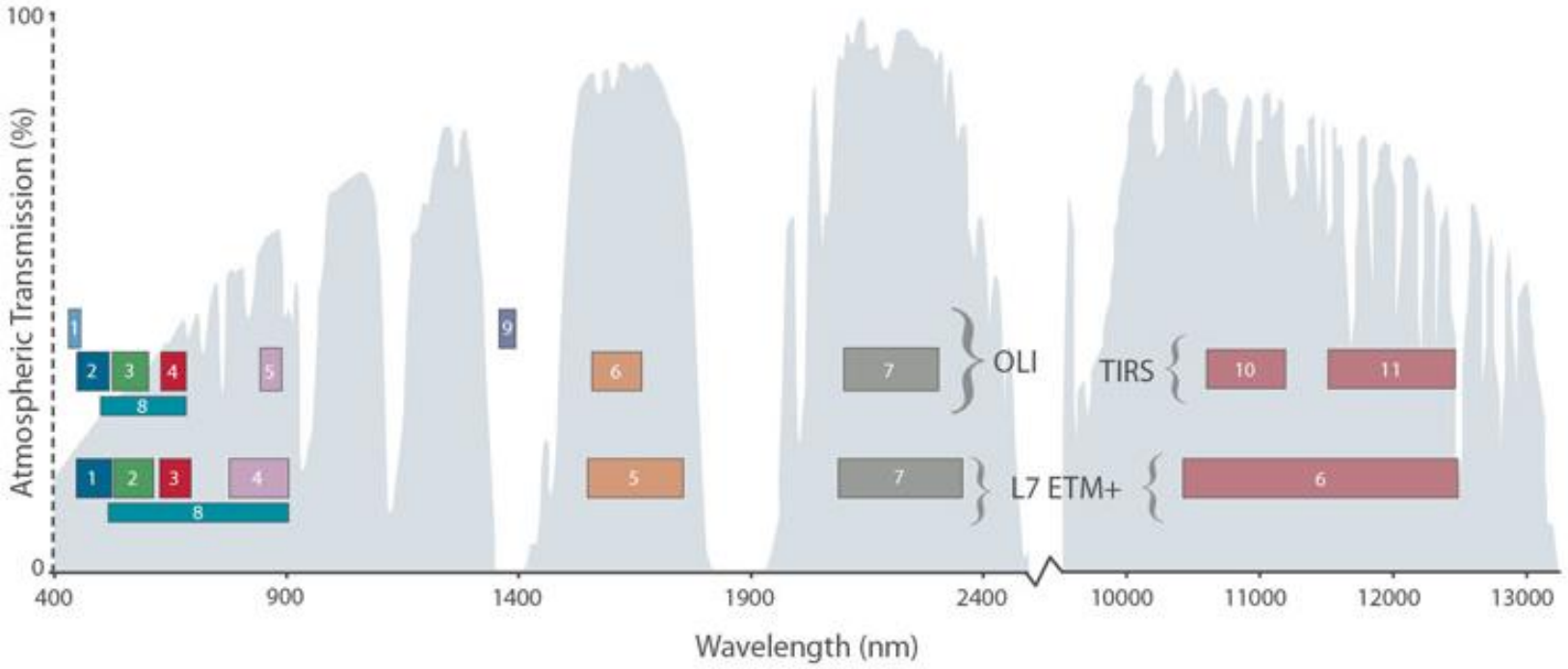
LANDSAT 8 OLI (Operational Land Imager)

LANDSAT 5 TM → LANDSAT 7 ETM+ → LANDSAT 8 OLI



радиометрическое разрешение:	12-bit, диапазон значений 0-4095 (4096)
размер пикселя, м:	15 / 30 / 100
уровень обработки:	1T (коррекция рельефа)
точность позиционирования:	OLI: 12 м. (90 %) TIRS: 41 м. (90 %)
формат изображений:	GeoTIFF
проекция:	UTM
система координат:	WGS84

КОМПЛЕКТ ПОСТАВКИ LANDSAT 8

tape archive — GNU Zip (gzip)

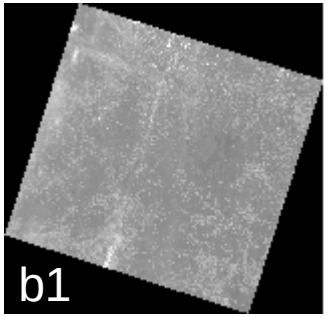
LC81820212013113LGN01.tar.gz – 859 Мб

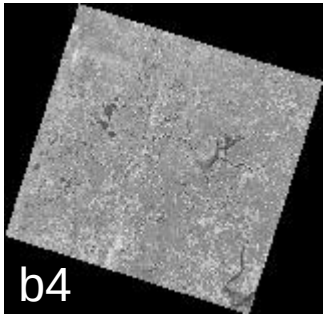
↓ разархивировать

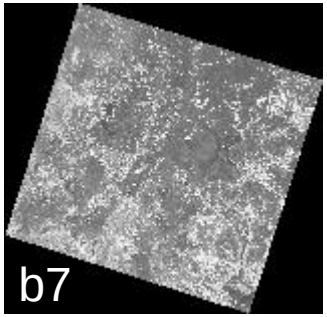
LC81820212013113LGN01.tar – 1700 Мб - хранение нескольких файлов

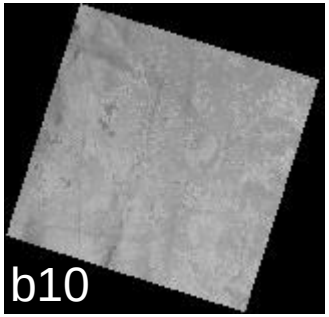
↓ распаковать **внутри одного**

мкм					
0.433-0.453	голубой	LC81820212013113LGN01_B1	TIF	123 633 078	7761 row x 7961 col x 16 bit
10.30-11.30	тепловой 1	LC81820212013113LGN01_B10	TIF	123 633 078	
11.50-12.50	тепловой 2	LC81820212013113LGN01_B11	TIF	123 633 078	
0.450-0.515	синий	LC81820212013113LGN01_B2	TIF	123 633 078	
0.525-0.600	зеленый	LC81820212013113LGN01_B3	TIF	123 633 078	
0.630-0.680	красный	LC81820212013113LGN01_B4	TIF	123 633 078	
0.845-0.885	БИК	LC81820212013113LGN01_B5	TIF	123 633 078	
1.560-1.660	СИК2	LC81820212013113LGN01_B6	TIF	123 633 078	
2.100-2.300	СИК3	LC81820212013113LGN01_B7	TIF	123 633 078	
0.500-0.680	видимый	LC81820212013113LGN01_B8	TIF	494 344 198	15521 row x 15921 col x 16 bit
1.360-1.390	СИК1	LC81820212013113LGN01_B9	TIF	123 633 078	7761 row x 7961 col x 16 bit
	качество съемки	LC81820212013113LGN01_BQA	TIF	123 633 078	
	метаданные	LC81820212013113LGN01_MTL	txt	7 748	









снимки в тепловых каналах приведены к разрешению 30 м

LANDSAT 8 OLI качество данных (QA)

LC81820212013113LGN01_**BQA**.TIF – **Quality Assessment** – **Качество данных**

№ БАЙТА	ХАРАКТЕРИСТИКА КАЧЕСТВА	значение	
		0	1
1	…	…	…
2	качество данных	норм	плохо
3	…	…	…
4	маска облаков (ACCA алгоритм[1])	нет	да
5	маска снега (ACCA алгоритм[1])	…	…
6	маска воды (топо)	нет	да
7	…	…	…
8	маска облаков (радиометрическая)	нет	да
9	маска тени от облаков (радиометрическая)	нет	да
10	маска снега (радиометрическая)	нет	да
11	маска воды (радиометрическая)	нет	да
12	полуоблачность (дымка)	нет	да
13	…		
14	…		
15	…		

показатели качества съемки каждого пикселя кодируется 16 битами (для экономии памяти)

[1]Automated Cloud-Cover Assessment

http://pubs.usgs.gov/tm/11/c07/pdf/tm11-c7.pdf

LANDSAT 8 OLI качество данных (QA)

LANDSAT-LDOPE Toolbelt – группа программ для работы с данными LANDSAT

Tool	Description
comp_sds_hist	Print the histogram of SDS values (frequency and values), excluding no-data and missing values, of specified SDSs.
create_mask	Apply relational and logical operators to one or more SDS in one or more data products to create an output 2D HDF SDS that can be read by conventional COTS. For example, create a binary SDS that shows the pixel locations where only non-cloudy values over 5000 are present.
create_sds_ts_stat	Create a summary statistic HDF file containing one or more output 2D SDS that describe the mean, standard deviation, minimum, maximum, sum, and number of observations, computed on pixel-wise basis from a time series of input HDF-EOS files.
mask_sds	Mask one or more SDS of an input HDF-EOS file and output the SDS values at pixels where the mask criteria are met and output fill values elsewhere.
math_sds	Perform simple arithmetic on two input SDSs of the same or different input HDF-EOS files and output the results to a 2D SDS.
read_pixvals	Read input HDF-EOS file values at specified pixel locations.
read_sds_attributes	Print the attributes of one or more SDS of input HDF-EOS files.
reduce_sds	Generate reduced spatial resolution of an SDS in an input HDF-EOS file by sub-sampling or averaging. Handle the no-data and missing values. This may be used to reduce data volumes, and to quickly enable comparison with coarser resolution data products.
sds2bin	Convert an SDS of an input HDF-EOS file to a flat binary image format.
subset_sds	Create spatial subset SDS(s) from one or more SDS of an input HDF-EOS file.
transpose_sds	Transpose one or more SDS in an input HDF-EOS file by rotating the SDS 180 degree in clockwise direction. This tool was originally designed to enable qualitative comparison of files from opposite orbit paths.
unpack_oli_qa	For use only with Landsat 8 OLI QA files. This tool extracts either individual or combinations of QA bits and writes them to a GeoTIFF file in simple binary terms.
*unpack_sds_bits	*This tool decodes requested bit fields in bit-encoded SDSs and writes them to 2D HDF SDSs that can be read by conventional COTS.*

Landsat_LDOPE_Tools.zip

comp_sds_hist	exe	755 781
create_mask	exe	781 505
create_sds_ts_stat	exe	763 925
cygwin1	dll	2 845 380
mask_sds	exe	800 480
math_sds	exe	767 937
read_pixvals	exe	766 367
read_sds_attributes	exe	753 993
reduce_sds	exe	791 905
sds2bin	exe	755 998
subset_sds	exe	757 040
transpose_sds	exe	754 998
unpack_oli_qa	exe	1 258 154
unpack_sds_bits	exe	761 906

программа разложение 16-битного кода на независимые слои отдельных характеристик

http://landsat.usgs.gov/L-LDOPE_Toolbelt.php

LANDSAT 8 OLI качество данных (QA)

1. скачать и распаковать **L-LDOPE Toolbelt**
2. переписать в папку с файлами сцены landsat 8 два файла
   cygwin1.dll
   unpack_oli_qa.exe

2. отредактировать текст командной строки под название файла своей сцены

папка с файлами снимка

cygwin1	dll	2 845 380
unpack_oli_qa	exe	1 258 154
LC81820212013113LGN01_B1	TIF	123 633 078
LC81820212013113LGN01_B10	TIF	123 633 078
LC81820212013113LGN01_B11	TIF	123 633 078
LC81820212013113LGN01_B2	TIF	123 633 078
LC81820212013113LGN01_B3	TIF	123 633 078
LC81820212013113LGN01_B4	TIF	123 633 078
LC81820212013113LGN01_B5	TIF	123 633 078
LC81820212013113LGN01_B6	TIF	123 633 078
LC81820212013113LGN01_B7	TIF	123 633 078
LC81820212013113LGN01_B8	TIF	494 344 198
LC81820212013113LGN01_B9	TIF	123 633 078
LC81820212013113LGN01_BQA	TIF	123 633 078
LC81820212013113LGN01_MTL	txt	7 748

исходный файл качества **шаблон файлов результатов**

unpack_oli_qa --ifile=**LC81820212013113LGN01_BQA.TIF** --ofile=**LC81820212013113LGN01 –all**

3. Скопировать и вставить отредактированный текст в командное окно Total Commander и выполнить команду (Enter).

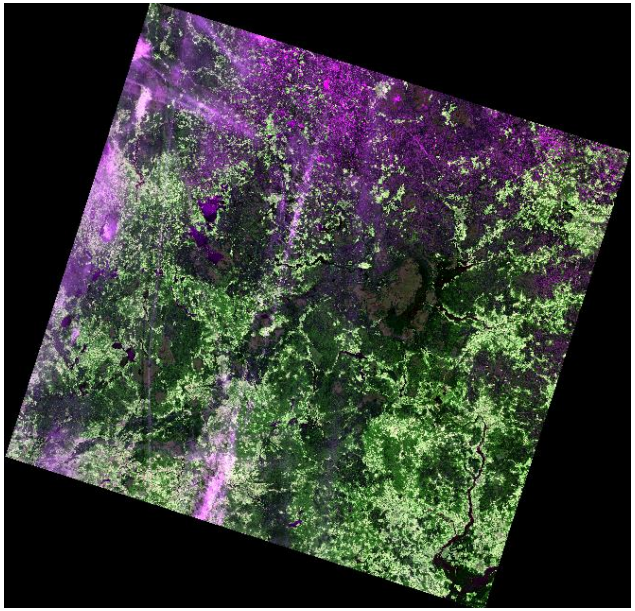
LC81820212013113LGN01_cirrus	tif	61 785 646
LC81820212013113LGN01_cloud	tif	61 785 646
LC81820212013113LGN01_cloud_shadow	tif	61 785 646
LC81820212013113LGN01_dropped_frame	tif	61 785 646
LC81820212013113LGN01_fill	tif	61 785 646
LC81820212013113LGN01_snow_ice	tif	61 785 646
LC81820212013113LGN01_terrain_occl	tif	61 785 646
LC81820212013113LGN01_vegetation	tif	61 785 646
LC81820212013113LGN01_water	tif	61 785 646
LC81820212013113LGN01_MTL	txt	7 748

-all
-combine
-fill
… и др. см
http://landsat.usgs.gov/documents/lldope_toolbelt_userguide.pdf

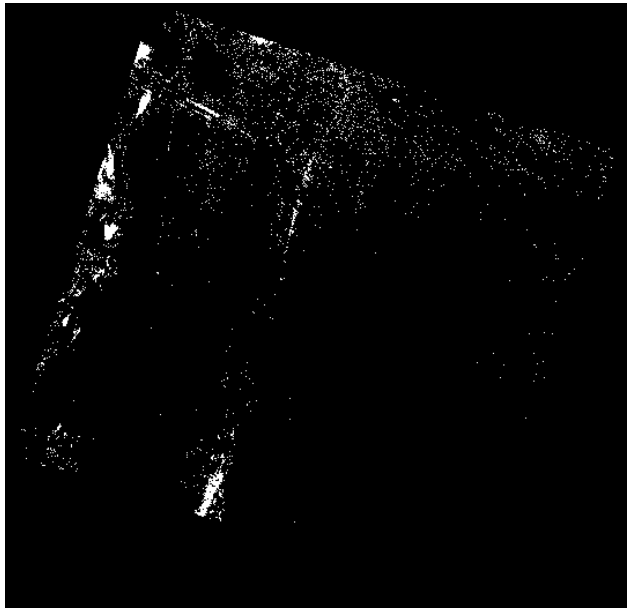
http://landsat.usgs.gov/L-LDOPE_Toolbelt.php

LANDSAT 8 OLI качество данных (QA)

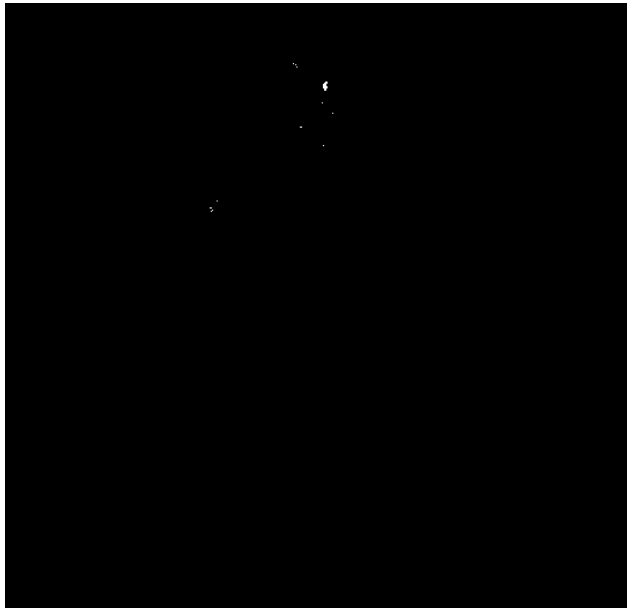
изображение снимка

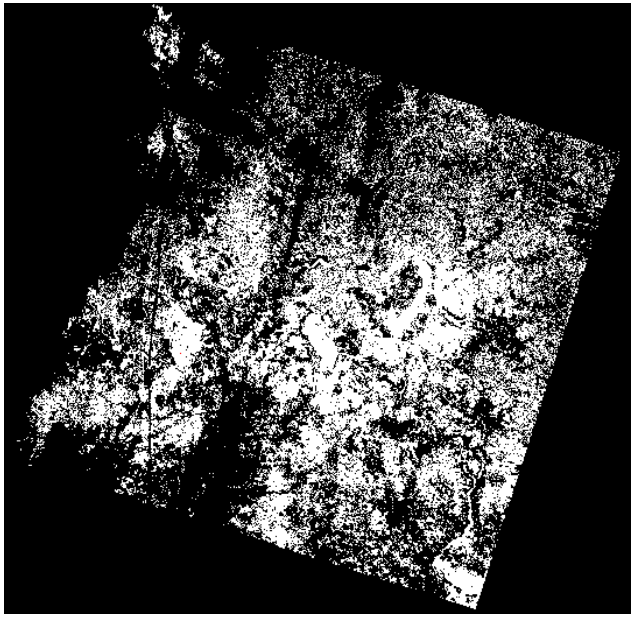


маска облачности



маска снега





маска водных объектов ???

LANDSAT 8 OLI МЕТАДАННЫЕ

файл LC81820212013113LGN01_MTL.txt

GROUP = IMAGE_ATTRIBUTES
  CLOUD_COVER = 1.35
  IMAGE_QUALITY_OLI = 9
  IMAGE_QUALITY_TIRS = 9
  ROLL_ANGLE = -0.001
  SUN_AZIMUTH = 160.61028301
  SUN_ELEVATION = 45.59453595
  EARTH_SUN_DISTANCE = **1.0055139** - расстояние Земли от Солнца
  GROUND_CONTROL_POINTS_MODEL = 440
  GEOMETRIC_RMSE_MODEL = 7.700
  GEOMETRIC_RMSE_MODEL_Y = 5.633
  GEOMETRIC_RMSE_MODEL_X = 5.250
  GROUND_CONTROL_POINTS_VERIFY = 153
  GEOMETRIC_RMSE_VERIFY = 4.068
END_GROUP = IMAGE_ATTRIBUTES

LANDSAT 8 OLI РАДИОМЕТРИЧЕСКАЯ КАЛИБРОВКА

$$L_\lambda = \frac{L\max_\lambda - L\min_\lambda}{Qcal\max - Qcal\min}(Qcal - Qcal\min) + L\min_\lambda$$

$L\max_\lambda - L\min_\lambda$

```
GROUP = MIN_MAX_RADIANCE
  RADIANCE_MAXIMUM_BAND_1 = 772.55371
  RADIANCE_MINIMUM_BAND_1 = -63.79774
  RADIANCE_MAXIMUM_BAND_2 = 787.80151
  RADIANCE_MINIMUM_BAND_2 = -65.05690
  RADIANCE_MAXIMUM_BAND_3 = 721.36041
  RADIANCE_MINIMUM_BAND_3 = -59.57018
  RADIANCE_MAXIMUM_BAND_4 = 610.94812
  RADIANCE_MINIMUM_BAND_4 = -50.45229
  RADIANCE_MAXIMUM_BAND_5 = 370.73010
  RADIANCE_MINIMUM_BAND_5 = -30.61501
  RADIANCE_MAXIMUM_BAND_6 = 93.40548
  RADIANCE_MINIMUM_BAND_6 = -7.71346
  RADIANCE_MAXIMUM_BAND_7 = 30.38463
  RADIANCE_MINIMUM_BAND_7 = -2.50917
  RADIANCE_MAXIMUM_BAND_8 = 688.19440
  RADIANCE_MINIMUM_BAND_8 = -56.83132
  RADIANCE_MAXIMUM_BAND_9 = 152.34837
  RADIANCE_MINIMUM_BAND_9 = -12.58098
  RADIANCE_MAXIMUM_BAND_10 = 22.00180
  RADIANCE_MINIMUM_BAND_10 = 0.10033
  RADIANCE_MAXIMUM_BAND_11 = 22.00180
  RADIANCE_MINIMUM_BAND_11 = 0.10033
END_GROUP = MIN_MAX_RADIANCE
```

```
GROUP = MIN_MAX_REFLECTANCE
  REFLECTANCE_MAXIMUM_BAND_1 = 1.210700
  REFLECTANCE_MINIMUM_BAND_1 = -0.099980
  REFLECTANCE_MAXIMUM_BAND_2 = 1.210700
  REFLECTANCE_MINIMUM_BAND_2 = -0.099980
  REFLECTANCE_MAXIMUM_BAND_3 = 1.210700
  REFLECTANCE_MINIMUM_BAND_3 = -0.099980
  REFLECTANCE_MAXIMUM_BAND_4 = 1.210700
  REFLECTANCE_MINIMUM_BAND_4 = -0.099980
  REFLECTANCE_MAXIMUM_BAND_5 = 1.210700
  REFLECTANCE_MINIMUM_BAND_5 = -0.099980
  REFLECTANCE_MAXIMUM_BAND_6 = 1.210700
  REFLECTANCE_MINIMUM_BAND_6 = -0.099980
  REFLECTANCE_MAXIMUM_BAND_7 = 1.210700
  REFLECTANCE_MINIMUM_BAND_7 = -0.099980
  REFLECTANCE_MAXIMUM_BAND_8 = 1.210700
  REFLECTANCE_MINIMUM_BAND_8 = -0.099980
  REFLECTANCE_MAXIMUM_BAND_9 = 1.210700
  REFLECTANCE_MINIMUM_BAND_9 = -0.099980
```

$Qcal\max - Qcal\min$

```
GROUP = MIN_MAX_PIXEL_VALUE
  QUANTIZE_CAL_MAX_BAND_1 = 65535
  QUANTIZE_CAL_MIN_BAND_1 = 1
  QUANTIZE_CAL_MAX_BAND_2 = 65535
  QUANTIZE_CAL_MIN_BAND_2 = 1
  QUANTIZE_CAL_MAX_BAND_3 = 65535
  QUANTIZE_CAL_MIN_BAND_3 = 1
  QUANTIZE_CAL_MAX_BAND_4 = 65535
  QUANTIZE_CAL_MIN_BAND_4 = 1
  QUANTIZE_CAL_MAX_BAND_5 = 65535
  QUANTIZE_CAL_MIN_BAND_5 = 1
  QUANTIZE_CAL_MAX_BAND_6 = 65535
  QUANTIZE_CAL_MIN_BAND_6 = 1
  QUANTIZE_CAL_MAX_BAND_7 = 65535
  QUANTIZE_CAL_MIN_BAND_7 = 1
  QUANTIZE_CAL_MAX_BAND_8 = 65535
  QUANTIZE_CAL_MIN_BAND_8 = 1
  QUANTIZE_CAL_MAX_BAND_9 = 65535
  QUANTIZE_CAL_MIN_BAND_9 = 1
  QUANTIZE_CAL_MAX_BAND_10 = 65535
  QUANTIZE_CAL_MIN_BAND_10 = 1
  QUANTIZE_CAL_MAX_BAND_11 = 65535
  QUANTIZE_CAL_MIN_BAND_11 = 1
END_GROUP = MIN_MAX_PIXEL_VALUE
```

LANDSAT 8 OLI РАДИОМЕТРИЧЕСКАЯ КАЛИБРОВКА

```
GROUP = RADIOMETRIC_RESCALING
  RADIANCE_MULT_BAND_1 = 1.2762E-02
  RADIANCE_MULT_BAND_2 = 1.3014E-02
  RADIANCE_MULT_BAND_3 = 1.1916E-02
  RADIANCE_MULT_BAND_4 = 1.0092E-02
  RADIANCE_MULT_BAND_5 = 6.1242E-03
  RADIANCE_MULT_BAND_6 = 1.5430E-03
  RADIANCE_MULT_BAND_7 = 5.0193E-04
  RADIANCE_MULT_BAND_8 = 1.1369E-02
  RADIANCE_MULT_BAND_9 = 2.5167E-03
  RADIANCE_MULT_BAND_10 = 3.3420E-04
  RADIANCE_MULT_BAND_11 = 3.3420E-04
  RADIANCE_ADD_BAND_1 = -63.81050
  RADIANCE_ADD_BAND_2 = -65.06992
  RADIANCE_ADD_BAND_3 = -59.58209
  RADIANCE_ADD_BAND_4 = -50.46238
  RADIANCE_ADD_BAND_5 = -30.62114
  RADIANCE_ADD_BAND_6 = -7.71500
  RADIANCE_ADD_BAND_7 = -2.50967
  RADIANCE_ADD_BAND_8 = -56.84269
  RADIANCE_ADD_BAND_9 = -12.58350
  RADIANCE_ADD_BAND_10 = 0.10000
  RADIANCE_ADD_BAND_11 = 0.10000
  REFLECTANCE_MULT_BAND_1 = 2.0000E-05
  REFLECTANCE_MULT_BAND_2 = 2.0000E-05
  REFLECTANCE_MULT_BAND_3 = 2.0000E-05
  REFLECTANCE_MULT_BAND_4 = 2.0000E-05
  REFLECTANCE_MULT_BAND_5 = 2.0000E-05
  REFLECTANCE_MULT_BAND_6 = 2.0000E-05
  REFLECTANCE_MULT_BAND_7 = 2.0000E-05
  REFLECTANCE_MULT_BAND_8 = 2.0000E-05
  REFLECTANCE_MULT_BAND_9 = 2.0000E-05
  REFLECTANCE_ADD_BAND_1 = -0.100000
  REFLECTANCE_ADD_BAND_2 = -0.100000
  REFLECTANCE_ADD_BAND_3 = -0.100000
  REFLECTANCE_ADD_BAND_4 = -0.100000
  REFLECTANCE_ADD_BAND_5 = -0.100000
  REFLECTANCE_ADD_BAND_6 = -0.100000
  REFLECTANCE_ADD_BAND_7 = -0.100000
  REFLECTANCE_ADD_BAND_8 = -0.100000
  REFLECTANCE_ADD_BAND_9 = -0.100000
END_GROUP = RADIOMETRIC_RESCALING
```

УДОБНО ВМЕСТО:

$$L_\lambda = \frac{L\max_\lambda - L\min_\lambda}{Qcal\max - Qcal\min}(Qcal - Qcal\min) + L\min_\lambda$$

ИСПОЛЬЗОВАТЬ

$L\lambda$ = **RADIANCE_MULT_BAND_λ** * Qcal_λ + **RADIANCE_ADD_BAND_ λ**

НАПРИМЕР для Qcal_4

L4 = **0.010092*Qcal_4 - 50.46238**

КАЛИБРОВОЧНЫЕ КОЭФФИЦИЕНТЫ ДЛЯ ТЕПЛОВОГО КАНАЛА

```
GROUP = TIRS_THERMAL_CONSTANTS
  K1_CONSTANT_BAND_10 = 774.89
  K1_CONSTANT_BAND_11 = 480.89
  K2_CONSTANT_BAND_10 = 1321.08
  K2_CONSTANT_BAND_11 = 1201.14
END_GROUP = TIRS_THERMAL_CONSTANTS
```