Comparison OT brightness temperatures detected by MSG and AVHRR IR imagery - selected OT cases

Based on data from 2009 – 2014
summer periods

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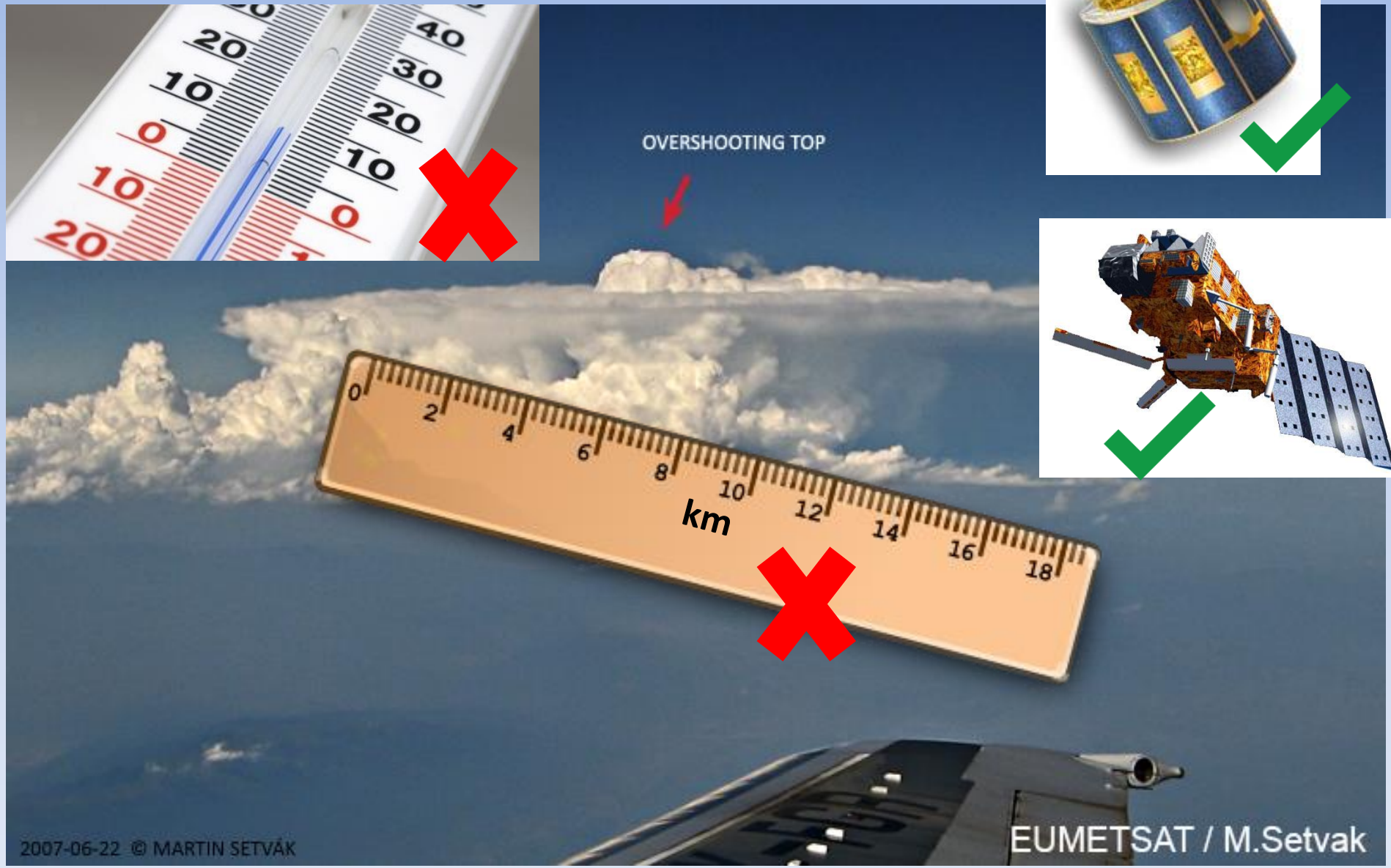
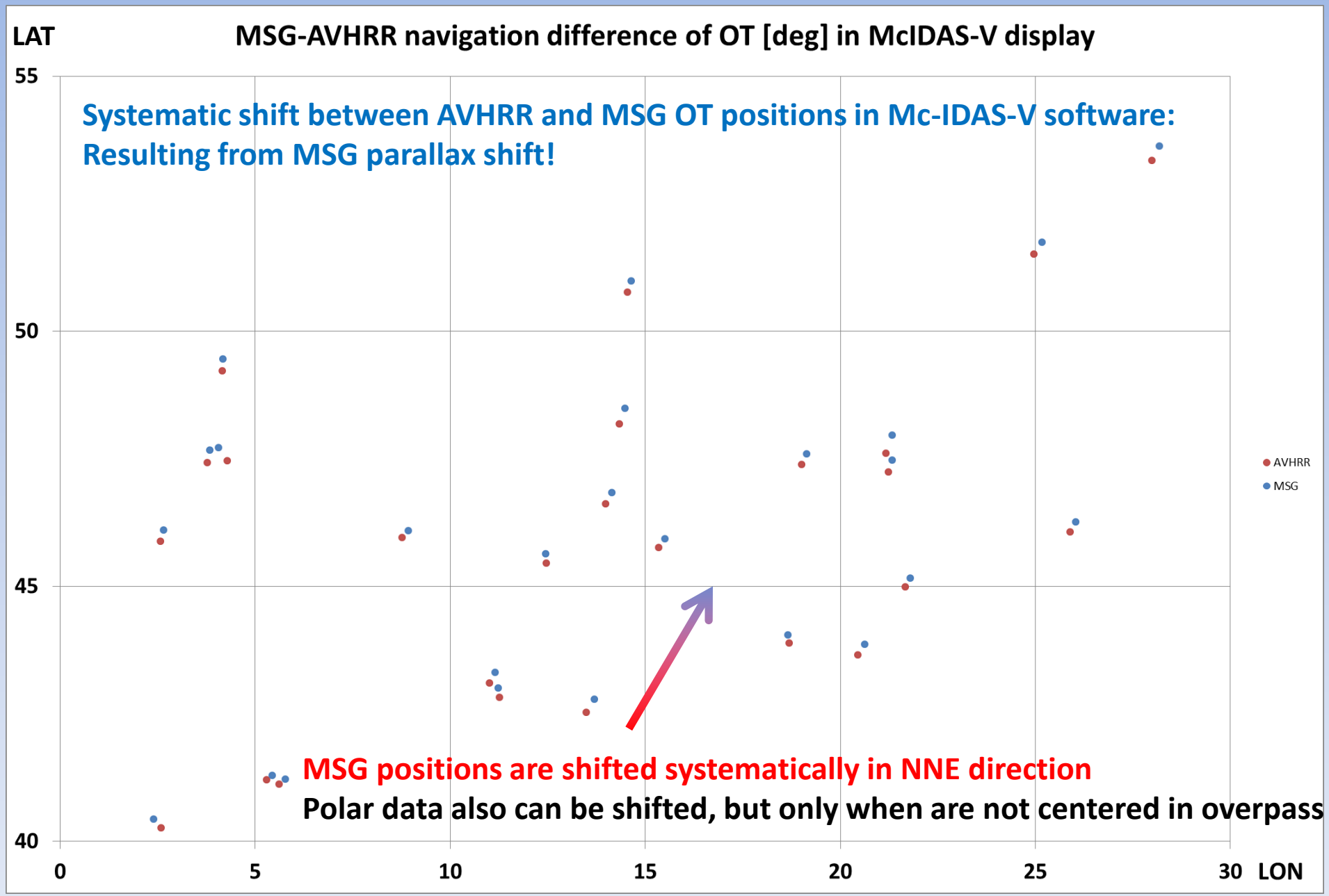
What tools are available to measure OT BT and height?



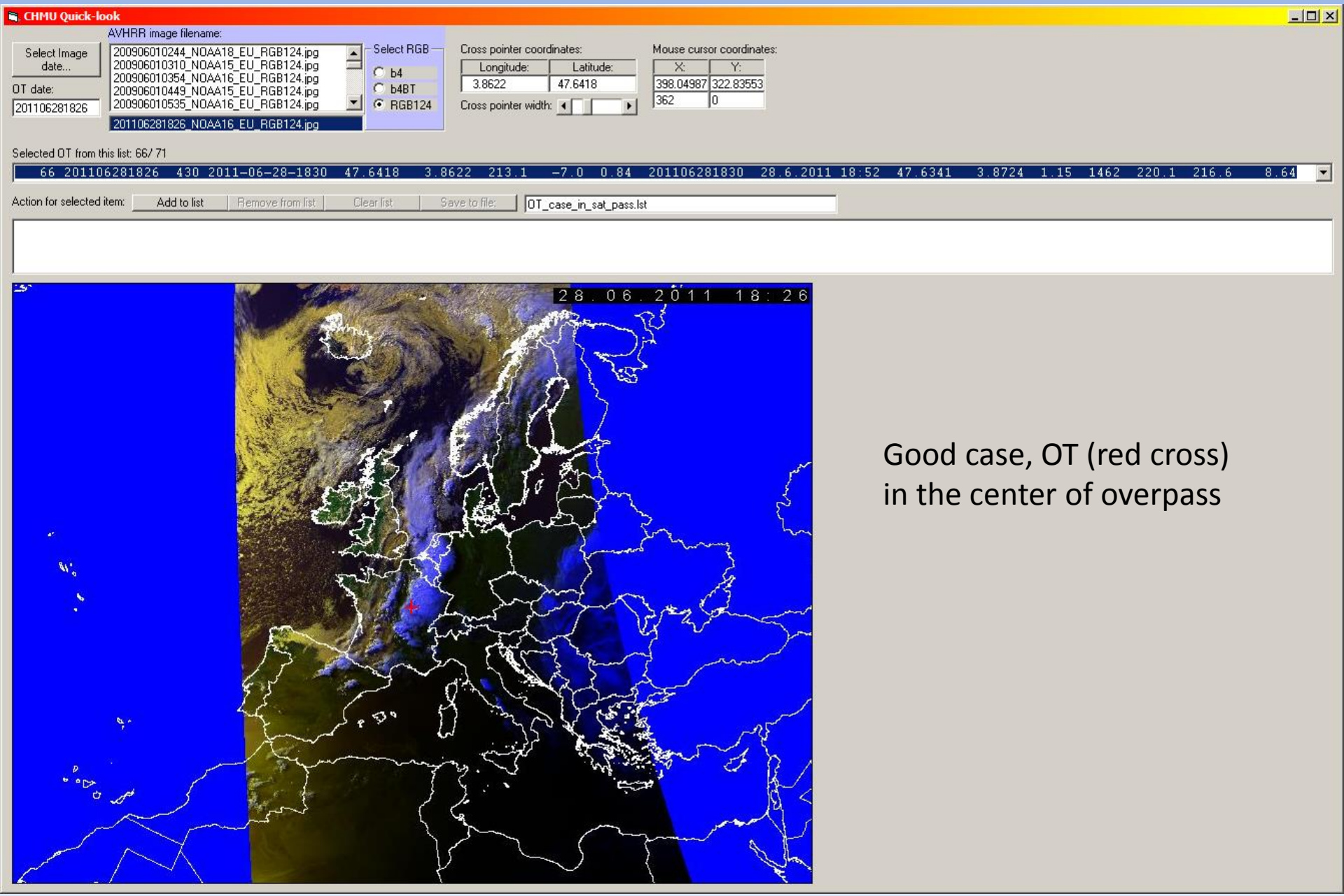
Step by step data processing and evaluation:

- **Input data:**
  - **OT from MSG channel 9 (IR 10.8µm) by Kristopher Bedka**
  - **OT from MSG channel 12 (HRV visible) by Ján Kaňák**
  - **NOAA and Metop overpasses – quick-looks from CHMI: b4, b4BT, RGB124 by M. Setvak, J. Šťástka**
- **Collocation** of MSG channel 9 and channel 12 OT detections
- **Mapping** collocated OTs to CHMI quick-looks (using proper map projection equations)
- **Automatic identification** of MSG timeslots/AVHRR overpasses corresponding to certain OTs from collocated database
- **Visual selection of overpasses** which contain well pronounced OT shadows with low Sun elevation angle and OT is situated in the central part of the overpass (the highest sub-satellite image resolution, example in next slides)
- **Manual read out AVHRR OT BT** and position from AVHRR channel 4 and read out AVHRR OT shadow position from AVHRR channel 2 in **McIDAS-V** (showed in next slides of this presentation)
- **Manual read out MSG OT BT** from channel 10 and MSG HRV OT BT and shadow position in **McIDAS-V**
- **Calculation of OT height** from AVHRR estimations and comparison to height estimation based on MSG HRV
- **Evaluation** of the results (showed in final slides of this presentation)

Collocation of MSG channel 9 and channel 12 OT detections

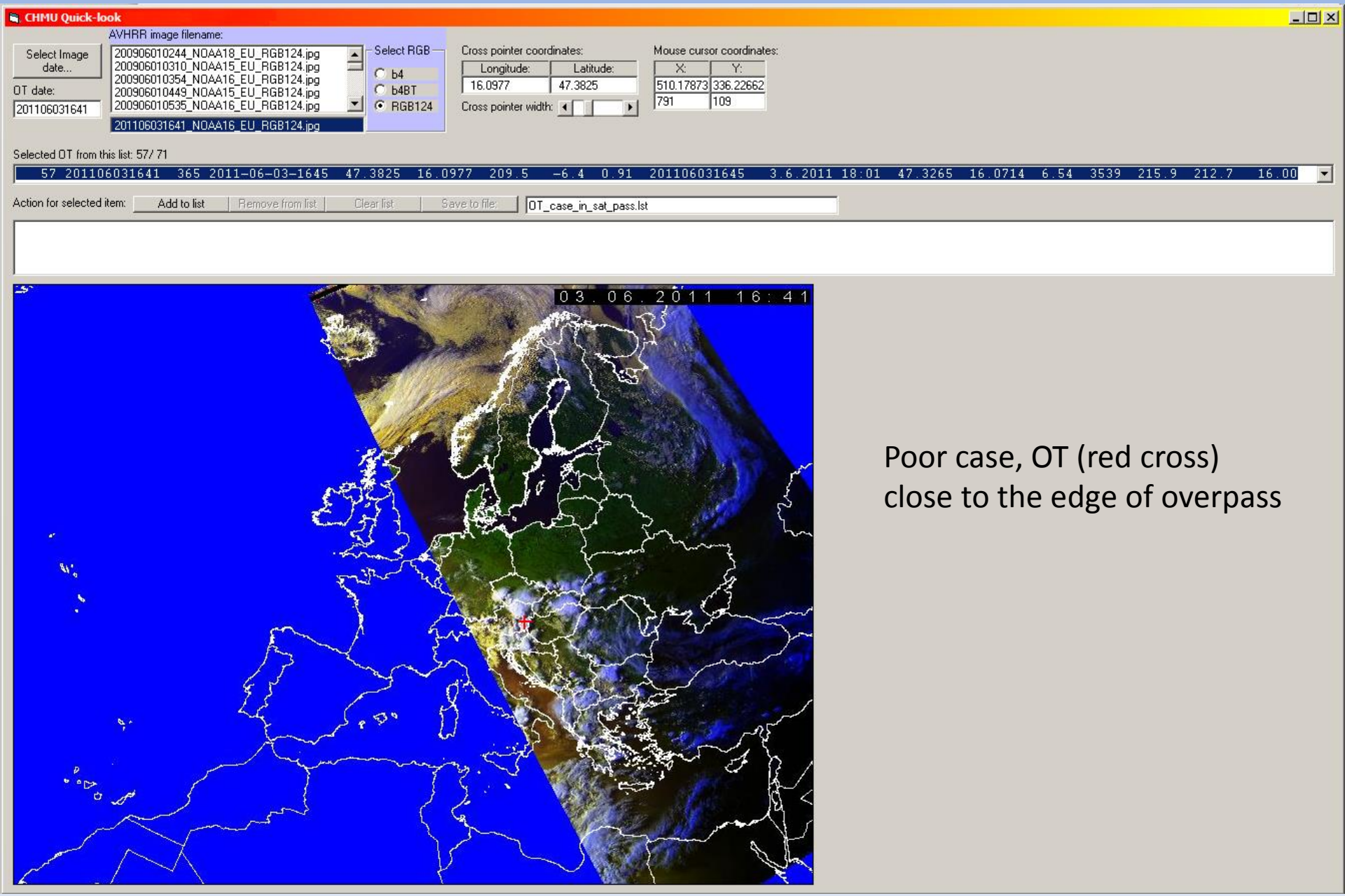


Mapping collocated OTs to CHMI quick-looks (using proper map projection equations)



Good case, OT (red cross) in the center of overpass

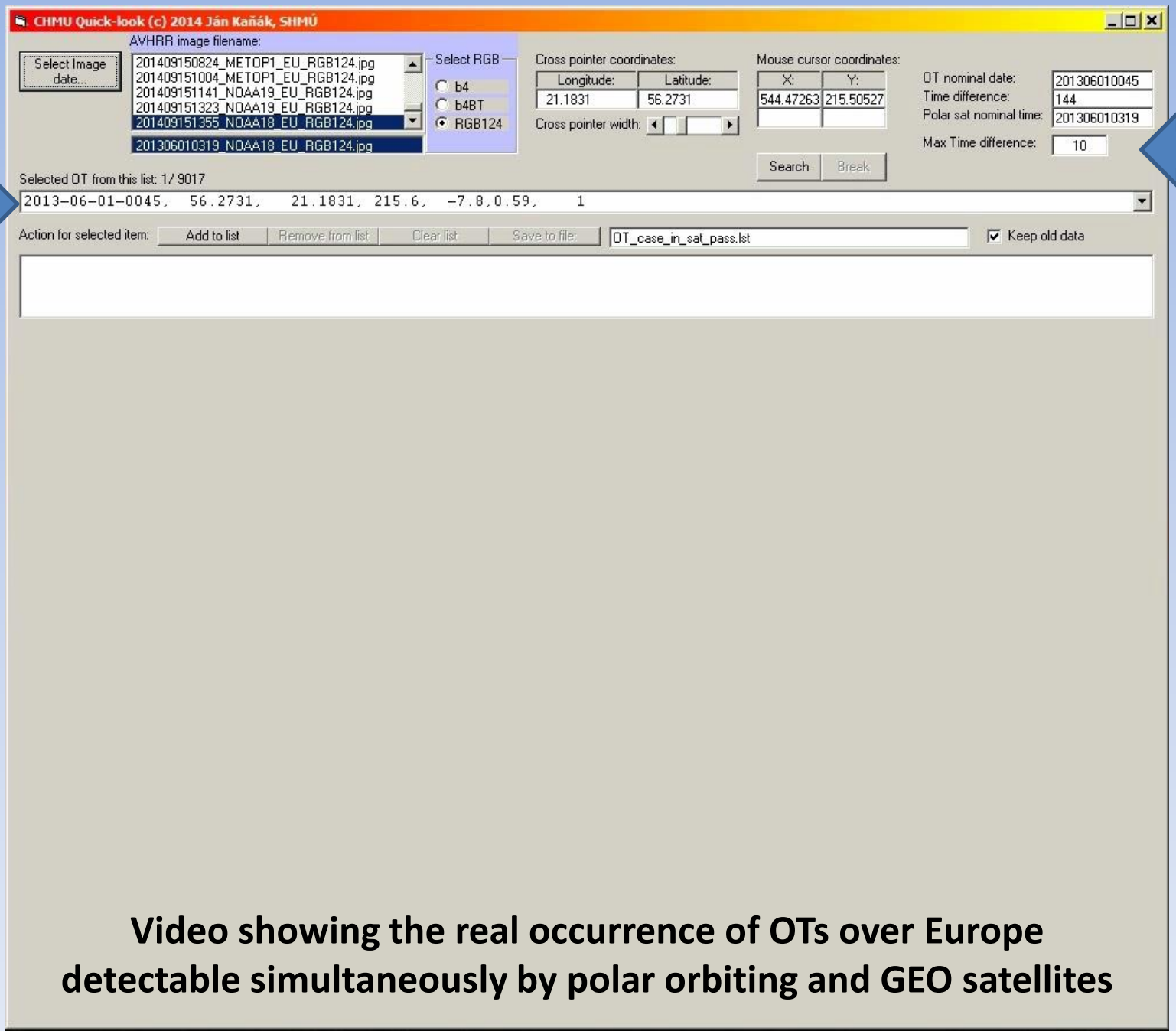
Mapping collocated OTs to CHMI quick-looks (using proper map projection equations)



Poor case, OT (red cross) close to the edge of overpass

Mapping collocated OTs to CHMI quick-looks (using proper map projection equations)

9000 OTs in database



Max TIME Diff = 10 min

Video showing the real occurrence of OTs over Europe detectable simultaneously by polar orbiting and GEO satellites

Automatic identification of MSG timeslots/AVHRR overpasses corresponding to certain OTs from collocated database leads to the result:

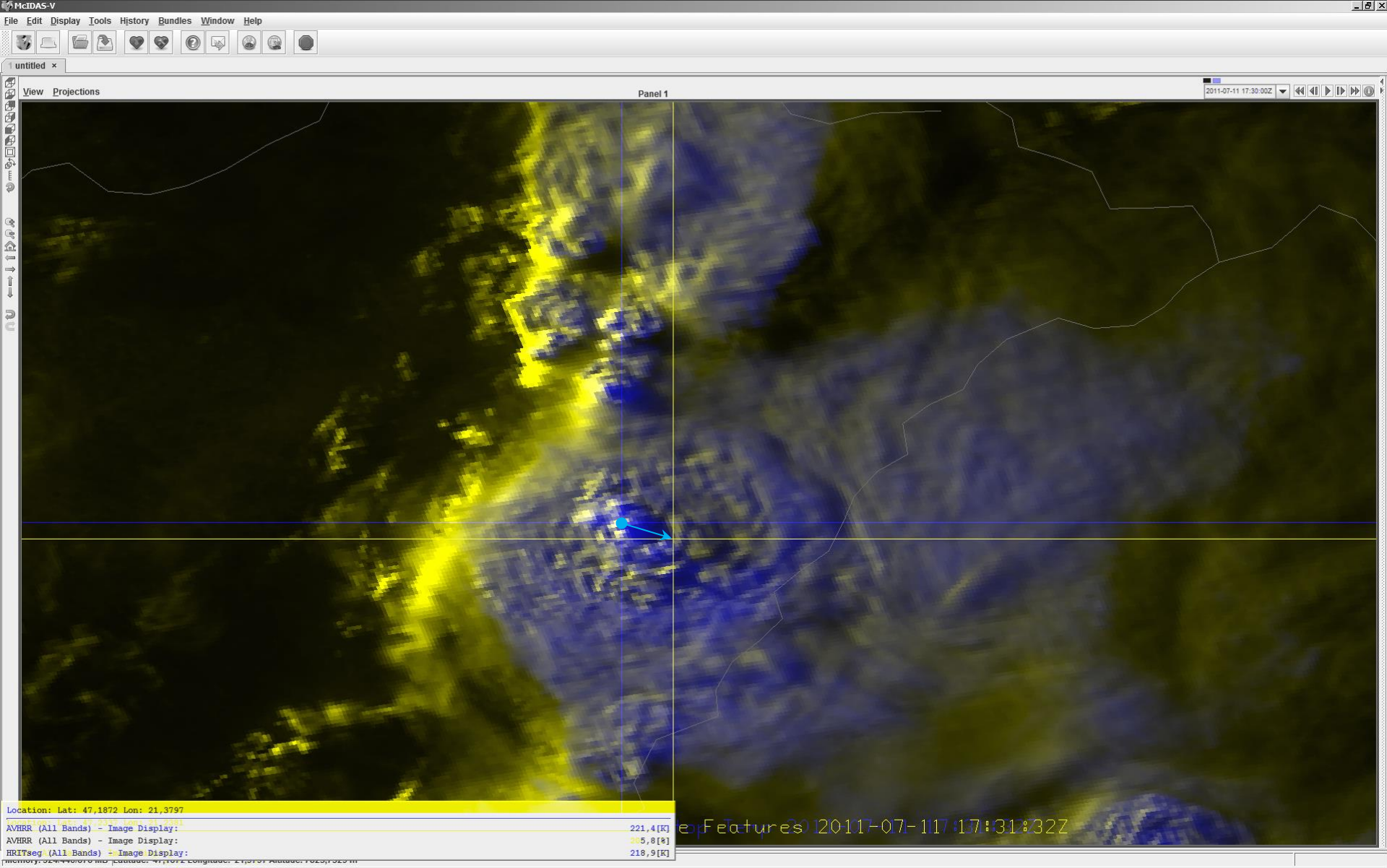
List of selected cases from quick-looks

ID	Polar_overpass		ID	MSG_timeframe	OT LAT	OT LON	IR-BT	Diff	Conf	MSG_Timeslot	DATE	TIME	TailLAT	TailLON	C[km]	H[m]	Anvil	OT BT	Sun El.
6	200906270529	NOAA16	50	2009-06-27-0530	45.6099	12.4654	215.0	-7.6	0.63	200906270530	27.6.2009	6:27	45.5862	12.5232	5.22	3301	222.6	218.8	21.12
11	200907150518	NOAA16	92	2009-07-15-0515	46.0766	8.9379	210.7	-8.9	0.84	200907150515	15.7.2009	5:55	46.0796	8.9794	3.22	2525	219.6	215.1	14.47
14	200907231529	NOAA15	104	2009-07-23-1530	50.7309	14.5265	205.6	-6.6	1.00	200907231530	23.7.2009	16:32	50.7134	14.5676	3.49	4681	212.2	208.9	28.97
15	200907231529	NOAA15	105	2009-07-23-1530	50.9553	14.6534	207.8	-6.4	1.00	200907231530	23.7.2009	16:33	50.9327	14.6816	3.20	4084	214.2	211.0	28.89
28	200908221602	NOAA16	178	2009-08-22-1600	46.8149	14.1601	208.2	-7.6	0.91	200908221600	22.8.2009	17:04	46.7838	14.1641	3.48	3101	215.8	212.0	17.58
29	200908221602	NOAA16	179	2009-08-22-1600	46.8149	14.1601	208.2	-7.6	0.91	200908221600	22.8.2009	17:04	46.8073	14.1497	1.16	2549	215.8	212.0	17.61
30	200908221602	NOAA16	180	2009-08-22-1600	46.8149	14.1601	208.2	-7.6	0.91	200908221600	22.8.2009	17:04	46.7419	14.1906	8.45	2388	215.8	212.0	17.59
31	200908260525	NOAA16	195	2009-08-26-0530	41.2761	5.4457	210.7	-7.0	1.00	200908260530	26.8.2009	5:59	41.2937	5.5147	6.10	1565	217.7	214.2	6.21
32	200908260525	NOAA16	196	2009-08-26-0530	41.2761	5.4457	210.7	-7.0	1.00	200908260530	26.8.2009	5:59	41.2598	5.5307	7.34	2138	217.7	214.2	6.17
33	200908271450	NOAA15	199	2009-08-27-1445	42.7573	13.7054	205.6	-9.3	0.88	200908271445	27.8.2009	15:48	42.7268	13.7256	3.78	3898	214.9	210.3	30.22
34	200908271450	NOAA15	200	2009-08-27-1445	43.2930	11.1574	213.9	-7.0	0.75	200908271445	27.8.2009	15:38	43.2951	11.2151	4.68	3948	220.9	217.4	31.80
35	200908271644	NOAA16	205	2009-08-27-1645	42.9872	11.2524	211.9	-9.1	0.44	200908271645	27.8.2009	17:38	42.9950	11.3351	6.79	1551	221.0	216.4	10.16
36	200908271644	NOAA16	206	2009-08-27-1645	42.9872	11.2524	211.9	-9.1	0.44	200908271645	27.8.2009	17:38	42.9875	11.2485	0.32	2299	221.0	216.4	10.19
38	200908291620	NOAA16	212	2009-08-29-1615	44.0197	18.6569	211.1	-7.3	1.00	200908291615	29.8.2009	17:39	44.0032	18.7155	5.04	1221	218.4	214.8	9.62
39	200908291620	NOAA16	213	2009-08-29-1615	44.0197	18.6569	211.1	-7.3	1.00	200908291615	29.8.2009	17:39	43.9907	18.7145	5.63	1049	218.4	214.8	9.63
41	201006121644	NOAA16	256	2010-06-12-1645	48.4666	14.4994	207.4	-9.9	1.00	201006121645	12.6.2010	17:54	48.4606	14.5035	0.73	3344	217.3	212.4	18.06
53	201008060605	NOAA16	343	2010-08-06-0600	47.5756	19.1394	211.5	-6.9	0.69	201008060600	6.8.2010	7:20	47.5618	19.1566	2.01	3471	218.4	214.9	25.42
56	201106011705	NOAA16	359	2011-06-01-1700	46.2349	26.0388	213.9	-6.6	0.84	201106011700	1.6.2011	18:58	46.2164	26.0306	2.15	2004	220.5	217.2	6.45
61	201106071734	NOAA16	387	2011-06-07-1730	45.9107	15.5172	210.7	-7.7	0.91	201106071730	7.6.2011	18:44	45.8655	15.5054	5.11	2155	218.4	214.6	8.89
62	201106171715	NOAA16	404	2011-06-17-1715	51.7170	25.1714	213.9	-7.6	0.63	201106171715	17.6.2011	19:06	51.7016	25.1301	3.32	2841	221.5	217.7	8.58
63	201106181704	NOAA16	405	2011-06-18-1700	53.5497	28.1609	210.3	-8.5	0.75	201106181700	18.6.2011	19:02	53.6044	28.2223	7.32	2751	218.8	214.6	9.97
64	201106241732	NOAA16	413	2011-06-24-1730	43.8470	20.6367	209.9	-8.5	0.97	201106241730	24.6.2011	19:01	43.8217	20.6090	3.59	1511	218.4	214.1	5.78
65	201106281826	NOAA16	429	2011-06-28-1830	49.4347	4.1935	204.7	-8.8	1.00	201106281830	28.6.2011	18:54	49.3943	4.2180	4.83	1731	213.5	209.1	9.17
66	201106281826	NOAA16	430	2011-06-28-1830	47.6418	3.8622	213.1	-7.0	0.84	201106281830	28.6.2011	18:52	47.6341	3.8724	1.15	1462	220.1	216.6	8.64
67	201107020504	NOAA15	435	2011-07-02-0500	40.4125	2.4083	212.7	-7.8	1.00	201107020500	2.7.2011	5:16	40.4068	2.4310	2.03	1411	220.5	216.6	6.90
68	201107111731	NOAA16	444	2011-07-11-1730	47.4468	21.3331	212.3	-7.9	1.00	201107111730	11.7.2011	19:01	47.4023	21.4039	7.28	1460	220.2	216.3	6.31

Automatic identification of MSG timeslots/AVHRR overpasses corresponding to certain OTs

Legend to the table:

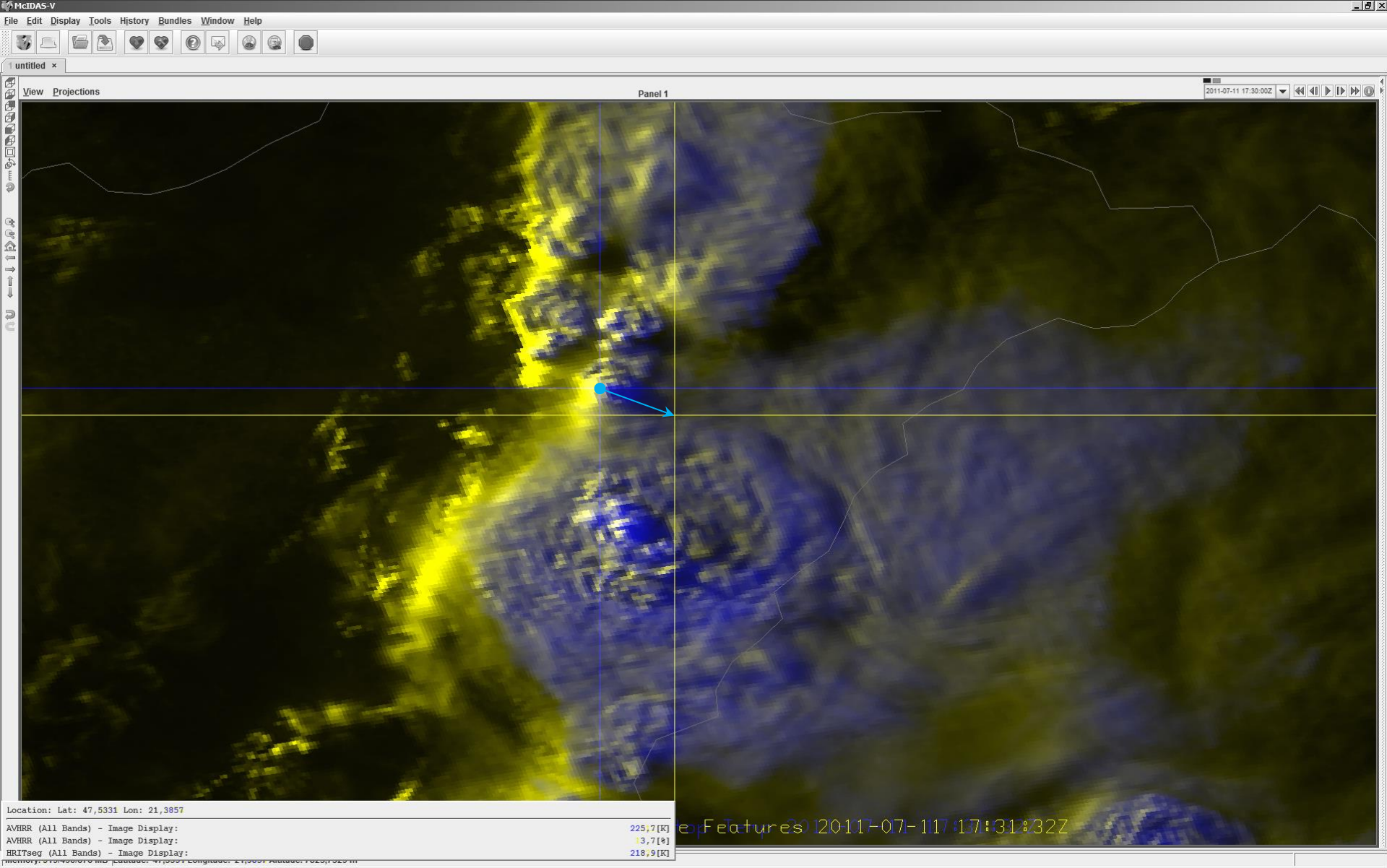
OT ID – internal number used to identify screenshots from McIDAS-V
Timestamp AVHRR – start time of Prague's HRPT station data files
Timestamp MSG – start time of MSG essential servis HRIT data (15 minutes) – in next round of this study 5 min data will be introduced to minimize time of OT scan difference
OT BT AVHRR – Minimum overshooting top brightness temperature measured manually in channel 4 of HRPT [K] using McIDAS-V software
OT BT MSG – Minimum overshooting top brightness temperature measured manually in channel 9 of MSG-SEVIRI [K] using McIDAS-V software
OT BT dT – difference between AVHRR and MSG OT BT [K]
OT Position AVHRR – lon, lat values of pixel with minimum OT BT in AVHRR ch 4 localized manually in McIDAS-V software
OT Position MSG – lon, lat values of pixel with minimum OT BT in SEVIRI ch 9 localized manually in McIDAS-V software (differs from AVHRR position because of different navigation quality of both data sets, instrument resolution and parallax shifts)
AVHRR shadow end – lon, lat values of pixel corresponding to OT shadow end localized on channel 2 VIS 0.8um manually in McIDAS-V software
AVHRR OT Height – penetrating OT height calculated on the base of "OT Position AVHRR" and "AVHRR shadow end" lon, lat values
MSG HRV OT Height – penetrating OT height calculated on the base of MSG HRV OT detections Using ViewMSG visualisation tool
Bedka Min OT BT – minimum OT BT detected by Kris Bedka algorithm (data collocated with HRV shadows)
Bedka OT BT Diff – temp difference between Min OT BT and Anvil BT detected by Kris Bedka algorithm
Bedka Anvil BT – Anvil BT calculated from previous two parameters
Height Difference – difference [m] in OT penetrating height between estimations based on MSG and AVHRR data
Relative Height Difference – relative difference [%] in OT penetrating height between estimations based on MSG and AVHRR data



OT ID	Timestamp AVHRR	Timestamp MSG	OT BT [K] AVHRR	OT BT [K] MSG	dT	OT Position AVHRR LAT	OT Position AVHRR LON	OT Position MSG LAT	OT Position MSG LON	AVHRR Shadow end LAT	AVHRR Shadow end LON	AVHRR OT Height	MSG HRV OT Height	Bedka Min OT BT [K]	Bedka OT BT diff[K]	Bedka Anvil BT [K]	Height Difference [m]
00001	201107111731	201107111730	206.4	212.3	-5.9	47.2337	21.2381	47.4623	21.3311	47.1872	21.3797	1652	1460	212.3	-7.9	220.2	192

AVHRR-MSG BT difference

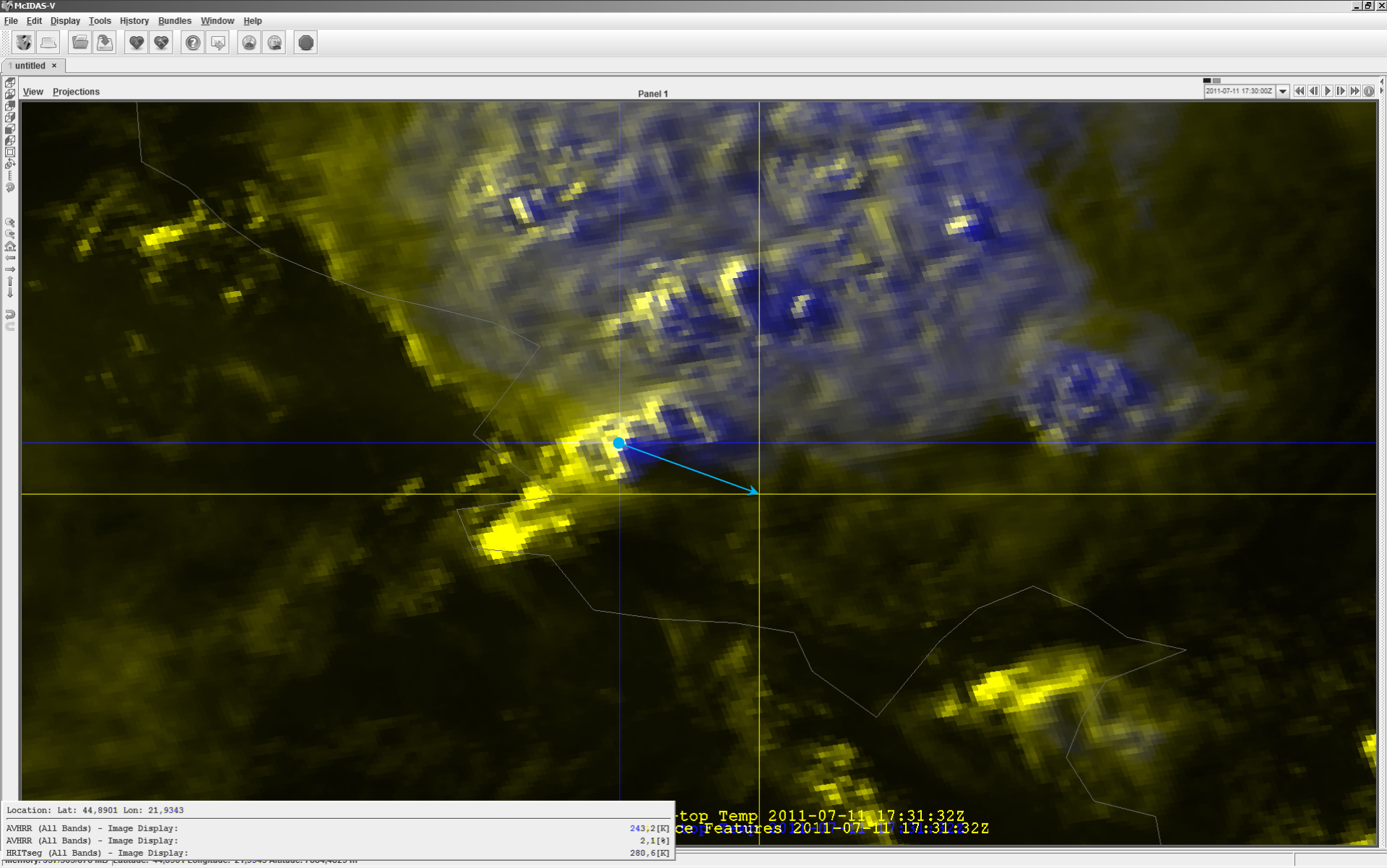
MSG – AVHRR OT height difference: 12%



OT ID	Timestamp AVHRR	Timestamp MSG	OT BT [K] AVHRR	OT BT [K] MSG	dT	OT Position AVHRR LAT	OT Position AVHRR LON	OT Position MSG LAT	OT Position MSG LON	AVHRR Shadow end LAT	AVHRR Shadow end LON	AVHRR OT Height	MSG HRV OT Height	Bedka Min OT BT [K]	Bedka OT BT diff[K]	Bedka Anvil BT [K]	Height Difference [m]
00002	201107111731	201107111730	212.0	215.4	-3.4	47.6079	21.1774	47.9578	21.3372	47.5331	21.3857	2526	2368				158

AVHRR-MSG BT difference

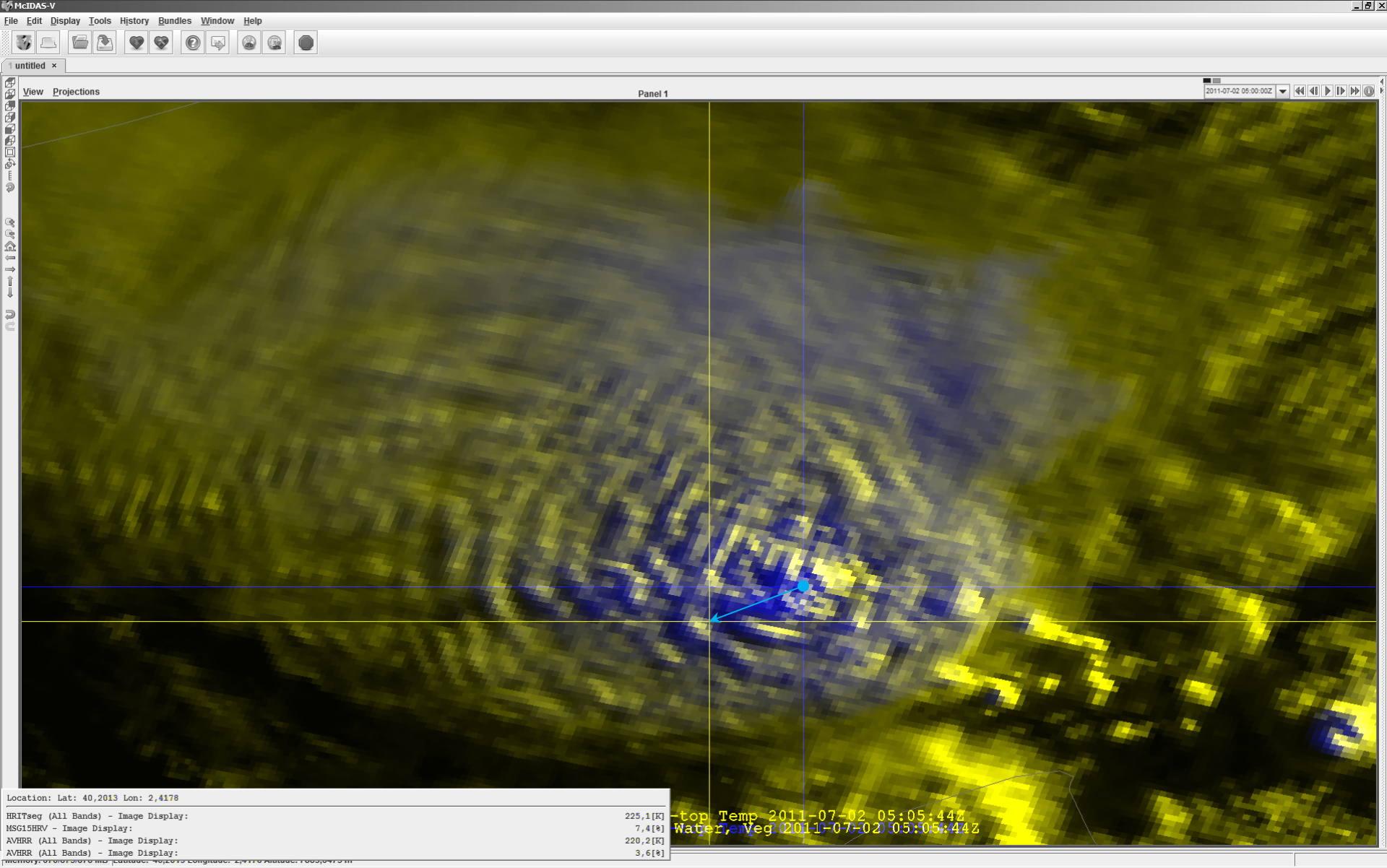
MSG – AVHRR OT height difference: 6%



OT ID	Timestamp AVHRR	Timestamp MSG	OT BT [K] AVHRR	OT BT [K] MSG	dT	OT Position AVHRR LAT	OT Position AVHRR LON	OT Position MSG LAT	OT Position MSG LON	AVHRR Shadow end LAT	AVHRR Shadow end LON	AVHRR OT Height	MSG HRV OT Height	Bedka Min OT BT [K]	Bedka OT BT diff[K]	Bedka Anvil BT [K]	Height Difference [m]
00003	201107111731	201107111730	212.0	218.6	-6.6	44.9853	21.6755	45.1569	21.8015	44.8901	21.9343	2712	2955				-243

AVHRR-MSG BT difference

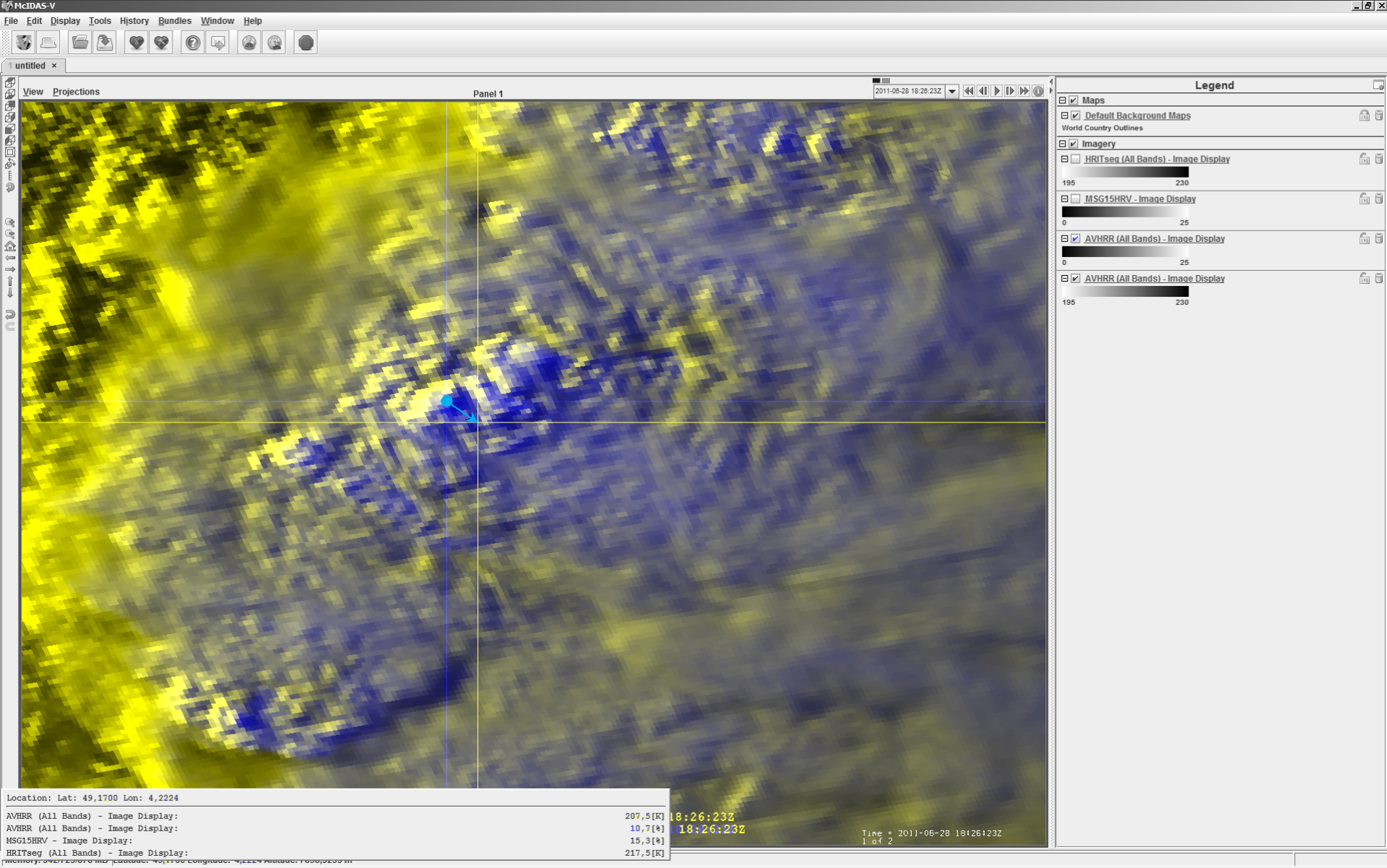
MSG – AVHRR OT height difference: -9%



OT ID	Timestamp AVHRR	Timestamp MSG	OT BT [K] AVHRR	OT BT [K] MSG	dT	OT Position AVHRR LAT	OT Position AVHRR LON	OT Position MSG LAT	OT Position MSG LON	AVHRR Shadow end LAT	AVHRR Shadow end LON	AVHRR OT Height	MSG HRV OT Height	Bedka Min OT BT [K]	Bedka OT BT diff[K]	Bedka Anvil BT [K]	Height Difference [m]
00004	201107020505	201107020500	208.9	212.7	-3.8	40.2661	2.5934	40.4268	2.3962	40.2013	2.4178	1550	1411	212.7	-7.8	220.5	139

AVHRR-MSG BT difference

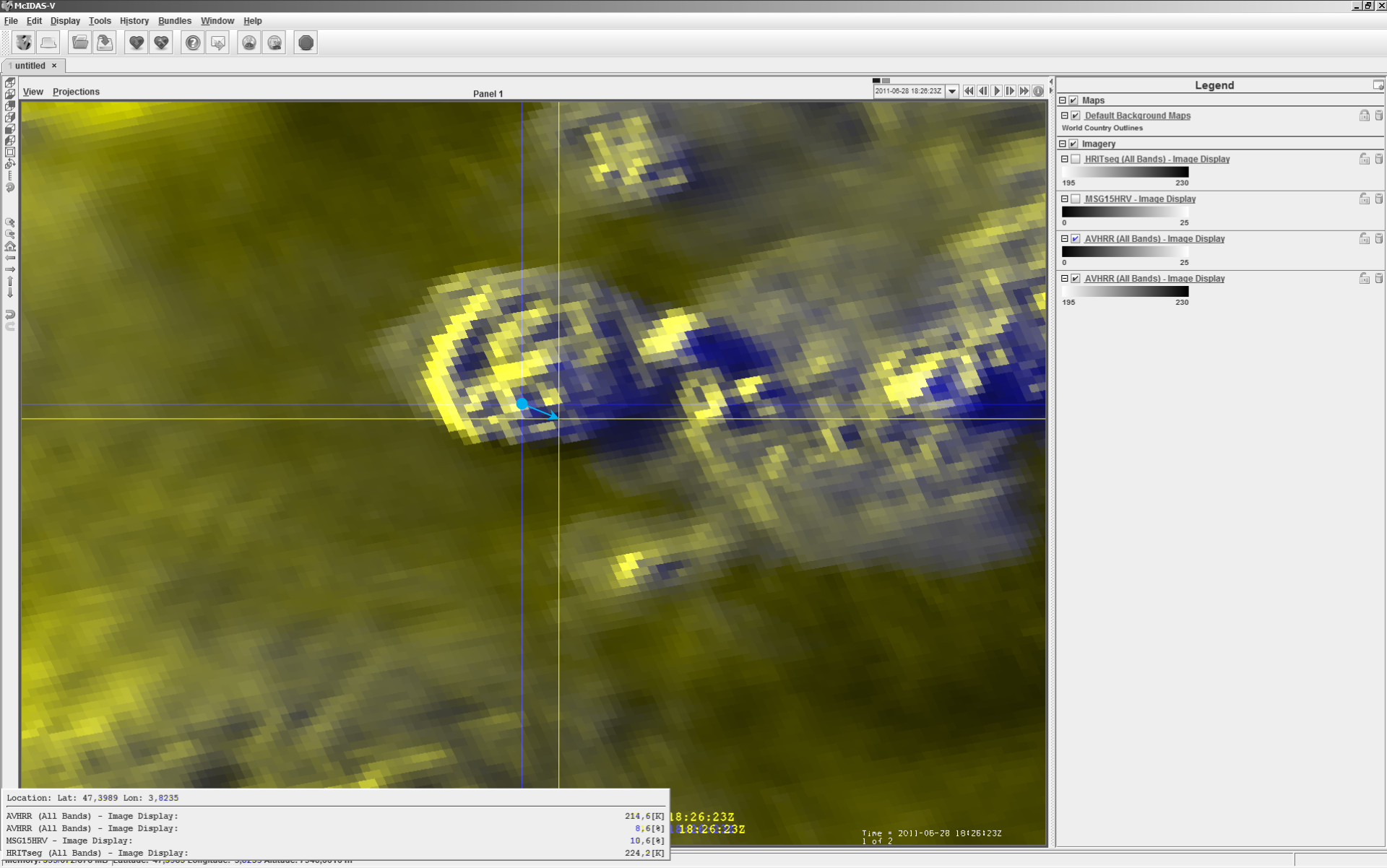
MSG – AVHRR OT height difference: 9%



OT ID	Timestamp AVHRR	Timestamp MSG	OT BT [K] AVHRR	OT BT [K] MSG	dT	OT Position AVHRR LAT	OT Position AVHRR LON	OT Position MSG LAT	OT Position MSG LON	AVHRR Shadow end LAT	AVHRR Shadow end LON	AVHRR OT Height	MSG HRV OT Height	Bedka Min OT BT [K]	Bedka OT BT diff[K]	Bedka Anvil BT [K]	Height Difference [m]
00005	201106281826	201106281830	199.6	204.7	-5.1	49.2152	4.1569	49.4567	4.1834	49.1700	4.2224	1312	1731	204.7	-8.8	213.5	-419

AVHRR-MSG BT difference

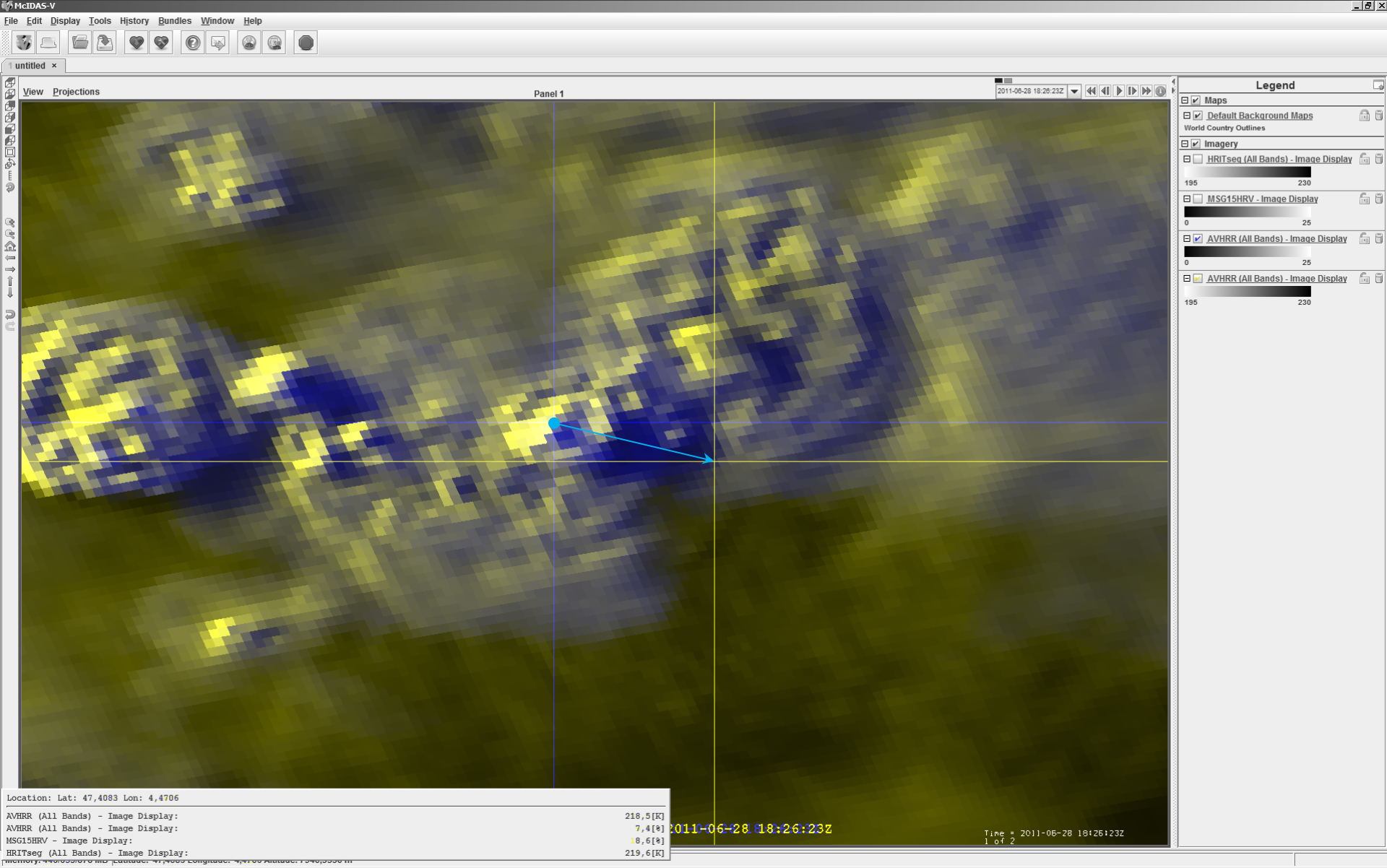
MSG – AVHRR OT height difference: -32%



OT ID	Timestamp AVHRR	Timestamp MSG	OT BT [K] AVHRR	OT BT [K] MSG	OT BT [K] dT	OT Position AVHRR LAT	OT Position AVHRR LON	OT Position MSG LAT	OT Position MSG LON	AVHRR Shadow end LAT	AVHRR Shadow end LON	AVHRR OT Height	MSG HRV OT Height	Bedka Min OT BT [K]	Bedka OT BT diff[K]	Bedka Anvil BT [K]	Height Difference [m]
00006	201106281826	201106281830	207.5	213.1	-5.6	47.4180	3.7761	47.6650	3.8490	47.3989	3.8235	745	1143	213.1	-7.0	220.1	-398

AVHRR-MSG BT difference

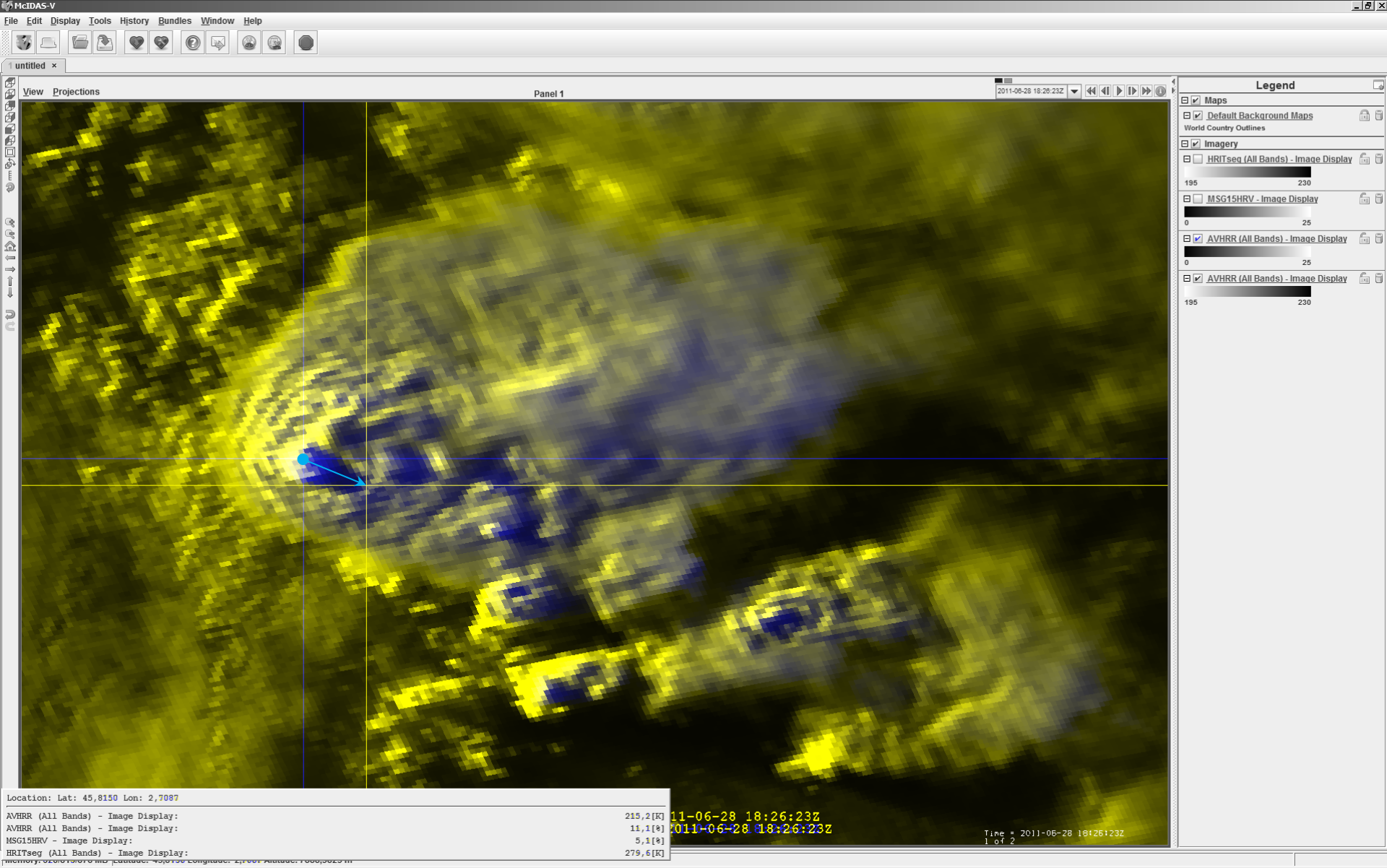
MSG – AVHRR OT height difference: -53%



OT ID	Timestamp AVHRR	Timestamp MSG	OT BT [K] AVHRR	OT BT [K] MSG	OT BT [K] dT	OT Position AVHRR LAT	OT Position AVHRR LON	OT Position MSG LAT	OT Position MSG LON	AVHRR Shadow end LAT	AVHRR Shadow end LON	AVHRR OT Height	MSG HRV OT Height	Bedka Min OT BT [K]	Bedka OT BT diff[K]	Bedka Anvil BT [K]	Height Difference [m]
00007	201106281826	201106281830	206.8	211.9	-5.1	47.4524	4.2889	47.7134	4.0639	47.4083	4.4706	2518	2145				373

AVHRR-MSG BT difference

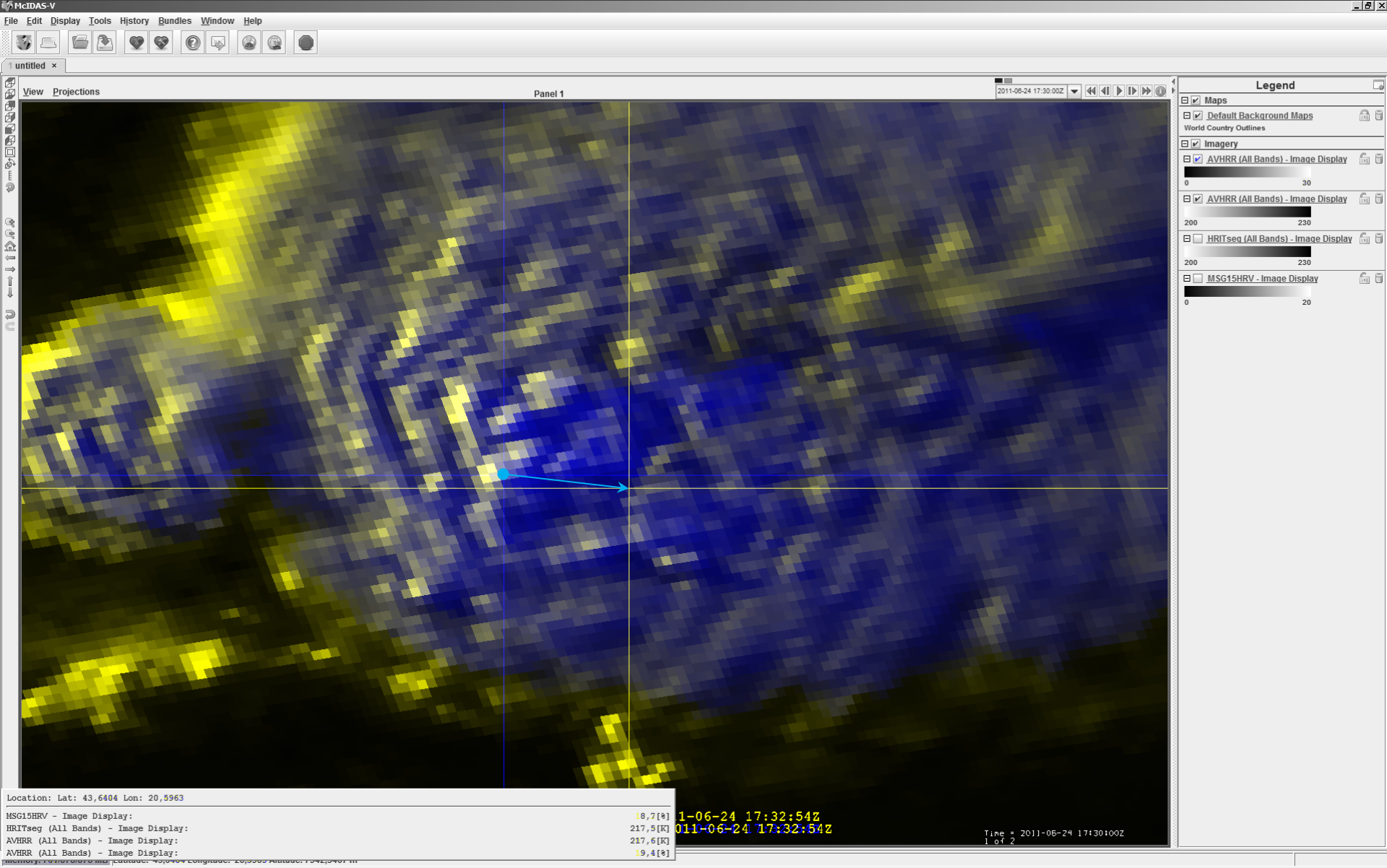
MSG – AVHRR OT height difference: 15%



OT ID	Timestamp AVHRR	Timestamp MSG	OT BT [K] AVHRR	OT BT [K] MSG	dT	OT Position AVHRR LAT	OT Position AVHRR LON	OT Position MSG LAT	OT Position MSG LON	AVHRR Shadow end LAT	AVHRR Shadow end LON	AVHRR OT Height	MSG HRV OT Height	Bedka Min OT BT [K]	Bedka OT BT diff[K]	Bedka Anvil BT [K]	Height Difference [m]
00008	201106281826	201106281830	202.1	209.9	-7.8	45.8717	2.5770	46.0937	2.6612	45.8150	2.7087	2161	2078				83

AVHRR-MSG BT difference

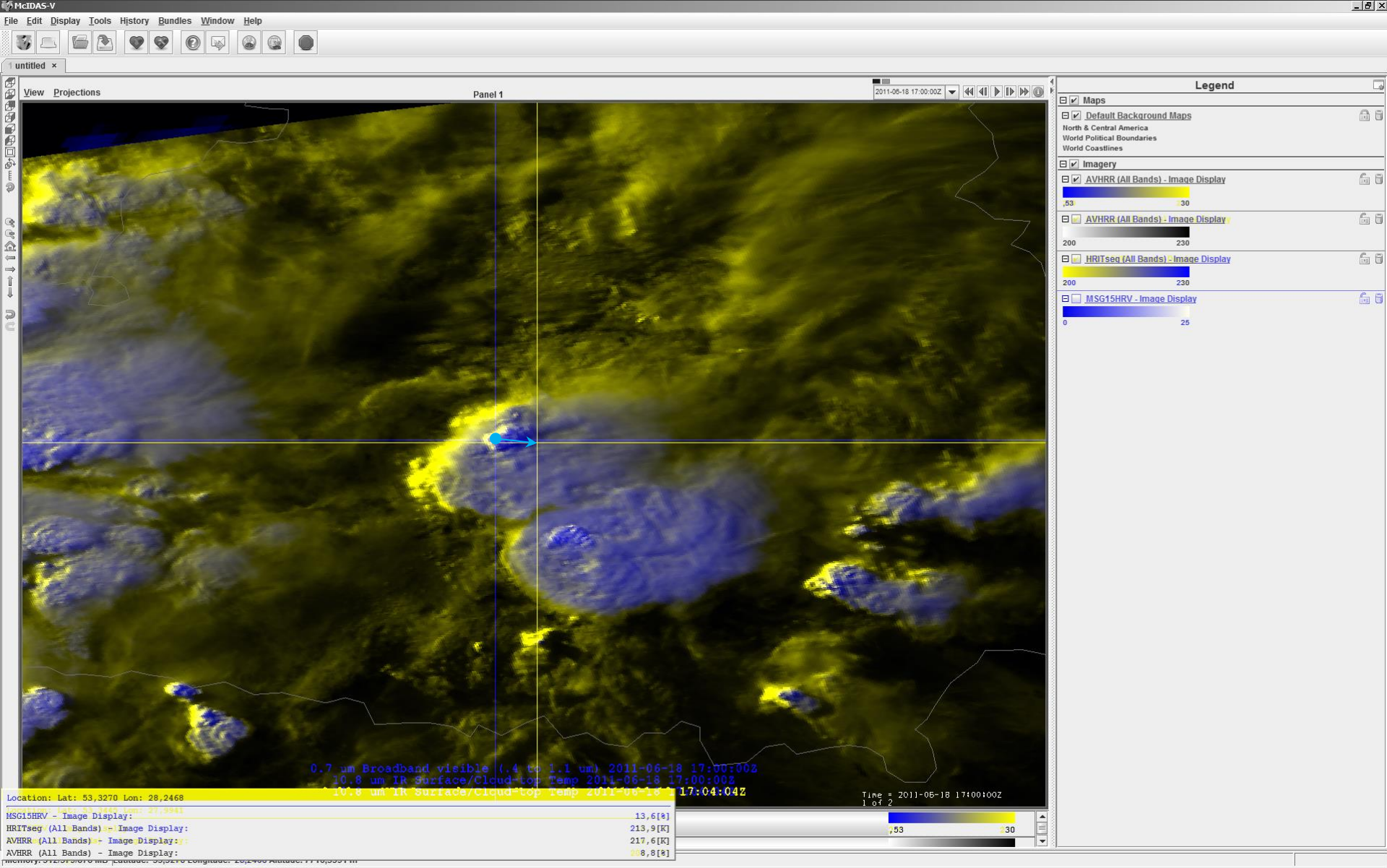
MSG – AVHRR OT height difference: 4%



OT ID	Timestamp AVHRR	Timestamp MSG	OT BT [K] AVHRR	OT BT [K] MSG	dT	OT Position AVHRR LAT	OT Position AVHRR LON	OT Position MSG LAT	OT Position MSG LON	AVHRR Shadow end LAT	AVHRR Shadow end LON	AVHRR OT Height	MSG HRV OT Height	Bedka Min OT BT [K]	Bedka OT BT diff[K]	Bedka Anvil BT [K]	Height Difference [m]
00009	201106241732	201106241730	207.5	209.9	-2.4	43.6546	20.4587	43.8603	20.6295	43.6404	20.5963	1487	1511	212.3	-7.9	220.2	-24

AVHRR-MSG BT difference

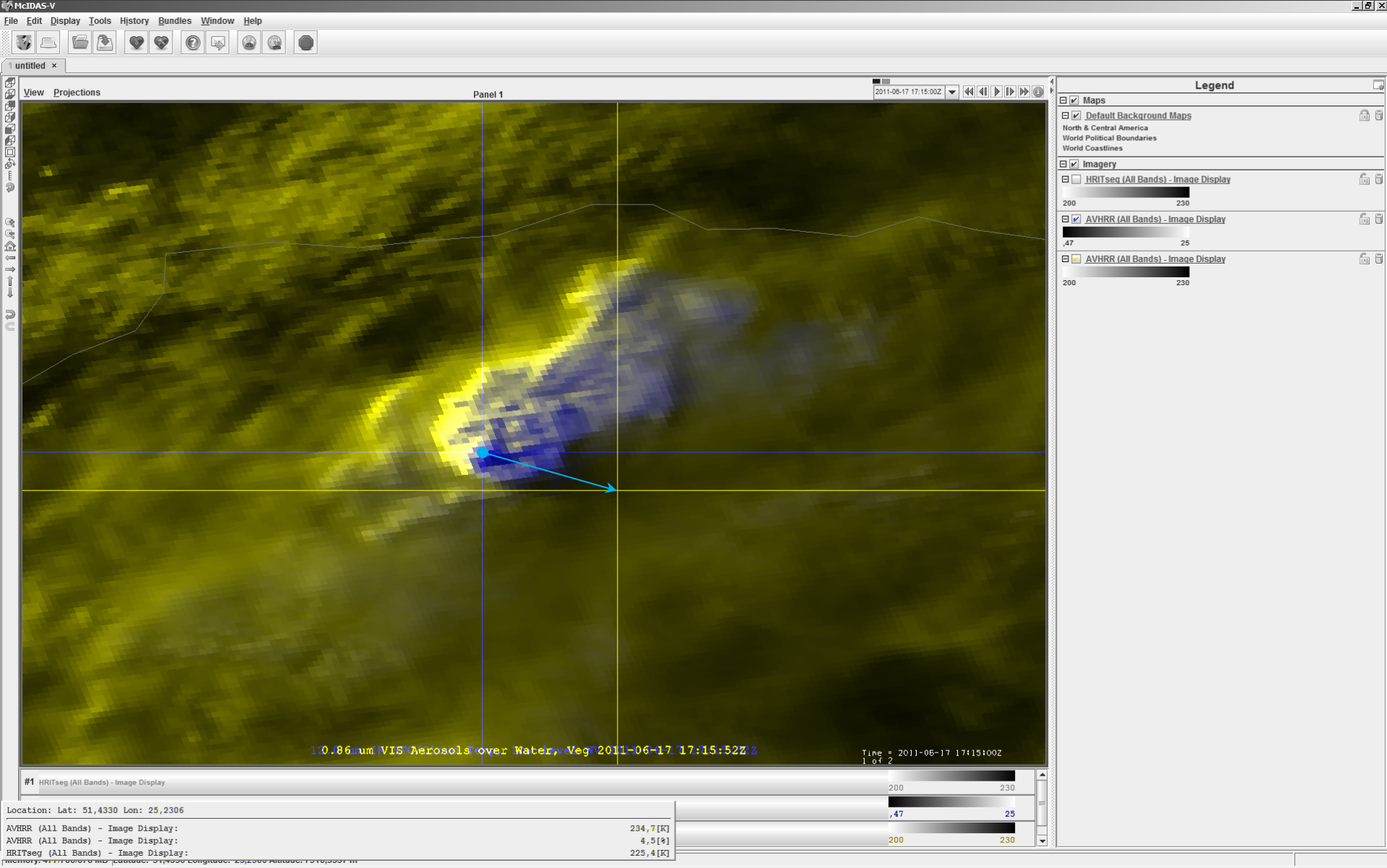
MSG – AVHRR OT height difference: -2%



	Timestamp		OT BT [K]			OT Position										
						AVHRR		MSG		AVHRR Shadow end		AVHRR OT Height	MSG HRV OT Height	Bedka Min OT BT [K]	Bedka OT BT diff[K]	Bedka Anvil BT [K]	Height Difference [m]
OT ID	AVHRR	MSG	AVHRR	MSG	dT	LAT	LON	LAT	LON	LAT	LON						
00010	201106181704	201106181700	204.5	210.3	-5.8	53.3445	27.9941	53.6232	28.1901	53.3270	28.2468	3382	2751	210.3	-8.5	218.8	631

AVHRR-MSG BT difference

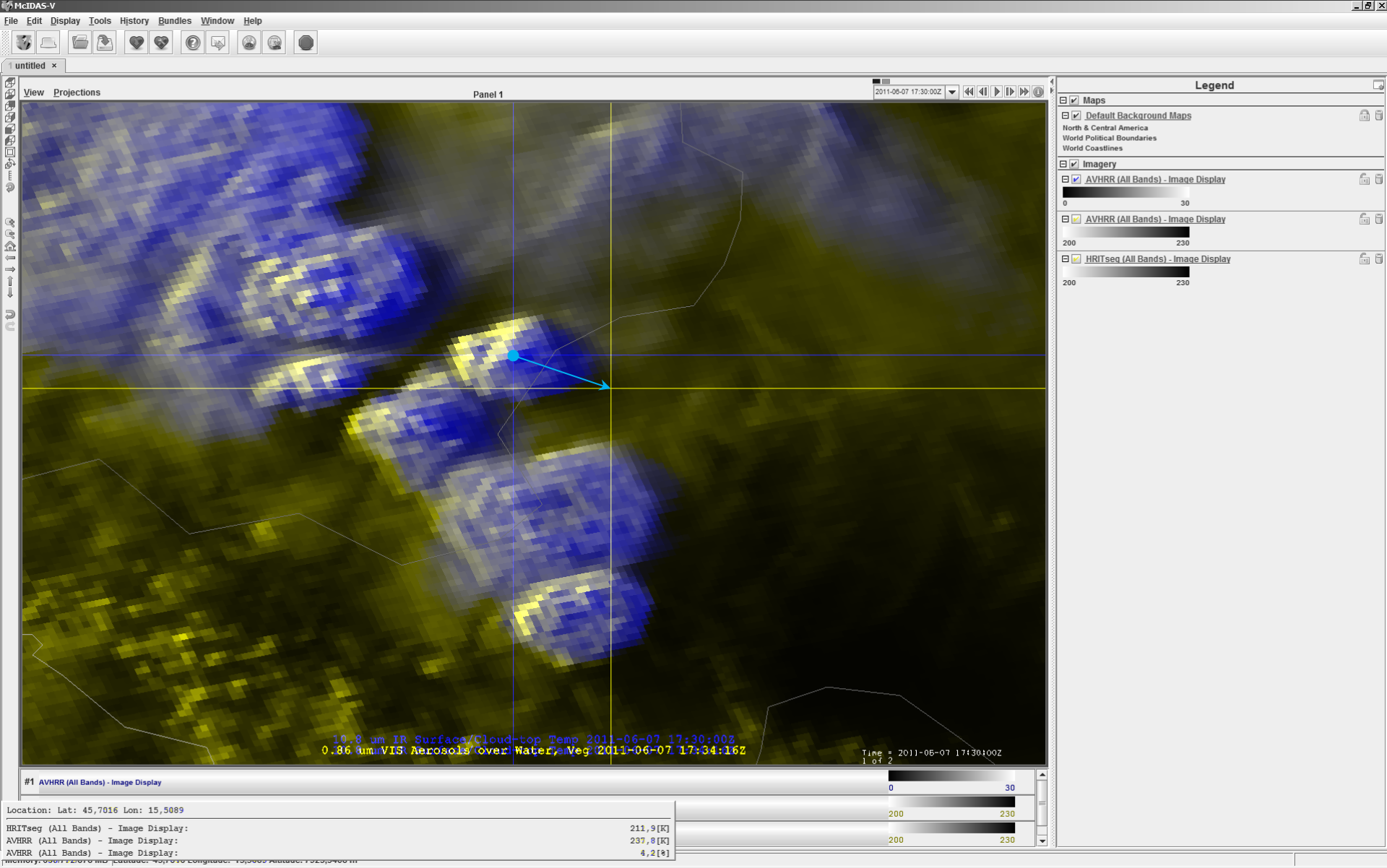
MSG – AVHRR OT height difference: 19%



OT ID	Timestamp AVHRR	Timestamp MSG	OT BT [K] AVHRR	OT BT [K] MSG	dT	OT Position AVHRR LAT	OT Position AVHRR LON	OT Position MSG LAT	OT Position MSG LON	AVHRR Shadow end LAT	AVHRR Shadow end LON	AVHRR OT Height	MSG HRV OT Height	Bedka Min OT BT [K]	Bedka OT BT diff[K]	Bedka Anvil BT [K]	Height Difference [m]
00011	201106171715	201106171715	206.6	213.9	-7.3	51.5059	24.9723	51.7423	25.1798	51.4330	25.2306	3457	2841	213.9	-7.6	221.5	616

AVHRR-MSG BT difference

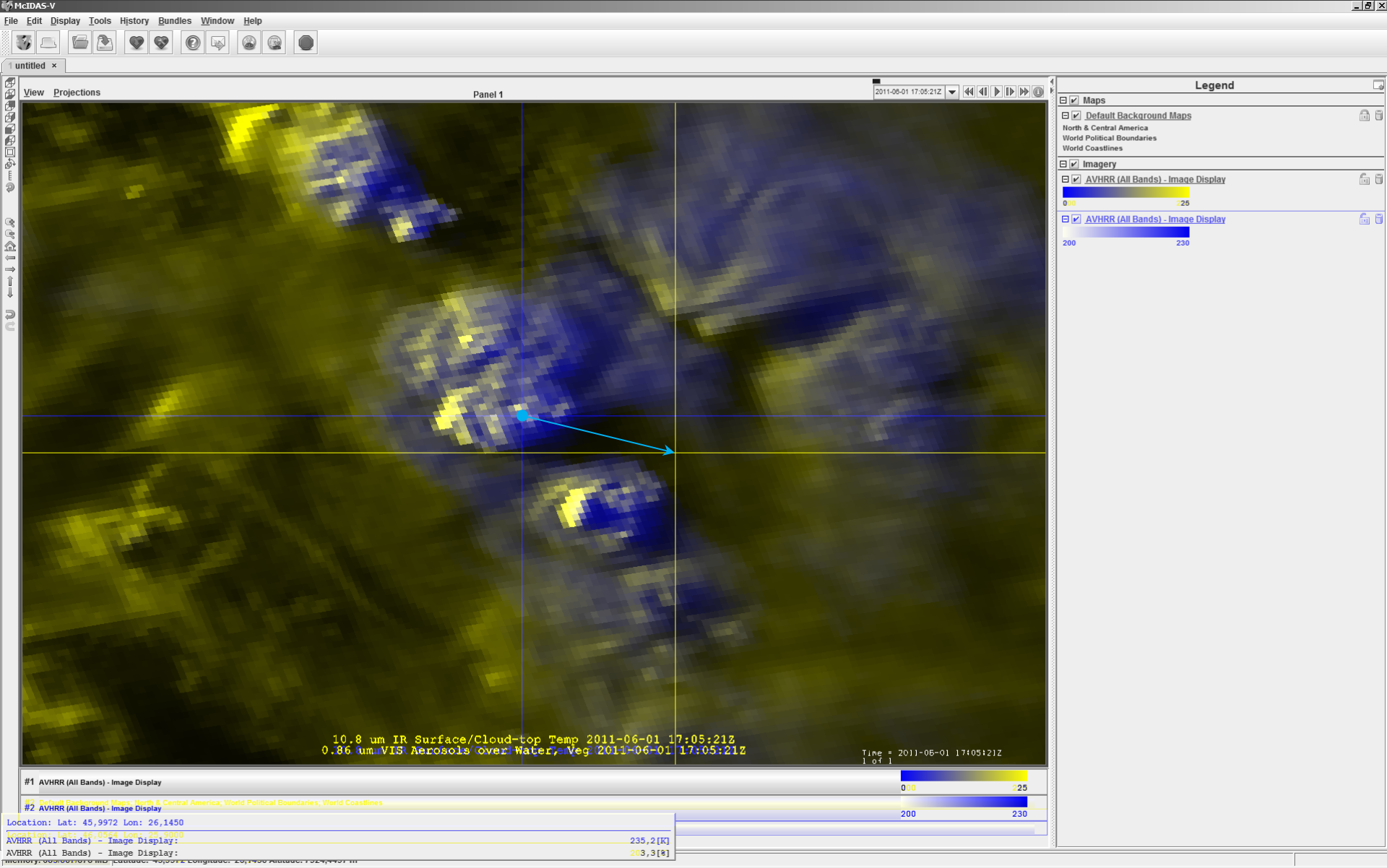
MSG – AVHRR OT height difference: 18%



	Timestamp		OT BT [K]			OT Position				AVHRR Shadow end		AVHRR OT Height	MSG HRV OT Height	Bedka Min OT BT [K]	Bedka OT BT diff[K]	Bedka Anvil BT [K]	Height Difference [m]
						AVHRR		MSG									
OT ID	AVHRR	MSG	AVHRR	MSG	dT	LAT	LON	LAT	LON	LAT	LON						
00012	201106071734	201106071730	205.7	210.7	-5.0	45.7558	15.3487	45.9278	15.5089	45.7016	15.5089	2576	2155	210.7	-7.7	218.4	421

AVHRR-MSG BT difference

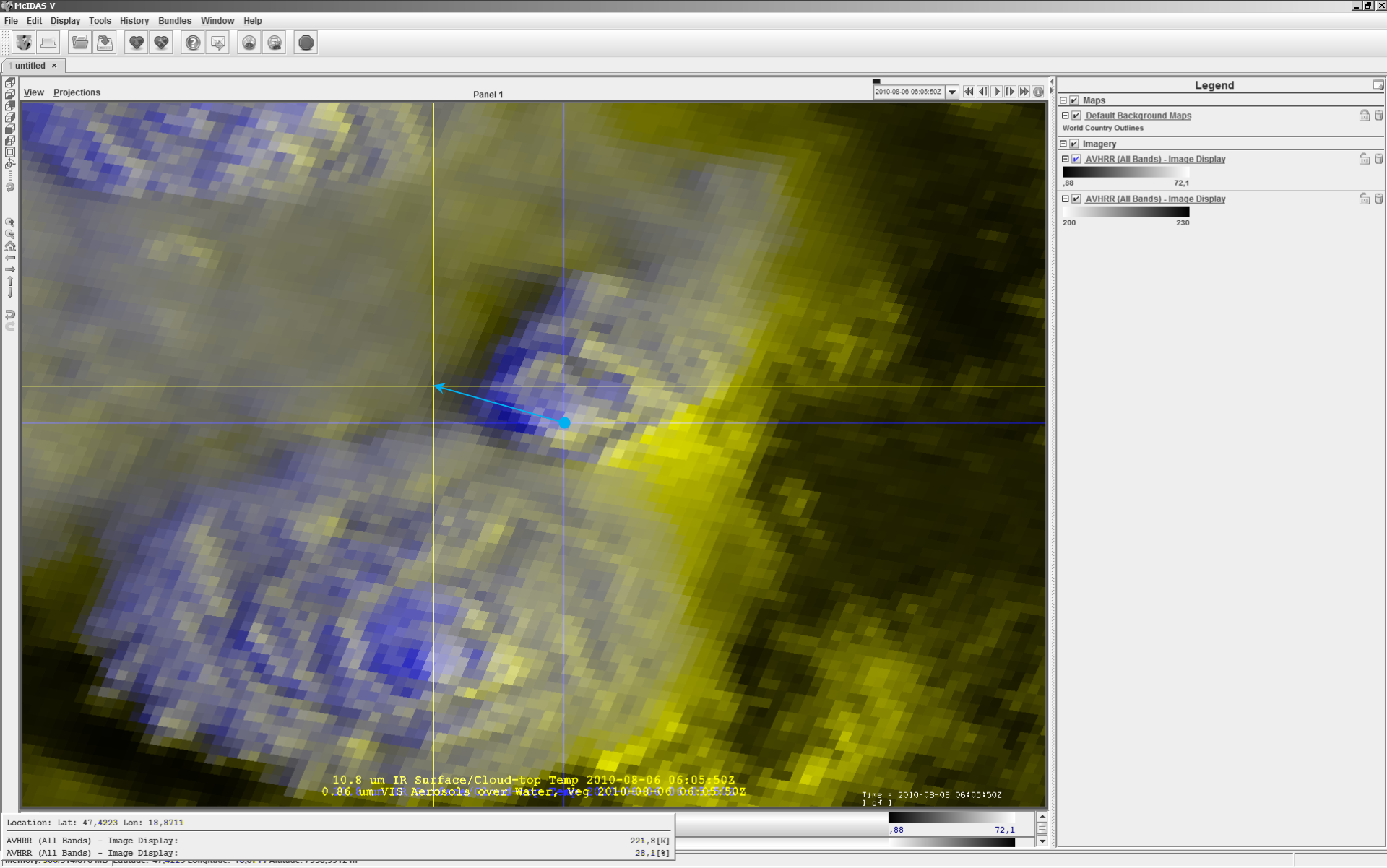
MSG – AVHRR OT height difference: 16%



OT ID	Timestamp AVHRR	Timestamp MSG	OT BT [K] AVHRR	OT BT [K] MSG	dT	OT Position AVHRR LAT	OT Position AVHRR LON	OT Position MSG LAT	OT Position MSG LON	AVHRR Shadow end LAT	AVHRR Shadow end LON	AVHRR OT Height	MSG HRV OT Height	Bedka Min OT BT [K]	Bedka OT BT diff[K]	Bedka Anvil BT [K]	Height Difference [m]
00013	201106011705	201106011700	208.9	213.9	-5.0	46.0564	25.9000	46.2538	26.0428	45.9972	26.1450	2869	2004	213.9	-6.6	220.5	865

AVHRR-MSG BT difference

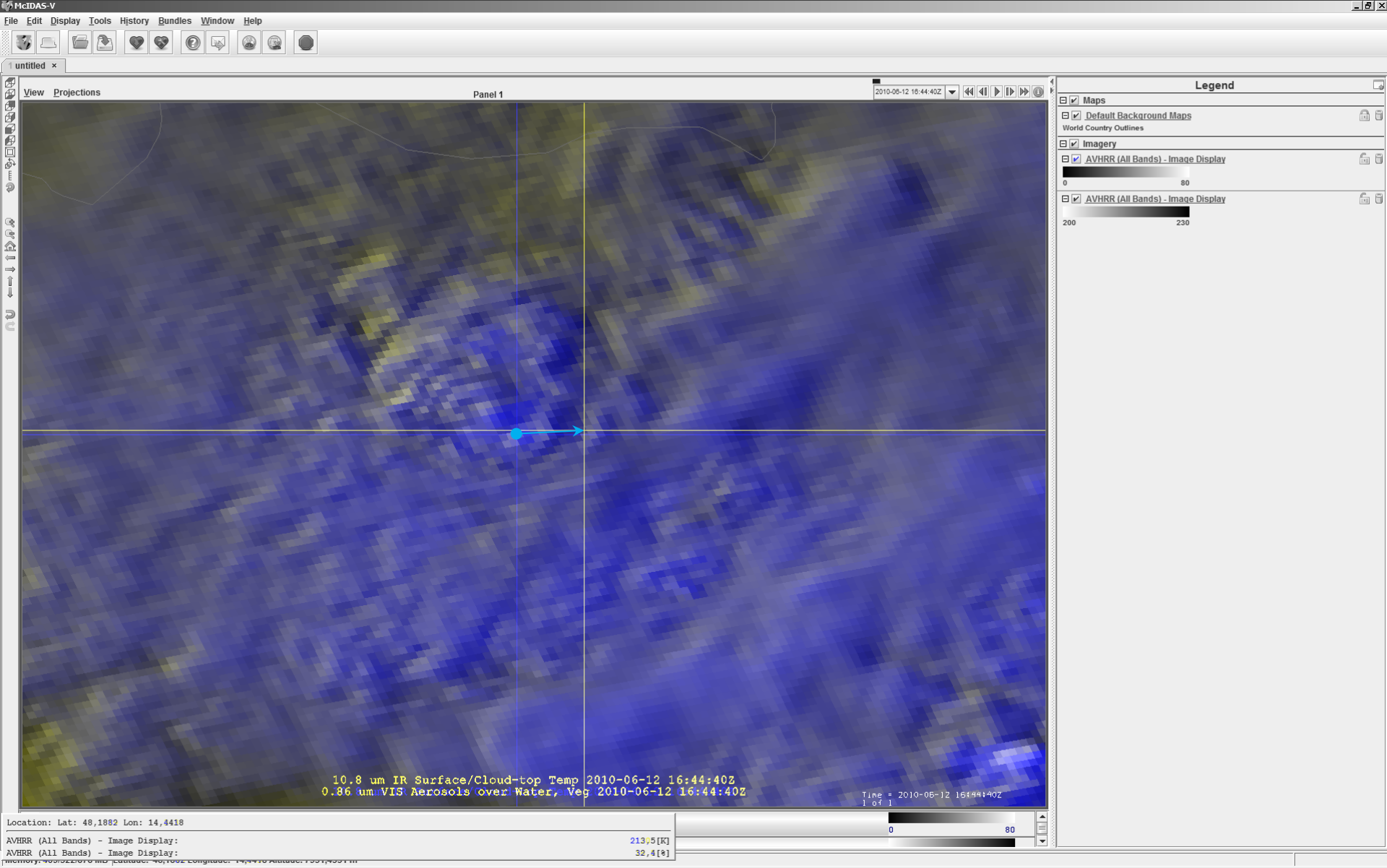
MSG – AVHRR OT height difference: 30%



OT ID	Timestamp AVHRR	Timestamp MSG	OT BT [K] AVHRR	OT BT [K] MSG	dT	OT Position AVHRR LAT	OT Position AVHRR LON	OT Position MSG LAT	OT Position MSG LON	AVHRR Shadow end LAT	AVHRR Shadow end LON	AVHRR OT Height	MSG HRV OT Height	Bedka Min OT BT [K]	Bedka OT BT diff[K]	Bedka Anvil BT [K]	Height Difference [m]
00014	201008060605	201008060600	206.8	211.5	-4.7	47.3835	19.0079	47.5907	19.1374	47.4223	18.8711	4842	3471	211.5	-6.9	218.4	1371

AVHRR-MSG BT difference

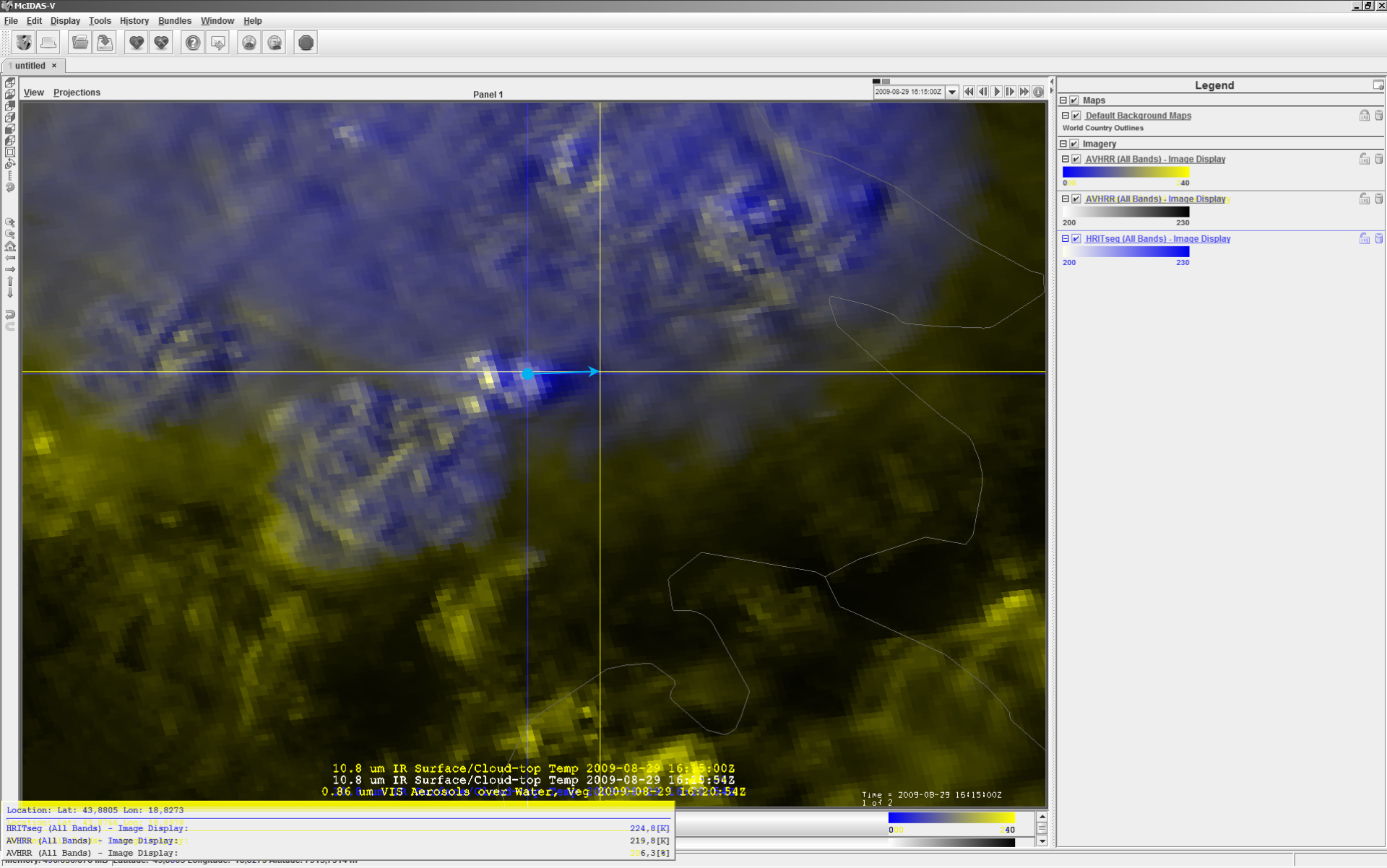
MSG – AVHRR OT height difference: 28%



	Timestamp		OT BT [K]			OT Position										
						AVHRR		MSG		AVHRR Shadow end		AVHRR OT Height	MSG HRV OT Height	Bedka Min OT BT [K]	Bedka OT BT diff[K]	Bedka Anvil BT [K]	Height Difference [m]
OT ID	AVHRR	MSG	AVHRR	MSG	dT	LAT	LON	LAT	LON	LAT	LON						
00015	201006121644	201006121645	205.0	207.4	-2.4	48.1819	14.3438	48.4882	14.4908	48.1882	14.4418	2562	3344	207.4	-9.9	217.3	-782

AVHRR-MSG BT difference

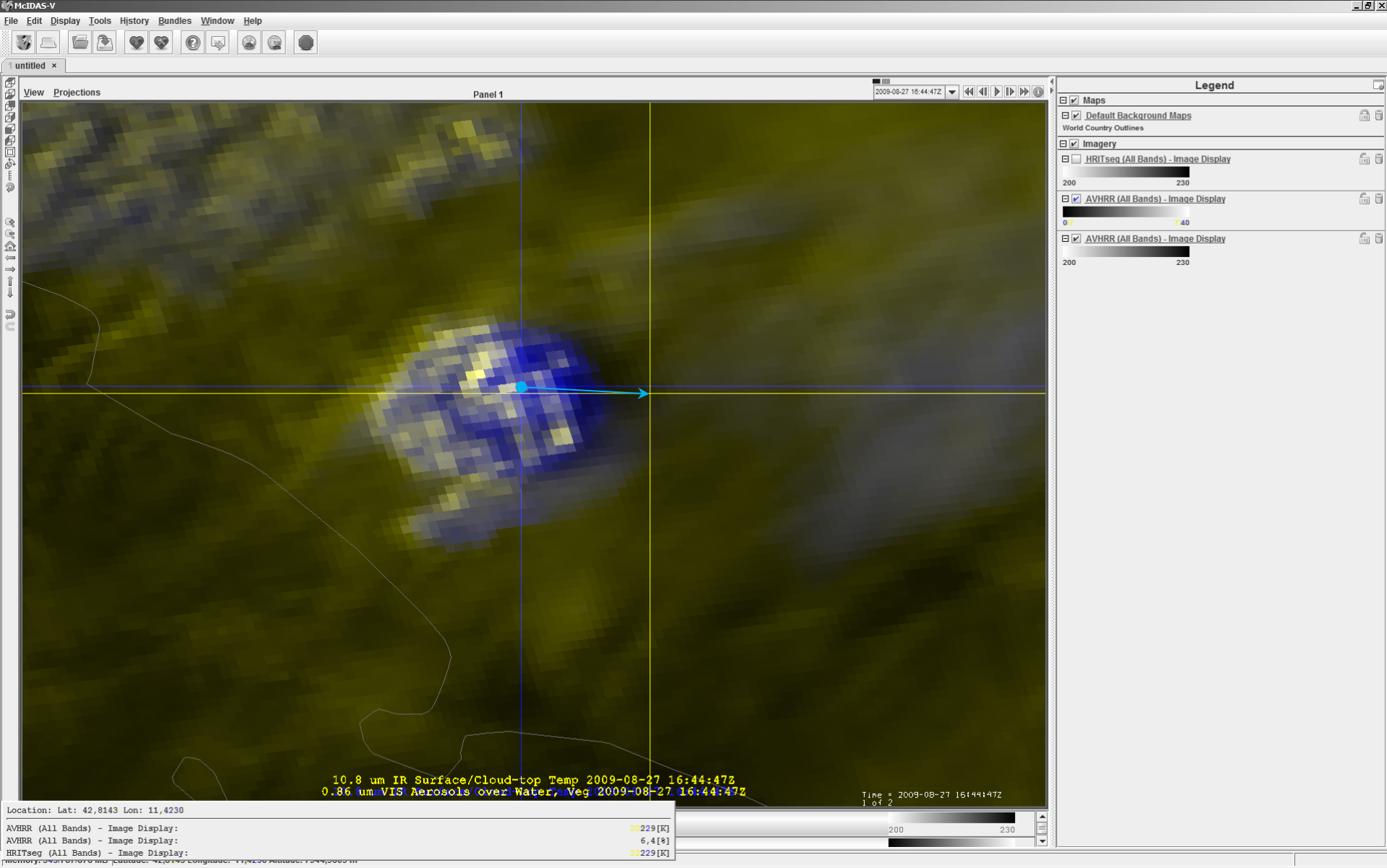
MSG – AVHRR OT height difference: -31%



OT ID	Timestamp AVHRR	Timestamp MSG	OT BT [K] AVHRR	OT BT [K] MSG	dT	OT Position AVHRR LAT	OT Position AVHRR LON	OT Position MSG LAT	OT Position MSG LON	AVHRR Shadow end LAT	AVHRR Shadow end LON	AVHRR OT Height	MSG HRV OT Height	Bedka Min OT BT [K]	Bedka OT BT diff[K]	Bedka Anvil BT [K]	Height Difference [m]
00016	200908291620	200908291615	206.3	211.1	-4.8	43.8766	18.6978	44.0364	18.6662	43.8805	18.8273	2070	2176	211.1	-7.3	218.4	-106

AVHRR-MSG BT difference

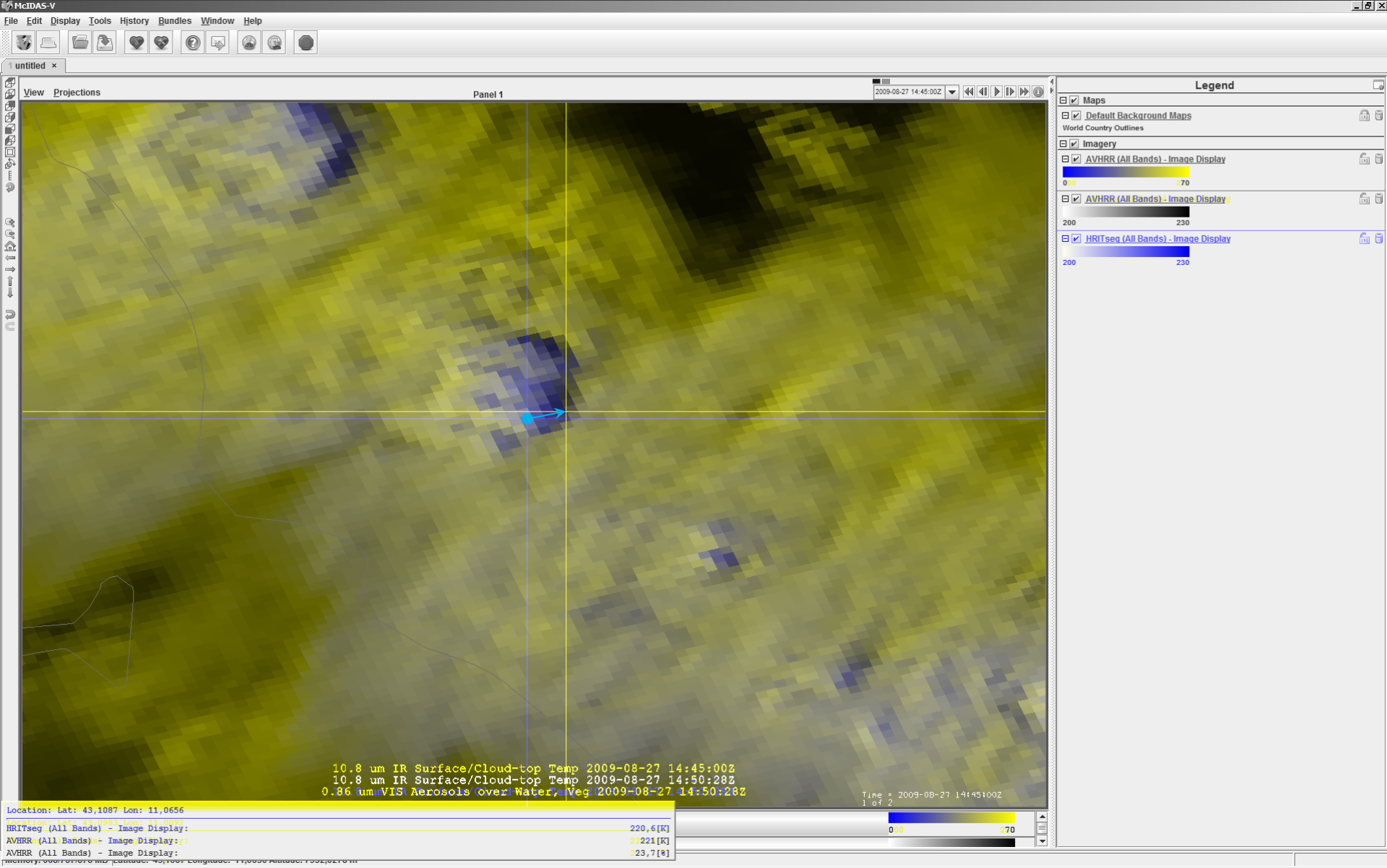
MSG – AVHRR OT height difference: -5%



OT ID	Timestamp AVHRR	Timestamp MSG	OT BT [K] AVHRR	OT BT [K] MSG	OT BT [K] dT	OT Position AVHRR LAT	OT Position AVHRR LON	OT Position MSG LAT	OT Position MSG LON	AVHRR Shadow end LAT	AVHRR Shadow end LON	AVHRR OT Height	MSG HRV OT Height	Bedka Min OT BT [K]	Bedka OT BT diff[K]	Bedka Anvil BT [K]	Height Difference [m]
00017	200908271644	200908271645	208.4	211.9	-3.5	42.8228	11.2716	43.0035	11.2426	42.8143	11.4230	2623	2299	211.9	-9.1	221.0	324

AVHRR-MSG BT difference

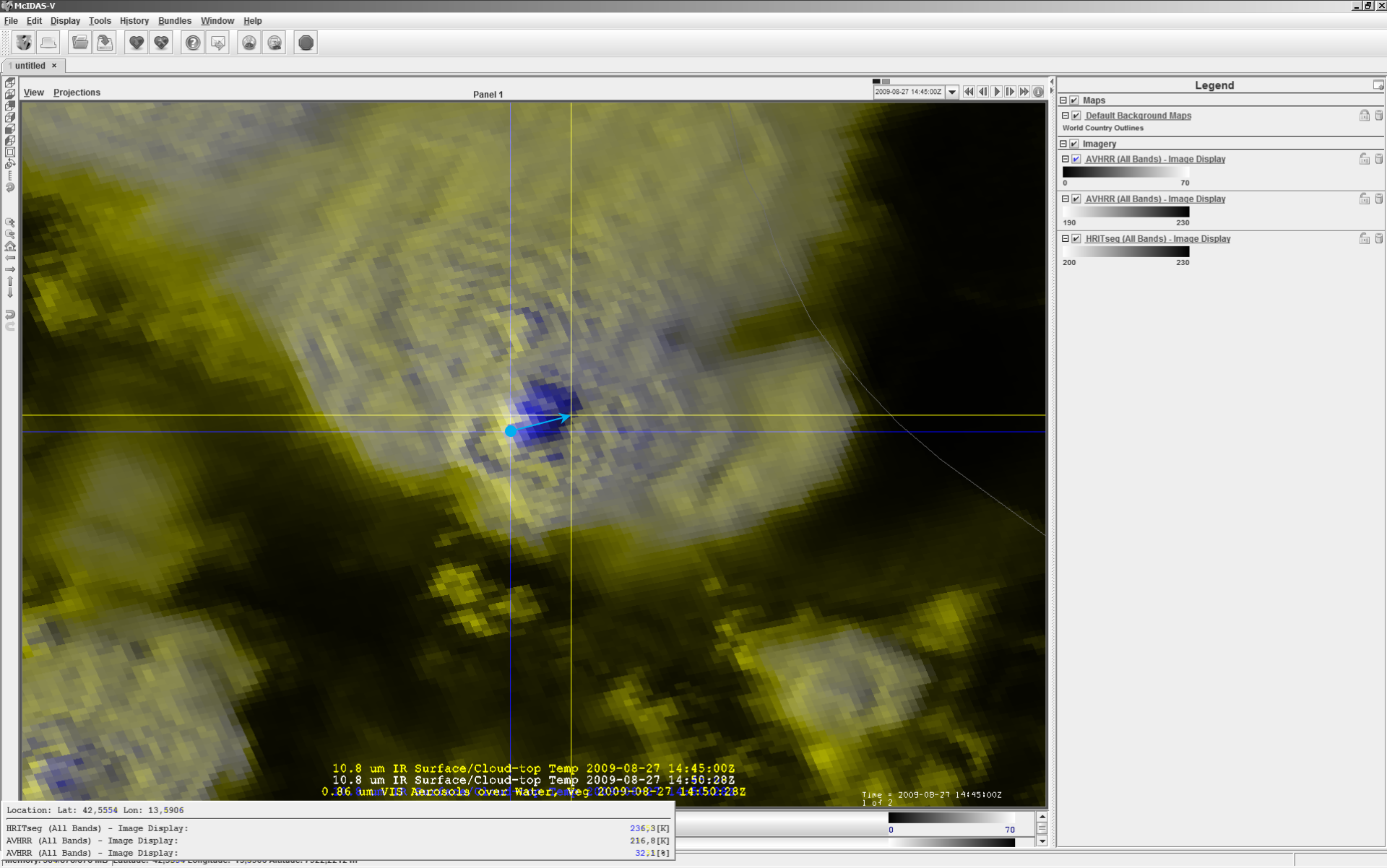
MSG – AVHRR OT height difference: 12%



OT ID	Timestamp AVHRR	Timestamp MSG	OT BT [K] AVHRR	OT BT [K] MSG	dT	OT Position AVHRR LAT	OT Position AVHRR LON	OT Position MSG LAT	OT Position MSG LON	AVHRR Shadow end LAT	AVHRR Shadow end LON	AVHRR OT Height	MSG HRV OT Height	Bedka Min OT BT [K]	Bedka OT BT diff[K]	Bedka Anvil BT [K]	Height Difference [m]
00018	200908271644	200908271645	210.7	213.9	-3.2	43.0983	11.0092	43.3087	11.1517	43.1087	11.0656	3083	3948	213.9	-7.0	220.9	-865

AVHRR-MSG BT difference

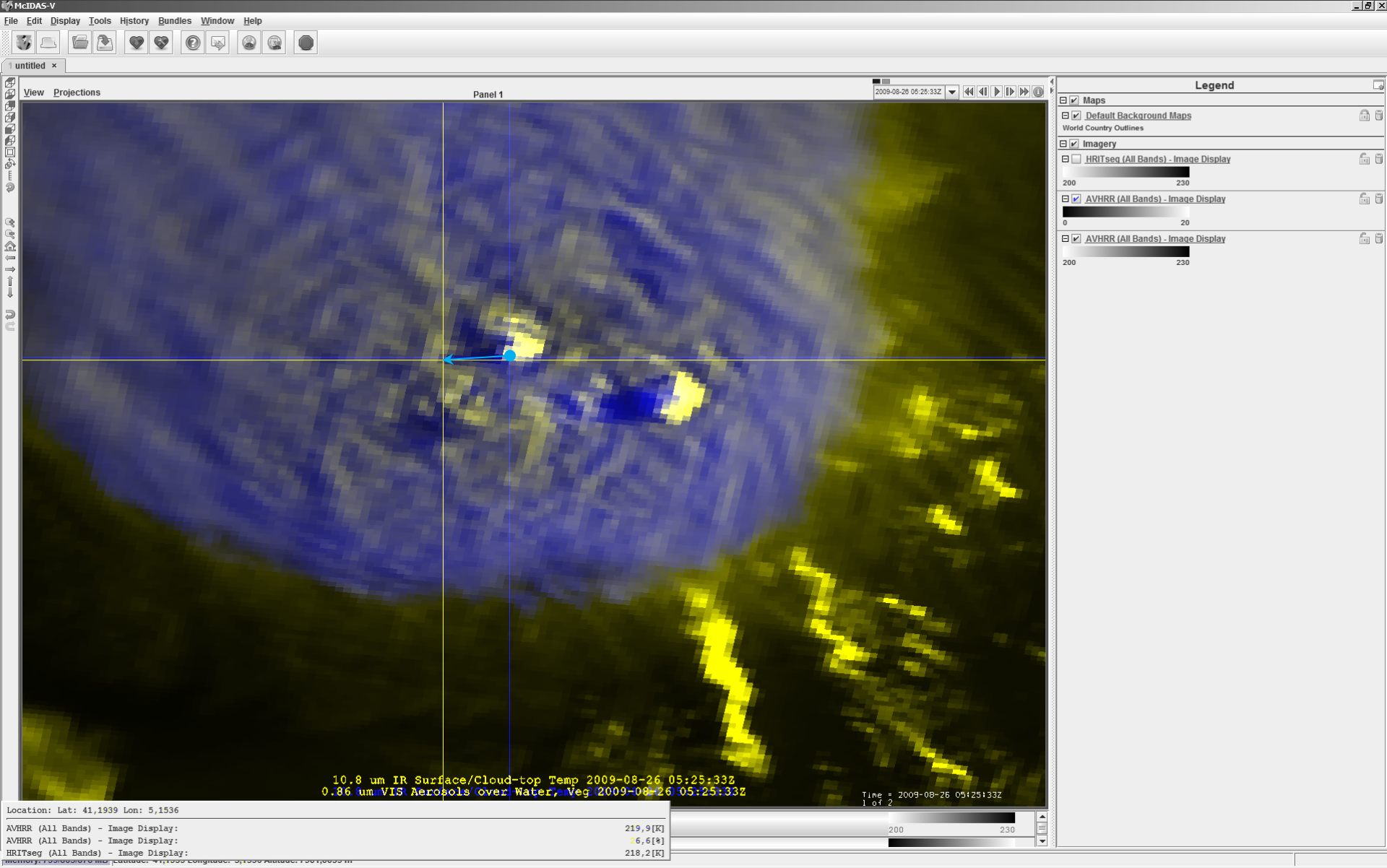
MSG – AVHRR OT height difference: -28%



	Timestamp		OT BT [K]			OT Position				AVHRR Shadow end		AVHRR OT Height	MSG HRV OT Height	Bedka Min OT BT [K]	Bedka OT BT diff[K]	Bedka Anvil BT [K]	Height Difference [m]
						AVHRR		MSG									
OT ID	AVHRR	MSG	AVHRR	MSG	dT	LAT	LON	LAT	LON	LAT	LON						
00019	200908271644	200908271645	196.8	205.6	-8.8	42.5279	13.4903	42.7771	13.7008	42.5554	13.5906	5424	3898	205.6	-9.3	214.9	1526

AVHRR-MSG BT difference

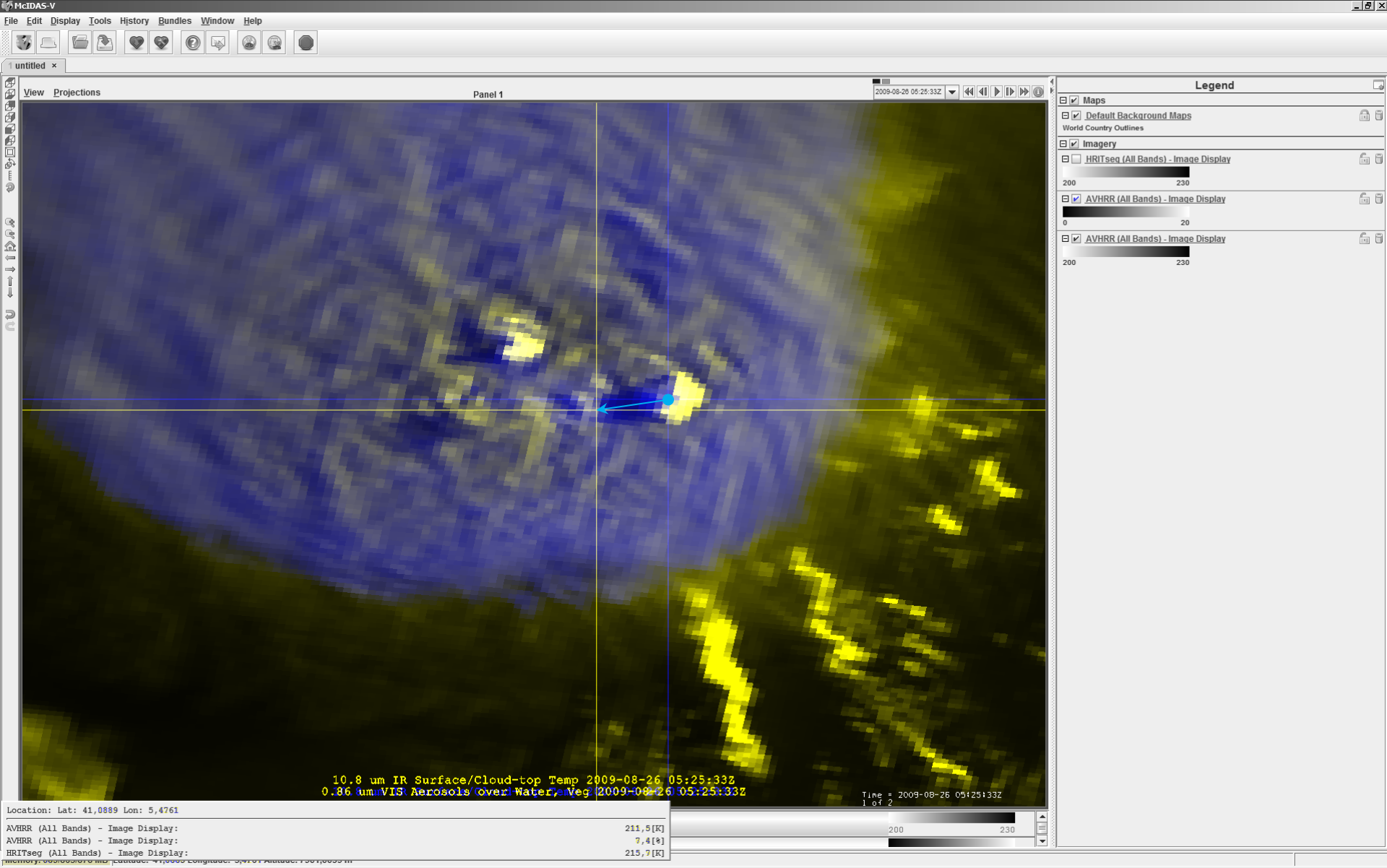
MSG – AVHRR OT height difference: 28%



OT ID	Timestamp AVHRR	Timestamp MSG	OT BT [K] AVHRR	OT BT [K] MSG	dT	OT Position AVHRR LAT	OT Position AVHRR LON	OT Position MSG LAT	OT Position MSG LON	AVHRR Shadow end LAT	AVHRR Shadow end LON	AVHRR OT Height	MSG HRV OT Height	Bedka Min OT BT [K]	Bedka OT BT diff[K]	Bedka Anvil BT [K]	Height Difference [m]
00020	200908260525	200908260530	207.3	210.7	-3.4	41.2000	5.2936	41.2891	5.4359	41.1939	5.1536	882	939	210.7	-7.0	217.7	-57

AVHRR-MSG BT difference

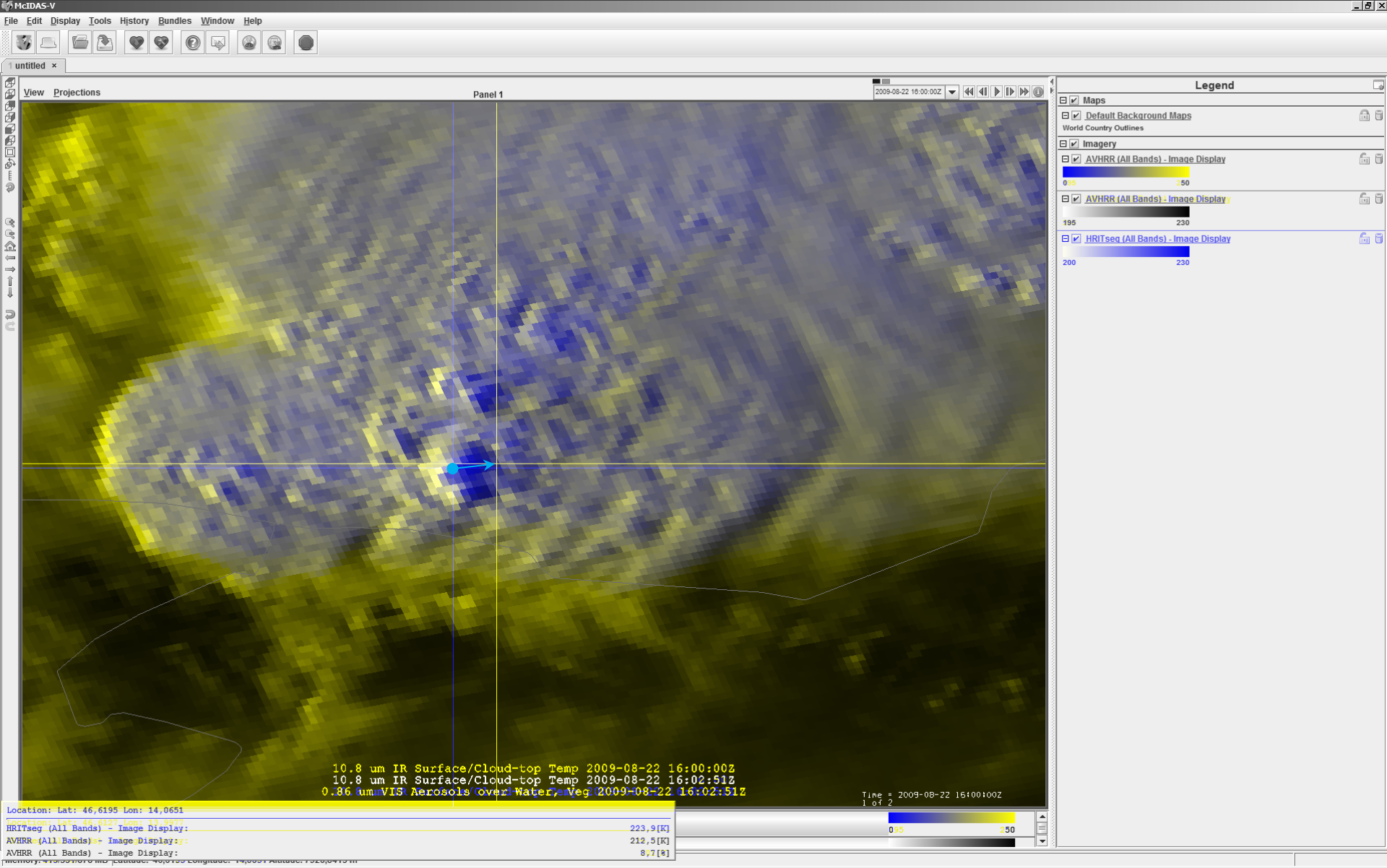
MSG – AVHRR OT height difference: -6%



	Timestamp		OT BT [K]			OT Position											
						AVHRR		MSG		AVHRR Shadow end		AVHRR OT Height	MSG HRV OT Height	Bedka Min OT BT [K]	Bedka OT BT diff[K]	Bedka Anvil BT [K]	Height Difference [m]
OT ID	AVHRR	MSG	AVHRR	MSG	dT	LAT	LON	LAT	LON	LAT	LON						
00021	200908260525	200908260530	205.8	211.5	-5.7	41.1118	5.6267	41.2091	5.7834	41.0889	5.4761	1018	1163				-145

AVHRR-MSG BT difference

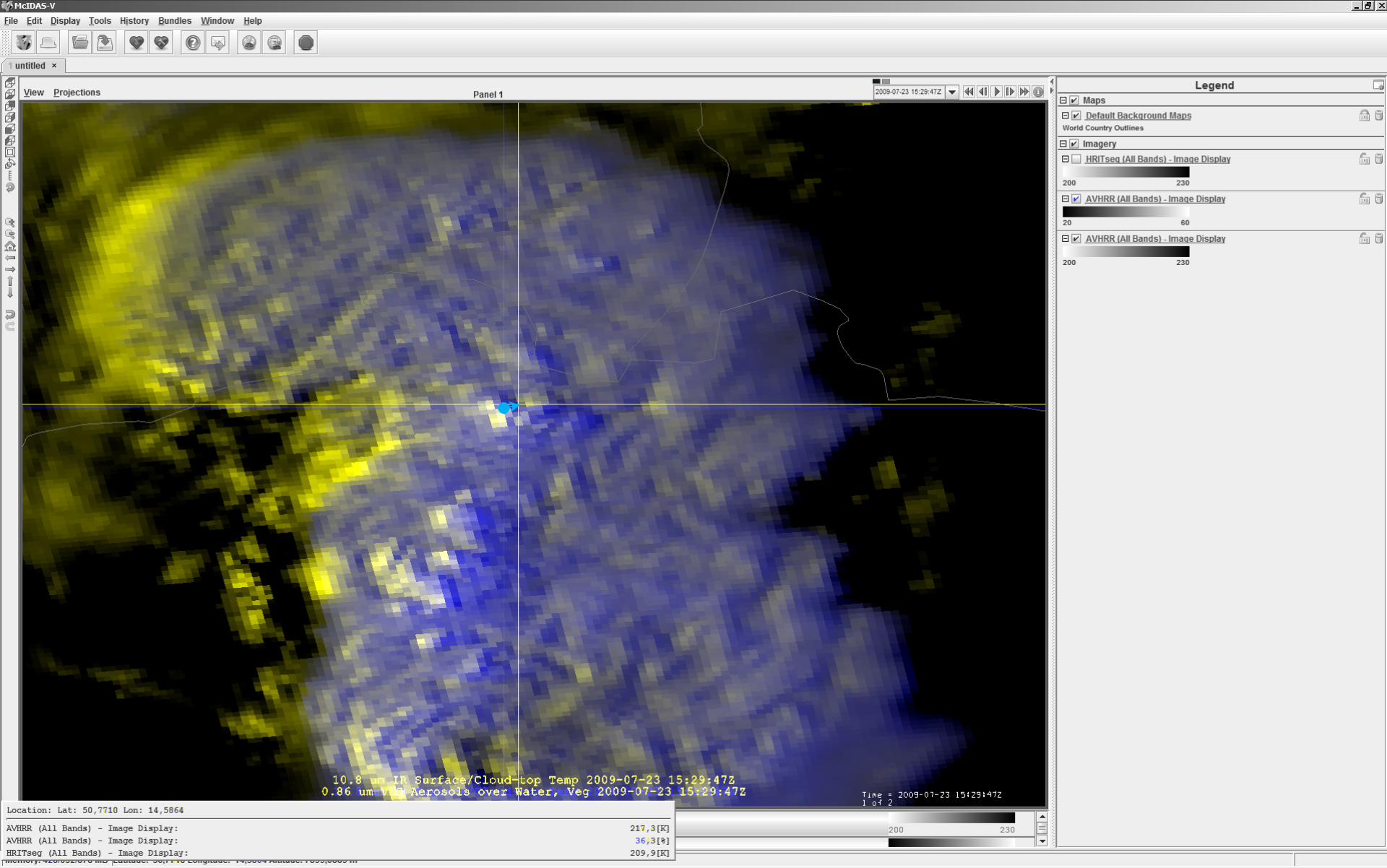
MSG – AVHRR OT height difference: -14%



OT ID	Timestamp AVHRR	Timestamp MSG	OT BT [K] AVHRR	OT BT [K] MSG	dT	OT Position AVHRR LAT	OT Position AVHRR LON	OT Position MSG LAT	OT Position MSG LON	AVHRR Shadow end LAT	AVHRR Shadow end LON	AVHRR OT Height	MSG HRV OT Height	Bedka Min OT BT [K]	Bedka OT BT diff[K]	Bedka Anvil BT [K]	Height Difference [m]
00022	200908221602	200908221600	201.0	208.2	-7.2	46.6127	13.9977	46.8324	14.1543	46.6195	14.0651	1826	2388	208.2	-7.6	215.8	-562

AVHRR-MSG BT difference

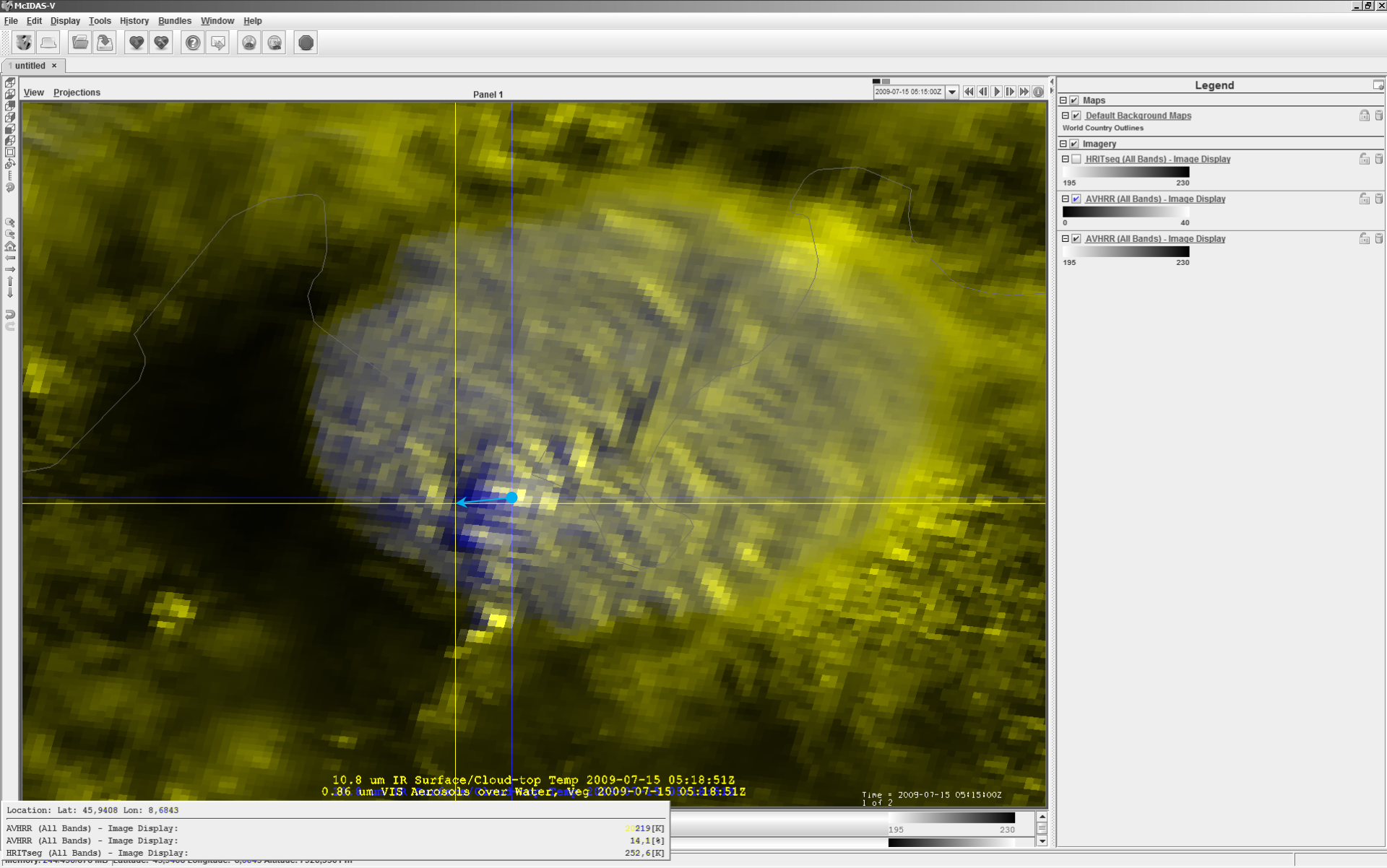
MSG – AVHRR OT height difference: -31%



	Timestamp		OT BT [K]			OT Position				AVHRR Shadow end		AVHRR OT Height	MSG HRV OT Height	Bedka Min OT BT [K]	Bedka OT BT diff[K]	Bedka Anvil BT [K]	Height Difference [m]
						AVHRR		MSG									
OT ID	AVHRR	MSG	AVHRR	MSG	dT	LAT	LON	LAT	LON	LAT	LON						
00023	200907231529	200907231530	204.4	207.8	-3.4	50.7648	14.5570	50.9778	14.6480	50.7710	14.5864	1261	1905	207.8	-6.4	214.2	-644

AVHRR-MSG BT difference

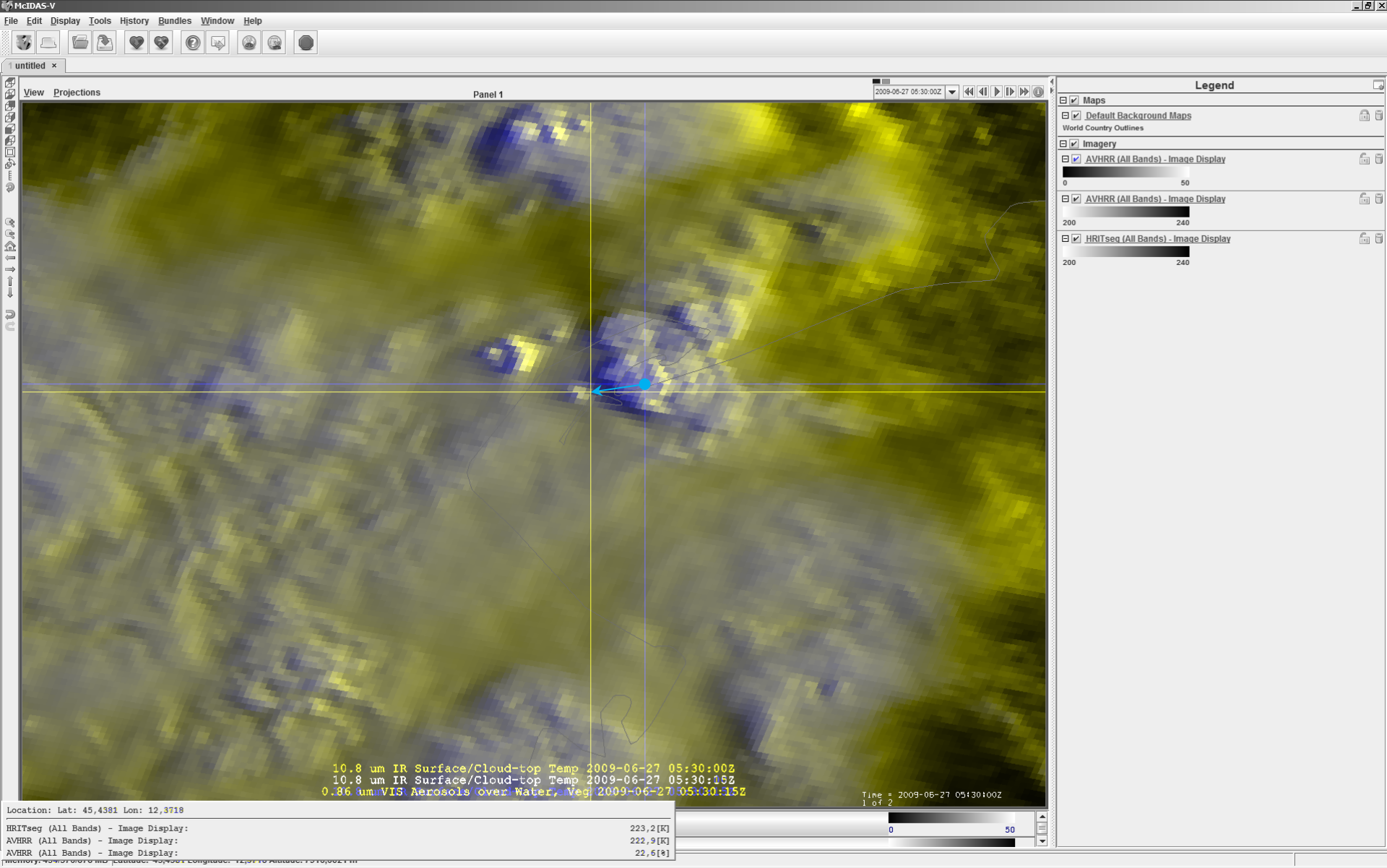
MSG – AVHRR OT height difference: -51%



	Timestamp		OT BT [K]			OT Position				AVHRR Shadow end		AVHRR OT Height	MSG HRV OT Height	Bedka Min OT BT [K]	Bedka OT BT diff[K]	Bedka Anvil BT [K]	Height Difference [m]
						AVHRR		MSG									
OT ID	AVHRR	MSG	AVHRR	MSG	dT	LAT	LON	LAT	LON	LAT	LON						
00024	200907150518	200907150515	206.2	210.7	-4.5	45.9506	8.7785	46.0910	8.9258	45.9408	8.6843	1664	2525	210.7	-8.9	219.6	-861

AVHRR-MSG BT difference

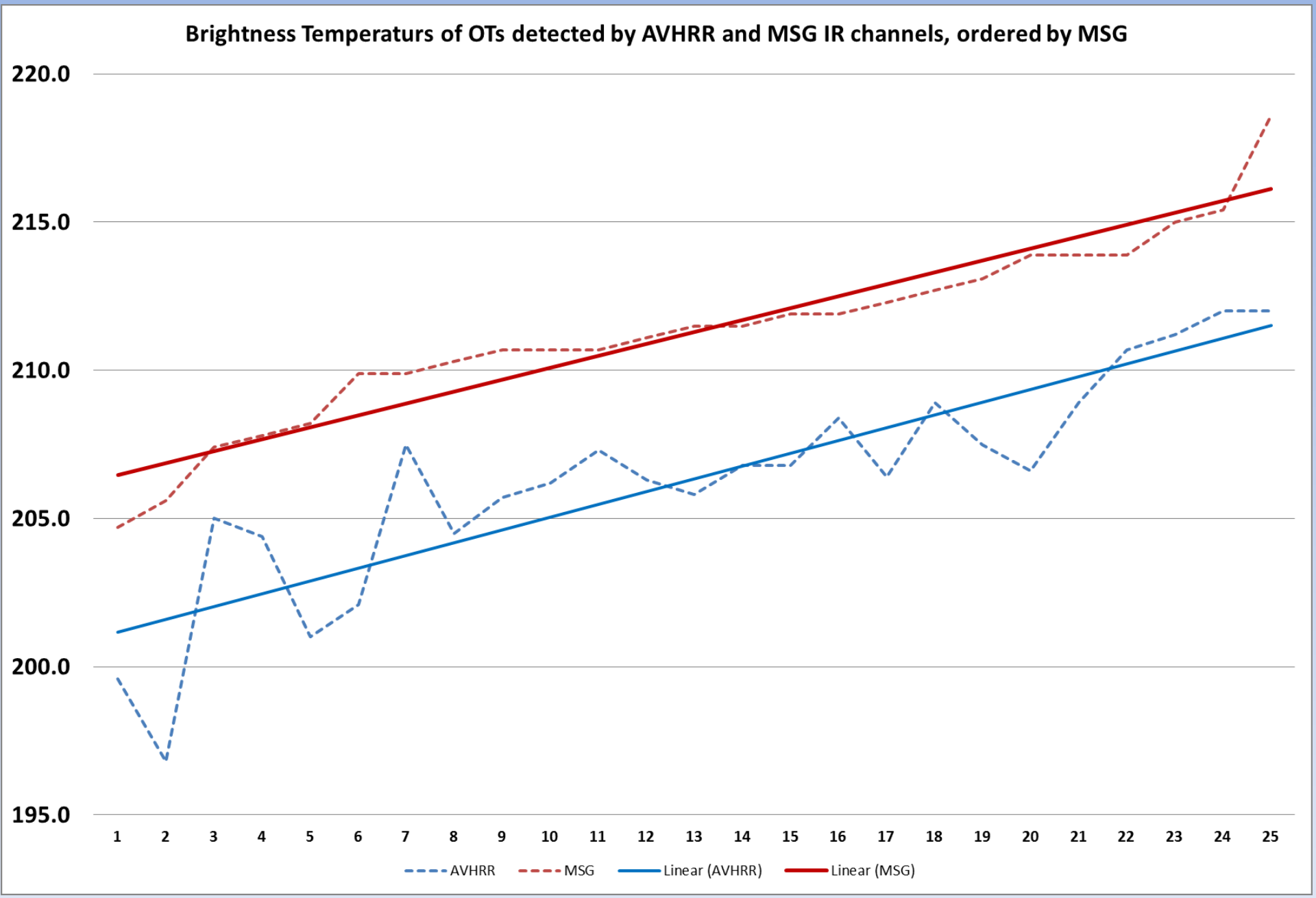
MSG – AVHRR OT height difference: -52%

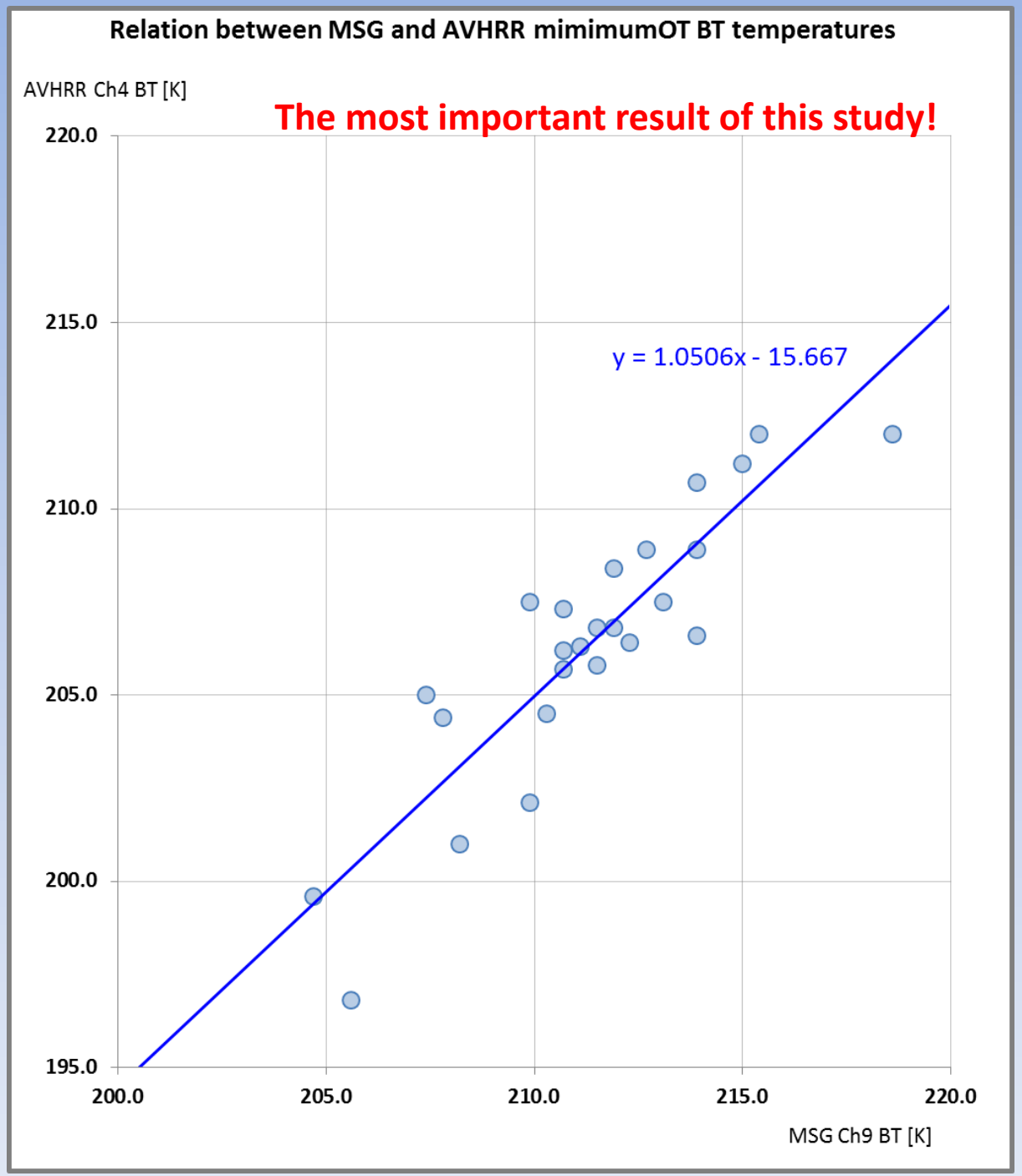


	Timestamp		OT BT [K]			OT Position				AVHRR Shadow end		AVHRR OT Height	MSG HRV OT Height	Bedka Min OT BT [K]	Bedka OT BT diff[K]	Bedka Anvil BT [K]	Height Difference [m]
						AVHRR		MSG									
OT ID	AVHRR	MSG	AVHRR	MSG	dT	LAT	LON	LAT	LON	LAT	LON						
00025	200906270529	200906270530	211.2	215.0	-3.8	45.4522	12.4679	45.6337	12.4599	45.4381	12.3718	2674	3301	215.0	-7.6	222.6	-627

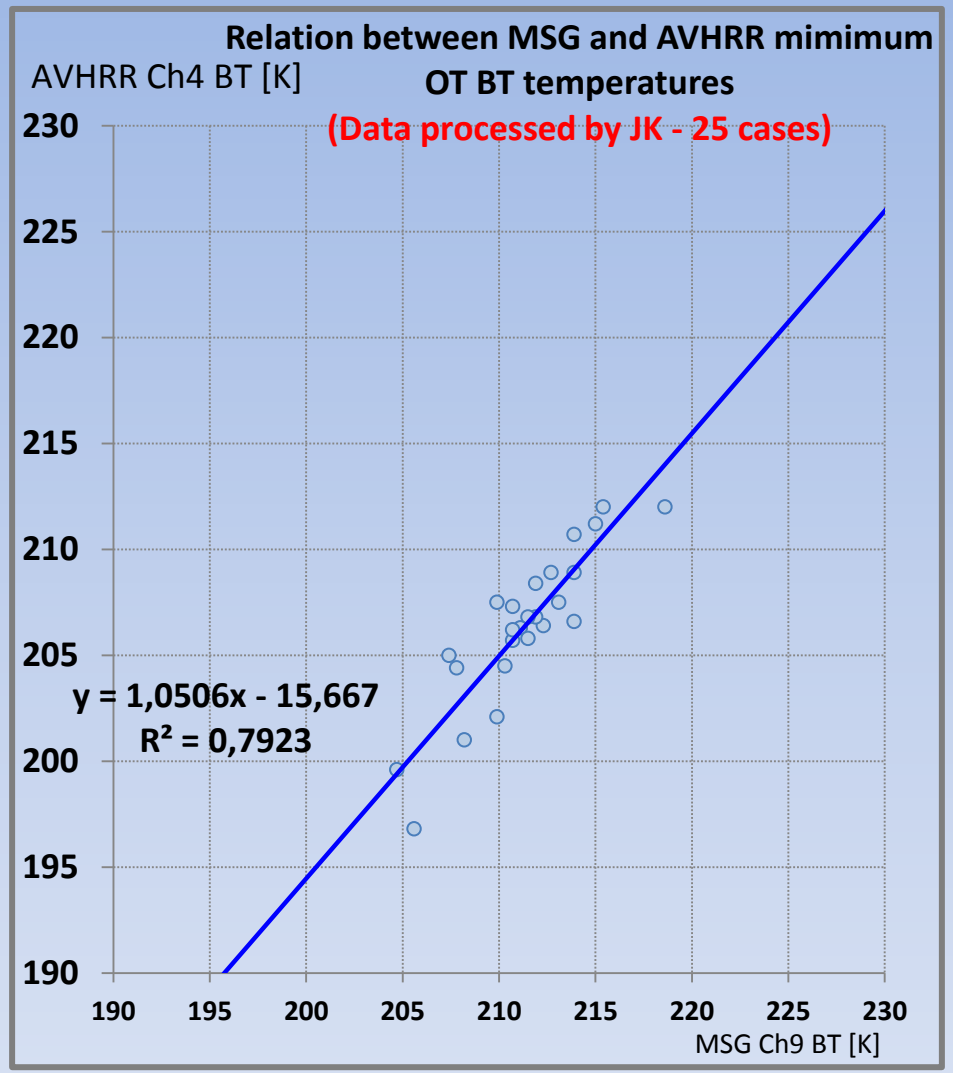
AVHRR-MSG BT difference

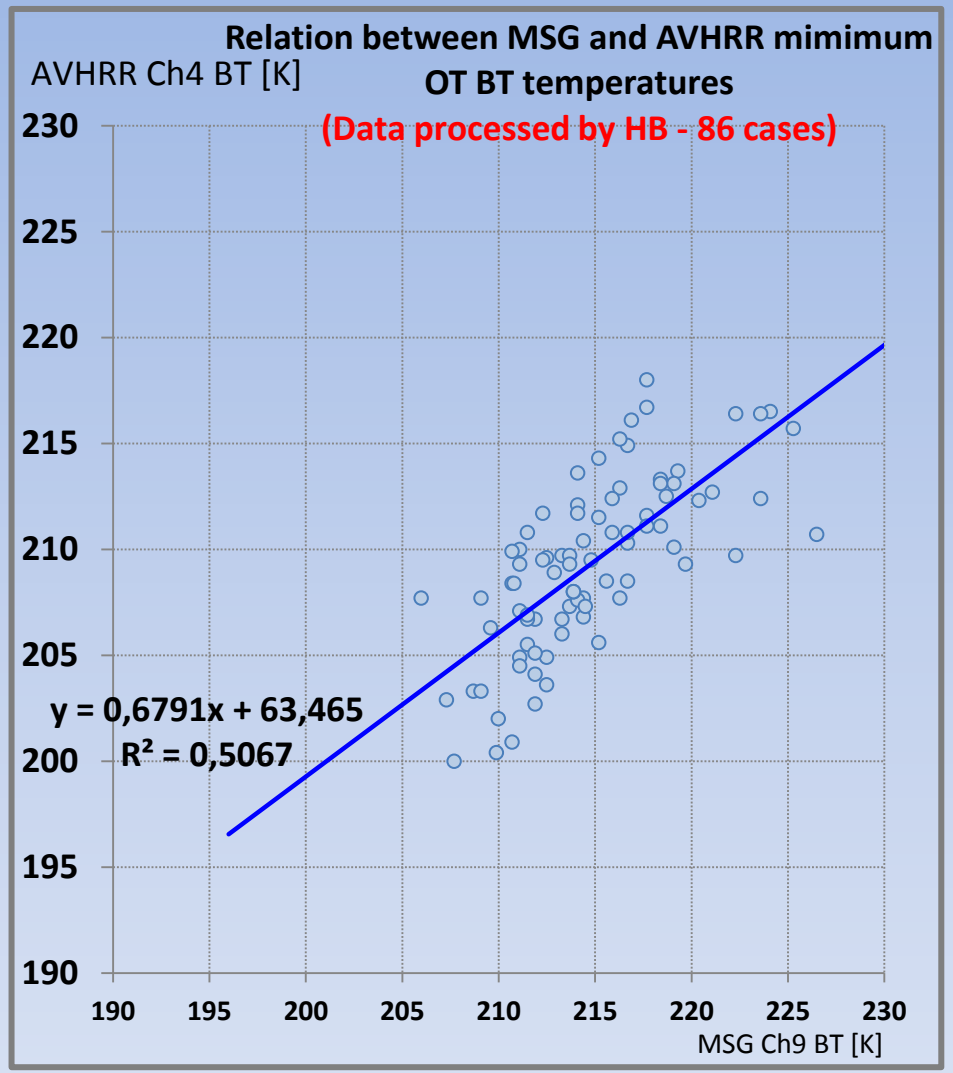
MSG – AVHRR OT height difference: -23%


Brightness Temperaturs of OTs detected by AVHRR and MSG IR channels, ordered by MSG
220.0
215.0
210.0
205.0
200.0
195.0
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25
AVHRR
MSG
Linear (AVHRR)
Linear (MSG)


Relation between MSG and AVHRR mimimumOT BT temperatures
AVHRR Ch4 BT [K]
The most important result of this study!
y = 1.0506x - 15.667
220.0
215.0
210.0
205.0
200.0
195.0
200.0
205.0
210.0
215.0
220.0
MSG Ch9 BT [K]

Comparison between two subjectively selected OT datasets:

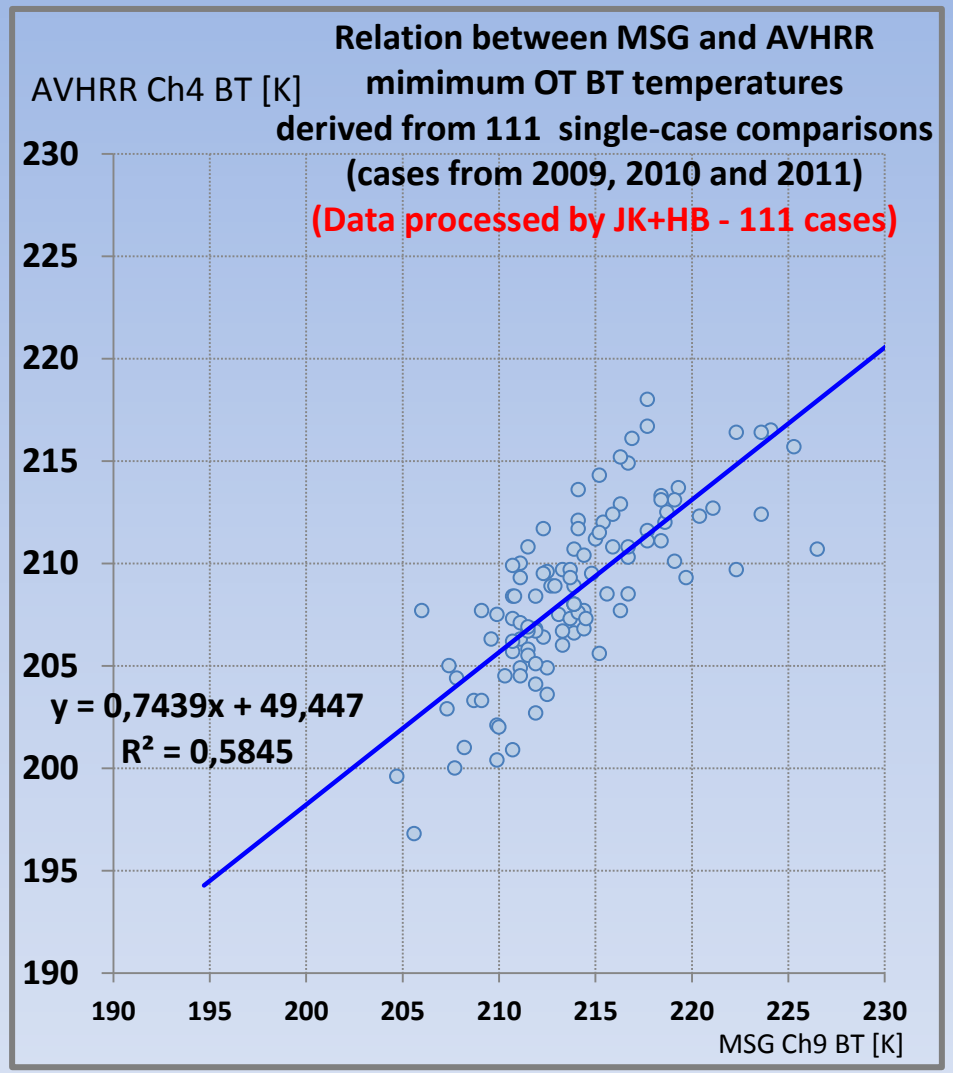


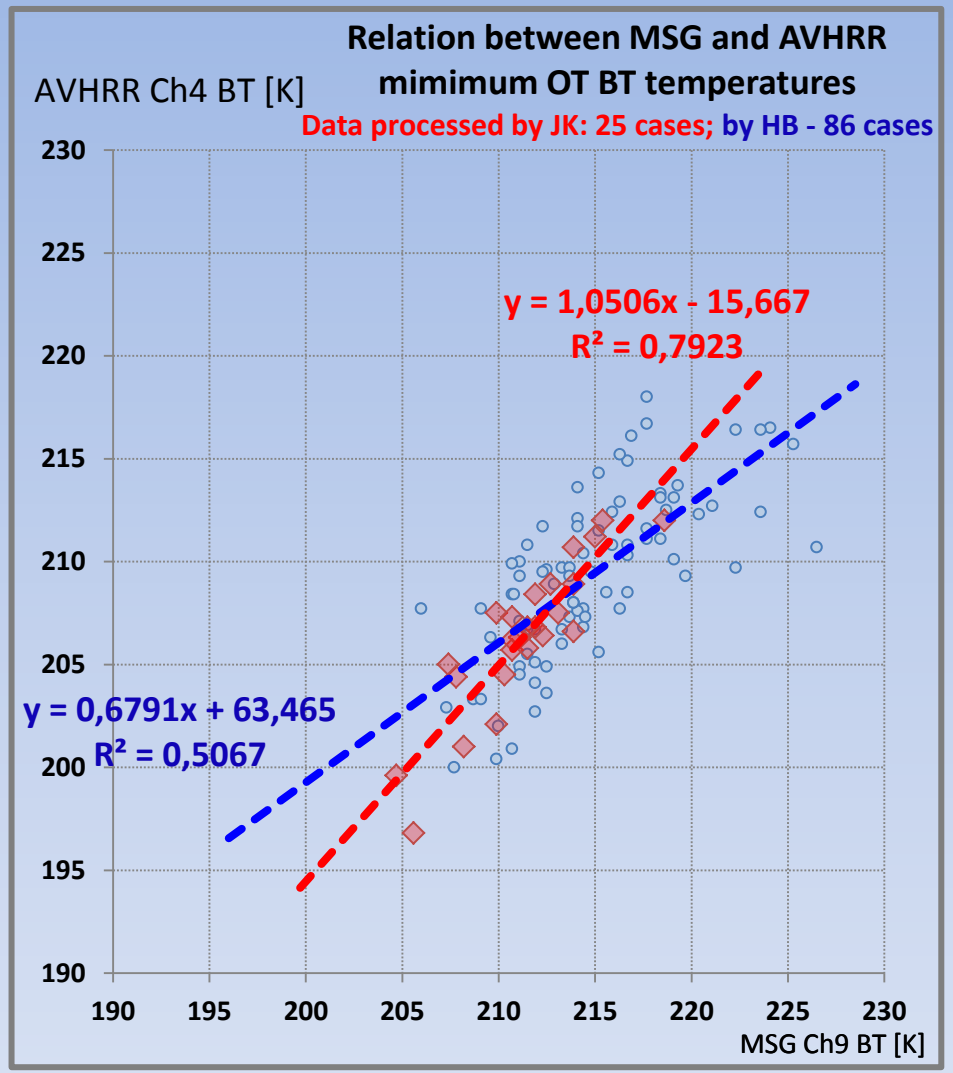


Higher reliability (0.8)

Lower reliability (0.5)

Comparison between two subjectively selected OT datasets:



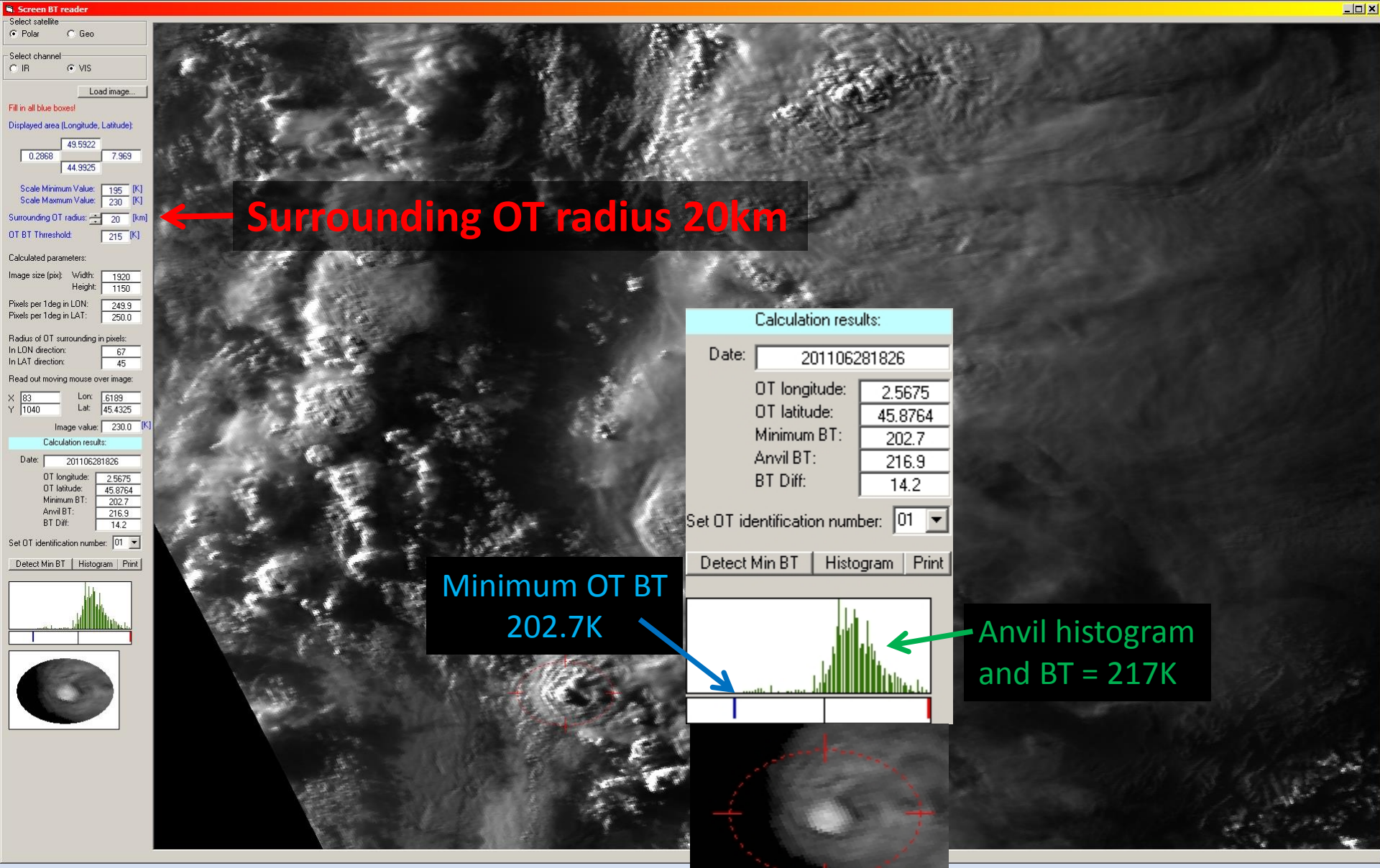


Not only different reliability, but also different slope!

How to avoid subjective readout of OT BT values, OT and shadows positions?

Missing functionality in McIDAS-V software can be supplemented when we export images into another supporting software tool.

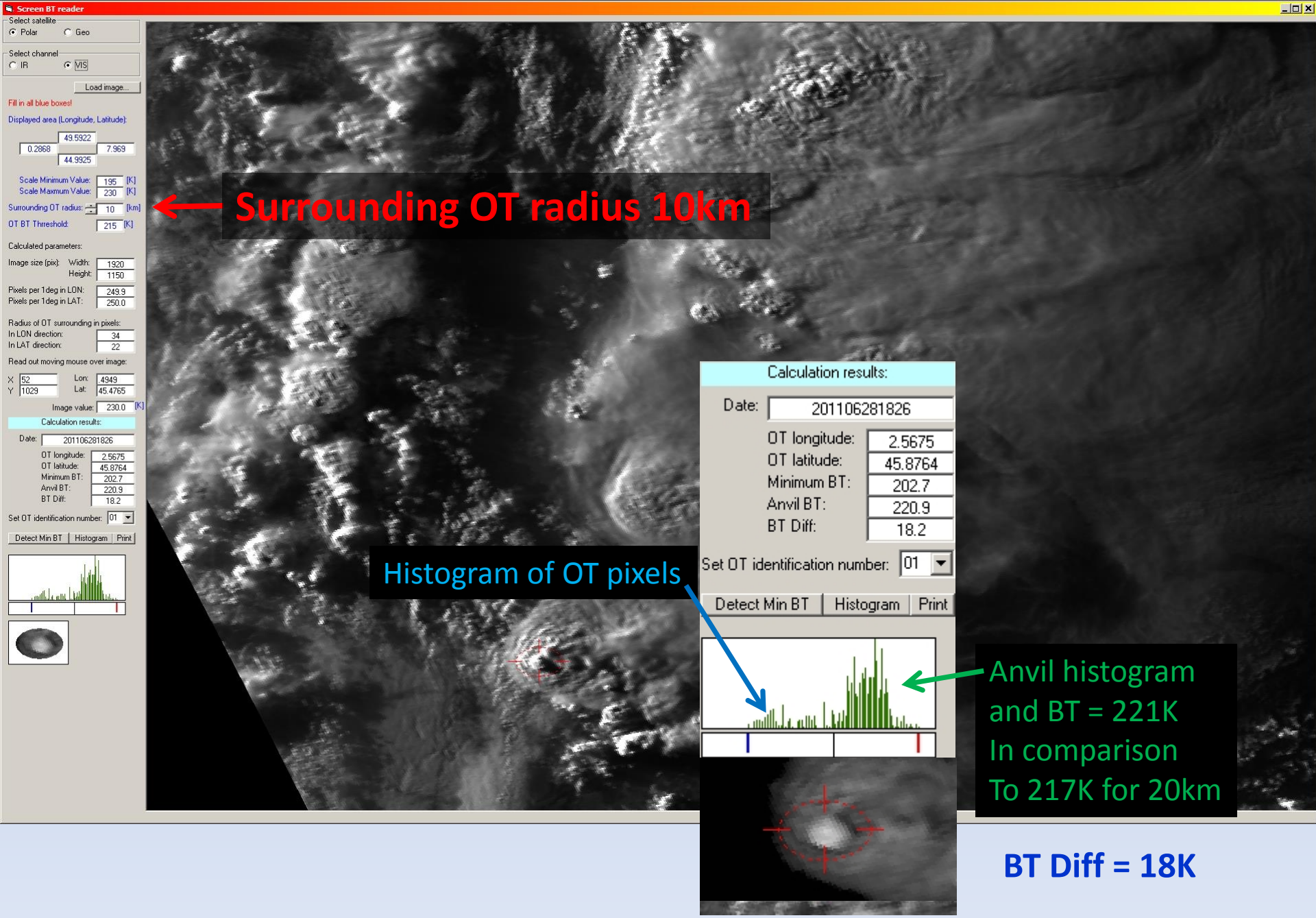
For this purpose We developed “Screen-BT-Reader” program …



20 km OT surrounding

BT Diff = 14K

More detailed histogram of Anvil BT!



BT Diff = 18K

More detailed histogram of OT center!

10 km OT surrounding

Finally selected and evaluated cases:

Relative difference [%] between Geo and Polar Satellite OT height estimations

						OT Position										
	Timestamp		OT BT [K]			AVHRR		MSG								
OT ID	AVHRR	MSG	AVHRR	MSG	dT	LAT	LON	LAT	LON	R OT [m]	MSG HRV OT Height [m]	Kris Bedka Min OT BT [K]	Kris Bedka OT BT diff[K]	Kris Bedka Anvil BT [K]	Height Difference [m]	Relative Height Difference [%]
00001	201107111731	201107111730	206.4	212.3	-5.9	47.2337	21.2381	47.4623	21.3311	2	1460	212.3	-7.9	220.2	192	12
00002	201107111731	201107111730	212.0	215.4	-3.4	47.6079	21.1774	47.9578	21.3372	6	2368				158	6
00003	201107111731	201107111730	212.0	218.6	-6.6	44.9853	21.6755	45.1569	21.8015	2	2955				-243	-9
00004	201107020505	201107020500	208.9	212.7	-3.8	40.2661	2.5934	40.4268	2.3962	0	1411	212.7	-7.8	220.5	139	9
00005	201106281826	201106281830	199.6	204.7	-5.1	49.2152	4.1569	49.4567	4.1834	2	1731	204.7	-8.8	213.5	-419	-32
00006	201106281826	201106281830	207.5	213.1	-5.6	47.4180	3.7761	47.6650	3.8490	5	1143	213.1	-7.0	220.1	-398	-53
00007	201106281826	201106281830	206.8	211.9	-5.1	47.4524	4.2889	47.7134	4.0639	8	2145				373	15
00008	201106281826	201106281830	202.1	209.9	-7.8	45.8717	2.5770	46.0937	2.6612	1	2078				83	4
00009	201106241732	201106241730	207.5	209.9	-2.4	43.6546	20.4587	43.8603	20.6295	7	1511	212.3	-7.9	220.2	-24	-2
00010	201106181704	201106181700	204.5	210.3	-5.8	53.3445	27.9941	53.6232	28.1901	2	2751	210.3	-8.5	218.8	631	19
00011	201106171715	201106171715	206.6	213.9	-7.3	51.5059	24.9723	51.7423	25.1798	7	2841	213.9	-7.6	221.5	616	18
00012	201106071734	201106071730	205.7	210.7	-5.0	45.7558	15.3487	45.9278	15.5089	6	2155	210.7	-7.7	218.4	421	16
00013	201106011705	201106011700	208.9	213.9	-5.0	46.0564	25.9000	46.2538	26.0428	9	2004	213.9	-6.6	220.5	865	30
00014	201008060605	201008060600	206.8	211.5	-4.7	47.3835	19.0079	47.5907	19.1374	2	3471	211.5	-6.9	218.4	1371	28
00015	201006121644	201006121645	205.0	207.4	-2.4	48.1819	14.3438	48.4882	14.4908	2	3344	207.4	-9.9	217.3	-782	-31
00016	200908291620	200908291615	206.3	211.1	-4.8	43.8766	18.6978	44.0364	18.6662	0	2176	211.1	-7.3	218.4	-106	-5
00017	200908271644	200908271645	208.4	211.9	-3.5	42.8228	11.2716	43.0035	11.2426	3	2299	211.9	-9.1	221.0	324	12
00018	200908271644	200908271645	210.7	213.9	-3.2	43.0983	11.0092	43.3087	11.1517	3	3948	213.9	-7.0	220.9	-865	-28
00019	200908271644	200908271645	196.8	205.6	-8.8	42.5279	13.4903	42.7771	13.7008	4	3898	205.6	-9.3	214.9	1526	28
00020	200908260525	200908260530	207.3	210.7	-3.4	41.2000	5.2936	41.2891	5.4359	2	939	210.7	-7.0	217.7	-57	-6
00021	200908260525	200908260530	205.8	211.5	-5.7	41.1118	5.6267	41.2091	5.7834	8	1163				-145	-14
00022	200908221602	200908221600	201.0	208.2	-7.2	46.6127	13.9977	46.8324	14.1543	6	2388	208.2	-7.6	215.8	-562	-31
00023	200907231529	200907231530	204.4	207.8	-3.4	50.7648	14.5570	50.9778	14.6480	1	1905	207.8	-6.4	214.2	-644	-51
00024	200907150518	200907150515	206.2	210.7	-4.5	45.9506	8.7785	46.0910	8.9258	4	2525	210.7	-8.9	219.6	-861	-52
00025	200906270529	200906270530	211.2	215.0	-3.8	45.4522	12.4679	45.6337	12.4599	4	3301	215.0	-7.6	222.6	-627	-23

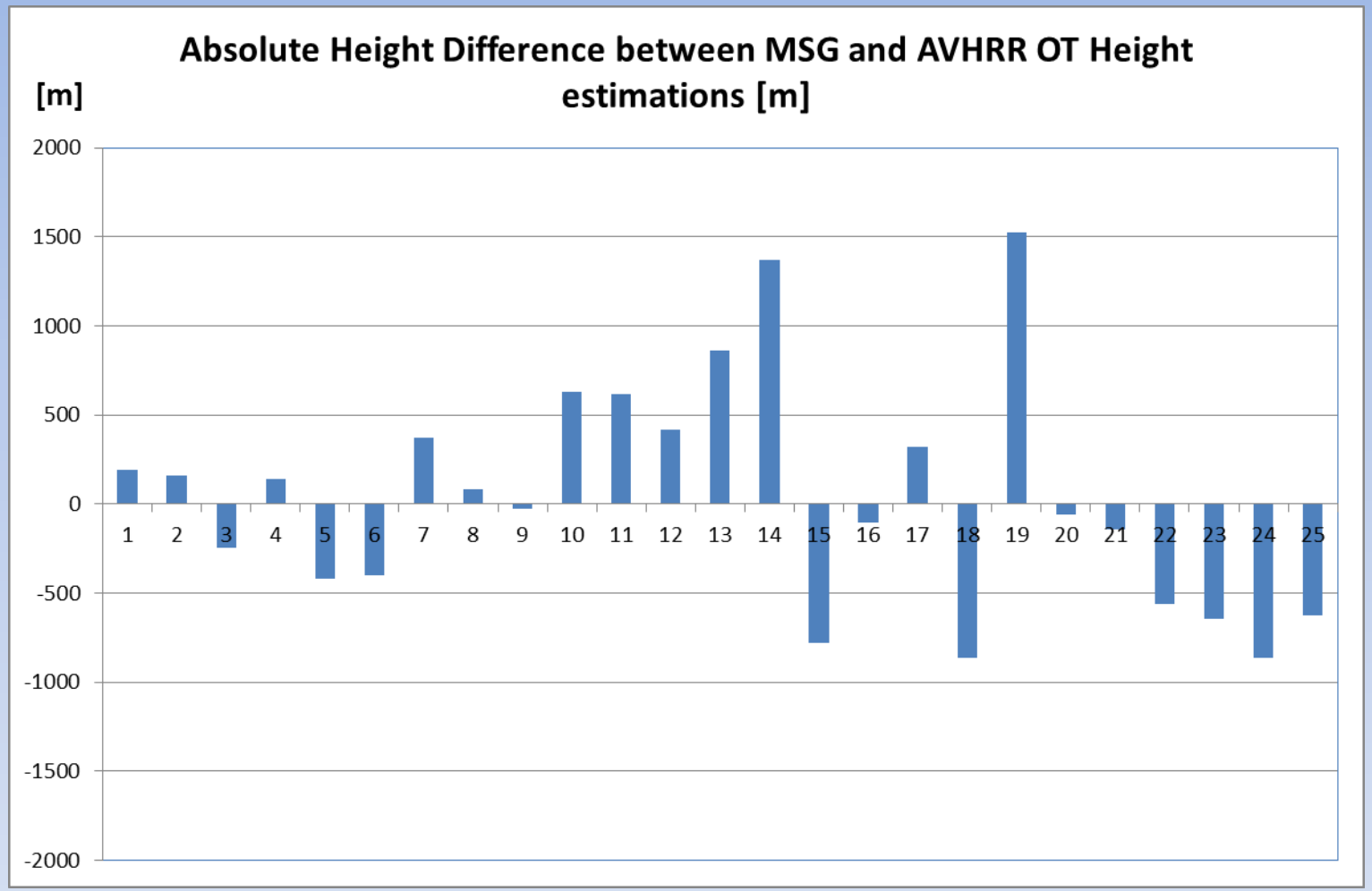
Relative Height Difference [%]
12
6
-9
9
-32
-53
15
4
-2
19
18
16
30
28
-31
-5
12
-28
28
-6
-14
-31
-51
-52
-23

Compliance rate of OT height detections:

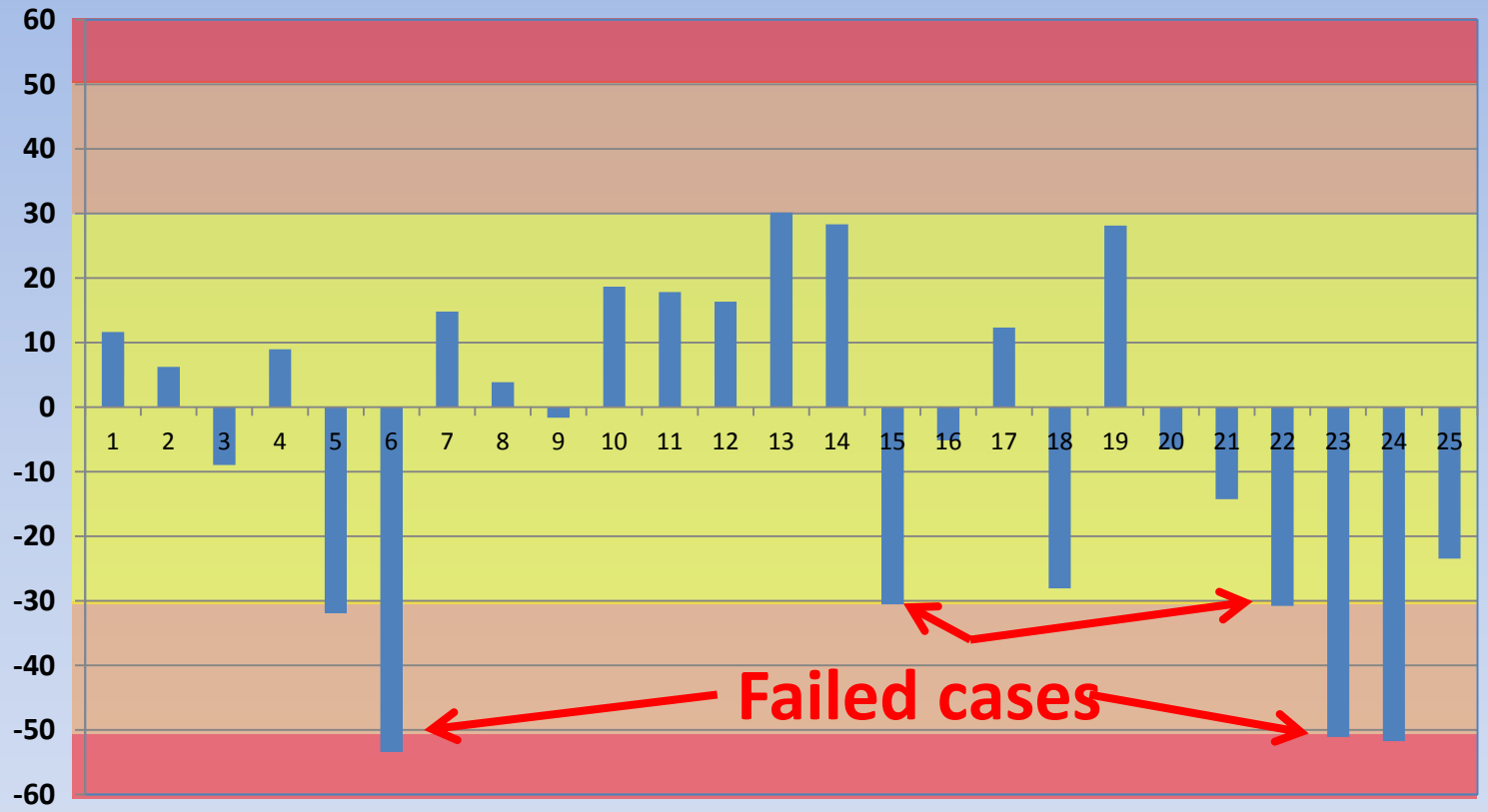
- Good
- Acceptable
- Low

Only few cases <0%

Most of cases >0%


Absolute Height Difference between MSG and AVHRR OT Height estimations [m]
[m]
2000
1500
1000
500
0
-500
-1000
-1500
-2000
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
21
22
23
24
25

Relative Height Difference between MSG and AVHRR OT Height estimations [%]



Compliance rate of OT height detections:

- Good
- Acceptable
- Low

Height differences can result from:

- Different satellite resolutions
- Different viewing angles
- Difference in scanning time of OT region
- Too high Sun elevation
- Complicated cloud top structures

Why measurement of OT height and its BT difference from anvil BT is useful?

Dry adiabatic lapse rate is easy to estimate:

$$\Gamma_d = \frac{g}{c_{pd}}$$

$\frac{\text{Gravitational acceleration}}{\text{Specific heat}}$ =9.8K/km

Wet adiabatic lapse rate is rather complicated:

$$\Gamma_w = g\,\frac{1 + \dfrac{H_v\, r}{R_{sd}\, T}}{c_{pd} + \dfrac{H_v^2\, r\, \epsilon}{R_{sd}\, T^2}}$$

where:

Γ_w = Wet adiabatic lapse rate, K/m

g = Earth's gravitational acceleration = 9.8076 m/s^2

H_v = Heat of vaporization of water, J/kg

r = The ratio of the mass of water vapor to the mass of dry air, kg/kg

R = The universal gas constant = 8,314 J/(kmol · K)

M = The molecular weight of any specific gas, kg/kmol = 28.964 for dry air and 18.015 for water vapor

R/M = The specific gas constant of a gas, denoted as R_s

R_{sd} = Specific gas constant of dry air = 287 J/(kg · K)

R_{sw} = Specific gas constant of water vapor = 462 J/(kg · K)

ϵ =The dimensionless ratio of the specific gas constant of dry air to the specific gas constant for water vapor = 0.6220

T = Temperature of the saturated air, K

c_{pd} = The specific heat of dry air at constant pressure, J/(kg · K)

where:

Γ_w = Wet adiabatic lapse rate, K/m

g = Earth's gravitational acceleration = 9.8076 m/s^2

H_v = Heat of vaporization of water, J/kg

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AVHRR OT BT Difference [K]	AVHRR OT Height [m]	MSG HRV OT Height [m]	Bedka Anvil BT [K]	AVHRR OT BT	Bedka Min OT BT [K]	AVHRR OT BT Difference [K]	MSG OT BT Difference [K]
13.8	1652	1460	220.2	206.4	212.3	13.8	7.9
	2526	2368		212.0			
	2712	2955		212.0			
11.6	1550	1411	220.5	208.9	212.7	11.6	7.8
13.9	1312	1731	213.5	199.6	204.7	13.9	8.8
12.6	745	1143	220.1	207.5	213.1	12.6	7.0
	2518	2145		206.8			
	2355	2316				12.7	7.8

AVHRR Lapse rate:	**5.4**	**K/km**
MSG Laps rate:	**3.4**	**K/km**

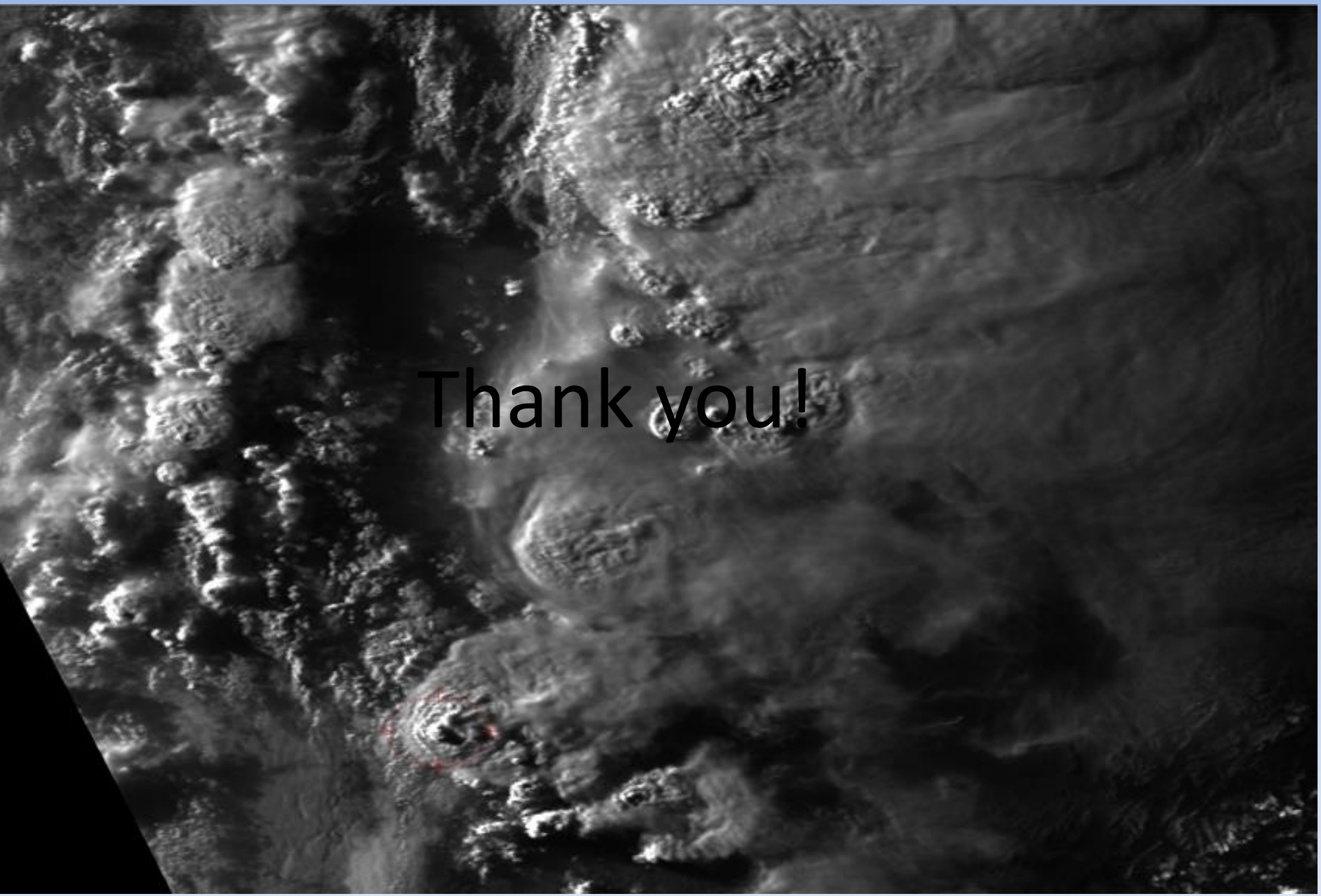
Resolution: 1km < 5km

Conclusions

Better satellite resolution provides more accurate measurements of OT minimum BT and estimations of geometrical OT height, from which lapse rates can be estimated with higher confidence.

But time and space coincidence between polar and GEO satellites is too small to obtain statistically reliable results.

Therefore new GEO satellites with higher space and time resolution will provide us with new possibilities to evaluate quantitative OT features.


Thank you!