State Scientific Center
of the Russian
Federation
VNIIFTRI

National Research Institute for
Physical-Technical and Radio Engineering Measurements

Some Unstable Factors Affecting Displacement in SLR Range Measurements

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IWLR2018

National Research Institute for Physical-Technical and Radiotechnical Measurements (VNIIFTRI) has a working SLR station «Mendeleevo-1874» and SLR station «Irkutsk-1891» in the East-Siberian Branch of VNIIFTRI in the city of Irkutsk.

Calibration and metrological control of these stations is carried out with the involvement of the national standard of time and frequency as well as the national special standard of length.

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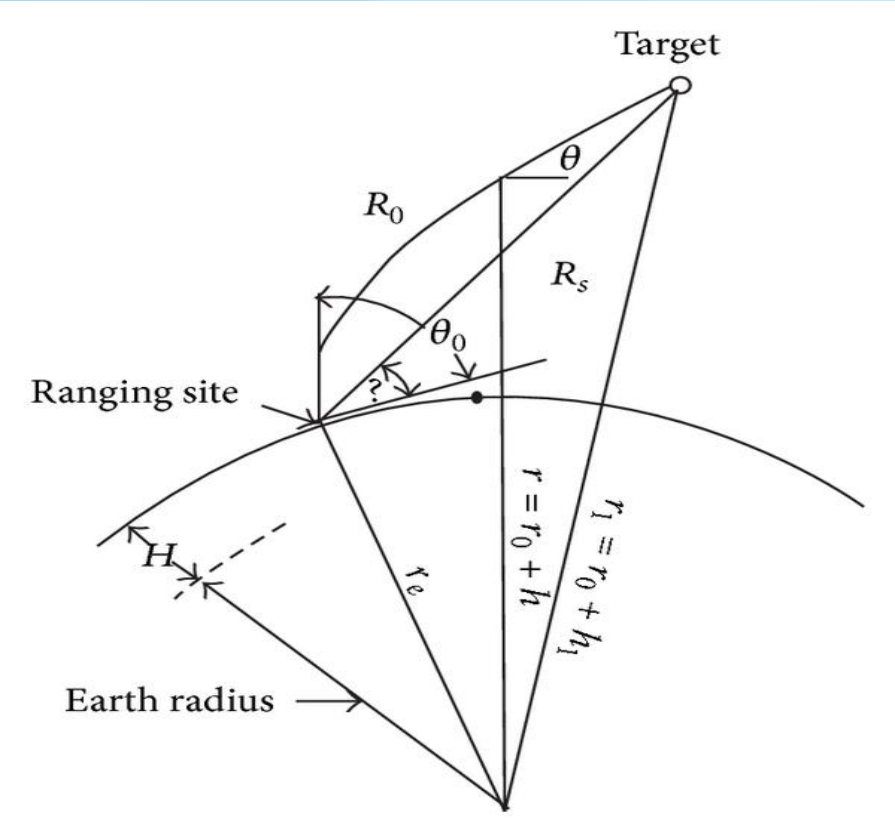
Influence of the atmosphere on the results of laser-ranging measurements



In the year 2006. as standard was adopted scaling function of the Mendes and model delays Mendes-Pavlis. This amendment allows you to work with measurements, the elevation of which is from 3 to 10 degrees.

The factors causing the deviation from the model:

- atmospheric turbulence;
- atmospheric front;
- convergence zones;
- inversion;
- atmospheric waves;
- tides.

Additional factors

- local conditions at the station location
- back scattering of light:
- et al...

Analysis of the results of the station "Mendeleevo»

Mission Control Center (Moscow)
MCC LAGEOS Weekly Analysis Report

MDVS (1874)

	DATA	T ini	T fin	SC	TTL	INC	ME	RMS	ORMS	ELEV	T	P	H	CALIB	TB	RB	PRMS	SCI	WavLen
							mm	mm	mm	deg	C	mbar	%	mm	us	mm	mm		mcm
1874	30.07.18	18:45	19:26	L1	22	22	7	8	11	026-059	15	1000.1	79	43210	-2	7	7	0	0.5320
1874	31.07.18	17:27	18:02	L1	19	16	3	9	9	028-079	18	999.9	62	43203	-4	5	5	0	0.5320
1874	31.07.18	20:57	21:34	L2	18	18	-2	3	4	026-049	14	1000.2	84	43213	1	-3	3	0	0.5320
1874	01.08.18	19:17	19:34	L2	10	10	25	7	26	026-029	17	998.5	77	43207	-6	26	5	0	0.5320
1874	01.08.18	19:40	20:14	L1	18	18	-2	10	10	026-045	17	998.5	81	43210	-4	-1	5	0	0.5320
1874	02.08.18	18:09	18:50	L1	22	22	0	6	6	026-066	19	994.5	72	43201	-1	-1	6	0	0.5320
1874	02.08.18	21:07	21:39	L2	17	17	6	4	8	026-054	16	994.3	84	43211	-2	6	4	0	0.5320

Adopted abbreviations

Date - Day, Month, Year
Tini,Tfin - Time Interval of Passes (hh:mm)
SC - Spacecraft Name
TTL - Total Measurements Number in the Pass
INC - Included Measurements Number in the Pass
ME - Math.Expectation
RMS - Root Mean Sguare for ME
ORMS - Root MEAN Sguare for the Orbit
ELEV - Elevation Angles (min-max)
T - Temperature, Celsium degrees
P - Atmospheric Pressure, mbar
H - Huminity, %
CALIB - Calibration Delay Shift, mm
TB - Time Bias, microsec (if TB = " * ", then no estimate for TB)
RB - Range Bias, mm (if RB = " * ", then no estimate for RB)
PRMS - Precise RMS for Approx. Polynomial, mm
SCI - System Configuration Indicator
WAVLEN - Wave length(mcm)

The value of the error (range bias) is determined from the solution and includes various errors of the laser rangefinder, hours, errors in the determination of meteorological parameters, delays in the system, etc.

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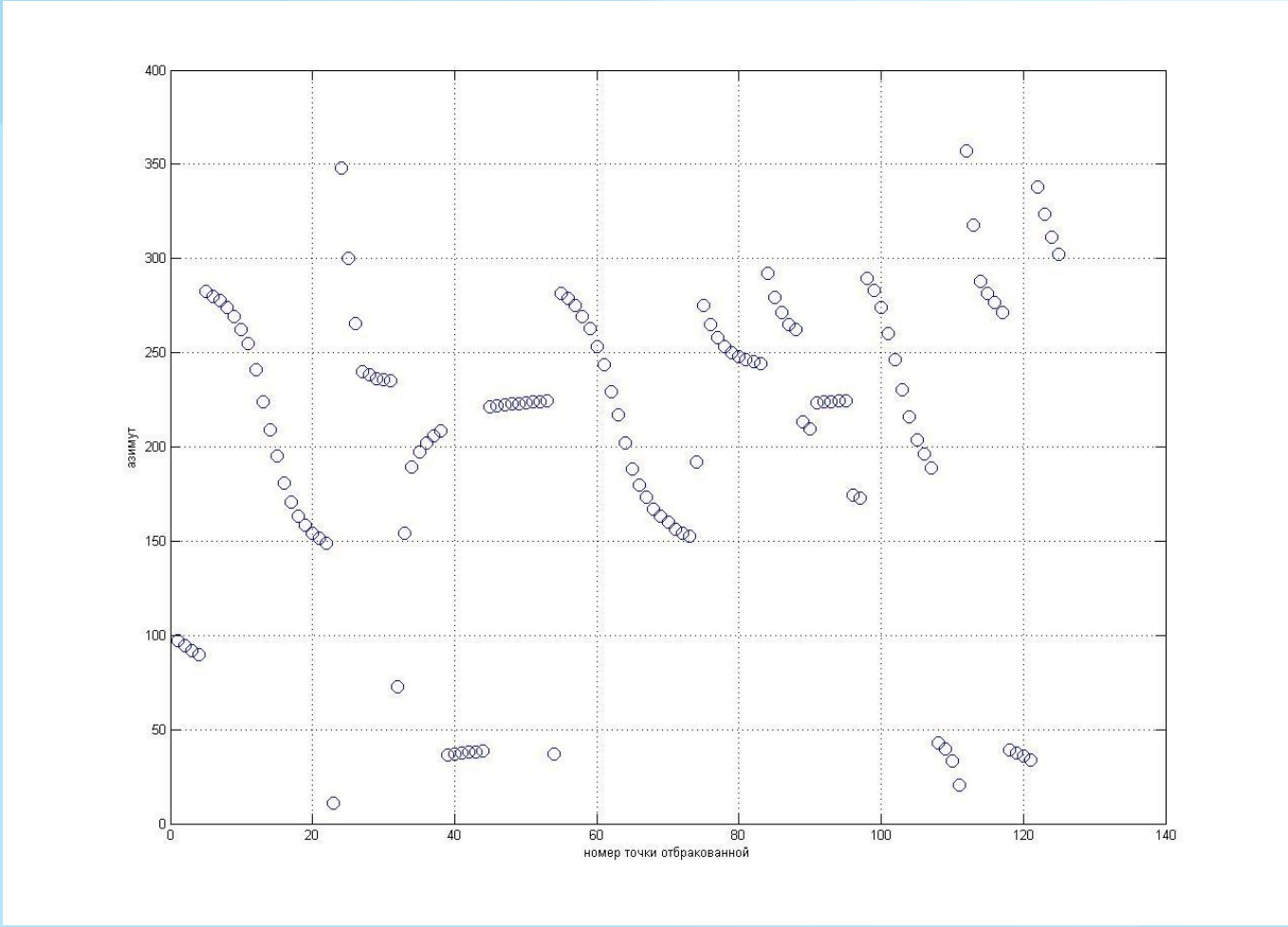
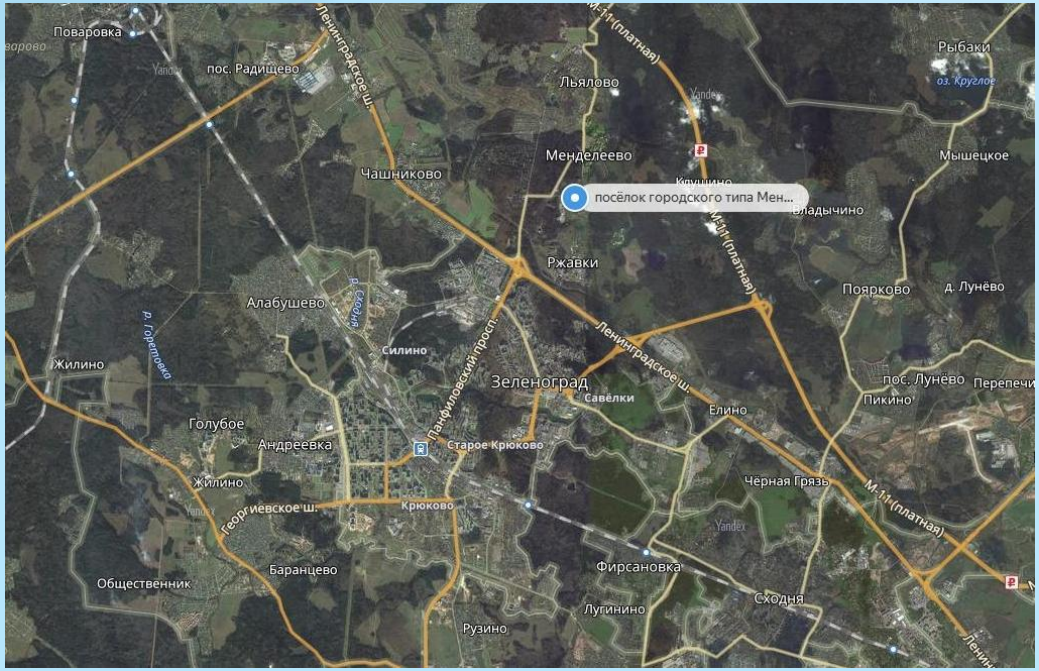
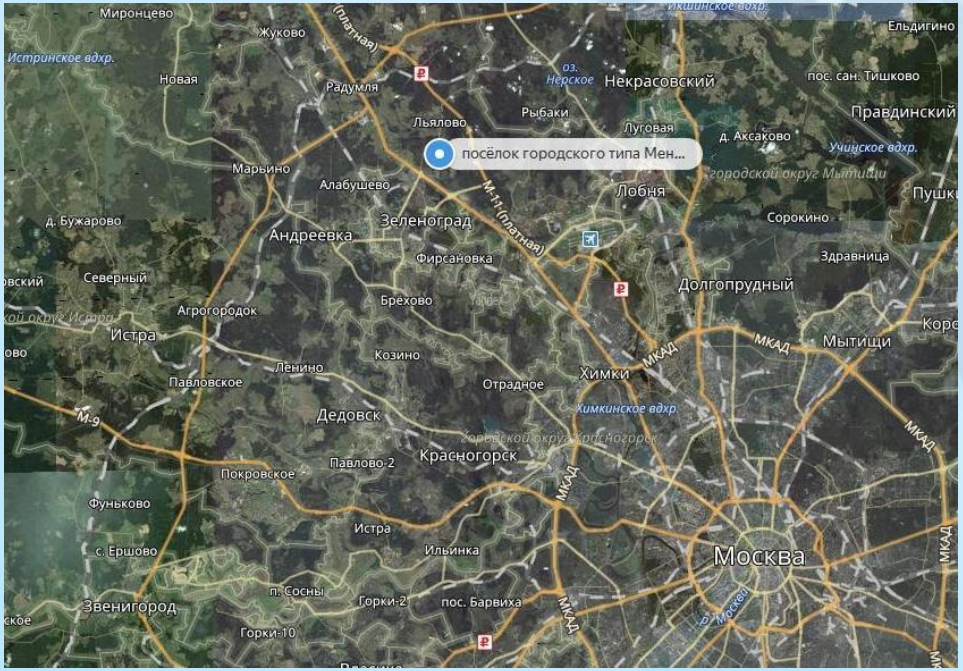
Rejection measurement station «Mendeleevo»



The interval of observations from April to mid-June. 125 points are subject to rejection. Most rejected points fall within the range of 150^0 to 250^0 in azimuth. The range of elevation angles 35^0 – 60^0..

The location of the station "Mendeleevo»





South and South-East of the station "Mendeleevo" is the urban infrastructure

Refraction and time of day

#
1874 = MENDELEEVO

# sat	site	date	time	dur	rb mm	error	tb us	error	prec	bad	total	rms	pres	temp	hum	sdelay	shft	rms	cfg	r	wlen
LAG1	1874	2018/10/11	14:39	22	13	(6)	-2.2	(3.6)	3	0 /	13	30	1005.1	283.0	62	21606	0	0	0	0	0	532
LAG2	1874	2018/10/11	16:55	43	3	(3)	-6.4	(1.7)	4	0 /	23	29	1006.1	278.1	85	21610	0	0	0	0	0	532
LAG1	1874	2018/10/15	16:01	36	8	(3)	-2.7	(1.9)	2	0 /	20	27	1001.1	283.6	76	21608	0	0	0	0	0	532
LAG2	1874	2018/10/15	17:23	44	2	(3)	-9.6	(1.6)	3	0 /	24	28	1001.0	281.4	85	21610	0	0	0	0	0	532
LAG1	1874	2018/10/16	14:57	18	12	(8)	-13.0	(4.6)	3	0 /	11	28	998.1	287.4	46	21606	0	0	0	0	0	532
LAG2	1874	2018/10/16	15:27	44	-1	(3)	-8.3	(1.6)	3	0 /	24	29	998.1	286.9	48	21607	0	0	0	0	0	532
LAG1	1874	2018/10/17	16:57	31	-0	(3)	-6.5	(2.7)	5	0 /	17	28	999.7	280.5	83	21609	0	0	0	0	0	532
LAG2	1874	2018/10/17	17:37	45	-1	(3)	-3.2	(1.6)	4	0 /	24	29	999.8	279.5	86	21609	0	0	0	0	0	532

#
each line contains:
sat = 4-char satellite name
site = 4-char site name (CDP ID)
date/time = pass starting time
dur = pass duration (min)
rb = estimated range bias (mm) with 1-sigma error
tb = estimated time bias (microsec) with 1-sigma error
prec = post-fit scattering rms (mm)
bad/total = number of bad/total normal-points
rms = single-shot rms (mm)
pres/temp/humi = pressure (hPa), temperature (K) and humidity (%)
sdelay = applied system delay (mm)
shft = system delay shift (mm)
rms = calibration single-shot rms (mm)
cfg = system configuration flag; SCH and SCI
r = data release flag
wlen = laser wavelength (nm)
#

About an hour before sunrise or sunset, and an hour later, measurements may contain errors due tohard-to-determine refraction.

Date	Sunset
2018/10/11	14:42
2018/10/15	14:32
2018/10/16	14:29

Analysis of the results of the station "Irkutsk»

Mission Control Center (Moscow)
MCC LAGEOS Weekly Analysis Report

IRKL (1891)

	DATA	T ini	T fin	SC	TTL	INC	ME	RMS	ORMS	ELEV	T	P	H	CALIB	TB	RB	PRMS	SCI	WavLen
							mm	mm	mm	deg	C	mbar	%	mm	us	mm	mm		mcm
1891	23.07.18	03:29	03:35	L1	4	4	-2	8	8	042-056	19	944.5	54	44679	*	-2	8	0	0.5320
1891	24.07.18	00:50	01:04	L2	7	7	11	13	17	036-068	16	941.9	59	44684	-11	30	12	0	0.5320
1891	24.07.18	02:03	02:14	L1	6	5	17	2	18	030-046	19	940.8	49	44686	-2	15	2	0	0.5320
1891	24.07.18	09:05	09:14	L1	6	6	2	3	4	031-049	28	936.4	33	44661	3	7	3	0	0.5320
1891	30.07.18	04:35	04:56	L1	9	8	-8	11	13	054-081	19	952.7	47	44685	-7	-12	8	0	0.5320
1891	30.07.18	07:59	08:34	L1	11	11	5	18	19	024-055	23	952.1	28	44665	-9	5	7	0	0.5320
1891	30.07.18	11:21	11:50	L1	15	13	8	8	11	027-072	23	952.0	30	44677	-4	6	6	0	0.5320
1891	03.08.18	02:29	02:44	L1	8	8	-2	8	8	029-059	21	945.0	58	44675	-4	-9	8	0	0.5320
1891	03.08.18	06:11	06:30	L1	6	6	-24	10	26	048-061	24	944.6	46	44663	-8	-22	2	0	0.5320

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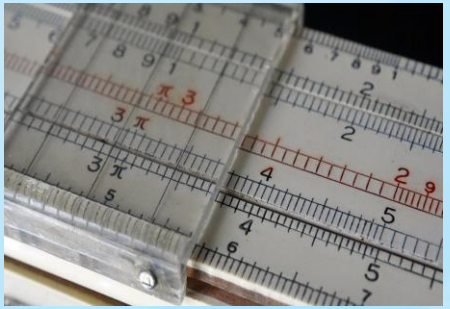

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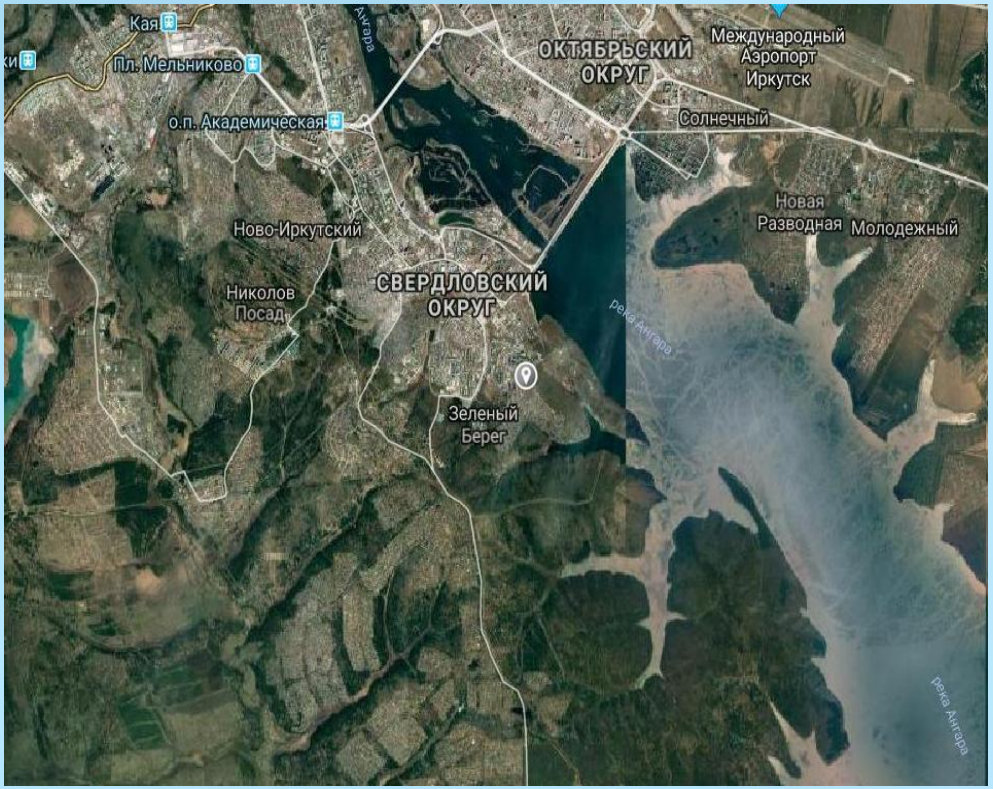
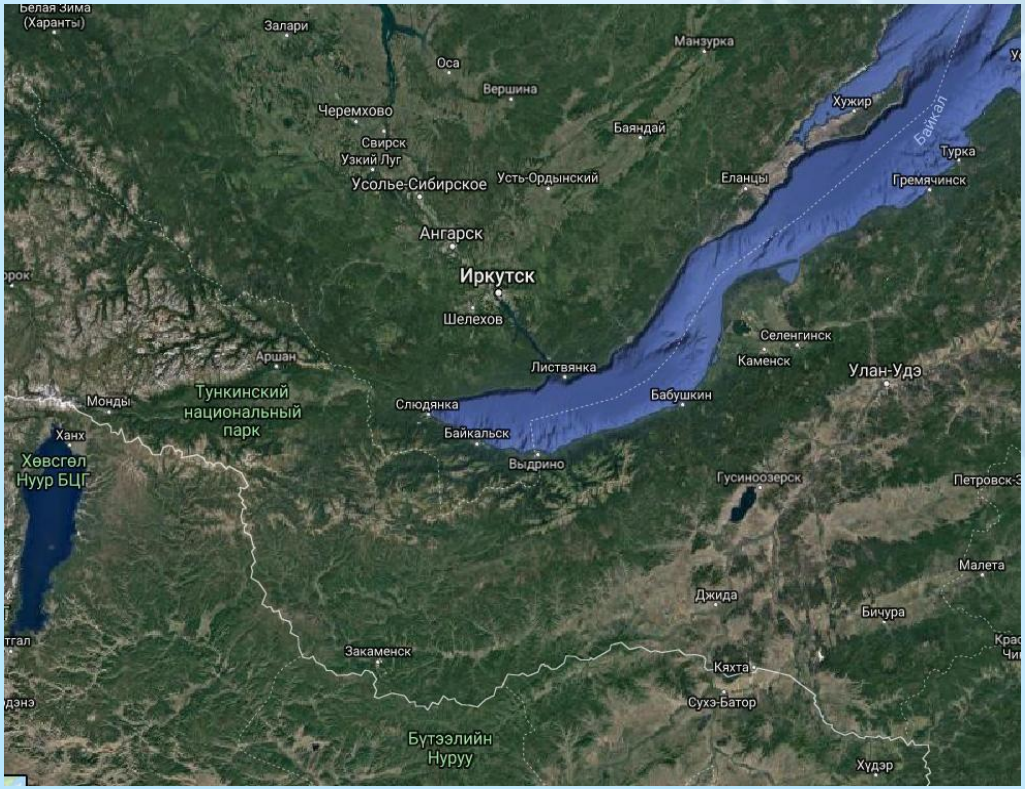
The location of the station "Irkutsk»





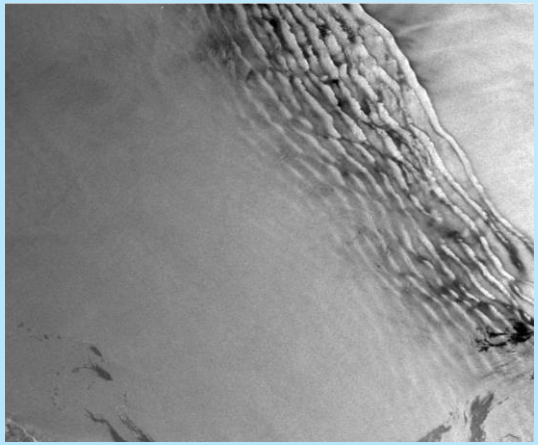
To the North of the station is the city of Irkutsk, to the East - lake Baikal, to the West and South — mountain ranges. The lake is surrounded by mountains. To the East of the station is a boost in relief.

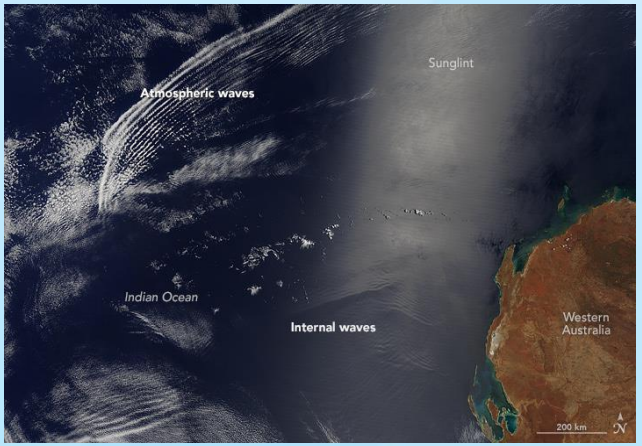
Internal waves in the atmosphere

$$N \equiv \sqrt{\frac{g}{\theta}\frac{d\theta}{dz}}$$

Brunt–Väisälä frequency
θ - potential temperature,
g - the local acceleration of gravity,
z - geometric height..

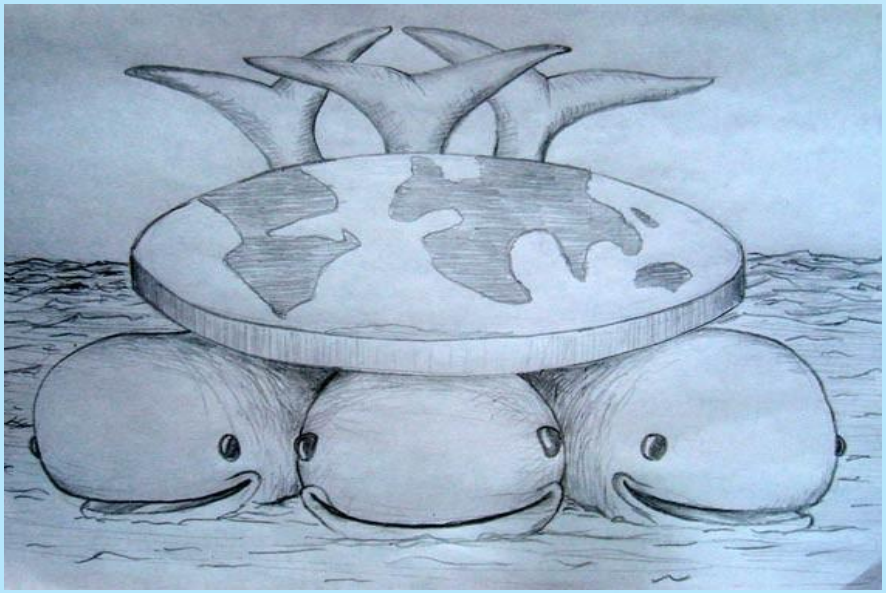
They arise as a result of changes in the density of air with height, when in conditions of stable temperature stratification of the atmosphere on the elementary volume of air, shifted for any reason up or down, the returning force acts. The speed of propagation of such waves varies from tens to hundreds of meters per second, the length reaches several tens of kilometers or more. In the lower atmosphere, the amplitudes of IGW are small, but in the upper layers they grow with decreasing air density. The magnitude of the amplitude can be several kilometers. At altitudes above 60 km can begin a rapid nonlinear growth of the wave amplitude, leading to its collapse.





Conclusion

Modern satellite laser ranging should take into account the local conditions of the station location and the current state of the atmosphere, which may differ from the conventional model.



Thanks!! ☺

Special gratitude to our colleagues, who participated in the discussion of the issues involved.

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