Multi-Year Air Temperature and Precipitation Variability on the Kola North

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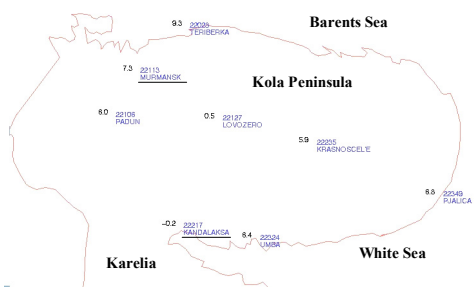
Abstract

Because "global warming" and its possible consequences are main topics of long-term discussions about reasons in the scientific and public communities, in our study we evaluated a multi-year variability of temperature and precipitation patterns on the Kola Peninsula (Murmansk Region, Russia). Moreover, such changes are supposed to be best seen in the regions above the Polar Circle, where a number of warm days has increased compared with previous measurements. Long-term series of daily observations (air temperature and precipitation) at two meteorological stations – Murmansk (1936-2005) and Kandalaksha (1915-2005) – have been constructed. Annual averaged summer (June-August) and winter (November-March) temperatures as those at higher degree influencing the human life and man-made activities were analyzed in order to identify periodic variability of warmer and colder both winter and summer periods. In these time-series periods of different duration with above and below the climatological norm are identified. Analysis of tendencies for month-to-month variability of precipitation pattern showed that at both stations it has increased during November-April (Murmansk) and October-May (Kandalaksha), and remained unchanged during other months. Similar analysis for the mean, maximum, and minimum air temperatures showed that, on average, a positive trend is more pronounced during February-May (Murmansk) and March-June (Kandalaksha); and it is negative during November-December (Murmansk) and November-January (Kandalaksha). Although a question on reasons of warming is still an open debate issue, it is possible to conclude that observed warming in the time-series studied can be a result of long-term natural variability of air temperature, but its anomalous character could be related to increased intensity of man-made activities during the recent decades.

Background

Systematical observations on the Kola Peninsula (Murmansk region, Russia) are carried out for almost a hundred years. These time-series of observations represent valuable data for analysis of long-term variability of different individual meteorological variables as well as their combination and the climate as a whole.



The main interest is connected with meteorological variables (air temperature and precipitation) variabilities during summer and winter months, which have the most influence on population and environment, as well as economic activities.

Main Factors and Processes

Main factors and processes influencing climate of the Kola Peninsula:

- Surrounding seas;
- Terrain;
- Solar radiation;
- Air masses circulation;
- ***Temperature regime***;
- ***Precipitation***.

Main Goal of the Study

The main goal is to study climatic variability on the Kola Peninsula by performing the evaluation of the time-series of meteorological observations at the Murmansk (68°58'N, 33°05'E) and Kandalaksha (67°10'N, 32°25'E) stations situated on the north and the south of the peninsula, respectively. Note that such latitudinal placement of the stations could allow more detailed figure of the climatic variability.

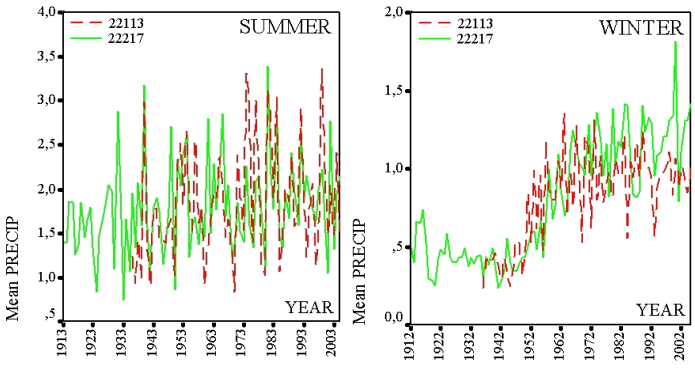
Time-Series and Analysis

Observations used:

- Kandalaksha — 1912-2005
- Murmansk — 1936-2005

Analysis for:

- Average air temperature and precipitation;
- Inter-annual variability;
- Seasonal variability;
- Month-to-month variability;
- Maximum, mean, and minimum values.



Inter-annual variability of averaged precipitation at the Murmansk (22113) and Kandalaksha (22217) measurement sites for the (left) summer and (right) winter periods.

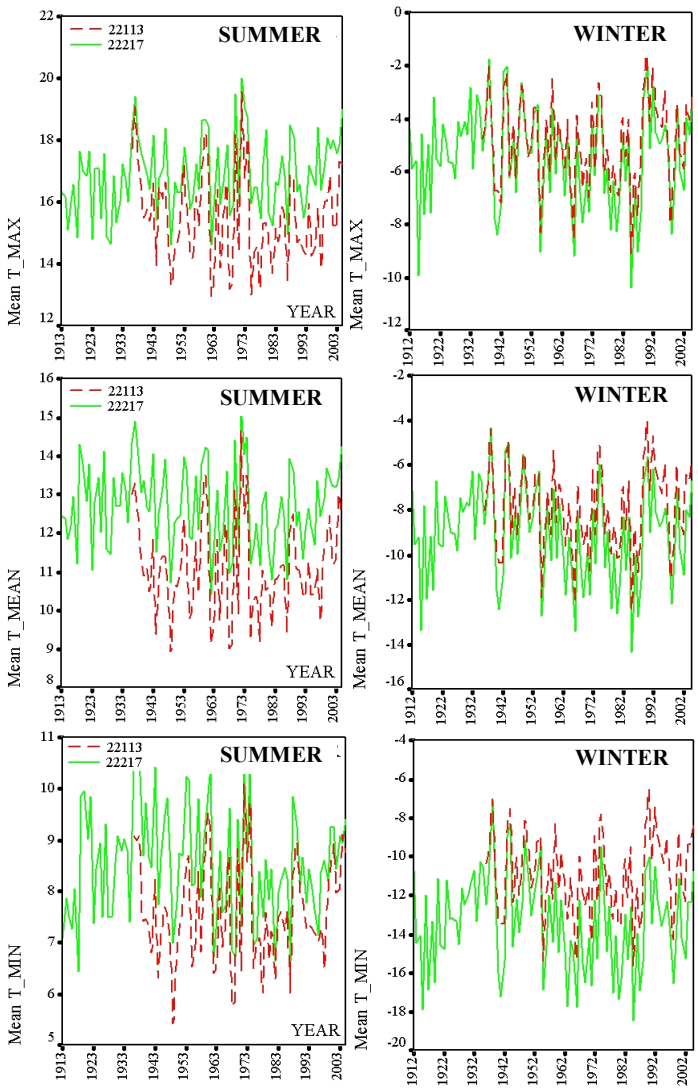
Dominating Tendencies

Station	Murmansk (22113)				Kandalaksha (22217)			
Month	Tavg	Tmax	Tmin	Precip	Tavg	Tmax	Tmin	Precip
1	0	0	0	1	-1	-1	-1	1
2	1	1	1	1	0	0	0	1
3	1	1	1	1	1	1	1	1
4	1	1	1	1	0	1	0	1
5	1	1	1	0	1	1	1	1
6	0	0	0	0	1	1	1	0
7	-1	0	-1	0	0	0	0	0
8	-1	-1	-1	0	-1	0	-1	0
9	0	0	0	0	-1	-1	-1	0
10	0	0	0	0	0	-1	0	1
11	-1	-1	-1	1	-1	-1	-1	1
12	-1	-1	-1	1	-1	-1	-1	1

Dominating tendencies (+1 — increase; -1 — decrease; and 0 —without changes) in changes of average air temperatures and precipitation /based on multi-year time-series for selectee stations on the Kola Peninsula/.

Seasonal Variability

For the Kola Peninsula, the summer period is associated with month from June till August, and the winter period is extended from November till March.



Inter-annual variability of the averaged maximum, mean, and minimum air temperature at 2 m measured at the Murmansk (22113) and Kandalaksha (22217) synoptical meteorological stations during summer vs. winter periods.

Periodicity and Extremes

The inter-annual air temperature variations show some peculiarities related to periodicity of the warmer and colder winter and summer periods. In that case the warm or cold winters/ summers are defined with respect to multiyear average air temperature (the norm) of the winter/ summer. The air temperature norm for winter (summer) for Murmansk is equal to -9.5°C (11.1°C), and for Kandalaksha it is equal to -10.9°C (12.7°C). In time-series of winter and summer air temperatures there are periods of different duration with temperatures above and below the norm.

For the Kola Peninsula there is a warming period started in 1989 till the recent years. There are also periods of relatively warm winters with duration with 8 and 6 years for the Kandalaksha and Murmansk, respectively.

The warmest winters for these cities were observed similar in 1937-1938 and 1989-1990; and the coldest winters — in 1965-1966 and 1984-1985. That could show at some degree on similarities in climatological processes in the southern and northern parts of the peninsula.

There are well seen periods of warm and cold years. For Kandalaksha, an average duration of both relatively warm and relatively cold periods is about 7 years; and it is 8 years for Murmansk. The warmest summer recorded was in 1972: with +15.2°C (in Kandalaksha) and +14.6°C (in Murmansk). Note that due to proximity of the Arctic: if winter is warmer in Murmansk that in Kandalaksha, than summer would be in opposite. Synchronization of temperature variability on an inter-annual cycle begun to change only in last years of observations analyzed.

For example, the period of warmer years on the Murmansk shore is started with a delay of 2 years compared with Kandalaksha. This could say that changes in climate, at first, start in more inland/ continental regions.

Inter-Annual Variability

Year	Sum	Win	Year	Sum	Win	Year	Ann	Year	Ann
1912	0,00	1,96				1912	0,11		
1913	-0,27	1,51				1913	-0,29		
1914	-0,63	-0,59				1914	-0,58		
1915	-1,22	-4,44				1915	-0,33		
1916	-1,38	-3,07				1916	-0,29		
1917	-0,27	-1,66				1917	-0,17		
1918	-1,28	-3,00				1918	-0,42		
1919	0,05	-2,61				1919	-0,69		
1920	2,65	-0,14				1920	-0,63		
1921	1,19	1,94				1921	-0,34		
1922	1,20	-1,00				1922	-0,32		
1923	-0,60	1,08				1923	-0,51		
1924	-1,59	2,35				1924	-0,64		
1925	0,82	0,73				1925	-0,71		
1926	0,03	0,04				1926	-0,56		
1927	0,71	-0,77				1927	-0,49		
1928	0,29	0,87				1928	-0,44		
1929	-2,38	2,59				1929	-0,41		
1930	-0,53	2,38				1930	-0,54		
1931	0,71	2,66				1931	-0,20		
1932	-0,02	4,06				1932	0,40		
1933	0,83	2,52				1933	-0,41		
1934	1,25	2,43				1934	-0,85		
1935	-0,05	5,12				1935	-0,54		
1936	1,17	2,87	1936	1,90	-0,12	1936	-0,69	1936	-0,47
1937	3,81	2,03	1937	4,10	0,69	1937	-0,66	1937	-1,00
1938	3,72	6,33	1938	3,65	4,35	1938	-0,65	1938	-1,00
1939	1,88	6,55	1939	1,67	4,47	1939	-0,71	1939	-0,99
1940	0,96	-0,72	1940	-0,02	-1,05	1940	-0,46	1940	-0,53
1941	0,59	-5,91	1941	-0,24	-4,37	1941	-0,58	1941	-0,53
1942	-0,20	-5,26	1942	-0,65	-4,80	1942	-1,09	1942	-1,12
1943	1,17	1,89	1943	0,13	-0,09	1943	-0,91	1943	-0,89
1944	0,12	7,78	1944	-0,95	5,40	1944	-0,46	1944	-0,56
1945	-1,41	2,96	1945	-1,97	1,92	1945	-0,55	1945	-0,79
1946	0,29	-0,11	1946	0,05	-0,22	1946	-1,01	1946	-0,87
1947	1,67	0,05	1947	0,58	-0,24	1947	-1,02	1947	-0,64
1948	0,84	0,50	1948	-0,51	-0,17	1948	-0,66	1948	-0,34
1949	-2,36	4,97	1949	-2,97	3,49	1949	-0,05	1949	-0,24
1950	-2,46	4,97	1950	-2,64	3,59	1950	-0,16	1950	-0,58
1951	-0,78	1,51	1951	-0,94	0,61	1951	-0,50	1951	-0,34
1952	-0,62	0,81	1952	-0,56	-0,36	1952	-0,28	1952	-0,07
1953	0,99	2,58	1953	1,19	1,69	1953	-0,14	1953	-0,18
1954	2,19	4,67	1954	1,86	3,22	1954	0,15	1954	0,09
1955	0,11	-0,84	1955	-0,73	-2,31	1955	-0,01	1955	0,26
1956	-1,68	-4,79	1956	-2,44	-4,91	1956	-0,51	1956	-0,20
1957	-0,11	-0,01	1957	-0,44	-0,17	1957	-0,33	1957	0,08
1958	0,12	-0,07	1958	0,02	-0,43	1958	-0,07	1958	0,32
1959	0,44	0,80	1959	0,63	1,39	1959	-0,32	1959	-0,09
1960	2,56	0,93	1960	3,70	1,94	1960	-0,52	1960	-0,46
1961	2,93	0,28	1961	4,03	0,46	1961	0,01	1961	-0,46
1962	-0,89	0,40	1962	-0,33	0,91	1962	0,31	1962	-0,13
1963	-3,56	-3,66	1963	-3,53	-1,83	1963	0,18	1963	0,14
1964	-0,85	-2,88	1964	-0,84	-1,39	1964	0,21	1964	0,26
1965	-0,78	-1,57	1965	-0,62	-1,50	1965	0,31	1965	0,17
1966	-1,95	-5,76	1966	-1,45	-5,96	1966	0,98	1966	0,40
1967	0,10	-3,54	1967	1,02	-3,18	1967	1,03	1967	0,39
1968	-0,86	-0,76	1968	-0,96	0,38	1968	0,52	1968	0,10
1969	-3,25	-4,41	1969	-4,05	-2,25	1969	0,19	1969	-0,36
1970	0,19	-3,69	1970	0,04	-2,35	1970	0,11	1970	-0,27
1971	0,51	-3,59	1971	0,83	-3,51	1971	0,40	1971	0,42
1972	1,36	-1,63	1972	2,36	-0,93	1972	0,40	1972	0,39
1973	3,86	-0,20	1973	4,95	0,69	1973	0,16	1973	0,10
1974	3,08	1,82	1974	3,80	1,67	1974	0,38	1974	0,58
1975	0,23	5,27	1975	0,52	4,65	1975	0,76	1975	1,02
1976	-2,58	0,62	1976	-2,70	0,67	1976	0,22	1976	0,37
1977	-1,52	-1,40	1977	-1,55	-1,17	1977	0,23	1977	0,16
1978	-2,03	-3,20	1978	-2,65	-2,07	1978	0,57	1978	0,56
1979	-1,53	-4,16	1979	-1,97	-2,82	1979	0,58	1979	0,06
1980	0,40	-4,36	1980	-0,63	-2,97	1980	0,41	1980	-0,35
1981	-0,62	-5,85	1981	-1,10	-4,36	1981	0,52	1981	0,11
1982	-2,90	-1,57	1982	-2,08	-1,18	1982	0,90	1982	0,61
1983	-2,52	-0,86	1983	-1,87	0,02	1983	0,84	1983	0,51
1984	-1,12	-0,85	1984	-0,58	0,25	1984	0,91	1984	0,30
1985	-0,27	-4,47	1985	-0,20	-3,26	1985	0,59	1985	0,14
1986	-0,04	-6,22	1986	0,13	-5,39	1986	0,24	1986	0,10
1987	-2,19	-4,66	1987	-1,64	-3,73	1987	0,09	1987	0,15
1988	-0,70	-5,75	1988	-0,77	-3,91	1988	-0,02	1988	0,16
1989	2,08	0,27	1989	2,33	1,32	1989	0,35	1989	0,44
1990	0,32	5,80	1990	1,38	6,30	1990	0,39	1990	0,34
1991	-0,71	3,50	1991	-0,07	4,73	1991	0,22	1991	0,20
1992	-1,55	2,94	1992	-0,73	4,05	1992	0,65	1992	0,44
1993	-2,06	3,89	1993	-1,45	4,96	1993	0,45	1993	0,17
1994	-0,73	1,33	1994	-0,60	2,71	1994	0,29	1994	-0,27
1995	-0,60	0,89	1995	-0,53	1,64	1995	0,68	1995	-0,01
1996	-1,56	1,71	1996	-1,37	2,67	1996	0,60	1996	0,36
1997	-0,39	1,26	1997	-0,70	2,08	1997	0,40	1997	0,00
1998	0,34	-3,03	1998	-1,42	-3,03	1998	0,69	1998	0,03
1999	-0,13	-4,32	1999	-0,91	-4,38	1999	0,89	1999	0,75
2000	1,13	0,86	2000	1,08	0,68	2000	0,94	2000	0,93
2001	1,65	1,38	2001	1,95	1,38	2001	0,39	2001	0,35
2002	1,20	-2,46	2002	1,43	-1,74	2002	0,15	2002	0,14
2003	1,01	-0,68	2003	0,28	0,35	2003	0,51	2003	0,34
2004	1,19	1,89	2004	2,12	2,77	2004	0,66	2004	0,53
2005	2,25	3,17	2005	3,27	3,39	2005	1,11	2005	0,55
ALL	1,54	2,39	ALL	1,35	2,14	ALL	0,66	ALL	0,20

Summary Outlook

Data analysis shows that in recent years there is increase in both summer and winter air temperatures on the Kola Peninsula, and moreover, such changes are started to be more pronounced in more inland areas than close to maritime.

Although there is an open question about all potential reasons and their contributions in such an increase of the temperature.

Analysis of multi-year variability of the air temperature on the Kola Peninsula shows that before the start of the warming period the cold one was proceeded. Hence, it is possible to suggest that the observed warming is a consequence of natural variability of air temperature on long-term observations. But, the abnormal character of recorder increase of air temperature is might be related to anthropogenic activity of population in recent decades.