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CHANGES OF EXTREME AIR TEMPERATURE IN THE BLACK SEA REGION

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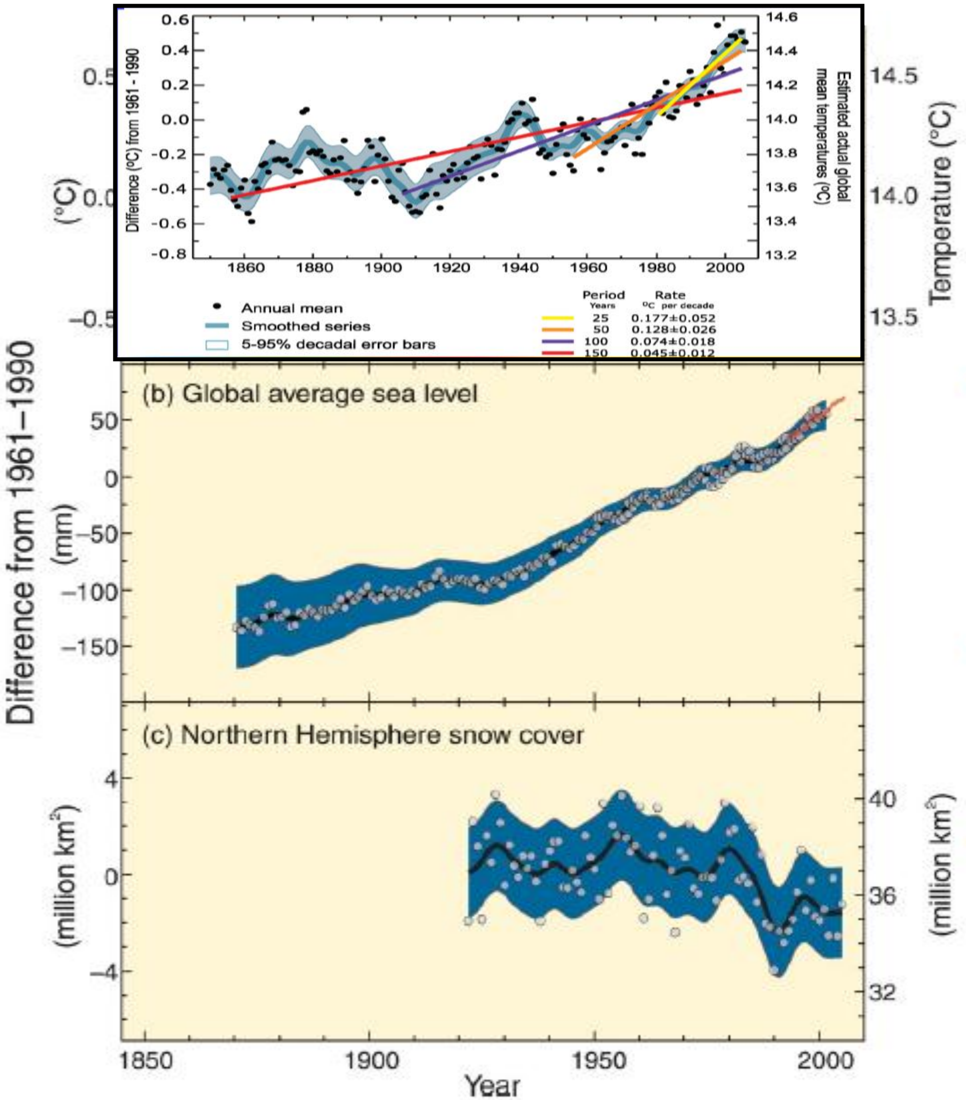
Current climate change



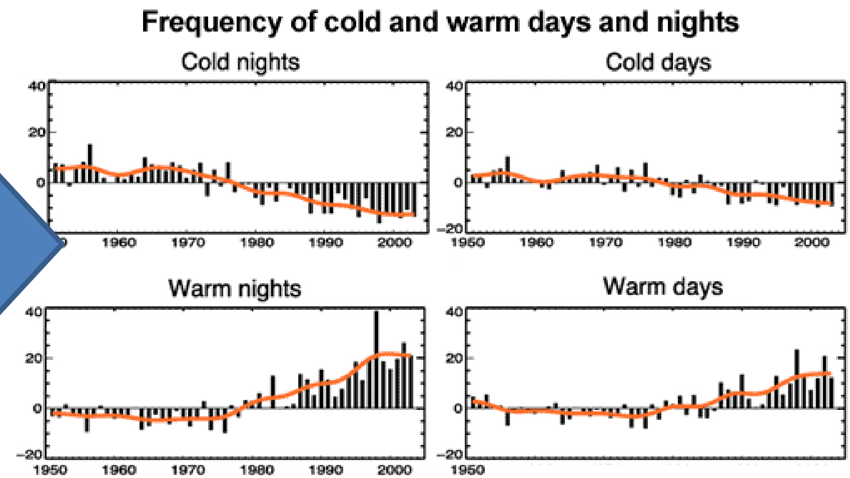
On the global scale:

- Increase of air and ocean temperatures
- Average sea level rise
- Reduction of area of snow and ice in the Northern Hemisphere

IPCC, 2007

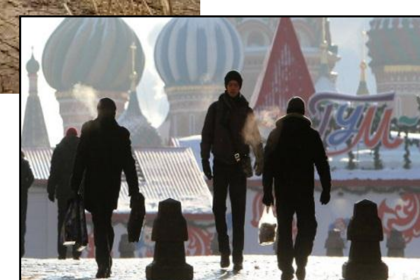
Current climate change: Extreme events

Since 1950, there has been an increase of the number of heat waves, the number of days with warm nights and a decrease of the number of days with cold nights, the amount of precipitation has decreased significantly (Alexander, 2006; IPCC 2007, 2013; Bardin, 2014; Voskresenskaya, 2016)



Alexander, 2006

Leads to **more frequent**



Negative economic and social consequences:

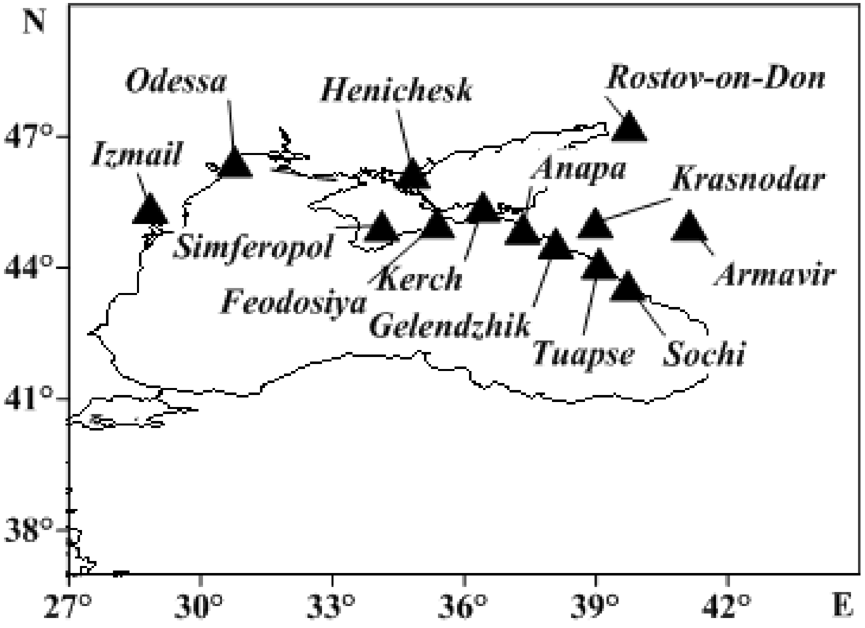
- In the summer of 2003, about 40 thousand people died in Europe due to the abnormal heat (Revich, 2006).
- In the summer of 2010, about 56 thousand Russians died due to an abnormal heat (Mokhov, 2011).
- The shortage of spring grain crops due to the drought in 2010 exceeded 50% of the level of the 2008 harvest in some regions of the Russian Federation (Roshydromet report, 2010).

Aim - to analyze long-term changes and interannual-decadal variability of the air temperature extremes in the Black Sea region in all seasons from 1950 to 2018.

Data:

- Daily air temperature data from 13 meteorological stations in the Black sea region from ECA&D, NCDC и «Raspisaniye Pogodi» projects for the period 1950 – 2018.
- NAO, PDO and AMO indexes from [https://climexp.knmi.nl] for the period 1950 – 2018.

Location of stations in the Black sea region

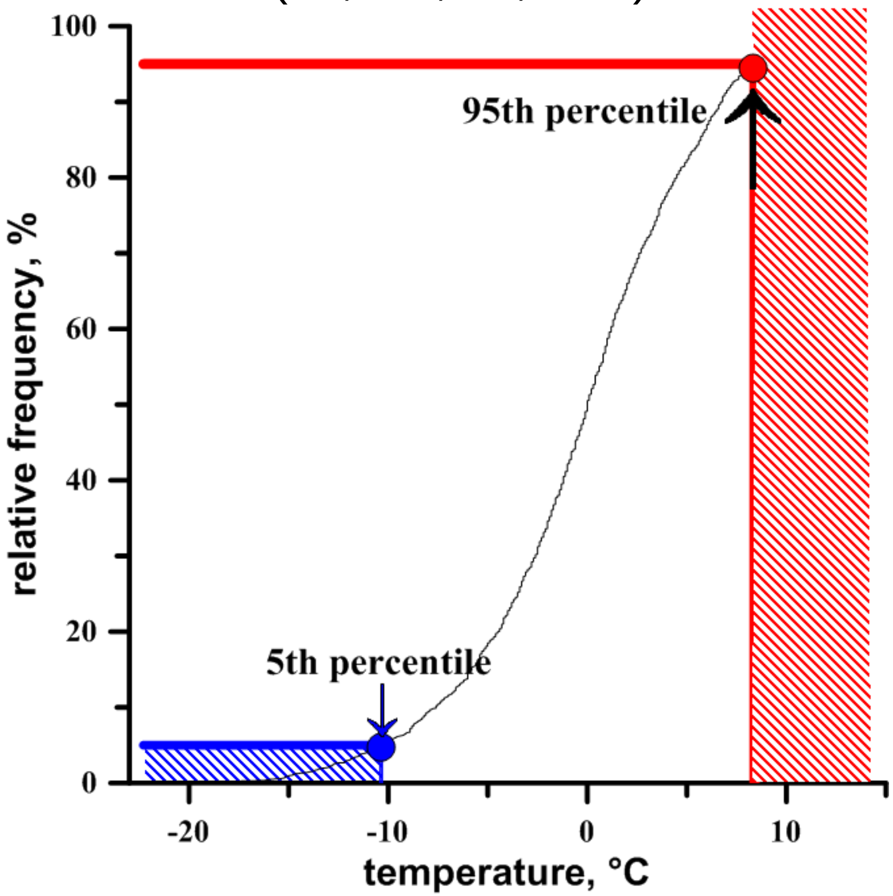


Extreme air temperature characteristics

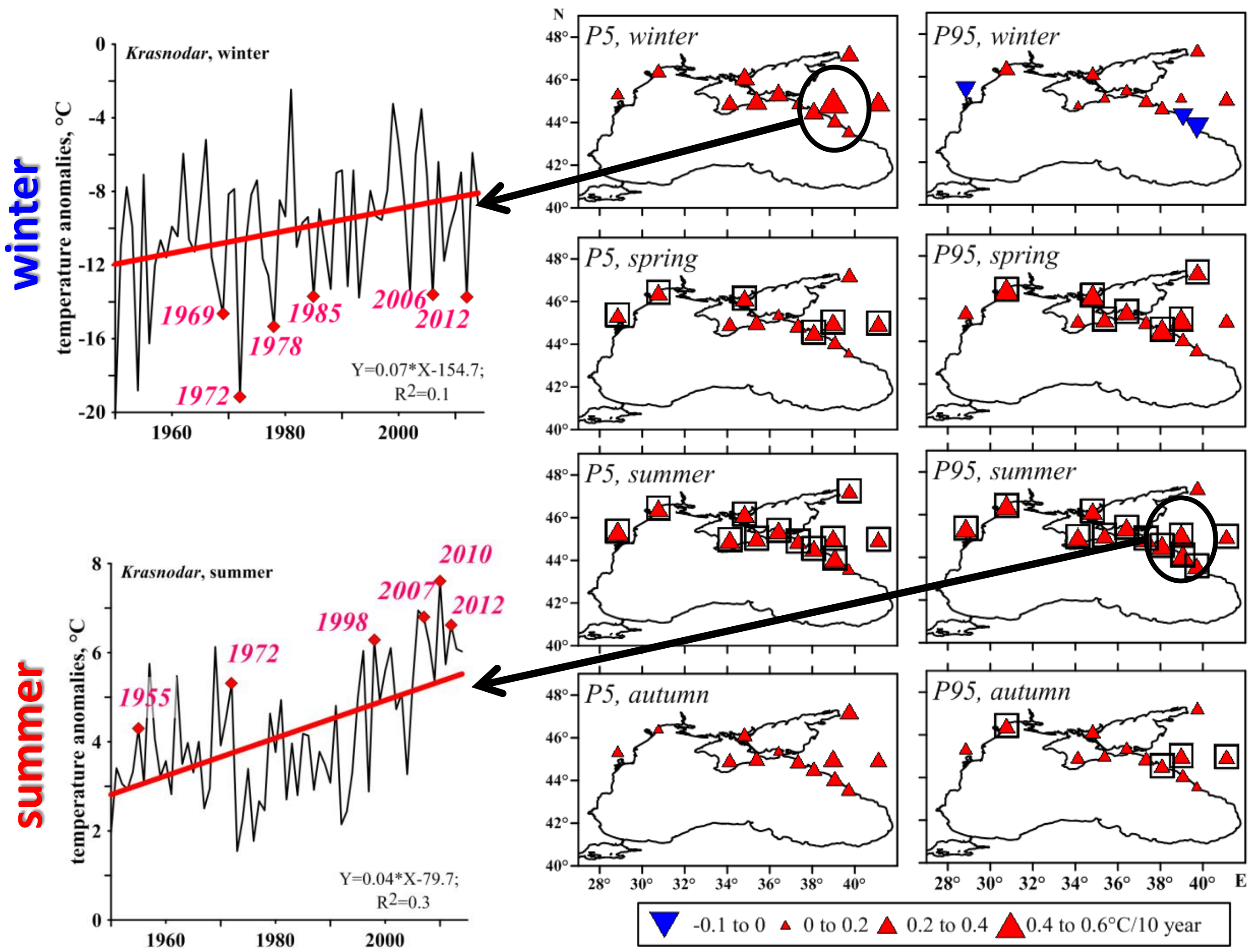
- The 5th and 95th percentiles of intra-seasonal daily air temperature anomalies; the temperature anomalies are calculated as deviations from the smoothed annual cycle.

- The number of days when temperatures below the 5th and above the 95th percentile is calculated using the methodology developed by the IPCC experts group on the extremes.

Probability curve of the mean air temperature (January) in the Simferopol station (44,7°N, 34,13°E)



Linear trends of the 5th (P5) and 95th (P95) percentiles of intra-seasonal air temperature anomalies



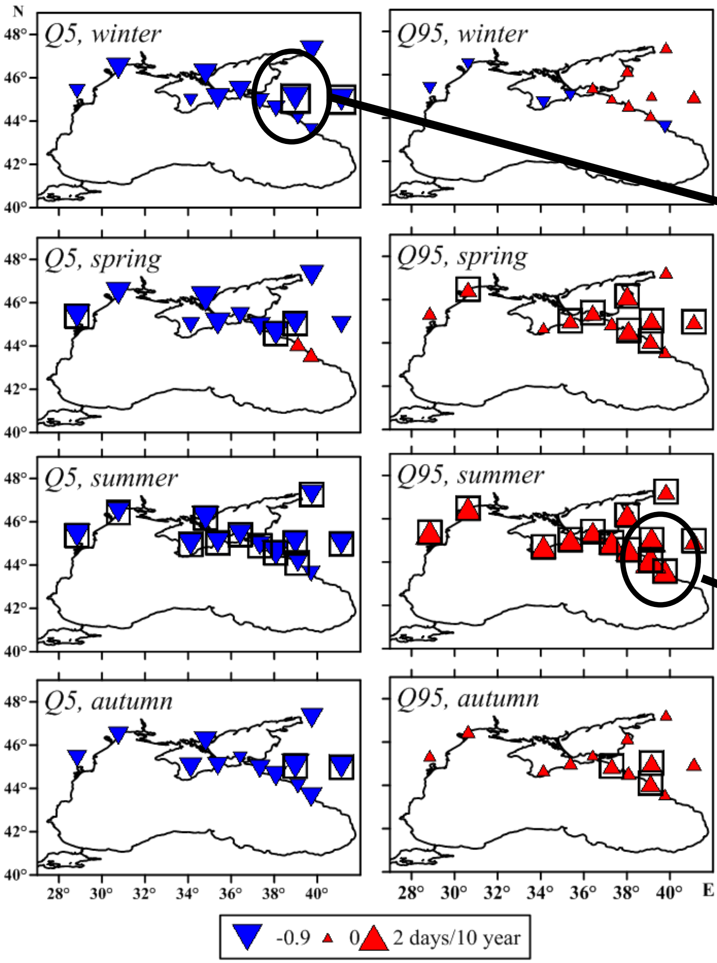
- *significant values at 95% or more levels*

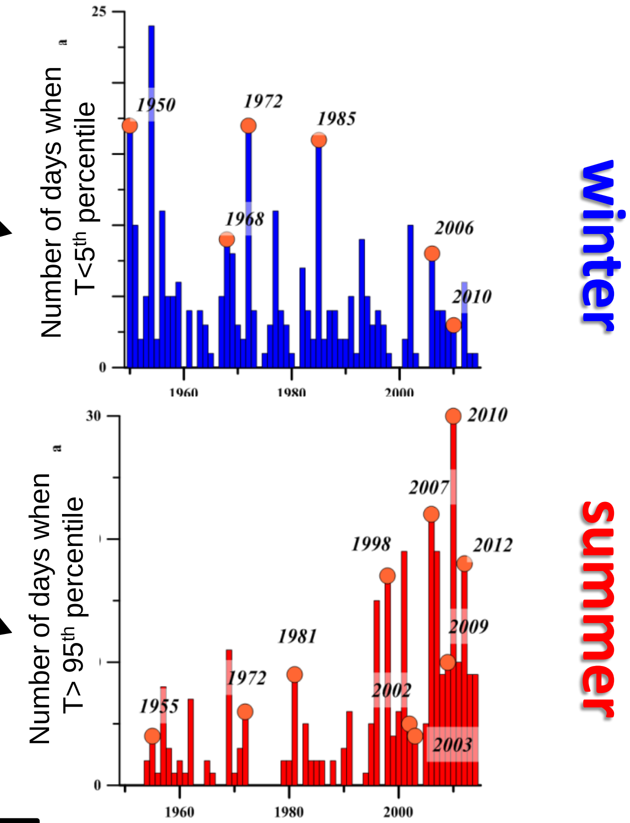
- *the years when the blocking anticyclone was observed in the Atlantic-European region and influenced on the Black sea region, according to the literature sources*

- Significant trends of P5 and P95 values for the period 1950 - 2018 are positive in all seasons. The changes of both threshold values of temperature anomalies in summer are most pronounced.

- It was found that the absolute maxima of the P5 and P95 values of the temperature anomalies are often associated with the blocking anticyclone.

Linear trends of the number of days when temperature < 5th (Q5) and >95th (Q95) percentiles



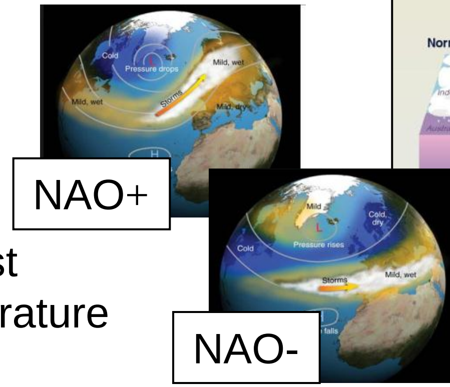


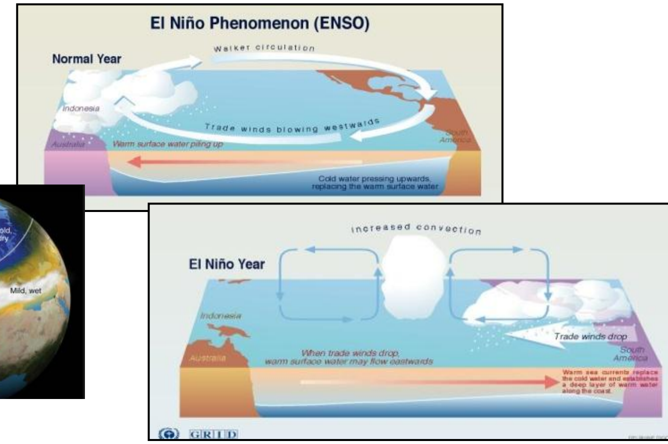
- *significant values at 95% or more levels*

- *the years when the blocking anticyclone was observed in the Atlantic-European region and influenced on the Black sea region, according to literary sources*

- The linear trends of number of days extreme low and high temperatures are opposite in sign in all seasons, but especially in summer.
- As in the case of the P5 and P95 values, the maxima of the number of days with extreme air temperature are associated with blocking anticyclone.

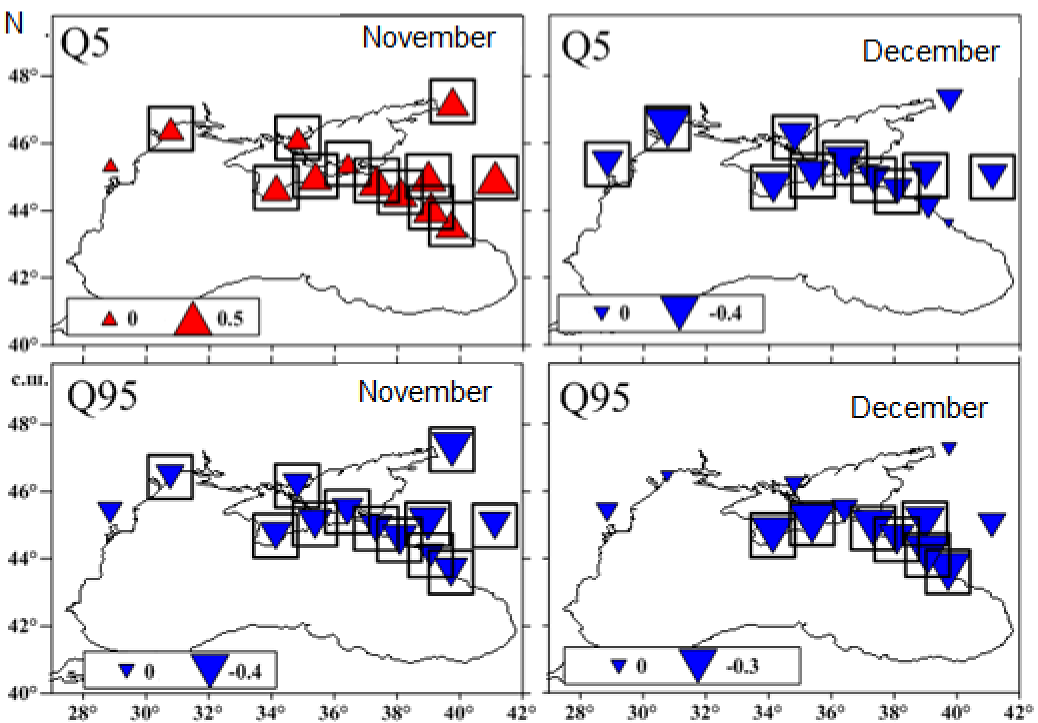
Interannual variability of winter extreme air temperature in the Black sea region





- Interannual climate processes are most clearly manifested in the low air temperature extremes in the autumn-winter period.

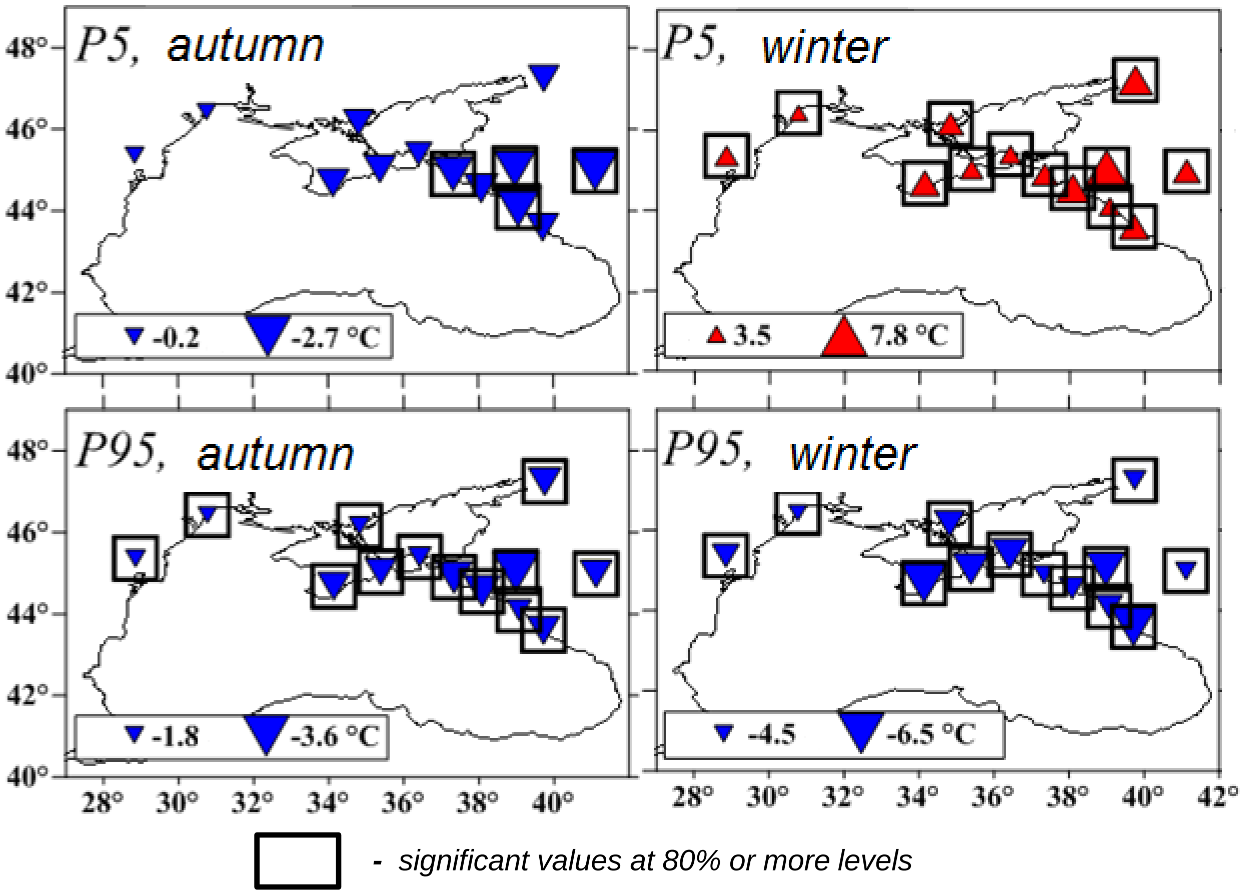
Correlation between the NAO index and the number of days when T<5th (Q5) and >95th (Q95) percentiles



▭ - *significant values at 80% or more levels*

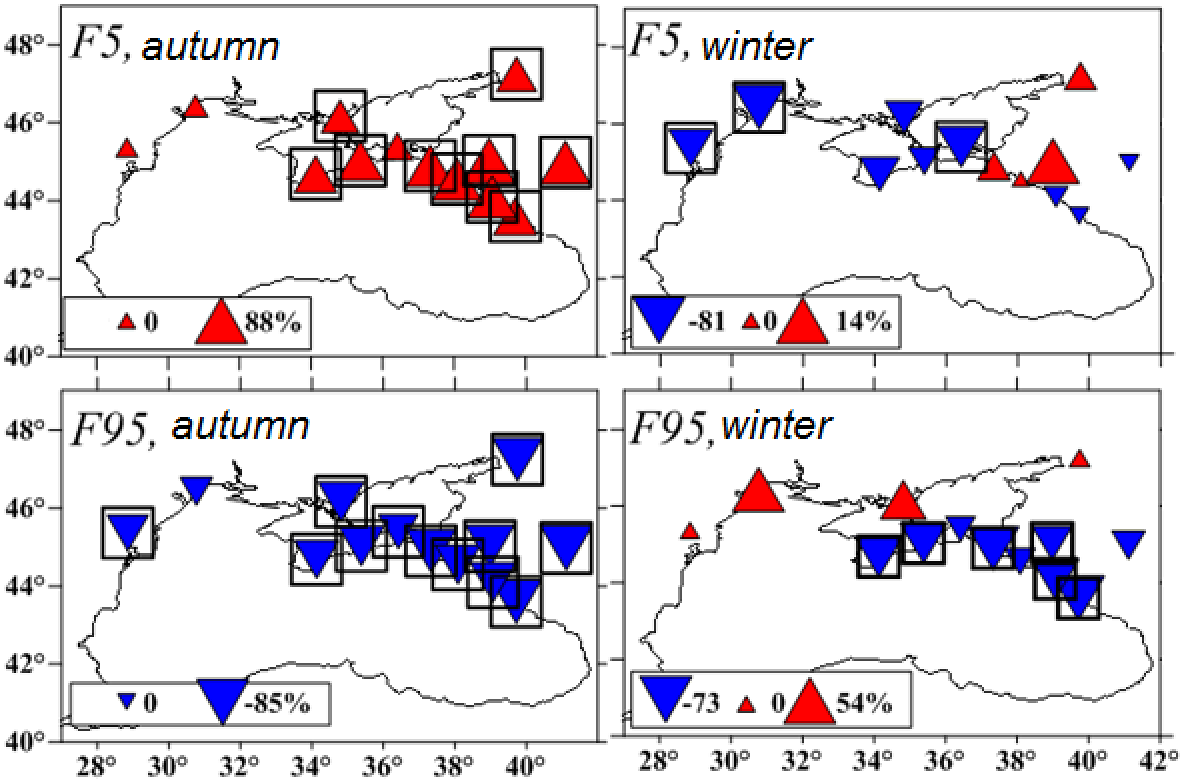
- Significant correlation coefficients between the NAO index and extreme air temperature are characterized for the number of days with extremes in the autumn and winter.
- The correlations between Q5 and the NAO index are positive in November and negative in December. At the same time, correlations with Q95 are negative in both November and December.

Difference between the 5th (P5) and 95th (P95) percentiles of intra-seasonal air temperature anomalies in the positive and negative NAO phases



- Significant changes of P5 and P95 in NAO phases are found in the winter and autumn.
- During NAO +, the winter P5 value increases to 8°C at all analyzed stations of the Black Sea region. At the same time, the P5 value in autumn decreases to 3°C, but significant results are not typical for all stations.
- During NAO+ the P95 values significantly decrease to 7°C in winter and to 4°C in autumn at all stations of the Black Sea region.

Difference between the frequency of extreme low (F5) and high (F95) temperatures in the positive and negative NAO phases



Frequency - the sum of monthly values of number of days when T<5th and >95th percentiles (for months included in the sample of the composite NAO+ or NAO-), calculated from the period 1950 - 2018, divided by the number days with available daily temperature data during these months.

▭ - *significant values at 95% or more levels*

- Significant differences in the F5 values in the NAO phases are observed only in the autumn. At the same time, F5 during NAO + is significantly higher than with a negative phase.
- Significant differences in the F95 values in the NAO phases are negative in all seasons, but significant results are not typical for all stations.

El Nino. Classification of El Nino events by Voskresenskaya, Mickhailova (2010)

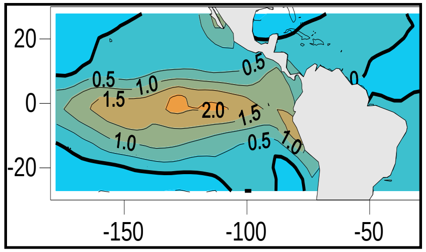
Features of El Niño events

Types	Spring events	Summer-spring short-lived events	Summer-spring long-lived events
Start time	April	July	September
Maximum SST anomalies in NINO-3.4 region, °C	+1,77	+1,24	+1,22
Average duration, months	12	9	20
Number of El Nino types for the period 1950 – 2018	11	7	2

SST anomalies in the tropical Pacific during the mature phase of development of different El Niño types

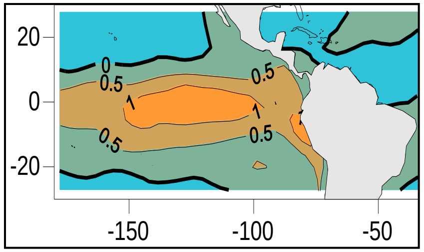
Spring type

January +1 year



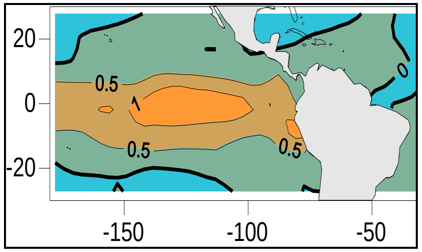
Summer-spring short-lived type

January +1 year

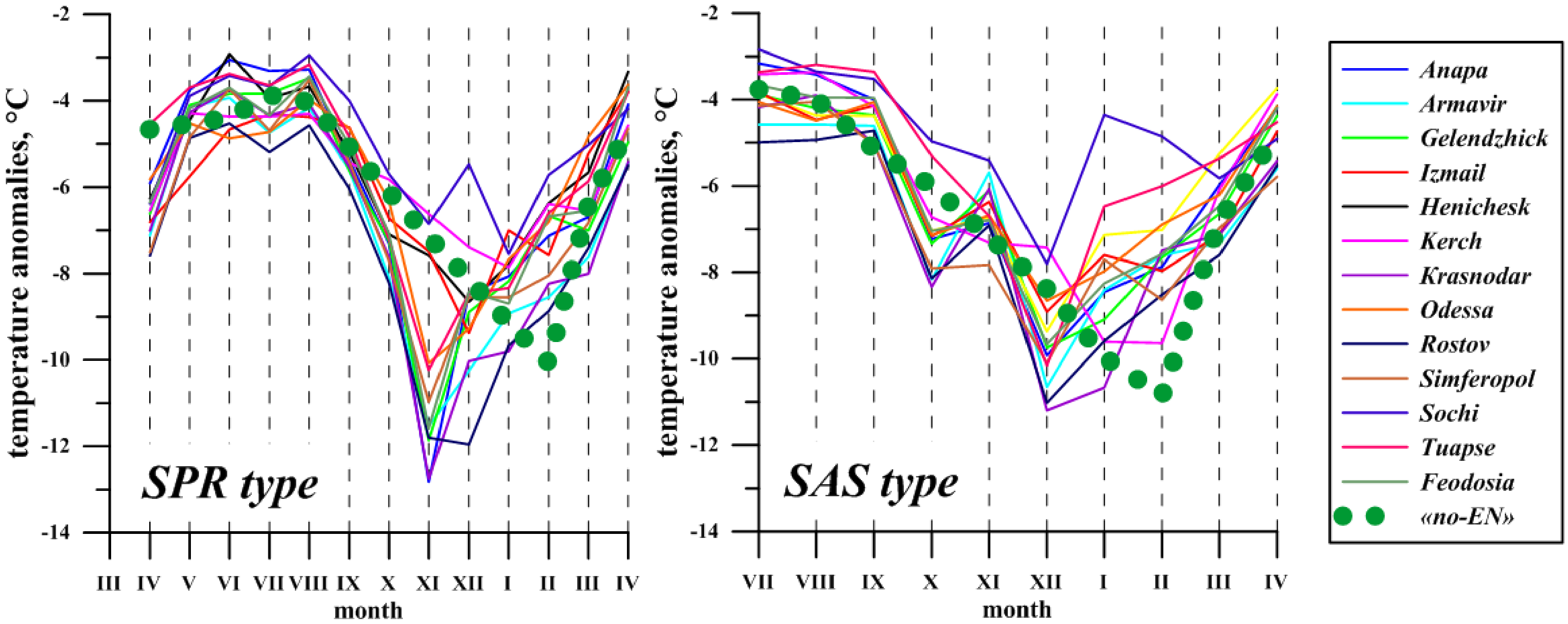


Summer-spring long-lived types

January +2 years



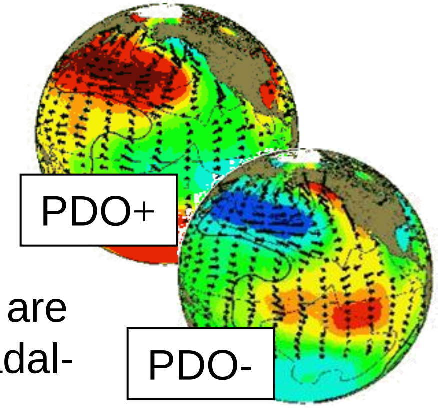
The 5th (P5) percentiles of intra-seasonal air temperature anomalies during spring (SPR), summer-autumn short-lived (SAS) types of El Niño and years without El Nino

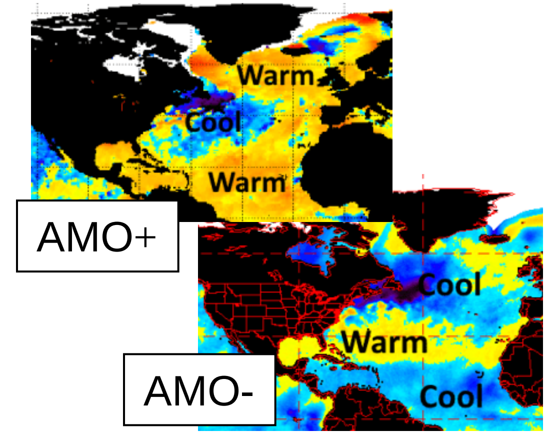


- Minimum of P5 composites for non-anomalous years (years without El Nino) is observed in February
- The minimum of the annual change of P5 during years with different El Nino types is shifted by 1 month. That minimum during SAS El Nino type is observed in December, and during SPR El Nino type - in November.
- SPR El Nino type is accompanied by colder extreme low air temperatures compared to SAS type.

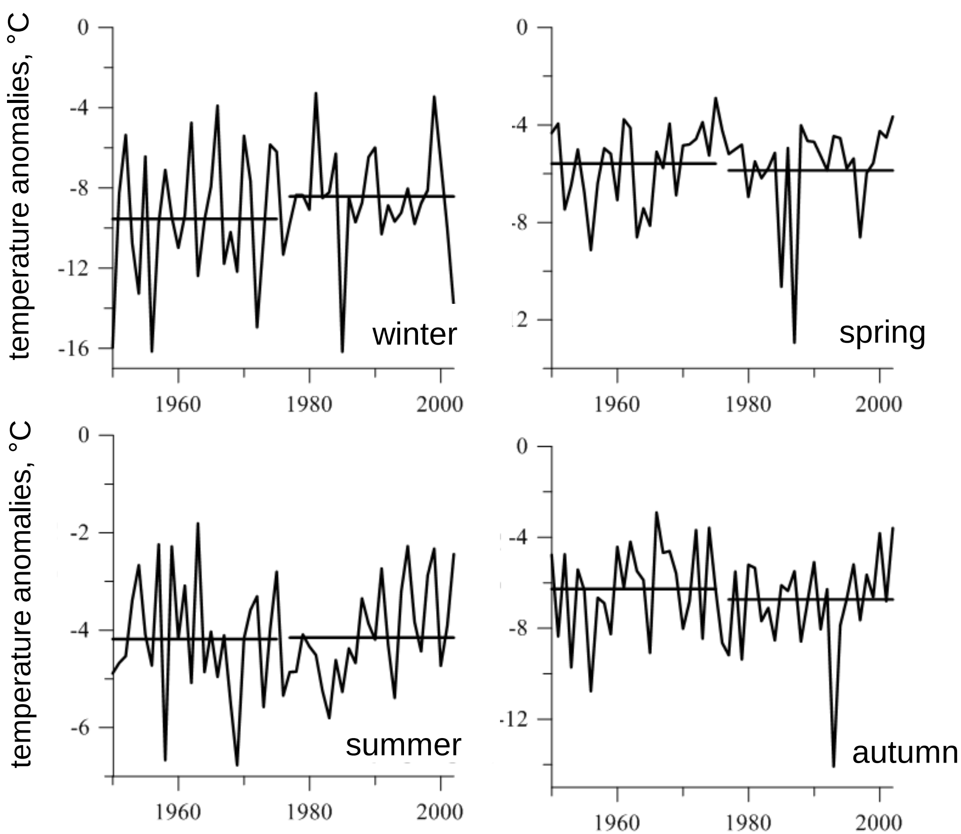
Decadal-multidecadal variability of winter extreme air temperature in the Black sea region

- Pacific decadal oscillation (PDO) and Atlantic multidecadal oscillation (AMO) are most important climate modes on decadal-interdecadal scale



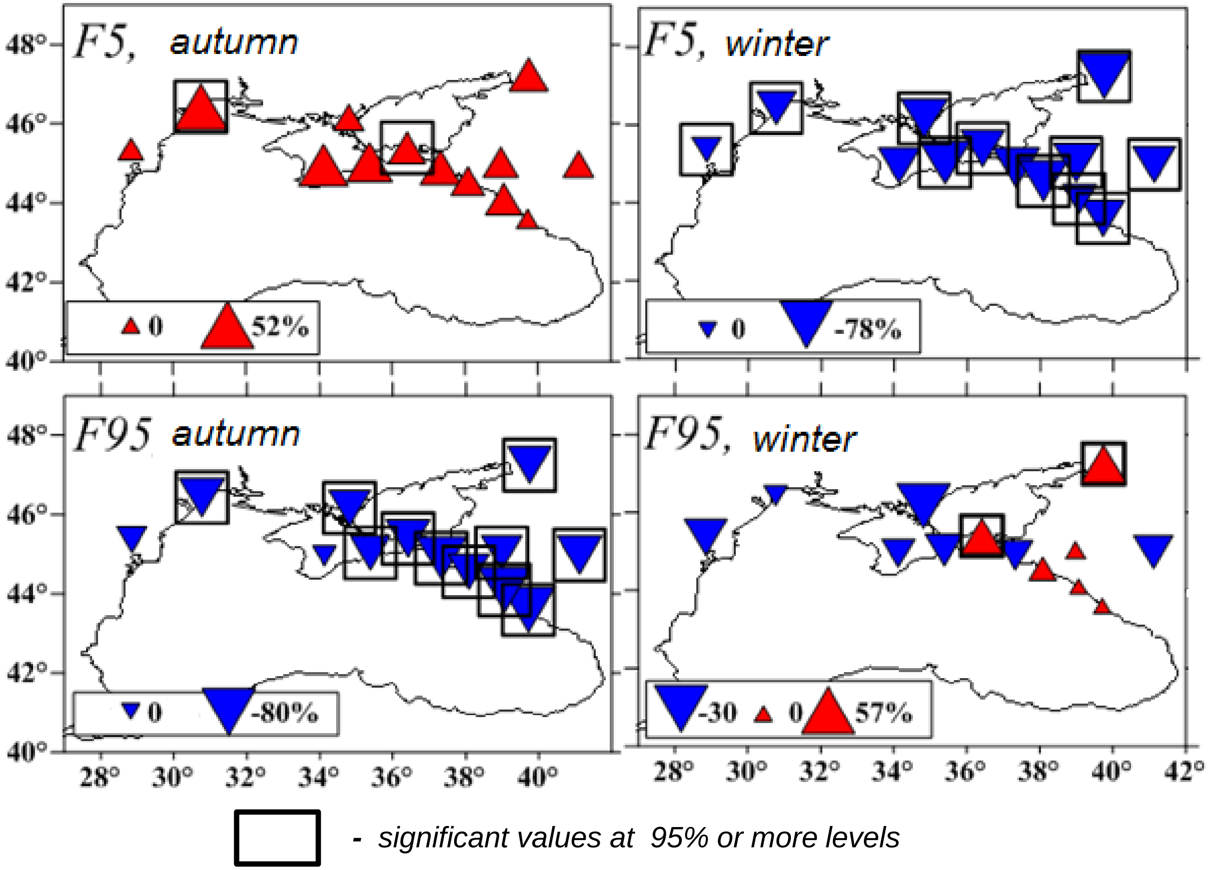


The 5th (P5) percentiles of intra-seasonal air temperature anomalies during PDO phases



- P5 values varies significantly from phase to PDO phase.
- The average P5 value after 1977 in the winter increased by ~ 1.5 ° C, while in autumn it decreased to 0.5 ° C.
- At the same time, in spring and summer, changes of P5 in PDO phases are less pronounced.

Difference between the frequency of extreme low (F5) and high (F95) temperatures in the positive and negative PDO phases

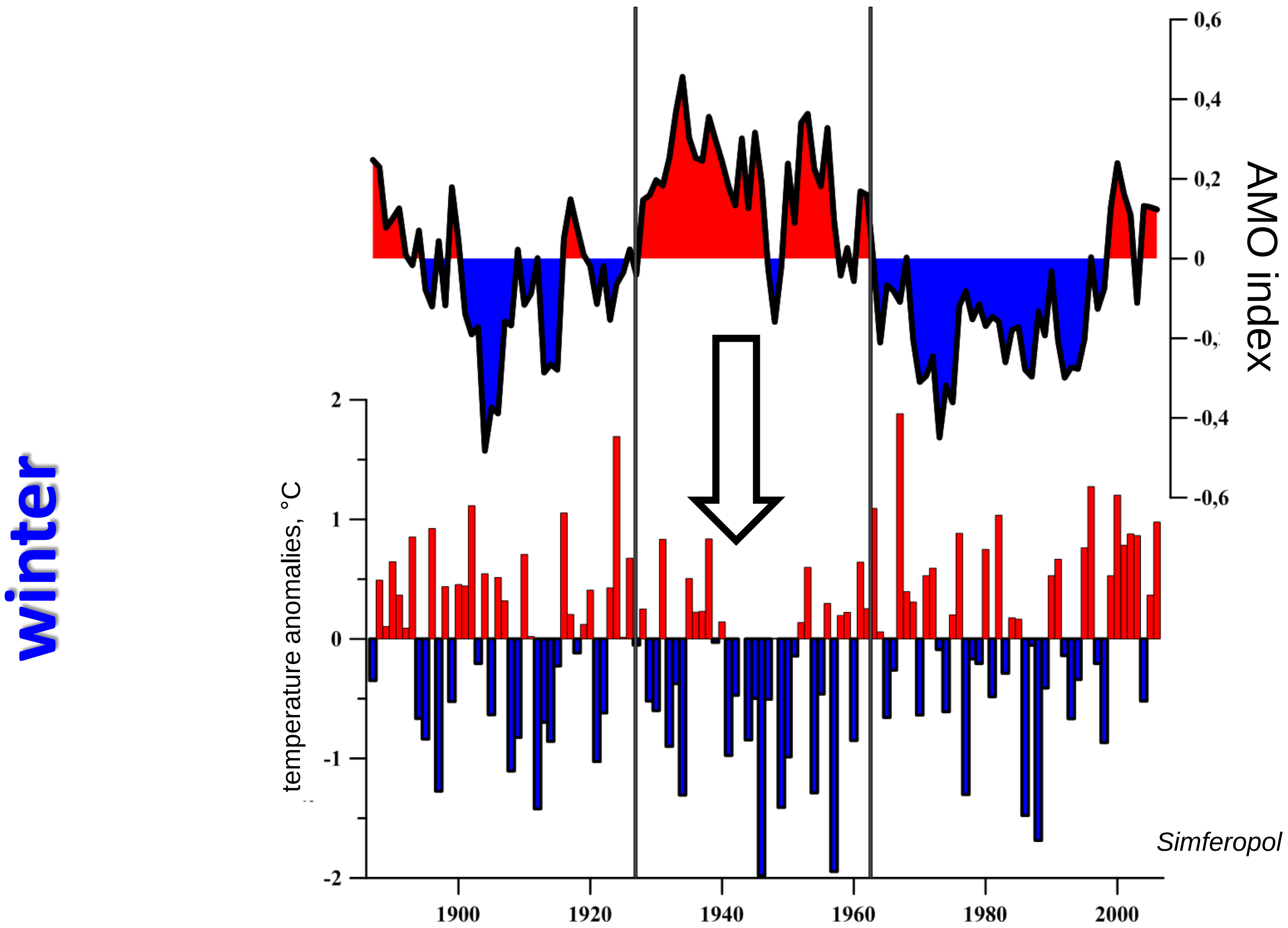


- significant values at 95% or more levels

- PDO+ is accompanied by a significant decrease by more than 2 times in the F5 value in the winter. At the same time, the F5 values in the autumn at PDO+ increases, but significant results are characteristic only for some stations.

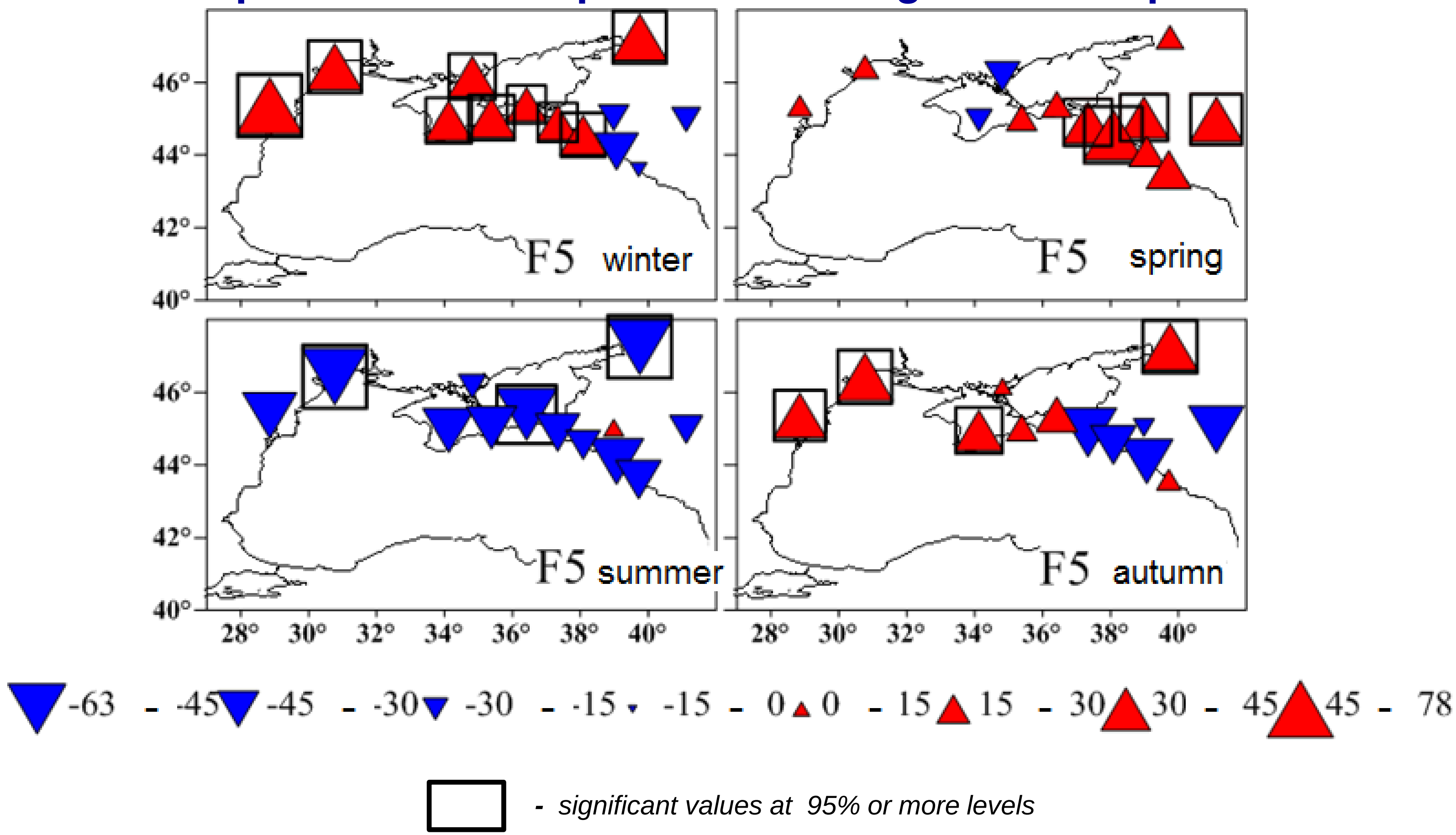
- The F95 value during PDO+ in the autumn decreases in the Black sea region, while the differences between the composites in the winter are mostly insignificant.

The Atlantic multidecadal oscillation (AMO) index and temperature anomalies in the Black sea region



- AMO + is accompanied by negative air temperature anomalies, while AMO- is accompanied by positive air temperature anomalies.

Difference between the frequency of extreme low (F5) and high (F95) temperatures in the positive and negative AMO phases



- The F5 values in the winter during AMO + increases by more than 2 times than with the AMO-.
- Difference of the F5 value in the AMO phases in spring and autumn are insignificant at most stations.
- Differences of the analyzed composites in the summer are negative

Conclusions

- The maximum values of linear trends of extreme temperature characteristics in the Black sea region are typical for the summer. They are positive.

- NAO explains up to 15% of the variance of the number of days when T<5th percentile in the Black Sea region. The positive NAO phase are characterized by more than 50% of the frequency of extreme low air temperatures increases.

- The 5th percentiles of intra-seasonal air temperature anomalies are significantly differ in the autumn-winter season during different El Nino types.

- The PDO intensification in the winter is accompanied by a statistically significant decrease by ~ 2 times in the frequency of extreme low temperatures in the Black Sea region.

- The AMO intensification in the winter is characterized by an increase of up to 49% in the frequency of extreme low temperatures in the Black Sea region.

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Thank you!

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