Precipitation regime variations in the Black Sea coastal area and regional climate change over the last 30 years

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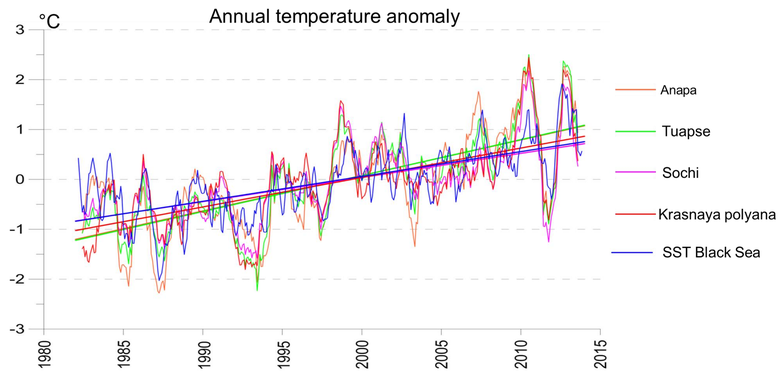
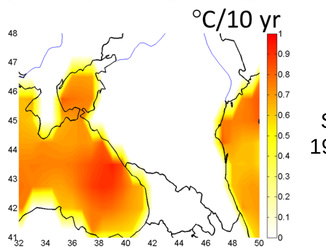
Motivation

Densely populated Ruassian Black Sea coastal area has experienced considerable climate change in the last 36 years with a number of devastating extreme events (e.g., Krymsk flooding in 2012 [Meredith E. P. et al. Crucial role of Black Sea warming in amplifying the 2012 Krymsk precipitation extreme //Nature Geoscience. – 2015. – Т. 8. – №. 8. – С. 615.]).
Quantitative estimates of these changes and mechanisms beyond then are still uncertain.





NOAA OI SST V2
Summer trend of SST
1982-2015, °C per 10 yr

The main goal of the study is

to select some key features of climate changes in the Black Sea coastal region and to give a feasible physical interpretation of these processes.

Data

- *Meteorological stations' data* [RIHMI-World Data Center, http://meteo.ru/]
- *Reanalysis ERA-Interim* [Dee D. P. et al. The ERA-Interim reanalysis: Configuration and performance of the data assimilation system //Quarterly Journal of the royal meteorological society. – 2011. – Т. 137. – №. 656. – С. 553-597.]
- *NOAA OI SST V2* [Reynolds R. W. et al. Daily high-resolution-blended analyses for sea surface temperature //Journal of Climate.–2007.–Т.20.– №. 22. – С. 5473-5496.]

Conclusions

•Observations and reanalysis data show overall positive temperature trends, the strongest in summer;
•Precipitation data show non-significant negative trends in winter and summer and non-significant positive trends in spring and autumn;
•Total column water vapor and CAPE in summer were growing, whereas air convergence was decreasing over the Sea and analyzed coastal regions over the last 30 years;
•The vertical velocity in the region also significantly decreased in summer;
•The two latter factors could contribute to the insignificant changes of precipitation intensity over the coast despite of the increase of total moisture content and CAPE.

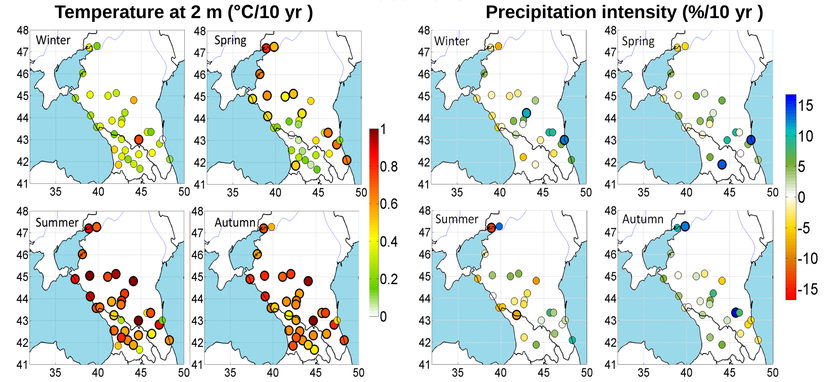
References

Aleshina M. A., Toropov P. A., Semenov V. A. Temperature and humidity regime changes on the black sea coast in 1982–2014 // Russian Meteorology and Hydrology. — 2018. — Vol. 43, no. 4. — P. 235–244. DOI: 10.3103/S1068373918040040

Toropov P. A., Aleshina M.A., Semenov V.A. Trends of climate change in the Black Sea-Caspian Sea region during recent 30 years //MSU Vestnik. Series 5 //Geography. – 2018

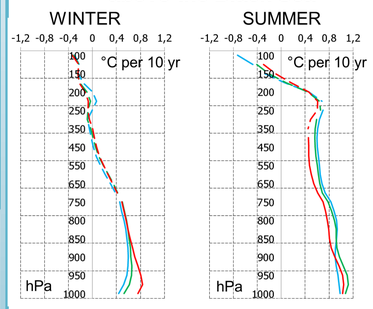
Seasonal trends
Meteorological observation stations
1980-2015

Temperature at 2 m (°C/10 yr) | **Precipitation intensity (%/10 yr)**



Boxes with significant linear trends at the 95% level are outlined by heavy black lines

ERA-Interim reanalysis
Seasonal trends (1980-2015)
of air temperature at pressure levels above the Black Sea

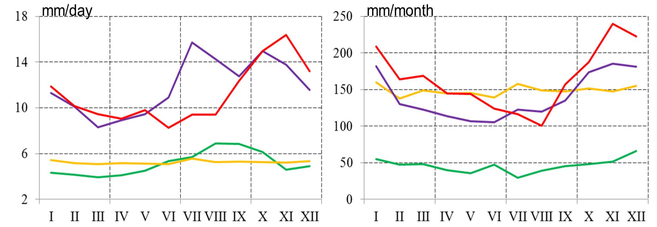


The average rate of summer warming is:
- **on the plains 0.7±0.2° per 10 yr,**
- **in the mountains 0.5° per 10 yr,**
- **over the Black sea 0.6° per 10 yr.**

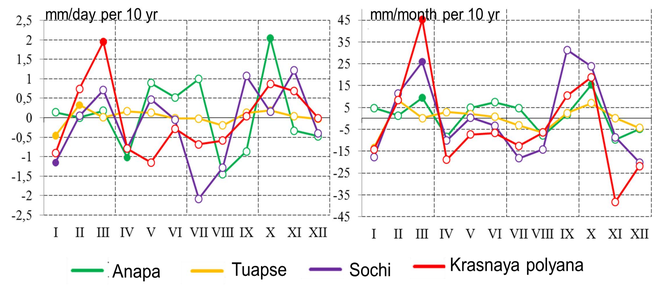
The temperature is growing not only at the surface.
In summer the temperatures are significantly rising from the surface to the level 300 hPa, and in winter to 750 hPa.
This implies a positive shift in the vertical temperature profile throughout the troposphere.

Precipitation changes showed a weak decrease, but the changes are non-significant.

Monthly mean precipitation intensity | **Monthly precipitation sum**



Monthly trends of precipitation intensity (1980-2015) | **Monthly trends of precipitation sum (1980-2015)**



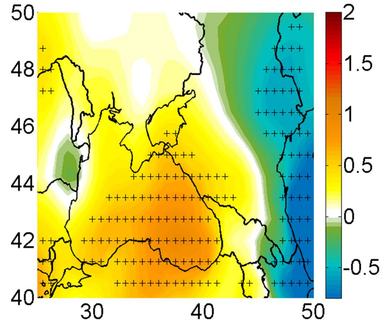
Circles with significant linear trends at the 95% level are painted

ERA-Interim reanalysis
(1980-2015)

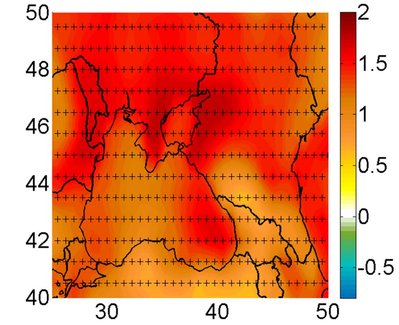
Specific humidity is expected to increase by 7% with 1°C temperature growth (Clausius–Clapeyron relation) [Min S. K. et al., 2011; Semenov V., Bengtsson L., 2002] →

Is the observed atmospheric moisture increase can be explained by the warming?

Summer trend of total column water vapor 1980-2015, kg/m² per 10 yr

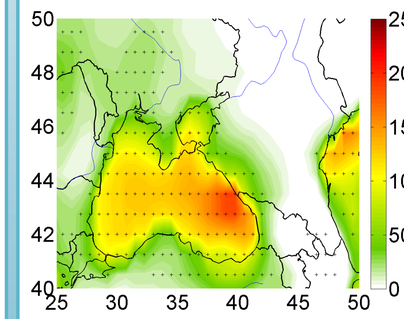


Summer trend of total column water vapor 1980-2015, kg/m² per 10 yr (by Clausius–Clapeyron relation)

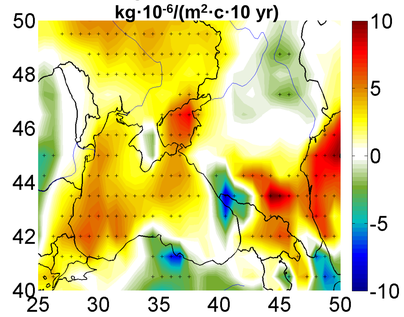


We have significant trends of moisture flux divergence over the Black sea.
It means that the convergence of air was decreasing in that region over the last 35 years.
Also, the intensity of upward vertical movements decreased.
This factors may have been responsible for the precipitation regime stability.

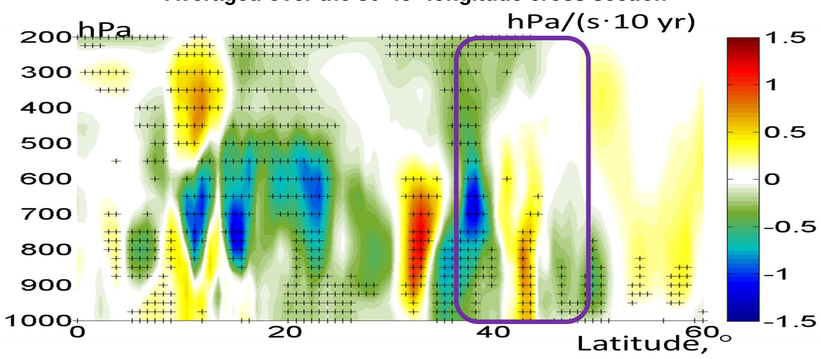
Summer trends of CAPE J/(kg·10 yr)



Summer trends of vertical integral of divergence of moisture flux kg·10⁻⁶/(m²·c·10 yr)



Vertical velocity trends (w')
Averaged over the 30-45° longitude cross section



Boxes with significant linear trends at the 95% level are outlined by black crosses