

3rd International Scientific Conference

“Energy and Climate Change”



« Indicators of climate changes in the Athens area »

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TARGET OF THIS STUDY

To examine the variations of six meteorological parameters in Greece, in order to propose suitable indicators for climate changes



METHODOLOGY

- **The data used in this work come from the Hellenic National Meteorological Service (EMY)**
- **Two stations covered: inside the city (Nea Filadelfeia) and outside the city (Tatoi)**
- **The data cover 45 years from 1956 to 2001**
- **For all data a point is generally measured every 3 hours (starting from midnight), except precipitation which is a 12 hours average**



METEOROLOGICAL PARAMETERS

Six meteorological parameters are measured:

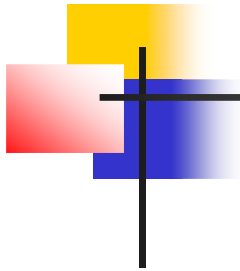
- **temperature (°C)**
- **atmospheric pressure (mm Hg)**
- **wind direction (°, with 0 to the north)**
- **wind force (knot)**
- **relative air humidity (%)**
- **precipitation (mm)**



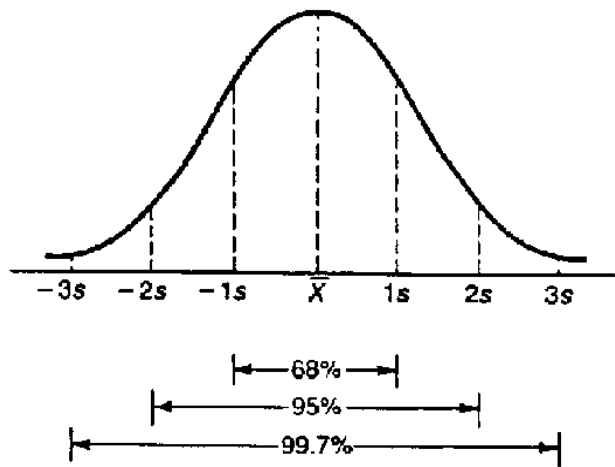
STATISTICAL PARAMETERS-1

For all meteorological parameters the following statistical parameters are calculated for all years:

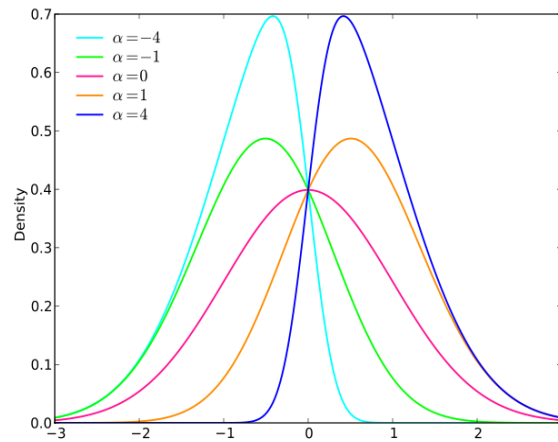
- **annual average value**
- **annual standard deviation**
- **annual skewness**
- **annual kurtosis**



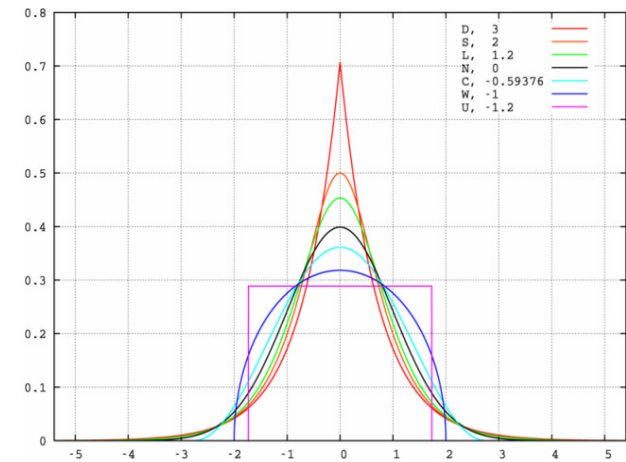
STATISTICAL PARAMETERS-2



average value
standard deviation



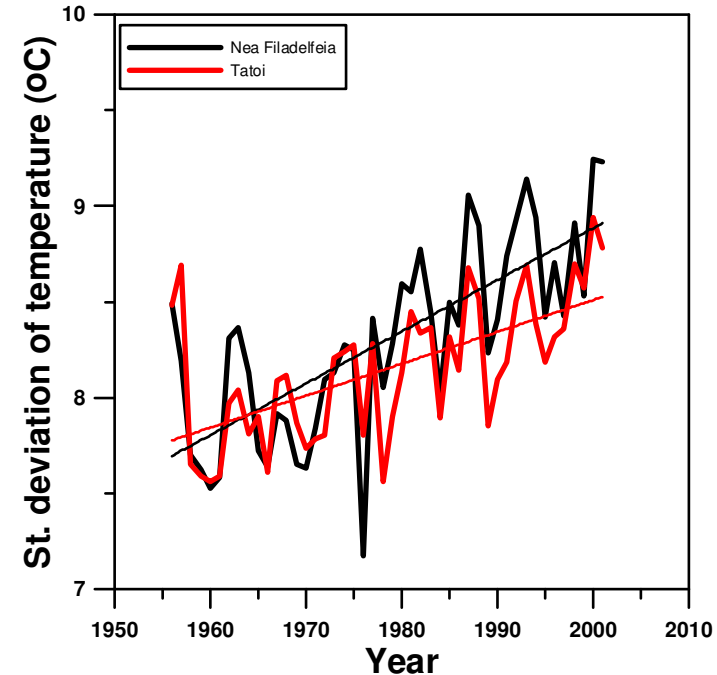
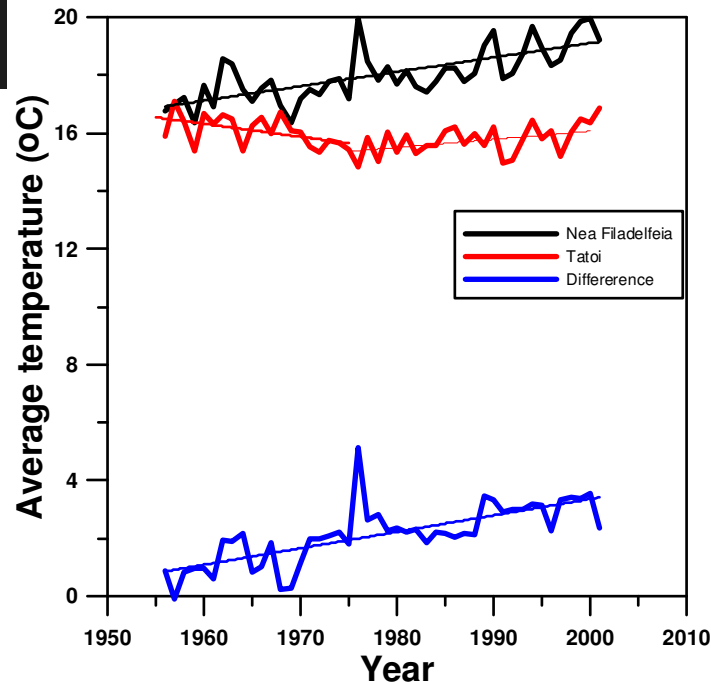
skewness



kurtosis

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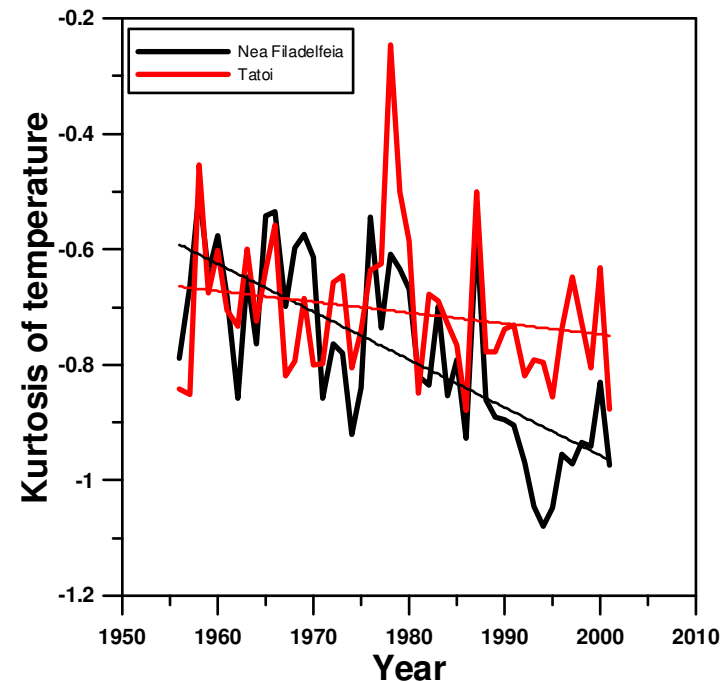
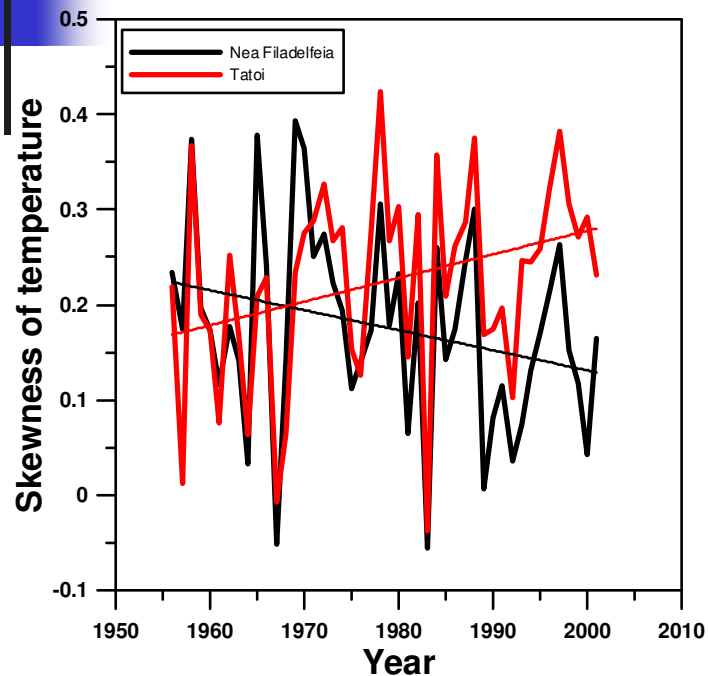
RESULTS – TEMPERATURE-1



- **Average temperature of Nea Filadelfeia is higher than that of Tatoi due to urban conditions and increases from 1956 due to the city expansion. Temperature of both station increases after 1975**
- **STDEV increases constantly for both stations**

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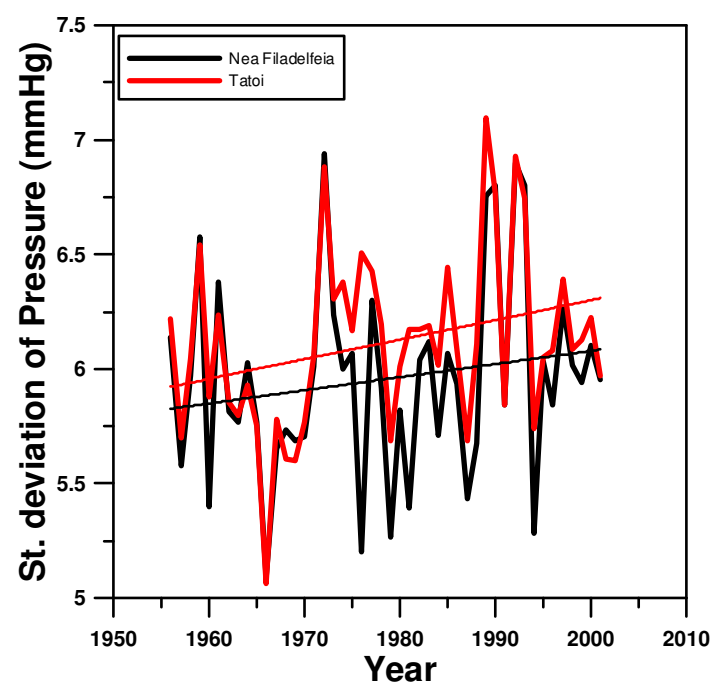
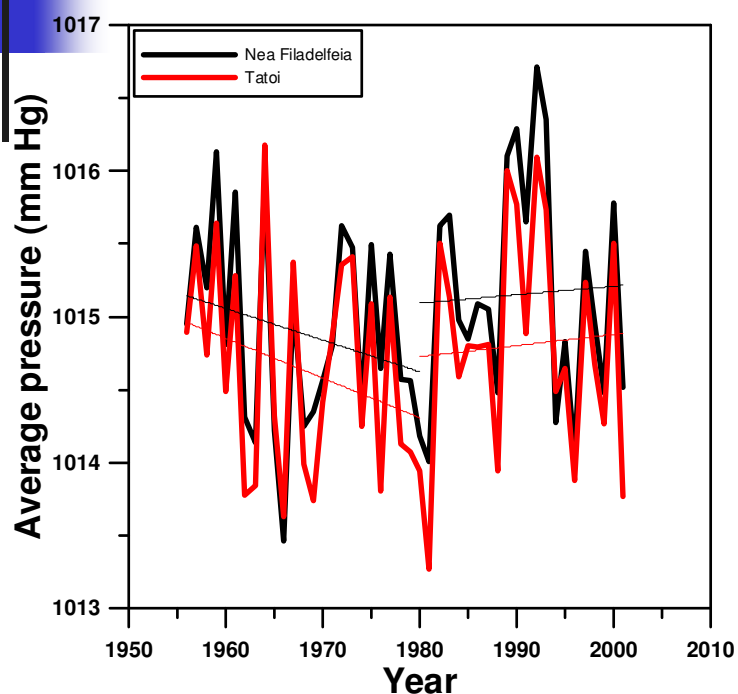
RESULTS – TEMPERATURE-2



- Annual skewness is slightly positive, indicating that the “tail” of temperature is found at the area of higher temperatures and the cases of extreme high temperatures increase with time.
- Annual kurtosis is slightly negative, indicating that there is quite flat distribution of temperature.

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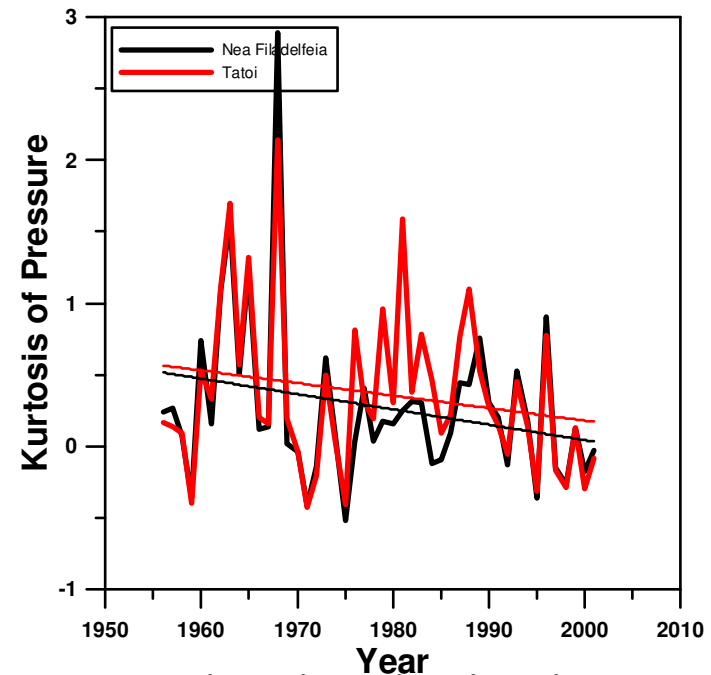
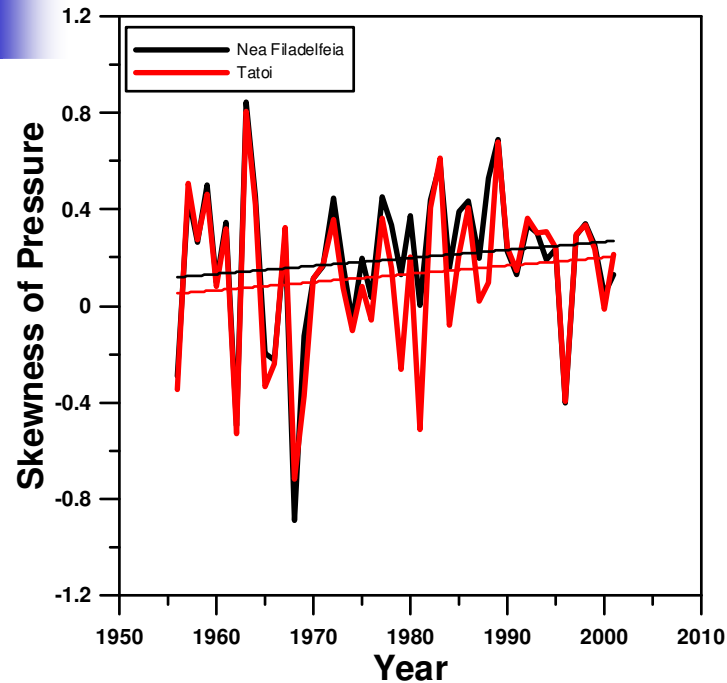
RESULTS - ATMOSPHERIC PRESSURE-1



- Nea Filadelfeia has slightly higher values of atmospheric pressure than Tatoi due to urban conditions, while its variability increases slightly with time (increased trend of STDEV).

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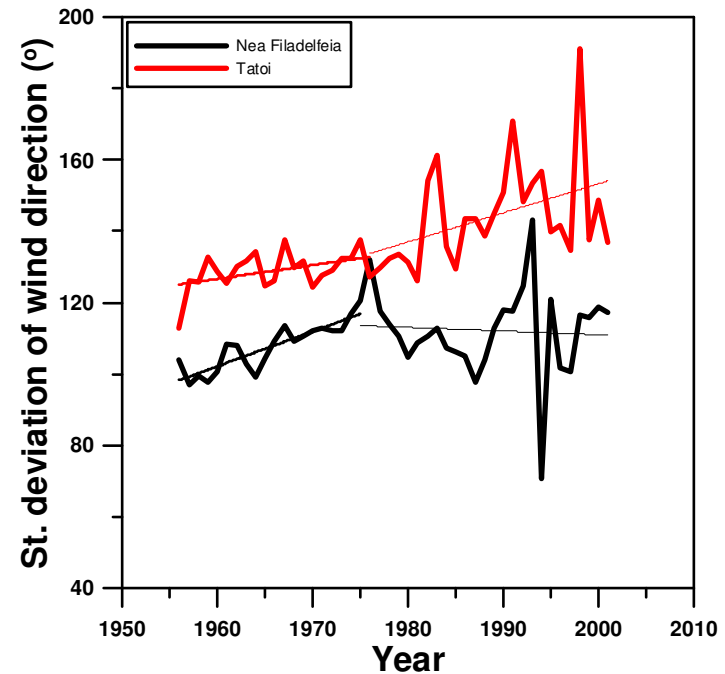
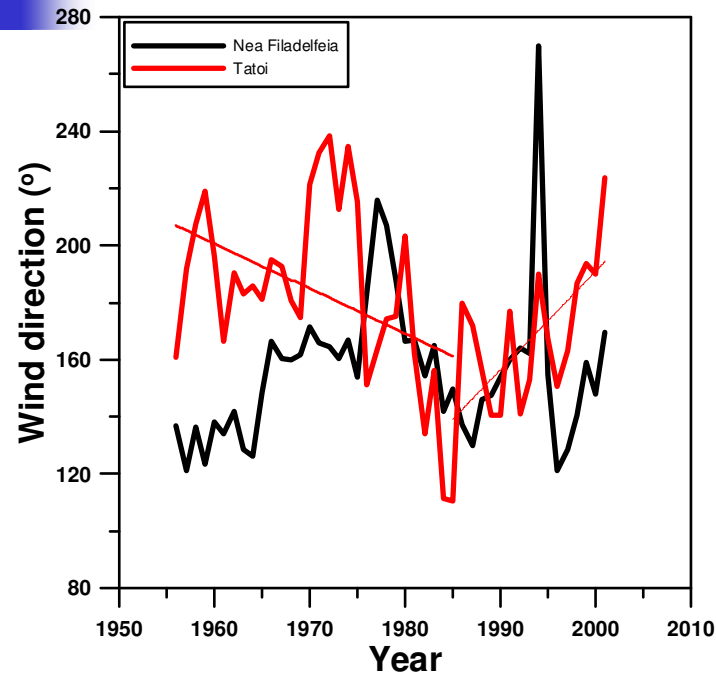
RESULTS - ATMOSPHERIC PRESSURE-2



- Annual skewness is slightly positive and increases with time indicating that the tail of the pressure distribution is shifted more and more to the right of the pressure distribution.
- Annual kurtosis is also slightly positive and decreases with time, indicating that pressure distribution is quite sharp around the average value, but this trend decreases with time.

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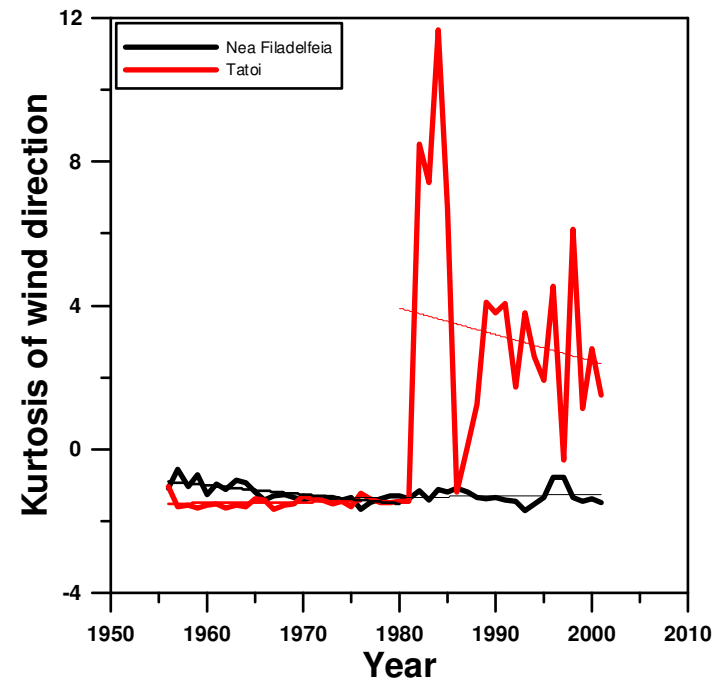
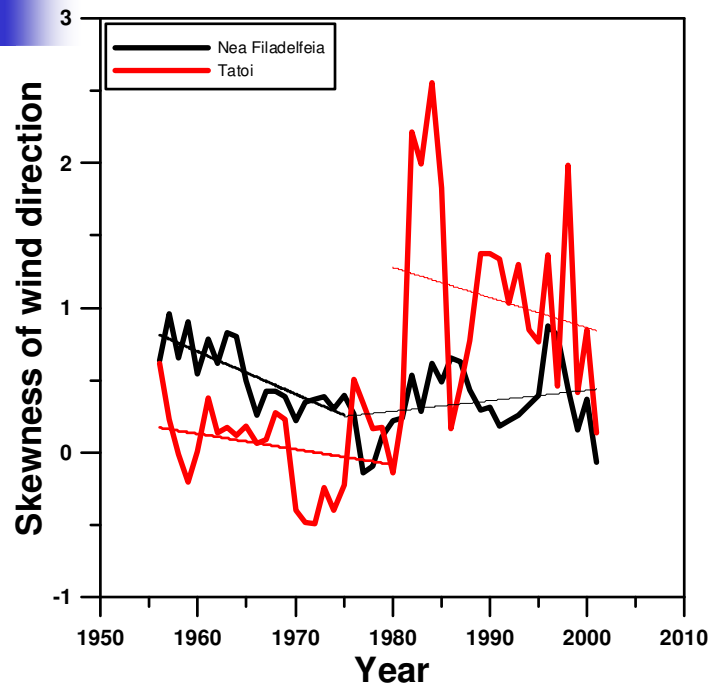
RESULTS - WIND DIRECTION-1



- **Wind direction is very different at the two stations due to urban and geographical conditions. The average annual wind direction of both stations shows significant changes over time, it has a high variability and this variability increases with time.**

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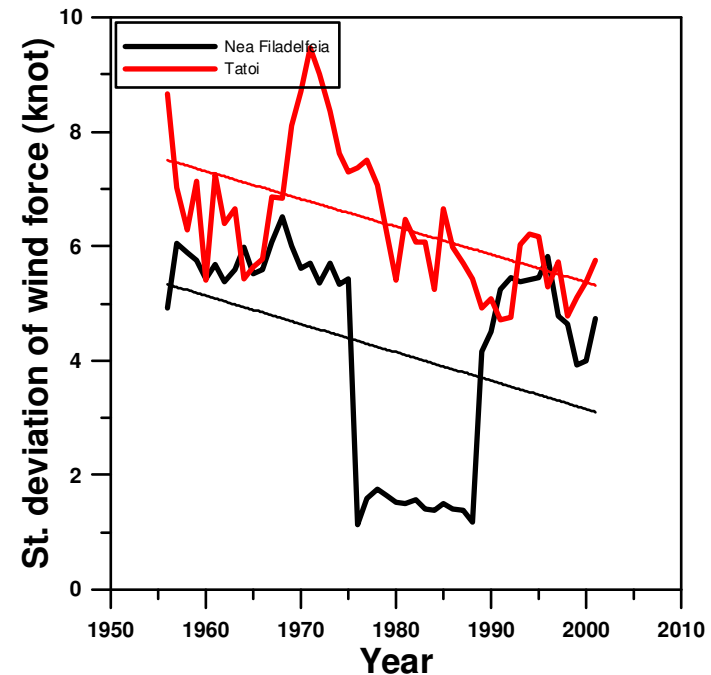
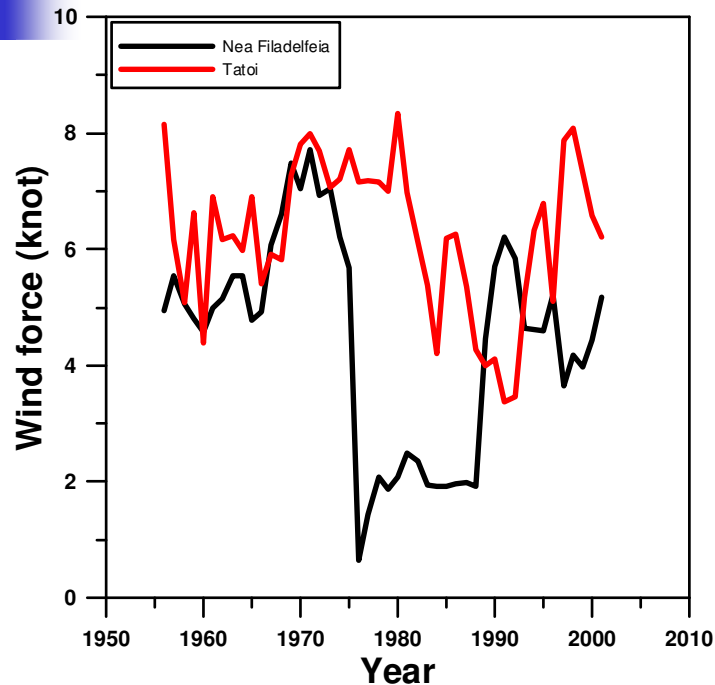
RESULTS - WIND DIRECTION-2



- Skewness and kurtosis of wind direction also have several changes over time. Skewness is generally higher than zero and kurtosis very close to zero until 1980 but increases after that year.

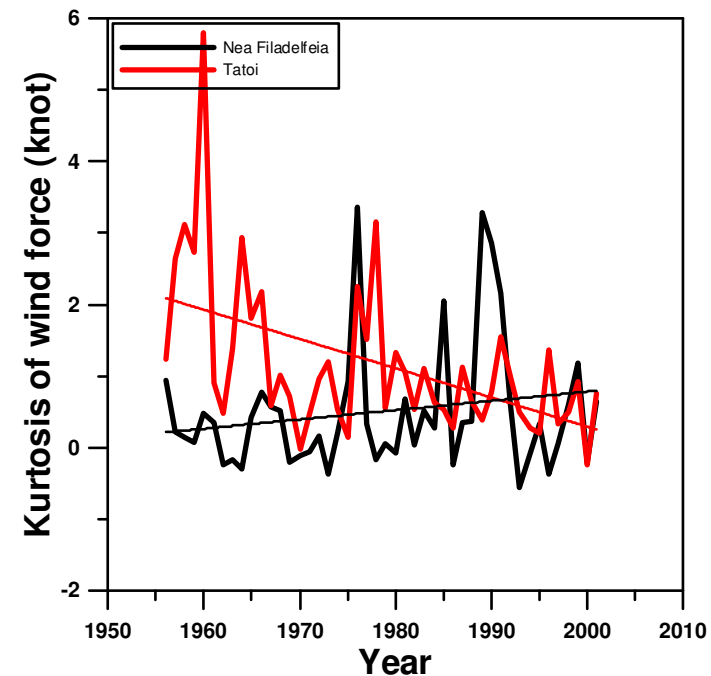
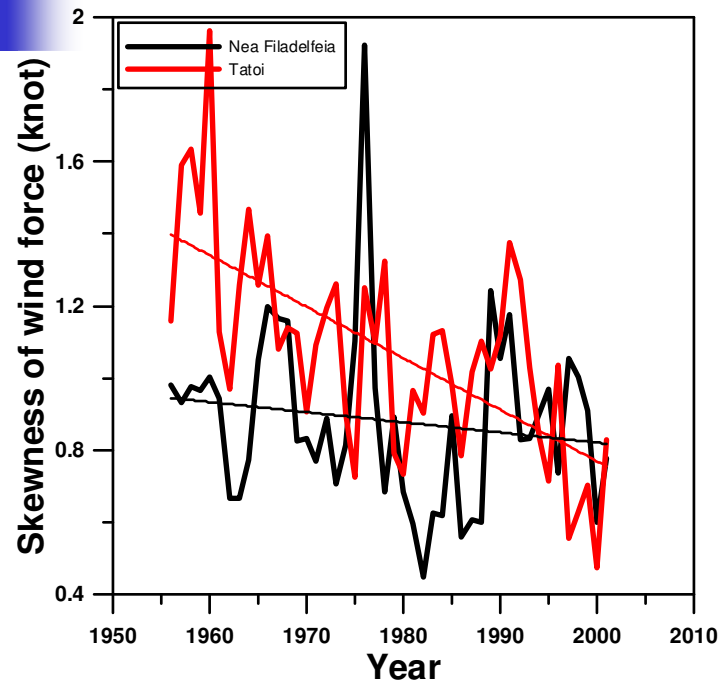
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RESULTS - WIND FORCE-1



- **The average annual wind force of both stations shows significant changes over time and has a high variability; however, the variability decreases over time.**

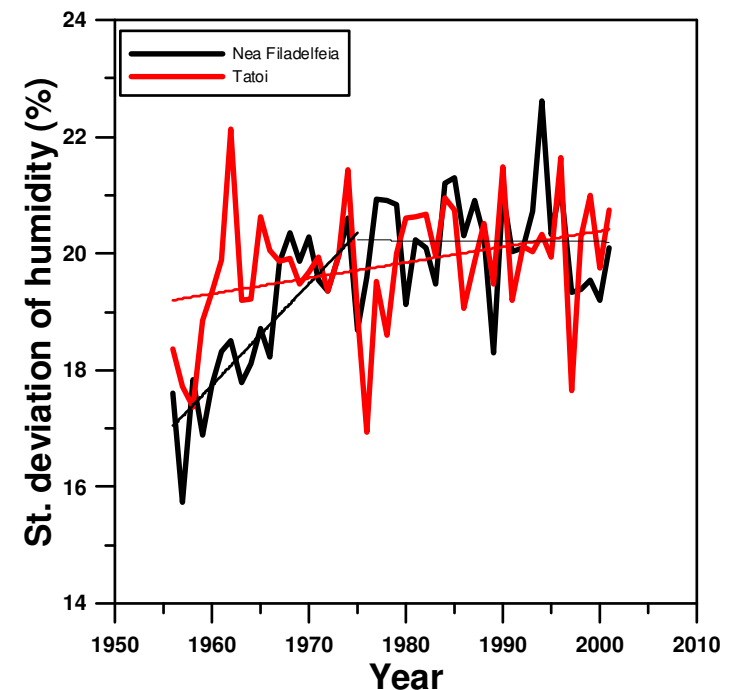
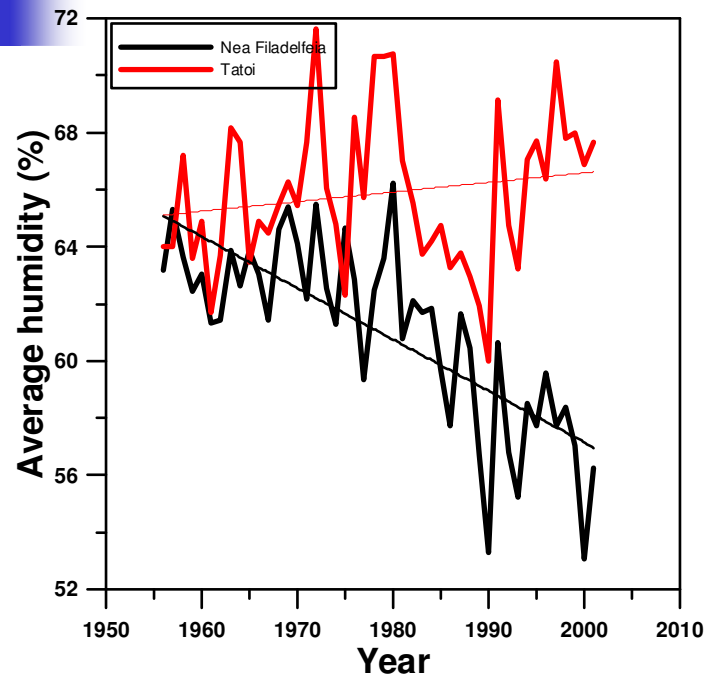
RESULTS - WIND FORCE-2



- **Skewness of wind force is positive, indicating that the tail of wind force distribution is found on the right of the distribution.**
- **Wind force kurtosis is quite close to zero indicating that this parameter has a distribution very close to the normal one. However, there is a slight increase with time.**

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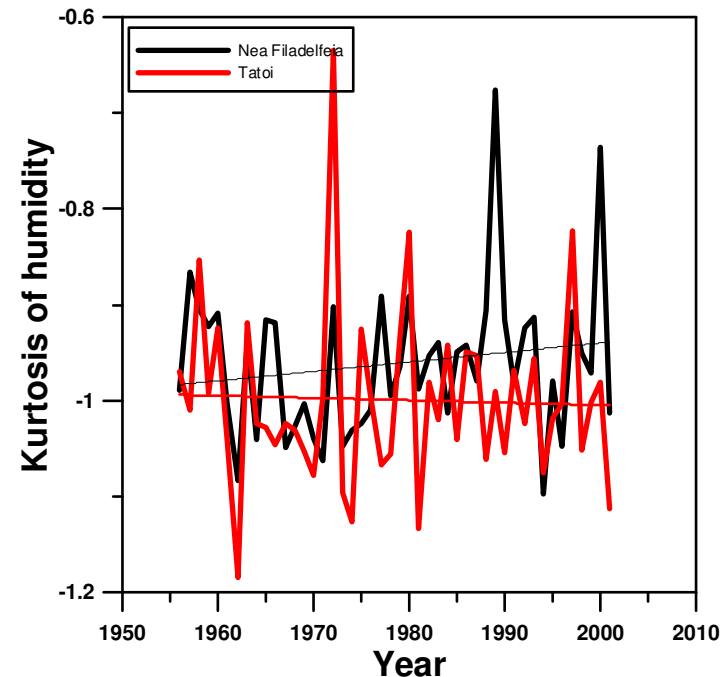
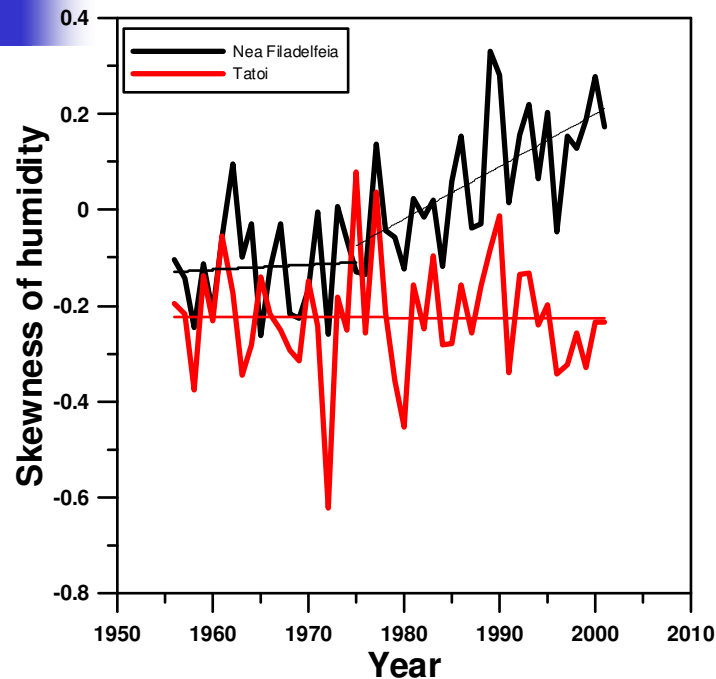
RESULTS - HUMIDITY-1



- **Average annual relative humidity increases slightly at Tatoi, but decreases significantly at Nea Filadelfeia due to urban conditions.**
- **STDEV increases slightly for both stations (after a sharp increase in the case of NF until 1975) indicating that the variability of humidity has an increased trend**

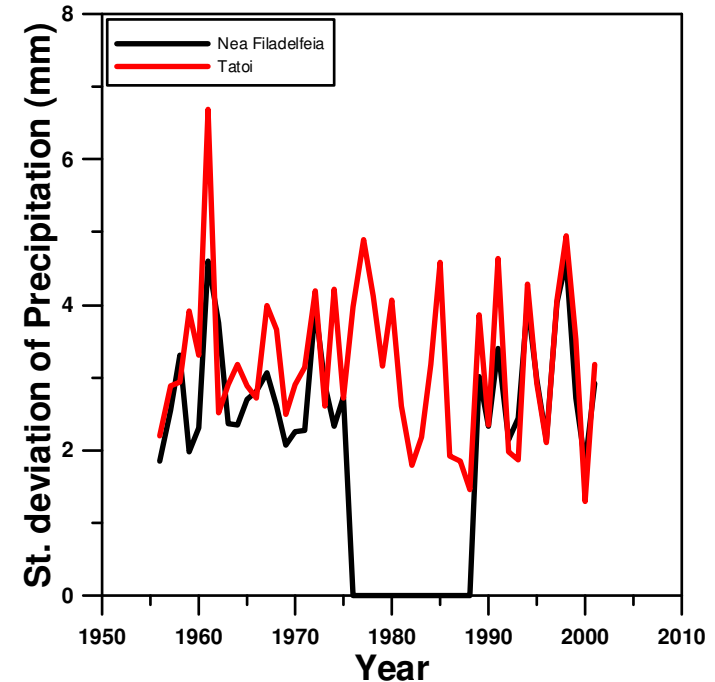
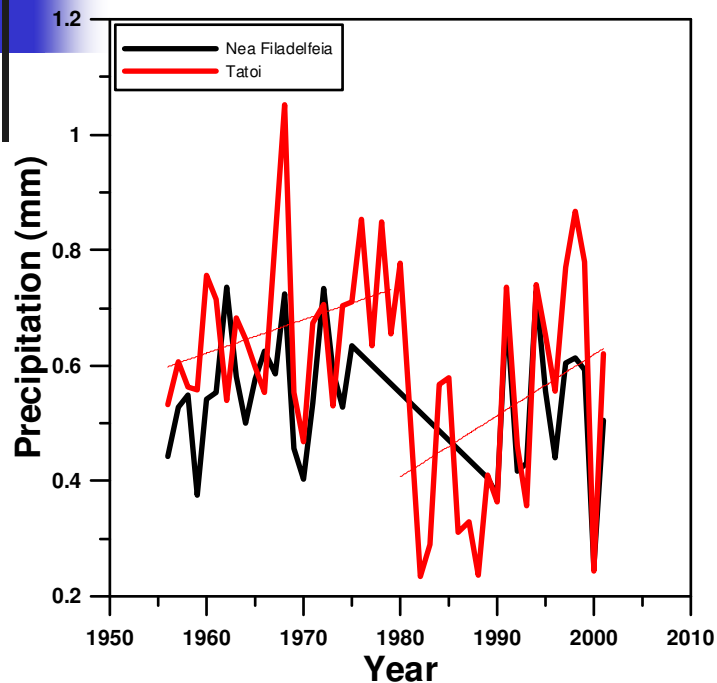
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RESULTS - HUMIDITY-2



- Annual skewness is slightly negative until 1975, indicating that the tail is on the left of the humidity distribution. Skewness of Tatoi remains quite constant. After 1975, skewness of Nea Filadelfeia increases constantly and becomes positive.
 - Kurtosis of both stations has a quite constant trend and remains negative, indicating that humidity distribution is quite flat
- Indicators of climate change in the Athens area

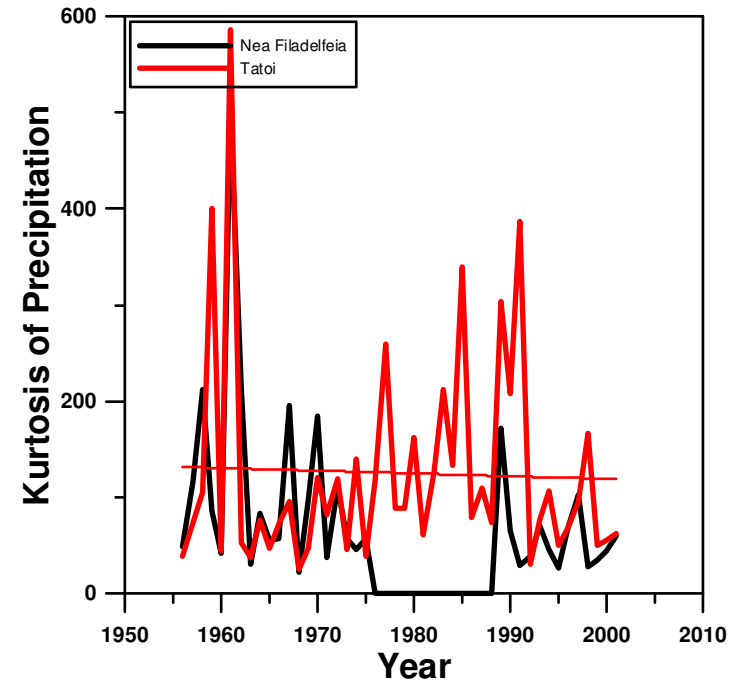
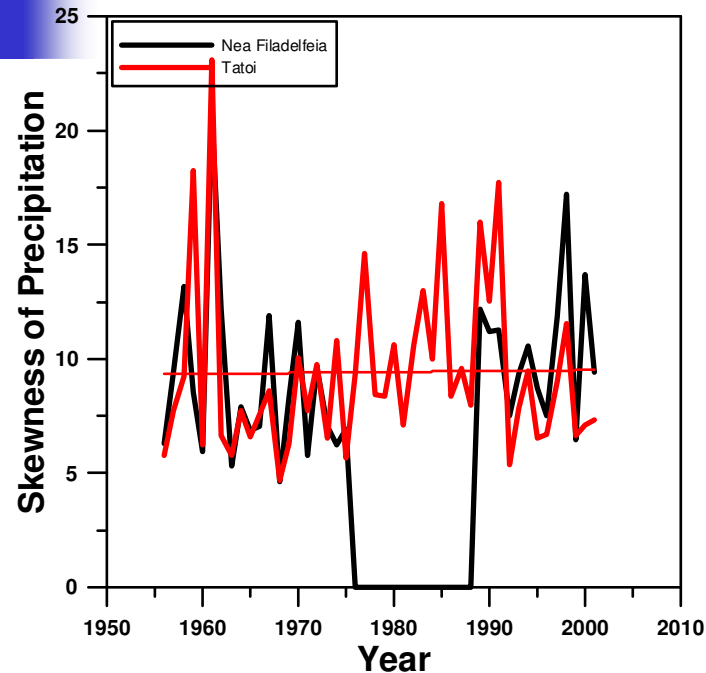
RESULTS – PRECIPITATION-1



- **Precipitation shows a general increase until 1980 and after a shift down, a new general increase is observed after 1990.**
- **STDEV of precipitation is quite high; however the trend is quite constant over time.**

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RESULTS - PRECIPITATION-2



- **Skewness of precipitation has a constant trend over time and is very positive, indicating that the tail of the distribution is on the right.**
- **Kurtosis trend is also constant with time and is very high indicating that the precipitation distribution is very flat.**

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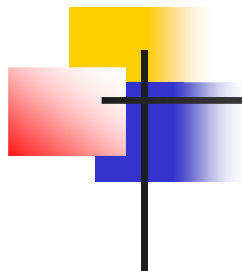
CONCLUSIONS-1

- **Four statistical parameters are used to characterize six meteorological parameters in the greater Athens area, inside and outside the city.**
- **The average value can be used to describe the evolution in the case of several of the above meteorological parameters**
- **The standard deviation shows that the variability of those parameters is generally not constant and shows significant changes with time**
- **The skewness can indicate the “core” and the “tail” of the above distributions, while the kurtosis can indicate if the peak of distribution is high or low. In some cases we have some interesting results**



CONCLUSIONS-2

- **More work is necessary to establish a more general trend of the application of the four statistical parameters on the meteorological parameters. For that are currently analyzed:**
- **Several other stations in Greece**
- **Seasonal and monthly values of all meteorological parameters**
- **A 7th parameter: daily duration of sunshine**
- **Extreme values of the meteorological parameters**
 - **Their frequency of distribution values**
 - **Their evolution in time**
 - **The application of the four statistical parameters to those extreme values**



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*I thank you very much for your
attention*