Climatological and environmental characteristics of Moscow according to 60 years of measurements at the Moscow State University Meteorological Observatory (MSU MO)

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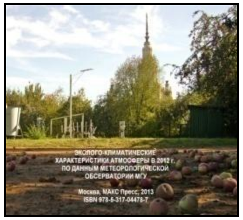


9th International Conference on Urban Climate, ICUC9, 20-24 July, 2015, Toulouse, France

Outline:

1. The MSU MO program of observations;
2. Long-term trends of different meteorological parameters and their possible drivers;
3. UV monitoring, estimates of UV health effects;
4. Chemical composition of precipitation;
5. Aerosol urban pollution;
6. Air quality.

our website: www.momsu.ru

Метеорологическая обсерватория МГУ

МГУ им. М.В.Ломоносова, Географический факультет, кафедра метеорологии и климатологии

- Главная
- История МО
- Метеорология
- Атмосферная радиация
- Атмосферный аэрозоль
- Химический состав осадков
- Химия атмосферного воздуха
- Акустическое зондирование
- Публикации
- Предложения к сотрудничеству
- English
- Контакты

Welcome to the Meteorological Observatory of Moscow State University

The Moscow State University Meteorological Observatory (MSU MO) has been organized in 1954 as a teaching and scientific center for the research of the Moscow climate. The MSU MO provides the unique continuous measurements of the environmental and climatic characteristics of the atmosphere, which are being in operation on the base of comprehensive methods in accordance with the Russian and international standards adopted by World Meteorological Organization and Russian Hydrometeorological Service. The complex of measurements consists of an extended program of meteorological observations, including the acoustic sounding of the boundary atmospheric layer, and a large program of radiative measurements, which also includes the observations of natural illuminance and UV irradiance. Within the frame of international AERONET program a monitoring of aerosol parameters is being carried out. The measurements of chemical composition of precipitation and snow cover are being in operation as well. A new station for atmospheric air composition has been organized together with the Oboukhov's Institute of the Atmospheric Physics RAS, which provides continuous measurements of different gas species.

The MSU MO produces monthly Bulletin (PDF,~700kb) with the results of the observations.

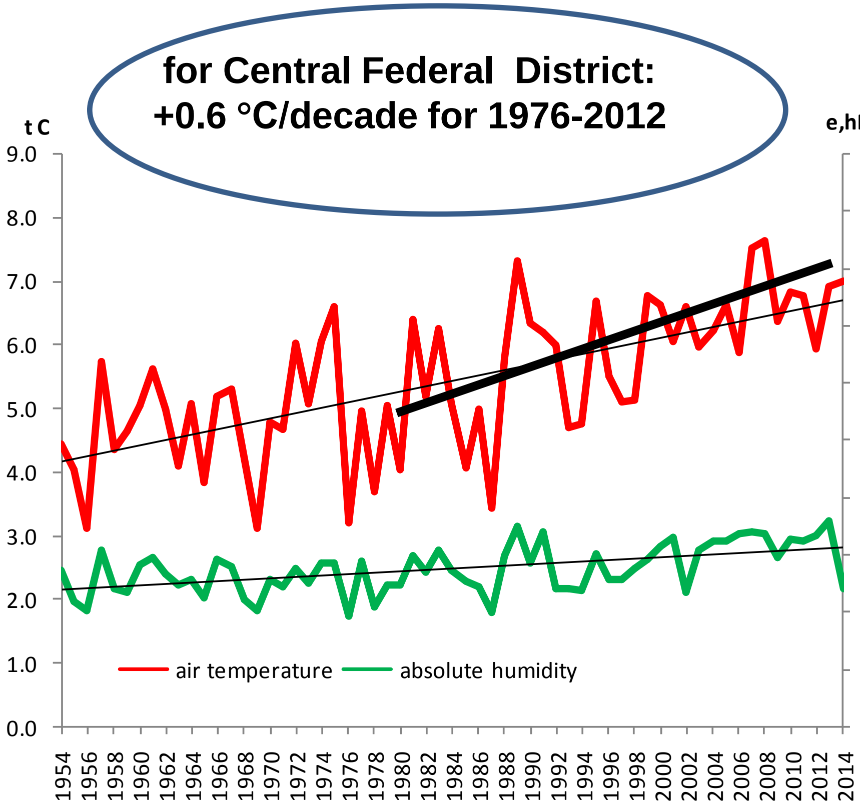
More detailed information can be found at corresponding sections of the site.

Monitoring program

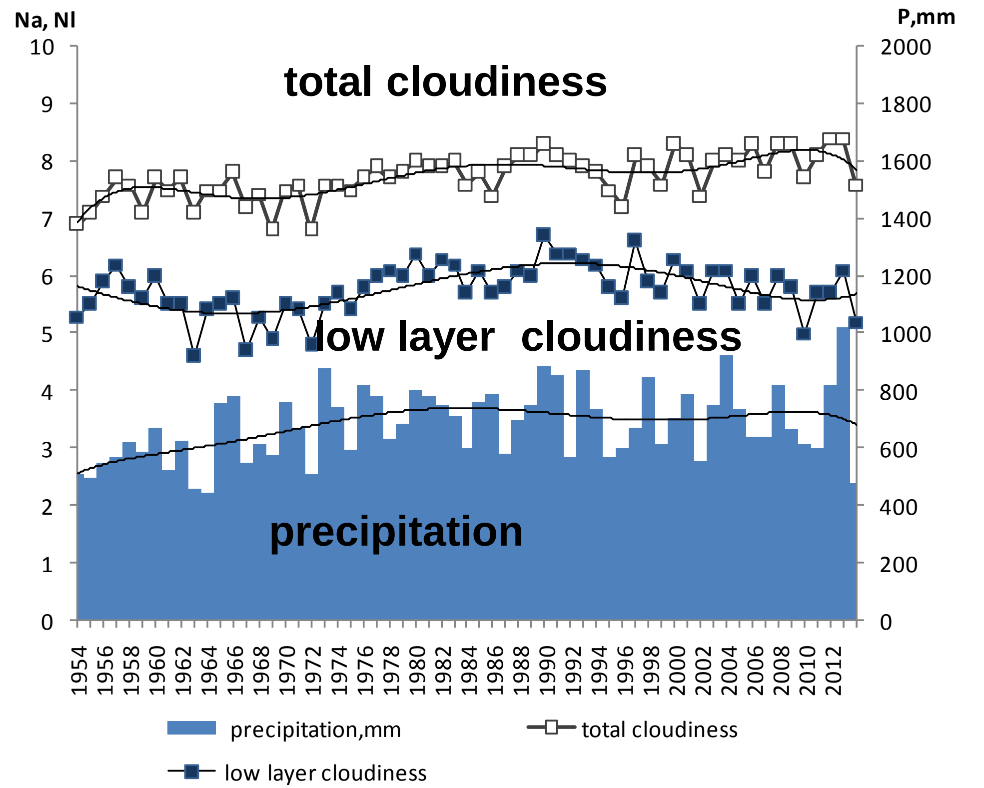
Meteorology since 1954	Radiation since 1954	Precipitation quality since 1982	Aerosol parameters since 1958	Air quality since 2002
large program of meteorological measurements, automated station (Vaisala); sodar program	longwave and shortwave net radiation components PAR radiation UV-B, UV 300-380nm radiation, natural illuminance	concentration of SO_4^{2-}, HCO_3^-, Cl^-, NO_3^- Ca^{2+}, Mg^{2+}, Na^+, K^+ NH_4^+ and pH in each rain and snowfall	AERONET - since 2001 , PM2.5 since 2010	gas species measurements close to the GAW requirements

2. Interannual variations of different meteorological characteristics: air temperature, absolute humidity, total, low cloud amount, and precipitation.

Moscow air temperature:
+0,4°C/decade over 1954-2014
+0.7 °C/decade for 1976-2012

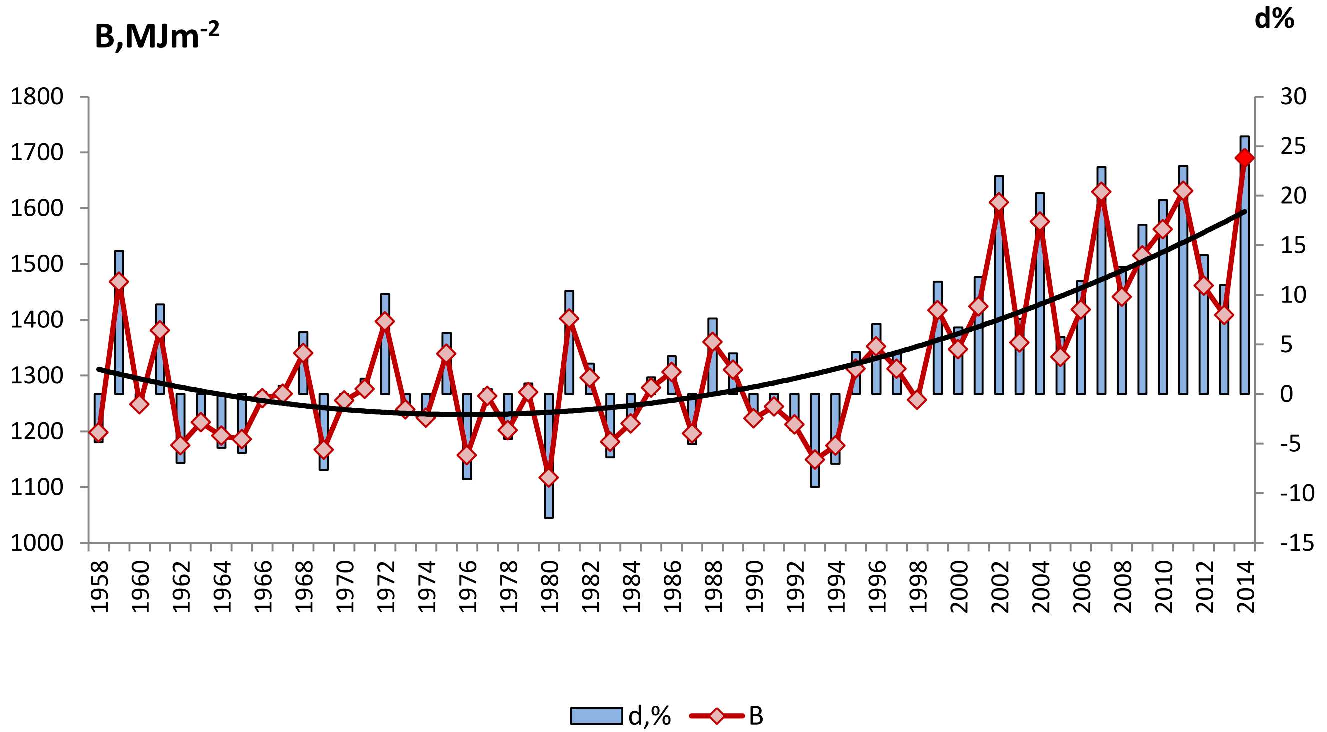


Trend in absolute humidity is +0.12 hPa per decade

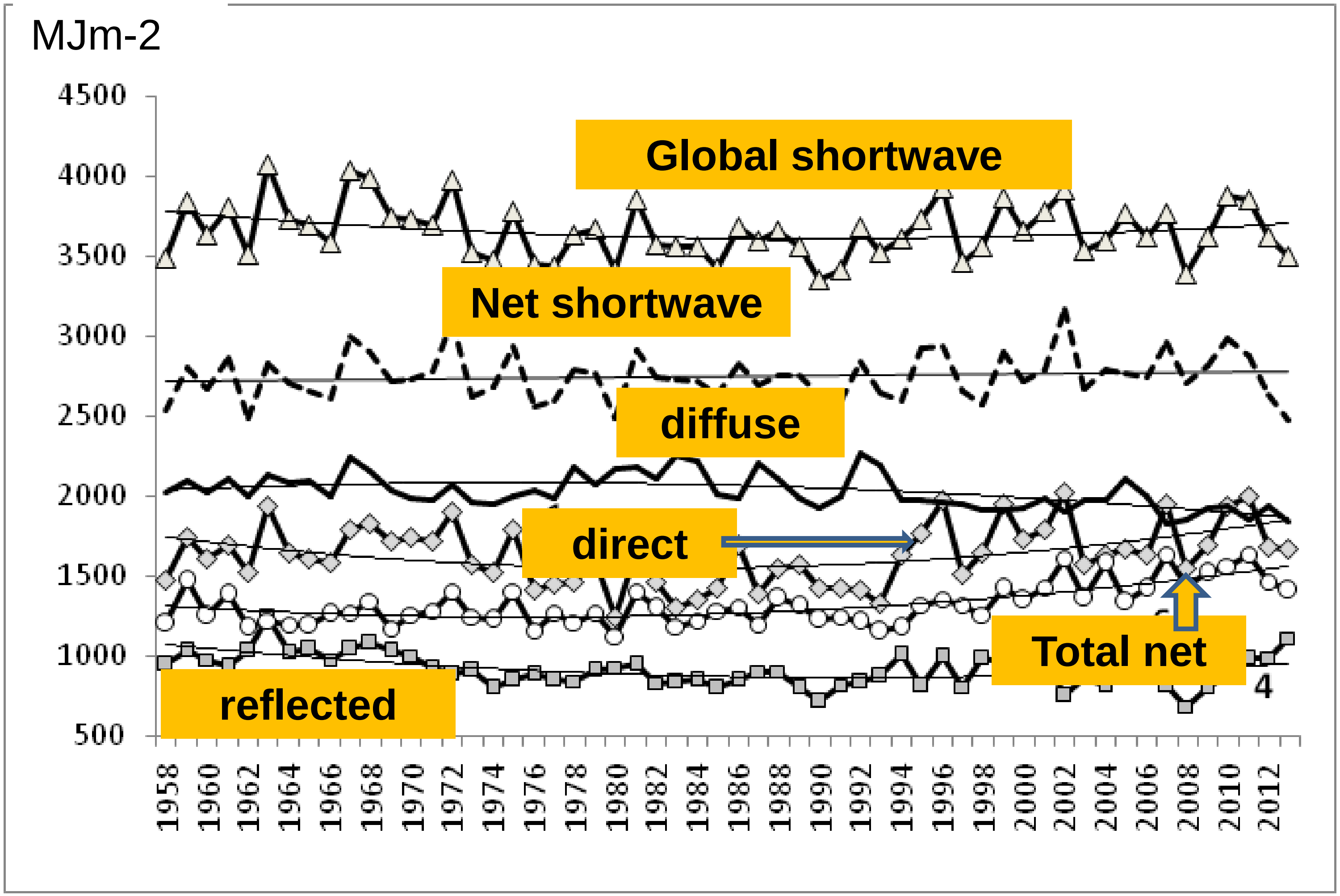


Trend in total cloudiness +0.1 per decade

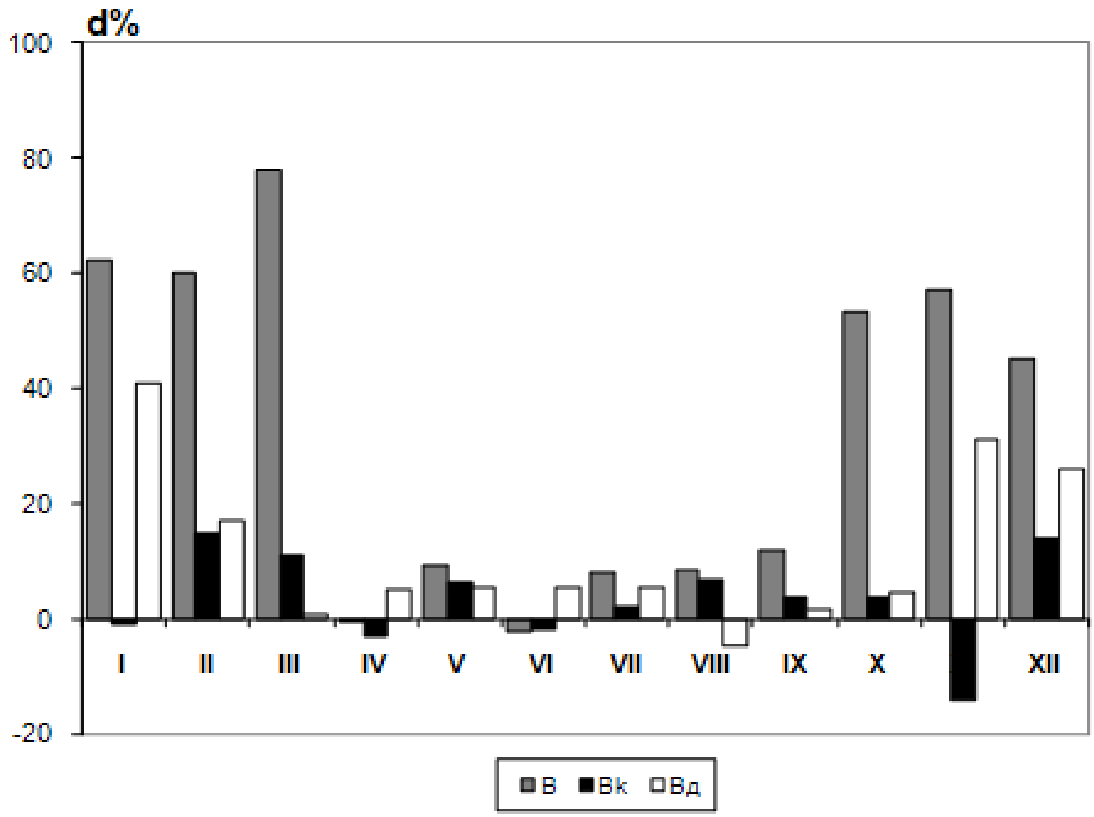
Interannual changes in total (shortwave +longwave) net radiation. Moscow.



Interannual changes in direct, diffuse, global, reflected, net shortwave radiation, and total net radiation over 1958-2013 period. Moscow MSU MO.

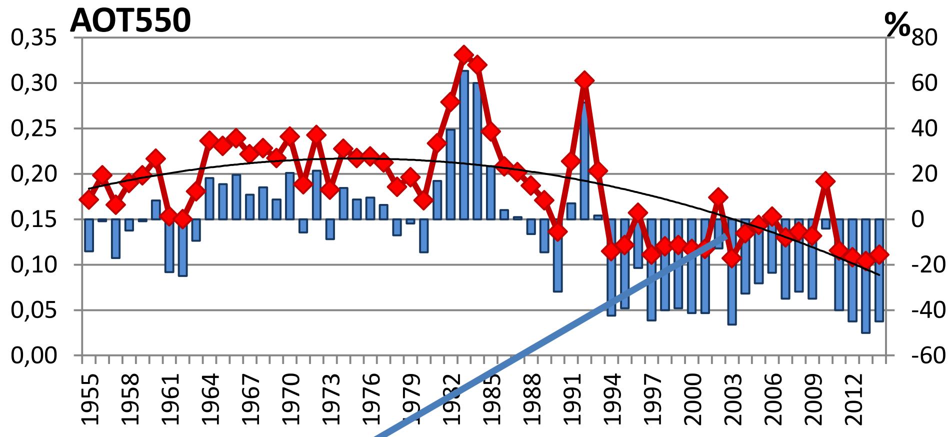


Seasonal changes of linear trends (in %) in total (B), shortwave (Bk) and longwave (Bd) net radiation in Moscow

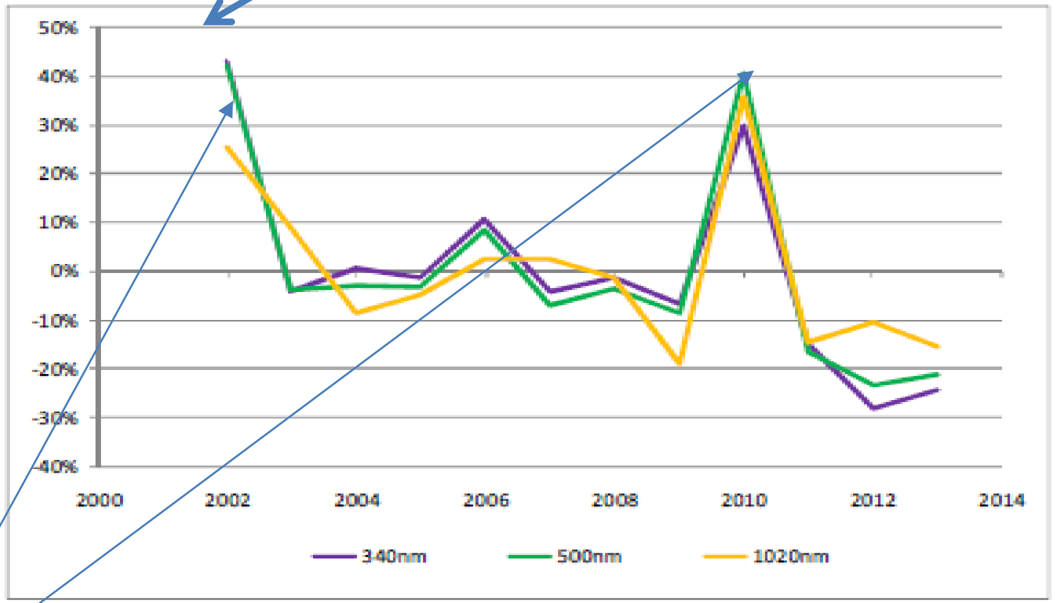


DRIVERS:

Interannual changes in aerosol optical thickness at 550nm retrieved from direct shortwave irradiance and water vapor in Moscow.

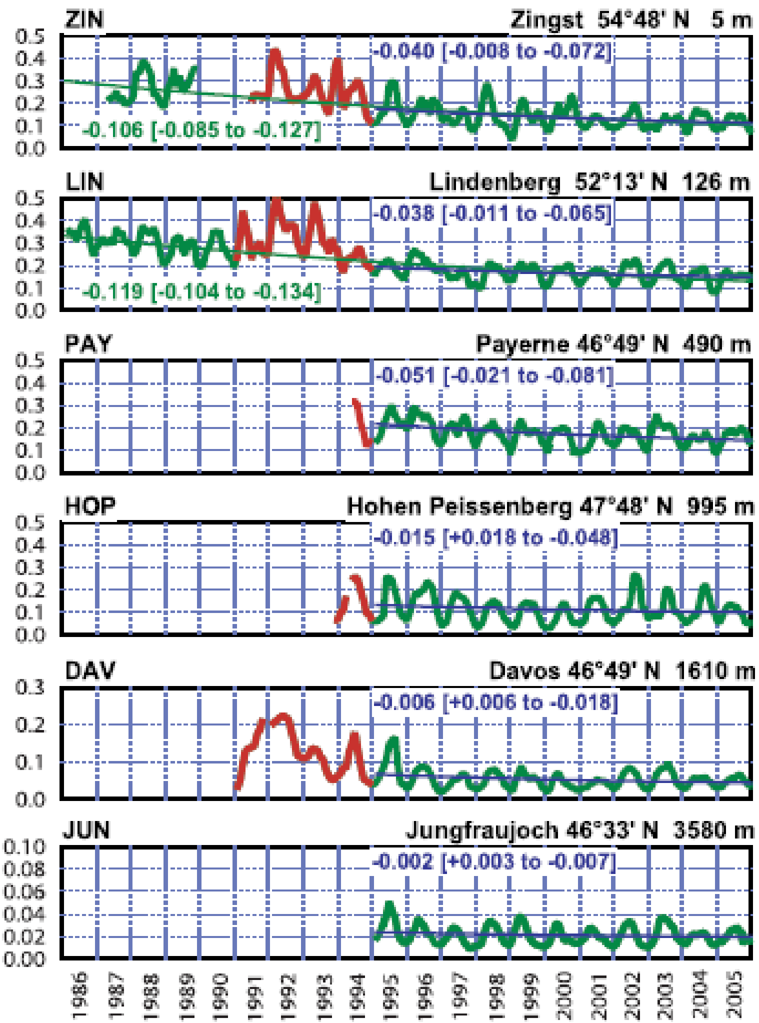


Interannual variability of aerosol optical thickness at 340nm, 500nm and 1020nm according to AERONET sun photometer data. Moscow.

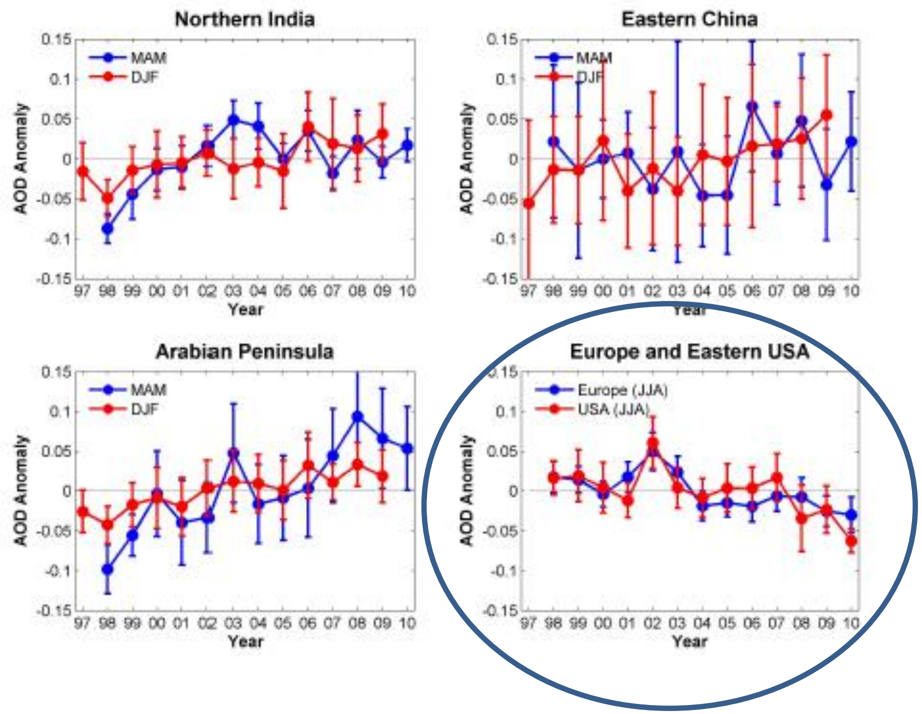


Forest fires

Long-term trends in AOT in Europe (left) and other parts of the world (right)

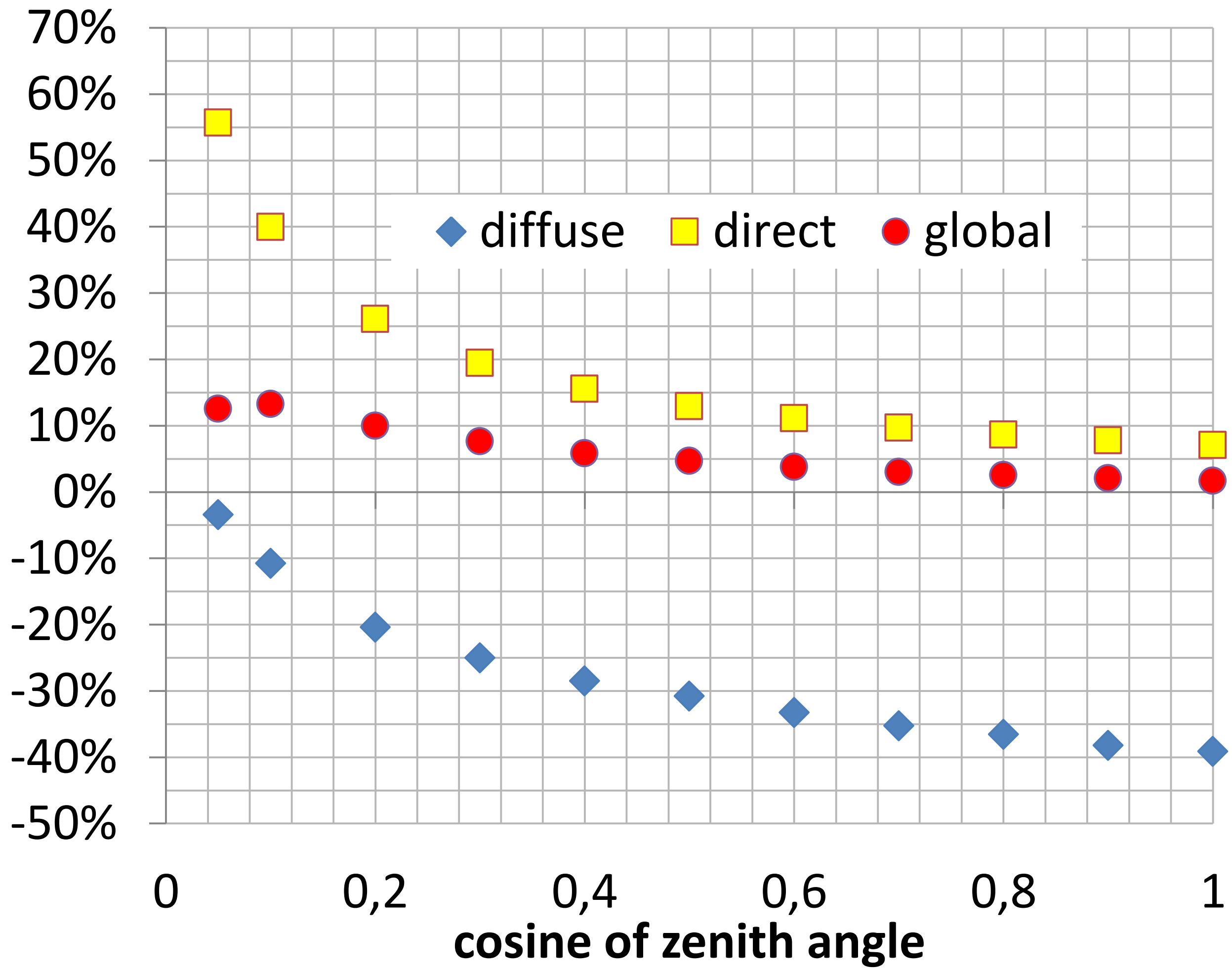


- From Ruckstuhl et al., 2008



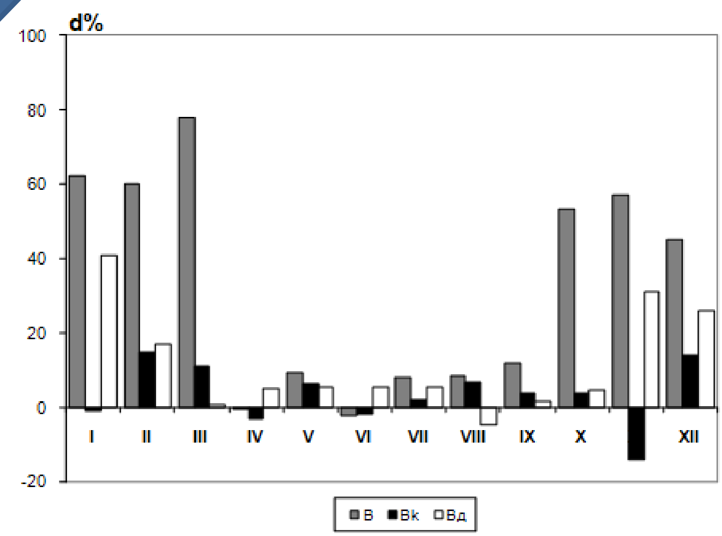
Hsu et al., 2011

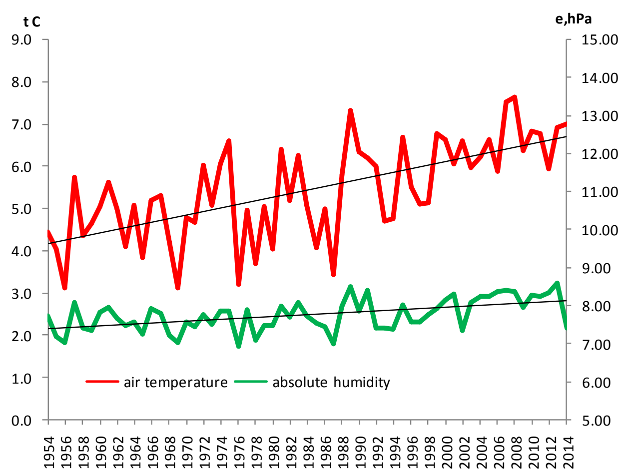
Model estimates of changes in shortwave irradiance due to decrease in AOT from 1960s. Clear sky conditions.



Can positive trend in net longwave radiation be a driver of <u>higher</u> <u>urban</u> temperature trend?

Positive net longwave trends (showed in white) are observed due to the increase in downwelling longwave irradiance





Additional sources of the observed extra downwelling longwave irradiance (DLI):

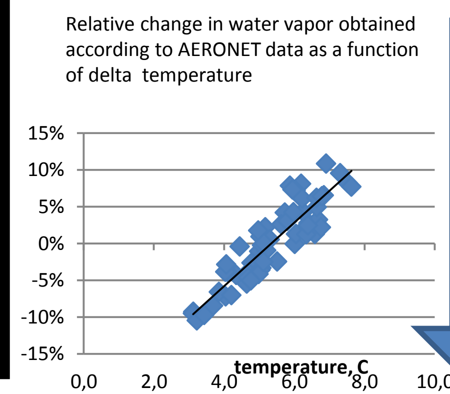
1. Inhomogeneous distribution of urban heat emission: i.e. air temperature at standard meteorological sites (MSU MO, as an example) is always lower than the surrounding urban air temperatures that provides an additional source for higher levels of DLI ;
2. Emission of heat from elevated heat sources: power plants, industry, etc. ;
3. GHG larger emissions over urban area (i.e. urban CO_2 growth (Bűns C., Kuttler , 2012));
4. Positive feedback - the additional water vapor absorption and further increasing of downwelling longwave irradiance .

The scheme of possible positive feedback effect for enhancing urban temperature trend

Inhomogeinity of heat flux, emission of heat from elevated heat sources ;
GHG larger emissions over urban area

Warming the upper part of the boundary layer

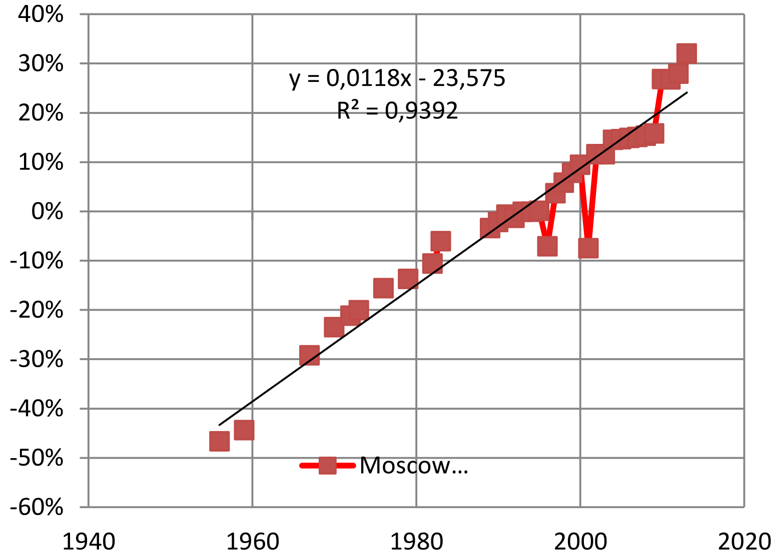
Temperature increase results in water vapor increase in the upper layers



Increase in absorption and as a result in downwelling longwave irradiance

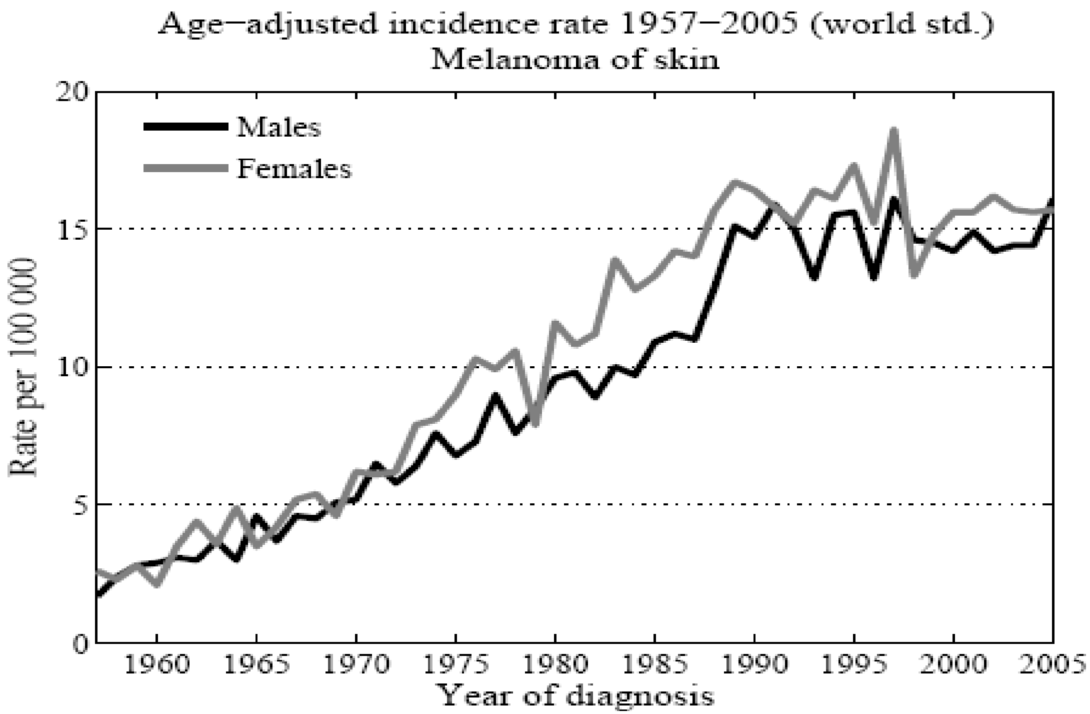
Increase in net radiation due to longwave component, and eventually, surface temperature increase

Percent growth of Moscow population, which now is over 12mln residents



ENHANCEMENT OF THIS PROCESS WITH THE MOSCOW POPULATION GROWTH SINCE 1954 COULD STRENGTHEN THE TEMPERATURE INCREASE

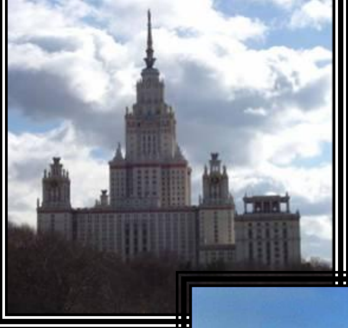
3. UV monitoring and UV health effects



For the 1991-2012 period

the Skin Cancer rate is +1.6% per decade in Russia

UV Monitoring program at the MOMSU



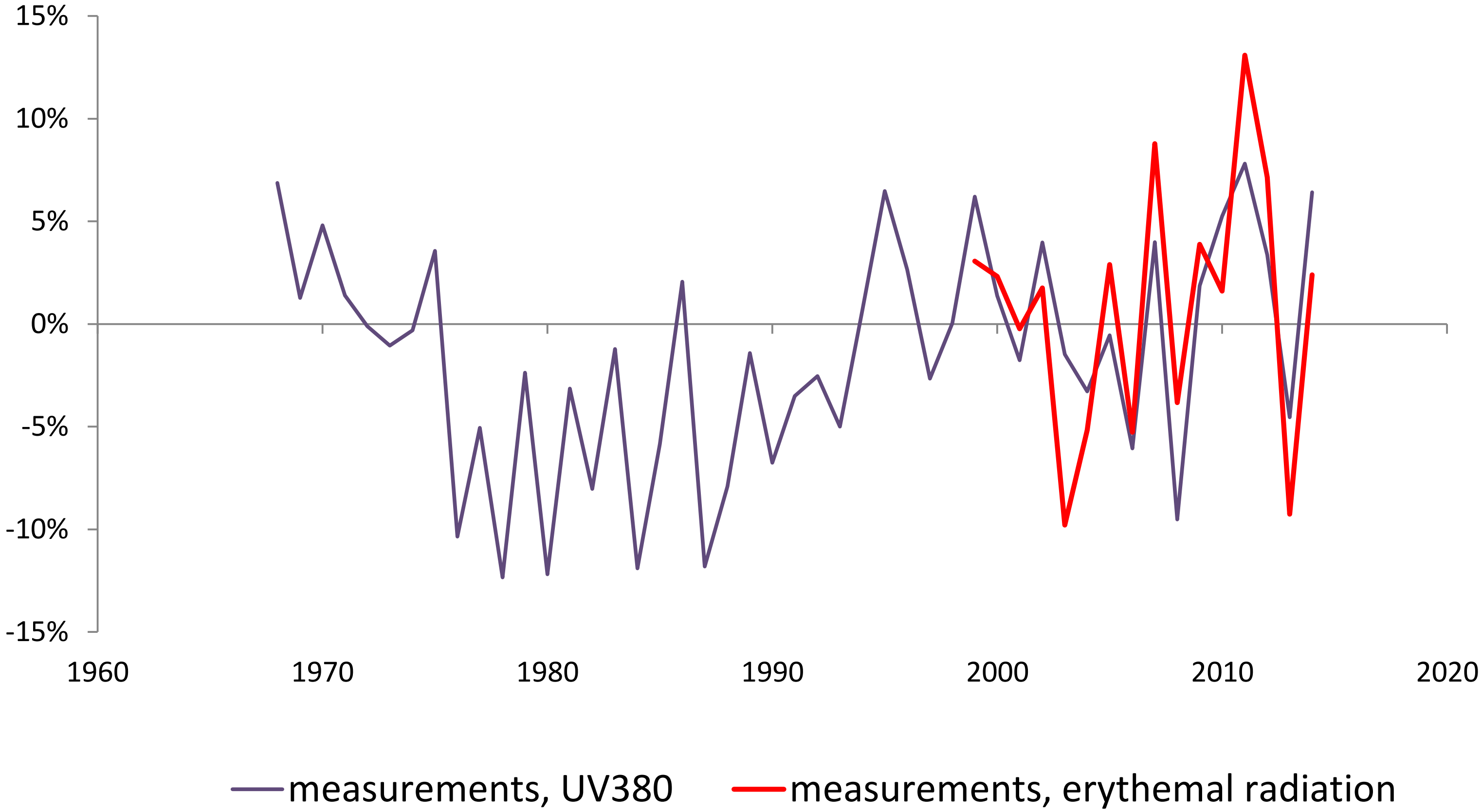
The program of continuous UV measurements since 1999

The longest UV data series in the world since 1968 (Ozone assessment 2006, UNEP 2015)

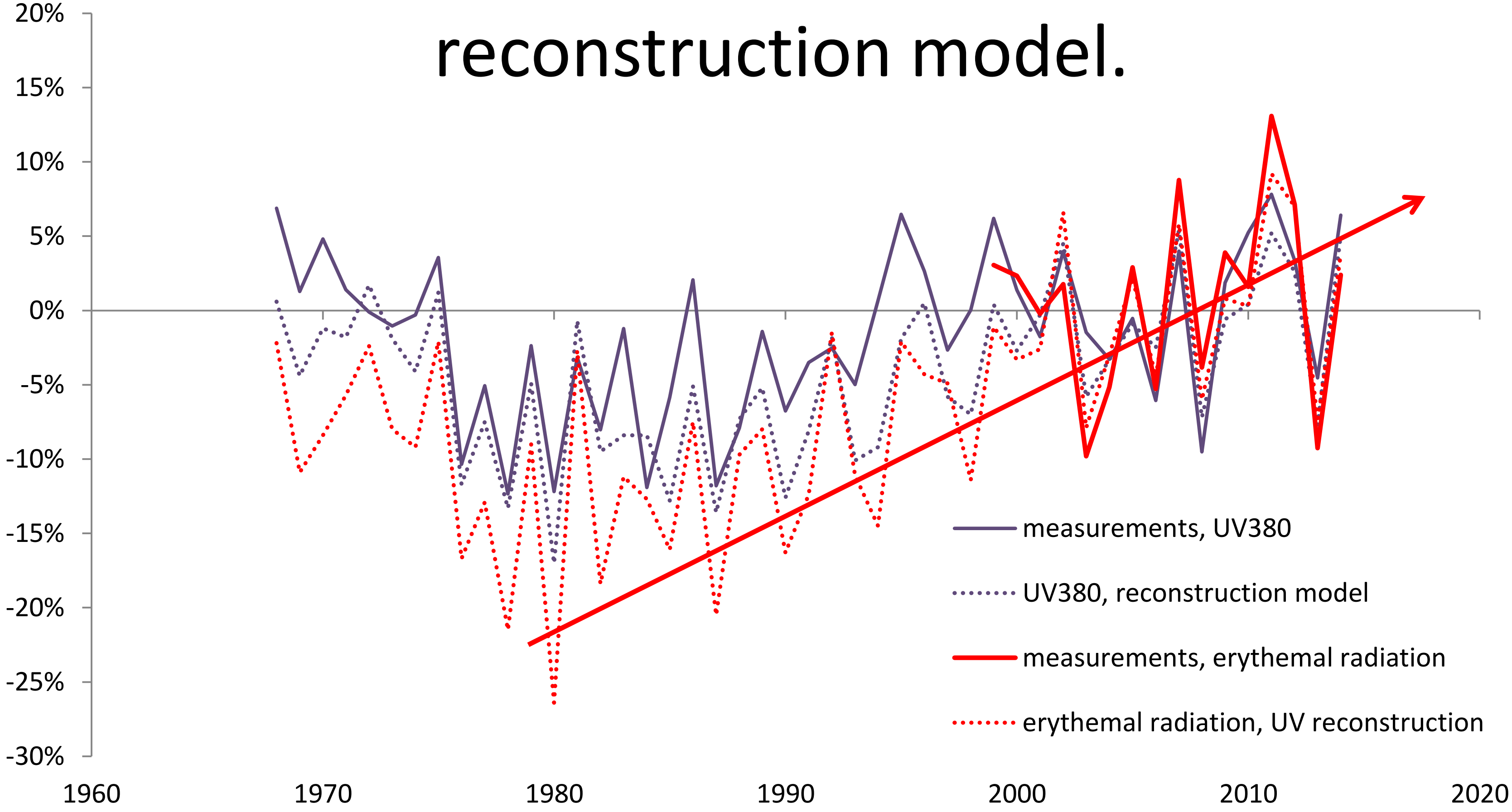
MOMSU UV pyranometer 300-380nm (Garadzha, Visotski)

Calibration according to the European and the US standards.

UV variability over 1968-2014 in Moscow.



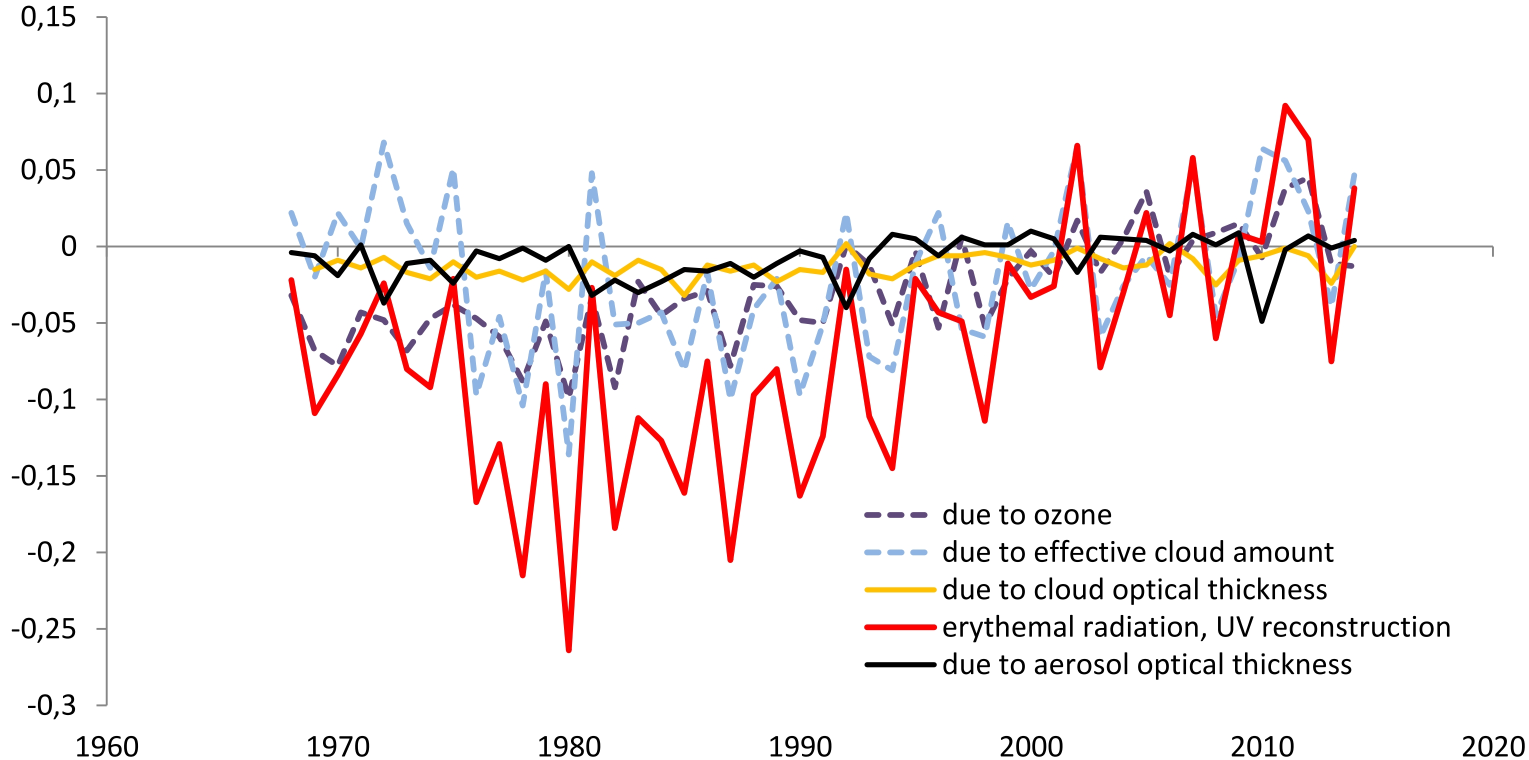
Erythemal and UV 300-380nm radiation interannual variability over 1968-2014 in Moscow according to the measurements and reconstruction model.



Normalized against 1999-2013 period

For erythemal radiation - 6% increase per decade since 1980

The contribution of different atmospheric parameters to erythemal UV irradiance changes according to reconstruction model.



Normalized against 1999-2013 period

UV RESOURCES – attributing health effects:

The harmful UV conditions:

UV deficiency

(no vitamin D)

Favorable UV conditions:

UV optimum

vitamin D – yes,

erythema – no.

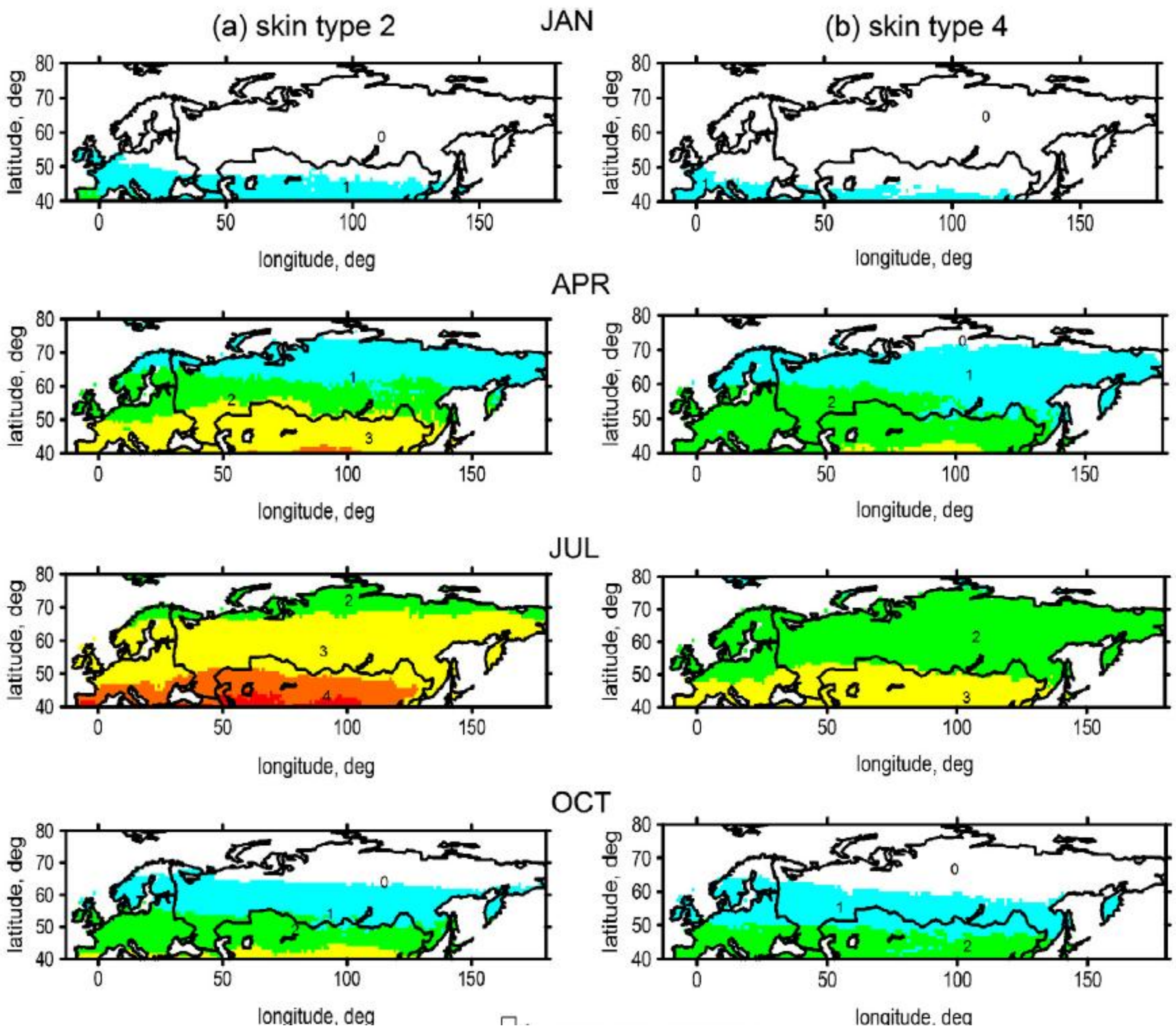
The harmful UV conditions

UV excess

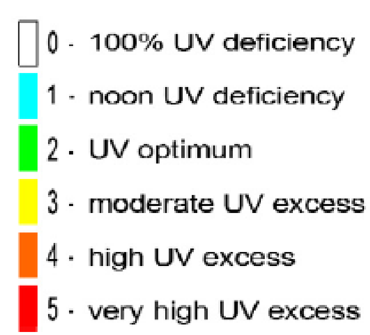
(erythema, eye damage, immune suppression).

Chubarova and Zhdanova, Photochemistry and Photobiology, 2013

UV resources: average cloudy conditions

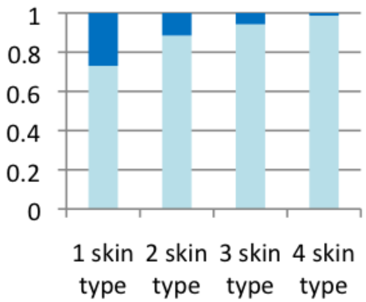


1x1 degree, clear and cloudy conditions, DISORT 8 stream simulations with accounting for specially developed datasets on aerosol, ozone, albedo and cloud modification factor parameters.

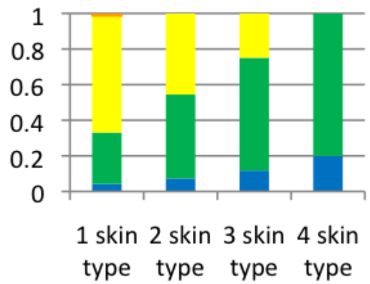


Probability of different types of the UV-resources for the various skin types in Moscow.

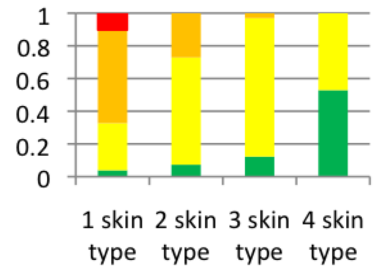
January



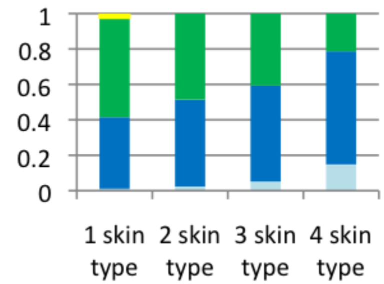
April

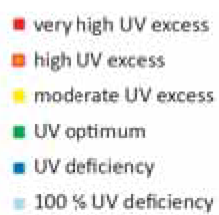


July



October





Calculation of UV resources

Tool | Description | Contacts

Latitude, degrees: 55.5

Latitude should be expressed in decimal degrees.

Longitude, degrees: 37.5

Longitude should be expressed in decimal degrees.Negative values indicate the longitudes in the Western hemisphere.

Altitude, km: 0.192

- ○ Enter surface UV albedo

  NOTE: If you do not know exactly the UV albedo at your point, you can use approximate UV albedo according to the type of surface and surroundings: ground (grass) - 2%; trees and snow - 40%; bare snow within 1 km - 70%
- ◉ Use climatological value of surface UV albedo

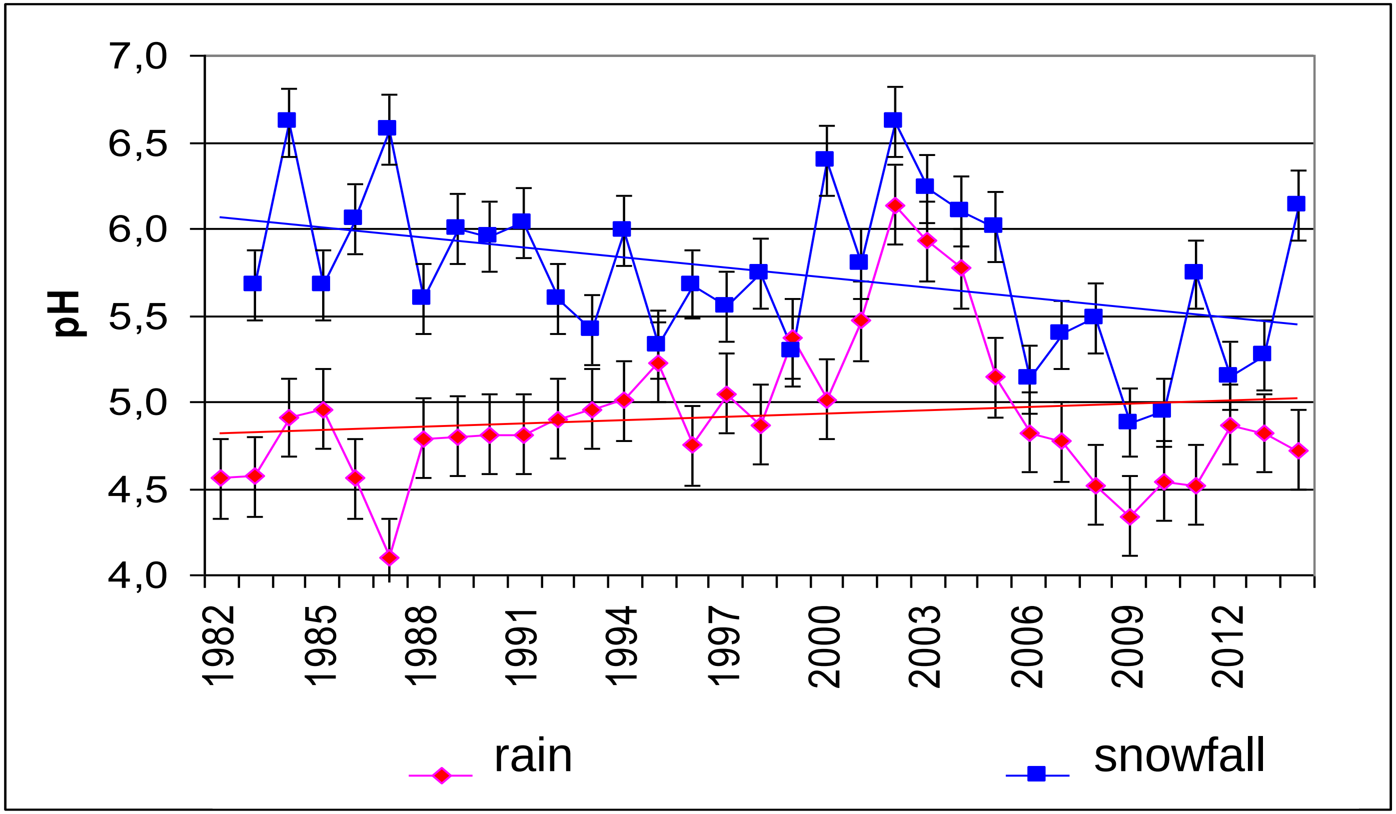
To check UV dose in France or any other place!

visit our online web tool:

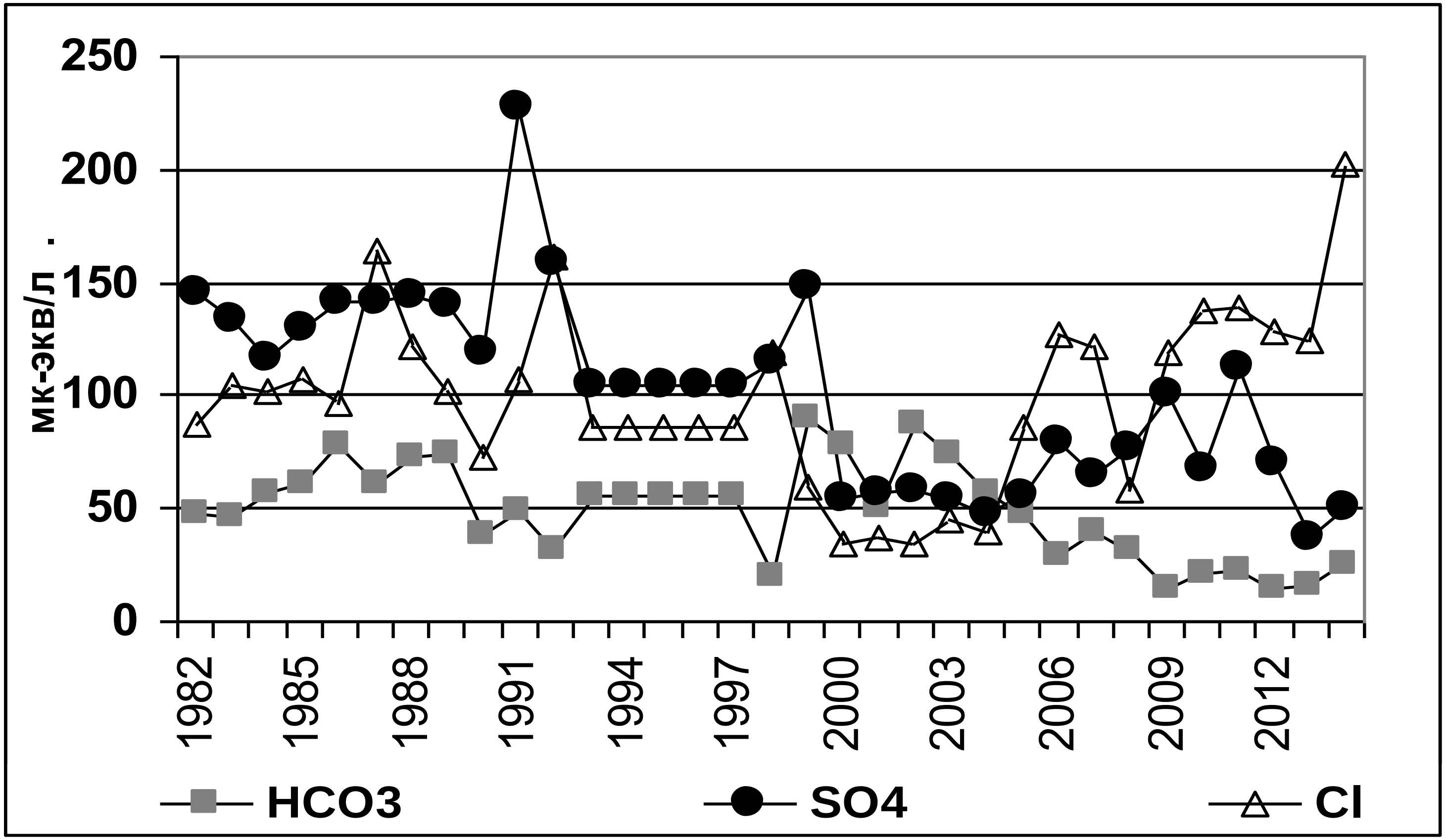
www.momsu.ru/uv/

4. **Chemical composition of precipitation**

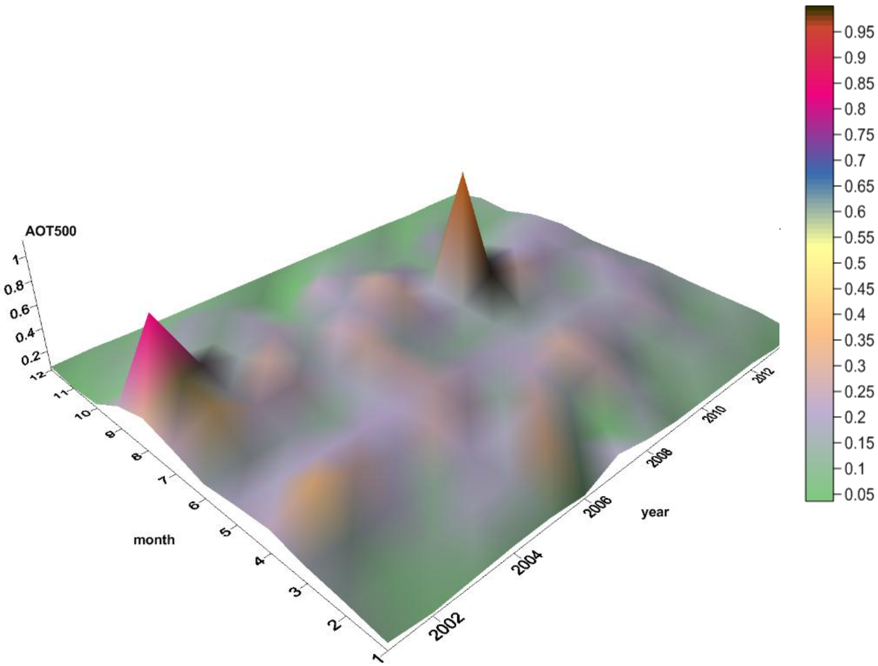
Trends in rain and snowfall pH since 1982 in Moscow



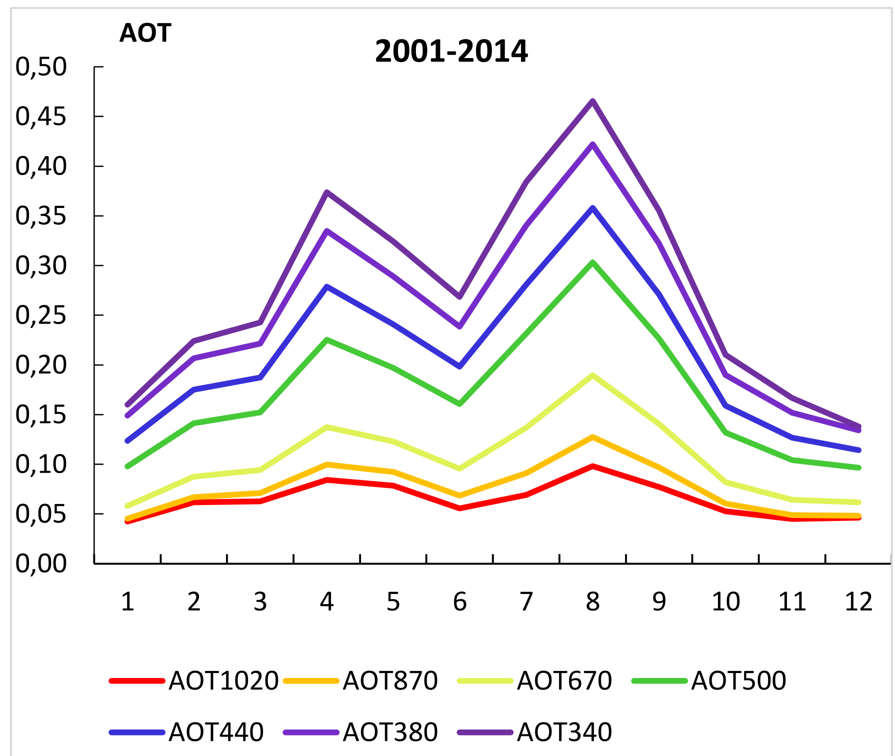
Interannual variability of main anions in precipitation. Moscow.



5. Urban aerosol pollution



Seasonal cycle of aerosol optical thickness at different wavelengths since 2001 in Moscow



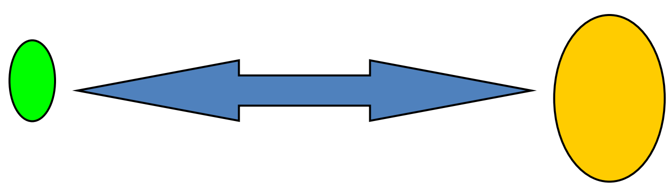
Interannual variability of aerosol optical thickness at 340nm, 500nm and 1020nm according to AERONET sun photometer data

Aerosol urban pollution study based on collocated AERONET sites

Sun sky photometer CIMEL of AERONET network

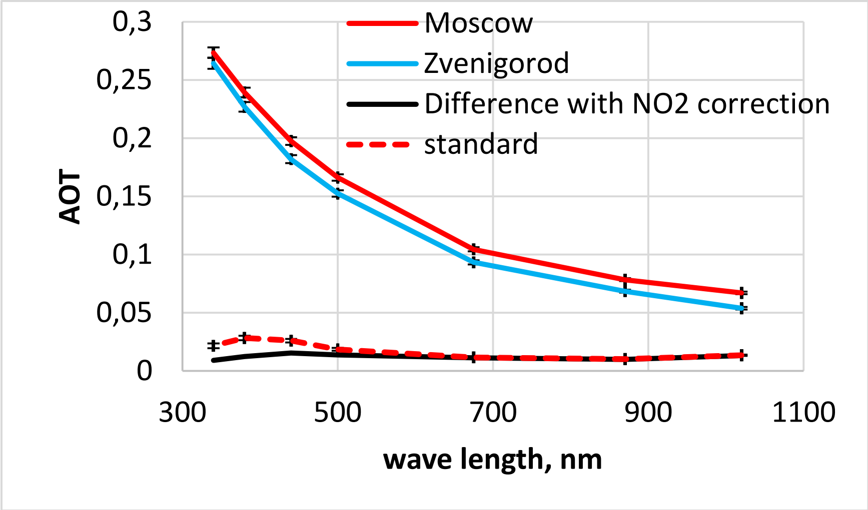
Zvenigorod IFARAS

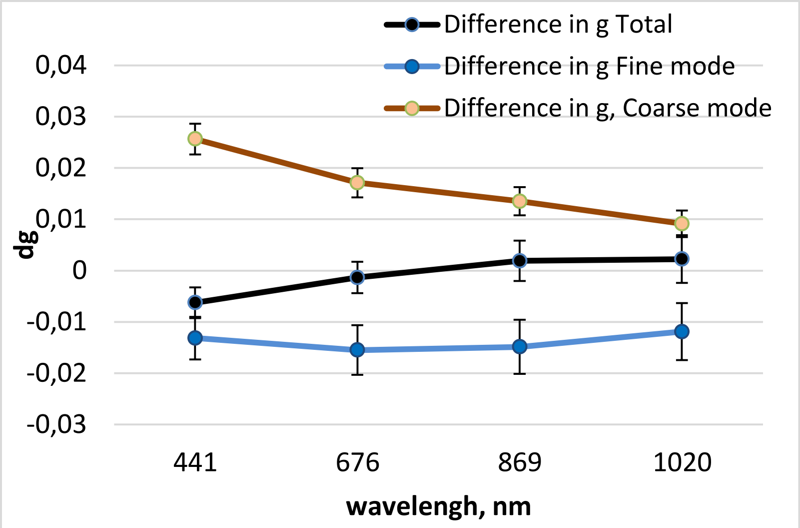
Moscow MSUMO site

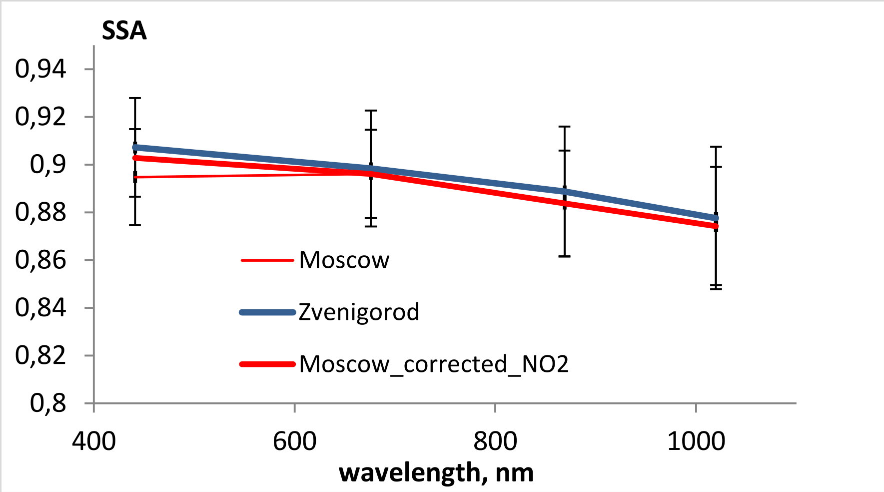


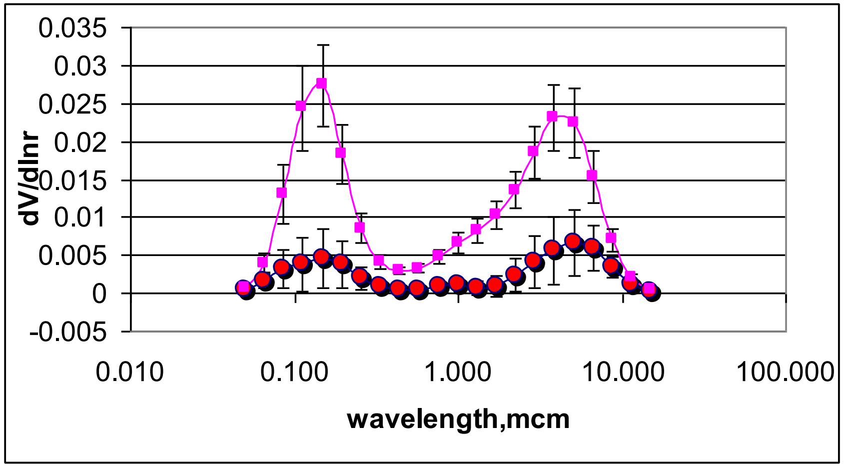
~55 km

Urban aerosol effects – differences in AOT, factor of asymmetry (g), single scattering albedo (SSA) and in volume size distribution between the two collocated AERONET sites (Moscow and Zvenigorod sites)

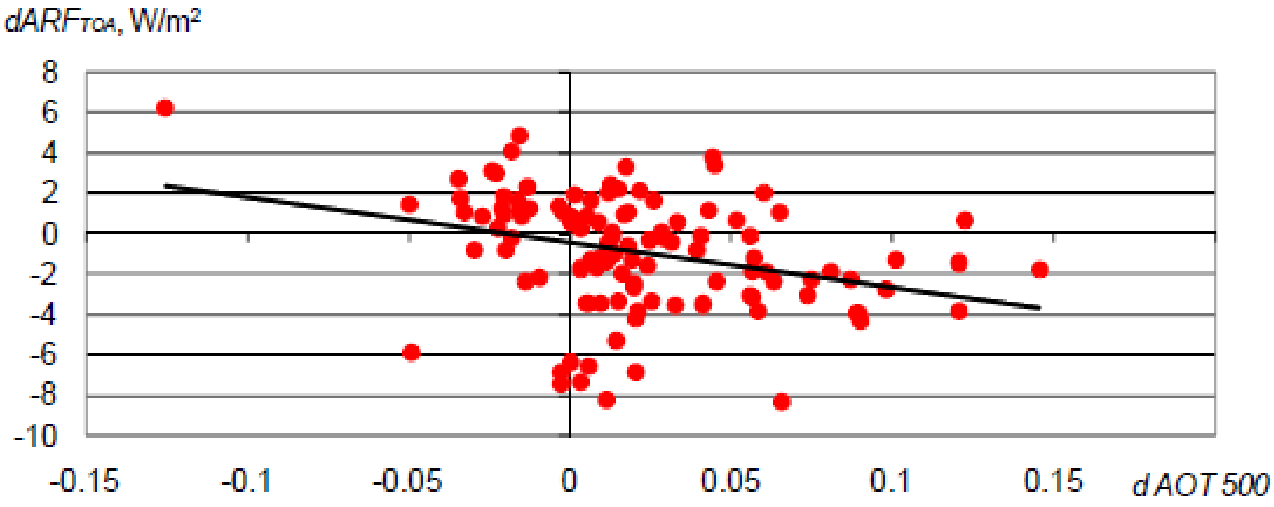






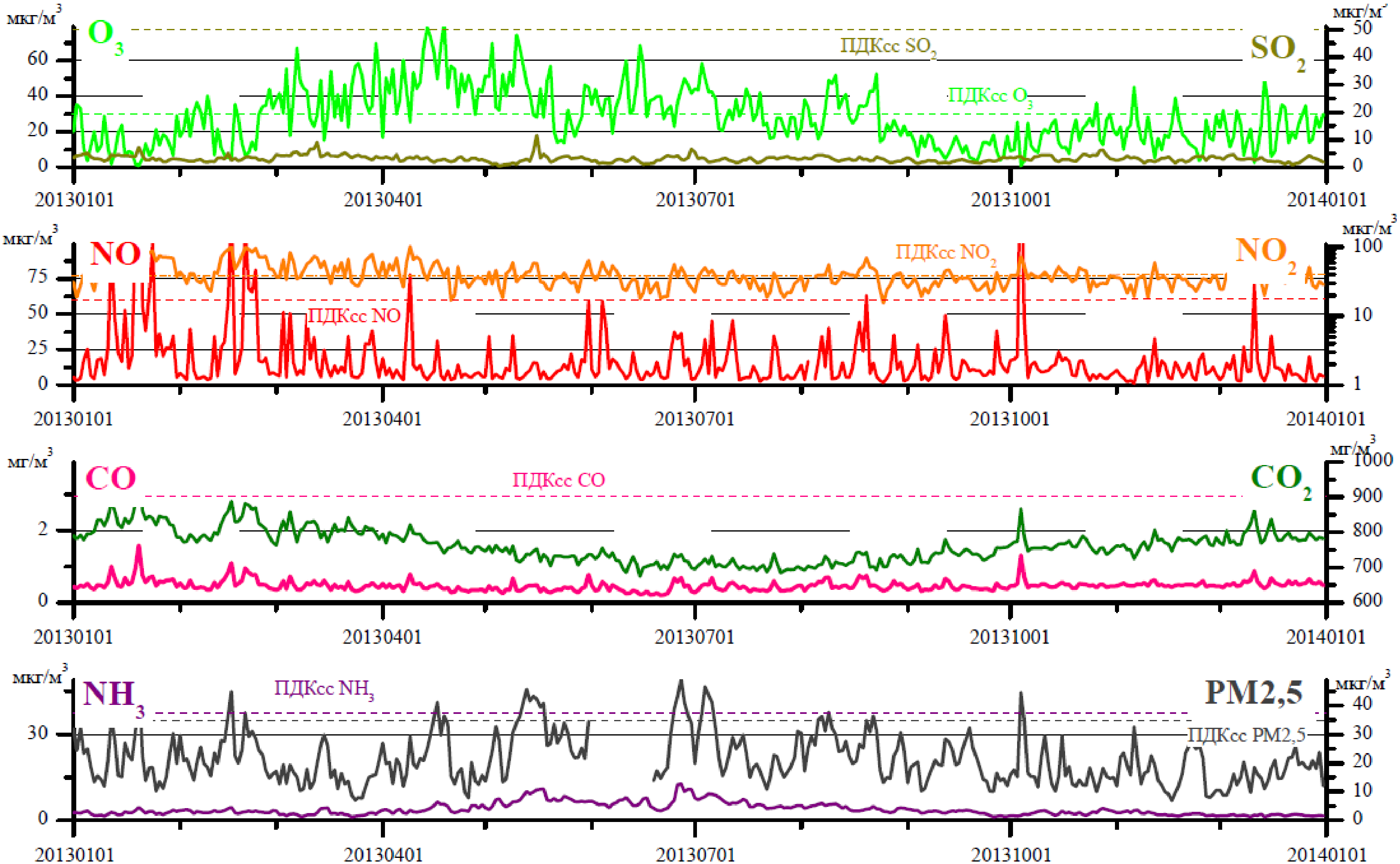


Dependence of the difference in urban aerosol radiative forcing at the top of the atmosphere (dARFTOA) between Moscow and Zvenigorod as a function of dAOT500. Model simulations, clear sky conditions.

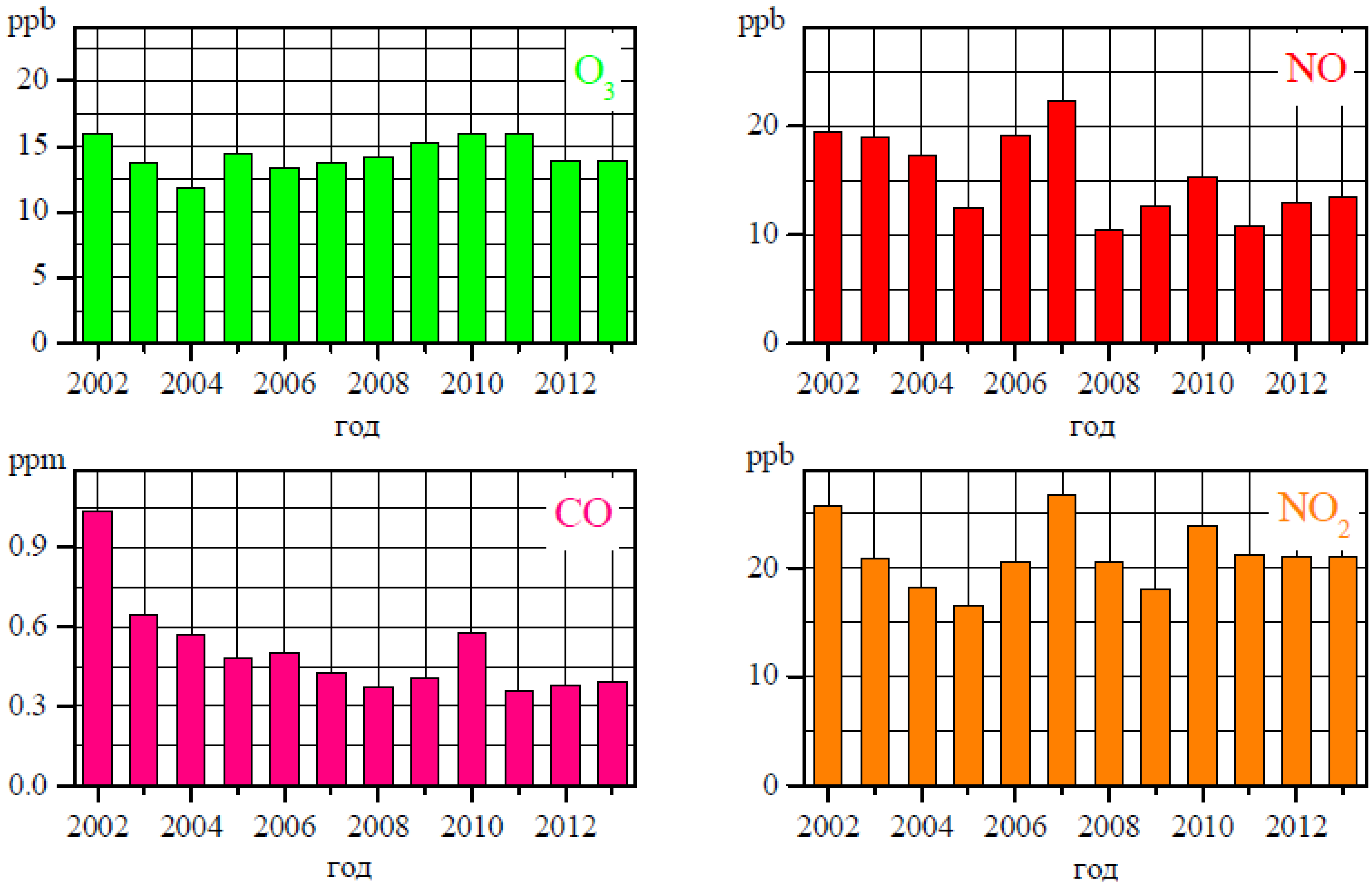


Urban aerosol leads to cooling effect due to larger aerosol content, which is characterized by small absorbing.

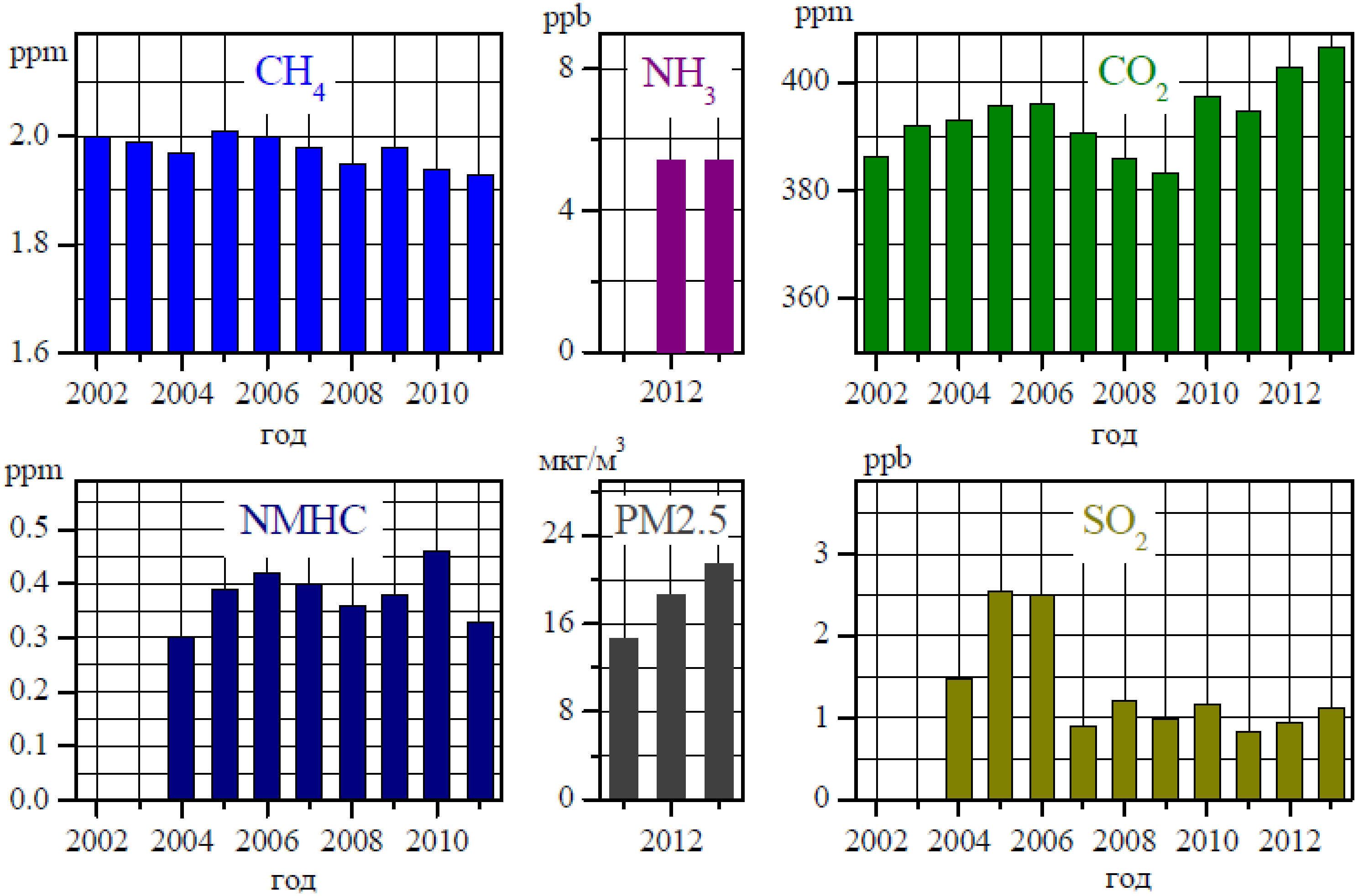
6.Air quality.
Gas species monitoring 2002-2013, MSU MO



Interannual variations of different gas species concentration

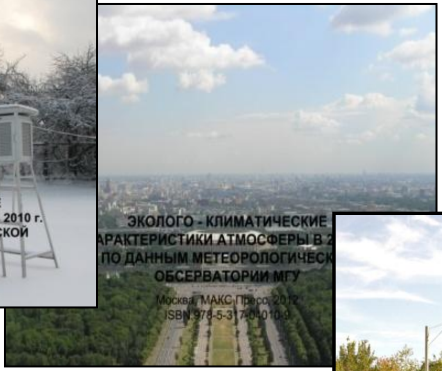


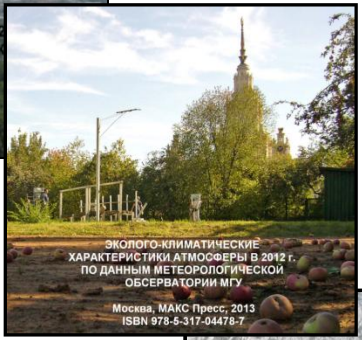
Interannual variations of different gas species concentration



CONCLUSIONS:

- There is a positive trend in temperature, which is higher than that in background conditions.
- This happens (very likely) due to increase in downwelling longwave irradiance. Need further analysis and model sensitivity study.
- There is a distinct negative AOT trend. The urban aerosol pollution has a cooling effect in Moscow.
- There is a pronounced positive UV increase since 1980s with a trend of 6% per decade. The UV health effects were estimated in Moscow and over Northern Eurasia. The developed UV –tool for determining UV level can be found at www.momsu.ru/uv/.
- The amount of acid rains are increasing during the last decade; the chemical composition of precipitation has changed significantly!
- The air quality in Moscow megalopolis is characterized by negative trends in CO, Nox and a positive trend in CO2.





HANDBOOK

OF MOSCOW ENVIRONMENTAL AND CLIMATIC FEATURES (ACCORDING TO THE OBSERVATIONS AT MOSCOW STATE UNIVERSITY METEOROLOGICAL OBSERVATORY)

Editor-in-chief:
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Thanks for your attention!

- Questions?