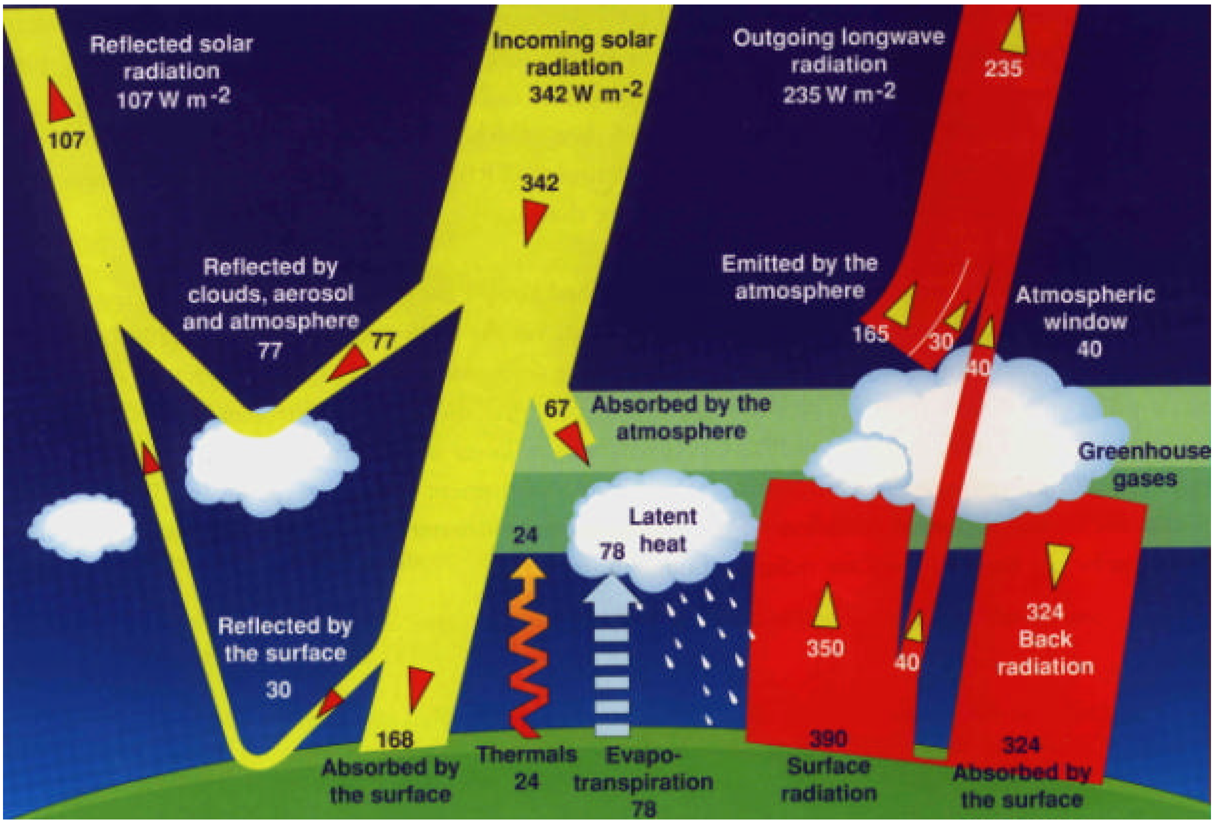
Radiation measurements at the solar-AOT station



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1. Motivation

Increase of the mean global temperature in XX century shows that Earth's climate changes. Temperature trend is correlated with increase of greenhouse gasses such as CO_2, water vapor. The greenhouse effect was estimated as change of the radiation balance at the top of the atmosphere by about 2 Wm^{-2} [IPCC, 2001]. However recent study shown that small particles (aerosols) in local scale have larger effect on climate and lead to cooling. The greenhouse effect is well known while the aerosol influence on climate system is still poorly understood. It is because aerosols are not uniformly distributed thought-out the globe and their radiative forcing strongly dependent on the geographic location on the Earth.

Atmospheric aerosols play an important role in many atmospheric processes. They modify the radiation balance and energetic of the earth-atmosphere system, providing the base for heterogeneous chemical reactions and also act as condensation nuclei in the formation of

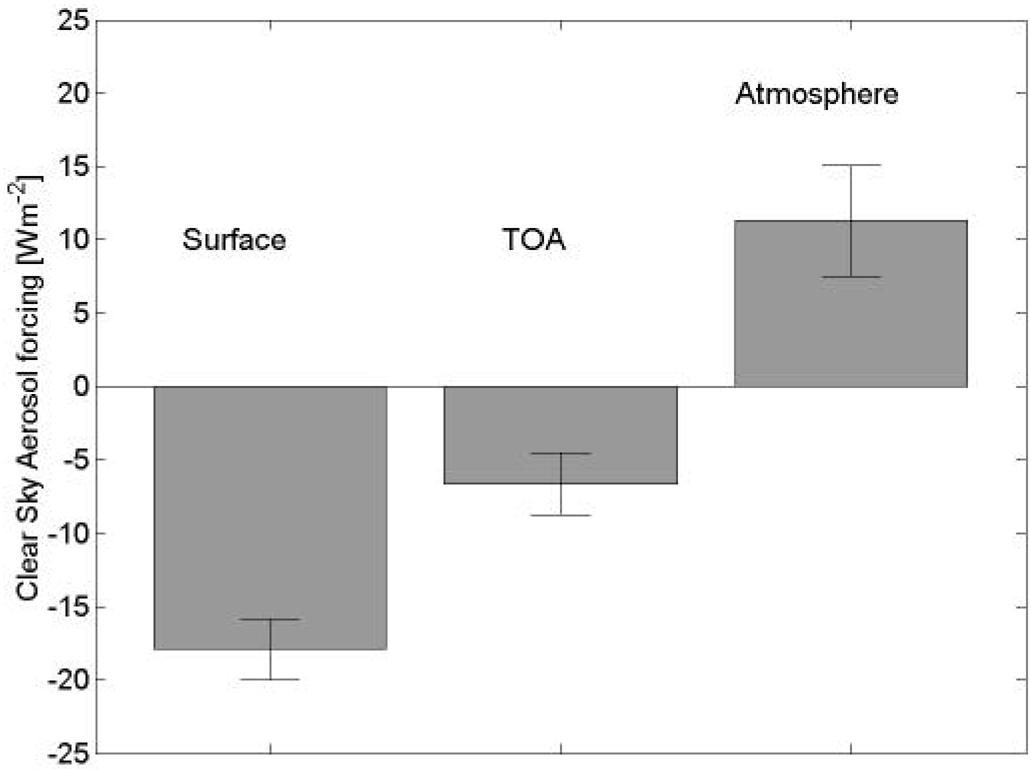

Fig. 1: Aerosol forcing at the surface at the top of the atmosphere and in the atmosphere over the Mediterranean Sea.

clouds. Major components of aerosols are: sulfates due to fossil fuel burning, oxidation of sulphure compounds and volcanic emission; carbonaceous particles which include black and organic carbon; mineral dust from soils.

Results of the MINOS campaign which took place in 2001 on Crete show (Fig. 1) that aerosol transported from central and eastern Europe in the Mediterranean Sea have large impact on radiation balance over the [*Lelieveld et al.*, 2002; *Markowicz et al.*, 2002]. [*Markowicz et al.*, 2002]. Aerosols reduce net solar radiation at the surface by about 18 Wm^{-2} (6%) and increase outgoing solar radiation by 6 Wm^{-2}. The last value is about 3 times larger than greenhouse radiation forcing. Aerosols lead also to extra atmospheric absorption by about 11 Wm^{-2} what is a significant part of mean global atmospheric absorption (70 Wm^{-2}). MINOS experiment shows that aerosol from biomass burning (in eastern and south-eastern part of Europe) play important role of aerosol forcing efficiency. This effect is due to large aerosol absorption by the soot and organic carbon particles.

2. Project

This proposal includes study of seasonal change of the aerosol direct effect. Aerosols produced by both natural and anthropogenic processes can affect the radiation balance of the earth-atmosphere system directly by reflecting sunlight back to space, by absorbing solar radiation and by absorbing and emitting infrared radiation (Fig. 2). Aerosol impact on climate system is described by aerosol forcing, which depend on aerosol concentration, aerosol optical properties it chemical composition, surface albedo, and sun declination. Because aerosols such as sulfates, soot, dust have the strongest effect on radiation balance therefore these aerosol species will be measured at Solar-AOT station.

Summer observations during MINOS experiment (Crete) showed that soot particles produced during fires lead to large aerosol impact on climate system. For example aerosol forcing during fires periods was –85 Wm^{-2} per unit of optical thickness [Markowicz et al., 2002]. For typical values of aerosol optical thickness in Poland (AOT=0.2) aerosol reduces solar radiation at the surface between 8 and 10 %. This maybe important on the boundary layer stratification. Therefore we going to measure structure of the lower boundary layer (temperature, humidity, wind) . These observations include measurement of sensible and

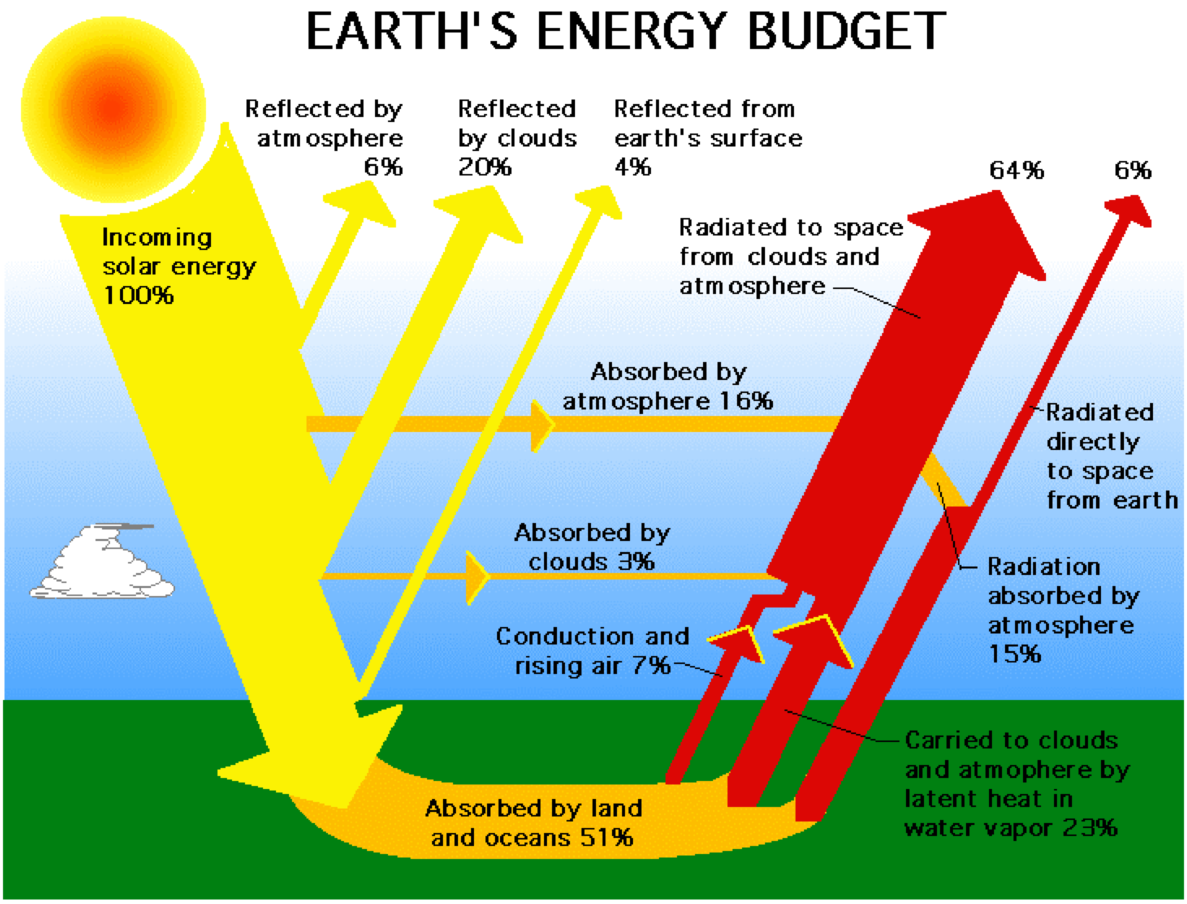

Fig. 2: Solar and infrared radiation budget.

latent fluxes. **We need emphasize there is no research station in Poland which measures aerosol impact on climate and weather.**

Observations of the annual cycle aerosol forcing are needed because of the surface albedo variation. For large albedo (e.g. over snow) aerosol absorption increase as a results of the multiple surface reflection and in consequence significant photon absorption probability. This can leads to decrease of planetary albedo (positive aerosol radiative forcing). Moreover over the snow magnitude of the aerosol forcing at the top of the atmosphere is significant larger than aerosol forcing at the surface. Over the surface with small albedo (e.g. water, soil) aerosol impact on climate system it different because lager part of solar radiation passes by the aerosol layer only one times.

Thus during winter aerosols may enhance greenhouse effect and during summer minimize it. For study this important phenomena continues measurement radiation flux at the surface and at the top of the atmosphere are necessary. The last one will be measured by the instruments such as CERES, MODIS and AVHRR onboard on TERRA and NOAA 16 17 satellites. Moreover aerosol optical properties will be performed join with air pollution monitoring. The most important parameters are: spectral aerosol optical thickness, absorption and scattering coefficient and the surface. The results of these observations will be compared with aerosol transport models such as NAAPS and GOCARD.

We going to use the vertical profiles of air temperature, pressure and relative humidity come from aerologic station at Lvov (about 200 km in east direction from Strzyzow) for interpretation the results and determine vertical structure of aerosol optical model.

Result of the observations will be applied to solar and infrared radiative transfer model. The MODTRAN version 4.1 will be used to determination of the solar and infrared aerosol radiative forcing at the top of the atmosphere, at the surface, and in the atmosphere. Because calculations in MODTRAN program are costly the radiative fluxes will be determined every 30 or 60 minute.

3. Information about research station

Solar-AOT (Fig. 3) is a new station but based on climatologic station MK1-260, which was working between 1985 and1993. This station was localized at the 260 meter above sea level and was built by Krzysztof Markowicz. Previous research at MK-260 station was

Fig 3: Solar-AOT localization

focused on climate of Strzyzow [*Markowicz K. M.*, 1992] and influence of the air pollution on the solar radiation reaching the surface [*Markowicz, K. M*. 1993]. Although most of the instruments will be mounted on the new station but we going to still collect the weather conditions at MK1-260 station. Because the previous station is about 170 meter below the Solar-AOT therefore we want to use this data to vertical profiles measurements.

Solar-AOT will be together with station of the Polish Academy of Science in Belsk (50 km from Warsaw) places in Central Europe, where similar observations will be performed.

Solar-AOT is located 433 meters above sea level and about 5 km in east direction from center town of Strzyzow. Geographical coordinates of the station are: latitude 49.88°N and longitude 21.86°E. Because Solar-AOT is about 200 meter over the Strzyzow and at the top of mountain this place is excellent to perform the meteorological observations.

Fig. 4 a b: Solar-AOT station in Dec 2002

4. Observations and access to database

Weather conditions will be measured by the Ultimeter2001 and the thermo-hygrometer (LAB-EL). Solar direct, diffuse and infrared broadband radiation fluxes will be measured by Kipp&Zonnen oraz Eppley pyranometers and pyrhelimeters. In addition we plane to perform observations of the solar fluxes in visible part of solar radiation. Sunphotometer and shodowband will be used to determine aerosol optical thickness, total water vapor content and total ozone content. Moreover aerosol scattering and absorption coefficients will be measured by Nephelometer and PSAP (Particle Soot Absorption Photometer). Stratification of the lower boundary layer will be measured by the thermometer localized in logarithmic scale up to 15 meters. In addition we plan measure the soil temperature up 1 m below the surface.

Most part of results will be presented on web page (www.igf.fuw.edu.pl/meteo/stacja/radiacja/stacja.htm). We plan to update it every 10-15 minute. Current data will be presented as figures and diagrams. We want to build data base with access to their in internet by password. All data will be available MATLAB binary format or in the NetCDF format.

Additional on main web page of the station will be shown name of company which wanted support this research.

5. Instrumentations

Current staff at station:

1) pyranometer: Kipp&Zonen

2) pyranometer: Eppley

3) two sunphotometrs with 5 channels

4) weather station Ultimeter2001

4a) heated anemometer – Ultimeter2001

4b) barometer – Ultimeter2001

4c) thermohigrometer – Ultimeter2001

4d) heated rain guide – Ultimeter2001

5) thermohigrometr supported by LAB-EL ELEKTRONIKA LABORATORYJNA S.
6) thermometers to gradient measurements in first 15 meters
7) thermohigrograph- Zootechnika Kraków
8) barograph- Zootechnika Kraków

9) Datalogger 34970A with 20-channels, Hewlett Packard

Future Instruments:

1) shadowband
2) pyrhelimeter
3) pyrgeometer
4) sun tracker
5) thermometers to measure air and soil temperature
6) PSAP
7) Nephelometer

8) snow depth detector
9) lightning detector

6. Collaboration with high school

We plane collaborate with high school close to the station. One of them located in Rzeszow (30 km from station) is a member of the international GLOBE project (www.globe.gov). In the GLOBE students from thousands of school on the world study environment (i.e. atmosphere, hydrosphere, biosphere). In Rzeszow's school students measure atmospheric conditions e.g. temperature, humidity, pressure, precipitation. Observations can be spread on aerosol field how is suggested in the GLOBE project. We going to do it and calibrate GLOBE sun photometers. This place is a perfect for the Langley calibration of these instruments. Moreover Solar-AOT station is good place to train teachers and students from GLOBE schools or new one which want to join to this project.

7. Additional using of the station

- calculations of the available solar energy and wind energy
- current monitoring of air pollution
- observations of the visibility
- warning against dangers atmospheric phenomena's
- the UV index
- climatologic research

8. Communication and connection to Internet

We plane connect the Solar-AOT to Internet by wireless system. Solar-AOT is about 4.1 km far from MK1-260 station, where is LAN. For this purpose we have to purchase two radio card with directional antennas. The antenna should have at least 20 dB

9. Monthly cost of the station.

- mean power consumption: 0.25 kW (190 kWh per month): 85 z^3 (about 25 $)

10. References

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Born

April 12, 1974 Poland

Education:

1999-present, Graduate Research Assistant, Institute of Geophysics, University of Warsaw, Atmospheric Science Group

1999 M.Sc, Institute of Geophysics, University of Warsaw, Atmospheric Science Group

Awards

Fulbright scholarship, 2001

Bardwin-Otwinowska award for the M.Sc. thesis "The role of vorticity on cloud droplets concentration" 1999

Polish Academy of Science award for "Klimate of Strzyzow" and "Extinction of visible solar radiation in lower troposphere" (1992, 1993)

Field Projects

2001 MINOS Crete, Greece

2001 ACE-Asia cruise, R/V Ronald H. Brown, Honolulu - Sea of Japan

1999 Indian Ocean Experiment (INDOEX) R/V Ronald H. Brown

Recent Collaborations and Research

2002 June-November Naval Research Laboratory, Monterey

2002 February-June Scripps Institution of Oceanography, UCSD

1998-1999 role of turbulence on cloud microphysics

1985-1992 developed and performed observations at the amateur meteorological station in Strzyzow

Interest

Aerosol and climate, meteorological instruments, cloud physics

Other Interest

Sport

List of publications

published

1. Krzysztof M. Markowicz Piotr, J. Flatau, M. V. Ramana, P. J. Crutzen,and V. Ramanatha, *Absorbing Mediterranean Aerosols Lead to a Large Reduction in the Solar Radiation at the Surface.,* 2002, Geophysical Research Letters

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3. E. J. Welton, Kenneth J. Voss, Patricia K. Quinn, P. J. Flatau, K Markowicz, J. R. Campbell, J. D. Spinhirne 7, H. R. Gordon , and J. E. Johnson, *Measurements of aerosol vertical profiles and optical properties during INDOEX 1999 using micro-pulse lidars* Journal of Geophysical Research – Atmospheres

4. Krzysztof M. Markowicz, Piotr J. Flatau, P. K. Quinn, Christian M. Carrico, M. K. Flatau, A. Vogelmann, *Influence of Relative Humidity on Aerosol Radiative Forcing*, Submited to Journal of Geophysical Research – Atmospheres, 2002

5. Andrew M. Vogelmann, Krzysztof Markowicz, Malgorzata Szczodrak, Piotr J. Flatau, and Peter J. Minnett, *Aerosol Infrared surface forcing observed during Ace-Asia*., *Aerosol Infrared surface forcing observed during Ace-Asia*, submitted to Nature, Oct. 2002

6. Krzysztof, M. Markowicz, P. J. Flatau, Andy Vogelmann,P. K. Quinn, *Modeled infrared aerosol forcing during ACE-Asia.* Submitted to Journal of Geophysical Research – Atmospheres, 2002

others

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1. Flatau, P. J., Mitchell, G., Welton, E. J., Wieland, J., Markowicz, K., Nolan, J., Voss, K., Gordon, H., Miller, M., Kahru, M., Nakajima, T., 2000, *Comprehensive ocean color measurements during the 1999 INDOEX project*, Eos, Transactions, vol. 80, no. 49, 1999, p.274, January 24-28, 2000, American Society of Limnology and Oceanography, American Geophysical Union, 2000 Ocean Sciences Meeting, San Antonio, Texas.

2. Welton, E. J., Flatau, Voss, K. J., P. J., Gordon, H. R., Markowicz, K., Campbell, J. R., Spinherne, J. D., 1999, *Measurement of the vertical distribution of the vertical distribution of aerosols and clouds during INDOEX 1999 using micro-pulse lidars*, Eos, Transactions, AGU 1999 Fall Meeting, Volume 80, Number 46, November 16, 1999, December 13-17, 1999, San Francisco, California, American Geophysical Union.

3. Konrad Bajer, Krzysztof Markowicz, Szymon Malinowski, *Influence of the small-scale turbulence structure on the concentration of cloud droplets* w: 13th International Conference on Cloud and Precipitation, Proceedings, str. 159-162, International Commision on Clouds and Precipitation (ICCP) of the International Assocoation of Meteorology and Atmospheric Sciences (IAMAS), r. 2000

4. P. J. Flatau, M. K. Flatau, K. Markowicz, P. Quinn, A. Vogelmann, Influence of relative humidity on aerosol radiative efficiency, 2002, AGU Fall Meeting, San Francisco. CONFERENCE PROCEEDINGS

5. K.,M., Markowicz, P. J. Flatau, A. Vogelmann, Modeling of infrared radiative forcing during the ACE-Asia experiment: influence of dust and sea-slat, 2002 AGU Fall Meeting, San Francisco. CONFERENCE PROCEEDINGS

6. A. M. Vogelmann, Piotr J. Flatau, M. Szczodrak, K. Markowicz and P. J. Minnett, 2002, Infrared radiative forcing of the ACE-Asia aerosol observed during the NOAA ship R.H. Brown cruise, 2002, Joint International Symposium on Atmospheric Chemistry within the Earth System, September, Crete, Greece. CONFERENCE PROCEEDINGS

7. K.,M. Markowicz, P. J. Flatau, J. P. Crutzen, V. Ramanathan, Aerosol Radiative Forcing at Finokalia Sampling Station during the MINOS Experiment, 2002, Joint International Symposium on Atmospheric Chemistry within the Earth System, September, Crete, Greece. CONFERENCE PROCEEDINGS

conference presentations

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Krzysztof Markowicz, *Badania zmian klimatu Ziemi, eksperyment INDOEX* Sympozjum Instytu

Krzysztof M Markowicz. *The solar aerosol forcing during MINOS experiment*, Workshop, Jun 2002 Munich.

Krzysztof Markowicz, *Przyczyny Zmian Klimatu Ziemi (Eksperyment INDOEX),* Festiwal Nauki Warszawa 1999.