Atmosphere aerosol properties from sunphotometer and satellite measurements over Ukraine for climate change studies

Danylevsky[1] V.O., Milinevsky[1] G.P., Sosonkin[2] M.G., Grytsai[1] A.V., Ivchenko[1] V.M., Bovchaliuk[1,2,4] A.P., Voytenko[3] V.P. and Goloub[4] P.

[1]Taras Shevchenko National University of Kyiv, Kyiv, Ukraine, vdan@observ.univ.kiev.ua

[2]Main Astronomical Observatory of NASU, Kyiv, Ukraine

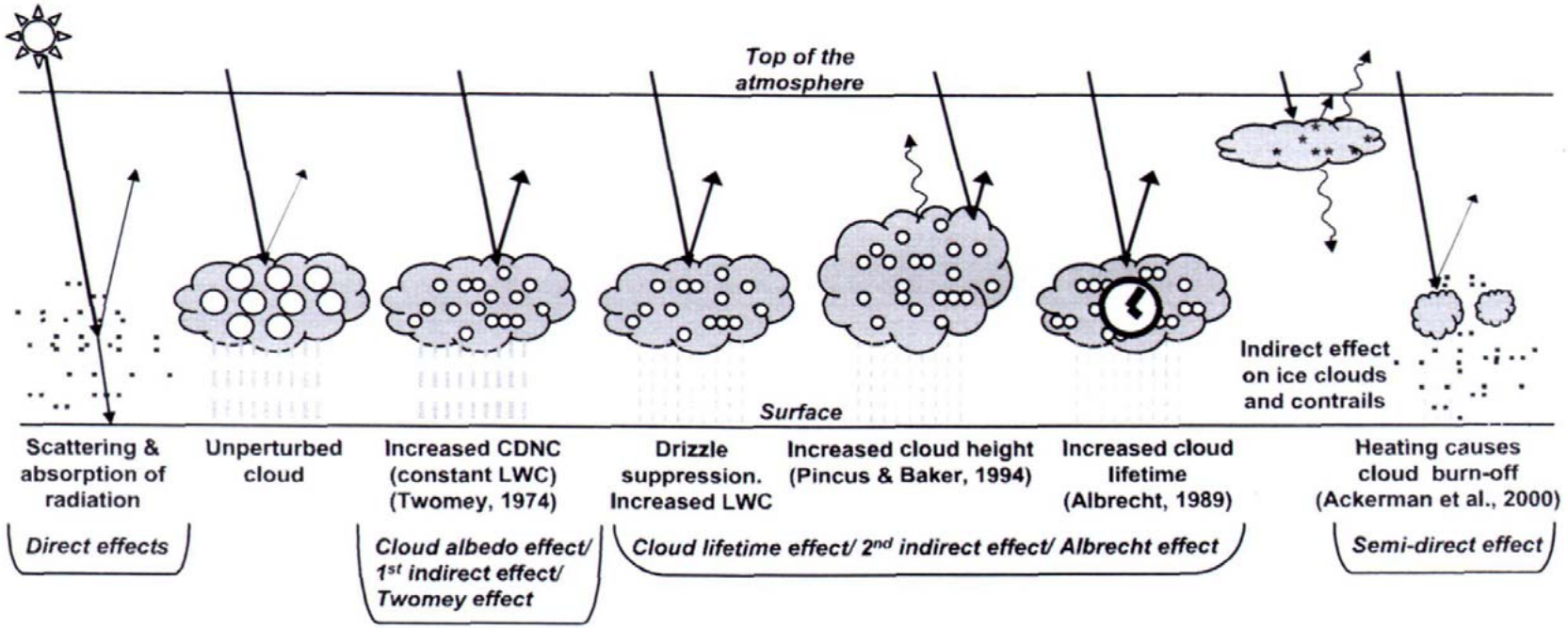
[3]Volodymyr Dahl East Ukrainian National University, Lugansk, Ukraine

[4]Laboratoire d'Optique Atmosphérique, Université Lille1, Lille , France

GLOBAL AND REGIONAL CLIMATE CHANGES

Kyiv, Ukraine,16-19 November 2010

Direct and indirect climate aerosol effect



(IPCC 2007)

- Direct climate aerosol effect – scattering and absorption of radiation
- Indirect climate aerosol effect – acting as cloud condensation nuclei and ice nuclei: the first indirect effect – clouds albedo increase; the second indirect effect – clouds lifetime increase

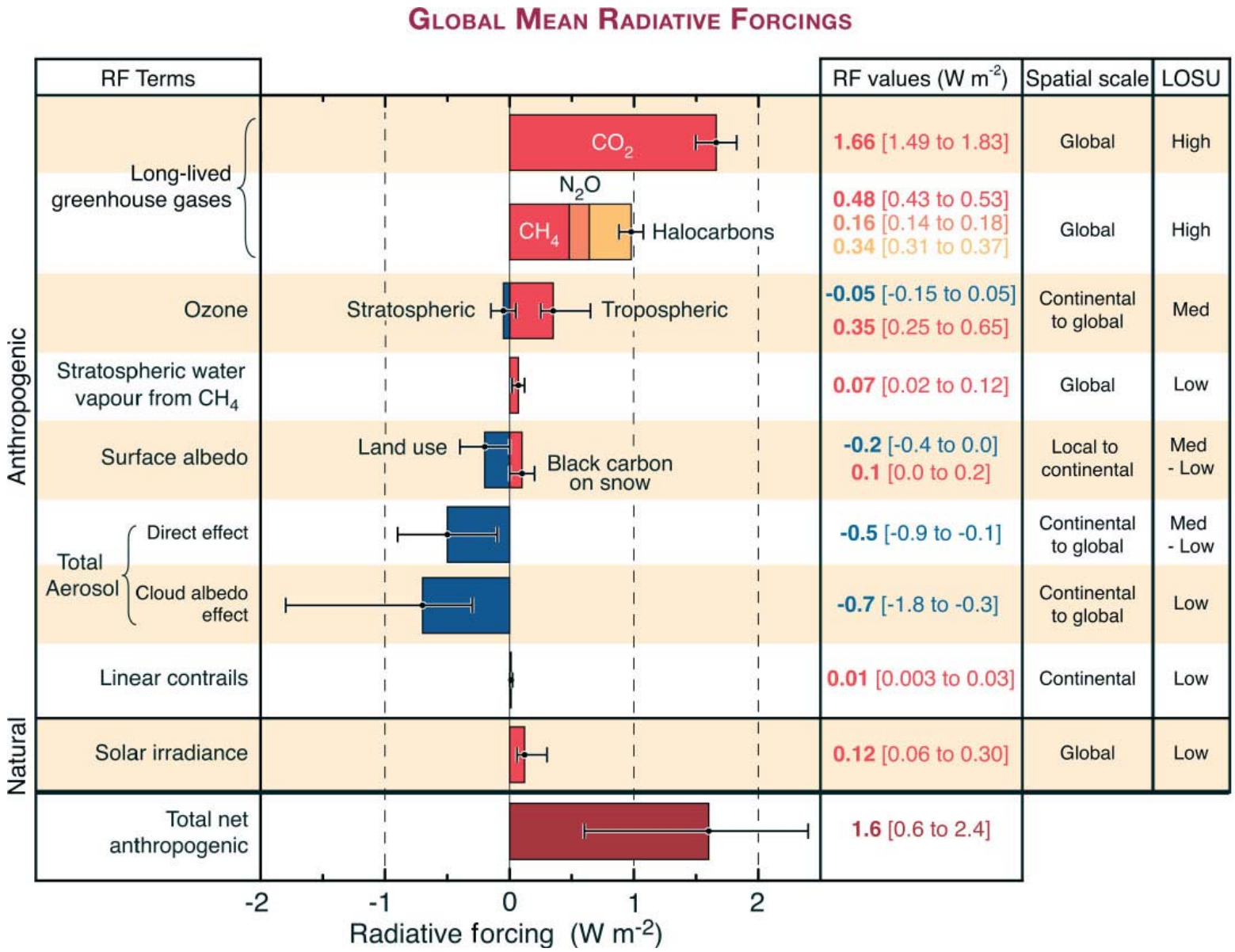
Radiative forcing concept

- The fundamental assumption: the Earth climate (surface – troposphere) system is in a state of radiative-convective equilibrium (RCE)
- The RCE result is: $\Delta T = \lambda \cdot F$

  ΔT – the climate system temperature change;

  F – the radiative (climate) forcing (RF) – an energy imbalance imposed on the climate system radiative budget by either external or internal changes;

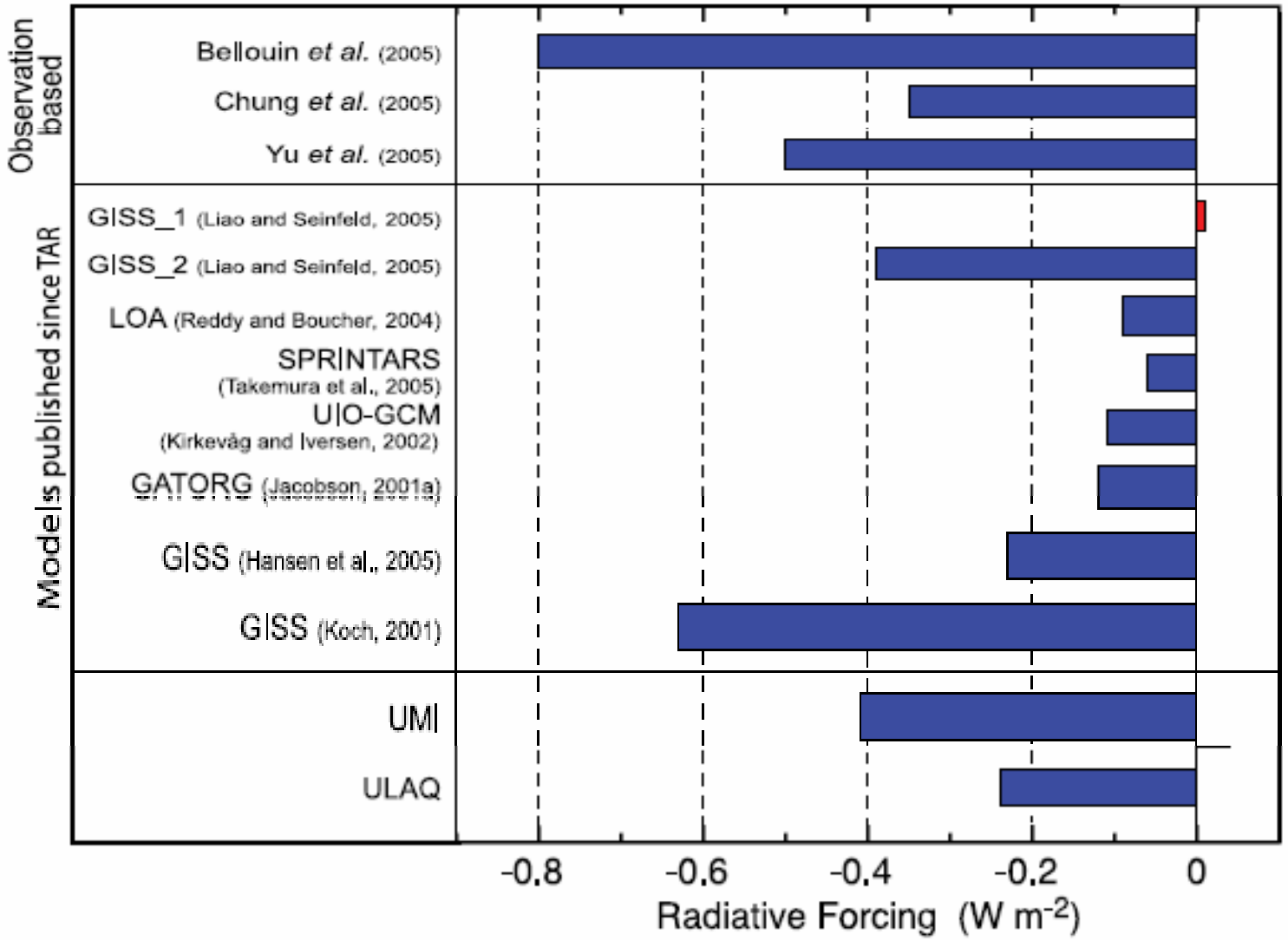
  λ – the climate sensitivity (feedback) parameter – the equilibrium global mean temperature change (°C) for a 1 W/m^2 TOA radiative forcing.



(From IPCC 2007 Scientific Report)

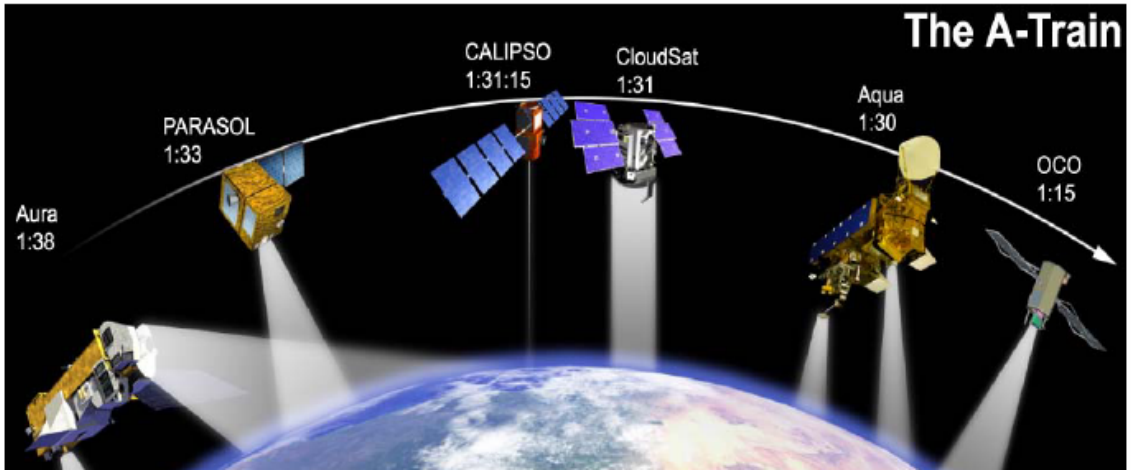
Aerosol direct radiative forcing – Comparison of different models

(IPCC 2007)

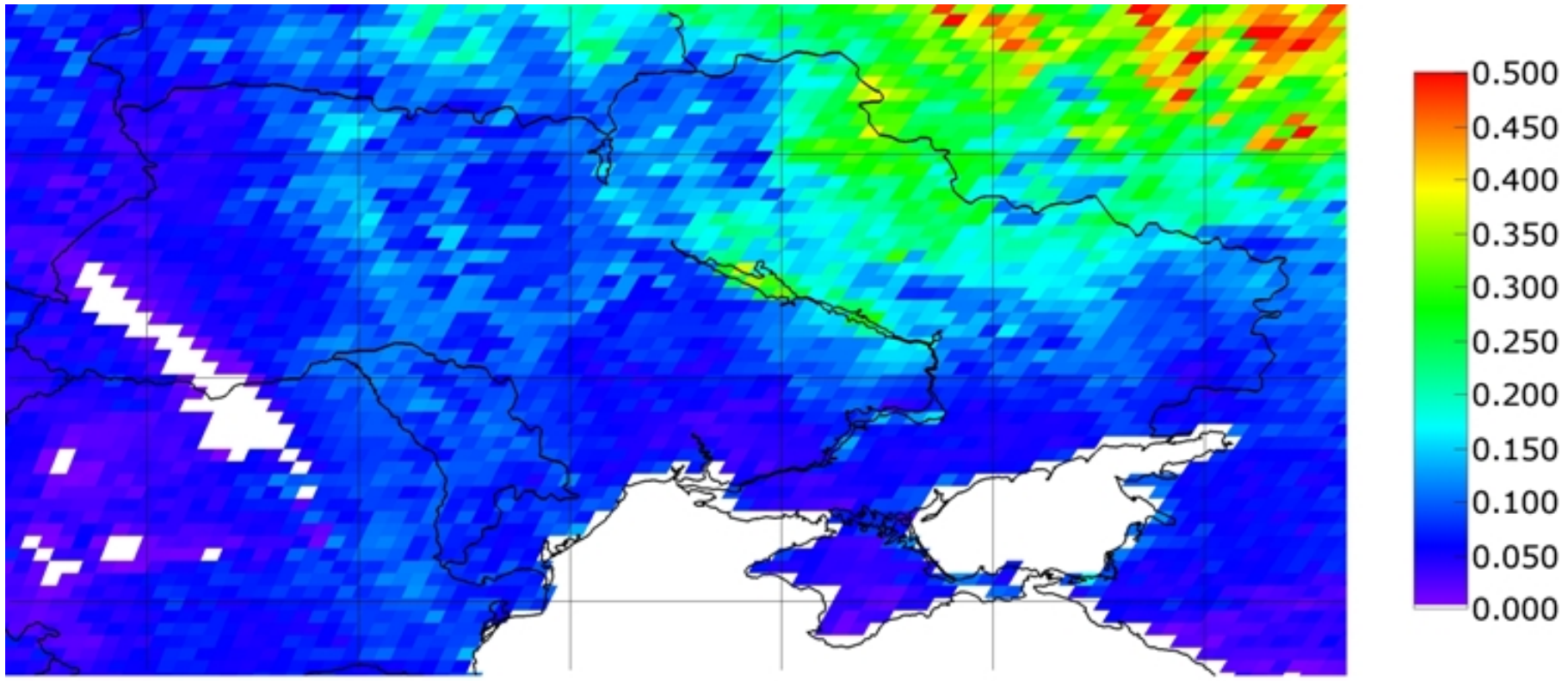


Satellite instruments engaged in aerosol studies :

- A-Train satellites and the others:
- MODIS / Terra (from 1999) and Aqua (from 2002) A-Train satellites http://modis.gsfc.nasa.gov/about/;
- MISR / Terra (from 1999);
- POLDER / ADEOS I (1996 - 1997)
- POLDER-2 / ADEOS II (2002 - 2003)
- POLDER / PARASOL (2004) http://www.icare.univ-lille1.fr/parasol/;
- APS/GLORY (2011 scheduled) http://glory.gsfc.nasa.gov/index.html

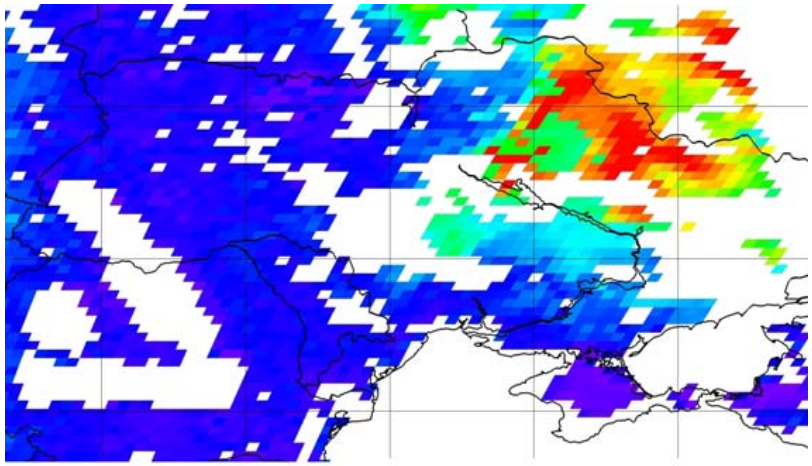


POLDER / PARASOL Monthly Average AOD at 865nm over Ukraine, August 2010 (A. Bovchaliuk)

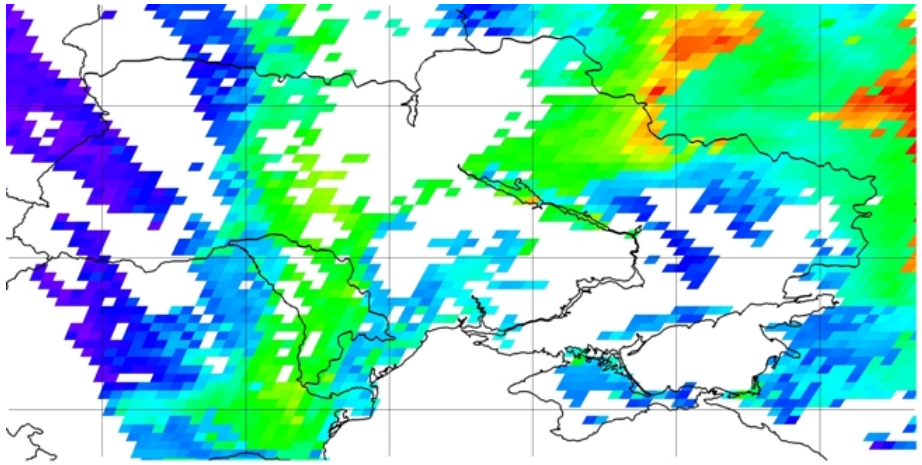


PARASOL Monthly Average AOD at 865nm for August 2010

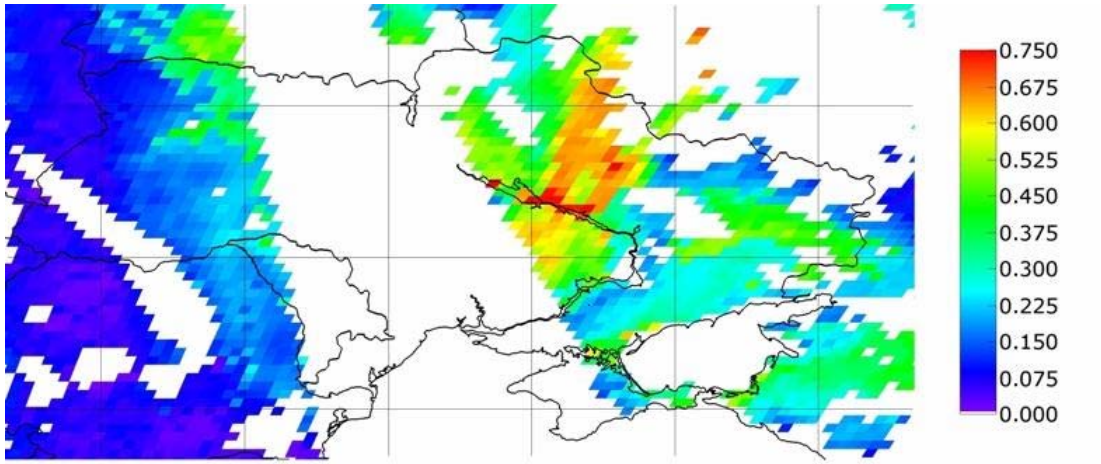
POLDER / PARASOL data, AOD at 865nm over Ukraine, 14-16 August 2010



Parasol AOD865 over Land, 14 August 2010



Parasol AOD865 over Land, 16 August 2010



Parasol AOD865 over Land, 15 August 2010

Almost all territory of Ukraine was covered by aerosol layers in this period.

The AERONET

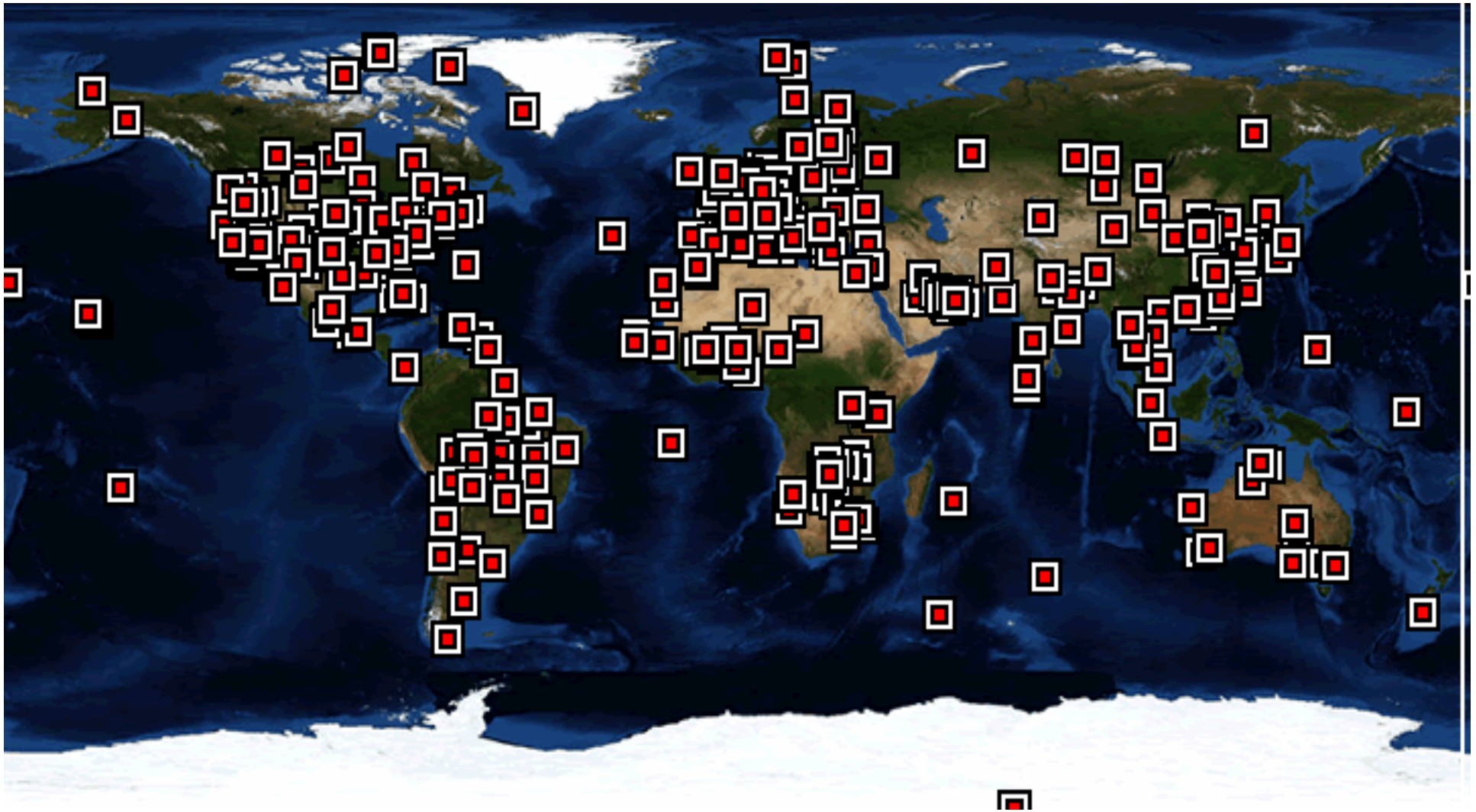
http://aeronet.gsfc.nasa.gov/index.html

- The AERONET (AErosol RObotic NETwork) program is a federation of ground-based remote sensing aerosol networks established by NASA and LOA-PHOTONS (CNRS) in 1992
- PHOTONS = PHOtometrie pour Traitement Observation et Normalisation Satellite - French contribution to AERONET Cimel sunphotometer network (http://www-loa.univ-lille1.fr/photons/)

- The AERONET/ PHOTONS has been established for long-term real-time monitoring of aerosols (column integrated properties):
  - aerosol climatology
  - satellite validation / calibration
  - modeling
  - synergetic studies (combination with passive / active systems)

AERONET stations distribution

more then 250 stations in operation over the world



AERONET / PHOTONS at Kyiv

- **Site is in operation from end of Marth, 2008**
- **Location at Kyiv, Golosiiv forest, MAO NASU**

- Sunphotometer CIMEL CE 318-2 polarized model with 8 filters: 440, 670, 870 (3), 936, 1020 nm.
- Bandwidths: 10 nm at full width at half a maximum
- Components:
- Optical head with 2 collimators – Solar and Sky collimator,
- FOV = 1.2°.
- Automatic and autonomous;
- Tracking in zenith and azimuth planes, accuracy better than 0.1°
- The Sunphotometer calibration - standard AERONET protocol:

  solar irradiance ≈ ±1% (AOD ≈ ±0.01),

  sky radiance ≤ ±5%

Kyiv AERONET / PHOTONS site

Measurements procedure

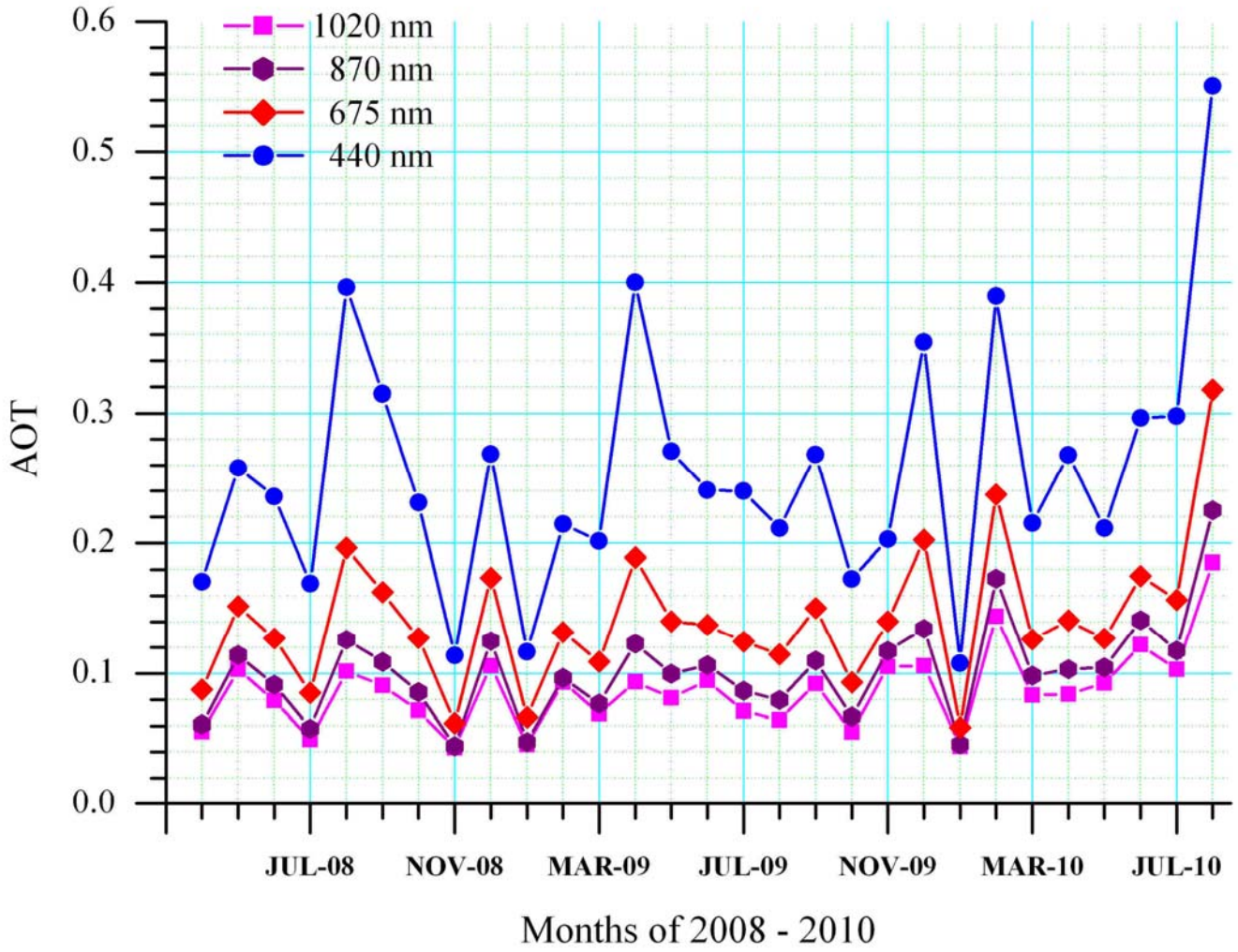
- Direct Sun irradiance measurements (Langley sequence) – air mass from m = 7, every m = 0.25 or m = 0.5;
- Direct Sun irradiance measurements (standard aerosol measurements) - every 15 min between m = 2 am and m = 2 pm;
- Sky radiance measurements (Langley sequence) – air mass from m = 7, every m = 0.25 or m = 0.5;
- Sky radiance measurements (almucantar scanning) – m = 4, 3, 2,1.7; then hourly between 9h am and 3h pm;
- Sky radiance measurements (Principal plane) - hourly between m = 3 am and m = 3 pm

Data may be obtained from http://aeronet.gsfc.nasa.gov/...Kyiv site

Spectral AOT (fine and coarse modes)

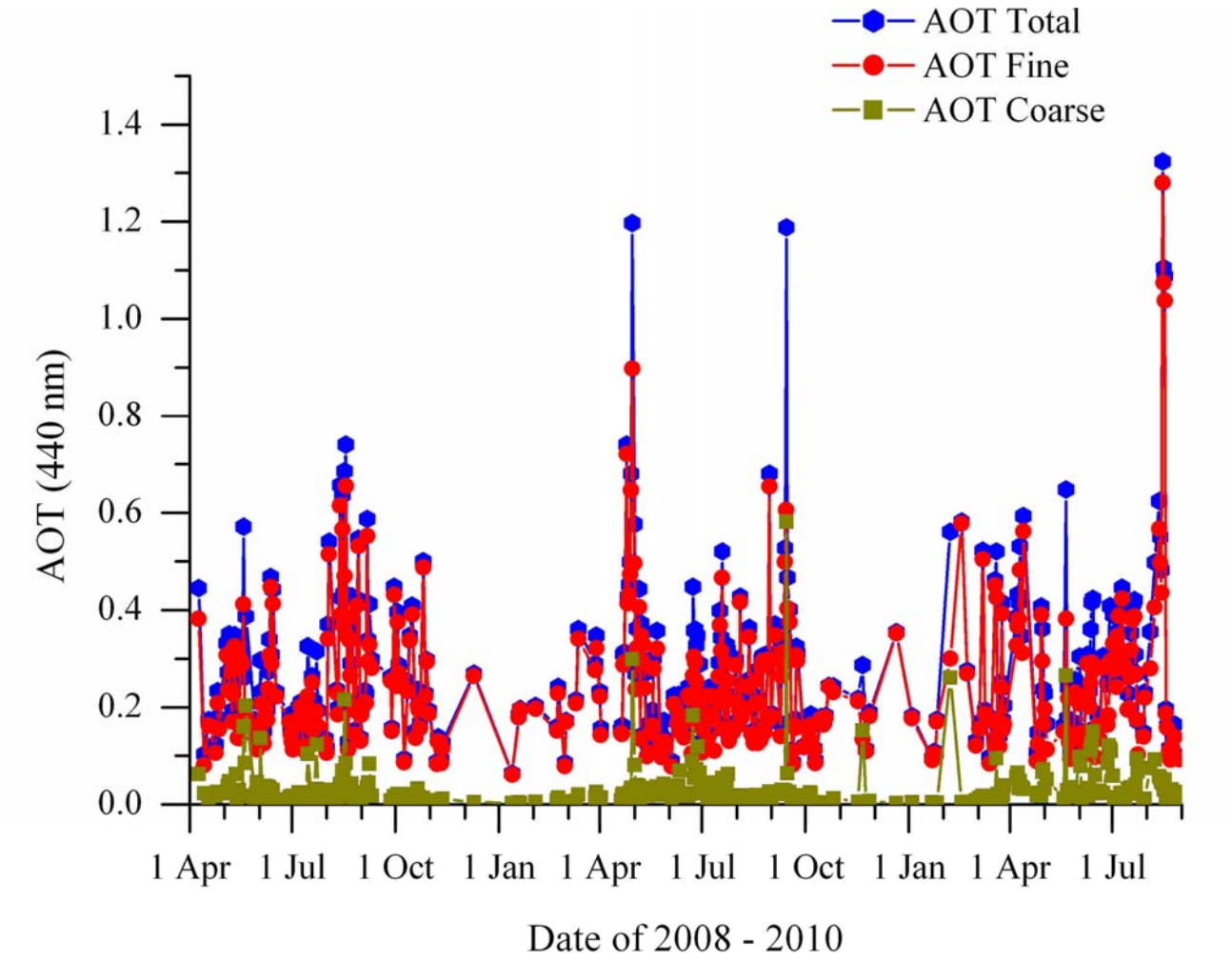
Apr. 2008 – Aug. 2010 (monthly averaged, Level 1.5)

ΔAOT ≈ 0.01

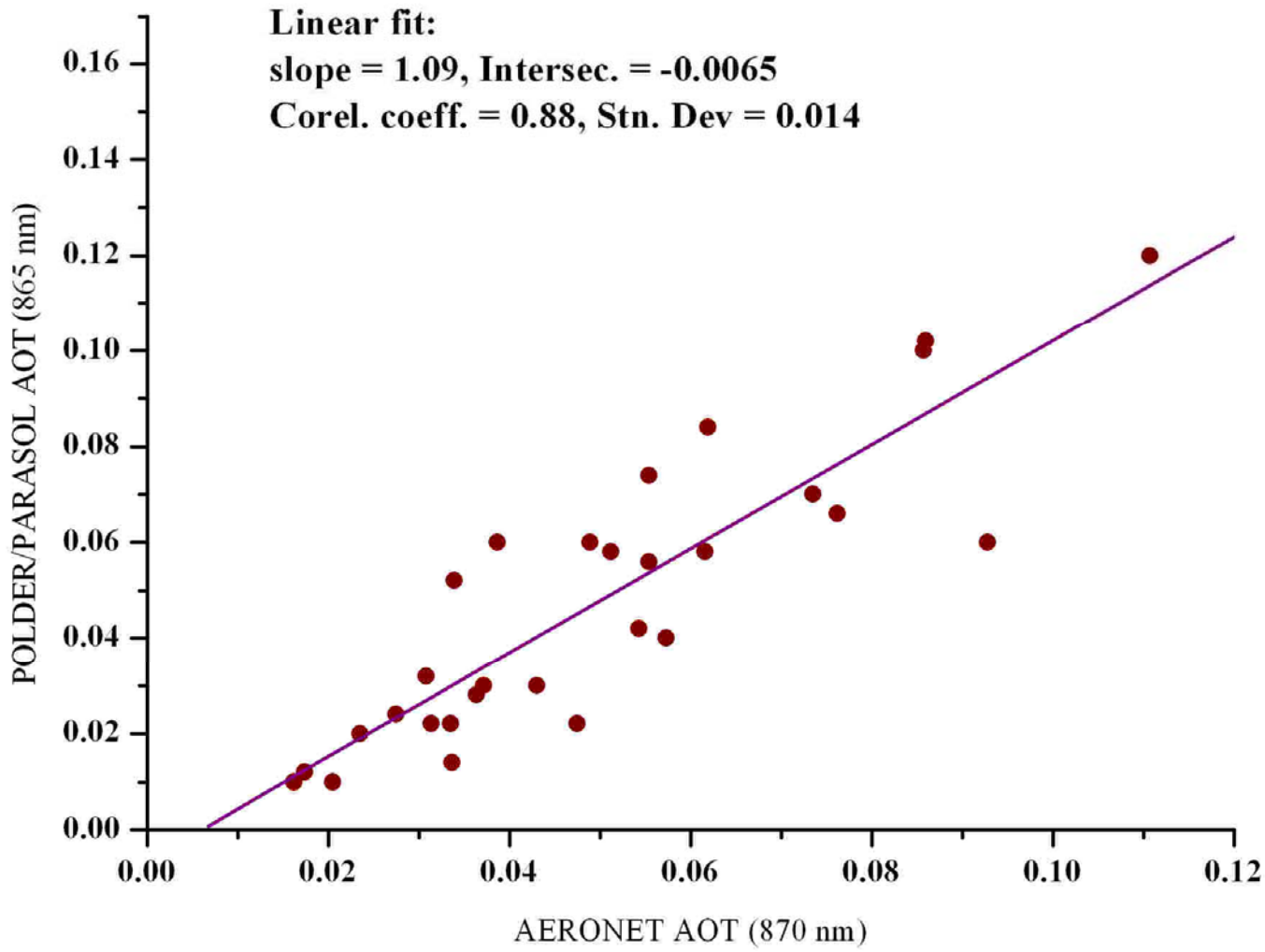


Site and time of observations	Range of AOT $\tau(\lambda,nm)$	Averaged AOT $\tau(\lambda,nm)$	Range of Angström parameter α	Aerosol type
Kyiv, 2008-09	$0.76 \geq \tau(440) \geq 0.06$	$\tau(440)=0.23$	$2.1 \geq \alpha \geq 0.4$	-
Greenbelt,USA, 1993 – 2000	$1.0 \geq \tau(440) \geq 0.1$	$\tau(440)=0.24$	$2.5 \geq \alpha \geq 1.2$	Urban-industrial and mixed
Crete-Paris, 1999	$0.9 \geq \tau(440) \geq 0.1$	$\tau(440)=0.26$	$2.3 \geq \alpha \geq 1.2$	- " -
Mexico City 1999 – 2000	$1.8 \geq \tau(440) \geq 0.1$	$\tau(440)=0.27$	$2.0 \geq \alpha \geq 0.4$	- " -
Amazonian forest, 1993 – 1999	$3.0 \geq \tau(440) \geq 0.1$	$\tau(440)=0.74$	$2.1 \geq \alpha \geq 1.2$	Biomass burning
African savanna, 1995 – 2000	$1.5 \geq \tau(440) \geq 0.1$	$\tau(440)=0.38$	$2.2 \geq \alpha \geq 1.4$	Biomass burning
Boreal forest, 1994 – 1998	$2.0 \geq \tau(440) \geq 0.1$	$\tau(440)=0.40$	$2.3 \geq \alpha \geq 1.0$	Biomass burning
Dalanzadgad, Mongolia, 1997-2000	$0.25 \geq \tau(550) \geq 0.05$	$\tau(550)=0.13$	$1.94 \geq \alpha \geq 0.61$	Desert dust
Lanai, Hawaii 1995-1999.	$0.12 \geq \tau(550) \geq 0.06$	$\tau(550)=0.08$	$0.96 \geq \alpha \geq 0.56$	Oceanic
San Nicolas Island, 1998-2000	$0.13 \geq \tau(550) \geq 0.04$	$\tau(550)=0.08$	$1.10 \geq \alpha \geq 0.78$	Oceanic

AOT 440 nm total, fine and coarse modes
Apr. 2008 – Aug. 2010
(daily averaged, Level 1.5)



POLDER / PARASOL and Kyiv AERONET sunphotometer AOT(865 nm) comparison



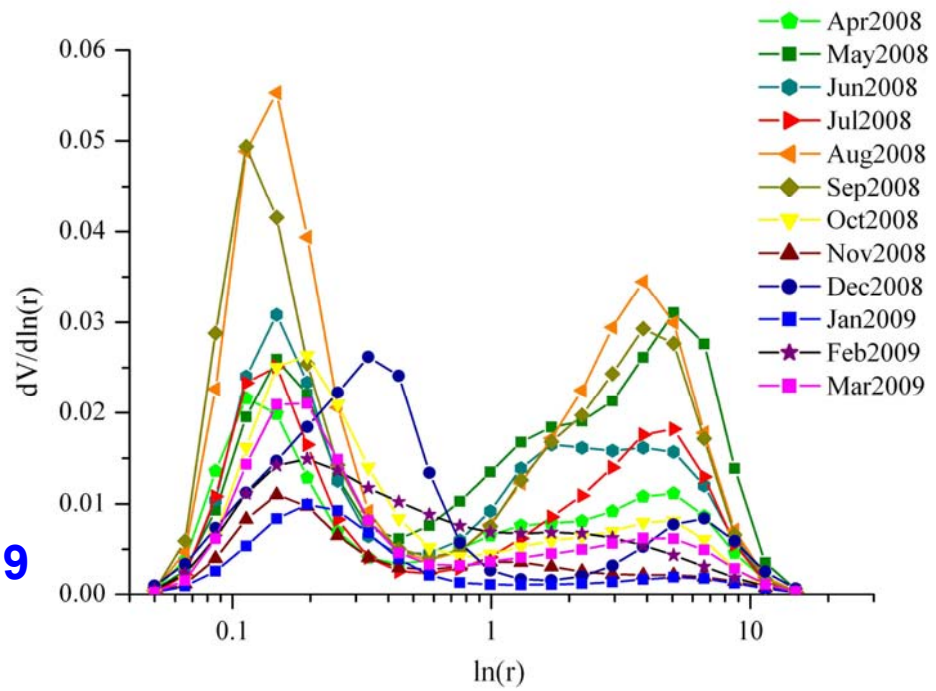
Aerosol particles volume size distribution

monthly averaged, Level 1.5

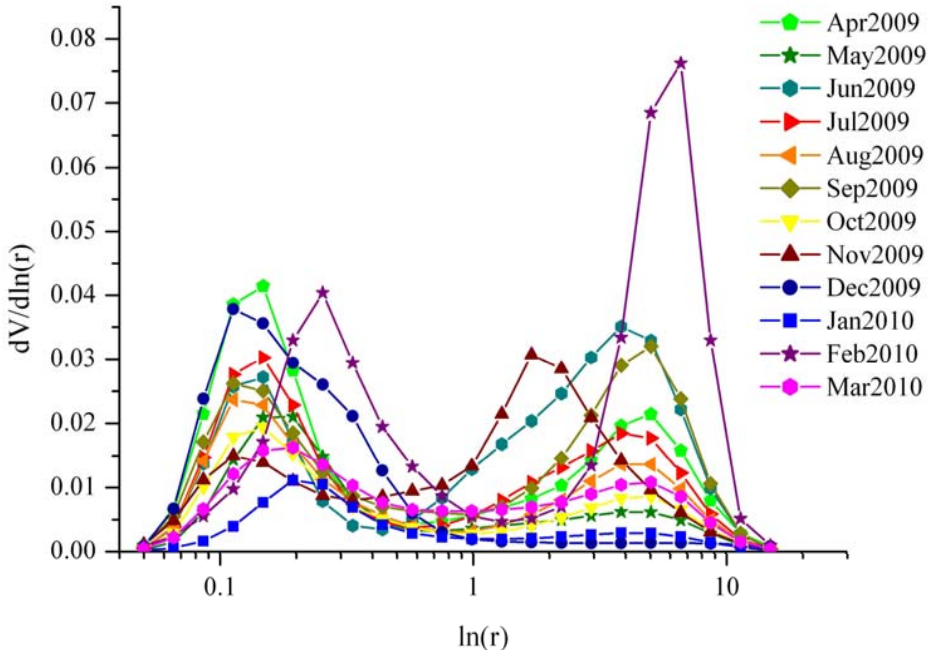
bimodal log-normal model

Errors: ≈±10% at max
≈±35% at min

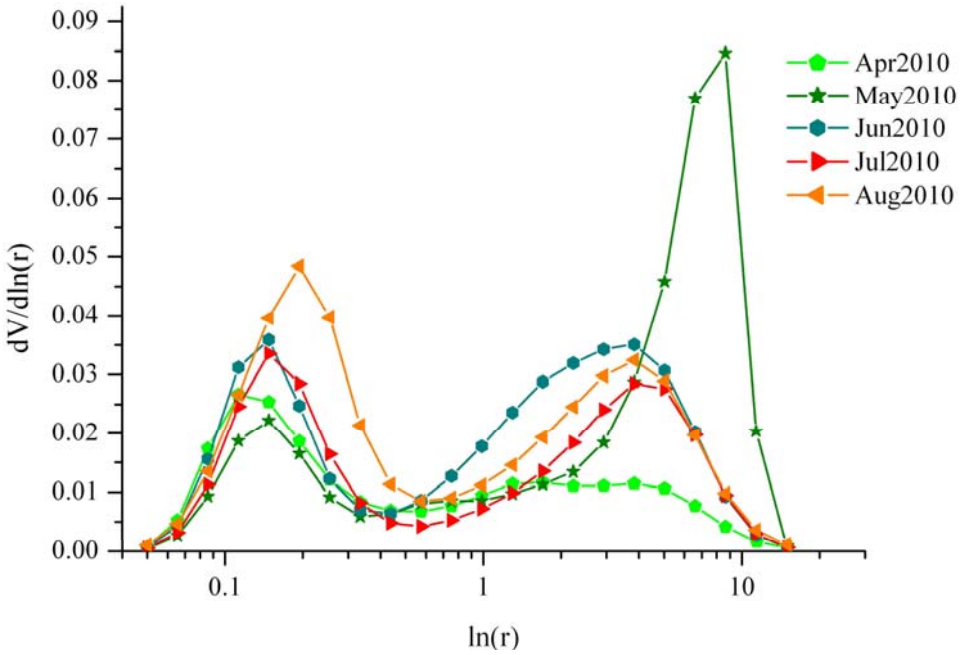
Apr. 2008 – Mar. 2009



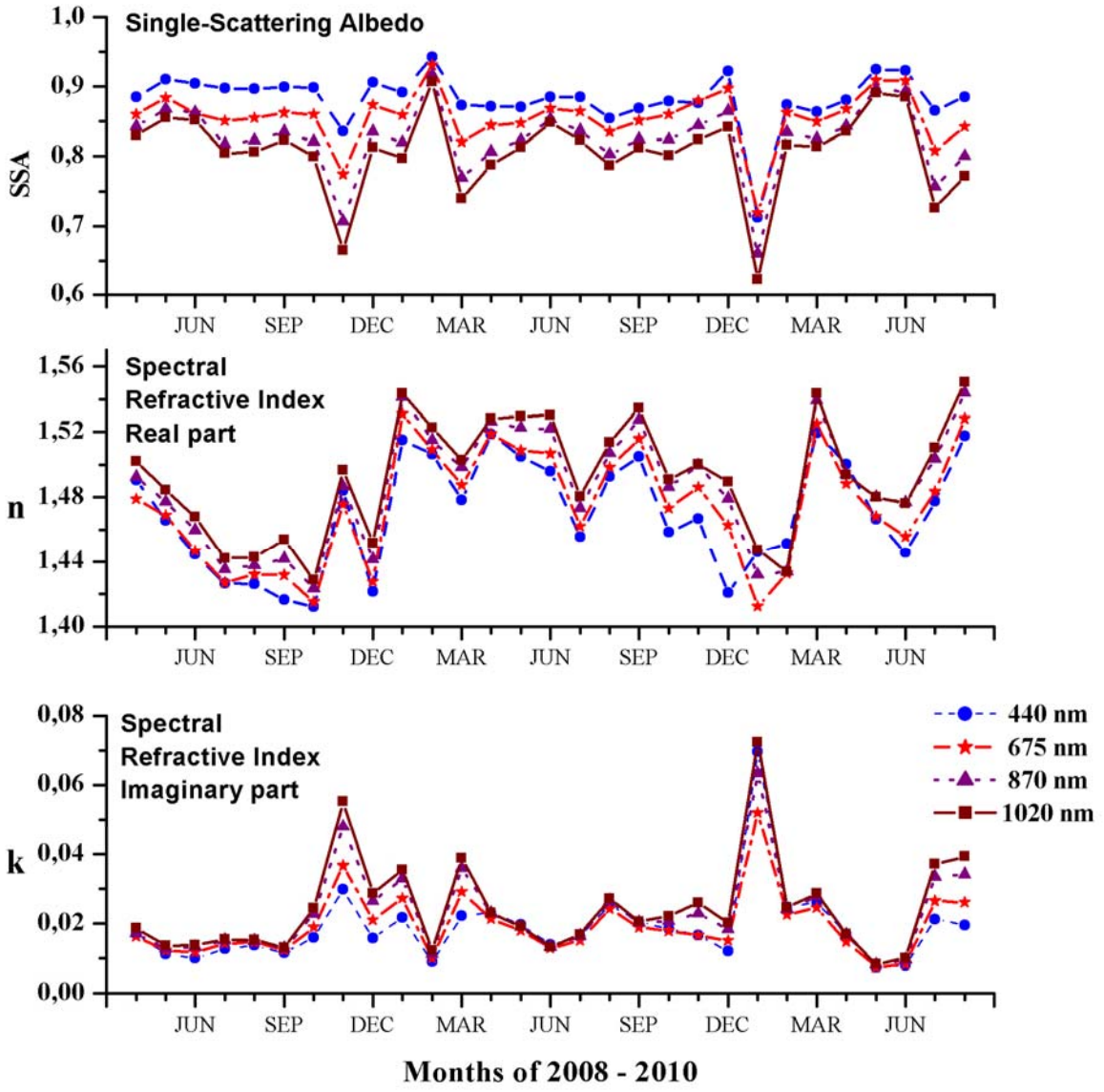
Apr. 2009 – Mar. 2010



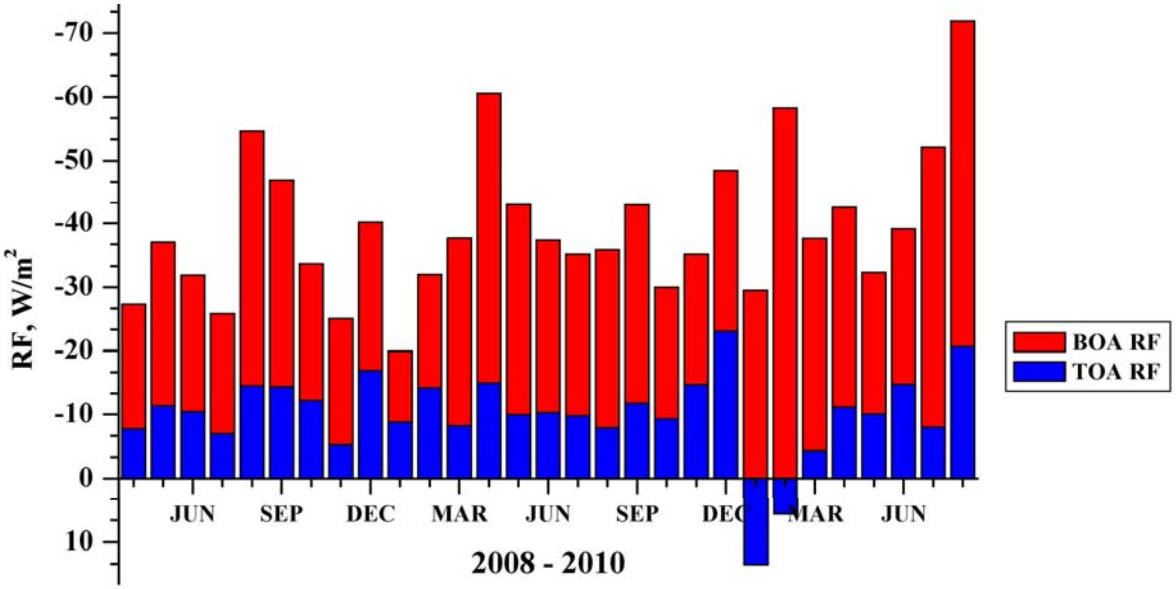
Apr. 2010 – Aug. 2010



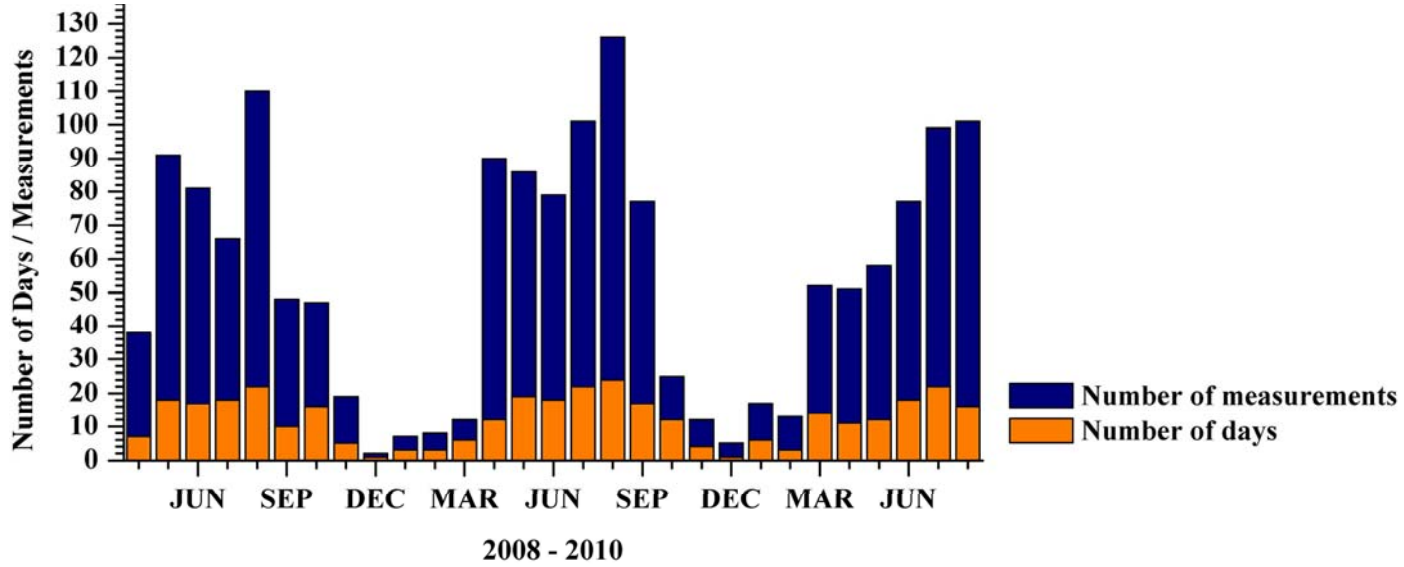
Aerosol particles optical properties during 2008 – 2010 (monthly averaged)



Radiative forcing at BOA and TOA at Kyiv site



Measurements statistics at Kyiv site

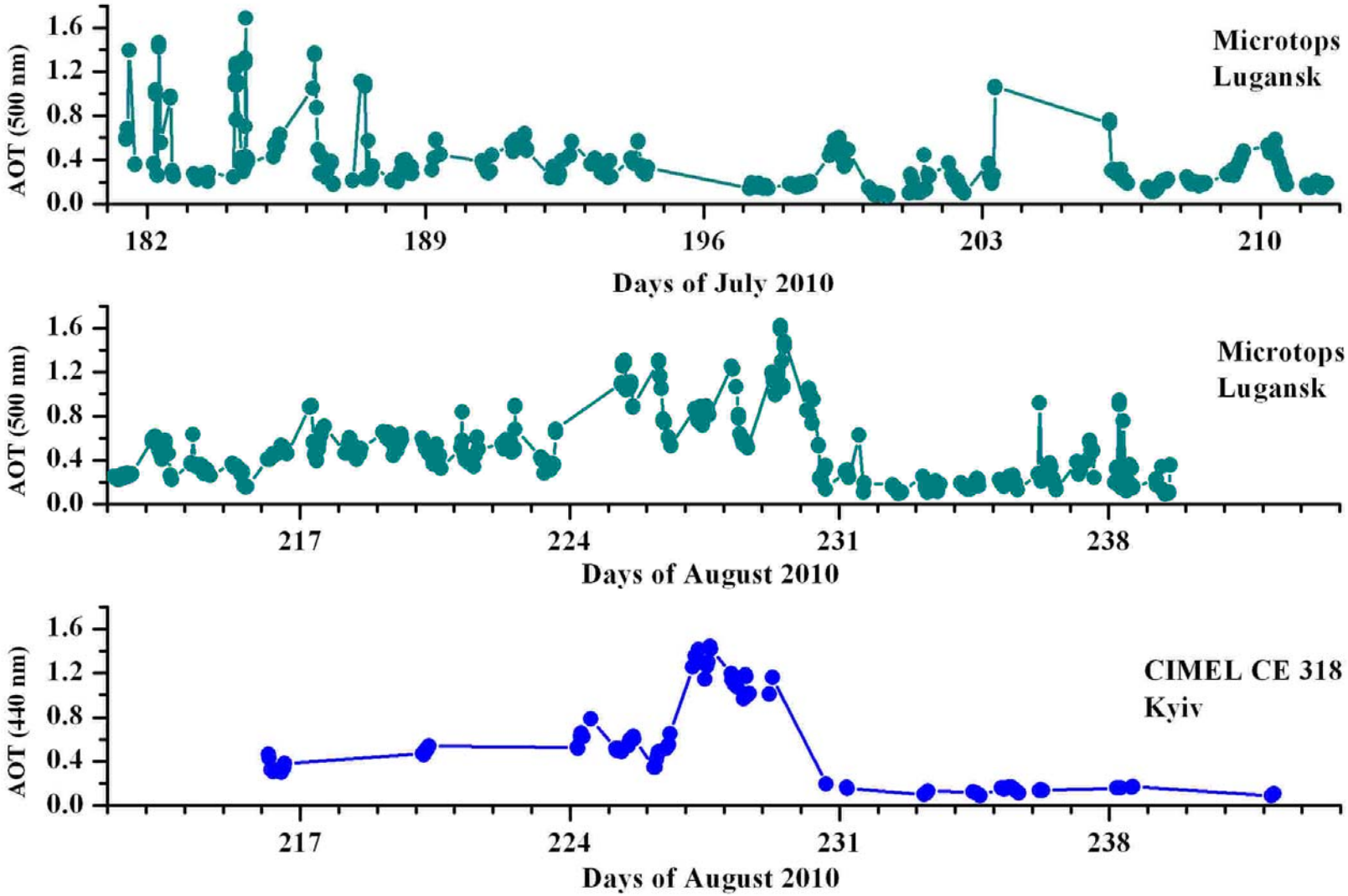


AOT Measurements in Lugansk with Microtops Sunphotometer July – August, 2010 (V. Voytenko)

- Optical channels:
- 440 ± 1.5nm
- 500 ± 1.5nm
- 675 ± 1.5nm
- 870 ± 1.5nm
- 936 ± 1.5nm
- Δλ = 10.0 ± 1.5nm FWHM

•Angle of view 2.5°
•Dynamic range > 3*105
•Precision: 0.001 AOT; 0.01cm Precip. Water vapor thickness
•Non-linearity Max. 0.002%

MICROTOPS sunphotometer AOT(500 nm) measurements at Lugansk during July – August 2010 (daily averaged data)



Plans

- Development the technique of comparison AERONET and satellite instruments (POLDER, MODIS etc.) data.
- To buy new CIMEL sunphotometer and incrporate it to AERONET, to perform aerosol properties measurements at several regions of Ukraine with CIMEL sunphotometer simultaneously with GLORY satellite mission during 2011 – 2012, and to perform comparison CIMEL and APS/GLORY data (CRDF grant).
- To install another AERONET/PHOTONS site in Ukraine (probably in South-East region).
- Our dream – to install a net of several (5 - 7) sunphotometers at different regions of Ukraine as a part of AERONET/PHOTONS for long time aerosol monitoring – governmental help need.

The work was supported by

Ministry of Education and Science of Ukraine, Agr.No.M/68-2009

EGIDE and LILLE-1 TOTECAT / MARIE-CURIE EUROPEAN PROJECT, France.

Дякую за увагу!

Thanks for your attention!

GLOBAL AND REGIONAL CLIMATE CHANGES
Kyiv, Ukraine,16-19 November 2010