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Atmospheric Chemistry and Physics Discussions

Interactive comment on "Variability of aerosol properties over Eastern Europe observed from ground and satellites in the period from 2003 to 2011" *by* A. Bovchaliuk et al.

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Dear Referee #1

We appreciate your useful comment and proposed corrections. We thank for your valuable recommendations. Considerable changes are made in article according your suggestions and questions. The reorganization of first two sections (merging and reworking) was applied for better perception of the material. We make the pictures more readable and Fig. 6 was reworked similar to Fig. 5. We corrected the figures and added new text according your suggestions (see below).

All the best

On behalf of authors

Andrii Bovchaliuk

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Answers to specific comments:

Pg 2642:

Ln 5-8: it is not clear if you refer to satellite retrieval, Aeronet, or both?

We refer to both retrievals, text corrected: after words at line 8 "from 0.3 to 0.5" follows "according to both retrievals."

Ln 10, 13: "first peak observed" and "second peak" is not very descriptive. text corrected:

"The spring peak observed in April–May is the result of solitary transportation of Sahara dust in the atmosphere over Eastern Europe, infrequent agricultural fires, transportation of sea salt aerosols by southern winds to Ukraine and Moldova from the Black and Azov Seas. The autumn peak in August–September is associated with forest and peat wildfires, considerable transportation of Sahara dust and presence of soil dust aerosols due to harvesting activity."

Ln 15: "presence of soil dust aerosols due to harvesting activity"; citations needed on pg 2649; ln 21-23 and pg 2658; ln 9-11.

citations added (Manders et al., 2010; Aan de Brugh at al., 2011)

Ln 20-26: needs to be revised and condensed

text revised and condensed:

"The comparison of the AOT fine mode particles with radius <0.3 μm derived by standard POLDER/PARASOL algorithm from reflected polarized radiances with those recomputed from AERONET inversions was performed over several AERONET sites.

The correlation coefficients for POLDER/ AERONET AOT retrievals comparison are equal 0.78 for Moscow site, 0.76 – Minsk, 0.86 – Belsk, 0.81 – Moldova (period 2005–2009), 0.93 – Kyiv, and 0.63 for Sevastopol sites (2008–2009)."

Pg 2643

Ln 4-4: What is meant by “stable atmospheric conditions”? Clear skies, no aerosol plumes, etc.?

text corrected:

"The AOT and single scattering albedo retrieved by the algorithm over Kyiv were compared with the closest AERONET retrievals within 30 min of satellite overpass time and cloudless day."

Ln 10-11: Forest fires may not always be natural and caused by anthropogenic activities text corrected:

"They are produced both by natural sources, such as forest wildfires, sea spray, desert sandstorms and volcanic eruptions, and by human activities, such as industry, fossil fuel and biomass burning, deforestation and others (Chin et al.,2009)."

Ln. 20-21 and 25-26: these phrases are redundant and discussion in ln 20-27 should be condensed.

text:

"Aerosol mass in the atmosphere comprises about $10-9$ of all air mass (the fraction of aerosol particles is20 smaller than $10-6$ in dusty air), which is by three-four orders of magnitude smaller than the mass fraction of water vapor (Seinfeld and Pandis, 2006). In spite of this fact, the role of aerosols in atmospheric processes is very important, especially in the formation of clouds and interaction with water vapor, since in the atmosphere without condensation nuclei a cloud can form only at high altitude due to condensation on the ions. The mass of water vapor per unit volume of air is by several

orders of magnitude greater than the mass of aerosol particles, and this has a considerable effect on the variability of aerosol optical characteristics (Chin et al., 2009). Almost at all wavelengths the coefficients of aerosol extinction, scattering and absorption are approximately of the same order as for all the atmospheric gases, but aerosol optical characteristics are much more variable both in time and space. Aerosols affect Earth’s energy budget by scattering and absorbing radiation and by modifying the amounts as well as microphysical and radiative properties of cloud cover (IPCC, 2007)."

replaced by:

"Aerosol mass in the atmosphere comprises about $10-9$ of all air mass, but the role of aerosols in atmospheric processes is very important, especially in interaction with water vapor and the formation of clouds. Also solar radiation scattering by aerosol particles is very important for terrestrial atmosphere energetic balance (Seinfeld and Pandis, 2006; Chin et al., 2009). Almost at all optical wavelengths (from near UV to near IR radiation) the coefficient of aerosol extinction, scattering and absorption are approximately of the same order as for all the atmospheric gases, but aerosol optical characteristics are much more variable both in time and space. Therefore aerosols effect on the Earth’s energy budget is determined with large uncertainties (IPCC, 2007)."

Pg 2644:

Ln 4 What is meant by “modifying the amounts?” What are you referring to? text corrected (see previous correction above for Ln. 20-21 and 25-26)

Ln 6-11: Need to include relevant references for networks and satellite observations here and throughout introduction and analysis sections.

references included:

"AERONET (Holben et al. 1998); SKYNET (Takamura et al. 2004; http://atmos.cr.chiba-u.ac.jp/index.html); GLOBE (Finarelli, 1998; Boersma and De Vroom, 2006; http://www.globe.gov/)."

Ln 15-16: Be more descriptive on why Lidar is different than passive remote sensing techniques and provide references.

new text included (ln 15-29)"

"The passive remote sensing techniques are based on the measurements of solar radiance scattered by terrestrial surface and atmosphere whereas active techniques use radiance generated by special devices such a laser (lidar sounding devices) and scattered by atmosphere. The passive ground-based measurements, realized by sunphotometers networks mentioned above, cannot be used to determine the vertical distribution of aerosols in the atmosphere. They refer to the average aerosol properties along extended vertical columns, usually from the ground to a height of several kilometers (Kokhanovsky, 2008). Information on the vertical aerosols distribution is provided by lidars. Lidar emits a monochromatic beam in the direction from which aerosol properties are required. The backscattered photons can be classified with respect to their arrival times, which also give the distance to the observation volume. This makes it possible to study the aerosol vertical or horizontal distribution and its dynamics (Porter et al. 2000; Kokhanovsky, 2008). Also, lidar systems can be used to study aerosol at night atmosphere (Huang et al., 2008; Raj et al., 2008). Regional and global lidar networks are created to study aerosol evolution in terrestrial atmosphere, such as EARLINET or MPLNET (Amodeo et al., 2006; Welton et al., 2006). CALIOP instrument onboard the CALIPSO space craft is an example of space borne lidar systems realization (Winker et al., 2009; Schuster et al., 2012).

The satellite techniques enable us to derive the aerosol distribution over the globe by scanning the atmosphere and surface along and across satellite ground tracks at specific overpass time. There are several data sets of global aerosol properties over land and oceans available from various satellite sensors, for example MODIS, MERIS, MISR, AVHRR, POLDER,TOMS and OMI, that cover rather long time span from months to decades (Kinget al.,1999; Mishchenko et al., 2007; Kaufman et al., 2002). The ground-based technique also allows the continuous accumulation of data

over long periods of time (years and decades) but only at specific observational locations. From data collected by both ground-based and satellite techniques, aerosol properties are estimated as the parameters of models solving the inverse problem (King et al., 1999; Dubovik et al., 2002, 2011; Kokhanovsky and de Leeuw, 2009). The extreme complexity and variability of Earth's atmosphere-surface system are the main source of errors when retrieving aerosol parameters from satellite data. Therefore, the retrievals of aerosol parameters from satellite remote measurements are more complicated than those from ground-based observations, so extensive validation of satellite retrievals is required. As a rule, the data of ground-based sunphotometers network AERONET are used as references for validation (Lee et al., 2009; Li et al., 2009; Mishchenko et al., 2010; Schuster et al., 2012). In the paper we analyze and compare the results of the aerosol distribution and variability over Eastern Europe region obtained by ground-based sunphotometers and satellite data collected in 2003–2011 by POLDER-2 and POLDER-3 instrument."

Ln 22-23: This statement is not very clear. Satellites may also provide long term records. I think you are trying to say the "ground based remote sensing systems provide high temporal resolution at specific locations while satellites provide greater geographic resolution at low temporal resolution."

text corrected, see above the comment for Ln 15-16

Ln 28-29: References needed on synergism of ground- and space- based remote sensing data.

text corrected, see above the comment for Ln 15-16

Pg 2645

Section 2: The section is not very well organized and should significantly be revised. Perhaps one or two figures will help focus the discussion and orient the reader? You could, for example, use data from AERONET to show changes in aerosol loading and

particle size at some of the sites in the regions. In that case, you may need to discuss AERONET data first and then analyze the aerosol dynamics.

Section partly reorganized and will be rewritten according comment.

For Ln 11-21 new text:

"The field of interest in this work is Eastern Europe region with latitudes from 40°Nto 60° N and longitudes from 20° E to 50° E. Authors of preceding analysis (Gileset al., 2012) considered this region as source of urban-industrial aerosols in concordance with general aerosol types classification (Dubovik et al., 2002). Indeed, there are many existing and potential aerosol pollution sources here: transport, intensive agriculture, heavy industry, metallurgy, as well as exploitation of open mines. Besides, this region is characterized by numerous forest, grassland and peat fires, and also we can consider the region as source of biomass burning aerosol (http://www.ceip.at/). For example, the forest and peat wildfires in Moscow Region in September 2002 caused increase of AOT and transportation of aerosols by air masses to Moldova through Belarus and Ukraine (Aculinin et al., 2004; Eck et al., 1999). Moreover, ten cases of very high AOT value during 2001–2005 (mainly in August) were observed with UV-Raman lidar over Thessaloniki, Greece (Amiridis et al., 2009). These events were identified as agricultural burning across Russia in the latitudinal belt between 45° N and 55° N, as well as in Eastern Europe (Baltic countries, Belarus and Ukraine)."

Ln 2: Why are satellite remote measurements “problematic”; please be more descriptive and add references.

text corrected and references added, see above the comment for Ln 15-16

Ln 4-7: This transition statement does not state well the comparisons made with POLDER/POLDER-2 satellite measurements.

corrected, sentence deleted.

Ln 10-11: delete “where a lot of natural and anthropogenic aerosol sources are located”

deleted

Ln 12-14: References missing

added link to EMEP Program resource http://www.ceip.at/

Ln 21-24: Smoke characteristics also depend on fuel types and combustion phases.

Will be included in the text

Ln 25: State why the “particle size is likely to increase with the age of the advected air mass”.

The sentence (Ln 25-26) deleted

Pg 2647:

Ln 14: Wavelengths in AERONET range from 340 nm to 1640 nm. A statement should be made regarding the uncertainty of AERONET spectral AOD measurements (+/-0.01 to +/-0.02) with the highest uncertainty in the UV (Holben et al 1998; Eck et al 1999).

The sentence will be inserted in the text:

"The uncertainty of AERONET spectral AOD measurements varies from $\pm$ 0.01 to $\pm$ 0.02 with the highest uncertainty in the UV range (Holben et al 1998; Eck et al 1999)."

Ln23-24: Should include Holben et al. 1998, 2006, Smirnov 2000, Dubovik et al 2002, 2006.

included

Pg 2649:

Ln3: Figure 1 is very difficult to read and should be revised. In the PDF, I need to zoom to at least 400% to evaluate the charts.

Using format as shown on Fig. 1 one can see the peaks simultaneously at all stations for the entire period. That is why this format was chosen.

Ln 6-10: Needs reference. Perhaps “banned” (instead of illegal) would be more appropriate here? The months “April-May” are not clearly visible on the graph.

Text changed replacing “banned” instead of "illegal"

The months “April-May” and “August-September” on the graph will be allocated for better visualization and understanding. Reference added in the text.

Ln 14-15: It should be indicated that these estimates are from “model simulations”. corrected

Ln 15-18: References are needed here regarding the transport of sea salt aerosols to Moldova which is not immediately convincing given the 160 km distance from the Black Sea. SSA spectra at Moldova in April 2003 are quite absorbing (0.91 to 0.86 from 440 nm to 870 nm), hence, sea salt may not be so significant. Supporting evidence (e.g., particle sphericity) is also needed to show it is not partly Saharan dust which can also occur in the spring. Figure 2 and 3 should show the number of retrievals for each year to understand the significance of the average plots. Also, how do you explain the coarse mode peak at Moscow?

Reference and explanation will be included in the text, citation added: (Manders et al., 2010; Aan de Brugh at al., 2011). Figure 2 and 3 reworked for showing the number of retrievals for each year to understand the significance of the average plots.

Pg 2650

Ln 1-29: The analysis is very difficult to read and is not informative. These paragraphs should be rewritten to give scientific analysis and not dictation of the data charts.

The text significantly corrected according comment to provide scientific analysis.

Pg 2651

Ln 3-6: The NCEP analysis is quite old 1961-1990. More recent data (through 2013) are available using the same reanalysis package and resolution (6 hourly, 2.5 degree).

In addition, more advances in data assimilation have been made since the 1990s (including improved spatial resolution) and information on these reanalysis data sets can be found at the NCAR Climate Data Guide web site.

Will try to renew this analysis.

Ln 6-14: A figure is not provided for the analysis indicated. A figure showing the wind field or back trajectory analysis should be useful here.

Text will be corrected.

Pg 2652

Ln 10: What wavelength range do you refer to for Angstrom exponent?

Angstrom exponent is calculated for 670 nm and 865 nm wavelengths. Inserted in the text.

Pg 2653

Ln 1: Why “except 2004”?

Because POLDER/PARASOL not received the data during 2004.

Ln 2: Figure 4 is difficult to follow with so many plots the authors point seems to be lost. Also, it is confusing having differ scales in different images. Ln 20: Why is it “problematic”?

The explanation of key point from Figure 4 will be inserted in the text. The sentence (Ln 20) will be rewritten with additional reference.

Ln21-25 Listing of cities is not very helpful and should not be in the main body. Please delete or put in a table. Perhaps you can show AOD data over each city and place in a temporal plot?

Corrected.

Pg. 2654

Ln 5: “aerosol radius cutoff” Are you referring to r<0.03um or another threshold? Please state.

Explained in the text in details.

Ln 21-23: What methodology did you use to determine the fine mode aerosols as computed by AERONET? Did you run your own algorithm or extract the information from AERONET products? More details are needed here.

Details how we determine the fine mode aerosols inserted in the text.

Ln 25-26: Are zero values from POLDER or AERONET? Why would AERONET Level 2 have zero values for AOT?

POLDER sometimes produces zero values in some cases (lack of phase angles, cloudiness, etc), so we exclude zero values from analysis. AERONET Level 2 haven’t produce zero values for AOT. Text will be corrected.

Ln 27: What is meant by “recomputed”? You will need to provide the equation(s) or reference to the model used to recompute AERONET data for AOD 870nm with radius less than 0.3. Do you use AERONET Level 2 or another data level?

We recomputed results with AERONET Level 2 data and provide details.

Pg. 2655

Ln 19 (17): “the fine aerosol mass concentration is typical for this territory” This statement is not clear. Please provide reference and/or further explanation.

The reference included

Ln 21-29: A distinction should be made here that the “new” algorithm does not have the r<0.03 (should be 0.3) um limitation (at least Dubovik 2011 does not show this).

Yes, in the text included that "new" algorithm does not have the r<0.3 um limitation and

retrieves characteristics for all particles.

Pg 2656

Ln 28-29: The 2-hour period is quite long. Why is the period so long? Please provide references as to why this is a technique used for POLDER collocations with ground sites.

The data has been recomputed with period 30 min

Pg 2657

Ln 1: What does it mean the atmosphere usually changes in 1-2 hours? What atmospheric property or condition are you referring to? Please provide a reference.

The data has been recomputed with period 30 min. The sentence (Ln 1:) deleted.

Ln 5-15: In Figure 6, the data show very low SSA values for both POLDER and AERONET. A check of the AERONET Level 2.0 product shows SSA above 0.8 at 440 nm (see plot 1). How do you obtain values below? Do you use Level 1.5 AERONET data instead (see plot 2)? Only AERONET Level 2.0 data should be used for publications and matchups with satellite data. It also should be stated that AERONET SSA has uncertainty of +/-0.03 (Dubovik et al. 2002). Temporal plots are not very revealing of the performance of the algorithm. Perhaps you can provide the scatter plot of POLDER and AERONET (similar to Figure 5) with uncertainty intervals for POLDER retrievals.

Data have been recomputed with AERONET Level 2

Pg. 2658: The conclusions section does not provide many conclusions but a summary of the paper. Please focus on key results and present the conclusions appropriately.

Conclusions will be rewritten according your comment when the finat text will be arranged.

Pg 2659:

Ln. 9: What is meant by “low loading”? Is this an AOD threshold or another measure? Acknowledgements: Authorship should be offered to AERONET PIs for which data has been use and if declined should be at least acknowledged by name.

Sentence "and presents the results over Kyiv in the conditions of low loading of anthropogenic aerosols" rewritten as "and presents the results over Kyiv site."

Acknowledgements corrected according AERONET rules and new text inserted:

"We thank B. Holben (NASA-GSFC) for managing the framework of the AERONET program and the sites, we appreciate effort in establishing and maintaining AERONET sites by PIs: P. Sobolewski and A. Pietruczuk (the Belsk site), A. Chaikovsky (the Minsk site), N. Chubarova (the Moskow site), and A. Aculinin (the Moldova site)."

Technical Corrections

Pg 2643:

Ln 2: “accomplished”; do you mean “evaluated”

corrected

Pg 2647:

Ln 16: Probably not necessary to provide a specific web address (address to www.cimel.fr should be appropriate)

corrected

Ln 18: Change “vapour” to “vapor”

corrected

Pg. 2654

Ln 24- “tranfer” should be “transfer”

corrected

Interactive comment on Atmos. Chem. Phys. Discuss., 13, 2641, 2013.

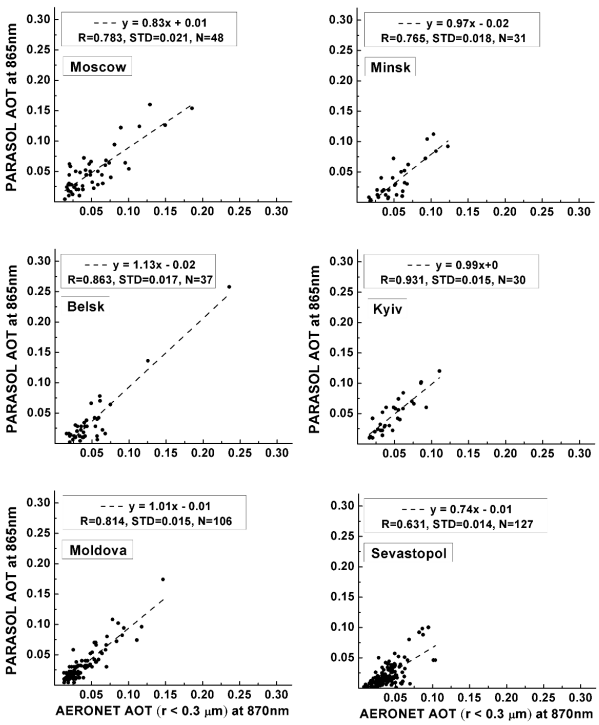
y = 0.83x + 0.01
R=0.783, STD=0.021, N=48
Moscow
y = 0.97x - 0.02
R=0.765, STD=0.018, N=31
Minsk
y = 1.13x - 0.02
R=0.863, STD=0.017, N=37
Belsk
y = 0.99x+0
R=0.931, STD=0.015, N=30
Kyiv
y = 1.01x - 0.01
R=0.814, STD=0.015, N=106
Moldova
y = 0.74x - 0.01
R=0.631, STD=0.014, N=127
Sevastopol
PARASOL AOT at 865nm
AERONET AOT (r < 0.3 μm) at 870nm

Fig. 1.

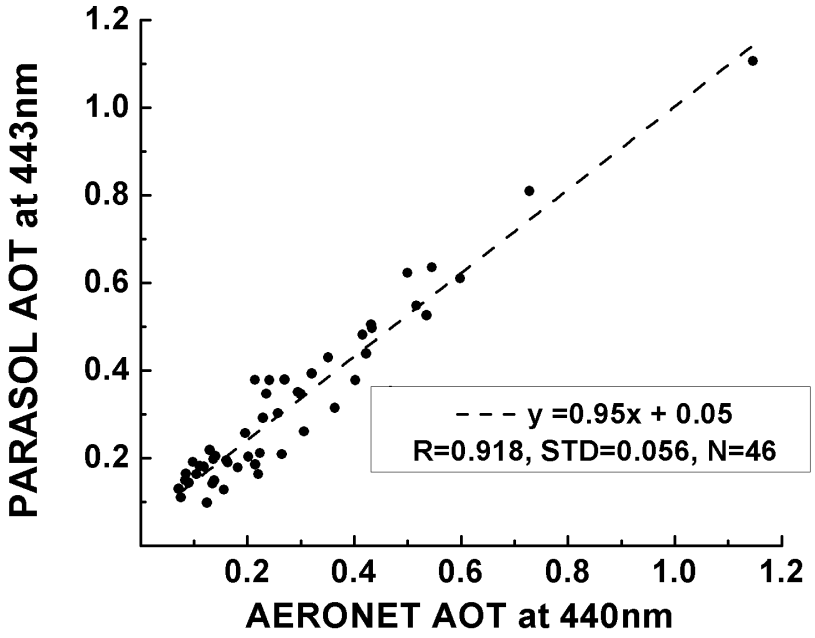
y =0.95x + 0.05
R=0.918, STD=0.056, N=46
PARASOL AOT at 443nm
AERONET AOT at 440nm

Fig. 2.

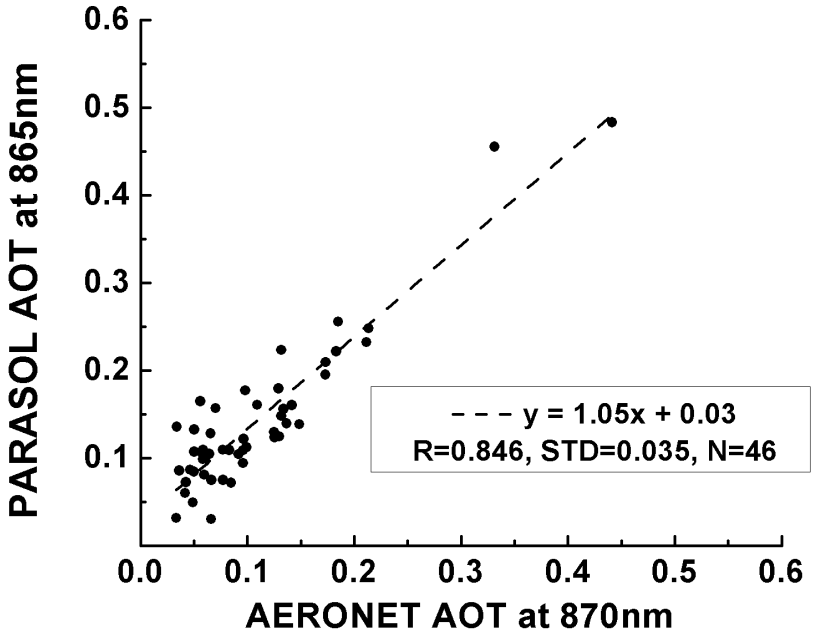
PARASOL AOT at 865nm
AERONET AOT at 870nm
– – – y = 1.05x + 0.03
R=0.846, STD=0.035, N=46
0.0
0.1
0.2
0.3
0.4
0.5
0.6

Fig. 3.

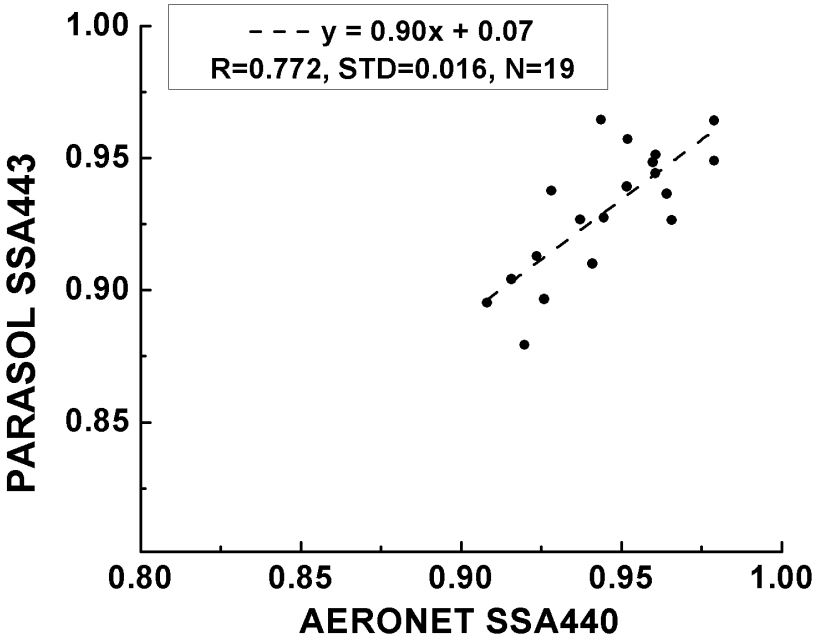
PARASOL SSA443
AERONET SSA440
– – – y = 0.90x + 0.07
R=0.772, STD=0.016, N=19
0.80
0.85
0.90
0.95
1.00

Fig. 4.

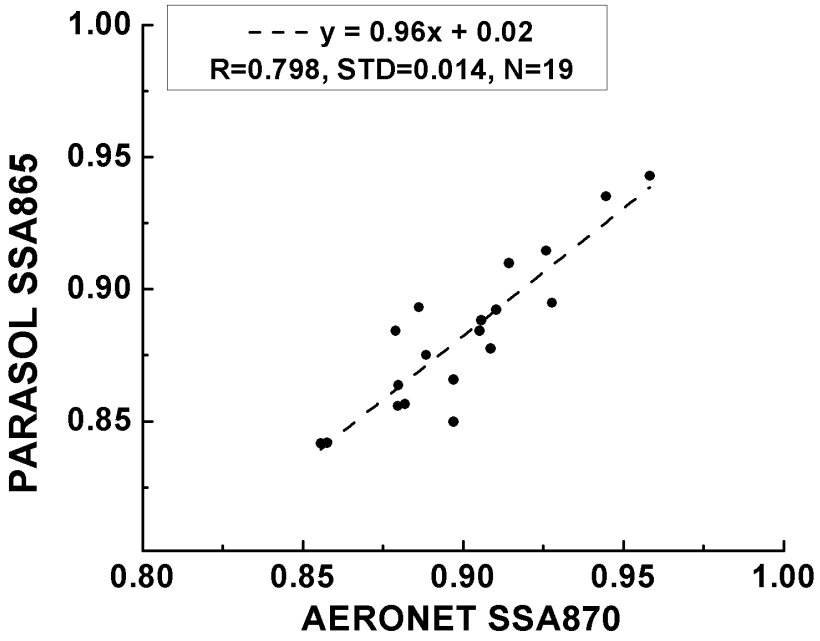
– – – y = 0.96x + 0.02
R=0.798, STD=0.014, N=19
PARASOL SSA865
AERONET SSA870
1.00
0.95
0.90
0.85
0.80
0.85
0.90
0.95
1.00

Fig. 5.