Version 3 AERONET processing – data product assessment for model validation and assimilation

AEROCOM Workshop, Steamboat Springs, Colorado, September 29 – October 3, 2014

AERONET (Aerosol Robotic Network)

 Alexander (Sasha) Smirnov

 presenter on behalf of the AERONET Project Leader
 Brent Holben
 and AERONET Team





Piers Sellers is on our side !

Friends in High Places

Principal Investigator: Brent Holben, NASA GSFC

Administrative Support and Shipping: Amy Scully

Instrumentation, Calibration & Maintenance: Mikhail Sorokin, Jon Rodriguez, Jason Kraft

Calibration & Quality Assurance: Thomas Eck, Alexander Smirnov, Joel Schafer

Data Processing, Database, & Web Support: Ilya Slutsker, David Giles

Scientific Research: Brent Holben, Thomas Eck, Alexander Smirnov, Aliaksandr Sinyuk, David Giles, Joel Schafer











AERONET - the ground based Satellite Over 20 Years of Observations and Research

15 May 1993

15 May

2014

The AERONET program is a federation of ground-based remote sensing aerosol networks established by NASA and LOA-PHOTONS (CNRS) and has been expanded by collaborators from international agencies, institutes, universities, individual scientists and partners.

AERONET provides a long-term, continuous public database of aerosol optical, microphysical, and radiative properties for aerosol research and characterization, validation of satellite measurements, and synergism with other databases.

- >7000 citations
- >400 sites
- Over 80 countries
- http://aeronet.gsfc.nasa.gov

AERONET Federated Calibration Center Coordination:

NASA GSFC (U.S.), PHOTONS (France), RIMA (Spain)

Elements of Data Structure

- Every data point is geo-referenced
- Every data point is time stamped for each processing or data management action
- Data files organized by instrument rather than location—Multiple sites
- Data Processing-Auto processing of all requests crash proof, faster processing
- Daily data indexing--small reprocessing jobs and up-to-date database
- Condensed data storage: levels stored by product

V3 development schedule

- Demonstrat Development and implementation (Ilya)
 - Level 1
 - O3 correction: use current V2 corrections
 - NO₂ correction Monthly diurnal high res: (Tom and Dave late August)
 - Reanalysis: (Dave ~Sept. 1)
 - · Temperature corrections (Iridian filters remain): (Ilya and Joel end of August)
 - Recalibrations: (Ilya and Tom late August)
 - Case study computations of AOD (use 70 cld clearning case studies Sept. team to evaluate)
 - Case study computations of sky radiance w/all corrections: Sept. team to evaluate
 - Case study computations of inversion products: Sept 15 (Ilya & Sinyuk)
 - Level 1.5
 - Cld screening: Completed, Algorithm defined.
 - Level 1.5v/2.0
 - QA instrument Check: Dave/Brent September
 - Pattern recognition: Ilya and Joel September
 - AOD comparisons to V2 results (mid Sept)
 - Inversions (Sinyuk)
 - Vector Code assessment (Sinyuk late August)
 - » Timing & Code selection
 - Quality assessments: SZA dependence, fine vs coarse, dynamic criteria (Sinyuk O SSA, size dist, etc Comparison to V2 results using V2 criteria (Sinyuk September)
 - SSA, size dist. etc Comparison to V2 results using V2 criteria (Sinyuk Sept
 Inversion products recomputation and assessment (October 1)
- AOD V3 database re-computation and assessment (Oct. 1)
- Inversion V3 re-computation and assessment (Nov. 1-??)
- Release of V3 Jan 1 2014 (rather optimistic)
- New product development



Brent's notes after team meeting on Aug 30, 2013

V3 QA Instrument checks first steps (refer to current weekly checks)

- Assess fraction of L2 retrieval database affected by:
 - Dark current check (Mikhail to provide written explanation of digital DC and effect on voltages)
 - Temperature jumps (±∆12°C/15 min)
 - Temperature limits (>55°C or <-30°C)
 - A or K voltages Too low (<0.3v) 4.8x and 5.x standard only
 - A/K Discrepancy (A> 10% of K) 4.8x and 5.x standard only
 - Evaluate A & K from PP & Almucantars
 - Asymmetric Almucantars/PP/Hybrids (scattering angle: 3 to 6°)
 - InGaAs vs Si 1020 nm (±∆ 0.06/m) AOD 5.x extended only
 - Retrieval limits (SSA₄₄₀ < 0.70?)
 - AOD Diurnal Dependence (refer to wkly check for details)
 - AOD triplet variability for each channel
 - Dual filter wheel/polar instrument?????

Current cloud screening algorithm



Advantages: Simplicity **Reliability Standardization** Proven to be operational **Treats all aerosol** types equally

Current cloud screening algorithm



Problems: Thin stable cirrus clouds Highly variable dust or smoke



attempt to modify AERONET cloud screening algorithm in 2006



Current cloud screening algorithm **Problems:** AOD data not cloud screened Thin stable AOD < -0.01 cirrus clouds **Highly variable** AOD range within a triplet is higher than MAX {0.02, 0.03*τ_a} dust or smoke Standard deviation (σ) of the τ_a (500 nm) Smoothness criterion for the entire day is less than 0.015 D<16 Find the term with the Check if any measurement

have exceeded the limits of $\tau_a(500 \text{ nm})\pm 3\sigma$ and $\alpha\pm 3\sigma$

Cloud screened database

Find the term with the maximum input in D and eliminate the maximum τ_a associated with it

Identified as cloudy or poor quality Air mass range will be extended from 7 to 7.

Compute number of potential measurements: It is equal to number of SUN measurements plus a number of humidity statuses. We will reject a day if after all checks below are applied the number of the remaining measurements is less than 3 or 10% of "potential" measurements (whatever is greater).

Triplet criterion – only THREE channels (675, 870 and 1020 nm) are considered. Measurement is considered "cloudy" when at ALL THREE wavelengths within a triplet (tau_max – tau_min) exceeds 0.01 or 0.015*tau (whatever is greater).

AOD stability check – if daily averaged AOD at 500 nm (or 440 nm if 500 nm channel is not available) is less than 0.015 we do not perform a 3 sigma check.

3 sigma check – AODs at 500 nm (or 440 nm) and corresponding Alphas (computed using available channels within 440-870 nm range) should be within MEAN +/- 3 Standard deviations.

Smoothness check – instead of D16 as in the current version we presume that AOD at 500 nm (or 440 nm) should not change greater than by 0.01 per minute. For any pair when AOD exceeds this threshold the highest AOD is eliminated. Then the process repeats itself.

Curvature check – we compute curvature for measured at 1020 nm sky radiances within 3 – 6 degrees SCATTERING angle. If curvature computed for the first available scattering angle is greater than 0.001 we do not apply a "curvature check". If curvature is less than 0.001 we compute a slope of Ln Curvature vs Ln Scat Angle. If the slope is greater than 8 (empirically found) we consider point to be "cloud contaminated". Also we expand this to +/- 30 minute time period and eliminated points within.

Standalone and Extras. We call a point a "standalone" point when it does not have any measurements left within plus or minus one hour. In this case we reject a standalone point. However if Alpha for such point is greater than 1 (one) we retain it.

Number of measurements left should be either 3 or 10% of the potential (actual plus humidity statuses) measurements, whatever is greater.

If the number of measurements left is LESS than 3 or 10% of the potential measurements we eliminate measurements with Alpha<1 and keep measurements with Alpha>1.

Suggested modifications

- Triplet criterion only THREE channels (675, 870 and 1020 nm) are considered. Measurement is considered "cloudy" when at ALL THREE wavelengths within a triplet (tau_max – tau_min) exceeds 0.01 or 0.015*tau (whatever is greater).
- Smoothness check instead of D16 as in the current version we presume that AOD at 500 nm (or 440 nm) should not change greater than by 0.01 per minute.

Parameterization of sky radiance shape

The angular shape of sky radiances is conveniently parameterized by curvature which give the rate of turning of tangent vector, see below

$$k = \lim_{\Delta s \to 0} \Delta \varphi / \Delta s = \frac{|f|}{(1 + \dot{f}^2)^{3/2}}$$



According to the formula above the stronger the forward scattering peak the smaller the curvature value (it is inverse proportional to the first derivative)

The first curvature value: fine mode aerosols

Curvature value at the smallest scattering angle (K) in the 3 to 6 range is sensitive to the presence of large particles. The fraction of clouds with K greater than 0.001 is relatively small. This can be used as an additional constrain in cloud screening.



Effect of cirrus cloud on sky radiances

Slope of curvature in ln - ln scale for the 3 to 6 degrees range of scattering angles is sensitive to cirrus cloud presence.



Suggested modifications

• Curvature check – we compute curvature for measured at 1020 nm sky radiances within 3 – 6 degrees SCATTERING angle. If curvature computed for the first available scattering angle is greater than 0.001 we do not apply a "curvature check". If curvature is less than 0.001 we compute a slope of Ln Curvature vs Ln Scat Angle. If the slope is greater than 8 (empirically found) we consider point to be "cloud contaminated". Also we expand this to +/- 30 minutes time period and eliminate points within.

AERONET – MPL Validation Dataset

- MPLNET cirrus only detection within ±10 minutes of AERONET measurement
- •AERONET measurement within various solar zenith angles (e.g., 30°)
- Homogeneous cirrus conditions assumed



Singapore, #22, 2007-2011 Fine mode aerosol and Ci

	Ν	AOD	Alpha
Lev 1.0	25500	0.61	0.58
Lev 1.5	8680	0.45	0.79
Lev 2.0	6920	0.34	1.21
NEW			
Lev 1.5 (no/CURV)	8640	0.35	1.17
Lev 1.5 (w/CURV)	5029	0.33	1.40

Nauru, #168, 2000-2005, 2010 Sea salt aerosol and Ci

	Ν	AOD	Alpha
Lev 1.0	25579	0.23	0.09
Lev 1.5	13326	0.11	0.33
Lev 2.0	9371	0.08	0.58
NEW			
Lev 1.5 (no/CURV)	13048	0.09	0.45
Lev 1.5 (w/CURV)	7879	0.08	0.55

Ilorin, #29, 1998-2013 Biomass Burning and Dust

	Ν	AOD	Alpha
Lev 1.0	58151	0.84	0.42
Lev 1.5	37370	0.84	0.46
Lev 2.0	35392	0.77	0.51
NEW			
Lev 1.5 (no/CURV)	32601	0.73	0.55
Lev 1.5 (w/CURV)	29348	0.76	0.55

Mexico City, #10, 2000-2004 Fine mode aerosol

	Ν	AOD	Alpha
Lev 1.0	26354	0.44	1.20
Lev 1.5	11394	0.32	1.45
Lev 2.0	10548	0.31	1.54
NEW			
Lev 1.5 (no/CURV)	14534	0.32	1.61
Lev 1.5 (w/CURV)	12070	0.32	1.67

Nes Ziona, 5/27/2005 – Level1.0





Nes Ziona, 5/27/2005 – Level 1.5



Nes Ziona, 5/272005- new Level1.5



Advantages of the new cloud screening algorithm

- Automated algorithm delivers AODs and α at Level1.5 statistically very close to current Level2.0
- Stable thin cirrus clouds became a lesser problem (less residual cloud contamination)
- Wrongly filtered in the current version highly variable AODs (dominated by fine aerosols) will be (at least partly) restored in the database

What is behind new cloud screening

3WM/N1/0.010/F/CRV8.0A_1_1020/EXTR (AOD)

IAN FFR MAR APR MAY IUN JUL AUG SEP OCT NOV DEC Alta_Flore -0.00215 0.001134 0.01178 0.021332 -0.00668 0.001289 0.026635 0.001701 -0.03441 -0.03527 -0.02021 -0.00148 0.01849 0.019249 0.014653 -5.85-05 0.000376 0.00059 -0.00201 0.006924 0.000315 0.001011 0.000283 0.009737 Turson 0.007607 0.002372 0.000739 0.004768 0.010272 0.015369 0.002275 -0.00566 0.000098 0.007046 0.001636 0.004271 GSFC Harvard_F -0.00362 0.000567 0.00227 -0.00066 -0.00259 0.016906 -0.00106 0.01887 0.014567 0.013075 0.04263 -0.00055 Mallons 0.001828 0.003734 0.005246 0.017089 0.005725 0.006575 0.017939 0.017636 0.014328 0.002513 0.002244 0.003508 -0.00514 0.031107 0.015673 0.004088 -0.0075 0.007585 0.009716 0.044411 0.013475 0.015043 -0.00326 0.000153 Ussurivsk Waskesiu 0.014351 0.002544 0.027151 -0.00008 -0.00966 -0.01714 -0.01705 0.002281 0.000067 0.006194 0.00302 n/a Key Biscan 0.003255 0.0055 -0.00569 0.010021 0.019886 -0.00426 -0.01161 0.000438 0.010083 0.003119 -0.00024 -0.00211 -0.00137 -0.00095 0.001272 0.000257 0.002164 0.002225 -0.00484 -0.00026 0.00002 0.000266 0.000612 0.000668 Sevilleta Cart Site 0.008441 0.010066 0.022242 0.02843 0.012131 0.0021 0.014109 0.003785 0.00529 0.002041 0.00318 0.002135 0.020431 0.017349 0.00255 -0.00279 -0.0053 -0.00287 -0.00209 0.010162 n/a Bonanza (n/a n/a n/a Thompson n/a n/a n/a n/a 0.003999 -0.01979 0.004335 0.005472 0.025628 0.009352 n/a n/a HJAndrew: n/a n/a -0.00338 -0.00243 0.003545 0.006616 0.000925 0.002144 0.006887 0.000517 0.002467 0.012872 Missoula 0.02492 0.032931 0.003587 0.024233 0.010101 -0.00155 0.020909 0.013564 -0.00045 0.000539 0.013361 -0.00648 Capo Verc 0.011327 0.004611 0.014101 0.01578 0.006495 0.038818 -0.01241 -0.01267 0.00673 0.005083 0.010942 -0.01572 Ouagadou -0.04341 -0.0485 -0.09369 -0.04221 -0.07567 -0.01148 -0.0327 -0.04073 -0.02942 0.003947 -0.01659 -0.00761 UCSB 0.004336 0.011379 0.013731 0.009181 0.000685 0.005546 0.01354 0.000579 0.007587 0.015318 0.004392 0.000053 SERC 0.00259 0.004329 0.008403 0.003937 0.004276 0.008673 -0.00414 0.004375 0.006865 0.00211 0.001549 0.000541 0.001409 -0.00134 -0.00176 0.001093 -0.00578 -0.00448 -0.0016 0.003868 -0.00318 -0.00484 -0.0013 0.00097 La Jolla Barcelona -0.00461 0.013136 0.00558 0.007067 0.000395 -0.00029 0.004667 0.006511 -0.00736 -0.0012 0.000931 -0.0011 SEDE BOK 0.006827 -0.00498 -0.00061 -0.00883 -0.00086 0.001811 0.000677 0.000942 0.000096 -0.00256 0.000007 0.001537 Tuxtla Gut -0.00144 -0.00541 -0.00217 -0.01802 -0.0566 -0.01019 0.010281 -0.00142 0.006385 0.003425 -0.00022 -0.00114 Trinidad_+ 0.045366 0.022922 0.026998 0.039591 0.044038 0.016918 0.009954 0.054045 0.087468 0.03882 0.01618 0.022421 CARTEL 0.004199 0.003245 0.006974 0.007017 0.0136 0.00696 0.005426 0.007371 0.001546 0.008792 0.009843 -0.01216 0.00622 0.004472 0.01633 0.001687 0.001226 -0.00107 0.006659 0.014152 -0.0035 0.000325 0.012265 0.025929 Toronto -0.00862 0.000995 -0.00152 0.002835 0.000528 0.017339 0.003244 -0.00178 0.017106 -0.00996 -0.0084 -0.01126 Mongu SANTA CR 0.004609 0.006811 -0.00228 0.00816 -0.00145 0.001227 0.006398 0.007956 0.082005 0.018944 0.008282 0.010778 Banizoumi -0.02928 -0.03043 -0.06007 -0.03213 -0.03304 -0.02723 -0.00729 -0.02617 -0.0135 -0.0125 -0.00819 -0.00671 Lanai 0.000981 -8.4E-05 -0.00133 -0.00299 -0.00124 0.000329 -0.00163 0.000825 -0.00066 0.002676 -0.00066 0.000261 Coconut I: -0.00285_0.038556_-0.00115_-0.00146_-0.00015_0.000323_-0.00875_0.000057_0.001843_0.003997_0.019716_-0.00152 Bermuda -0.00431 -0.00305 0.012823 -0.00075 0.023557 0.008998 0.014331 0.001965 0.004919 0.013017 0.014949 0.008058 Dry Tortu: 0.008091 0.001464 0.001423 0.002938 0.01434 0.004256 -0.01011 -0.03424 -0.01975 0.001771 -0.00211 0.004545 Ascension -0.00354 -0.00346 0.00252 0.004684 -0.00241 0.001116 0.010017 0.012813 0.003157 0.006272 0.000945 -0.00057 Barbados 0.002718 -0.00612 0.011256 -0.00291 -0.00339 0.059029 0.047266 0.07055 0.096607 0.050914 -0.00444 -0.00039 Tahiti -0.0046 -0.00431 -0.00284 0.001673 0.009141 0.00146 0.000326 0.001691 0.001924 0.001291 0.00043 -0.00202 Barrow n/a 0.026377 0.040242 0.006362 0.004952 0.026581 0.023497 0.002135 n/a n/a n/a n/a REUNION -0.00419 -0.00477 0.001819 0.006139 0.002248 0.001321 -0.00062 0.008795 0.00203 0.002062 -0.00016 0.003333 -0.0203 -0.00719 -0.00747 -0.00366 -0.00876 -0.01282 -0.02572 -0.00404 0.006841 -0.01058 -0.00787 -0.00596 Dakar Guadelour -0.00827 -0.00628 -0.00993 -0.00499 -0.01082 0.001111 0.002047 -0.0237 -0.00467 -0.01977 -0.00148 -0.00061 BONDVILL 0.013502 0.008273 0.002678 0.007222 -0.00066 0.020968 0.006796 -0.00595 0.001378 0.015121 0.003866 0.014717 Bratts_Lak -0.00074 -0.0009 0.000186 0.007291 -0.00041 0.001196 0.002372 0.005948 -0.00132 0.000338 0.009468 0.003202 Dalanzadg 0.005347 0.003477 -0.01777 -0.00038 -0.01039 -0.00268 -0.00146 -0.00855 0.002545 -0.00574 -0.0016 0.00411 Venise 0.009285 0.007953 -0.01948 -0.00101 -0.00612 0.000801 0.000372 0.001578 -0.00077 0.001566 -0.00156 0.002203 San Nicola 0.00057 -0.00092 0.0026 0.002725 -0.00301 0.000442 0.003154 0.004849 0.000582 0.003369 0.000607 -0.00319 Sioux Fall: 0.009737 0.004408 0.001135 0.010853 0.011641 0.005504 0.004533 0.002909 0.027172 0.00062 0.004901 0.002749 Walker Br 0.003237 0.014412 0.011361 0.005169 0.019786 -0.02258 -0.00249 0.009235 0.003409 0.013533 0.01317 0.009101 Egbert 0.012209 0.012264 0.018409 0.016644 0.009843 0.016804 0.001862 0.012799 0.00791 -0.00436 0.016637 0.008786 -0.00218 -0.00712 0.005783 -0.02388 -0.001 0.008191 0.003873 0.023358 0.001612 -0.01577 0.005827 -0.00013 Ispra 0.002611 0.009724 0.002403 0.003134 -0.00299 -0.00452 -0.00689 0.00517 0.002919 0.003267 0.01075 0.007031 Mainz Brookhave 0.056783 0.011821 0.03389 0.017841 0.033464 0.022703 0.018428 -0.00439 0.020814 0.012759 0.041607 0.008336 Saturn_Isi 0.006977 0.007889 0.002988 0.007657 0.056681 -0.00186 0.000067 0.002517 0.032156 0.000922 -0.00183 0.003683 Kaashidho 0.001191 -0.00028 -0.00363 -0.01969 0.01931 -0.00442 0.02382 0.001831 -0.00691 0.004057 -0.00786 0.008312 Surinam -0.03397 -0.02481 0.006754 -0.04376 0.026815 -0.00229 -0.0047 -0.00016 -0.00329 -0.03105 n/a 0.004106 NCU Taiw -0.02704 -0.00752 0.015583 0.0829 0.004851 0.088992 0.125545 0.033812 0.014606 0.037139 0.042529 0.048552 -0.03221 -0.01663 -0.065 -0.05345 0.056508 0.11875 0.045946 -0.03122 -0.0499 -0.04517 -0.02727 -0.02151 Ilorin Dongsha_I 0.025737 0.015055 0.035341 0.025785 -0.0122 0.023769 0.008864 n/a 0.001211 n/a n/a 0.067139

-0.01018 -0.04873 -0.0215 -0.00952 -0.00178 -0.00304 -0.00584 -0.00872 -0.00518 -0.00973 -0.00517 -0.00186 Arica Tinga_Ting 0.000468 -0.00000 0.001150 -0.00001 0.007007 0.002077 0.00040 0.001651 0.000027 0.00555 0.002077 -0.00021

n/

0.009159 0.0131 -0.00769 -0.0

0.018572 0.010871 0.

MCO-Hani -0.00035 -0.00' Pickle Lak n/a 0.0049 IMAA_Pot 0.01755 0.0205 Kejimkujik n/a 0.121 Skukuza 0.013684 0.055: Bahrain 0.005646 -0.00 TABLE MC 0.006851 0.0178 Chequamen/a n/a IFT-Leipzig Solar_Villa -0.00477 -0.01(Railroad V 0 Oostende 0 Abracos_H -0.01173 -0.0: Davos Mexico_Ci 0.022069 0.0164 CONY The Hague Rimrock 0.00544 -0.003 Columbia 0 Helgoland n/a n/a Jabiru Nauru 0.003799 0.0063 Lake_Argy Munich U 0 Gotland n/a n/a Lecce_Uni 0 Palaiseau 0.004712 0.0146 Kuwait Ur 0 0.00694 0.0002 Hermosille Paris Yekaterint 0 Moldova 0.008876 0.0035 Mussafa 0 MD Scient 0.002635 0.002 Tomsk Yakutsk n/ 0.021715 0.0050 Belterra ATHENS-N Balbina -0.02726 -0.015 ISDGM_CN Taipei_CW CEILAP-BA 0.02336 0.0226 Chen-Kuns Anmyon 0.002347 0.0250 Fontainebl Cordoba-C 0.008946 0.019 Monterey Belsk COVE -0.00203 0.0029 Fresno IMS-METU 0.003029 -0.014 Toravere n/ Andenes n/ Avignon -0.00042 0.0024 Halifax Rogers Dr 0.000585 0.003; Villefranch 0 Stennis 0.005953 0.03: Wits Univ 0 Kuujjuarar n/ El_Arenosi -0.01073 -0.00: FORTH CR 0 UCLA 0.001772 0.0135 Palencia -Nes Ziona -0.00228 -0.013 Canberra 0 Amsterdar 0 Maricopa 0.002412 0.0037 Pimai Kviv 0.003651 -0.003 Bac Giang Churchill n/a Bac_Lieu 0 n/a Kellogg_LT n/ IMC Oristi 0.00206 0.0105 Cabauw Azores n/a 0.0175 Toulon Dunkerque 0 Hamburg 0.000233 0.0027 Irkutsk KONZA EE 0.000206 0.00 Evora ETNA Modena -0.00163 0.0023 Sao_Marti La Pargue 0.005574 0.0012 Petrolina : -Rio Branci -0.00765 -0.001 Campo Gr 0 Hyytiala n/ Lampedus 0.006265 -0.002 MVCO Osaka -0.00186 0.0125 Laegeren 0.025998 -0.002 Shirahama 0.007949 -0.002 Blida BSRN BAC 0.01045 0.0044 Kanpur -0.00505 0.0133 Midway Is 0.000562 -0.00: Billerica 0.001212 0.005 Moscow_N 0.019051 0.002100 -0.00240 0.007001 0.012. Minsk 0.048052 -0.00337 -0.00856 0.008237 0.022 -0.00308 -0.00761 -0.08524 -0.11518 -0.059 Beijing Kelowna 0.01312 0.006227 0.009553 0.049395 0.014 Kuopio n/a n/a n/a Agoufou -0.05169 -0.02107 -0.0853 -0.00238 -0.02159 0 Sao_Paulo 0.034848 0.017905 0.014213 0.004386 0.008345 -0 Rome Tor 0.013385 0.00286 -0.0045 0.001981 0.00824 0.0

0.009588 0.031021 0.008336 0.001635 0.004824 0.017272 0.011871 -0.00345 n/a SMHI n/a n/a Rottnest_| 0.001825 0.001136 -0.00333 0.002434 -0.00884 -0.00555 -0.00294 -0.00843 -0.00163 0.001278 0.001134 0.000872 Gosan_SN 0.119205 -0.00536 0.010647 -0.01145 0.023153 -0.00986 0.022363 -0.00167 -0.00183 0.028538 n/a 0.032462 CUIABA.M. 0.000806 0.03719 0.003842 -0.00142 0.003942 0.002906 0.019741 -0.00229 -0.0059 -0.01217 0.017299 0.005579 XiangHe

Crozet_isia	-0.00756	0.015152	0.009945	-0.0013	1 n/a	n/a	n/a	n/a	0.0	000183	0.00099	-0.0115	0.038832		
Mukdahan	0.007548	0.003067	-0.00503	-0.0179	0.006	6 -0.0075	4 0.005	992 0.03	10791 0.4	005962 0	012839	-0.00965	0.000961		
Cabo_da_i	-0.00855	0.011507	-0.00307	0.01115	0.00145	4 -0.0025	AG 0.000	309 -0.0	0207 -0	000251 -	0.00092	-0.00319	-0.006		
Dioueou	-0.15657	-0.04567	-0.01532	-0.0164	0.0828	3 -0.0055	3 -0.03	615 n/a	-0	.07598 0	0.029169	-0.00785	-0.01484		
Gwangiu 4	0.030869	0.016584	-0.00446	-0.0052	0.03681	8 -0.0550	2 -0.03	192 0.0	3545 -0	.00858	0.00806	0.008768	0.00412		
Thessaloni	-0.00249	0.005226	0.009003	-0.0024	-0.0085	7 0.00673	6 0.002	513 0.00	00592 -0	.00345 0	.000151	0.012166	-0.00054		
Ames	0.019371	0.013054	0.005028	-0.000	5 -0.0006	8 0.01119	6.00	555 -0.0	00024 0.0	010066 0	.029218	0.005206	0.043576		
IER_Cinzer	-0.031	-0.02074	-0.03161	-0.0213	-0.0250	4 -0.0698	6 -0.0	476 -0.0	03712 -0	.00484	0.02485	-0.00731	-0.01052		
Granada	0.001012	0.002639	-0.0043	-0.0075	0.00154	6 -0.0013	12 -0.00	172 -0	.0014 0.0	001223	0.00418	-0.00115	-0.00101		
Mezaira	-0.00509	-0.02252	-0.01256	0.00692	0.0011	6 -0.0113	0.000	971 -0.0	01287 -0	00116 0	000242	0.003473	-5.9E-05		
Saada	0.000336	0.00349	_0.01423	-0.0030	0.0064	7 -0.003/	12 -0.00	977 -0	0095 -0	00665 0	007988	0.002351	-0.00267		
Dhadnah	0.019418	-0.00279	-0.00916	-0.0117	-0.0099	6 0.0020	9 -0.01	065 -0.0	1033 -0	.00769	0.00328	0.002173	0.072758		
Resolute_I	n/a	n/a	n/a	0.00575	0.01564	7 0.02255	12 0.001	596 0.03	1766 0.4	001882 n	fa i	1/a	n/a		
Abu_Al_Bi	0.083971	-0.00171	-0.02133	-0.0097	5 0.00628	8 -0.0095	6 0.013	467 0.00	04197 0.4	003245 0	.004092	0.016077	0.007087		
Pune	-0.01383	0.00722	-0.00174	-0.0087	-0.0046	4 0.06546	69 n/a	n/a	0.4	006632	0.01709	-0.03138	0.003116		
Santa_Cru	0.007381	0.011086	0.007925	0.01001	2 0.00008	6 -0.0044	1 0.001	307 -0.0	00416 0.0	002916	0.00032	0.000387	0.000258		
Cape_san	-0.00052	0.000101	-0.052205	0.00022	0.0210	7 -0.0144	4 0.022	692 -07	4197 04	015155 0	0.02104	-0.00325	-0.00544		
Gustav Dr	n/a	n/a	n/a	-0.0021	0.0017	9 0.00024	12 0.00	749 0.00	4585 0.0	000316	0.00175	n/a	n/a		
Hornsund	n/e	n/a	0.003598	0.0079	0.01755	7 0.00522	5 0.016	346 0.00	08934 0.4	003239 n	le	1/4	n/a		
COVE_SEA	-0.00098	-0.00055	0.004382	-0.0053	8 0.00296	4 0.0151:	15 -0.00	178 0.00	2837 0.4	000749 0	012555	0.008795	0.001113		
Fort_McM	-0.01014	-0.01256	0.011435	0.02584	-0.0010	7 -0.000	15 -0.00	523 0.00	06291 0.4	003385 0	.003875	0.000936	n/a		
OHP_OBSE	-0.00203	-0.00506	-0.00063	0.00983	0.00631	4 0.01474	18 0.004	439 -0.4	00192 -0	.00547	0.00237	0.001061	0.013444		
Caceres	-0.00626	-0.00453	-0.01297	0.00258	-0.0070	7 -0.0015	8 -0.00	035 -0.0	01034 0.4	009833 0	003891	-0.0009	-0.00048		
Birdsville	-0.00108	-0.00721	-0.00318	0.00067	-0.0003	5 -0.000	12 -0.00	099 -0.0	00016 0.4	000261	0.00096	-0.00862	-0.00712		
Red Mour	0.001471	-0.02534	0.000148	0.00026	0.00254	0.00575	12 0.001	912 0.0	10511	005437 0	0.00042	0.000282	0.009		
Dunedin	0.003526	0.00147	0.003514	-0.0021	0.01623	5 0.0025	9 0.004	346 0.00	13517 04	005054 0	002396	0.000081	-0.00123		
Chilbolton	0.028437	0.015256	0.026527	0.01224	-0.0086	6 0.00680	3 0.006	918 0.00	0755 0.4	013533	0.00209	0.022232	0.01912		
Trelew	-0.00034	0.004662	0.012558	0.00071	5 0.00949	2 -0.0003	1 -0.00	039 -0.0	00519 -0	.00365 0	.000701	-0.00017	-0.00018		
CEILAP-RG	-0.00059	0.000131	-1.8E-05	-0.0003	0.00350	\$ 0.00416	2 0.004	116 0.00	01085 0.0	004263	0.00025	-0.00043	0.001105		
Hong_Kon	0.00283	0.039238	0.017545	0.01004	-0.0358	2 -0.0054	11 0.093	399 0.0	19859 0.0	005699	0.03955	-0.0206	-0.00713		
DMN_Mai	-0.02383	-0.01945	-0.07131	-0.0561	0.1851	\$ 0.03984	6 -0.01	301 -0.0	01399 -0	.02375	0.01904	-0.0184	-0.0006		
Naisohii	-0.00633	-0.0079	-0.02132	-0.0273	-0.0139	6 0.036	2 0.005	286 0.0	13163 -0	063083 6	0.015644	-0.00979	-0.00674		
Ji Parana	n/a	-0.01000	-0.01000	0.0002	0.0002			300 03				0.000017	0.023.04		
La_Paz	0.01062														
Tamanrass	0.01298														
Xinglong	-0.007														
Tudor_Hill	0.00486		White_Sar	0.001142	0.002976	-0.00212	0.000588	0.002034	0.002291	0.0011	2 -0.0022	4 0.00311	0.008905	0.002644	0.001525
Lulin	-0.0088		Frenchma	0.004273	0.007156	0.003666	0.00131	0.003507	0.00293	8 -0.0023	3 0.0012	6 0.0083	-0.00014	-0.00104	0.000219
Guam	-0.0016		Filat	-0.0147	0.015412	-0.002102	-0.01743	-0.0143	-0.00083	-0.0576 3 -0.0001	3 -0.00173	9 0.0064 3 -0.0026	-0.01731	-0.02419	-0.00057
Gandhi Cr	n/a		Thule	n/a	n/a	0.032801	0.022901	0.004498	0.007653	8 0.00161	9 0.00075	9 0.00100	s n/a	n/a	n/a
Helsinki_Li	n/a		PEARL	n/a	n/e	-0.00219	0.016114	0.00133	0.001863	2 0.00709	5 0.0048	7 0.00025	s n/a	n/a	n/#
Chapais	n/a		Eurjassot	-0.01335	0.001736	-0.00546	0.002232	-0.00866	-0.00372	2 0.00445	6 -0.0029	2 0.00596	-0.00869	0.002865	-0.00052
EPA-NCU	-0.0023		furbarest	0.005464	0.025521	0.000282	0.001867	-0.0091	-0.003	5 0.00405	5 0.00022	2 0.00224	-0.00152	-0.00599	0.002767
Sevestopo	0.00116		Silpakorn_	-0.0069	0.006434	0.007916	0.015702	0.021986	0.019961	0.03705	5 0.03521	8 0.02336	-0.02184	0.027664	-0.00222
Brussels	-0.0039		Chiang_M.	-0.00267	-2.7E-05	-0.01603	-0.03762	-0.01016	0.042493	0.02523	7 0.01451	7 -0.002	0.01491	0.000748	-0.00526
sacoi	-0.0103		Songkhia_	-0.00481	-0.004999	0.01068	0.029289	0.056112	0.034505	5 0.01242	3 0.1065	d rva	-0.00149	0.025462	0.007518
NAM CO	-4.15-0		CRPSM_M	0.00465	-0.01462	-0.01305	0.001404	0.023444	-0.01741	0.0039	3 -0.0011	7 0.00254	0.003199	0.102772	-0.00309
Univ of H	0.00974		Le_Fauge	0.001689	0.007726	0.006813	0.01508	0.006913	0.00441	0.00493	2 0.02005	8 -0.0103	-0.00044	0.000123	0.000331
Karachi	0.02897		Kangerluss	n/a	n/a	0.02872	0.011719	0.005362	0.031579	9 0.0024	2 0.00018	1 0.00153	0.037256	6/2	n/a
Appledore	0.00829		Bozeman	0.003781	0.003896	0.001547	0.004993	-0.00268	-0.00054	5 0.0001	3 0.00208	2 -0.0014	0.002119	0.00074	0.003523
Thompson	-0.0018		Helsinki	n/a	n/a i	Va	0.006473	-0.00515	0.004128	5 0.0057	5 0.00562	9 0.00411	-0.00414	n/a	n/a
Singapore	0.031		Camaguey	0.001463	0.003859	0.007036	0.005377	0.007653	0.001625	9 -0.009	8 0.0022	8 0.00466	-0.00231	-0.00291	-0.00072
			Dayton	0.014326	0.004075	-0.00254	0.018595	0.067922	n/a	0.02987	4 -0.0050	5 0.0599	0.007776	0.009714	-0.00043
			Arcachon Wothern 1	0.038058	0.00135	0.000586	0.00388	0.000717	-0.00151	0.00837	9 0.00482	3 0.00184	-0.00131	0.004001	0.005057
			Marvia Ot	0.019387	0.045927	0.009263	0.018627	0.042234	-0.035	5 0.09175	1 n/a	0.07612	5 0.023935	0.04137	0.051861
			Ubon_Rati	0.00352	0.01498	-0.01154	0.012392	-0.01004	n/a	0.00700	3 n/a	-0.0057	0.05243	0.043903	0.001835
-0.00212	-0.01		Malaga	-0.00586	0.007421	-0.00621	-0.01352	-0.00585	-0.00463	2 -0.0010	3 -0.0075	3 -0.0021	-0.00022	-0.0076	0.004355
0.00212	.0.04		Seysses Jainur	-0.07283	0.00549	-0.00417	0.008635	-0.007988	-0.0204	0.0104	1 0.03482	6 J0 0029	0.002312	-0.00052	0.019687
0.01314/	0.0		2019-01	Alerenda	0.000040		0.000701	-0.00143	0.014534	4 -0.000	4 -0.0119	9 0.01092	-0.00027	1/4	n/a
	-0.0		Yellowinif	n/a	N# 1	V4	C. C								
-0.0004	-0.0		Yellowinif Birkenes	n/a n/a	n/a i n/a	0.006297	-0.00506	0.009433	0.00815	5 0.00457	9 0.00511	\$ 0.00109	5 0.003426	n/a	n/a
-0.0004	-0.0 -0.02		Yellowknif Birkenes Bandung	n/a n/a n/a	n/a n/a	0.006297 0.05526	-0.00506	0.009433	0.00815	0.00457	9 0.00511	8 0.00109 8 0.01092	0.003426 0.215128	nia nia	n/a n/a
-0.0004	-0.0 -0.02		Yellowinif Birkenes Bandung Zinder_Air USCD	n/a n/a -0.00079 -0.00695	n/a n/a -0.01419 -0.0025*	0.006297 0.05526 -0.04684 0.002701	-0.00506 0.048201 -0.09486 -0.09054	0.009433 0.075824 -0.05236	0.00815	0.00457 0.0111 0.01457 0.00910	9 0.00511 2 -0.0452 3 -0.0663 9 0.00177	5 0.00109 8 0.01092 4 -0.0244 5 0.00145	0.003426 0.215128 0.07017 0.07017	n/a n/a -0.03012 0.005973	n/a -0.05549 -0.00024
-0.0004	-0.0 -0.02		Yellowind Birkenes Bandung Zinder_Air USCO UMBC	n/a n/a -0.00079 0.00698 0.006506	n/a n/a -0.01439 -0.00238 0.006341	V# 0.006297 0.05526 -0.04634 0.002701 0.000431	-0.00506 0.048201 -0.09486 -0.00044 0.003743	0.009433 0.075824 -0.05234 0.004206 0.000693	0.00815 -0.01054 -0.06203 0.00455 0.005463	0.00457 4 0.011 2 0.01457 5 0.00928 2 0.00403	9 0.00511 2 -0.0452 3 -0.0663 9 0.00127 4 0.00434	8 0.00109 8 0.01092 4 -0.0244 5 0.00143 9 0.02395	5 0.003426 9 0.215128 5 -0.07017 1 0.003463 1 0.00241	n/a -0.03012 0.005971 -0.00122	n/a -0.05549 -0.00024 0.003442
-0.0004	-0.0 -0.02		Yellowind Birkenes Bandung Zinder_Air USCO UMBC SAGRES	n/a n/a -0.00079 -0.00698 0.006506 0.004561	n/a -0.01439 -0.00238 0.006341 -0.006	V# 0.006297 0.05526 -0.04634 0.002701 0.000431 -0.00651	-0.00506 0.048201 -0.09486 -0.00044 0.003743 0.015731	0.009433 0.075824 -0.05234 0.004206 0.000693 0.003435	0.00815 -0.01054 -0.06205 0.00455 0.005465	5 0.00457 4 0.011 2 0.01457 5 0.00920 2 0.00403 4 0.00198	9 0.00511 2 -0.0452 3 -0.0663 9 0.00127 4 0.00434 3 -0.0087	8 0.01092 8 0.01092 4 -0.0244 5 0.00143 9 0.02395 2 0.00500	5 0.003426 9 0.215128 5 -0.07017 1 0.003463 1 0.00241 9 0.001908	n/a -0.03012 0.005971 -0.00122 -0.01043	n/a -0.05549 -0.00024 0.003442 -0.00175
-0.0004	-0.0 -0.02		Yellowkoff Birkenes Bandung Zinder_Air USCO UMBC SAGRES Easton_Air	n/a n/a -0.00079 -0.006566 0.006566 -0.00267	n/a -0.01439 -0.00258 0.006341 -0.006 0.00687	V# 0.006297 0.05526 -0.04654 0.002701 0.000431 -0.00651 0.016153	-0.00506 0.048201 -0.09486 -0.00044 0.003743 0.015731 0.007621	0.009433 0.075824 -0.05236 0.004208 0.000693 0.003435 0.008643	0.00815 -0.01054 -0.06201 0.00455 0.005461 0.005461 -0.0195	5 0.00457 4 -0.011 2 0.01457 5 0.00920 2 0.00403 4 0.00198 2 -0.0091	9 0.00511 2 -0.0452 3 -0.0663 9 0.00127 4 0.00634 3 -0.0087 3 0.00811	\$ 0.00109 \$ 0.01092 4 -0.0244 5 0.00143 9 0.02395 2 0.00500 5 0.00071	5 0.003426 9 0.215128 5 -0.07017 1 0.003463 1 0.00241 9 0.001908 5 0.005644	n/8 -0.03012 0.005971 -0.00122 -0.01043 0.135155	n/a -0.05549 -0.00024 0.003442 -0.00175 0.09123
-0.0004	-0.0 -0.02		Tailowinif Birkenes Bandung Zindar_Air USCO UMBC SAGRES Easton_Ai Kalowna, I	n/a n/a -0.00079 -0.00696 0.006506 0.004561 -0.00267 -356-06 -0.00755	n/a -0.03439 -0.00238 0.006341 -0.006 0.00657 -0.00517	V# 0.006297 0.05526 -0.04684 0.002701 0.000431 -0.00651 0.016153 0.000754	-0.00506 0.048201 -0.09486 -0.00044 0.003743 0.015731 0.007621 0.00994	0.009433 0.075824 -0.05236 0.004206 0.000693 0.000693 0.000643 -0.003435	0.00815 -0.01054 -0.06201 0.005461 0.005461 -0.0150 -0.0150	5 0.00457 4 0.011 2 0.01457 5 0.00920 2 0.00403 4 0.00198 2 -0.0091 5 0.0004 5 0.0004	9 0.00511 2 -0.0452 3 -0.0663 9 0.00127 4 0.00634 3 -0.0087 3 0.00811 7 -0.0053 5 0.0053	8 0.00109 8 0.01092 4 -0.0244 5 0.00143 9 0.02395 2 0.00500 5 0.00071 1 -0.0004 5 0.0024	5 0.003426 9 0.215128 5 -0.07017 5 0.003463 1 0.00241 9 0.001908 5 0.006644 5 0.006644 5 0.006644	n/a -0.03012 0.005971 -0.01043 0.155155 0.003861 -0.003861	n/a n/a -0.05549 -0.00024 0.003442 -0.00175 0.09123 -0.00052 0.00352
-0.0004	-0.02		Tellowinif Birkenes Bandung Zinder_Air USCO UMBC SAGRES Easton_Air Kelowna_1 ND_Marbie Pokhara	n/a n/a -0.00079 -0.006566 0.004561 -0.00257 -3E-06 -0.00753 0.007058	n/a -0.03439 -0.0258 0.006341 -0.00687 -0.00517 0.00517 -0.00596	V* 0.006297 0.05526 -0.04634 0.002701 0.00631 -0.00631 0.016153 0.000754 V* 0.001539	-0.00506 0.048201 -0.09486 -0.00044 0.003743 0.015731 0.007621 0.00994 0.02912 -0.01991	0.009433 0.075824 -0.05236 0.004208 0.000691 0.005435 0.006643 -0.00333 0.012663 0.012063	0.00815 -0.01054 -0.06203 -0.005463 -0.005463 -0.0193 -0.0193 -0.0193 -0.0193	5 0.00457 4 0.011 2 0.01457 5 0.00920 2 0.00405 4 0.00198 2 -0.0091 5 -0.0094 0.0058 7 n/8	9 0.00511 2 -0.0452 3 -0.0663 9 0.00127 4 0.00634 3 -0.0087 3 0.00811 7 -0.0053 5 0.01509 0.00092	5 0.00109 8 0.01092 4 -0.0244 5 0.00143 9 0.02395 2 0.00500 6 0.00071 1 -0.0004 5 0.0254 1 -0.007	5 0.003426 9 0.215128 5 -0.07017 5 0.003463 1 0.00241 9 0.001908 5 0.006644 5 0.006644 5 0.00197 5 0.010902 5 0.00264	n/8 n/8 -0.03012 -0.005971 -0.00122 -0.01043 0.155155 0.003861 -0.00455 0.009295	n/a n/a -0.05549 -0.0024 0.003442 -0.00175 0.09123 -0.0052 0.003442 -0.0052 0.003442 -0.001052
-0.0004	-0.02		Yallowinif Birkenes Bandung Zindar "Air USCO UMBC SAGRES Easton "Air Kalowna "I ND "Marba Pokhara Huelva	n/a n/a -0.00079 -0.006506 0.004561 -0.00257 -35-06 -0.00755 0.007058 0.00037	n/a -0.01439 -0.00288 0.006341 -0.00517 -0.00517 0.007818 -0.00996 0.003639	V* 0.005297 0.05526 -0.04634 0.002701 0.000431 0.00651 0.00651 0.001533 0.000754 V* 0.001539 -0.00011	-0.00506 0.048201 -0.09486 -0.00044 0.009743 0.015731 0.007621 0.00994 0.02912 -0.01991 0.025399	0.009433 0.075824 -0.05236 0.004208 0.000691 0.003435 0.006641 -0.00333 0.012665 0.018037 -0.00495	0.00835 -0.01054 -0.06203 -0.005463 -0.005463 -0.01563 -0.01563 -0.01463 -0.01463 -0.01463	5 0.00457 4 0.011 2 0.01457 5 0.00920 2 0.00403 4 0.00198 2 -0.0091 5 -0.0004 0.0086 7 n/8 5 -0.0053	9 0.00511 2 -0.0452 3 -0.0663 9 0.00127 4 0.00634 3 -0.0087 3 0.00811 7 -0.0063 5 0.01309 0.00092 5 0.00030	5 0.00109 8 0.01092 4 -0.0244 5 0.00143 9 0.02395 2 0.00500 5 0.00071 1 -0.0004 5 0.0254 1 -0.007 2 -4.350	5 0.003426 9 0.215128 5 -0.07017 5 0.003463 1 0.00241 9 0.001908 5 0.006644 5 0.005644 5 0.00564 5 0.00564 5 0.00264 5 0.002186	n/e n/e -0.03012 0.005971 -0.00122 -0.01043 0.155155 0.003861 -0.00455 0.009295 -0.00099	n/a n/a -0.05549 -0.0024 0.003442 -0.00175 0.09123 -0.0052 0.003442 -0.0052 0.09123 -0.0052 0.003442 -0.00052 0.003442 -0.00052 -0.00055 -0
-0.0004	-0.0 -0.02		Yallowinif Birkenes Bandung Zindar "Air USCO UMBC SAGRES Easton "Air Kalowna, J ND "Marba Pokhara Hustva Sable, Jular	n/a n/a -0.00079 -0.006566 0.005565 -0.00267 -3E-06 -0.00755 0.007558 0.007558 0.007558 0.00037	n/a -0.01439 -0.00585 0.006341 -0.00517 0.00517 0.007818 -0.00996 0.003639 -0.0035	V* 0.006297 0.05526 -0.04684 0.002701 0.00651 0.016153 0.000754 V* 0.001539 -0.00011 0.00016262	-0.00506 0.048201 -0.09486 -0.00044 0.003743 0.015731 0.007621 0.02952 -0.02912 -0.029519 0.0025399 0.000839	0.009433 0.075824 0.05236 0.005236 0.005435 0.005435 0.005435 0.005435 0.012665 0.012665 0.012665 0.012037 -0.00497 -0.00497	0.0083 -0.01054 -0.06203 0.005463 0.005463 0.005463 0.001033 m/s -0.01463 -0.01463 -0.01463 -0.00388 -0.00388	5 0.00457 4 0.011 2 0.01457 5 0.00920 2 0.00403 4 0.00198 2 0.0091 5 0.0004 0.0086 7 n/8 5 0.0053 7 0.03189	9 0.00511 2 -0.0452 3 -0.0663 9 0.00127 4 0.00636 3 -0.0087 3 0.00511 7 -0.0063 5 0.01309 0.00052 5 0.00016 9 0.00545 	5 0.00109 8 0.01092 4 -0.0244 5 0.00143 9 0.02395 2 0.00500 6 0.00071 1 -0.0004 5 0.0254 1 -0.007 2 -4.36-0 2 0.0015	5 0.003426 9 0.215128 5 -0.07017 5 0.003463 0.00241 9 0.001908 5 0.006644 5 0.006644 5 0.00197 5 0.010902 2 -0.00264 5 0.000196 5 0.000196	n/e -0.03012 -0.005971 -0.00122 -0.01043 0.155155 0.003861 -0.00455 -0.009295 -0.00099 -0.00099	n/a n/a -0.05549 -0.00024 0.003442 -0.00175 0.09123 -0.00052 0.003342 -0.00106 -0.00034 0.001015
-0.0004	-0.0 -0.02 3 0.(8 -0		Yallowinif Birkenes Bandung Zinder, Air USCO UMBC SadiRIS Easton_Air Kelowna_i ND_Marbs Pokhars Huelva Sable_Islas CUT-TEPAI Ouchenbac	n/4 n/5 -0.00079 -0.00698 0.006560 -0.00267 -3E-06 -0.00755 0.00755 0.00755 0.001375 0.001326 -0.0037 0.013326	n/a -0.02439 -0.02585 0.006341 -0.00587 -0.00517 -0.00516 -0.00966 -0.00966 -0.00966 -0.00965 -0.00968 -0.00255 n/a	V# 0.006297 0.05526 -0.040544 0.000741 -0.000741 -0.000754 V# 0.001539 -0.001539 -0.001539 -0.001539 -0.001539 -0.001594 9 -0.001594	-0.00506 0.048201 -0.0948201 0.0048201 0.00944 0.003743 0.00743 0.00743 0.00743 0.00743 0.00743 0.00743 0.00743 0.00743 0.00743 0.00743 0.002912 -0.01991 0.000839 -0.0154	0.009433 0.075824 -0.05238 0.004206 0.000693 0.008643 0.008643 0.008643 0.008643 0.008643 0.008643 0.008643 0.008643 -0.00856 -0.00495 -0.00495 -0.00495 -0.00495	0.00815 -0.01054 -0.08203 0.005463 0.005463 0.005463 0.005463 -0.0193 n/a -0.01035 n/a -0.01467 -0.01467 -0.01467 -0.01467 -0.01467 -0.01990	5 0.00457 4 0.011 2 0.01457 5 0.00920 2 0.00409 4 0.00196 2 -0.0091 5 -0.0049 5 -0.0058 7 n/8 5 -0.0058 7 0.03138 7 0.03132 3 -0.0053 2 -0.0053 3 -0.0053 2 -0.0055 2 -0.0	9 0.00511 2 -0.0452 3 -0.063 9 0.00127 4 0.00454 3 -0.0087 3 0.00811 7 -0.0063 5 0.01309 0.0052 5 0.00105 5 0.00105 9 0.00551 1 -0.0055 1 -0.0055 2 0.0052	8 0.00109 8 0.01092 4 -0.0244 5 0.00143 9 0.02395 0 0.02395 6 0.00071 1 -0.0004 5 0.0254 1 -0.007 2 -4.360 2 0.0013 3 0.01579 6 -0.0071	5 0.003426 9 0.215128 0.003463 0.003463 0.00241 9 0.001908 5 0.006644 4 0.00137 5 0.020902 4 0.00136 5 0.000186 5 0.000186 5 0.000186 5 0.000186 5 0.000185	n/s n/s -0.01012 -0.015971 -0.01022 -0.01023 0.155155 0.003861 -0.00455 -0.0099 -0.00467 -0.00195 0.00854	n/a n/a -0.05549 -0.0024 -0.0024 -0.00175 -0.00123 -0.00123 -0.0052 -0.0052 -0.00165
-0.0004	-0.0 -0.02		Yellowknif Birkenes Bandung Zinder, Air USCO UMBC SAGRES Easton_Ais Kelowna_1 ND_Marbis Pokhara Huelva Sable_Isle CUT-TEPAI Dusharbis Aubiere_L	n/4 n/4 -0.00879 -0.00898 0.006506 0.004506 -0.00257 -35-06 -0.00755 0.007058 0.007058 0.001375 -0.00319 0.004052 -0.00135	//a n//a -0.01439 -0.00588 0.005841 -0.00517 -0.007818 -0.00986 -0.00986 -0.00358 //a 0.025841 0.02556	Va 0.006297 0.05526 -0.04634 0.002701 0.000431 -0.00631 0.0001530 0.0001539 -0.000139 -0.000139 -0.000139 -0.000130 -0.00014 -0.0001	-0.00506 0.048201 -0.094820 0.003743 0.003743 0.003743 0.003743 0.003743 0.003743 0.003743 0.003743 0.003743 0.003539 -0.01991 0.0025399 0.0025399 0.002539 0.002539	0.009433 0.075824 -0.05238 0.004206 0.00593 0.005693 0.005643 0.003663 0.010037 -0.00459 -0.00459 -0.00459 -0.00459 0.003576	0.00815 -0.01054 -0.08200 0.00455 0.005460 -0.0195 -0.0195 -0.0195 -0.0195 -0.0195 -0.0196 -0.0196 -0.0099 -0.02955 -0.00295 0.000935 0.000935	5 0.00457 4 0.011 2 0.01457 5 0.0020 2 0.00405 6 0.00188 7 n/8 6 0.0038 7 n/8 6 0.0038 7 0.03189 7 0.03189 7 0.03189 7 0.03189 2 0.00108	9 0.00511 2 0.0452 3 0.0653 9 0.00127 4 0.00635 5 0.00127 3 0.00811 7 0.0063 5 0.01309 0.00092 5 0.00109 0 0.00192 5 0.00109 0 0.00192 5 0.00109 0 0.00192 5 0.00119 0 0.00192 5 0.00119 0 0.00192 5 0.00215 5 0.0	8 0.0109 8 0.01992 4 0.0145 5 0.00145 9 0.02595 2 0.00500 5 0.0071 1 -0.0004 8 0.0254 1 -0.0074 2 -4.36 0 2 -4.36 0 2 0.0133 3 0.01579 6 -0.010 1 0.00200	5 0.003426 9 0.215128 9 0.215128 9 0.003463 1 0.00240 9 0.001463 9 0.00106 5 0.006644 4 0.00137 5 0.000463 1 0.00264 9 0.002664 9 0.00264 9 0	n/s n/s -0.03012 -0.005971 -0.0122 -0.01043 0.155155 0.003861 -0.00455 -0.0099 -0.00467 -0.0096 0.008245 -0.0099	n/a n/a -0.05540 -0.00224 -0.00175 -0.00175 -0.00123 -0.00126 -0.0

AERONET Version 3 Update – AOD Additional Modifications

- Implement spectral temperature corrections (-40°C to +60°C)
- Update to OMI L3 NO₂ climatology (2004-2013)
- Continue to use TOMS O₃ climatology (1978-2004)
- Continue to use NCEP Reanalysis for atmospheric pressure (1993-present)





Temperature Characterization

Need a temperature characterization for every filter+detector combination

- Also, filter response differences between manufacturers often require separate characterization for each
- 1020Si filters are the most temperature sensitive (> 3x greater). Other filters exhibit sensitivity ranging from negligible to moderate.
- For a typical 1020Si case, a 10 degree change in temperature results in ~ 3% change in signal

Default Sensitivity Determination

All valid temperature data files are used in calculation of defaults, with a 2 sigma outlier filter Individual CIMELs may have temperature sensitivity that departs **significantly** from the default values– *default only used for some of the older historical data*

Agreement between independent characterizations at GSFC and Lille is good for all manufacturers







AERONET Version 3 Update - AOD

- Level 2.0 Automated Quality Assurance
 - Temperature anomalies
 - Allows for restoration of 1020nm data affected by bad sensor temperatures partly based on NCEP surface temperature climatology
 - AOD diurnal dependence
 - Removes persistently affected data mainly due to obstruction in collimator or debris on window



AERONET Version 3 Update - AOD

- Level 2.0 Automated Quality Assurance (in development)
 - AOD with channel out of spectral wavelength dependence
 - Remove channel due to systematic instrument anomaly
 - Solar eclipse AOD increase
 - Remove AOD affected during solar eclipse period
 - Possibly implement an eclipse correction



AERONET Version 3 Update -Inversions

- Implement a vector radiative transfer code
 - radiation field in UV (e.g., 380 nm retrieval)
 - degree of linear polarization
- Integrate CALIOP monthly climatology of extinction profiles (or MERRA assimilated profile) to estimate aerosol vertical profile
- Provide lidar and depolarization ratio products
- Estimate uncertainties for each retrieval (e.g., random error plus biases due uncertainty in AOD and sky radiance calibration)
- Update inversion quality assurance criteria



Accounting for polarization in modeling of atmospheric radiation is important:

-at short wavelengths where contribution of molecular scattering is significant

- for fine mode aerosol particles exhibiting high degree of linear polarization

In version 3 scalar RT model is replaced by vector RT model.

Approach:

-several well known RT models were selected as candidate for version 3 :

Adding/Doubling (AD;GISS), Discrete Ordinate (DOM; Korkin, Lyapustin, GSFC), Successive Order of Scattering (SO; Lille)

- the agreement between different RT models was found to be within 1%

- SO RT model finally was selected due to its superior speed for small and moderate AOSs

As alternative to error bars based on sensitivity studies, new error bars estimates will be provided for each individual retrieval:

-the approach is based on Dubovik, 2004

- the error bars estimates accounts for effect of random errors in optical

measurements as well as effect of biases such as calibration uncertainty

The above approach does not accounts for errors due to model assumptions such as uncertainties in prescribed surface albedo or BRDF. These uncertainties are estimated using sensitivity studies assuming maximum absolute error in surface albedo ~ 0.05 (according to MODIS team estimations).

> Error bars for the following aerosol parameters will be provided : particle size distribution, complex refractive index, single scattering albedo, aerosol phase function, sphericity parameter.



MODIS Images: 2000m 1000m 500m 250m

AQUA-MODIS Granule Overpass Times: 16:50, 18:30 UTC Large jump in AOD (~0.3 at 440 nm) at the DRAGON Essex site occurred just after solar noon on July 5 (<u>No Cloud Screening</u>). However, the Angstrom exponent (440-870 nm) remains very high (>1.9) suggesting possible new particle formation in the cloud environment since a particularly dense cluster of clouds is seen in the vicinity of the Essex site. Also note the larger variance of AOD (1 min intervals) in the afternoon versus morning indicating relatively high frequency variation in columnar aerosol.



Average AOD computed for each Hour independently – Mid Afternoon drop in AOD in L2 (Cloud Screened & QA) likely due to missing Variable AOD associated with enhanced aerosol near Cumulus clouds



Observations of rapid aerosol optical depth enhancements in the vicinity of polluted cumulus clouds T. F. Eck, B. N. Holben, J. S. Reid, A. Arola, R. A. Ferrare, C. A. Hostetler, S. N. Crumeyrolle, T. A. Berkoff, E. J. Welton, S. Lolli, A. Lyapustin, Y. Wang, J. S. Schafer, D. M. Giles, B. E. Anderson, K. L. Thornhill, P. Minnis, K. E. Pickering, C. P. Loughner, A. Smirnov, and A. Sinyuk Atmos. Chem. Phys. Discuss., 14, 18785-18848, 2014

AERONET New Instrumentation/Enhancements

- Greater control over instrument measurement scenarios (e.g., Hybrid)
- Additional capabilities such as SD card storage, GPS, USB, and Zigbee
- Lunar measurements
 - 1st to 3rd quarter lunar phase (waxing to waning gibbous)
 - Processing for lunar measurements (e.g., ROLO, Tom Stone)
- Development toward attachment for CO2 measurements (Emily Wilson)
- Synergism with MPLNET, PANDORA, and in situ measurements



Cimel Sun/Sky/Lunar Radiometer

Maritime Aerosol Network as a Component of AERONET

- MAN represents an important strategic sampling initiative and ship-borne data acquisition complements island-based AERONET measurements
- In the last several years data acquisition was extended to the areas that previously had very little or no coverage at all
- Data are easily accessible in the web-based public data archive and will stimulate research and international collaboration in various scientific areas

Maritime Aerosol Network global coverage from October 2006 to September 2014



AERONET Maritime Aerosol Network

Cruise tracks and daily averages of aerosol optical depth at 500 nm (squares are colored with respect to AOD values, i.e. blue – AOD<0.10 green – 0.1≤AOD<0.2 yellow – 0.2≤AOD<0.3 orange – 0.3≤AOD<0.5 red – 0.5≤AOD<0.7 purple – AOD≥0.7)

Smirnov, A., B. N. Holben, I. Slutsker, D. M. Giles, C. R. McClain, T. F. Eck, S. M. Sakerin, A. Macke, P. Croot, G. Zibordi, P. K. Quinn, J. Sciare, S. Kinne, M. Harvey, T. J. Smyth, S. Piketh, T. Zielinski, A. Proshutinsky, J. I. Goes, N. B. Nelson, P. Larouche, V. F. Radionov, P. Goloub, K. Krishna Moorthy, R. Matarrese, E. J. Robertson, and F. Jourdin, Maritime Aerosol Network as a component of Aerosol Robotic Network, J. Geophys. Res., 114, D06204, doi:10.1029/2008JD011257, 2009.

Maritime Aerosol Network current status



AERONET Maritime Aerosol Network

Cruise tracks and daily averages of aerosol optical depth at 500 nm (squares are colored with respect to AOD values, i.e. <u>blue – AOD<0.10</u>, <u>greened</u>, <u>stablesta</u>

SolRad-net and contributed flux data



AERONET Data Synergy Tool



http://aeronet.gsfc.nasa.gov/cgi-bin/bamgomas_interactive

- Utilized for data discovery, data download, and analysis
- New Product: HYSPLIT back trajectories

Acknowledgments





We thank the EOS Project Science Office and Cal/Val Program for their support
We thank Dr. Hal Maring of the NASA Headquarters for his support of AERONET