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Global maps of aerosol single scattering albedo using combined CERES-MODIS retrieval

Archana Devi and Sreedharan K. Satheesh

Correspondence to: Archana Devi (archana.shiva13@gmail.com)

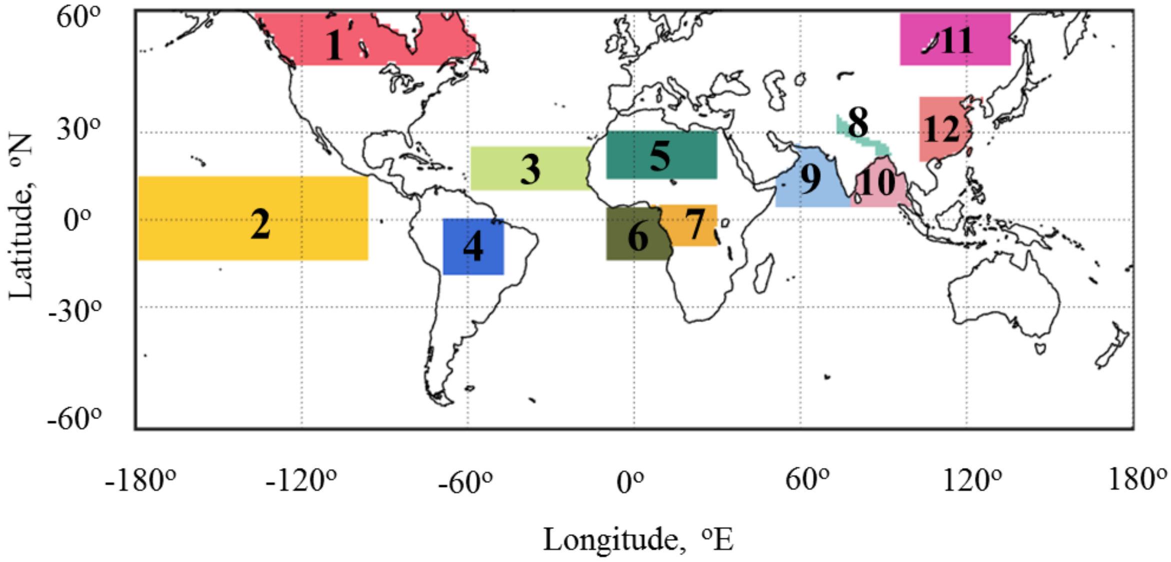

Figure S1. Regions of interest (ROI). Details of each region are provided in Table S1

Table S1. Details of the regions shown in Fig. S1

ROI No:	Region	General aerosol characteristics	Lat limit, °N	Lon limit, °E
1	Canadian Boreal Forest	Relatively pristine with seasonal biomass burning	48 to 60	-140 to -58
2	Eastern Pacific	Less polluted oceanic region	-15 to 15	-180 to -97
3	North East Atlantic	Highly polluted by dust transport and continental outflow from biomass burning	10 to 25	-60 to -10
4	Amazon	Relatively pristine with seasonal biomass burning	-20 to 0	-70 to -48
5	Sahara	Desert region with seasonal dust storms	14 to 30	-11 to 28
6	Southeast Atlantic	Highly polluted by dust transport and continental outflow from biomass burning	-15 to 4	-11 to 15
7	South African Forest	Relatively pristine with seasonal biomass burning	-10 to 5	3 to 29
8	Indo Gangetic Plain	A highly polluted industrial region with seasonal stubble burning and dust from the Thar desert	22 to 35	72 to 92
9	Arabian Sea	Continental outflow of pollution and dust	4 to 26	50 to 77
10	Bay of Bengal	Continental outflow of pollution	4 to 24	77 to 99
11	Russian Boreal Forest	Relatively pristine with seasonal biomass burning	48 to 60	95 to 135
12	Eastern China	A highly polluted industrial region	20 to 40	102 to 125

Table S2. Seasonal mean SSA over regions of interest from combined CERES-MODIS, OMI (given in round brackets) and POLDER (given in square brackets). Details of these regions are given in Table S1 and Fig. S1

Region	CERES-MODIS SSA 550 nm (OMI SSA 500 nm) [POLDER SSA 565 nm]			
	DJF	MAM	JJA	SON
Canadian Boreal Forest	(0.95 ± 0.02) [0.96 ± 0.04]	0.96 ± 0.02 (0.94 ± 0.01) [0.84 ± 0.05]	0.91 ± 0.02 (0.94 ± 0.01) [0.89 ± 0.04]	0.94 ± 0.02 (0.93 ± 0.01) [0.90 ± 0.05]
Russian Boreal Forest	(0.95 ± 0.02) [0.81 ± 0.08]	0.96 ± 0.02 (0.94 ± 0.01) [0.89 ± 0.03]	0.90 ± 0.01 (0.94 ± 0.01) [0.91 ± 0.03]	0.96 ± 0.01 (0.93 ± 0.01) [0.89 ± 0.05]
South African Forest	0.91 ± 0.02 (0.93 ± 0.01) [0.84 ± 0.03]	0.92 ± 0.01 (0.94 ± 0.01) [0.90 ± 0.03]	0.83 ± 0.01 (0.93 ± 0.02) [0.88 ± 0.03]	0.90 ± 0.01 (0.94 ± 0.01) [0.85 ± 0.05]
Amazon Forest	0.96 ± 0.02 (0.95 ± 0.01) [0.84 ± 0.07]	0.98 ± 0.01 (0.95 ± 0.01) [0.91 ± 0.05]	0.97 ± 0.02 (0.93 ± 0.01) [0.92 ± 0.02]	0.89 ± 0.02 (0.94 ± 0.01) [0.87 ± 0.04]
North East Atlantic	0.96 ± 0.02 (0.90 ± 0.01) [0.94 ± 0.03]	0.94 ± 0.02 (0.92 ± 0.01) [0.93 ± 0.01]	0.92 ± 0.02 (0.95 ± 0.01) [0.93 ± 0.02]	0.93 ± 0.03 (0.94 ± 0.01) [0.94 ± 0.01]
South East Atlantic	0.92 ± 0.02 (0.92 ± 0.01) [0.88 ± 0.04]	0.94 ± 0.02 (0.92 ± 0.01) [0.94 ± 0.01]	0.89 ± 0.01 (0.91 ± 0.01) [0.88 ± 0.03]	0.92 ± 0.02 (0.94 ± 0.01) [0.89 ± 0.03]
Eastern Pacific	0.97 ± 0.01 (0.94 ± 0.02) [0.97 ± 0.01]	0.97 ± 0.01 (0.95 ± 0.02) [0.95 ± 0.02]	0.96 ± 0.01 (0.95 ± 0.02) [0.95 ± 0.02]	0.97 ± 0.01 (0.95 ± 0.02) [0.93 ± 0.03]
Sahara	0.93 ± 0.01 (0.92 ± 0.01) [0.90 ± 0.03]	0.93 ± 0.01 (0.93 ± 0.01) [0.88 ± 0.03]	0.91 ± 0.02 (0.94 ± 0.01) [0.87 ± 0.04]	0.92 ± 0.02 (0.93 ± 0.01) [0.90 ± 0.03]
Indo Gangetic Plain	0.88 ± 0.01 (0.92 ± 0.01) [0.89 ± 0.01]	0.87 ± 0.01 (0.92 ± 0.01) [0.83 ± 0.02]	0.85 ± 0.02 (0.95 ± 0.01) [0.77 ± 0.03]	0.83 ± 0.01 (0.92 ± 0.01) [0.89 ± 0.01]
Eastern China	0.92 ± 0.01 (0.92 ± 0.01) [0.91 ± 0.01]	0.90 ± 0.01 (0.94 ± 0.01) [0.87 ± 0.02]	0.87 ± 0.01 (0.95 ± 0.01) [0.84 ± 0.04]	0.88 ± 0.02 (0.93 ± 0.01) [0.91 ± 0.03]
Arabian Sea	0.92 ± 0.01 (0.91 ± 0.02) [0.94 ± 0.02]	0.89 ± 0.01 (0.93 ± 0.01) [0.92 ± 0.02]	0.91 ± 0.01 (0.96 ± 0.01) [0.94 ± 0.02]	0.89 ± 0.01 (0.93 ± 0.02) [0.93 ± 0.02]
Bay of Bengal	0.91 ± 0.01 (0.92 ± 0.01) [0.93 ± 0.02]	0.90 ± 0.01 (0.94 ± 0.01) [0.91 ± 0.02]	0.91 ± 0.02 (0.95 ± 0.01) [0.95 ± 0.02]	0.91 ± 0.02 (0.94 ± 0.02) [0.93 ± 0.03]

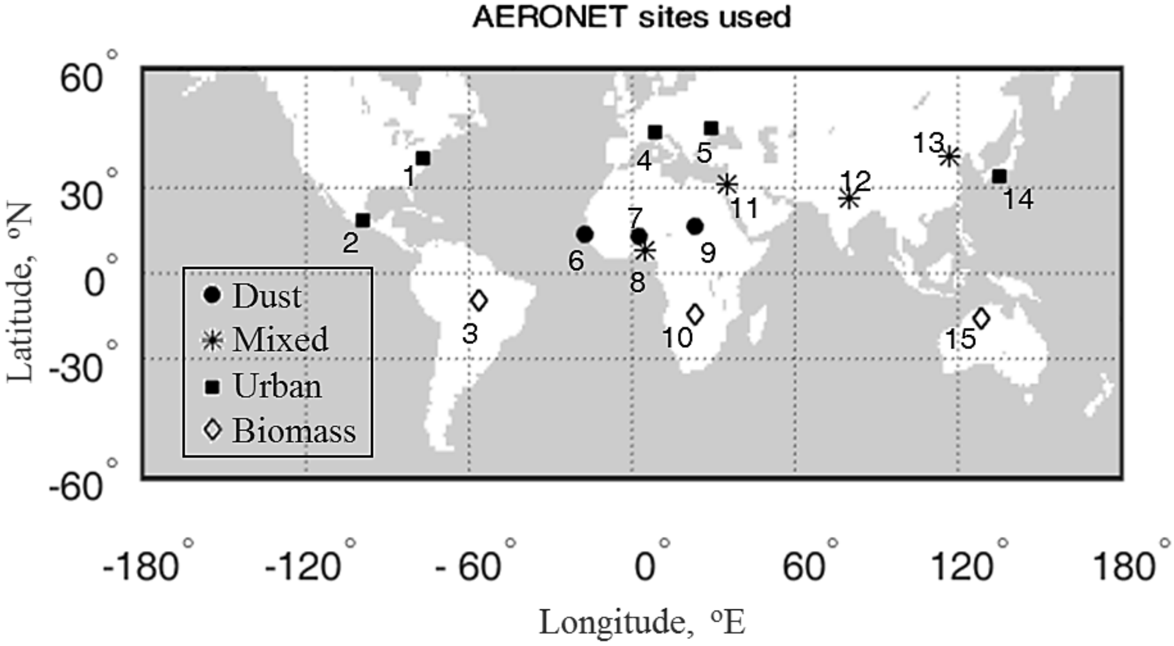

Figure S2. Map showing location of AERONET sites used in this study. The type of aerosols (dust, mixed, urban and biomass) were as defined in Giles et al., 2012

Table S3: Name of AERONET site as shown in Fig. S2

No.	Name	No.	Name	No.	Name
1	GSFC	6	Capo Verde	11	Sede Boker
2	Mexico City	7	Dakar	12	Kanpur
3	Alta Floresta	8	Illorin	13	XiangHe
4	Ispra	9	Banizoumbou	14	Shirahama
5	Moldova	10	Mongu	15	Lake Argyle

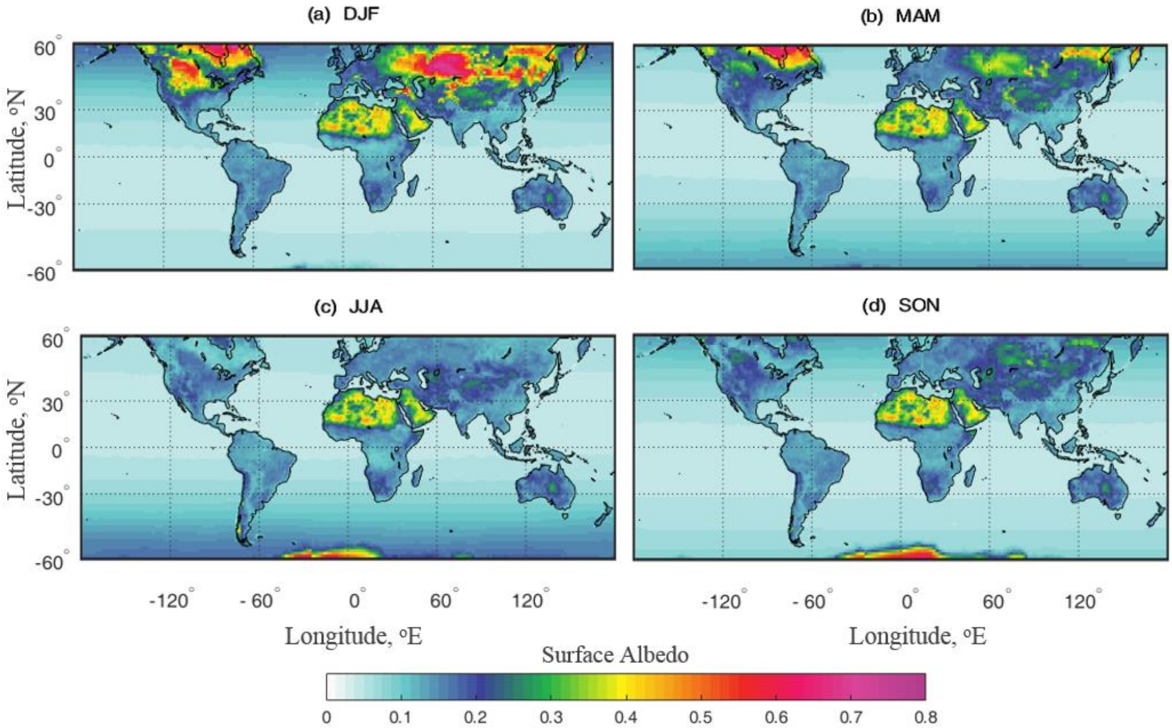

Figure S3. Seasonal mean shortwave-integrated surface albedo from CERES

Table S4. Shortwave integrated seasonal mean surface albedo from CERES over regions of interest. Details of these regions are given in Table S1 and Fig. S1

Region	Surface Albedo			
	DJF	MAM	JJA	SON
Canadian Boreal Forest	0.36 ± 0.13	0.30 ± 0.12	0.12 ± 0.03	0.16 ± 0.05
Russian Boreal Forest	0.37 ± 0.10	0.27 ± 0.08	0.13 ± 0.02	0.20 ± 0.05
South African Forest	0.12 ± 0.01	0.13 ± 0.01	0.12 ± 0.02	0.13 ± 0.01
Amazon Forest	0.14 ± 0.01	0.14 ± 0.01	0.13 ± 0.02	0.14 ± 0.02
North East Atlantic	0.06 ± 0.01	0.05 ± 0.01	0.05 ± 0.01	0.05 ± 0.01
South East Atlantic	0.05 ± 0.01	0.05 ± 0.01	0.05 ± 0.01	0.05 ± 0.01
Eastern Pacific	0.05 ± 0.01	0.05 ± 0.00	0.05 ± 0.01	0.05 ± 0.00
Sahara	0.35 ± 0.06	0.34 ± 0.06	0.34 ± 0.06	0.34 ± 0.06
Indo Gangetic Plain	0.13 ± 0.02	0.13 ± 0.02	0.14 ± 0.02	0.13 ± 0.01
Eastern China	0.13 ± 0.04	0.13 ± 0.03	0.13 ± 0.03	0.13 ± 0.03
Arabian Sea	0.06 ± 0.01	0.05 ± 0.01	0.05 ± 0.02	0.05 ± 0.01
Bay of Bengal	0.05 ± 0.01	0.05 ± 0.01	0.05 ± 0.01	0.05 ± 0.01

Details of aerosol models used

The aerosol models used are from OPAC (Optical Properties of Aerosols and Clouds), developed by Hess et al., (1998). The existing mixture of aerosol types in OPAC is used – clean ocean, polluted ocean, arid, clean land, polluted land, and highly polluted land.

A LUT is indexed by surface albedo, water vapour, and SSA. The LUT of the aerosol type selected for the pixel is used to compute SSA from τ_c.

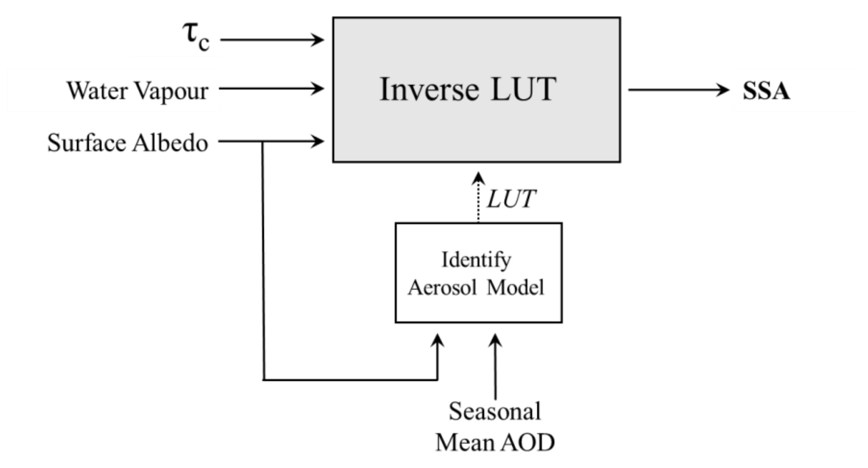

Fig S4. An inverse look-up is performed to computer SSA from τ_c. Details of the "Identify Aerosol Model" block are shown in Fig S5.

The aerosol type is selected based on geographical location (Ocean/land, surface albedo) and aerosol loading (AOD).

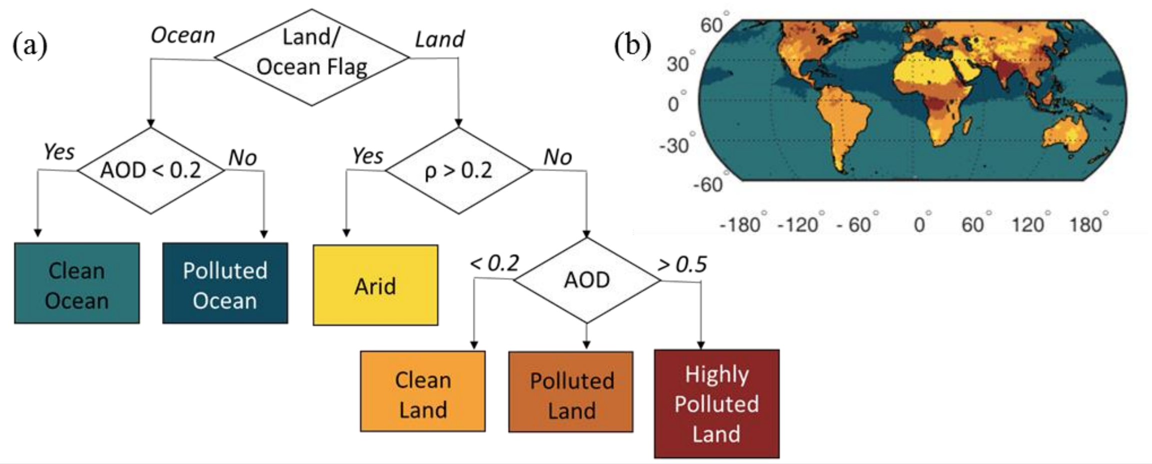

Fig S5. (a) Decision tree for selecting the aerosol model. (b) Shows a sample map of the aerosol model used for a particular day 03 Jun 2017, following the color code used in the decision tree

Table S5. Components of the mixed aerosol types used

Aerosol Type	Components	Number density (1/cm^3)	Number mixing ratio	Volume mixing ratio	Mass mixing ratio
clean ocean	waso	1.50E+03	9.87E-01	6.44E-02	7.05E-02
	ssam	2.00E+01	1.32E-02	9.15E-01	9.09E-01
	sscm	3.20E-03	2.11E-06	2.03E-02	2.01E-02
Polluted ocean	waso	3.80E+03	4.22E-01	1.47E-01	1.60E-01
	soot	5.18E+03	5.76E-01	8.53E-03	6.53E-03
	ssam	2.00E+01	2.22E-03	8.26E-01	8.15E-01
	sscm	3.20E-03	3.56E-07	1.83E-02	1.80E-02
Arid	waso	2.00E+03	8.70E-01	3.19E-02	1.77E-02
	minm	2.70E+02	1.17E-01	3.26E-02	3.31E-02
	miam	3.05E+01	1.33E-02	7.35E-01	7.46E-01
	micm	1.42E-01	6.17E-05	2.00E-01	2.03E-01
Clean land	inso	1.50E-01	5.77E-05	3.27E-01	4.07E-01
	waso	2.60E+03	1.00E+00	6.73E-01	5.93E-01
Polluted land	inso	4.00E-01	2.61E-05	3.15E-01	3.96E-01
	waso	7.00E+03	4.58E-01	6.53E-01	5.83E-01
	soot	8.30E+03	5.43E-01	3.29E-02	2.07E-02
Highly polluted land	inso	6.00E-01	1.20E-05	2.28E-01	2.99E-01
	waso	1.57E+04	3.14E-01	7.07E-01	6.58E-01
	soot	3.43E+04	6.86E-01	6.56E-02	4.31E-02

**

inso – insoluble *minm – mineral (nuclei mode)*
waso – water soluble *miam – mineral (accumulation mode)*
ssam – sea salt (accumulation mode) *micm – mineral (coarse mode)*
sscm - sea salt (coarse mode)

* *More details such as refractive index and size distributions can be referred to in Hess et al 1998*

Table S6. Normalized extinction coefficient for each aerosol type

Aerosol Type	Wavelength (microns)											
	0.25	0.35	0.45	0.55	0.65	0.75	0.90	1.25	2.00	3.00	3.39	4.00
Clean ocean	1.13	1.06	1.03	1.00	0.98	0.96	0.93	0.84	0.60	0.57	0.45	0.31
Polluted ocean	1.41	1.22	1.09	1.00	0.94	0.89	0.82	0.70	0.48	0.47	0.36	0.24
Arid	1.12	1.07	1.03	1.00	0.98	0.96	0.95	0.92	0.82	0.66	0.59	0.50
Clean land	2.27	1.70	1.29	1.00	0.79	0.64	0.48	0.29	0.13	0.17	0.08	0.07
Polluted land	2.29	1.71	1.30	1.00	0.79	0.64	0.48	0.29	0.13	0.17	0.09	0.07
Highly polluted land	2.33	1.74	1.30	1.00	0.79	0.64	0.49	0.30	0.14	0.16	0.09	0.07

Table S7. Spectral SSA

Aerosol Type	Wavelength (microns)											
	0.25	0.35	0.45	0.55	0.65	0.75	0.90	1.25	2.00	3.00	3.39	4.00
Clean ocean	0.96	0.99	1.00	1.00	1.00	1.00	1.00	0.99	0.99	0.45	0.88	0.97
Polluted ocean	0.90	0.95	0.96	0.96	0.97	0.97	0.97	0.97	0.97	0.42	0.87	0.95
Arid	0.68	0.75	0.83	0.88	0.91	0.92	0.93	0.93	0.93	0.77	0.86	0.94
Clean land	0.88	0.97	0.97	0.96	0.95	0.94	0.92	0.87	0.88	0.33	0.78	0.85
Polluted land	0.83	0.90	0.90	0.89	0.88	0.87	0.84	0.79	0.77	0.31	0.69	0.74
Highly polluted land	0.72	0.77	0.77	0.75	0.74	0.72	0.69	0.62	0.55	0.24	0.50	0.53

Table S8. Asymmetry Parameter

Aerosol Type	Wavelength (microns)											
	0.25	0.35	0.45	0.55	0.65	0.75	0.90	1.25	2.00	3.00	3.39	4.00
Clean ocean	0.77	0.76	0.75	0.76	0.76	0.76	0.77	0.78	0.78	0.75	0.71	0.71
Polluted ocean	0.75	0.74	0.73	0.74	0.74	0.74	0.75	0.76	0.78	0.74	0.71	0.71
Arid	0.82	0.79	0.75	0.73	0.71	0.70	0.70	0.69	0.69	0.71	0.70	0.68
Clean land	0.73	0.71	0.69	0.68	0.67	0.66	0.64	0.62	0.71	0.76	0.76	0.78
Polluted land	0.72	0.70	0.69	0.67	0.66	0.65	0.64	0.62	0.70	0.76	0.76	0.78
Highly polluted land	0.70	0.68	0.66	0.65	0.64	0.63	0.62	0.61	0.69	0.75	0.75	0.78