1.0 Terrestrial sediment record

Tables S1-S7 show the terrestrial sediment record data compiled as part of this paper.

2.0 Current climate comparisons

Further comparisons of the current climate simulations to observations are included here. Comparison to observations suggests that the model is able to capture the annual averaged distribution of dust well. Figure S1a shows a comparison of the annually averaged surface concentrations at 17 stations, and over 4 orders of magnitude, the model does a good job of simulating the observed variability. Observations are courtesy of D. Savoie, J. Prospero and R. Arimoto [e.g. *Prospero and Nees,* 1986; *Prospero,* 1990, *Prospero et al.,* 1996; *Arimoto et al.,* 1990, 1997]. The sites are located at Barbados (13.17ºN, 59.43ºW), Miami (27.75ºN, 80.25ºW), Bermuda (32.27ºN, 64.87ºW), Izana (28.30ºN, 16.50ºW), Cape Verde (16.70ºN, 22.90ºW), Mace Head (53.32ºN, 9.85ºW), Cheju (33.52ºN, 126.48ºE), Hedo (26.92ºN, 128.25ºE), Cape Grim (40.68ºS, 144.68ºE), Enewtak (11.33ºN, 162.30ºE), Funafuti (8.50ºS, 179.20ºE), Norfolk (29.08ºS, 167.98ºE), Midway (28.22ºN, 177.35ºW), Oahu (21.33ºN, 157.70ºW), King George (62.18ºS, 58.30ºW), New Caledinia (22.15ºS, 167.00ºE), Cape Point (34.35ºS, 18.48ºE). At most of the stations, for all four versions of the model, the model is within a factor of 2. At all but 2 of the stations for most of the model versions, the model is within a factor 10. Observations at Cape Grim may include some local stations not included in the model, so this station should represent an upper limit. The other station the model underpredicts is King George in the South Atlantic, far from large sources.

Figure S1b shows a comparison of the annually averaged deposition in the model versions compared to the compilation of *Ginoux et al.* [2001], and again the model versions all are able to simulate the 4 order of magnitude difference in deposition estimated from observations. Site locations are Shemya (52.92ºN, 174.06ºE), Fench Alps (45.5ºN, 6.5ºE), Spain (41.8ºN, 2.3ºE), Midway (28.2ºN, 177.35ºW), Miami (25.75ºN, 80.25ºW), Oahu (21.3ºN, 157.6ºW), Enewetak (11.3ºN, 162.3ºE), Fanning (3.9ºN, 159.3ºW), Nauru (0.53ºS, 166.95ºE), Samoa (14.25ºS, 170.6ºW), Rarotonga (21.25ºS, 159.75ºW), New Caledonia (22.15ºS, 167.0ºE), Norfolk Island (29.08ºS, 167.98ºE), New Zealand (34.5ºS, 172.75ºE), Taklimakan (40.0ºN, 85.0ºE), Tel Aviv (32.0ºN, 34.5ºE). Some underestimate in the models is seen in the South Pacific. Shown in Figure S2 is the comparison spatially between deposition in the model simulations and sediment trap observations compiled in *Tegen et al.* [2004] and the observationally based estimates from *Ginoux et al.* [2001]. The sediment trap data has some uncertainties associated with them, as discussed in the main text. Generally, the model versions capture the large variability in dust deposition in the observations. The SOMB version tends to be the most different from the other versions, due to the different vegetation map used for determining the source.

For the seasonal cycle, the model does less well. Figure S3 shows a comparison of aerosol optical depth from the AERONET sites [*Holben et al.,* 2001; aeronet.gsfc.nasa.gov]. The model is only able to capture the seasonal cycle at Dalazadgad—at the other six stations, the model has the maximum and minimum optical depths at the wrong time of the year. Figure S4 shows the monthly mean concentration at the surface sites in the model and observations (same sites as in Figure S1a). Here again we can see some large discrepancies between the seasonal cycle simulated in the model compared with observations. This discrepancy is similar to previous published model studies [e.g. *Woodward,* 2001], although recent studies have shown an

improvement when model parameters are optimized to reduce discrepancies [*Miller et al.,* in press].

Figure Captions

Figure S1: Scatter plot of annual averaged concentration and deposition data compared against model values. For S1a, in situ concentration data courtesy of D. Savoie, J. Prospero and R. Arimoto are shown for the observations (the locations of the sites is in the text). For S1b, the observational deposition compilation from *Ginoux et al*. [2001] is used. The same color scheme and symbol scheme is used in both a) and b).

Figure S2: Annually averaged deposition fluxes ($g/m^2/s$) in the SOM (a), AMIP (b), T85 (c) and SOMB (d) versions of the model are shown. Also shown are sediment trap observations compiled in *Tegen et al.* [2002] and deposition fluxes estimated from observations from *Ginoux et al. I*2001].

Figure S3: Monthly averaged optical depth (500 nm) from the AERONET network sites [*Holben et al.,* 2001; aeronet.gsfc.nasa.gov] are compared against modeled values (500nm) for the four model versions. The same color scheme is used as in Figure S1.

Figure S4: Monthly averaged surface concentrations ($\mu g/m^3$) from the 17 in situ sites from Figure S1a are shown compared against the four model versions. The same color scheme is used as in Figure S1.

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