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Supplement of

Full-coverage 250 m monthly aerosol optical depth dataset (2000–2019) amended with environmental covariates by an ensemble machine learning model over arid and semi-arid areas, NW China

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Table S1. Commonly utilized AOD satellite product sources

Sensor	Abbreviation	Platform	Launch time	Spatial resolution
Moderate Resolution Imaging Spectroradiometer	MODIS	Terra Aqua	2000 2002	1 km, 3 km, 10 km, 1°
Multi-angle Imaging Spectro-Radiometer	MISR	Terra	2000	17.6 km, 0.5°
Ozone Monitoring Instrument	OMI	Aura	2004	13×24 km^2, 1°
Cloud-Aerosol Lidar with Orthogonal Polarization	CALIOP	CALIPSO	2006	5 km
Advanced Himawari Imager	AHI	Himawari-8	2014	5 km
Visible Infrared Imaging Radiometer Suite	VIIRS	Suomi-NPP	2011	6 km, 1°

Table S2. AERONET site information

Name of site	Latitude (°N)	Longitude (°E)	Elevation (m)	Timespan
Asia1	43.783	87.650	941	200708-200708
Kashi	39.504	75.930	1304	201606-201912
Zhangye	39.079	100.276	1461	200804-200806
Dunhuang	40.038	94.794	1381	200103-200105
Dunhuang_LZU	40.492	94.955	1061	201203-201205
SACOL	35.946	104.137	1966	200607-201305
Minqin	38.607	102.959	1373	201005-201006
Mt_WLG	36.283	100.896	3816	200909-201307
Lanzhou_City	36.048	103.853	1516	200910-201003
Jingtai	37.333	104.100	1583	200802-200805
Yulin	38.283	109.717	1080	200104-200210
Muztagh_Ata	38.408	75.039	3674	201106-201110

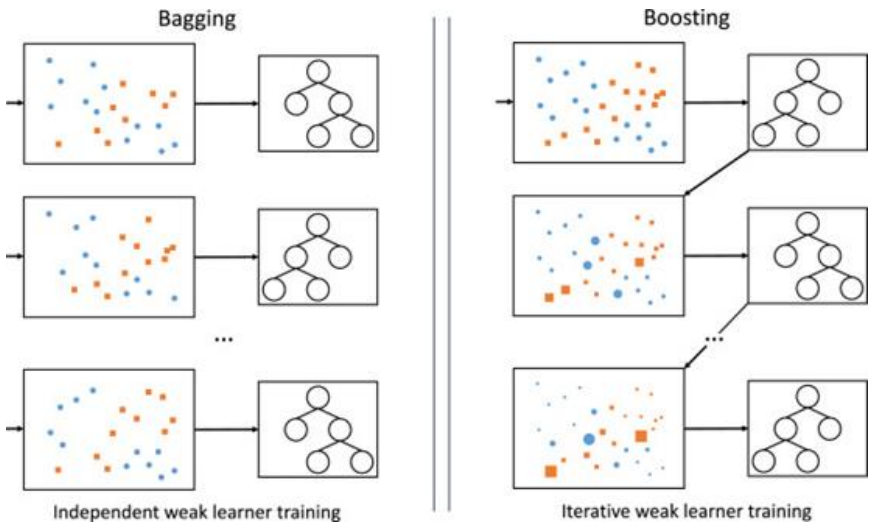

Figure S1. Representation of the workflows of the bagging and boosting strategies.

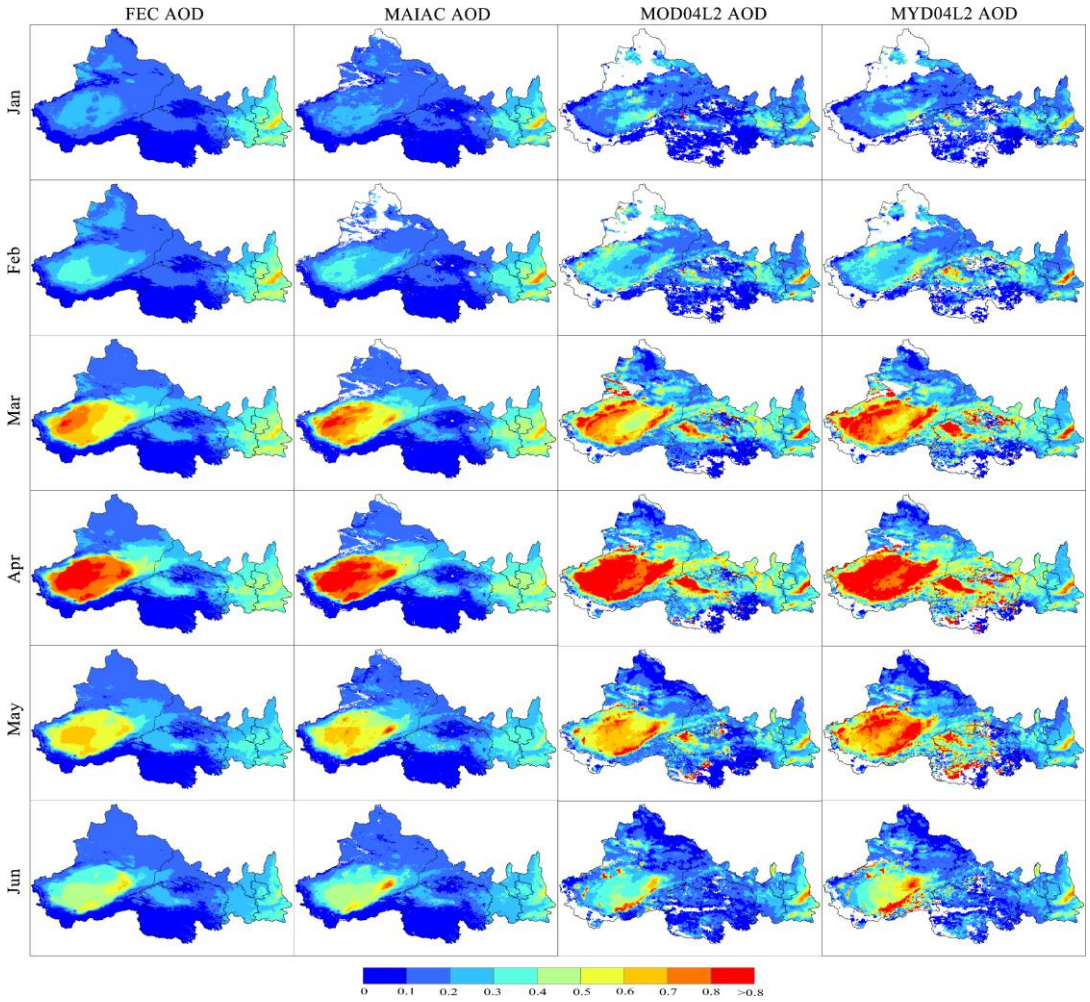

Figure S2. Multiyear monthly average AOD spatial patterns of four AOD products from 2000 to 2019.

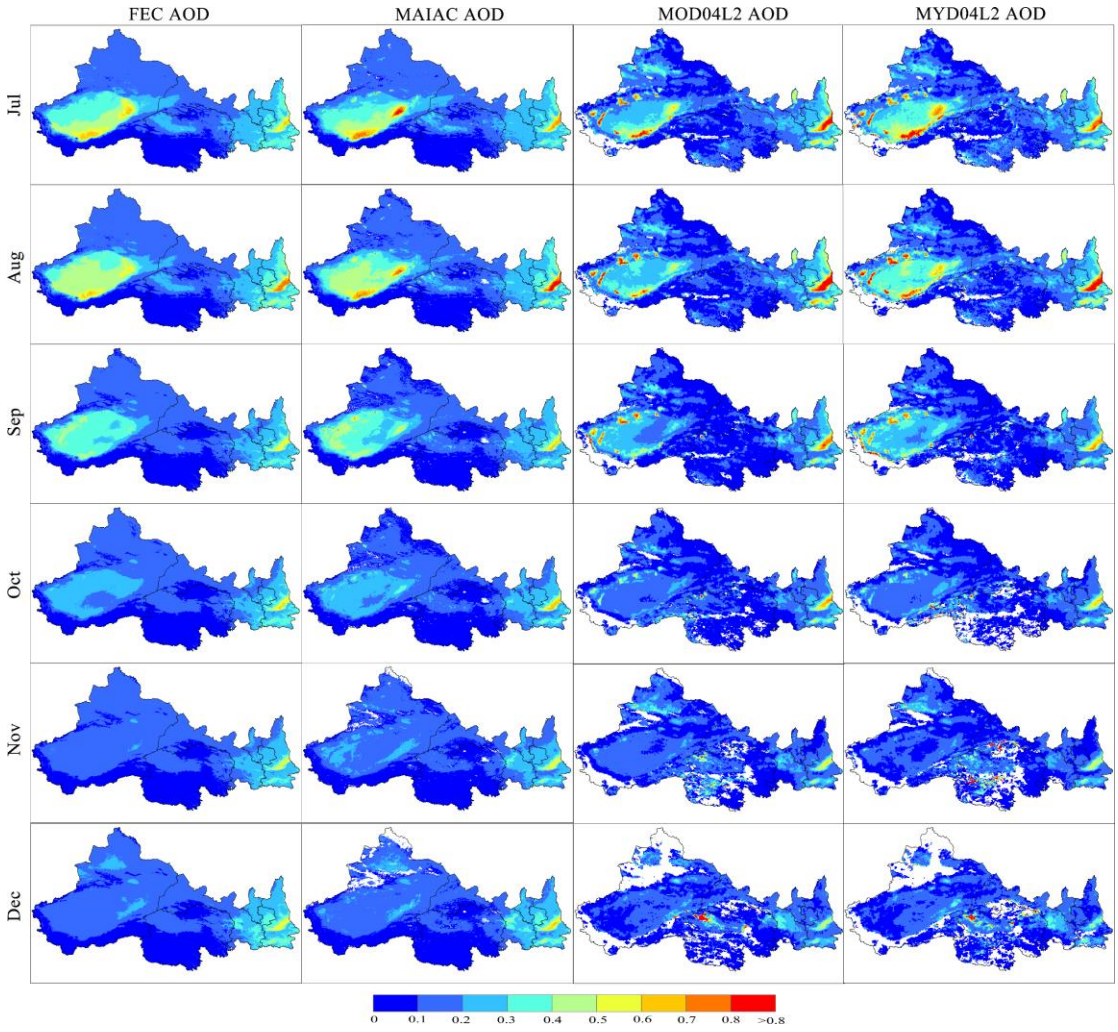

Figure S2. (Continued).

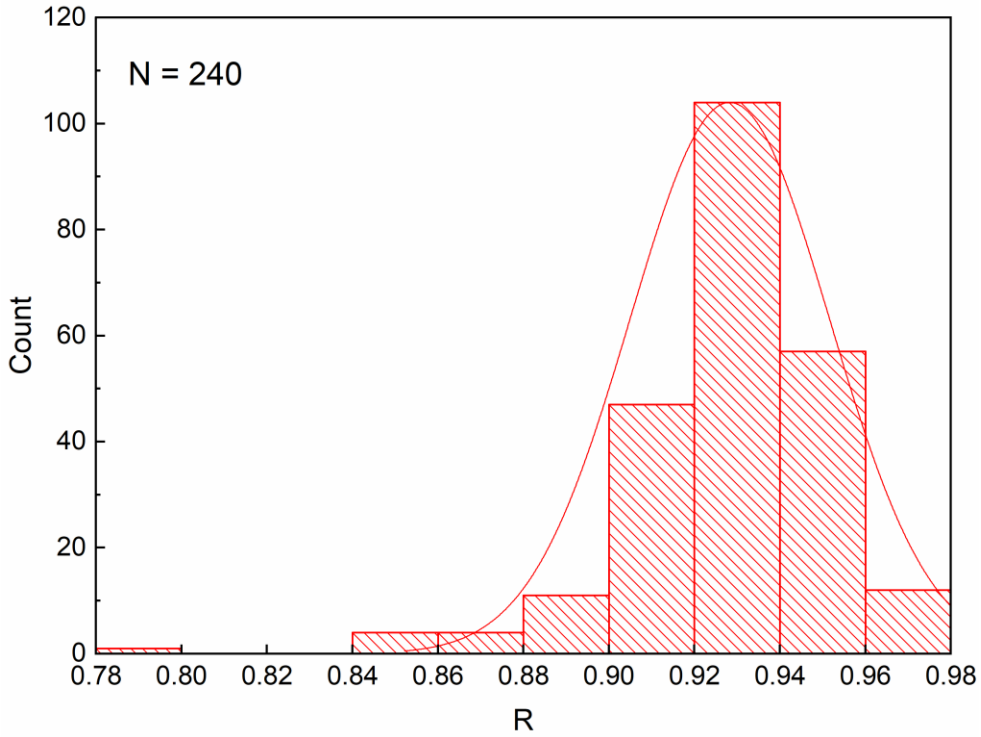

Figure S3. Monthly correlation between the FEC AOD and MAIAC AOD in the study area ($P < 0.001$).

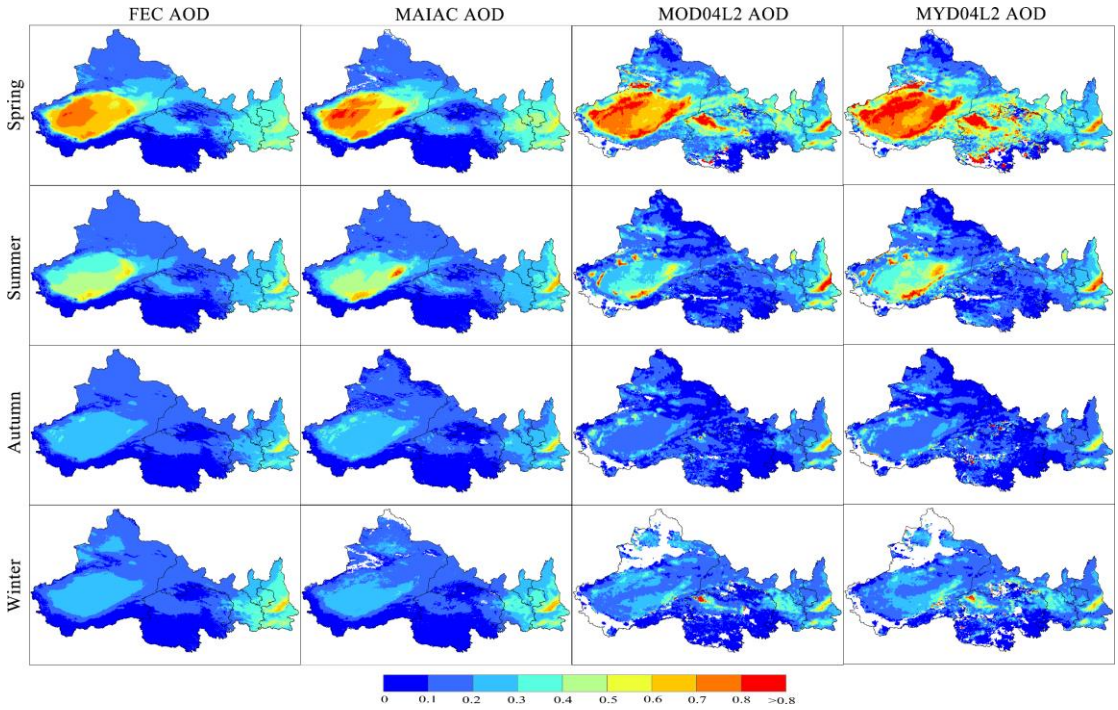

Figure S4. Multiyear seasonal average AOD spatial patterns of four AOD products from 2000 to 2019.

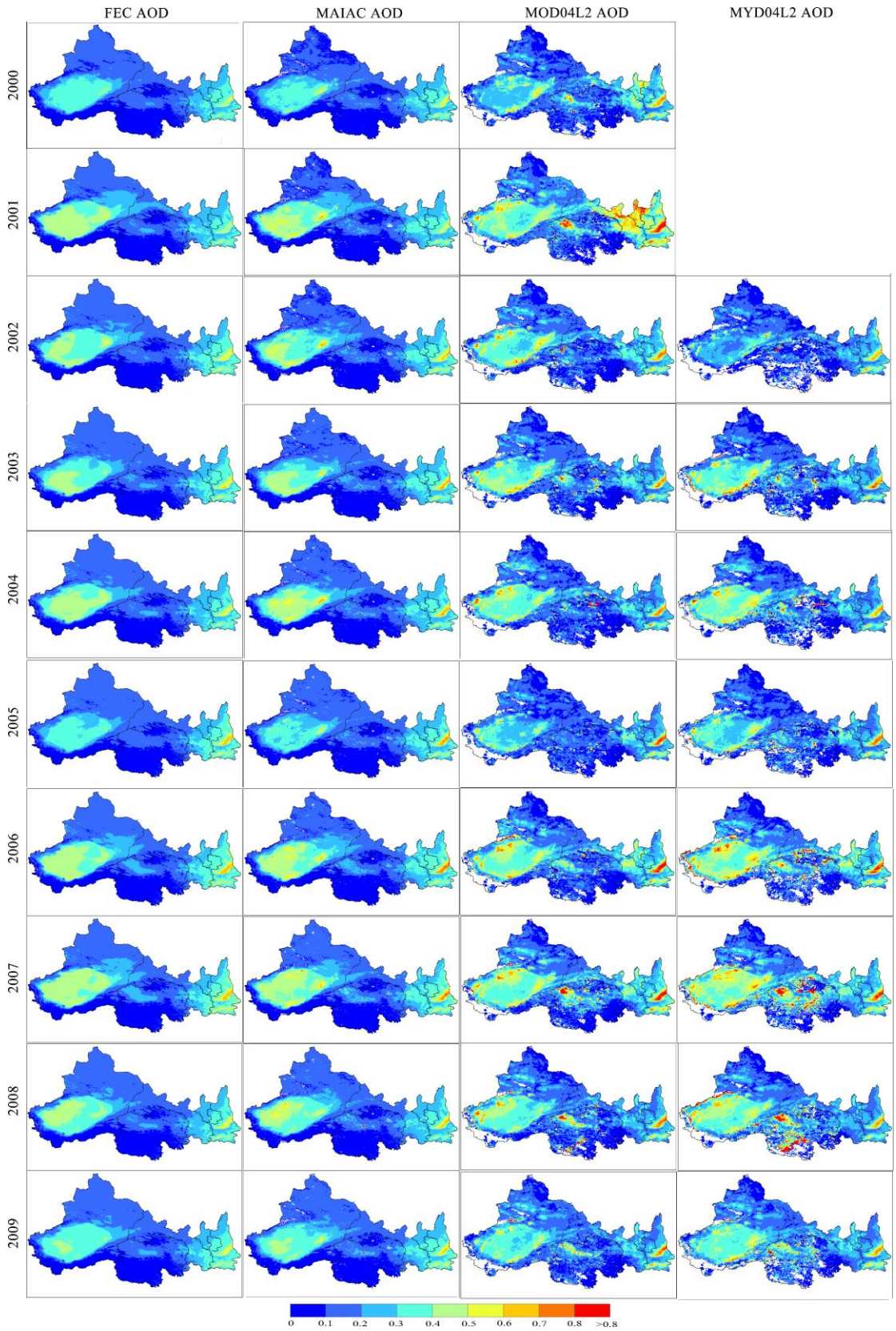

Figure S5. Multiyear yearly average AOD spatial patterns of four AOD products from 2000 to 2019.

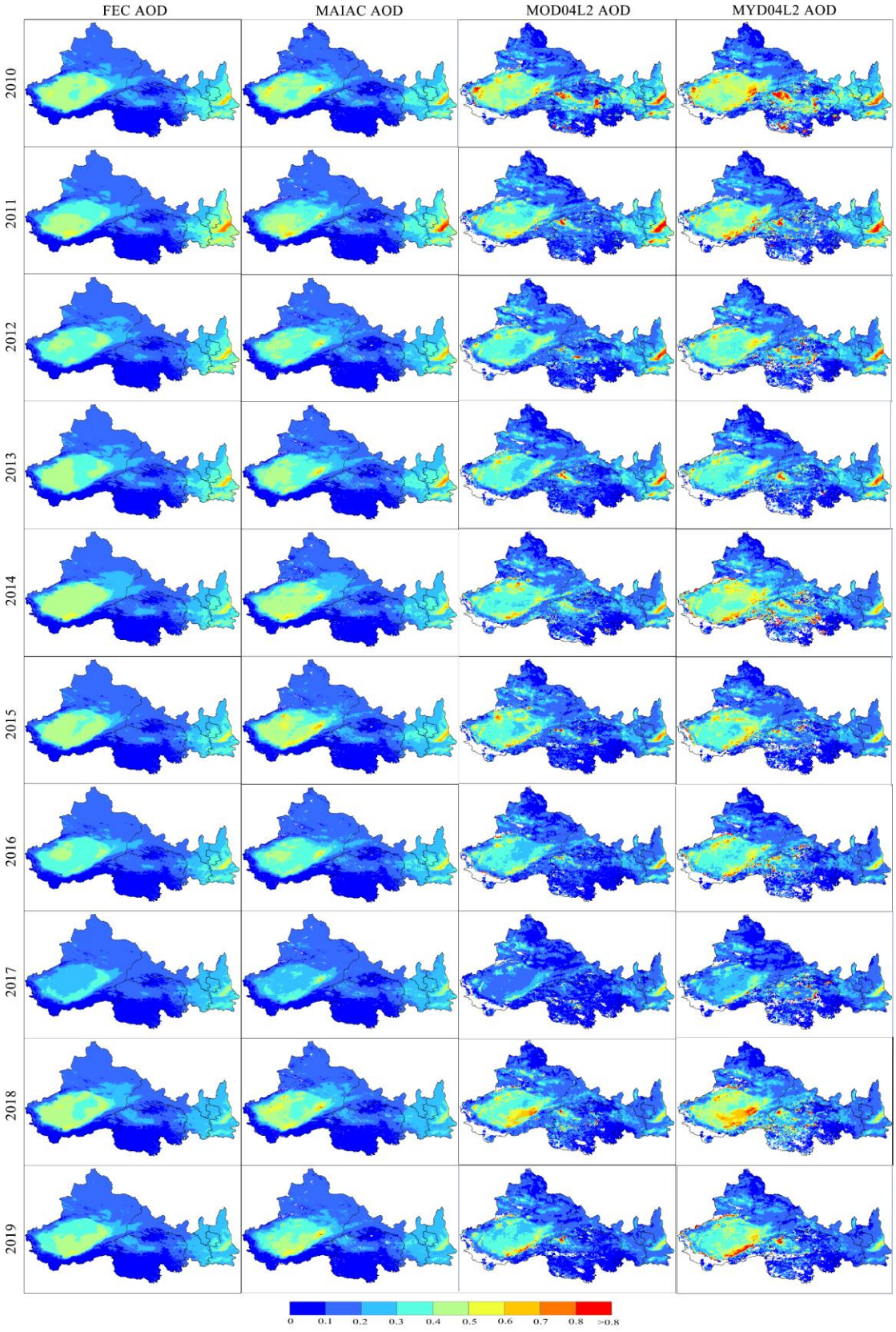

Figure S5. (Continued).

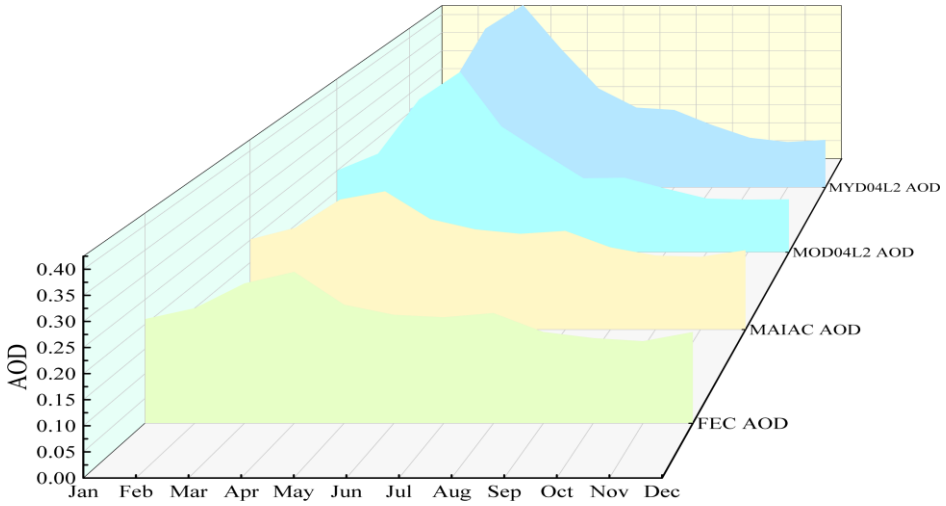

Figure S6. Multiyear monthly average AODs of four AOD products.

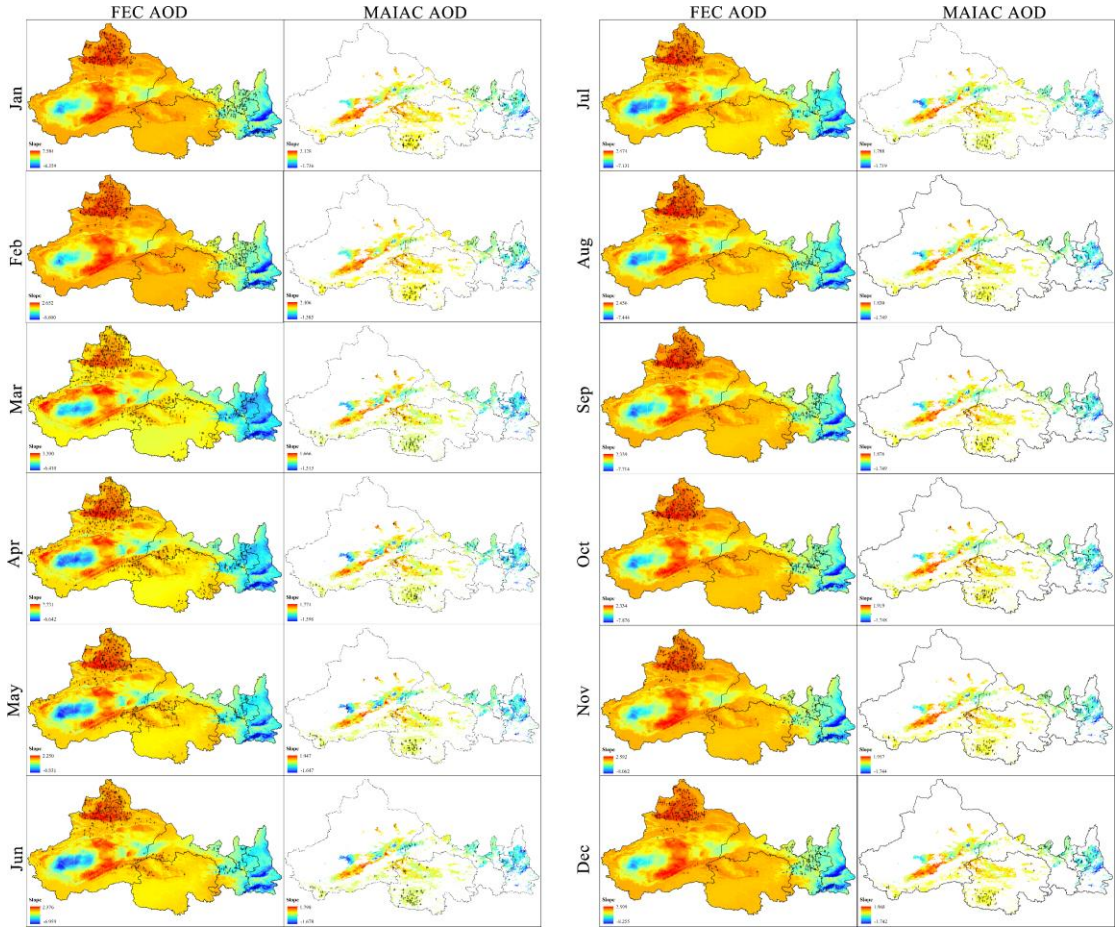

Figure S7. Monthly FEC AOD (10^{-3}) and MAIAC AOD (10^{-2}) spatial change trends from 2000 to 2019. The label '+' indicates a statistically significant trend ($P < 0.05$).

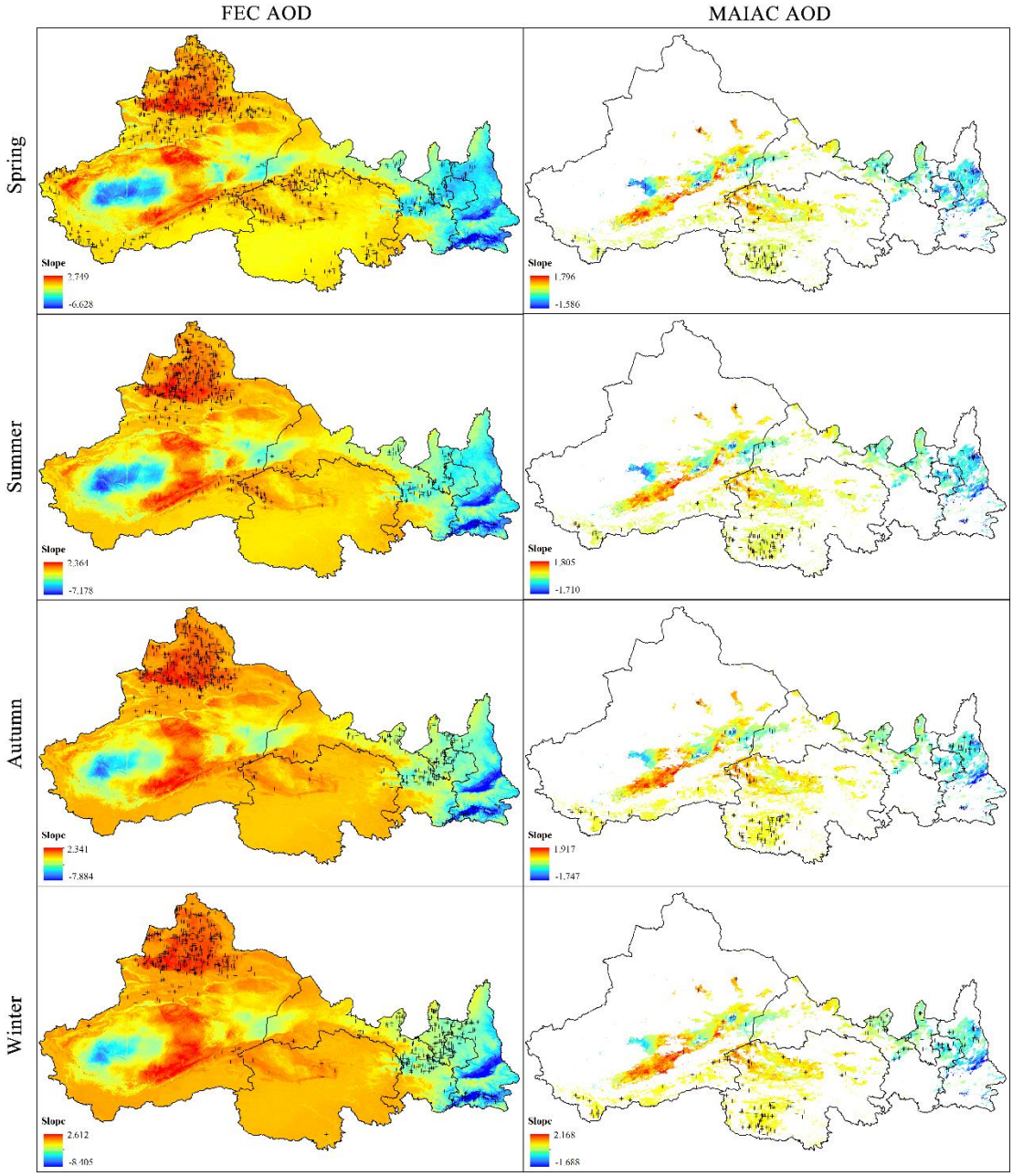

Figure S8. Seasonal FEC AOD (10^{-3}) and MAIAC AOD (10^{-2}) spatial change trends from 2000 to 2019. The label '+' indicates a statistically significant trend ($P < 0.05$).

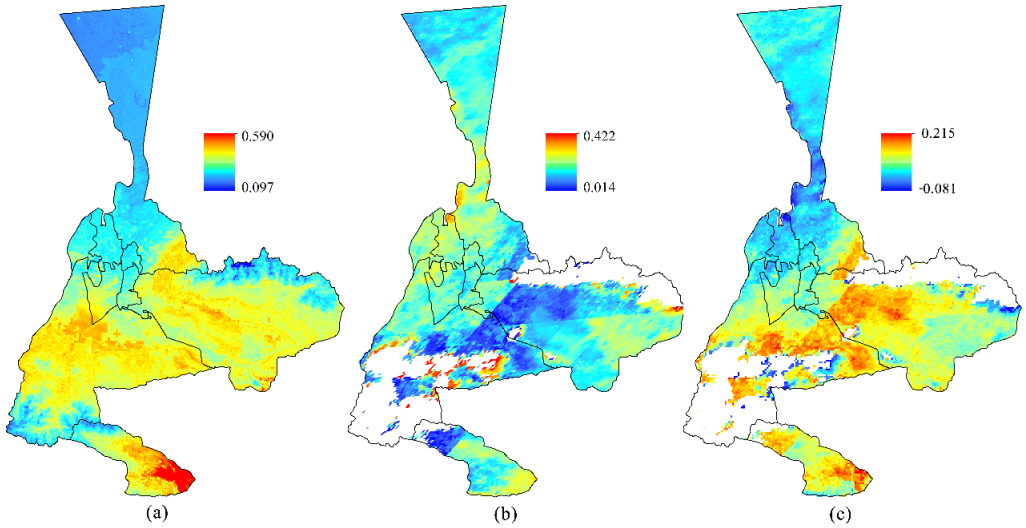

Figure S9. Spatial patterns and the corresponding differences between the FEC and MAIAC AODs in April 2010 over Urumqi: (a) FEC AODs, (b) MAIAC AODs, and (c) FEC minus MAIAC AODs.

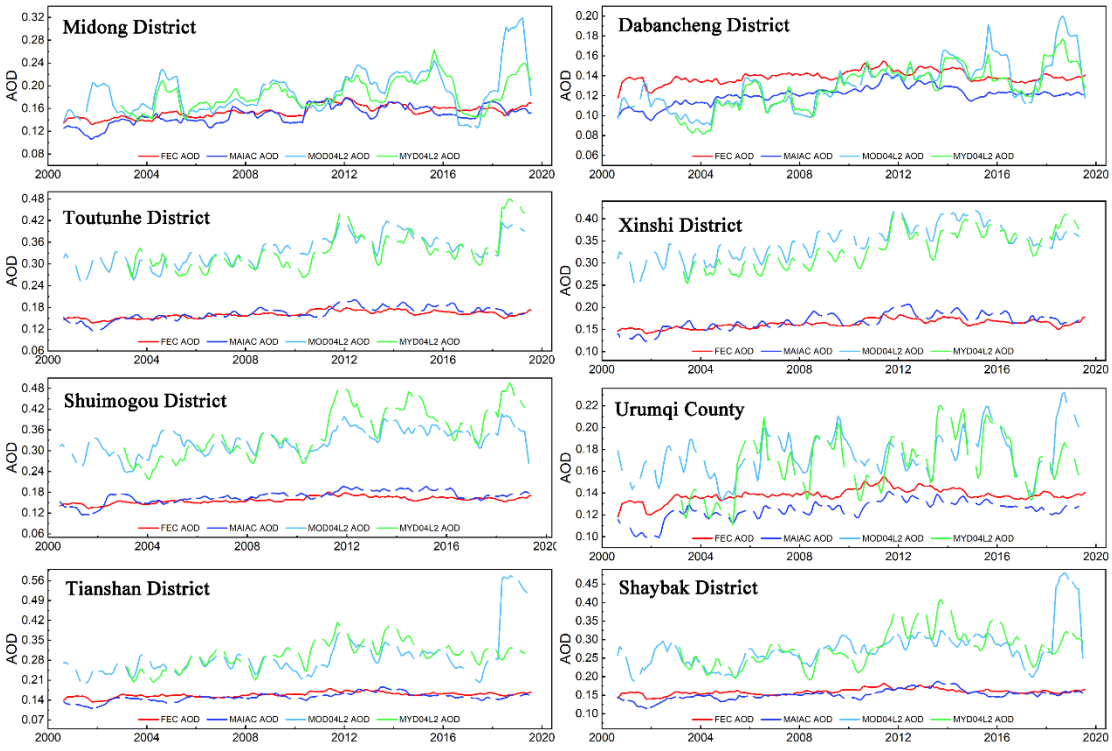

Figure S10. Long-term change trends of four AOD products over each district/county in Urumqi obtained by removing seasonal cycles.

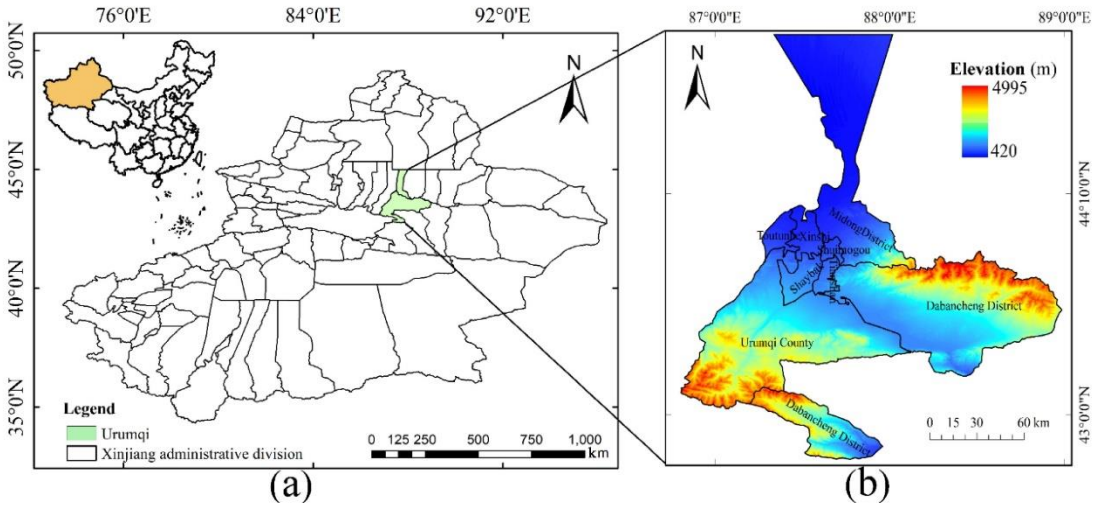

Figure S11. Urumqi administrative map.

Text S1. Calculation of model uncertainty

To ensure the reliability and reasonability of the FEC AOD results, we performed 100 simulations and predictions for August 2010; that is, we conducted 100 predictions for each pixel, and the final prediction result was obtained as the average of these 100 predictions:

$$AOD_{mean}\ (j)=\frac{1}{n}\sum_{i=1}^{n} AOD_i\ (j)$$

where n is the number of simulations and predictions (n = 100), $AOD_i(j)$ is the predicted AOD value of the j_{th} pixel and i_{th} simulation, and $AOD_{mean}\ (j)$ is the predicted mean AOD of the j_{th} pixel.

The model uncertainty was calculated as follows:

$$\mathrm{CI}_{upper}\ (j) = \mu + 1.96 \times \frac{\sigma}{\sqrt{n}}$$

$$\mathrm{CI}_{lower}\ (j) = \mu - 1.96 \times \frac{\sigma}{\sqrt{n}}$$

$$AOD_{uncertainty}\ (j) = \left[\mathrm{CI}_{upper}\ (j) - \mathrm{CI}_{lower}\ (j)\right]/\mathrm{AOD}_{\mathrm{mean}}\ (j)$$

where $\mathrm{CI}_{upper}\ (j)\ and\ \mathrm{CI}_{lower}\ (j)$ are the upper and lower limits of the 95% confidence interval (CI) of the j_{th} pixel, respectively, μ is the j_{th} pixel mean AOD among the 100 predictions, σ is the j_{th} pixel standard deviation AOD among all predictions, n is the number of samples, and $AOD_{uncertainty}\ (j)$ is the uncertainty of the j_{th} pixel prediction.