Supplementary Material

S1. Semivariogram

The spatial statistics can be developed in n-dimensional space, however for the purpose of this study, only one map is filled at a time, which is two-dimensional. Therefore, only two-dimensional setting is discussed here. Let $Y(s)$ be a random variable which represents AOD at a pixel s at any given time t. We assume that the mean of random variables $Y(s_1)$ and $Y(s_2)$ are equal for any two pixels s_1 and s_2; and covariance between $Y(s_1)$ and $Y(s_2)$ is a function of distance between s_1 and s_2. Following this assumption, AOD will be called as a second-order stationary spatial process. We also assume that AOD is isotropic intrinsic stationary, which refers to the variance of the difference of AOD (semivariogram) at two pixels is a function of distance only, as shown in Eq. (S1).

$$\gamma(h) = \frac{1}{2} E\left[\left(Y(s+h) - Y(s)\right)^2\right] \quad \text{(S1)}$$

When assuming isotropy, we have:

$$\gamma(h) = \gamma(|h|) \quad \text{(S2)}$$

In Eq. (S2) $|h|$ represents norm of the vector h.

AOD values at pixels separated by small distance are similar in nature and those far away are not. Therefore, the semivariogram function should be zero for $h = 0$ and it should increase with increasing value of h. Additionally, semivariogram function is conditionally negative definite. AOD data retrieved from satellites are available only at discrete pixels and therefore semivariogram can only be calculated at some discrete points from $h = 0$ to M (upper bound for h). The semivariogram computed from these discrete points is called experimental semivariogram. Mathematically it defined as in Eq. (S3),

$$\hat{\gamma}(h) = \frac{1}{2|N(h)|} \sum_{(s_1,s_2)\in N(h)} \left(Y(s_1) - Y(s_2)\right)^2 \quad \text{(S3)}$$

where $|s_1 - s_2| = h$ and $N(h)$ is number of pairs (s_1, s_2) such that $|s_1 - s_2| = h$.

Continuous semivariogram can be formed by approximating discrete semivariogram with a continuous function, which satisfies semivariogram properties. Three of the commonly used continuous semivariograms are Gaussian, exponential and spherical. In this paper, spherical semivariogram model is used, which is defined in Eq. (S4).

$$f(h) = \begin{cases} b + c\left[\frac{3}{2}\frac{h}{a} - \frac{1}{2}\left(\frac{h}{a}\right)^3\right], & h \le a \\ b + c, & h > a \end{cases} \quad \text{(S4)}$$

where a is called range b is called nugget and c is called sill of the semivariogram. Practically, for h greater than certain value of the range, the semivariogram becomes constant.

In Co-Kriging we need cross semivariogram between MISR and MODIS which is defined in Eq. (S5) by modifying Eq. (S3).

$$\hat{\gamma}(h) = \frac{1}{2|N(h)|} \sum_{(s_1,s_2) \in N(h)} \left(Y(s_1) - Z(s_2)\right)^2 \quad \text{(S5)}$$

where Y and Z represents MISR and MODIS AOD data, respectively.