

## Supplementary Material

### Enhancing the advection module performance in the EPIC-Model V1.6.0 via GPU-HADVPPM4HIP V1.0 coupling and GPU-optimized strategies

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1. The formulas for calculating the root mean square error (RMSE) and correlation coefficient are :

$$\text{RMSE} = \sqrt{\frac{1}{n} \sum_{i=1}^n (M_i - O_i)^2}$$
$$R = \frac{\sum_{i=1}^n (M_i - \bar{M})(O_i - \bar{O})}{\sqrt{\sum_{i=1}^n (M_i - \bar{M})^2} \sqrt{\sum_{i=1}^n (O_i - \bar{O})^2}}$$

where  $M_i$  and  $O_i$  are simulated and observed concentrations, respectively;  $\bar{M}$  and  $\bar{O}$  are the simulated and observed mean concentrations, respectively; and  $n$  is the total number of individual observations.