New method helps reduce uncertainty in numerical models

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The uncertainty related to physical parameters is a major challenge in numerical modeling. However, due to the large number of such parameters in numerical models, reducing the uncertainty for all of them would be extremely expensive in terms of manpower and resources.

Therefore, it is critical to be able to identify and study the most important and sensitive physical parameters and parameter combinations in numerical models.

To address this issue, CAS member Mu Mu and his team from Fudan University and the Institute of Atmospheric Physics at the Chinese Academy of Sciences proposed a new method—"conditional nonlinear optimal perturbations sensitivity analysis (CNOPSA)"—to reduce uncertainties in numerical models.

Their findings were published in *Advances in Atmospheric Sciences*.

They first analyzed limitations of the traditional (variance-based) approach for parameter sensitivity analysis, which seems unable to consider extreme events because of the statistical influence of discrete parameter samples, and then proposed the new method from the deterministic point of view.

They found that the CNOPSA method was capable of fully considering nonlinear synergistic effects of the parameters and could deterministically estimate the maximum effect on the model output due to uncertainties in physical parameters. Thus, the greater the maximum effect on the model output due to parameter uncertainty, the more important and sensitive the parameter is.

The researchers applied CNOPSA to a grassland ecosystem model to test its feasibility. Numerical results showed that the method was effective in identifying the sensitivity of physical parameters in the tested grassland ecosystem model. These parameters shifted the modeled wilted biomass, which affected the transformation of the grassland state in the ecosystem.

By comparison, the variance-based approach underestimated the parameter sensitivity because it failed to consider the effects of all parameters in the parameter space.

"In future work, we intend to employ even more complex land surface process models to validate the usefulness and effectiveness of the CNOPSA method," said Prof. Mu.

More information: Qiujie Ren et al, A New Sensitivity Analysis Approach Using Conditional Nonlinear Optimal Perturbations and Its Preliminary Application, *Advances in Atmospheric Sciences* (2022). DOI: 10.1007/s00376-022-1445-3

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