How to Identify Good Coupling Methods With Error Analysis

Objective

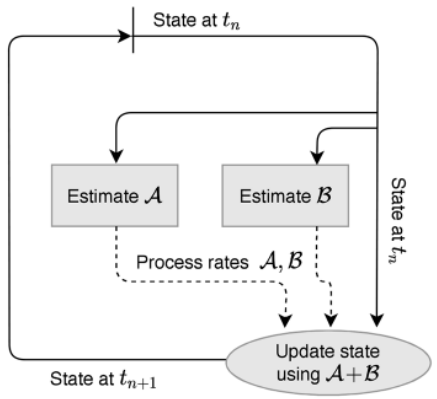
- Leverage mathematical error analysis techniques to provide general guidance on choosing numerical methods for coupling physical processes in complex models like the Energy Exascale Earth System Model (E3SM).
- As an example, help explain the improved dust lifetime when parallel splitting is used over sequential splitting for aerosol life cycles in E3SM version 1.

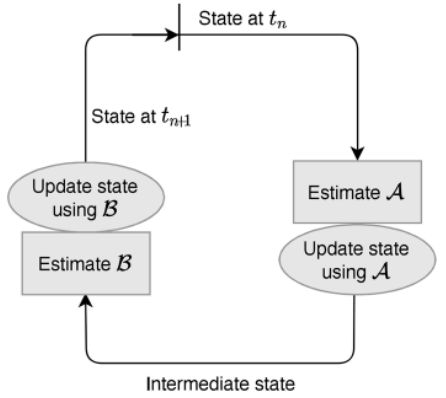
Approach

- Treat model equations in a semi-discrete manner that distinguishes splitting error from integration errors of individual processes.
- Demonstrate the impact of two sources of splitting error: (1) treating processes in isolation and (2) using input that contains error.
- Generalize analysis into a framework and share with the Earth system modeling community along with a specific application to aerosol life cycles.

Impact

- Increases confidence that the revised aerosol process coupling proposed to E3SM provides the right answer for the right reason, i.e., that the proposed method is numerically more accurate.
- Provides an intuitive way for the Earth system modeling community to analyze current splitting methods and develop new methods.





The analysis framework provides deep insights into the sources of splitting error and their possible interactions for some examples of coupling methods widely used in Earth system modeling. The insights can be used as building blocks to assess and design additional methods.

CJ Vogl, H Wan, CS Woodward, QM Bui. 2024. "Numerical coupling of aerosol emissions, dry removal, and turbulent mixing in the E3SM Atmosphere Model version 1 (EAMv1)—Part 2: A semi-discrete error analysis framework for assessing coupling schemes," *Geoscientific Model Development*, Volume 7, Issue 3, p1409-p1428, 2024. DOI: 10.5194/gmd-17-1409-2024