Interactive Data Exploration Helps Reveal Gaps in Aerosol-Cloud Interactions Research

BER/ASCR SciDAC Partnership (PAESCAL)

Scientific Achievement

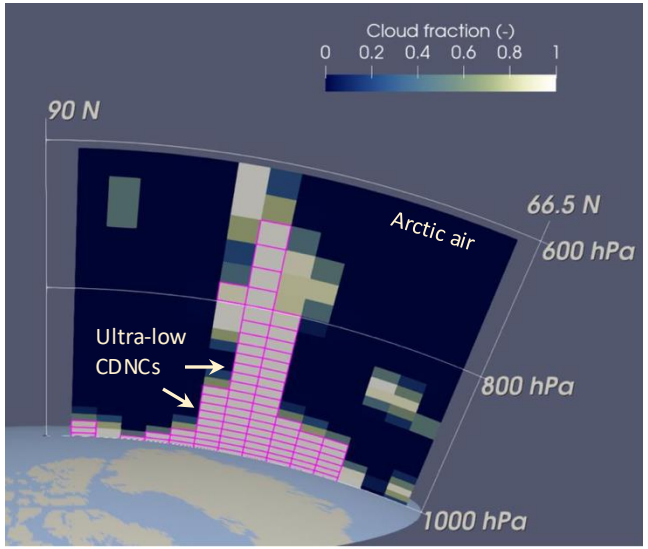
- Global simulations of aerosol-cloud interactions often produce cloudy grid cells with unrealistically low (ultra-low) cloud droplet number concentrations (CDNCs), which significantly affects the simulated atmospheric energy balance.
- Key features of atmospheric conditions associated with the ultra-low CDNCs are identified for DOE's Energy Earth System Model version 2 (E3SMv2).

Significance and Impact

- A key cloud regime has been identified to help the global atmosphere and Earth system modeling communities understand the root causes of unrealistic CDNCs and improve the numerical models' ability to simulate atmospheric energy balance.
- The collaboration with industry demonstrates the value of advanced visualization tools in scientific research.

Technical Approach

- For interactive data exploration, Python-based plugins were developed for ParaView to support new unstructured mesh, allow domain-specific data mapping and selection, and enable fast data processing.
- For improving understanding of physics, in-situ (during simulation) analysis and sampling were used to obtain detailed information of process interactions under key conditions while keeping the output data volume manageable.



A snapshot of clouds in an 2D slice of the Earth's atmosphere within the Arctic Circle. Color shading shows the cloud amount. Magenta boxes indicate where ultra-low droplet number concentrations are found in the E3SMv2 simulation. Snapshots like this from ParaView reveal that unrealistic results may prevail large core areas of low-altitude stratus clouds, suggesting that more research is needed to understand the life cycle of such clouds and their representation in numerical models like E3SM.

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