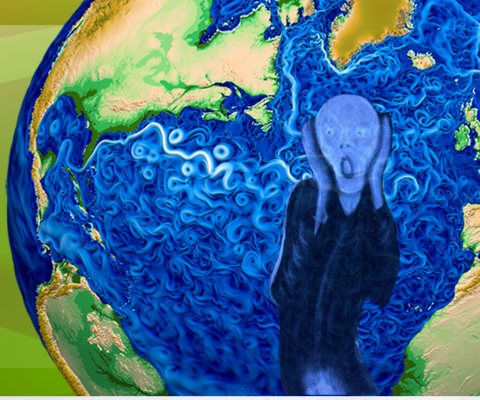
E3SM
Energy Exascale
Earth System Model



Design of a Next-Generation Atmospheric Driver for SCREAM

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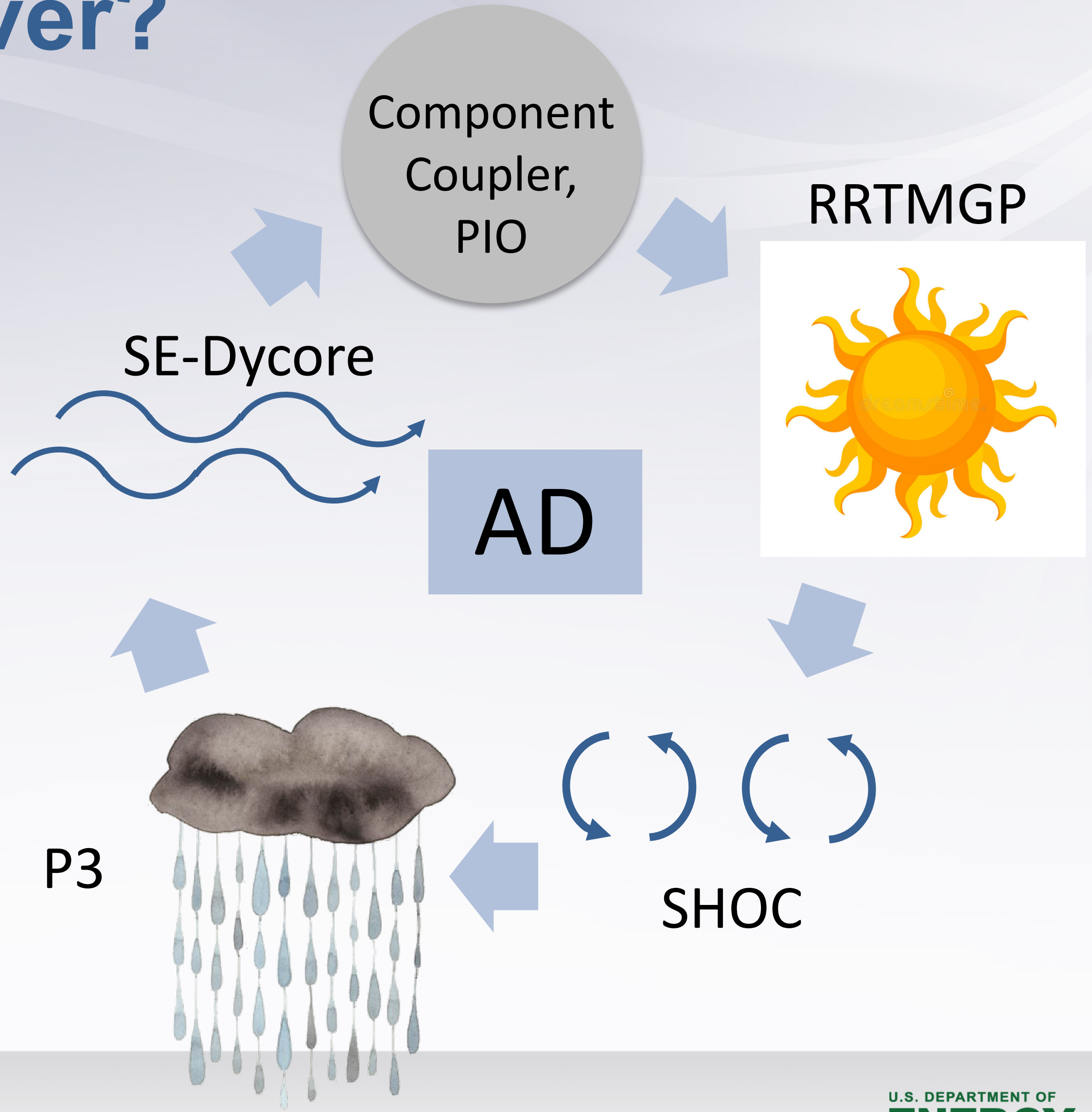
What is the Atmospheric Driver?

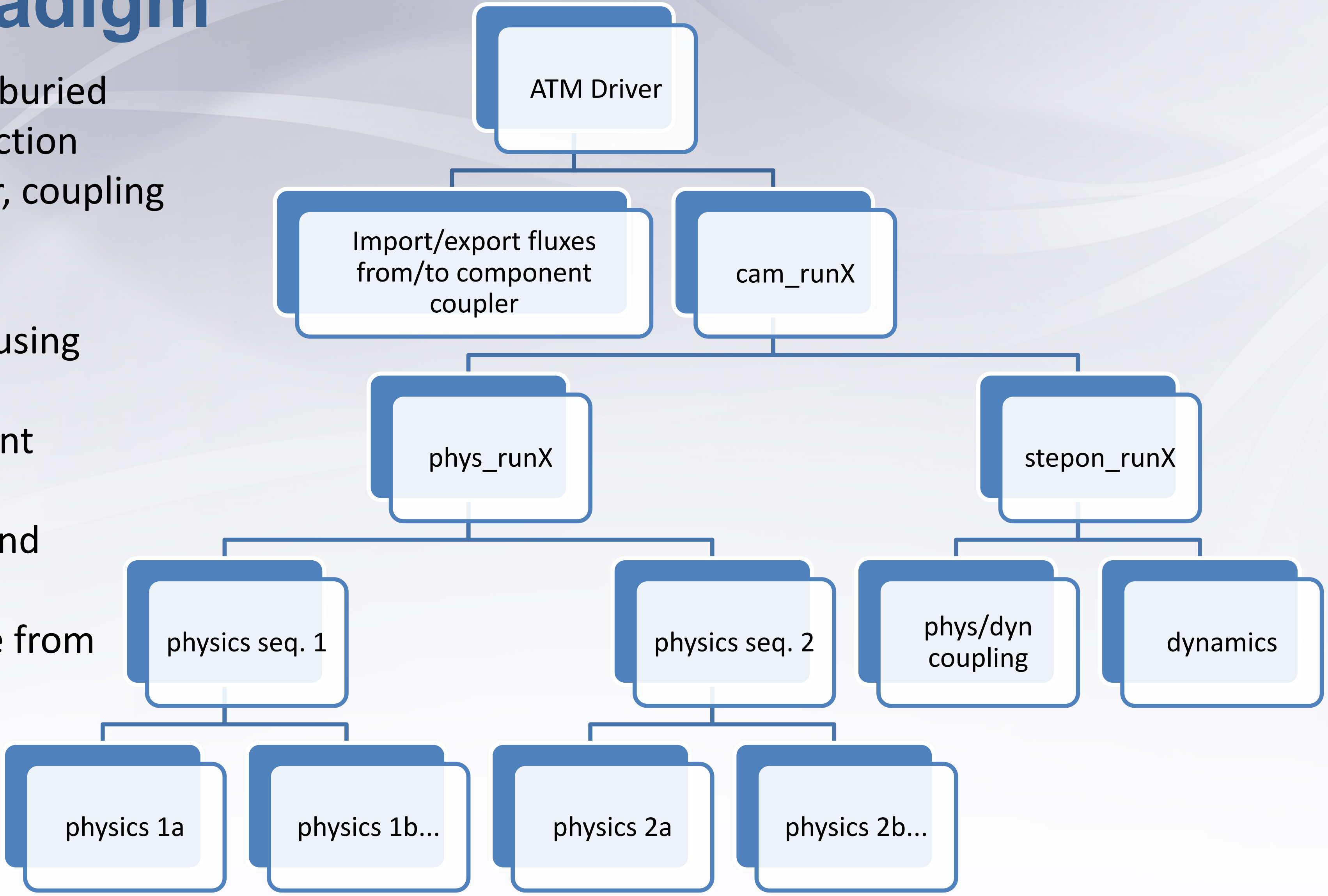
- Controls the coupling of atmospheric processes.
- Controls the passage of information between atmospheric processes.
- Controls the import/export of data from the atmosphere to the other model components.
- Interfaces with the input/output routines.



Current E3SM paradigm

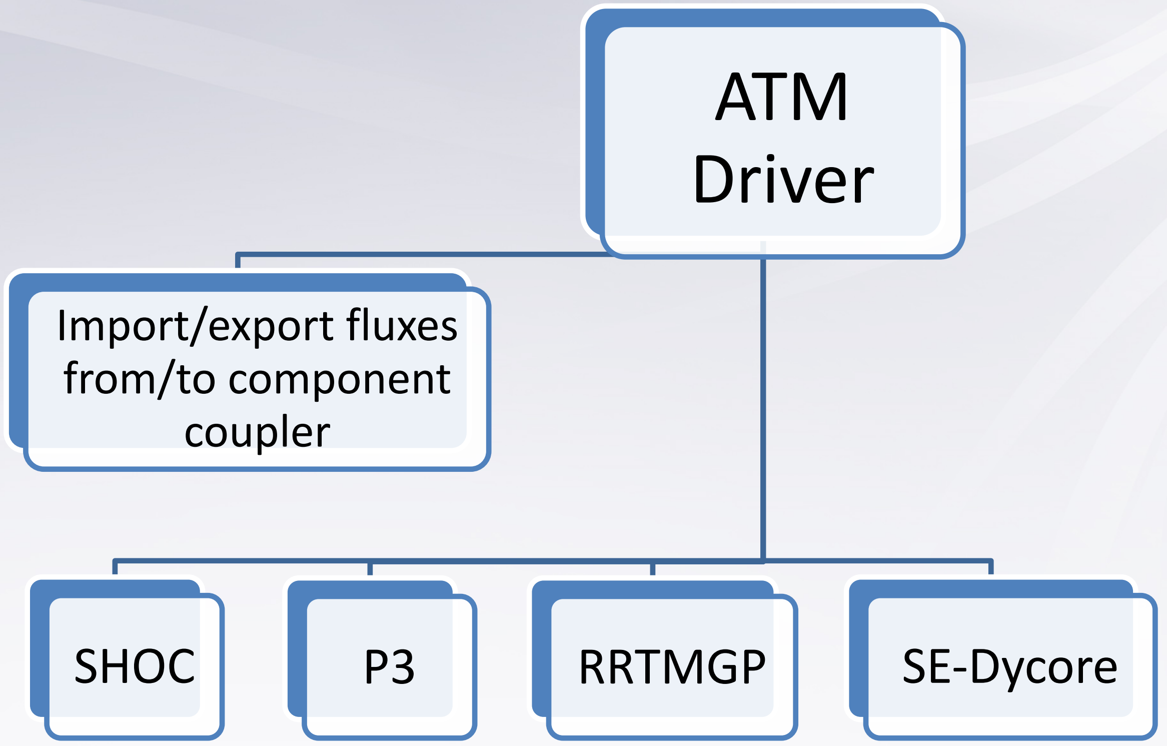
- Actual atmospheric processes are buried beneath multiples layers of abstraction
  - makes changing process order, coupling approach, or adding new parameterizations difficult
  - makes the run sequence confusing

- Different processes require different information, limiting code reuse:
  - Dynamics needs both states and tendencies from physics.
  - Physics receives only the state from dynamics.
  - Only tendencies are passed between parameterizations.



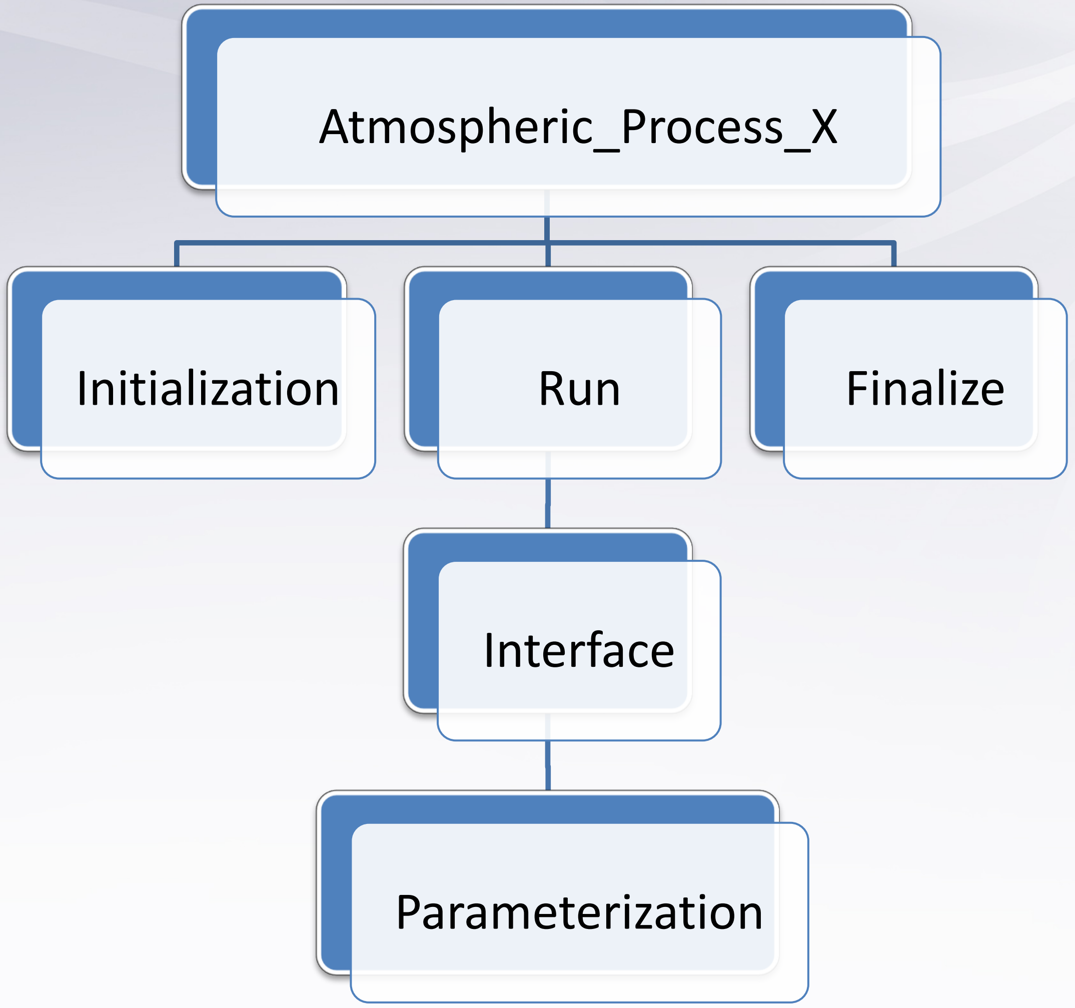
SCREAM Atmospheric Driver

- Uses a generic **atmospheric process class** for both dynamics and physics which is responsible for:
  - The import and export of surface fluxes
  - Interfacing with the set of atmospheric processes
- This simpler paradigm allows for:
  - Straightforward changes to process order
  - Switching between parallel & sequential splitting
  - Easy addition of new parameterizations
- Enables consistent passage of information between processes:
  - Only the model state will be passed in and out of atmospheric processes



Atmospheric Process Class

- Provides consistent infrastructure for all processes
- Each process has init, run, and finalize methods
- Parameterization portability is enabled by using an ‘interface’ layer to convert input/output between AD- and parameterization-specific data structures



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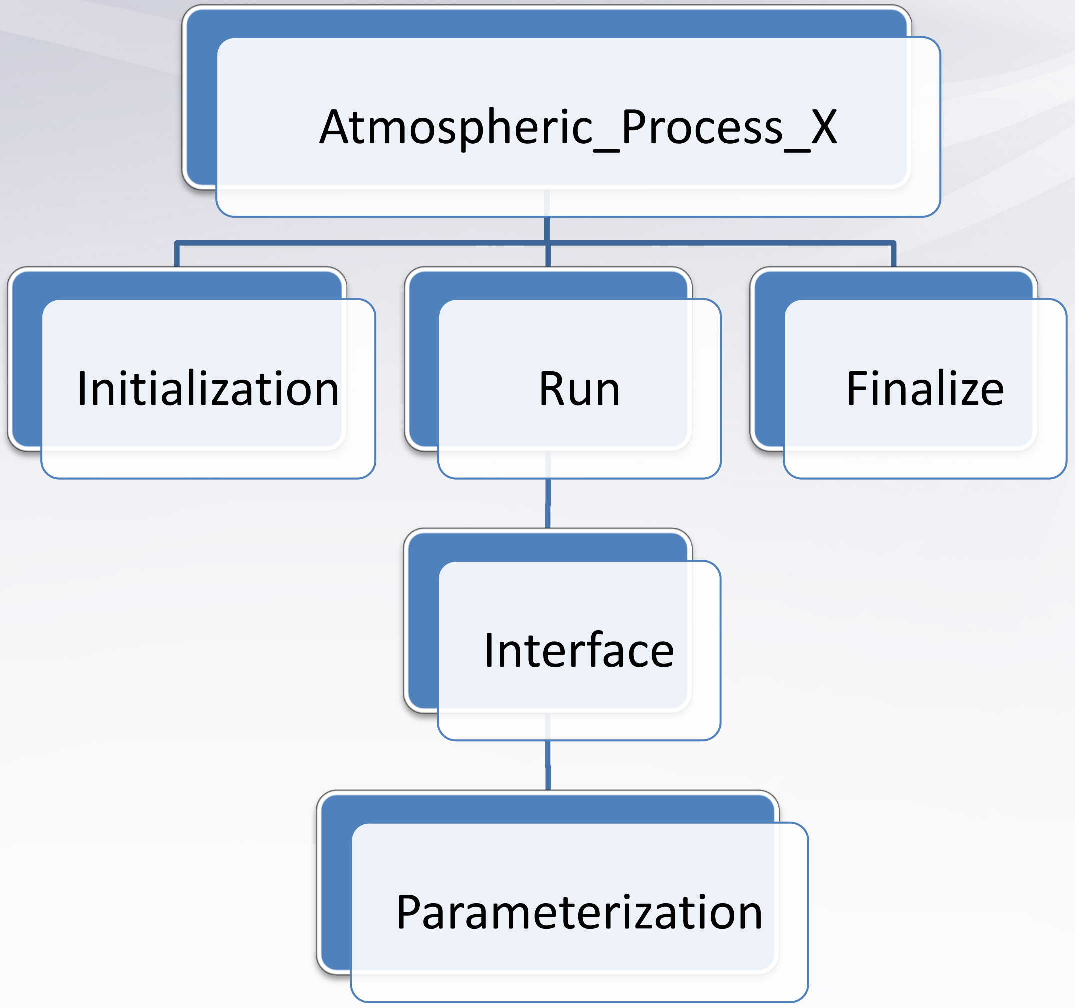
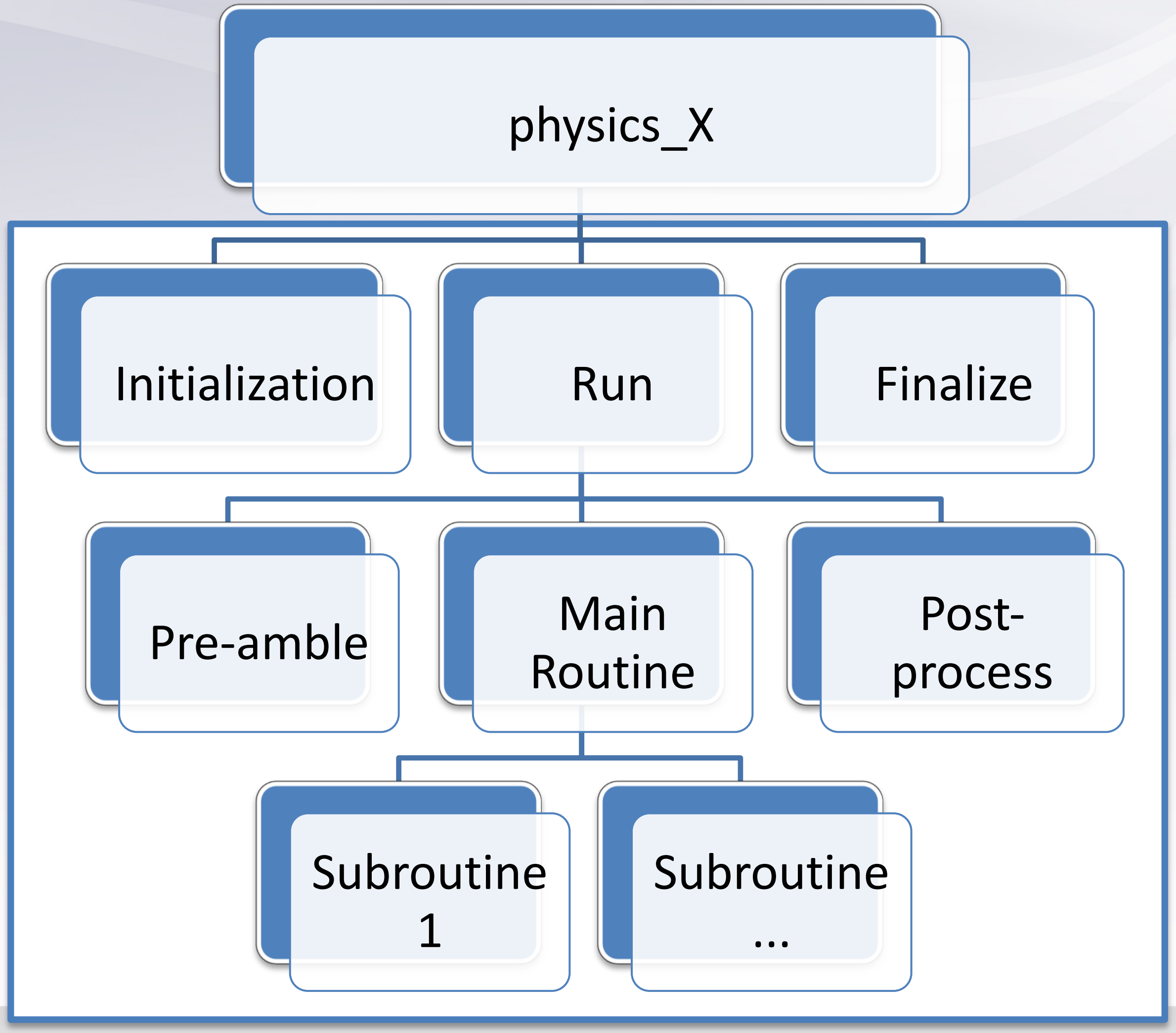


How data is passed around currently:

ATM Driver

Physics Buffer (PBUF)



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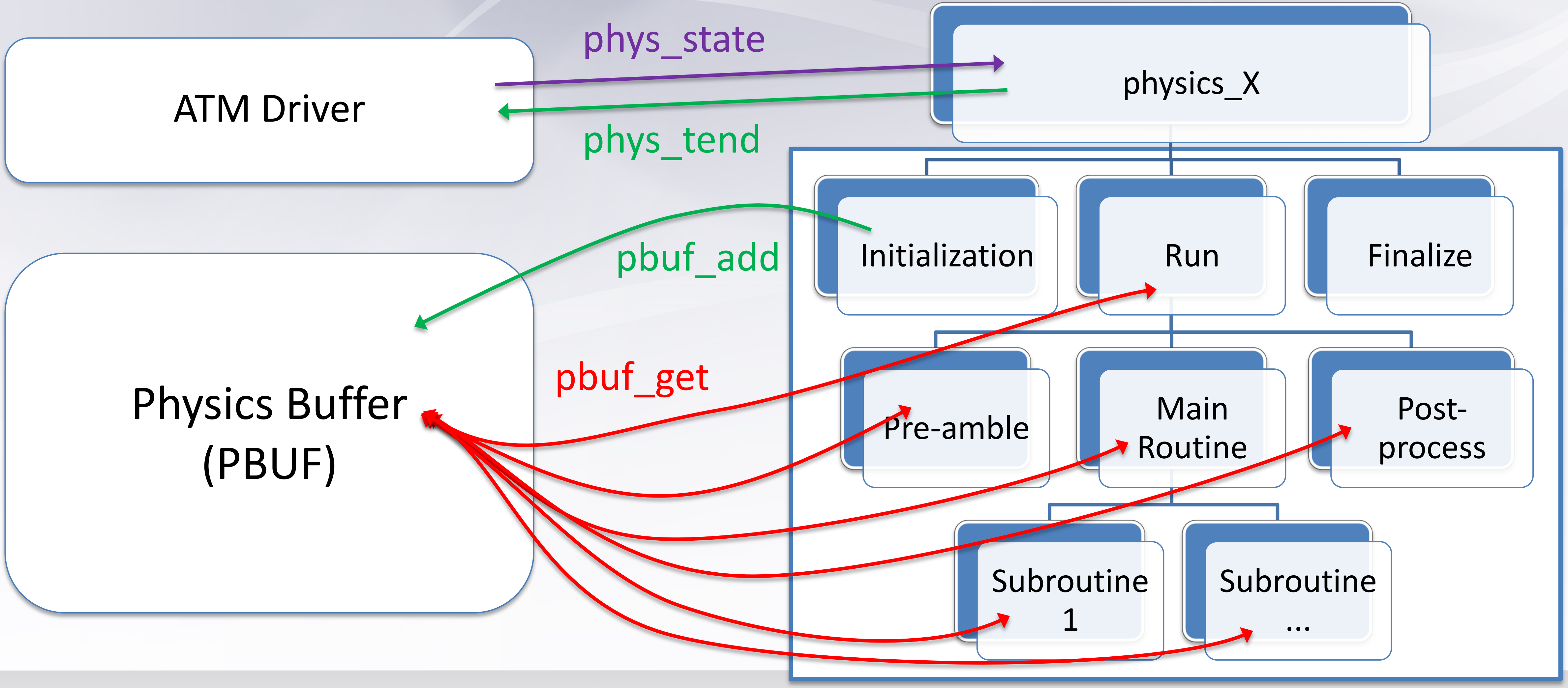
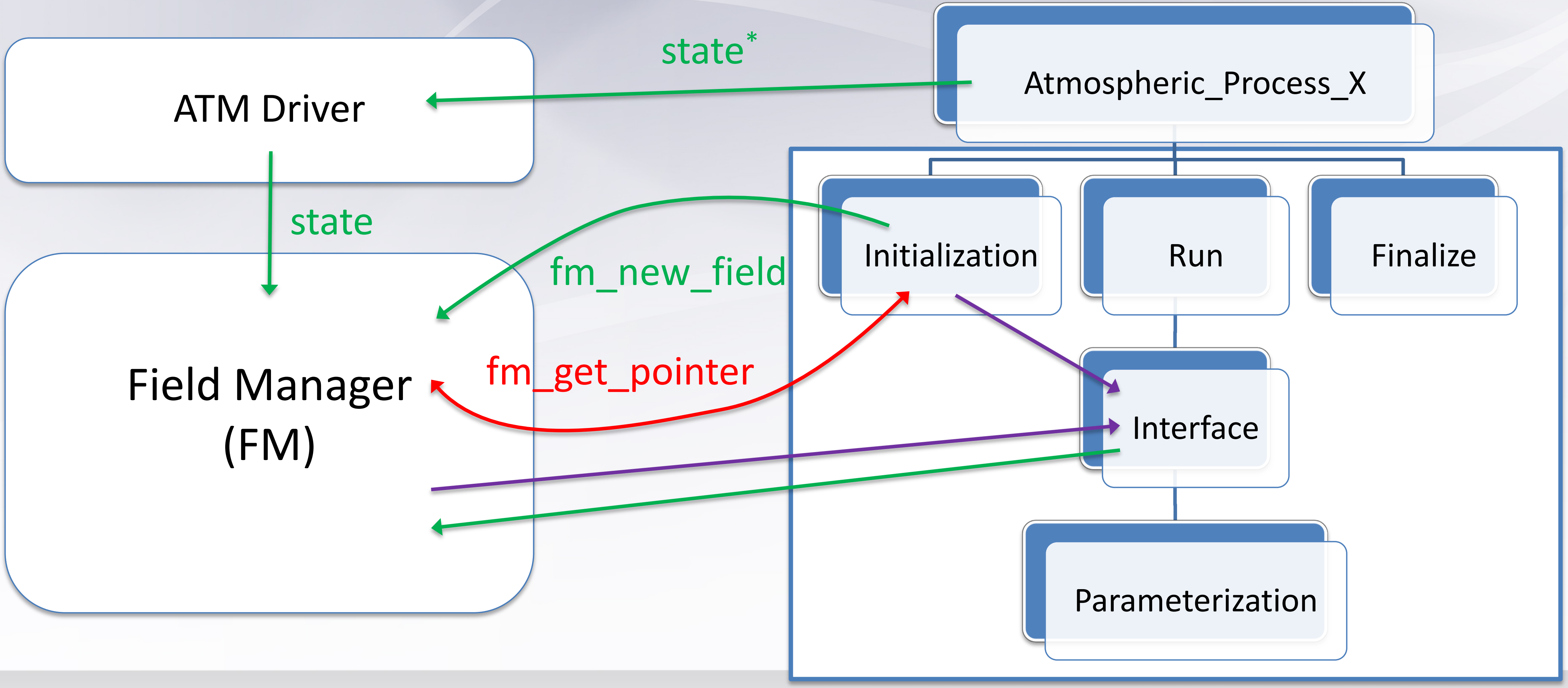


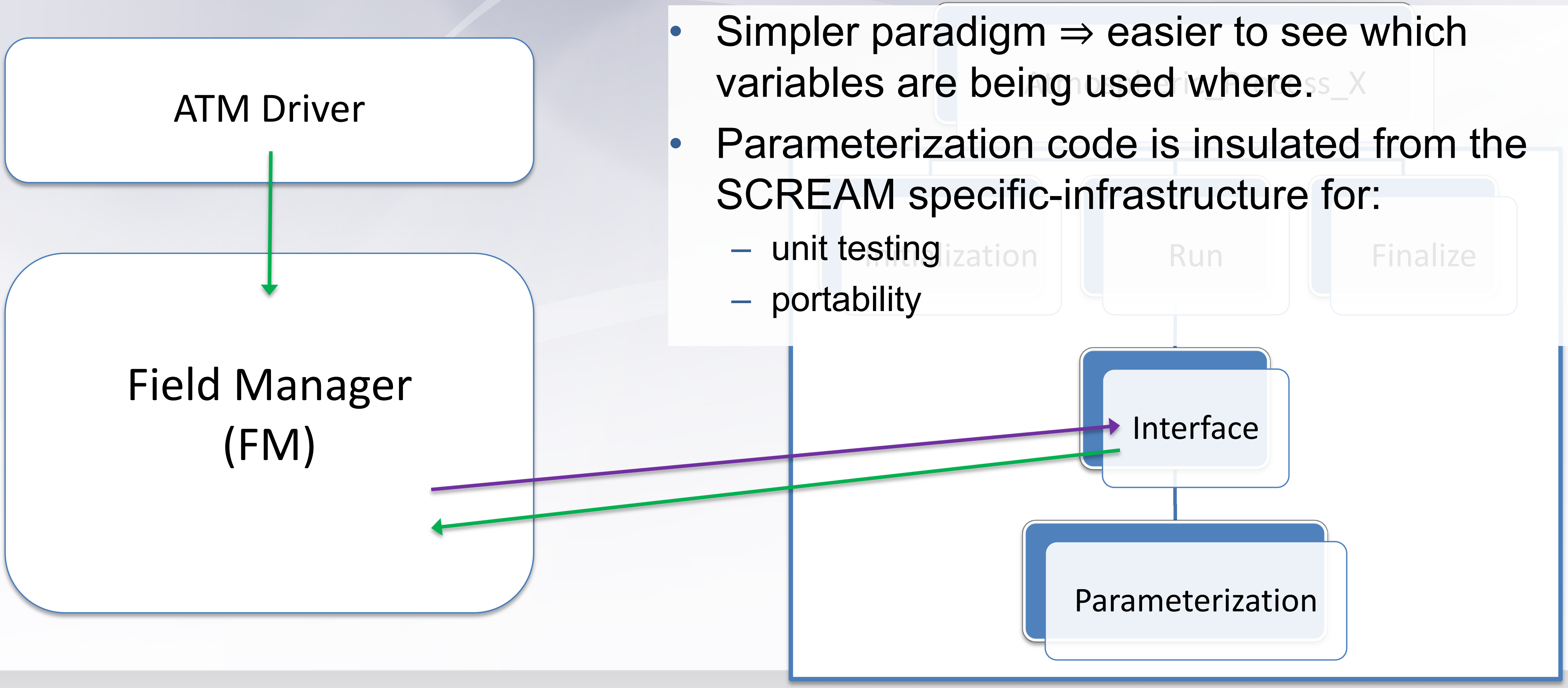
Field Manager (FM)

- Like PBUF, FM will associate variables with pointers to memory.
- FM will handle all AD variables, including prognostic state variables.
  - Only the AD layer will be able to change prognostic state variables.
- FM will only be accessible by initialization and parameterization-interface layers.
  - As a result, all input/output to parameterizations must be passed as input and/or output.
- FM will include new tools to:
  - track where variables are used
  - identify where variables are changed

How data will be passed around in SCREAM FM



How data will be passed around in SCREAM FM



- Simpler paradigm ⇒ easier to see which variables are being used where.
- Parameterization code is insulated from the SCREAM specific-infrastructure for:
  - unit testing
  - portability

Accomplishments and Conclusions

- Written SCREAM-AD design document and will submit for external review shortly.
  - Available on Confluence: https://acme-climate.atlassian.net/wiki/spaces/NGDNA/pages/907378934/SCREAM-AD+Design+Docs
- Ongoing C++ development of SCREAM-AD code.
- The SCREAM-AD maintains the good properties of E3SM's driver logic but simplifies and improves things where possible.
- Our **atmospheric process** class streamlines the interface between the atmosphere model driver and the individual processes.
- A new **field manager class** improves on the current physics buffer structure by
  - simplifying the interface between processes and variables.
  - Insulating parameterization code from model infrastructure, facilitating unit tests and portability.