Computing New Diagnostic Fields in MPAS-Atmosphere Simulations

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Motivation

As the number of people using MPAS-Atmosphere increased to even a very modest number, it was recognized that we needed some structured way of introducing the computation of new diagnostics

We wanted a framework that could handle:

- Instantaneous diagnostics
- Cumulative diagnostics
- Extreme value diagnostics
- *Or anything that looked like the above from a computational standpoint!*

Diagnostics should be able to change in response to modifications of the streams that write them, too.

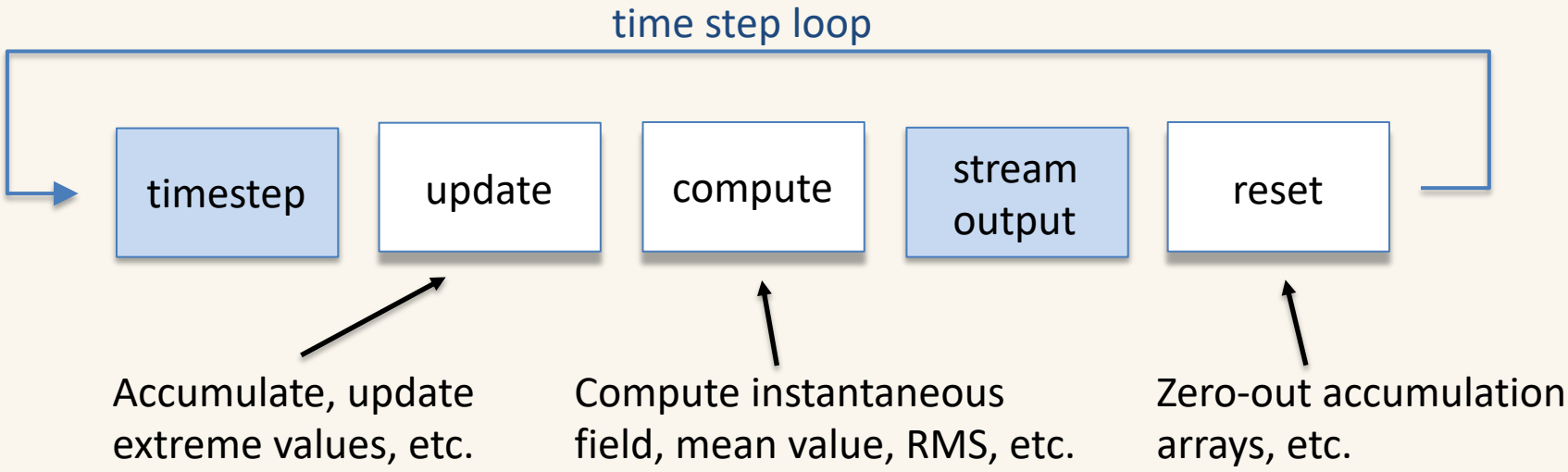
Introduction

Broadly, there are five stages in the computation of diagnostics like those types listed on the previous slide:

1. **Setup** – Pre-allocate arrays that will be needed by the diagnostic during the simulation, initialize values, etc.
2. **Update** – Accumulate values, update extrema, etc.
3. **Compute** – Divide by the accumulation period to get mean values, compute instantaneous fields, etc.
4. **Reset** – After writing the diagnostic, zero-out accumulation arrays, etc.
5. **Cleanup** – Deallocate any memory that was allocated by the diagnostic

Diagnostics framework

Other than *Setup* and *Cleanup*, how do these phases fit into the sequence of a model timestep?

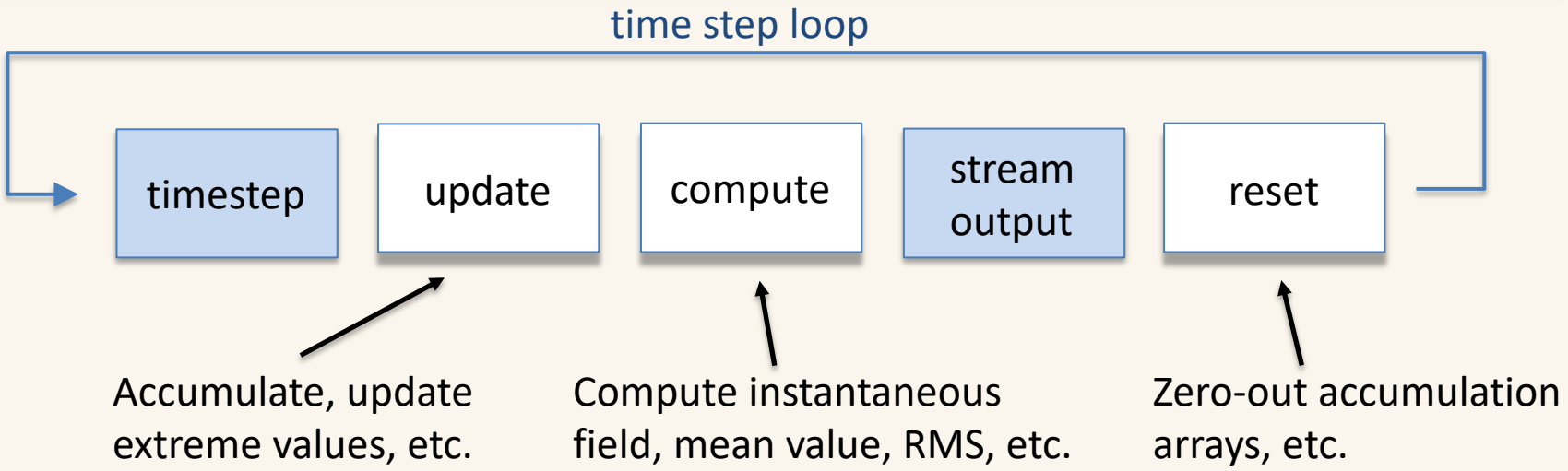


Critically, we need some way for a diagnostic to determine whether it will be written out in a given timestep!

Diagnostics utilities

Along with the diagnostics framework, a utility module has been written that will tell a diagnostic:

- Whether its field will be written in a given timestep
  - Generally called from the *Compute* phase
- How many output streams include its field



Code organization

In terms of code structure, where do we add diagnostics?

- The idea is that all diagnostics should be implemented as self-contained modules
- All diagnostics modules should reside in the same place

```
MPAS-Model/
    src/
        core_atmosphere/
            diagnostics/
            dynamics/
            inc/
            physics/
            Registry.xml
            utils/
```

Add new diagnostics in this directory

The main Registry.xml file will include "sub-Registry" sections from the diagnostics directory

Code organization

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```
MPAS-Model/
    src/
        core_atmosphere/
            diagnostics/
                Makefile
                Registry_diagnostics.xml
                mpas_atm_diagnostics_manager.F
            dynamics/
            inc/
            physics/
            Registry.xml
            utils/
```

These files serve as the interface between your new diagnostic and the rest of MPAS

How to add a new diagnostics?

1. Define new namelist options and fields in a new `Registry_<your_diagnostic>.xml` file. Add a `#include` statement for this new Registry section in the `Registry_diagnostics.xml` file.
2. Create a new module for the diagnostic.
3. Add calls to your diagnostic's *setup*, *update*, *compute*, *reset*, and *cleanup* routines in the main diagnostic driver.
4. Update the `Makefile` to compile your new diagnostic module.

The `README` file in the `diagnostics/` subdirectory describes the step-by-step process to adding a new diagnostic

MPAS
Model for Prediction Across Scales

Example: Maximum SW downward flux

Working in the `src/core_atmosphere/diagnostics/` directory:

1. Define the maximum SWDOWN field in a new `Registry_swdown.xml` file

```
<var_struct name="diag_physics" time_levs="1">
        <var name="gsw_max" type="real"
             dimensions="nCells Time"
             units="W m^{-2}"
             description="Maximum surface SW radiation flux"/>
</var_struct>
```

2. Include `Registry_swdown.xml` in `Registry_diagnostics.xml`

```
<!-- SW radiation diagnostics -->
#include "Registry_swdown.xml"
```

Example: Maximum SW downward flux

Working in the `src/core_atmosphere/diagnostics/` directory:

3. Write the *setup*, *update*, and *reset* routines for the diagnostic:

```
subroutine swdown_setup(all_pools)

    type (MPAS_pool_type), pointer :: all_pools

    type (MPAS_pool_type), pointer :: diag_physics

    call mpas_pool_get_subpool(all_pools, 'diag_physics', diag_physics)
    call mpas_pool_get_array(diag_physics, 'gsw', gsw)
    call mpas_pool_get_array(diag_physics, 'gsw_max', gsw_max)

    gsw_max(:) = 0.0

 end subroutine swdown_setup
```

Not shown in the code above is the declaration of gsw and gsw_max pointers as module variables…

Example: Maximum SW downward flux

Working in the `src/core_atmosphere/diagnostics/` directory:

3. Write the *setup*, *update*, and *reset* routines for the diagnostic:

```
subroutine swdown_update()

    gsw_max(:) = max(gsw_max(:), gsw(:))

end subroutine swdown_update
```

Example: Maximum SW downward flux

Working in the `src/core_atmosphere/diagnostics/` directory:

3. Write the *setup*, *update*, and *reset* routines for the diagnostic:

```
subroutine swdown_reset()

   use mpas_atm_diagnostics_utils, only : mpas_field_will_be_written

    if (mpas_field_will_be_written('gsw_max')) then
        gsw_max(:) = 0.0
    end if

end subroutine swdown_reset
```

Example: Maximum SW downward flux

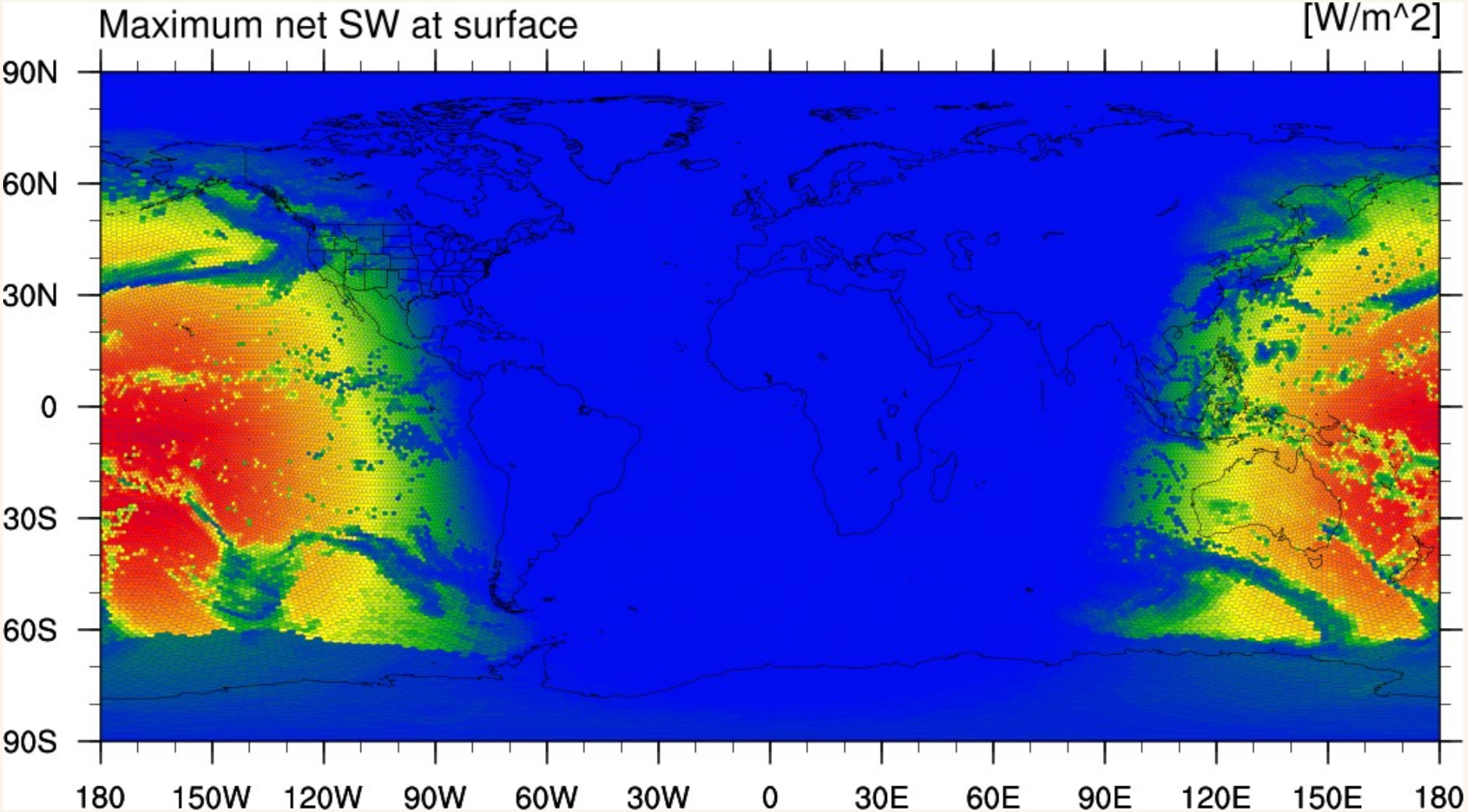
After adding a couple of lines to the `Makefile`, we're ready to compile MPAS-Atmosphere and try out our new diagnostic

We'll test it by:

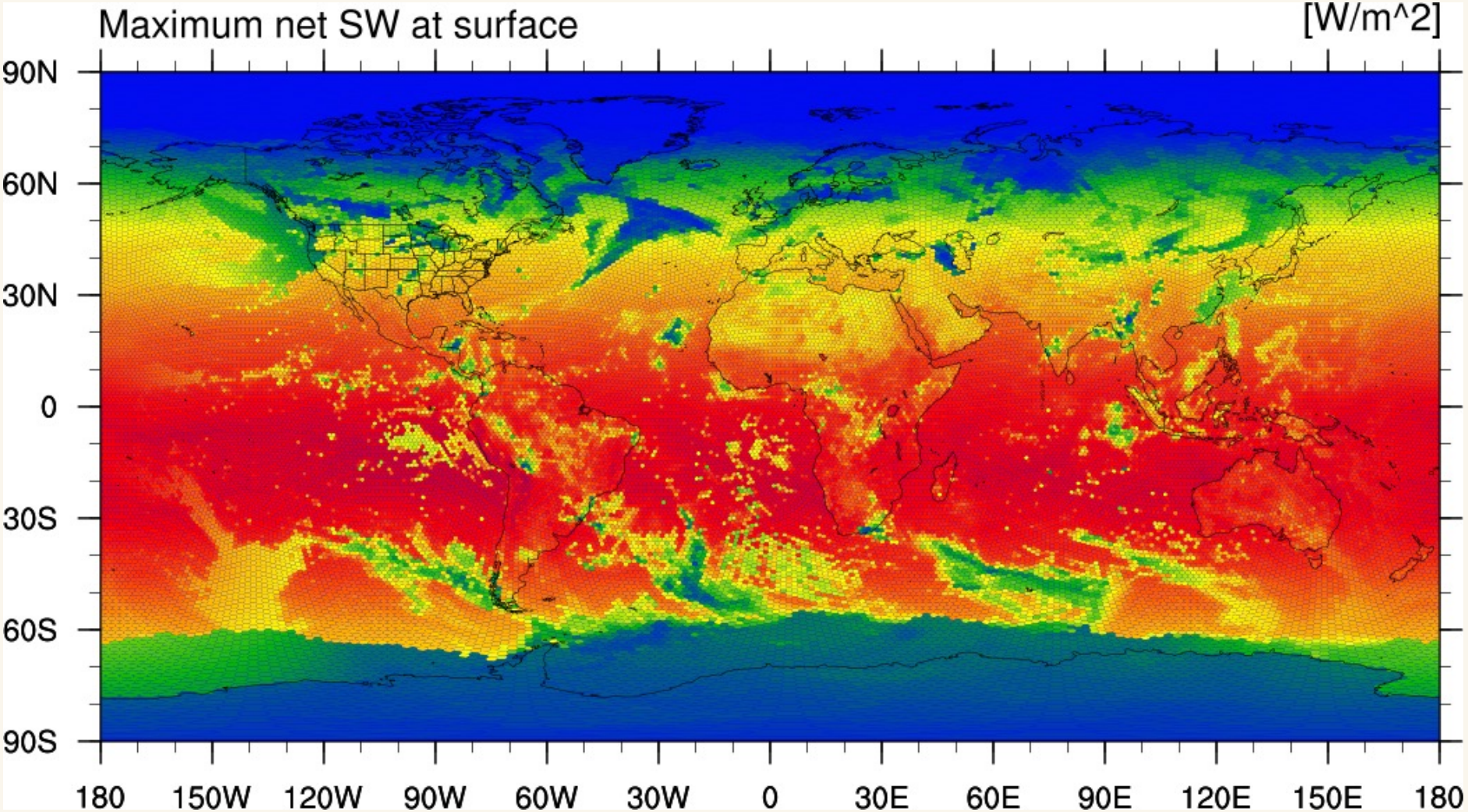
- Outputting the gsw_max field every 60 minutes
- Outputting the gsw_max field every 1440 minutes

Our test simulation will start at 2010-10-23 at 00 UTC, and we'll look at the output that we get at 2010-10-24 at 00 UTC…

Example: 60-minute output interval



Example: 1440-minute output interval



Conclusion

MPAS-Atmosphere provides a framework that enables many types of diagnostic fields to be implemented in a modular way

The file
`MPAS-Model/src/core_atmosphere/diagnostics/README`
summarizes the steps to implementing a new diagnostic.