Debugging MPAS-Atmosphere Aborts

(1) What is an “abort”?

Abort - the simulation ends before reaching the end time.

Graceful shutdown: when an error condition is recognized by MPAS and communicated in the shutdown.

Ungraceful shutdown: when an error condition is not recognized by MPAS-A; system error messages may or may not appear.

A Successful MPAS-A Integration Should Look Like This

In the log.atmosphere.0000.out file, at the very end

```
*********************************************************
   Finished running the atmosphere core
*********************************************************


 Timer information:
    Globals are computed across all threads and processors

                    .
                    .
                    .

----------------------------------------
Total log messages printed:
   Output messages =                185939
   Warning messages =                  103
   Error messages =                      0
   Critical error messages =             0
----------------------------------------
Logging complete.  Closing file at 2025/09/24 12:21:47
```

MPAS-A has finished

MPAS-A has not detected any errors that would cause it to abort.

Note: There may still be NaNs in the output files, but neither MPAS-A nor the system have caused the model integration to cease before the simulation end time.

Debugging MPAS-Atmosphere Aborts

(2) Graceful shutdowns of MPAS-A simulations

Startup:

- Problems with system configuration (batch queue submission specification, libraries, other resources, etc)
- Files expecting to be read are not found; some inconsistencies in configuration diagnosed by MPAS-A
- Initialization issues causing errors.
- Errors in namelist.atmosphere entries
- Errors in stream entries

Integration: NaNs detected in the solution; (some) other system issues.

Debugging MPAS-Atmosphere Aborts

Example: mistyped namelist.atmosphere entry

```
skamaroc@derecho2:/glade/derecho/scratch/skamaroc/2010_test_case> more log.atmosphere.0000.err
------------------------------------------------------------------------
Beginning MPAS-atmosphere Error Log File for task       0 of     128
    Opened at 2026/07/24 13:51:14
------------------------------------------------------------------------


CRITICAL ERROR: Error while reading namelist record damping.
Logging complete.  Closing file at 2026/07/24 13:51:14


&damping
    config_zd = 22000.0
    config_xnutr = 0.2
    config_nonexistant = 0.0
/
```

Debugging MPAS-Atmosphere Aborts

Example: mistyped streams.atmosphere entry

```
skamaroc@derecho2:/glade/derecho/scratch/skamaroc/2010_test_case> more log.atmosphere.0000.err

-------------------------------------------------------------------------
Beginning MPAS-atmosphere Error Log File for task       0 of     128
    Opened at 2026/07/24 14:03:32
-------------------------------------------------------------------------


ERROR: In file streams.atmosphere, line 14, unterminated string. Is a closing quote not present?
CRITICAL ERROR: stream xml get attribute failed: streams.atmosphere
Logging complete.  Closing file at 2026/07/24 14:03:32
```

```
<stream name="output"
        type="output
        filename_template="history.$Y-$M-$D_$h.$m.$s.nc"
        output_interval="6:00:00" >
```

Debugging MPAS-Atmosphere Aborts

(3) Ungraceful shutdowns (aborts)

- File system errors: file corruption for input files, running out of file space, file-system connection problems…
- Floating Point Errors (FPEs) causing aborts at system level
- Bad input data (state, physics inputs, etc)
- Issues with configuration (timesteps, filters, physics, etc)

MPAS-A Does Not Complete the Simulation
What Should I Do?

Does the job produce any log files? `log.atmosphere.*.out; log.atmosphere.*.err`

No: *There is probably a system or executable problem – see other error messages in, for example, the batch system output and error files, or in the terminal output if you are running interactively.*

Yes: *Look at the existing log files and at the batch system output and error files for error conditions. The first thing determine is if this is (1) a computing system issue or (2) an MPAS-A problem. Hopefully the error message(s) will give a strong indication here.*

MPAS-A Does Not Complete the Simulation
Typical System Error Issues

- File system read/write permissions: access to inputs, ability to write outputs
- Insufficient memory for the executable
- Insufficient file space for the output files
- User environment issues (libraries, etc)
- Batch submission errors
- Other…

Looks like an MPAS-A Problem
Did the Time Integration Begin?

From the `log.atmosphere.*.out` file

```
min/max of meshScalingDel2 = 1.00000 1.00000
min/max of meshScalingDel4 = 1.00000 1.00000
Timing for diagnostic computation: 0.562618 s
Timing for stream output: 0.933133 s

Begin timestep 2018-05-12_12:00:00
```

last output lines from model start-up

begin first integration timestep,
`config_start_time = '2018-05-12_12:00:00'`
in `namelist.atmosphere`

If the `log.atmosphere.*.out` file has the first "`Begin timestep`" line, then the time integration has begun. If MPAS-A aborts before this line appears then something went wrong in the model start-up.

Time Integration Didn't Begin…

Beginning of the `log.atmosphere.*.out` file

```
-------------------------------------------------------------------------
Beginning MPAS-atmosphere Output Log File for task       0 of     128
    Opened at 2025/10/23 13:31:17
-------------------------------------------------------------------------
                              .
                              .
                              .

 Reading namelist from file namelist.atmosphere
 *** Encountered an issue while attempting to read namelist record assimilation
     The following values will be used for variables in this record:

         config_jedi_da = F

 *** Encountered an issue while attempting to read namelist record development
     The following values will be used for variables in this record:

         config_halo_exch_method = mpas_halo


 ----- I/O task configuration: -----

     I/O task count  = 128
     I/O task stride = 1

 Initializing MPAS_streamInfo from file streams.atmosphere
```

MPAS-A has started

namelist.atmosphere is being read

Informational, everything still OK

Begin reading stream files. namelist.atmosphere read complete and OK!

Time Integration Didn't Begin…

Beginning of the `log.atmosphere.*.out` file

```
-------------------------------------------------------------------------
Beginning MPAS-atmosphere Output Log File for task       0 of     128
    Opened at 2025/10/23 13:31:17
-------------------------------------------------------------------------
```

MPAS-A has started

-
-
-

```
 Initializing MPAS_streamInfo from file streams.atmosphere
```

Begin reading stream files. namelist.atmosphere read complete and OK!

-
- *Lots of stuff here!*
-

```
----- done parsing run-time I/O from streams.atmosphere -----
```

streams.atmosphere read complete and OK! Other checks complete.

Time Integration Didn't Begin…

Beginning of the `log.atmosphere.*.out` file

```
-------------------------------------------------------------------------
Beginning MPAS-atmosphere Output Log File for task       0 of     128
    Opened at 2025/10/23 13:31:17
-------------------------------------------------------------------------
                              .
                              .
                              .
 ----- done parsing run-time I/O from streams.atmosphere -----
                              .
                              .
                              .
 ----- done assigning dimensions from Registry.xml -----


 Allocating fields ...
  59 MB allocated for fields on this task
  7603 MB total allocated for fields across all tasks
  ----- done allocating fields -----
```

MPAS-A has started

streams.atmosphere read complete and OK! Other checks complete.

Here is where memory availability issues sometimes appear.

Time Integration Didn't Begin…

Beginning of the `log.atmosphere.*.out` file

```
-------------------------------------------------------------------------
Beginning MPAS-atmosphere Output Log File for task       0 of     128
    Opened at 2025/10/23 13:31:17
-------------------------------------------------------------------------
```

MPAS-A has started

-
-
-

```
 Reading initial state from 'input' stream
WARNING: Variable qi not in input file.
WARNING: Variable qs not in input file.
WARNING: Variable qg not in input file.
  Timing for read of 'input' stream: 1.73571 s
  ----- done reading initial state -----
```

Reading init file.

- physics init here
- (data files input for LSM, microphysics, etc)
- some calculations

```
Begin timestep 2018-05-12_12:00:00
```

begin first integration timestep

Time Integration Did Begin

From the `log.atmosphere.*.out` file

```
min/max of meshScalingDel2 = 1.00000 1.00000
min/max of meshScalingDel4 = 1.00000 1.00000
Timing for diagnostic computation: 0.562618 s
Timing for stream output: 0.933133 s

Begin timestep 2018-05-12_12:00:00
--- time to update background surface albedo, greeness fraction.
--- time to run the LW radiation scheme L_RADLW = T
--- time to run the SW radiation scheme L_RADSW = T
--- time to run the convection scheme L_CONV    = T
--- time to update the ozone climatology for RRTMG radiation codes
--- time to apply limit to accumulated rainc and rainnc L_ACRAIN   = F
--- time to apply limit to accumulated radiation diags. L_ACRADT   = F
--- time to calculate additional physics_diagnostics               = F
 split dynamics-transport integration 3
 (or "coupled RK3 dynamics-transport integration")

 global min w: -0.282735 k=27, -32.3466 lat, -70.3201 lon
 global max w: 0.506747 k=26, 6.08766 lat, -117.174 lon
 global min u: -177.920 k=83, -3.89578 lat, -159.832 lon
 global max u: 177.985 k=83, -3.98240 lat, -160.950 lon
 global max wsp: 178.045 k=83, -3.98240 lat, -160.950 lon
 Timing for integration step: 0.922176 s

Begin timestep 2018-05-12_12:15:00
```

last output lines from model start-up

begin first integration timestep

physics first

dynamics next

timestep complete,
output diagnostics

begin second integration timestep

Time Integration Did Begin

From the `log.atmosphere.*.out` file

```
Begin timestep 2018-05-12_12:00:00
 --- time to update background surface albedo, greeness fraction.
 --- time to run the LW radiation scheme L_RADLW = T
 --- time to run the SW radiation scheme L_RADSW = T
 --- time to run the convection scheme L_CONV    = T
 --- time to update the ozone climatology for RRTMG radiation codes
 --- time to apply limit to accumulated rainc and rainnc L_ACRAIN   = F
 --- time to apply limit to accumulated radiation diags. L_ACRADT   = F
 --- time to calculate additional physics_diagnostics               = F
  split dynamics-transport integration 3
```

begin first integration timestep

physics first. This is output directly ***before*** the physics calculations

If you see the physics lines but not the dynamics line, then MPAS-A aborted somewhere in the first calls to physics

Time Integration Did Begin

From the `log.atmosphere.*.out` file

```
Begin timestep 2018-05-12_12:00:00
 --- time to update background surface albedo, greeness fraction.
 --- time to run the LW radiation scheme L_RADLW = T
 --- time to run the SW radiation scheme L_RADSW = T
 --- time to run the convection scheme L_CONV    = T
 --- time to update the ozone climatology for RRTMG radiation codes
 --- time to apply limit to accumulated rainc and rainnc L_ACRAIN   = F
 --- time to apply limit to accumulated radiation diags. L_ACRADT   = F
 --- time to calculate additional physics_diagnostics               = F
```

begin first integration timestep

physics first. This is output directly ***before*** the physics calculations

A fatal error here can be the result of *a problem with the initial state* or a *problem with the physics initialization* (that didn't cause an abort in the physics initialization).

Things to try:

Compile with DEBUG=true and run again.

Look for the subroutine and line number where the FPE occurred (system error output), this may tell you which data to check in the input files.

Look at (visualize, find max/min of the input state fields and other physics inputs).

Time Integration Did Begin

From the `log.atmosphere.*.out` file

```
Begin timestep 2018-05-12_12:00:00
 --- time to update background surface albedo, greeness fraction.
 --- time to run the LW radiation scheme L_RADLW = T
 --- time to run the SW radiation scheme L_RADSW = T
 --- time to run the convection scheme L_CONV    = T
 --- time to update the ozone climatology for RRTMG radiation codes
 --- time to apply limit to accumulated rainc and rainnc L_ACRAIN   = F
 --- time to apply limit to accumulated radiation diags. L_ACRADT   = F
 --- time to calculate additional physics_diagnostics               = F
  split dynamics-transport integration 3

  global min w: -0.282735 k=27, -32.3466 lat, -70.3201 lon
  global max w: 0.506747 k=26, 6.08766 lat, -117.174 lon
  global min u: -177.920 k=83, -3.89578 lat, -159.832 lon
  global max u: 177.985 k=83, -3.98240 lat, -160.950 lon
  global max wsp: 178.045 k=83, -3.98240 lat, -160.950 lon
  Timing for integration step: 0.922176 s

 Begin timestep 2018-05-12_12:15:00
```

dynamics step begins

If the diagnostics do not appear then the model blew up in the time step integration. Note that ***microphysics is called*** during the dynamics step

Time Integration Did Begin

What to do when MPAS-A aborts during an integration after the first physics call

(1) Check time step settings, filter settings, especially if abort is early in the simulation (< 10 time steps).
(2) Try a reduced timestep if the abort occurs within the first several timesteps. If this works then it is likely an imbalance in the initial state is the cause.

If the simulation makes it through a lot of timesteps before it aborts:

(1) Dump a restart file a few timesteps before the abort. Compile with DEBUG=true and run again. Look (in the system error log) for the subroutine and line number where the FPE occurred.
(2) Turn off the physics and see if MPAS-A runs OK. If so this indicates that physics may be the issue (unphysical tendencies being fed by the physics to the dynamics). Try different physics options (e.g. change convection schemes; change PBL and surface layer schemes; microphysics).

Time Integration Did Begin

Still looking for the problem?

Where in the domain did a calculation cause MPAS-A to abort?

Min-max timestep diagnostics – set `config_print_detailed_minmax_vel = true` in namelist.atmosphere under the `&printout` section. This turns on

(1) Location of min/max velocity prints – where do velocities get unphysically large first?
(2) ieee check for NaN in w field, print if found + graceful error exit (but no location information on the NaN).

Finding a NaN in the w field does not tell us what is responsible for the abort.

If `config_print_detailed_minmax_vel = false (default)`, then there is no NaN check. Depending on compilers/systems, MPAS-A may continue running while producing NaNs

Time Integration Did Begin

(1) Get restart files near the time the model aborts. There is lots of information in the restart files, including physics tendencies from individual physics components.
(2) Visualized/examine fields shortly before the abort in the region where the model goes unstable.
(3) Insert write statements to check variable values near the blowup point.
(4) Blowups in the radiation schemes are usually caused by problems with the inputs – not the scheme itself.
(5) Dynamics – is the jet stream very strong later in a simulation, perhaps leading to a timestep instability? Are there strong horizontal velocities at the lid? Timestep, absorbing layer configuration and/or vertical grid may need attention.

The cause of the abort is still not clear – arghhh!

At this point you're in the deep end of the debugging pool!

Identify a configuration close to what you have that has integrated stably. Slowly change the configuration moving towards your unstable configuration, and see at what step your simulation becomes unstable. Closely examine what changed in that last step where it became unstable. *Try to not change more than one thing at a time.*

Check online (WRF/MPAS Forum) – are others seeing a similar problem and are their suggested solutions to try?

Good luck!