CAM History and I/O Infrastructure Changes

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June 16, 2015

Outline

- What is the problem?
- Introdution to new structures
- Creating CAM grids
- Using CAM grids for input and history – UI changes
- Advantages of new infrastructure
- Status and upcoming changes

Acknowledgments: Brian Eaton
This work was funded by the National Science Foundation and the Department of Energy

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What does this look like?

cam_history (e.g. addfld) and ncdio_atm (infld)

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- Special case code for dycore-specific NetCDF attributes (but not specific enough as some attributes leak into other dycore's files).
- Convoluted user interfaces (example below)

cam_pio_utils

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- Special case code for column (regional) output
- More special case code for column output with new collected-column code
- Special case code for physics decomposition
- Special case code for physics decomposition and regional output
- Special case code for different variable file ordering

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- Special case code for physics decomposition
- Special case code for physics decomposition and regional output
- Special case code for different variable file ordering
- Regional output still doesn't work for SE

Introduction to five new structures

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1. `cam_filemap_t`
   Contains a map between a distributed 2-D array and that array in NetCDF file order along with methods to create maps for higher-dimensional arrays.
   For every element in the array, the map shows where this element will show up in the NetCDF file representation of that array

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   For every element in the array, the map shows where this element will show up in the NetCDF file representation of that array
2. `horiz_coord_t`
   Contains information about a horizontal coordinate (i.e., lat, lon). Coordinates can be distributed across processors.

Introduction to new structures (cont.)

3. `cam_grid_t`
   Contains information about a distributed 2-D grid along with methods for reading and writing distributed arrays defined on that grid.

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4. `cam_grid_patch_t`
   Contains a subset of the points of a distributed 2-D grid. This type is useful for regional output.
5. `cam_grid_attribute_t`
   Each attribute is a NetCDF attribute associated with a `cam_grid_t` and is output into any file which contains arrays defined on that grid.

Steps for creating a CAM grid

1. Create horizontal coordinates, usually including mapping (`horiz_coord_register`)
2. Create map from basic 2-D array to file order
3. Add grid (`cam_grid_register`)
4. Add grid attributes (`cam_grid_attribute_register`)

Creating CAM grids – Coordinates

1. Create horizontal coordinates, usually including mapping. Example for unstructured grid:

```
call horiz_coord_register('lat', 'ncol', ngcols_d,   &
                          'latitude', 'degrees_north',   &
                          pelat_deg, pemap)
```

'lat' – The name of the coordinate

'ncol' – The name of the coordinate's dimension. This will be the same as the coordinate name for a rectangular (lat/lon) grid.

ngcols_d – The global size of the coordinate

'latitude' – Coordinate long name

'degrees_north' – Coordinate units

pelat_deg – Values for the coordinate on this PE

pemap – 1-D map between local coordinate values and NetCDF order. May be omitted for a non-distributed coordinate

Creating CAM grids – Grid

3. Create CAM grid. Example for unstructured grid

```
call cam_grid_register('GLL', dyn_decomp, 'lat',     &
                  pelat_deg, 'lon', pelon_deg,        &
                  grid_map, unstruct=.true.)
```

'GLL'	–	The name of the grid
dyn_decomp	–	An integer ID for the grid
'lat'	–	The name of the grid's latitude coordinate
pelat_deg	–	Grid latitude values for this PE (may be the same as associated coordinate)
'lon'	–	The name of the grid's longitude coordinate
pelon_deg	–	Grid longitude values for this PE (may be the same as associated coordinate)
pemap	–	2-D map between local array elements and their NetCDF order.

Using CAM grids for input

infld – old interface

```
call get_dyn_decomp(elem, nlev, pio_double, iodesc)
lsize = pio_get_local_array_size(iodesc)
tlncols = lsize/nlev
allocate(tmp(tlncols,nlev))
call infld(’U’, ncid_ini, iodesc, tlncols,’ lev’, &
      tmp, found)
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allocate(tmp(npsq, nlev, nelemd))
call infld(’U’, ncid_ini, ’ncol’, ’lev’,     &
      1, npsq, 1, nlev, 1, nelemd,           &
      tmp, found, gridname=’GLL’)
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'ncol', 'lev'	–	NetCDF names of array dimensions
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How does all this improve things?

Advantages of new infrastructure

- All dycore specific information compact and local to dycore code

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- All dycore specific information compact and local to dycore code
- Physics package gets column locations and areas from dycore but defines its own grid (decomposition)
- History and I/O infrastructure does not need any dycore specific information
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- Grids manage their own coordinates and variables

Impact on cam_pio_utils

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Impact on cam_pio_utils

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- No special case code for column (regional) output
- Column output is a parallel operation
- SE column-output fix is automatic

Status and upcoming changes

- Code review complete
- Going through final testing

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Coming soon (not the infrastructure trunk tag):

- Support for output of zonal means (probably only FV and SE)
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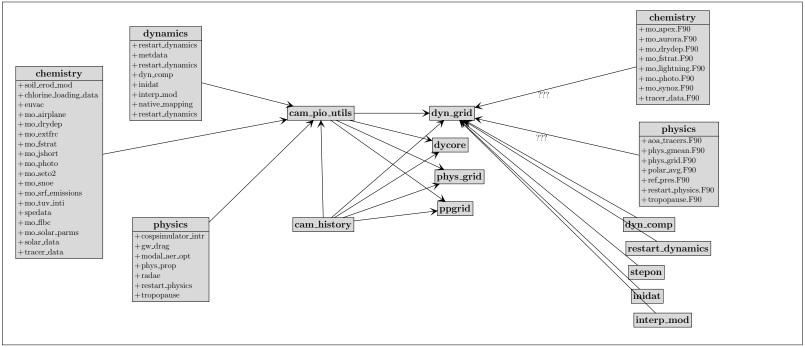
Possible future developments

- Online mapping between grids?
- Convert more of CAM to use grid infrastructure
- Move new grid infrastructure to public CIME infrastructure for use by other components or models?

Questions?

Current CAM I/O and history interface



dynamics
- +restart_dynamics
- +metdata
- +restart_dynamics
- +dyn_comp
- +inidat
- +interp_mod
- +native_mapping
- +restart_dynamics

chemistry
- +soil_erod_mod
- +chlorine_loading_data
- +euvac
- +mo_airplane
- +mo_drydep
- +mo_extfrc
- +mo_fstrat
- +mo_jshort
- +mo_photo
- +mo_seto2
- +mo_snoe
- +mo_srf_emissions
- +mo_tuv_inti
- +spedata
- +mo_flbc
- +mo_solar_parms
- +solar_data
- +tracer_data

physics
- +cospsimulator_intr
- +gw_drag
- +modal_aer_opt
- +phys_prop
- +radae
- +restart_physics
- +tropopause

cam_pio_utils

dyn_grid

dycore

phys_grid

ppgrid

cam_history

chemistry
- +mo_apex.F90
- +mo_aurora.F90
- +mo_drydep.F90
- +mo_fstrat.F90
- +mo_lightning.F90
- +mo_photo.F90
- +mo_synoz.F90
- +tracer_data.F90

???

physics
- +aoa_tracers.F90
- +phys_gmean.F90
- +phys_grid.F90
- +polar_avg.F90
- +ref_pres.F90
- +restart_physics.F90
- +tropopause.F90

???

dyn_comp

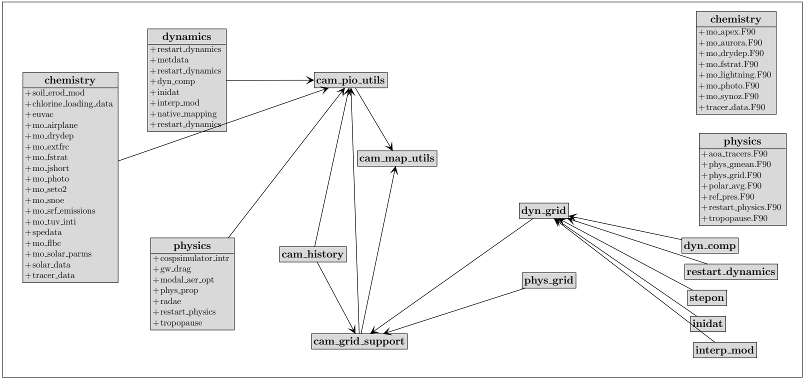
restart_dynamics

stepon

inidat

interp_mod

Proposed CAM I/O and history interface



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+mo_extfrc
+mo_fstrat
+mo_jshort
+mo_photo
+mo_seto2
+mo_snoe
+mo_srf_emissions
+mo_tuv_inti
+spedata
+mo_flbc
+mo_solar_parms
+solar_data
+tracer_data

physics
+cospsimulator_intr
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+modal_aer_opt
+phys_prop
+radae
+restart_physics
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cam_pio_utils

cam_map_utils

cam_history

cam_grid_support

dyn_grid

phys_grid

dyn_comp

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stepon

inidat

interp_mod

chemistry
+mo_apex.F90
+mo_aurora.F90
+mo_drydep.F90
+mo_fstrat.F90
+mo_lightning.F90
+mo_photo.F90
+mo_synoz.F90
+tracer_data.F90

physics
+aoa_tracers.F90
+phys_gmean.F90
+phys_grid.F90
+polar_avg.F90
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+restart_physics.F90
+tropopause.F90

Infrastructure user interface – Horiz coords

- horiz_coord_register
- horiz_coord_get_index
- horiz_coord_get_dim_name

Infrastructure user interface – Grids

- cam_grid_register
- cam_grid_attribute_register
- cam_grid_write_attrs
- cam_grid_write_vars
- cam_grid_read_dist_array
- cam_grid_write_dist_array

Infrastructure user interface – Grids (cont.)

- cam_grid_dimensions
- cam_grid_num_grids
- cam_grid_check ! T/F if grid ID exists
- cam_grid_id ! Grid ID (decomp) or -1 if error
- cam_grid_get_local_size
- cam_grid_get_file_dimids
- cam_grid_get_decomp
- cam_grid_get_gcid
- cam_grid_get_array_bounds

Infrastructure user interface – cam_pio_utils

- cam_pio_createfile
- cam_pio_openfile
- cam_pio_closefile
- cam_pio_newdecomp
- init_pio_subsystem ! called from cam_comp
- cam_pio_get_decomp
- cam_pio_handle_error
- cam_permute_array
- calc_permutation

Infrastructure user interface – cam_pio_utils

! Convenience interfaces

- cam_pio_def_dim
- cam_pio_def_var
- cam_pio_get_var

Infrastructure user interface – cam_pio_utils

! General utility

- cam_pio_var_info
- cam_pio_find_var
- cam_pio_check_var

Creating CAM grids – Coordinates

```
call horiz_coord_register(’lat’, ’ncol’, ngcols_d,  &
                          ’latitude’, ’degrees_north’,   &
                          pelat_deg, pemap)


call horiz_coord_register(’lon’, ’ncol’, ngcols_d,  &
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```
call horiz_coord_register(’slat’, ’’, (plat - 1),  &
                     ’staggered latitude’,         &
                     ’degrees_north’, slatvals)

call horiz_coord_register(’lon’, ’lon’, plon,     &
                     ’longitude’, ’degrees_north’,  &
                     lonvals, coord_map)
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call cam_grid_register('GLL', dyn_decomp, 'lat',     &
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```
call cam_grid_register('fv_centers', dyn_decomp,   &
                  'lat', latvals, 'lon', lonvals, &
                  grid_map)
```

```
call cam_grid_register('fv_u_stagger',               &
                  dyn_ustag_decomp,                  &
                  'slat', slatvals, 'lon', lonvals,  &
                  grid_map)
```