Sharing Physics Between WRF and MPAS with CCPP

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Big Picture: Sharing

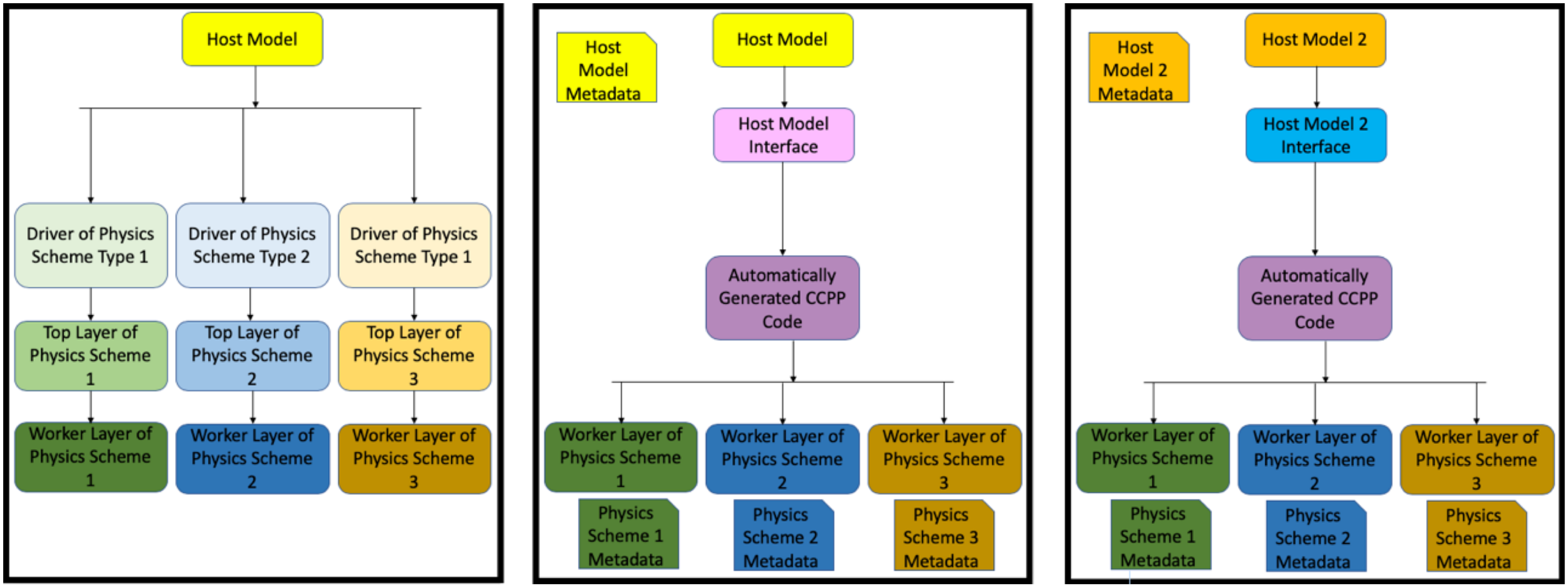
- MPAS and WRF share
  - Support technology: http://forum.mmm.ucar.edu
  - Pre-processor input from WPS
  - Repo management (git) and hosting services (github)
  - Basic tenets of gitflow-esque workflow
  - A couple of physics suites (officially)
  - Hybrid vertical coordinate and moist theta in WRF came from MPAS

- Want to more easily transfer physics between MPAS and WRF
- A goal is to allow physics transfer between MPAS and other models

- Several groups within NCAR (ACOM, CGD, MMM) and NOAA are working on (and are in various stages of implementing) a strategy for more widely sharing physics

CCPP = Common Community Physics Packages

Big Picture: Why are we doing this



Original interface to physics and host model.

The CCPP interface permits the same physics to be used with both the original and a new host model.

Initially Selected Schemes to Port

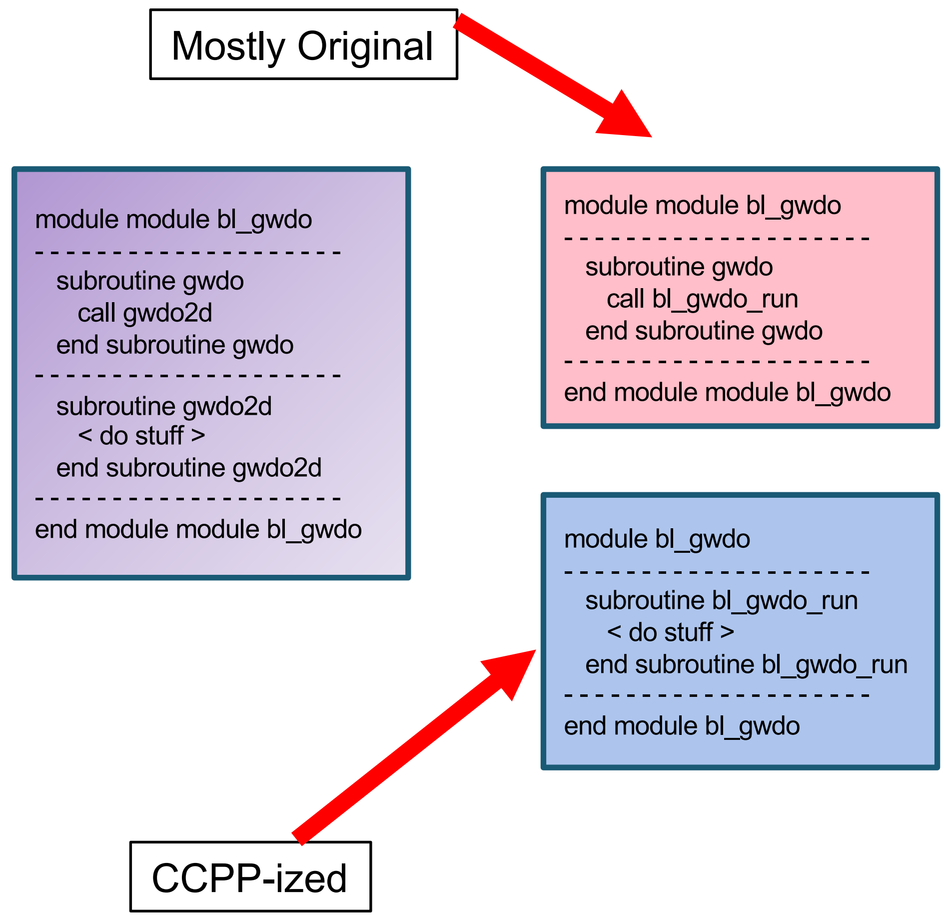
Surface Layer	Xu-Randall Cloud Fraction
YSU PBL	GWDO
New Tiedtke CU	RRTMG LW
WSM6 MP	RRTMG SW

- Choosing to wait for the Land Model.
  - Does not pose troubles for eventual CESM port.
  - Does not pose troubles for MPAS or WRF port.

- CTSM effort is underway at NCAR. LILAC may provide a preferred way to access a supported land model for both MPAS and WRF.

Process / What defines a “Ported Scheme”

- Modifications to scheme for CCPP
  - Split the top-level scheme (usually WRF-centric 3d) apart from the scheme’s 2d (column) routine (still callable from existing MPAS and WRF drivers)
  - Have *_run*, *_init*, *_final*, *_timestep_init*, and *_timestep_final* top-level routine names



Process / What defines a "Ported Scheme"

- Modifications to scheme for CCPP
  - Single horizontal index (if any) in the CCPP-ized routines
  - No horizontal halo-dimensioned fields in CCPP-ized routines

No "j" dimension

No horizontal memory dimensions

```
   real, dimension(its:ite,kts:kte)  , intent(in   ) :: t1, q1, zl
   real, dimension(its:ite,kts:kte)  , intent(in   ) :: prsl
   real, dimension(its:ite,kts:kme)  , intent(in   ) :: prsi
```

Process / What defines a "Ported Scheme"

- Modifications to scheme for CCPP
  - Push as much pre- and post-processing into scheme as makes sense
  - Array assignments in scheme top-level call due to horizontal index reduction are OK and expected
  - Basically: allow removal of top-level of scheme

```
xt24 = mod(xtime+radt*0.5,1440.)
tloctm = gmt + xt24/60. + xlong(i,j)/15.
hrang = 15. * (tloctm-12.) * degrad
xxlat = xlat(i,j) * degrad
```

```
!
   qv2d(its:ite,:) = 0.0
!
```

ZAP: Computation of constants
ZAP: Initializations to zero
ZAP Diagnostics

```
!
     do k = kts,kte
       do i = its,ite
         rthblten(i,k,j) = rthblten(i,k,j)/pi3d(i,k,j)
```

Process / What defines a "Ported Scheme"

- Modifications to scheme for CCPP
  - Interstitial code for helper routines called in top-level (non CCPP-ized) routines

NEW:
Assignments (3d -> 2d)
call ra_rrtmg_sw_mpas_timestep_init
call ra_rrtmg_sw_run
call ra_rrtmg_sw_mpas_timestep_final
Assignments (2d -> 3d)

ORIGINAL:
Starting on line 10000 – 400 lines of diagnostics surrounding the call to SWRAD

Process / What defines a “Ported Scheme”

- General Modifications
  - Clean up INTENT – missing, particularize, wrong
  - Reduce argument list to required minimal set
  - Fix internal comments
  - Single argument *mostly* = single field
    - Unless multiple fields are not distinguishable within scheme
    - Derived types are allowable, but break portability
    - So, interstitial code would be OK for MPAS DDTs
  - Most of the OPTIONAL arguments were not

- A cookbook for developers to follow
  - Automated code depends on an accurate metadata file
  - Constructing the metadata file takes time

The Metadata File

- For each of the CCPP-ized files, a metadata file is required
- For each CCPP-ized subroutine, a metadata section is required in that file
- Each argument in a CCPP-ized routine has a metadata entry

- The mapping of the host model's variables (also with a metadata file) and the physics scheme's variables are through the unique identifier of the field's name
- The ordering of the arguments in the subroutine matches the ordering of the variables in the metadata file

Physics Scheme and Metadata

```
subroutine bl_gwdo_run(      &
    sina, cosa,              &
    rublten,rvblten,         &
    dtaux3d,dtauy3d,         &
    dusfcg,dvsfcg,           &
    uproj, vproj,            &
    t1, q1,                  &
    prsi, prsl, prslk, zl,   &
    kpblmax,                 &
    var, oc1,                &
    oa2d1, oa2d2,            &
    oa2d3, oa2d4,            &
    ol2d1, ol2d2,            &
    ol2d3, ol2d4,            &
    g_, cp_, rd_,            &
    rv_, fv_, pi_,           &
    dxmeter, deltim, kpbl,   &
    its, ite,                &
    kts, kte, kme,           &
    errmsg, errflg           )
```

```
[ccpp-arg-table]
  name = bl_gwdo_run
  type = scheme
[sina]
  standard_name = sine_of_map_rotation
  long_name = sine of map rotation
  units = dimensionless
  dimensions = (horizontal_loop_begin:horizontal_loop_end)
  type = real | kind = kind_phys
  intent = in
  optional = F
[cosa]
  standard_name = cosine_of_map_rotation
  long_name = cosine of map rotation
  units = dimensionless
  dimensions = (horizontal_loop_begin:horizontal_loop_end)
  type = real | kind = kind_phys
  intent = in
  optional = F
```

The Metadata File

- A github repository holds the growing list of known fields (such as dimensions) and conventionally accepted names:

https://github.com/ESCOMP/CCPPStandardNames/blob/master/Metadata-standard-names.md

- Fields with vertical indexing may have “layers” (default) and “levels” (explicitly stated in name)
- Horizontal indexing allows full size (without halo) and threaded size
- The list of known constants is increasing

- Construction of names is often required

The Suite Definition File (SDF mostly TBD)

```
<suite name="MPAS_meso_ref_rad" version="1.0">
   <group name="radiation">
      <scheme>cld_xurandall</scheme>
      <scheme>ra_rrtmg_sw_mpas</scheme>
      <scheme>ra_rrtmg_sw</scheme>
      <scheme>ra_rrtmg_lw_mpas</scheme>
      <scheme>ra_rrtmg_lw</scheme>
   </group>
</suite>

<suite name="MPAS_meso_ref_sfc" version="1.0">
   <group name="surface_layer">
      <scheme>sf_sfclay</scheme>
   </group>
</suite>

<suite name="MPAS_meso_ref_pbl" version="1.0">
   <group name="boundary_layer">
      <scheme>bl_ysu</scheme>
      <scheme>bl_gwdo</scheme>
   </group>
</suite>

<suite name="MPAS_meso_ref_cu" version="1.0">
   <group name="cumulus">
      <scheme>cu_ntiedtke</scheme>
   </group>
</suite>

<suite name="MPAS_meso_ref_mp" version="1.0">
   <group name="microphysics">
      <scheme>mp_wsm6</scheme>
   </group>
</suite>
```

```
<suite name="mesoscale_reference" version="1.0">
   <group name="physics_pre_LSM">
      <suite name="MPAS_meso_ref_rad" group="radiation" />
      <suite name="MPAS_meso_ref_sfc" group="surface_layer" />
   </group>
   <group name="physics_post_LSM">
      <suite name="MPAS_meso_ref_pbl" group="boundary_layer" />
      <suite name="MPAS_meso_ref_cu" group="cumulus" />
   </group>
   <group name="physics_post_dynamics">
      <suite name="MPAS_meso_ref_mp" group="microphysics" />
   </group>
</suite>
```

The “group” element allows MPAS to schedule physics in a requested order

The “group” attribute allows other host models to locate where the call to a particular scheme should go in the time step

Changes MPAS

- The WRF model will not be converted to a CCPP-ized host model

- MPAS will have a transition period, allowing access to physics by the original driver and the new CCPP option
- The existing top-level drivers of each scheme remain in place
  - These are not required when CCPP is used
- Rolling the calls to the *_to_MPAS* and *_from_MPAS* routines into interstitial routines
  - Interstitial routines are by definition associated with the host model
  - Maintains bit-for-bit results

Easy Changes to MPAS to “interface” and “drivers”

mpas_atmphys_interface

- (k,i) -> (i,k,j) -> (i,k) -> (i,k,j) -> (k,i)

mpas_atmphys_interface_ccpp

- (k,i) -> (i,k) -> (k,i)

```
if(.not.allocated(psfc_p) ) allocate(psfc_p(ims:ime,jms:jme) )

rho_p(i,k,j) = zz(k,i) * rho_zz(k,i)
```

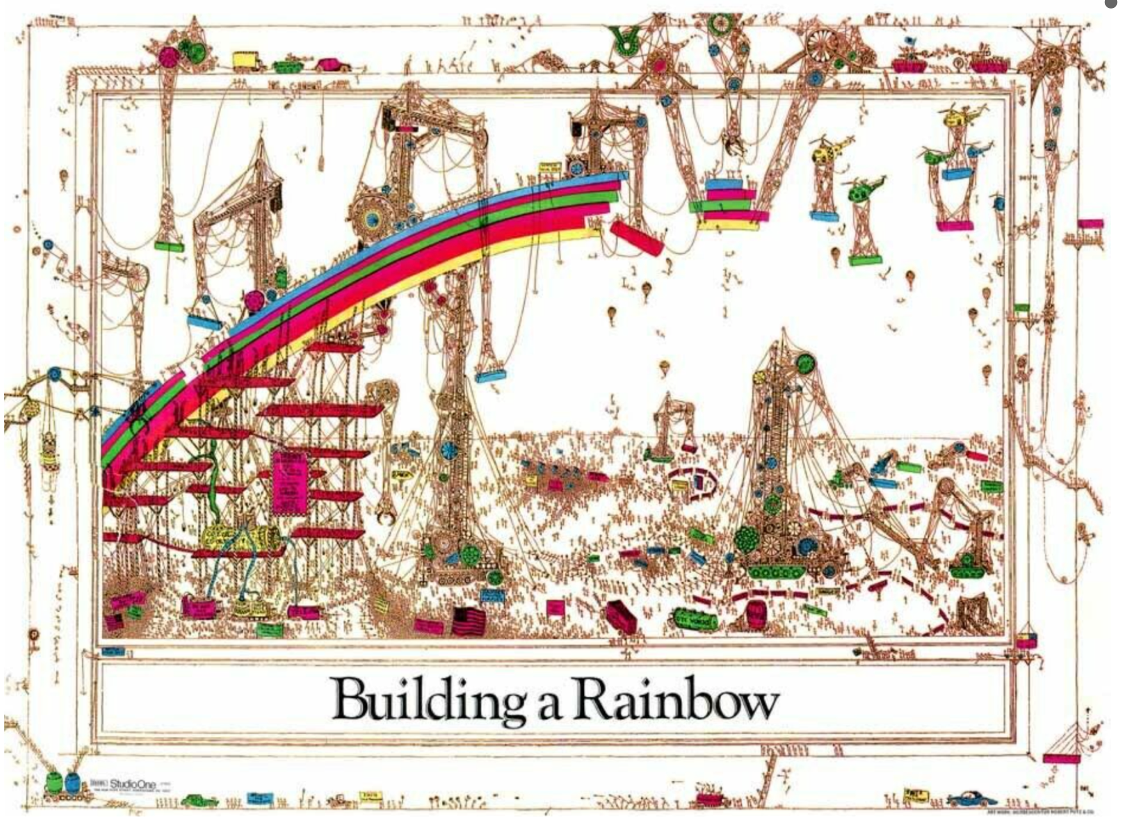
```
if(.not.allocated(psfc_p) ) allocate(psfc_p(ims:ime)         )

rho_p(i,k) = zz(k,i) * rho_zz(k,i)
```

Big Picture: What we are doing

- Scheme sharing between MPAS and WRF
- Purpose is to get MPAS and CAM physics available for each other
- Using a jointly developed utility to provide Common Community Physics Packages (CCPP)
- Conventionalize the top-level physics schemes
- Describe the arguments in the top-level physics schemes in a separate metadata file
- Describe the available fields from the host model is a metadata file
- Map the available fields from the host model and those required by the physics schemes

Status: Importance of Verb Tense

- Started and stopped a few times to get our bearings and scope
- All first suite physics is ported, including non-conventionalized metadata files
- Getting all metadata and CCPP-ized routines to be uniform
- Merging all separate git repositories into a single location



- Figuring out the data flow for the physics diagnostic data, leaning towards including / wrapping calls inside of interstitial routines