Singletrack: Unified Physics
Roadmap

Purpose of this Document

- Define a minimal set of schemes to do science across scales from weather to climate
- Identify likely paths forward
    - We would likely start with existing schemes from WRF and CAM
    - What do we want to do that is new?
    - What would this look like, and how would we get there?
- Clarify path to guide infrastructure development (Community Physics Driver)
    - What schemes and frameworks are we targeting?
    - Current models (WRF/CAM) will implement a common driver (CPD): prioritize

HOW do we move forward? Some Ideas

- Developments that enable new science (see below)
    - Focus on frameworks below.
- Test target schemes in current frameworks (WRF/CESM) from weather to climate scale.
    - Start with a single framework for testing: Likely CESM-MPAS [See below]
    - Test target schemes with prototype of physics driver [CESM/CAM & WRF]
    - List target schemes
- Requirements: have a set of unified physics requirements (separate document)
    - Would like to have a common interface available for a subset of schemes
        - Prototype of CPD
    - Could it be integrated with effort above (porting packages to CESM-MPAS)

Which developments/applications enable new science?

[What configurations are desired]

- Coupled simulations at weather scale: [CESM-MPAS. 10km, 3km Two refined meshes: (A) CONUS, (B) Tropical cyclones]
    - Need to get MPAS into CESM
    - Physics modifications: Graupel/Hail, Deep Convection
    - Infrastructure impediments (Land model initialization, regridding)
- Physics across scales. ([Climate Scale CESM: 100km, 14km refined mesh]. [Weather scale CESM-MPAS: 10km, 3km] Also [WRF 1km or higher: initialized hindcasts]
    - Process studies would be regional (1km). Could do with WRF. WRF+CPD.
- Land Atmosphere interactions (Cold: ice, snow, permafrost, Warm: soil moisture)

Based on Priorities where might resources for CPD project be prioritized?

- Implementation of MPAS in CAM
- CPD prototype in CAM with test schemes.
- Test schemes: MG, Deep Convection, CLUBB
- Then (or in parallel) implementation of CPD prototype in MPAS/WRF.

Roadmap Timeline

- Flesh out requirements [next month]: what does a driver need to do.
    - Base this on science questions/goals: map them to requirements
        - Have a document in Singletrack group.
    - Prioritize requirements
- Test desired physics suites from CAM6 and WRF within the same framework
    - A single test framework is desired. This might be CESM-MPAS
        - Benefits: Coupled. Have CAM6 suite available, know dynamics works at these scales.
        - Disadvantages: need a proper implementation of CESM-MPAS, may need to port some WRF schemes.
    - Note: if we go this route with CESM/MPAS: in the near term getting the MPAS as dycore in CAM is a high priority. Get it in correctly (i.e. pulled from MPAS repository on checkout, or at least a version on the CAM trunk.
- Proposed test configurations Experiment Descriptions:
    - CESM-MPAS (1st)
        - Select 'scale aware' schemes: CAM6 modified physics
        - Use CPD Prototype to implement selected schemes (see below)
        - Global AMIP (Fixed SST, 10-20 year) 'climate' runs
            - 15km, 25km (refined) 100km (uniform)
        - Short term forecasts with CESM/MPAS 15km and 3km refined mesh.
        - Compare to Forecasts with WRF physics in MPAS stand alone at ~10km
        - Coupled CESM-MPAS Climate simulations at 100km.
        - Will also want to vary the vertical resolution
    - WRF (2nd)
        - Standard 10km, 10 day forecast experiments
        - Run same modified CESM/MPAS schemes in WRF with CPD prototype
        - Eventually: nested down to turbulence scales (LES)
- Goal: Prototype implementation of Community Physics Driver & Unified physics tests
    - Using CPD headers/cap/interface is first goal. Would enable testing towards unified physics & prototype for CPD.
    - Prototype only: interface with existing driver structures. Can be only a few schemes (unfied physics group will decide)
    - Enables swapping a physics suite between WRF/MPAS and CAM (See above)
        - Weather suite and a climate suite: what we can do now.
        - Do we really need a whole suite of everything?
    - As noted above, this likely means accessing the CPD from WRF/CAM

Target Schemes for Testing Across Scales (What to Port: Priority)

- Deep convection: [CAM: Zhang-McFarlane, WRF: nTiedtke ("n" = scale aware), Tiedtke, Grell-Frietas]
- Microphysics [CAM: MG3, WRF: Thompson-Eidhammer, WSM6]
- Cloud scheme [CAM: CLUBB, WRF: ?]
- Turbulence [CAM: CLUBB,WRF: YSU PBL]
- Gravity Waves

What has already been done/being done [Expand]

- MPAS Global 10 day forecasts at 15 km (once per day for over a year)
    - Suite: YSU PBL, WSM6 microphysics, new Tiedtke cumulus, MM5 surface layer, Noah LSM, RRTMG radiation, orographic gravity wave drag
- WRF Ensemble system: 3km CONUS, 10 members, 48 hour. (Uncoupled)
    - Suite: MYJ PBL and surface layer, Thompson microphysics, no cumulus (old Tiedtke in 9 km DA domain), Noah LSM, RRTMG radiation
- MPAS 3km Forecasts (15 km global refined to 3 km North America for April-May 2017)
    - Suite: MYNN PBL and surface layer, Thompson microphysics, Grell-Freitas scale-aware cumulus, Noah LSM, RRTMG radiation, orographic gravity wave drag (apart from LSM, physics suite is based on NCEP's operational 3km HRRR suite)
- CAM-SE 12km, 25km refined mesh simulations: In the last 2 years CGD (Gettelman/Zarzycki) have done 20 year AMIP climate simulations with CESM and CAM6 physics using refined meshes and the SE dynamical core over the continental US. The CAM6 physics works well in these hydrostatic tests down to 12km.
- CAM-MPAS 3km Forecasts: MMM (Skamarock) and CGD (Gettelman/Zarzycki) have been collaborating with PNNL (Leung) to run CESM-MPAS with a 3km mesh over the US to duplicate the Spring forecast tests done in MPAS (See above). 'Modified' CAM6 physics with MG3 (Graupel/Hail) and Grell/Freitas Deep convection.
    - CAM-MPAS is not a clean implementation (hacked in)
    - CESM has trouble with short 3km simulations (too many points: initialization)
- WRF in CESM: Texas A&M/China + NCAR (Gokhan & Mariana): Ping Chang. [Need more details]
- Unified Microphysics Development (Gettelman, Morrison, Thompson): Want to test microphysics at high resolution (1-3km) currently in CAM/CESM. Want higher resolution of CESM-MPAS and/or WRF.
- Seasonal WRF Studies [Rasmussen]: 4km resolution CONUS, 13 years current climate from reanalysis boundary conditions.
    - Suite: YSU PBL and MM5 surface layer, Thompson microphysics, no cumulus, NoahMP LSM, RRTMG radiation + spectral nudging (also pseudo-global warming future perturbation run)

Other Specific Schemes we might want to build into 'Suites'

What schemes/suites might we take forward from CAM6? [Why]

- Note: CAM only has one ‘suite’ now. CAM6
    - Some flavor of CAM5+ physics is probably a reasonable second suite for CAM. (This doesn’t necessarily have to be fully supported scientifically)
- Boundary Layer/Unified Turbulence (CLUBB) [Designed for different scales: LES]
- Radiation Code (RRTMG) [Reference, best code available]
- Aerosol Model (Modal: MAM4-7) [Flexible: different number of modes]
- Gravity Waves?
- Others?

What Schemes/suites might we take forward from WRF? [Why]

- Grell-Freitas Deep Convection [Scale Aware]
- Thompson-Eidhammer Microphysics

WRF/MPAS Global 10-day suite

- Tiedtke cumulus
- WSM6 microphysics
- YSU PBL
- old “mm5” surface layer
- Noah LSM [See land model notes below]
- RRTMG radiation [Essentially same as CAM version, do not need to duplicate]

Note that the land surface and chemistry are developing unified approaches that unified physics will interact with. We need to discuss land and chemistry (including aerosols) specifically with relevant groups.

- Chemistry is likely considered as ‘part’ of the physics, and will be integrated into the atmosphere model
- Land is treated differently: part of physics in WRF, a separate component in CESM.
    - It is likely we will adopt the separate component method.
    - If we want CTSM to be a ‘parameterization’, or available through a physics driver (as currently in WRF) we probably need to discuss that.
    - Option to port Noah LSM if felt to be necessary

Maybe think of above as ‘suites’: weather suite, climate suite (short term)

- Suggestion is we pick a subset to evolve first
- In short term: we can use first ‘suite’ ported into CPD in WRF to test in Forecast mode
- Then think about porting other schemes to CPD (WRF/MPAS 10 day suite)

What schemes are new/need to be developed?

- Unified Microphysics (MG2 + Thompson/Eidhammer) [Designed to work across scales]
- Others? (Unified chemistry/aerosols?)