Physics Dynamics Coupling 'Issues/Goals/Requirements/Recommendations'

1. **Mass-conservation** in physics-dynamics coupling (is the amount of mass that physics wants to add/remove actually added/removed in physics-dynamics coupling). Diagnostics (in physics and dynamics) to verify that should be part of any model validation (e.g., exists in CAM-SE). Proposal: column integral.
   - Similar to note below: define mass mixing ratio relative to the dry air mass.

2. **Dry Mixing Ratios**: Physics-dynamics coupling would be a lot cleaner if physics was always using dry mixing ratios, i.e. density of tracer/density of dry air. Then a particular mixing ratio will not change when other tracers undergo changes (assuming dry air density is constant during physics updates).

3. **Dry hydrostatic pressure**: A step towards more accurate total energy conservation in physics and physics-dynamics coupling would be to use dry pressure as the vertical coordinate. Dry pressure levels stay constant during physics processes. Moist pressure, on the other hand, is not necessarily constant although many physics packages assume it is constant during physics processes. This leads to energy conservation problems as the work done by, e.g. water vapor, is not accounted for during each physics process.
   - Option: move to dry hydrostatic pressure (for physics side, see above). Dynamics needs to know this
   - Will need to understand energy conservation implications.
   - Want a vertical coordinate that does not move up and down with heating

4. **Vertical Coordinate:** If the dynamical core uses a vertical coordinate different from the physics suite we need to assess the source/sink of total energy during the mapping/transformation to/from the different coordinate systems; in particular if there is a bias. Ideally we should try and make the mapping total energy conserving (that said, conserving energy locally has proven difficult/ill-conditioned in some applications).
   - Add to infrastructure (or develop a routine for it).

5. Interfaces/infrastructure should allow for research in **conservation during physics-dynamics coupling**. For example,
   - one could make sure internal energy is conserved in physics dynamics coupling by using rho*c_p*T instead of T as the forcing term for the thermodynamic equation (assuming T is the prognostic variable; c_p is a generalized heat capacity incl. all water loading tracers). Helpful if infrastructure should support it. Diagnostics for what physics THINKS is added v. what is added in dynamics.
   - Similarly, it may be possible to conserve total energy in the physics (kinetic to internal or to potential energy) and add to dy core.
   - Diagnostics to assess energy conservation during physics-dynamics coupling is recommended for model validation (e.g., exists in CAM-SE) so that we know the loss of energy conservation in the dynamical core, physics-dynamics coupling and, if applicable, physics.
     - Is this dy core specific? I assume the physics will take care of this.
   - Sequential v. Parallel (Physics and dynamics in parallel). Do we permit this? Clipping unavoidable in parallel mode.

6. **Different grids:** Interfaces/infrastructure should accommodate running physics on a different grid than the dynamical core (to support basic research in physics-dynamics coupling). Need for horizontal grids. Different vertical grids too?
(Mic not working) The plan is to couple to the ionosphere from the physics in order to be dycore independent. [Will add some further clarification from Steve/Hanli about Ionosphere]
Might also apply to a lower resolution chemistry grid.

7. **Total Energy:** The dynamical core, physics suite and the physics-dynamics coupling layer should ideally use the same discrete total energy formula.

- Define energy in one place.

8. **Physics Tendencies:** Does the physics need to know about how tendencies are put into dynamics (all at once, 'dribbling')? NO.

9. **Chemistry-Physics Coupling.** We are 'sort of' treating chemistry as part of the physics module. It has sources and sinks of tracers, and associated heating terms as a result of chemistry, radiation, etc. Besides advection, are there any special issues? No. This is Chemistry-Physics coupling. See below for heat capacity under 'tracers'

10. **Tracer Requirements**
- Water is 'just another tracer': no special treatment, arbitrary position, can be absent.
- Specify which water (or any other) tracers are energetically active (usually the water loading tracers), i.e. the indices of the water tracers and associated heat capacities must be known to both dynamics and physics to compute pressure, total energy, specific humidity, etc.. An example of how this can be done can be found in the CAM-SE dycore.

11. **Functions for pressure, energy, humidity.** Similar to physical constants, functions to compute pressure, total energy, specific humidity, water saturation, etc. and the index location of water tracers as well as associated heat capacities, should be defined in one place where they can be accessed from physics, dynamics and the coupling layer.
- Different compositions of the atmosphere should be supported (paleo, geospace, other planets), i.e., other tracers may be thermodynamically/energetically active than in the current earth's lower atmosphere.
- Heat capacity function.

12. Diagnostic Grid (Infrastructure: Where between physics and dynamics)
- Regional or zonal averaging: This should be part of the diagnostics.
- (Diagnostic grid? Don't output high res.) Tied into diagnostics and I/O

I think that interpolating to another grid needs to be part of the grid as they are fairly specialized.