Science Goals for Unified Physics

- Minimal set of parameterizations that works from weather to climate (across models)
  - Efficient development
- Works across time and space scales
  - Consistency across parameterizations
- Current science Capabilities/Needs
  - Weather: Tropical Cyclones, Severe Convection (Supercells, Squall Lines), Winter storms
  - Weather Prediction (verification, surface and upper air, global and various regions)
  - Precipitation: timing and intensity across scales.
  - Unresolved wave driving of the general circulation, it's role in the chemical & dynamical coupling of atmospheric layers, and it response to climate change
  - Climate
    - Global climatology (cloud radiative forcing, energy balance)
    - Low frequency climate variability
  - Impacts of Aerosols & Chemistry on Climate and Weather (and vice versa).
  - Complex terrain effects (precip, valley flows, mountain waves)
  - Accurate and Efficient Radiative transfer that is consistent with chemistry for gas phase and cloud scheme for condensed phase (liquid and ice)
- Frontiers:
  - Effects of Organized Convection on weather and climate
    - Momentum transport, Diurnal cycle, interaction/generation of waves
  - Interannual to decadal prediction
  - S2S phenomena, Kelvin waves, MJO, Monsoons
  - Surface-Atmosphere interactions (ocean, ice, land), interactions with planetary boundary layer
  - Medium-range global forecasting (anomaly correlations, etc.)
  - Virtual global field campaigns (high-resolution 10-km grid global NWP analysis
  - Upper atmosphere: Space Weather and impacts on weather and climate
    - Upper atmospheric physics [Ask Hanli/Dan]

Requirements For Unified Physics

- Numerical stability of schemes over a range of timesteps and scales
  - Weather: seconds and km
  - Climate: up to 10-30 minutes and 100-200 km resolution
- Schemes should conserve mass and energy (also water budget)
- Conservation of momentum is desired
- Able to handle cloud scale updraft velocities (several m/s).
- Tracer transport should be efficient and conserve mass and energy.
- Chemistry: will be its own separate model, but physical processing of chemical species done in the atmosphere model.
  - Wet deposition (aqueous chemistry).
  - Vertical mixing (including dry deposition)
  - Convective transport
  - Emissions, especially natural emissions
- Aerosol physics: options for a range of simplified aerosols, fixed aerosols, or interface to a full aerosol model (e.g.: WRF-Chem or CESM treatments)
  - Connection to physics - CCN, IN for microphysics, optical depths for radiation
- Suite of parameterizations that is scientifically consistent
  - Aerosols/Deposition and Clouds
  - Cloud schemes themselves (Turbulence, Microphysics, Convection)
  - Clouds/aerosols consistent with radiation code.
- Schemes suitable for geospace modeling (or shut themselves off)
- Desired: compatibility of physics for current NCAR models (runs in CESM/WRF)
  - Coding standards and interface standards
  - Agnostic to dycore variables or vertical coordinate details
- Simplified workflows: hierarchy of models to develop, evaluate and test. (1-D to 3-D, isolated cases/parameterizations)
  - Off line testing. (unit testing).
  - Diagnostic calls to parameterizations (could be multiple calls).
  - Optional diagnostic calculations.
- Supports community development (API allows adding a new scheme for testing)
- Computationally Efficiency for science problem at hand (simple to complex)
- Ability to handle sub-columns
- A path for communication with nearby columns (stencils)
  - This could be a computational hit for now. Frontier