Working Group on Climate Change to 2030

Question #1: What are the most important climate change science questions to be addressed in this time frame?

- Regional climate variations
  - Especially extremes
  - Precip, soil moisture, snow pack
  - Temperature (heat events)
- Hurricanes
- Potential Impacts on human health (aerosols, ozone, disease vectors)
- Impacts on fisheries
- Magnitude of aerosol forcing (from models and observations) - leading to a better indication of climate sensitivity

Question 2: What models are most relevant to address these science questions in this time frame?

- **AOGCMs**
- **Earth System-type Models**
  - **Some components can be done off-line**

PROBLEM: ISSUE CONCERNING THE PARTITIONING OF RESOURCE EXPENDITURE BETWEEN THESE TWO TYPES OF MODELS

- **No real necessity for EMICs**

Current Institutional Pressure is to use AOGCM

- Climate change simulations out to 2030 with fine resolution (0.5° for atmosphere and ocean)
  - Regional assessments of relevance to policy makers
- Would need to start from the correct initial climate state
  - Would require ocean (and perhaps land:soil moisture and temperature) initialization
  - Global ocean assimilation being done for 1990
- Gridded emission data (for aerosols and short-lived gases) would be required at this resolution
- Further downscaling probable for impacts

How would a very fine resolution model be developed in this time frame?

- Japanese experience is that tuning only had to be done with respect to extremes
  - Some tuning of convection and boundary layer schemes, and for radiation balance
  - Little in the way of parameterization changes necessary down to 20km resolution
  - Climate sensitivity function of physics, not resolution
- Result may be different with different models, or with finer vertical resolution
- Extremes and hurricanes better simulated
- Still has problems with rainfall frequency distribution tails and ENSO frequency

How would a very fine resolution model be validated?

- Historical simulations with goal of regional accuracy would be computational prohibitive
- Weather forecasts would require atmospheric data initialization not previously done
- Ability to produce events impacting regional prediction (ENSO) not guaranteed
- Physics won't be improved and people will use these as forecasts

Alternate Approach: Use Earth-System type model

- Keep current resolution (or close to it)
- Add in physics useful for this time-range
  - Aerosol models
  - Appropriate tropospheric chemistry
  - Stratospheric chemistry for ozone changes
  - Dynamic vegetation for the health of the biosphere and possible succession
  - Better fire prediction module
- Would provide more accurate assessment of climate change forcing, including indirect effect
- Would allow for air quality assessments

Compromise approach

- Finer horizontal/vertical resolution than currently
- Somewhat simplified aerosol and chemistry routines
- Would still limit number of ensemble members or scenarios explored
  - Full aerosol package factor of 2
  - Doubling horizontal resolution factor of 8
  - Doubling vertical resolution factor of 2
- Would still require coarser resolution models to be used for historical simulations and standard future projection (~ A1B)
  - Would have to show finer resolution model has similar sensitivity

Question #3: What emissions scenarios are most appropriate for this time frame?

- Well-mixed trace gas scenarios do not differ greatly prior to 2030
- For aerosols and short-lived gases, need fine resolution emission inventories for regional projections
  - Historical inventories and future emissions would have to be gridded
  - Would need some process to make this happen
  - Should use different projected levels of pollution
  - Decisions needed on what emissions are required
  - Alternate ozone precursors may be more interesting than alternate sulfur projections (may be scaled linearly)
- For mitigation, geo-engineering using sulfate aerosols is getting attention
  - Injection into stratosphere (long-lived) or into troposphere (more accessible)
  - Possible consequences unexplored (e.g., acid rain)

Question #4: What would be an appropriate experimental design to address these scientific questions?

- "Compromise" approach would have more simplified extra physics (aerosols, chemistry, dynamic vegetation) and somewhat finer resolution.
- Longer-time scale issues (ocean biogeochemistry, land ice, ecosystem migration) would be omitted or done off-line
- Solar forcing would use mean or 11-year cycle with no prediction
- Volcanic forcing could use time-average or stochastic volcanic eruption (less important)

Question #5: What is the proper combination of ensemble/scenario simulations?

- Regional predictions require ensemble simulations (especially for hydrologic cycle changes)
  - Number uncertain, 10-15 perhaps
  - With smaller climate change, determination of change in extremes is more difficult
- One base scenario for well-mixed gases, perhaps several for aerosol or short-lived gases

Question #6: What is the starting point for the simulations?

- Some historical spin-up will be required
  - Ocean data initialization for 1990 onward
    - If earlier start, would have to nudge the ocean toward these values in 1990
  - Emissions data best from 1980 onward
  - Land/atmosphere/ocean systems might require spin-up from 1970
  - Better planetary radiation balance in 1950 (would better avoid unresolved warming)
- Historical aspects will require historical emissions
  - Ozone precursors
  - Land use, biomass burning and fire data
  - Black carbon emissions
  - Must be merged with future emissions

Conclusions/Concerns

- **Mix of finer resolution, more physics and sufficient ensemble members would require some 4 dedicated machine-years for regional predictions**
- **This is without considering simulations for longer-term projections**