# FESD Ozone Hole and Climate Project Kick-off Meeting

## Held at Columbia University, June 2013

KEY ACTION ITEMS IDENTIFIED:

1. Development of improved ozone 'relaxation techniques' for specified chemistry models.

   Most global atmosphere/ocean climate model simulations prescribe zonally-averaged climatologies of the observed ozone to probe the dynamical response of ozone changes. The Waugh et al. (2009) study, however, suggests that trends in tropospheric temperature and zonal wind and sea level pressure are significantly underestimated when stratospheric ozone chemistry is imposed using zonal-mean ozone, as compared to when stratospheric chemistry is interactive. Recently, Waugh has shown (using the GEOS model) that much of the effect of interactive chemistry can be obtained by relaxing back to zonally-averaged ozone distributions but only on a 3 day timescale. This permits the ozone distribution to evolve dynamically in 3 dimensions. At our meeting several other alternative approaches were suggested, such as referencing to PV contours, equivalent latitude…. etc,

   In the next 6 months, then, we propose to experiment with the way in which chemistry is specified in SC-WACCM and compare results with WACCM (which uses interactive chemistry) which will be regarded as providing the 'truth'. Guided by the studies of Waugh we will attempt to arrive at a methodology that is an improvement on prescribing zonally-averaged climatologies, but one which is simple to implement and much more efficient than using full interactive chemistry.

   This is an essential step to making it computationally feasible to couple atmospheric models in which chemistry is specified to ocean models and launch ensembles of climate change projections.

2. Ozone-hole single forcing runs

3. Computation of Ozone Hole Climate Response Functions in Coupled Models

   Once step 1 is completed we can use a SC atmospheric model coupled to an ocean to compute Climate Response Functions in which a seasonally cycling ozone hole is prescribed. Our goal is to do this with NCAR, GFDL and GISS models so that we can get an idea of the spread of the response across models.

Suggested protocol would be:

a. Spin up coupled to ocean model to equilibrium state corresponding to 1850 conditions.
b. Impose a perpetual cycle of time-varying ozone using the approach developed in 1. We would relax to the following prescribed ozone distribution, month by month….
c. Launch ensembles of 10, 50-year integrations storing the following data:

   (a) Monthly-mean fields of: - SST, ocean temperature throughout the thermocline , mixed-layer depth, sea ice concentration
   (b) monthly-mean fields of: - surface wind stress, air-sea heat fluxes, E-P, w & v or streamfunction of the meridional overturning circulation (Eulerian, and residual).

2. O3 hole CRF with seasonal cycle.

This will show the importance / dependence on seasonal cycle. Links into next point

3. Wind perturbation CRF with same perturbation as from the O3 CRF.

Can we use the wind perturbation approach? If so can make some comparisons with existing studies. More importantly will enable cleaner comparisons of ocean response between models. If we use the same ozone forcing in different models will produce different surface wind changes, and will be difficult to tease this out from differences in ocean.

4. CRF with large perturbation.

Not sure which of the above to do this in (wind perturbation is likely easiest). Do you get the same response as small perturbation (i.e. another test of linearity)? Perhaps more importantly, does larger perturbation mean fewer ensembles needed to see clear signal?

4. Transient simulation with O3 hole formation and recovery, and O3 hole CRF simulations with same model.

Can we reproduce the transition runs with the CRF (or more likely, what features of the transition can you reproduce)? Showing this will help to convince some of the skeptics. This connects clearly with 2.

5. Computation of SAM climate response functions in ocean-only models.

   One might anticipate that the response of the surface wind and air-sea fluxes in the coupled models in 2. above could be rather different across models. To probe the response of the ocean, then, to the same forcing, it is suggested that we impose a SAM-like wind-forcing in an ocean-only context as follows.

   Describe the protocol…

   We can do this with the MITgcm, the GISS ocean model….. GFDL and NCAR?