# FESD Ozone Hole Summer 2014 meeting

Room FL0-2512 of the Atmospheric Chemistry Division, Foothills Lab, NCAR

## Monday 28th July, 2014

Morning: 8.30 to 12

Welcome from Bill Randel
Director, Atmospheric Chemistry Division

Logistics and Introductions: Marika Holland/John Marshall

# Scientific Program

Darryn Waugh
Ozone asymmetries

Ryan Neely (talk being given by Lorenzo Polvani)
Effects of Temporally Smoothing the Ozone Hole

Doug Kinnison
WACCM ozone tracer development update and results

Lorenzo Polvani
Cloud-dynamics coupling over the Southern Ocean

Susan Solomon
The extent to which CMIP5 models simulate circulation changes with ozone versus GHG versus combined forcing

## Lunch: 12 till 1.30

## Afternoon: 1.30 to 5.30

Aditi Sheshadri
Can the delay in Antarctic polar vortex breakup due to ozone depletion explain the trends in surface westerlies?

Ari Solomon
The effect of ozone depletion on Southern Ocean temperatures

David Schneider
Ozone and Tropical SST Forcing of Southern Ocean Climate Trends

Clara Deser
Ozone and Tropical SST Forcing of Southern Ocean Climate Trends (contd)

Ute Hausmann
Climatological constraints on air-sea damping rates of SST in the southern ocean

Marika Holland
Sea ice variations within our large ensemble simulations

Jordan Thomas
Natural variability in southern oceans using CMIP5 runs

### Dinner together in Boulder

## Tuesday 29th July, 2014

### Morning: 8.30 till 12.

David Ferreira
Antarctic ocean and sea ice response to ozone depletion: a two timescale problem

Ute Hausmann
An observational study of the response of the southern ocean, SST and sea-ice to SAM forcing

John Marshall
The ocean's role in polar climate change: asymmetric Arctic and Antarctic responses to greenhouse gas and ozone forcing

Darryn Waugh
Ocean age

Anand Gnanadesikan
Controls on Southern Ocean stratification and why this matters for biogeochemical cycling

### Lunch: 12 till 1.30

### Afternoon: 1.30 to 5.30

### FESD project discussions

How are we doing? - progress, plans, collaborations.
Future meetings.

# Summary of key action items

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

It appears that much of the effect of interactive chemistry can be obtained by relaxing back to zonally-averaged ozone distributions. However, this must be done with care so as not to introduce too much temporal smoothing and prevent attenuation of a rapidly deepening ozone hole. In the last year the problem has been studied at length and a way forward mapped out.

We propose to relax back to DAILY zonally-averaged ozone distributions – simple to implement and more computationally efficient than using full interactive chemistry.

This requires us to develop a zonal-mean daily ozone climatology.

We will use SD-WACCM, 79 to present.

Compare with MLS observations to validate (2005 and ongoing).

Prior to 1979? Begin in 1950…., continue in to future with chosen RCP.

Doug K to carry out.

From these daily fields we will also construct an annually-repeating ozone hole climatology for Green's function applications. Use average of 2005 to 2010.

Run with tropospheric chemistry…

Make available to the wider community..

## 2. Ozone-hole single forcing runs

Few studies using high-top interactive chemistry models to date have separated the GHG-induced changes in the stratosphere from those related to CFC changes.  We will therefore do several suits of calculations with CFS changing, but not carbon dioxide, and then compare to runs using both of these forcing agents.

Doing the CFC only runs for comparison should be our priority. It doesn't need a new spin-up since ozone depletion isn't significant until after 1970.

Control is historical run with all forcing or use Doug's daily ozone. (SD-WACCM-ozone)

Keep ozone (or ODS) fixed at 1960 values and integrate on.

Minimum of 5 ensembles.

Perturb atmosphere.

Make internal list of who's interested in what.

Science objectives:

- How clouds change with ozone (Grise)
- Hadley cell, trop circulation (Justin Bandoro)
- Changes of surface climate – sea ice, winds, SST (Marika)
- Ocean tracers, OBC, ACC, overturning, mixed layers (JHU)

The following modelling groups will participate:

CESM-LE

WACCM

SC-WACCM

GISS

JHU (GFDL)

IPSL

Goddard

UK???

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

### A. Ozone hole CRF protocol

Once step 1 is completed we can use a SC atmospheric model coupled to an ocean-ice model 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.

Other models..

Suggested protocol would be:

a. Spin up coupled to ocean model to equilibrium state corresponding to pre-industrial conditions - same as used in 2. Extend control with 1955-1965 daily climatology of ozone.

b. Impose a perpetual cycle of time-varying ozone using the daily ozone forcing approach developed in 1.

c. Launch ensembles with a minimum of 5, 50-year integrations (including one or two longer ensemble members) storing the following data:

(a) Monthly-mean fields of: SST, ocean temperature, Salinity 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) over the globe.

(c) winds, theta, height, clouds, surface p.

CRF with full chemistry (WACCM)

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

Can we reproduce the transient single-forcing runs by convolution of the forcing with the CRF (or more likely, what features of the transient can you reproduce)?

This connects clearly with 2.

### C. Wind perturbation CRF with same perturbation as from the O3 hole CRF.

Can we use the wind perturbation approach? If so we can make some comparisons with existing studies. More importantly will enable cleaner comparisons of ocean response between models (see also 4. below). If we use the same ozone forcing in different models we will produce different surface wind changes, and will be difficult to tease this out from differences in ocean.

Repeat Gent calculations (pert.1)

### D. CRF with large perturbation.

Does one get the same scaled response with a large perturbation as with a small perturbation (i.e. another test of linearity)? Perhaps more importantly, does larger perturbation mean fewer ensembles needed to see clear signal?

Multiply perturbation by a scaling factor.

## 4. 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, e.g. 1. and 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.

We need to describe the protocol. We are currently discussing this at MIT but have not finalized the approach.

Change in E-P, wind…..

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

This connects with task 3D.

## 5. Observables

As ozone depletion recovers in the next half-century or so we will have an unprecedented opportunity to observe how the climate system relaxes from a known perturbation. Moreover, the effects of GHG and ozone forcings are very likely to oppose each other, at least in respect of their projection on to SAM.

Can we identify exactly what needs to be observed to parse out the signatures of ozone and GHG forcing from the natural variability. Although both GHG and ozone forcing project on to similar dynamical atmospheric modes, the pronounced seasonal cycle in ozone forcing may enable us to parse out its effects from those of GHGs.

What might the list be?

- Stratospheric temp, winds, seasonal evolution
- Surface wind stress, SAM, air-sea fluxes including radiation.
- SH clouds and relation to jet.
- jet shifts, precipitation, Hadley cell, ITCZ, trop circulation.
- Changes of surface climate – sea ice, winds, SST
- Ocean tracers, OBC, ACC, overturning, mixed layers

MIT and JHU to make a first stab at compiling initial list and quantifying expected changes.

How might we influence observing programs?