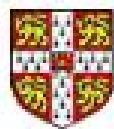


Reassessment of the Atmospheric Response to the Pinatubo eruption using a Nudged CCM

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UNIVERSITY OF
CAMBRIDGE

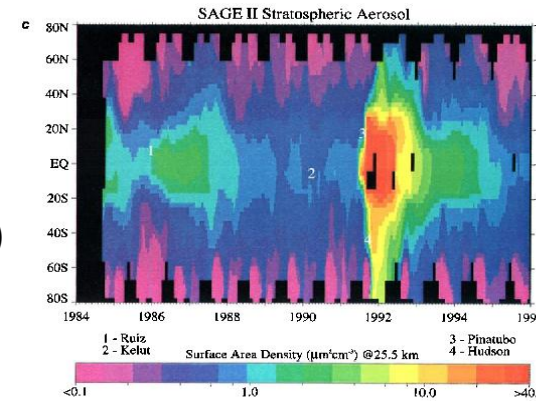
Introduction

- Pinatubo large **perturbation** to climate system
- Produced record **ozone depletion**
- Constrain atmospheric response using **nudging**
- Investigate response of **chemistry**
- Study **causes** of the response

Pinatubo Eruption

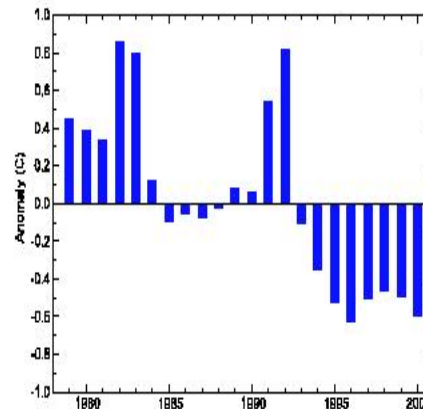
- Largest **stratospheric aerosol** loading in C20th
- **Heated** stratosphere, cooled troposphere
- Record **ozone depletion** at mid-latitudes
- **Many** causes (SAD, radiation, uplift, T)

SAD
at
26km)



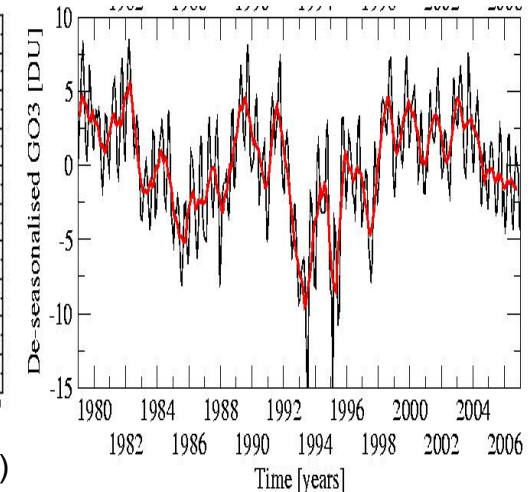
(Thomas
on et al
JGR'97)

MSU Strat T
anomalies



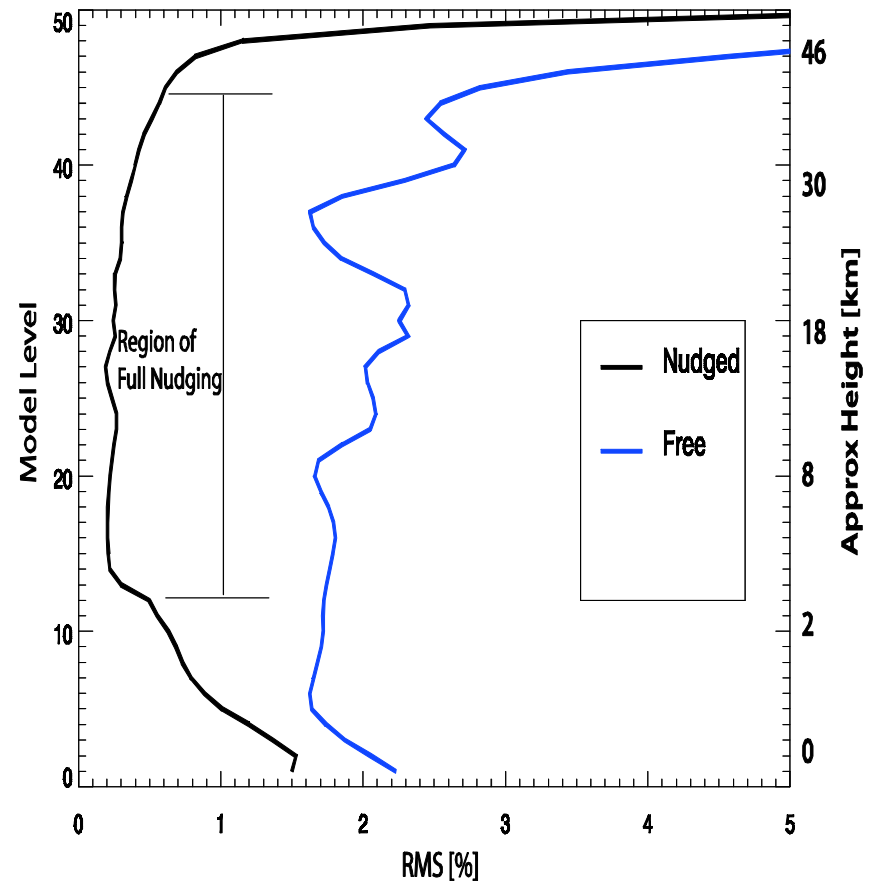
(Lawrimore et al BAMS'01)

TOMS/SBUV Ozone
Column anomalies



Model Description

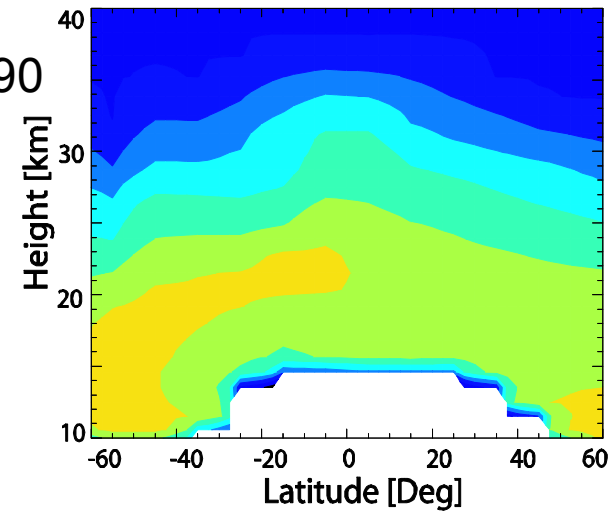
- **UM** (New Dynamics)
 - ❖ N48 ($2.5^\circ \times 3.75^\circ$)
 - ❖ L60 (0-84km)
- **UKCA** Chemistry
- **Nudge** to ERA-40 u, v, θ
- Prescribe **SAD** (*Thomason et al '97, updated*)
- Prescribe **Optical Depth** (*Sato et al '95, updated*)
- Concentrate on **60°S** to **60°N**



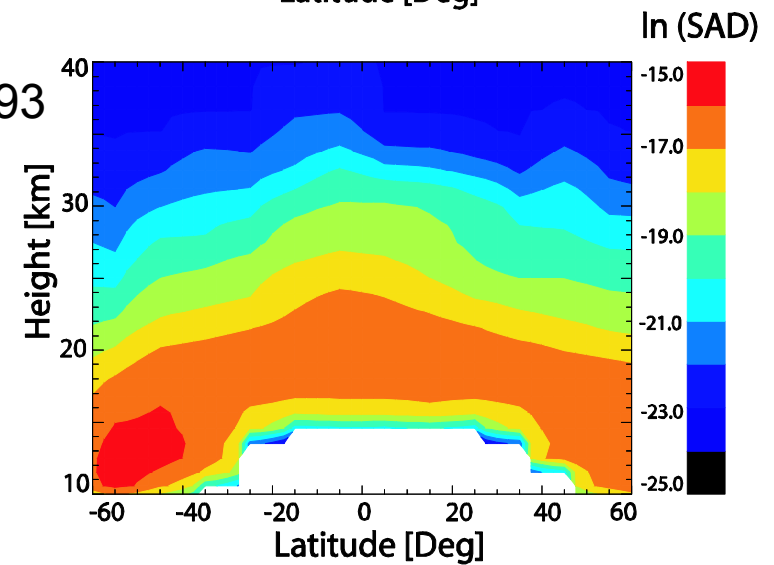
Experiments

Run	Dynamics	SAD
A	Nudged 90-95	1990- 1995
B	Nudged 90-95	Fixed 1990
C	'Free'	1990- 1995

Sept. 1990



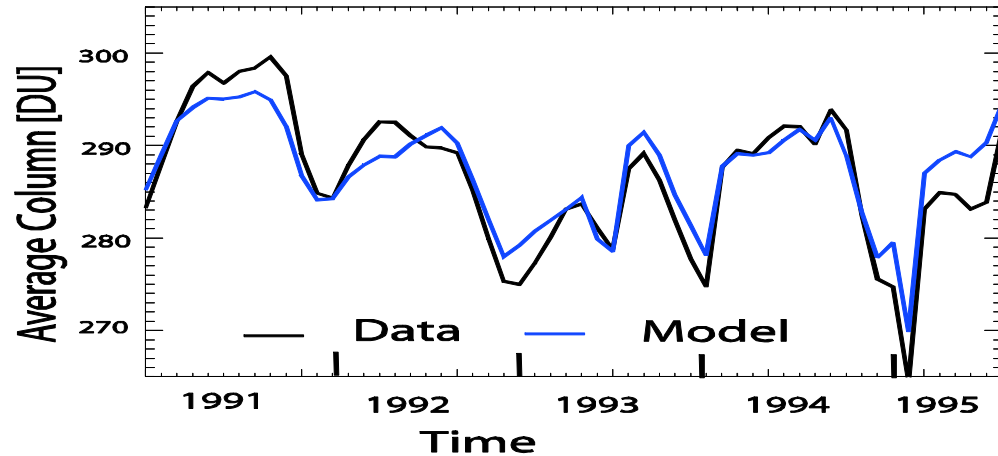
Sept1993



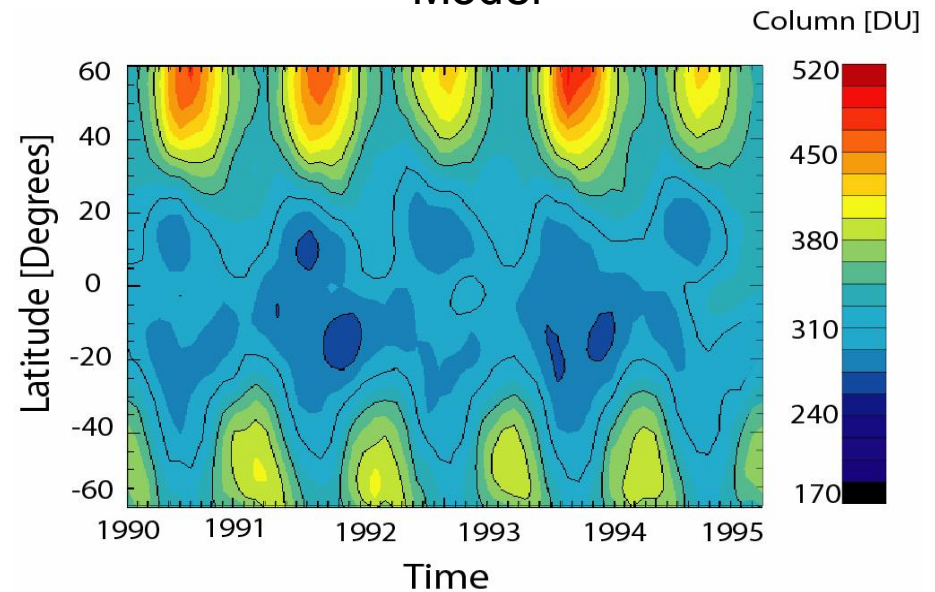
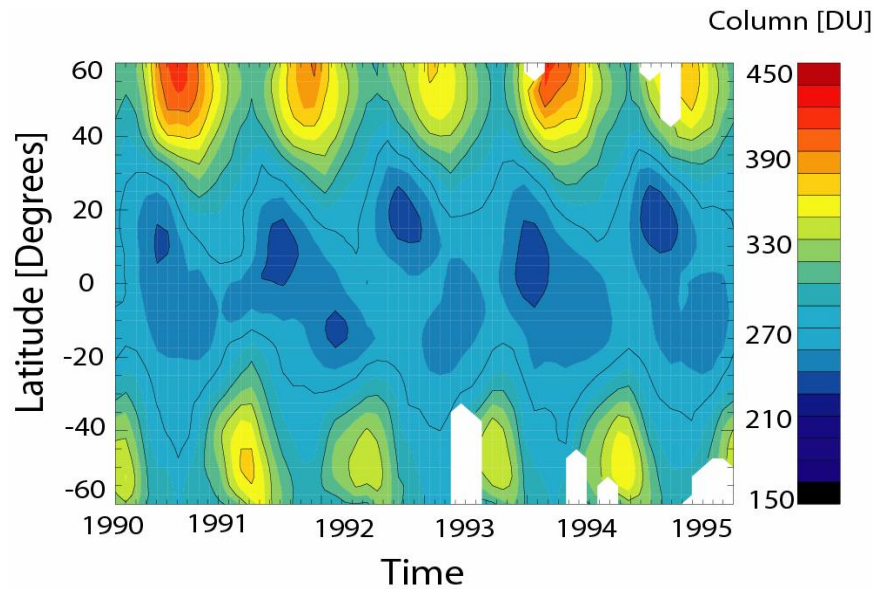
Ozone Response

- Ozone column
Run A & Data
- 'Scale' to see
Anomalies:

TOMS/SBUV

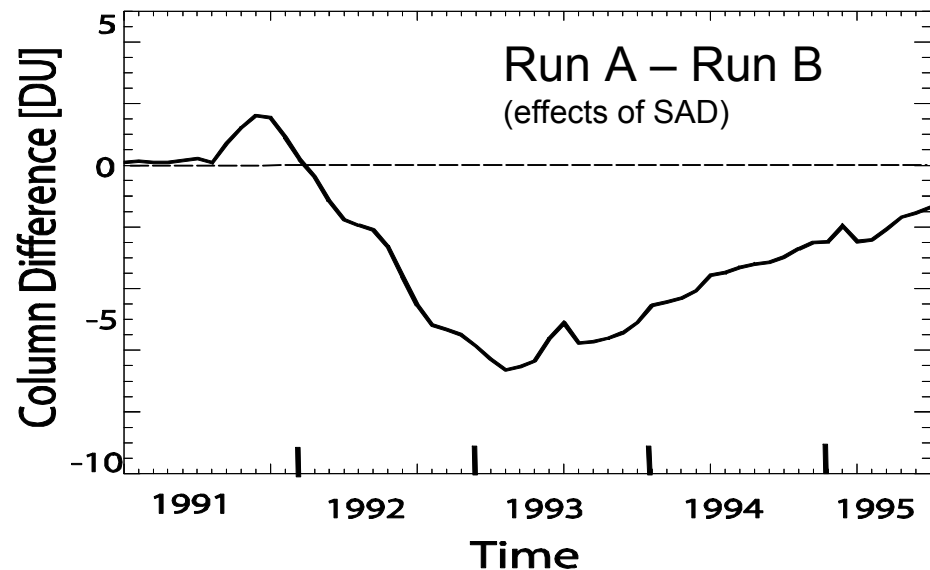
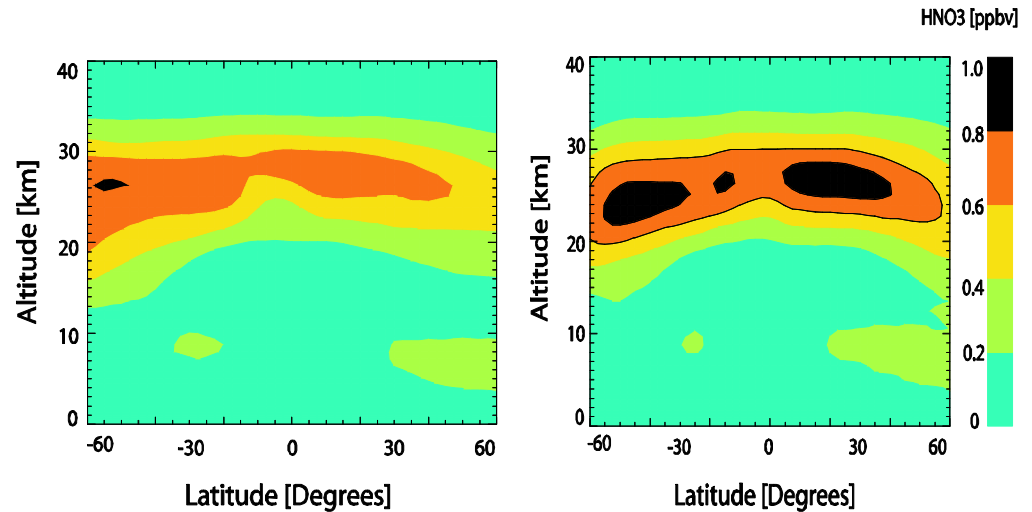


Model



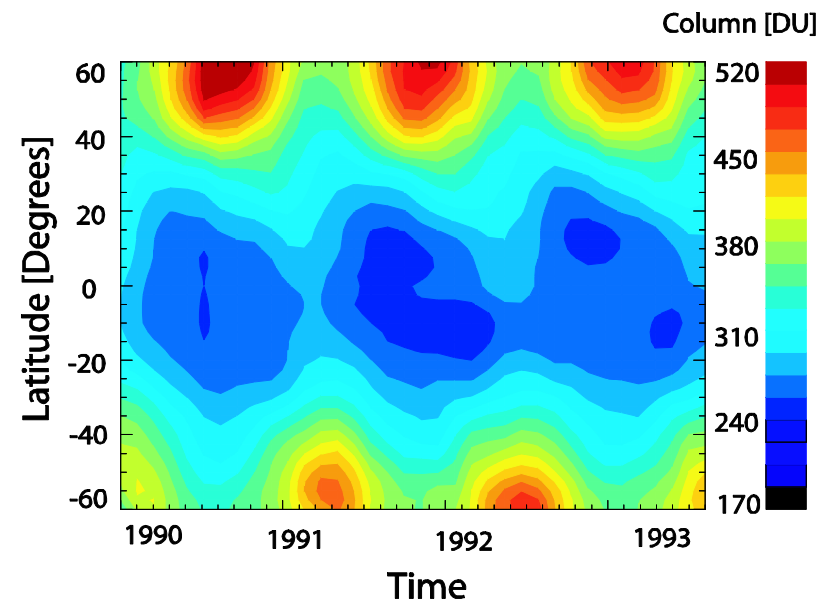
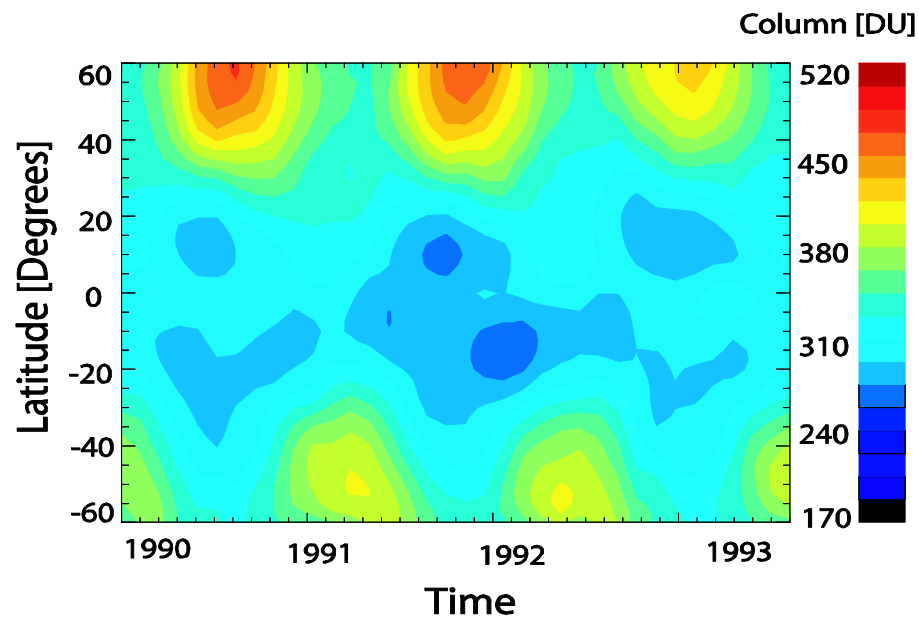
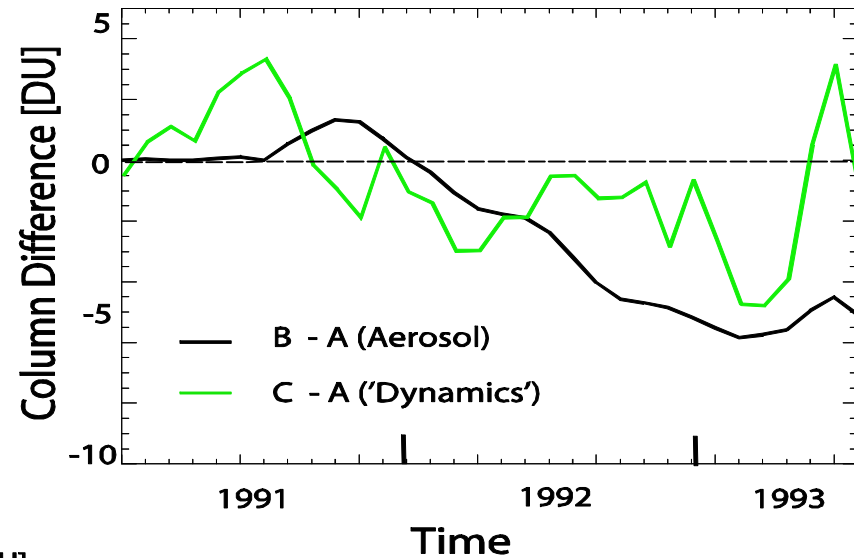
Surface Aerosol (Run B vs A)

- Increased surface for heterogeneous chemistry
- Effects include increases HNO_3
- Ozone increase then decrease
- Effect peaks at 6 DU in '92/'93
- Decrease mainly in Extra-tropics



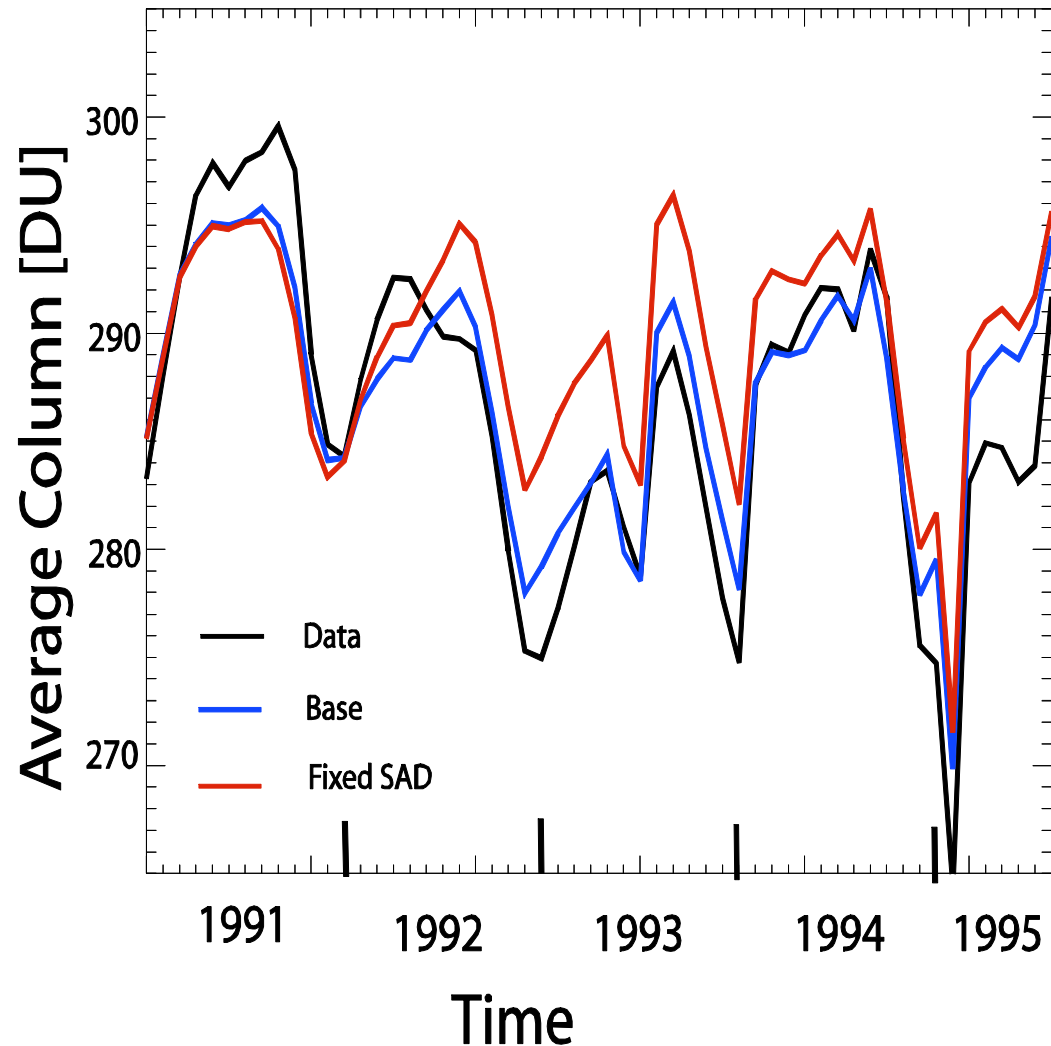
'Dynamics' (Run C vs A)

- **Heat** stratosphere, increase **uplift**
- Run **w/o** nudging
- **Noisy**, different structures (A left, C right)



Summary

- Plot Runs **A, B** and data
- Need **both** dynamics and aerosol
- **Het. depletion** peaks in '92-'93
- Depletion in '94/'95 **dynamics** driven



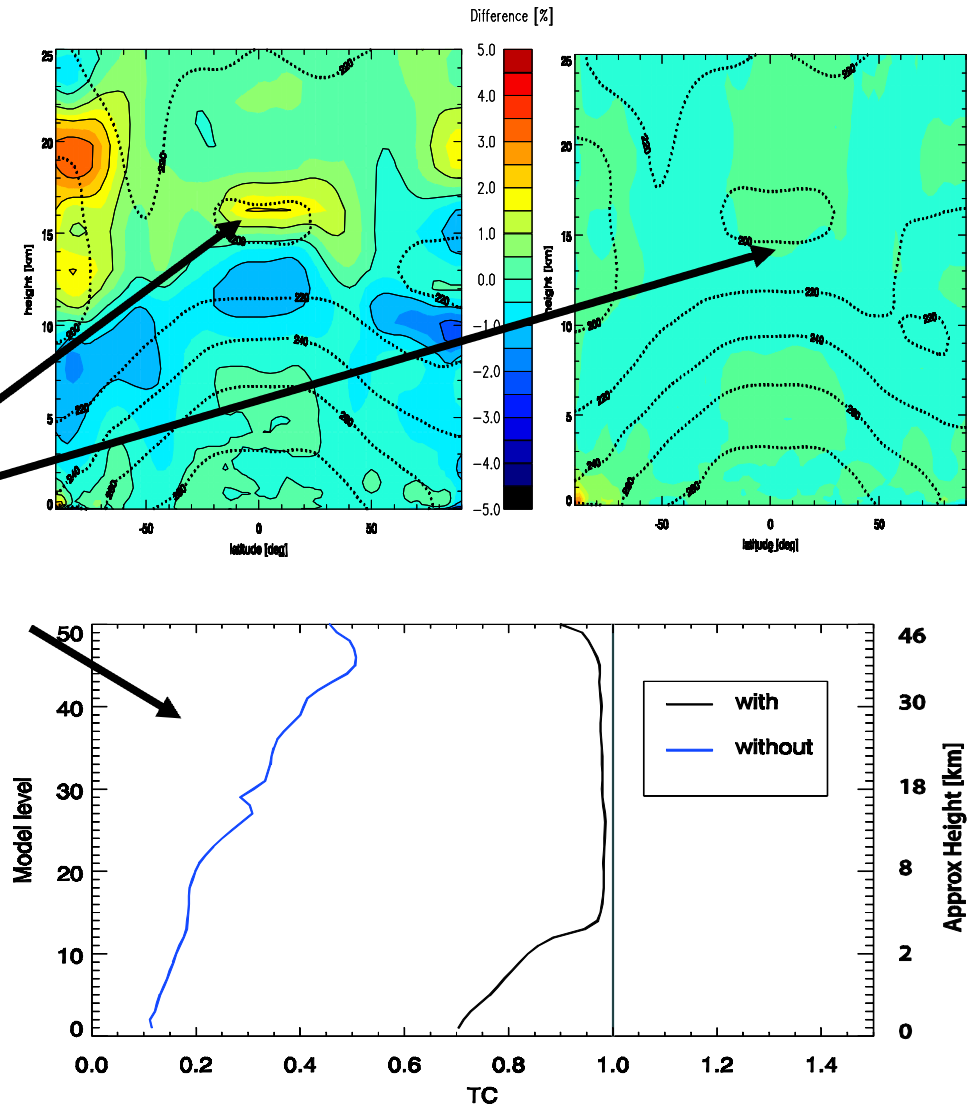
Conclusions

- Nudged model used to study **Pinatubo**
- **Ozone column** shows similar features to data
- Contribution from **het chemistry** peaks at **6DU** in NH winter '92/'93
- Looking at dynamical contribution
- Part of **UKCA CCM** development & validation process

Back Up Slides....

Nudging

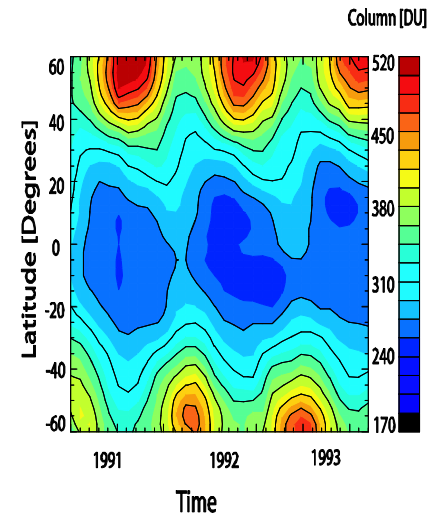
- Nudging reads in analyses to give model 'real climate'
- Use ERA-40
- Removes Biases
- Reproduces variability
- ACP Tech Note with details (*Telford et al 2008*)



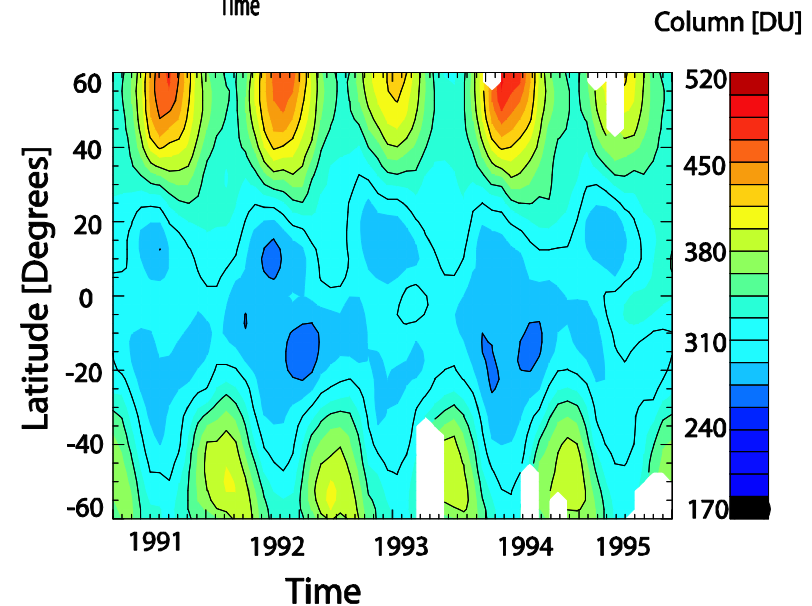
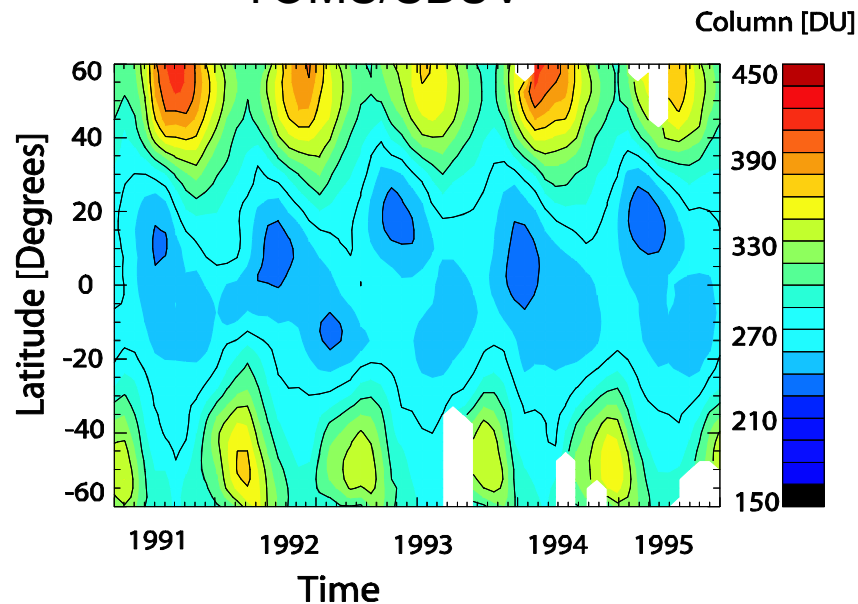
Ozone Response

Run A

- Ozone column Run A & Data
- To see Anomalies: 'Normalise'

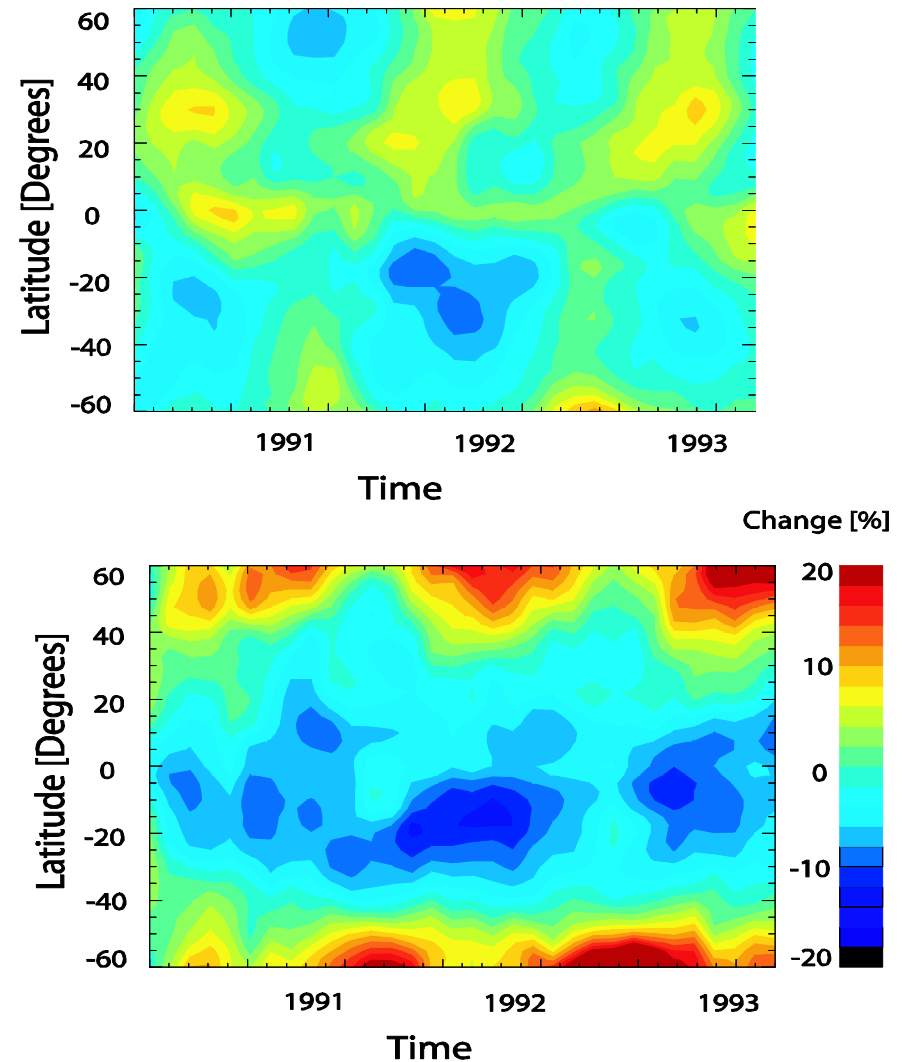


TOMS/SBUV



Nudged (A) vs Free (C)

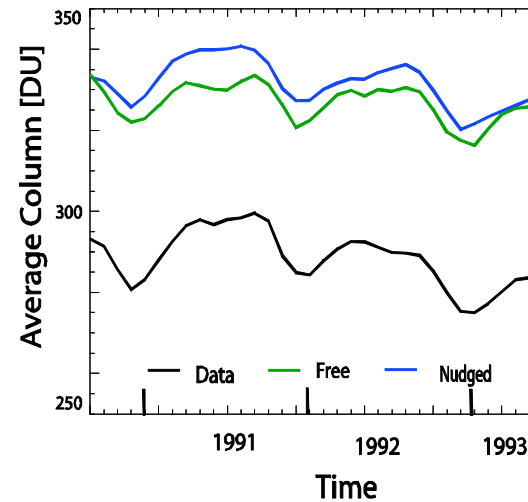
- Compare Run A & C
ozone column to data
- Normalise to compare
Anomalies
- Latitude gradient in free
model (C, bottom)
different to data
- Seems to agree in
nudged model (A, top)
- Reflects differences in
circulation



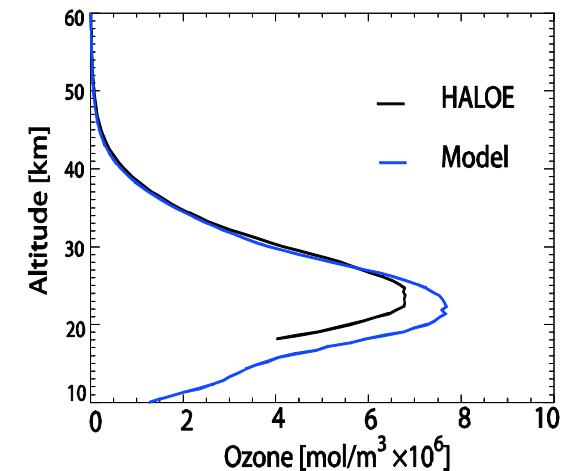
Nudged Ozone

- Nudging has **small** effect on **average**
- Model still **high** biased
- Compare to **HALOE**
- Compare models with data **distribution**
- Reflects **circulation** changes

Nudged vs Free

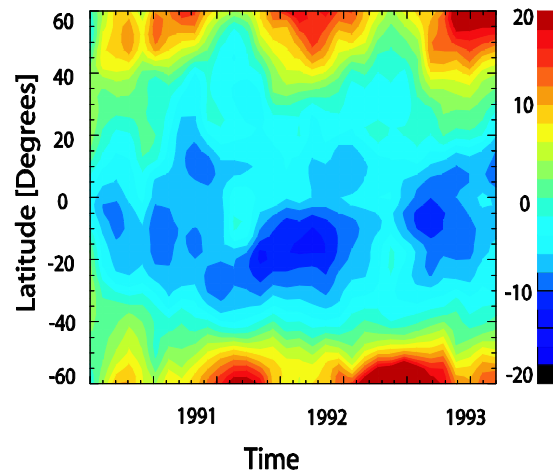


Haloe Early '94



Free

Change [%]



Nudged

