Impact of the Pinatubo eruption on Isoprene

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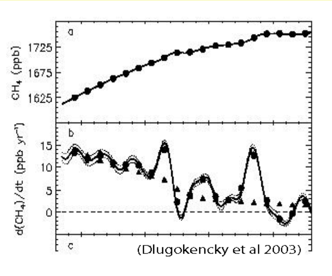
Introduction:

The eruption of Mount Pinatubo volcano in June 1991 resulted in the largest stratospheric aerosol loading in the C20th. The aerosols affected the atmosphere's dynamics, heating the lower stratosphere and cooling the troposphere. These changes had significant impacts on atmospheric chemistry, producing record lows in the mid-latitude ozone column and affecting the concentrations of methane (shown below, Dlugokencky 2003) and other GHGs.



Bousquet et al (2006) link much of the reduction to changes in wetland & NH anthropogenic emissions using an inversion technique. This technique leaves uncertainties in the tropics & does not directly address BVOC emissions or the impact of Pinatubo on them.

We study the impact of the eruption on the emission on the important BVOC, isoprene, and the consequences on OH. We also examine the effects of the pollutant ozone. We perform this study using a CCM and an offline isoprene emission model. We 'nudge' the model (Telford et al, 2008) to reproduce the temperature changes and associated changes in circulation and investigate the changes in the atmospheric chemistry and emissions. We probe the causes of variability by fixing either the emissions of isoprene or the meteorology and noting the differences with the base-line case. In addition to being an interesting study this is part of the development of the QUEST Earth System Model (QESM), probing the connection between the biosphere & the atmosphere.

Model Set-up

We use the new UKCA CCM (Morgenstern et al 2008a,b) with a

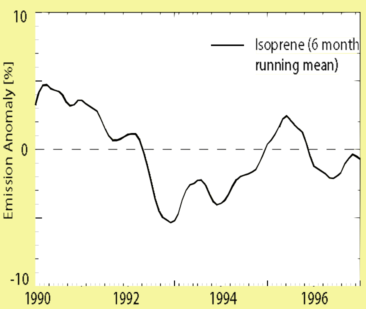
- Horizontal grid of 3.75°×2.5°
- 60 vertical levels from surface to 84 km
- Dynamical time-step of 30 minutes
- Tropospheric chemistry (CH4, CO, NMHC, NOx...)
- Methane fixed to X ppbv
- Newton Raphson solver with time-step of 1 hour

The Pinatubo eruption is introduced into the model by

- Nudging to ERA-40 T(θ),u,v to obtain dynamical response
- Including time-varying isoprene emissions

	Meteorology	Emissions
BASE	Pinatubo	Pinatubo
Emfix	Pinatubo	Background (1990)
Metfix	Background (1990)	Pinatubo

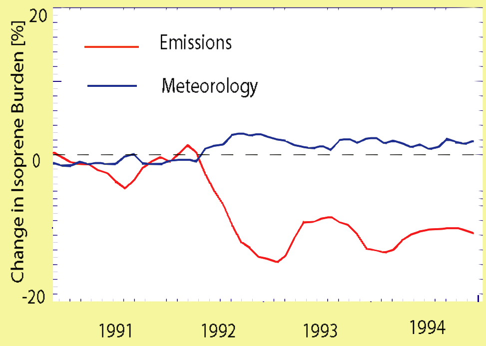
The isoprene emissions are calculated using the SDGVM (Beerling et al, 1997) and MEGAN (Guenther et al, 2006) models. The SDGVM takes information about the climate to produce a distribution of different vegetation types. Information about vegetation type and climatic conditions are used by MEGAN to calculate isoprene emissions.



Isoprene Emission Anomalies: Changes in the global emissions from the long term ('90-'97) aveage. The climatic changes following Pinatubo lowered modeled emissions, with the maximum impact in late 1992

Effect on Isoprene Burden:

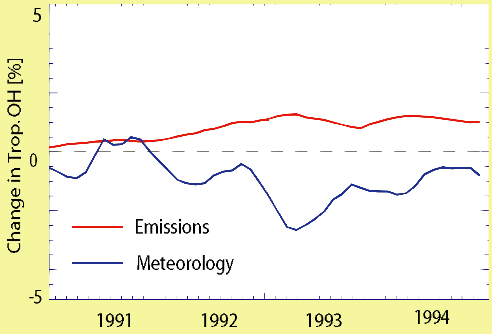
- Investigate effect of changing emissions & meteorology
- Compare isoprene burden between the different runs
- Effect of changing isoprene emissions is determined from the difference between the base & emfix runs (base - emfix)
- Effect of changing meteorology is determined from the difference between the base & metfix runs (base - metfix)



- Effect of changing isoprene emissions correlates with changes in emissions
- Much larger than the effect of varying meteorology

Effect on 'Tropospheric' OH:

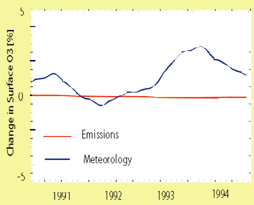
- Changes in isoprene concentrations impact on the oxidising capacity of the troposphere
- Repeat the comparisons performed for isoprene for OH burden in the lowest 8km of the troposphere



- The variation of the isoprene emissions caused increases in the amount of OH in the troposphere
- The magnitude of the impact of changing meteorology is similar in magnitude, but opposite in direction

Effect on Surface Ozone:

- Plot surface ozone changes from meteorology & emissions
- Effect of fixing isoprene emissions is very small
- Fixing meteorology has a larger effect

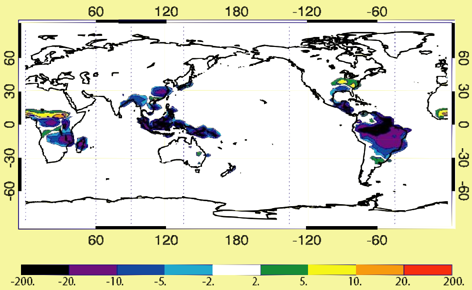


References:

1. D. Beerling er al, GEBL 6 (1997)
2. P. Bousquet et al, Nature 443 (2006)
3, E. Dlugokencky, GRL, 30 (2003)
4 A. Guenther et al, ACP 6 (2006)
5. O. Morgenstern et al, GRL 35 (2008a)
6. O. Morgenstern et al, in prep. for GMDD (2008b)
7. P. Telford et al, ACP 8 (2008)

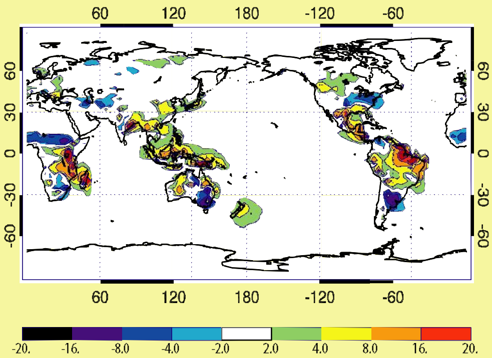
Regional Changes of Emissions:

- Investigate the distribution of (Base-Emfix) averaged over 1993
- Calculate in Boundary Layer, to maximise sensitivity
- First plot changes in isoprene burden



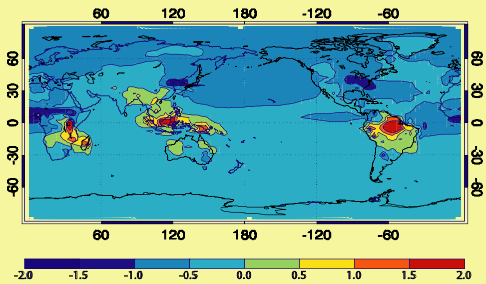
ΔIsoprene Burden in BL (Mg)

- Large decreases in main regions of isoprene emissions
- Increases at the edge, in particular in Africa & Americas
- Investigate regional changes in OH concentrations



Changes in OH Concentration in BL [%]

- Changes in OH anticorrelate with those in Isoprene
- Important regions for evaluating methane growth rates



Changes in O3 Concentration in BL [%]

- Increases in ozone correlates with increases in OH
- Size of effect is an order of magnitude smaller

Conclusions and Status:

- Demonstrated that modelled changes in emissions of isoprene are important after the eruption of Pinatubo
- These changes have a sizeable impact on OH concentrations and localised impact on ozone
- May explain part of the changes in growth rates of methane in the early 1990s
- However work is only preliminary, want to repeat with a more complete model including an interactive photolysis scheme
- Need a more complete analysis of sources and sinks of Ozone and OH

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Summary: The eruption of Mount Pinatubo produced a significant perturbation to the Earth's climate. This change in climate is expected to produce changes in the emissions of isoprene, an important BVOC, affecting OH concentrations. This may help explain some of the observed changes in the growth rate of methane. In preliminary model results we note that the post Pinatubo climatic change does produce a reduction in Isoprene and increase in OH. This increase in OH might be expected to decrease methane growth rates.