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NATURAL ENVIRONMENT RESEARCH COUNCIL

Tropospheric Chemistry Modelling

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UKCA Launch Meeting, Royal Society, 12 January 2009

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Objective of UKCA

- To build and evaluate a new UK community atmospheric chemistry-aerosol model suitable for a range of topics in climate and environmental change research

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Outline of Presentation

- Description and Evaluation
- Scientific Highlights
- Conclusions
- Future work

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Description and Evaluation

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Variety of Chemistry Schemes

	Trop	TropIsop = Trop+MIM	Aerchem = Trop + S	RAQ	ExtTC = TropIsop + VOCs
Tracers	26	40	27	40	60
Species	46	60	49	58	82
Ethane, Propane	Yes	Yes	Yes	Yes	Yes
Isoprene	No	Yes	Yes	Yes	Yes
Other non-CH_4 VOCs	No	No	No	Alkenes, Aromatics	Alkenes, Terpenes, Aromatics
Aerosol formation	No	No	Sulphate	No	SOA

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Other Features

- Uses UM 'New Dynamics' – SL advection
- Coupled to various UM configurations – climate and forecast models
- Surface and aircraft emissions
- Interactive CH_4 wetland, DMS, and lightning NO_x emissions
- Offline or online photolysis
- Simple or multiple-resistance dry deposition
- Wet deposition
- Prescribed top boundary

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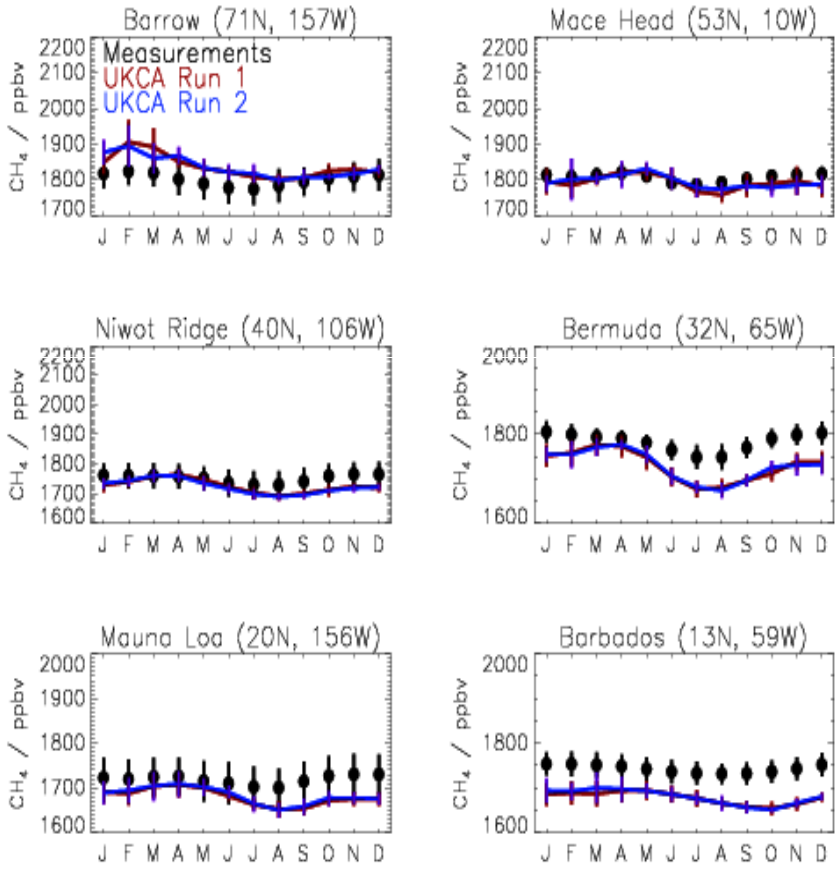
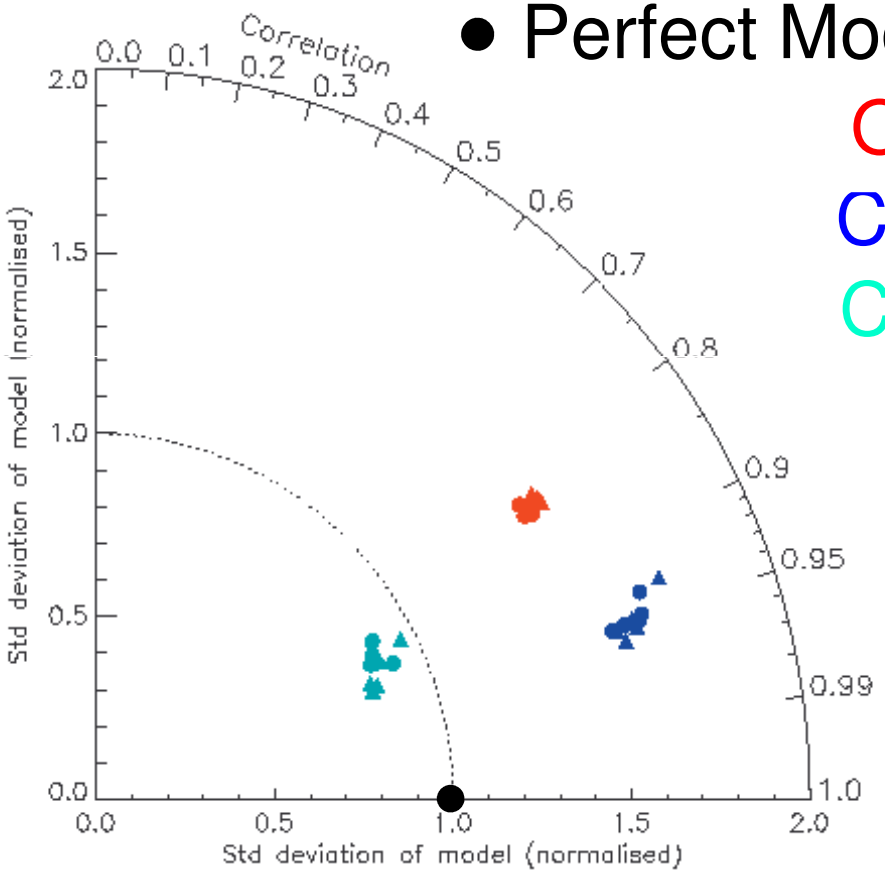
UKCA Evaluation – Surface





- Perfect Model

O_3

CH_4

CO

Various statistical measures of skill are also calculated (e.g. AAMB, RAMB, Model score, etc..)

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UKCA Evaluation – O_3 Profiles

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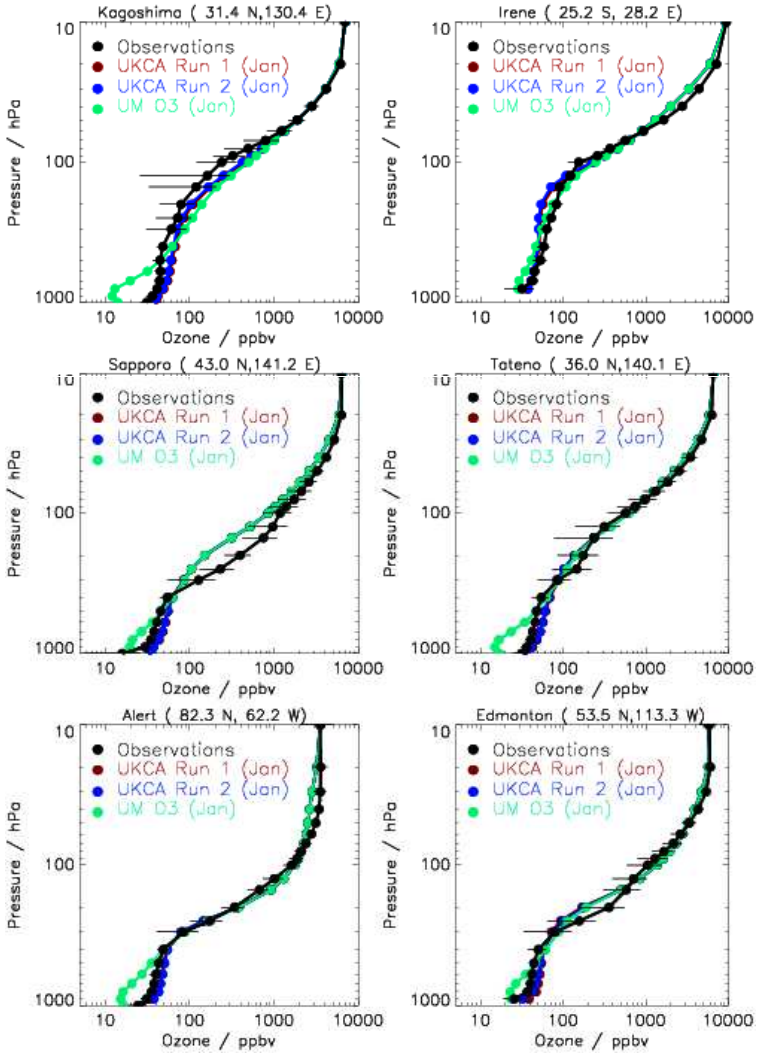

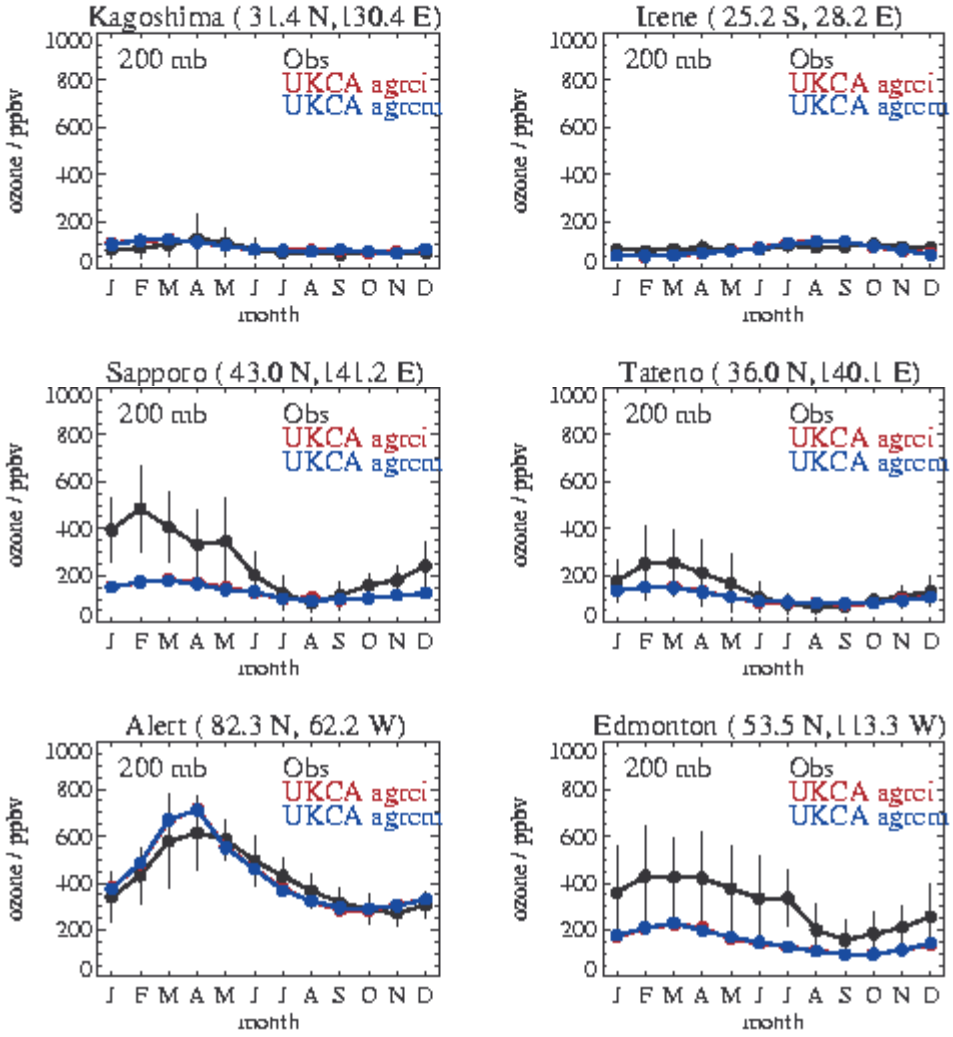

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Scientific Highlights

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PAN from Trop and ExtTC

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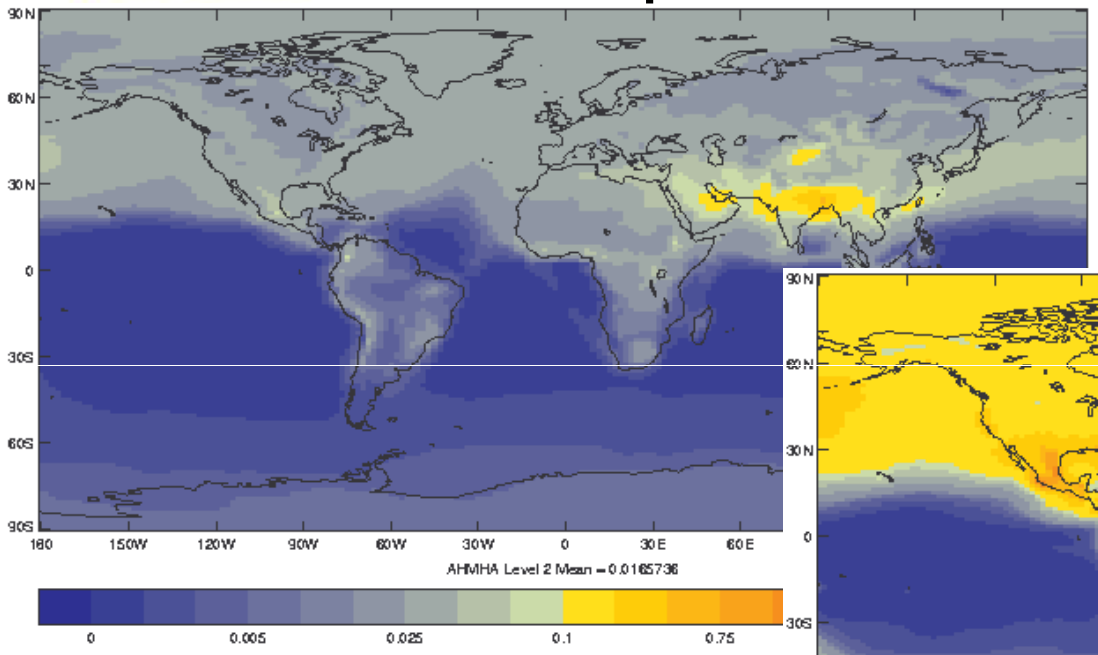
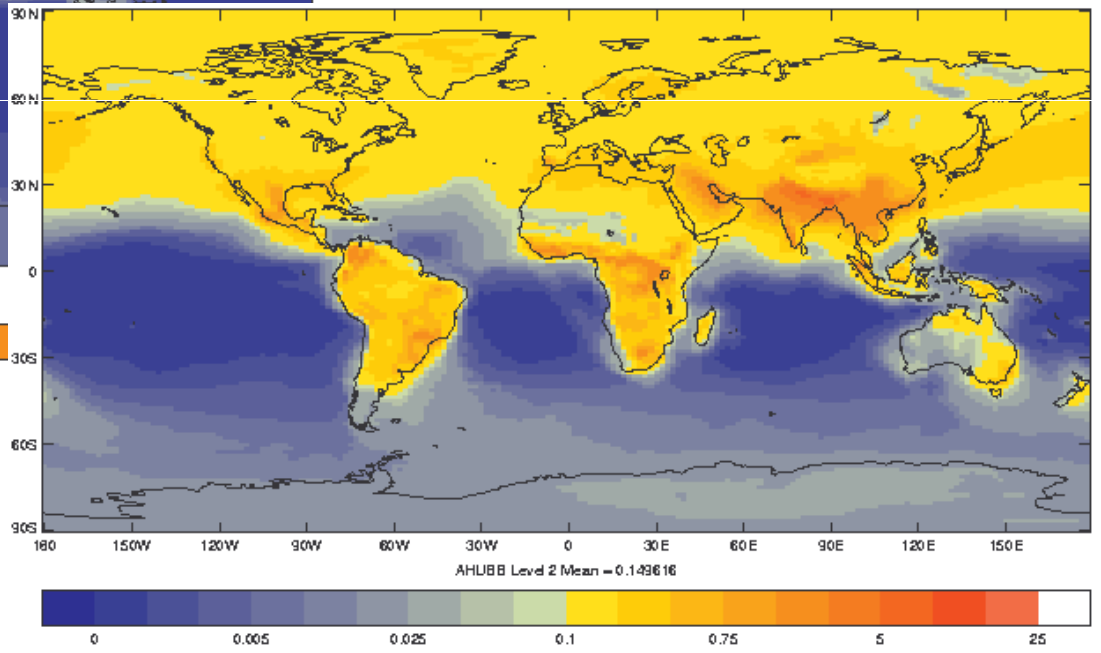
Trop



ExtTC



DJF

Gerd Folberth, Met Office Hadley Centre

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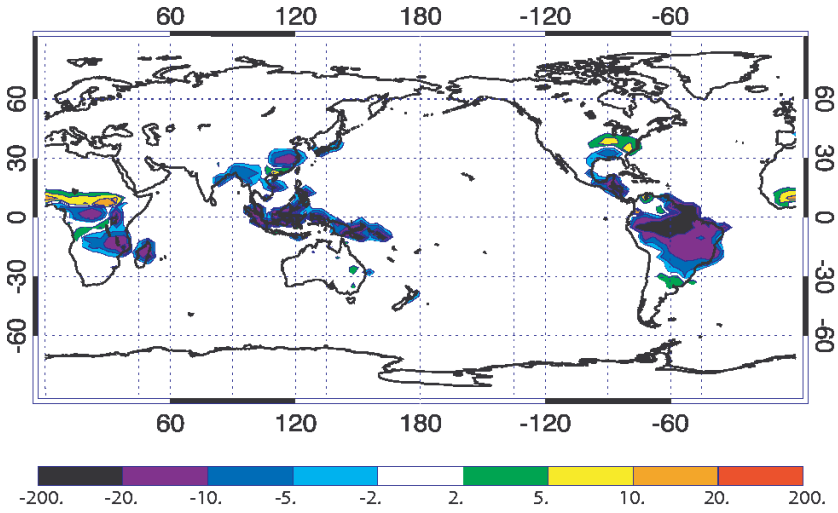
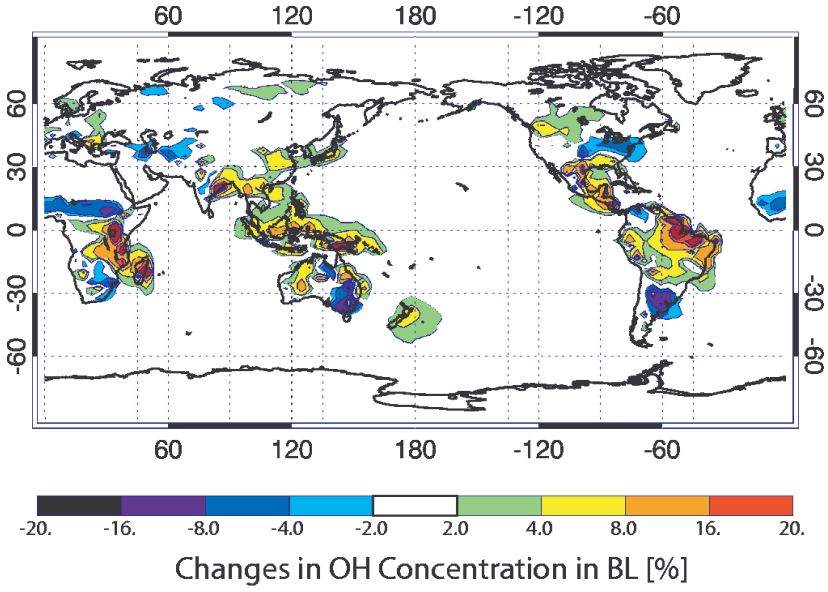
Pinatubo, ENSO & Isoprene Emissions

- Climate dependent C5H8 emissions in ’90s
- Effects of Pinatubo & ENSO
- Compare to background emissions
- Peak effect (1993) on both C5H8 & OH large





Paul Telford
Cambridge University

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Chemistry-aerosol coupling

Rae et al., JGR, 2007:

- Effect of oxidant and climate changes on sulphate
- 21st-century oxidant changes important for sulphate

Added coupling between HadGEM2 sulphate and UKCA

Tested by performing 3 model experiments:

- CTRL (original prescribed oxidants)
- UKCA_OL (on-line oxidants)
- UKCA_PR (prescribed oxidants from UKCA_OL)

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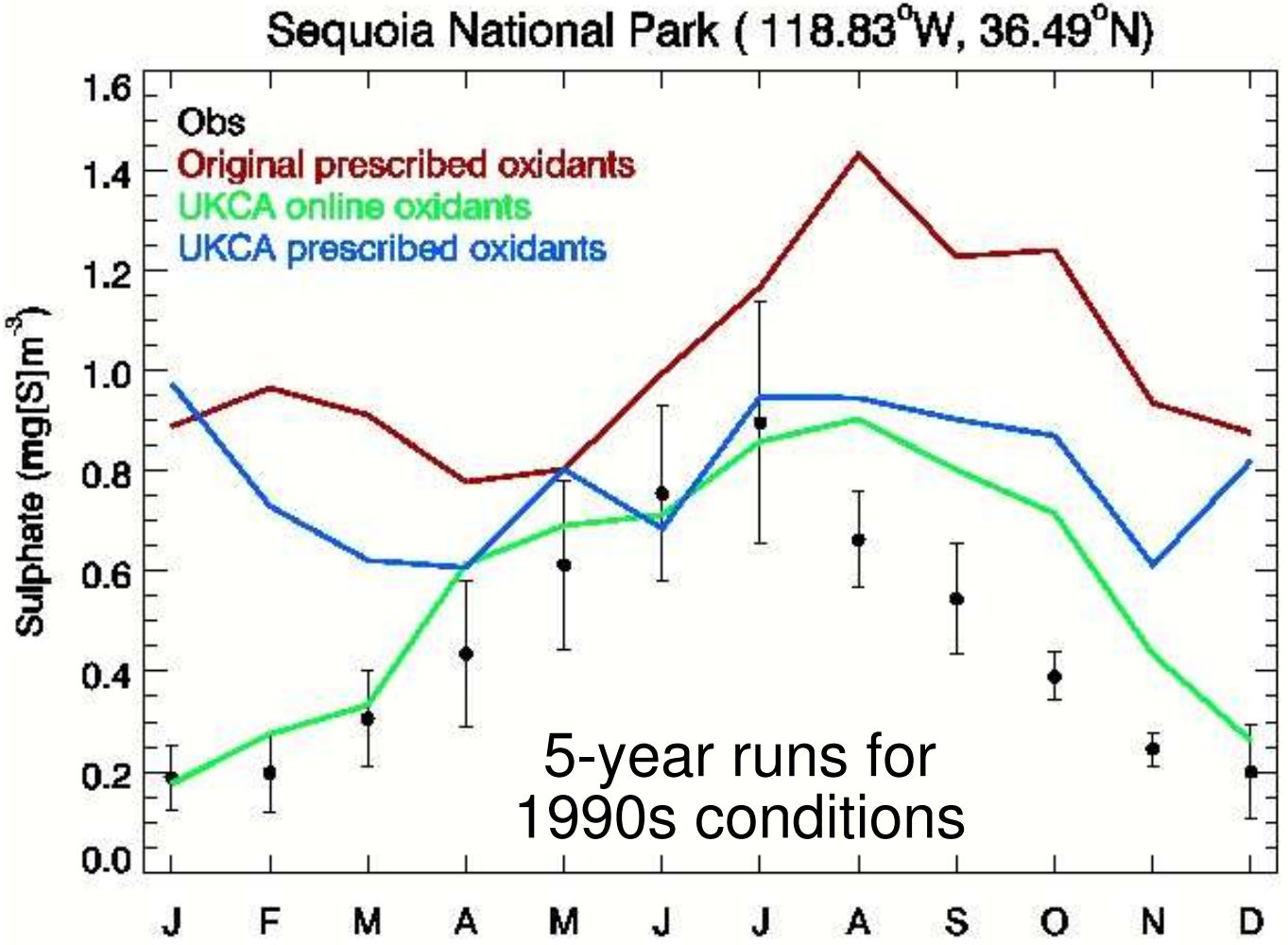
Comparison with Sulphate Obs



Jamie Rae, Met Office Hadley Centre

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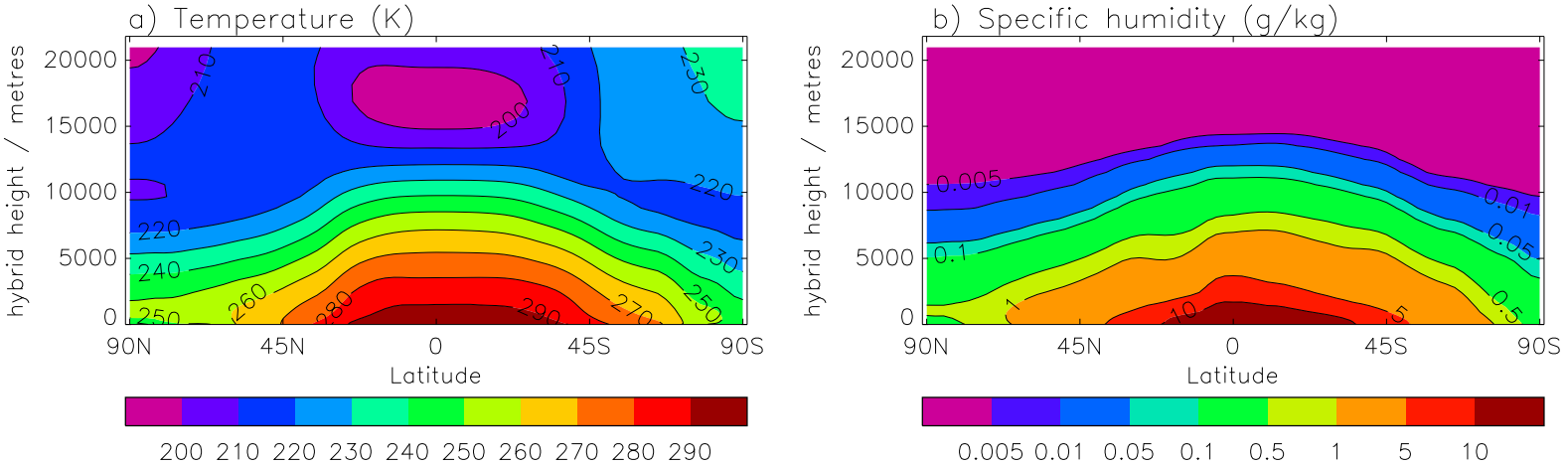
Climate Model Biases



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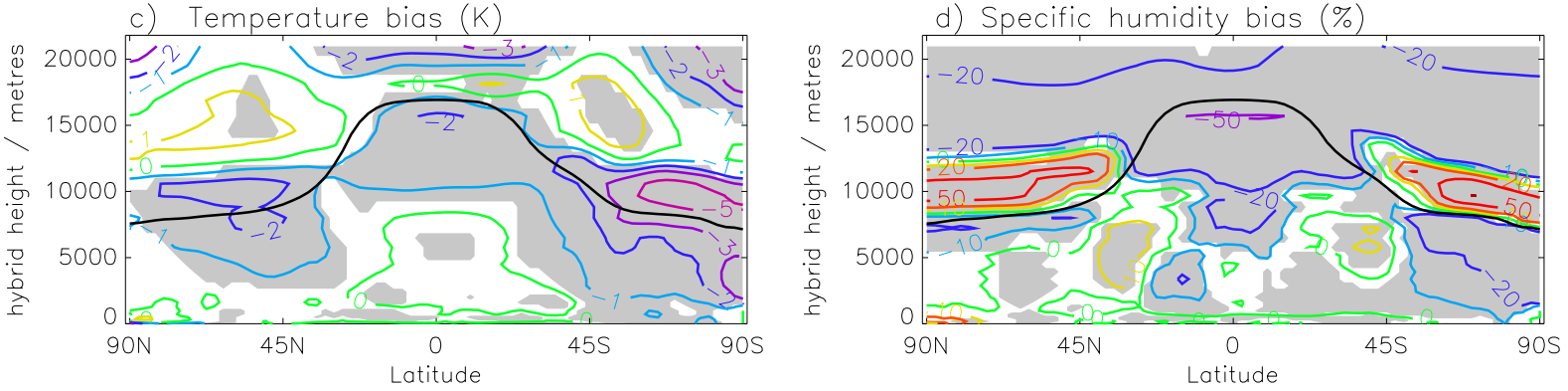

Fiona O'Connor, Met Office Hadley Centre

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Effect of Biases on O_3 & OH

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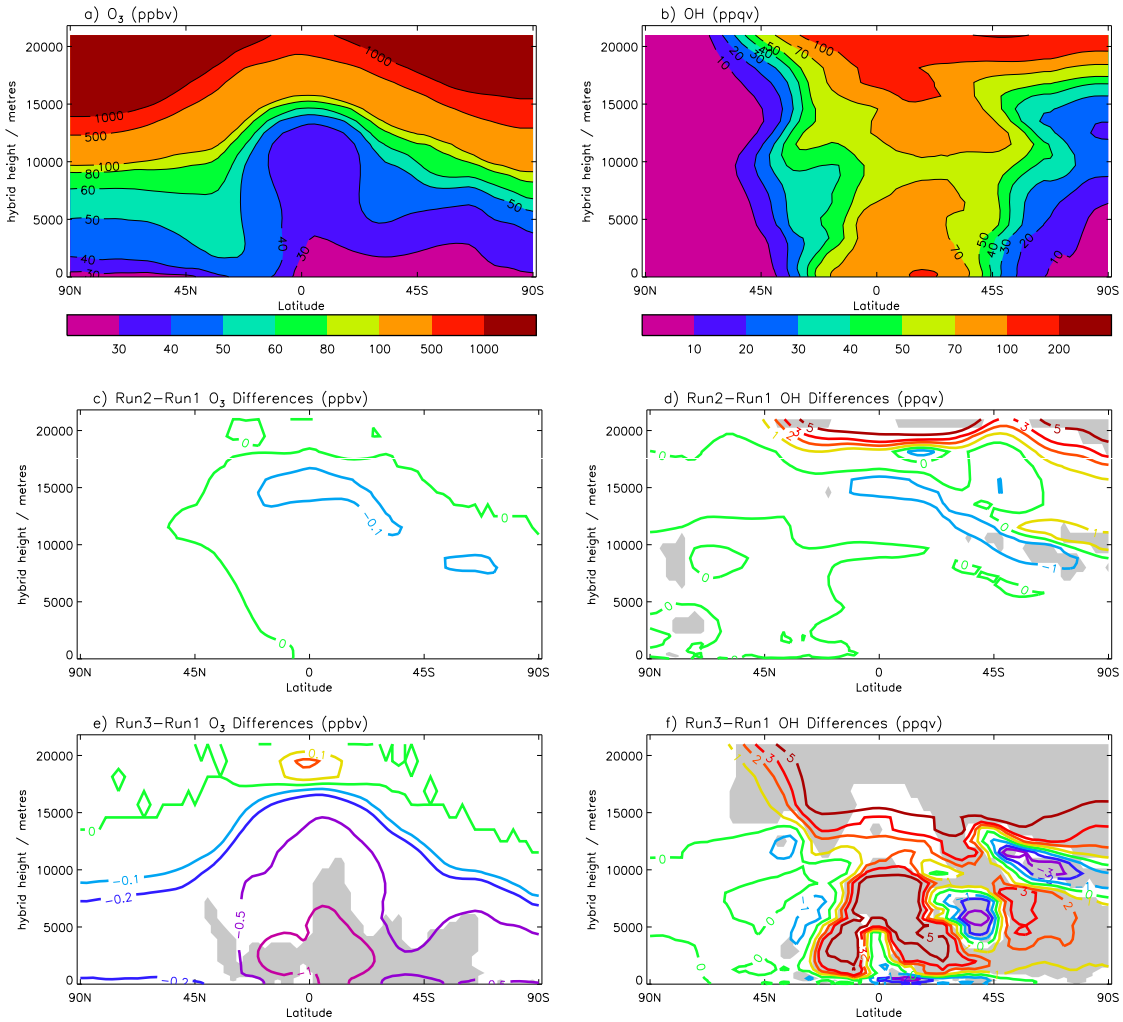

Impact of T bias

Impact of Q bias

GRL draft paper ready to be submitted

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C21st Integration with Tropospheric Chemistry

- N96L38 HadGEM2-AO using A1B emissions scenario
- Full suite of aerosol species and UKCA “Trop”

New couplings:

- UKCA oxidants and sulphate
- UKCA and land surface (dry deposition)
- Interactive CH_4 wetland emissions
- O_3 and CH_4 Radiative Feedback

Integration has completed 85 years

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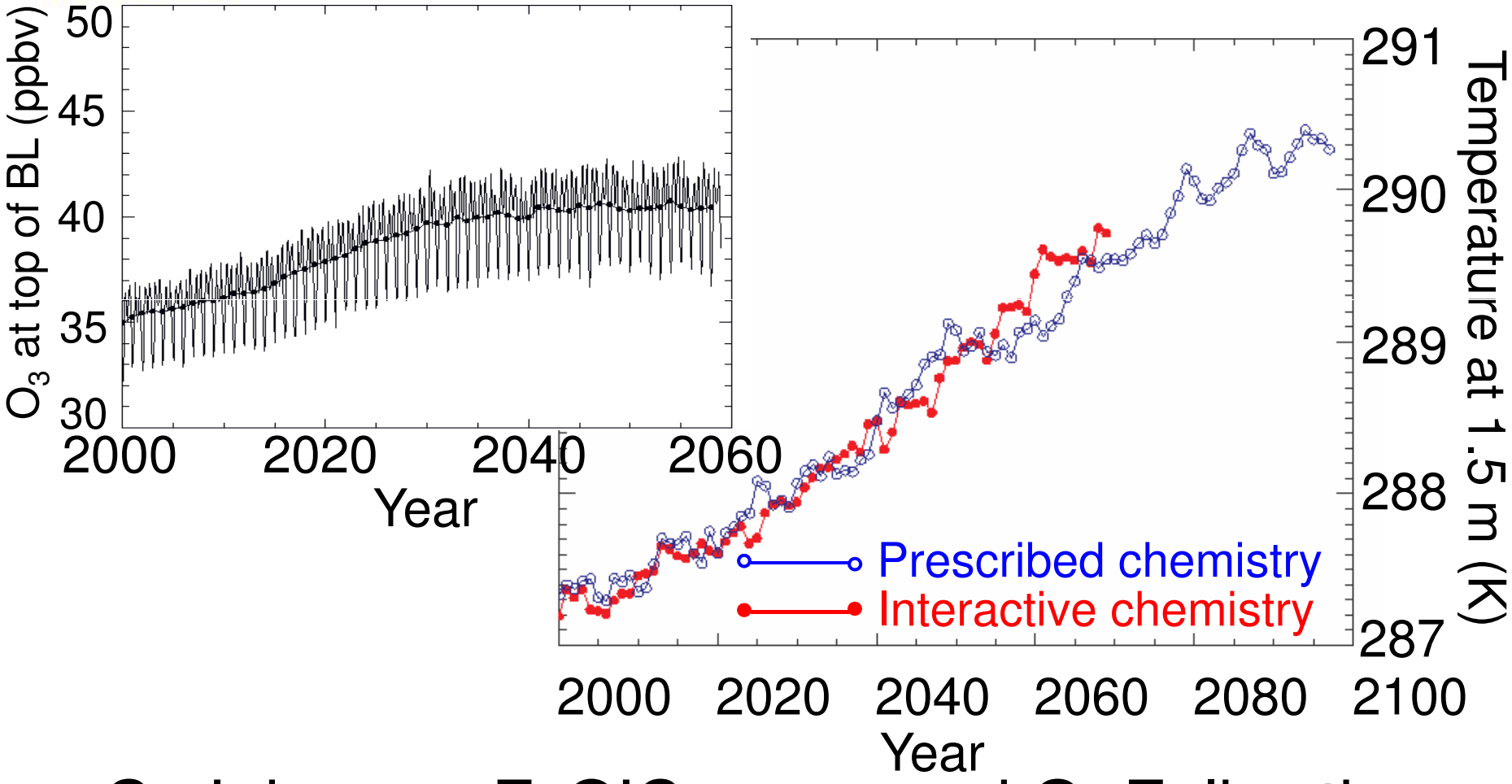
C21st Integration: First Look



C. Johnson, F. O'Connor, and G. Folberth

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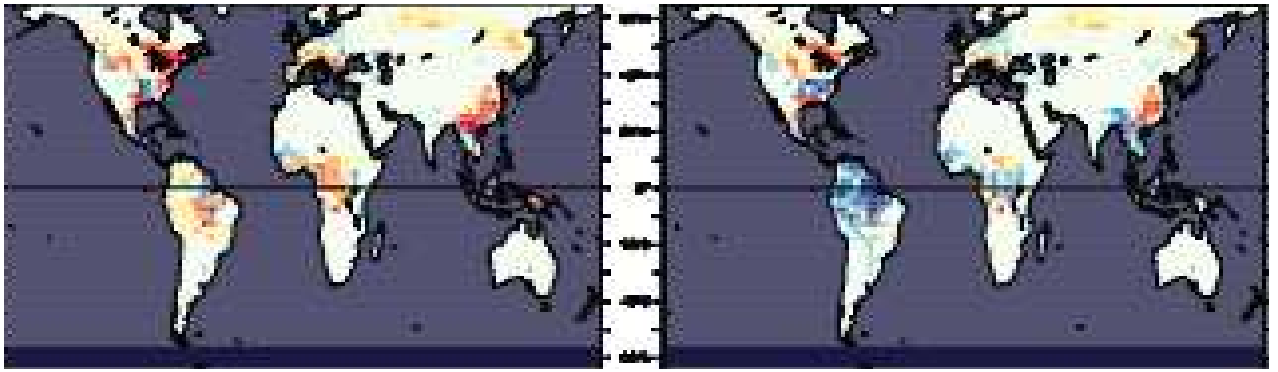
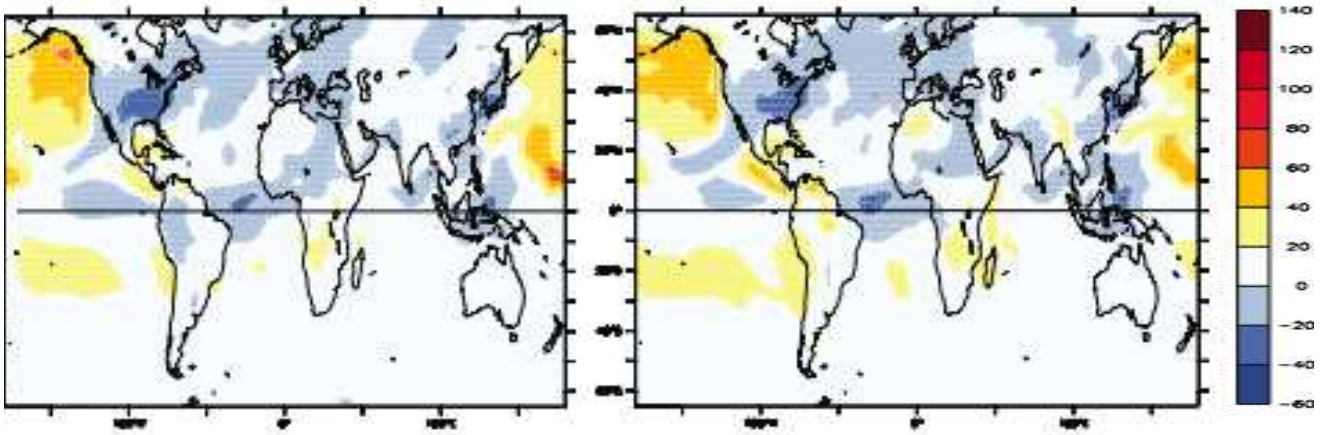
Future Land Use: Impact on C_5H_8 Emissions and O_3

Ems

JUL



O_3



Rachel Pike
Cambridge University

Letter to Nature
In Preparation

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Conclusions

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Main conclusions

- Tropospheric chemistry model fit for purpose
- Good comparisons with observations and other models
- Supports a variety of chemistry schemes
- Further development ongoing
- Will be included in QESM and HadGEM2-ES
- Various scientific work underway

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Papers

- Collins et al., Evaluation of the HadGEM2 model, *Hadley Centre Tech. Note 74*, 2009.
- O'Connor et al., Sensitivity of a tropospheric chemistry scheme to climate model temperature and humidity biases, *Geophys. Res. Lett.*, To be submitted.
- O'Connor et al., Evaluation of the new UKCA climate-composition model. Part 2: The Troposphere, *Geosci. Model Develop.*, In preparation.
- Pike et al., Future Land Use Change: Impacts on Isoprene and Ozone, *Nature*, In preparation.
- Telford et al., Effects of Climate Induced Changes in Isoprene Emissions After the Eruption of Pinatubo, In preparation.

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Future Work

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- Further evaluation incl. satellite data
- Interactive biogenic emissions
- Improve coupling: chemistry and aerosol aerosols and photolysis
- AR5 simulations (coupled vs uncoupled)
- CH_4 – wetlands, hydrates, mitigation
- Climate change and air quality

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Additional Slides

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The need for chemistry-aerosol coupling

- Current model:
  - §Monthly-mean prescribed oxidant concentrations.
  - §Seasonal variation but no annual variation.

    → No variation with emissions and climate.
- Rae et al. (2007, JGR):
  - Effect of oxidant and climate changes on sulphate.
  - 21st-century oxidant changes important for sulphate.

→ Accurate 21st-century sulphate prediction therefore requires fully-coupled runs.

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Implementation of chemistry-aerosol coupling

- Coupling with UKCA introduced
  - Currently one-way: no feedback to UKCA
  - Two-way coupling is being introduced.
- Tested by performing 3 model experiments:
  - CTRL (original prescribed oxidants)
  - UKCA_OL (on-line oxidants)
  - UKCA_PR (prescribed oxidants from UKCA_OL)
- 5-year runs for 1990s conditions.

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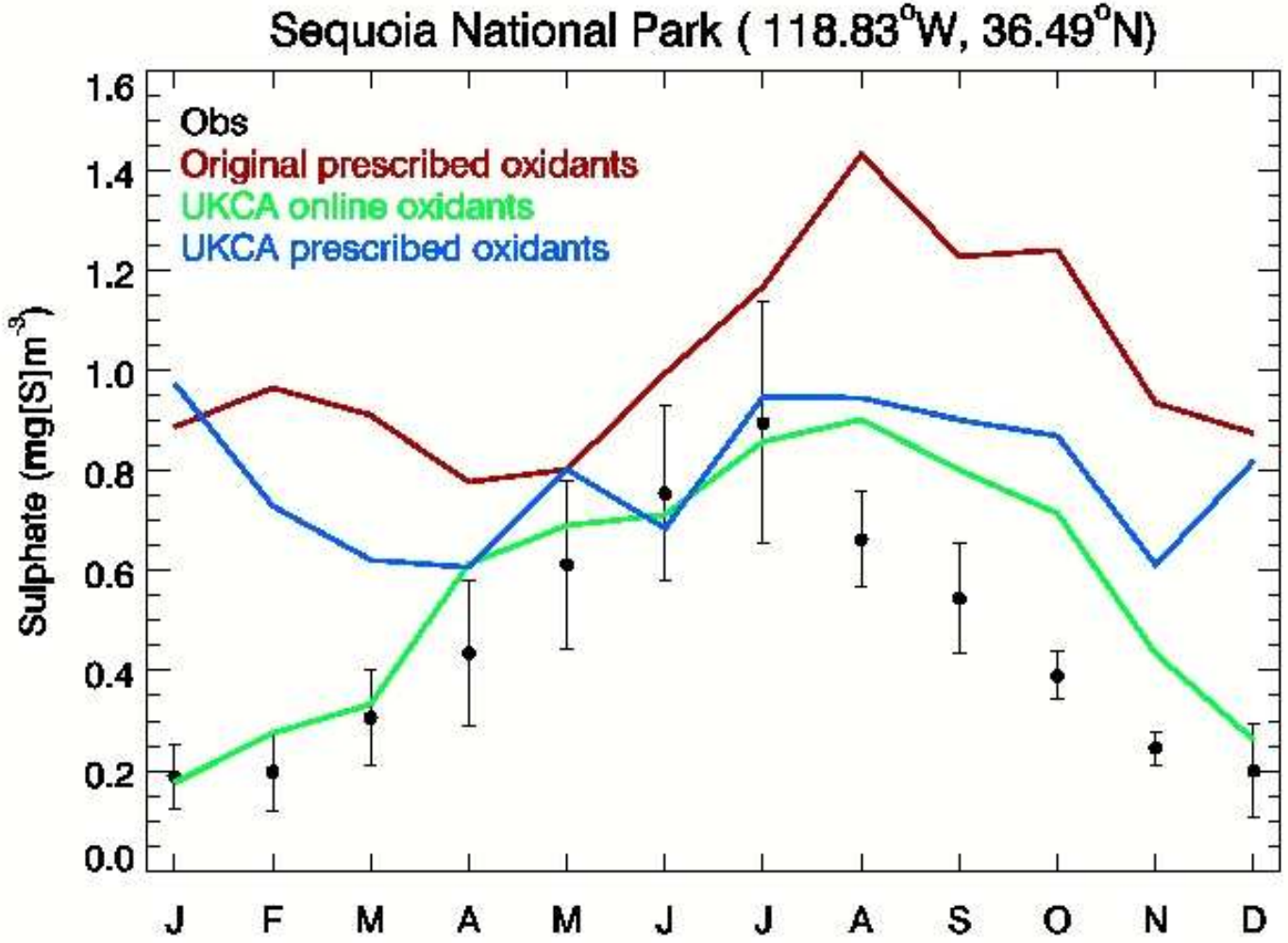
Sulphate concentration: annual cycle



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