School of Earth and Environment
INSTITUTE FOR CLIMATE AND ATMOSPHERIC SCIENCE

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The UK Chemistry and Aerosol Project (UKCA)

Ken Carslaw

www.ukca.ac.uk
http://researchpages.net/glomap

UKCA

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NCAS–Met Office programme to develop a coupled aerosol-chemistry-climate model based on the UM

Streamlines the aerosol and chemistry code in the UM to create a single “UKCA sub-model”

Project partners are the Hadley Centre and the Universities of Cambridge, Leeds (with Oxford and Reading)

Running since 2004 with 1 PDRA in Leeds and Cambridge

The need for UKCA aerosol

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Dynamic aerosol size distribution (ptcl size distribution)

Internal mixing of particles

Missing components (NH_4, NO_3, SOA, etc)

Coupled aerosol-chemistry

UKCA collaboration

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Leeds: aerosol dynamics, composition, evaluation

Inorganic mixed aerosol composition was supported by Manchester's DIAC work

Secondary organic aerosol development as part of the QUEST-QUAAC project

Met Office: Tropospheric chemistry, cloud chemistry, radiation coupling, UM sub-model coding

Cambridge: Trop and strat chemistry, nudging

UKCA aerosol strategy

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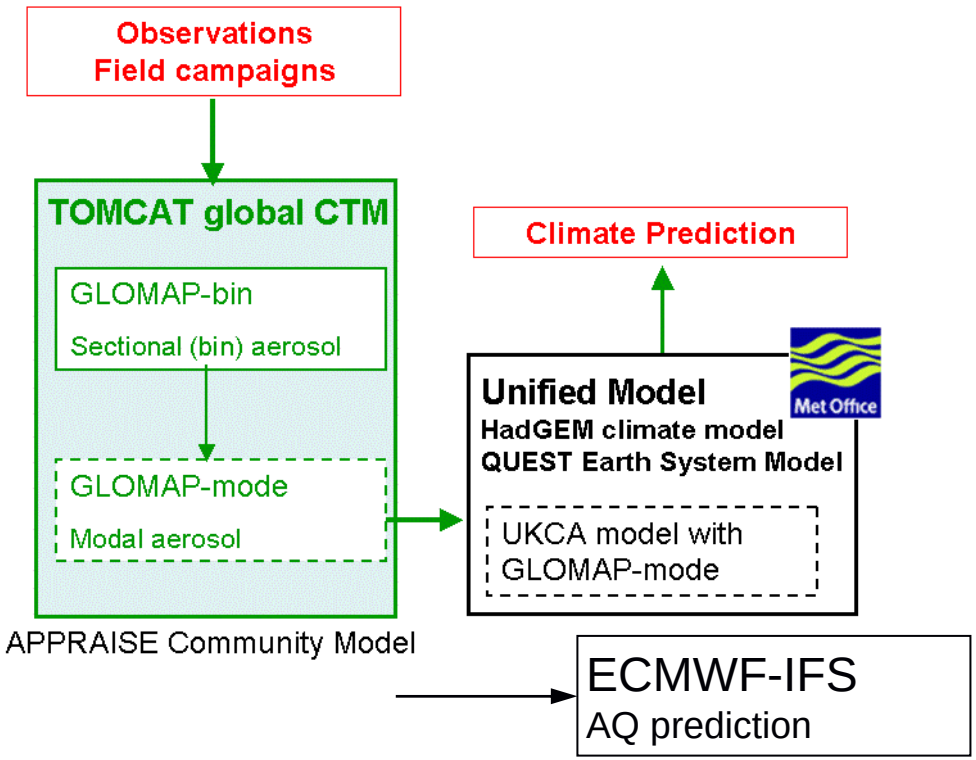
GLOMAP-mode: a fast size-resolved model using size modes. Developed in UKCA. Now incorporated in UM6.6

GLOMAP-bin: a bin-resolved model for detailed studies of global aerosol

Both models run side by side in the TOMCAT CTM



Our aim is to make a strong connection between the future development of the UM (UKCA) aerosol scheme and new observations and process knowledge

Comparison of GLOMAP bin and mode (in TOMCAT)

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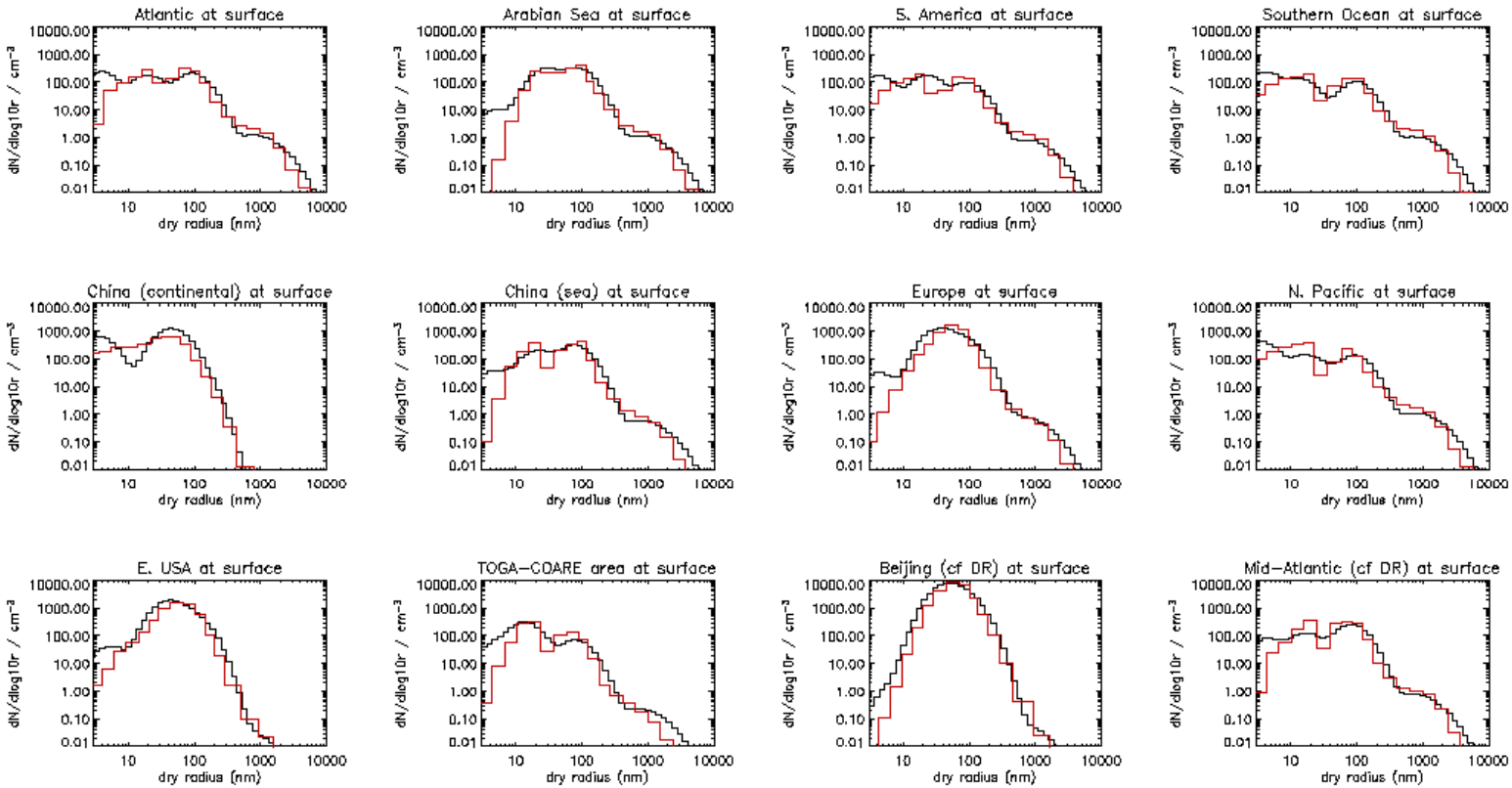
So far, inter-model differences are smaller than model-observation differences



Model applications and results

…and examples of KT

DMS-CCN link

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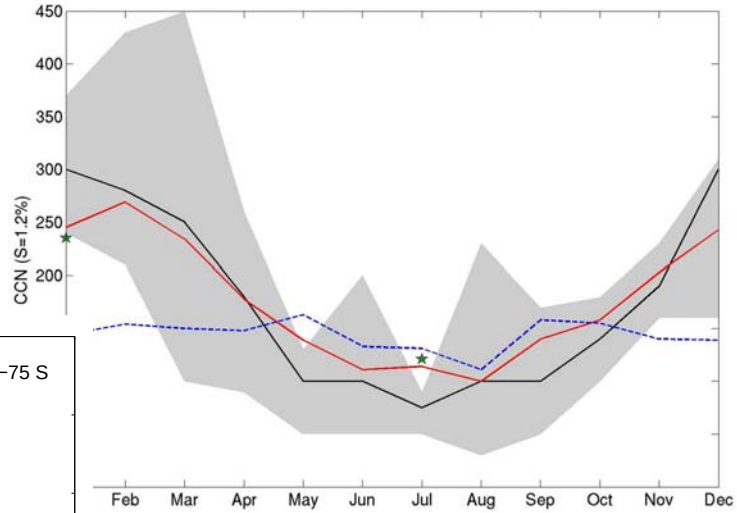
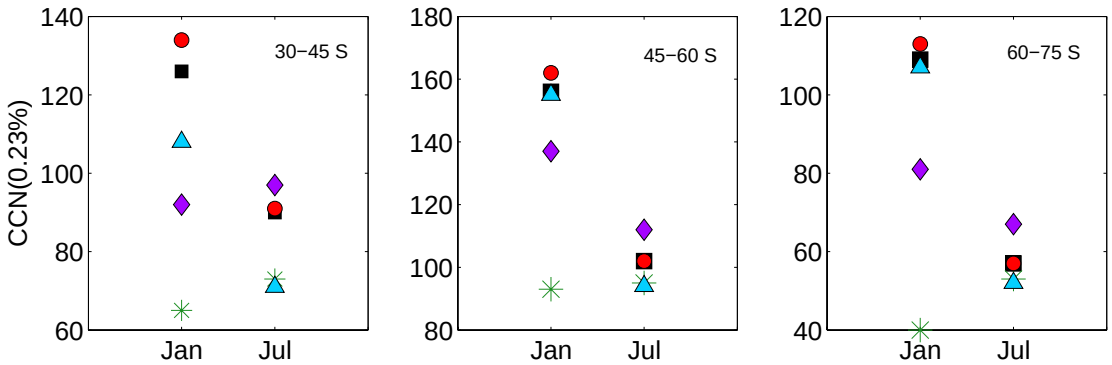
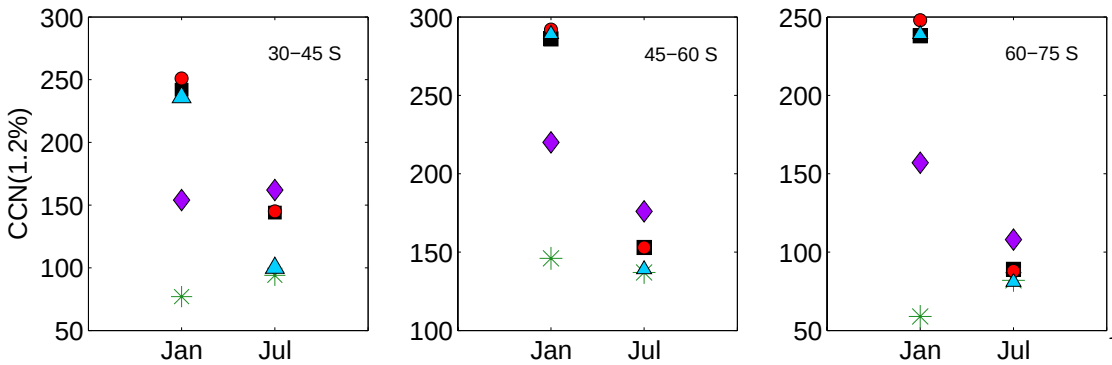
Sensitivity of MBL CCN to DMS is less than derived from satellite observations







Changes in CCN in several control experiments

SOLAS → CASE project

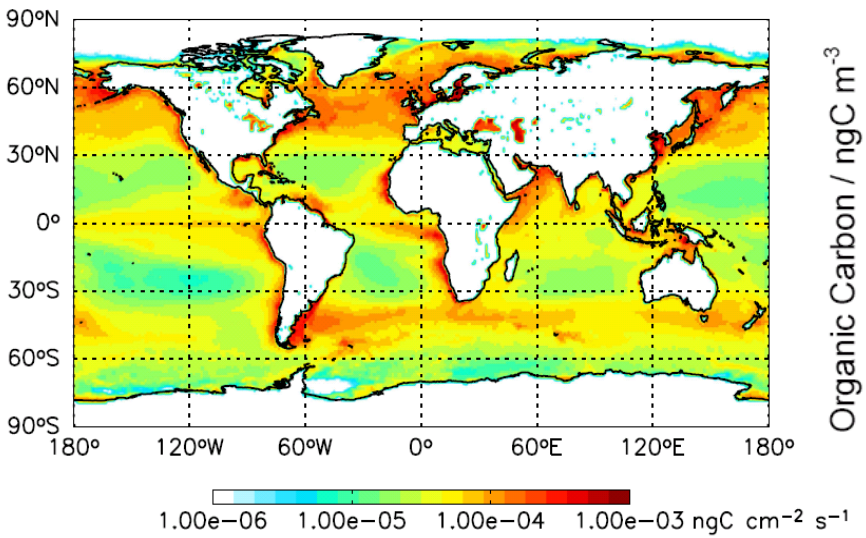
Korhonen et al., JGR, in review 2008

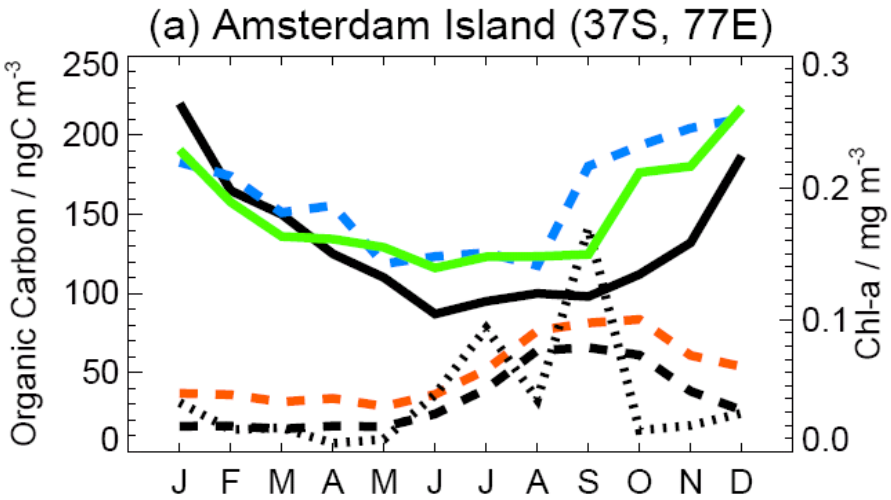
Marine OC source

Estimate of global marine OC using global models, satellite data, back trajectories

7Tg/a comparable to anthropogenic OC

Annual Mean OC emission (2001-2005)





Spracklen, Arnold et al., GRL 2008

Arctic aerosol

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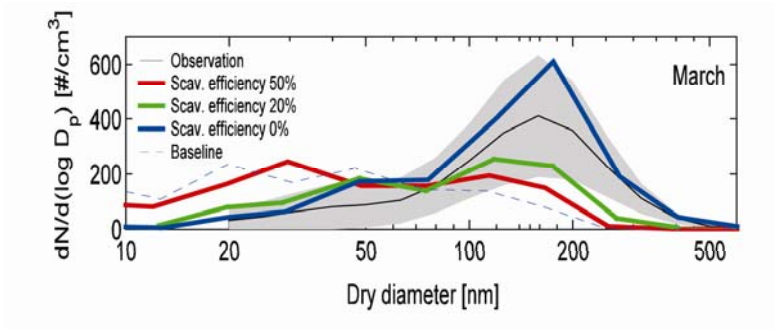
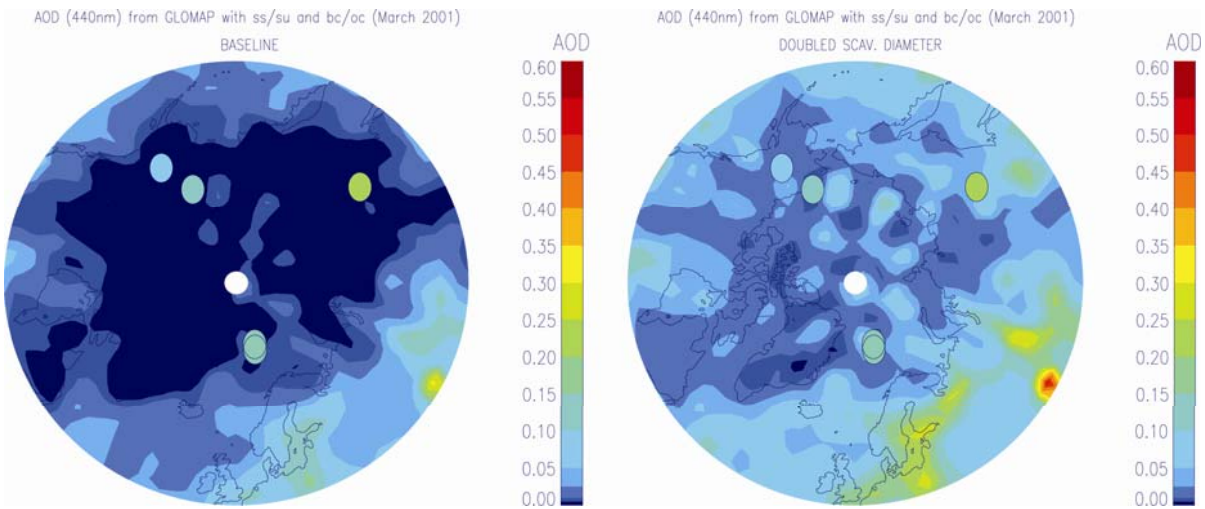
Factors controlling seasonal changes in size distribution

SOLAS → Met Office CASE studentship 2009-11





Korhonen et al., JGR 2008

Global CCN

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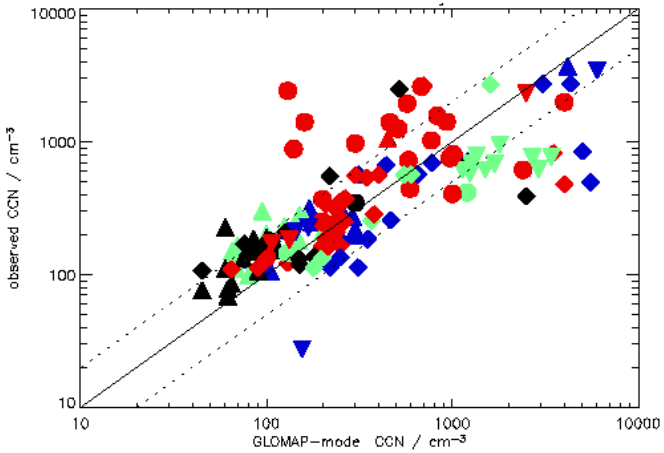
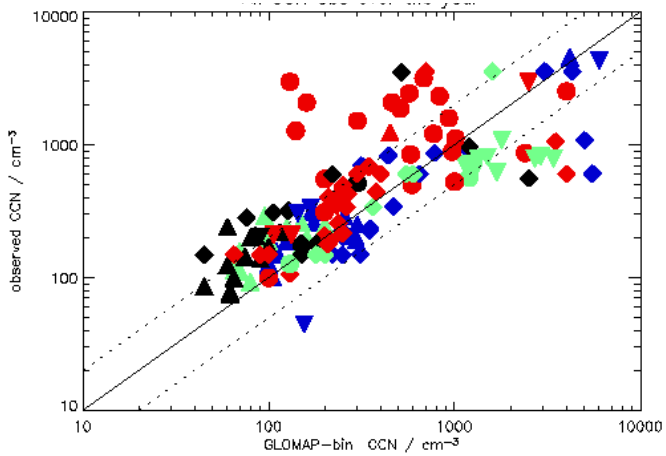
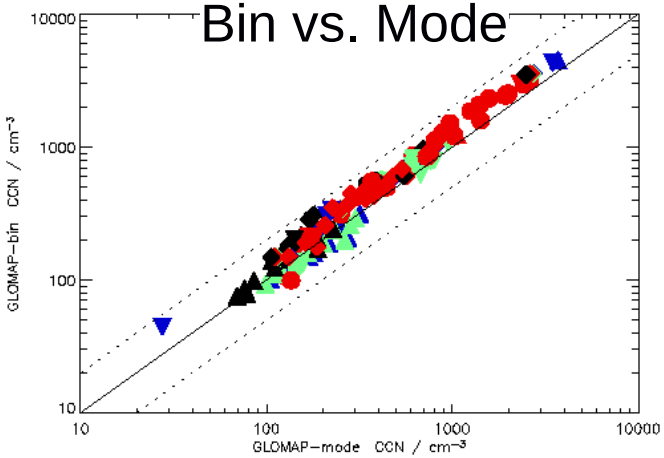
Mode vs. observation

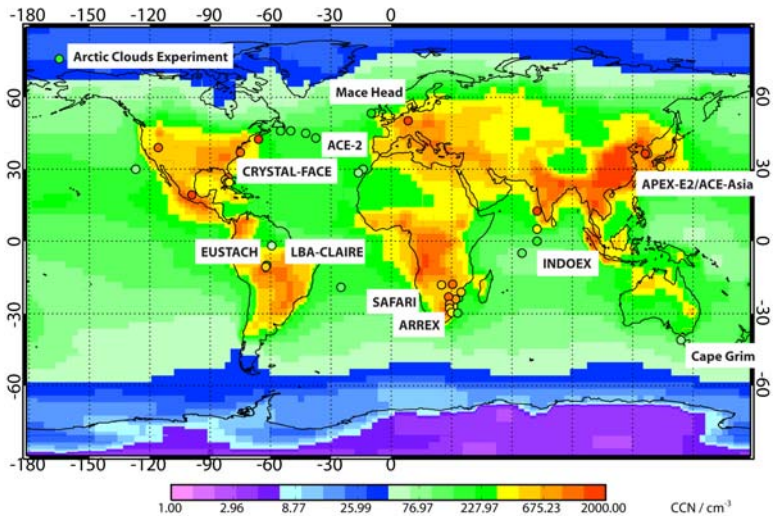


bin vs. observation

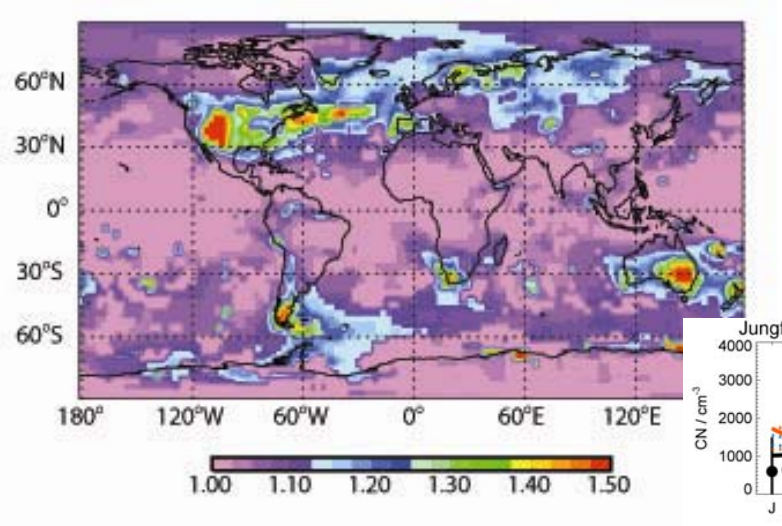


Bin vs. Mode





Nucleation and CCN

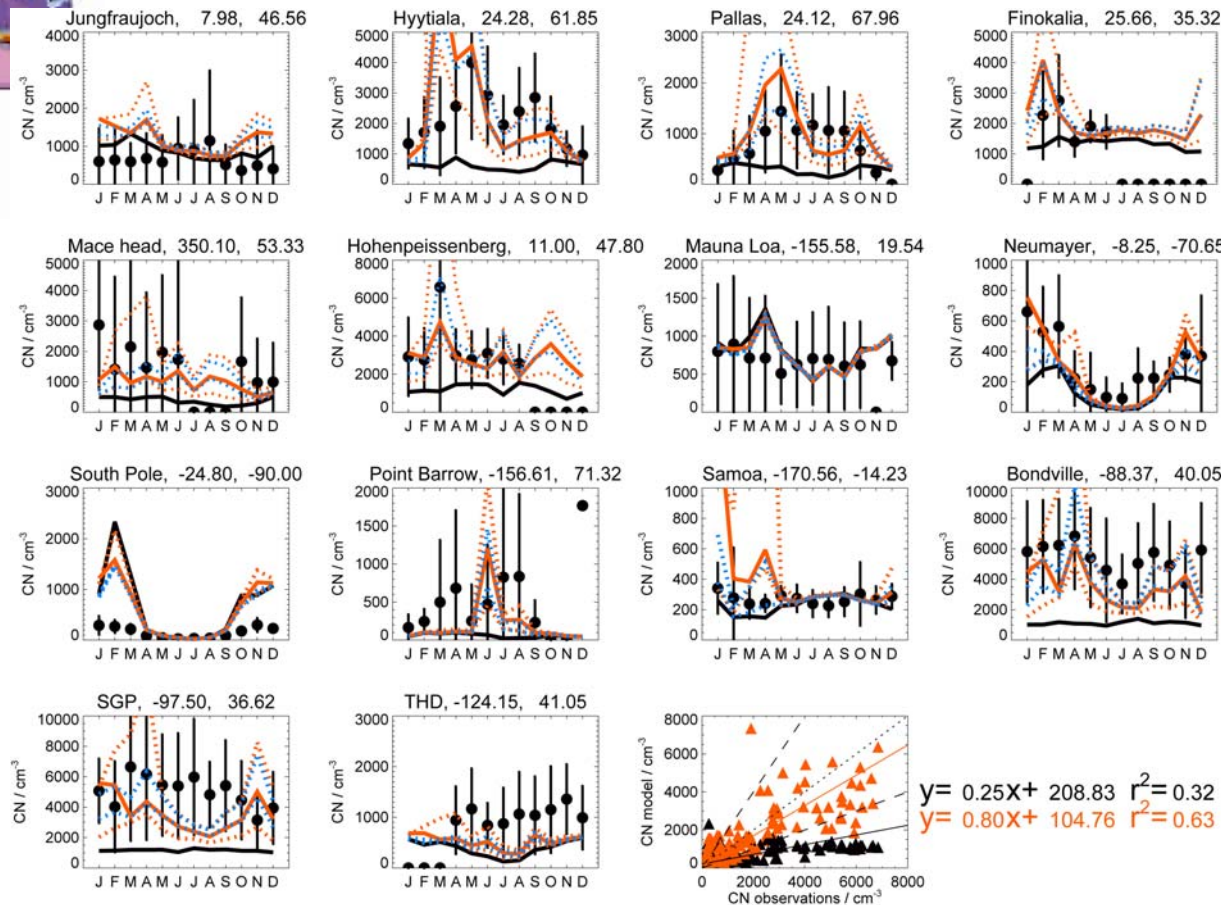


Global enhancement of CCN of 5-30%

Being implemented in UKCA

Spracklen et al., GRL 2008
Spracklen et al., in prep 2008

EUCAARI → UM



Regional forcing potential of SO_2 emissions

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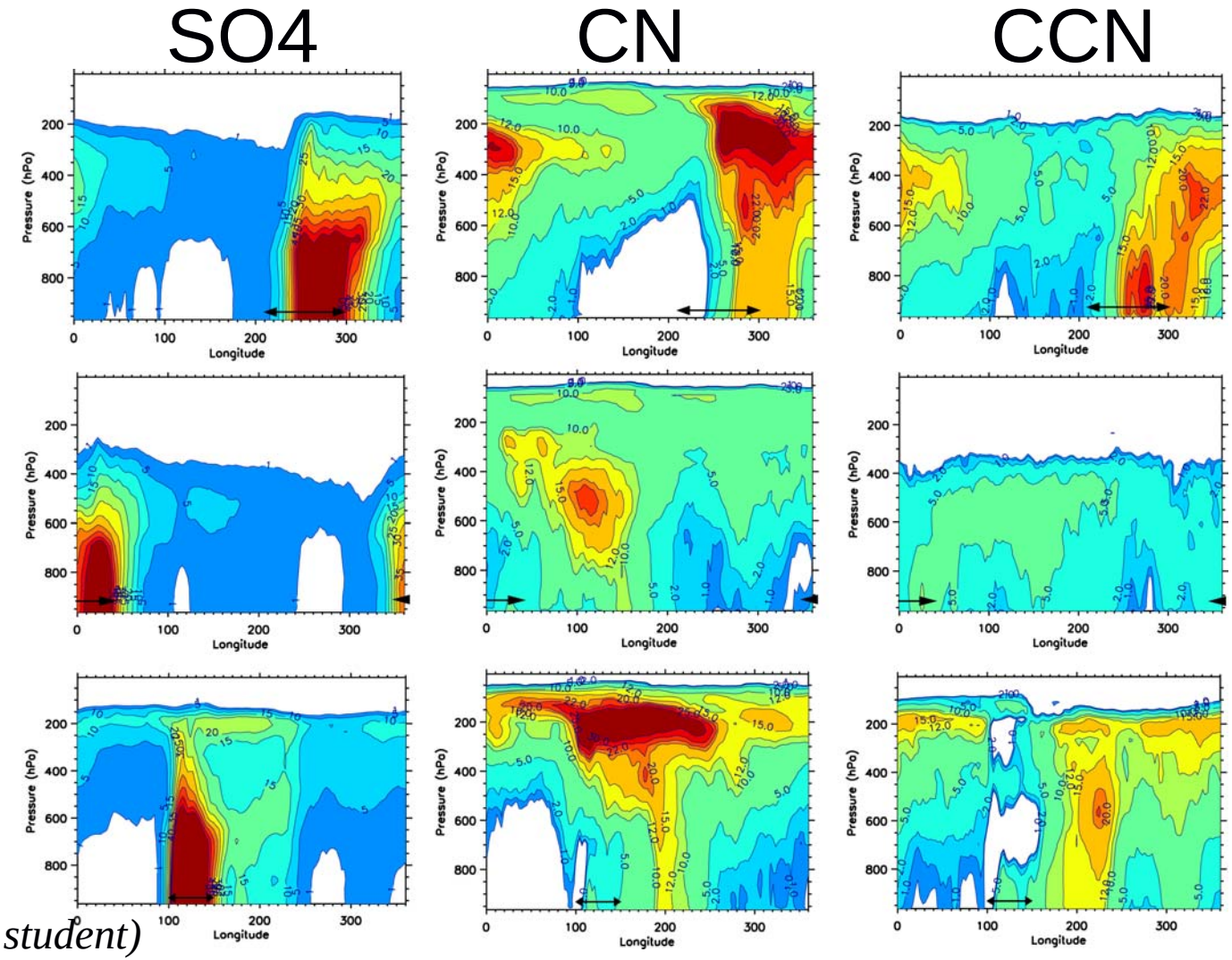
Regional formation efficiency of CCN very different to SO4 mass



Manktelow 2008 (NCAS student)

Cloud drop number

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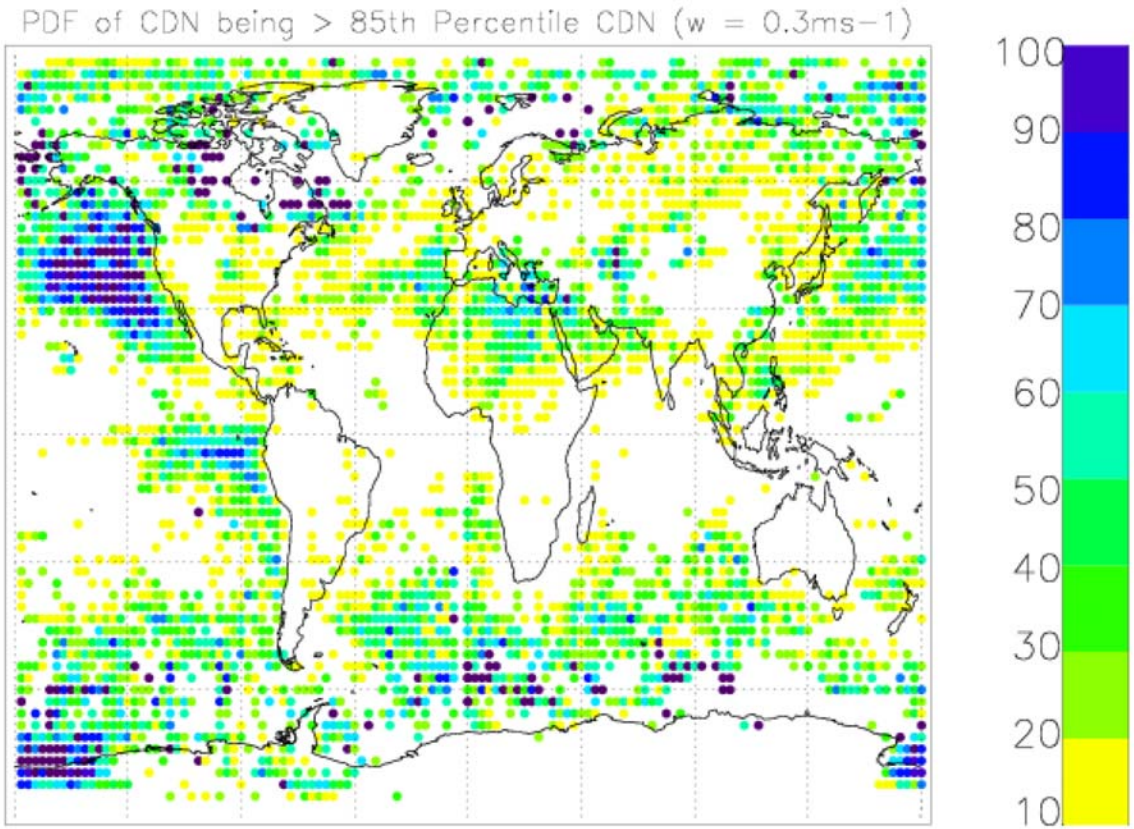
Prediction based on size distribution and mechanistic cloud updraught scheme



Deviation from global CDN-aerosol relation

Stier (Oxford) will carry this work on in CASE studentship

Pringle, 2006

Biome changes and aerosol

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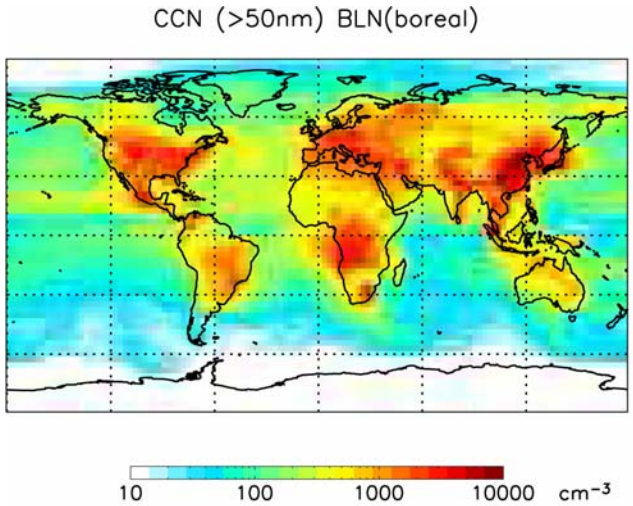

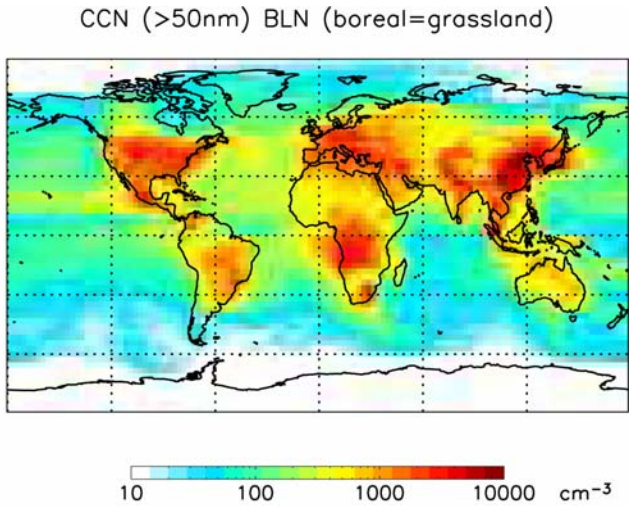

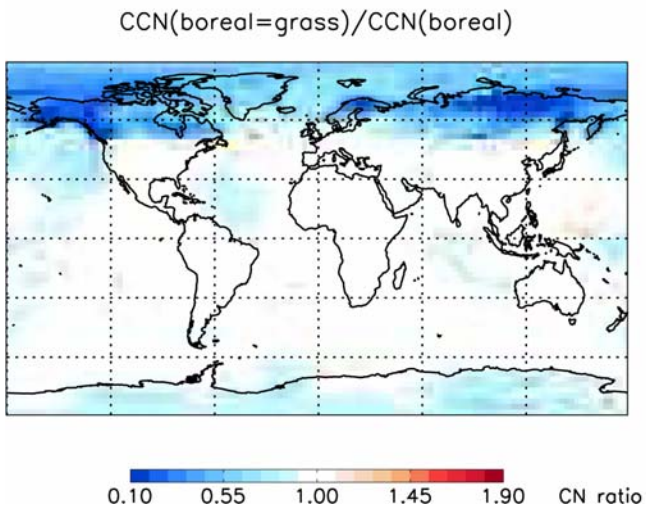

Boreal CCN falls by 50-90% if trees are replaced with grassland

Future use of BIOME4 output → QUEST ESM

Courtesy Dominick Spracklen

Aerosol and ancient climate

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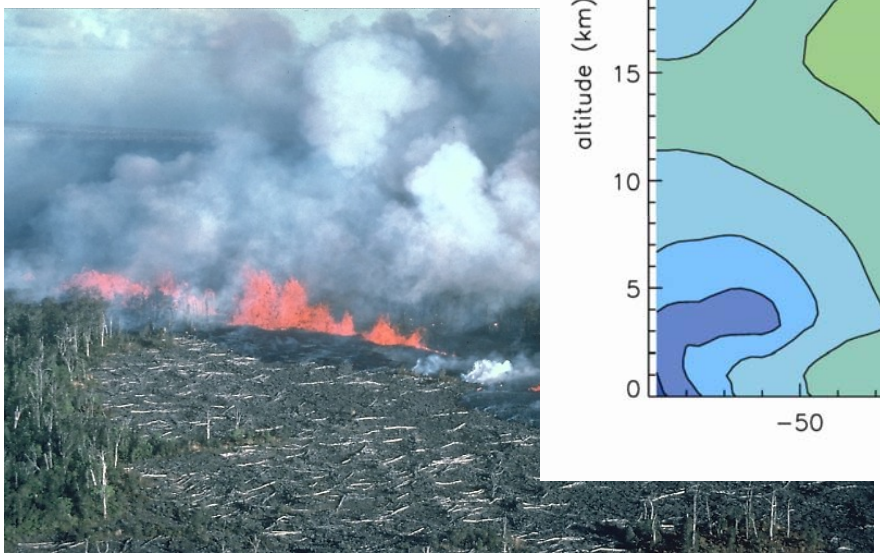
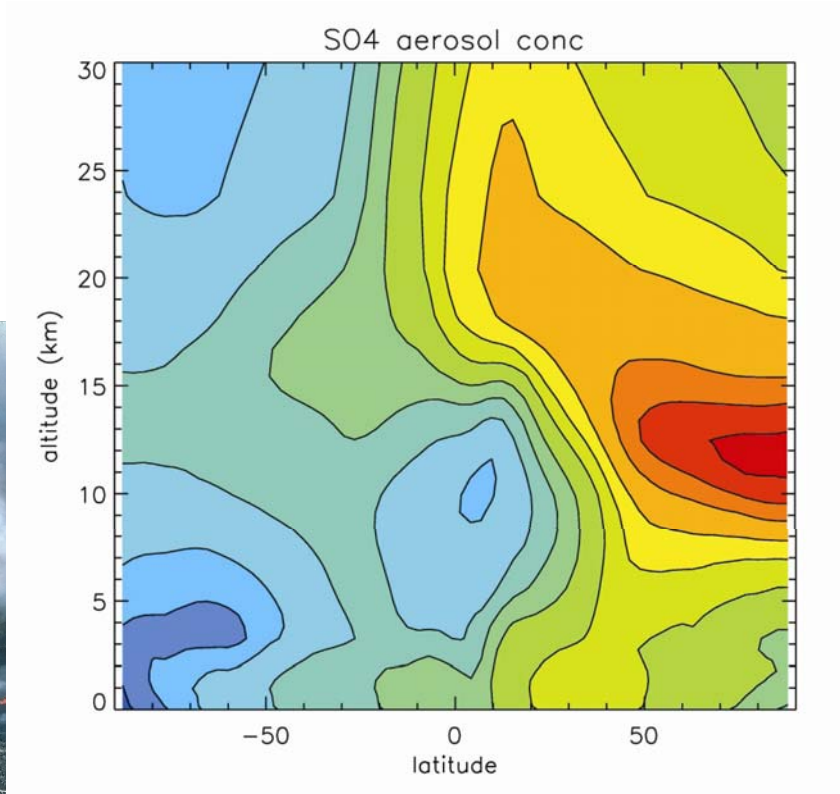
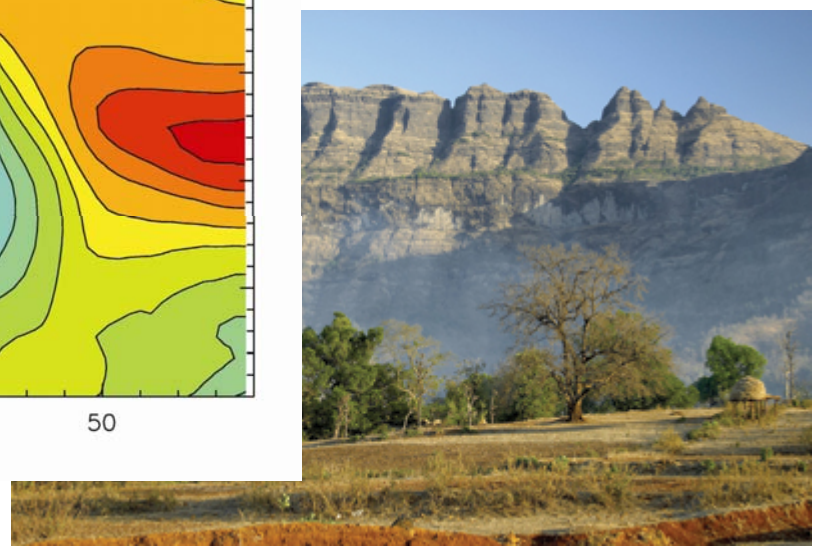
SO_2 emissions from Continental Flood Basalts 65My ago

Plan to use UKCA in QUEST-ESM







Courtesy Anja Schmidt, PhD Leeds

UM status

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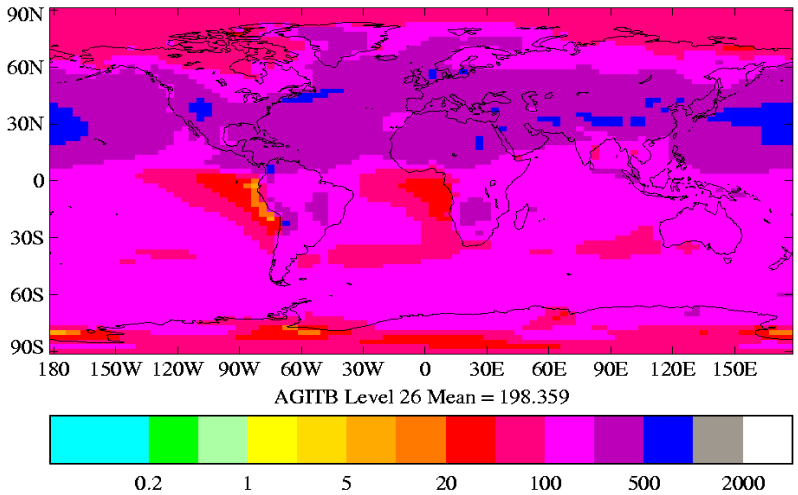
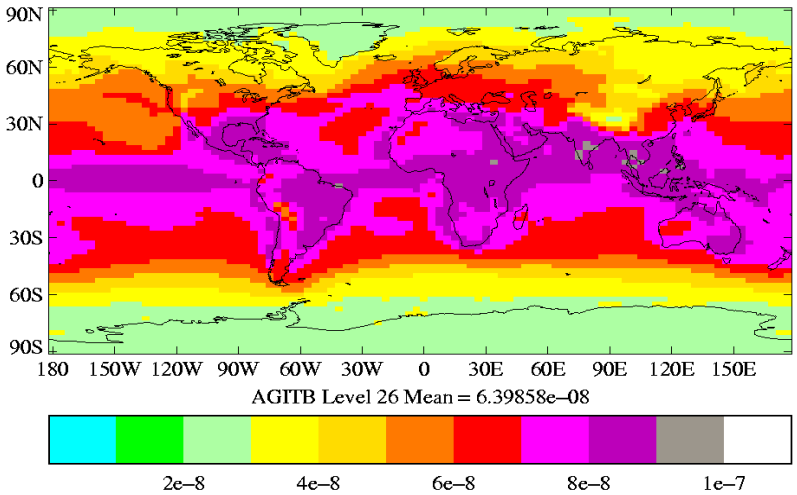
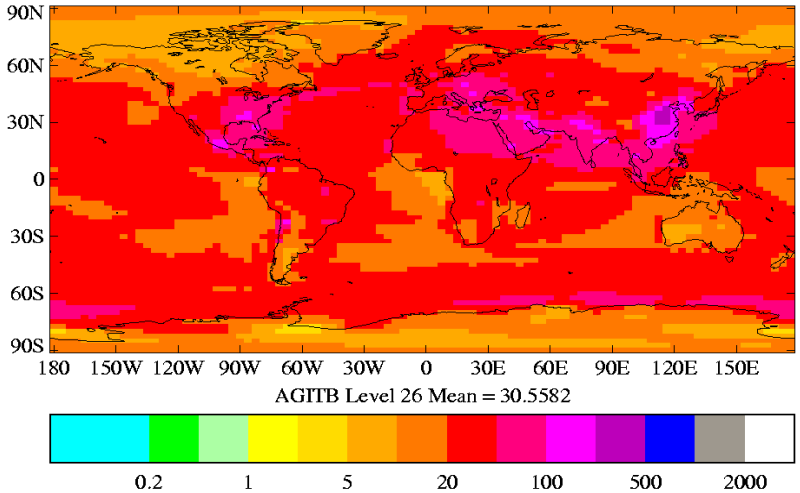
Aitken mode number conc. (cm^{-3})



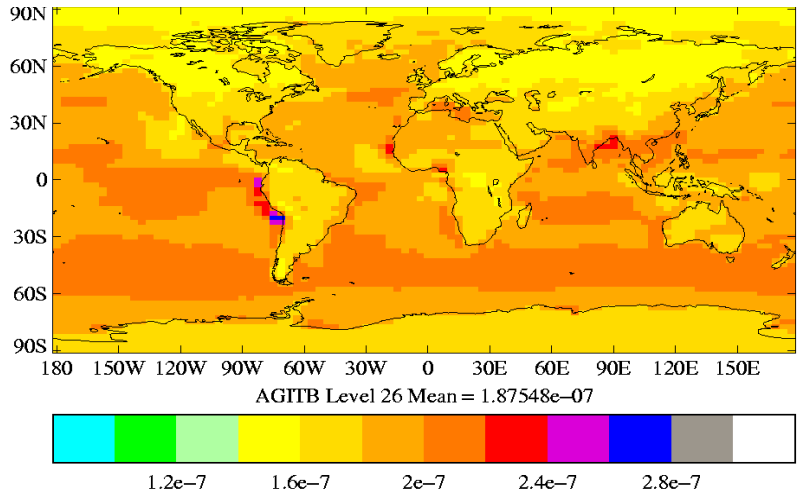
Aitken mode g. mean diameter (m)



accum. mode number conc. (cm^{-3})



accum. mode g. mean diameter (m)



UKCA aerosol collaborations and projects

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•The European Integrated Project (EUCAARI) using UKCA/UM as part of the Earth System modeling work package; GLOMAP-bin/mode for campaign analysis

• Edinburgh (Palmer): organic aerosol in APPRAISE-ACES

• Marine aerosol is being investigated as part of a SOLAS project, a SOLAS tied studentship (halogen/sulphur cycle).

• Stratospheric aerosol and geoengineering in a NERC Cambridge/Leeds collaboration

• EU Marie Curie on ion-induced nucleation and cosmic rays

• Met Office CASE projects: Heterogeneous chemistry (M. Evans); Dust and DMS in the Earth System (G. Mann); Arctic aerosol/climate (K. Carslaw); Ozone indirect effects (S. Arnold); Cloud drop number and indirect effect (P. Stier, Oxford)

• UKCA is the basis for QUEST ESM

• Will be implemented in the ECMWF-IFS in the EU MACC project

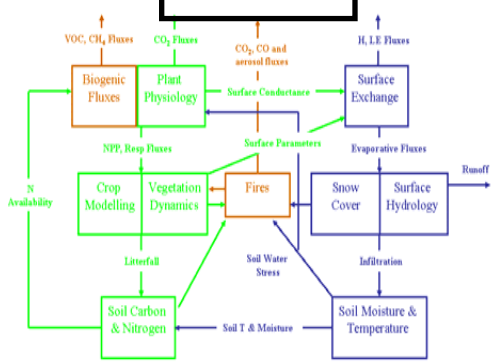
UKCA in the Met Office

UM

UKCA Troposphere & Stratosphere & Aerosols MODE

Biogenic emissions

JULES



Land surface

MACC project

AQUM project

Aerosol forcing

UKCA-trop
UKCA-strat

UKCA-whole atm
UKCA-MODE

Short-term numerical weather prediction & Visibility forecasts

AQ forecasts

Seasonal forecasting

Decadal prediction

Climate projections AR5 - HadGEM2-ES

Climate projections Post-AR5 HadGEM2/3-ES

Seamless prediction

UKCA Strategy

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- UKCA has created a strong connection between university “basic aerosol research” and Met Office operational research (through observations/campaigns, NERC/EU projects, collaborations)
- Joint model development has created optimum KT
- Wide reach: Basic aerosol process research, Met Office seamless prediction, QUEST-ESM, ECMWF-IFS, air quality…

- Strategy should ensure that:
  - UKCA continues to evolve and remain state-of-the-science
  - We exploit KT benefits (both ways)
  - It is used, evaluated, developed in a wide range of applications (process studies, climate, Earth System, regional AQ)
- Needs to be supported, flexible, desirable to use in the university community