The UK Chemistry and Aerosol Project (UKCA)

Ken Carslaw

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

Dynamic aerosol size distribution (ptcl size distribution)
Internal mixing of particles
Missing components (NH$_4$, NO$_3$, SOA, etc)
Coupled aerosol-chemistry
UKCA collaboration

**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**

**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

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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)

So far, inter-model differences are smaller than model-observation differences
Model applications and results

…and examples of KT
Sensitivty of MBL CCN to DMS is less than derived from satellite observations

Changes in CCN in several control experiments

SOLAS $\rightarrow$ 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

Spracklen, Arnold et al., GRL 2008
Arctic aerosol

Factors controlling seasonal changes in size distribution

SOLAS → Met Office CASE studentship 2009-11

Korhonen et al., JGR 2008
Global CCN

Mode vs. observation

Bin vs. observation

Bin vs. Mode

Map showing global distribution of CCN with various labels and regions marked.
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 $\text{SO}_2$ emissions

Regional formation efficiency of CCN very different to SO4 mass

US

Europe

Asia

Manktelow 2008 (NCAS student)
Cloud drop number

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

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

SO$_2$ emissions from Continental Flood Basalts 65My ago

Plan to use UKCA in QUEST-ESM

Courtesy Anja Schmidt, PhD Leeds
UM status

Aitken mode number conc. (cm⁻³)

Accum. mode number conc. (cm⁻³)

Aitken mode g. mean diameter (m)

Accum. mode g. mean diameter (m)
UKCA aerosol collaborations and projects

• 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

UKCA Troposphere & Stratosphere & Aerosols MODE

MACC project

AQ forecasts

Short-term numerical weather prediction & Visibility forecasts

Seasonal forecasting

Decadal prediction

Aerosol forcing

Climate projections AR5 - HadGEM2-ES

Climate projections Post-AR5 HadGEM2/3-ES

AQ forecasts

Biogenic emissions

JULES

Land surface

UKCA-trop

UKCA-strat

UKCA-whole atm

UKCA-MODE

UM

Seamless prediction
UKCA Strategy

• 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