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- Collection and synthesis of global aerosol microphysics data
- Model 'calibration' using new statistical sampling of the model uncertainty
- Constrained global model of CCN and indirect forcing

Objectives of GASSP

GASSP aims to **reduce the uncertainty in the indirect effect by constraining model predictions of CCN using an extensive synthesis of in situ aerosol microphysics measurements.**

We aim to produce:

- An observationally calibrated model of global CCN, including uncertainties and biases
- Identify the causes of model-observation discrepancy at the process level
- Define the observational needs to further reduce uncertainty in global aerosol
- Use the calibrated aerosol model to estimate the indirect effect and the uncertainty due to aerosol processes

Unique aspects of GASSP

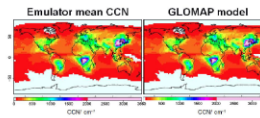
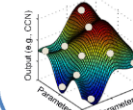
- Synthesis of a wide array of aerosol microphysics measurements from aircraft, ground stations and ships.
- Use of unique model statistical data. Fast model emulators enable effectively thousands of model runs covering the uncertainty range of the model processes. (Section "Model Emulation")
- Variance-based sensitivity analysis to understand the causes of model-observation bias. (Section "Uncertainty analysis")
- Model calibration and "history matching" to reject implausible parameter space and identify the "best" model from the ensemble. (Section "Datasets and model calibration")
- Robust identification of biases when observations do not lie within the model ensemble uncertainty range.

Model emulation

- Emulation is a way of generating essentially continuous model output across a multi-dimensional parameter space
- The emulator output for any parameter setting can then be sampled in a Monte Carlo way.

We built an emulator to describe GLOMAP monthly mean CCN, BC, CN and PM across the uncertainty range of 28 parameters related to processes and emissions. A separate emulator was built for each grid cell

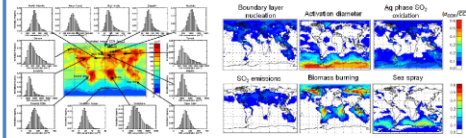
A 2-D example of an emulator, which we extended to 28 dimensions. The 'response surface' is calculated using Bayesian statistics from the model points



Dakley, J. and O'Hagan, A.: Probabilistic sensitivity analysis of complex models: a Bayesian approach, *J. Roy. Stat. Soc. B*, 66, 751-769, 2004.
Lee, L.A. et al., Emulation of a complex global aerosol model to quantify sensitivity to uncertain parameters, *ACP*, 13, 32253-32273 (2013).

Uncertainty analysis

- The emulator makes it feasible to perform a Monte Carlo sampling of the complete model uncertainty space
- We then use variance decomposition to quantify how much each parameter contributes to the uncertainty in the outputs.



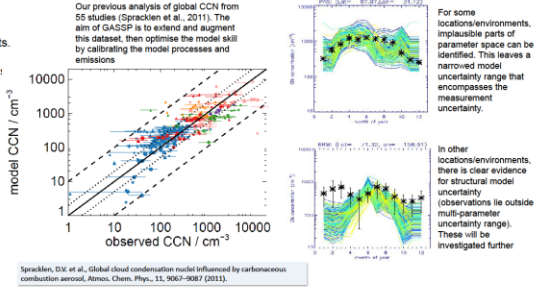
Lee, L.A. et al., The magnitude and causes of uncertainty in global model simulations of cloud condensation nuclei, *ACP*, 13, 8879-8914 (2013).

These pdfs and the uncertainty contribution maps provide a robust way to identify plausible and implausible parts of parameter space when compared with observations, and thereby define an optimum model with defined uncertainties.

Datasets and model calibration

- GASSP is a collaboration with a large number of instrument scientists.
- We focus on CCN, but will synthesise related microphysics measurements that will ensure the model is right for the right reason:
- GASSP will create a harmonised dataset of microphysics measurements in a common format for community use.

| Instrument/Station | Category/Variable | Location | Source | Class | Type |
|--------------------|-------------------|-------------------|--|-----------------|-----------------|
| CCN | CCN (0.2-1.0 μm) | London, UK | London Aerosol Synthesis and Science Project | CCN | CCN |
| Sea distribution | Sea spray | Various locations | Sea spray | Sea spray | Sea spray |
| Biogenic emissions | Biomass burning | Various locations | Biomass burning | Biomass burning | Biomass burning |
| SO2 emissions | SO2 emissions | Various locations | SO2 emissions | SO2 emissions | SO2 emissions |
| Sea spray | Sea spray | Various locations | Sea spray | Sea spray | Sea spray |
| CCN | CCN | Various locations | CCN | CCN | CCN |



Spracklen, D.V. et al., Global cloud condensation nuclei influenced by carbonaceous combustion aerosol, *Atmos. Chem. Phys.*, 11, 9067-9087 (2011).