School of Earth and Environment
INSTITUTE FOR ATMOSPHERIC SCIENCE

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Insights into global sources of CCN

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GLOMAP
Global Model of Aerosol Processes

GLOMAP aerosol model

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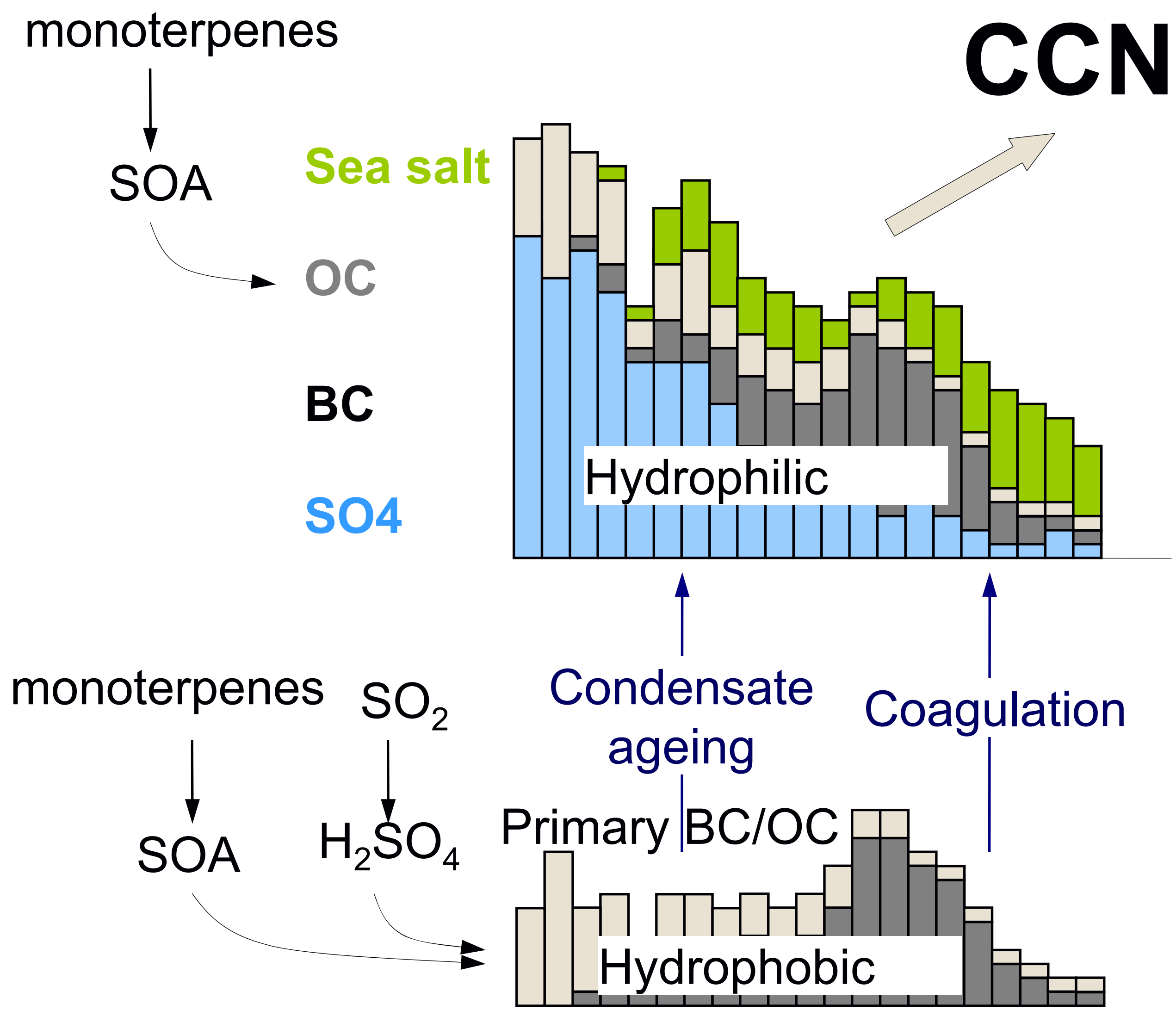
- Build on top of global offline CTM TOMCAT
- 2.8°x2.8° resolution
- Sectional aerosol scheme with 20 bins, 3 nm – 20 μm



Modelling total particle number (CN)

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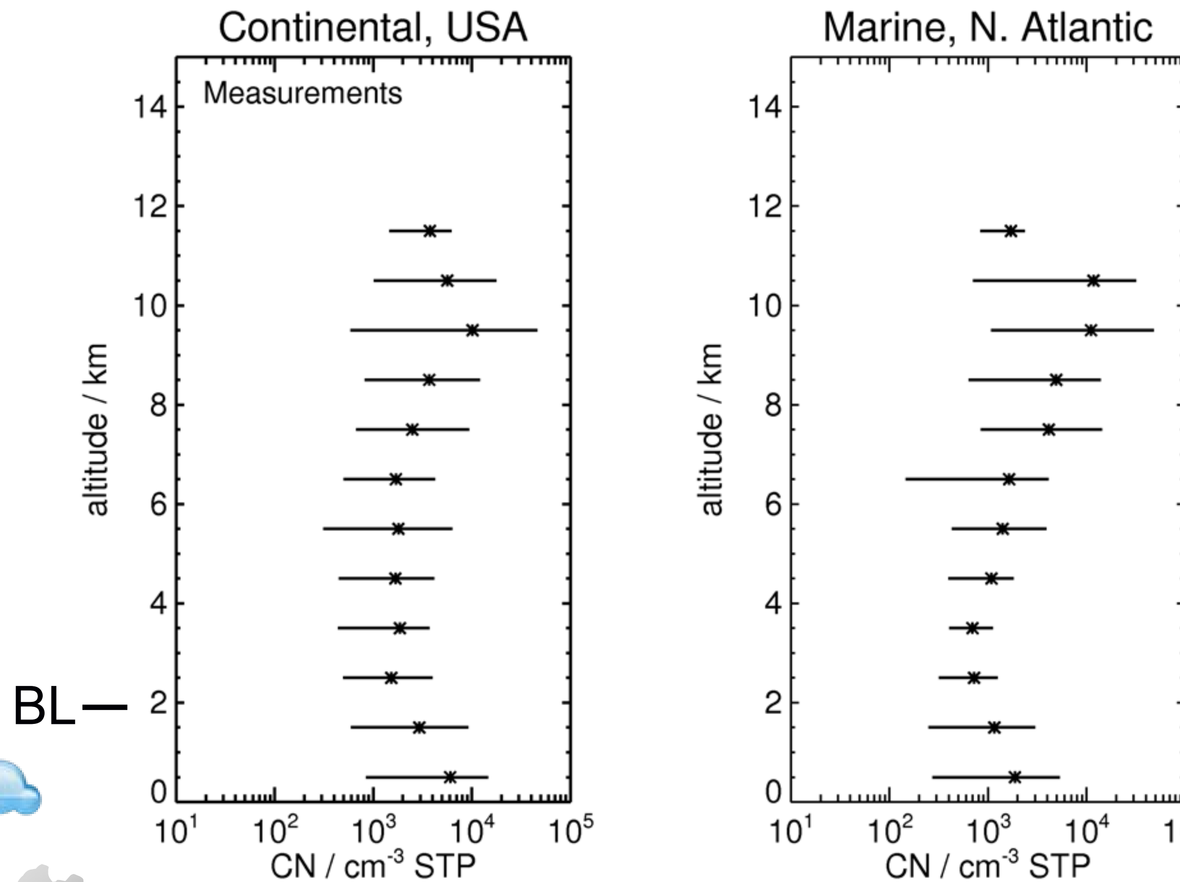
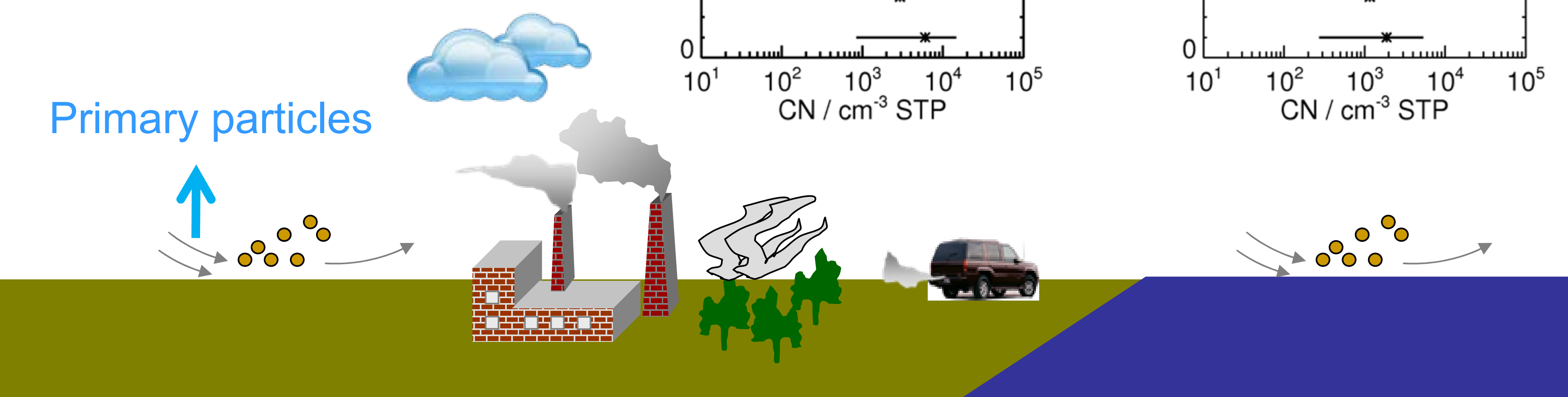
We have mainly used CN measurements to constrain the model.

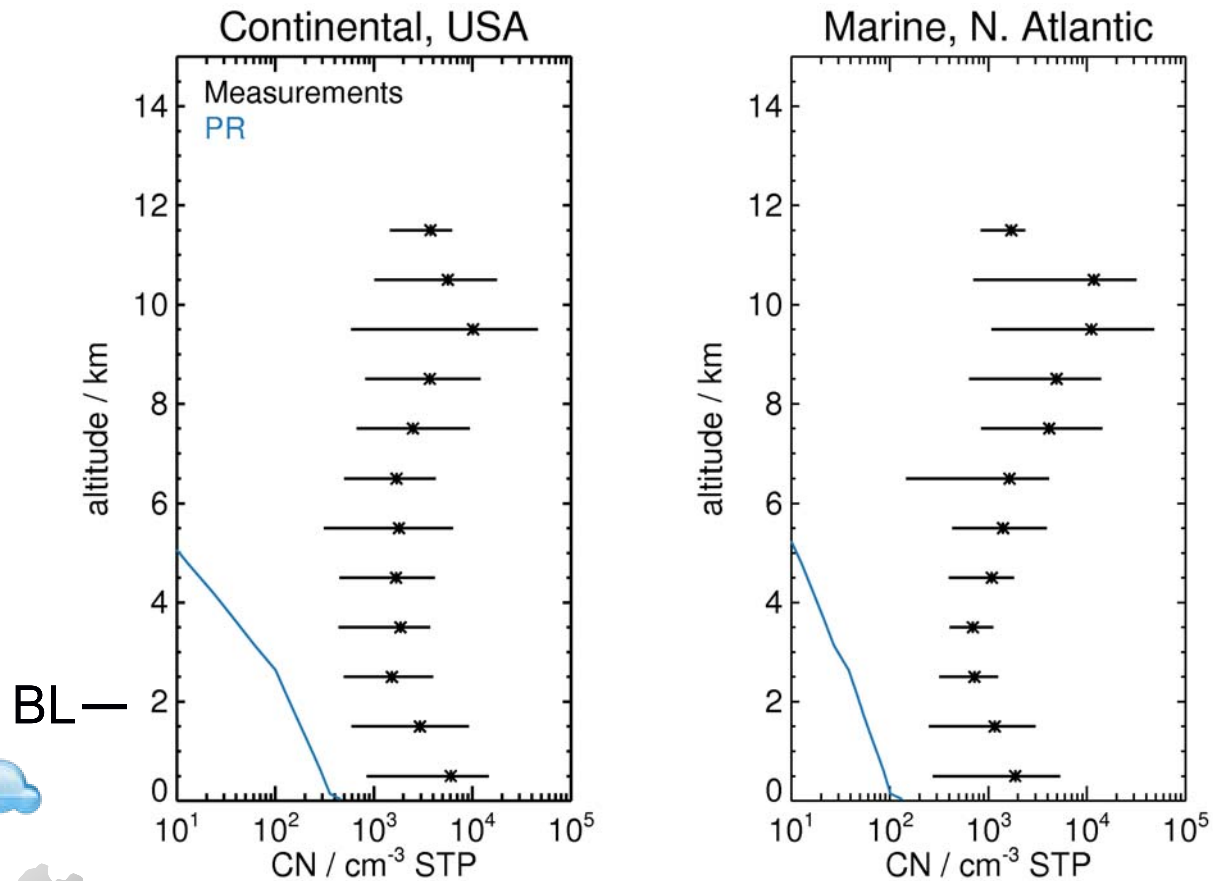
So what makes CN in the tropospheric column?



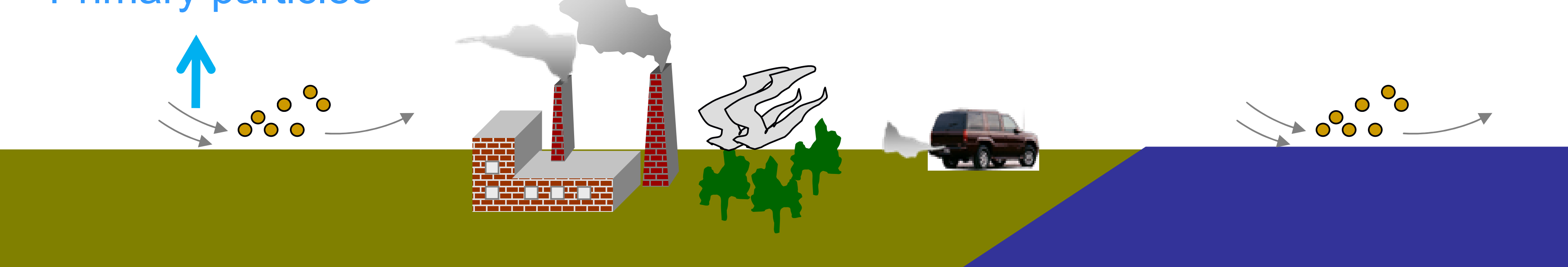


Modelling total particle number (CN)

UT nucleation
($H_2SO_4+H_2O$)



Primary particles



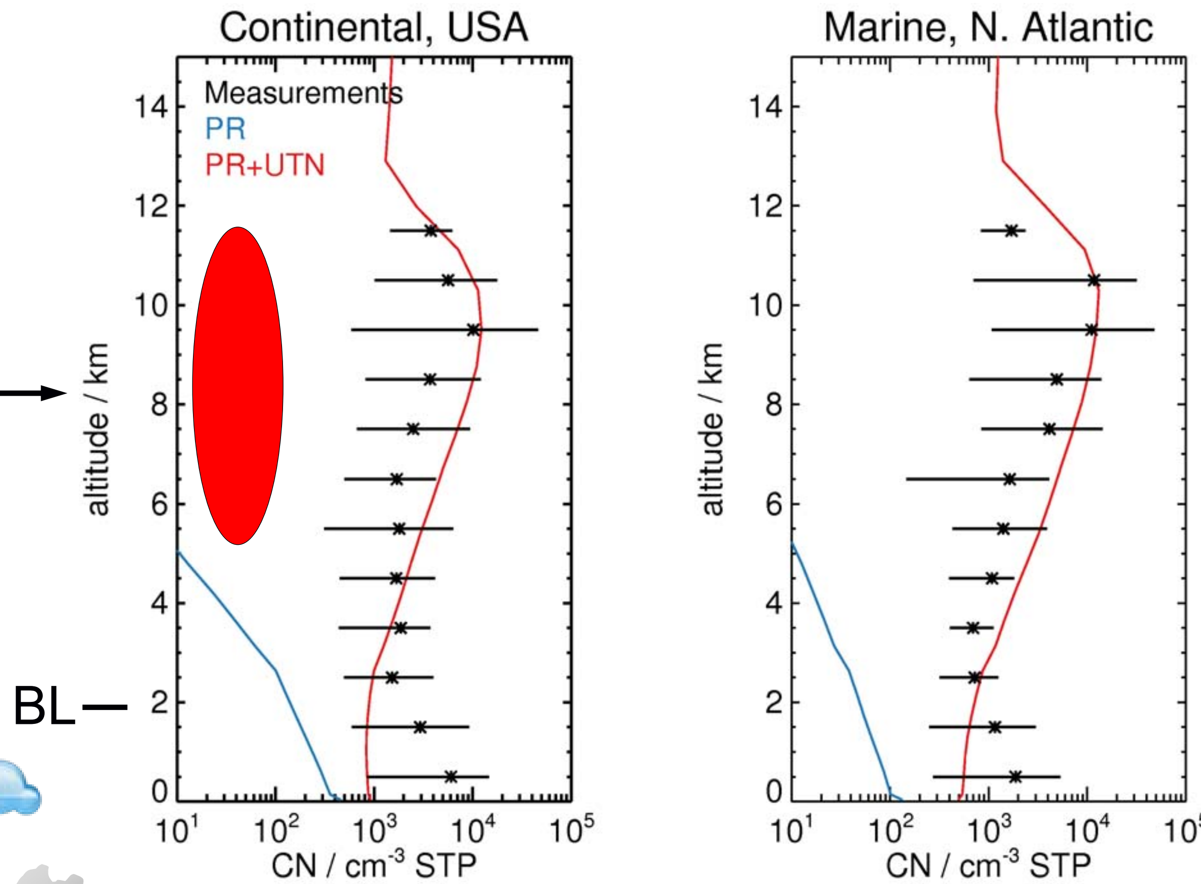
Modelling total particle number (CN)

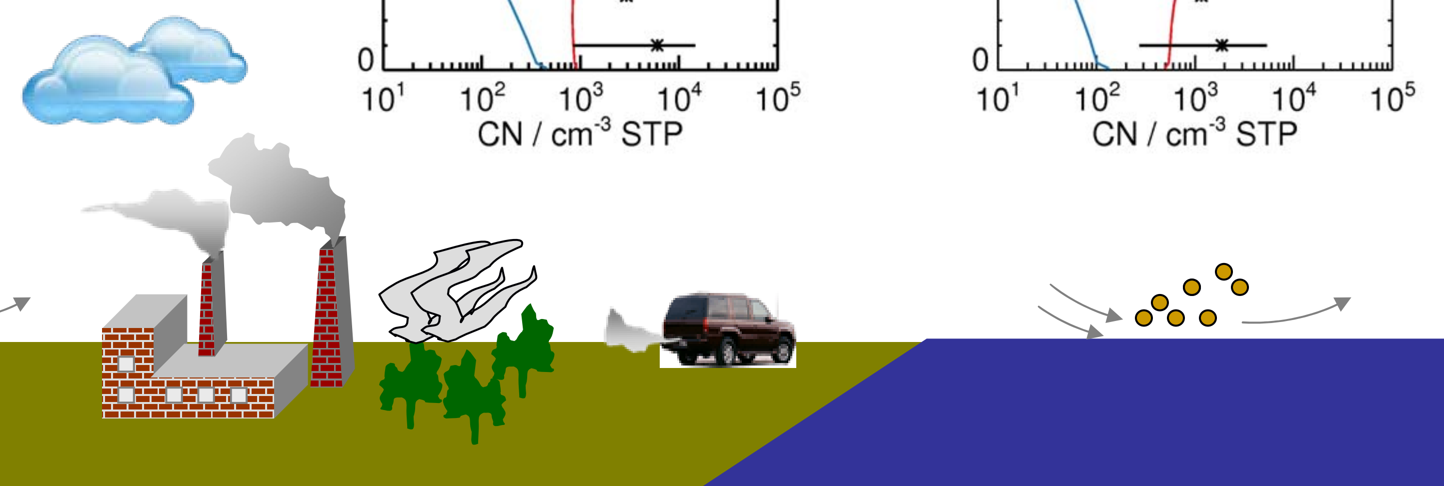
UT nucleation
(H2SO4+H2O)

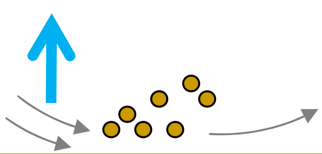
Nucleation zone

BL nucleation (activation
or kinetic H2SO4)

Primary particles







Modelling total particle number (CN)

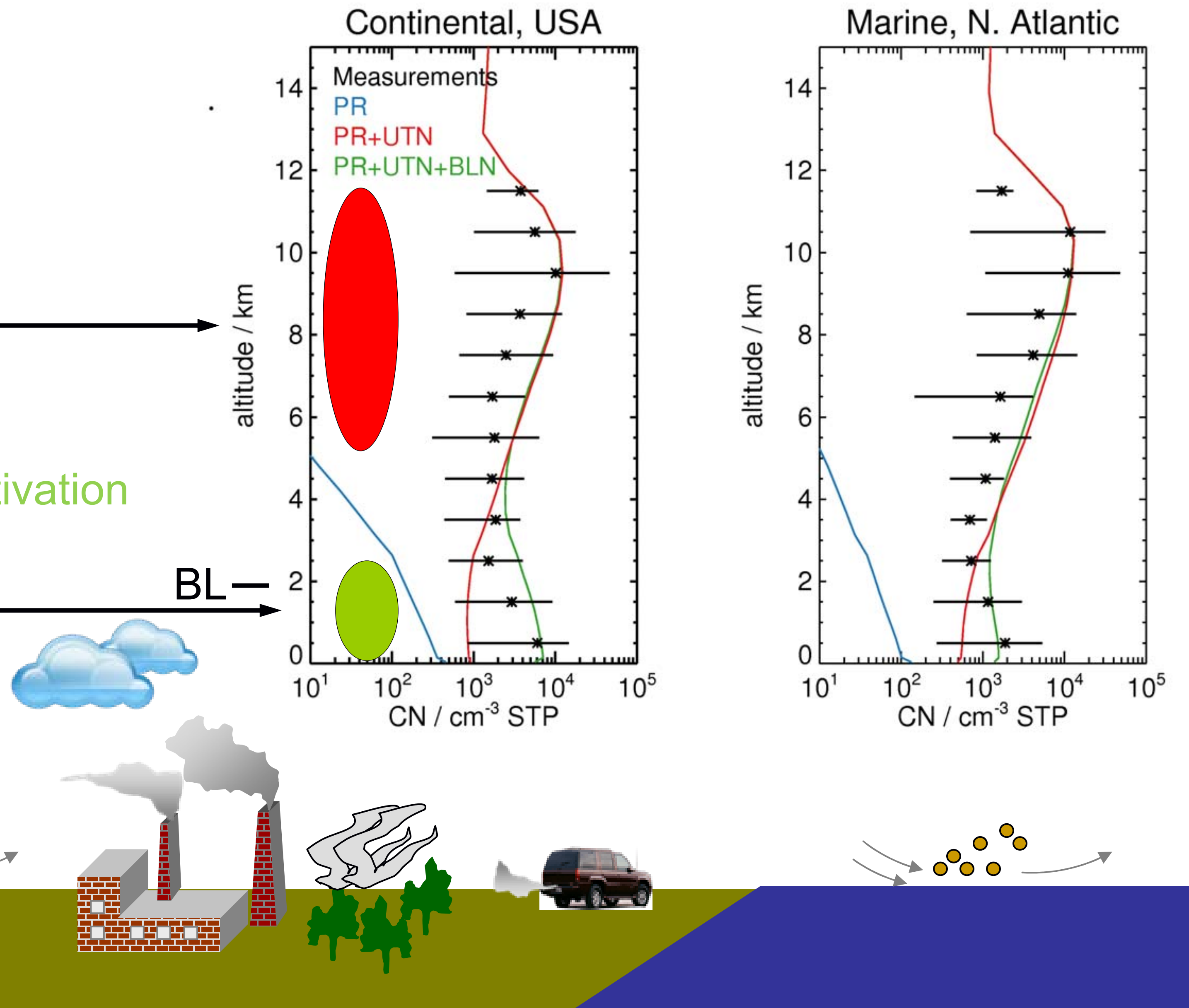
UT nucleation (H2SO4+H2O)

Nucleation zone

BL nucleation (activation or kinetic H2SO4)

Nucleation zone

Primary particles



GLOMAP vs. observations of total concentrations

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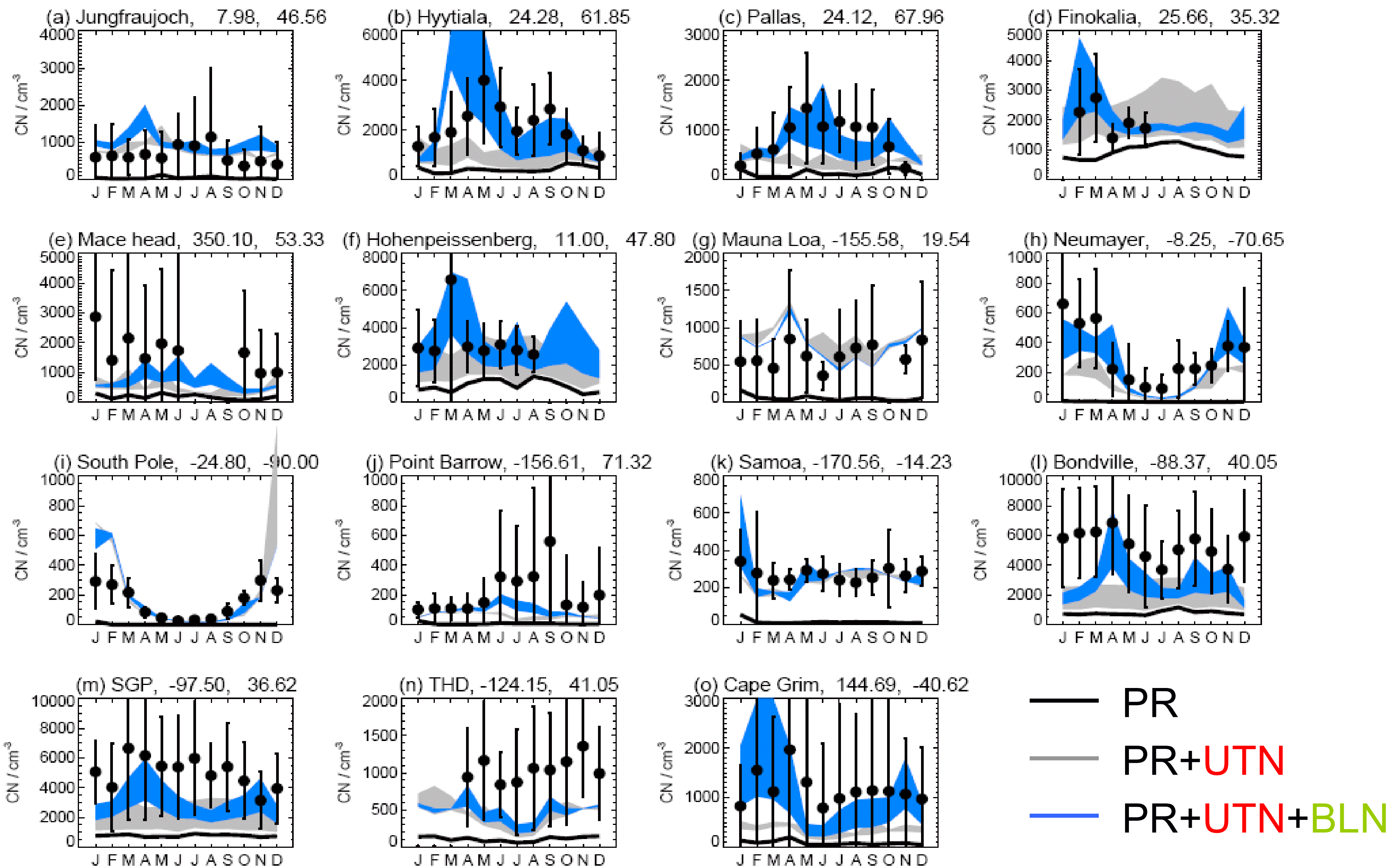
Ground level concentrations (D. Spracklen et al., to be submitted)



Percentage of primary vs. nucleated CN in BL (all particles over 3 nm)

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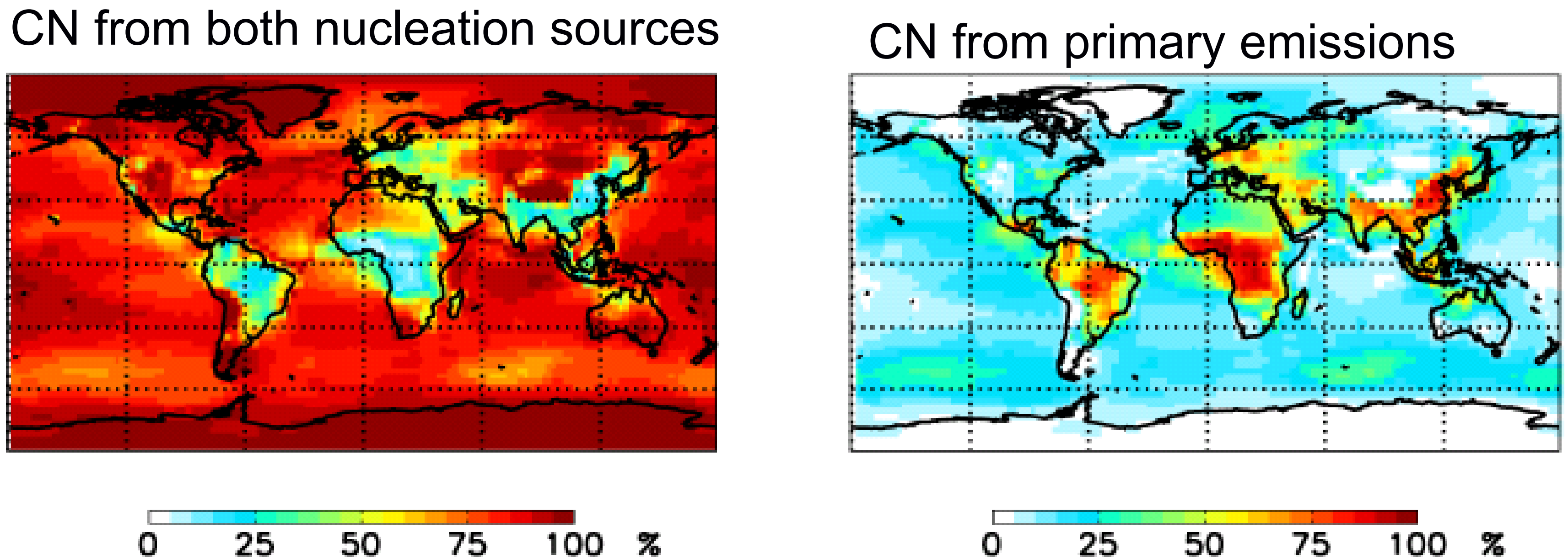
Model giving the best representation of measured CN in 35 sites:



Nucleated particles dominate ground level total aerosol concentrations nearly everywhere

However, most of them are small and have no impact on climate

Primary particles as a source of CCN

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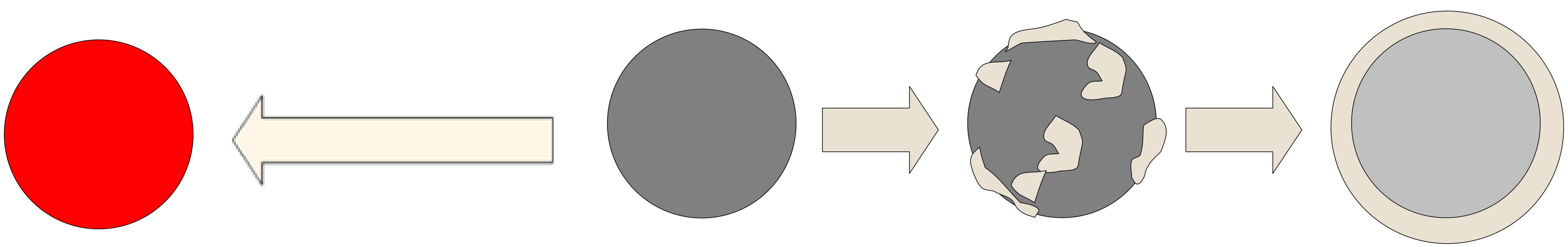
For particles to act as cloud condensation nuclei (CCN), they need to be:

1. Fairly "big" (over ~70nm in diameter) -Nucleated particles are born "small", while primaries are typically "big"
2. Water soluble – composition matters

PRIMARY PARTICLES

Soluble | Unsoluble | Partially soluble | More soluble

Sulfate, sea salt | OC, BC, dust



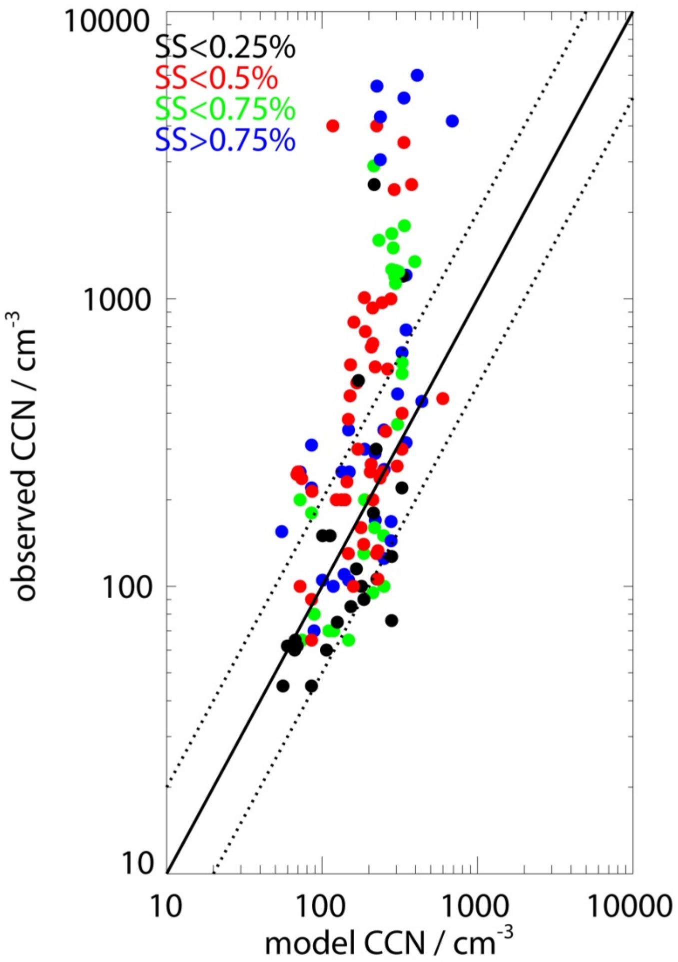
Coagulation

Condensation aging

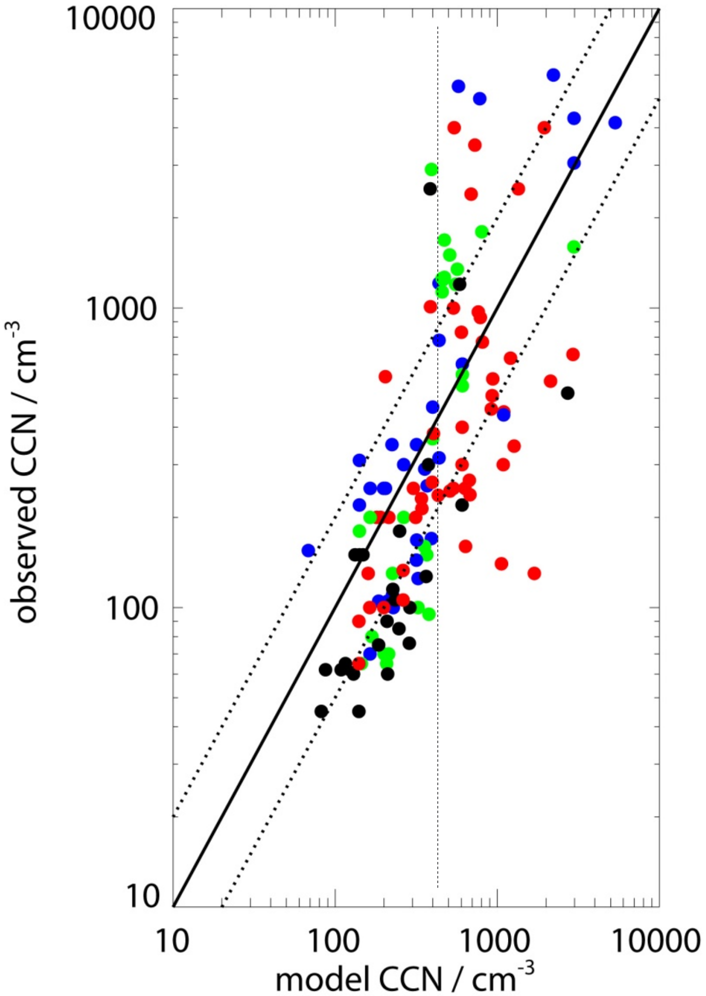
(H2SO4 & secondary organics)

Observed and modelled global CCN

BC/OC **not** condensation aged



BC/OC condensation aged



Importance of secondary organics

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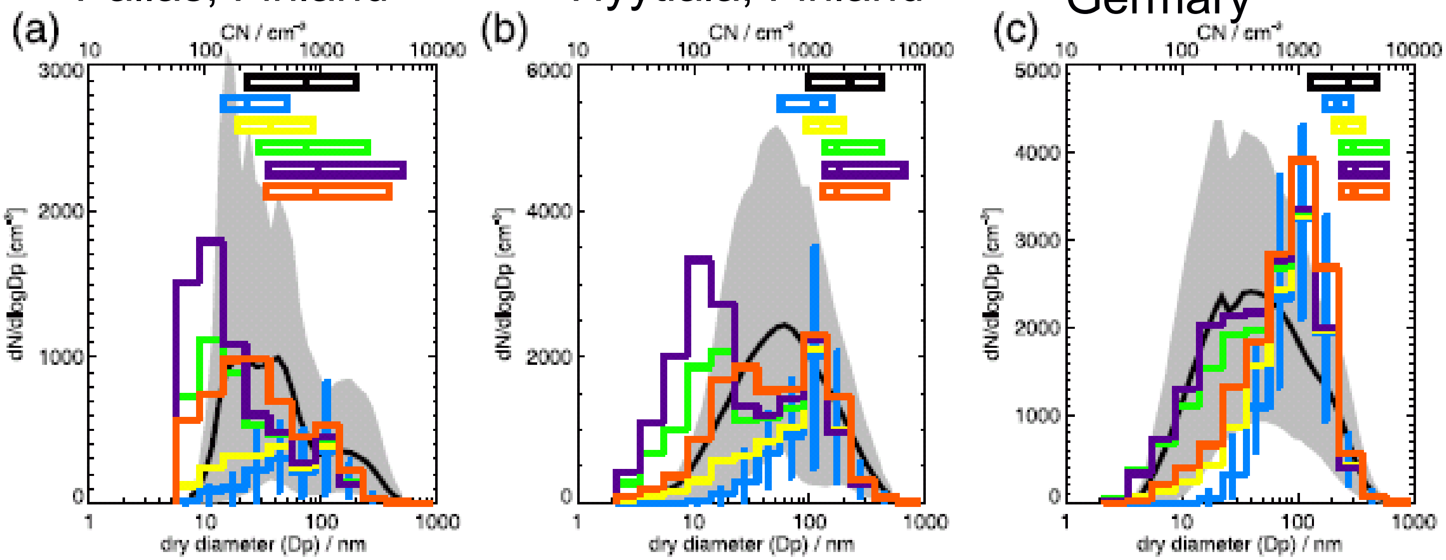
Measured vs. modelled aerosol size distributions:



— Measurements

D. Spracklen et al., GRL 2008

— Model, SOA yield from monoterpenes 13%

— Model, SOA yield from monoterpenes 65%

More SOA → more CCN from BL nucleation

Sulfate mass vs CCN

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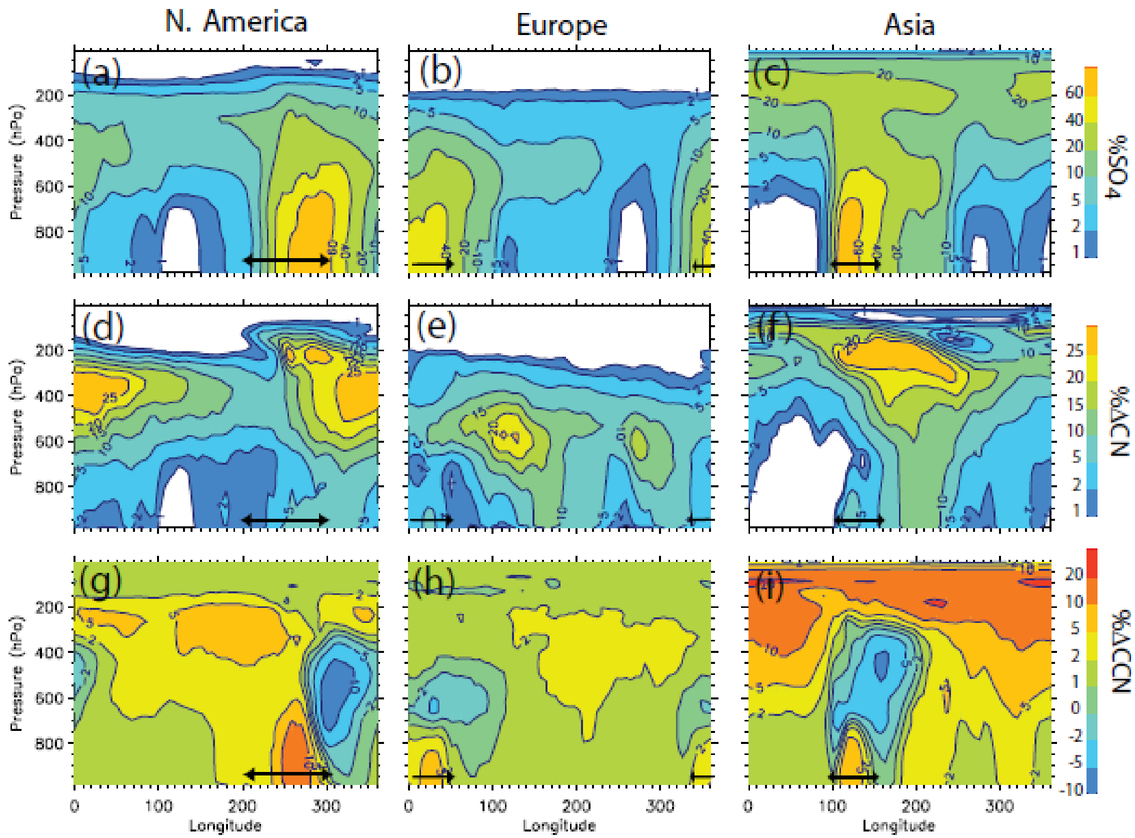
Spatial footprint of sulfate mass emitted from a particular region is completely different from the footprint of CCN produced by the emissions.

Fractional contribution of sulfur emissions to sulfate mass and CCN:

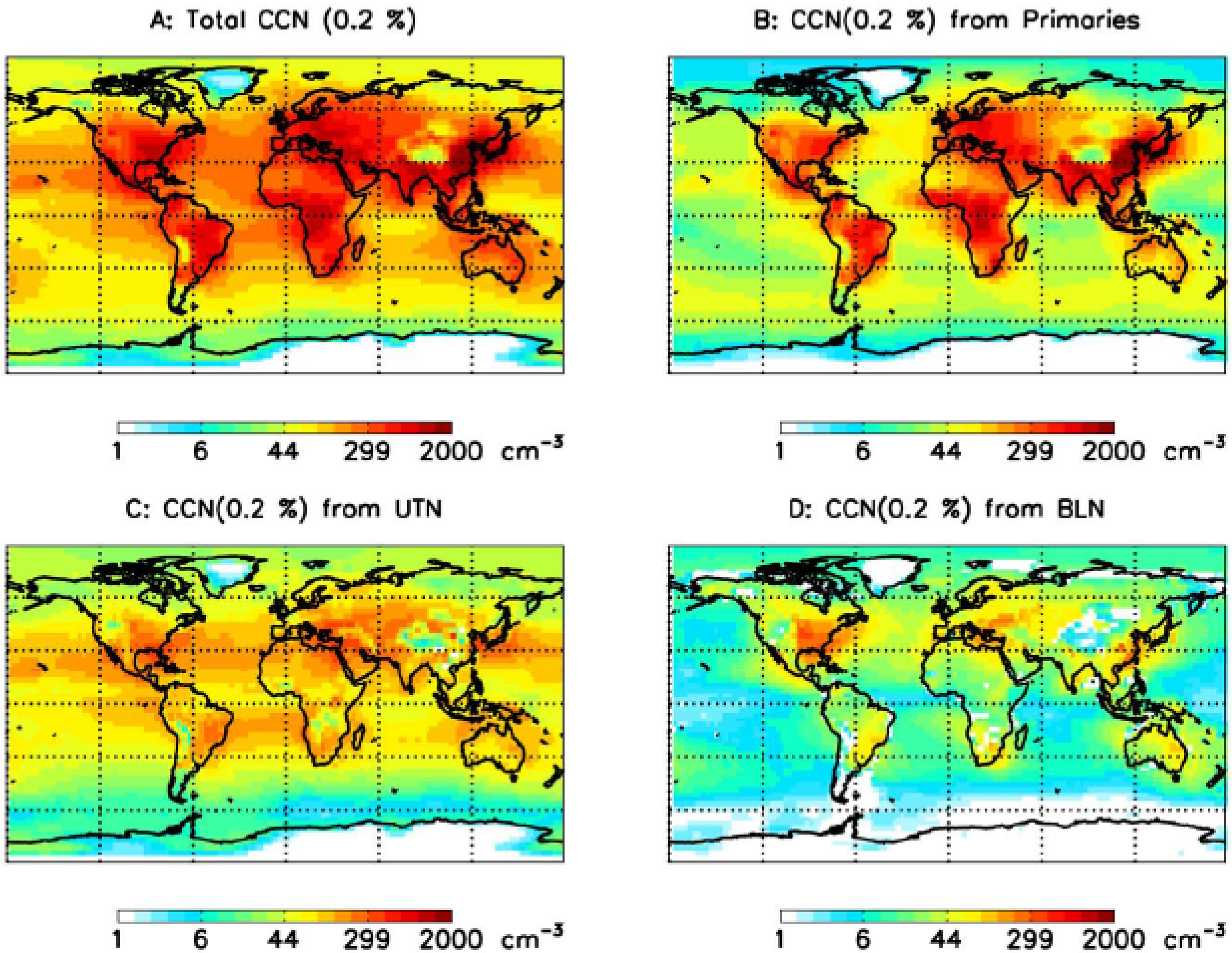


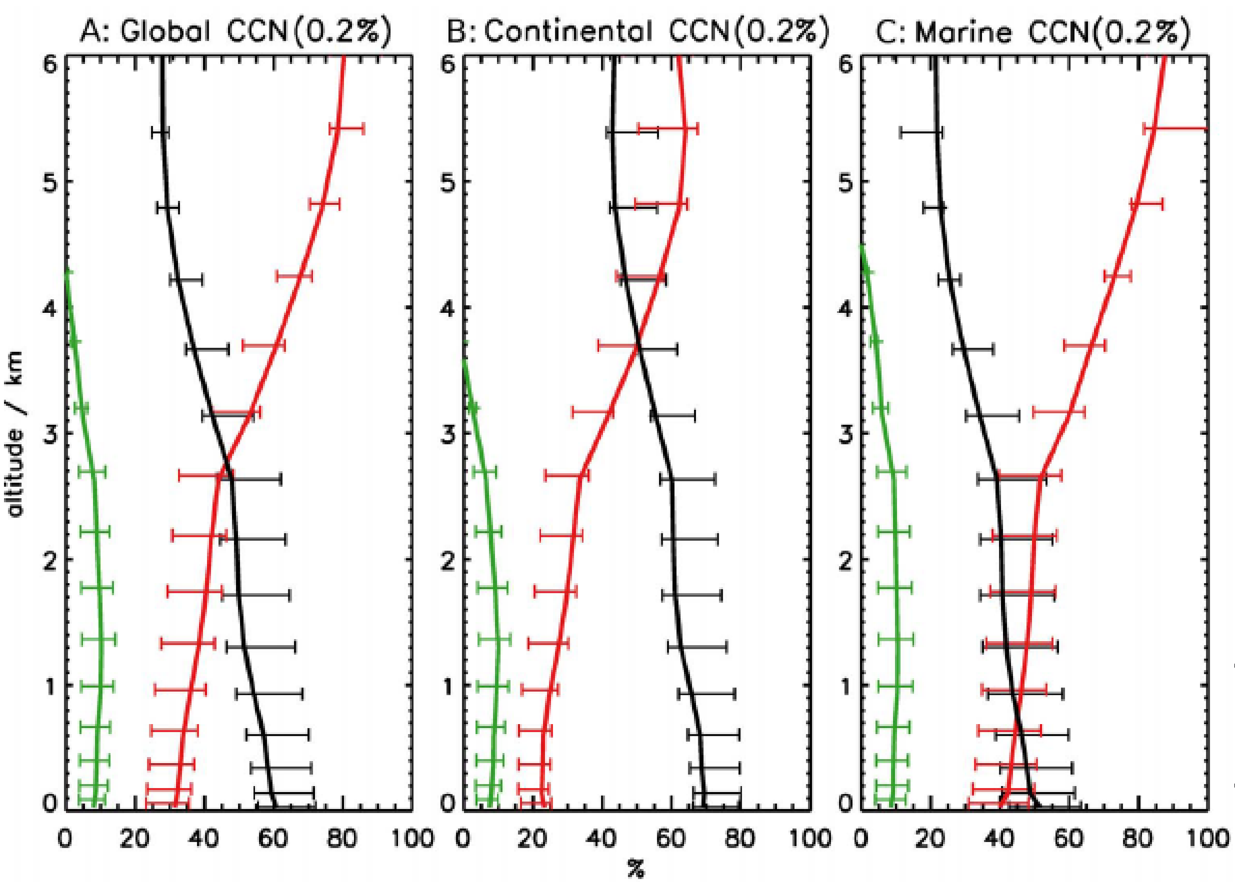
Paul Manktelow, ACP (2009)

	N. America	Europe	Asia
Sulfate burden potential	0.89	0.93	0.59
CCN potential	0.1	0.06	0.08

Boundary layer CCN

We use the constrained model to estimate the impact of nucleation vs. primary emissions on CCN





Primary particles

UT nucleation

BL nucleation

Between 300-1200 m:

PR:	55%	67%	45%
UTN:	35%	24%	45%
BLN:	10%	9%	10%

Percentage of primary versus nucleated CCN

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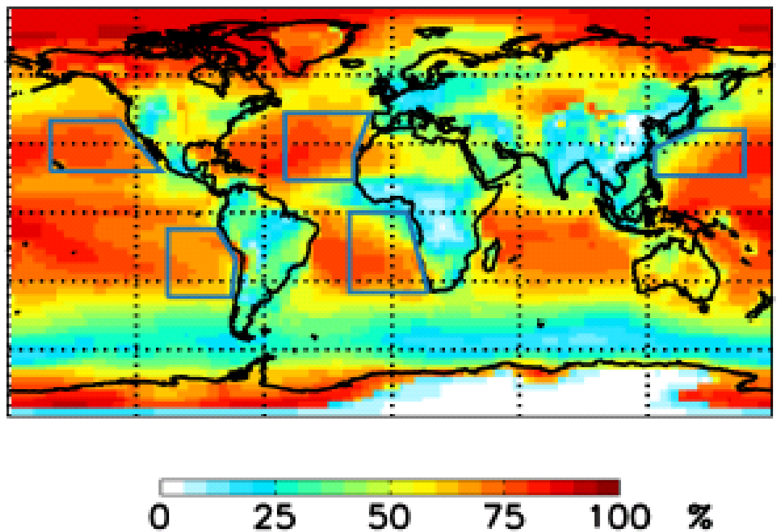
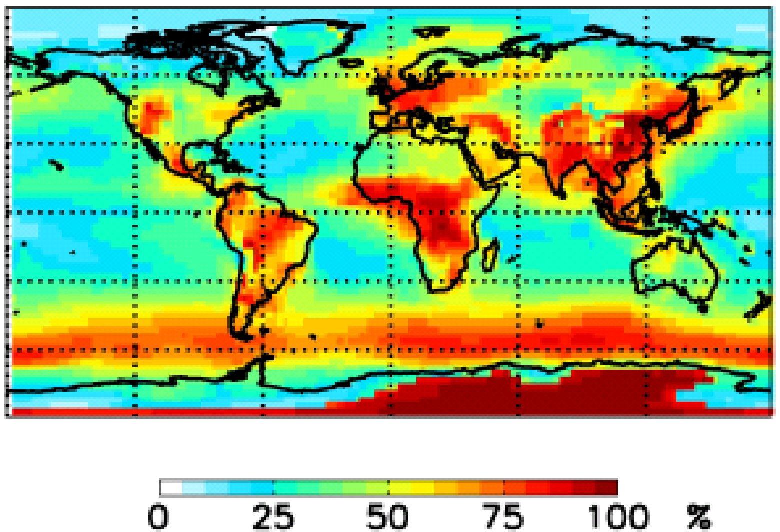
CCN(0.2%) from nucleation sources



CCN(0.2%) from primary particles



Primary particles dominate CCN over most land areas, but nucleation dominates over midlatitude oceans

J. Merikanto et al., ACPD 2009

BL vs. UT nucleated CCN

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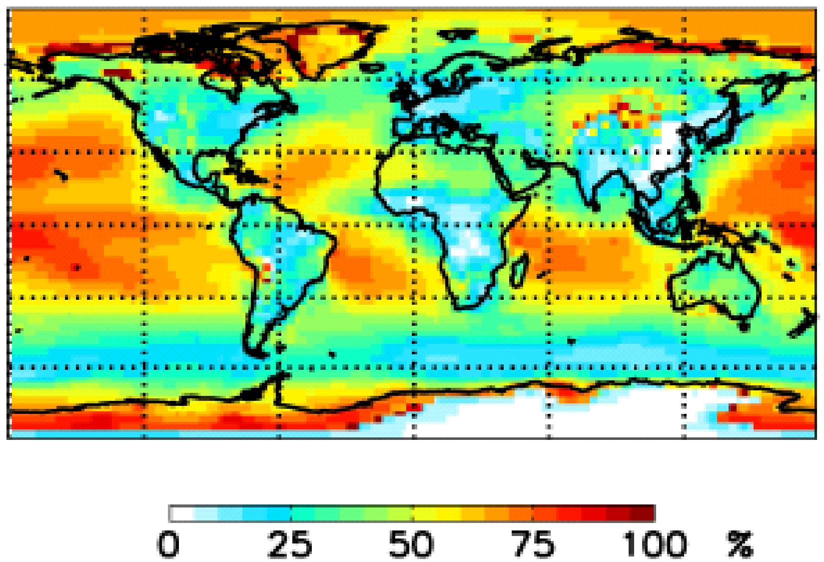
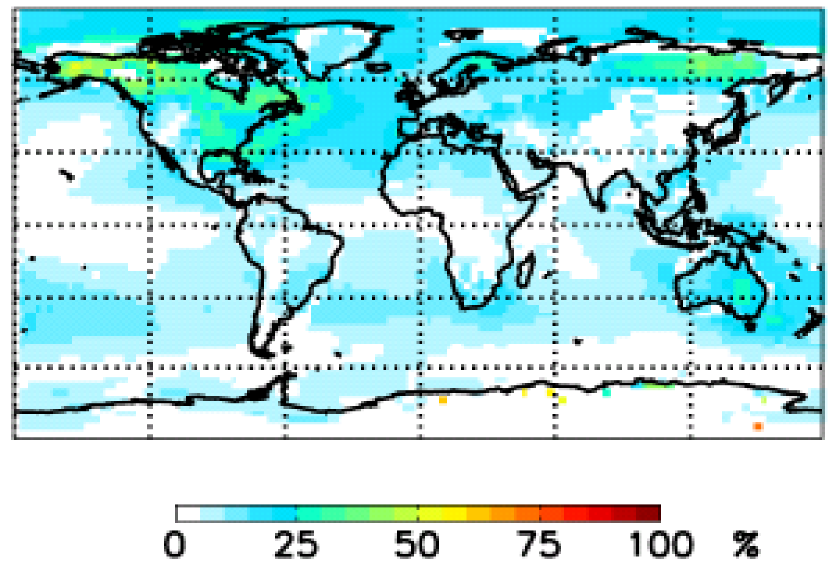
CCN production from upper tropospheric and boundary layer nucleation:

CCN from UTN



CCN from BLN



J. Merikanto et al., ACPD 2009

Most of nucleated boundary layer CCN is produced in upper troposphere

BLN also contributes to over 30% of CCN in some regions

Interactions between CCN production mechanisms

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CCN production by boundary layer nucleation is greatly suppressed by primary particles.