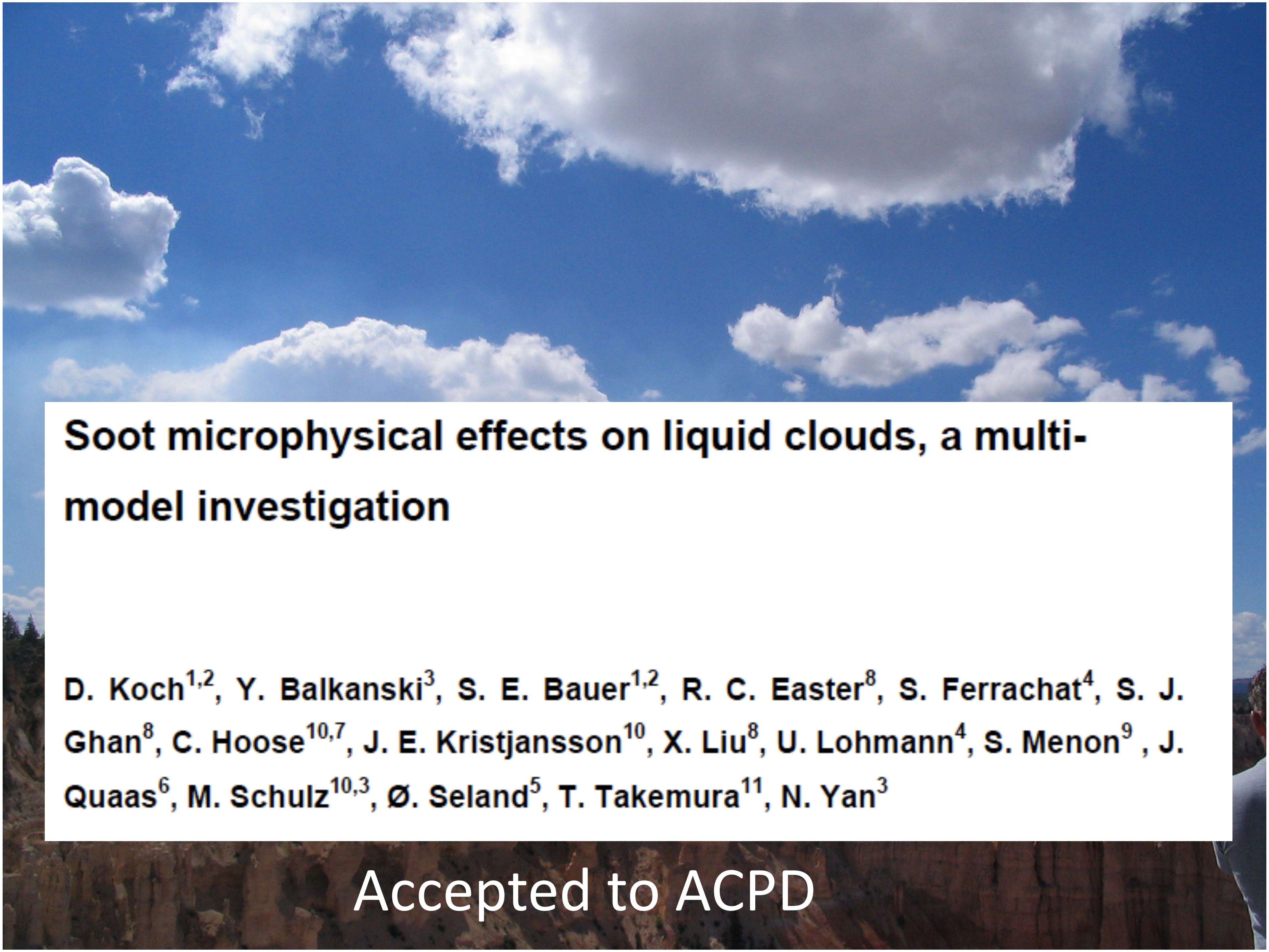

Soot microphysical effects on liquid clouds, a multi-model investigation

D. Koch[1,2], Y. Balkanski[3], S. E. Bauer[1,2], R. C. Easter[8], S. Ferrachat[4], S. J. Ghan[8], C. Hoose[10,7], J. E. Kristjansson[10], X. Liu[8], U. Lohmann[4], S. Menon[9] , J. Quaas[6], M. Schulz[10,3], Ø. Seland[5], T. Takemura[11], N. Yan[3]

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Although “soot” (carbonaceous aerosols) warms climate from direct and snow-albedo effects, its effects on clouds are very uncertain and may be cooling:

1) semi-direct effects (both positive and negative, but global models mostly negative, Koch and Del Genio, ACP, 2010)
2) Ice and mixed-phase clouds (positive?)
3) **Liquid cloud indirect effects (focus of this study)**
   Two previous studies:

   1. Chen et al., 2010 showed negative effect;

   2. Bauer et al., 2010 showed negative for biofuel but positive for fossil fuel BC.

More models are needed!

Experiments

Using similar model configuration as Quaas et al. (2009)

1. FF reduce all fossil fuel BC
2. BF reduce all biofuel BC and OC
3. D remove all diesel BC and OC

Compare indirect effects for these with full year-2000 experiments

Models

- CAM-Oslo
- CAM-PNNL
- ECHAM5
- GISS
- LSCE
- SPRINTARS

First 4 models include detailed aerosol microphysics: nucleation, condensation-mixing, coagulation.

Aerosol mixing changes affect the CCN population

Soot removal: 2 competing effects on CCN

1. Fewer particles, fewer CCN
2. Secondary species that were on soot now deposit on other particles or nucleate new particles. These may activate faster, more CCN.

BF (biofuel BC+OC) reduction: 1. dominates

a) Bigger particles
b) BC + OC (OC makes more hygroscopic)
c) Expt has Bigger emission reduction

FF (fossil fuel BC) reduction: 2. also important

a) BC only (low hygroscopicity)
b) Smaller particles

Cloudy-sky effect of soot reduction Wm^{-2}

	Average of models	Range
BF	+0.11	-0.08 to +0.11
FF	-0.08	-0.21 to +0.03

BF reduction usually causes warming

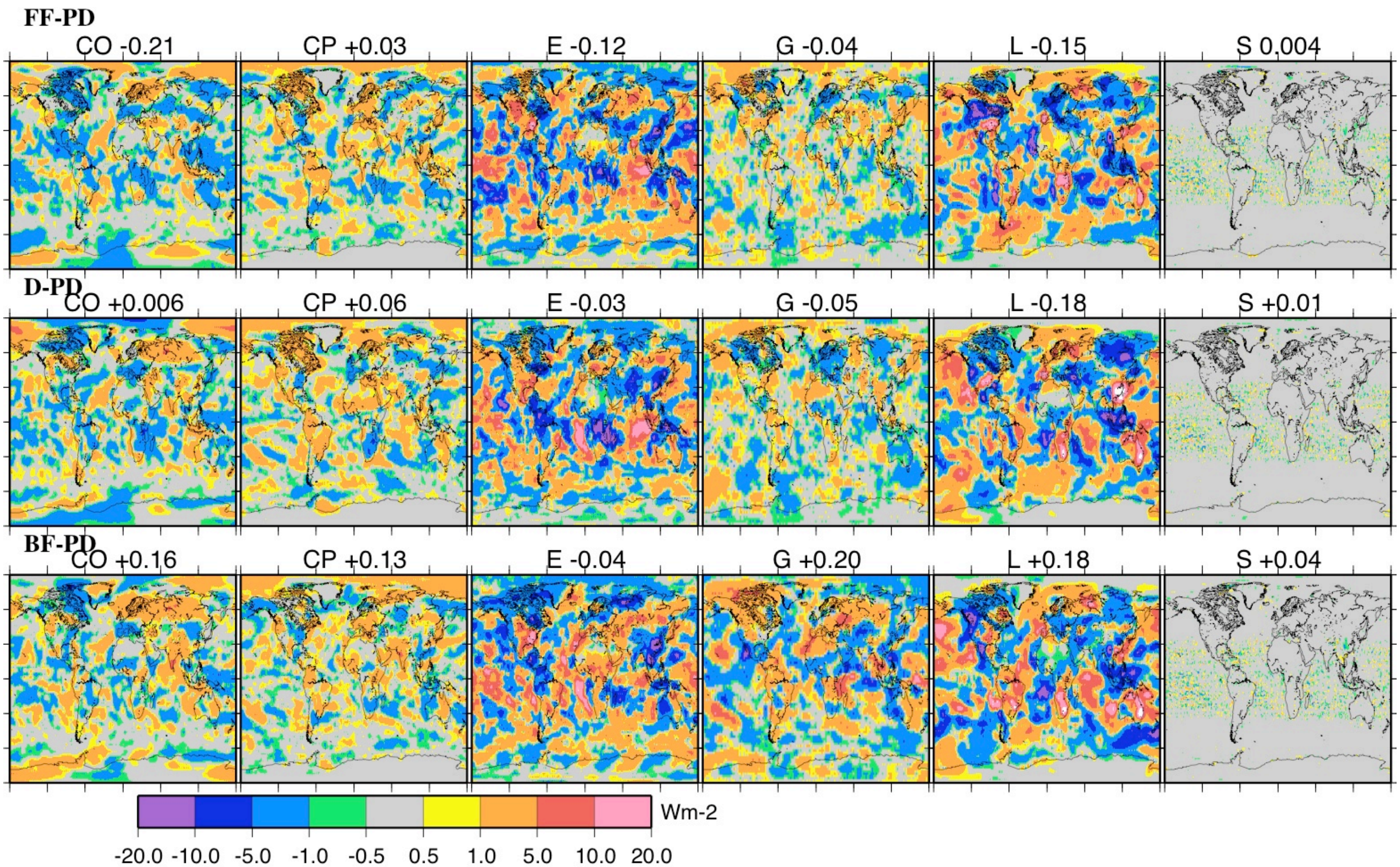
FF (BC) reduction usually causes cooling

(Diesel reduction had small response)

Cloudy sky radiative effect
All models have BF > FF

FF
generally
more
blue

BF
generally
more
orange



Caveats, conclusions

1. Lots of variability among models and within each (standard deviation similar to signal size)
2. Experiments idealized:

   BF is unrealistically big emission reduction.

   FF is BC only, if co-emitted OC and SO_2 were reduced then the effect could reverse.

3. Nonlinearities in both aerosol microphysics and indirect effect.

Catch-22: More realistic emission reductions are unlikely to be large enough to get statistically significant response.


Thanks!