Indirect effect intercomparison

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Contents

Status
Method
Forcings
Twomey
Second indirect
Thermo-dynamics
Summary
Conclusion

- Status
- Method: Comparison to satellite statistics

- Short-wave forcings, clear and all-sky
- Cloud microphysics / Twomey effect
- Cloud cover / cloud water / second indirect effect
- Thermodynamic effects?

- Summary
- Preliminary conclusions

Indirect effect intercomparison and evaluation

model	forcing*	status	institution
GFDL GCM	-2.1 Wm^{-2}	submitted	GFDL Princeton
GISS	-0.6 Wm^{-2}	submitted	LBL / GISS
SPRINTARS	-1.0 Wm^{-2}	submitted	Univ Kyushu
CCM	-1.9 Wm^{-2}	submitted	Univ Michigan
CAM3.5	-2.6 Wm^{-2}	submitted	NCAR Boulder
ECHAM5-eth	-1.4 Wm^{-2}	submitted	ETH Zürich
HadGEM	-1.5 Wm^{-2}	submitted	Met Office Exeter
ECHAM5-rh	-1.1 Wm^{-2}	submitted	MPI Met Hamburg
ECHAM5-lc	-1.6 Wm^{-2}	submitted	MPI Met Hamburg
LMDZ-INCA		running	LSCE Gif s/ Yvette
CCM-Oslo		in prep	Univ Oslo
CAM		in prep	PNNL
EC-Earth		in prep	ETH Zürich
ECHAM5		in prep	Univ Oxford
GMI		in prep	Georgia Tech

* all aerosol effects

Method

The models are compared to satellite data:

CERES SSF dataset including
CERES broadband SW and LW radiative fluxes
MODIS cloud and aerosol properties

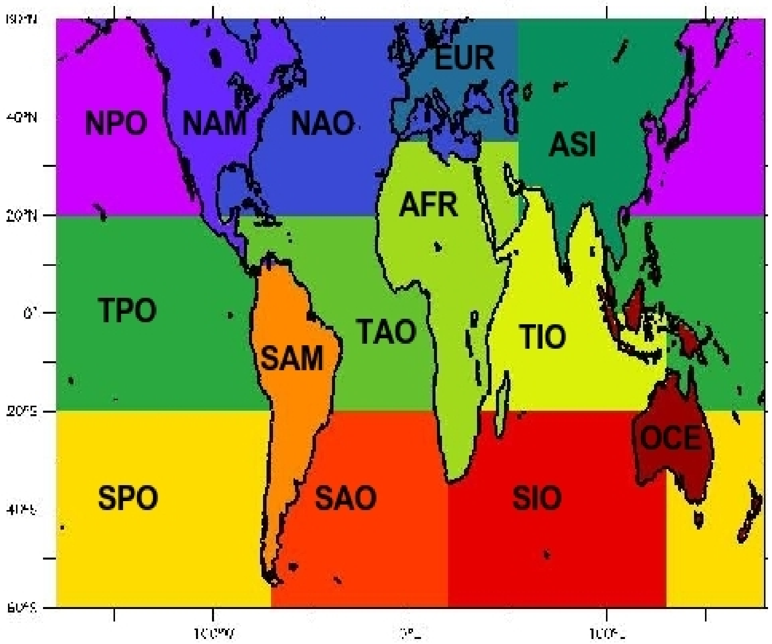
Terra satellite (10.30 am overpass time): Edition 2B
1 March 2000 – 28 February 2006 data (6 years)

Aqua satellite (13.30 pm overpass time): Edition 2A
1 January 2003 – 31 December 2006 data (4 years)

All data are interpolated to a 2.5°x2.5° regular lat-lon grid

Method relies on Quaas et al., J. Geophys. Res. 2008

Method



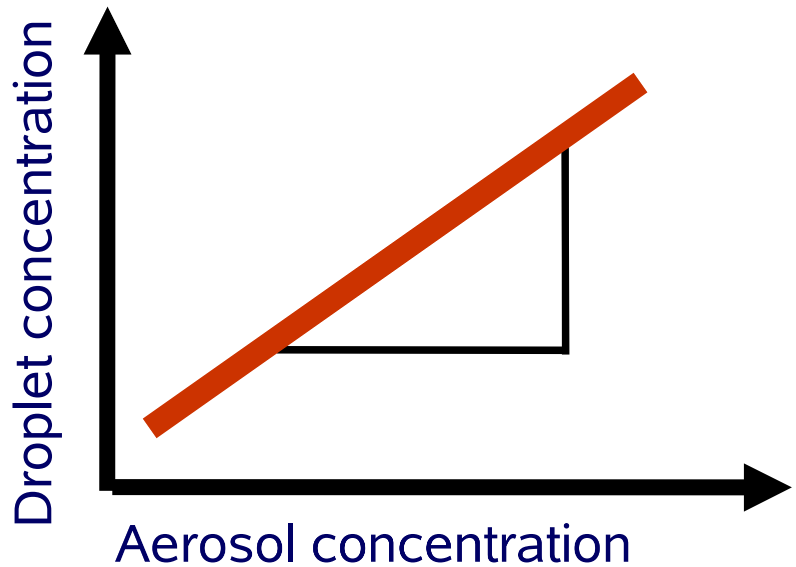
NPO: North Pacific Ocean
NAM: North America
NAO: North Atlantic Ocean
EUR: Europe
ASI: Asia
TPO: Tropical Pacific Ocean
TAO: Tropical Atlantic Ocean
AFR: Africa
TIO: Tropical Indian Ocean
SPO: South Pacific Ocean
SAM: South America
SAO: South Atlantic Ocean
SIO: South Indian Ocean
OCE: Oceania

MAM: March-April-May
JJA: June-July-August
SON: September-October-November
DJF: December-January-February

Analyse separately
- 14 different regions
- 4 seasons (MAM,JJA,SON,DJF)

Quaas, Boucher, Bellouin, Kinne, J. Geophys. Res., 2008

Method



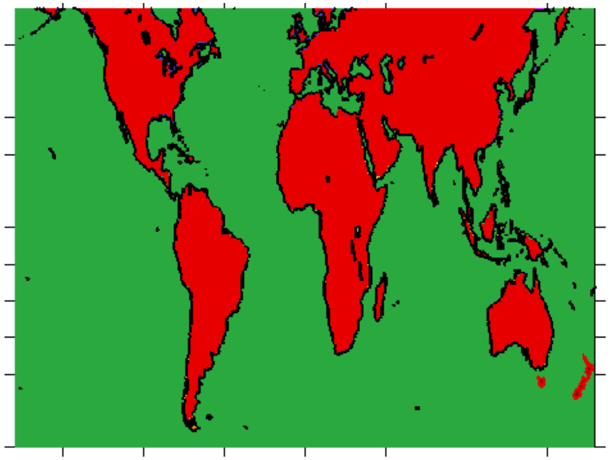
Slopes of the statistical relationship

$$b = \frac{\Delta \ln \Phi}{\Delta \ln \tau_a}$$

with τ_a AOD and Φ being a cloud or radiation parameter shown.

The slopes are computed as a linear regression ln Φ vs. ln τ_a for individual regions/seasons

Method



Summary plots:

Separate **land** / **ocean**

All regions are weighted equally.

The land mean is the mean over (4x6 = 24 slopes)
- MAM, JJA, SON, DJF
- NAM, EUR, ASI, AFR, SAM, OCE

The ocean mean is the mean over (4x8 = 32 slopes)
- MAM, JJA, SON, DJF
- NPO, NAO, TPO, TAO, TIO, SPO, SAO, SIO

Error bars show standard deviation around mean.

Total aerosol forcing [W m^{-2}]

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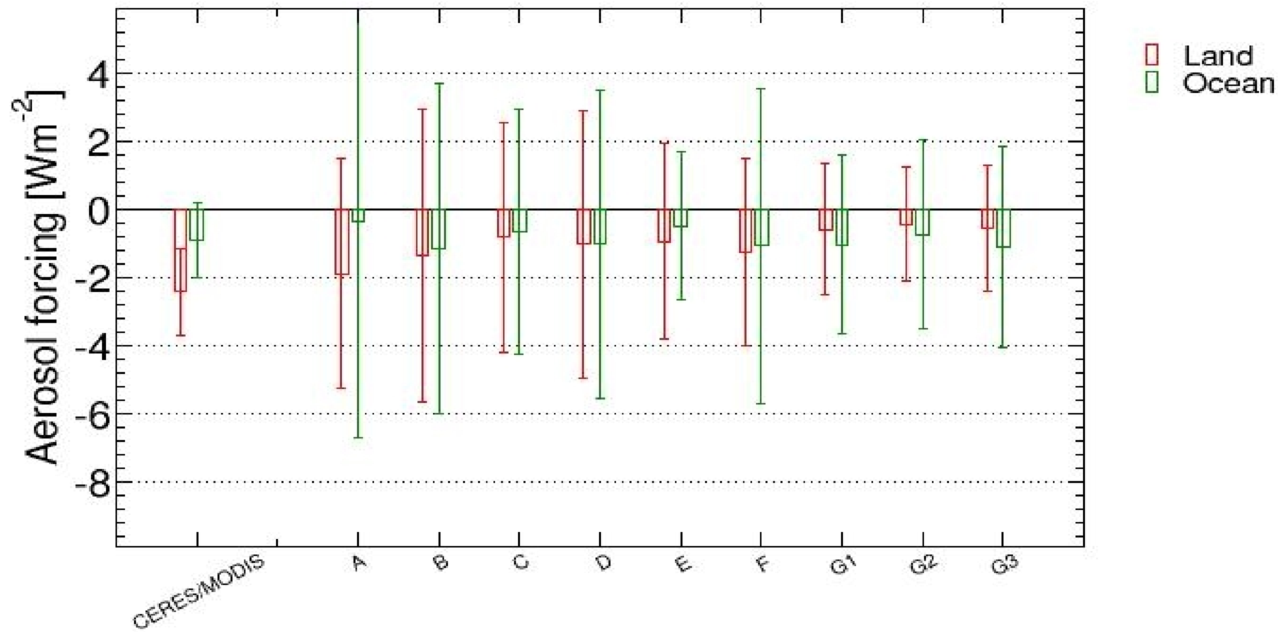
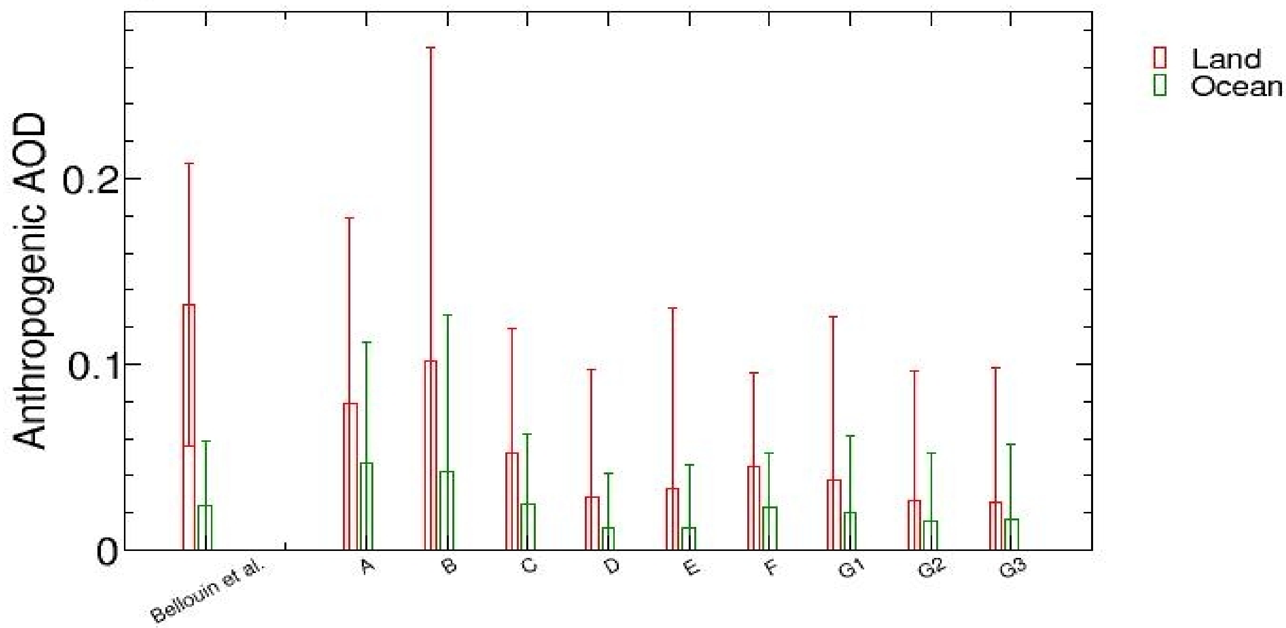


Models:
Forcing is
rst (PD run) –
rst (PI run)

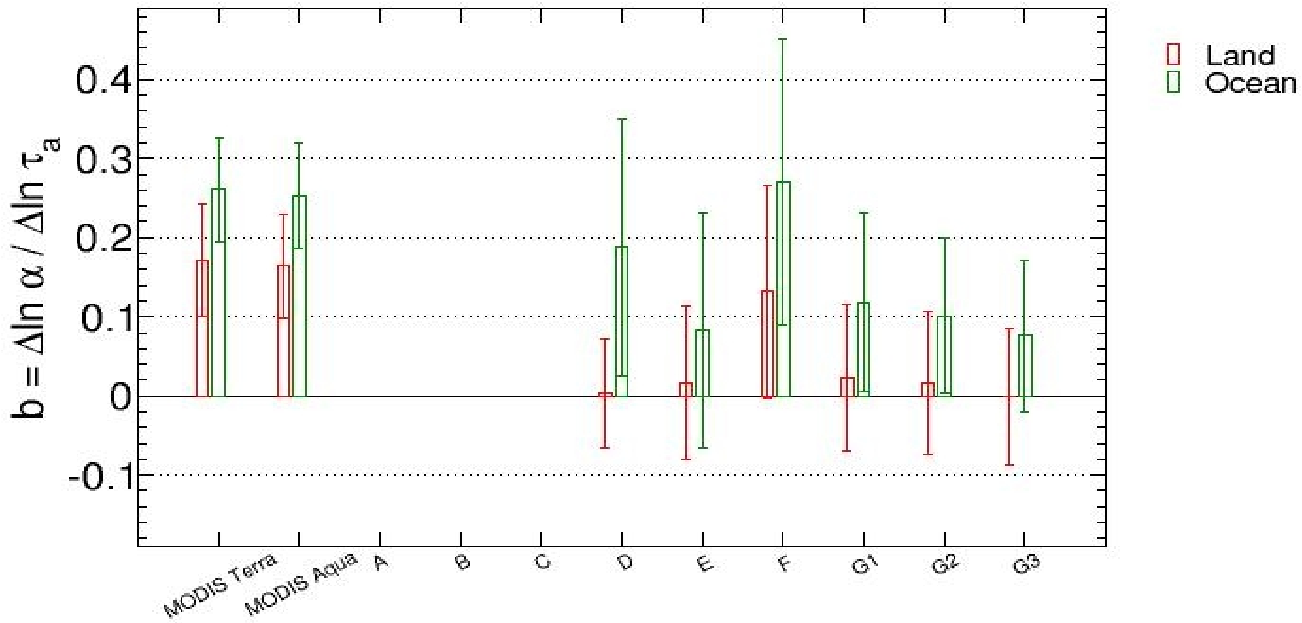
CERES/MODIS:
Forcing is the sum direct + **first** indirect effect from Quaas et al. (2008)



od550 (PD) –
od550 (PI)

“Observations”:
Bellouin et al., Nature 2005

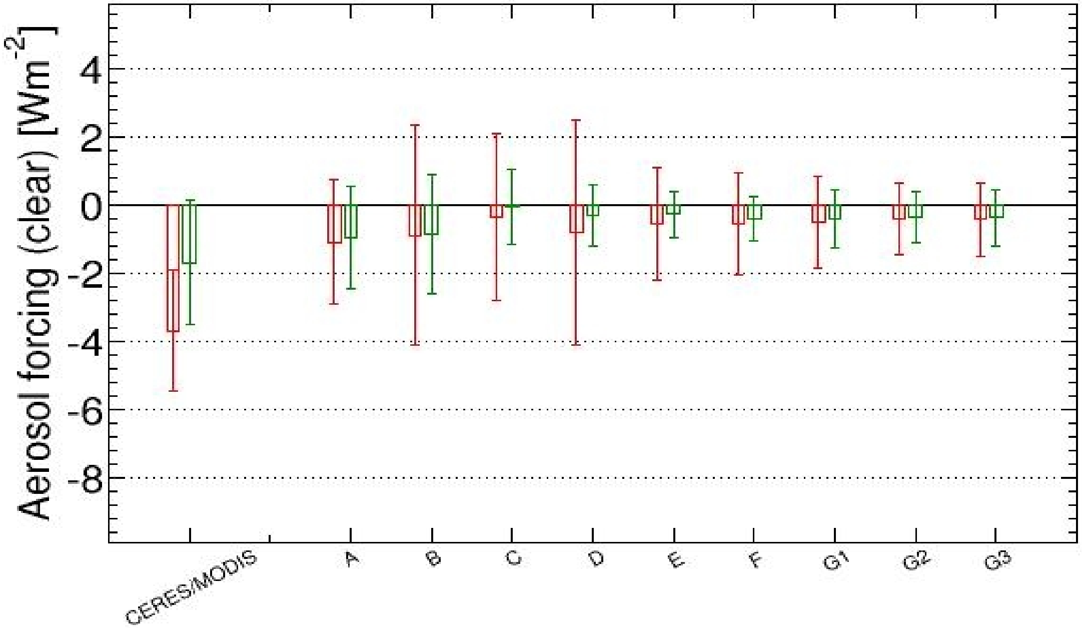
Relationship SW albedo - AOD



All-sky TOA broadband SW planetary albedo

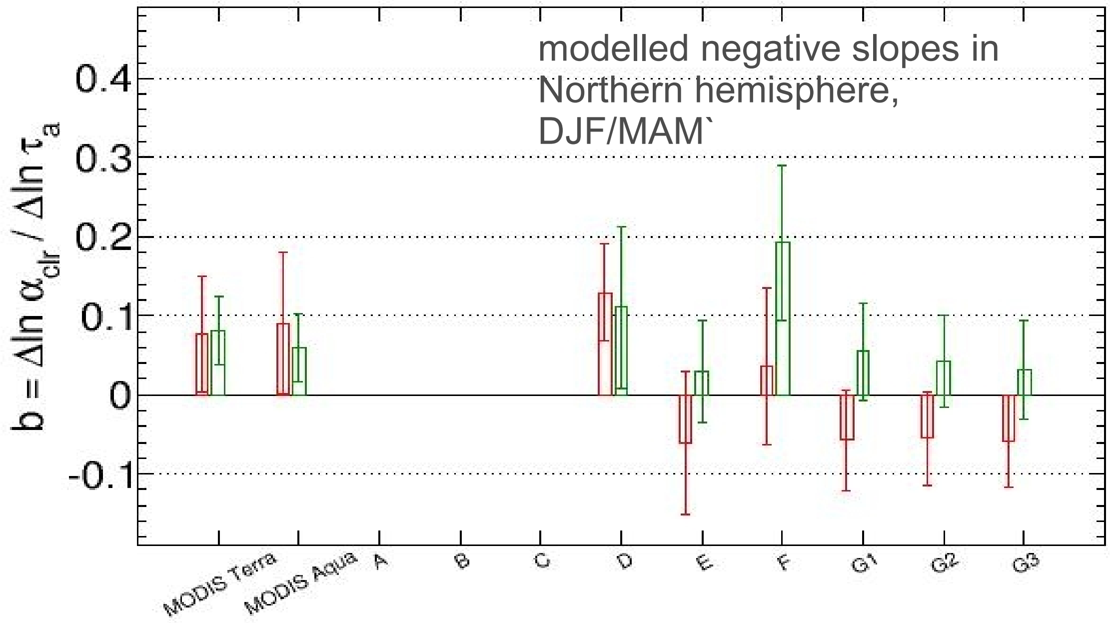
albs

Relationship clear-sky SW albedo - AOD



Models:
Forcing is
rstcs (PD run) –
rstcs (PI run)

CERES/MODIS:
Forcing is the clear sky direct effect from Quaas et al. (2008)



Clear-sky TOA broadband SW planetary albedo

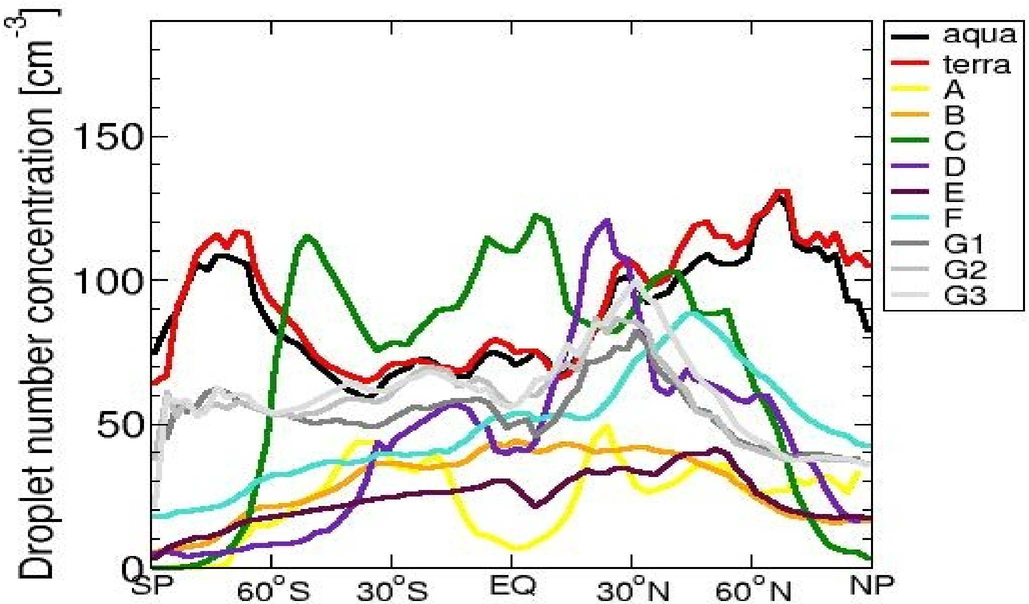
(in models computed as

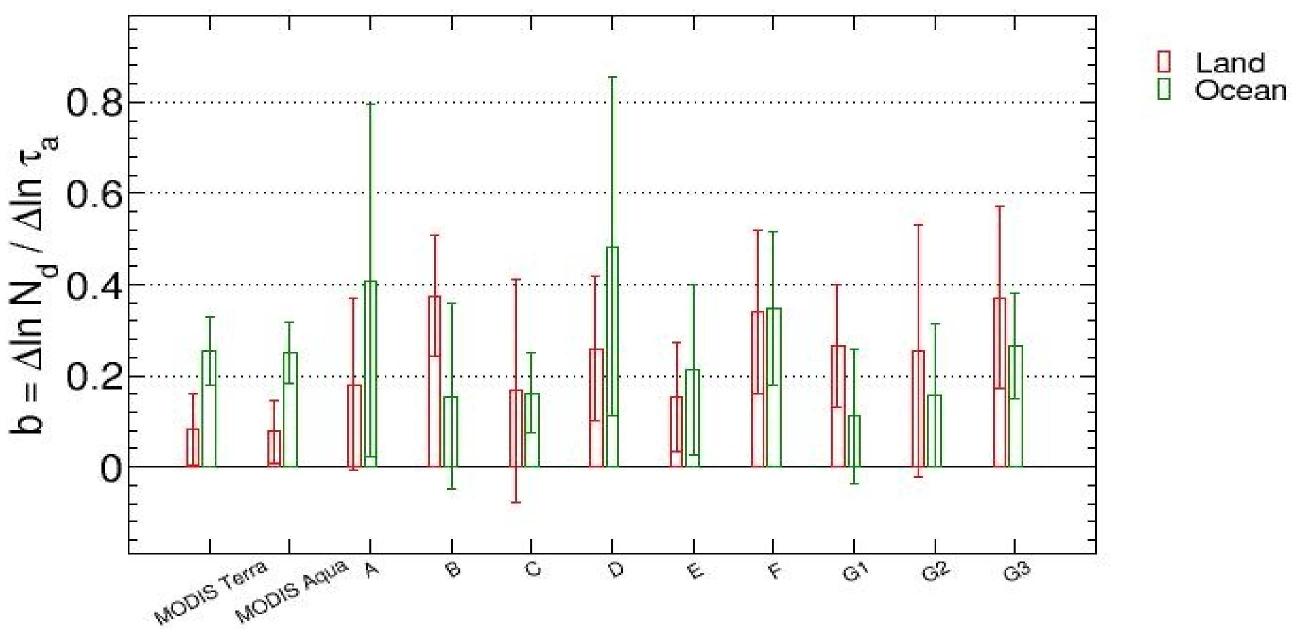
1 – rstcs / rsdt

where rsdt not available computed from albs and rst if available

in CERES obs: computed for pixels with cloud fraction zero)

Cloud droplet number concentration [cm^{-3}]



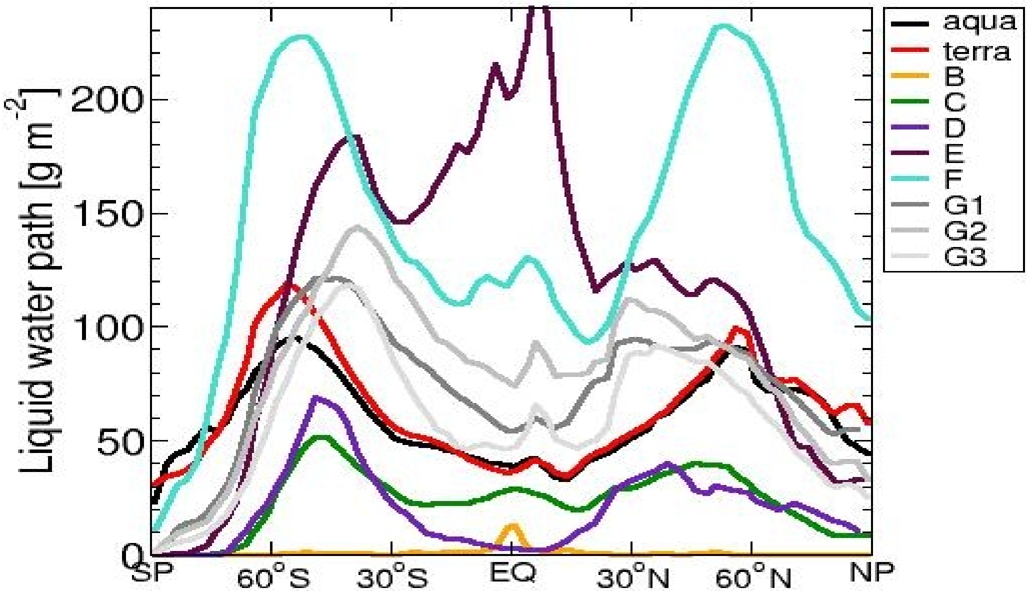


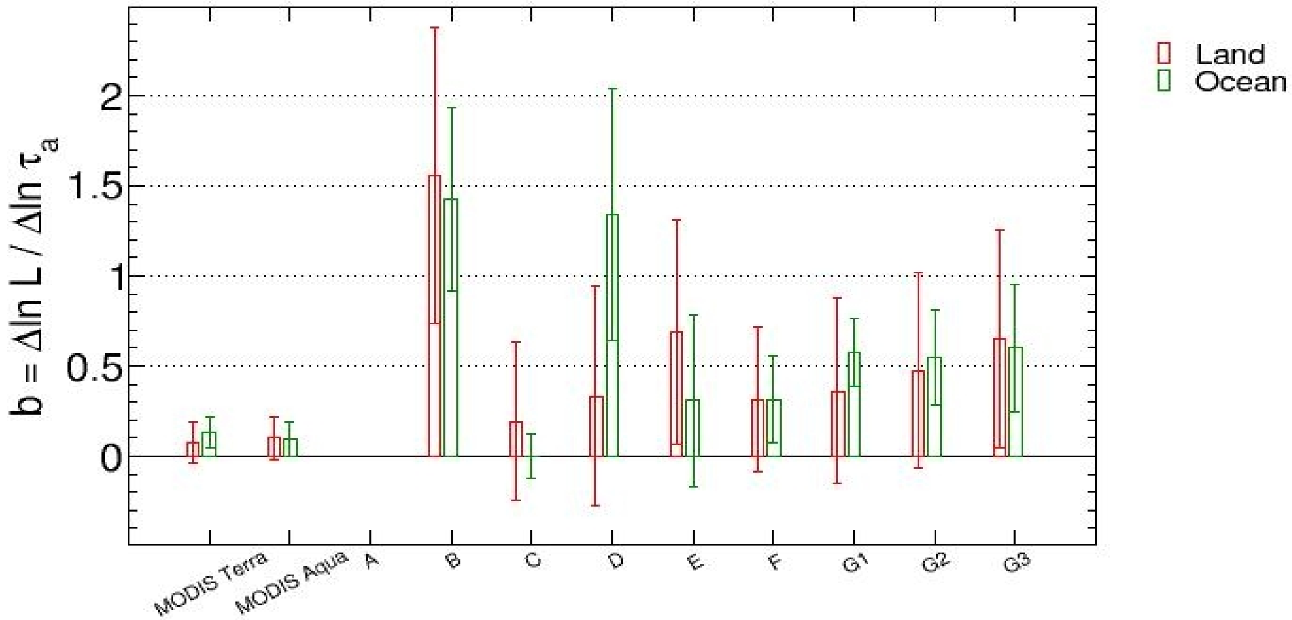
Cloud-top droplet number concentration (liquid clouds)

Models: cdnc

MODIS: Computed from cloud optical depth and cloud-top droplet effective radius assuming adiabatic clouds (Quaas et al., Atmos Chem Phys 2006)

Cloud liquid water path [g m^{-2}]





Cloud liquid water path
lwp

Total cloud cover

Status

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Forcings

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Summary

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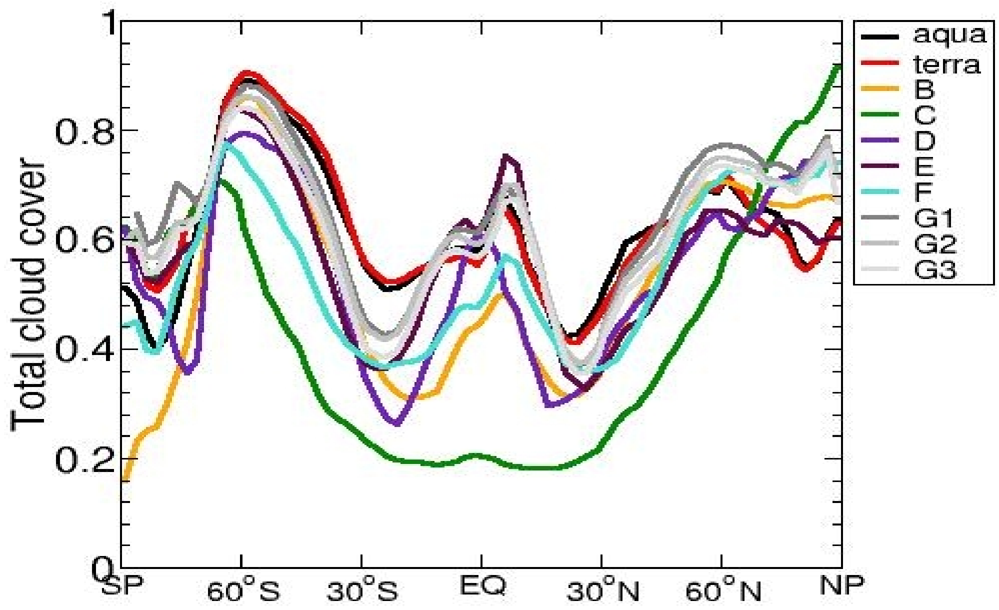

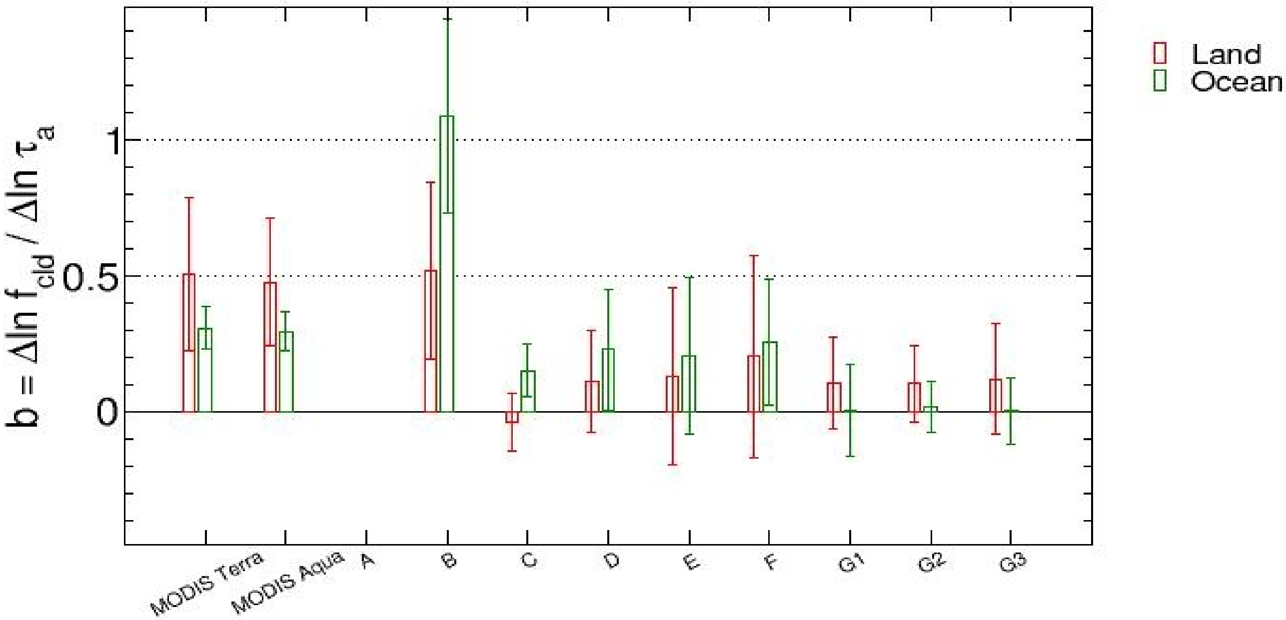

Total cloud cover
tcc

Cloud top temperature [K]

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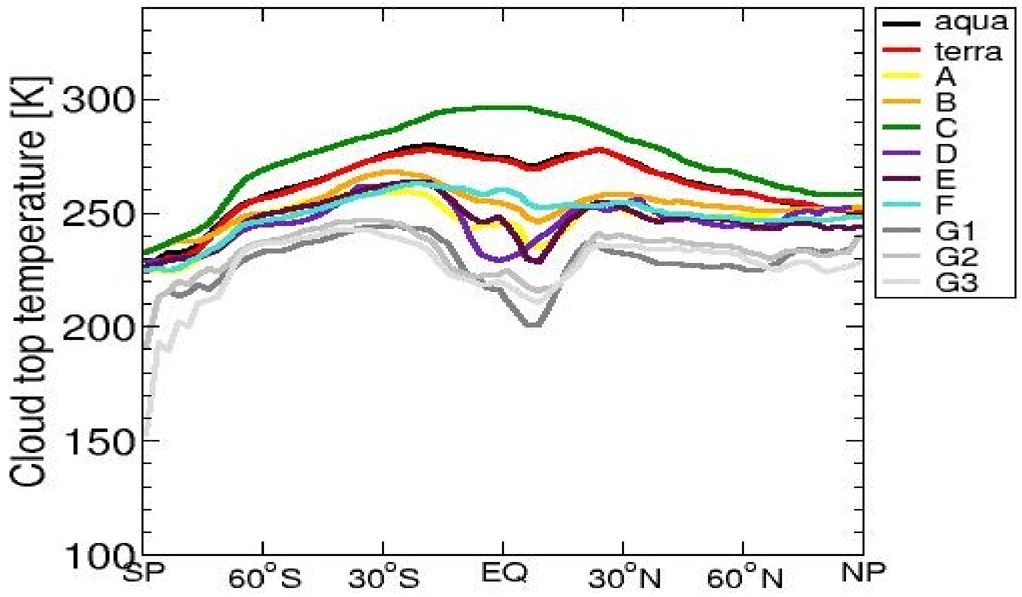
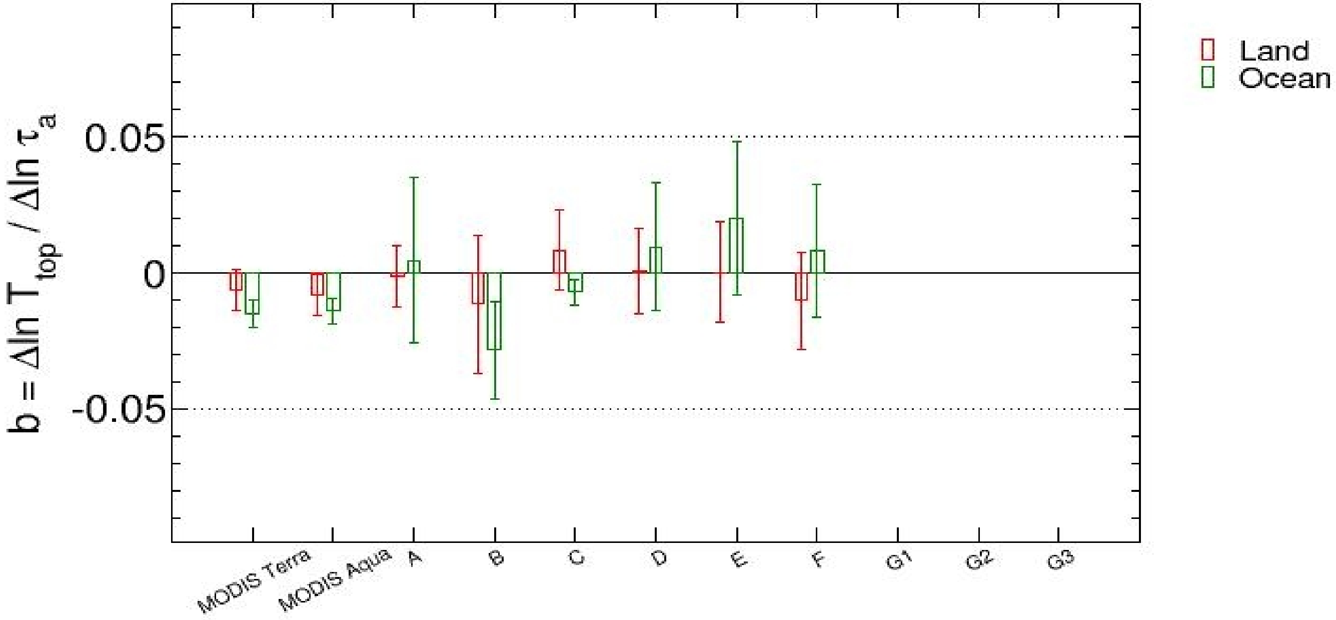
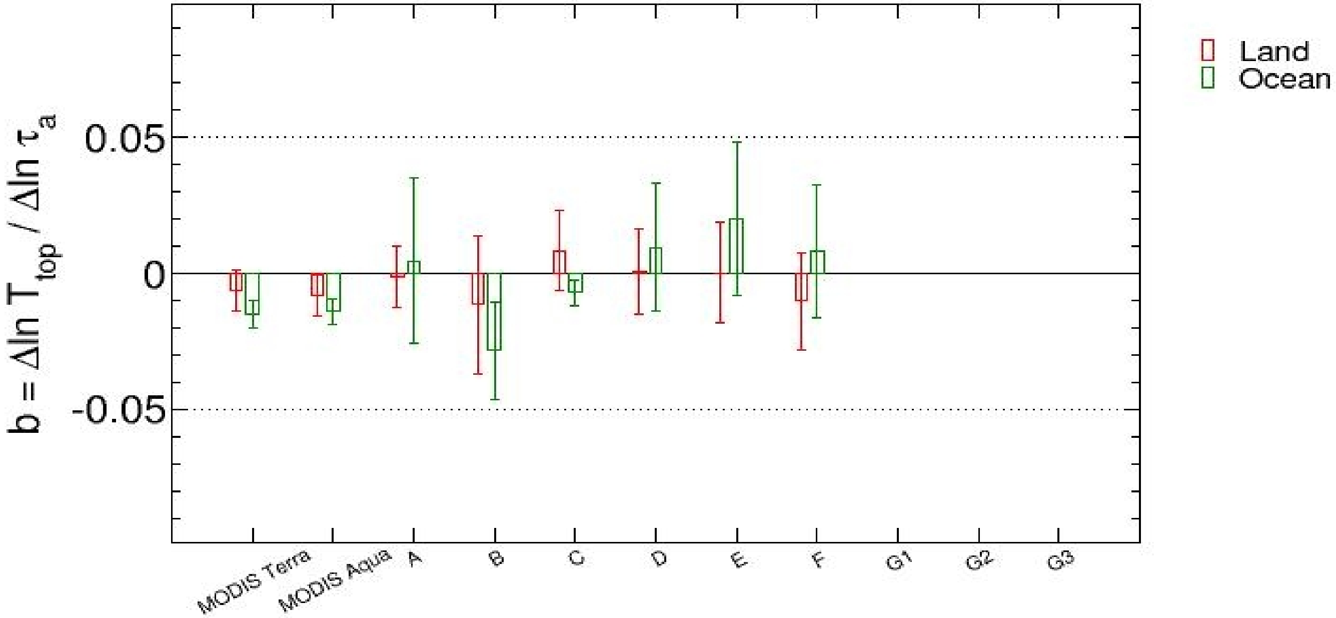


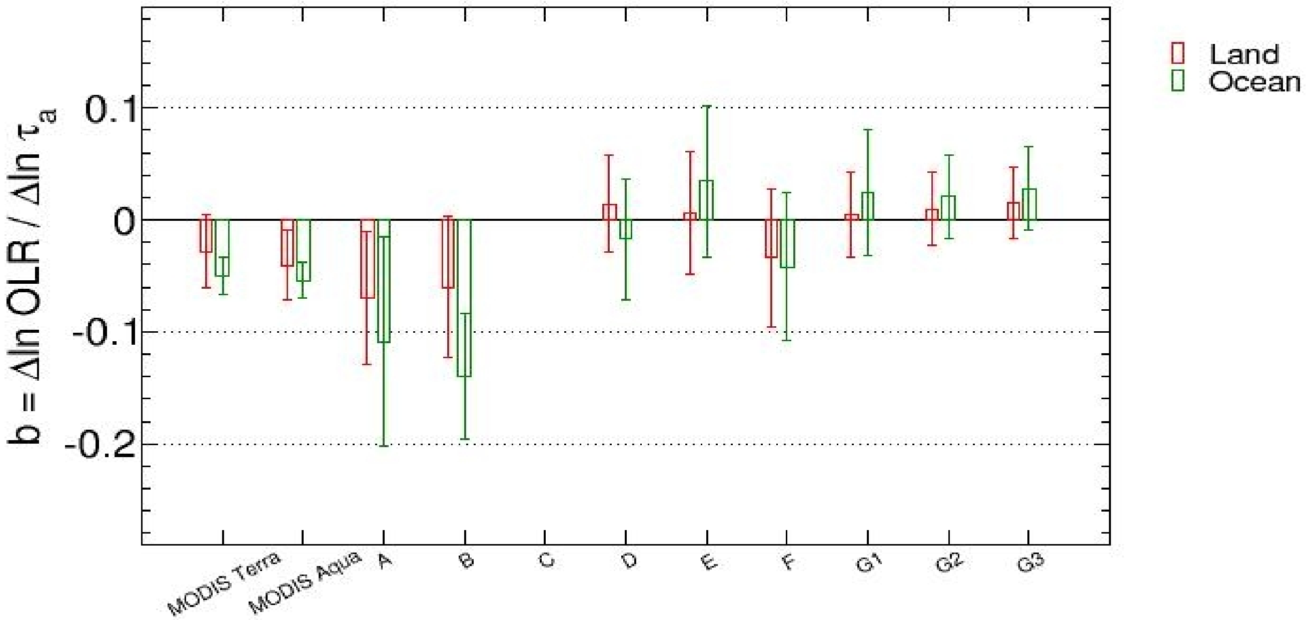


Cloud top temperature [K]
ttop

Cloud top temperature [K] and OLR [W m^{-2}]



Cloud top temperature [K]
ttop



TOA outgoing long-wave radiation [Wm-2]
rlt

Summary

		Terra	Aqua	A	B	C	D	E	F	G1	G2	G3
Albedo – AOD	land	**0.18**	**0.17**				0.074	0.11	**0.18**	0.09	0.10	0.09
	sea	**0.25**	**0.25**				0.19	0.15	0.30	0.14	0.12	0.11
Clear-sky albedo – AOD	land	**0.094**	0.113				0.070	0.040	0.129	0.030	0.035	0.038
	sea	**0.082**	0.067				0.105	0.049	0.189	0.073	0.066	0.060
TCC – AOD	land	**0.61**	0.52		**0.61**	0.09	0.17	0.31	0.42	0.18	0.16	0.24
	sea	**0.30**	**0.29**		1.04	0.15	**0.30**	**0.31**	**0.32**	0.11	0.08	0.08
LWP – AOD	land	**0.12**	0.15		1.75	0.42	0.76	0.91	0.46	0.55	0.64	0.75
	sea	**0.15**	0.12		1.30	**0.12**	1.26	0.58	0.37	0.55	0.52	0.63
CDNC – AOD	land	**0.11**	0.09	0.21	0.37	0.25	0.25	0.17	0.31	0.29	0.31	0.39
	sea	**0.26**	**0.25**	0.41	**0.25**	0.15	0.48	**0.23**	0.36	0.21	**0.25**	0.30

- most models slightly underestimate sensitivity of albedo to AOD

sensitivity slightly weaker / much weaker (less than ½) / **equal** / slightly stronger / much stronger (more than x2) than in data

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- most models slightly underestimate sensitivity of **albedo** to AOD
- most models strongly (land) / slightly (oceans) underestimate sensitivity of **clear-sky albedo** to AOD

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- models strongly overerestimate sensitivity of **liquid water path**
- models strongly overerestimate (land) / simulate relatively well (oceans) sensitivity of **CDNC** to AOD

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Preliminary conclusions

- seven models (4 US, 2 Europe, 1 Japan; one in 3 realisations; forcing -2.6 to -0.6 W m^{-2})
- compared zonal mean fields and statistical relationships to satellite observations

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- **overall aerosol effect / albedo sensitivity** (slightly) underestimated
- **Twomey effect** good over sea / overestimated over land
- **2nd indirect effect**: sensitivity of cloud cover underestimated / sensitivity of LWP overestimated

Preliminary conclusions

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- **overall aerosol effect / albedo sensitivity** (slightly) underestimated
- **Twomey effect** good over sea / overestimated over land
- **2nd indirect effect**: sensitivity of cloud cover underestimated / sensitivity of LWP overestimated
- All models do show **positive correlation between TCC and AOD**, over sea good agreement for some models with data
- Some models show a **thermodynamic effect** (relation cloud-top temperature – AOD, OLR – AOD) consistent with data

Thank you

http://wiki.esipfed.org/index.php/Indirect_forcing

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