Minimizing the effects of aerosol swelling and wet scavenging in ECHAM6-HAM2 for comparison to satellite data

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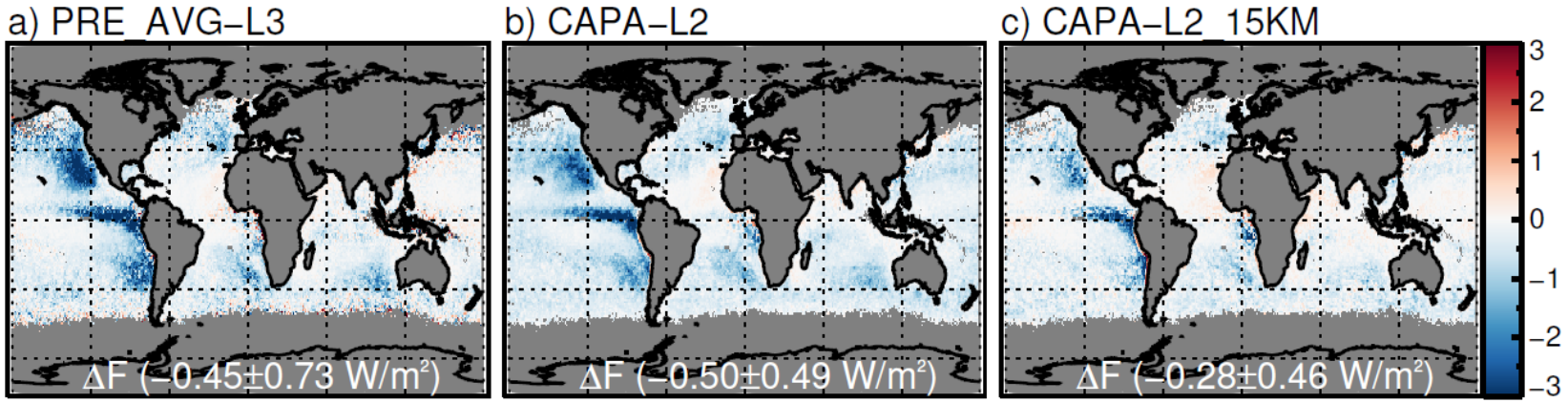
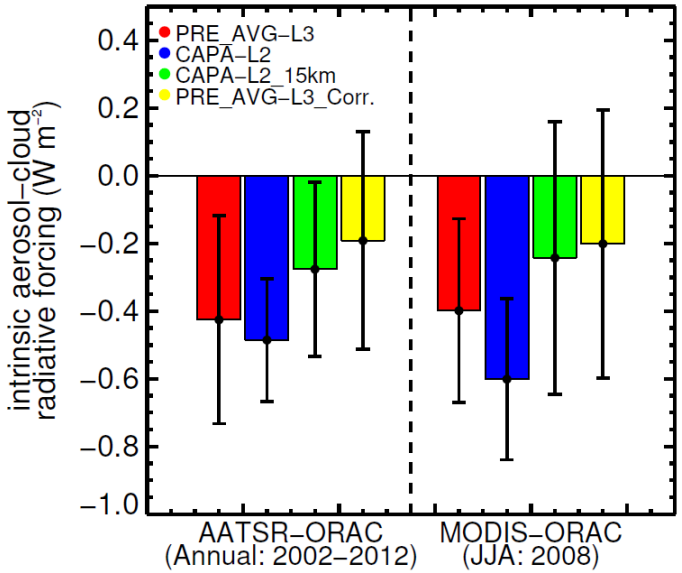
aerosol cci

Cloud contamination in satellite products enhances the aerosol indirect forcing estimate





- Near cloud aerosol retrievals possibly influenced by: aerosol swelling; misclassification of cloud particles; 3D effects near cloud edges
- Marked reduction in aerosol forcing by excluding near cloud aerosol

Figures from Christensen et al., 2017, ACP, accepted

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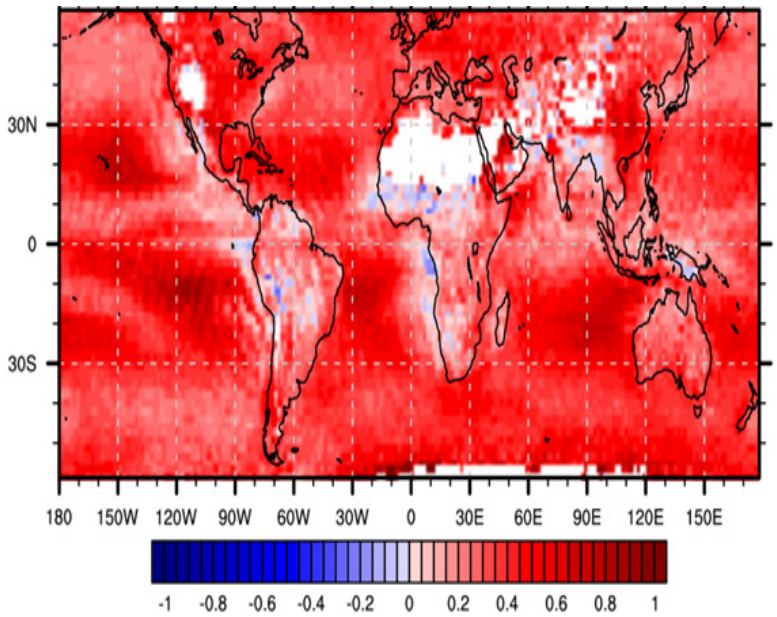
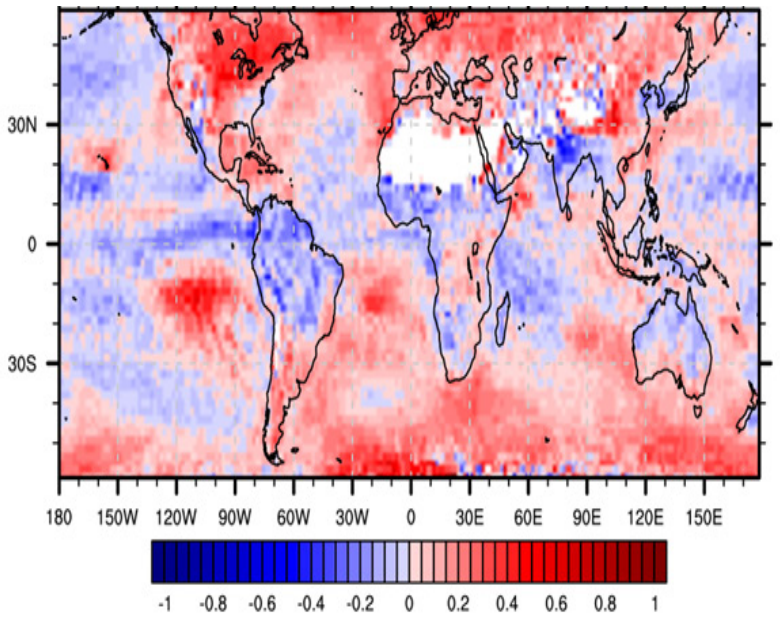
Aerosol swelling

- Global model resolution is typical 100x100 km
- Water uptake of aerosol is known → dry aerosol index (AIdry)

ECHAM6-HAM2_Ref – dln(LWP)/dln(AI)



ECHAM6-HAM2_Ref – dln(LWP)/dln(AIdry)



low liquid clouds; 3-hourly instantaneous data; 1995-2012;
susceptibilities are computed for each season and grid point; 60°N-60°S

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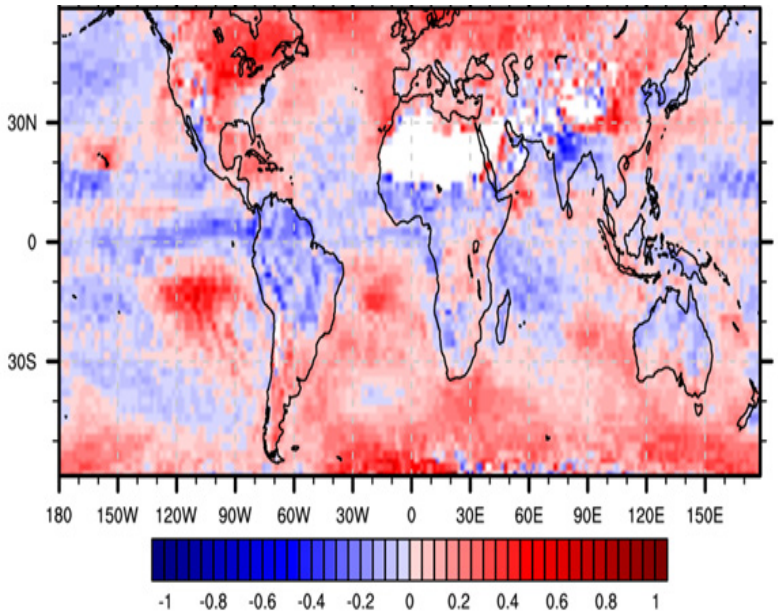
Wet scavenging

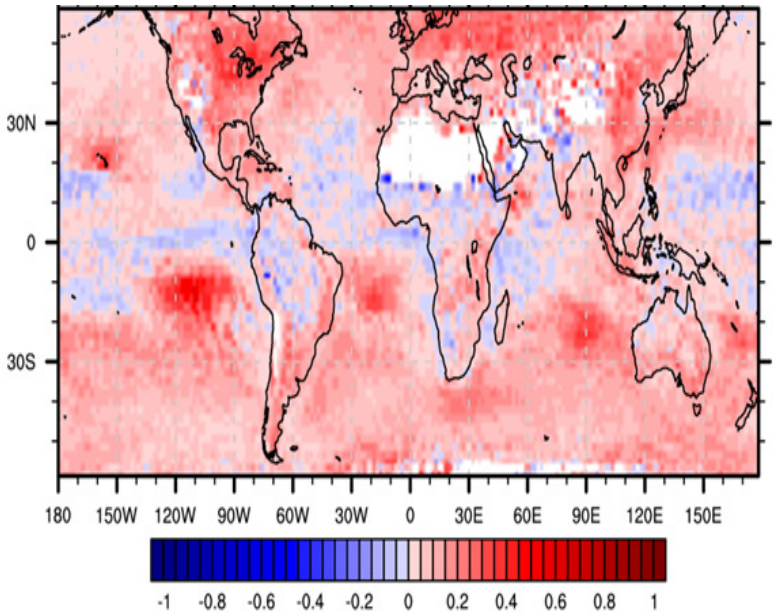
- Removing raining scenes reveals the cloud lifetime effect
- Moderate and heavy precipitation cause a lasting impact on AIdry

ECHAM6-HAM2_Ref – dln(LWP)/dln(AIdry)



ECHAM6-HAM2_Ref – dln(LWP)/dln(AIdry)

non-raining (precipitation < 0.5 mm / day)



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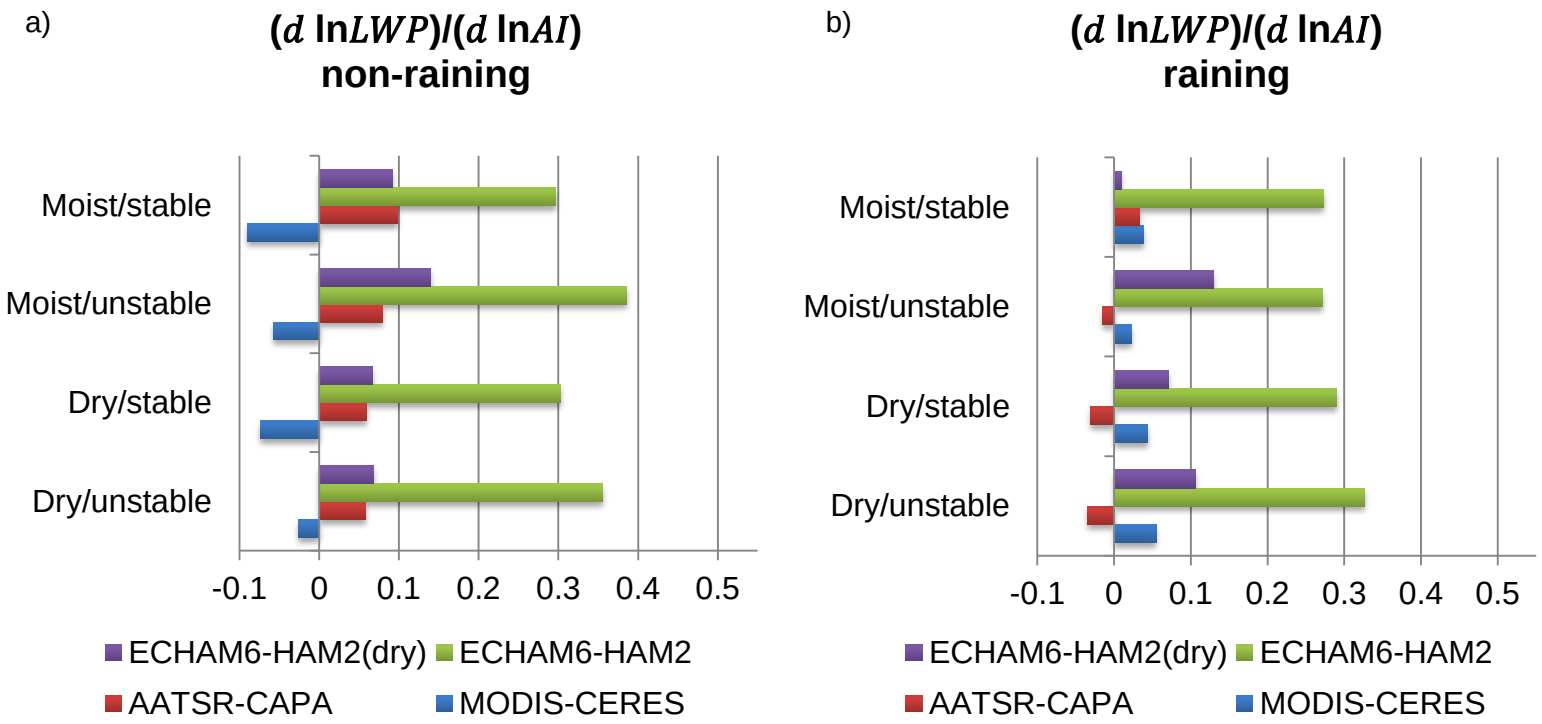
Environmental regime composites



Regimes defined by:

- Precipitation state: Non-raining: precip. < 0.5 mm/day; Raining: precip > 0.5 mm/day
- Free tropospheric relative humidity (RH_{FT}): Dry: RH_{FT} < 40%; Moist: RH_{FT} > 40%
- Lower tropospheric stability (LTS): Unstable: LTS < 17K; Stable: LTS > 17K

Average over global oceans

MODIS-CERES data from Christensen et al. (2016)

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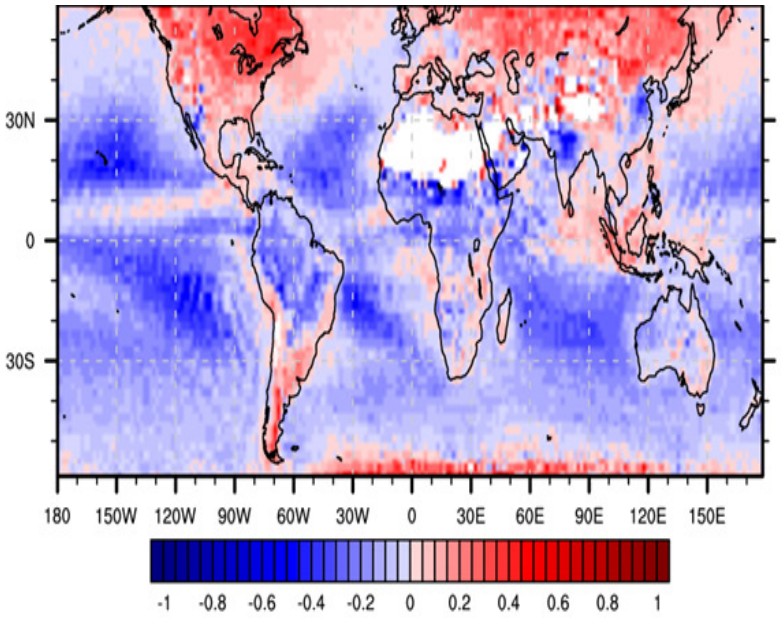
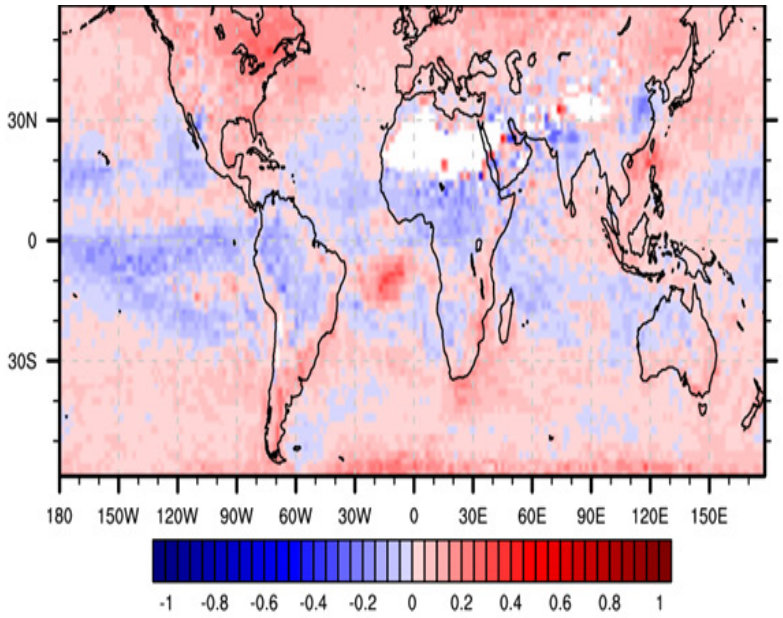
In-cloud aerosol processing

- Aerosol processing increases aerosol size
- AODdry depends less on size than AIdry → less negative susceptibilities

ECHAM6-HAM2_AProc – dln(LWP)/dln(AIdry)
non-raining (precipitation < 0.5 mm / day)



ECHAM6-HAM2_AProc – dln(LWP)/dln(AODdry)
non-raining (precipitation < 0.5 mm / day)



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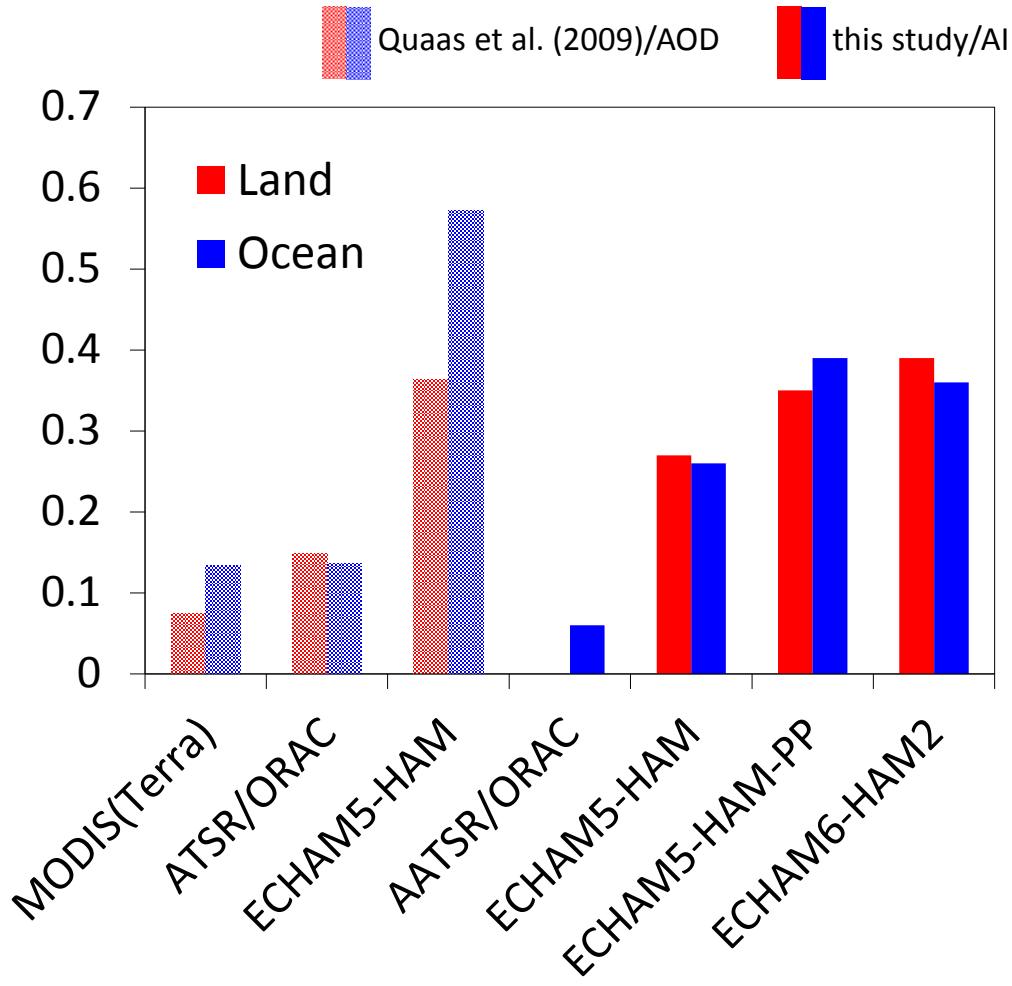
Prognostic vs. diagnostic precipitation scheme

$$\mathrm{ACI_L} = \frac{d \ln LWP}{d \ln \mathrm{AOD/AI}}$$

- Low liquid clouds in this study
- Prognostic precipitation (PP) leads to increased susceptibilities although the accretion/autoconversion ratio is increased (Sant et al., 2015)
- Shift from rain to drizzle of marine stratocumulus



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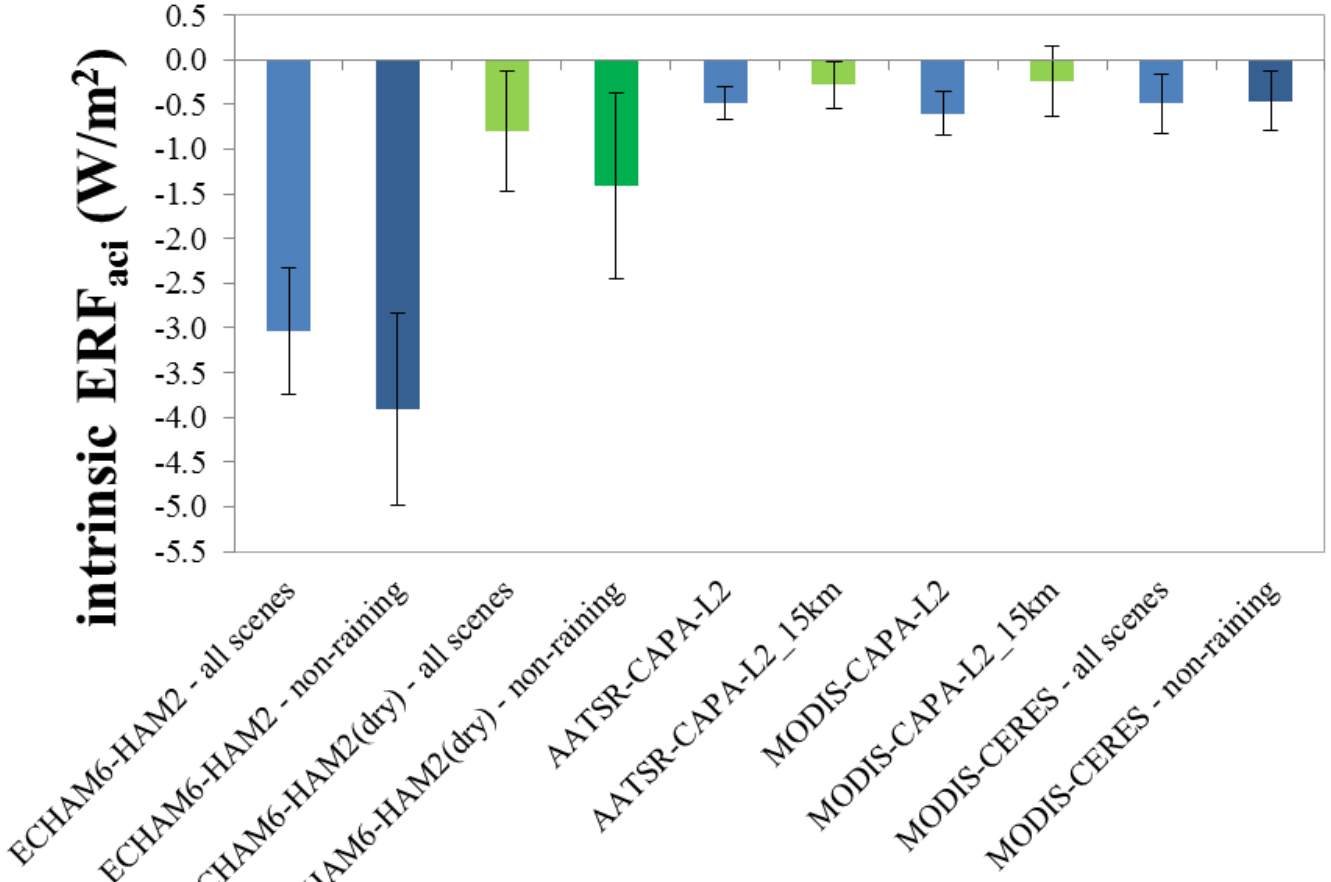
Effective radiative forcing (ERF_{aci}) of low liquid clouds
(average over global oceans)



$$intrinsic\ ERF_{aci} = \overline{LCC_m}\left[\frac{d\alpha_{clr}}{d\ln AI} - \frac{d\alpha}{d\ln AI}\right]\Delta a_{AI} F_d$$

Neubauer et al. (2017), ACP, accepted

AATSR-CAPA and MODIS-CAPA data from Christensen et al. (2017), ACP, accepted
MODIS-CERES data from Chen et al. (2014)

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Summary and Outlook

- **Better to compare the dry aerosol from model simulations to (artefact reduced) satellite data for studying susceptibilities**
- **Smaller ACI_L susceptibility in ECHAM6-HAM2 than in previous studies due to reduced RH impact**
- Smaller ERF_{aci} in ECHAM6-HAM2 for dry than for humid aerosol
- Wet scavening and aerosol processing have an impact
- ACI_L is negative in non-raining scenes for MODIS-CERES but positive for AATSR-CAPA and ECHAM6-HAM2

Thank you for your attention!

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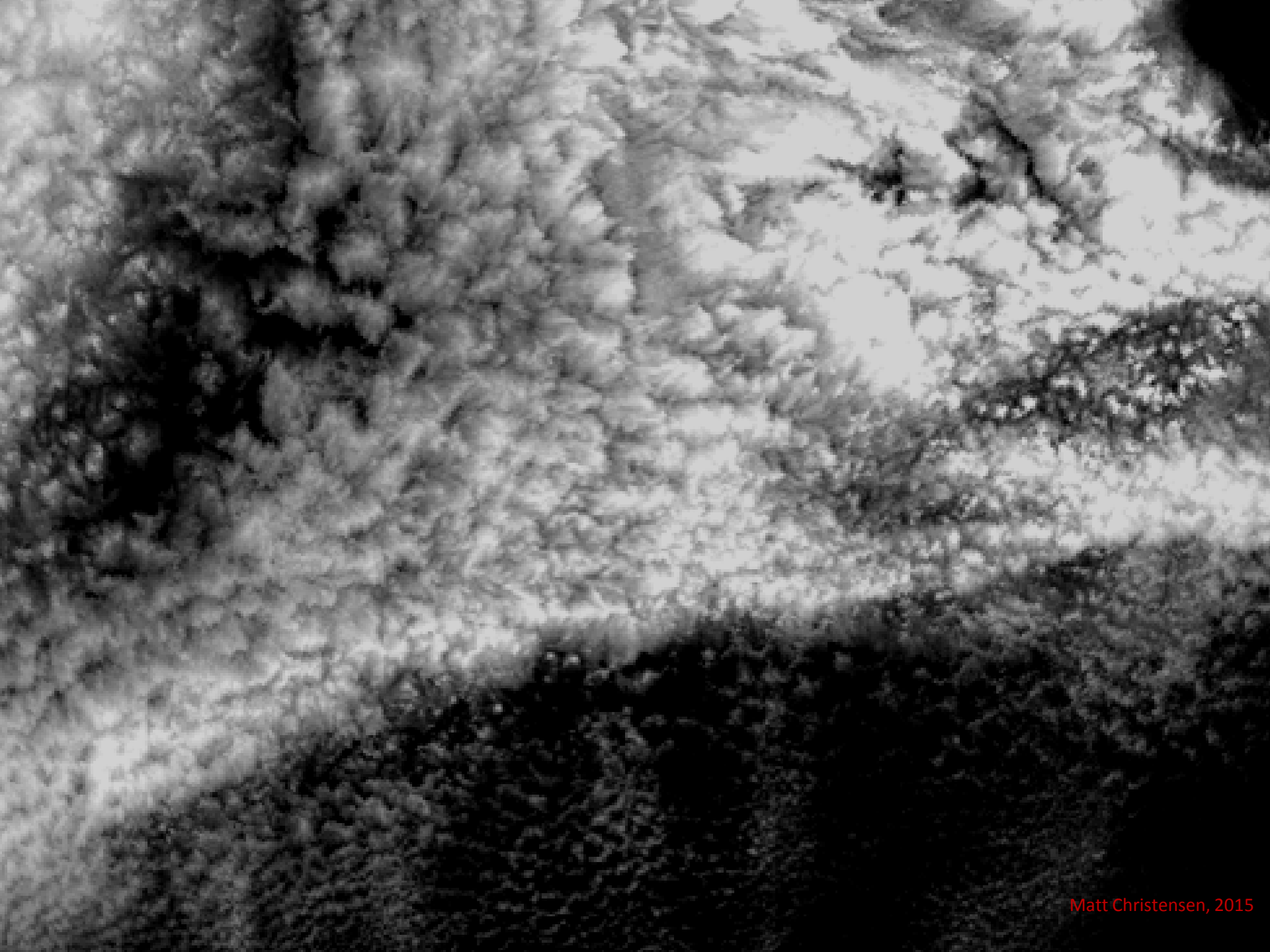
Matt Christensen, 2015