



Atmosphere Monitoring

Copernicus Atmospheric Monitoring Service

Climate Forcings

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Idir Bouarar

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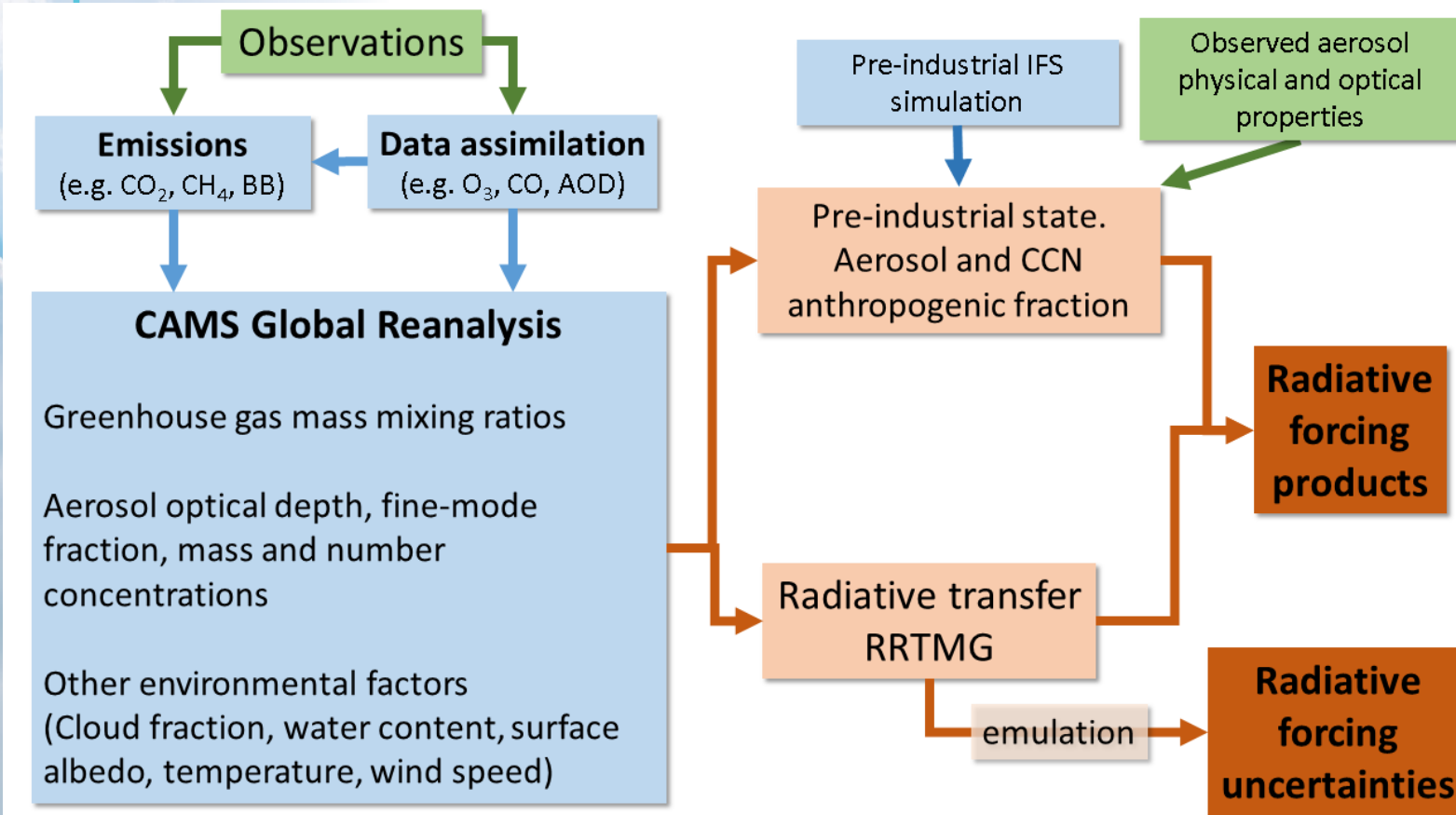
CICERO Oslo: Gunnar Myhre



- The IPCC Assessment Reports provide estimate of radiative forcings for different forcing agents using a variety of methods
 - Global modelling
 - Line-by-line radiative transfer
 - Simplified formulas
 - Observation-based calculations
- CAMS Climate Forcings aims to bring some consistency among radiative forcing estimates
 - Carbon dioxide, methane
 - Tropospheric and stratospheric ozone
 - Aerosol-radiation and aerosol-cloud interactions



Methods

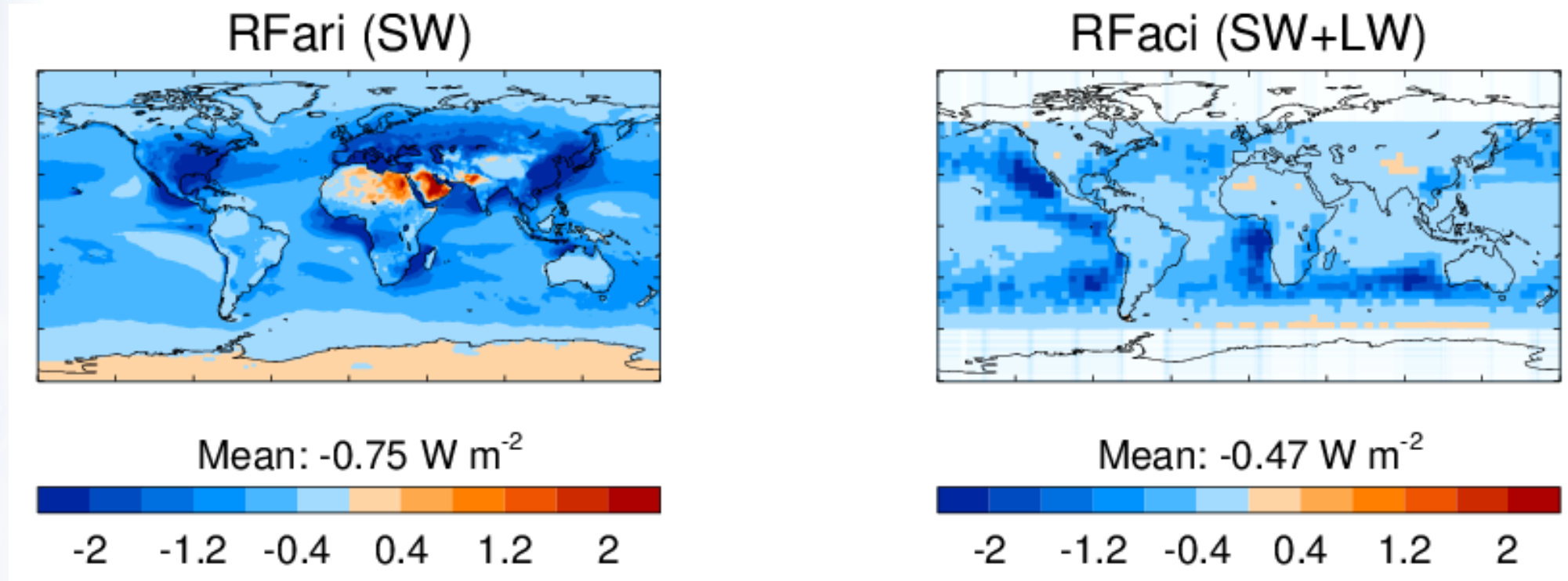


- Use of CAMS Global Reanalysis of atmospheric composition to derive anthropogenic fraction of aerosol optical depth and cloud droplet number
- Offline calculations to estimate radiative forcing
- Account for parametric and structural uncertainties
- No tuning 😊



Results

- RFari and RFaci 2003–2012 with respect to present-day natural



- Uncertainty ranges: -1 to -0.5 W m^{-2} for RFari, -1 to 0 W m^{-2} for RFaci
 - Parameter space could probably be constrained further



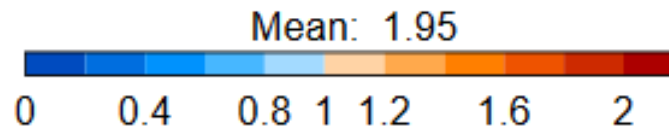
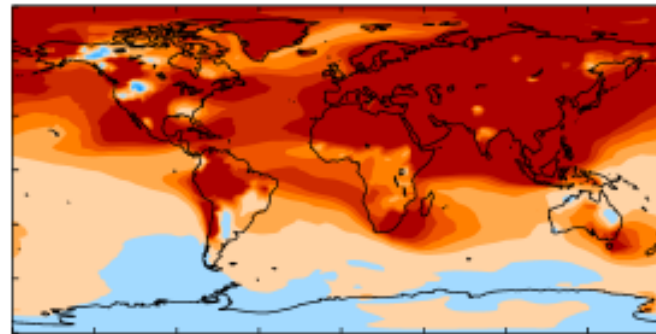
Atmosphere
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Pre-industrial state: Lessons from global modelling

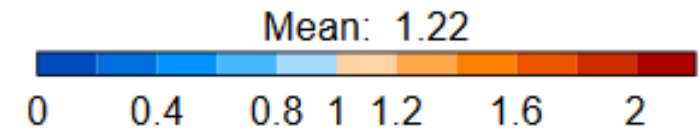
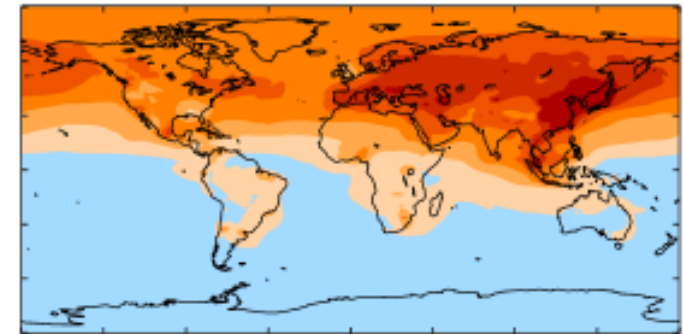
AeroCom 2 models	Anthro. fraction of AOD wrt PI
Without SOA	28%
With SOA	23%

Coming up: marine organics, more biogenics...

Ratio present-day to pre-industrial CDNC in HadGEM3
one moment scheme



two moment scheme



Bellouin et al. (2013)

It is becoming more difficult to exert a perturbation...

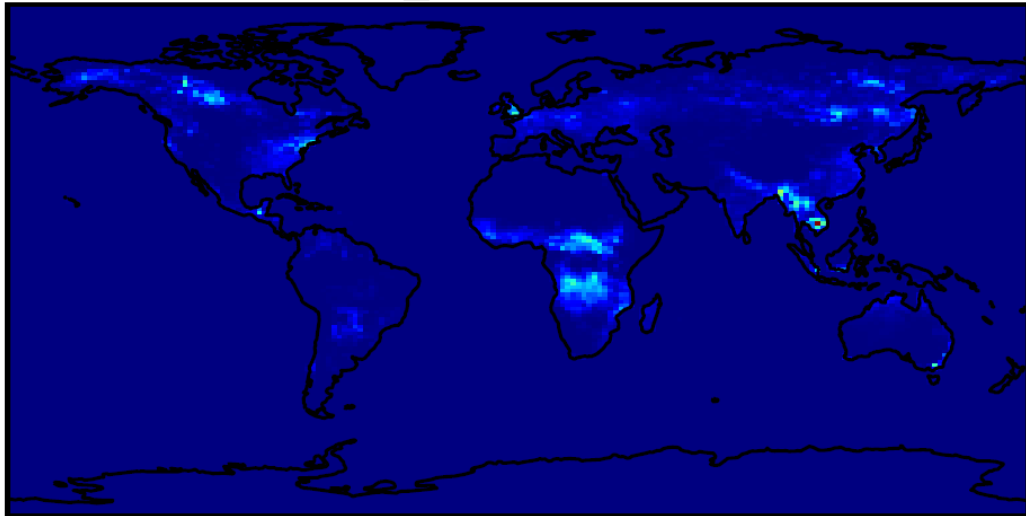


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Use of different pre-industrial states

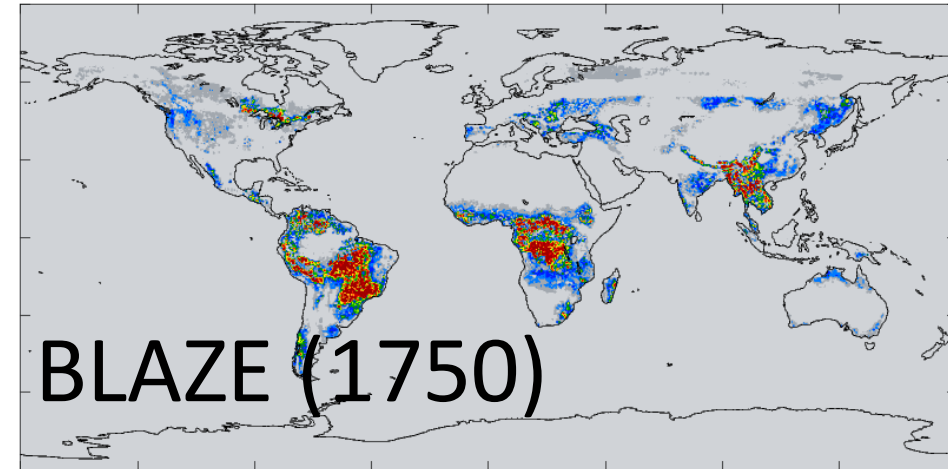
CMIP6 OC_tot emission 1850



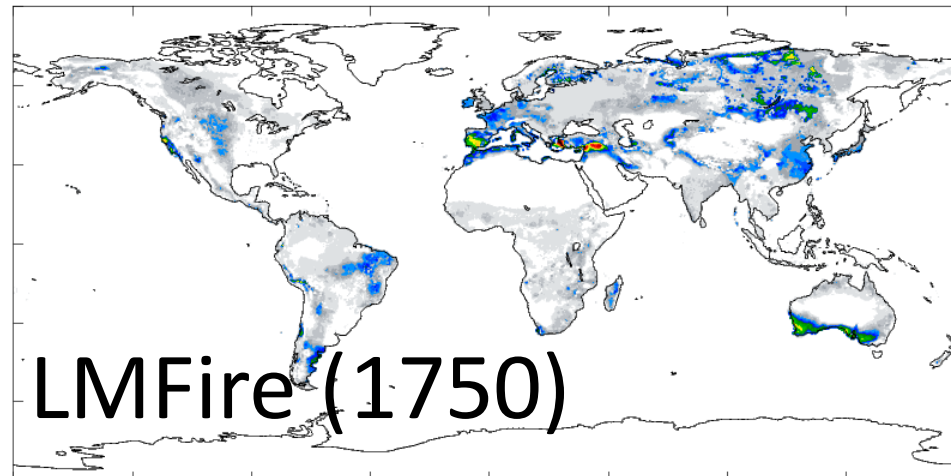
Global total : 17.96 Tg[C]/year



Figure by Steve Rumbold, Met Office



BLAZE (1750)

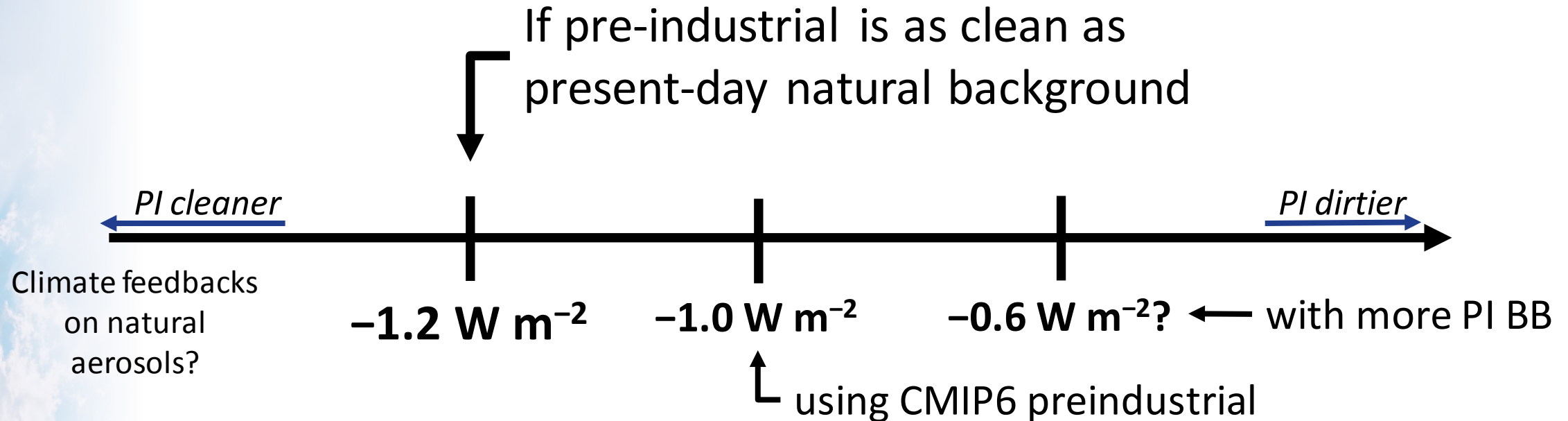


LMFire (1750)

Data from
Douglas
Hamilton and
Chris Smith
U. Leeds



Choose your radiative forcing!



- The pre-industrial reference makes aerosol RF an unanswerable question – but the RF-response-feedback framework is well established.
- Perhaps use a “mythical” pre-industrial based on the present-day natural baseline instead? That would at least make it observable.

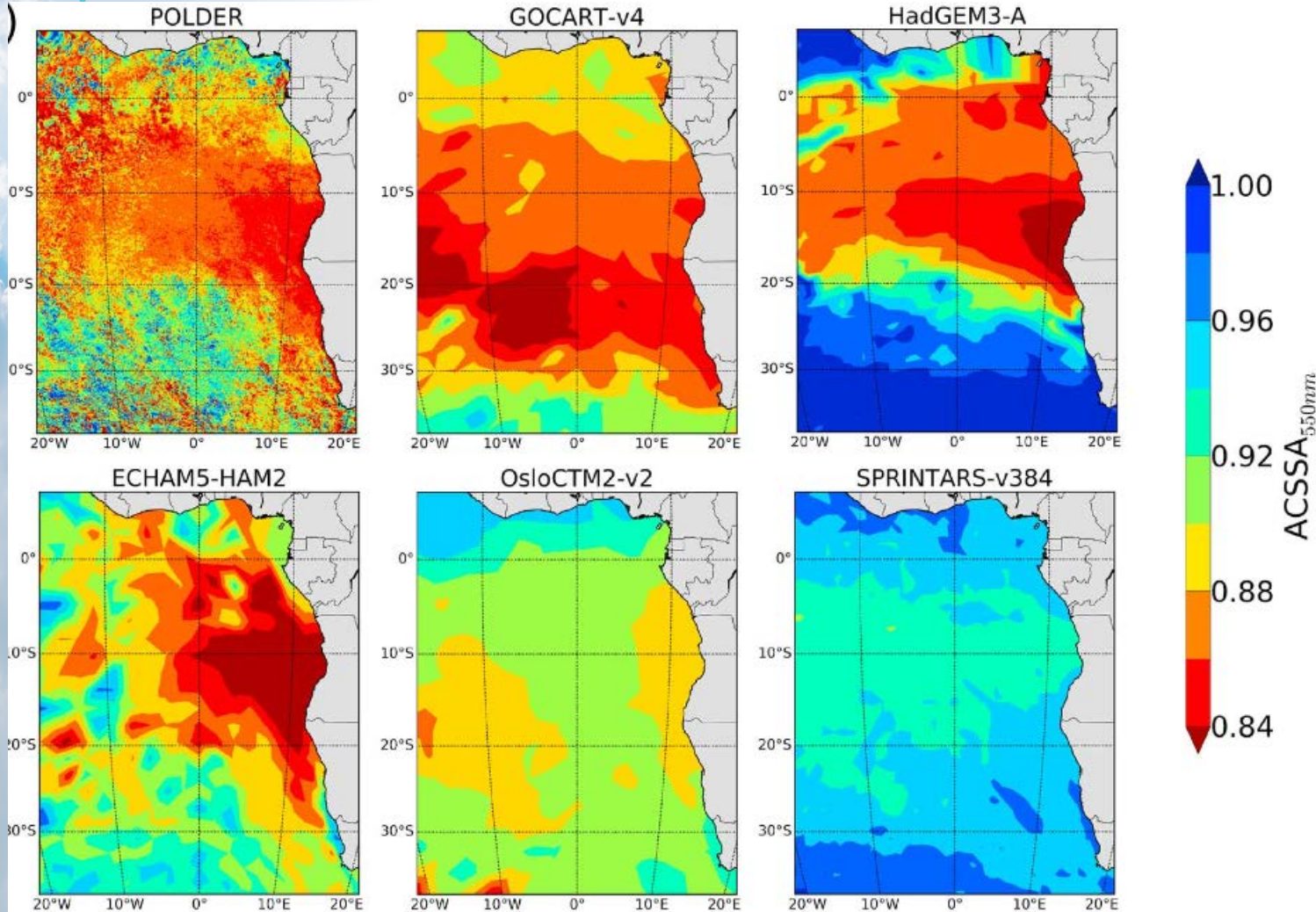


Why our best estimates could be wrong?

- We may under- or over-estimate the anthropogenic fraction
 - Currently at 39% of total present-day, some indications of over-estimate
- We may over-estimate anthropogenic absorption
 - We use AERONET and there are indications it is biased towards more absorbing events
- Cloud albedo may be less strongly dependent on aerosol changes than we think
- We currently neglect rapid adjustments in cloud thickness and cloud fraction, but they may in fact be sizeable



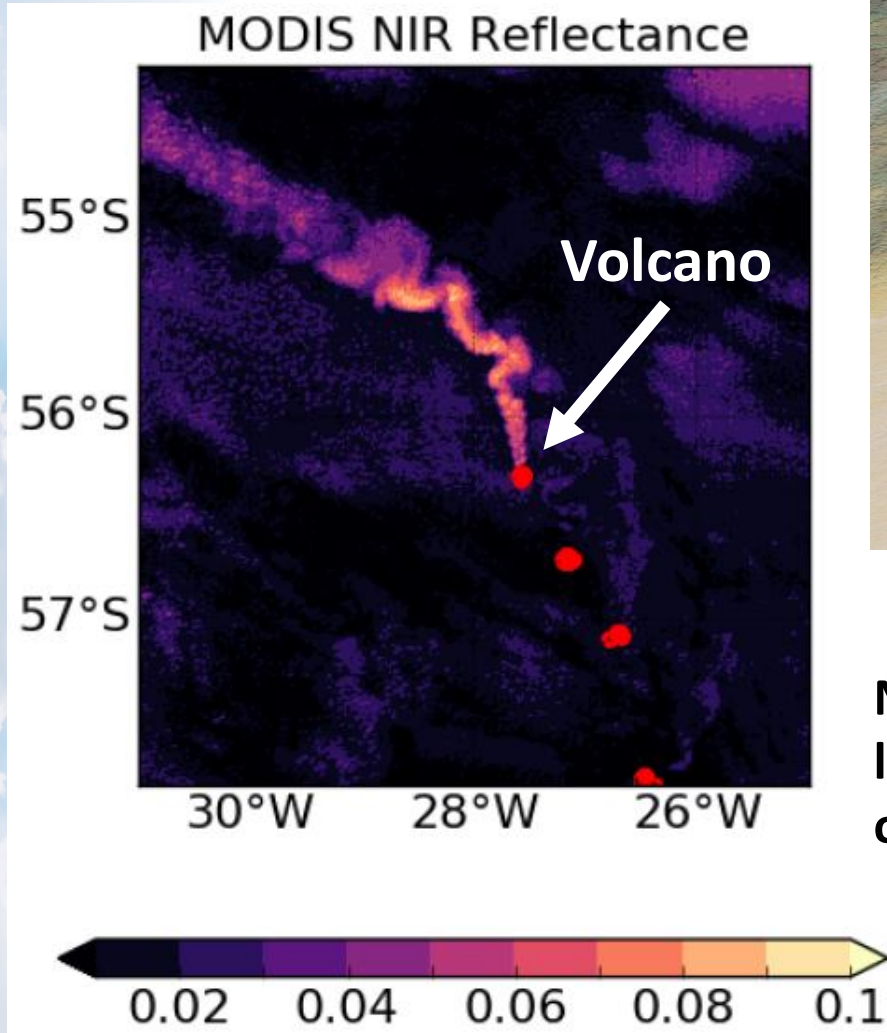
Anthropogenic absorption



- Above-cloud single-scattering albedo from POLDER compared to AeroCom models, Aug-Sep 2006
- Satellite retrievals of single-scattering albedo provide useful constraints on absorption, and we plan to move towards them.
- Aircraft campaigns are also a useful source of absorption constraints.
CLARIFY, ORACLES, ...

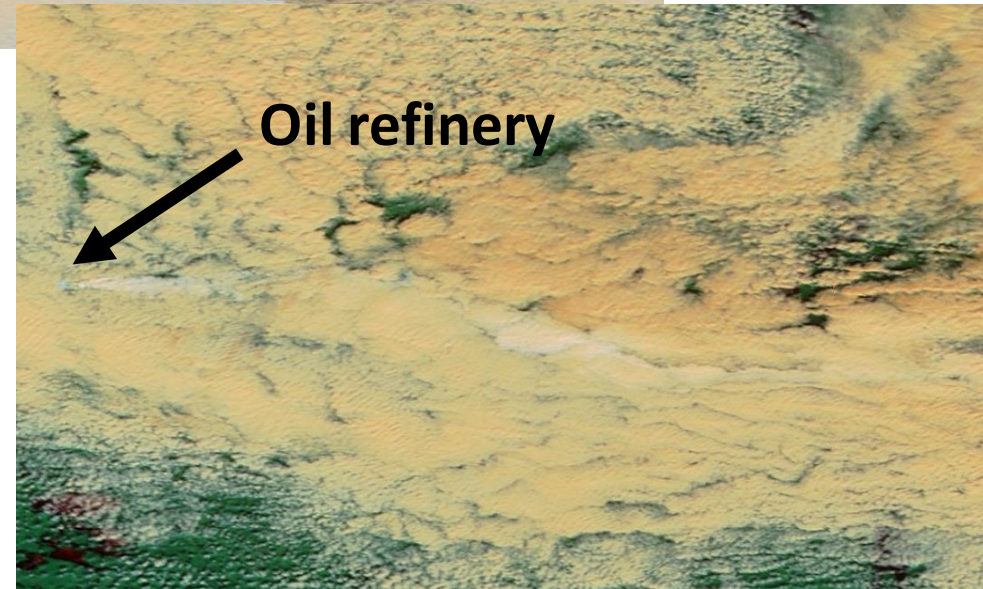


Indirect effects and rapid adjustments: Tracks



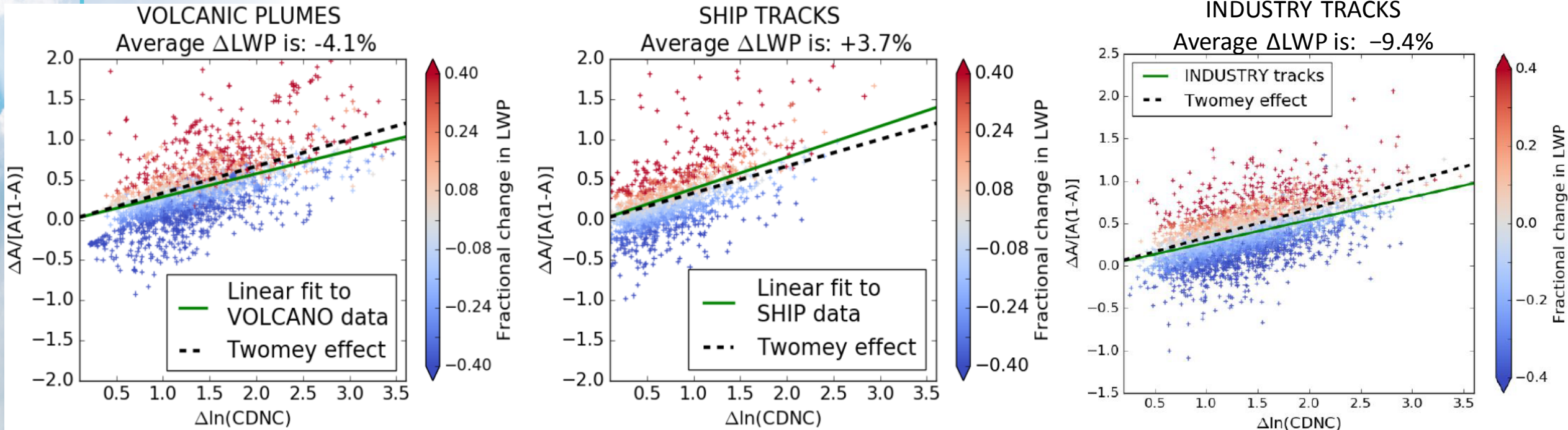
Courtesy
Velle Toll,
U. Reading

Note: Marine and
land stratocumulus
only.





Indirect effects and rapid adjustments: Tracks

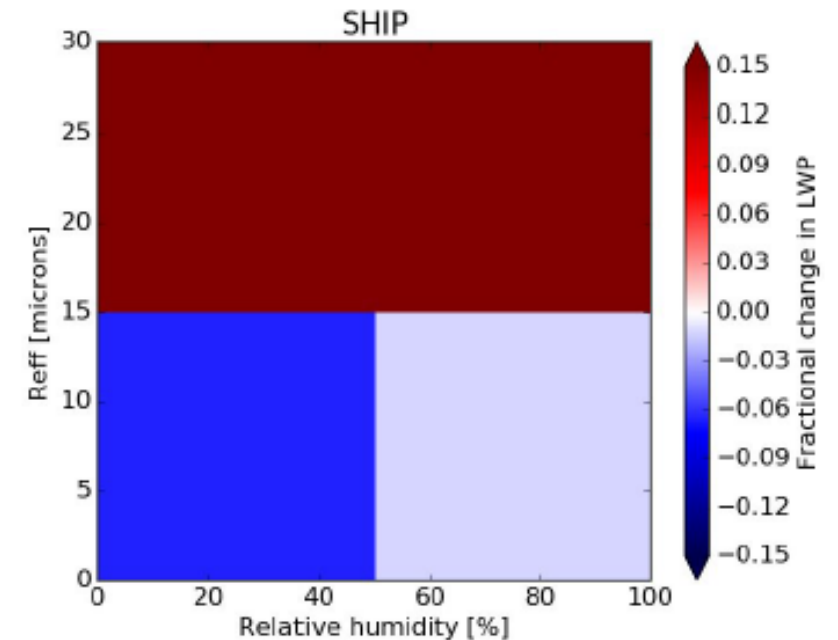
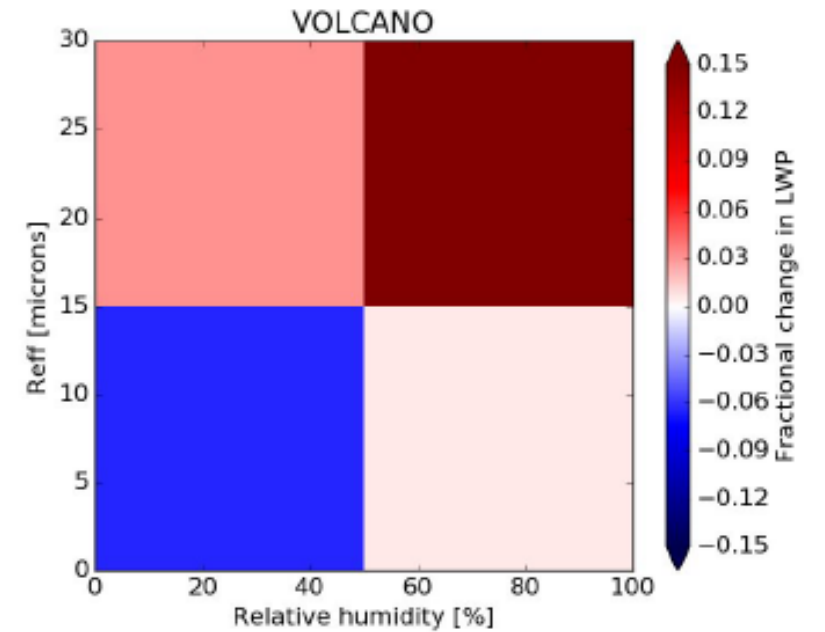


- Cloud albedo response follows the expectations of the Twomey effect
- But no evidence for enhancements from rapid adjustments
 - On average – locally changes of both signs occur
- Toll et al., *Geophys. Res. Lett.*, under review, 2017



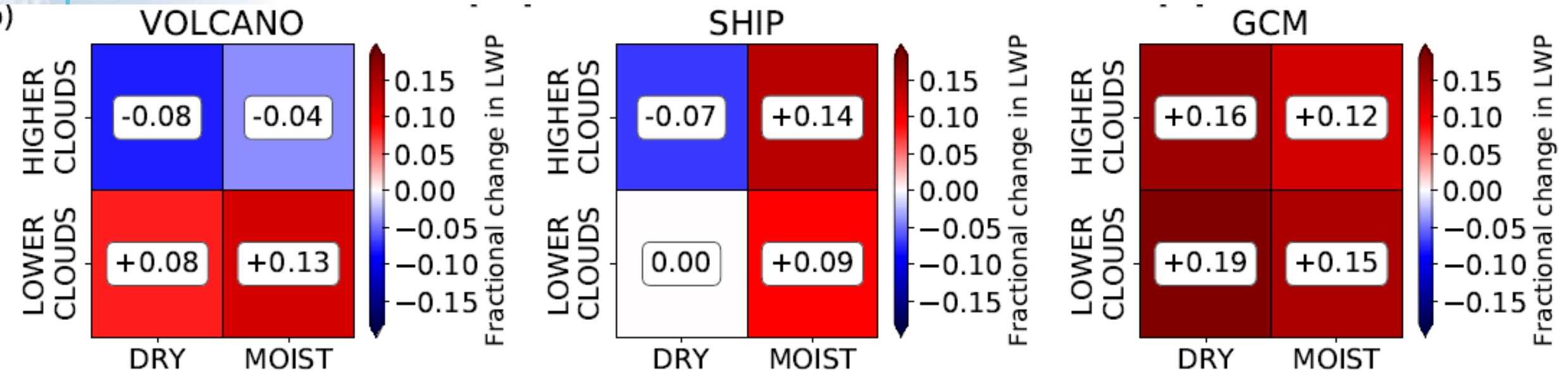
Tracks: driving processes

- Strong decreases in LWP in non-precipitating clouds with dry air aloft.
- Above-cloud relative humidity dependence point to importance of entrainment.
- Response is qualitatively similar to that in Ackerman et al. (2004)





Tracks compared to HadGEM3



- The model response is driven by autoconversion, which means it cannot simulate decreases in LWP.
- So cannot base our estimates on global modelling just yet...



- Nicolas' best estimates and comments

Forcing mechanism	Best estimate and range	Comments
ari	-0.75 [-1 to -0.5]	Strong evidence of its existence. Possibly too strong, unless absorption is indeed overestimated
ari: semi-direct	Not known [*]	Evidence is elusive. ORACLES/CLARIFY?
aci: albedo	-0.47 [-1 to 0]	Good evidence. Liquid clouds only.
aci: LWP	Not known [*]	Good evidence for responses of both sign. But what about convective clouds?
aci: CF	Ed Gryspeerdt: -0.5 Matt Christensen: -0.4	Evidence building up.

[*] Does “in the noise” means “weak radiative forcing”? If not, do we have a chance to separate zero from non-zero?

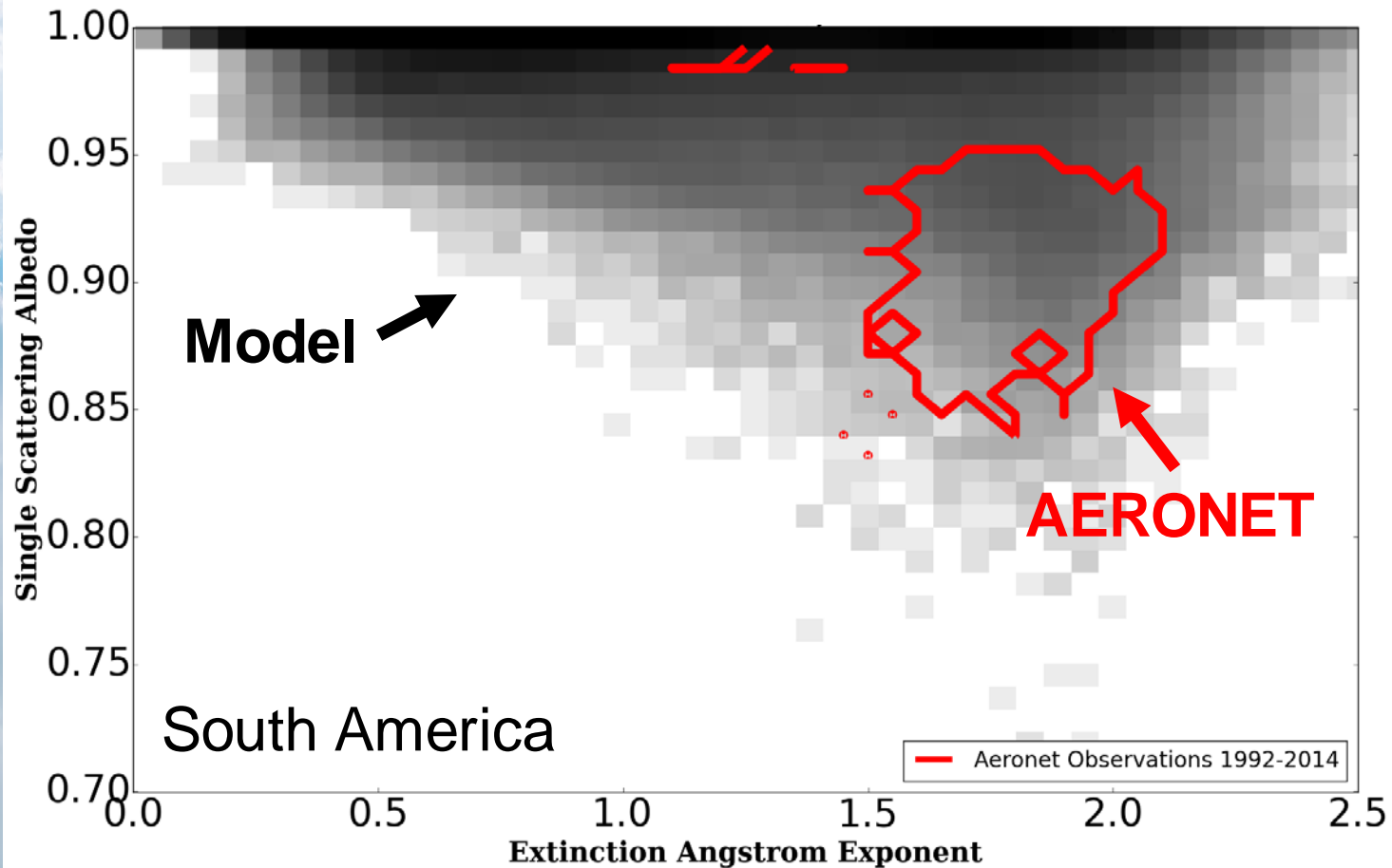


CAMS and AeroCom

- We aim to provide benchmark distributions of aerosol anthropogenic fractions and radiative forcing
 - First series of products at apps.ecmwf.int/datasets/data/cams-climate-forcings
 - Second series of products coming by the end of the year
- We rely on AeroCom and AeroSat science to build confidence in our estimates. The most pressing open questions for us are:
 - Better understanding of the possible range of pre-industrial states
 - Better knowledge of the variance of natural aerosol AOD and CCN
 - Better constraints on absorption
 - Better constraints on rapid adjustments



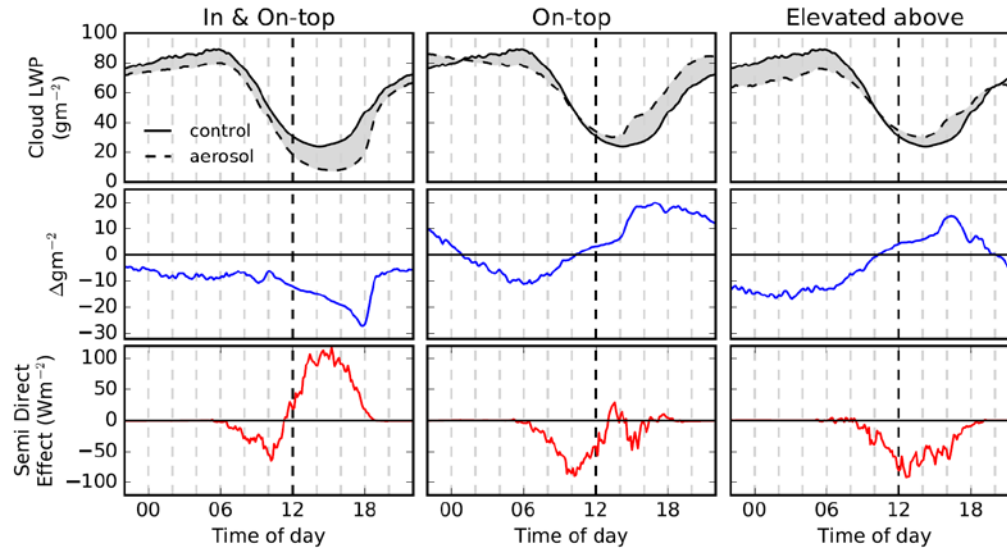
Anthropogenic absorption



- We use AERONET inversions to prescribe SSA.
- AERONET inversions perform best at large AODs and large SZAs
- The more optically diverse aerosol background is not observed, yet contributes more than half of R_{Fari}.
- So AERONET absorption is probably biased high.
- Also Wang et al. (2014), Samset et al. (2014), ...

Semi-Direct effect of BBA on stratocumulus - CLARIFY2017

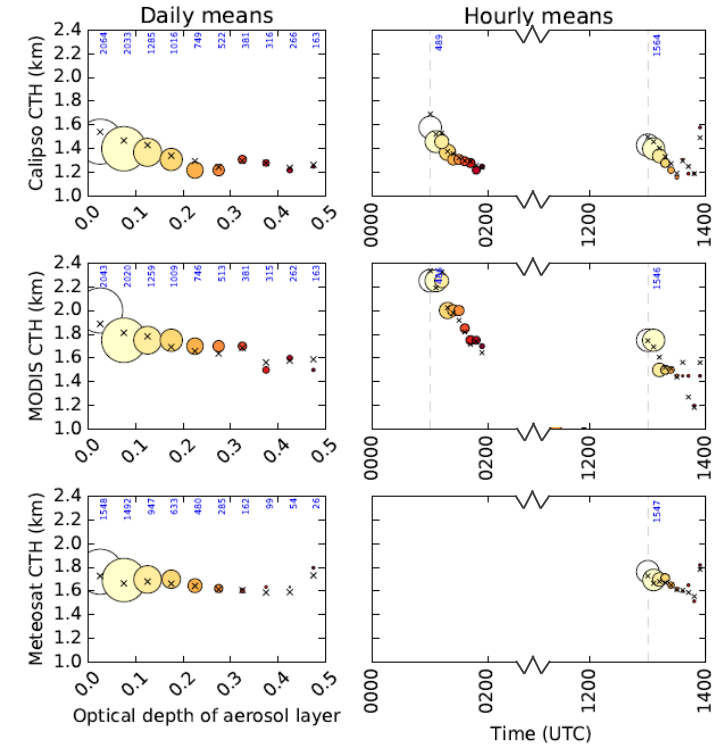
LES modelling - FIRE Sc case (aerosol layer AOD 0.1 and SSA 0.9)



**Semi-Direct effect manifests as a change
in daily mean cloud properties
but also as a change in diurnal cycle**

**Position of the elevated aerosol layer
(gap between cloud top and aerosol layer)
appears to play important role**

Identifying SD effect in satellite products



**Use co-located satellites to identify
cloud-radiation interactions**

**Using CALIPSO to subset scenes
when aerosol is above cloud only**