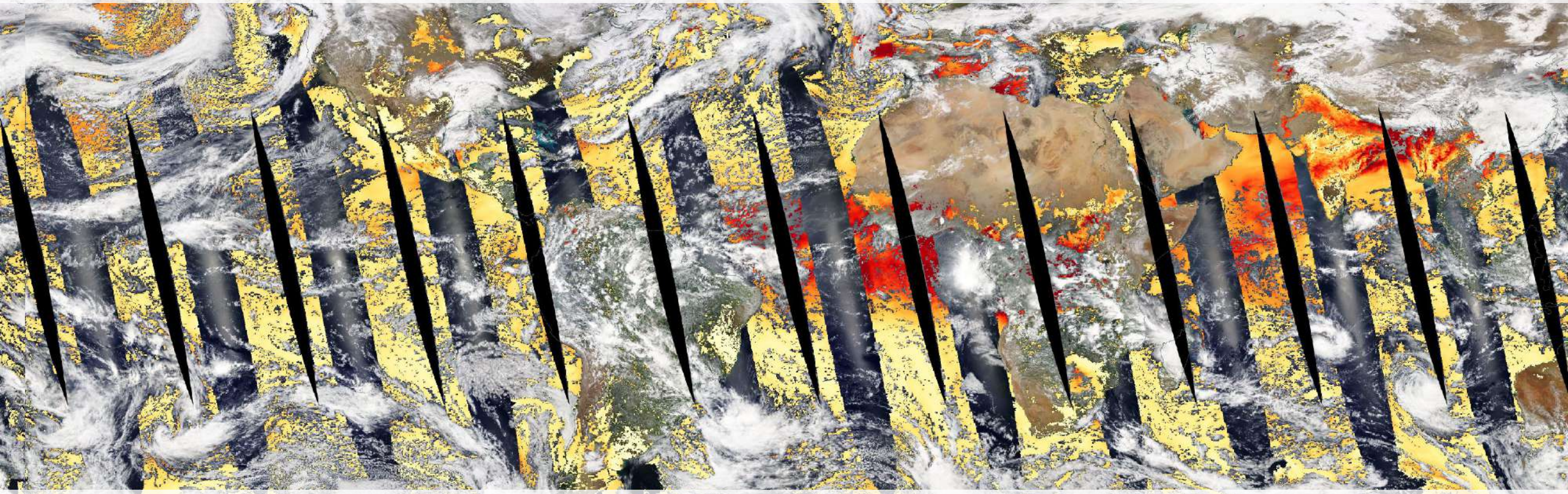
Novel observational constraints on aerosol-cloud interactions combining active and geostationary satellites

ESA-JAXA EarthCare Science and Validation Workshop

13/11/2023

Philip Stier, Philipp Weiss, Will Jones
Atmospheric, Oceanic and Planetary Physics
Department of Physics
University of Oxford

Aerosol-cloud interactions from space



Assumptions in satellite based assessments:

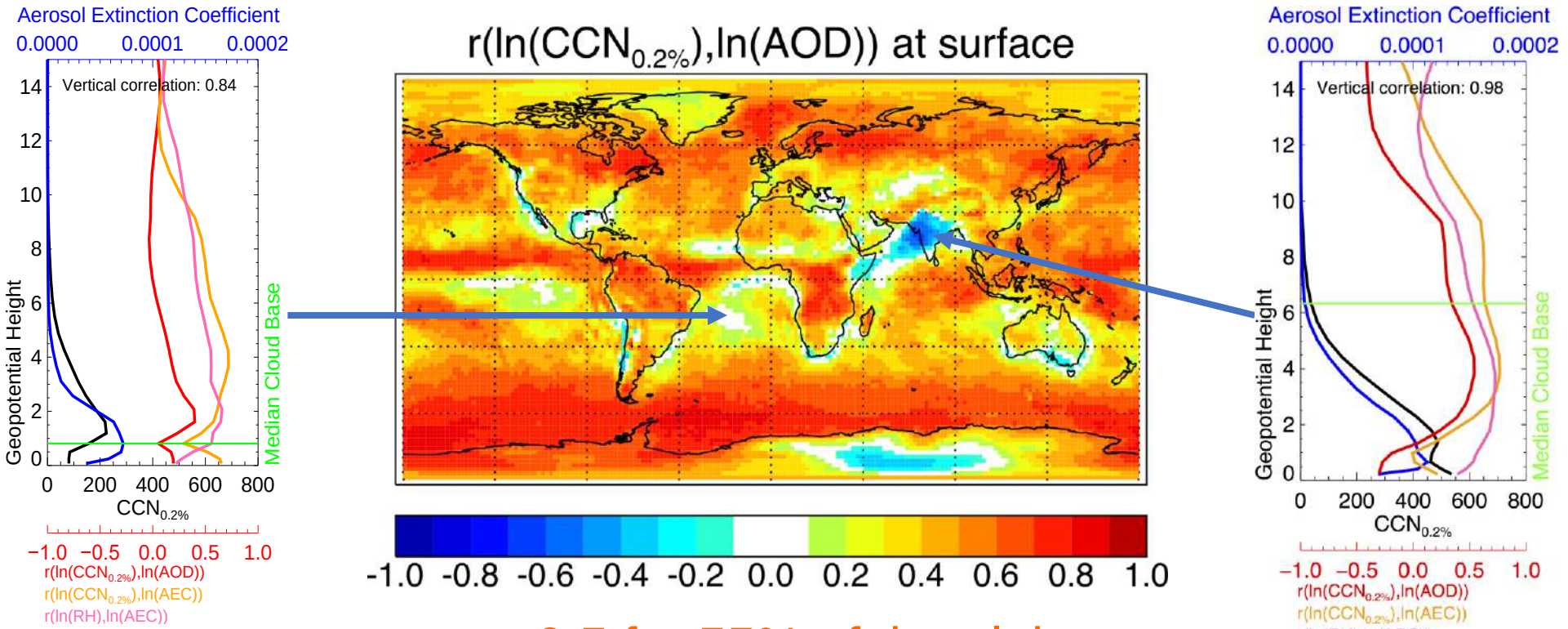
i. Aerosol optical depth (AOD) is ***suitable proxy*** for cloud condensation nuclei (CCN)
ii. Clear-sky aerosol optical depth is ***representative*** for CCN in updrafts
iii. ***Causal*** relationship between retrieved aerosol, clouds and precipitation

Observational constraints on aerosol-cloud interactions

(Bellouin et al., Rev. Geophys, 2019)

Suitability of AOD as proxy for CCN

Correlation of 6h CCN and AOD from ECHAM-HAM climate model:

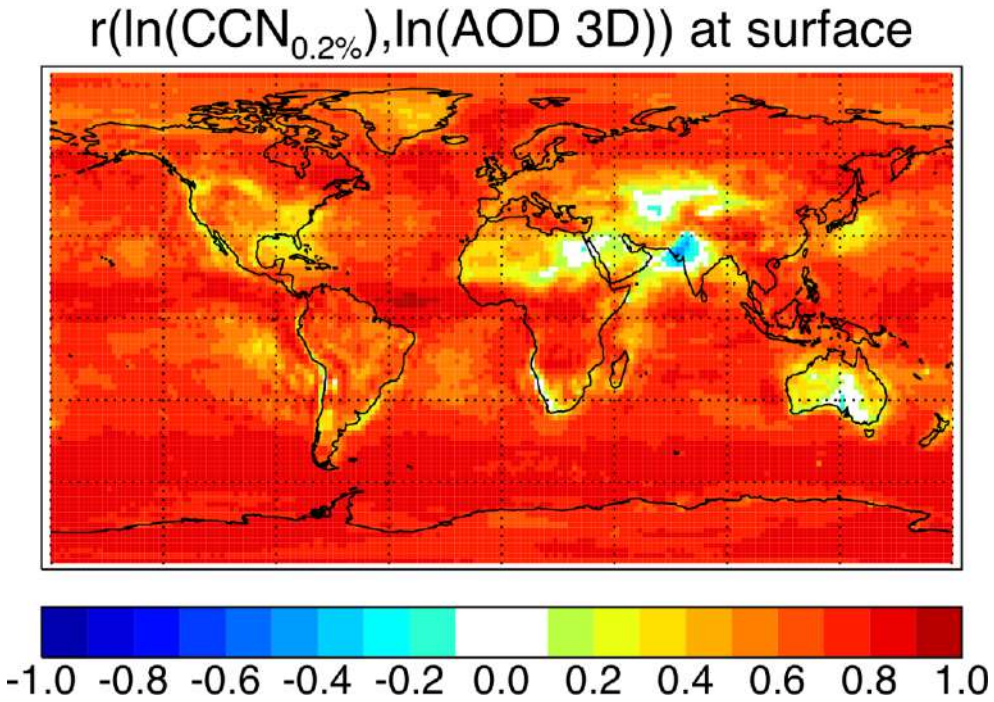


r<0.5 for 55% of the globe

(Stier, ACP, 2016)

Suitability of AOD as proxy for CCN

Correlation of 6h CCN and AOD from ECHAM-HAM climate model:

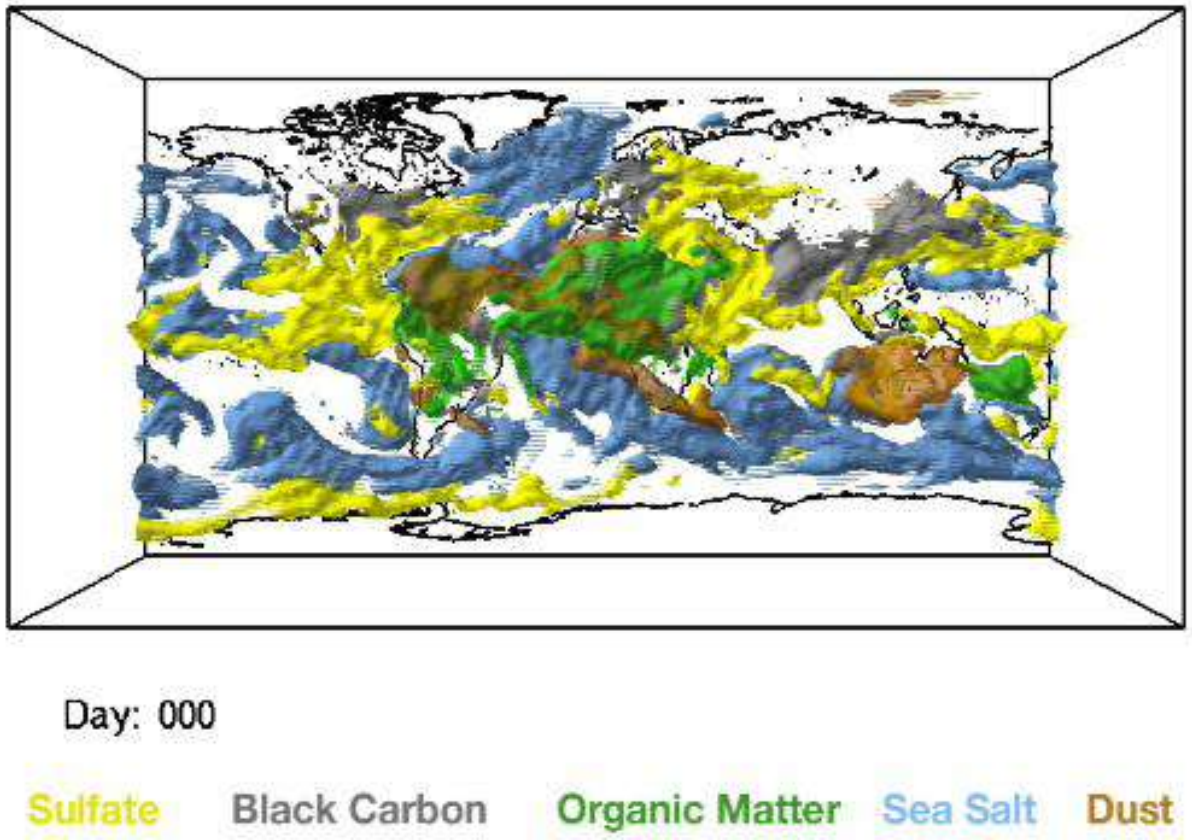


Vertical information key

(Stier, ACP, 2016; c.f. Painemal et al., ACP, 2020)

Suitability of AOD as proxy for CCN

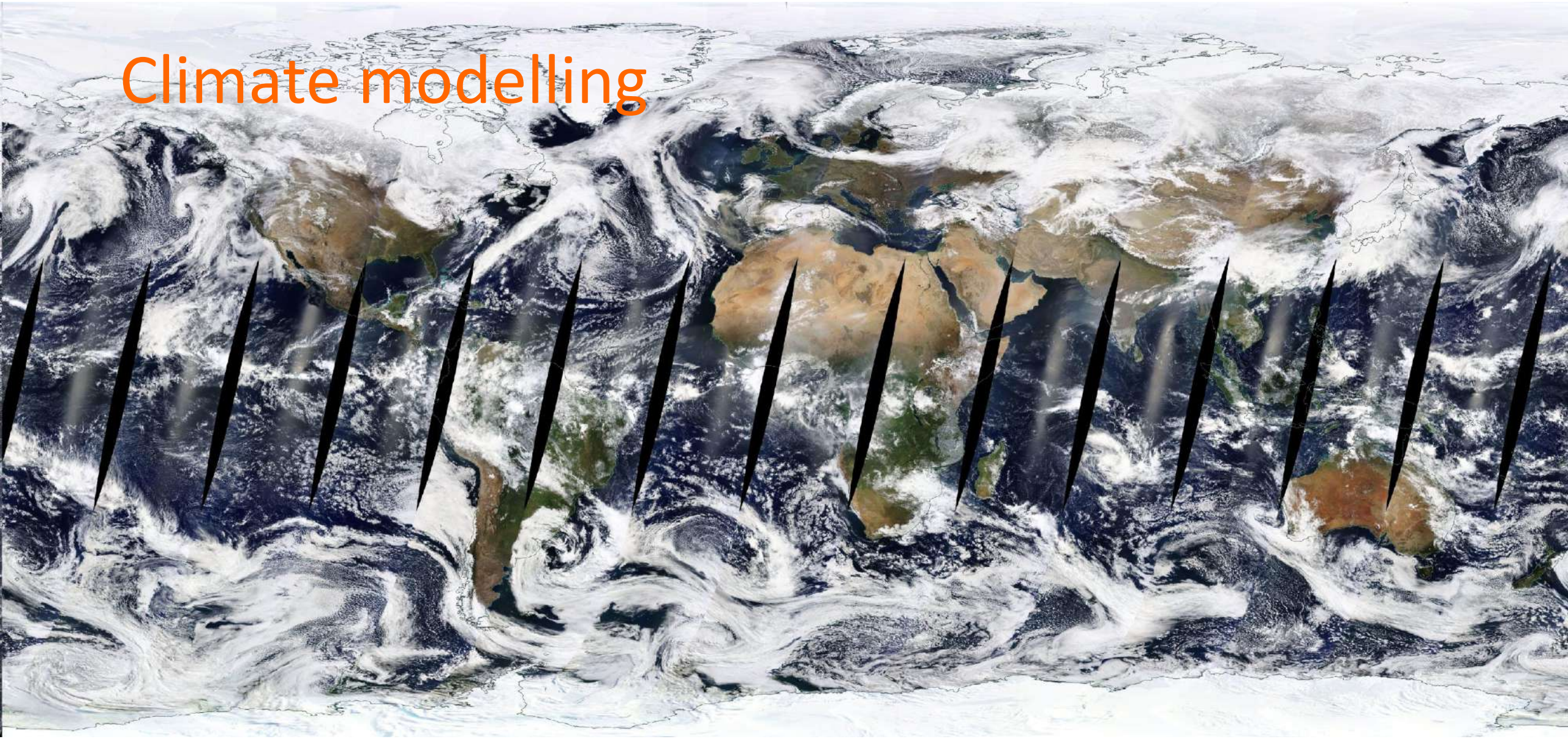
Correlation of 6h CCN and AOD from ECHAM-HAM climate model:



Not possible to test if AOD ***representative*** for CCN in updrafts

(Stier, ACP, 2005, 2016)

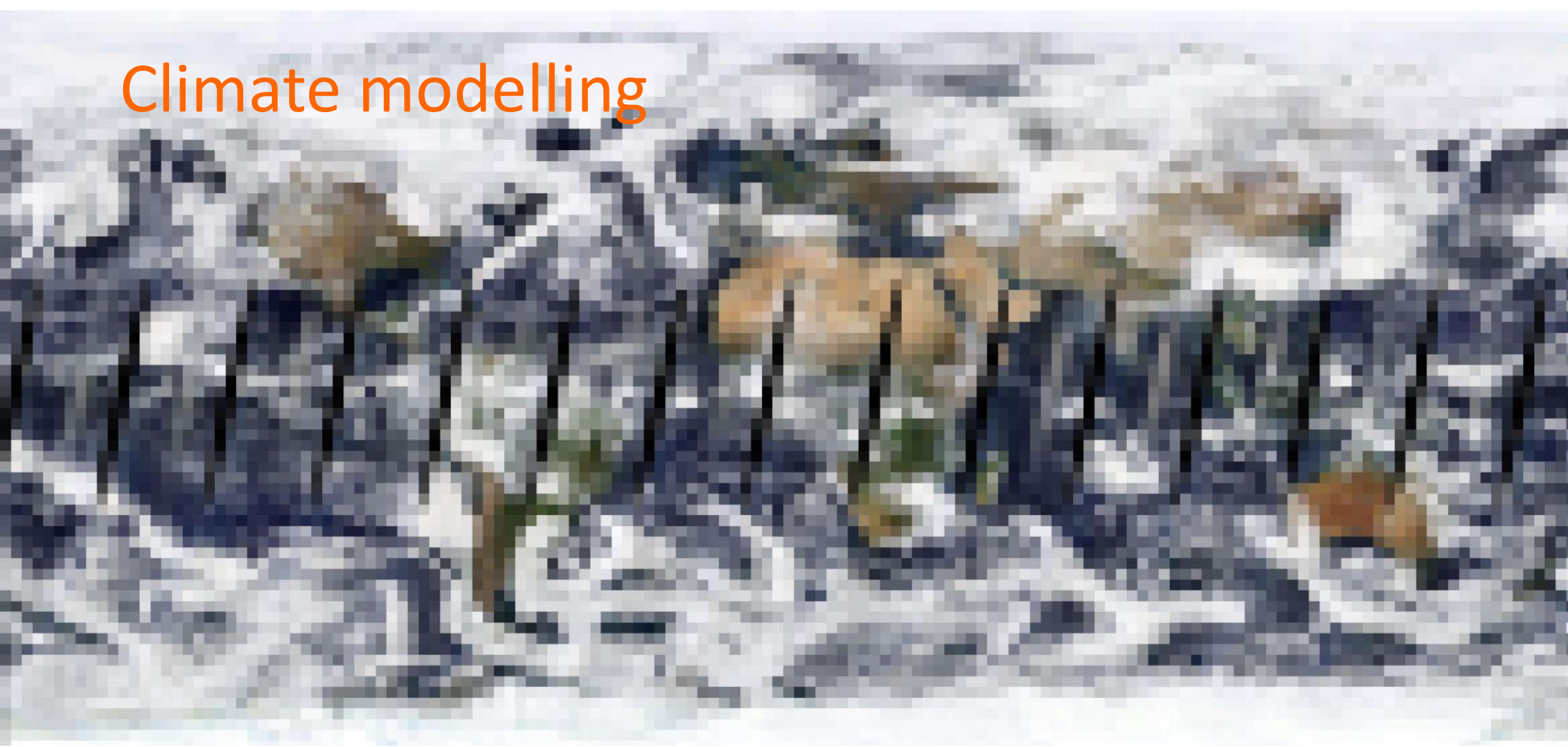
Climate modelling



Observational constraints on aerosol-cloud interactions

Philip Stier

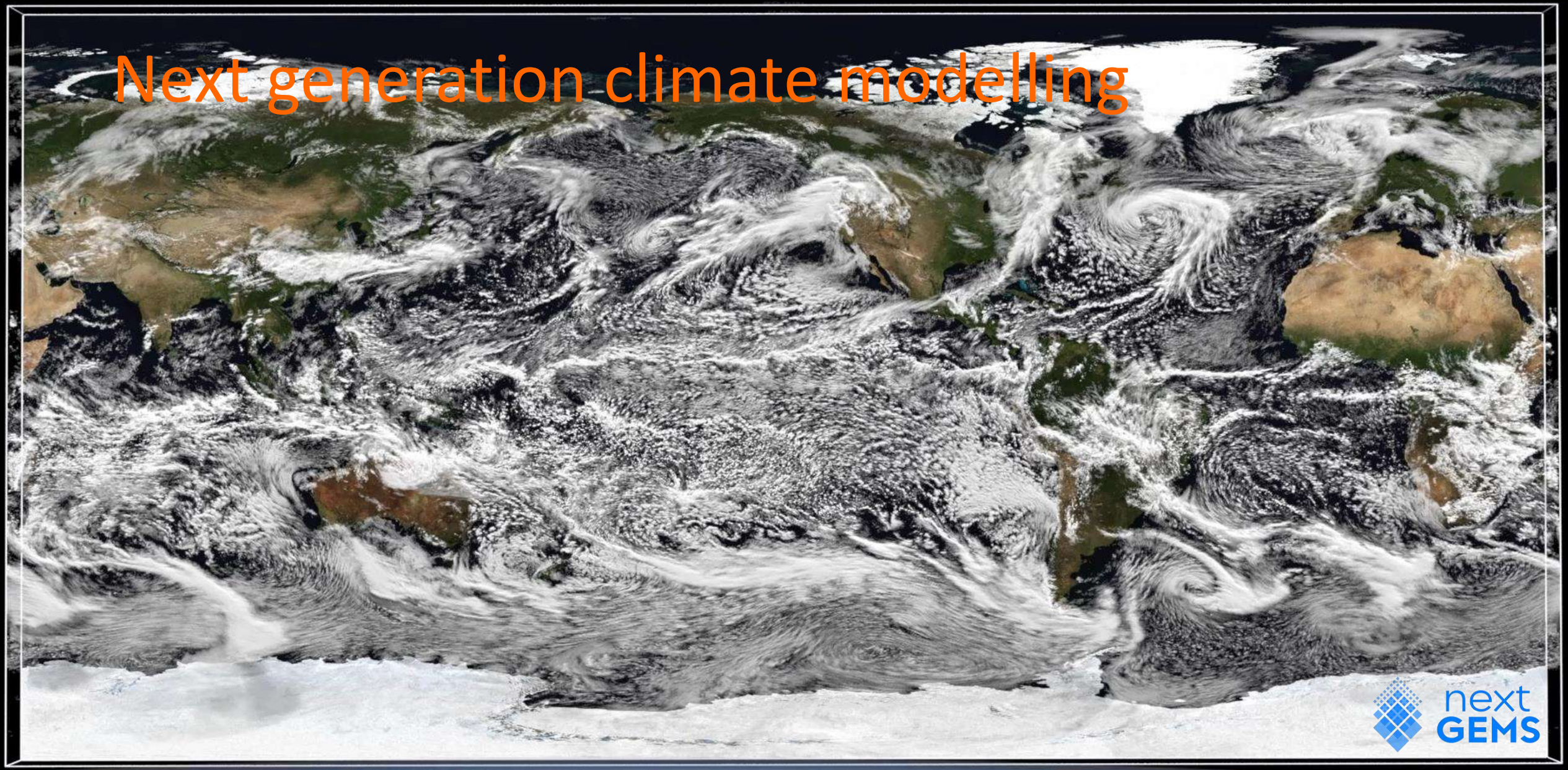
Climate modelling



Observational constraints on aerosol-cloud interactions

Philip Stier

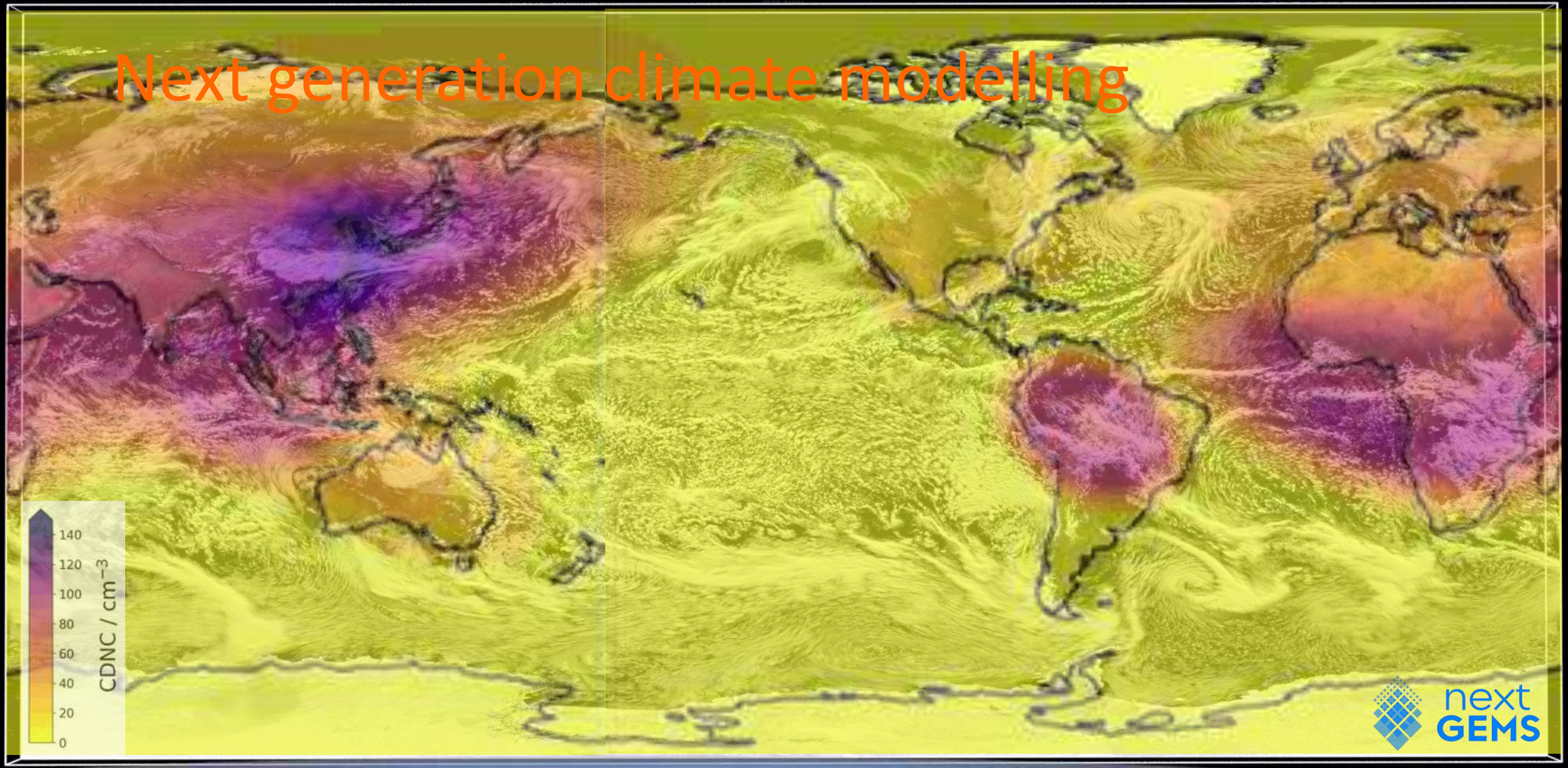
Next generation climate modelling



Observational constraints on aerosol-cloud interactions

Philip Stier

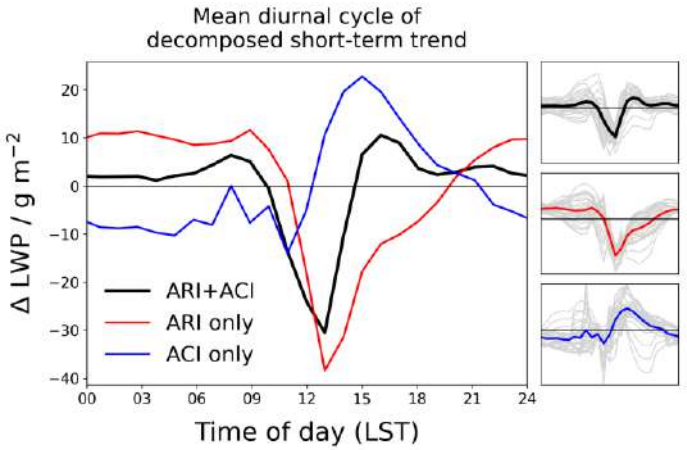
Next generation climate modelling

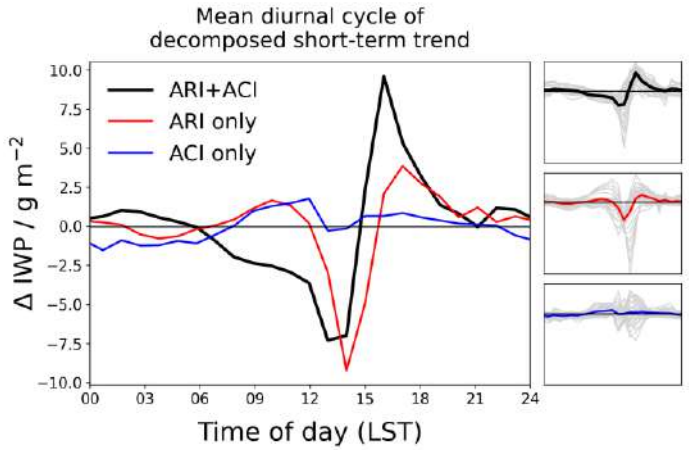


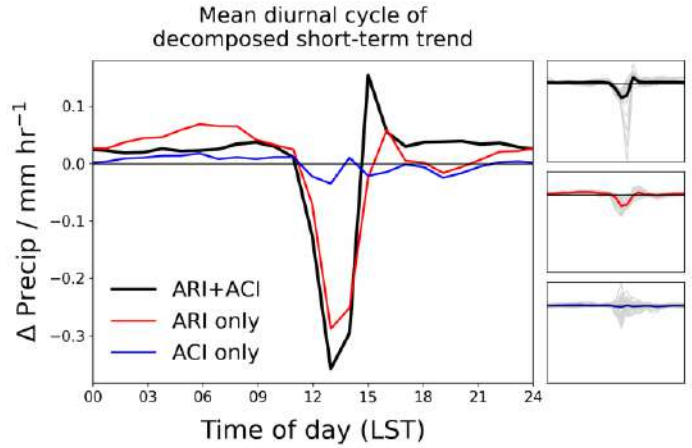
Idealised Aerosol effects in global km-scale simulations

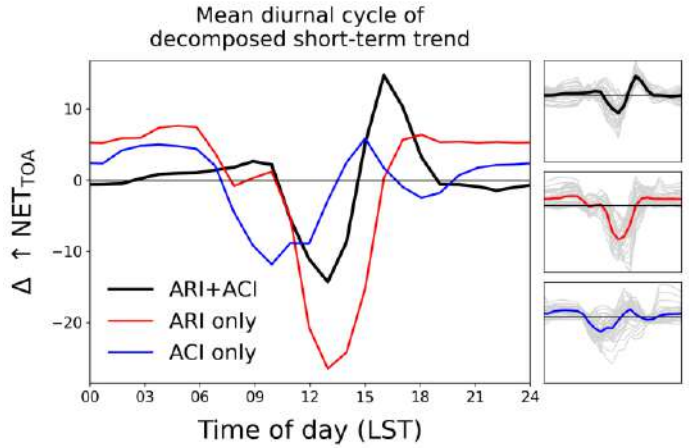
Herbert et al. (in prep)

Regional Effects: Amazon







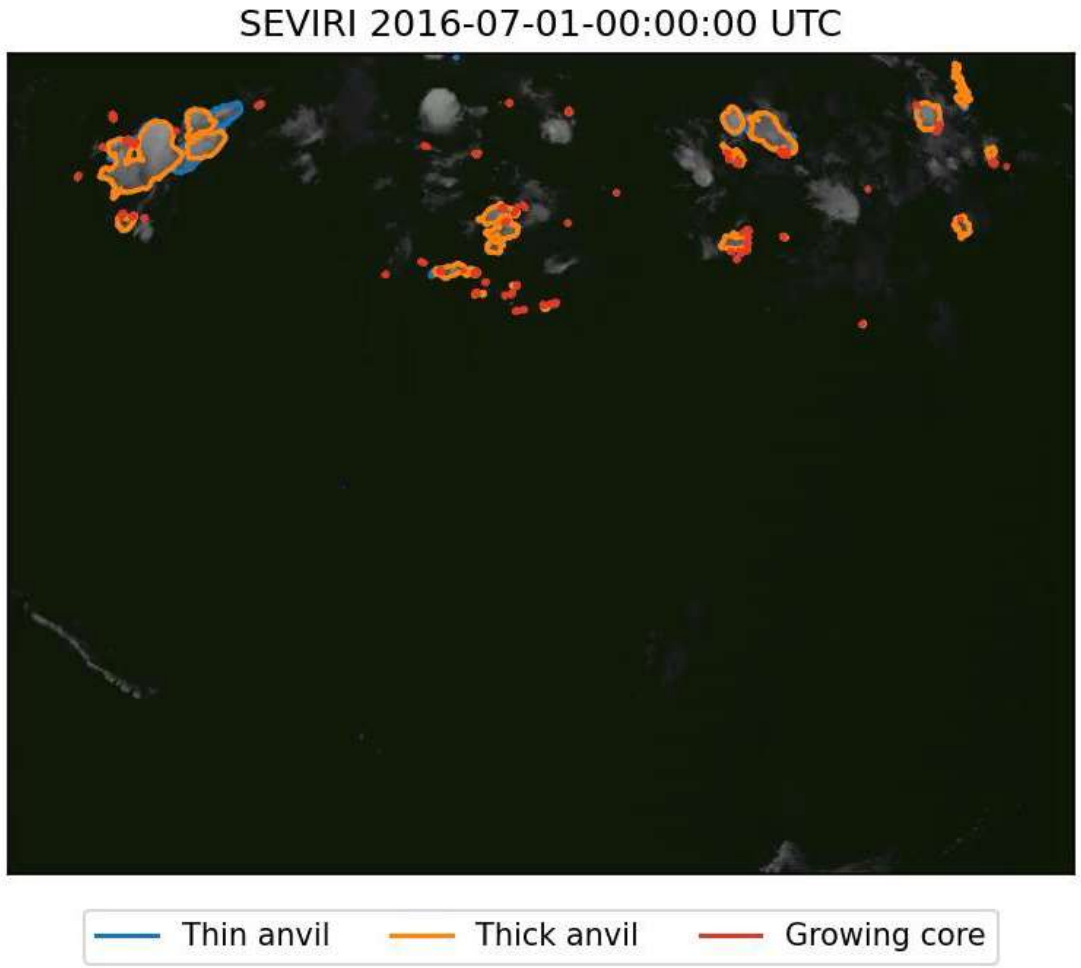


- Strong diurnal cycle of aerosol effects on convection
- Major challenge for sun-synchronous observations
- Synergy with geostationary observations

Idealised Aerosol effects in global km-scale simulations

Herbert et al. (in prep)

Observational constraints on the diurnal cycle

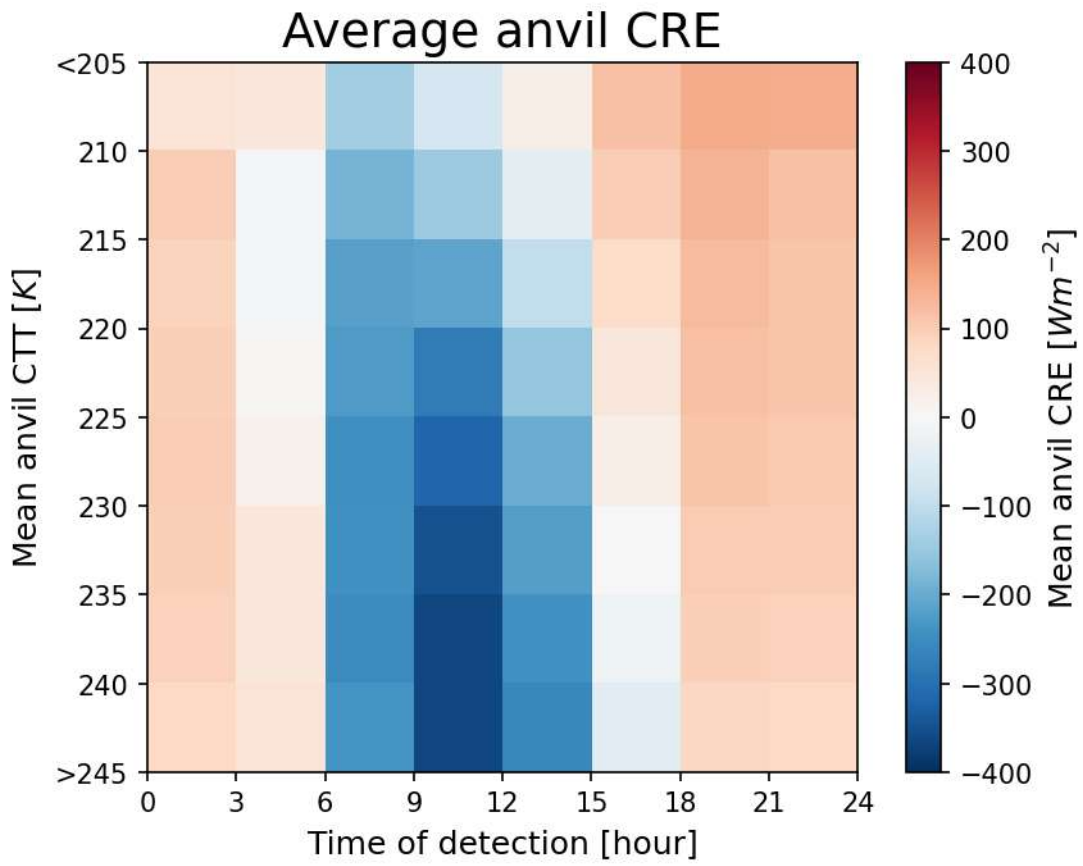


ESA Cloud CCI+:

- Detection and tracking of growing deep convective cores and associated anvils from SEVIRI & GOES-R in a semi-Lagrangian framework
- Combination with ESA Cloud CCI+ radiative flux product
- Unique insights into diurnal cycle of cloud radiative effects

(Jones et al., AMT, 2023)

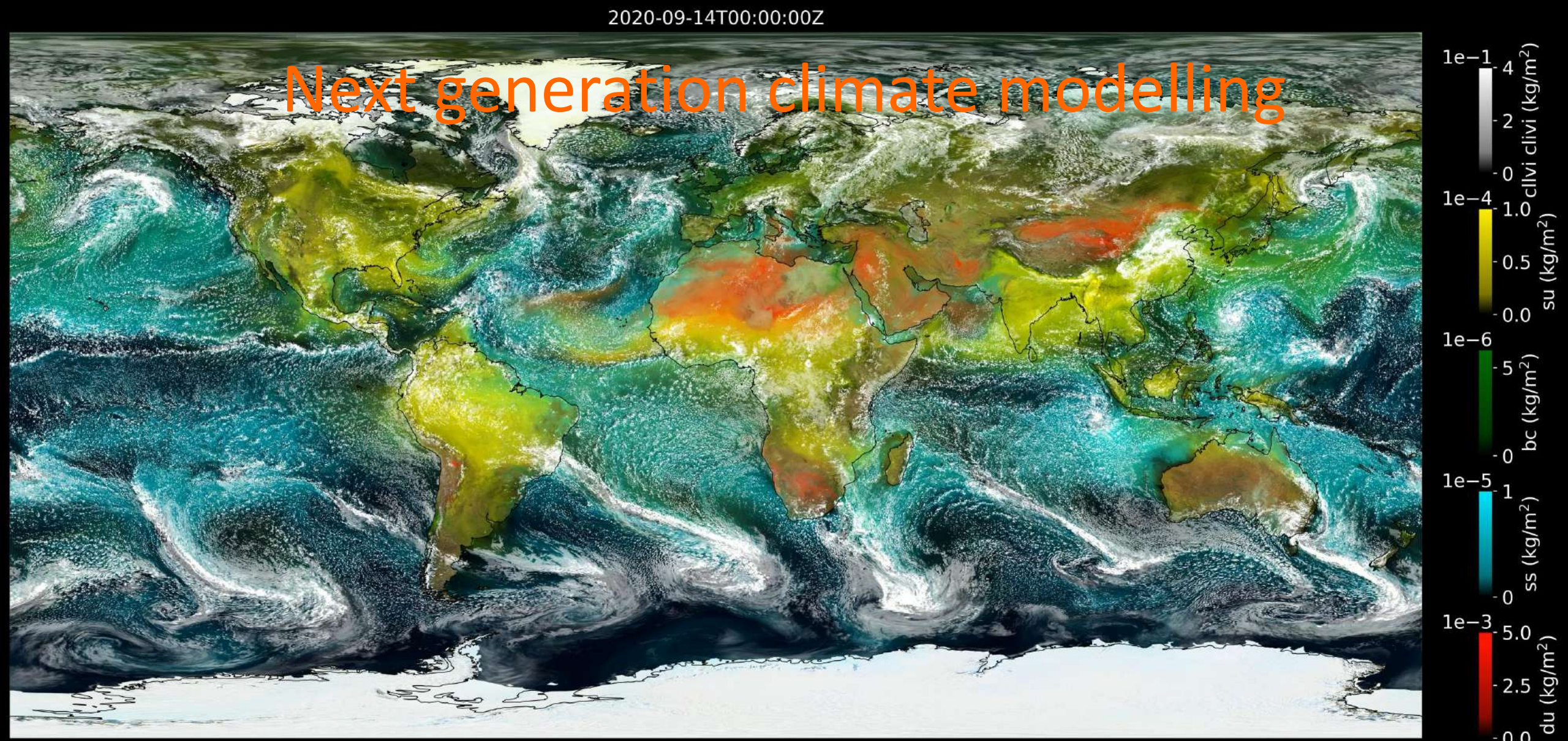
Observational constraints on the diurnal cycle



ESA Cloud CCI+:

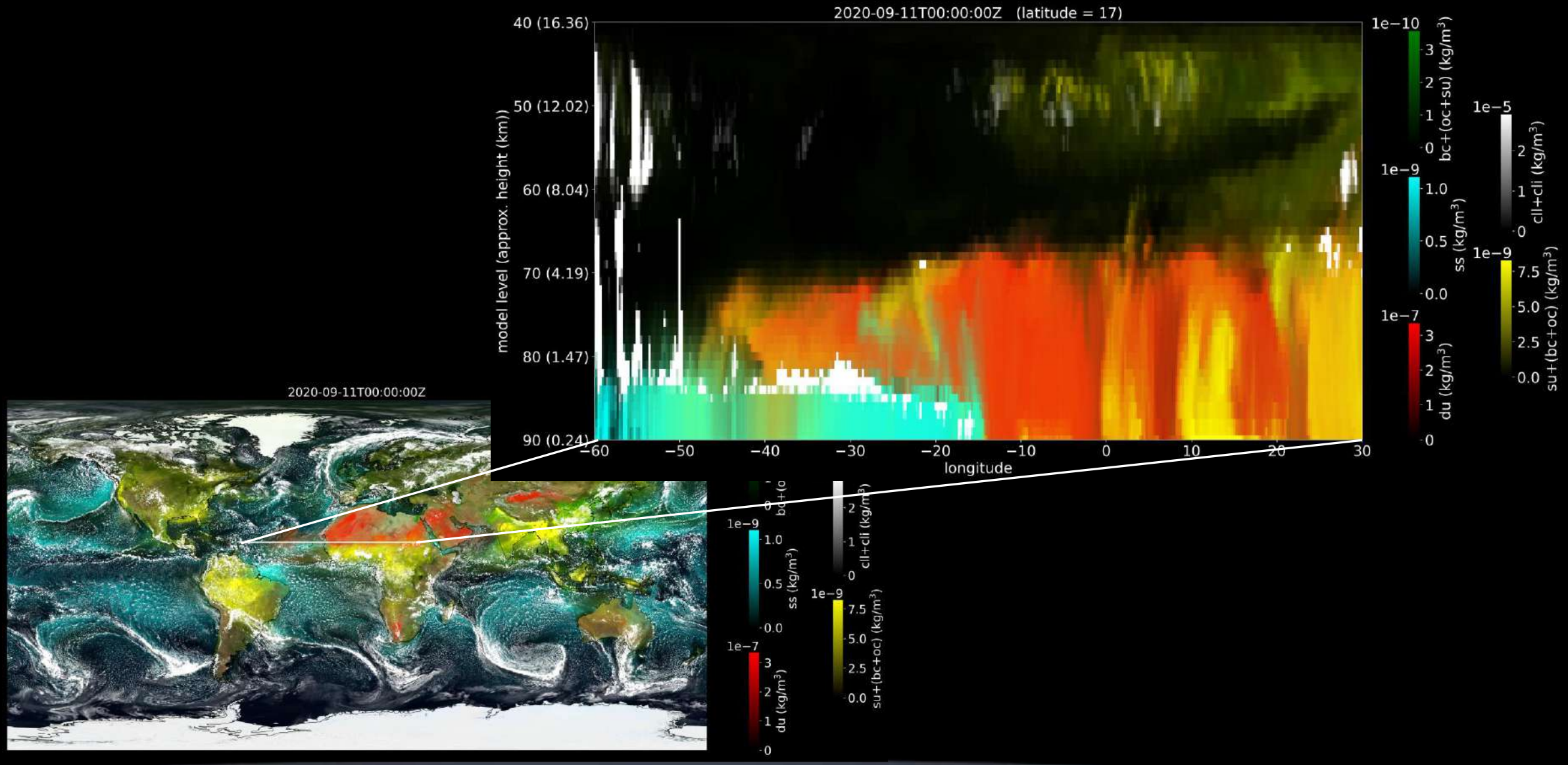
- Detection and tracking of growing deep convective cores and associated anvils from SEVIRI & GOES-R in a semi-Lagrangian framework
- Combination with ESA Cloud CCI+ radiative flux product
- Unique insights into diurnal cycle of cloud radiative effects

(Jones et al., in prep.)



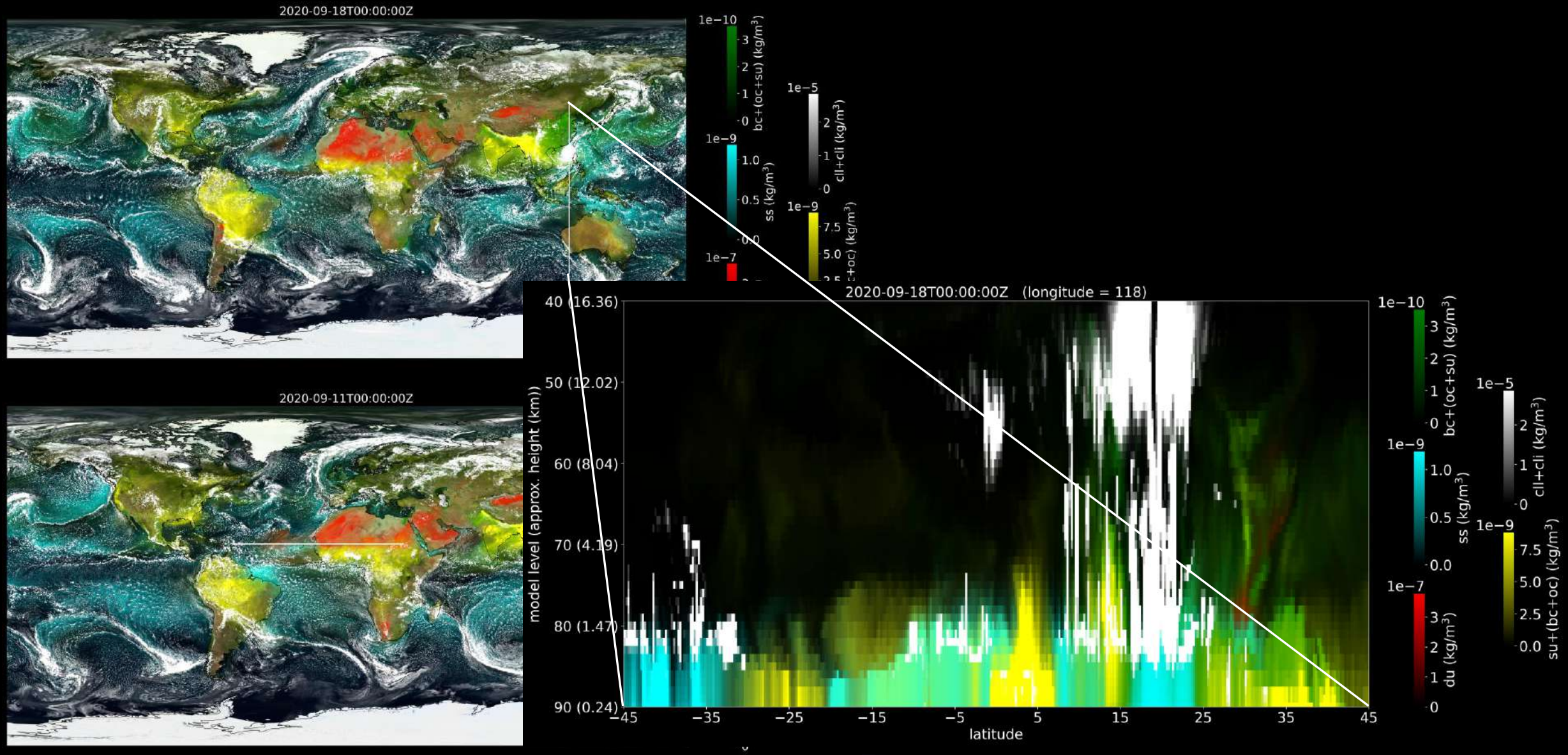
Aerosol-cloud interactions in global km-scale ICON

(Philipp Weiss)



Aerosol-cloud interactions in global km-scale ICON

(Philipp Weiss)



Aerosol-cloud interactions in global km-scale ICON

(Philipp Weiss)

Conclusions

EarthCARE may have been delayed a little...

but could not be more timely!

- Expect major advances in observational constraint on vertical distribution of CCN, cloud dynamics and structure, hence aerosol-cloud interactions
- Advanced geostationary cloud and aerosol products provide significant synergies, in particular global ISCCP-NG
- Emergence of global km-scale Earth system models allows to study key climate processes at processes level – and requires entirely new ways of thinking…