

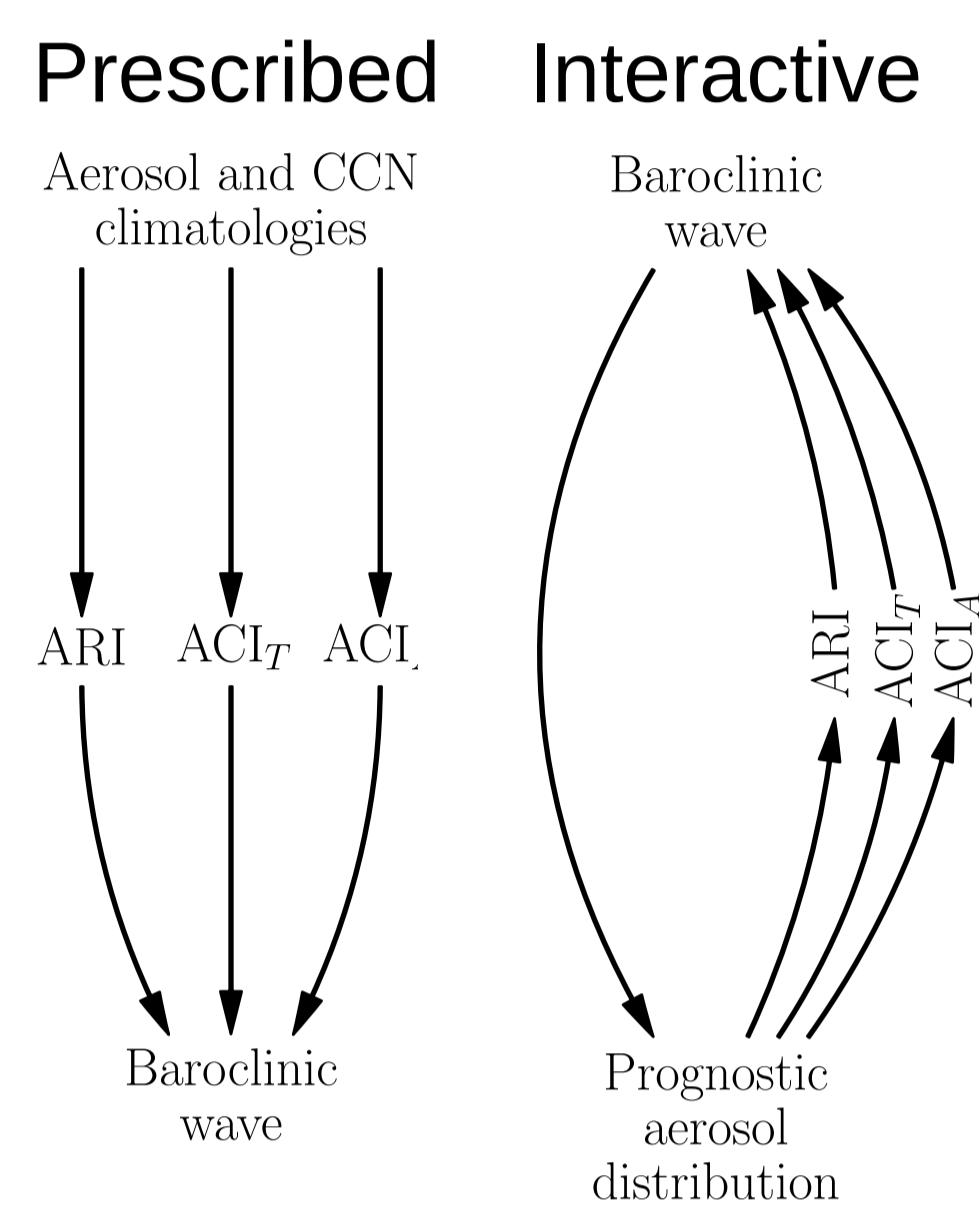
# Impacts of interactive sea salt aerosol on reflected shortwave radiation in idealized extratropical cyclones

C. Braun, A. Voigt, G. Hoshyaripur, H. Vogel, B. Vogel

Institute of Meteorology and Climate Research, Karlsruhe Institute of Technology

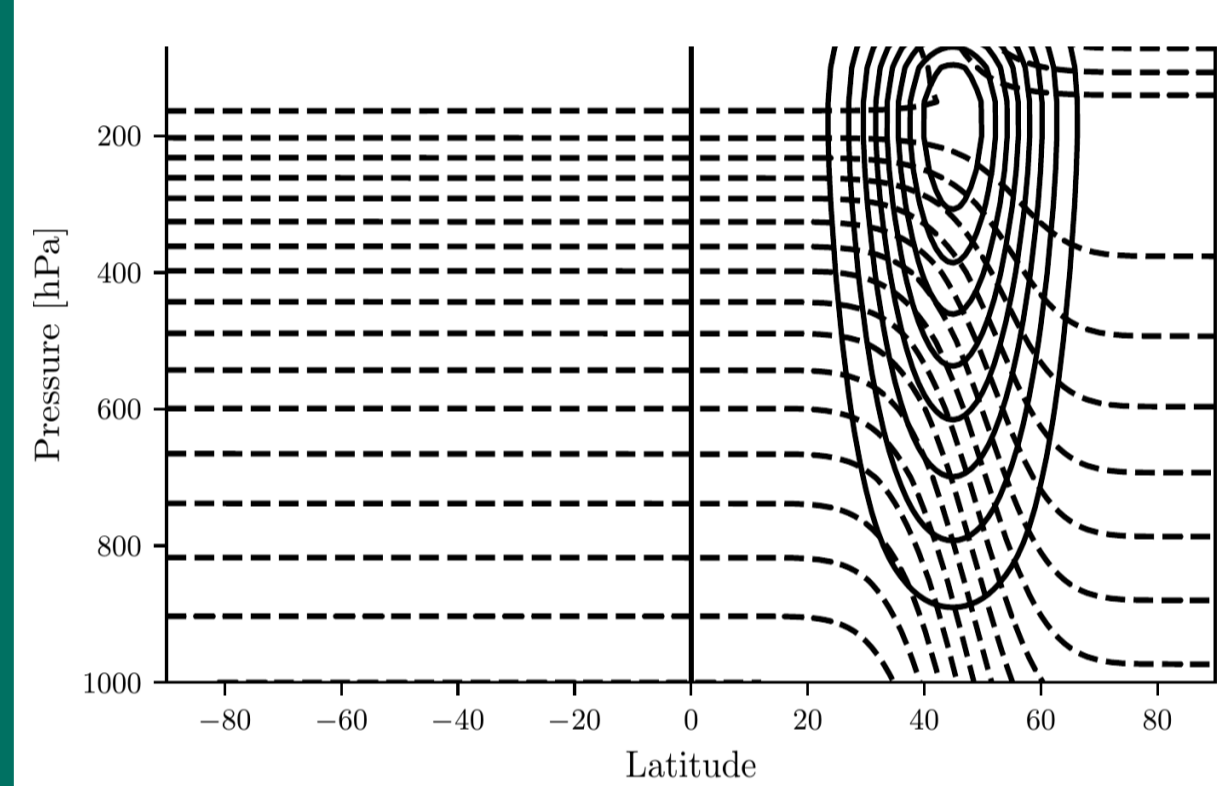
## 1. Motivation and research questions

- General circulation models yield bias in reflected shortwave radiation over Southern Oceans of up to 25  $\text{Wm}^{-2}$  (e.g. Bodas-Salcedo, 2014)
- Is this bias related to the representation of aerosol?
- What is the impact of interactive compared to prescribed aerosol on reflected shortwave radiation in extratropical cyclones?



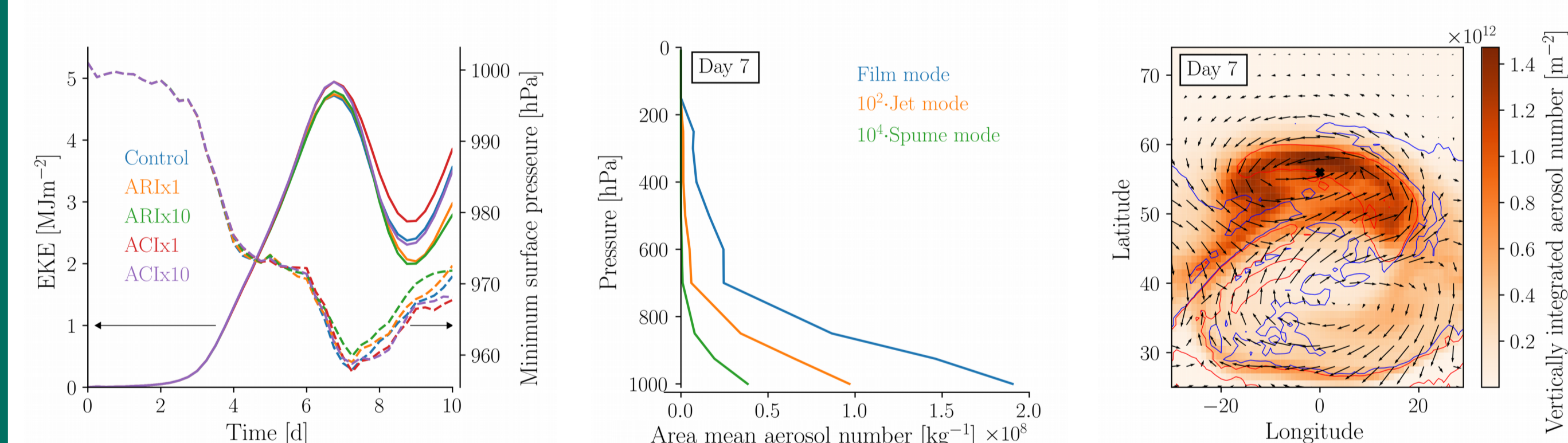
## 2. Model setup

Initial temperature and zonal wind fields



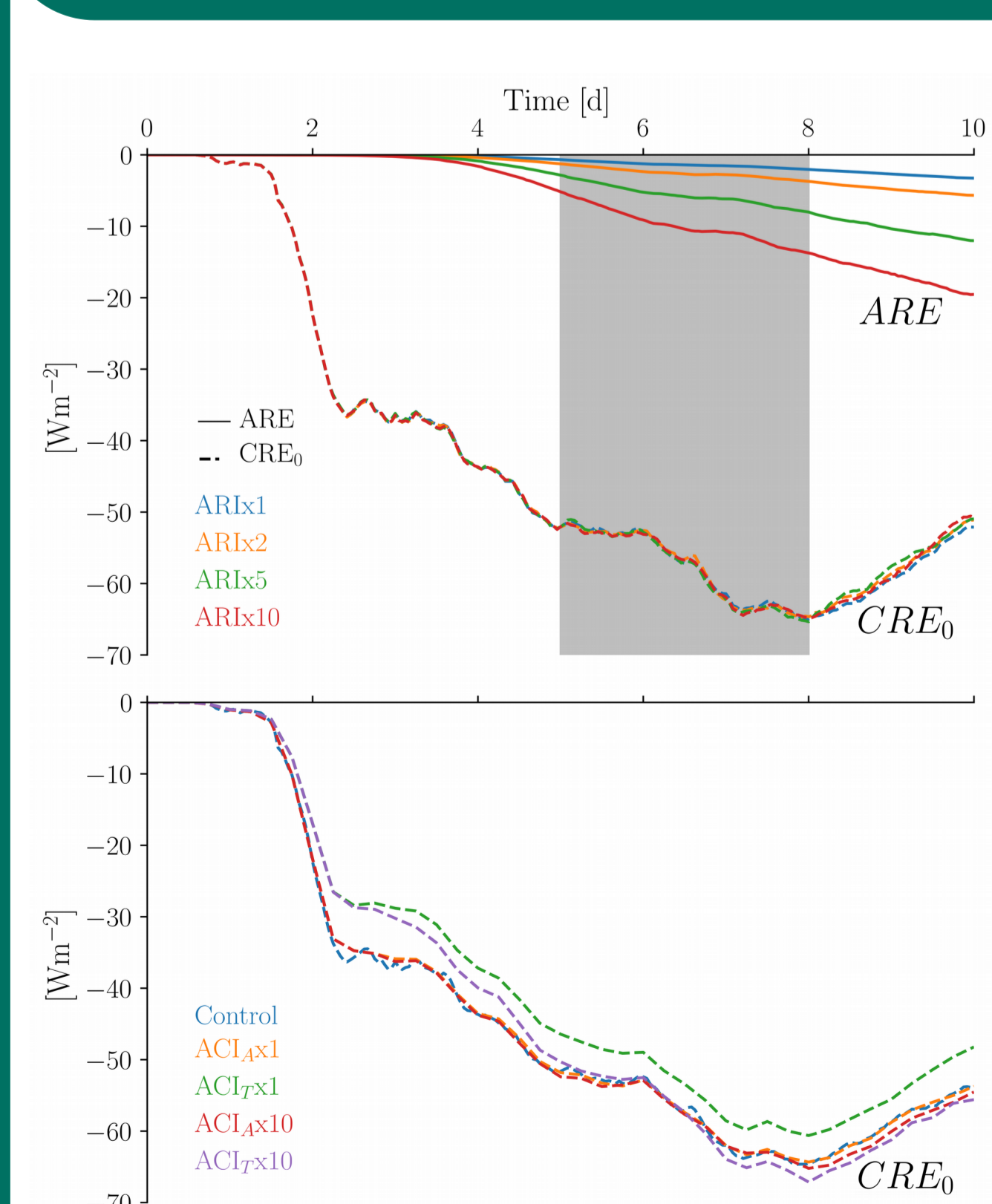
- ICON-ART, R2B06 (~40 km)
- Aquaplanet with prescribed SST
- Sea salt is single aerosol
- Initially pristine atmosphere with wave number 6 perturbation
- Simulation of idealized baroclinic waves

## 3. Baroclinic wave and sea salt distribution



- Dynamics of baroclinic wave is insensitive to sea salt aerosol due to prescribed SST
- Sea salt distribution is similar across simulations  $m(t, \varphi, \lambda) = m_{tot}(t) \cdot \delta(t, \varphi, \lambda)$

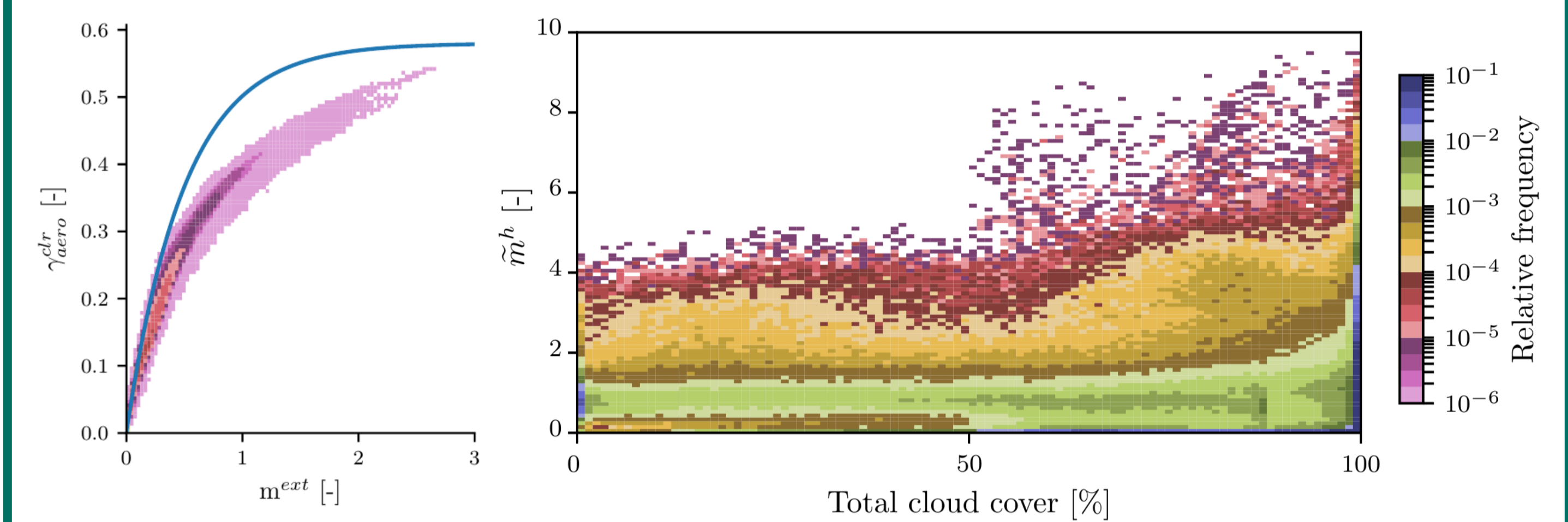
## 4. Variation of reflected shortwave radiation with total aerosol mass



$$R = R_0^{clr} + CRE_0 + ARE$$

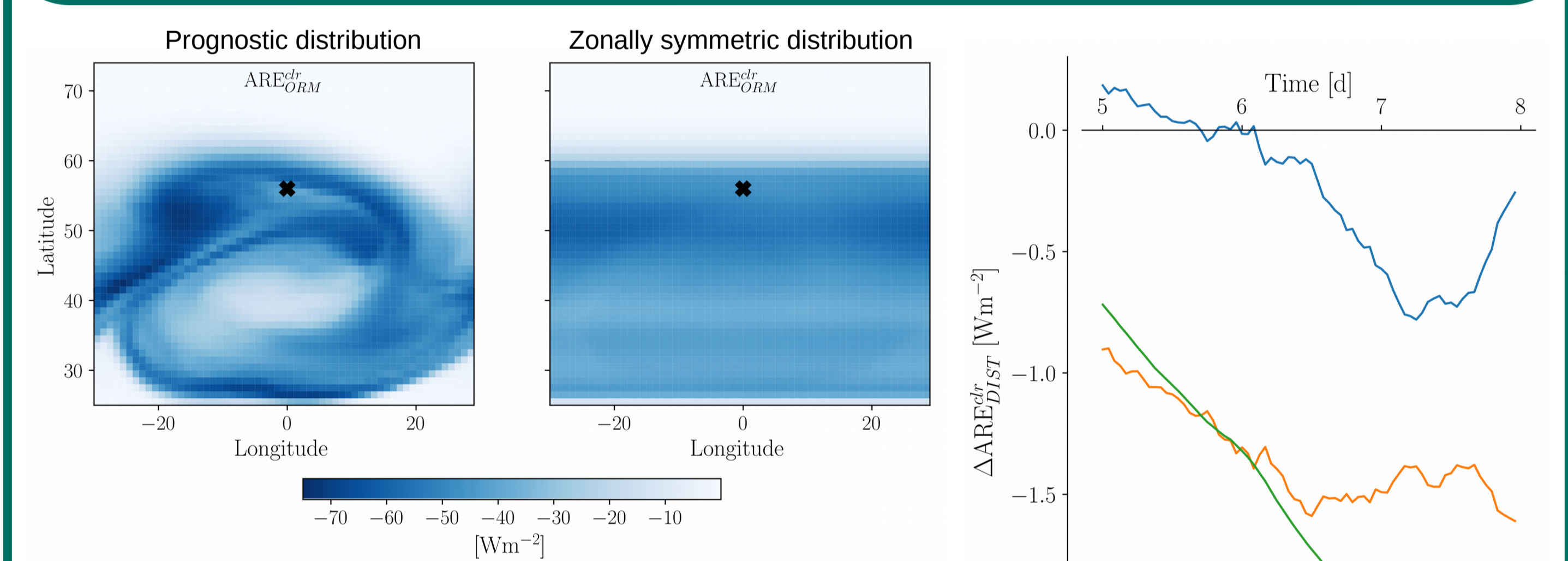
- ARE is approximately proportional to  $m_{tot}$
- Albrecht effect shows no impact on CRE
- Twomey effect considerably impacts CRE
- Tenfold  $m_{tot}$  translates to enhancement of CRE by 5  $\text{Wm}^{-2}$  and ARE by 11  $\text{Wm}^{-2}$  at maximum cyclone intensity

## 5. Aspects of interactive aerosol distribution



- Sea salt bulk reflectivity saturates at high total aerosol mass
- More aerosol is found in regions with high total cloud cover

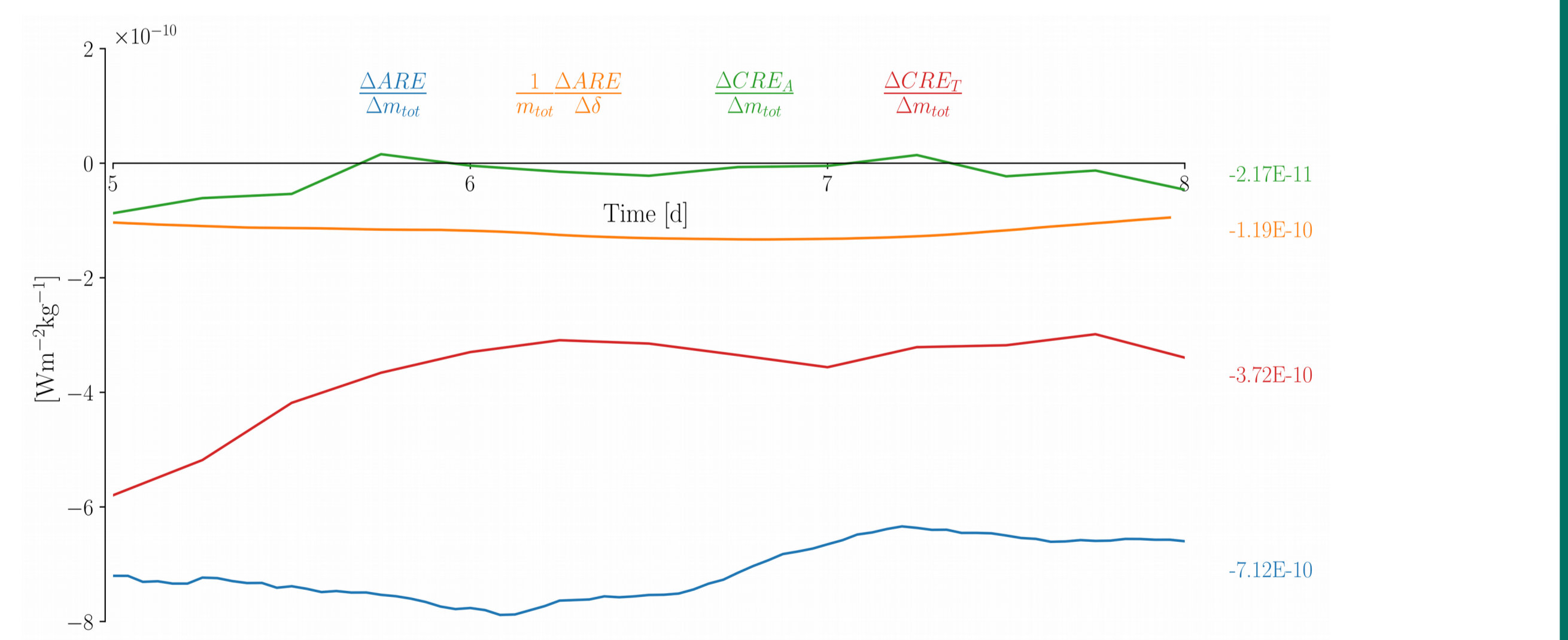
## 6. Variation of reflected shortwave radiation with aerosol distribution at constant mass



- Horizontal redistribution of aerosol in 1D single-layer offline radiative model (Taylor et al., 2007)
- Redistribution of aerosol locally causes strong changes in ARE of about  $\pm 20 \text{ Wm}^{-2}$
- Yield area-mean ARE is enhanced by 2  $\text{Wm}^{-2}$

## 7. Conclusions

$$dR = \left( \frac{\partial ARE}{\partial m_{tot}} + \frac{\partial CRE_{0,T}}{\partial m_{tot}} + \frac{\partial CRE_{0,A}}{\partial m_{tot}} \right) dm_{tot} + \frac{\partial ARE}{\partial \delta} d\delta$$



- Aerosol-radiation interactions and Twomey effect show considerable impacts on reflected shortwave radiation
- Strong sensitivity of reflected shortwave radiation to total aerosol mass via aerosol-radiation interactions is expected to be well confined by climatologies derived from observations
- Twomey effect may help to reduce biases in reflected shortwave radiation in general circulation models, but is unlikely to entirely eradicate biases