DEPARTMENT OF PHYSICS
University of Oxford

# Host Model Uncertainties in Aerosol Radiative Forcing Estimates: Results from the AeroCom Prescribed Intercomparison Study

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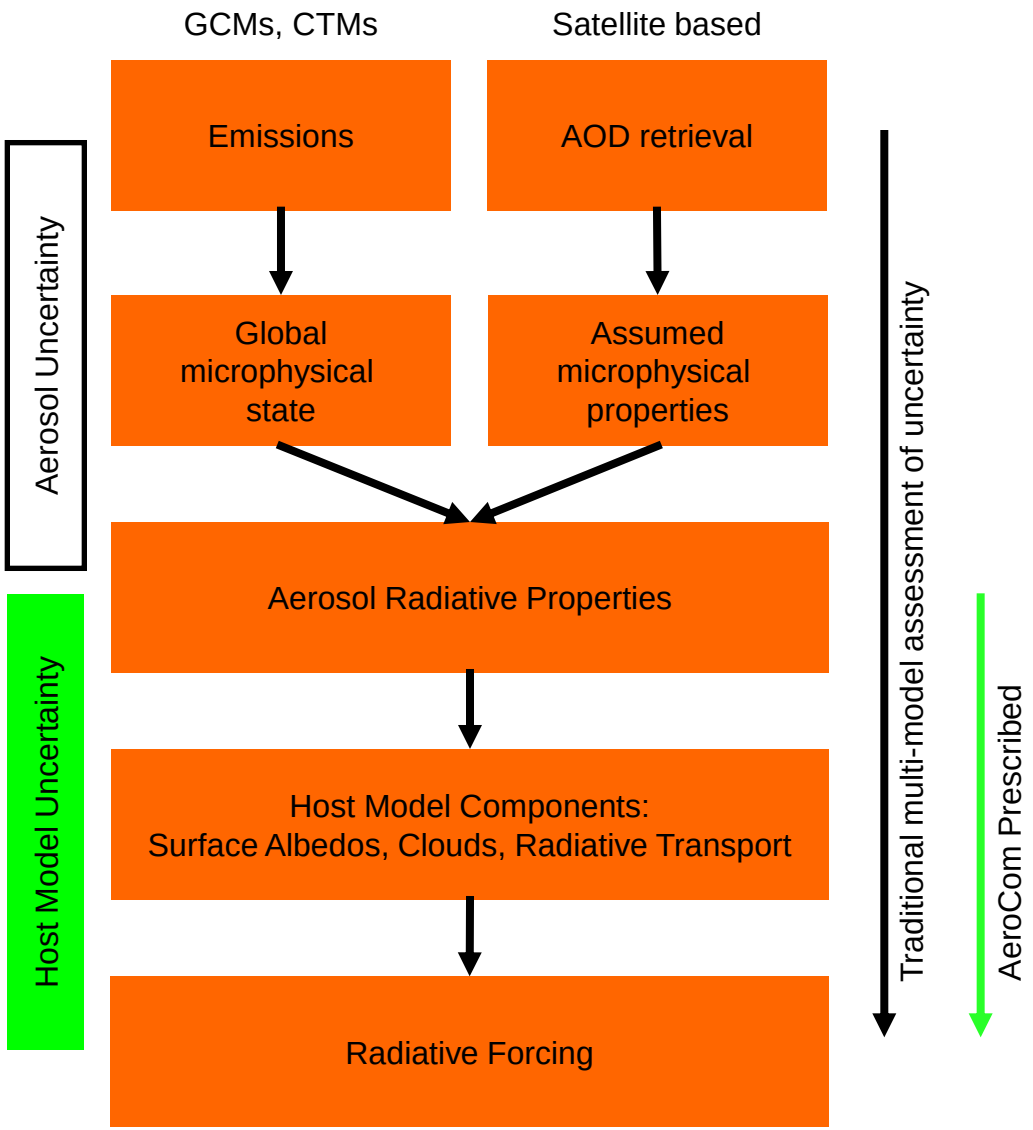
# Assessment of aerosol direct radiative forcing




AeroCom Radiative Forcing

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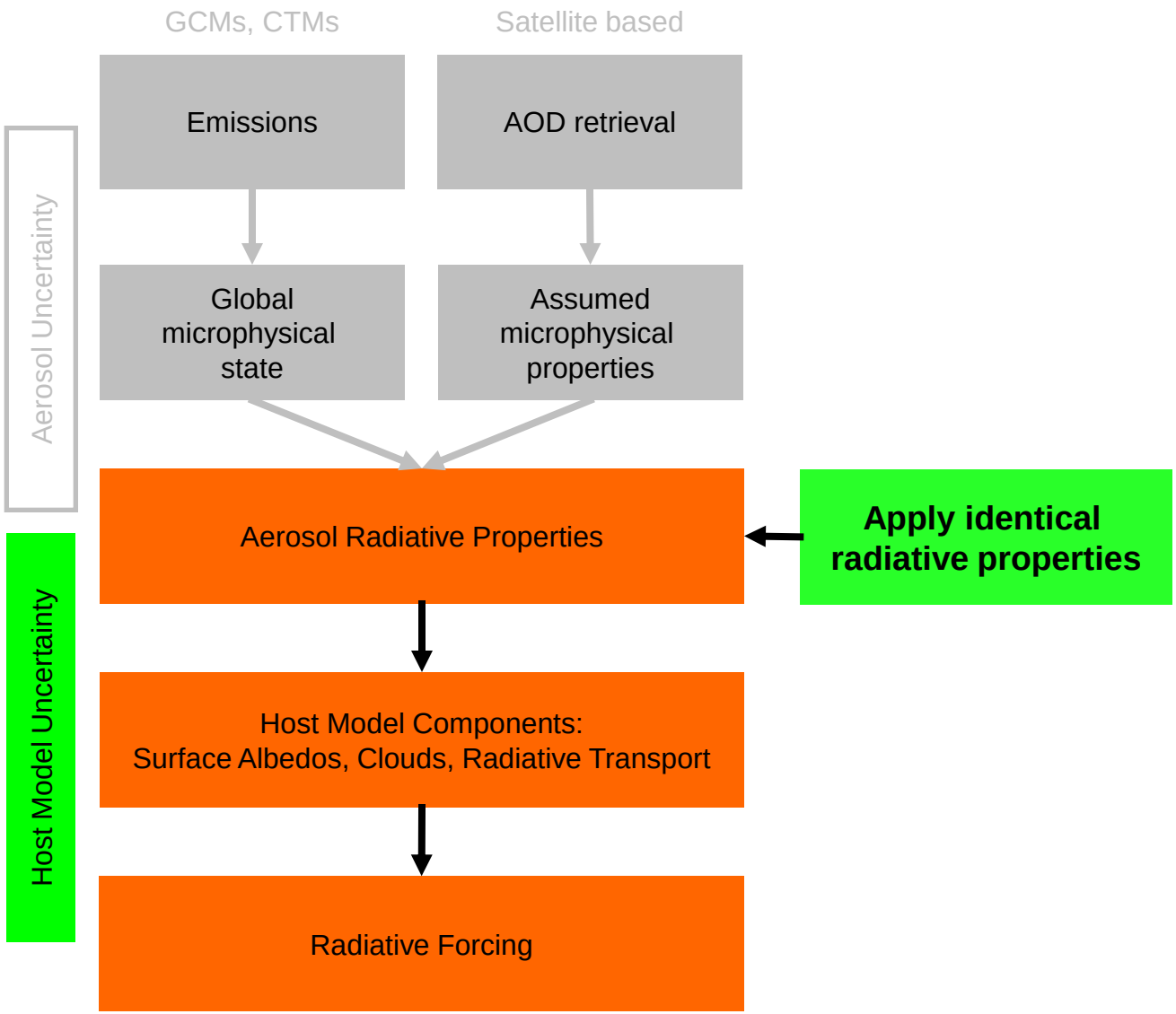


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# Setup of AreroCom Prescribed

Prescribe aerosol radiative properties identically in all “models”

| Name | Parameters | Comment |
|---|---|---|
| FIX0 | AOD=0.0<br>SSA= n/a<br>ANG=n/a<br>ASY= n/a | *specified at 550 nm* |
| FIX2 | AOD=0.2<br>SSA= 1.0<br>ANG=1.0<br><br>ASY=0.7 | *Linear by height over lowest 2km*<br>*Purely scattering case*<br>*Used for spectral dependence of AOD at other solar wavelengths* $\lambda$<br>*Solar-spectrally invariant forward scattering* |
| FIX3 | AOD=0.2<br>SSA=0.8<br>ANG = 1.0<br><br>ASY=0.7 | *Linear by height over lowest 2km*<br>*Absorbing case*<br>*Used for spectral dependence of AOD at other solar wavelengths* $\lambda$<br>*Solar-spectrally invariant forward scattering* |
| FIX1 | $AOD_{PD}$=0.132<br>$SSA_{PD}$ = 0.963<br>$AOD_{PI}$=0.092<br>$SSA_{PI}$ = 0.978 | *Present-day (PD) at 545 nm*<br>*AOD weighted mean*<br>*Pre-industrial (PI)*<br>*AOD weighted mean*<br>*Monthly 3D distribution early release of Kinne et al. (2012)* |

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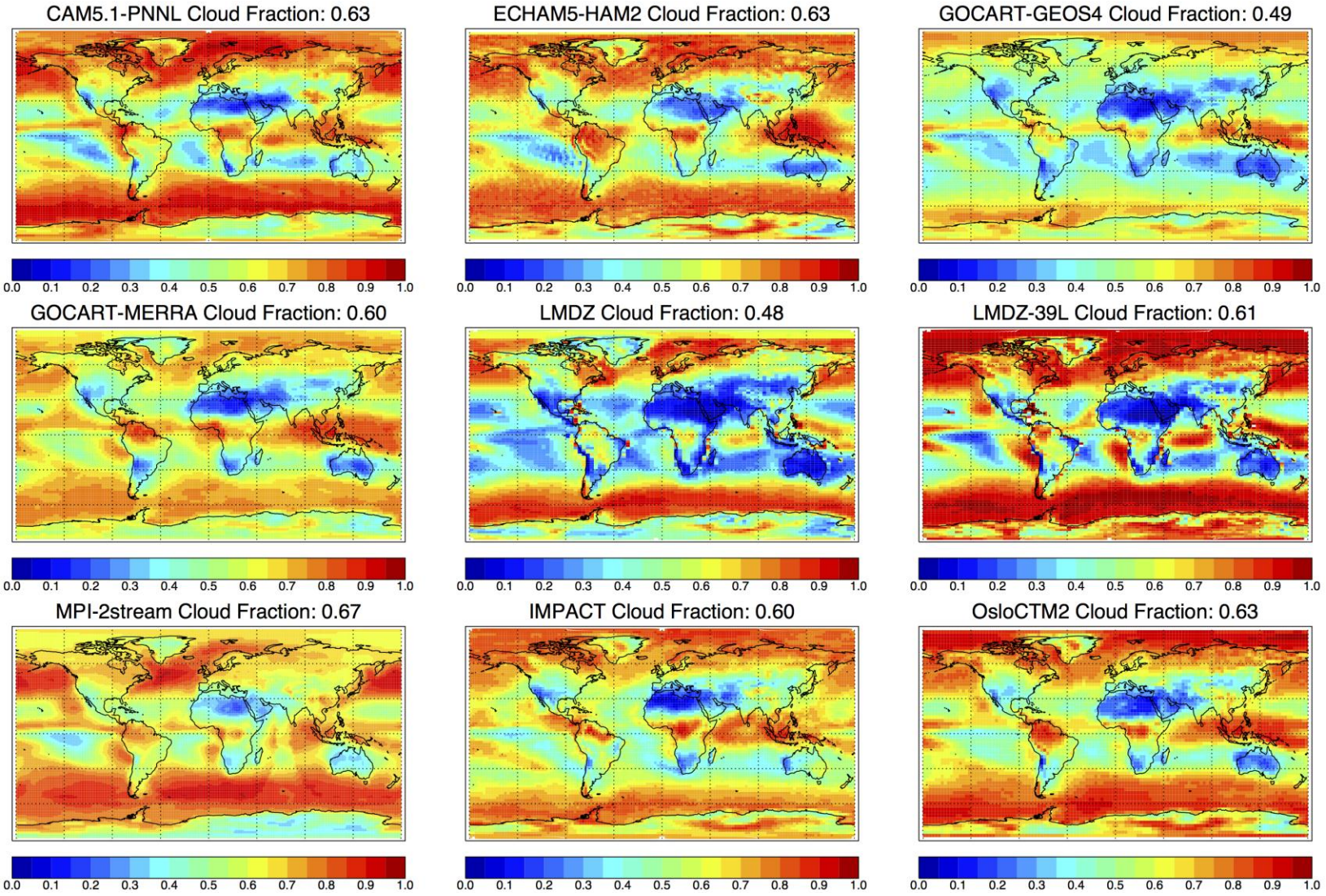
# Host Model Effects

## Cloud Fraction

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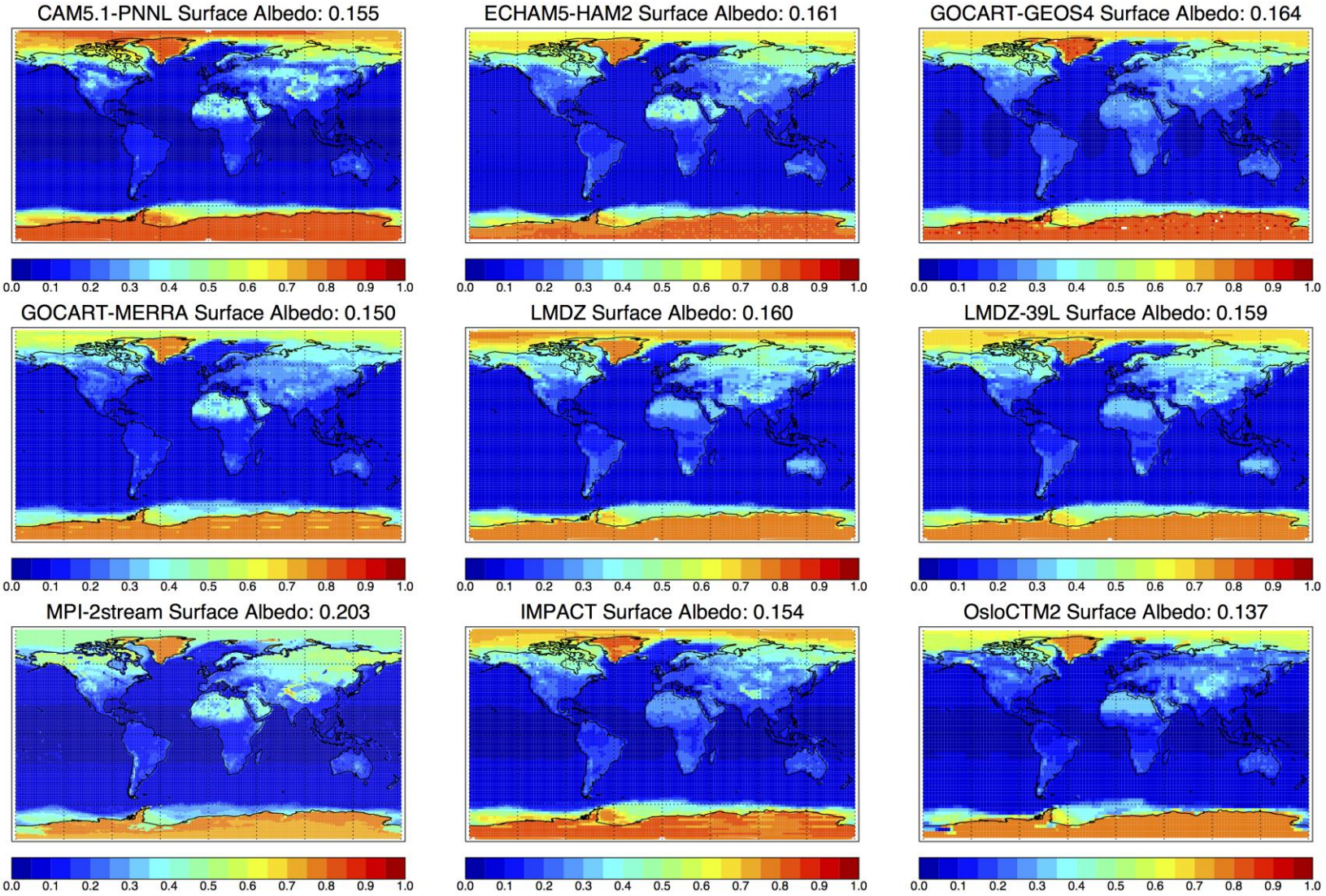
# Host Model Effects

## Surface Albedo

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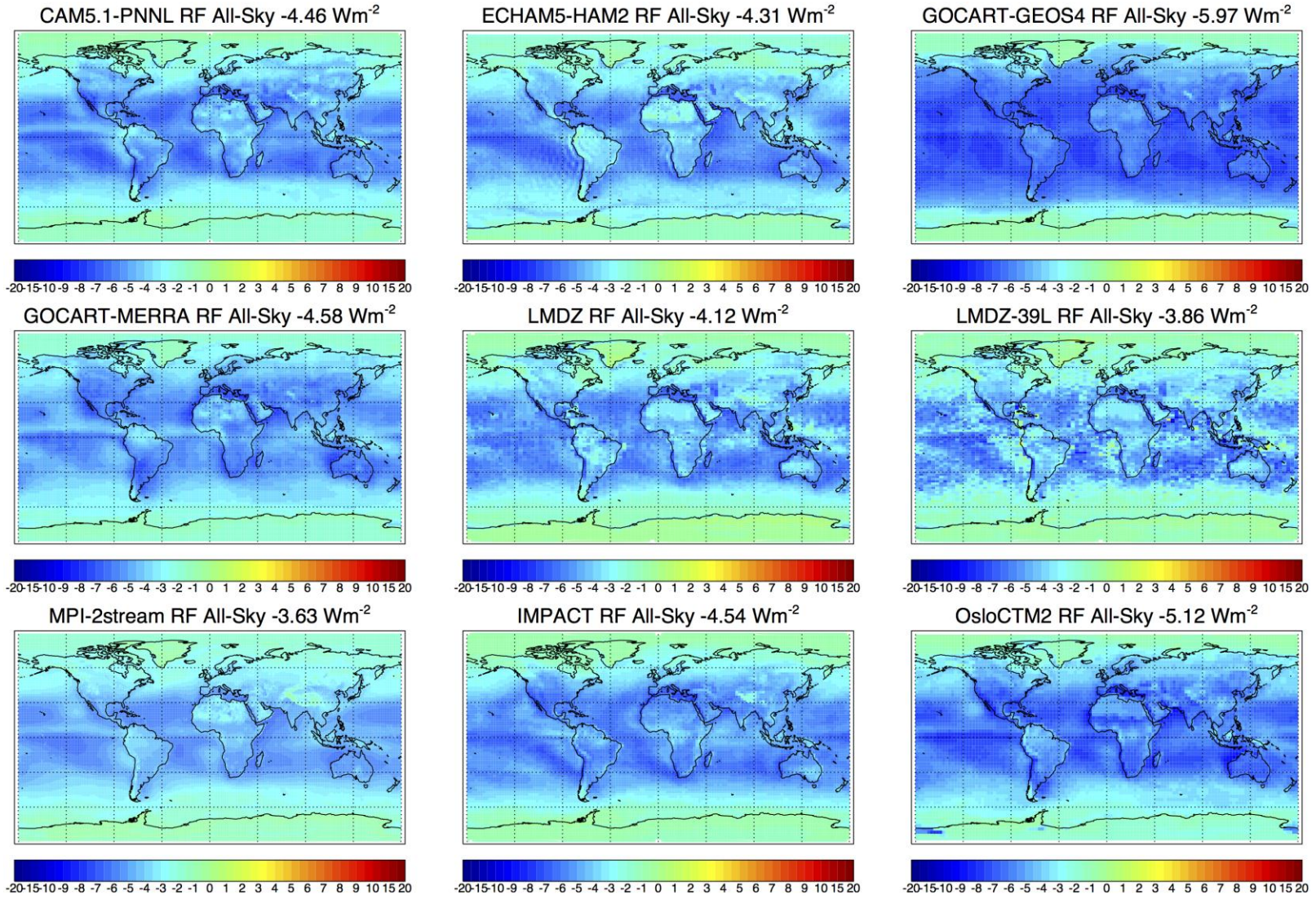
# Radiative Forcing: Scattering Case

All-sky **top-of-atmosphere** radiative forcing for FIX2-FIX0

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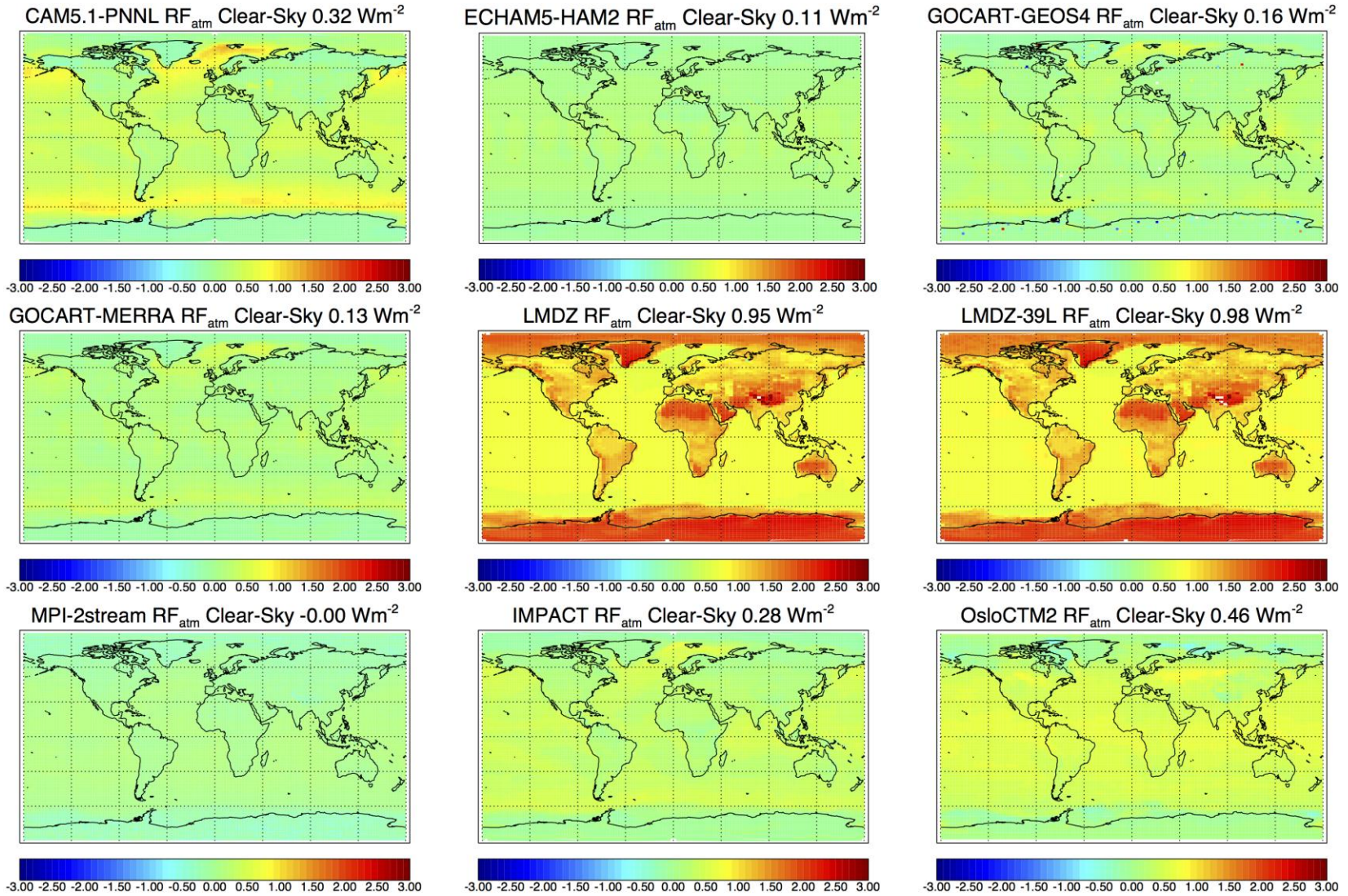
# Radiative Forcing: Scattering Case

**Clear-sky atmospheric** radiative forcing for FIX2-FIX0

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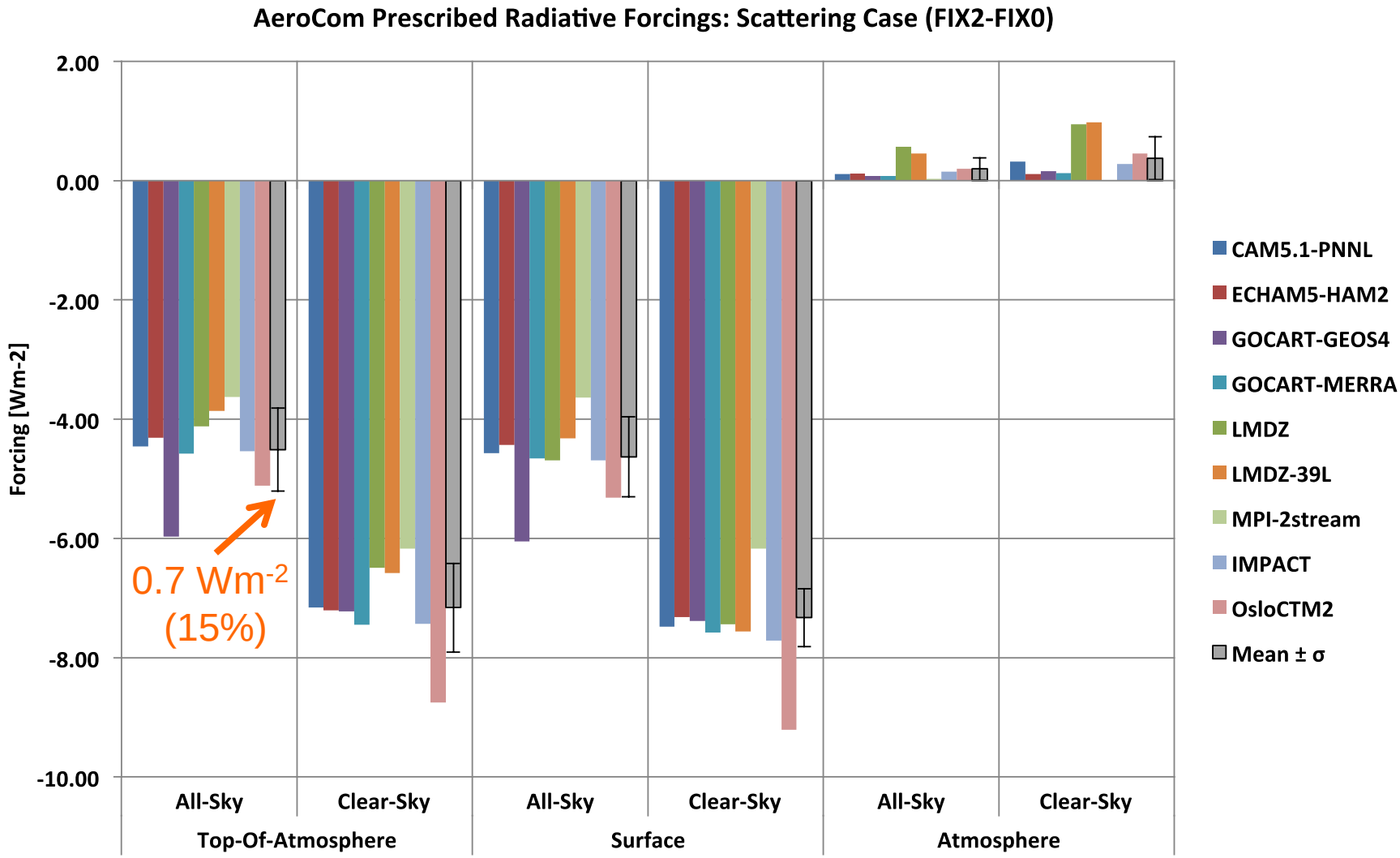
# Summary: Scattering Case (FIX2-FIX0)

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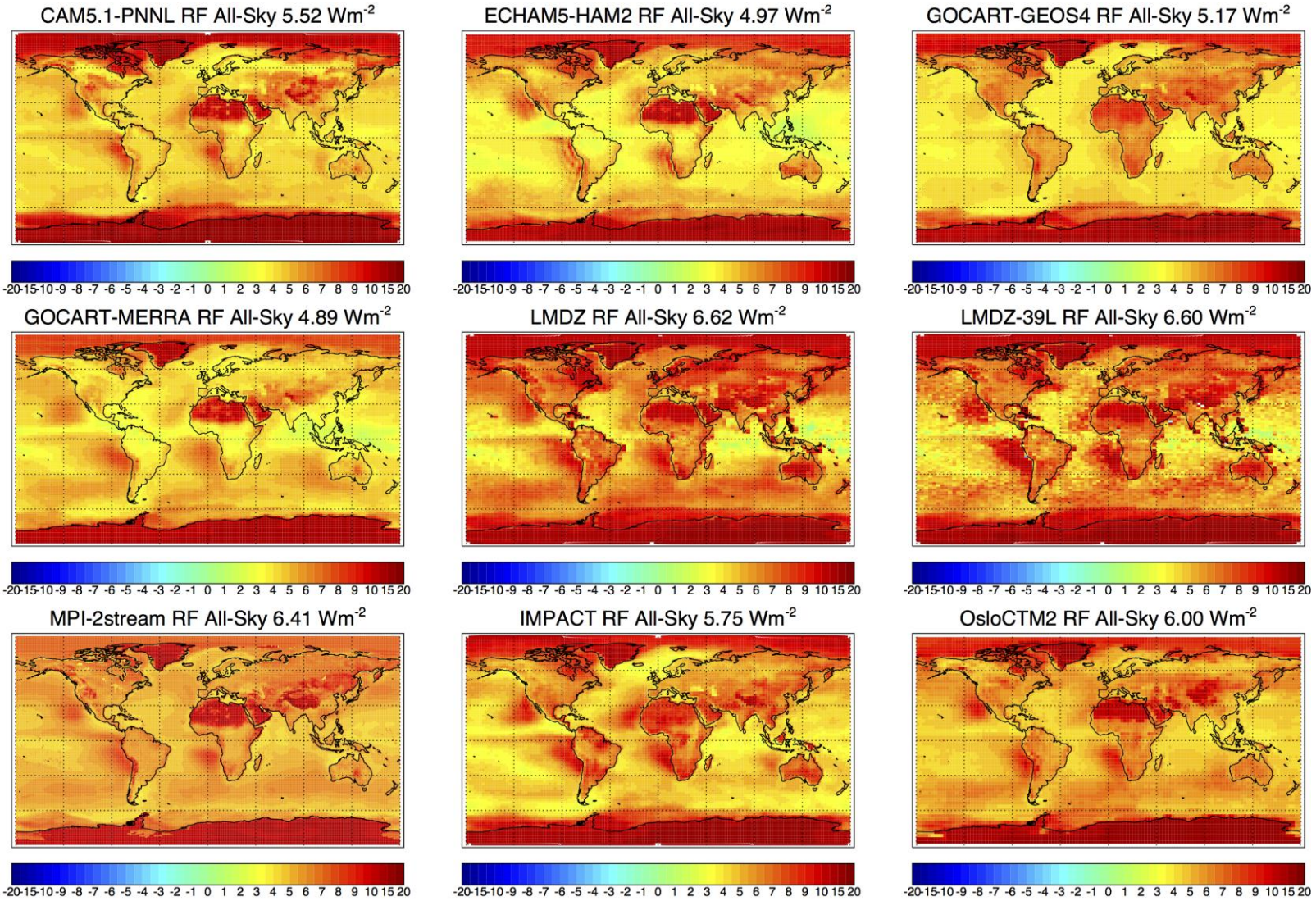
# Radiative Forcing: Absorbing Case

All-sky **top-of-atmosphere** radiative forcing for FIX3-FIX2

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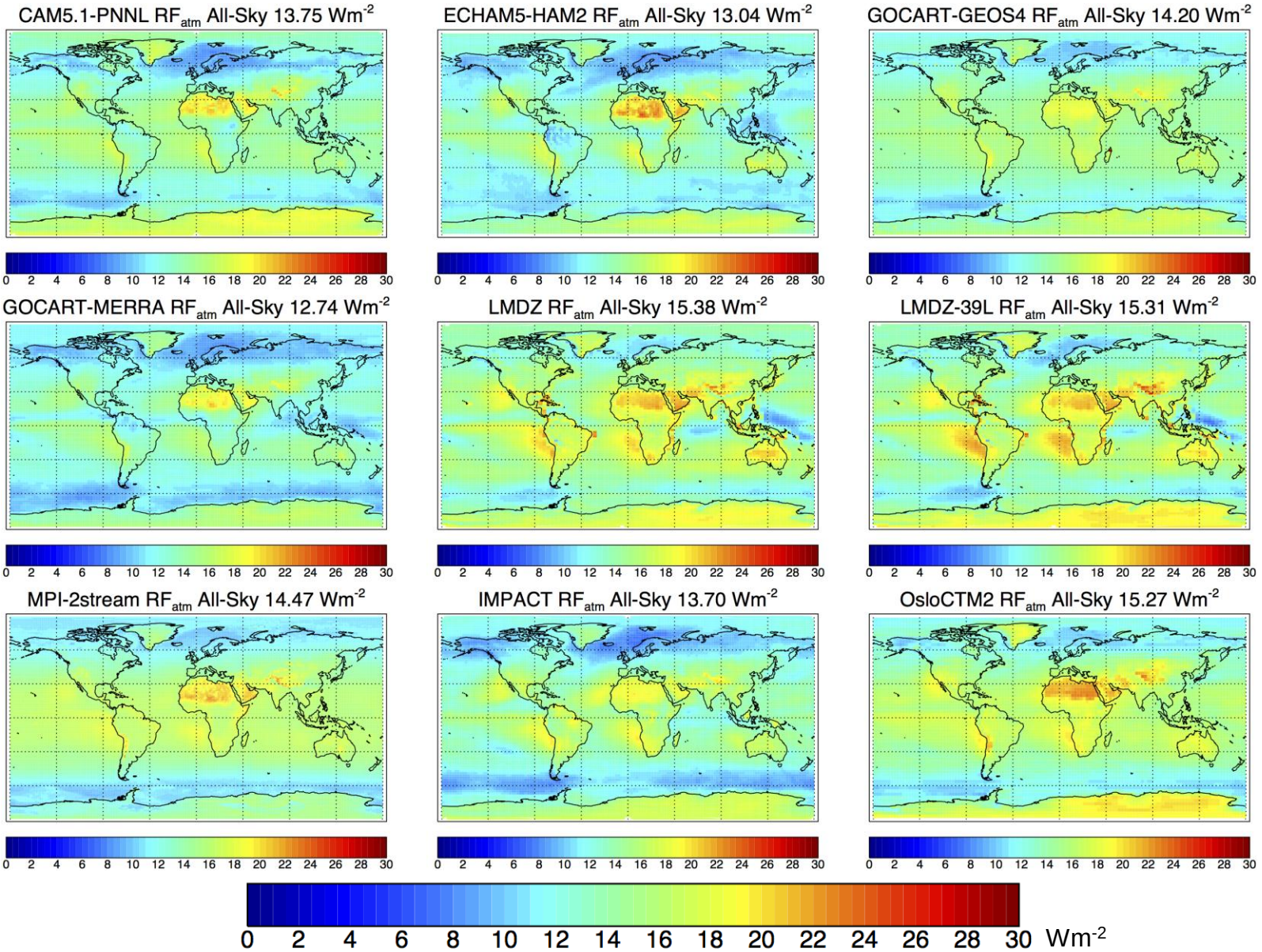
# Radiative Forcing: Absorbing Case

All-sky **atmospheric** radiative forcing for FIX3-FIX2

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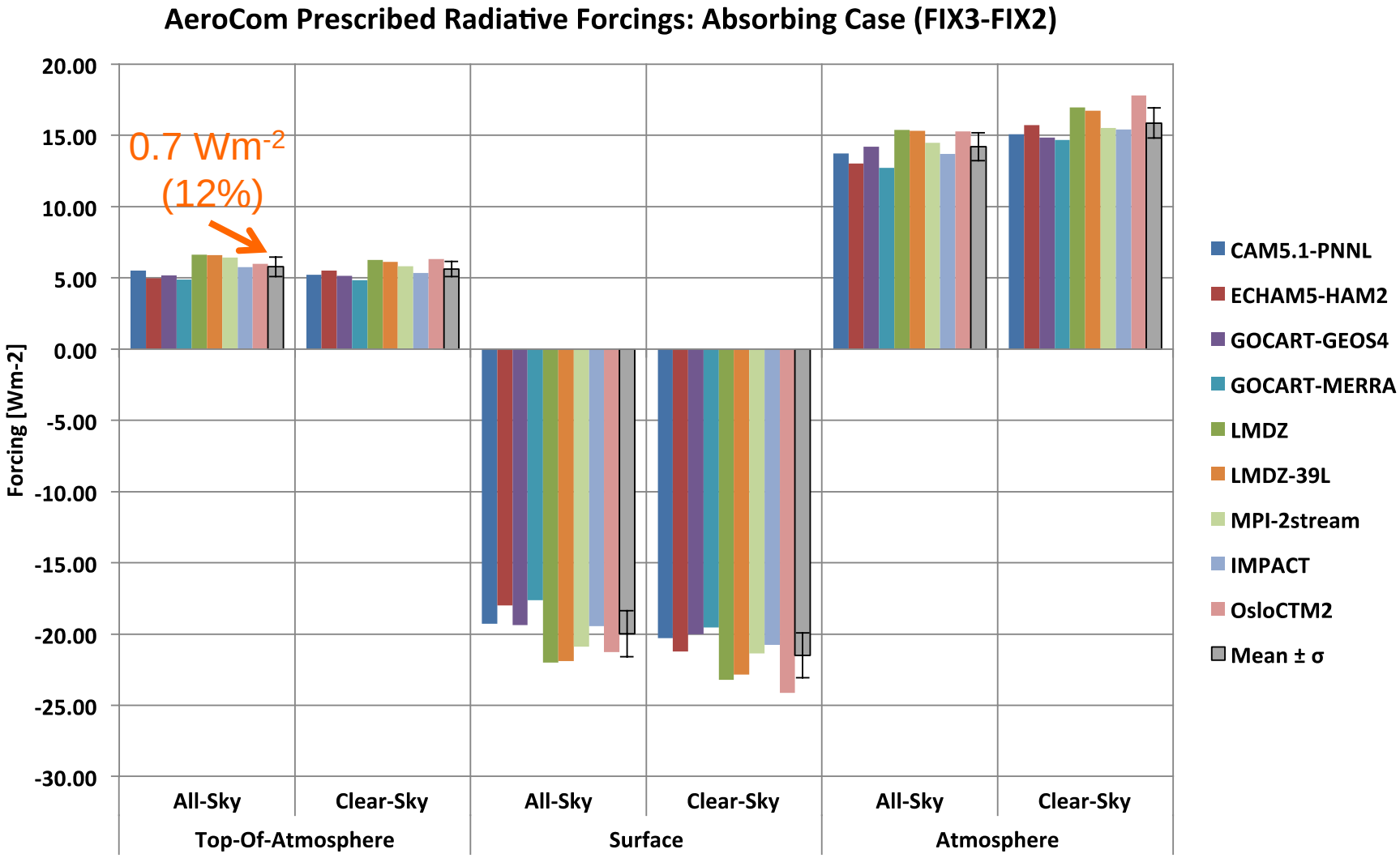
# Summary: Absorbing Case (FIX3-FIX2)

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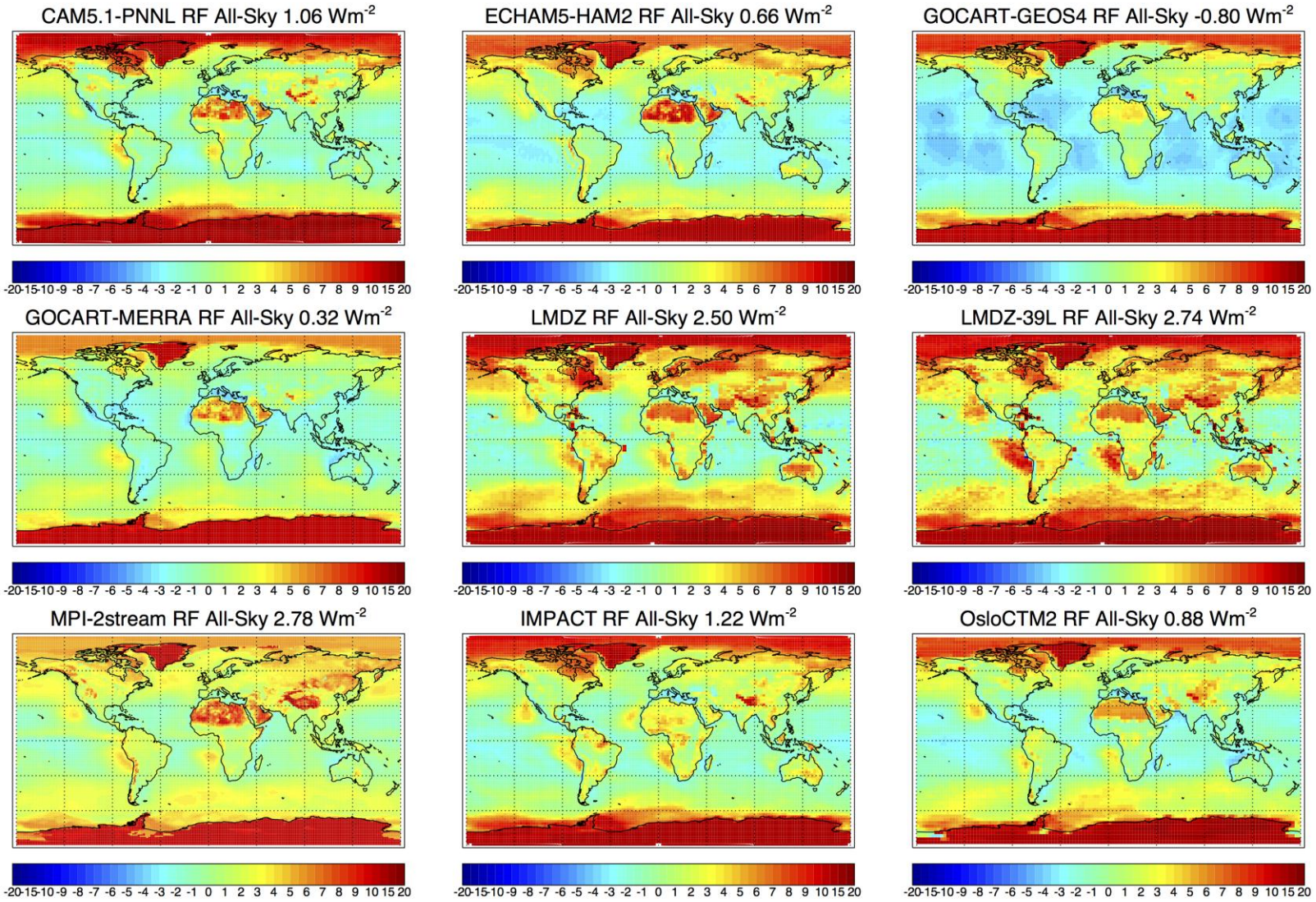
# Radiative Forcing: Scattering & Absorbing Case

All-sky **top-of-atmosphere** radiative forcing for FIX3-FIX0

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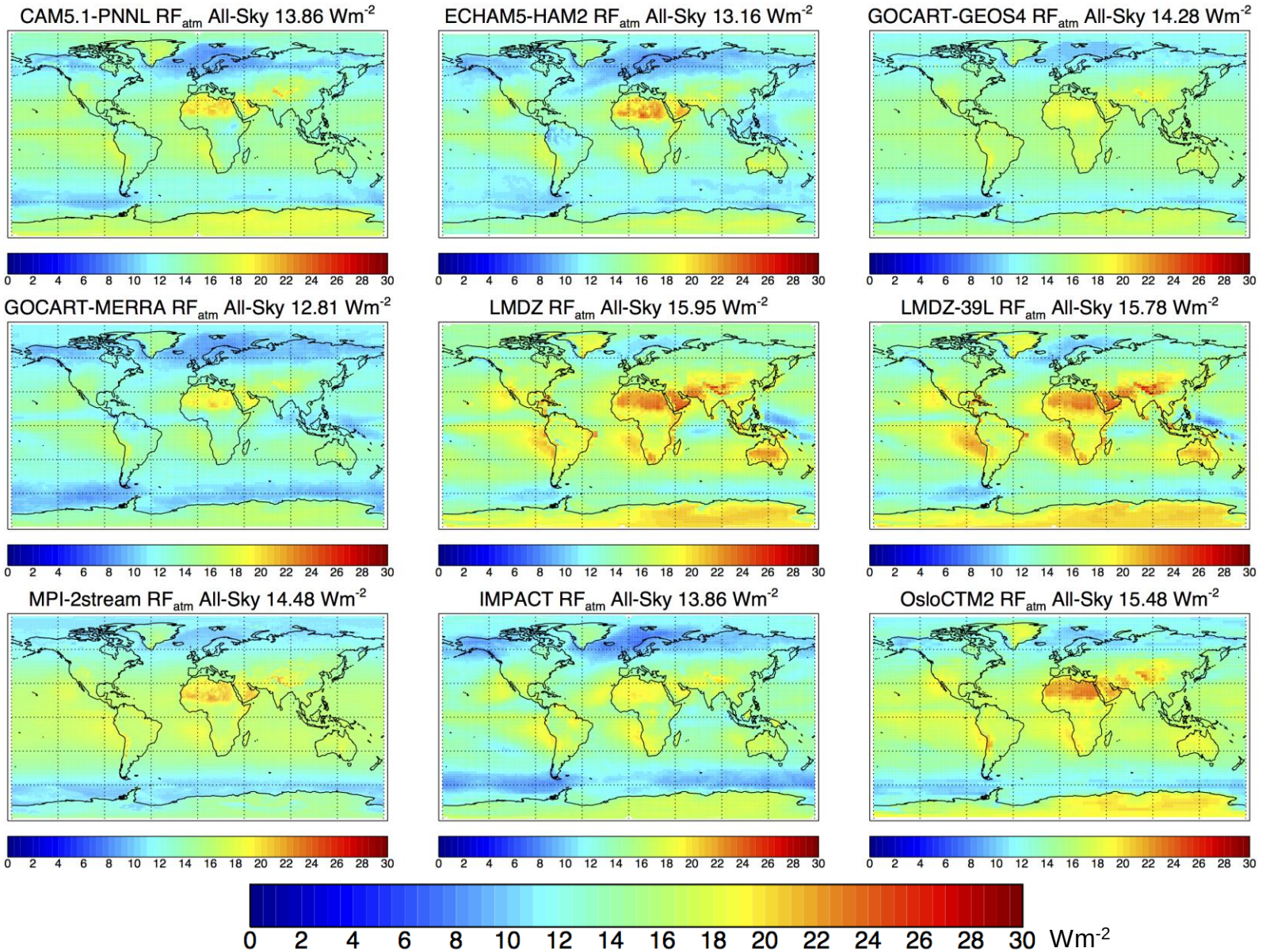
# Radiative Forcing: Scattering & Absorbing Case

All-sky **atmospheric** radiative forcing for FIX3-FIX0

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# Summary: Scatting & Absorbing Case (FIX3-FIX0)

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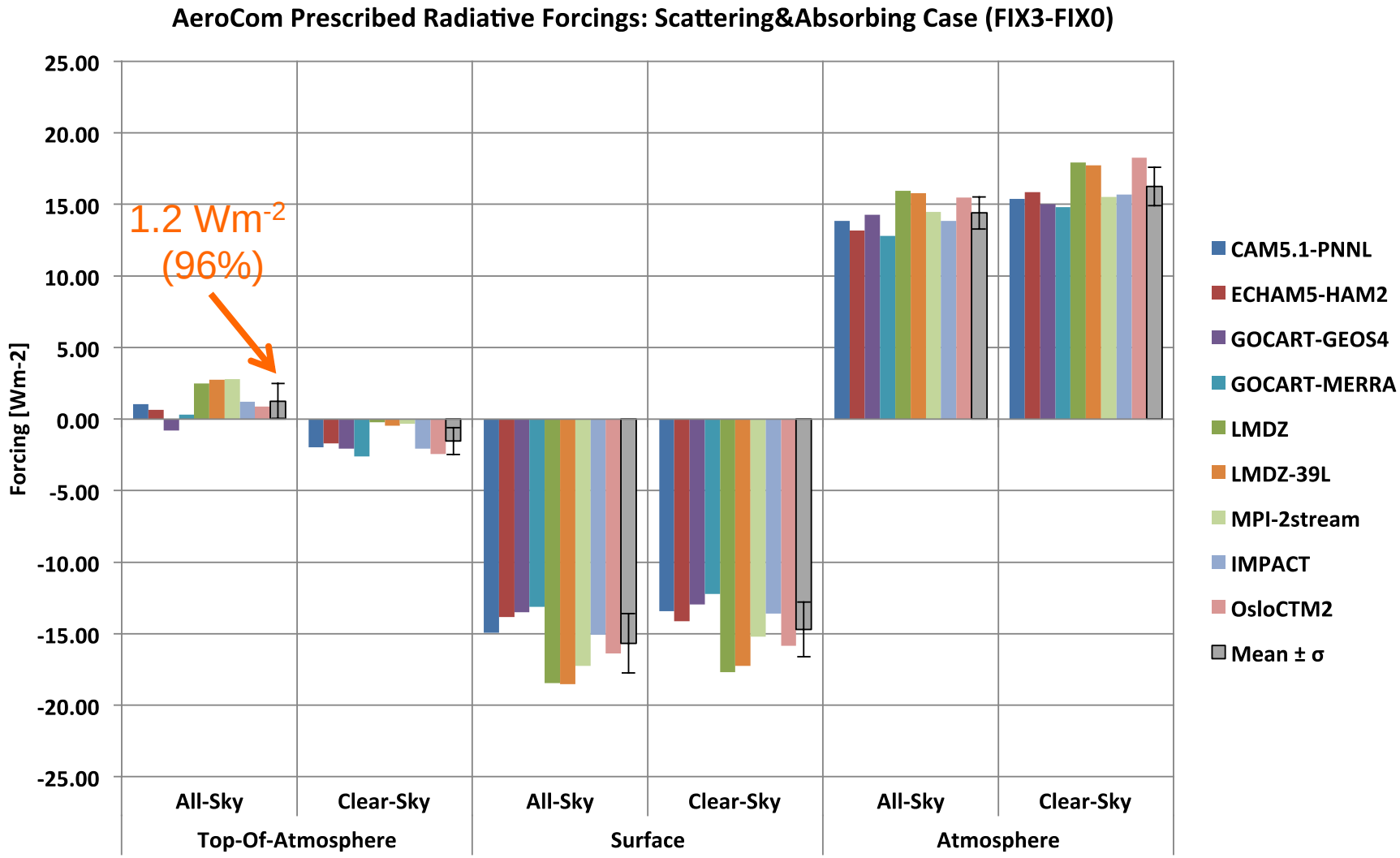


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# Attribution to Host Model Effects

How do we attribute inter-model forcing variability to host model effects?

Locally decompose forcing error:

$$\Delta RF^{all}_{TOA} = \underbrace{\overbrace{\frac{\partial RF^{all}_{TOA}}{\partial A_{sur}}}^{\text{Sensitivity}} \Delta A_{sur}}_{\text{Surface albedo}} + \underbrace{\overbrace{\frac{\partial RF^{all}_{TOA}}{\partial A_{cld}}}^{\text{Sensitivity}} \Delta A_{cld}}_{\text{Clouds}}$$

where

$$A_{cld} = \frac{F^{\uparrow}_{all} - F^{\uparrow}_{clr}}{F^{\downarrow}_{all}}$$

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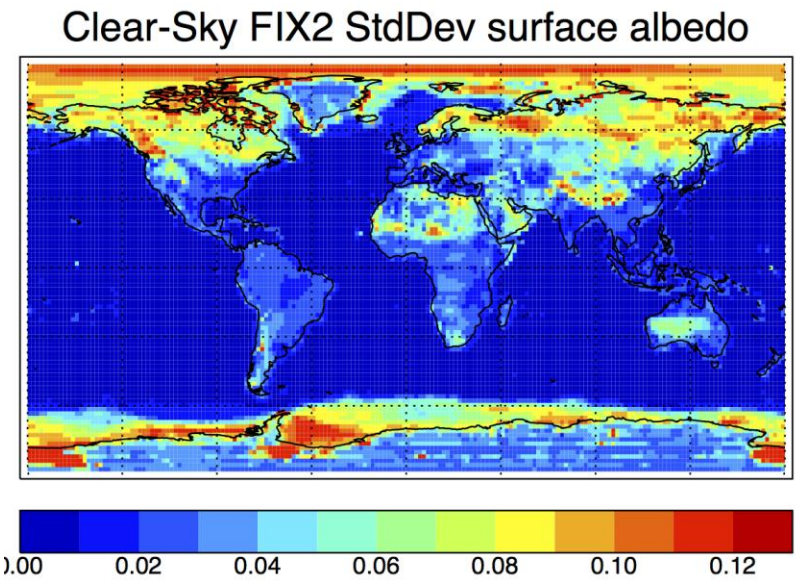
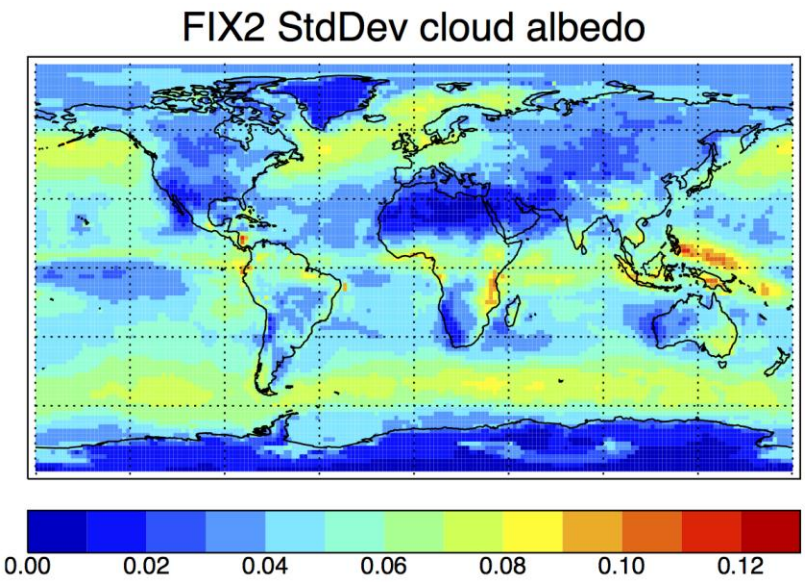
# Attribution to Host Model Effects

Host model perturbations (inter-model standard deviation):

Surface Albedo $\Delta A_{sur}$




Cloudy Albedo $\Delta A_{cld}$

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# Attribution to Host Model Effects

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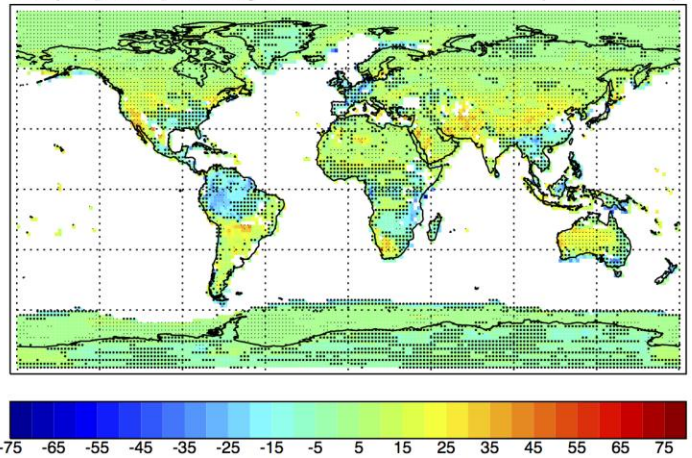
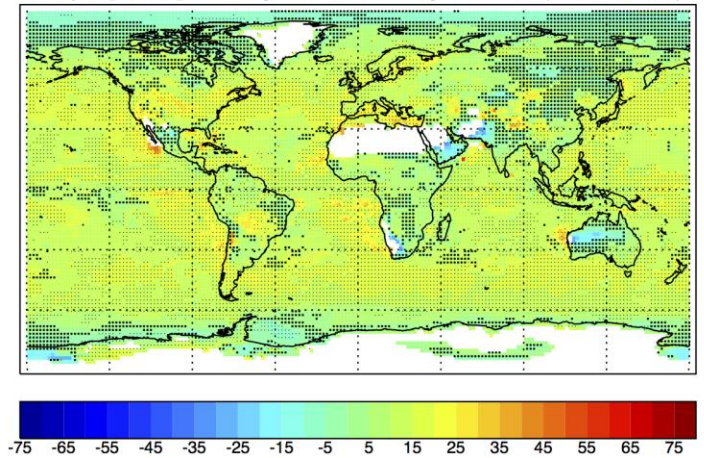
Scattering Case: FIX2-FIX0

Sensitivity

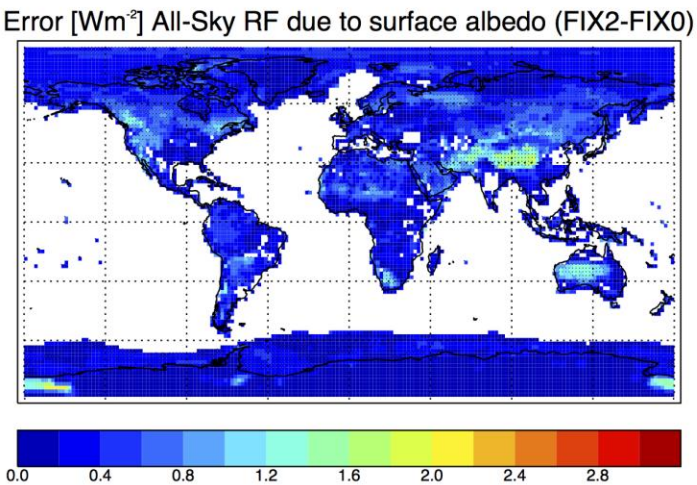
$$\frac{\partial RF^{all}_{TOA}}{\partial A_{sur}}$$



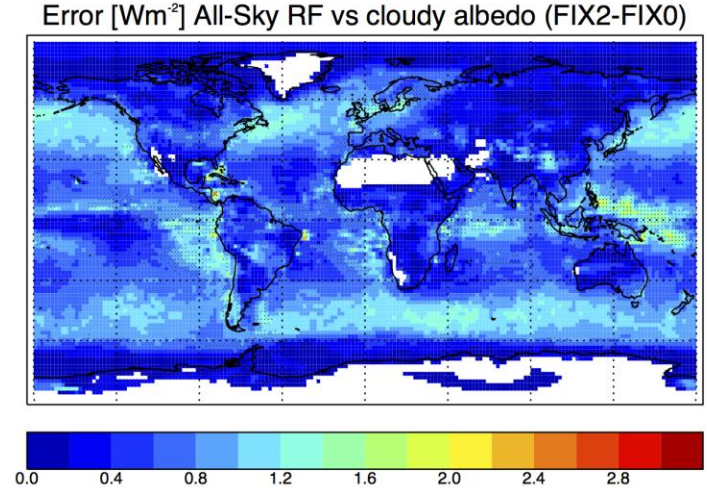

$$\frac{\partial RF^{all}_{TOA}}{\partial A_{cld}}$$




Forcing Error




$$\frac{\partial RF^{all}_{TOA}}{\partial A_{sur}} \Delta A_{sur}$$




$$\frac{\partial RF^{all}_{TOA}}{\partial A_{cld}} \Delta A_{cld}$$

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# Attribution to Host Model Effects

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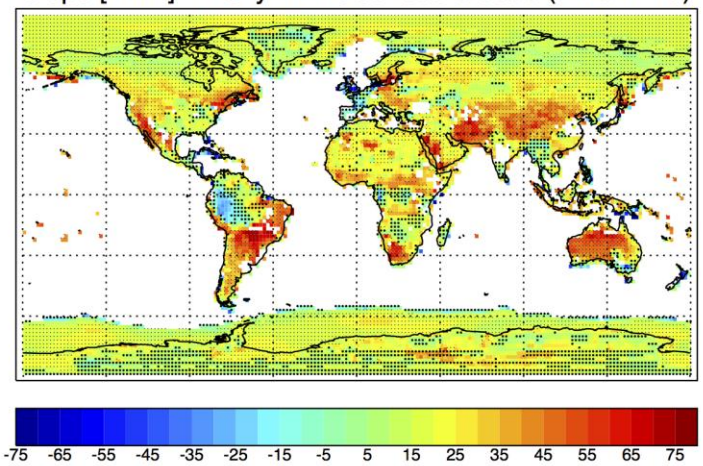
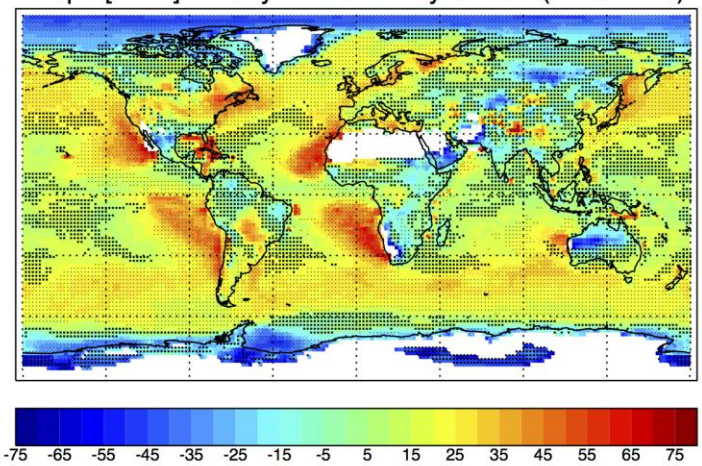
Absorbing Case: FIX3-FIX0

Sensitivity

$$\frac{\partial RF^{all}_{TOA}}{\partial A_{sur}}$$




$$\frac{\partial RF^{all}_{TOA}}{\partial A_{cld}}$$

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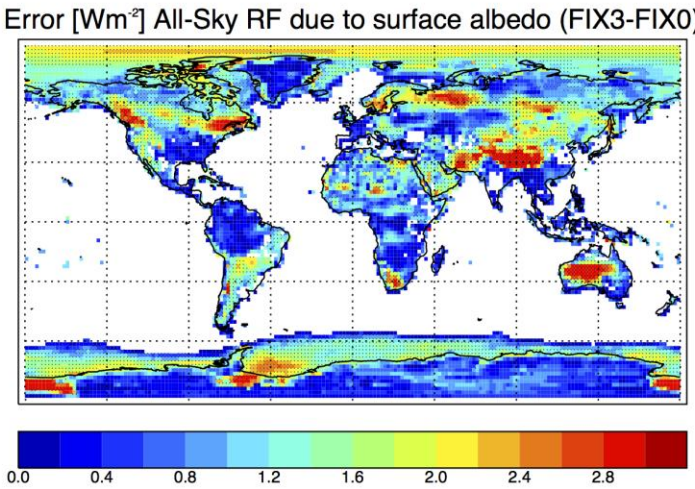
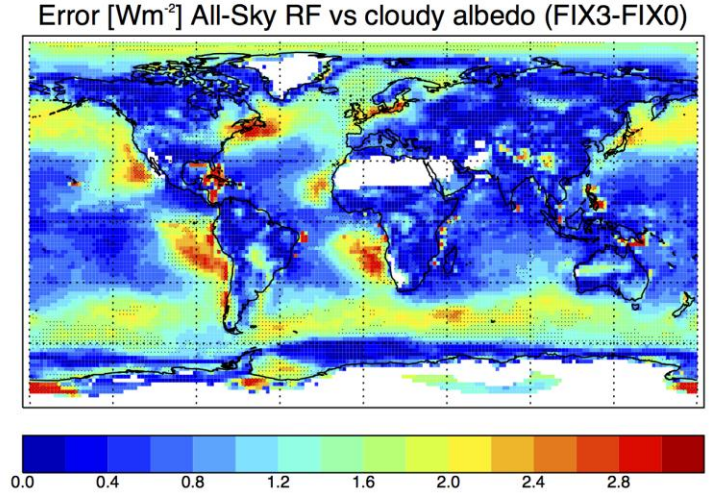



$$\frac{\partial RF^{all}_{TOA}}{\partial A_{sur}} \Delta A_{sur}$$




$$\frac{\partial RF^{all}_{TOA}}{\partial A_{cld}} \Delta A_{cld}$$

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# Conclusions

- Current models show considerable diversity in model parameters relevant for the calculation of aerosol radiative forcing
- Significant differences in atmospheric forcings for the purely scattering case highlight the contribution of structural differences in the radiation schemes
- Even for identically prescribed aerosol radiative properties aerosol radiative forcings show significant diversity:

  Scattering case: 0.70 $Wm^2$ (15%)

  Partially absorbing case: 1.21 $Wm^2$ (96%)
- Multi-model “diversity” is not a true measure of aerosol uncertainty

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# So what do we do now?

- **We are still accepting submissions for the revised paper**
- Uncertain host model effects should be part of AeroCom evaluation suite
- Diversity of absorption in scattering case demands for careful evaluation of some radiative transfer scheme
- Aim to reduce host model effect diversity by next AeroCom / AR6 (at least for surface albedos)
- A number of obvious follow up studies

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