

ICAO Symposium on Non-CO₂ Aviation Emissions

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Speaker

Session 2: Enhancing Scientific Knowledge
Part II - Contrails

- Flight trajectories
- Cooling contrails
- Warming contrails

- We broadly know where contrails form
- Contrails occur in 'outbreaks' (Ice Supersaturation Regions)
- We know which contrails are likely to warm or cool

Sources of Global Contrail RF Uncertainty

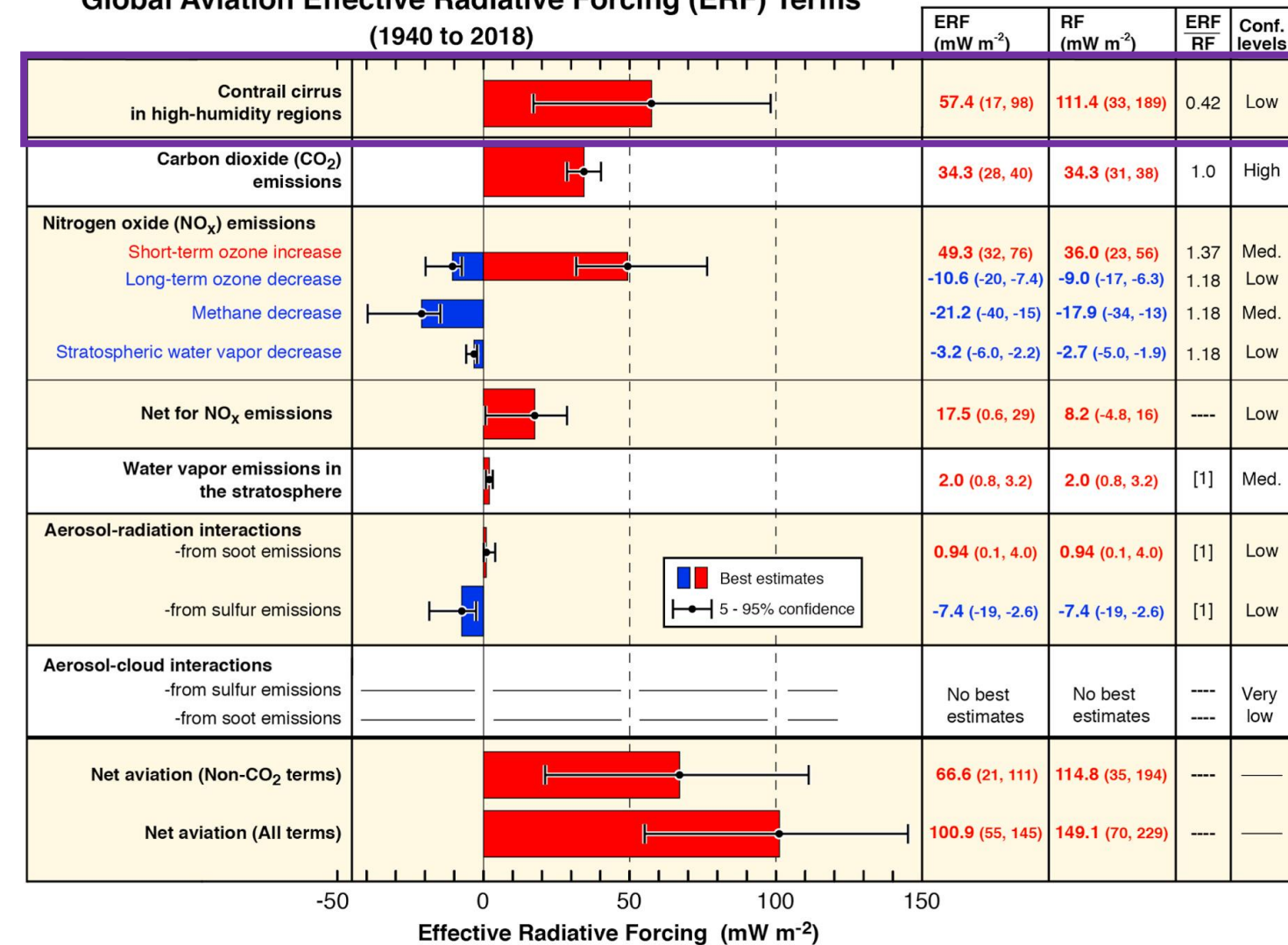
The global uncertainty in contrail RF may not be decision relevant

- **Model diversity** (methods)
- **Emissions** (inventories)
- **Contrail properties** (observational constraints)
- **Meteorological variability**

Lee et al attempted to harmonize estimates

- **We know the basics** (where, when)
- **Can reduce persistent contrail climate impact by focusing on what we know**
- **The uncertainty on any individual flight is always going to be large**

Global Aviation Effective Radiative Forcing (ERF) Terms (1940 to 2018)



Lee et al 2021



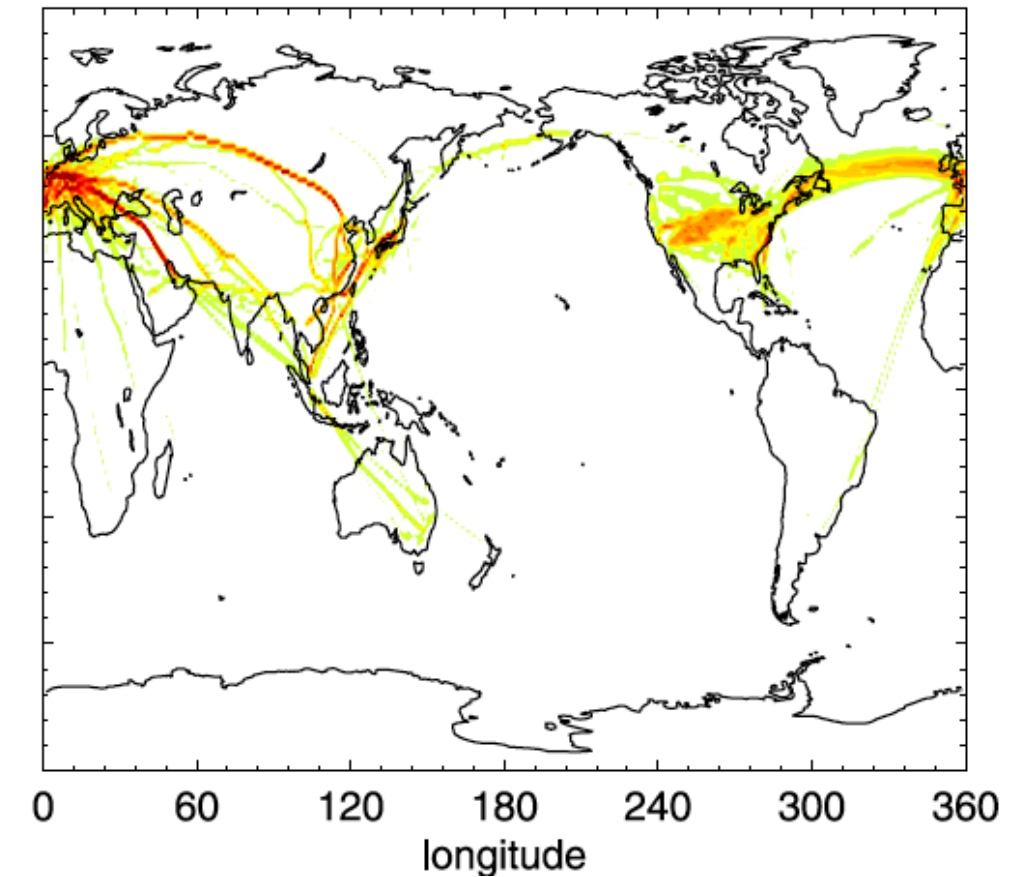
Simulating Contrails & Aerosol in Climate (& Weather) Models

- Emissions: gridded (monthly, daily, hourly) or individual flights
- Contrail Parameterization
 - Initialize based on observations or plume models (CoCiP even)
 - Add to GCM fields
 - Integrate in time with rest of model
- Different models
 - Here: CESM. Used by others (PreTrails, UK, Google)
 - Similar GCM modeling from DLR (Bock & Burkhardt)

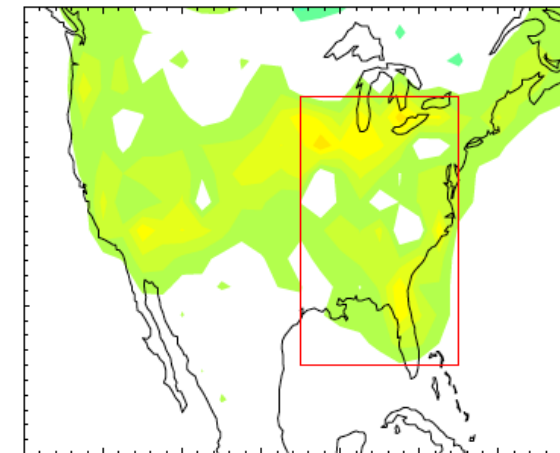
PRO: Full feedbacks/lifecycle: Aerosol & T_s effects possible
 Parametric testing of contrail properties
Testbed for weather forecast modeling (also GCMs)

CON: Simplified initial contrail parameterization
 Mostly inventory based, coarse (100km) [So far]

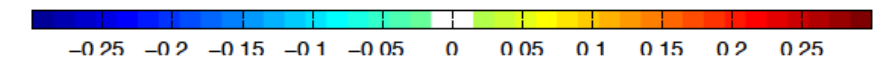
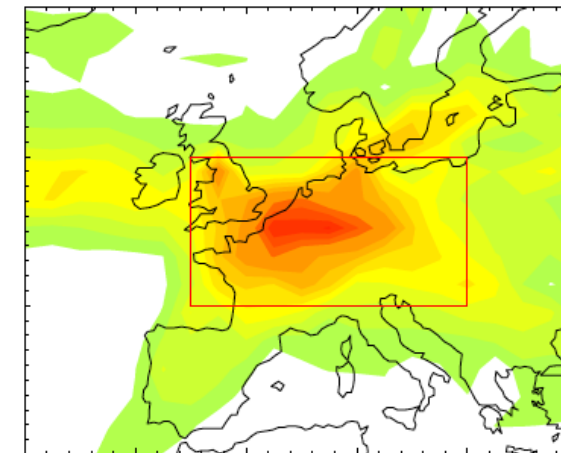
(d) FUELBURN at 197.9081 hPa, JUL ($\times 10^{13}$)



(b) Δ RESTOM (W/m²) above 2 σ , US



(c) Δ RESTOM (W/m²) above 2 σ , Europe

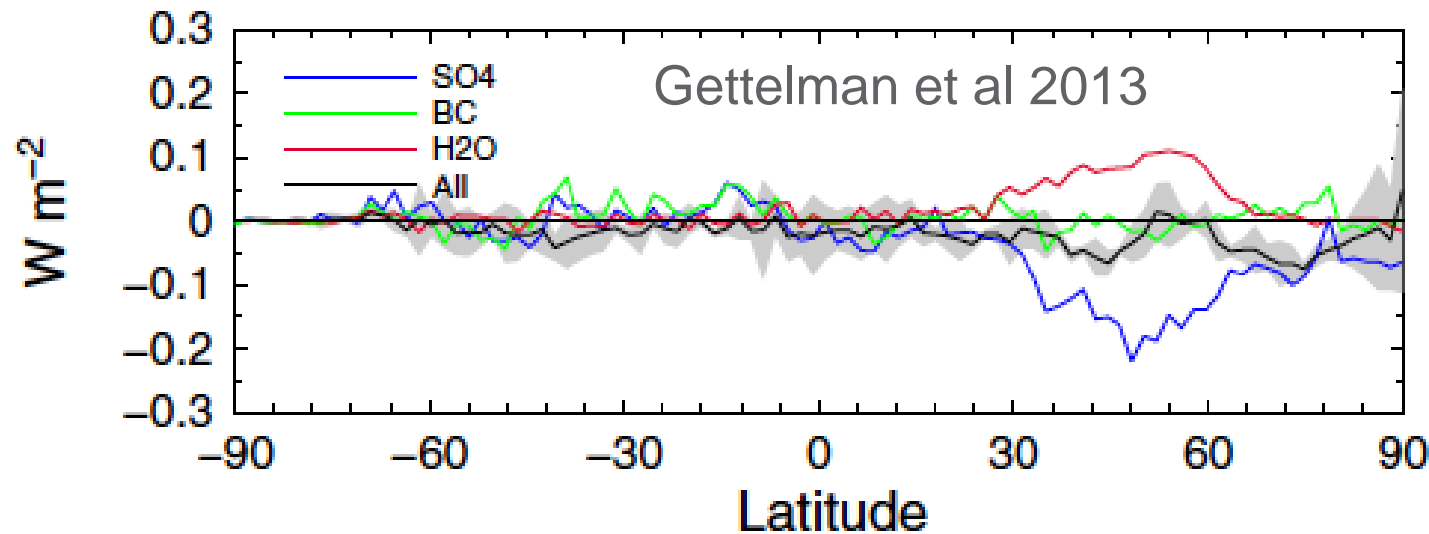


Chen & Gettelman 2013
 Gettelman et al 2021
 Lee et al 2021

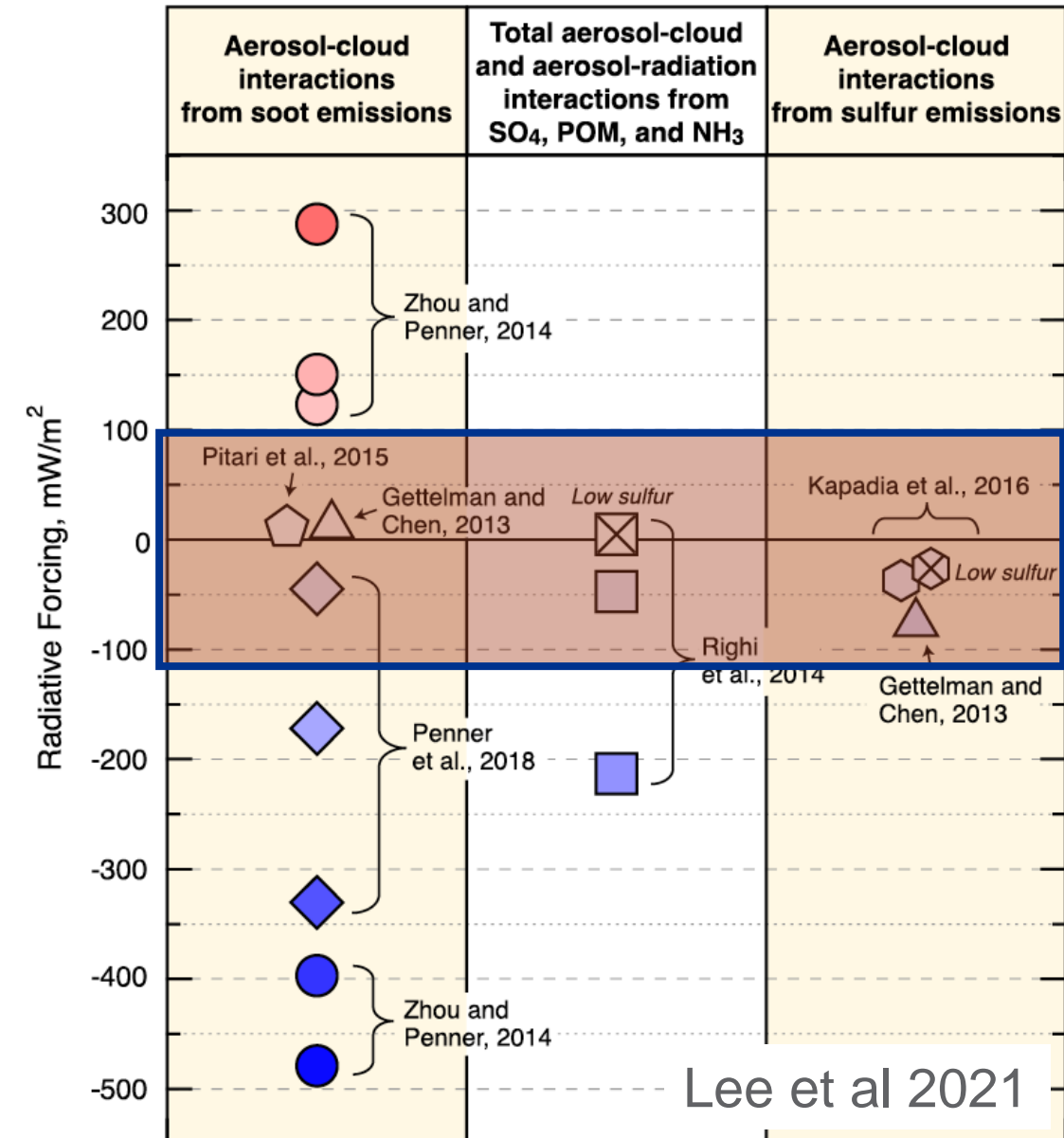
Aviation Aerosol Effects

- **H₂O:** (Contrails) warm (more high clouds & ice)
- **BC (nvPM):** small cooling effects (0.1% activation), ~~large cooling if high numbers/efficiency (unlikely)~~
- **SO₄:** impact liquid clouds & increase cooling (uncertain)
- **Net:** depends on **BC**, **SO₄**
- Aerosols effects may alter understanding of non-CO₂ effects. Need to constrain this better!
- SAF = different aerosols, no S. Modifies aerosol effects

Net Cloud Radiative Effect



RF Estimates for Aerosol-Cloud Interactions



Thank You

