Comparisons of simulated radiative properties of cirrus across the mid- and far-infrared with aircraft-based observations

Richard Bantges

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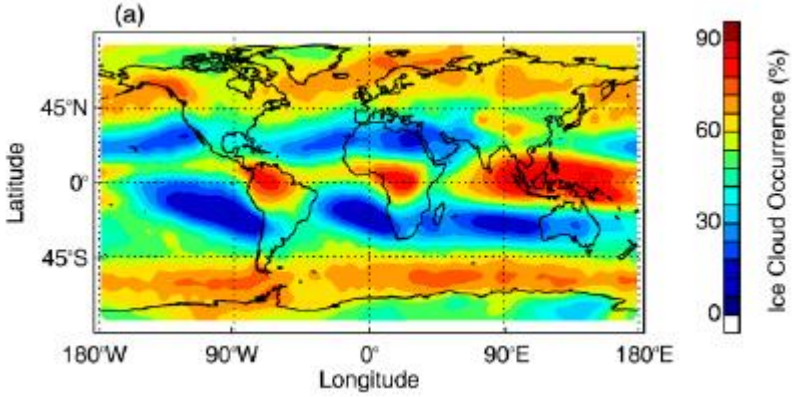
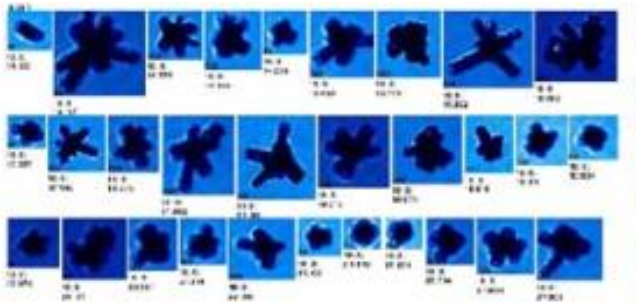
Aim and motivation

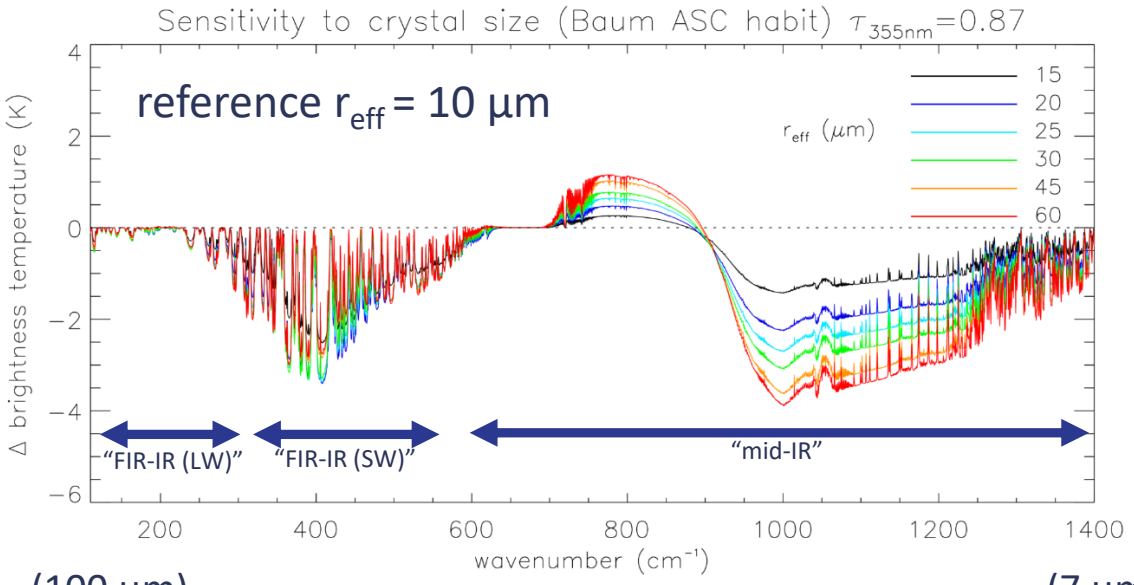
- Aim: Test ability to simulate radiative properties of (thin) cirrus across the mid- and far- infrared
- Motivation: Cirrus clouds
  - cover >30% of the globe (seasonal / latitudinal variation)
  - are composed of non-spherical complex ice crystals
  - climate feedback: solar albedo vs IR greenhouse effect
    - ↑IWP: VIS –ve (cooling), IR +ve (heating)
    - ↑D_e: VIS +ve (heating), IR –ve (cooling)
  - GCM estimates (Gasparini 2016) of TOA net CRE ~5.7 Wm^{-2} vs satellite obs. (Chen 2000, Hartmann 1992) ~1.3-2.4 Wm^{-2} (FIR contribution? CLR: 35% Earth's energy, CIR: 50%; Harries 2008)
  - Baran 2012: GCM – simulated LW (10-30 Wm^{-2}) & SW (-10 to -35 Wm^{-2}) flux differences assuming different crystal models





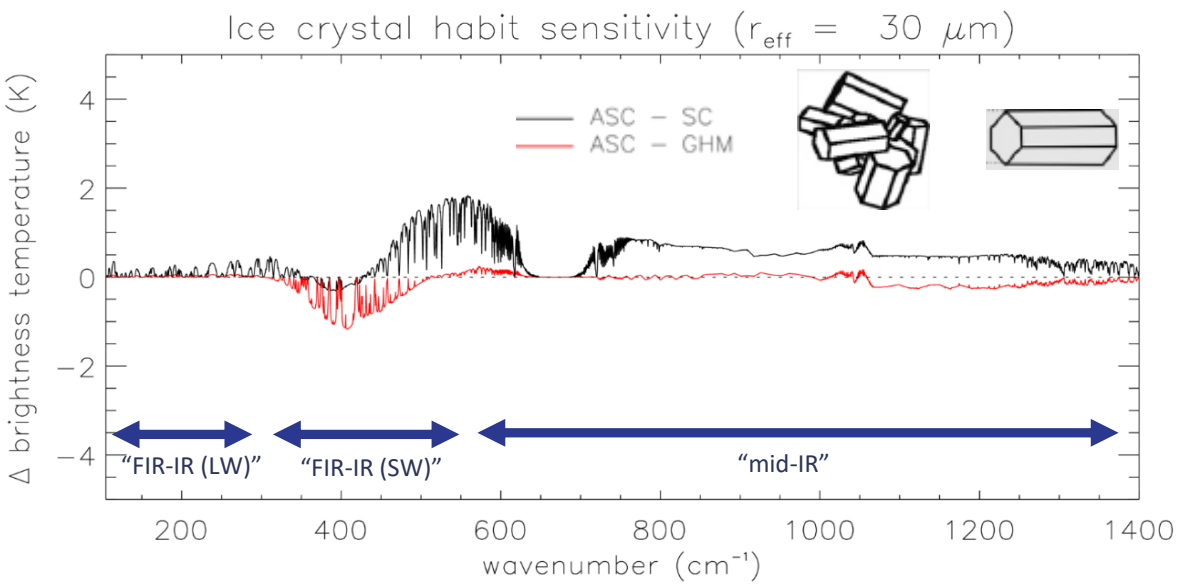
Sensitivity to ice crystal size and habit (model)

Sensitivity to ice crystal size



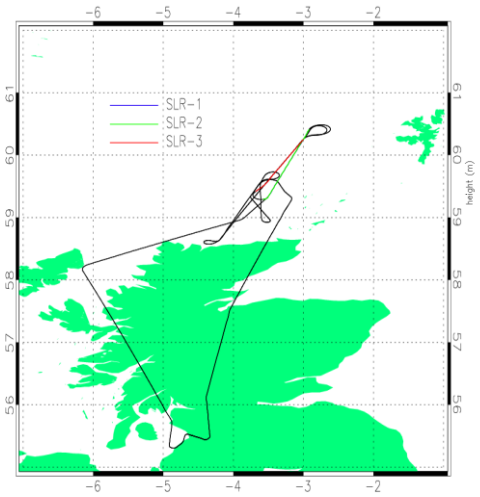
(100 µm) (7 µm)

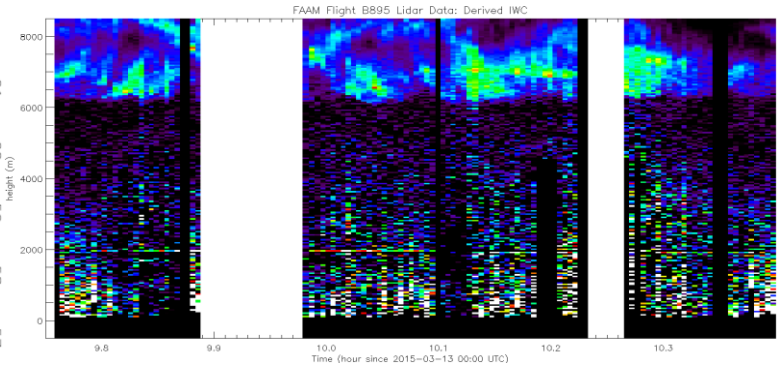
Sensitivity to ice crystal habit (shape)

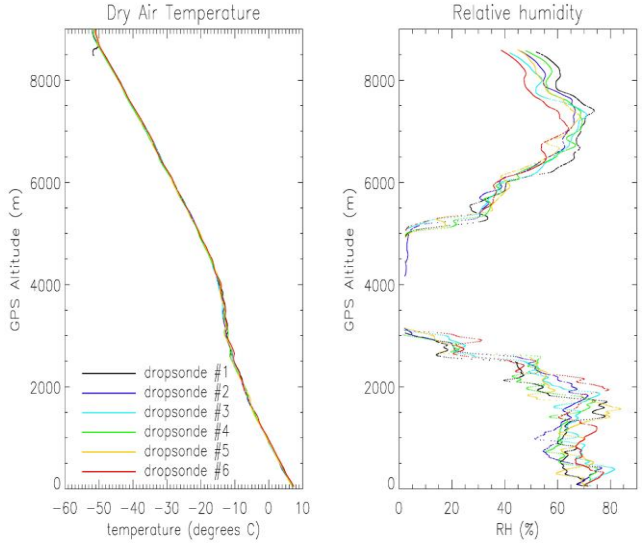


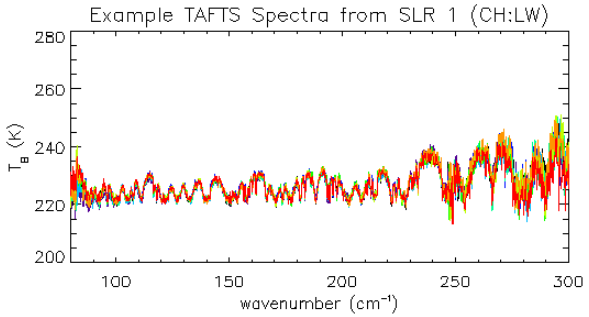
Aircraft-based datasets

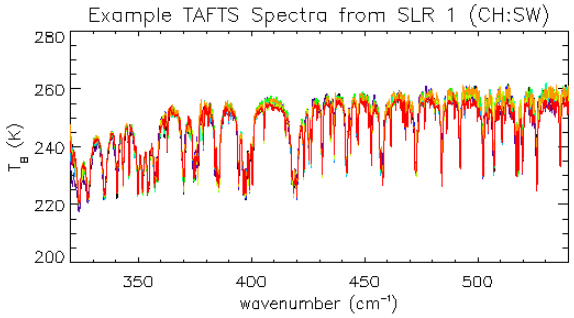
- FAAM Flight B895 (13 March 2015)
  - **Cir**rus **C**oupled **C**loud-**R**adiation **Ex**periment
  - Lidar (constrain cloud vertical profile)
  - Dropsondes (characterise atmospheric column)
  - ARIES – MIR radiance spectra (4-16 µm)
  - TAFTS – FIR radiance spectra (16-100 µm)

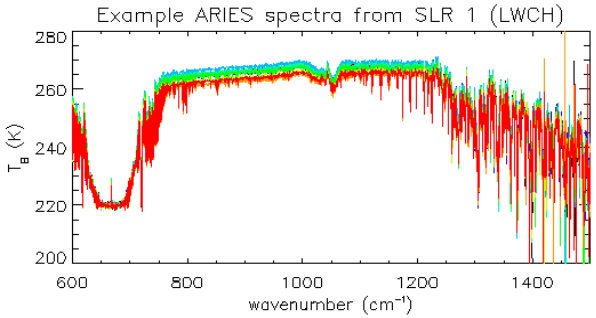










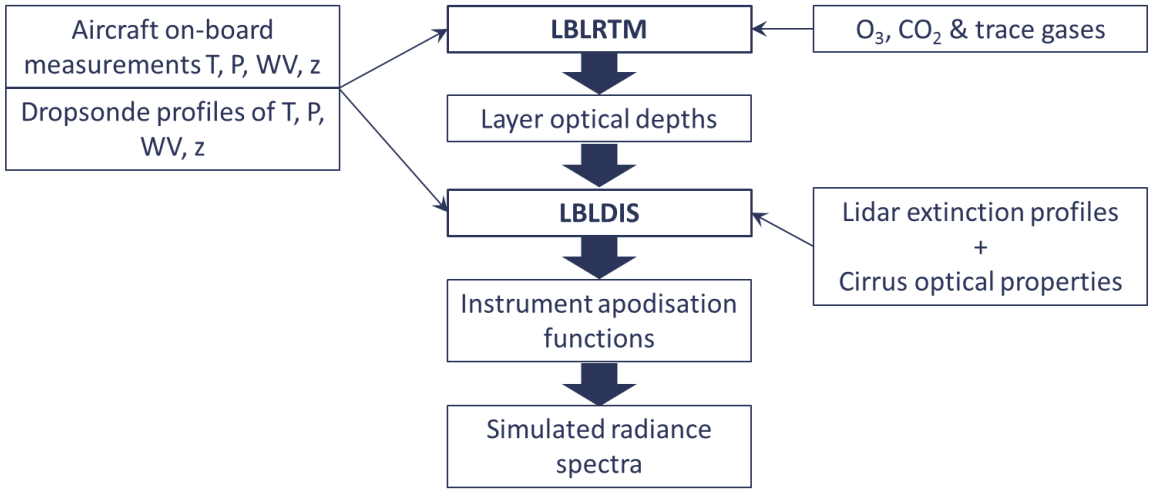


Tools and simulation methodology

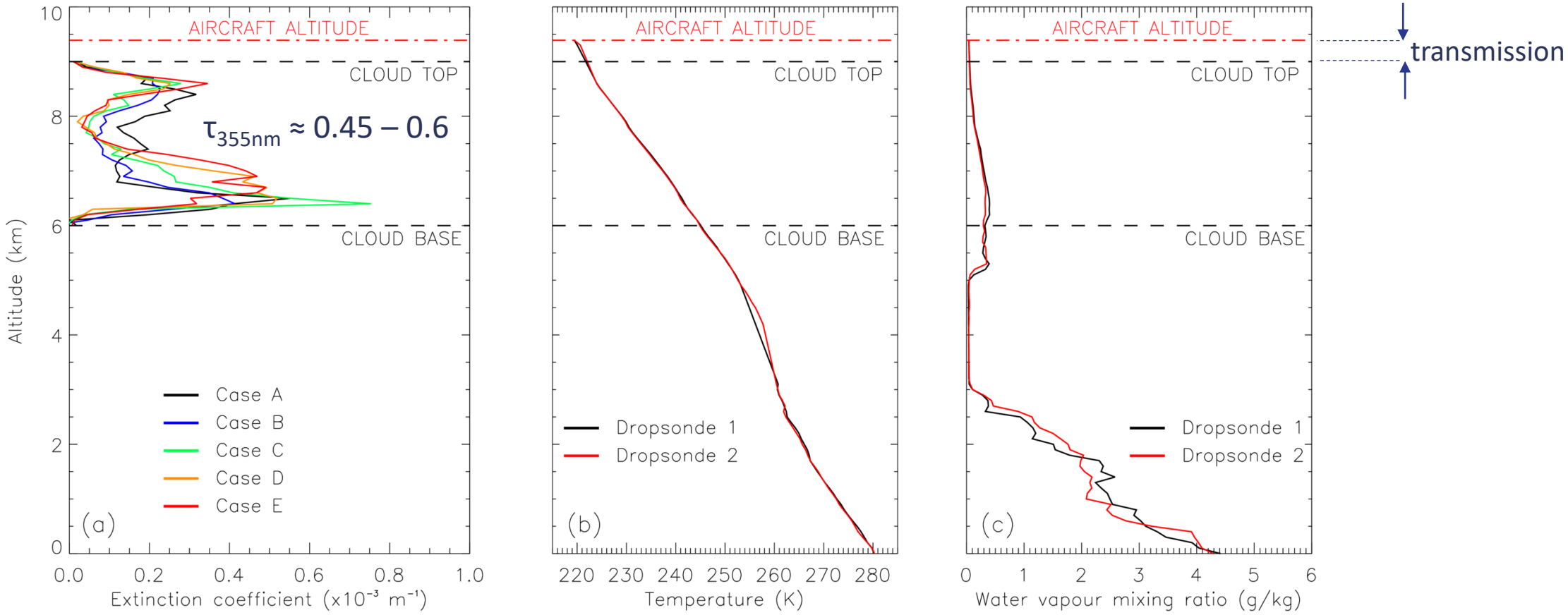
Tools

- State-of-the-art cirrus optical models (Baum, Yang, Baran)
- Sophisticated line-by-line radiative transfer codes:
  - LBLRTM v12.8 (HITRAN 2012)
  - LBLDIS v3.0

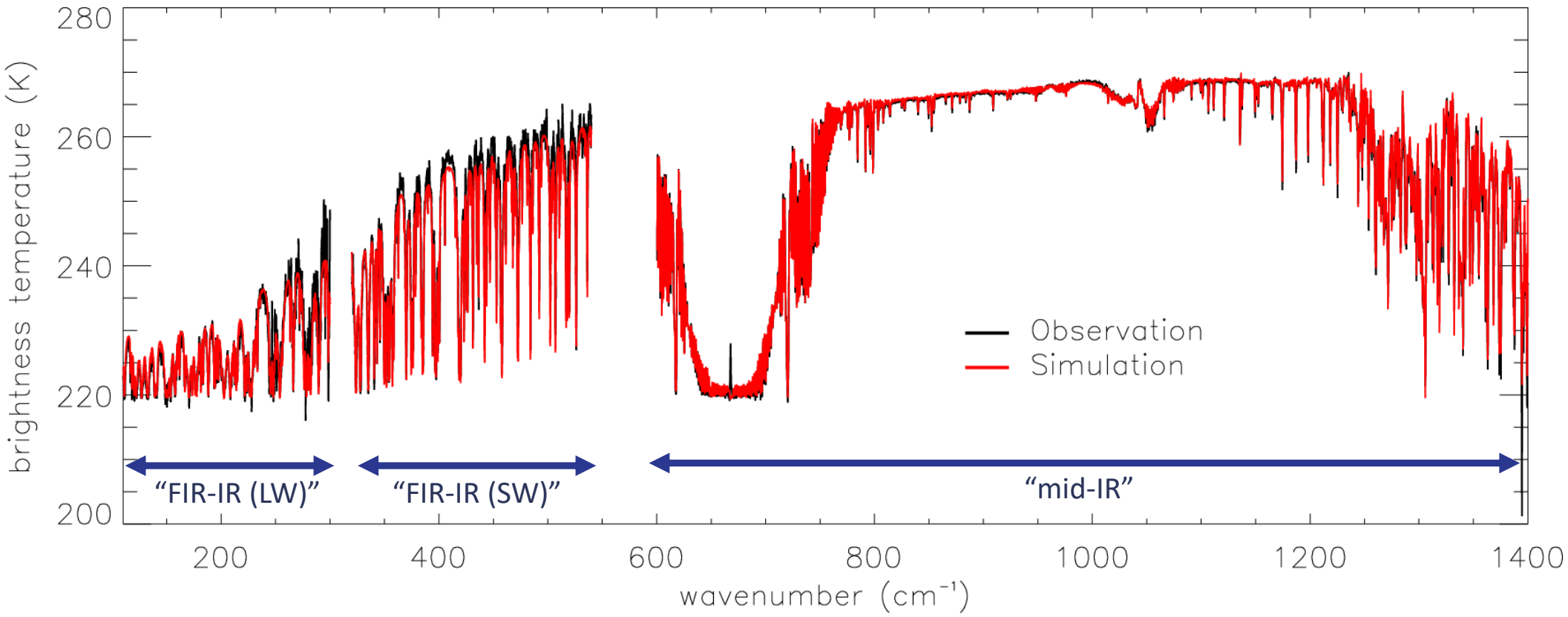
Simulation methodology



Case Studies from B895 (SLR 1)

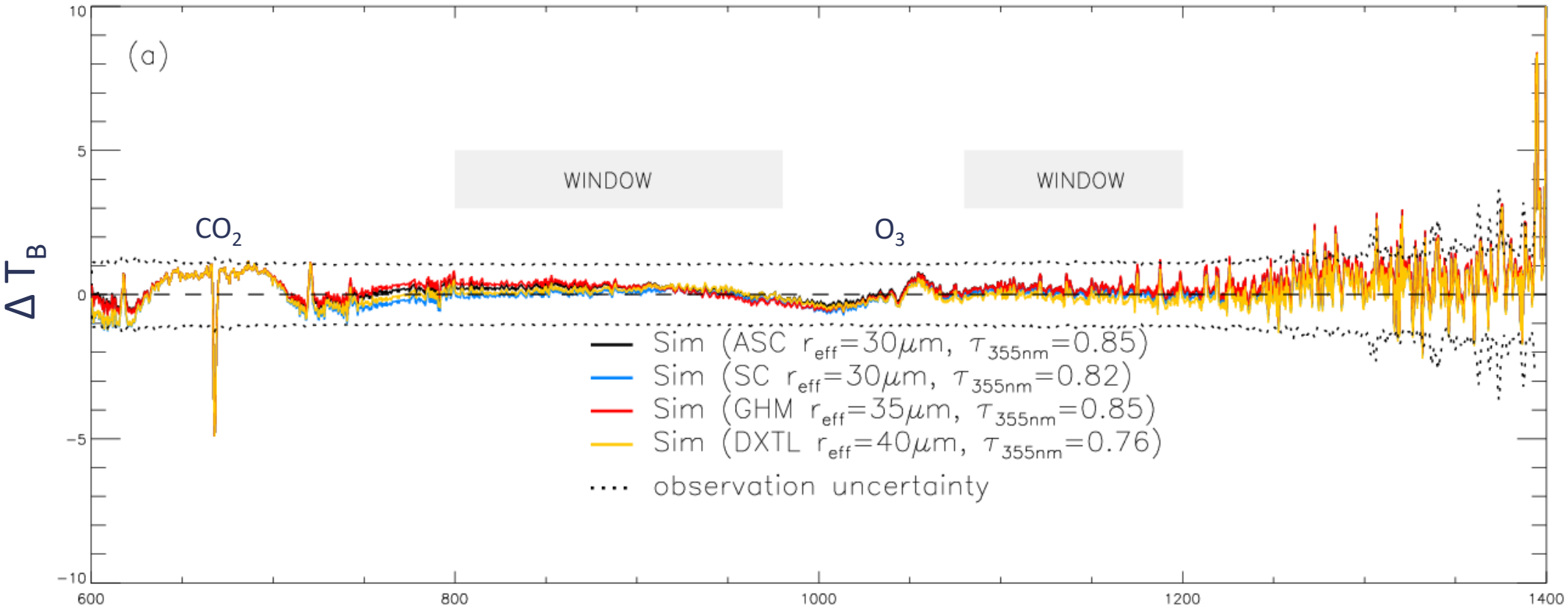


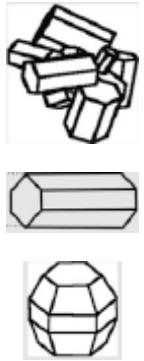
Example comparison for “Case A”



Case Study A: Mid InfraRed (LW: 600 – 1400 cm^{-1})

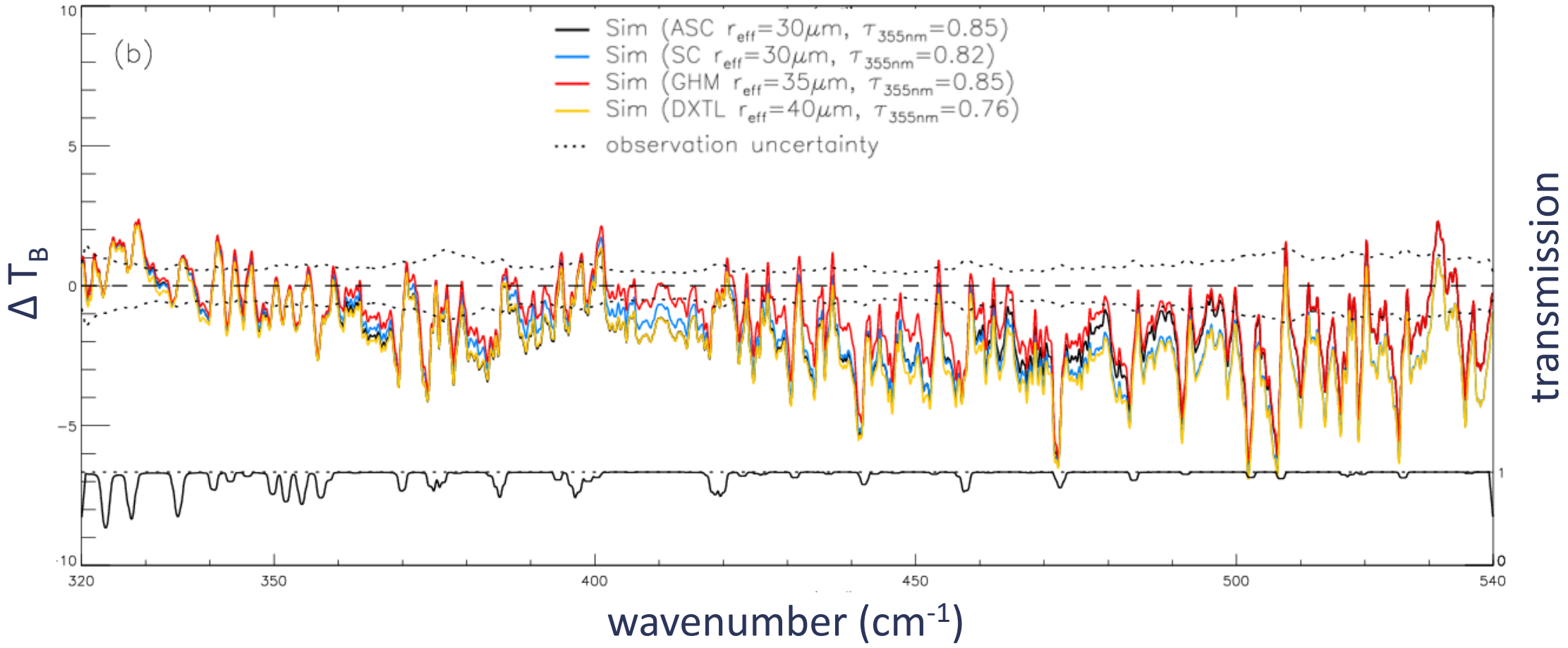
Differences: Simulation - Observation





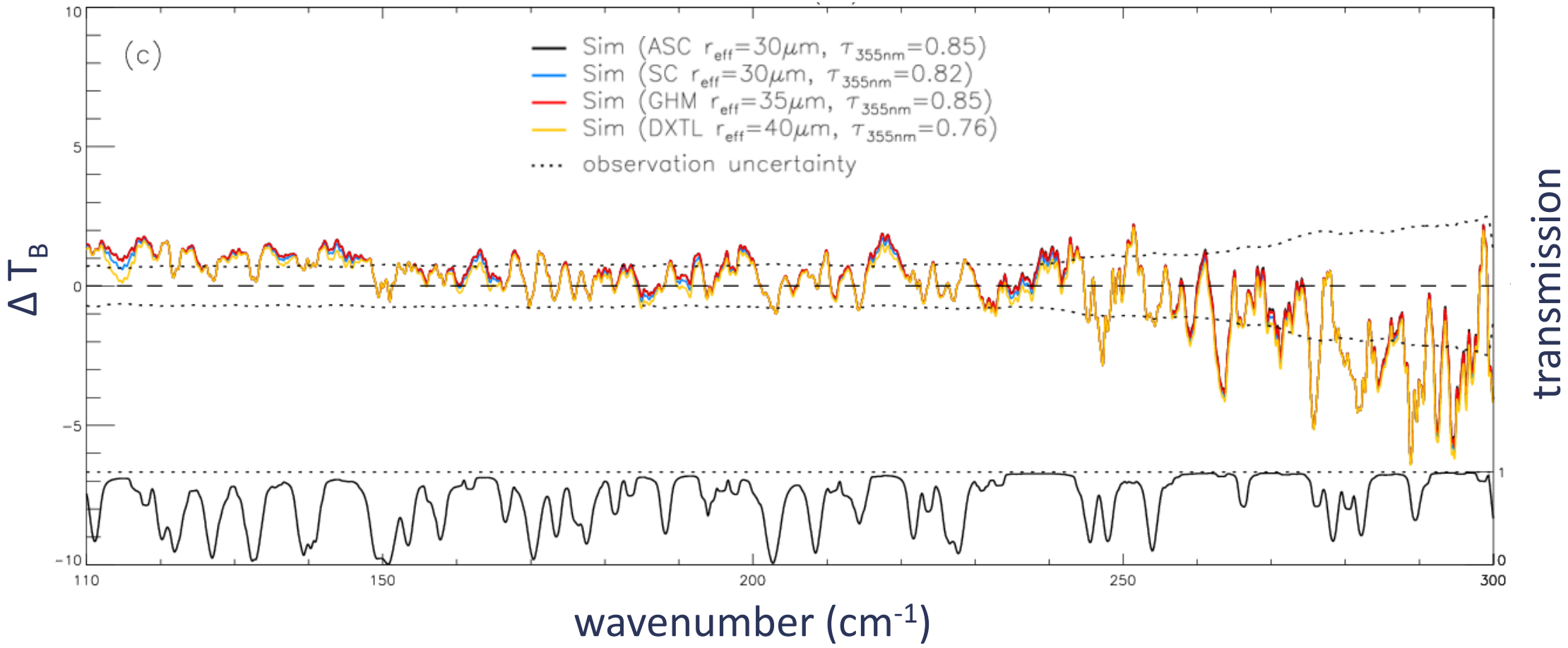
Case Study A: Far InfraRed (SW: 320 – 540 cm^{-1})

Differences: Simulation - Observation



Case Study A: Far InfraRed (LW: 110 – 300 cm^{-1})

Differences: Simulation - Observation



Summary

- The net radiative impact of cirrus clouds remains highly uncertain
- Parameterisations of cirrus in GCMs lead to large discrepancies with observations in VIS & MIR
- Current state-of-the-art cirrus optical models suggest FIR may provide ability to determine ice crystal habit and size
- Observations of radiative properties of cirrus in FIR are rare
- Attempts to simulate the radiative properties of cirrus across MIR & FIR result in significant differences in FIR
- Improved cirrus parameterisation in GCMs will reduce model prediction uncertainty
- More observations in FIR are required over a wide range of cirrus cloud types to rigorously test model ability

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