EarthCARE 2026 Science and Validation workshop

8–12 June 2026 | Rhodes House | Oxford, UK

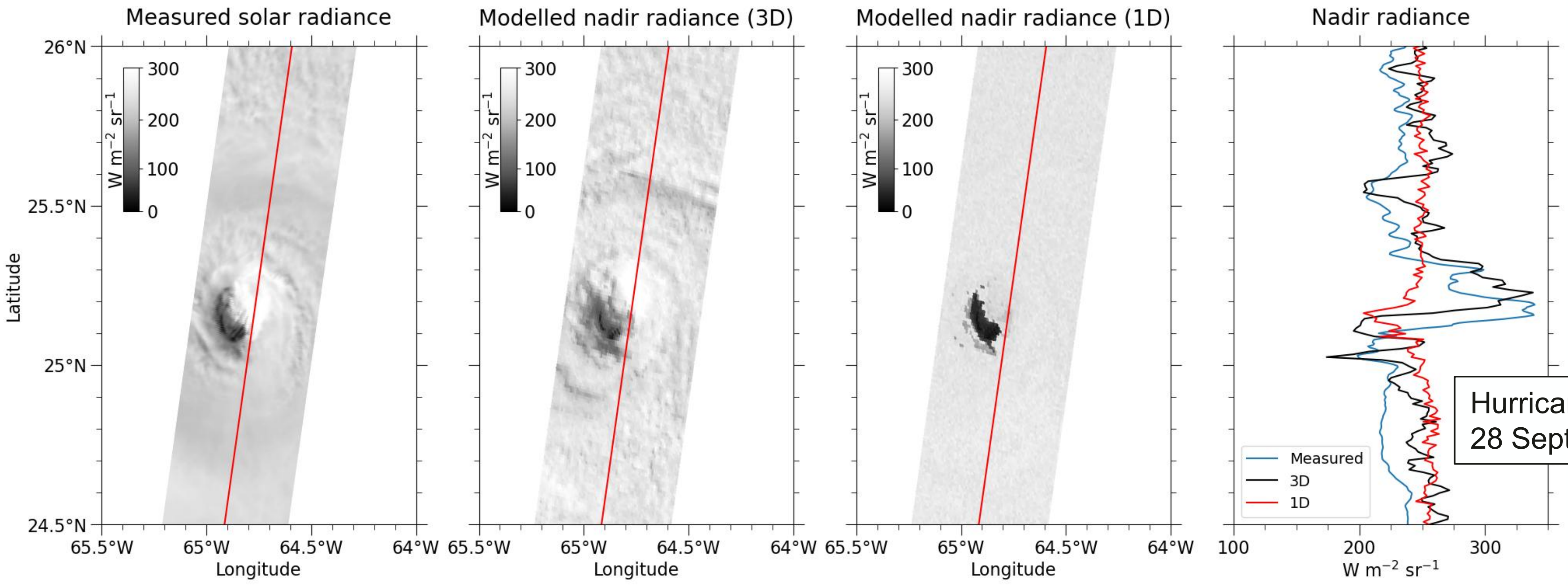
A year of 3D radiative effects as inferred using EarthCARE data

Jason Cole, Howard Barker, Zhipeng Qu, Meriem Kacimi, Environment and Climate Change Canada

Introduction

- A novel aspect of the EarthCARE mission is the use of 3D radiative transfer applied to radiative closure assessment and modelling the radiative effects of clouds and aerosols

- The effect of using 3D instead of 1D radiative transfer for both applications is presented using one year of data from the EarthCARE mission

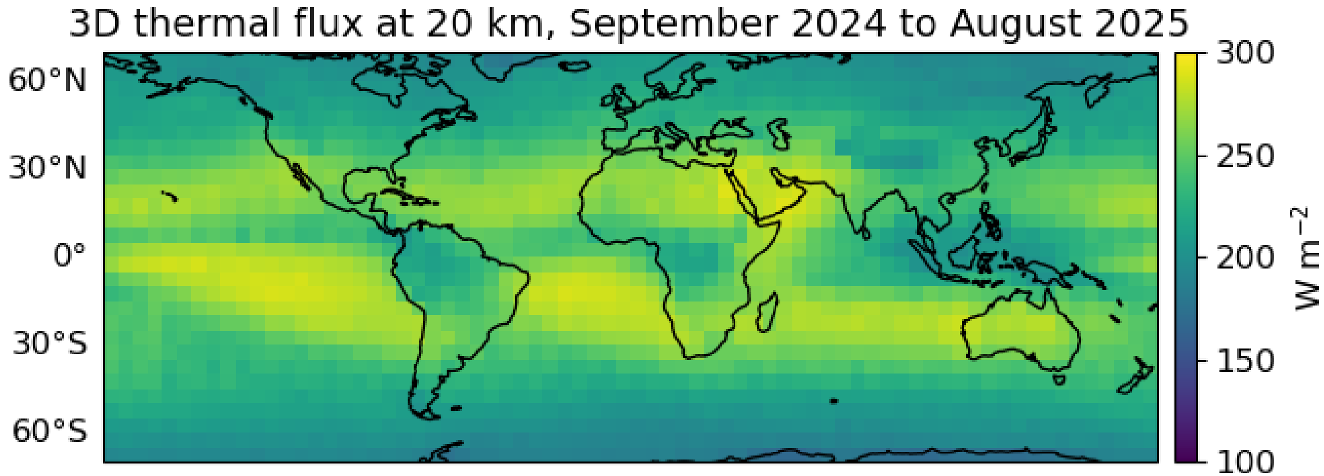


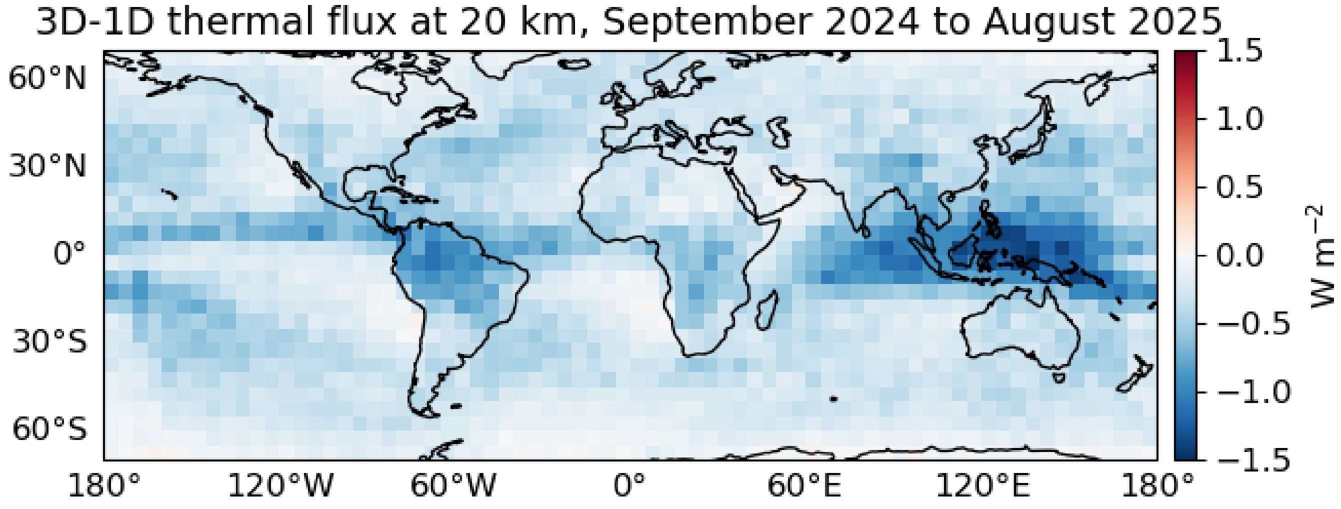
Hurricane Humberto
28 September, frame 07590D

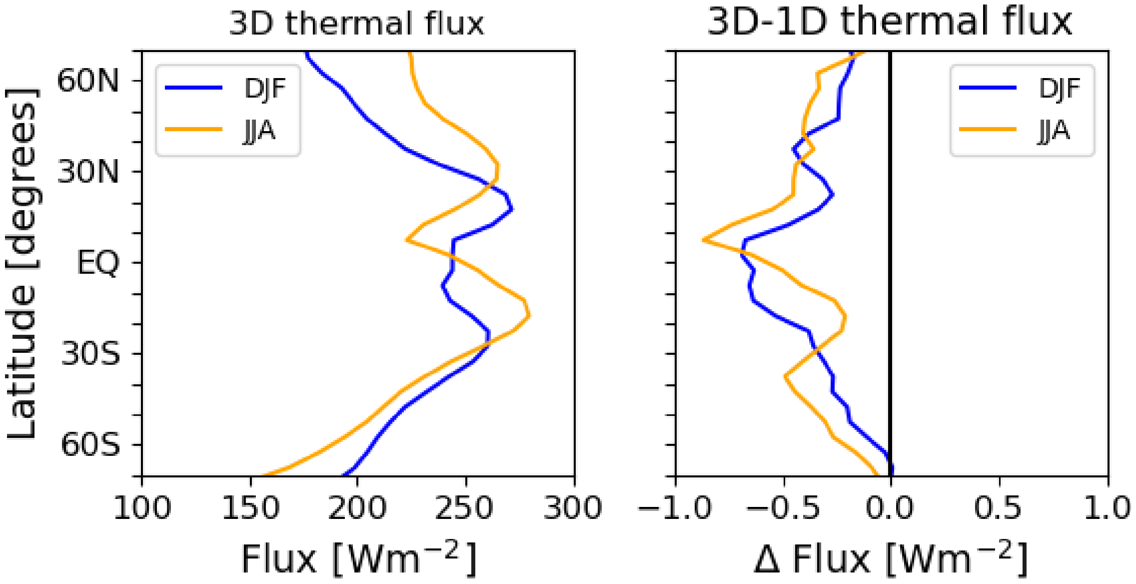
Methods

- Two types of fluxes shown
  - “Hemispheric” fluxes directly from radiative transfer models at 20 km (dynamical models)
  - “Effective” fluxes derived from co-registered radiances for each BBR view (radiative closure)
- Radiative transfer inputs from the “BA” baseline
- Radiative transfer uses the “BC” baseline version of the ACM-RT processor
- Monte Carlo models for radiative transfer
  - 3D uses $\Delta x=\Delta y=1$ km and 1D uses $\Delta x=\Delta y=1E6$ km
  - Pixel level results averaged into non-overlapping domains (21 km by 5 km)
  - For climatological results, domain means are further averaged into 5° longitude by 5° latitude bins
  - Additional solar calculations using randomly sampled solar zenith angles
- Results at TOA from September 2024 to August 2025 are used in the analysis

Thermal (climatology)

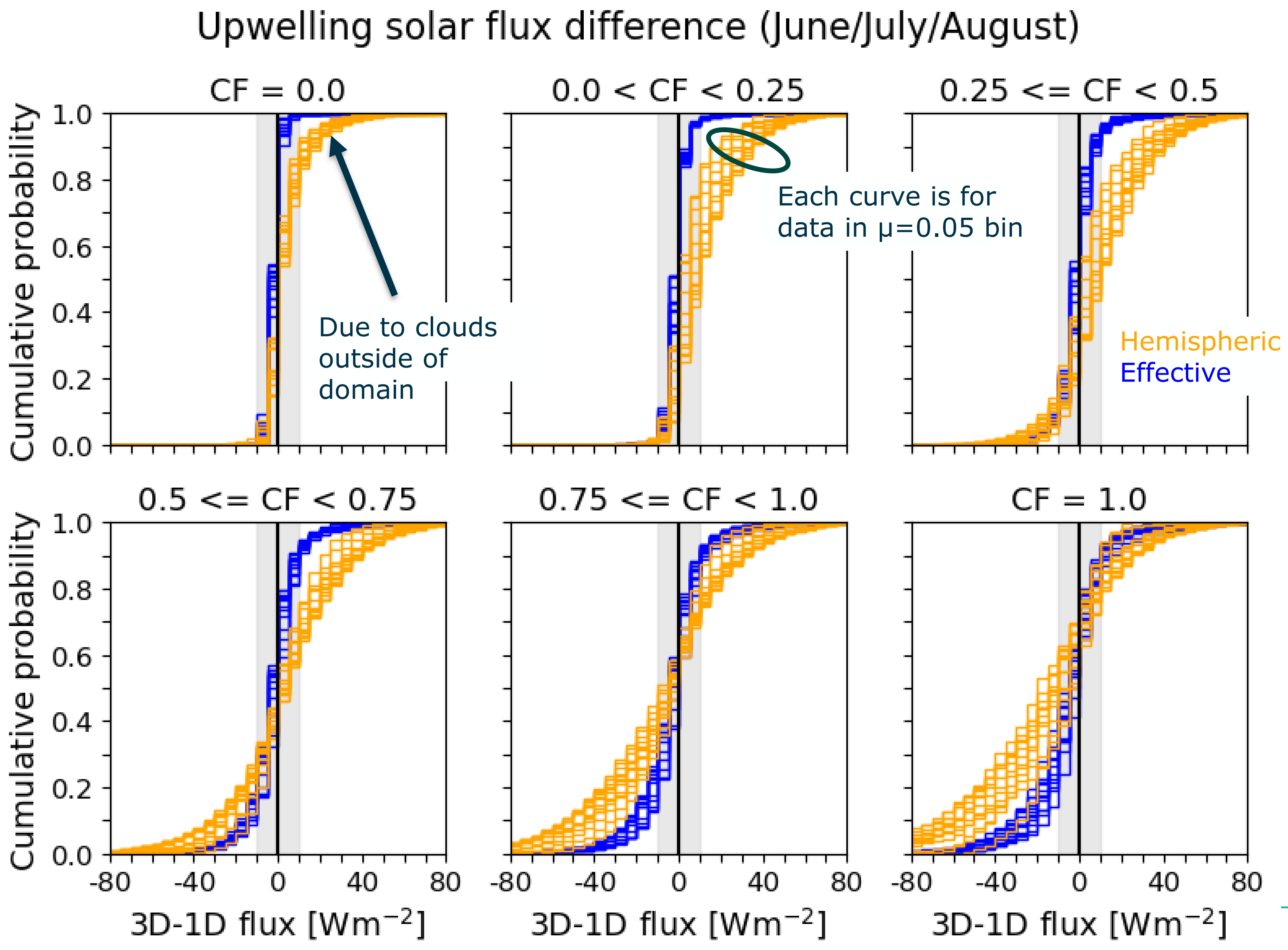






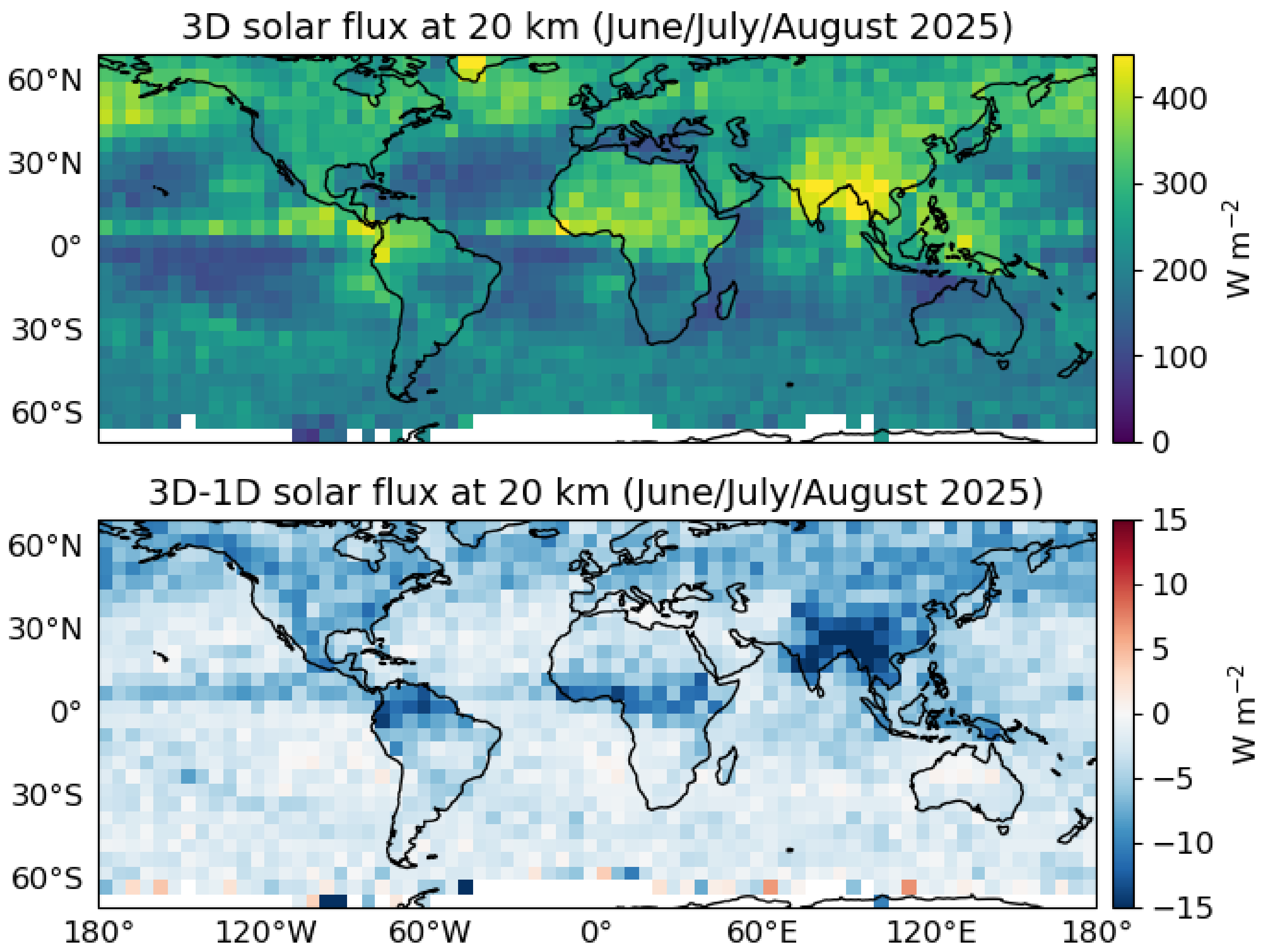
- Instantaneous 3D-1D flux differences < 10 W/m^2
- Smaller than solar but is active day and night

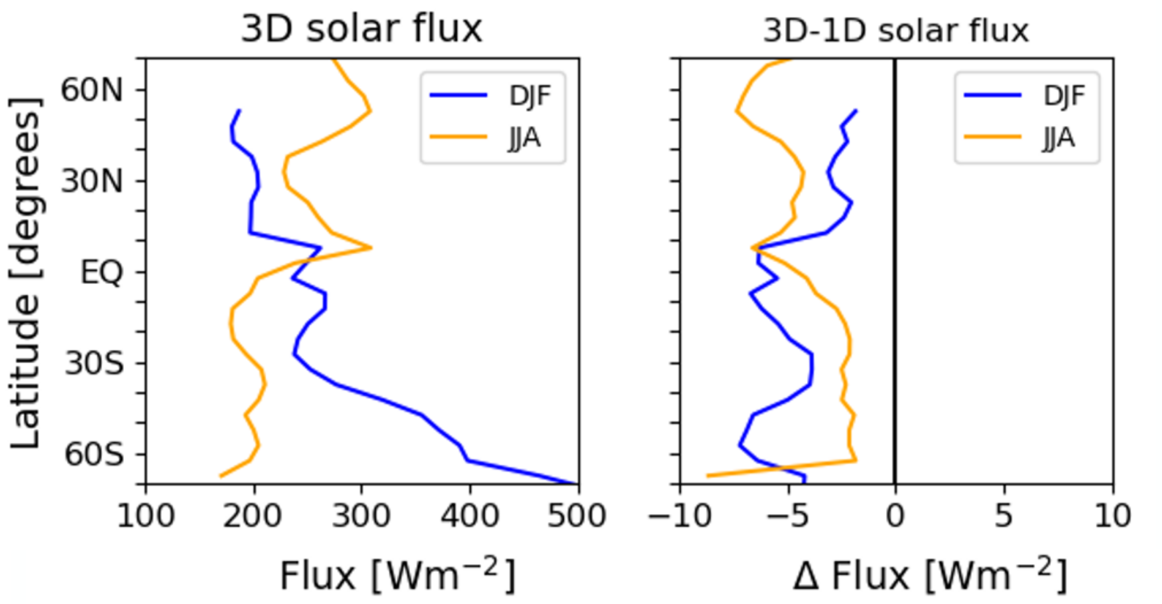
Solar (Instantaneous)



- |3D-1D| is frequently > 10 W/m^2
- 1D RT would affect ability to perform solar closure
- Flux difference function of cloud fraction and solar zenith angle
- 3D-1D difference depends on flux type
- Uses solar geometry at time of EarthCARE overpass

Solar (climatology at time of overpass)

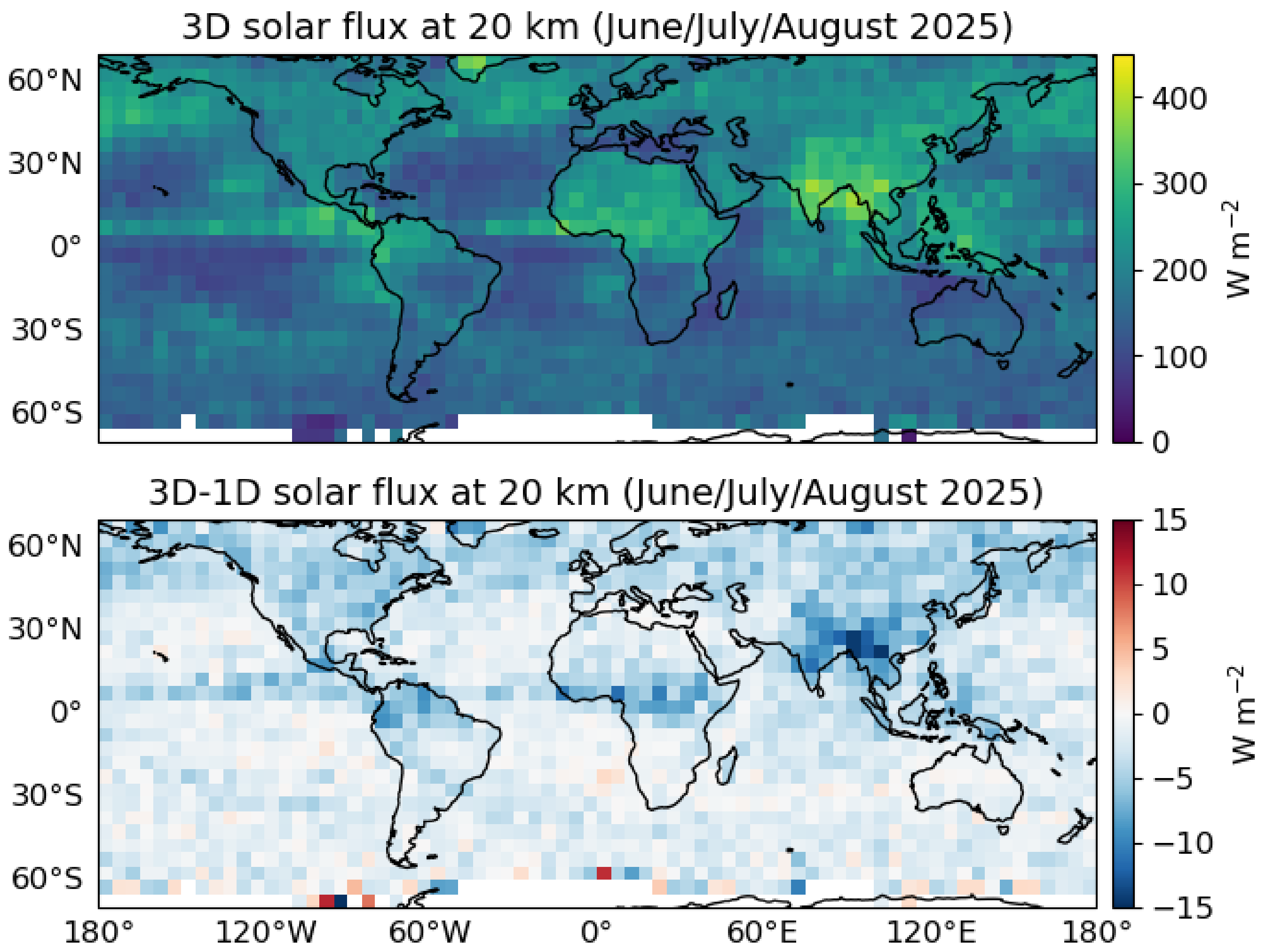


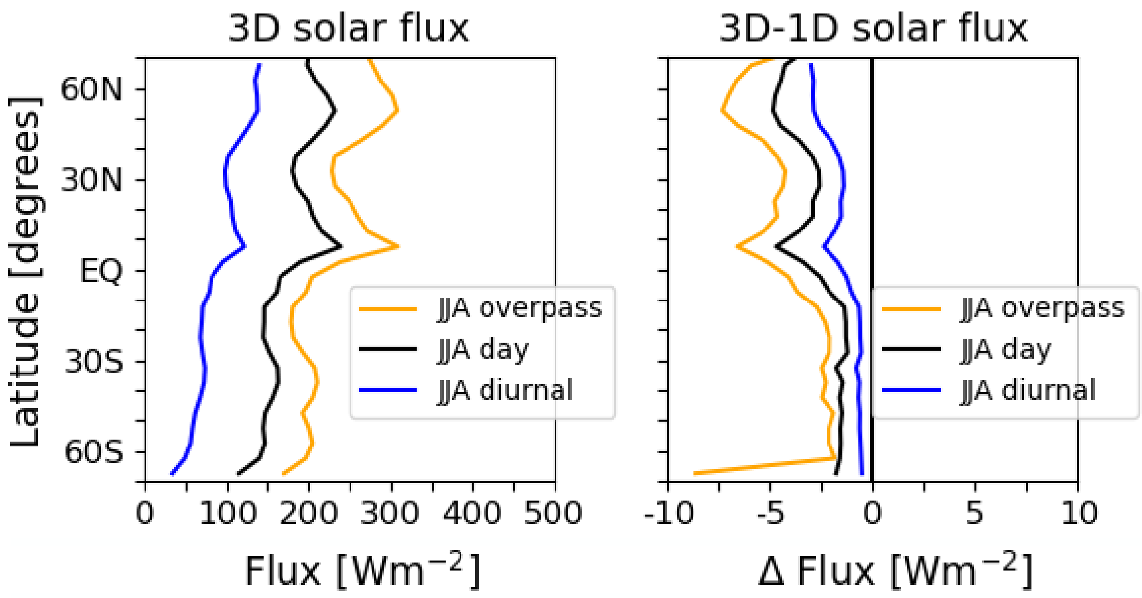


- Use hemispheric fluxes to be consistent with previous studies

- Results shown here use solar geometry at time of EarthCARE overpass

Solar (diurnal mean climatology, JJA)





- Repeat 3D and 1D calculations but randomly sample solar zenith angle for each domain
- Black line shows daytime mean solar flux
- Blue line scales daytime mean by the sunlit fraction of day to estimate diurnal mean

Summary

- Instantaneous |3D-1D| is frequently > 10 W/m^2 for solar but always < 10 W/m^2 for thermal

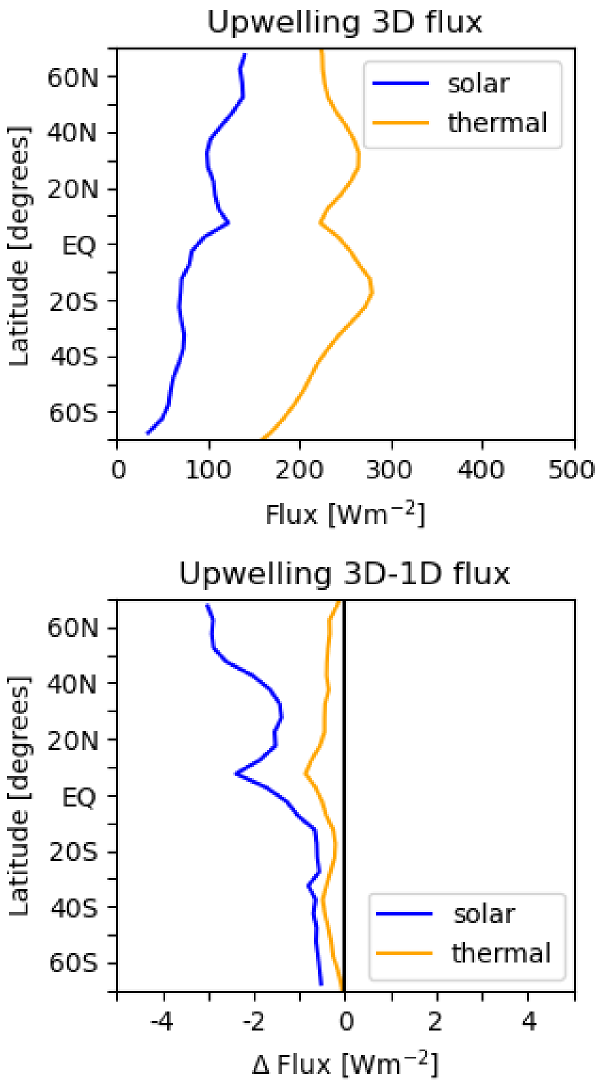
- 3D radiative effects in solar and thermal are in general agreement with previous studies

- Averaged over 60S to 60N and JJA 2025,
    - The mean for solar is 91 W/m^2 and for thermal is 246.4 W/m^2
    - The mean 3D-1D for solar is -1.4 W/m^2 and for thermal is -0.5 W/m^2

- However, the 3D-1D is locally larger, e.g., in the tropics and summer hemisphere

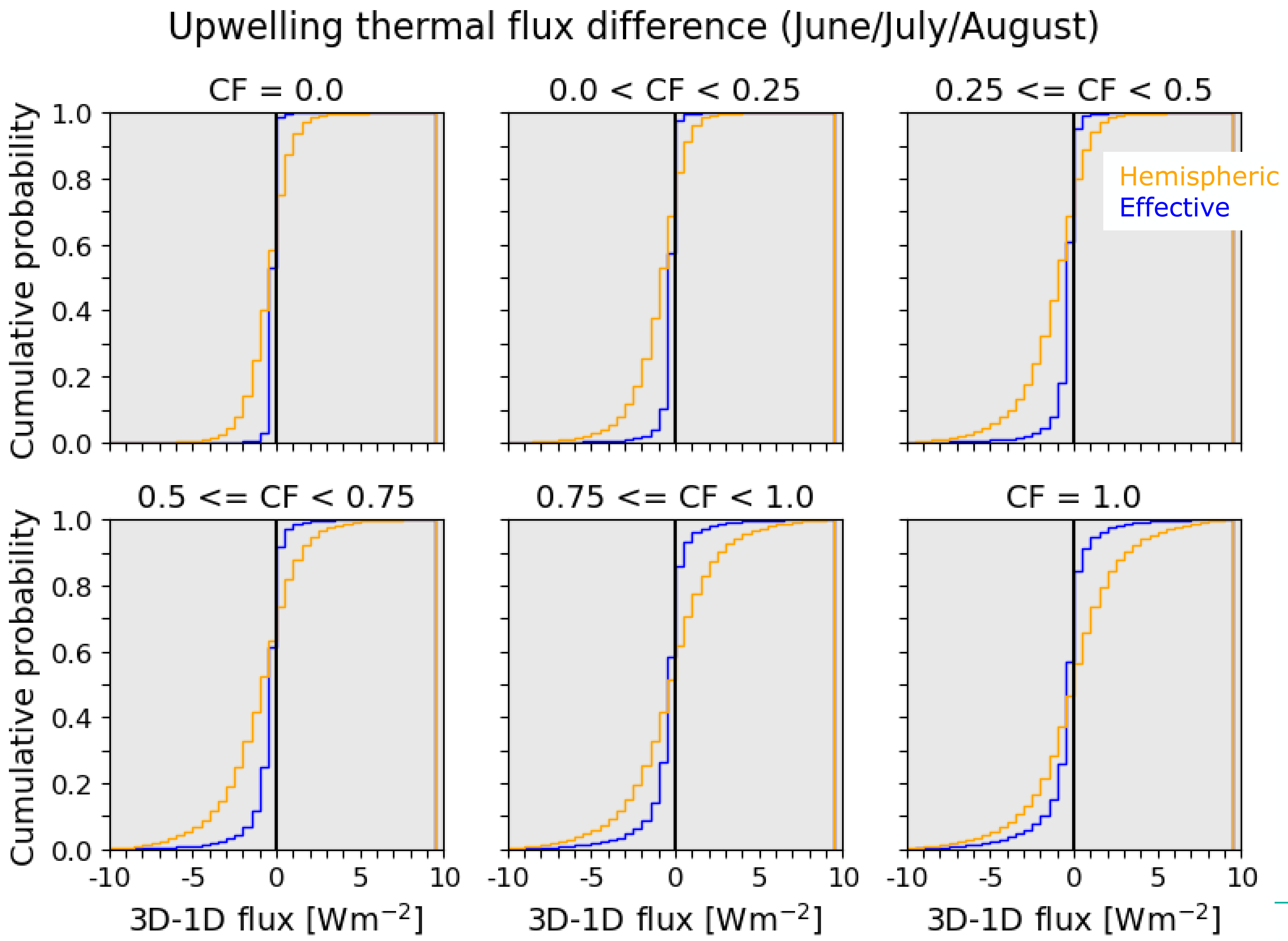
- Further analysis will complete the quantification of the effect throughout the year and associate the 3D effects with cloud properties

TOA fluxes for JJA 2025



Extra slides

Thermal (Instantaneous)



- Instantaneous effects are < closure delta

Solar (solar zenith angle dependence)