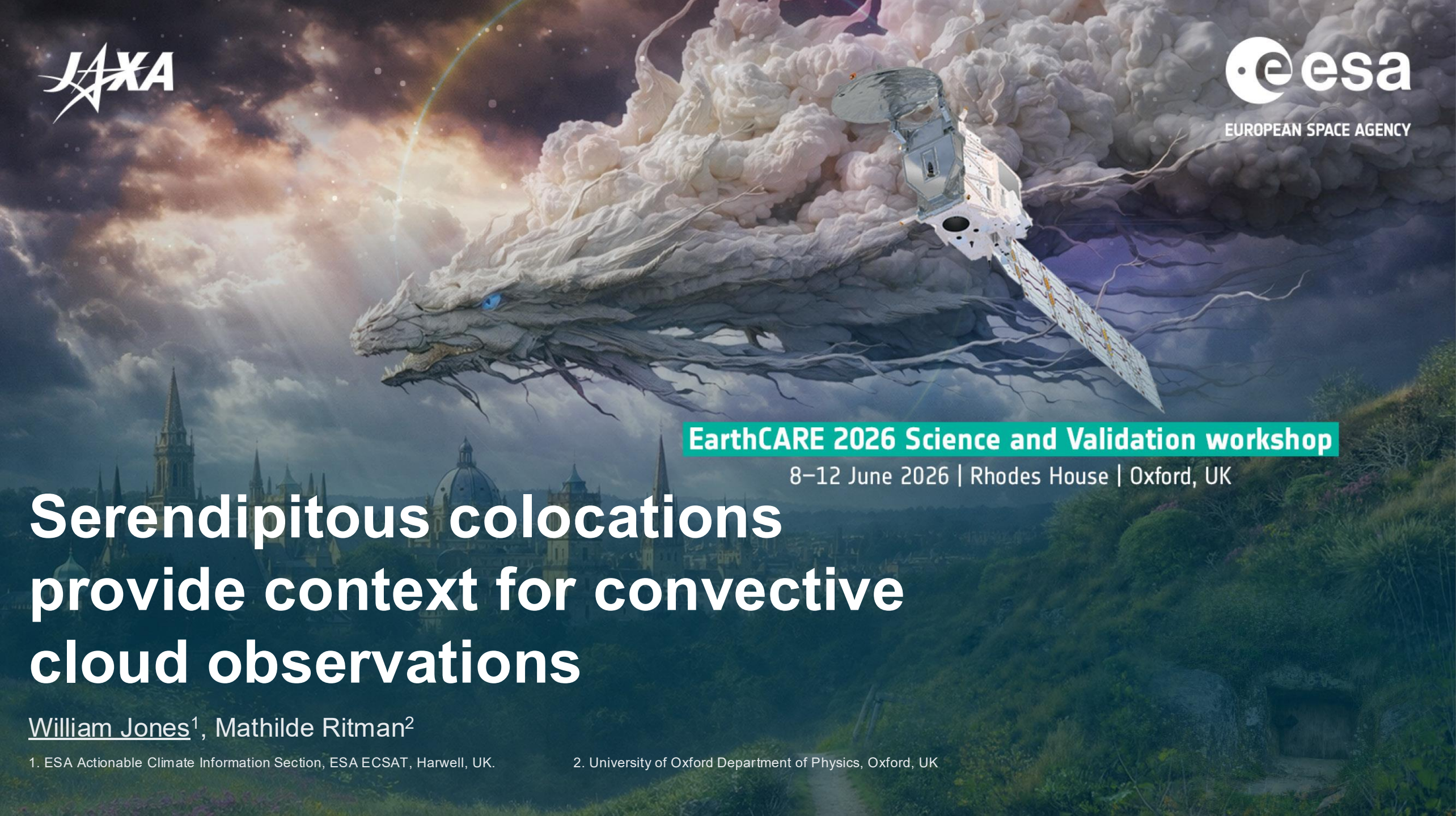



# Serendipitous colocations provide context for convective cloud observations

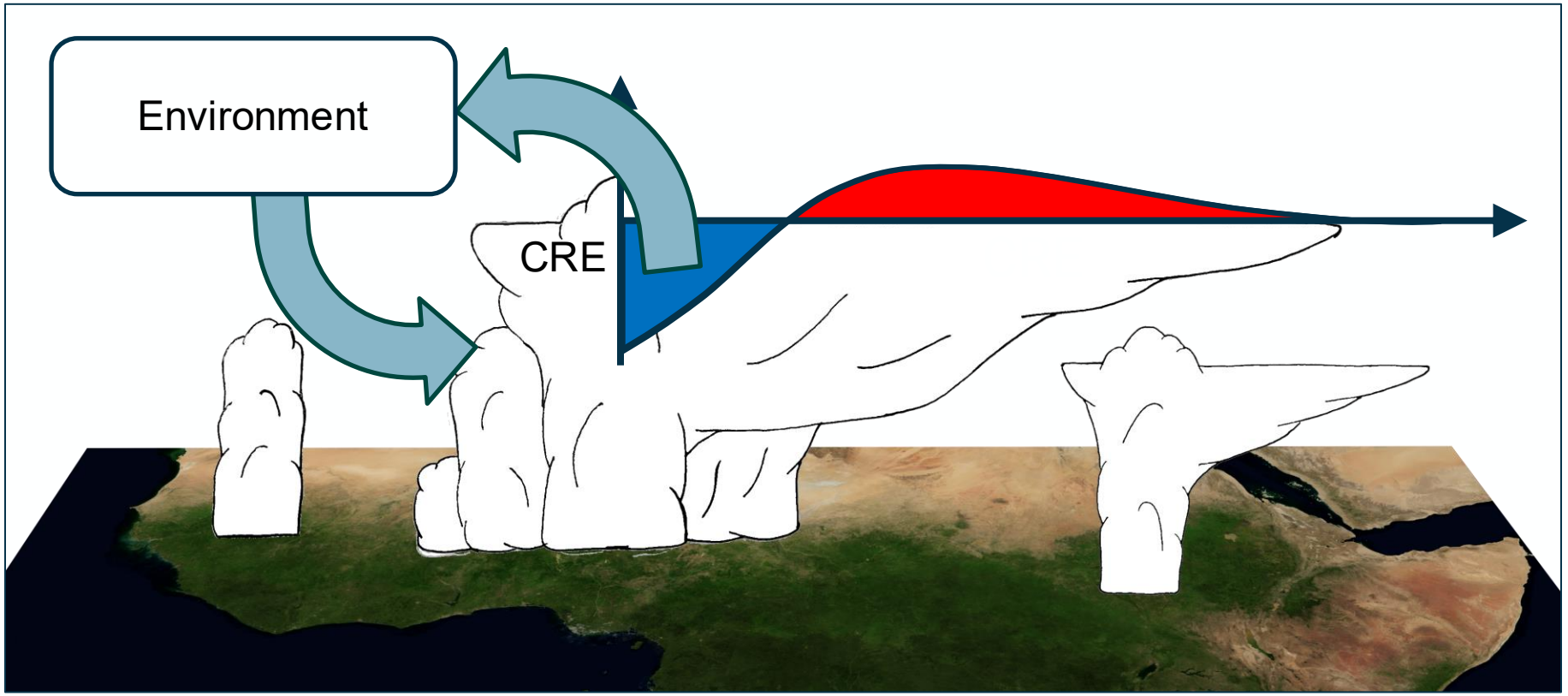
William Jones[1], Mathilde Ritman[2]

1. ESA Actionable Climate Information Section, ESA ECSAT, Harwell, UK.

2. University of Oxford Department of Physics, Oxford, UK

# Motivation

- How does the development of convective storms affect their properties across their lifecycle?
- How do changes in the environment affect storm cloud lifecycles?
- How do changes in anvil cloud properties across their lifecycle impact the climate?



# Motivation

Recent research has highlighted the potential of changes in anvil cloud thickness (i.e. ice water content) to be an important climate feedback, both in models and observations

A key factor to consider is the large variance in anvil CRE between different convective storms, and how different changes in individual storms may contribute to net, global effects

Effect of IWC changes on anvil CRE

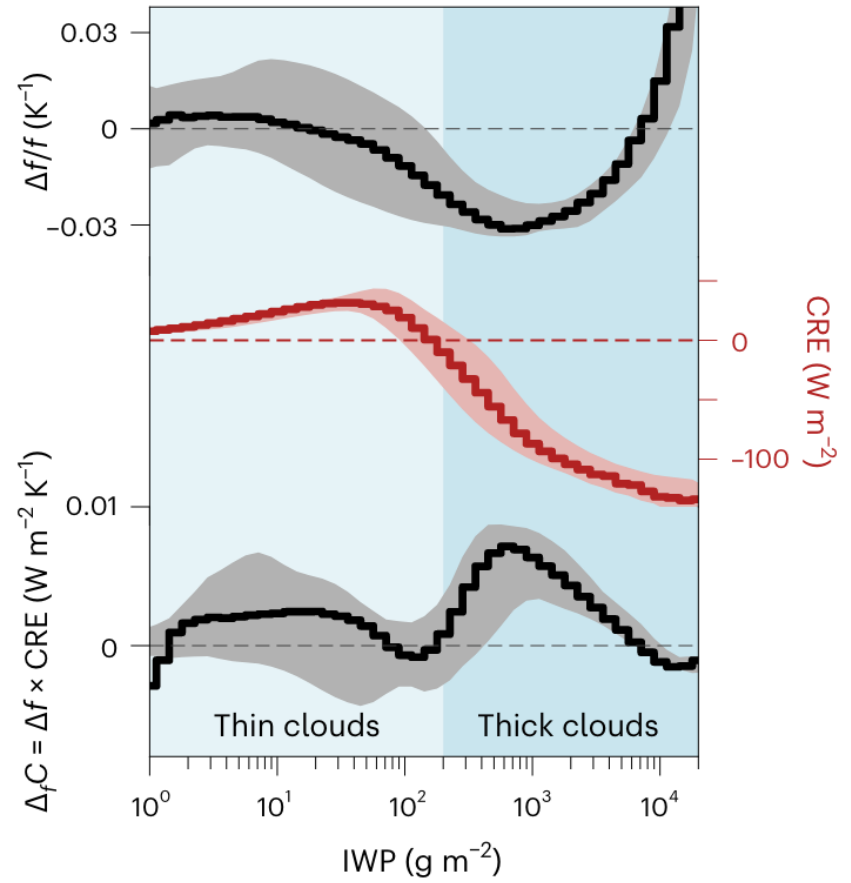



Fig. 3, Sokol et al., 2024

Distribution of anvil CRE for individual DCCs

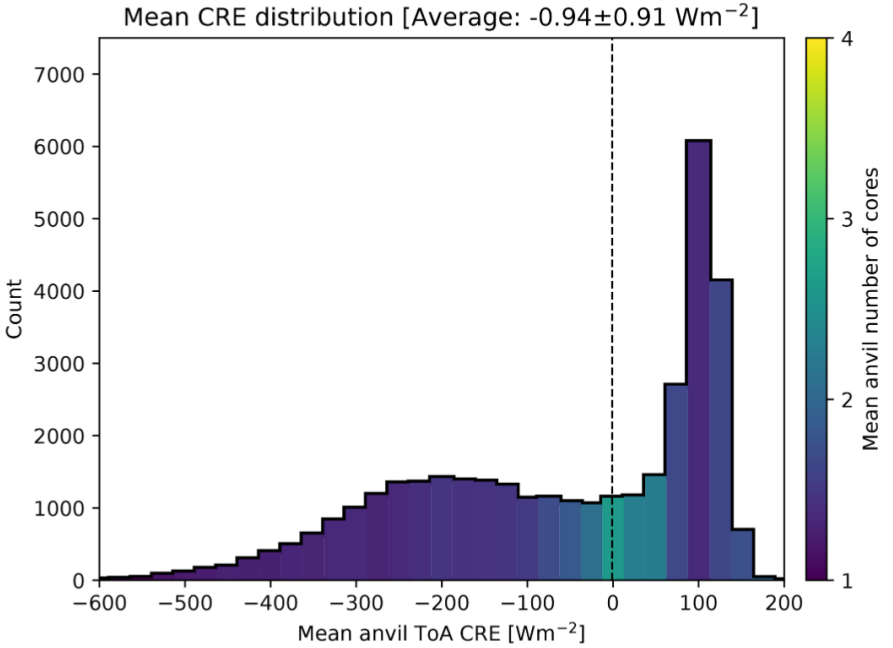


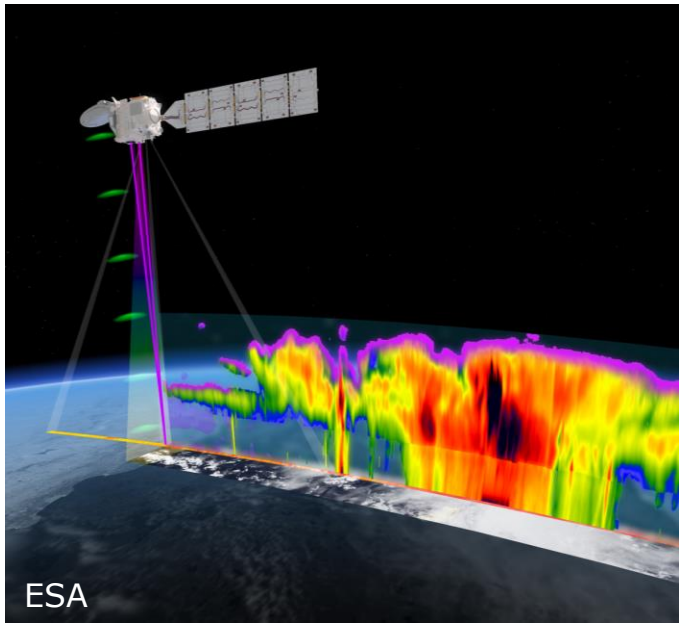

Fig 11, Jones et al. 2024

# Adding context to EarthCARE

EarthCARE provides fantastic observations of deep convective clouds and their anvils, but these are only snapshots. To understand changes across the cloud lifecycle, we need to understand both where they originated, and how the cloud develops after EarthCARE observes it

## EarthCARE overpass

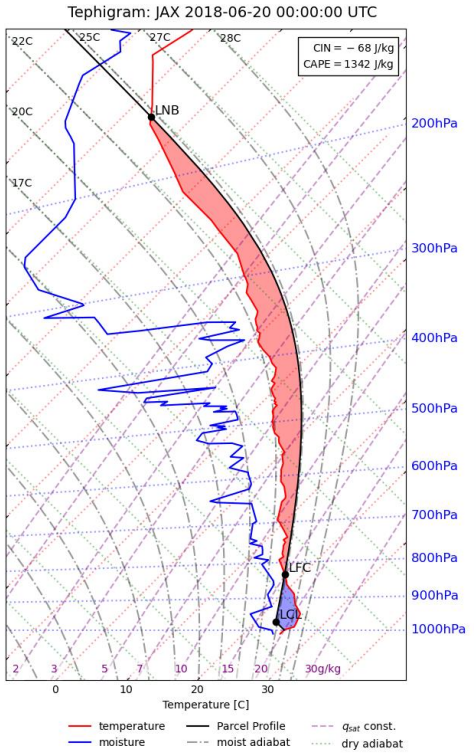
High quality observations, but a limited snapshot…



# Adding context to EarthCARE

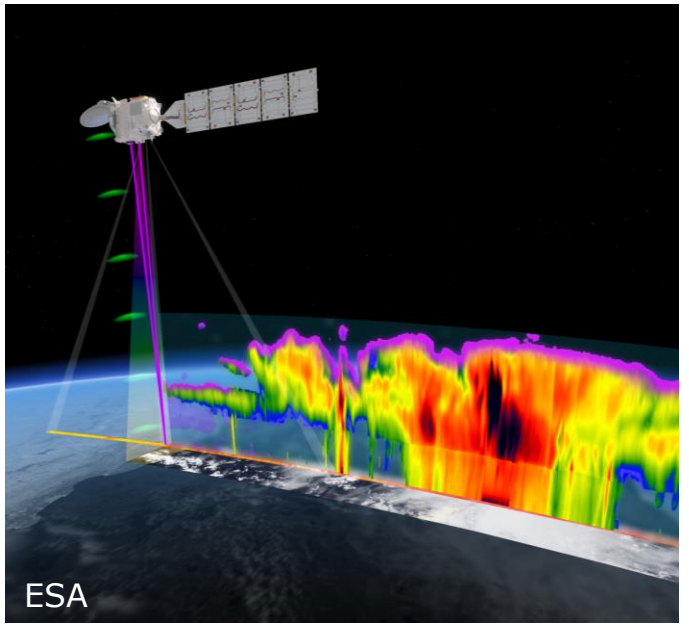
EarthCARE provides fantastic observations of deep convective clouds and their anvils, but these are only snapshots. To understand changes across the cloud lifecycle, we need to understand both where they originated, and how the cloud develops after EarthCARE observes it

## Convective environment




## EarthCARE overpass

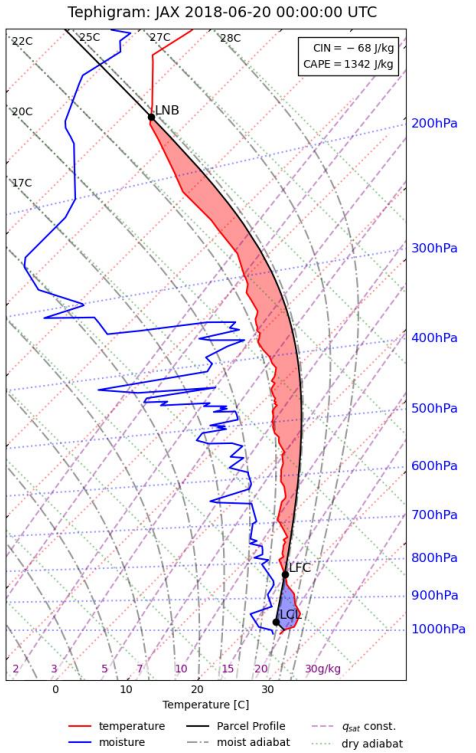
High quality observations, but a limited snapshot…



# Adding context to EarthCARE

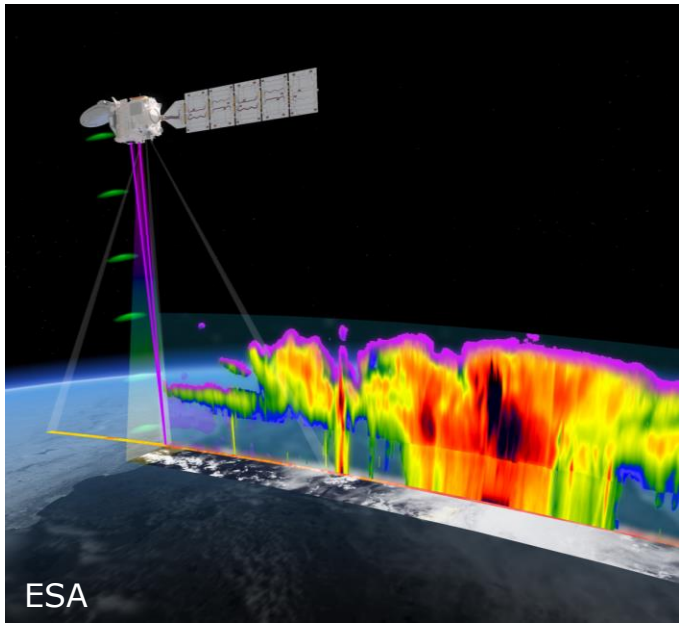
EarthCARE provides fantastic observations of deep convective clouds and their anvils, but these are only snapshots. To understand changes across the cloud lifecycle, we need to understand both where they originated, and how the cloud develops after EarthCARE observes it

## Convective environment

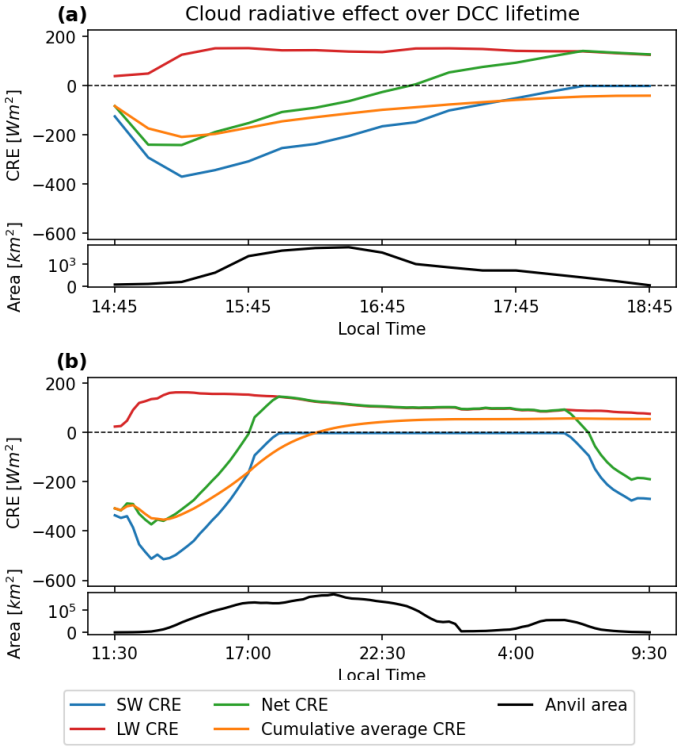



## EarthCARE overpass

High quality observations, but a limited snapshot…



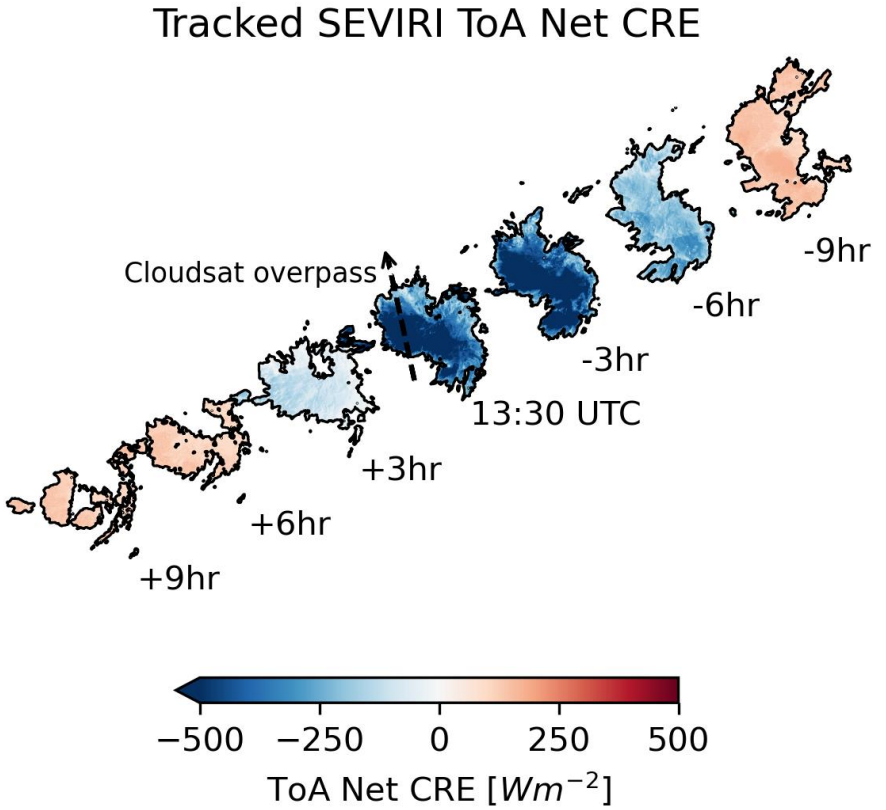

## Convective lifecycle

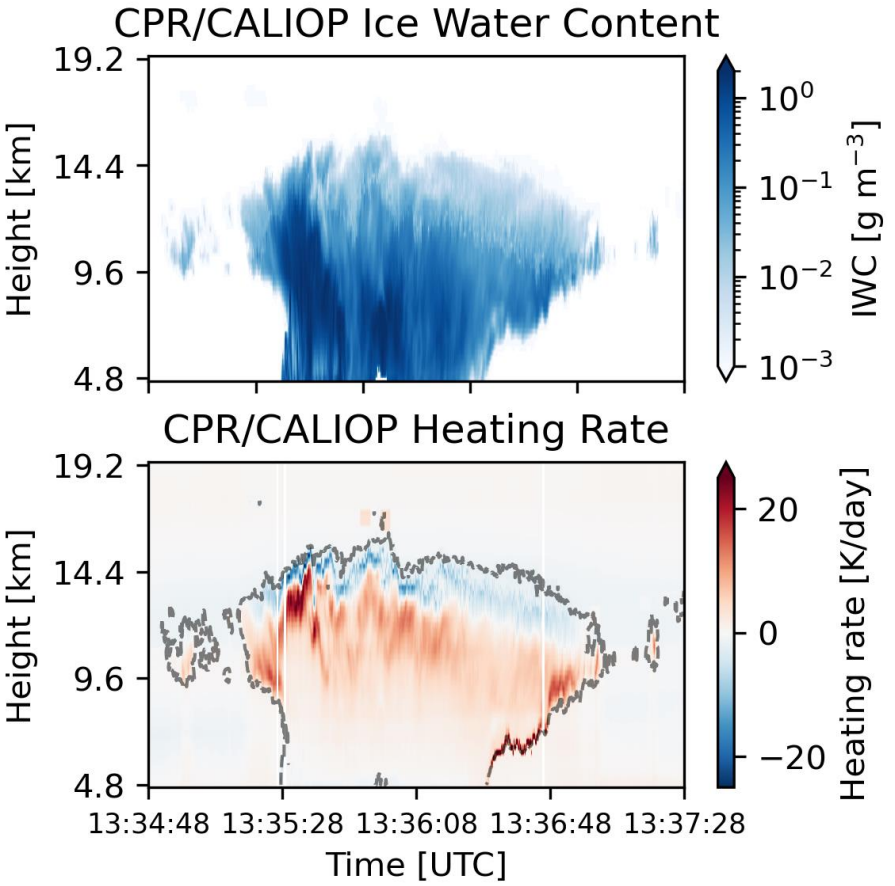


# Cloud tracking provides temporal context

Cloud tracking using geostationary sensors can be used to understand the evolution of DCCs before and after observations from EarthCARE and other active sensors

Using tracking, we can both link EarthCARE observations to the environment that the storm developed in, along with the future development of the cloud properties



# Anvil growth rate model

Inspiration from Elsaesser et al., 2022 – great example of power of combining multiple observations to provide insights into convective processes

$$\frac{dA}{dt} \approx A_{c,SRC} - \frac{1}{\rho}\frac{dM_c}{dz} - \frac{A}{\tau}$$

Area growth

Core area

Mass flux divergence

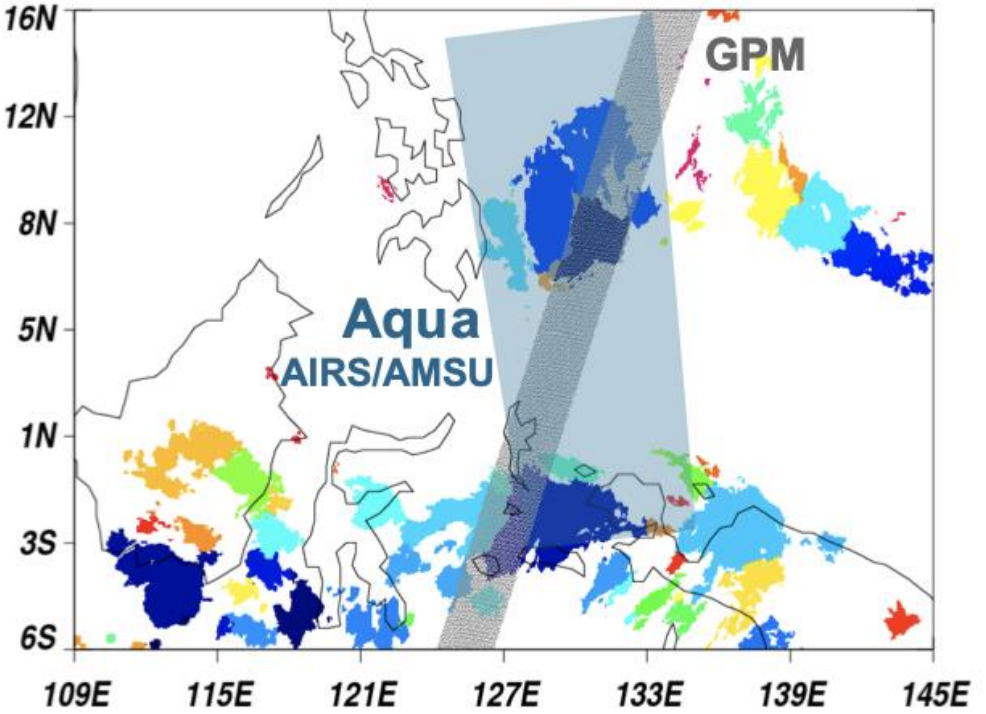
Anvil decay

GPM

AIRS

$$-\frac{A_c}{\rho}\frac{d}{dz}\left(\frac{Q_L}{\rho\,(\Gamma - \Gamma_d)}\right)$$

Colocated GPM and AIRS observations with tracked MCSs

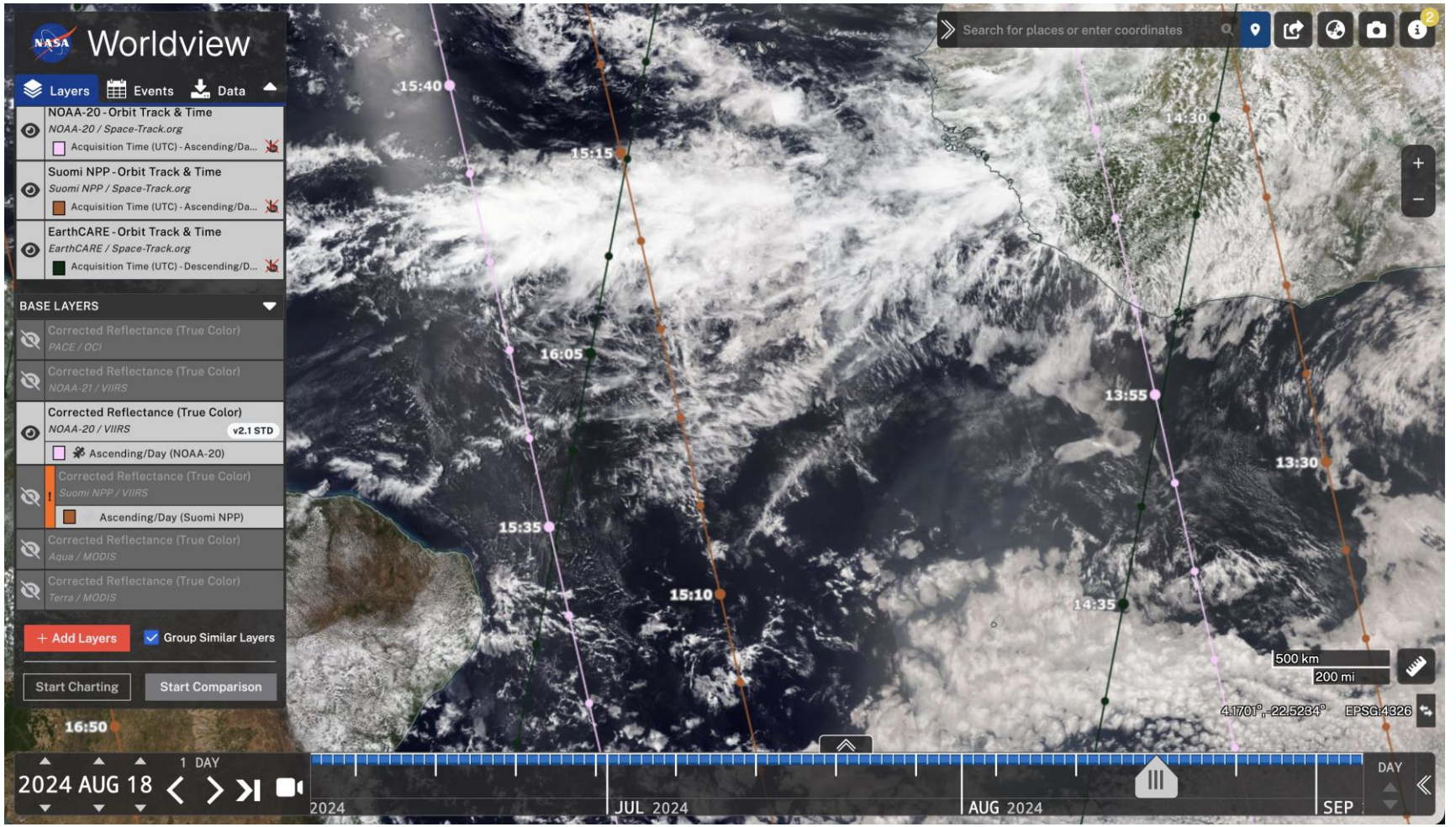



Elsaesser et al. (2022, JGR)

# Adding T/q profiles to EarthCARE

EarthCARE does not have a sounder instrument onboard (dropped from early proposals), and unlike CloudSat it is not in a constellation with other satellites that can provide this information.

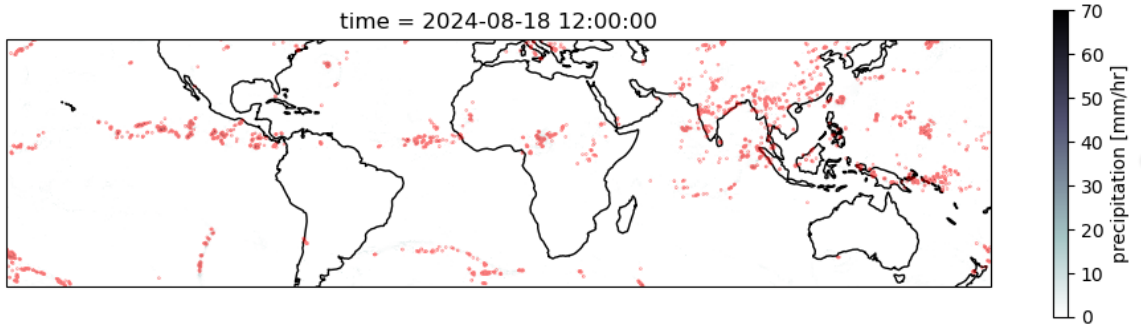
However, operational weather satellites (SNPP, NOAA-20) with similar equator crossing times provide opportunities for colocated T/q profiles with EarthCARE observations throughout the tropics.




Intersecting EarthCARE, SNPP and NOAA-20 orbit tracks from NASA Worldview

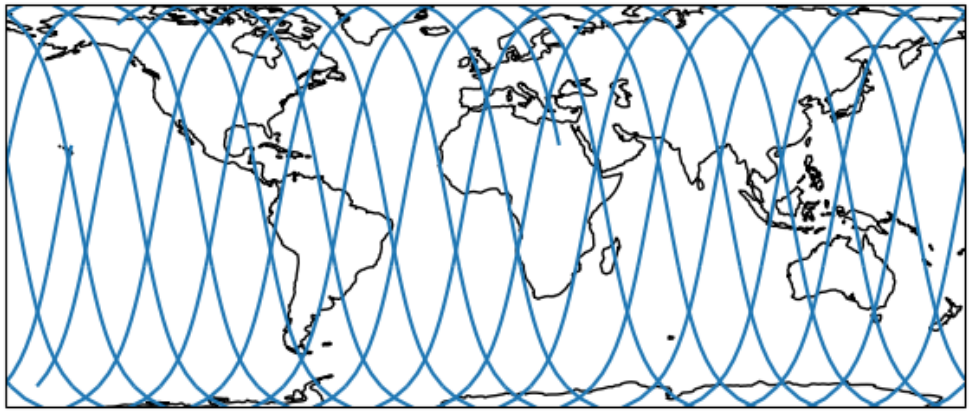
# Method – finding colocations

## 1. IMERG tracking using *tobac*

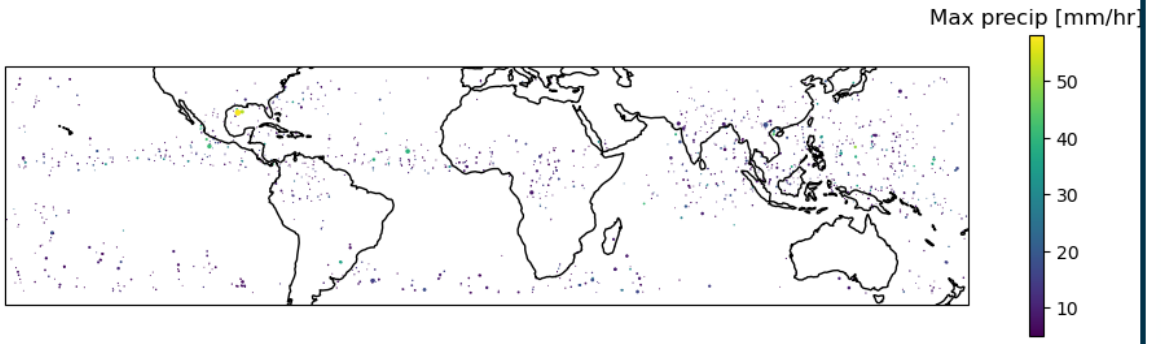



*O(10⁶) systems*

## 2. EarthCARE orbits



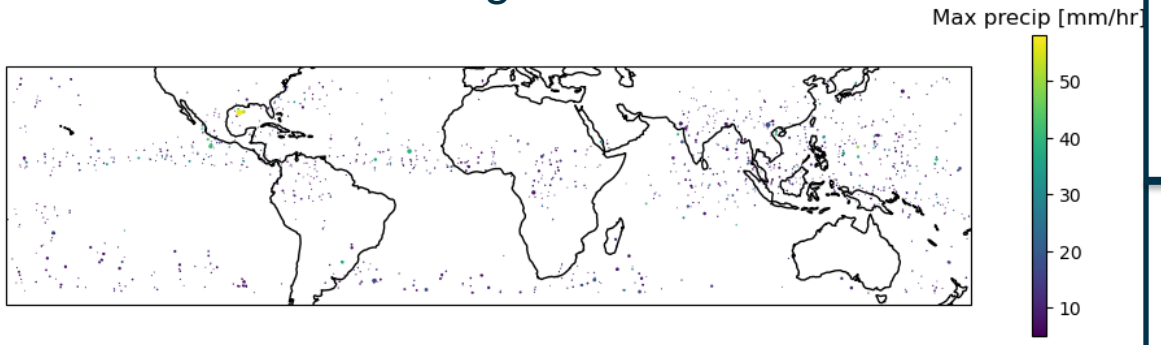
## 3. EarthCARE/tracking intersection




~1500 systems

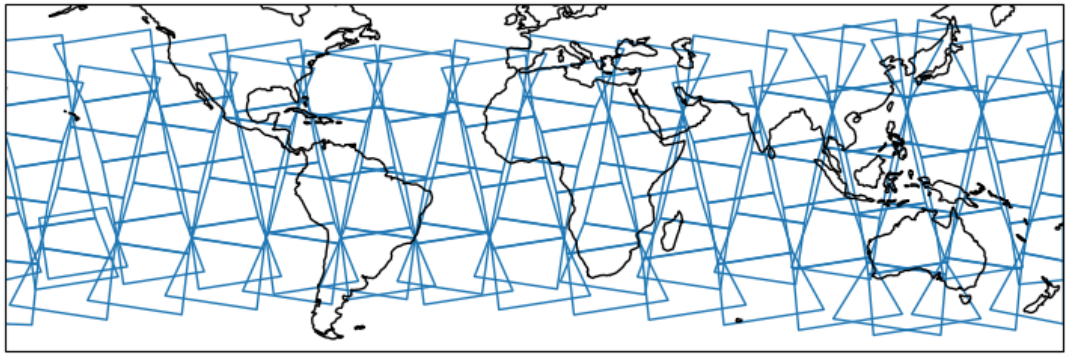
# Method – finding colocations

## 3. EarthCARE/tracking intersection

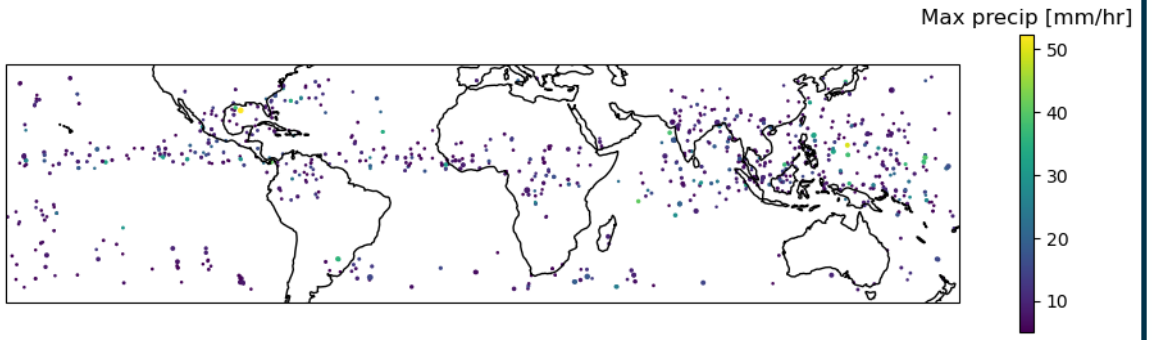



~1500 systems

## 4. Sounder granule search



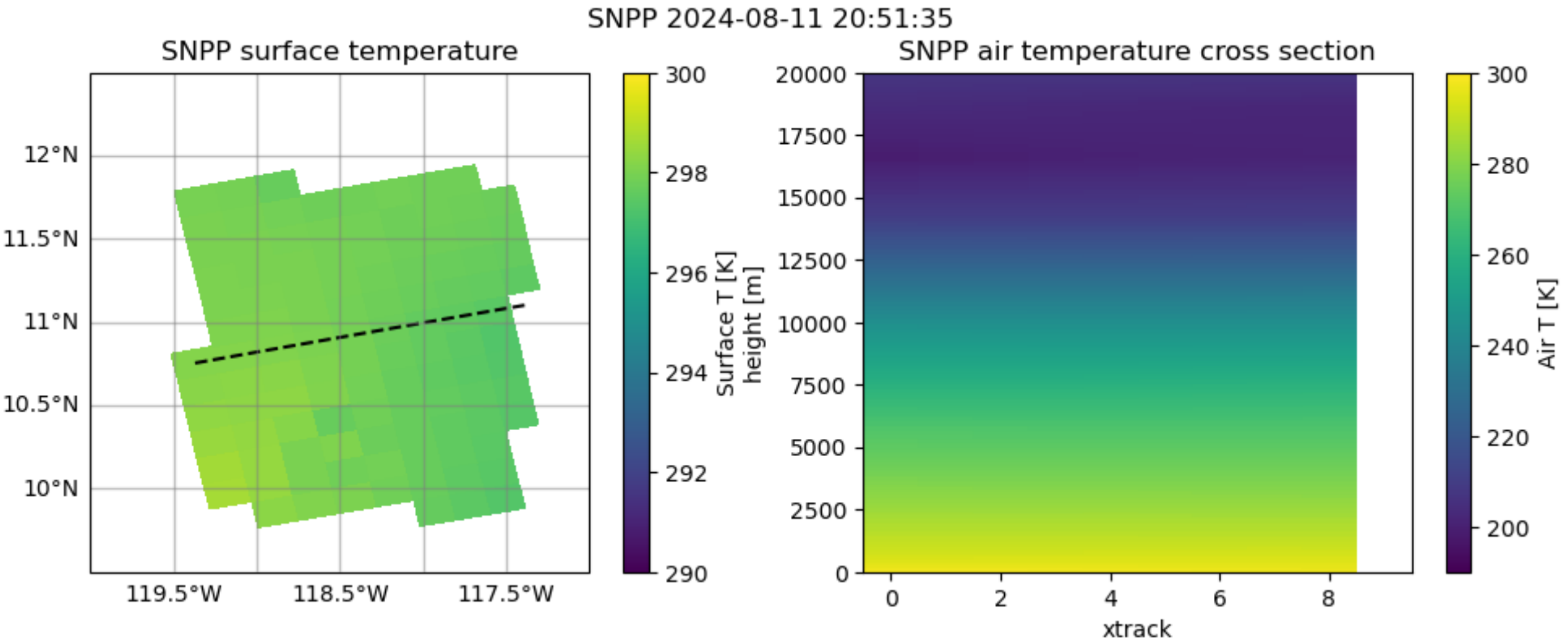
## 5. Final colocations



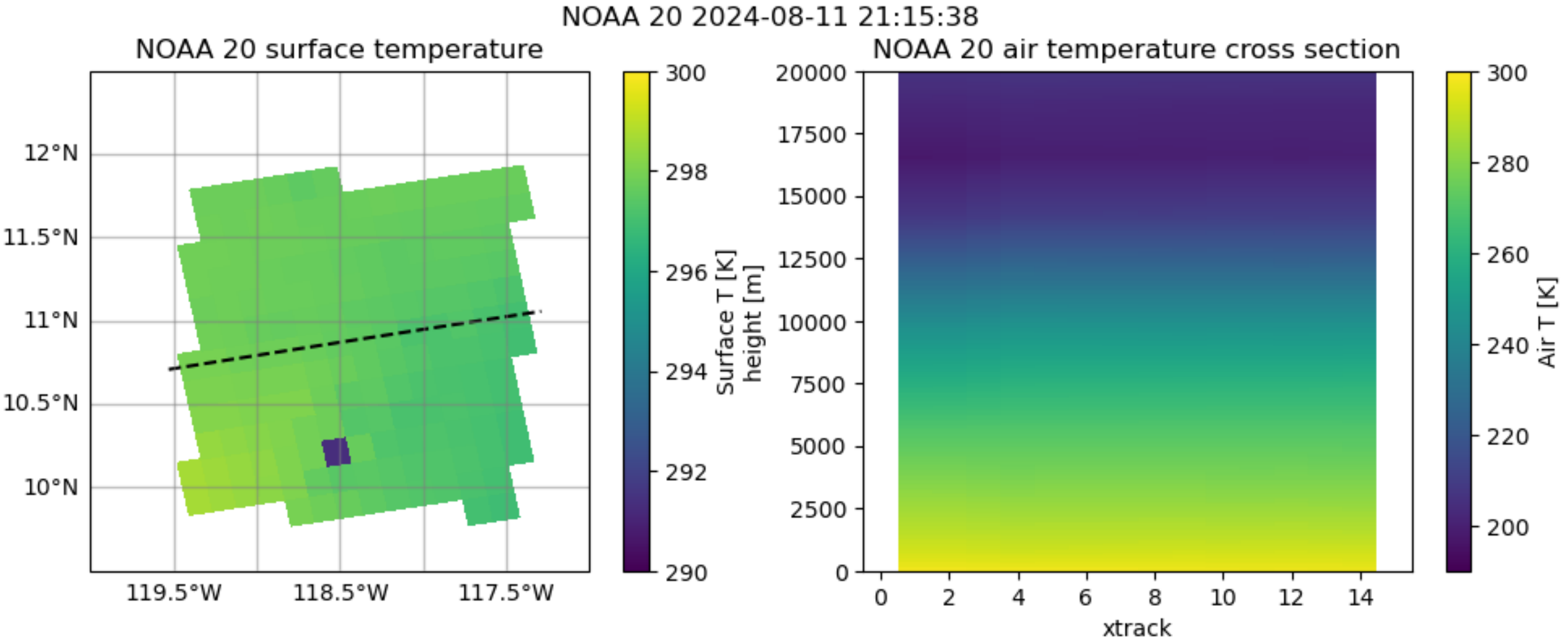

~1000 systems

This results in substantially fewer cases which have to download and process data for

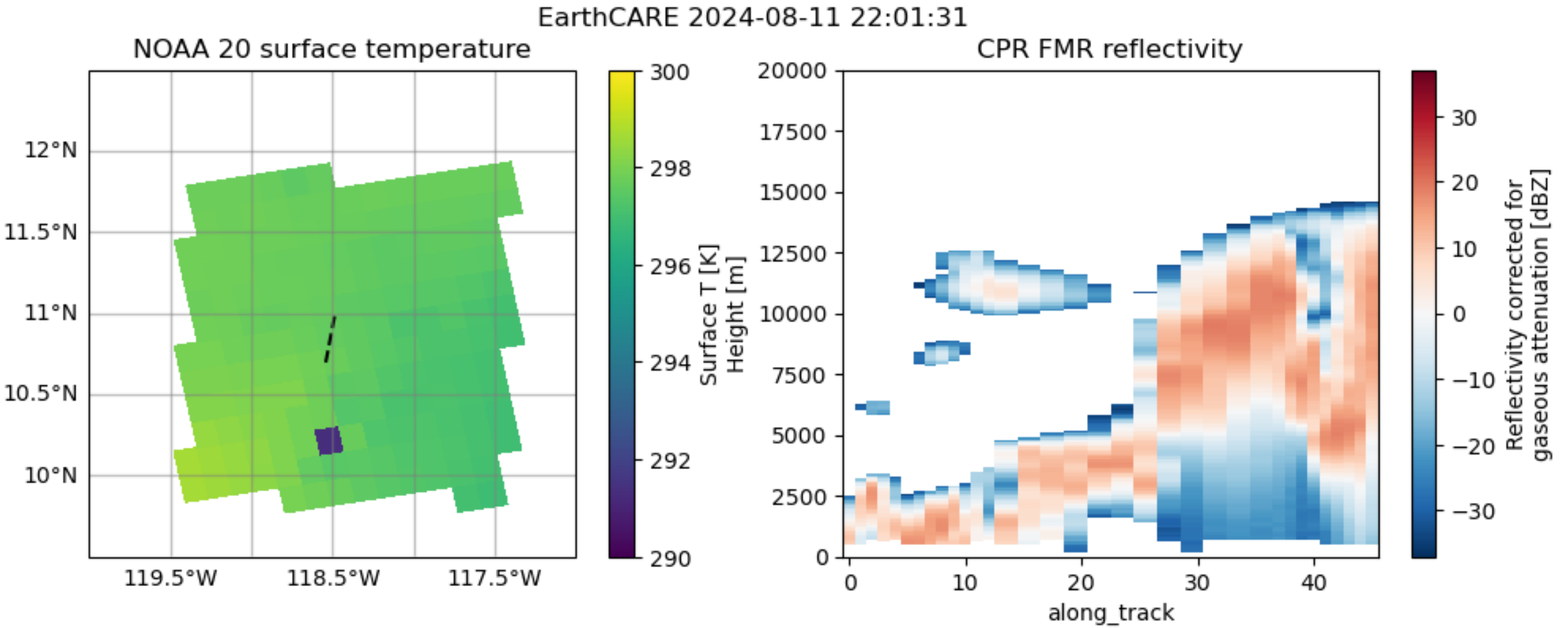
# Example overpass – SNPP



# Example overpass – NOAA 20

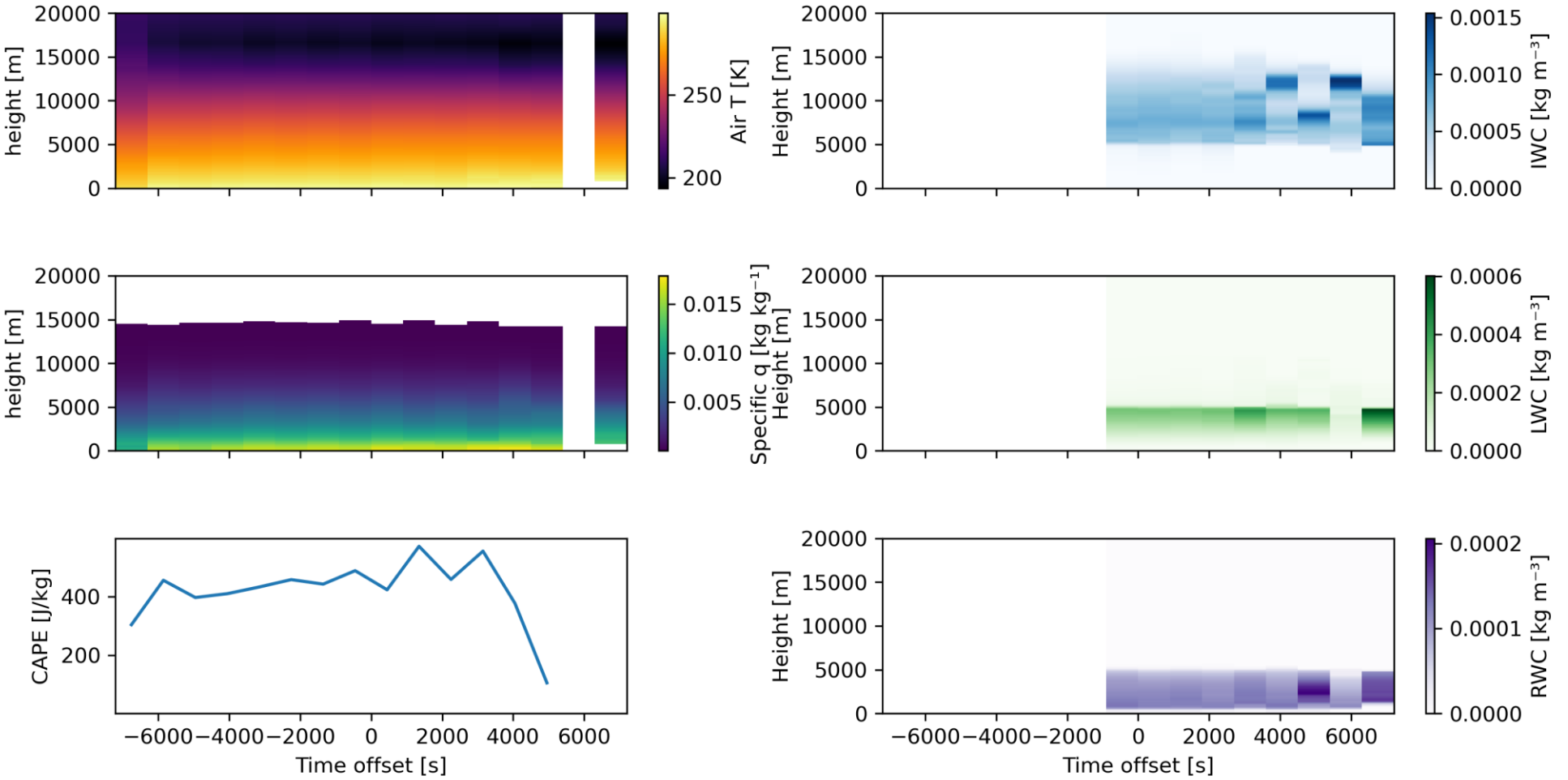


# Example overpass – EarthCARE



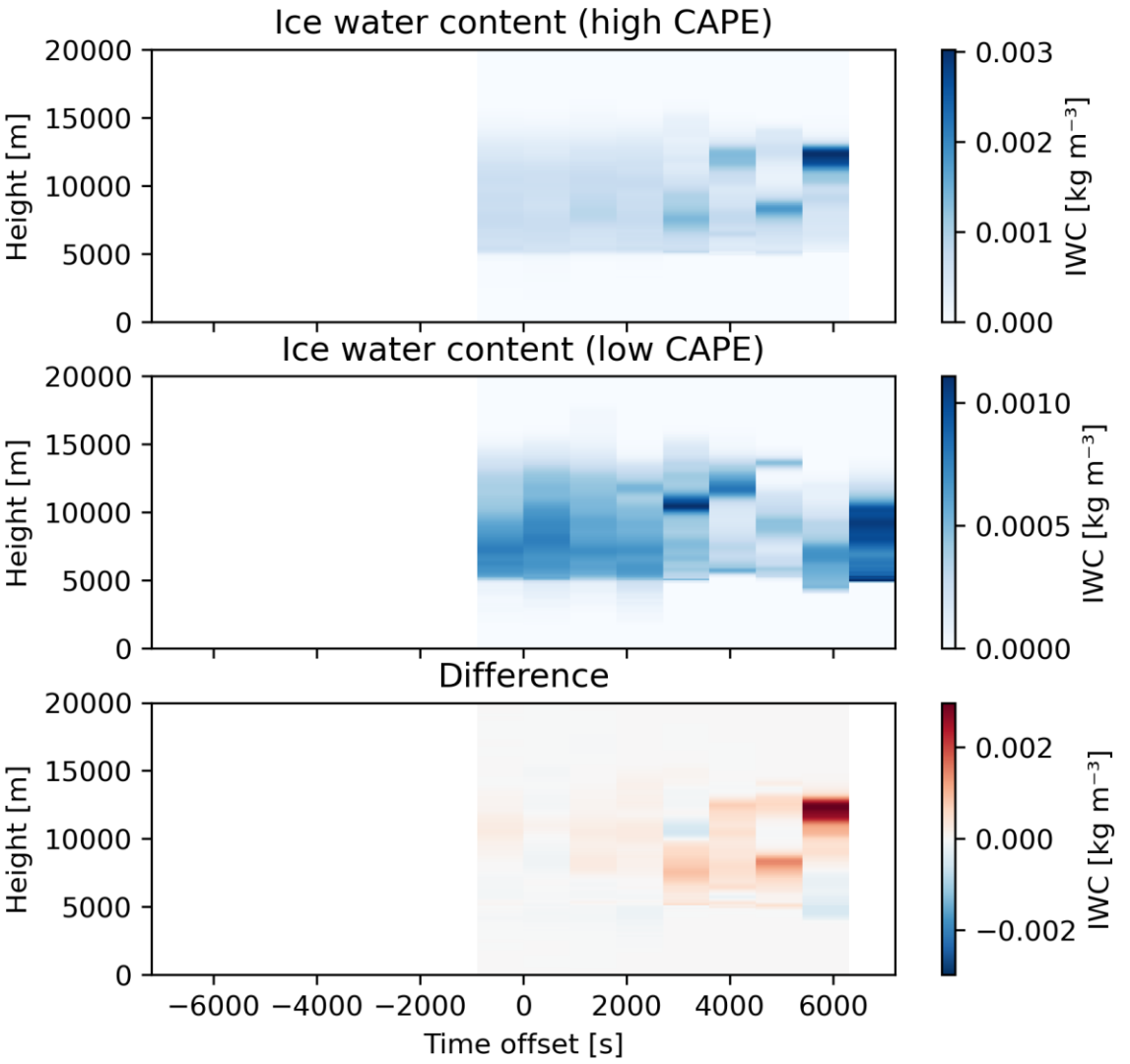
# Composite DCC evolution

With a large number of overpasses, we can produce composites of DCC development due to the variance in relative overpass times and the lifetime of the tracked system



# Composite DCC evolution

These composites can be further divided by properties of interest (e.g. high/low CAPE) to study how different environmental properties affect observed DCC properties, and vice versa how different DCC properties (e.g. high/low doppler velocities) relate to the preceding environment



# Summary, thoughts and next steps

Many of the questions we wish to answer require data not provided by EarthCARE, or at different times

Cloud tracking provides a framework to discover ‘serendipitous’ colocations – can be extended to other properties such as prior aerosol measurements, surface properties etc.

Over a long enough time, these colocations can be used to study how various environmental conditions affect the development of clouds observed by EarthCARE

Requirement for more high temporal resolution observations for convective core development – geostationary data, lightning…

Lots of interest in EarthCARE DCC properties – is there scope for a standardised EarthCARE storm directory?