

# The vertical change of the radiative energy budget derived from multi-aircraft observations

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Arctic airborne campaigns workshop  
Bergen, 1-4 June 2026

**HALO:** Priority Programme for the scientific use of the "High Altitude and Long Range Research Aircraft" (SPP 1294)  
**(AC)<sup>3</sup>:** Transregional Collaborative Research Centre on "Arctic Amplification" (TR 172)

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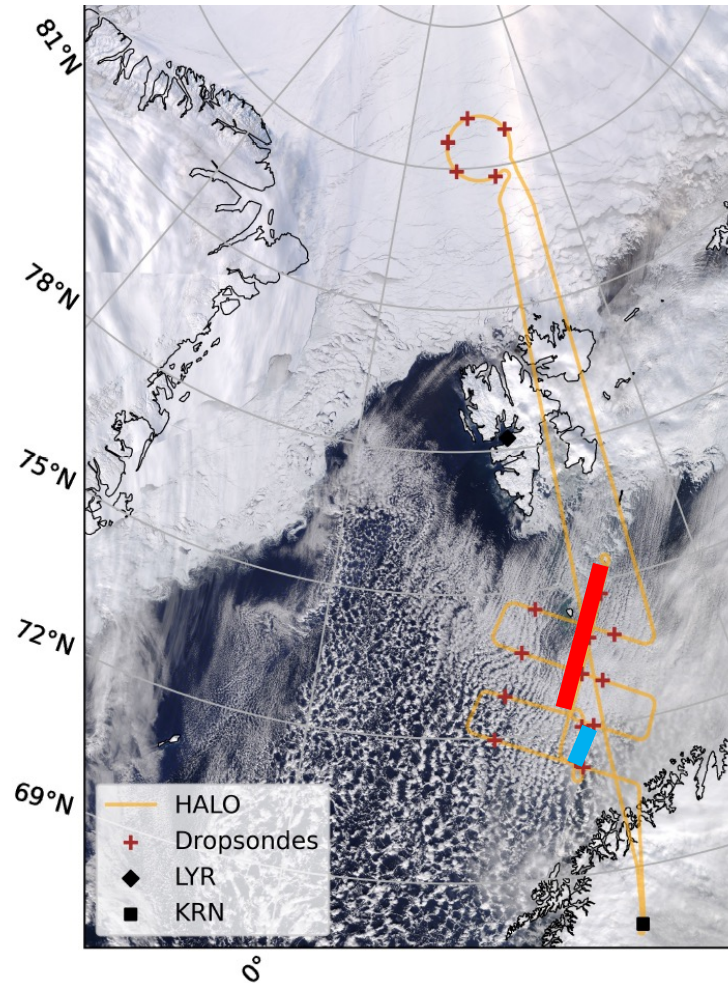


## 1) Collocated Flights

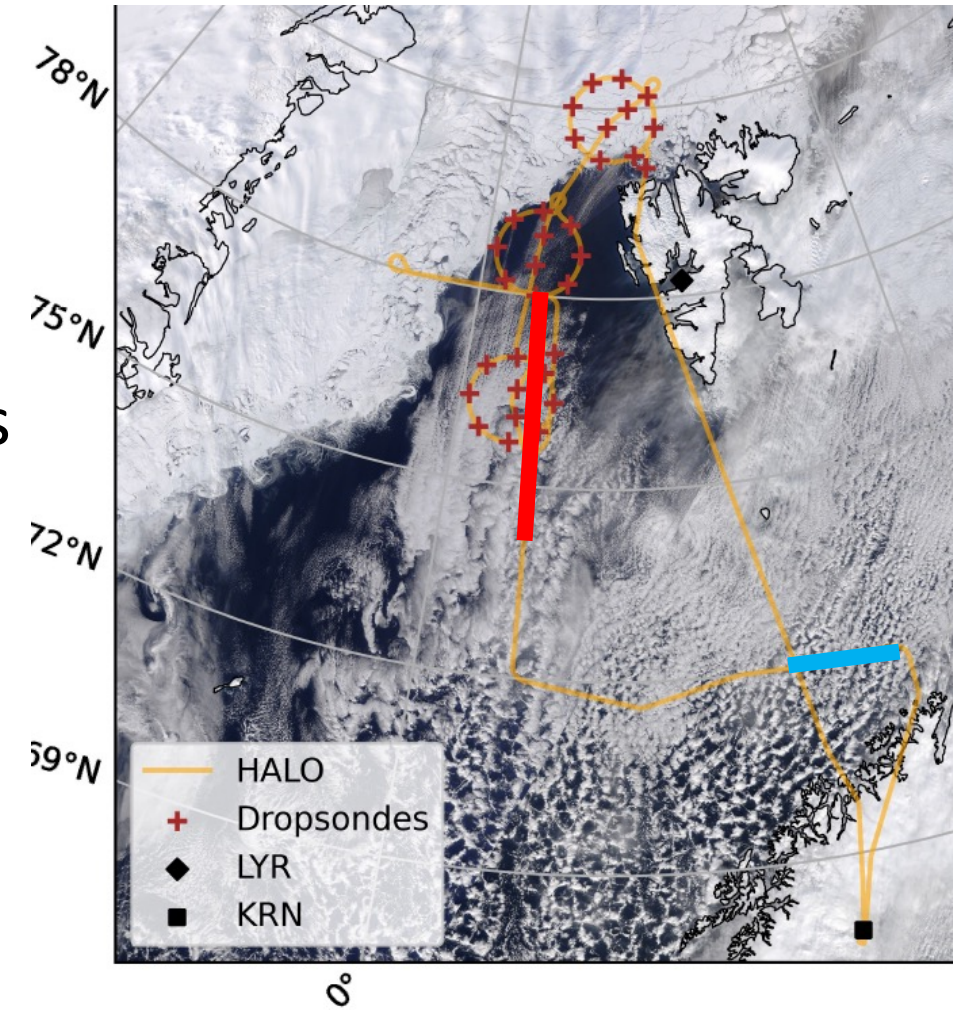


Continuous layer radiative properties

## 29 March 2022



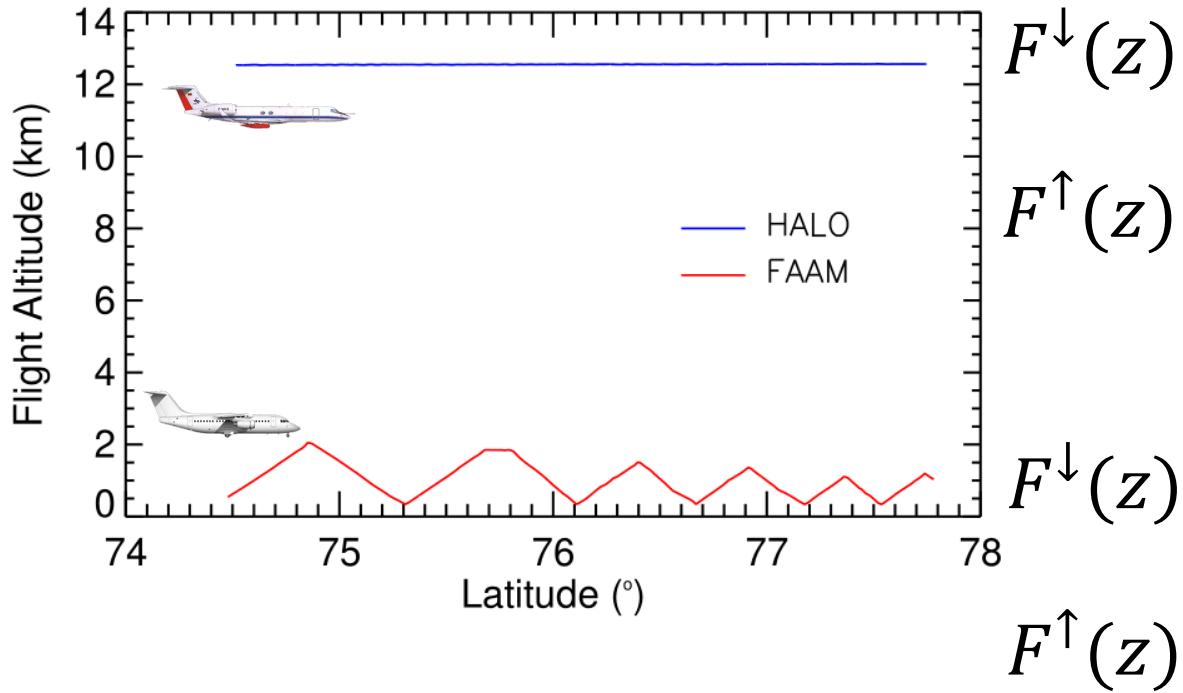
## 30 March 2022



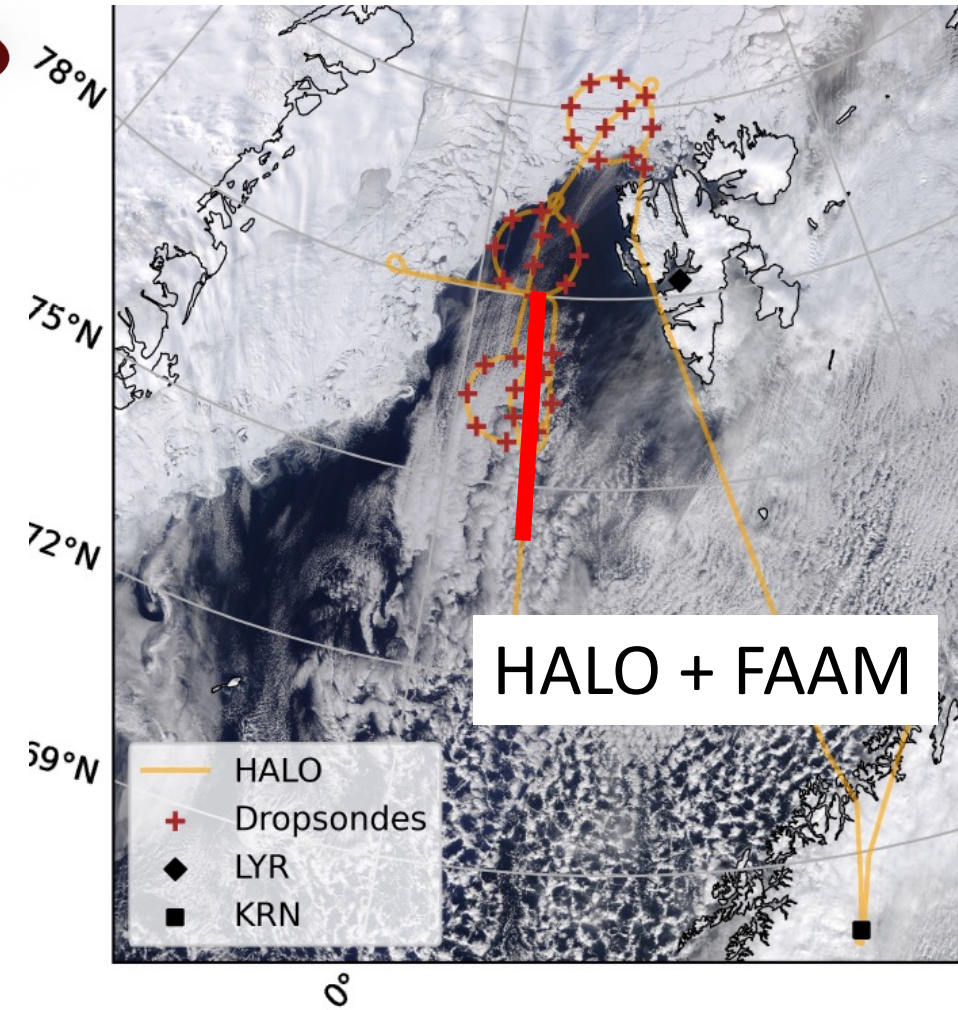
— HALO + FAAM

— HALO + ATR

timing and conditions  
not always perfect



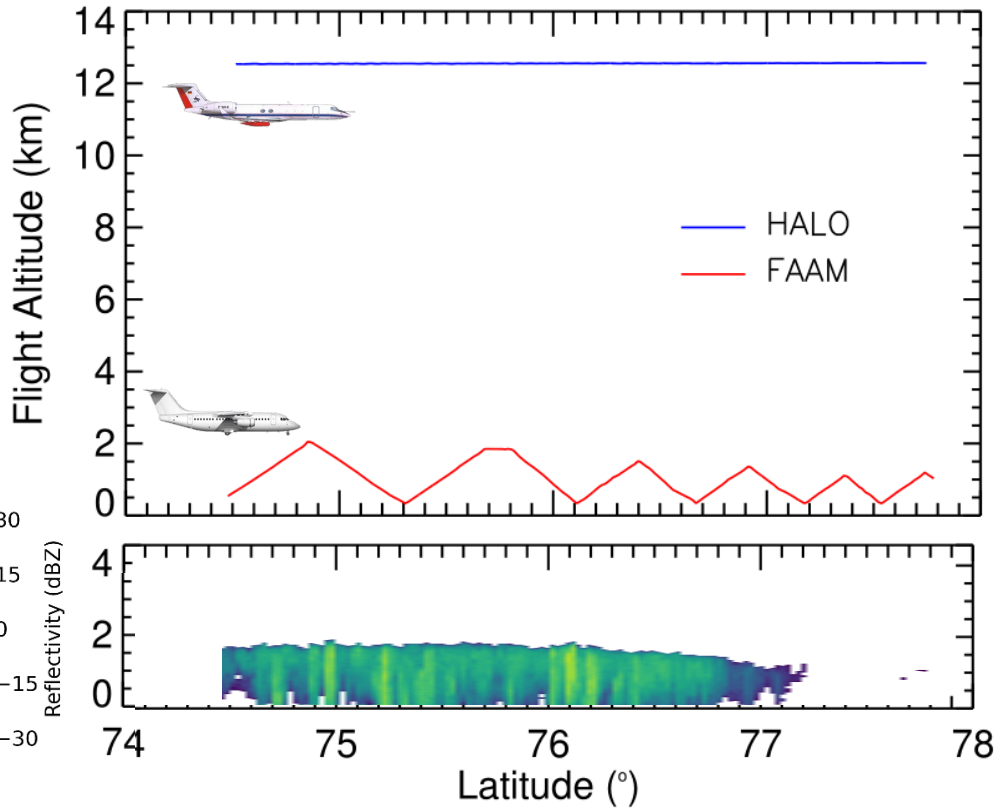
30 March 2022



## Broadband Radiometer

- downward/upward irradiance
- solar/thermal-IR
- net irradiance
- radiative energy budget (REB)

# Collocated Flight HALO-FAAM 30 March 2022



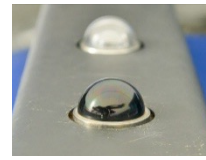
$F^\downarrow(z)$



$F^\uparrow(z)$



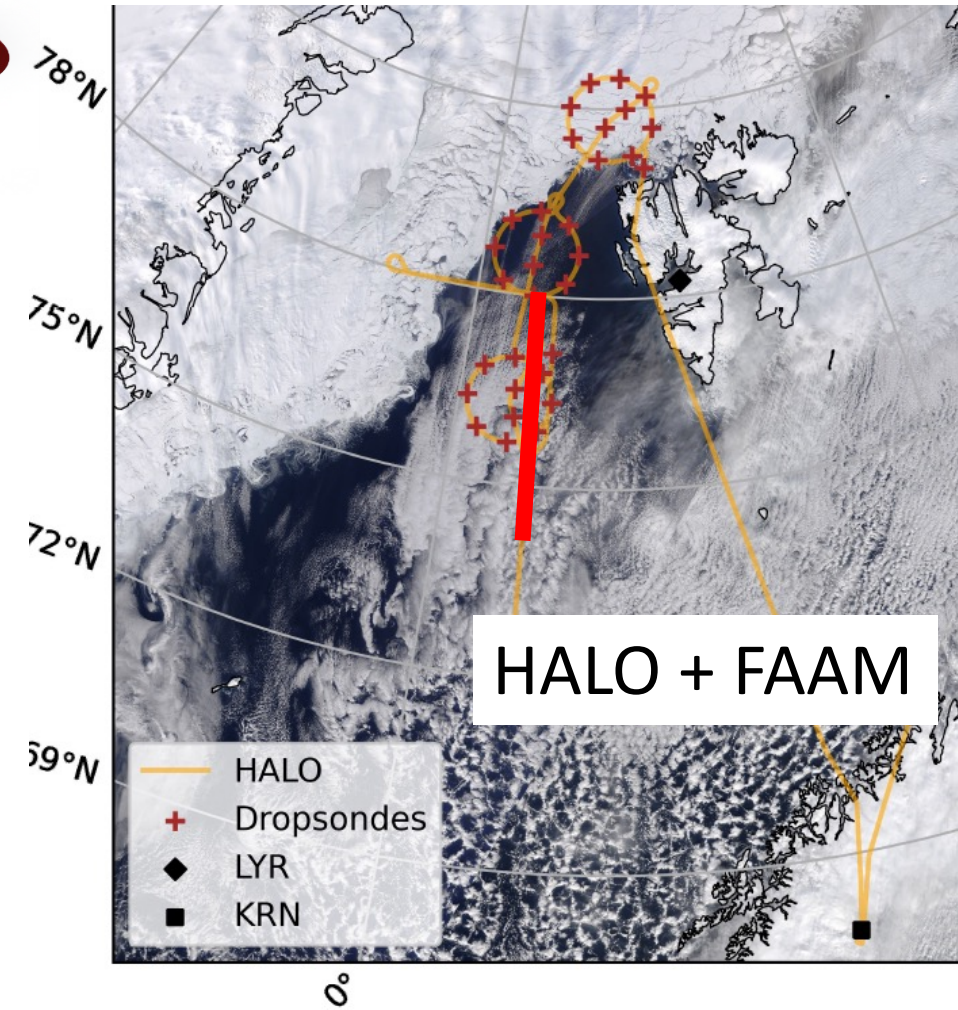
$F^\downarrow(z)$



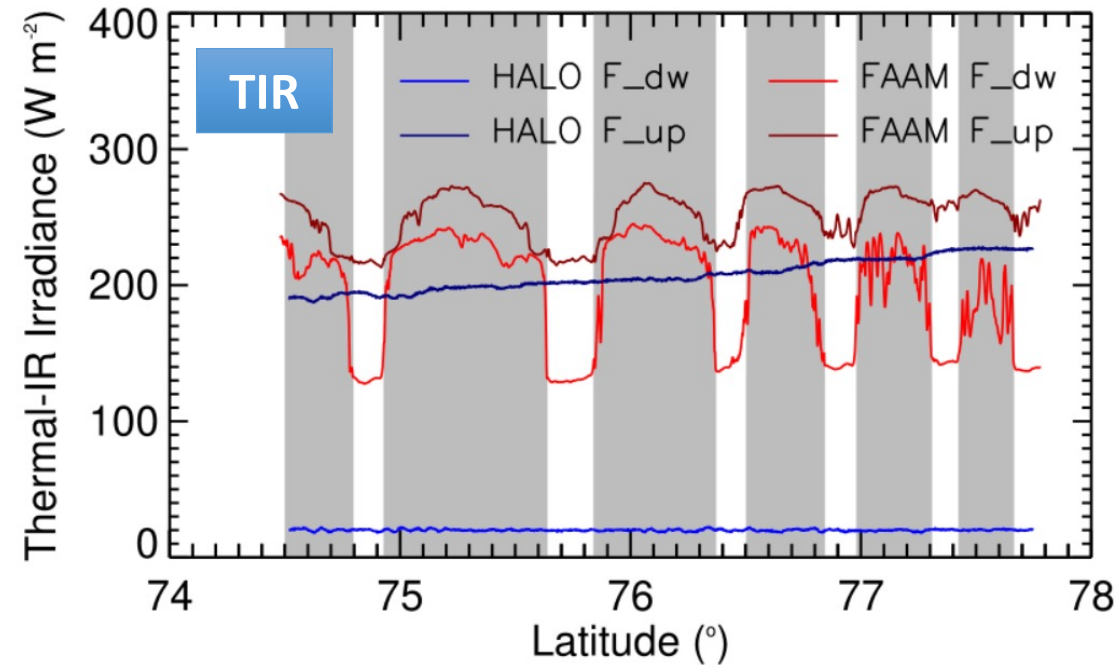
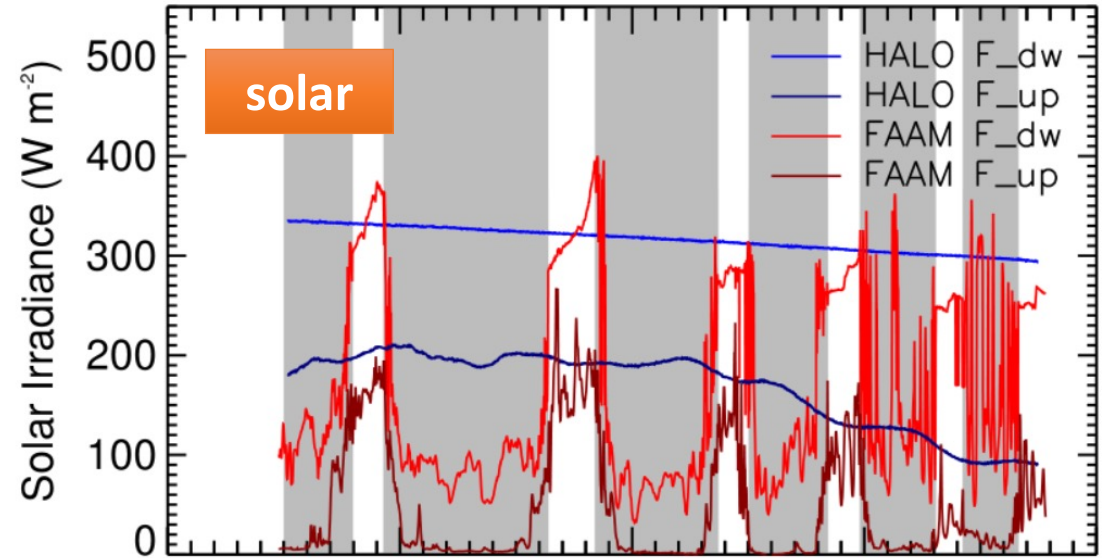
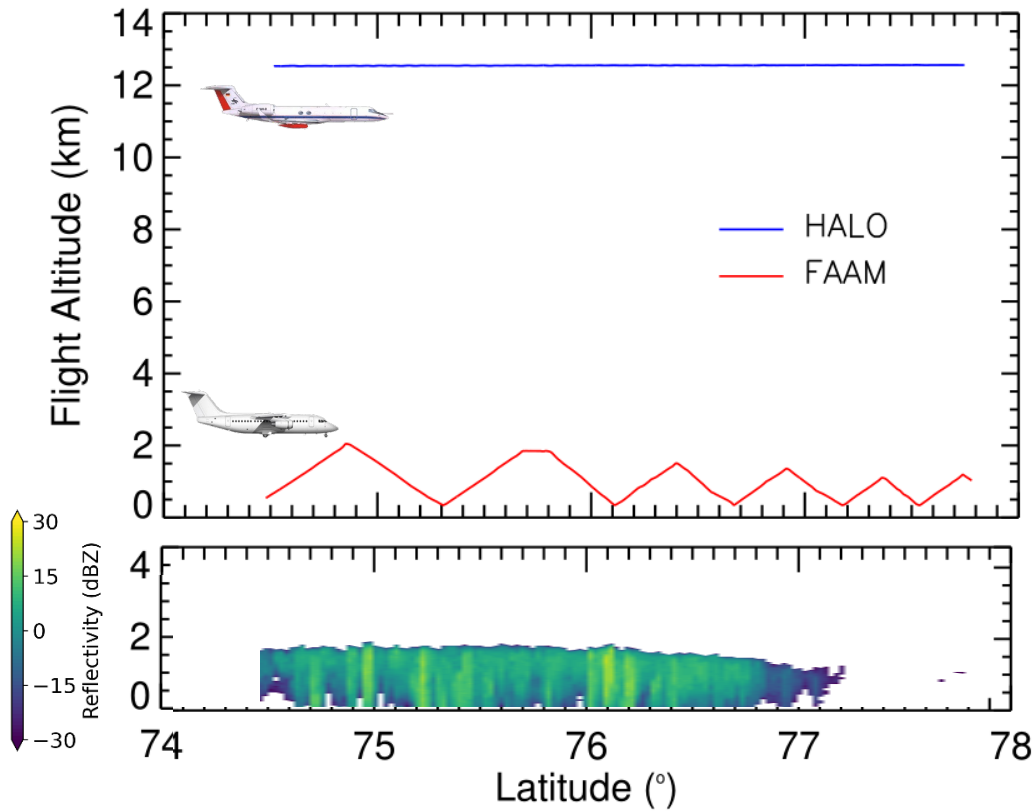
$F^\uparrow(z)$

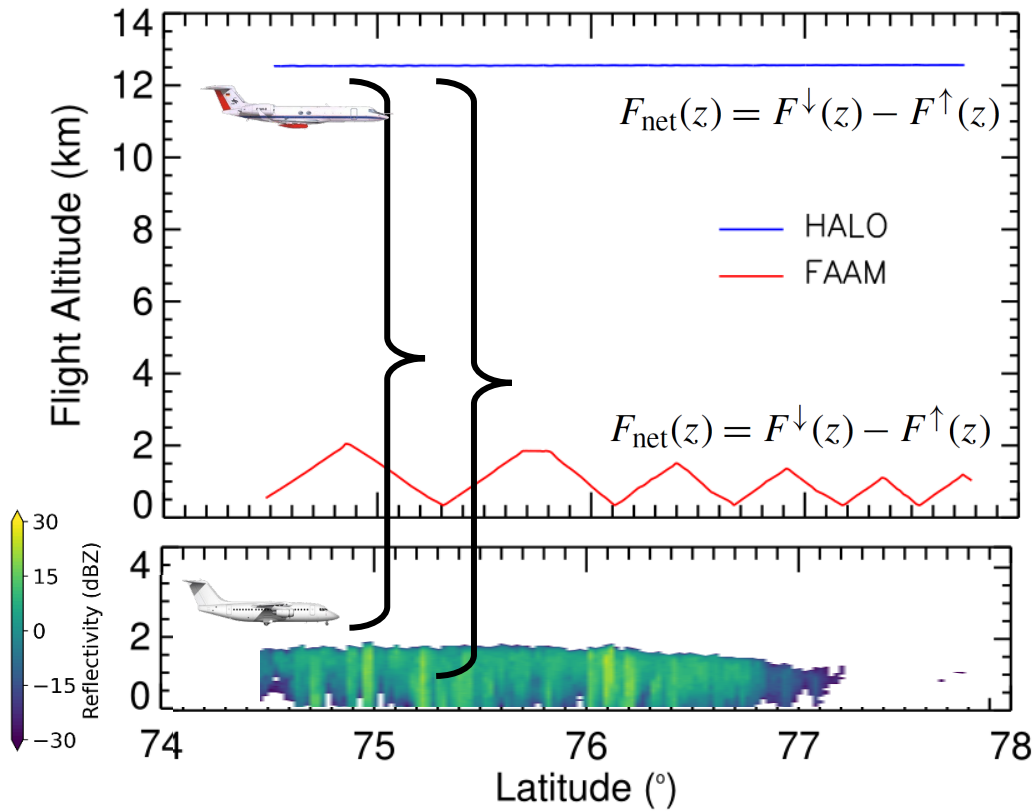


## 30 March 2022



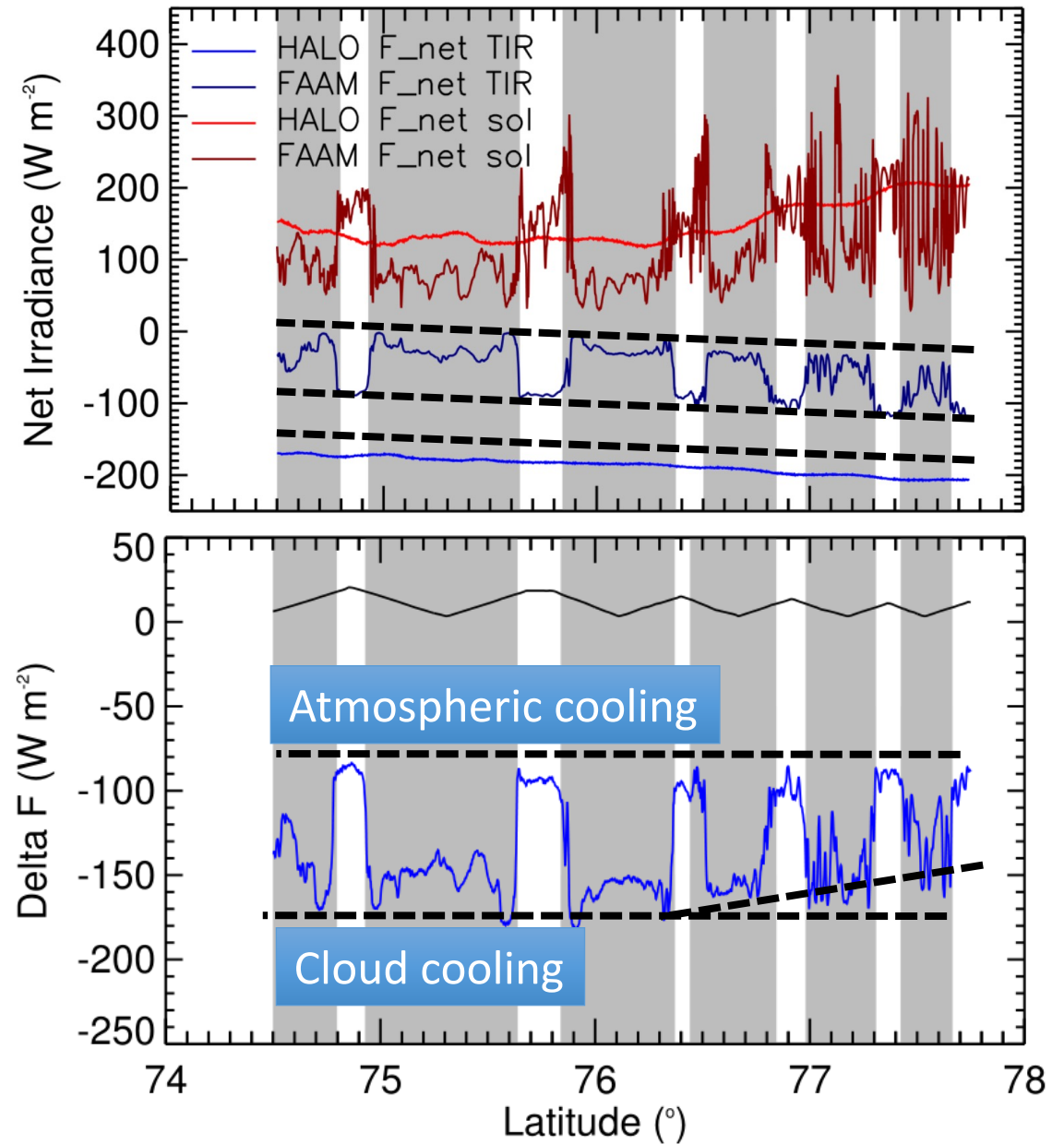
# Collocated Flight HALO-FAAM 30 March 2022





$$\zeta = \frac{1}{\rho \cdot c_p} \frac{F_{\text{net}}(z_{\text{top}}) - F_{\text{net}}(z_{\text{bot}})}{z_{\text{top}} - z_{\text{bot}}}$$

Radiative cooling/heating rate

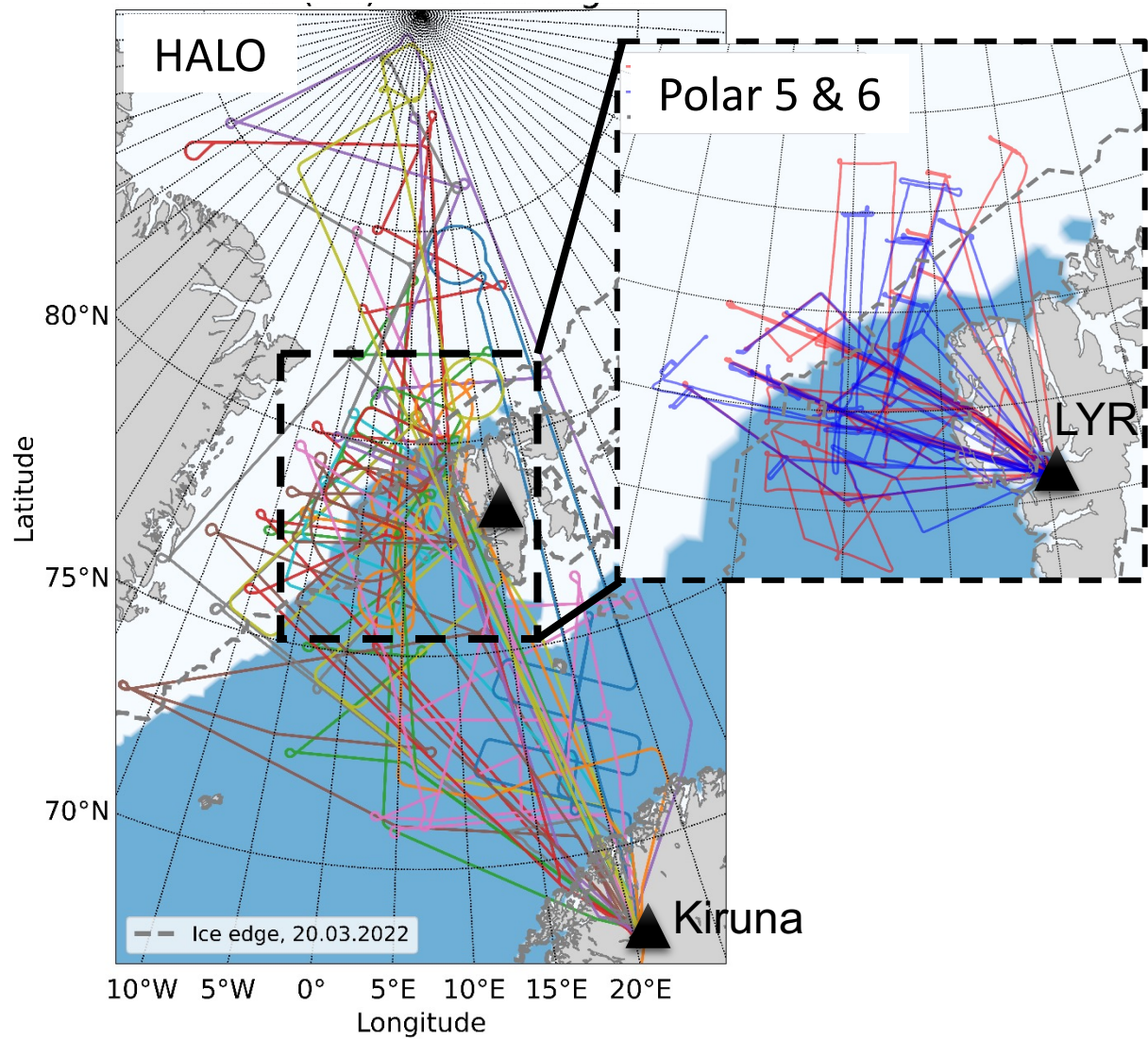


## 2) Statistical Analysis



**Variability of the Radiative Energy Budget (REB) in different altitudes**

# REB in different altitudes



HALO

> 8000 m

$$F_{\text{net}}(z) = F^{\downarrow}(z) - F^{\uparrow}(z)$$

P5&P6

FAAM

ATR



2500- 4500 m

$F_{\text{net}}(z) = F^{\downarrow}(z) - F^{\uparrow}(z)$

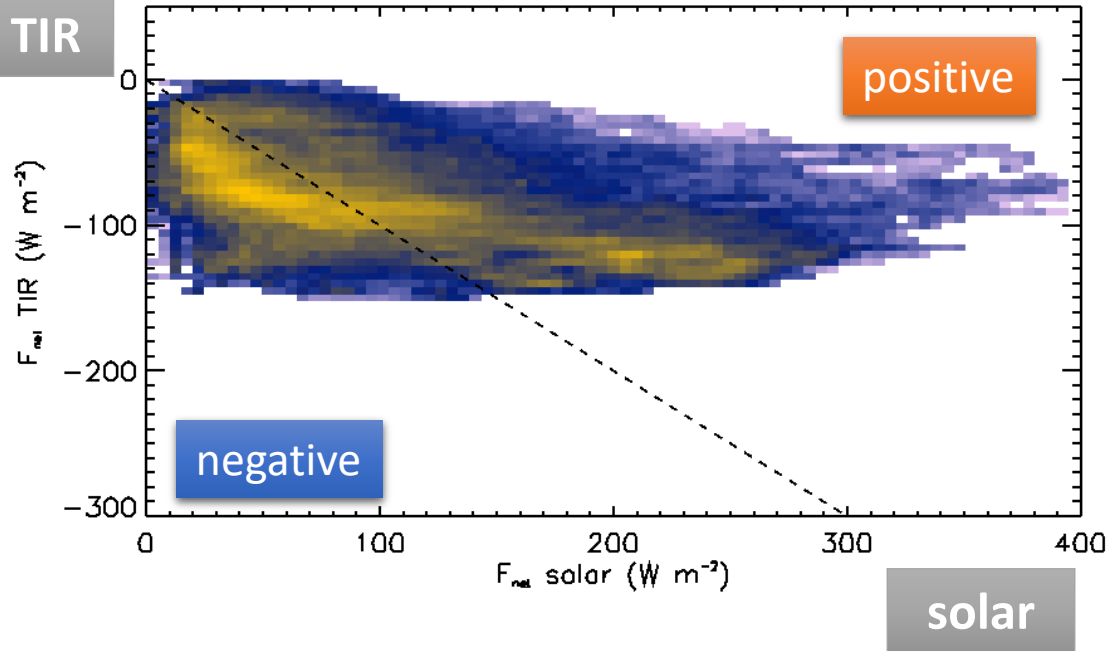
cloud layer



< 500 m

# REB in different altitudes

TIR

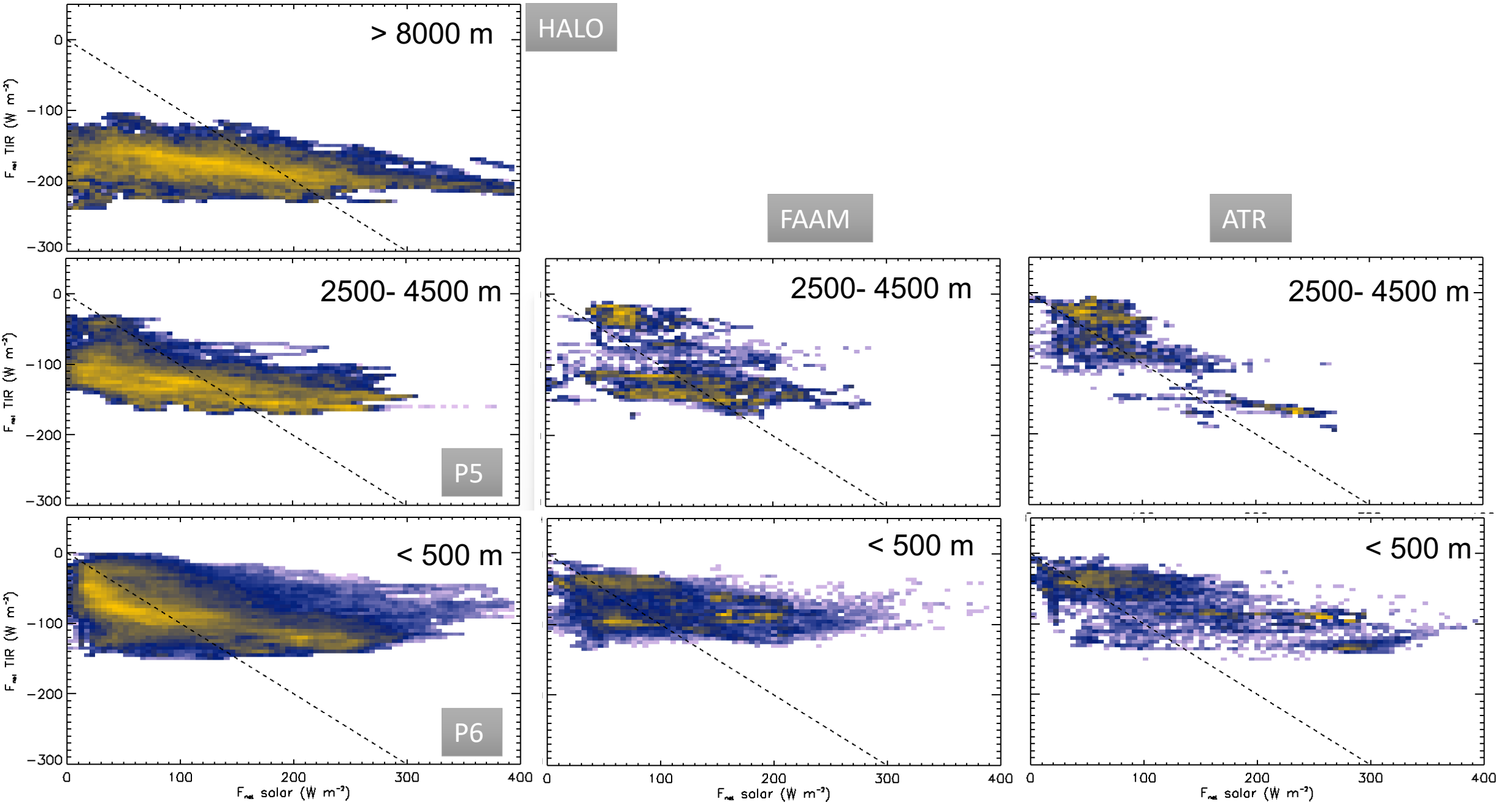


**HALO >8000 m**

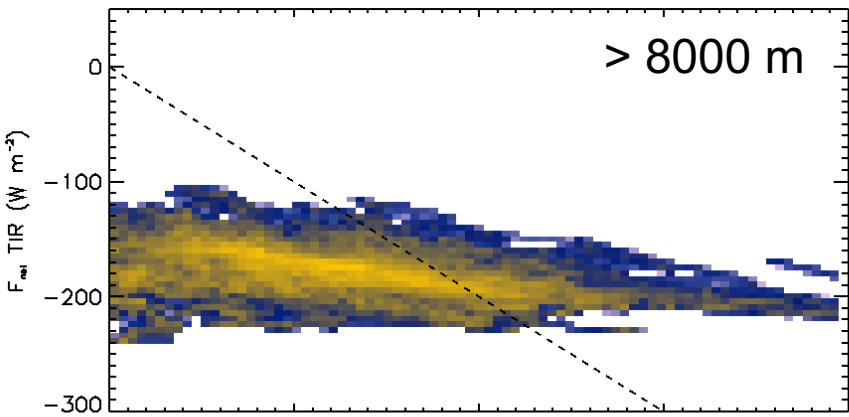
**P5 2500- 4500 m**

**P6 <500 m**

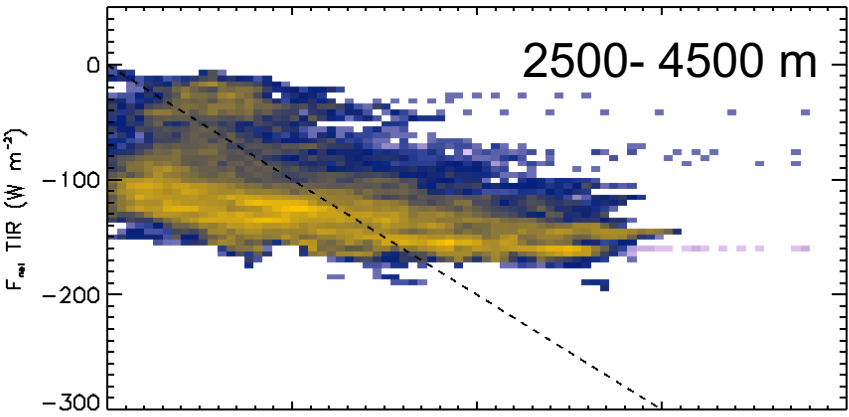
# REB in different altitudes



# REB in different altitudes



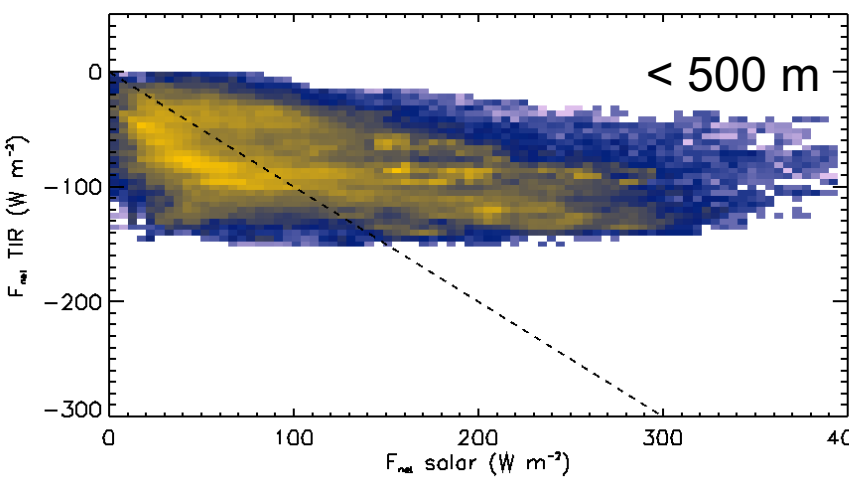
HALO



P5

FAAM

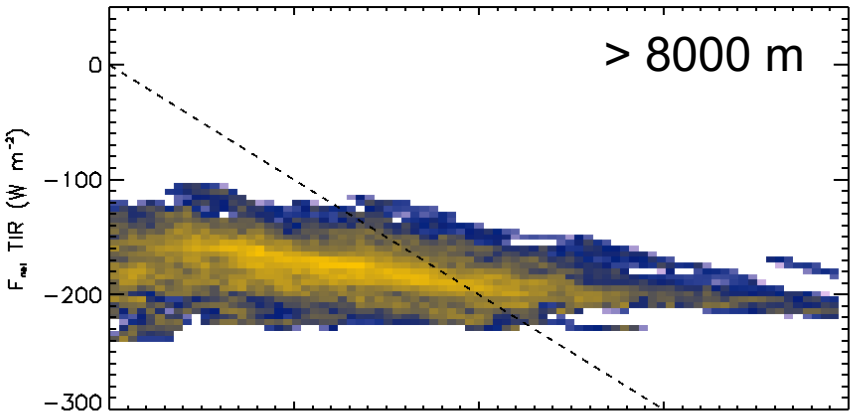
ATR



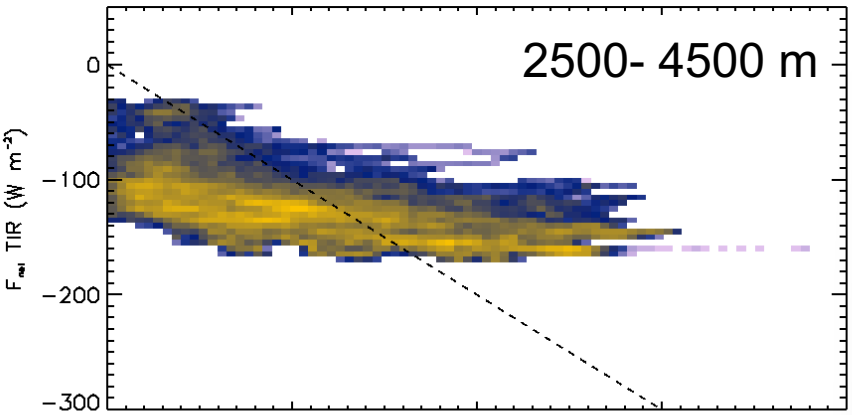
P6

FAAM

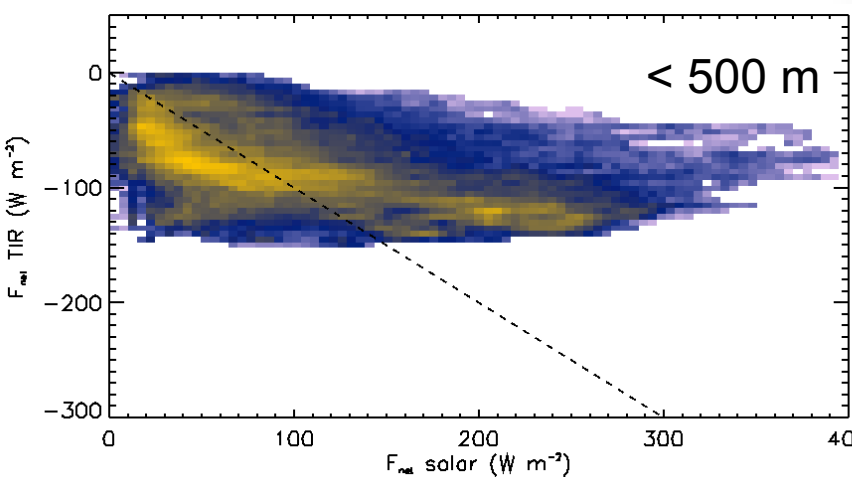
ATR



HALO



P5

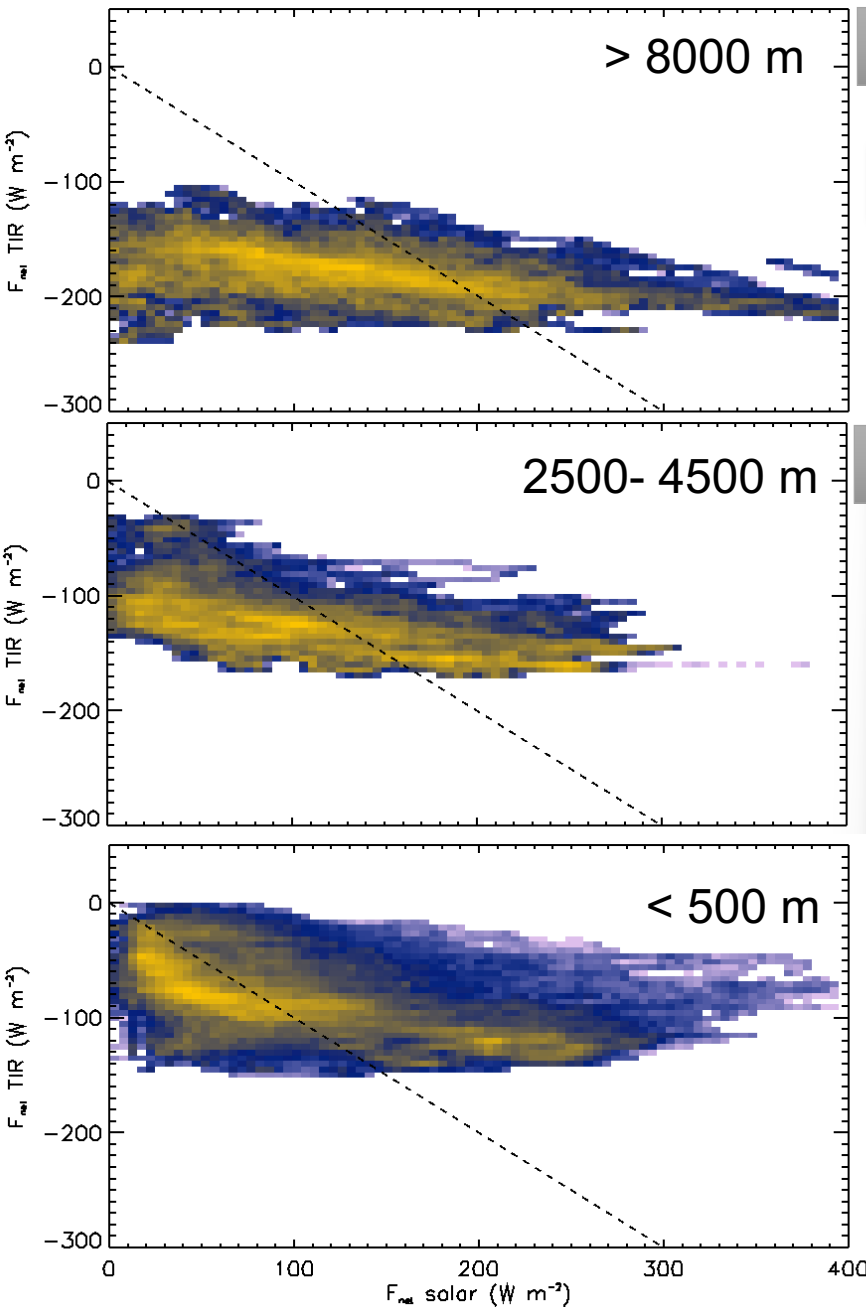


P6

**How the REB is represented in IFS/EcRad simulations?**



# REB in different altitudes vs. IFS



HALO

Break between cloud-free and cloudy

Break between sea ice and ocean

Footprint?!

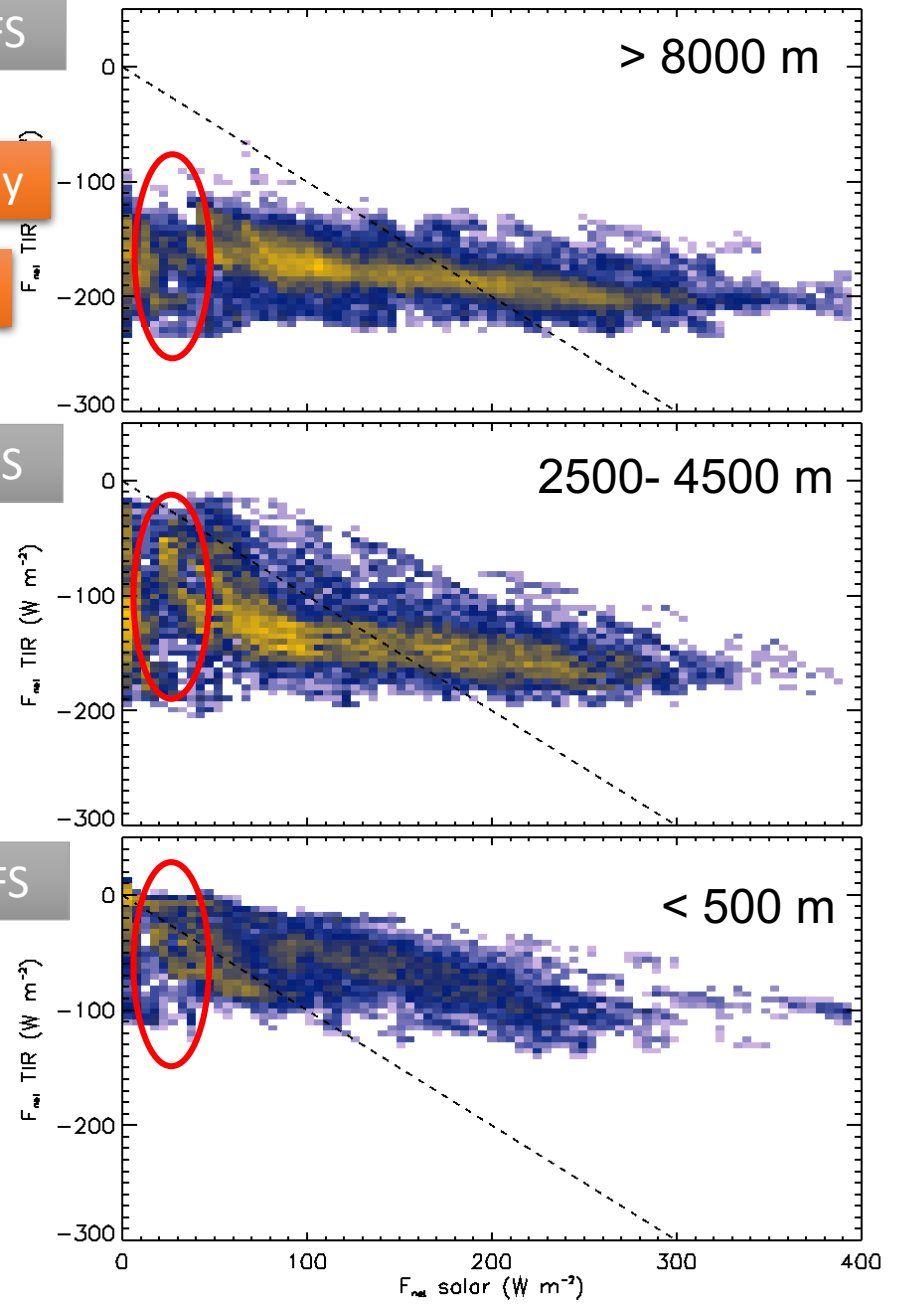
P5

P6

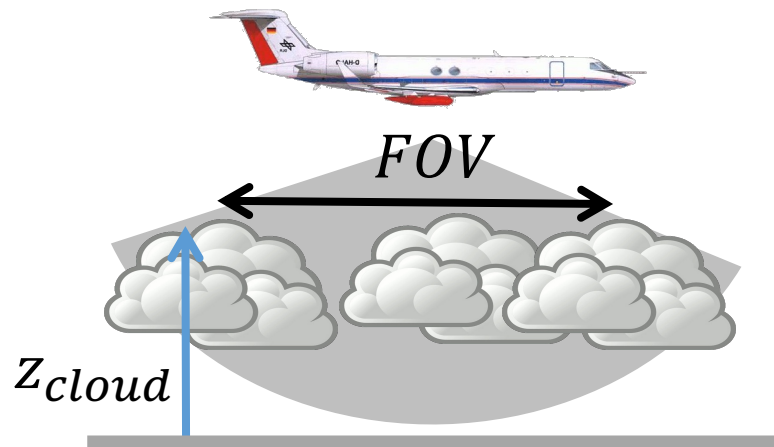
IFS

IFS

IFS



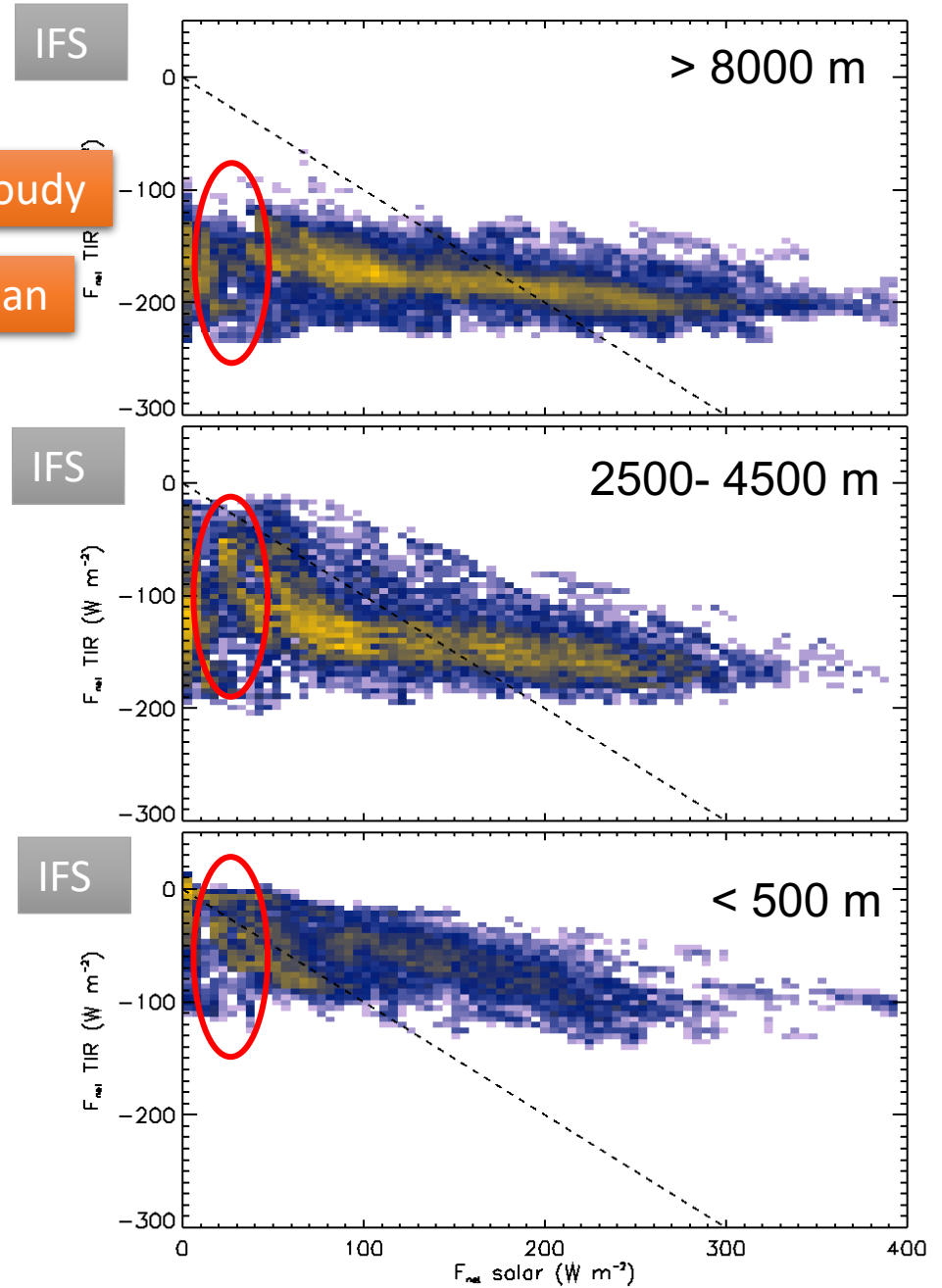
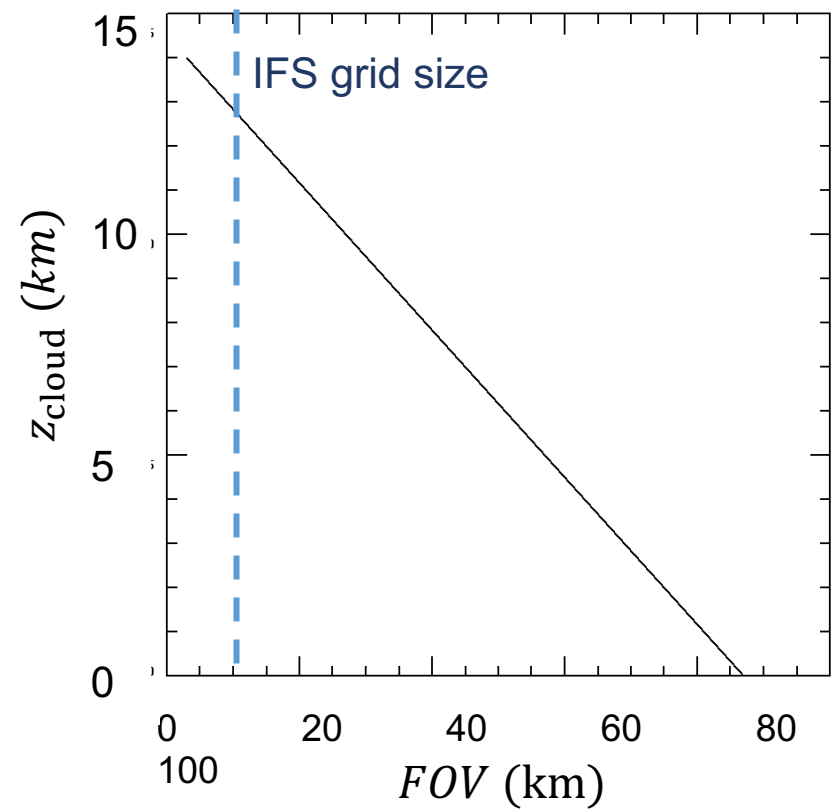
# REB in different altitudes vs. IFS



Break between cloud-free and cloudy

Break between sea ice and ocean

Footprint?!



Collocation

Different aircraft

Different campaigns

→ layer properties

→ change of REB with altitude

→ extend statistics and atmospheric regimes

Make use of all data!