

# Characterization of Inhomogeneities within Satellite Footprints

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EUMETSAT Fellow Day

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- **Satellite Footprints**

IASI            12 – 36 km

AMSU-A        48 – 130 km

ATMS          76 – 340 km

- **ICON – NWP**

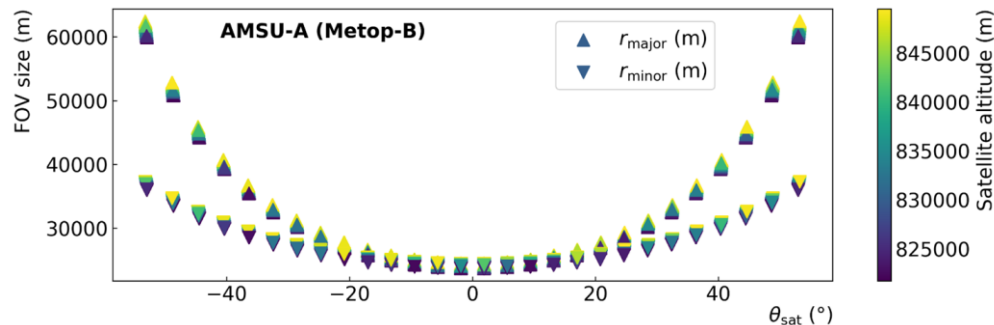
13 km – 6.5 km – 2 km → 500 m

Global → Regional

➔ **Introduces challenges in DA**



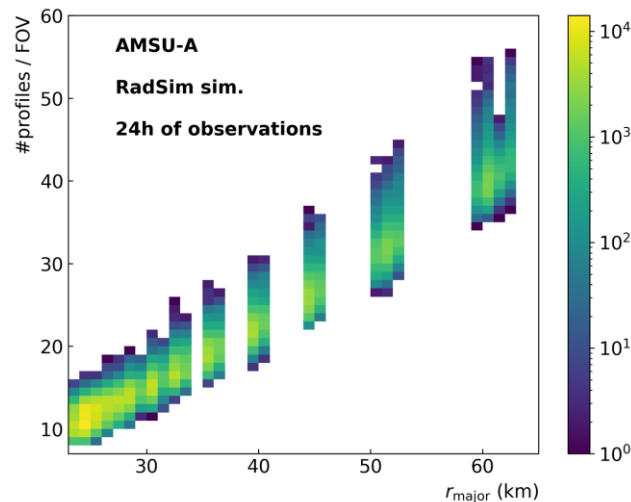
- AMSU-A FOV sizes
  - Nadir: ~24 km
  - Larger semi-axes with larger  $\theta_{\text{sat}}$



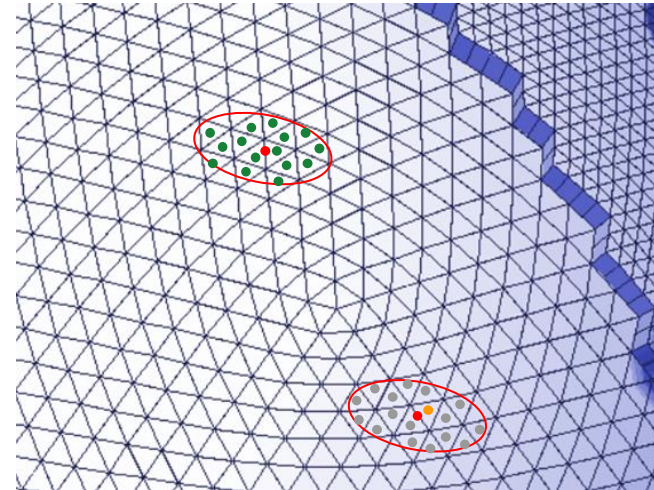
- AMSU-A FOV on ICON 13 km
  - Between 8 and 59 model profiles per FOV

➔ **Raises Question of Representativeness**

Only one interpolated profile is used!

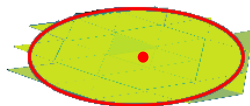


- **Investigate inhomogeneities within FOVs** using simulated data
  - **Single-profile calculations** vs. **FOV averaged BT**
  - Characterize representativeness error
  - Datasets created for AMSU-A, MHS (global 13km); SEVIRI (regional 500m)
- **Tools**
  - RTTOV v14
  - fov\_operator
- **Determine main influencing parameters**
  - Surface parameters (land fraction, emissivity, ...)
  - Atmospheric parameters (clouds, humidity, ...)

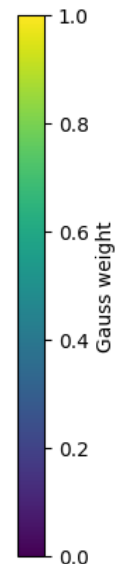
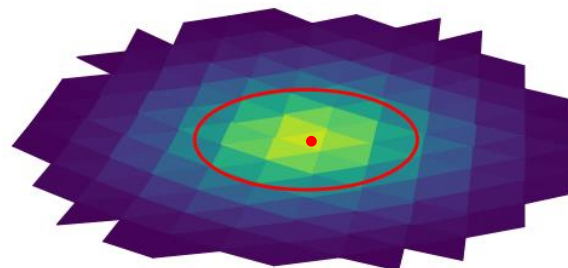


- Averaging of radiance field and all other atmospheric and surface variables
- **VIS and IR Sensors:** no weights
- **MW Senors:** Antenna patterns with 2D Gauss function

$\min(gw) = 1.0$



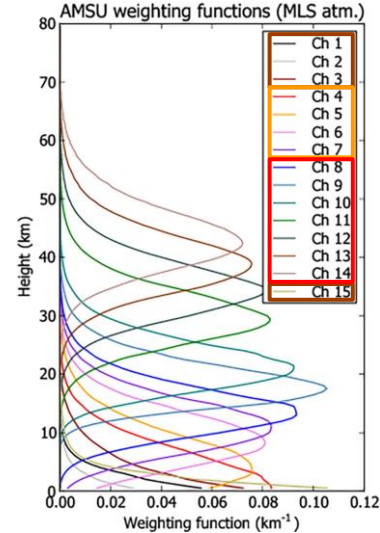
$\min(gw) = 0.013$



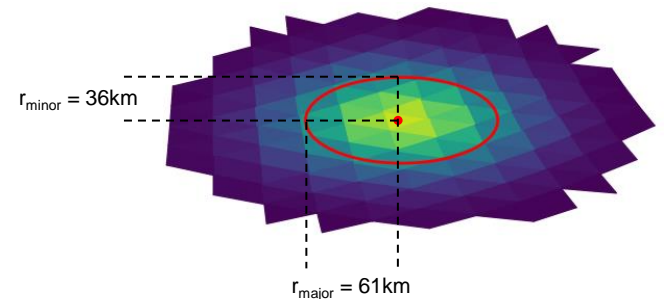
# Results based on...

- **Database** ICON reanalysis  
37 days x 4 times = 370 dates over 2024  
Global data on 13 km grid
- **Instrument** AMSU-A and MHS  
Zenith angle = 53°  
AMSU-A Channels 1, 3, 5, 9

- $\Delta T_b = T_{b, \text{single-profile}} - T_{b, \text{fov avg}}$



- **full surface transmittance**
- **partial surface transmittance**
- **zero surface transmittance**

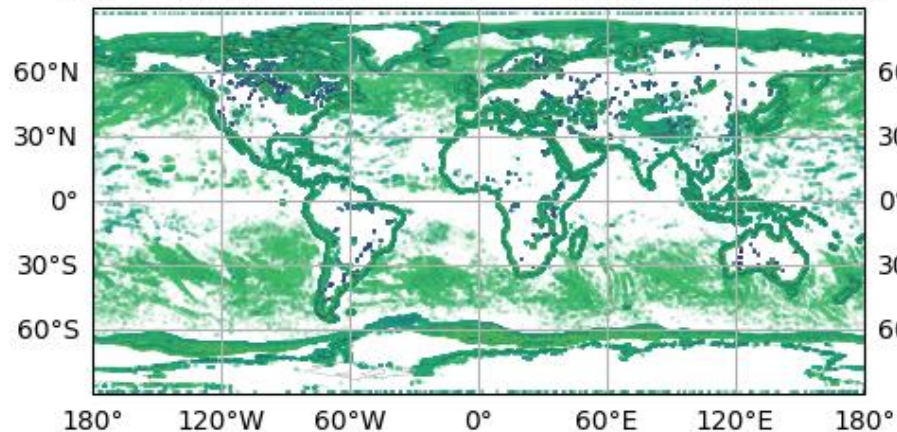


# Location of largest $|\Delta T_b|$

- Location of  $|\Delta T_b| > 95\text{th percentile}$
- **Window channels**
- JJA 2024 – all-sky

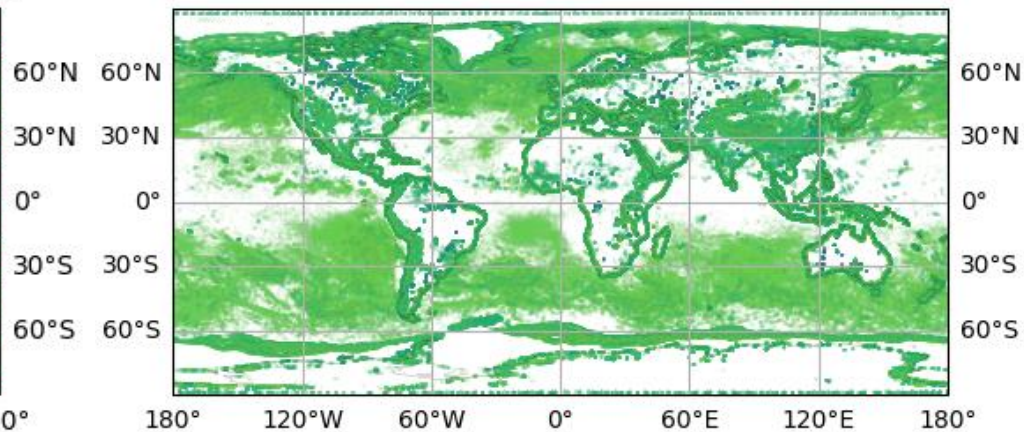
Ch 1 (23.8 GHz)  $|\Delta T_b| > 9.75\text{ K}$

180° 120°W 60°W 0° 60°E 120°E 180°



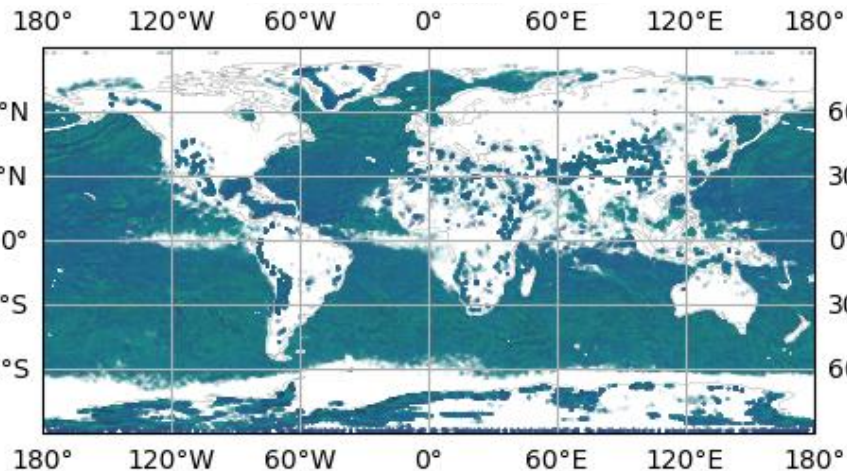
Ch 3 (50.3 GHz)  $|\Delta T_b| > 4.55\text{ K}$

180° 120°W 60°W 0° 60°E 120°E 180°

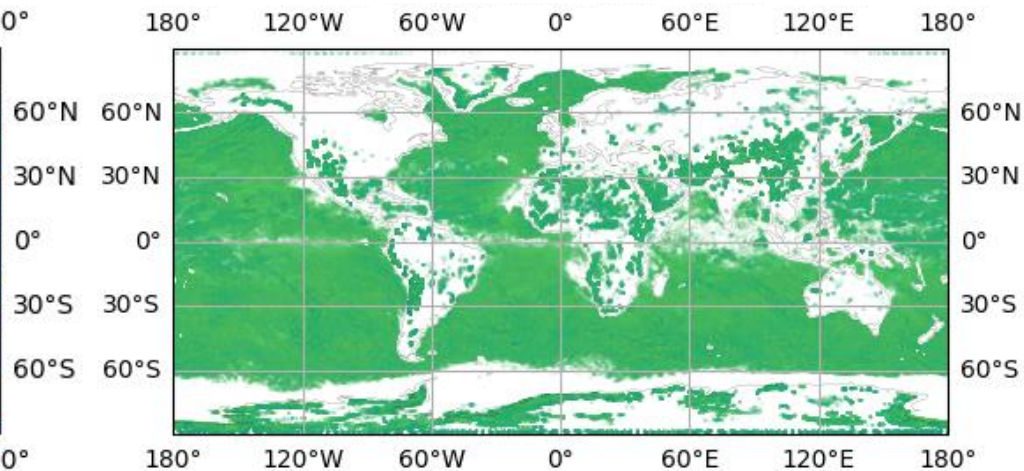


- Location of  $|\Delta T_b| > 95\text{th percentile}$
- **Window channels**
- JJA 2024 – all-sky

Ch 1 (23.8 GHz)  $|\Delta T_b| > 3.86\text{ K}$



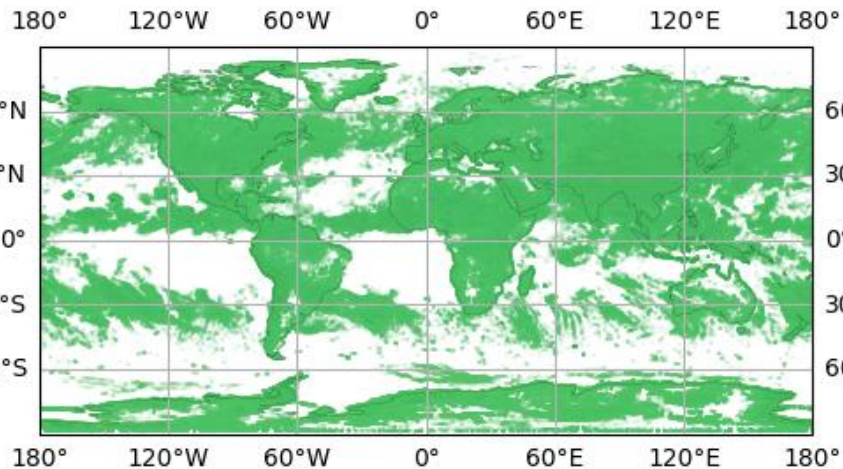
Ch 3 (50.3 GHz)  $|\Delta T_b| > 2.23\text{ K}$



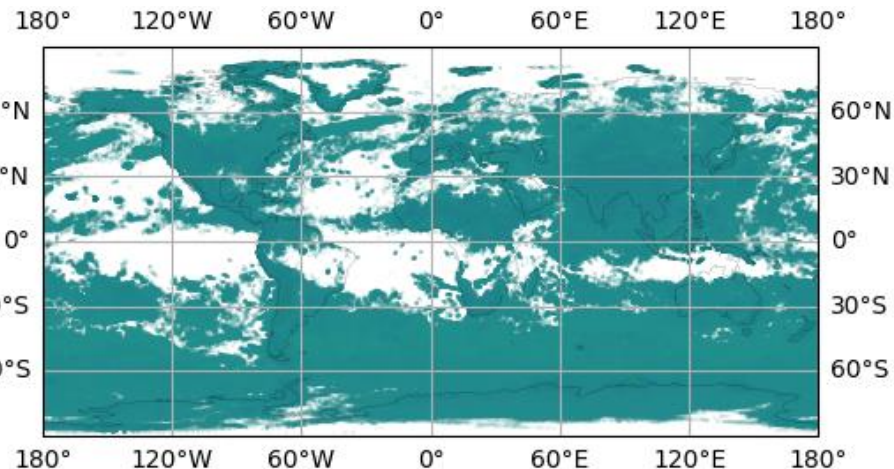
# Location of largest $|\Delta T_b|$

- Location of  $|\Delta T_b| > 95\text{th percentile}$
- **Atmospheric sounding channels**
- JJA 2024 – all-sky

Ch 5 (53.6 GHz)  $|\Delta T_b| > 0.18\text{ K}$

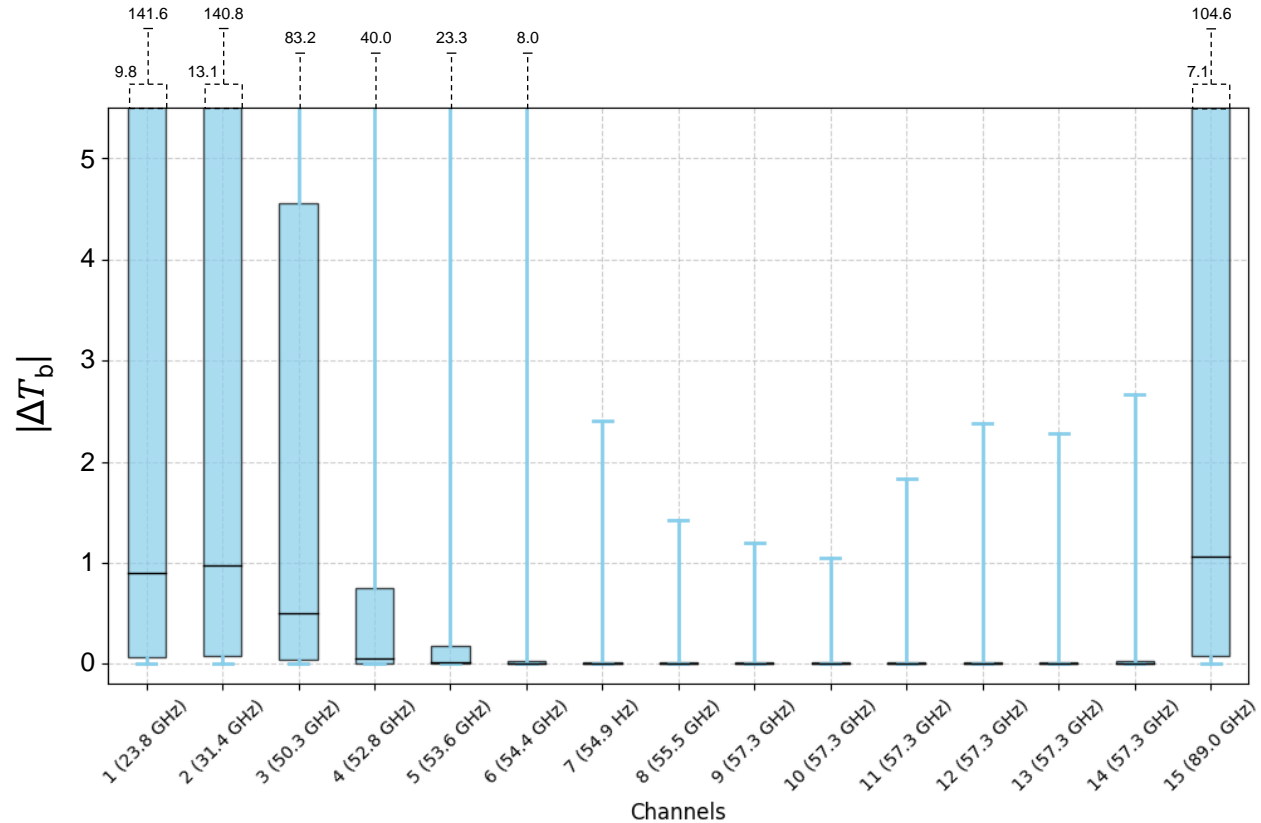
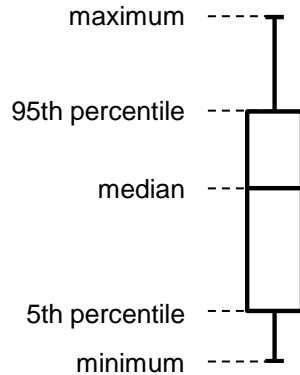


Ch 9 (57.3 GHz)  $|\Delta T_b| > 0.01\text{ K}$

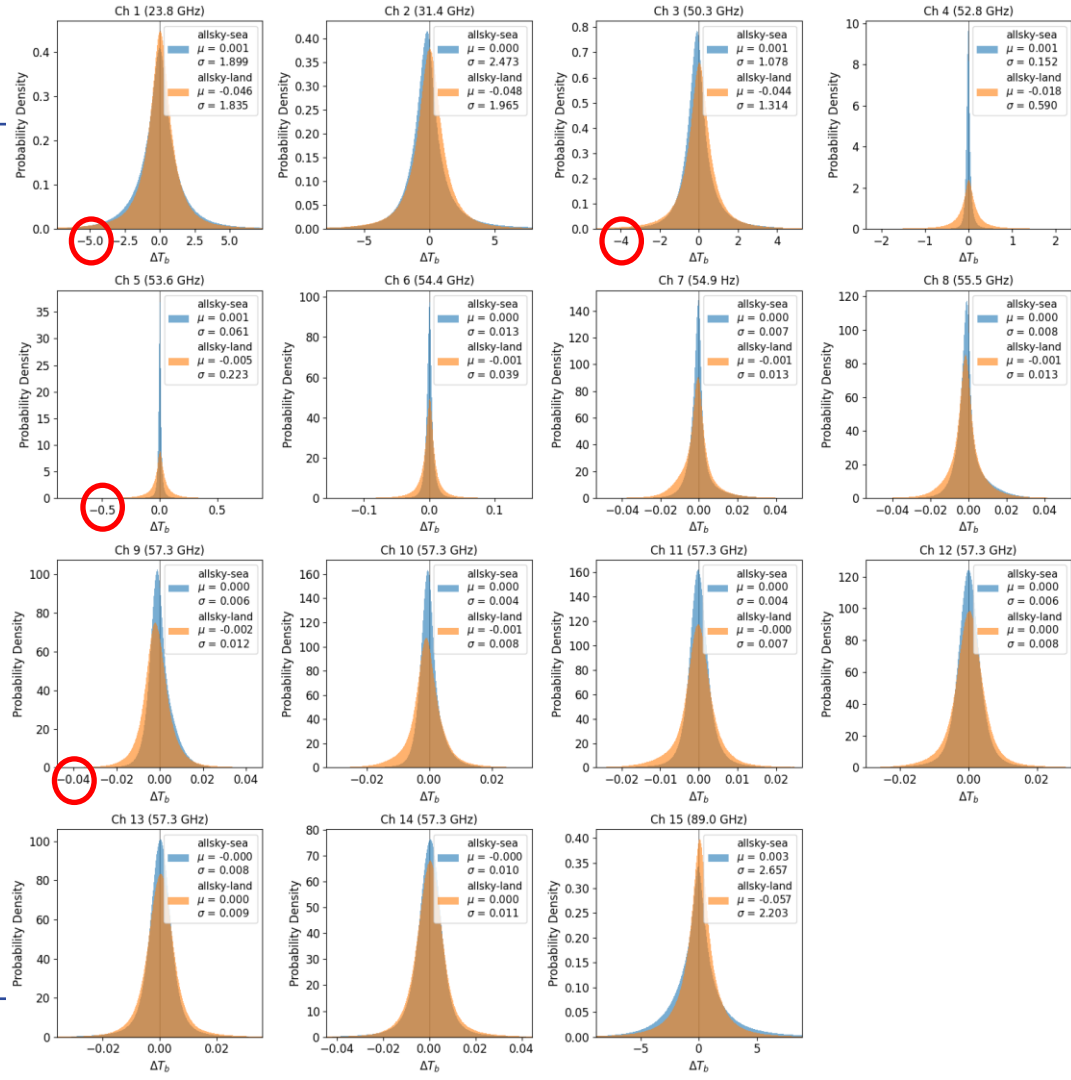


# Boxplot – AMSU-A – all-sky

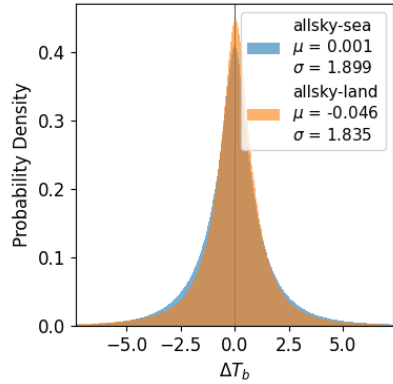
- JJA 2024



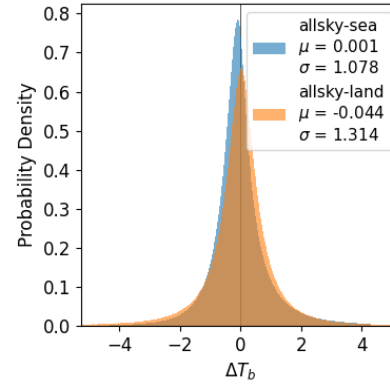
# AMSU-A



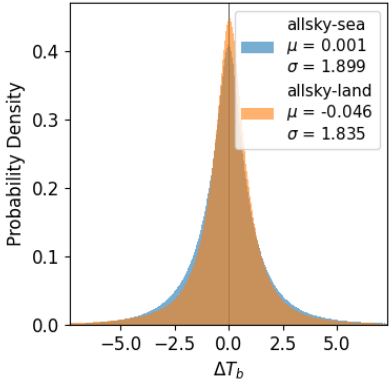
Ch 1 (23.8 GHz)



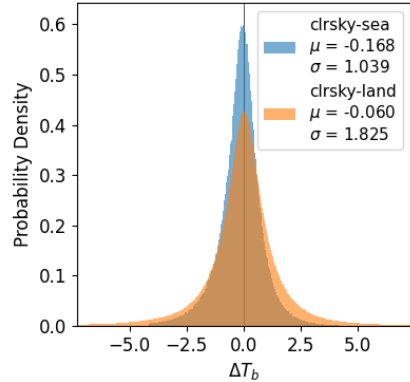
Ch 3 (50.3 GHz)



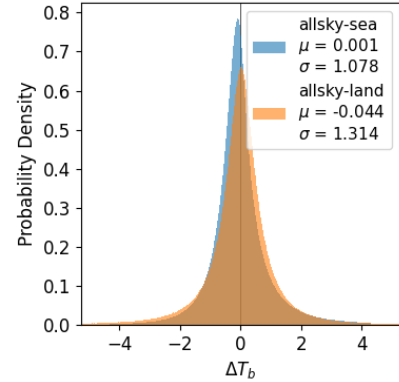
Ch 1 (23.8 GHz)



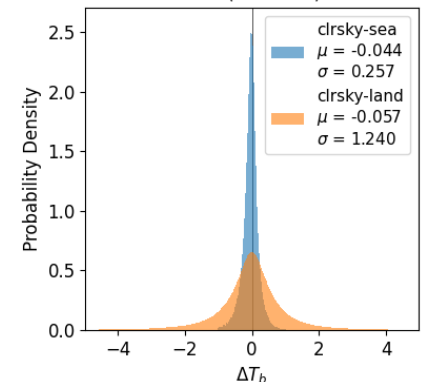
Ch 1 (23.8 GHz)



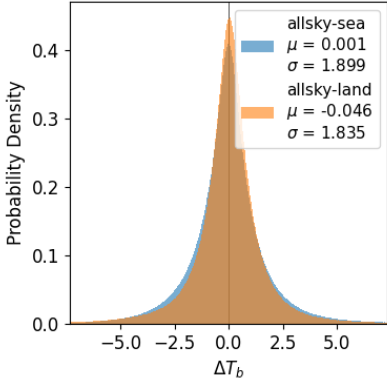
Ch 3 (50.3 GHz)



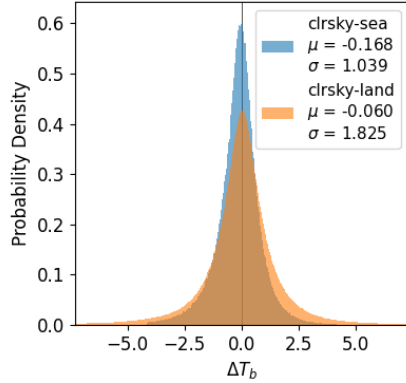
Ch 3 (50.3 GHz)



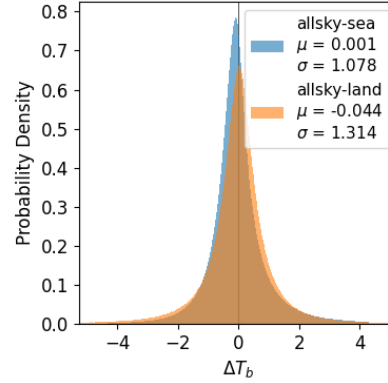
Ch 1 (23.8 GHz)



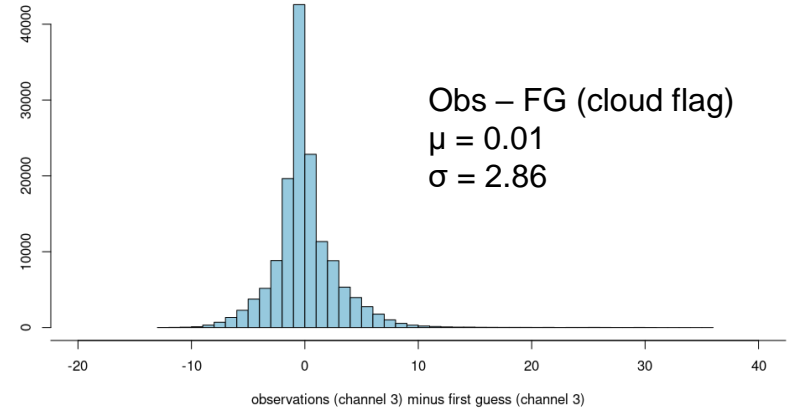
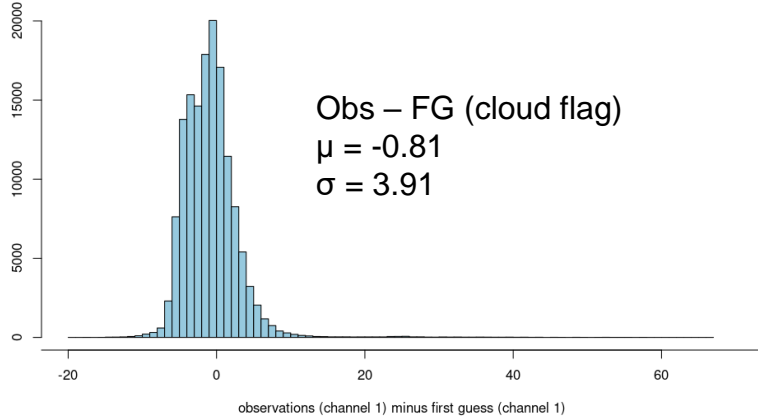
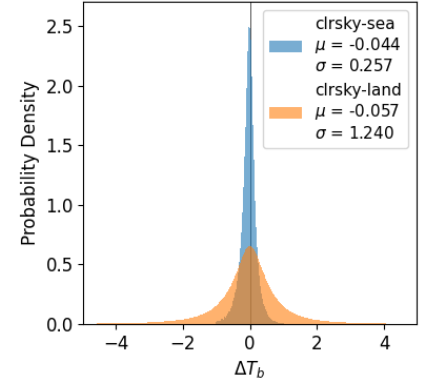
Ch 1 (23.8 GHz)

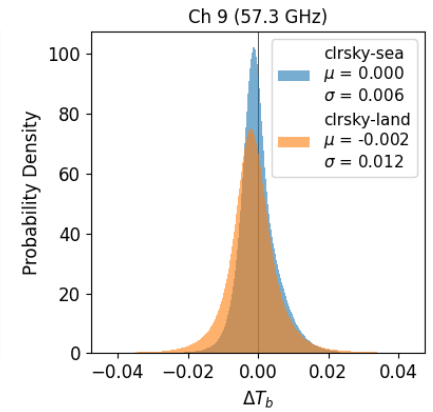
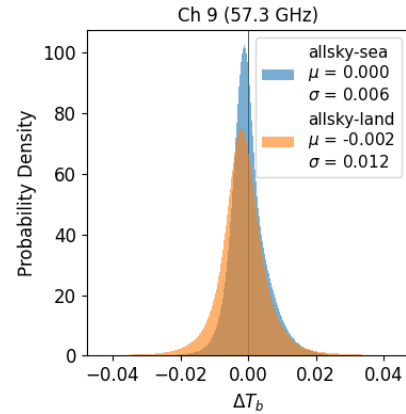
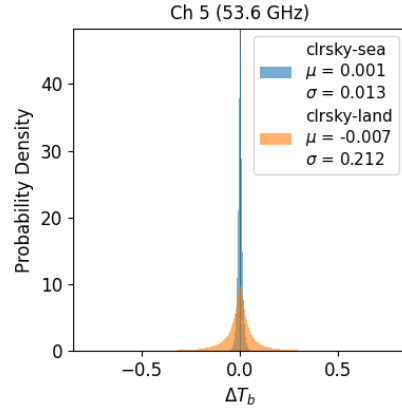
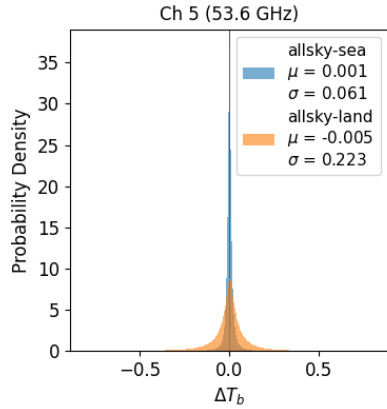


Ch 3 (50.3 GHz)

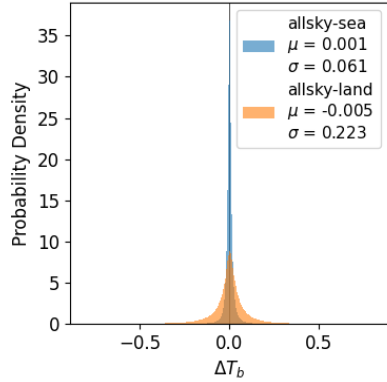


Ch 3 (50.3 GHz)

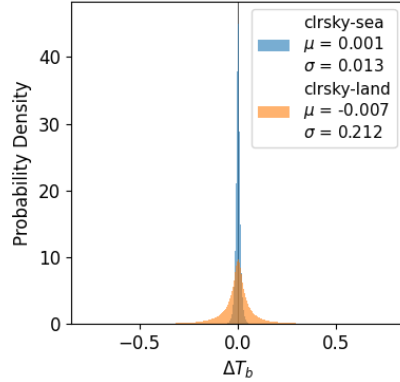




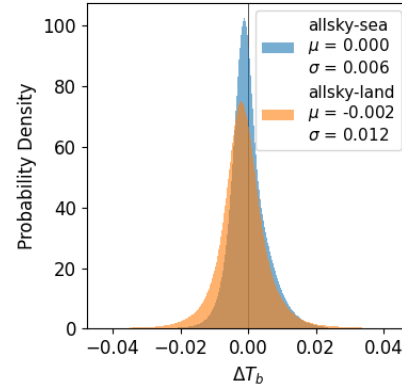
Ch 5 (53.6 GHz)



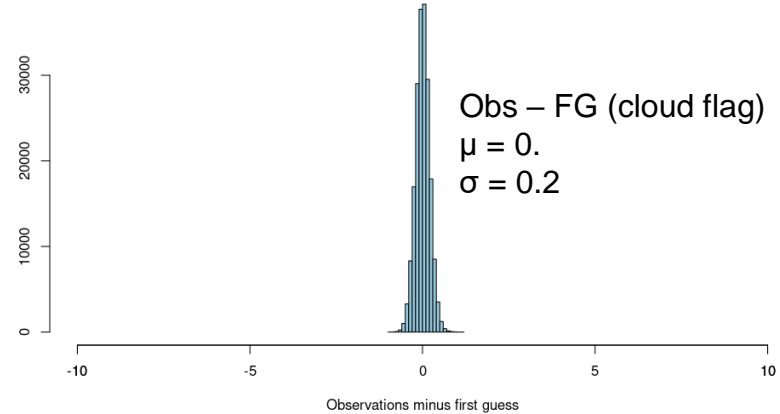
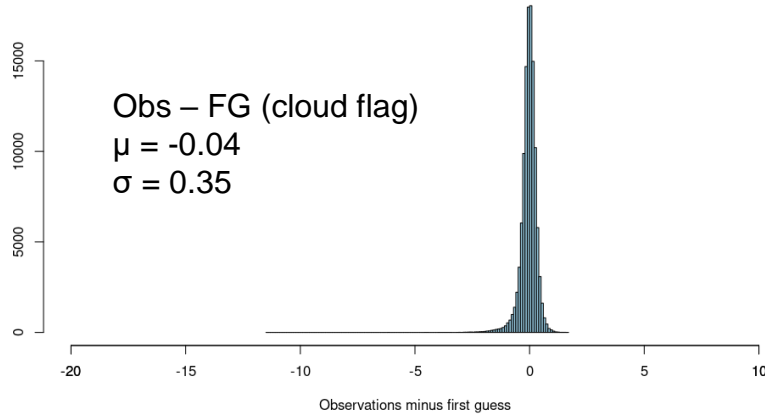
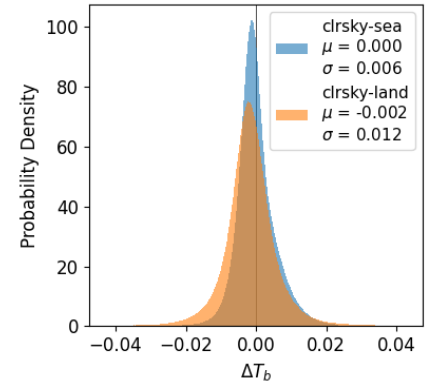
Ch 5 (53.6 GHz)



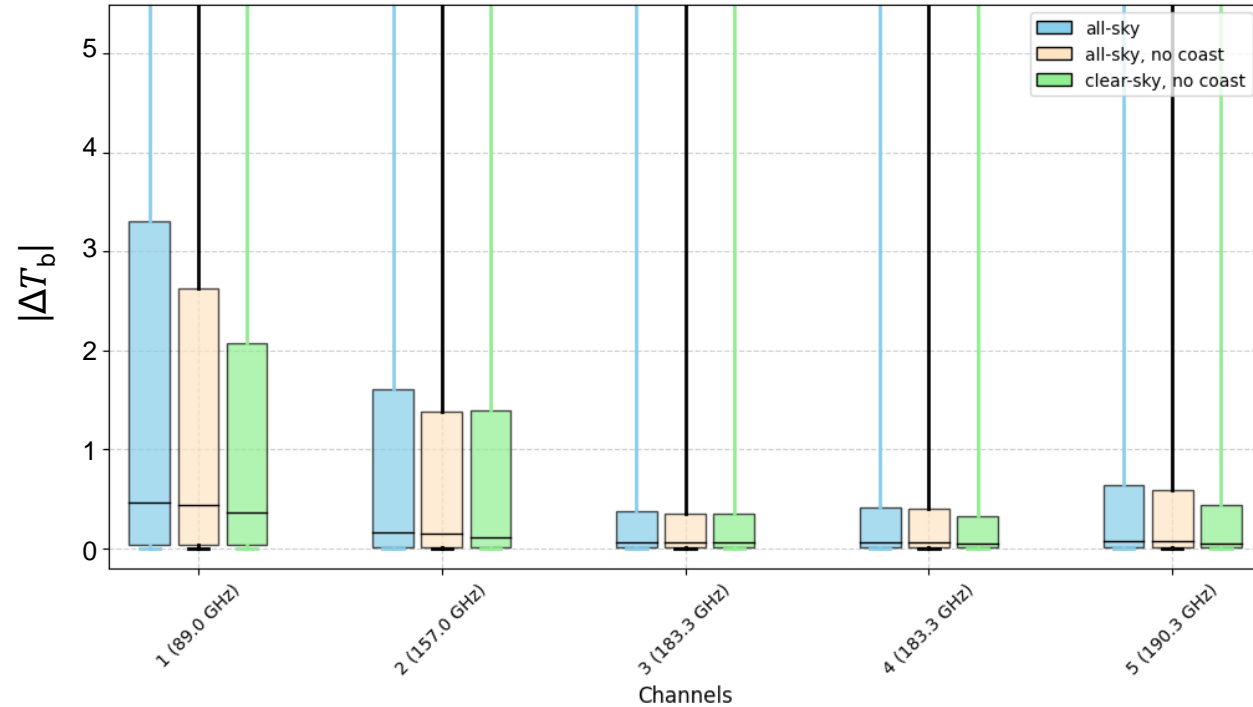
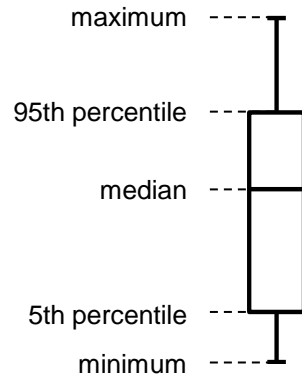
Ch 9 (57.3 GHz)

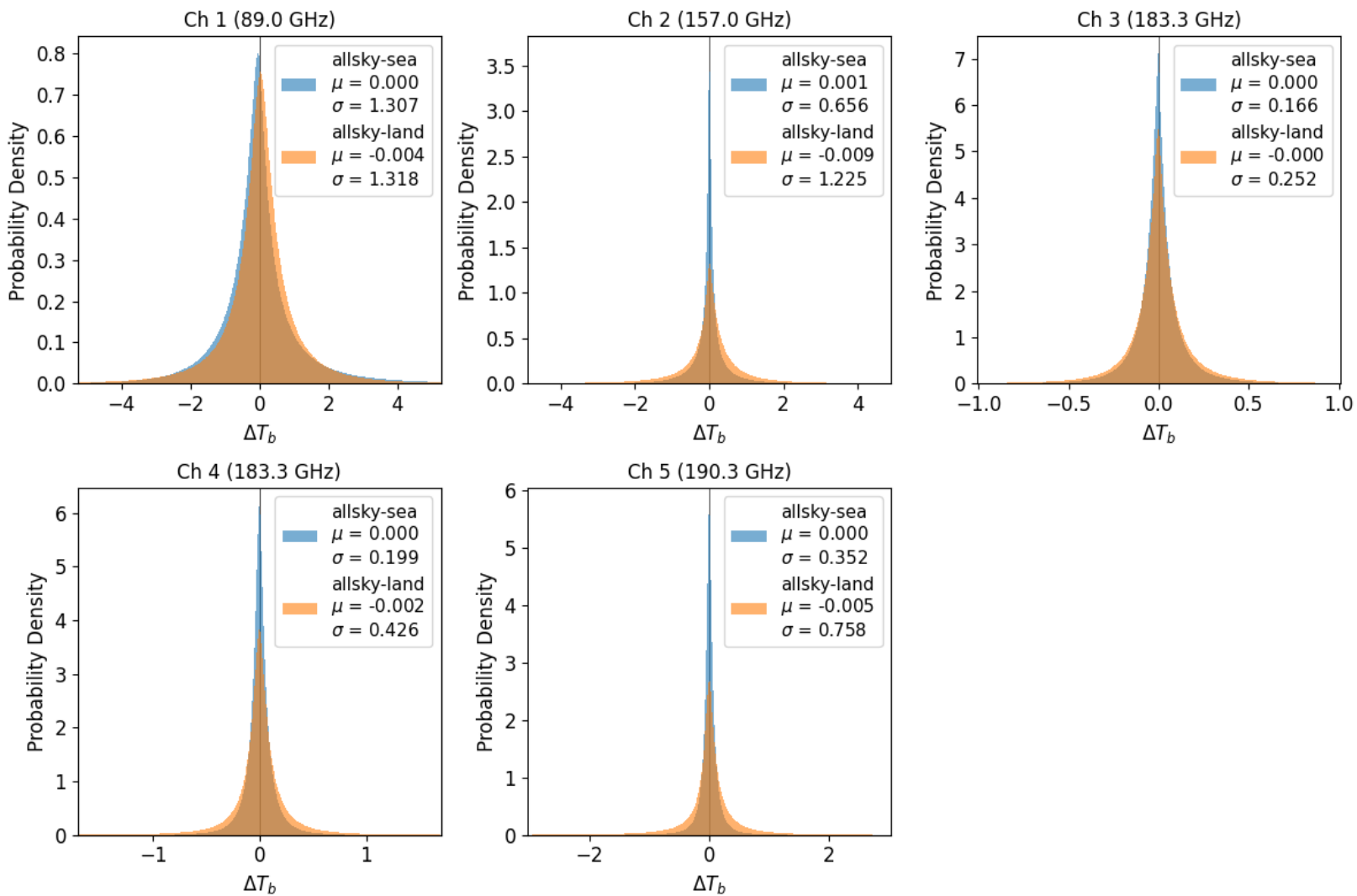


Ch 9 (57.3 GHz)

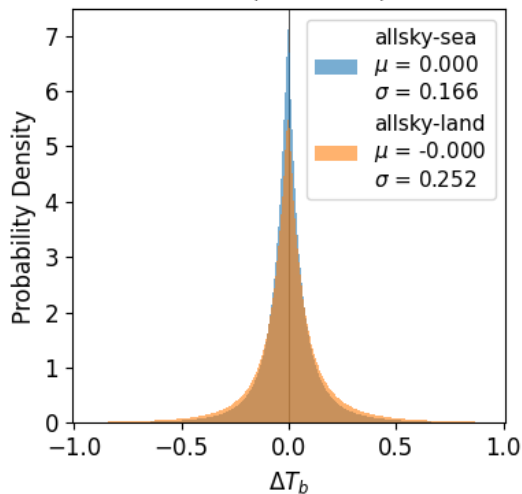


- JJA 2024
- Zenith Angle = 53°

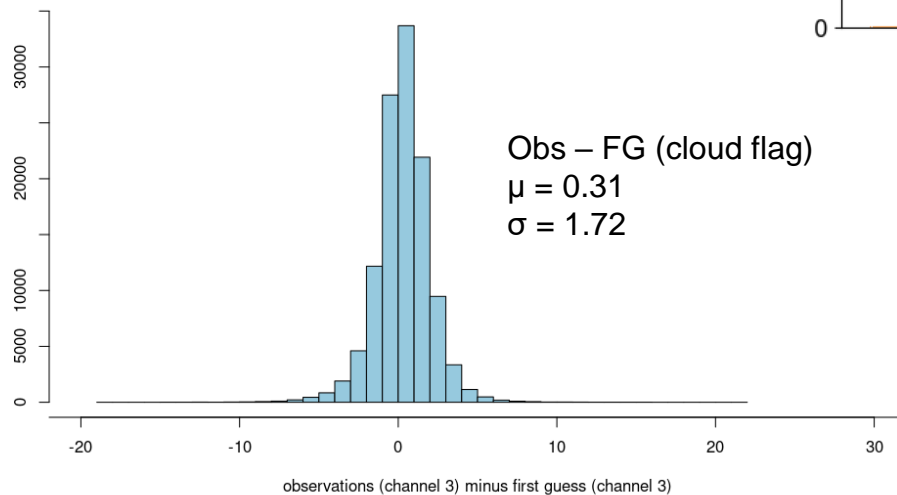
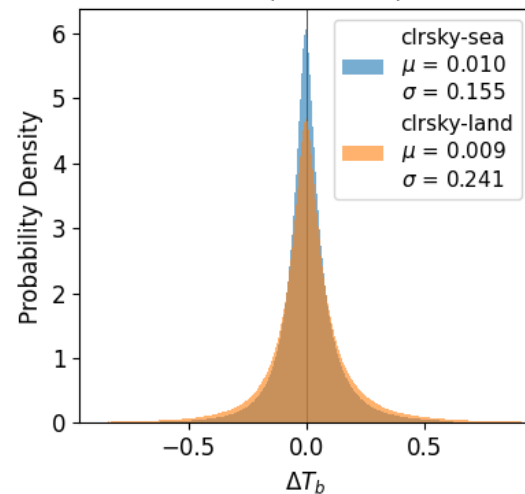




Ch 3 (183.3 GHz)

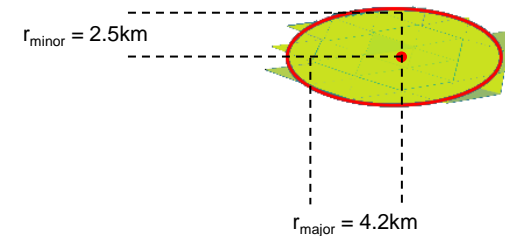
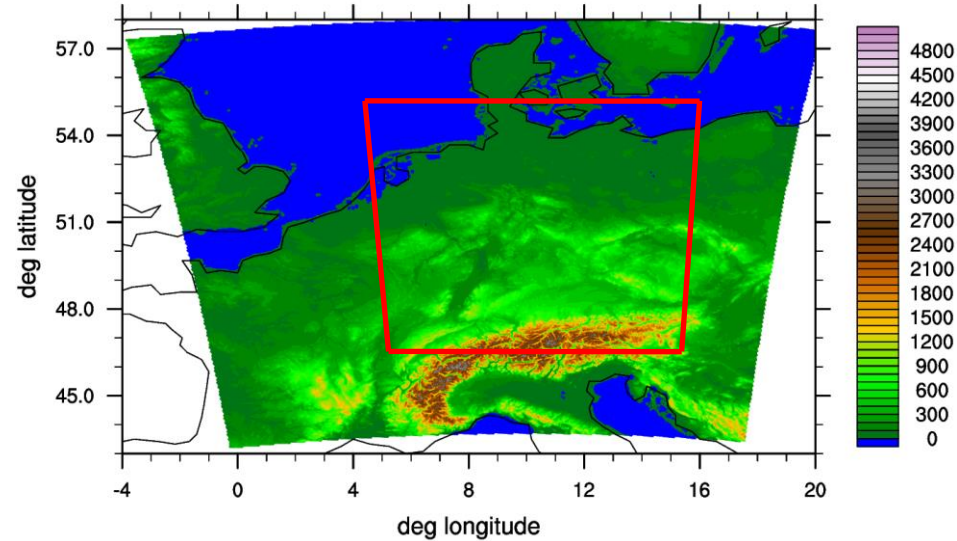


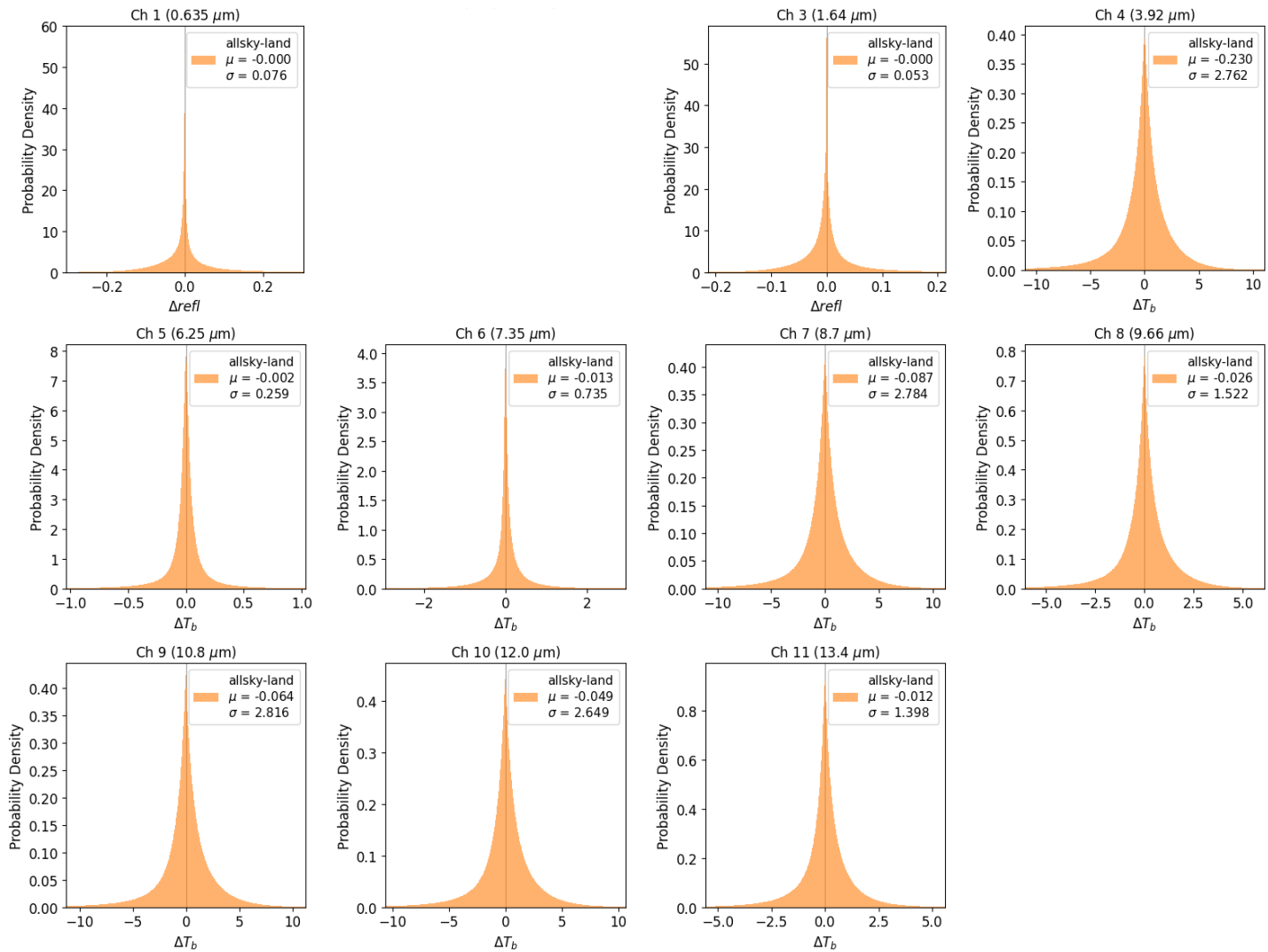
Ch 3 (183.3 GHz)



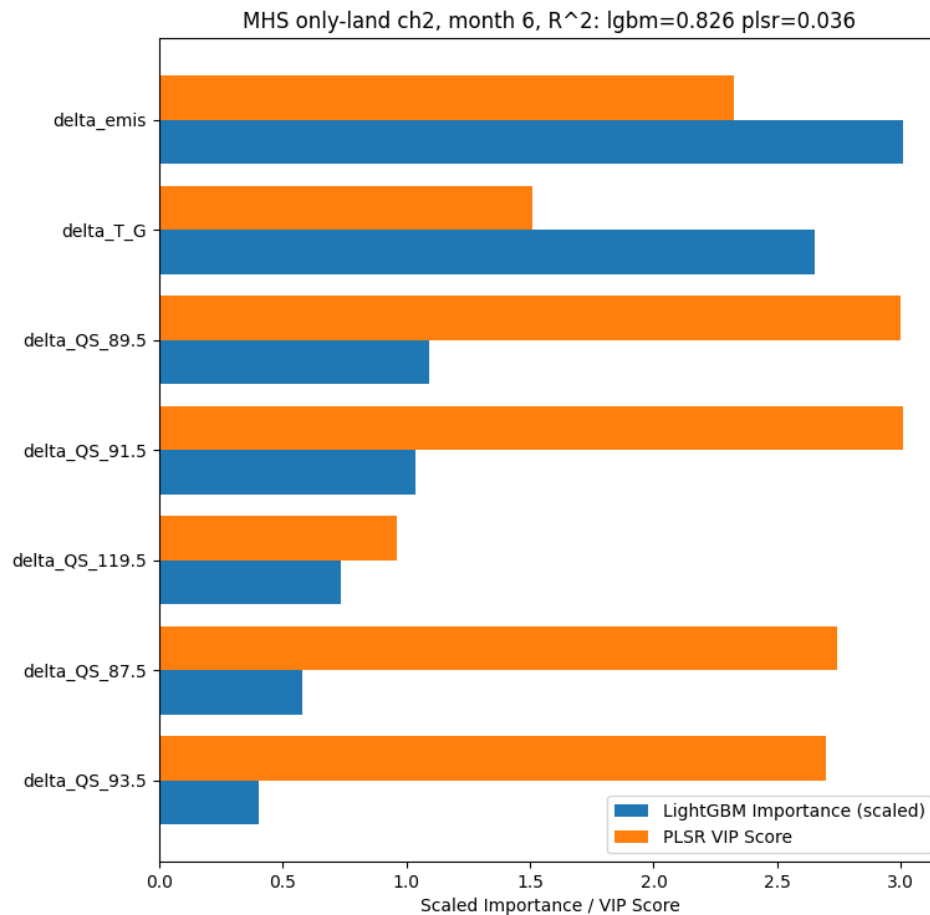
# Results based on...

- **Database** ICON routine forecast  
44 days at 12 UTC over 2025  
Regional data on 500 m grid (Germany)
- **Instrument** SEVIRI  
zenith angle = 53°
- $\Delta T_b = T_{b, \text{single-profile}} - T_{b, \text{fov avg}}$
- $\Delta \text{refl} = \text{refl}_{\text{single-profile}} - \text{refl}_{\text{fov avg}}$





- MHS channel 2 over land
- Test with different methods
  - lightGBM
  - Partial Least Square Regression
- Ongoing ...



- Typical **satellite FOVs cover multiple model profiles**
  - Only single profiles are used for operational DA
- **Variance of emissivity** has large influence on  $\Delta T_b$  in window channels
  - Coasts, sea-ice edge
- **Negligible Differences** for AMSU-A temperature sounding channels  
**Differences** for MHS humidity sounding channels
- Investigate multi variant input parameters
- Predict potential bias and representativeness error