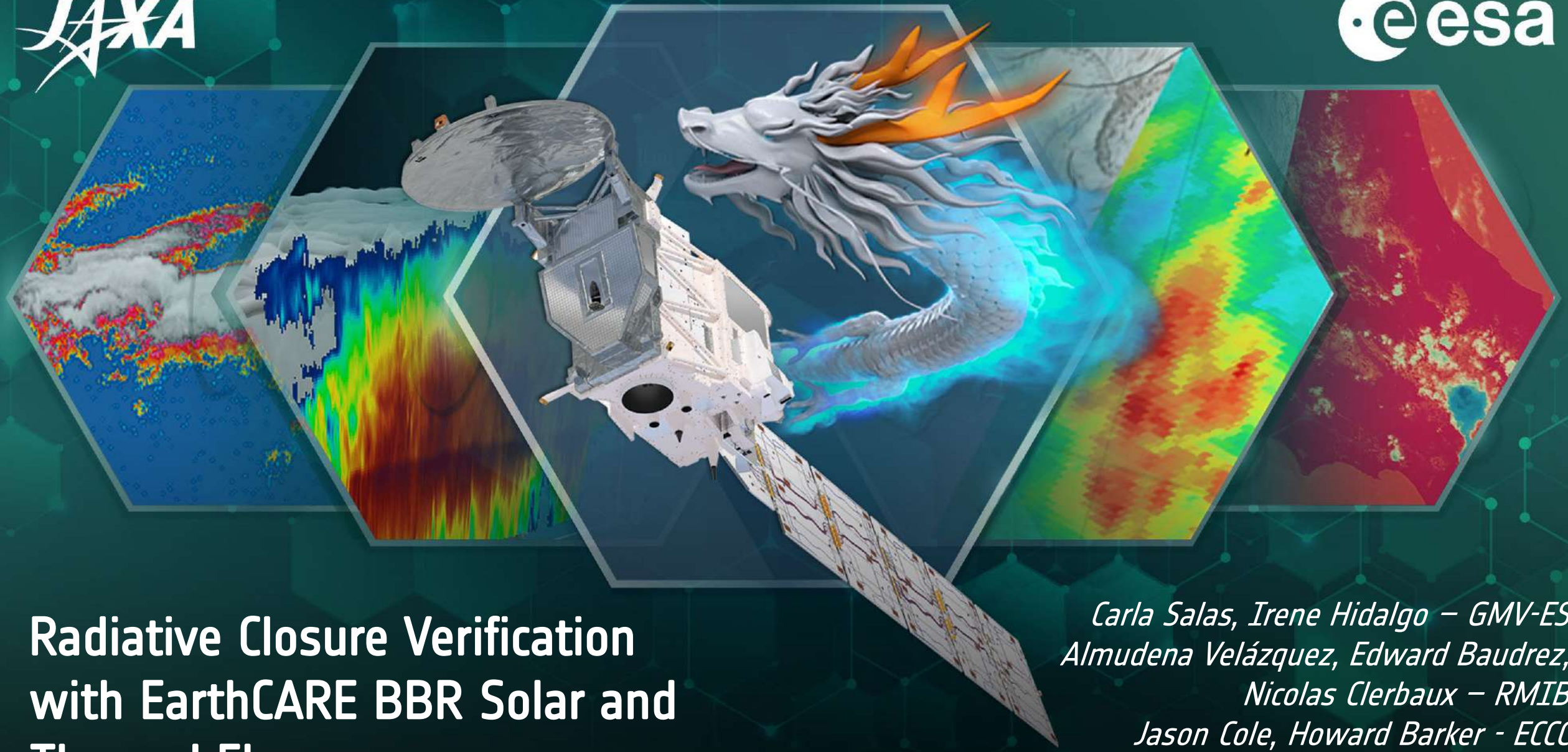


Radiative Closure Verification with EarthCARE BBR Solar and Thermal Fluxes

Carla Salas, Irene Hidalgo – GMV-ES
Almudena Velázquez, Edward Baudrez, Nicolas Clerbaux – RMIB
Jason Cole, Howard Barker - ECCC

2nd ESA-JAXA EarthCARE In-Orbit Validation Workshop
17 – 20 March 2025 | ESA-ESRIN | Frascati (Rome), Italy

Environment and Climate Change Canada

Radiative closure

Evaluation on how well the retrieved atmospheric properties reproduce the observed radiative measurements

The radiance requirement aims to achieve closure by using EarthCARE's cloud and aerosol properties, along with additional data, to simulate observed radiances as a final validation of the retrieved properties

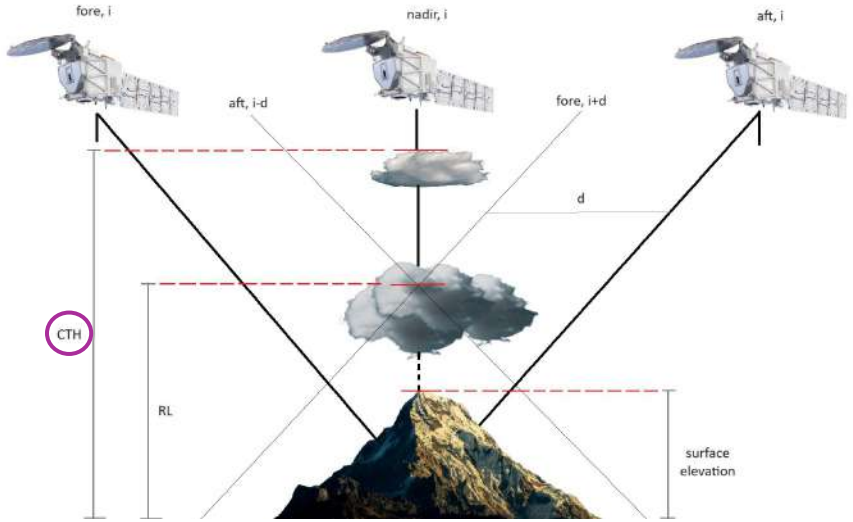
Radiative transfer results contained in the ACMB-DF product for the radiative closure assessment

Barker, H. W., Cole, J. N. S., Villefranque, N., Qu, Z., Velázquez Blázquez, A., Domenech, C., Mason, S. L., and Hogan, R. J.: Radiative Closure Assessment of Retrieved Cloud and Aerosol Properties for the EarthCARE Mission: The ACMB-DF Product, EGUsphere [preprint], https://doi.org/10.5194/egusphere-2024-1651, 2024

Assessment of the radiative closure for each type of scene (surface type and cloud coverage)
14-16 Jan 2025 (orbits: 3579-3628)

Introduction

BMA-FLX



Solar/Thermal unfiltered radiances for each view, L_j

ANN*
ADM**-based

+

Illumination and viewing geometry BM-RAD
Surface type BM-RAD, X-MET
Cloud cover M-CM

Anisotropic factor for each view, R_j

Solar/Thermal top-of-atmosphere flux for each BBR view, F_j

Co-registration at the reference level (different for SW and LW)

+

Cloud top height M-COP, A-CTH
Cloud optical thickness M-COP

Solar/Thermal combined top-of-atmosphere flux obtained from the weighted average of the retrieved radiative fluxes for each BBR telescope

* Artificial Neuronal Network
** Angular Distribution Model

ACMB-DF

From ACM-RT…

1D broadband flux profiles

- Based on the **Independent Column Approximation (ICA)**, which assumes that radiation is not transferred horizontally to adjacent columns

ACMB-DF →

- Comparison to BMA-FLX TOA** fluxes

3D solutions of the RT* equation

- Used to study the 4d interaction of radiation with the three phases of water
- Monte Carlo RT algorithm

ACMB-DF →

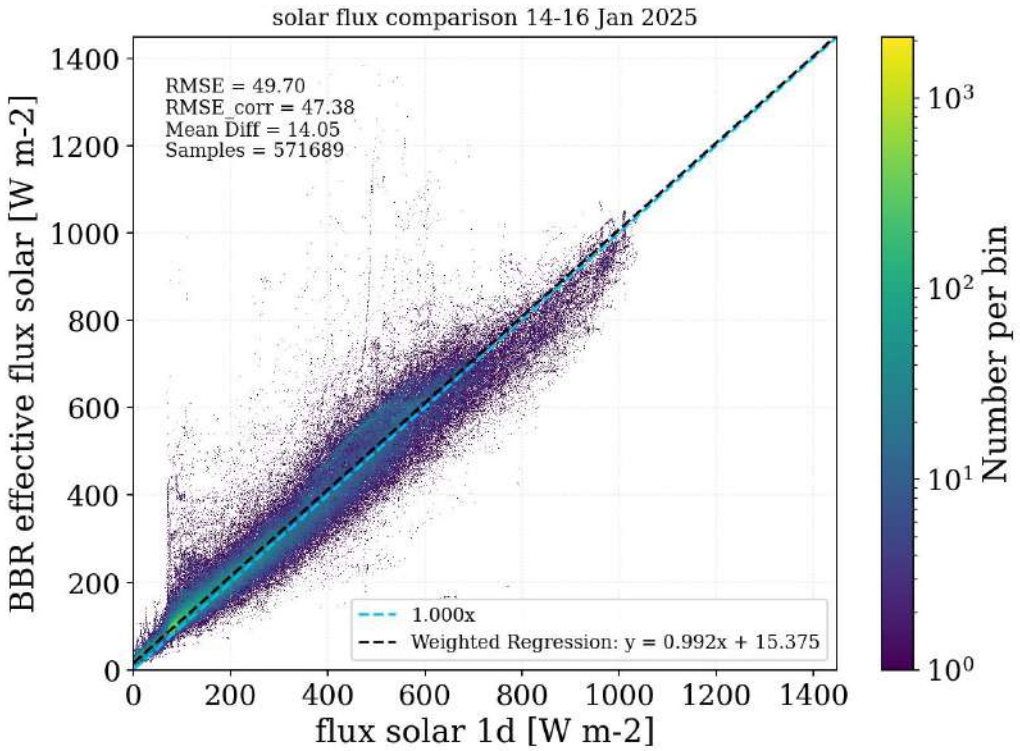
- Radiance-to-flux conversion using the same methodology as BMA-FLX SW alg.
- Comparison to BMA-FLX TOA fluxes

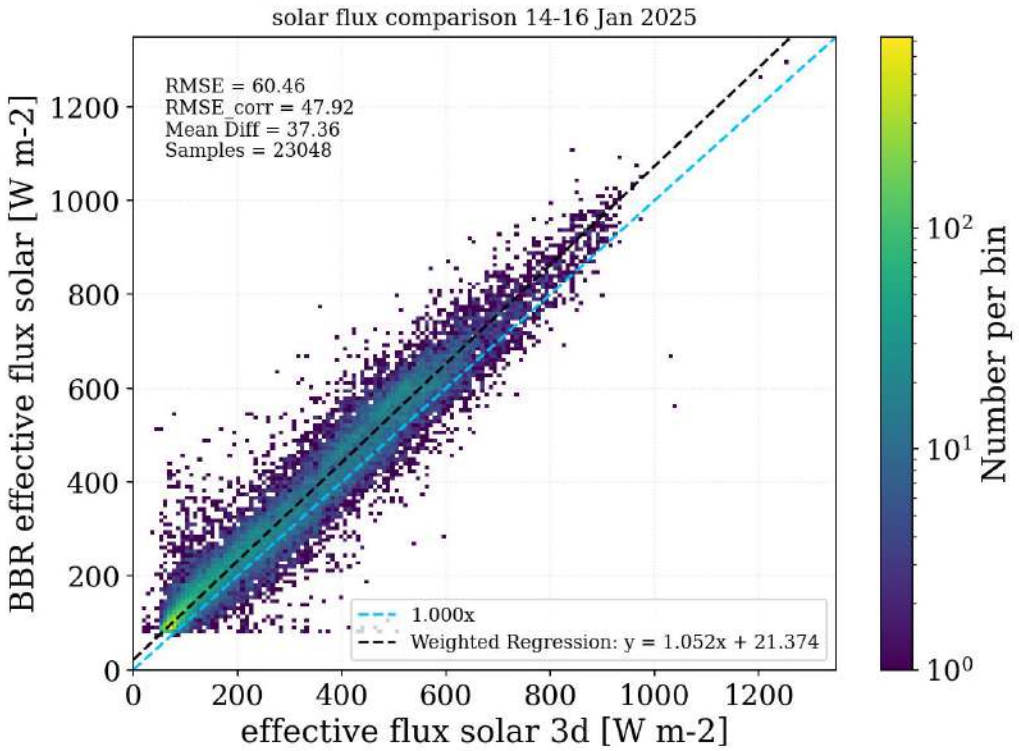
* Radiative Transfer

** Top-of-atmosphere

Solar combined flux comparison

BMA-FLX solar TOA fluxes against 1d/3d modelled fluxes from ACMB-DF

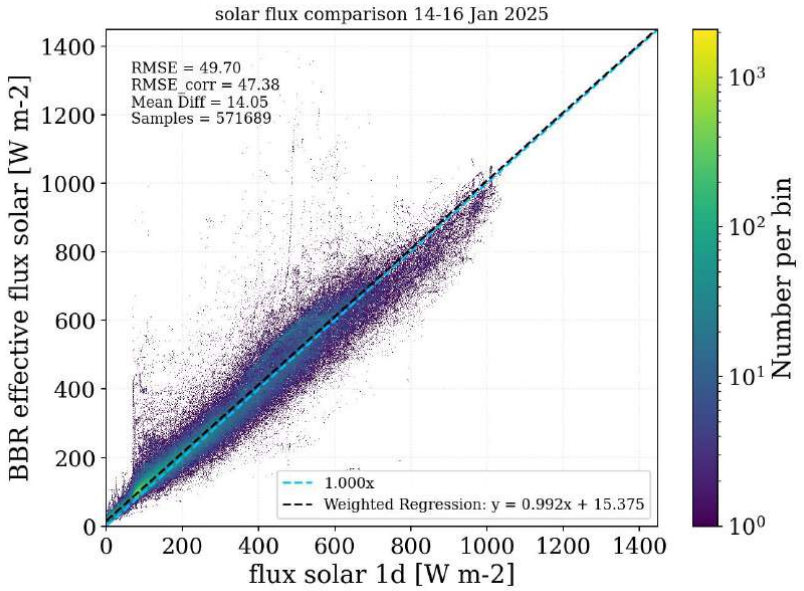




Good agreement but still needs improvement

Solar combined flux comparison

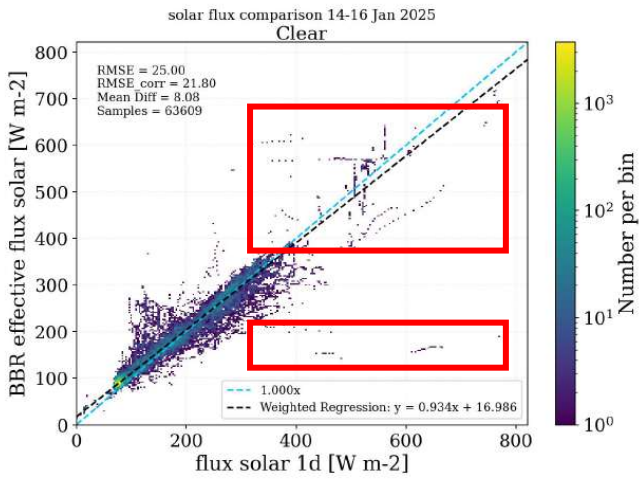
Cloud cover
1d calculations



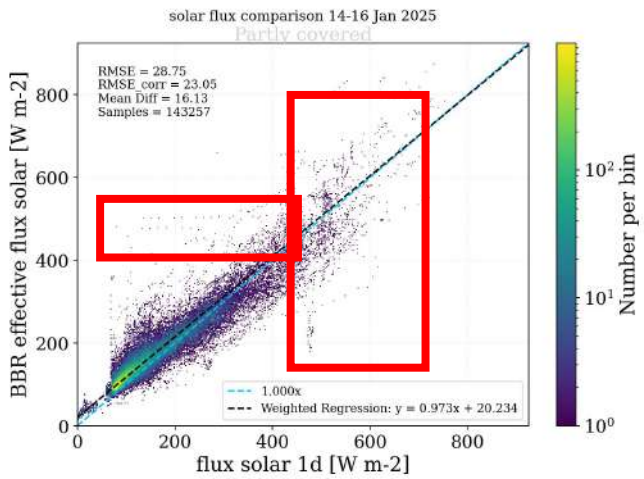
Issues

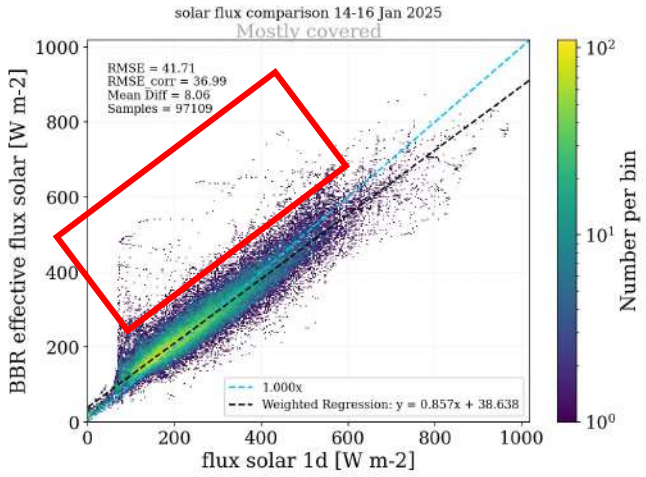
- Arrow-shaped pattern in clear sky
- Horizontal pattern in clear sky
- Spikes in overcast cloud conditions

CF* < 0.1

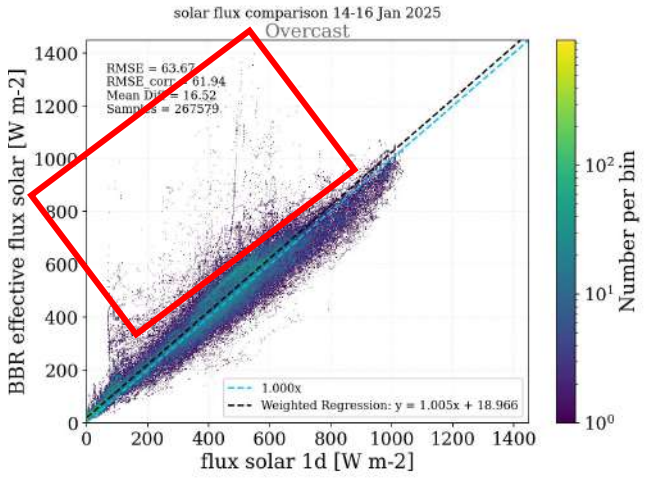


0.1 <= CF <= 50.0





50.0 < CF < 99.0

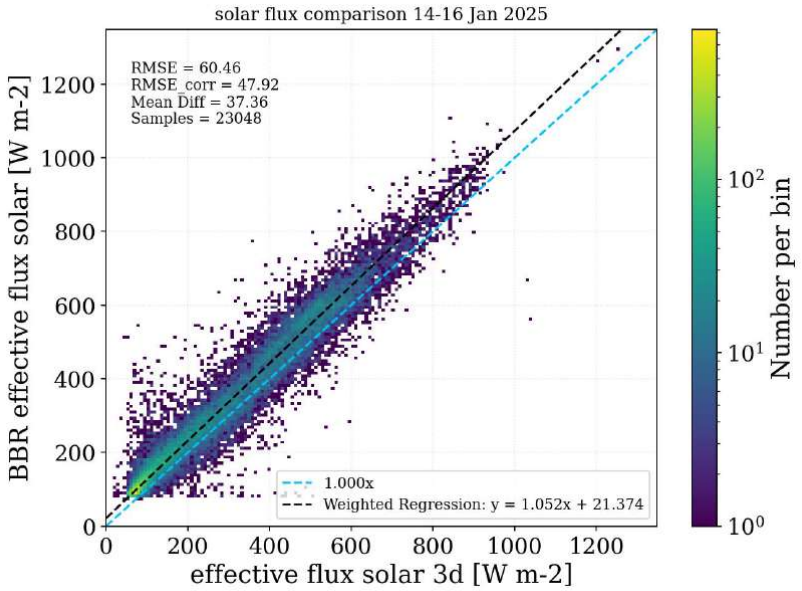


CF >= 99.0

* Cloud Fraction

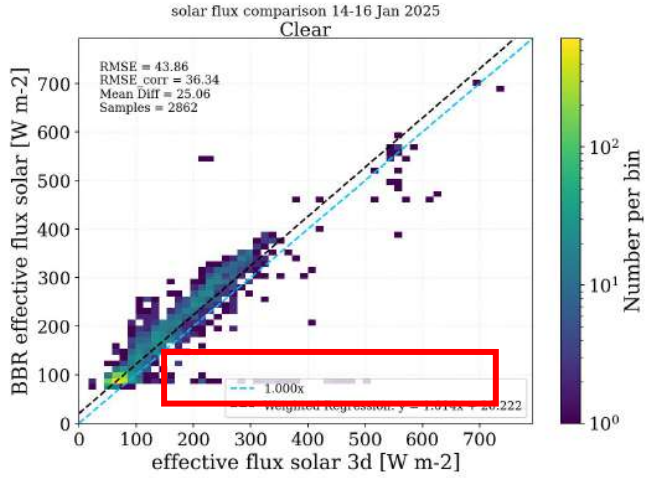
Solar combined flux comparison

Cloud cover
3d calculations

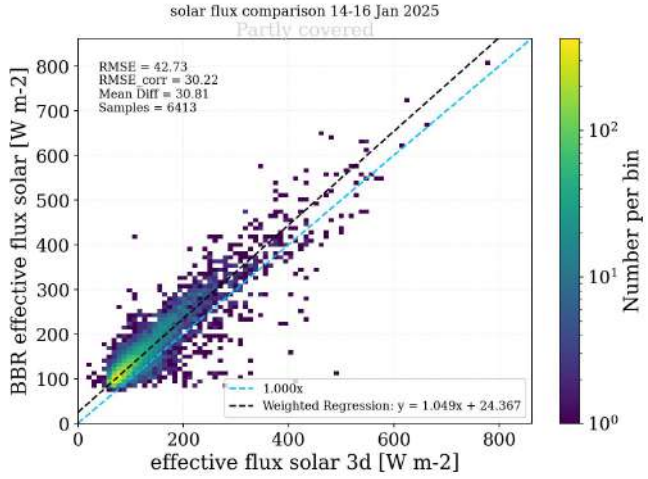


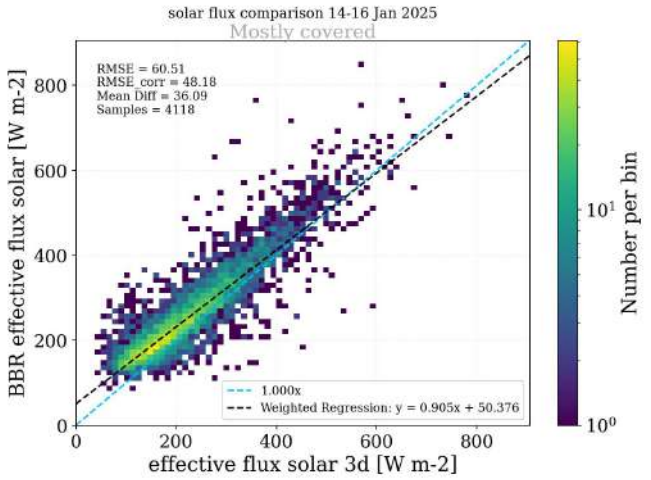
Issue • Horizontal pattern in clear sky

CF* < 0.1

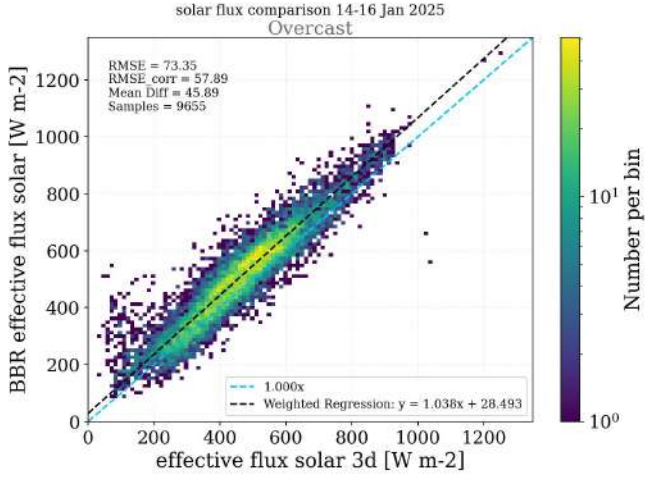


0.1 <= CF <= 50.0





50.0 < CF < 99.0



CF >= 99.0

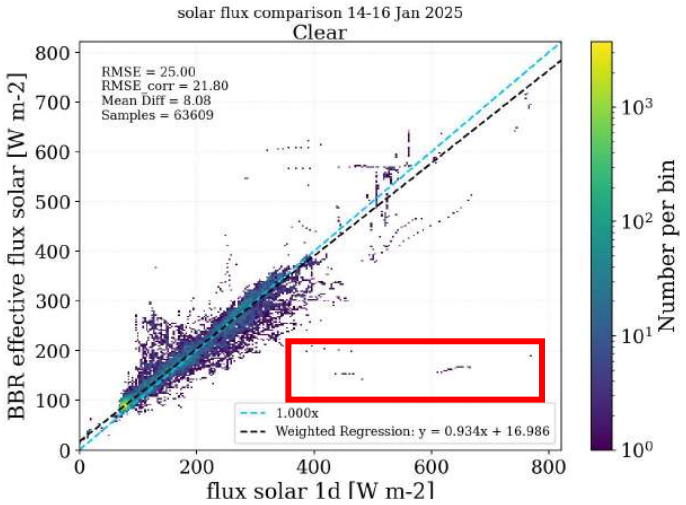
* Cloud Fraction

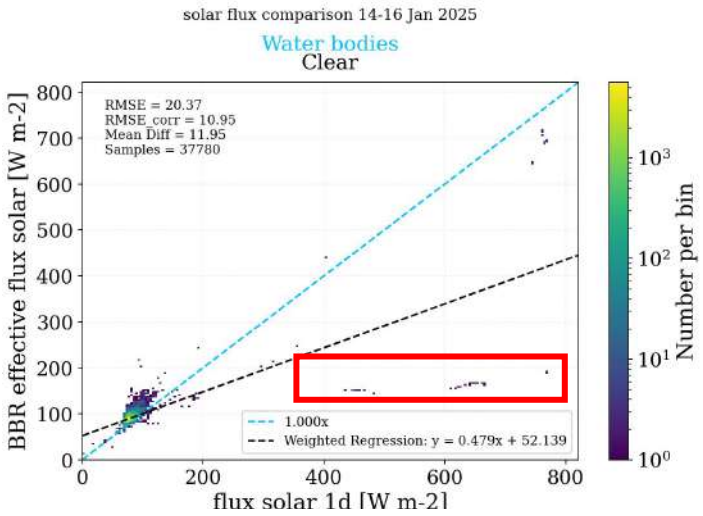
Current issues – ocean

Solar fluxes over ocean in clear sky

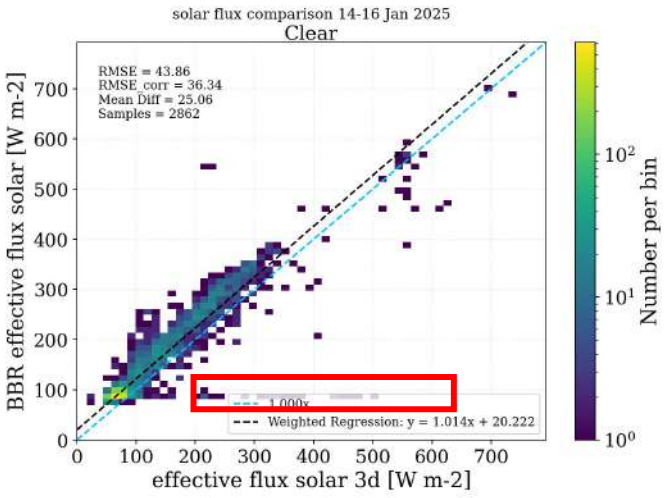
CF* < 0.1

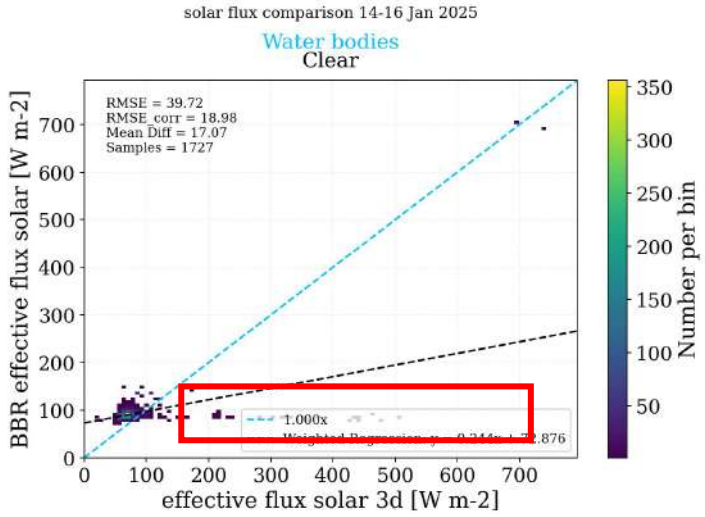
1d





3d





The horizontal pattern is caused by clear-sky scenes over ocean

Frames causing the horizontal pattern:
03601F, 03615G, 03622F, 03623F

Found selecting
- BBR effective flux solar < 200 W m-2
- Flux solar 1d > 200 W m-2

Frames causing the horizontal pattern:
03579G, 03580F, 03586F, 03588G, 03595G, 03597E, 03599F, 03606G, 03610G, 03615G, 03619G, 03621E, 03622G

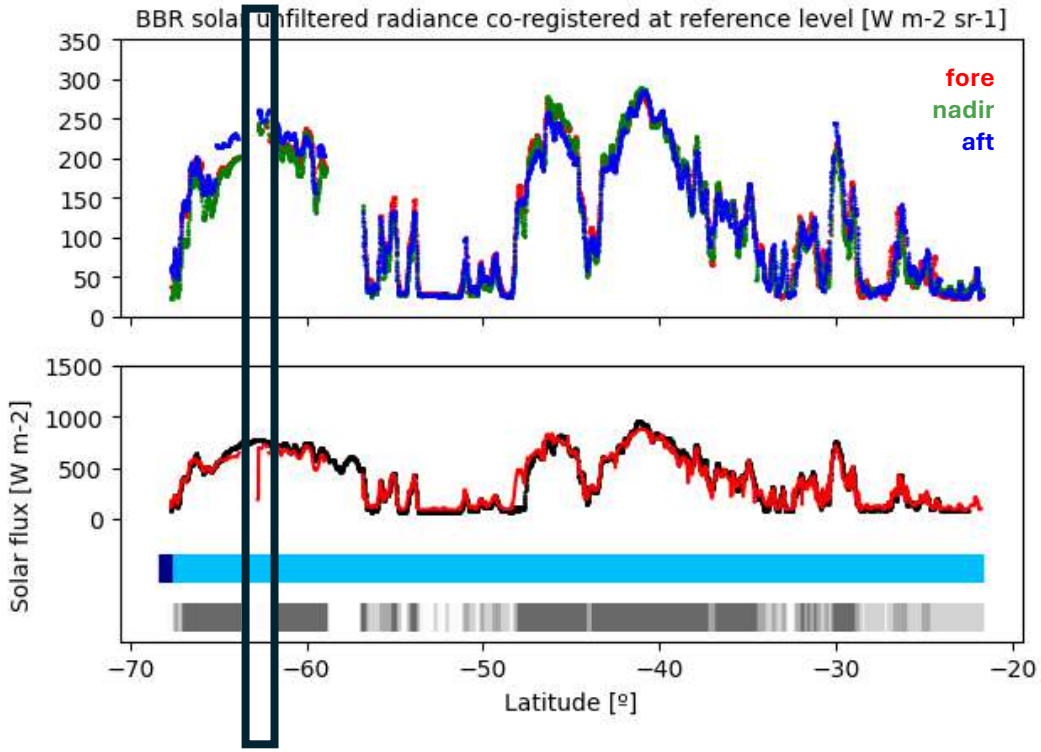
Found selecting
- BBR effective flux solar < 100 W m-2
- Effective flux solar 3d > 110 W m-2

* Cloud Fraction

Current issues – ocean

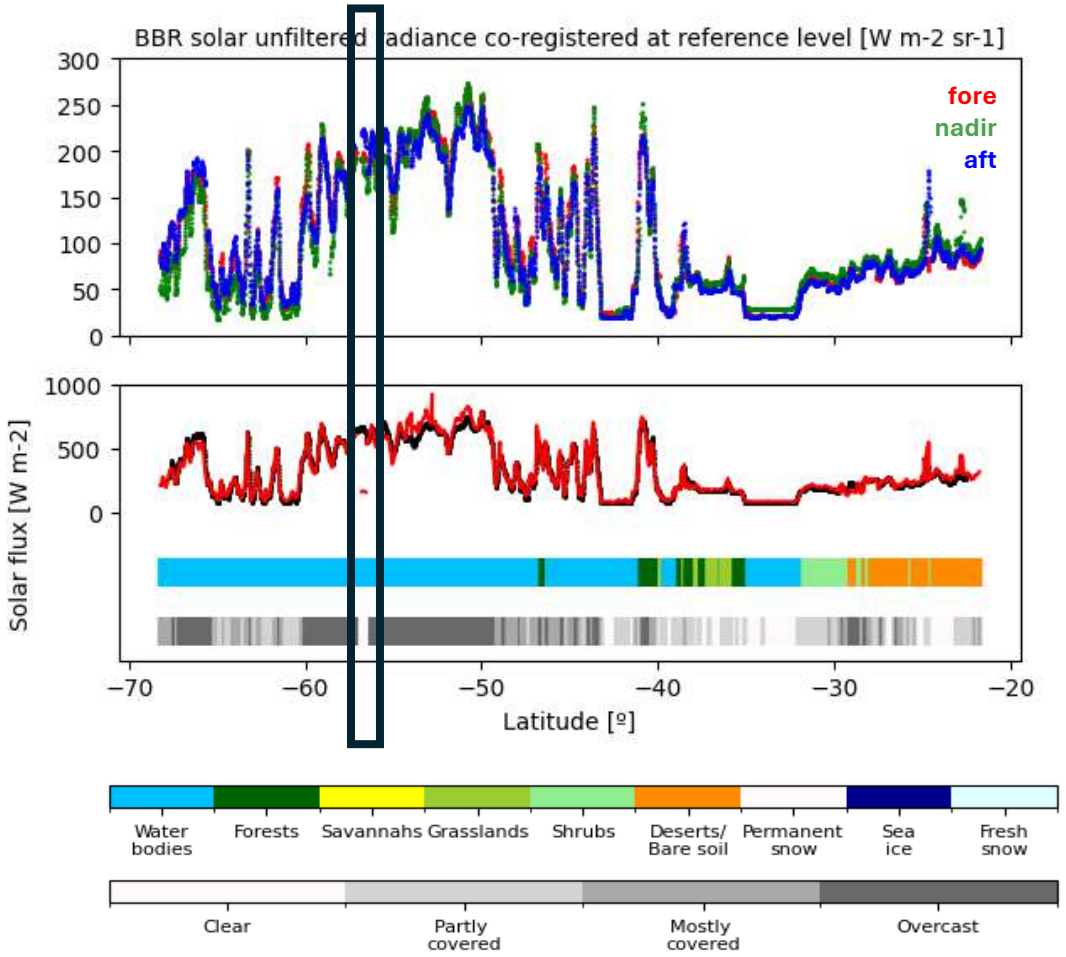
Solar fluxes over ocean in clear sky – 1d calculations

Frame: 03601F



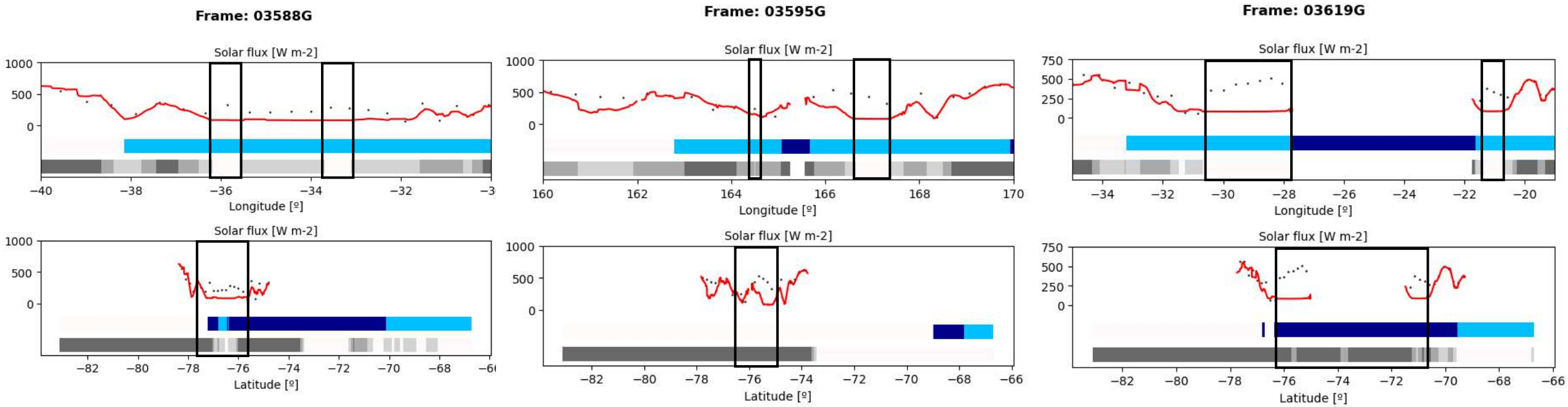
- BMA-FLX solar combined TOA flux
- ACMB-DF flux solar 1d

Frame: 03622F

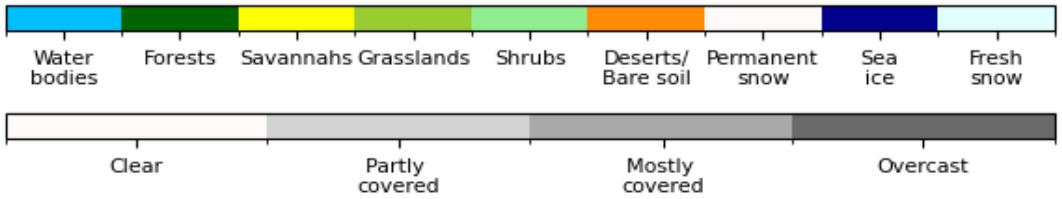


Current issues – ocean

Solar fluxes over ocean in clear sky – 3d calculations



- BMA-FLX solar combined TOA flux
- ACMB-DF effective flux solar 3d



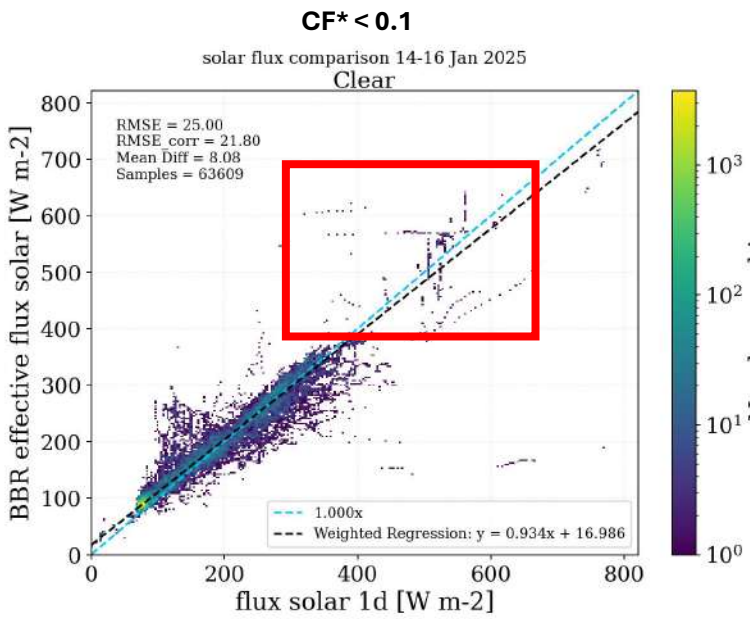
Surface classification and cloud cover

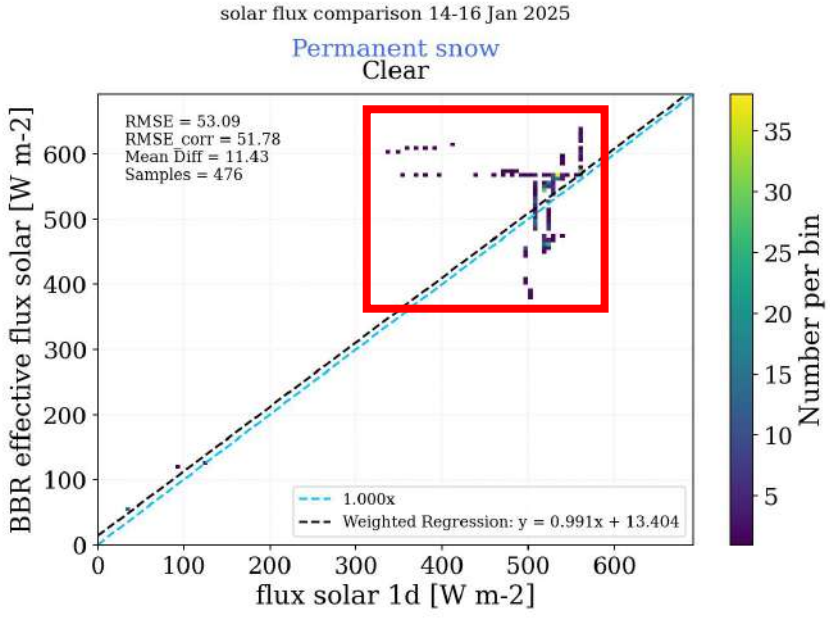
Current issues – permanent snow

Solar fluxes over permanent snow – 1d calculations

SW

CF* < 0.1





CF < 0.1

Accounting for the effects of sastrugi in the CERES clear-sky Antarctic shortwave angular distribution models

J. Corbett[1] and W. Su[2]

[1]Science Systems and Applications, Inc., NASA Langley Research Center, Mail Stop 420, Hampton, Virginia 23681-2199, USA

[2]NASA Langley Research Center, Mail Stop 420, Hampton, Virginia 23681-2199, USA

https://doi.org/10.5194/amt-8-3163-2015

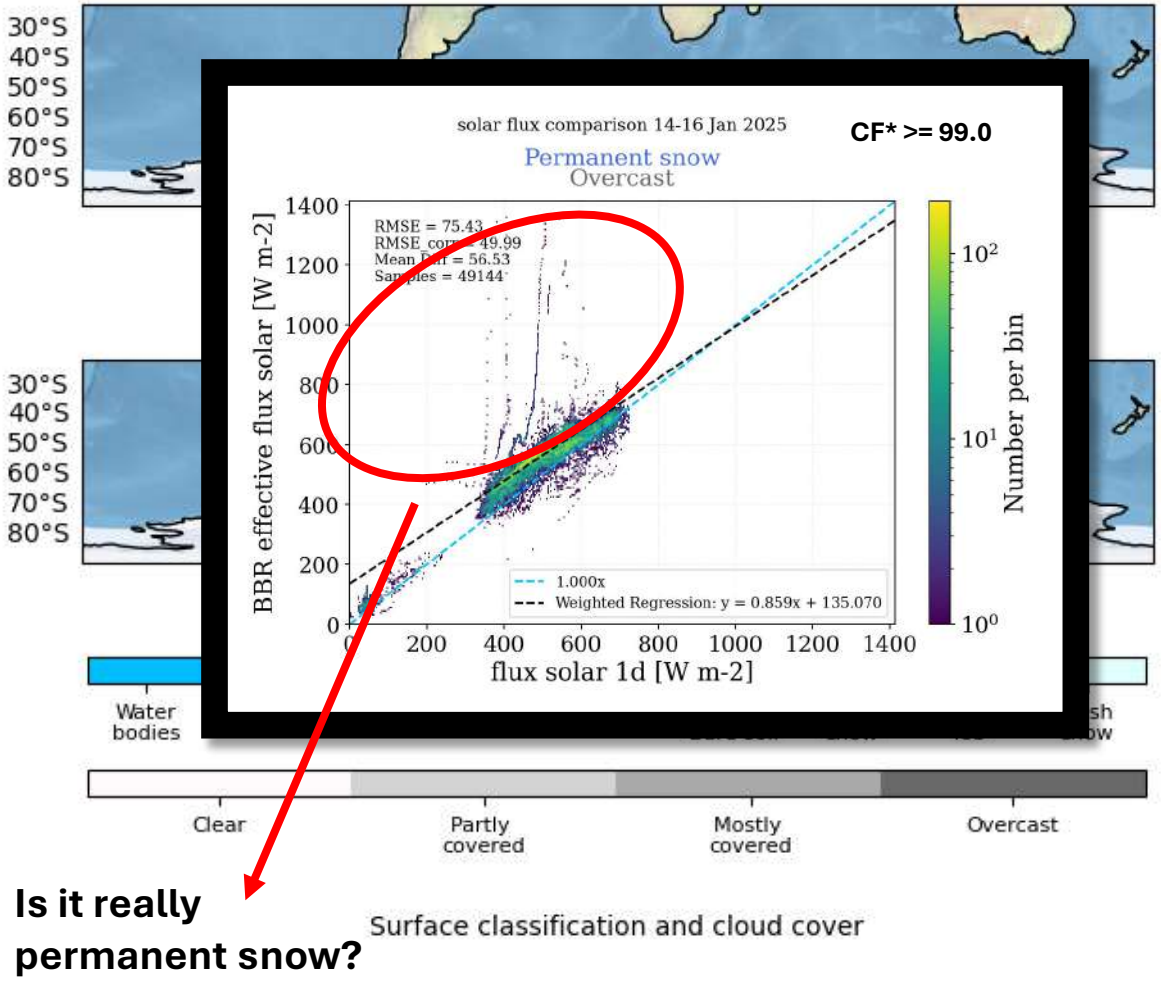
→ CERES data used to train the current ANN is from before the sastrugi effect was considered →

Train new ANN?

* Cloud Fraction

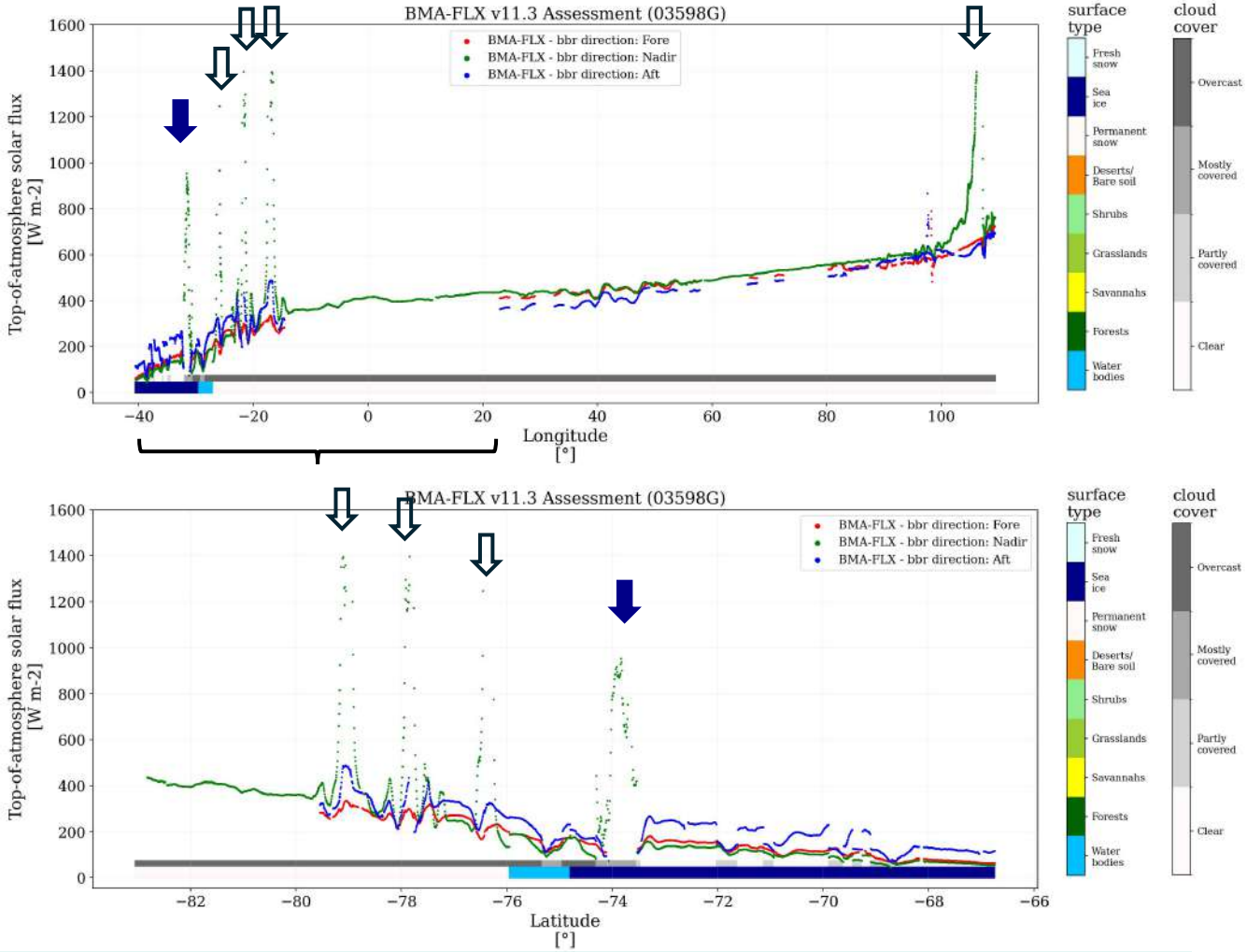
Current issues – permanent snow

Solar fluxes over permanent snow



Is it really permanent snow?

Nadir spikes observed 03598G SW



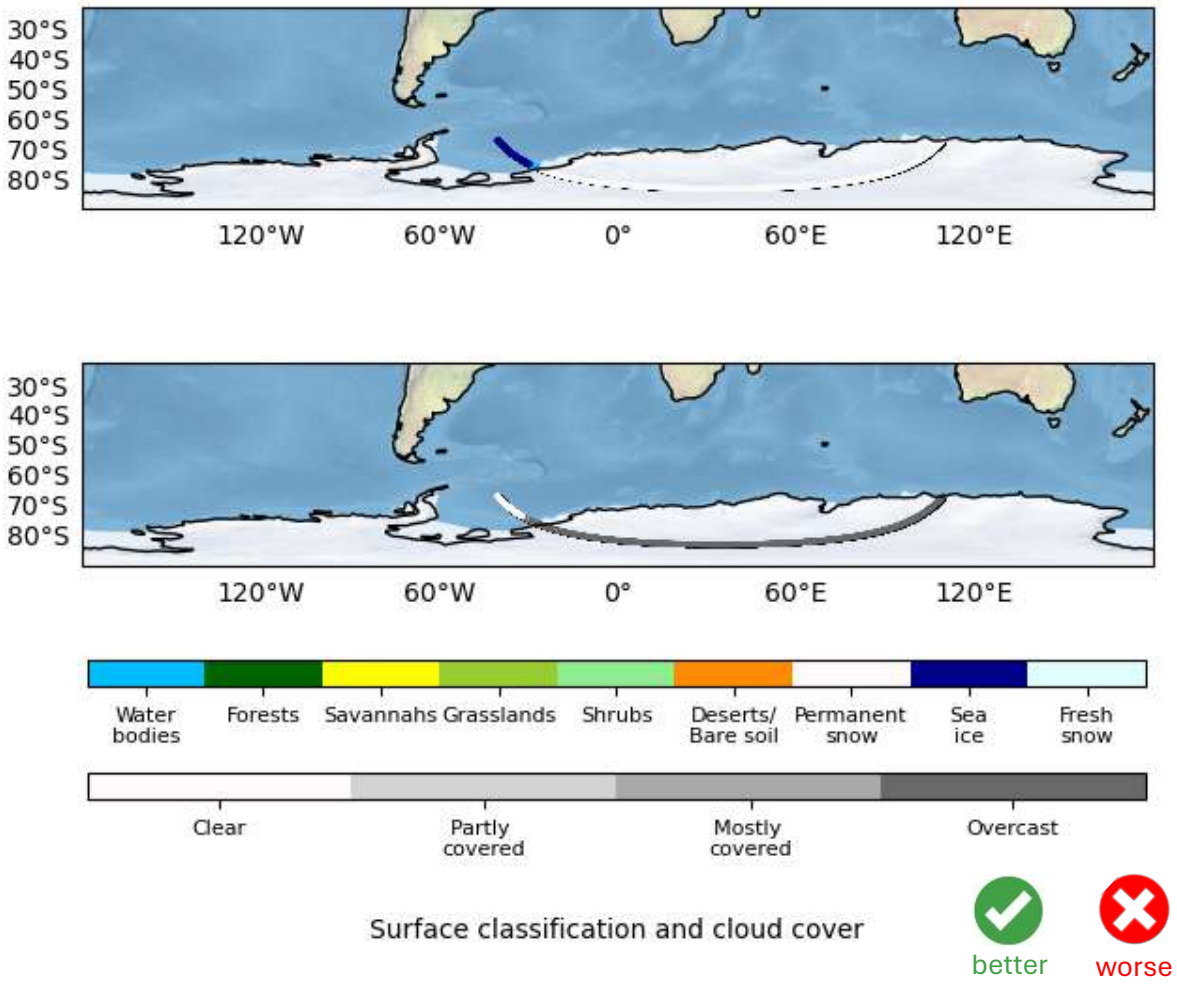
* Cloud Fraction

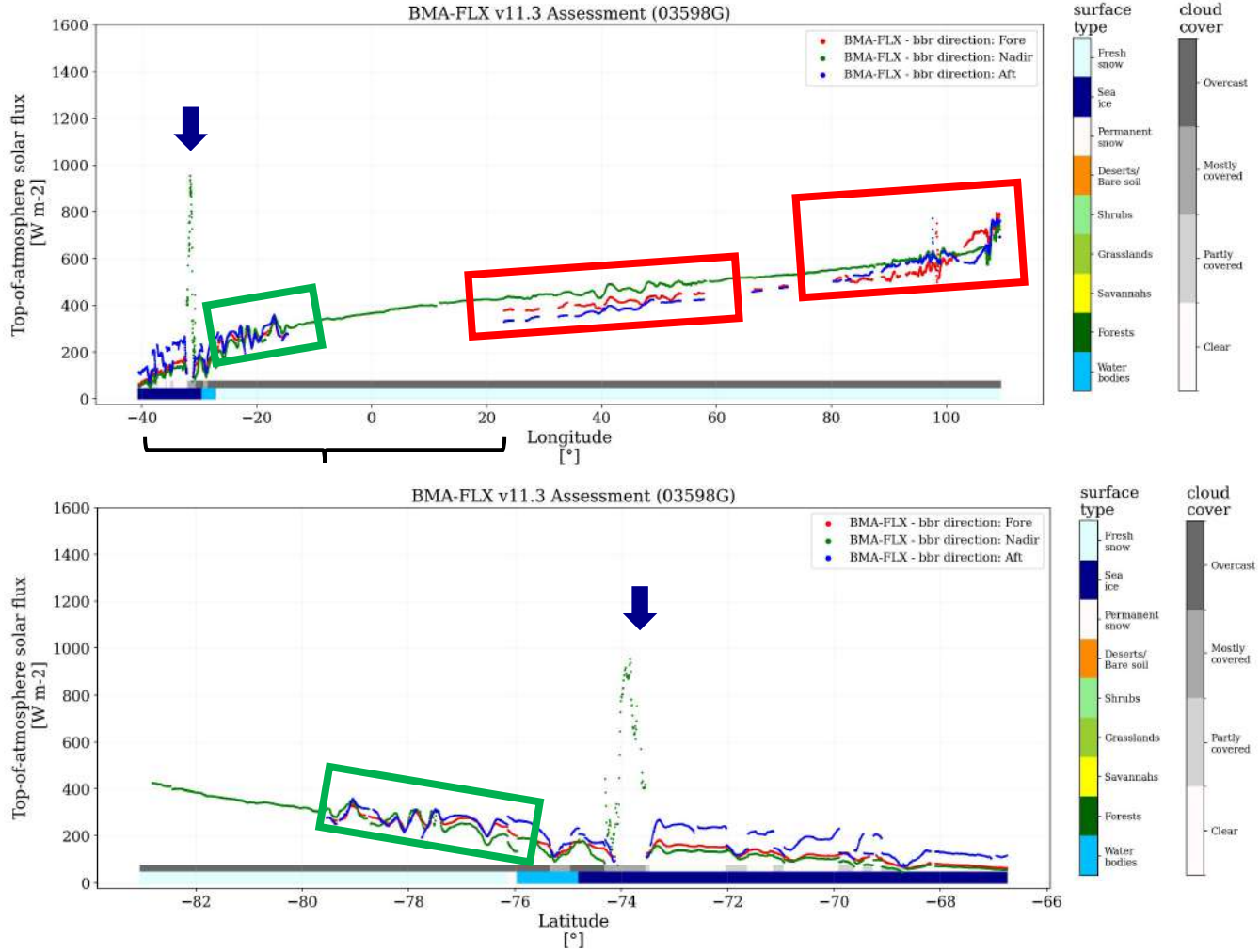
Current issues – permanent snow

Solar fluxes over permanent snow

Nadir spikes disappear when turning **Permanent snow** into **Fresh snow**

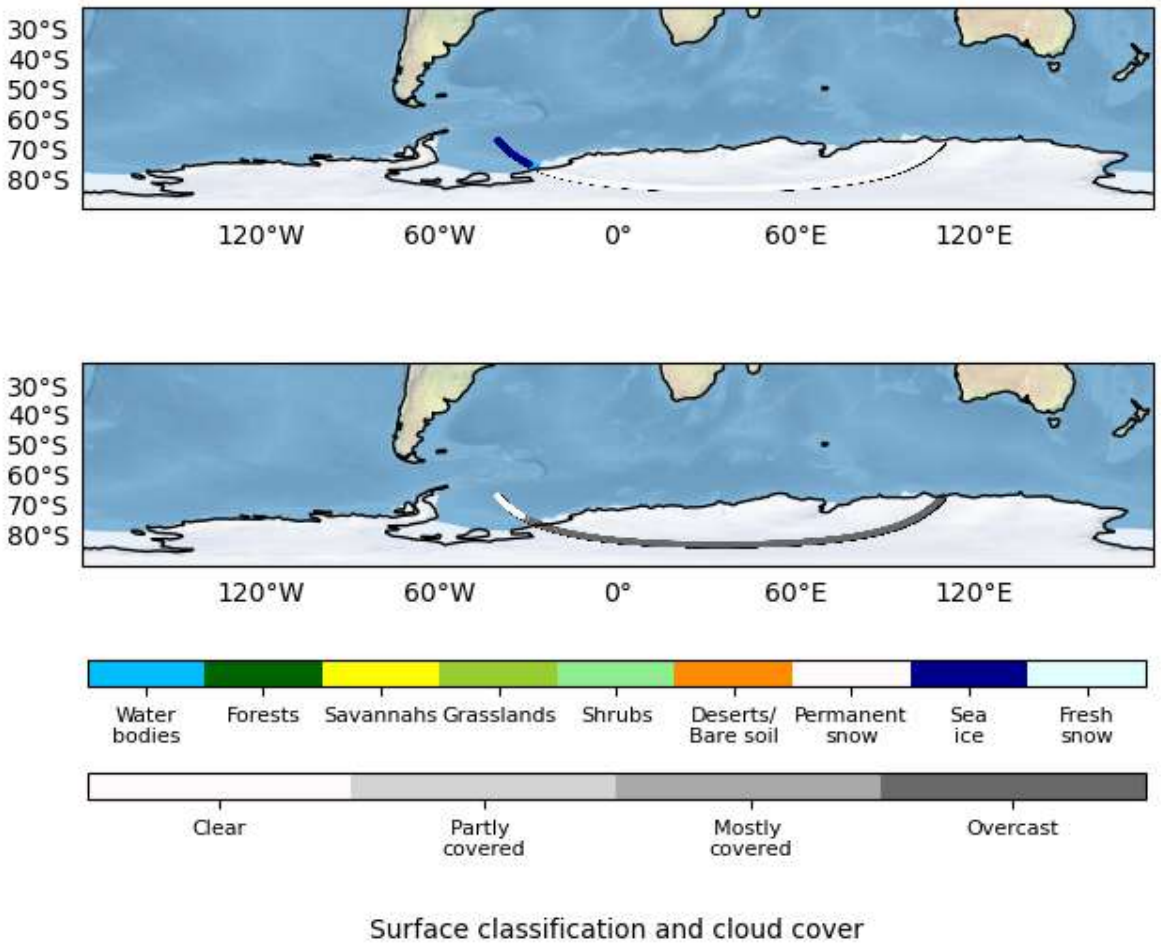
SW





Current issues – sea-ice

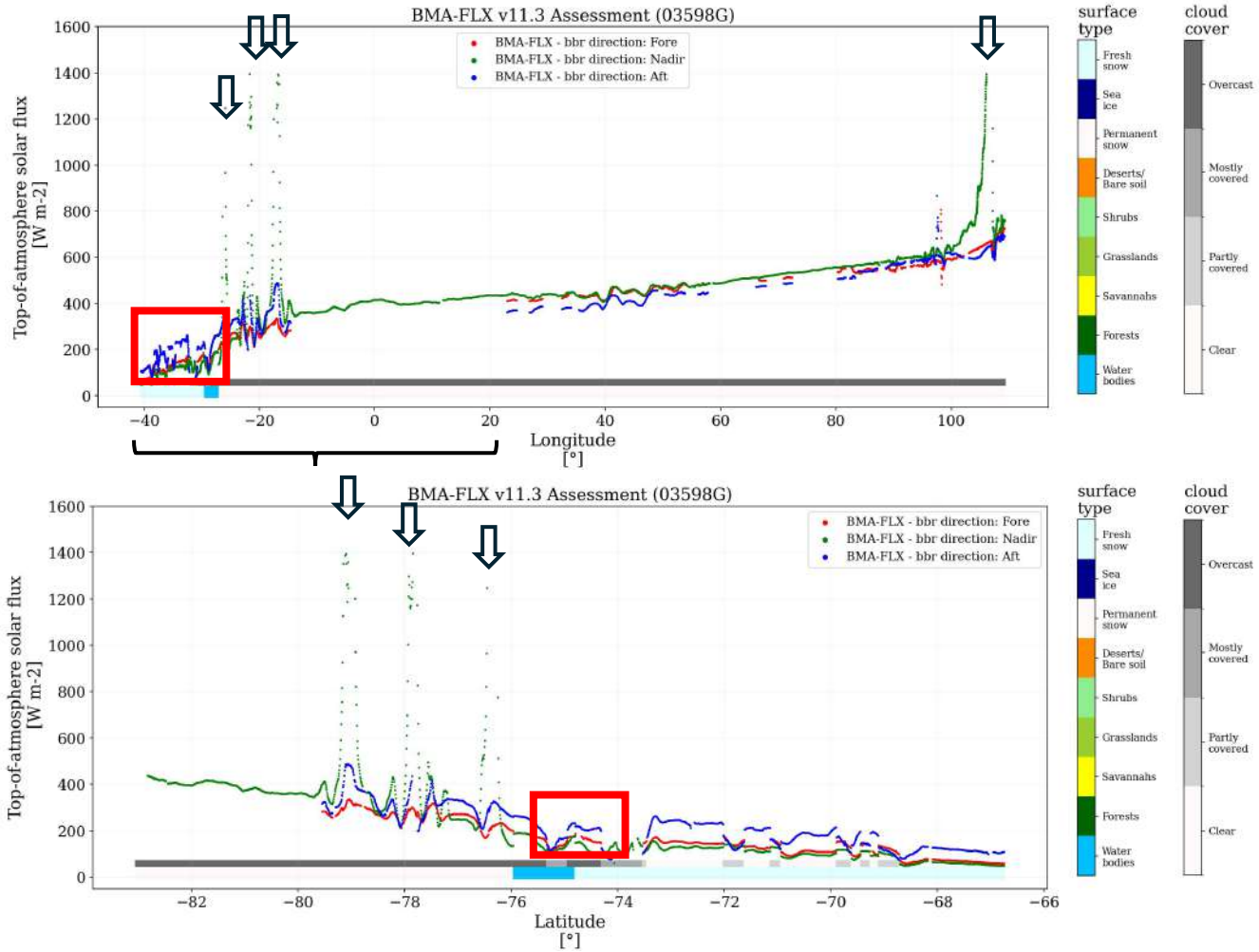
Solar fluxes over sea-ice



worse

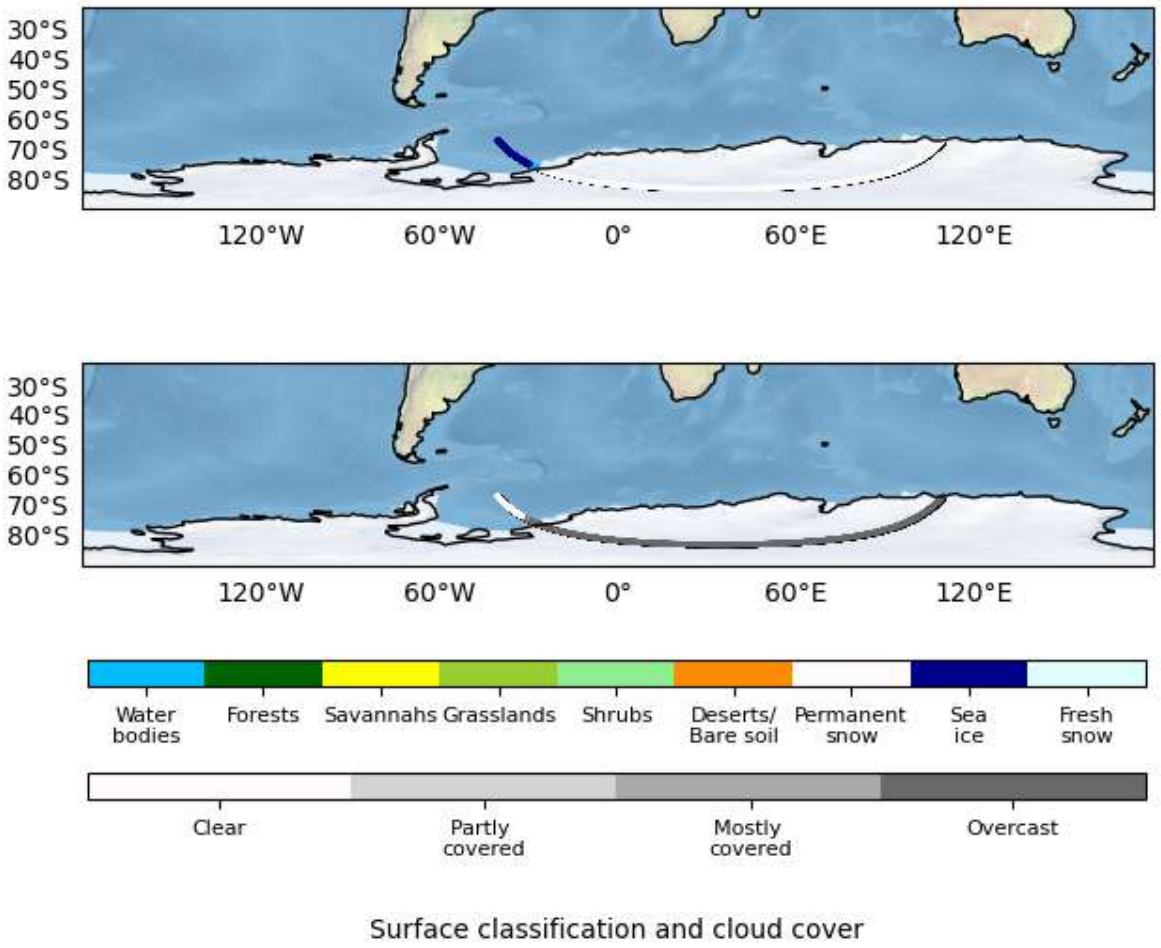
Nadir spike disappears when turning **Sea-ice** into **Fresh snow**

SW



Current issues – sea-ice

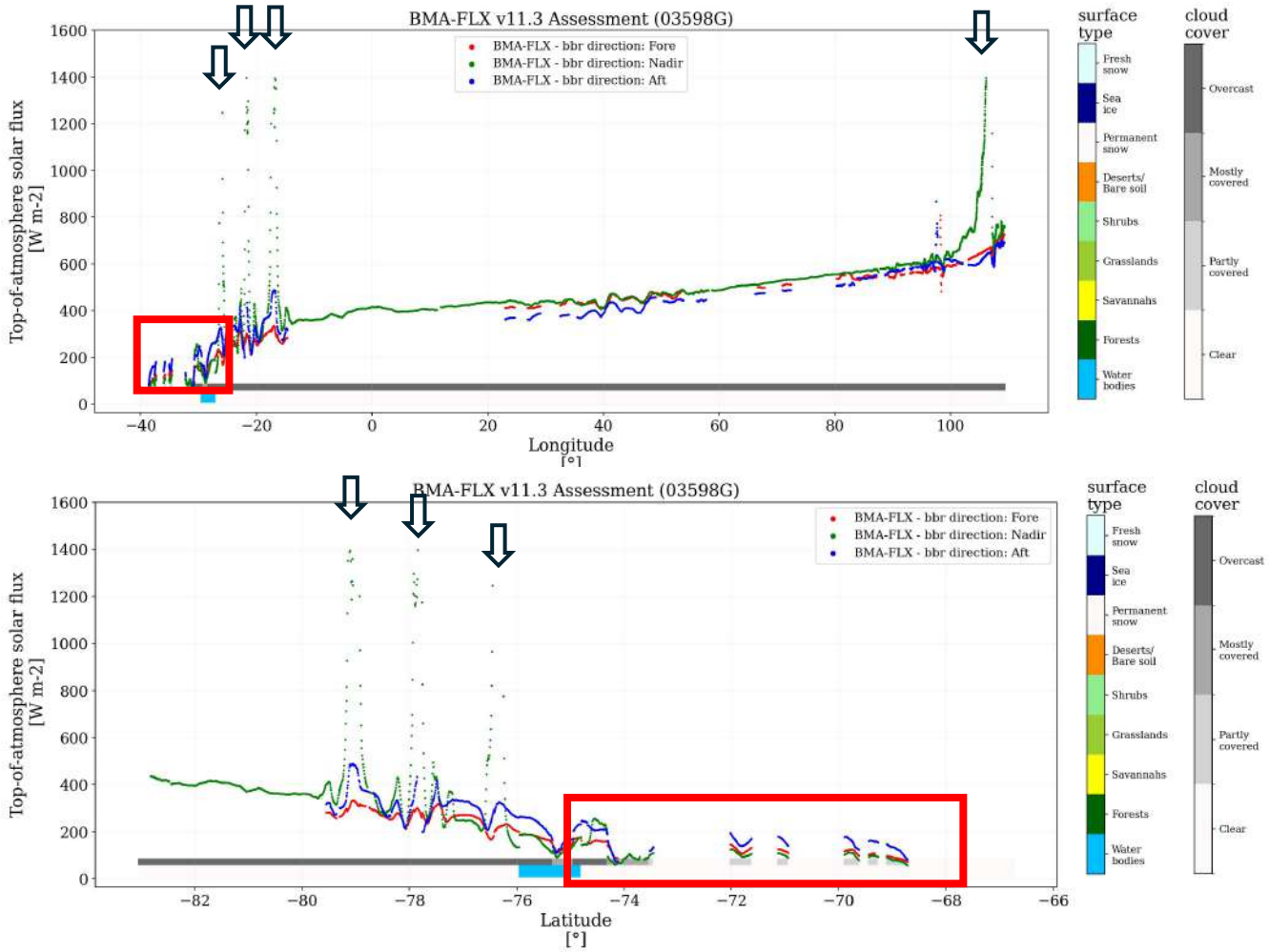
Solar fluxes over sea-ice



worse

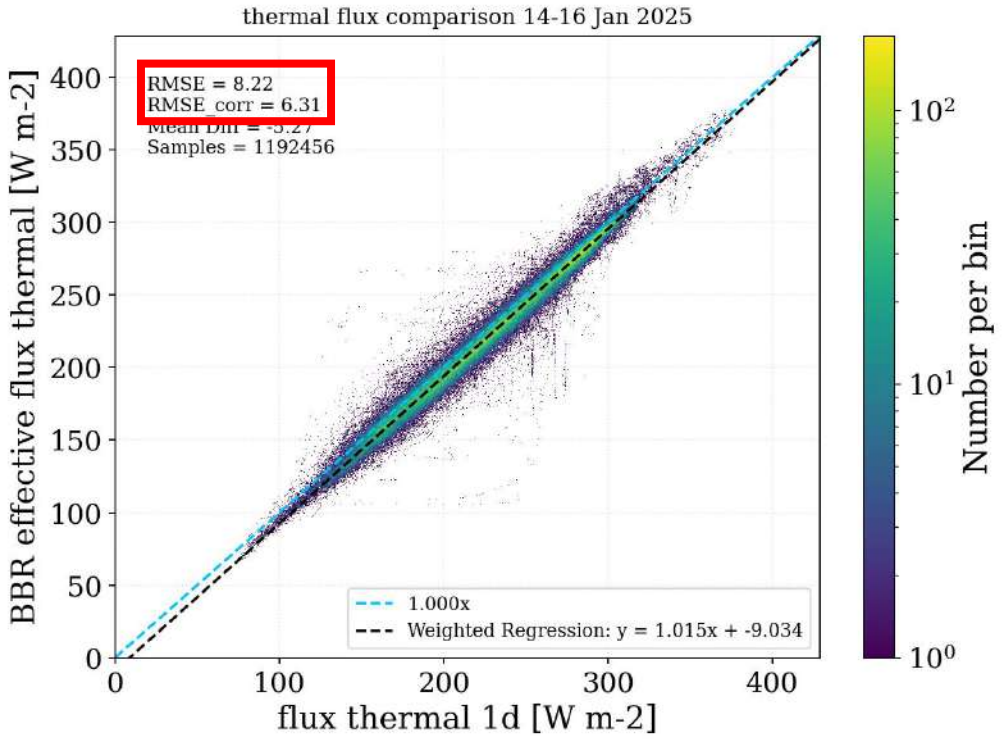
Nadir spike disappears when turning **Sea-ice** into **Permanent snow**

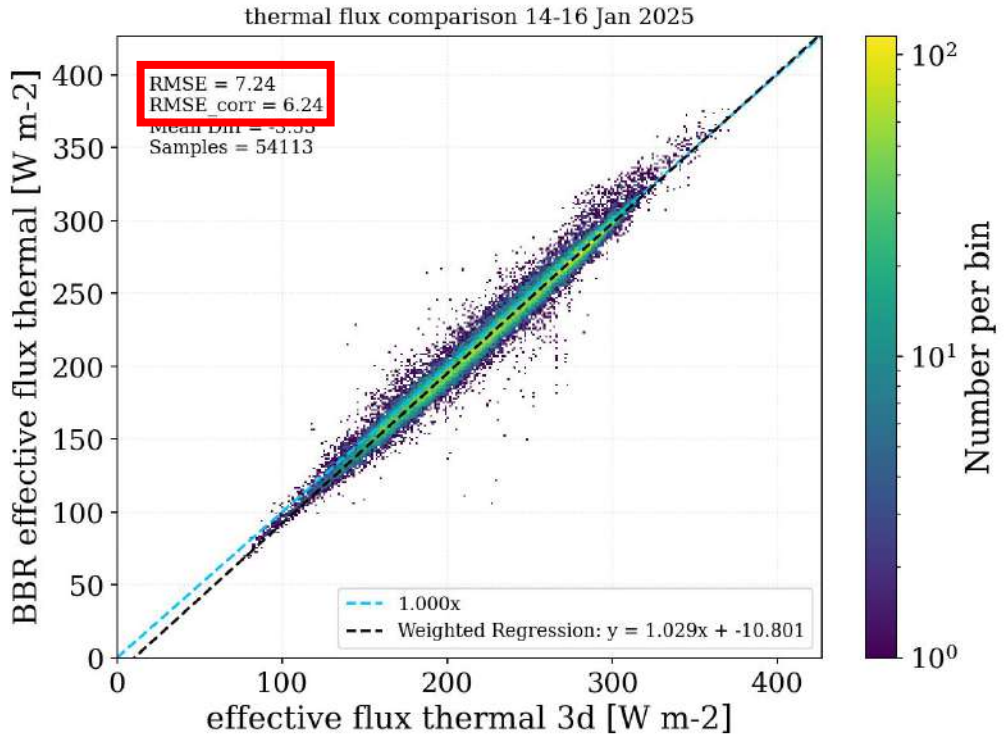
SW



Thermal combined flux comparison

BMA-FLX thermal TOA fluxes against 1d/3d modelled fluxes from ACMB-DF





RMSE < 10 W m-2 and slope ~1 !!

Summary

- In general, there's a good agreement between ACMB-DF and BMA-FLX solar and thermal fluxes during the January period.
- BBR solar fluxes are brighter than those from the 3d calculations.
- Thermal flux comparisons classified by cloud cover have a bias-corrected lower than 10 W m-2.
- Four issues being investigated:
  - Horizontal pattern in solar fluxes over water bodies in clear-sky scenarios
    Could be related to cloud misclassification
  - Arrow-shaped pattern in solar fluxes which appears to originate from permanent snow surfaces
    Could be something related to the ADMs
  - Nadir flux spikes in the permanent snow surface classification under overcast cloud conditions
    Could be something related to the ADMs.
  - Nadir flux spikes have been observed in the sea-ice surface classification.

Thank you!

csalas@gmv.com

Environment and Climate Change Canada

Annex

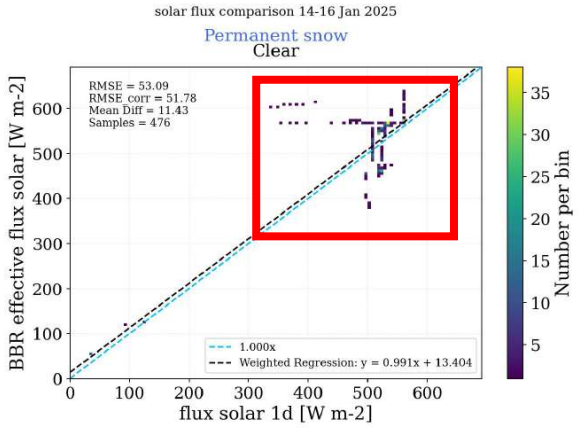
Current issues – permanent snow

Solar fluxes over permanent snow – 1d calculations SW

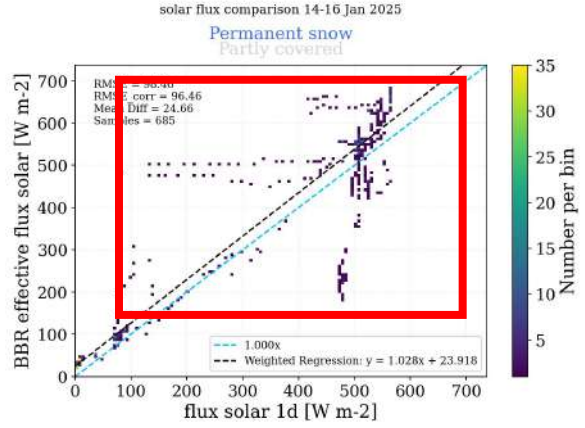
Cloud cover	Samples	% in permanent snow
Clear	476	0.916
Partly covered	685	1.318
Mostly clovered	1667	3.207
Overcast	49144	94.559

?

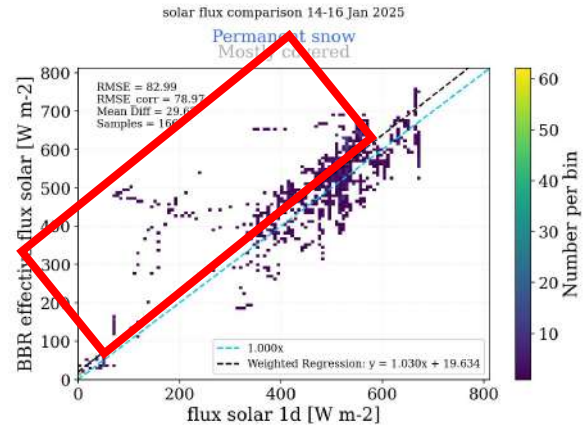
~95% of the permanent snow surface classification is under overcast cloud conditions



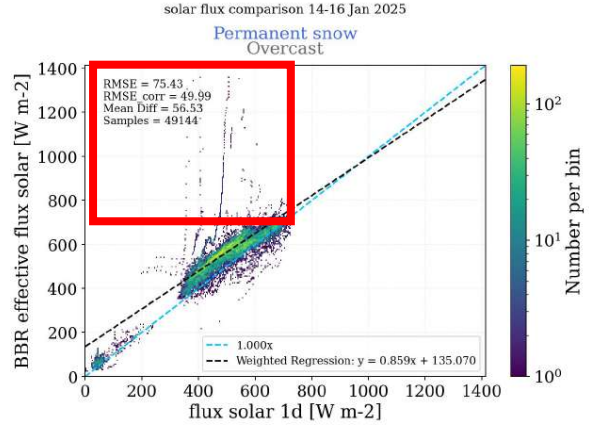
CF* < 0.1



0.1 <= CF <= 50.0



50.0 < CF < 99.0



CF >= 99.0

* Cloud Fraction