

Validation of the operational D-Region Absorption Prediction (D-RAP) model at the NOAA Space Weather Prediction Center (SWPC)

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D-RAP Product

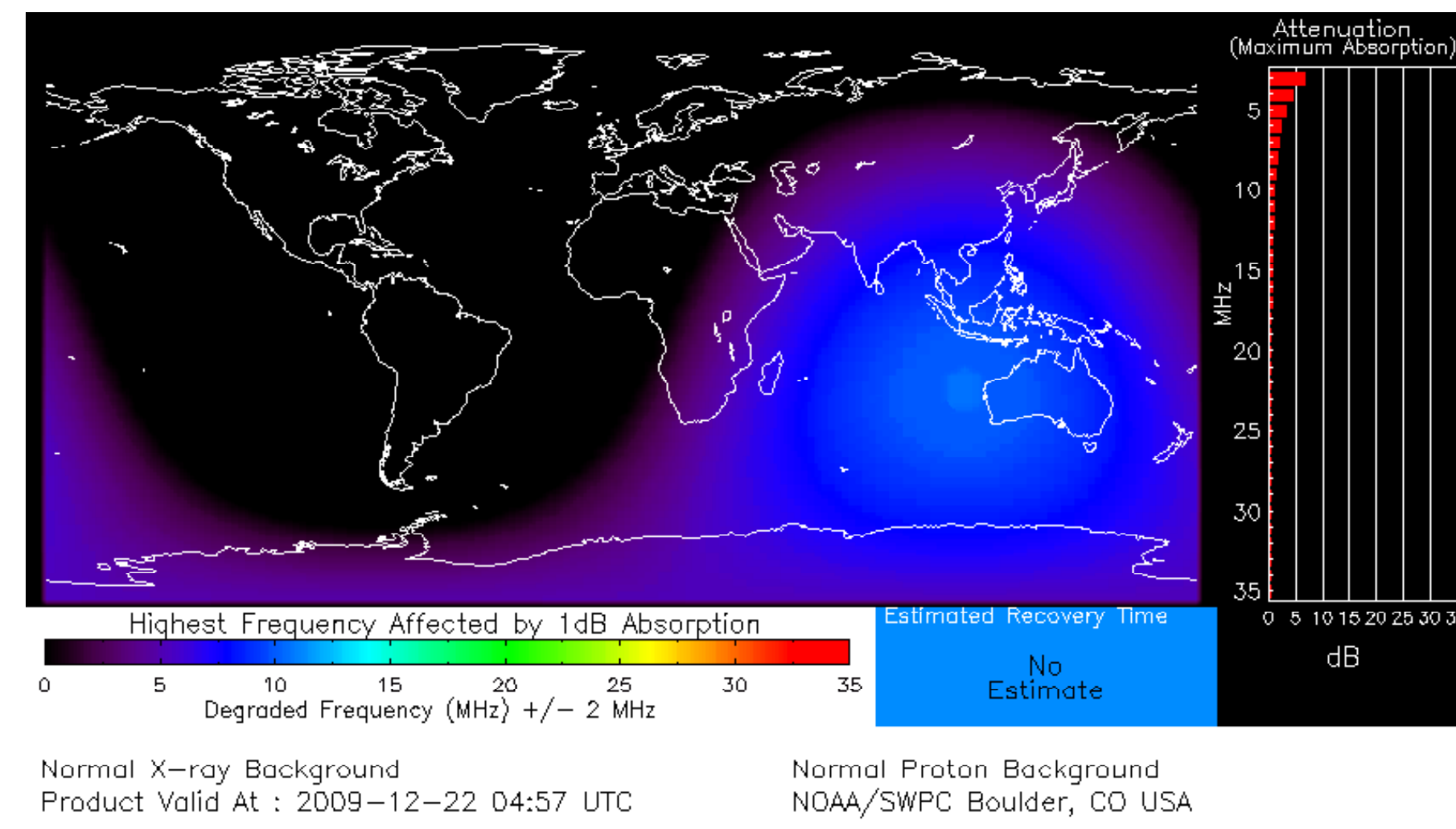
Provides real-time global estimates of combined HF ionospheric absorption:

- Polar Cap Absorption (PCA) due to solar energetic particle (SEP) precipitation (new feature) after Sauer and Wilkinson (2008).
- X-ray absorption due to solar X-ray flares on the dayside.

Products:

- Global map of highest frequency affected by 1-dB absorption.
- Two polar maps of highest frequency affected by 10-dB absorption.
- Estimated recovery time.
- Text file with highest frequency affected by 1-dB absorption.

Global Display



Validation

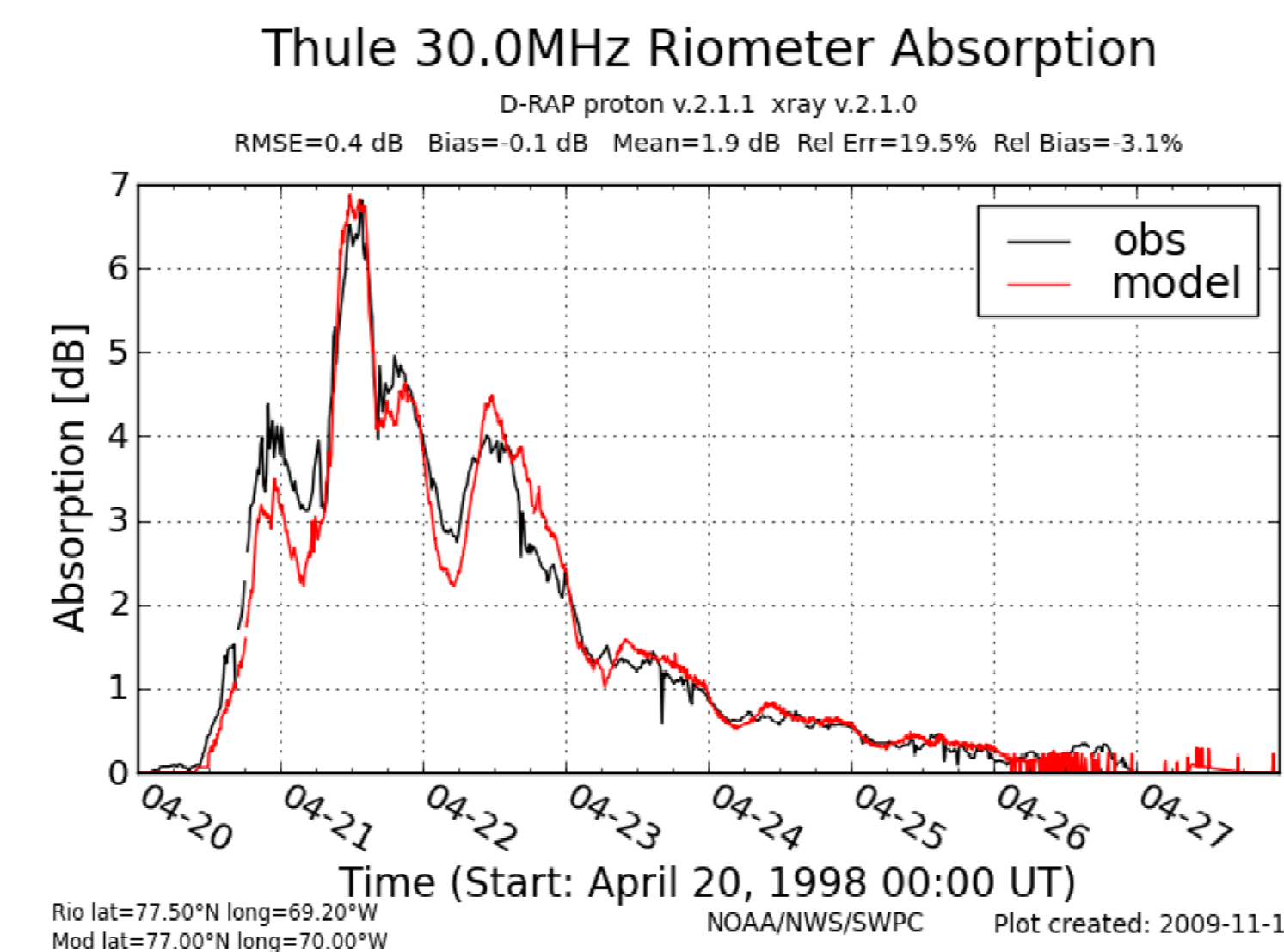
Stations

	Station	Latitude	Longitude	Frequency
1	Thule, Greenland	77.50° N	69.20° W	30.0 MHz
2	Taloyoak, Canada	69.54° N	93.55° W	30.0 MHz
3	Rovaniemi, Finland	66.78° N	25.94° E	32.4 MHz
4	Dawson, Canada	64.05° N	139.11° W	30.0 MHz
5	Jyväskylä, Finland	62.42° N	25.28° E	32.4 MHz
6	Pinawa, Canada	50.20° N	96.04° W	30.0 MHz

Events

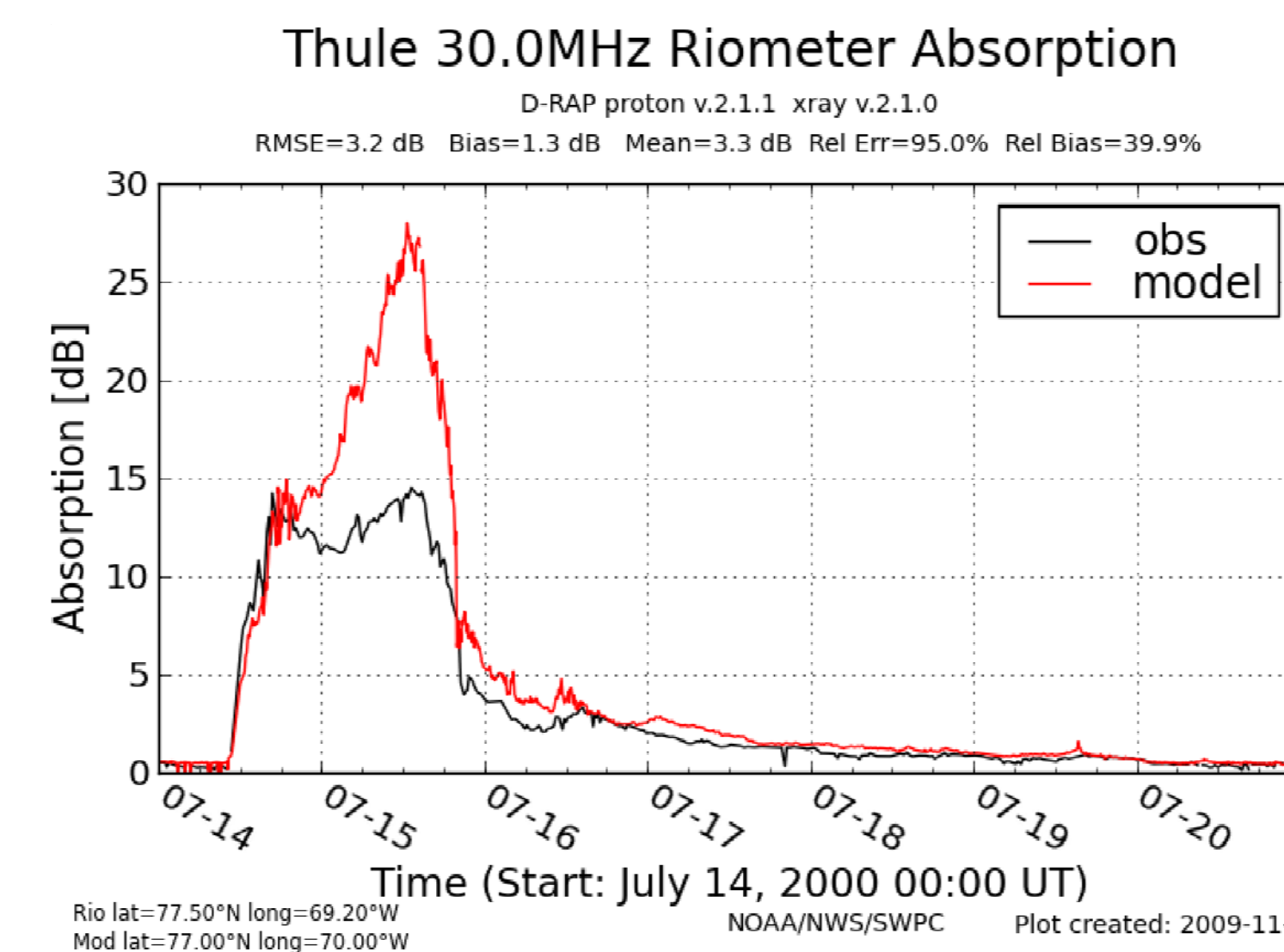
	Start date	Stations	X-rays
1	April 20, 1998	1, 2, 4, 6	yes
2	July 14, 2000	1, 2, 4, 6	yes
3	November 8, 2000	1, 2, 4, 6	
4	April 2, 2001	1-6	yes
5	April 15, 2001	1-6	
6	September 24, 2001	1-6	
7	October 1, 2001	1-6	
8	November 4, 2001	1-6	yes
9	November 22, 2001	1-6	yes
10	December 26, 2001	1, 2, 3, 4, 5	yes
11	April 21, 2002	1, 2, 4, 6	
12	January 19, 2005	2, 4, 6	yes
13	September 6, 2005	none	yes

Examples

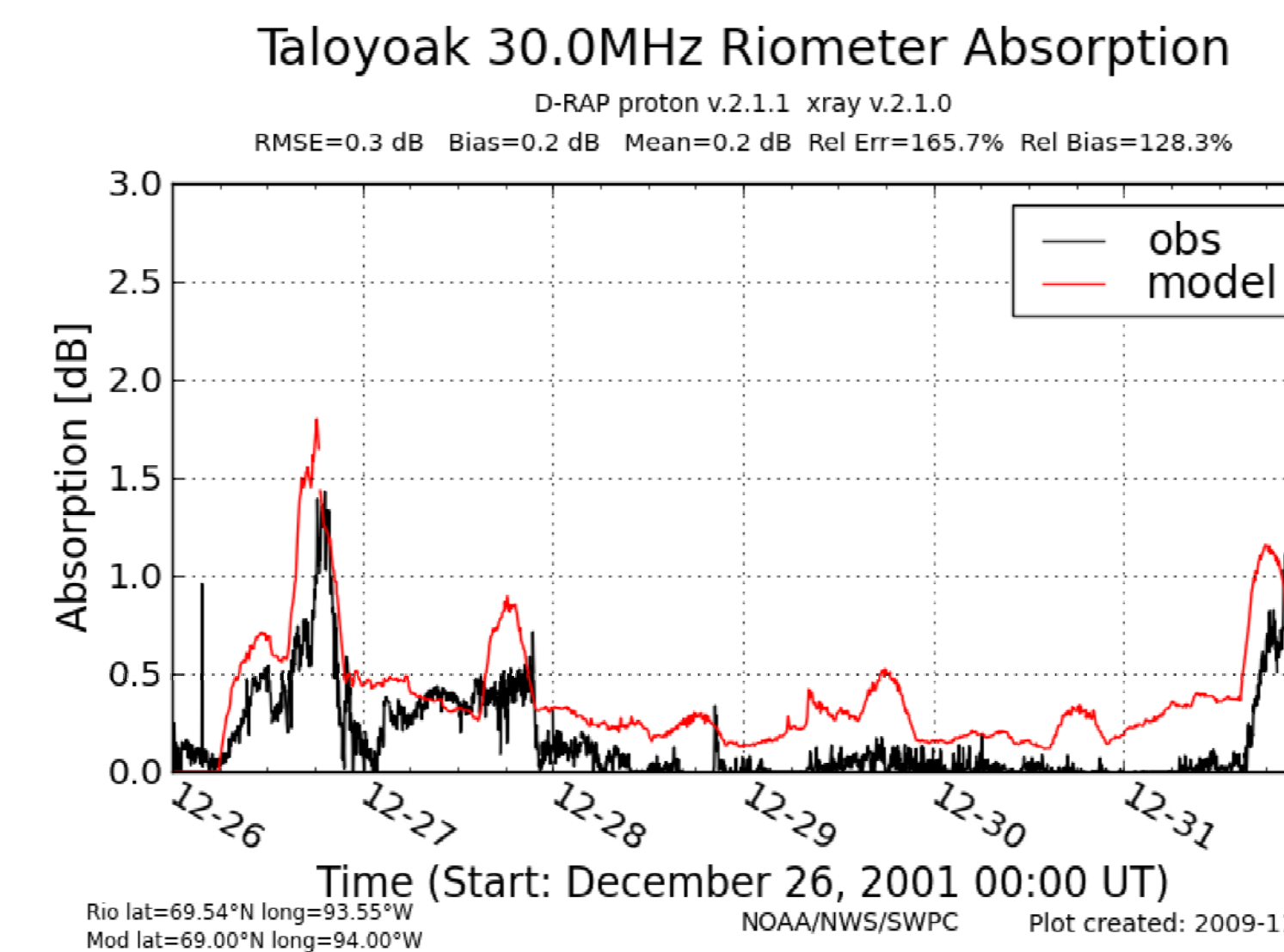


Period 1 at Thule.

Thule generally exhibits good performance but during some periods the model overestimates absorption substantially.

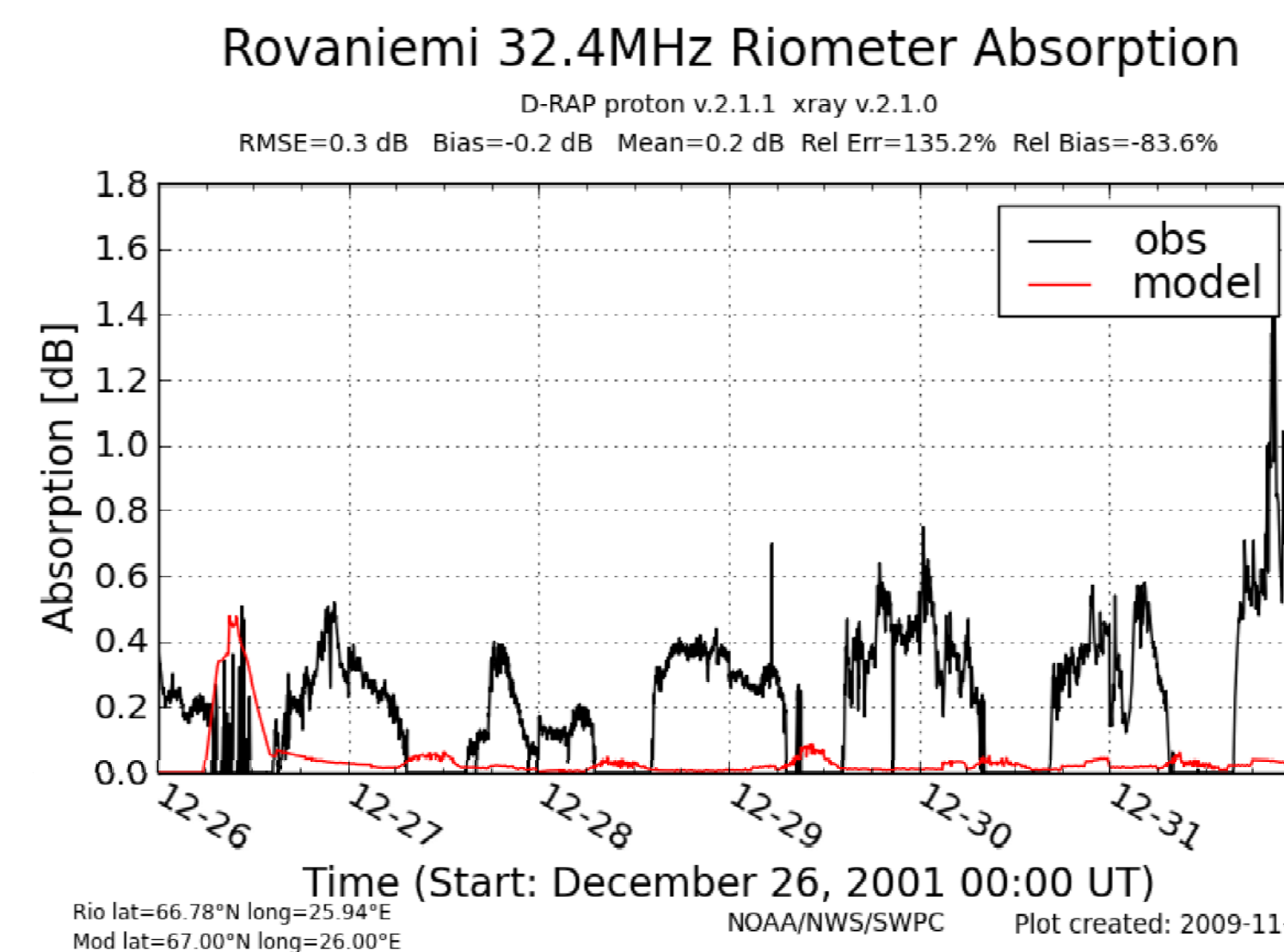


Period 2 at Thule.

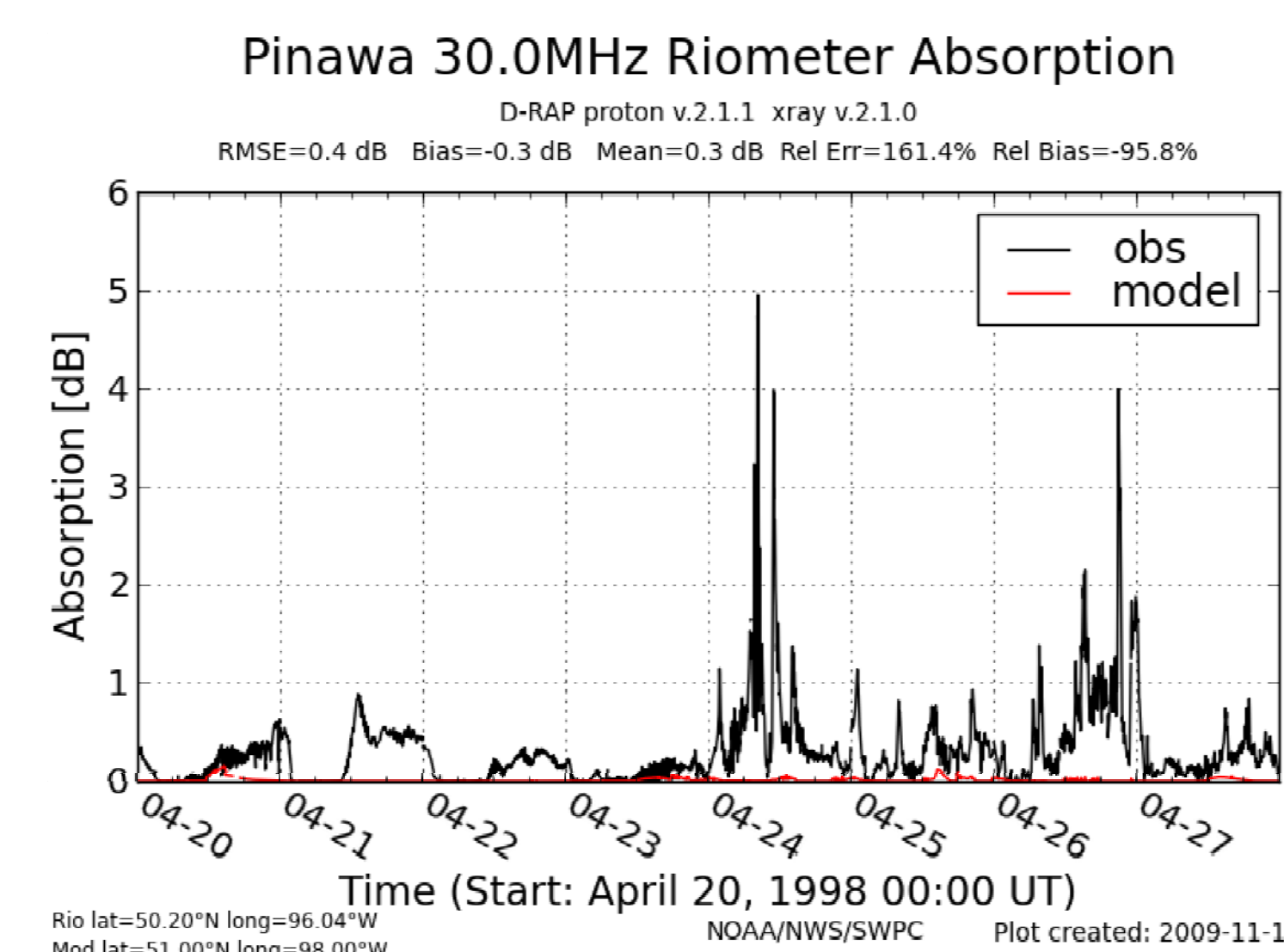


Period 10 at Taloyoak.

In the European sector absorption is often substantially underestimated by the model.



Period 10 at Rovaniemi.



Period 1 at Pinawa.

Summary Results

Station	RMSE (dB)	Bias (dB)	Mean (dB)	Rel. Err. (%)	Rel. Bias (%)
Thule	1.1	0.1	1.5	69.2	3.8
Taloyoak	1.7	0.4	1.2	144.1	30.6
Rovaniemi	0.9	-0.4	0.7	120.2	-51.9
Dawson	2.0	0.1	1.2	173.4	6.6
Jyväskylä	0.6	-0.2	0.3	227.5	-61.5
Pinawa	1.8	-0.2	0.6	319.7	-44.3

The combined absorption model performs reasonably well inside the auroral oval (e.g., Thule). In general, however, the model output should be treated as a *qualitative indicator* of disturbed conditions.

The following areas may need to be addressed in future model development and validation:

- The present validation project could not validate the X-ray component.
- At high-latitude stations in the American sector the PCA model substantially (about a factor of 2) overestimates absorption during some events.
- In the European sector the model systematically underestimates absorption.
- The model also underestimates absorption at midlatitudes apparently due the lack of parameterization of auroral absorption.
- This project did not address validation of the estimated recovery time

Recommendations

Future validation effort:

- Validate the X-ray component model on well isolated flare events using data from more midlatitude stations or other data sources at lower latitudes.
- Consider the feasibility of (near) real-time “on-the-fly” verification of the model.
- Expand the present effort to other longitude sectors and the Southern Hemisphere.

Scientific model improvements:

- With more data available consider further “tuning” of the PCA model (Sauer and Wilkinson, 2008) by a more accurate treatment of the SEP spectrum and the geomagnetic energy cutoff at subauroral latitudes.
- Initiate an R&D effort to parameterize the auroral absorption.

Reference

Sauer, H. H., and D. C. Wilkinson, Global mapping of ionospheric HF/VHF radio wave absorption due to solar energetic protons, *Space Weather*, 6, S12002, 2008.