Observations of HF radio propagation at high latitudes and predictions using data-driven simulations

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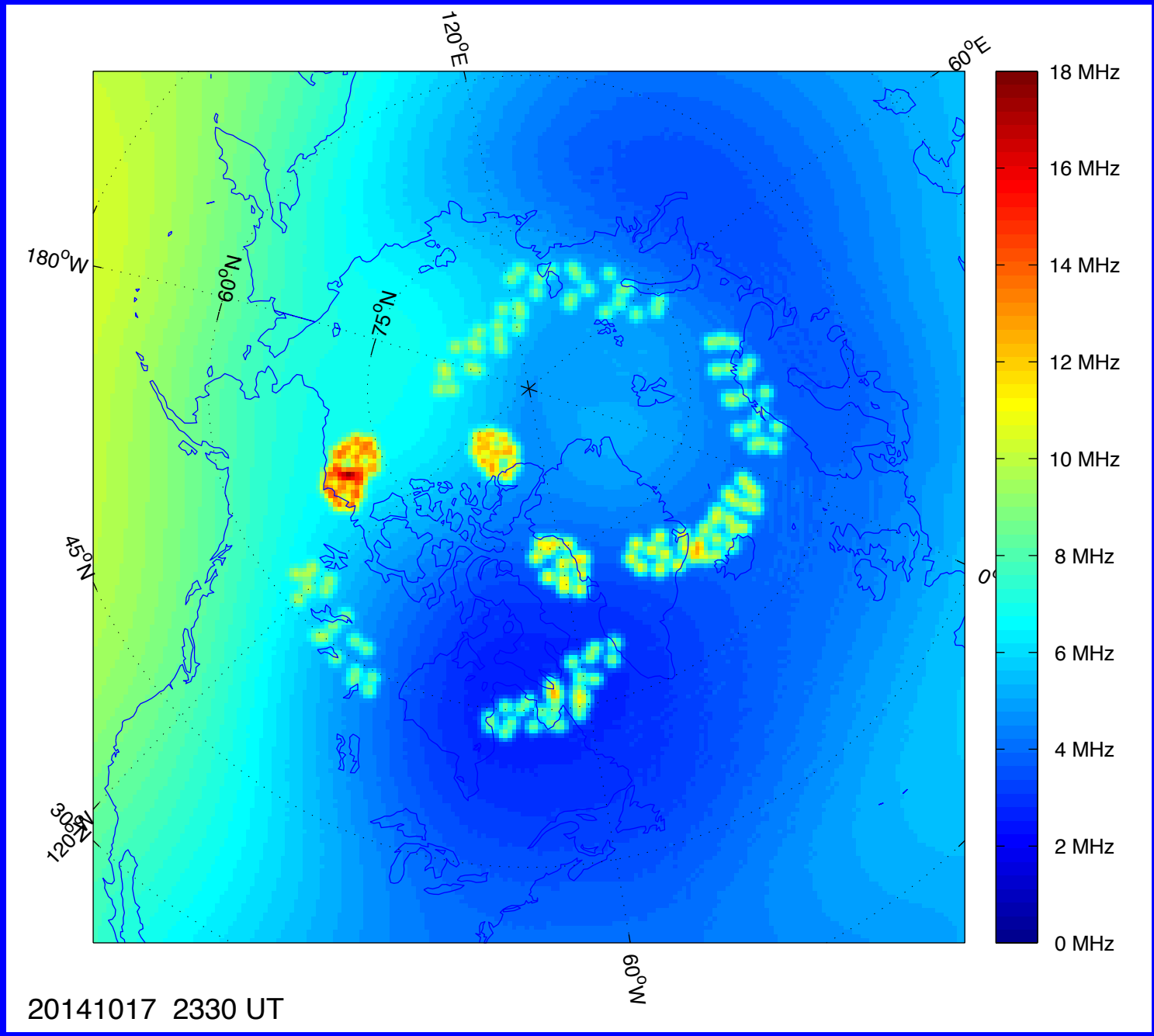
Model of the ionosphere

A computational model of the high-latitude ionosphere suitable for ray-tracing has been developed which includes:

- the background ionosphere
- electron density enhancements associated with the presence F-layer patches and arcs in the polar cap, coupled with a reasonable approximation of the convection flow
- electron density irregularities in the auroral oval region
- the electron density distribution inside the mid-latitude trough

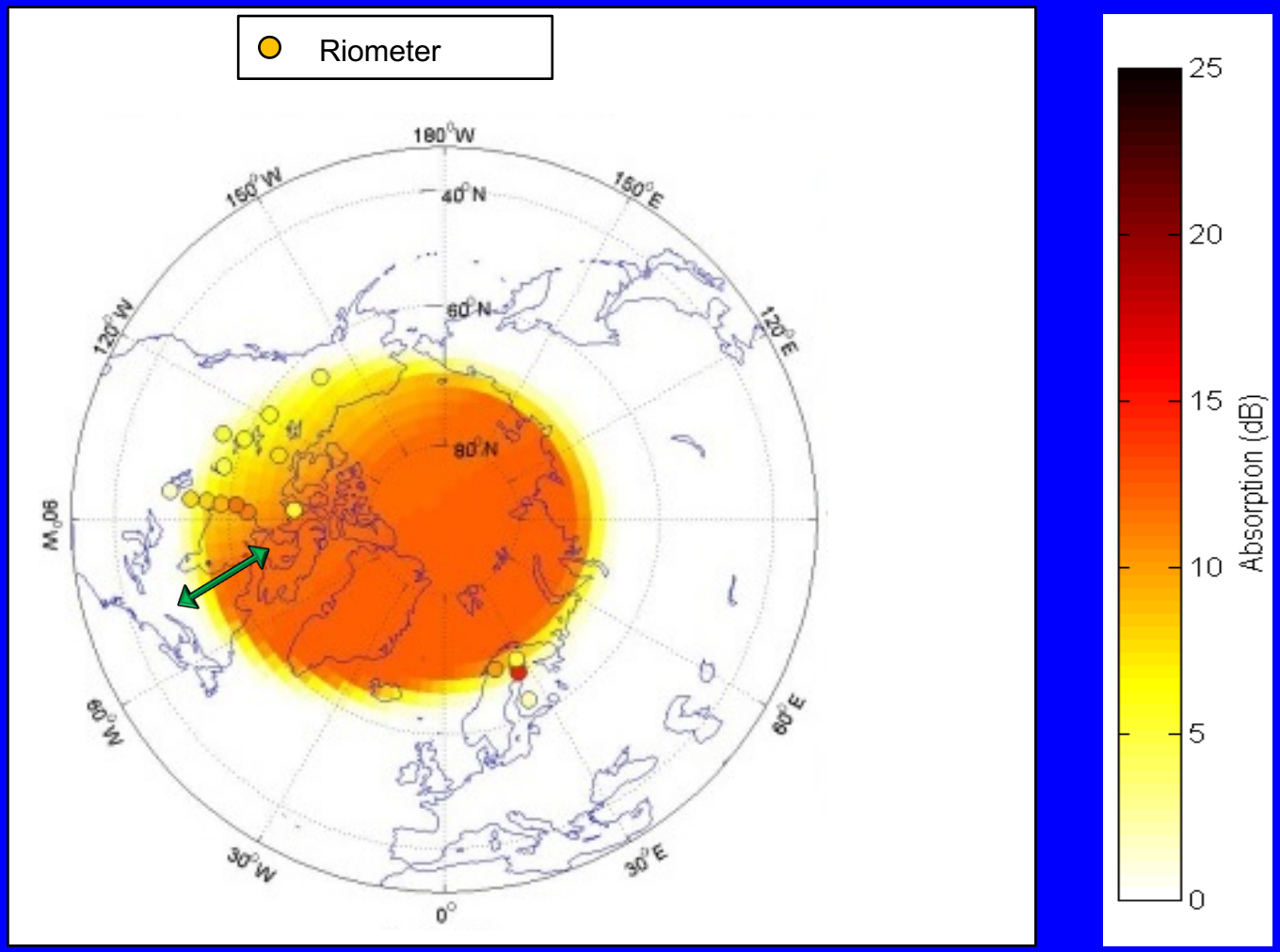
The underlying concepts behind the model have been presented before. We are currently refining and recoding.

- Remove the need for intensive user interaction in operating the model.
- IRI based background ionosphere with assimilation of measurements (ionosondes where available, TEC from GPS, etc).
- TEC measurements to inform on ionospheric features (e.g. patches).
- Combining the ray-tracing model with the absorption model.
- Validation of the model

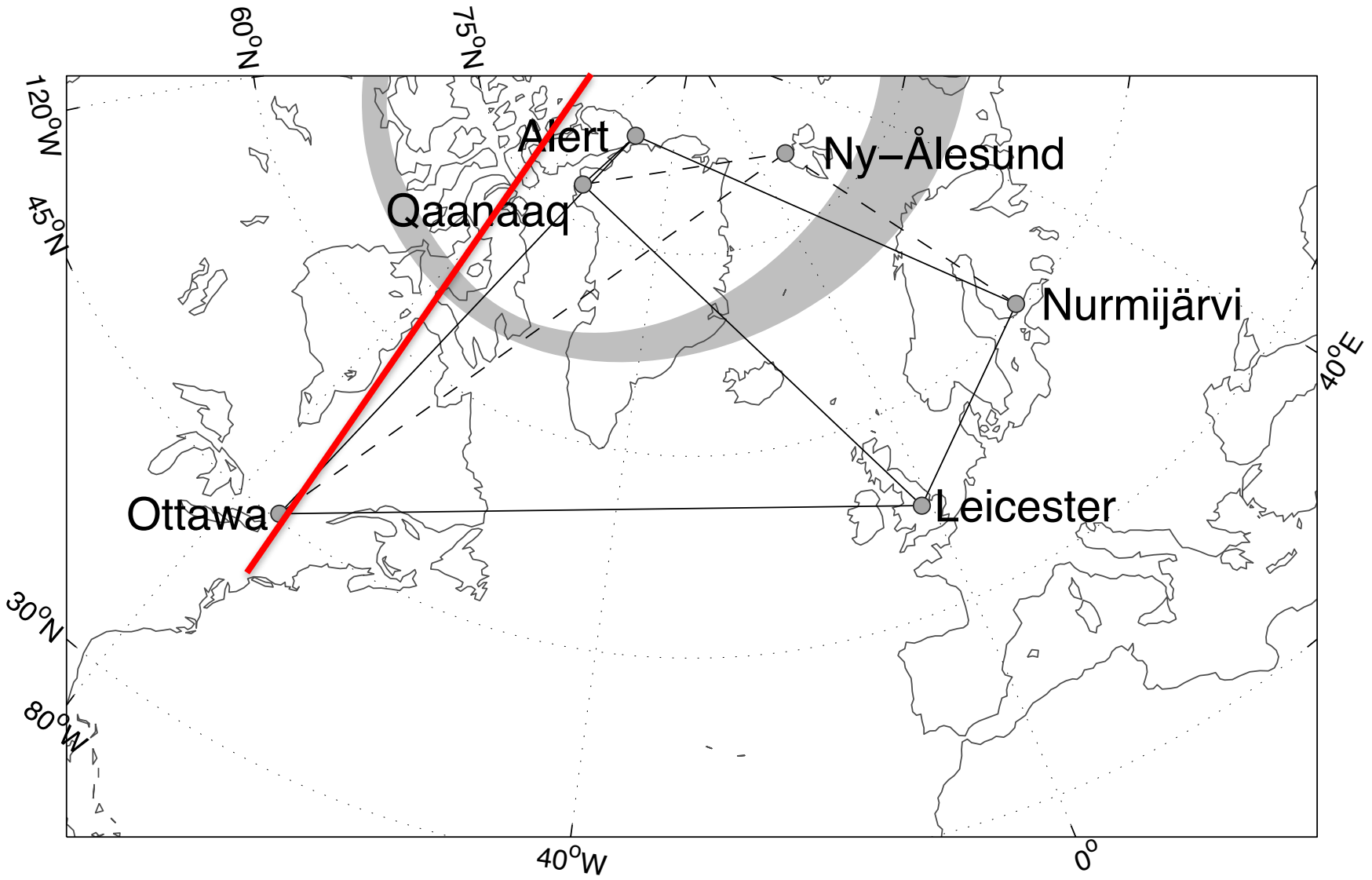

120°E
60°E
180°W
90°N
75°N
45°N
30°N
120°W
60°W
0°
18 MHz
16 MHz
14 MHz
12 MHz
10 MHz
8 MHz
6 MHz
4 MHz
2 MHz
0 MHz
20141017 2330 UT

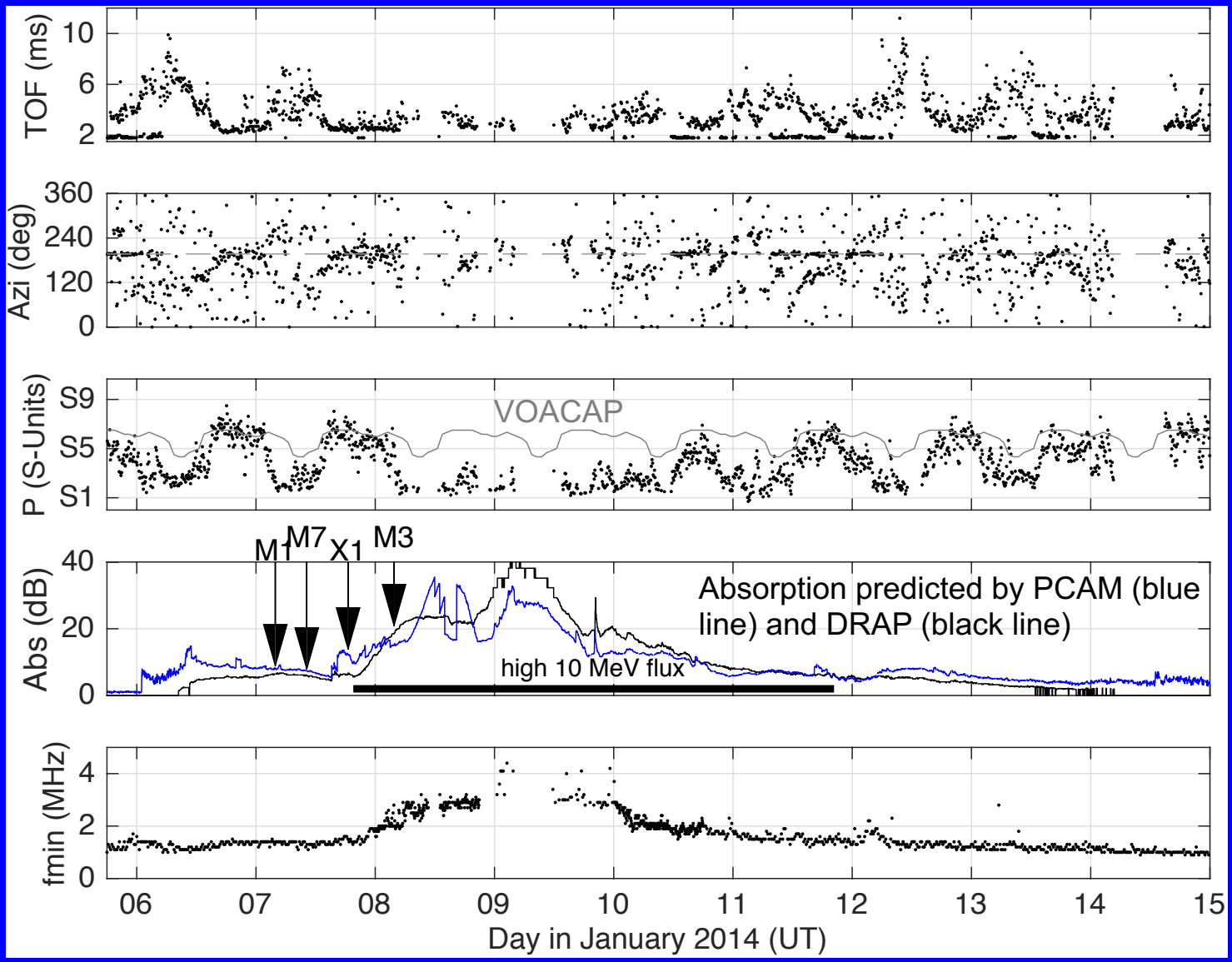
Polar Cap Absorption Model (PCAM)

- Empirical nowcasting model of D-region HF absorption
  - PCAM Optimises the Rigidity Cutoff
  - PCAM Optimises the Twilight Transition
- Real-time data streams:
  - GOES satellite
    - Energetic (>1 MeV) proton flux
    - X-ray flux
  - ACE/DSCOVR satellite
    - Solar wind / IMF
  - Riometers
    - Global Array – GloRiA

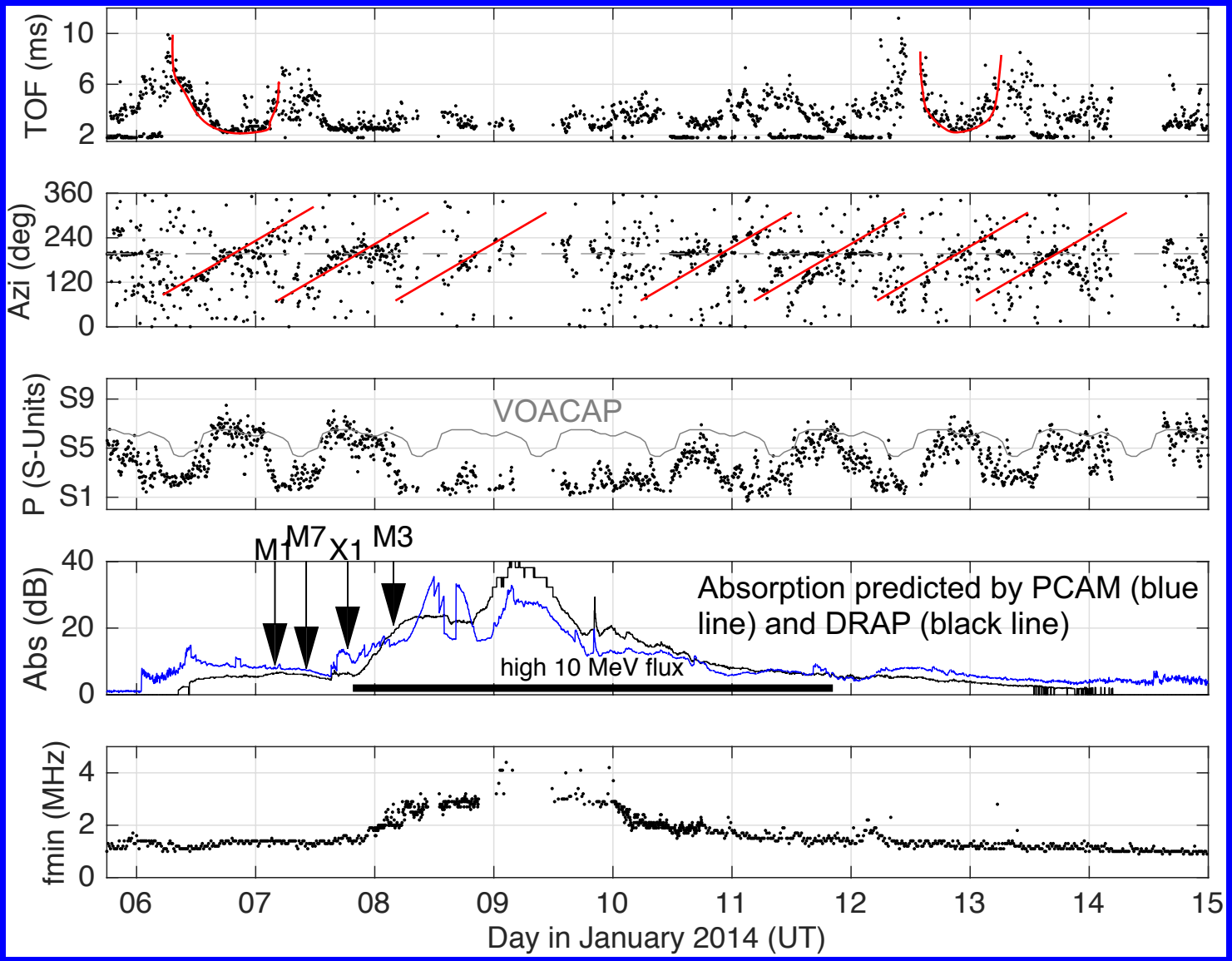


Map of predicted 30 MHz absorption during a polar cap absorption event

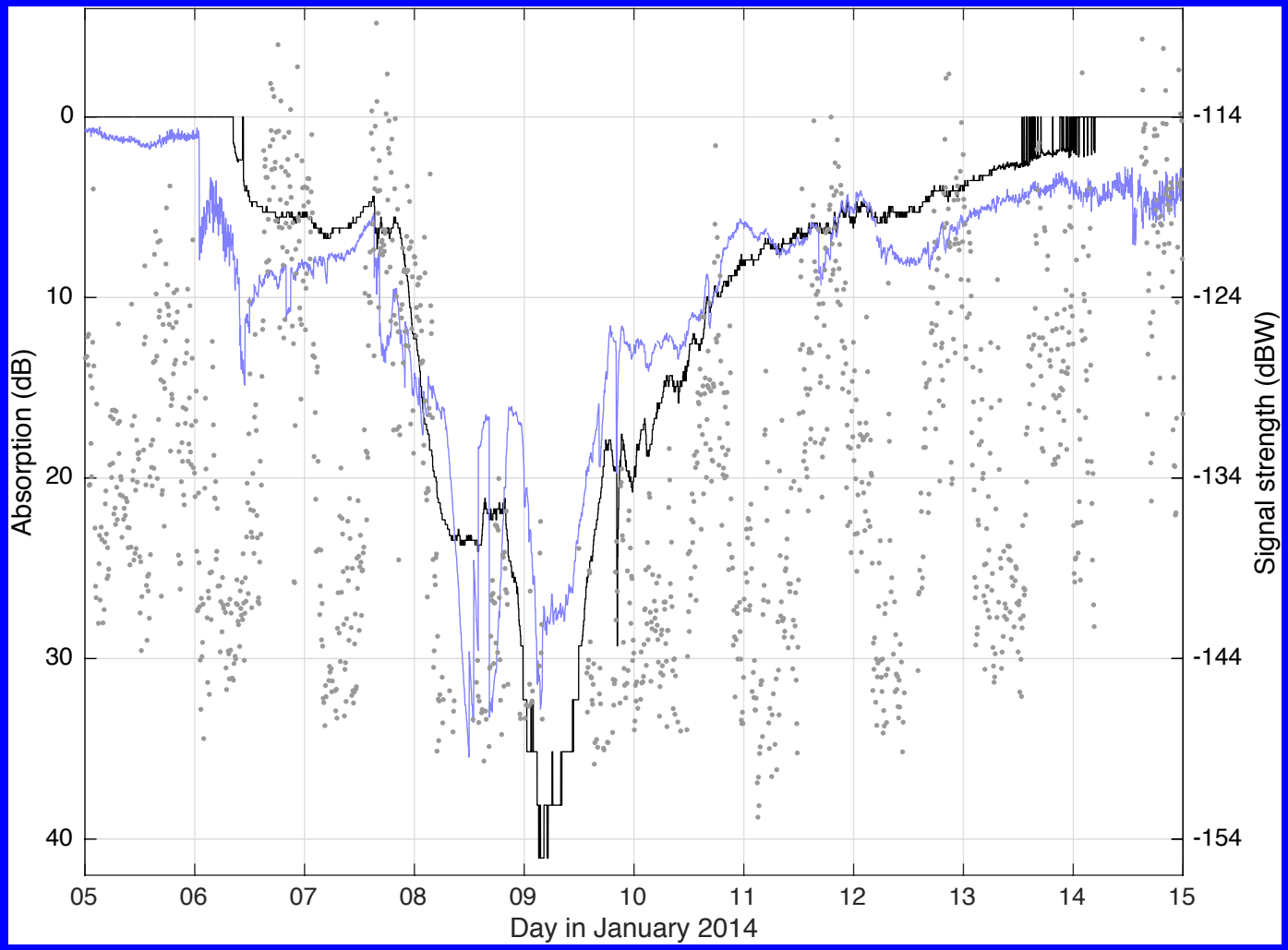

60°N
75°N
120°W
45°N
80°W
30°N
40°W
0°
40°E
Alert
Ny–Ålesund
Qaanaaq
Nurmijärvi
Ottawa
Leicester

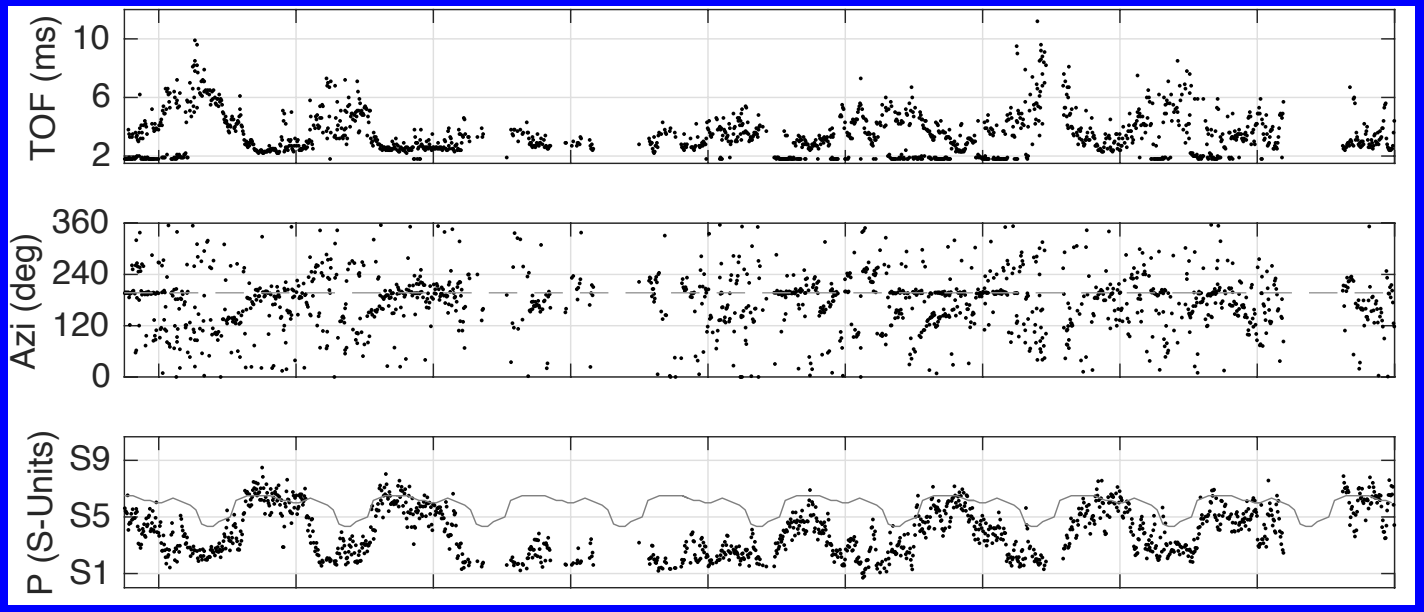


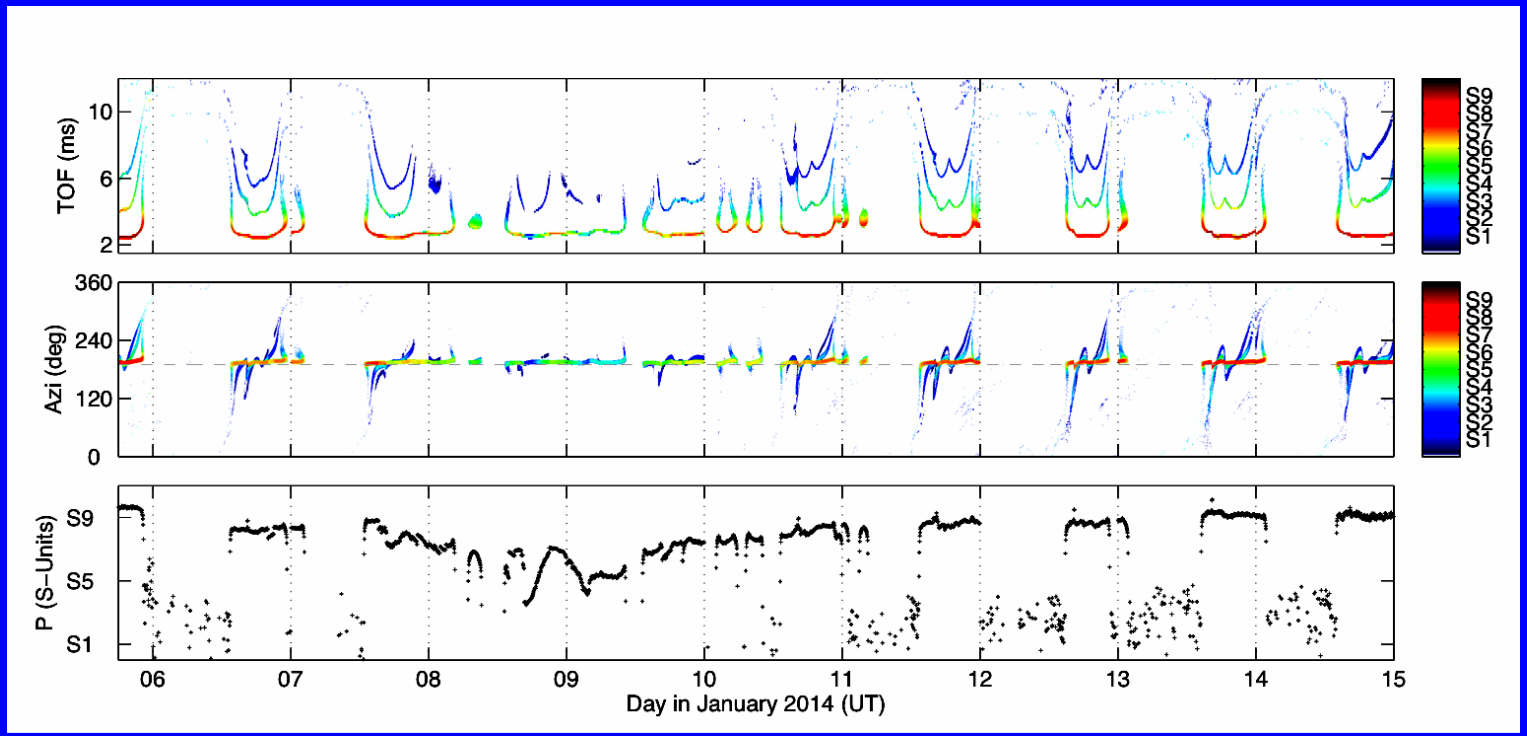
Measurements for the Qaanaaq to Alert path at 7.0 MHz

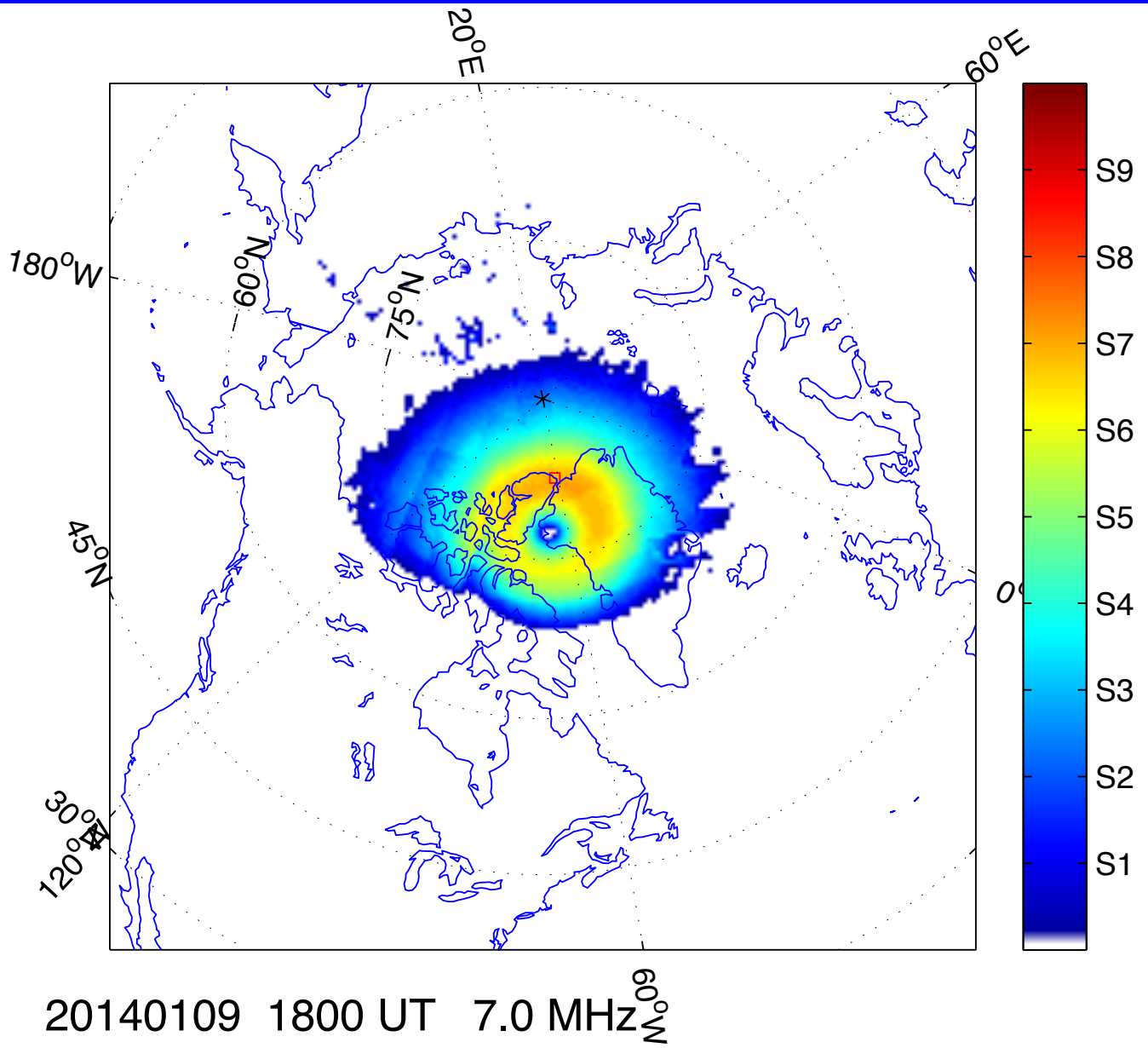


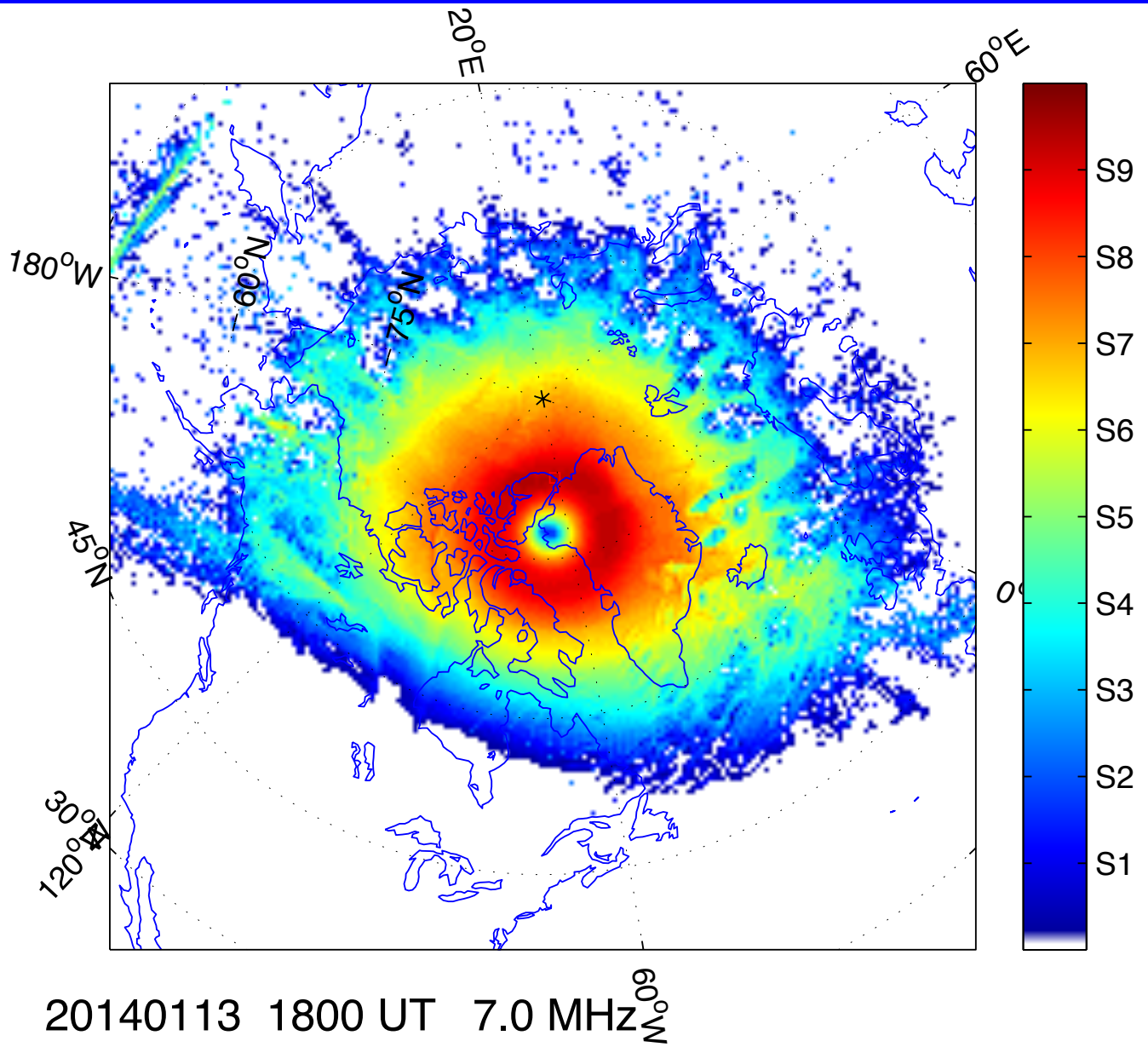
Measurements for the Qaanaaq to Alert path at 7.0 MHz

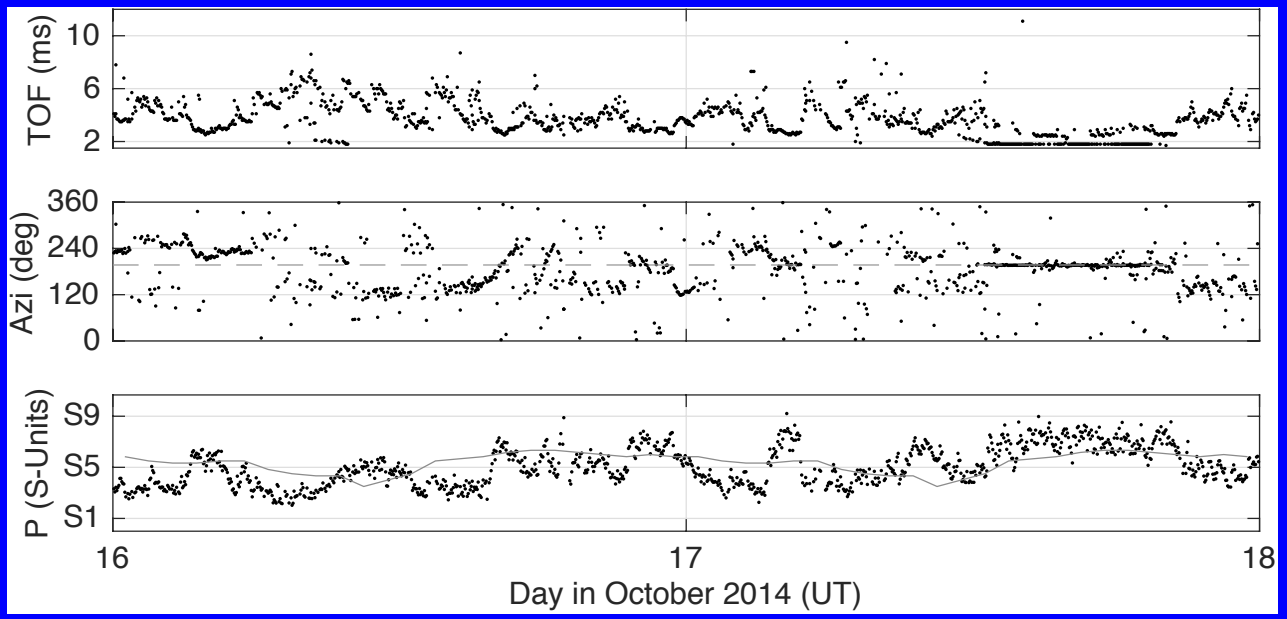

0
10
20
30
40
Absorption (dB)
-114
-124
-134
-144
-154
Signal strength (dBW)
05
06
07
08
09
10
11
12
13
14
15
Day in January 2014

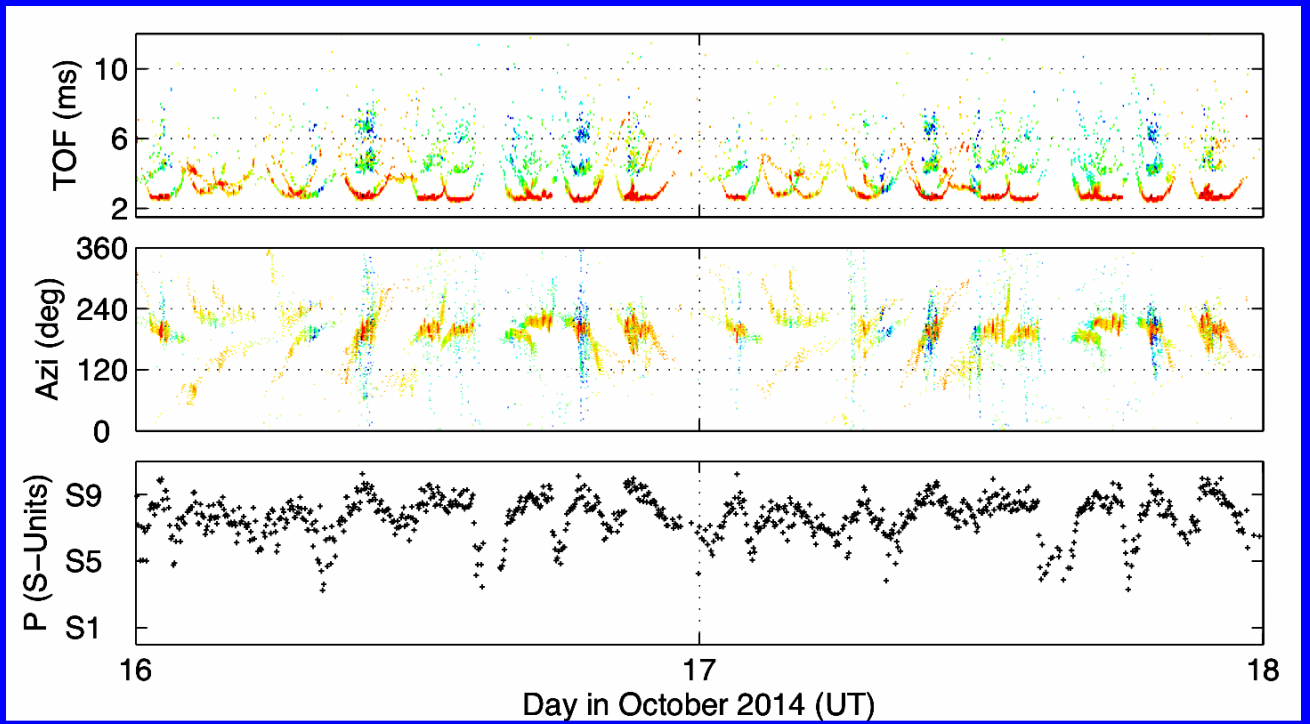

TOF (ms)
10
6
2
Azi (deg)
360
240
120
0
P (S-Units)
S9
S5
S1

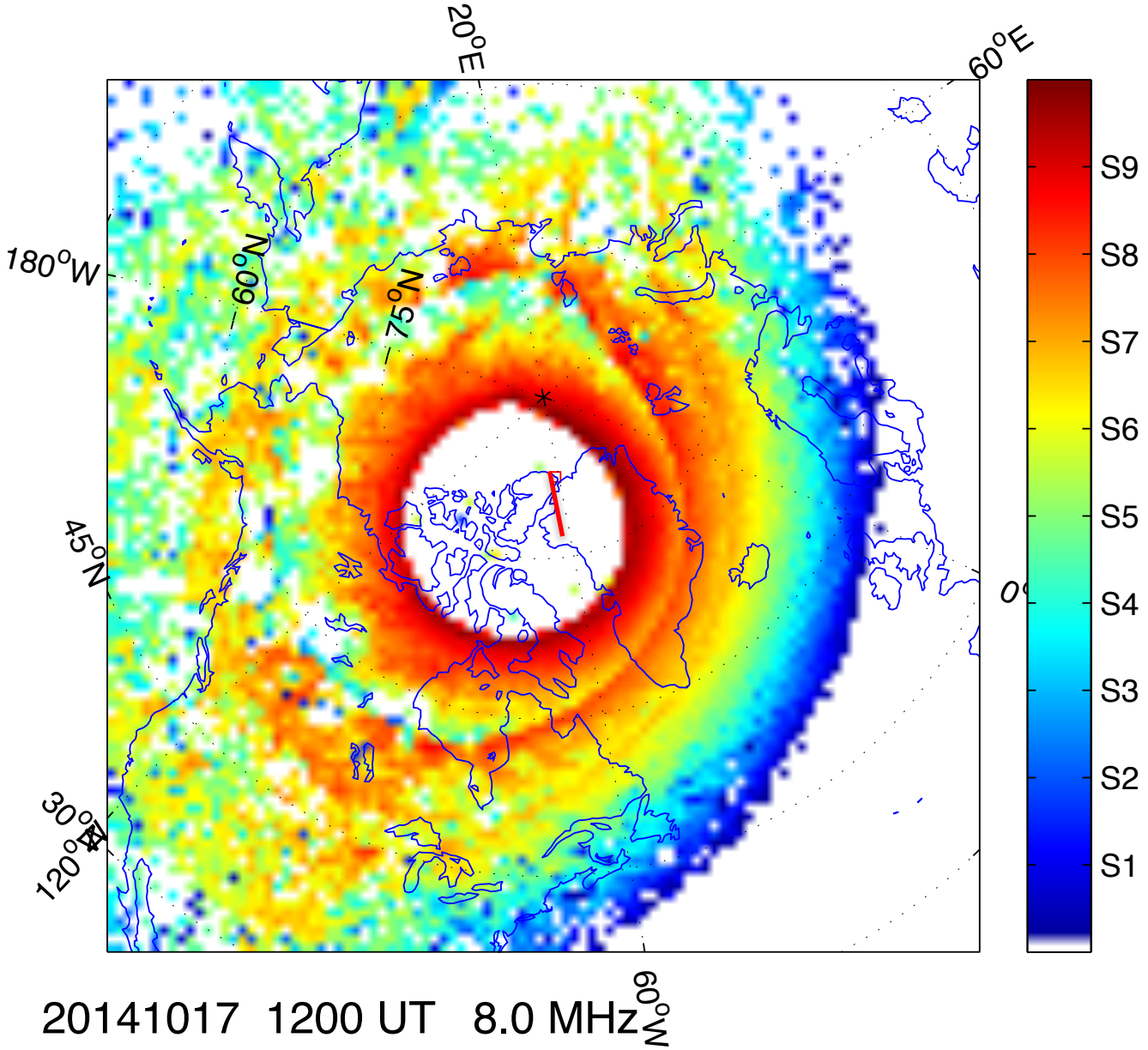

TOF (ms)
10
6
2
Azi (deg)
360
240
120
0
P (S-Units)
S9
S5
S1
S9
S8
S7
S6
S5
S4
S3
S2
S1
06
07
08
09
10
11
12
13
14
15
Day in January 2014 (UT)

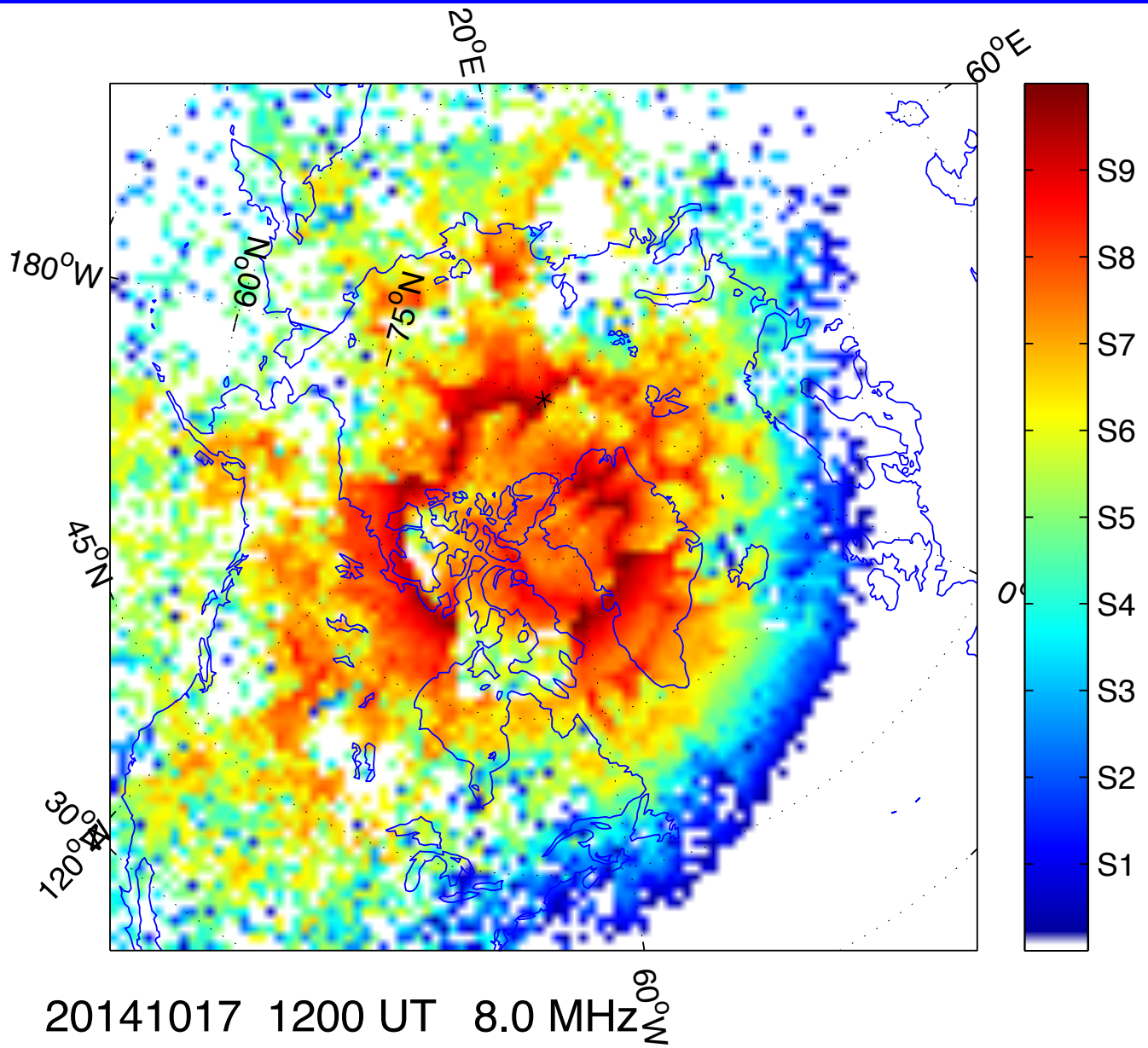

20°E
60°E
180°W
60°N
75°N
45°N
30°N
120°W
60°W
S9
S8
S7
S6
S5
S4
S3
S2
S1
20140109 1800 UT 7.0 MHz


20°E
60°E
180°W
60°N
75°N
45°N
0°
30°N
120°W
60°W
S9
S8
S7
S6
S5
S4
S3
S2
S1
20140113 1800 UT 7.0 MHz


TOF (ms)
10
6
2
Azi (deg)
360
240
120
0
P (S-Units)
S9
S5
S1
16
17
18
Day in October 2014 (UT)


TOF (ms)
10
6
2
Azi (deg)
360
240
120
0
P (S–Units)
S9
S5
S1
16
17
18
Day in October 2014 (UT)


20°E
60°E
180°W
60°N
75°N
45°N
30°N
120°W
60°W
S9
S8
S7
S6
S5
S4
S3
S2
S1
20141017 1200 UT 8.0 MHz


20°E
60°E
180°W
60°N
75°N
45°N
30°N
120°W
60°W
S9
S8
S7
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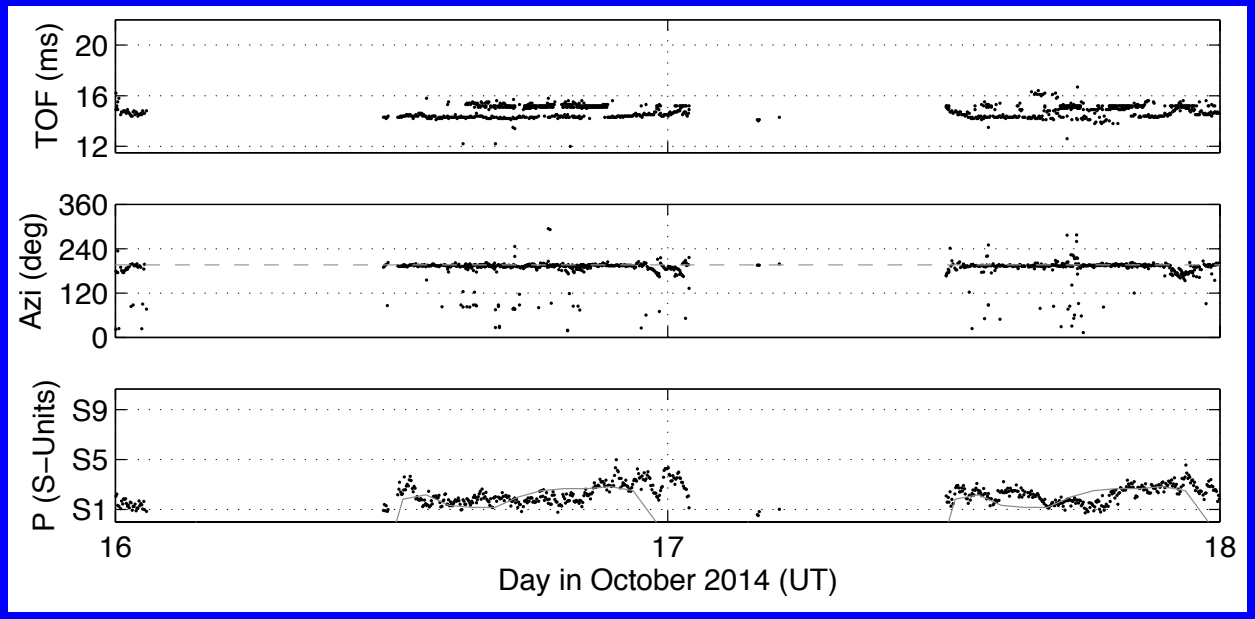
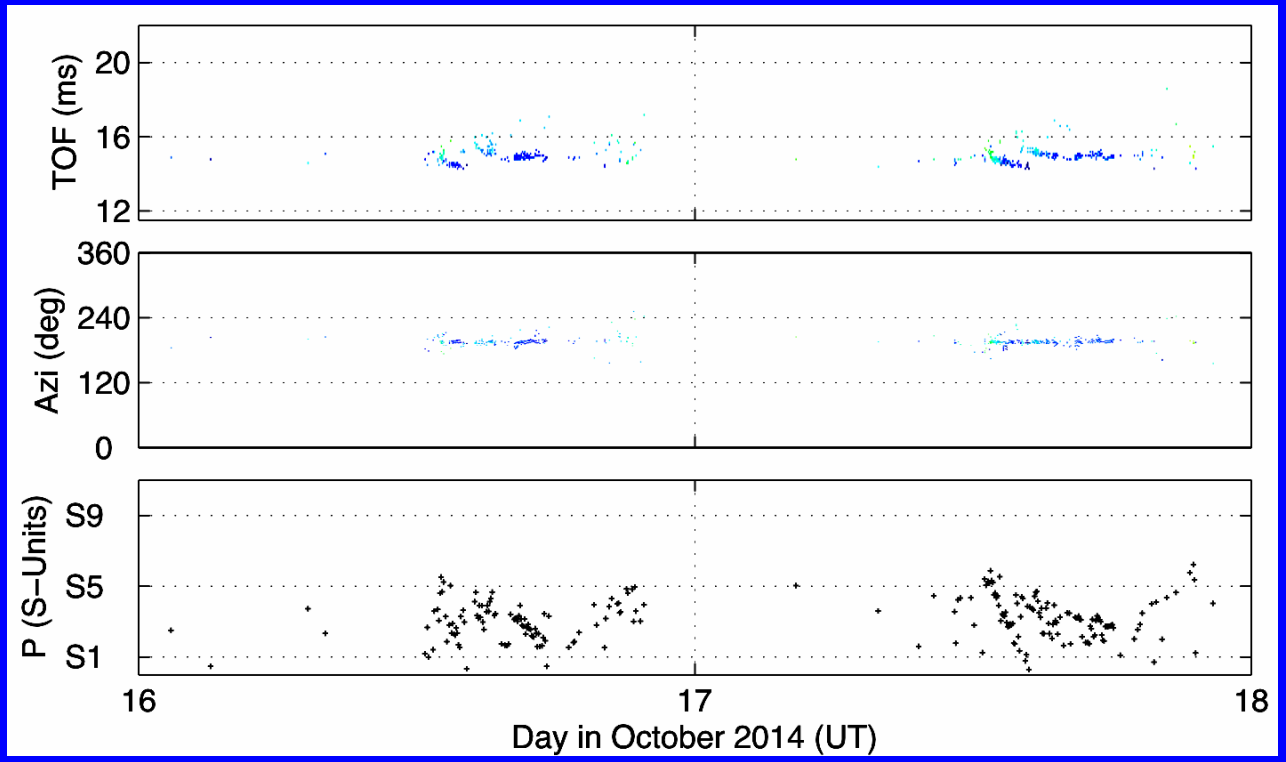
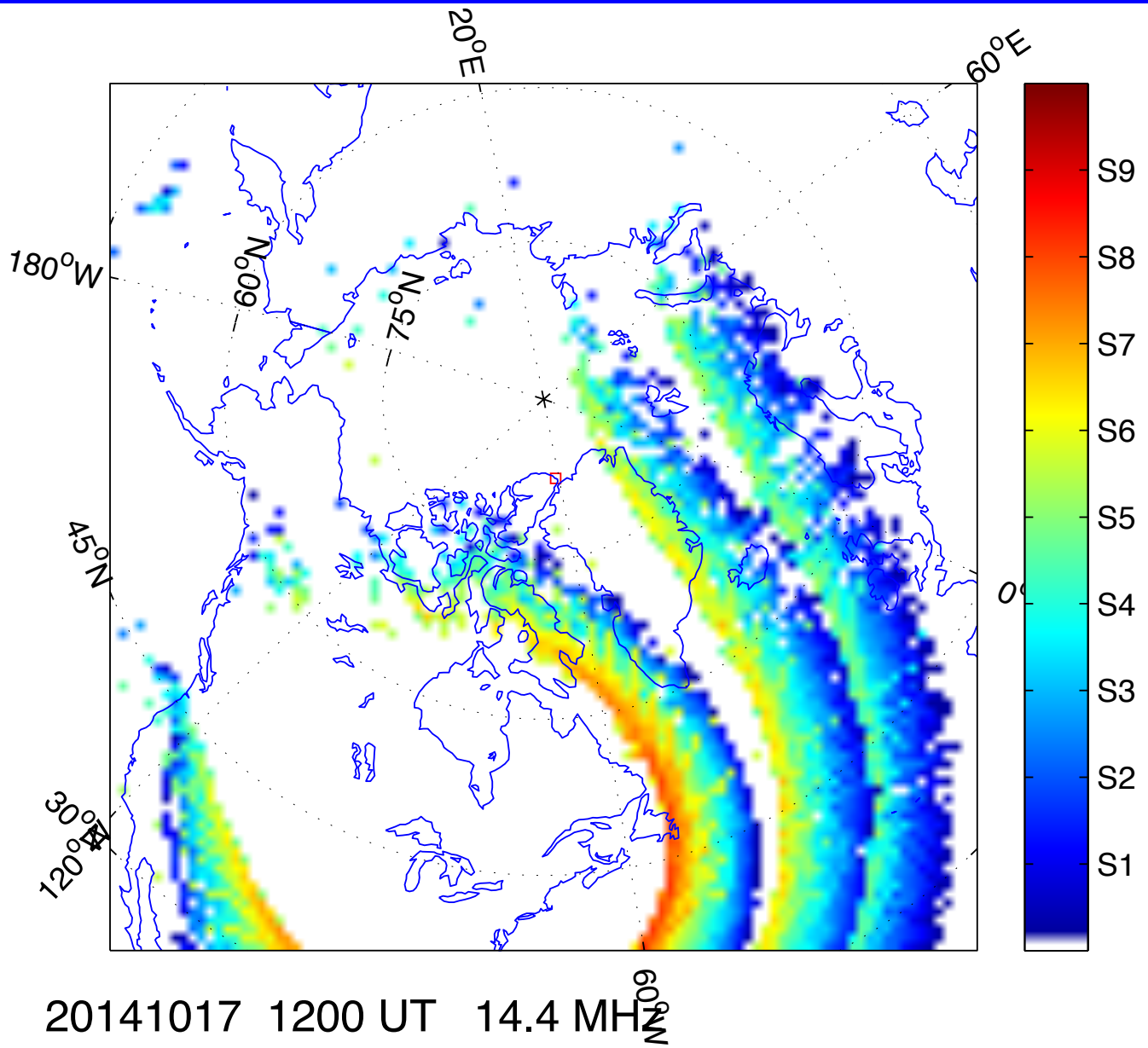
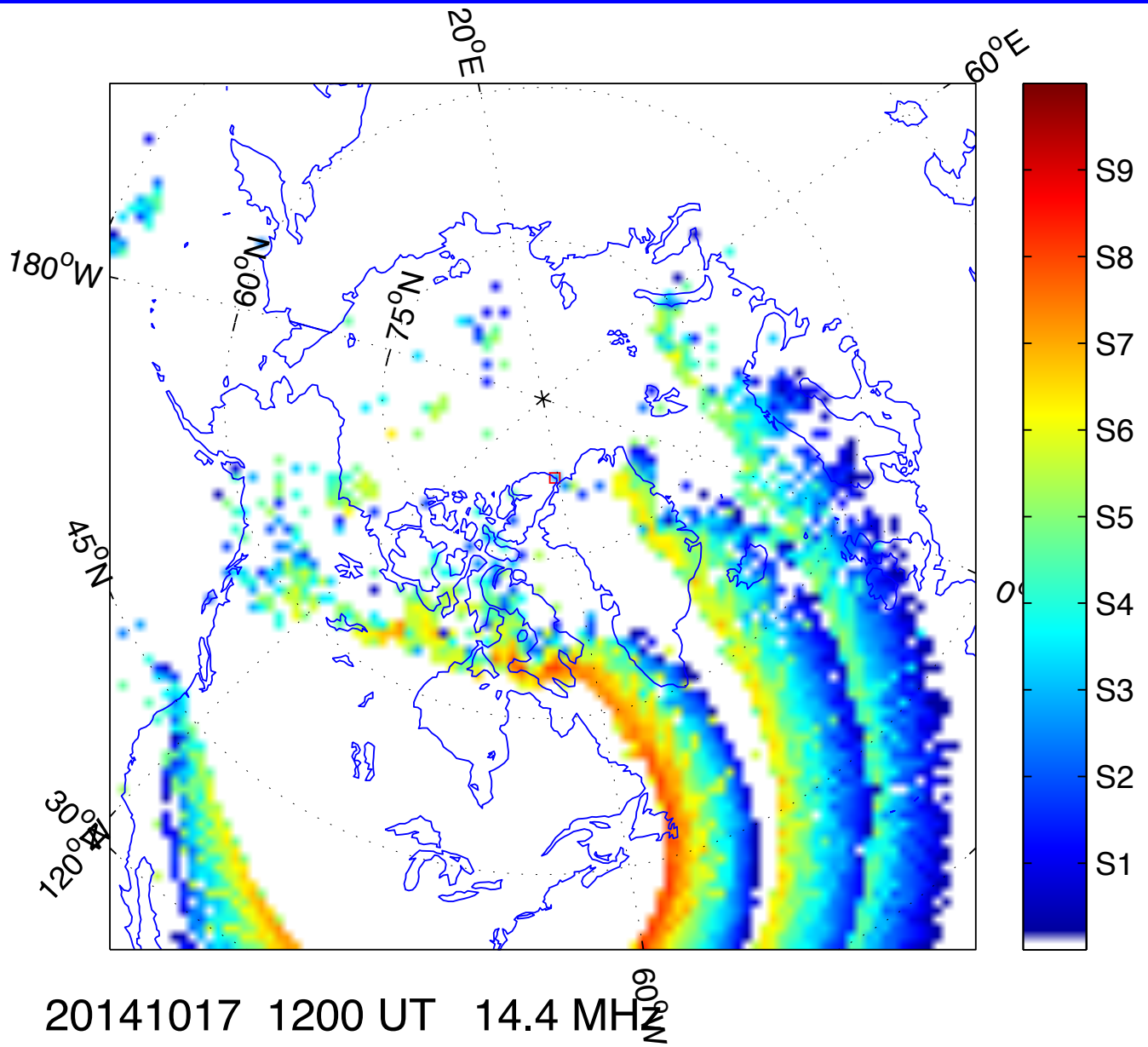
S4
S3
S2
S1
20141017 1200 UT 8.0 MHz


TOF (ms)
20
16
12
Azi (deg)
360
240
120
0
P (S–Units)
S9
S5
S1
16
17
18
Day in October 2014 (UT)


TOF (ms)
20
16
12
Azi (deg)
360
240
120
0
P (S–Units)
S9
S5
S1
16
17
18
Day in October 2014 (UT)


20°E
60°E
180°W
60°N
75°N
45°N
30°N
120°W
60°N
S9
S8
S7
S6
S5
S4
S3
S2
S1
20141017 1200 UT 14.4 MHz


20°E
60°E
180°W
60°N
75°N
45°N
30°N
120°W
60°N
S9
S8
S7
S6
S5
S4
S3
S2
S1
20141017 1200 UT 14.4 MHz

Concluding remarks

- Combined ray-tracing model of the high latitude ionosphere with D-region absorption model
- Good fit to observations
- Currently developing the model to assimilate data from real-time sources to produce accurate nowcasts (frequency management) for trans-polar flights
- Longer term aim is to be able to forecast HF propagation conditions several hours ahead and to provide this information for airline despatchers

Thank you for your attention