Intensity and localisation of African storm centre based on data from ELF station

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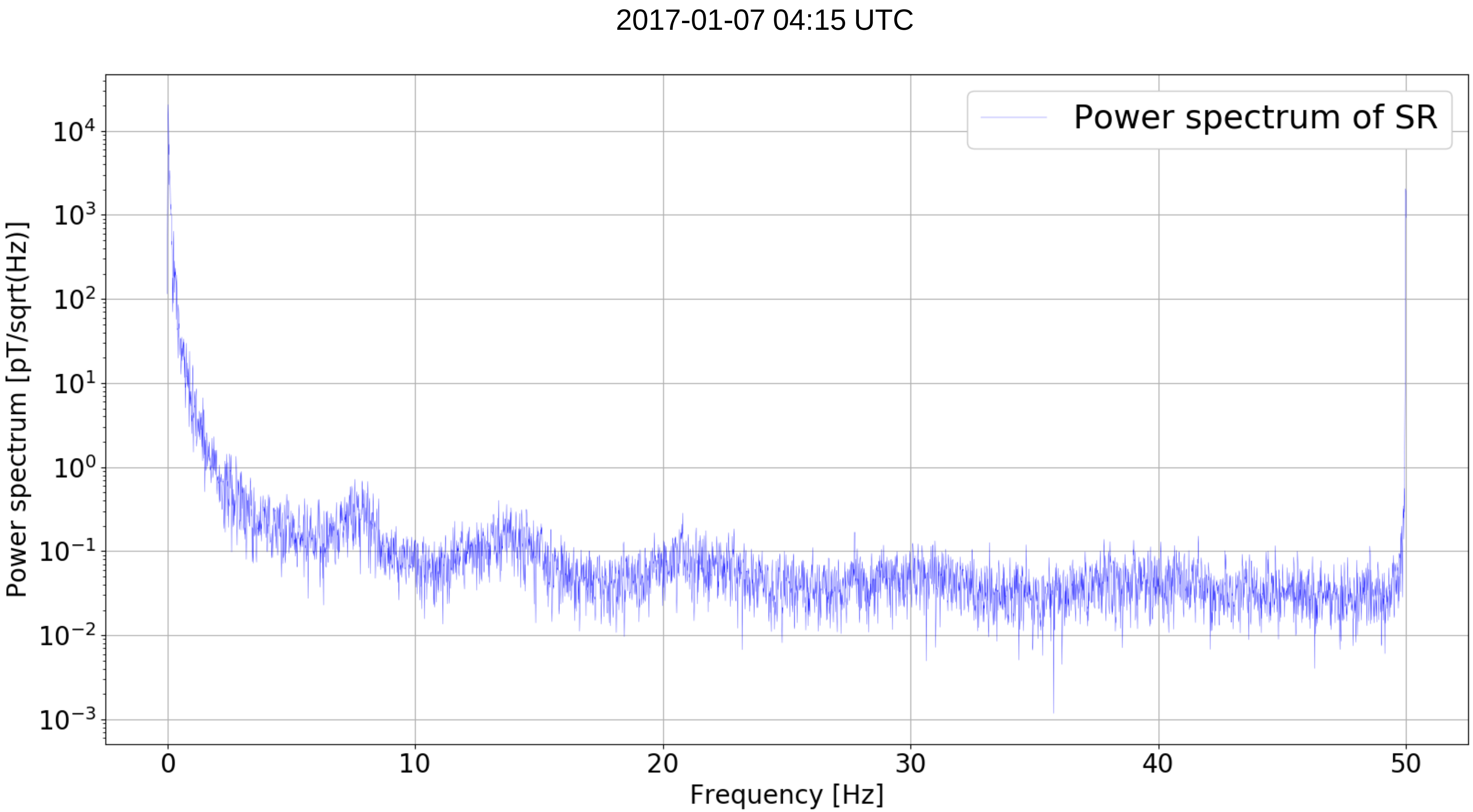
Plan of presentation:

- Brief review of the decomposition method
- Thunderstorm detection and intensity
- Maps 1D and diagrams
- 2D maps (ideas etc.)

Schumann Resonance (SR):

- Process excited by global thunderstorm activity;
- Typical spectrum contains 7 peaks;
- Earth-Ionosphere cavity causes strong damping;
- Resonance peaks contain travelling and standing waves;
- Asymmetry of the power spectrum caused by travelling waves;
- Decomposition solves problem of asymmetry;

An example of FFT from Hylaty



Field Decomposition method

$$W(f,\theta) = s + \frac{z}{f^m} + \sum_{k=1}^{N} \frac{p_k(\theta)[1 + e_k(\theta)(f - f_k)]}{(f - f_k)^2 + (\frac{g_k}{2})^2}$$

Kulak et al. 2006

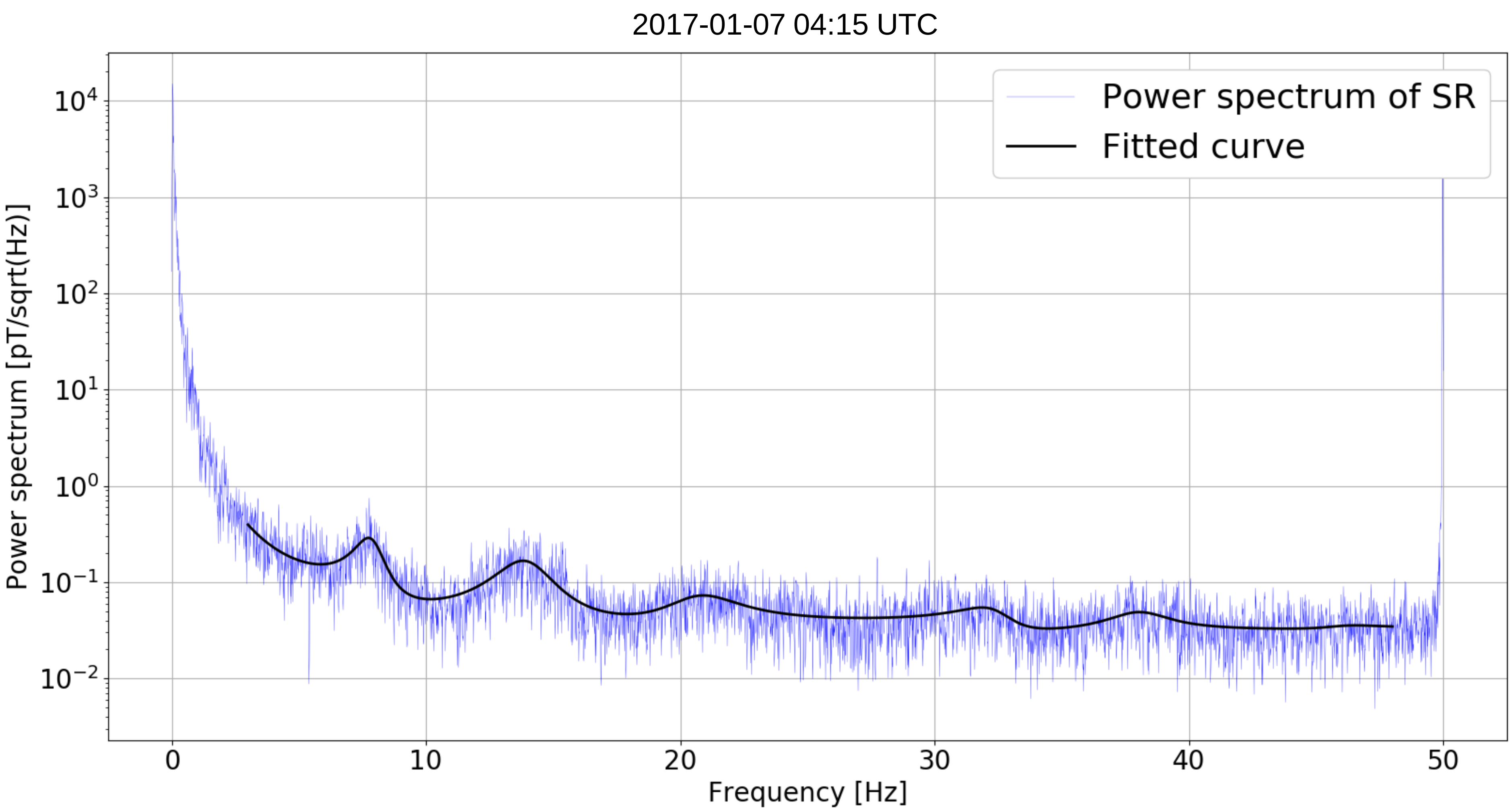
$W(f,\theta)$ [T^2/Hz] – decomposition curve
s – white noise term [T^2/Hz]
z/f^m – color noise term , z -> [$Hz^{m-1}T^2$]
p_k – power parameter of k^{th} mode [T^2Hz]
e_k – asymmetry parameter [Hz^{-1}]
f_k – resonant (intrinsic) frequency [Hz]
g_k – peak width [Hz]
N = 7 in our case

Lack of asymmetry
$e_k = 0$

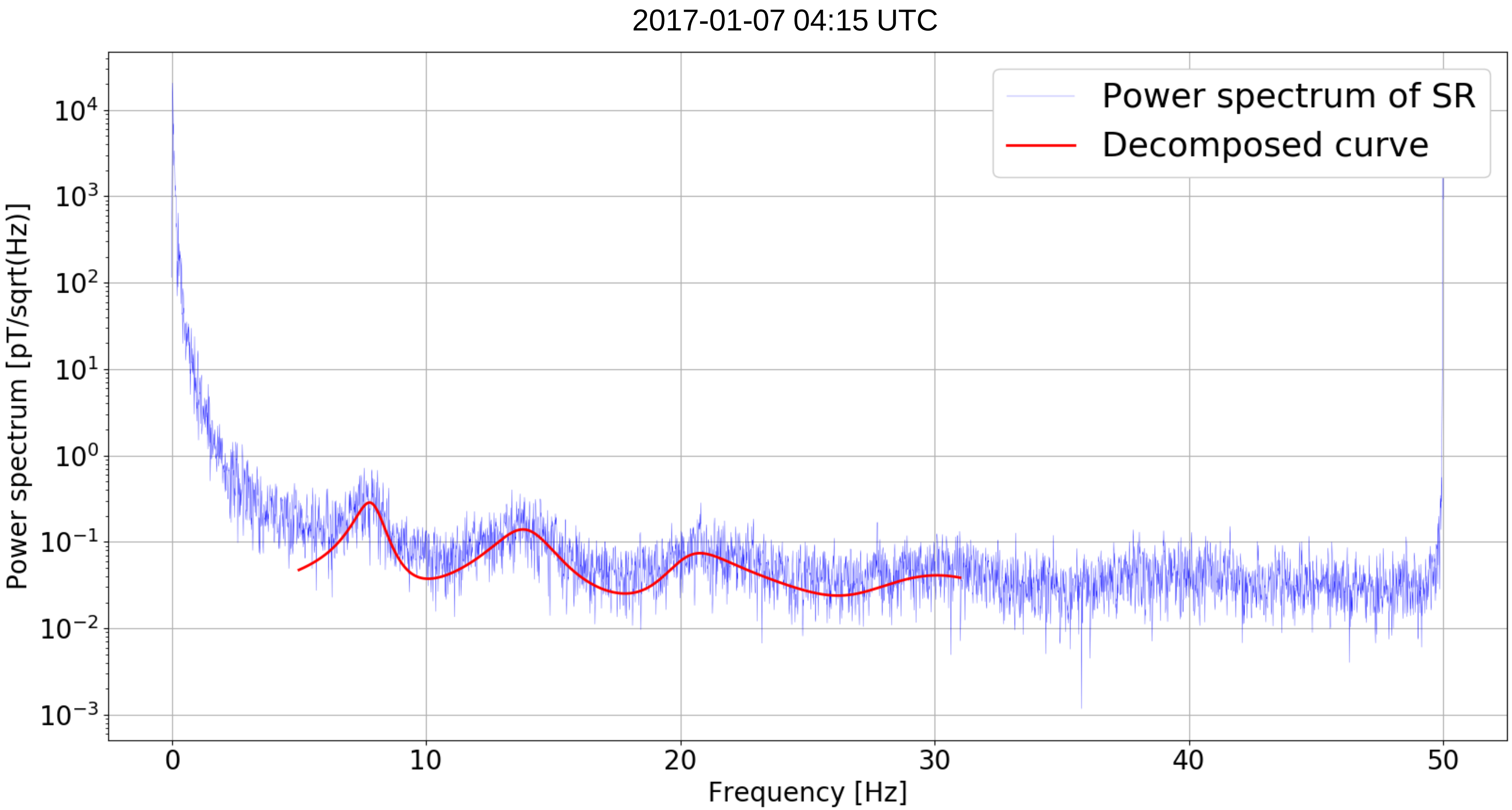
Lorentzian Curve
but $f_k \to f_k^*(\theta)$
all parameters – classical meanings

Parameter m:
<m> = 2.06

Fitted curve



Symmetrical curve without 1/f noise



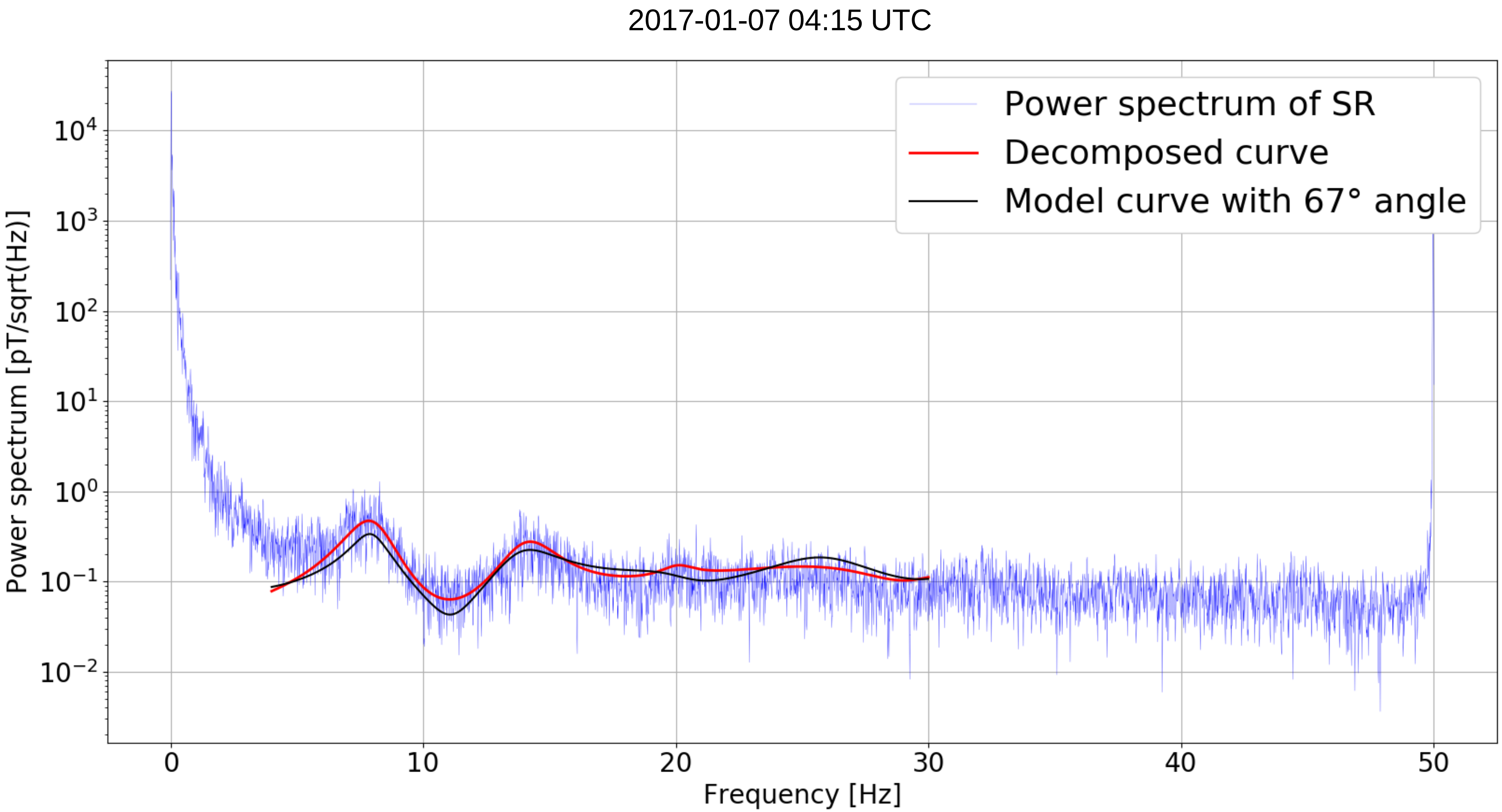
Storm centre localisation:

- Comparison between decomposed curve and analytical modelled curves (20 - 90°);

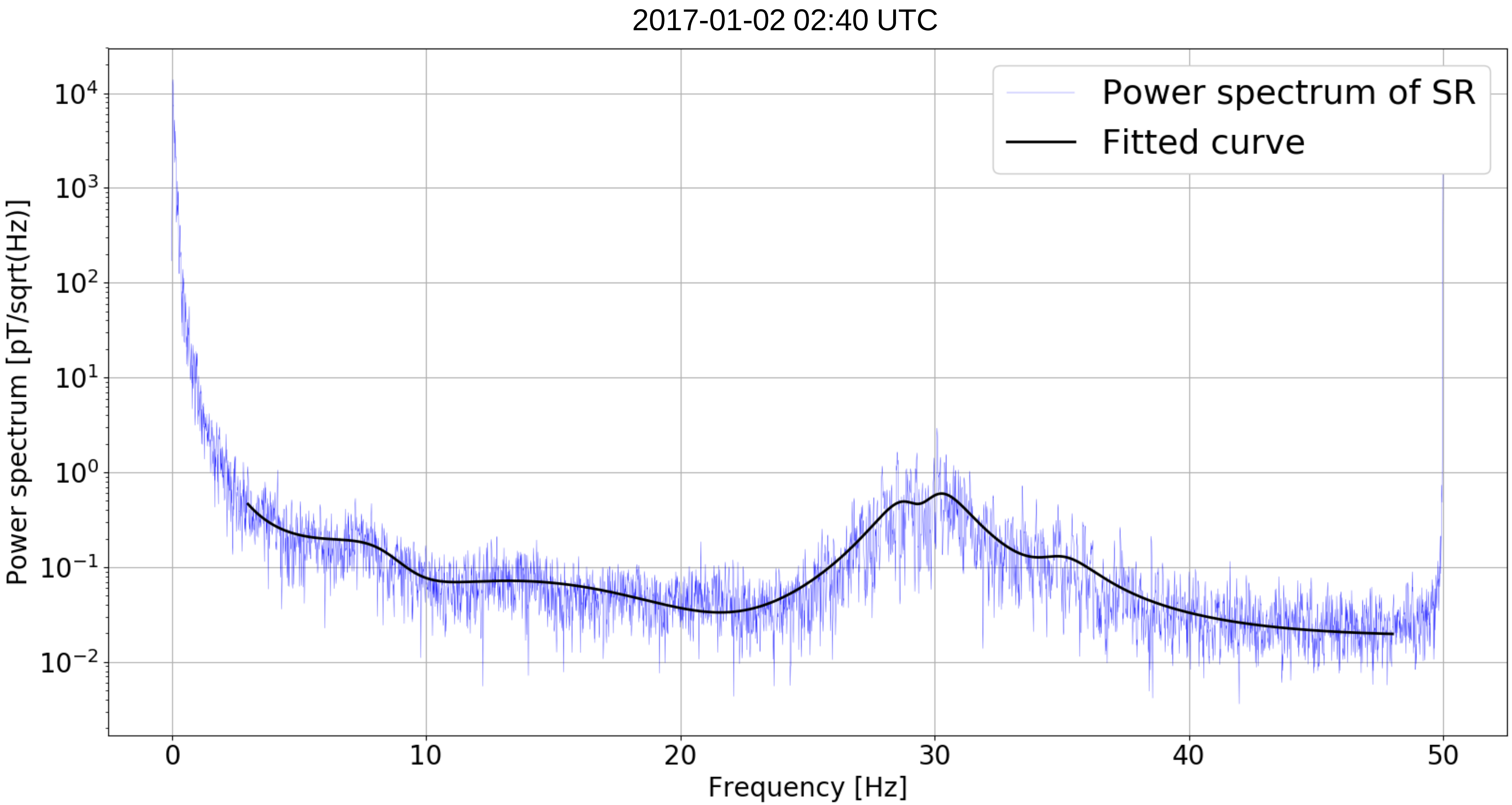
- Resolution of model is equal to 1°;

- Using chisquare method to compare curves;

Comparison between model and decomposition curve

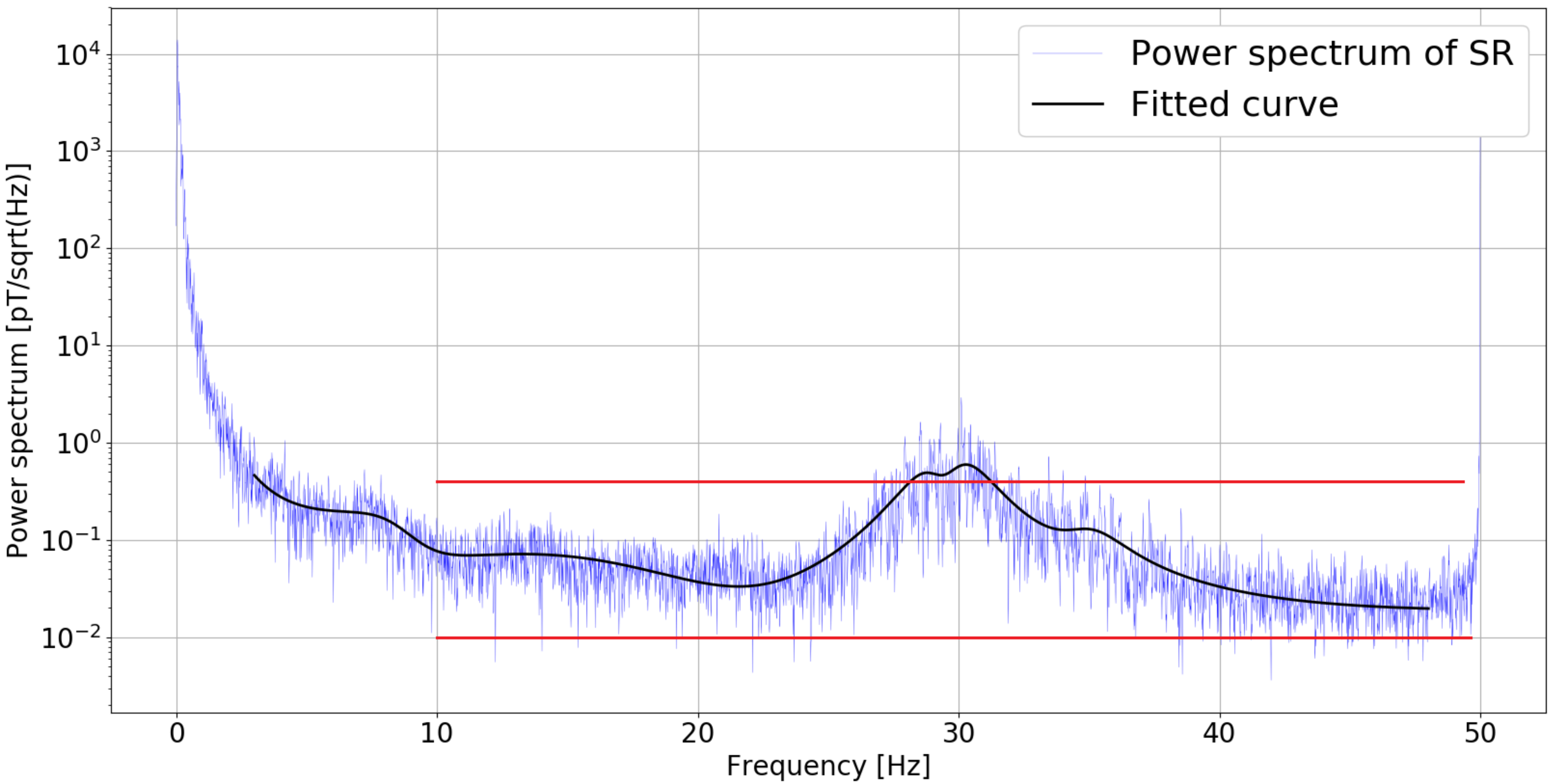


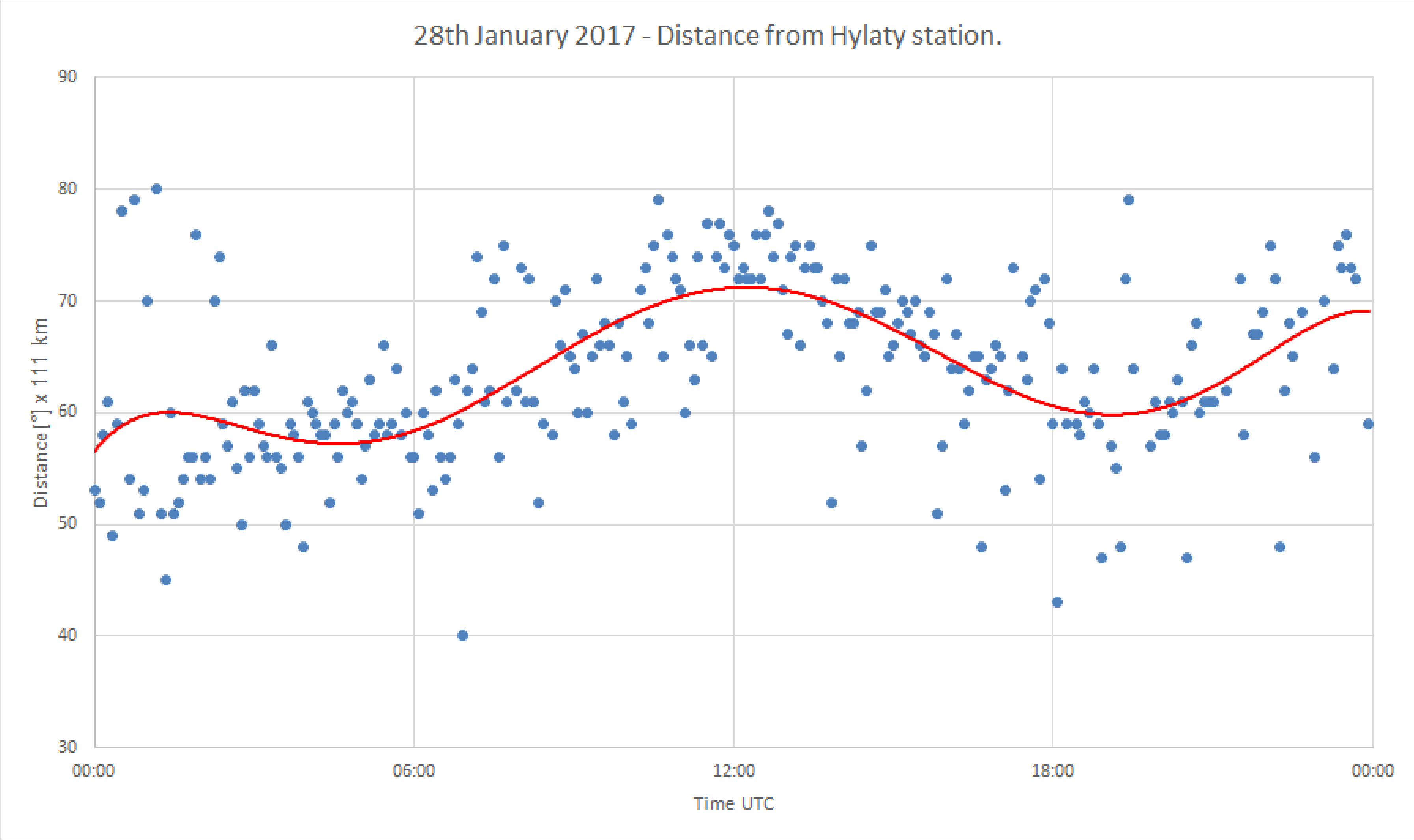
Capturing errors



Capturing errors

2017-01-02 02:40 UTC





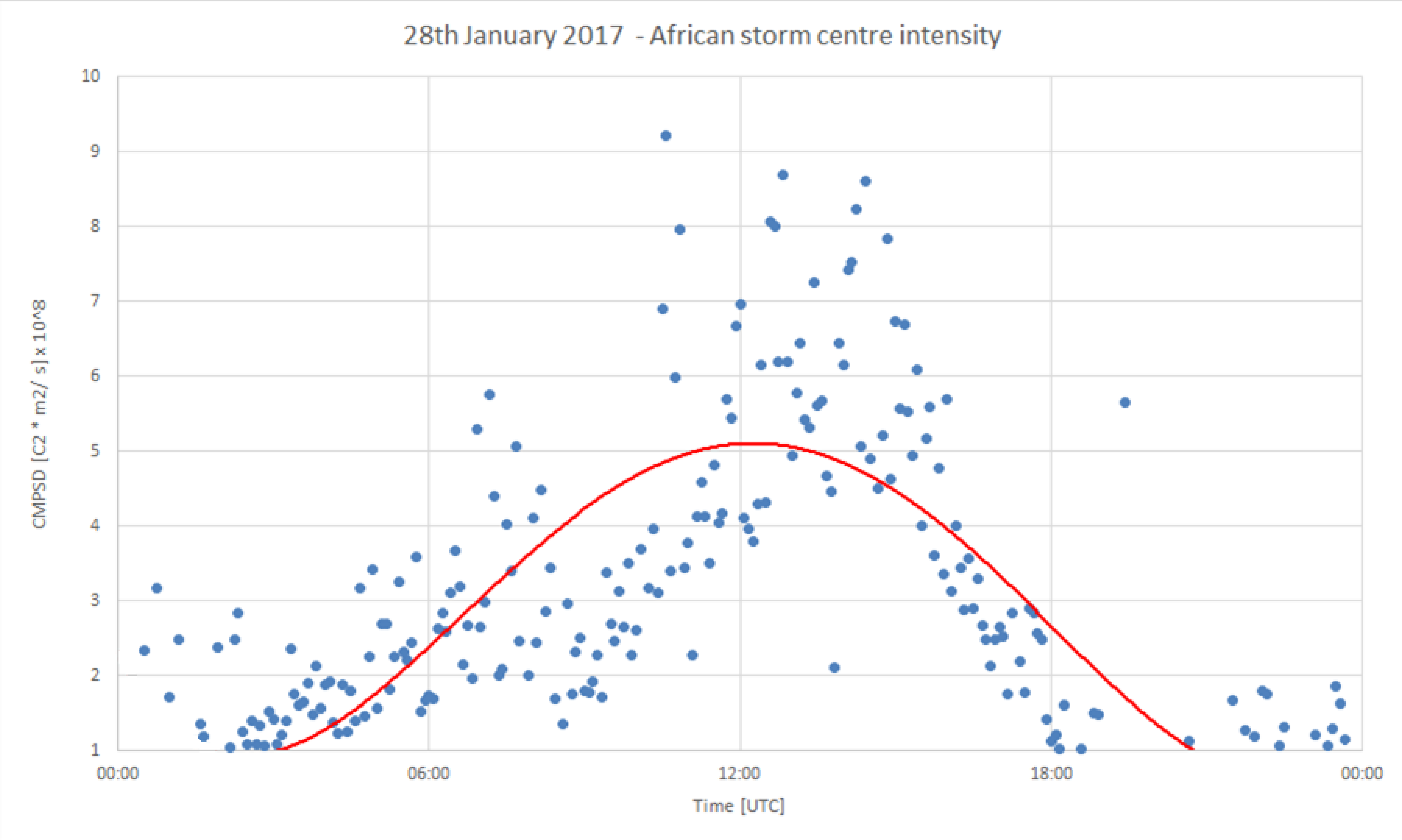
28th January 2017 - Distance from Hylaty station.
90
80
70
60
50
40
30
Distance [°] x 111 km
00:00
06:00
12:00
18:00
00:00
Time UTC

How to measure thunderstorm activity:

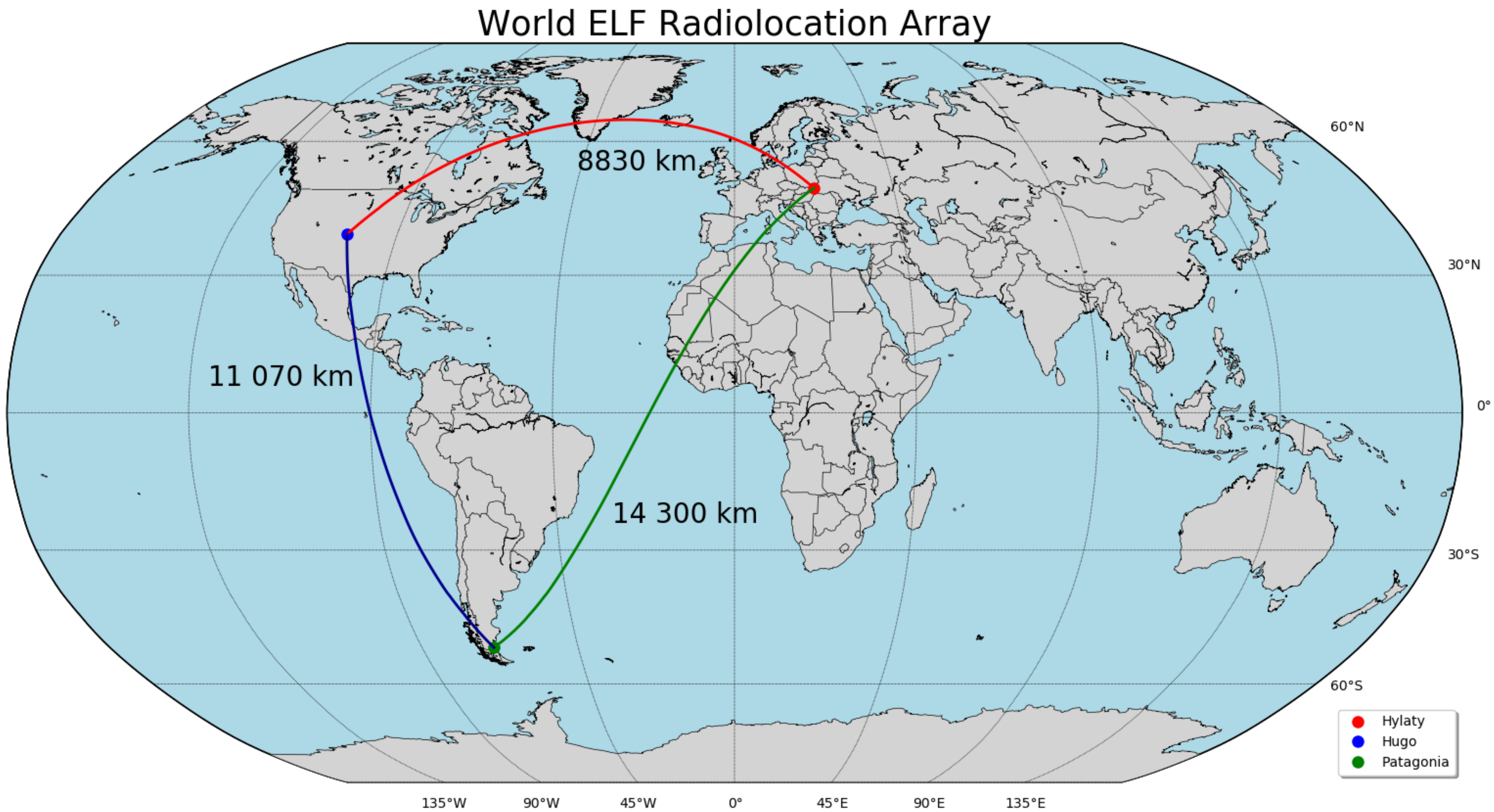
- Solved cavity model shows relations between spectral power density of the magnetic field and Current Moment Power Spectrum Density (CMPSD)

$$|B_n(\theta, f_n)|^2 = C_n D_n(\theta) < \lambda >< p >^2$$

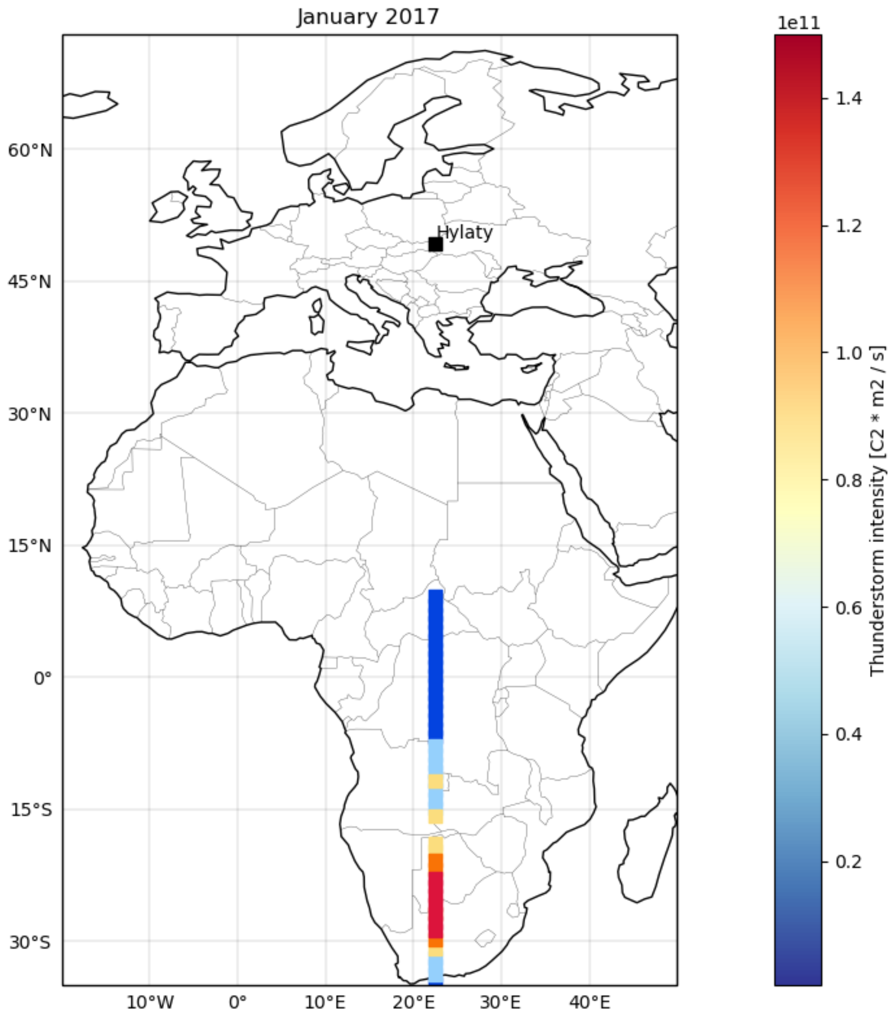
$< \lambda >$	[1/s] – discharges per second
$< p >^2$	[C m] – dipole moment
$D_n(\theta)$	Mode function dependant on the distance to the thunderstorm
C_n	Constans dependant on the cavity damping

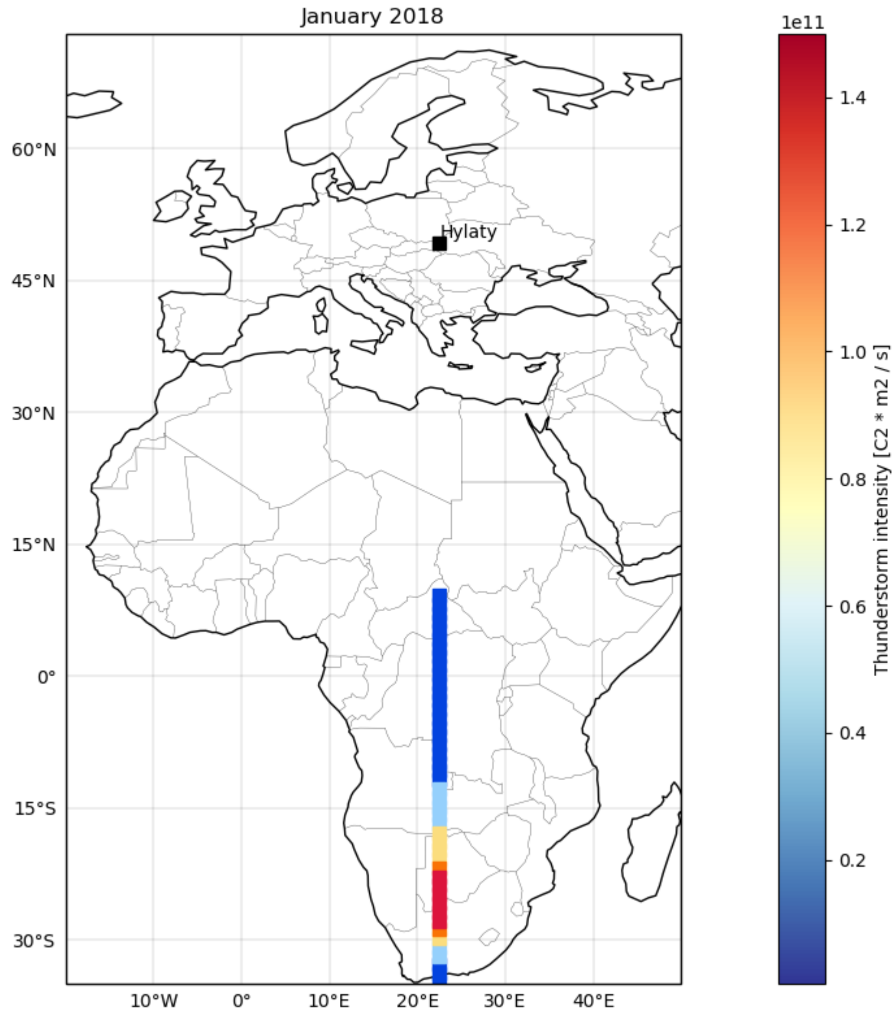


28th January 2017 - African storm centre intensity
CMPSD [C2 * m2/ s] x 10^8
10
9
8
7
6
5
4
3
2
1
00:00
06:00
12:00
18:00
00:00
Time [UTC]

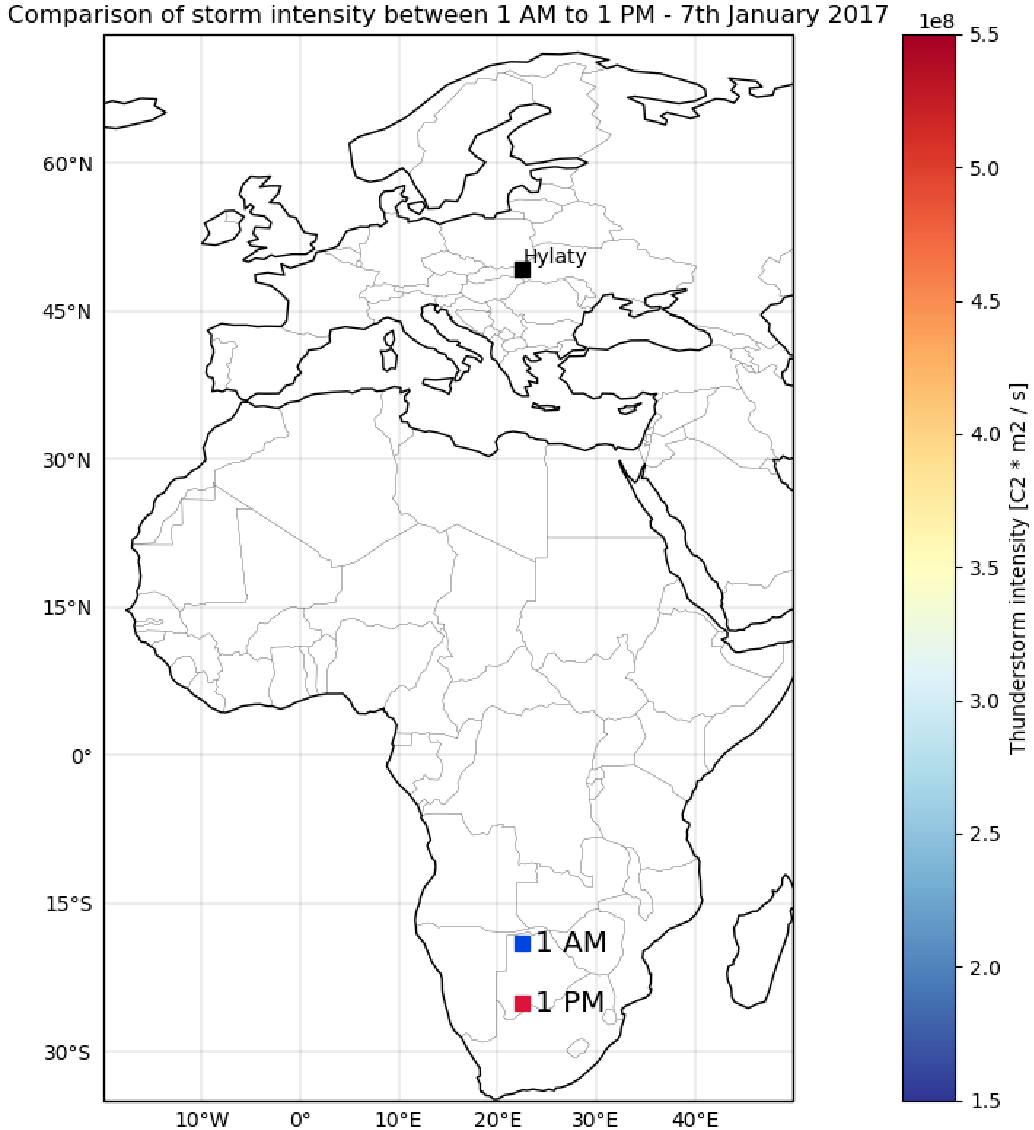

World ELF Radiolocation Array
8830 km
11 070 km
14 300 km
60°N
30°N
0°
30°S
60°S
135°W
90°W
45°W
0°
45°E
90°E
135°E
Hylaty
Hugo
Patagonia

African storm centre activity in years 2017 and 2018

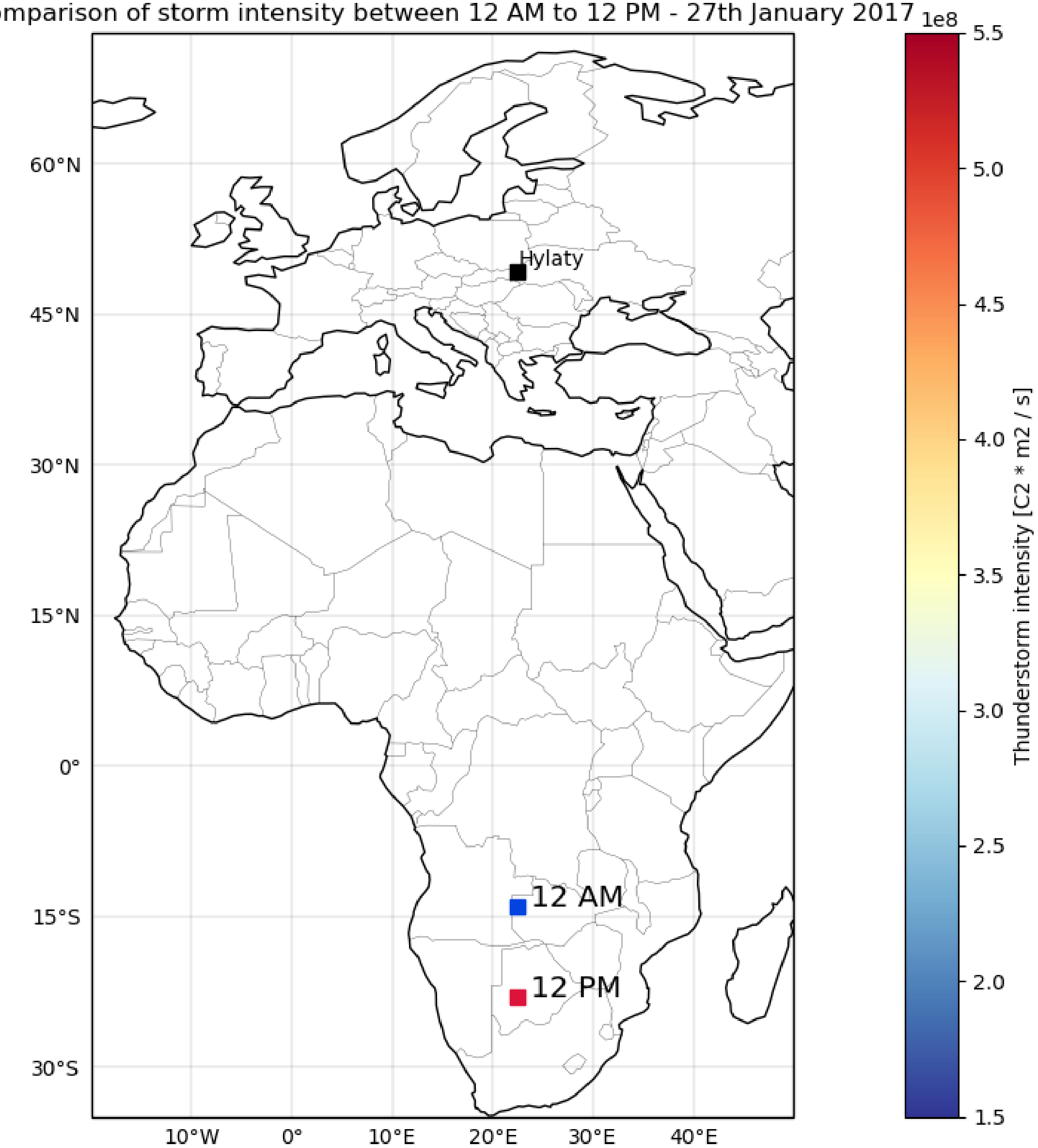




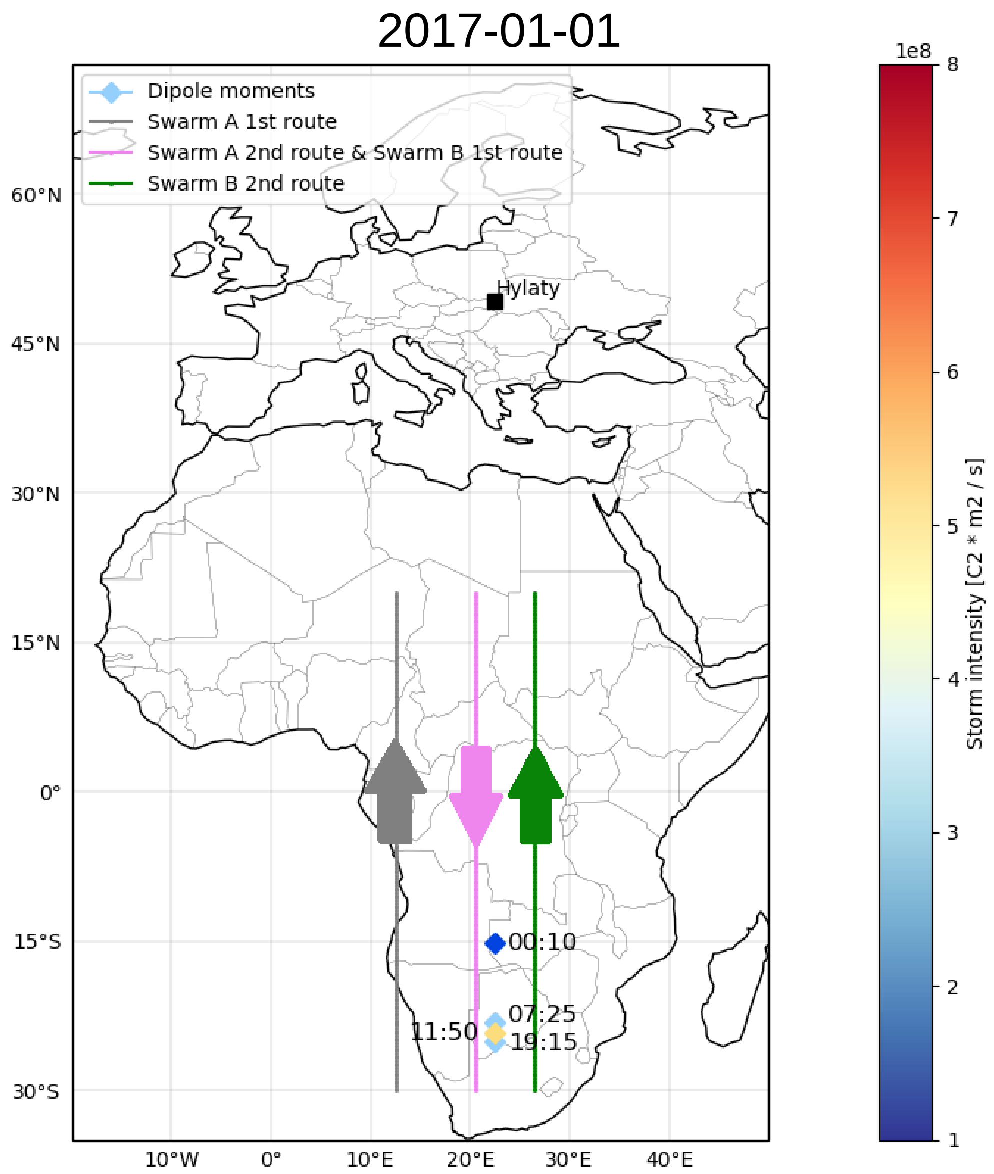
Daily activity of african storm centre

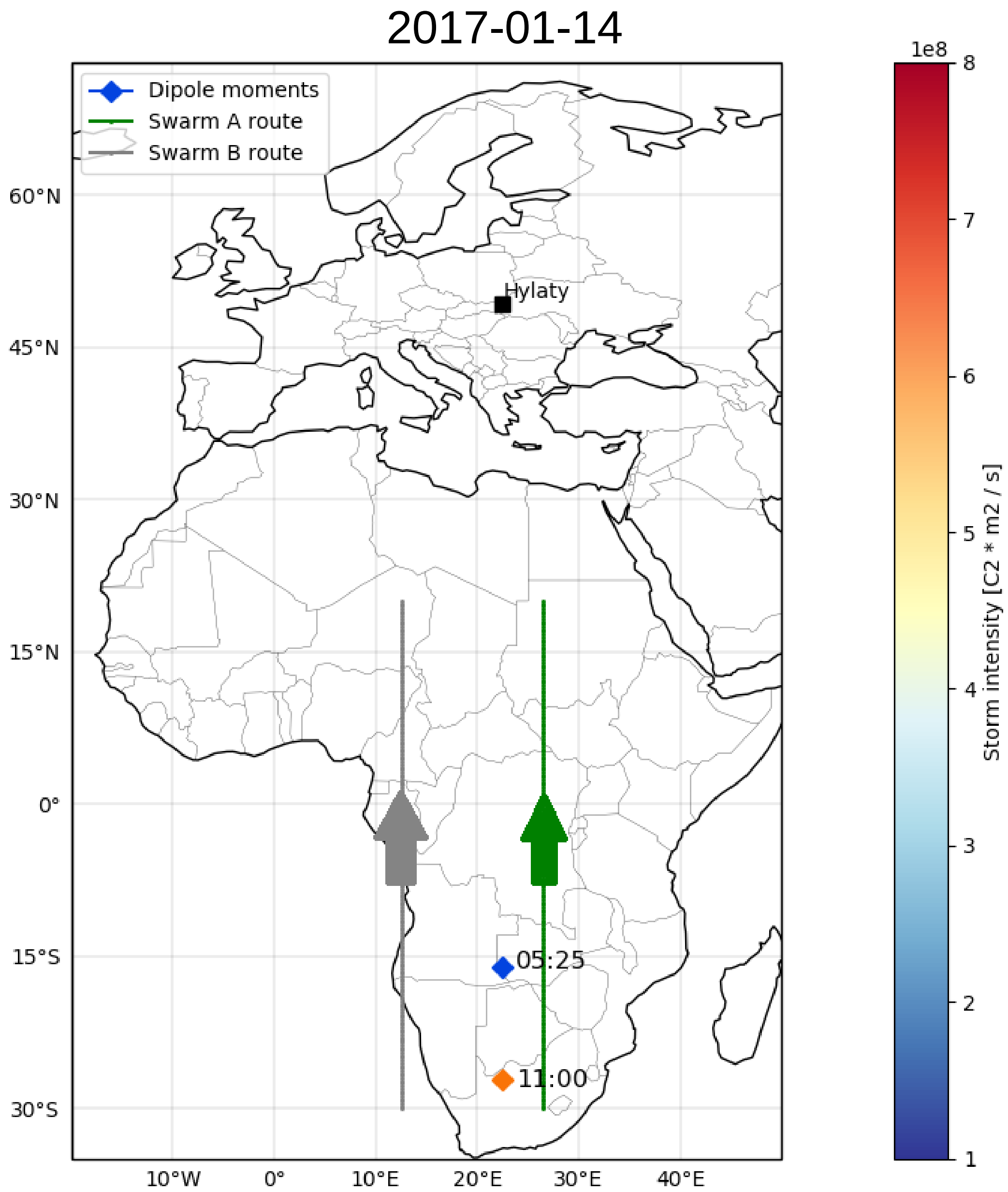


Comparison of storm intensity between 12 AM to 12 PM - 27th January 2017

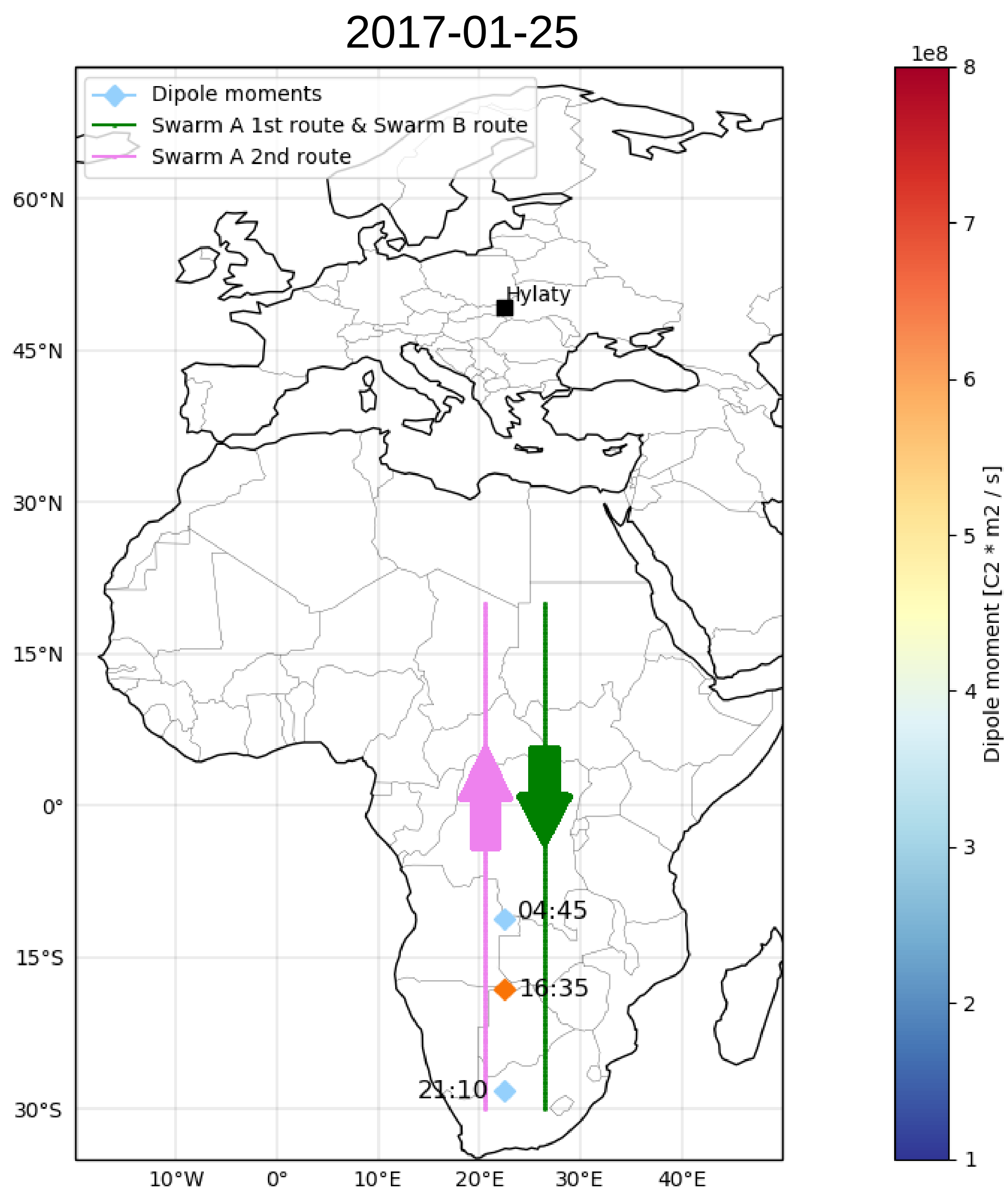


Swarm A & B flybys with distances to African storm centre measured by Hylaty station.

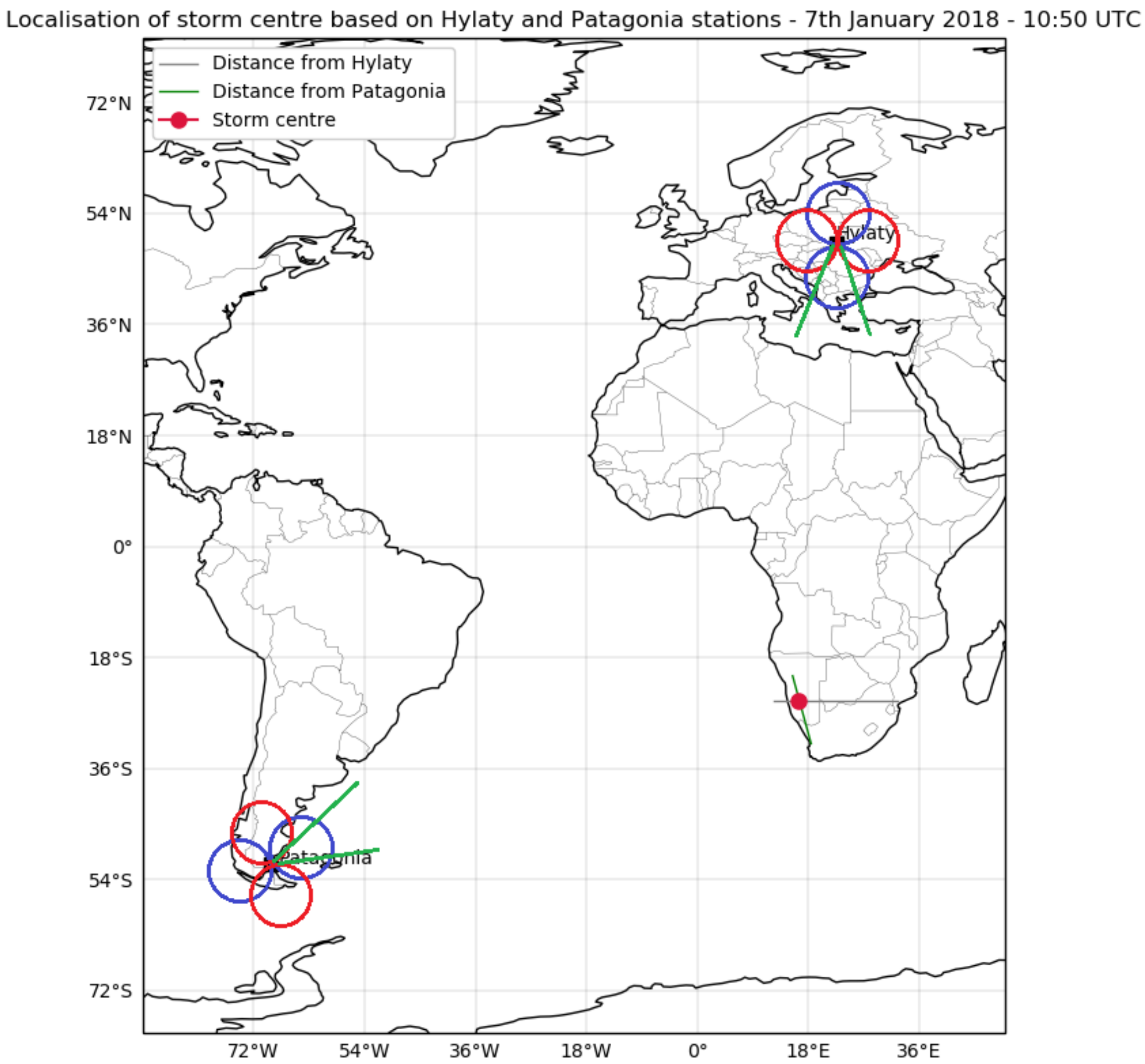




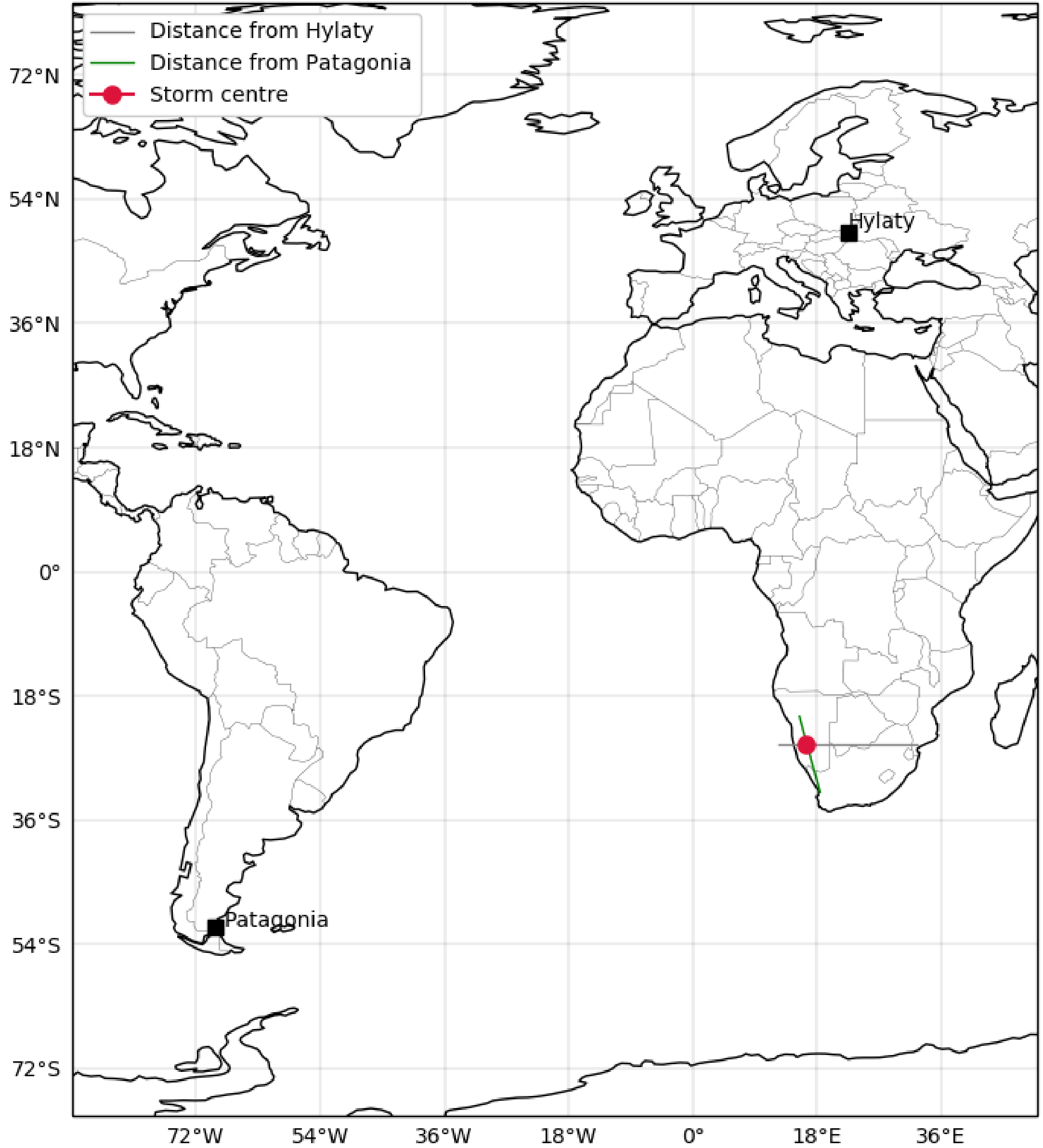
2017-01-14
Dipole moments
Swarm A route
Swarm B route
Hylaty
05:25
11:00
60°N
45°N
30°N
15°N
0°
15°S
30°S
10°W
0°
10°E
20°E
30°E
40°E
1e8
8
7
6
5
4
3
2
1
Storm intensity [C2 * m2 / s]

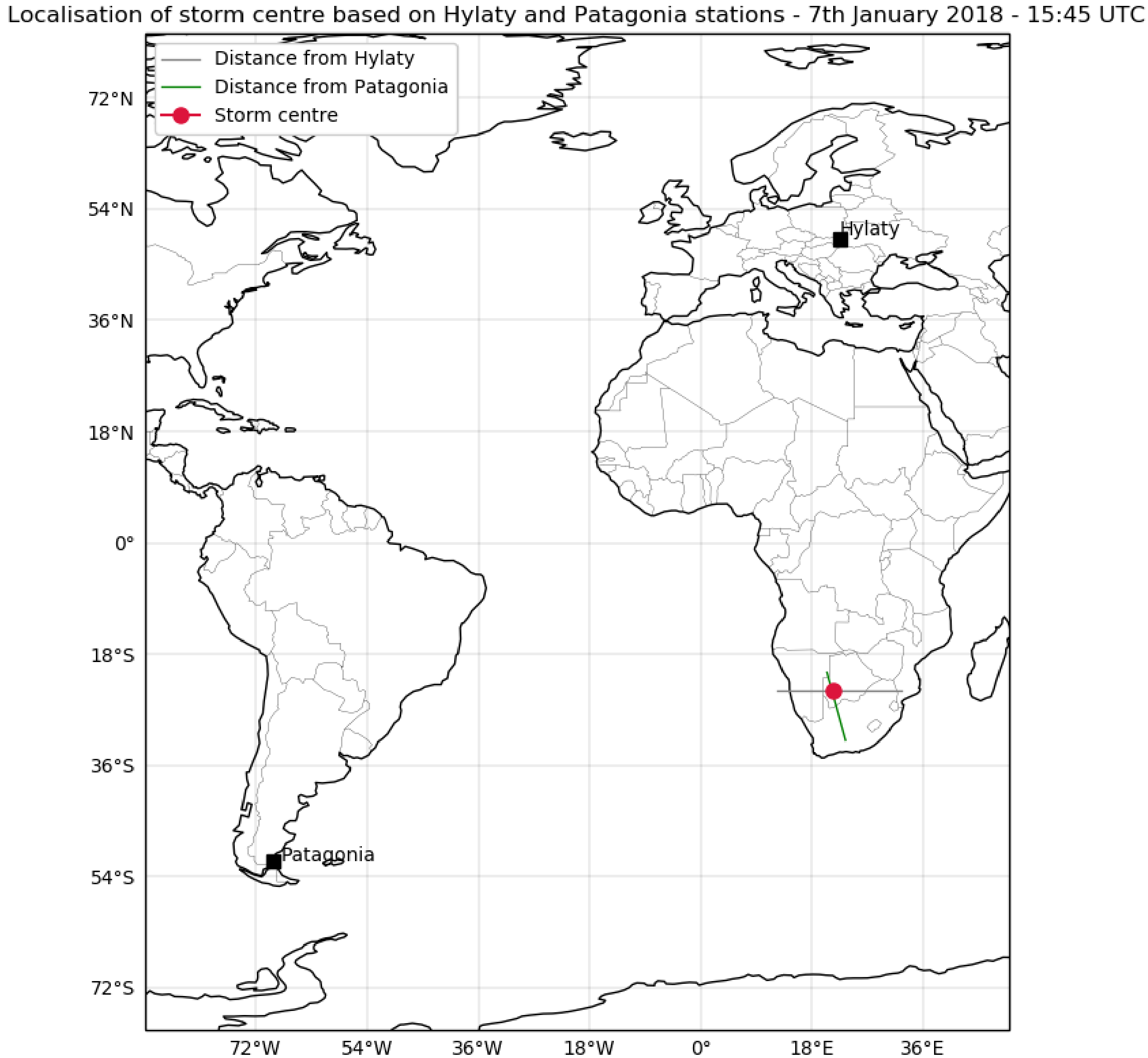

2017-01-25
Dipole moments
Swarm A 1st route & Swarm B route
Swarm A 2nd route
Hylaty
04:45
16:35
21:10
60°N
45°N
30°N
15°N
0°
15°S
30°S
10°W
0°
10°E
20°E
30°E
40°E
1e8
8
7
6
5
4
3
2
1
Dipole moment [C2 * m2 / s]

Example of dipole antennas regarding to 2D mapping



Localisation of storm centre based on Hylaty and Patagonia stations - 7th January 2018 - 10:50 UTC




Localisation of storm centre based on Hylaty and Patagonia stations - 7th January 2018 - 15:45 UTC
Distance from Hylaty
Distance from Patagonia
Storm centre
Hylaty
Patagonia
72°N
54°N
36°N
18°N
0°
18°S
36°S
54°S
72°S
72°W
54°W
36°W
18°W
0°
18°E
36°E

What’s next?

Thank you