Simulations of the April 2024 Total Solar Eclipse

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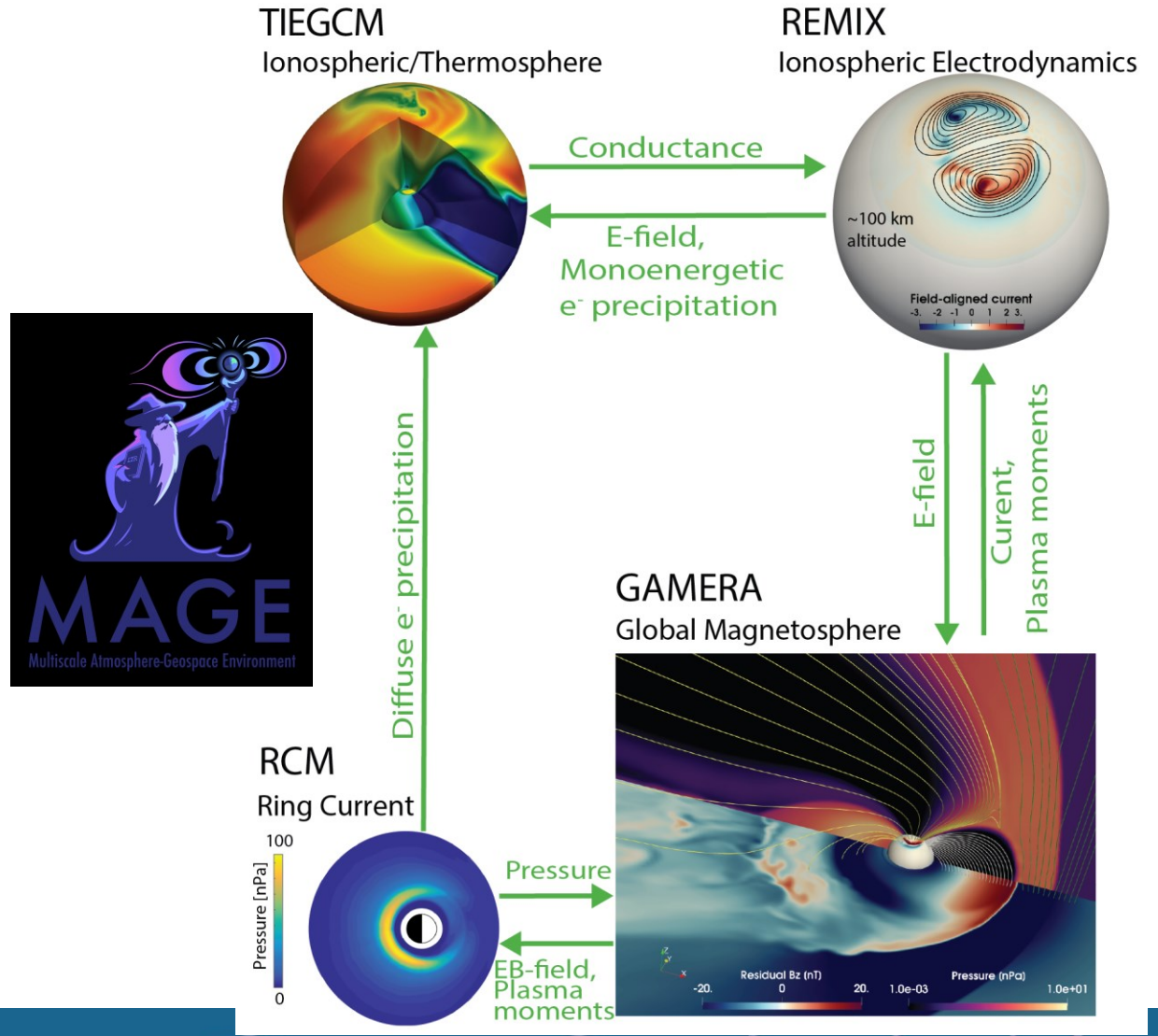
Multiscale Atmosphere Geospace Environment Model (MAGE)
Fully Coupled Geospace Model with High Resolving Power

- TIEGCM – The coupled thermosphere-ionosphere system and where solar eclipse has a direct impact
- REMIX – Ionospheric electrodynamic solver that calculates the high-latitude potential, convection electric field, and monoenergetic precipitation
- GAMERA – MHD model of the magnetosphere
- RCM – Inner magnetosphere model that includes drift physics to produce better informed diffuse precipitation and to model the ring current

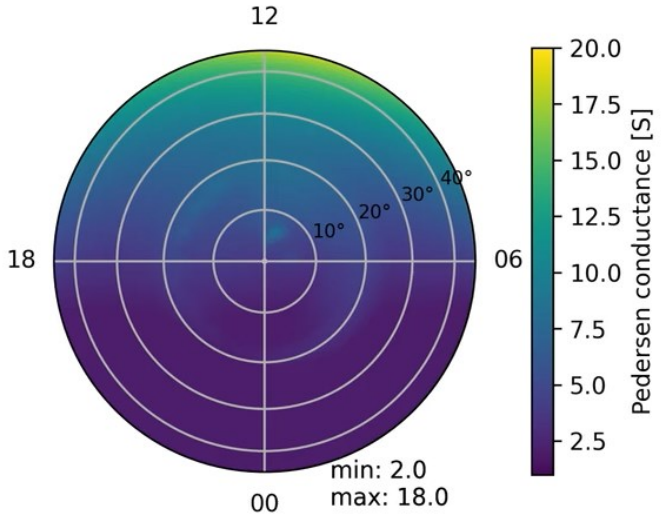


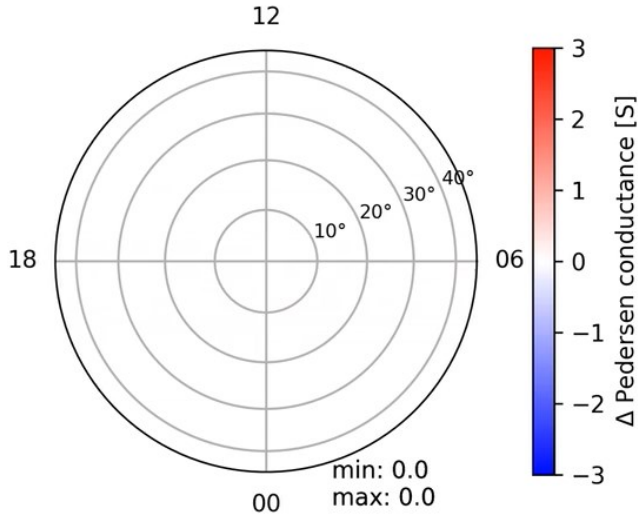
No Eclipse

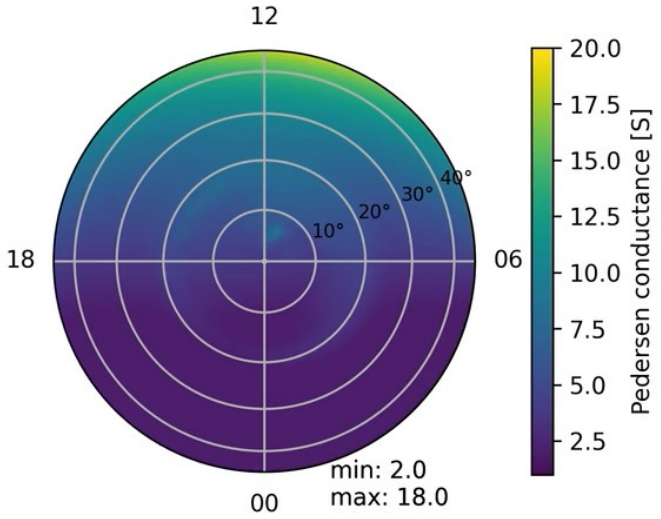
Eclipse

MIX
2024-04-08 13:00:00.165

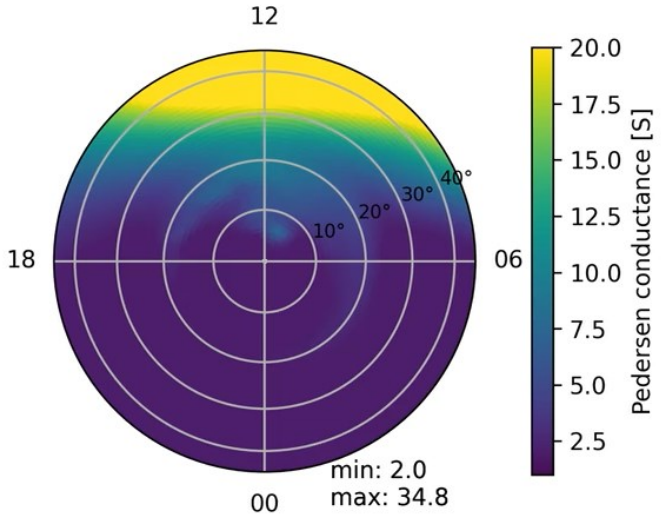
NH

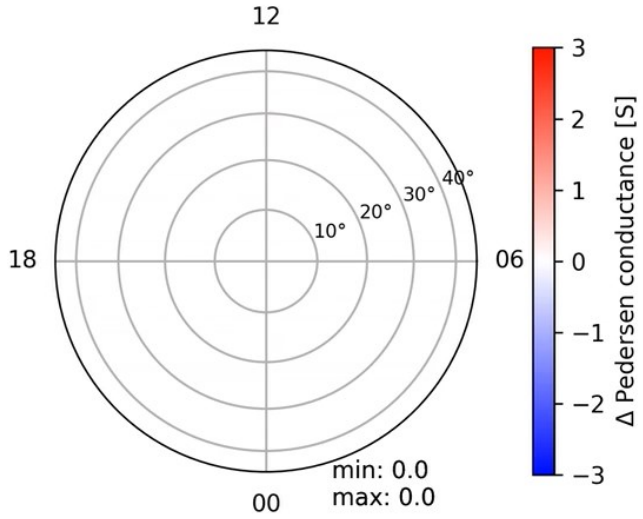


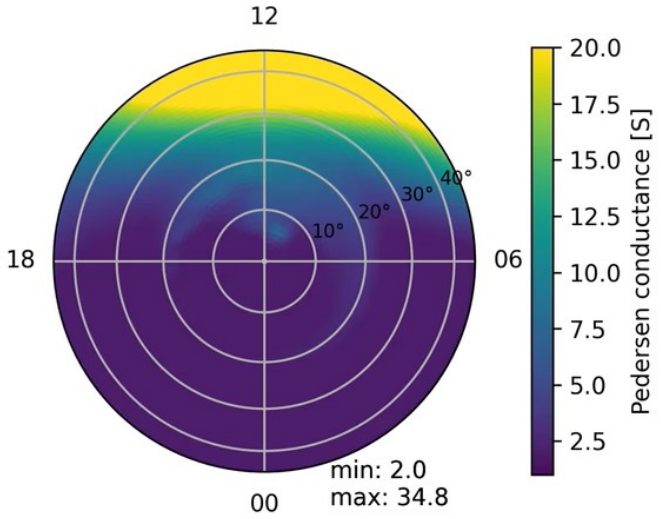




SH







IMF By = -5 nT

Solar Wind Conditions for MAGE Simulations

- First initialized using: 2hr of -5nT Bz, 2hr of +5nT Bz

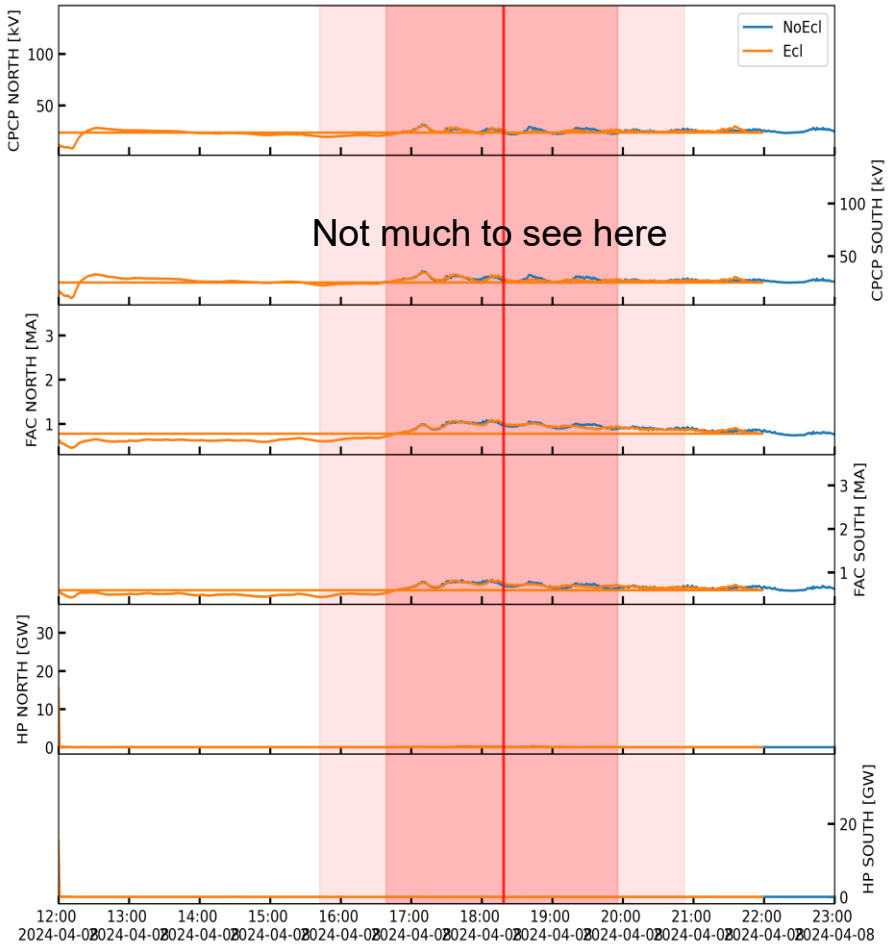
- Then we pick something for event

- |B| = 0 nT (suppose to be quiet….)
- By = -1nT, -5nT
- Bz = -1nT, -5nT

- Everything else is kept constant: 5/cc, -400 km/s Vx, Vy=Vz=Bx=0

Event	UTC Time
First location to see the partial eclipse begin	Apr 8 at 15:42:15
First location to see the full eclipse begin	Apr 8 at 16:38:52
Maximum Eclipse	Apr 8 at 18:17:21
Last location to see the full eclipse end	Apr 8 at 19:55:35
Last location to see the partial eclipse end	Apr 8 at 20:52:19

0B

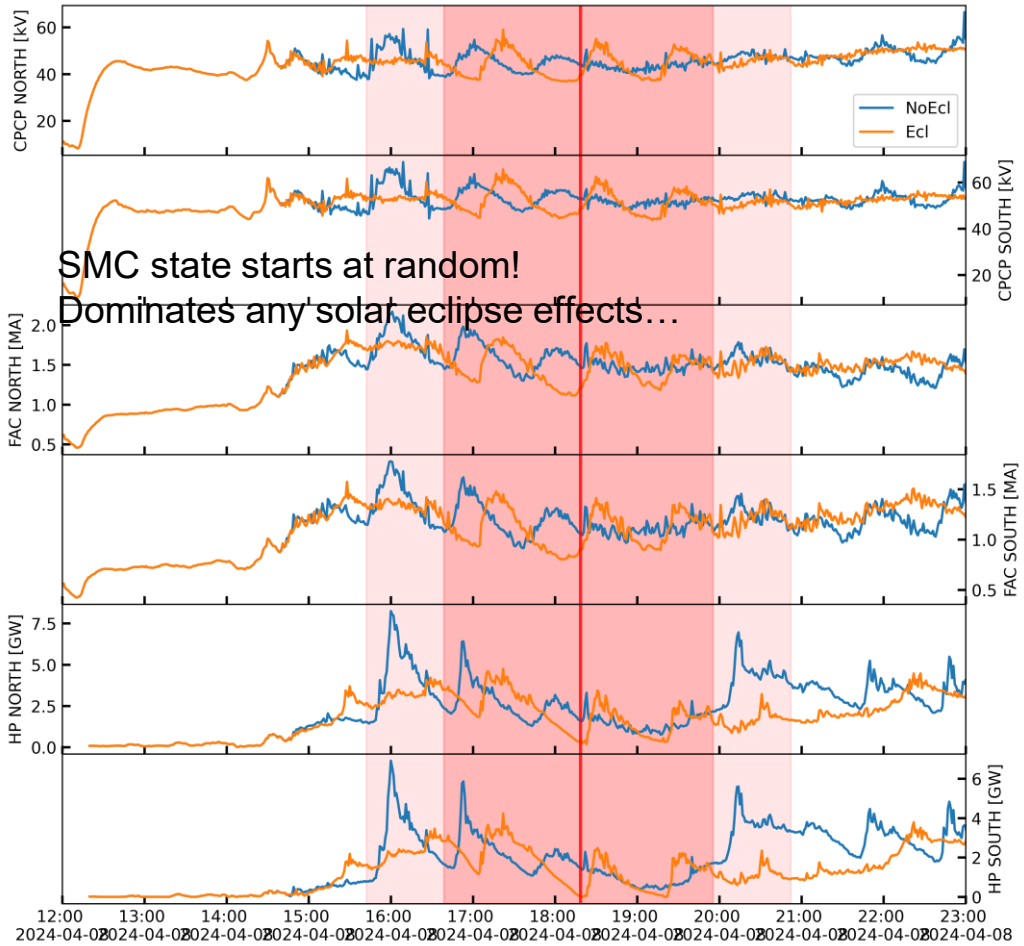


CPCP
NH
SH

FAC
NH
SH

HP
NH
SH

-1nT Bz

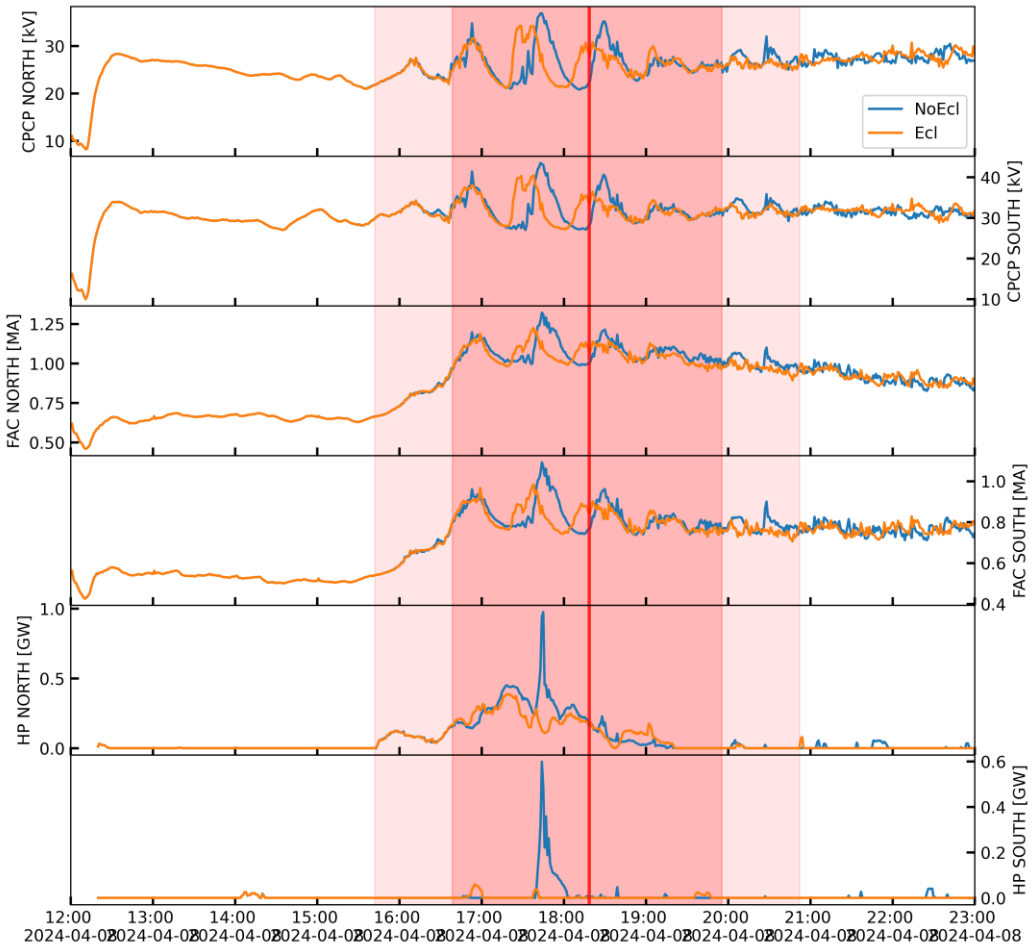


Not affect viscous interaction, conductance affects reconnection

SMC: Steady magnetospheric convection

By = -1 nT

Difference: eclipse - non eclipse



CPCP

NH

SH

FAC

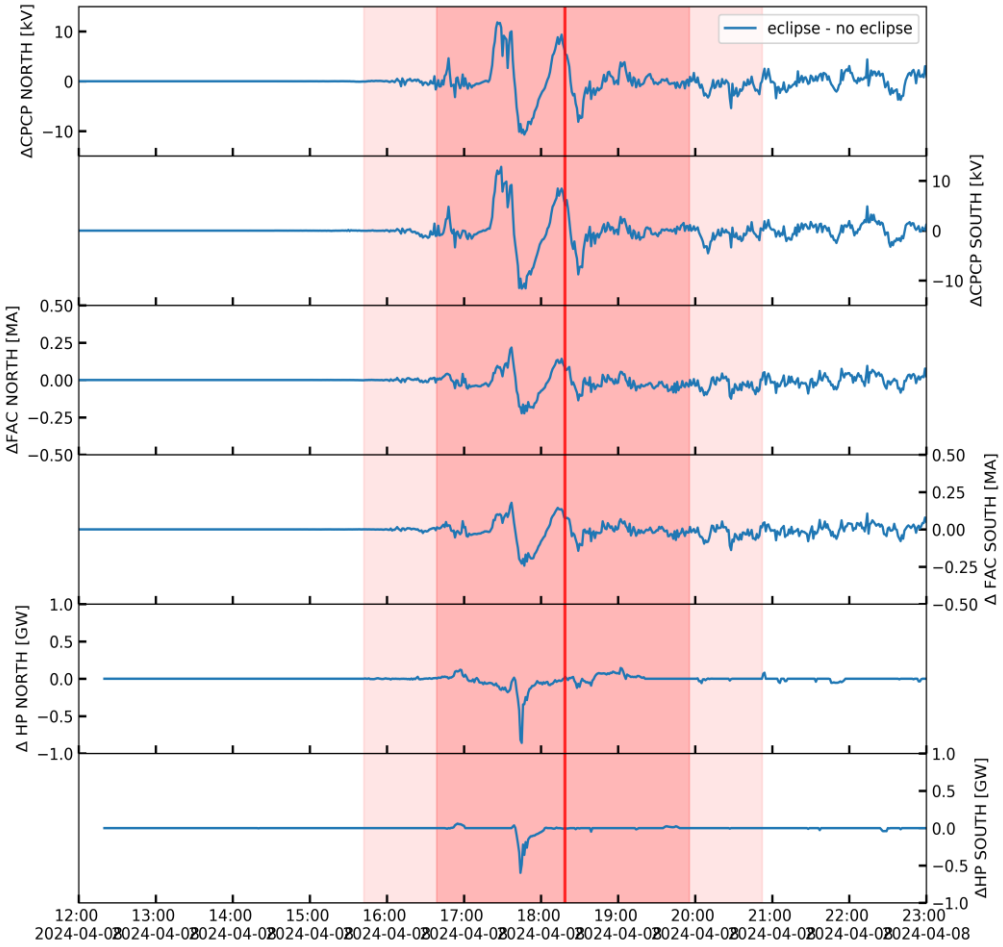
NH

SH

HP

NH

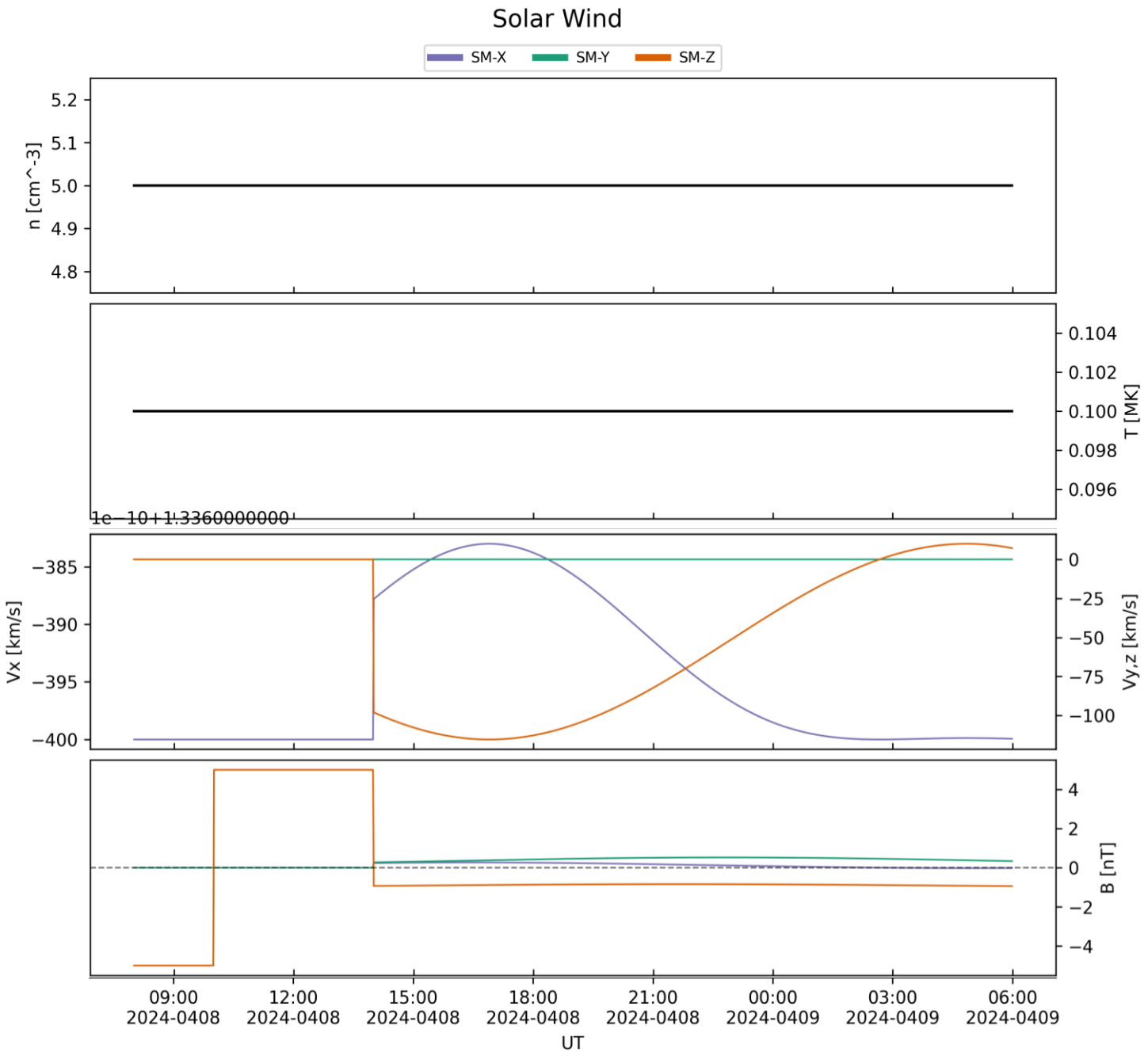
SH



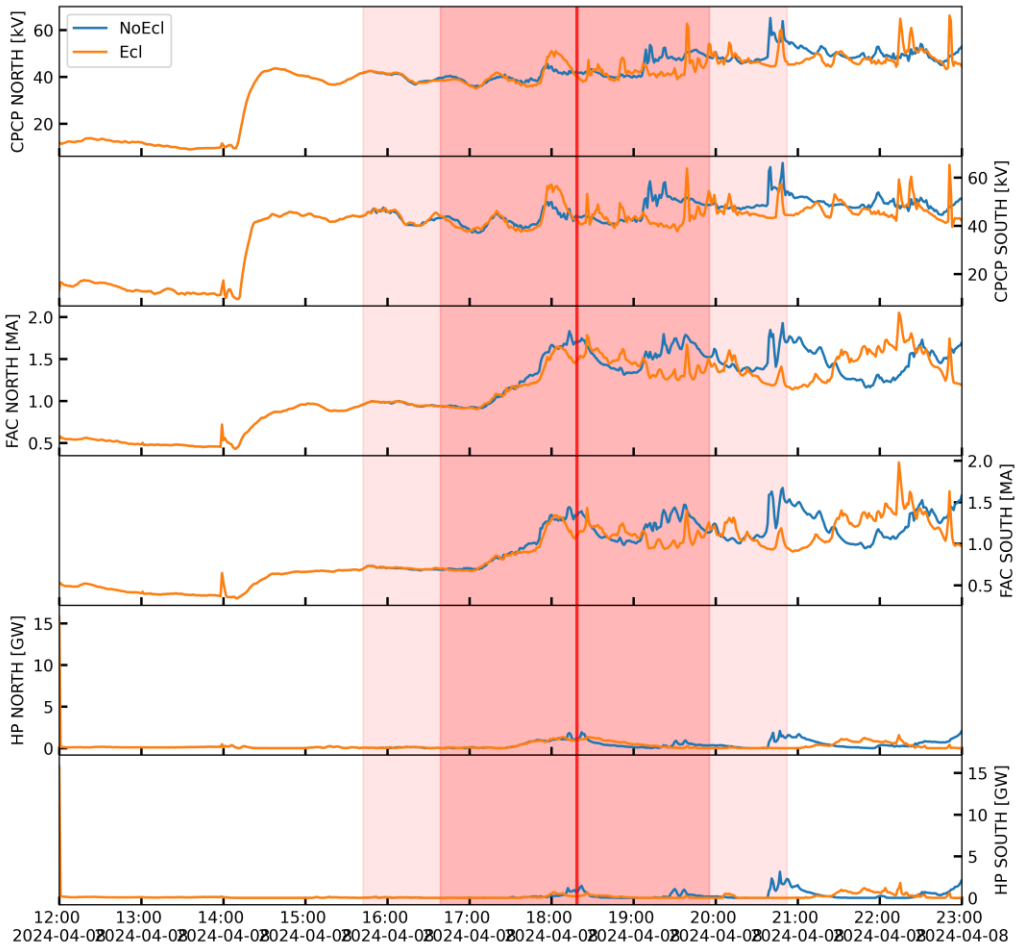
Big change in CPCP, about 30%, peak occurs earlier and smaller in eclipse case.
Energy releases earlier and not builds up as much, eclipse affects the build up of the energy

Preventing SMC state?

- Super steady is not the right way
- Let's add a diurnal variation
  - GSE -> SM
- Start closer to the eclipse



Bz = -1nT



CPCP

NH

SH

FAC

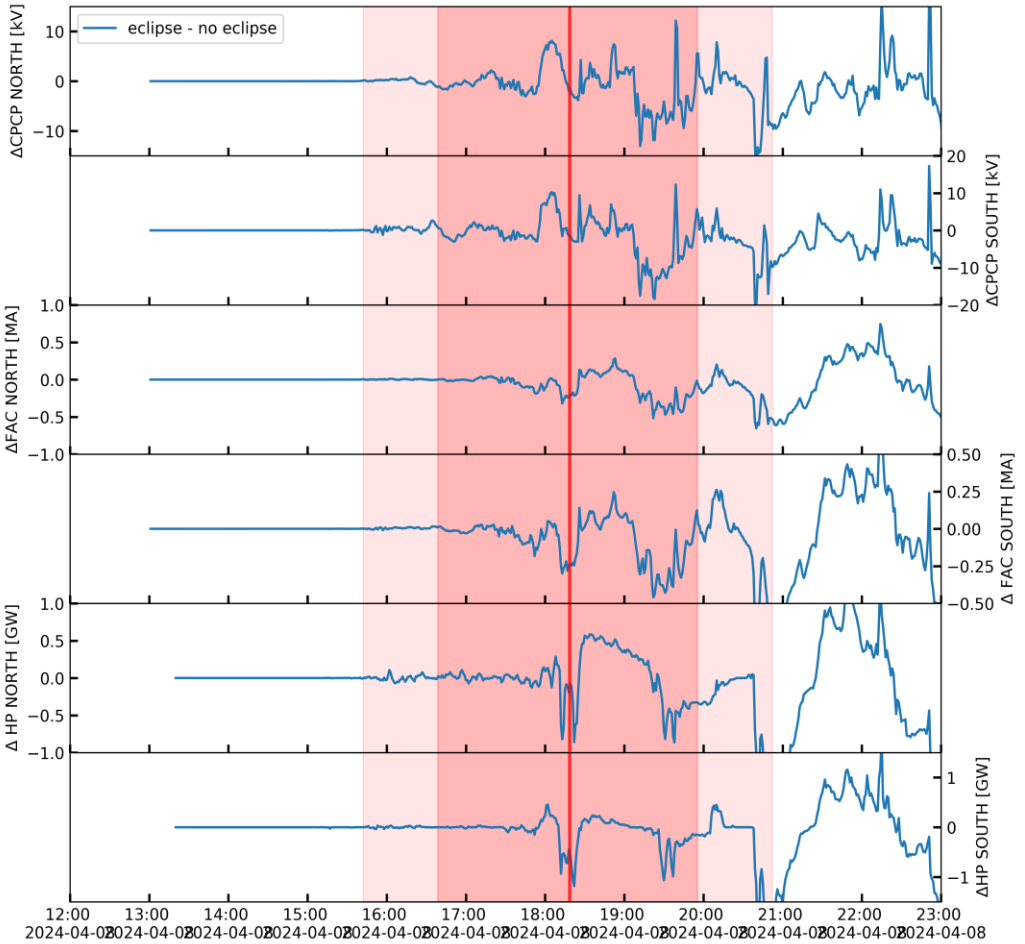
NH

SH

HP

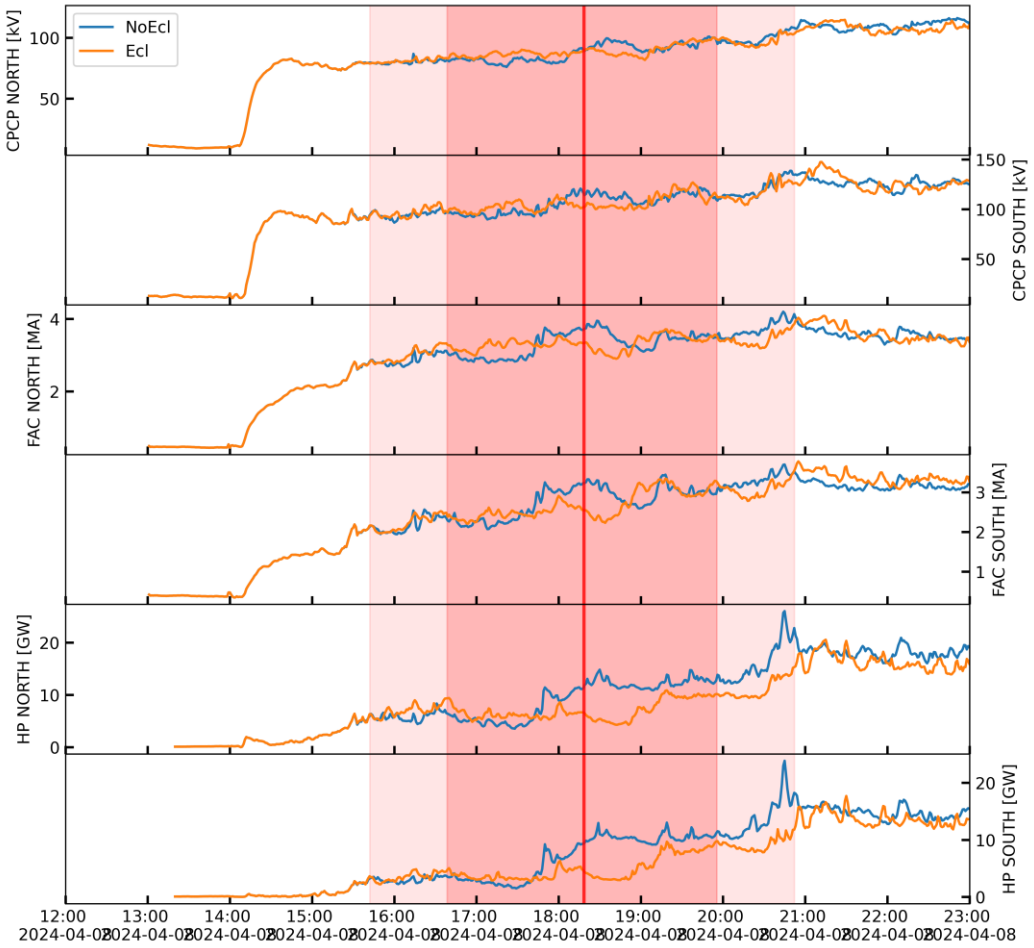
NH

SH



Increase in CPCP in the eclipse run, decrease in FAC 25% change at the same time
In both hemispheres

By = -5nT



CPCP

NH

SH

FAC

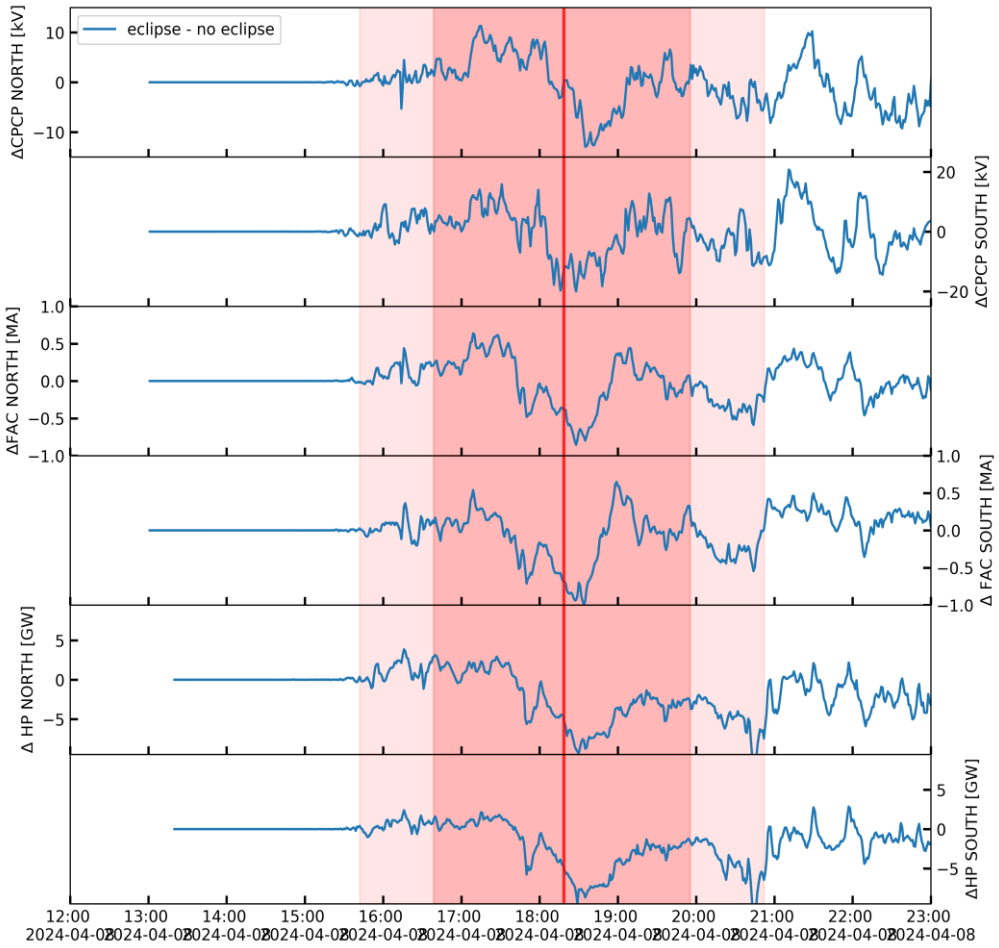
NH

SH

HP

NH

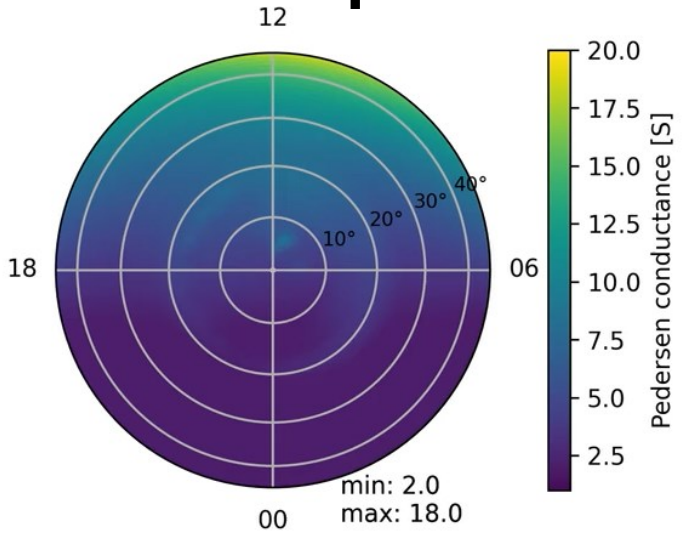
SH

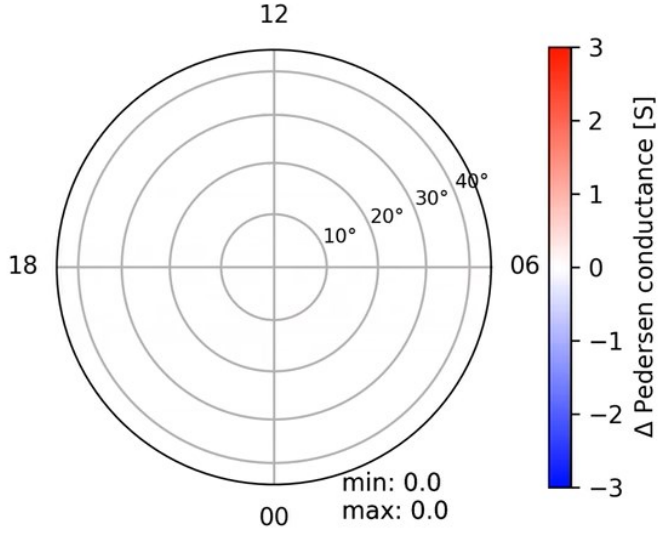


CPCP increases one hour before totality, followed by a decrease
Reconnection dominates

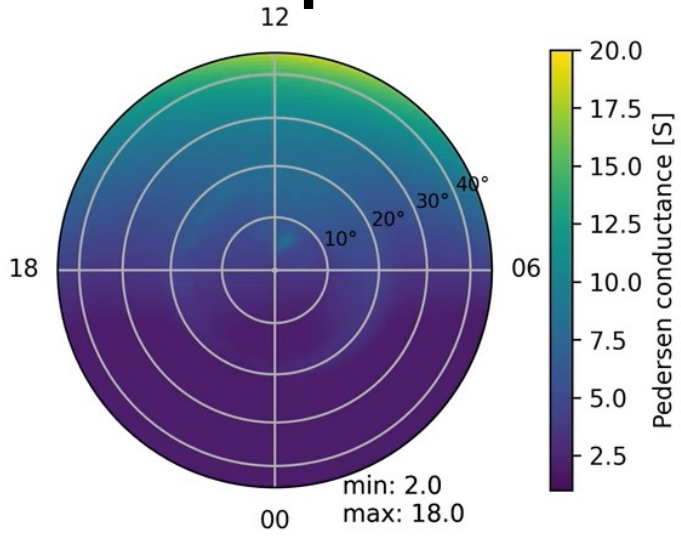
MIX
2024-04-08 13:00:00.165

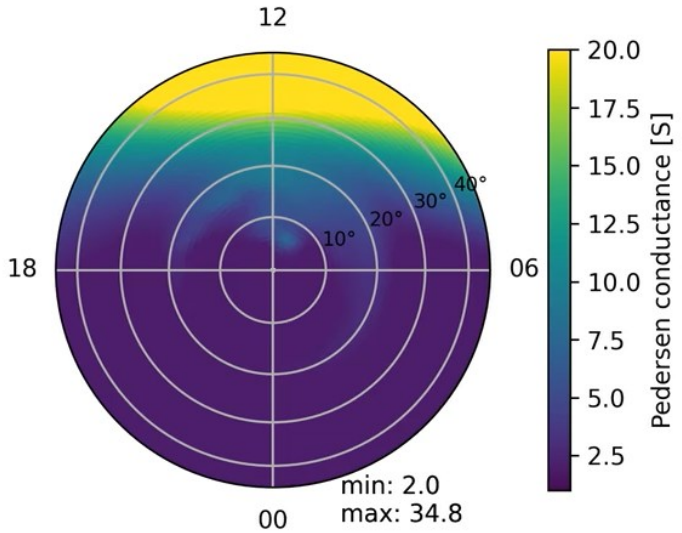
No Eclipse

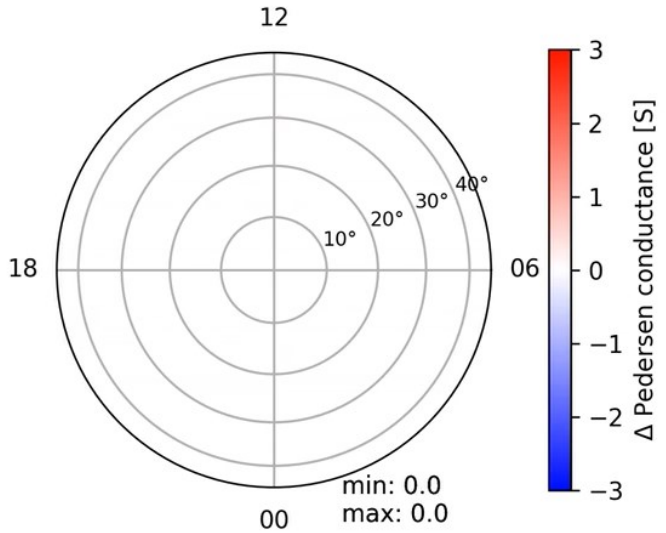


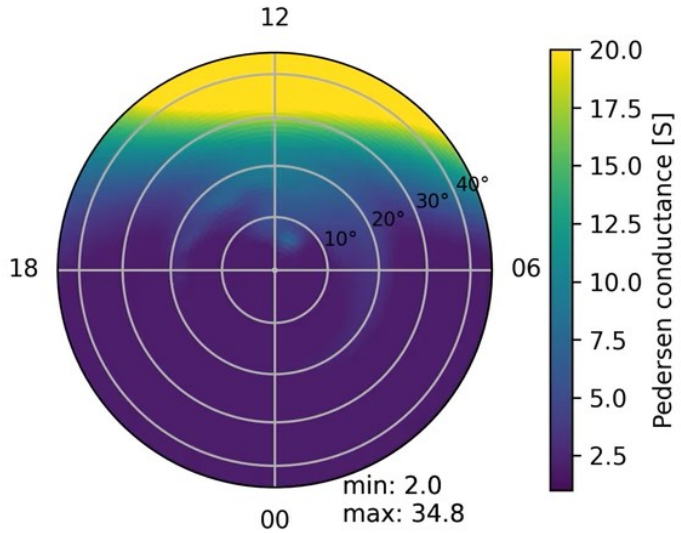


Eclipse

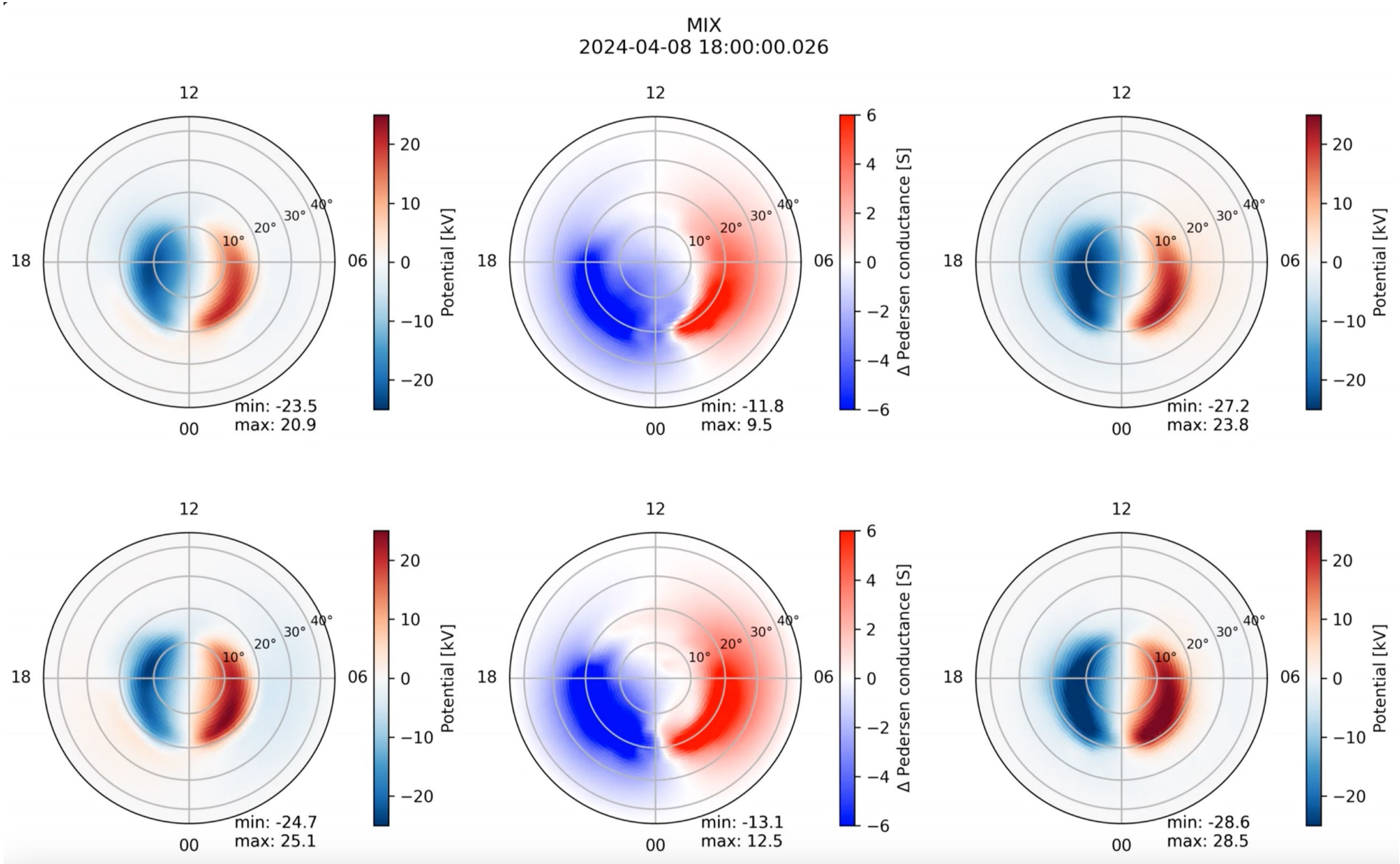




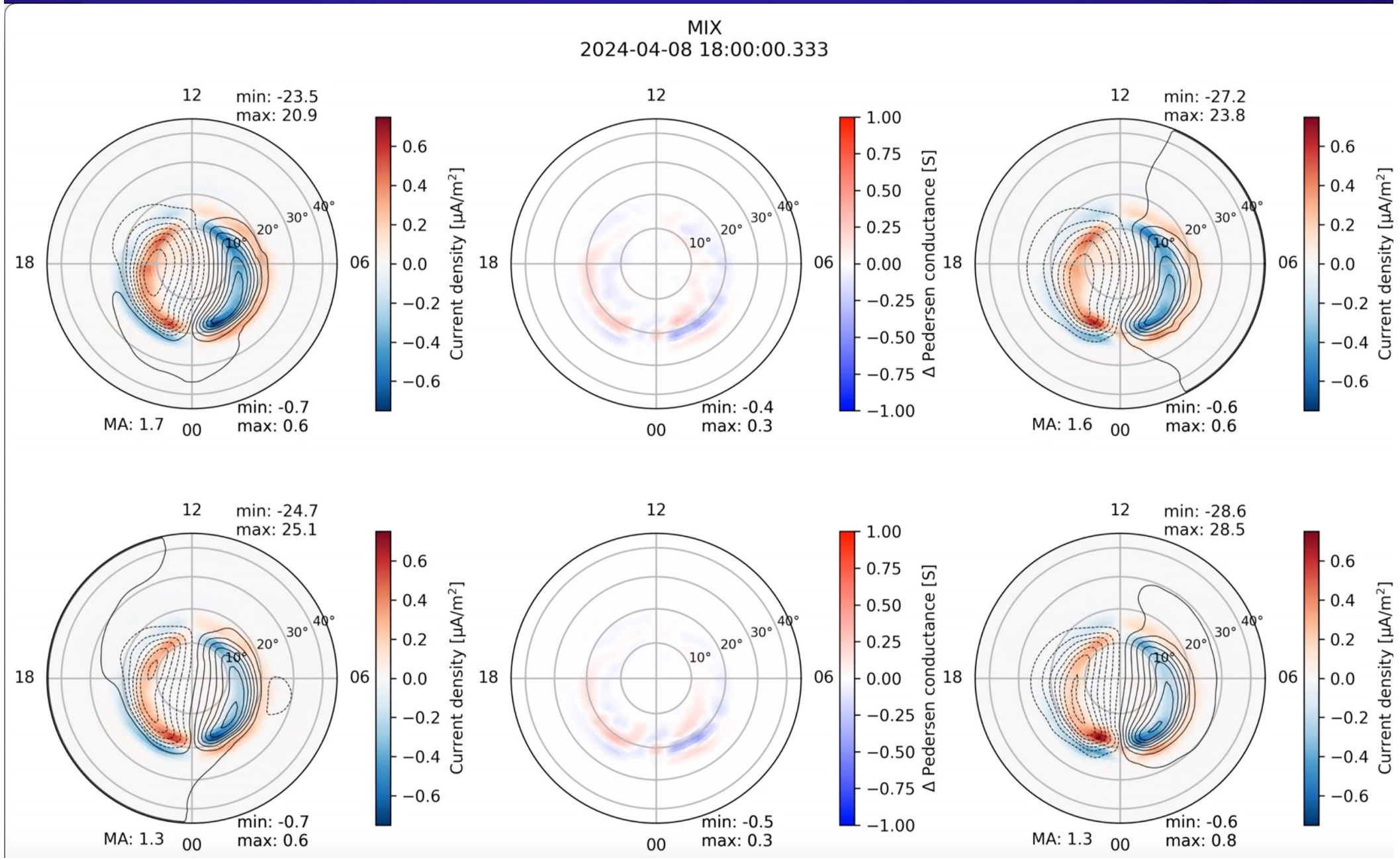




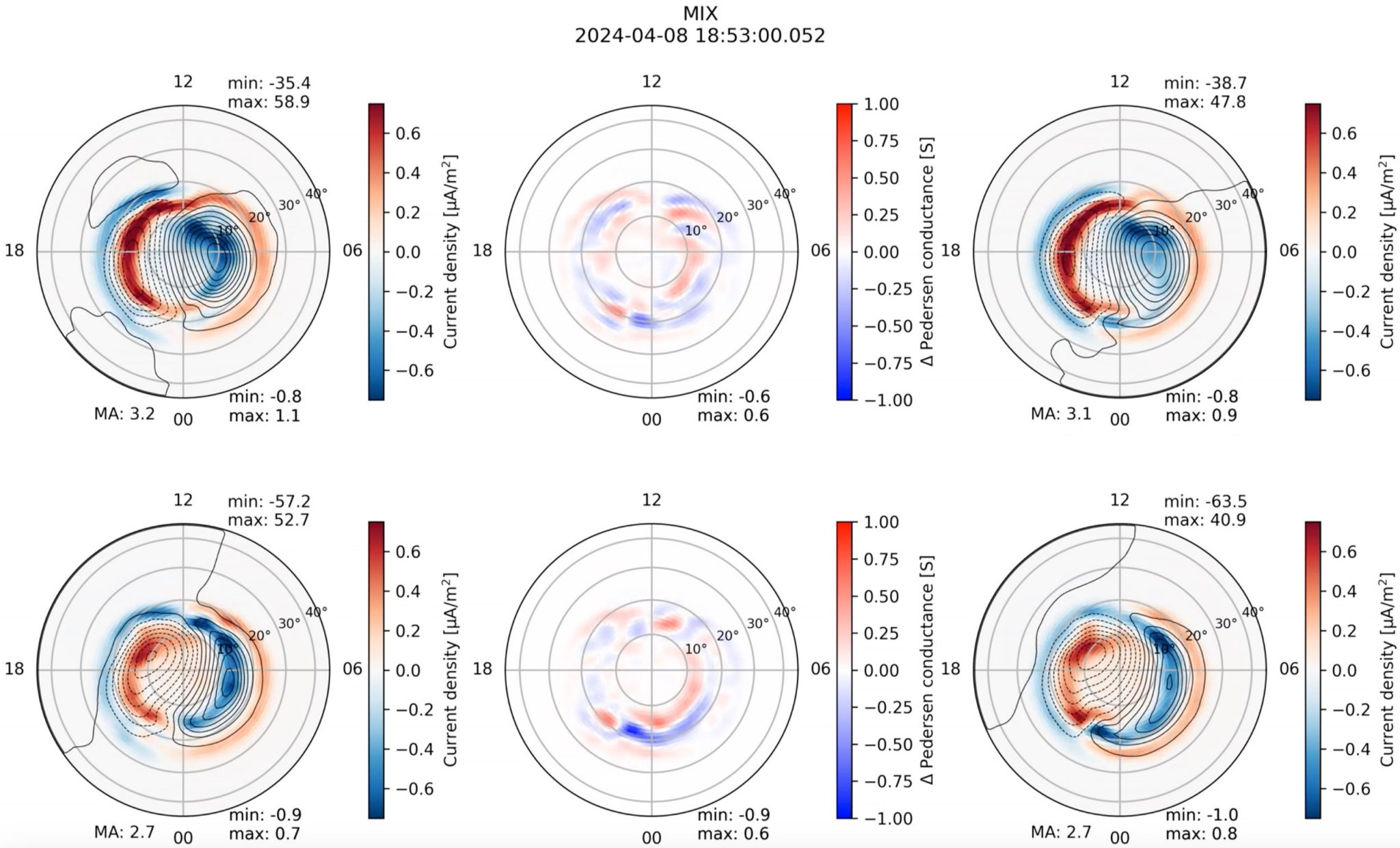
Bz = -1 nT



Similar changes in potential in the two hemispheres


MIX
2024-04-08 18:00:00.333
12
min: -23.5
max: 20.9
18
06
00
MA: 1.7
min: -0.7
max: 0.6
10°
20°
30°
40°
0.6
0.4
0.2
0.0
−0.2
−0.4
−0.6
Current density [μA/m²]
12
18
06
00
min: -0.4
max: 0.3
1.00
0.75
0.50
0.25
0.00
−0.25
−0.50
−0.75
−1.00
Δ Pedersen conductance [S]
12
min: -27.2
max: 23.8
18
06
00
MA: 1.6
min: -0.6
max: 0.6
Current density [μA/m²]
12
min: -24.7
max: 25.1
18
06
00
MA: 1.3
min: -0.7
max: 0.6
Current density [μA/m²]
12
18
06
00
min: -0.5
max: 0.3
Δ Pedersen conductance [S]
12
min: -28.6
max: 28.5
18
06
00
MA: 1.3
min: -0.6
max: 0.8
Current density [μA/m²]

By = -5nT


MIX
2024-04-08 18:53:00.052
12
18
06
00
10°
20°
30°
40°
min: -35.4
max: 58.9
MA: 3.2
min: -0.8
max: 1.1
min: -0.6
max: 0.6
min: -38.7
max: 47.8
MA: 3.1
min: -0.8
max: 0.9
min: -57.2
max: 52.7
MA: 2.7
min: -0.9
max: 0.7
min: -0.9
max: 0.6
min: -63.5
max: 40.9
MA: 2.7
min: -1.0
max: 0.8
Current density [μA/m²]
Δ Pedersen conductance [S]
0.6
0.4
0.2
0.0
−0.2
−0.4
−0.6
1.00
0.75
0.50
0.25
0.00
−0.25
−0.50
−0.75
−1.00

Summary

The total solar eclipse affects reconnection, but does not modify the viscous interaction

Eclipse effects on M-I coupling depends on solar wind conditions

The eclipse causes a peak in CPCP to occur earlier, resulting in a smaller peak later. This shows up as an oscillation in delta CPCP (an increase followed by a decrease)

The increase in delta CPCP typically occurs prior to the Eclipse Maximum

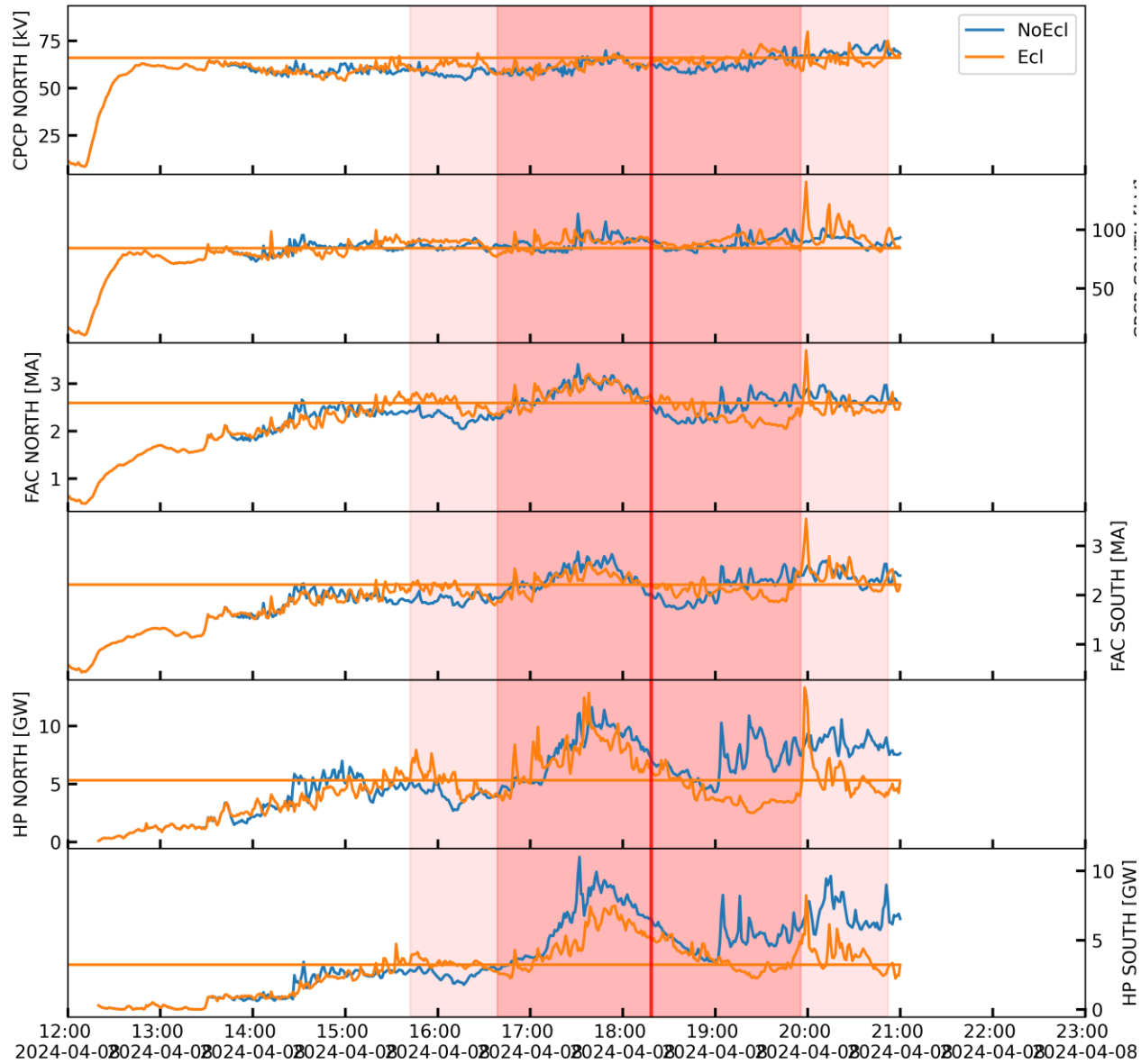
The decrease in delta CPCP typically occurs after the Eclipse Maximum

A clockwise rotation of the potential pattern near Eclipse Maximum seen

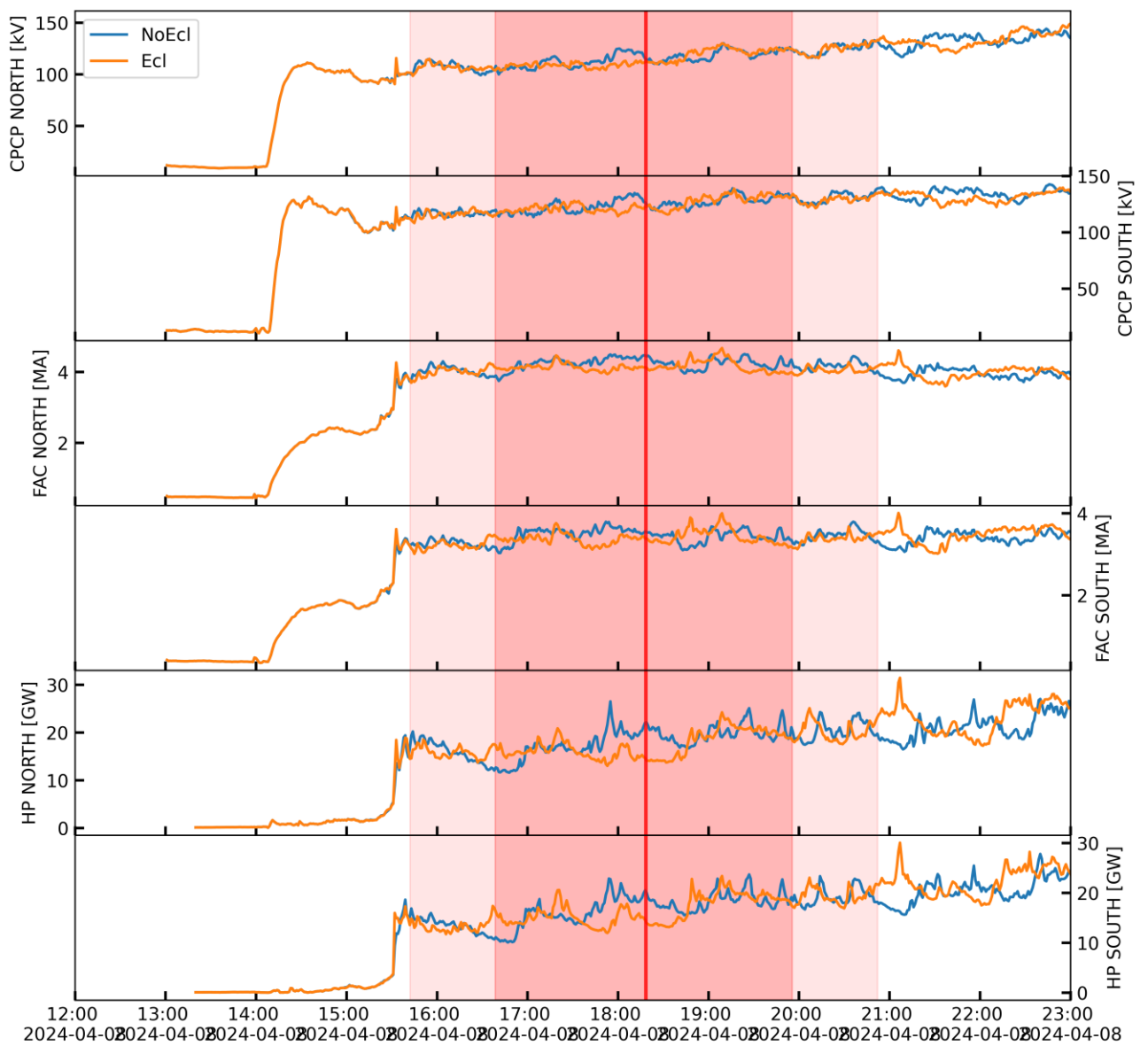
Both hemispheres are impacted and show the same behavior

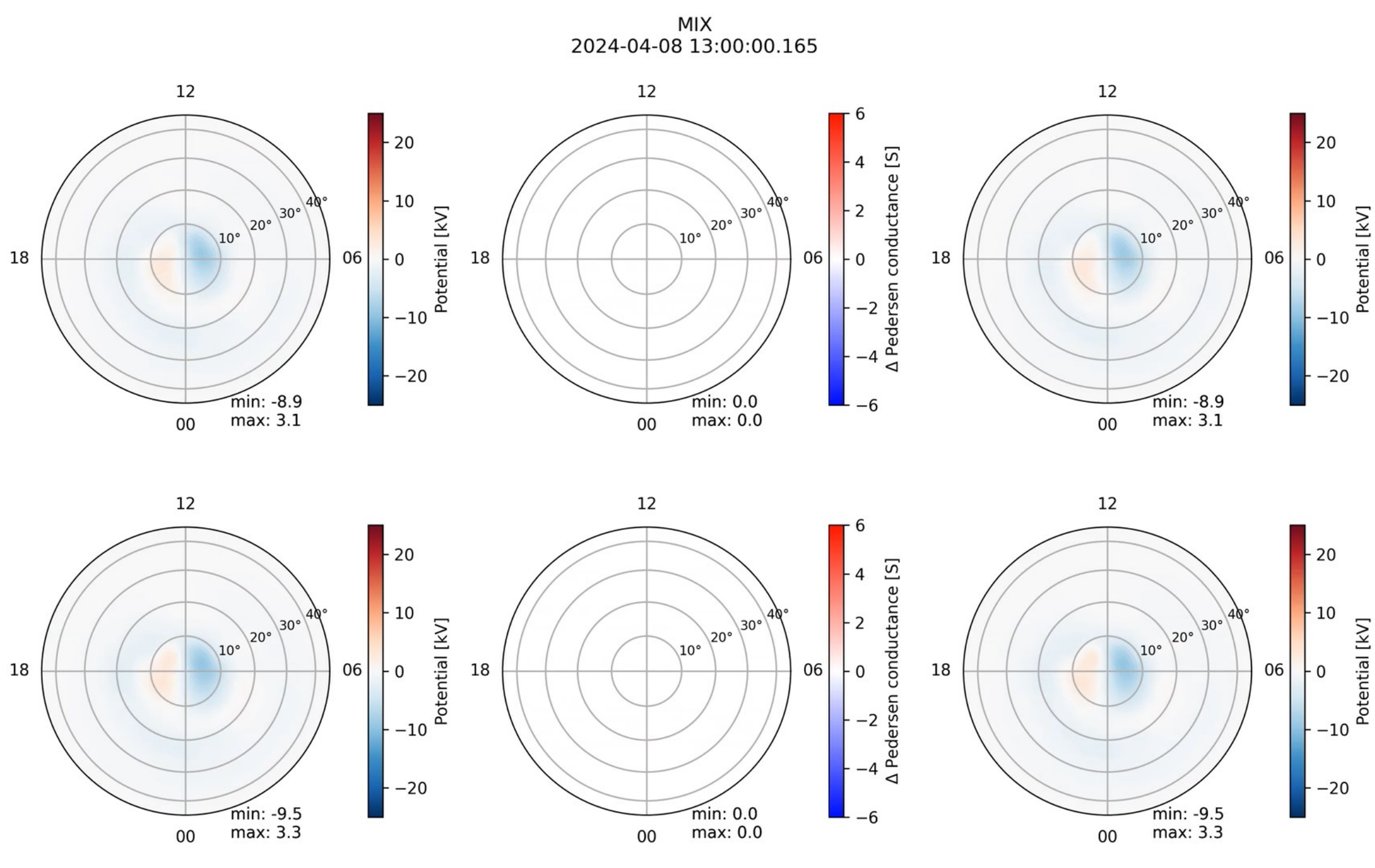
BACKUP

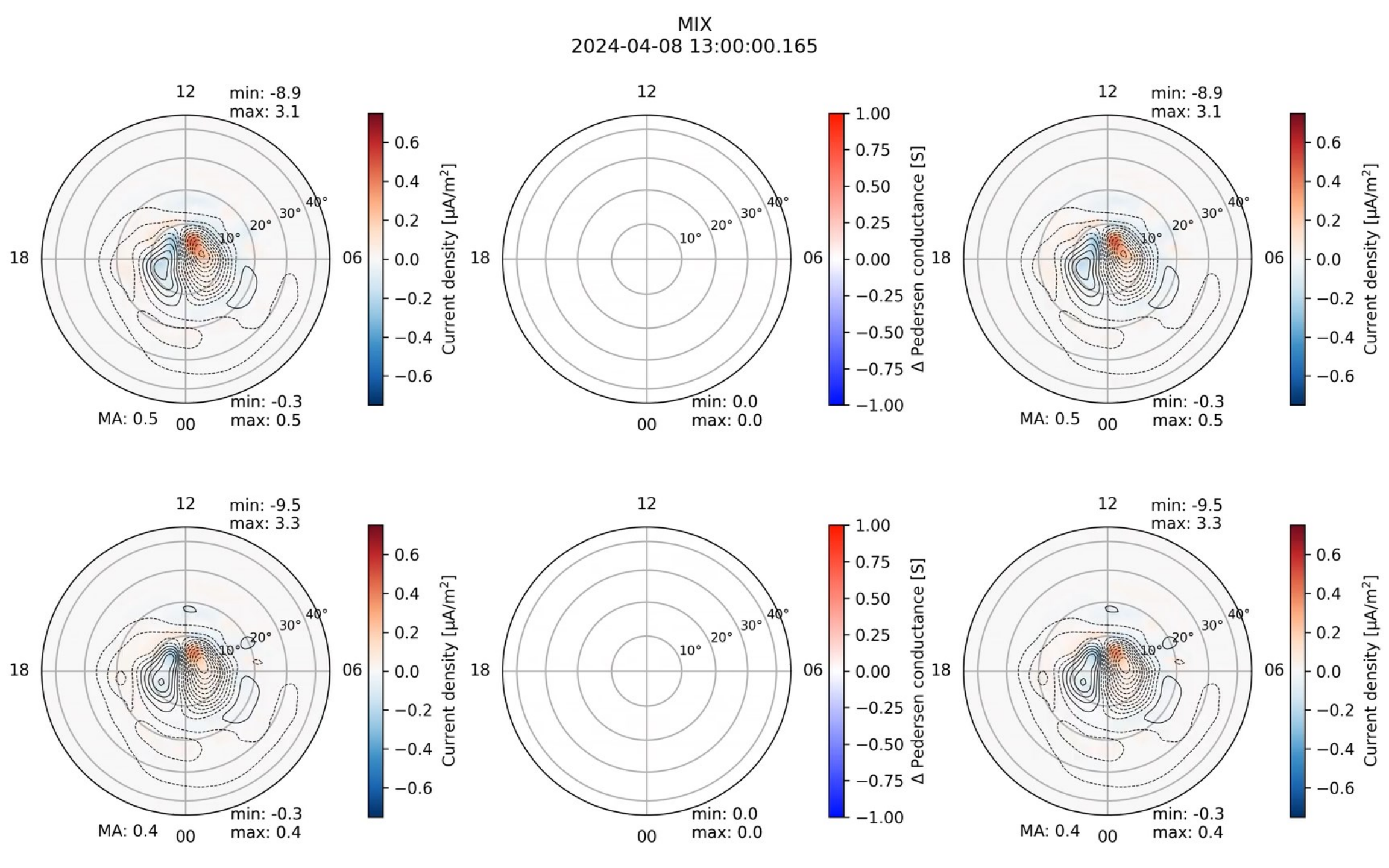
By = -5nT GSE

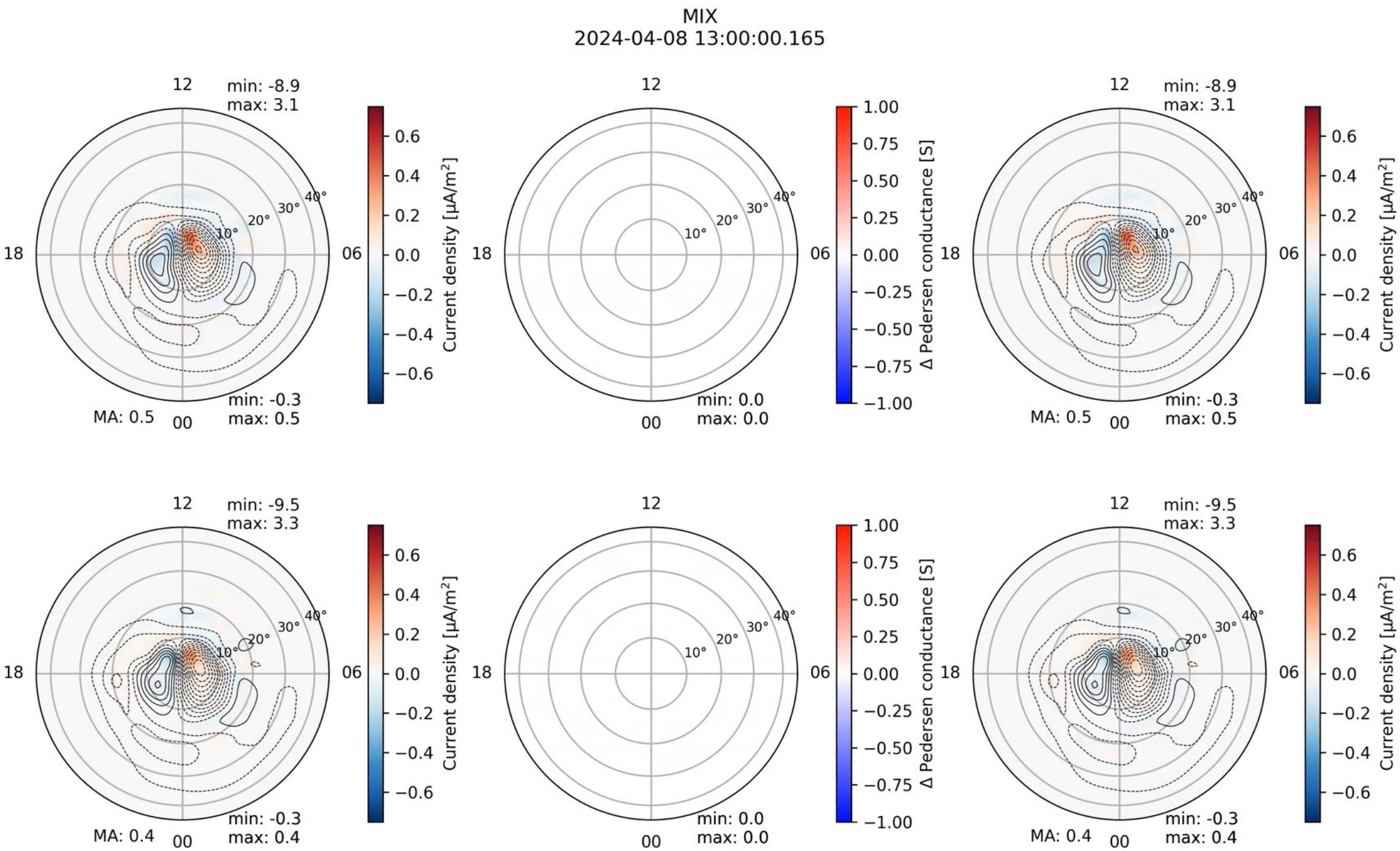


Bz = -5nT SM




MIX
2024-04-08 13:00:00.165
12
18
06
00
10°
20°
30°
40°
min: -8.9
max: 3.1
Potential [kV]
20
10
0
−10
−20
min: 0.0
max: 0.0
Δ Pedersen conductance [S]
6
4
2
0
−2
−4
−6
min: -9.5
max: 3.3


MIX
2024-04-08 13:00:00.165
12
18
06
00
10°
20°
30°
40°
min: -8.9
max: 3.1
min: -0.3
max: 0.5
MA: 0.5
min: 0.0
max: 0.0
min: -9.5
max: 3.3
min: -0.3
max: 0.4
MA: 0.4
Current density [μA/m²]
Δ Pedersen conductance [S]


MIX
2024-04-08 13:00:00.165
12
min: -8.9
max: 3.1
18
06
00
MA: 0.5
min: -0.3
max: 0.5
10°
20°
30°
40°
0.6
0.4
0.2
0.0
−0.2
−0.4
−0.6
Current density [μA/m²]
min: 0.0
max: 0.0
1.00
0.75
0.50
0.25
0.00
−0.25
−0.50
−0.75
−1.00
Δ Pedersen conductance [S]
min: -9.5
max: 3.3
MA: 0.4
min: -0.3
max: 0.4