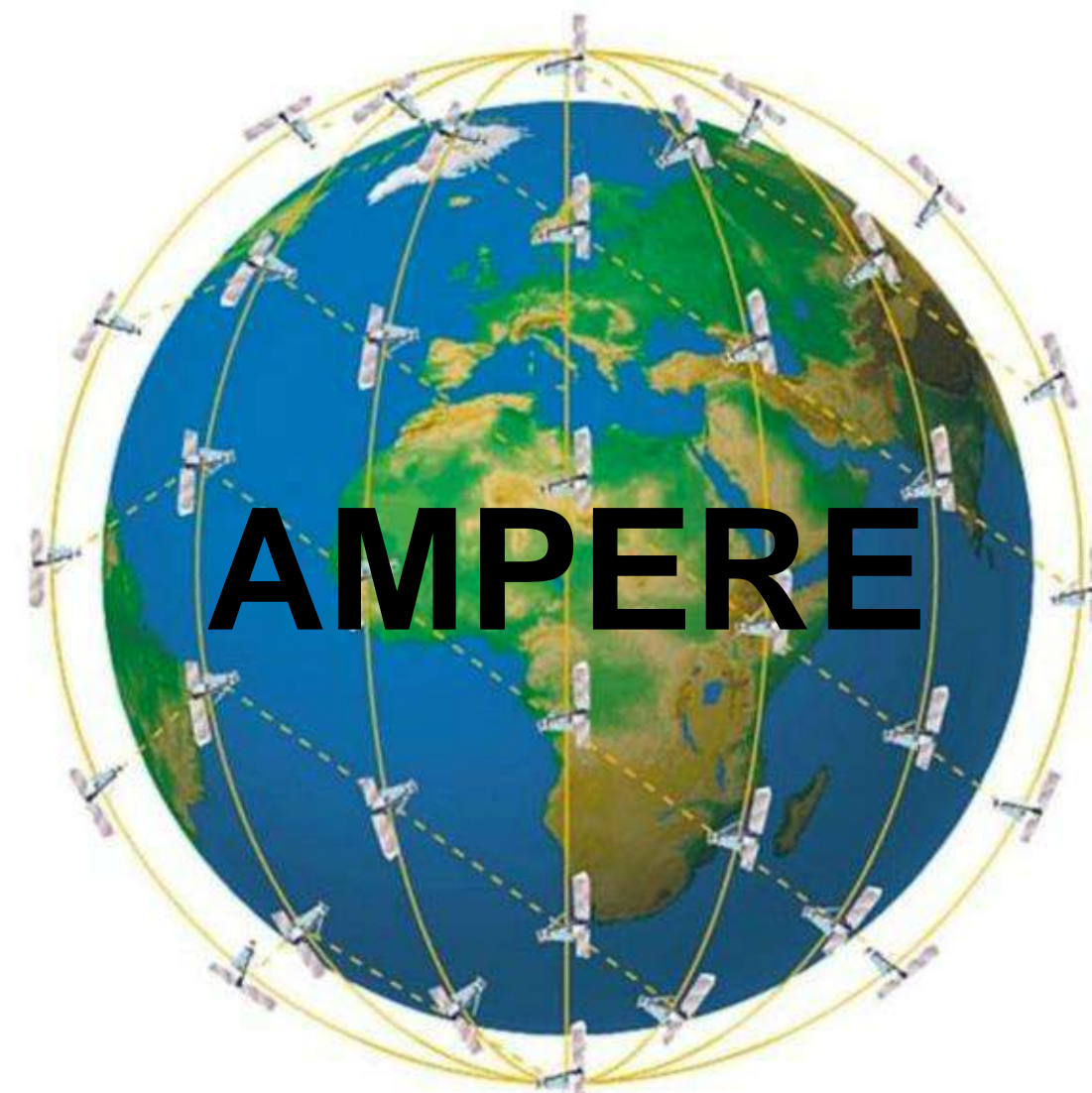


SuperDARN

Photo: Ashton Reimer



Iridium Communications



Multi-Scale Ionospheric Poynting Fluxes Using Ground and Space-Based Observations

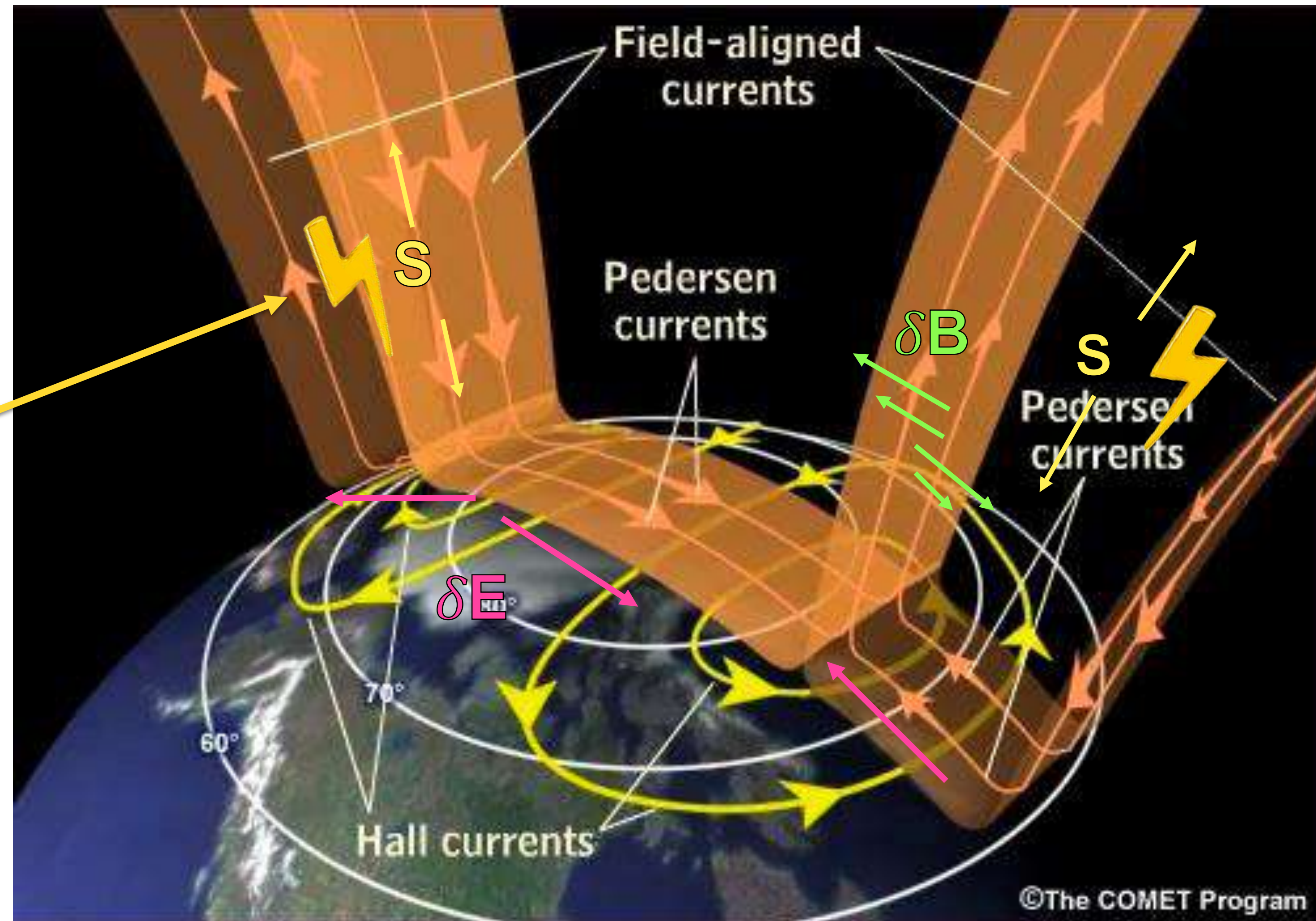
Daniel Billett,
K. A. McWilliams,
P. V. Ponomarenko,
D. J. Knudsen,
C. J. Martin,
S. K. Vines



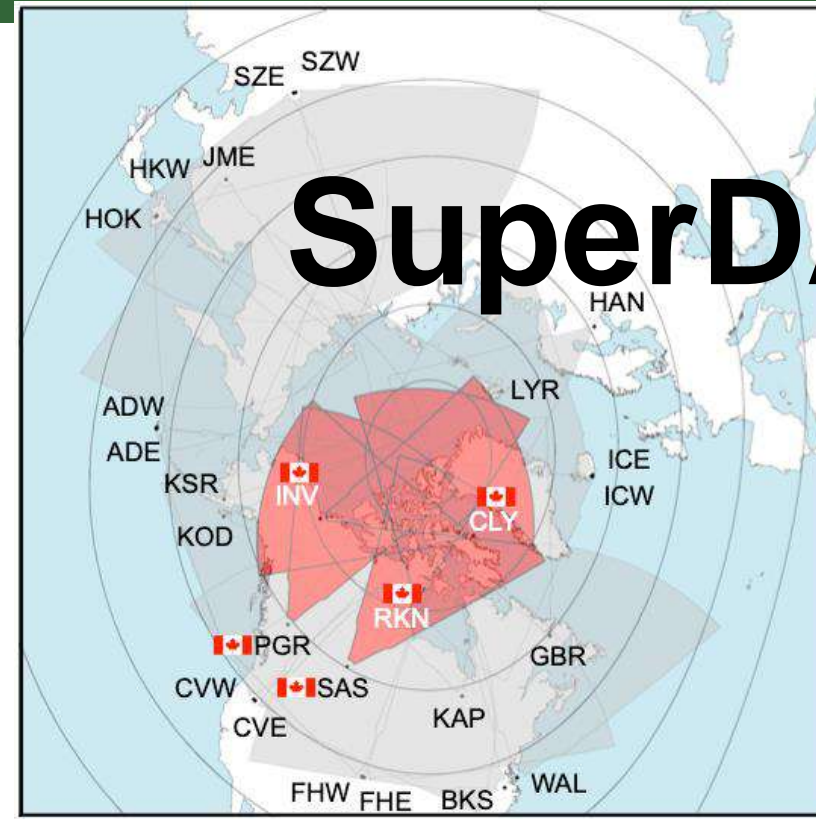
The quasi-static* system

*or: large-scale, DC, big picture, field-aligned currents, convection, etc

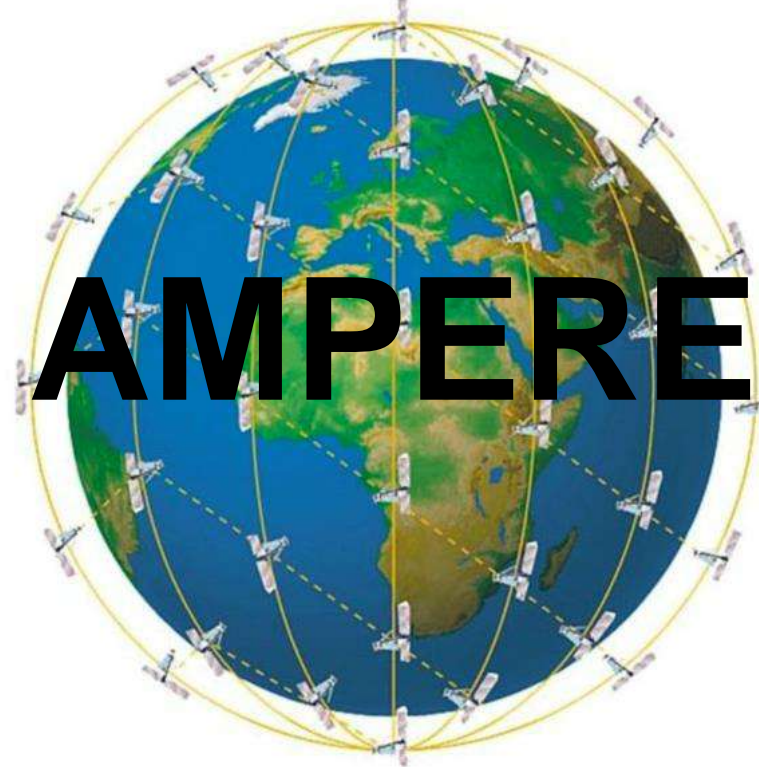
What is Poynting flux?



Large-scale Poynting flux

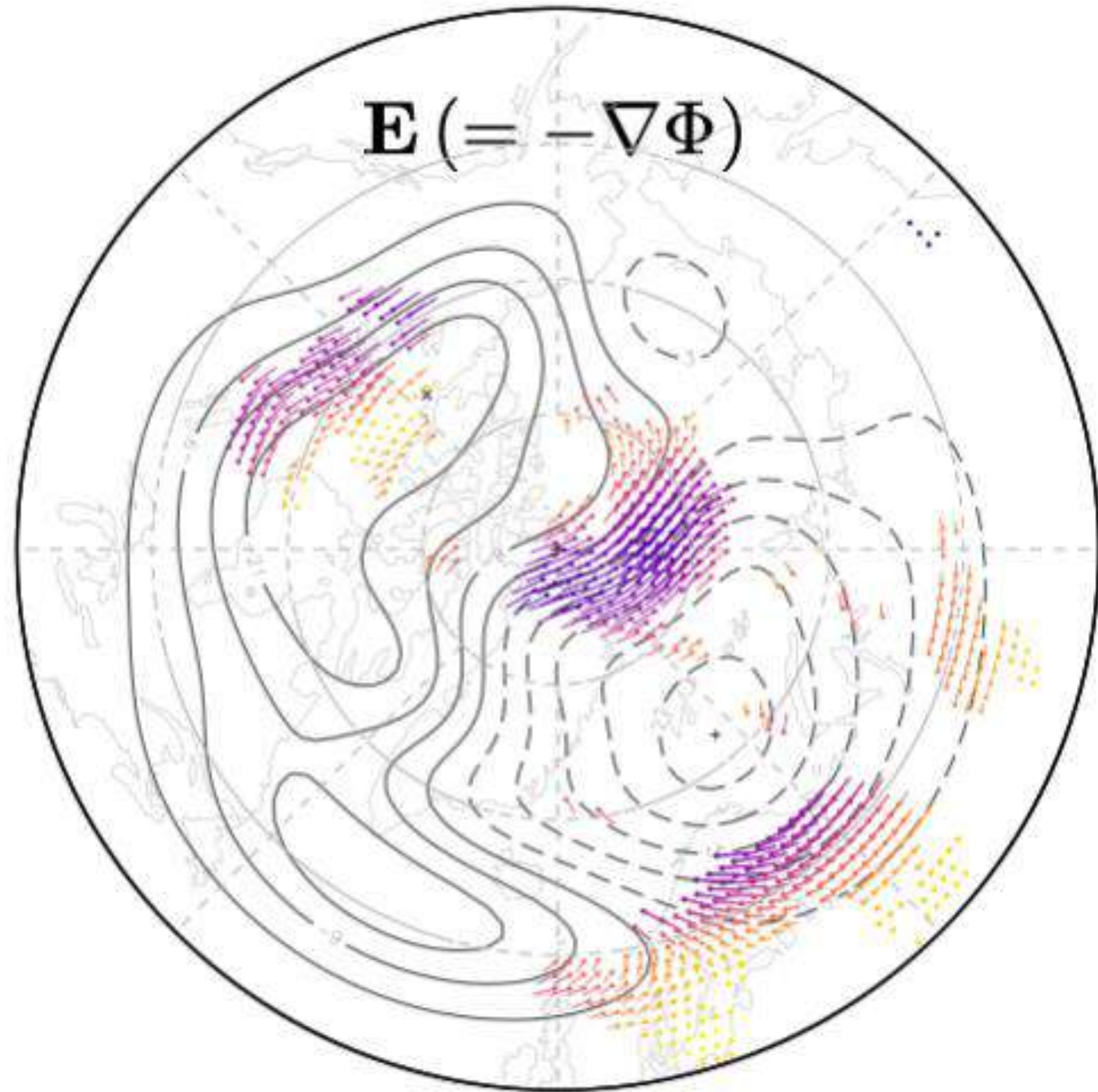


SuperDARN

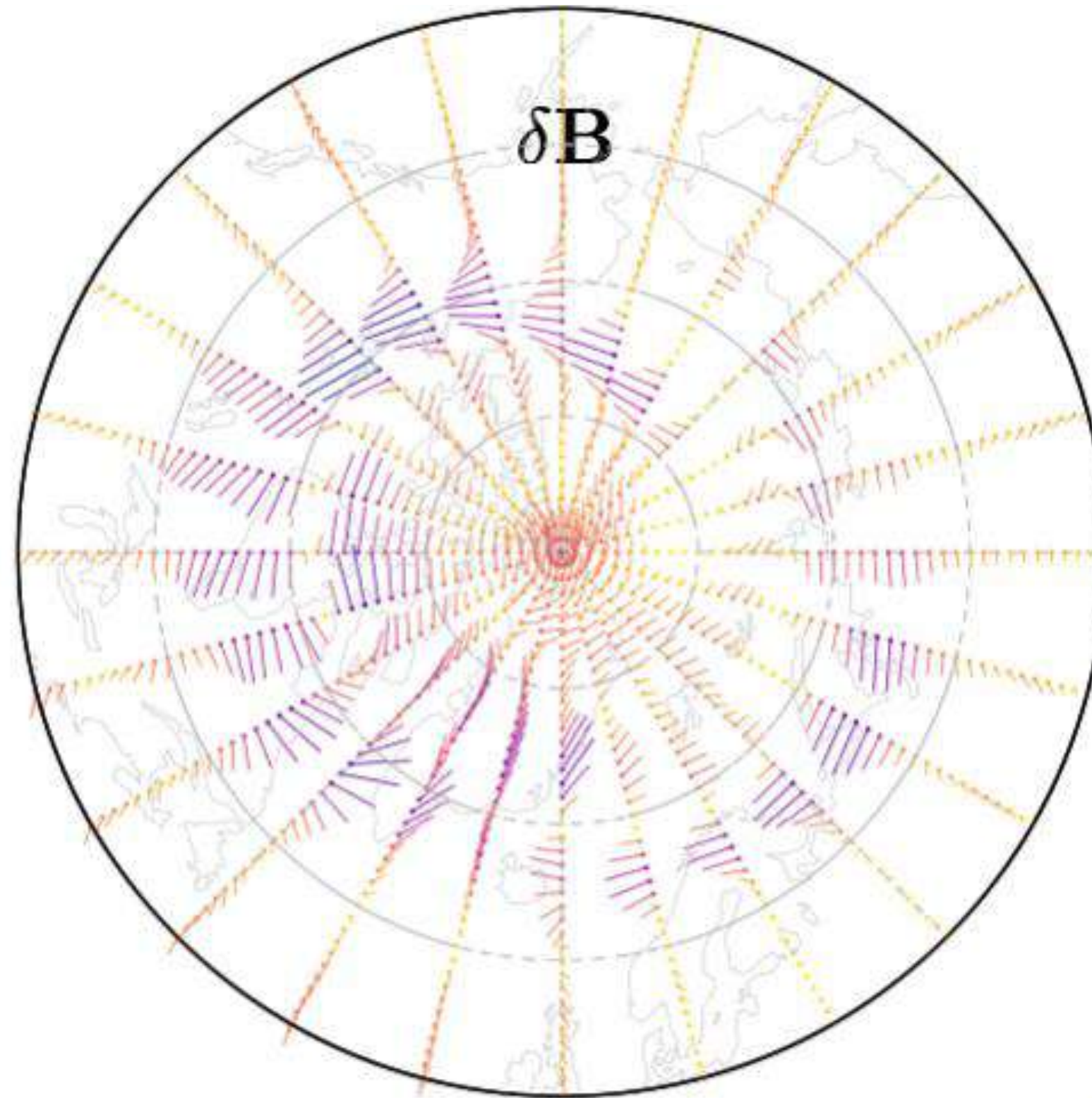


AMPERE

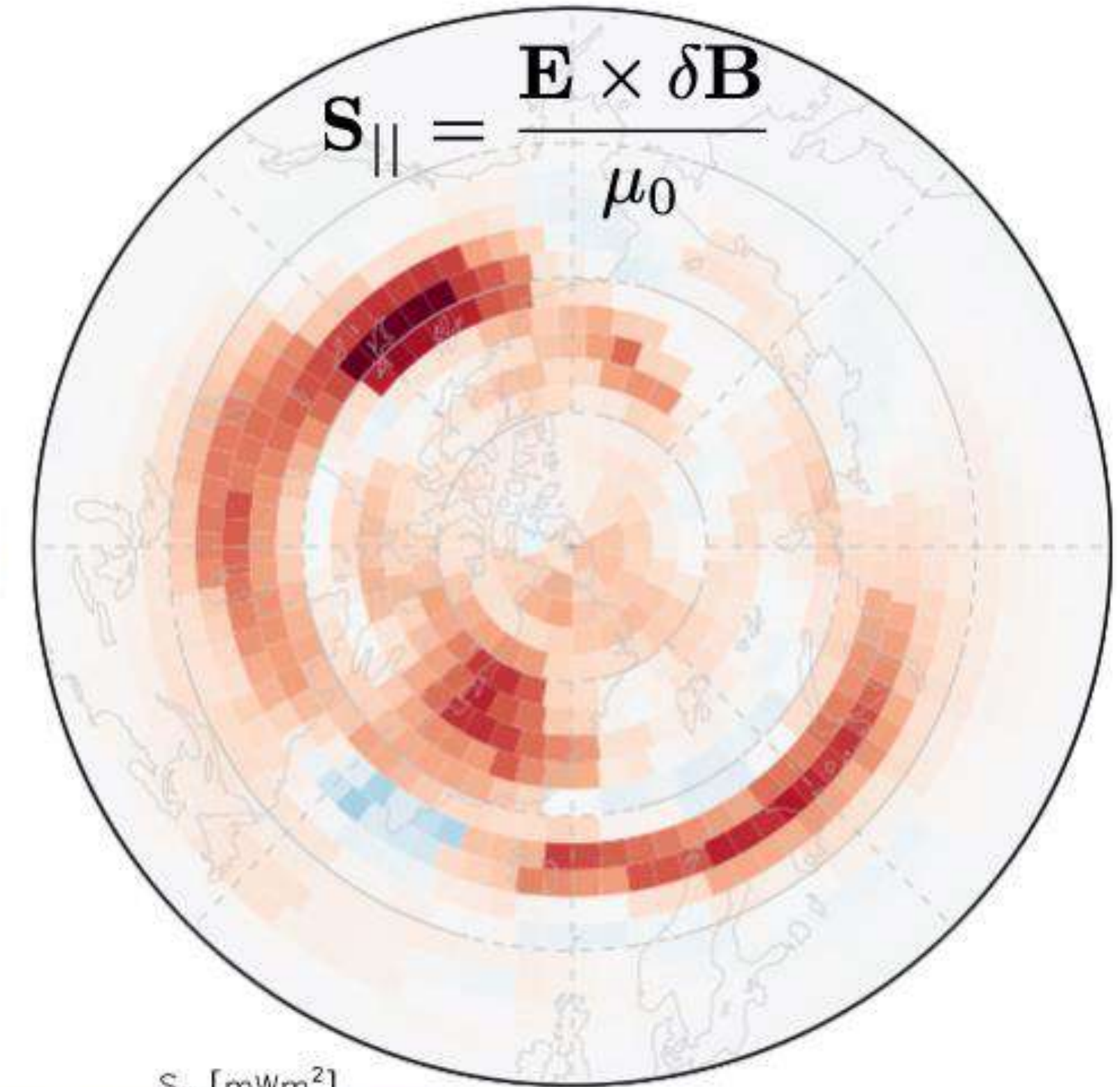
Polar Poynting flux pattern



$\mathbf{E} (= -\nabla\Phi)$

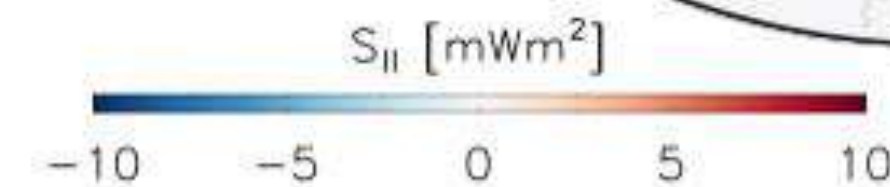


$\delta\mathbf{B}$



$S_{||} = \frac{\mathbf{E} \times \delta\mathbf{B}}{\mu_0}$

Polar plots, northern hemisphere

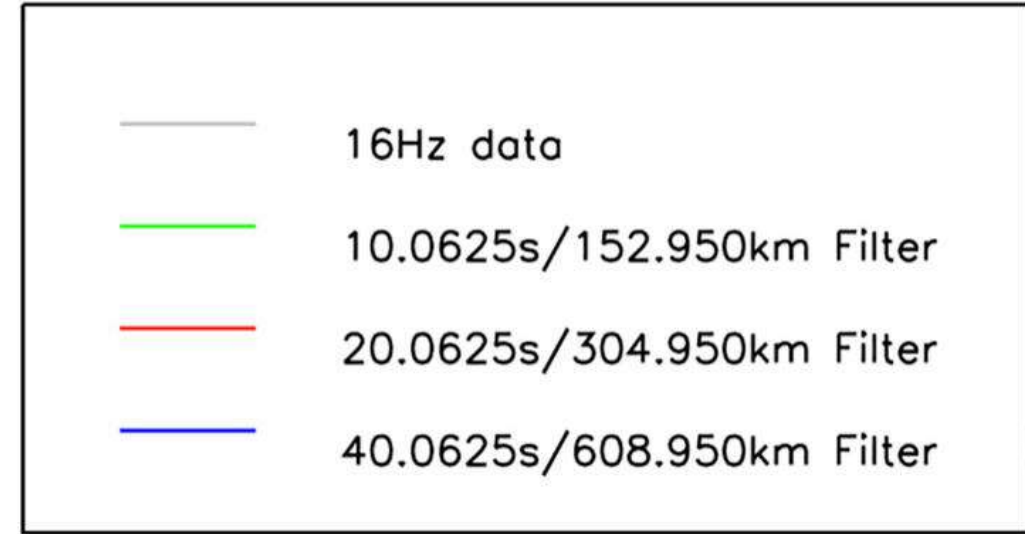
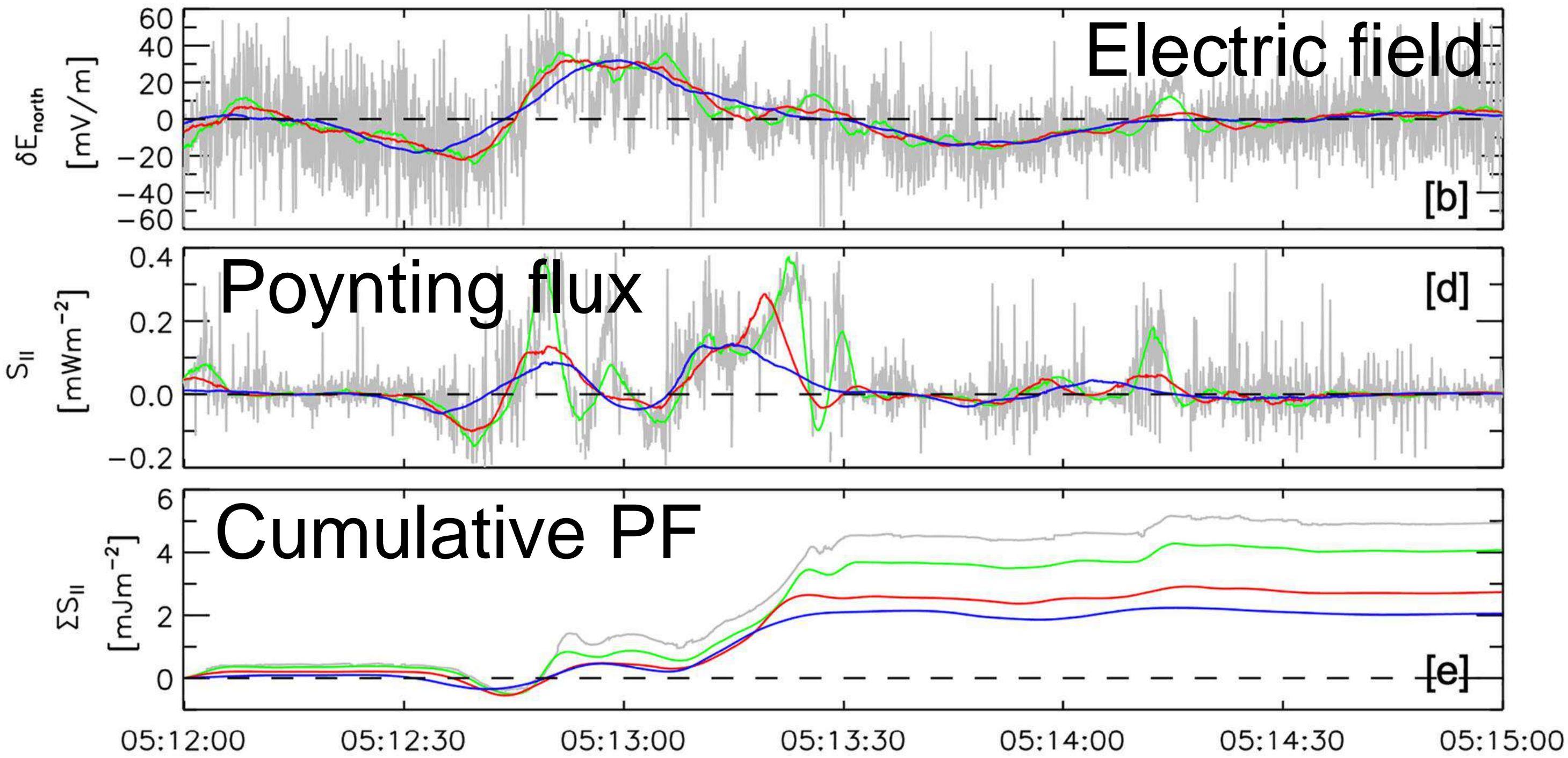
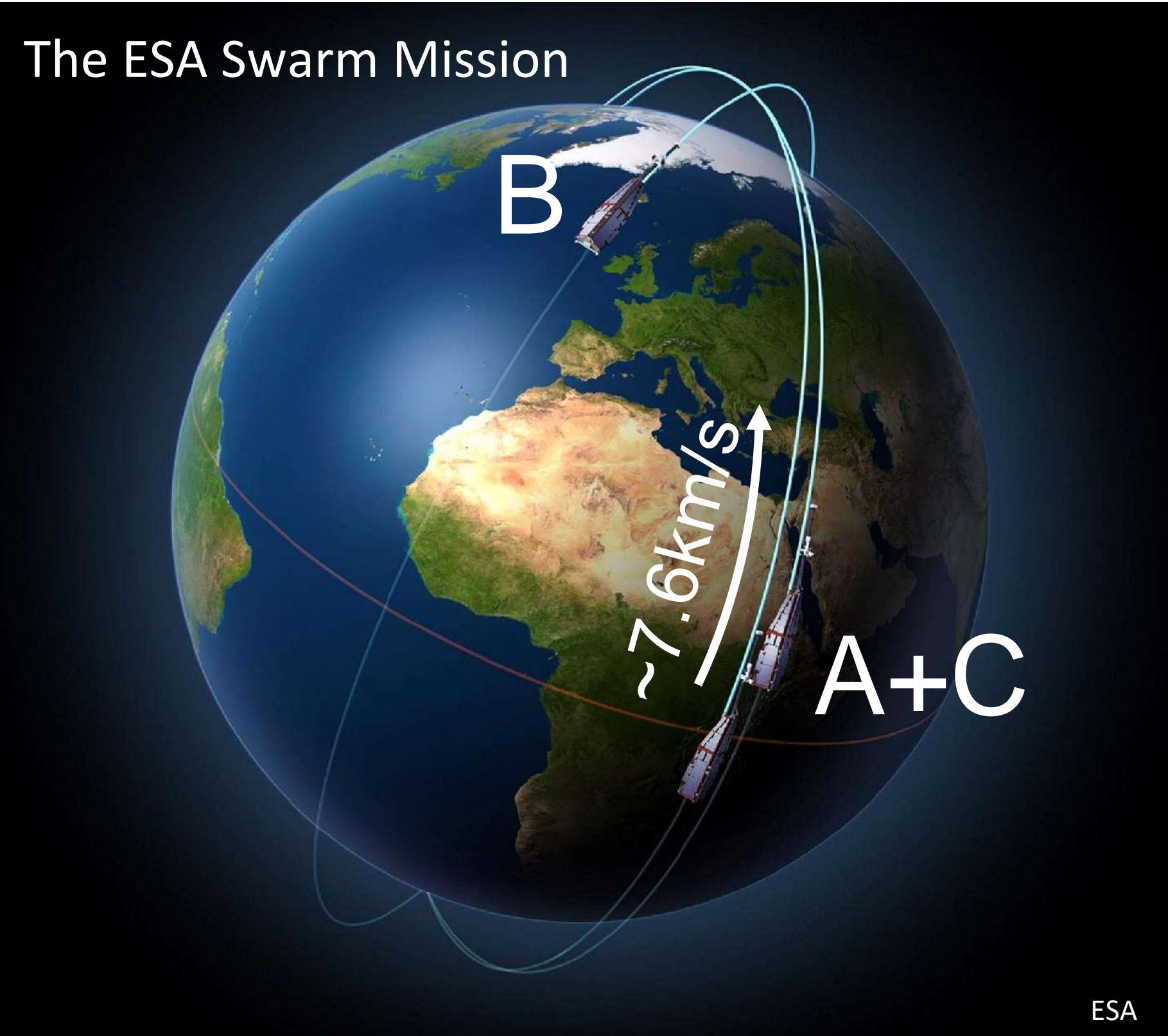


Billett et al. [2023]

The small-scale system



The “everything else” Poynting flux



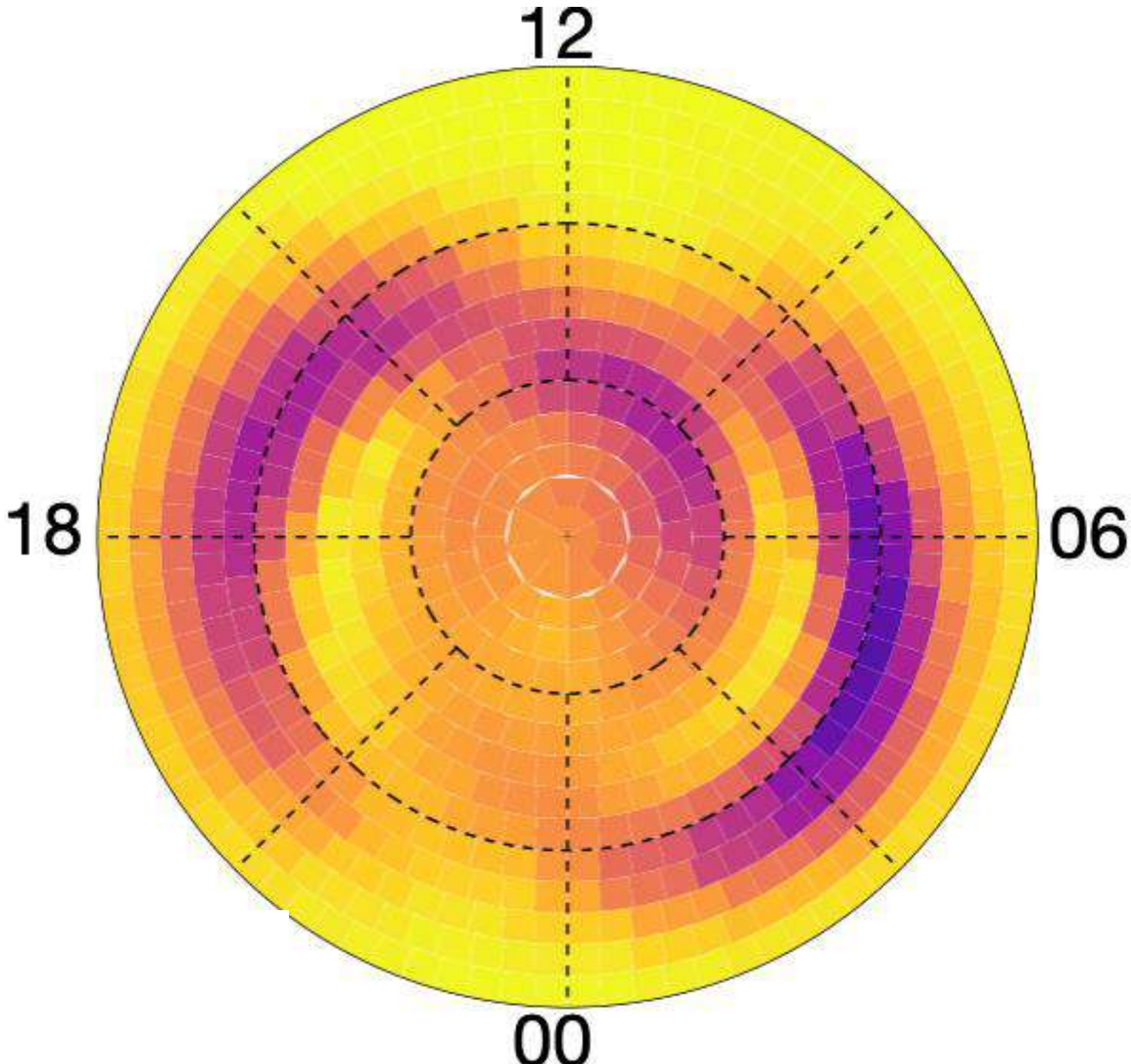
Billett et al. [2022]

Result

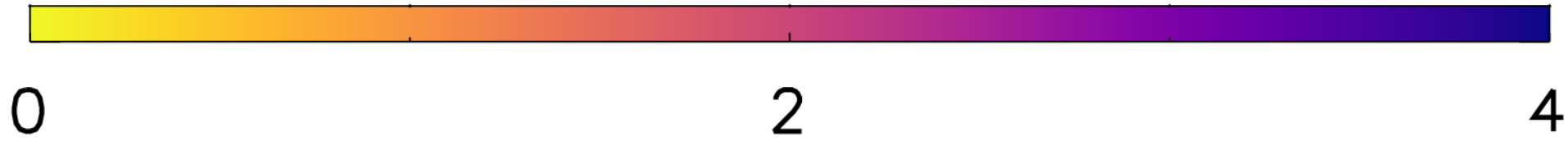
The smaller scales we look at, the more Poynting Flux we see

Statistics across instruments

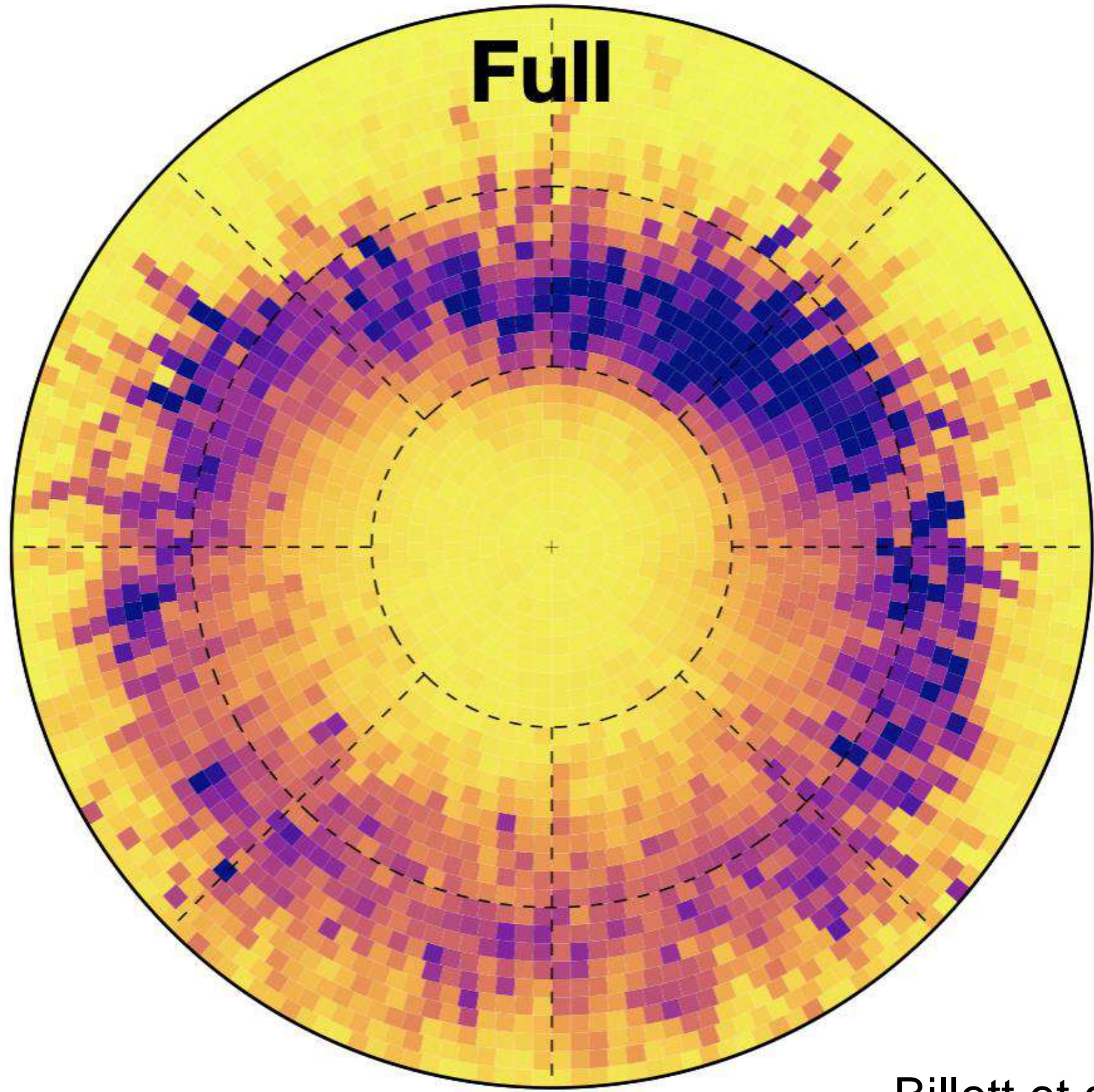
SuperDARN **E** and
AMPERE $\delta\mathbf{B}$ fields:



S_{II} [mWm⁻²]



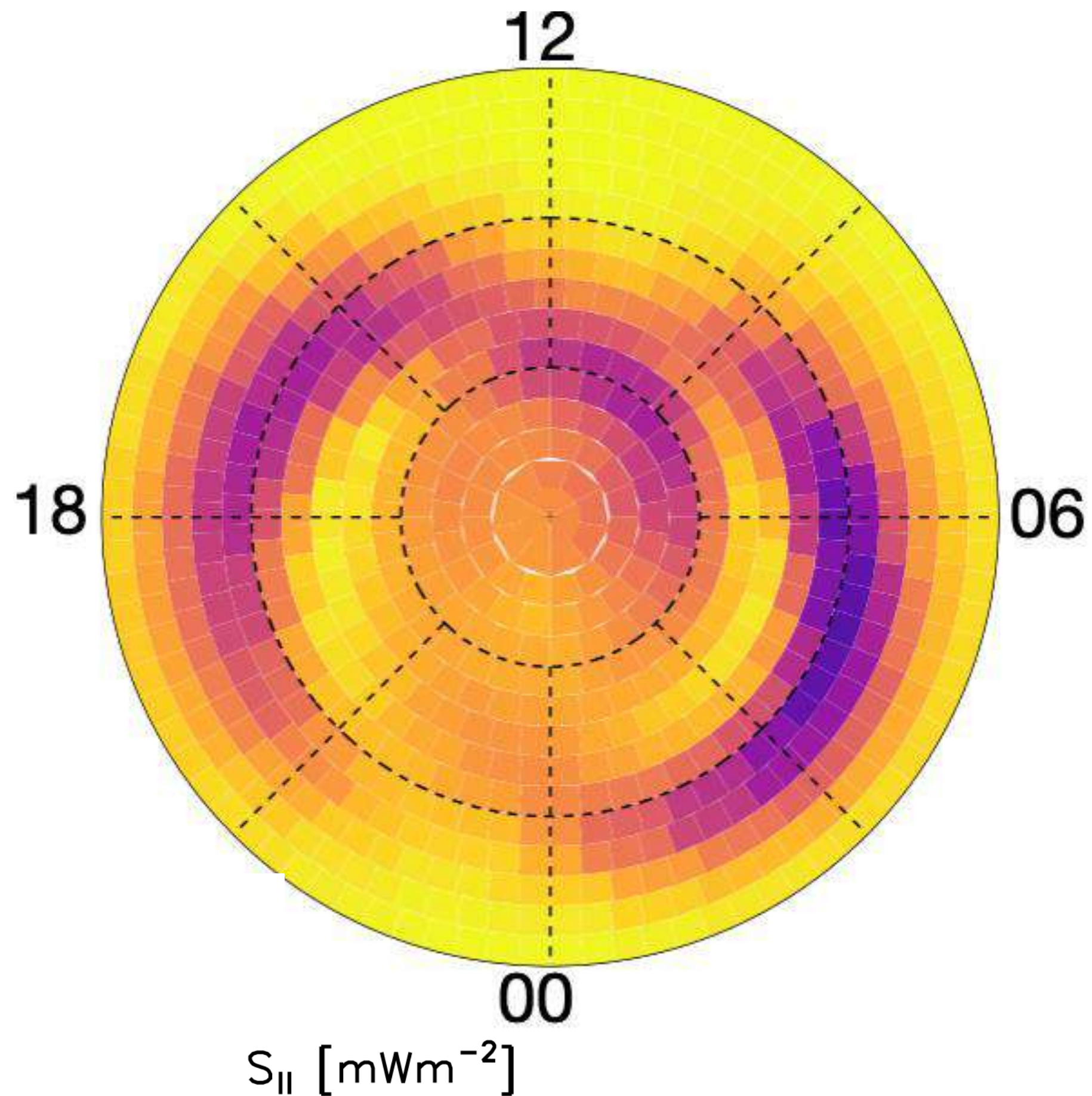
Swarm **E** and $\delta\mathbf{B}$ fields:



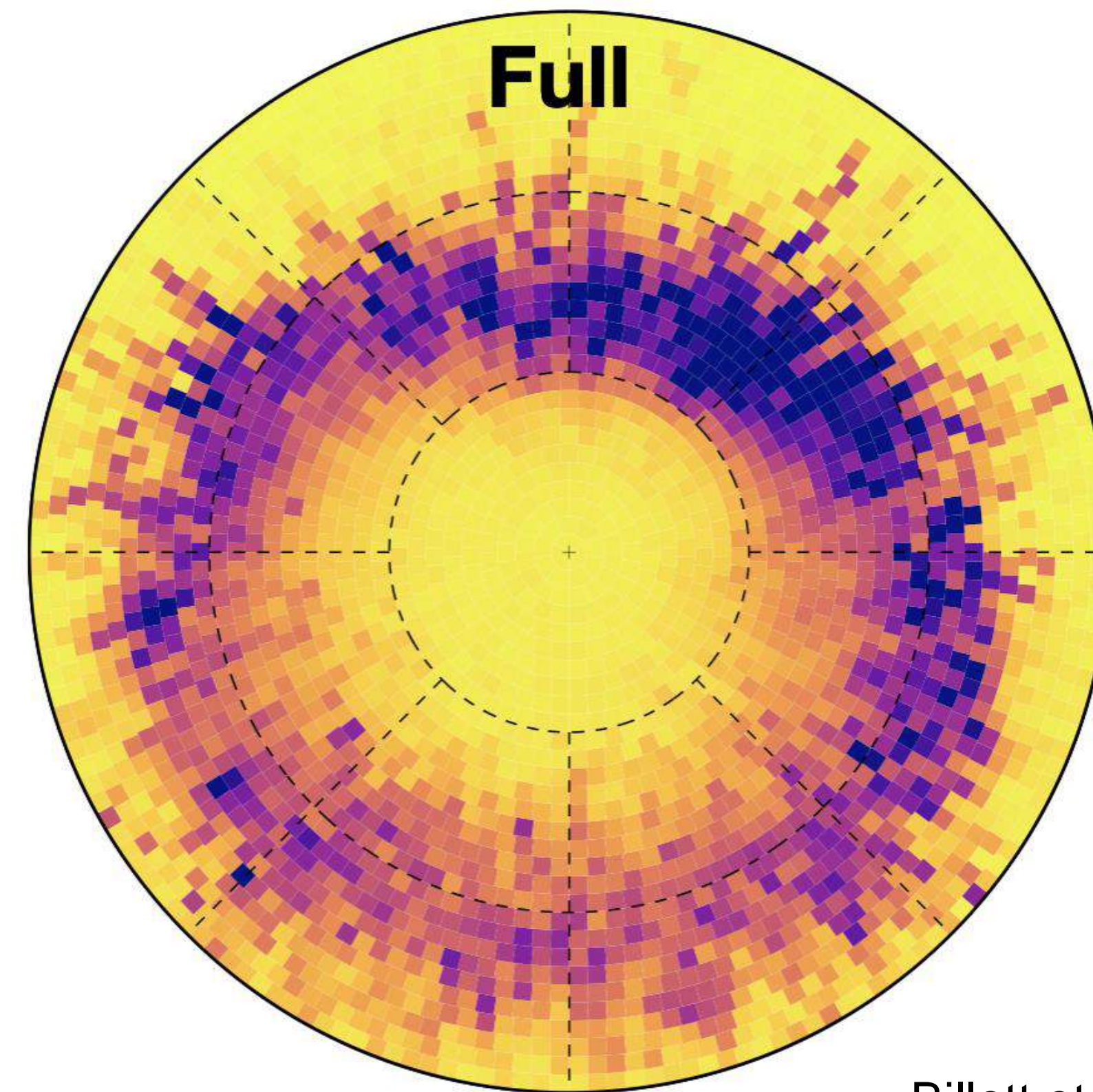
Billett et al. [2021]

Just one problem... the data doesn't agree

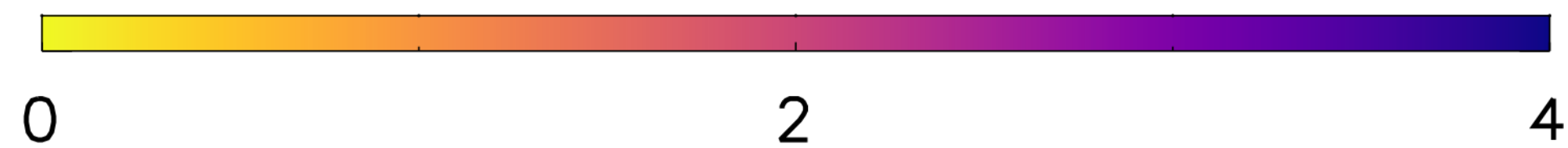
SuperDARN **E** and
AMPERE $\delta\mathbf{B}$ fields:



Swarm **E** and $\delta\mathbf{B}$ fields:



Billett et al. [2021]



...why don't these match?

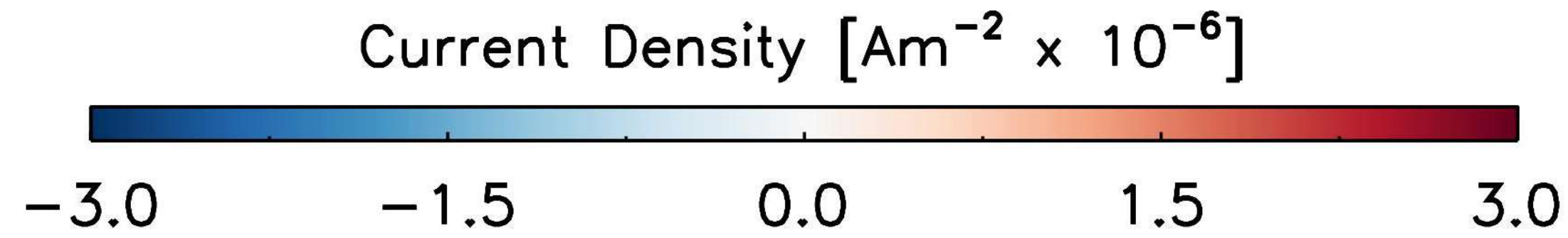


Seeing embedded structures

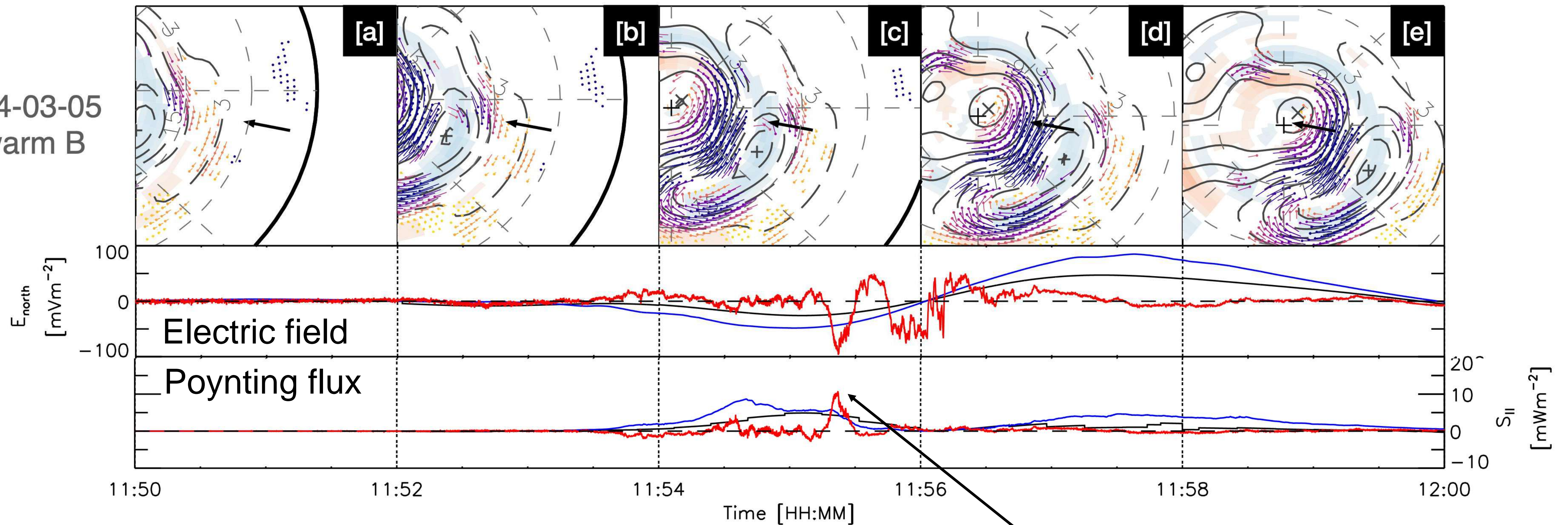
SuperDARN/AMPERE
“large-scale”

Swarm “large-scale”

Swarm “everything else”



2014-03-05
Swarm B



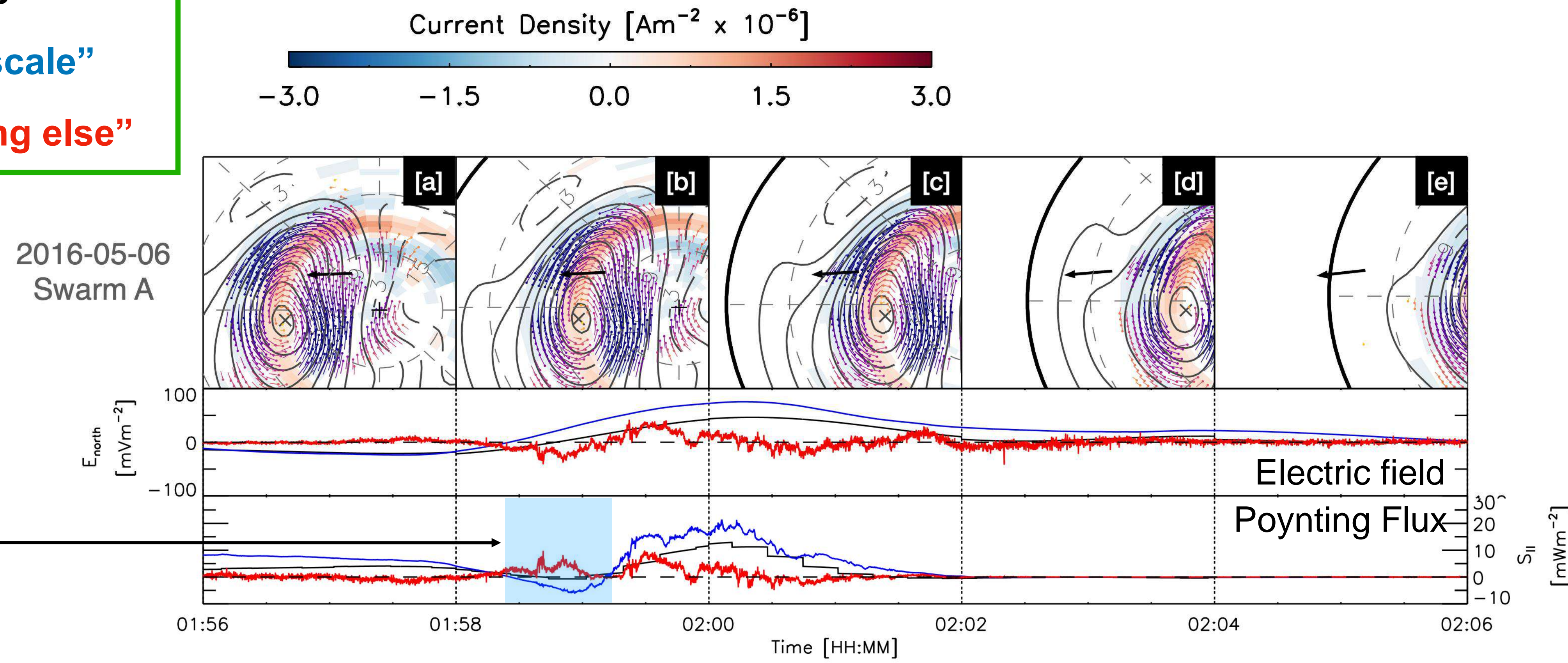
So this is the “invisible” Poynting Flux

Upward Poynting flux: Small scales balancing the large?

SuperDARN/AMPERE
"large-scale"
Swarm "large-scale"
Swarm "everything else"

Upward driving on **large-scales**, balanced by downward driving on **smaller scales**

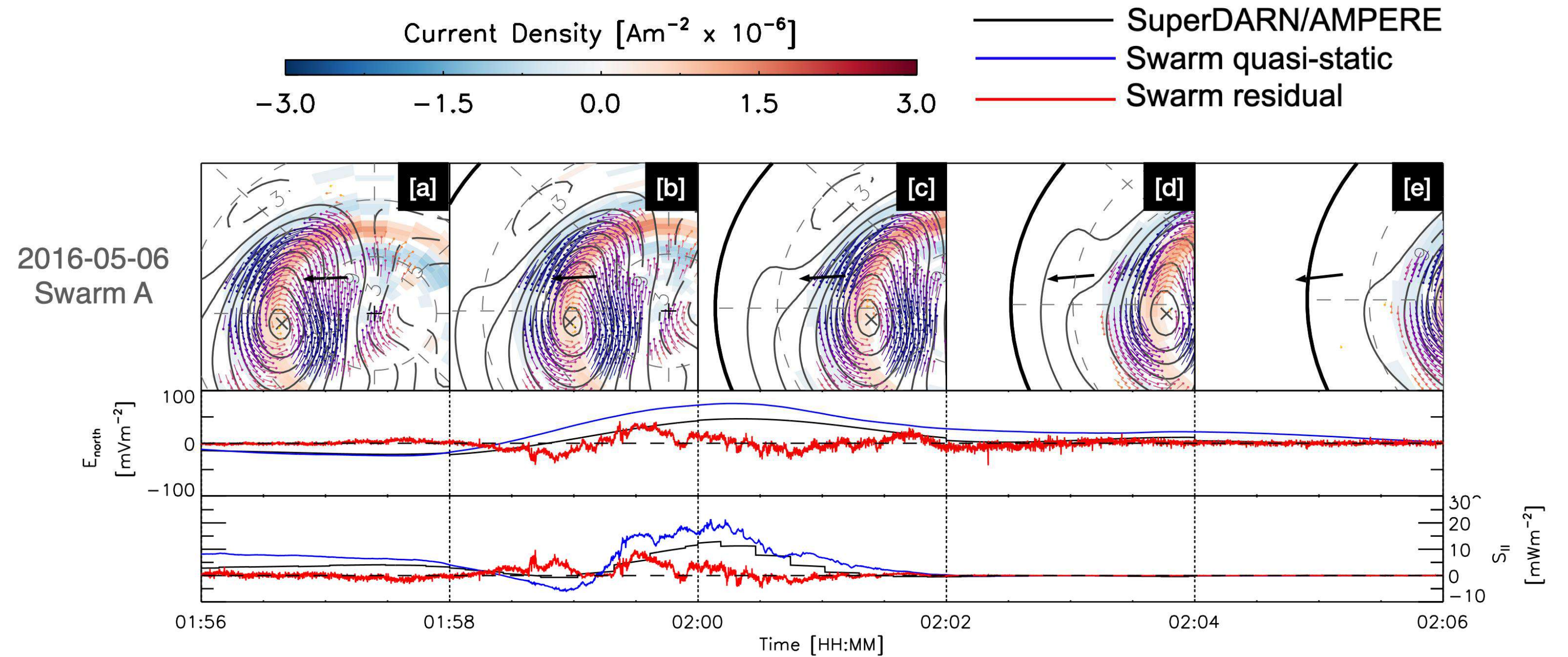
Net = 0



Duskside FACs

Summary

Capturing **large-scale** dynamics is vital for understanding **everything else**



Geophysical Research Letters*

Research Letter | [Open Access](#) |

Multi-Scale Ionospheric Poynting Fluxes Using Ground and Space-Based Observations

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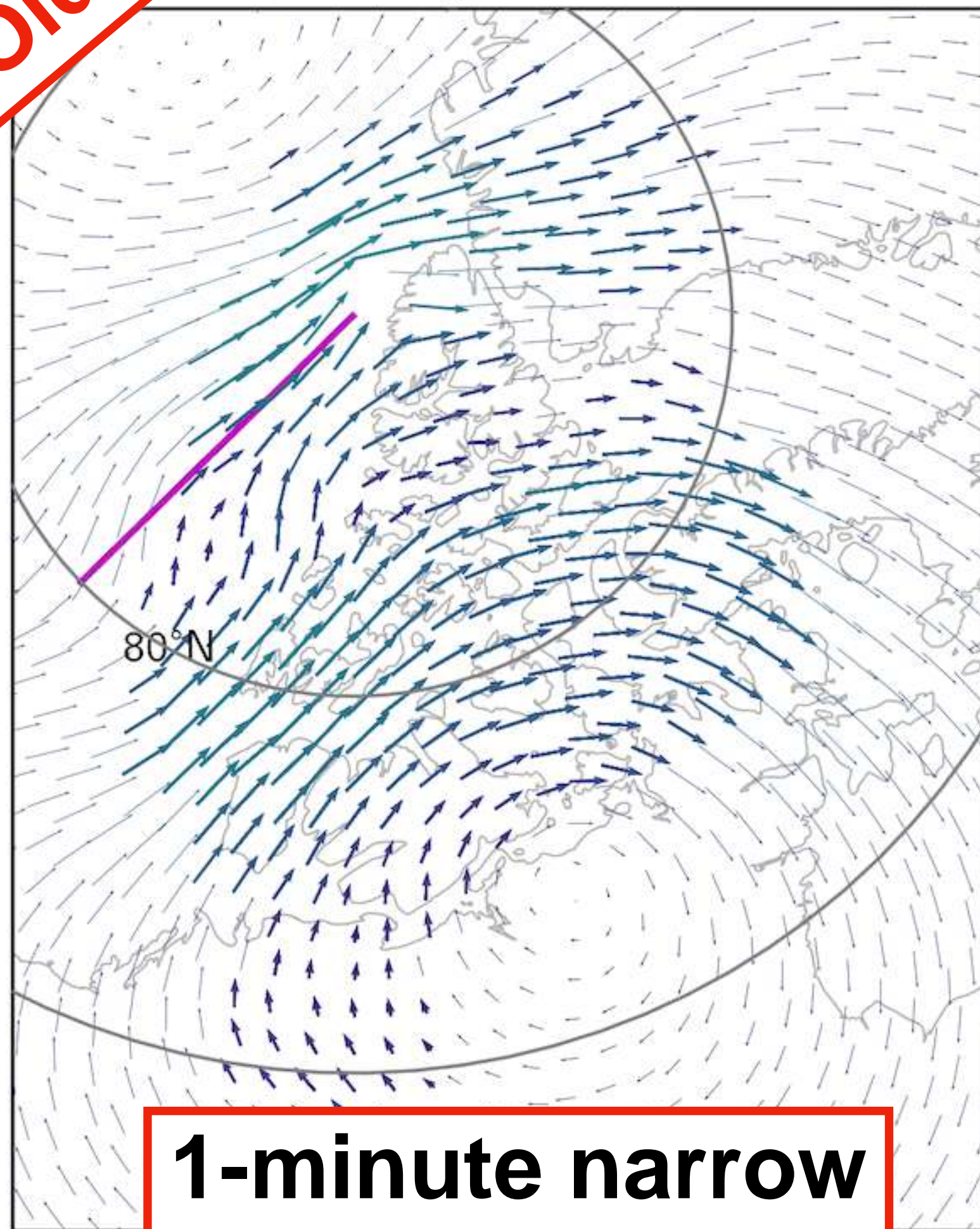
First published: 24 May 2023 | <https://doi.org/10.1029/2023GL103733>

BREAKING NEWS

SUPERDARN CANADA

Old

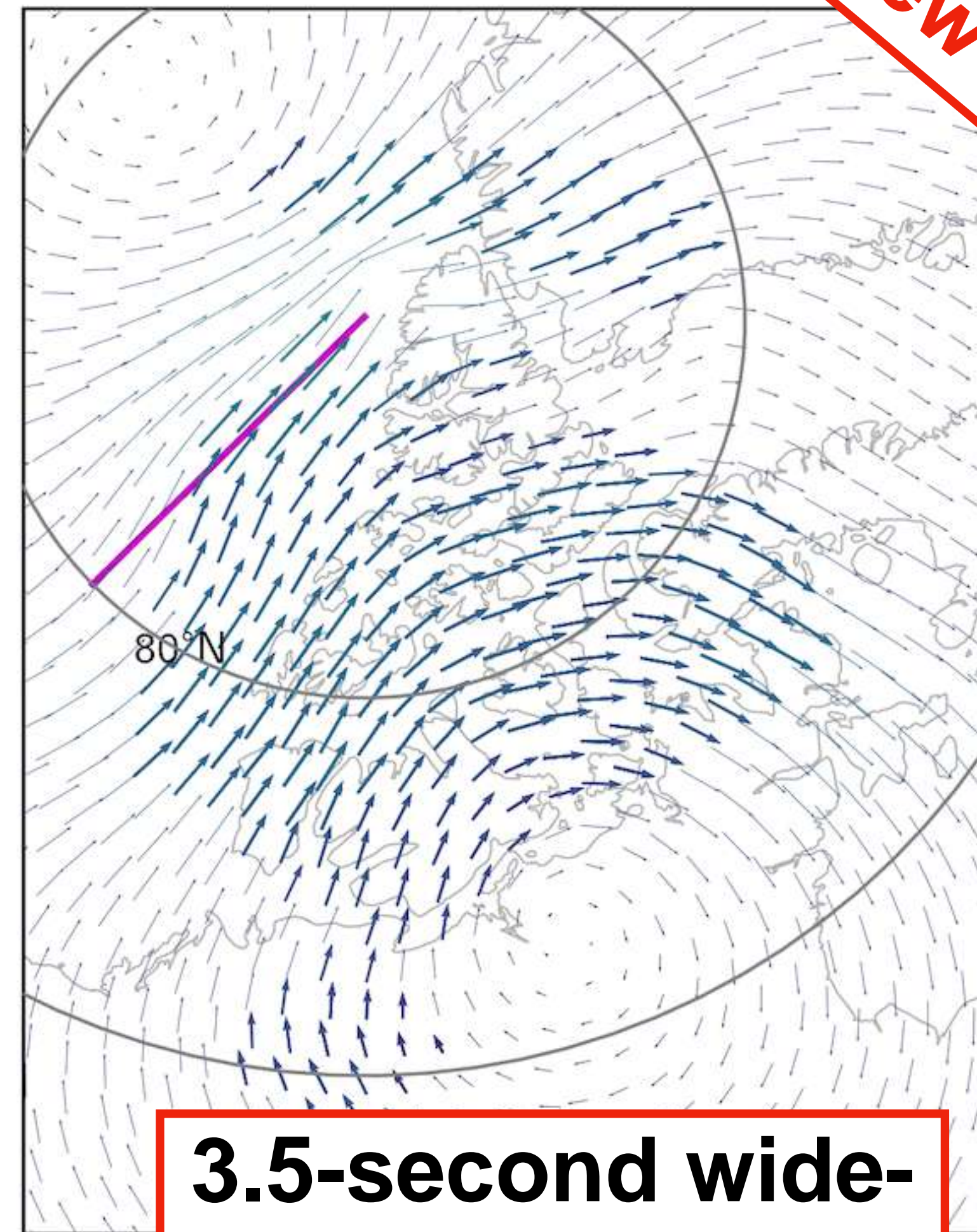
2023-12-17 00:10:33



1-minute narrow beam scanning

2023-12-17 00:10:00

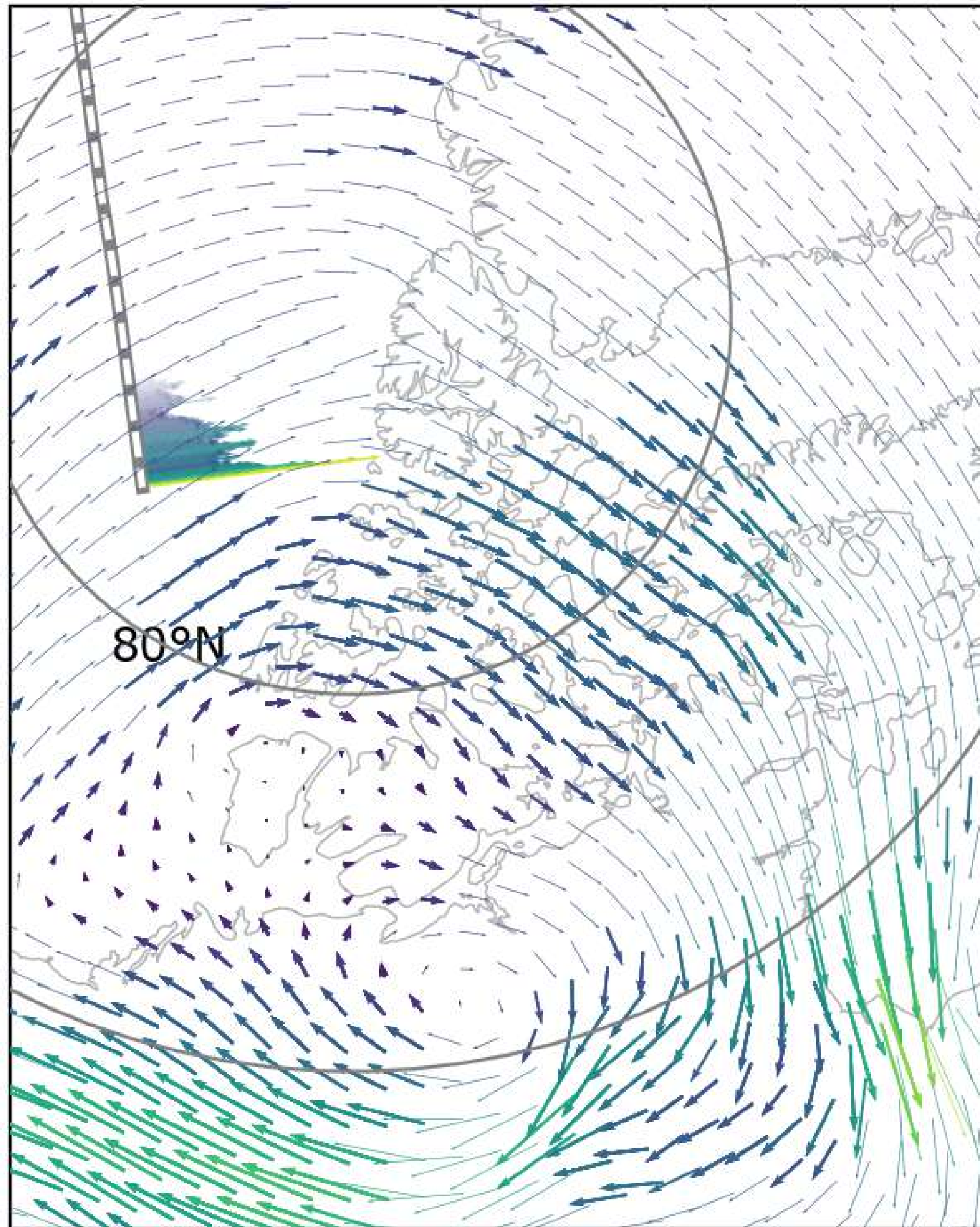
New



3.5-second wide-beam imaging

Upgrades to SuperDARN Canada radars have recently allowed us improve temporal resolution **sixteenfold**

Swarm B: 2024-01-16 04:58:37:225000



SuperDARN convection patterns can now update every 3.5s seconds in localised regions

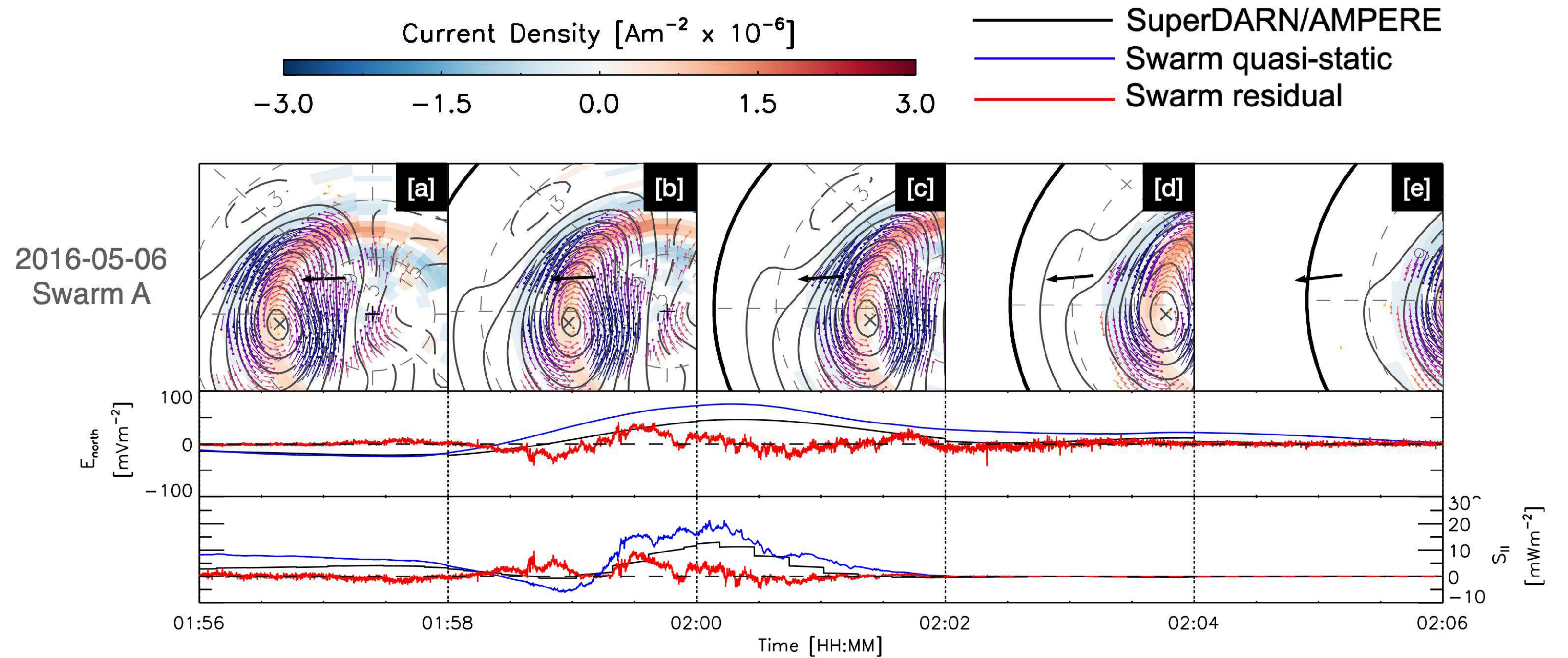
Currently Canada-Greenland only - other SuperDARN radars will make global maps possible soon™

Swarm(s) moves ~27km during one SuperDARN integration. Previously ~900km.

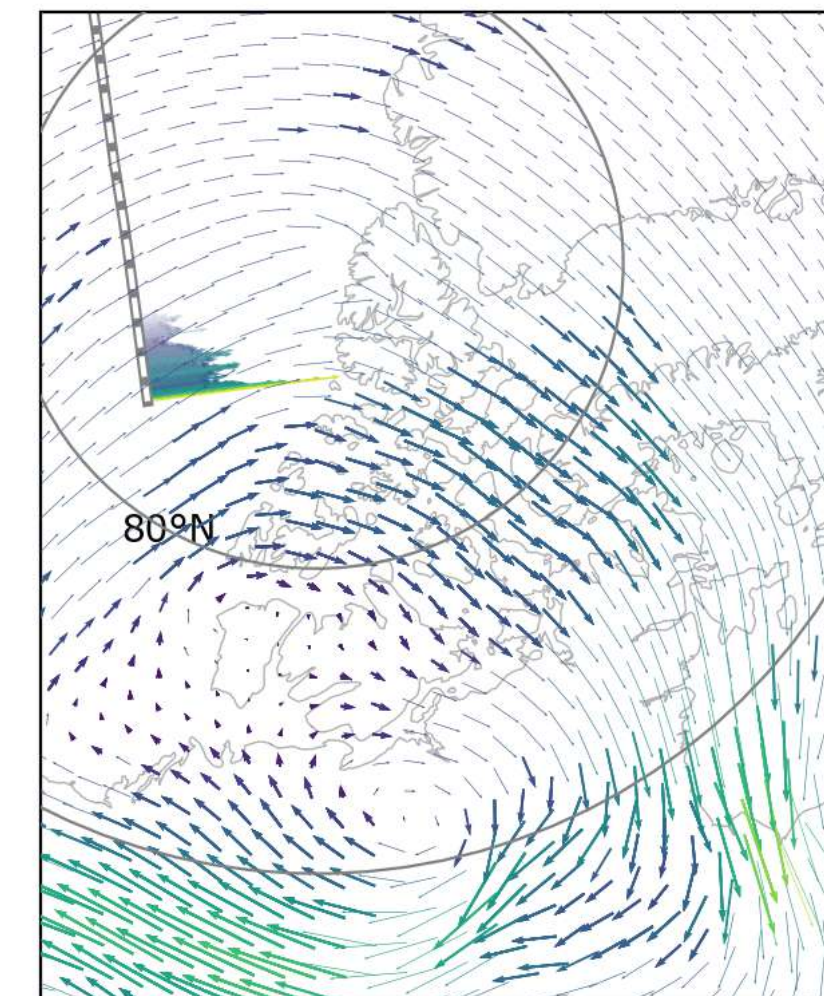
We are **very** excited about this

Summary

Capturing **large-scale** dynamics is vital for understanding **everything else**



Swarm B: 2024-01-16 04:58:37:225000



Geophysical Research Letters

Research Letter | [Open Access](#) |

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Extra slide: Comparisons

EXTREME

Kp 7+

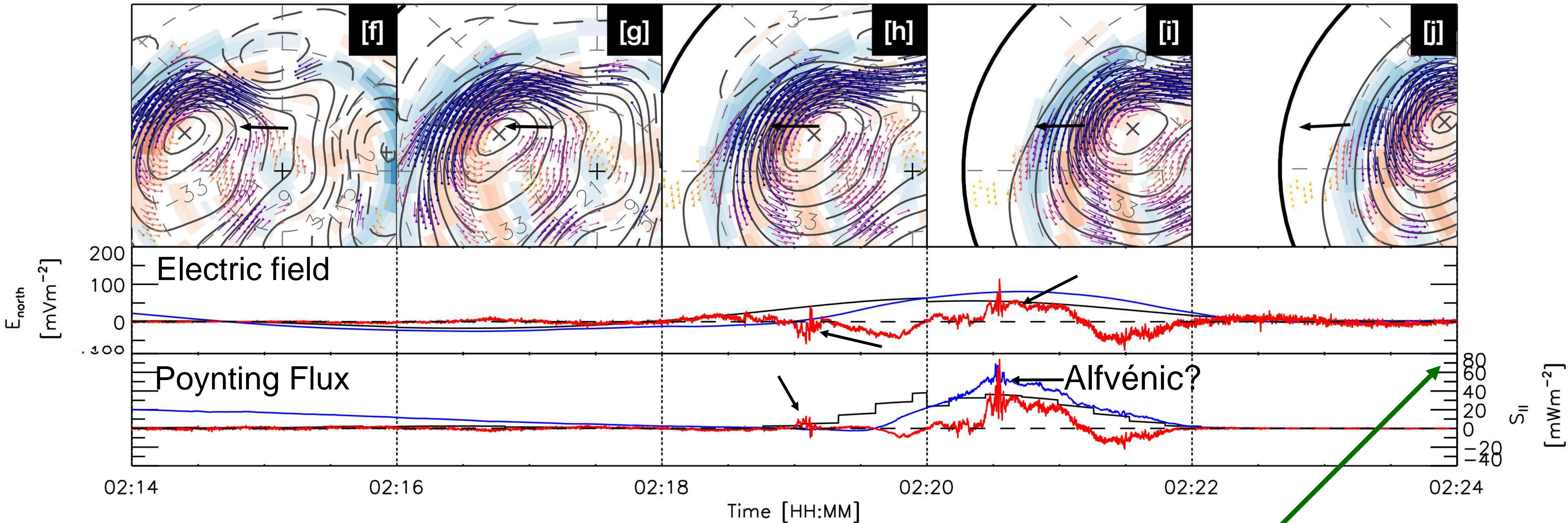
SuperDARN/AMPERE
"large-scale"

Swarm "large-scale"

Swarm "everything else"

Swarm A, 2016-05-08

Duskside FACs

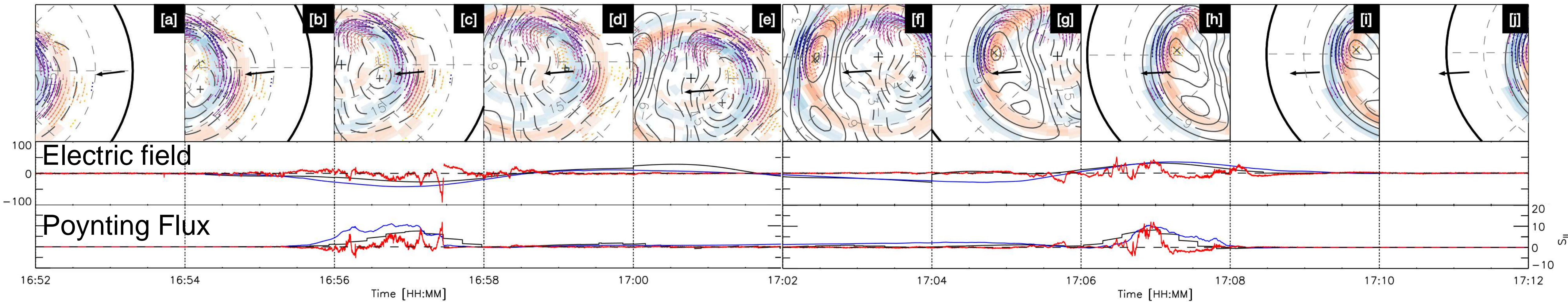
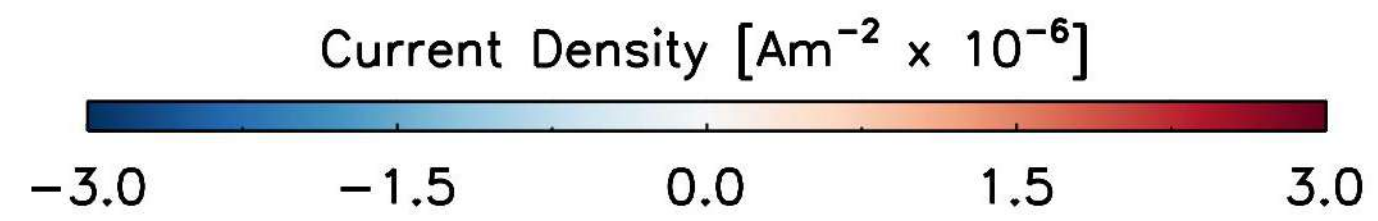


Look at those magnitudes!

SuperDARN - AMPERE - Swarm comparisons: Steady convection

Swarm B: 2014-02-18

SuperDARN/AMPERE
"large-scale"
Swarm "large-scale"
Swarm "everything else"

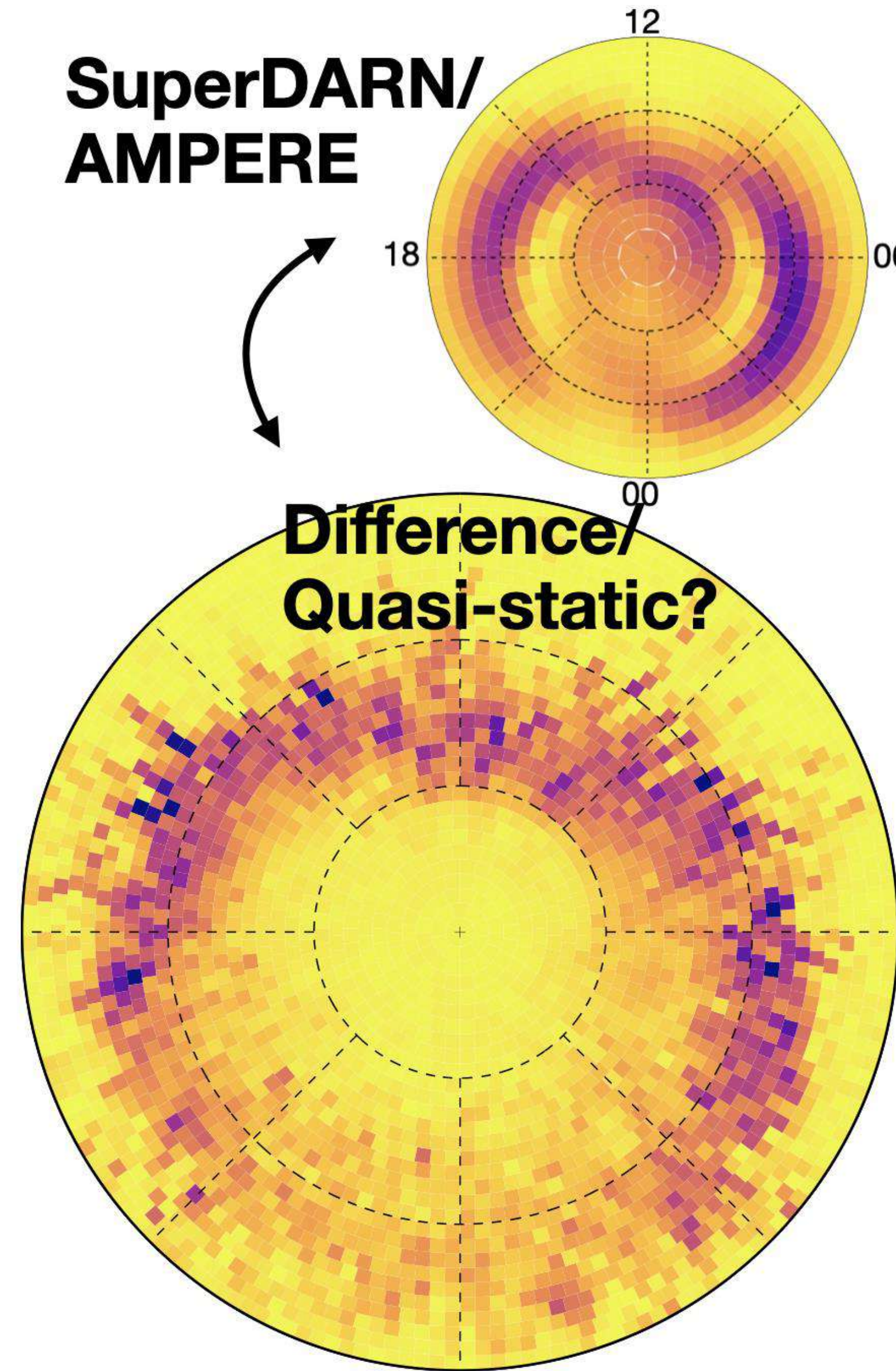
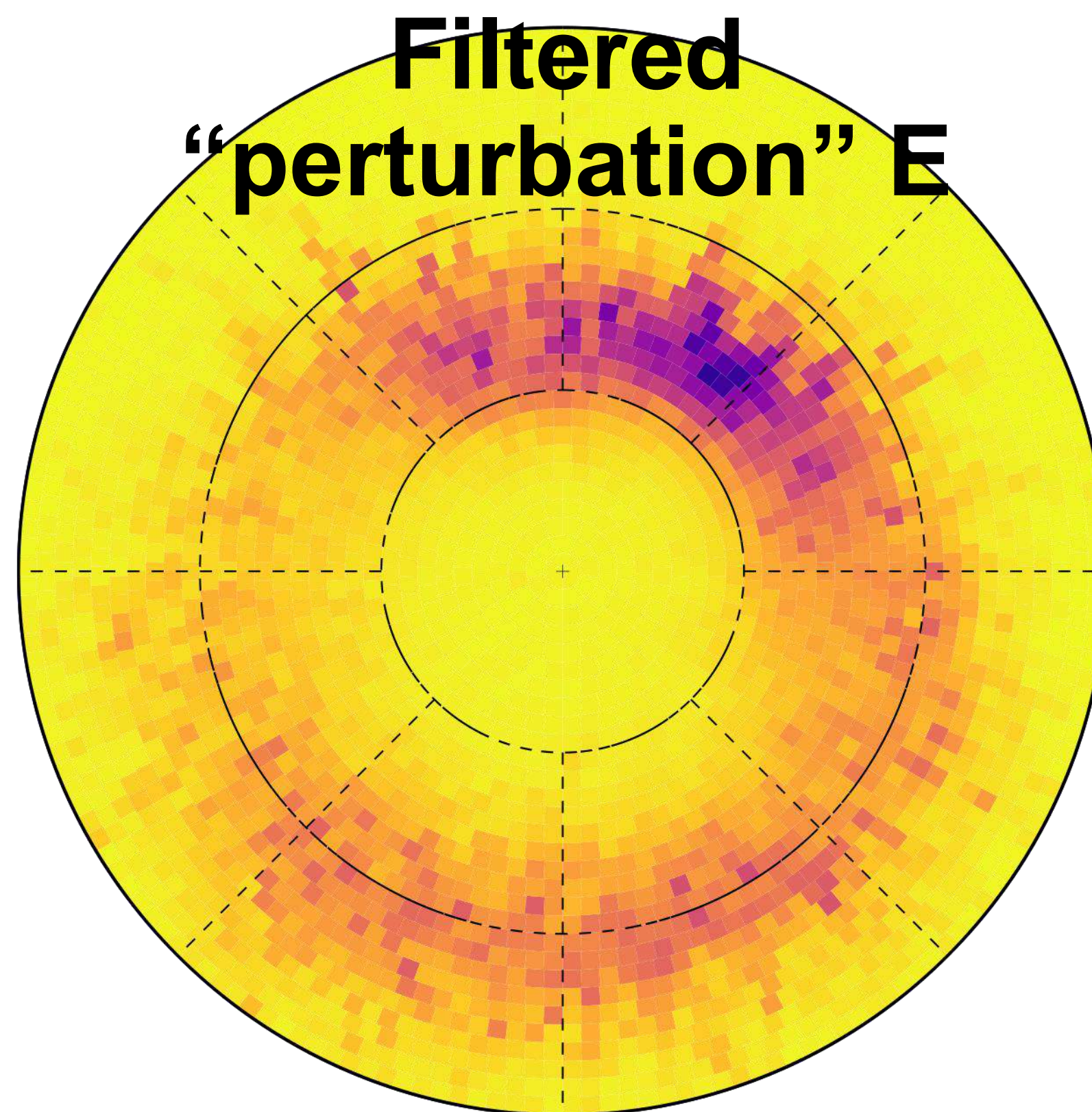
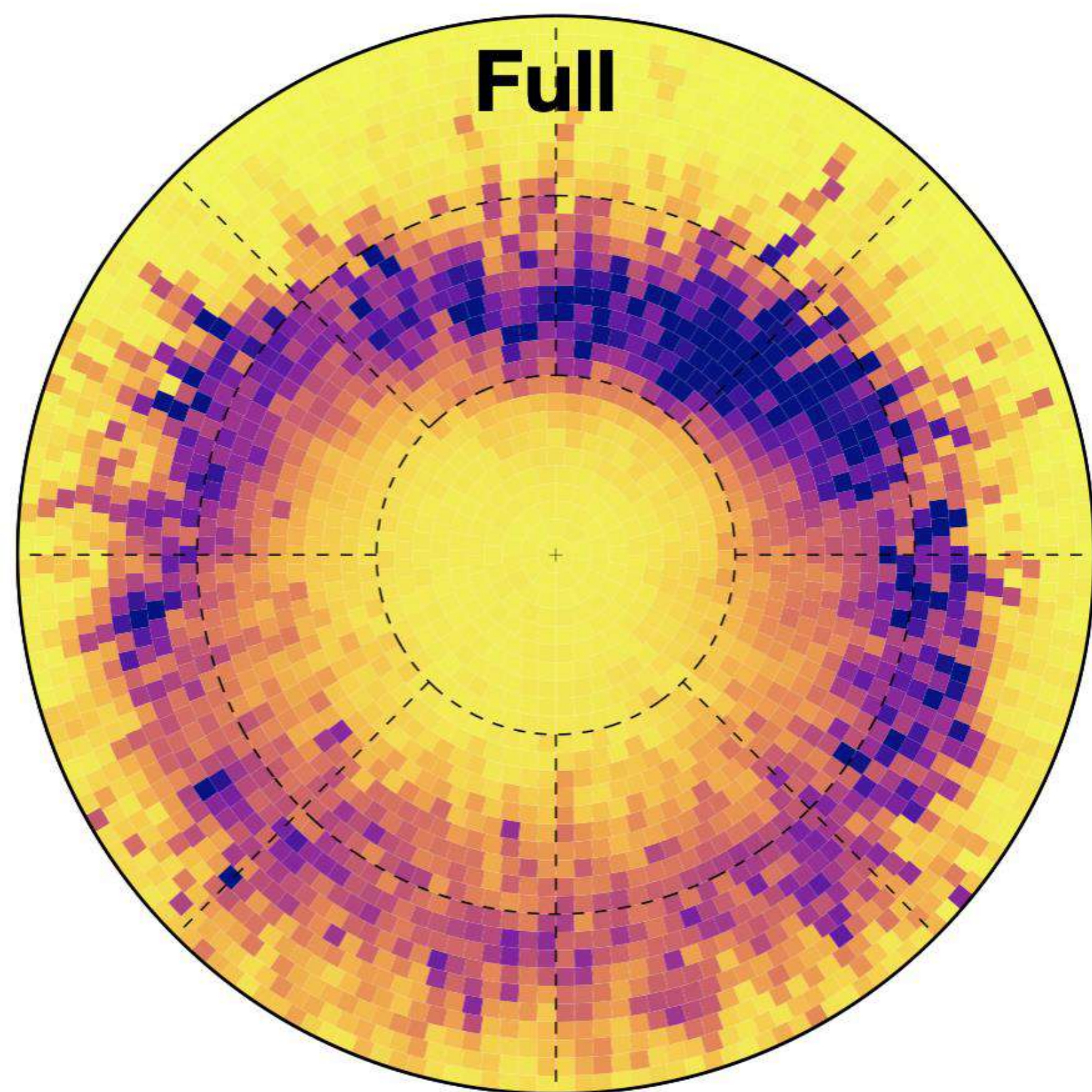


Dawnside FACs

Duskside FACs

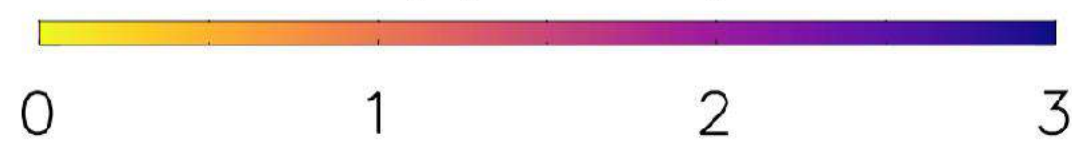
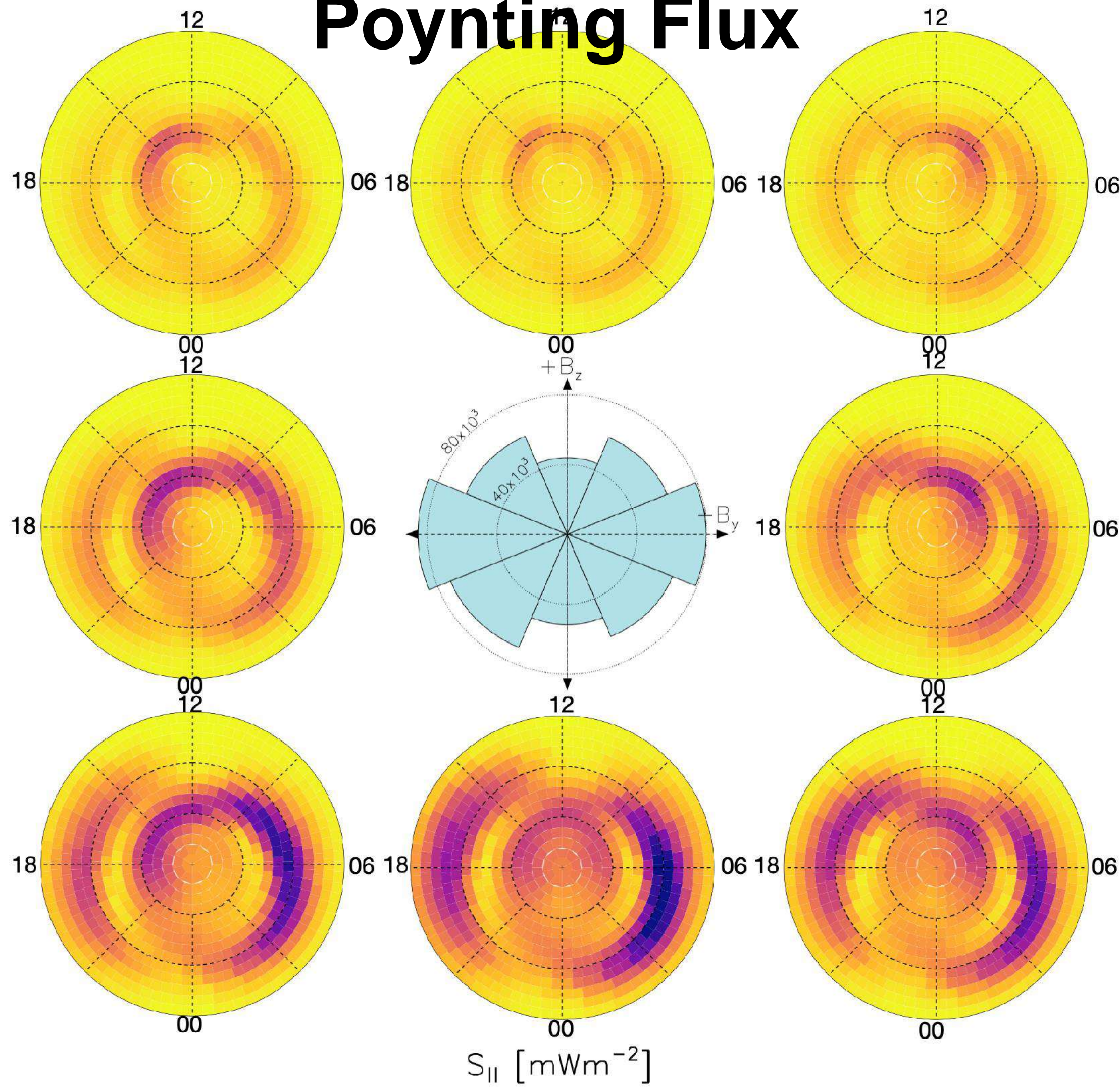
Extra slide: Making SuperDARN and Swarm match

The “full” Poynting flux will contain the perturbation and quasi-static components...



Extra slide: Project CHAMPERE

SuperDARN/AMPERE Poynting Flux



Billett et al., 2021

CHAMP Perturbation Neutral Density

