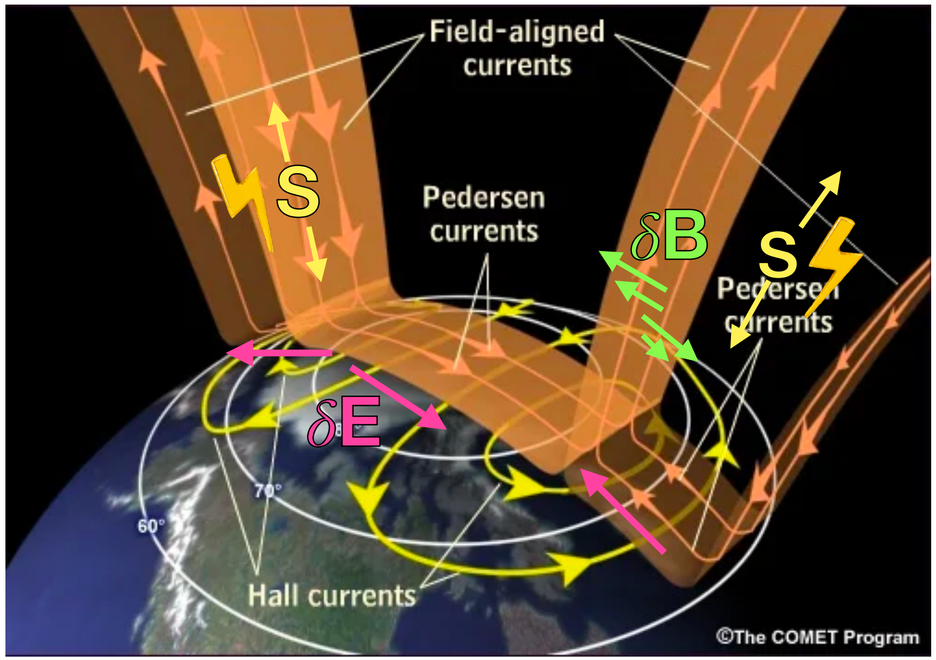
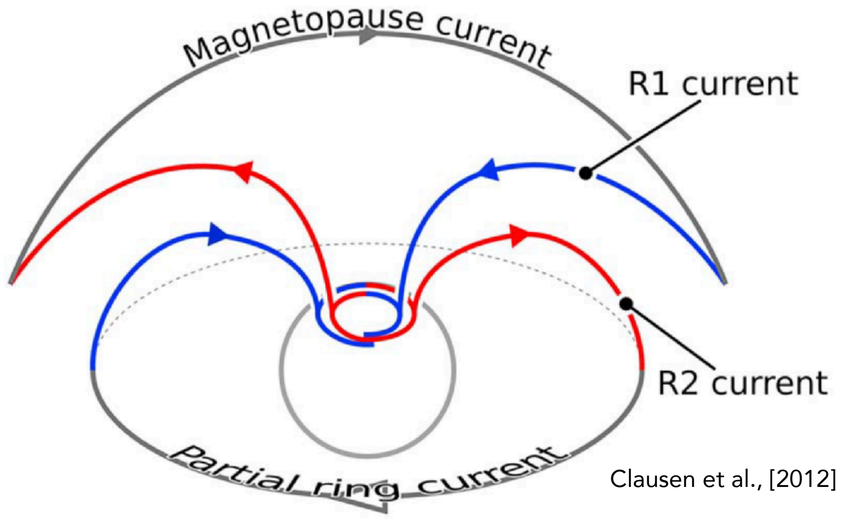
The Poynting flux problem: How much are we underestimating?

D. D. Billett[1], K. A. McWilliams[1], I. P. Pakhotin[2], D. J. Knudsen[2], J. K. Burchill[2], C. J. Martin[1]

[1]University of Saskatchewan
[2]University of Calgary

Poynting flux





Clausen et al., [2012]

Total rate of electromagnetic energy transferred between the **magnetosphere** and **ionosphere**

Field aligned Poynting Flux

Perturbation Electric field

Perturbation Magnetic field

$$\mathbf{S} = -\frac{1}{\mu_0}\left(\delta\mathbf{E} \times \delta\mathbf{B}\right) \cdot \hat{B}$$

Unit vector (along magnetic field)

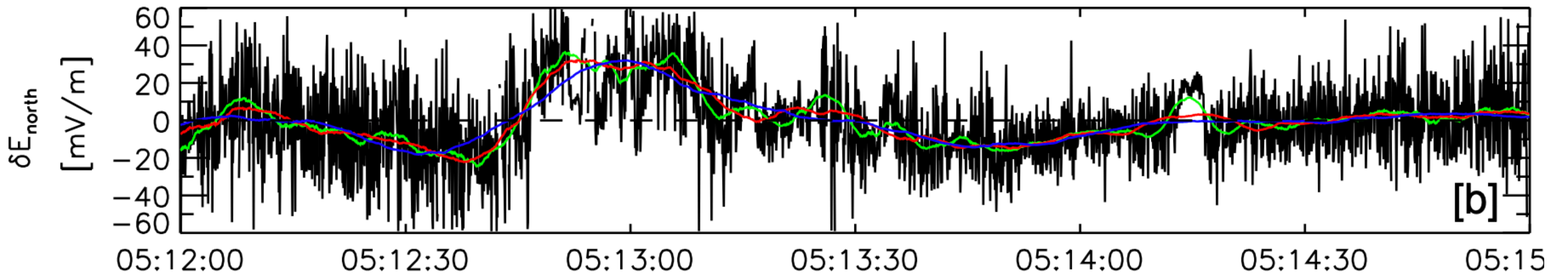
Poynting flux can be downward or upward

E + **B** measurements = Success?

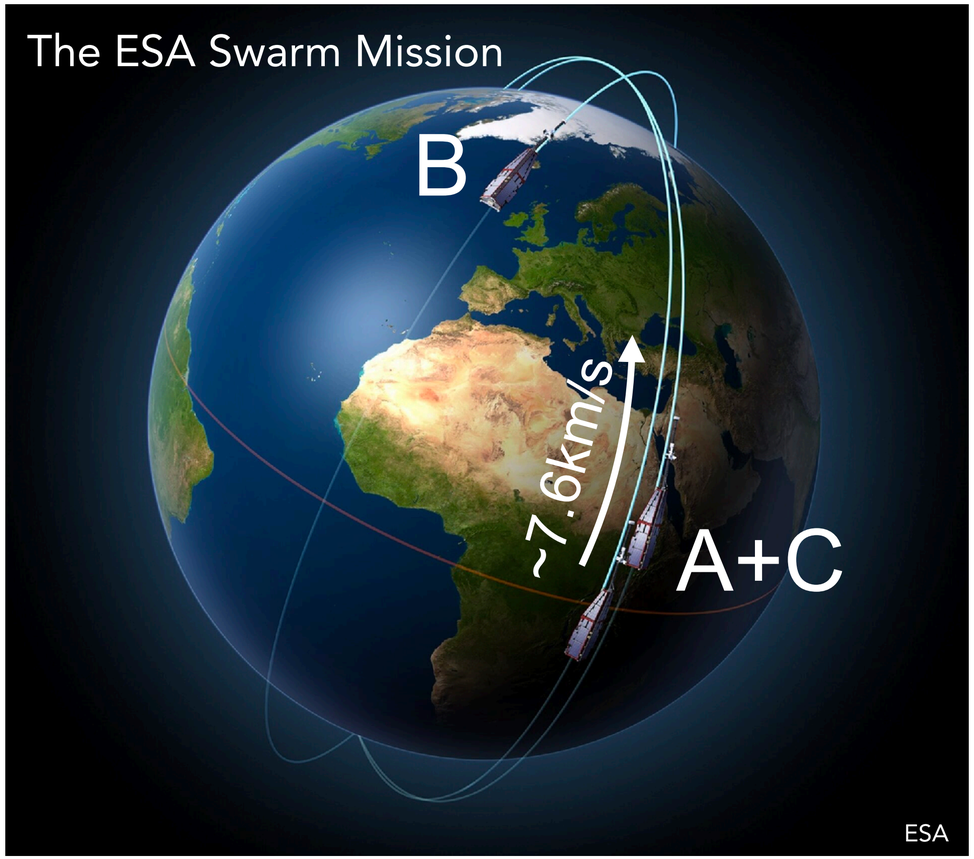
What's the problem?

Ionospheric electric field variability is significant, especially at small scales

Swarm Mission: 16Hz electric field measurements, ~1km scale size



Question: How much do the small-scales actually matter?



Example Swarm A auroral zone pass

Field aligned Poynting Flux

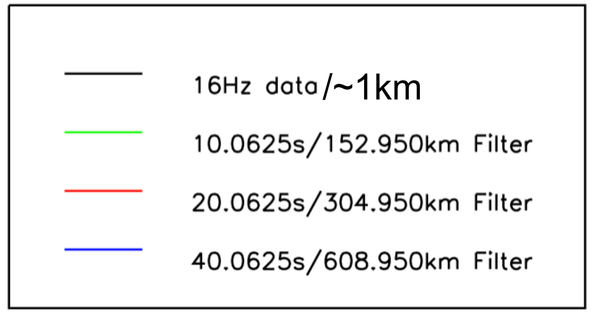
Perturbation Electric field

Perturbation Magnetic field

$$\mathbf{S} = -\frac{1}{\mu_0}(\delta\mathbf{E} \times \delta\mathbf{B}) \cdot \hat{B}$$

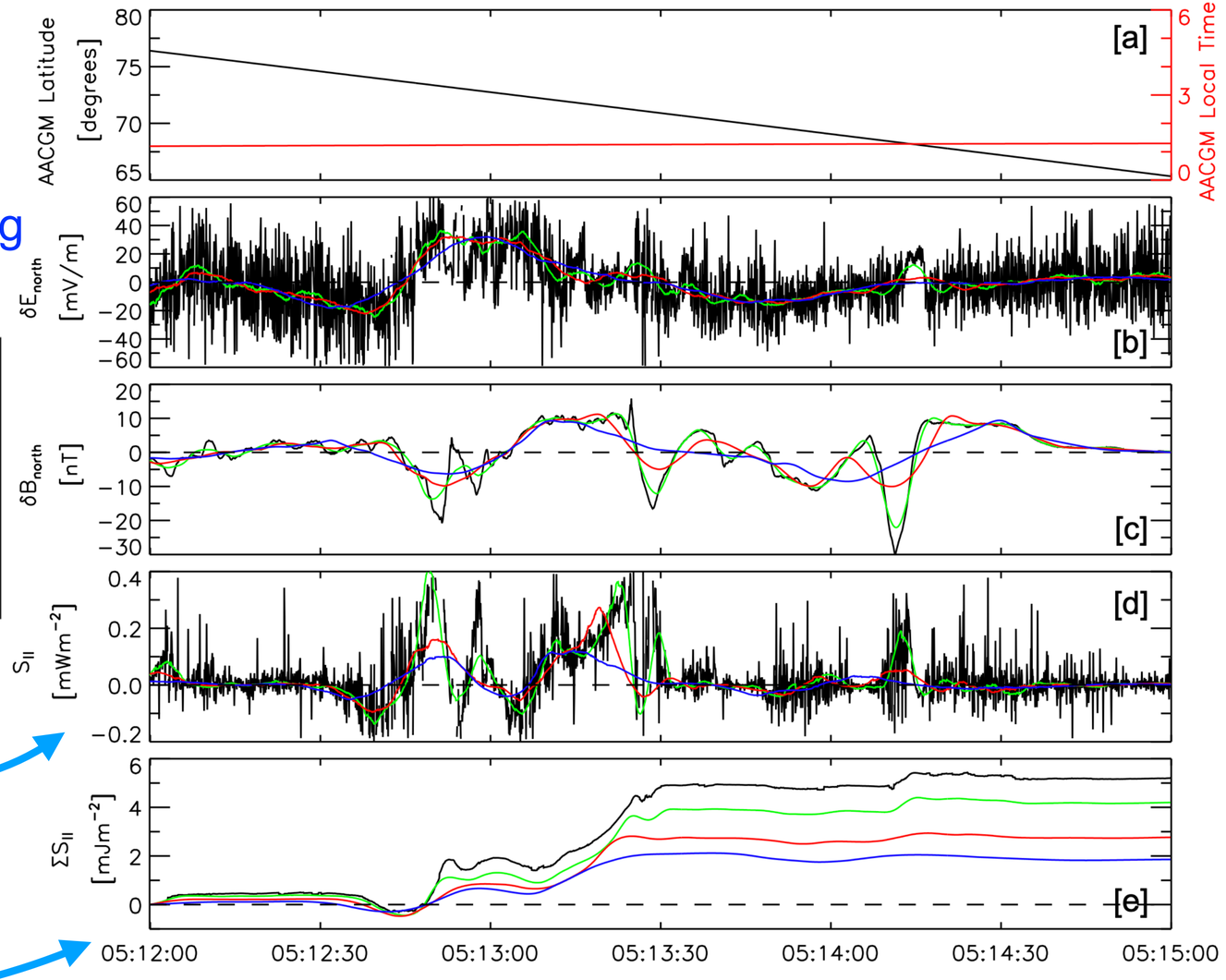
Unit vector (along magnetic field)

1. Low-pass filters to “increase” the scale-size of measurements:



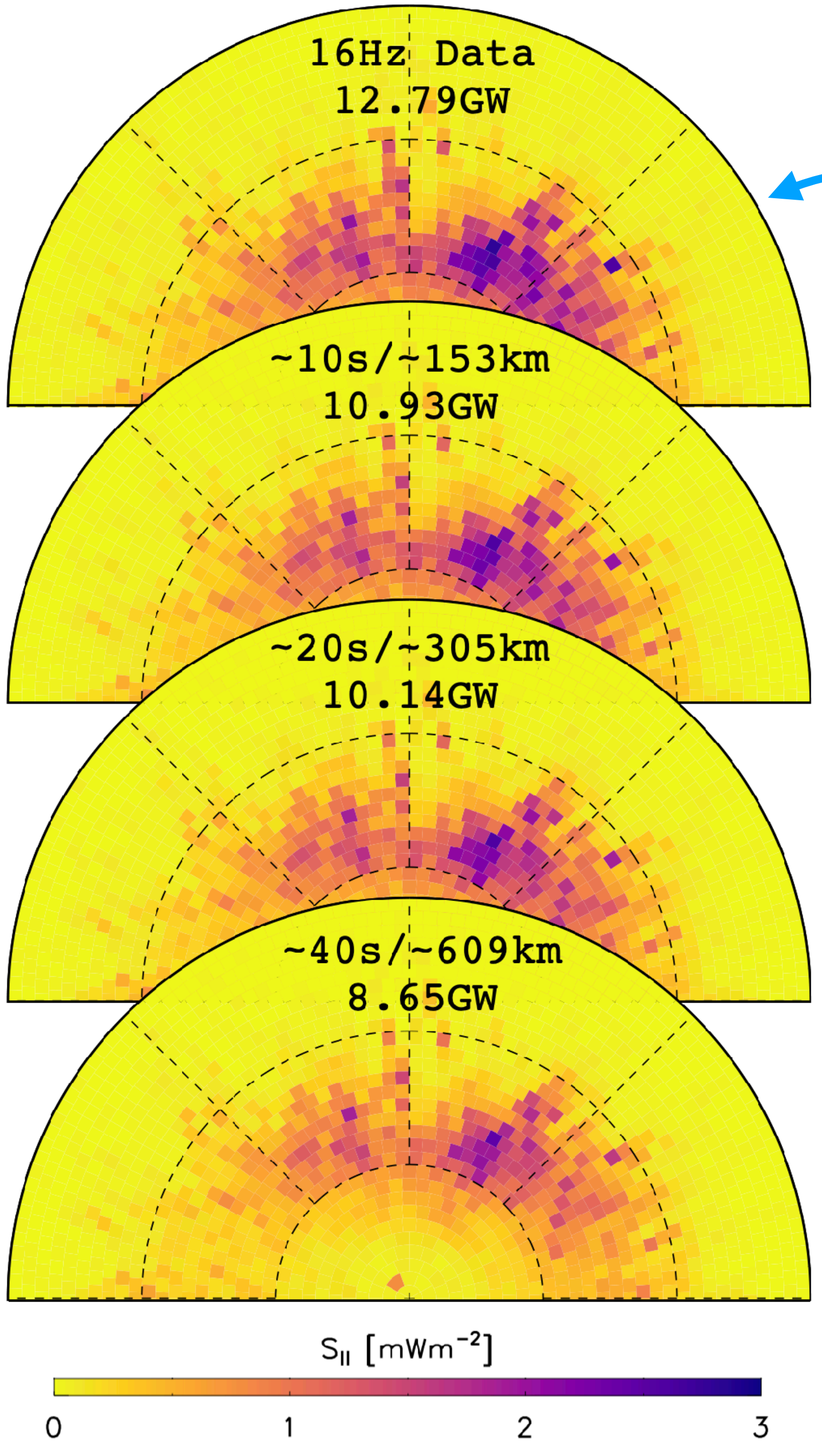
2. Poynting flux variability is **smoothed out** at larger scales

3. Integrated Poynting flux energy **decreases**

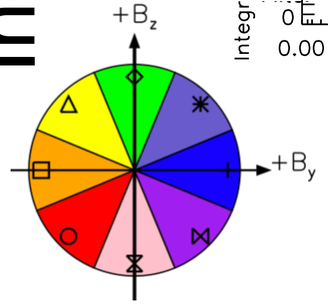


Statistics with increasing scale-size

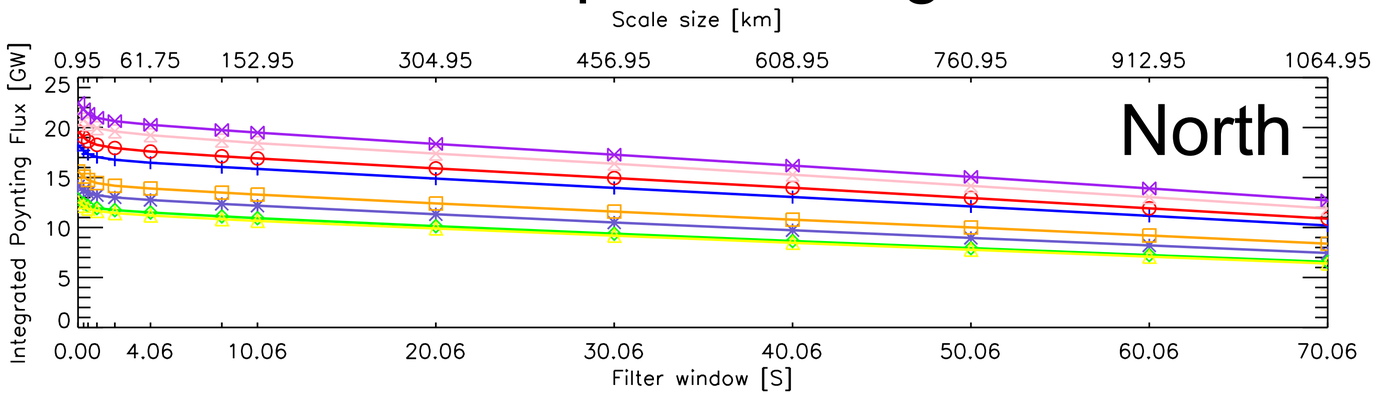
Northern hemisphere, dayside plots
(mLat-MLT coordinates)

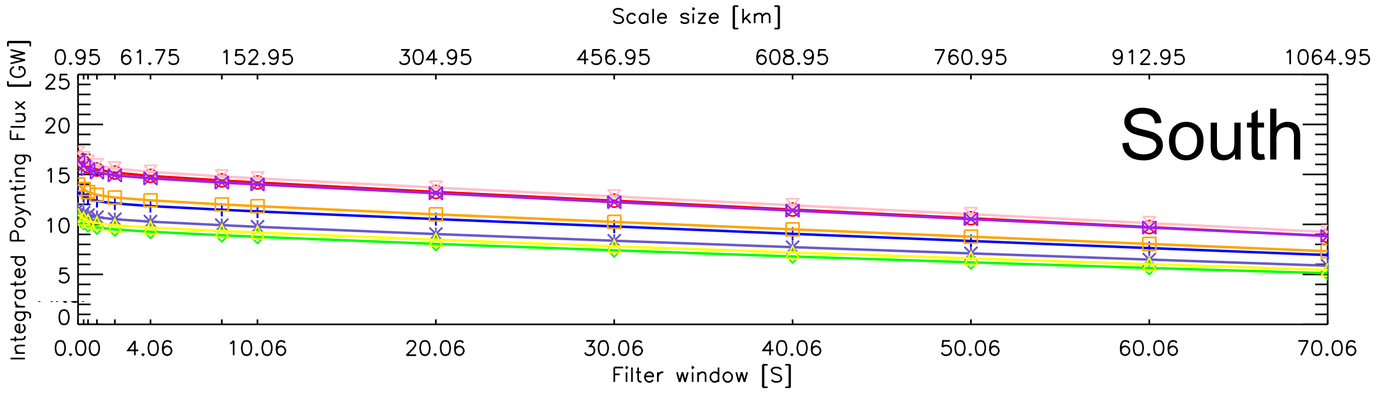


Increasing scale-size



Hemispheric integrated values:

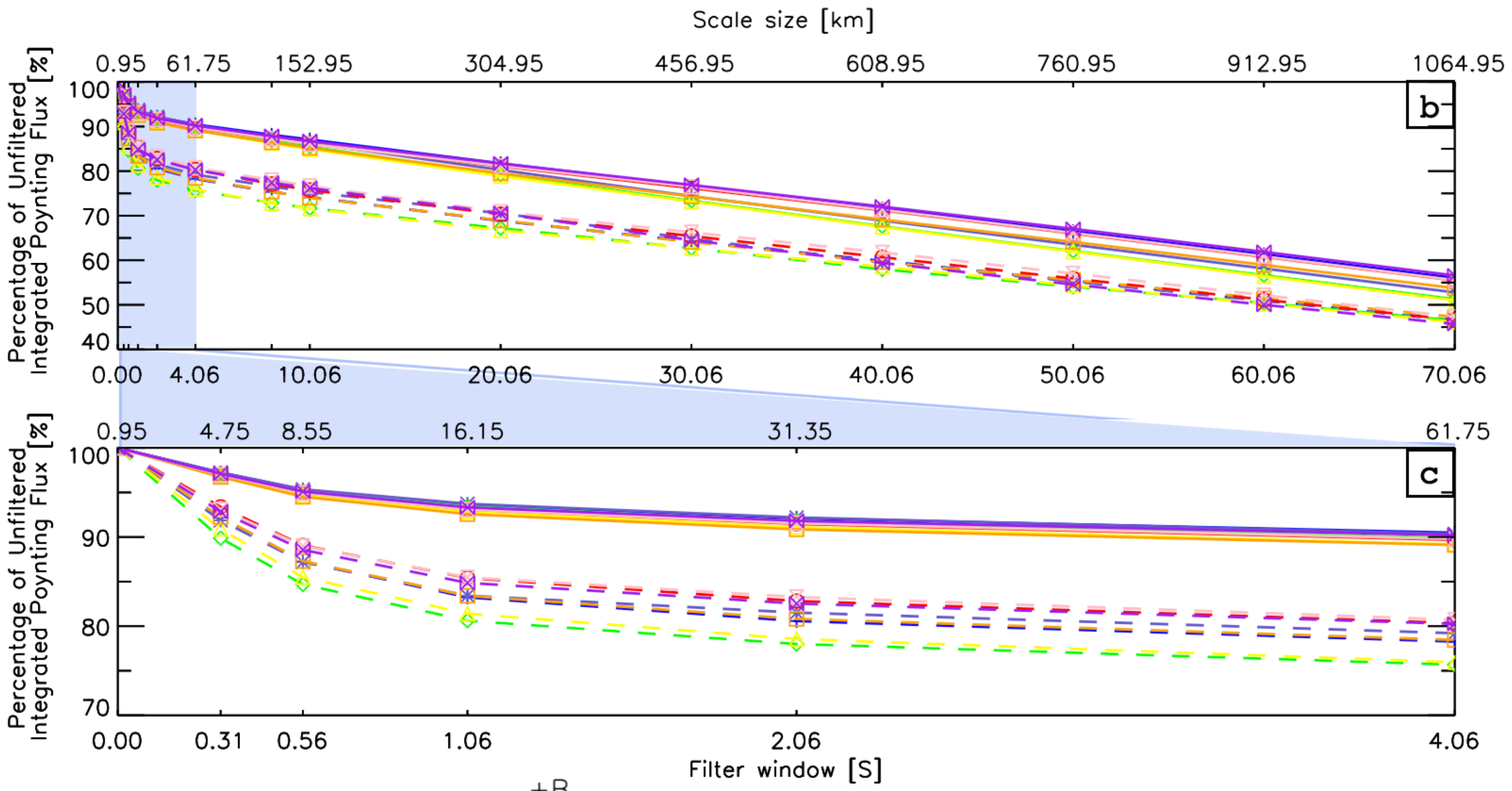


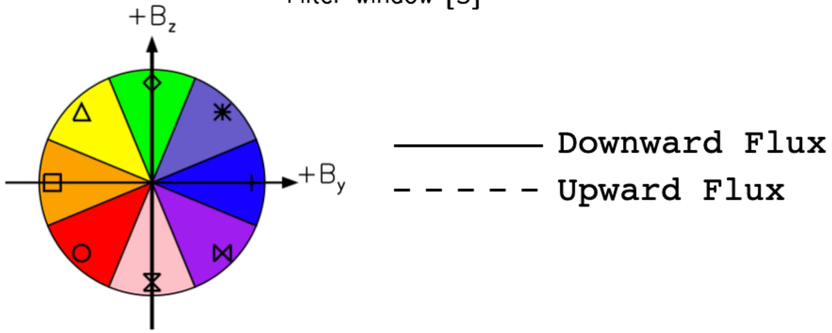


Northern hemisphere preference

The Poynting Flux drop off with scale: enhanced

Percentage of unfiltered data - Northern hemisphere:





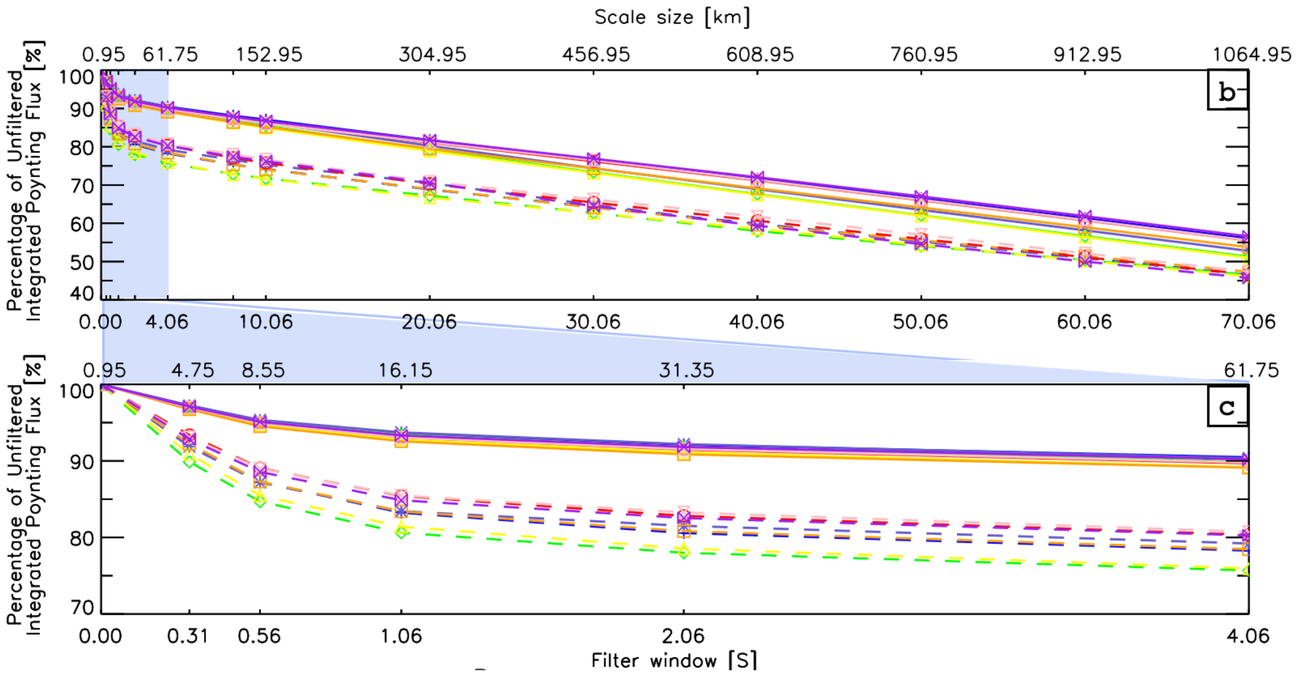
~50% drop in Poynting flux measured at largest scales

~10-20% drop within the smallest scales!

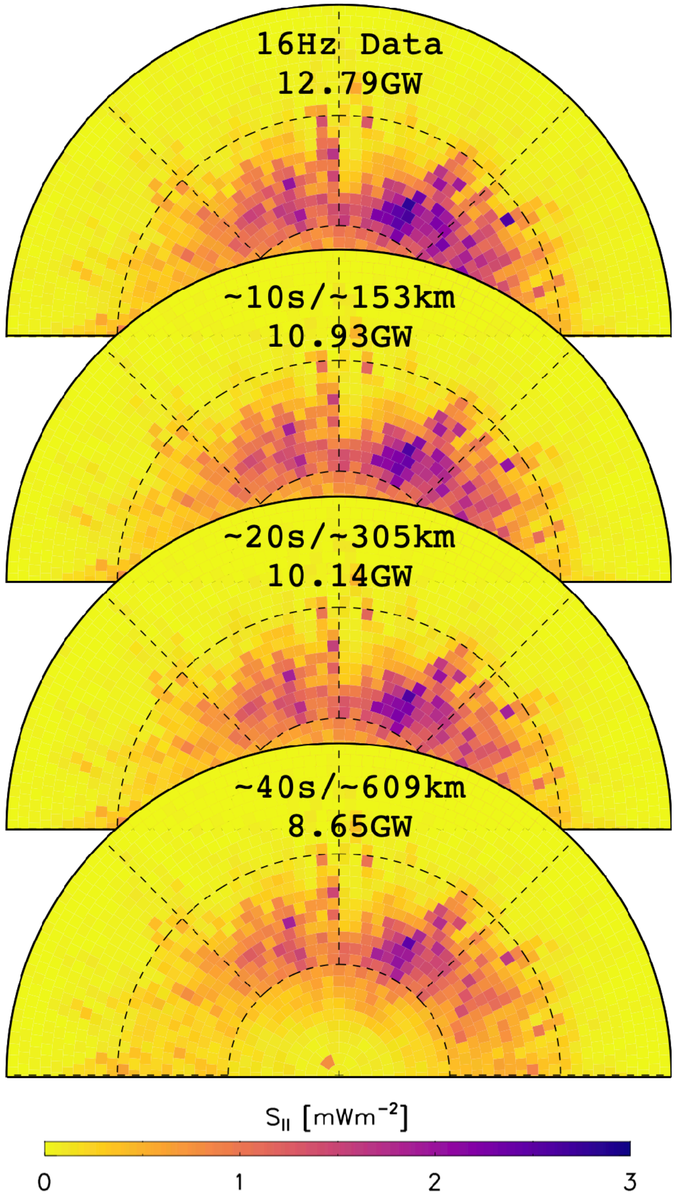
Many instruments measure upwards of tens of kilometres scales! How much are we missing?

Summary

Contact: daniel.billett@usask.ca



1. Measured Poynting flux drops off **quicker** at **small-scales**

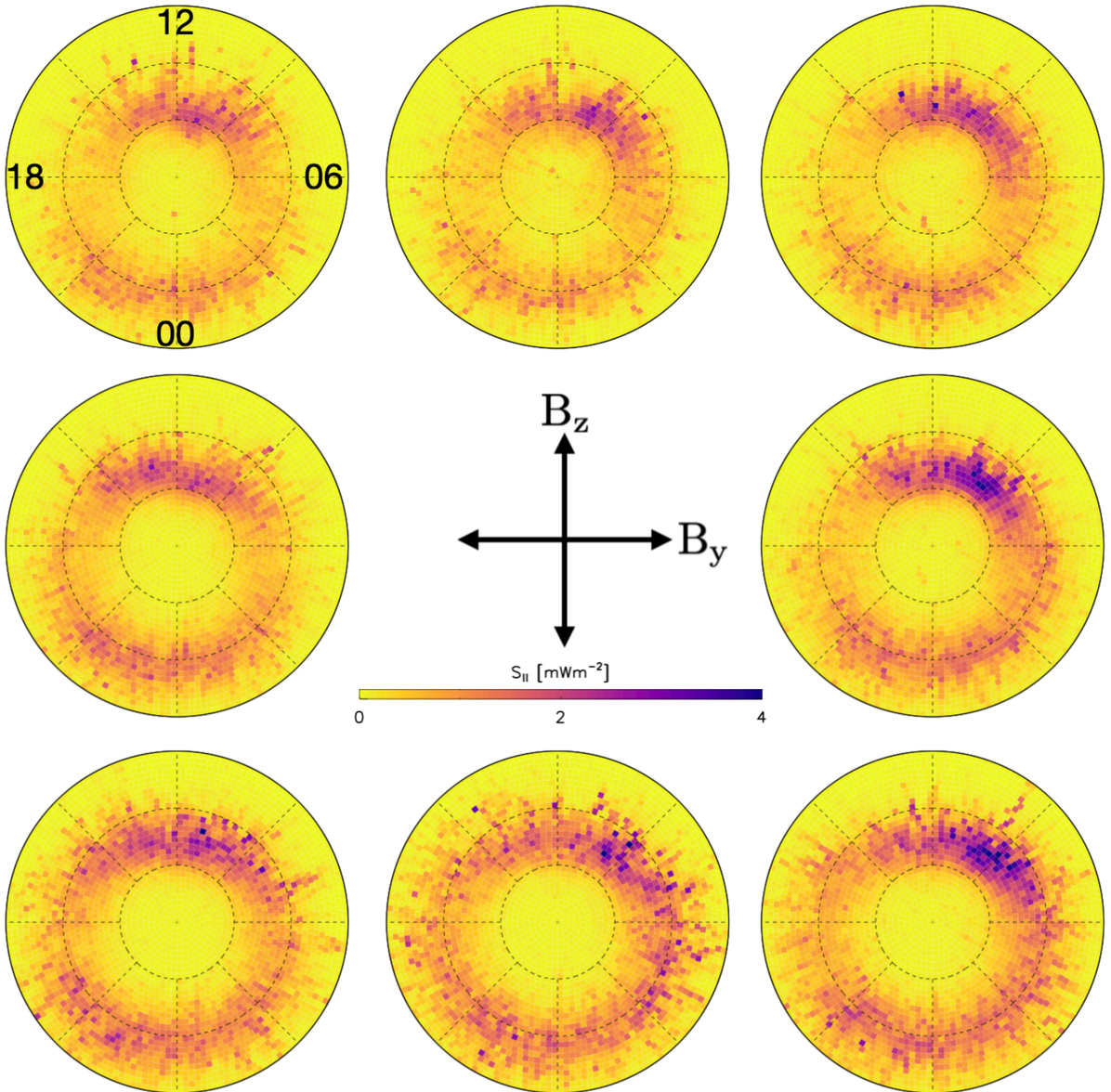


2. **Mesoscale** to **large-scale** measurements have potential for large underestimations

3. Importance of **small-scale electric field variability** in calculating the energy budget

16Hz/~1km Poynting flux statistics

Northern hemisphere



Southern hemisphere