

# MIRACLE ASC data & tools — auroral structures and heights

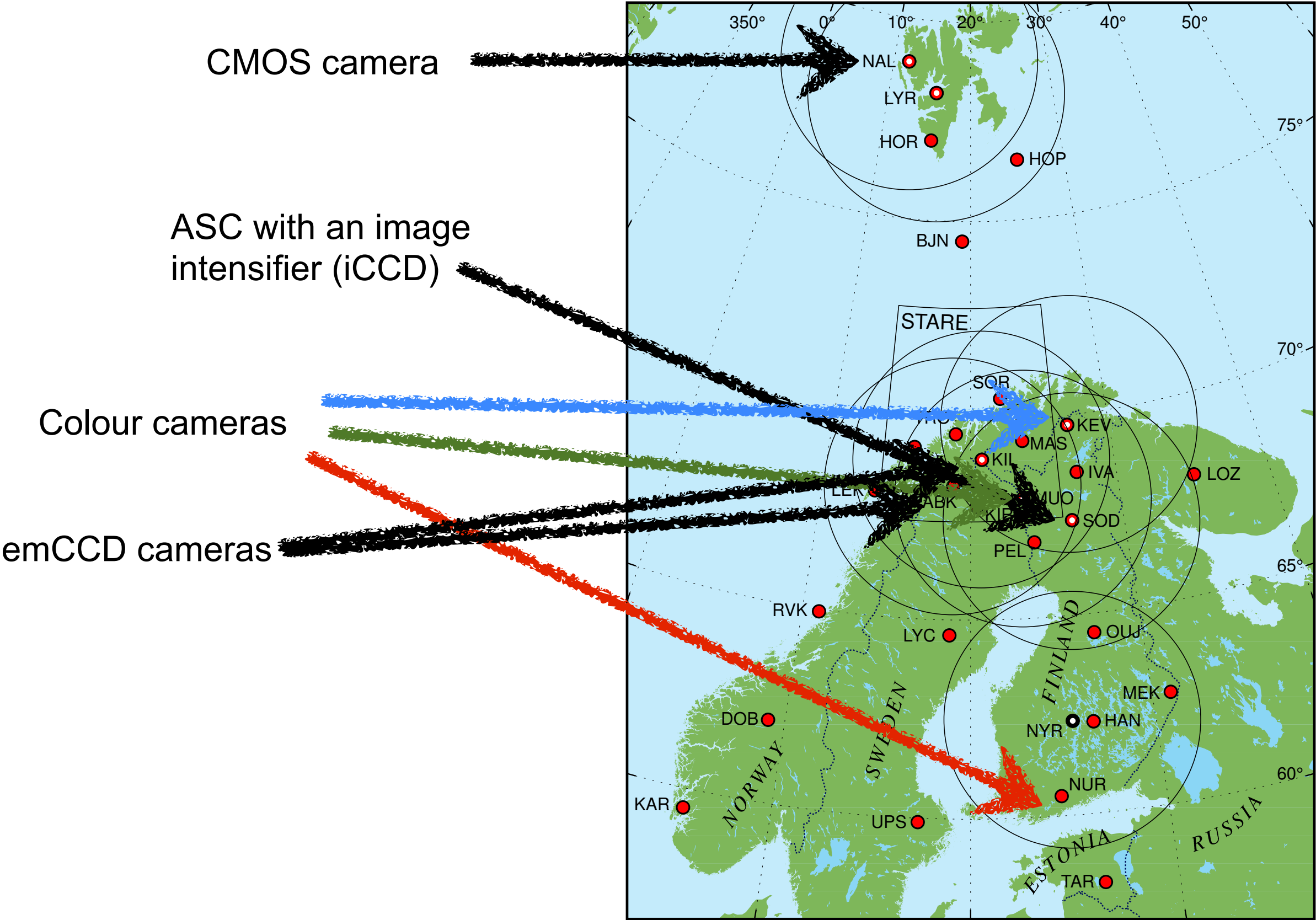
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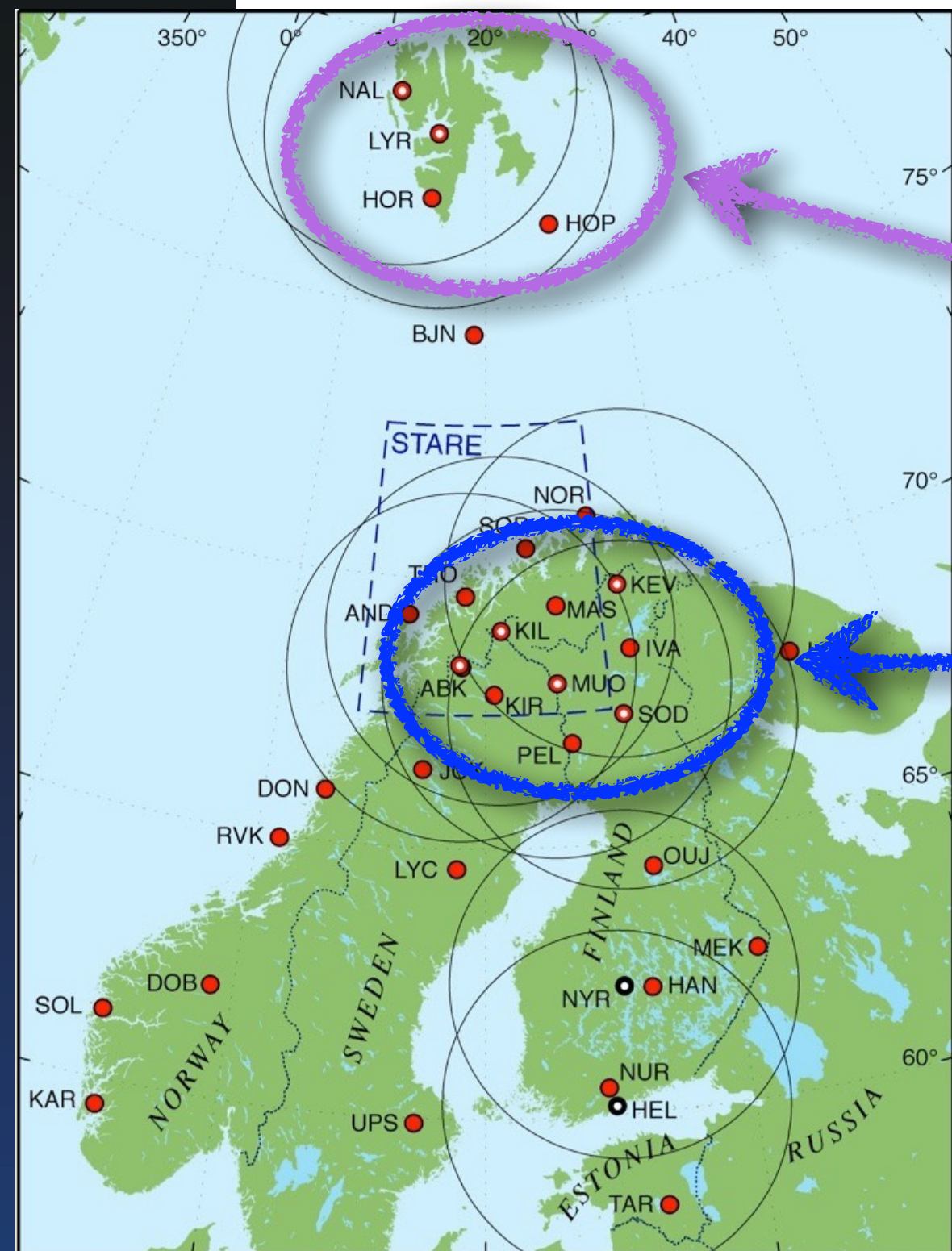
# Current MIRACLE camera network



- Magnetometer
- All-sky camera
- Magnetometer and all-sky camera

October 2004

# Data testbed for our experiments



In 1999-2012 cameras at LYR and NAL, magnetometers at NAL, LYR, HOR and HOP.

In 1996-2007 cameras and magnetometers at ABK, KIL, MUO, SOD and KEV.

- 7 identical cameras
- imaging mode 1 green every 20 sec
- about 0.8 million images / station / season

● Magnetometer  
● All-sky camera  
● Magnetometer and all-sky camera

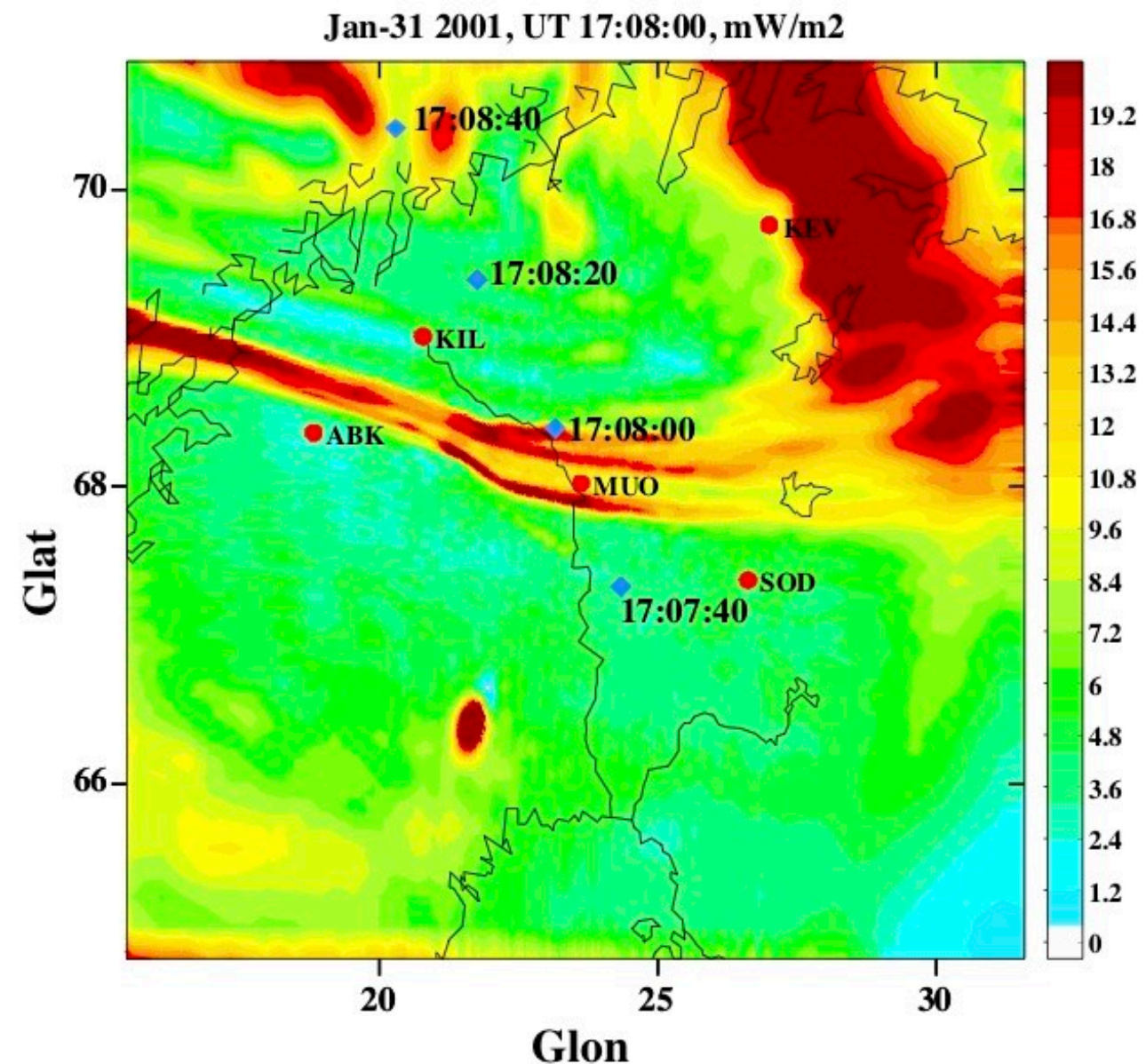
February 2013



# Inversion from brightness to energy flux

*Janhunen, JGR, 2001 & Partamies et al., Ann. Geo., 2004*

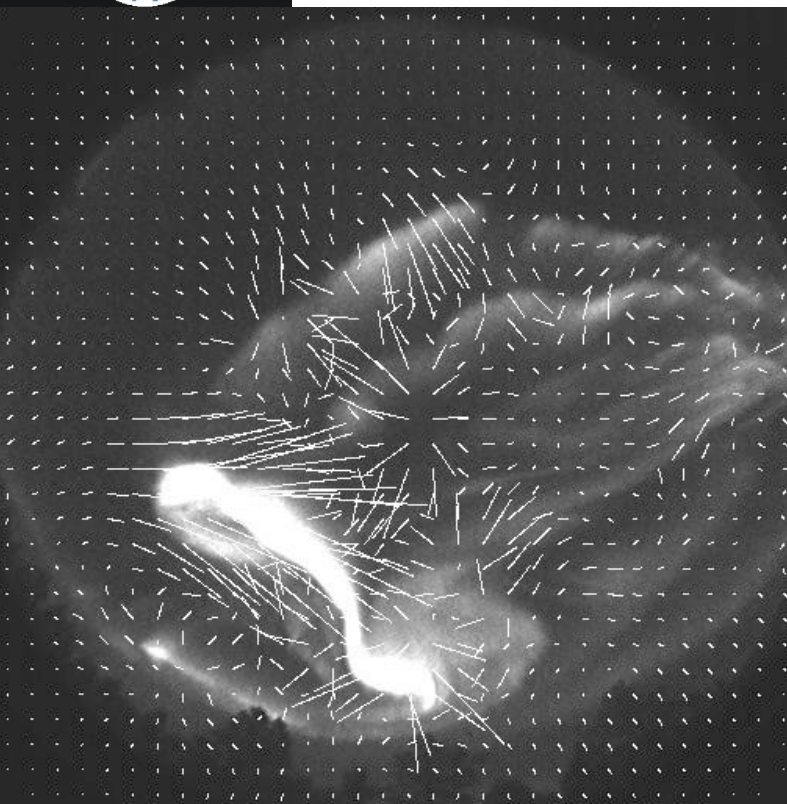
- ASC inversion converts brightness to electron energy flux
- Calibrated brightness desired
- Paired data not required
- Validated against DMSP measurements: combination of green and blue wavelengths give the best results





# Optical flow

- Implementation of Horn-Schunck to convert brightness changes into a vector field (C program by *P. Janhunen*, also currently available in Matlab)
- An improved version allows morphological changes (an AIDA function by *B. Gustavsson*)
- Facilitates drift motion studies of fairly stable structures (e.g. omega bands and some pulsating aurora patches)



UTC 17:26:20 13 Jan 1998 N  
FMI/GE0 All Sky Camera Image Filter: 557 nm W + E  
Station KEV0, N69.76 E27.01 Exposure: 1000 ms S



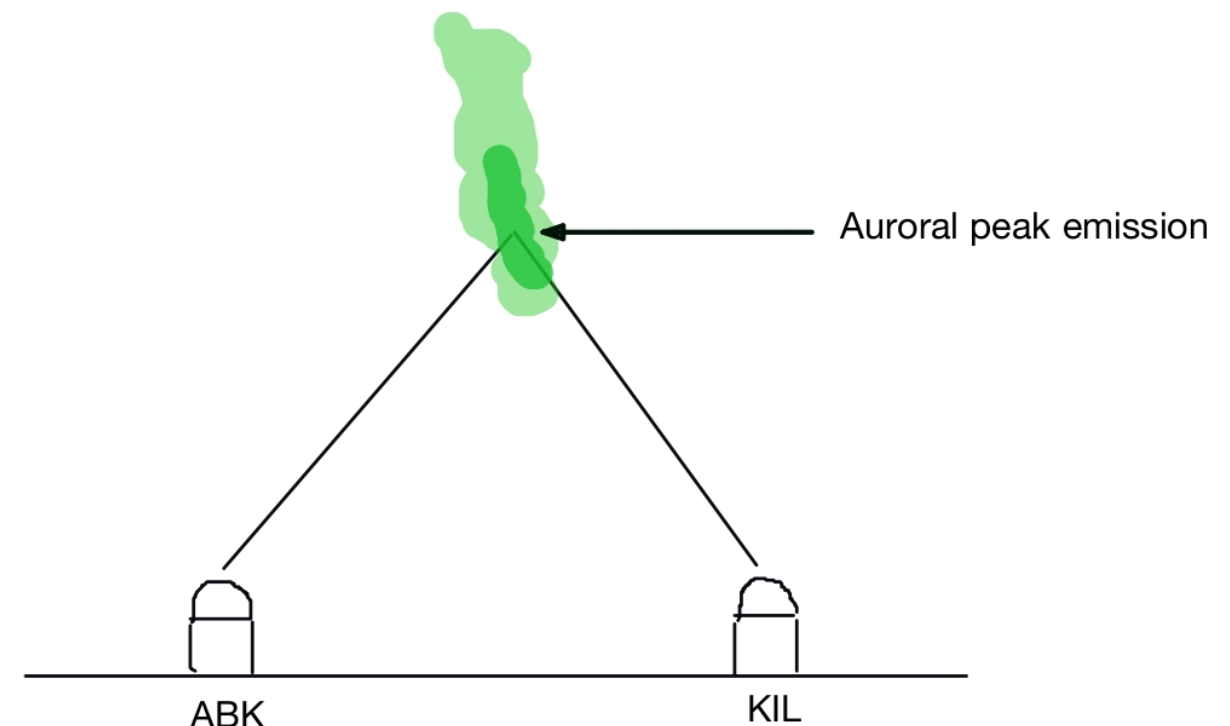
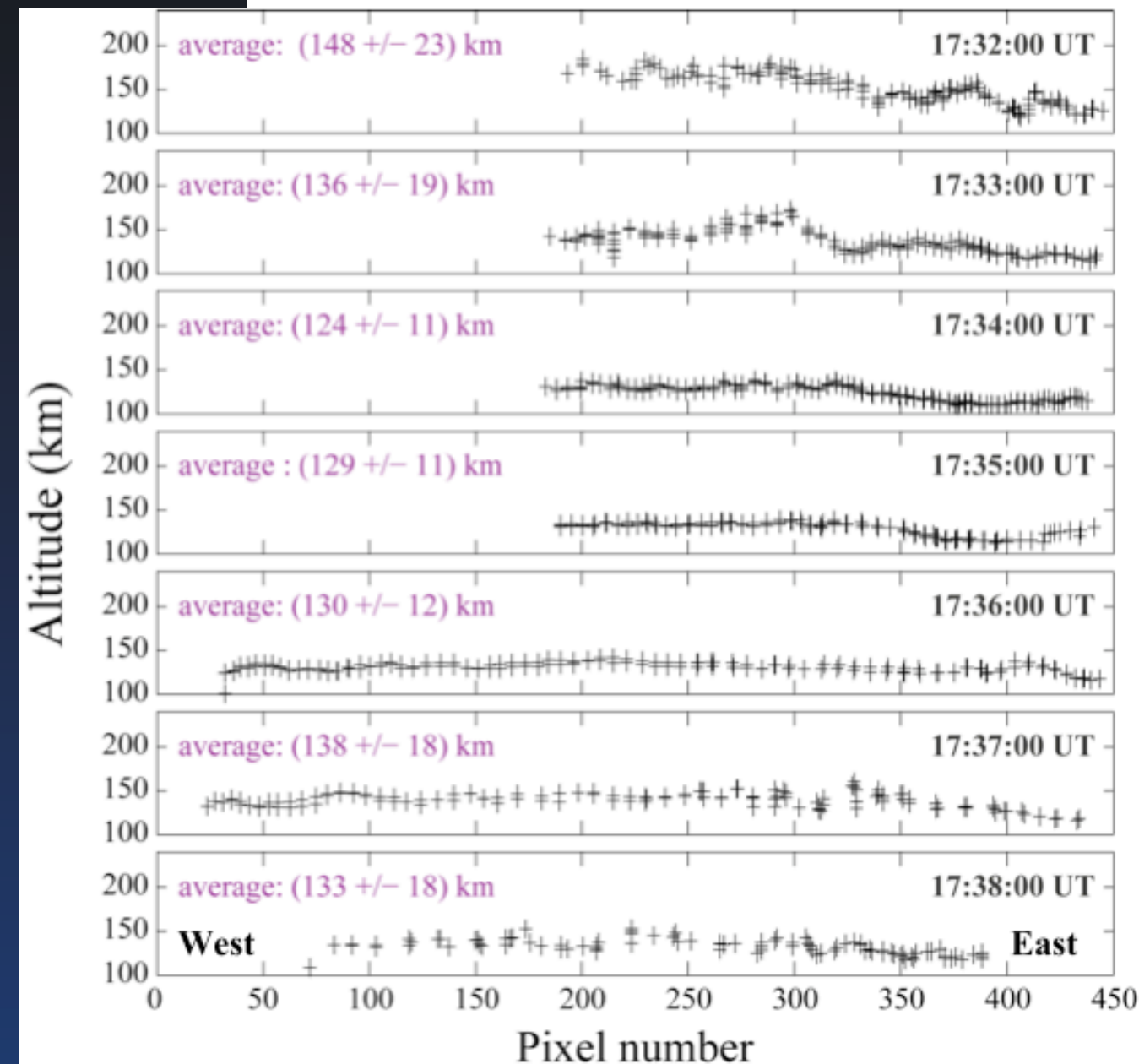
UTC 17:26:40 13 Jan 1998 N  
FMI/GE0 All Sky Camera Image Filter: 557 nm W + E  
Station KEV0, N69.76 E27.01 Exposure: 1000 ms S



# AIDA triangulation of ASC data

*Gustavsson, PhD thesis, 2002*

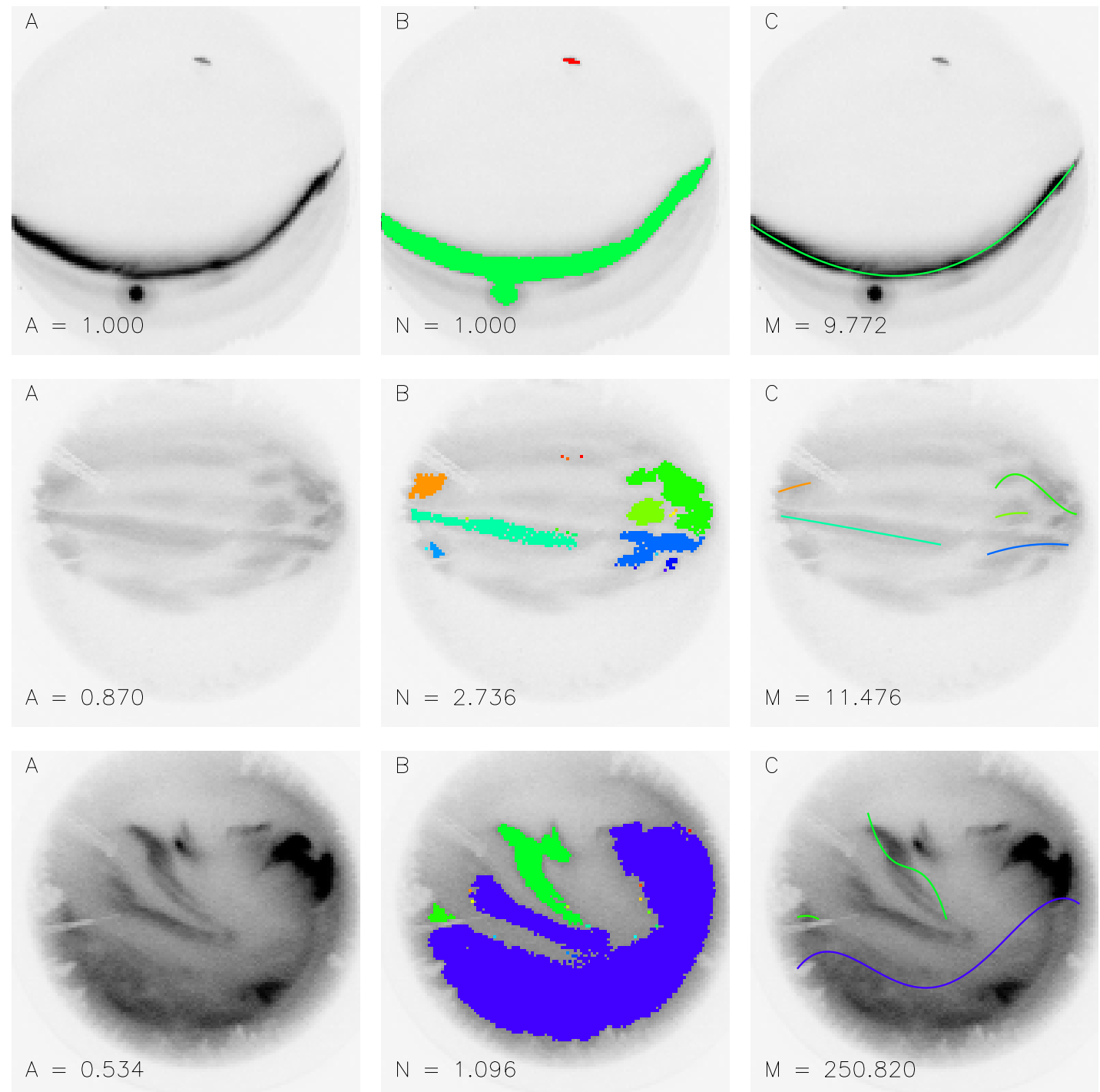
- Geometric calibration etc. required by AIDA has been done for MIRACLE ASC data
- Auroral tomography for ASC data has been tested
- Triangulation part of the software package have been more heavily used



*Sangalli et al., Óptica Pura y Aplicada, 2011*

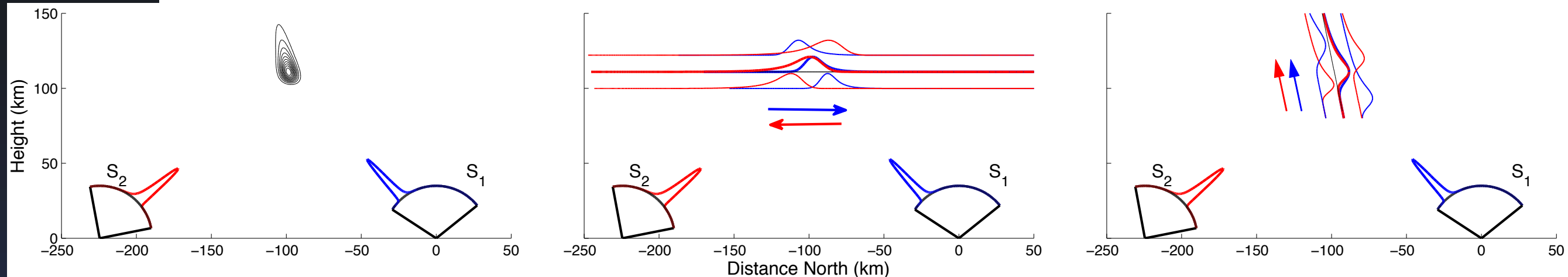
***“How arc-like the dominant auroral structure in an image is”***

- Empirically defined parameter  $A$  from 0 to 1 based on clustering of brightest pixels in the image
- $A=1$  corresponds to well-defined auroral arcs
- Smaller arciness is less obviously organised



# Peak emission heights

*Whiter et al., Geosci. Instrum. Method. Data Syst., 2013*



- Fully automatic height estimate
- Compares the result of traditional horizontal plane method to the result of field-aligned brightness projection
- Requires a correlation  $> 0.5$  with the projected brightness distributions
- Requires an agreement between the methods within 20km
- Validated using synthetic images

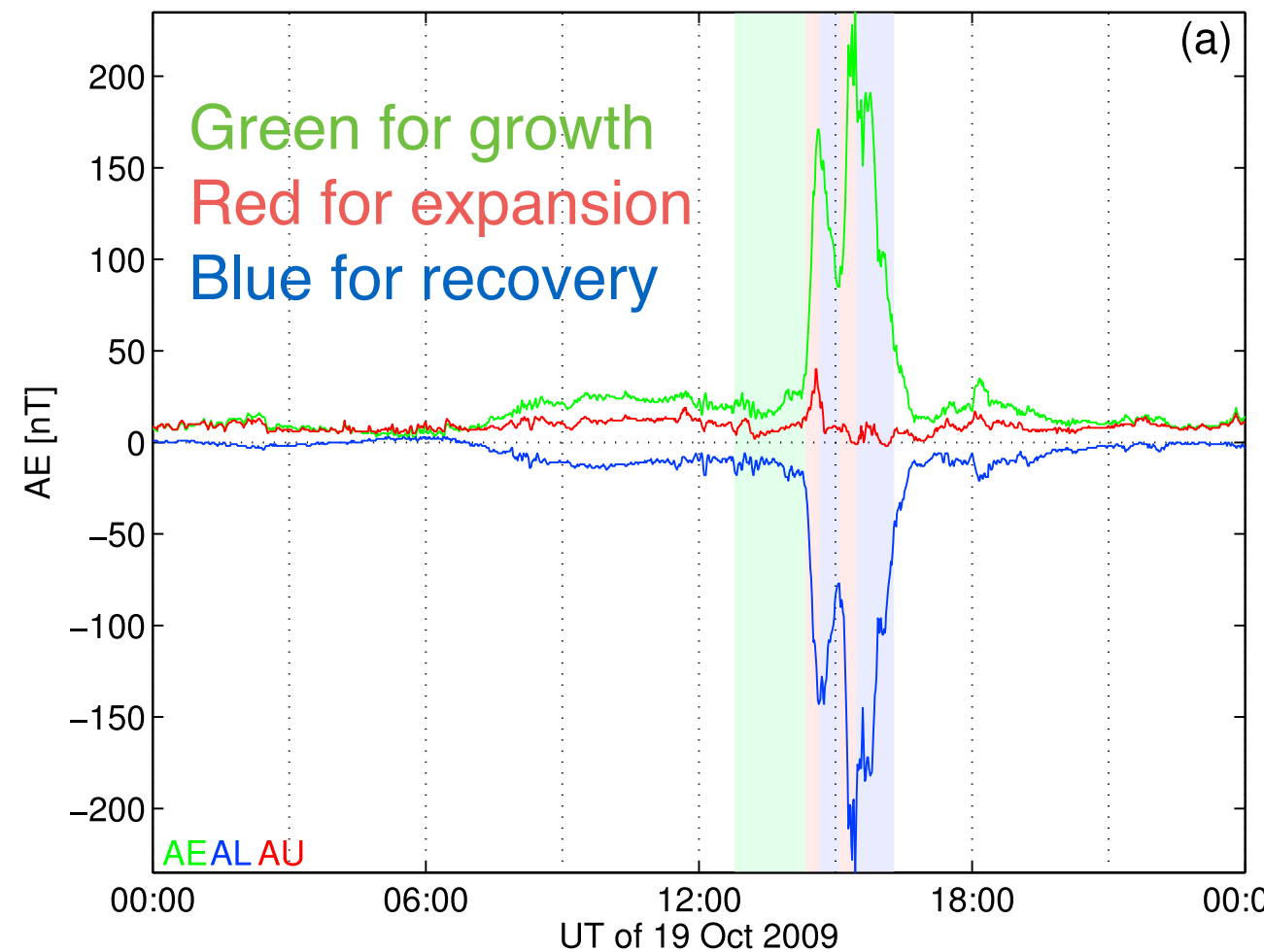




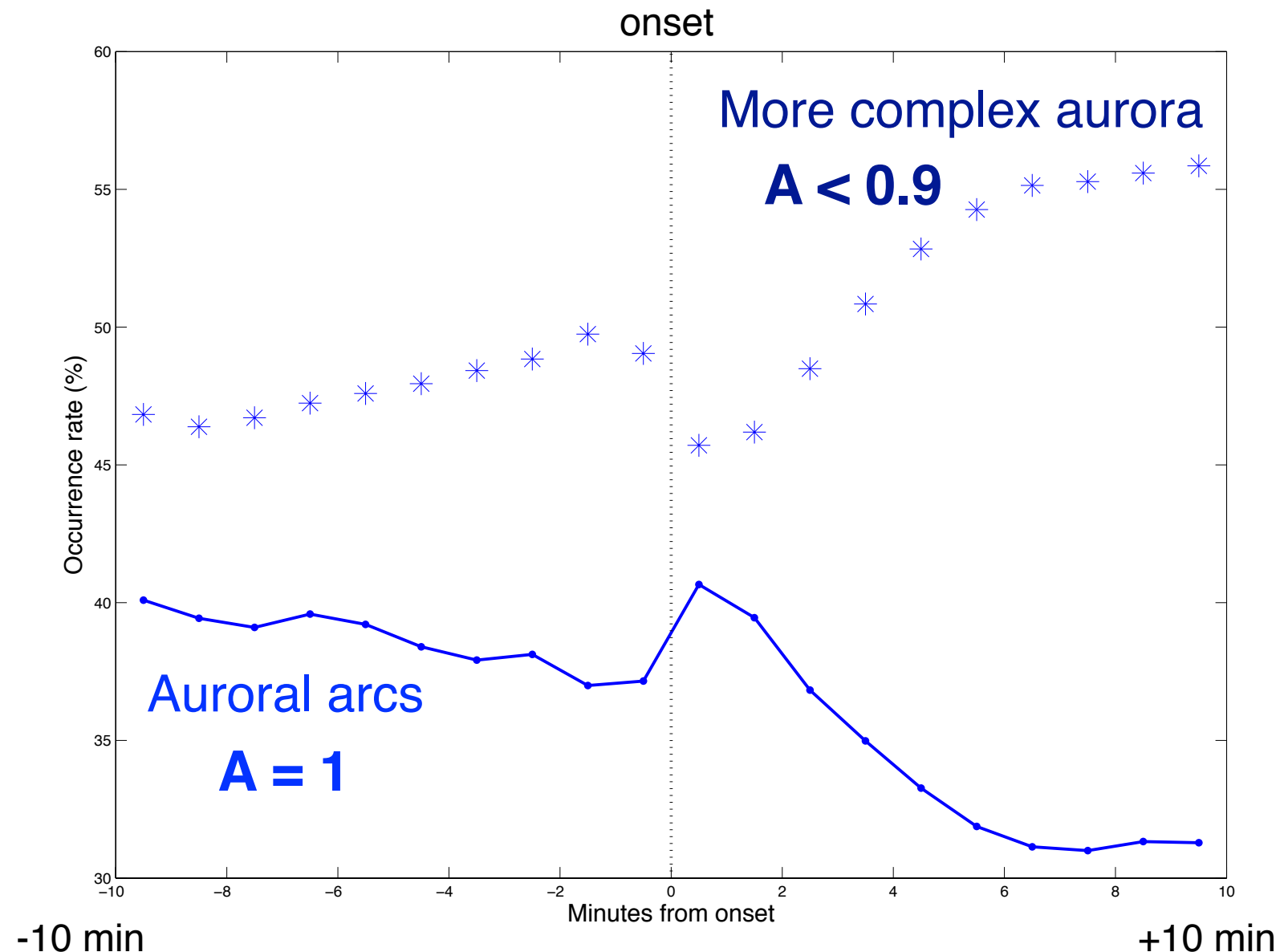
# Substorm phase detection

*Juusola et al., JGR, 2011 & Partamies et al., Ann. Geo., 2013*

- **Growth phase:** IMF Bz turning south
- **Onset:** sharp decrease of AL,  $dAL/dt < -4$  nT/min where the minimum is below a long-term median
- **Expansion:** from onset to the minimum AL
- **Recovery:** from minimum AL to the pre-onset level AL
- Validated by comparing the substorm list by Frey et al. JGR (2004)

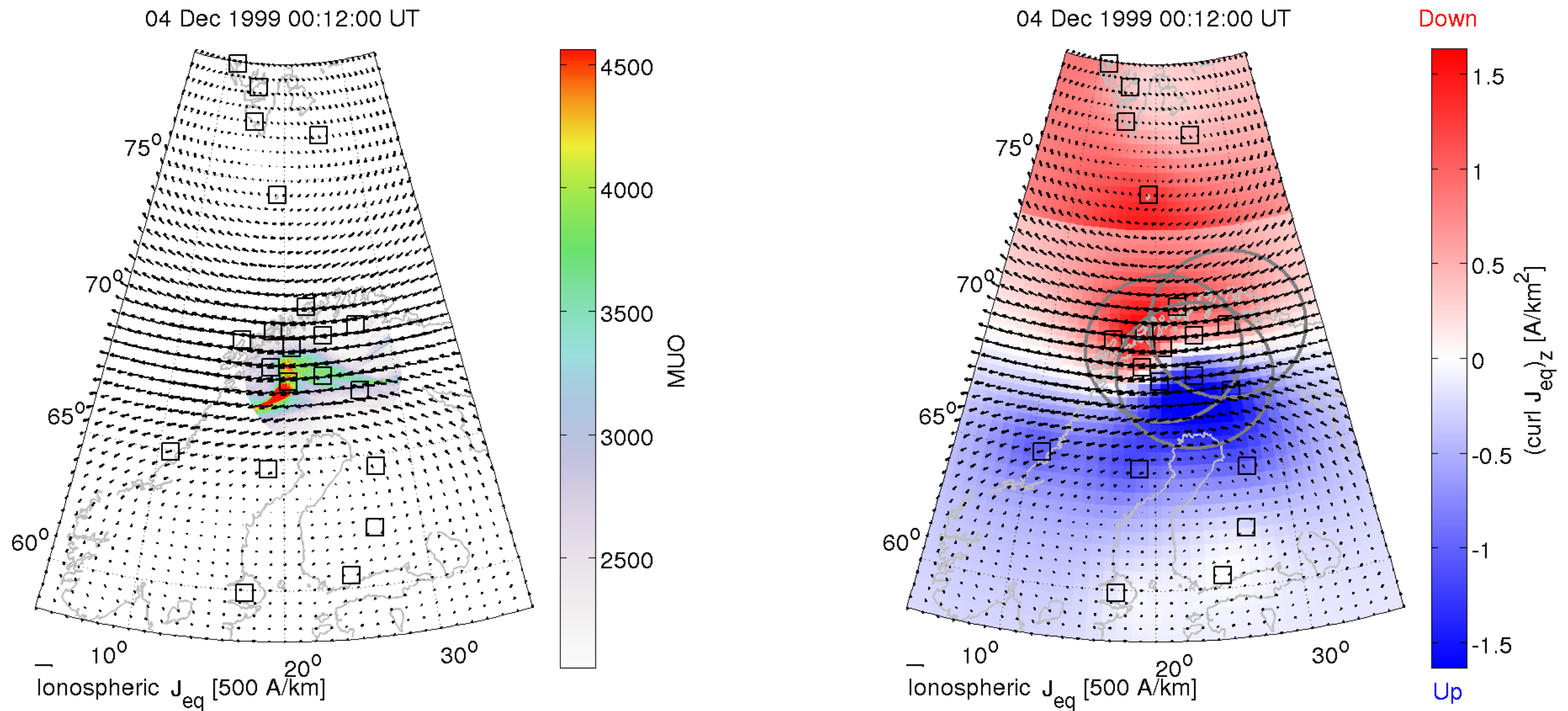


# Structural evolution of aurora at onset



- Occurrence rate of Arcs ( $A=1$ ) decreases after onset
- Occurrence rate of Others ( $A < 0.9$ ) increases after onset
- Brightening → Structural change

# Equivalent currents for auroral forms

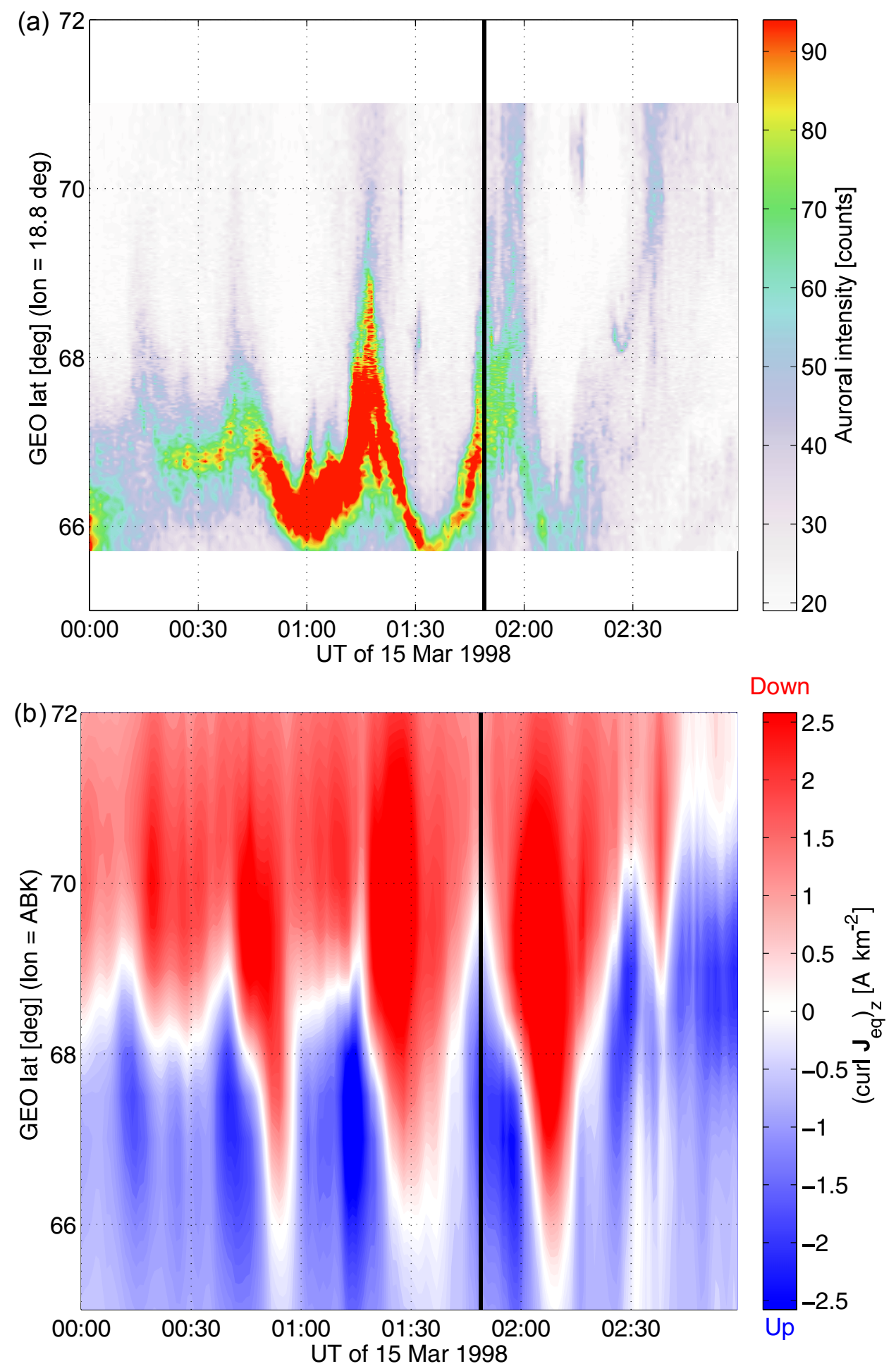


- Equivalent currents from IMAGE magnetometer data [Juusola et al., 2016]
- Omegas occur at the equatorward boundary of a strong westward electrojet
- Boundary undulation corresponds to observed optical structure





# Undulation of electrojet boundary



# Potentially helpful MIRACLE products

- A couple of decades of image data
- Precipitation energy fluxes
- Drift motions
- Peak emission heights
- Structural index values
- Substorm/storm phases
- Equivalent currents

*Image from Suomi-NPP satellite, NASA*