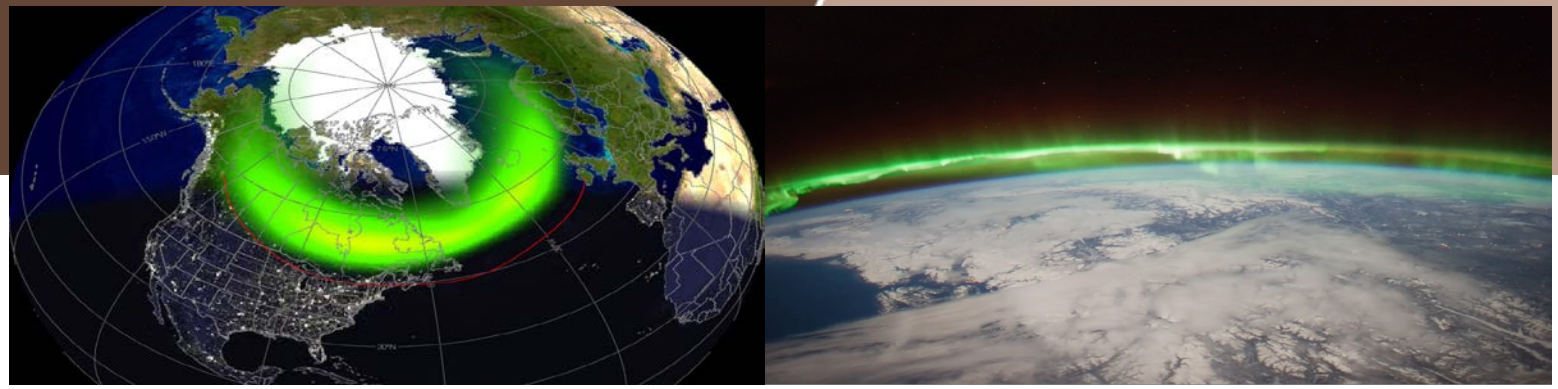


Analyses of the geomagnetic variations and GPS scintillation over the Canadian auroral zone

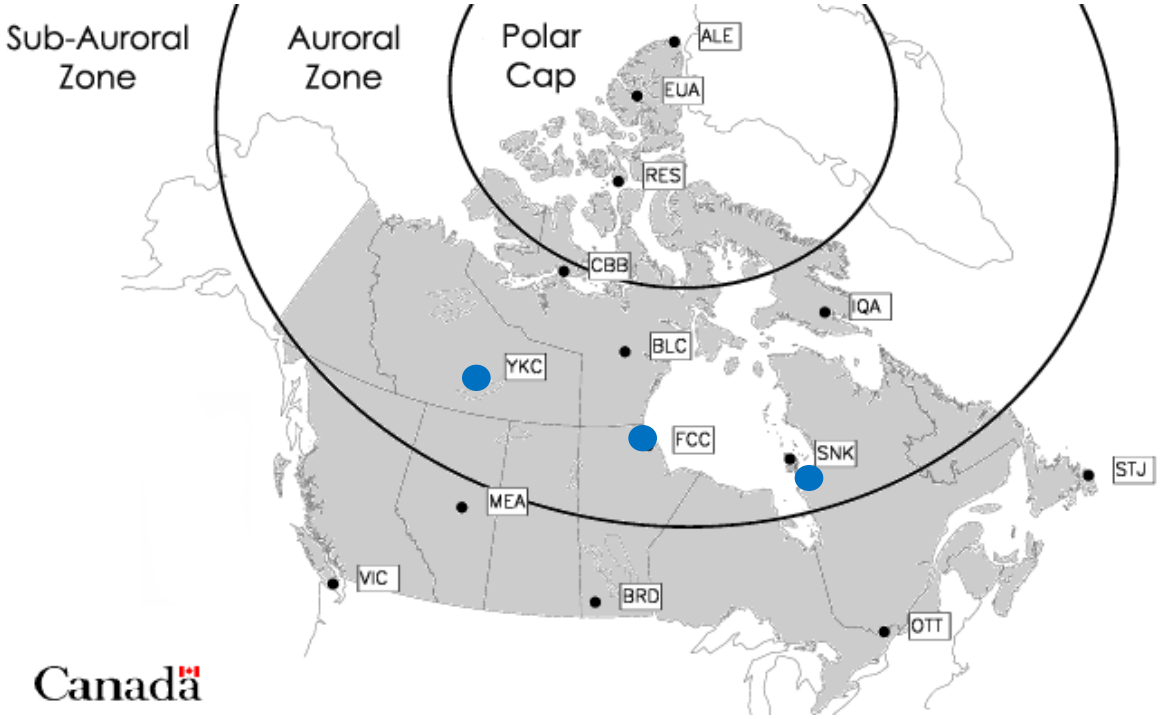
Lidia Nikitina[1], D.W. Danskin[1], R. Ghoddousi-Fard[2], P. Prikryl[1]

[1]Geomagnetic Laboratory, Natural Resources Canada
[2]Geodetic Survey, Natural Resources Canada

IES 2015, May 12-14, Old Town Alexandria

Motivation

- Canada has a special location which is dominated by the auroral zone
- The ionosphere and geomagnetic activity are strongly affected by space weather
- Geomagnetic activity has been forecasted by NRCan since 1970's and is based on hourly ranges of geomagnetic field
- Structures in the ionosphere causes scintillation of GPS signals
- Need to assess if there is a way to forecast of GPS scintillation based on magnetic activity
- The magnetic data and GPS receiver data are available in 2013 at three locations in auroral zone

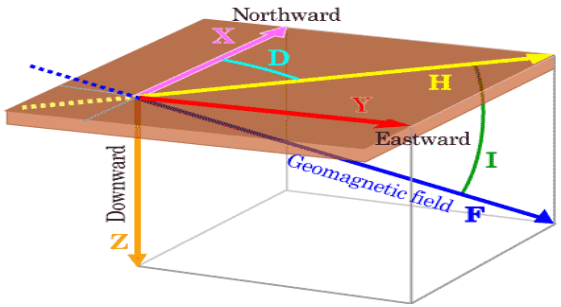


GPS station	Latitude	Longitude	Magnetic observatory	Latitude	Longitude
yell	62.481	-114.481	Yellowknife YKC	62.48	-114.482
chur	58.759	-94.089	Churchill FCC	58.75	-94.082
kuuj	55.278	-77.745	Sanikiluaq SNK	56.5	-79.2

Magnetic and scintillation indices

Geomagnetic index

- Hourly range of the magnetic variations is used as indicator of the geomagnetic activity
- Hourly range = Max(per hour)-Min(per hour)
- Hourly range can be computed for each of the three magnetic components
  HRX, HRY, HRZ



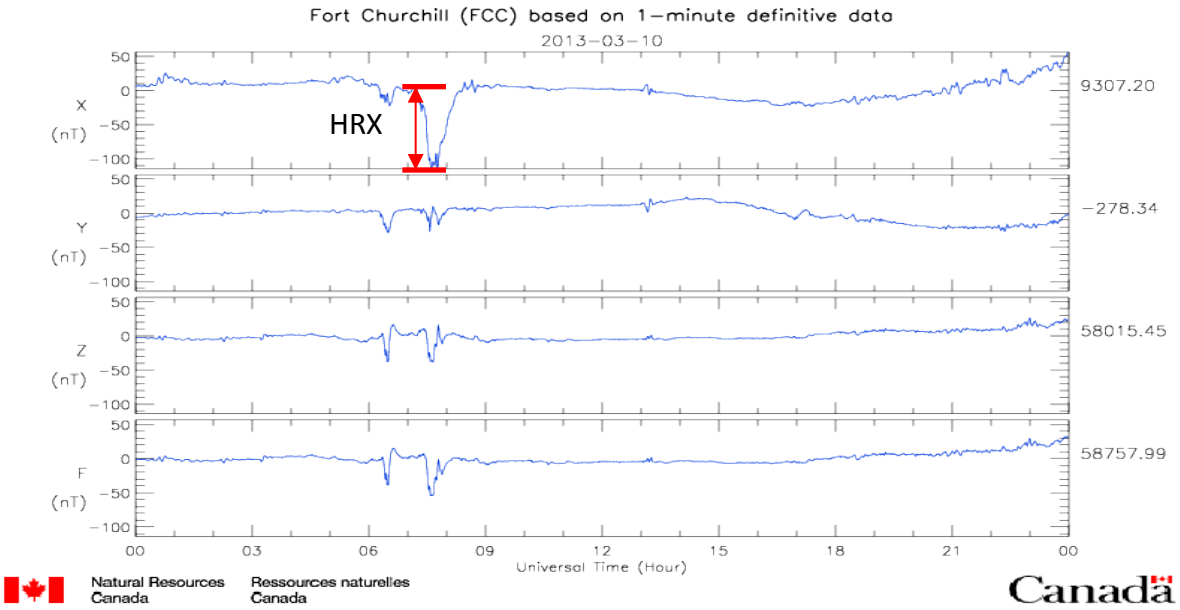
http://wdc.kugi.kyoto-u.ac.jp/element/elefig.gif

Ionosphere index

- Delta phase rate (DPR) is the rate of change for the GPS dual frequency phase based on 1s measurements
- DPR is averaged for 30 s to determine mDPR
- To be comparable with geomagnetic index, a hourly index is needed
- In this study the maximum of mDPR in each hour (mDPRmax) is used

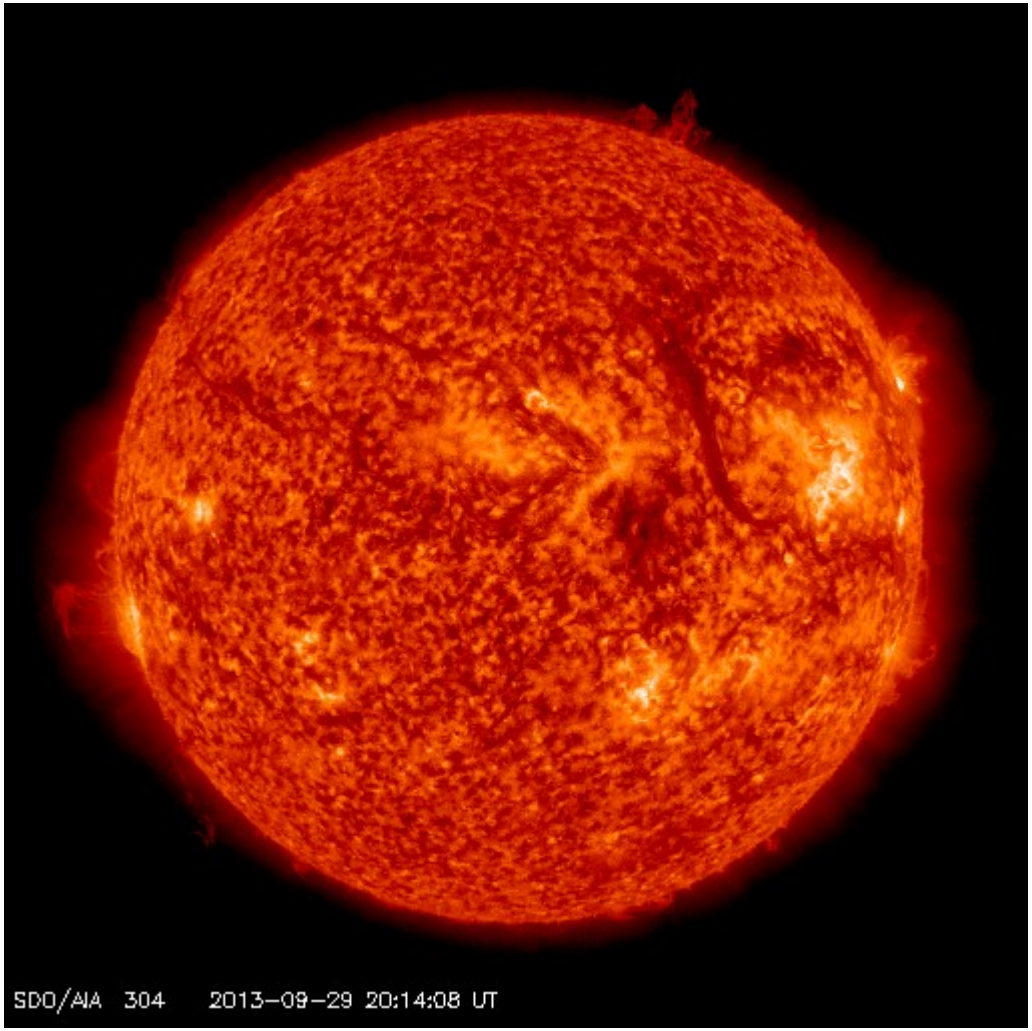
Geomagnetic indices

Zone	Quiet	Unsettled	Active	Stormy	Major Storm
Auroral (Fort Churchill)	0 – 90 nT	90 – 170 nT	170 – 300 nT	300 – 1000 nT	1000+



Space Weather Event October 2013

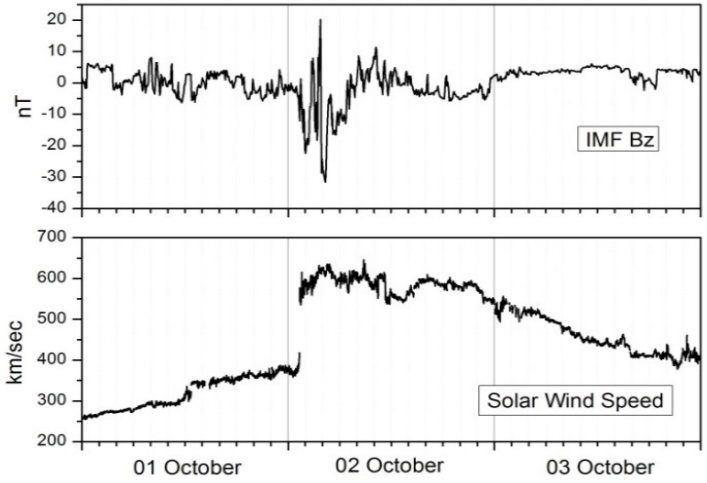
Solar Source and solar wind response



29 September 2013/2337 UT:
CME produced by filament eruption
Origin: N15W40

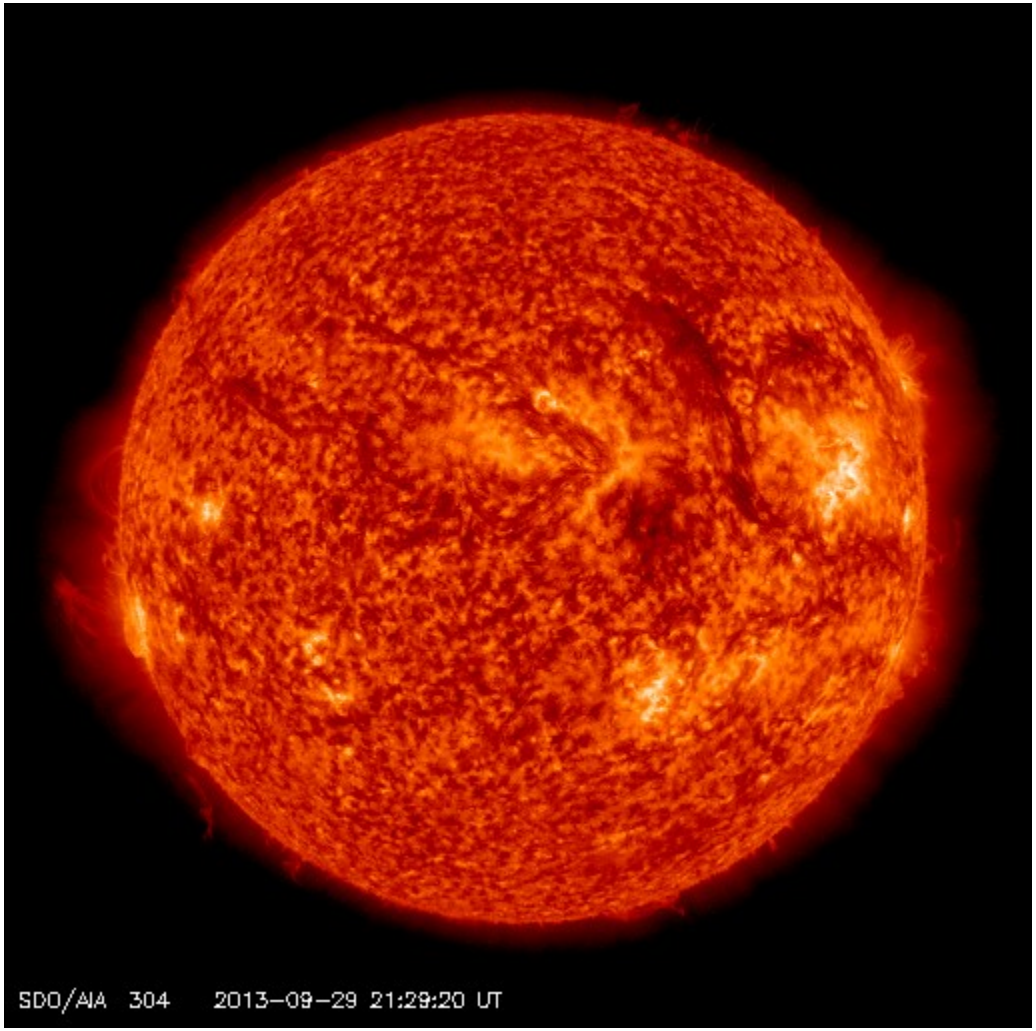
02 October ~01:20 UT:
ACE Solar wind speed increased from ~ 400 km/s just before the shock to ~ 636 km/s.

02 October ~0425 UT:
IMF Bz decreases to ~ -30 nT



Space Weather Event October 2013

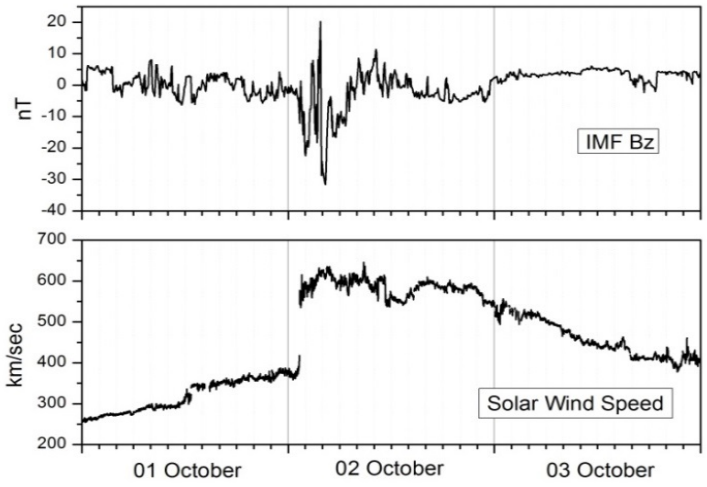
Solar Source and solar wind response



29 September 2013/2337 UT:
CME produced by filament eruption
Origin: N15W40

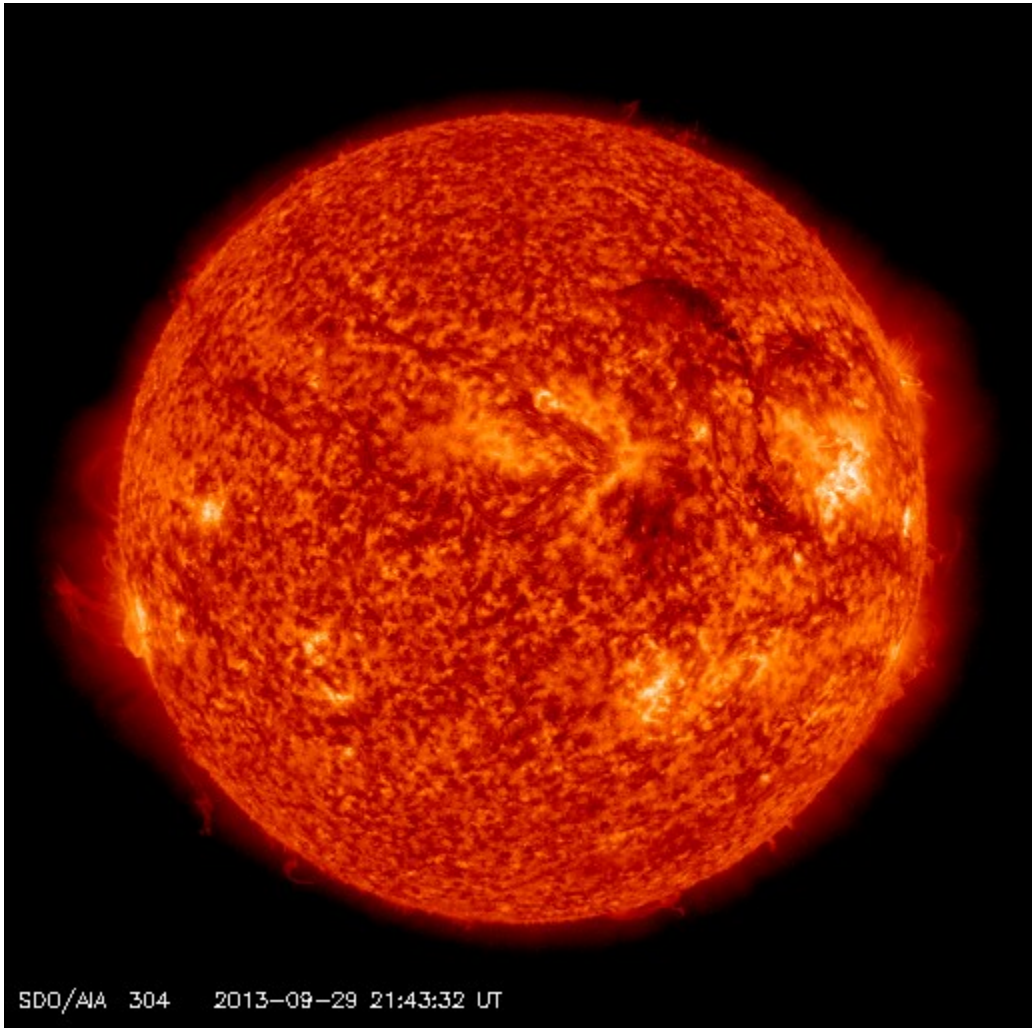
02 October ~01:20 UT:
ACE Solar wind speed increased from ~ 400 km/s just before the shock to ~ 636 km/s.

02 October ~0425 UT:
IMF Bz decreases to ~ -30 nT



Space Weather Event October 2013

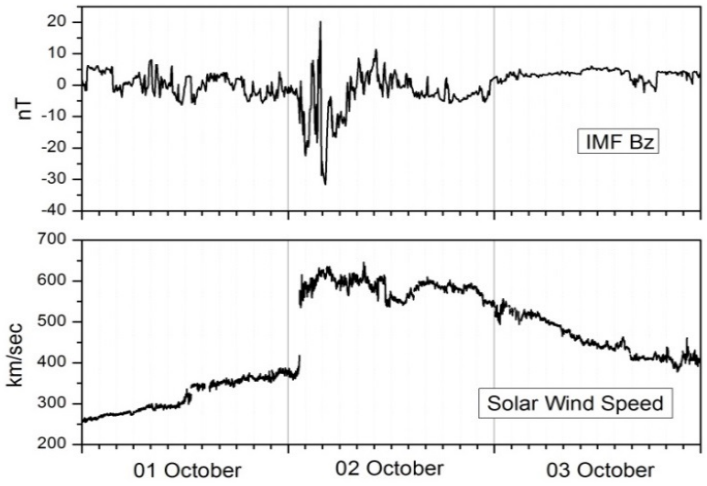
Solar Source and solar wind response



29 September 2013/2337 UT:
CME produced by filament eruption
Origin: N15W40

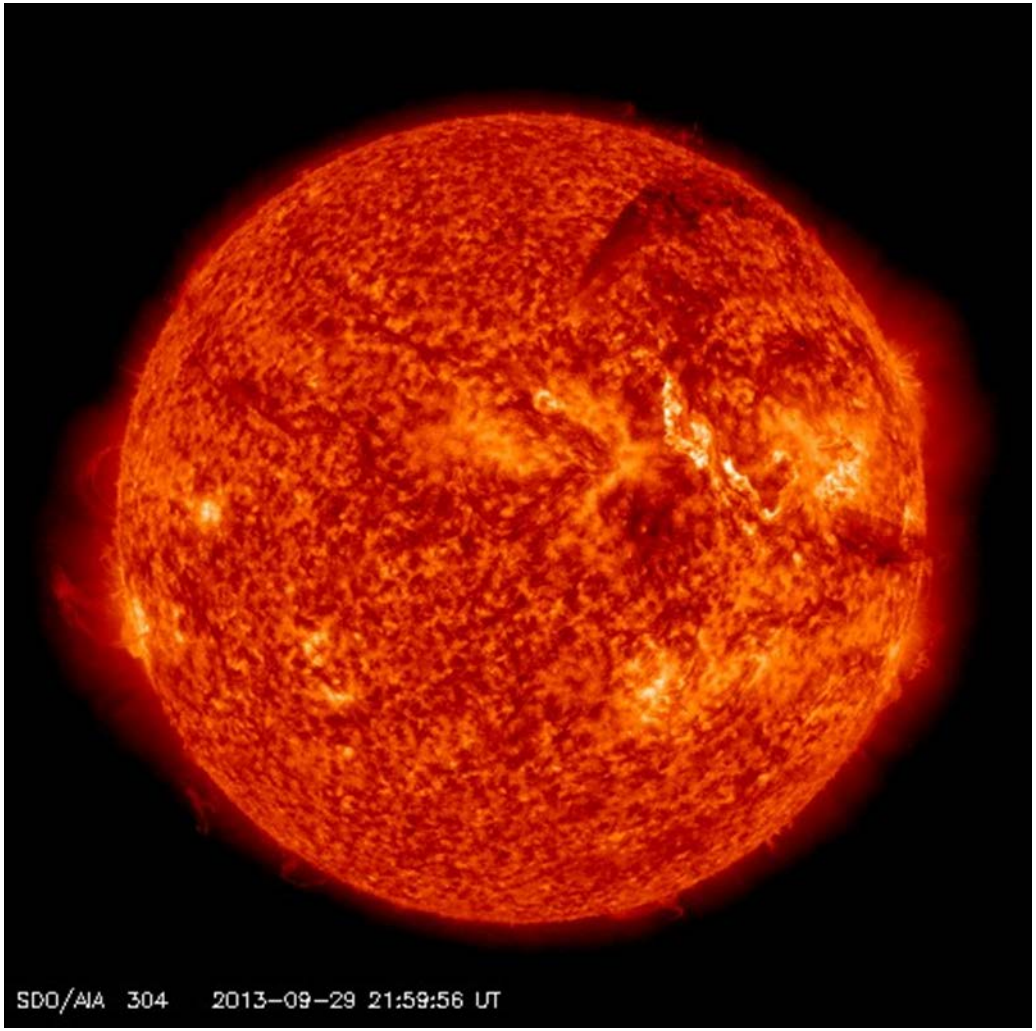
02 October ~01:20 UT:
ACE Solar wind speed increased from ~ 400 km/s just before the shock to ~ 636 km/s.

02 October ~0425 UT:
IMF Bz decreases to ~ -30 nT



Space Weather Event October 2013

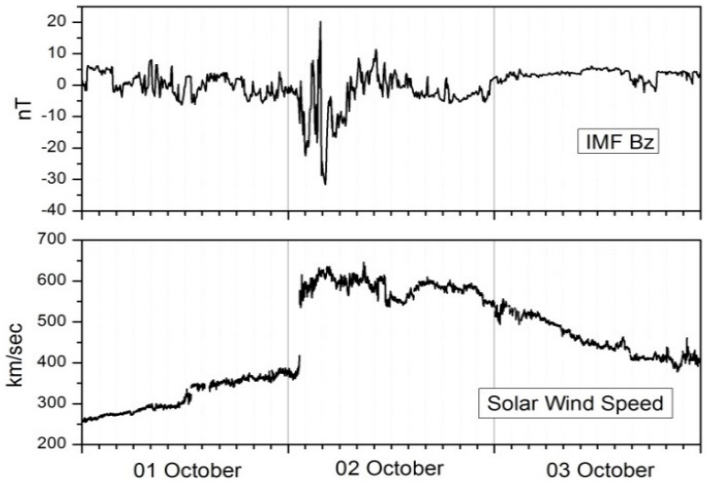
Solar Source and solar wind response



29 September 2013/2337 UT:
CME produced by filament eruption
Origin: N15W40

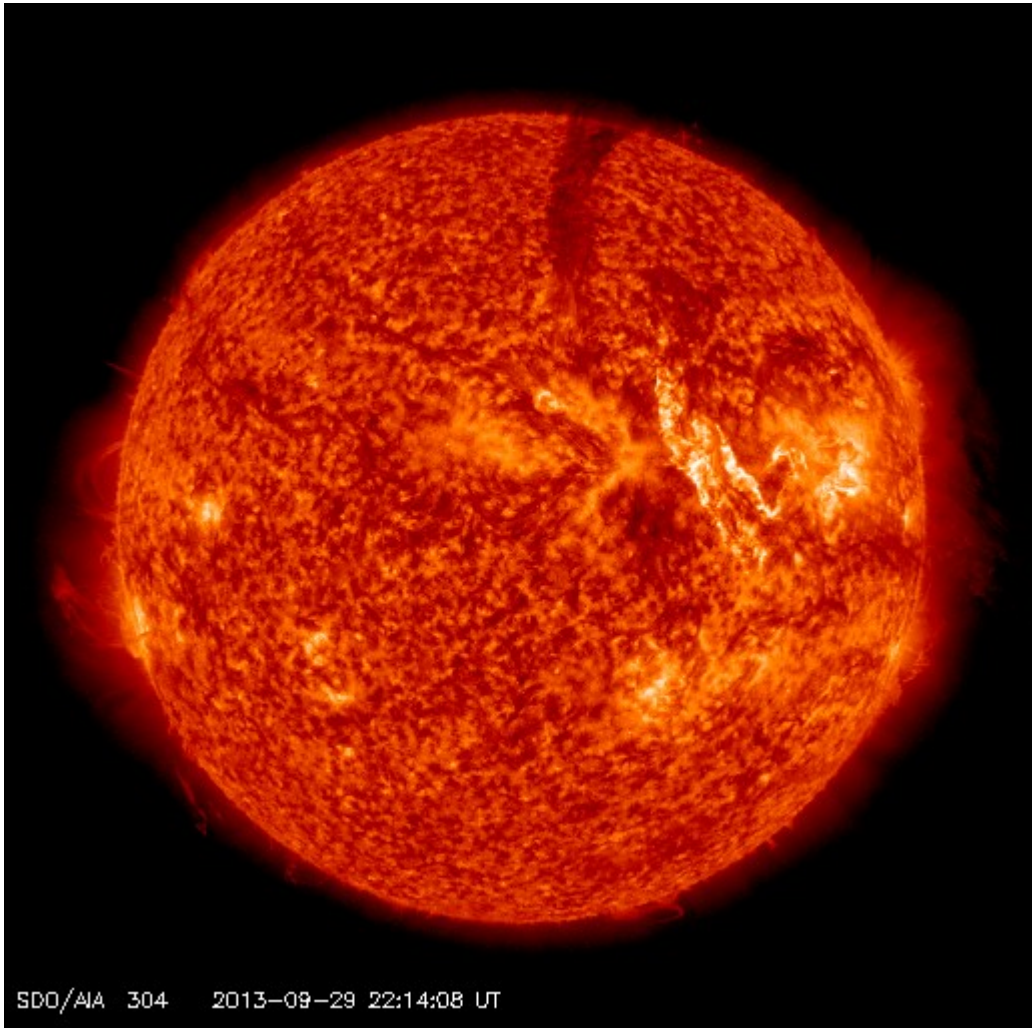
02 October ~01:20 UT:
ACE Solar wind speed increased from ~ 400 km/s just before the shock to ~ 636 km/s.

02 October ~0425 UT:
IMF Bz decreases to ~ -30 nT



Space Weather Event October 2013

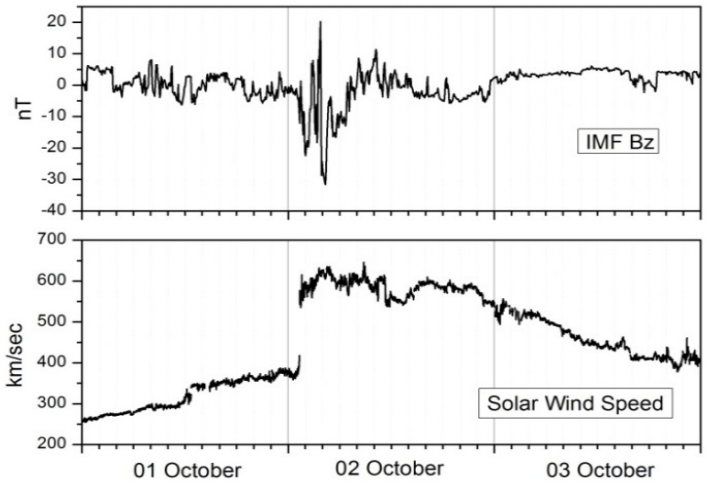
Solar Source and solar wind response



29 September 2013/2337 UT:
CME produced by filament eruption
Origin: N15W40

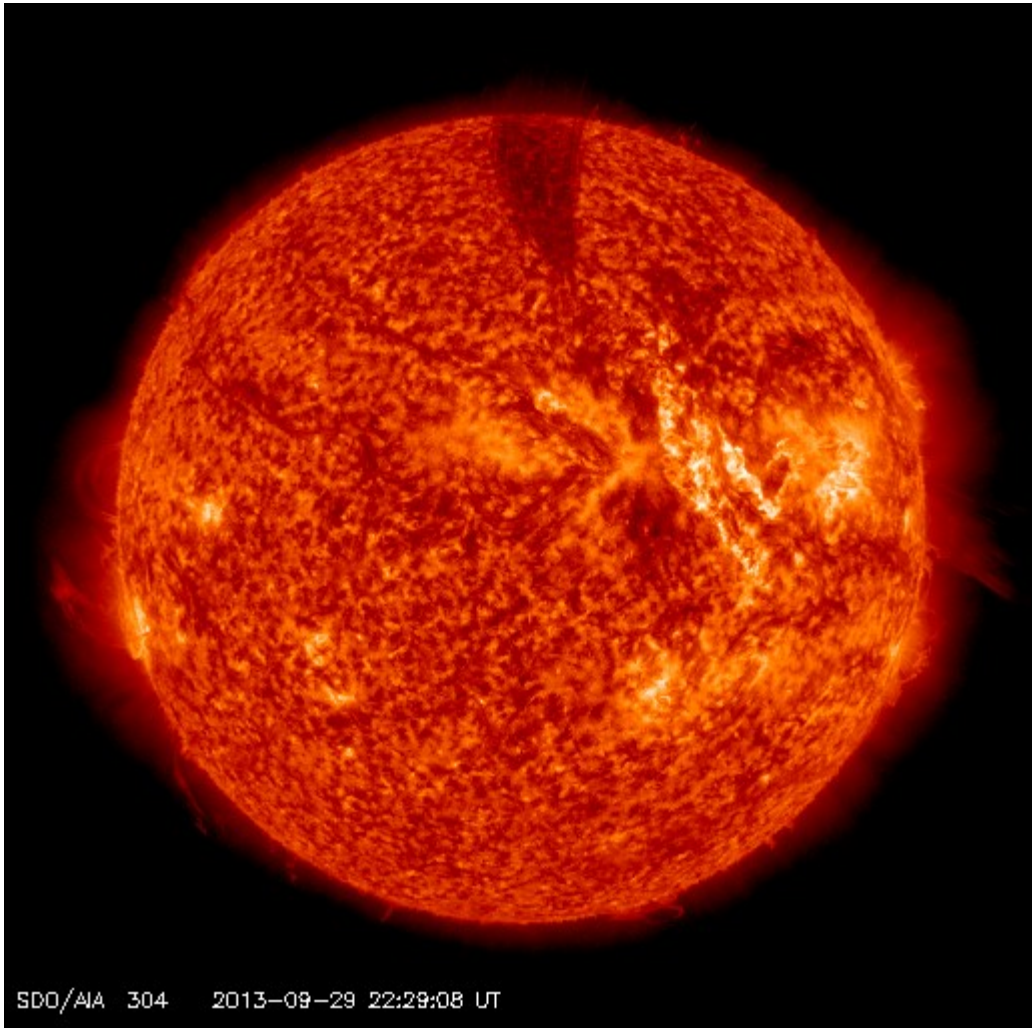
02 October ~01:20 UT:
ACE Solar wind speed increased from ~ 400 km/s just before the shock to ~ 636 km/s.

02 October ~0425 UT:
IMF Bz decreases to ~ -30 nT



Space Weather Event October 2013

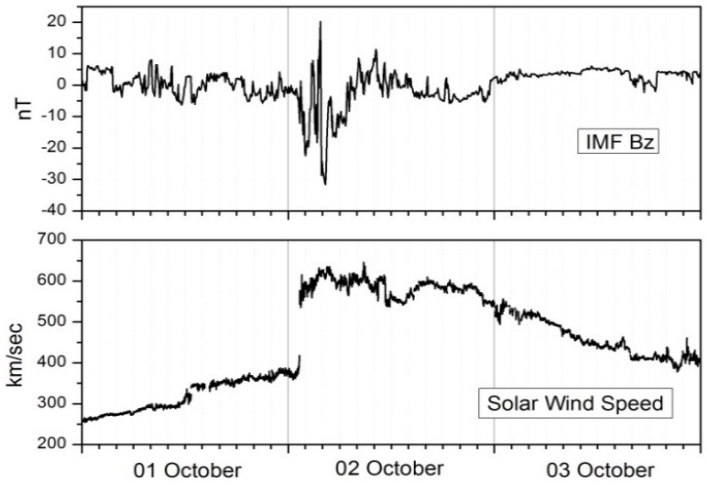
Solar Source and solar wind response



29 September 2013/2337 UT:
CME produced by filament eruption
Origin: N15W40

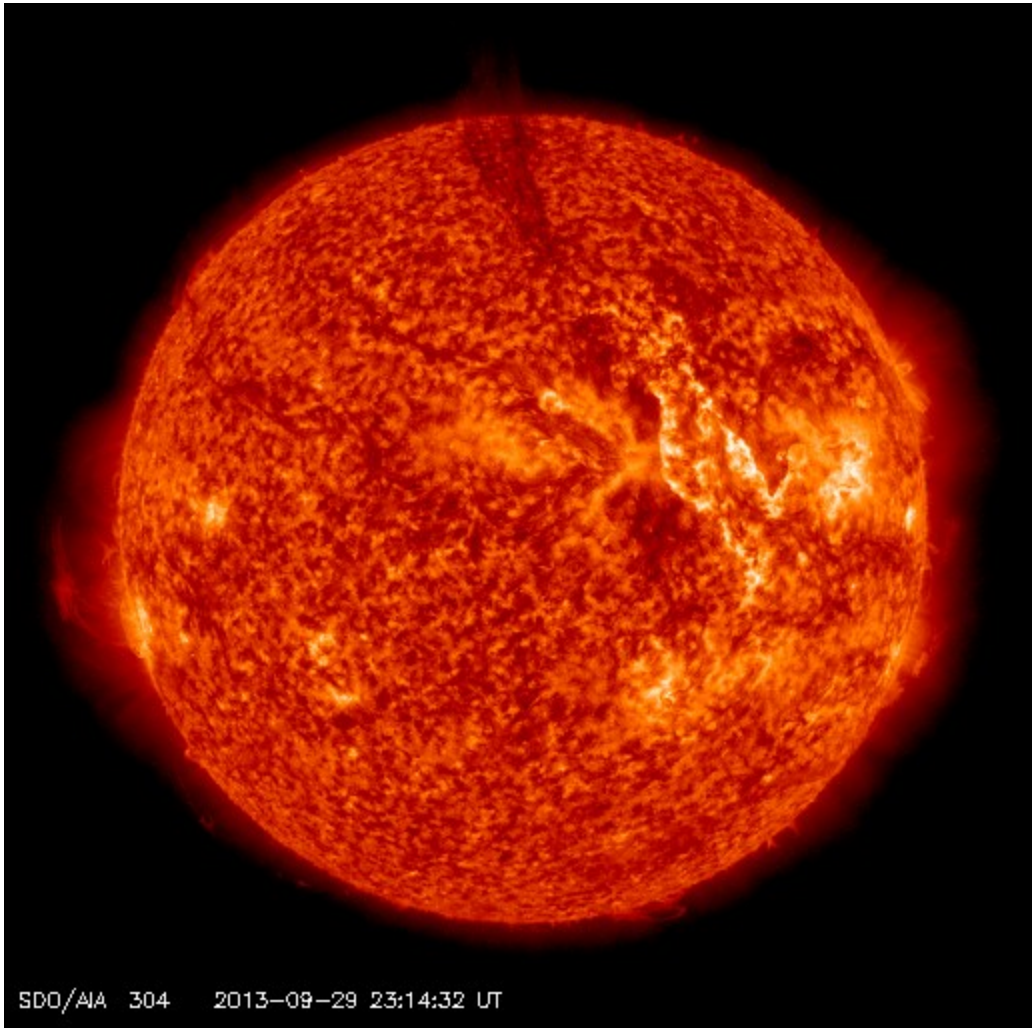
02 October ~01:20 UT:
ACE Solar wind speed increased from ~ 400 km/s just before the shock to ~ 636 km/s.

02 October ~0425 UT:
IMF Bz decreases to ~ -30 nT



Space Weather Event October 2013

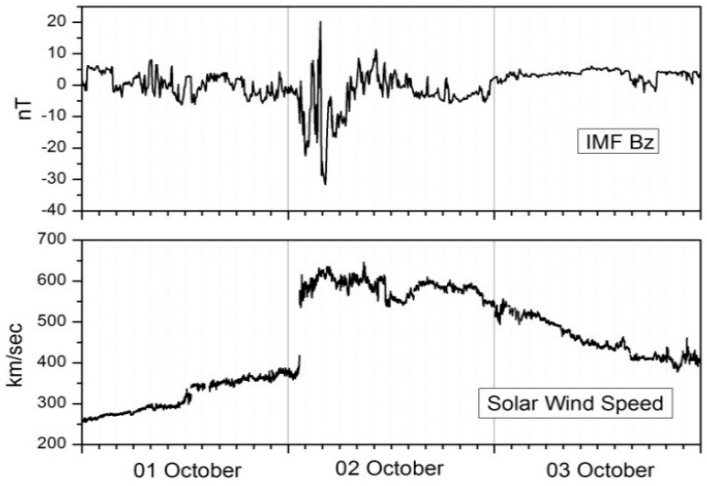
Solar Source and solar wind response



29 September 2013/2337 UT:
CME produced by filament eruption
Origin: N15W40

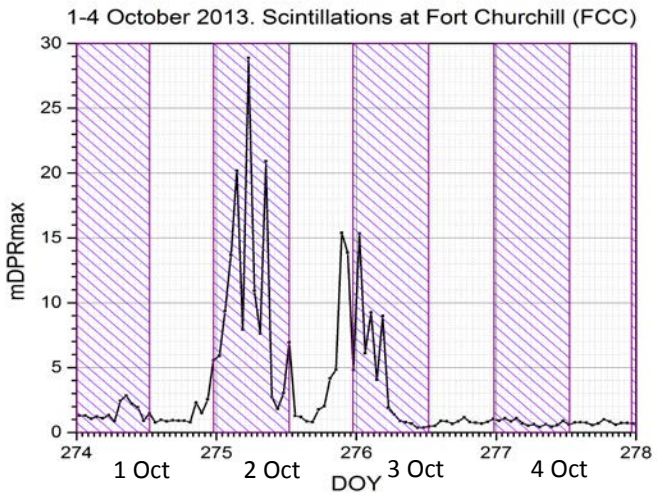
02 October ~01:20 UT:
ACE Solar wind speed increased from ~ 400 km/s just before the shock to ~ 636 km/s.

02 October ~0425 UT:
IMF Bz decreases to ~ -30 nT

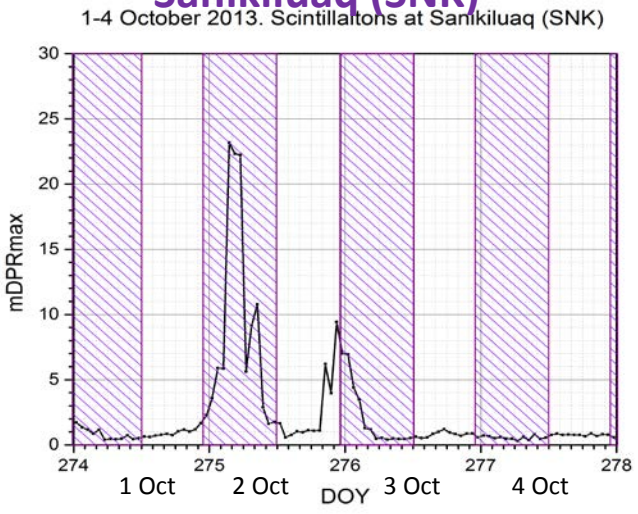


Geomagnetic and ionospheric response at two locations due to event of October 2013

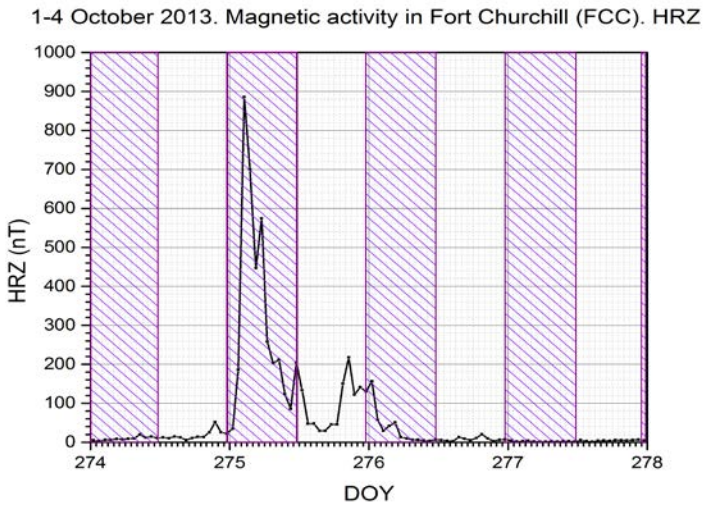
Fort Churchill (FCC)



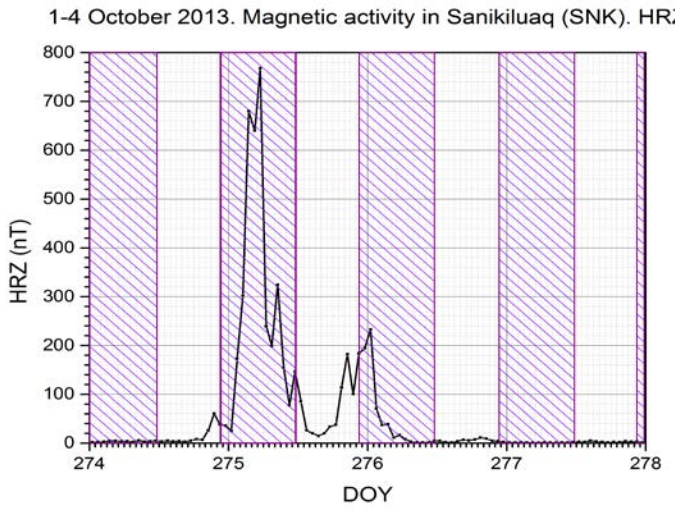
Sanikiluaq (SNK)



Scintillation



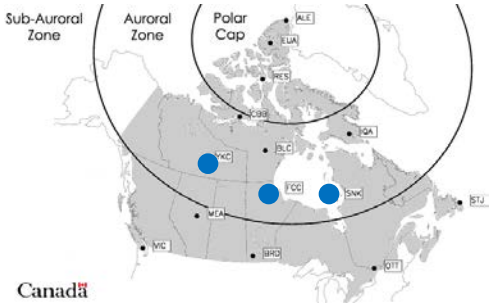
Magnetic variation



night

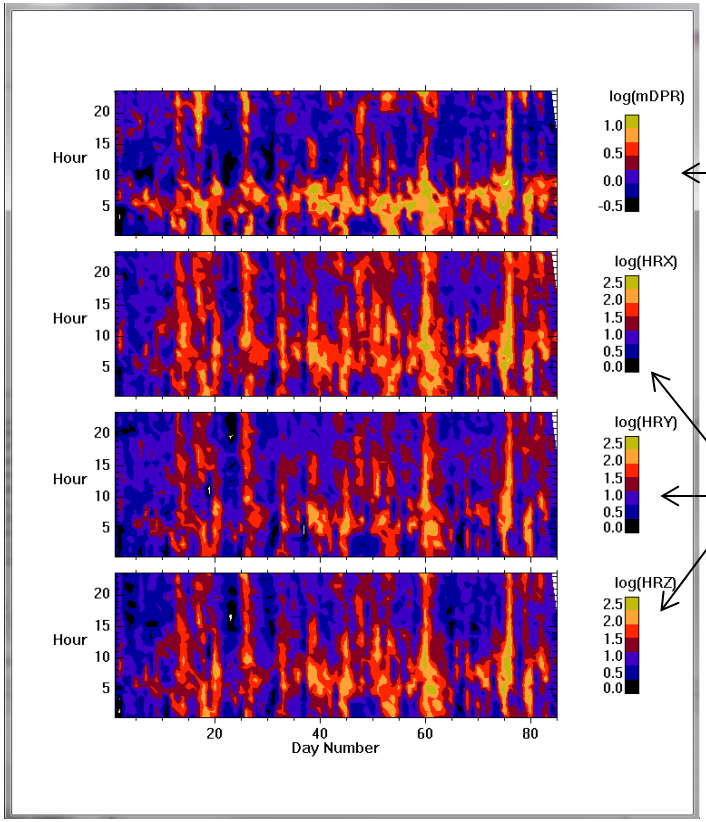
day

geomagnetic and scintillation comparison for first 85 days in 2013



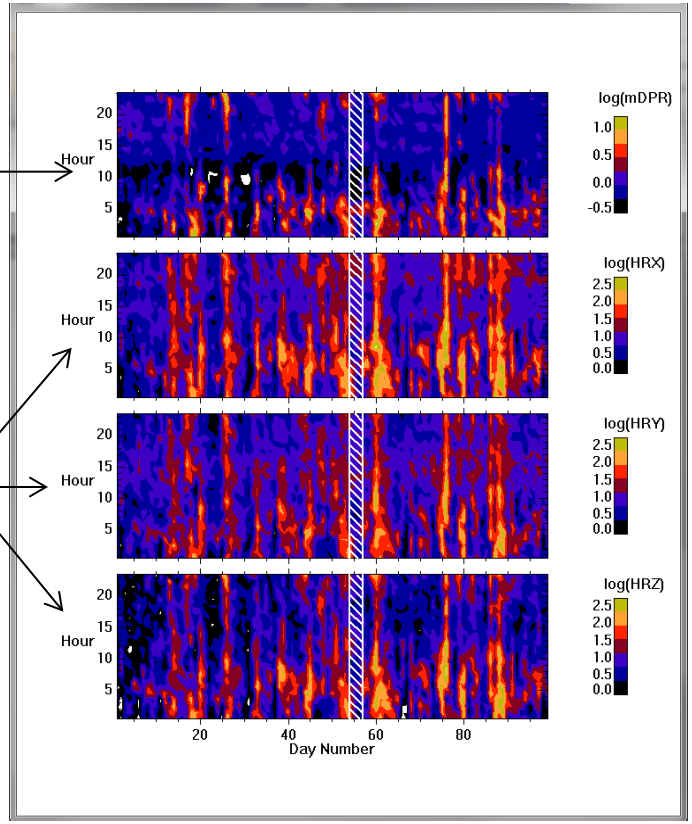
Fort Churchill (FCC)

Sanikiluaq (SNK)



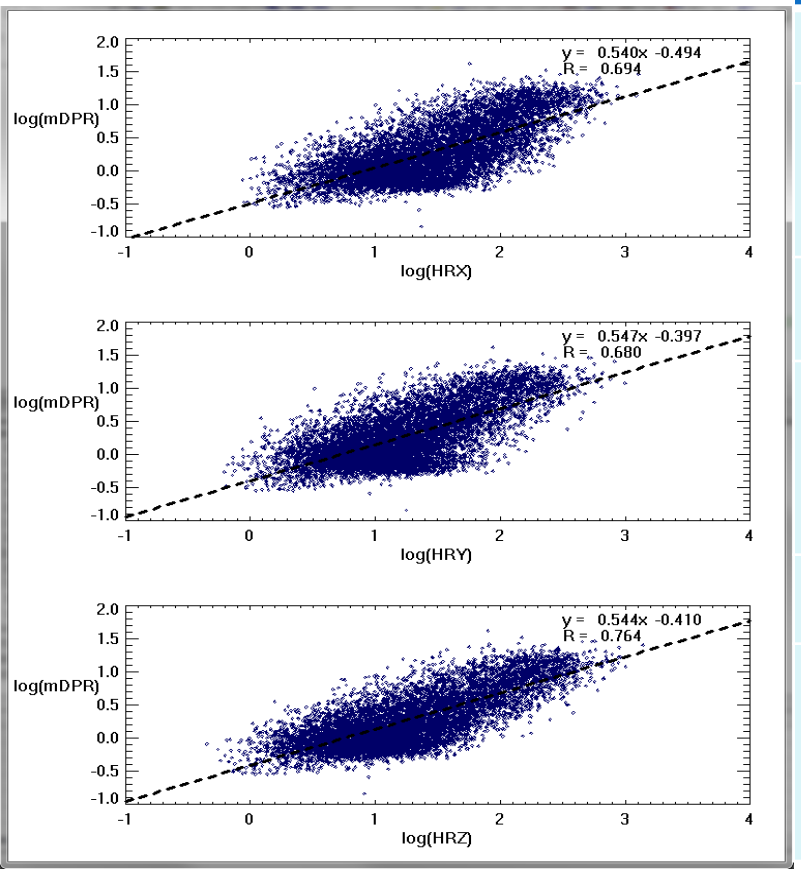
Scintillation

Magnetic variation



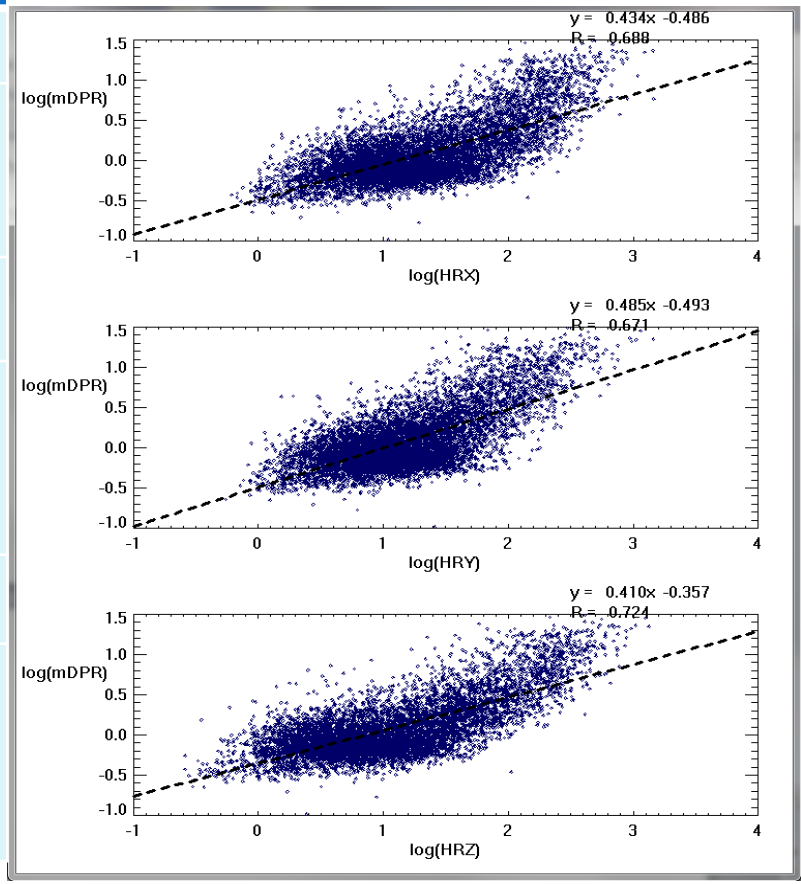
geomagnetic and scintillation indices for 2013

Fort Churchill (FCC)



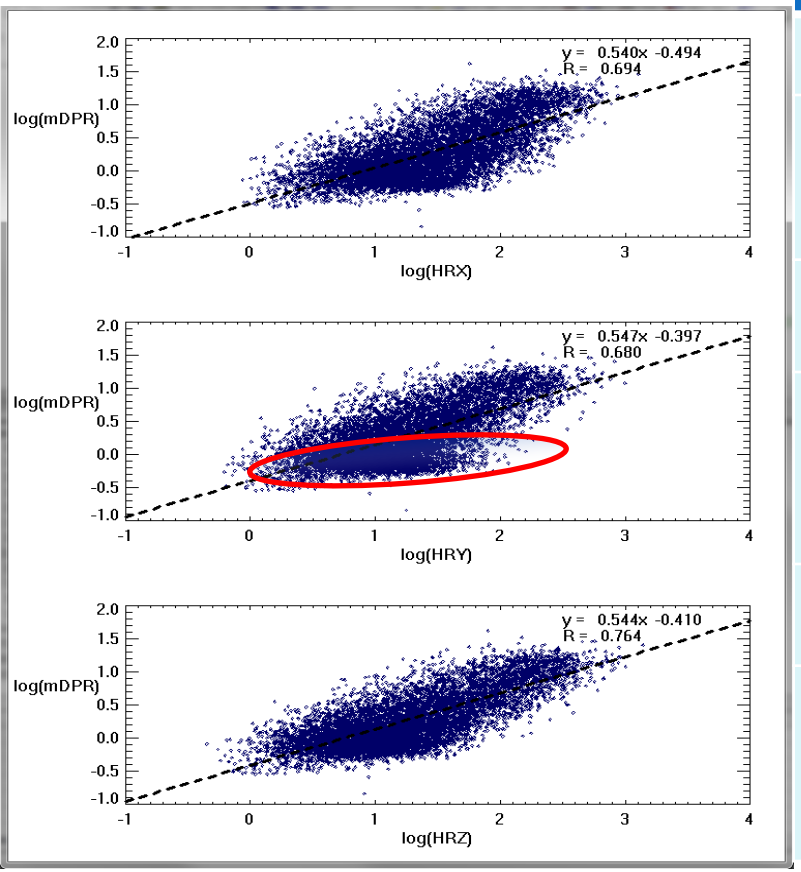
FCC	SNK
HRX	
r=0.694	r=0.688
k=0.540	k=0.434
HRY	
r=0.680	r=0.671
k=0.547	k=0.485
HRZ	
r=0.726	r=0.764
k=0.544	k=0.41

Sanikiluaq (SNK)



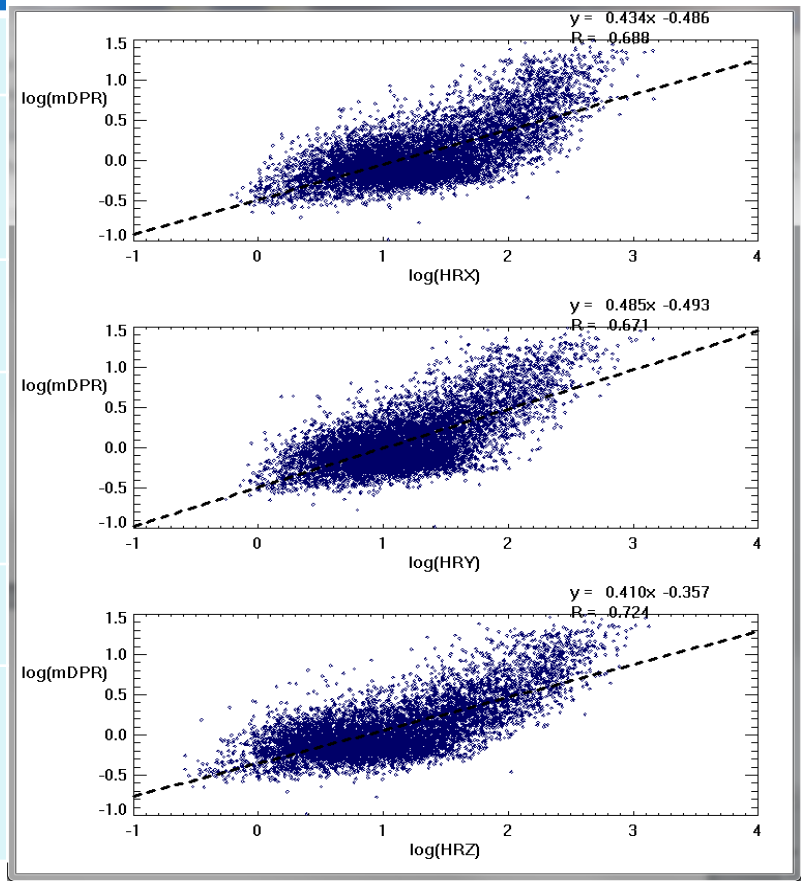
geomagnetic and scintillation indices for 2013

Fort Churchill (FCC)



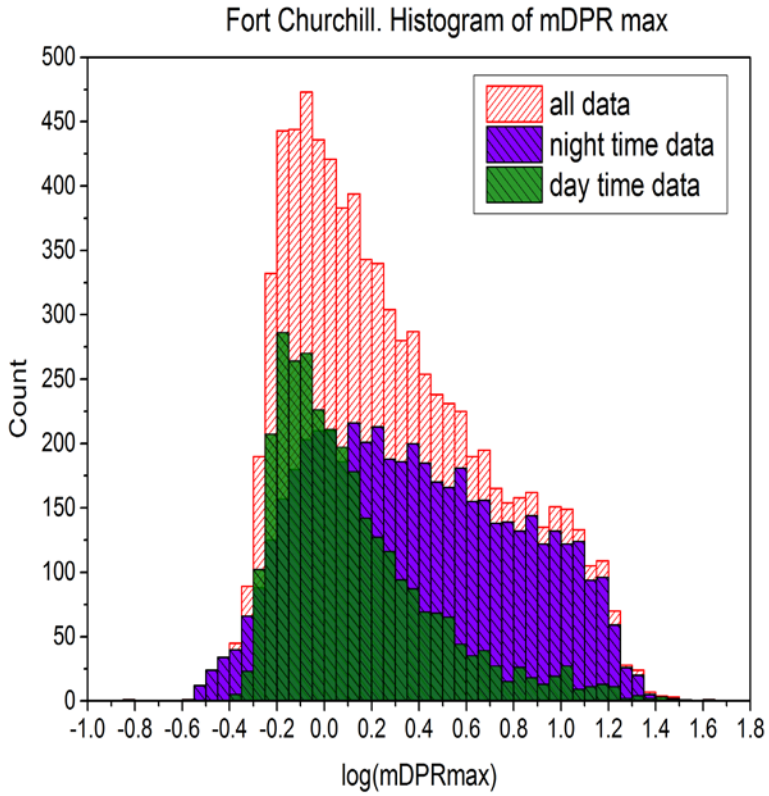
FCC	SNK
HRX	
r=0.694	r=0.688
k=0.540	k=0.434
HRY	
r=0.680	r=0.671
k=0.547	k=0.485
HRZ	
r=0.726	r=0.764
k=0.544	k=0.41

Sanikiluaq (SNK)

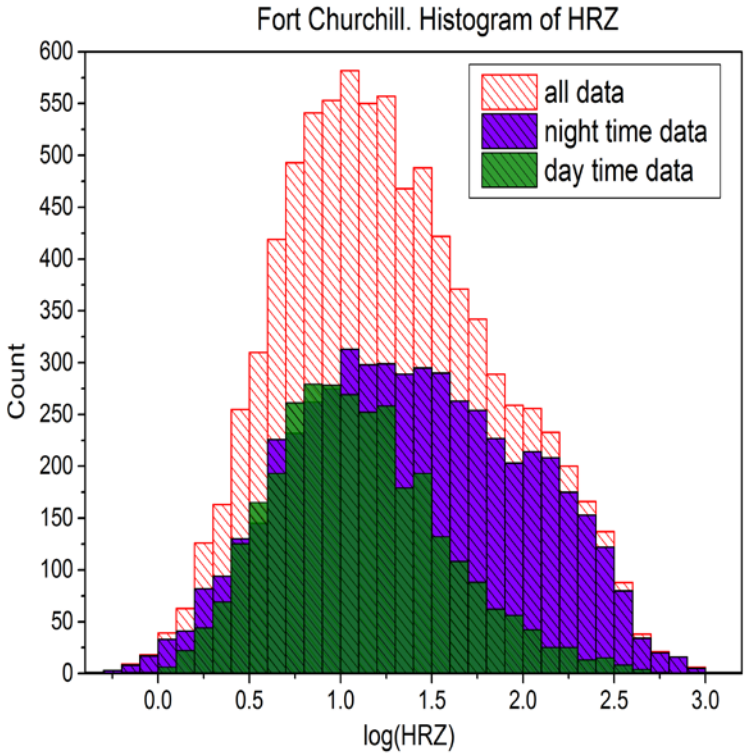


Distributions

Scintillation



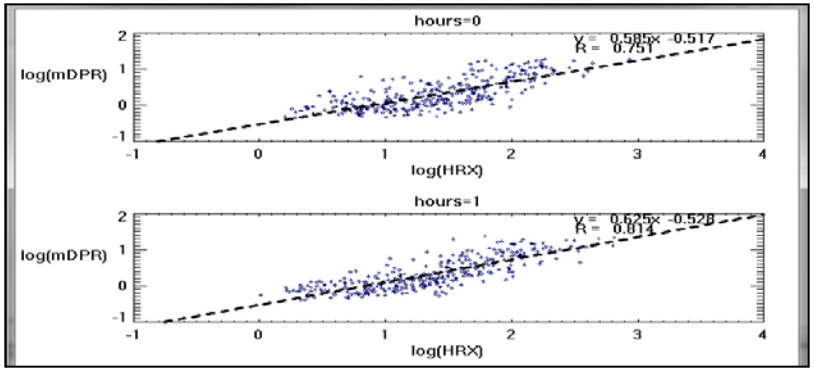
Magnetic variation



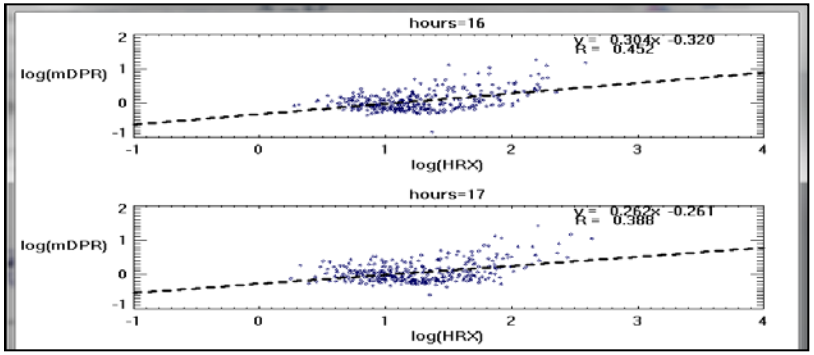
Histogram for night time data look similar for the ionosphere index and magnetic variations

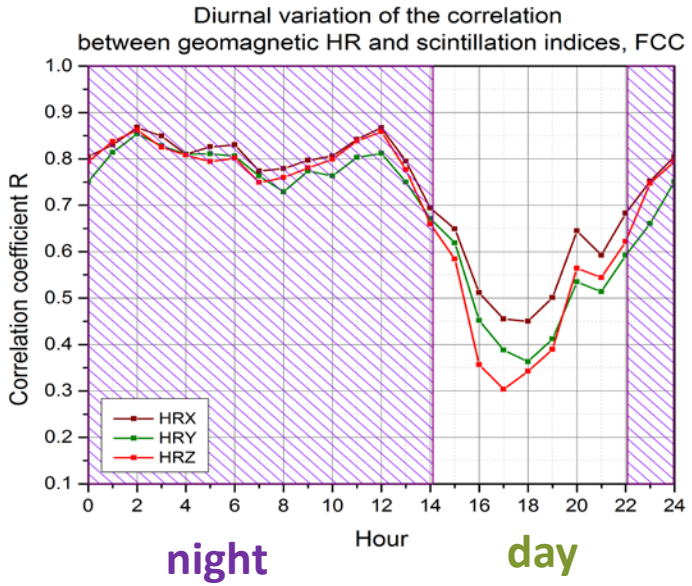
Variation of the correlation coefficient between magnetic and scintillation indices Fort Churchill

night time



day time

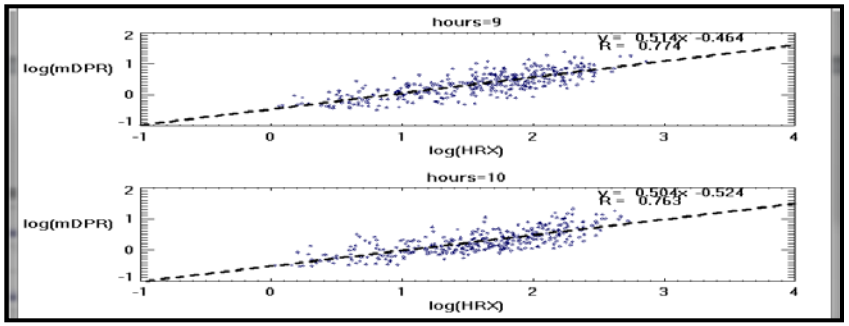




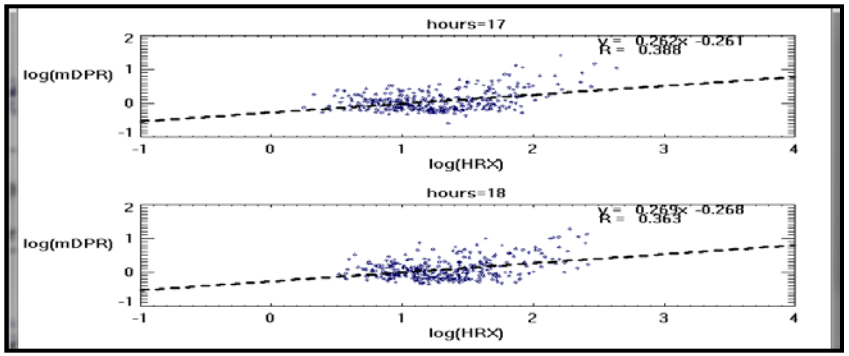
Daytime drop in correlation between mDPRmax index and geomagnetic activity

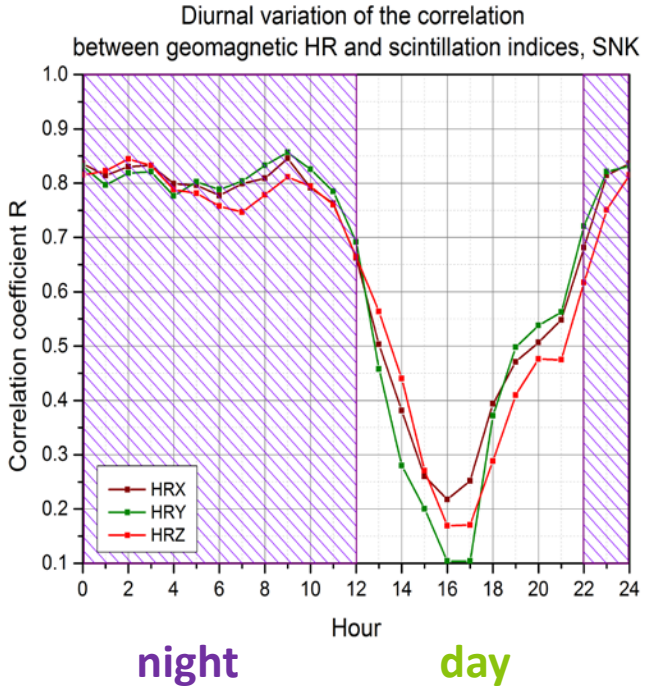
Variation of the correlation coefficient between magnetic and scintillation indices. Sanikiluaq.

night time



day time

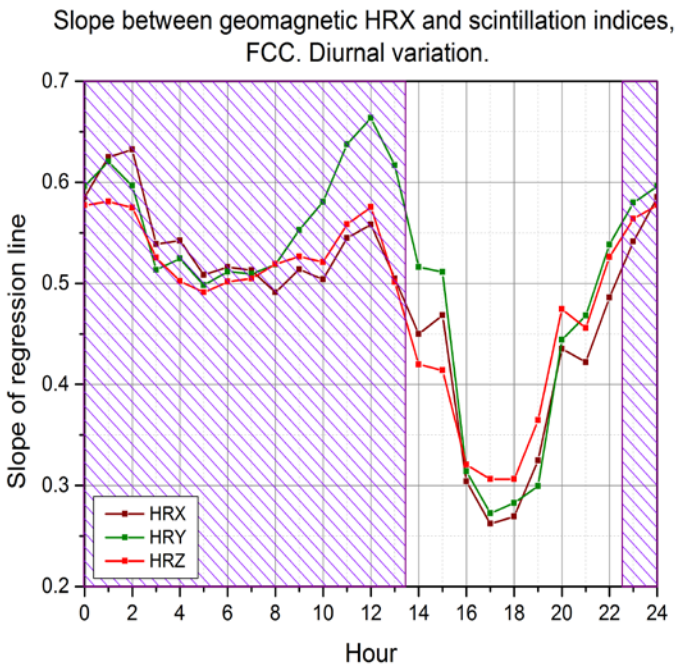




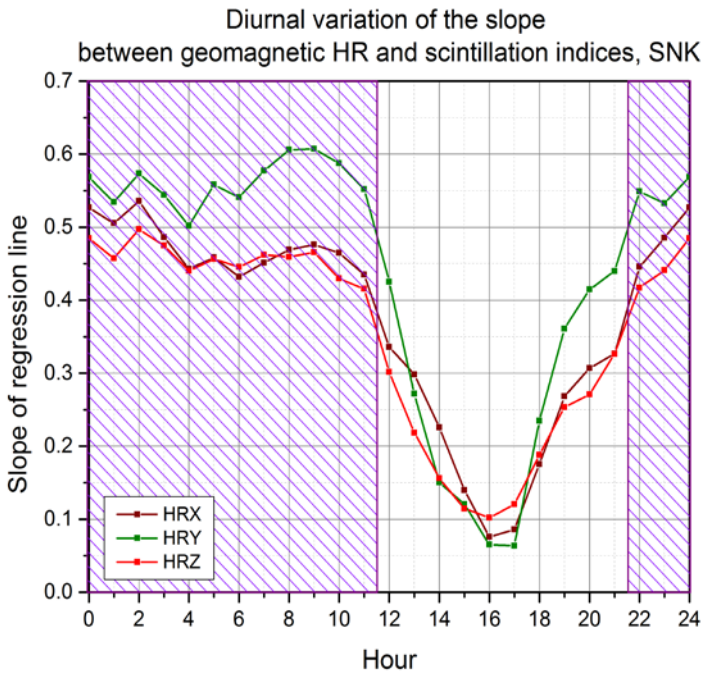
Daytime drop in correlation between mDPR index and geomagnetic activity

Variation of the slope between magnetic and scintillation indices.

Fort Churchill (FCC)

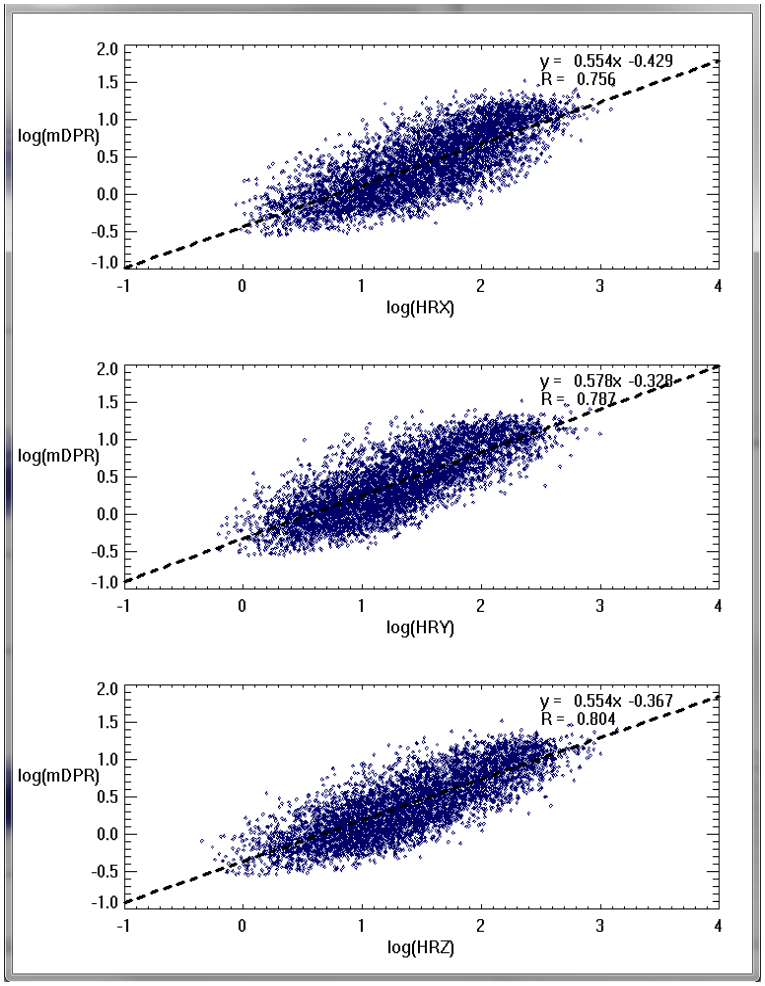


Sanikiluaq (SNK)



Slope of the fitting line between mDPR index and geomagnetic activity is ~ 0.5-0.6 during night time and drops during day time

Correlation between magnetic and scintillation indices excluding hours 13-23 FCC



Correlation Of mDPRmax	All data	Night time
with HRX	0.69	0.75
with HRY	0.68	0.78
with HRZ	0.76	0.80

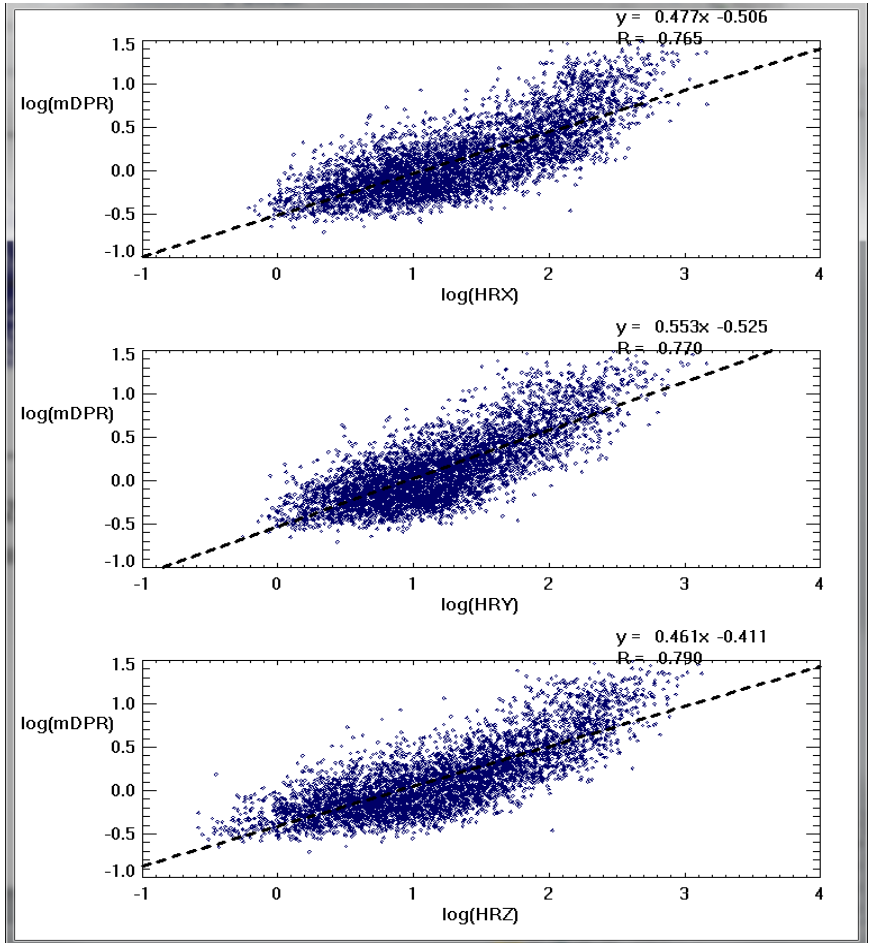
Model

log(mDPRmax)= a*log(HR)+b

To a first approximation, mDPRmax index is proportional to the square root of HR
The best correlation is with HRZ.

$mDPRmax \approx 0.429 * HRZ^{0.554}$

Correlation between magnetic and scintillation indices excluding hours 12-22 Sanikiluaq



Correlation Of mDPRmax	All data	Night time
with HRX	0.69	0.77
with HRY	0.67	0.78
with HRZ	0.72	0.80

Model

Log(mDPRmax)= a*log(HR)+b

To a first approximation, mDPRmax index is proportional to the square root of HR

The best correlation is with HRZ.

$mDPRmax \approx 0.388 * HRZ^{0.461}$

Conclusion

- As an attempt to forecast scintillation, one year of data in 2013 from auroral magnetic observatories and co-located GPS stations was analysed
- To a first approximation, mDPRmax index is proportional to the square root of HR
- The nighttime correlation coefficient is much greater than during the day
- The correlation is strongest with the HRZ of the magnetic field
- hourly indices of geomagnetic field variations could be a representative measure for the maximum GPS scintillation proxy index (mDPRmax) for the auroral zone