An Examination of the Causes and Consequences of the March 13, 1989 Magnetic Storm

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Outline

Solar Activity

Interplanetary Disturbances

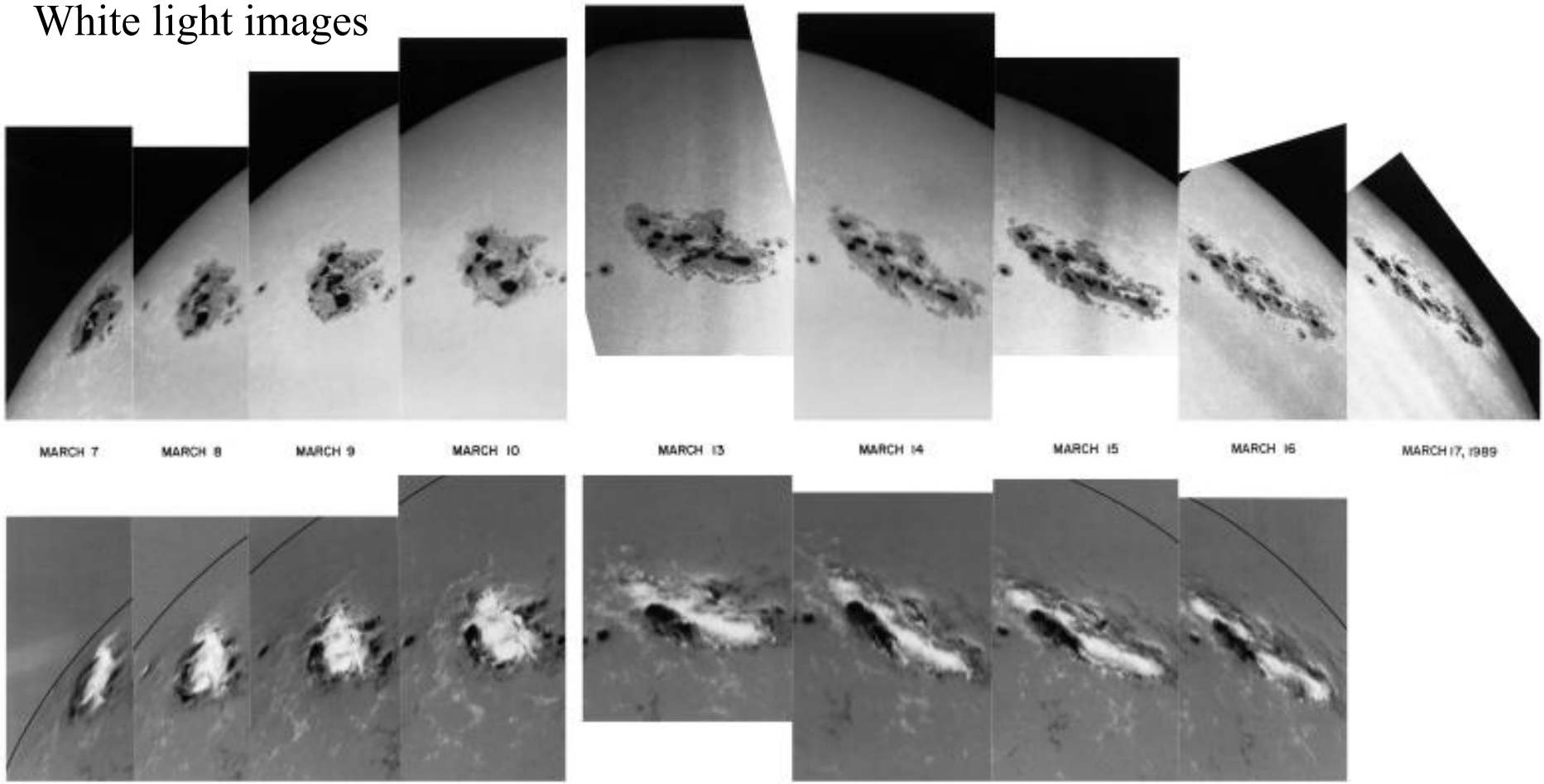
Magnetosphere Response

Geomagnetic and Geo-electric Fields

Effects on Power Systems

Region 5395

White light images



Solar magnetograms

Kitt Peak

NSO/AURA/NSF

Region 5395

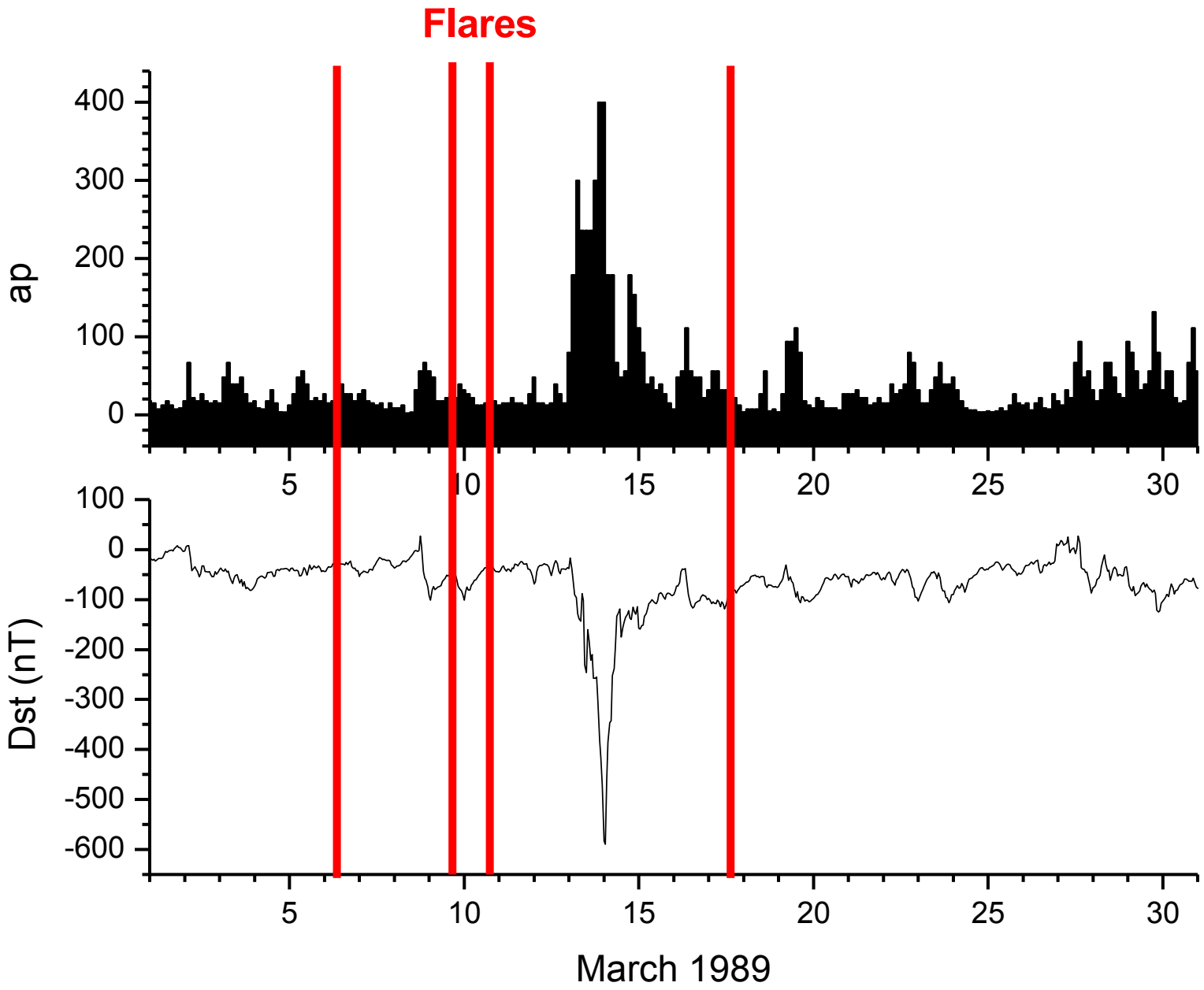
Visible from 5 March 1989 to 19 March 1989

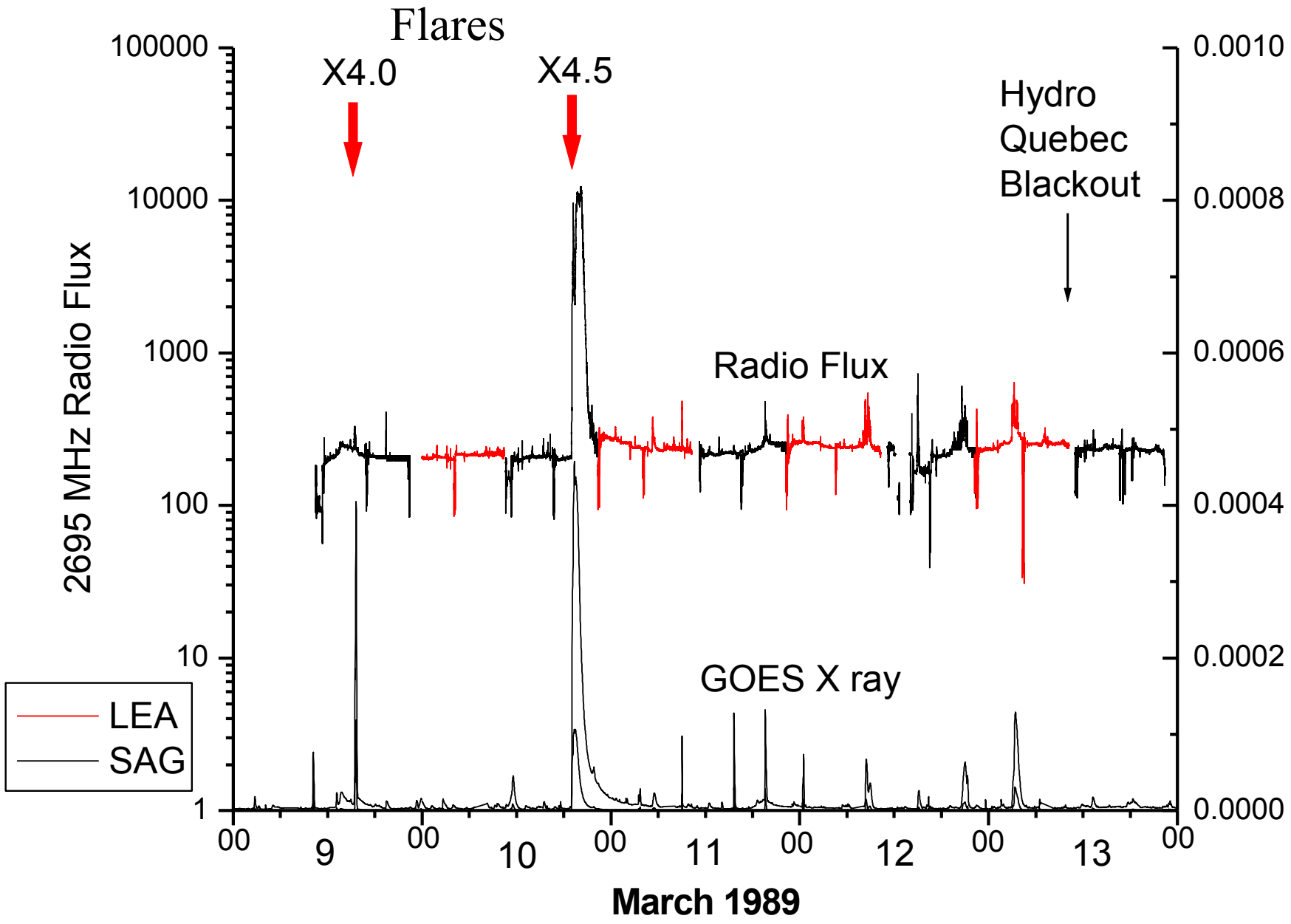
Central meridian passage on 12 March 1989.

During time it was visible produced 11 X-class flares.

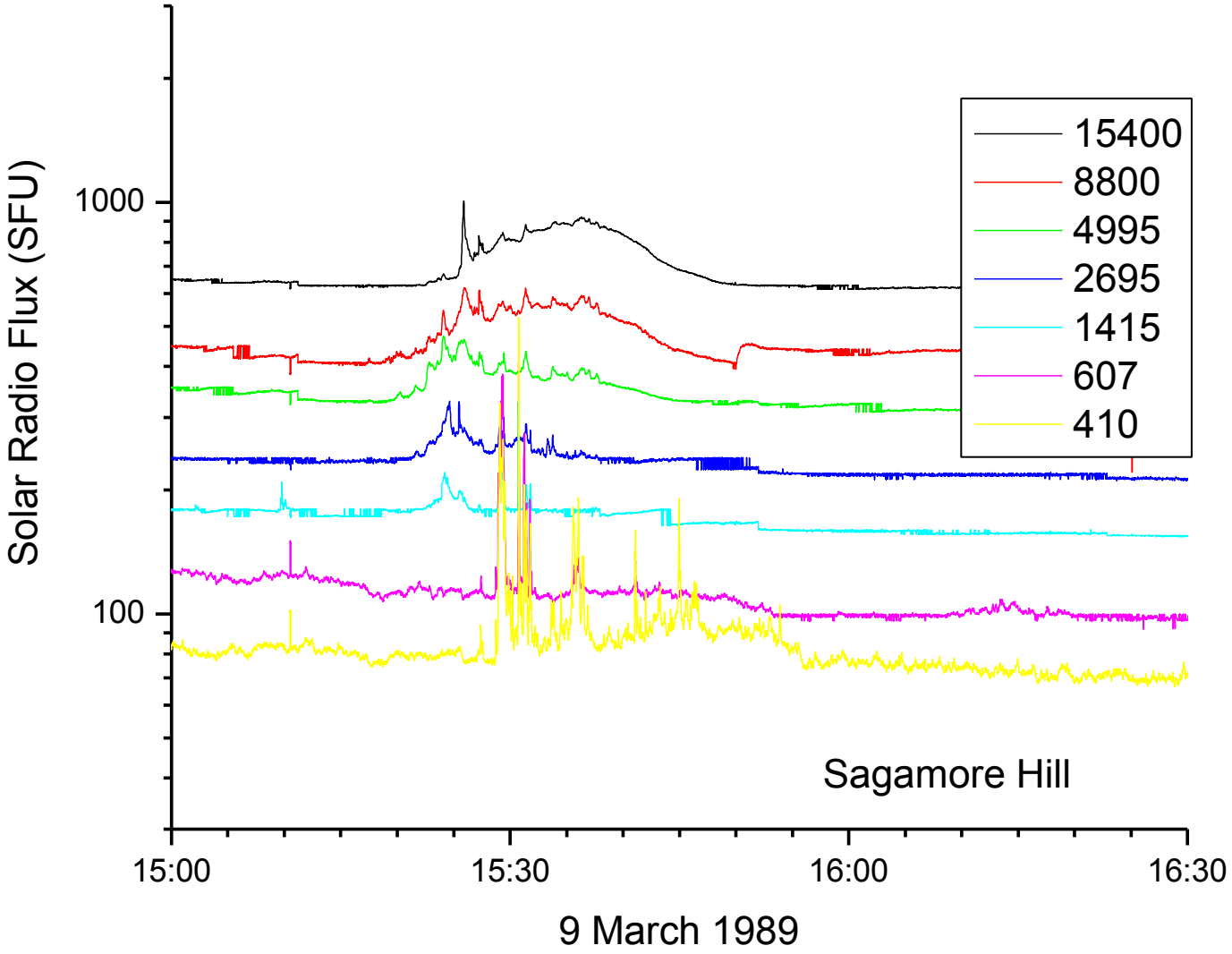
Of these 4 were greater than or equal to X 4.0:

March 6	13:54	X15.0
March 9	15:15	X4.0
March 10	18:48	X4.5
March 17	17:29	X6.5

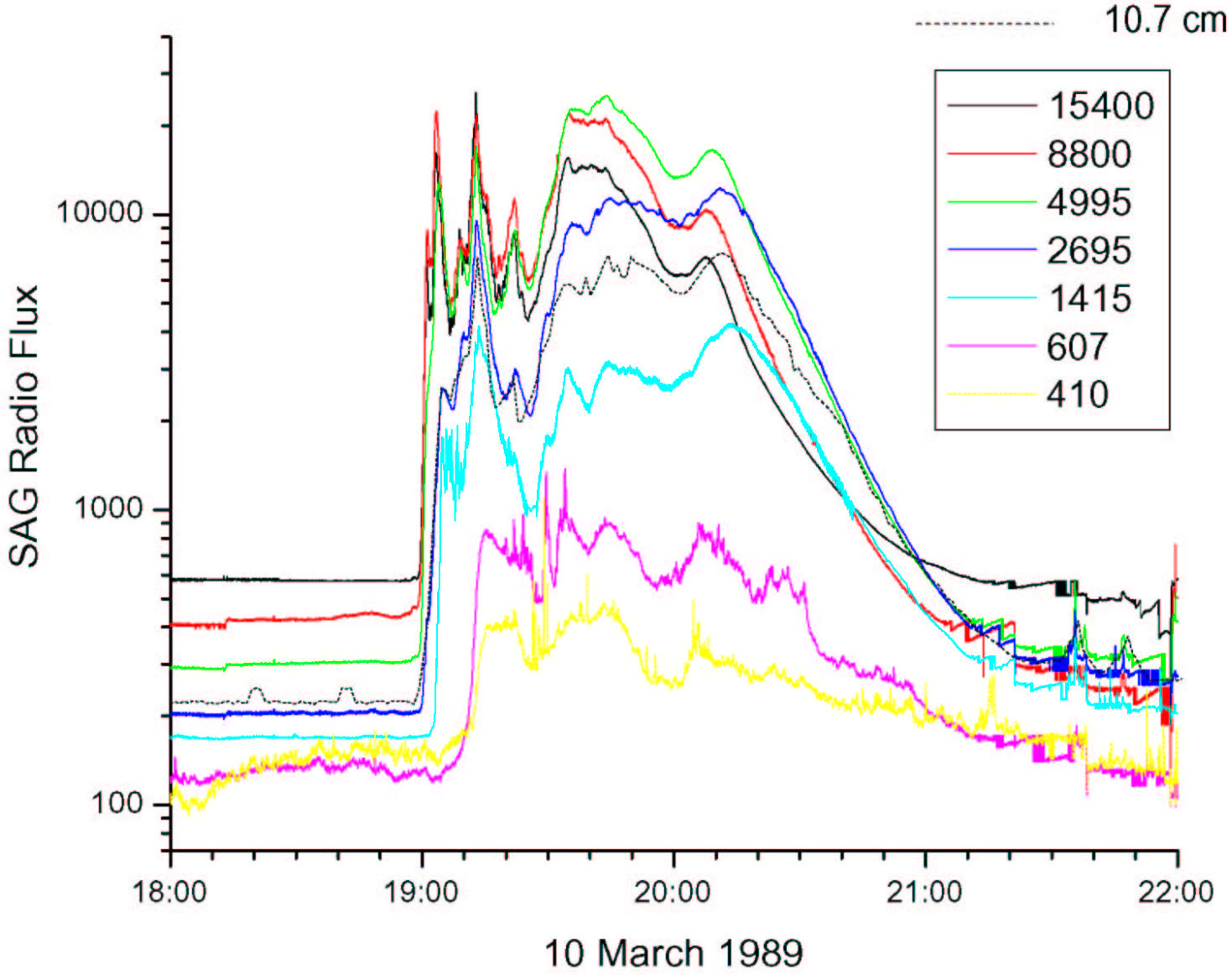

Flares
ap
400
300
200
100
0
5
10
15
20
25
30
Dst (nT)
100
0
-100
-200
-300
-400
-500
-600
5
10
15
20
25
30
March 1989


Flares
X4.0
X4.5
Hydro
Quebec
Blackout
Radio Flux
GOES X ray
2695 MHz Radio Flux
100000
10000
1000
100
10
1
0.0010
0.0008
0.0006
0.0004
0.0002
0.0000
LEA
SAG
00
9
00
10
00
11
00
12
00
13
00
March 1989

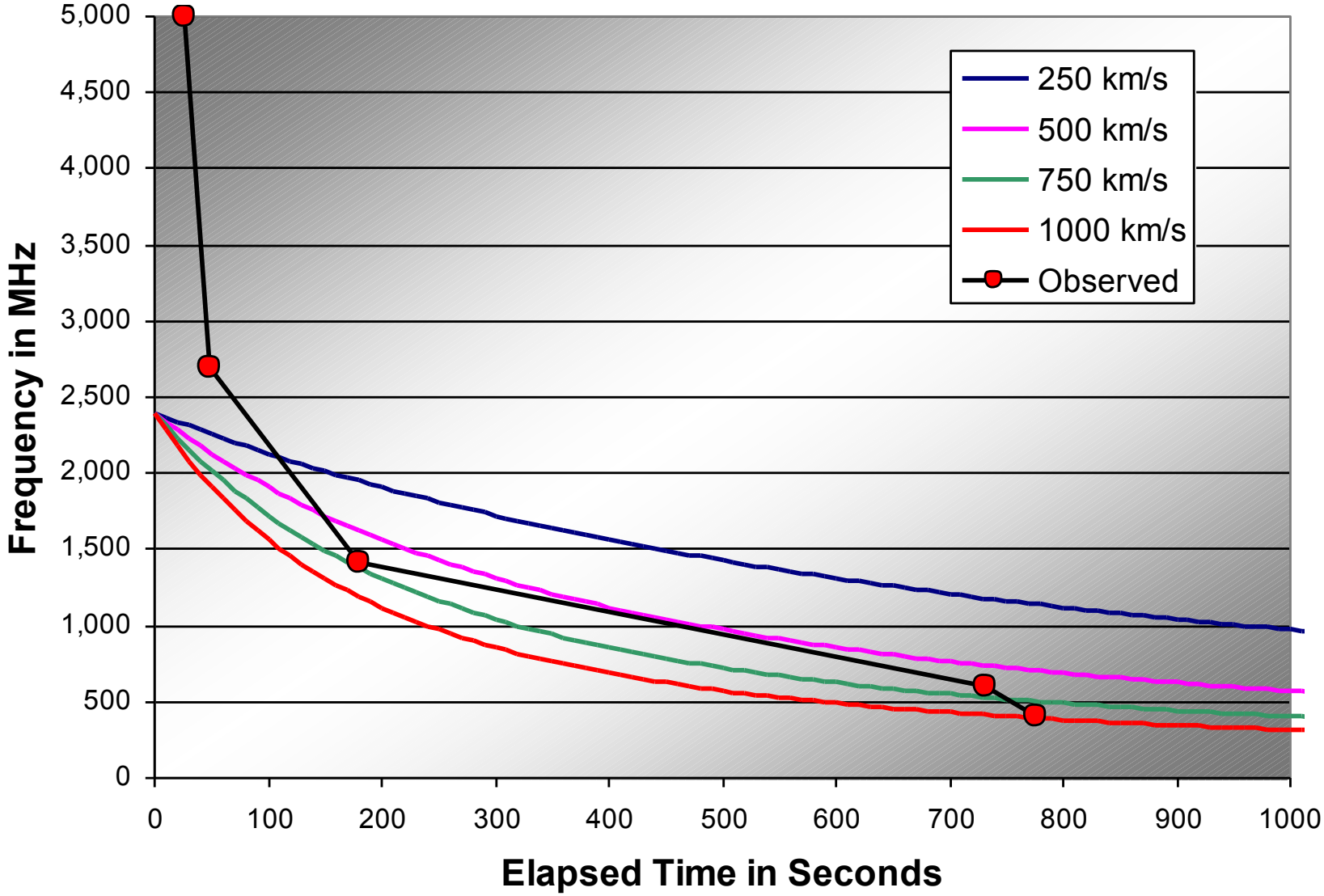
March 9 Flare

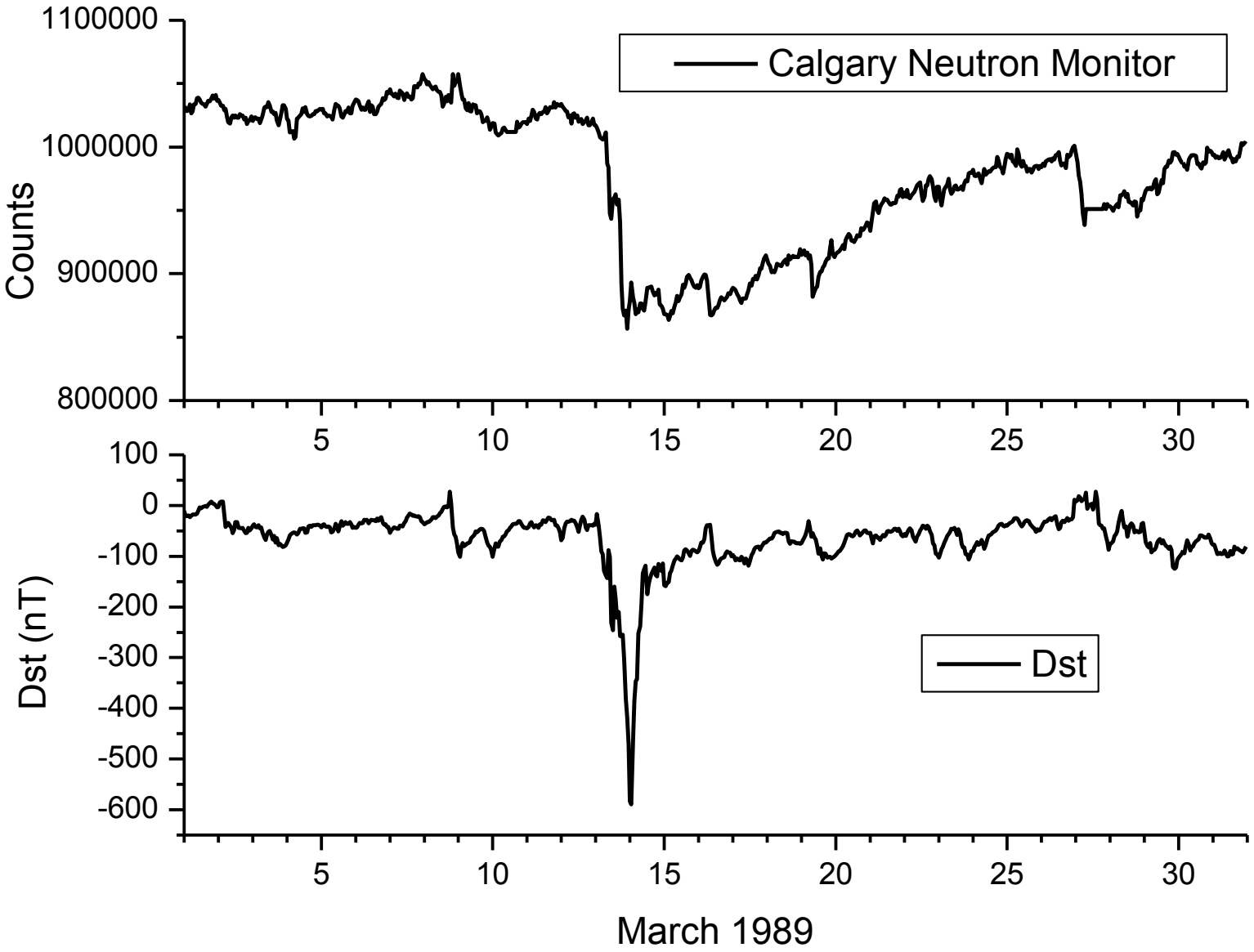


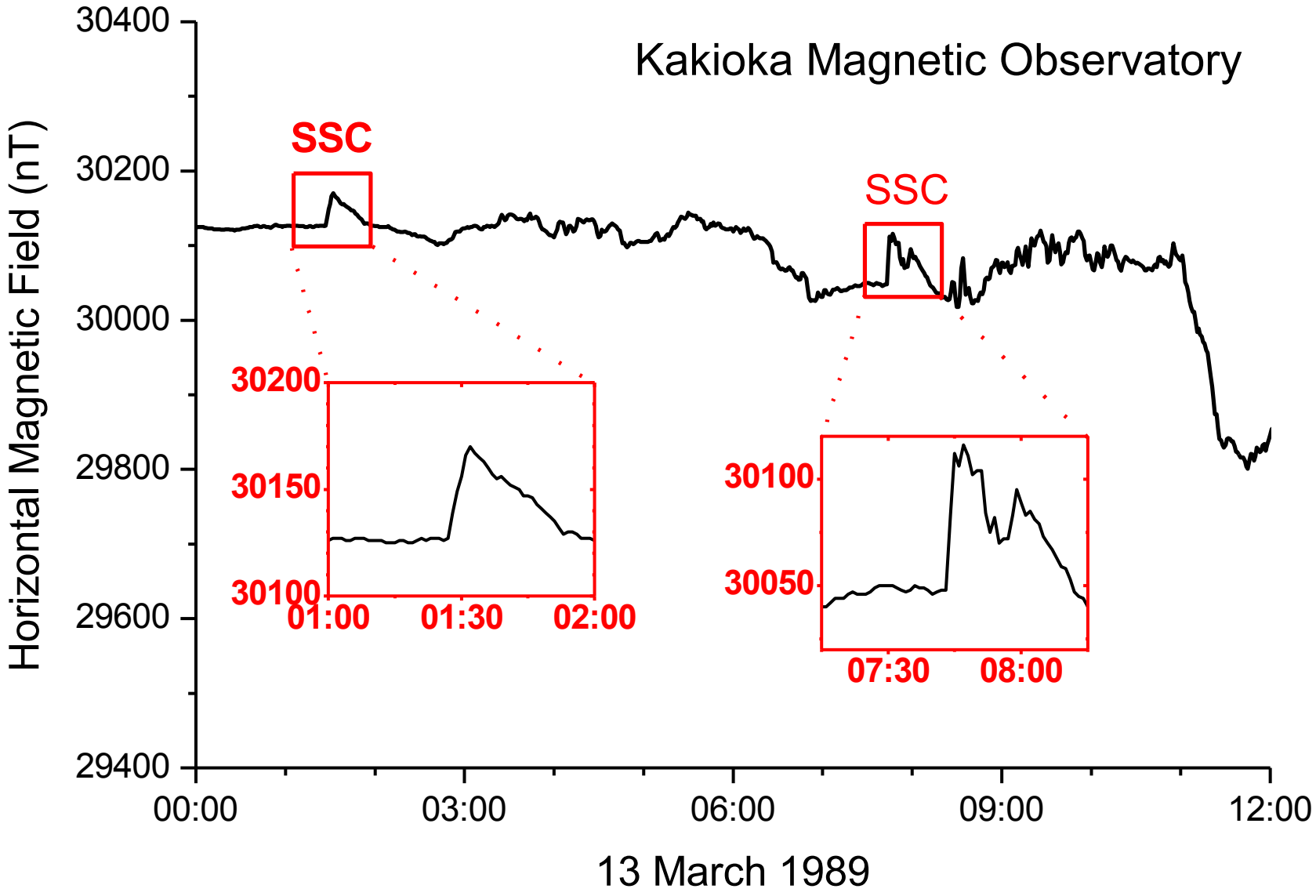
March 10 Flare

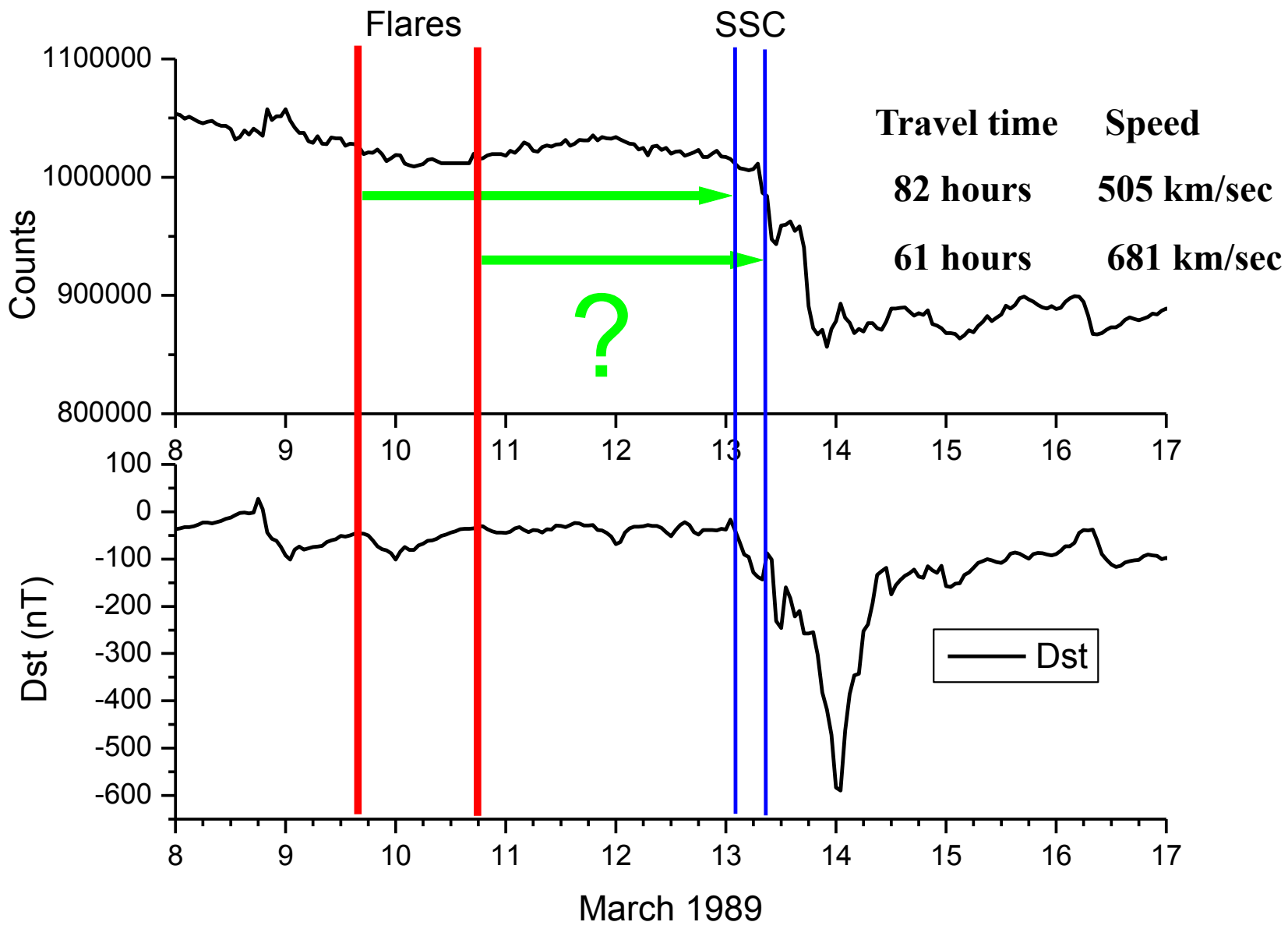


10th March, 1989 Event




1100000
1000000
900000
800000
Counts
Calgary Neutron Monitor
5
10
15
20
25
30
100
0
-100
-200
-300
-400
-500
-600
Dst (nT)
Dst
March 1989


Kakioka Magnetic Observatory
SSC
SSC
Horizontal Magnetic Field (nT)
30400
30200
30000
29800
29600
29400
00:00
03:00
06:00
09:00
12:00
13 March 1989
30200
30150
30100
01:00
01:30
02:00
30100
30050
07:30
08:00

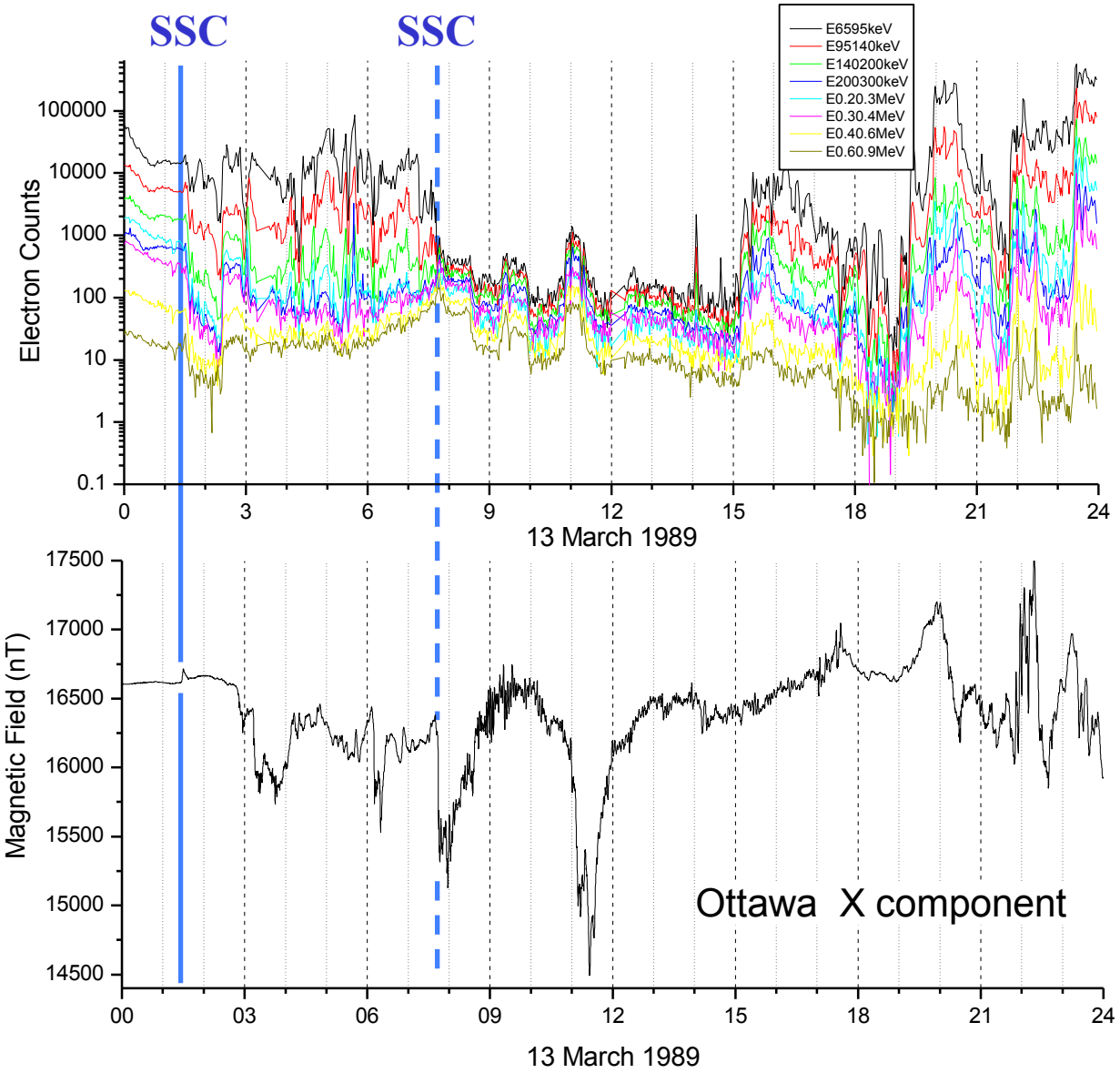

Flares
SSC
Travel time
Speed
82 hours
505 km/sec
61 hours
681 km/sec
?
Counts
1100000
1000000
900000
800000
8
9
10
11
12
13
14
15
16
17
Dst (nT)
100
0
-100
-200
-300
-400
-500
-600
Dst
March 1989

Geostationary Electrons

(LANL)

Ground Geomagnetic Field

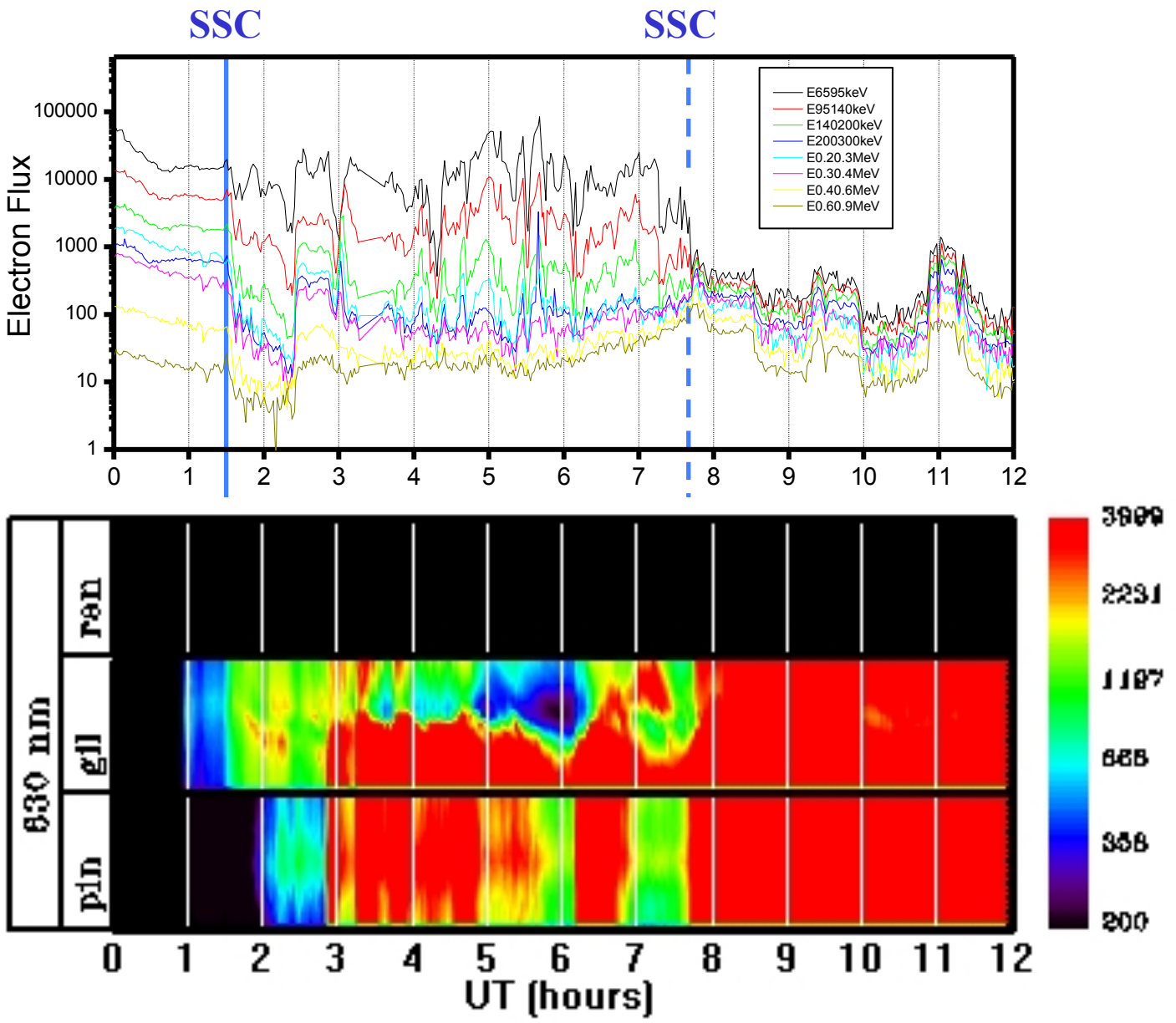
(Ottawa)

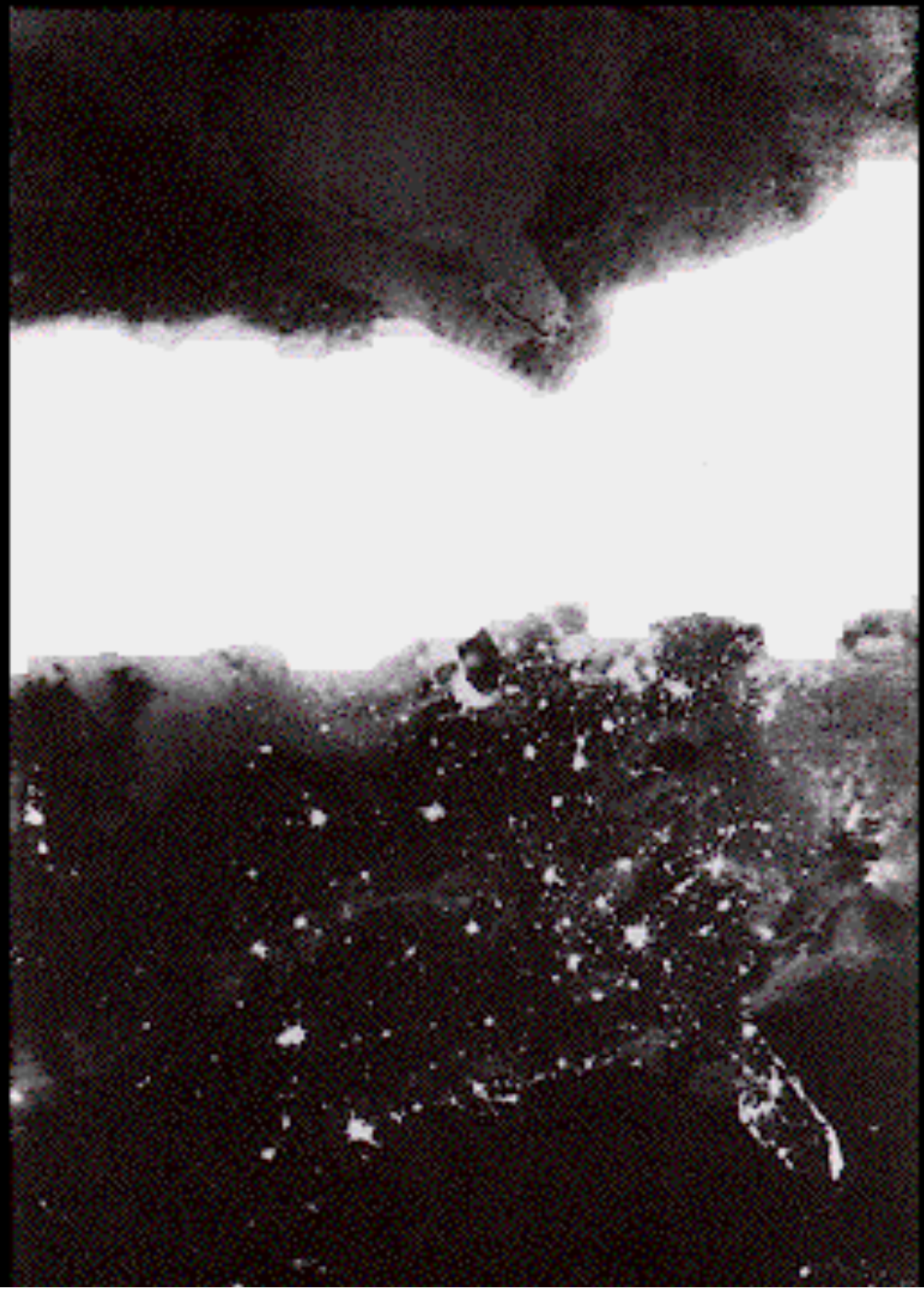


Geostationary Electrons

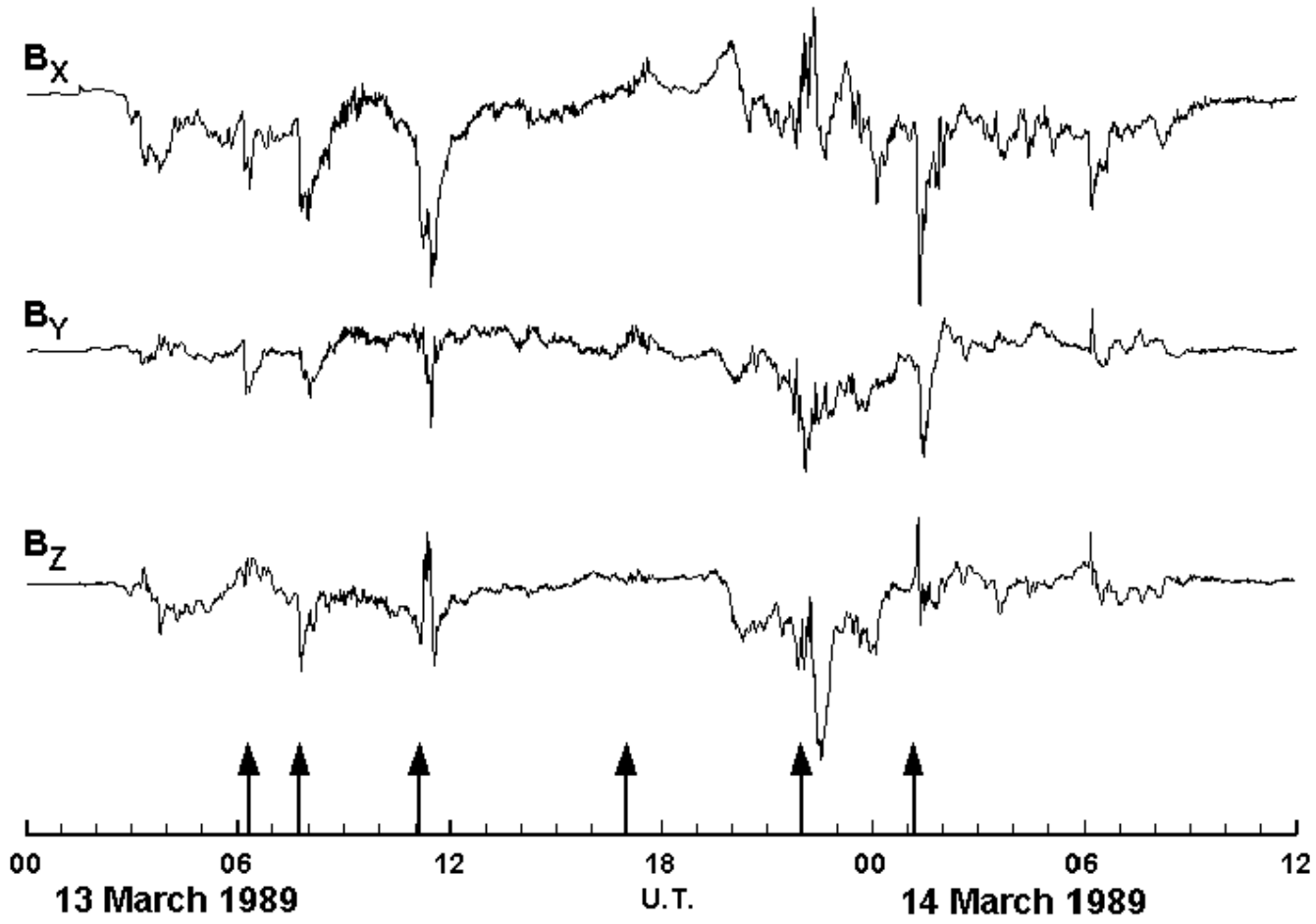
(LANL)

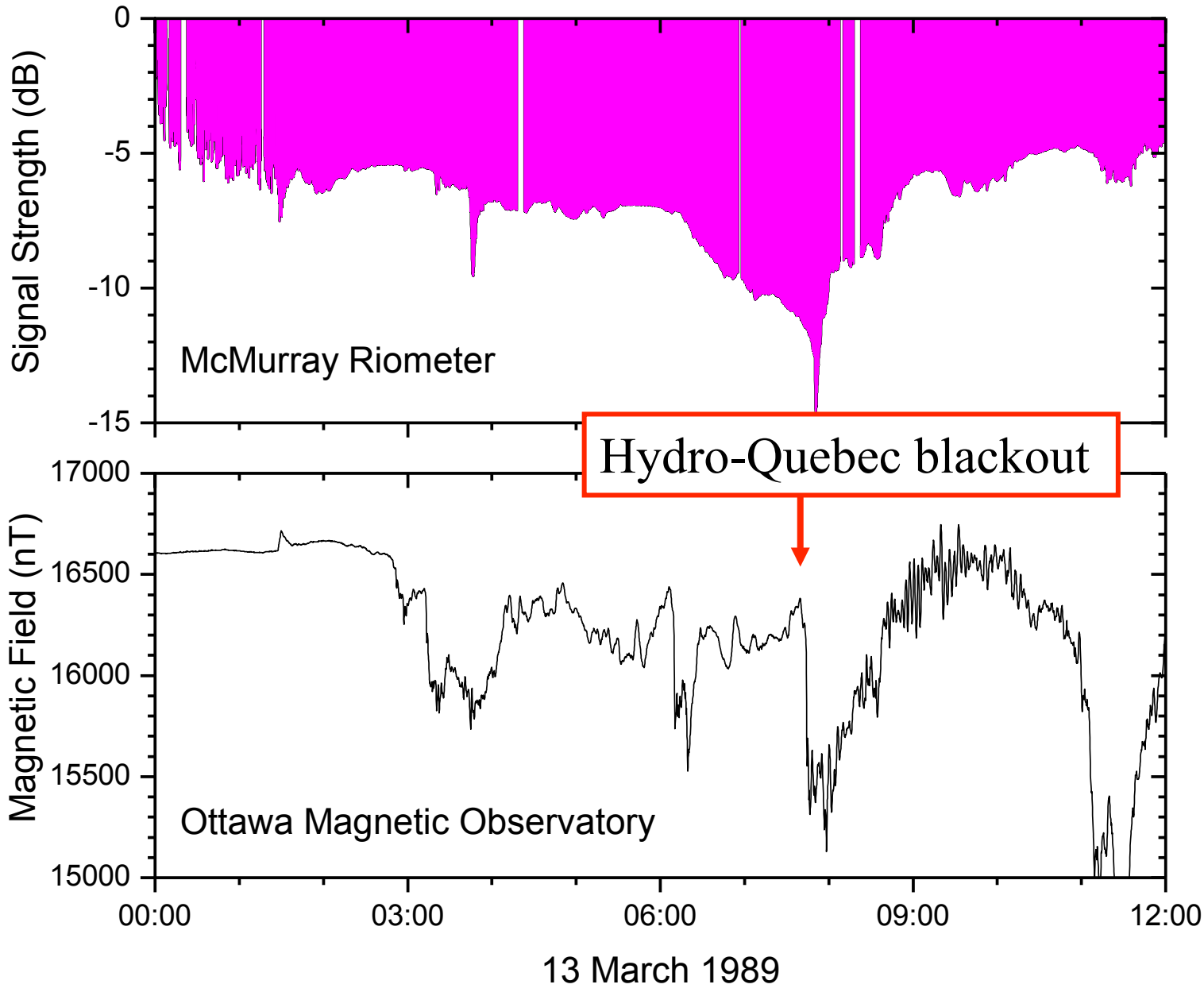
Auroral Intensity



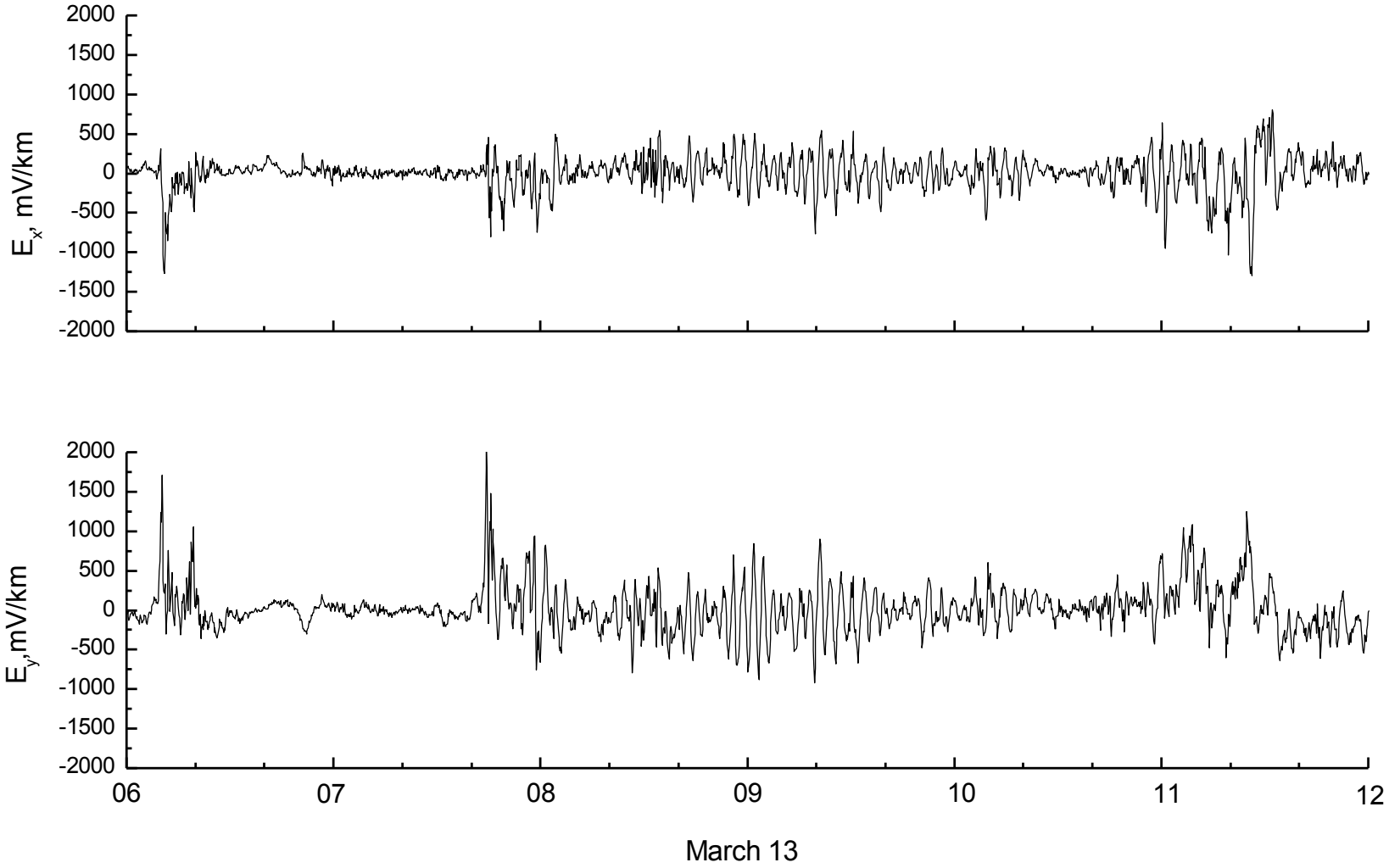


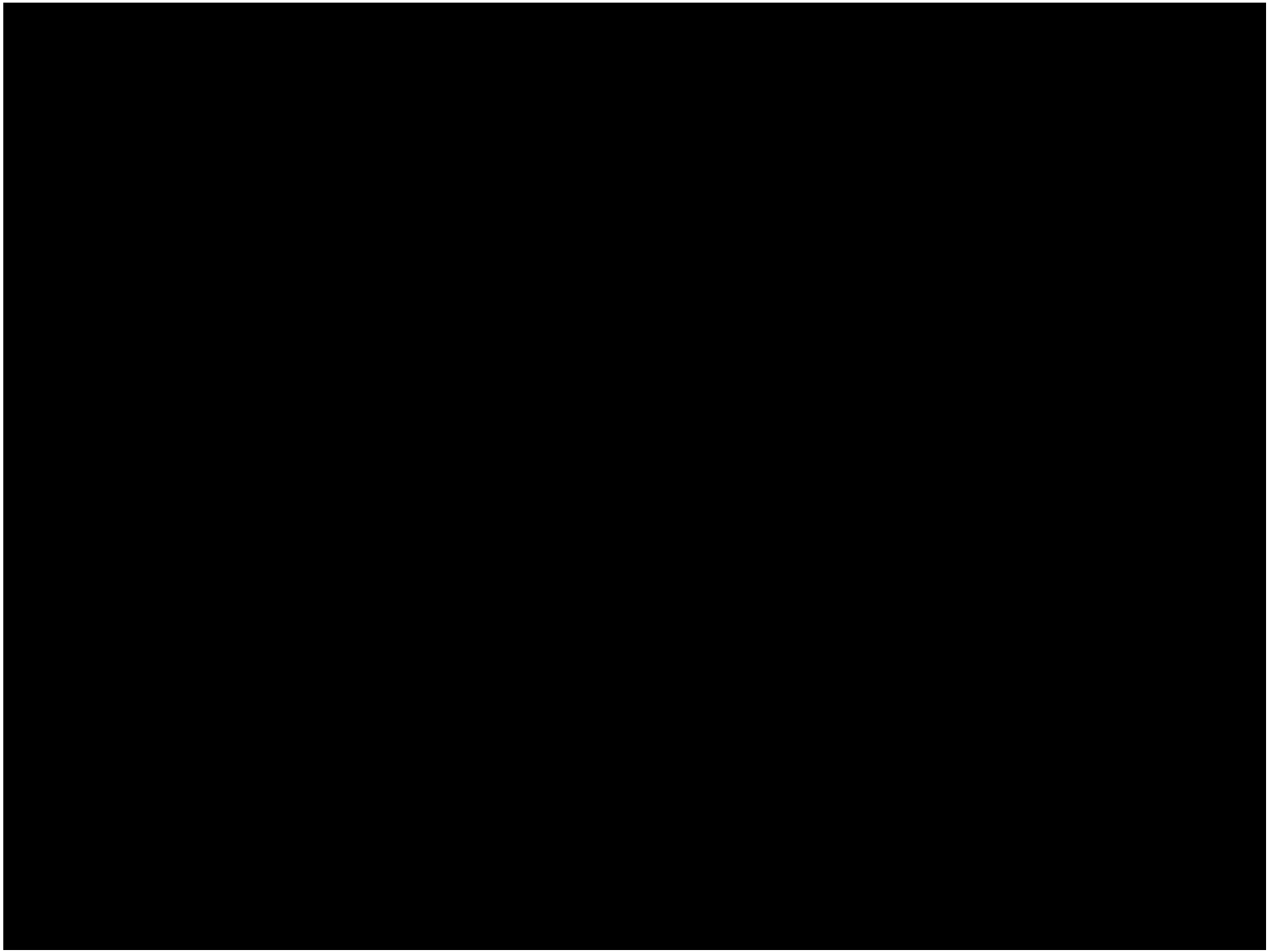
Disturbance recorded at the Ottawa Magnetic Observatory




Signal Strength (dB)
0
-5
-10
-15
McMurray Riometer
Hydro-Quebec blackout
Magnetic Field (nT)
17000
16500
16000
15500
15000
Ottawa Magnetic Observatory
00:00
03:00
06:00
09:00
12:00
13 March 1989

Electric Field at Ottawa





EARLY ED.
The Gazette
MONTREAL TUESDAY, MARCH 14, 1989 50¢

The Gazette
BUSINESS
MONTREAL, TUESDAY, MARCH 14, 1989

We're sorry for the delay

Yesterday's power failure may have delayed delivery of your paper. We're sorry.

Before the blackout hit at 2:45 a.m., *The Gazette* had printed 125,000 copies. After power returned at 1:30 p.m., another 60,000 copies containing coverage of the blackout were printed for delivery to homes and stores.

About 70 per cent of subscribers received their copies in the morning as usual.

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By
Gazet

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Hydro-Québec
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Hydro bl

Francine Perreault serves coffee by can

Maine won't reconsider Quebec pov

By SHIRLEY WON
of The Gazette

The Maine Public Utilities Commission yesterday turned down a petition to reconsider its decision against the purchase of $4 billion of power from Hydro-Quebec.

The petition was made last month by Maine's public advocate, Stephen Ward, who represents consumers in state proceedings on utility issues. Ward could not be reached for comment.

The Maine utilities commission in January rejected the contract, which was signed between Central Maine Power Co. and Hydro-Québec for the sale of 300 megawatts of power.

Jacques Guevremont, executive-vice-president of external sales for Hydro-Quebec, said he is disappointed by the decision but stressed in a telephone interview yesterday that the "deal is not dead yet."

Guevremont said there can still be appeals to the Maine Supreme Court by parties involved in the original hearings, or possibly a new petition by Central Maine Power to the commission.

In voting down the contract two months ago, the commission said the state's largest utility had not adequately explored alternative energy sources — such as cogeneration or small power plants — and energy savings from conservation.

Charles Jacobs, administrative director for the commission, said the decision to reject reconsideration was 2-to-1, the same margin as the January vote. He sai
rejection will be iss
The Maine power
last July, could hav
to $15 billion for
Central Maine exec
buy more power ov
The Maine contra
contracts with uti
and New York —
last spring's annou
mier Robert Bouras
phase of the James
hydro complex.

SATURDAY
The Gazette
* MONTREAL, FINAL EDITION MARCH 18, 1989 $1.00

Stocks plummet as inflation rises

By JAY BRYAN
of The Gazette

North American stock markets plunged yesterday as inflation rates jumped, and economists quickly warned that more bad news is on the way in the form of higher interest rates.

Jittery investors dumped their stocks, causing the Dow Jones industrial average to plummet 48.57 points to 2292.14, its biggest drop in 11 months. The Toronto Stock Exchange's 300 index fell by 37.34 points to close at 3614.32.

At the same time, a round of hikes in mortgage rates spread to two more major banks yesterday, raising the rate on a one-year mortgage at four of them by half a point to 13.75 per cent, the highest level in five years.

Economists predict that rates on business and consumer loans will rise soon.

In Canada, the Consumer Price Index was up by 0.7 per cent in February, raising the inflation rate for the past 12 months to 4.6 per cent, its highest level since July 1987. The 12-month inflation rate was 4.3 per cent in January.

But observers said stock markets were reacting mostly to yesterday morning's announcement of a big jump in the U.S. Producer Price Index, an inflation measure that often foreshadows moves in U.S. consumer prices. The index jumped by 1 per cent in February — about double what financial markets had expected.

This sparked heavy selling as investors speculated that authorities in both the United States and Canada would react to the threat of rising inflation with higher interest rates, said Harvey Bradley, an economist with Wood Gundy Inc.

Higher inflation is expected to bring another round of increases in the prime rate of chartered banks, which has been 12.75 per cent for the past month.

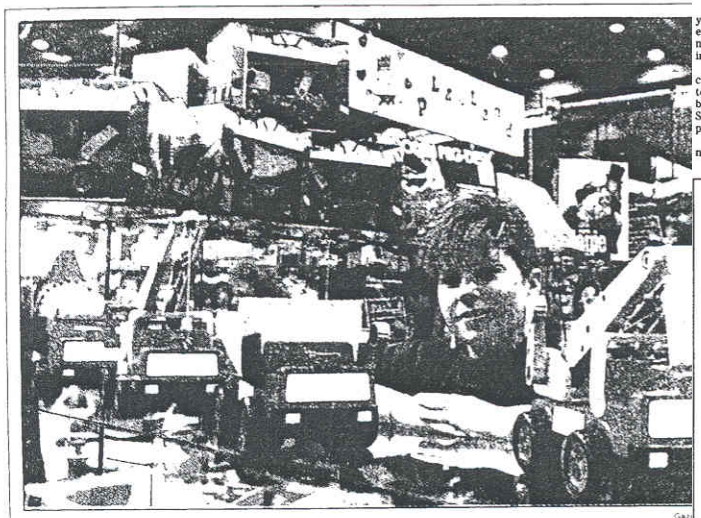
The prime, which was at 10.75 per cent as recently as last June, is the benchmark rate from which many business and consumer rates are scaled up.

"We're heading for 13.25 per cent within a matter of days and 14 per cent is not inconceivable over the next several months," said George Saba, chief economist with Montreal Trust.

With the rate for a one-year mortgage at 13.25 per cent, monthly payments will be $26.63 higher on a $75,000 mortgage paid off over 25 years.

Authorities raise interest rates to choke off inflation. As borrowing becomes more expensive, people buy less, making it harder for producers to raise prices.

• *Investors run for cover. Page G-1*



Robin Levinson of R.F. Enterprises works at one of the booths at Spring Gift Show at Place Bo

Jumbo colored blocks are hot in toyl

By JAN RAVENSBERGEN
of The Gazette

Robin Levinson let out a groan yesterday afternoon as the lights went out at the Montreal Spring Gift Show at Place Bonaventure.

But just as quickly they came on and it was back to business for Levinson and the more than 1,000 others handling the roughly 325 booths at the trade-only gift show, which continues until tomorrow at 5 p.m.

Levinson's enthusiasm was undimmed. The fast-talking administrative co-ordinator for Montreal toy importer and wholesaler R.F. Enterprises Inc. quickly resumed her explanation of why she's so certain her employer's sales will more than double this year.

"Eighty per cent of our toys are made in East Germany. People hear it's East German, they won't go there for their summer vacation.

"But they'll buy the little workbench for $7.90" wholesale from R.F. — and sell it in Baie Comeau, Winnipeg and points between for $12.99 retail, or perhaps lower.

"Jumbo colored blocks. Everybody wants them," Levinson asserted. "Anything in wood is hot, very hot." Much of it, the wooden stuff from R.F. anyway, is now imported from Chile and Brazil.

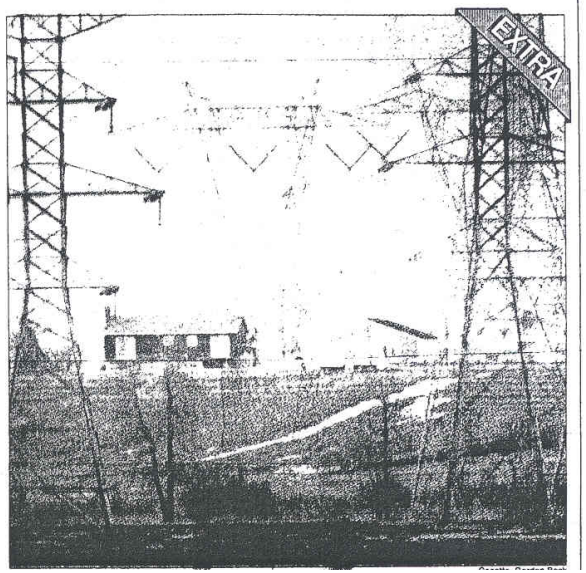
"On price point, we can beat Taiwan any day," chimed in R.F. sales representative Femiria Nanni. "They might be able to knock us off
down the line
something else

After a quick
Elizabeth in the
how far she could
Levinson confided
was good. We do
dollars in sales. I
na double that
Even triple
n which all the m
pany has been sig
ing Zellers Inc

Consumers fear Hydro is a monster, answerable to no one

PRISONERS OF POWER

ROBERT BOURASSA

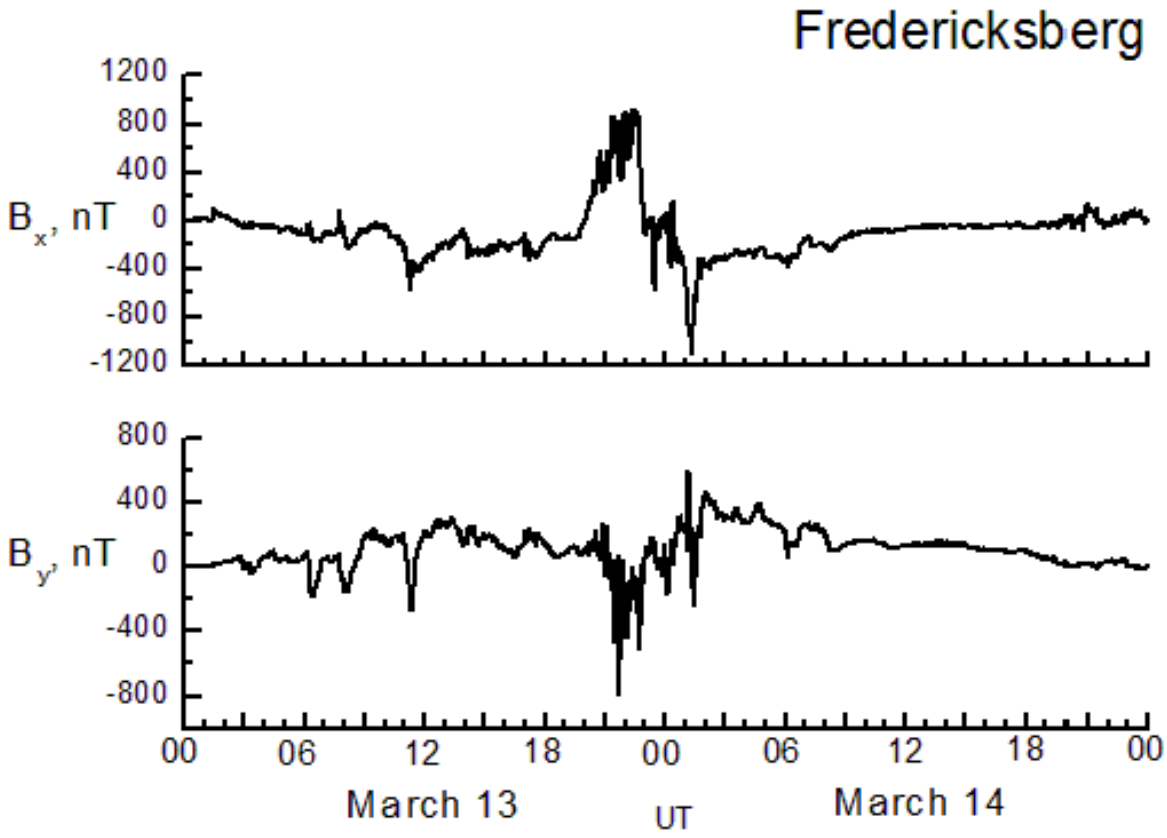


Other Power System Problems in North America

21:58 UT Widespread power system problems

Subsequent inspections showed transformer damage at Salem nuclear generating station - removed from service

Also evidence of transformer heating at Meadow Brook
- temperature estimated to reach 400^{o} C


Fredericksberg
1200
800
400
B_x, nT 0
-400
-800
-1200
800
400
B_y, nT 0
-400
-800
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06
12
18
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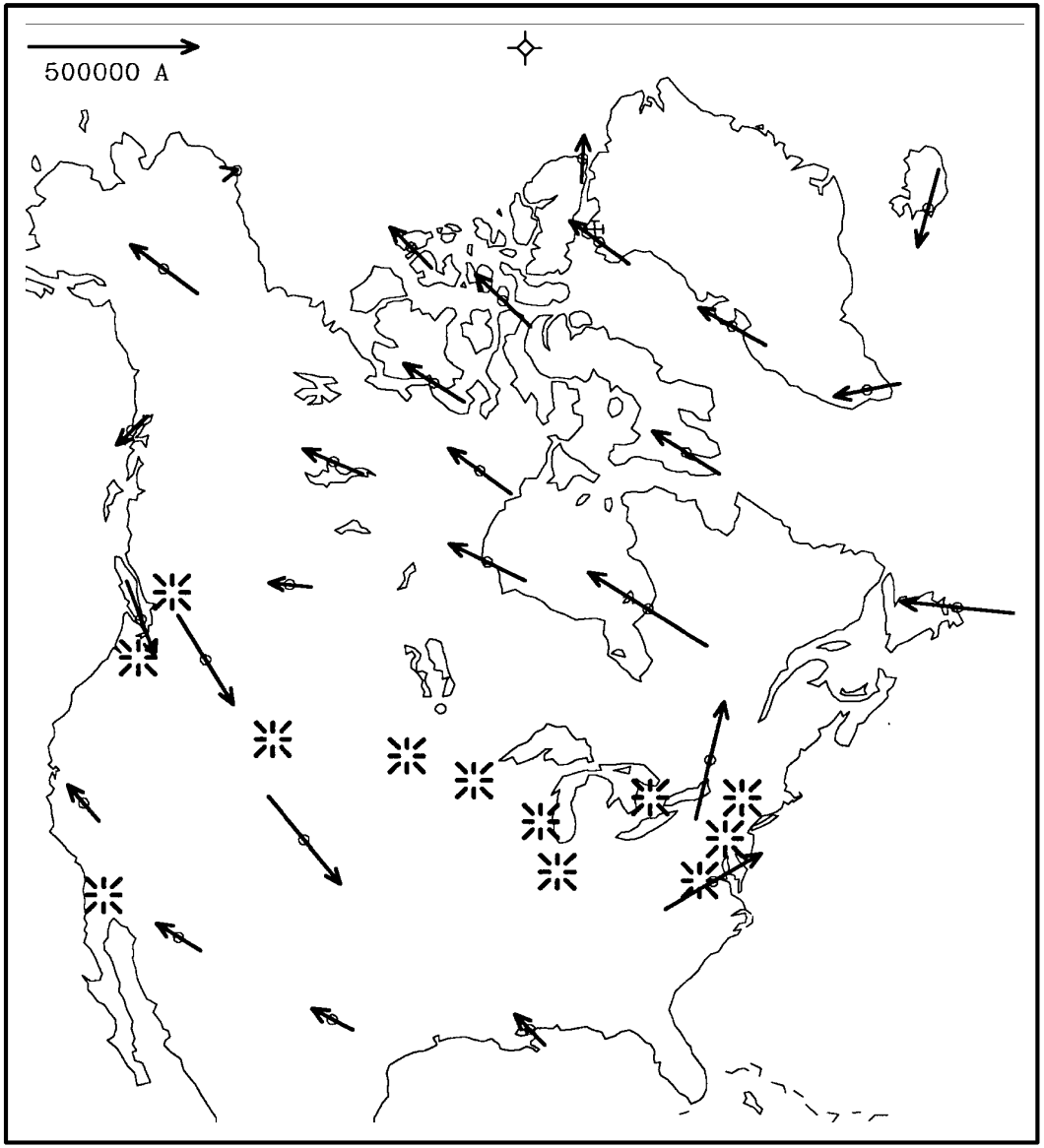
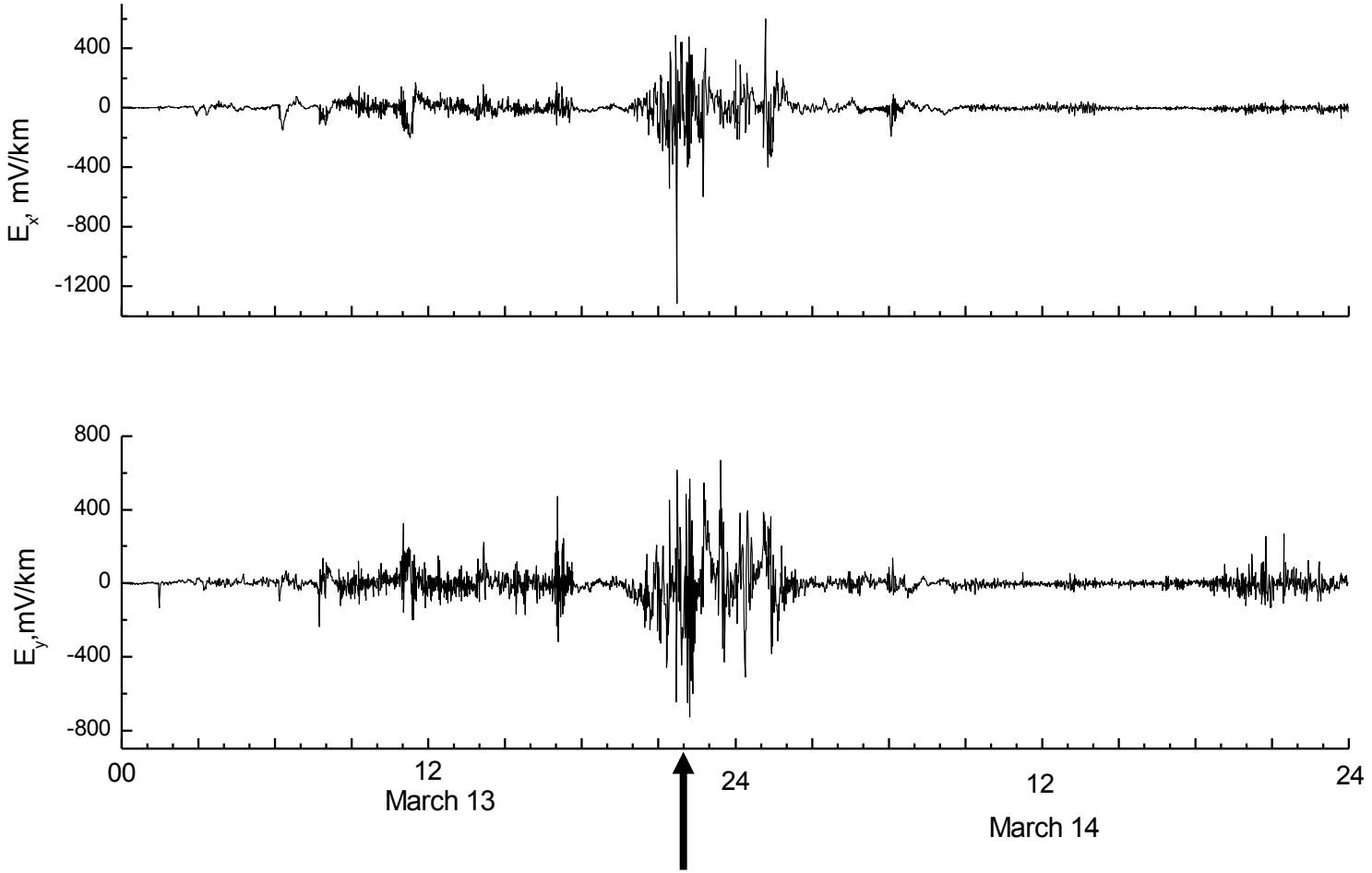
06
12
18
00
March 13
UT
March 14


500000 A

Electric Field at Fredericksburg



Salem transformer damage

Power System Problems in England

Effects peaked in UK in 4 hours around midnght of 13/14 March

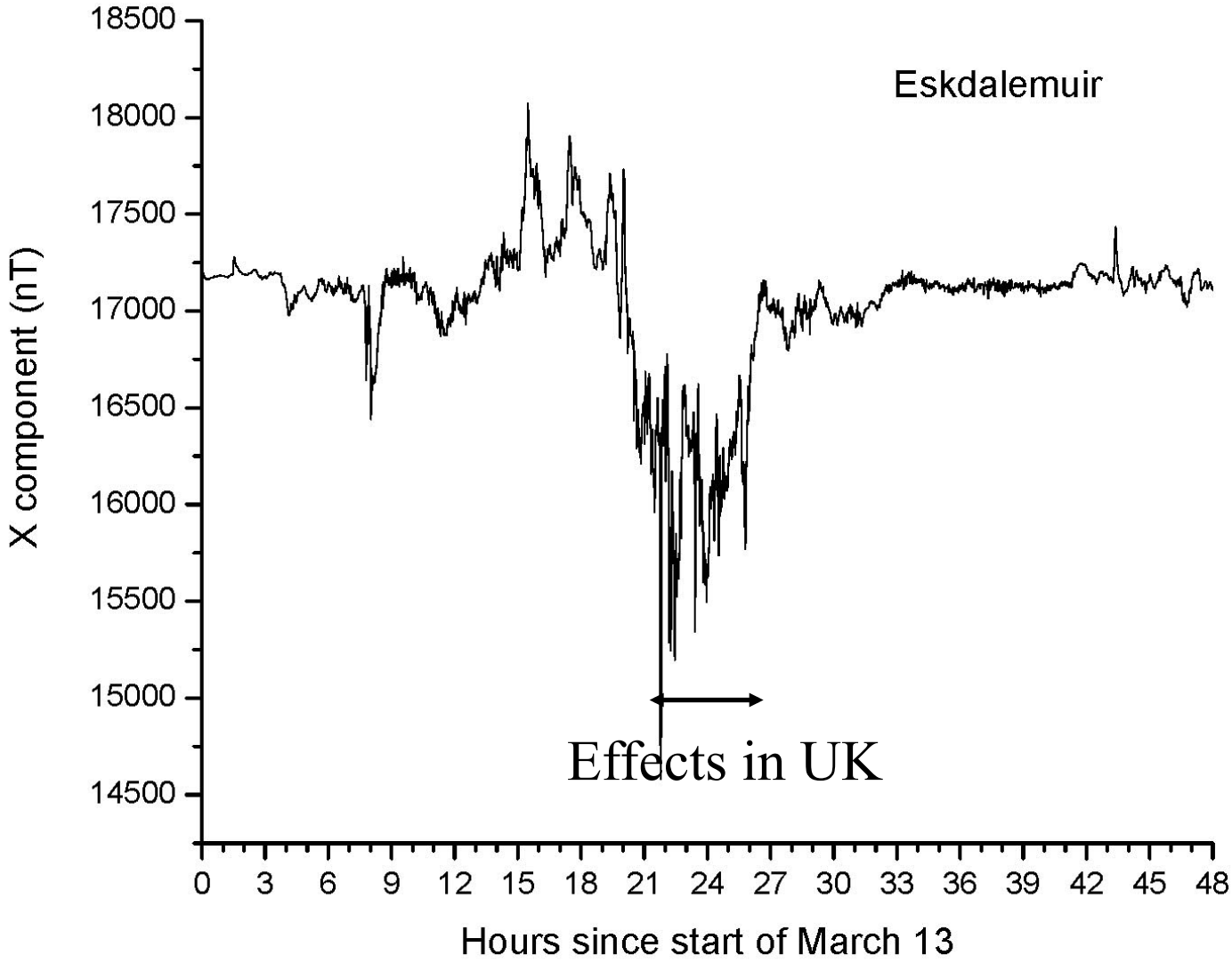
Numerous reports of communication channel failures and alarms

Alarms from British Telecom stand-by generators

(occurs when voltage dips below 90% for more than 30 seconds)

20:20 - 20:40	30
21:40 - 21:48	150

2 “supergrid” transformers at Norwich Main and Indian Queens brought up gas alarms within short time of one another and were switched out - both found to have damaged core-bolt insulation, amongst other things

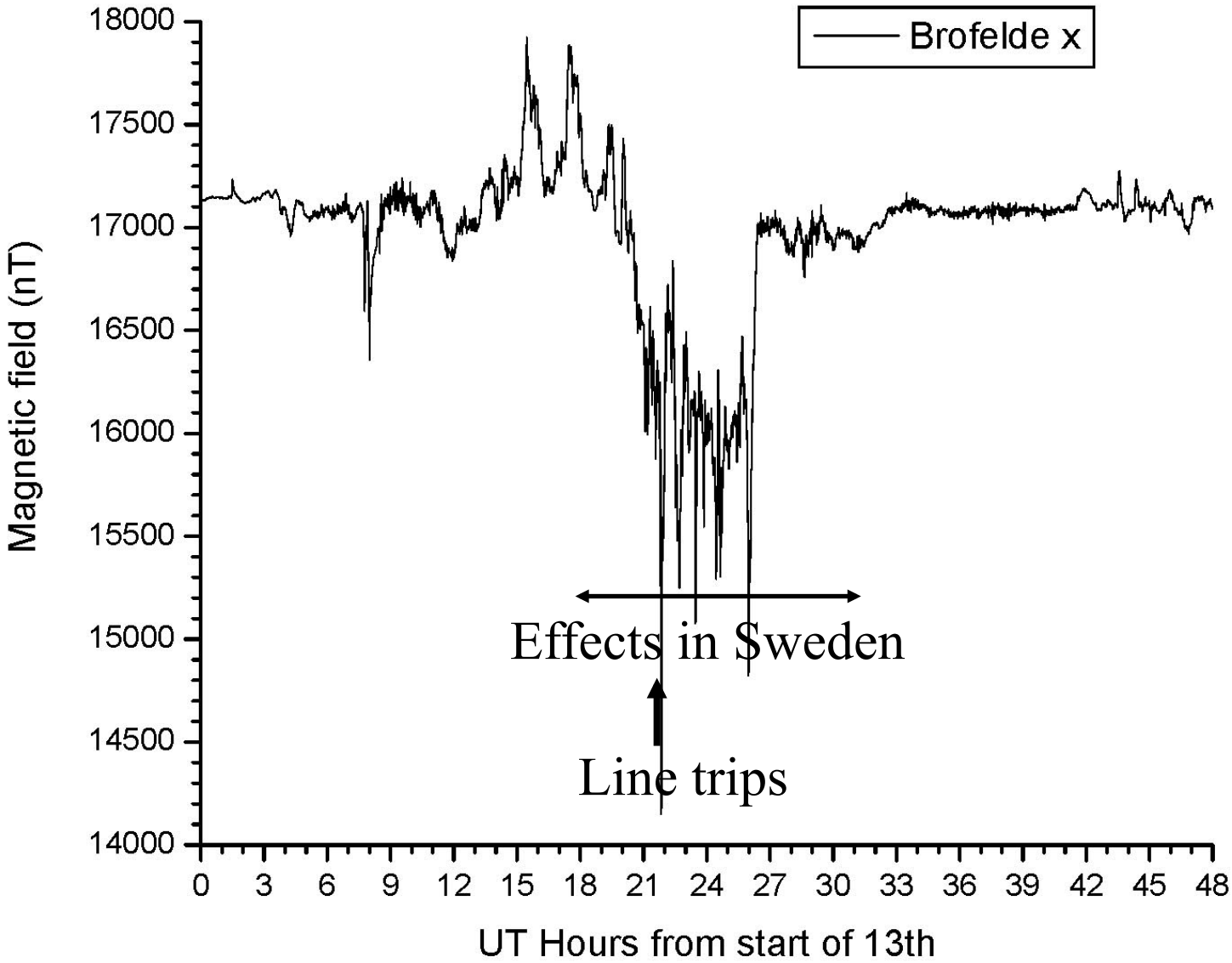

Eskdalemuir
X component (nT)
18500
18000
17500
17000
16500
16000
15500
15000
14500
Effects in UK
0 3 6 9 12 15 18 21 24 27 30 33 36 39 42 45 48
Hours since start of March 13

Power System Problems in Sweden

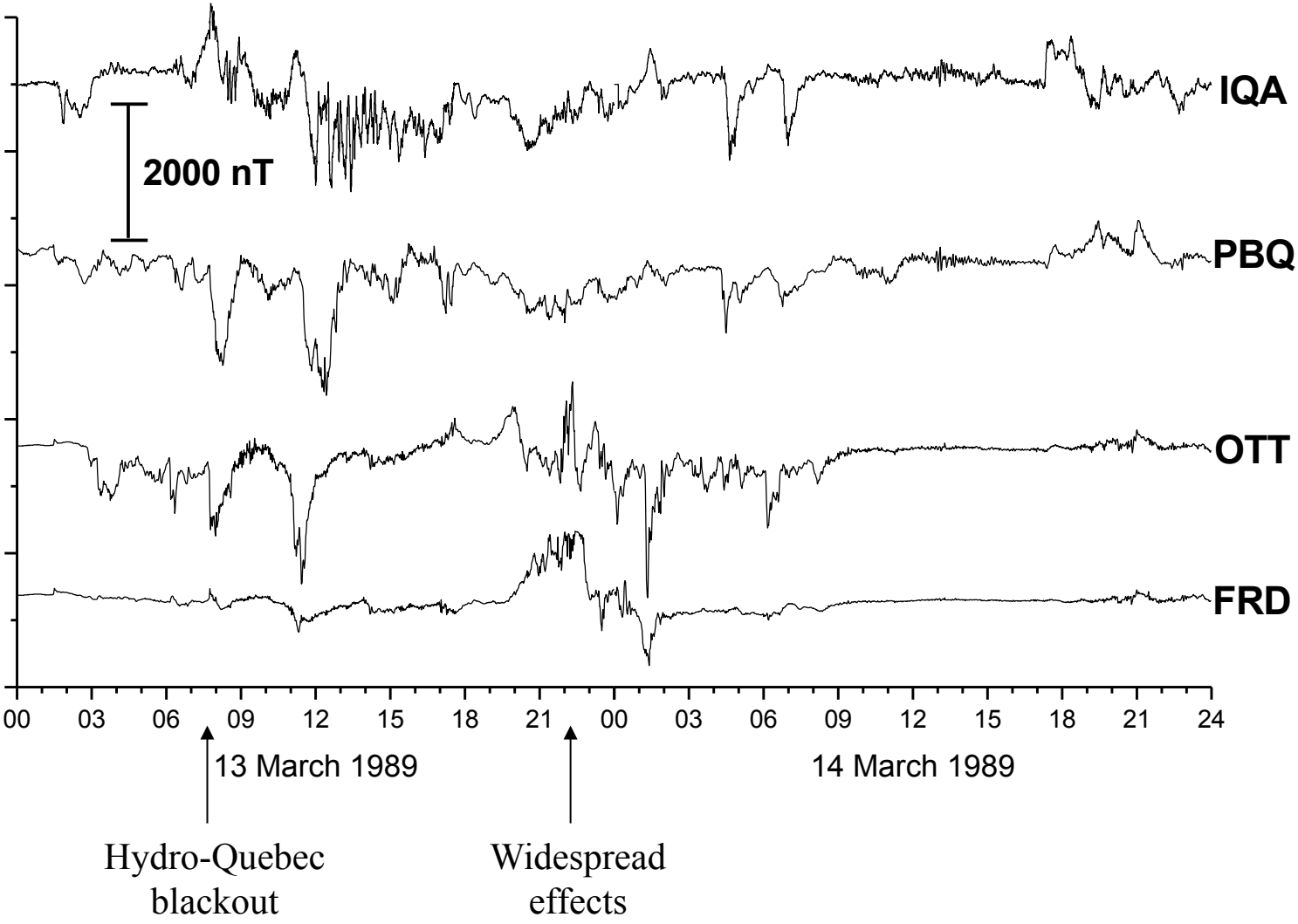
Problems experienced between 17.15 and 07.44 UT

21:41 UT 130 KV Nässjö-Marienlund line tripped

21.43.53	G3 Minus current signal (GIC indications)
21.43.57	G3 Minus current, signal (GIC indicatons)
21.44	increased reactive power, max 540 MVAr
21.47.31	T3 ground error protection start
22.31.03	G3 Minus current signal (GIC indications)
22.40	Oscillating reactive power, due to GIC


Brofelde x
Magnetic field (nT)
18000
17500
17000
16500
16000
15500
15000
14500
14000
0
3
6
9
12
15
18
21
24
27
30
33
36
39
42
45
48
UT Hours from start of 13th
Effects in $weden
Line trips

March 1989


IQA
2000 nT
PBQ
OTT
FRD
00
03
06
09
12
15
18
21
00
03
06
09
12
15
18
21
24
13 March 1989
14 March 1989
Hydro-Quebec blackout
Widespread effects

Summary

March 1989 disturbances was caused by
a double eruption on the Sun.

Effects occurred in the morning (local time)
- due to a westward electrojet

Effects occurred in the evening (local time)
- due to an eastward electrojet

Power system vulnerability dependent on
local time of magnetic disturbance