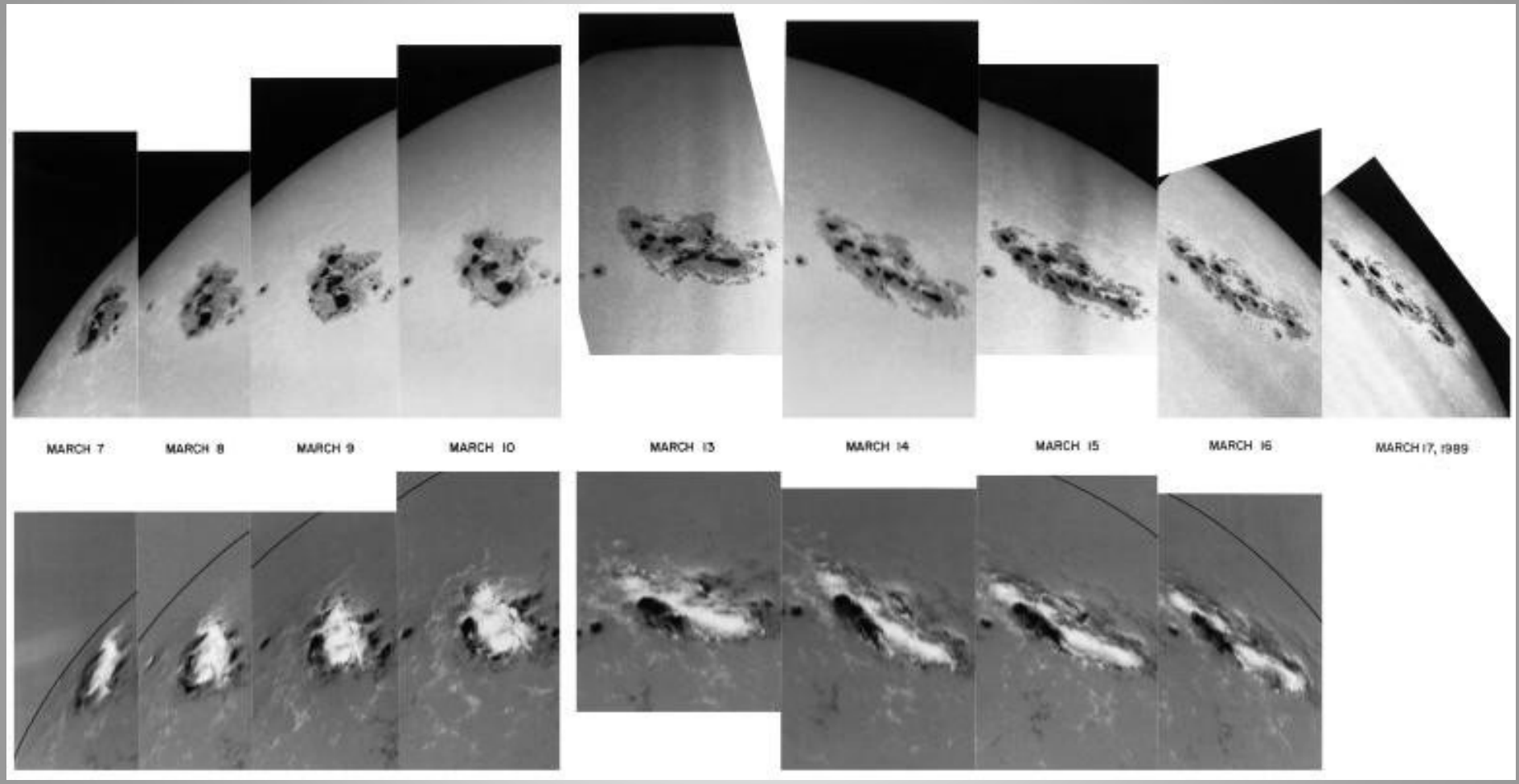
JOINT SPRING MEETING
AERONAUTICS AND SPACE ENGINEERING BOARD (169th Meeting)
and SPACE STUDIES BOARD (184th Meeting)
WEDNESDAY, JUNE 8, 2022

Example of Space Weather effects on Power Grids: the March 1989 storm

David Boteler
Natural Resources Canada
David.Boteler@Canada.ca

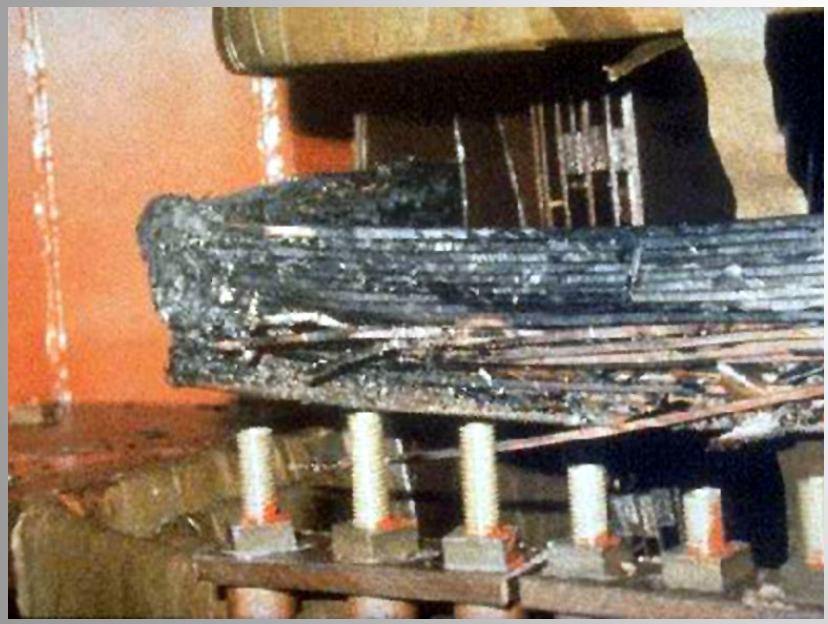
Solar Activity

Region 5395



Hydro-Quebec blackout

Salem transformer overheating



MONEY
From over 100 countries. Drafts in 18 currencies
Commission Free Travellers Cheques in 13 currencies
GUARDIAN TRUST
De Maisonneuve 849-0470
Saint-Jacques 842-7161
Sainte-Catherine 875-5600
Laval 682-6622

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

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.

Hydro will be kept on short leash: Bourassa

By SARAH SCOTT
Gazette Quebec Bureau

QUEBEC — The government will keep Hydro-Québec on a short leash, Premier Robert Bourassa said yesterday after calling in officials of the giant utility to account for the second province-wide blackout in a year.

Hydro will have to report monthly to the province on the progress of its $2-billion plan to halve the number of yearly blackouts by 1995, Bourassa said.

And the utility will have to speed up its plan to make the system more reliable, he said after meeting Hydro chairman Richard Drouin and president Claude Boivin.

Boivin observed, however, that technical problems could prevent any significant speeding up of the plan.

The plan calls for Hydro to spend $704 million over seven years to upgrade the distribution system and $1.3 billion by 1994 on transmission facilities for power from the northern hydroelectric dams.

In 1988, the average Quebecer sat in the dark for 9.1 hours due to power failures, including the province-wide blackout last April. Between 1981 and 1986, the average was 5.5 hours a year.

Parti Québécois energy critic Christian Claveau charged that Hydro is spending too much time and money on producing electricity for export to the United States and neglecting maintenance.

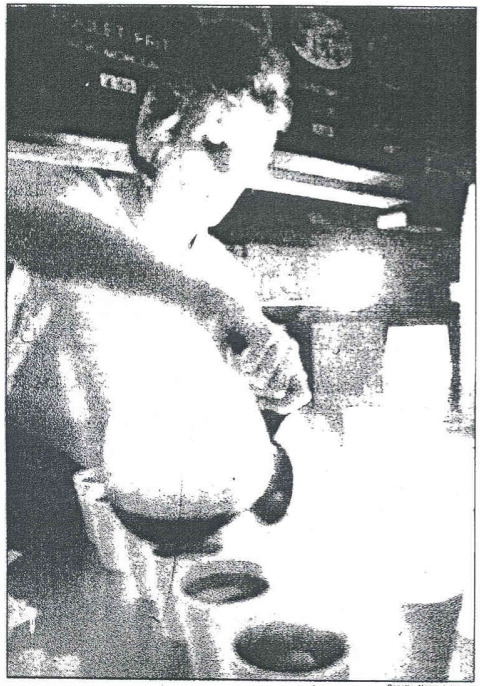
Bourassa wants Quebec to export 12,000 megawatts of power and said so frequently before and after he was elected. But so far only 2,250 megawatts of firm long-term power have been sold, excluding a deal with Maine which hasn't yet received regulatory approval by the state.

Claveau called for a "complete moratorium" on contracts to export Quebec hydroelectricity.

Bourassa agreed that Hydro's reduced maintenance spending is responsible for the increased number of blackouts in recent years, but he rejected Claveau's other criticisms.

"We know very well that none of the contracts that were signed — except surplus sales and contracts signed before we came to power — call for delivery before 1995 or 1996. So how can you link deliveries that won't happen until 1995 to a lack of electric power in 1989?"

Hydro blames sun for power failure



Gazette, Nancy Ackerman
Francine Perreault serves coffee by candlelight at L'Express Deli-Burger yesterday.

It says solar storm overloaded system

By PEGGY CURRAN
of The Gazette

Hydro-Québec is blaming yesterday's massive power failure on the stars.

Officials at the utility are citing a magnetic storm — touched off by an explosion on the sun and marked by a spectacular display of the northern lights — as the main culprit in the third province-wide blackout in less than a year.

Scientists at the National Research Council in Ottawa say they recorded the strongest pulse in the earth's magnetic field in a decade at 2:48 a.m. yesterday.

Giant generator

That's was about two minutes after the lights went out across the province.

Ken Tapping, a solar physicist at the NRC, said the magnetic charge acted like a giant solar generator, causing transmission lines to overload.

Disruptions in the magnetic field also played havoc with power lines in British Columbia and Ontario.

But Quebec was by far the hardest hit. That's because the province's vast hydroelectric system extends farther north and because all Hydro-Québec's transmission lines are connected.

Now Hydro officials say they may have to abandon the province's "unique" grid system if they can't find a way to safeguard it against province-wide blackouts.

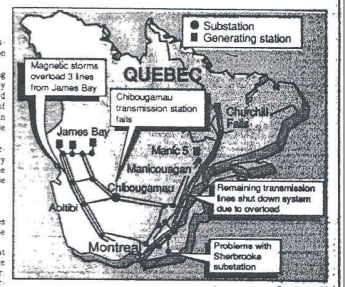
Schools closed

And they'll be comparing Quebec's performance with Ontario's to see whether we can learn from our neighbor's superior track record for blackouts and breakdowns.

Yesterday's blackout closed schools and business, kept the Metro shut down during the morning rush hour, and paralyzed Dorval airport, delaying flights.

It cost Quebec businesses tens of millions of dollars as it stalled production, idled workers and spoiled products.

It's been a rough winter for Hydro, which has come under fire from the public and the government for a rash of blackouts and systematic breakdowns.



Gazette graphic
Hydro-Québec ran into problems everywhere yesterday.

Hoping to regain public confidence, the utility has promised to spend $704 million on new equipment over the next few years.

Energy Minister John Ciaccia suggested labor problems at Hydro may have contributed to yesterday's blackout. But union officials said the power failure was the result of Hydro scrimping on maintenance while the provincial government skimmed off $300 million in profits last year alone.

Power surges from magnetic storms are nothing new, said Charles Cuerrier, president of local 1500 of the Canadian Union of Public Employees, which represents Hydro repair workers.

"They've been happening for years, but because we've let the maintenance slide over the past four years, (the network) can't take it now."

Ciaccia ordered a special meeting with top Hydro officials to get an explanation for the power failure.

"This is very upsetting, not only for the people but for the government," he said. "It's frustrating because despite all our efforts to upgrade the system, we still wake up at 5 a.m. with a total blackout."

By 10 a.m., power had been restored to about 50 per cent of Hydro customers in the Montreal region. By evening, power had been restored to all but about 35,000 of the utility's 842,000 customers on the island.

But Hydro official Michel Turenne warned clients to expect isolated power failures over the next 24 hours while Hydro slowly rebuilds its power system.

And residential customers are right at the bottom of the list when Hydro begins restoring service — well behind hospitals, Métros, police and fire departments, television and radio stations and even industrial and commercial users.

So far no one at Hydro-Québec can explain precisely what happened when power went off at 2:46 a.m. But vice-president Jean Houde identified some factors that played a part in the blackout:

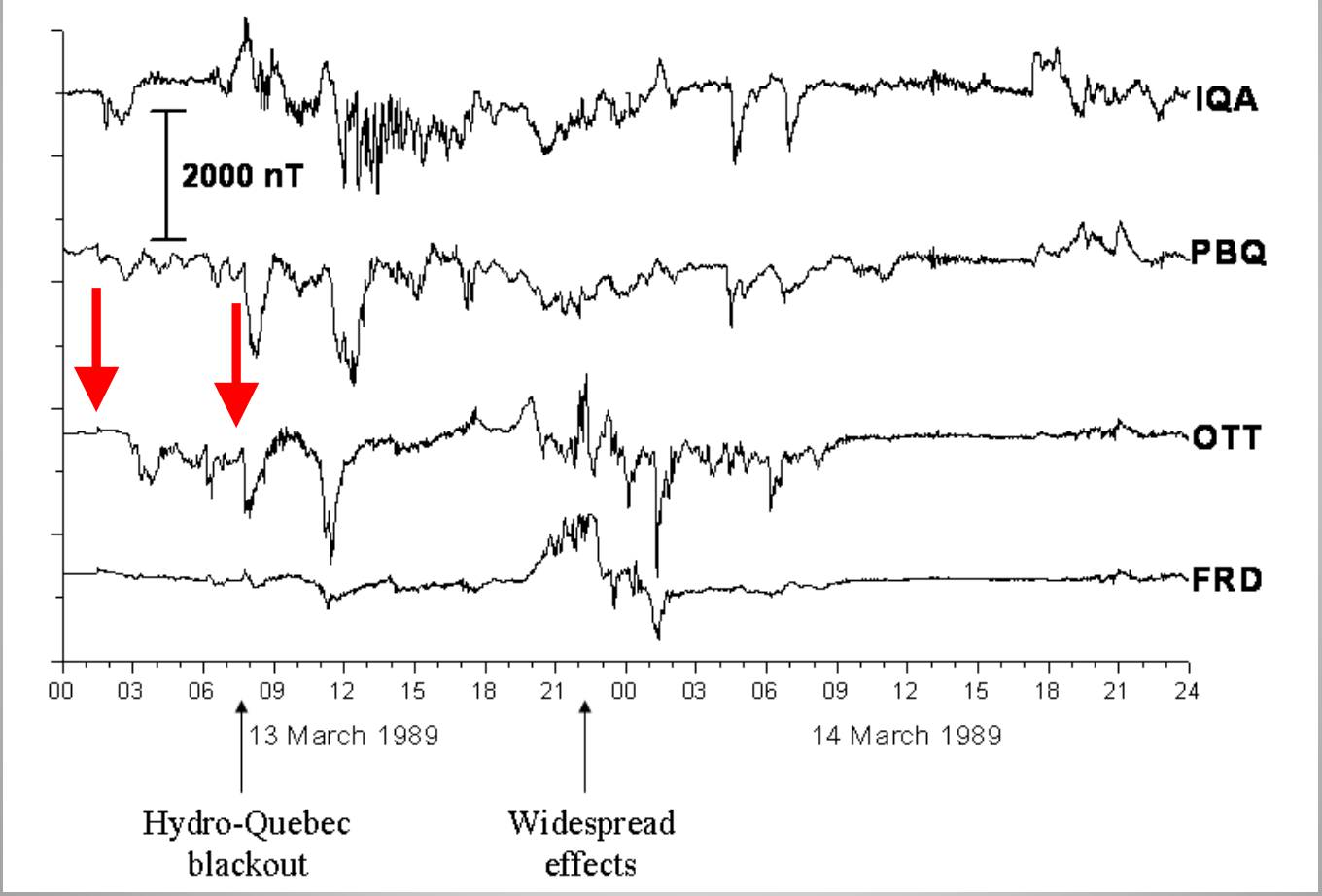
A magnetic storm caused an overload on three transmission

(See HYDRO, Page A-2)

• *Recovery delayed. Page A-3*
• *Counting the cost. Page C-1*

March 10, X4.5 flare accompanied by Coronal Mass Ejection (CME)

CME shock arrival (SSC) at 01.27 UT, March 13 -- slow transit of CME



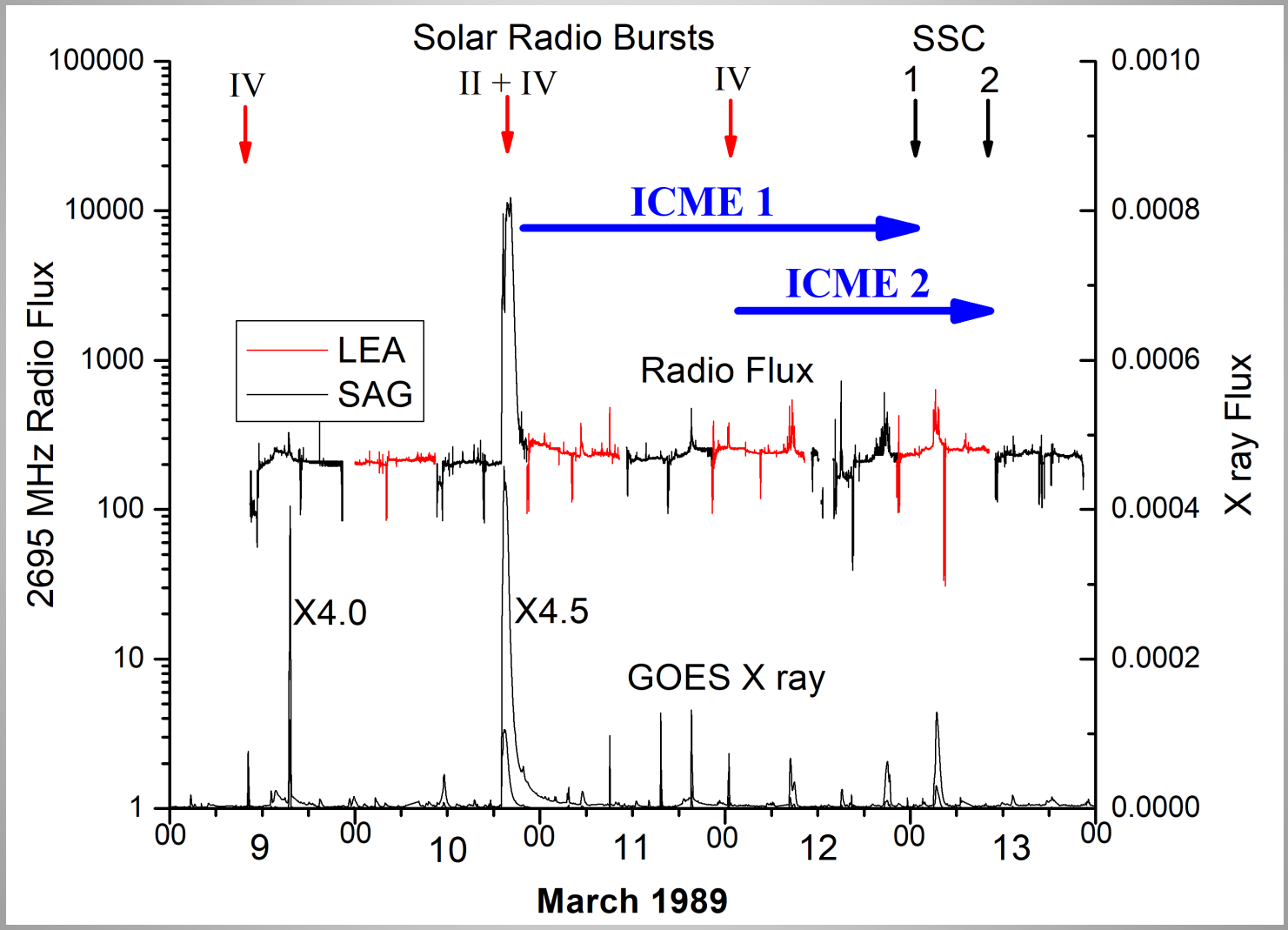
Second SSC identified

Therefore there must have been a second CME

Solar Flares > M5.0

Date	Start Time (UT)	X-ray Classification
March 6	13.54	X15.0
March 7	14.47	X1.8
March 8	08.26	M5.7
March 9	10.03	M7.6
March 9	15.15	X4.0
March 10	**18.48**	**X4.5**
March 11	08.29	M9.7
March 11	15.35	X1.2
March 11	19.33	X1.3
March 12	**00.16**	**M7.3**
March 12	08.16	M6.7
March 12	20.28	M6.3
March 13	02.59	X1.2
March 14	16.46	X1.1
March 15	16.43	M8.4
March 16	15.24	X3.6
March 16	18.26	M6.5
March 16	20.35	X1.4
March 17	07.15	M6.8
March 17	17.29	X6.5

Interplanetary Coronal Mass Ejections (ICME)

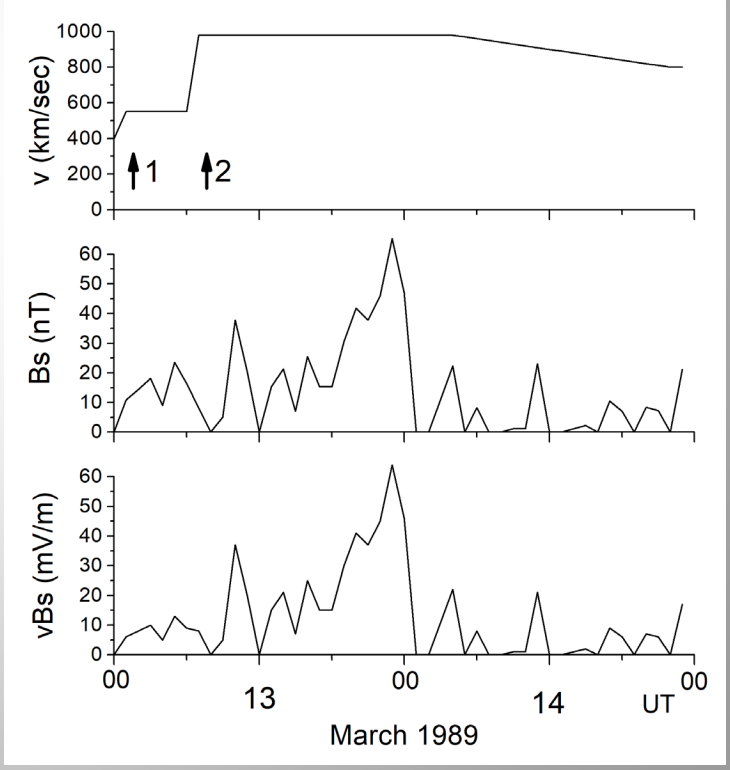


Solar Wind Speed and Interplanetary Magnetic Field (IMF)

ICME	Flare Size	Flare Date & time (UT)	SSC Date & Time (UT)	Travel time (hr min)	Shock Speed (km/sec)	Max solar wind speed (km/sec)
1	X4.5	10 Mar 18.58	13 Mar 01.27	54 hr 30 min	760	550
2	M7.3	12 Mar 00.16	13 Mar 07.43	31 hr 27 min	1320	983

Solar wind speed = 983 km/sec

Southward IMF = 40 to 60 nT

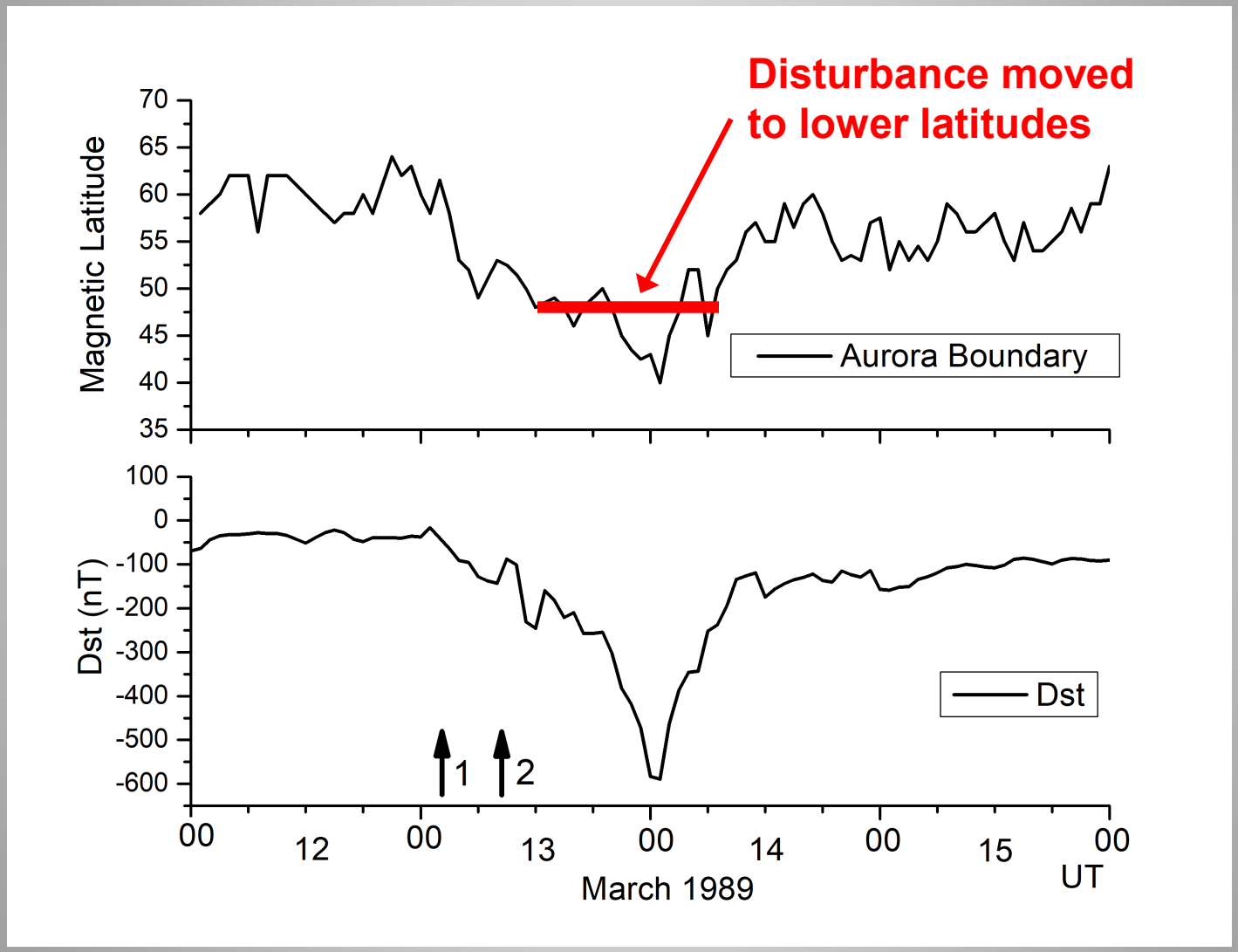


Initial Phase

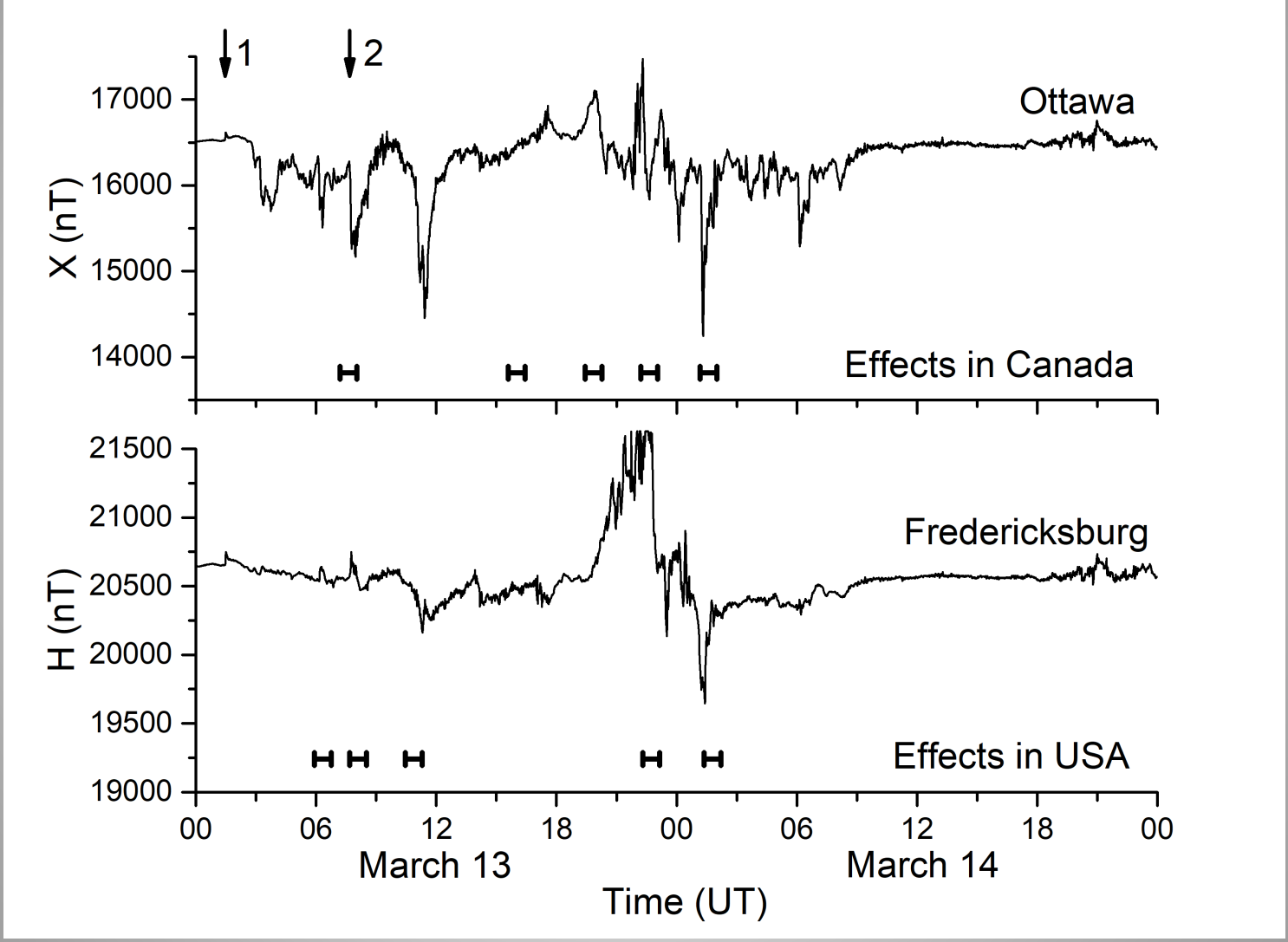
Auroral zone expanded to sit across Quebec

Auroral electrojet surge produced the magnetic substorm that caused the Hydro-Quebec blackout

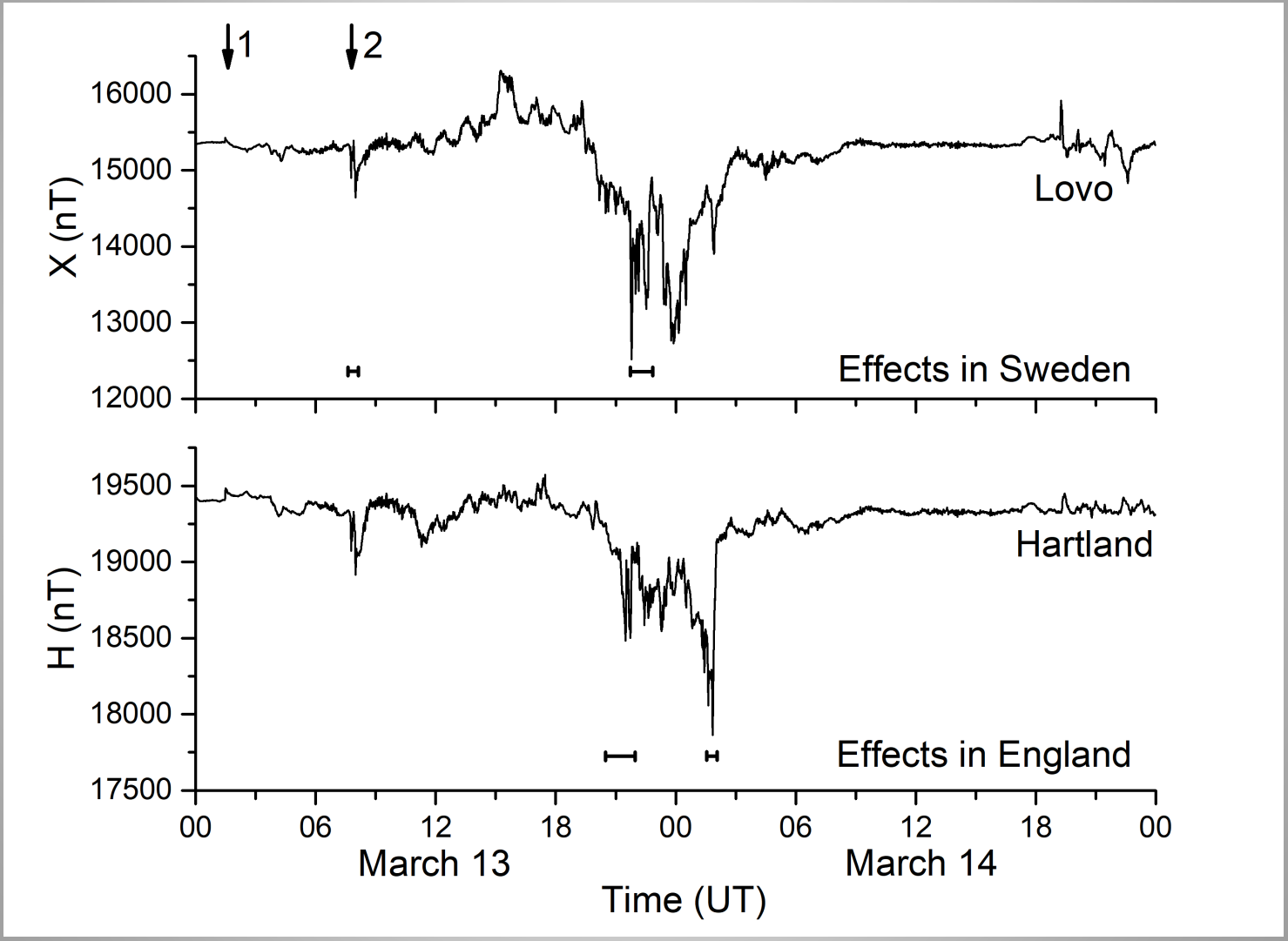
Later Phase: Further expansion of the auroral zone



Effects in North America



Effects in Europe



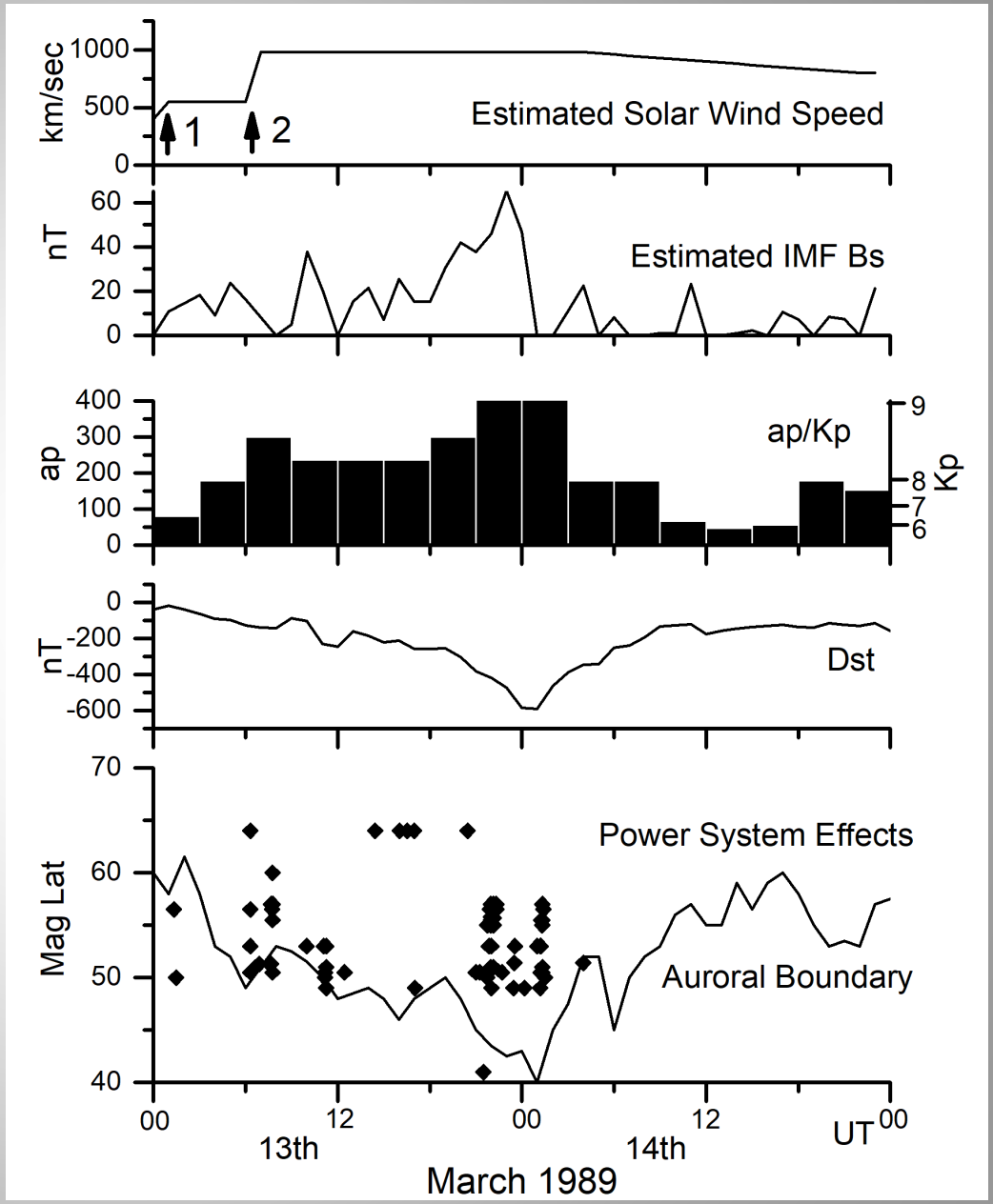
Summary

March 1989 event had 2 CMEs

Second CME triggered substorm that caused Hydro-Quebec blackout

Main effects in US (including Salem transformer damage) and Europe occurred later in the storm

Associated with expansion of the auroral zone



References

Allen, J., L. Frank, H. Saur, and P. Reiff, Effects of the March 1989 solar activity, Eos Trans. AGU, 70(46), 1479, 1486-1488, 1989.

Boteler, D. H. A 21st century view of the March 1989 magnetic storm, Space Weather, 17, 1427–1441, 2019. https://doi.org/10.1029/2019SW002278

Cliffswallow, W., ed., Region 5395 of March 1989, NOAA Technical Memorandum ERL SEL-82, pp40, Space Environment Laboratory, Boulder, Nov 1993

Cucchi, G. and Ponder, J., "Summary of March 13, 1989 geomagnetic Storm effects", presented at the *Dallas T&D Conference*, Sept 26, 1991.

Czech, P., Chano, S., Hunh, H., Dutil, A., The Hydro-Québec system blackout of 13 March 1989: system response to geomagnetic disturbances, Proc. Geomagnetically Induced Currents Conference, Electric Power Research Institute Report EPRI TR-100450, 1992.

Guillon, S., Toner, P., Gibson, L., Boteler, D., A Colorful Blackout, IEEE Power and Energy Magazine 14(6), 59-71, November/December 2016.