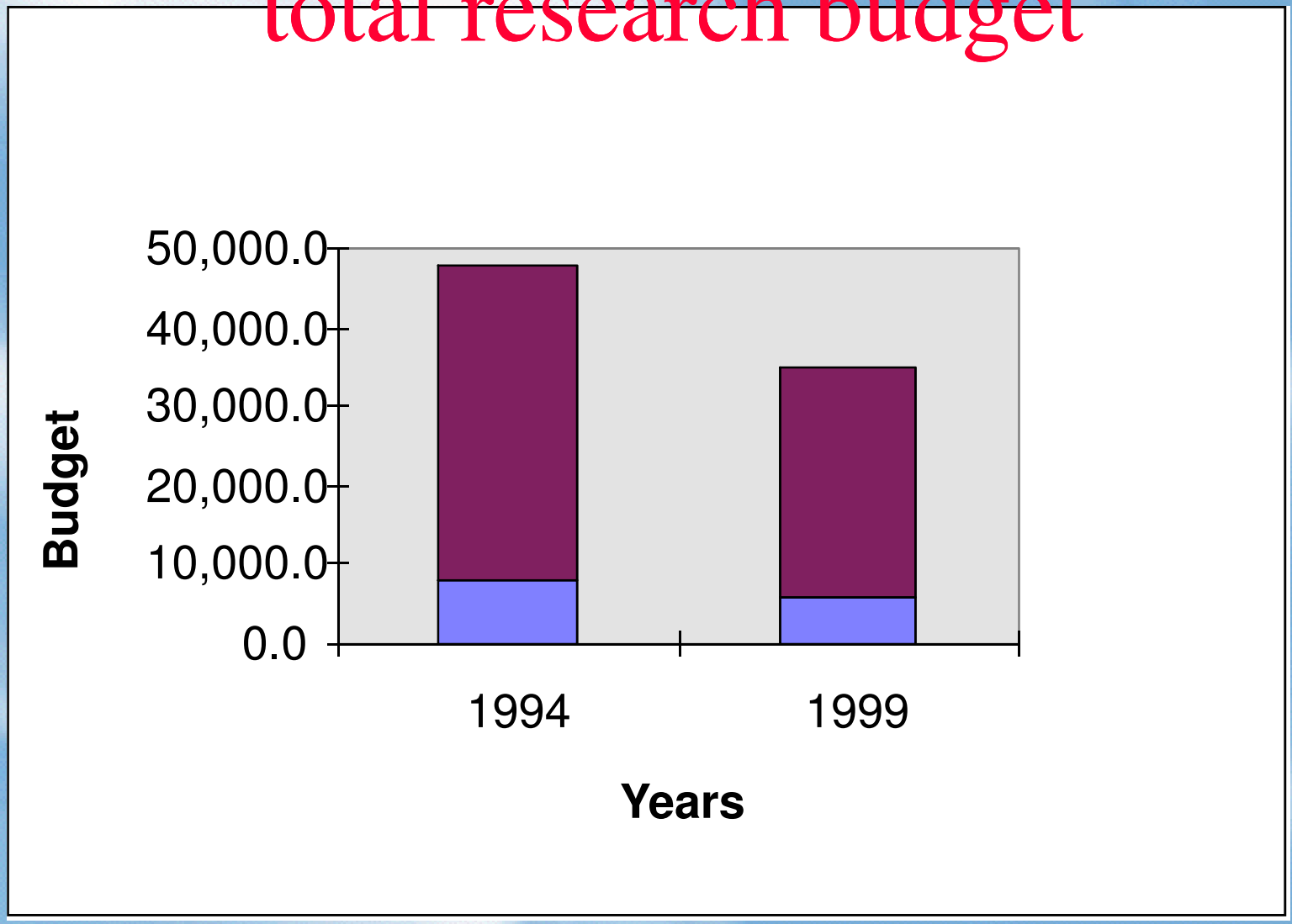
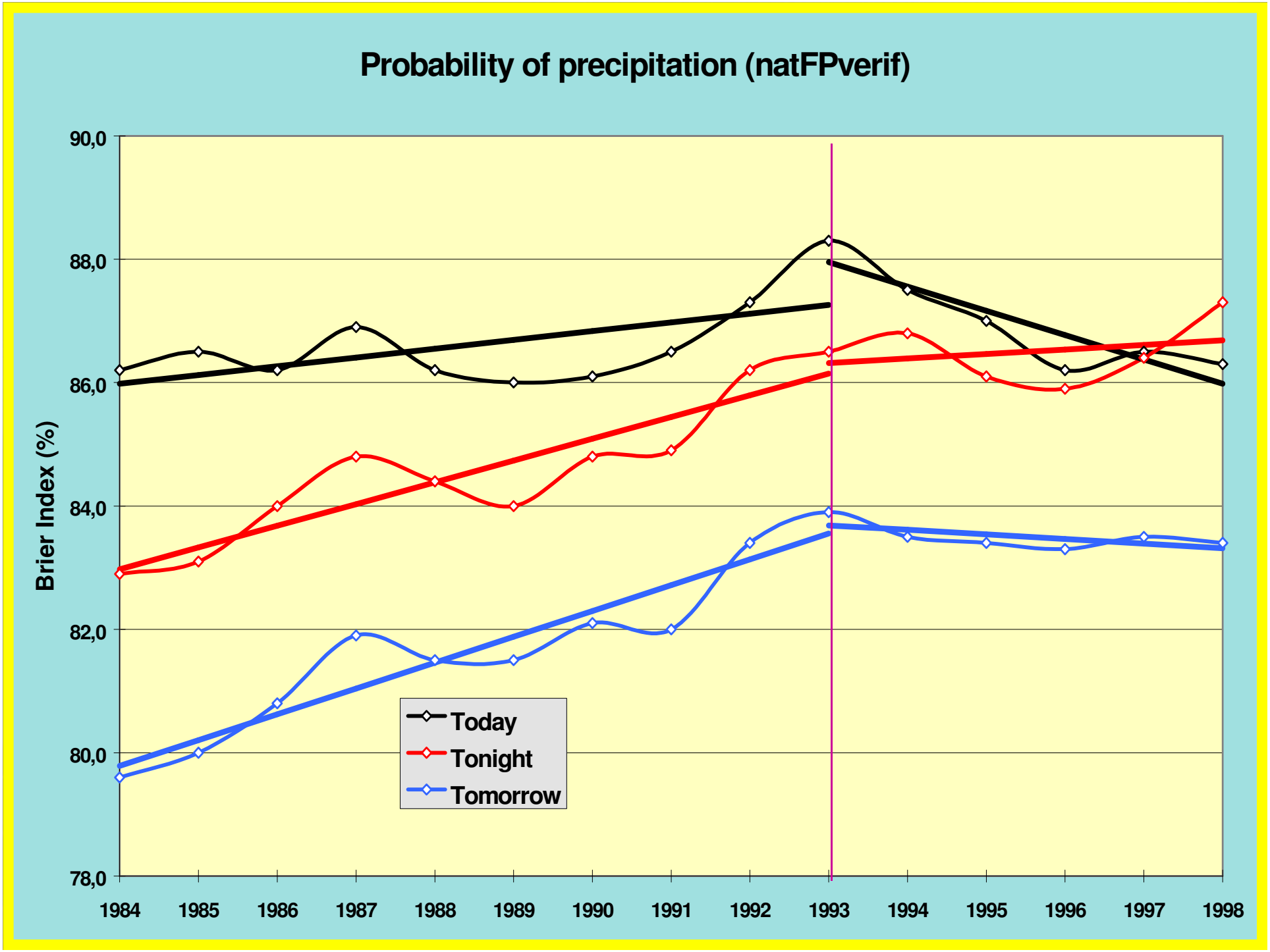
Canadian Weather Research Program

Jim Abraham
Environment Canada

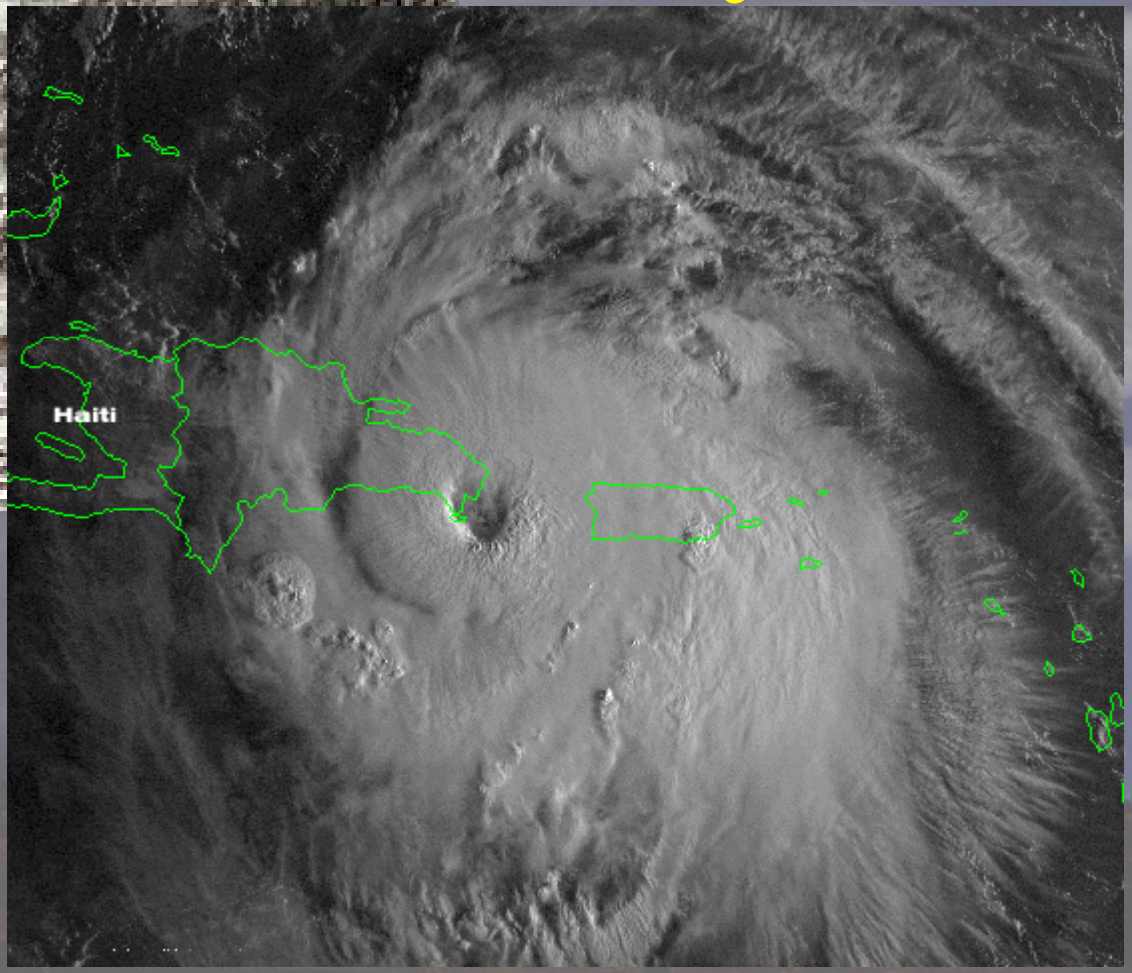
- √ **EC Leadership**
- √ **Focus/Priorities**
- √ **Partnerships**
- √ **Improved detection, better prediction, & reduced impacts due to severe weather**

Meteorology Research… 20% total research budget

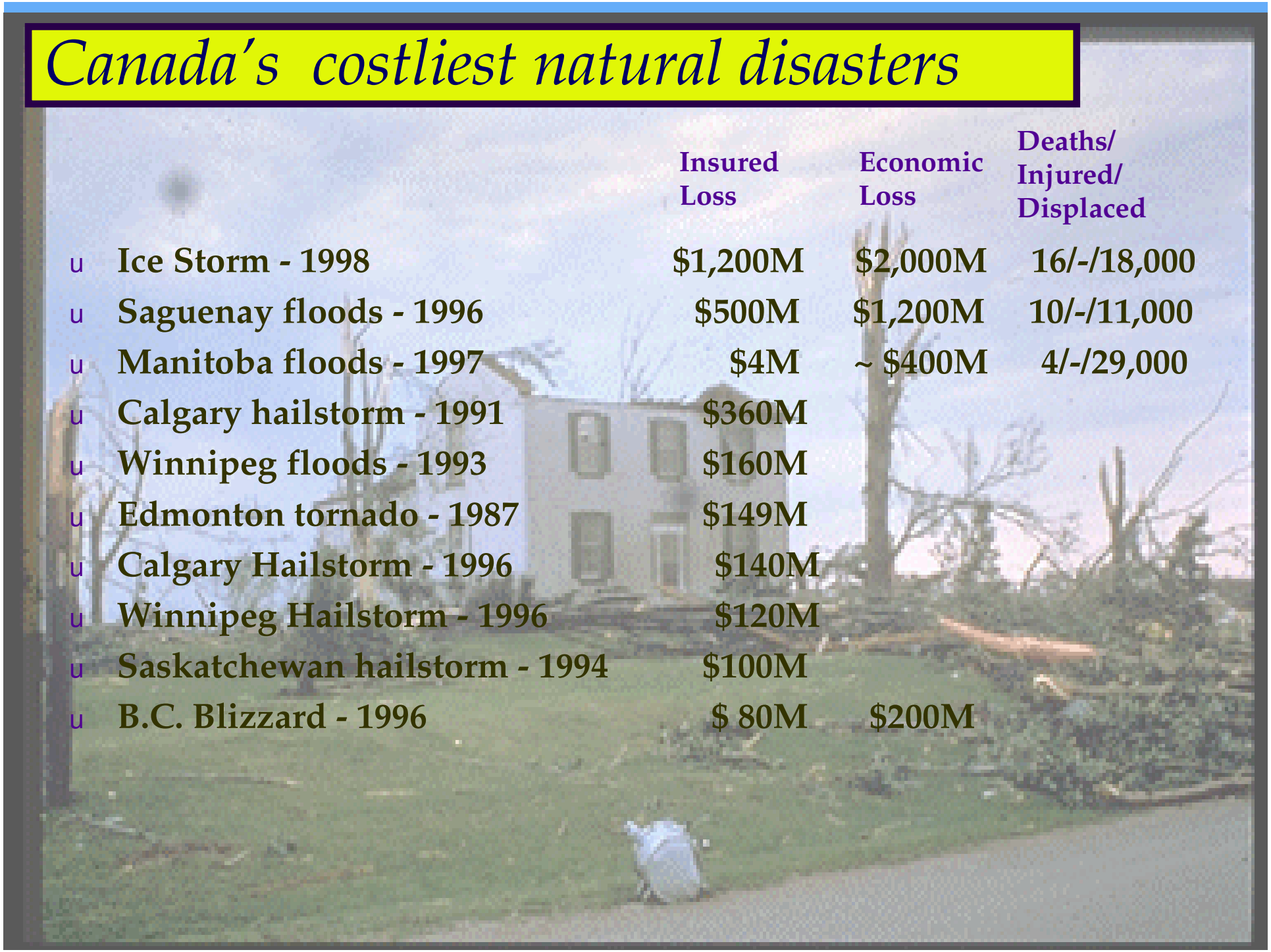



Probability of precipitation (natFPverif)
Brier Index (%)
90,0
88,0
86,0
84,0
82,0
80,0
78,0
1984
1985
1986
1987
1988
1989
1990
1991
1992
1993
1994
1995
1996
1997
1998
Today
Tonight
Tomorrow

Impacts: a reflection of a change in vulnerability



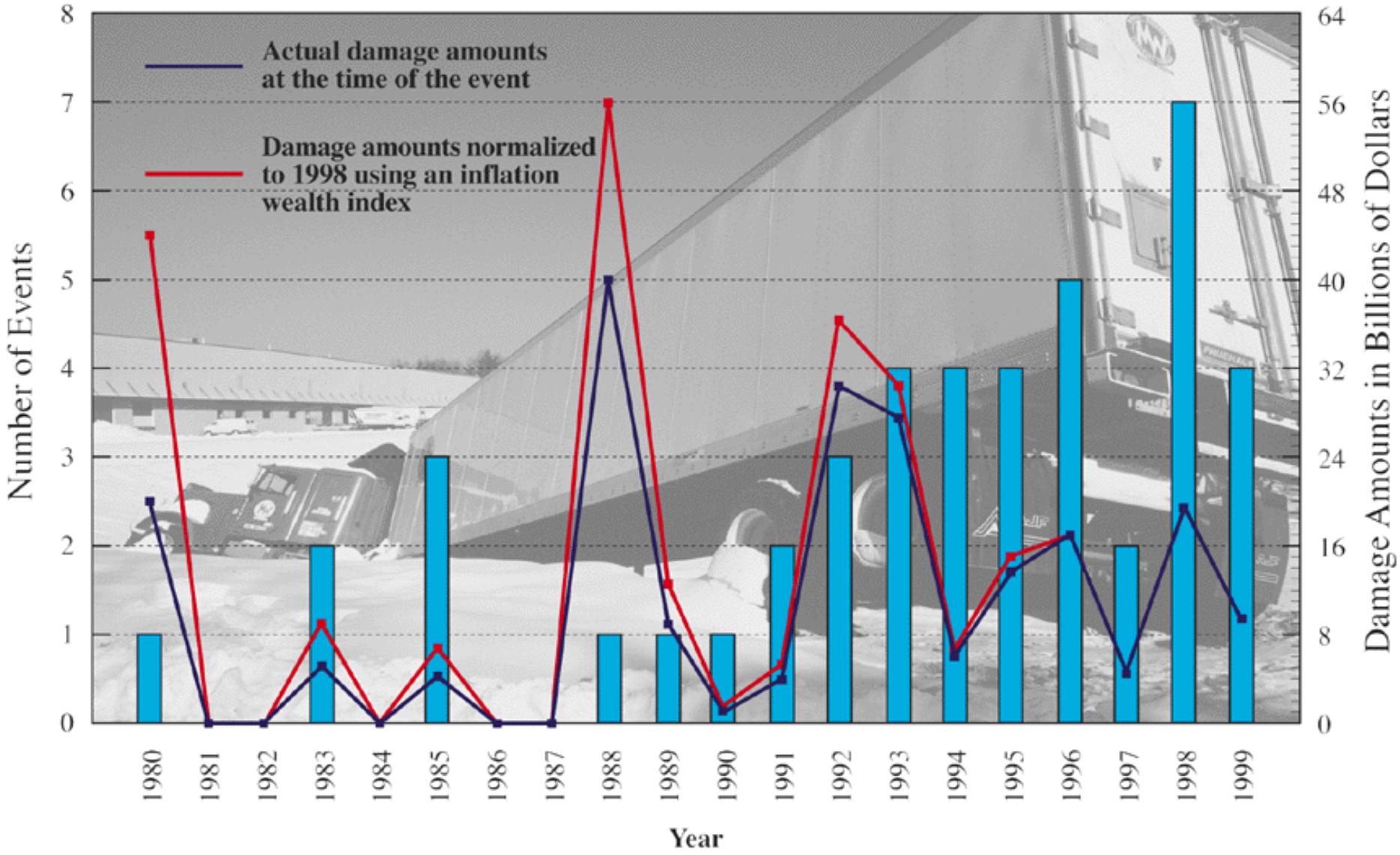
Canada's costliest natural disasters



	Insured Loss	Economic Loss	Deaths/ Injured/ Displaced
Ice Storm - 1998	$1,200M	$2,000M	16/-/18,000
Saguenay floods - 1996	$500M	$1,200M	10/-/11,000
Manitoba floods - 1997	$4M	~ $400M	4/-/29,000
Calgary hailstorm - 1991	$360M		
Winnipeg floods - 1993	$160M		
Edmonton tornado - 1987	$149M		
Calgary Hailstorm - 1996	$140M		
Winnipeg Hailstorm - 1996	$120M		
Saskatchewan hailstorm - 1994	$100M		
B.C. Blizzard - 1996	$ 80M	$200M	

Billion Dollar U.S. Weather Disasters 1980-1999

NOAA / NESDIS / NCDC

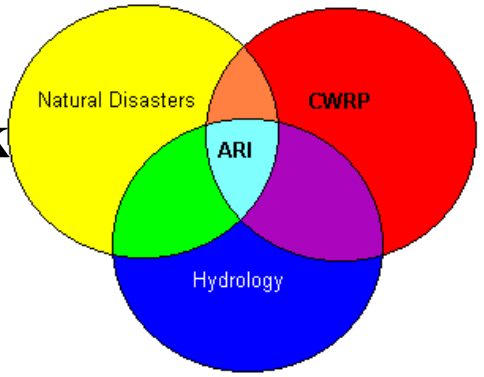


Priorities

- **Better detection and prediction of precipitation amount and type**
  - **best use of our infrastructure: radar, lightning, supercomputer**
  - **hydrological coupled modeling**
  - **mesoscale prediction (community model)**
- **Monitoring and Data Assimilation**
  - **new and existing datasets (radar) into NWP**
  - **simulation experiments and field experiments to assess new technology**
- **Socio-economic impacts**
  - **determine best value and best approach to reduce impacts**

Partnerships

- **Within EC, OGD's, universities, private sector**
  - **regions with headquarters**
  - **academic chairs (NSERC/CFI)**
  - **CMEP, EPC/DND**
  - **Industry: Insurance (ICLR), Canadian Tire, WeatherNetwork Hydro (BC, Quebec….)**
  - **Natural Disaster Institute UWO**
- **Natural Disaster Research Network**
  - **Marine (Dal)**
  - **Radar/Severe Weather (McGill)**
  - **Hydrology (Ottawa? Waterloo? INRS-eau, Manitoba?)**
  - **Engineering (UWO)**
  - **Earth Science (UBC)**

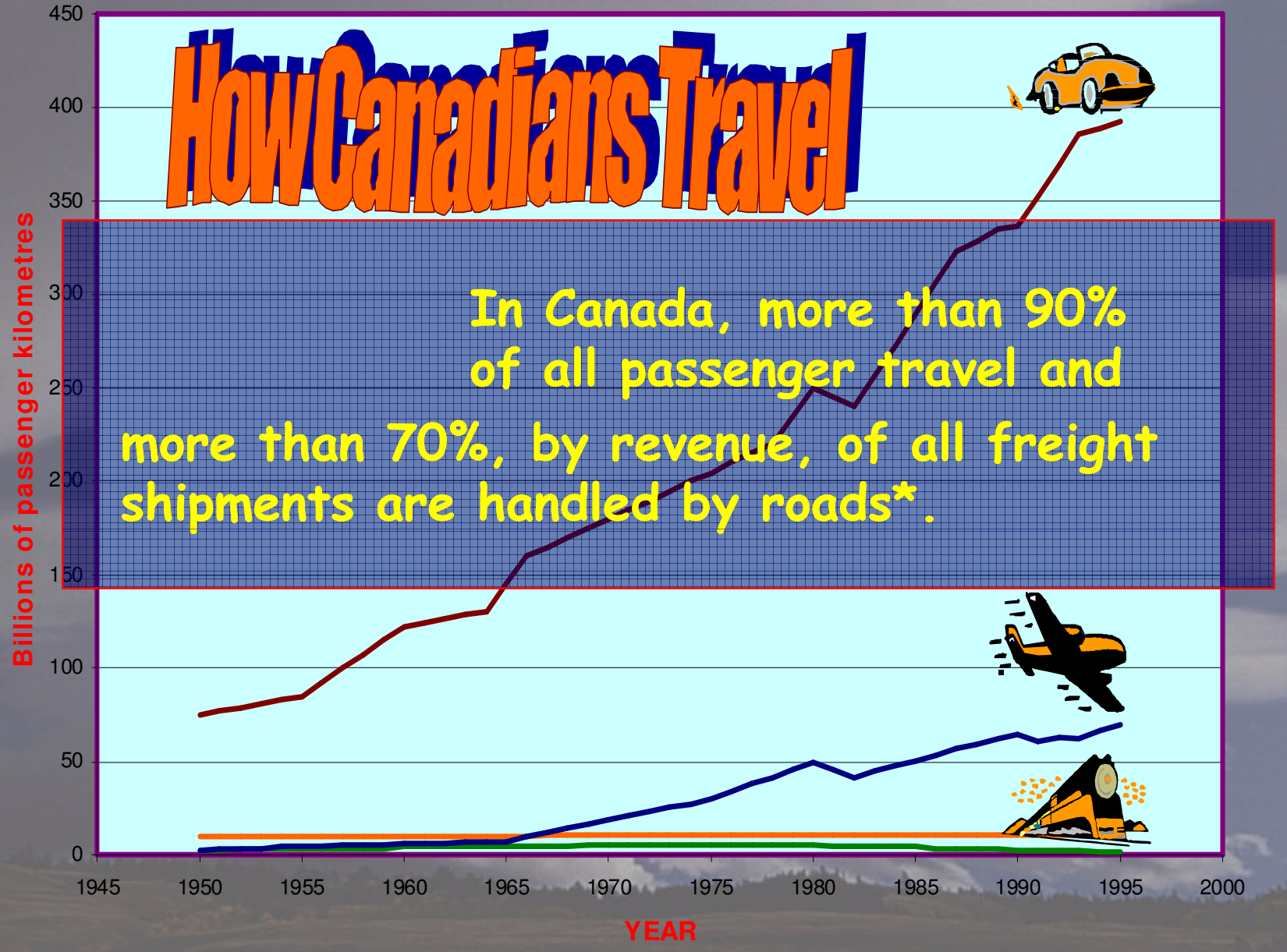


Activities

- **TRANSPORTATION**
  - **aircraft and road icing**
- **WEATHER RADAR**
  - **doppler and polarization**
- **NUMERICAL WEATHER PREDICTION**
  - **mesoscale and coupled models**
- **MARINE DISASTERS**
  - **hurricanes (extratropical transition)**
  - **storm surges**

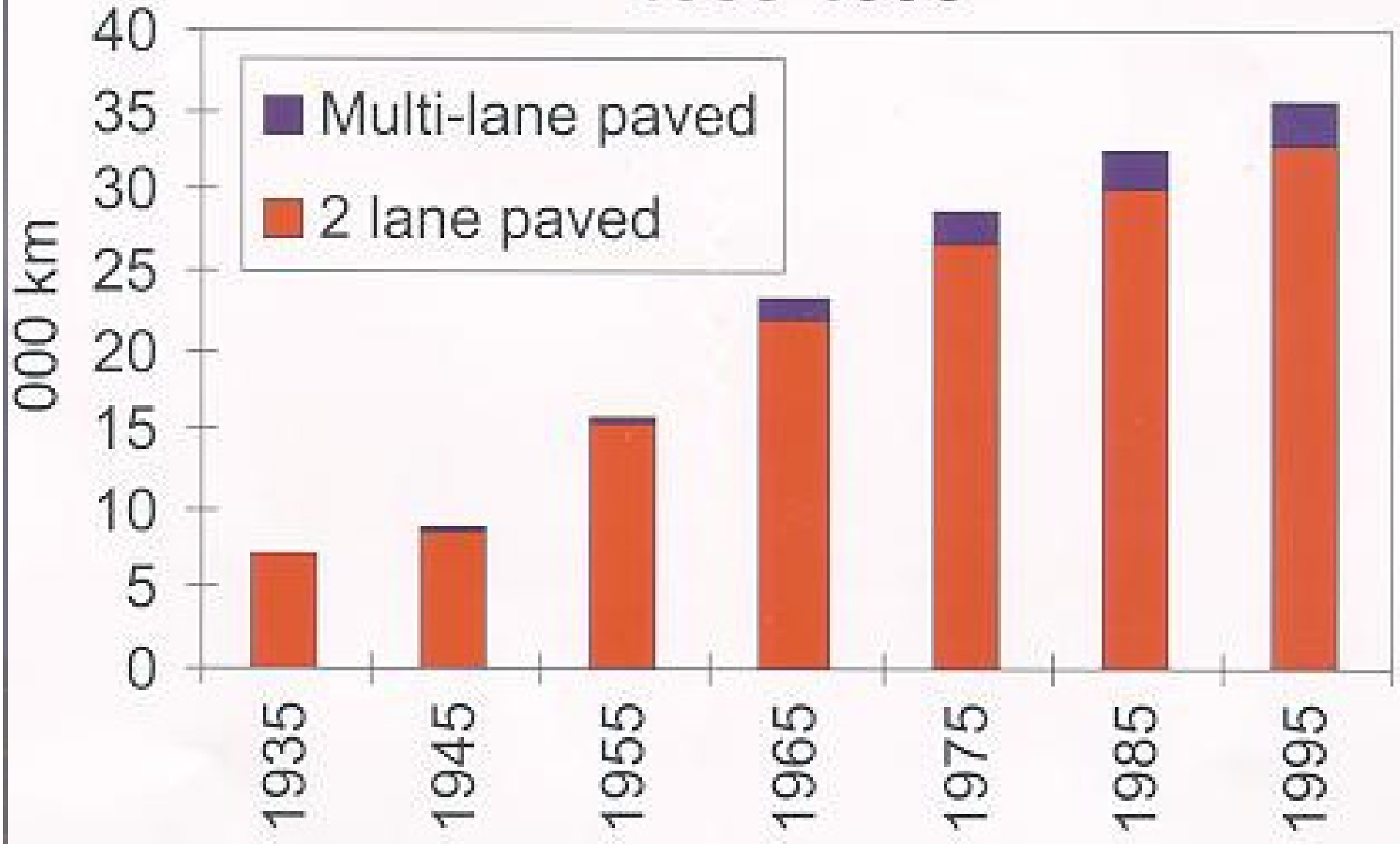
TRANSPORTATION

How Canadians Travel

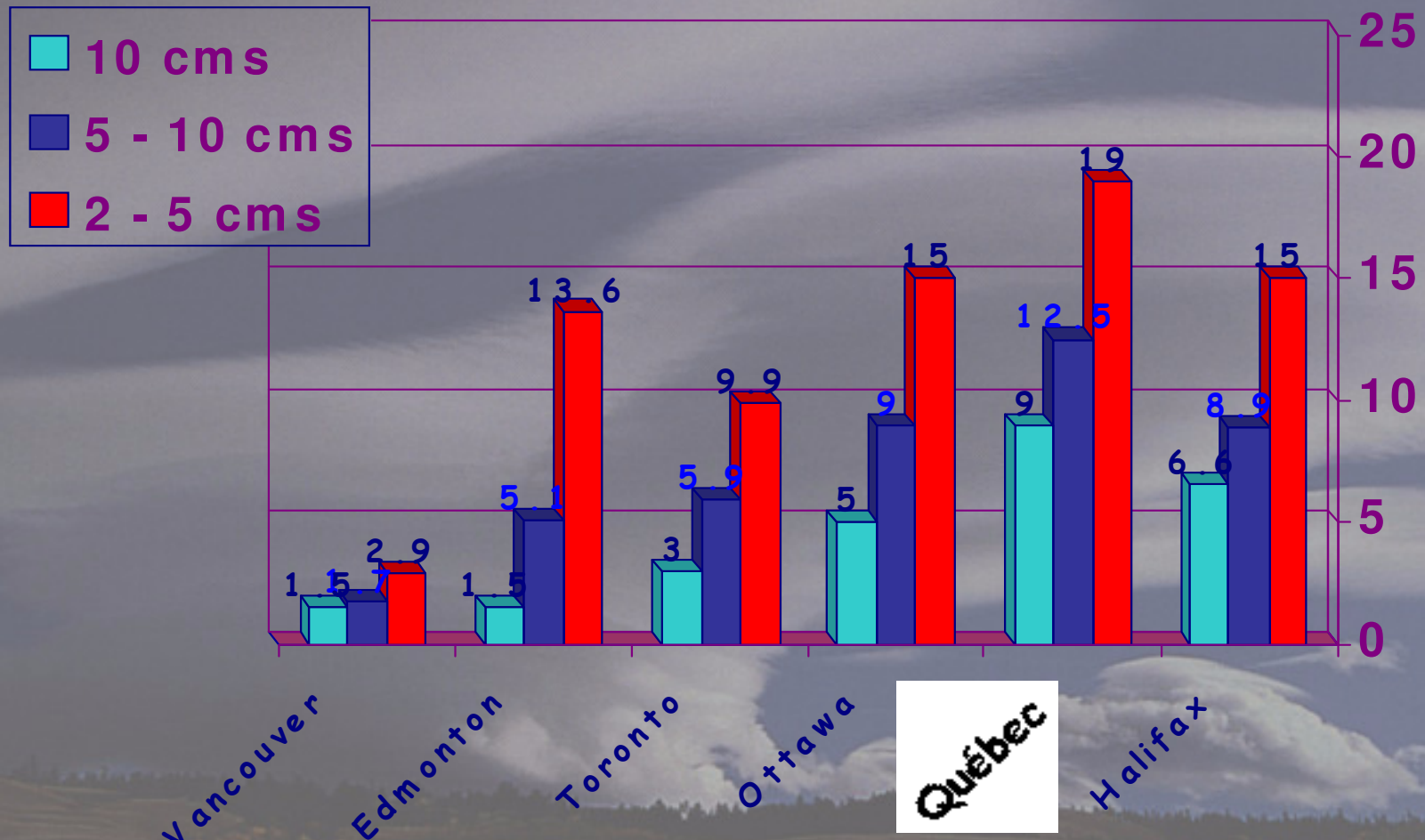


In Canada, more than 90% of all passenger travel and more than 70%, by revenue, of all freight shipments are handled by roads*.

Major Roads of Southern Ontario 1935-1995



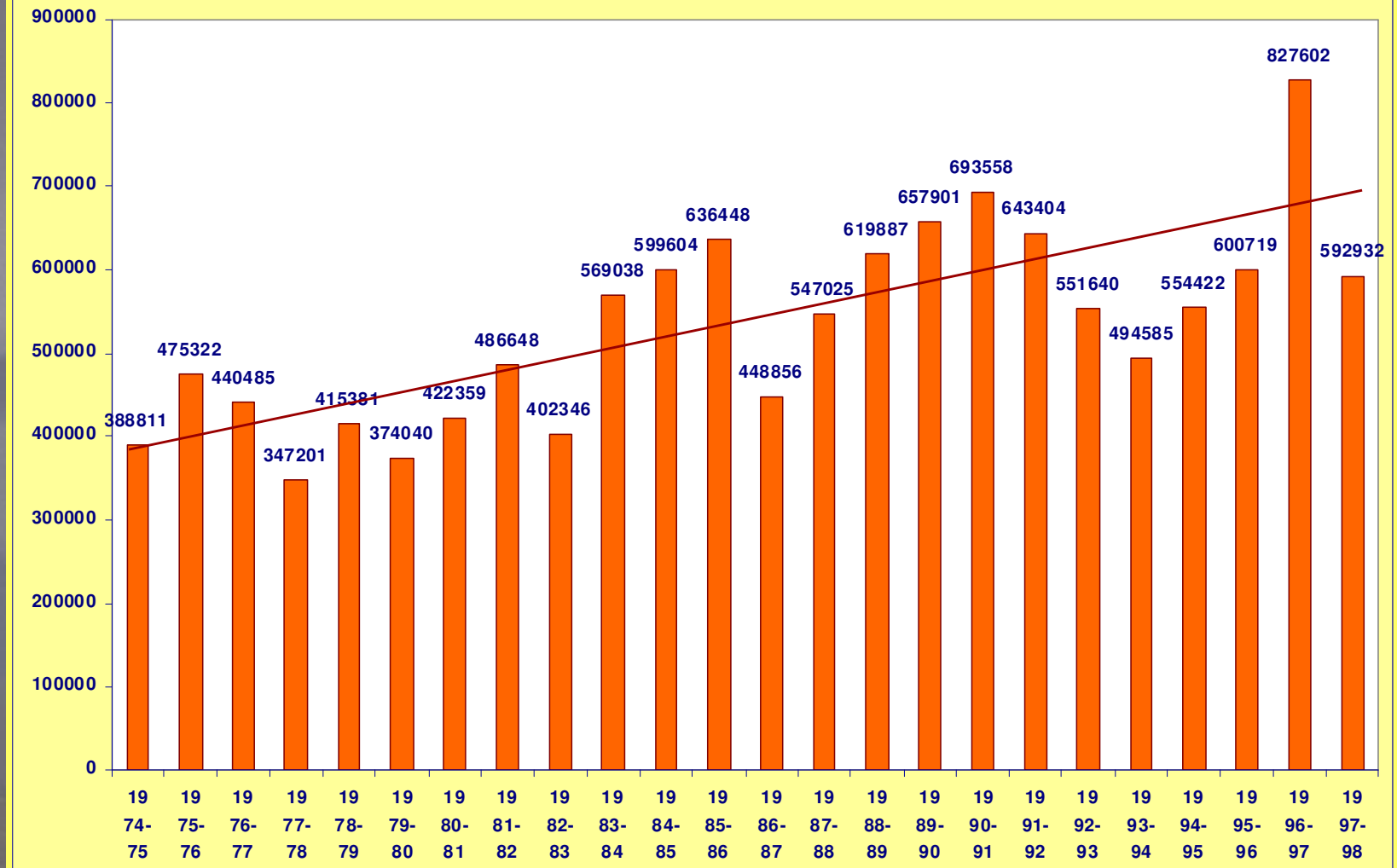
Mean Number of Days/Year with Snow Occurances*



* 1966-1996 Environment Canada

Environnement Canada Service de l'Environnement Atmosphérique
Environment Canada Atmospheric Environment Service

Tonnes of Salt Used by MTO



Accidents by mode and severity*

CATEGORY	FACTOR	MEAN	YEAR 1997	1996	1995	1994	1993	1992	1991	1990
										
Accidents	all	479		390	453	437	488	501	522	559
Serious Inj	all	65		46	67	41	71	83	69	79
Deaths	all	146		88	122	100	108	107	393	102
										
Accidents	all	1,089		1281	1248	1206	1022	971	991	904
All Injuries	all	244		128	128	117	129	375	454	375
Deaths	all	119		119	120	112	116	137	124	103
										
Accidents	all	487		363	421	478	441	497	577	629
All Injuries	all	57		38	52	48	61	102	27	70
Deaths	all	16		8	22	8	9	20	21	21
										
Accidents	all									
Accs w Inj	all	165,453	150,041	156,268	164,099	166,635	167,966	169,520	170,662	178,432
Fatal Accs	all	2,988	2,648	2,705	2,851	2,867	3,112	3,058	3,223	3,442
Accs w Inj	snow+ice	12,085	13,001	12,654	13,396	10,972	11,509	11,438	11,206	12,505
Fatal Accs	snow+ice	226	245	235	221	211	279	233	190	197

Road Weather Information System (RWIS)

Atmospheric data

(In accordance with UN-WMO)

- Wind speed and direction
- Precipitation (Yes/No)
- Temperature & Relative Humidity
- Telemetry devices

- Visibility, amount of precipitation
- Camcorders, traffic counters

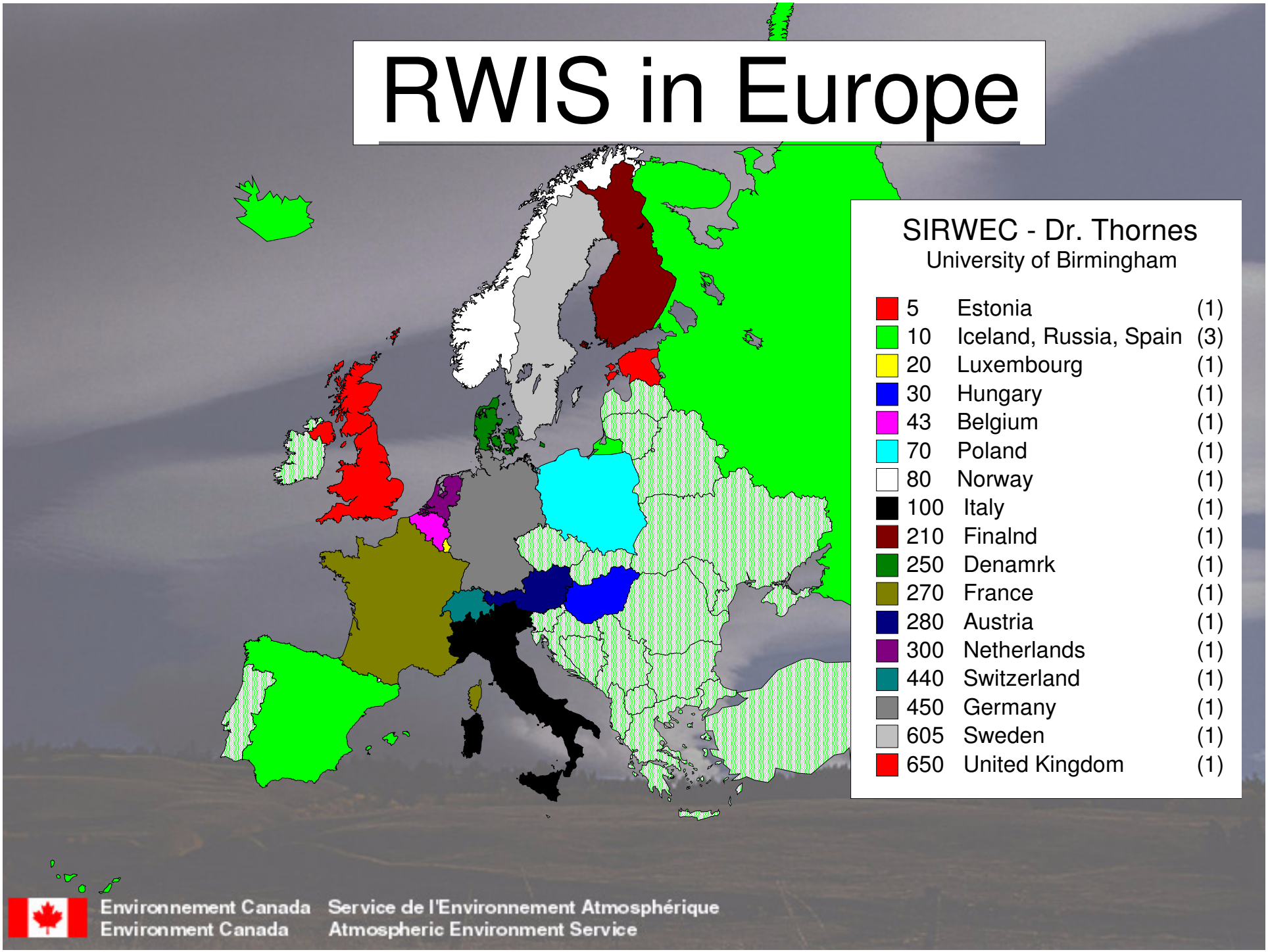
Road sensor

- Road surface temperature
- Presence of moisture
- Residual chemical factor
- Calculated freezing point T

Subsurface sensors (temp)

- 40 centimetres
- 1,5 metres

RWIS in Europe



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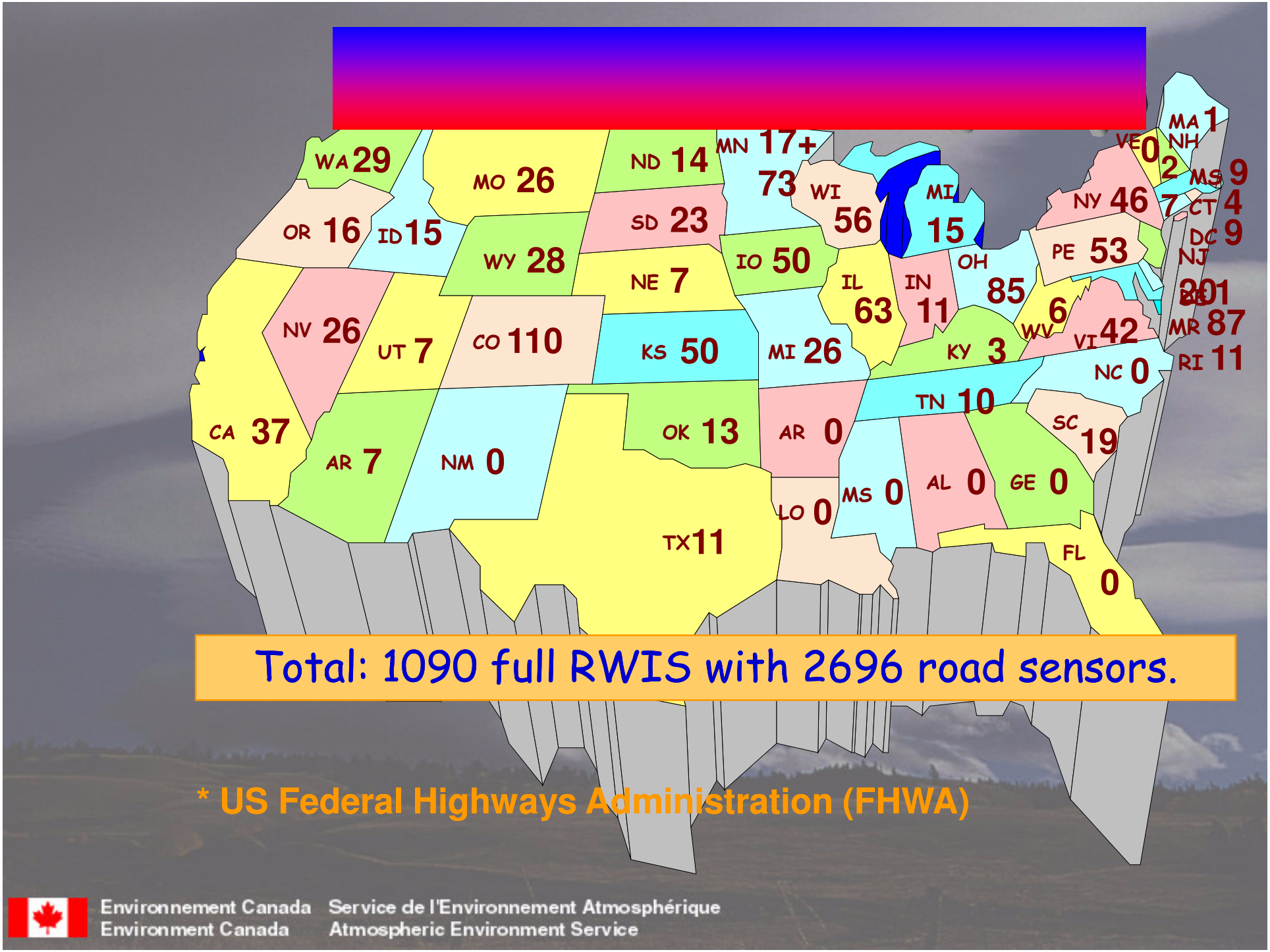
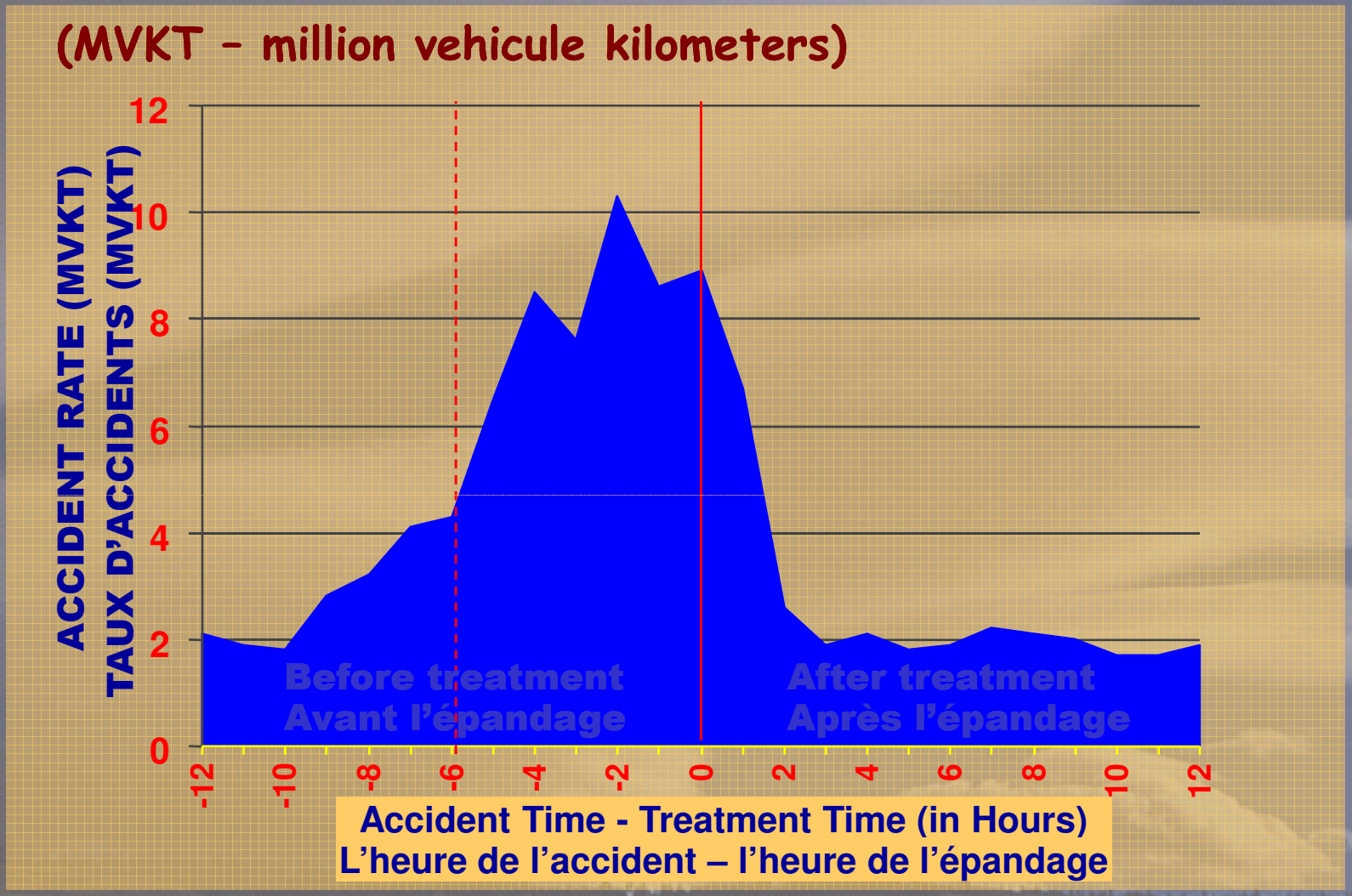

WA 29
OR 16
ID 15
NV 26
CA 37
UT 7
AR 7
CO 110
NM 0
WY 28
MO 26
ND 14
SD 23
NE 7
KS 50
OK 13
TX 11
MN 17+
73
IO 50
MI 26
AR 0
LO 0
WI 56
IL 63
MI 15
IN 11
OH 85
KY 3
TN 10
MS 0
AL 0
GE 0
FL 0
SC 19
NC 0
WV 6
PE 53
NY 46
VE 0
VI 42
MA 1
NH 2
MS 9
CT 4
DC 9
NJ 201
MR 87
RI 11
Total: 1090 full RWIS with 2696 road sensors.
* US Federal Highways Administration (FHWA)
Environnement Canada
Environment Canada
Service de l'Environnement Atmosphérique
Atmospheric Environment Service

RWIS in Canada

* Environment Canada

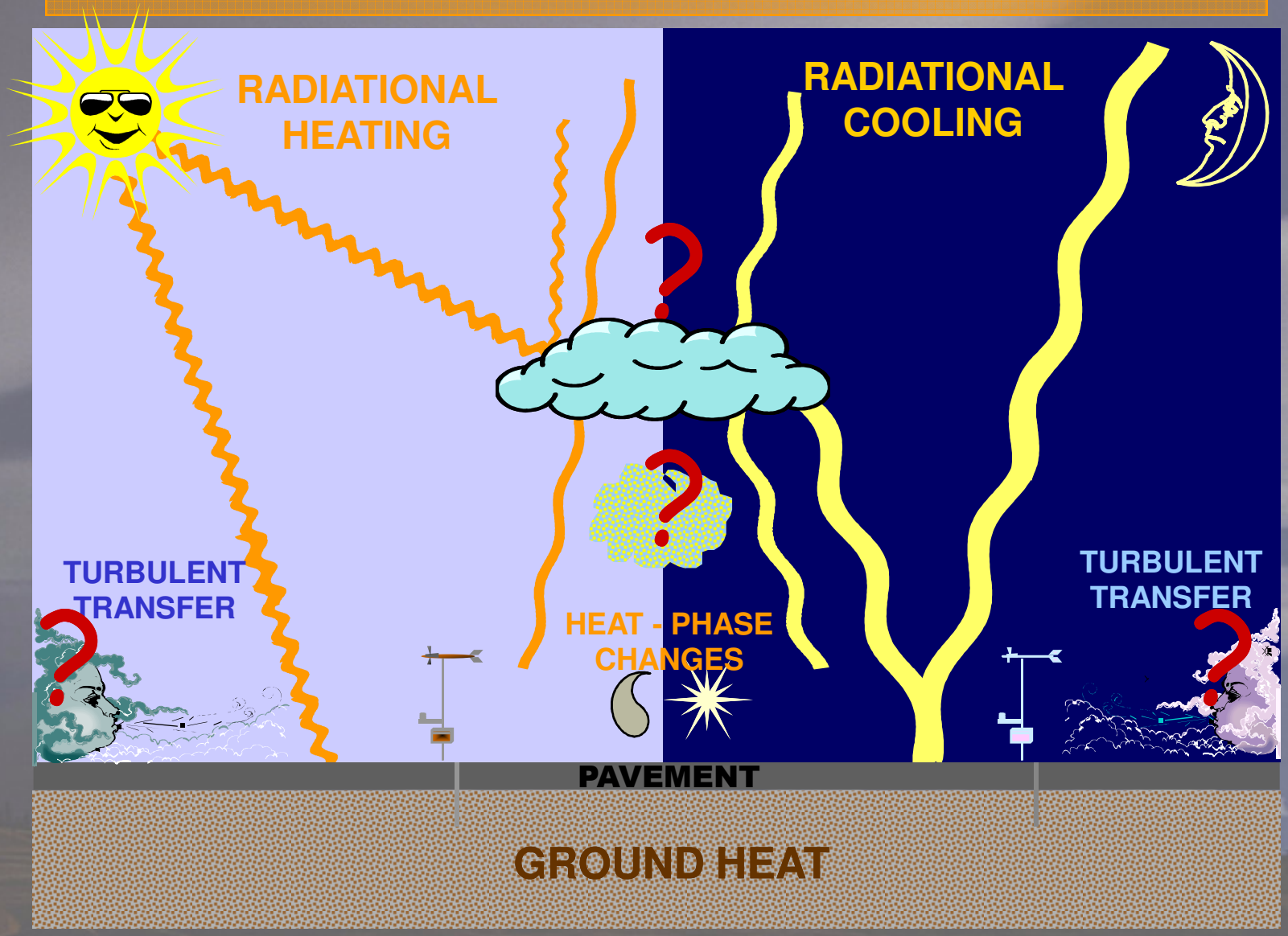
Environnement Canada Service de l'Environnement Atmosphérique
Environment Canada Atmospheric Environment Service

(MVKT – million vehicule kilometers)



* Hanke & Levin (1988) - 650 kms Deutschland

HEAT BALANCE IN THE ATMOSPHERE



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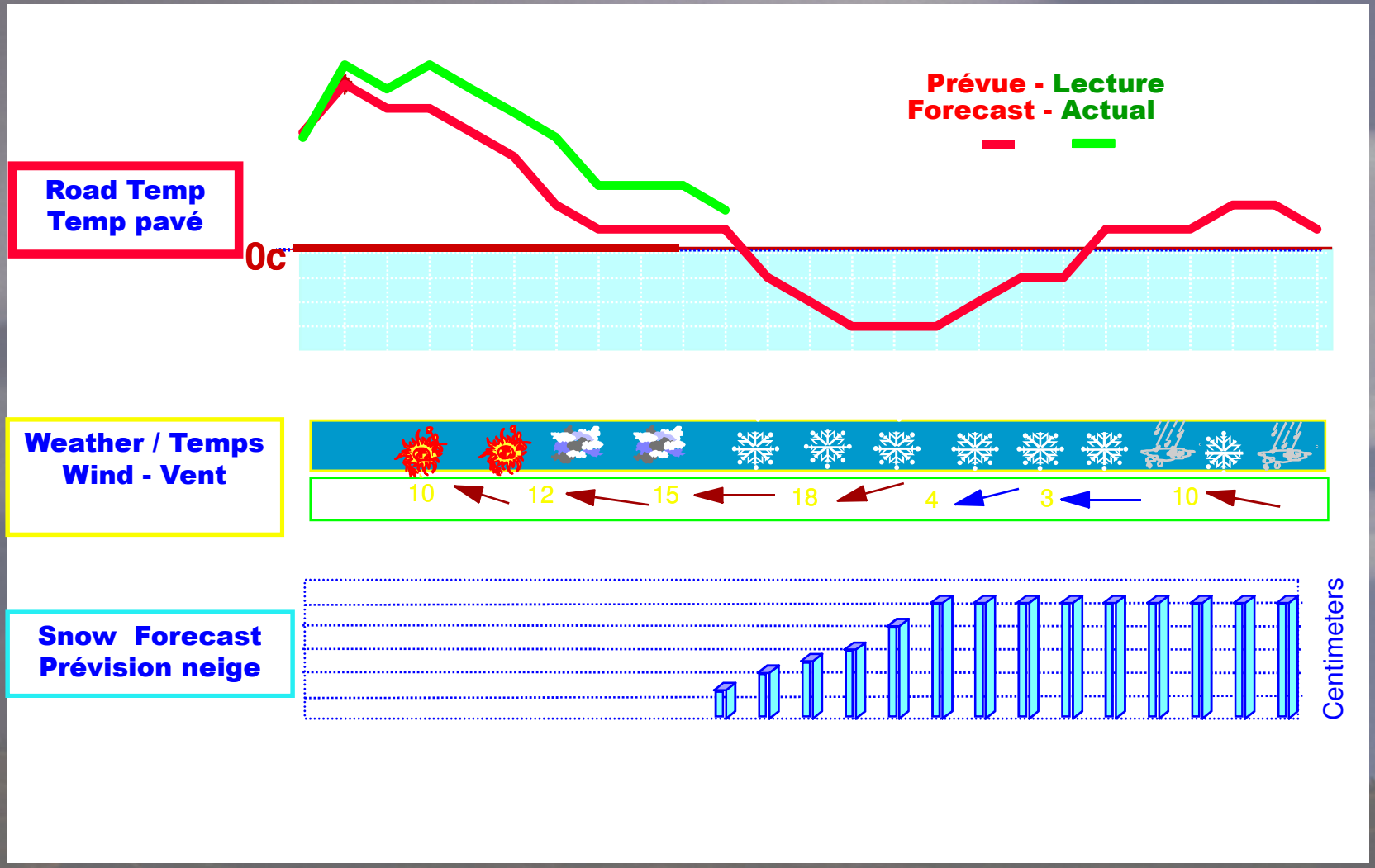
Environment Canada Atmospheric Environment Service

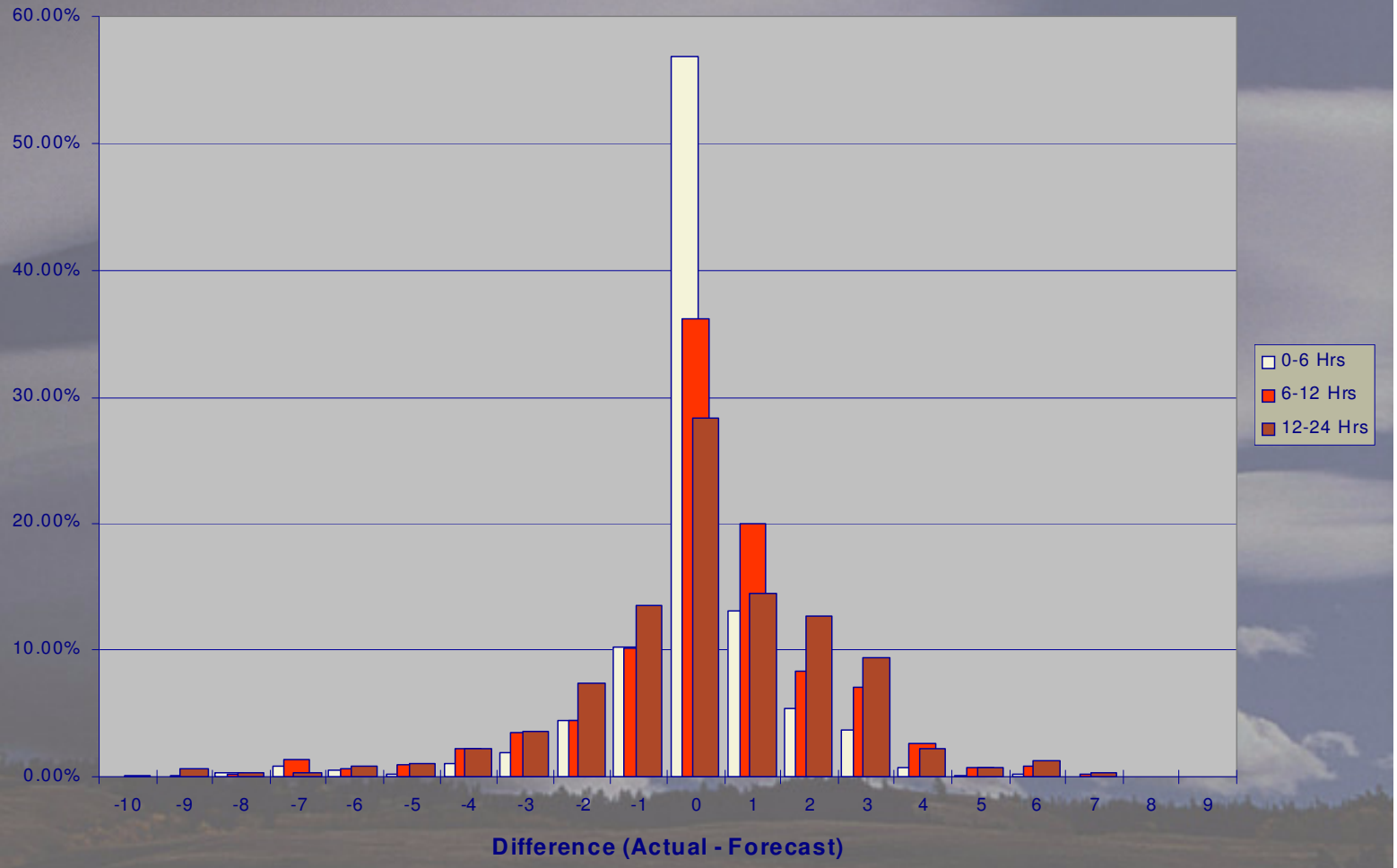
Pavement Forecast * Prévision de pavé



VERIFICATION*

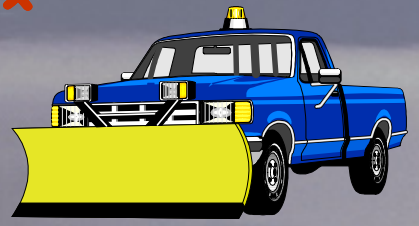
DIFFERENCE BETWEEN OBSERVED & FORECAST ROAD SURFACE TEMPERATURES

3 dec 96 - 31 mar 97



Benefits of RWIS

Benefit/Cost over life of RWIS*



- **Direct Benefits - Ratio 2.11:1**
  - operating - labour, equipment, fuel etc.
- **Indirect Benefits - Ratio 11.04:1**

  - reduced accidents and legal fees
  - reduced salt damage to roads, structures & environment (well contamination etc.)
  - greater more efficient use of existing roads

* Wikelius M. J., Director RWIS, MN/DOT, August 1996

Front Page Story... *The Globe and Mail, Saturday, July 26, 1997.*

Ontario must pay $2.2 Million for crash

Ministry liable for not salting road

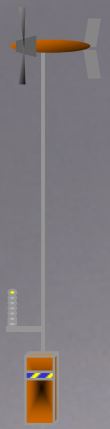
BY THOMAS CLARIDGE
Courts Reporter

TORONTO – A superior-court judge has found the Ontario government partly liable for catastrophic injuries to a teen-age driver who stopped to help another motorist whose car had spun out on an icy section of Highway 401.

In a 133-page judgement released yesterday, Mr. Justice Joseph O'Brien of the Ontario Court's General Division found that the government's ***Transportation Ministry failed to maintain the highway properly by permitting ice to develop when it knew of an approaching ice storm.***

In ordering the ministry to pay half the $4.45-million damages he awarded to Penny Roberts, the judge said ***evidence at a 43-day trial showed that salting of the highway had not begun until a few minutes before Ms. Roberts was struck by a car*** driven by defendant Salvatore Morana near Neilson Road in eastern Metro Toronto about 11:20 p.m., on March 3,1991.

"I have concluded that there were dangerous and icy road conditions in the patrol area for 11/2 hours prior to the
accident, Judge O'Brien said. He went on to ***conclude that the ministry official responsible for patrolling the road failed to monitor weather forecasts or road conditions, "and had little, if any, communication with adjoining patrolmen."***



Benefits of RWIS

Benefit/Cost Ratios

State	Direct	Indirect
Minnesota	2.11 : 1	11.04 : 1
Sweden	2.5 : 1	20 : 1
United Kingdom		100 : 1

WEATHER RADAR


CWRP
better use of our infrastructure: $35M doppler radar network and our powerful supercomputer
ent Atmosphérique
Environment Canada
Atmospheric Environment Service

Polarization Diversity Has Been Recently Implemented on the McGill S-band Radar

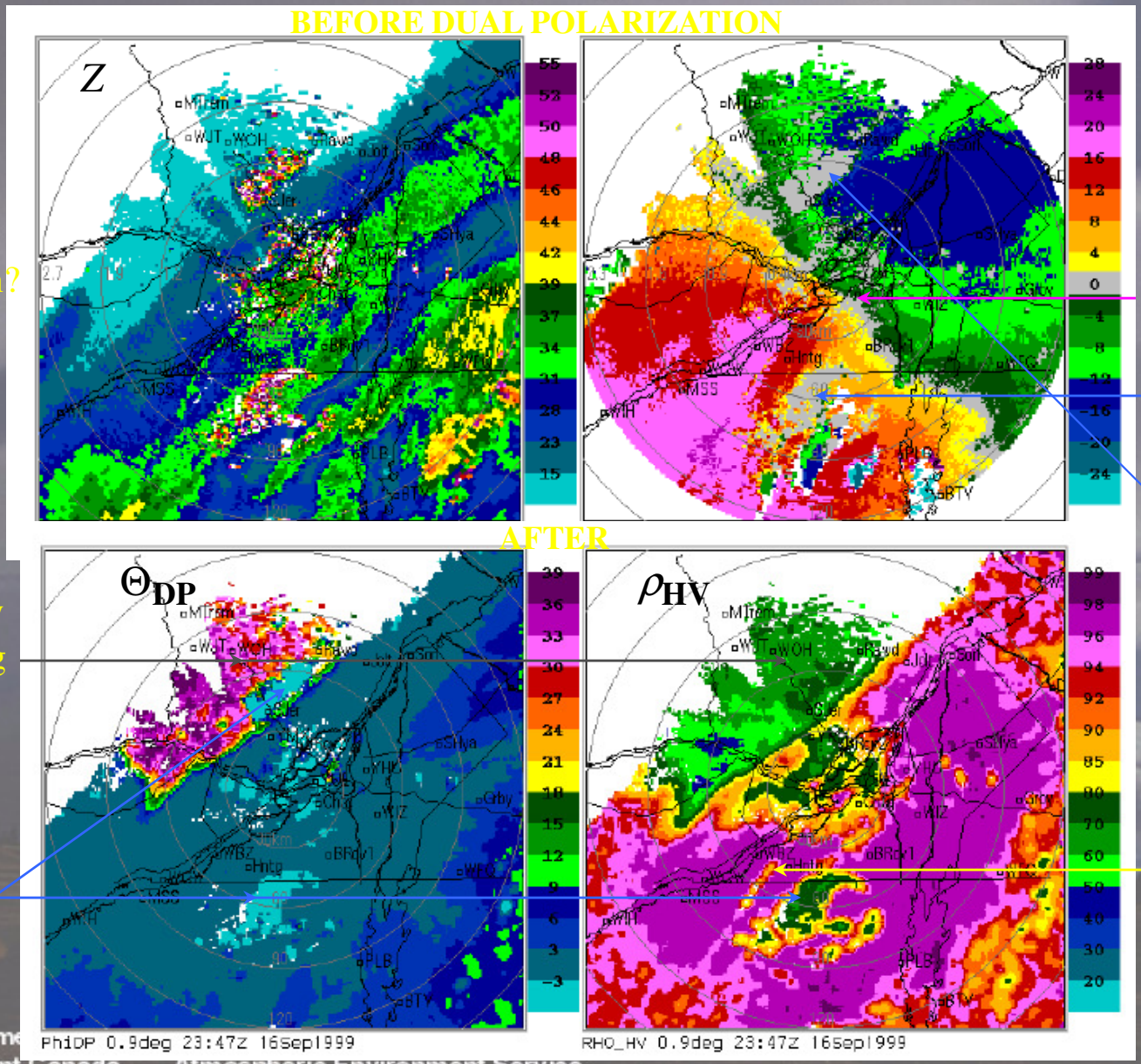
What for?

Radar measures the reflectivity of the targets and their motion.

The reflectivity may be due to rain, snow, hail, birds, ground, insects, etc.

We want to distinguish between these targets.

IDENTIFICATION OF ARTIFACTS, etc. (on a 0.9º PPI through FLOYD)



Is it all precipitation?

But zero Doppler velocity is also found in precipitation.

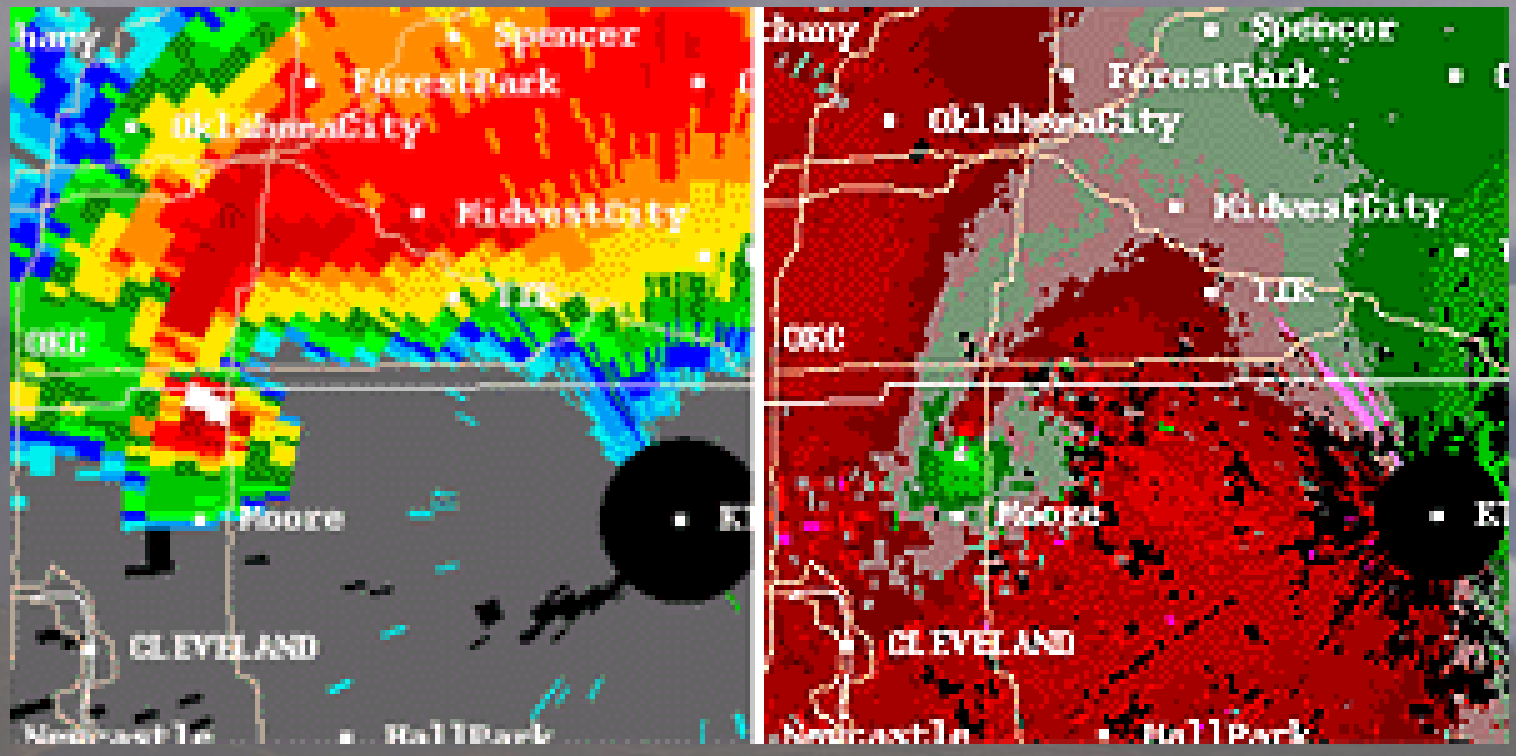
GROUND CLUTTER (identified By zero Doppler velocity)

More likely birds taking advantage of the good winds.

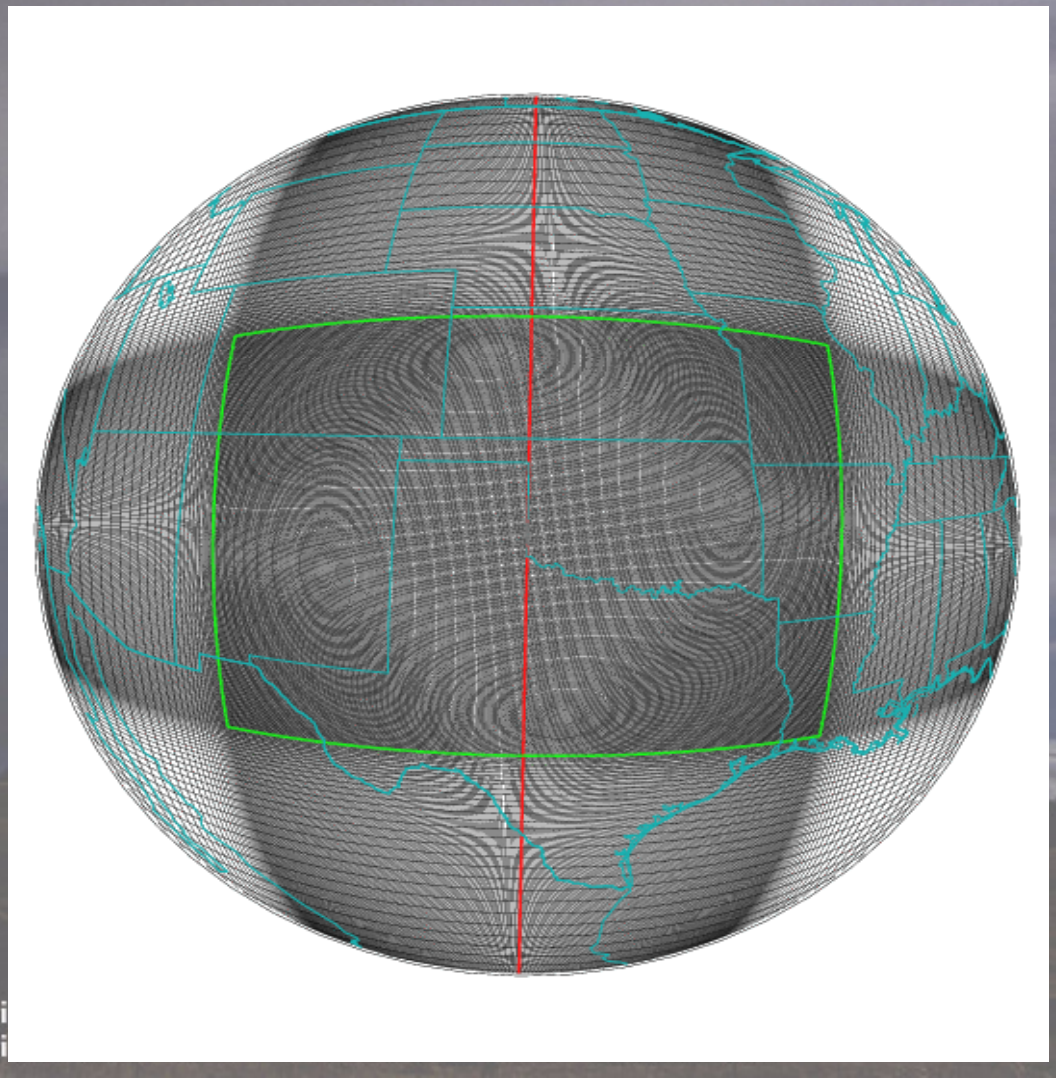
GROUND CLUTTER

Partial beam blocking by a nearby building

Oklahoma City Doppler Radar



Non-hydrostatic modelling in Oklahoma 3km



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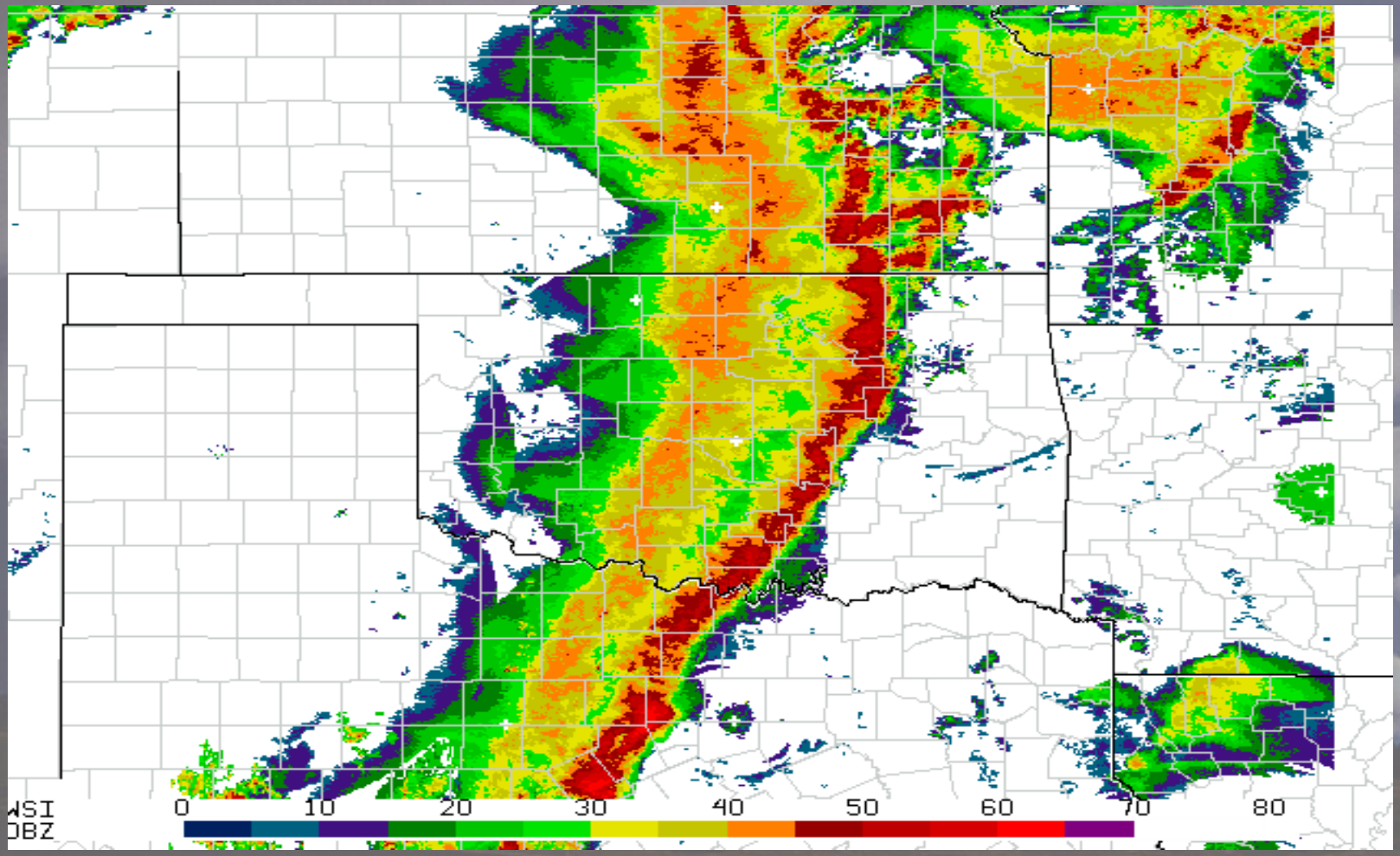
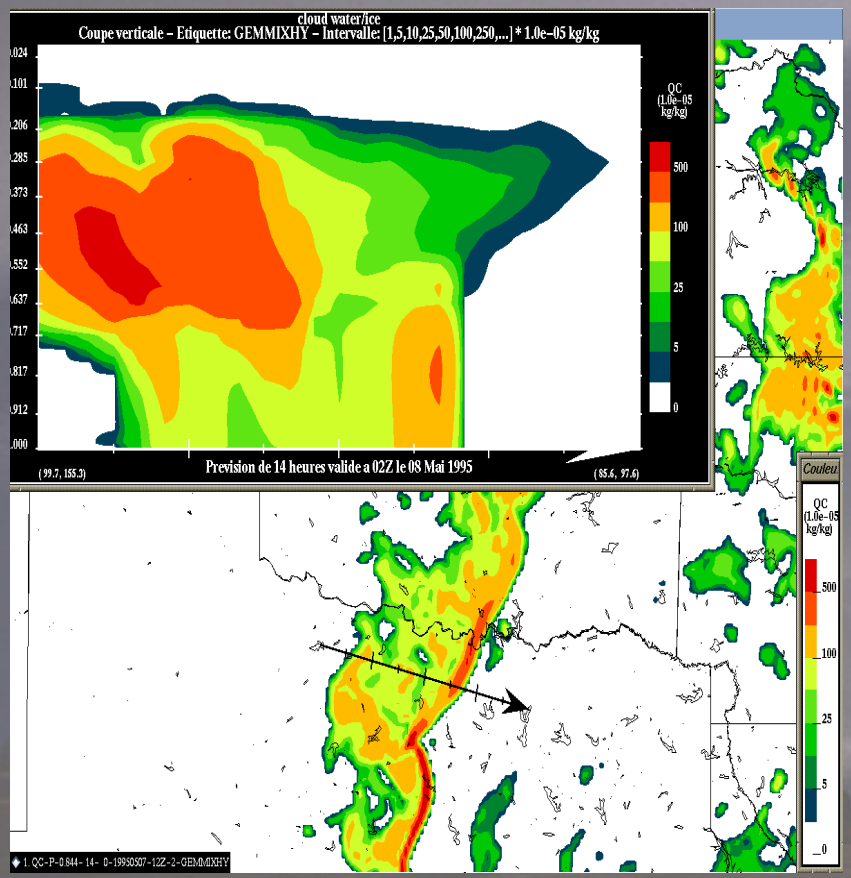
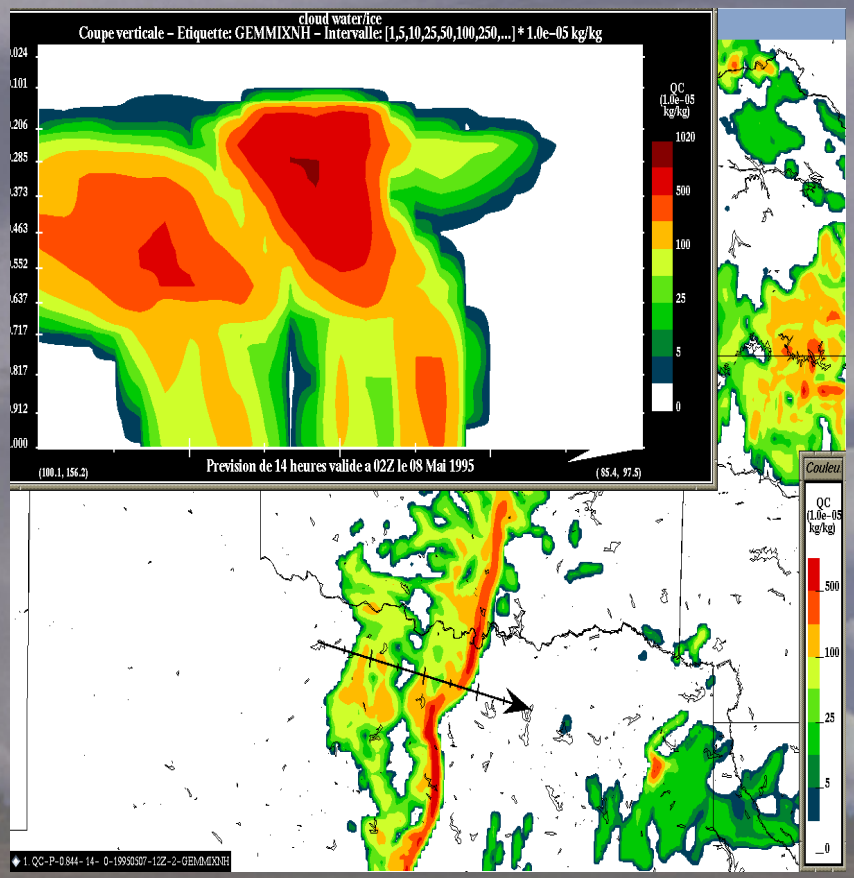
Radar reflectivity of the event



Cloud water/ice

Hydrostatic Non-Hydrostatic





MARINE: Extratropical Transition of Hurricanes

Canadian Hurricane Centre

1886-1986 - All Tropical Cyclones

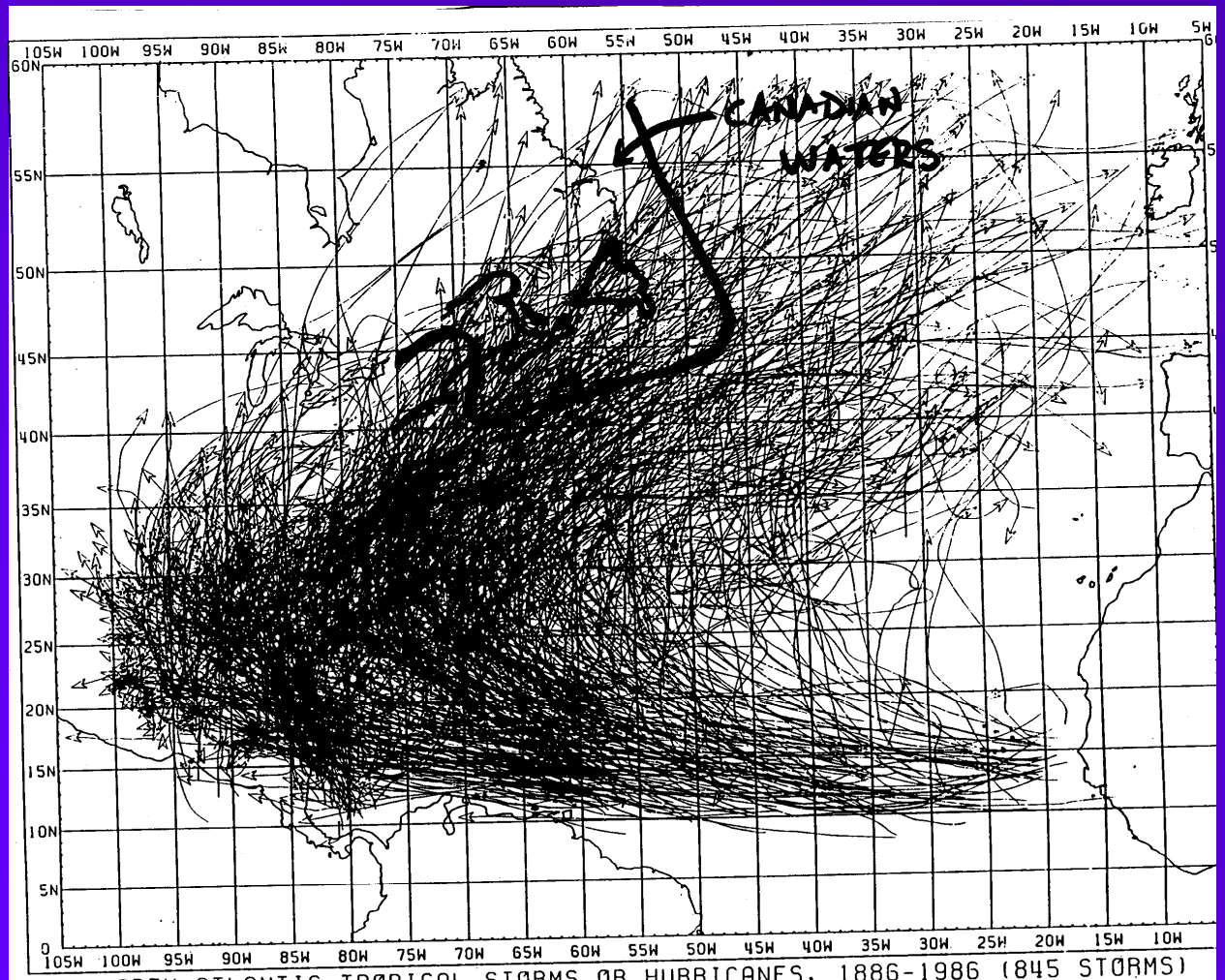


Figure 1. Computer plot showing the tracks of the 845 known Atlantic tropical cyclones reaching at least tropical storm intensity (see section over the 101-year period 1886 through 1986.

Canadian Hurricane Centre

Extratropical Transition

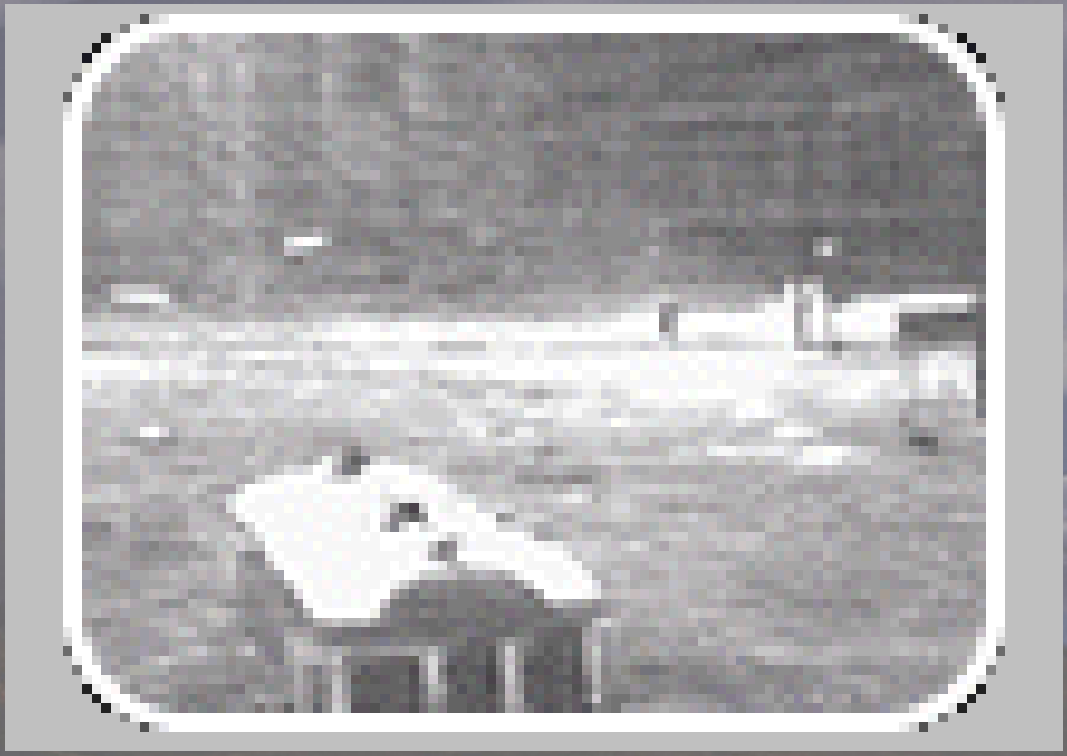
- This rare event combines the energies of a frontal storm and a tropical cyclone
  - Reintensifies to a large hurricane strength storm
  - Extreme rainfalls of 200-300mm in less than 24 hours
  - Even storm surges of 1.5m are particularly destructive if they occur at high astronomical tide

Canadian Hurricane Centre

IMPACTS

- **The costliest Canadian Hurricane and two of the top ten U.S. Hurricanes were *explosive extratropical transitions:***
  - **"1938 Hurricane": 600 deaths/$400M**
  - **"Agnes" 1972: 129 deaths**
  - **"Hazel" 1954: 83 deaths/$100M damage**

1938 Hurricane 35 foot river flood crest in Lowell River

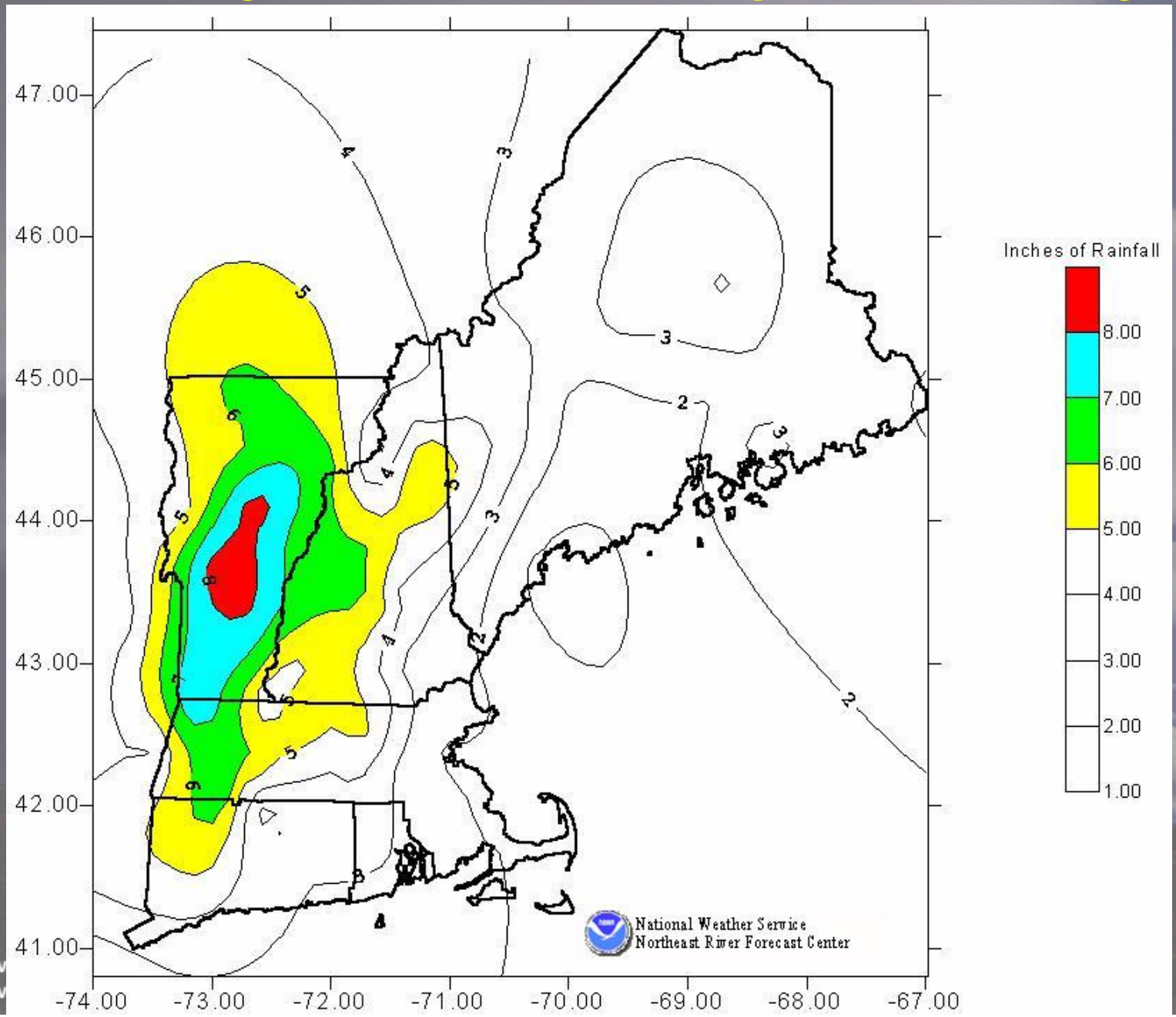


New England Flood of November 1927

Environnement Canada Service de l'Environnement Atmosphérique
Environment Canada Atmospheric Environment Service

Holyoke Dam, Holyoke, Massachusetts

Rainfall during November 1927 flooding event in New England



Canadian Hurricane Centre

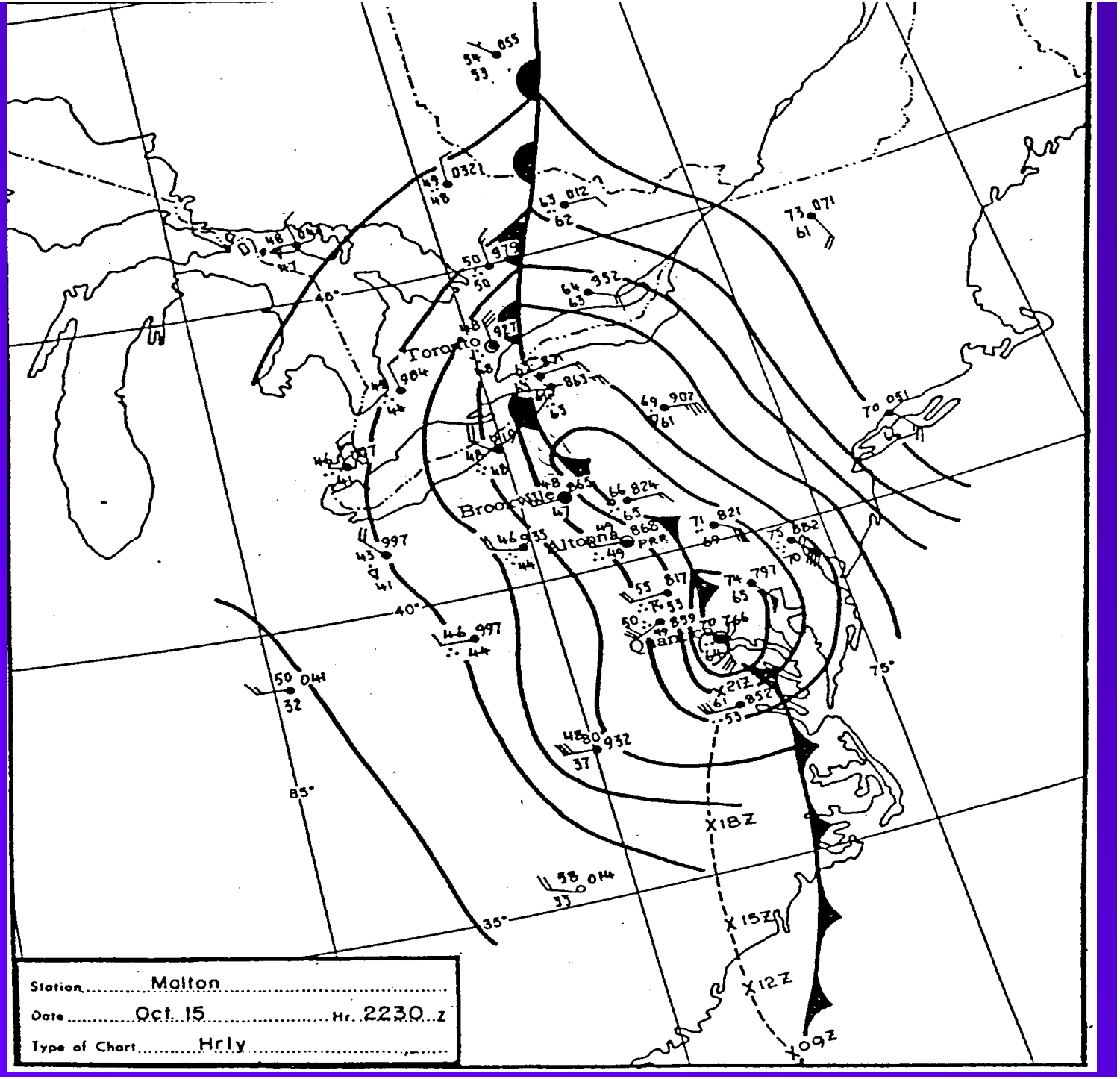
HURRICANE HAZEL - 1954

- 81 deaths
- > $100 million damage near Toronto, Ont.
- Lower Humber River rose 20 feet in 1 hour submerging whole blocks of houses
- Holland Marsh became a vast lake of turbulent waters, marooning 1500 people on drifting rooftops and floating debris

Hurricane Hazel

Oct.15

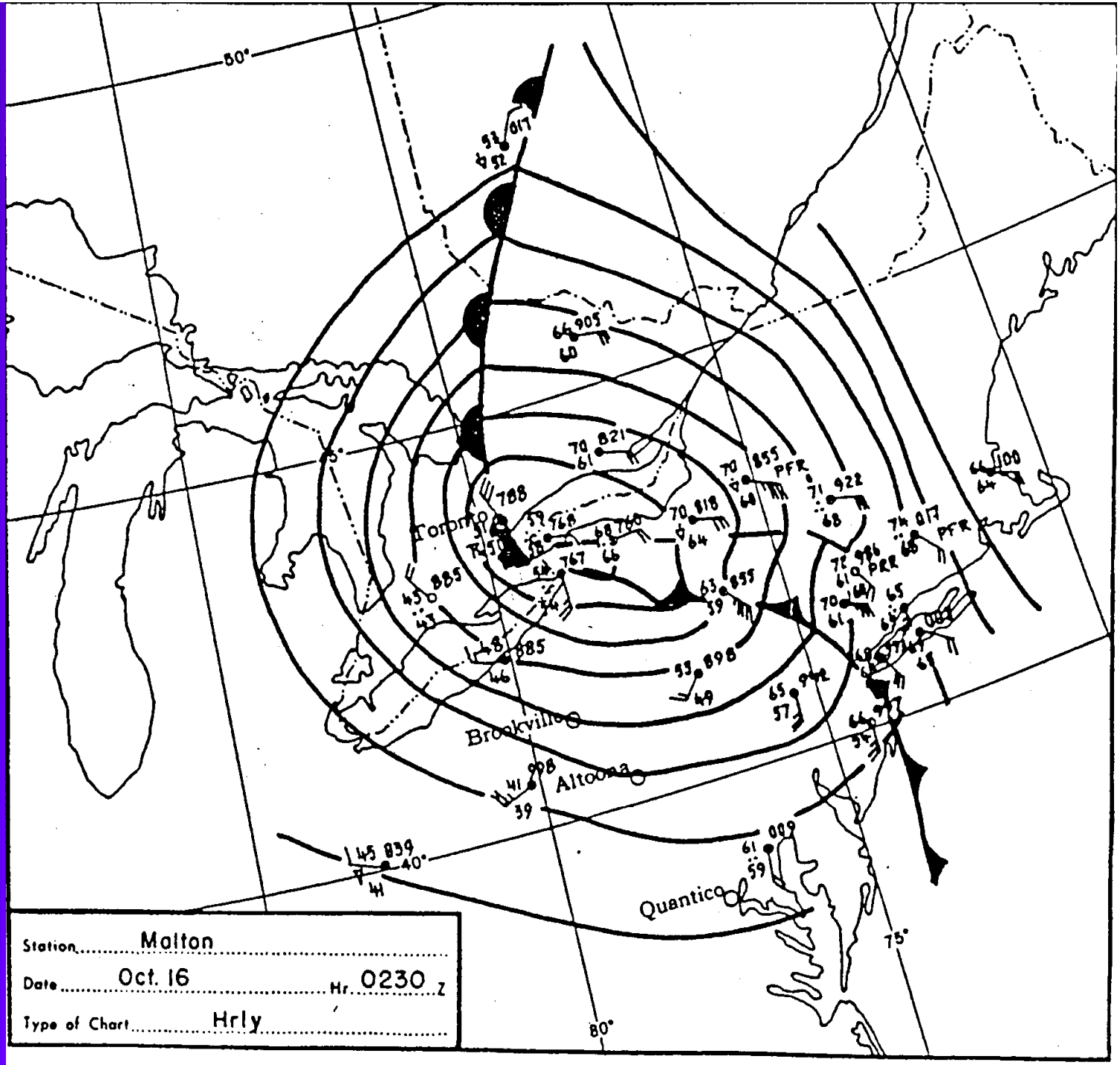
2230 UTC



Hurricane Hazel

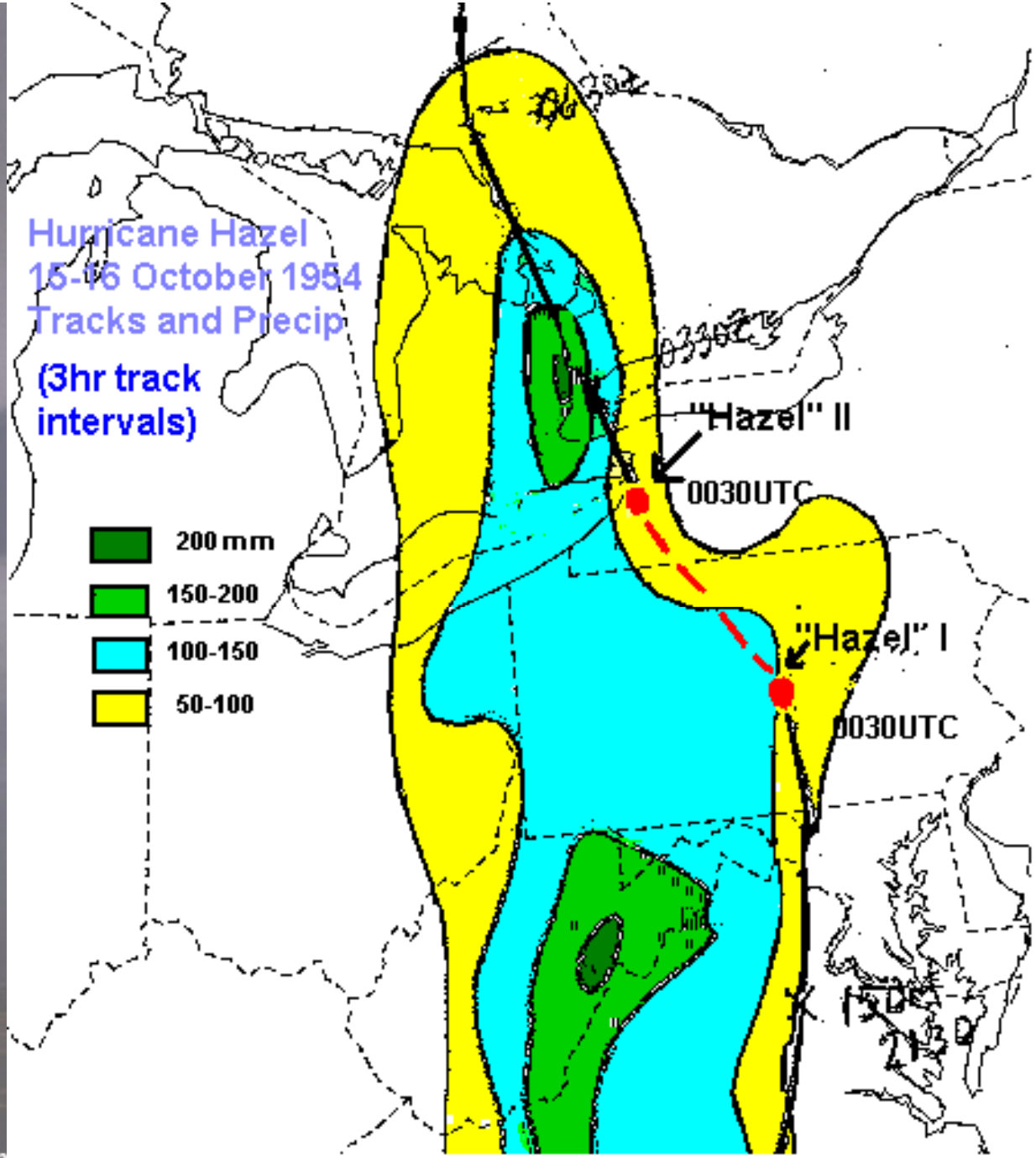
Oct.16

0230 UTC



Hazel I and II track and precipitation

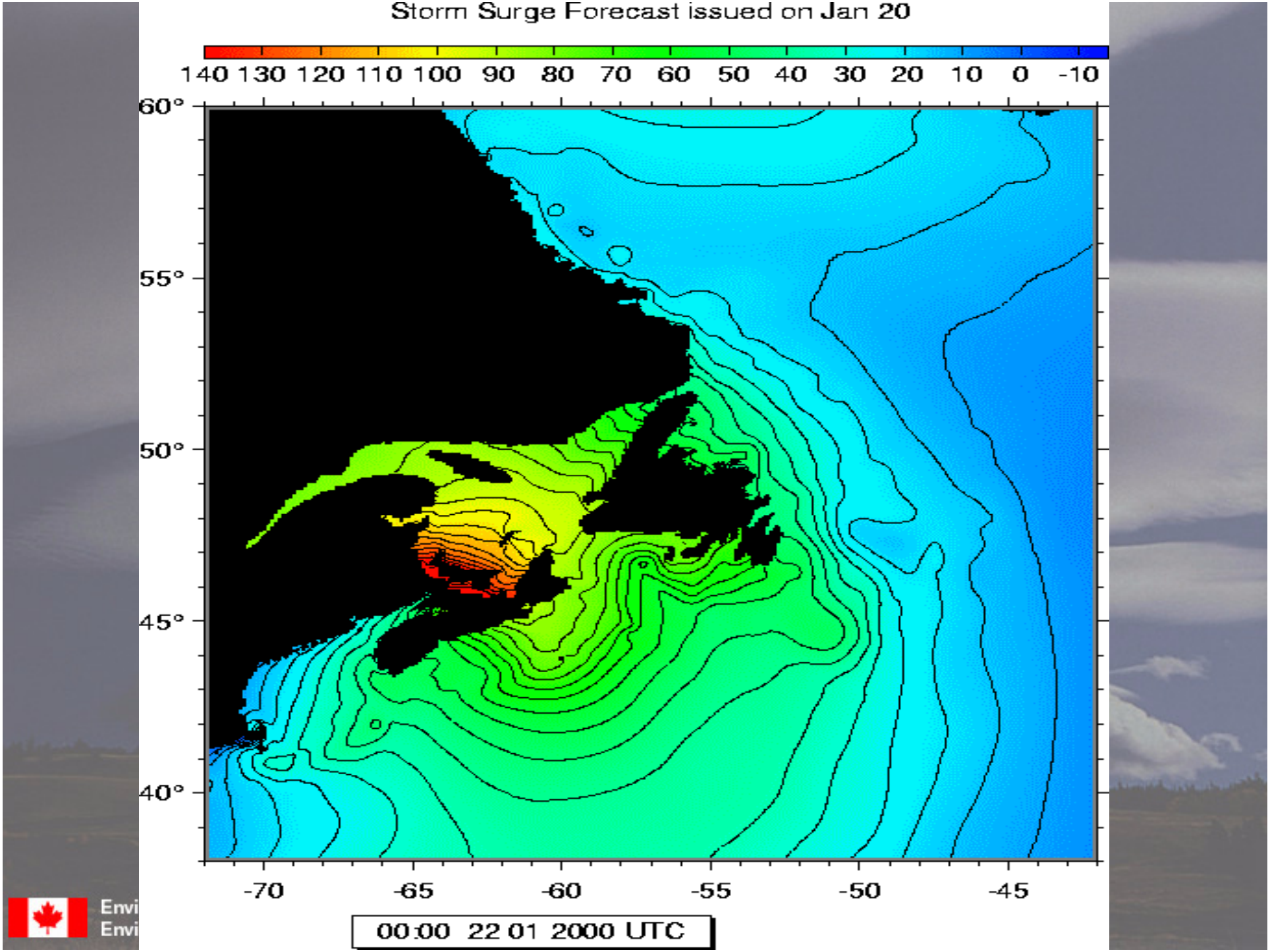
October 15-16 1954

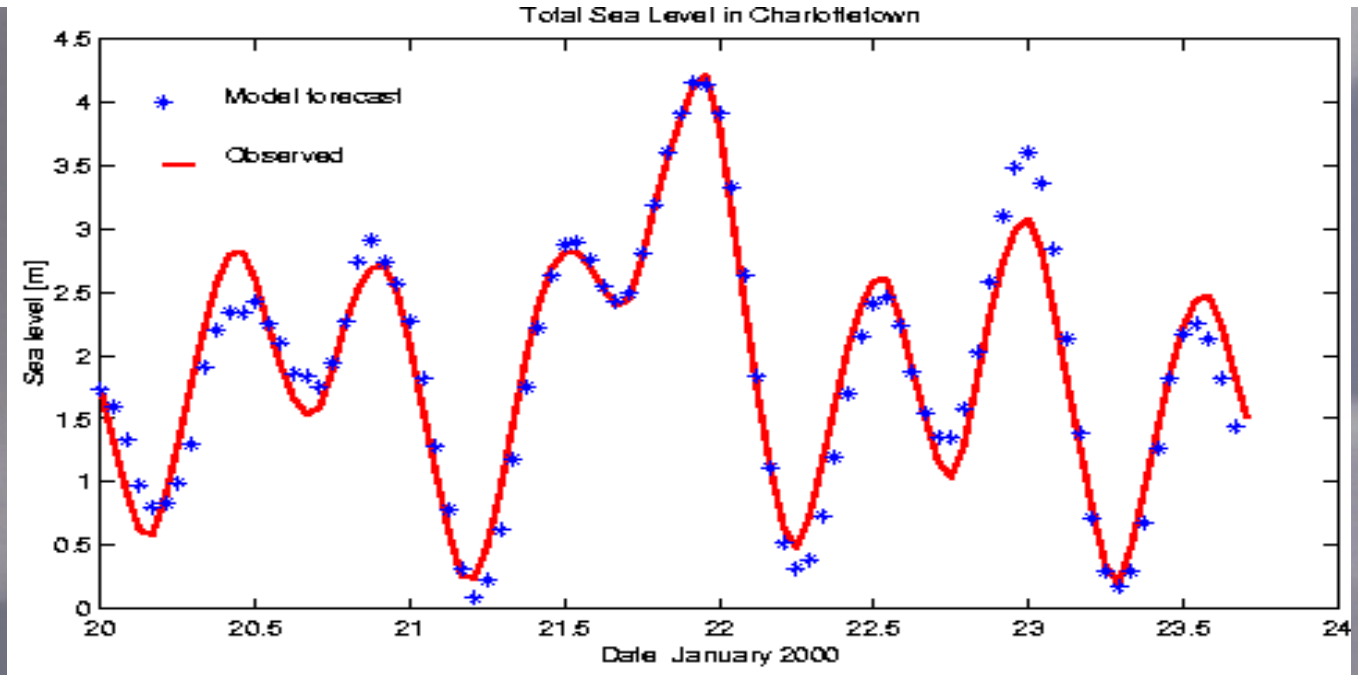


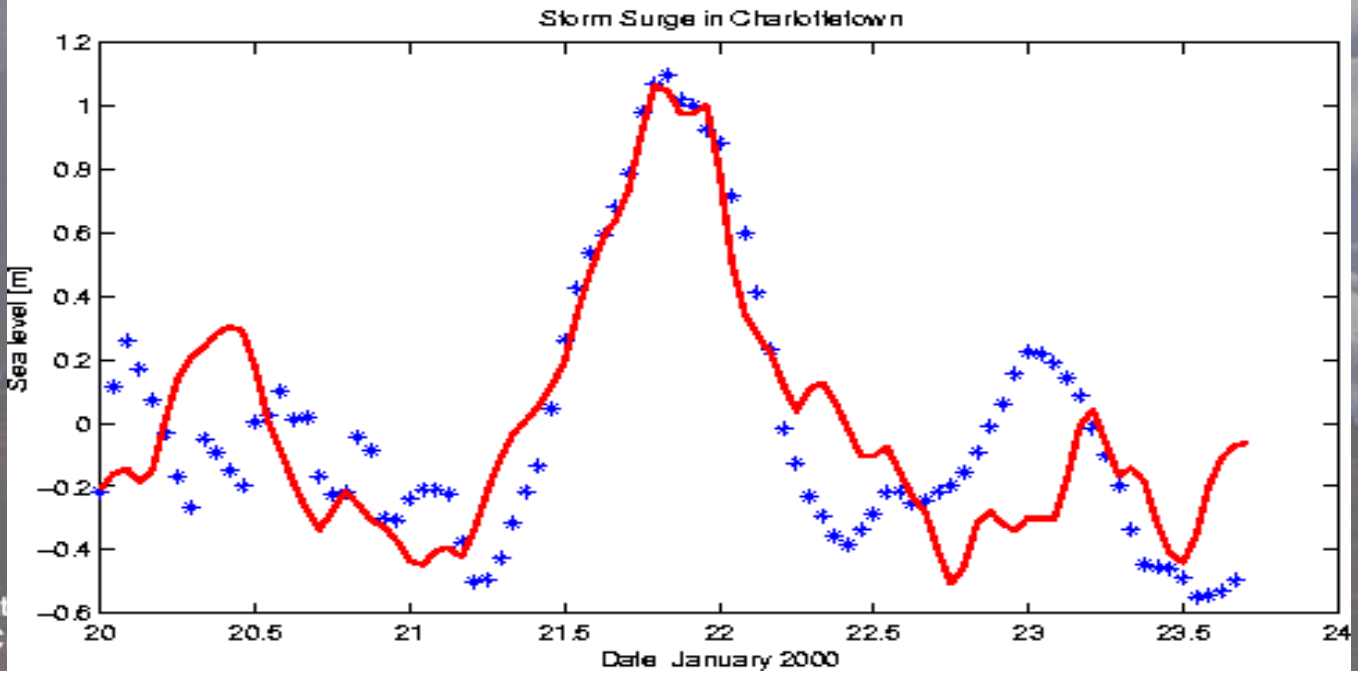
Environnement Canada Service de l'En
Environment Canada Atmospheric E

Partnership: CCAF study

- Establish definitive storm surge climatology
- Establish return periods of total water levels
- Study rates and processes of coastal retreat
- Correlate retreats with wave/storm surge activity/ice season
- Study the potential impacts of a warmer climate on the ice season
- Study extreme events
- Model storm surges spatially/with extreme events/with rising sea levels/with increased storminess
- Construct flood risk maps/maps of shoreline destiny
- Examine socio-economic impacts


Storm Surge Forecast issued on Jan 20
140 130 120 110 100 90 80 70 60 50 40 30 20 10 0 -10
60°
55°
50°
45°
40°
-70
-65
-60
-55
-50
-45
00:00 22 01 2000 UTC





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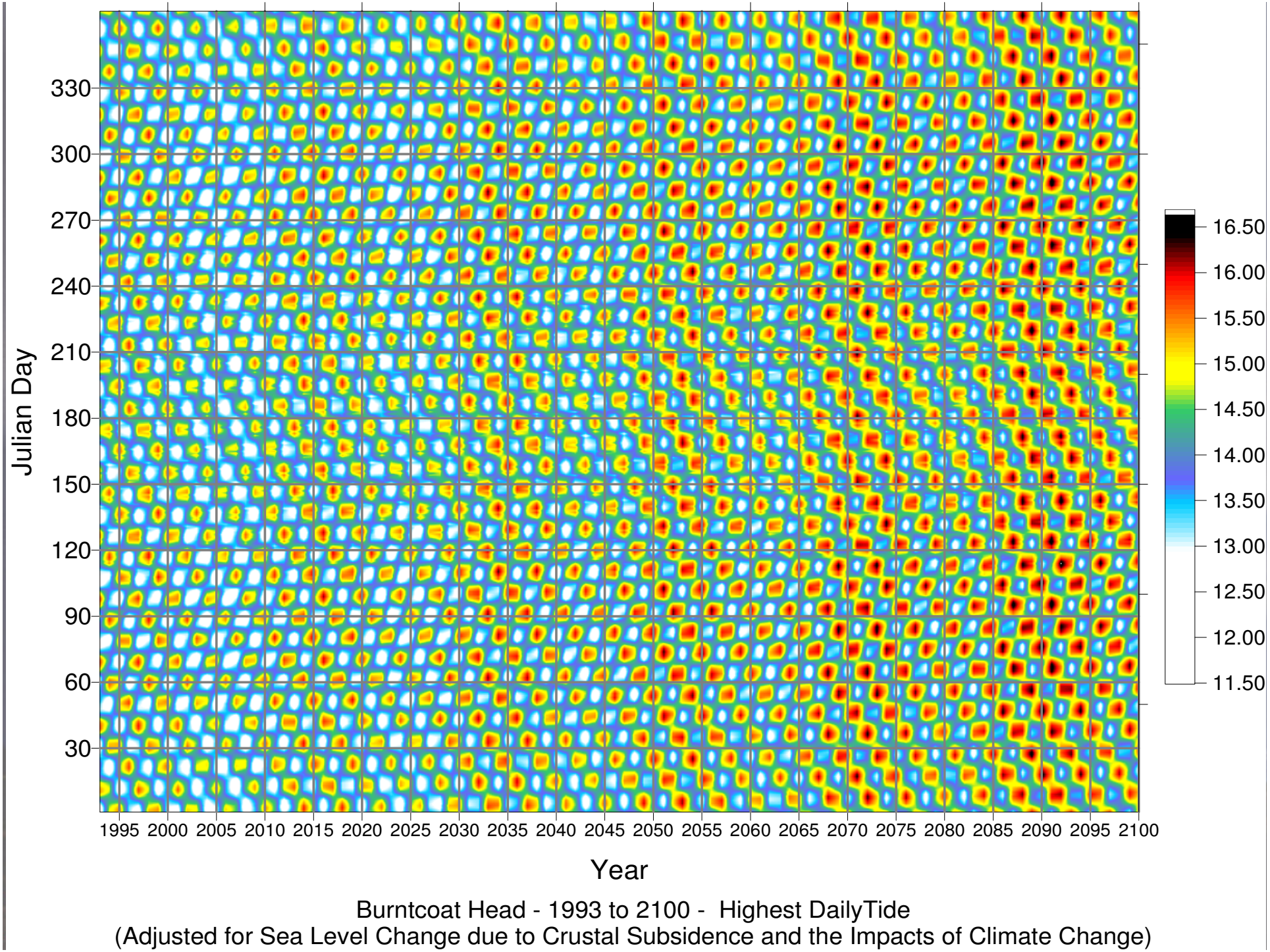
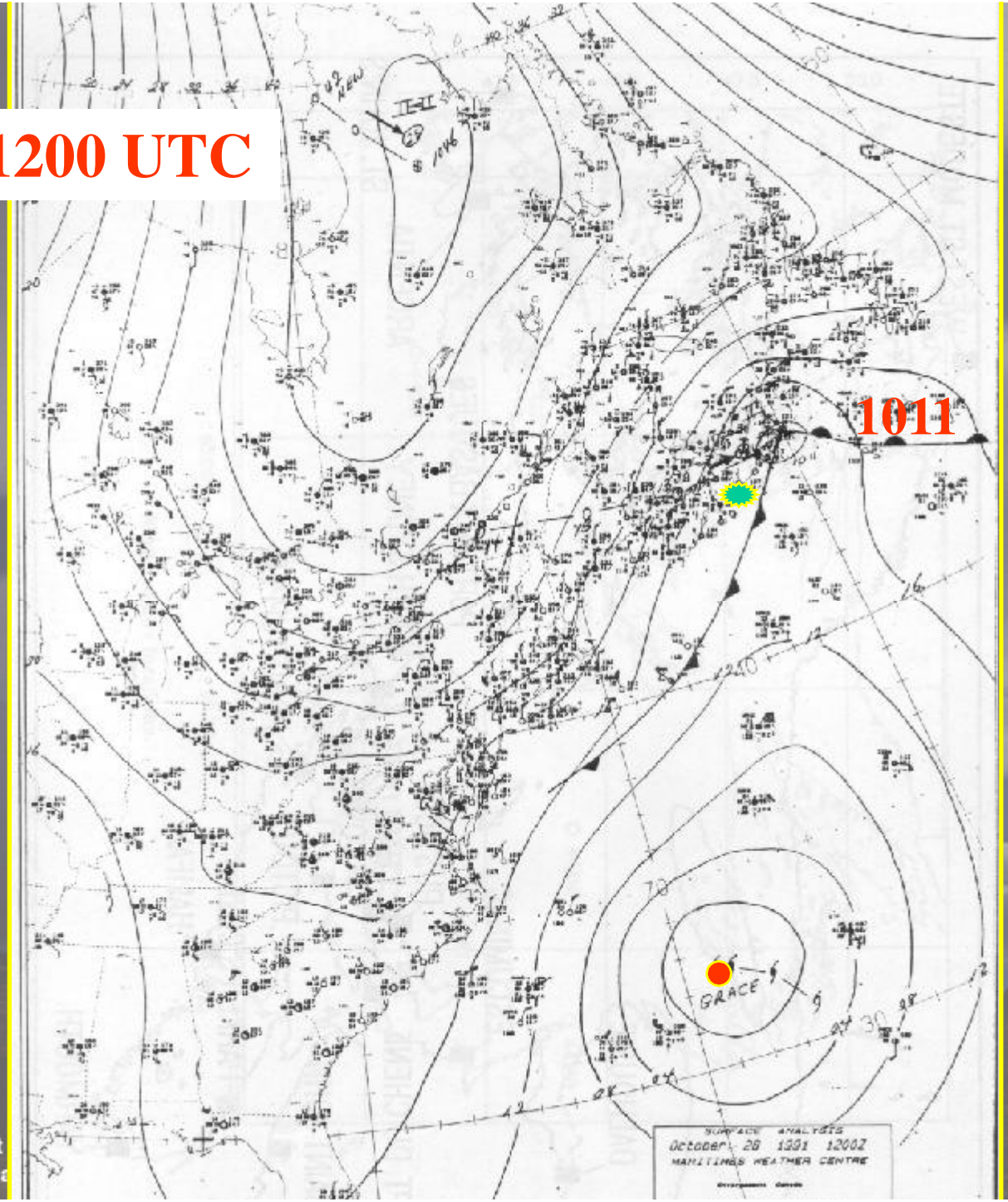
Environment C



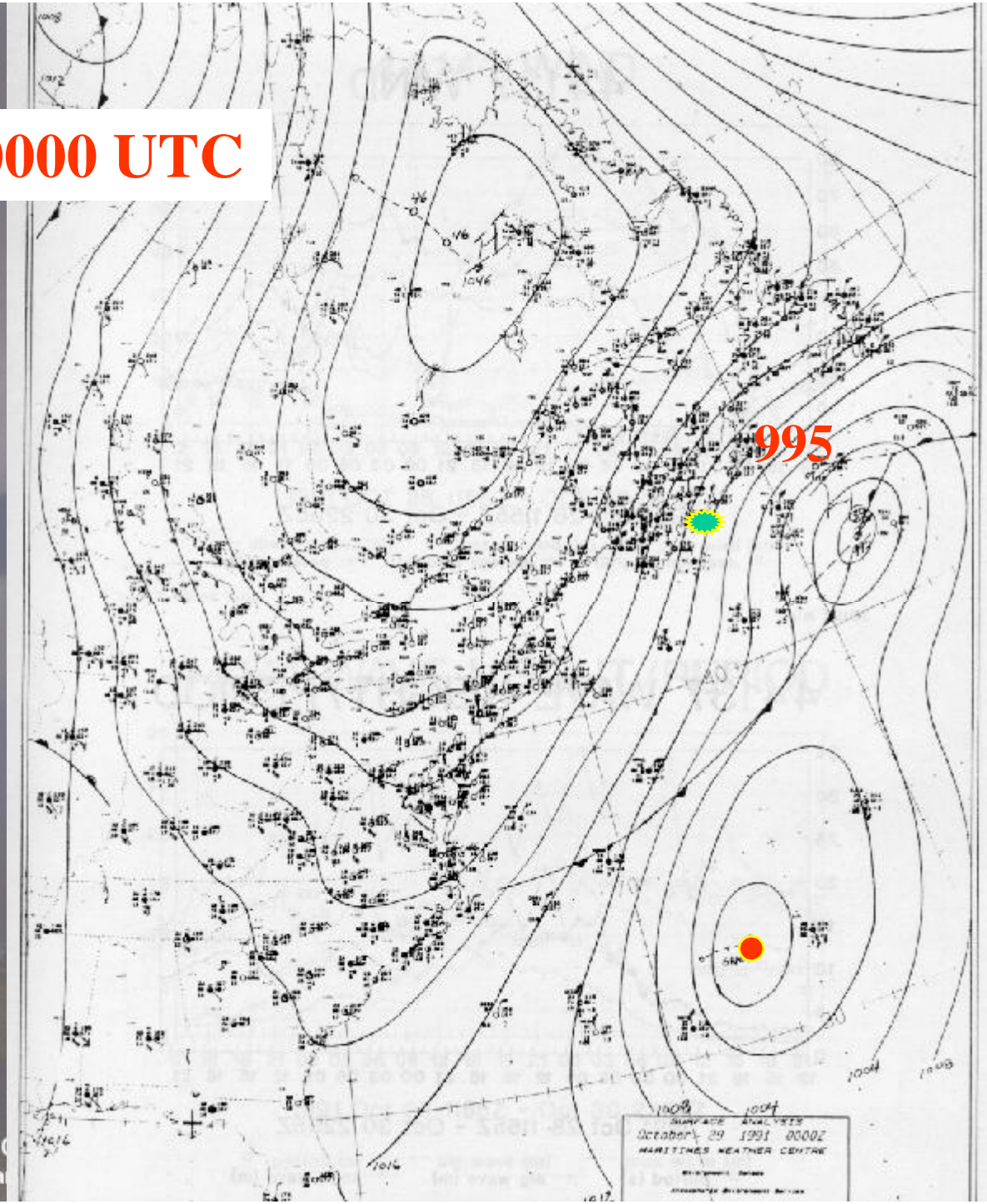
Burntcoat Head - 1993 to 2100 - Highest DailyTide
(Adjusted for Sea Level Change due to Crustal Subsidence and the Impacts of Climate Change)

Oct 28 1200 UTC



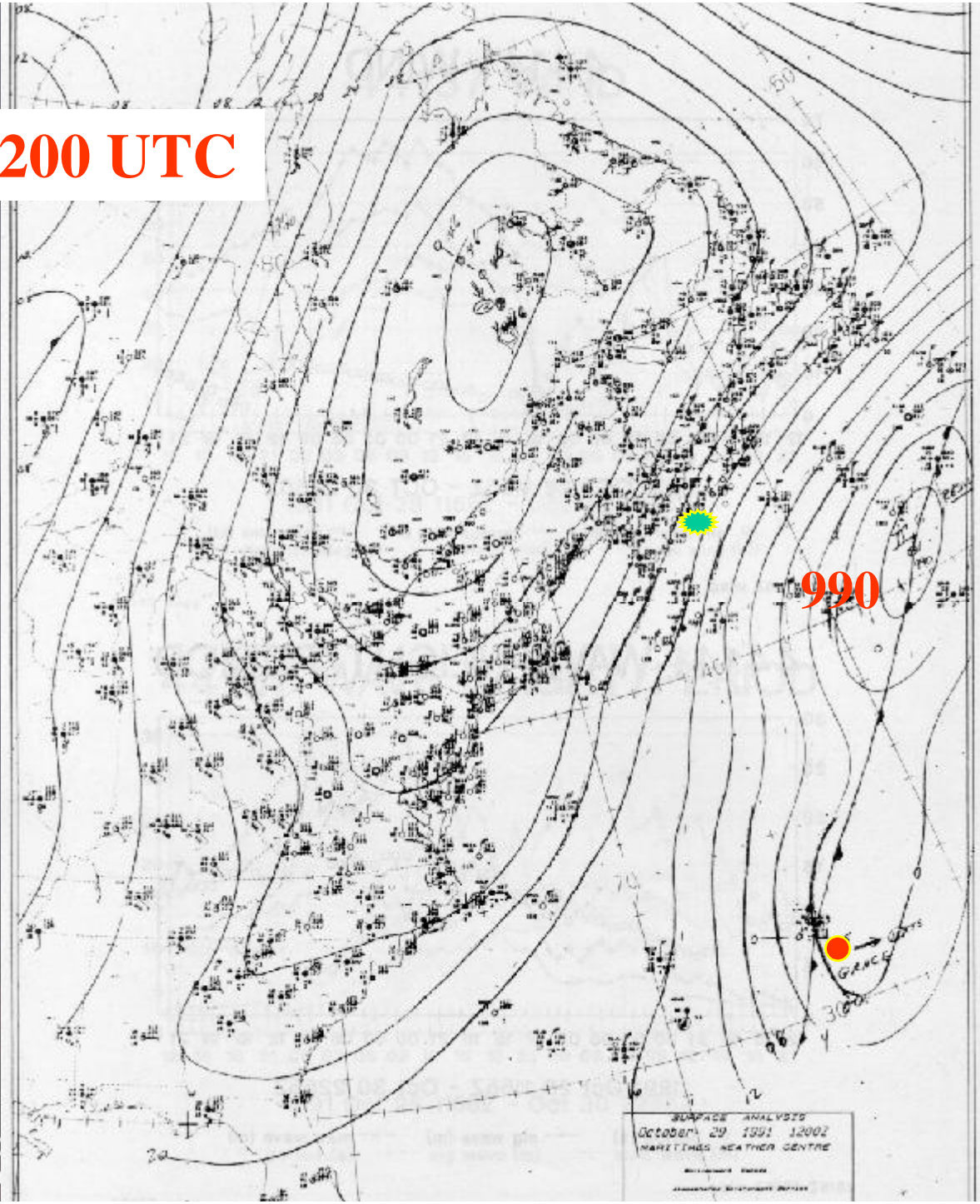
Environnement
Environment Ca

Oct 29 0000 UTC



Environnement C
Environment Ca

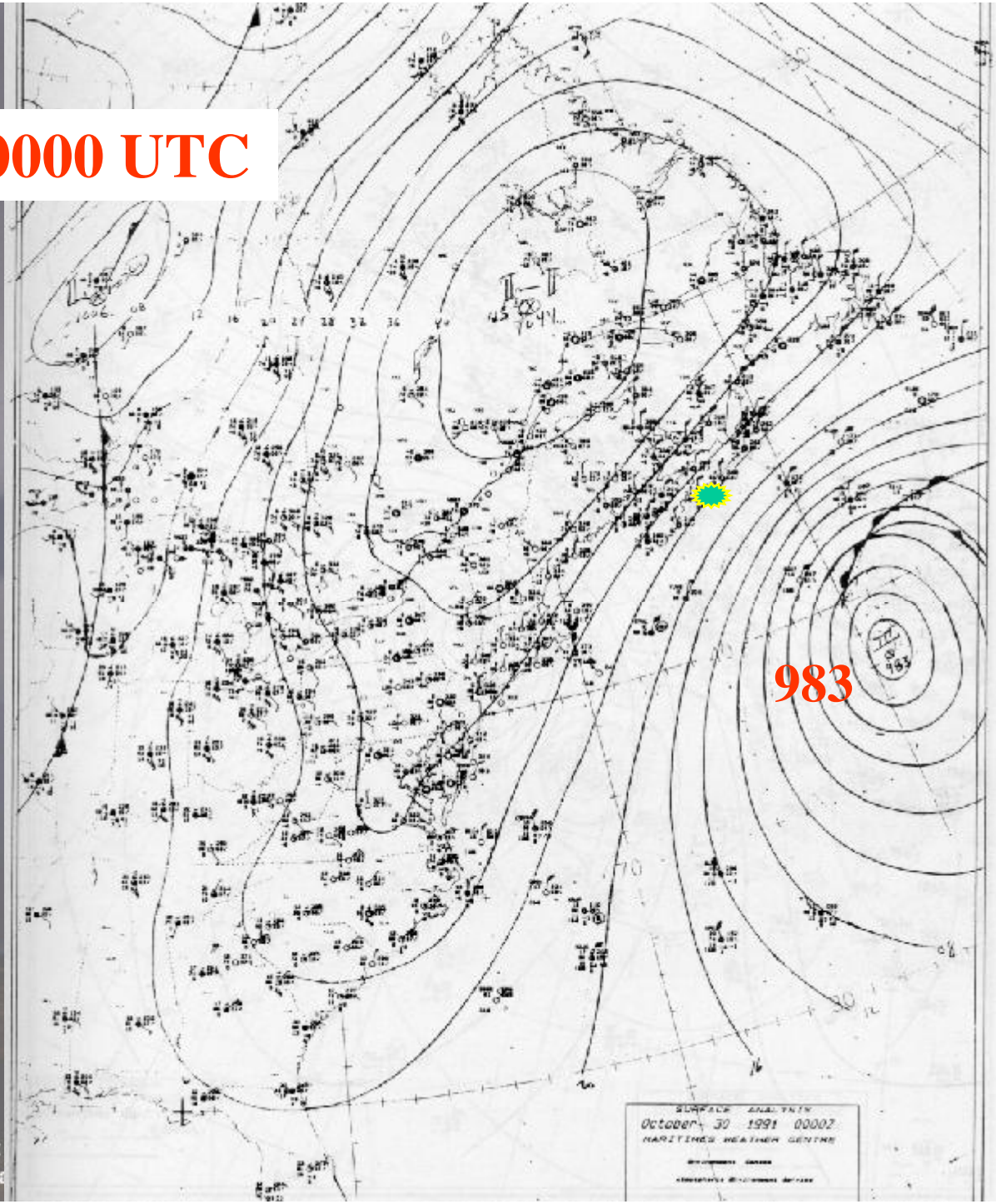
Oct 29 1200 UTC



Environnement C
Environment Ca

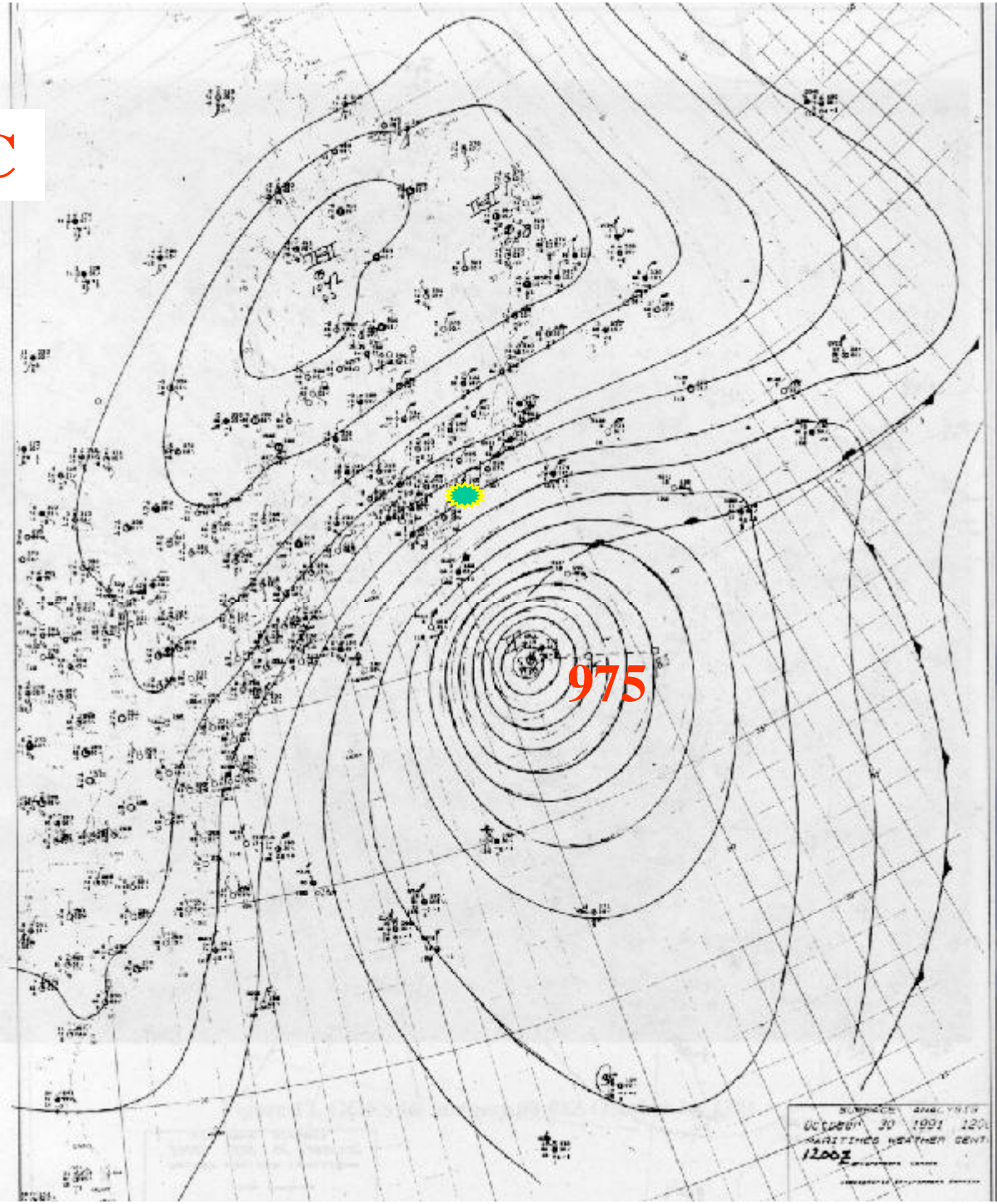
Oct 30 0000 UTC

Max Waves



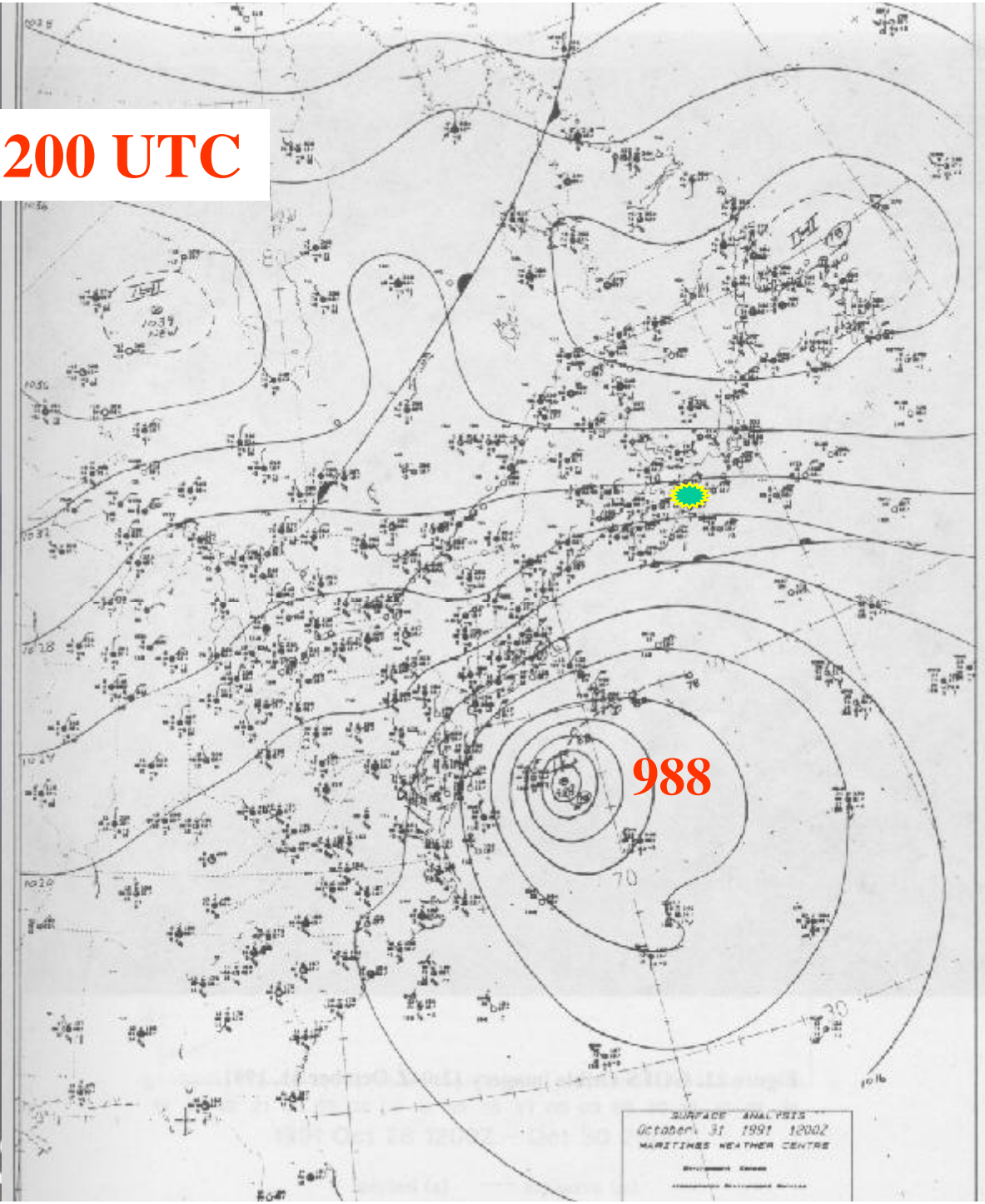
Environnement
Environment Ca

Oct 30 1200 UTC



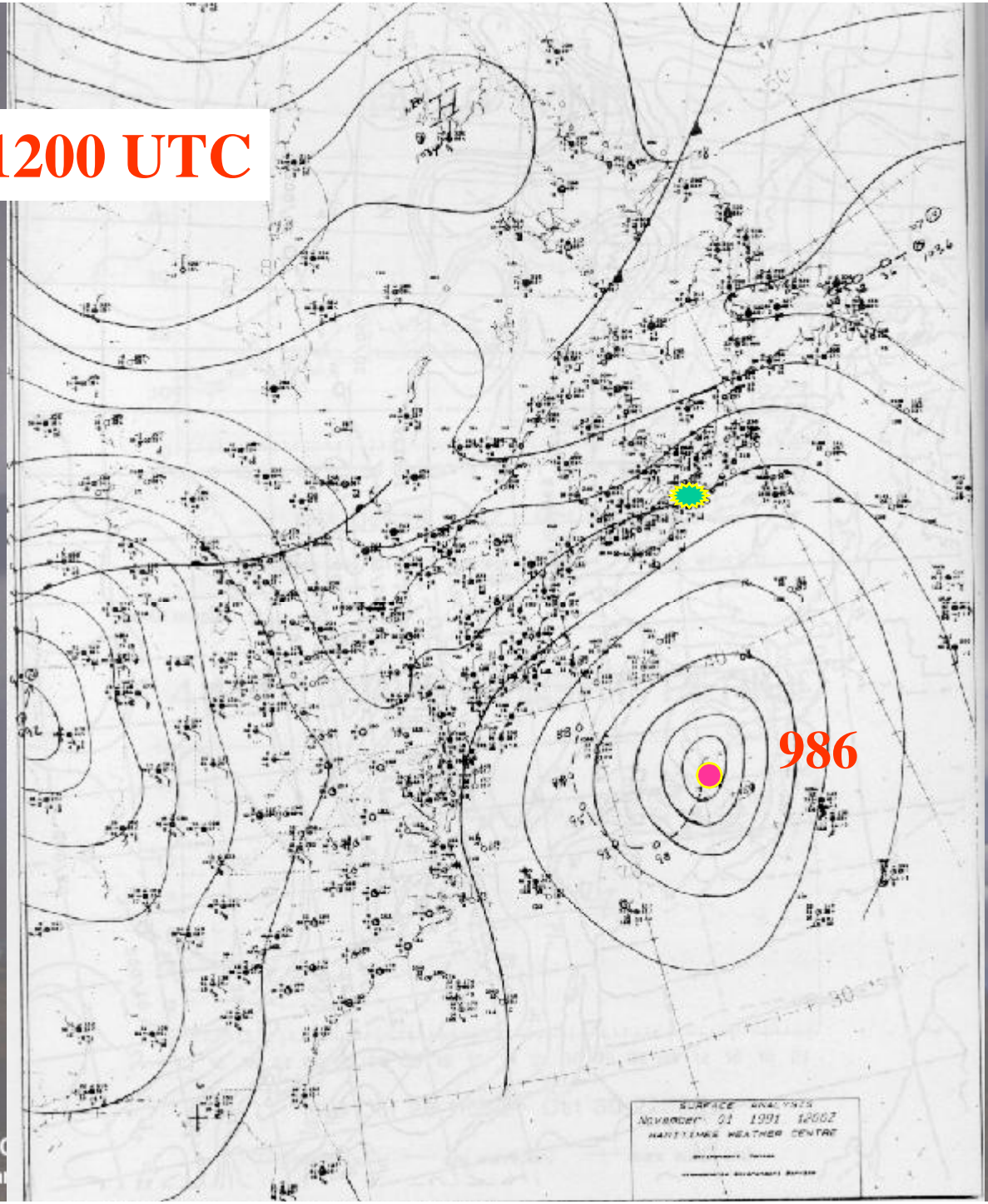
Environnement Canada Service de
Environment Canada Atmosphe

Oct 31 1200 UTC



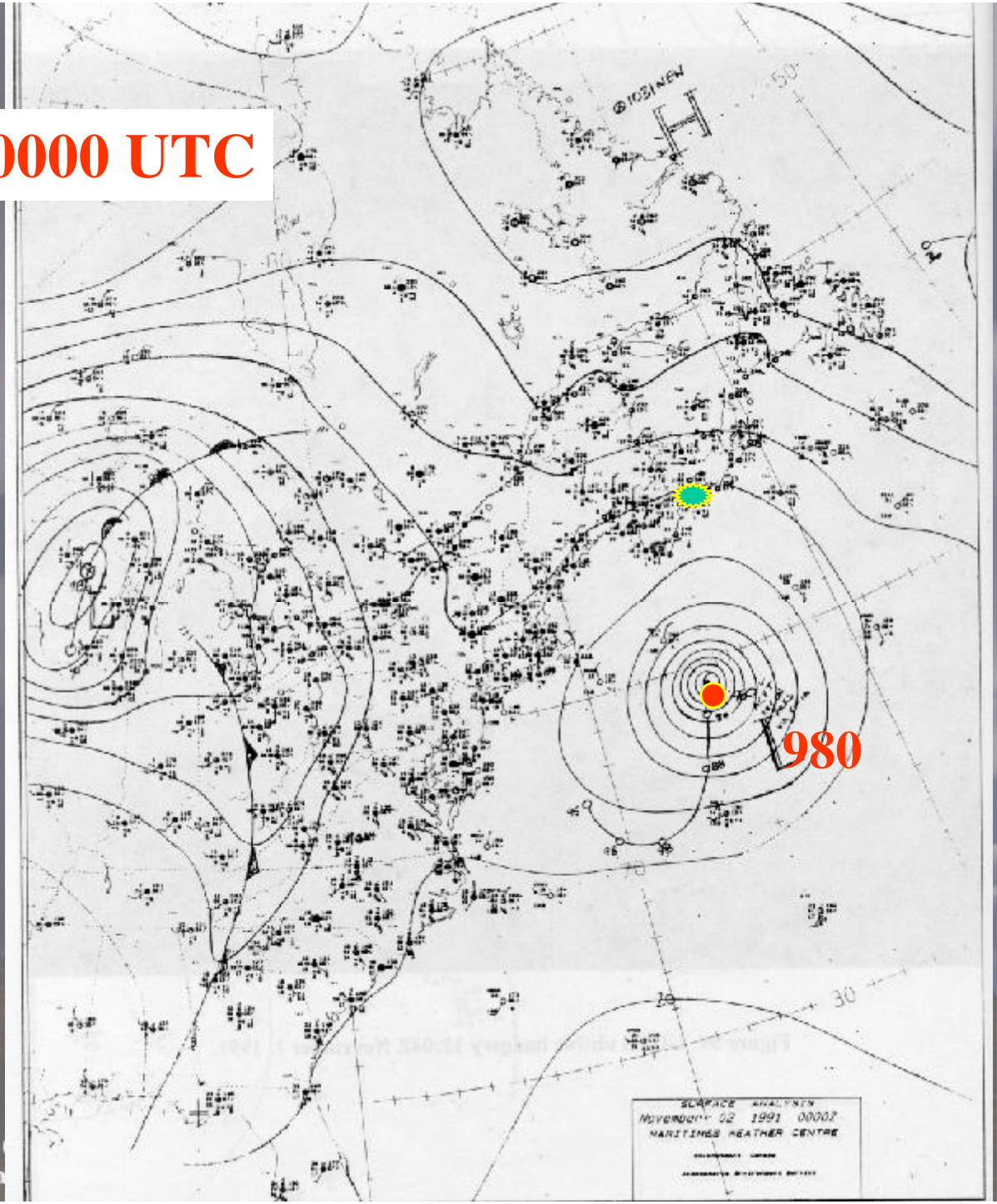
Environnement
Environment Ca

Nov 01 1200 UTC



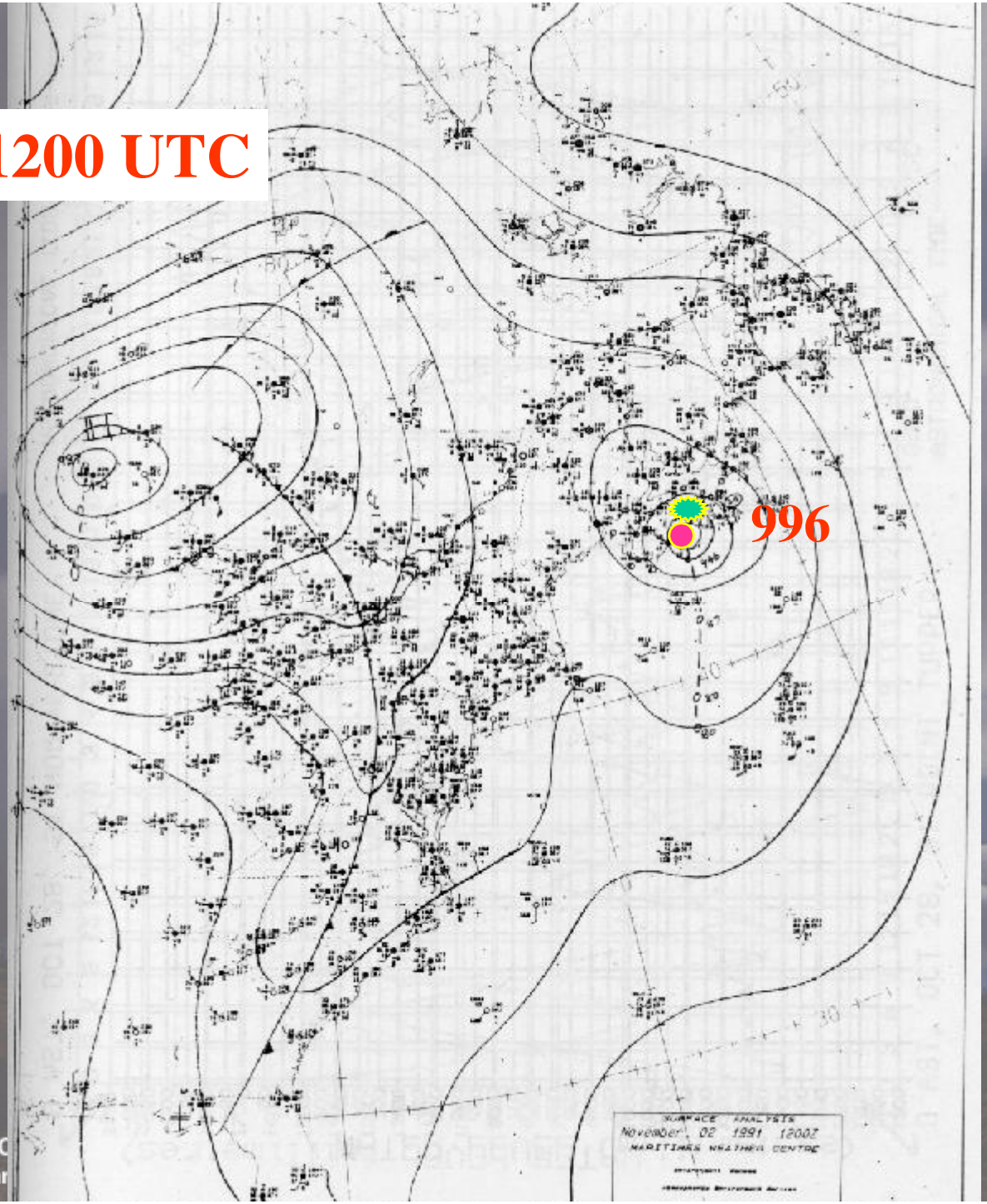
Environnement C
Environment Ca

Nov 02 0000 UTC



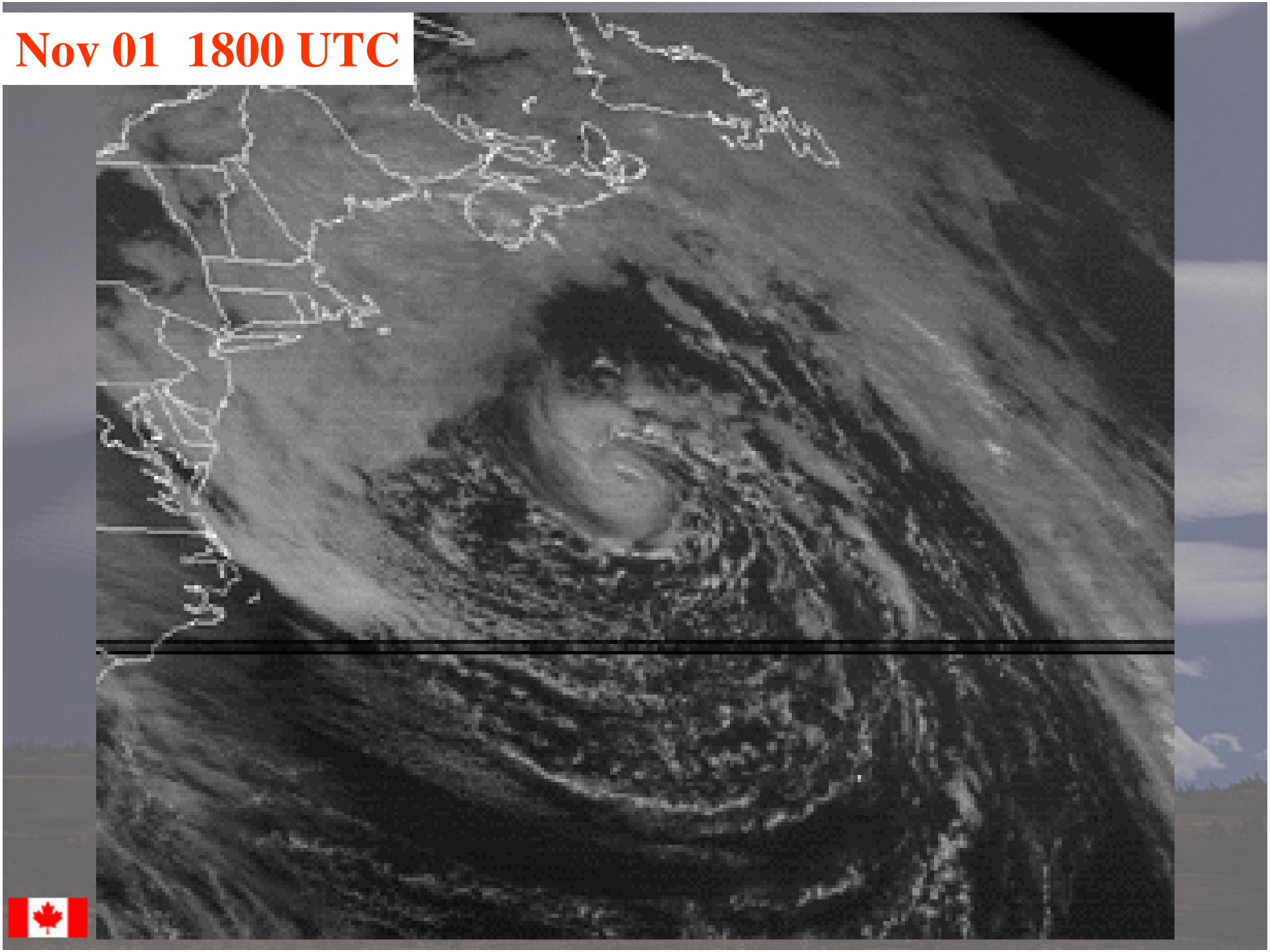
Environnement
Environment Ca

Nov 02 1200 UTC



Environnement C
Environment Ca

Nov 01 1800 UTC



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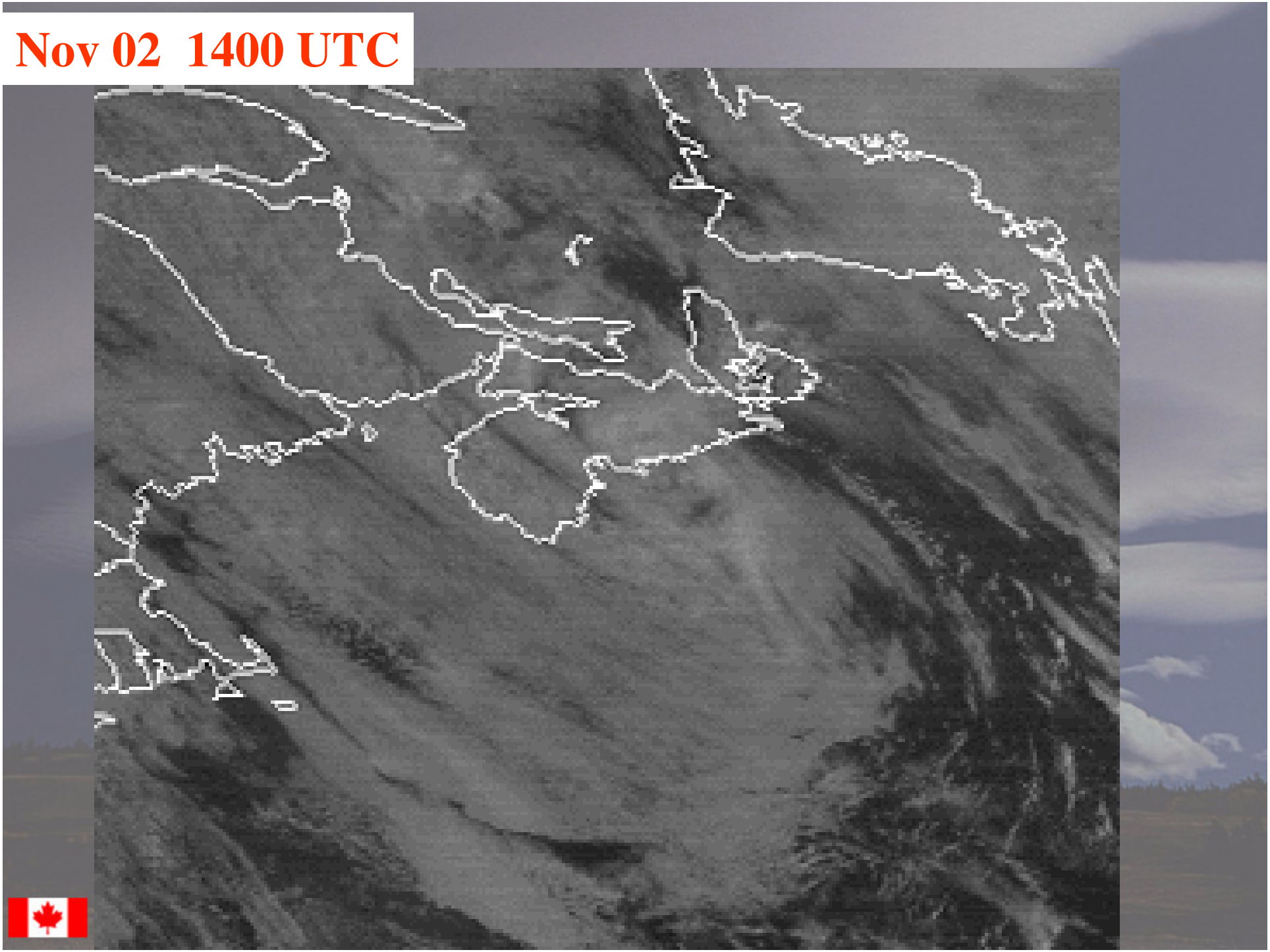
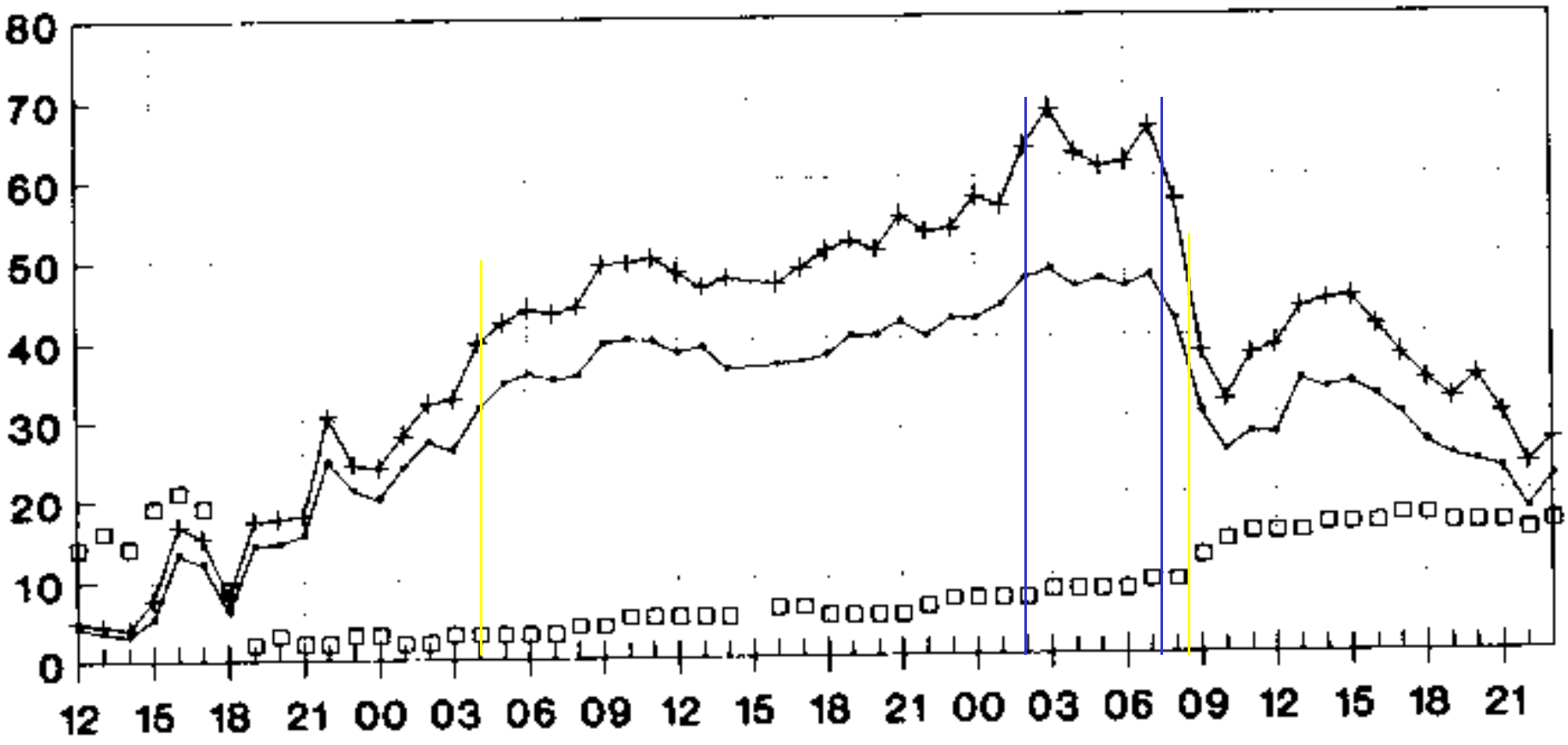
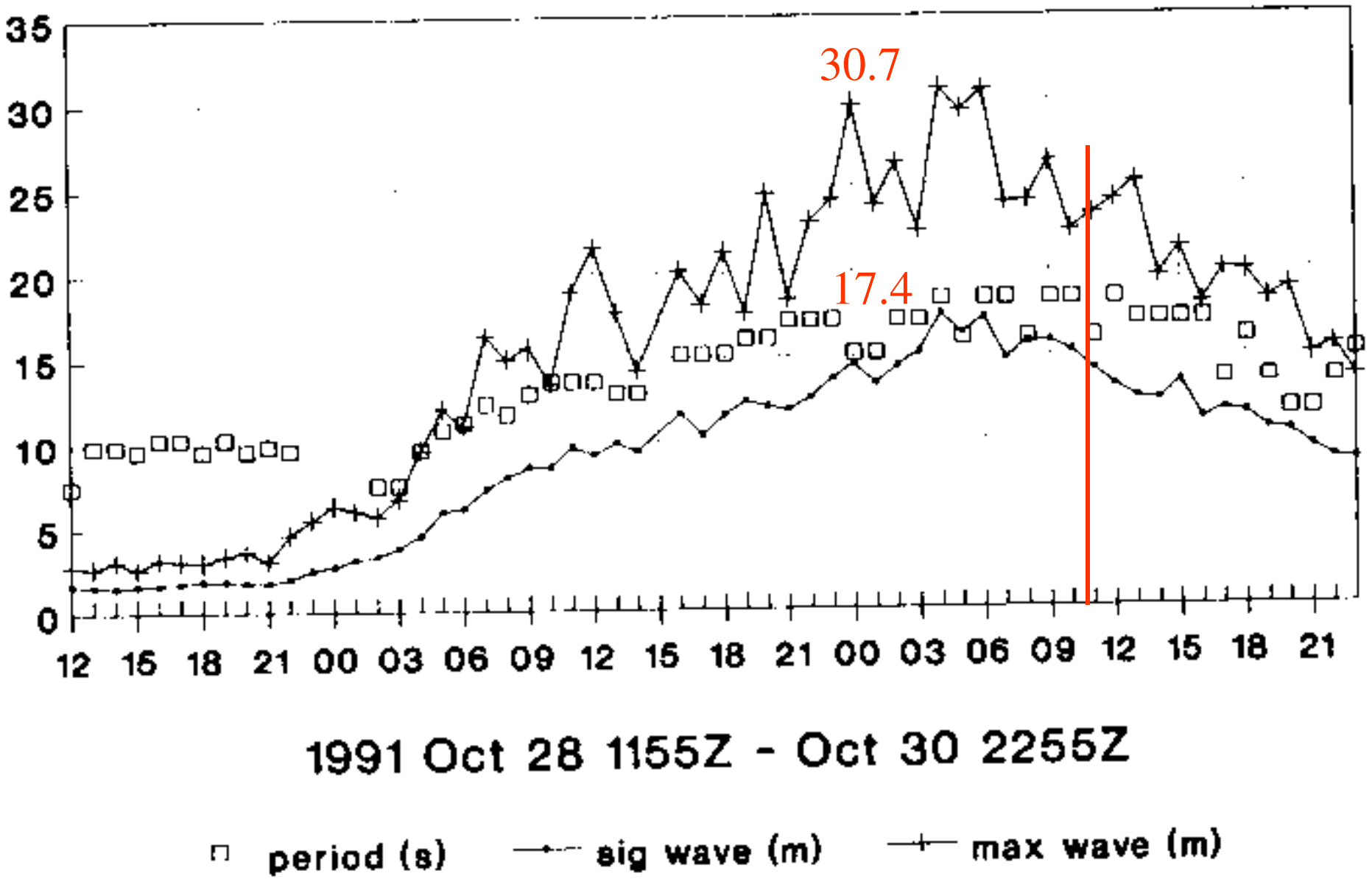


44137 WIND

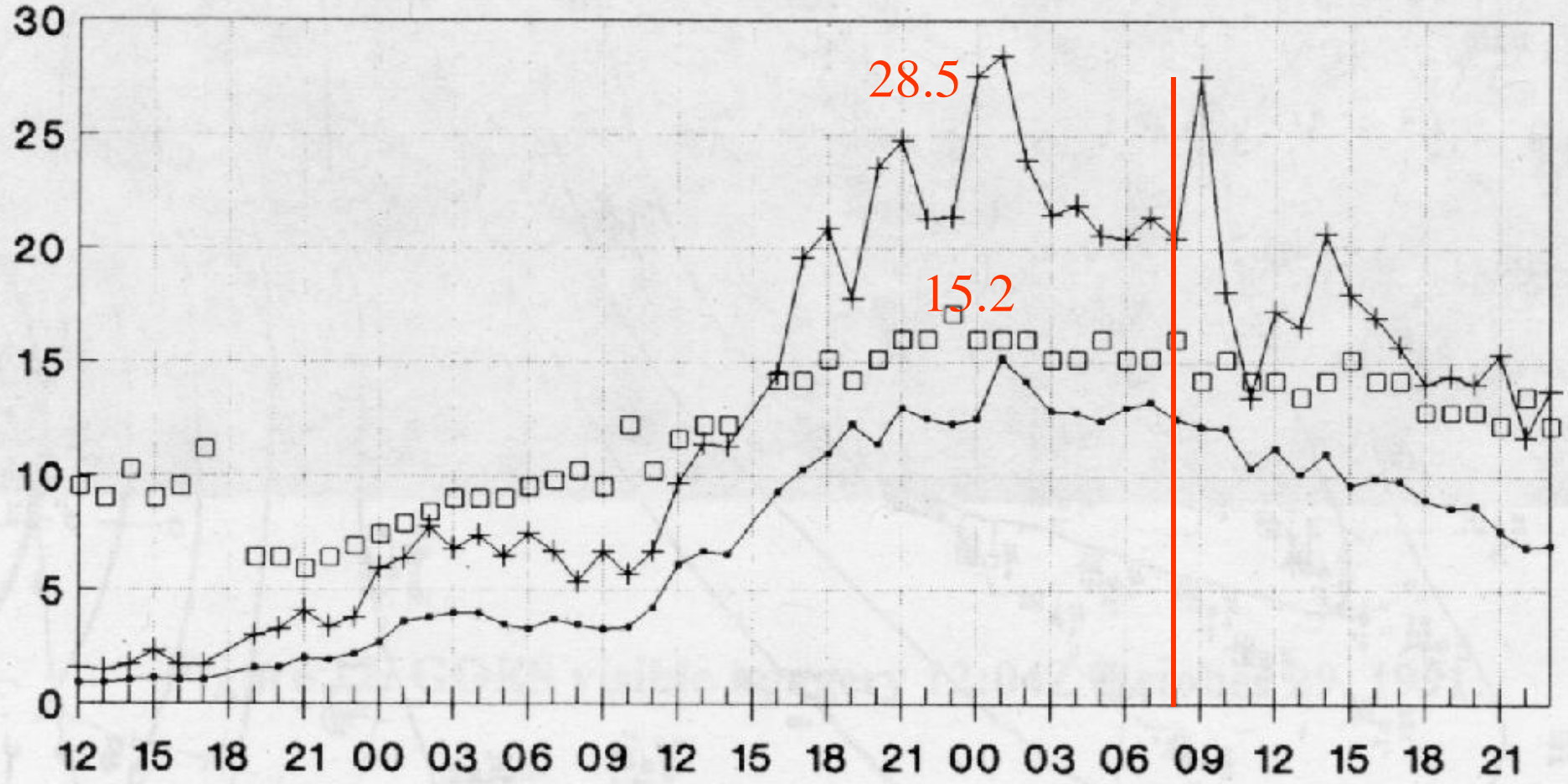


1991 Oct 28 1155Z - Oct 30 2255Z

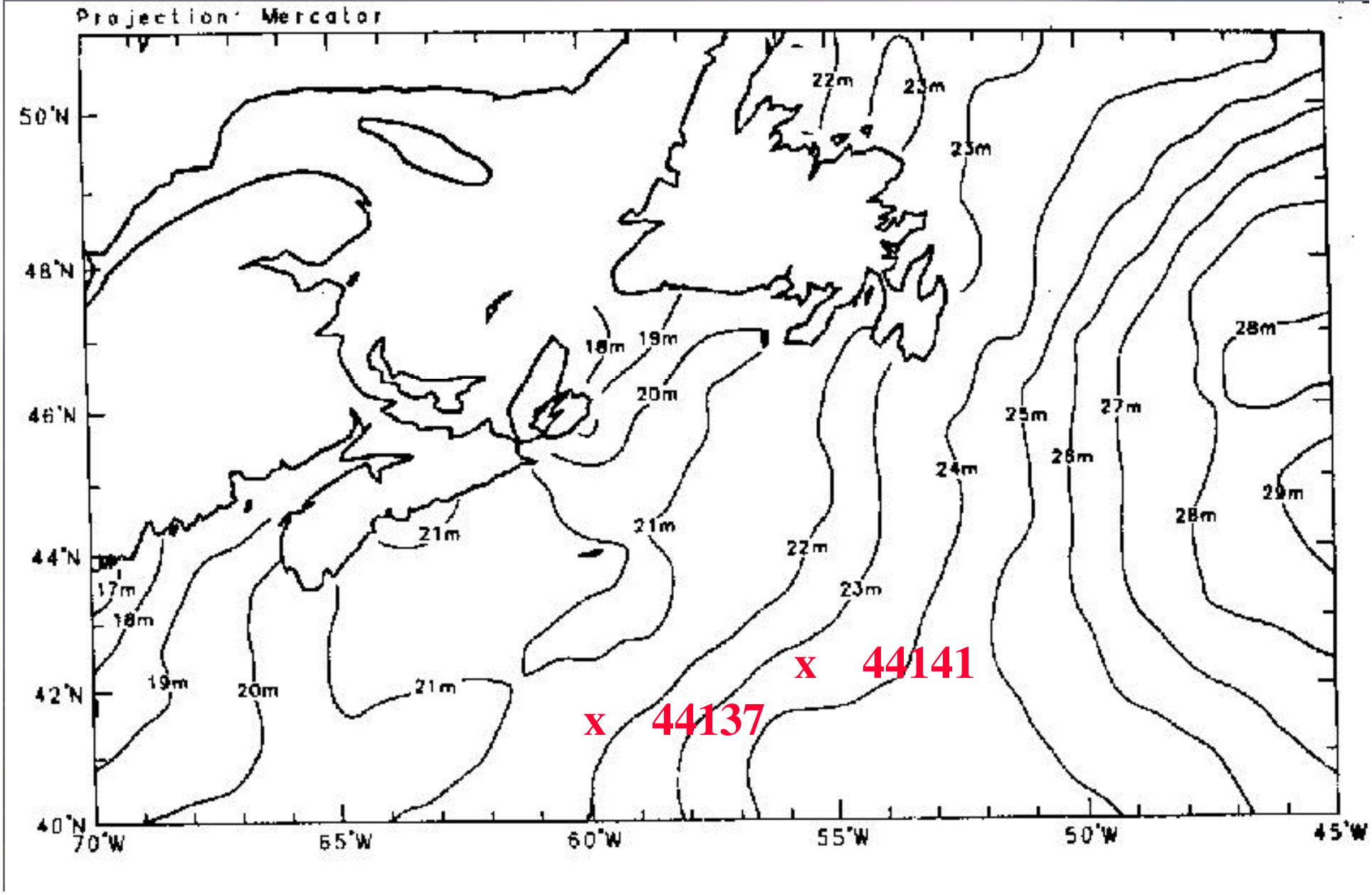
44137 WAVE HEIGHT/PERIOD



44141 WAVE HEIGHT/PERIOD



1991 Oct 28 1155Z - Oct 30 2255Z


Projection: Mercator
50°N
48°N
46°N
44°N
42°N
40°N
70°W
65°W
60°W
55°W
50°W
45°W
17m
18m
19m
20m
21m
22m
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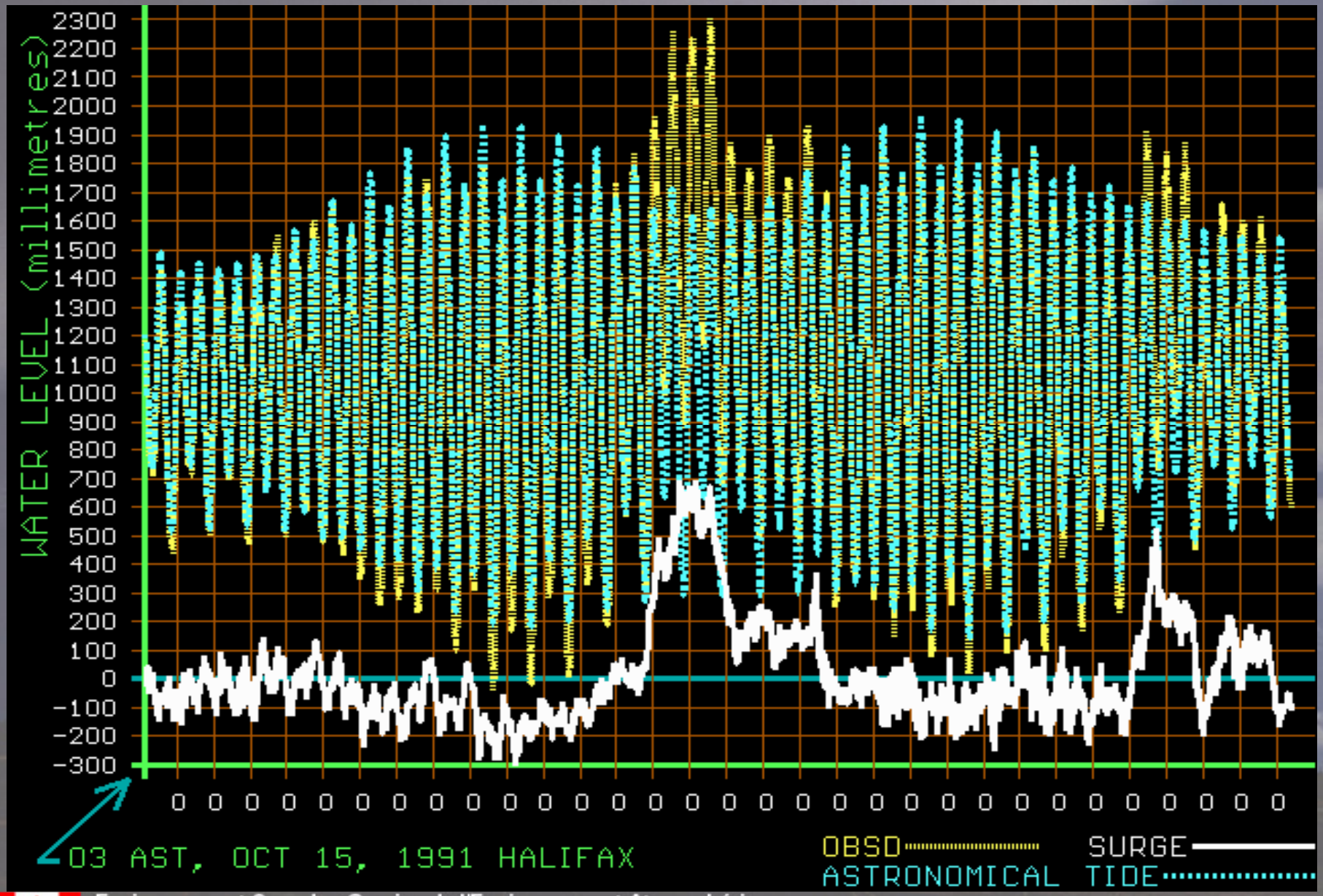
24m
25m
26m
27m
28m
29m
x 44141
x 44137

Halloween Storm - Oct 30 1991



Environnement Canada Service de l'Environnement Atmosphérique
Environment Canada Atmospheric Environment Service

Canadian Weather Research Program

- √ **MSC Leadership**
- √ **Focus/Priorities**
- √ **Partnerships**
- √ **Improved detection, better prediction, & reduced impacts due to summer and winter severe weather**