FORECASTING AIR QUALITY IN THE LOWER FRASER VALLEY OF BRITISH COLUMBIA

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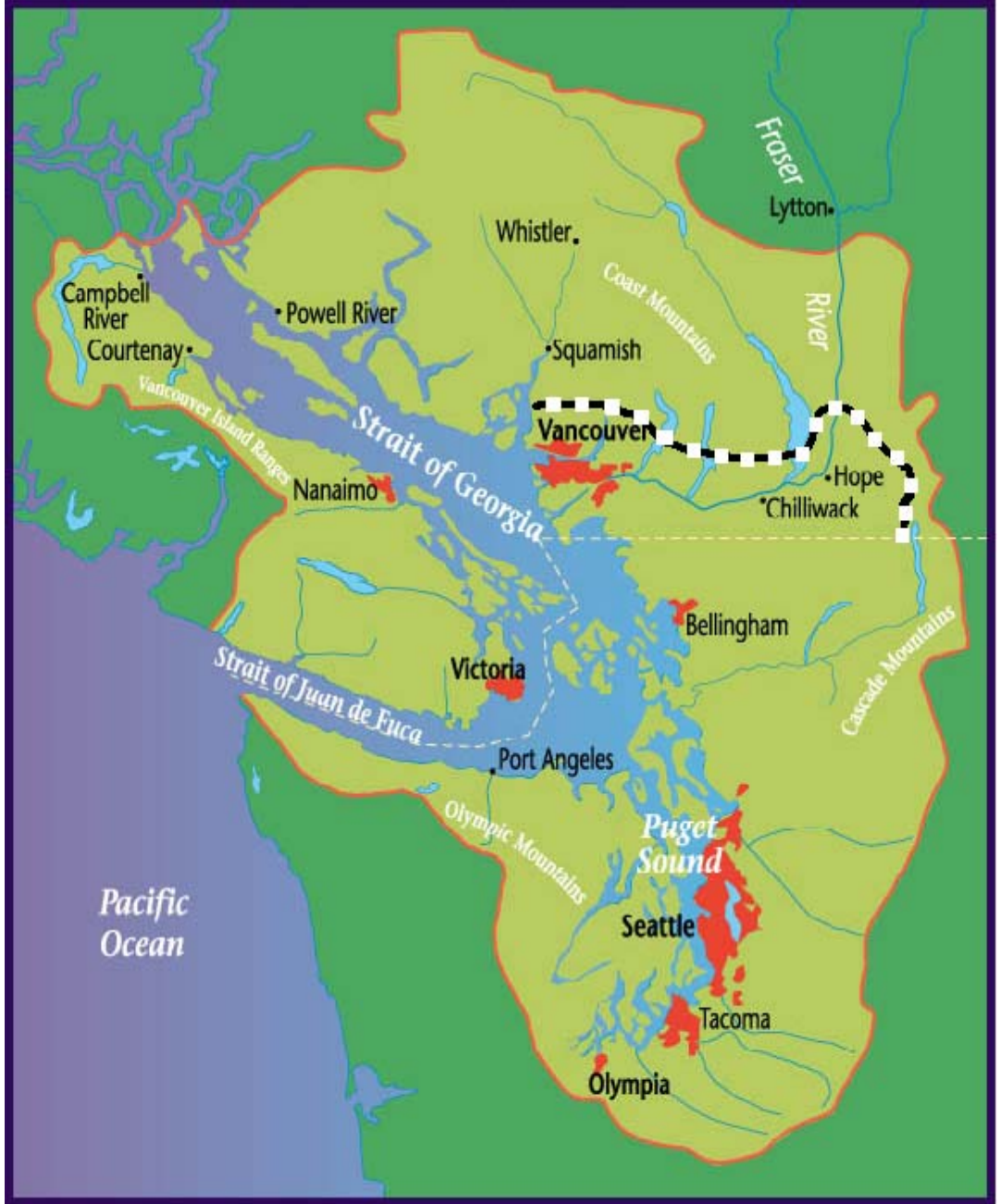
Environment Canada **Environnement Canada**

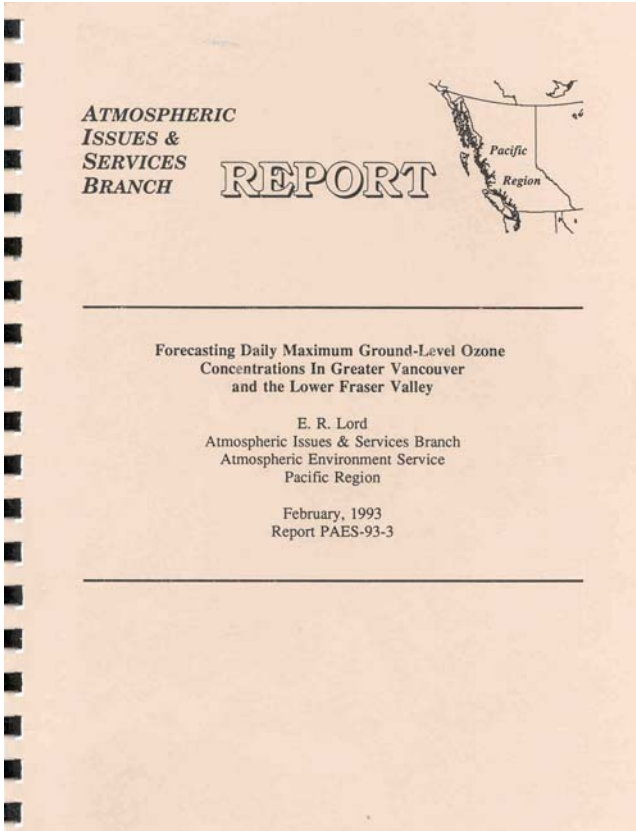
Georgia Basin/Puget Sound



NAAQO FOR OZONE

1-hr Conc. (ppb)	AQI Sub Index	Category
0 - 51	0 - 25	Good
52 – 82	26 – 50	Fair
>82	50 – 100	Poor

HISTORY OF AIR QUALITY FORECASTING IN LFV



ATMOSPHERIC ISSUES & SERVICES BRANCH

REPORT

Pacific Region

Forecasting Daily Maximum Ground-Level Ozone Concentrations In Greater Vancouver and the Lower Fraser Valley

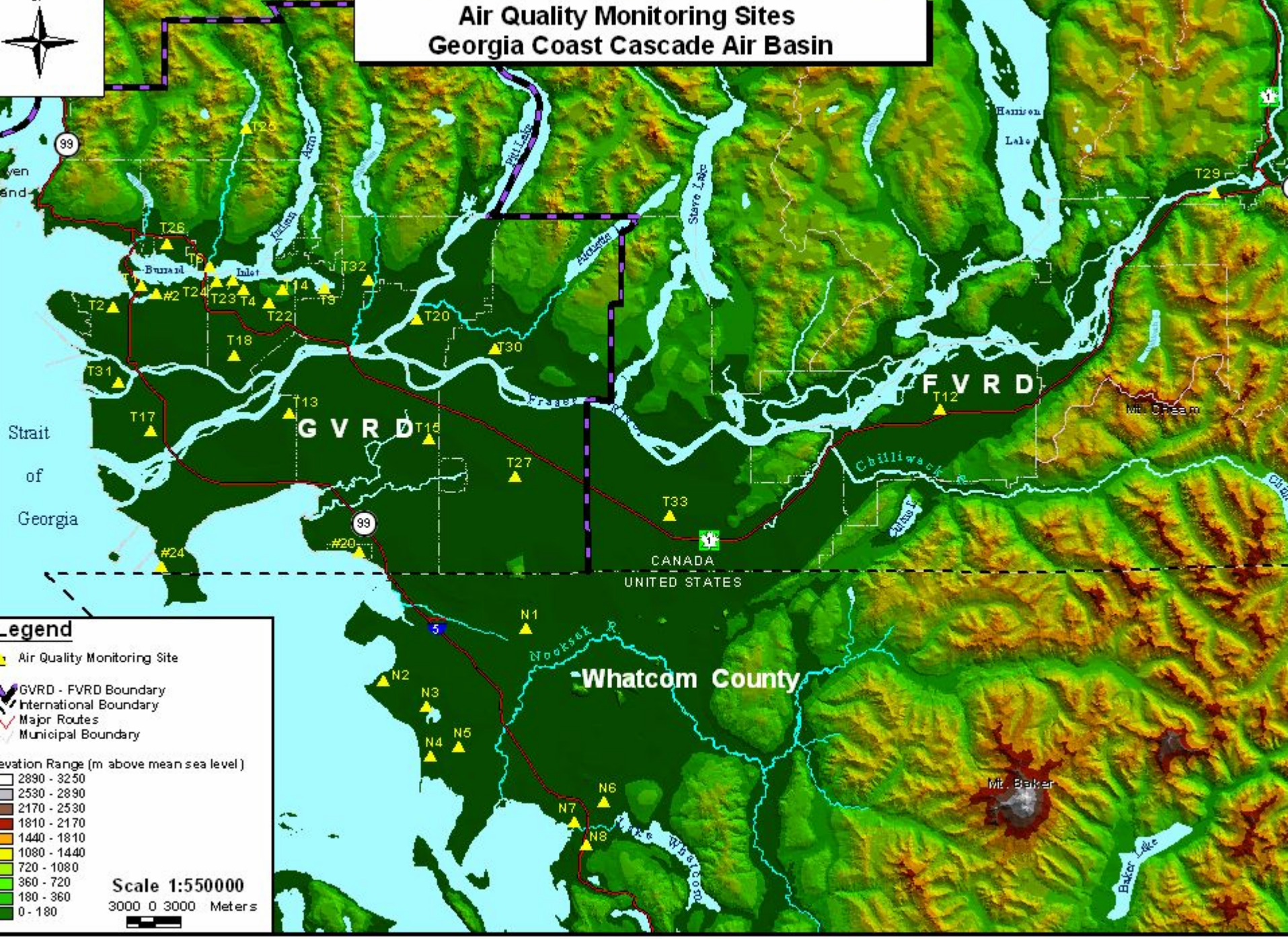
E. R. Lord
Atmospheric Issues & Services Branch
Atmospheric Environment Service
Pacific Region

February, 1993
Report PAES-93-3

- 1992 – ozone forecasting pilot project
- 1993 to 1998 – ozone monitoring and weather support to municipal and provincial agencies for air quality advisory decisions
- 1999 to 2000 – GBEI support for daily ozone forecasts disseminated by e-mail to members of LFV AQCC Monitoring Sub Committee
- 2001 – daily ozone forecast released to public (good, fair, poor)

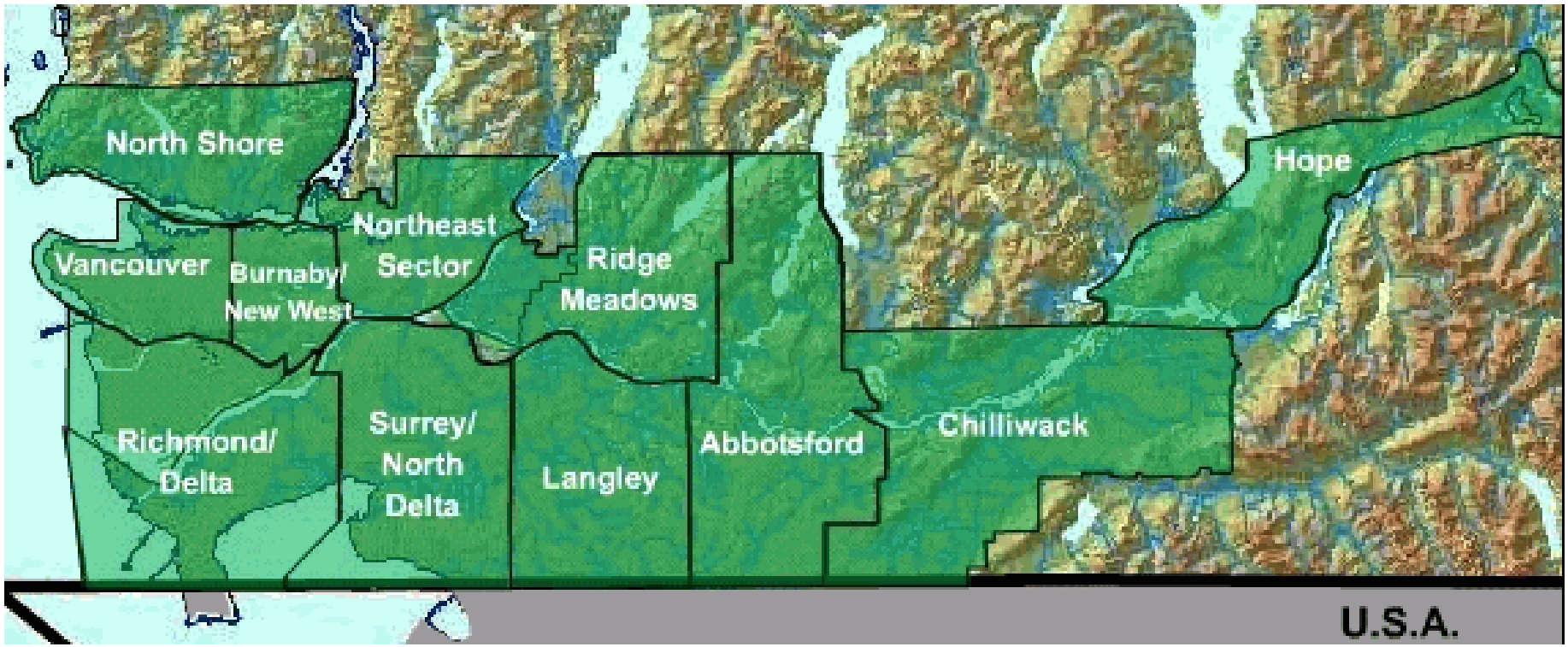
PARTNERSHIPS

GOV'T LEVEL	GOV'T UNIT	ROLE
FEDERAL	EC	Weather Watch; O_3 Prediction
PROVINCIAL	MWLAP	Regulatory AQ Management & Enforcement; AQ Advisories
MUNICIPAL	GVRD FVRD	Monitoring Ambient Air Quality; AQ Advisories



NOTE: Detailed elevation data for the area north of the FVRD was unavailable at the time of map preparation.

REGIONS


North Shore
Vancouver
Burnaby/
New West
Northeast
Sector
Ridge
Meadows
Hope
Richmond/
Delta
Surrey/
North
Delta
Langley
Abbotsford
Chilliwack
U.S.A.

SXCN35 CWVR BULLETIN

SXCN35 CWVR 172309

Facility: GVRD

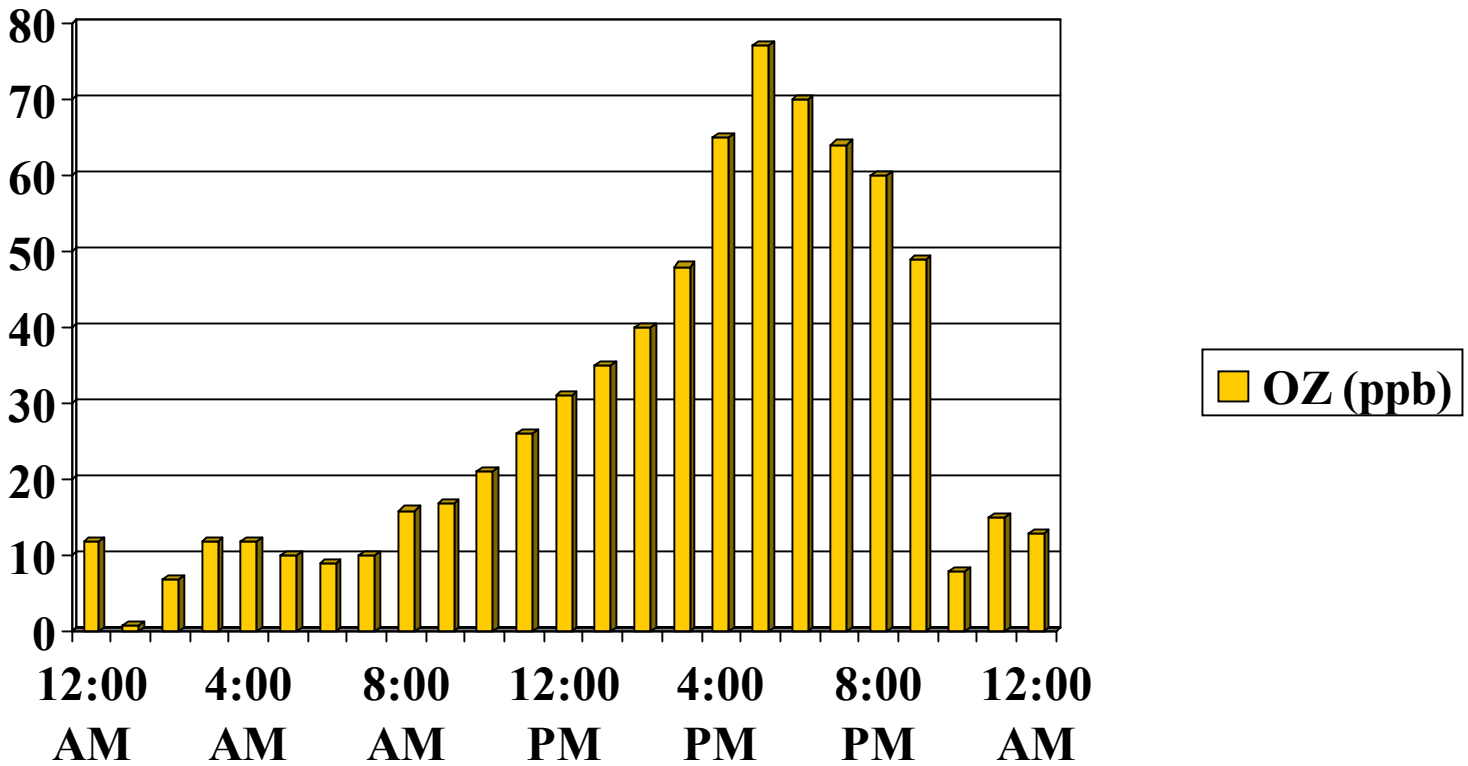
Period: 4th Quarter Hour

Location	DateTime (GMT)	T (CEL)	WD (DEG)	WSS (KPH)	Gust (KPH)	RF (MM)	OZ (PPB)
Robson Square	172300					0.0	2
Kitsilano	172300	5.7	303	003	004	0.0	2
Kensington Park	172300		315	004	007		8
Second Narrows	172300		061	003	008		6
Rocky Point Park	172300	4.9	094	005	007	0.0	3
Chilliwack Airport	172300	4.1	075	003	009		13
North Delta	172300	5.2	290	004	005	0.0	***
Burnaby Mountain	172300	4.0	143	008	010	0.0	12
Surrey East	172300	3.9	018	003	006	0.0	3
Richmond South	172300	4.3	220	003	005		2

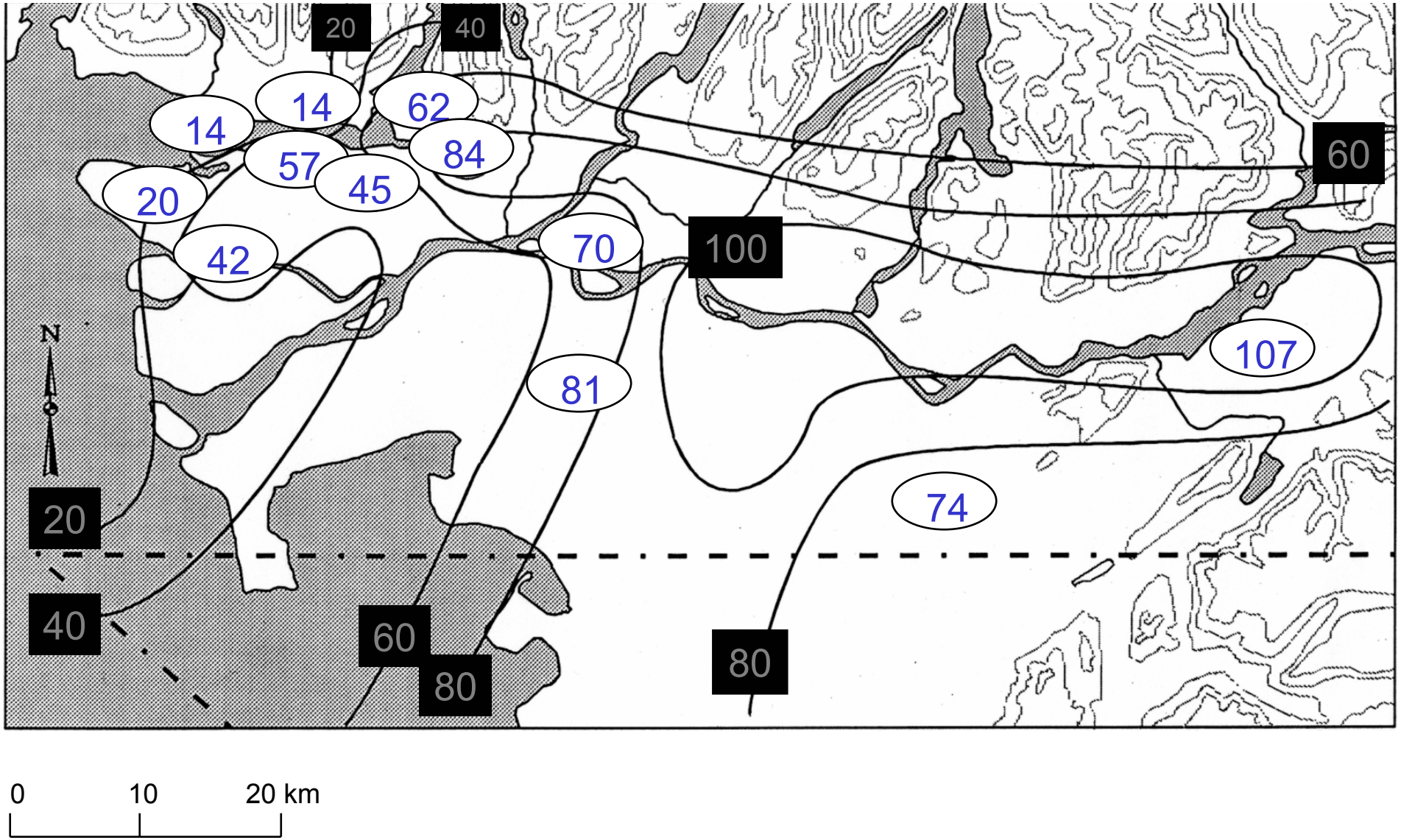
SXCN35 CWVR BULLETIN

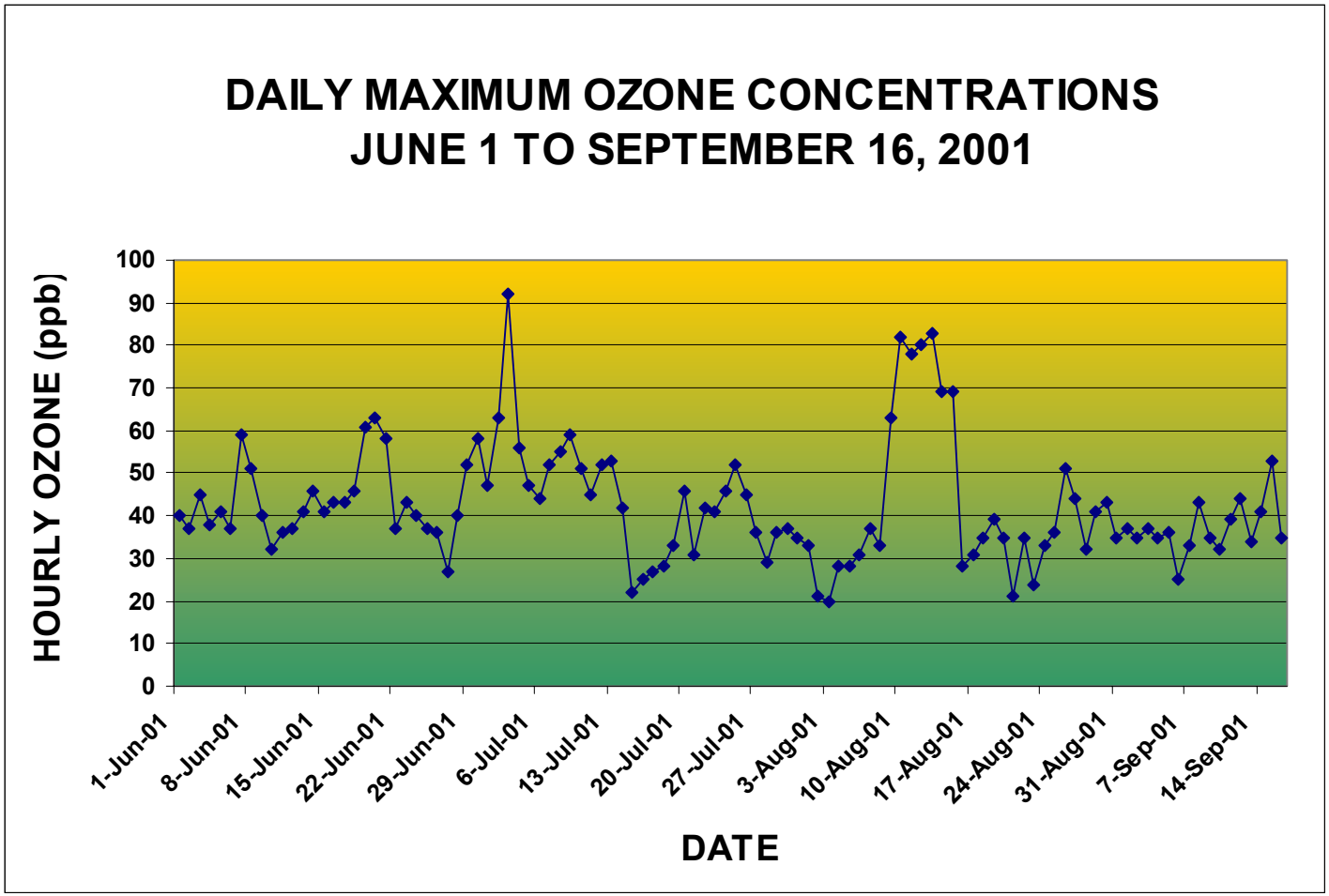
Location	DateTime (GMT)	T (CEL)	WD (DEG)	WSS (KPH)	Gust (KPH)	RF (MM)	OZ (PPB)
Burnaby South	172300	4.8	231	005	006		3
Meadowlands Elementary	172300	4.0	114	002	005		3
Burmount	172300	4.5	125	003	005		
Capitol Hill	172300	3.7	059	005	006		
Burnaby North	172300	5.3	342	002	005		
Mahon Park	172300		231	003	004		2
Langley	172300	4.5	001	001	003	0.0	8
Hope Airport	172300	3.8	104	008	011		10
Golden Ears Elementary	172300	3.5	228	003	008	0.0	3
Vancouver Inter. Airpo	172300	4.8	214	005	008		2
Douglas College	172300		100	004	006		3
Abbotsford	172300	3.6	029	003	005		3
Aldergrove	172300	3.7	031	005	005		

O_3 DIURNAL CYCLE -T12- 27/6/00

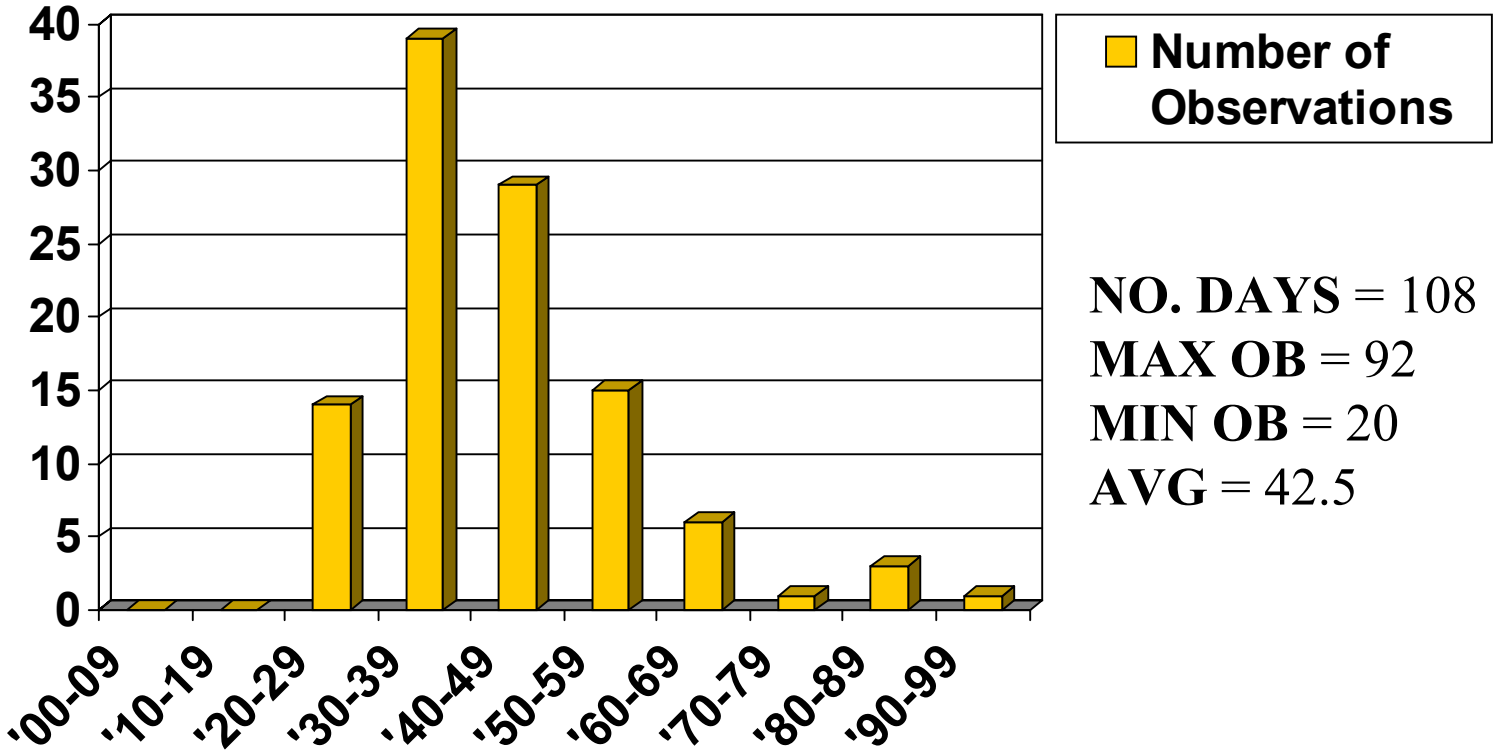


Ozone Concentration Contours (ppb) 4 pm 19 July 1985



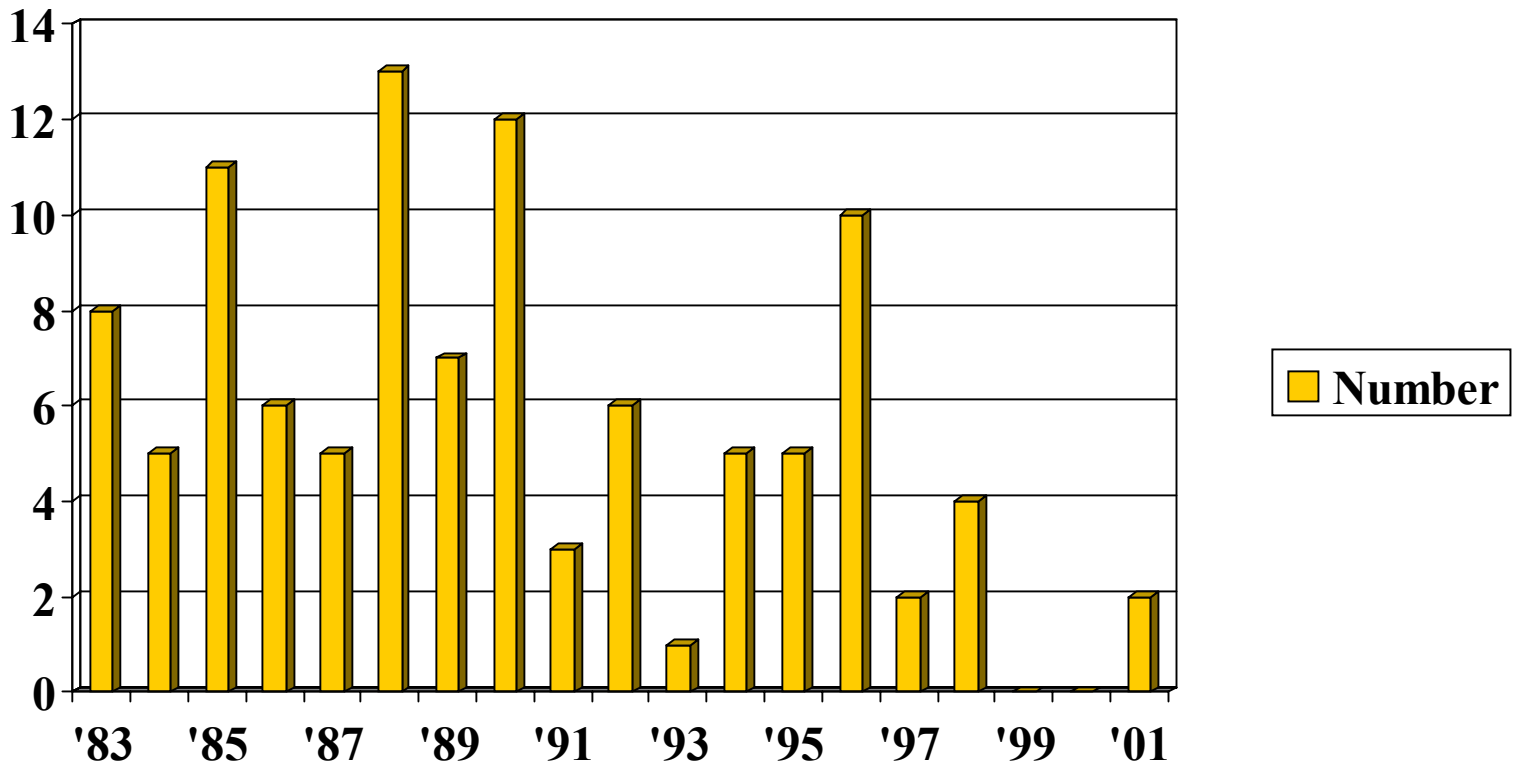

DAILY MAXIMUM OZONE CONCENTRATIONS
JUNE 1 TO SEPTEMBER 16, 2001
HOURLY OZONE (ppb)
100
90
80
70
60
50
40
30
20
10
0
1-Jun-01
8-Jun-01
15-Jun-01
22-Jun-01
29-Jun-01
6-Jul-01
13-Jul-01
20-Jul-01
27-Jul-01
3-Aug-01
10-Aug-01
17-Aug-01
24-Aug-01
31-Aug-01
7-Sep-01
14-Sep-01
DATE

DISTRIBUTION OF DAILY MAX OZONE JUNE 1 TO SEP 16 2001



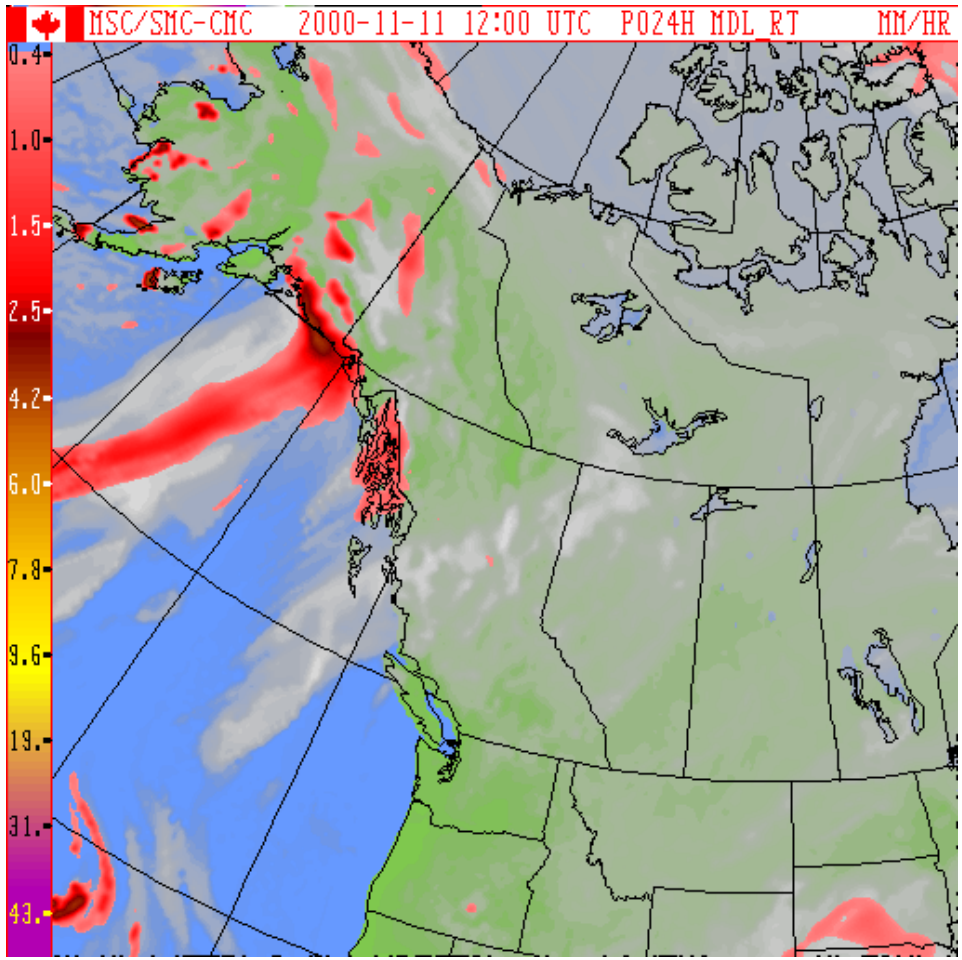
NO. DAYS = 108
MAX OB = 92
MIN OB = 20
AVG = 42.5

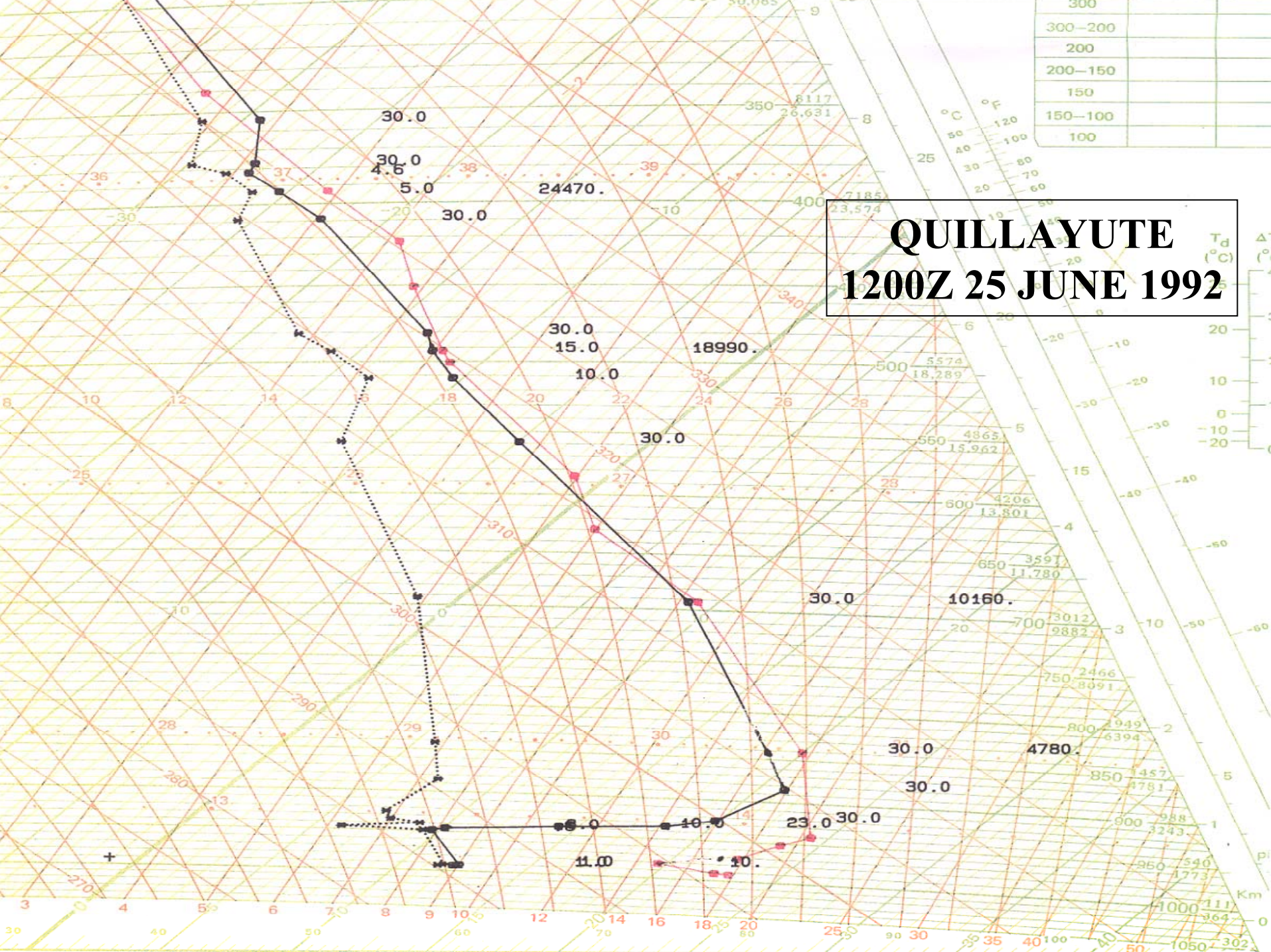
OZONE EXCEEDENCE DAYS 1983 TO 2001



FORECASTING TOOLS

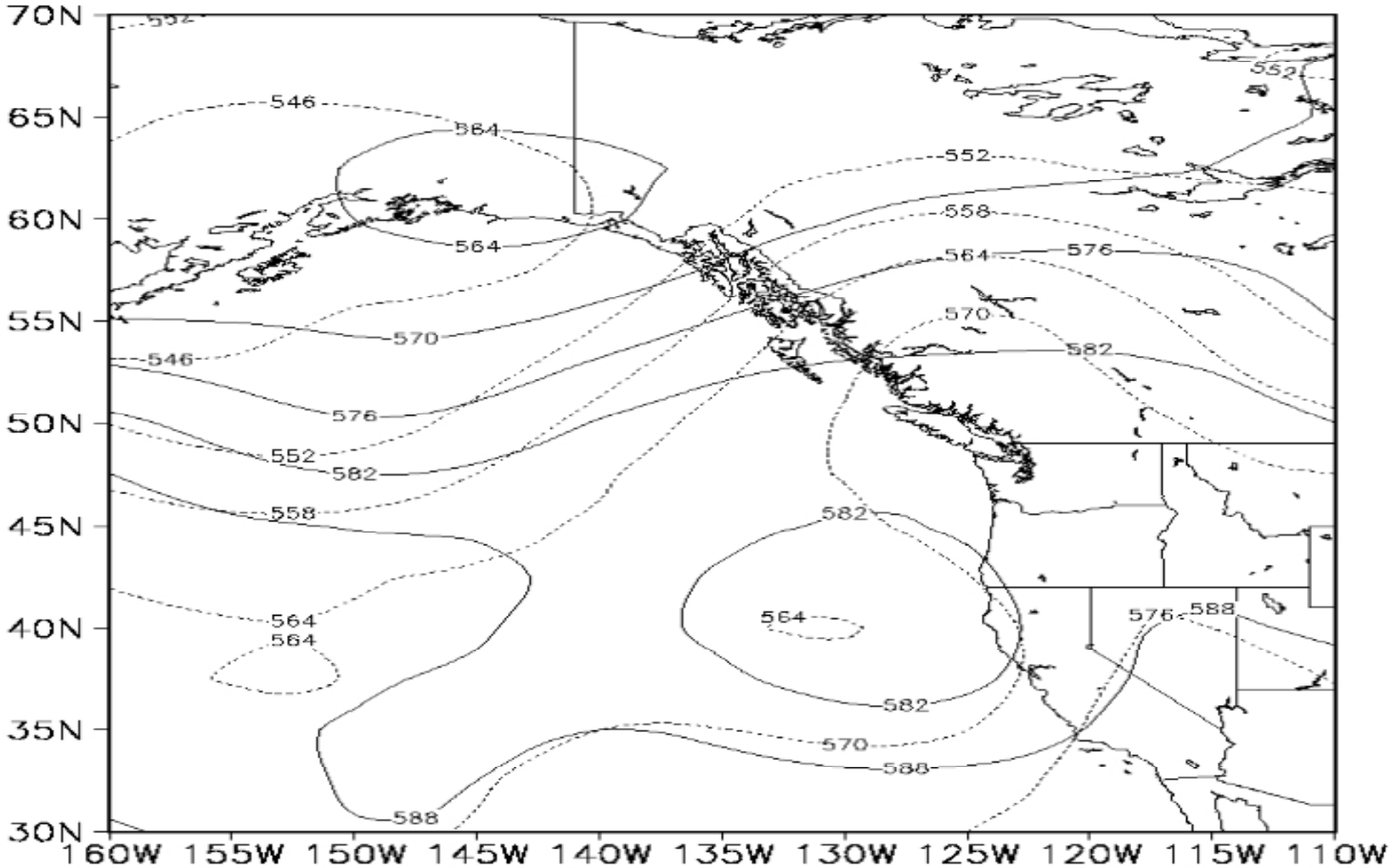
- Knowledge of meteorology in LVF airshed
- Numerical weather prediction
- Pattern recognition
- Statistically based models




QUILLAYUTE
1200Z 25 JUNE 1992
30.0
30.0
4.6
5.0
24470.
30.0
30.0
15.0
18990.
10.0
30.0
30.0
10160.
30.0
4780.
30.0
30.0
23.0
10.0
11.0
10.

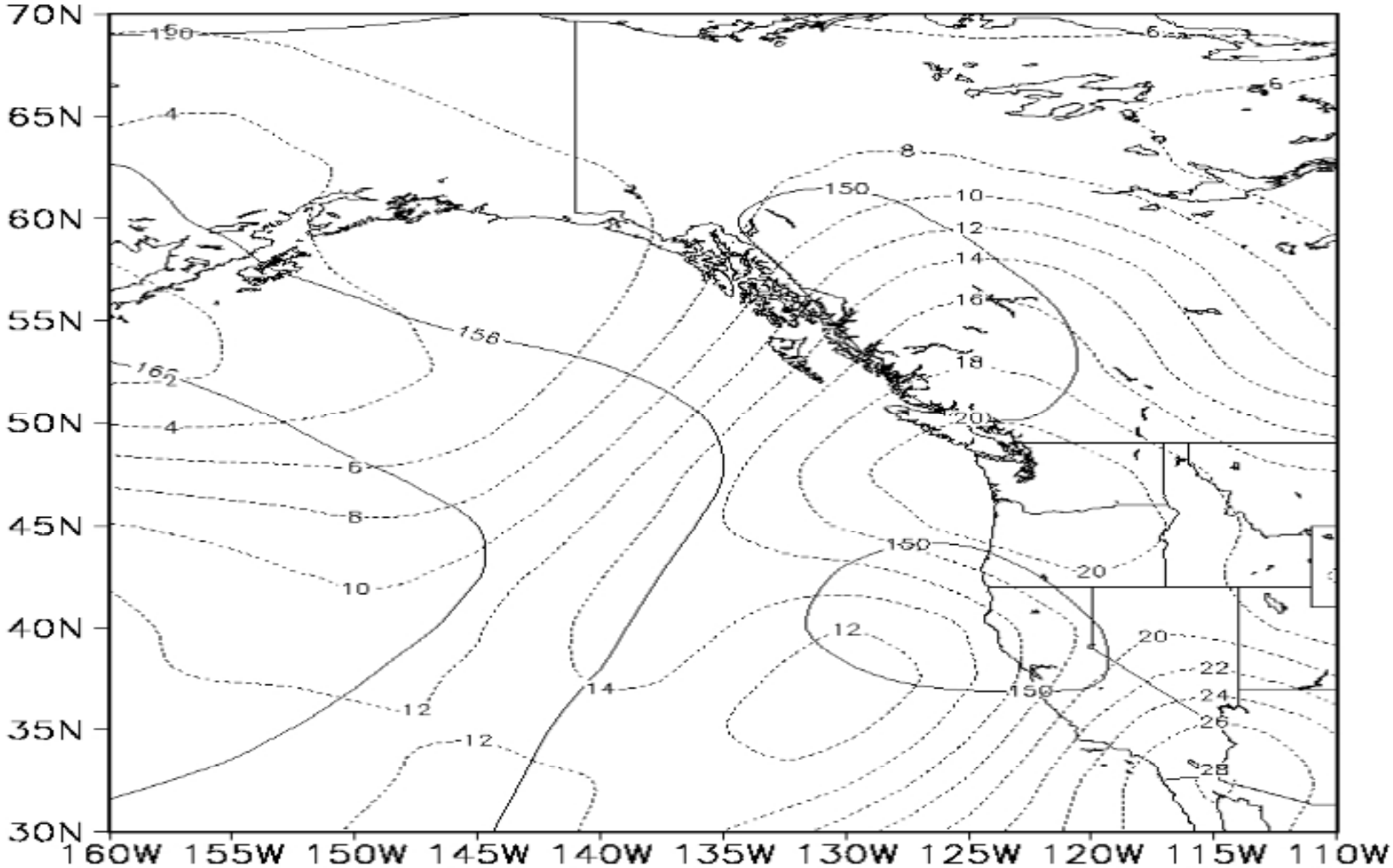
500 mb geopotential height / 1000–500 mb thickness

12Z Jul 29 1998



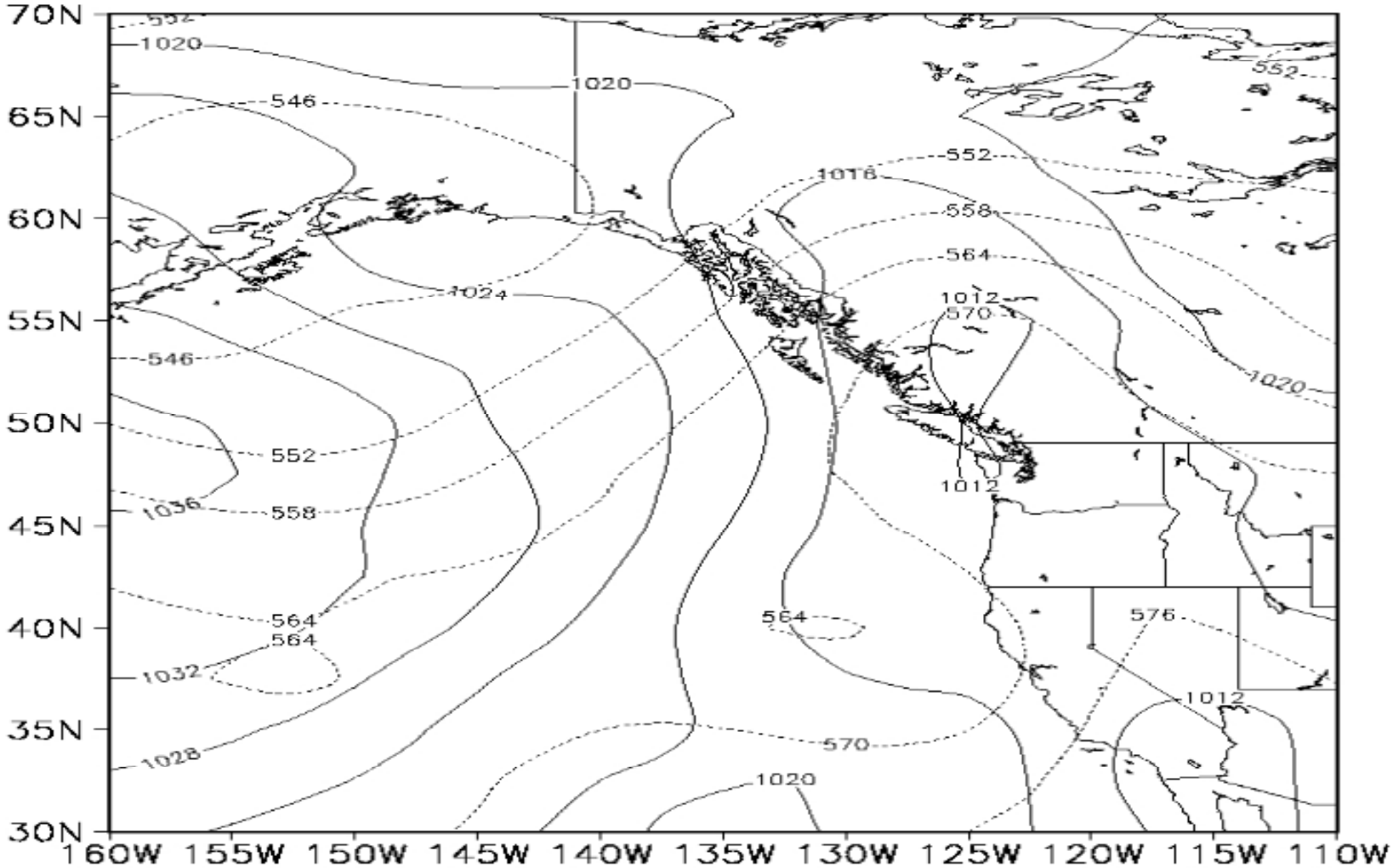
850 mb geopotential height/ 850 mb temperature

12Z Jul 29 1998



Sea level pressure / 1000–500 mb thickness

12Z Jul 29 1998



STATISTICAL MODELS

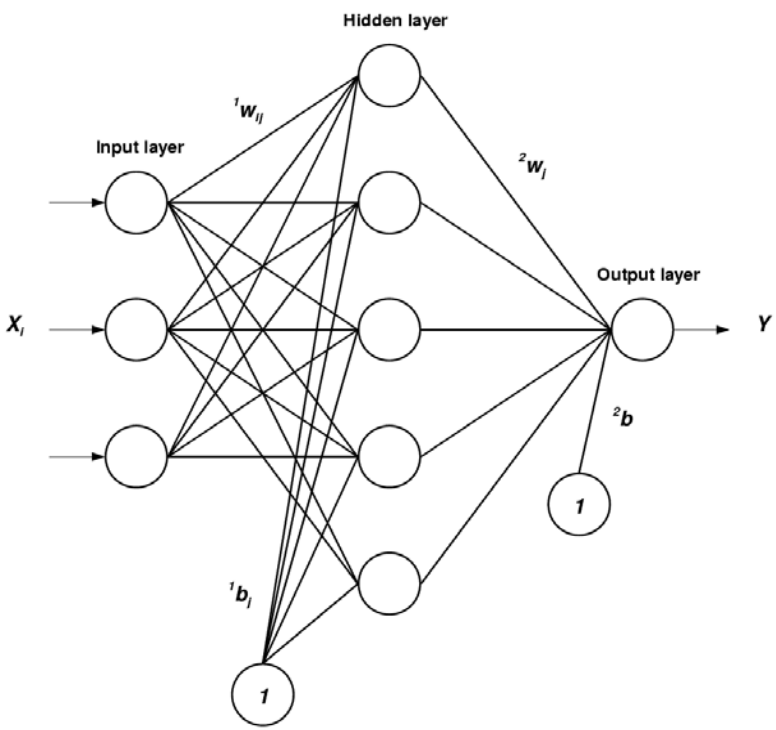
- Lognormal regression (Concord)
- Neural Networks (Cannon and Lord)
  - NNn ensembles for near normal conditions
  - NNx ensembles for above normal conditions

LOGNORMAL REGRESSION EQUATION

$$\text{Log } O_3 = a + b \text{ Log } O_{3ant} + c\,T_{max} + d\,d_r + e\,d_p + f\,J + g\,\frac{J^2}{10000} + h\,T_{850}$$

- O_3 = maximum ozone concentration for station
- O_{3ant} = antecedent maximum ozone concentration at station
- T_{max} = forecast maximum temperature for YVR or YXX
- δ_r = yes/no precipitation forecast for YVR or YXX
- δ_p = inflow/outflow forecast for LFV
- J = Julian day number
- $J^2/10^4$ = second julian day variable
- T_{850} = 850 hPa temperature forecast at YVR or YXX

ARTIFICIAL NEURAL NETWORKS



- 7 inputs (O_{3ant}, T_{max}, δ_r, δ_p, J, $J^2/10^4$, and T_{850})
- 50 neurons in hidden layer
- 1 output (max ozone)
- NNn model
  - 50 multilayer perceptrons
  - Trained on 6 years of station data
- NNx model
  - 50 multilayer perceptrons
  - Trained on 6 years of station data using histogram equalization

MODEL INPUT FORM

```
T001) ANTECEDENT 1-HR MAX OZONE AT ROBSON SQUARE (PPB).......: 40
T002) ANTECEDENT 1-HR MAX OZONE AT KITSILANO (PPB)...........: 47
T004) ANTECEDENT 1-HR MAX OZONE AT KENSINGTON PARK (PPB).....: 51
T006) ANTECEDENT 1-HR MAX OZONE AT SECOND NARROWS (PPB)......: 57
T009) ANTECEDENT 1-HR MAX OZONE AT ROCKY POINT PARK (PPB)....: 62
T012) ANTECEDENT 1-HR MAX OZONE AT CHILLIWACK (PPB)..........: 80
T013) ANTECEDENT 1-HR MAX OZONE AT NORTH DELTA (PPB).........: 53
T014) ANTECEDENT 1-HR MAX OZONE AT BURNABY MOUNTAIN (PPB)....: 71
T015) ANTECEDENT 1-HR MAX OZONE AT SURREY EAST (PPB).........: 62
T017) ANTECEDENT 1-HR MAX OZONE AT RICHMOND SOUTH (PPB)......: 60
T018) ANTECEDENT 1-HR MAX OZONE AT BURNABY SOUTH (PPB).......: 57
T020) ANTECEDENT 1-HR MAX OZONE AT MEADOWLANDS (PPB).........: 65
T026) ANTECEDENT 1-HR MAX OZONE AT MAHON PARK (PPB)..........: 66
T027) ANTECEDENT 1-HR MAX OZONE AT LANGLEY (PPB).............: 65
T029) ANTECEDENT 1-HR MAX OZONE AT HOPE AIRPORT (PPB)........: 82
T030) ANTECEDENT 1-HR MAX OZONE AT GOLDEN EARS (PPB).........: 67
T031) ANTECEDENT 1-HR MAX OZONE AT VANCOUVER AIRPORT (PPB)...: 37
T033) ANTECEDENT 1-HR MAX OZONE AT ABBOTSFORD (PPB)..........: 69
V001) FORECAST JULIAN DAY....................................: 224.0
V002) FORECAST MAX SURFACE TEMP AT YVR (DEG C)...............: 23.0
V003) FORECAST AFTERNOON 00Z 850 HPA TEMP AT YVR (DEG C).....: 19.0
V004) FORECAST POP AT YVR > 50? (Y/N)........................: n
V005) FORECAST MAX SURFACE TEMP AT YXX (DEG C)...............: 29.0
V006) FORECAST AFTERNOON 00Z 850 HPA TEMP AT YXX (DEG C).....: 20.0
V007) FORECAST POP AT YXX > 50? (Y/N)........................: n
V008) FORECAST MORNING 12Z SLP AT YVR >= SLP AT YHE? (Y/N)...: y
```

MODEL OUTPUTS

STN	NAME	REGION	LNR	NNn AVG	NNn std	PROB GOOD	PROB FAIR	PROB POOR	NNx AVG	NNx std	PROB GOOD	PROB FAIR	PROB POOR
T001	ROBSON SQUARE	VANCOUVER	22	23	2	100	0	0	29	7	100	0	0
T002	KITSILANO	VANCOUVER	40	44	4	94	6	0	42	7	92	8	0
T006	SECOND NARROWS	NORTH SHORE	30	35	3	100	0	0	42	6	90	10	0
T026	MAHON PARK	NORTH SHORE	41	49	4	64	36	0	47	8	68	32	0
T017	RICHMOND SOUTH	RICHMOND/DELTA	36	38	4	100	0	0	46	10	76	24	0
T031	VANCOUVER AIRPORT	RICHMOND/DELTA	34	41	5	94	6	0	48	9	64	36	0
T004	KENSINGTON PARK	BURNABY/NEW WEST	33	36	3	100	0	0	46	8	76	24	0
T014	BURNABY MOUNTAIN	BURNABY/NEW WEST	43	50	3	64	36	0	58	6	10	90	0
T018	BURNABY SOUTH	BURNABY/NEW WEST	31	34	2	100	0	0	36	7	100	0	0
T009	ROCKY POINT PARK	NORTHEAST SECTOR	43	52	3	34	66	0	58	5	8	92	0
T013	NORTH DELTA	SURREY/NORTH DEL	32	36	2	100	0	0	36	6	100	0	0
T015	SURREY EAST	SURREY/NORTH DEL	52	53	4	32	68	0	52	9	48	52	0
T020	MEADOWLANDS	RIDGE MEADOWS	46	49	3	78	22	0	46	7	80	20	0
T030	GOLDEN EARS	RIDGE MEADOWS	54	54	7	26	74	0	40	6	94	6	0
T027	LANGLEY	LANGLEY	53	54	4	22	78	0	58	7	14	86	0
T033	ABBOTSFORD	ABBOTSFORD	47	51	4	44	56	0	47	8	70	30	0
T012	CHILLIWACK	CHILLIWACK	48	54	3	16	84	0	62	4	0	100	0
T029	HOPE AIRPORT	HOPE	54	60	4	0	100	0	74	4	0	98	2
RGNL	MAX	REGIONAL MAX	62	64	4	0	100	0	71	4	0	100	0

EXAMPLE FORECAST

FLCN40 CWVR 141200

GROUND-LEVEL OZONE FORECAST FOR GREATER VANCOUVER AND THE LOWER FRASER VALLEY ISSUED AT 6 AM PDT TUESDAY 14 AUGUST 2001 FOR TODAY AND WEDNESDAY. FORECAST ISSUED JOINTLY BY THE PACIFIC WEATHER CENTRE OF ENVIRONMENT CANADA AND THE GREATER VANCOUVER REGIONAL DISTRICT AND THE B.C. MINISTRY OF WATER LANDS AND AIR PROTECTION. THE NEXT SCHEDULED FORECAST WILL BE ISSUED AT 4 PM TODAY.

AN AIR QUALITY ADVISORY IS IN EFFECT FOR THE GREATER VANCOUVER REGIONAL DISTRICT AND THE LOWER FRASER VALLEY FOR TODAY AND WEDNESDAY.

REGIONAL FORECASTS.

	TODAY	WEDNESDAY
VANCOUVER	GOOD	GOOD
NORTH SHORE	GOOD	GOOD
RICHMOND/DELTA	GOOD	GOOD
BURNABY/NEW WESTMINSTER	FAIR	FAIR
NORTHEAST SECTOR	FAIR	FAIR
SURREY/NORTH DELTA	FAIR	FAIR
RIDGE MEADOWS	FAIR	FAIR
LANGLEY	FAIR	FAIR
ABBOTSFORD	FAIR	FAIR
CHILLIWACK	FAIR	FAIR
HOPE	FAIR	FAIR

GROUND-LEVEL OZONE CATEGORIES OF 'GOOD', 'FAIR', 'POOR' CORRESPOND TO AIR QUALITY SUB-INDEX RANGES OF 0-25, 26-50 AND >50 RESPECTIVELY. GROUND-LEVEL OZONE LEVELS NORMALLY DROP TO GOOD AFTER SUNSET.

"ADVERSE HEALTH EFFECTS INCREASE AS AIR QUALITY DETERIORATES."

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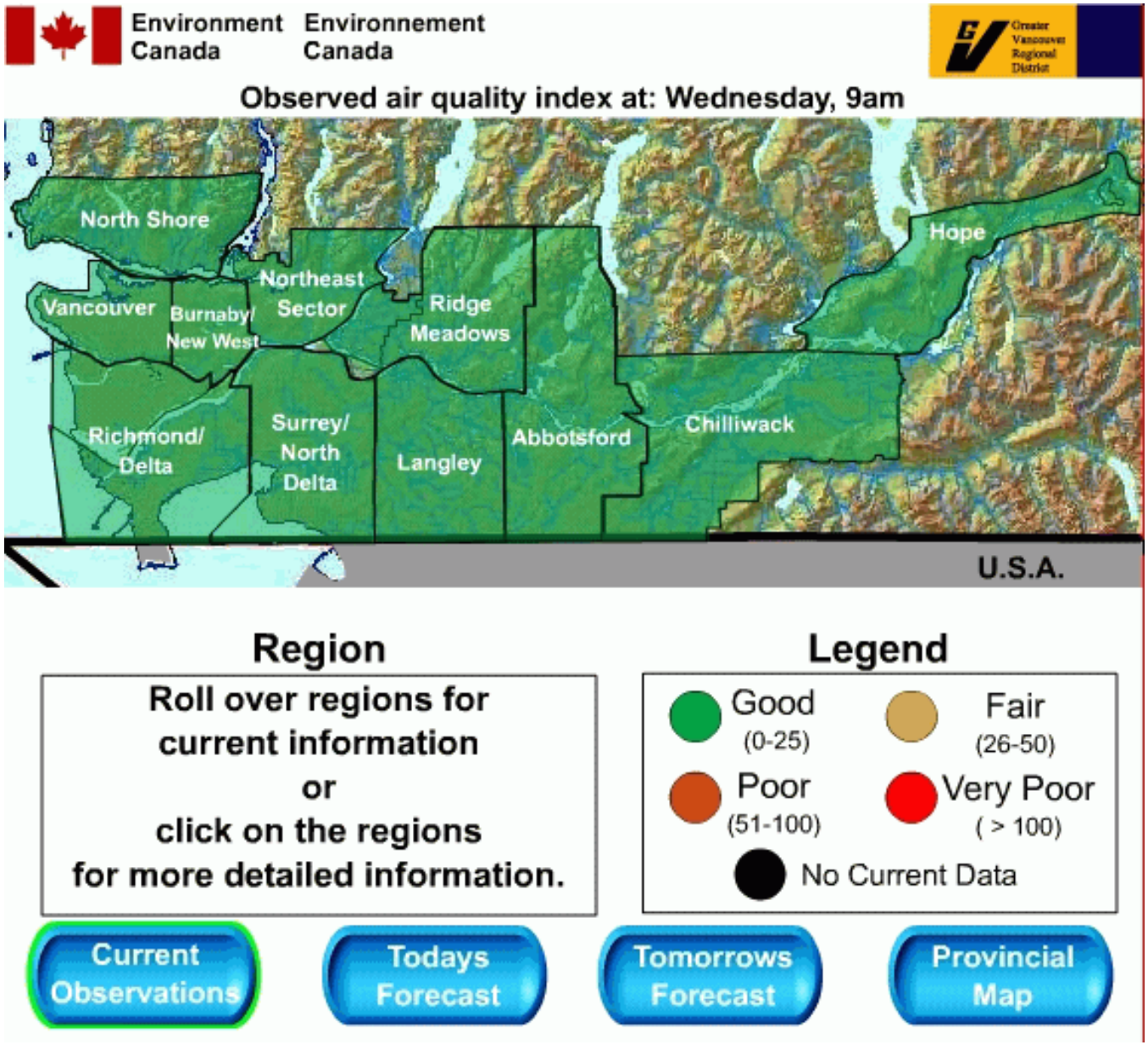
END/RN

www.weatheroffice.pyr.ec.gc.ca/wxhealth/airquality



FORECAST VERIFICATION

			FCST		
		GOOD	***FAIR***	***POOR***	***TOTAL***
	GOOD	1051	32	0	1083
OBS	**FAIR**	46	56	0	102
	POOR	0	3	0	3
	TOTAL	1097	91	0	1188

	GOOD	***FAIR***	***POOR***
BIAS	1.013	0.892	0.000
POD	0.970	0.549	0.000
FAR	0.042	0.385	-

MODEL	**#COR**	**SKILL**
PWC	1107	-
CHC	1008	0.550
GOOD	1083	0.228
PER	1095	0.129
LNR	1106	0.012
NNn	1111	-0.052
NNx	1046*	0.110*
ENS	1115	-0.110

FUTURE PLANS

- Incorporate approved H/E/A messages
- Forecast AQI numbers not categories
- Improve dissemination of forecasts
- Expand forecast program to other regions in PYR – Kamloops and Kelowna May 2002
- Build models for daily maximum 24-hr average PM_{10} and $PM_{2.5}$ for sites in LFV – 2002/03
- Combine O_3 and PM forecasting into a numerical AQI forecast - 2003