THE AIR QUALITY PREDICTION PROGRAM IN BRITISH COLUMBIA

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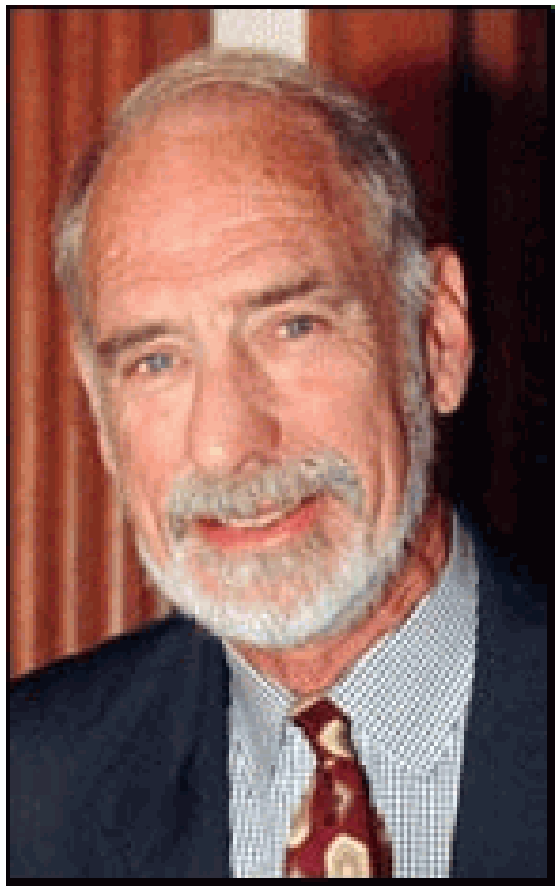
Environment Canada Environnement Canada

OVERVIEW

- Prediction program across Canada
- Prediction program in B.C.
  - Partnerships
  - Ozone forecasts
  - Guidance
  - Verification
- PM forecast model development
- Future

WHY AN AIR QUALITY PREDICTION PROGRAM?



- Negative effects on health occur at pollutant concentrations below the levels that trigger smog advisories
- *"Every Canadian has the right to know the quality of air that they breathe"*
  - Rt. Hon. David Anderson
  - Minister of Environment

PREDICTION PROGRAMS IN CANADA

- Prediction programs currently exist in Pacific, Ontario, Quebec, & Atlantic regions
- Goal is for a national, daily, air quality prediction program by 2004

- Two types of forecast:
  - Ozone in warm weather season
  - Ventilation or dispersion year round
- Daily forecast program augmented by advisory program
- Prediction programs are in partnership with provincial and municipal agencies and health organizations

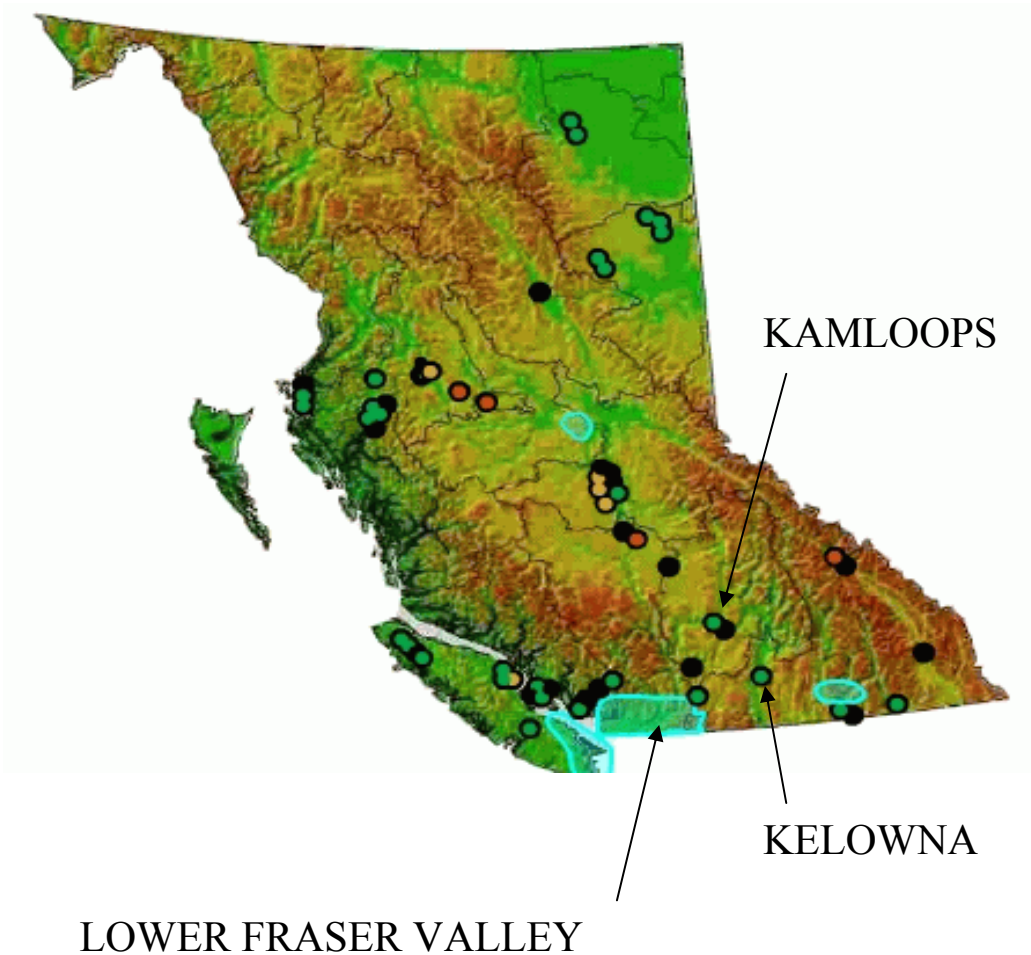
PARTNERSHIPS IN B.C.

LEVEL	UNIT	ROLE
FEDERAL	2 Weather Centres National Centre	Weather Watch Daily O_3 Prediction Numerical Models
PROVINCIAL	Ministry of Water, Land and Air Protection	Ambient Monitoring Advisories
MUNICIPAL	Greater Vancouver Regional District	Ambient Monitoring Advisories

FORECAST PROGRAM IN PACIFIC REGION

- Daily max ozone
- 13 regions
- Today and tomorrow
- 6 am and 4 pm issues
- May thru September
- Text bulletin
- Media
- Text/graphics at

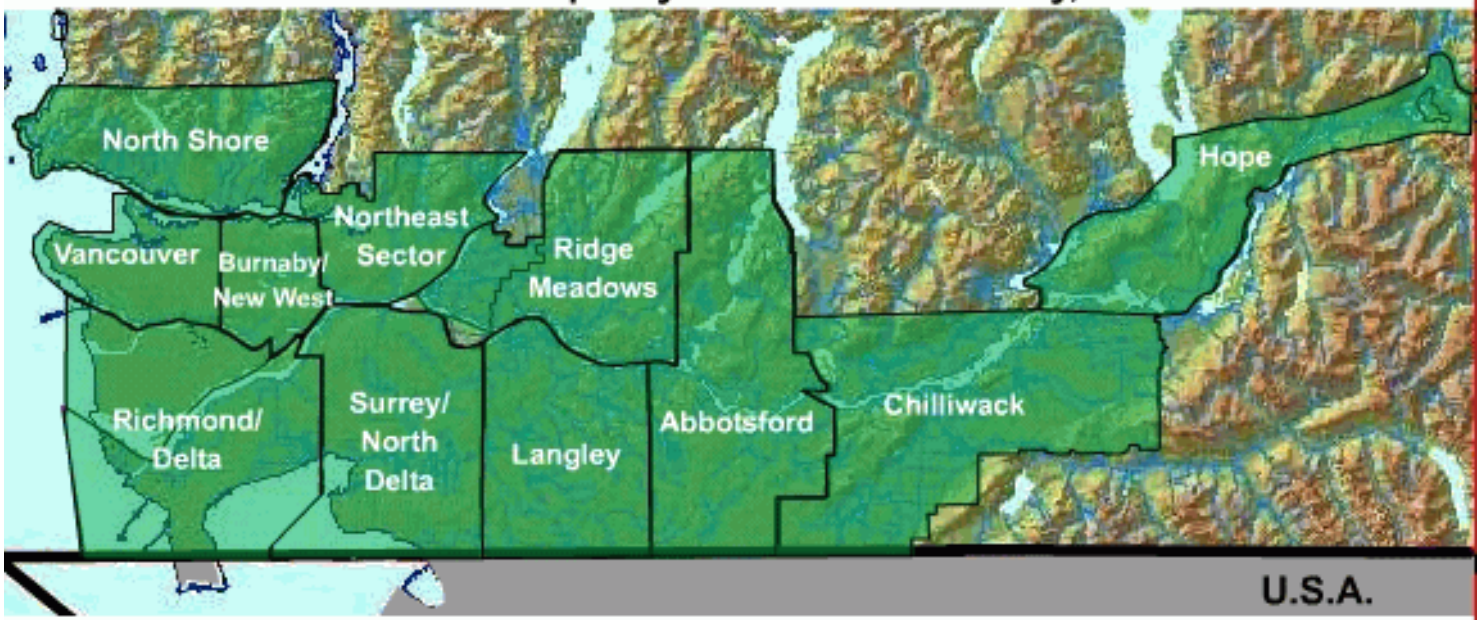
  www.weatheroffice.ec.gc.ca



Environment Canada Environnement Canada

Greater Vancouver Regional District

Observed air quality index at: Wednesday, 9am



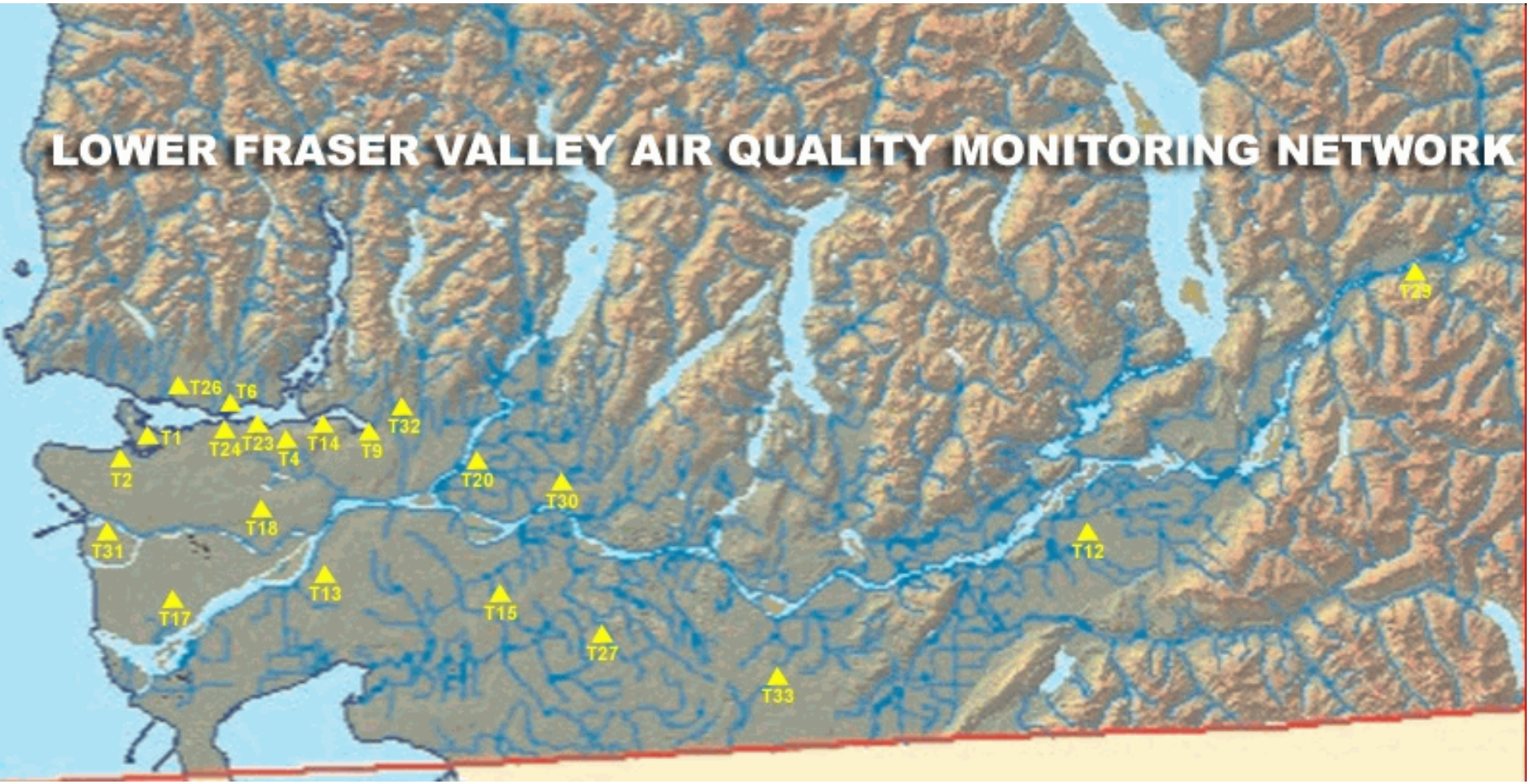
Region

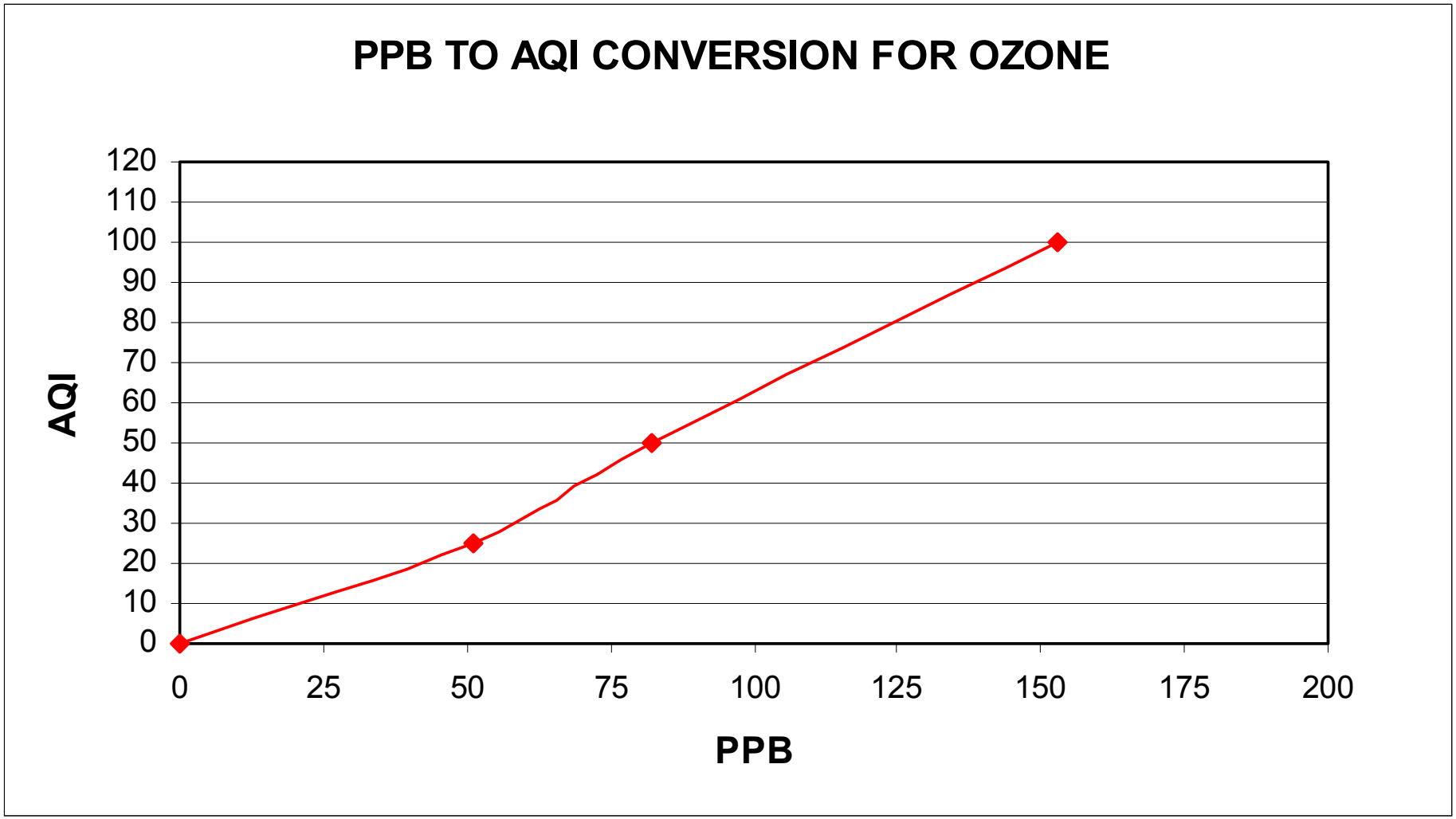
Roll over regions for current information or click on the regions for more detailed information.

Legend

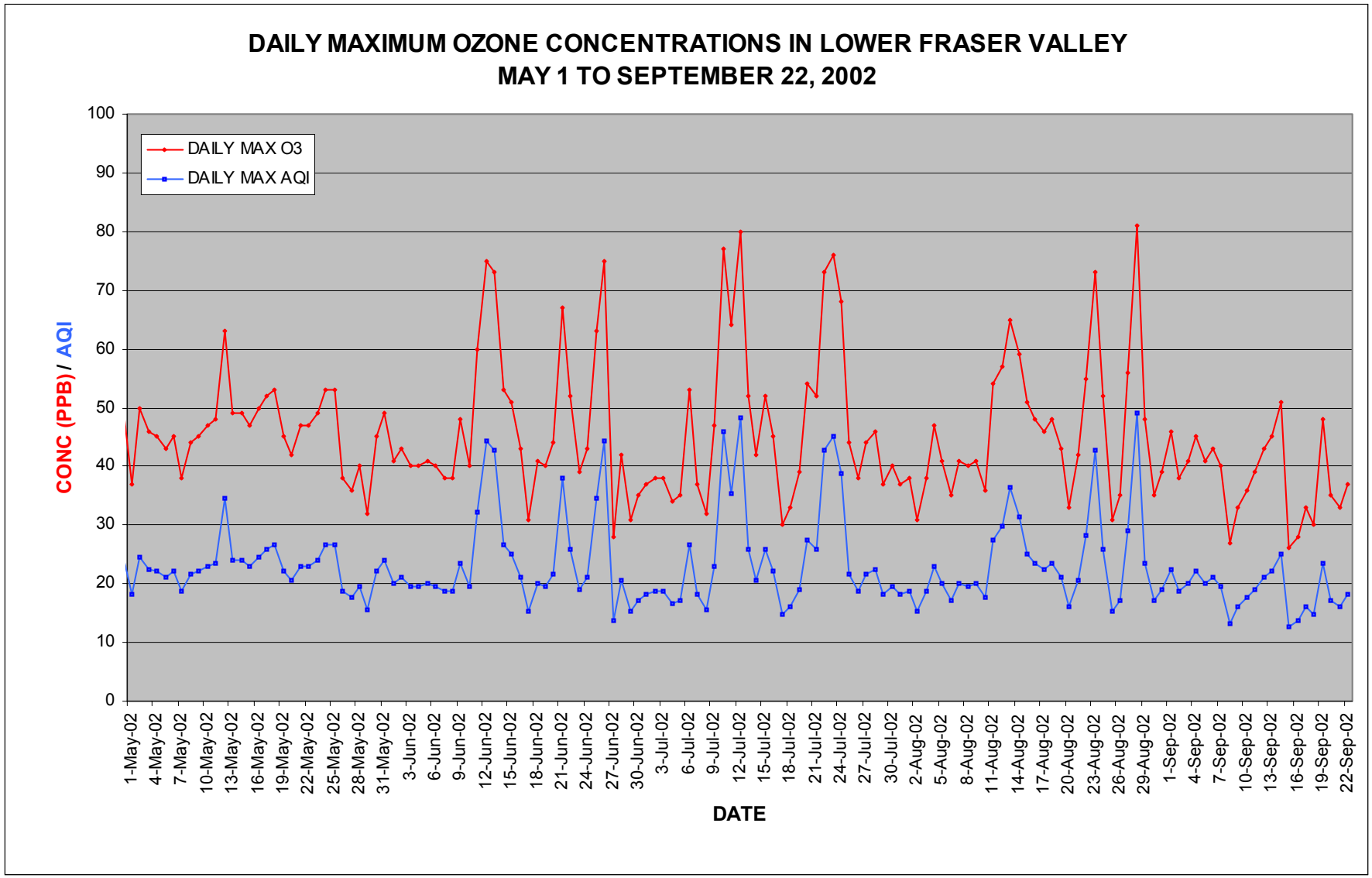
- Good (0-25)
- Fair (26-50)
- Poor (51-100)
- Very Poor (> 100)
- No Current Data

Current Observations | Todays Forecast | Tomorrows Forecast | Provincial Map

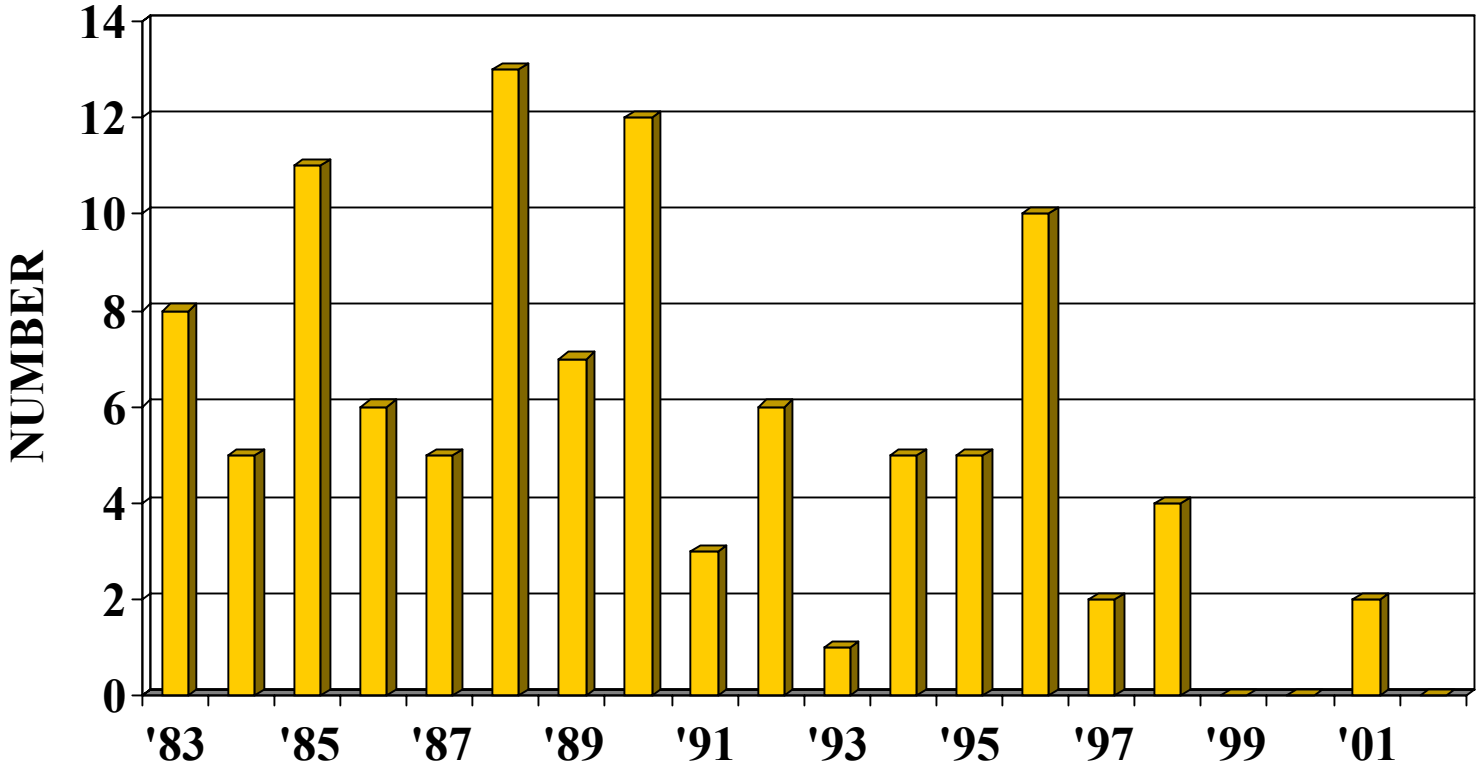

LOWER FRASER VALLEY AIR QUALITY MONITORING NETWORK
T26
T6
T1
T24
T23
T4
T14
T9
T32
T2
T20
T30
T18
T31
T13
T17
T15
T27
T33
T12
T29


PPB TO AQI CONVERSION FOR OZONE
AQI
120
110
100
90
80
70
60
50
40
30
20
10
0
0
25
50
75
100
125
150
175
200
PPB

1-hr Conc. (ppb)	AQI Sub Index	Category
0 – 51	0 - 25	Good
52 – 82	26 – 50	Fair
83 – 153	50 – 100	Poor

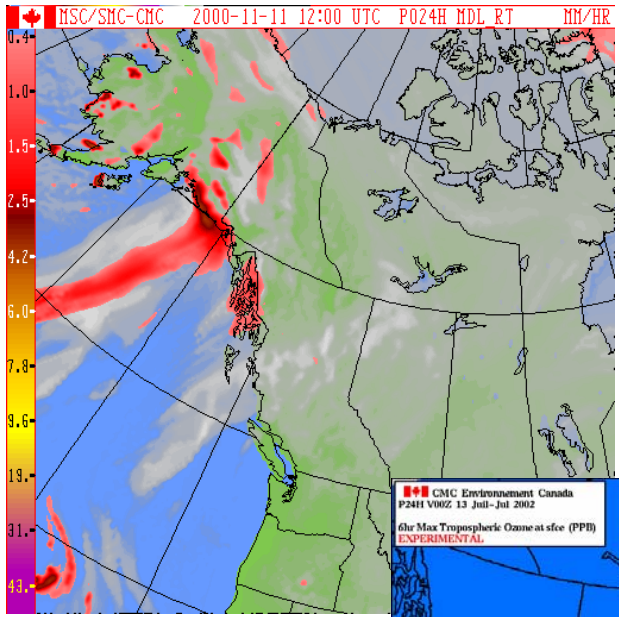

DAILY MAXIMUM OZONE CONCENTRATIONS IN LOWER FRASER VALLEY
MAY 1 TO SEPTEMBER 22, 2002
DAILY MAX O3
DAILY MAX AQI
CONC (PPB) / AQI
DATE
0
10
20
30
40
50
60
70
80
90
100
1-May-02
4-May-02
7-May-02
10-May-02
13-May-02
16-May-02
19-May-02
22-May-02
25-May-02
28-May-02
31-May-02
3-Jun-02
6-Jun-02
9-Jun-02
12-Jun-02
15-Jun-02
18-Jun-02
21-Jun-02
24-Jun-02
27-Jun-02
30-Jun-02
3-Jul-02
6-Jul-02
9-Jul-02
12-Jul-02
15-Jul-02
18-Jul-02
21-Jul-02
24-Jul-02
27-Jul-02
30-Jul-02
2-Aug-02
5-Aug-02
8-Aug-02
11-Aug-02
14-Aug-02
17-Aug-02
20-Aug-02
23-Aug-02
26-Aug-02
29-Aug-02
1-Sep-02
4-Sep-02
7-Sep-02
10-Sep-02
13-Sep-02
16-Sep-02
19-Sep-02
22-Sep-02

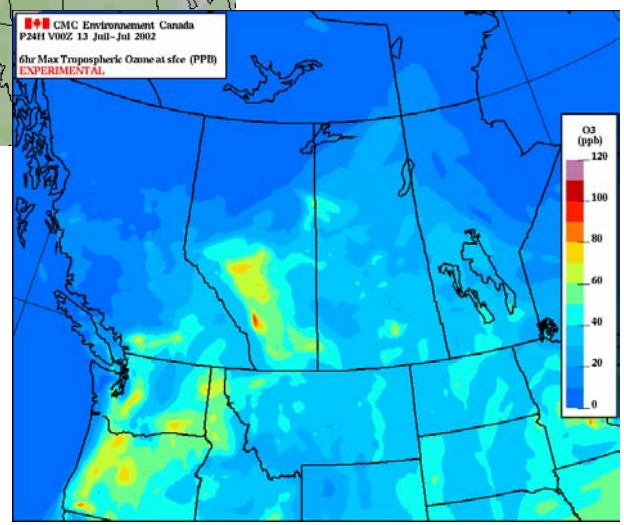
OZONE EXCEEDENCE DAYS 1983 TO 2002



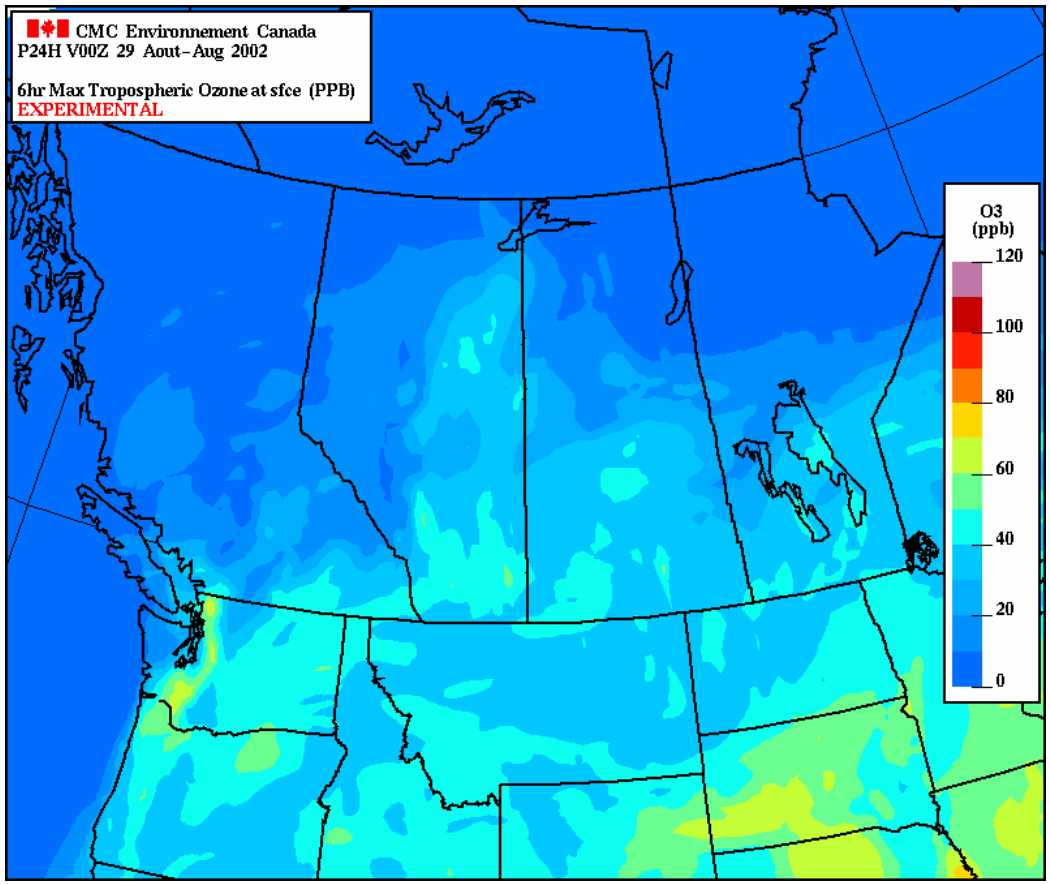
FORECASTING TOOLS

- Local meteorology
- Pattern recognition
- Numerical weather prediction models
- Numerical air quality prediction models
- Statistical models





CHRONOS



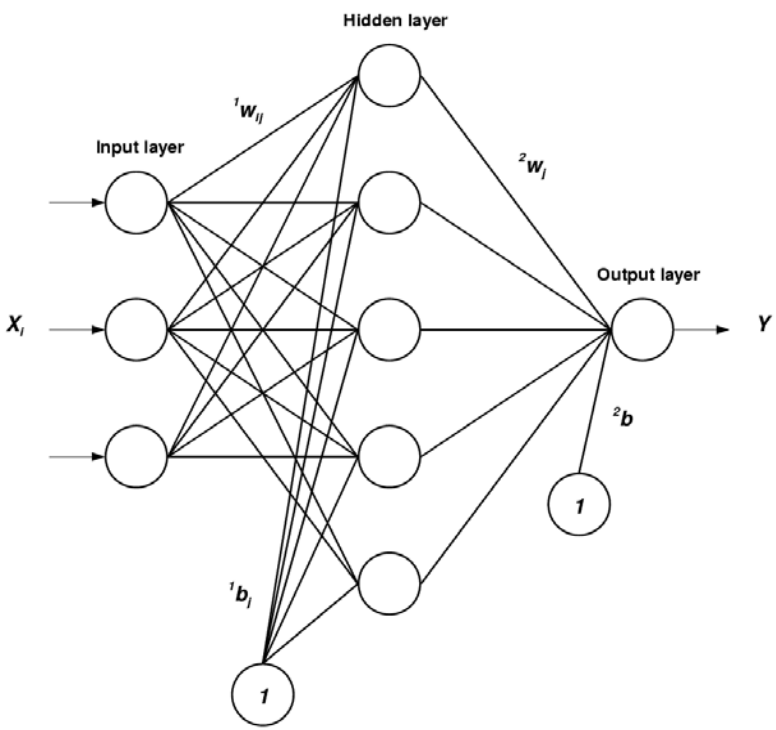
- O_3 patterns and trends
- under-predicts
- large errors at specific points
- not as useful as numerical weather prediction models

REGRESSION EQUATION

$$Log(O_3) = a + bLog(O_{3_{ant}}) + cT_{\max} + d\delta_r + d\delta_p + fJ + g\frac{J^2}{10^4} + hT_{850}$$

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

ARTIFICIAL NEURAL NETWORK ENSEMBLES



- 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

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T001) ANTECEDENT 1-HR MAX OZONE AT ROBSON SQUARE (PPB).......: 25
T002) ANTECEDENT 1-HR MAX OZONE AT KITSILANO (PPB)...........: 53
T004) ANTECEDENT 1-HR MAX OZONE AT KENSINGTON PARK (PPB).....: 33
T006) ANTECEDENT 1-HR MAX OZONE AT SECOND NARROWS (PPB)......: 34
T009) ANTECEDENT 1-HR MAX OZONE AT ROCKY POINT PARK (PPB)....: 32
T012) ANTECEDENT 1-HR MAX OZONE AT CHILLIWACK (PPB)..........: 54
T013) ANTECEDENT 1-HR MAX OZONE AT NORTH DELTA (PPB).........: 45
T014) ANTECEDENT 1-HR MAX OZONE AT BURNABY MOUNTAIN (PPB)....: 39
T015) ANTECEDENT 1-HR MAX OZONE AT SURREY EAST (PPB).........: 59
T017) ANTECEDENT 1-HR MAX OZONE AT RICHMOND SOUTH (PPB)......: 47
T018) ANTECEDENT 1-HR MAX OZONE AT BURNABY SOUTH (PPB).......: 45
T020) ANTECEDENT 1-HR MAX OZONE AT MEADOWLANDS (PPB).........: 50
T026) ANTECEDENT 1-HR MAX OZONE AT MAHON PARK (PPB)..........: 46
T027) ANTECEDENT 1-HR MAX OZONE AT LANGLEY (PPB).............: 60
T029) ANTECEDENT 1-HR MAX OZONE AT HOPE AIRPORT (PPB)........: 64
T030) ANTECEDENT 1-HR MAX OZONE AT GOLDEN EARS (PPB).........: 57
T031) ANTECEDENT 1-HR MAX OZONE AT VANCOUVER AIRPORT (PPB)...: 37
T033) ANTECEDENT 1-HR MAX OZONE AT ABBOTSFORD (PPB)..........: 49
V001) DAY 1 FORECAST JULIAN DAY.....................................: 193.0
V002) DAY 1 FORECAST MAX SURFACE TEMP AT YVR (DEG C)................: 23.0
V003) DAY 1 FORECAST AFTERNOON 00Z 850 HPA TEMP AT YVR (DEG C).....: 19.0
V004) DAY 1 FORECAST POP AT YVR > 50? (Y/N)........................: n
V005) DAY 1 FORECAST MAX SURFACE TEMP AT YXX (DEG C)................: 28.0
V006) DAY 1 FORECAST AFTERNOON 00Z 850 HPA TEMP AT YXX (DEG C).....: 19.0
V007) DAY 1 FORECAST POP AT YXX > 50? (Y/N)........................: n
V008) DAY 1 FORECAST MORNING 12Z SLP AT YVR >= SLP AT YHE? (Y/N)...: n
V009) DAY 2 FORECAST MAX SURFACE TEMP AT YVR (DEG C)................: 23.0
V010) DAY 2 FORECAST AFTERNOON 00Z 850 HPA TEMP AT YVR (DEG C).....: 16.0
V011) DAY 2 FORECAST POP AT YVR > 50? (Y/N)........................: n
V012) DAY 2 FORECAST MAX SURFACE TEMP AT YXX (DEG C)................: 28.0
V013) DAY 2 FORECAST AFTERNOON 00Z 850 HPA TEMP AT YXX (DEG C).....: 16.0
V014) DAY 2 FORECAST POP AT YXX > 50? (Y/N)........................: n
V015) DAY 2 FORECAST MORNING 12Z SLP AT YVR >= SLP AT YHE (DEG C)..: n


P001) Julian Day Number for FRIDAY 12 JUL 2002: 193
P002) Julian Day Number for SATURDAY 13 JUL 2002: 194
P003) Observed 1-hr Max Ozone at Brocklehurst (ppb) on THURSDAY 11 JUL 2002: 65.0
P004) Observed 1-hr Max Ozone at Kelowna (ppb) on THURSDAY 11 JUL 2002: 65.0
P005) Observed Daily Max Temperature (DEG C) at Kamloops on THURSDAY 11 JUL 2002: 37.0
P006) Forecast Daily Max Temperature (DEG C) at Kamloops for FRIDAY 12 JUL 2002: 37.0
P007) Forecast Daily Max Temperature (DEG C) at Kamloops for SATURDAY 13 JUL 2002: 37.0
P008) Observed Daily Max Temperature (DEG C) at Kelowna on THURSDAY 11 JUL 2002: 39.0
P009) Forecast Daily Max Temperature (DEG C) at Kelowna for FRIDAY 12 JUL 2002: 38.0
P010) Forecast Daily Max Temperature (DEG C) at Kelowna for SATURDAY 13 JUL 2002: 37.0
P011) Forecast 850 MB Temperature (DEG C) at Kelowna for 12z FRIDAY 12 JUL 2002: 19.0
P012) Forecast 850 MB Temperature (DEG C) at Kelowna for 00z SATURDAY 13 JUL 2002: 27.0
P013) Forecast 850 MB Temperature (DEG C) at Kelowna for 12z SATURDAY 13 JUL 2002: 19.0
P014) Forecast 850 MB Temperature (DEG C) at Kelowna for 00z SUNDAY 14 JUL 2002: 28.0
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STN	NAME	REGION	LNR ppb/aqi	NNn AVG ppb/aqi	NNn std ppb/aqi	PROB GOOD %	PROB FAIR %	PROB POOR %	NNx AVG ppb/aqi	NNx std ppb/aqi	PROB GOOD %	PROB FAIR %	PROB POOR %
T001	ROBSON SQUARE	VANCOUVER	19/9	21/10	2/1	100	0	0	27/13	8/4	98	2	0
T002	KITSILANO	VANCOUVER	36/18	42/20	2/1	100	0	0	49/24	6/3	62	38	0
T006	SECOND NARROWS	NORTH SHORE	27/13	30/14	2/1	100	0	0	35/17	4/2	100	0	0
T026	MAHON PARK	NORTH SHORE	37/18	42/21	2/1	100	0	0	52/26	4/2	32	68	0
T017	RICHMOND SOUTH	RICHMOND/DELTA	33/16	34/17	2/1	100	0	0	44/21	8/4	84	16	0
T031	VANCOUVER AIRPORT	RICHMOND/DELTA	30/15	34/17	3/1	100	0	0	40/19	9/4	90	10	0
T004	KENSINGTON PARK	BURNABY/NEW WEST	31/15	34/17	2/1	100	0	0	34/17	4/2	100	0	0
T014	BURNABY MOUNTAIN	BURNABY/NEW WEST	39/19	41/20	2/1	100	0	0	38/19	5/2	100	0	0
T018	BURNABY SOUTH	BURNABY/NEW WEST	30/15	33/16	2/1	100	0	0	41/20	5/3	96	4	0
T009	ROCKY POINT PARK	NORTHEAST	36/18	38/18	2/1	100	0	0	38/19	6/3	100	0	0
T013	NORTH DELTA	SURREY/NORTH DEL	30/15	32/16	2/1	100	0	0	34/17	4/2	100	0	0
T015	SURREY EAST	SURREY/NORTH DEL	44/22	49/24	3/2	74	26	0	51/25	5/3	48	52	0
T020	MEADOWLANDS	RIDGE MEADOWS	43/21	50/25	3/1	66	34	0	59/31	5/2	4	96	0
T030	GOLDEN EARS	RIDGE MEADOWS	48/24	55/28	3/1	8	92	0	72/42	4/2	0	100	0
T027	LANGLEY	LANGLEY	47/23	52/26	3/1	36	64	0	62/34	4/2	0	100	0
T033	ABBOTSFORD	ABBOTSFORD	45/22	53/27	4/2	34	66	0	52/26	4/2	46	54	0
T012	CHILLIWACK	CHILLIWACK	47/23	56/29	2/1	0	100	0	62/34	2/1	0	100	0
T029	HOPE AIRPORT	HOPE	56/29	67/38	3/1	0	100	0	79/48	3/1	0	78	22
RGNL	MAX	REGIONAL MAX	59/31	67/38	2/1	0	100	0	79/48	3/1	0	90	10

T001	ROBSON SQUARE	VANCOUVER	18/9	21/10	1/1	100	0	0	31/15	6/3	100	0	0
T002	KITSILANO	VANCOUVER	32/16	33/16	3/1	100	0	0	37/18	9/5	92	8	0
T006	SECOND NARROWS	NORTH SHORE	26/13	28/14	1/1	100	0	0	31/15	3/2	100	0	0
T026	MAHON PARK	NORTH SHORE	35/17	37/18	3/1	100	0	0	43/21	7/4	88	12	0
T017	RICHMOND SOUTH	RICHMOND/DELTA	33/16	34/17	2/1	100	0	0	44/21	6/3	92	8	0
T031	VANCOUVER AIRPORT	RICHMOND/DELTA	31/15	34/17	2/1	100	0	0	42/21	7/4	92	8	0
T004	KENSINGTON PARK	BURNABY/NEW WEST	32/16	34/17	1/1	100	0	0	36/18	3/1	100	0	0
T014	BURNABY MOUNTAIN	BURNABY/NEW WEST	39/19	40/20	2/1	100	0	0	40/19	8/4	94	6	0
T018	BURNABY SOUTH	BURNABY/NEW WEST	29/14	32/16	1/1	100	0	0	44/22	4/2	90	10	0
T009	ROCKY POINT PARK	NORTHEAST	38/19	37/18	3/1	100	0	0	39/19	8/4	94	6	0
T013	NORTH DELTA	SURREY/NORTH DEL	29/14	30/15	1/1	100	0	0	35/17	4/2	100	0	0
T015	SURREY EAST	SURREY/NORTH DEL	41/20	40/20	4/2	100	0	0	40/19	8/4	92	8	0
T020	MEADOWLANDS	RIDGE MEADOWS	42/21	45/22	5/2	88	12	0	57/30	9/4	24	76	0
T030	GOLDEN EARS	RIDGE MEADOWS	45/22	46/23	4/2	88	12	0	62/34	8/4	12	88	0
T027	LANGLEY	LANGLEY	44/21	43/21	4/2	98	2	0	49/24	9/5	64	36	0
T033	ABBOTSFORD	ABBOTSFORD	42/20	45/22	4/2	96	4	0	53/26	9/4	40	60	0
T012	CHILLIWACK	CHILLIWACK	42/21	42/21	4/2	98	2	0	45/22	7/3	78	22	0
T029	HOPE AIRPORT	HOPE	51/25	49/24	4/2	70	30	0	56/29	11/5	30	70	0
RGNL	MAX	REGIONAL MAX	56/29	55/29	3/2	8	92	0	69/40	7/4	0	92	8

FLCN40 CWVR 121200

GROUND-LEVEL OZONE FORECAST FOR SELECTED REGIONS OF BRITISH COLUMBIA ISSUED AT 6 AM PDT FRIDAY 12 JULY 2002 FOR TODAY AND SATURDAY. 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.

GREATER VANCOUVER.

	TODAY AQI/CATEGORY	SATURDAY AQI/CATEGORY
VANCOUVER	21/GOOD	17/GOOD
NORTH SHORE	21/GOOD	19/GOOD
RICHMOND/DELTA	18/GOOD	18/GOOD
BURNABY/NEW WESTMINSTER	19/GOOD	19/GOOD
NORTHEAST	18/GOOD	19/GOOD
SURREY/NORTH DELTA	24/GOOD	20/GOOD
RIDGE MEADOWS	31/FAIR	25/GOOD
LANGLEY	27/FAIR	22/GOOD

LOWER FRASER VALLEY.

	TODAY AQI/CATEGORY	SATURDAY AQI/CATEGORY
ABBOTSFORD	25/GOOD	23/GOOD
CHILLIWACK	28/FAIR	21/GOOD
HOPE	38/FAIR	26/FAIR

B.C. INTERIOR.

	TODAY AQI/CATEGORY	SATURDAY AQI/CATEGORY
KAMLOOPS	32/FAIR	31/FAIR
KELOWNA	35/FAIR	35/FAIR

AIR QUALITY CATEGORIES OF 'GOOD', 'FAIR', 'POOR' CORRESPOND TO AIR QUALITY SUB-INDEX RANGES OF 0-25, 26-50 AND >50 RESPECTIVELY.

"ADVERSE HEALTH EFFECTS INCREASE AS AIR QUALITY DETERIORATES."

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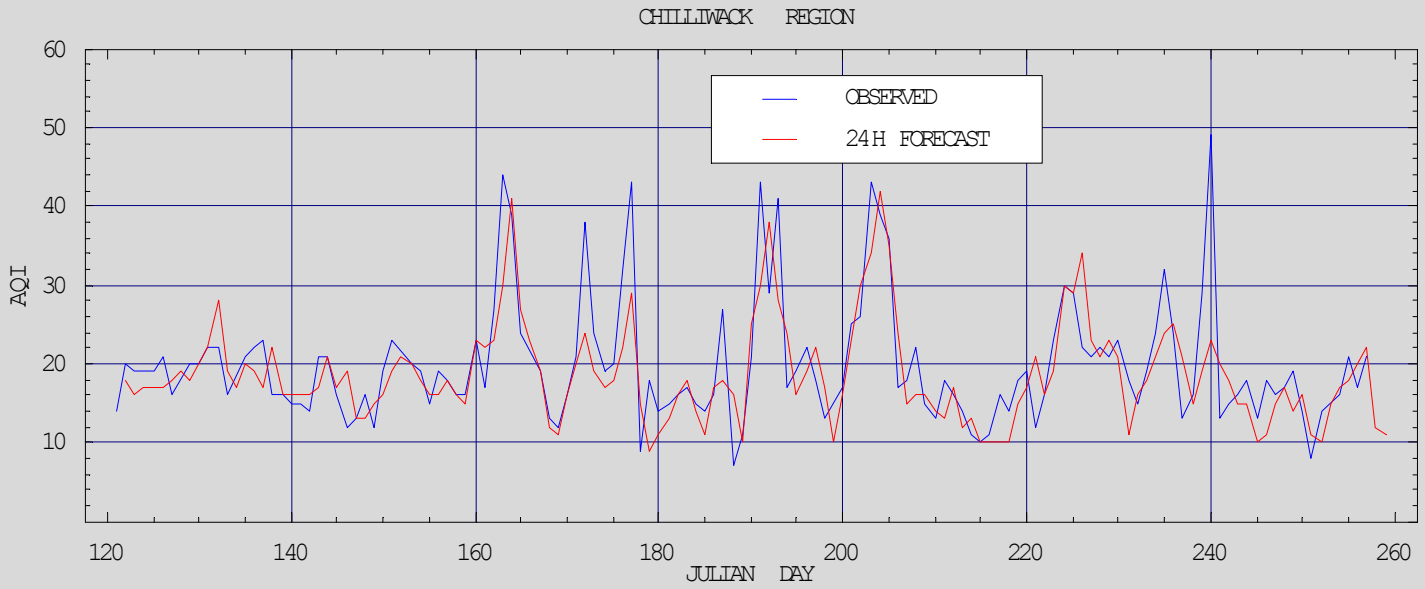
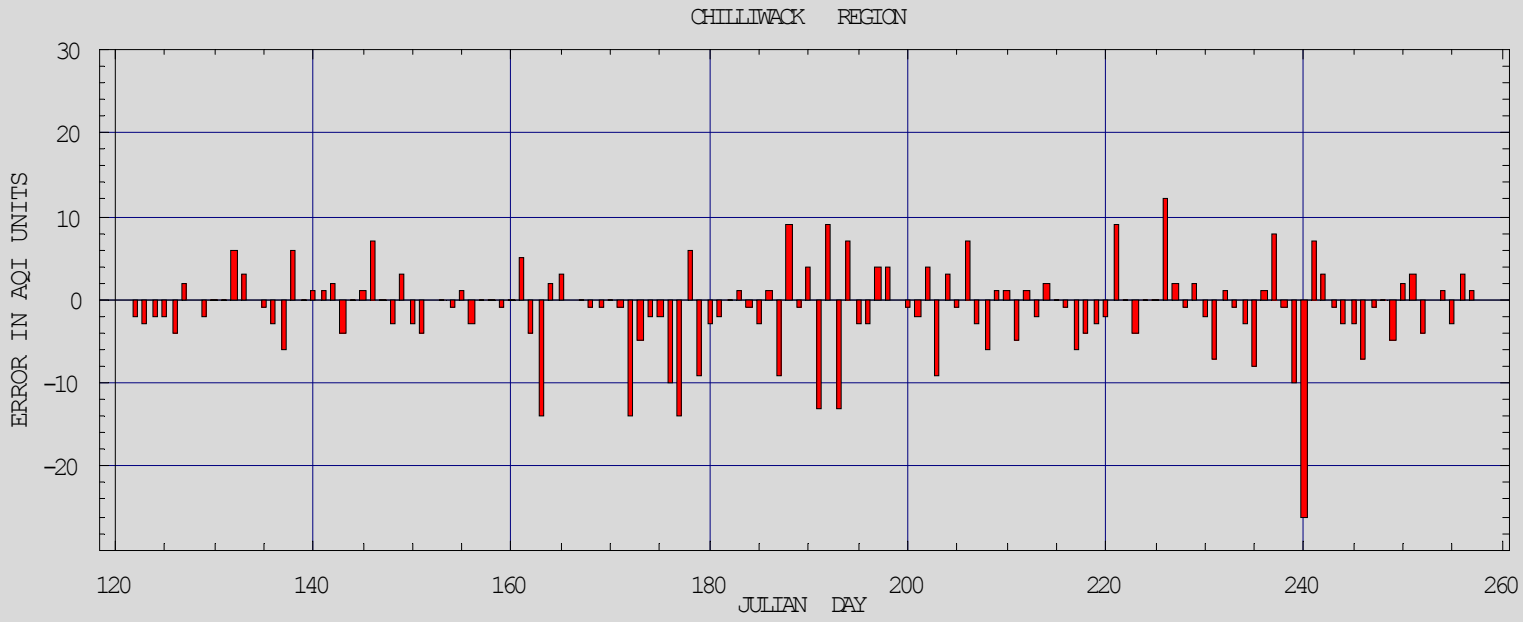
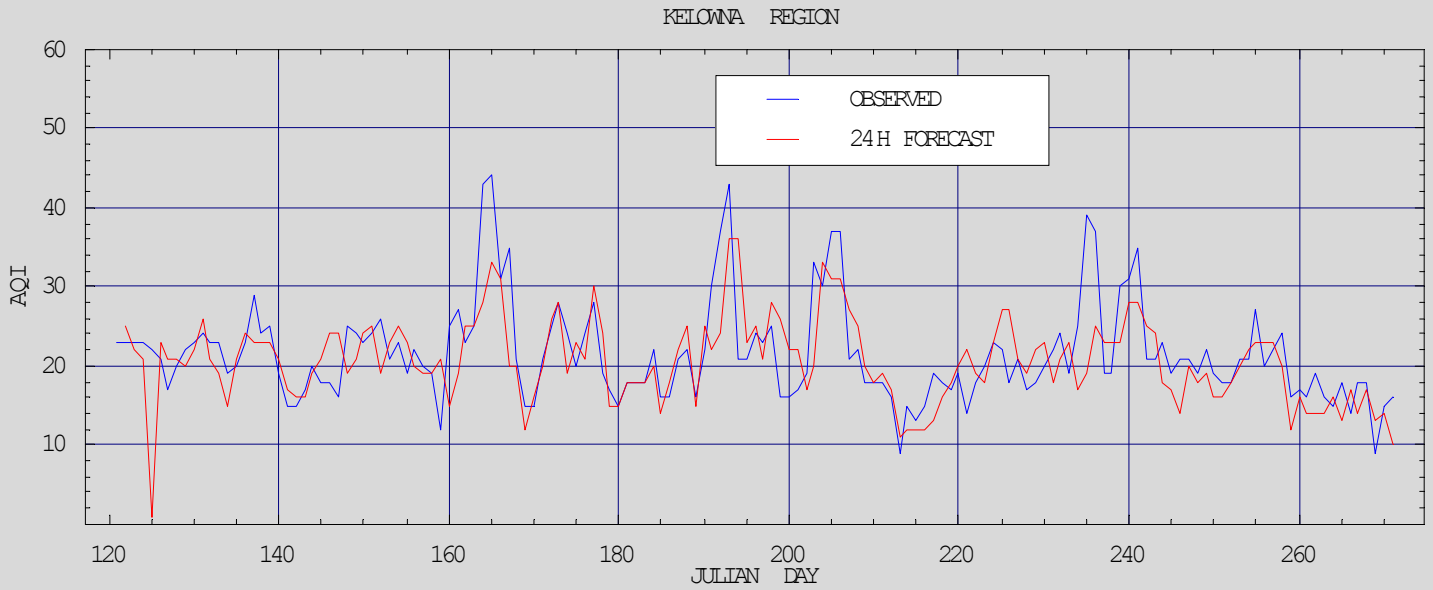
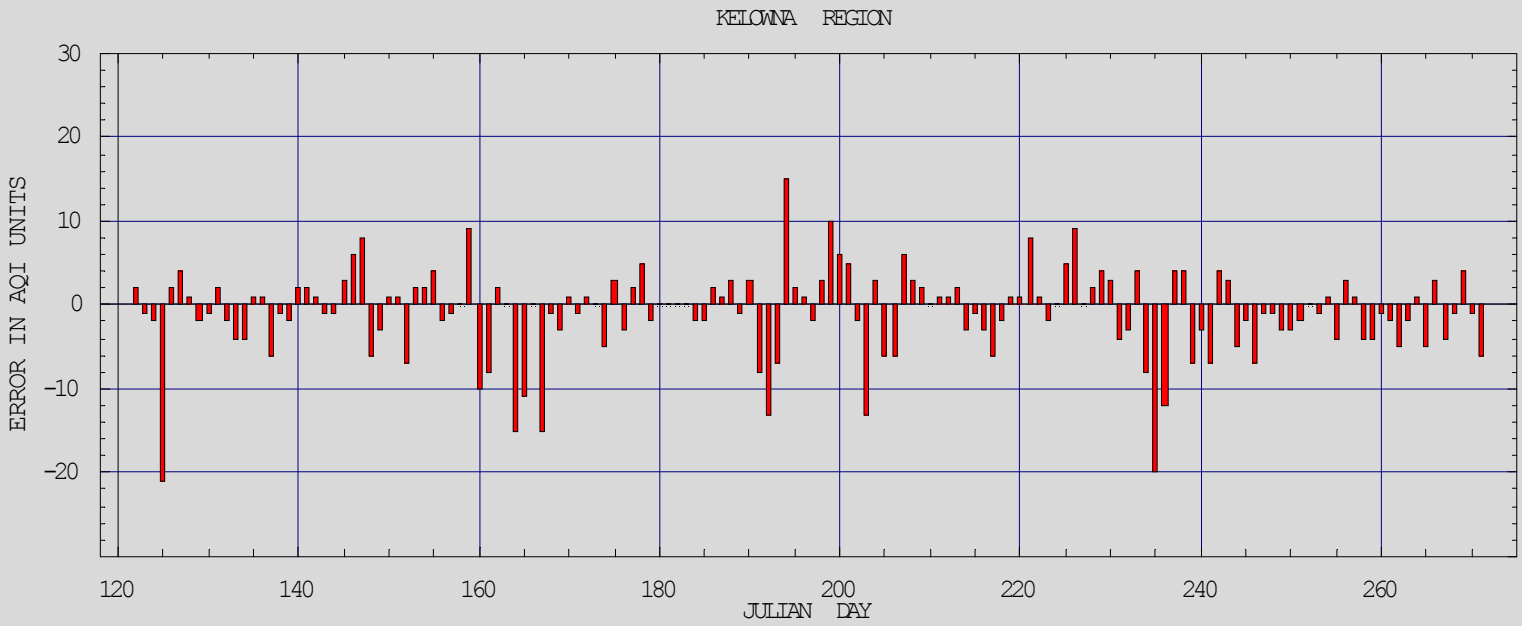
END/RN

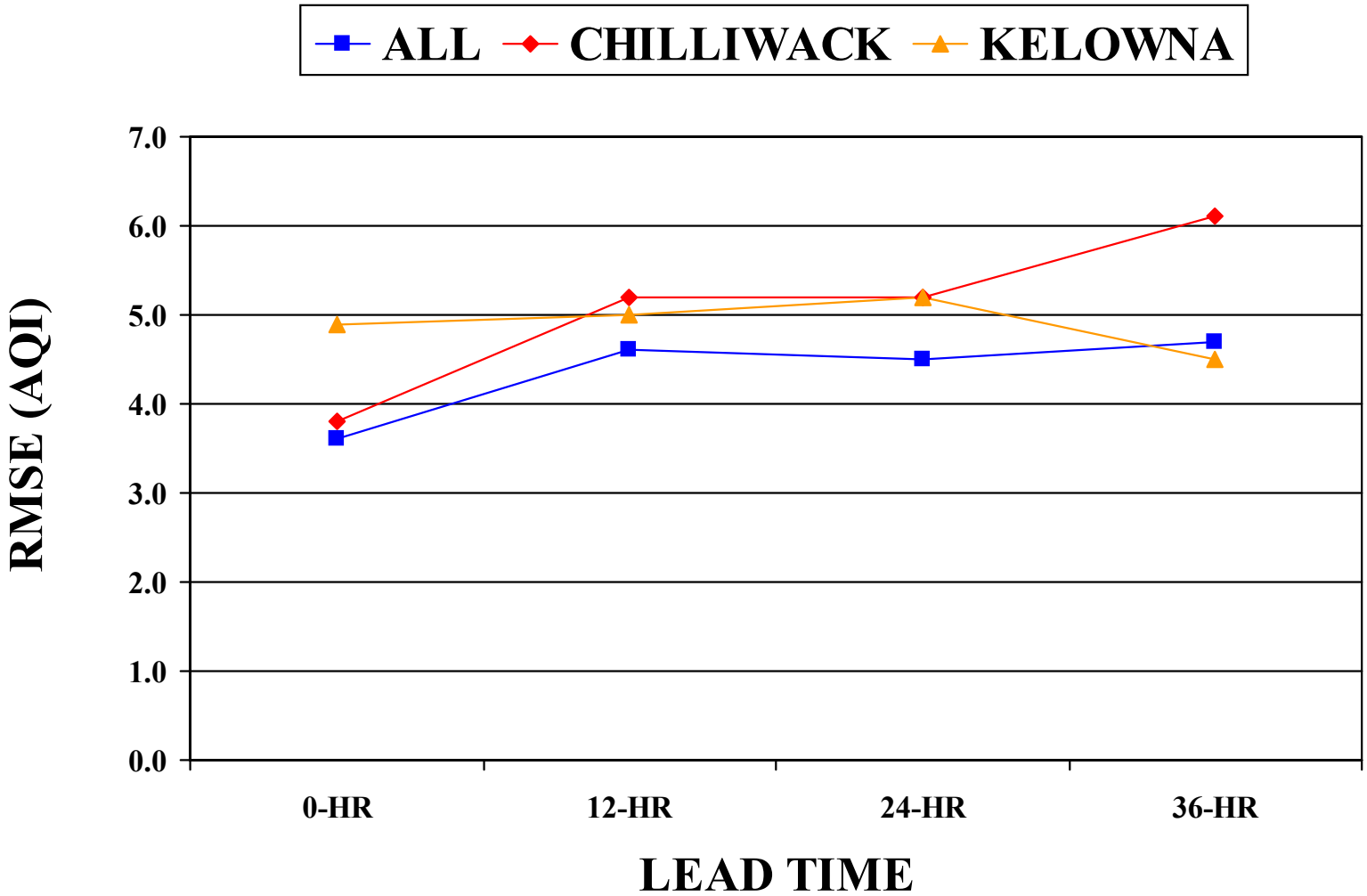

CHILLIWACK REGION
OBSERVED
24H FORECAST
AQI
60
50
40
30
20
10
120
140
160
180
200
220
240
260
JULIAN DAY


CHILLIWACK REGION
ERROR IN AQI UNITS
30
20
10
0
−10
−20
120
140
160
180
200
220
240
260
JULIAN DAY

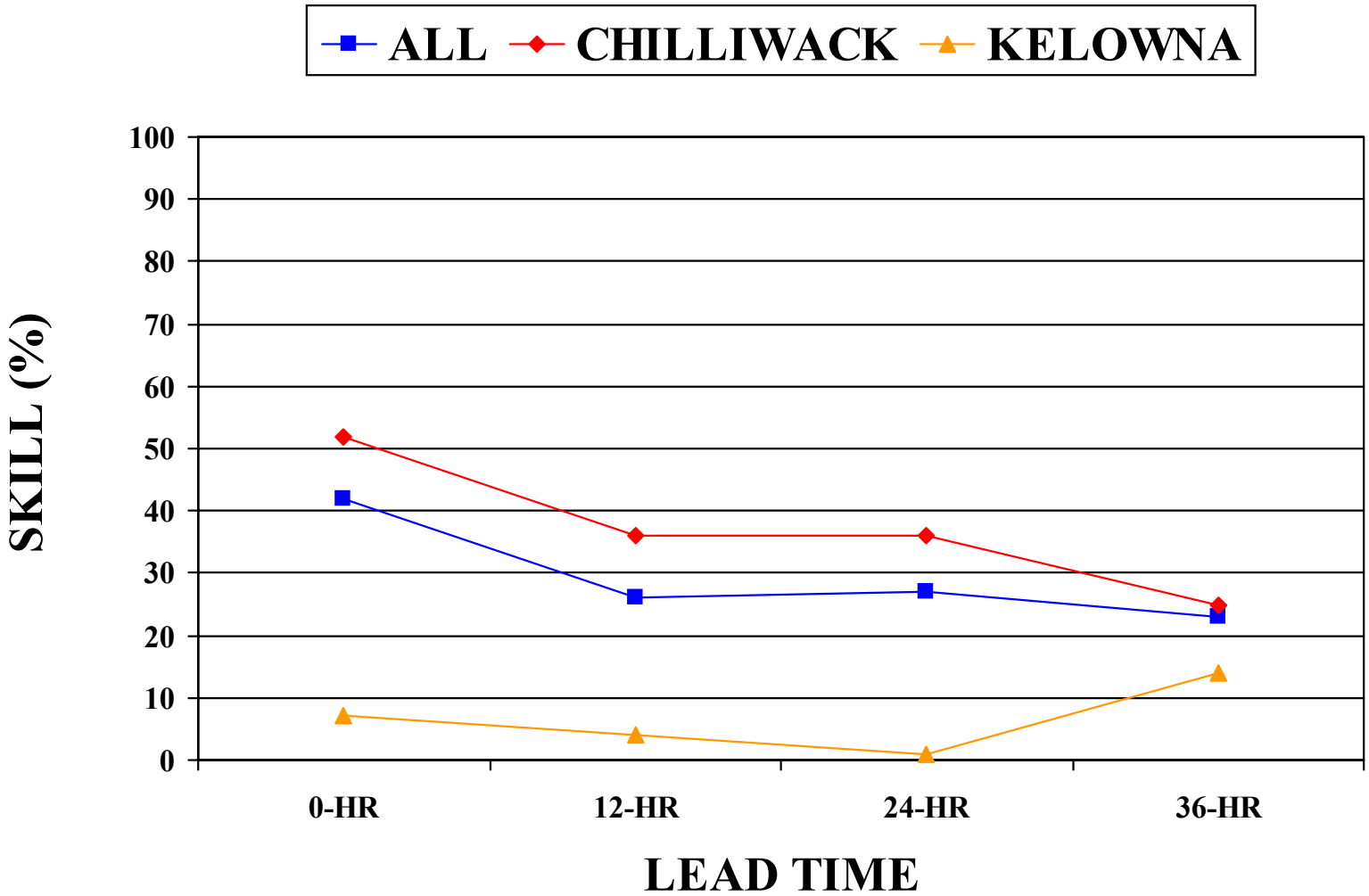

KELOWNA REGION
OBSERVED
24 H FORECAST
AQI
60
50
40
30
20
10
120
140
160
180
200
220
240
260
JULIAN DAY


KELOWNA REGION
ERROR IN AQI UNITS
30
20
10
0
−10
−20
120
140
160
180
200
220
240
260
JULIAN DAY

RMSE VS LEAD TIME



SKILL VS LEAD TIME



FORECASTER ACCEPTANCE OR ADJUSTMENT OF MODEL GUIDANCE

Overall	Accepted	Adjusted	Total
$\lvert E \rvert \leq 5$	81%	3%	84%
$5 < \lvert E \rvert \leq 10$	12%	1%	13%
$\lvert E \rvert > 10$	3%	<1/2%	3%
Total	96%	4%	100%

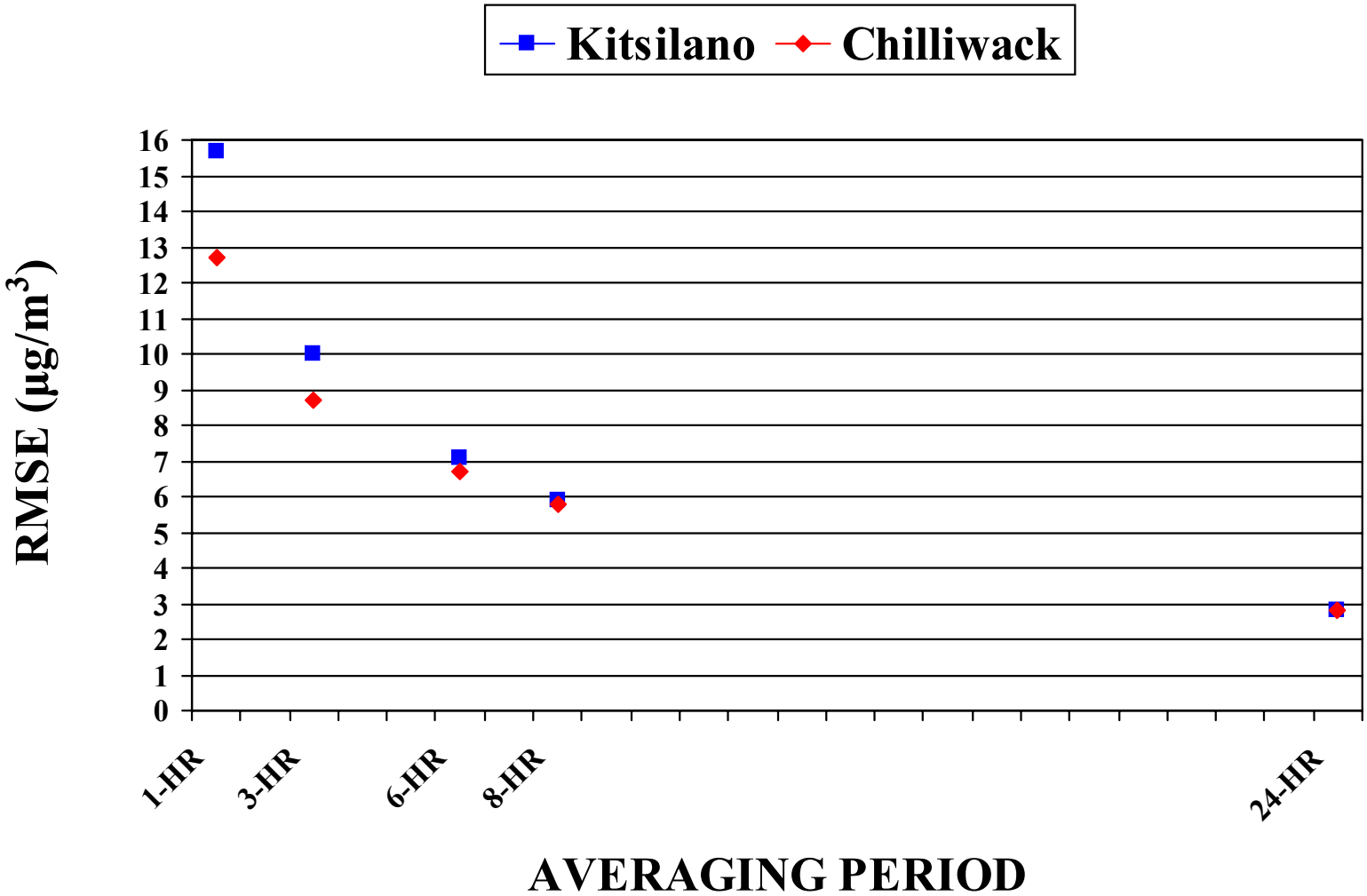
PM_{10} FORECAST MODELS

- Artificial neural network ensemble models
- 9 stations Lower Fraser Valley
- Predictands were daily maximum 1-, 3-, 6-, 8- and 24-hour concentrations of PM_{10} in $\mu g/m^3$

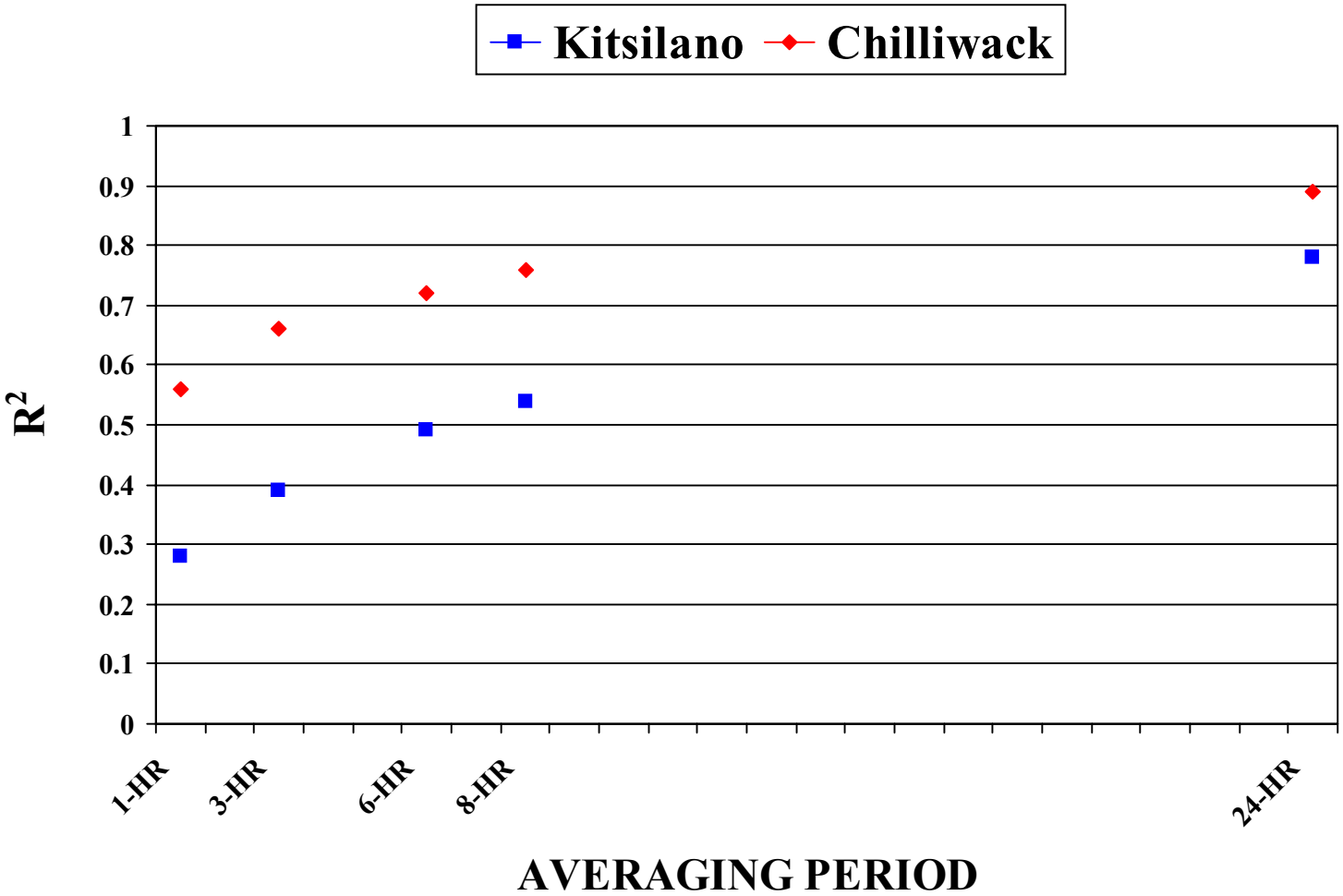
PREDICTORS FOR PM_{10} MODELS

- 65 potential predictors → screening → 17 final predictors
  - Antecedent daily maximum PM_{10} and O_3 concentrations
  - PM_{10} tendency
  - Maximum surface temperature anomaly
  - Occurrence of precipitation and length of dry spells
  - Vertical temperature gradient
  - Horizontal pressure gradient
  - Day of year and day of week

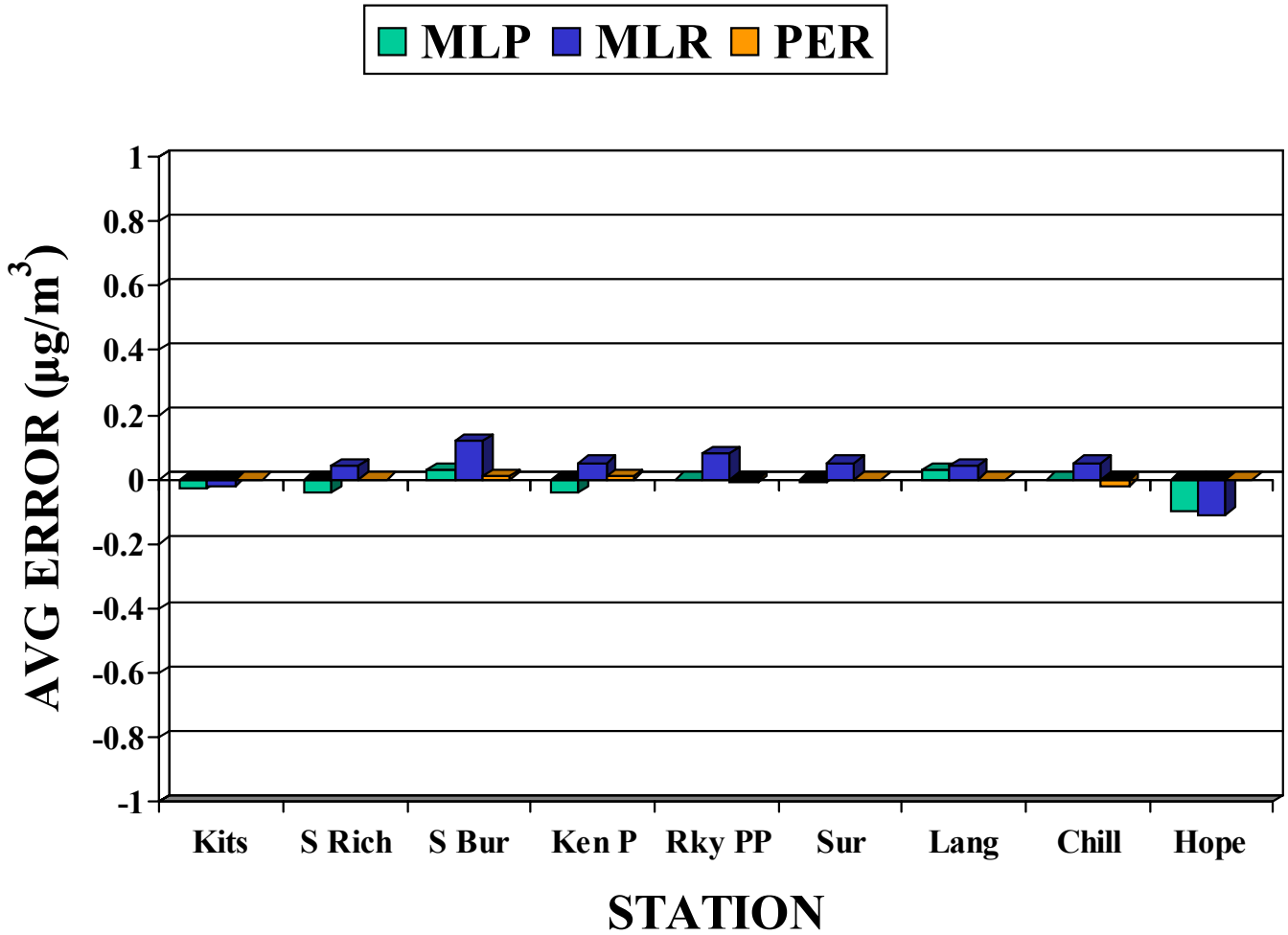
PM_{10} MODEL ACCURACY: RMSE VS AVERAGING PERIOD



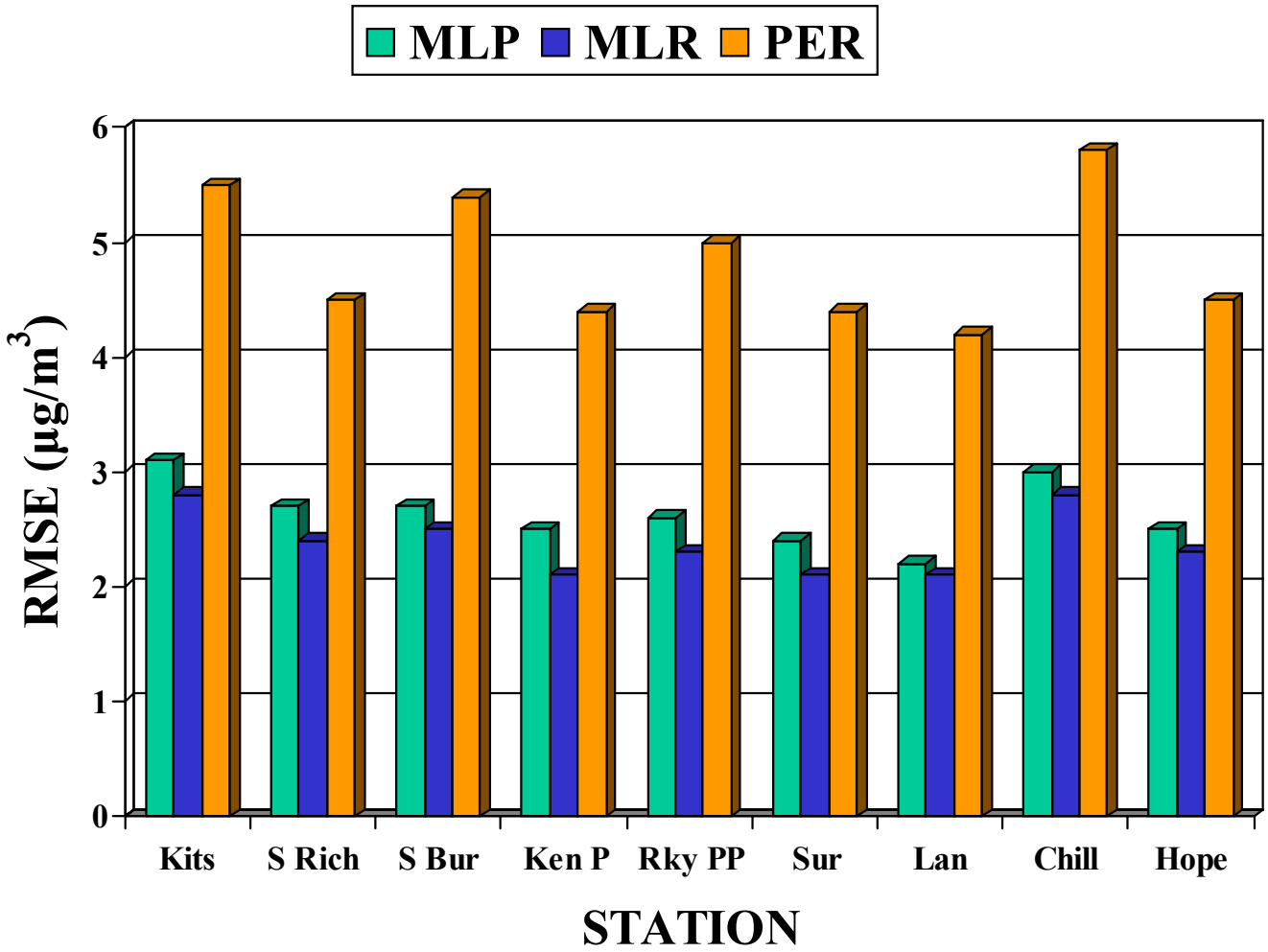
PM_{10} MODEL ACCURACY: R^2 VS AVERAGING PERIOD



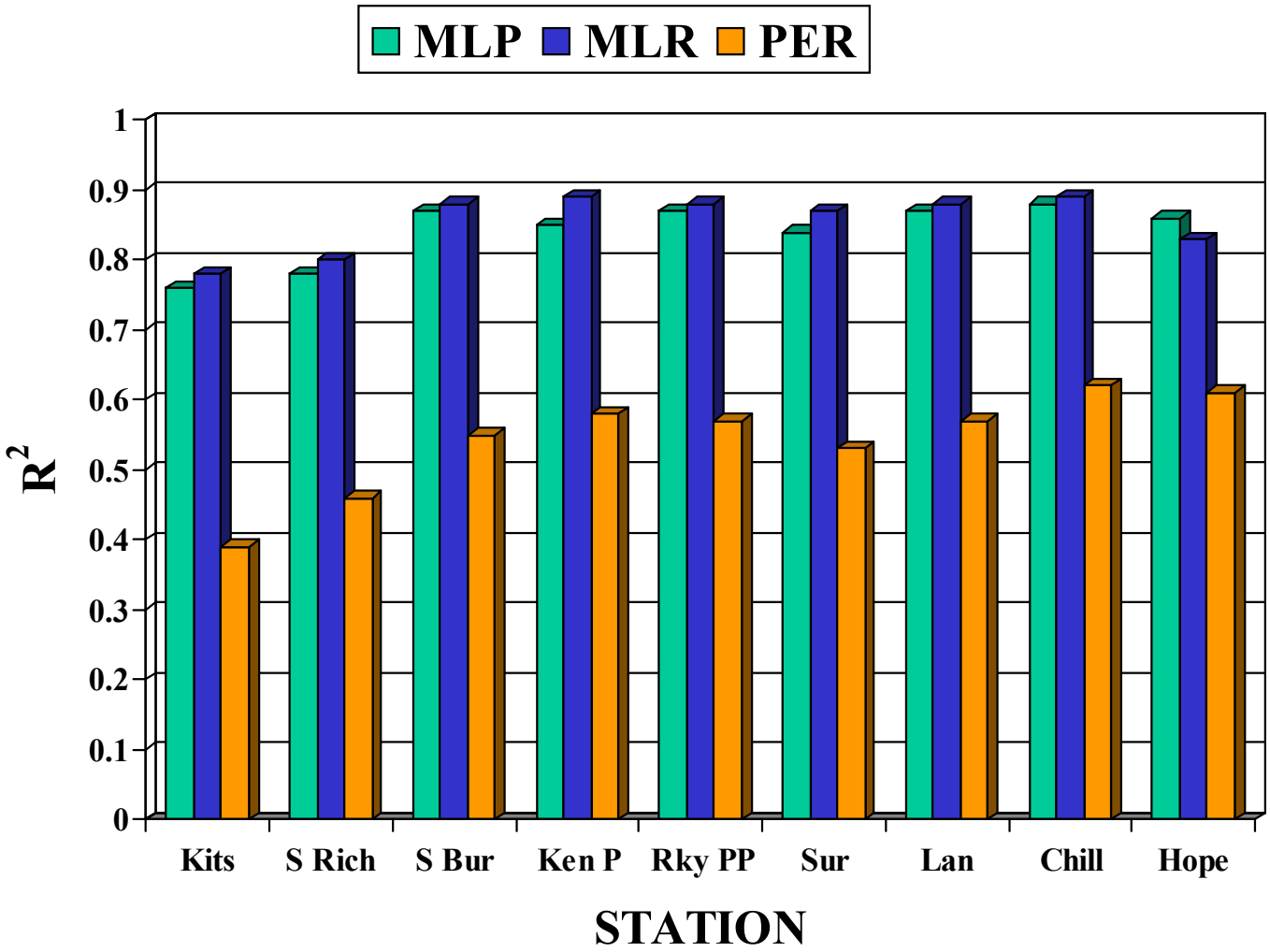
24-HR AVG PM_{10} MODEL ACCURACY - BIAS



24-HR AVG PM_{10} MODEL ACCURACY – RMSE



24-HR AVG PM_{10} MODEL ACCURACY – R^2



CONCLUSION

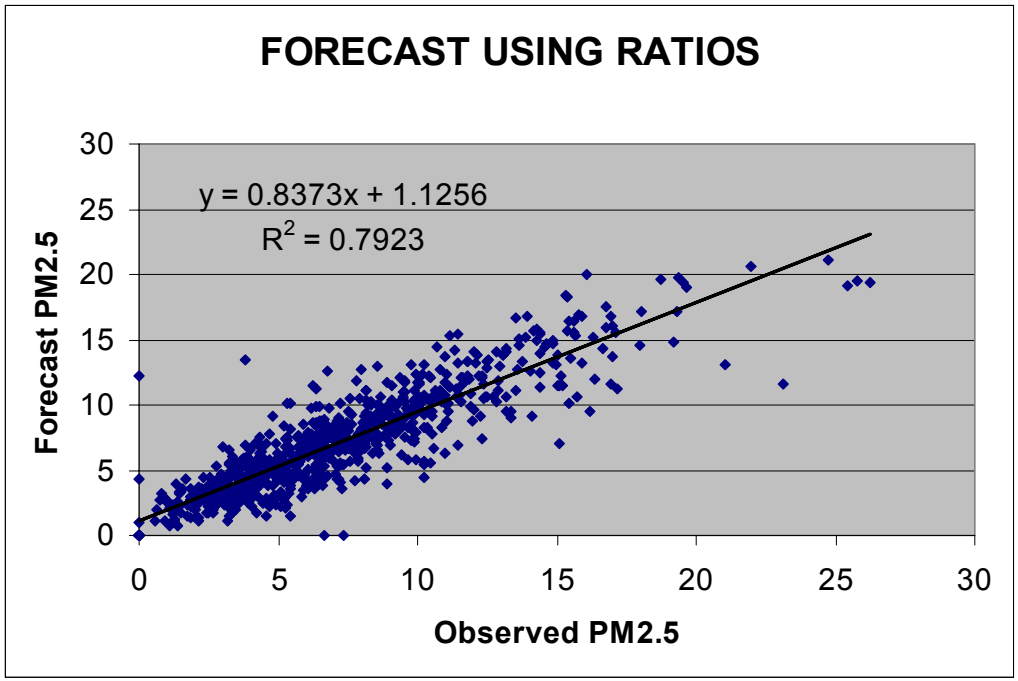
- MLP models better than persistence but not better than MLR using these predictors
- Process inherently linear in these predictors
- Predictor set incorrect and/or incomplete
- PM_{10} observations not amenable to statistical modeling

PREDICTING DAILY MAXIMUM 24-HOUR AVERAGE $PM_{2.5}$

1. Build MLP ensemble model at Chilliwack
2. Infer a $PM_{2.5}$ forecast from a PM_{10} forecast and a ratio of (daily max $PM_{2.5}$)/(daily max PM_{10})

(Antecedent ratio) x (PM_{10} model forecast)

TEST OF 24-HR AVG $PM_{2.5}$ FCST USING RATIO METHOD



N	853
BIAS	0.0
MAE	1.3
RMSE	1.9
R2	0.79
SKILL	29%

- Chilliwack
- 06/95 – 06/00 (May through October)
- 24 hour lead time
- antecedent daily max PM ratios

PRIORITIES FOR THE FUTURE

- Short term
  - Build $PM_{2.5}$ models
  - Include PM_{10} and $PM_{2.5}$ in the forecast bulletin
  - Promote the forecast to reach more people especially those who are sensitive to air pollution - outreach
- Medium term
  - Build wintertime PM_{10} and $PM_{2.5}$ models
  - Include health/education/action messaging in bulletin
  - Expanding the geographical coverage of the forecast
- Longer term
  - Better guidance from numerical models
  - Definition of a nationally accepted AQI