Real Time Measurements of Aerosol Optical Properties for Data Assimilation

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MAIN OBJECTIVES OF AEROCAN NETWORK

- To provide aerosol optical depth measurements at specific representative sites across Canada to satellite atmospheric correction systems.

- To provide "ground truth" measurements of aerosol optical depth for validation of satellite-derived values.

- To analyze the spatial and temporal variations of the aerosol optical depth across Canada and to provide inputs for the validation of the Northern Aerosol Regional Climate Model.

Integrated Global Atmospheric Chemistry Observations System (IGACO) Theme Report (*draft 8)*

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…there needs to be a reasonably comprehensive set of global observations for both the troposphere and the stratosphere using a sparse number of satellites with Low Earth Orbit (LEOs), **ground-based stations** and aircraft platforms. Atmospheric modelling capabilities are required to begin to assimilate them into a global picture.

Necessary measures include the development of the next generation of satellites, **the reinforcement of** routine aircraft and **ground-based observations**, and the systematic development and **implementation of data assimilation** techniques. **Existing networks require maintenance, gap-filling and coordination.**

WMO/GAW Experts Workshop
8 – 10 March 2004, Davos, Switzerland

ECMWF: GEMS
Global Earth-system Monitoring using Space and in-situ data

GEMS: Extend the Data Assimilation system at ECMWF to describeatmospheric dynamics, thermodynamics and composition:

- **GREEHOUSE GASES**
- **REACTIVE-GASES**
- **AEROSOL**

- **Aerosol is the biggest source of error in ECMWF clear-sky radiation computations (JJ Morcrette, pers.comm.)**
- **HIRS channels sensitive to the surface temperature, lower tropospheric temperature, and moisture are subject to a 0.5 K or more reduction in the brightness temperature during heavy dust loading conditions. (Weaver, Joiner, GinouxJGR April 2003)**

NEW OBJECTIVE

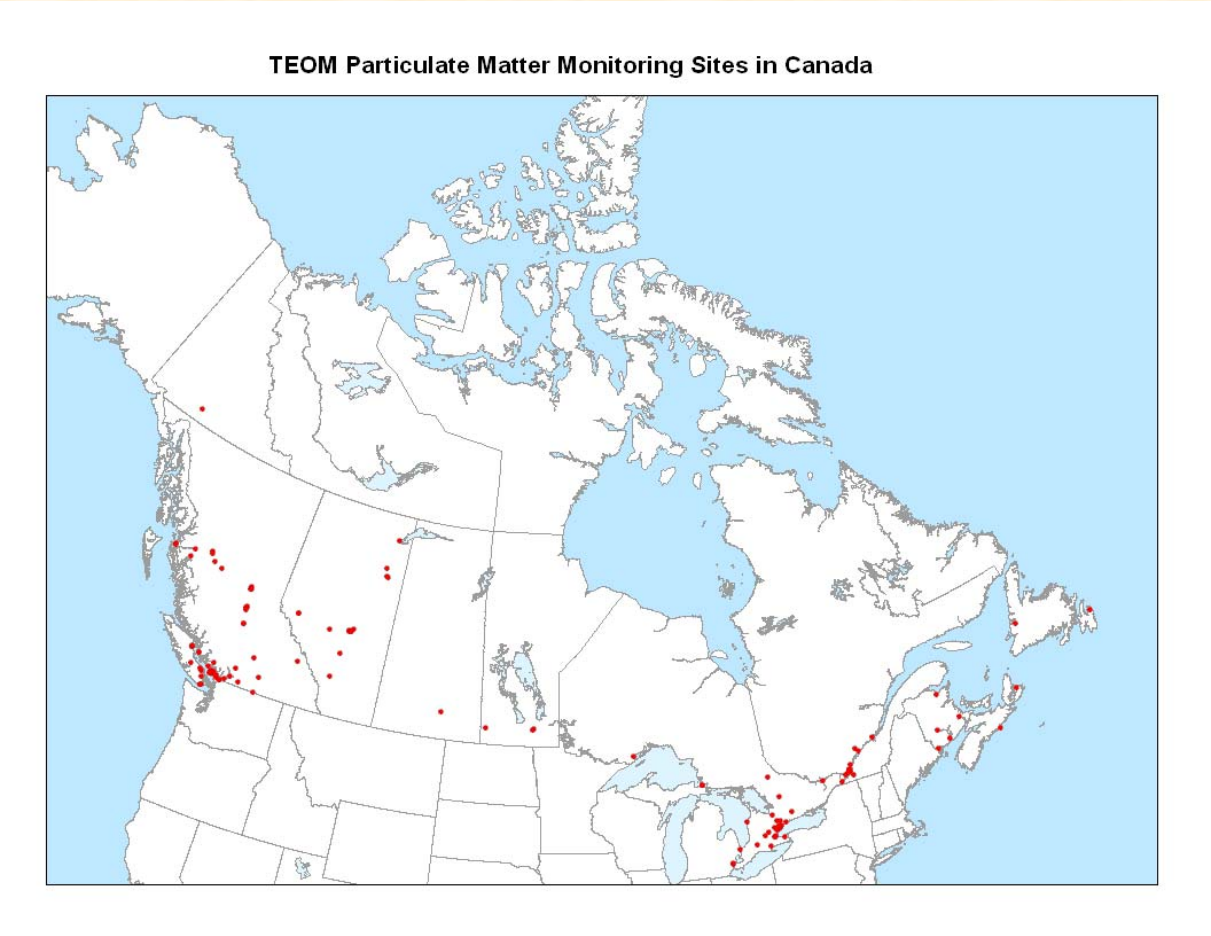
To provide real-time data for assimilation into the Air Quality forecast model.

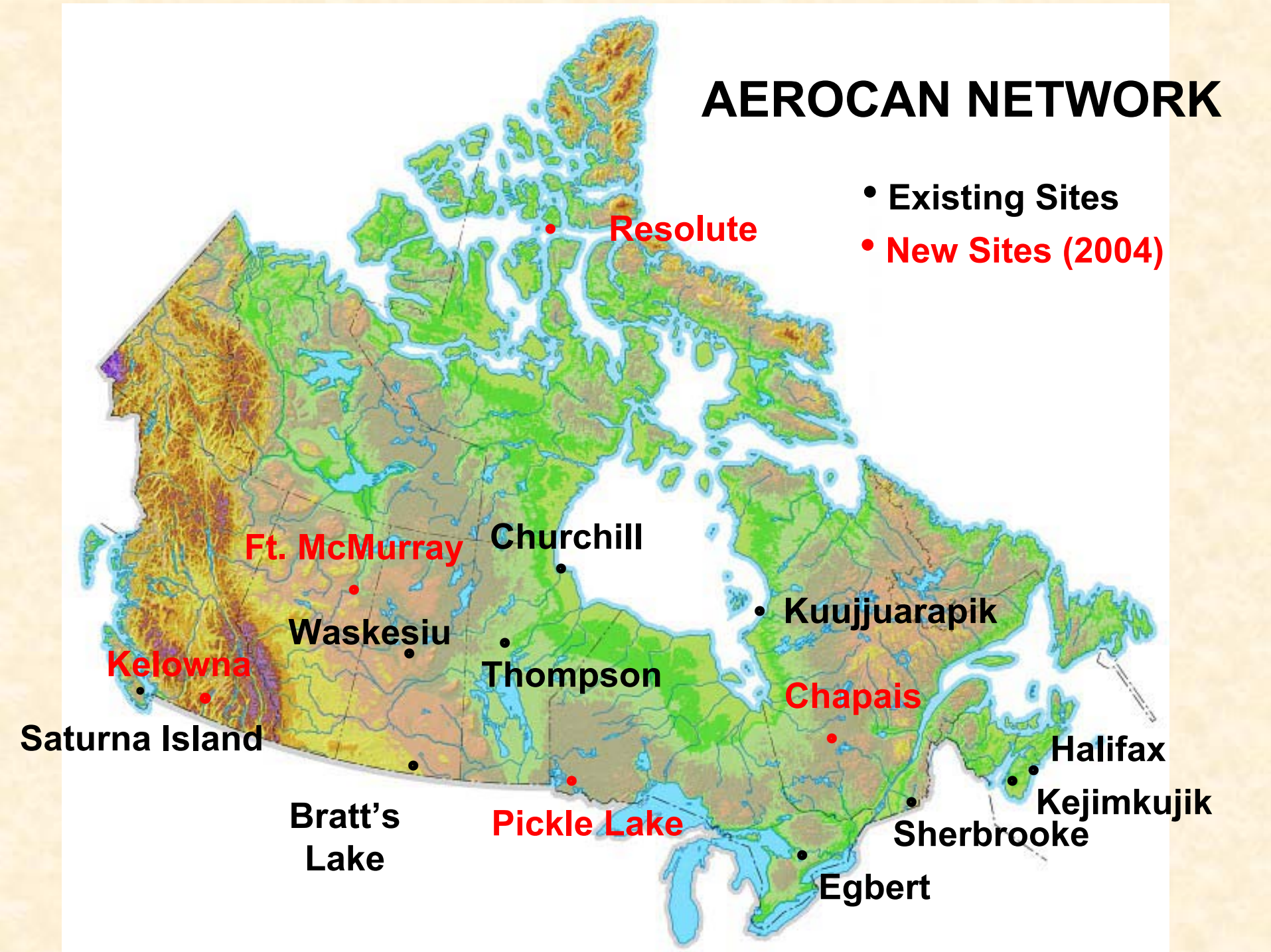
- **'Chemical Weather' – initiative by MSC to incorporate data assimilation of aerosol and chemical properties into the forecast model**
- **Similar to the plans of ECMWF, but on a smaller scale**
- **Use MODIS aerosol products from FTP site**
- **Include AEROCAN optical depths and Ångström coefficients, and TEOM PM 2.5 and PM 10 observations**
- **Couple air quality, GHG and numerical weather prediction by 2008**
- **Assimilation of AEROCAN products to begin in 1 to 2 years**

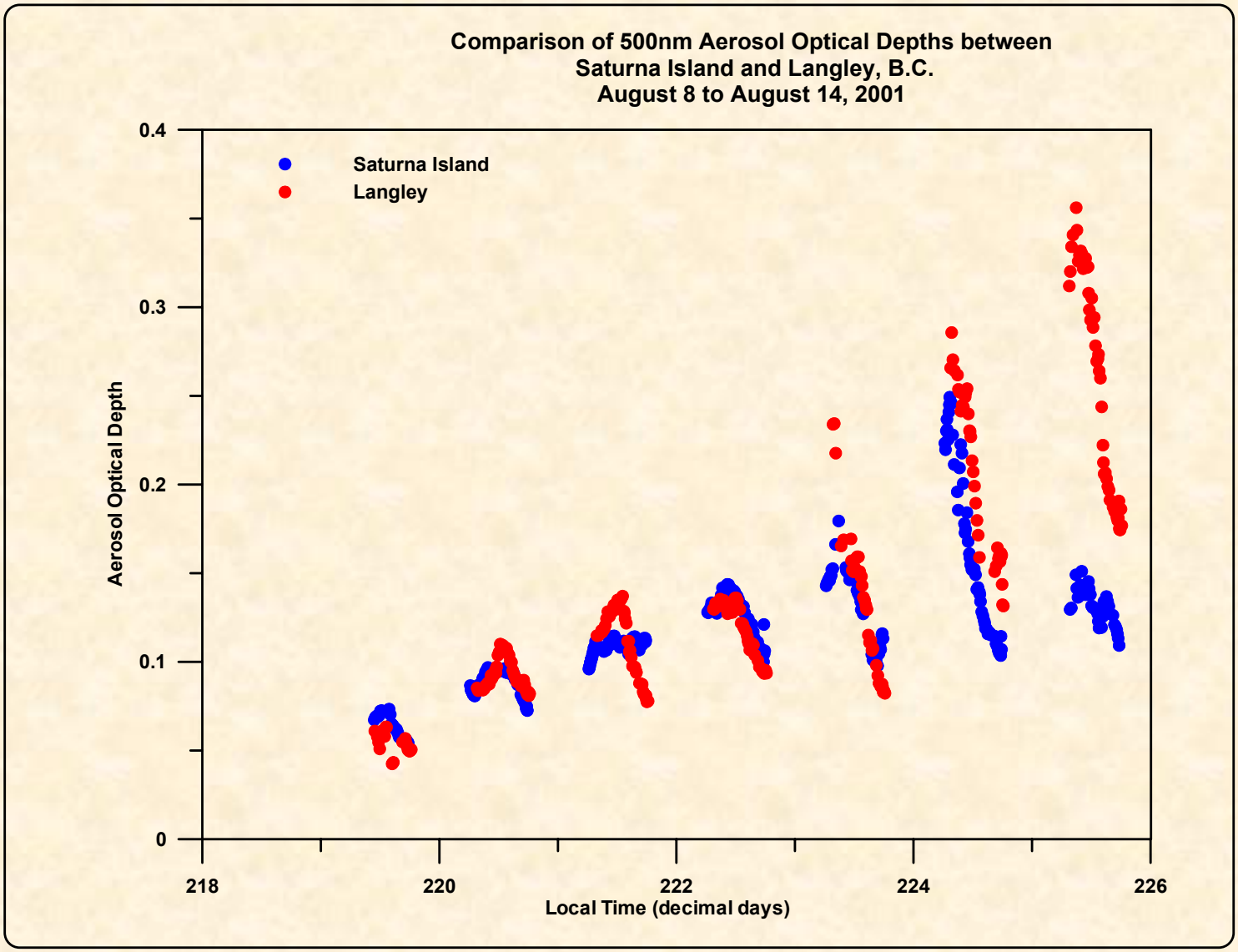
Data Assimilation of aerosols within the MSC NWF Model will be a combination of surface and columnar observations

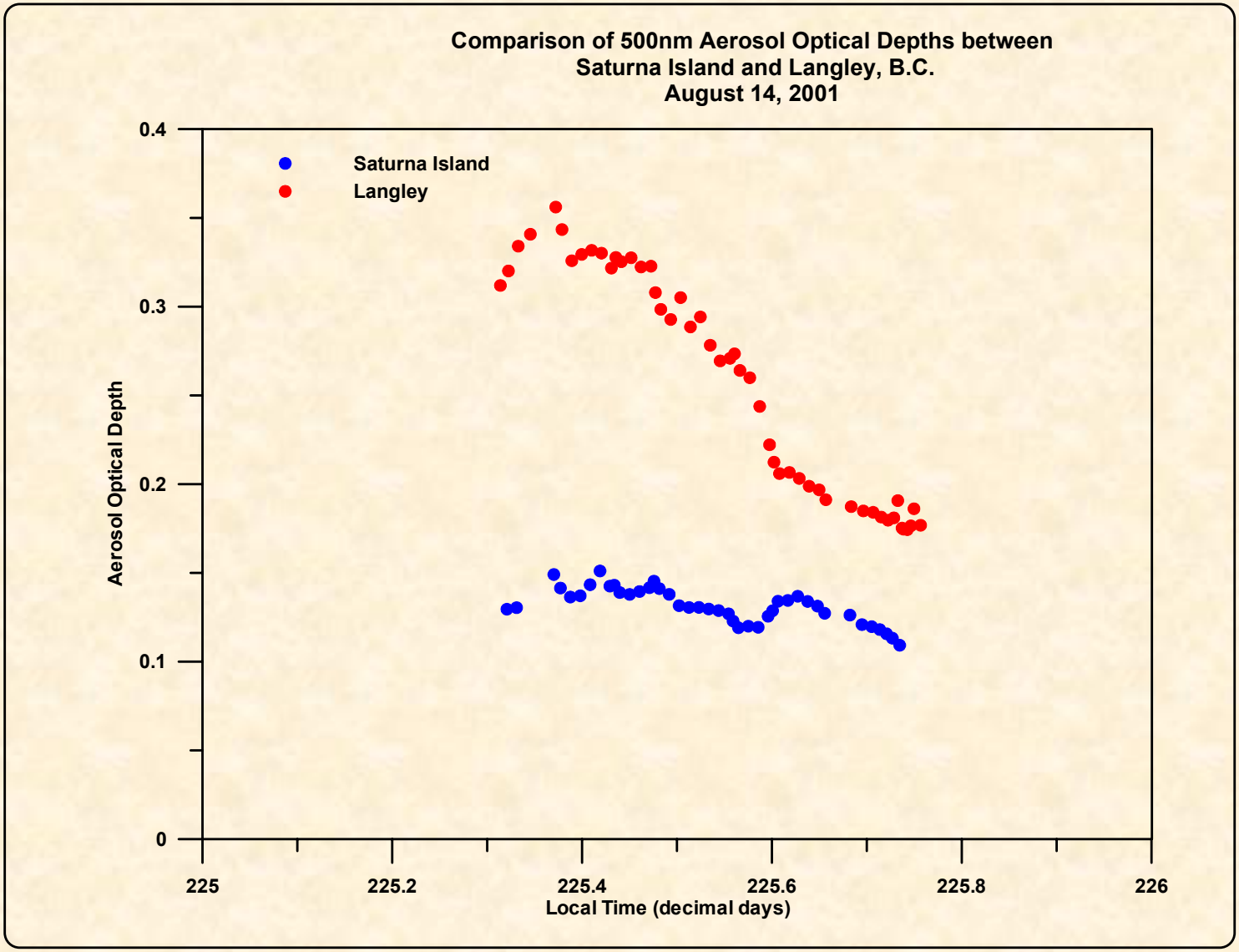
TEOM (tapered element oscillating microbalance)

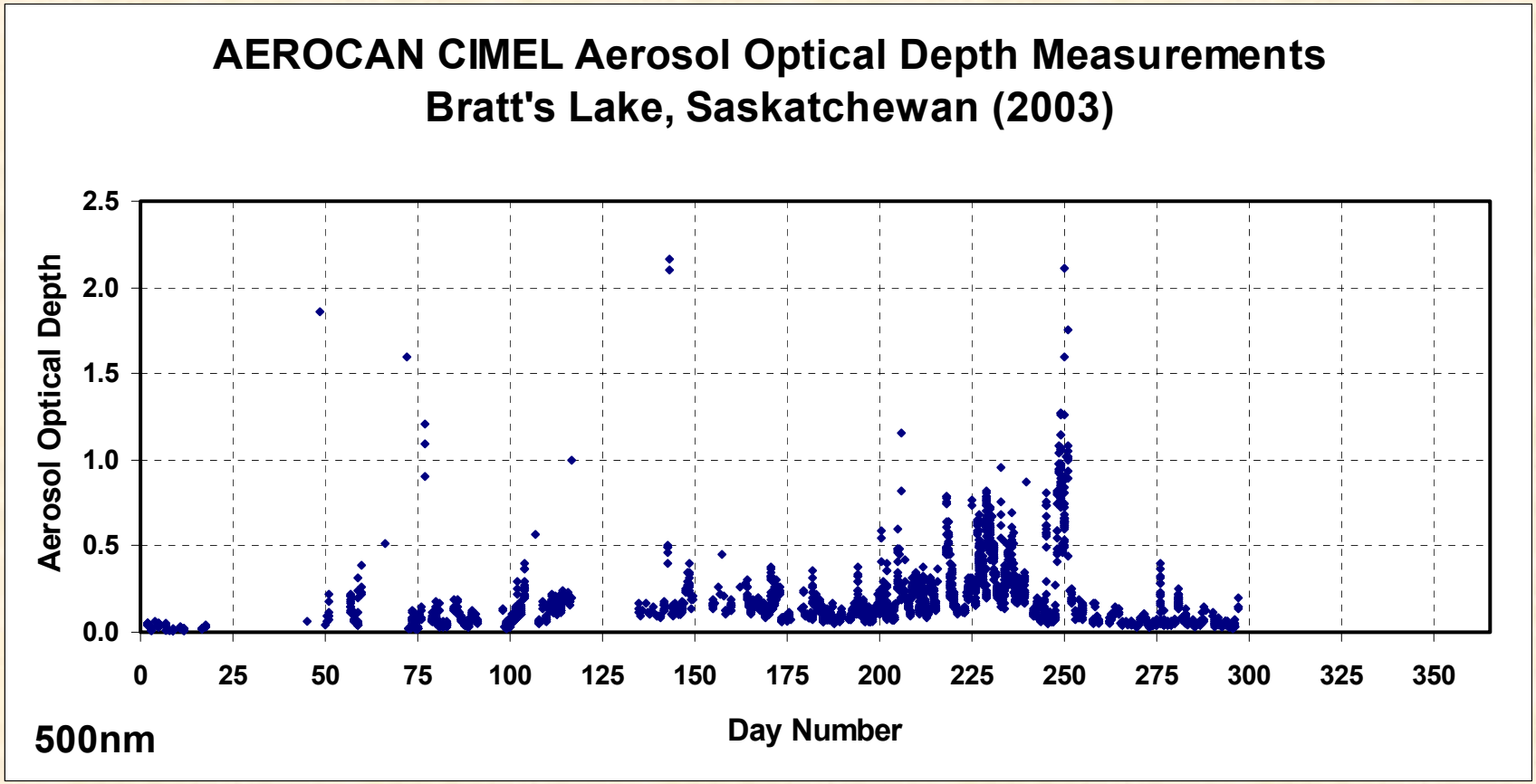
•Real Time Measurement of PM2.5 and PM10
•Primarily an urban network

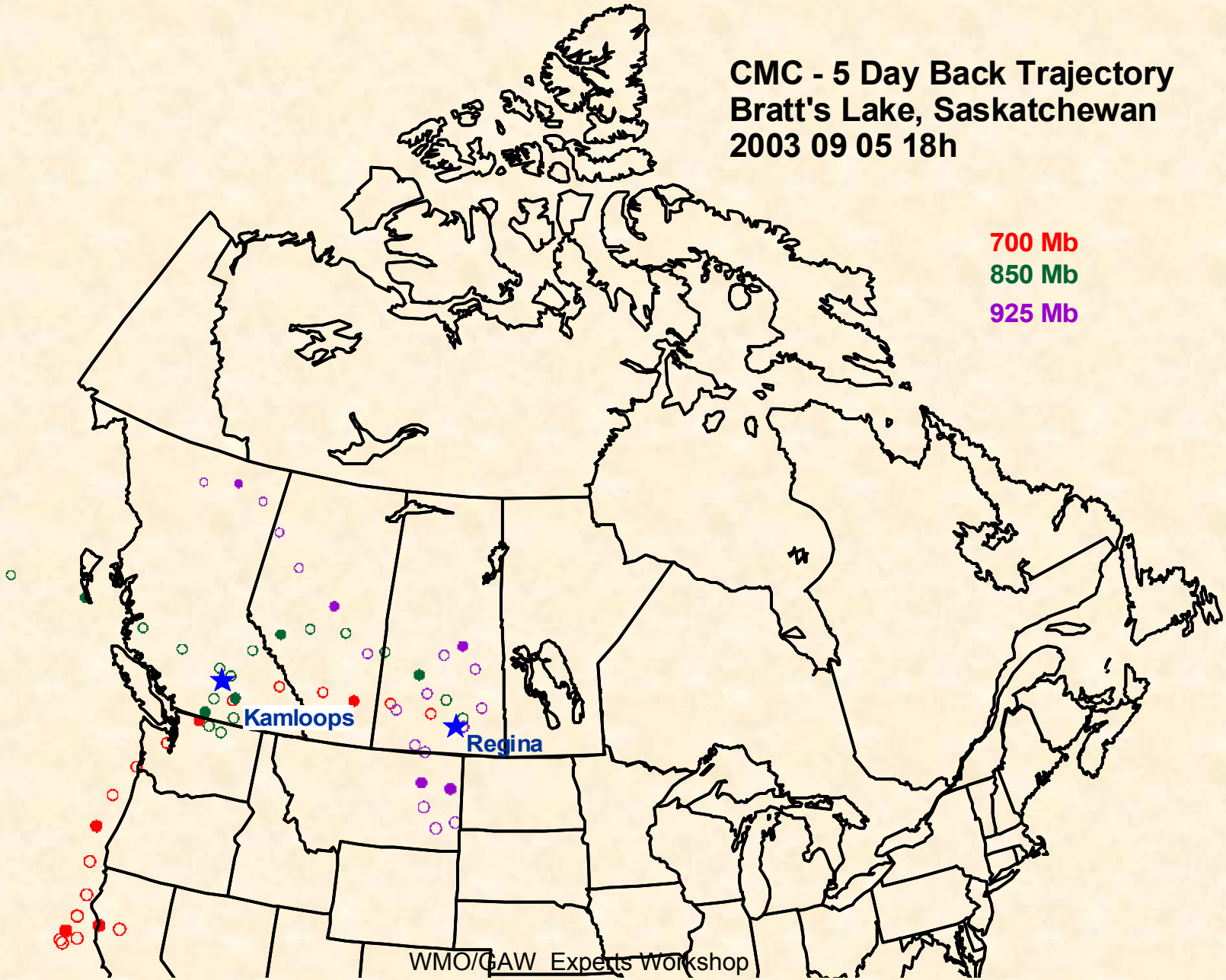



AEROCAN NETWORK
• Existing Sites
• New Sites (2004)
Resolute
Ft. McMurray
Churchill
Waskesiu
Kuujjuarapik
Kelowna
Thompson
Chapais
Saturna Island
Halifax
Kejimkujik
Bratt's Lake
Pickle Lake
Sherbrooke
Egbert


Comparison of 500nm Aerosol Optical Depths between
Saturna Island and Langley, B.C.
August 8 to August 14, 2001
Saturna Island
Langley
Aerosol Optical Depth
0.4
0.3
0.2
0.1
0
218
220
222
224
226
Local Time (decimal days)

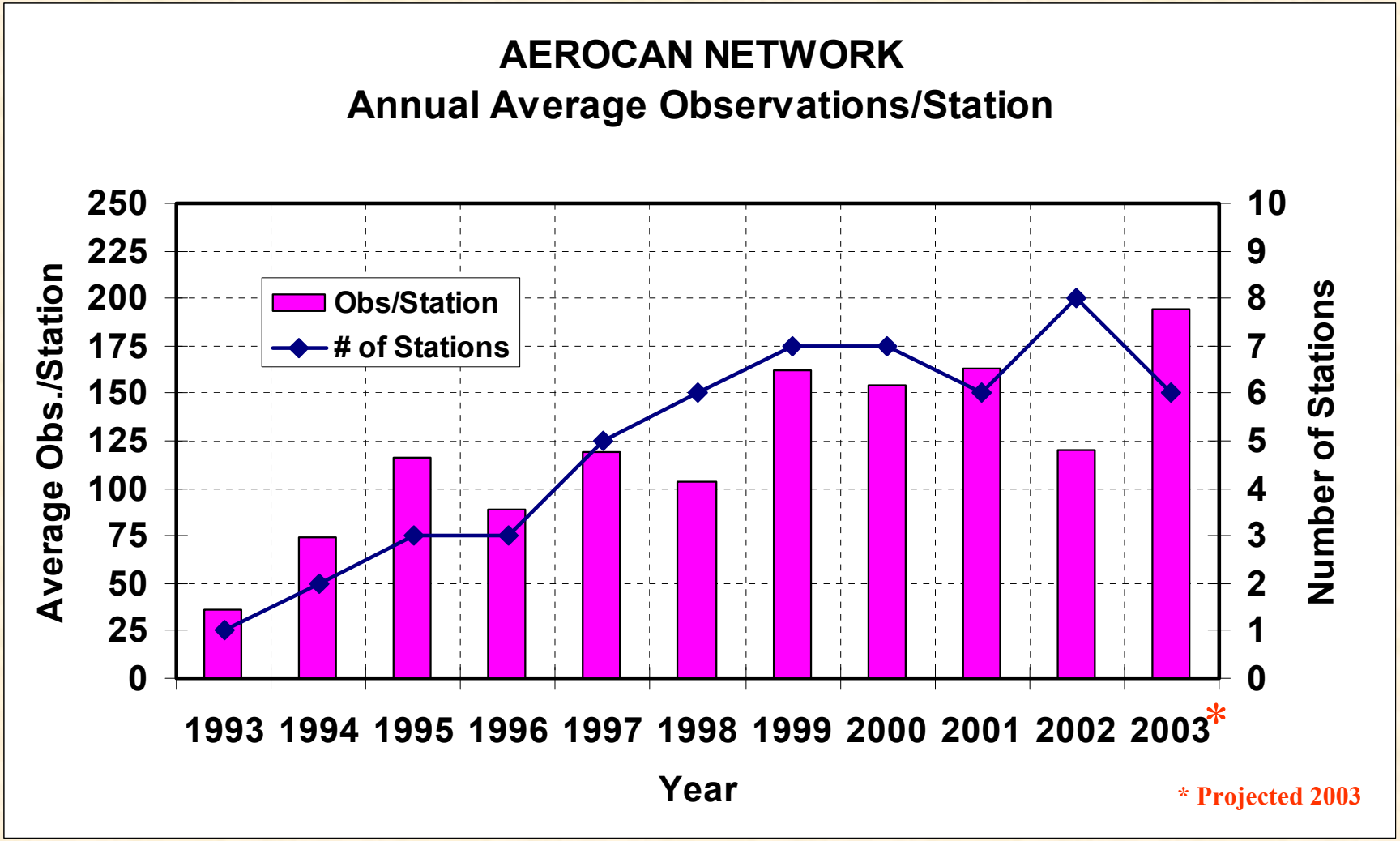

Comparison of 500nm Aerosol Optical Depths between
Saturna Island and Langley, B.C.
August 14, 2001
Saturna Island
Langley
Aerosol Optical Depth
0.4
0.3
0.2
0.1
0
225
225.2
225.4
225.6
225.8
226
Local Time (decimal days)

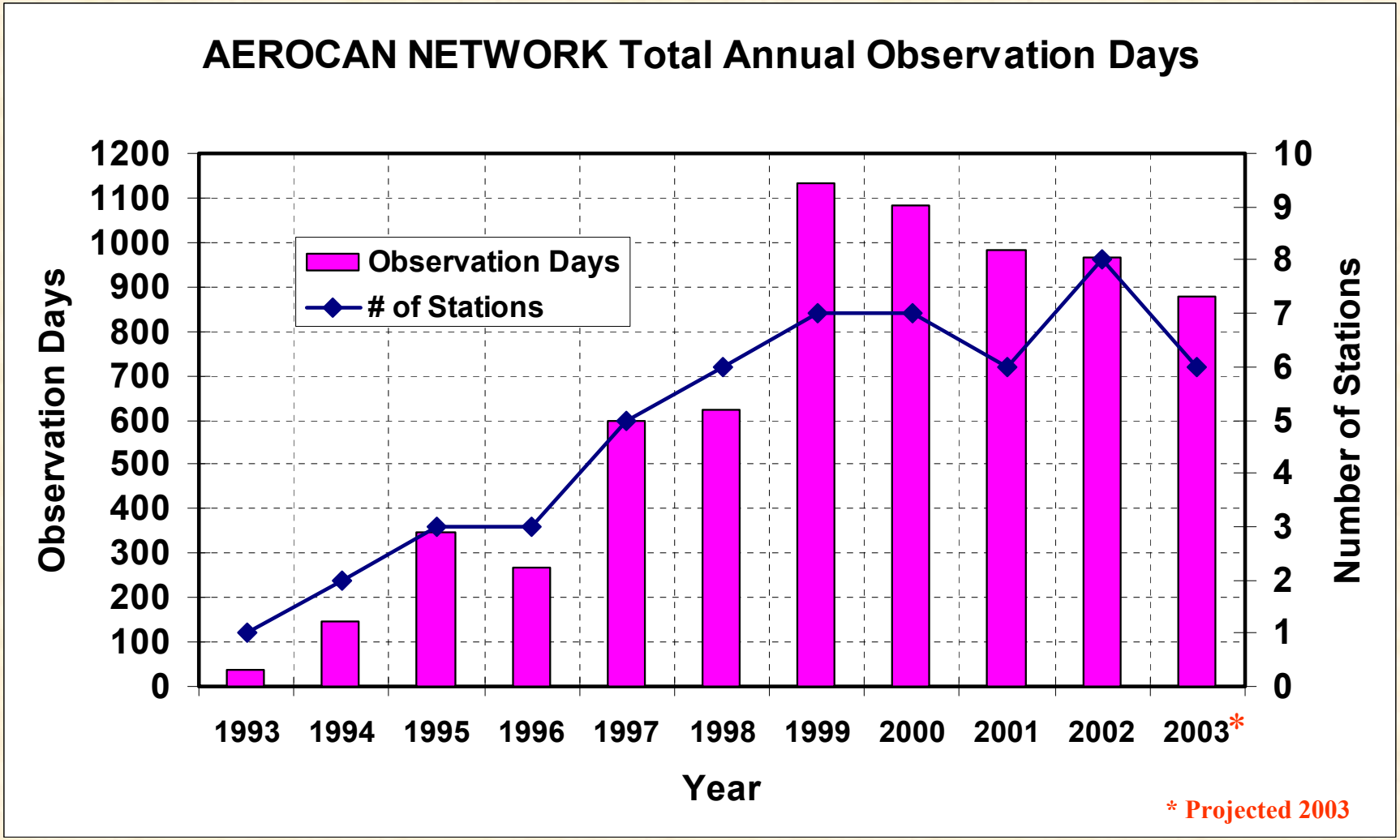

AEROCAN CIMEL Aerosol Optical Depth Measurements
Bratt's Lake, Saskatchewan (2003)
Aerosol Optical Depth
2.5
2.0
1.5
1.0
0.5
0.0
0
25
50
75
100
125
150
175
200
225
250
275
300
325
350
Day Number
500nm


CMC - 5 Day Back Trajectory
Bratt's Lake, Saskatchewan
2003 09 05 18h
700 Mb
850 Mb
925 Mb
Kamloops
Regina

AERONET Observation Sequence

- individual direct sun triplet: sequence of three direct sun measurements taken 30 seconds apart
- during the large airmass periods direct sun measurements are made at 0.25 airmass intervals
- at smaller airmasses the interval between measurements is typically 15 minutes
- measure the sky radiance along the solar principal plane (i.e., at constant azimuth angle, with varied scattering angles) up to nine times a day
- along the solar almucantar (i.e., at constant elevation angle, with varied azimuth angles) up to six times a day
- **for the RTM program direct sun observations will be increased to once every 2 minutes during gaps in the AERONET sequence**

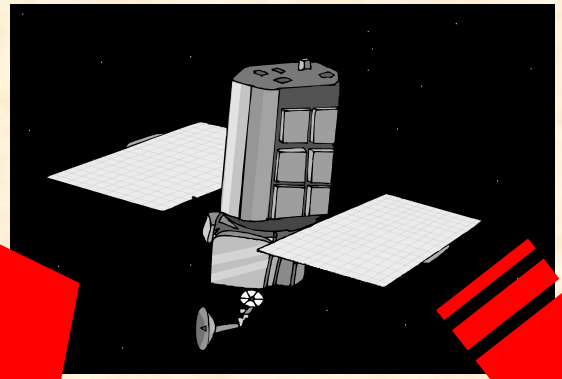

AEROCAN NETWORK
Annual Average Observations/Station
Average Obs./Station
Number of Stations
Obs/Station
# of Stations
250
225
200
175
150
125
100
75
50
25
0
10
9
8
7
6
5
4
3
2
1
0
1993 1994 1995 1996 1997 1998 1999 2000 2001 2002 2003*
Year
* Projected 2003


AEROCAN NETWORK Total Annual Observation Days
Observation Days
Number of Stations
Year
Observation Days
# of Stations
1200
1100
1000
900
800
700
600
500
400
300
200
100
0
10
9
8
7
6
5
4
3
2
1
0
1993
1994
1995
1996
1997
1998
1999
2000
2001
2002
2003*
* Projected 2003

AEROCAN Improvements

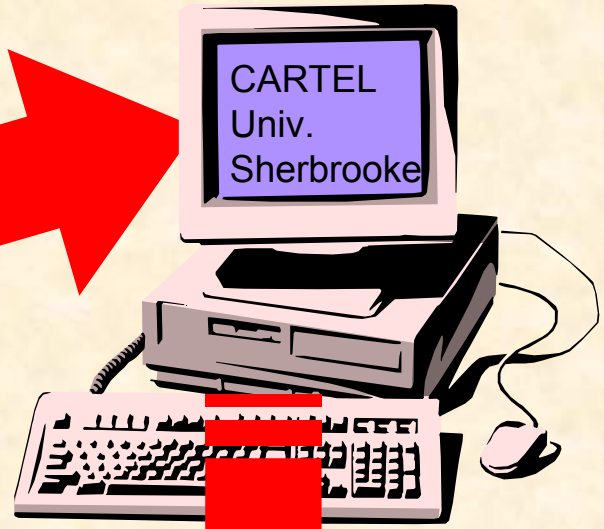
- Increased number of direct sun observations for assimilation
- Reduced downtime from instrument failures (increased CIMEL robustness)
- Reduced downtime for instrument calibrations
- Increased technical capabilities within AEROCAN
- Change the path for data transfer
- Real time processing of AOD(T?)

Present

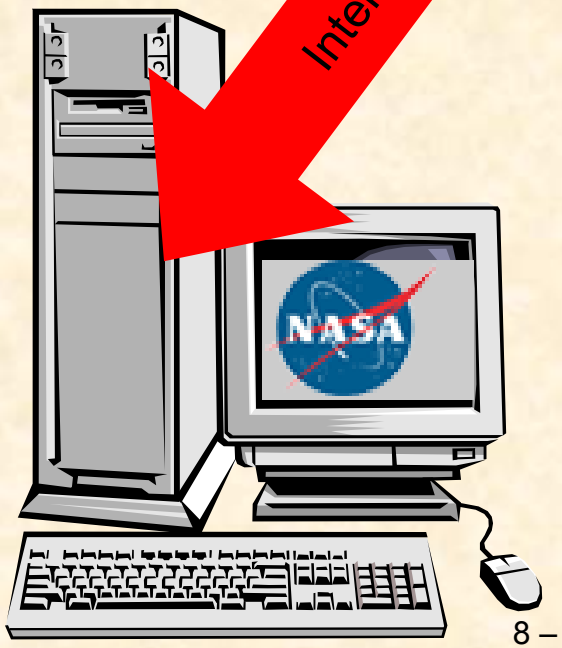


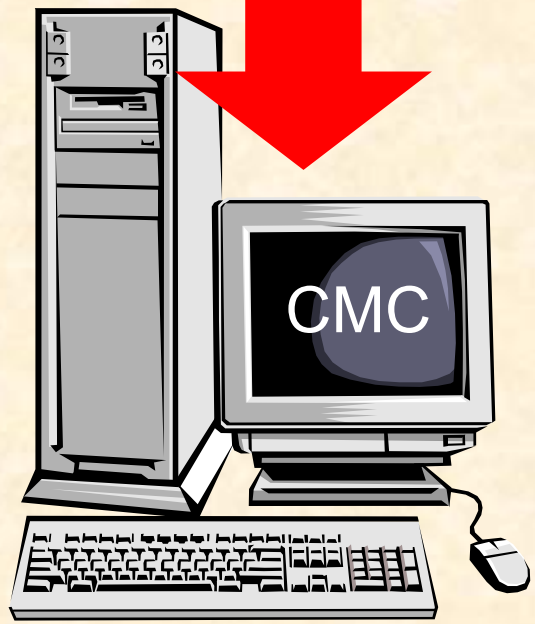
Future

Internet



Internet





Timeline

- Delivery of 4 new Cimel instruments – immediate
- Installation of new sites – summer 2004
- Internet transfer of data to CARTEL database – fall 2004
- Real time AOD – winter 2004
- Data assimilation pilot project at CMC – summer 2005
- Development of Canadian technical facility – summer 2004 ->

The End

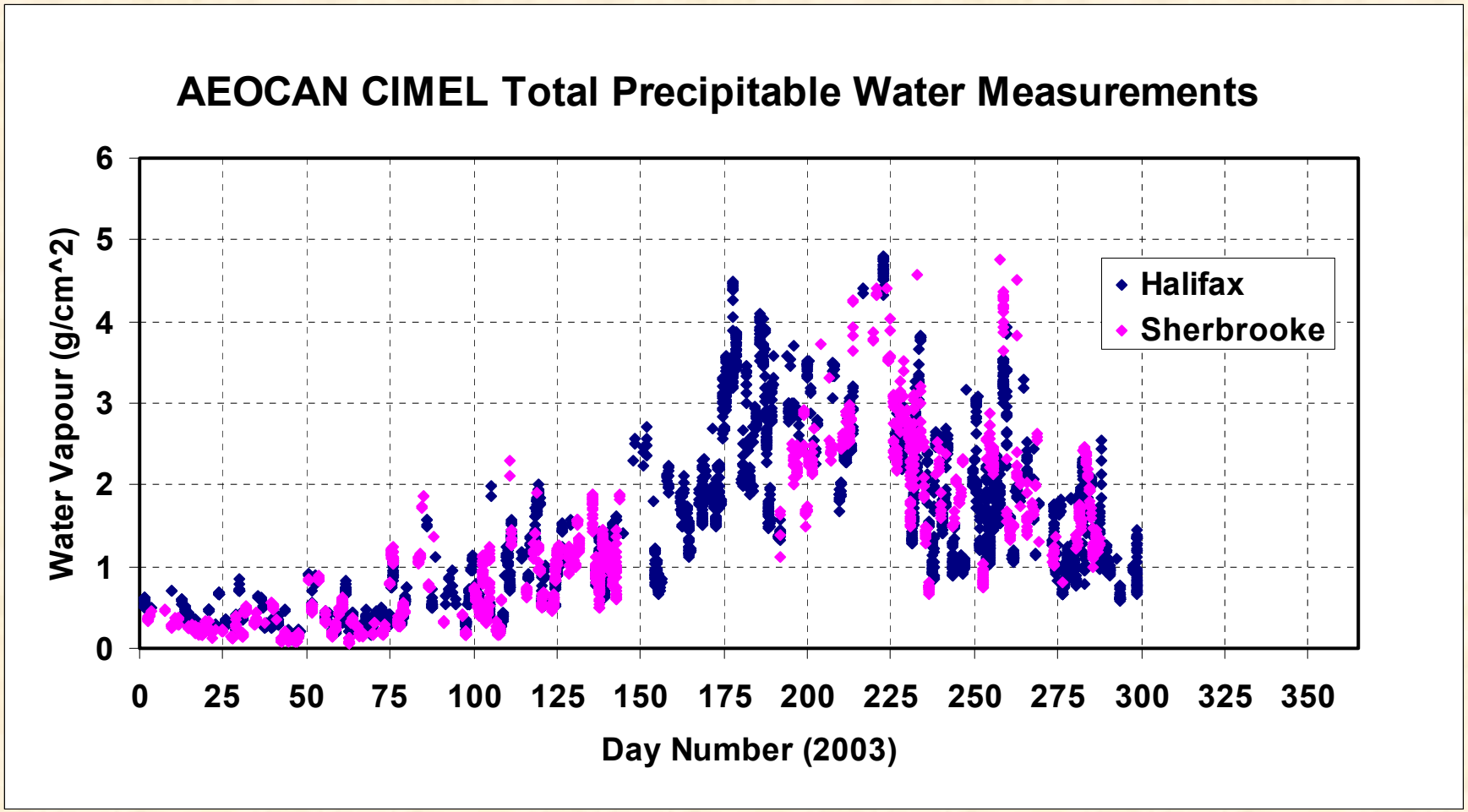
Cost-effective information provision through partnerships of Weather & Environment experts*

- **Policymakers' global environmental information needs cannot be met without an Earth-system modelling and data assimilation capability.**
- **Numerical Weather Prediction (NWP) Centres will exploit most of the new instruments anyway. To achieve good estimates of T, q, O3, ocean stress…., NWP centres must do a superb job on key tasks such as Calibration, Channel selection, Cloud detection, Assimilation…**
- **The NWP tasks are essential pre-requisites to meeting environmental information needs**
- **A partnership of environmental and NWP experts offers two big PAYOFFS**
    1. **a thorough exploitation and validation of satellite data and in-situ data for both weather and environmental purposes.**
    2. **Improved models for Weather & short-range climate & environmental forecasts, because of the experience from long data assimilations.**

*GEMS **G**lobal **E**arth-system **M**onitoring using **S**pace and in-situ data for ECMWF, A. Hollingsworth

Aerosol Size Information (Ångström Coefficients)

Location	Condition	α	β
Saturna	AM	1.430	0.053
Langley	Dirty (AM)	1.819	0.072
Saturna	Clean (PM)	1.633	0.038
Langley	Clean (PM)	1.643	0.037


AEOCAN CIMEL Total Precipitable Water Measurements
Water Vapour (g/cm^2)
0
1
2
3
4
5
6
0
25
50
75
100
125
150
175
200
225
250
275
300
325
350
Day Number (2003)
Halifax
Sherbrooke