Cruise Ship Emissions to Air – Victoria BC

GVHA Board Meeting – Nov 20, 2014

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Photo By Ghislain Bonneau

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Collaborators and Funders

University of Victoria

NSERC CRSNG

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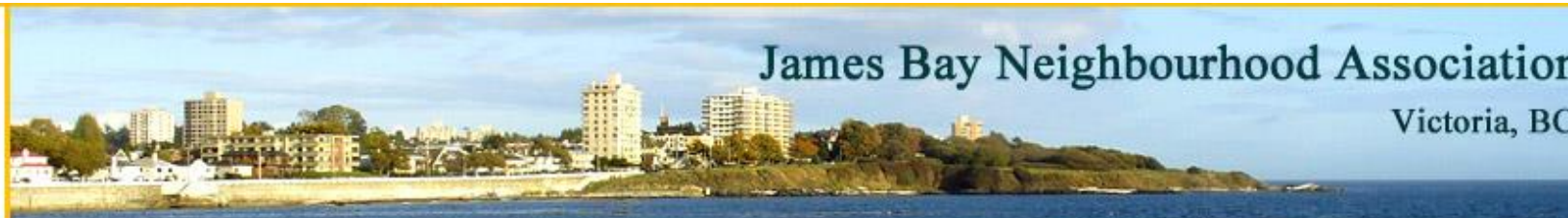
British Columbia
Ministry of Environment

BC Clean Air Research Fund

Vancouver Island health authority

Greater Victoria Harbour Authority

JBNA



FINE PARTICULATE

$PM_{2.5}$

NITROGEN DIOXIDE

NO_2

SULFUR DIOXIDE

SO_2

	2006	2007	2008	2009	2010	2011	2012	2013	2014
Number of cruise ships visiting	179	161	201	217	215	209	222	204	207
Hours with cruise ships	962	816	982	1188	1160	1165	1136	1097	

2006 →

TOPAZ

NORTH

2011 →

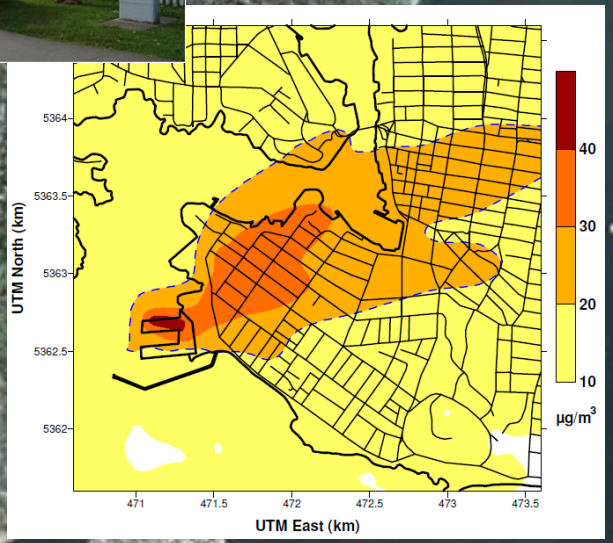
2009

ERIE

MAML

JAMES BAY NEIGHBOURHOOD

OGDEN POINT

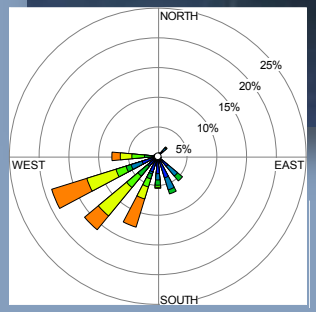


CRUISE SHIP DOCKS

2007

EXPLORATORY MONITORING & MODELLING

5 kilometers



FINE PARTICULATE

$PM_{2.5}$

NITROGEN DIOXIDE

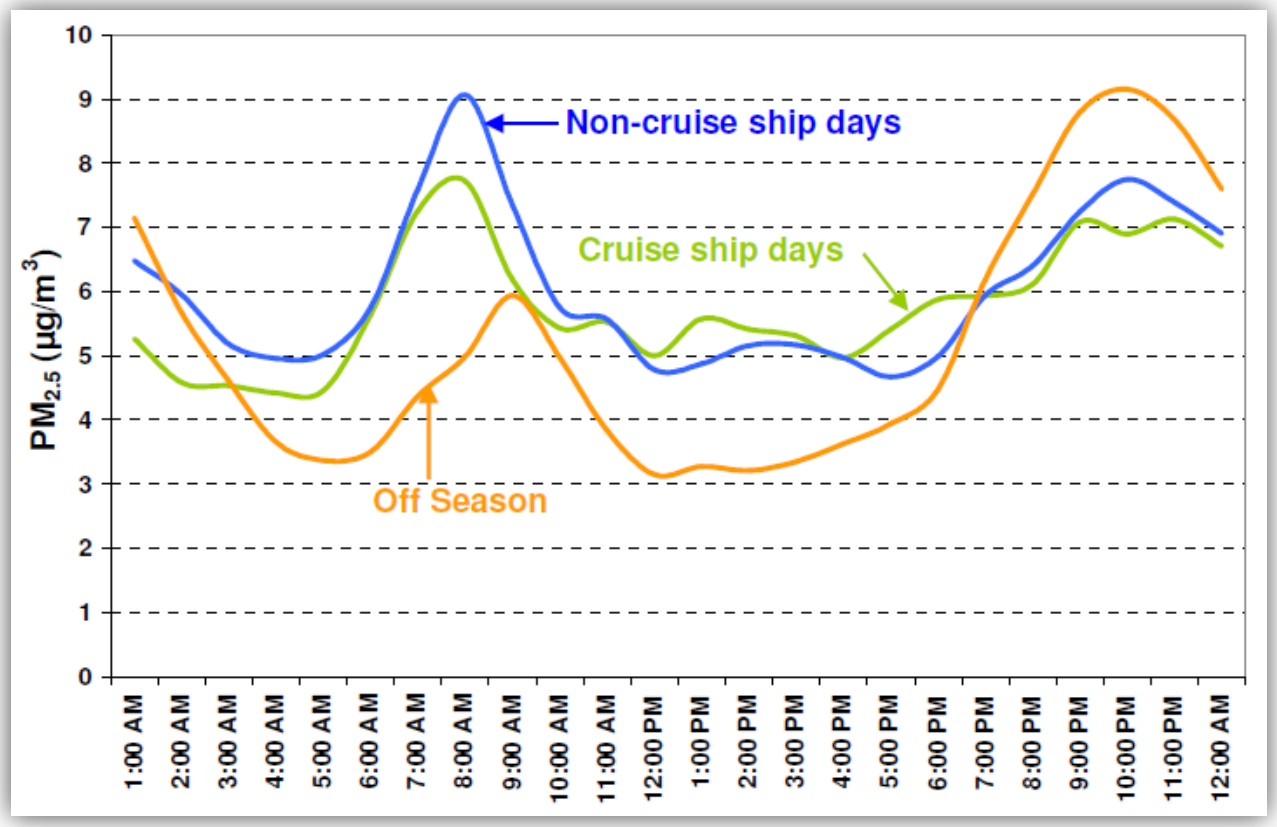
NO_2

SULFUR DIOXIDE

SO_2

2006 Topaz Station

Average levels by time of day can help show different sources but are NOT appropriate to compare to guidelines



2007 Exploratory monitoring:

- **Maximum hourly measured was ~ 14 µg/m^3**
- **Maximum 24 hour average was 5.2 µg/m^3 in James Bay and 6.7 µg/m^3 at Topaz,**
  - **similar on days with and without cruise ships**

2009 MAML and Topaz data also showed levels typical of region, max level 17 µg/m^3 at both locations, below new CWS 24-hour guideline of 28 µg/m^3, BC 24 hour guideline of 25 µg/m^3

FINE PARTICULATE

$PM_{2.5}$

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SO_2

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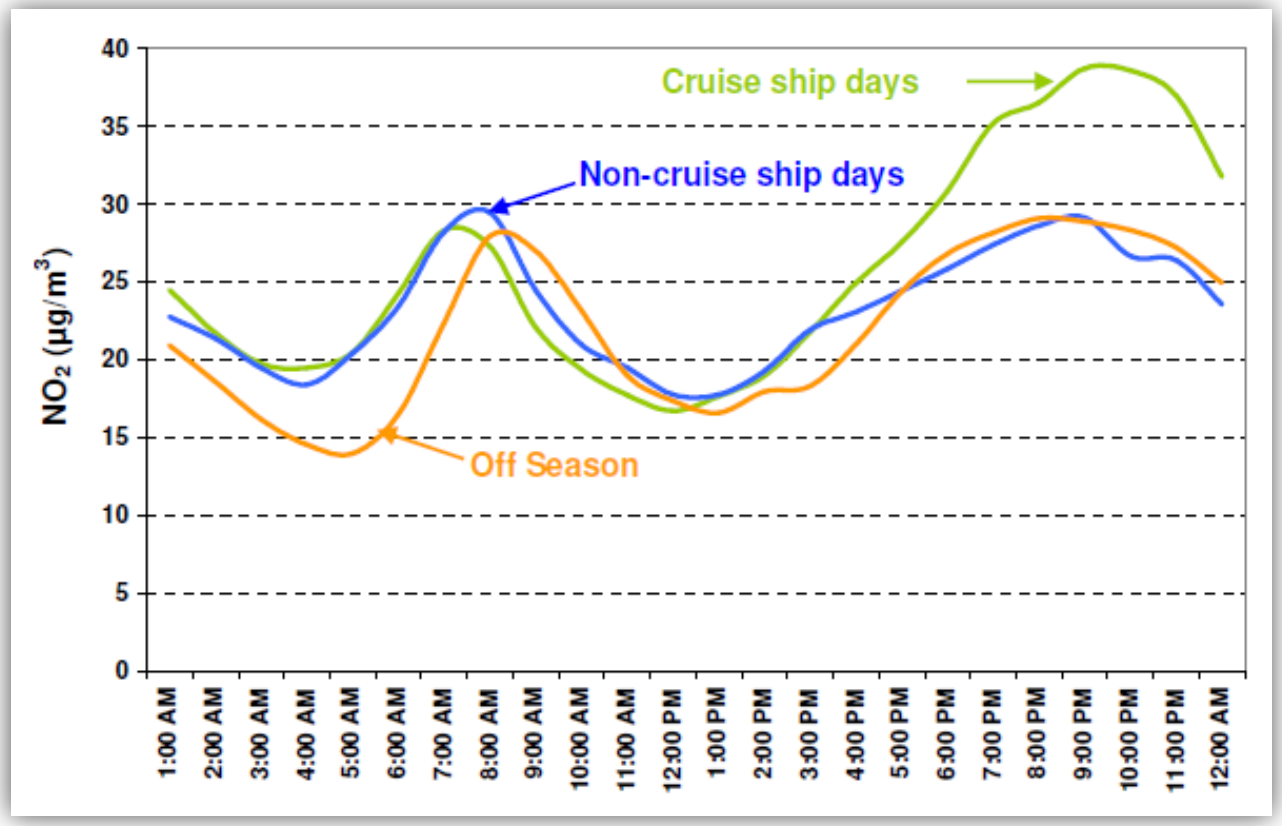
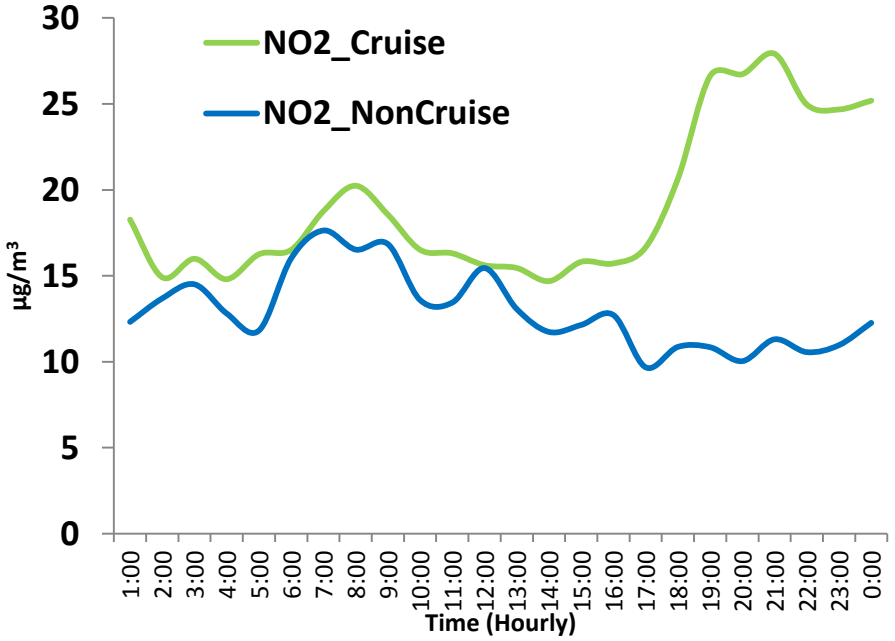


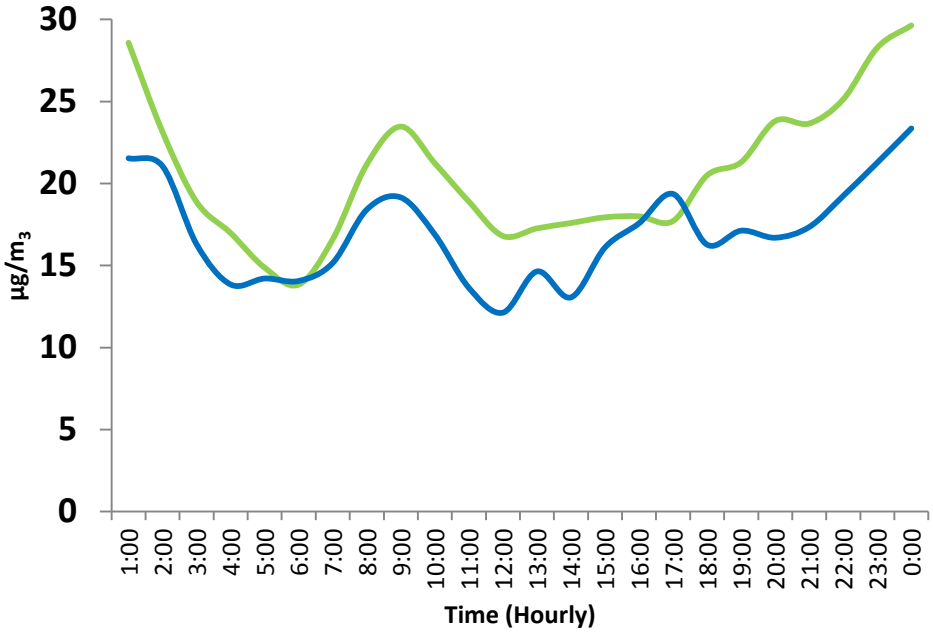
2007 Exploratory monitoring:

- **Average hourly (14 days integrated) measured at 31 different sites ranged from 4.5 to 23.7 µg/m^3**
- **Average hourly measured at Topaz was ~ 20 µg/m^3 for same time periods**
- **Similar on days with and without cruise ships**

2009 MAML



2009 TOPAZ



Average levels by time of day can help show different sources but are NOT appropriate to compare to guidelines

2009 monitoring MAML

WHO hourly guideline: 200 µg/m³

Percentiles	HOURLY NO_2 Cruise	No Cruise
5th	2.7	2.1
50th	15.5	10.7
90th	38.9	26.6
95th	48.5	31.8
99th	66.8	41.5
Max	78.5	51.7

FINE PARTICULATE

$PM_{2.5}$

NITROGEN DIOXIDE

NO_2

SULFUR DIOXIDE

SO_2

2006 Topaz Station

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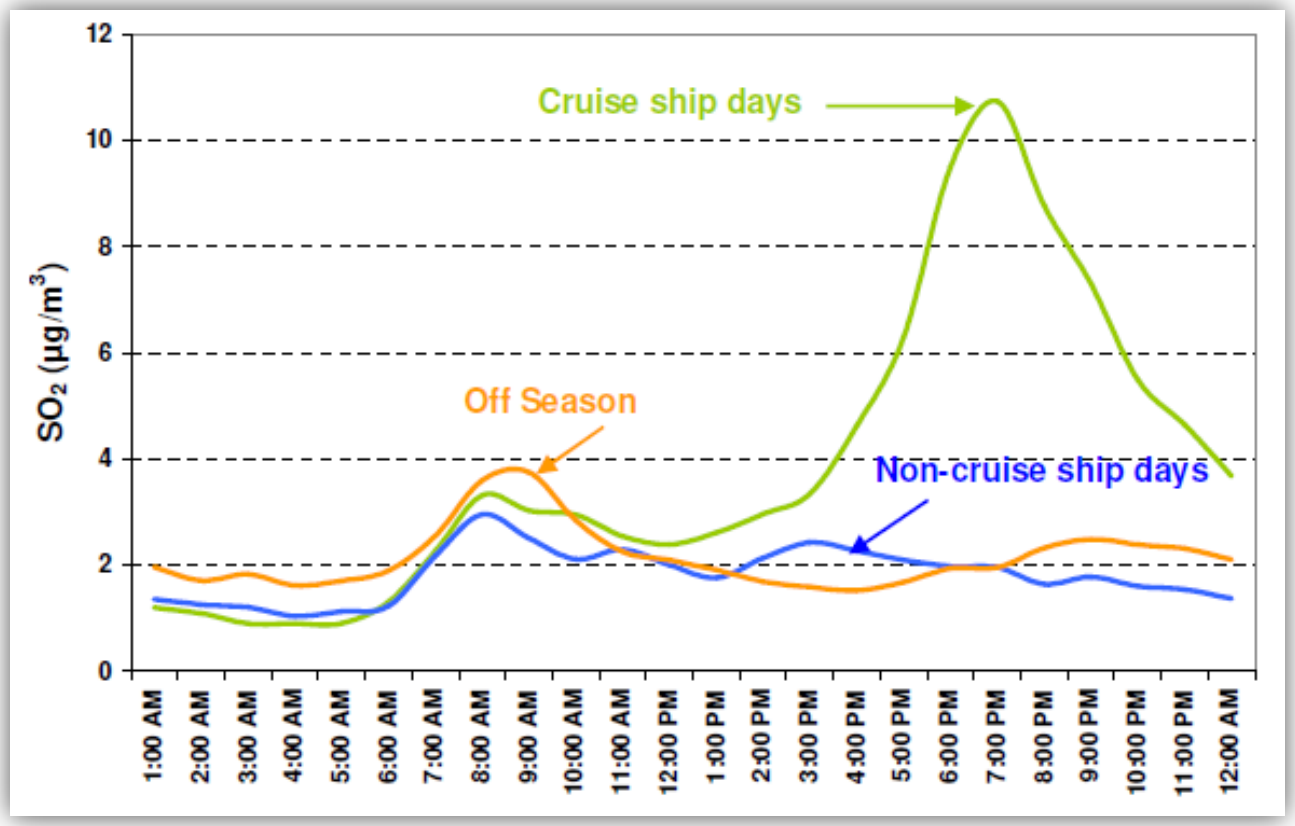


Guidelines:

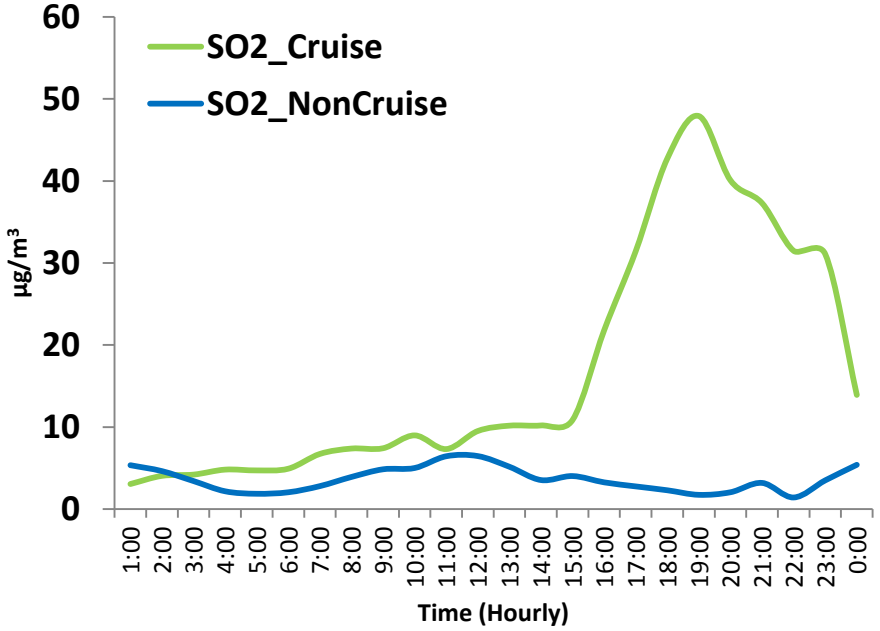
BC Level A	450
Canada Max Desirable	450
US EPA	265

HOURLY SO_2

Percentiles	Cruise
5th	0
50th	3
90th	16
95th	29
99th	55
Max	77

Well under guidelines, but shows presence of infrequent high episodes at Topaz location

2009 MAML



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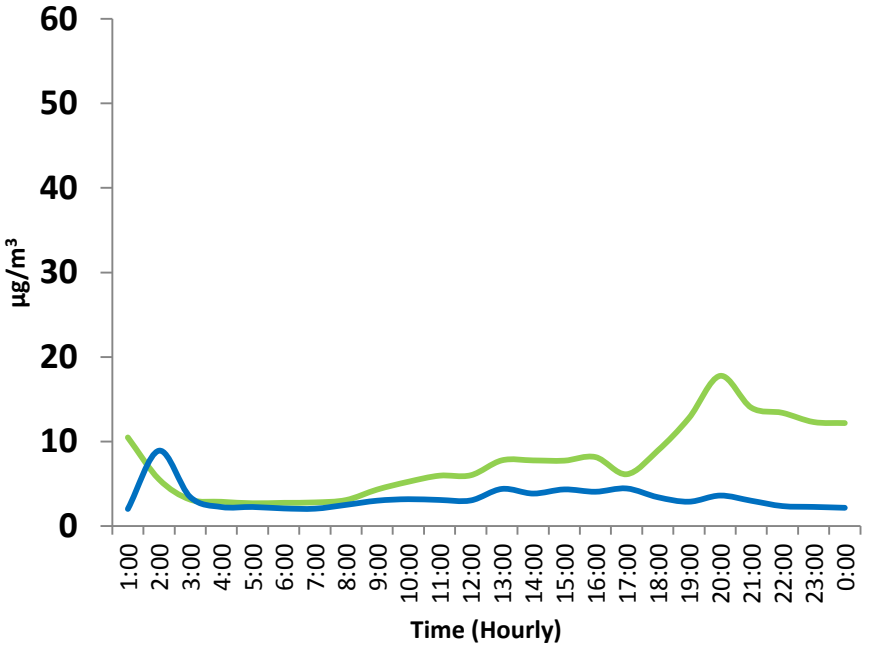


Average levels by time of day can help show different sources but are NOT appropriate to compare to guidelines

2009 monitoring MAML

Guidelines:

BC Level A	450
Canada Max Desirable	450
US EPA	265

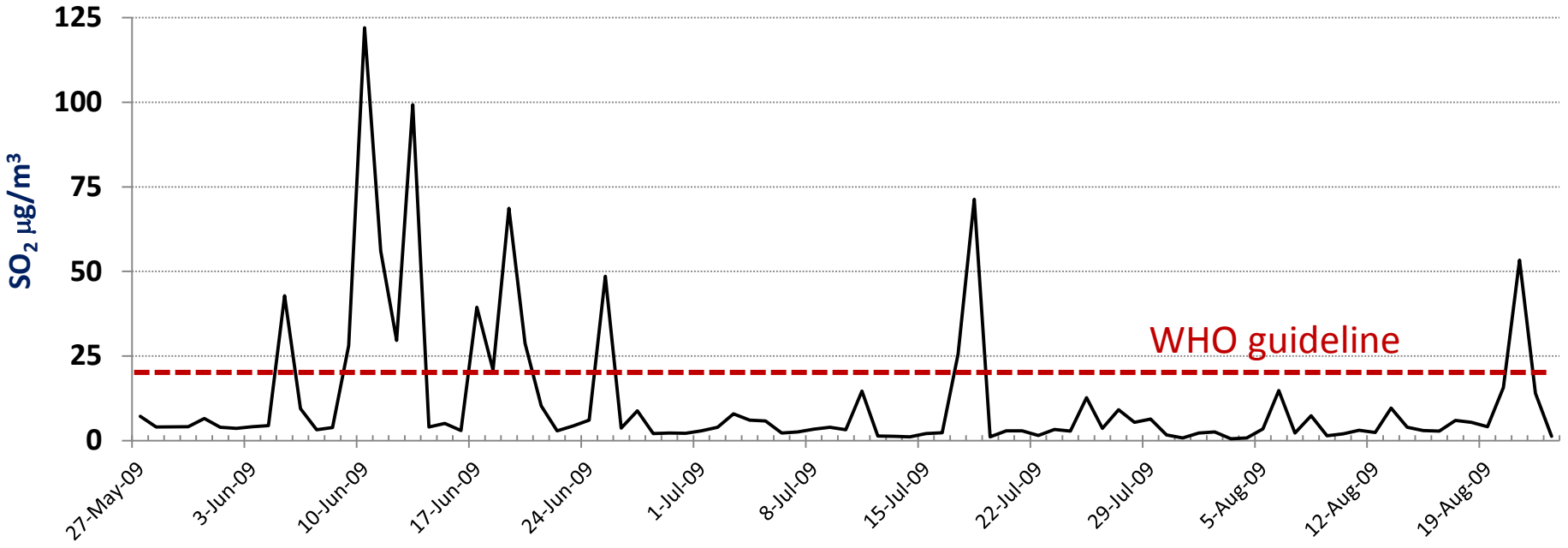
(50 hours / 2072 hours)

HOURLY SO_2

Percentiles	Cruise
5th	0
50th	3
90th	27
95th	109
99th	278
Max	448

ALSO: 10 minute levels exceeded WHO guideline (500 µg/m³) three times

2009 MAML



2009 monitoring MAML

Guidelines:

BC Level A	160
Canada Max Desirable	150
WHO (14 days / 87 days)	20

24-HOUR AVERAGE SO_2

Percentiles	µg/m³
5th	1.2
50th	3.9
90th	34.5
95th	55.4
99th	102.7
Max	122.0

2009 - Based on this evidence, a health risk assessment was conducted for VIHA by Dr. Tom Kosatsky of the BC Centre for Disease Control:

- Cruise ship derived SO_2 would be expected to have a very small, but calculable impact on the **risk of dying** on the days ships are in port (although too small to calculate yearly average).
- **The risk of dying indicator is a marker for other less severe, but probably more numerous, health impacts.**
  - Health conditions which might be exacerbated by exposures to SO_2 are asthma and COPD
  - These are largely self-managed, unlikely to appear in physician's offices, emergency rooms or inpatient wards during periods of exceedences

2009 - Based on this evidence, a health risk assessment report was prepared for VIHA by Dr. Tom Kosatsky of the BC Centre for Disease Control:

- It is not expected that there will be long-term health effects for James Bay residents. However, short term effects could occur in susceptible and **even in non compromised** individuals.

- For example, SO_2 exposure, especially at the higher levels recorded during 10- minute intervals at MAML in James Bay could plausibly cause wheeze and difficulty breathing in persons with asthma, and to a lesser degree, even in persons who do not have respiratory disease.

- These reactions are made more likely during exercise, when deep breathing allows SO_2 to reach deeply into the lungs. Under these circumstances, not actively exercising would be protective.

VIHA Health Risk Guide HOURLY levels

0 to ~ 90 μg/m³

~90 to ~ 200 μg/m³

~200 to ~ 480 μg/m³

Higher than ~ 480 μg/m³

Sulphur Dioxide Concentration (ppb*)	Air Quality	At-Risk Populations**	General Population
0 - 35 Good	Air quality is satisfactory, SO2 concentrations pose little or no risk	Enjoy your usual outdoor activities. Follow Dr's advice for exercise regime and condition management.	No need to modify usual outdoor activities.
36 - 75 Moderate	There may be a moderate health risk for a very small number of people who are unusually sensitive to SO2.	A small number of persons with asthma who are very sensitive to SO2 may experience symptoms. Follow Dr's advice for managing condition.	No need to modify usual outdoor activities.
76 - 185 Unhealthy for Sensitive Groups	Members of sensitive groups may experience health effects. The general public is not likely to be affected.	Increasing likelihood of respiratory symptoms such as chest tightness and breathing discomfort in people with asthma. People with asthma should consider limiting outdoor exertion or reschedule when SO2 concentrations are lower. Follow Dr's advice for managing condition.	No need to modify usual outdoor activities unless you experience symptoms of cough or wheeze when exercising.
more than 185 Unhealthy	Everyone may begin to experience health effects; members of sensitive groups may experience more serious health effects.	Children, the elderly, asthmatics and people with heart and lung disease should limit exertion outdoors or reschedule when SO2 concentrations are lower. Follow Dr's advice for managing condition.	At elevated SO2 concentrations, chest tightness and wheezing can occur, even with very brief exposures (minutes) in healthy people without asthma. Reschedule outdoor activity when SO2 levels are lower.

2009 - Dr. Richard Stanwick of VIHA made the following recommendations:

- Individuals with chronic lung or heart disease who live in the vicinity, [should] consult with their personal physician to manage their disease, as best they can, as it may serve to ameliorate any short-term SO_2 health effects.

- Given that the latest regulatory decision of the International Maritime Organization (IMO) will restrict emissions of SO_2 from Cruise Ships equivalent to **1% sulfur fuel by August 2012**, request **voluntary mitigation measures** for the next three cruise line seasons.

  - voluntary use of lower sulfur fuel (1%) by cruise ships while approaching, in port and departing Victoria Harbor with or without monetary incentives from Transport Canada or the Harbor Authority;

  - Adoption of lease language by the Harbor Authority to require the above low sulfur fuel use during these activities;

  - Issuance of health alerts targeting susceptible population groups

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TOPAZ

2011 →

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JAMES BAY NEIGHBOURHOOD

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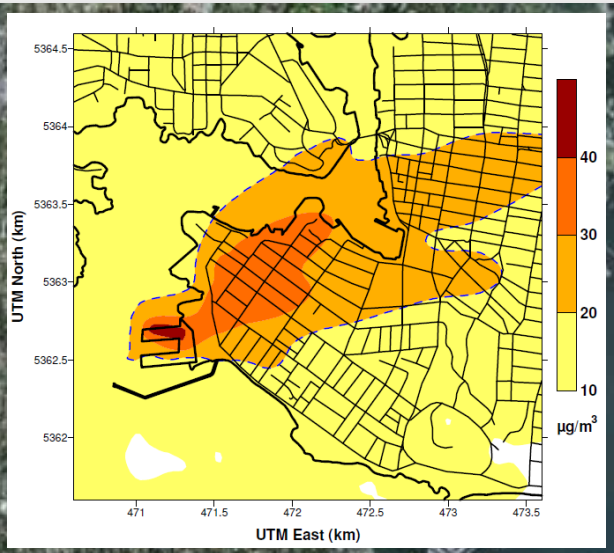
CRUISE SHIP DOCKS

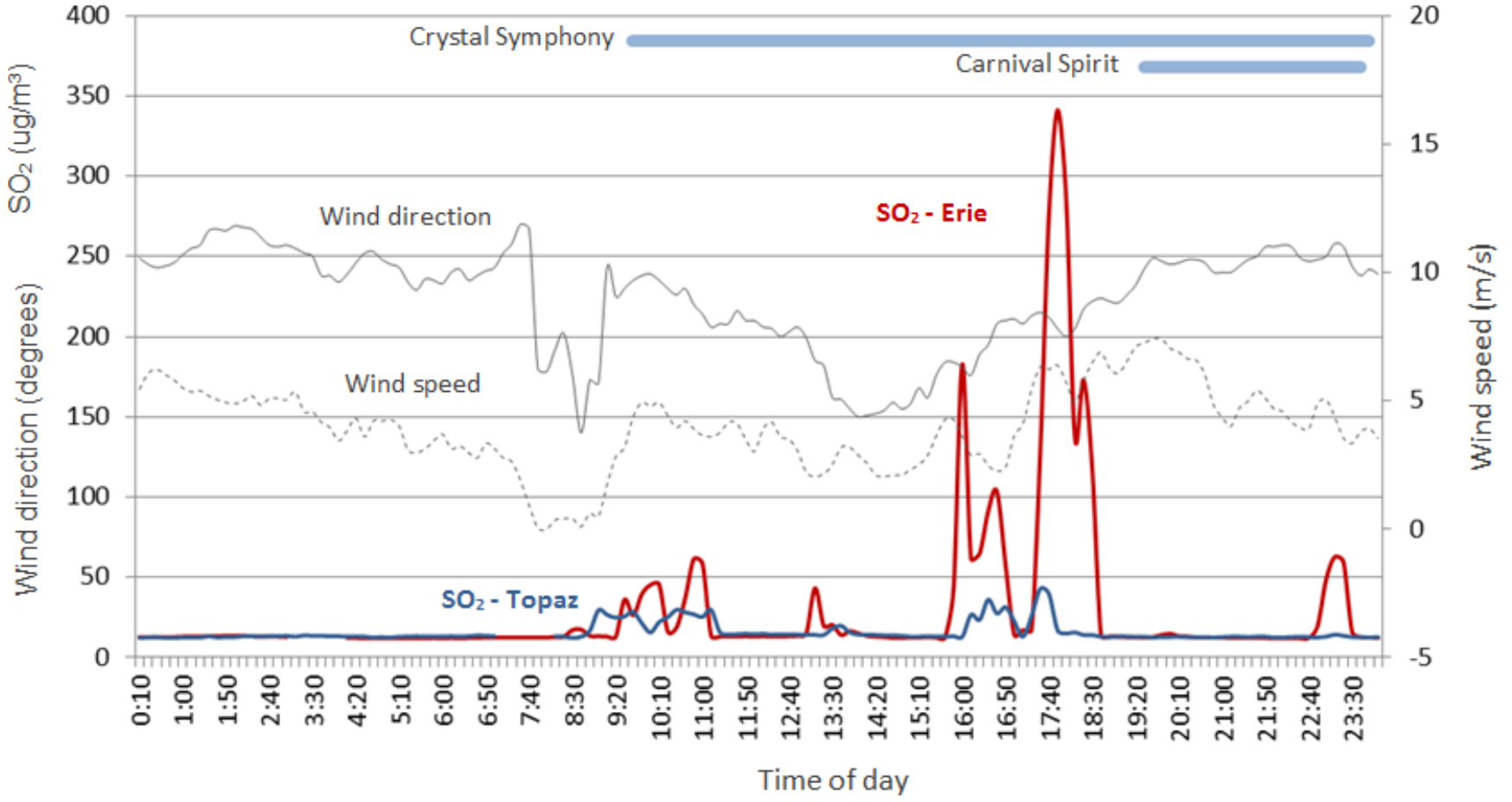
2007

EXPLORATORY MONITORING & MODELLING

5 kilometers

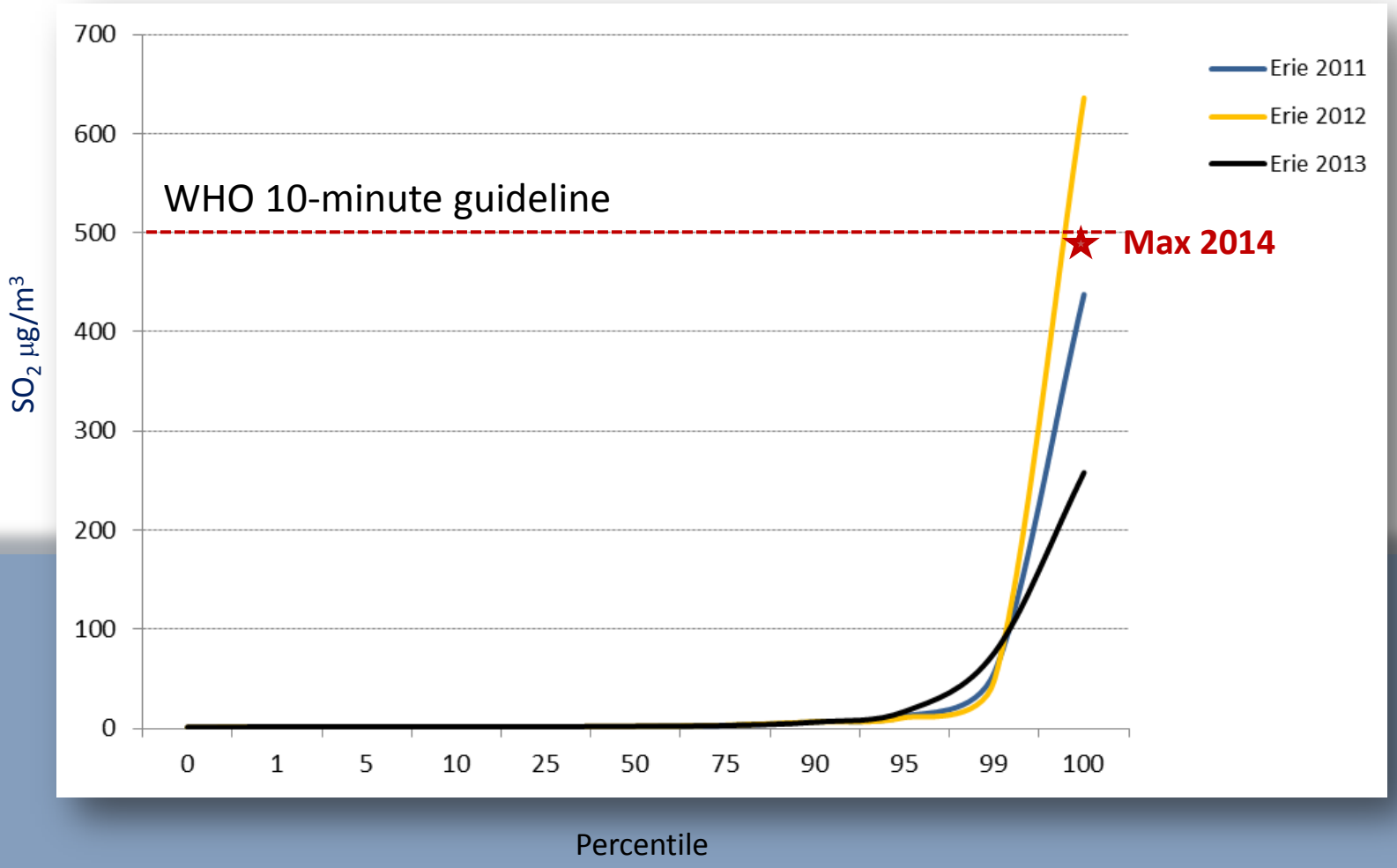


Typical episode of high SO_2 (µg/m³) – 10 minute average level

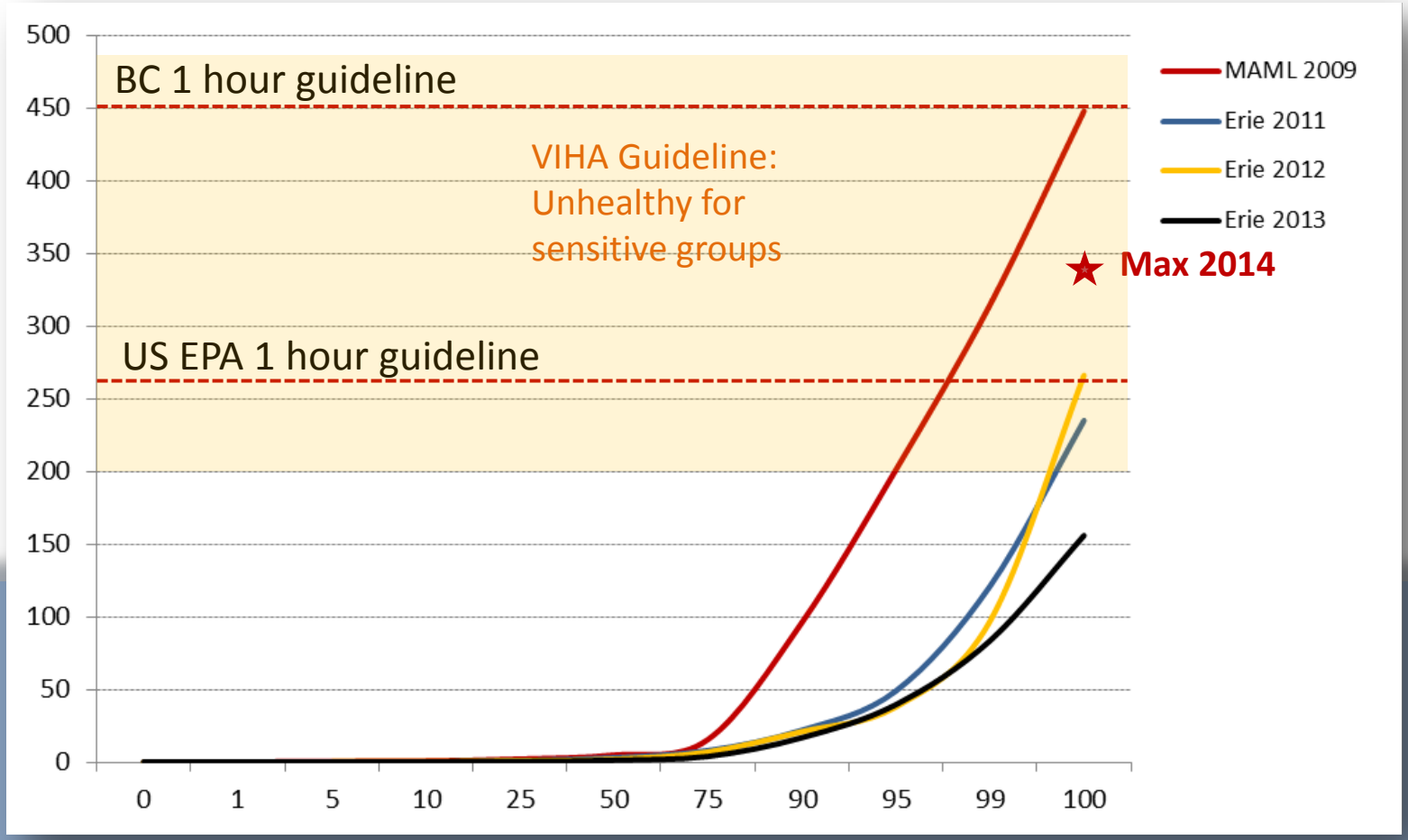


May 2011

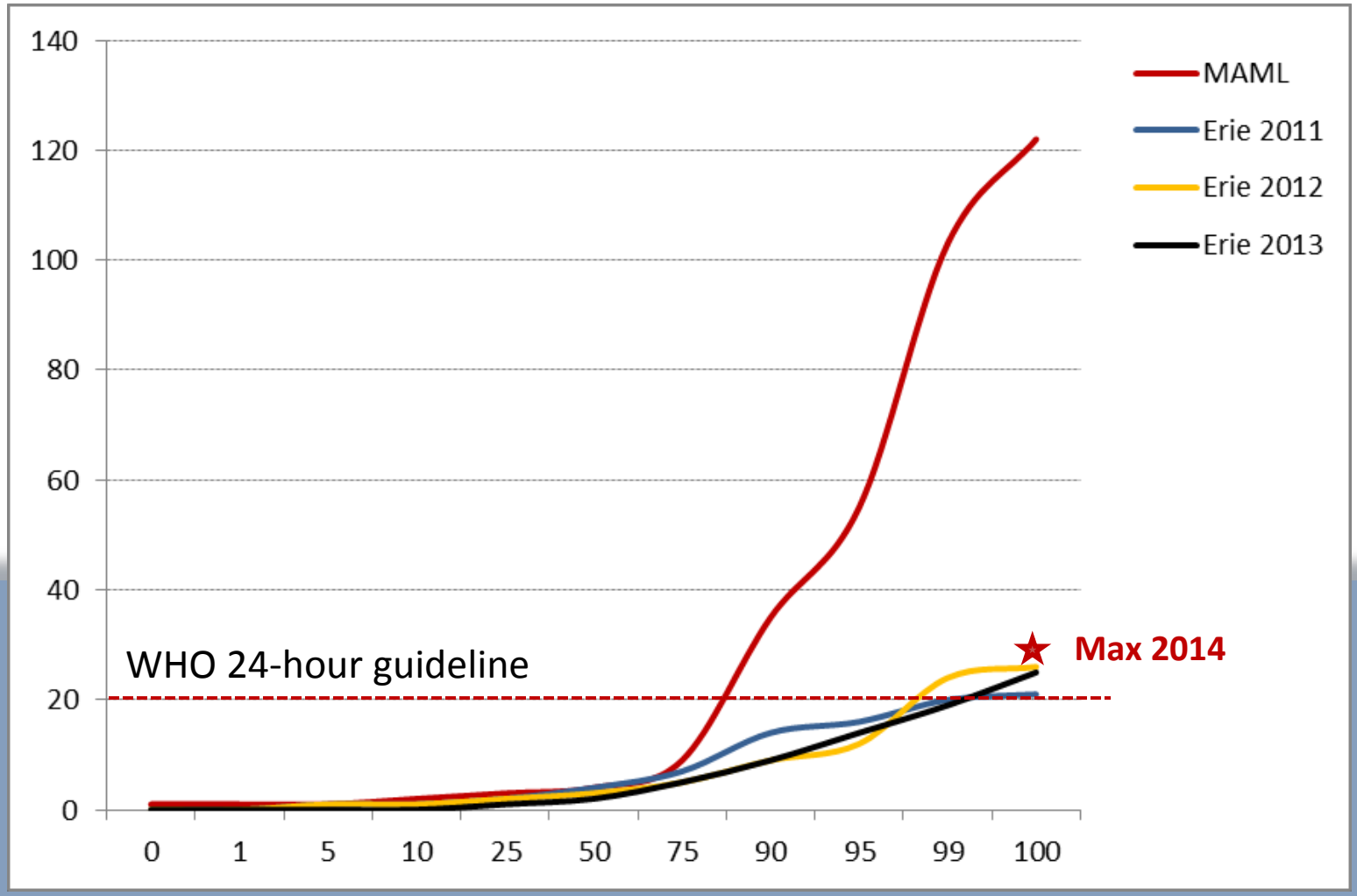
10 minute average when ships present: SO_2 ($\mu g/m^3$)



Hourly average when ships present: SO_2 (µg/m³)

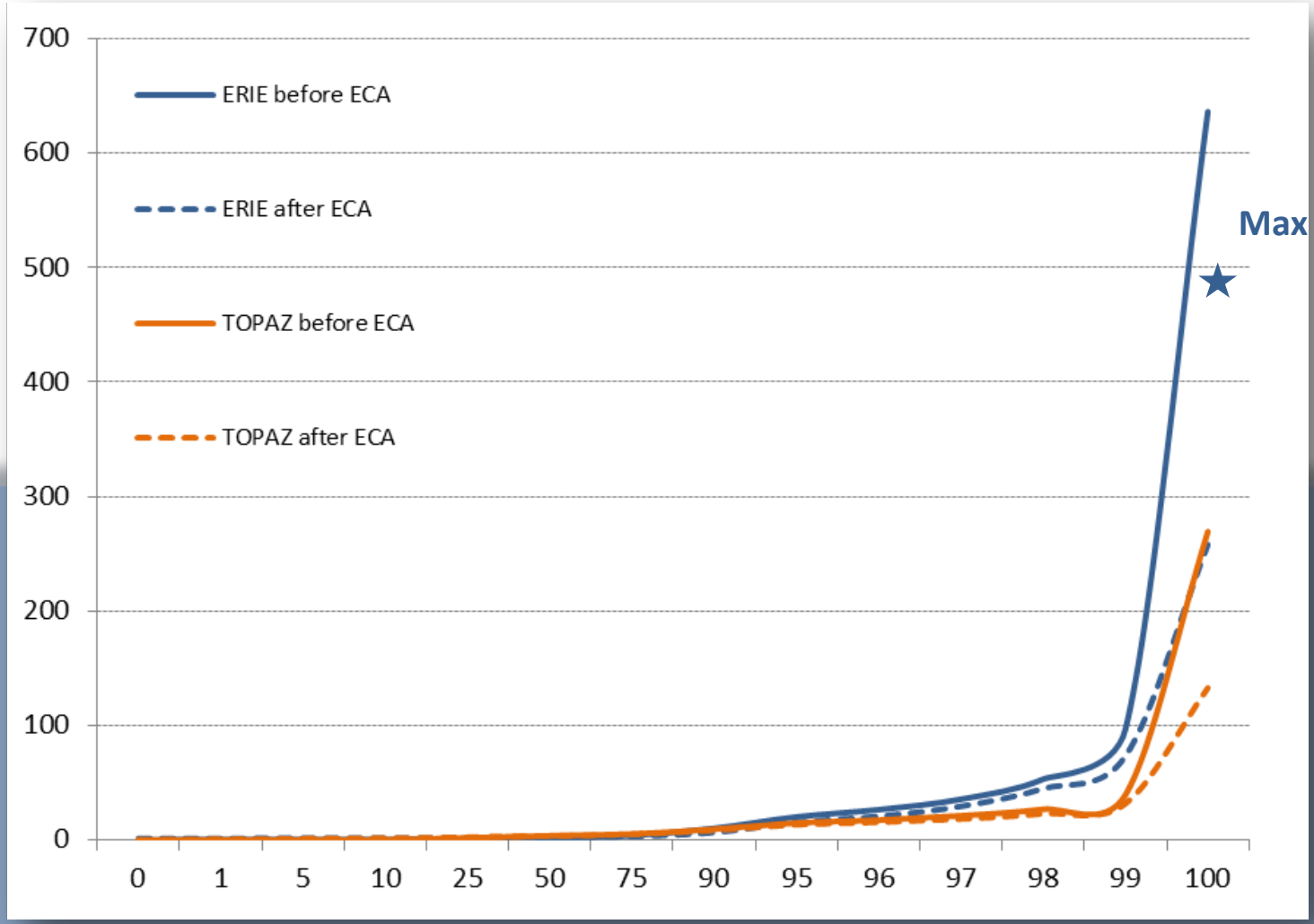


Daily (24-hour) average when ships present: SO_2 (μg/m³)



10 minute average when ships present: SO_2 ($\mu g/m^3$)

8 months pre-ECA (May – Sept 2011 and May - July 2012)
7 months post-ECA (Aug – Sept 2012 and May – Sept 2013)



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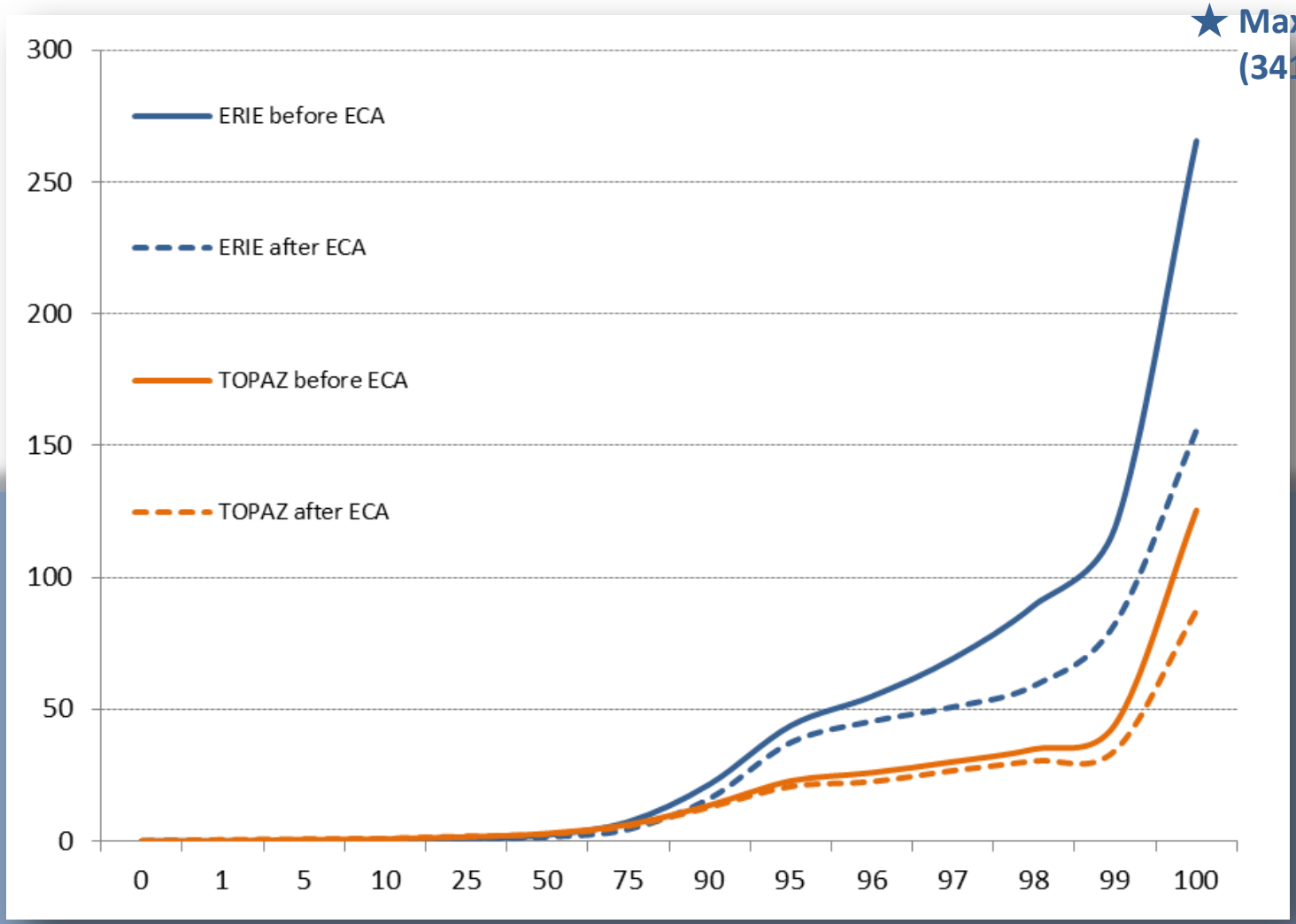
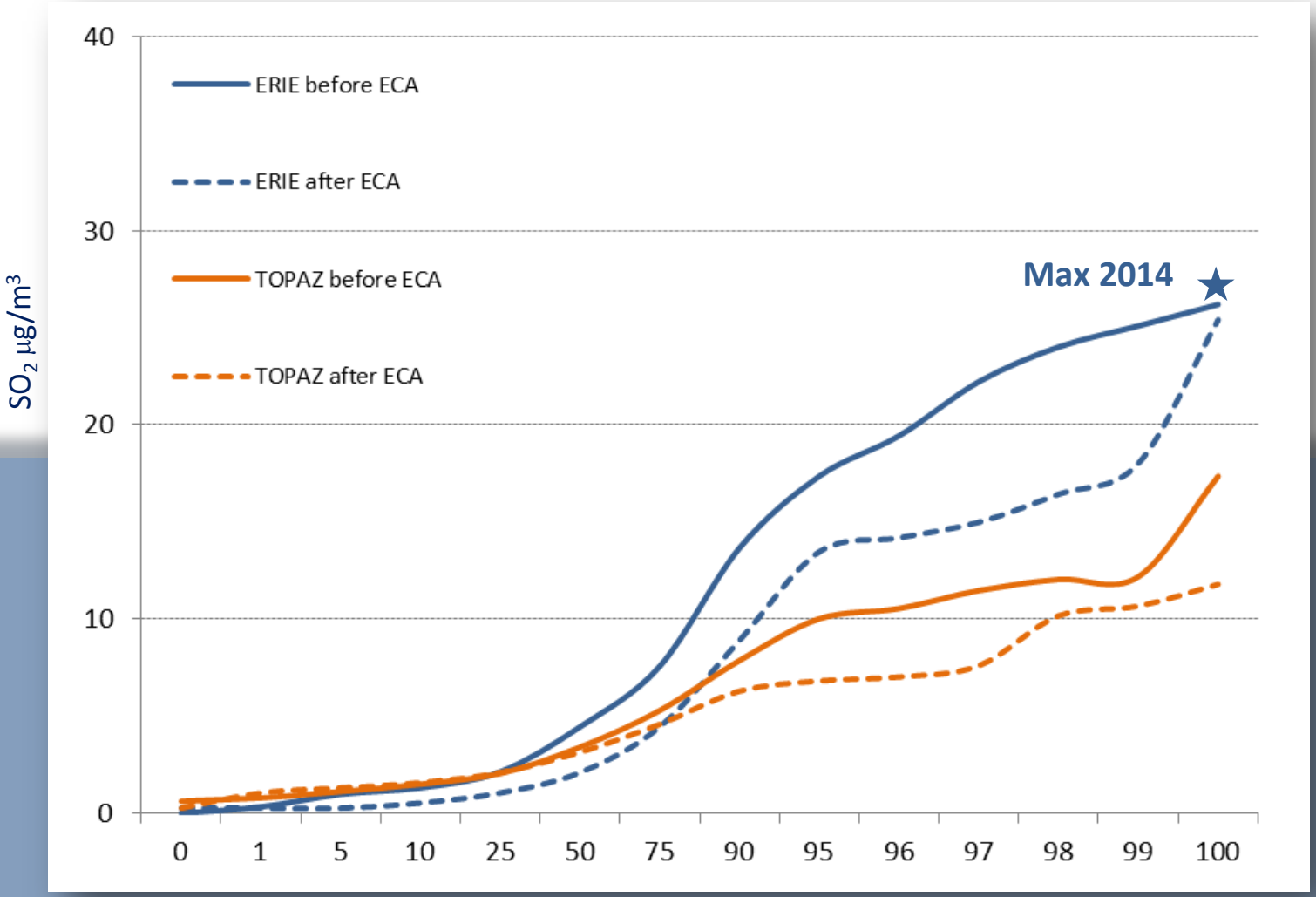


24 hour average when ships present: SO_2 (μg/m^3)

8 months pre-ECA (May – Sept 2011 and May - July 2012)
7 months post-ECA (Aug – Sept 2012 and May – Sept 2013)



In conclusion:

- **A significant challenge has been the use of a single monitor location: produces high quality data, but may not capture levels and variations at other locations in the neighbourhood.**

- **Still, local stations have been located generally downwind, and can reasonably be assumed to represent the worst case conditions in terms of frequency of high episodes over the season. Levels at other locations remain unknown.**

- **SO_2 impacts generally lower, with additional reduction expected in 2015 when the ECA requires fuel with no more than 0.1% sulfur content, but some impacts remain due to ECA exemption for ships scheduled to install scrubbers and occasional use of higher sulfur content fuel.**

THANK YOU

Reports available at http://www.viha.ca/mho/air_quality.htm