



Using Spatial Information for Communicable Disease Control

David Buckeridge, MD PhD

Canada Research Chair in Public Health Informatics

Christian Jauvin, MSc

Lead Software Developer

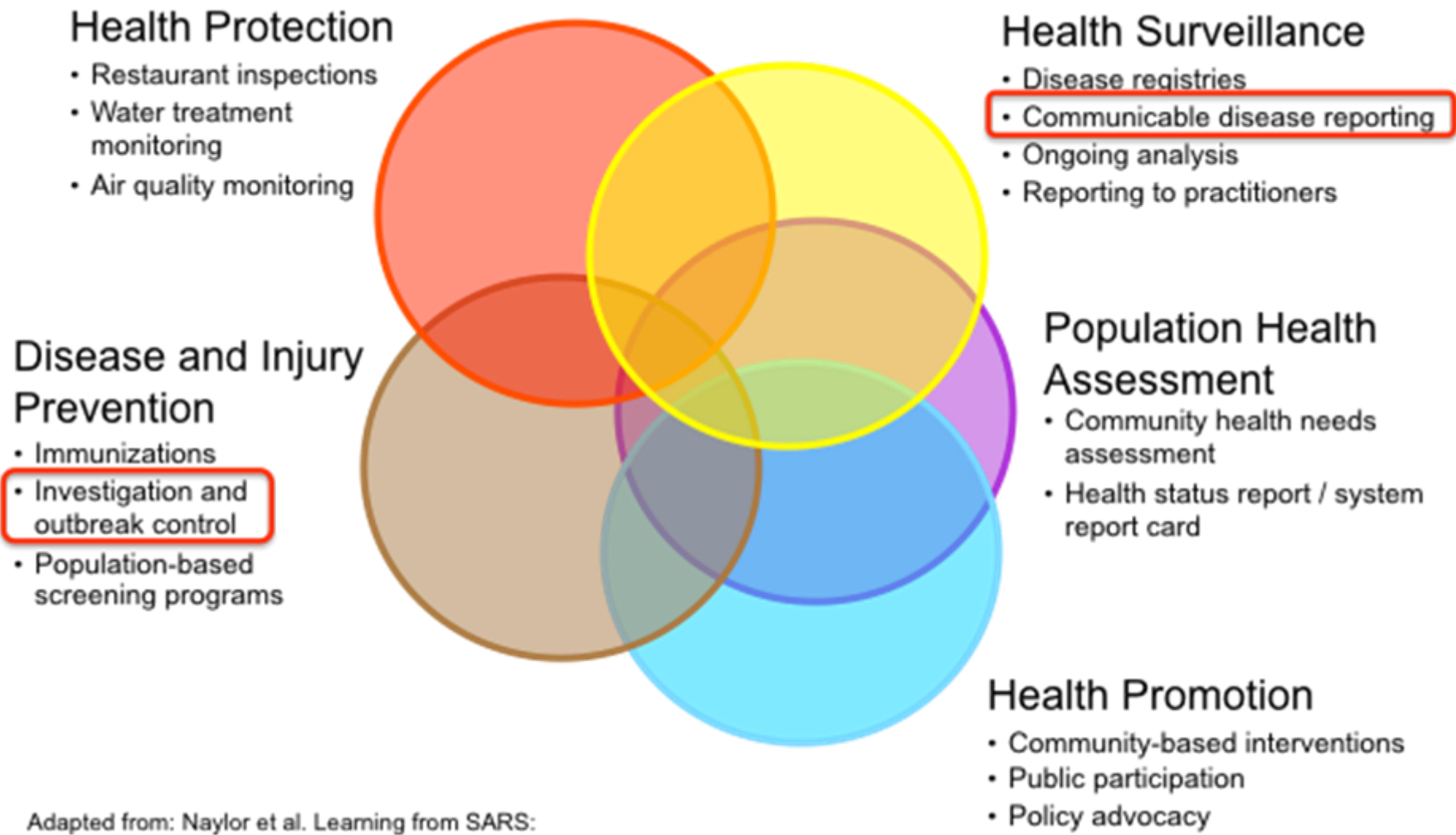
Epidemiology and Biostatistics, McGill University

Surveillance and Epidemiology, Montreal Public Health

NCCPH Summer Institute

Mont Ste-Anne, Québec, July 8th, 2009

Communicable Disease Control: A Core Public Health Function



Bringing Location into Communicable Disease Control



- ❖ Using Spatial Information
 - ◆ The Rationale
 - ◆ Some Issues
- ❖ DraconesPH – A System for Using Spatial Information in Communicable Diseases
 - ◆ The Origin
 - ◆ The Current Status
 - ◆ The Future

Bringing Location into Communicable Disease Control



- ❖ Using Spatial Information
 - ◆ The Rationale
 - ◆ Some Issues
- ❖ DraconesPH – A System for Using Spatial Information in Communicable Diseases
 - ◆ The Origin
 - ◆ The Current Status
 - ◆ The Future

Disease Transmission Occurs in a Geographic Location



- ❖ Shared geography provides critical clues for some diseases
 - ◆ Person-to-person: Two people must be in the same location at the same time
 - ◆ Common source: People must all visit the same location
- ❖ Shared geography less important for fomite and vector-borne transmission



Locations Associated with Cases Serve Many Purposes



❖ Routine Surveillance

- ◆ Ongoing person-to-person spread: Multiple cases with 'close' home, work addresses
- ◆ Ongoing exposure: Multiple cases with 'close' dining, shopping address

❖ Case Investigation and Management

- ◆ Search for 'connected' cases

❖ Outbreak Investigation

- ◆ Search for common exposure

Bringing Location into Communicable Disease Control



- ❖ Using Spatial Information
 - ◆ The Rationale
 - ◆ Some Issues
- ❖ DraconesPH – A System for Using Spatial Information in Communicable Diseases
 - ◆ The Origin
 - ◆ The Current Status
 - ◆ The Future

Use of Spatial Information is 'Ad Hoc' in Most Settings



- ❖ Address Collection is Generally Limited
 - ◆ Focus on residential address
 - ◆ Addresses not validated
- ❖ Spatial Analysis does not 'Fit' Workflow
 - ◆ Looking at addresses
 - ◆ Addresses as categorical variables
 - ◆ Data extracted into 'offline' GIS

Spatial Analysis Must be Accurate and Intuitive



- ❖ Decades of Research in Medical Informatics Identify Determinants of Use
 - ◆ Clearly identifiable benefit
 - ◆ Intuitive to use
 - ◆ ‘Fit’ with workflow
- ❖ We Developed DraconesPH
 - ◆ To address barriers to adoption of spatial information in communicable diseases
 - ◆ To create a research platform

Bringing Location into Communicable Disease Control



- ❖ Using Spatial Information
 - ◆ The Rationale
 - ◆ Some Issues
- ❖ DraconesPH – A System for Using Spatial Information in Communicable Diseases
 - ◆ The Origin
 - ◆ The Current Status
 - ◆ The Future

The DraconesPH Development Project



- ❖ Funded by Three Groups
 - ◆ GeoConnections
 - ◆ Montreal Public Health
 - ◆ McGill University
- ❖ Goal: develop web-based system for spatial case management, surveillance
- ❖ Project ran from 2006 to summer 2008

The Development Process



❖ Management Team

- ◆ Led by public health MD with informatics training
- ◆ Members from each area of DSP involved
- ◆ Lead developer with computer science and web programming background

❖ User Involvement

- ◆ Users on management team
- ◆ Input throughout requirements, design, development
- ◆ User groups worked through use cases and guided refinement of functions, data, and interface



❖ 'Current' Situation

- ◆ Information on paper entered into system (Oracle DB + Forms)
- ◆ System contains sensitive data (names, addresses)
- ◆ Limited tools for analyzing case data

❖ Project Goal

- ◆ Capture spatial data
- ◆ Visualize and analyze spatial distribution of cases

The screenshot shows a web application window titled "Création rapide d'un épisode". The form is organized into several sections:

- Top Section:** Fields for "Id événement", "No. client", "Condition de santé", "Micro-organisme", "Date d'épisode" (pre-filled with "30-JAN-2006"), "Statut de validation" (pre-filled with "en suspens"), "Date de validation", and "Adresse".
- Déclarations Section:** Fields for "Date de réception", "Mode de réception", "Date de déclaration", and a "Copier" button.
- Déclarant Section:** A sub-section titled "Demandeur" containing three columns for "Etablissement", "Médecin", and "Individu". Each column has fields for "Id", "Nom", "Autre nom", "Code", "Prénom", and "Nom".
- Bottom Section:** Fields for "Type de déclarant", "Type de garde", and a button for "Analyses de laboratoire".
- Médecin traitant Section:** Fields for "Médecin traitant" and "Milieu de consultation".
- Gestion Section:** Fields for "Date de la relance", "Destination de transfert", "Infos manquantes?", "État du dossier", and "Raison de fermeture". It also includes buttons for "Intervenants DSP" and "Notes d'évolution".

Why Location Matters – Case Management Pre-DraconesPH



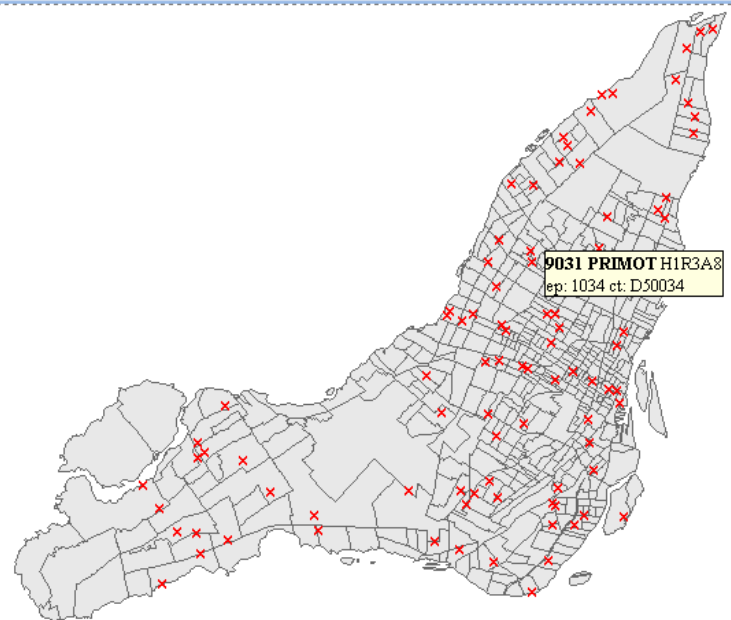
	id [PK] serial	street_number integer	apartment character(10)	street_name character(25)	street_direct character(10)	street_type character(25)	city character(50)	city_area character(50)	postal_code character(6)	country_id integer	is_institution boolean
1	1	2784		VAN HORNE		AV	MONTREAL	MONTREAL	H3S1P9	39	FALSE
2	2	10746		MILLEN		AV	MONTREAL	MONTREAL	H2C2E8	39	FALSE
3	3	3264		SAINTE-LUCIE		RUE	MONTREAL	MONTREAL	H1Z1S3	39	FALSE
4	4	6676		DARLINGTON		AV	MONTREAL	MONTREAL	H3S2J5	39	FALSE
5	5	272		HICKSON		RUE	VERDUN	MONTREAL	H4G2J6	39	FALSE
6	6	2245		EMILE-NELLIGAN		RUE	LASALLE	MONTREAL	H8N2Y9	39	FALSE
7	7	3278		PUCCINI		RUE	MONTREAL	MONTREAL	H2A1P4	39	FALSE
8	8	4874		DE LA COTE-DE:		CH	MONTREAL	MONTREAL	H3V1H4	39	FALSE
9	9	968		WILSON		AV	MONTREAL	MONTREAL	H4A2T2	39	FALSE
10	10	579		12E		AV	LASALLE	MONTREAL	H8P2R6	39	FALSE
11	11	5300		VAN HORNE		AV	MONTREAL	MONTREAL	H3X4A9	39	FALSE
12	12	10587		DE L'ESPLANADE		AV	MONTREAL	MONTREAL	H3L2Y4	39	FALSE
13	13	5095		JEAN-TALON	E	RUE	SAINT-LEONARD	MONTREAL	H1S3G4	39	FALSE
14	14	3151		LA FONTAINE		RUE	MONTREAL	MONTREAL	H1W1T4	39	FALSE
15	15	3445		RIDGEWOOD		AV	MONTREAL	MONTREAL	H3V1B7	39	FALSE
16	16	3121		DU MONT-ROYAL	E	AV	MONTREAL	MONTREAL	H1Y3L2	39	FALSE
17	17	7081		DE LORIMIER		AV	MONTREAL	MONTREAL	H2E2N7	39	FALSE
18	18	8533		WISEMAN		AV	MONTREAL	MONTREAL	H3N2P8	39	FALSE
19	19	5330		PIE-IX		BOUL	MONTREAL	MONTREAL	H1X2B7	39	FALSE
20	20	54		THURLOW		CH	HAMPSTEAD	MONTREAL	H3X3G9	39	FALSE
21	21	3512		GOYER		RUE	MONTREAL	MONTREAL	H3S1J1	39	FALSE
22	22	4690		DE LA COTE-DE:		CH	MONTREAL	MONTREAL	H3V1E9	39	FALSE
23	23	2692		DEZERY		RUE	MONTREAL	MONTREAL	H1W2S5	39	FALSE
24	24	1199		DE BLEURY		RUE	MONTREAL	MONTREAL	H3B3J1	39	FALSE
25	25	3		CUMMINGS		CAR	MONTREAL	MONTREAL	H3W3E8	39	FALSE
26	26	7763		GEORGE		RUE	LASALLE	MONTREAL	H8P1C8	39	FALSE
27	27	7705		DE L'ACADIE		BOUL	MONTREAL	MONTREAL	H3N2W1	39	FALSE
28	28	280		REGINA		RUE	VERDUN	MONTREAL	H4G2G5	39	FALSE
29	29	4420		DRAPER		AV	MONTREAL	MONTREAL	H4A2P2	39	FALSE
30	30	6899		HURTEAU		RUE	MONTREAL	MONTREAL	H4E2Y8	39	FALSE
31	31	6714		SHERBROOKE	E	RUE	MONTREAL	MONTREAL	H1N1C9	39	FALSE
32	32	201		DU CLUB-MARIN		CH	VERDUN	MONTREAL	H3E1T4	39	FALSE
33	33	2102		CHAMPDORE		RUE	MONTREAL	MONTREAL	H1Z1E9	39	FALSE
34	34	6710		TARDIF		RUE	MONTREAL-NOF	MONTREAL	H1G6G2	39	FALSE
35	35	11725		TOLHURST		RUE	MONTREAL	MONTREAL	H3L3B1	39	FALSE
36	36	6956		WILDERTON		AV	MONTREAL	MONTREAL	H3S2M5	39	FALSE
37	37	4671		ARAMIS		RUE	SAINT-LEONARD	MONTREAL	H1R1R3	39	FALSE
38	38	12317		MONTY		RUE	MONTREAL-NOF	MONTREAL	H1G3N9	39	FALSE
39	39	3680		SAINT-URBAIN		RUE	MONTREAL	MONTREAL	H2X2P2	39	FALSE
40	40	137		CHARTWELL		CRES	BEACONSFIELD	MONTREAL	H9W1C2	39	FALSE
41	41	953		DE LIEGE	O	RUE	MONTREAL	MONTREAL	H3N1B6	39	FALSE
42	42	245		ASH		AV	MONTREAL	MONTREAL	H3K2R1	39	FALSE
43	43	6528		ALEXIS-CONTAP		AV	MONTREAL	MONTREAL	H1M1E9	39	FALSE
44	44	11573		GILLES-TROTTIER		RUE	MONTREAL	MONTREAL	H1E6W7	39	FALSE
45	45	4250		47E		RUE	MONTREAL	MONTREAL	H1Z1L9	39	FALSE
46	46	153		BEAUBIEN	O	RUE	MONTREAL	MONTREAL	H2V1C5	39	FALSE
47	47	4413		COUTURE		BOUL	SAINT-LEONARD	MONTREAL	H1R3J3	39	FALSE
48	48	550		DE LIEGE	O	RUE	MONTREAL	MONTREAL	H3N1A6	39	FALSE
49	49	6575		VICTORIA		AV	MONTREAL	MONTREAL	H3W2T1	39	FALSE
50	50	5700		DE LA COTE-DE:		CH	MONTREAL	MONTREAL	H3T2A8	39	FALSE
51	51	8285		VIAU		BOUL	SAINT-LEONARD	MONTREAL	H1R2T5	39	FALSE
52	52	1562		VICTOR-HUGO		PLACE	MONTREAL	MONTREAL	H3C4R2	39	FALSE

Why Location Matters - Case Management with DraconesPH



DraconesPH

Dracones Selection Full Extent Layers Undo Redo Remove Export



Cases Places SaTScan

Health Condition

Temporal

Is:

And:

Is days before/after the earliest/latest selected case date

Spatial

Case/place link options:

None

Show links to selected places

Restrict to cases linked to selected places

Episode ID	Client ID	First Name	Last Name	Sex	Date of Birth	Address	Episode Date	Health Condition
1002	D50002			M	1954-03-07	3420 JULES-HUOT H1A5T5	2008-04-11	VHB
1008	D50008			F	1983-05-22	6272 BOUVRET H1N1N7	2009-09-27	HANTAVIRUS
1011	D50011			F	1922-01-26	7227 MOLSON H2A3K5	2008-04-17	TYPHUS BRO
1012	D50012			M	1945-01-07	4600 REHE-EMARD H9A3A7	2008-06-07	EXP ALIM
1013	D50013			F	1966-03-18	69 MORLEY HILL H9J2Y4	2009-03-12	CRYPTOSP
1018	D50018			F	1973-07-24	8143 DE L'EPEE H3N2G2	2008-10-24	PAR. FLASQ
1023	D50023			M	1982-11-08	6526 DES ECORES H2G2J7	2008-10-28	PSITT
1034	D50034			F	1946-05-28	9031 PRIMOT H1R3A8	2009-12-10	SYP NER SY
1036	D50036			F	1977-06-15	7489 PINEVIEW H4W1K2	2009-07-13	SIDA
1044	D50044			M	1957-01-02	1777 COURSOL H3J1B4	2008-09-09	ENCV TIQUE
1060	D50060			M	1938-11-04	1266 MOFFAT H4H1Y9	2008-05-19	HERPES
1070	D50070			M	1922-01-11	8257 MARCO-POLO H1E7K1	2008-05-25	MARBURG

Population Surveillance at Montreal Public Health



❖ 'Current' Situation

- ◆ Routine temporal and space-time statistical analysis
- ◆ Capacity to visualize time-series but not maps

❖ Project Goal

- ◆ Add mapping capacity
- ◆ Extend range of analytic methods

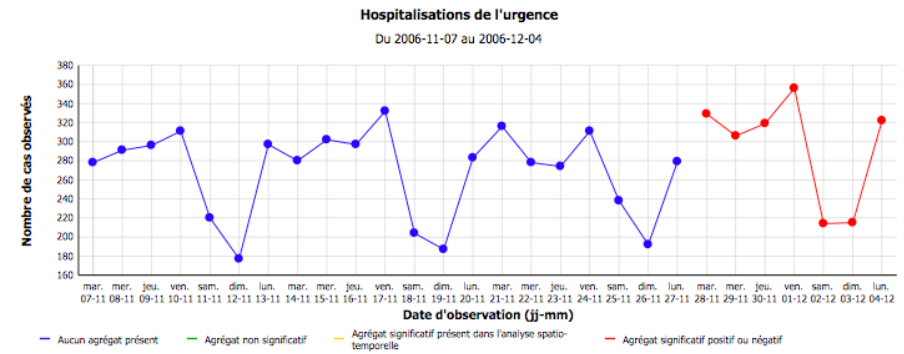
Analyse SaTScan - résultats

Indicateur : Hospitalisations de l'urgence
Date d'exécution : mer. 2006-12-06
Période de l'analyse : 28 jours du 07-11 au 04-12 Période des agrégats : 7 jours
Nombre de valeurs absentes : 9

No. agrégat	Emplacement de l'agrégat	Rayon	État	p-value	p-value référence	Période de l'agrégat	Cas observés	Cas attendus	Observés / attendus
Type d'analyse : Prospective purement temporelle, modèle Poisson									
1	Région de Montréal		■	0,0018	0,0027	28-11 au 04-12	2 061	1 921,26	1,07
Fichiers input-output : 1-Paramètres 2-Cas analysés 3-Coordonnées géographiques 4-Ajustements 5-Résultats									
Type d'analyse : Prospective spatio-temporelle, modèle Permutation spatio-temporelle									
1	Hôpital Notre-Dame du CHUM, Hôpital Saint-Luc du CHUM	1,50	■	0,0730	0,0027	02-12 au 04-12	57	84,71	0,67
2	Hôpital général du Lakeshore, Hôpital de Lachine	12,34	■	0,0820	0,0027	01-12 au 04-12	33	54,75	0,60
3	Hôpital du Sacré-Coeur de Montréal	0,00	■	0,1800	0,0027	01-12 au 04-12	103	75,87	1,36
4	Hôpital-Dieu du CHUM, Hôpital Royal Victoria, Hôpital Saint-Luc du CHUM	1,60	■	0,5210	0,0027	04-12 au 04-12	30	46,02	0,65
5	Hôpital général de Montréal, Hôpital Royal Victoria, Hôpital-Dieu du CHUM, CHU Sainte-Justine, L'Hôpital de Montréal pour enfants	2,85	■	0,7900	0,0027	02-12 au 04-12	246	212,71	1,16
6	Hôpital de Verdun, Hôpital général de Montréal	4,37	■	0,9160	0,0027	04-12 au 04-12	45	32,39	1,39
7	Hôpital de Lachine, Hôpital de LaSalle, L'Hôpital de Montréal pour enfants, Centre hospitalier de St. Mary	6,88	■	0,9180	0,0027	03-12 au 04-12	90	71,66	1,26
8	L'Hôpital général juif Sir Mortimer B. Davis, Centre hospitalier de St. Mary, CHU Sainte-Justine, L'Hôpital de Montréal pour enfants, Hôpital général de Montréal	3,20	■	0,9380	0,0027	02-12 au 04-12	272	240,20	1,13
9	Pavillon Maisonneuve/Pavillon Marcel-Lamoureux, Hôpital Santa Cabrini, Institut de cardiologie de Montréal, Hôpital Jean-Talon, Hôpital Notre-Dame du CHUM, Hôpital Fleury, Hôpital Saint-Luc du CHUM	7,03	■	0,9680	0,0027	02-12 au 04-12	271	304,14	0,89
10	Hôpital Jean-Talon, Hôpital Fleury, Institut de cardiologie de Montréal, Hôpital Notre-Dame du CHUM	4,39	■	0,9920	0,0027	01-12 au 04-12	162	186,08	0,87
11	Hôpital Fleury	0,00	■	0,9960	0,0027	30-11 au 04-12	45	57,57	0,78
Fichiers input-output : 1-Paramètres 2-Cas analysés 3-Coordonnées géographiques 4-Ajustements 5-Résultats									

Analyse SaTScan - représentation graphique de l'agrégat

Date d'exécution : mer. 2006-12-06
Type d'analyse : Prospective purement temporelle, modèle Poisson Période de l'analyse : 28 jours
Emplacement de l'agrégat : Région de Montréal
Période de l'agrégat : 7 jours p-value : 0,0018



Why Location Matters – Population Surveillance Pre DraconesPH



SUMMARY OF DATA

```

Study period.....: 2000/01/01 - 2000/05/31
Number of locations.....: 540
Total population.....: 1810068
Total number of cases.....: 307
Annual cases / 100000.....: 40.8
  
```

MOST LIKELY CLUSTER

```

1. Location IDs included.: 251
   Coordinates / radius...: (291146, 5.04323e+06) / 0.00
   Time frame.....: 2000/3/1 - 2000/3/31
   Population.....: 4750
   Number of cases.....: 33
   Expected cases.....: 0.16
   Annual cases / 100000.: 8185.4
   Observed / expected...: 200.844
   Relative risk.....: 224.913
   Log likelihood ratio...: 143.970933
   Monte Carlo rank.....: 1/1000
   P-value.....: 0.001
  
```

SECONDARY CLUSTERS

```

2. Location IDs included.: 104, 103, 92, 94, 117, 105, 116, 85,
   124, 109, 113, 79, 101, 86, 100, 81,
   74, 93, 123, 134, 129, 131, 108, 133,
   87, 119, 127, 77, 70, 141, 95, 63,
   120, 1
   Coordinates / radius...: (295851, 5.04908e+06) / 2657.11
   Time frame.....: 2000/1/1 - 2000/1/31
   Population.....: 97026
   Number of cases.....: 46
   Expected cases.....: 3.36
   Annual cases / 100000.: 558.6
   Observed / expected...: 13.706
   Relative risk.....: 15.945
   Log likelihood ratio...: 80.921678
   Monte Carlo rank.....: 1/1000
   P-value.....: 0.001

3. Location IDs included.: 139
   Coordinates / radius...: (298924, 5.04706e+06) / 0.00
   Time frame.....: 2000/4/1 - 2000/4/30
   Population.....: 4445
   Number of cases.....: 15
   Expected cases.....: 0.15
   Annual cases / 100000.: 4108.5
   Observed / expected...: 100.809
   Relative risk.....: 105.936
   Log likelihood ratio...: 54.712510
   Monte Carlo rank.....: 1/1000
   P-value.....: 0.001
  
```

Location Matters - Population Surveillance with DraconesPH



DraconesPH

Dracones Selection Full Extent Layers Undo Redo Remove Export

Cases Places **SaTScan**

Retrospective Analysis:
 Purely Spatial Space-Time

Prospective Analysis:
 Space-Time

Probability Model:
 Poisson Space-Time Permutation

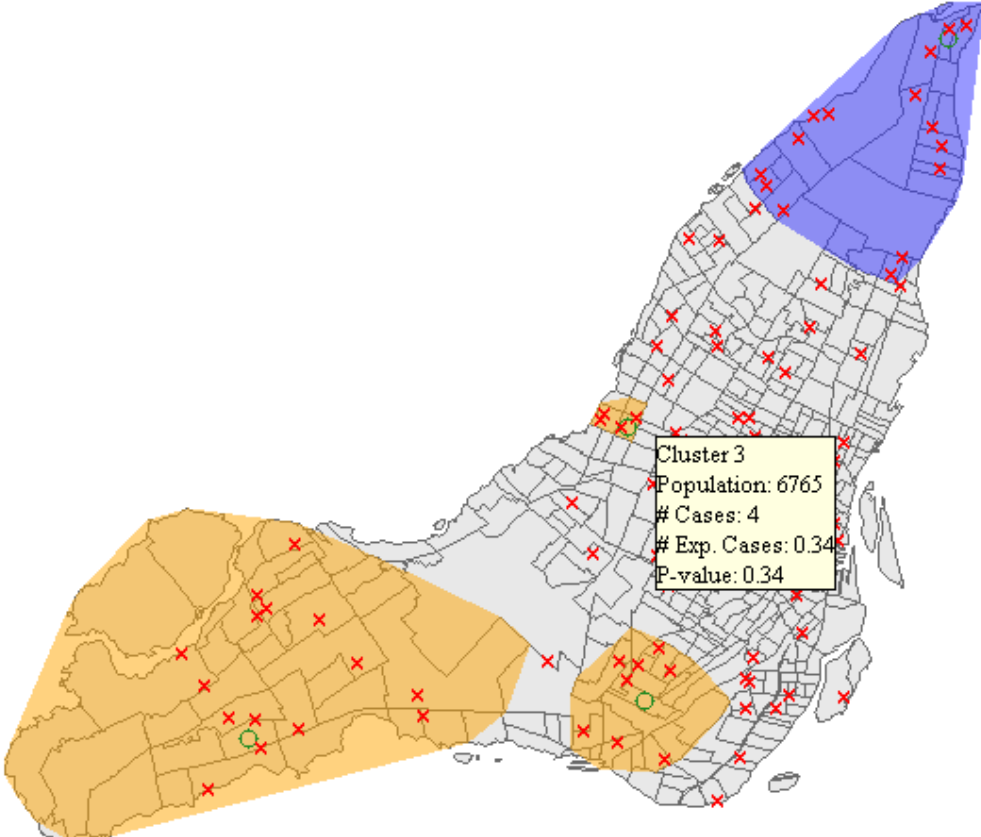
Start Date: 2008-01-04 **End Date:** 2009-12-26

Time Aggregation Units: Length:
 Year Month Day

Max Spatial % Size: 50

Max Temporal % Size: 50

Submit



Cluster 3
 Population: 6765
 # Cases: 4
 # Exp. Cases: 0.34
 P-value: 0.34

SaT

ID	Radius	Population	# Cases	# Expected Cases	P-Value	Start Date	End Date	Visible
1	9377.45	30964	15	1.57	0.001			<input checked="" type="checkbox"/>
2	8184.8	33954	15	1.73	0.001			<input checked="" type="checkbox"/>

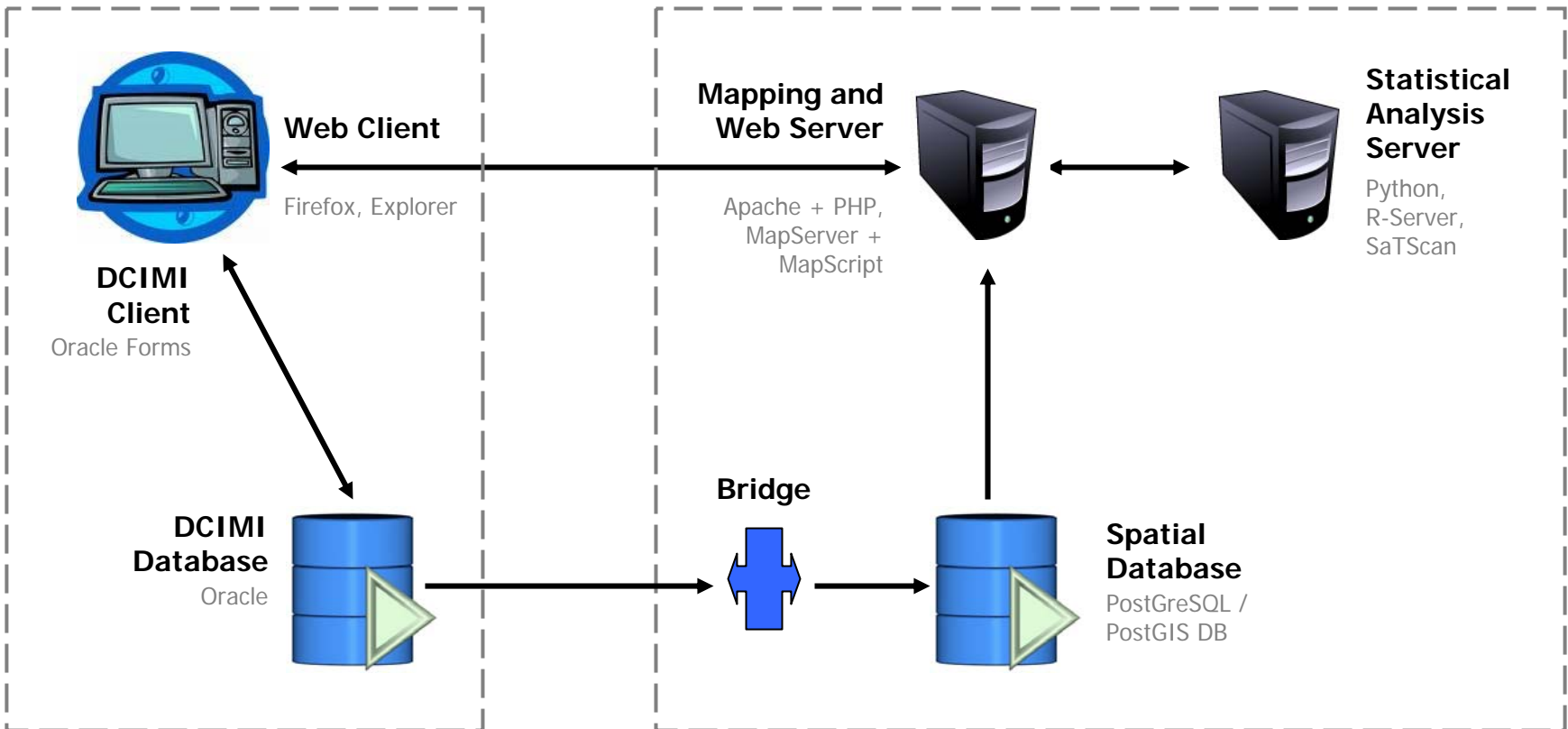
Cases (92) Places **SaTScan Clusters (4)** Cluster 1 (15) Cluster 2 (15) Cluster 3 (4) Cluster 4 (8)

System Architecture



Current Case Management System

DraconesPH



Bringing Location into Communicable Disease Control



- ❖ Using Spatial Information
 - ◆ The Rationale
 - ◆ Some Issues
- ❖ DraconesPH – A System for Using Spatial Information in Communicable Diseases
 - ◆ The Origin
 - ◆ The Current Status
 - ◆ The Future

Current Status of DraconesPH



- ❖ ‘Live’ at the Montreal Public Health for all Reportable Diseases
 - ◆ Accessible within MPH via web browser
 - ◆ Power users are working with system
 - ◆ Ongoing focus groups / training session
- ❖ Main Functions
 - ◆ Address validation and correction
 - ◆ Visualization of cases and links to other contacts, cases, locations
 - ◆ Spatial statistical analysis

DraconesPH and the H1N1 Influenza Pandemic



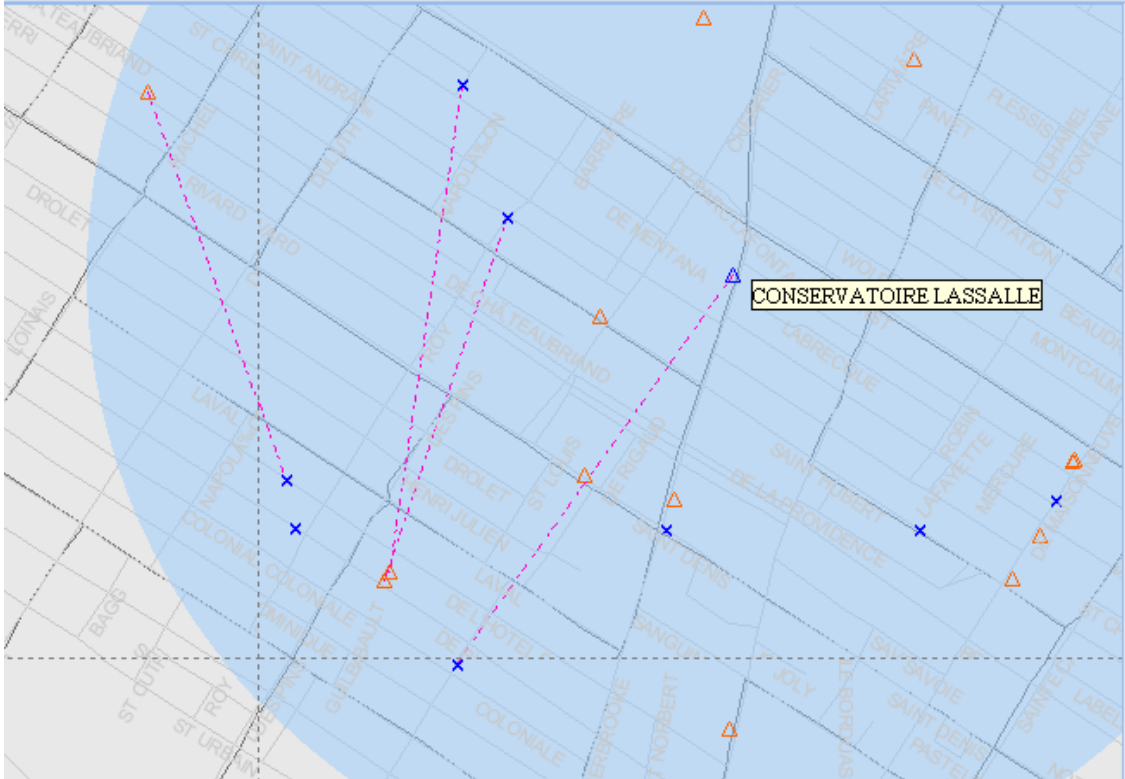
- ❖ Spatial Distribution of Cases is Core Component of Daily Analysis
 - ◆ Regional distribution guides control efforts
 - ◆ Linkage of cases to schools was critical in assessing spread and guiding closures
- ❖ Feature Refinement and Modification is Ongoing throughout the Summer

Examining H1N1 Influenza Spread Within Schools



DraconesPH

Dracones Selection Full Extent Layers Undo Redo Remove Export



Cases **Places** SaTScan

Find **places** of types:

- Schools
- Food Stores
- Restos and Bars
- Inside a radius of meters centered on selected **cases**
- Inside a radius of meters centered at **address**:
- Inside selected **regions**

Place/case link options:

- None
- Show links to selected cases
- Restrict to places linked to selected cases

Cases (11) **Places (19)** SaTScan Clusters


Type	Name	Address
School	COLLEGE SALETTE INC.	
School	COLLÈGE SUPÉRIEUR DE MONTRÉAL (C.S.M.) INC.	
School	CONSERVATOIRE LASSALLE	
School	ÉCOLE ARC-EN-CIEL	
School	ÉCOLE BONICE JEUNESSE	

Bringing Location into Communicable Disease Control



- ❖ Using Spatial Information
 - ◆ The Rationale
 - ◆ Some Issues
- ❖ Dracones – A System for Using Spatial Information in Communicable Diseases
 - ◆ The Origin
 - ◆ The Current Status
 - ◆ The Future

DraconesPH Development, Support, and Use



- ❖ DraconesPH at Montreal Public Health
 - ◆ Ongoing funding and priority setting transferred to Public Health Department
 - ◆ Plans include: integration with population surveillance ‘dashboard’, tighter integration with DCIMI, alerts based on similar cases
- ❖ DraconesPH in Canada
- ❖ DraconesPH Abroad



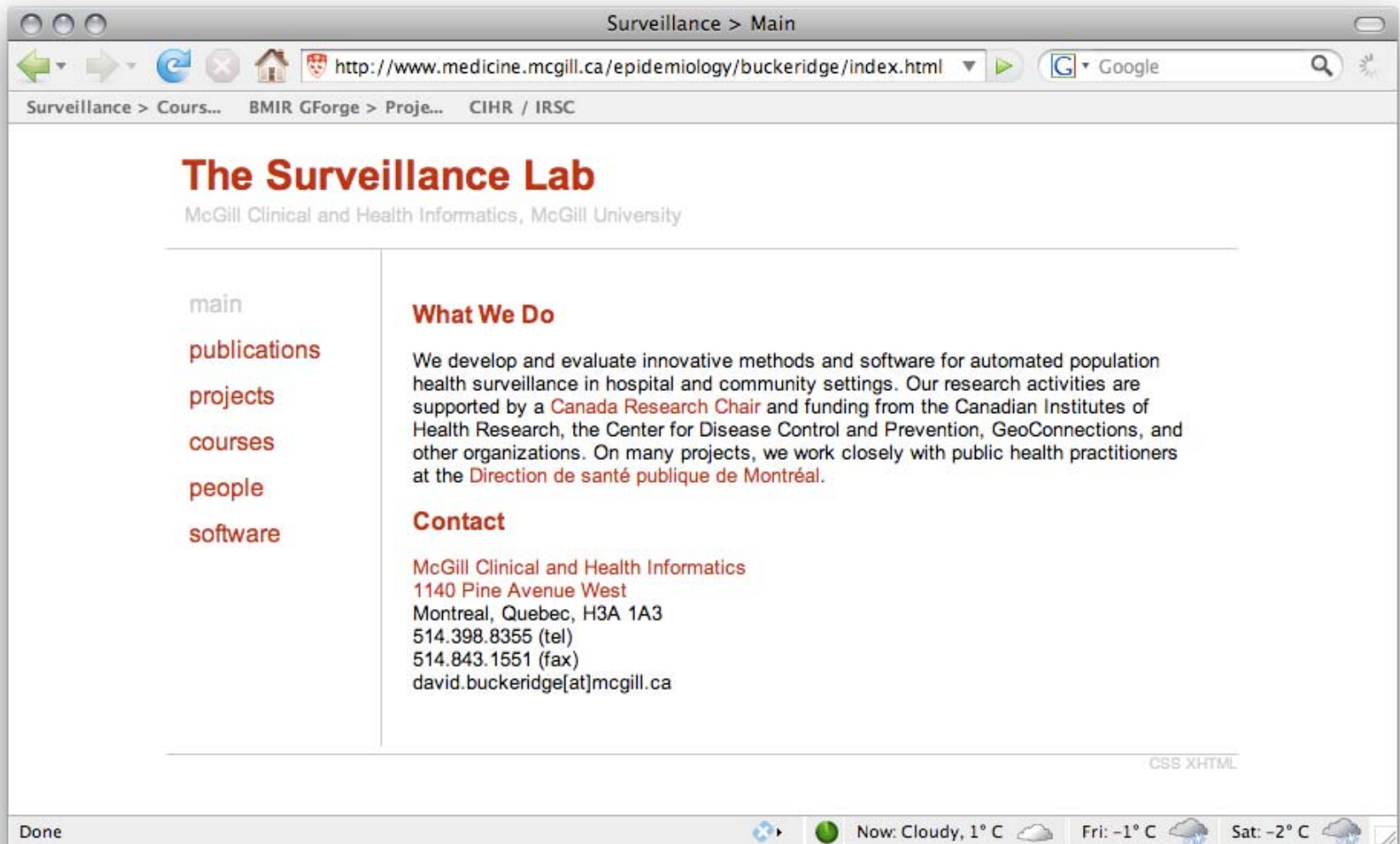
❖ Ongoing Studies

- ◆ Validation of address correction module
- ◆ Assessment of magnitude of address error and impact on cluster detection
- ◆ Assessment of prospective space—time cluster detection

❖ Future Studies

- ◆ Systematically analyze use of system
- ◆ Assess contribution of spatial information to decision-making

For more information...



Surveillance > Main

http://www.medicine.mcgill.ca/epidemiology/buckeridge/index.html

Surveillance > Cours... BMIR GForge > Proje... CIHR / IRSC

The Surveillance Lab

McGill Clinical and Health Informatics, McGill University

- main
- publications**
- projects
- courses
- people
- software

What We Do

We develop and evaluate innovative methods and software for automated population health surveillance in hospital and community settings. Our research activities are supported by a **Canada Research Chair** and funding from the Canadian Institutes of Health Research, the Center for Disease Control and Prevention, GeoConnections, and other organizations. On many projects, we work closely with public health practitioners at the **Direction de santé publique de Montréal**.

Contact

McGill Clinical and Health Informatics
1140 Pine Avenue West
Montreal, Quebec, H3A 1A3
514.398.8355 (tel)
514.843.1551 (fax)
david.buckeridge[at]mcgill.ca

CSS XHTML

Done

Now: Cloudy, 1° C

Fri: -1° C

Sat: -2° C