

Space time problems that we need to think about

Jim Ramsay, McGill University
National Center for Atmospheric Research
24 October 2014

Overview

- Climate change the demand for modelling space/time data
- Assessing our current space/time modelling technology
 - Time series origins
 - The Gaussian framework
 - The coordinate box
- Texture over space and time domains and its implications
- Simplicial meshes as examples of alternative coordinate systems
- Where we need to get over the next couple of decades

Climate change and mitigation

- The prospects for averting climate change are not promising
- With these changes will come huge challenges to human populations
- These populations will demand action from governments
- Governments will turn to the sciences for help
- Scientists will gain new sources of data, and will ask the statistical community for help
- Will we be ready?

A quick look at our space/time modelling toolbox

- Reviews of recent stats texts aimed at climate science have been instructive
- Much as been achieved, and there is no need to be apologetic
- But it's clear that we are yet not ready to offer much of real value
- We begin by looking at the mathematical substructure employed by current space/time modelling technology.

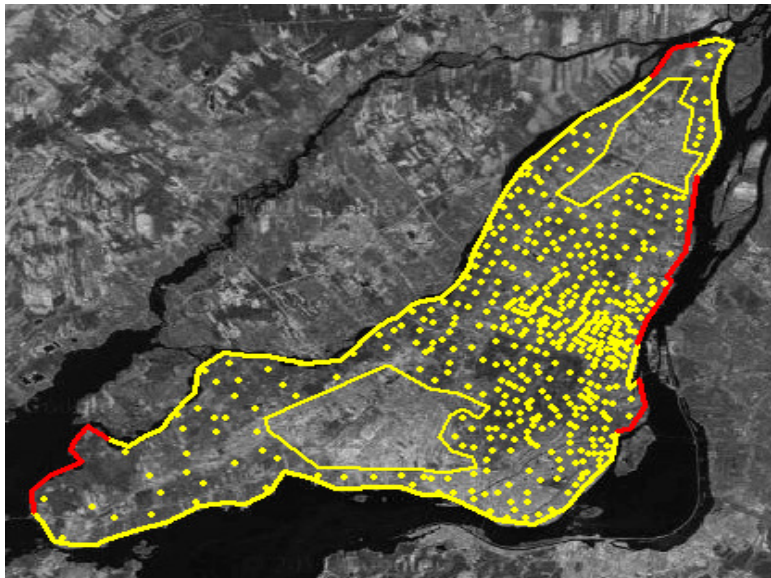
figs/StorchZwiers.pdf

figs/CressieWikle.pdf

A quick look at our space/time modelling toolbox

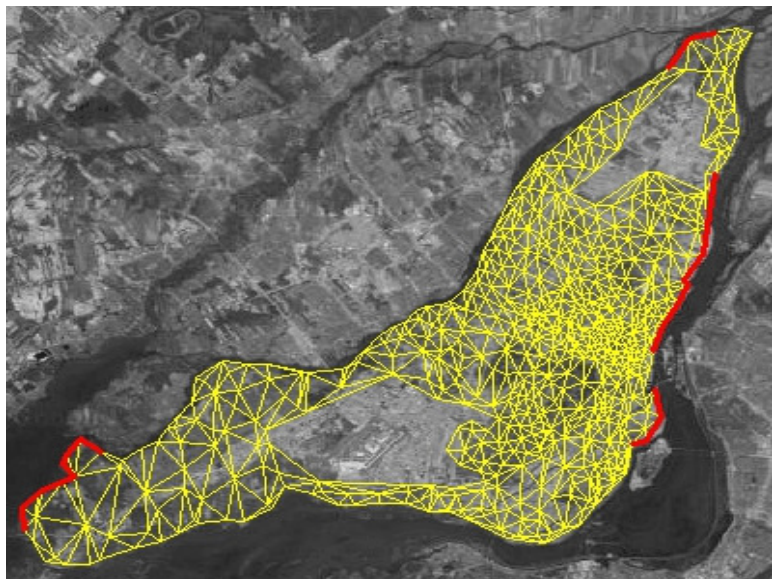
- Reviews of recent stats texts aimed at climate science have been instructive
- Much as been achieved, and there is no need to be apologetic
- But it's clear that we are yet not ready to offer much of real value
- We begin by looking at the mathematical substructure employed by current space/time modelling technology.

figs/BoxJenkinsReinsel.pdf



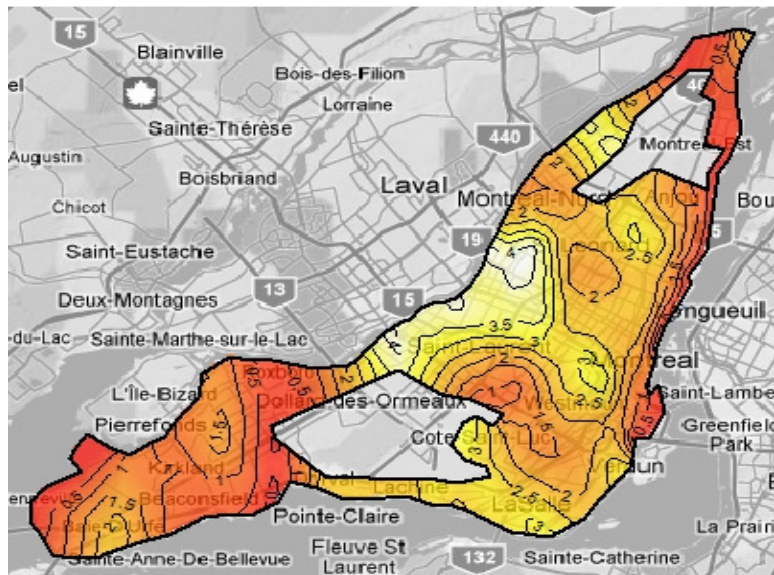
Census tract locations on the Island of Montreal

- Yellow boundary points are locations of zero normal flow.
- Red boundary points are locations of zero level.
- Lower hole is Trudeau Airport.
- Upper hole is oil refinery and water treatment complex.
- This object is embedded in a two-dimensional locally Euclidean space.
- This space has no natural zero, is invariant under translations, and is therefore affine.
- There is no natural Cartesian coordinate system here, and consequently no vector space structure.
- We could compute principal components of point locations, but we would have to use a coordinate system to do.



Census tract mesh on the Island of Montreal

- Tract locations are vertices in a Delaunay triangulation.
- Now we have a two-level coordinate system:
 - Edges connect vertices
 - Barycentric coordinates navigate us within triangles
- We need to learn how to do data analysis with multi-level coordinate systems.



Smoothed annual income over the Island of Montreal

Smoothing algorithm described in Sangalli, L. M., Ramsay, J. O. and Ramsay, T. O. (2013) Spatial spline regression models. *Journal of the Royal Statistical Society, Series B*, **75**, 681-703.