An Atlas of Canada's changing ocean soundscape

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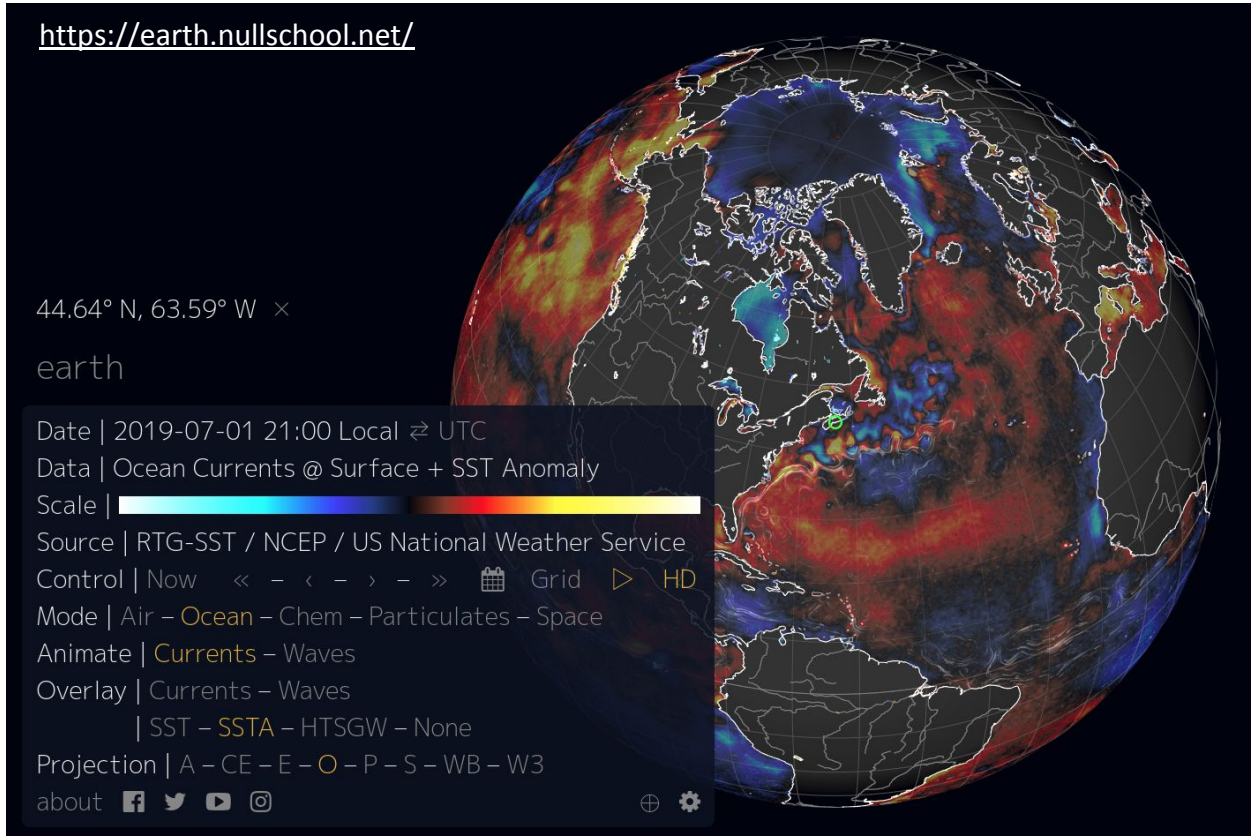
The goal ...

is to have a tool, similar to this one, for visualizing underwater noise



Concept:

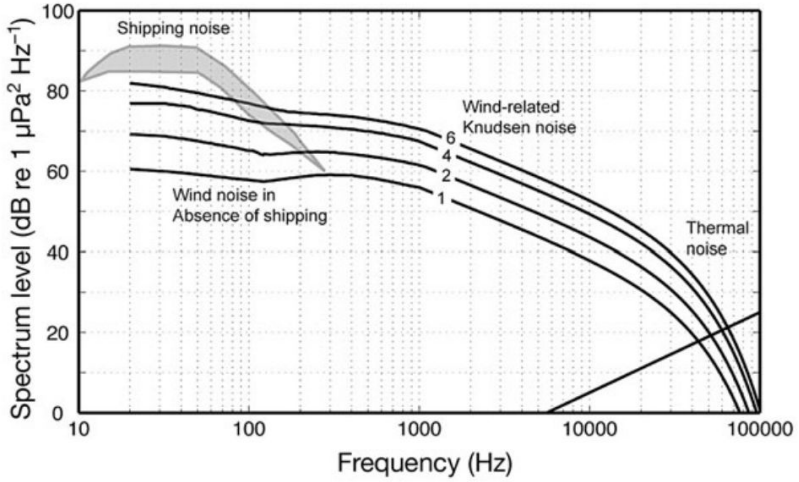
- Web-based interactive application
- 2D and 3D visualization of modeled underwater noise

Purpose:

- Facilitate transfer of scientific results from researchers to the public
- Allow managers and policy makers to monitor trends in the ocean acoustic environment
- Ensure timely, effective, and efficient marine environmental management

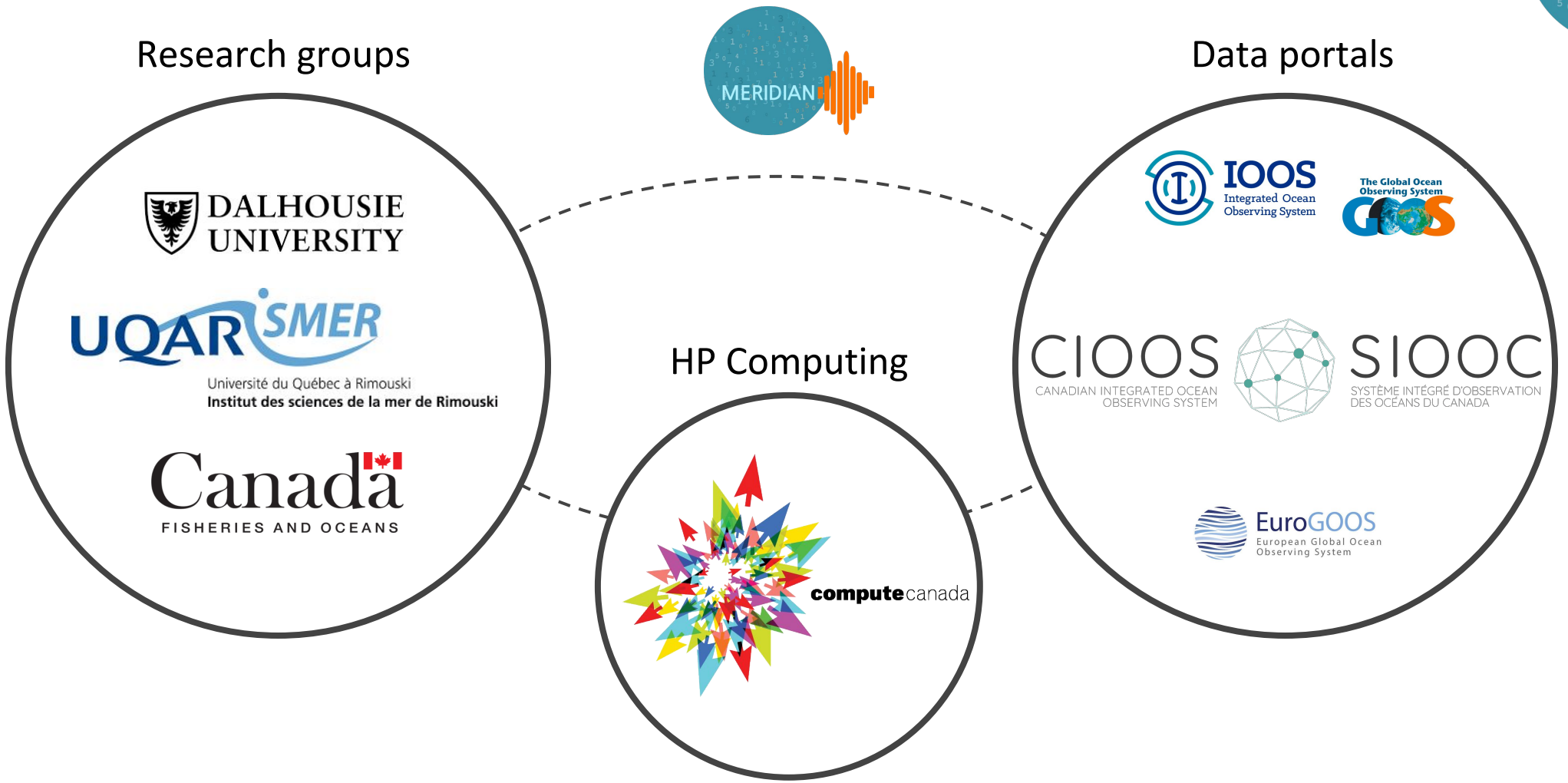
Motivation

- Fish and marine mammals use sound for navigation, habitat selection, mating, communication, prey detection, etc
- Marine organisms may be expected to modify their behavior based on natural and anthropogenic background noise.
- Ships are a dominant source of noise at low frequencies.
- Significant increase in the number and size of vessels over the past 50 years + new transportation corridors in the arctic.
- Evidence suggests overall increase of ~20 dB from pre-industrial conditions to the present.



Hildebrand, J. A. (2009). "Anthropogenic and natural sources of ambient noise in the ocean," Marine Ecology Progress Series 395, 5-20.

Context


Research groups
MERIDIAN
Data portals
DALHOUSIE UNIVERSITY
UQAR SMER
Université du Québec à Rimouski
Institut des sciences de la mer de Rimouski
Canada
FISHERIES AND OCEANS
IOOS
Integrated Ocean Observing System
The Global Ocean Observing System
GOOS
CIOOS
CANADIAN INTEGRATED OCEAN OBSERVING SYSTEM
SIOOC
SYSTÈME INTÉGRÉ D'OBSERVATION DES OCÉANS DU CANADA
HP Computing
computecanada
EuroGOOS
European Global Ocean Observing System

Soundscape components

Anthropo-phony

Shipping, oil and gas (air-guns, ships, drilling), naval operations (sonars, communications, explosions), fishing (sonars, acoustic deterrent devices), research (air-guns, sonars, telemetry, communication, navigation), construction, icebreaking, recreational boating, ...

Bio-phony

Sounds produced by fish and marine mammals

Credit: Reinhard Dirscherl/Alamy Stock Photo

Geo-phony

Earthquakes, waves, rain, thermal, ...

First prototype

- Estuary and Gulf of St. Lawrence
- 2013 and 2018
- Noise sources:
  - Shipping
  - Waves and rain

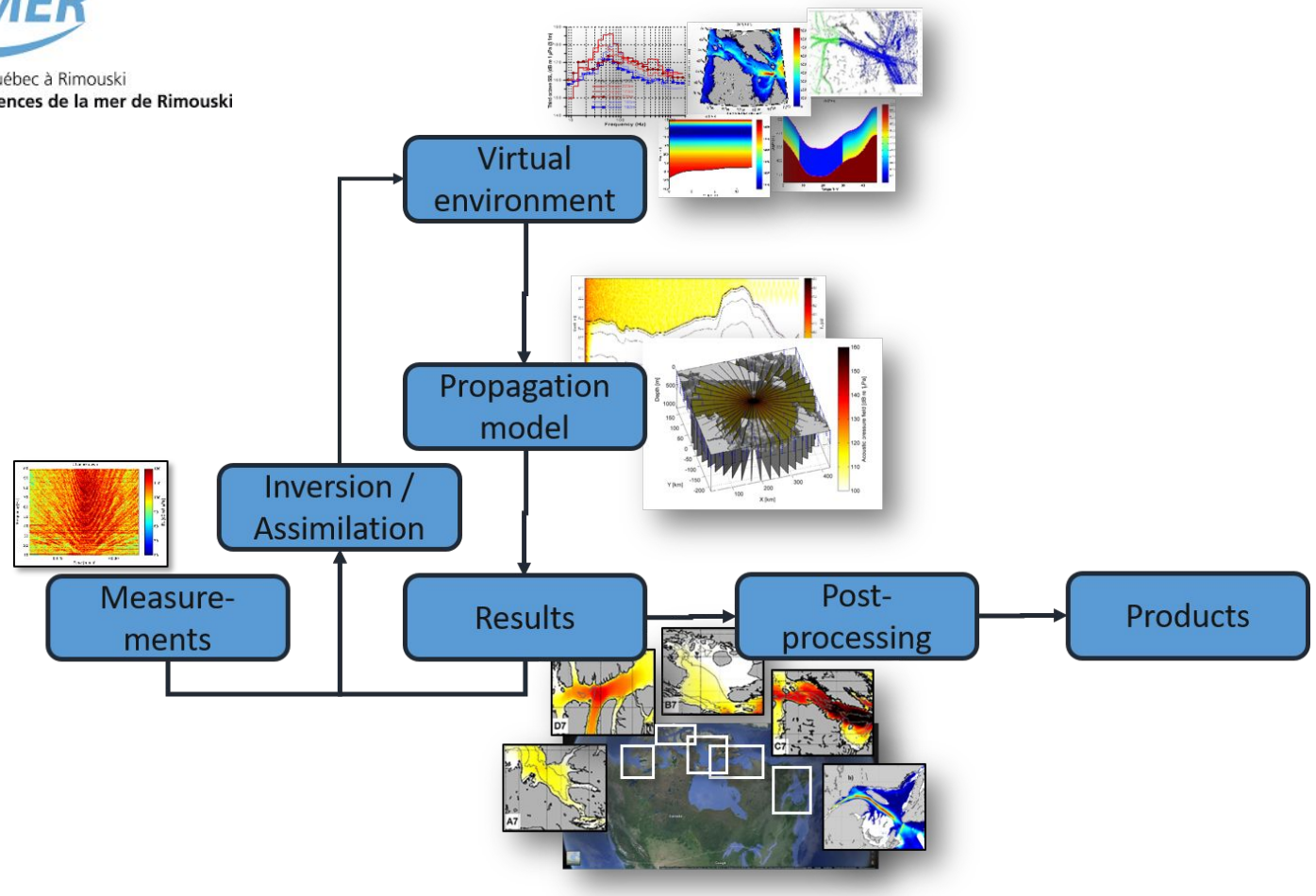
North Atlantic Blue Whale (endangered)

- a few hundred individuals
- A and B calls, 15-19 Hz
- D call, 30-100 Hz

Shipping noise modeling

Key ingredients:

- AIS vessel tracking data
- Realistic ship source levels
- Accurate modeling of sound propagation
  - Bathymetry
  - Seafloor acoustic properties
  - Water properties (temp, salinity, etc)
  - Numerical solution of wave equation
- Validated by measurements



[Aulanier, Simard et al. Proc. Mtgs. Acoust. 27, 070006 (2016)]

Environmental noise modeling

Environmental variables:

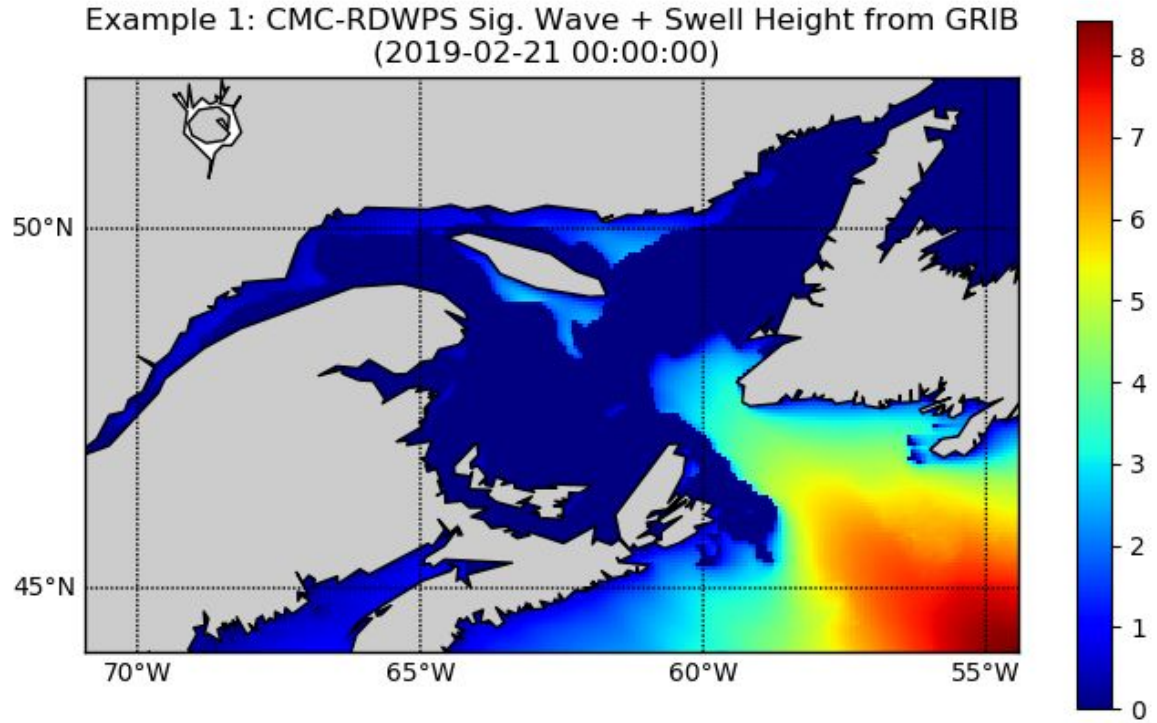
- Significant height of combined wind waves and swell
- Mean wave direction
- Mean wave period

Data sources:

- ECMWF ERA 5
- NOAA Wavewatch III
- Env. Can. RDWPS

Open-source Python package:

- Retrieval and interpolation of environmental data
- Source level estimates
- Transmission loss calculations



DALHOUSIE UNIVERSITY
David Barclay
Department of Oceanography

Technical structure

Software stack

Dataflow

Infrastructure

Modelling and mapping

Data assimilation models

Soundscape models

Formatting scripts

Acoustic data
wav, flac

Model inputs

NetCDF
CF standard

Compute Canada Computing Servers (Arbutus, Beluga)

User interface

Geospatial Database

PostgreSQL-PostGIS

Toolboxes (Backend)

- Map server (Geoserver)
- Rest API
- Python API

Graphical (Frontend)

- Open Layer
- Cesium
- Javascript library plotly

Web server

- Apache
- NGinX

•Rasters
•Point cloud
•Iso-contour

SQL outputs

WFS, WMS

HTML

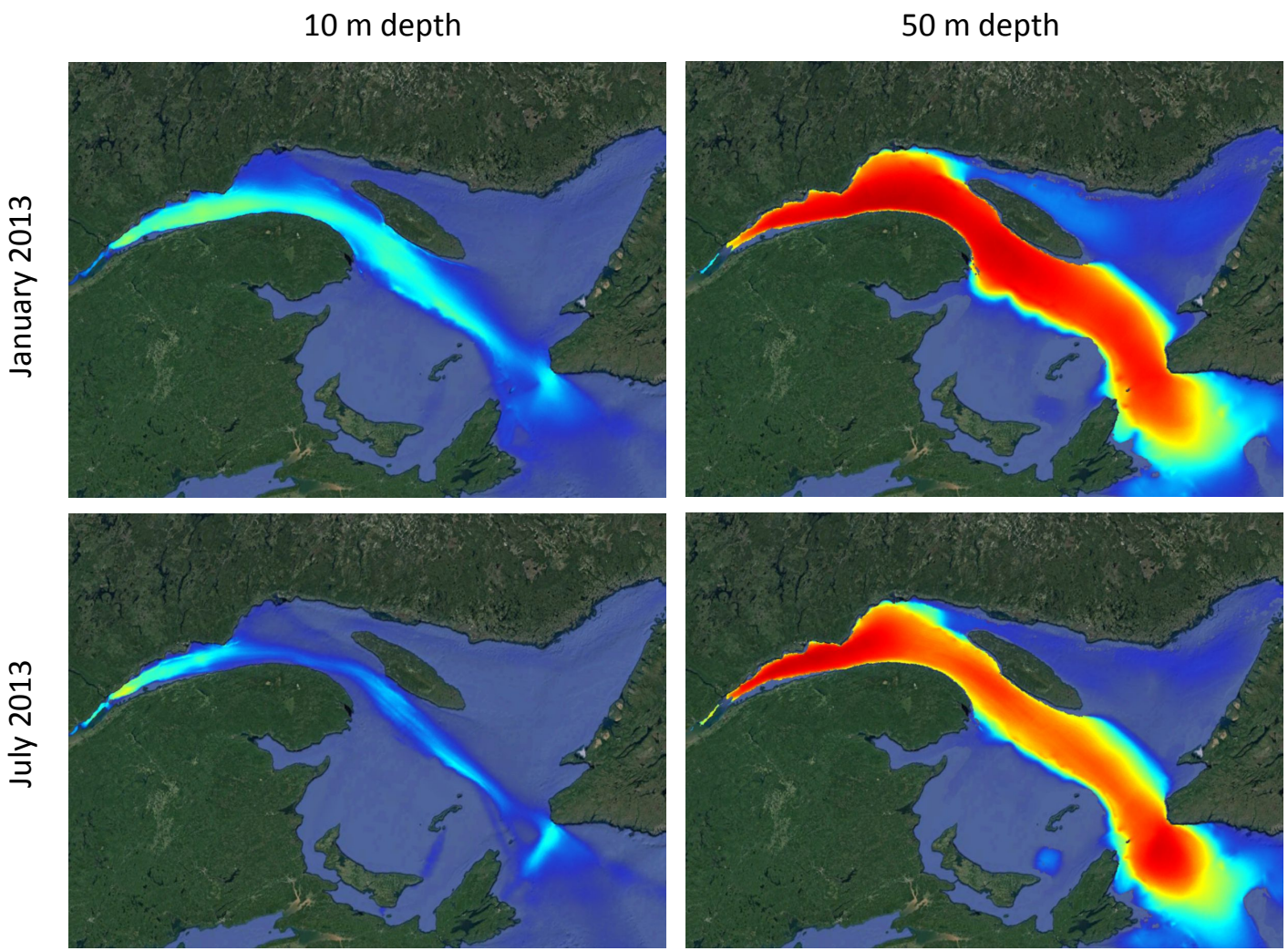
HTML

Compute Canada Persistent Servers (Arbutus)

End users

Some snapshots

Risk maps of exceeding 90 dB (at 40 Hz)



Due to changes in ocean acoustic propagation conditions the risk to exceed 90 dB at 40 Hz

- is greater at 50 m than at 10 m
- is greater in winter than in summer, despite almost constant shipping activity
- shows high day-to-day variability

Risk maps of exceeding 90 dB (at 40 Hz)

video:

Kirsebom_An_Atlas_of_Canada_slide_12.mp4

User interface

Risk to exceed 30 dB at 50-m depth and 16 Hz in January 2013

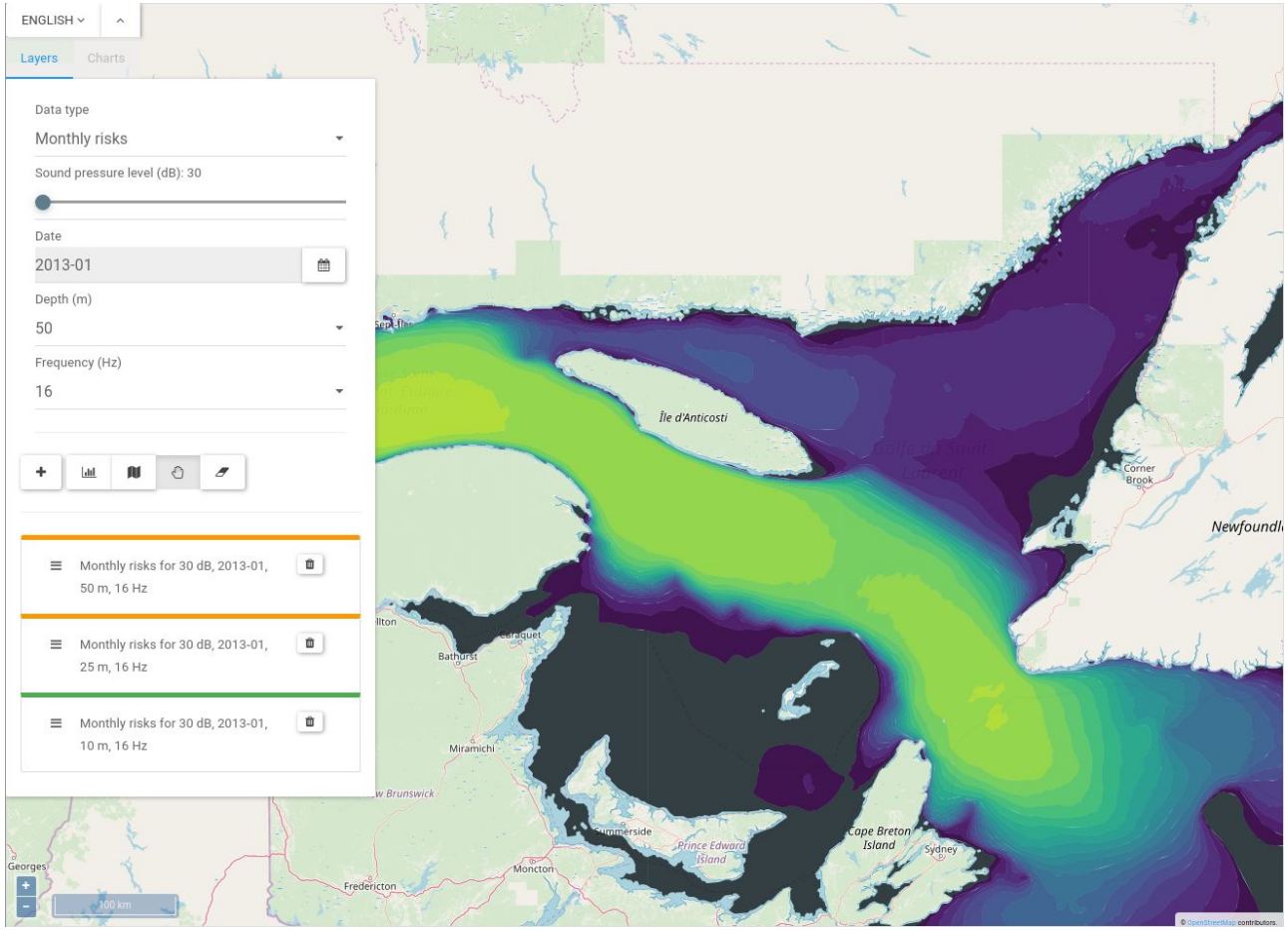
Language

Layer selection:

- map type
- risk threshold
- date
- depth
- frequency

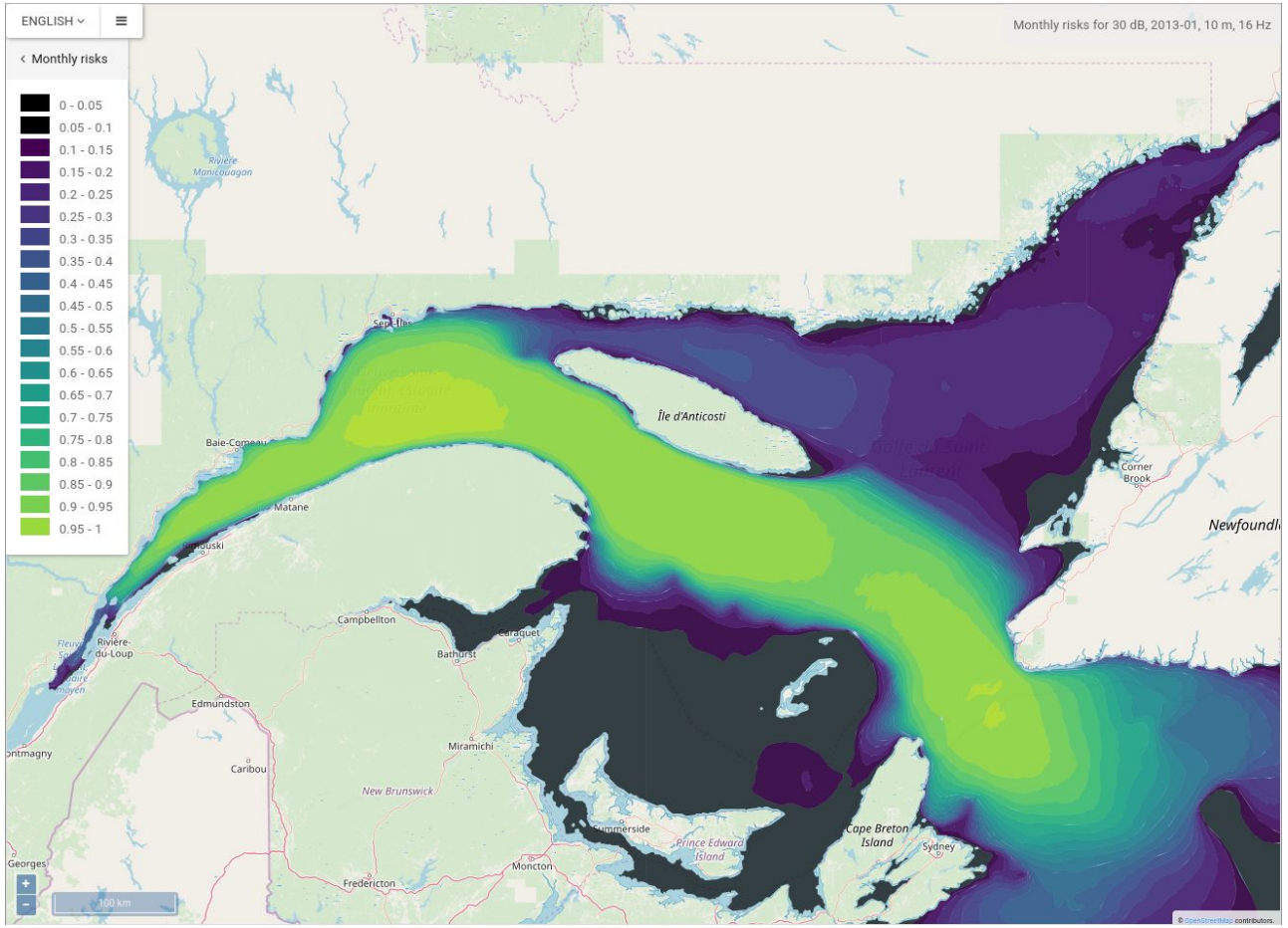
Toolbar

Layer stack



User interface

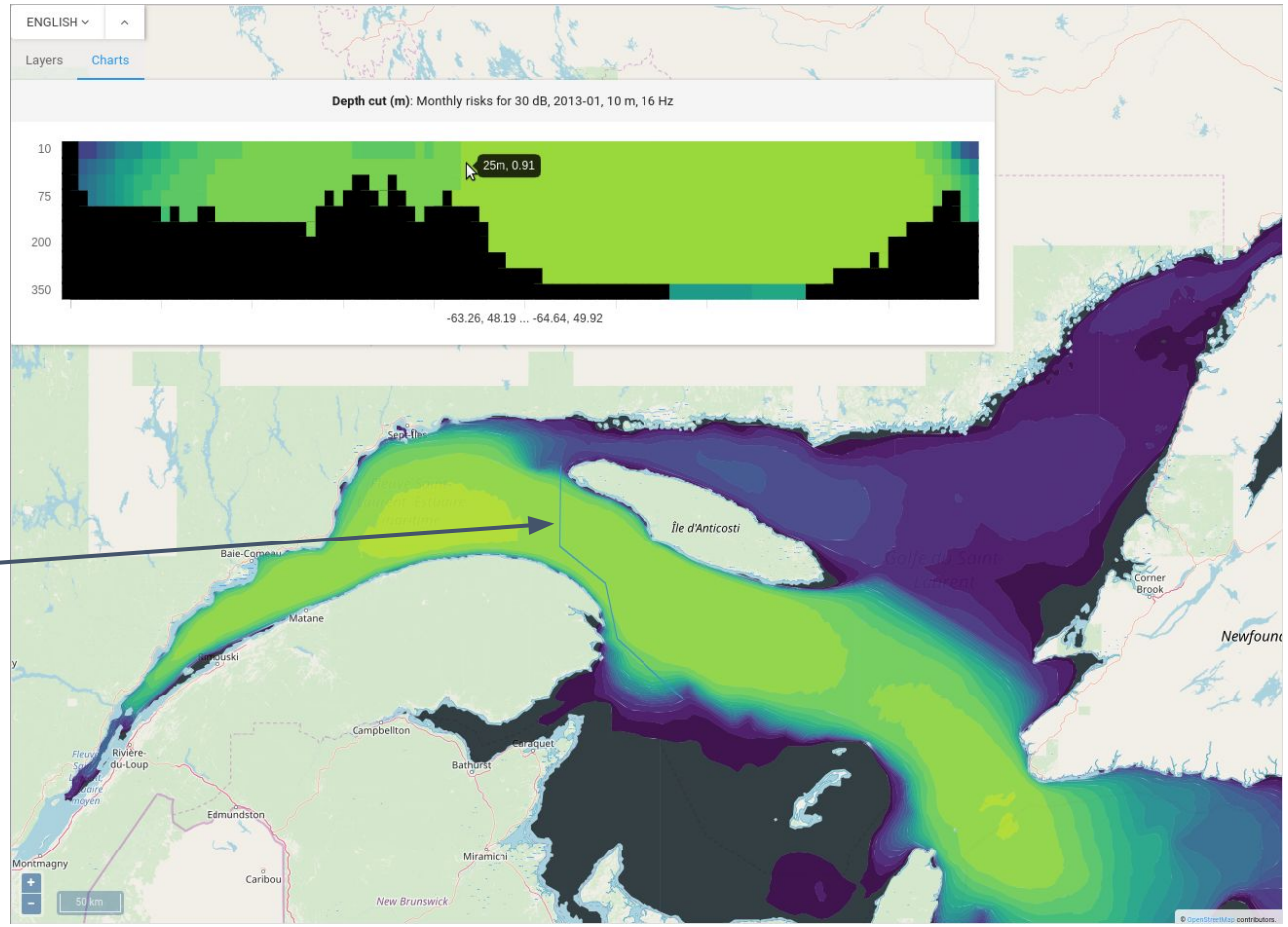
Risk to exceed 30 dB at 50-m depth and 16 Hz in January 2013



Vertical slice

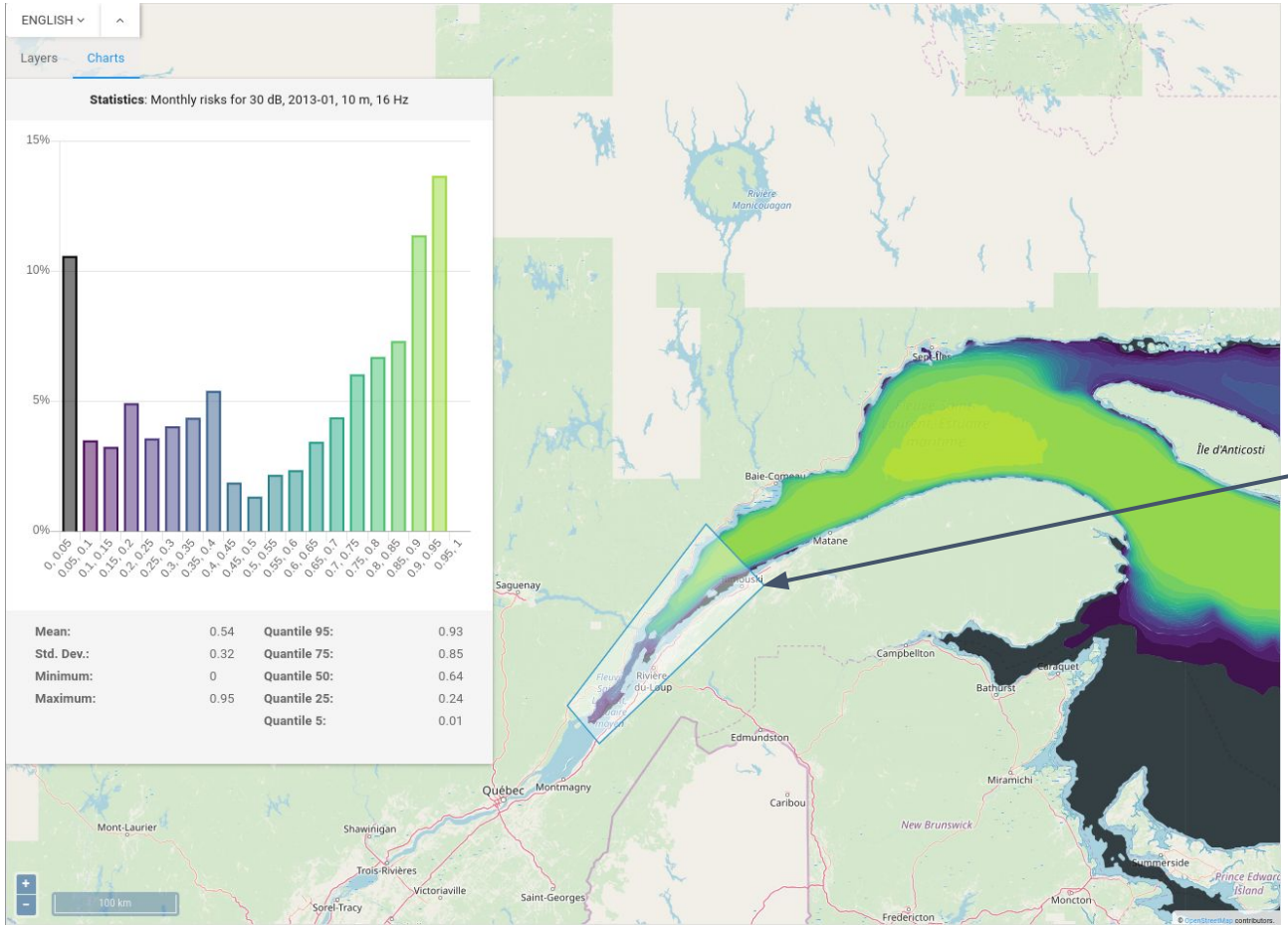
Risk to exceed 30 dB at 50-m depth and 16 Hz in January 2013

user-defined path



On-the-fly risk statistics

Risk to exceed 30 dB at 50-m depth and 16 Hz in January 2013



user-defined area

Conclusion

- MERIDIAN is developing an web-based, interactive application for **visualizing modeled underwater noise** in Canadian waters
- We call it the "Ocean Soundscape Atlas"
- The first prototype of the Atlas will focus on the Estuary and Gulf of St. Lawrence and include noise due to shipping and waves and rain.
- We envision that the Atlas will contribute to increased ocean literacy and ensure timely, effective, and efficient marine environmental management

Acknowledgements

Funders

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