BRUIT-FM Kickoff meeting

8 April 2022
IPGP Salle 108 (salle des conseils)
Onsite: Mohammad Amin Aminian, Guilhem Barruol, Wayne Crawford, Richard Dréo, Stephan Ker, Jean-Paul Montagner, Eleonore Stutzmann, Alistair Trabbattoni
Videoconference: Felix Bernauer, Laurent Duval, Frederic Guattari, Jean-Yves Royer, Flore Samaran, Martin Schimmel, Spahr Webb

Program

11h-12h30: Project Presentations

11h00-11h15	Overall project	Wayne
11h15-11h30	WP2 and technical	Wayne
11h30-111h45	WP3: Modeling	Eleonore
11h45-12h00	WP4: Signal separation	Stephan
12h00-12h15	WP5: Soundscape	Guilhem
12h15-12h30	Discussion	Wayne

12h30-14h: Lunch

14h-16h: Scientific Presentations

14h00-14h20	OBS data and baleen whales	Flore SAMARAN
14h20-14h40	Whale and ship tracking	Richard DREO
14h40-15h00	Seafloor noise and compliance	Mohammad Amin AMINIAN
15h00-15h20	Current and compliance noise removal	Wayne CRAWFORD
15h20-15h40	Signal processing	Laurent DUVAL
15h40-16h00	Scientific Discussion	

16h-16h30: Coffee

16h30-18h: Discussion

16h30-17h15	WP issues
17h15-18h	Organizational Issues

Files

Video files and presentations and available at the RESANA project page, under Dossiers -> Meetings

Project Presentations (11h-12h30)

Project and WP 2 (Wayne)

All project details, tasks and deliverables can be found on the project website (bruit-fm.org)

WP2 tasks and deliverables

Presented here because they are not in the slides and because they affect the other WPs

- Map and list of datasets to use, with specific information about how to access and what stations have what kind of channels/sensors (M12)
- Seafloor pressure low noise and high noise models (article and on webpage): can be used as a basis for evaluating what local signals/noise are in a particular dataset (M36)
- Seismological noise source catalog: all non-earthquake signals seen on seafloor data sets and their characteristics (frequency range, impulsiveness…) (M48)

Website

bruit-fm.org . Has an overview of all Work Packages (WPs), Deliverables, Tasks, Budget, Members, etc. Modifiable by WP leaders, should contain information useful to all, not intermediate work. Also has links to project management pages (one for the project, one for each work package)

Project Management pages

Links can be found on the website, must register with RESANA to use them. Allow document sharing, co-editing and versioning ("Dossiers" tab). Also task listing and assignment, if you like that sort of thing ("Project" tab). Lots of other stuff surely but only use what you need/like.

The Project-level management page will store all reference documents as well as meeting minutes, presentations and videos. If you have a problem registering, logging on or using, contact Wayne (crawford@ipgp.fr)

Mailing lists

bruit-fm@services.cnrs.fr is for all email communication. When you schedule a WP meeting, please post the information here so that others can join in (or ask to). If you are teaching someone about your tool/method, post here too in case someone else wants to learn

bruit-fm_admin@services.cnrs.fr is for management/admin emails

Slack channel

For informal/temporary chatting. Post everything to the general# channel for now.

https://join.slack.com/t/bruit-fm/shared_invite/zt-16vsjqepf-69F~zkglpBiRM7ojMDuFOQ

Data Management Plan

Must be delivered in M6 and updated in M24 and M48. There are three axes:

- **Data**: Access and openness, in principle we will not be generating much data, but will use open methods (FDSN webservices) for access. SEIS-ADELICE data will go onto the open access RESIF data center.
- **Codes**: We can collaborate/share codes at the Gitlab "BRUIT-FM" group (https://gitlab.com/b2305). This is a private group, though the goal is to be able to share the codes openly after the development phase.
- **Articles**: In acknowledgements, cite "ANR project ANR-21-CE01-0031". If papers aren't Open Access, put at least the accepted version (most editors allow this) on an Open Access website (HAL for French researchers).

WP3 (Eleonore)

Details are in the presentation file "20220407_WP3.pdf"

- Comparison of wave spectra and land seismological spectra, explication of theory (Longuet-Higgins, Hassellmann, Ardhuin et al…)
- Explanation of primary and secondary microseisms
- Noise characteristics of continental, island and arctic stations compared to ocean wave-based models
- How to separate static/dynamic effects? (cyclone signal observed on Z/H channels but not on horizontals (Davy 2019))
- Using DAS to constrain ocean wave reflection coefficient, future DAS expt around Mayotte
- Other DAS cables Toulon and Monaco

Questions

Wayne: IG wave generation/reflections were observed using the Cascadia Array: Smit et al., 2018

WP4 (Stephan)

Details are in the presentation file "20220407_WP4.pdf"

- Presentation of two major axes of WP4:
- Noise separation and reduction using existing sensors
    - Wayne's original transfer function based codes, used as a benchmark
    - Martin+wayne looking at better ways to estimate transfer function
    - Stephan, Laurent, Jerome and Michel looking at alternative, methods for noise separation/reduction
- Developing and evaluating a prototype rotational/translational BBOBS
    - Could reduce horizontal noise levels considerably
    - Requires integration of blueSeis 1C rotational seismometers into BBOBS seismometer package

Questions

Frederic: We need to schedule a technical meeting for mechanical specifications (next Wed?)

Frederic: Also need to set up a scientific meeting on noise separation and tilt correction (Wayne and Felix papers). Frederic has PhD student looking at new algorithms to improve 6-component tlt removal. Student is only here through May, then returns to Mars seismology.

Stephan: A workshop would be a good idea, WP4 can support it

Felix: Agrees to workshop on sharing experience and expertise.

Felix: How many blueSeis 1Cs do you plan to put in the BBOBS package?

Frederic: at least 2, up to 3.

Felix: What is power consumption?

Frederic: 3C blueSeis is 18W, but they have a 1W/axis board on the shelf for 2023. If that isn't ready, there is also a new but existing 6W (2C? 3C?) board

Wayne: BBOBS powers 1W for 12+ months, could last for 1.7 months with 6W rotational electronics, or 19 days with 18W electronics. Enough for planned tests.

Fredieric: Where could we do the workshop?

Felix: Could add this to the iXblue rotational workshop in October

But we should have a preliminary, limited one before the student leaves

WP5 (Guilhem)

Details are in the presentation file "20220407_WP5.pdf"

- A detailed explanation of shipping noise and factors controlling the frequencies/strength
- Cryoseismology: SEISADELICE expt w/SPOBS and accel OBS
- Cyclone monitoring: will focus on higher frequencies than microseisms (wind generation)
- Whale sources (detection and tracking)
- Noise Pollution

Questions

Eleonore: Where does the HF signal come from during cyclones?

Guilhem: From wind, signal is in the band from 5-25 Hz

Richard: Can follow cyclone center with higher precision than when using microseisms. Can follow cyclones and determine distance at up to 400 km distance (winds > 50 kts)

Eleonore: What is the source of the HF energy?

Fabrice Ardhuin: Walter Munk looked into this, determined that it was also (capillary?) wave-wave interactions

Jean-Paul Montagner: Are icequakes the dominant signal in Antarctica?

Guilhem: The dominant activity is very small magnitude icequakes. There are also some lower frequency signals (basal sliding?). Don't see the same signal as in Greenland because there seem to be fewer capsizing processes. The longer dataset that we are currently collecting should help to verify this.

Jean-Paul: If you install OBSs next to glaciers, will this help to improve icequake locations?

Guilhem: The small "antenna" network we deployed should help, but will be challenging.

Scientific Presentations (14h-16h30)

Cetacean sound production (Flore)

Details are in the presentation file "20220407_Scientific_1_BaleenWhales_Samaran.pdf"

- OHASBIO (large array of water-column hydrophones) is great for studying population movements, but not for tracking individual whales
- Several papers show the usefulness of using OBSs for tracking baleen whales: Dunn & Hernandez, Wilcock JASA 2012, Harris et al., Dreo et al.…
- Showed "Whale superhighways" map from WWF-whales.org (online since one month ago)
- Benefits of OBS studies: long-term monitoring with reduced field effort, wide spatial coverage, well adapted to studying large/remote areas, dedicated to baleen whales, can track individuals non-invasively

Questions

Eleonore: How do you determine the whale distribution without acoustics?
Flore: With ARGOS tags directly on the whales, effective but invasive
Guilhem: How about using gliders?
Flore: Can put a hydrophone on gliders, useful for prospecting in regions but not for tracking, very expensive…

Whale and Ship Tracing using OBSs (Richard Dréo)

Details are in presentation file "20220407_Scientific_2_ShipWhaleTracking_Dreo.pdf"
Presented Trabattoni work on OBS orientation and location, ship tracking
Richard's thesis topics:

- Whale trajectory estimates
- Whale detection using Inter-Call Interval (ICI) detector
  - ICI is highly characteristic for each species
  - Uses quefrency, simple and robust
- OBS blind orientation (w/o knowing ship positions)

Presentation of available OBS networks

Questions

Jean-Paul:
Eleonore: Does the whale change depth during calls?
Richard: Most calls are made between 0 and 50m depth
Stephan: Can individual whales be distinguished?
Richard: very difficult to do so based on calls, can do based on different positions
Flore: Loud VLF sounds are only produced by males, Females produce higher frequency, less stereotyped calls. Whale groups are relatively small during migration. Larger during feeding, but quiet. During migration they are solitary but chatty.
Stephan: What are the harmonics you showed?
Richard: Not harmonics, rhamonics! (ICI detection)
Stephan: And are there harmonics?
Richard: Fin whale harmonics would be too high frequency for typical OBS recordings (<= 100 sps)
Guilhem: What is the directivity of the whale source?
Flore: We don't really know the mechanism, but it seems very isotropic compared to dolphins, for example

Ocean floor seismological and environmental monitoring (MA AMINIAN)

Details are in the presentation file "20220407_Scientific_3_Compliance_Aminian.pdf"
Showing coherency and spectra before and after noise correction
Data are from 7D.J43A 2012-02-02

Questions

Frederic Guattari: Can we tell if the coherence between Z and P at 0.01 Hz is real seafloor motion, or tilt? Can we determine the ratio between vertical motion and tilt?

Mohammad Amin: We have corrected for tilt in the data so what is left over should only be vertical motion

Spahr Webb: Tilt correction is solely to make the vertical insensitive to tilt. There are other non-"motion" signals on the vertical channel, such as the gravitational attraction of the ocean waves

Wayne: There is also a second order (so double frequency) tilt effect on the vertical, but it is much smaller than the mis-tilt levels and probably below the instrument sensitivity. A last term to account for is the change in distance of the seismometer's mass from the center of the earth, this actually becomes significant near 3000 seconds, too long for our study (see Figure 1, Crawford et al. 1998) .

"Benchmark" transfer function correction code

Details are in presentation file "20220407_Scientific_4_NoiseRemovalCode_Crawford.pdf"
Most of the existing papers on transfer function-based noise correction either use a Matlab code written by Crawford or the "Automatic Tilt And Compliance Removal" (ATACR) code (Matlab + Python). Bell et al. 2014 improved on Crawford's technique by subtracting a single horizontal channel, chosen to have the highest coherence. They also analyzed tilt correction over time, finding that it does not fully stabilize even over half a year, so should be recalculated every day. Don't know of any code available from Bell, but horizontal reorientation is available in the ATACR codes. Wayne is not sure that ATACR is ideal for waveform correction because the transfer function is not applied to original data but rather the averaged spectral densities.
Wayne wrote a new, open-source Python code for transfer-function based noise correction which should be easy to install and implement. He will put the code and some example data sets and results on the bruit-fm.org website, to serve as a benchmark for other methods.

Questions

Martin Schimmel: Do orientations change over time?

Wayne: Articles I've seen (e.g. An et al., 2021) seem to find that the horizontal noise orientation is stable over time, although I don't know why. If the tidal and long-term currents are not aligned, the current direction should change as the tides wax and wane. Could it be related to direction of instability of the sensor package or its gimbal axes?

Spahr Webb: Simple rotation will not account for different response functions between the different seismometer components (slightly different corner frequencies can result in very different multipliers below the corner freq)

Stephan: Your linear transfer function method implies a stationary random process. Maybe your problems with further reducing noise have to do with pushing this limit.

On echos and morphing (Laurent Duval)

Details are in presentation file "202204_Scientific5_TemplateMorphing_Duval.pdf"
Source separations (echo cancellation multiple)

Adaptivity remove template
People usually do removal in the time domain, but we work in the wavelet domain

Questions

Wayne: How does this apply to seafloor noise data?
Laurent: Is probably more useful for data with templates, such as whale calls
Eleonore: Could be used for microseisms, which have common shape but have several sources
Laurent: I hope so, but am cautious
Jean-Paul: You showed active seismic data, which use the acoustic approximation, can you apply this to elastic waves with P & S waves?
Stephan: Laurent is actually working after the approximation stage; it is probably acoustic but in theory an elastic model could be used.
Laurent: The forward modelling is done by CGG and is in fact secret.

Science Discussion

Eleonore: I'd like to talk with Stephan about the postdoc for noise removal, will do so separately
Frederic: Thank you and we should plan a technical rotational BBOBS meeting right away.

WP and Organizational Discussions (16h30-18h)

WP 2

What datasets should we use?

Should have at least one dataset from each major ocean. No datasets that don't have FDSN webservices access.

Mediterranean: **AlpArray** is the only publicly available expt with broadband instruments, a decent coverage, and an interesting biological and shipping context.

Indian Ocean: **RHUM-RUM** is the biggest broad-wideband experiement, covers major shipping lanes and has some common coverage with OHASISBIO.

Atlantic: **EMSO-MOMAR** (long time coverage) and **PiLAB** (broadband, widespread). Wayne should send French PiLAB data/metadata to IRIS. EMSO-MOMAR should be on RESIF data center starting later this year. Other datasets include VOILA (Antilles) and SISMANTILLES (not on FDSN-compatible data center).

Pacific: Many choices, including Alaska, Cascadia, 3xPacificArray, PLUME, NOMELT, ORCA, YoungORCA. Jean-Paul will talk with Japanese colleagues about some of their very high-quality datasets, but access to data/metadata should be standard (FDSN webservices). No decision made.

Eleonore: Should add channel names to the website's dataset list

Wayne: Even that is insufficient, as HDH could mean, for IRIS, a broadband hydrophone, a differential pressure gauge or an absolute pressure gauge. For the Alaska expt, only about 1/3 of the OBSs have a hydrophone: they are labelled EDH instead of HDH to distinguish them from the pressure gauges on the same instrument.

Eleonore: How do you define the lower frequency ranges shown on the datasets page?

Wayne: I think I used 0.001 Hz for Trillium 240 or Guralp CMG-1/3, 0.01 for Trillium Compact or CMG-40T, 1 for SP. But even that's not complete, as pressure and motion sensors can have different dynamic ranges, and different stations can have different sensors. For the chosen datasets we should to a complete inventory of each type of instrument deployed.

Eleonore: Would like WP2 results to be open, would be very useful for the community

ToDo: Add stations map to "datasets" webpage

WP3

Looking for a postdoc, if anyone has good candidates/leads

WP4

Put benchmark noise removal data, processes and results on website

Set up initial rotational seismometer/BBOBS mechanical conception meeting (iXblue and INSU-IPGP OBS park)

WP5

Should we include shrimp in the study: noisy, could be sensitive to shipping/noise, but shallow water, no specialist in group (Jean-Charles MASSABUAU?). Would imply using higher frequency datasets, as the signals are at around 100Hz. One publicly available high-frequency dataset is from the Monterey Bay Aquarium Research Institute MARS observatory.

Windmills: again, it's a shallow water problem and it would need a specialist.

Stephan Ker will inform IFREMER Service Acoustique Marine (Yves Le Gall) of what we are doing, could have useful tie-ins.

Organizational Questions

How to ensure interactions between WPs?

- Maling list: bruit-fm@services.cnrs.fr
    - WP messages. Meeting announcements should pass by here as well so that interested people outside the WP can participate
- 2nd project meeting in Year 1: to make sure that people are starting
- Slack channel: https://join.slack.com/t/bruit-fm/shared_invite/zt-16vsjqepf-69F~zkglpBiRM7ojMDuFOQ
    - For quick sharing that doesn't need to clog up email inboxes, isn't meant to be long-lasting.
- Gitlab Project that people can put/share their code on.

Meetings

- Project meetings once/year, one more possible if necessary (like in first year to make sure that things are starting up correctly).
- WP meetings: as necessary
- Tutorials: No organized project-wide tutorials, but if a student/colleague asks for a walk-through of using a code or making a calculation, inform the group so that others can participate if there is interest.

References

WP3 references

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WP4 references

An C., C. Cai, L. Zhou and T. Yang (2021), Characteristics of Low-Frequency Horizontal Noise of Ocean-Bottom Seismic Data, *Seis. Res. Lett.*, doi:10.1785/0220200349.

Crawford W. C. and S. C. Webb (2000), Removing tilt noise from low frequency (<0.1 Hz) seafloor vertical seismic data, *Bull. Seis. Soc. Am.*, **90(4)**, 952-963, doi:10.1785/0119990121.

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WP5 references

https://wwfwhales.org/resources/protecting-blue-corridors-report

Dunn R. A. and O. Hernandez (2009), Tracking blue whales in the eastern tropical Pacific with an ocean-bottom seismomter and hydrophone array, *J. Acoust. Soc. Am.*, **126**, doi:10.1121/1.3158929.

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