Evaluating microbarom source models using infrasound recorded on a stratospheric balloon

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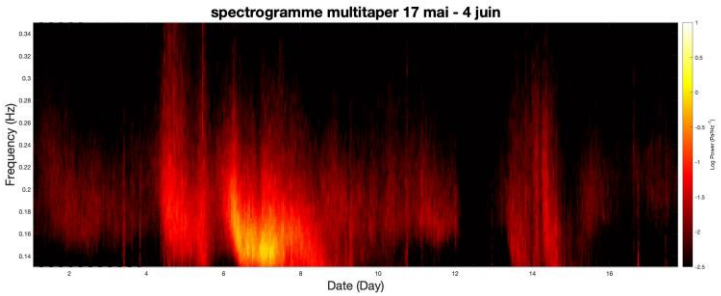
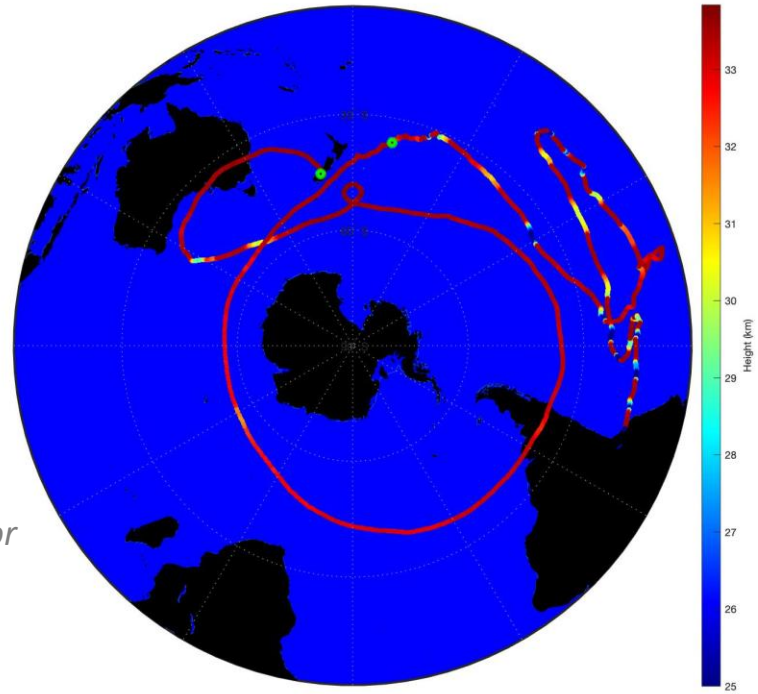
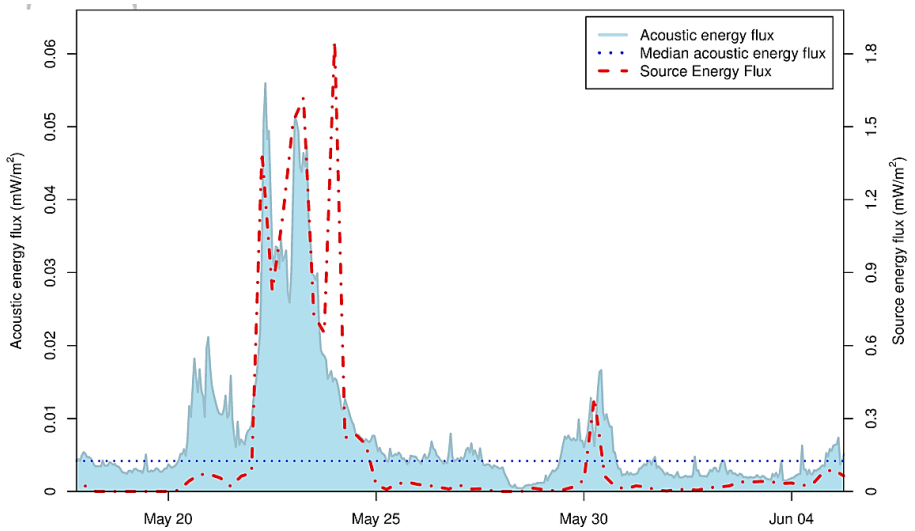
- Microbaroms continuously generated by ocean wave interactions around 0.2 Hz
- NASA Ultra Long Duration Balloon (ULDB)
  - Data recorded: from May 16th to June 5th 2016
  - Around the peri-antarctic belt
- Bowman and Lees 2018
  - Comparison between observations and model
  - Wave model: ECMWF
  - Source model: Waxler et al. 2007





ULDB trajectory (with altitude color coded)



From Bowman & Lees, 2018 : Upper atmosphere heating from ocean-generated acoustic wave energy, Geophys. Res. Lett., doi:10.1029/2018GL077737

Motivations for the study:

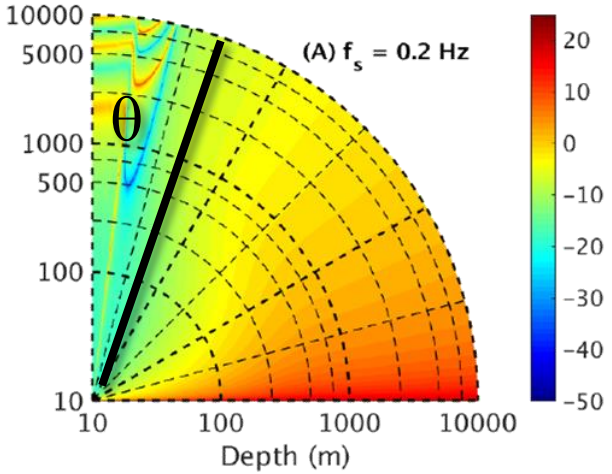
- New source model (*De Carlo et al, 2020*) depending on the elevation angle : high bathymetry dependency for elevation angle up to 13° from the vertical
- Looking for enhancement in the modeling with this new source
- Evaluate the influence of different parameters

How to model the acoustic flux energy at the balloon?

Wave Model + Source Model + Propagation Model = Energy modelled

$$E_b = \sum_{i \in N} \int_f \underbrace{\int_{\theta_i} C(\theta_i, f) d\theta_i}_{\text{Source model}} \times \underbrace{H_i(f)}_{\text{Wave Model}} \, df \times att_i$$

N : Number of sources, $C(\theta_i, f)$: Coefficient of the bathymetry impact,
$H_i(f)$: Hasselman integral, att_i : Attenuation for the cell i.



Radiation pattern at 0.2 Hz. Polar representation against the angle θ and the depth (according to Eq. 41 from De Carlo et al., Geophys. J. Int., 2020, https://doi.org/10.1093/gji/ggaa015)

Model 0 (*Bowman & Lees, 2018*): ECMWF Wave Model + $C(f)$ (*Waxler et al, 2007*) + No Propa

Model 1 : WW3 Wave Model + $C(f)$ (*Waxler et al, 2007*) + No Propa

Model 2 : WW3 Wave Model + $\int_0^{90} C(\theta, f) d\theta$ (*De Carlo et al, 2020*) + No Propa

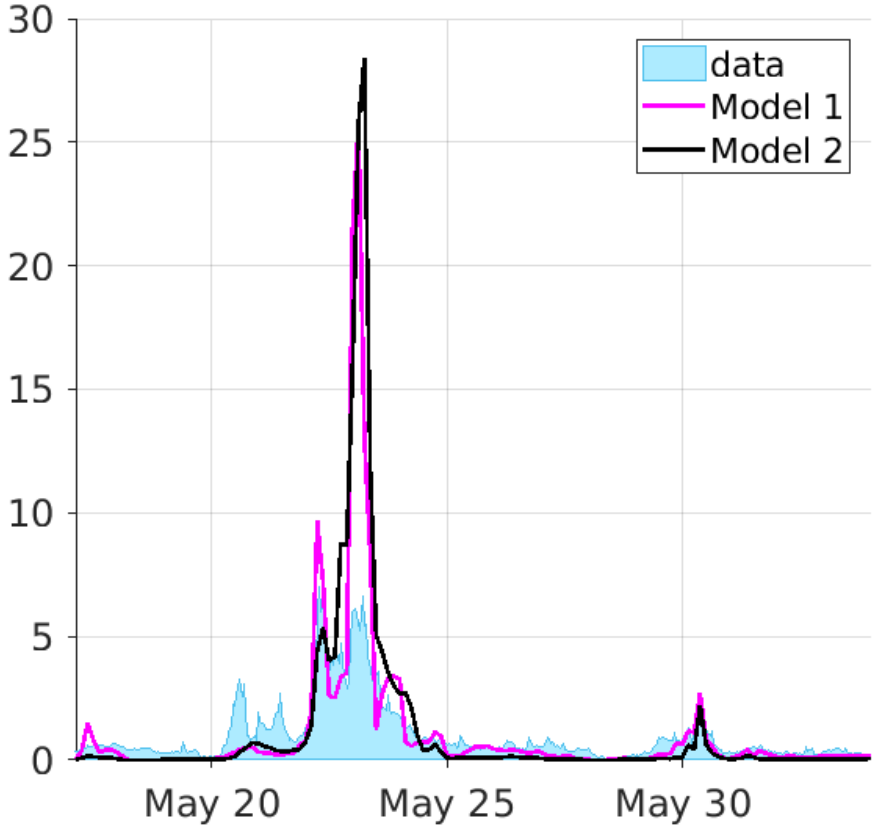
Model 3 : WW3 Wave Model + $\int_{\theta_{i,1}}^{\theta_{i,2}} C(\theta_i, f) d\theta_i$ (*De Carlo et al, 2020* elev. angle impact) + No Propa

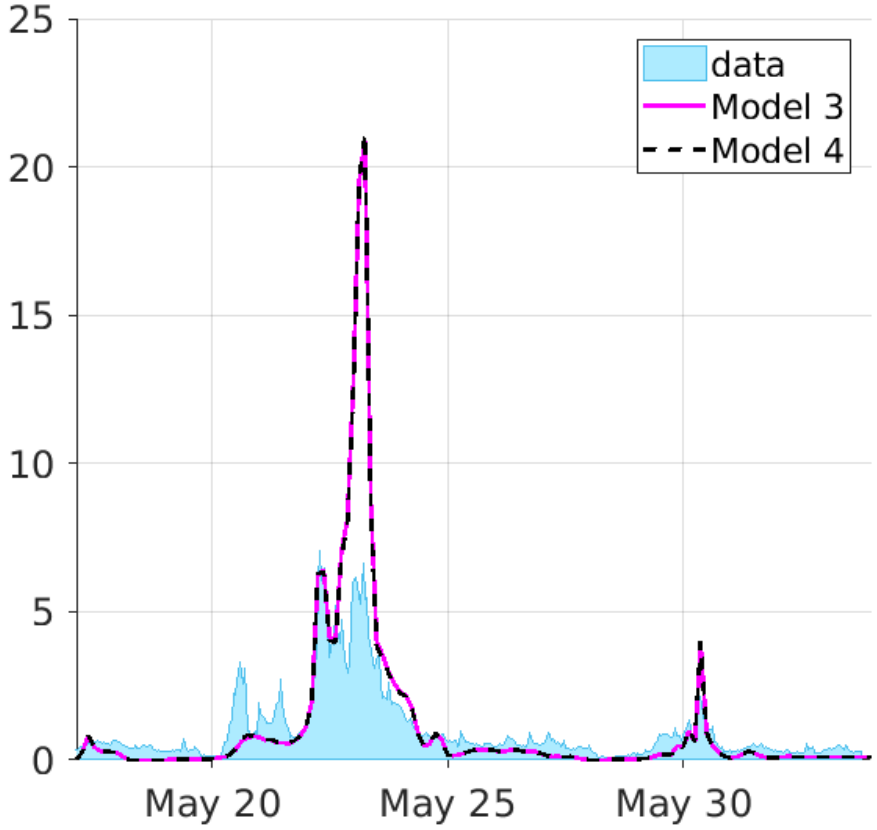
Model 4 : WW3 Wave Model + $\int_{\theta_{i,1}}^{\theta_{i,2}} C(\theta_i, f) d\theta_i$ (*De Carlo et al, 2020* elev. angle impact) + $1/R$ attenuation

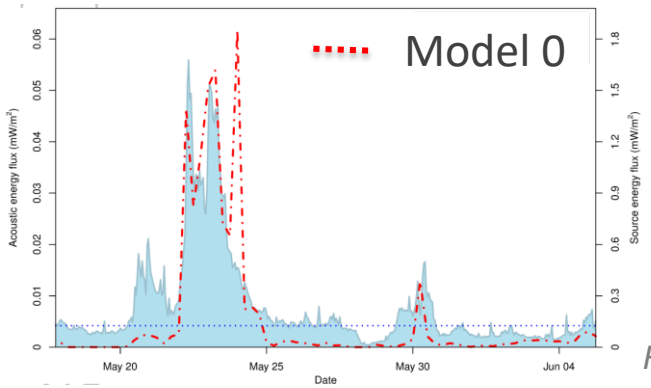
Key numbers for calculation:

- frequencies : **0.13 - 0.35 Hz**
- sources in a **100 km** radius circle above the balloon
- wave model: **3 hours**

Acoustic energy flux (relative amplitude)







- **Model 1 vs Model 0**: relative amplitude of 2nd peak compared to 1st and 3rd one: depends on the wave action model
- **Model 2 vs Model 1**: 1st and 3rd peaks smoothed, partly driven by high bathy impact
- **Model 2 vs Model 3**: almost no differences. Relative amplitude of 3rd peak decreases
- **Model 3 vs Model 4**: almost no differences

From Bowman & Lees, 2018

Overview

- The ocean microbarom is a global phenomenon, involving multiple source regions at any time
- Analyzing infrasound data from balloon-borne observation campaigns offers unique opportunities to evaluate ocean wave models and multiple source regions active at any given time
- The main differences between Bowman & Lees 2018 and these results are the 3rd peak around May 23rd which decreases according to the data and the overestimation of the 2nd peak, when the Wave Model WW3 is used.
- The comparison between source models reveals that the 1st and 3rd peaks are partly generated by bathymetry effect (the difference between Model 1 and 2 is explain the bathymetry effect: Model 1 shows measurable effect)
- Accounting for the elevation angle has no significant impact on the modelled relative amplitude: except for the 2nd peak where the main source of microbaroms is located strictly under the balloon
- This work is still on-going so we are open to any suggestions !