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Interactive comment on "Meteotsunami occurrence in the Gulf of Finland over the past century" *by* Havu Pellikka et al.

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We thank Agusti Jansa for the constructive comments that have helped us to clarify and improve some points in our manuscript. To reply to the more specific points we would like to note the following:

1. The differing trends observed at the two locations studied are indeed interesting. As we note below (#5), the tide gauge of Hamina is situated in a location which is potentially more vulnerable for meteotsunami amplification. Also, Hamina's location near the eastern end of the Gulf of Finland probably explains some of the difference in the magnitude and number of the observed meteotsunamis, as the potential distance of air-sea resonance is longer for disturbances moving from west to east.

The increasing trend in the time series from Hamina is largely due to the absence of events in the beginning of the series, from the 1930s to the 1950s (Fig. 5 in the manuscript). The reason for this gap in the occurrence of meteotsunamis is unknown. As we speculate in the text (p. 10 l. 28), changes in the propagation direction of atmospheric disturbances may cause differing trends in meteotsunami occurrence at different locations. However, studying the propagation direction of the disturbances is not straightforward as the available high-resolution air pressure data is mostly non-digital. The effect of coastal topography and local resonance effects could be studied with models. These are topics for future work.

We have added discussion on the differing locations of the tide gauges in the text, as well as some suggestions for future work.

2. We have considered all kinds of rapid pressure disturbances, pressure drops in addition to jumps, and also of smaller magnitude (∼1 hPa). We have reworded the text to clarify this. Only events with no unusual accompanying changes in air pressure were excluded from the analysis (a small proportion of all events).

It is an interesting question whether nonconvective pressure disturbances connected with atmospheric gravity waves might generate meteotsunamis in the Gulf of Finland. Our results show that the observed meteotsunamis are strongly connected to thunderstorms, and thus convective phenomena seem to be clearly the dominant factor of meteotsunami generation in the study area, but the possibility of other generation mechanisms cannot be ruled out. Sepic et al. (J. Sepic et al. 2015, High-frequency sea level oscillations in the Mediterranean and their connection to synoptic patterns. Progress in Oceanography 137, 284–298) state that meteotsunamis in the Mediterranean have a characteristic synoptic pattern: “(i) an inflow of warm air in the lower troposphere and (ii) a jet at mid-tropospheric levels embedded in (iii) unstable atmospheric layers. These conditions are conducive to generating and trapping atmospheric gravity waves in the lower troposphere - -“. It is not impossible that such conditions could occur in Finland (M. Bister, pers. comm.), but more exact analyses are a topic for future work.

The northern coastline of the Gulf of Finland is very irregular with bays and narrow inlets of different shapes and sizes, so seiche oscillations in small basins may cause sea level variations in the tsunami frequency range.

3. We have not included an estimate of the wave periods in the manuscript, as aliasing may distort the periods of short-term variations in the 15-min observations (see #7). We have added a note on this in the manuscript. Typical periods of the observed waves in the recorded signals are 1–2 hours; however, shorter-term variations may have been shifted to this period range because of aliasing.

Basin-wide seiches in the Gulf of Finland have generally a considerably longer period than meteotsunamis: around 23–27 hours (e.g. Neumann 1941, Eigenschwingungen der Ostsee, Arch. Dtsch. Seewarte Mar., 61, 1– 59; Lisitzin 1944, Die Gezeiten des Finnischen Meerbusens, Fennia, 68, 1– 19; Jönsson et al. 2008, Standing waves in the Gulf of Finland and their relationship to the basin-wide Baltic seiches, J. Geophys. Res. 113, C03004). Transverse seiche oscillations across the gulf may have periods close to meteotsunamis, however; with L = 80 km and H = 40 m, Merian's formula gives the period of a uninodal seiche oscillation of 2.2 hours.

4. The standard deviations of the filtered 15-min sea level signal were 0.45 cm for Hanko, 0.41 cm for Helsinki, and 0.92 cm for Hamina. We have changed the unit to mm for clarity.

We have used the standard deviations only to motivate the choice of height threshold for Helsinki tide gauge, for which no chart data is available.

5. The tide gauge of Hanko is located on a relatively open coast on the southern side of the tip of the Hanko peninsula (see attached Fig. 1). On the contrary, the tide gauge of Hamina is located in a potentially more vulnerable place for local resonance: inside a rather narrow bay, ca. 5 km long and 1 km wide (see attached Fig. 2). Assuming a mean depth of 6 m (an approximative estimate), the period of a uninodal seiche oscillation in the semi-enclosed basin would be around 35 minutes.

These differences in the settings of the two tide gauges probably explain some of the difference in the sea level variability between the two stations, but more detailed modelling studies would be needed to quantitatively resolve this. We have added discussion on this in the manuscript.

6. We agree that investigating the propagation speed and direction of the atmospheric disturbances would give us valuable information about the amplification mechanisms and the observed differences in meteotsunami occurrence at the two stations. However, with the air pressure data available (mostly non-digital) investigating the speed and direction is not straighforward, and is a topic for future work.

7. We agree that using 15-min sea level data is not optimal for meteotsunami detection, but higher-resolution data is not available to create a continuous time series. Most of the time series is based on tide gauge charts, however, where sea level is recorded as a continuous curve on paper.

It is possible that some events are missed after 1989 because of the 15-min resolution of the digital sea level data, but this does not seem very likely. Otherwise the number of events would drop in the time series after 1989, which is not the case.

Oscillations with a period of less than 30 min are aliased in the 15-min signal, but they are not completely missing; they can be seen in the time series with a distorted period. For example, oscillations with a period of 20 min would be seen in the data as 60-min oscillations. We have added discussion on the effect of data resolution and aliasing in the manuscript.

8. This issue is due to problems in the digitization of the data, which was performed by a human-assisted computer program over the period 1980–1987, as explained in Section 2.3 of the manuscript. All high-frequency oscillations that were recorded by the instrument (and are shown on the paper charts) are not accurately reproduced in the digitized 15-min data during this period. This problem in the quality of the digitization does not affect the time series after 1987, when the instrumentation of the tide gauges

was updated. We have clarified this issue in the text.

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Fig. 1. Location of Hanko tide gauge

Fig. 2. Location of Hamina tide gauge