Geophysical Research Abstracts
Vol. 15, EGU2013-13859, 2013
EGU General Assembly 2013

On the long waves disturbing ship operations in Ferrol (Spain)

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Long waves may cause significant disturbances for port operations. This paper is concerned with the long wave problems at Ferrol, a port in NW Spain. Long wave periods range between a few tens of seconds to several hours. In shallow water their wavelengths are on the order of hundreds of meters to kilometres. As a result, these waves can match the natural periods of oscillation of semi-enclosed bodies of water like gulfs, bays, fiords, or harbours, resulting in resonant oscillations. During resonance, the vertical displacement of the free surface increases until the energy input is balanced by losses due to friction, flow separation, boundary absorption, and radiation from the mouth (Okihiro et al., 1993). The induced horizontal displacements of the water mass are responsible for the large movements on ships.

The non-linear interaction of long and wind waves and the direct atmospheric forcing are the main sources of long waves in the ocean. In the first case, the long waves are also known as infragravity waves and tend to have relatively small periods. In the second case, the atmospheric forced long waves, different mechanisms have been used to explain their generation. Atmospheric disturbances passing over the continental shelf (Sepic et al., 2008) or wind convection cells (de Jong and Battjes, 2004) are two of the causes for these 'meteorological' waves. Whatever their cause, they tend to have relatively large periods and, therefore, a significant potential to excite the first modes of oscillation of harbours. In addition, other different forcing mechanisms can generate long waves, including submerged landslides (Cecioni and Bellotti, 2010) and seisms (Candella et al., 2008).

Disturbances to load and unload operations have been reported from 2005 at the Exterior Port of Ferrol (NW Spain). On-site measurements of sea-level oscillations revealed energy peaks possibly related to resonant processes (López et al., 2012; López and Iglesias, 2013). This work is focused on the long waves at the Port of Ferrol and their implications for the operations at the port.

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