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# Operational information on the secondary tidal undulation (meteotsunami)

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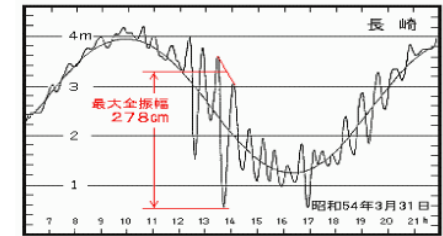
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# Introduction

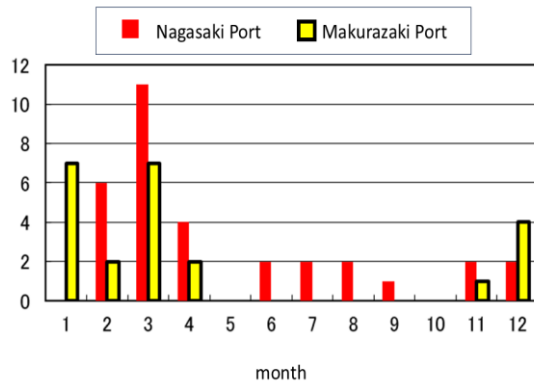
- In years, far western part of Japan “Kyushu” has suffered from “*abiki*”.
- *Abiki* is a local name of a secondary undulation what we call “*meteotsunami*”.
- *Abiki* usually occur in the spring.
- The historical case is the one on 31 March in 1979 in which the largest amplitude of 2.78m was observed at the Nagasaki tide station.



Observed water levels (abiki) on 31 March 1979 at the Nagasaki tide station

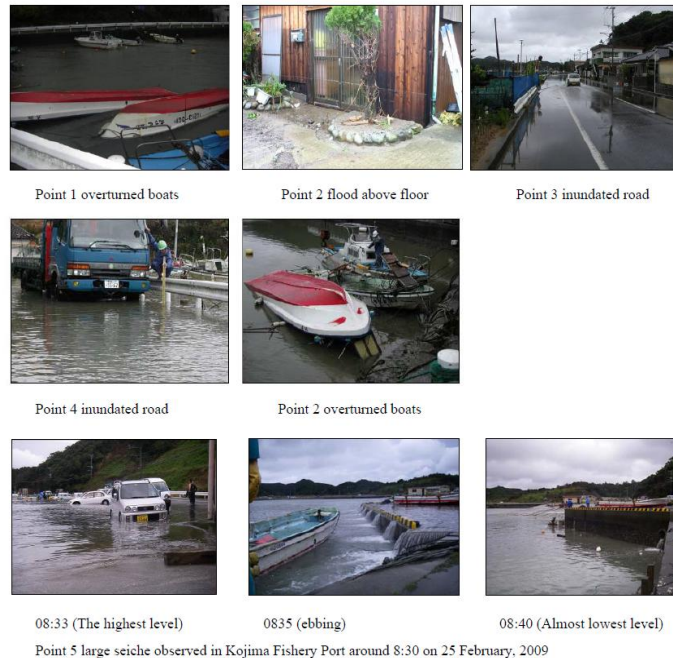


A photo of abiki webbing at the Uragami river, taken on 16 March 1998



Number of occurrences of abiki (>100 cm) in Nagasaki Port and Makurazaki Port.

(Statistical period: 1997-2019)

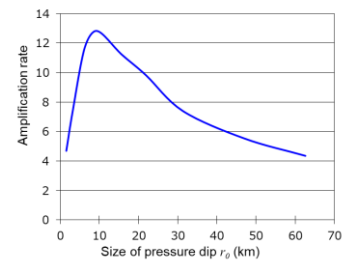
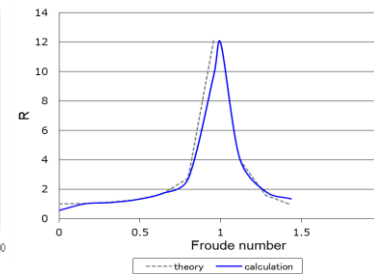
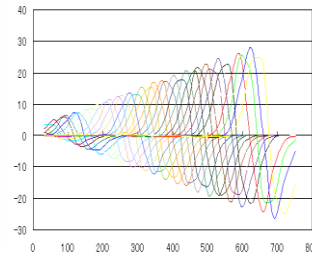
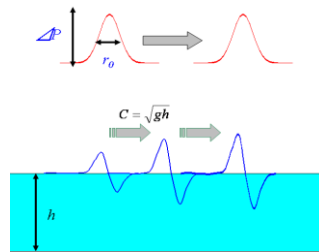


# mechanism of abiki

## Proudman resonance (Proudman, 1929; Monserrat et al., 2006)

- When a moving speed of the pressure disturbance is comparable to the phase speed of a shallow water gravity wave, the wave becomes large by resonance with the amplifying factor R

$$R = \frac{1}{1 - \left(\frac{V}{c}\right)^2} = \frac{1}{1 - \frac{V^2}{gh}}$$



### Calculation of Proudman resonance.

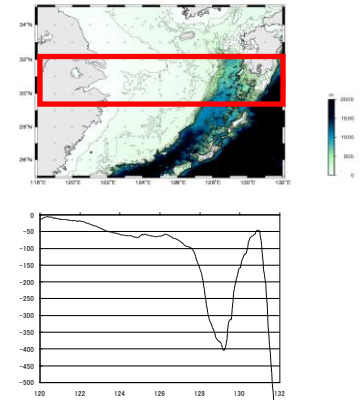
$$\Delta P = 5hPa, \quad V = 30m/s, \quad h = 100m \quad (c = 31.3m/s), \quad 36 \text{ hours}$$

- Once a wave is generated, it propagates as free waves same as usual tsunamis.
- The waves may further amplify in coasts by Green's law etc.

### Key points

- ✓ Wave can continuously amplify with small pressure depression
- ✓ Small and sharp pressure dips are preferable for wave amplification

(Operational NWP models can not such small disturbances...)



### Bathymetry in the East China Sea

JMA developed operational estimating method and issuing alert on possibility of such the secondary tidal undulation, although it is still vague contents.



***Thank You for attention!***



**The JMA Mascot “*Harerun*”**  
(The word “hare” means fine weather in Japanese. )

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