On the origin of short internal waves trailing strong internal solitary waves observed on spaceborne SAR images acquired over the northern South China Sea

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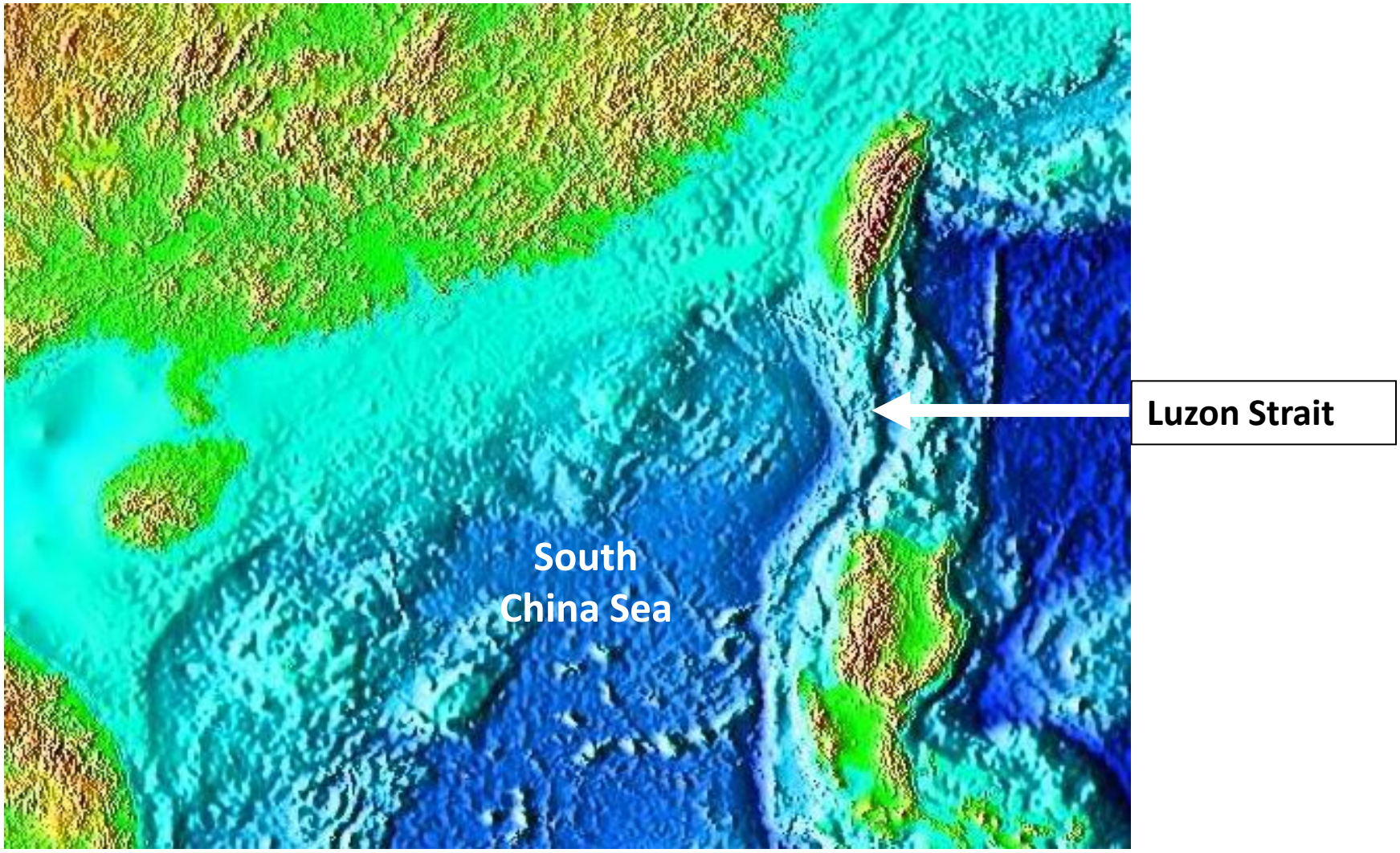
The South China Sea is one of the ocean regions with the strongest internal waves.

The internal wave field is very complex and exhibits strong spatial and temporal variability, which is a consequence of many factors:

- the intricate bathymetry of the generation area (the Luzon Strait) and the basin of the northern South China Sea,
- the irregularity of the barotropic currents in the Luzon Strait,
- the variability of the Kuroshio current, which sometimes causes meso-scale eddy shedding.



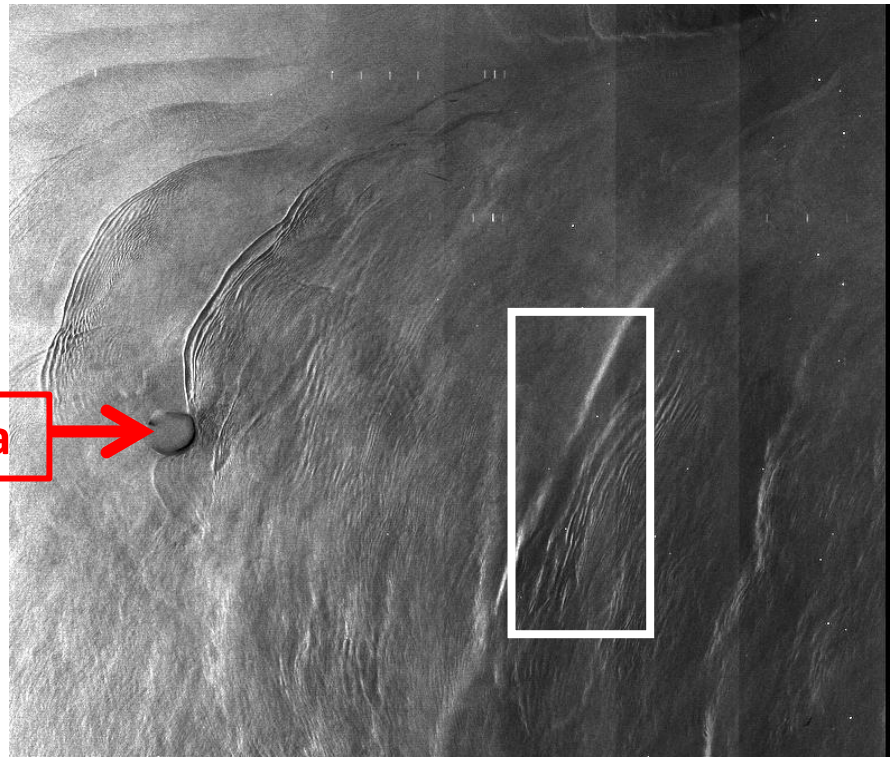
Bottom topography of the South China Sea

- Acoustic data often show second mode internal waves in the South China Sea.

- This seems to be linked to the double-ridged structure of the generation area in the the Luzon Strait.

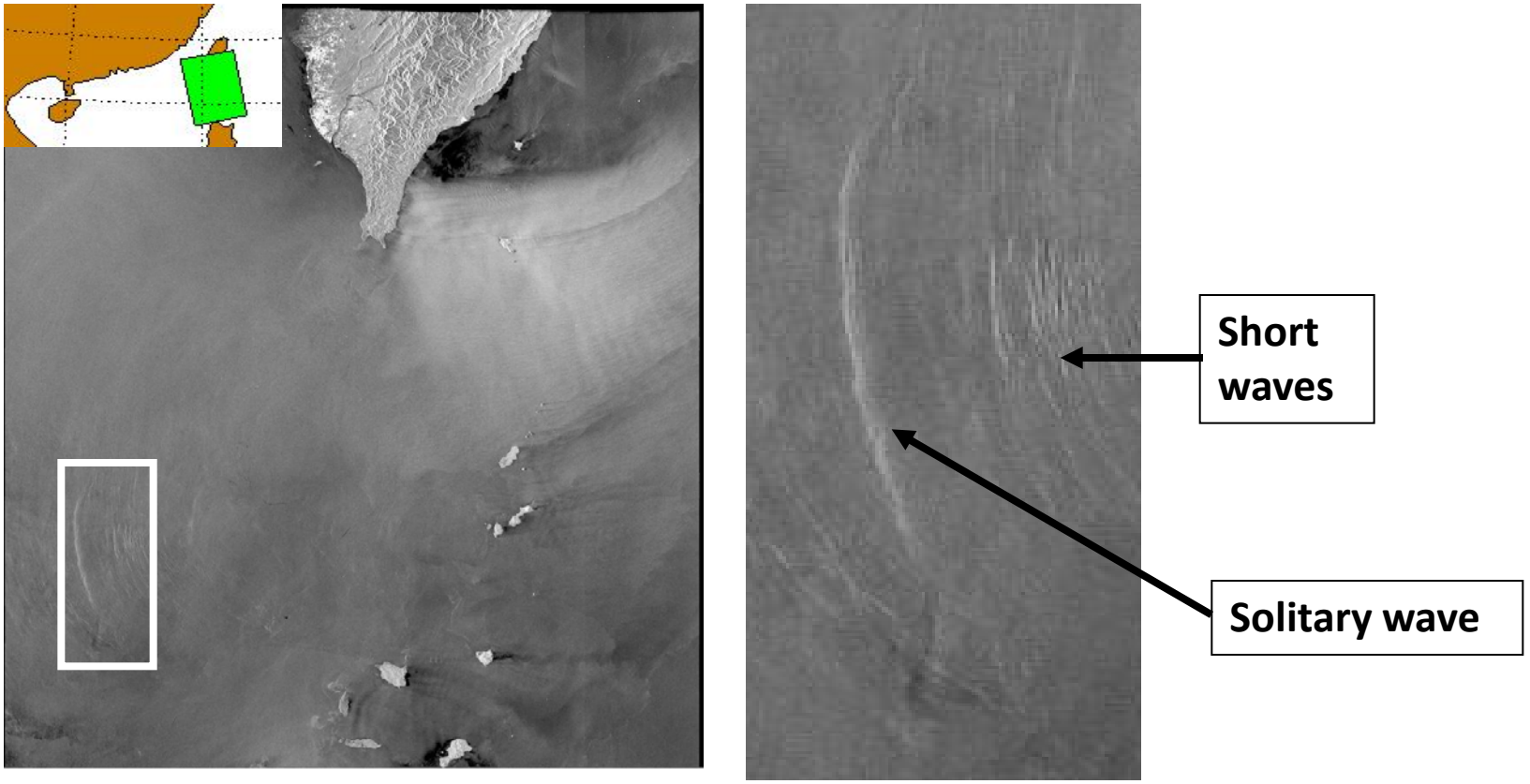
- **Often short internal waves following a strong internal solitary wave are observed on SAR images.**

Internal solitary wave followed by a packet of short internal waves



Left: Envisat ASAR WS image acquired at 1407 UTC on 21 June 2005 over the South China Sea in the far-field area. Right: Enlargement of the area marked by a square on the left image. Visible is the radar signature of a strong ISW followed by a detached short wave packet.

Internal solitary wave followed by a packet of short internal waves



Left: Envisat ASAR WS image acquired at 1358 UTC on 16 May 2007 over the South China Sea in the near-field area. Right: Enlargement of the area marked by a square on the left image. Visible is the radar signature of a strong ISW followed by adetached short wave packet.

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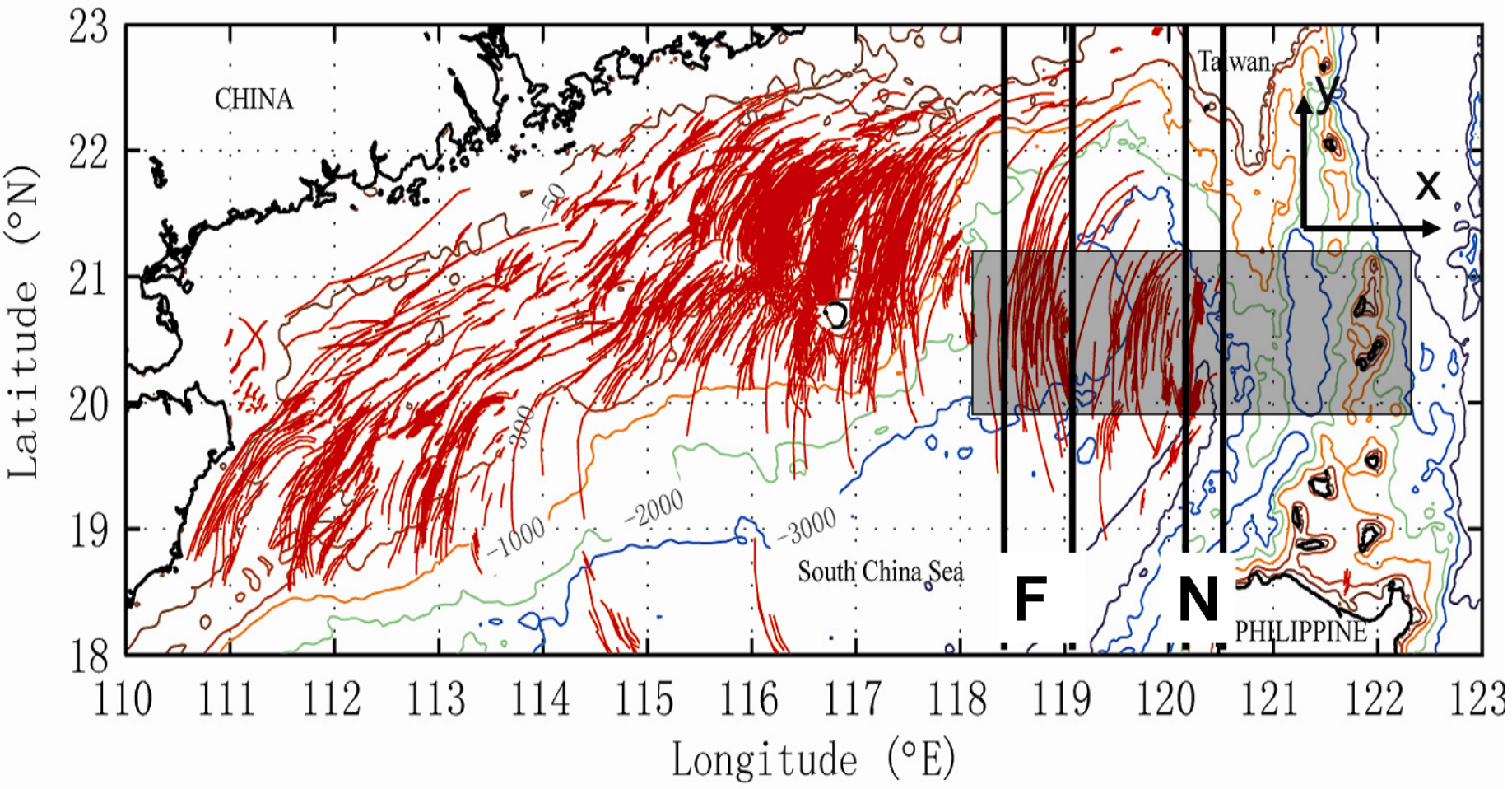
Distribution of radar signatures of internal waves in the South China Sea



Bathymetric map of the northern South China Sea with overlayed radar signatures of internal solitary waves compiled from a set of 344 ERS SAR and Envisat ASAR images acquired between 1995 and 2007 (courtesy of Weigen Huang). The bands N and F denote the near-field and far-field regions, respectively.

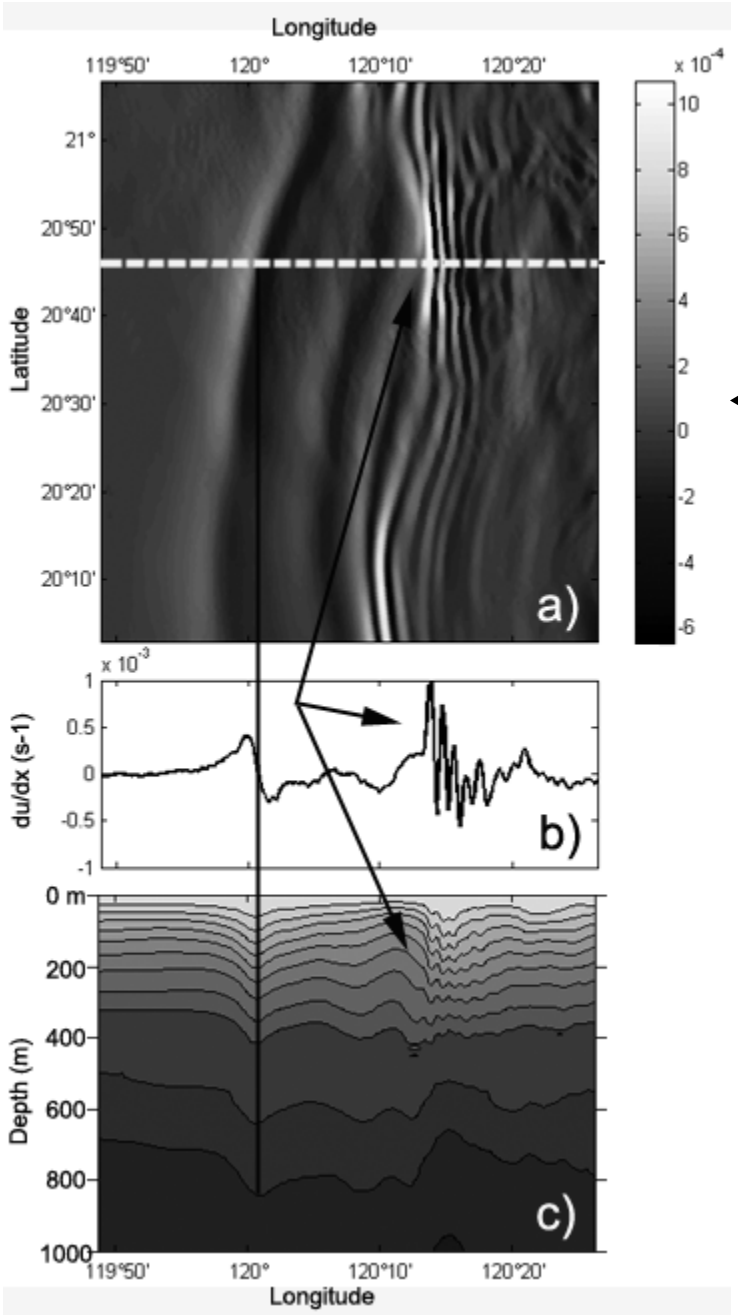
- **The generation of short internal waves in the South China Sea can be explained by numerical simulations carried out with the MIT general circulation model (MITgcm).**

- **Their generation is linked to the presence of second mode internal waves.**

- **The second mode internal waves are associated with a vertical shear in the vertical background current that causes the generation of short internal waves.**

- **The short internal waves travel with the speed of the second mode internal solitary waves. " They ride on them".**

- **The short internal waves are associated with a strong surface current gradient which render them visible on SAR images.**

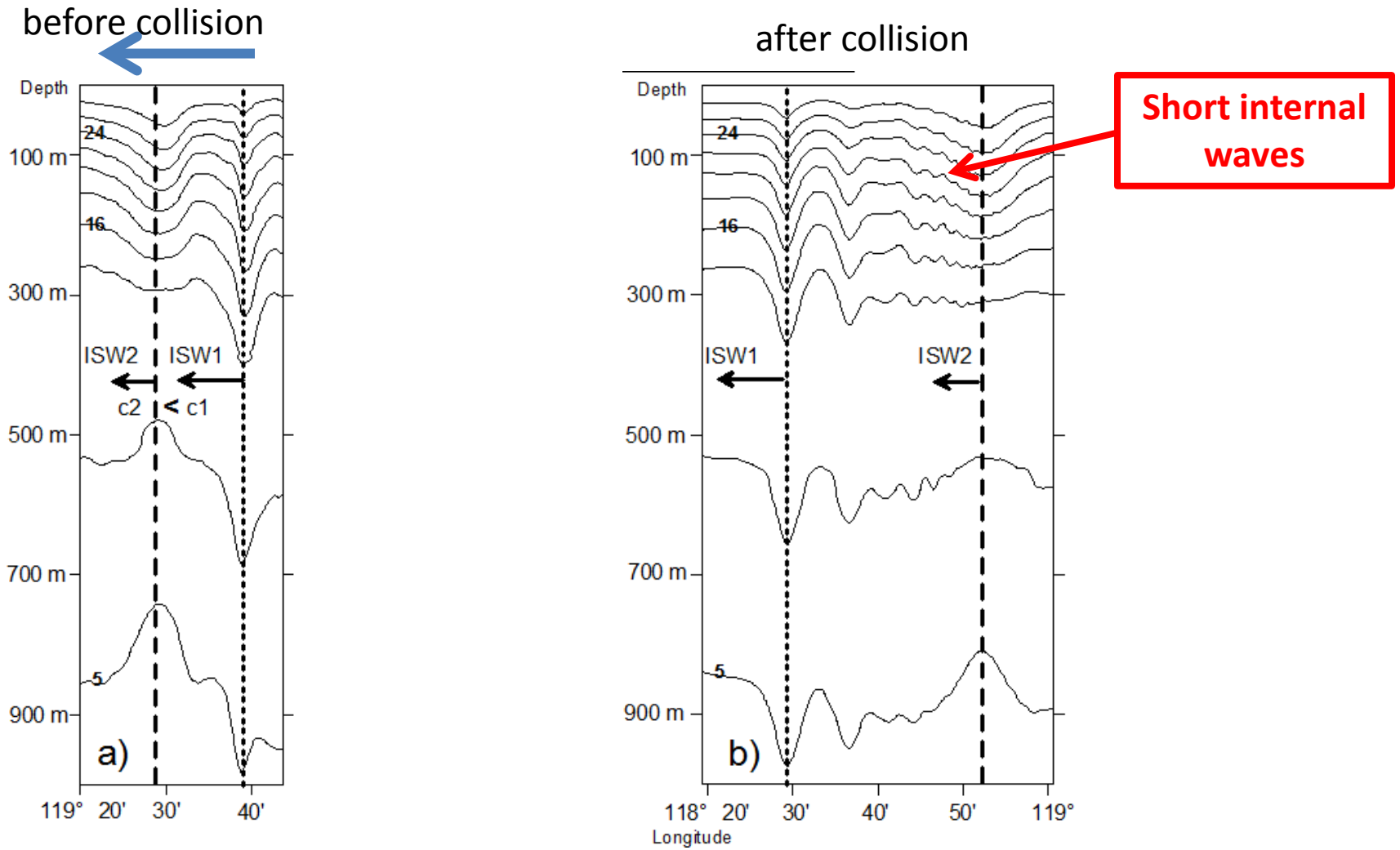


Simulations of short internal waves in the near-field

du/dx - field

Simulated internal wave field after 2.875 M2 tidal periods Panel a: Two-dimensional map of the simulated surface cur rent gradient du/dx(s−1) in x-direction (the horizontal direction) in the area 119◦50’ − 120◦25’E and 20◦ − 21◦5’N Panel b: Variation of du/dx along the transect 20◦47’N marked by a bright dashed line in panel a. Panel c: depth profile of temperature along the same transect. The x-coordinates are the same in all the three panels. The vertical solid line marks the location of the leading first mode ISW, whereas the three arrows indicate where the short waves are located.

Generation of short internal waves by interaction of a first mode internal wave with a second mode internal wave in the far field



Simulated depth profile of temperature as a function of longitude for the upper 1000 m showing the generation of short internal waves in the far-field at two different times. Panel a: t=4.125 M_2 tidal periods, before the collision and panel b: t= 5 M_2 tidal periods, after the collision. The dashed and dotted lines mark the center of the second and the first mode ISW, respectively.

Conclusions

- **Short internal waves following a strong first mode internal solitary wave are observed in the northern South China Sea in two distinct areas: one close to the Luzon Strait and the other further away.**

- **Their generation is linked to the presence of second mode internal waves.**

- **The generation of second mode internal waves seems to be linked to the two-ridged structure of the generation area.**

- **The short internal waves ride on the second mode internal solitary waves**

- **They become visible on SAR images because they are (surprisingly) associated with large gradients in the surface current.**

Thank you for your attention!