Short internal waves trailing strong internal solitary waves in the South China Sea

Chuncheng Guo[a,b]; Vasiliy Vlasenko[a]; Werner Alpers[c]; Nataliya Stashchuk[a]; Xueen Chen[b]

[a]School of Marine Science and Engineering, University of Plymouth, UK
[b]College of Physical and Environmental Oceanography, Ocean University of China, China
[c]Certre for Marine and Atmospheric Sciences, University of Hamburg, Germany

Keywords: short internal wave; internal solitary wave (ISW); South China Sea (SCS)

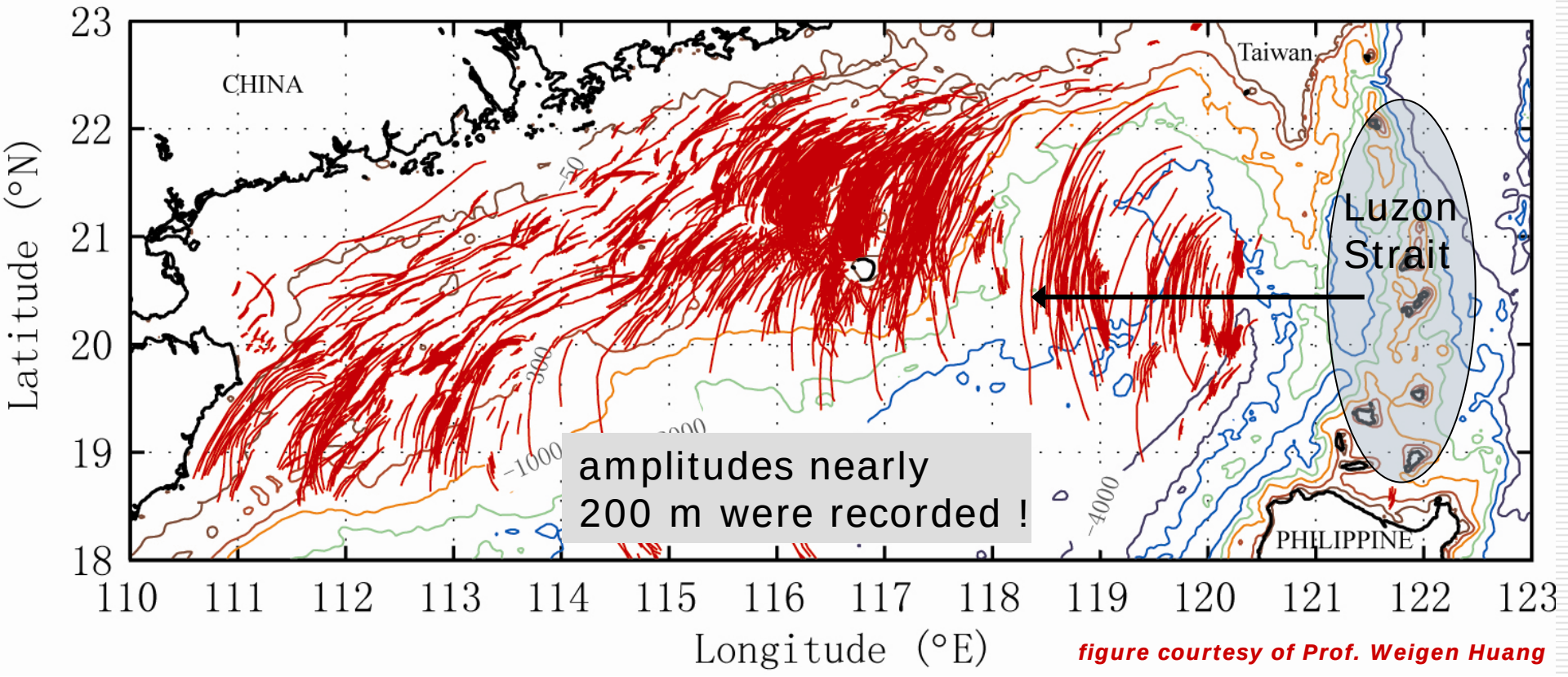


figure courtesy of Prof. Weigen Huang

- Numer
  and IS

3D MITgcm;

High resolution;

Fully nonlinear and nondydrostatic.

Nonlin. Processes Geophys., 17, 529-543, 2010
www.nonlin-processes-geophys.net/17/529/2010/
doi:10.5194/npg-17-529-2010

Multimodal structure of baroclinic tides in the South China Sea

V. Vlasenko[1], N. Stashchuk[1], C. Guo[2], and X. Chen[2]

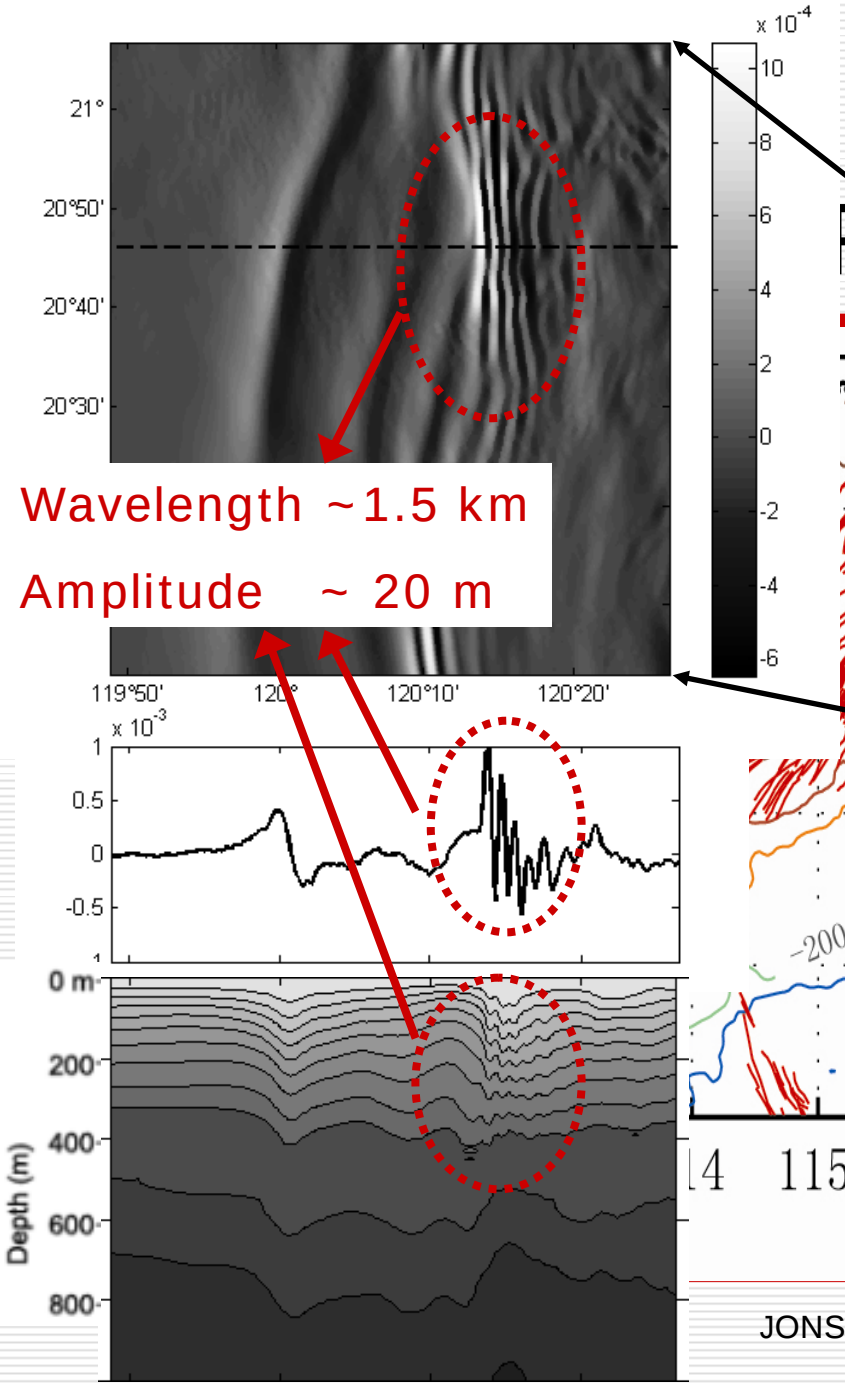
[1]School of Marine Science and Engineering, Plymouth University, Drake Circus, Plymouth PL4 8AA, UK
[2]Ocean University of China, 238 Songling Road, Qingdao, 266100, China

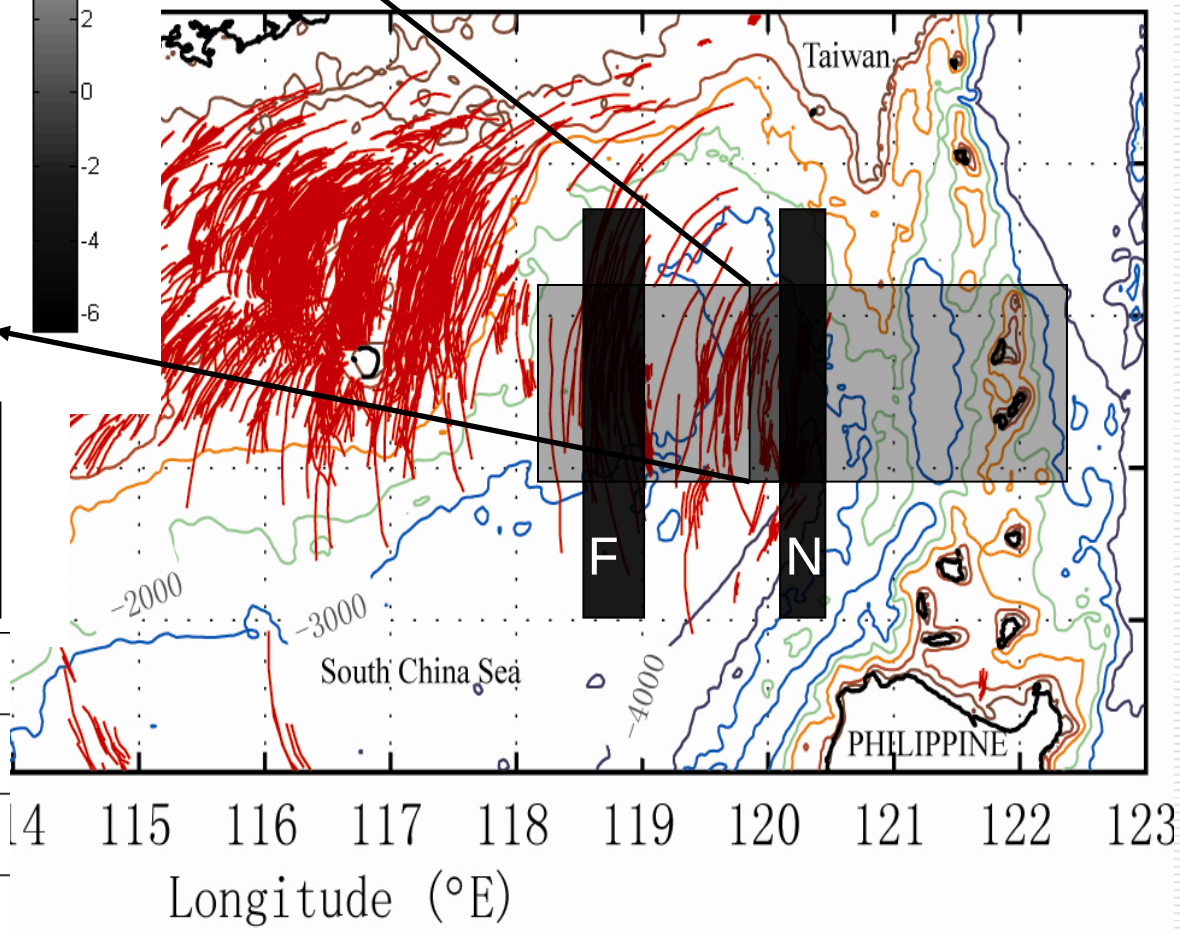
- Evidence of short waves from Envisat Synthetic Aperture Radar (SAR) imagery

End of mission; to be replaced by GMES Sentinel satellites

sea surface zonal velocity gradient du/dx (s^{-1})

Results

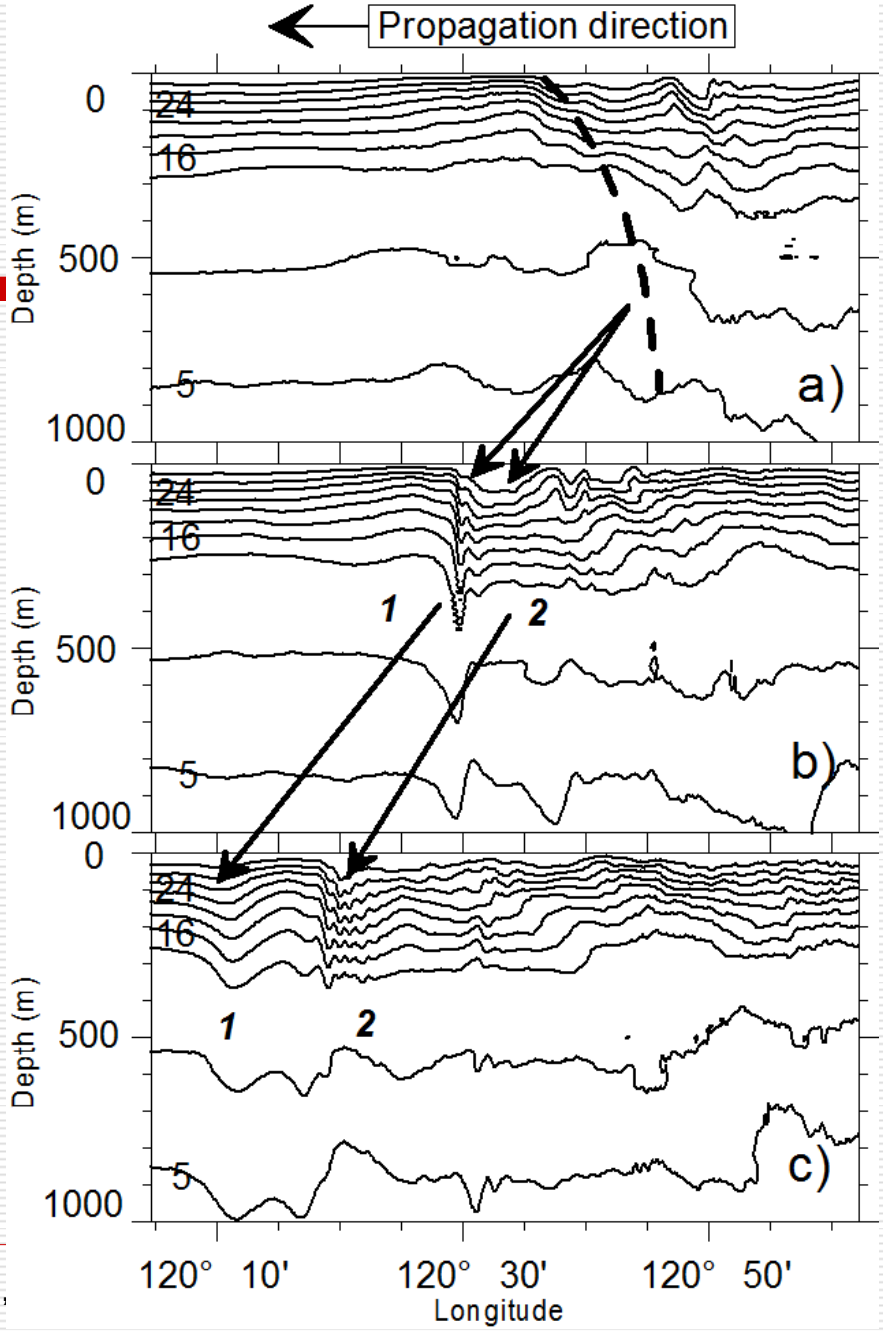




Generation in the near-field (N)

Process:

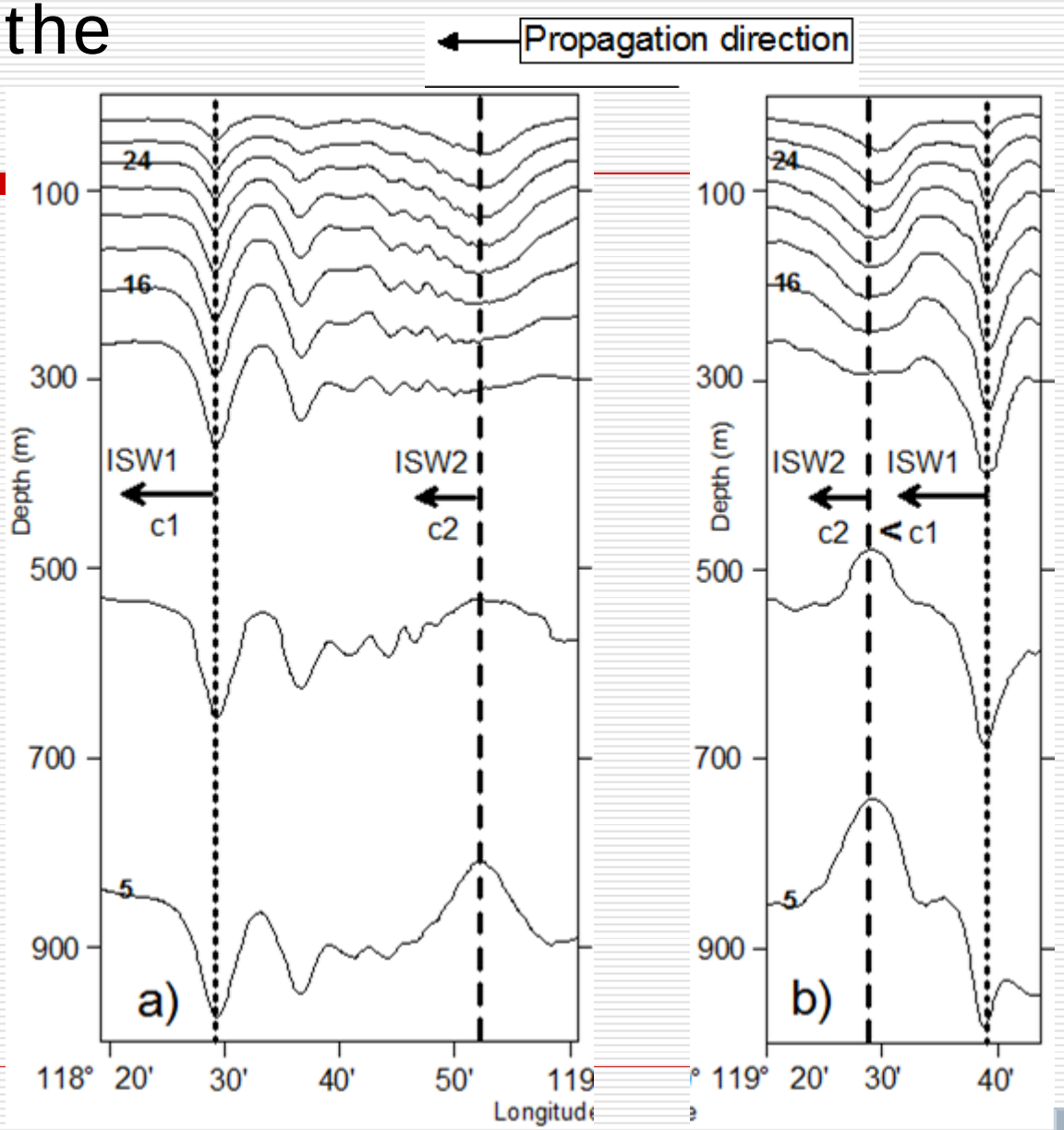
Disintegration of a baroclinic tidal bore that is generated by the strong interaction of barotropic tides with the two steep ridges and the attendant two-ridge interference.



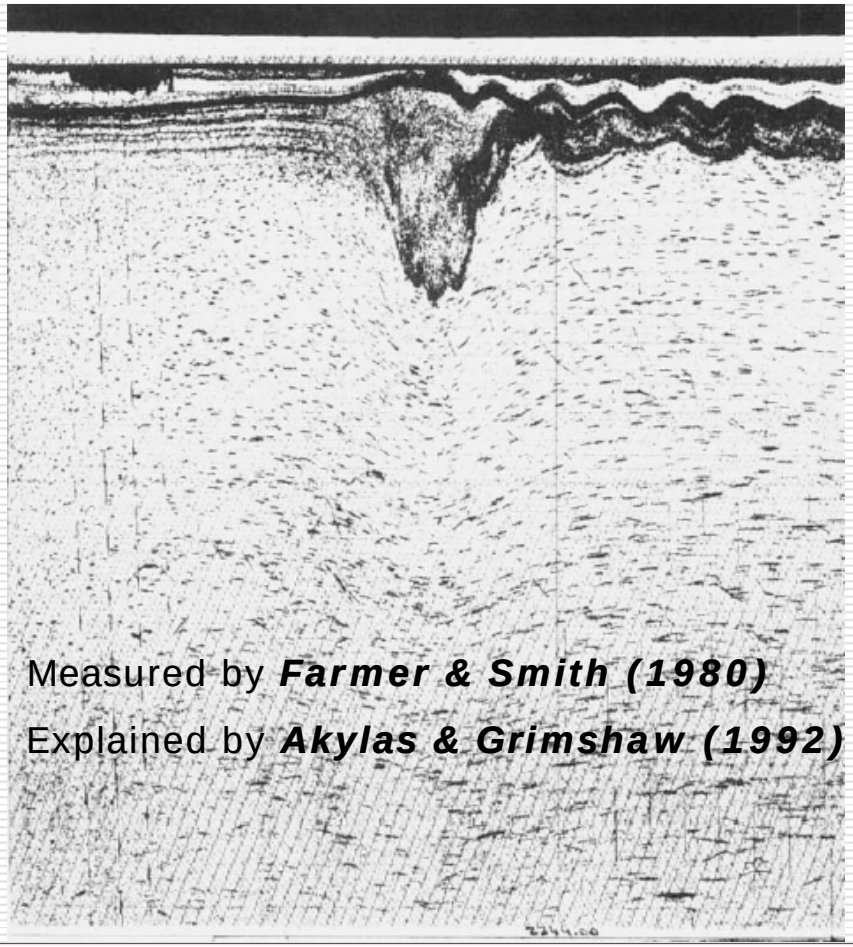
Generation in the far-field (F)

Process:

Overtaking of a faster first mode ISW with a slower second mode ISW that was generated on tidal cycle earlier.



Theoretical explanation



Measured by ***Farmer & Smith (1980)***

Explained by ***Akylas & Grimshaw (1992)***

Theoretical explanation

Taylor-Goldstein Equation:

$$\frac{d^2 g_j}{dz^2} + \left\{ \frac{N^2(z)}{[U(z)-c]^2} - \frac{U''(z)}{(U(z)-c)} - k^2 \right\} g_j = 0,$$

$$g_j(-H) = g_j(0) = 0, \quad j = 1,2,3,\ldots$$

g(z): vertical isopycnal displacement

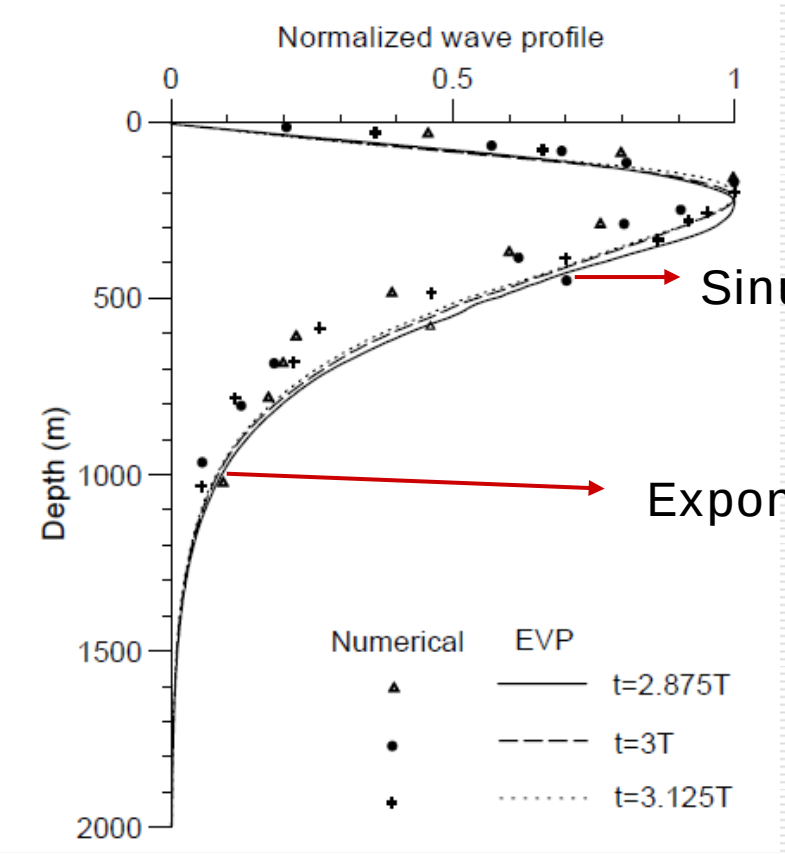
j: mode number

N(z): background stratification

U(z): background current

k: wavenumber

c: phase speed



A half-way summary

- What we have:

~ state-of-the-art simulation ***(MITgcm)***

~ previous theoretical finding ***(Akylas & Grimshaw, 1992)***

~ support from the eigen-value problem ***(Taylor-Goldstein Equation)***

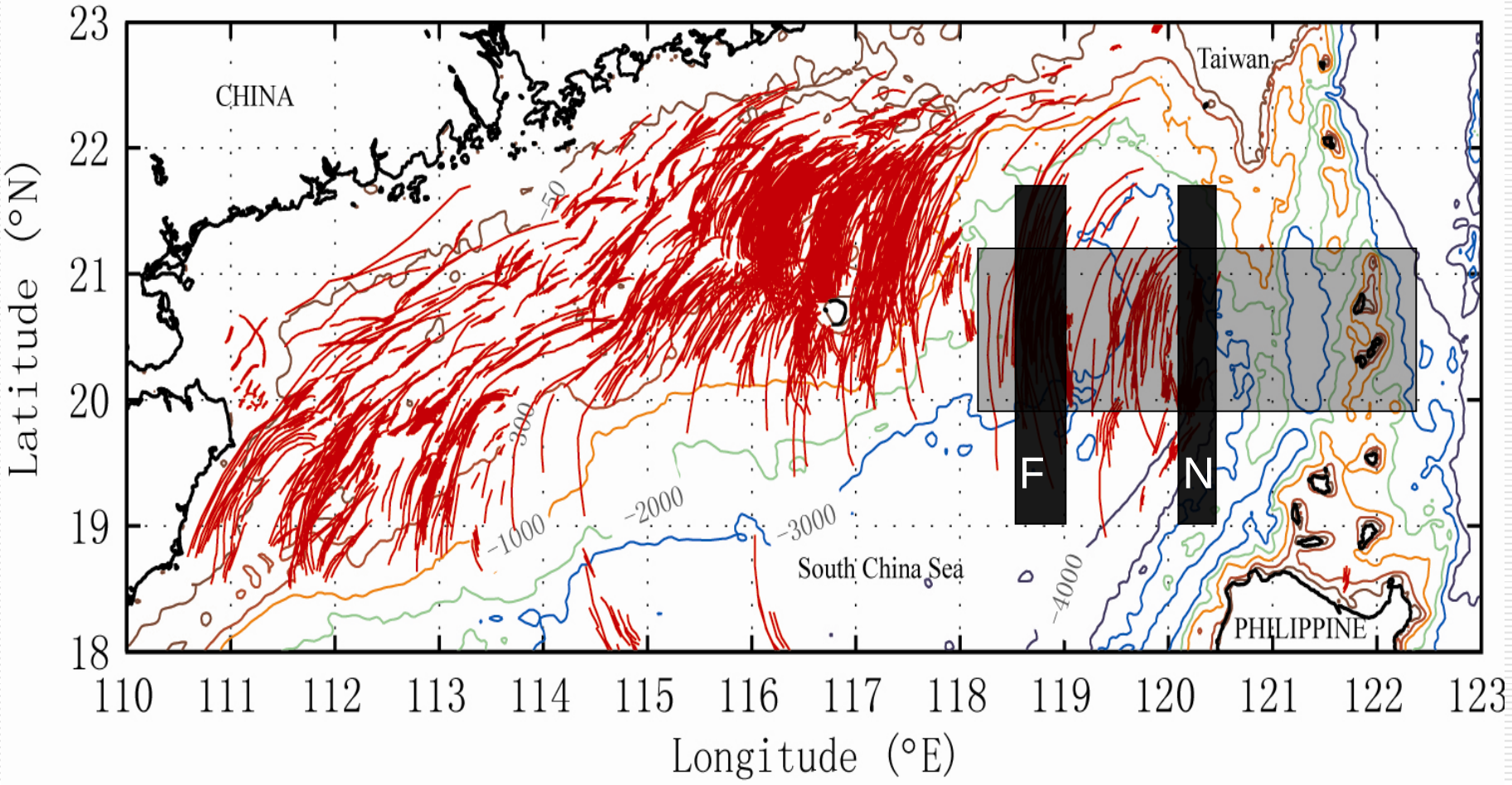
- What we lack:

~ observational evidence, either from in-situ measurements or satellite imagery

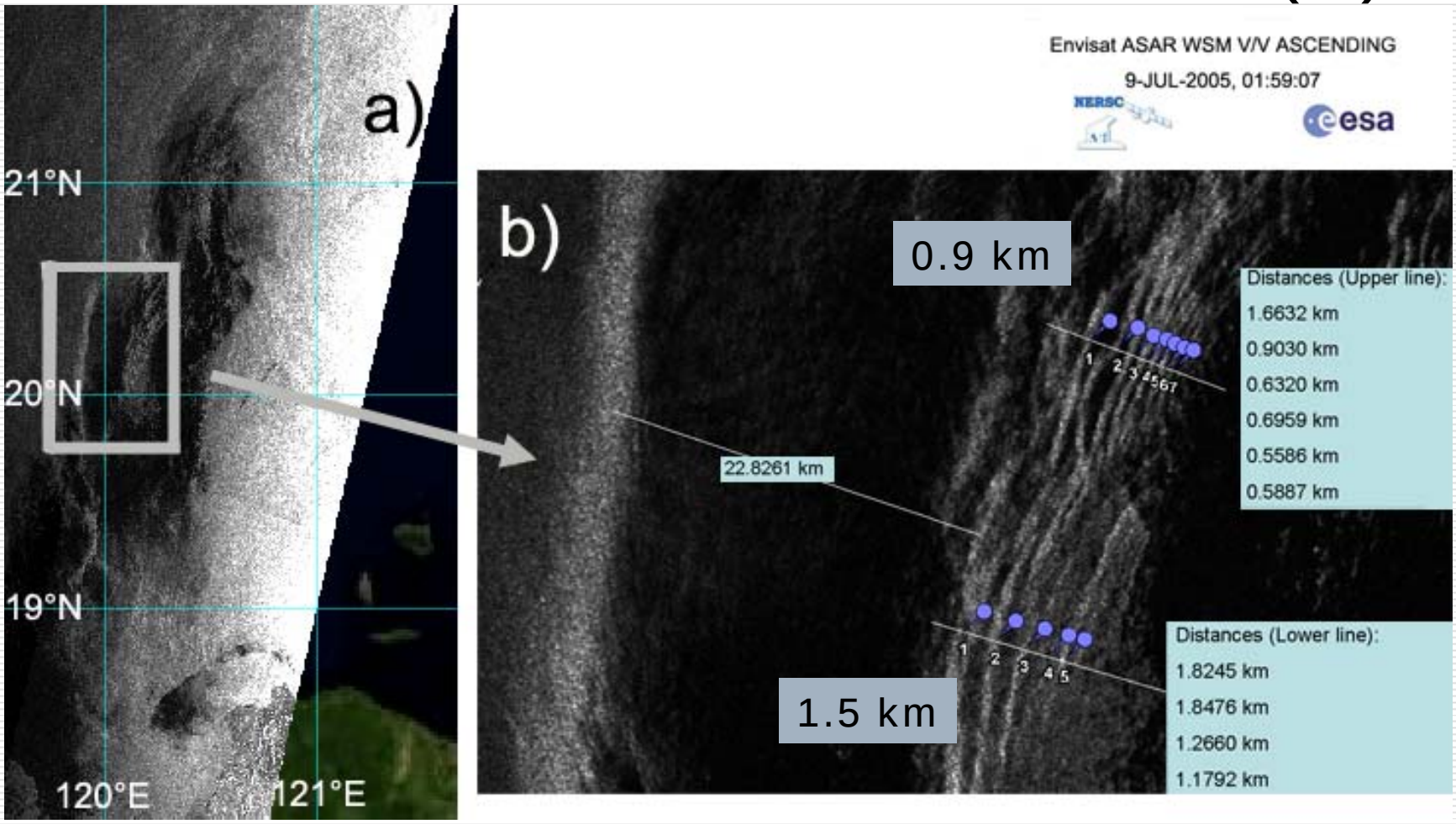
2. Evidence from SAR imagery

- Source: Envisat Advanced SAR archive from European Space agency
- Wide Swath Mode
- Resolution: 150 m
- Swath width: 405 km

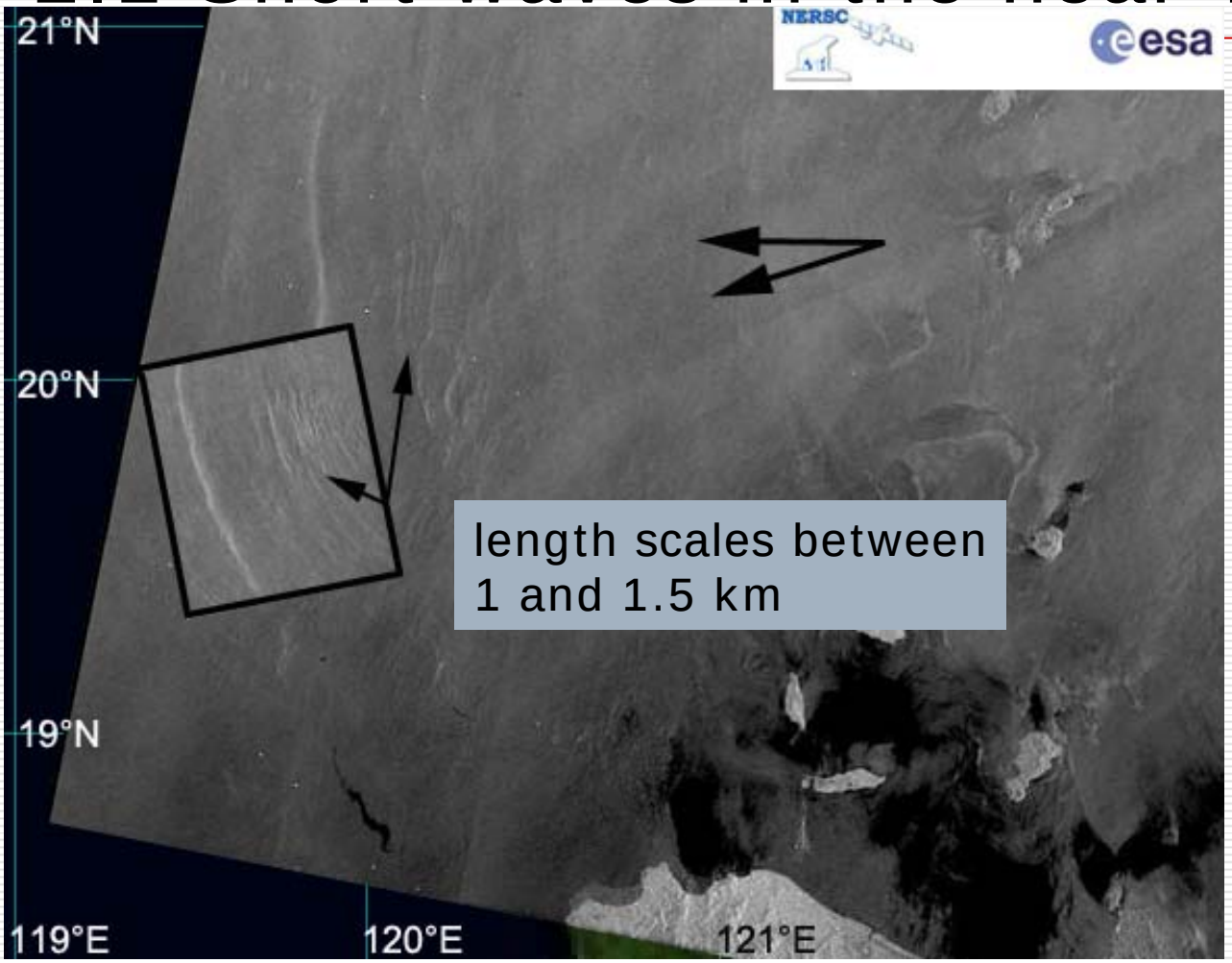
Some tens of ASAR images were found to feature with ‘first mode ISW + short waves’ signature; almost all of them lie in *Areas N and F*.


CHINA
Taiwan
PHILIPPINE
South China Sea
F
N
-50
-300
-1000
-2000
-3000
-4000
Latitude (°N)
Longitude (°E)
23
22
21
20
19
18
110
111
112
113
114
115
116
117
118
119
120
121
122
123

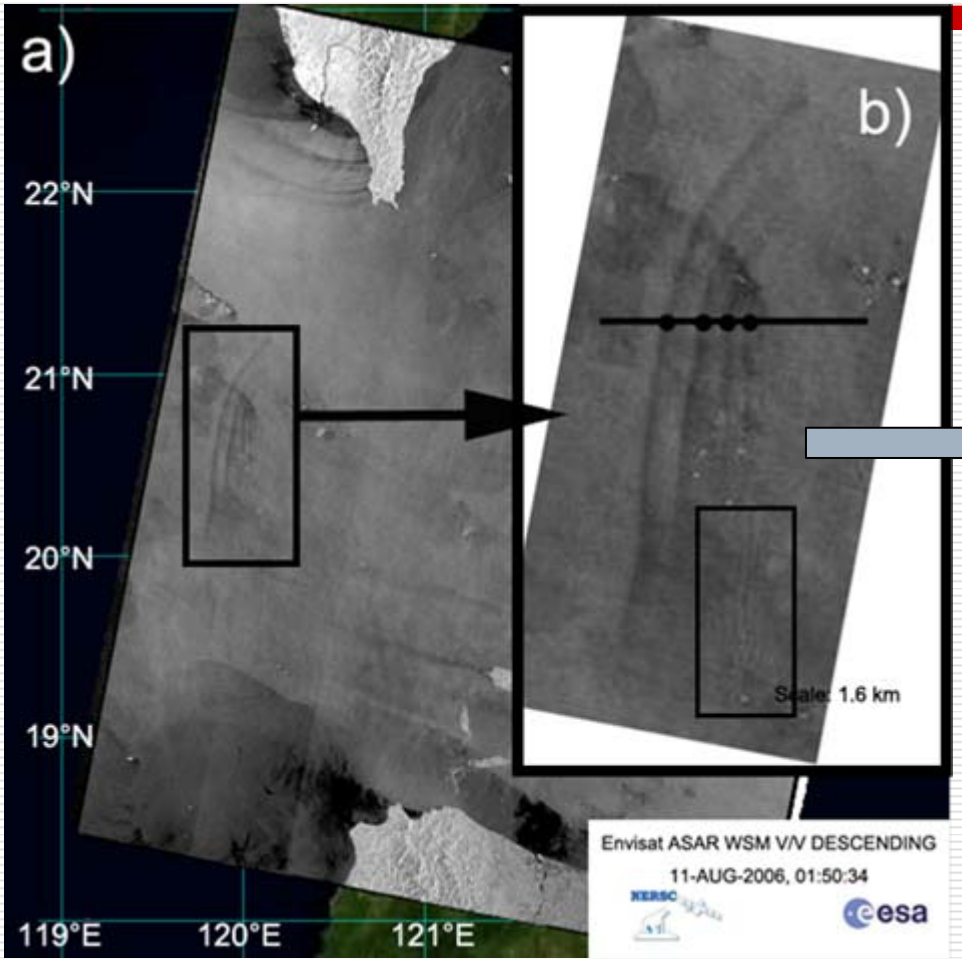
2.1 Short waves in the near-field (N)

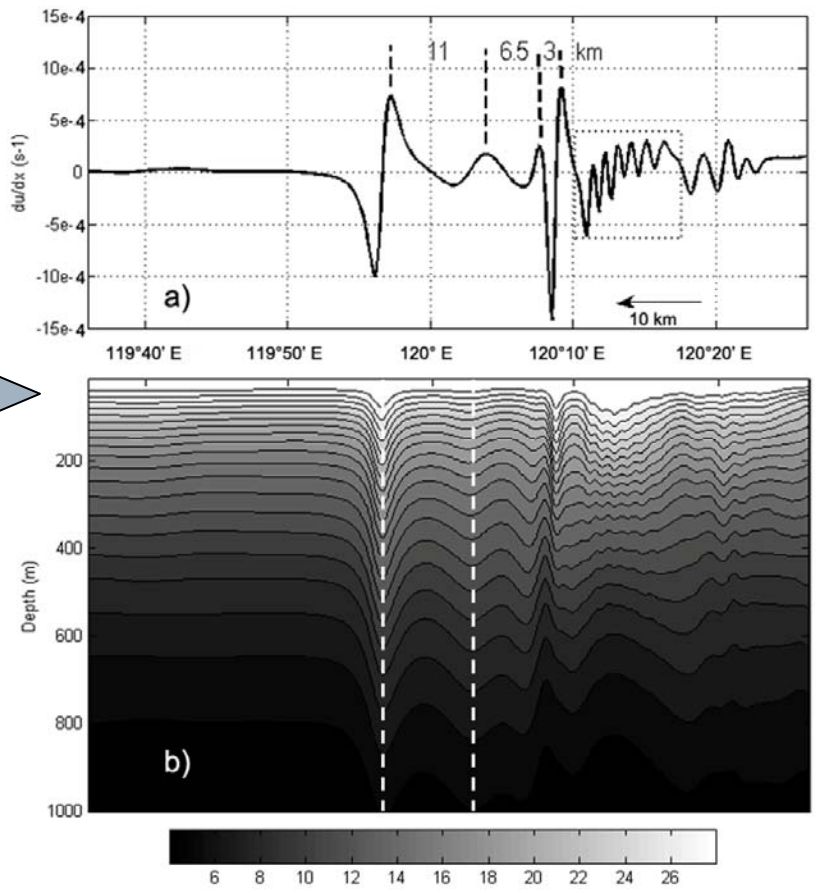


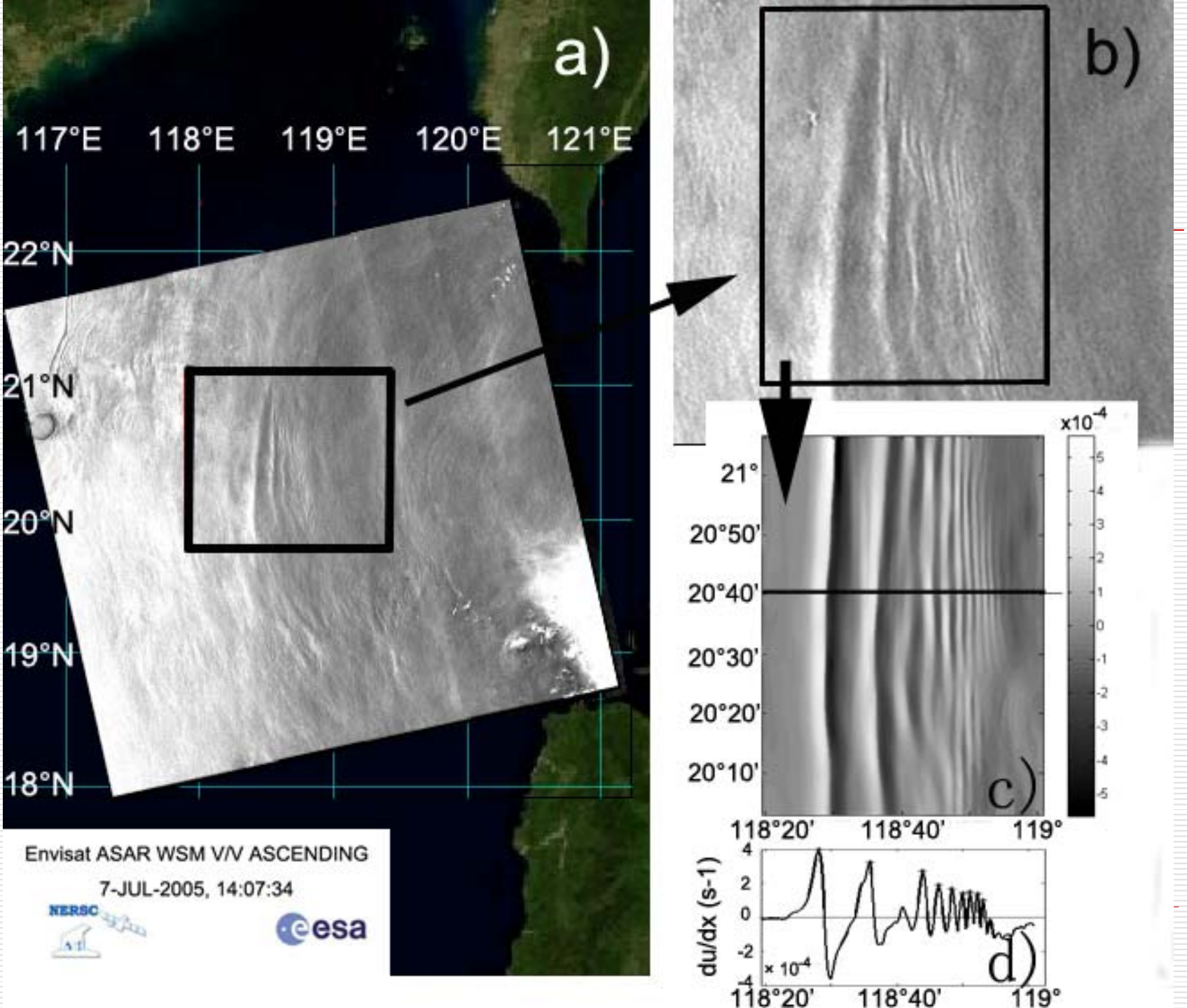
2.1 Short waves in the near-field (N)

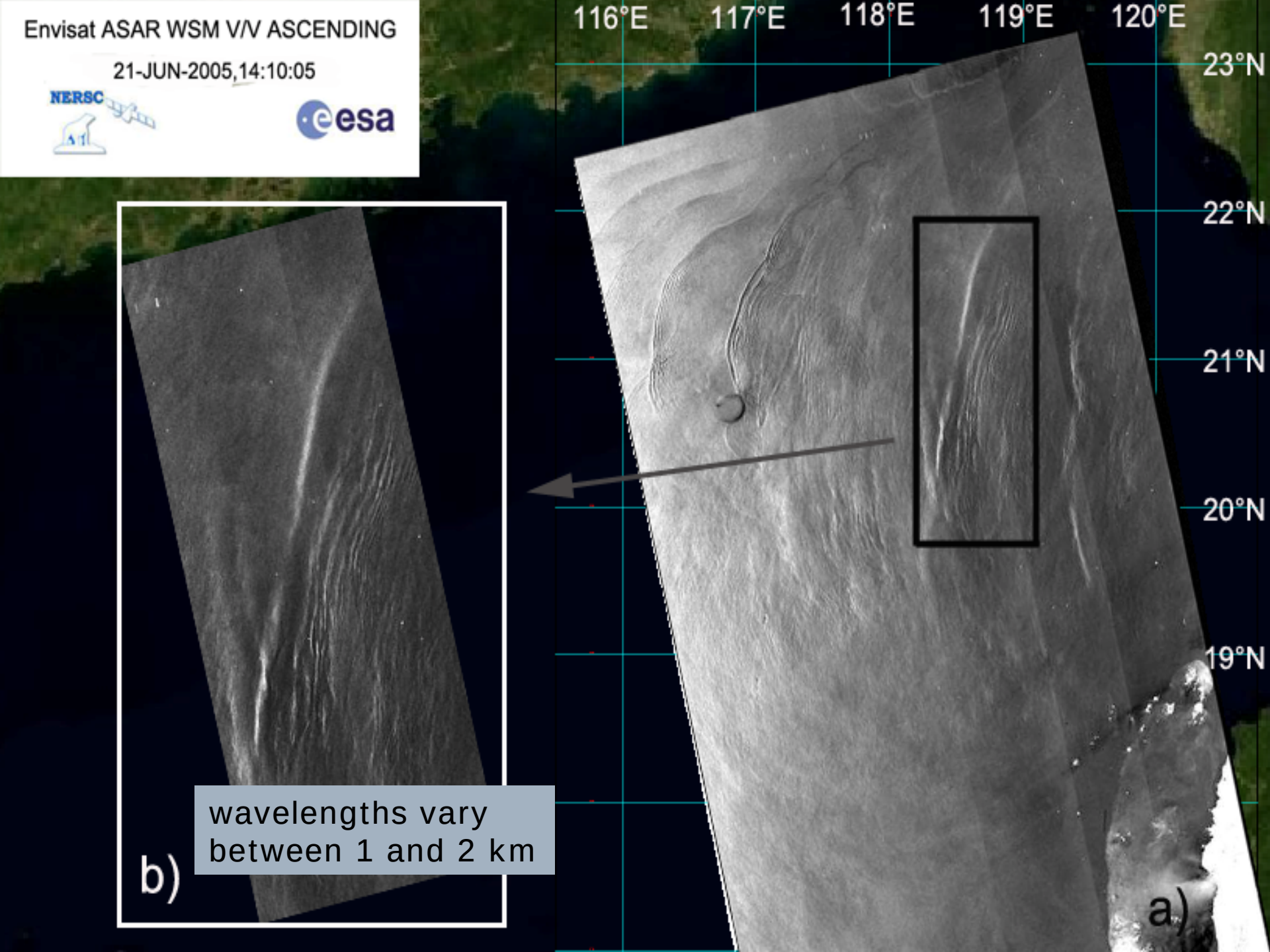


2.1 Short waves in the near-field (N)






a)
117°E
118°E
119°E
120°E
121°E
22°N
21°N
20°N
19°N
18°N
Envisat ASAR WSM V/V ASCENDING
7-JUL-2005, 14:07:34
NERSC
esa
b)
21°
20°50'
20°40'
20°30'
20°20'
20°10'
x10^-4
c)
118°20'
118°40'
119°
du/dx (s-1)
× 10^-4
d)


Envisat ASAR WSM V/V ASCENDING
21-JUN-2005,14:10:05
NERSC
esa
116°E
117°E
118°E
119°E
120°E
23°N
22°N
21°N
20°N
19°N
b)
wavelengths vary
between 1 and 2 km
a)

By now, the general agreements ***(wavelengths, the distance from the frontal first mode ISW, areas they emerge, etc.)*** between SAR imagery and model results corroborate the existence of such short waves.

Conclusions:

- A structure of ‘first mode ISW followed by a second mode ISW, on which short internal waves ride’ was simulated in the SCS;
- The short waves have amplitudes ~20 m and wavelengths ~1.5 km, and emerge in two meridional zones with two different mechanisms;
- Robust evidence from ASAR imagery substantiates the existence of such short waves.
- Is this structure expected to be seen in the other regions of the world, especially by at-sea measurements (although a challenge for the instruments)?

Manuscript to be accepted by Remote Sensing of Environment

Thank you all for your attention !