International Conference of Scour and Erosion

Long-term prediction of sediment budgets with dynamic cross-shore migration of sand spits

○Yoshihiro Hamada
Yoshimitsu Tajima
Bandula Wickramaarachchi
Shinichi Sobue
Tomoyuki Nukui

Coastal Engineering Lab., The University of Tokyo
Coastal Conservation Department, Sri Lanka
JAXA

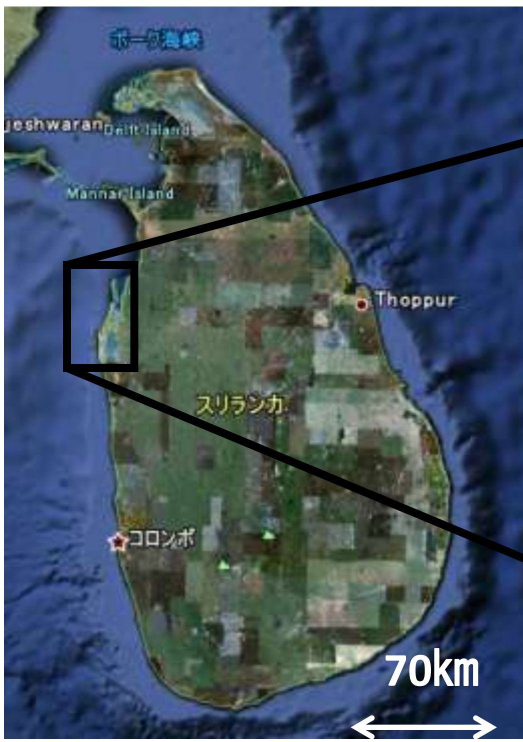
ICSE-6 in Paris on August 29th

Background and Target area

Long-term predictions of sediment budgets and resulting coastal morphology changes are essential for the near-shore development.

・Serious Erosion on the south west coast of Sri Lanka

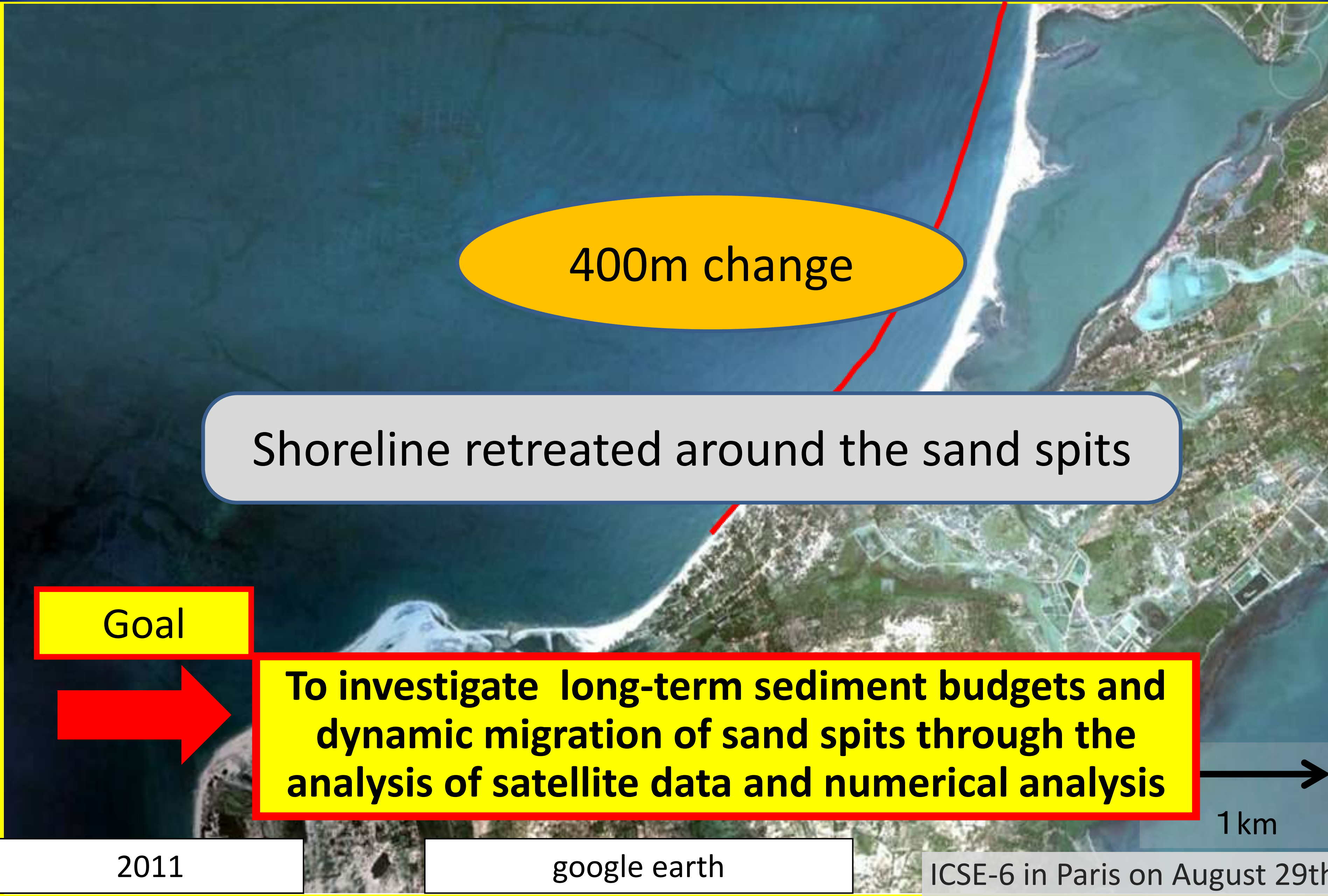
Influence on Kalpitiya, north west coast of Sri Lanka?



Sri Lanka

Kalpitiya

Coastal Erosion in Sri Lanka



Goal

To investigate long-term sediment budgets and dynamic migration of sand spits through the analysis of satellite data and numerical analysis

Outline

Analysis of Satellite images

→ To capture the overall shoreline changes

Following Funatake et al. (2012)

Wave Estimation(WAM)

→ Wave conditions near Kalpitiya were estimated from wind data

Following WAMDI GROUP (1988)

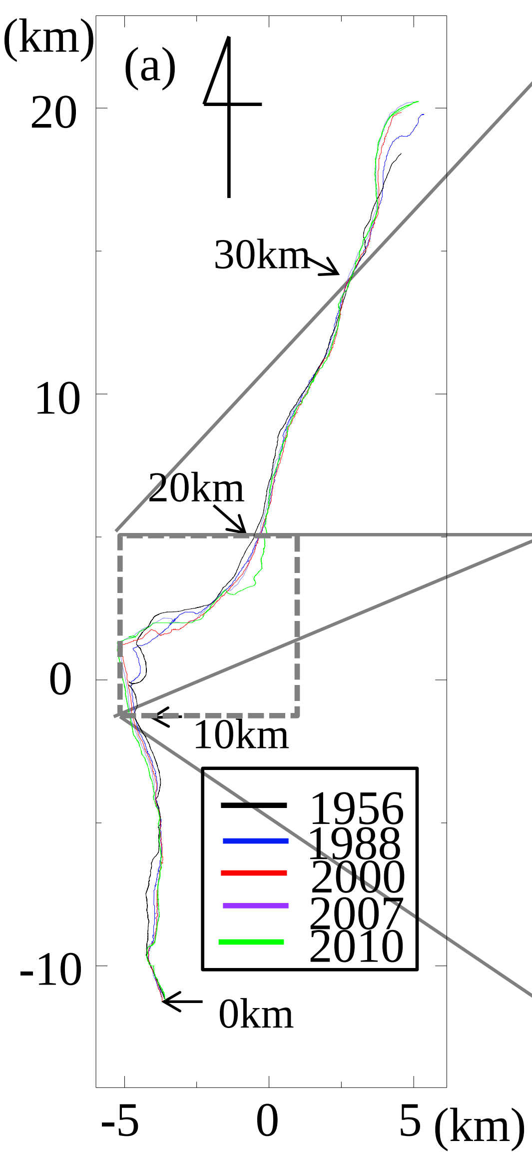
Numerical shoreline model

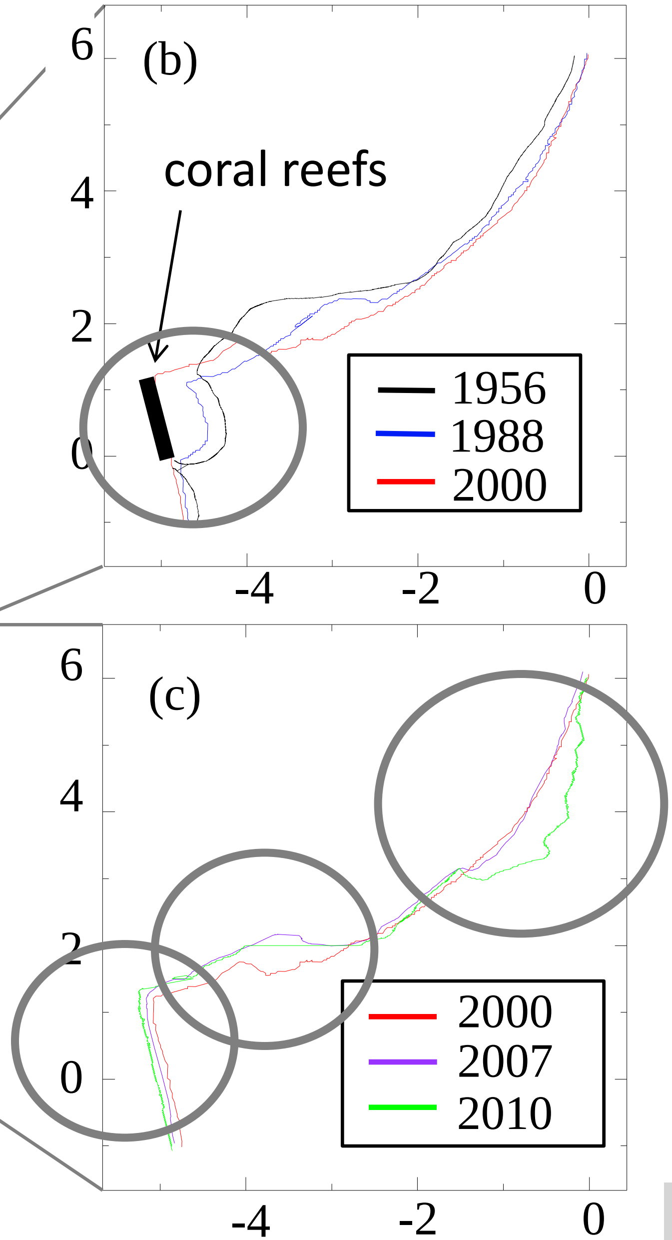
→ **Predictions of the observed shoreline changes**

Influence of sand spits migration

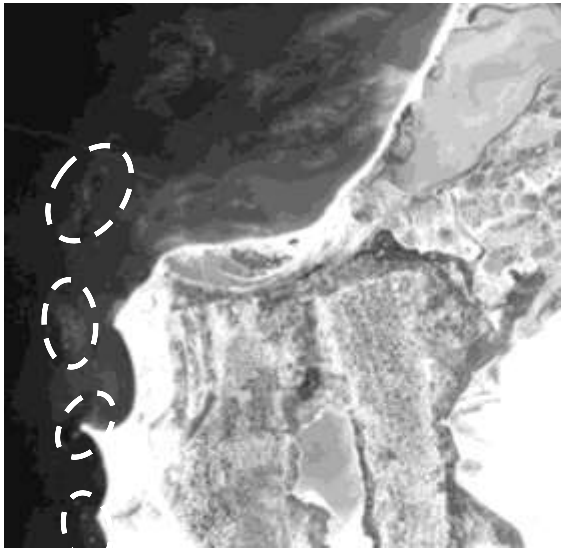
Shoreline changes by coral reefs

a)from1956 to 2010





b)from 1956 to2000

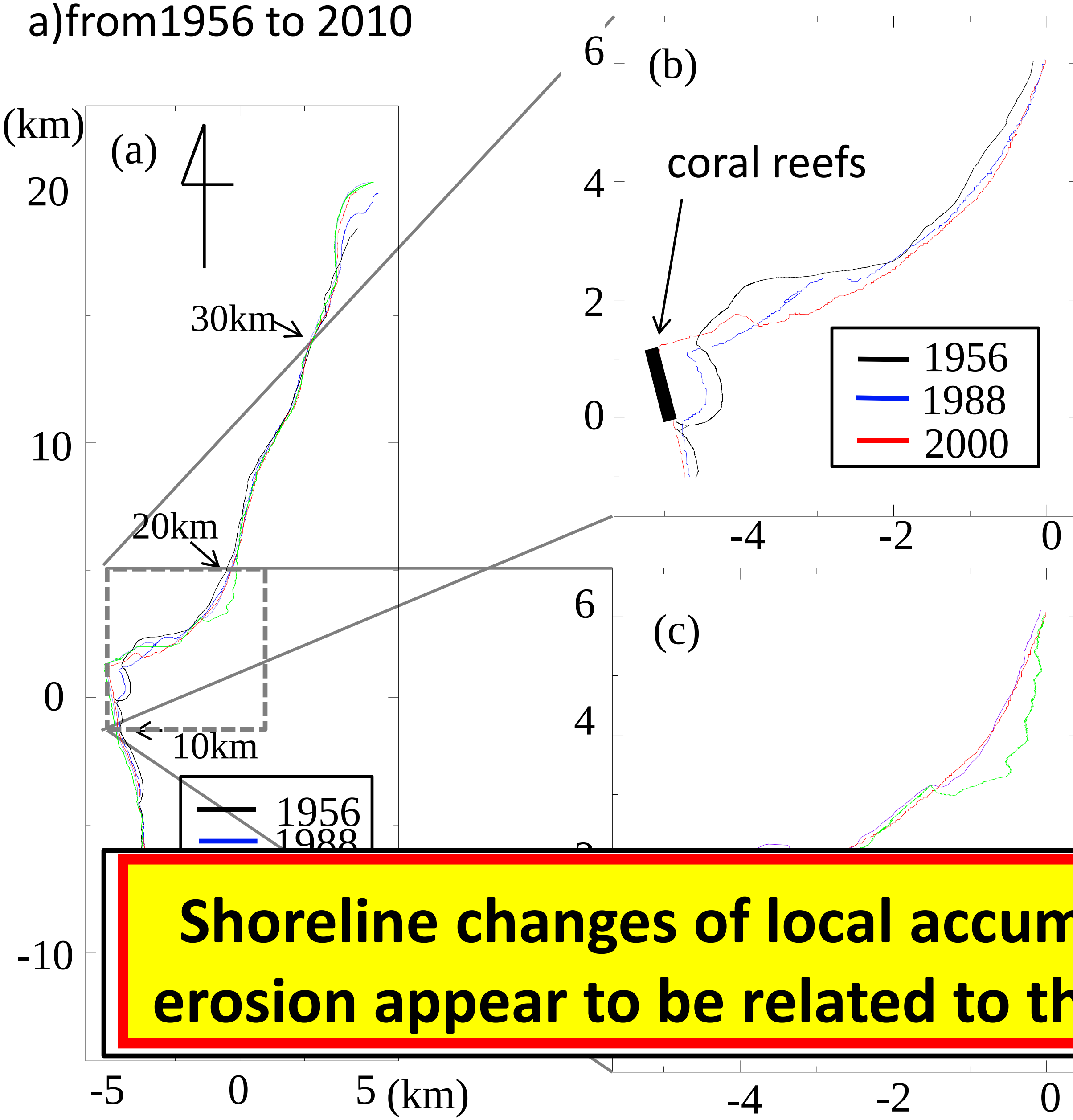


Coral reefs position

c)from 2000 to 2010

Shoreline changes by coral reefs

a)from1956 to 2010



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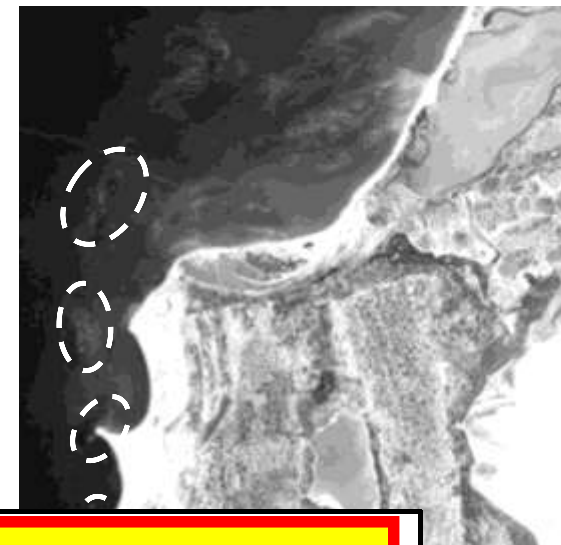
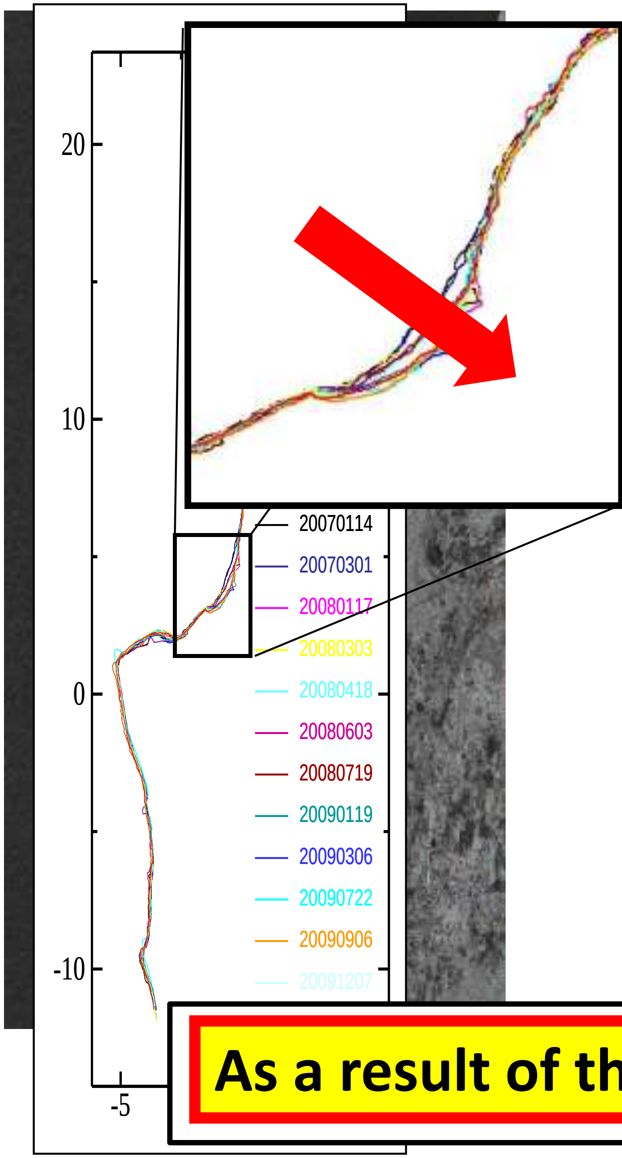
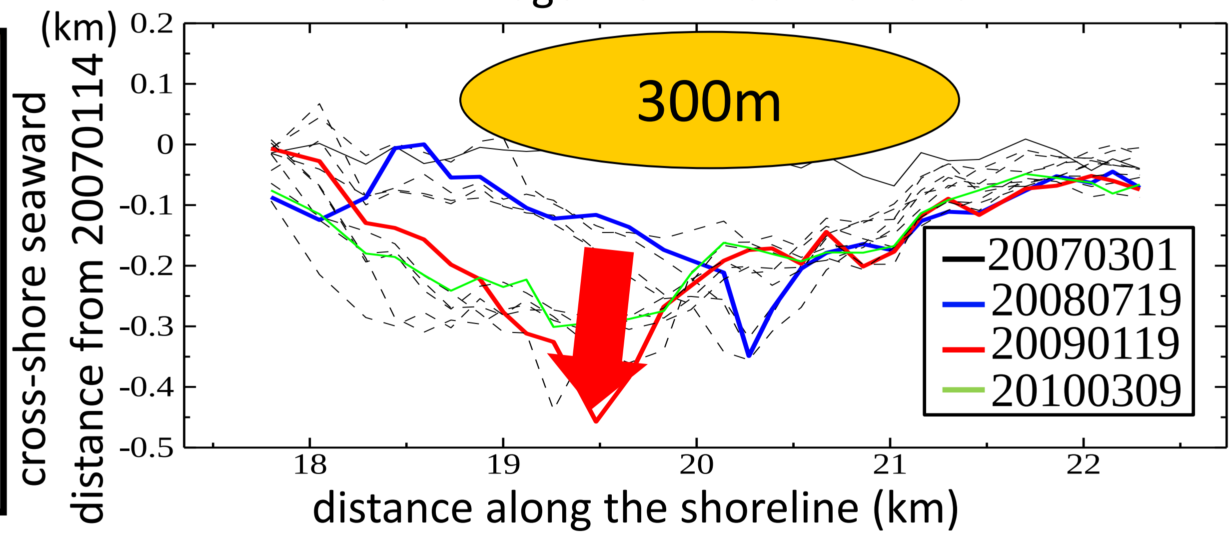


Shoreline changes of local accumulation and erosion appear to be related to the coral reefs.

PALSAR images analysis



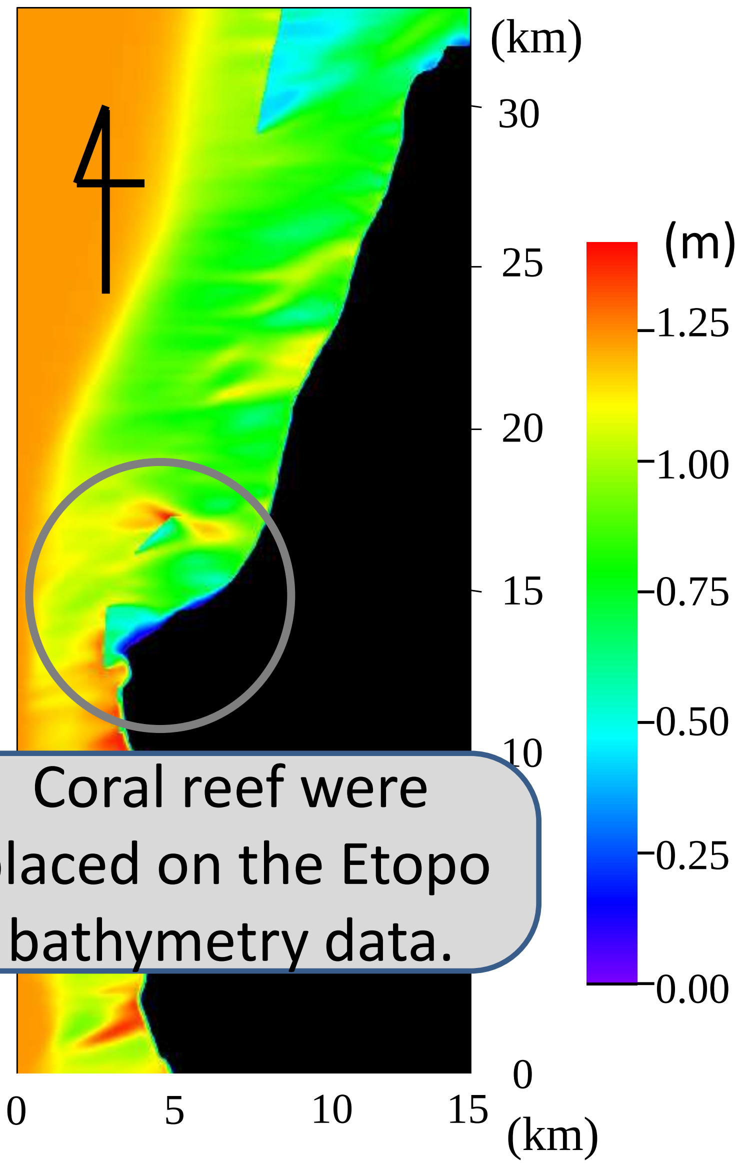


- ✓ cyclone hit the target site during this period
- ✓ overtopping waves were observed by local fisherman
- ✓ large amount of sand was transported behind the spit

As a result of this event, sand spit was largely deteriorated.

Shoreline reproduction by the model

Wave Height distribution



Coral reef were placed on the Etopo bathymetry data.

Calculation of Wave field

Height	1.2(m)
Period	7.7(s)
Direction	43°

- Coral reefs
- Energy balance equation

↓

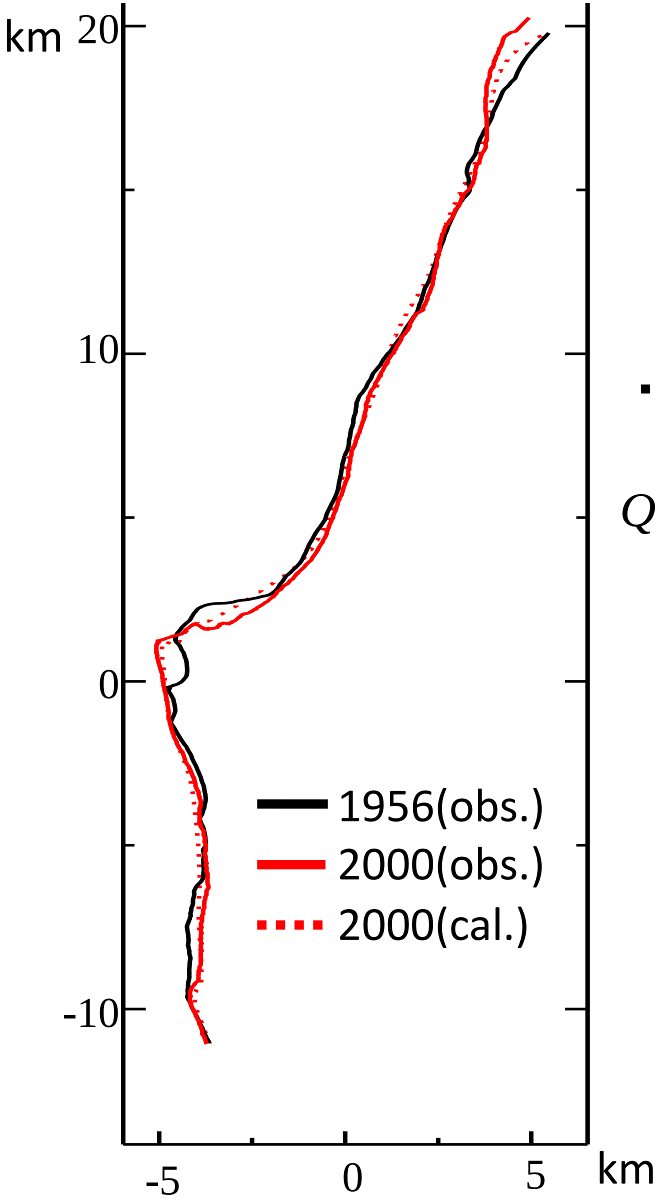
Sediment transport rate

↓

shoreline change was validly reproduced

Shoreline reproduction by the model

shoreline reproduction



Calculation of Wave field

↓

Sediment transport rate

・Ozasa and Brampton's formula

$$Q = \frac{(E \cdot C_g)_b}{(\rho_s - \rho) g (1 - \lambda)} \left(K_1 \sin \alpha_b \cdot \cos \alpha_b - K_2 \cos \alpha_b \cdot \cot \beta \frac{\partial H_b}{\partial y} \right)$$

$$\frac{\partial x_s}{\partial t} + \frac{1}{D_s} \left(\frac{\partial Q}{\partial y} - q \right) = 0$$

↓

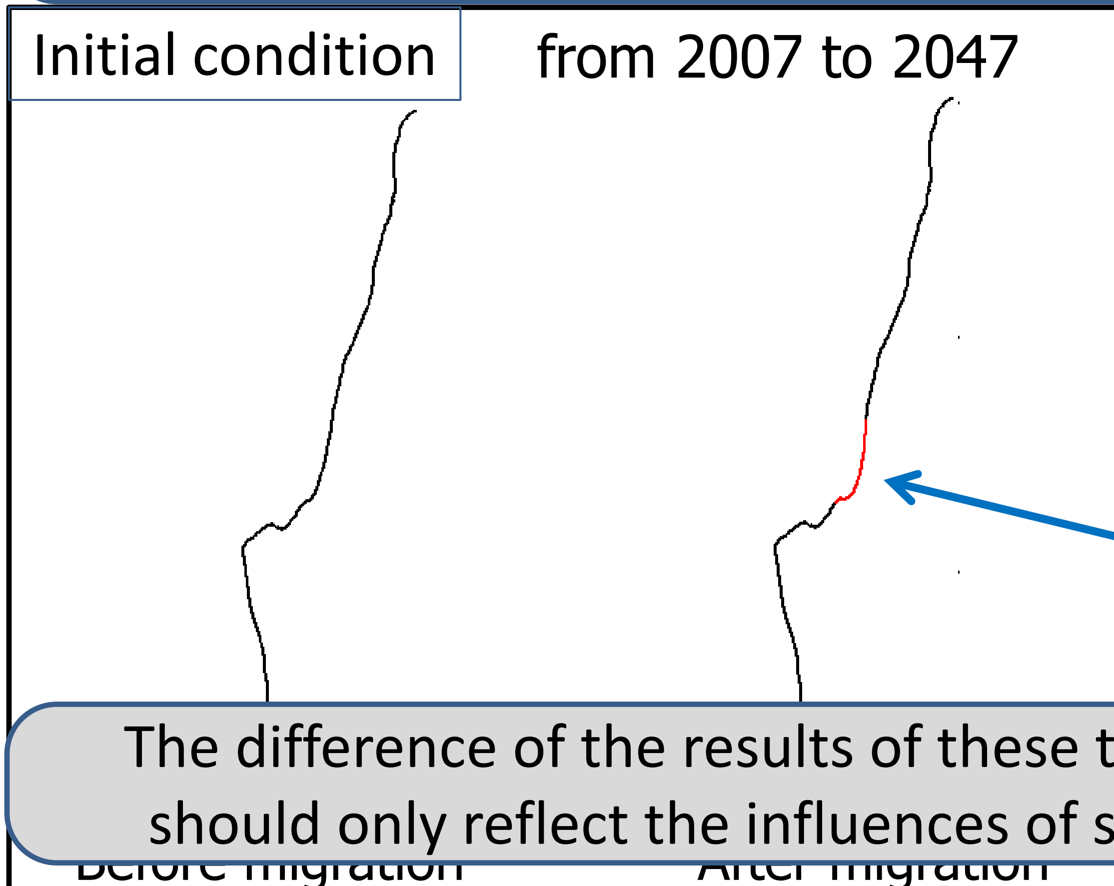
Validates the present model and support our assumption of coral reefs

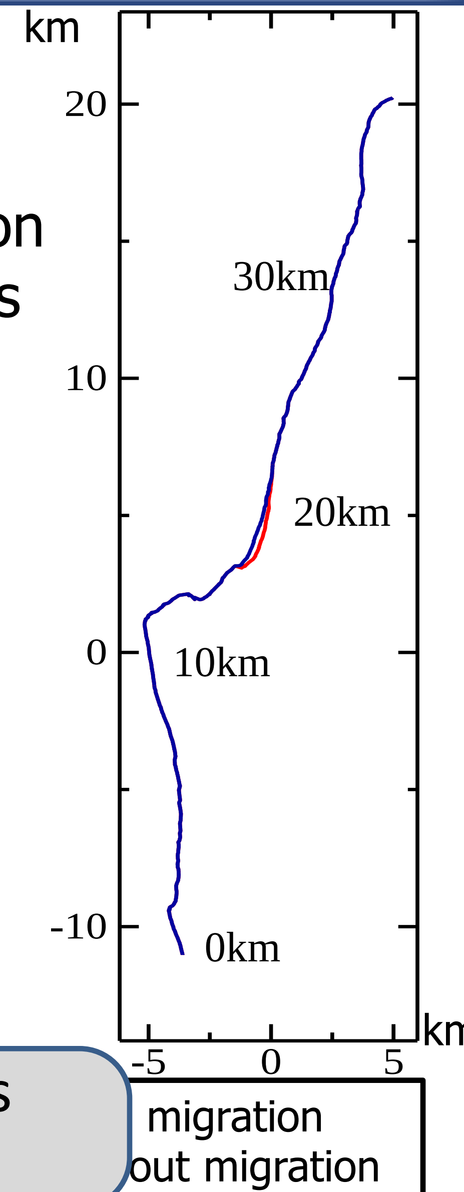
Influence of sand spit migration

influence of sand spit migration
on longshore sediment budgets

Compare the sediment transport rate and shoreline changes in two different cases

ndition
spits

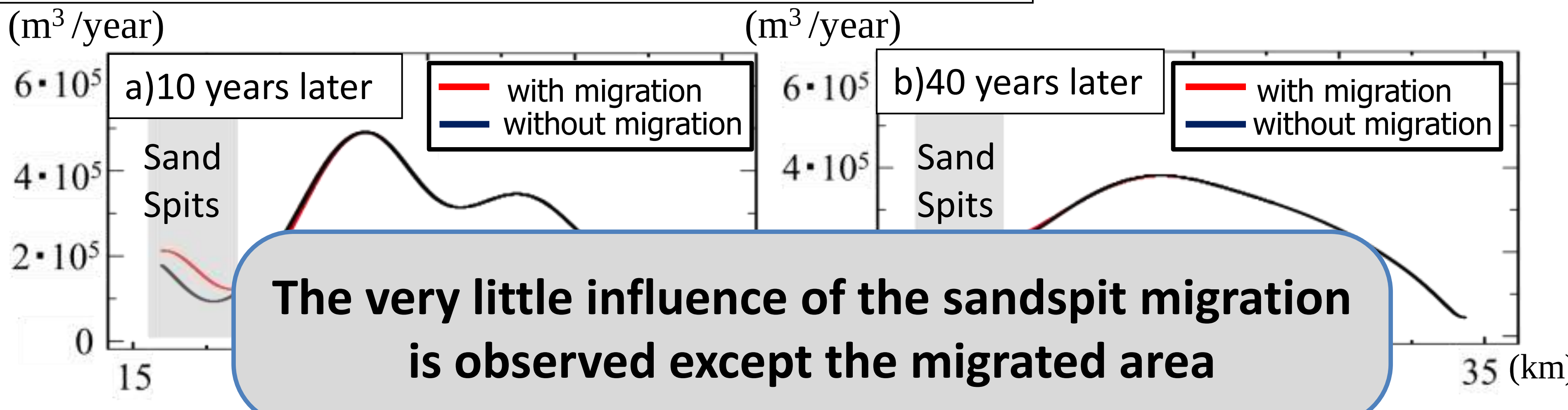




The difference of the results of these two cases should only reflect the influences of sand spit

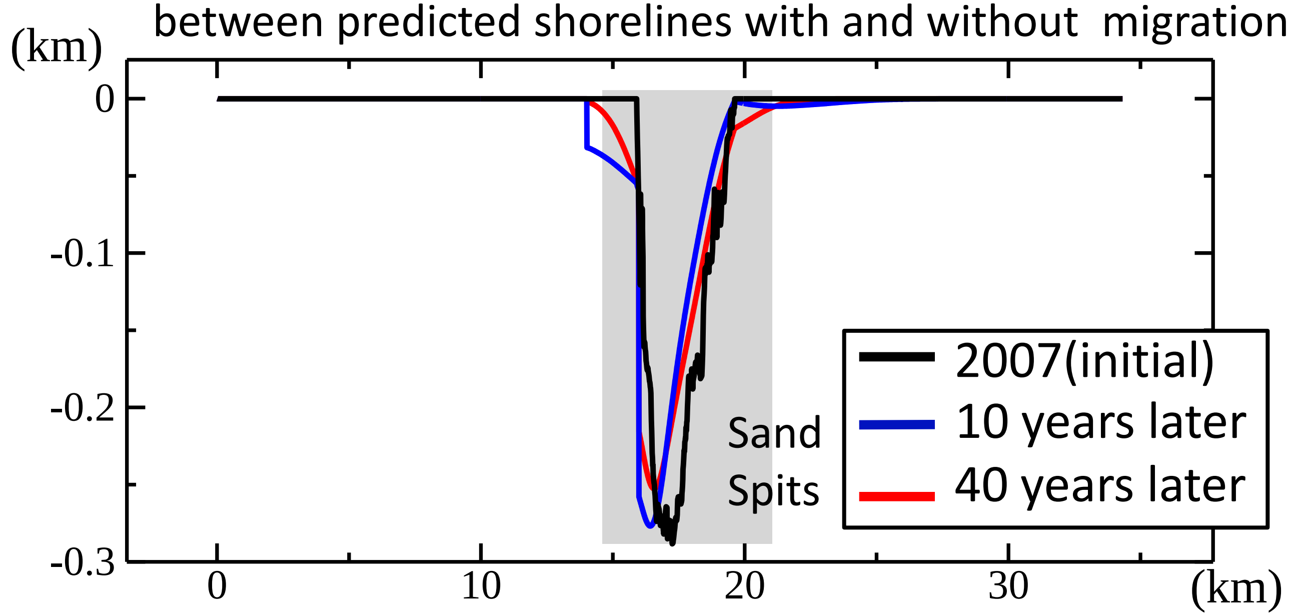
Sediment transport rate comparison

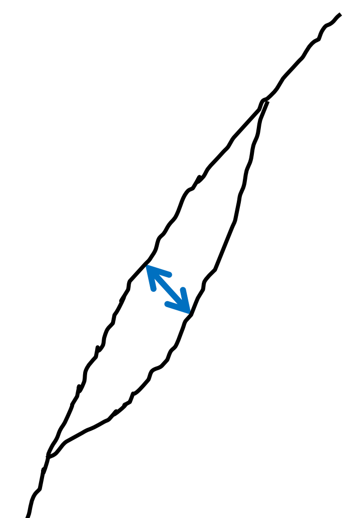
the longshore distributions of sediment transport rates



The very little influence of the sandspit migration is observed except the migrated area

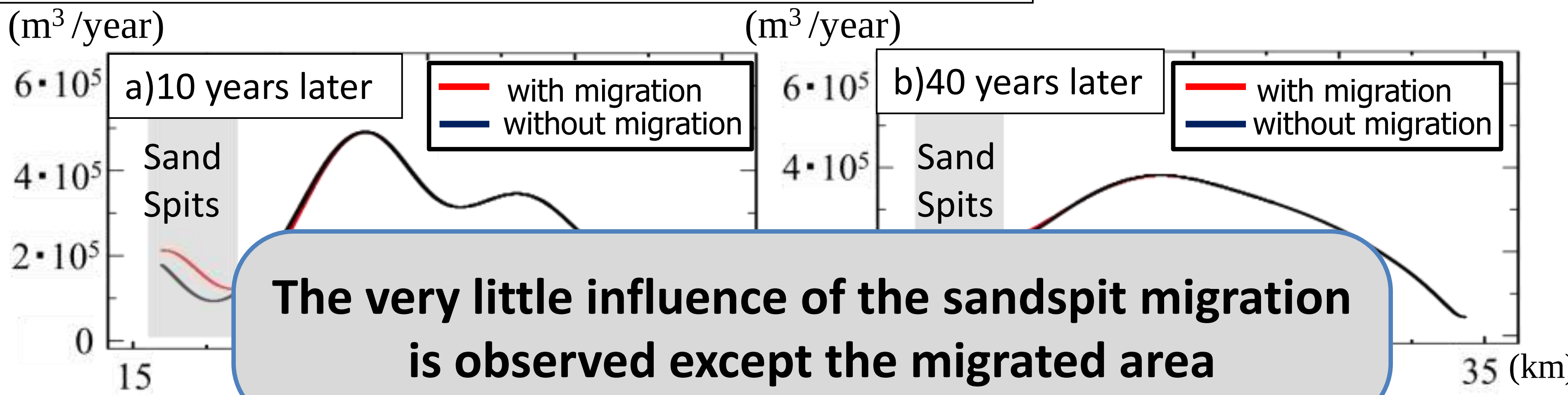
Alongshore distributions of the cross-shore distance between predicted shorelines with and without migration





Sediment transport rate comparison

the longshore distributions of sediment transport rates



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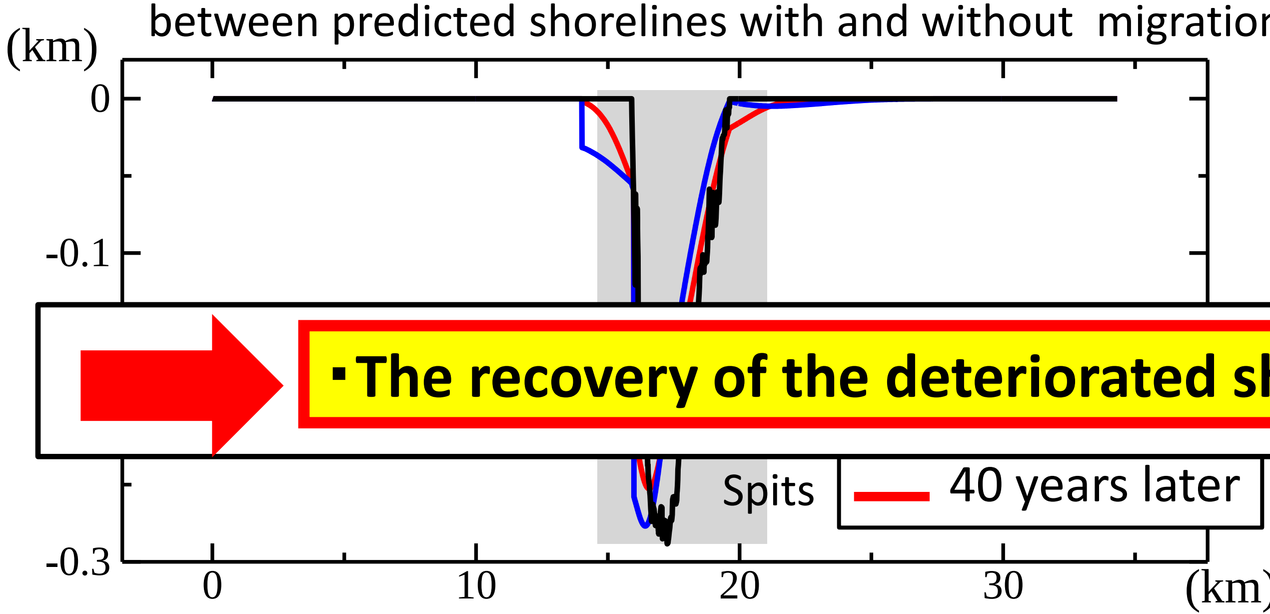
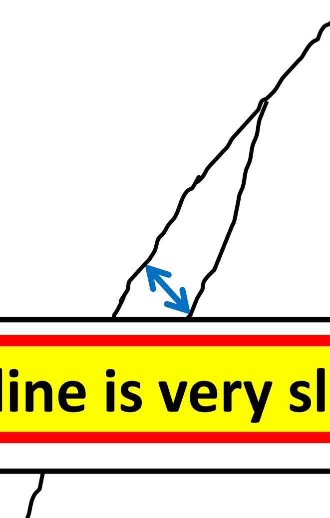




・The recovery of the deteriorated shoreline is very slow

Conclusion

・Long-term process of morphology changes on the west coast of Sri Lanka was investigated through satellite images, wind data and the shoreline model.

・The observed erosion and accumulation were mainly caused by local unbalance of the sediment transport rates due to coral reefs.

・Severe stormy event forces landward migration of the sand spit.
→migration has relatively little impact on the longshore sediment budgets
→retreated shoreline showed slow recovery processes.

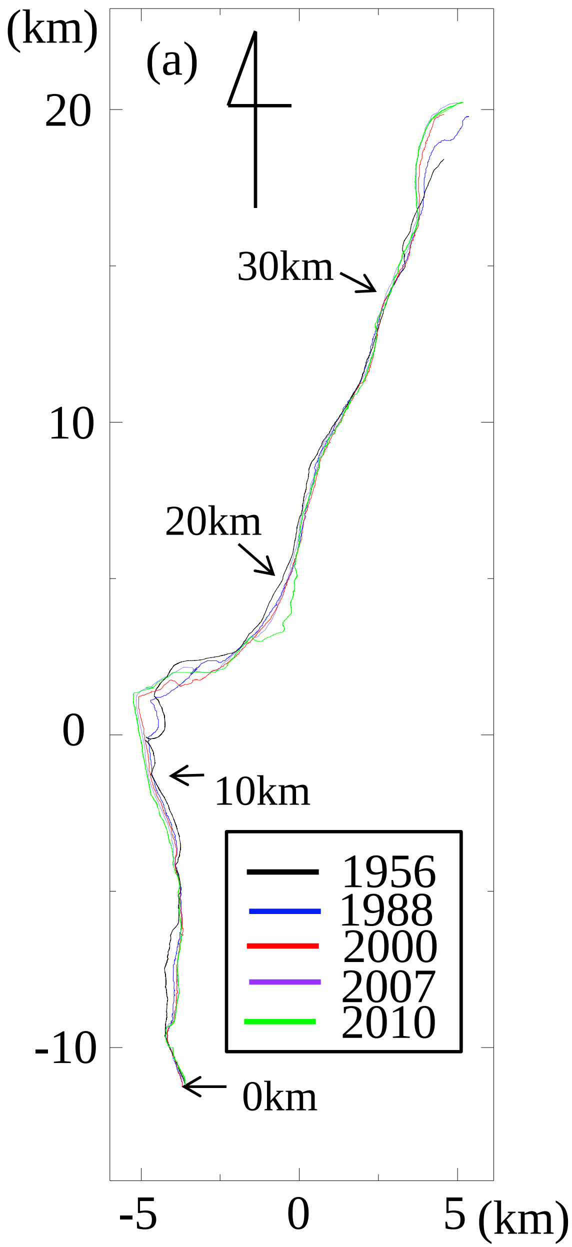
It is thus essential to keep the continuous monitoring around Kalpitiya area focusing on sand spit migration and generations of the coral reefs.

Field survey in Sri Lanka on August in2011

Thank you for listening

Q&A

Shoreline Extraction from images



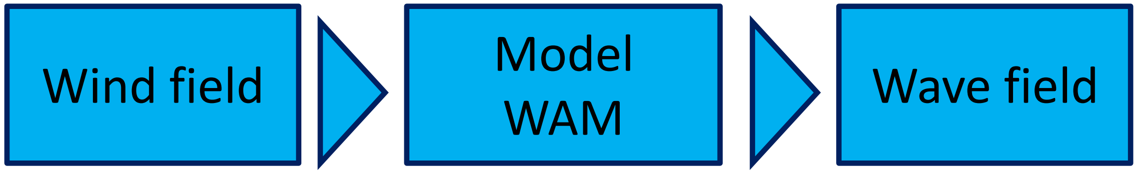
shoreline extraction

coordinate transformation

comparison

Wave estimation

Wave model (WAM)



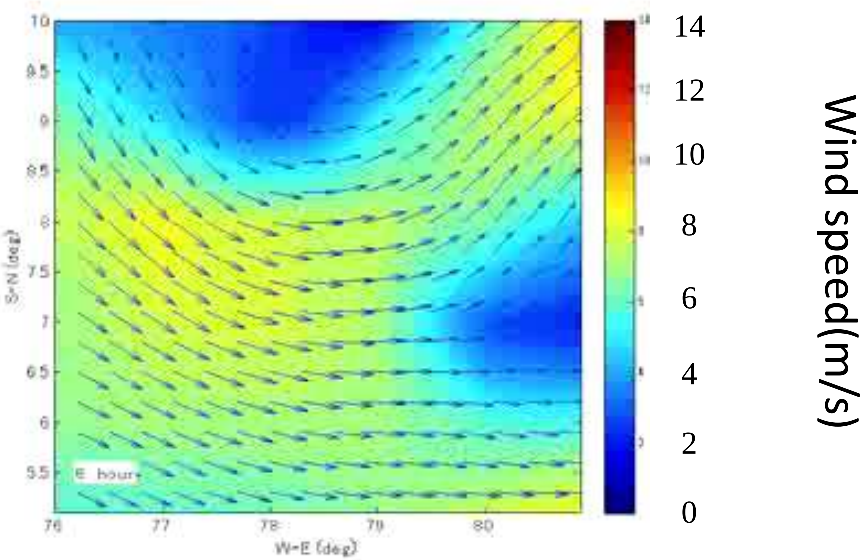
WAMDI GROUP in 1988

$$\frac{\partial F}{\partial t}+\frac{1}{\cos\phi}\frac{\partial}{\partial\phi}\left(\dot{\phi}\cos\phi F\right)+\frac{\partial}{\partial\lambda}\left(\dot{\lambda}F\right)+\frac{\partial}{\partial\theta}\left(\dot{\theta}F\right)=Sin+Sds+Snl$$

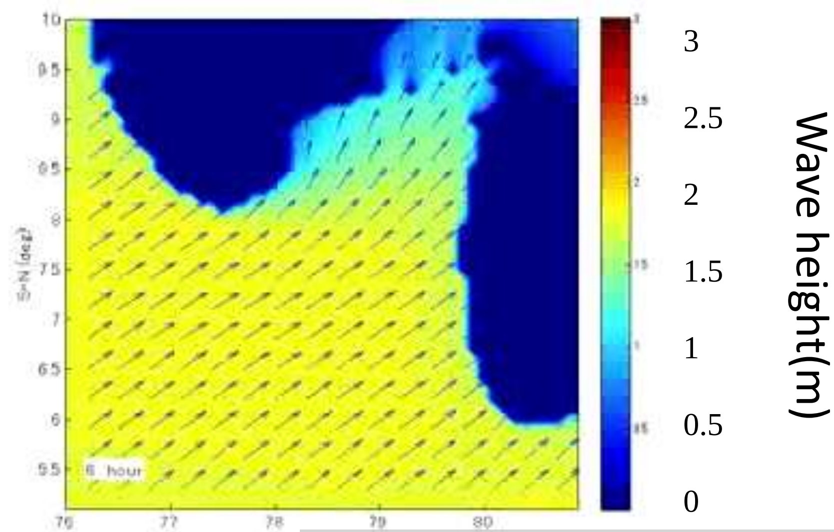
Sin = Wind energy
Sds = Energy dissipation
Snl = Nonlinear interaction

The result

Wind Field

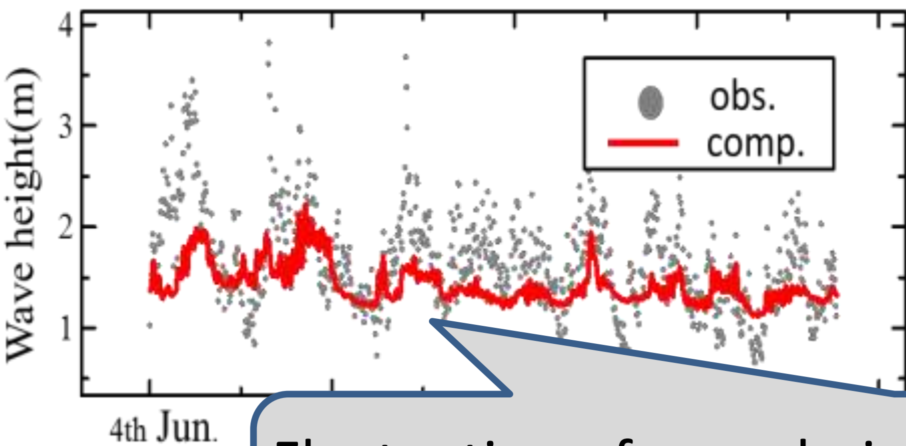


Wave Field

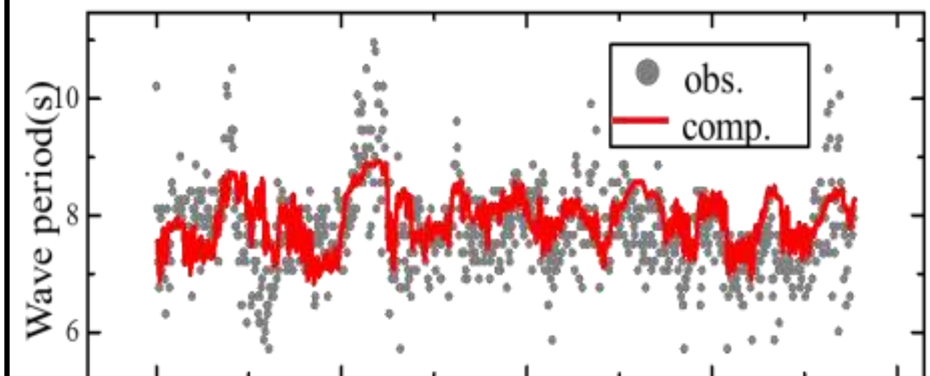


Observation and Calculation

Wave height

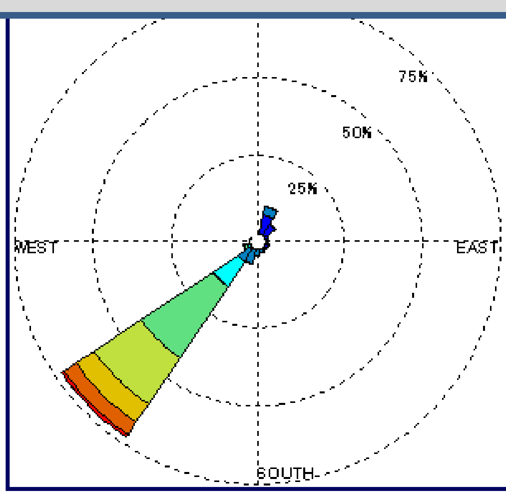


Wave period



Fluctuation of wave height is underestimated while "average wave heights" are well represented.

Calculation for 10 years



→Average height, period and direction

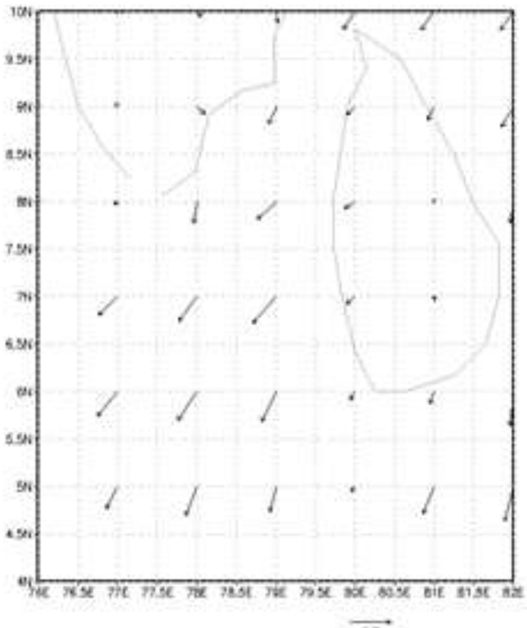
Offshore Condtion

Height	1.2(m)
Period	7.7(s)
Direction	43°

Wind field data

Wind field data（Final Operational Global Analysis data ）

・published by NCEP・10m height data (NCEP ： National Centers for Environmental Prediction)



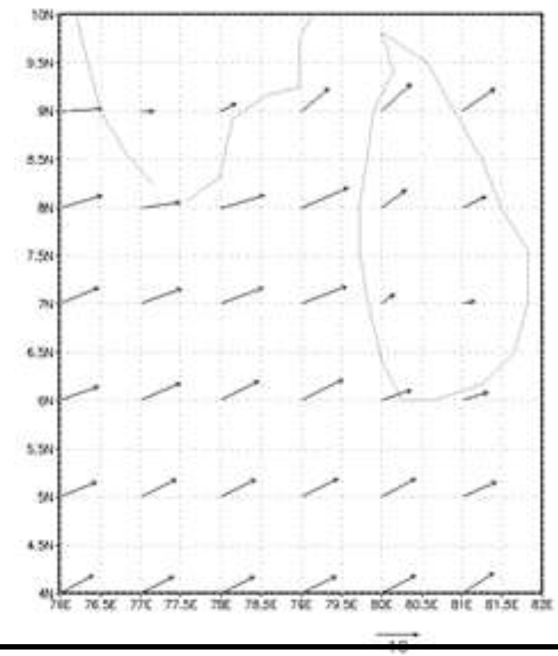
2010/1/1/0:00

NE monsoon

2010/6/12/6:00

SW monsoon

Monsoon Period	
NE monsoon	Nov.~Mar.
SW monsoon	May~Sep
inter monsoon	Apr. & Oct.



Wind field interpolation

・ **Development of Scheme for Predicting Atmospheric Dispersion of Radionuclides during Nuclear Emergency by Using Atmospheric Dynamic Model**（Nagai et al.1999）

Interpolation

・mass conservation

$$G = \frac{\partial u}{\partial x} + \frac{\partial v}{\partial y} = 0$$

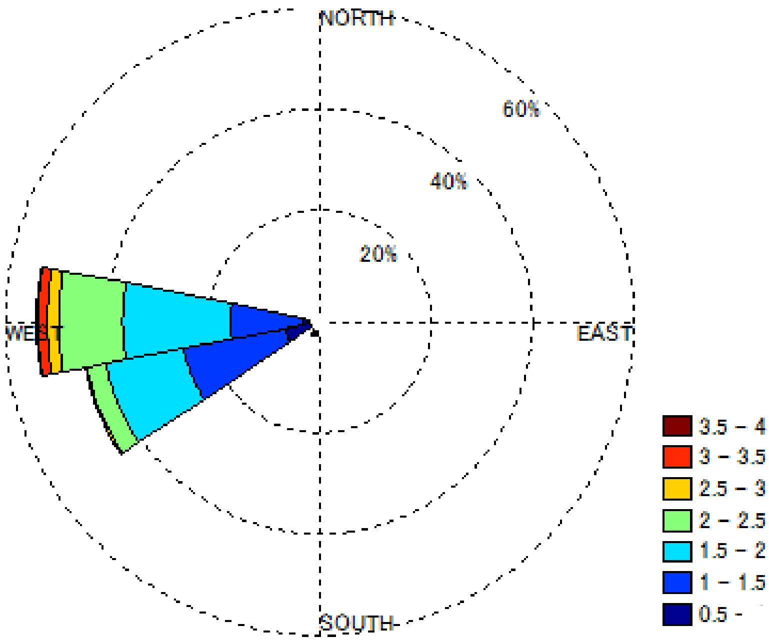
・modification by NCEP data

$$I = \int [\alpha_1^2 (u - u_0)^2 + \alpha_1^2 (v - v_0)^2] dV$$

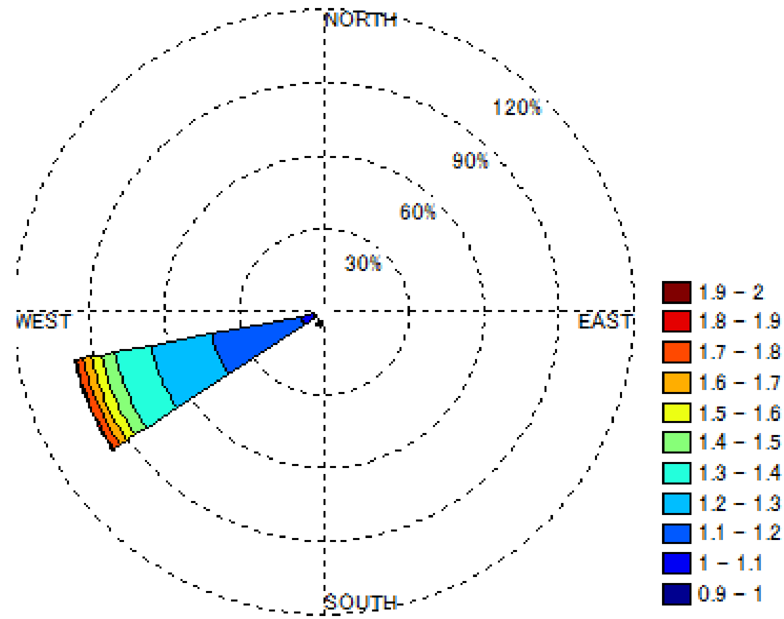
$$J = I + \int \lambda G dV$$

Wave direction

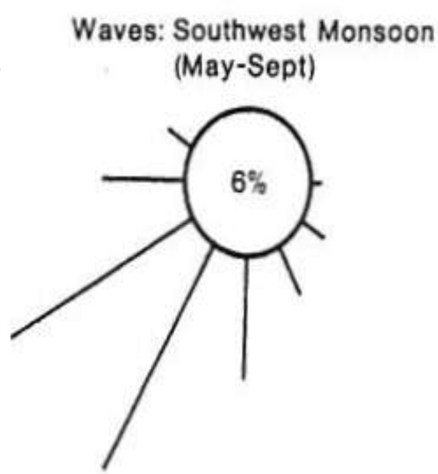
Observed direction



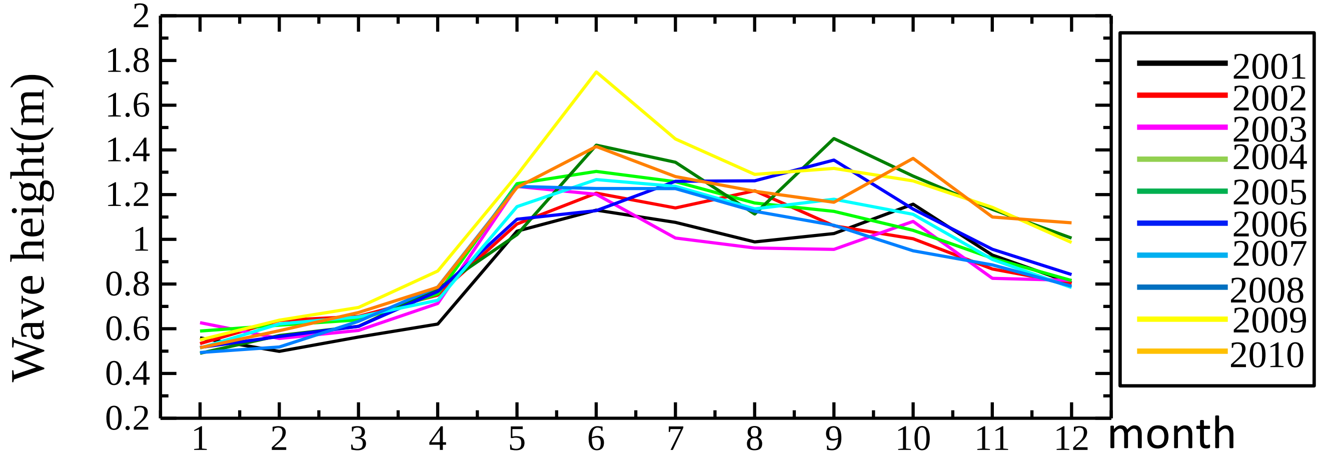
Calculated direction



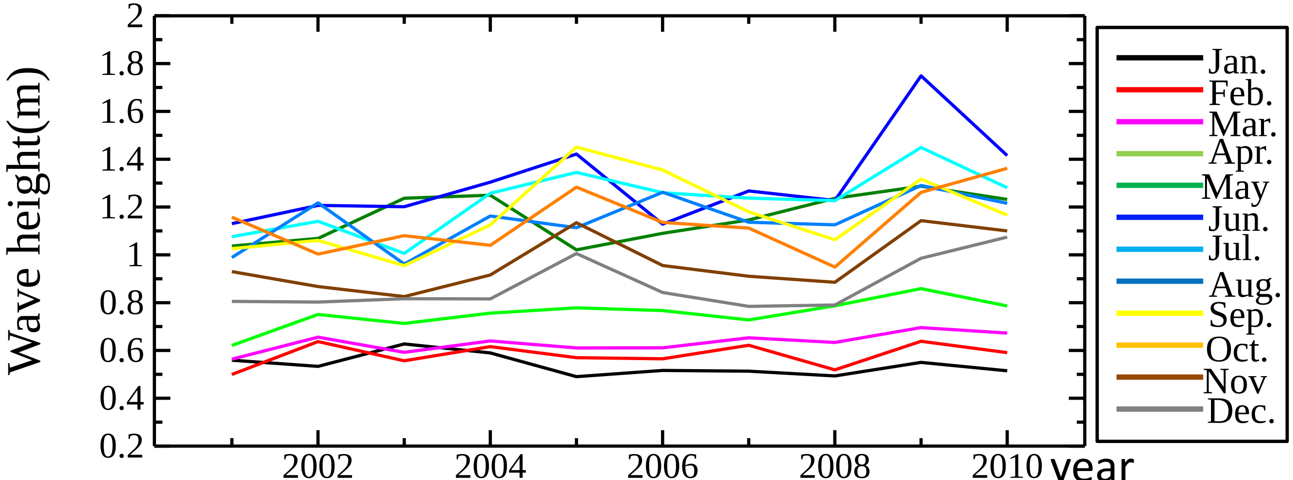
Past research



Wave estimation result

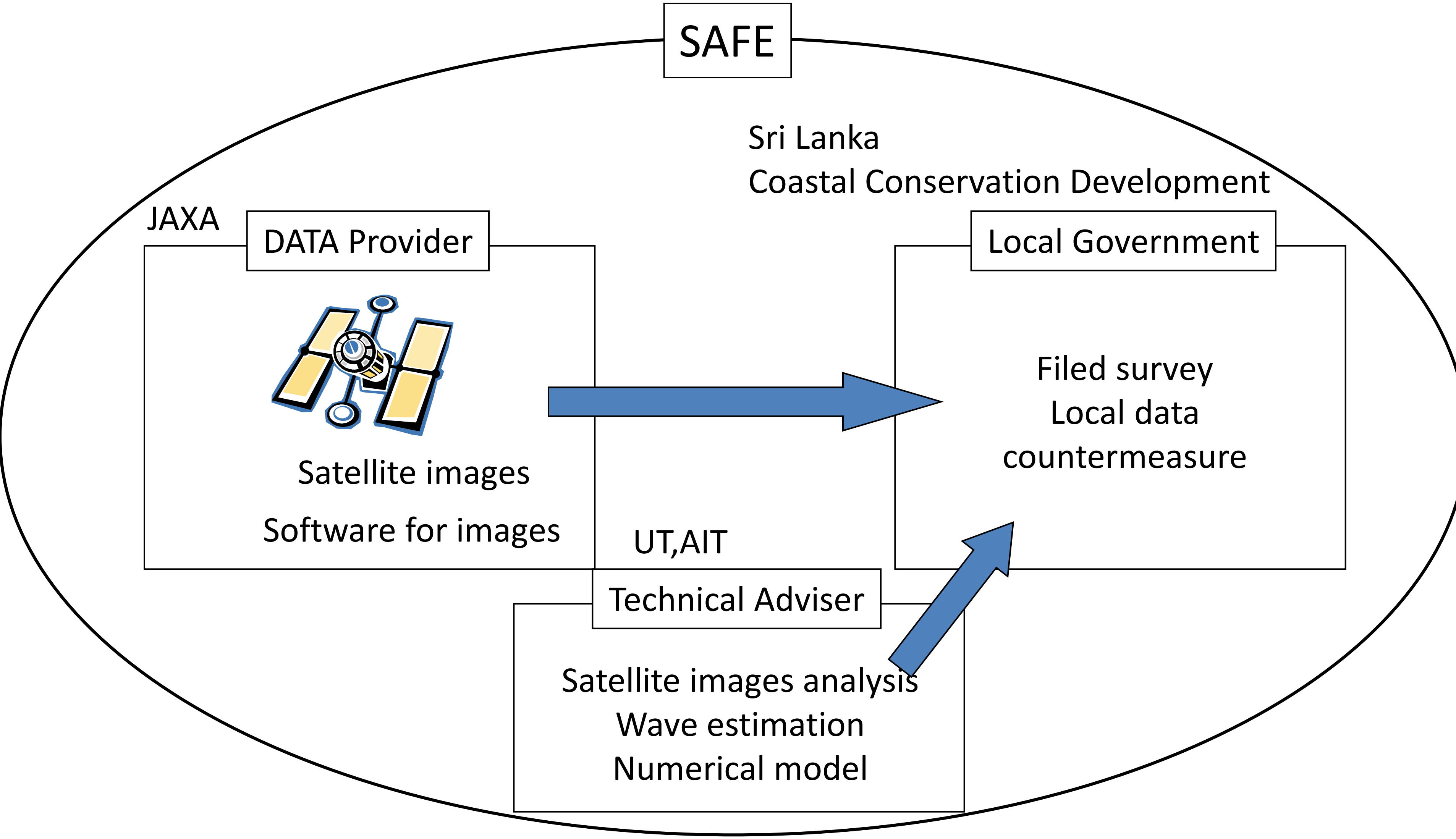


(b) monthly changes of significant wave heights averaged in each year and month.



a) Yearly changes of significant wave heights averaged in each year and month.

Space Application for Environment(SAFE)

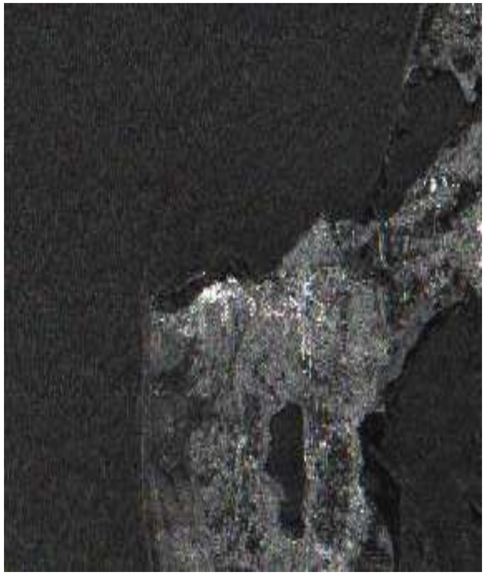


PALSAR, Landsat, aerial photo

Aerial Photo

LANDSAT

PALSAR Image



high resolution

low frequency

Optical interruptions

low resolution

good frequency

Optical interruptions

good resolution

high frequency

No Optical interruptions