

Model for Predicting Formation of Blowout on Coastal Sand Dune using Cellular Automaton Method

The 36th International Conference on Coastal Engineering

Takuya YOKOTA

Akio KOBAYASHI

Takaaki UDA

Masumi SERIZAWA

Atsunari KATSUKI

Yasuhito NOSHI

Nihon University

Nihon University

Public Works Research Center

Coastal Engineering Laboratory, Co., Ltd.

Nihon University

Nihon University

1. Introduction

2. Field observations

1. Field observation of blowout on sand dune at Node coast
2. Analysis result of aerial photograph and wind data

3. Predicting model

1. Explanation of predicting model
2. Calculation result

4. Conclusion

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Introduction

- On a coast composed of fine sand, windblown sand could be deposited to form a coastal sand dune along the shoreline.
- In such a coastal sand dune, part of sand dune may be eroded by the effect of wind as a natural agent, resulting in the formation of a blowout.



■ Importance of Sand Dune

- Effective barrier against the inundation of sea water into the land
- Seaward marginal line of the sand dune covered with vegetation is often selected as a hatching area for turtles



■ Impact of Blowout

- Function of the sand dune as a coastal dike will be lost



- **To investigate the formation of a blowout on the coastal sand dune by field observation**
- **To develop a model for predicting the formation of a blowout using a cellular automaton method**
- **By numerical simulation, determine the best possible access path condition.**

1. Introduction

2. Field observations

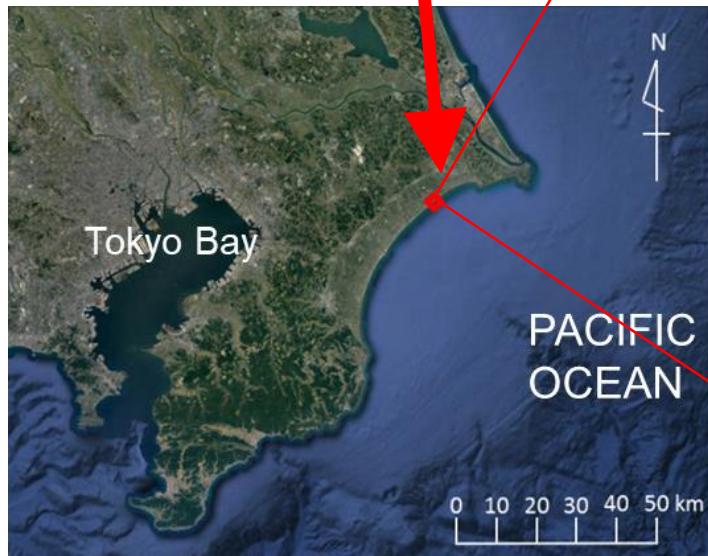
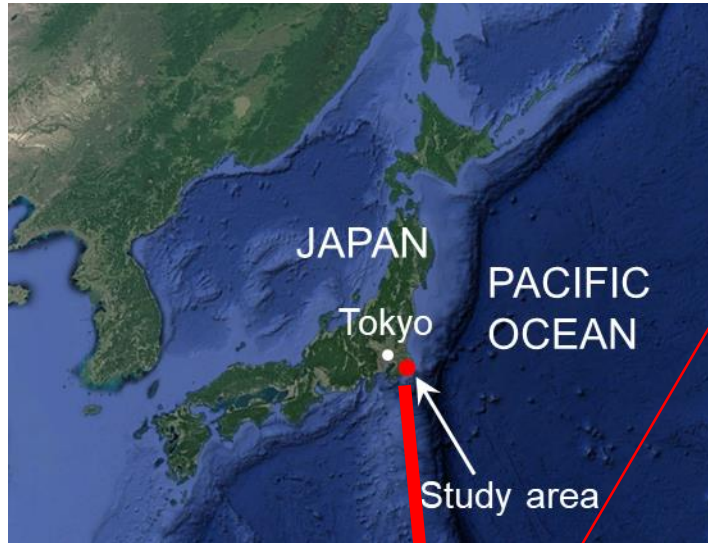
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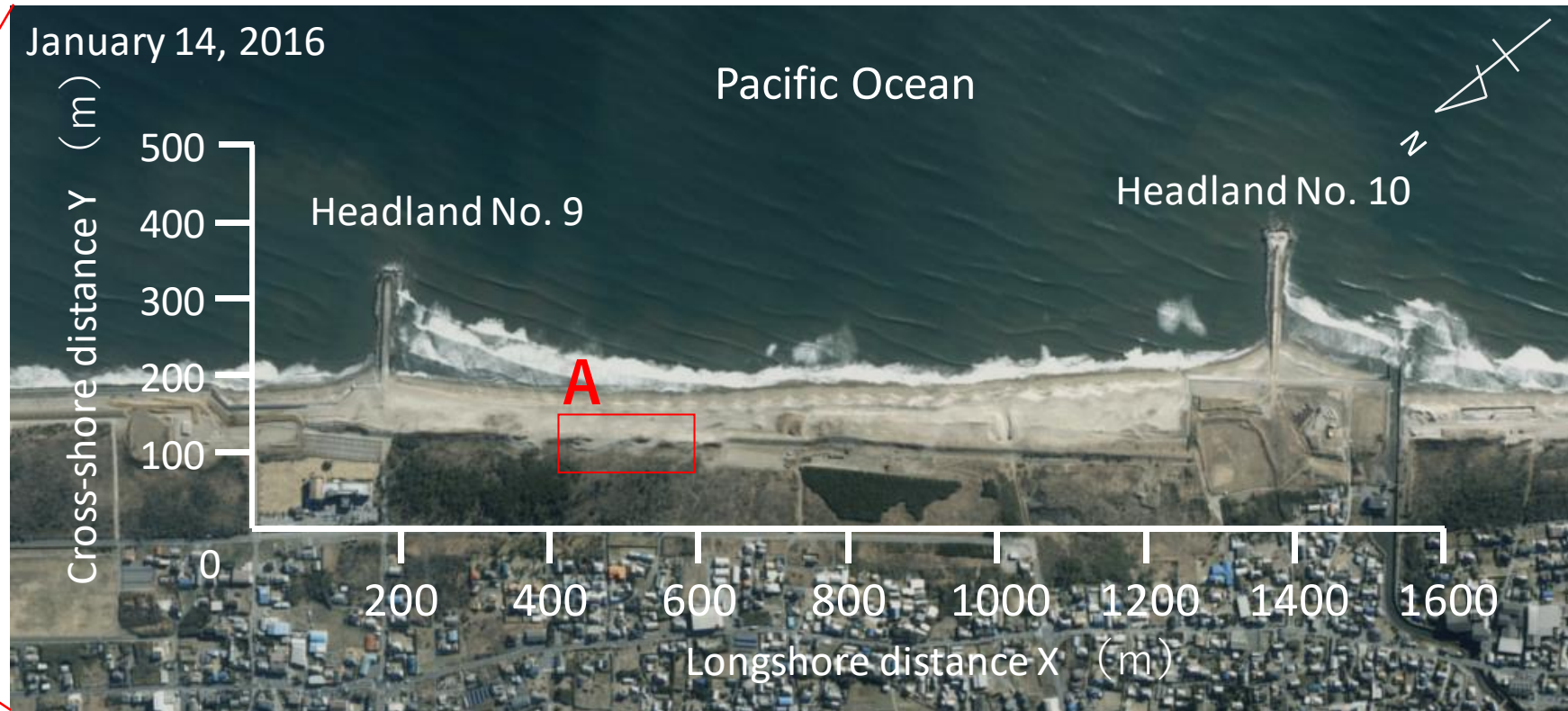
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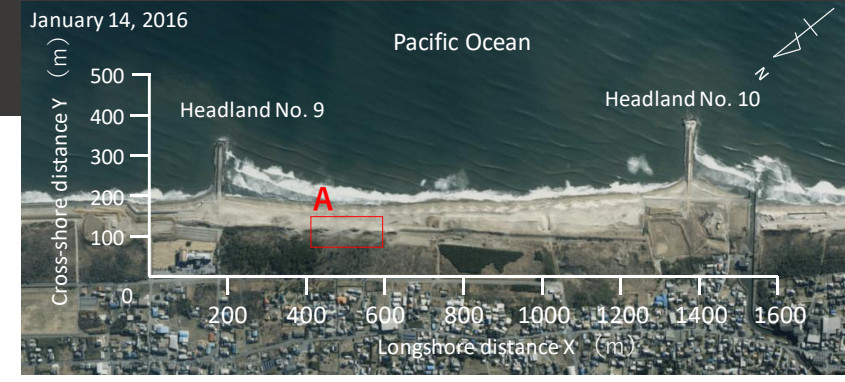
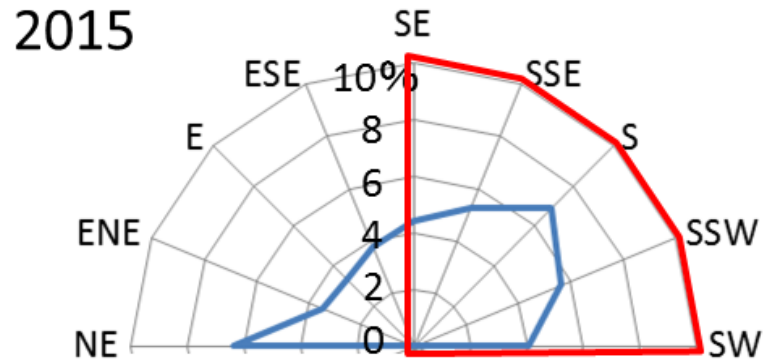
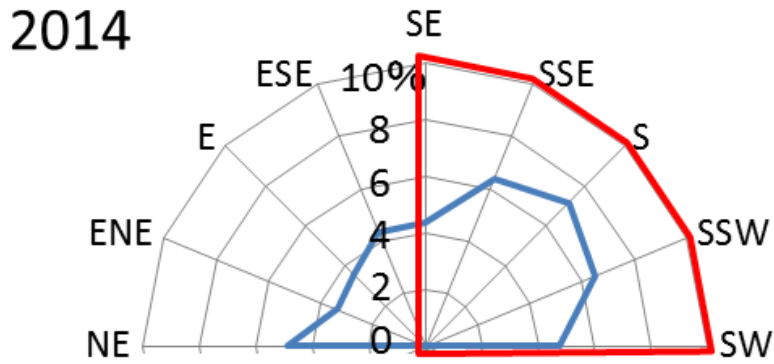
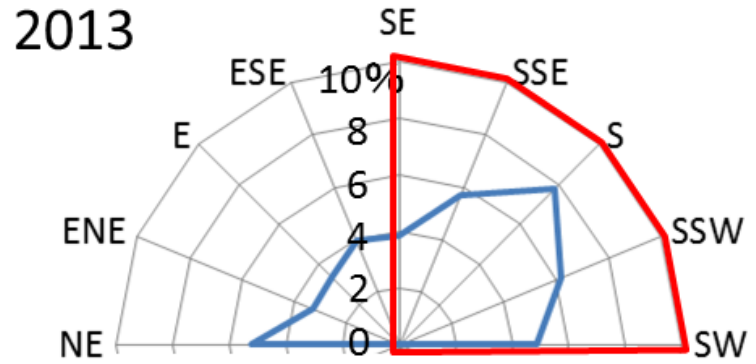
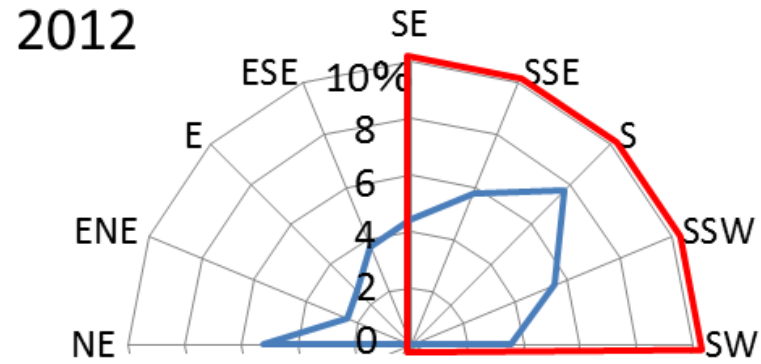


Node coast in Chiba Prefecture



2.1. Field observation of blowout on sand dune at Node coast

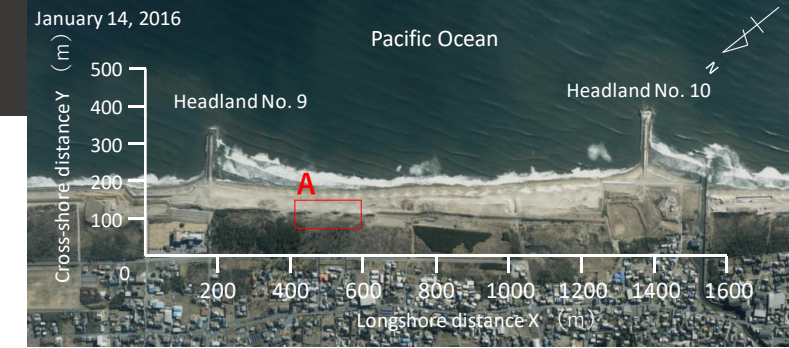
The probability of occurrence of the wind direction



The prevailing wind blows from the South in all seasons with an oblique incidence angle of 45° relative to the direction normal to the mean shoreline

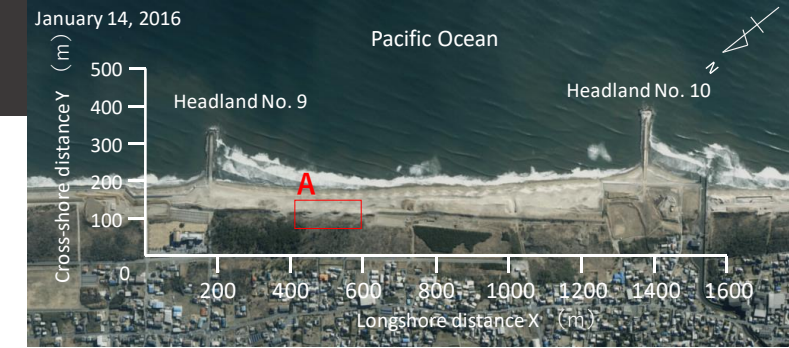
2.1. Field observation of blowout on sand dune at Node coast

Blowout formation on sand dune



2.1. Field observation of blowout on sand dune at Node coast

Steep slope of angle of repose of sand at landward end of blowout



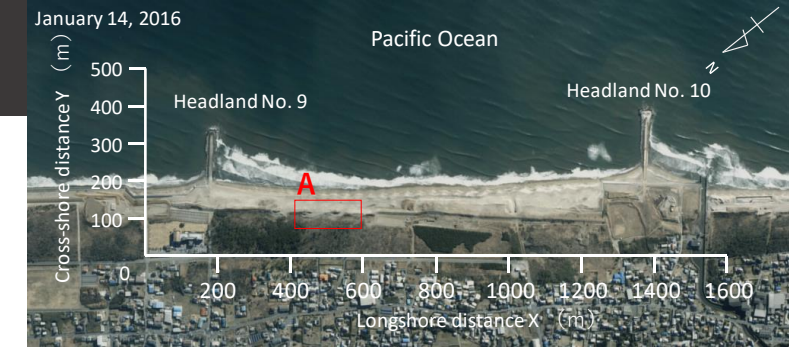
2.1. Field observation of blowout on sand dune at Node coast

Sand dune vegetation, *Carex kobomugi*, covering seaward slope of sand dune.

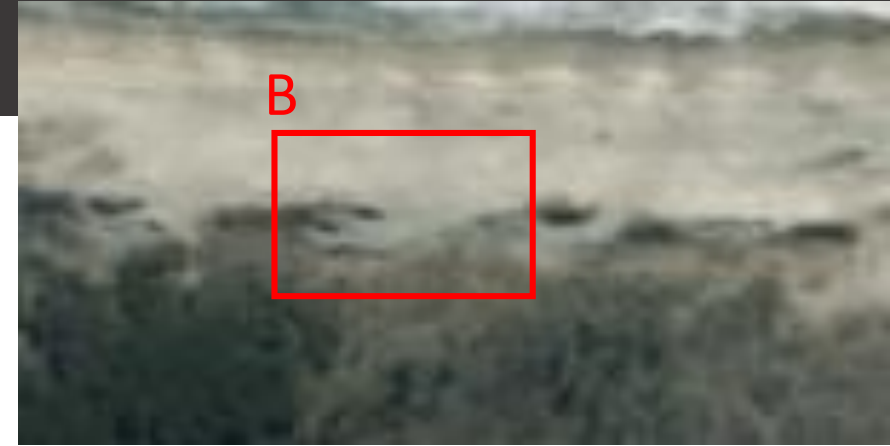
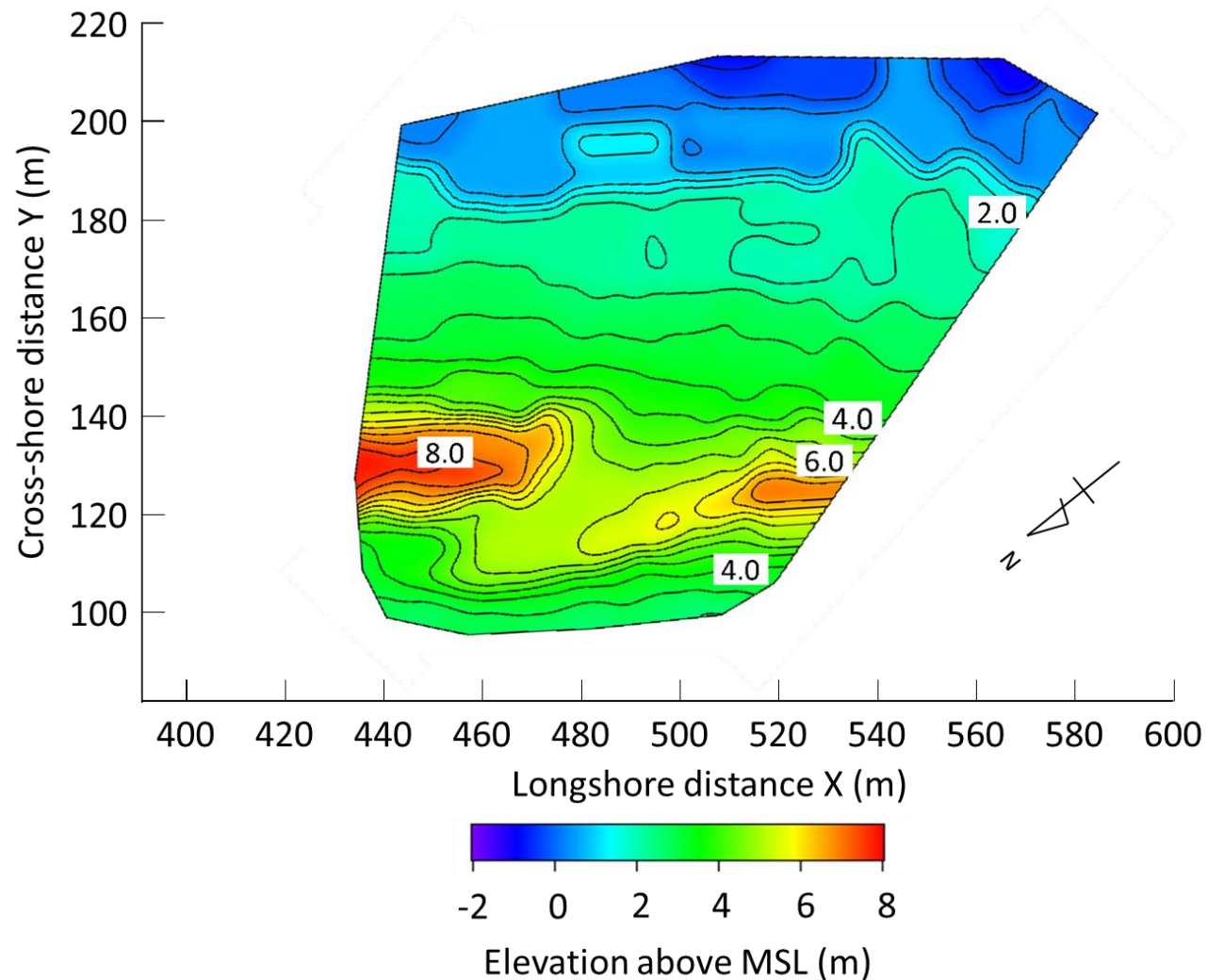


2.1. Field observation of blowout on sand dune at Node coast

Vegetation densely covering landward slope of sand dune



2.1. Field observation of blowout on sand dune at Node coast



- concave contours are formed at seaward slope of the blowout
- Steep slope at the landward end of the blowout
- Mound was on the south slope of the blowout
- The undercut steep slope was on the north slope

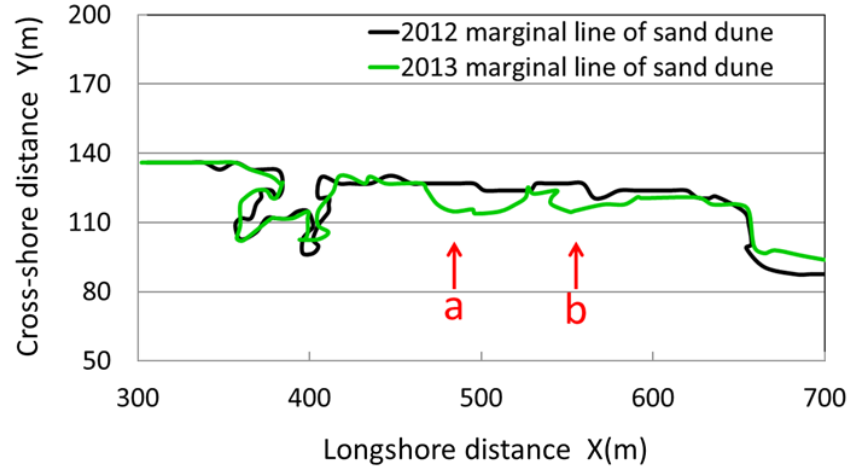
Analysis of Marginal Line of Sand Dune using Aerial Photograph



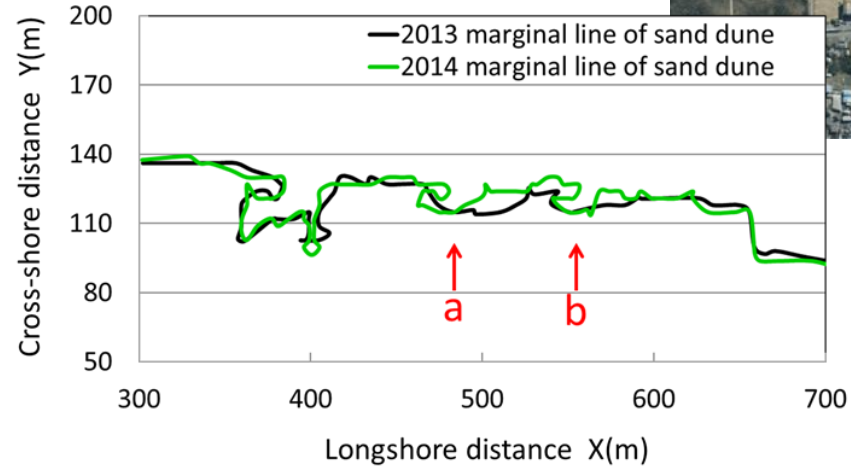
2.2. Analysis result of aerial photograph and wind data



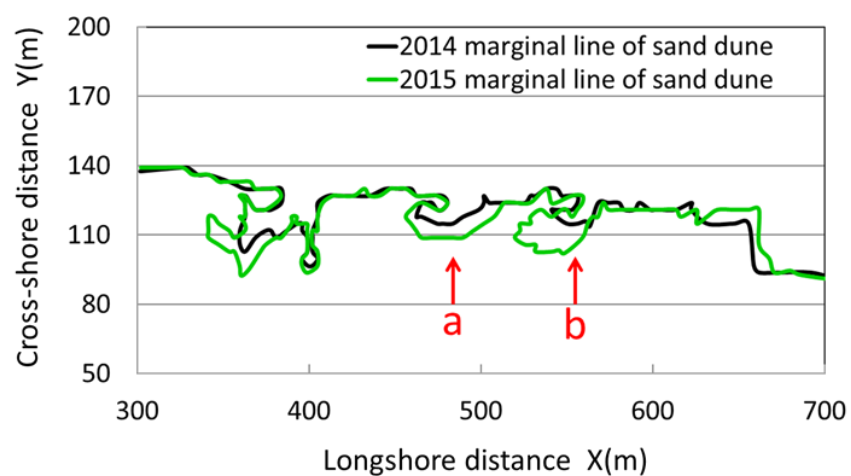
2012 vs 2013



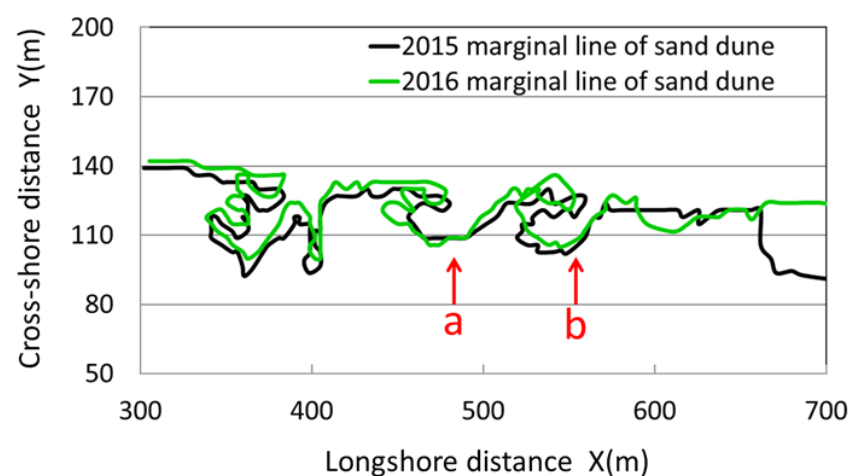
2013 vs 2014



2014 vs 2015

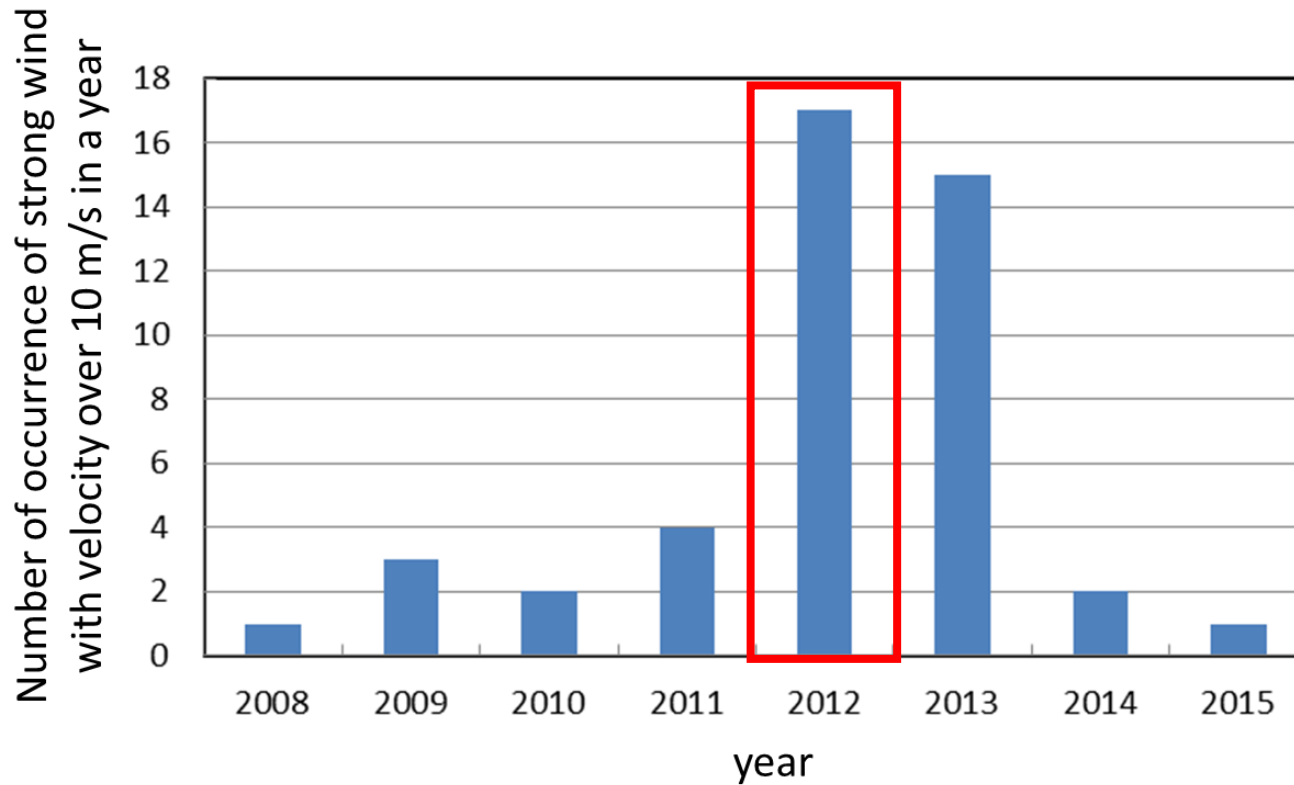


2015 vs 2016



2.2. Analysis result of aerial photograph and wind data

The probability of occurrence of strong wind with a velocity over 10 m/s from the South



Strong wind markedly increased in 2012

Occurrence of strong wind in 2012 resulted to the rapid development of blowout.

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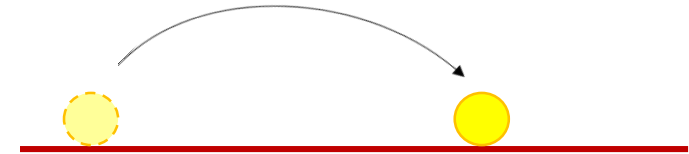
1. Explanation of predicting model
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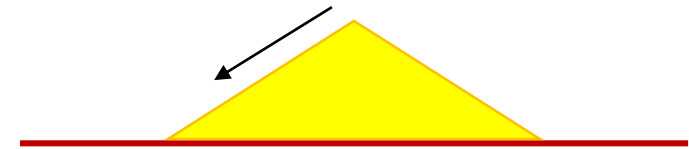
■ Saltation

(process of sand particle transport by the action of wind)

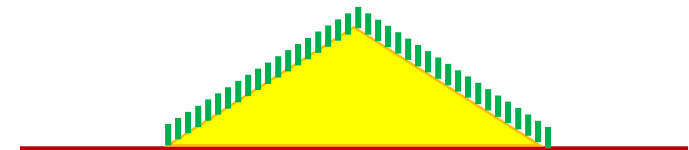


■ Avalanche

(flow of sand particle sliding down from the most steep slope)



■ effect of vegetation coverage on the sand dune

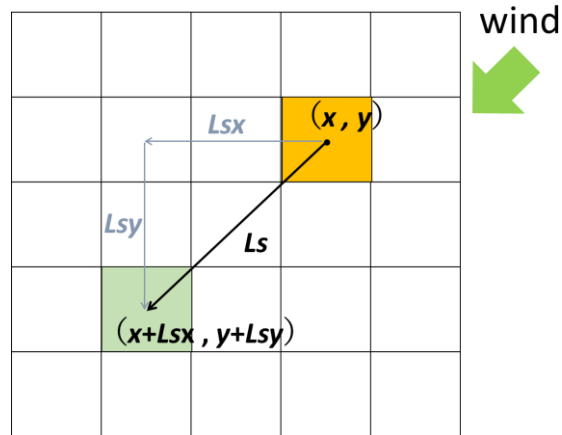


3.1. Explanation of predicting model

■ Saltation distance, L_S

$$L_S = a + bh(x, y, t) - ch^2(x, y, t)$$

- Schematic diagram of saltation process

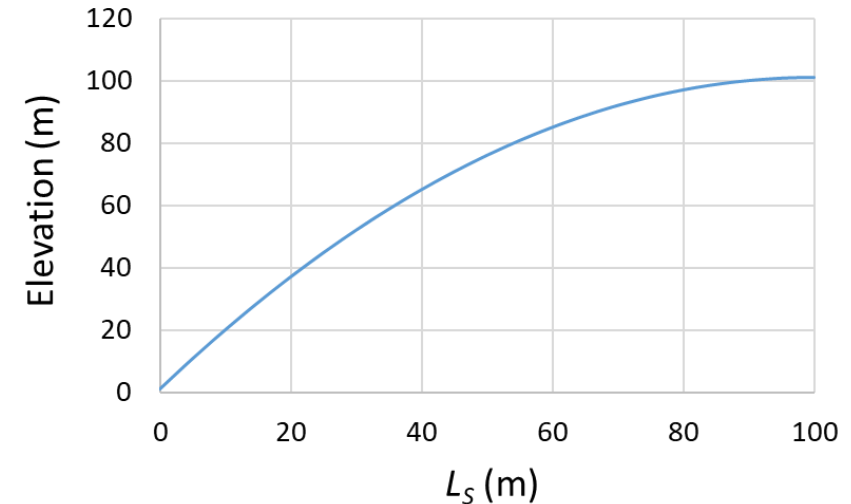


L_S : Saltation distance

$h(x, y, t)$: Elevation at mesh point

$a = 1.0$ $b = 2.0$ $c = 0.01$

- Relationship between saltation distance L_S and the elevation.

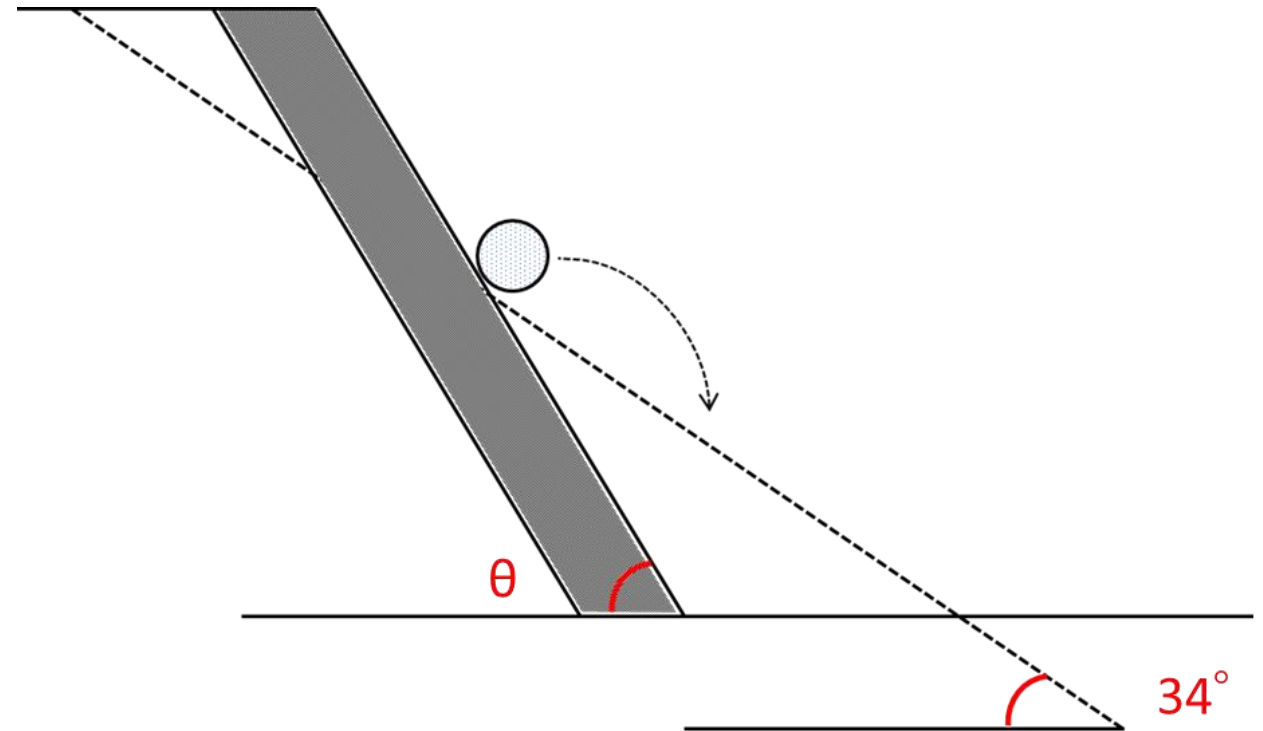
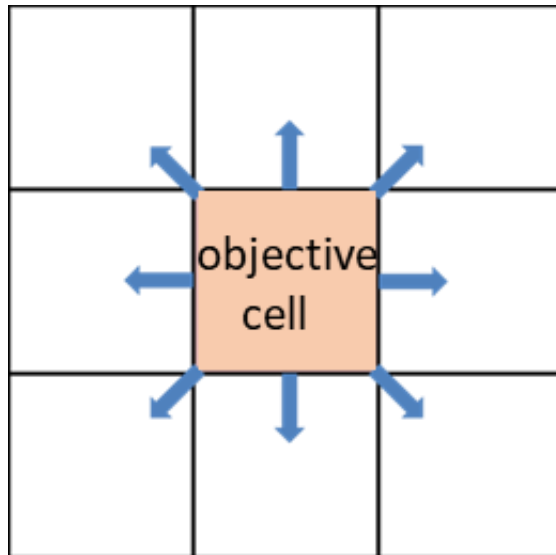


Katsuki et al, (2011).

Cellular model for sand dunes with saltation, avalanche and strong erosion: collisional simulation of barchans, Earth Surface Processes and Landforms, Vol. 36, pp. 372-382

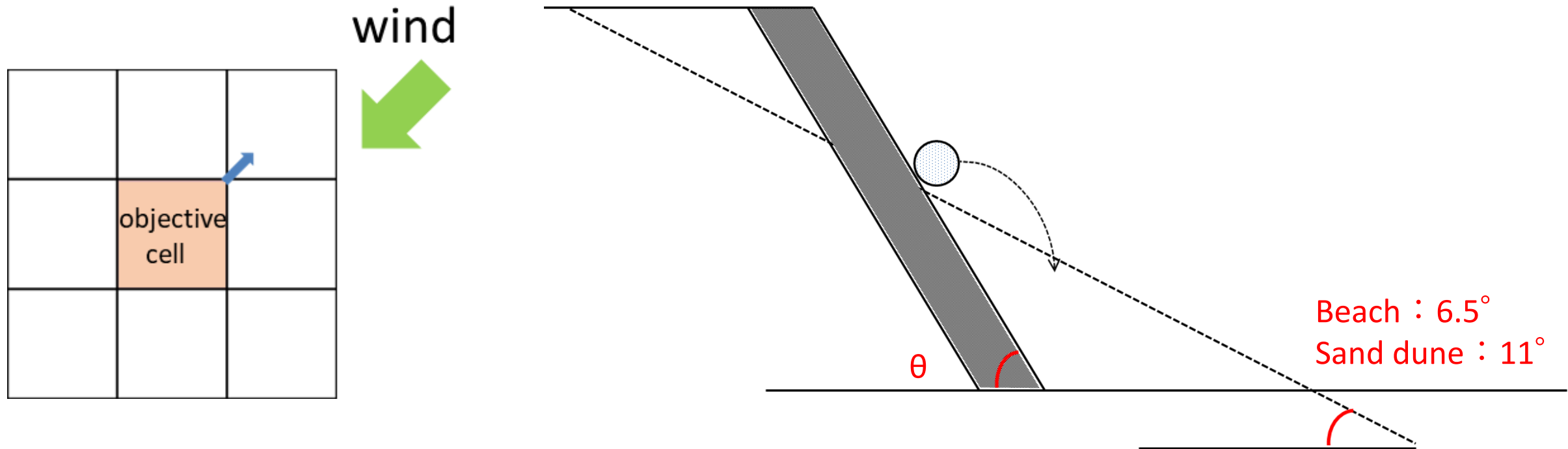
3.1. Explanation of predicting model

- ① Select the cell which has the largest differences in elevation relative to the objective cell
- ② Sand movement is assumed to occur from the objective cell to the new cell until the angle of the slope between the objective cell and new cell be the angle of repose of sand (34°)



3.1. Explanation of predicting model

- ① Obtain the difference in elevation between the objective cell and upwind cell
- ② Part of sand particle is transported into the upwind cell in case that a given slope is steeper than upwind slope

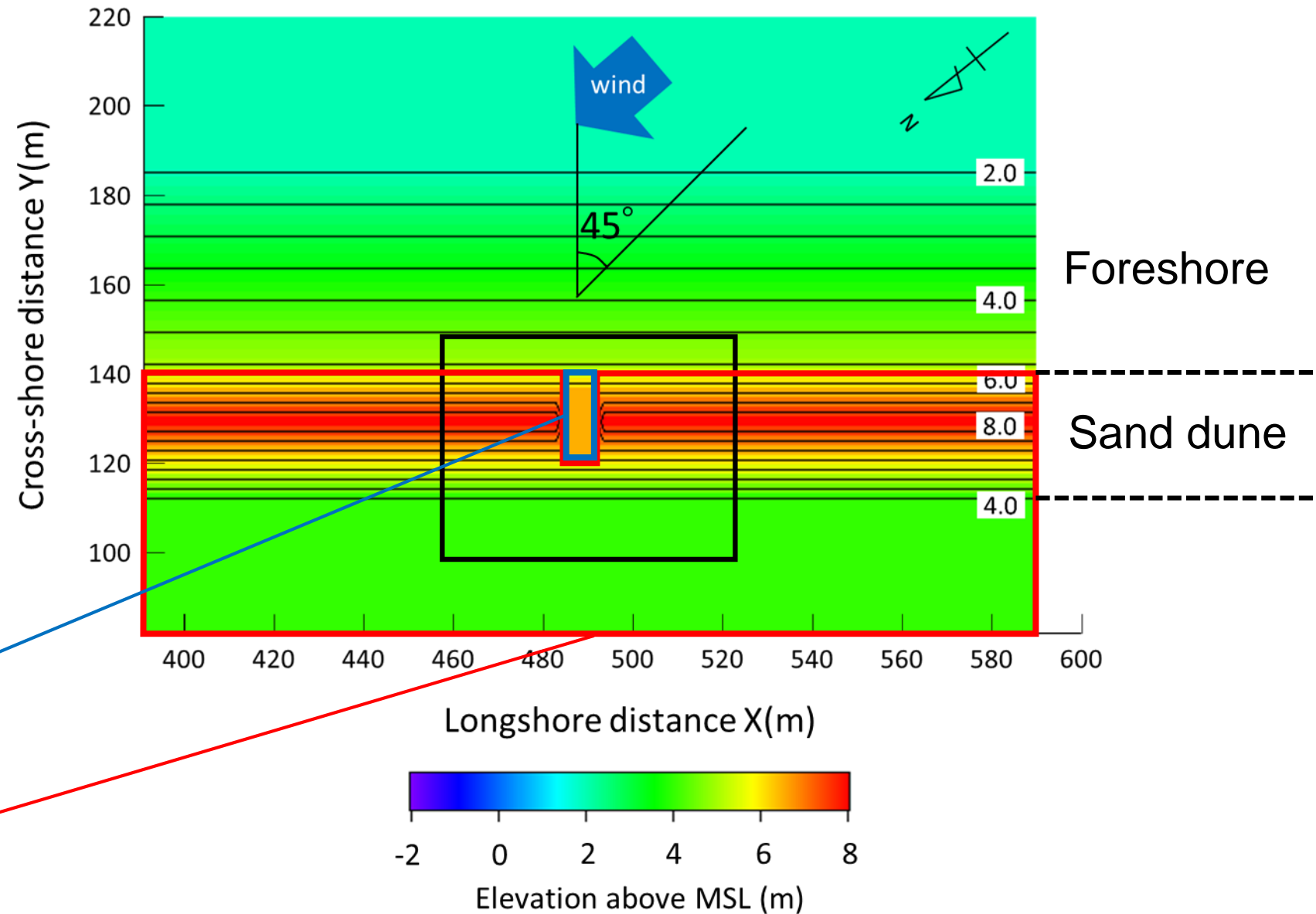


3.2. Calculation Result

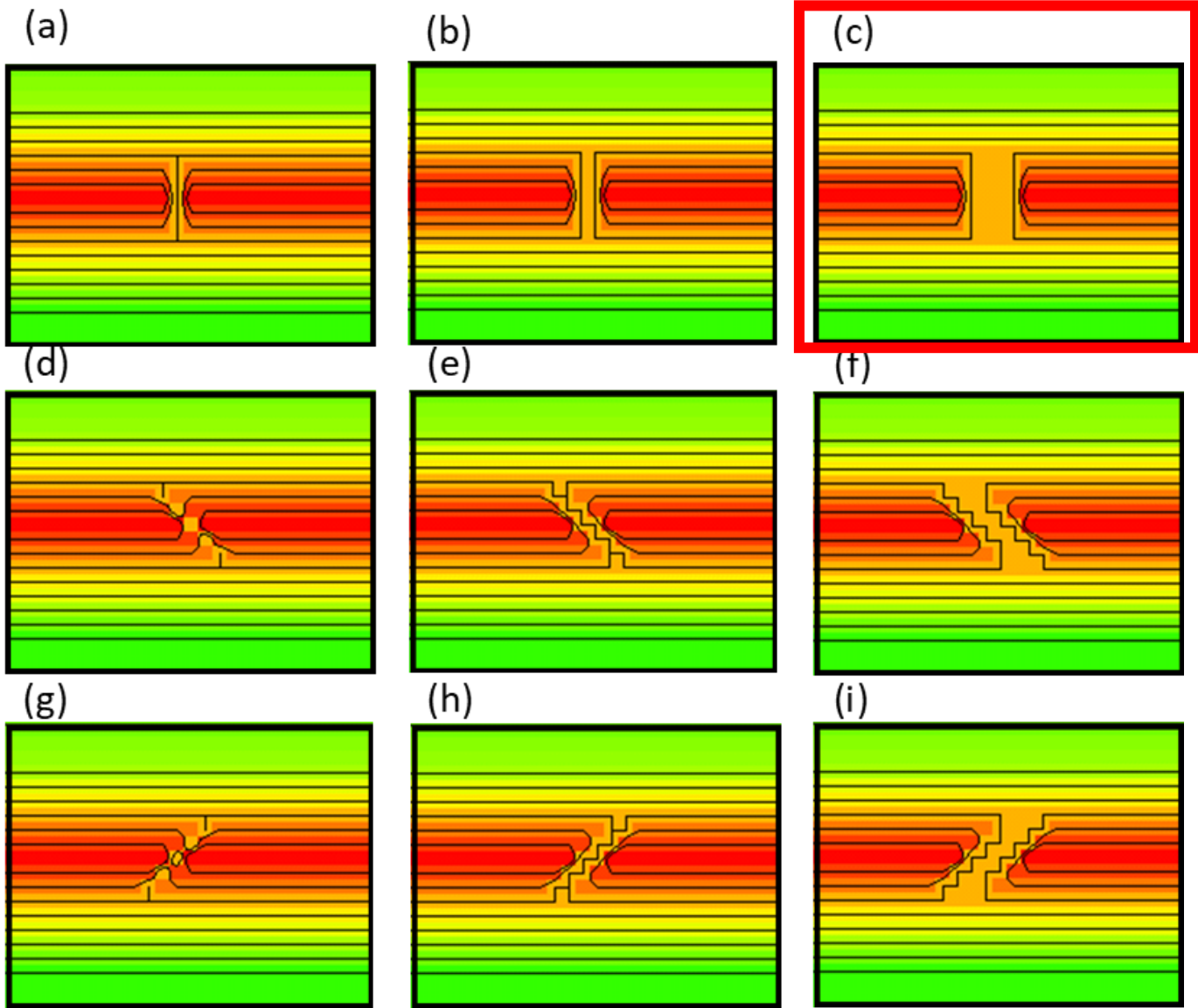
Initial topography

Part of the sand dune was cut forming a gap width in the sand dune.

The moving mass	q
Standard moving mass	0.01
The moving mass in the access	$10q$ (0.1)
The coverage of the sand dune by vegetation	0



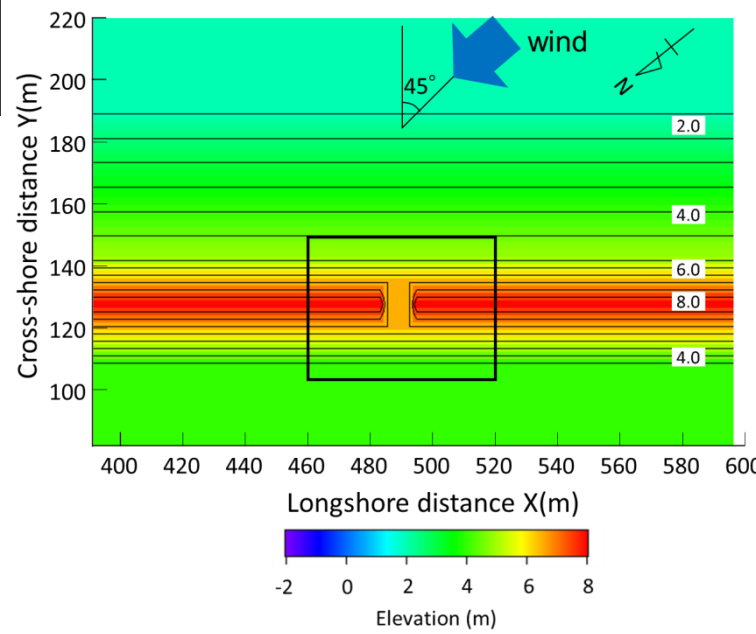
3.2. Calculation Result



Normal to sand dune

Normal to wind direction

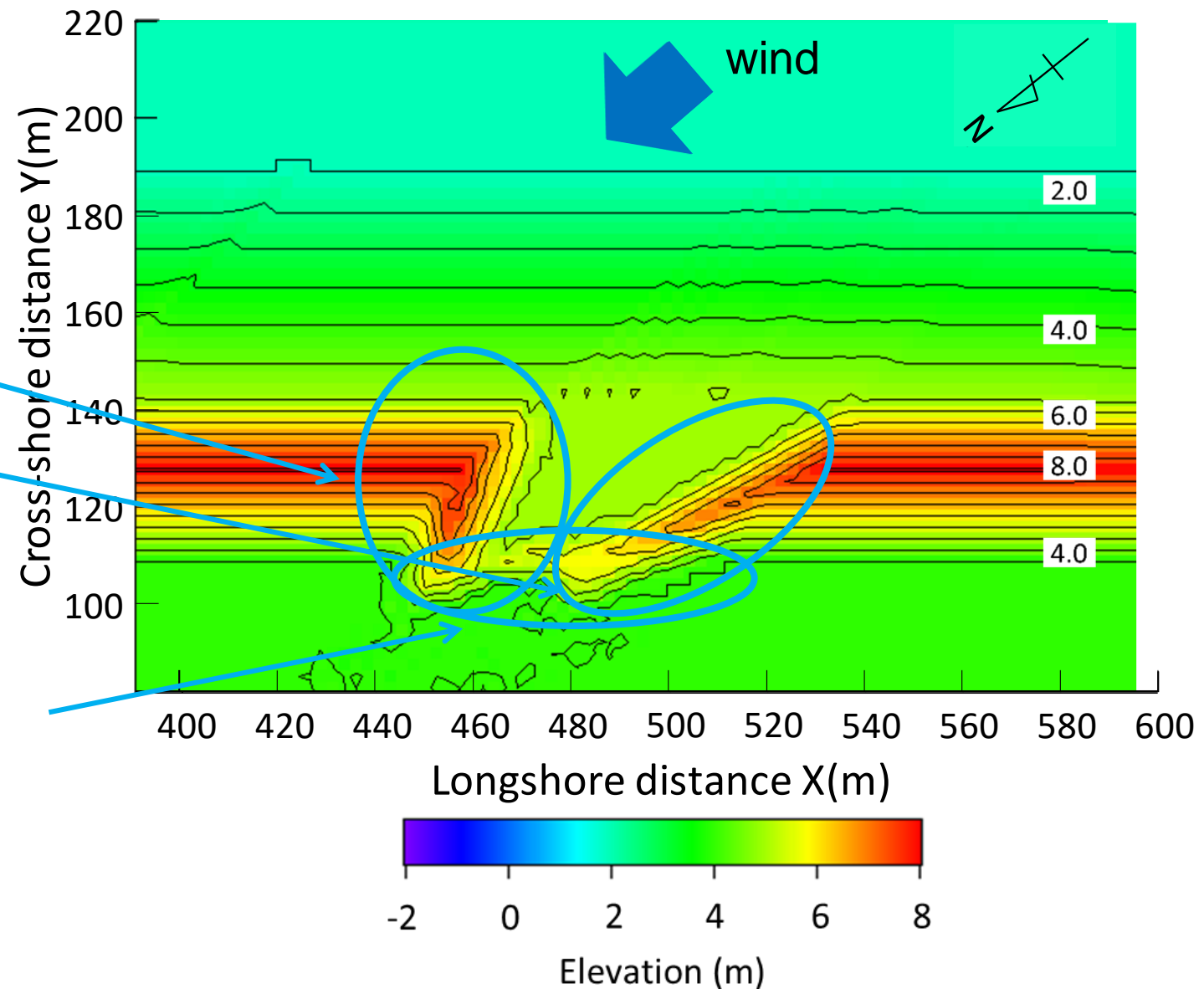
Along wind direction



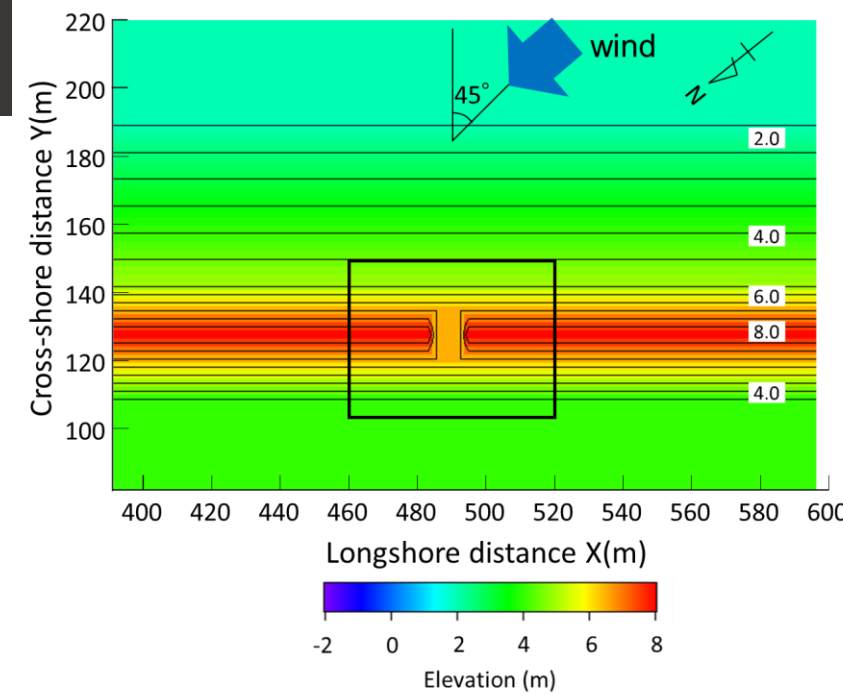
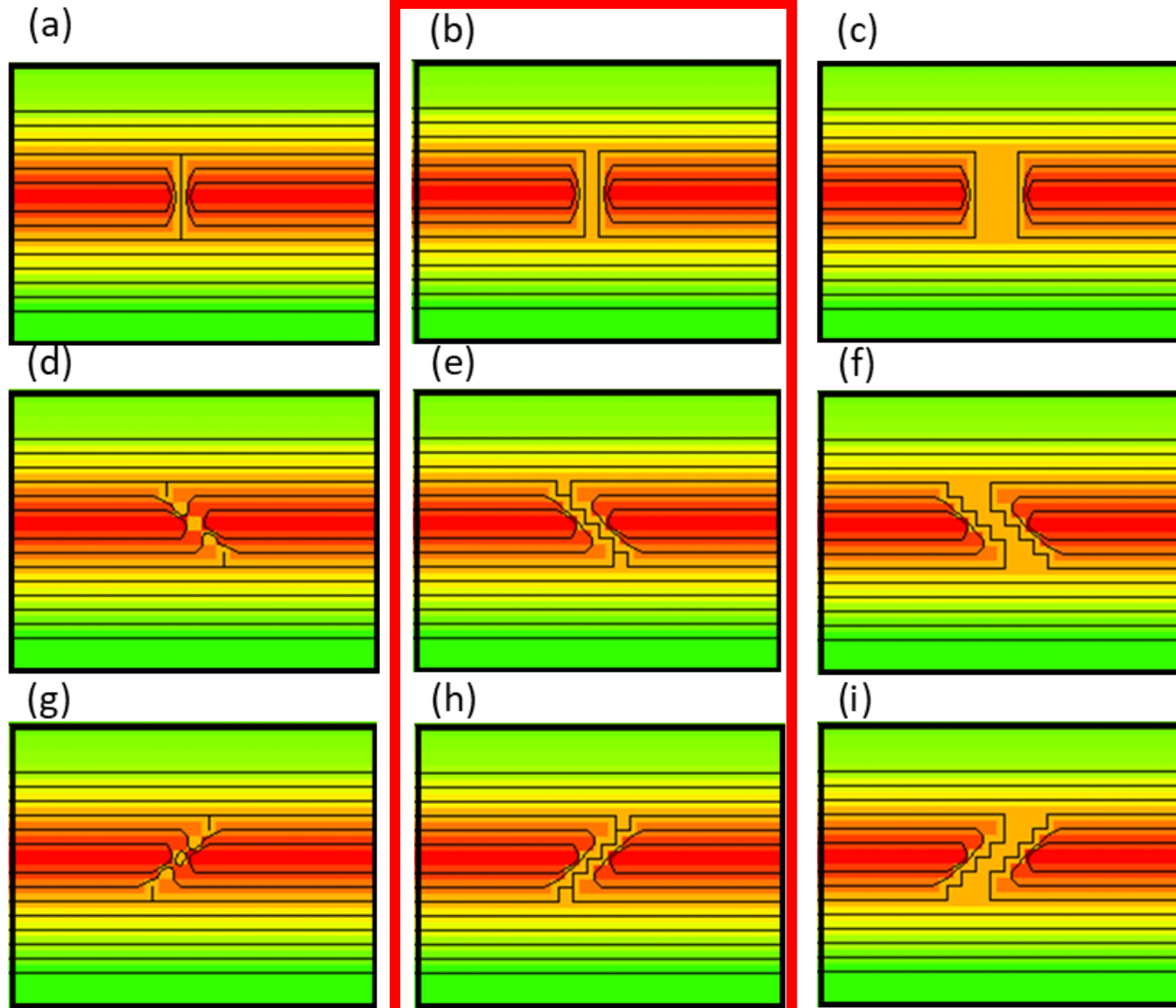
3.2. Calculation Result

■ Predicted topography after 800 steps

- Wind coming from the south
- Formation of steep slope
- Formation of slender mound
- Windblown sand was deposited behind the sand dune, while forming a steep slope with the angle of repose of sand

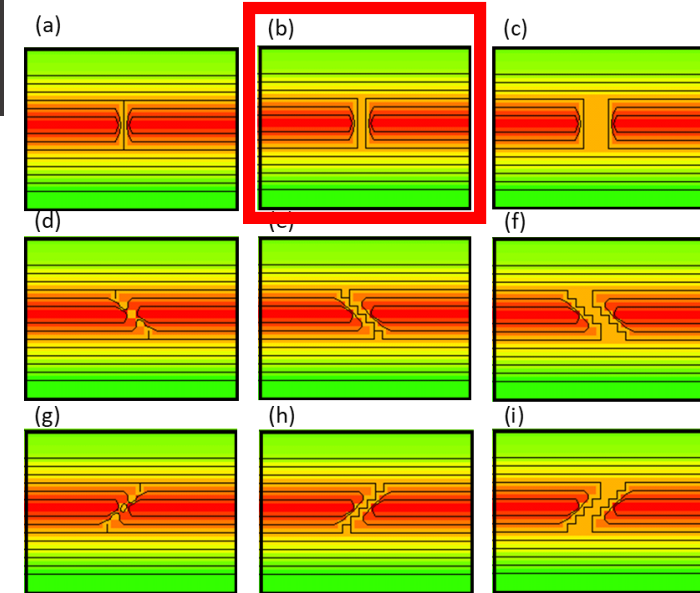
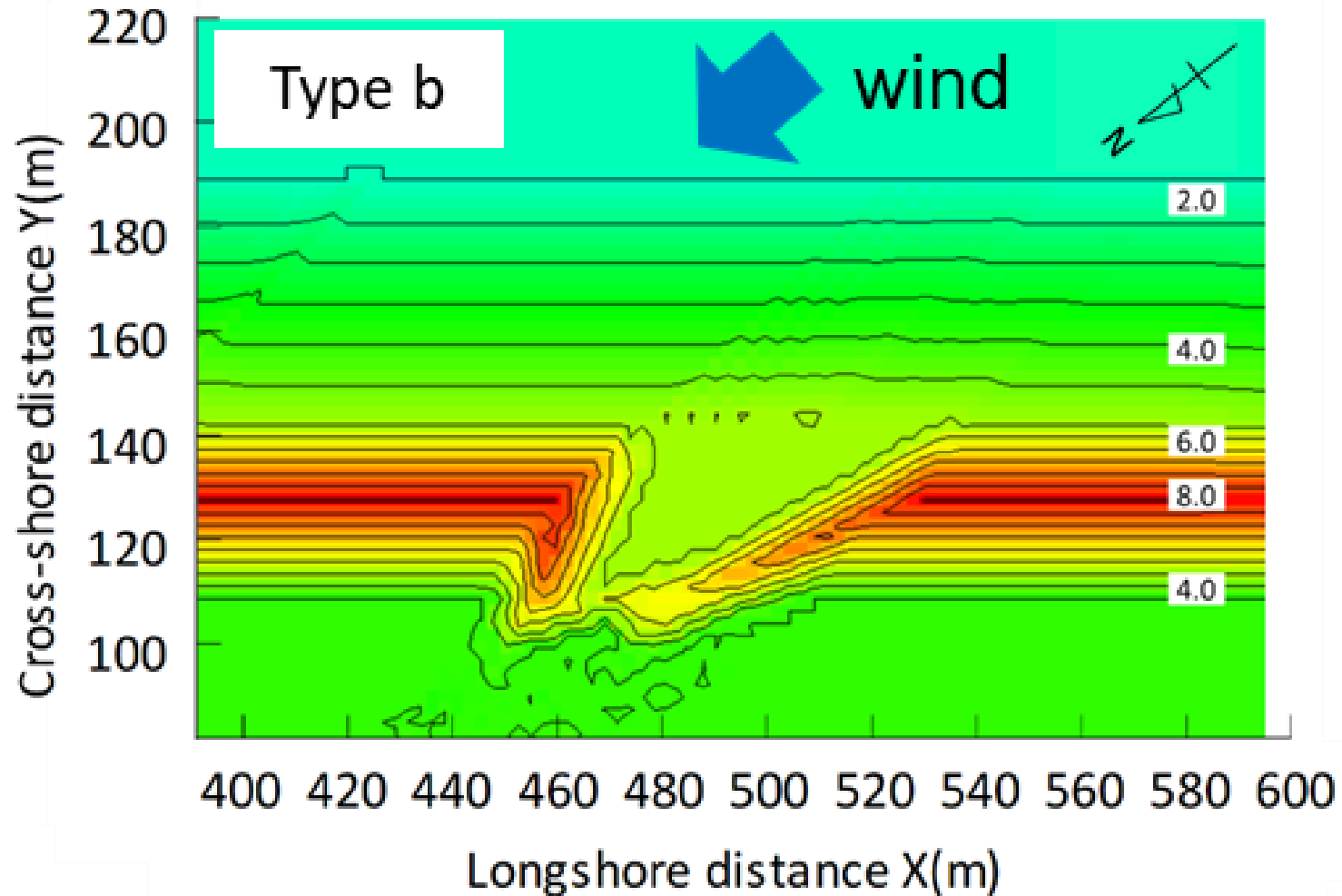


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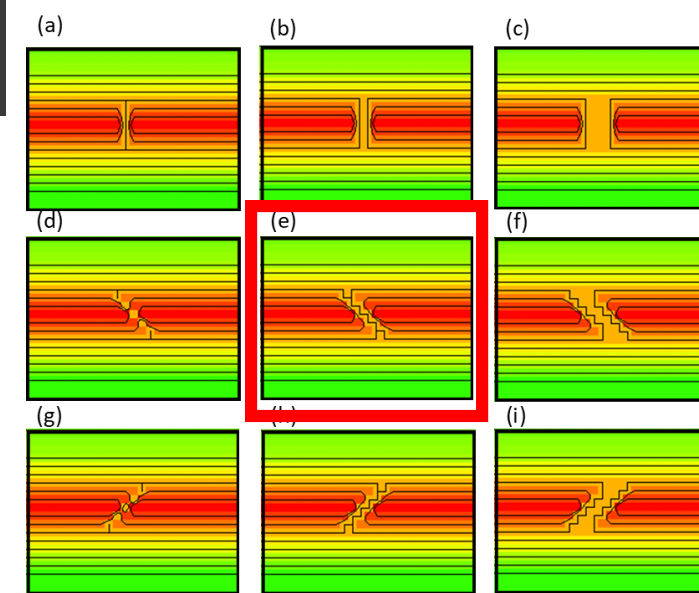
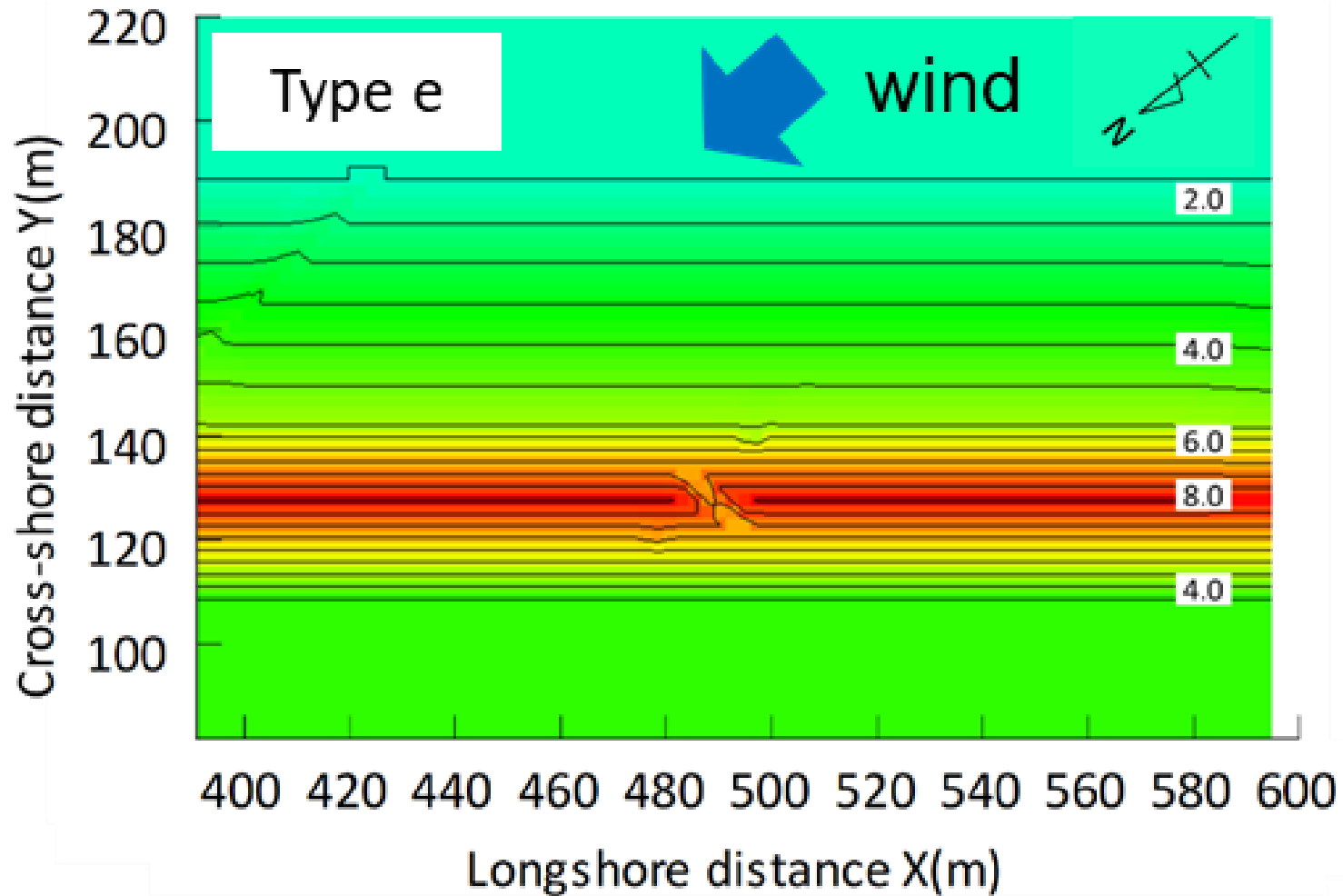
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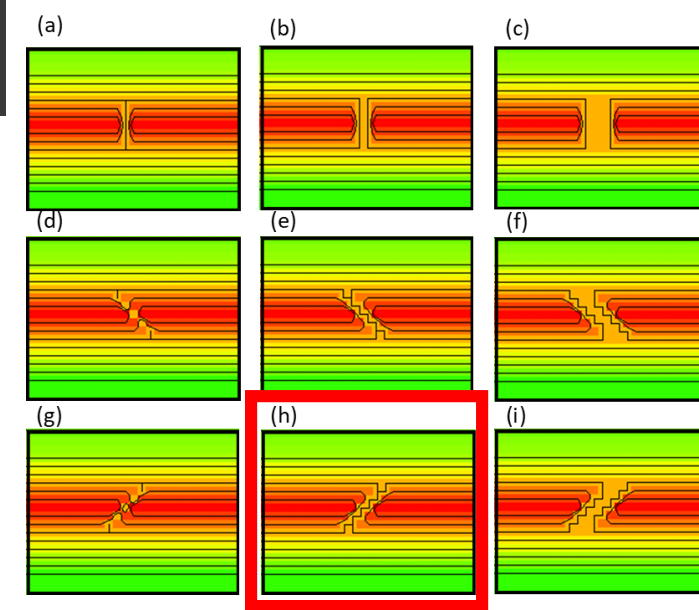
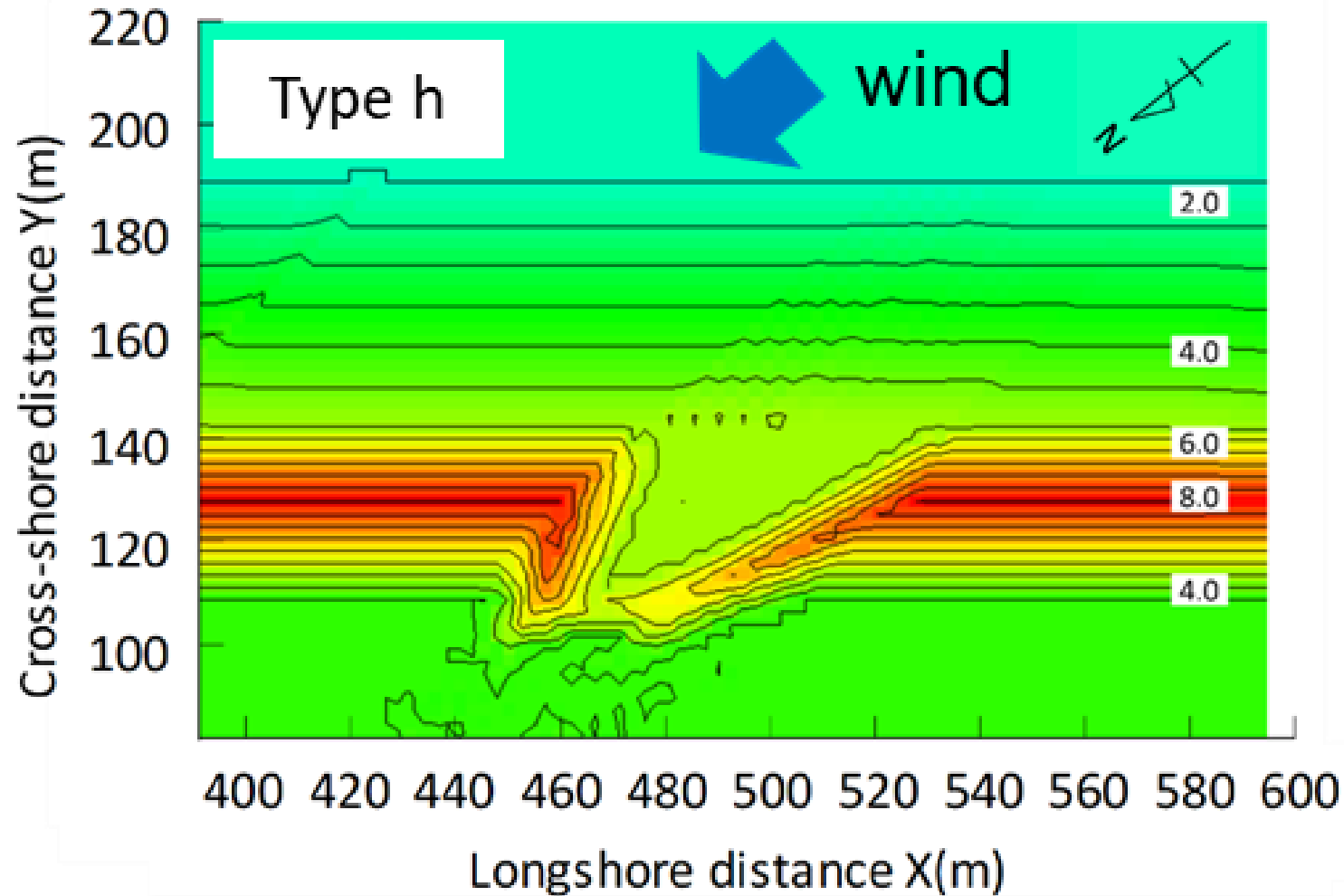
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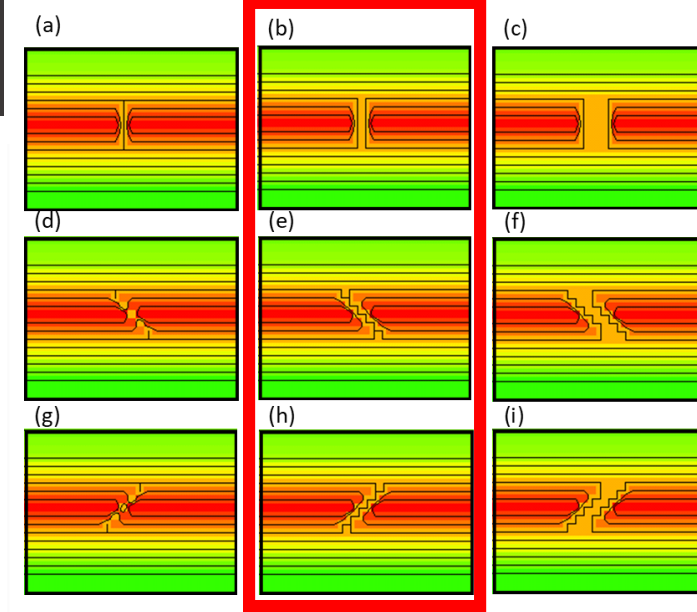
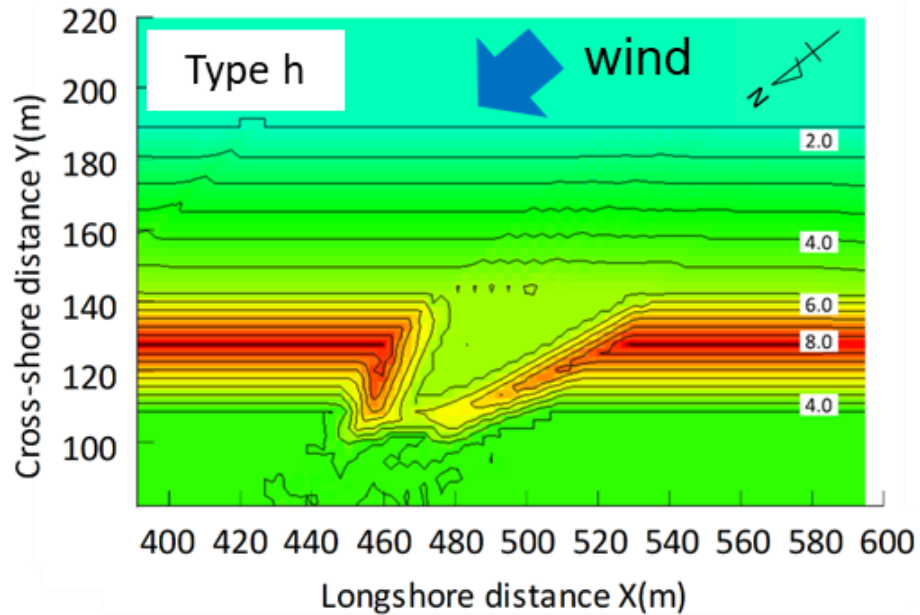
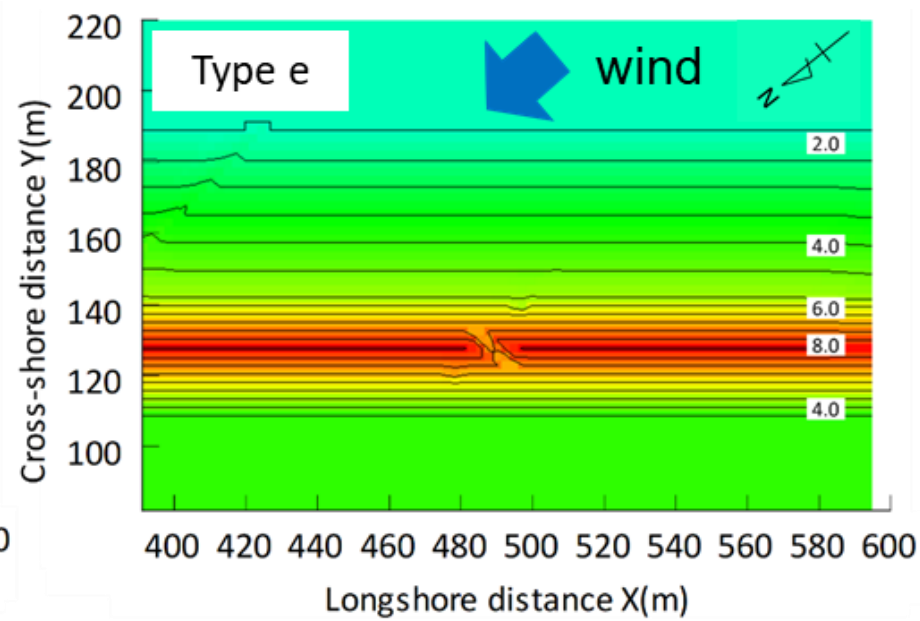
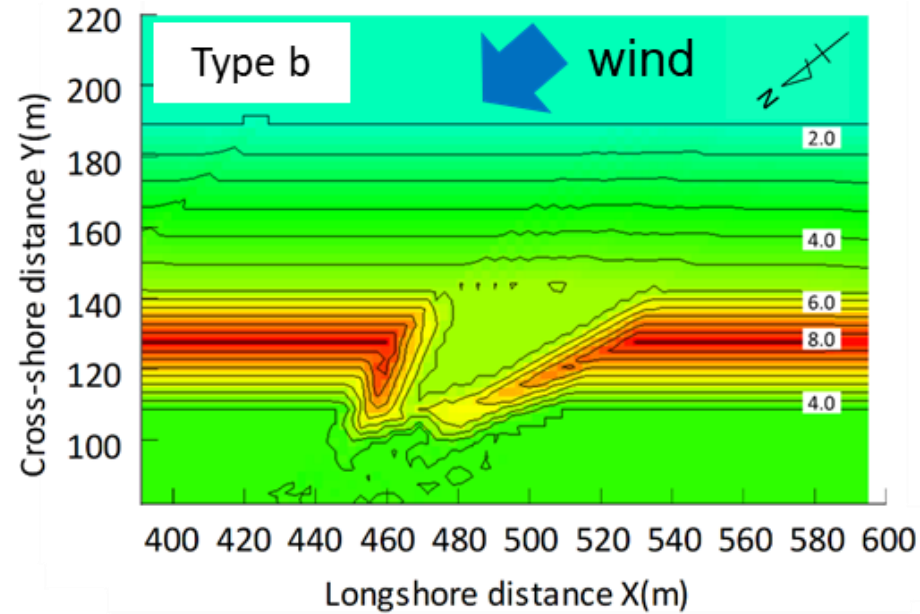


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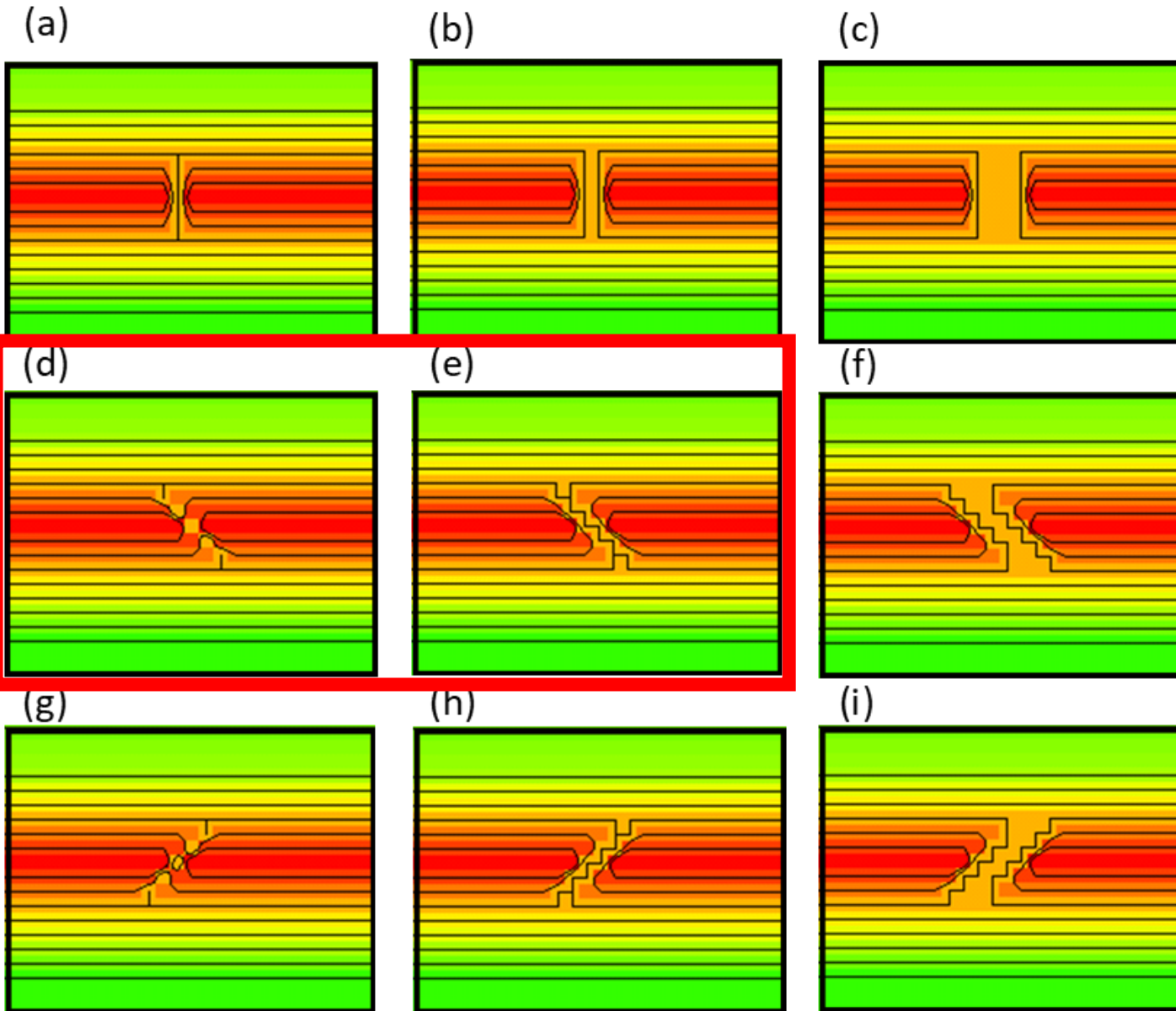
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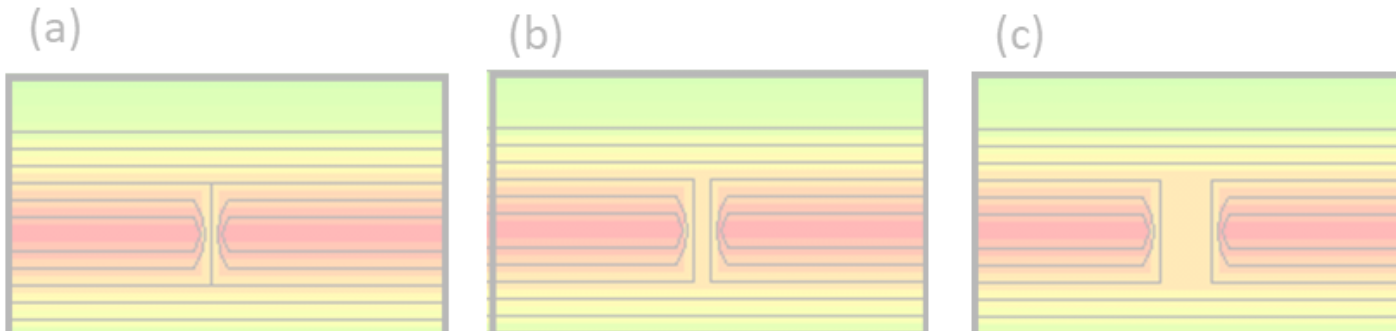
- No blow out formation was depicted in type e
 - the beach access was maintained
 - windblown sand was not able to advance behind the sand dune.

3.2. Calculation Result

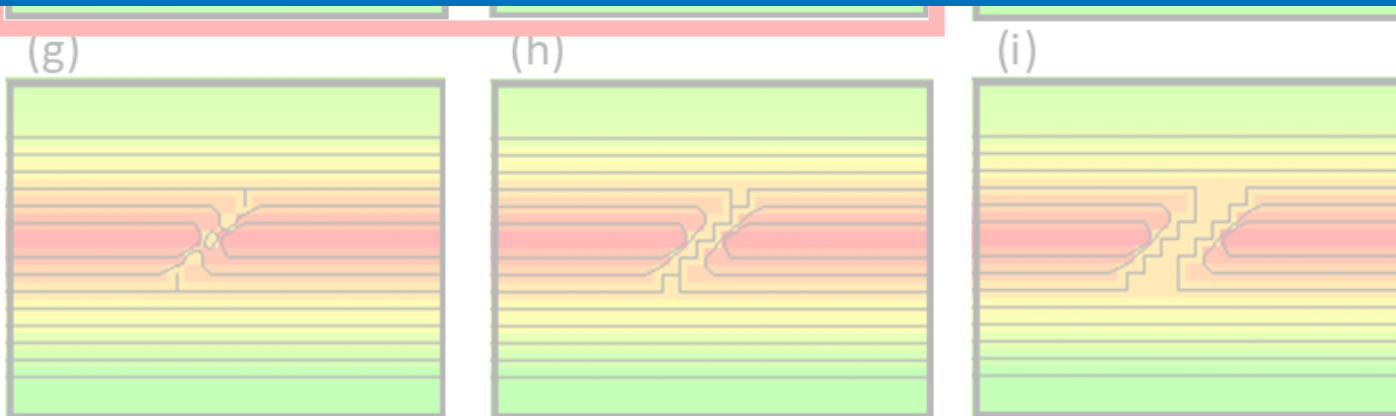
Types d & e
didn't depict
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3.2. Calculation Result



- It can be stated that in order to prevent blowout formation on the access, its direction should be set normal to the prevailing direction of the wind and as much as possible the access width should be narrow.



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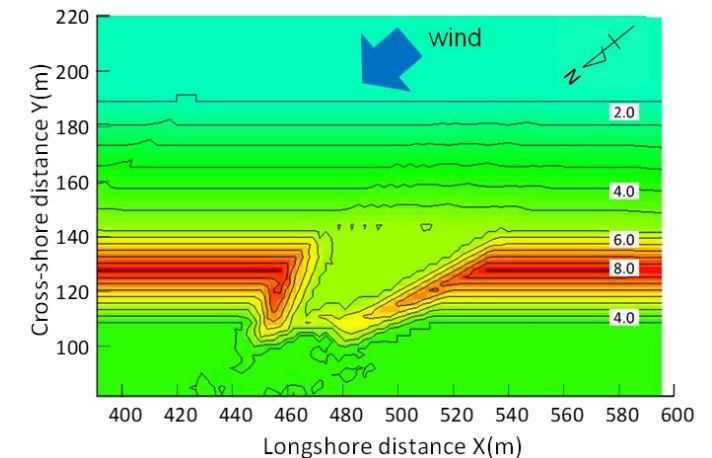
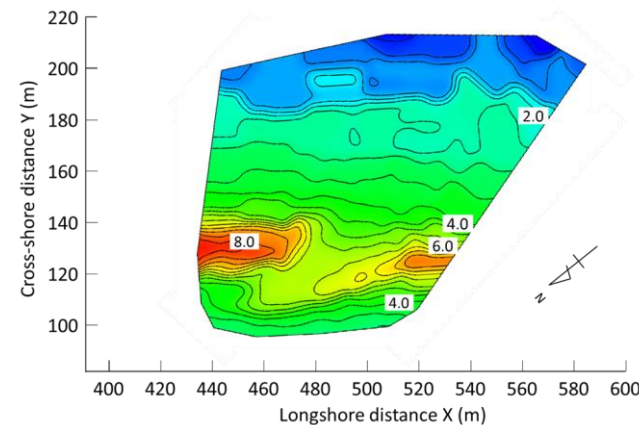
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1. Explanation of predicting model
2. Calculation result

4. Conclusion

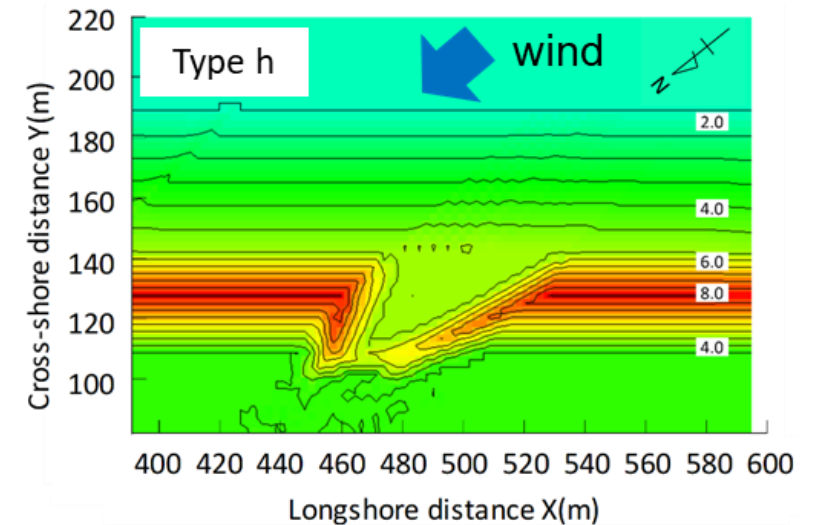
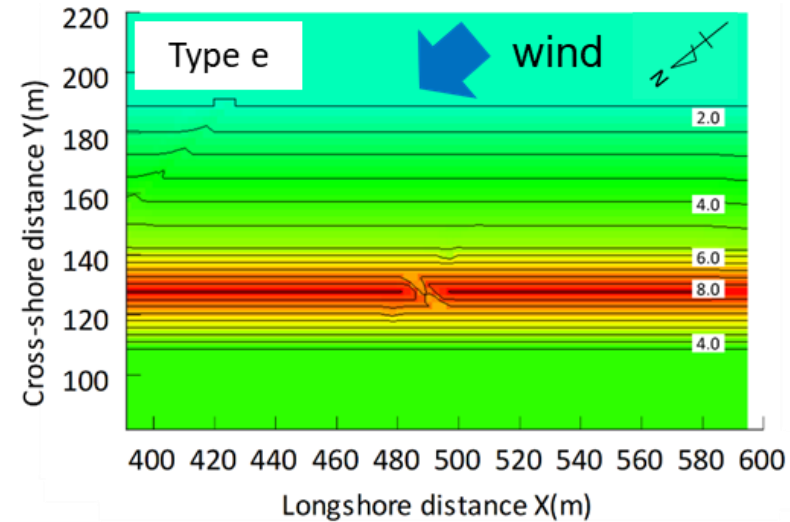
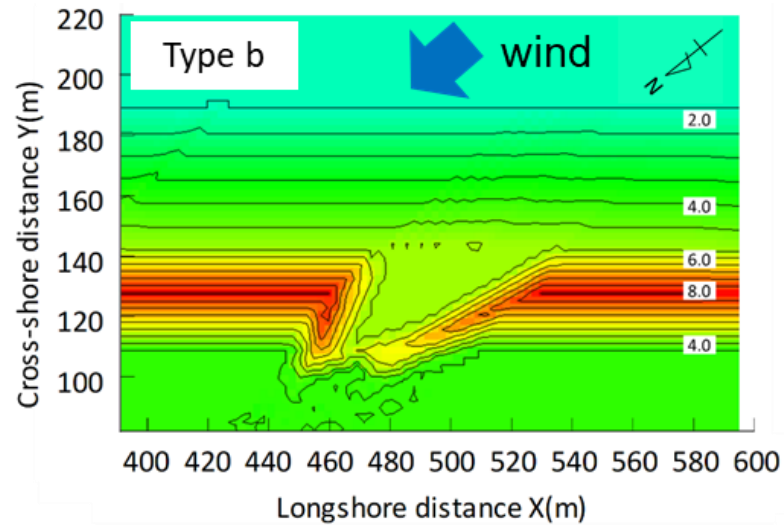
Conclusion

- From the Node Coast wind record analysis, development of sand dune blowout begun in 2012 because of the markedly increase of strong wind over 10m/s during that year. It resulted to rapid development of blowout. This is the cause of the rapid development of a blowout.
- Model for predicting the formation of a blowout was developed using a cellular automaton method.
- The results of the numerical simulation were in good agreement with those measured on the Node coast.



Conclusion

- It can be stated that in order to prevent blowout formation on the access, its direction should be set normal to the prevailing direction of the wind and as much as possible the access width should be narrow



Thank you for your attention

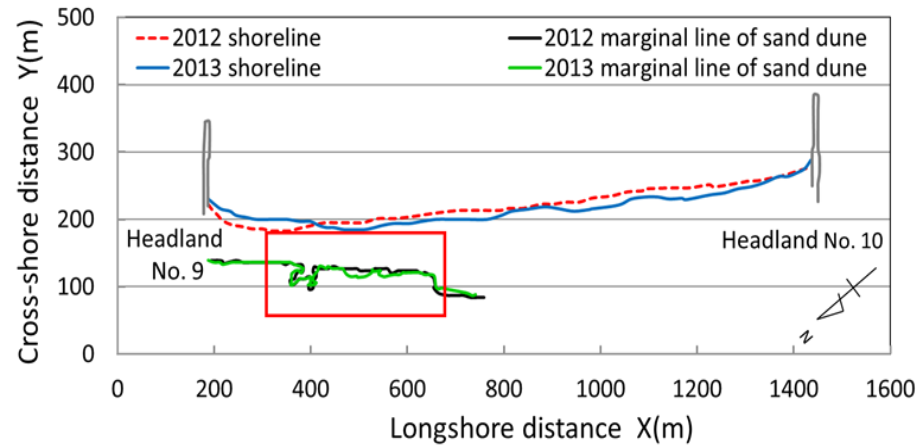
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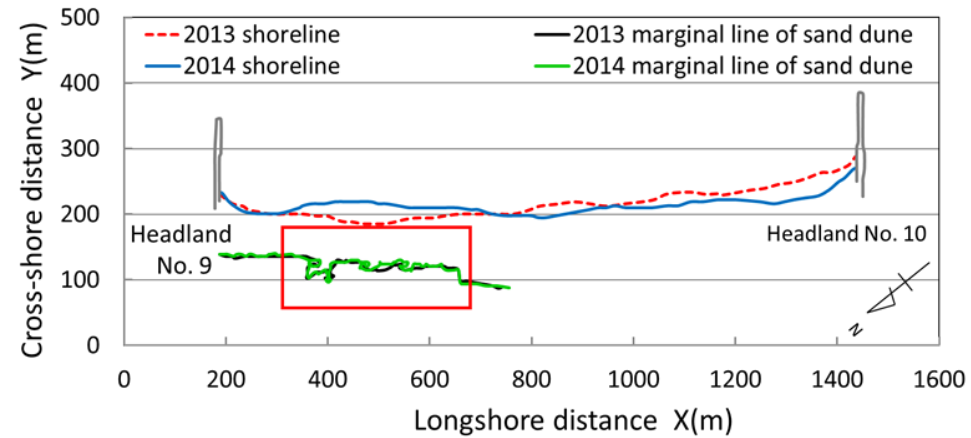


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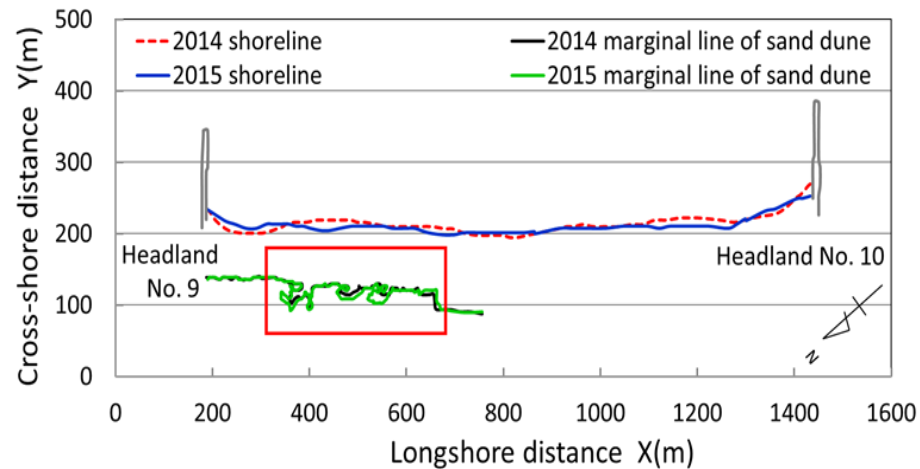
2012 vs 2013



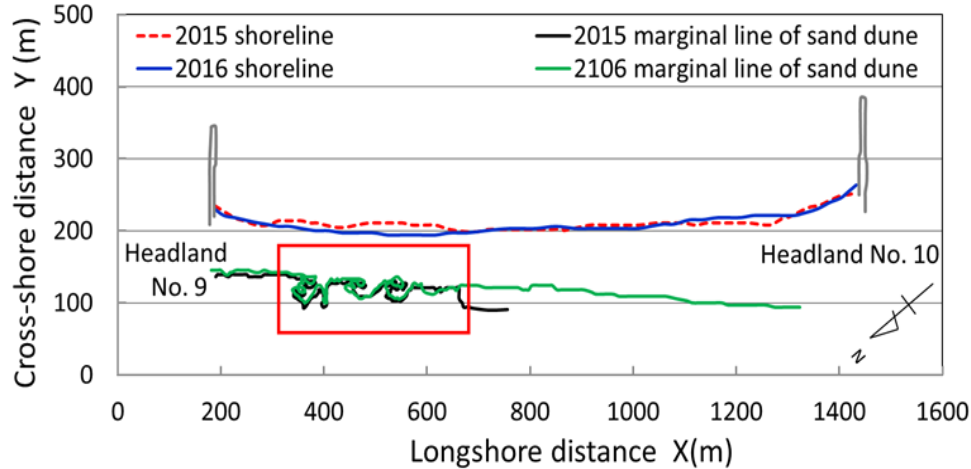
2013 vs 2014



2014 vs 2015

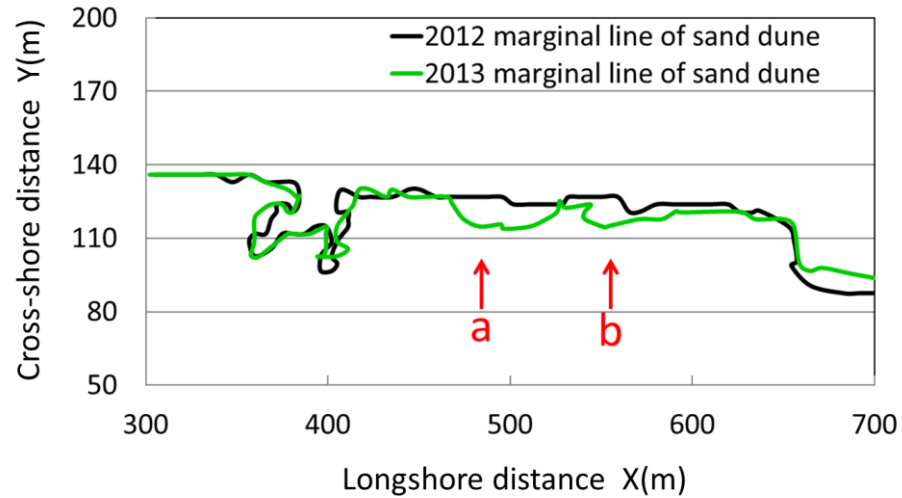


2015 vs 2016

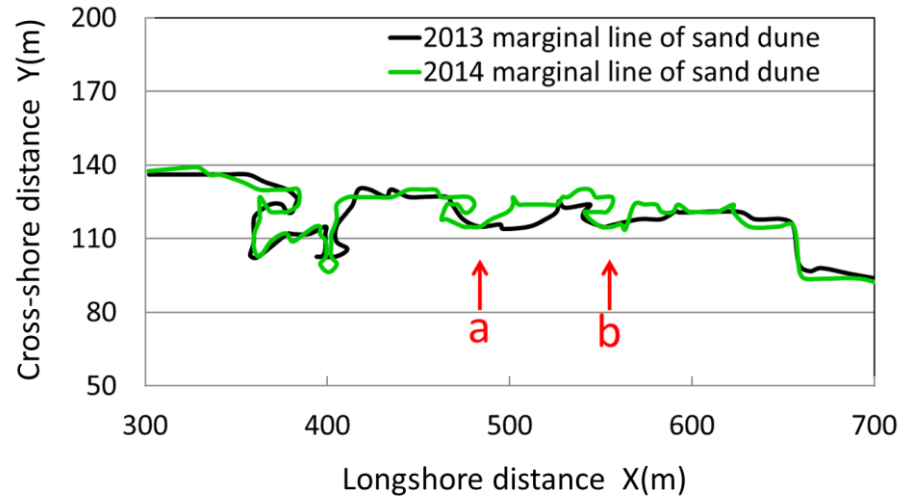


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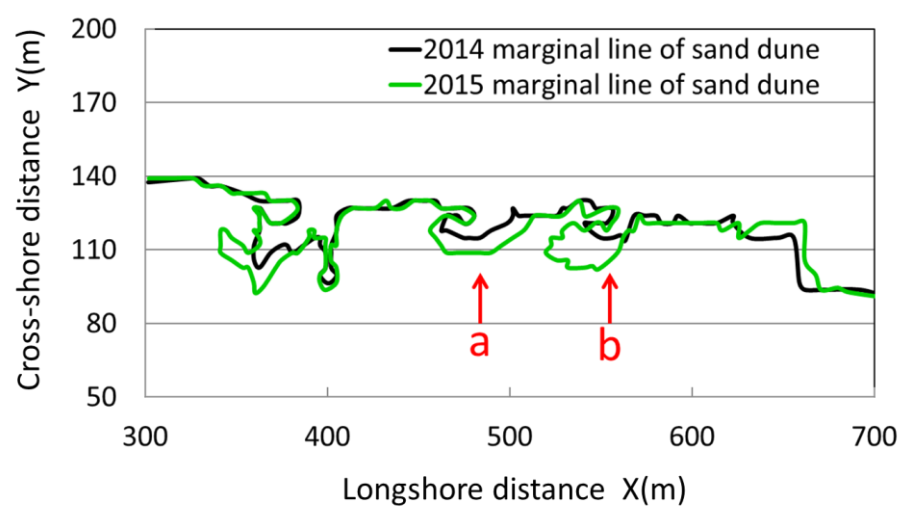
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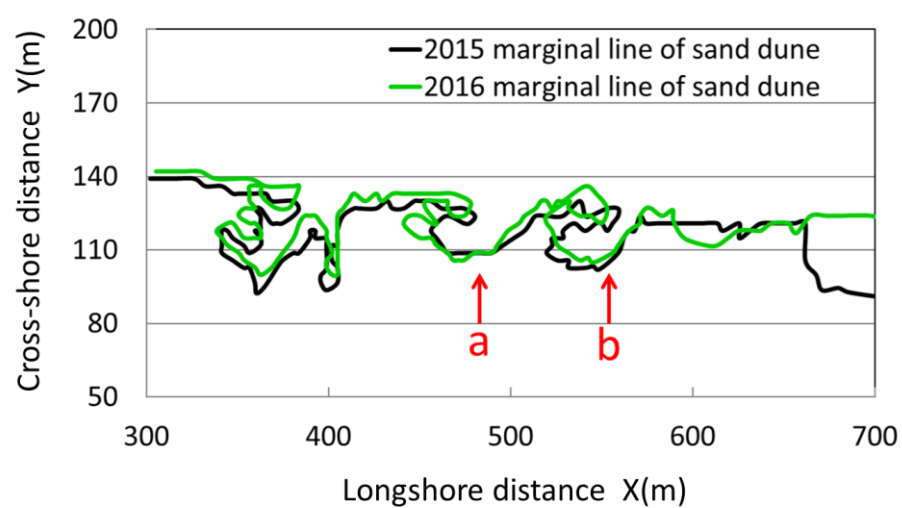
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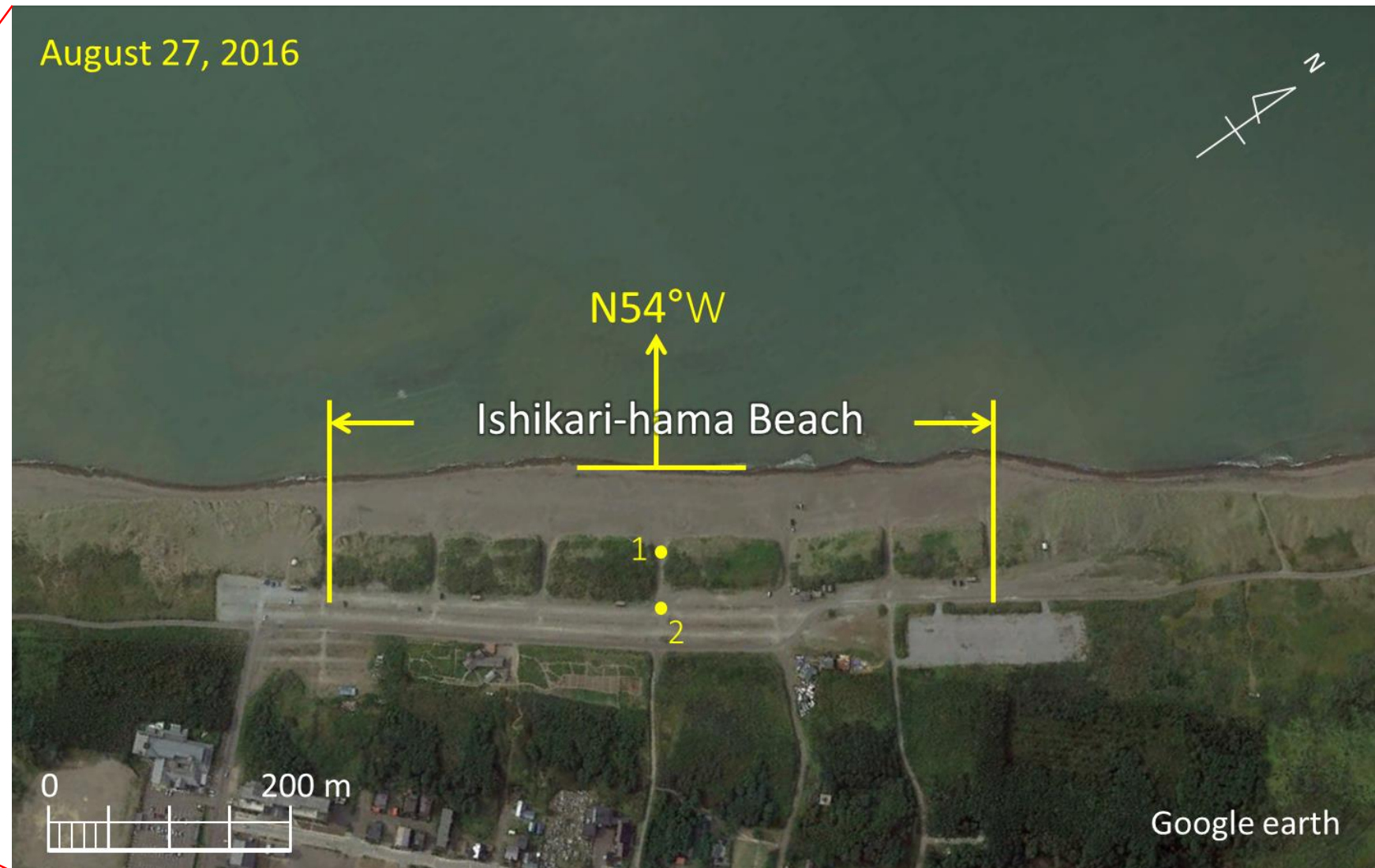
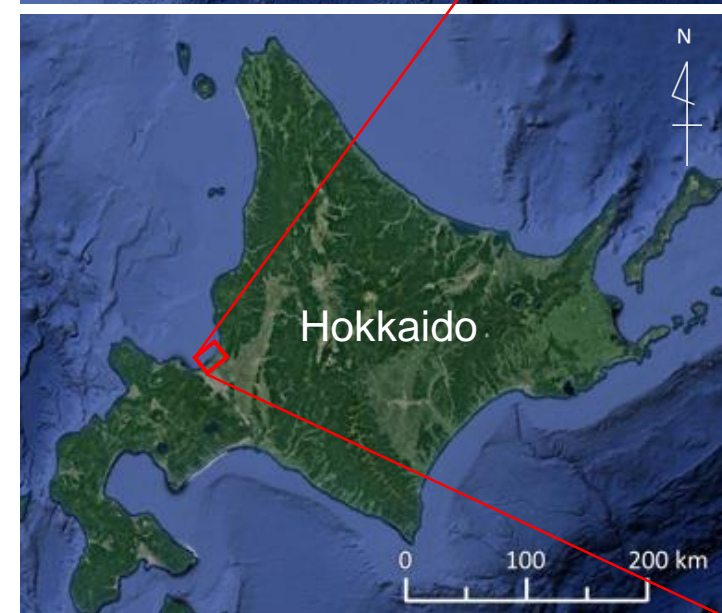
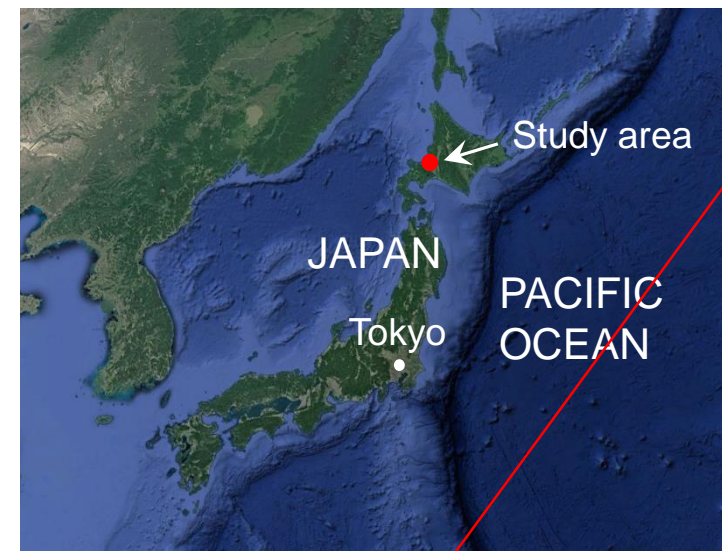
2014 vs 2015



2015 vs 2016



2.2. Field observation of sand dune on Ishikari-hama beach



2.2. Field observation of sand dune on Ishikari-hama beach



August 27, 2016



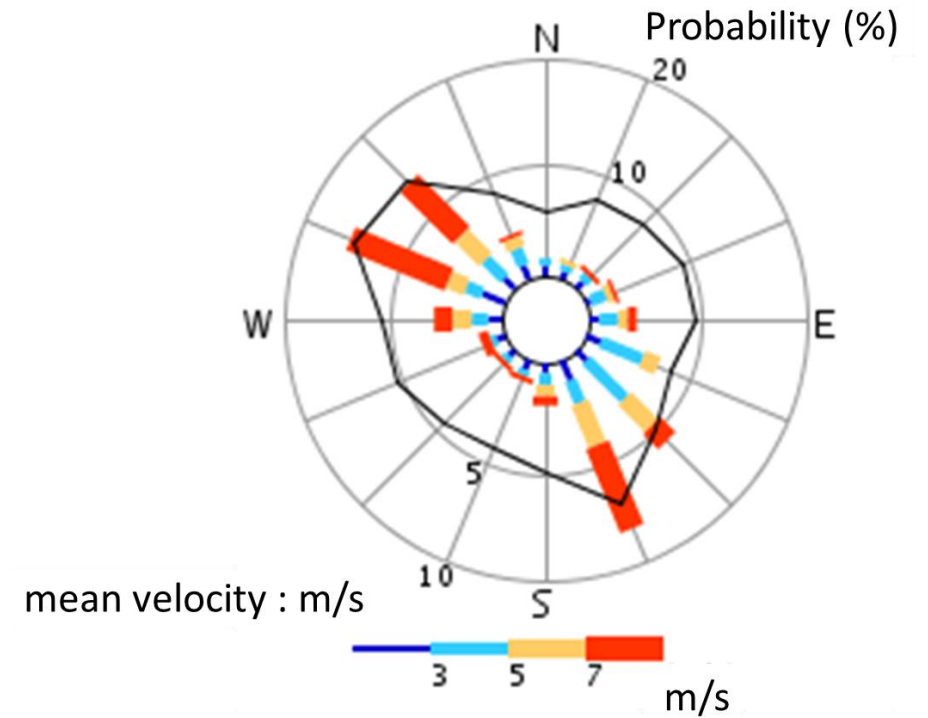
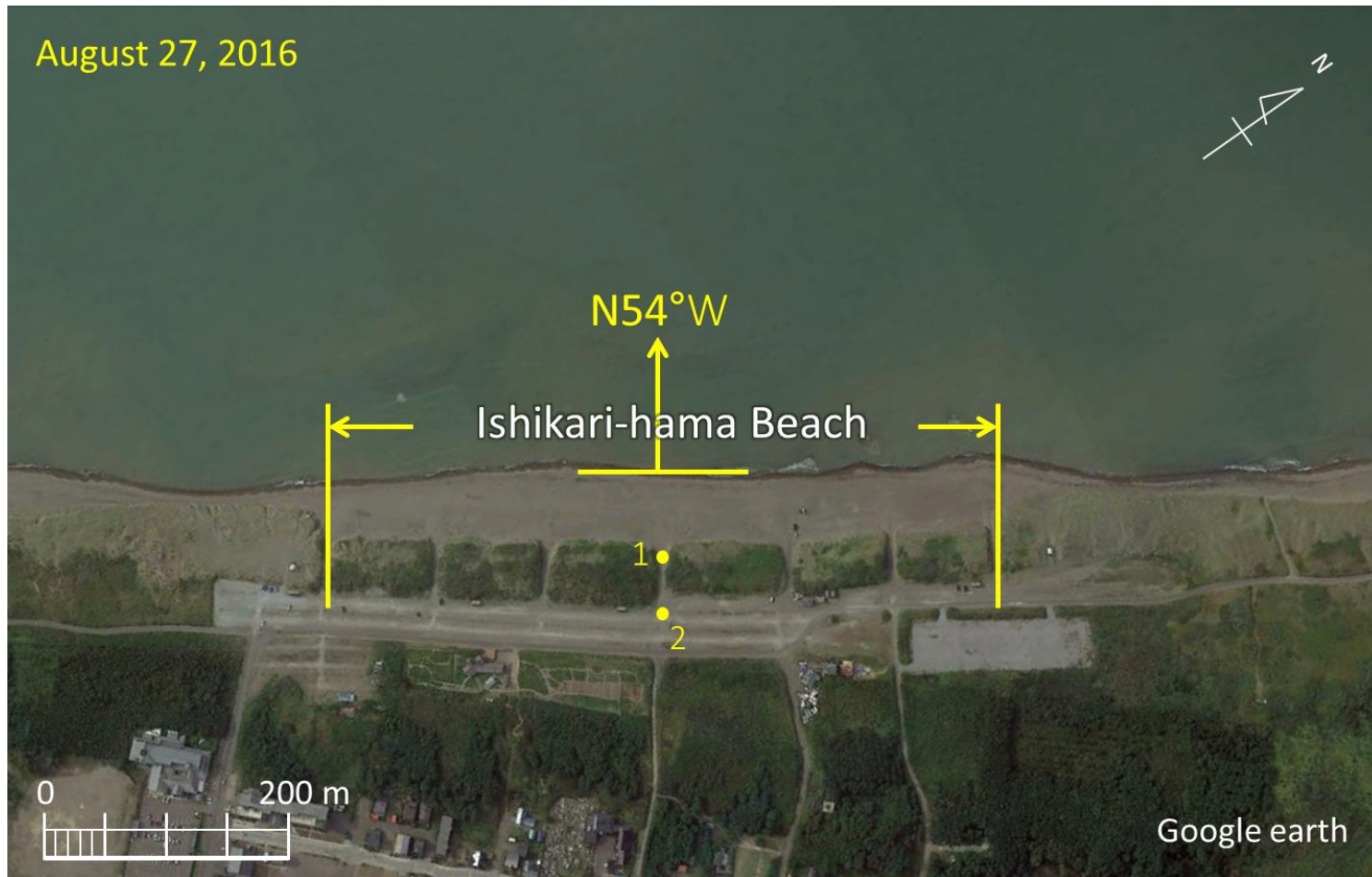
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August 27, 2016

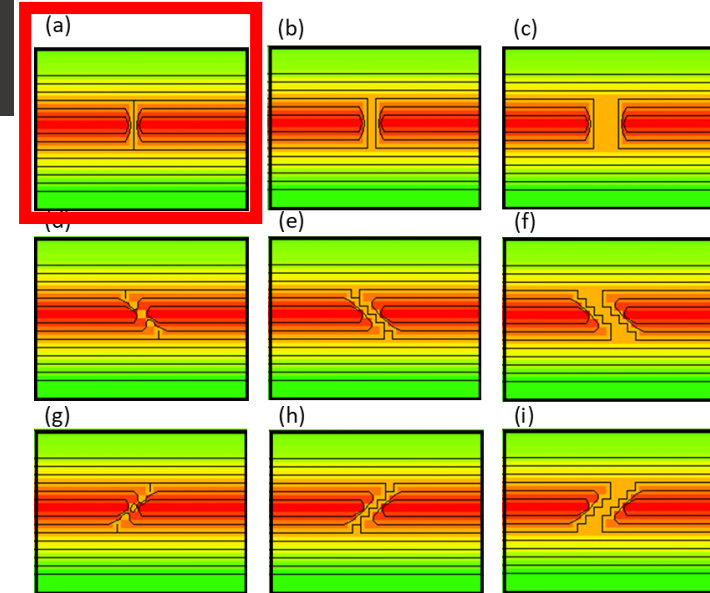
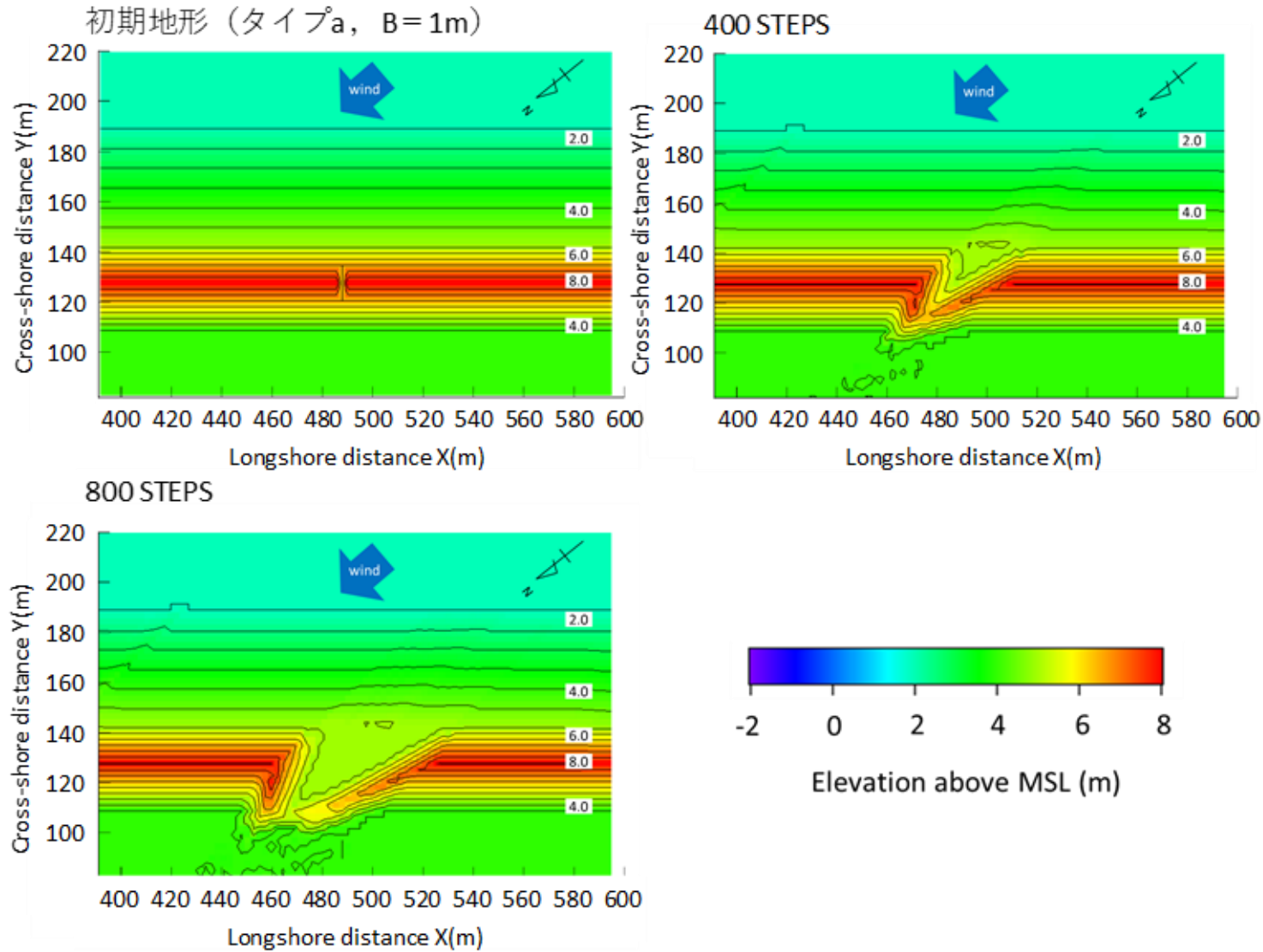


2.2. Field observation of sand dune on Ishikari-hama beach



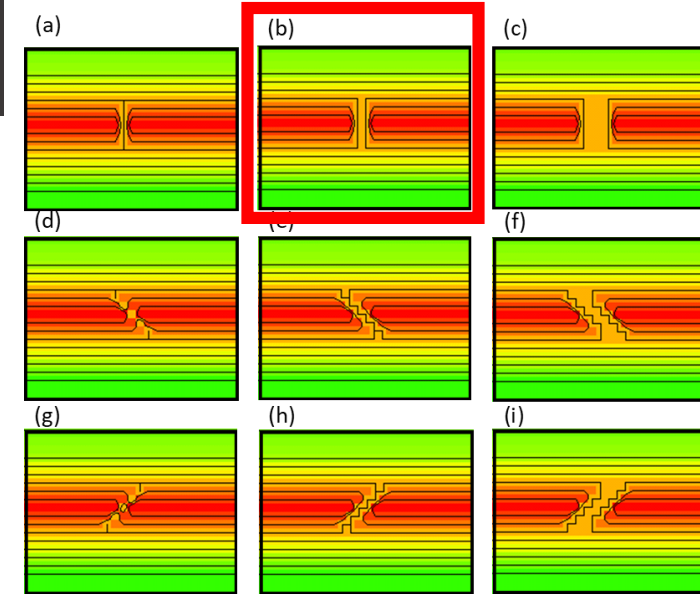
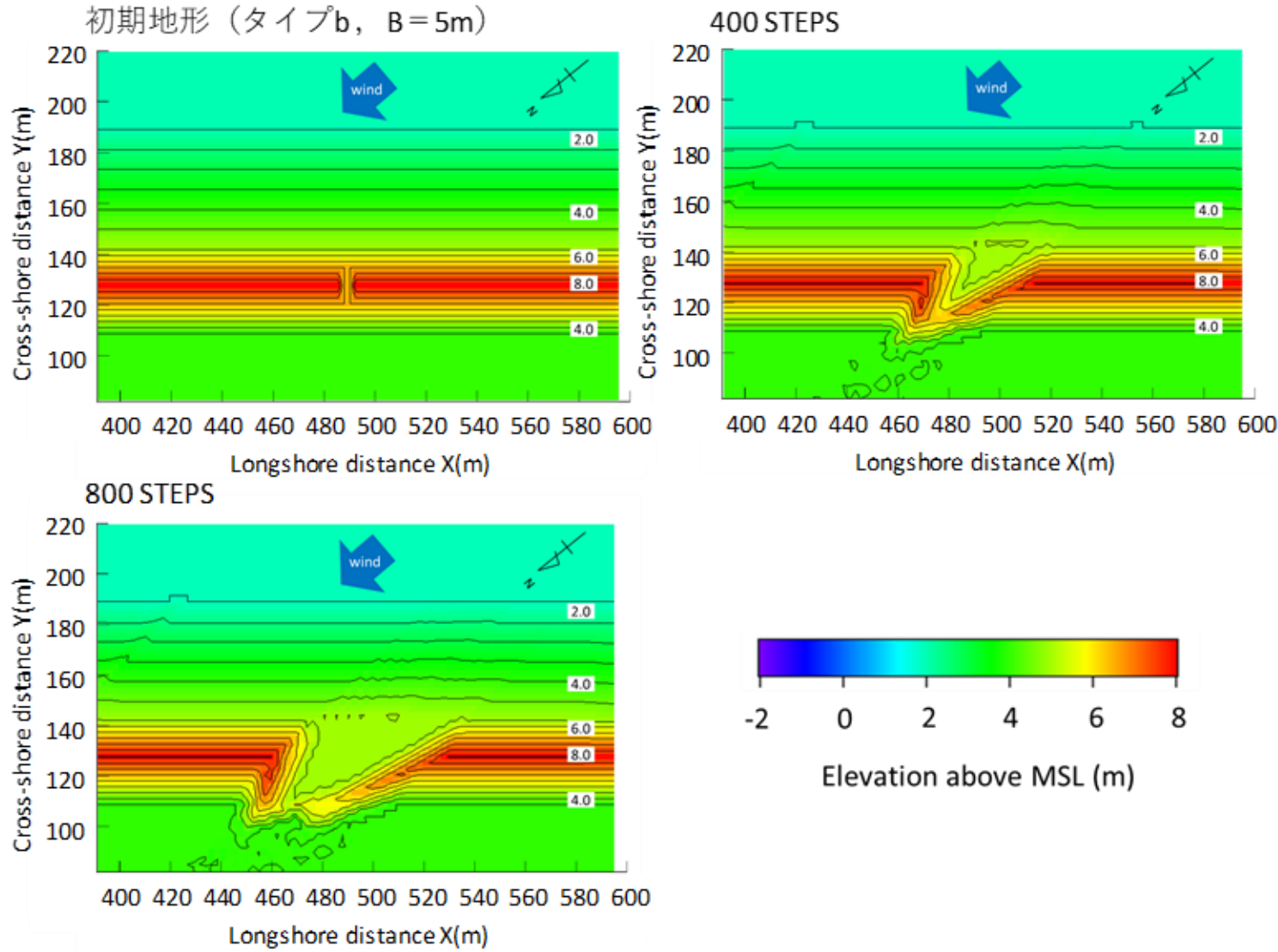
3.3. Calculation of some cases

■ Predicted topography type A



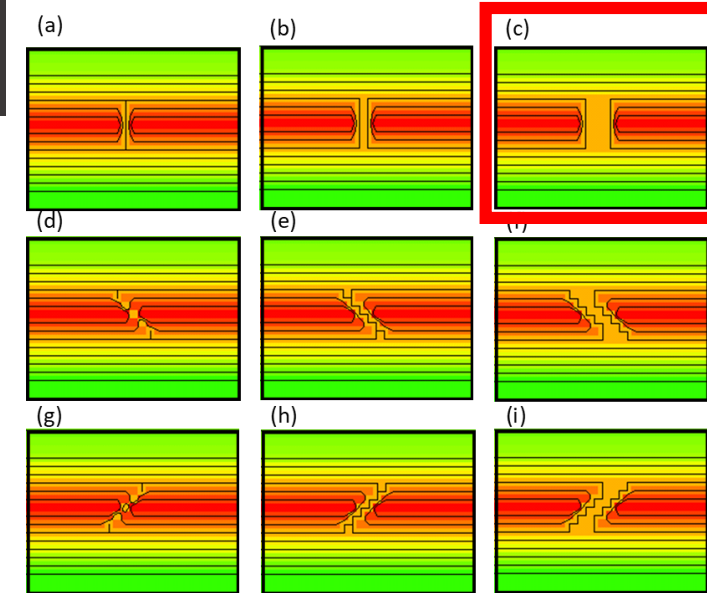
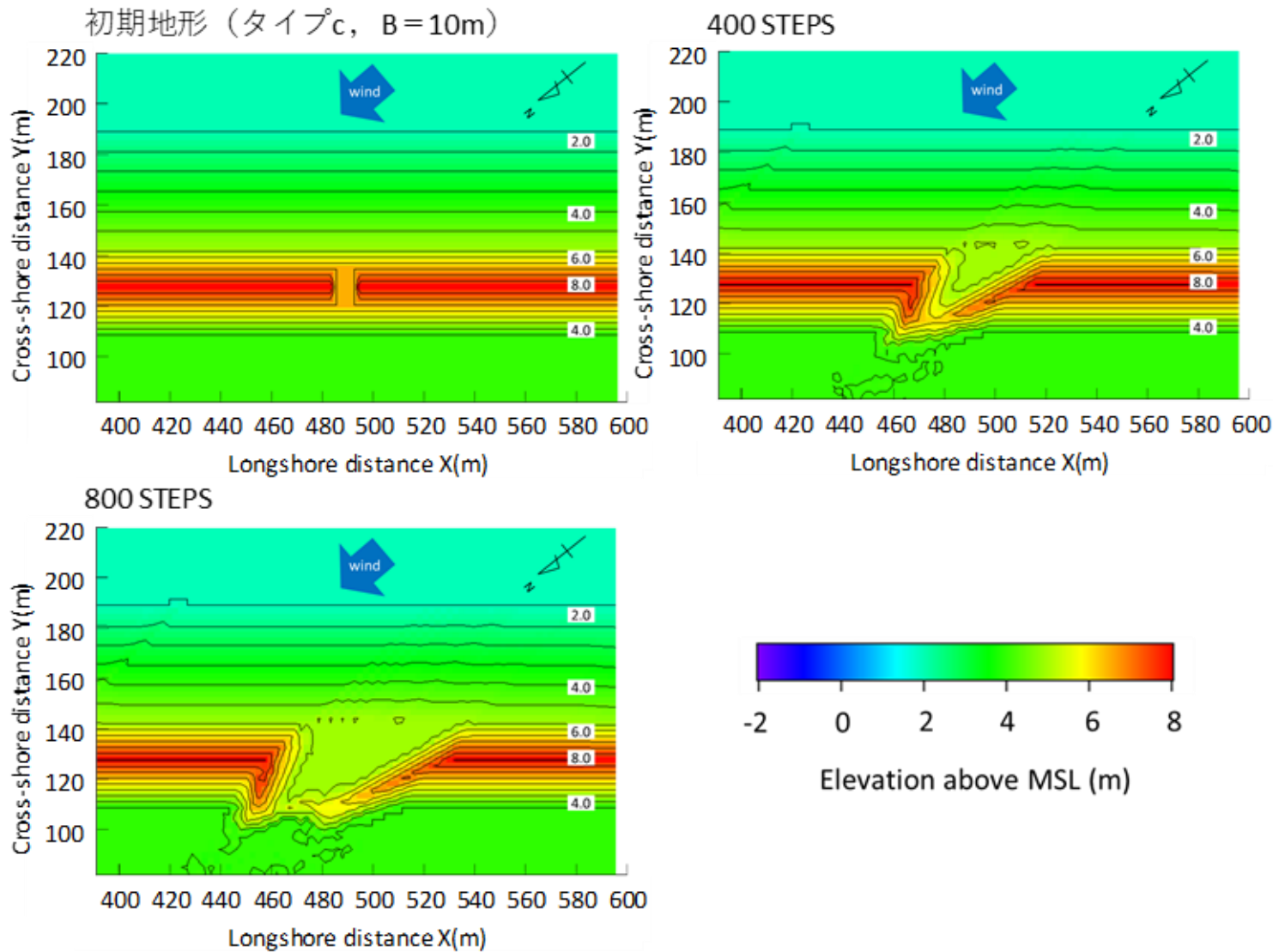
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■ Predicted topography type A



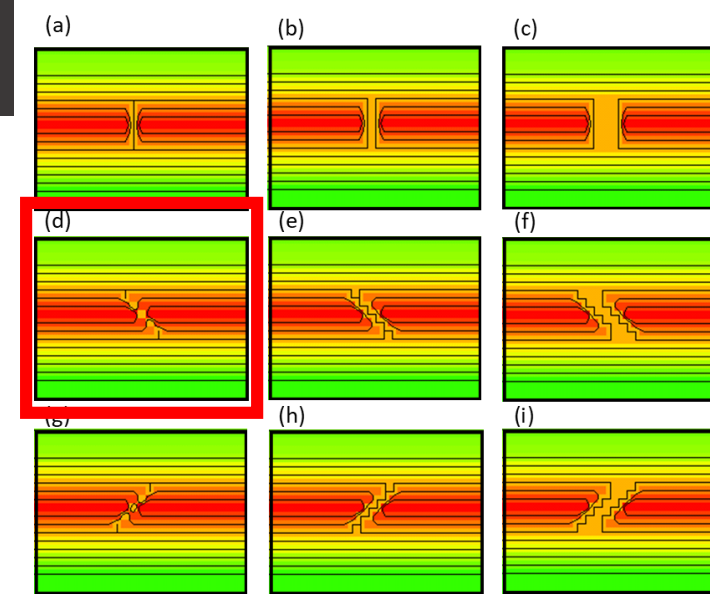
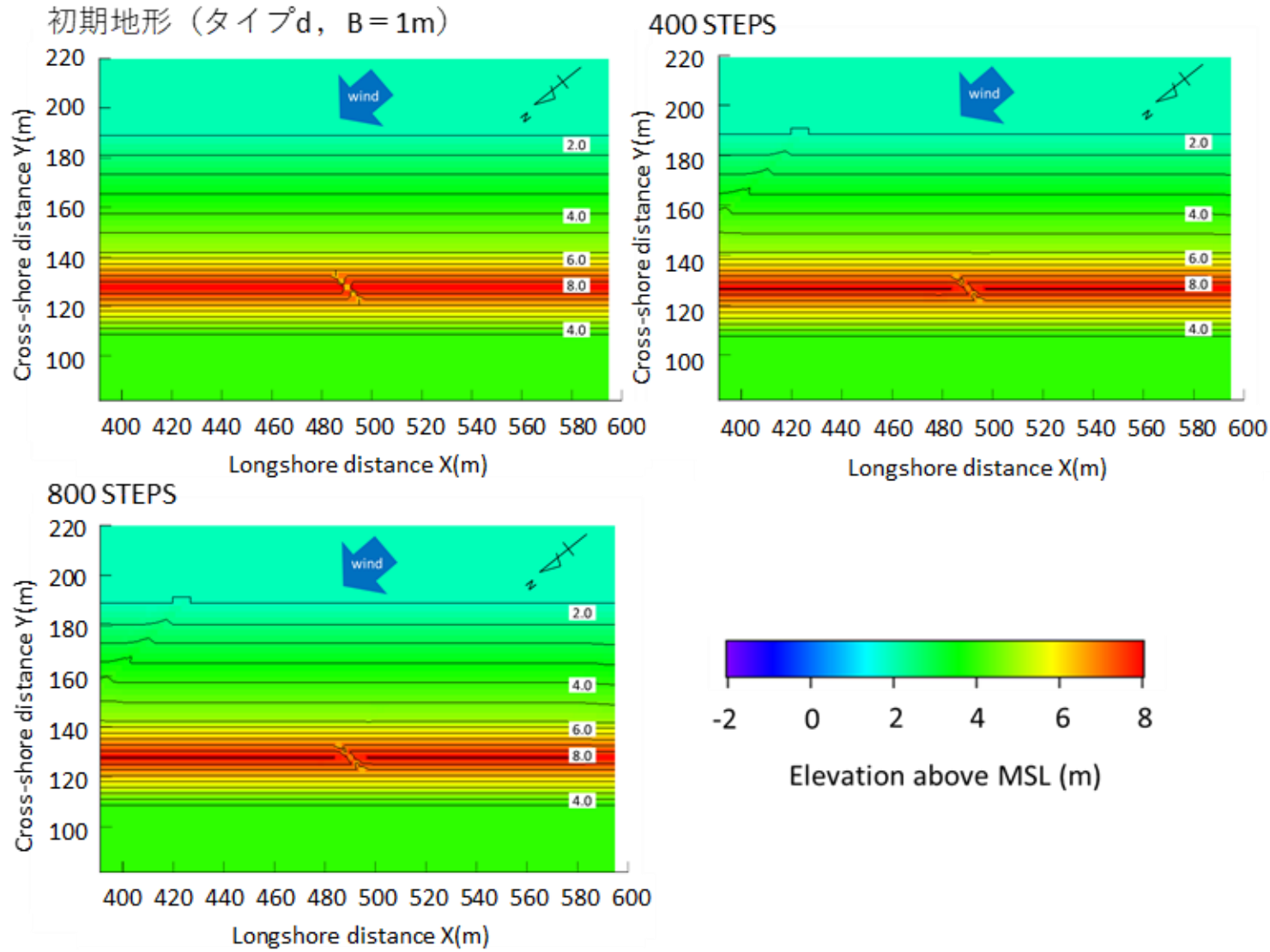
3.3. Calculation of some cases

■ Predicted topography type A



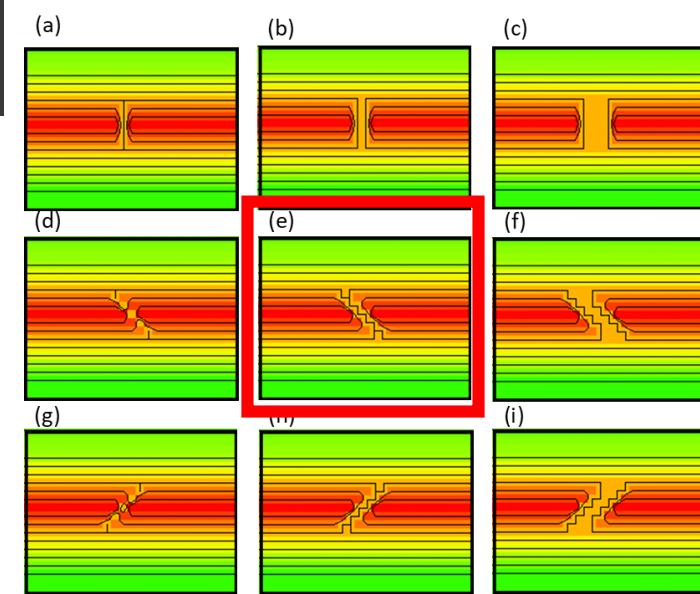
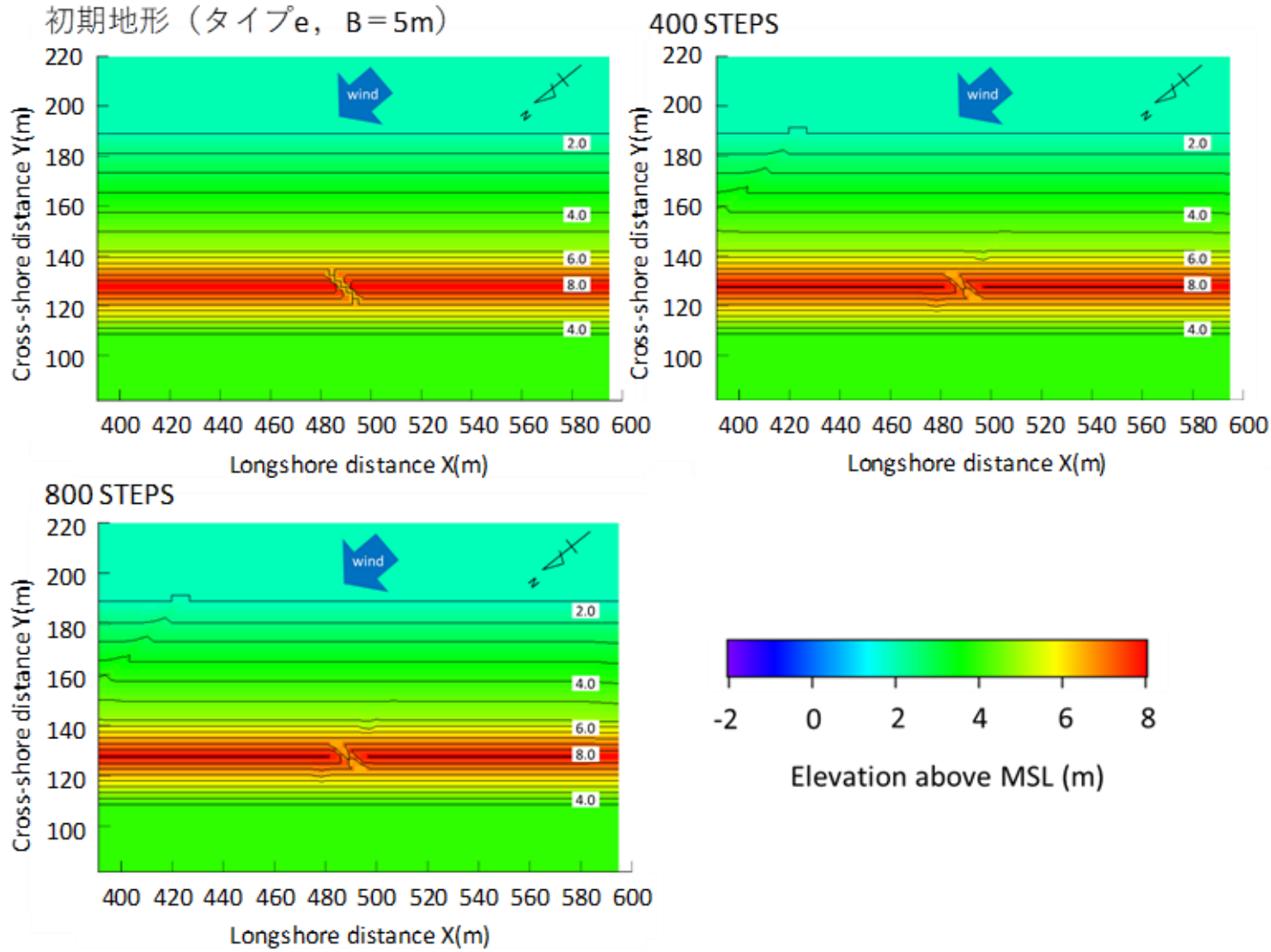
3.3. Calculation of some cases

■ Predicted topography type A



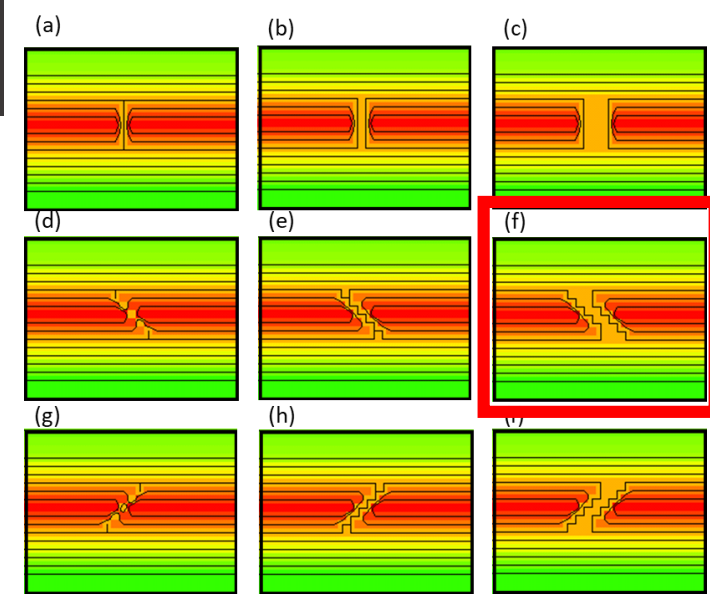
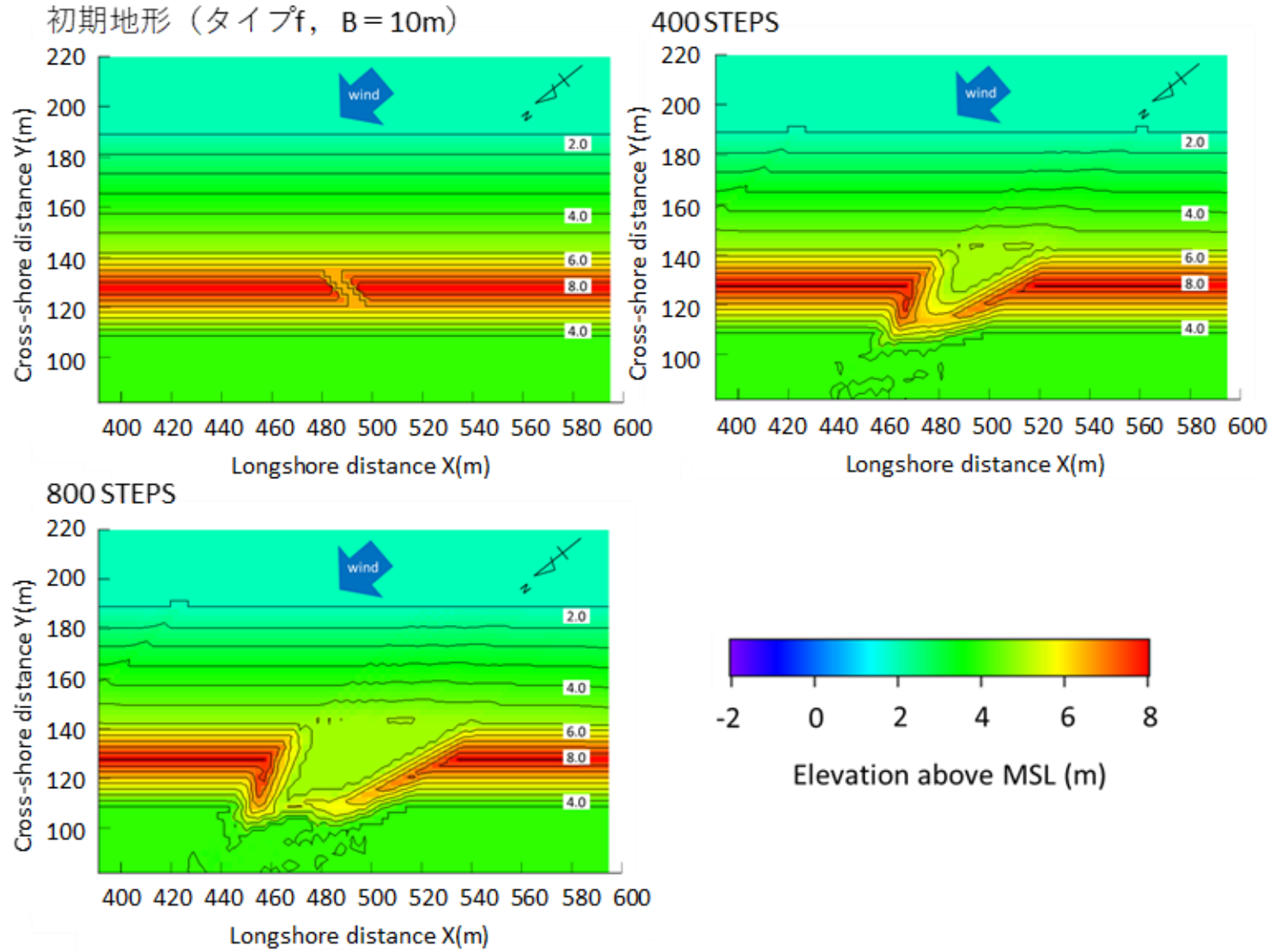
3.3. Calculation of some cases

■ Predicted topography type A



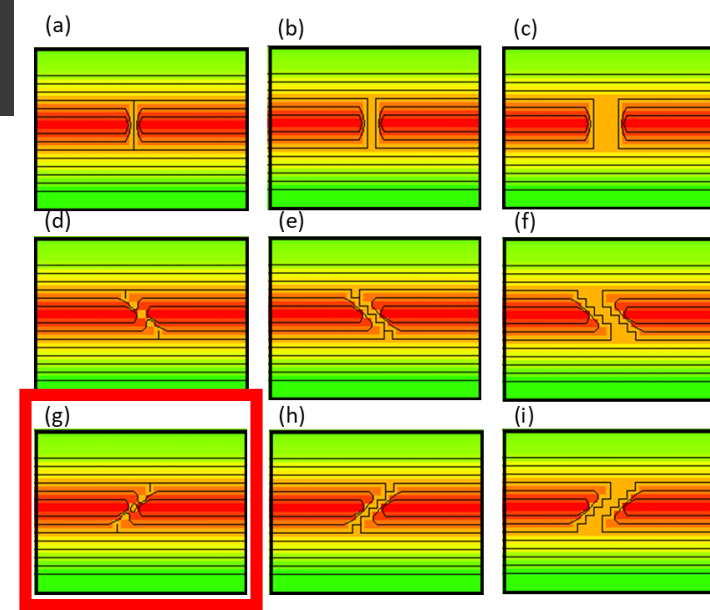
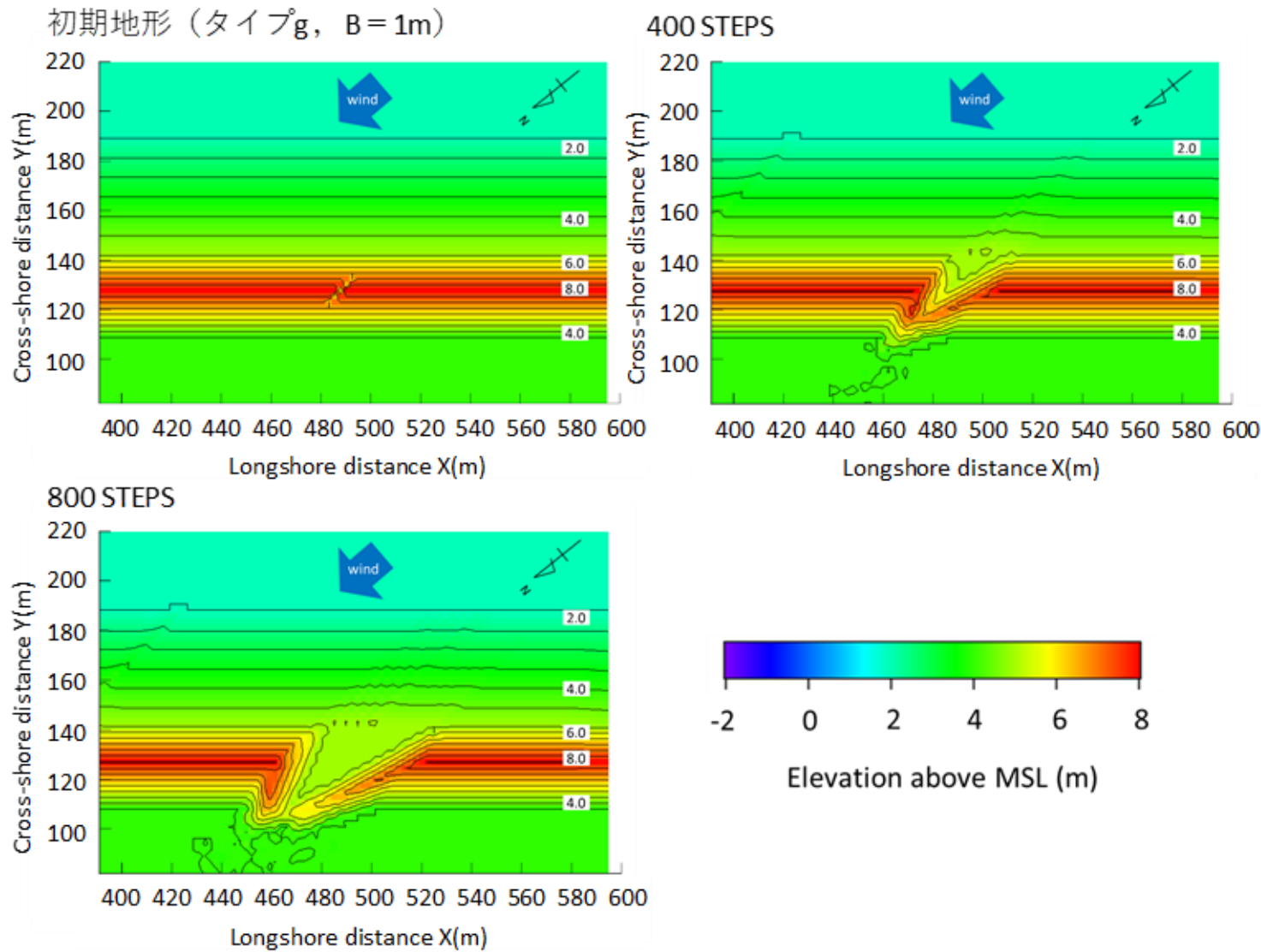
3.3. Calculation of some cases

■ Predicted topography type A



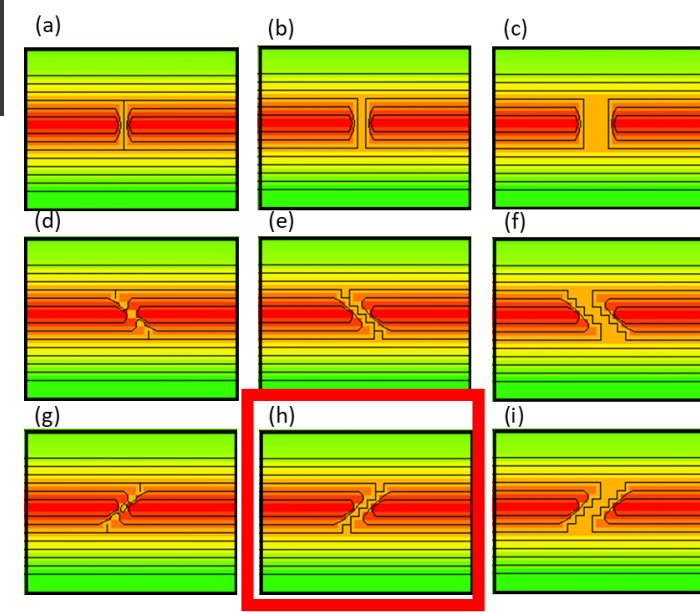
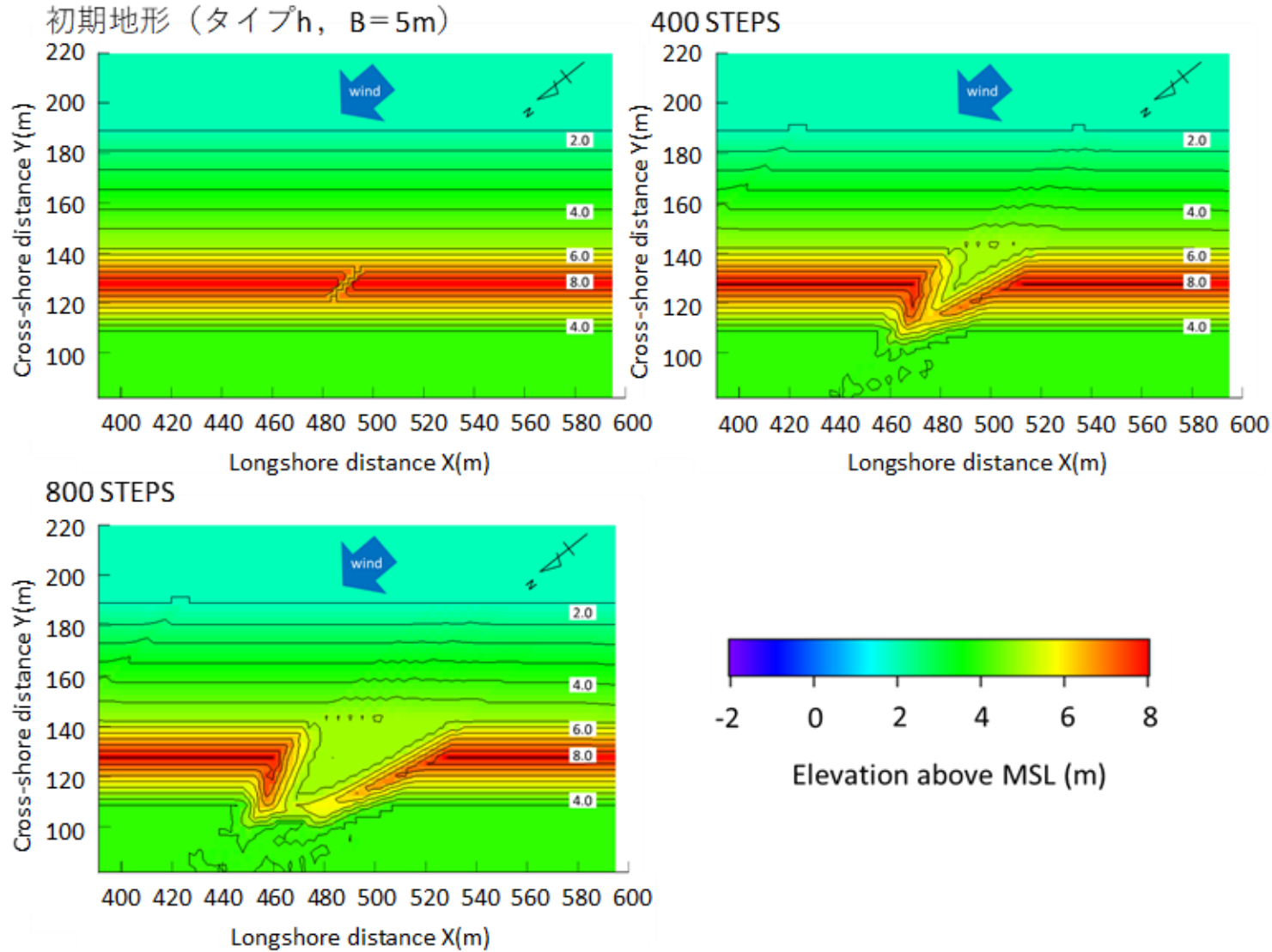
3.3. Calculation of some cases

■ Predicted topography type A



3.3. Calculation of some cases

■ Predicted topography type A



3.3. Calculation of some cases

■ Predicted topography type A

