4TH INTERNATIONAL WORKSHOP ON WAVES, STORM SURGES, AND COASTAL HAZARDS
Incorporating the 18th International Waves Workshop

# Record-Breaking Wave Height Surfed by Vinicius dos Santos at Nazaré, Portugal

*Douglas Duarte Nemes, Vinicius dos Santos & Letícia Sayuri Chiacchio Ito*

Nazaré, a small town in western Portugal, sits above a giant underwater canyon that, combined with powerful swells, produces waves over 100 feet at Praia do Norte.


IMAGE 1

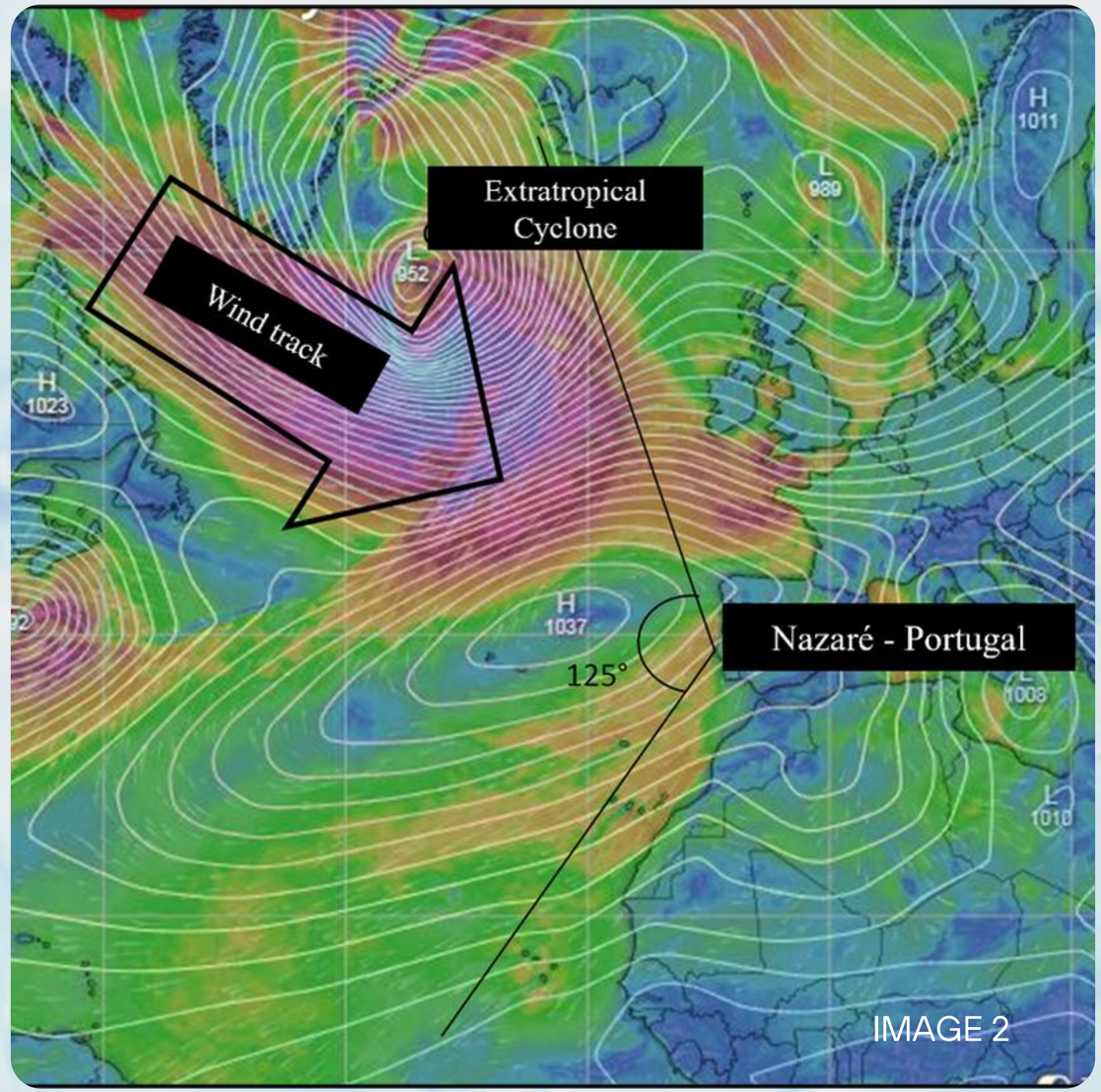



IMAGE 2

# The giant waves are created by cyclones near Greenland, with winds over 100 km/h blowing across 1,000–2,000 km of ocean

Nazaré’s underwater canyon amplifies the swell, creating some of the tallest surfable waves in the world

On February 25th, 2022, during the storm cluster Eunice, Nazaré experienced one of its biggest swells of the last years.

IMAGE 3

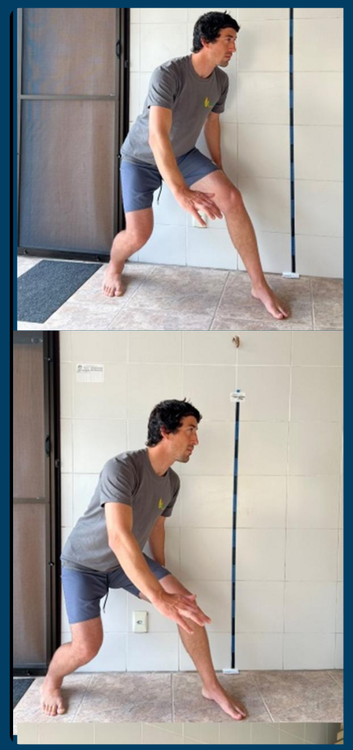
Video by Jorge Leal, 2022.

Professional surfer Vinicius dos Santos surfed a giant wave on that day.

With the aim of measuring the unique wave surfed by Vinicius, this study applies a method developed over the past 20 years by PhD Douglas Nemes.

IMAGE 4

# Methodology



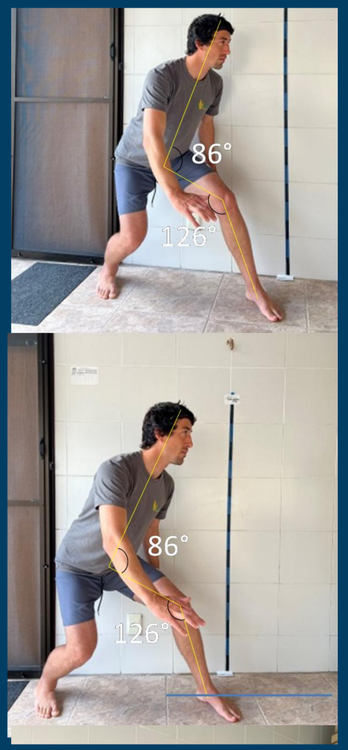



IMAGE 5

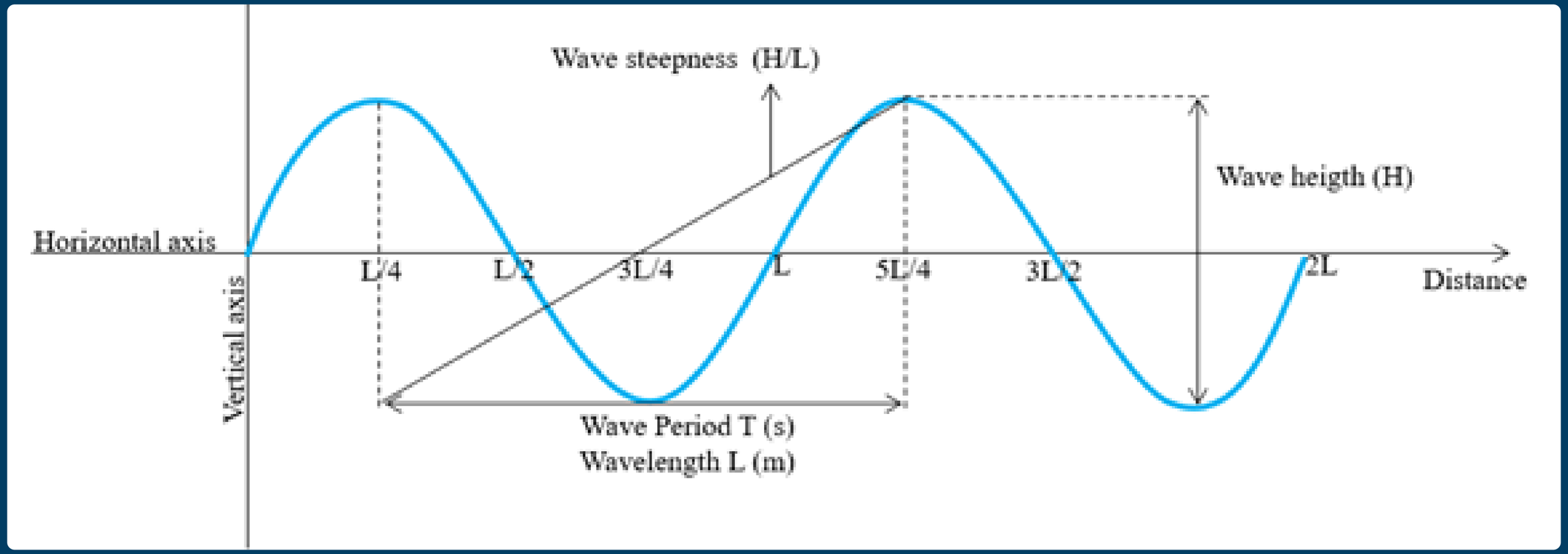

**01.** Mathematical model for the athlete: The surfer's tilt angles are measured out of the water using trigonometric decomposition with a vertical reference.

# Methodology

IMAGE 6

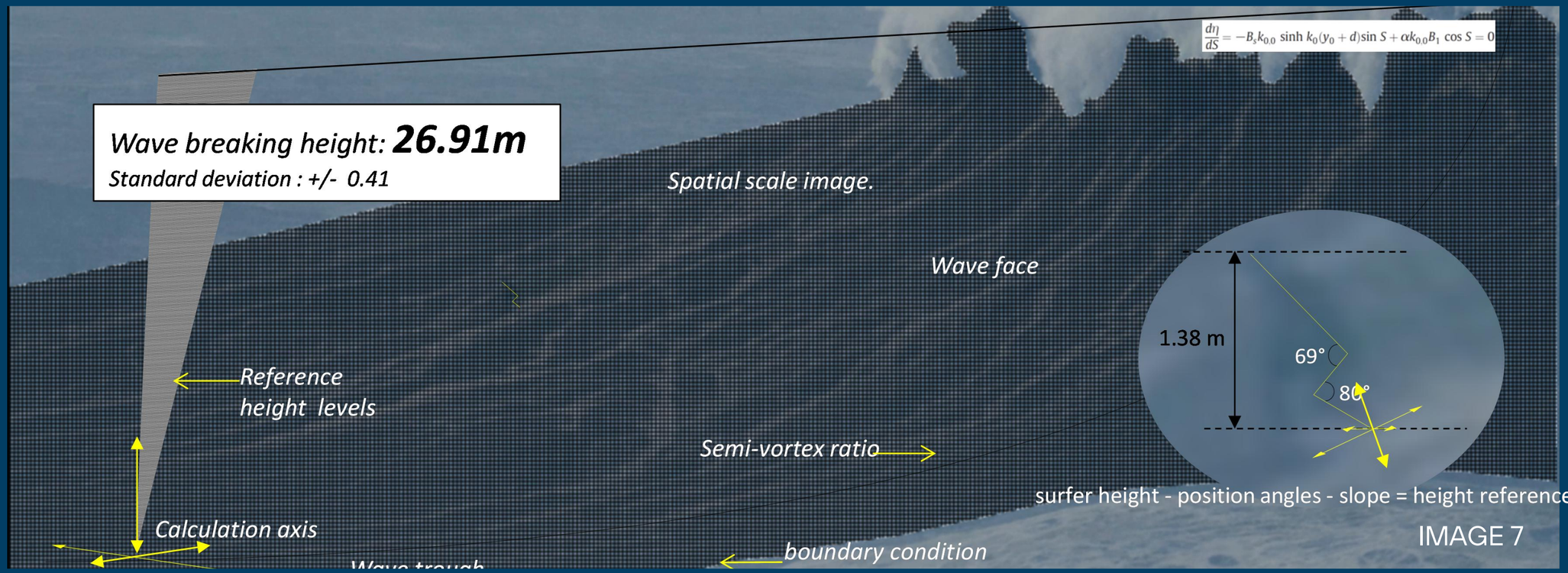
**02.** Pixel decomposition: different images of the wave had their pixels converted to a spatial scale (meters). The crest and base points of the wave are also defined in the image.

# Methodology




**03.** 2D to 3D: In this step, wave mechanics equations are applied to find the calculation axis at the base of the wave and the wave's concave.

# Methodology




**04.** Mathematical projection: The athlete's position is projected onto the calculation axis to estimate the wave breaking height, using a 100-iteration loop to stabilize uncertainty.

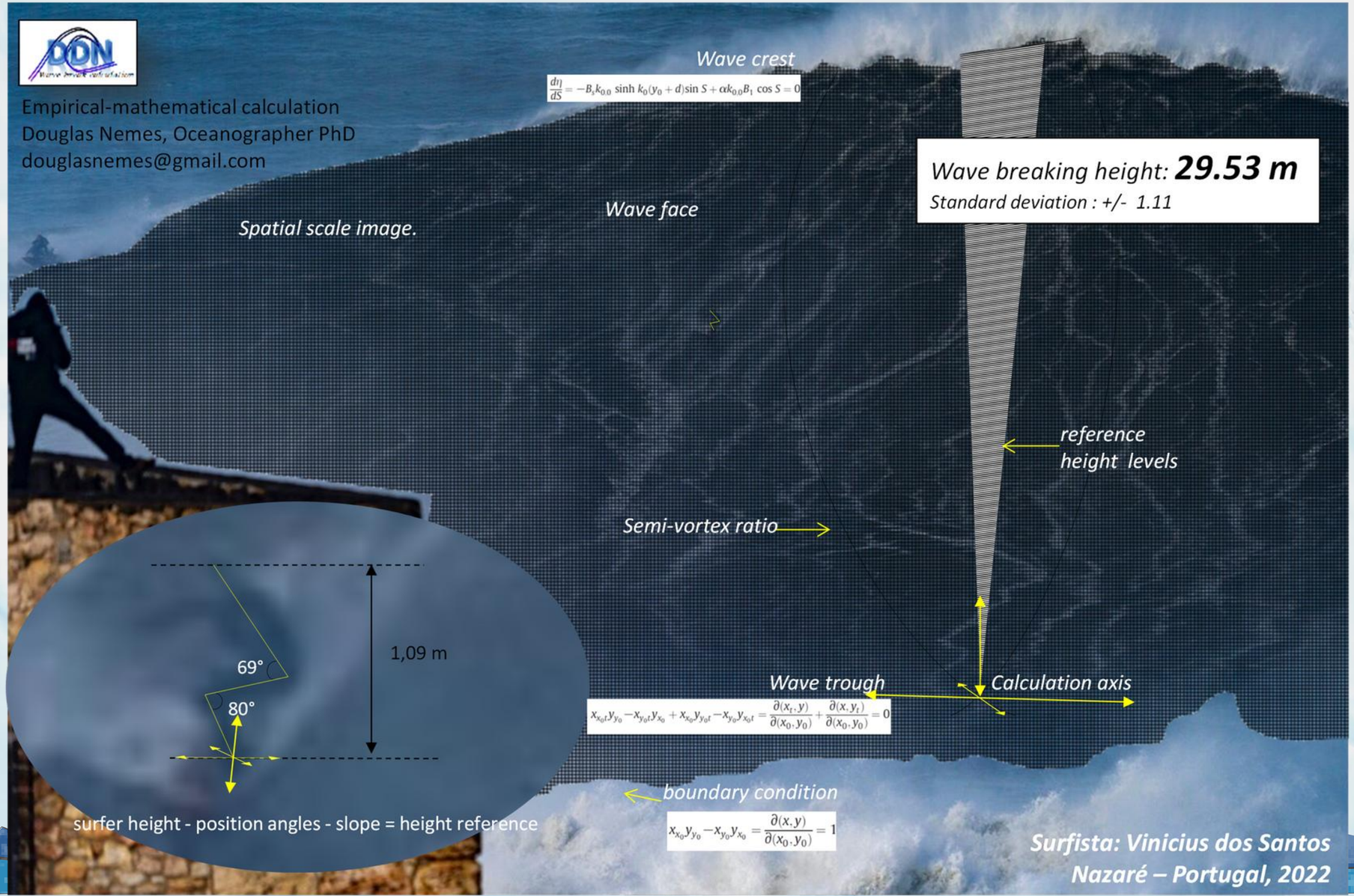
# Methodology

05. **Based on approximately 700 waves in Nazaré, previously calculated by the author, an algorithm was developed to compare the images and determine the final value with improved validation.**

Calculation models and mathematical analyses were carried out using Python programming tools

# Results

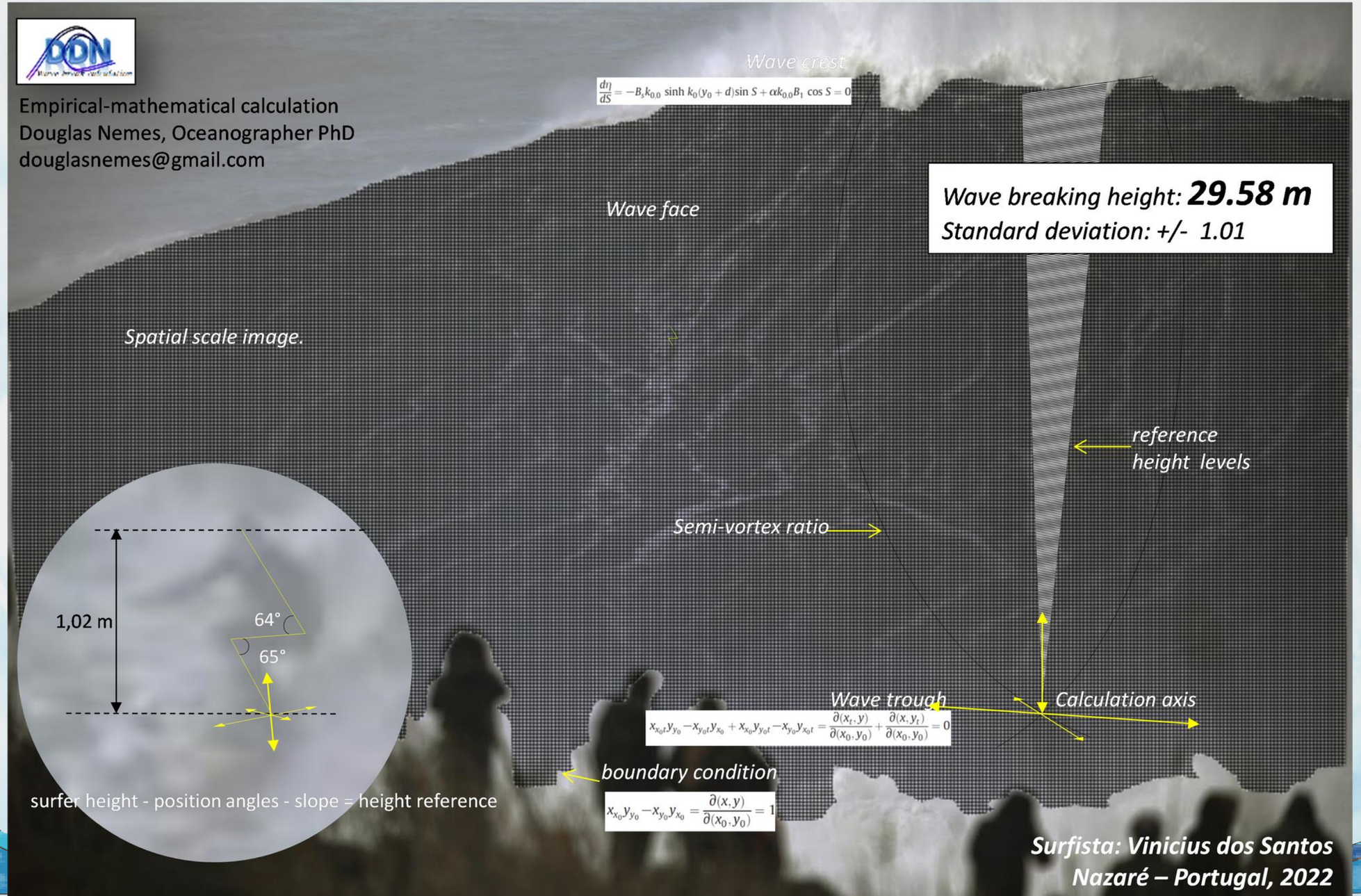
## Four different images of the same wave were analyzed



# Results


Empirical-mathematical calculation
Douglas Nemes, Oceanographer PhD
douglasnemes@gmail.com
Wave crest
$\frac{d\eta}{dS} = -B_s k_{0.0} \sinh k_0(y_0 + d)\sin S + \alpha k_{0.0} B_1 \cos S = 0$
Wave breaking height: 26.91m
Standard deviation : +/- 0.41
Spatial scale image.
Wave face
1.38 m
69°
80°
Reference
height levels
Semi-vortex ratio
surfer height - position angles - slope = height referenc
Calculation axis
boundary condition
Wave trough
$x_{x_0 t} y_{y_0} - x_{y_0 t} y_{x_0} + x_{x_0} y_{y_0 t} - x_{y_0} y_{x_0 t} = \frac{\partial(x_t, y)}{\partial(x_0, y_0)} + \frac{\partial(x, y_t)}{\partial(x_0, y_0)} = 0$
$x_{x_0} y_{y_0} - x_{y_0} y_{x_0} = \frac{\partial(x, y)}{\partial(x_0, y_0)} = 1$
Surfer: Vinicius dos Santos
Nazaré – Portugal, 2022

# Results


Empirical-mathematical calculation
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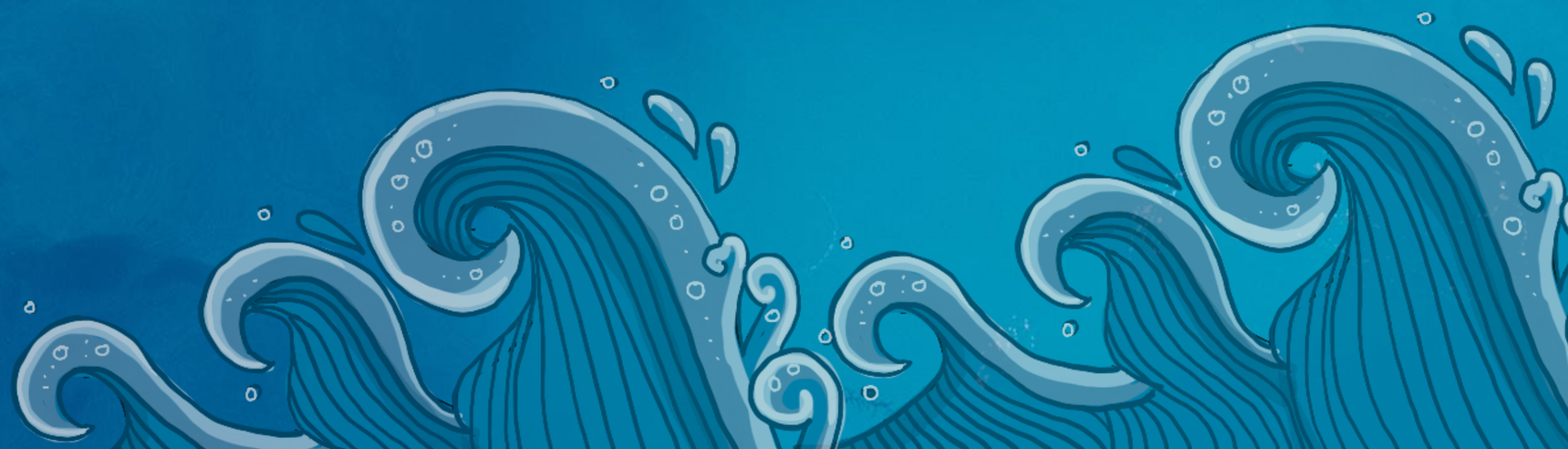
Wave crest
$\frac{d\eta}{dS} = -B_s k_{0.0} \sinh k_0(y_0 + d)\sin S + \alpha k_{0.0} B_1 \cos S = 0$
Wave face
Wave breaking height: 29.58 m
Standard deviation: +/- 1.01
Spatial scale image.
reference
height levels
Semi-vortex ratio
1,02 m
64°
65°
surfer height - position angles - slope = height reference
Wave trough
$x_{x_0 t} y_{y_0} - x_{y_0 t} y_{x_0} + x_{x_0} y_{y_0 t} - x_{y_0} y_{x_0 t} = \frac{\partial(x_t, y)}{\partial(x_0, y_0)} + \frac{\partial(x, y_t)}{\partial(x_0, y_0)} = 0$
Calculation axis
boundary condition
$x_{x_0} y_{y_0} - x_{y_0} y_{x_0} = \frac{\partial(x, y)}{\partial(x_0, y_0)} = 1$
Surfista: Vinicius dos Santos
Nazaré – Portugal, 2022

# World record?

The  wave breaking height was measured from different angles, with the highest being 29.68 meters (97 ft). The previous world record was 86 ft in October 2020.
This sugests that Vinicius dos Santos surfed the largest wave ever recorded up to September 2025.

The wave breaking height analysis method is continuously being developed and improved.

We welcome partnerships with research institutions worldwide.



# Thank you!

**Contact us!**

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# Thank you!

**Contact us!**

**For more information and inquiries about Big Wave Surf:**

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# Image Sources


1. 5W Infographics, research by Kyle Frischkorn and Sonya Maynard; Source: MaxSea / Dr. Kevin Horsburgh, National Oceanographic Centre, UK.
2. Forecast map of wind and atmospheric pressure from the European agency ECMWF for December 07, 2022, with the wind track over the Labrador Sea and North Atlantic.
3. https://www.fatosdesconhecidos.com.br/ondas-de-nazare-as-maiores-do-mundo/
4. Photo by Jorge Leal, 2022.
5. By Authors, 2022.
6. Photo by Mike Jones, 2022.
7. By Authors, 2022.