

Introduction the Ocean Radar System WERA

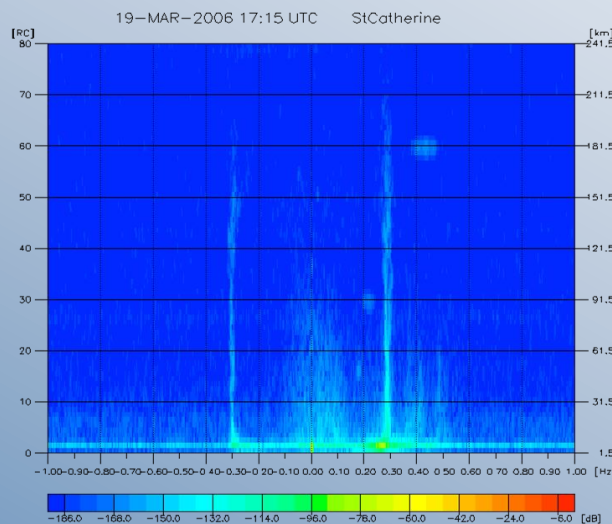
Features, Accuracy and Limitations

Presented by: Matthias Kniephoff (kniephoff@helzel.com)

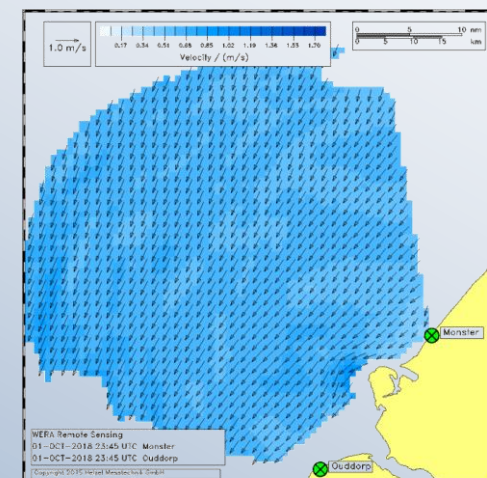
at Dual Use Marine Technologies Workshop in Larnaca, Cyprus, 18th of October 2019



WERA antenna array in the dunes of Ouddorp



Range resolved Doppler spectrum



Current map at Dutch coast

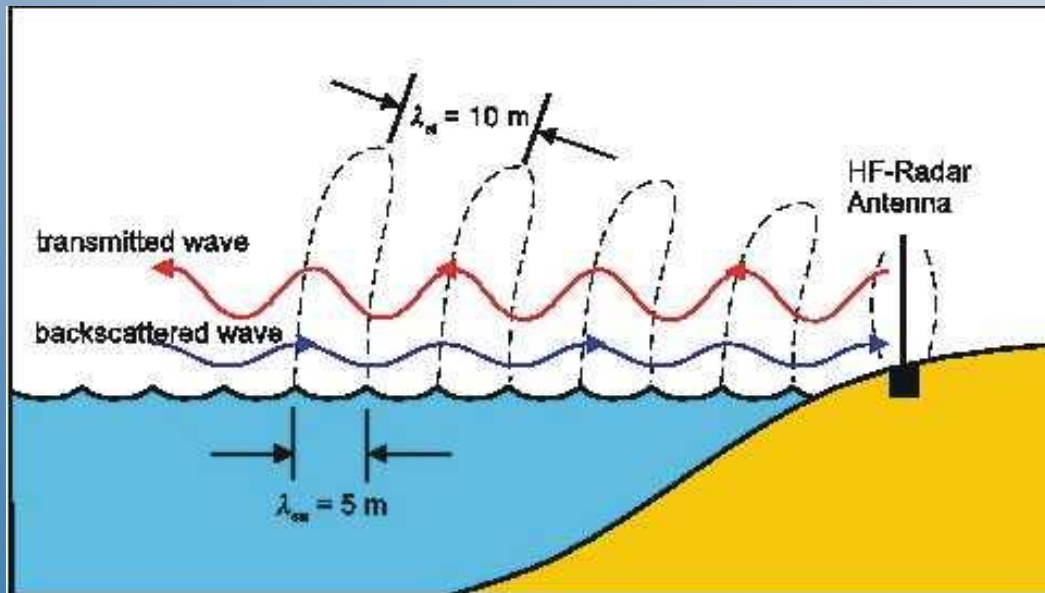


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2. Installation examples
3. Compact or Array Type Antenna
4. Features of WERA
5. Conclusions

1. Introduction

WERA is a shore based remote sensing system using the **over the horizon radar** technology to monitor ocean surface currents, waves and wind direction. A vertical polarised electromagnetic wave is **coupled to the conductive ocean surface** and will **follow the curvature of the earth**.

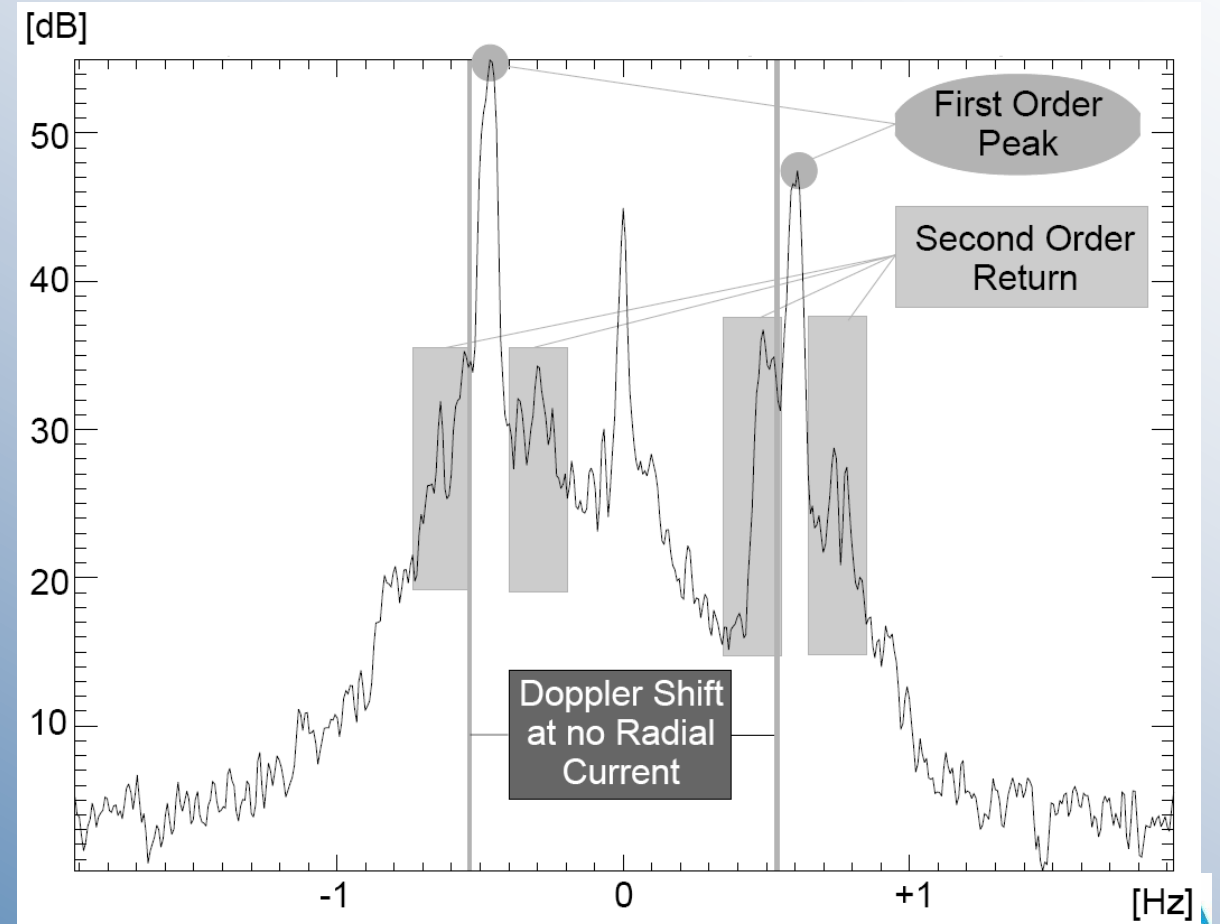


The **rough ocean surface** interacts with the radio wave and due to the **Bragg Effect** back-scattered signals can be detected from ranges of $>300 \text{ km}$.

1.1 Introduction

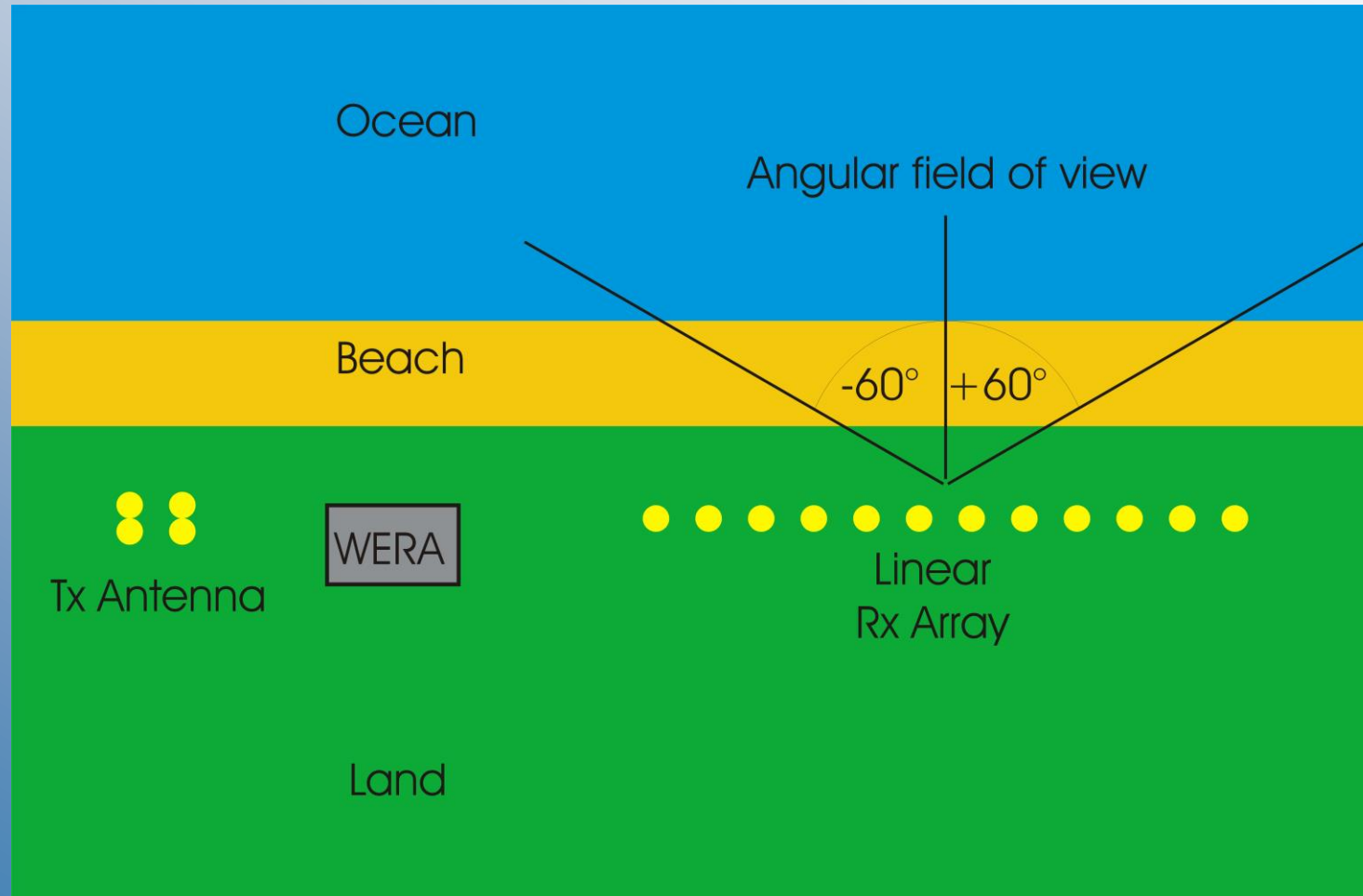
The **back-scattered** radar signal will be **Doppler shifted** with a specific **frequency offset** given by the **velocity** of the **gravity wave** that is responsible for the **Bragg** scattering.

These **Doppler shifted signals** will be **symmetrical** around the centre frequency as long as the ocean surface does not move. An **ocean current** will **shift these Bragg lines** up or down in frequency.



1.2 Introduction

Typical WERA site layout



Contents

1. Introduction of ocean radar “WERA”
2. Installation examples



2.0 WERA @ 5.26 MHz for Longest Ranges



12 Antenna Array

4 m pole, 5.5 m total height

Rx Array length 280 m

Current map: new data all 9 min

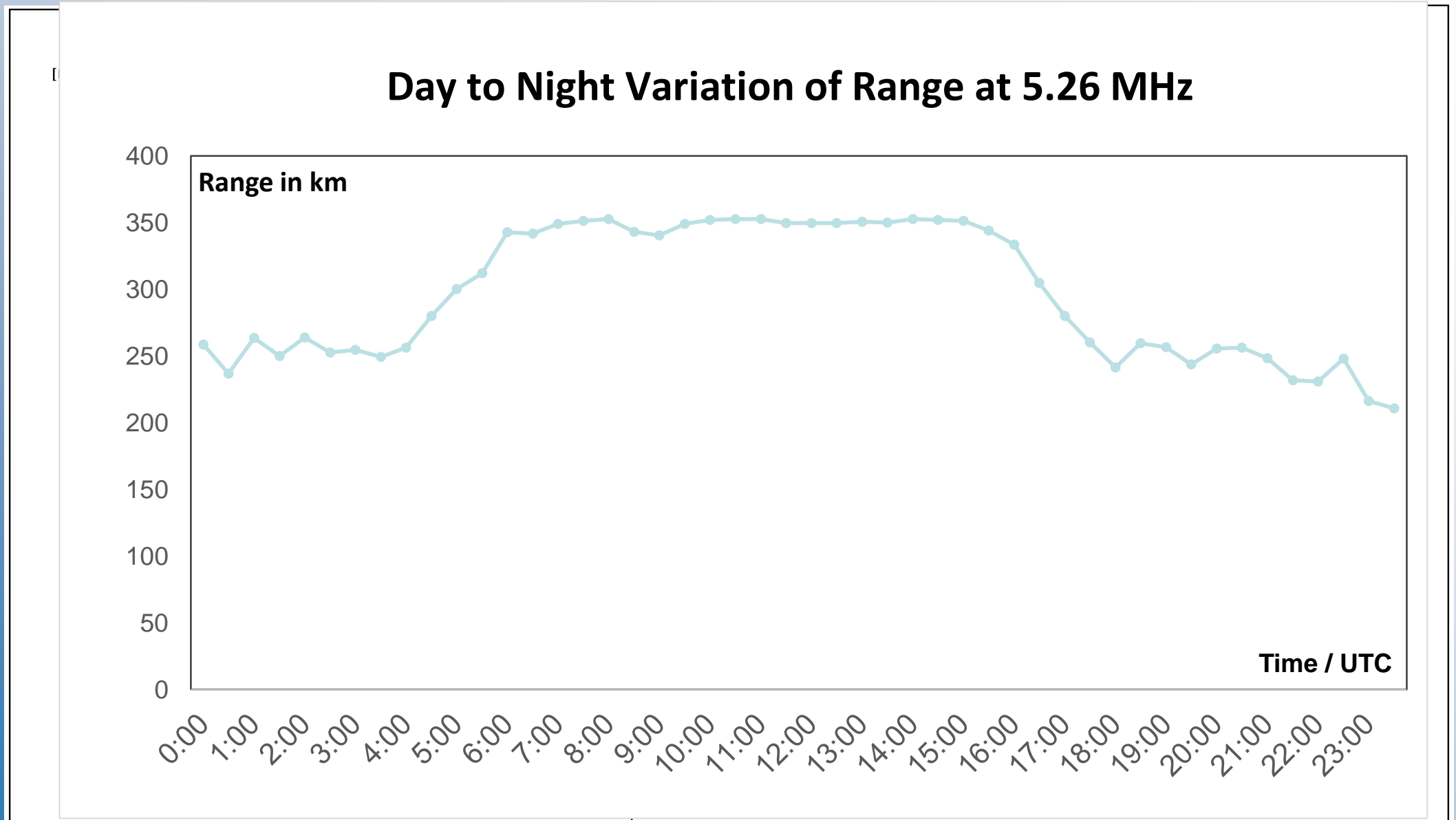
spatial resolution: 6 km

$f_0 = 5.26$ MHz

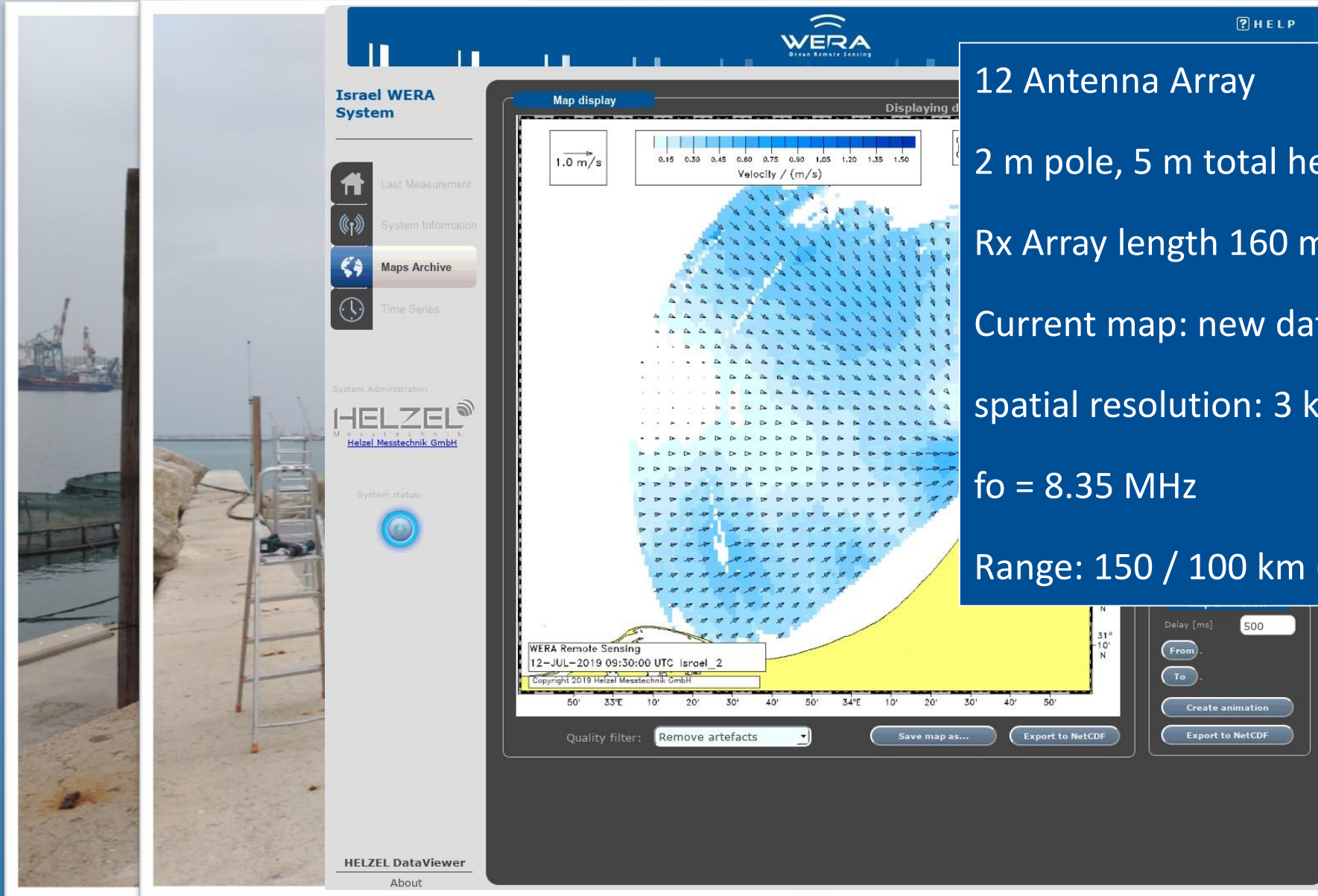
Range: 350 / 250 km (day / night)



2.1 WERA @ 5.26 MHz for Longest Ranges

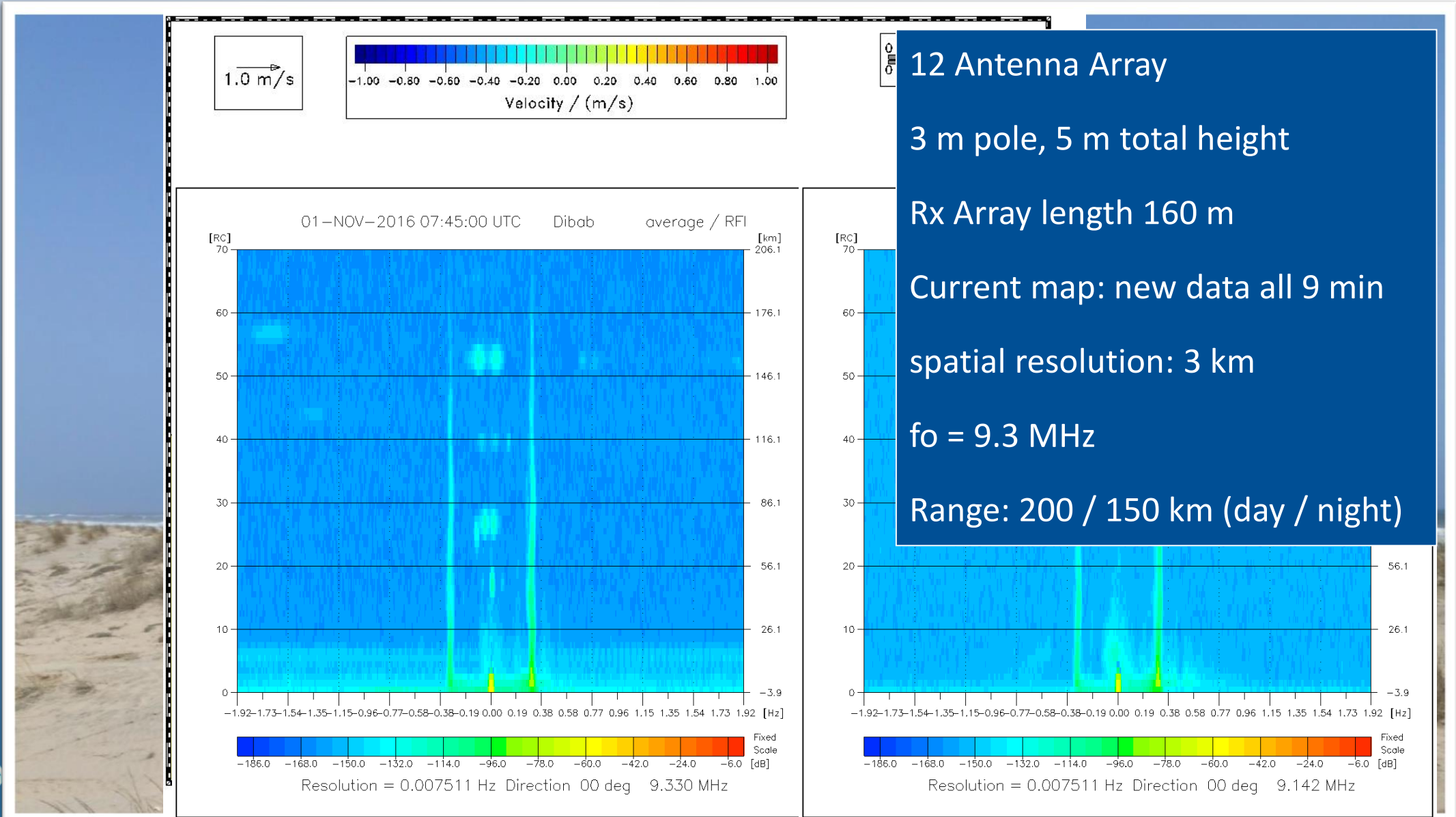


2.2 WERA @ 8.35 MHz for Long Ranges



12 Antenna Array
2 m pole, 5 m total height
Rx Array length 160 m
Current map: new data all 15 min
spatial resolution: 3 km
 $f_0 = 8.35$ MHz
Range: 150 / 100 km (day / night)

2.3 WERA @ 9.3 MHz for Long Ranges



2.4 WERA @ 13 or 16 MHz for Medium Ranges



12 Antenna Array (Receive) 16.2 MHz at Monster
Antennas, 2.5 m poles, 4 m height, length 90 m
new data all 9 min, spatial resolution: 1.0 km
Range: 50 / 70 km (day / night)



4 Element Tx Antenna Array
2.5 m Antenna poles,
4 m height, 8 x 3 m Array

2.5 WERA with active broadband Antennas



12 Antenna Array for Dual Frequency

At the coast of Oman near Sohar

Frequency 9.3 / 13.5 MHz

Active Antennas, 2 m height

Rx Array length 110 m

Current map: new data all 9 min

spatial resolution: 1.5 km

13.5 MHz Range: 60 / 80 km (day / night)

9.3 MHz Range: 160 / 130 km (day / night)

2.6 WERA for dual Frequencies



16 Antenna Array, dual Frequency

Dual Frequency 13.5 & 24.5 MHz

Active Loop Antennas 2.5 m height

Rx Array length 90 m

Current map: new data all 9 min

spatial resolution: 1.0 km

fo = 13.5 & 24.5 MHz alternating

13.5 MHz Range: 80 km

24.4 MHz Range: 30 km

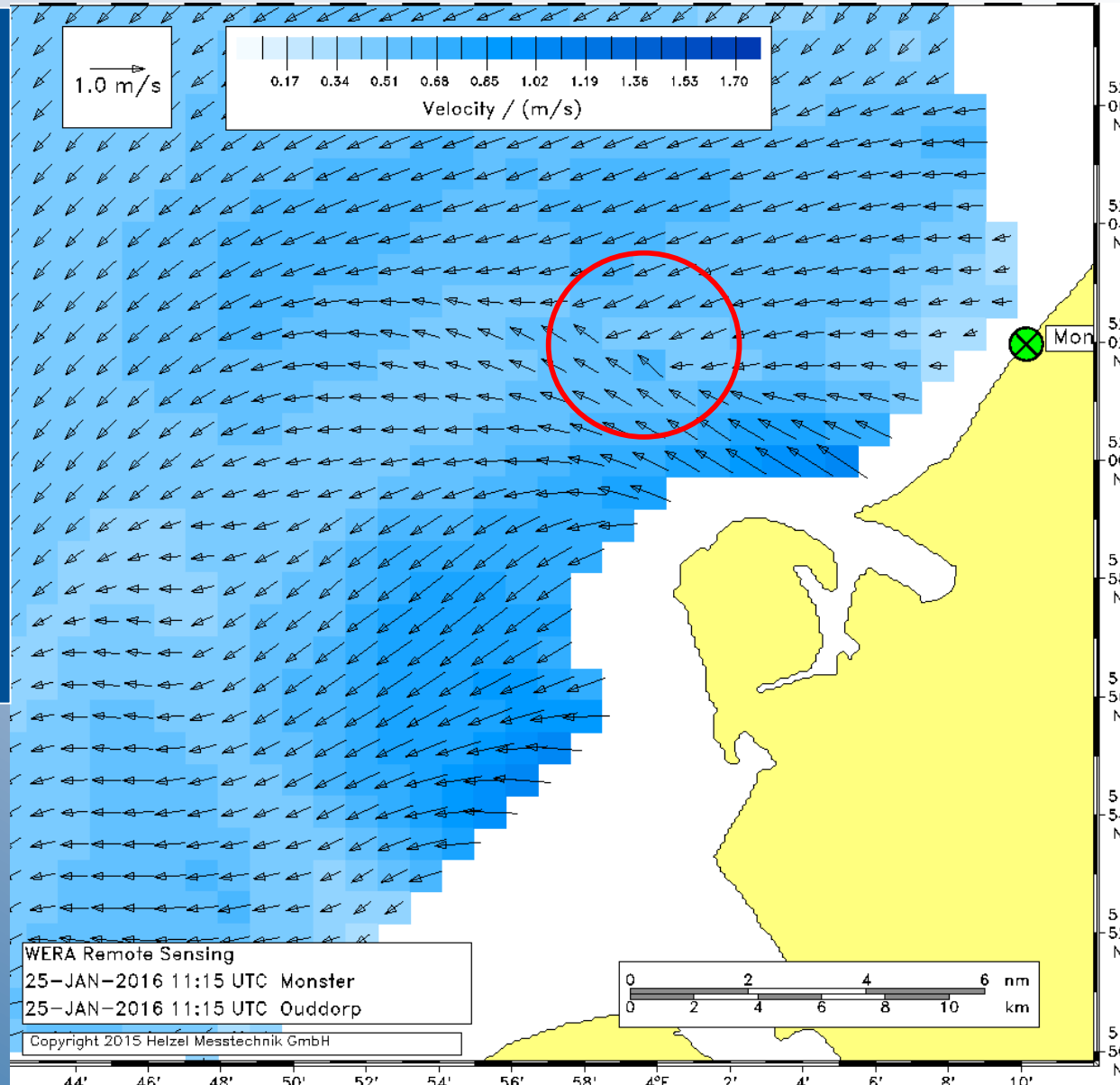
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3.1 Compact or Array Type Antenna System

Current map:
Port Area Rotterdam (NL)
Integration time 9 min
spatial resolution 1 km
 $f_0 = 16.15$ MHz
2 x 12 antenna arrays



3.2 Compact or Array Type Antenna System

Current map:

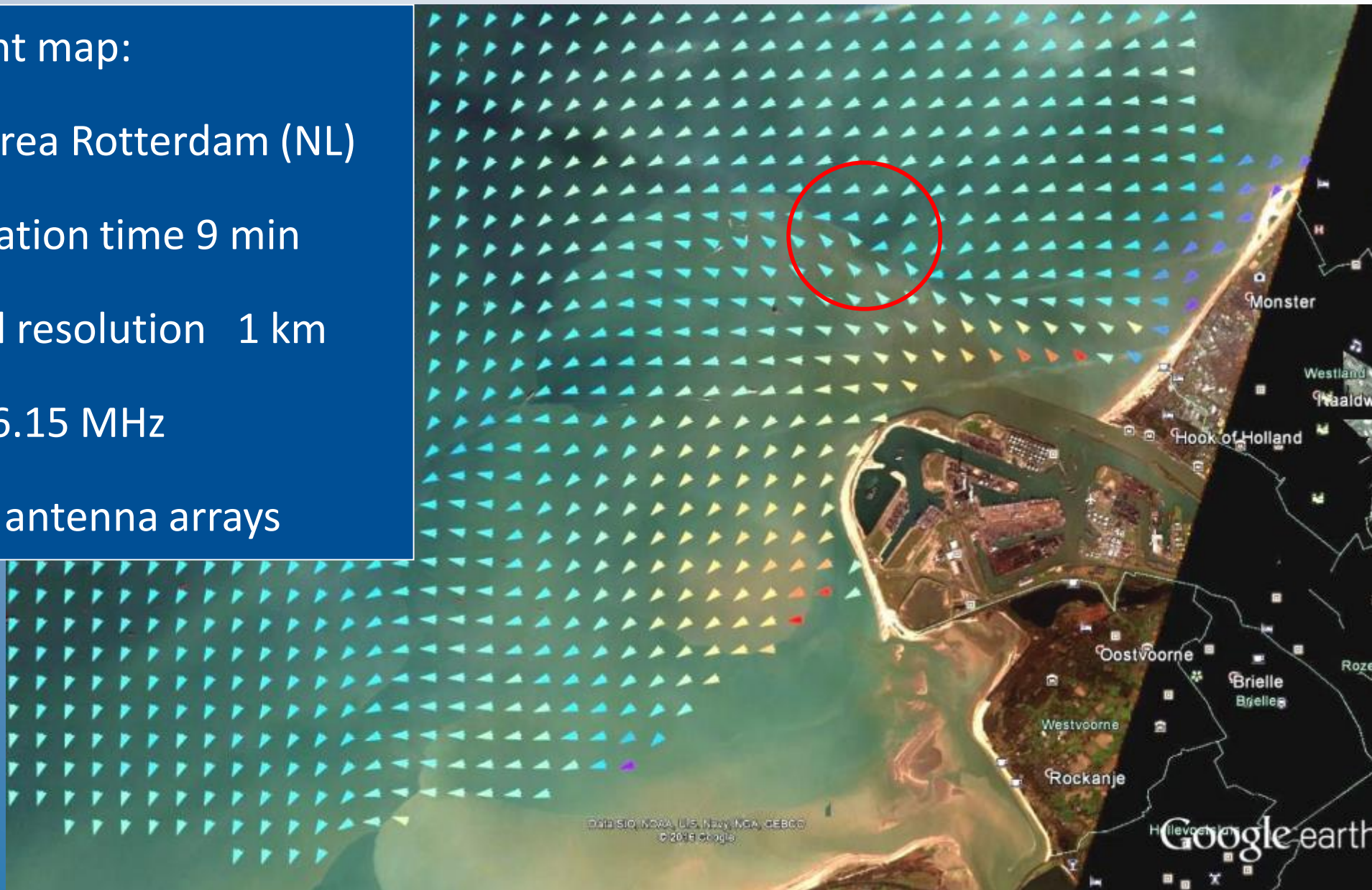
Port Area Rotterdam (NL)

Integration time 9 min

spatial resolution 1 km

$f_0 = 16.15$ MHz

2 x 12 antenna arrays

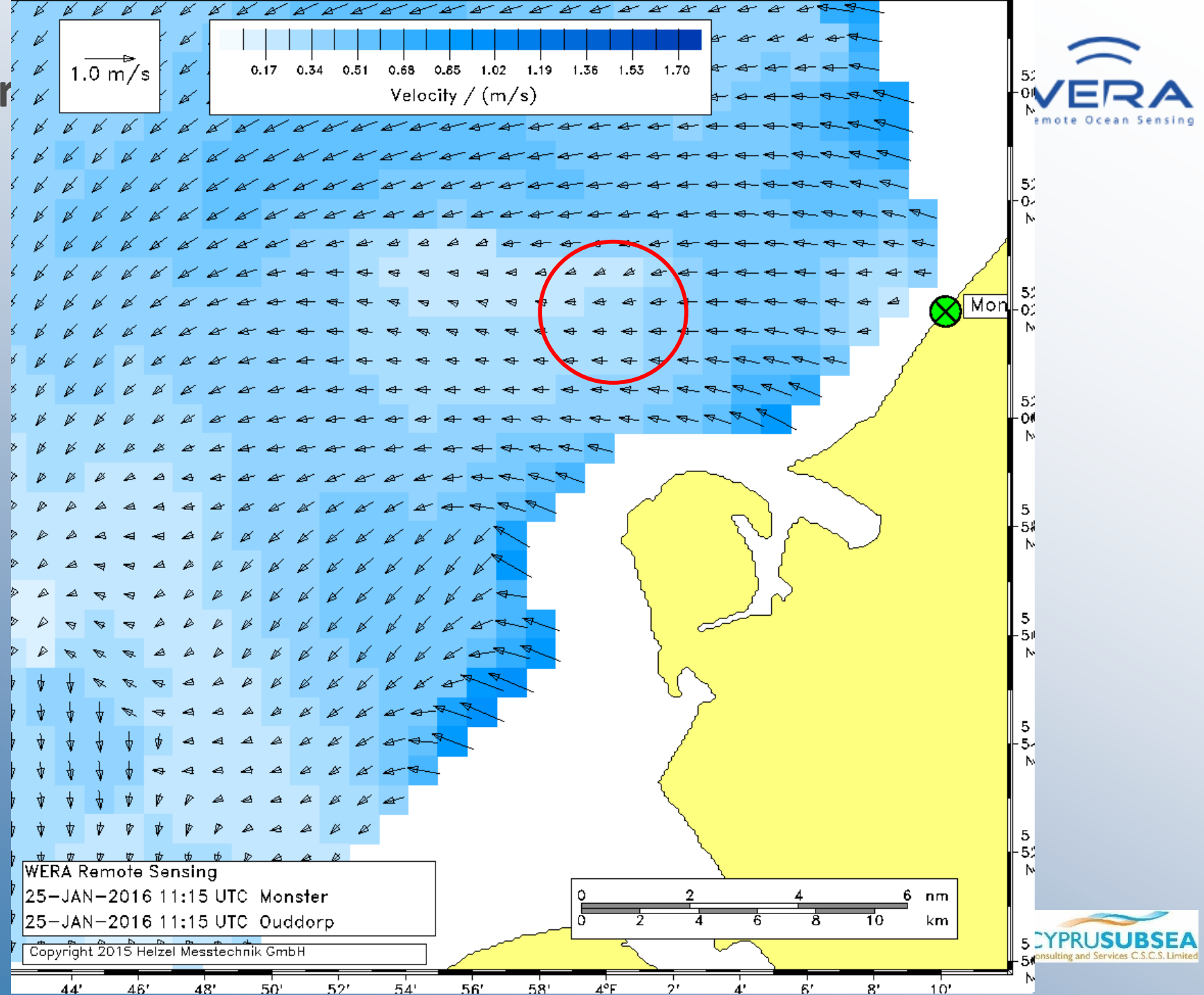


3.3 Compact or Ar

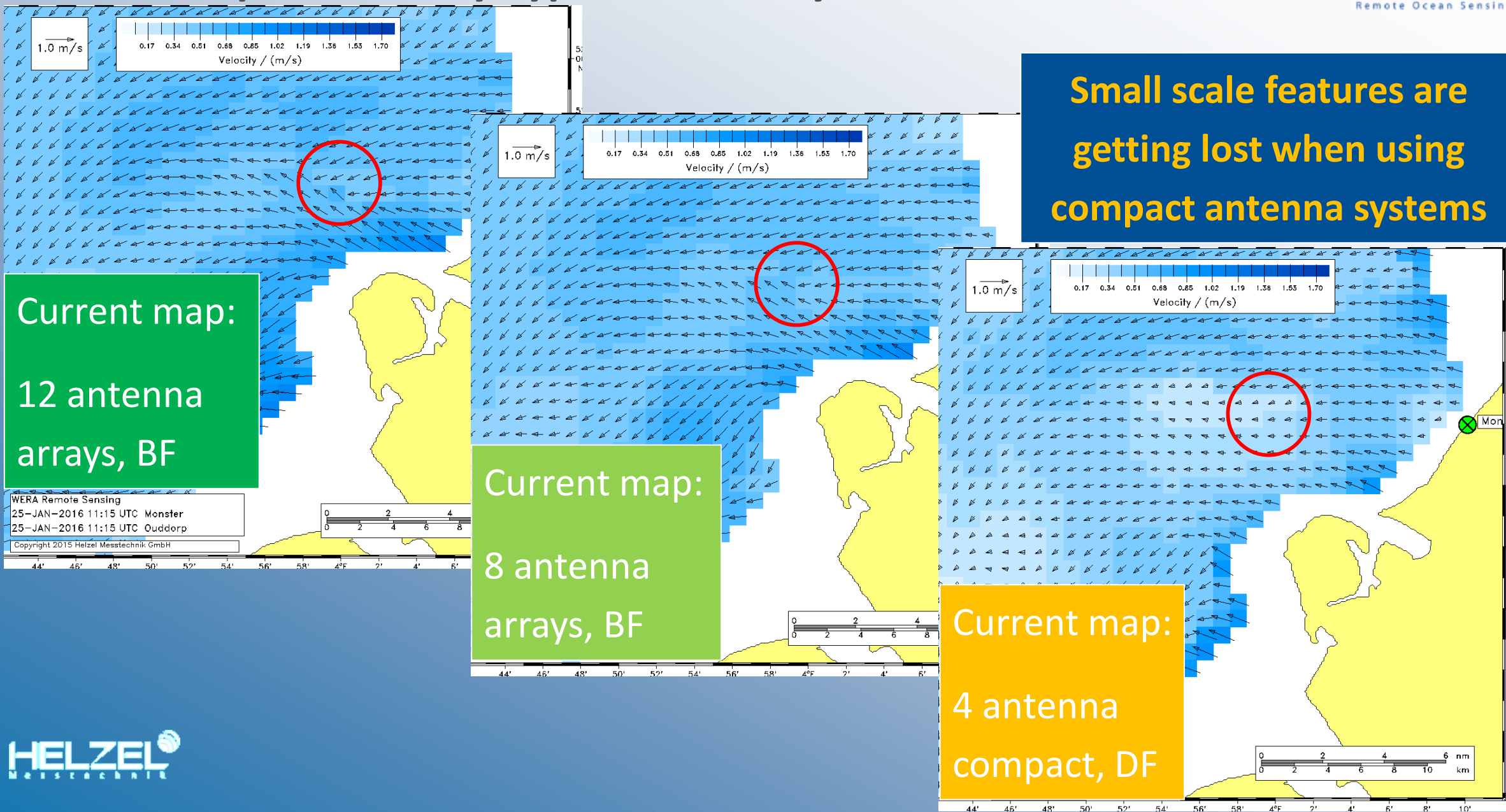
Current map:
12 antenna
arrays, BF

Current map:
8 antenna
arrays, BF

Current map:
4 antenna
compact, DF



3.4 Compact or Array Type Antenna System



Small scale features are getting lost when using compact antenna systems

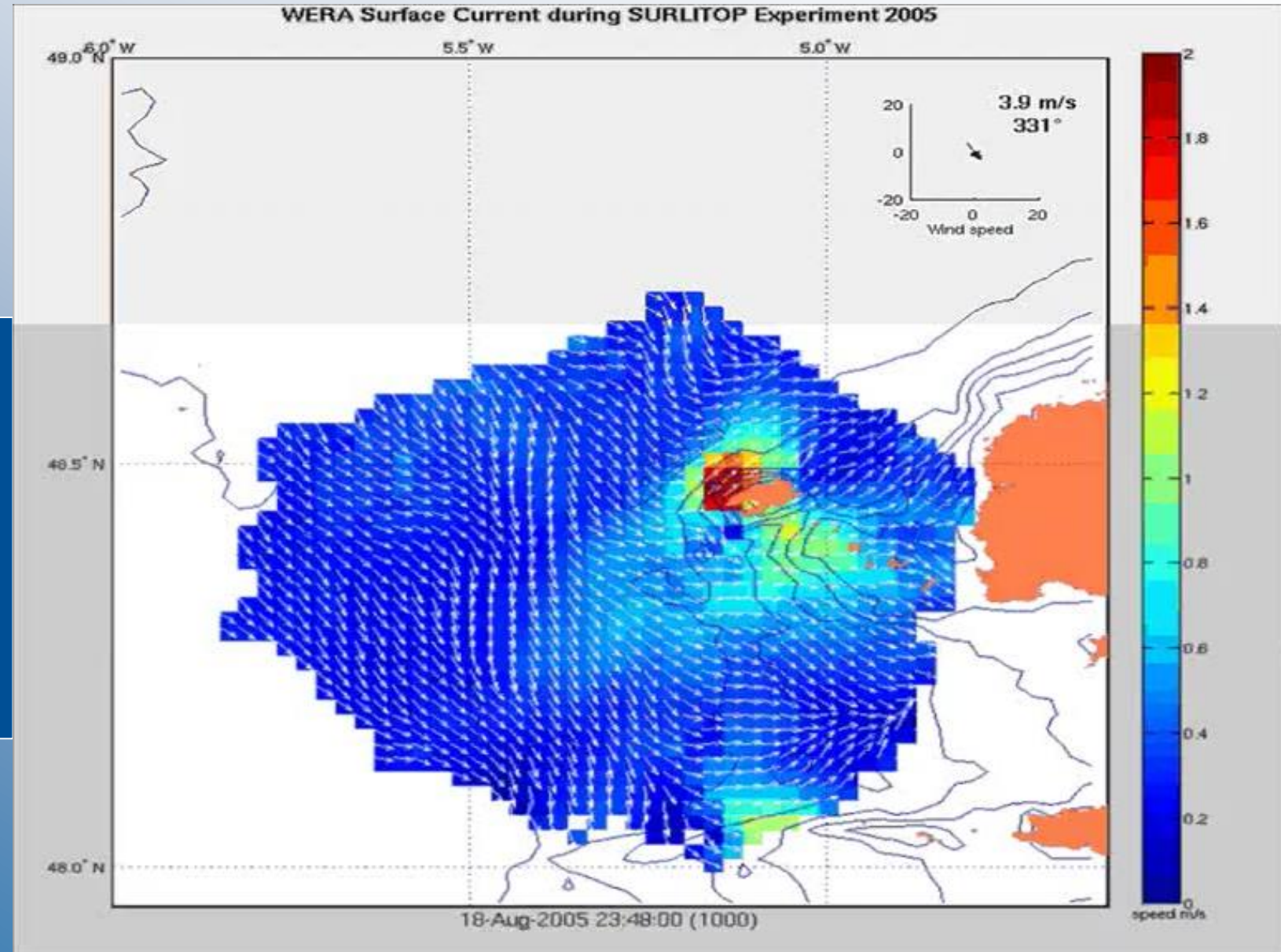
Current map:
12 antenna arrays, BF

Current map:
8 antenna arrays, BF

Current map:
4 antenna compact, DF

3.5 Array Type Antenna System Currents

Current map:
new data all 12 min
spatial resolution: 1.5 km
 $f_0 = 12.4$ MHz
2 x 16 antenna arrays





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4. Features of WERA

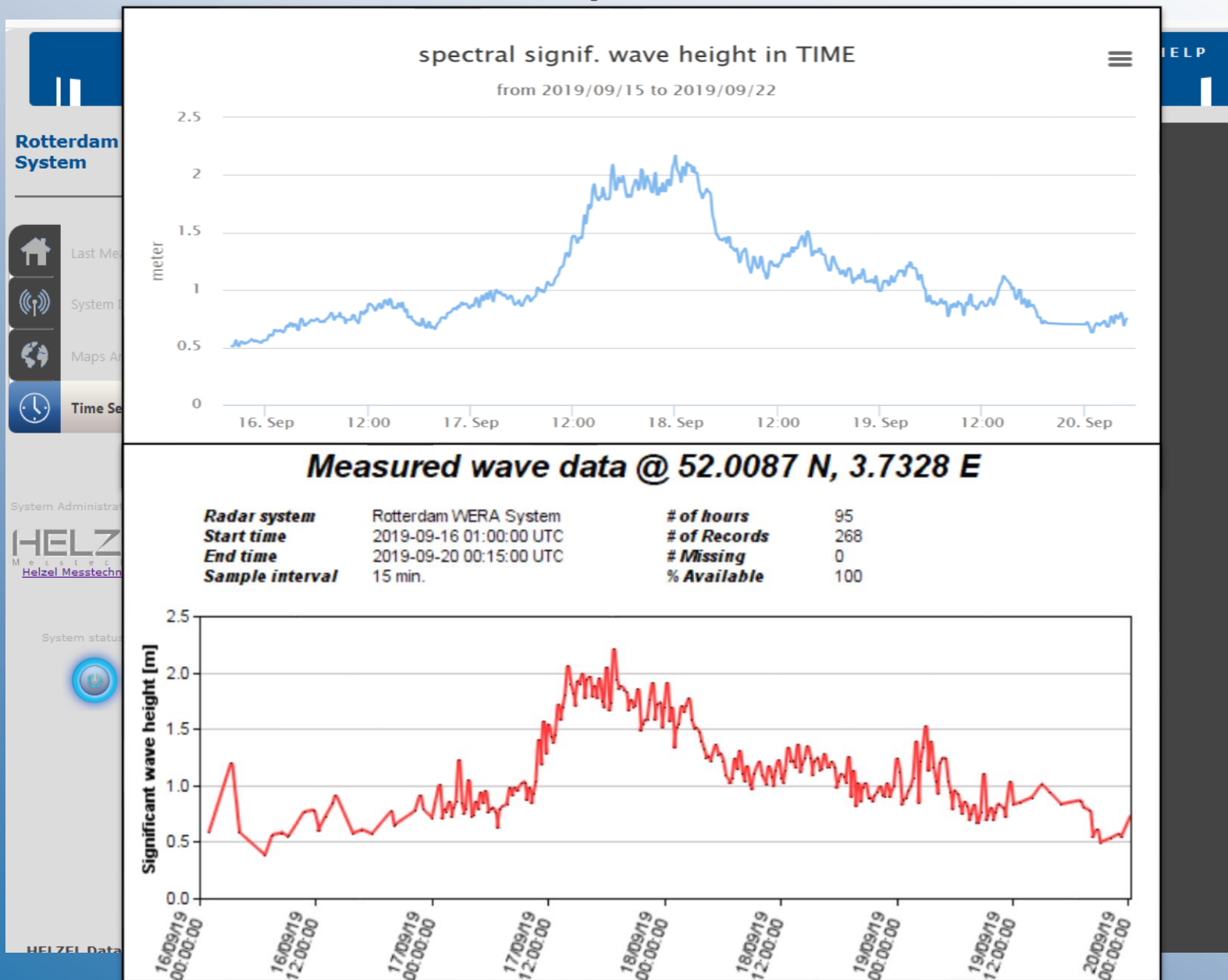
4.1 Range of WERA Products (Technique)

1. For **Direction Finding** or **Beam Forming** Mode
2. For **Short** or **Long Ranges**
3. In **Standard, Compact** or **Splitted Site** Geometry
4. **Optimised Integration Time** for individual applications
5. Intelligent **Frequency Management** to avoid interferences
6. Supports **Multiple Input – Multiple Output Mode, MIMO**
7. Provides very effective radio interference suppression, **RFI**
8. In **Single-** or **Multi-Frequency** Mode
9. Self organized **Frequency Band Sharing**
10. **Open Data Interfaces** for scientific applications

4.2 Range of WERA Products (Applications)

11. Ocean current maps with **Highest Temporal Resolution**
12. Various **Wave data** options available
 13. **Maps of Significant Wave Height**
 14. **Directional Wave Spectra** for individual grid cells

4.2.14 Wave Data on the Map and of Individual Grid Cells



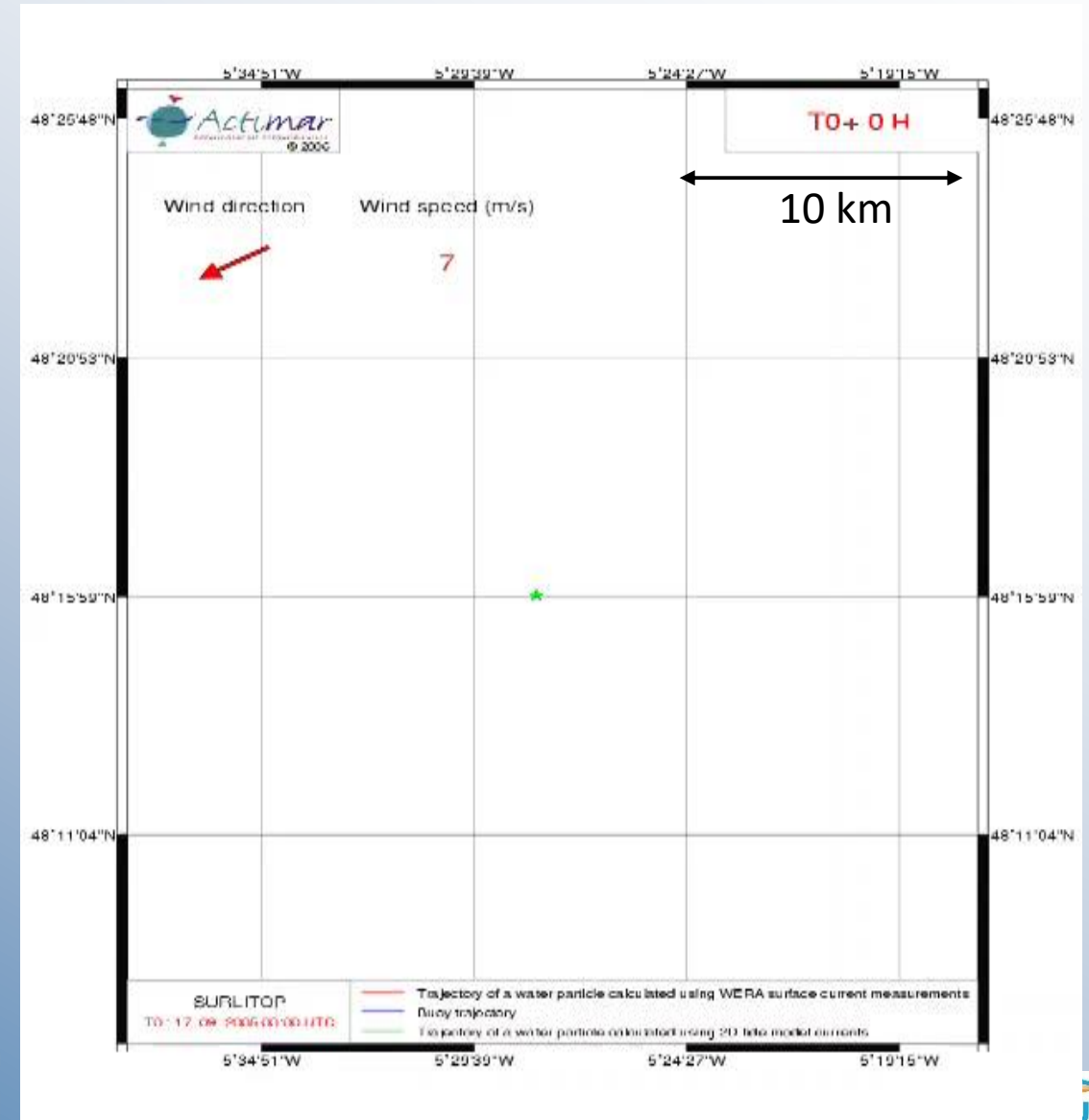
4.3 Range of WERA Products (Applications)

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15. **Drift Prediction** for Search and Rescue operations

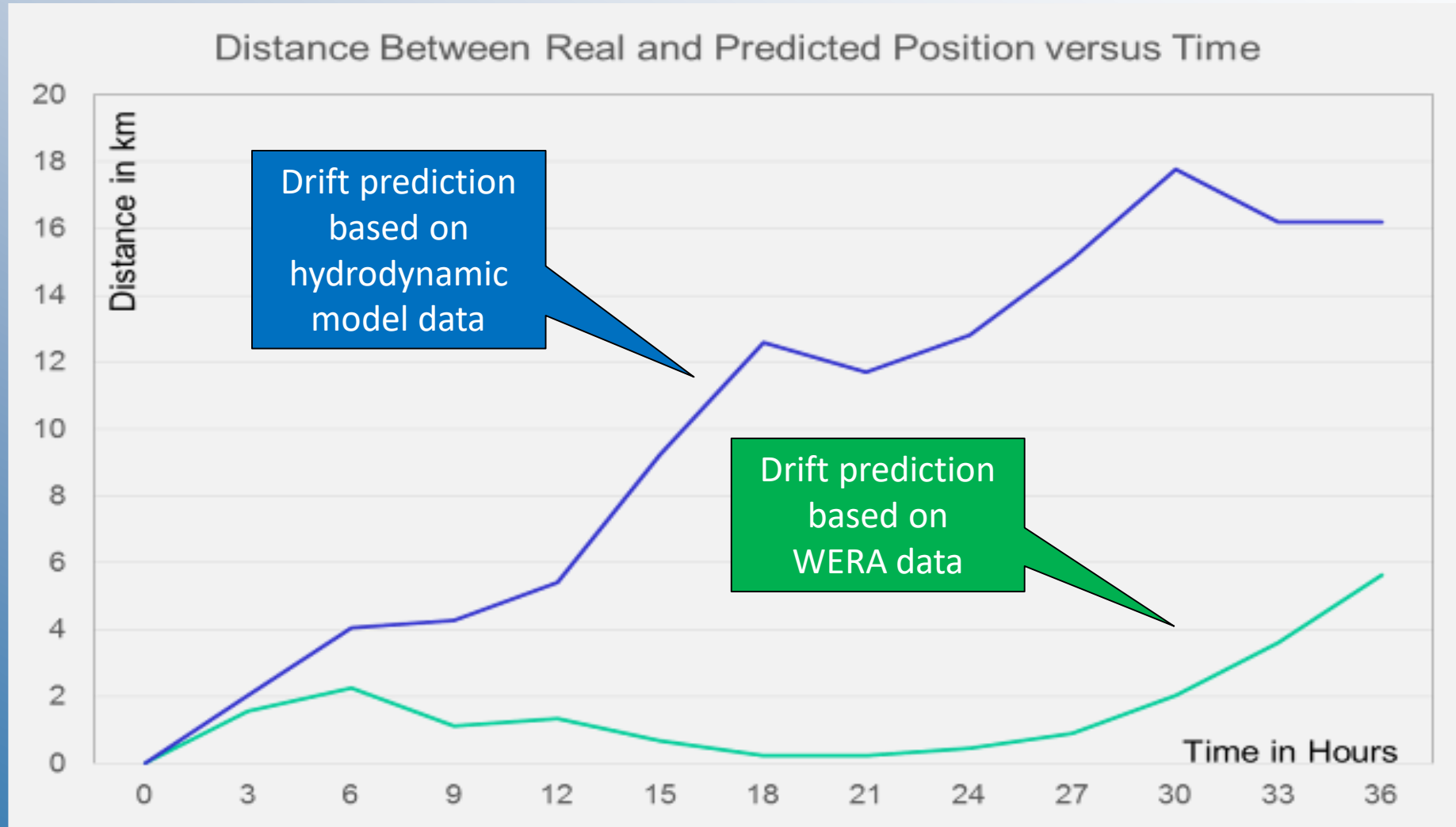
4.3.15 Application: Current Drift Prediction

Simulation of a Search and Rescue case. The prediction of the actual position of a drifting buoy “man-over-board” was compared with different trajectory methods. WERA based trajectories showed the best accuracy.

Data are kindly provided by Actimar.



4.3.15 Application: Current Drift Prediction



Drift prediction using WERA current data from Brest, France, around Ushant island

4.3 Range of WERA Products (Applications)

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 14. **Directional Wave Spectra** for individual grid cells
15. **Drift Prediction** for Search and Rescue operations
16. **Ocean Current Forecasting** for vessel traffic services
17. **Tsunami Detection & Probability** check in near real time

4.3.17 Application: Tsunami Detection

Meteo-Tsunami Observation at the Dutch Coast on 29 May 2017



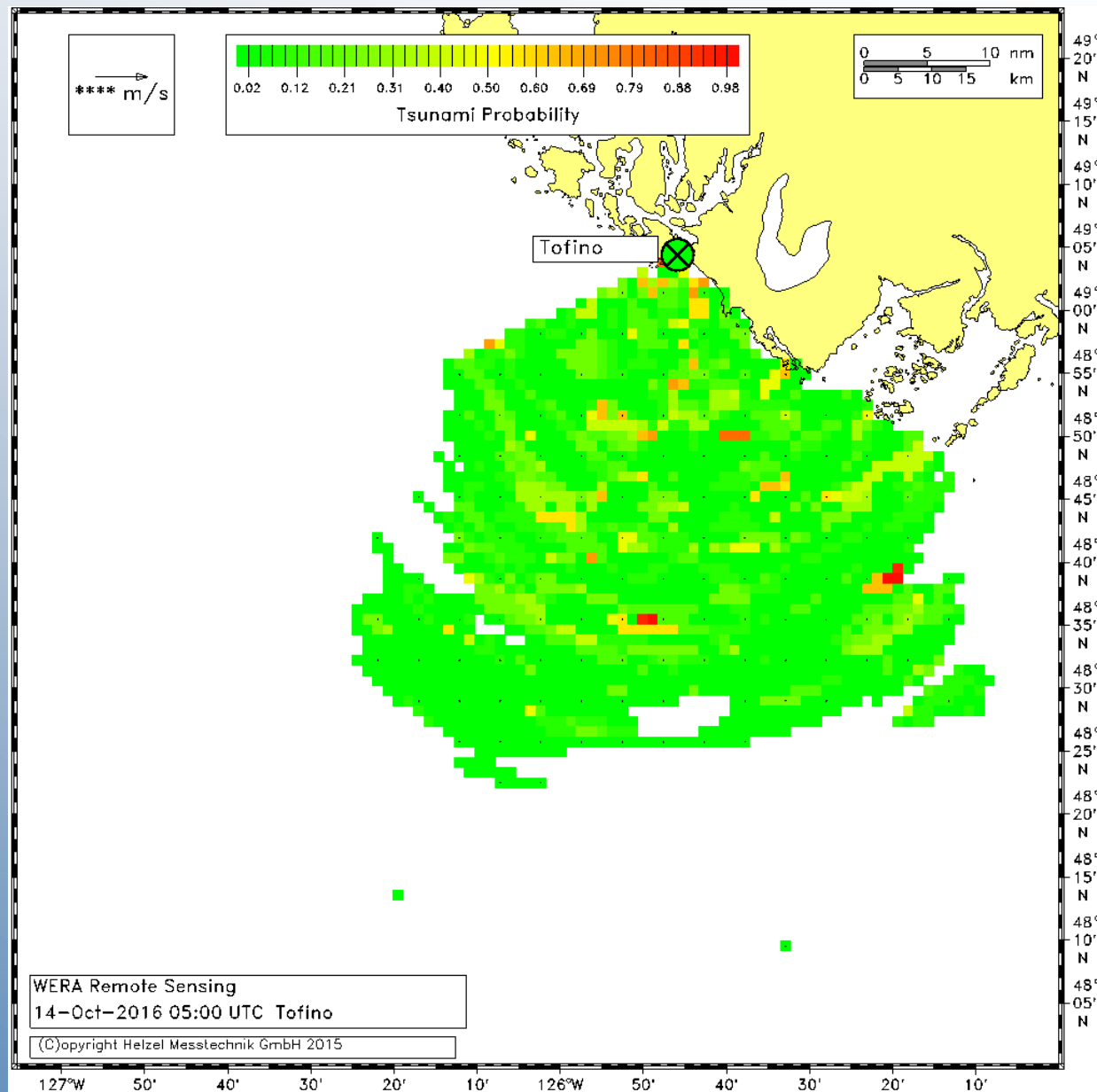
Video evidence of meteo-Tsunami wave propagation near Zandvoort in the Netherlands (posted on May 29, 2017). Retrieved from https://www.youtube.com/watch?v=CjQk_xt_WU0

4.3.17 Tsunami Warning

- For all beam forming WERA systems Tsunami Detection software packages are available.

- The WERA system is able to detect even small Tsunami events and can also be used to detect approaching Meteo-Tsunamis.

12 Antenna WERA, 16 MHz
on Vancouver Island,
operated by Ocean Network Canada



4.3 Range of WERA Products (Applications)

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16. **Ocean Current Forecasting** for vessel traffic services
17. **Tsunami Detection & Probability** check in near real time
18. **Ship Detection & Tracking** (with Dual use **OTHR** system only)

4.3.18 HELZEL OTHR @ 4 to 12 MHz for Ship Tracking

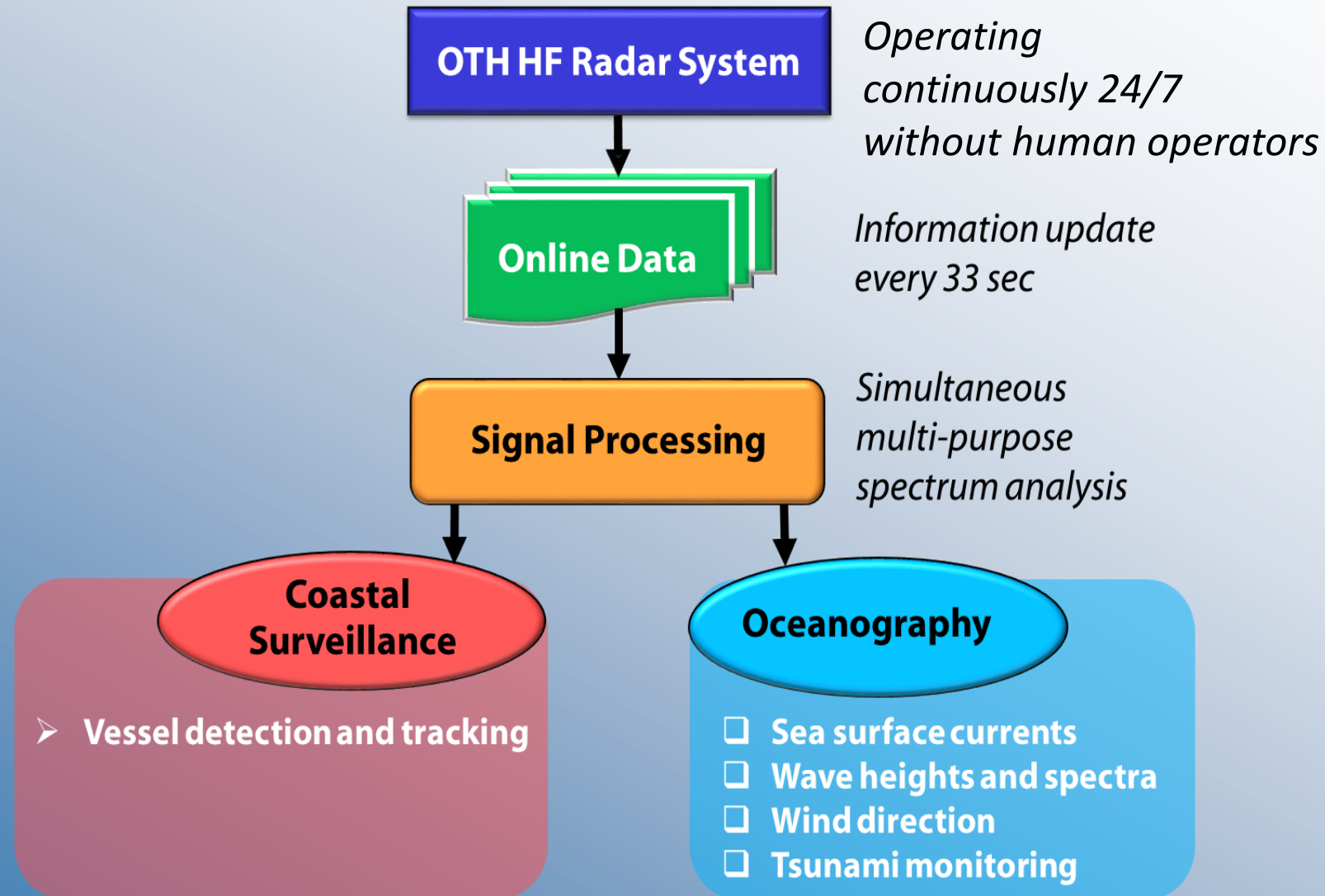


- For the Ship Detection & Tracking application we offer the “big brother” of WERA, the HELZEL OTHR system, which provides ranges of up to 200 NM

Please note:

- The WERA system can be used for Ship Detection & Tracking as well but will not reach the performance of the OTHR systems. Nevertheless ranges of more than 200 km are possible.
- This can be helpful for offshore operators to detect vessels operating illegally near their installations.
- It can be used to identify illegal fishing vessels.

4.3.18 Operational Block Structure



4.3.18 HELZEL OTHR test site for Ship Tracking



Covers the entire EEZ (200 NM) to detect illegal activities on sea.

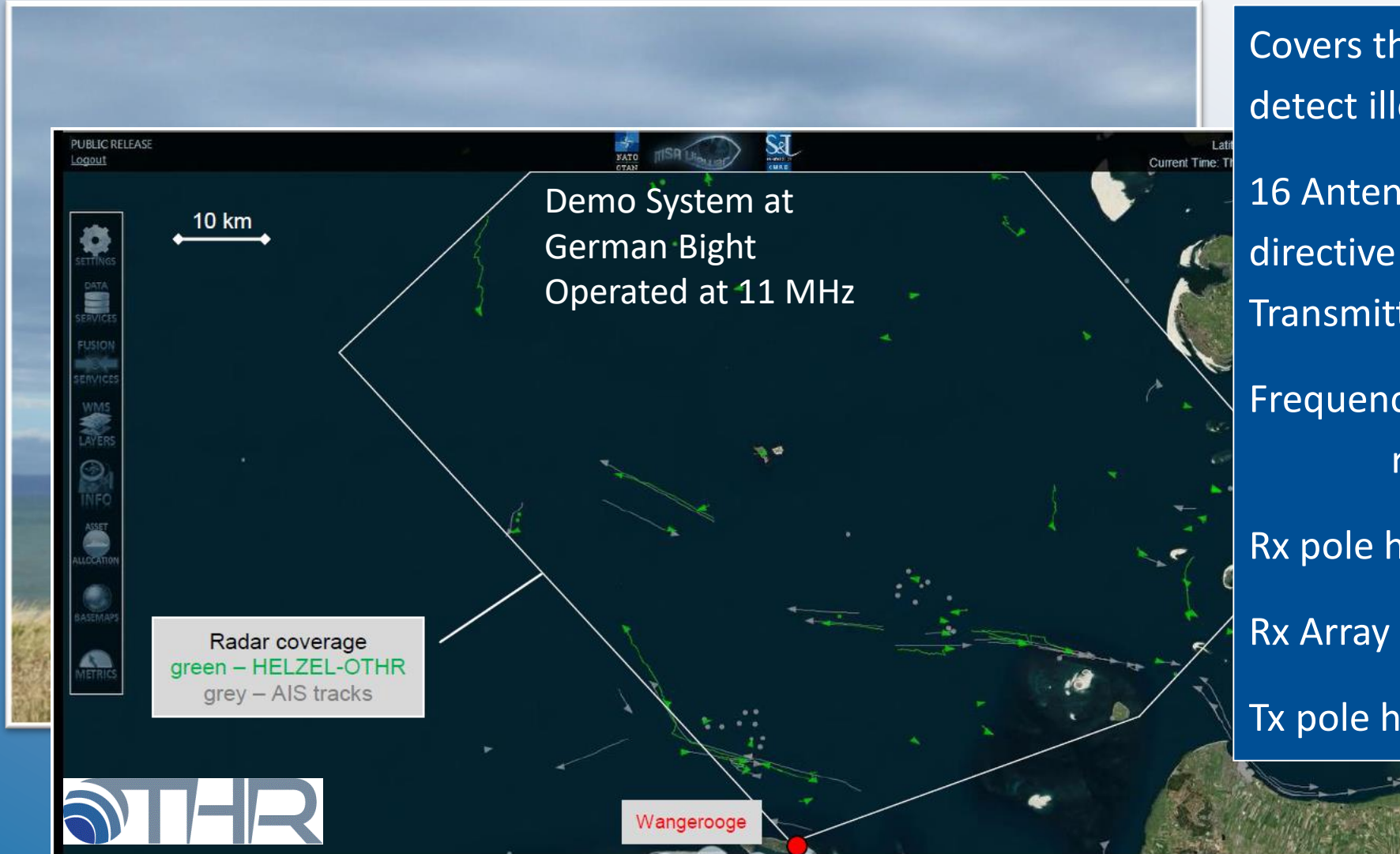
16 Antenna Arrays and directive Tx Antenna Systems
Transmitted power 1000 Watts_{EIRP}

Frequency of < 5 MHz
required to reach 200 NM

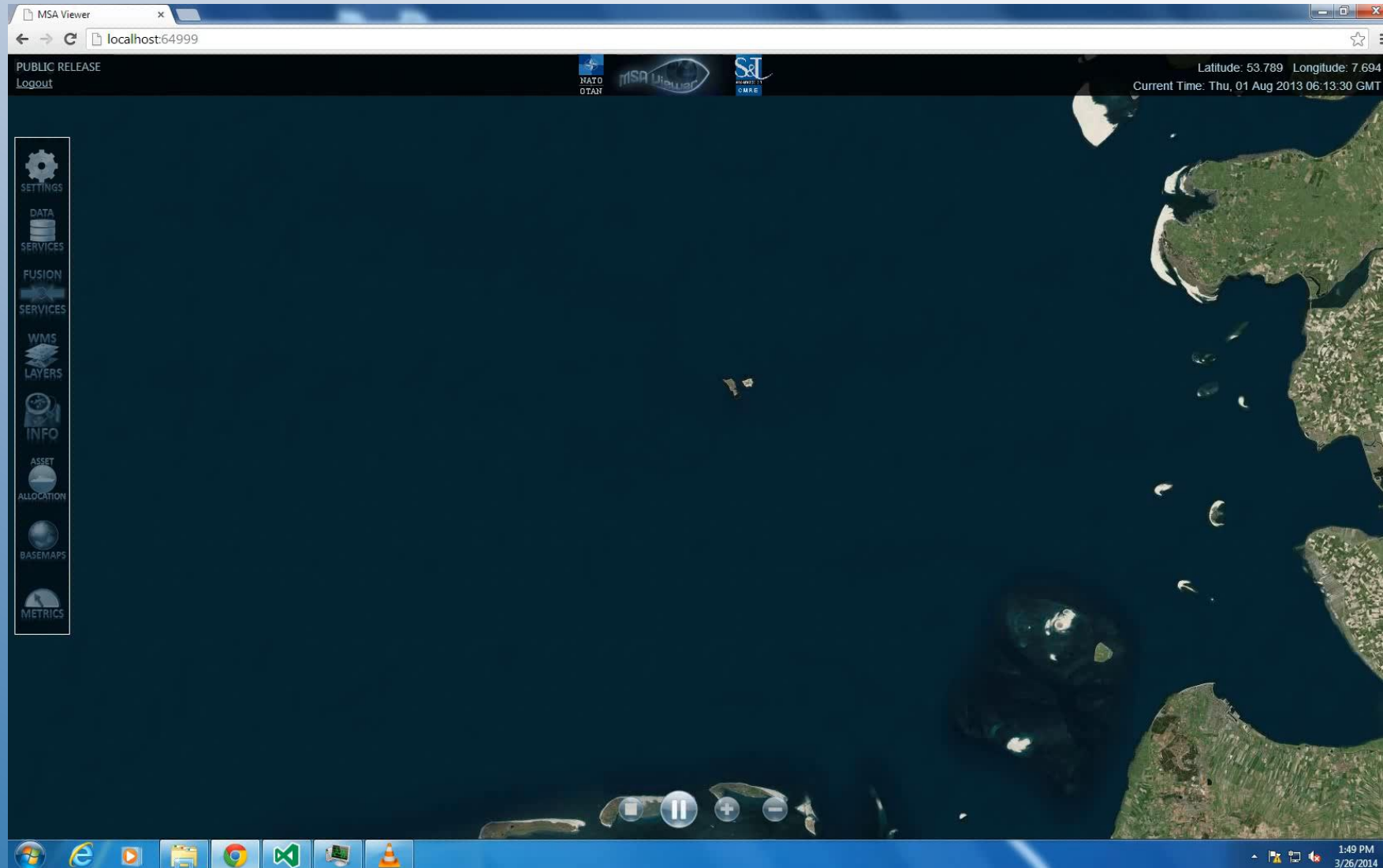
Rx pole height 6 to 9 m

Rx Array length 450 m

Tx pole height 15 to 18 m



4.3.18 HELZEL OTHR test site for Ship Tracking



4.3 Range of WERA Products (Applications)

11. Ocean current maps with **Highest Temporal Resolution**
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 13. **Maps of Significant Wave Height**
 14. **Directional Wave Spectra** for individual grid cells
15. **Drift Prediction** for Search and Rescue operations
16. **Ocean Current Forecasting** for vessel traffic services
17. **Tsunami Detection & Probability** check in near real time
18. **Ship Detection & Tracking** (with Dual use **OTHR** system only)
19. **Automatic Identification of Eddy Currents**
20. Near shore **Current Vector Maps** from **single WERA** station

4.4 Range of WERA Products (Quality)

21. **Certified Quality Management** implemented since 2001
22. System in **EMI tested** by independent authorized laboratory
23. **Highest data availability** of > 95 % (certified by customer)
24. All released **Software Validated by WERA Partners**
25. WERA hardware with integrated **Self Test Functions**
26. **Antenna Systems** are automatically tested once per hour
27. **Beam Forming with Self Calibration Function**
28. **Remote Controlled**, web interface via PC or smart phone
29. **Robust System** operates even with some defective antennas
30. **Safe Operation**, no dangerous voltage at Tx antennas

4.5 Range of WERA Products (Data)

31. Professional **Data Management** software
32. **Display of Data Maps** in near-real time
33. **Quality and Plausibility Check** of all data in near-real time
34. Easy generation of **Animated Maps**
35. Access to data of **Individual Grid Cells** with one mouse click
36. Access to **Archived Data**
37. Generation of **Time Series** for individual grid cells
38. Simple **Export Options** for all data and maps
39. **Warning**, if oceanographic parameter reaches defined value
40. Option to **Integrate External Sensor Data** into maps



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5.1 Conclusions - Summary

- WERA is the **most flexible** ocean radar, suited for **compact or array type antenna systems**
- Various small antenna options and **flexible site geometry** available
- **Dual frequency** options are available for multiple use applications
- Data interface for **MetOcean** applications (**GRIB**)
- **Hazard management** interface for Search and Rescue operations
- **Short term current prediction** for vessel traffic services
- **Dual use option with the OTHR system** includes ship detection & tracking

Thank you for your attention !



Since 1999, more than 150 WERA systems are installed.

- Permanent WERA Installation
- Temporary WERA Installations