

STATUS OF SHIP WAKES IN SAR IMAGERY

J.K.E. Tunaley

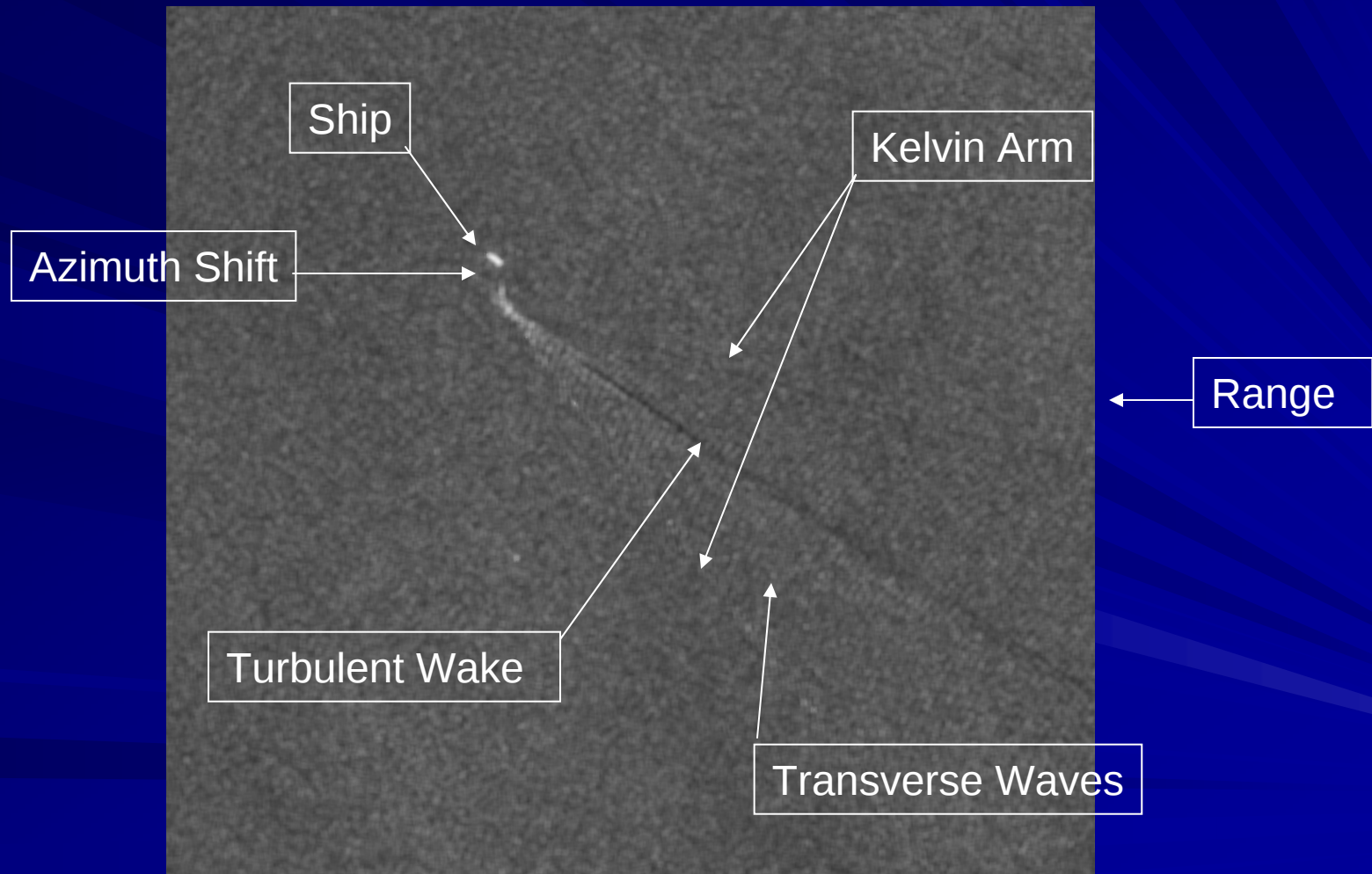
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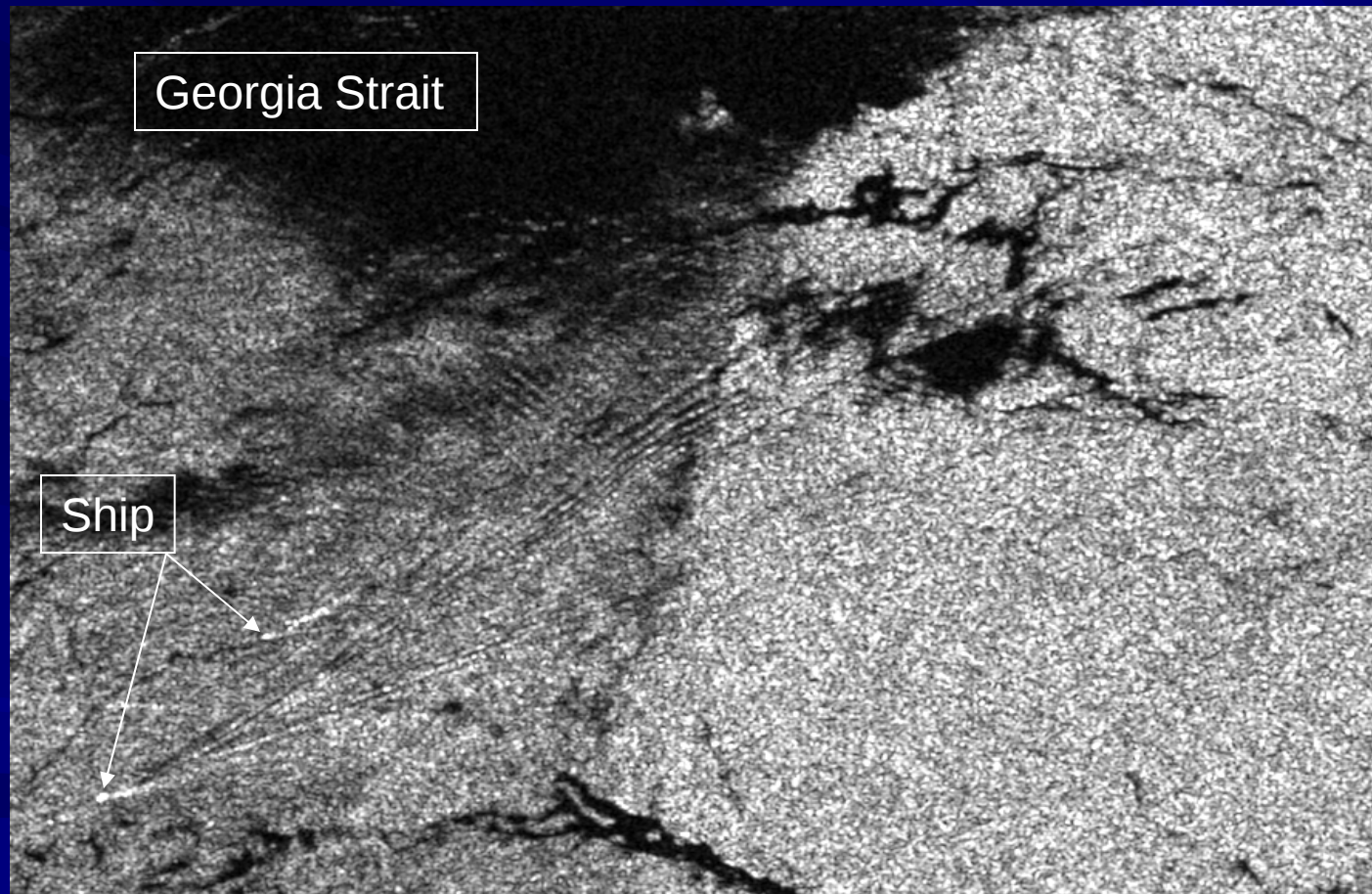
BACKGROUND

- Contribute to Maritime Domain Awareness
 - Extraction of Independent Target Parameters
 - Confirmation/Validation of other Data (AIS)
- Need better Understanding of Ship Wakes
- Program of Study started at RMC, Kingston
 - RADARSAT-2 Images
 - AIS Traffic Pattern Analysis
 - Compare Open Ocean with Lake Ontario/Seaway

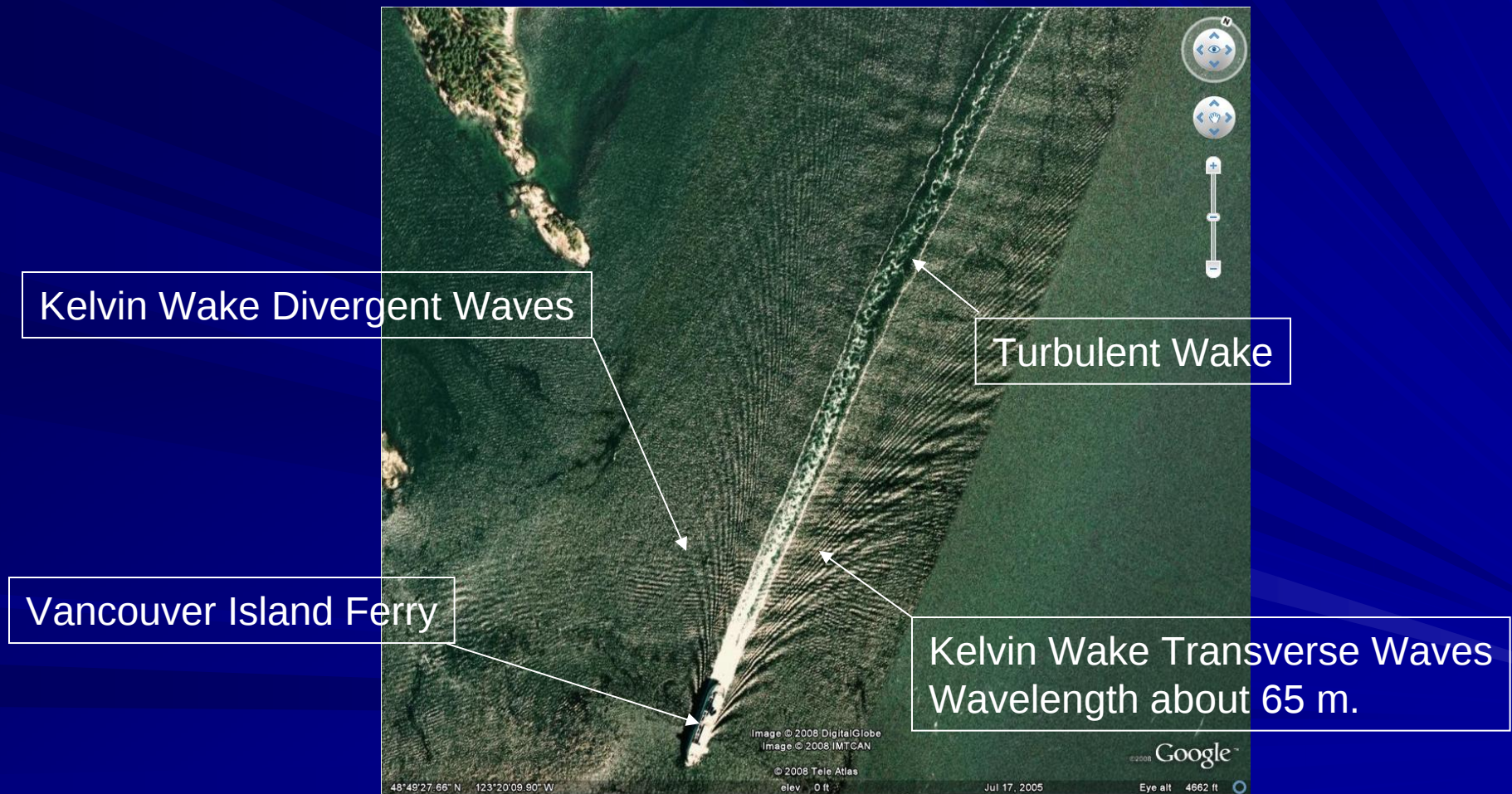
RADAR WAKE



INTERNAL WAVE WAKES



OPTICAL WAKE



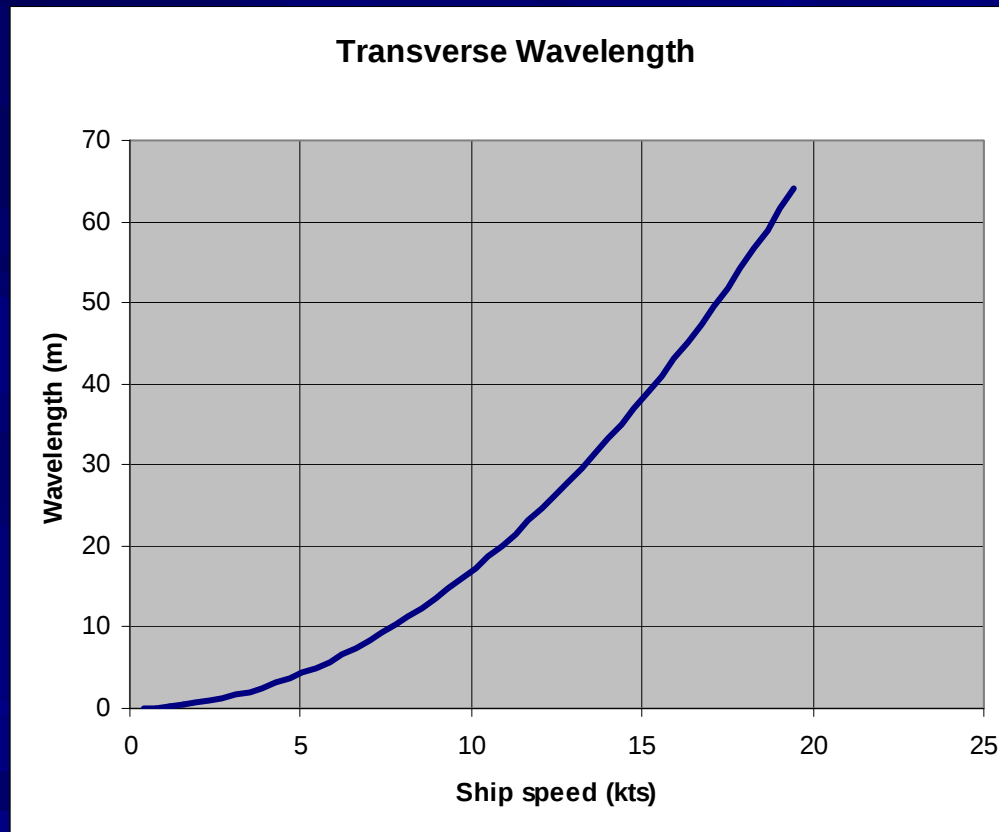
OUTLINE

- Information from Wakes
- Gravity Wakes (Deep and Shallow Water)
 - Kelvin
 - Internal
 - Unsteady (Surface and Internal)
- Turbulent Wake
- Surface Scattering
- SAR Effects

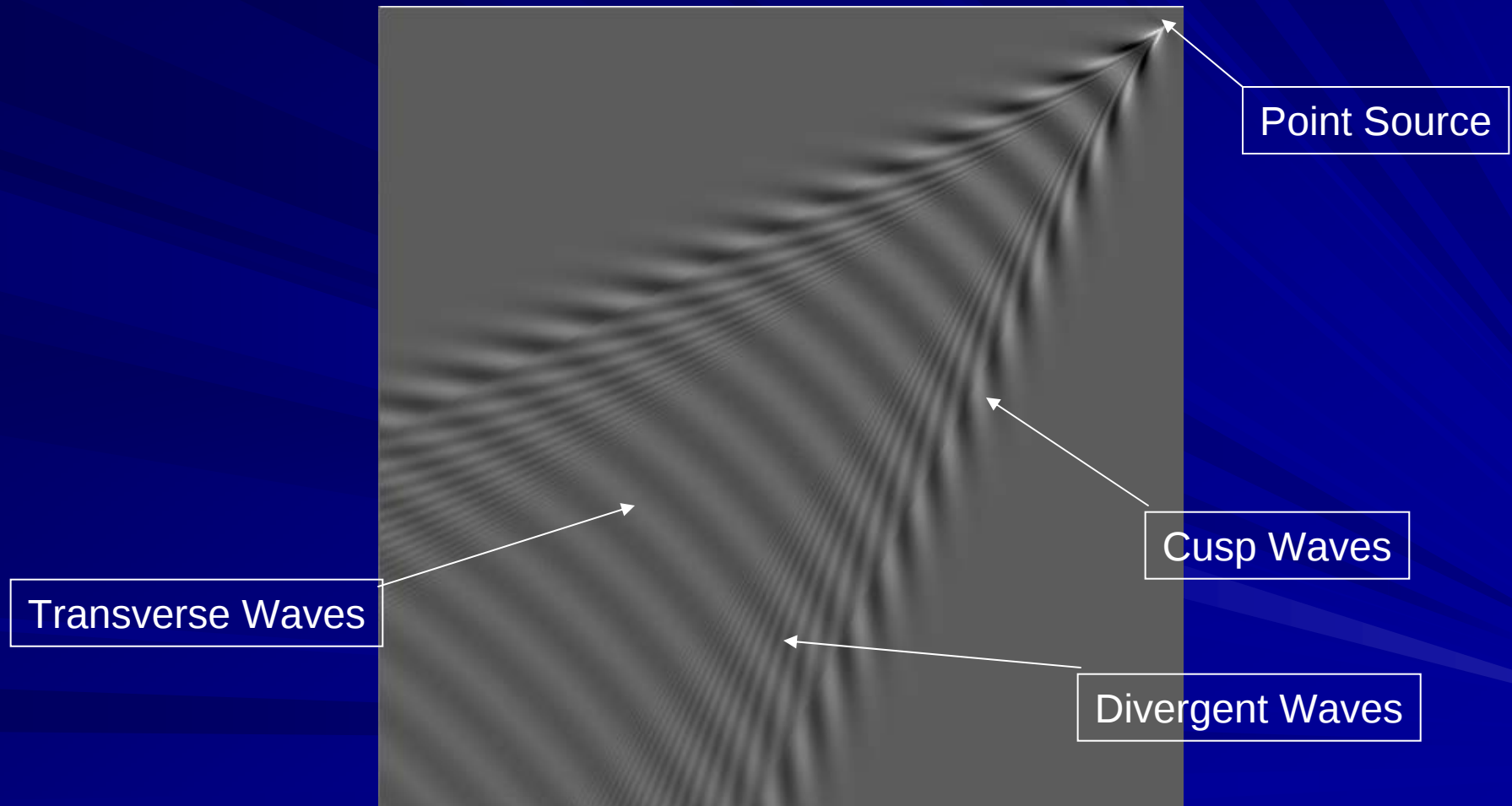
WAKE INFORMATION

- Ship Course
- Ship Speed
 - From Wake Offset
 - From Kelvin Transverse Wavelength
- Potential for Information about:
 - Propulsion System
 - Hull Form/Damage

KELVIN WAVELNGTHS

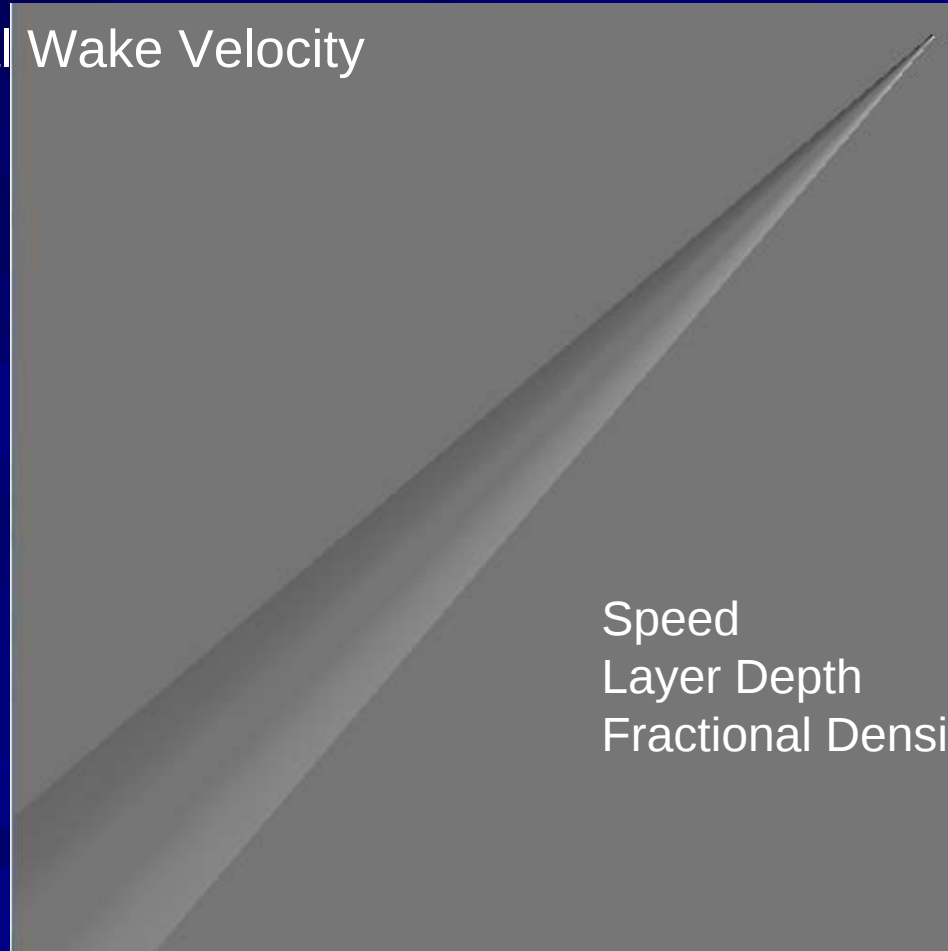


SIMULATED KELVIN WAKE



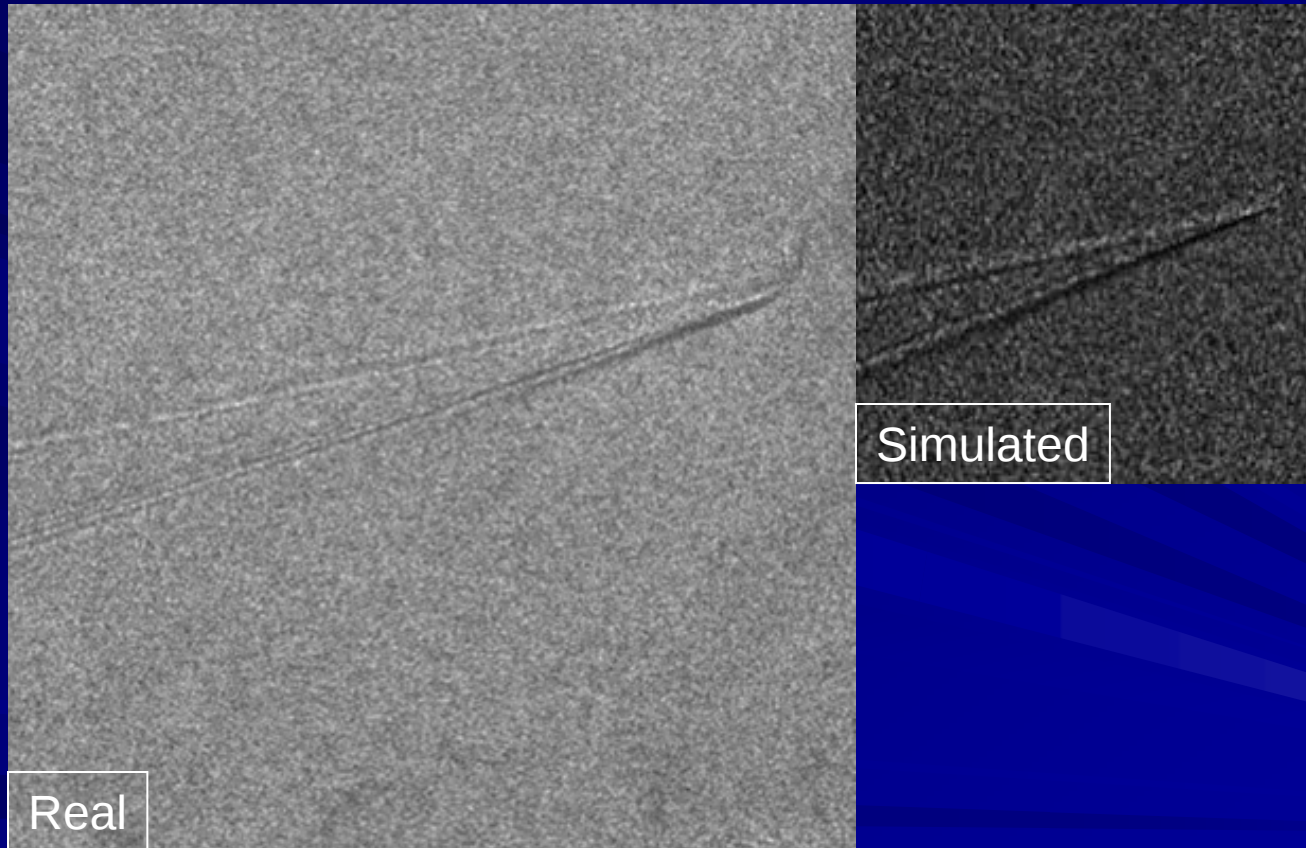
SIMULATED INTERNAL WAKE

Plot of Horizontal Wake Velocity
Component



Speed = 15 m/s
Layer Depth = 15 m
Fractional Density Change = 0.01

REAL AND SIMULATED

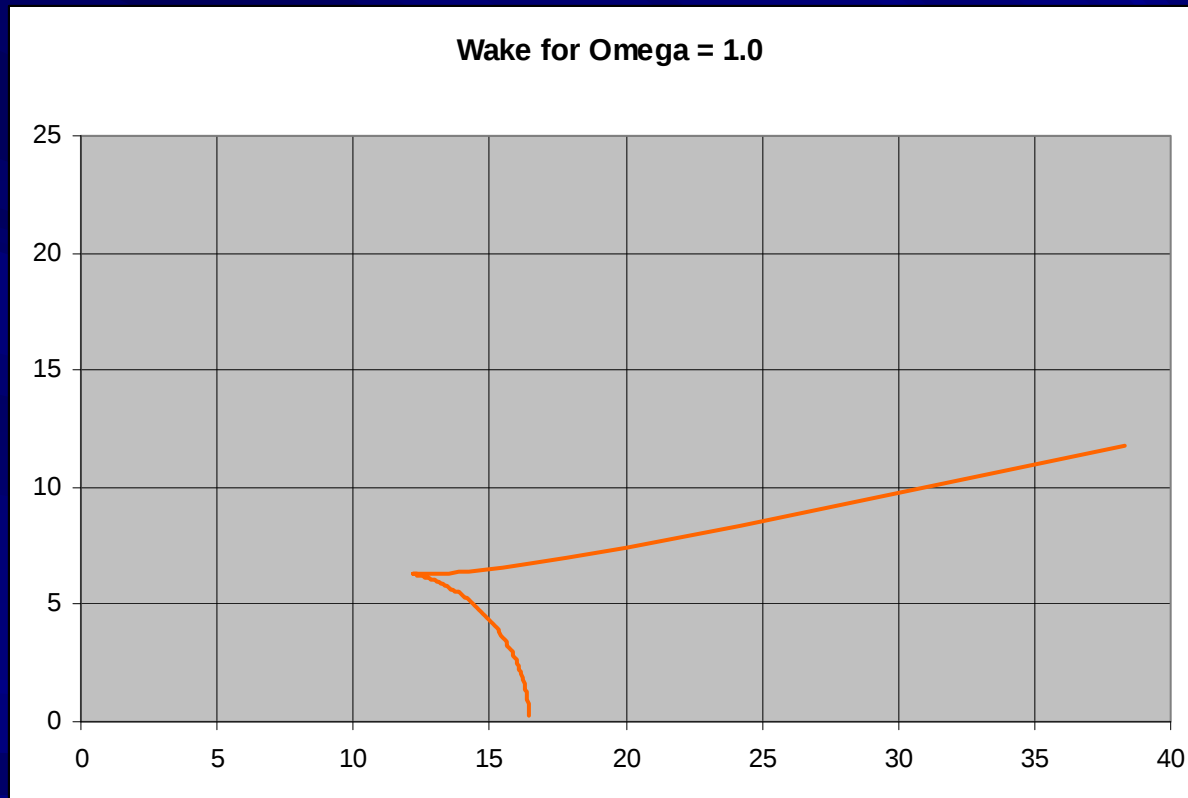


UNSTEADY GRAVITY WAKES

- Sinusoidal (or Random) Excitations
- Excitation due to
 - Heave and Pitch
 - Screws (Blade Frequency)
 - Reflection of Ambient Waves from Hull
- Wake Angle may be much Larger/Smaller than Kelvin Angle (39 degrees)
- Wave Crest Patterns can be Novel

UNSTEADY SINUSOIDAL

$\Omega = \Omega U/g$; Critical $\Omega = 0.25$



PROPELLER WAKE



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TURBULENT WAKE

- Comprises Random Vortices
- May contain Steady Flows
- Broadens slowly with Distance Astern, x
- Width, $b = Cx^{1/n}$
- Exponent $1/n$ depends on Environment and Propulsion

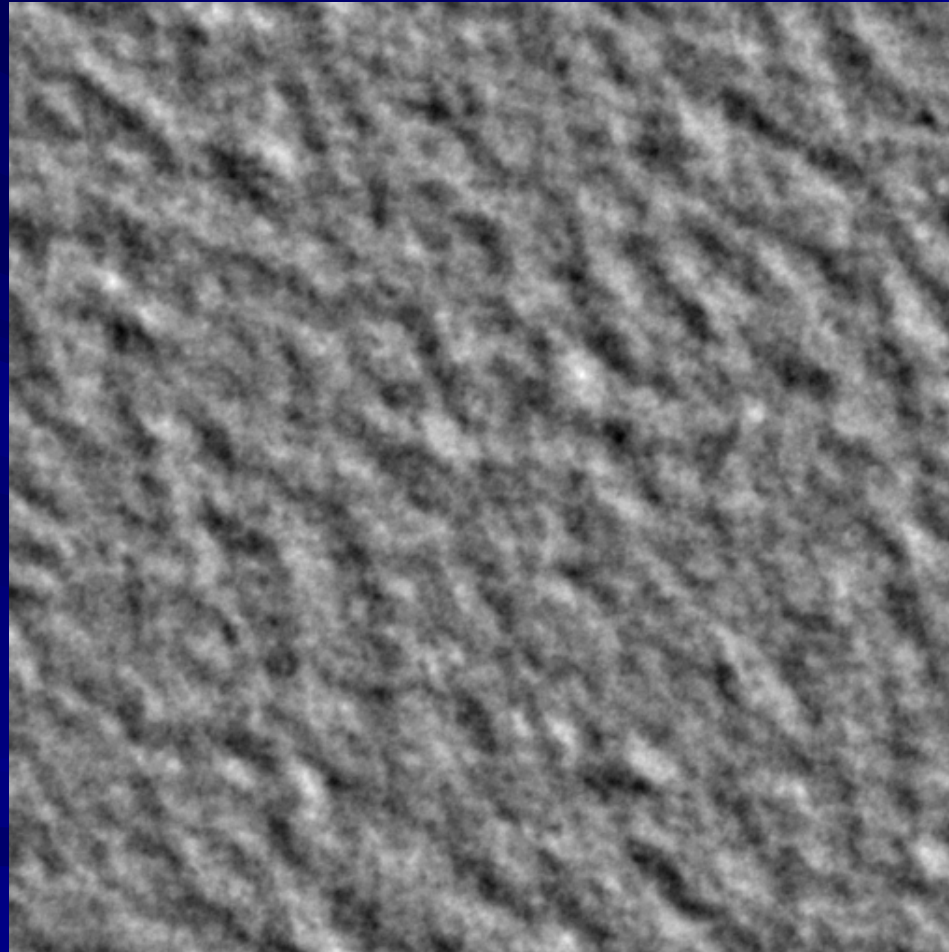
T-WAKE AND PROPULSION

Reciprocal Exponents, n

Large linear momentum in wake. Under sail.	3
Large angular momentum (swirl). Small linear momentum. Single screw.	4
Negligible mean linear/angular momentum but linear momentum variance high. Under sail at low speed or non-screw propulsion.	≥ 4
High swirls. Small mean linear and angular momenta. Two contra-rotating screws.	≥ 5

AMBIENT SEA

Sea State = 4



RADAR SCATTERING

- Bragg Scatter
 - Wright, 1968
- Wave Breaking
- Slope Modulation
- Surface Flows
 - Modify Bragg Waves and Trigger Breaking
- Surfactants

SAR EFFECTS

- Speckle
- Velocity Bunching
- Synthetic Aperture Time (in Ultrafine)
- Often Insufficient Resolution
 - Moire Fringe Effects due to Aliasing
- Bragg Wave Velocities (in Ultrafine)

TRAFFIC FROM AIS



Aug 6th, 2008
6:58LT

CONCLUSIONS

- Wake Theory to be Validated and Completed
 - Basics, Simulations and Visibility
- Inverse Problem Unexplored
- Significant Potential for MDA in Cross-Validation
 - Ship Velocity
 - Low Grade but Valuable Information for Fusion
 - Does not compensate for no AIS Fusion

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