STATUS OF SHIP WAKES IN SAR IMAGERY

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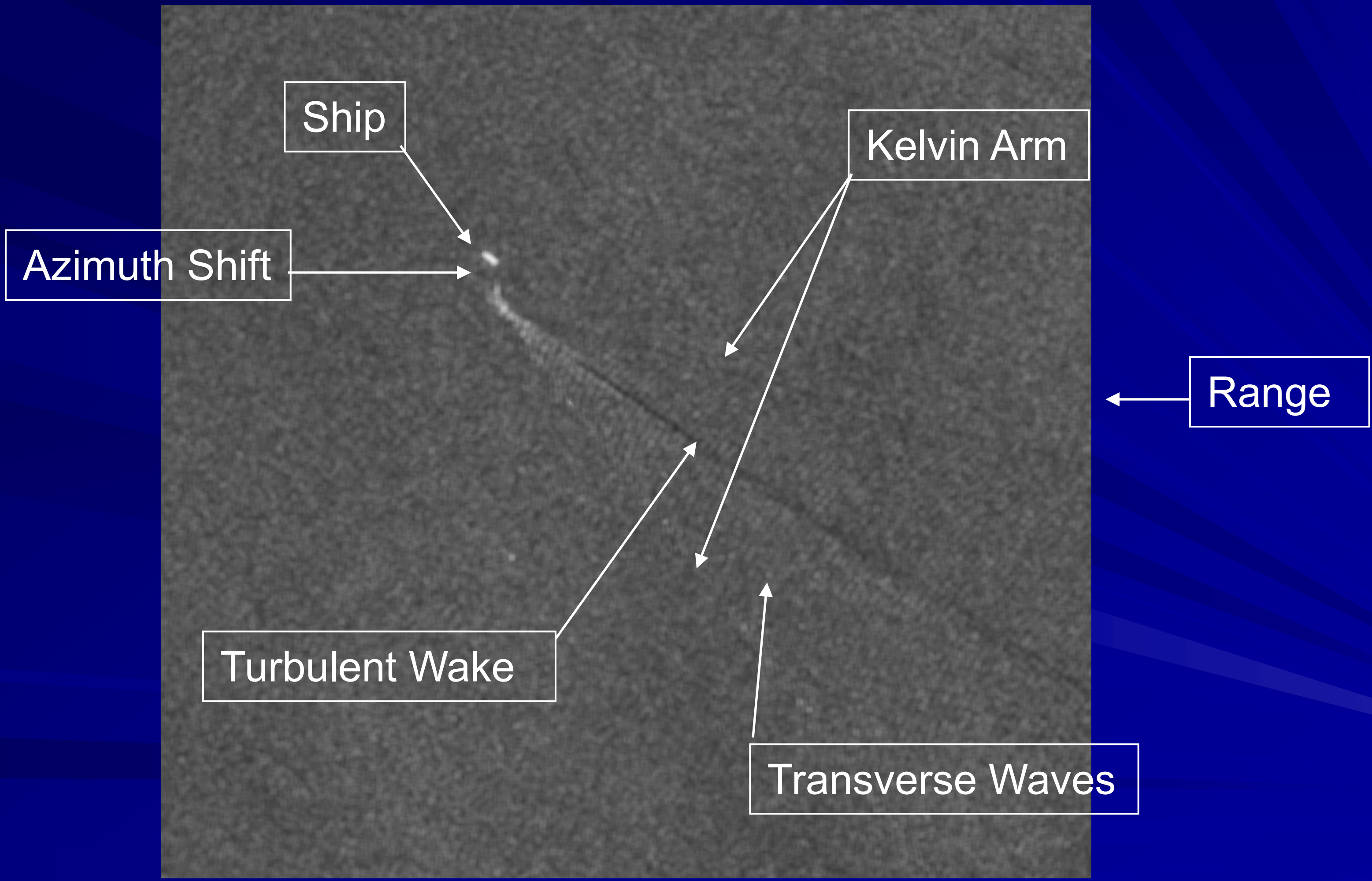
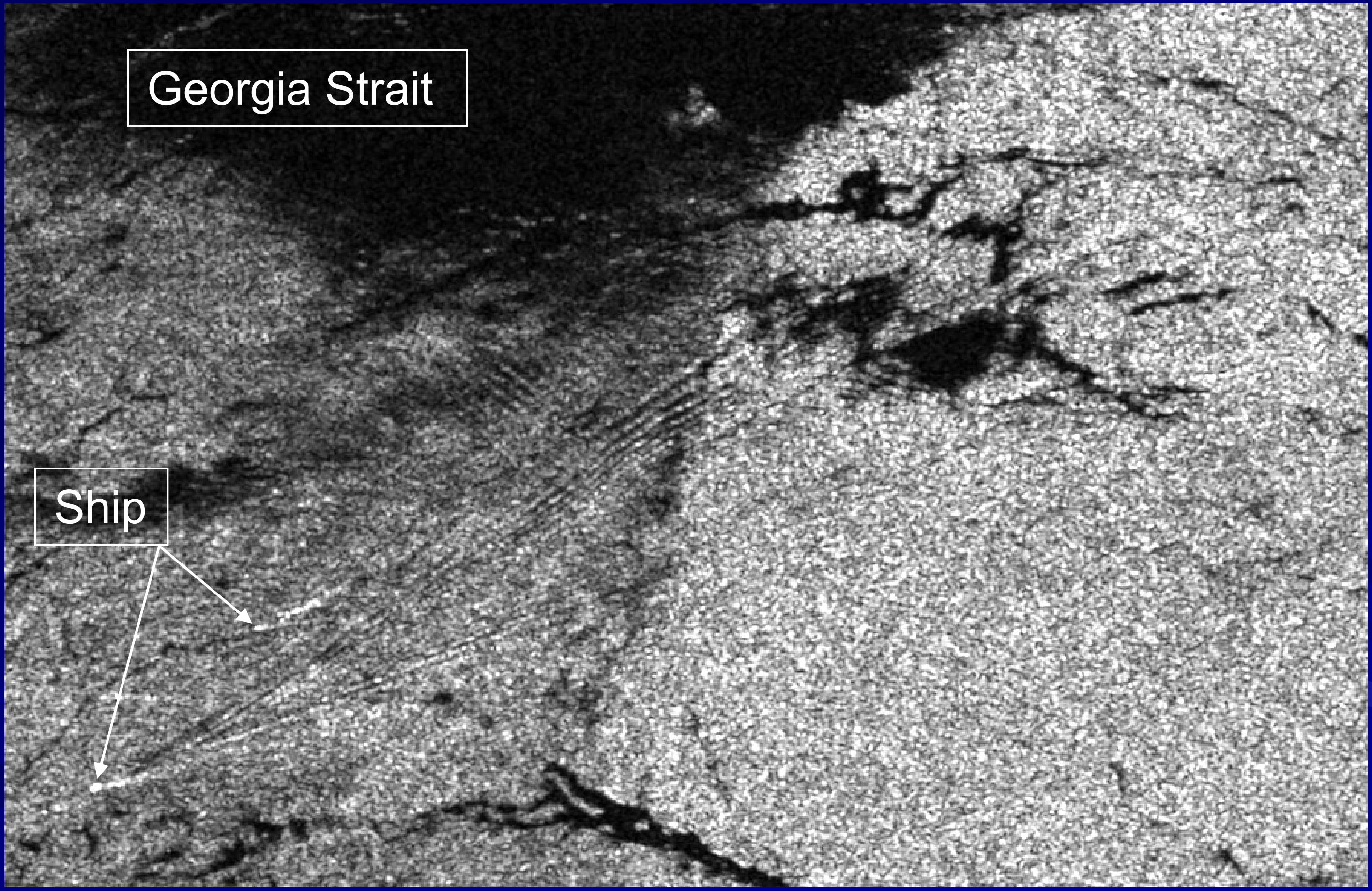
BACKGROUND

- 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

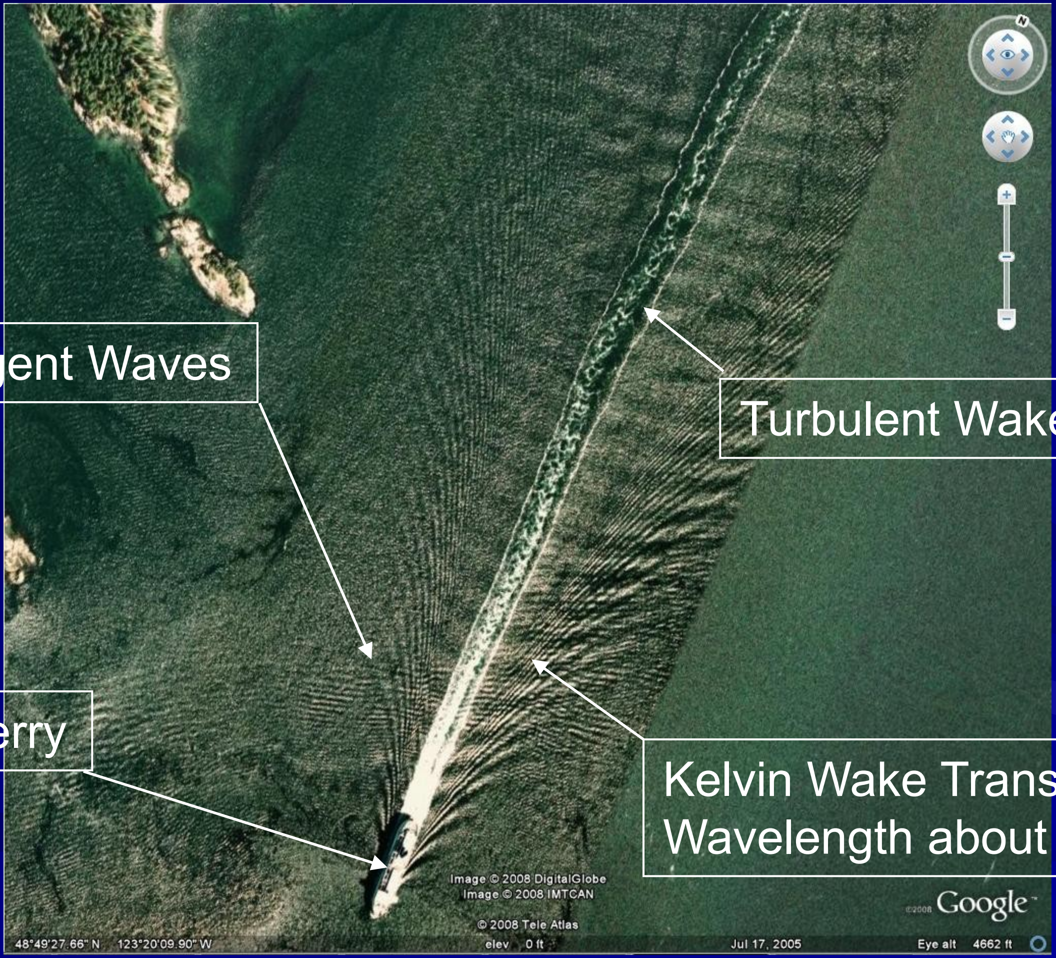

Ship
Kelvin Arm
Azimuth Shift
Range
Turbulent Wake
Transverse Waves

INTERNAL WAVE WAKES



Range

OPTICAL WAKE



Kelvin Wake Divergent Waves

Turbulent Wake

Vancouver Island Ferry

Kelvin Wake Transverse Waves
Wavelength about 65 m.

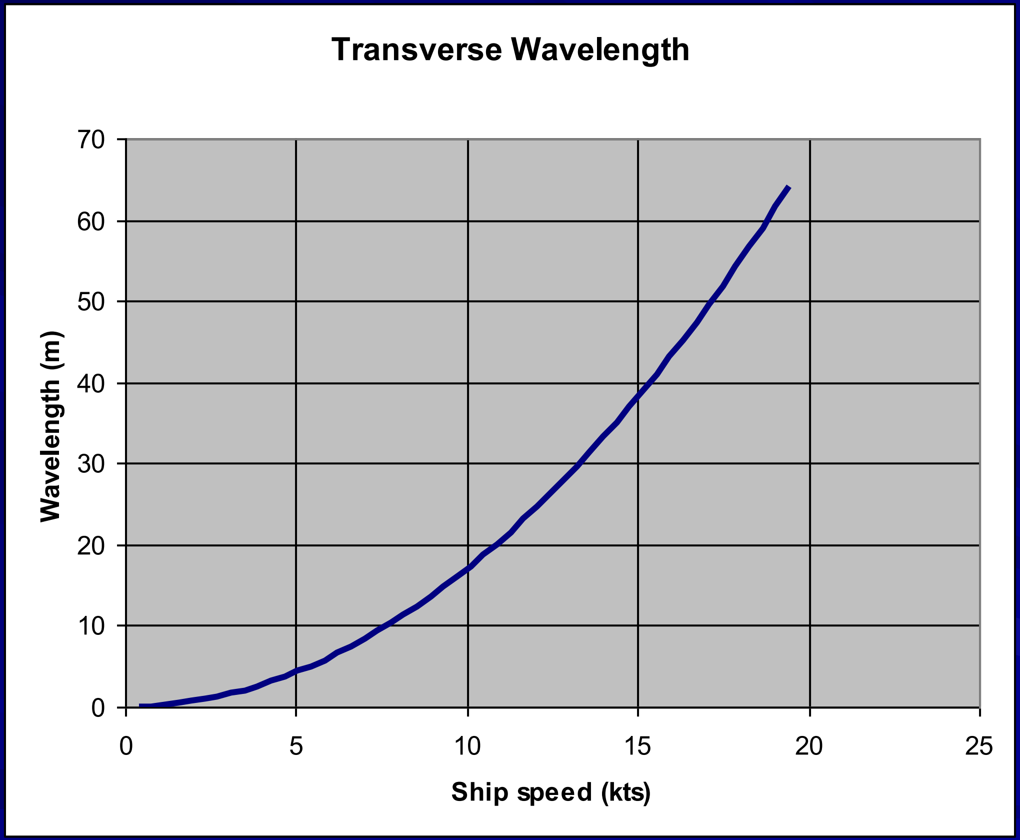
OUTLINE

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

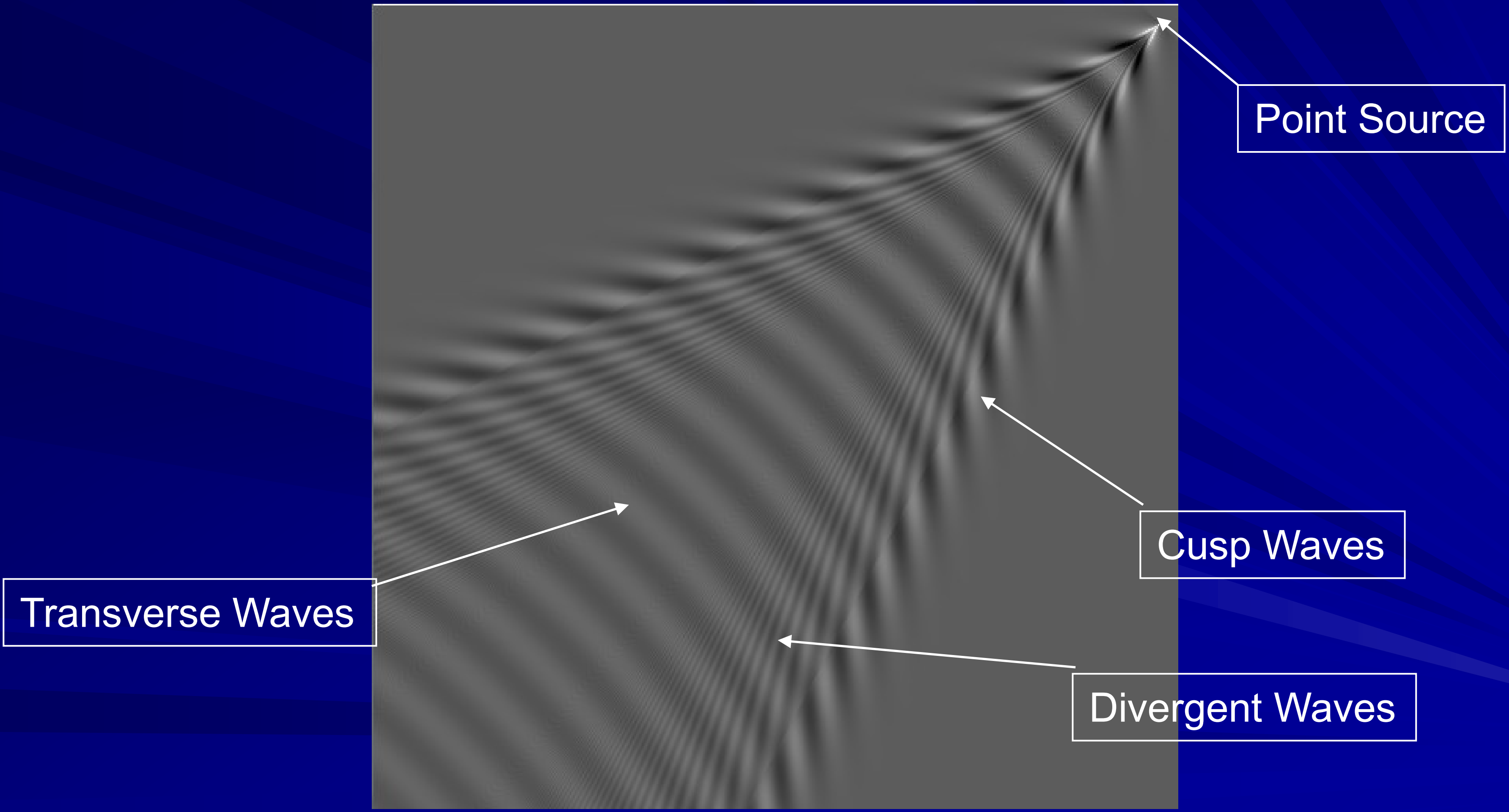
WAKE INFORMATION

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

KELVIN WAVELENGTHS

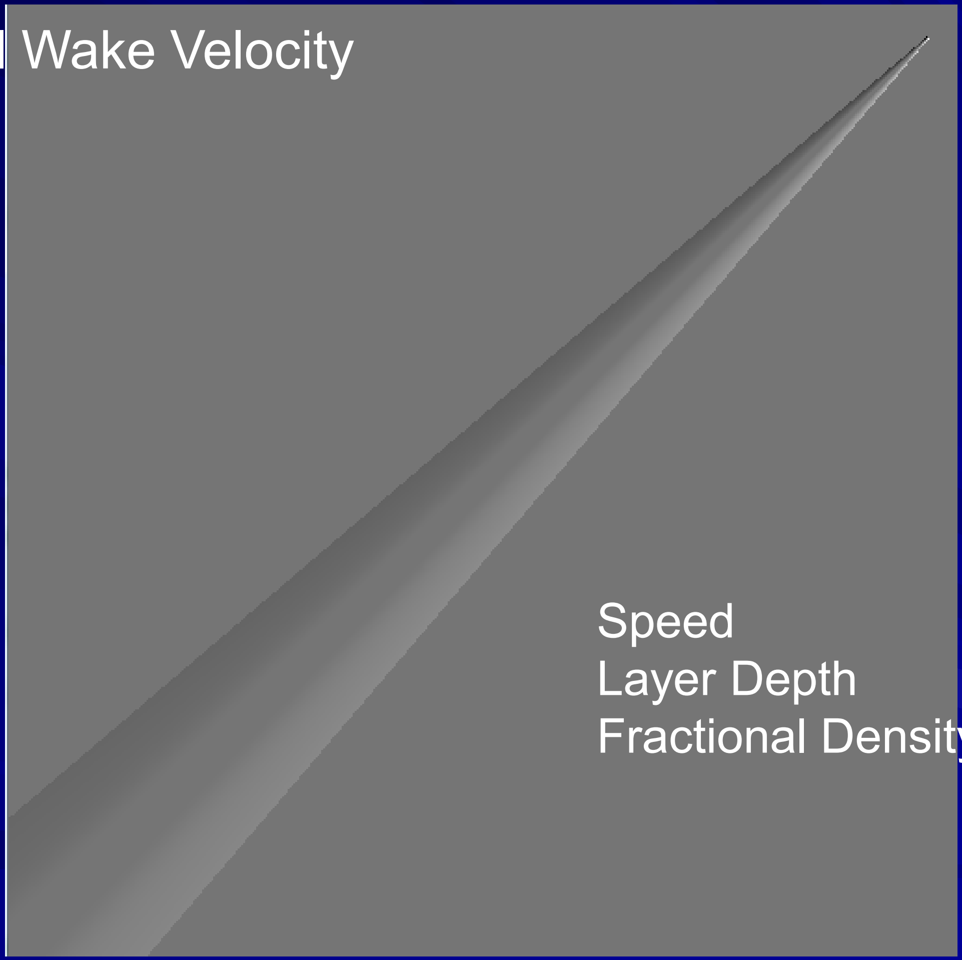


SIMULATED KELVIN WAKE



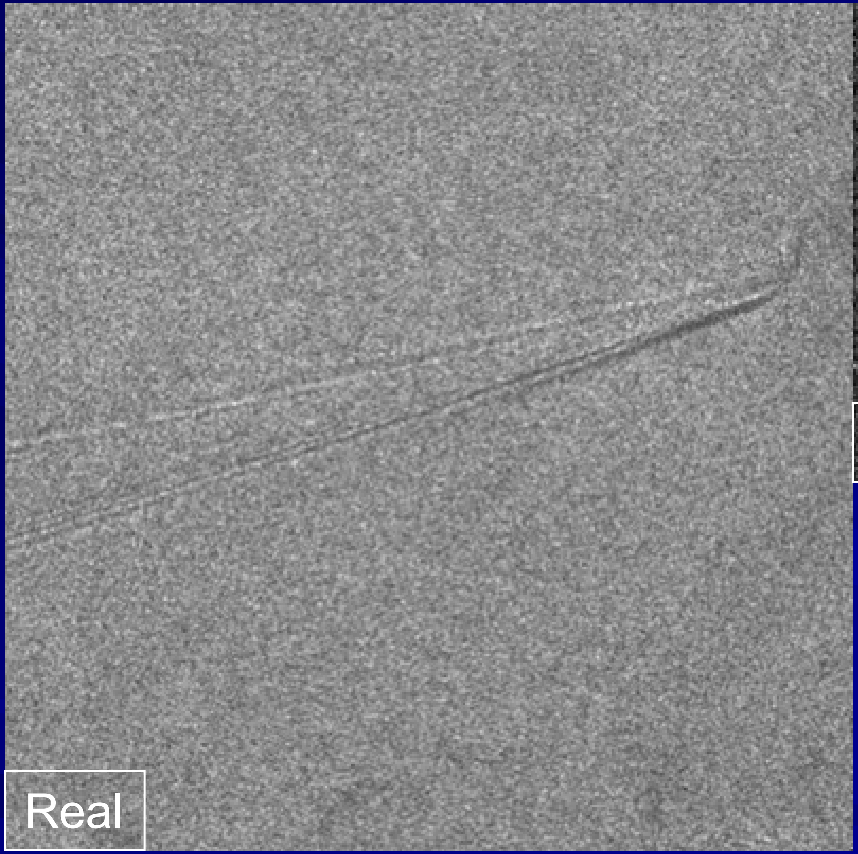
SIMULATED INTERNAL WAKE

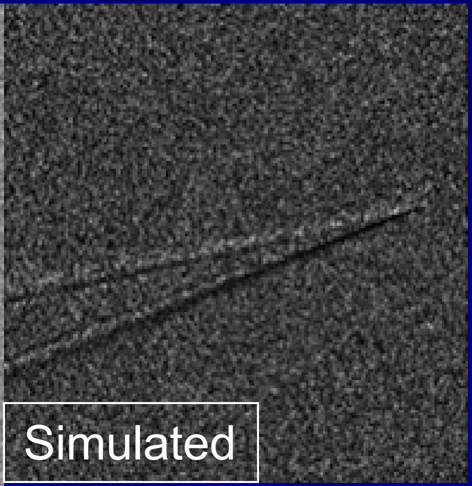
Plot of Horizontal Wake Velocity Component



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

REAL AND SIMULATED



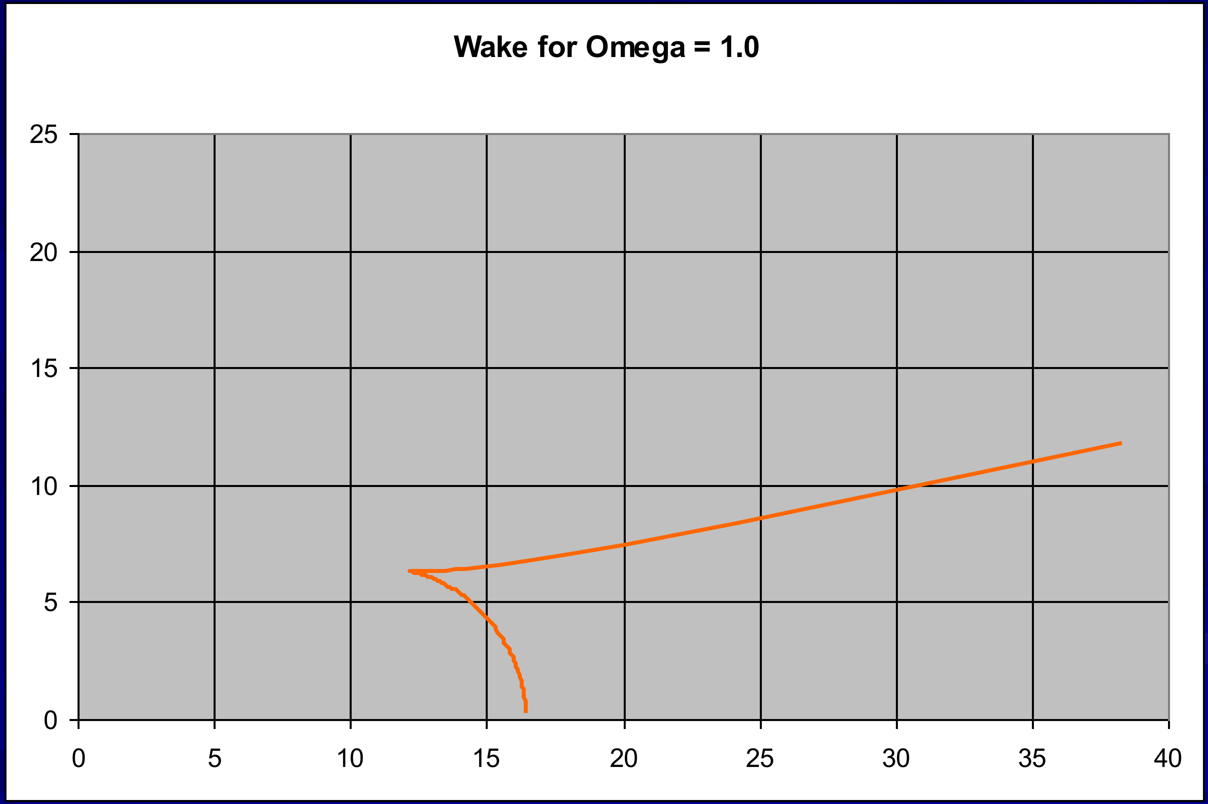


UNSTEADY GRAVITY WAKES

- 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 = ΩU/g; Critical Omega =0.25



PROPELLER WAKE

TURBULENT WAKE

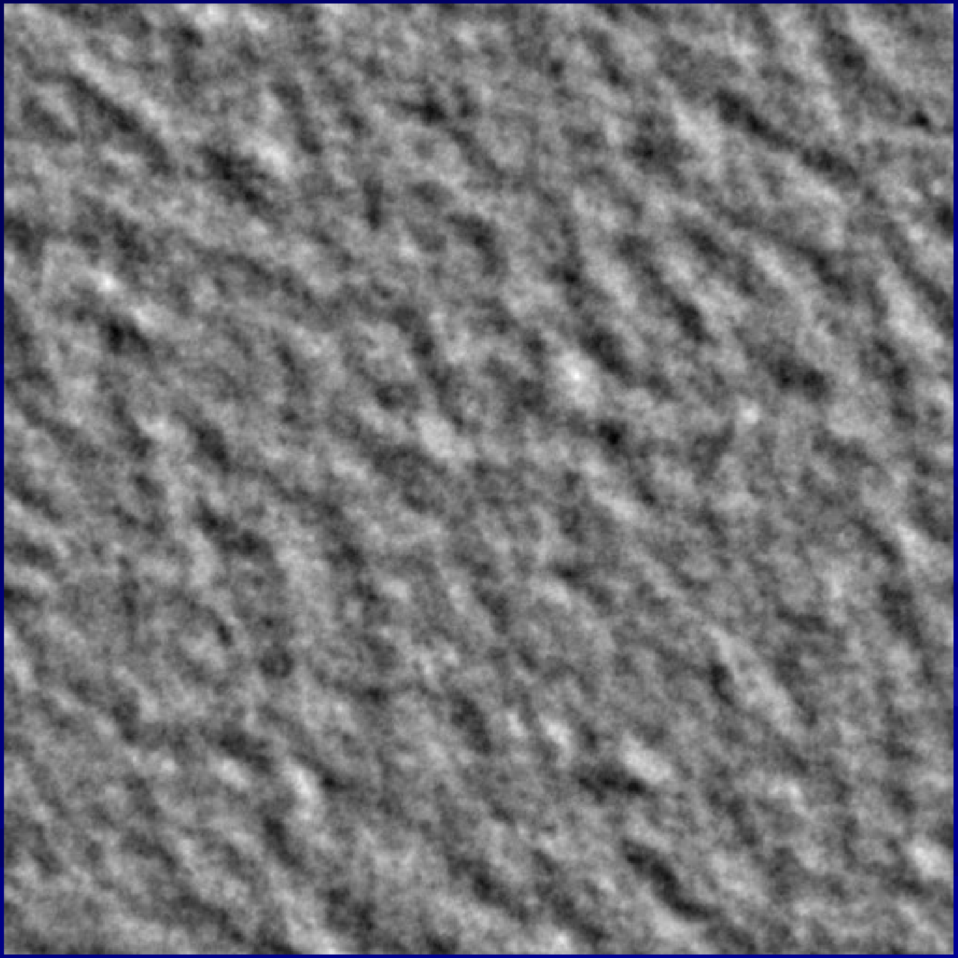
- Comprises Random Vortices
- May contain Steady Flows
- Broadens slowly with Distance Astern, x
- Width, b = $Cx^{1/n}$
- Exponent 1/n depends on Environment and Propulsion

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



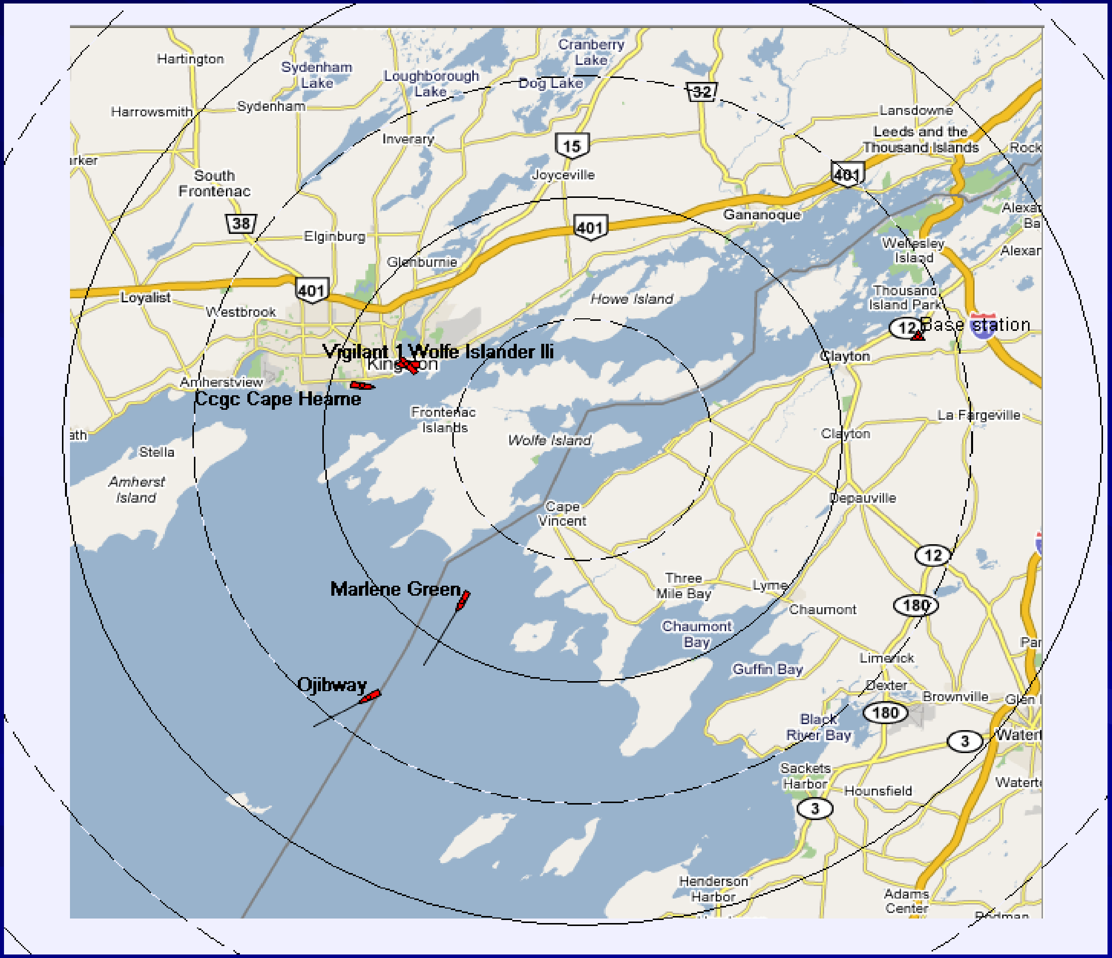
RADAR SCATTERING

- 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



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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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