Improved Quantification of Sea Spray Source Function: New Possibilities and Recent Developments at NRL

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Whitecap method

\[
\frac{dF(r, a, b, \ldots)}{dr} = f(U) \cdot f(r)
\]

\[f(U) = W(U_0) \quad \text{Scaling factor Magnitude}\]

\[f(r) = \frac{dF(r_0)}{d\log_{10} r_0} \quad \text{Size distribution Shape}\]

Necessary improvements

- For the size distribution \(f(r)\)
  - Extend the size range, large and small ends
  - \(1 \mu m < r_0 < 25 \mu m \quad 0.1 \mu m < r_0 < 250 \mu m\)
  - Recognize and include the effect of organics
  - Introduce ambient factors \(f(r) \Rightarrow f(r, a, b, \ldots)\)

- For the scaling factor \(f(U)\)
  - Less uncertainty in measuring \(W\)
  - Introduce ambient factors \(W(U) \Rightarrow W(U, a, b, \ldots)\)

Variability of the scaling factor

\[W(U) = W(U, a, b, \ldots)\]

Satellite remote sensing

- Measure microwave emissivity of sea surface
- Various frequencies \(\Rightarrow\) various possibilities

Data base

- Global coverage
- Environmental variables
  - Wave field
  - Atmospheric stability
  - Water temperature
  - Salinity
  - Surfactants

New possibilities

- Separate active whitecap fraction
  - Active and residual foam
    \[W(U, a, b, \ldots) = W_A + W_B\]
    \[W_B \geq O(10 W_A)\]
  - Why?
    - Various air-sea interaction processes
    - Different production rates?
    \[(dF/dr)_A \neq (dF/dr)_B\]
    - So that
    \[(dF/dr) = W_A (dF/dr)_A + W_B (dF/dr)_B\]

Semi-theoretical approach for \(W_A\)

- Physical basis
  - Phillips concept for breaking crest length distribution \(A(c)\)
  - Allows relationship \(W_A(c)\)
  - Associates \(W_A\) with the dynamic (moving) part of the whitecaps

- Realization
  - Derive expression for \(W_A(c)\)
  - Obtain \(\langle c \rangle\) from wave spectra measured from buoys
  - Obtain ratio \(W_A/W\) regionally for buoys at various locations
  - Generalize \(W_A/W\) for global application.

- Initial results
  - Favorable comparison with the photographic data for \(W_A\)
    (panels a and b) \(\Rightarrow\) our approach is sound
  - Expected difference with the radiometric data for \(W_A\) (panel c)
  - Sensitivity to parameter choice investigated
  - Needs more work and validation

Experimental approach for \(W_A\)

- Physical basis
  - Distinctly different signatures of \(W_A\) and \(W_B\) in the IR region
  - Different but WEAK signatures of \(W_A\) and \(W_B\) in the microwave region
  - Use the former to gain insights for the latter

- Realization
  - Laboratory data to confirm differences of \(W_A\) and \(W_B\) in the IR region
  - Multi-instrument field campaign

Summary

Conclusions

- Separation of \(W_A\) and \(W_B\) could be useful
- Separation of \(W_A\) and \(W_B\)
  - Demonstrated with Phillips concept for breaking crest length
  - Anticipated from IR signature of whitecaps
- Many more data to process

Challenges

- Are the production rates for \(W_A\) and \(W_B\) different?
- How to measure them?
- Is the IR signature of \(W_A\) and \(W_B\) reliable for separation?

Expected difference with the radiometric data for \(W_A\)
Favorable comparison with the photographic data for \(W_A\)

Derive expression for the scaling factor \(W\)
"WA = \frac{W_A}{W} \Rightarrow(12)\)

Obtain ratio \(W_A/W\)
"WA = \frac{W_A}{W} \Rightarrow(12)\)

To confirm differences of \(W_A\) and \(W_B\) in the IR region
Multi-instrument field campaign