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

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Whitecap method

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

$\mathrm{f}(U) \equiv W(U_{10})$ Scaling factor Magnitude

$\mathrm{f}(r) \equiv \frac{d\mathrm{f}(r_{80})}{d\log_{10} r_{80}}$ Size distribution Shape

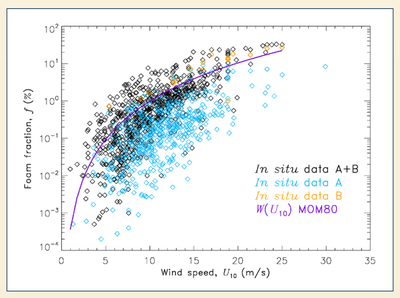
Necessary improvements

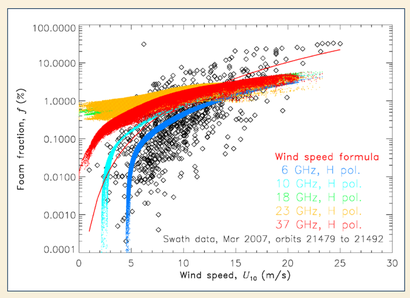
- For the size distribution $\mathrm{f}(r)$
  - Extend the size range, large and small ends
    $1\,\mu\mathrm{m} < r_{80} < 25\,\mu\mathrm{m} \Rightarrow 0.1\,\mu\mathrm{m} < r_{80} < 250\,\mu\mathrm{m}$
  - Recognize and include the effect of organics
  - Introduce ambient factors $\mathrm{f}(r) \Rightarrow \mathrm{f}(r,a,b\ldots)$
- For the scaling factor $\mathrm{f}(U)$
  - Less uncertainty in measuring W
  - Introduce ambient factors $W(U) \Rightarrow W(U,a,b\ldots)$

Variability of the scaling factor

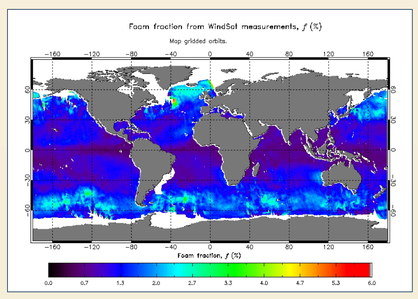
$W(U) \Rightarrow W(U,a,b\ldots)$

- 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

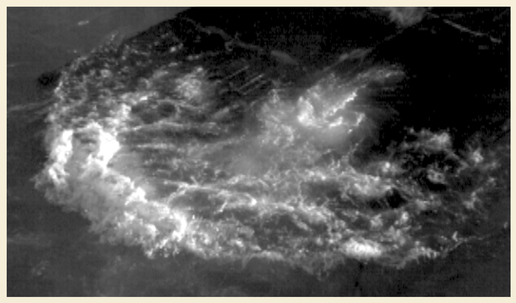
$$W(U,a,b\ldots) = W_A + W_B$$
$$W_B \geq O(10W_A)$$

- Why?
  - Various air-sea interaction processes
  - Different production rates?

$$(dF/dr)_A \neq (dF/dr)_B$$

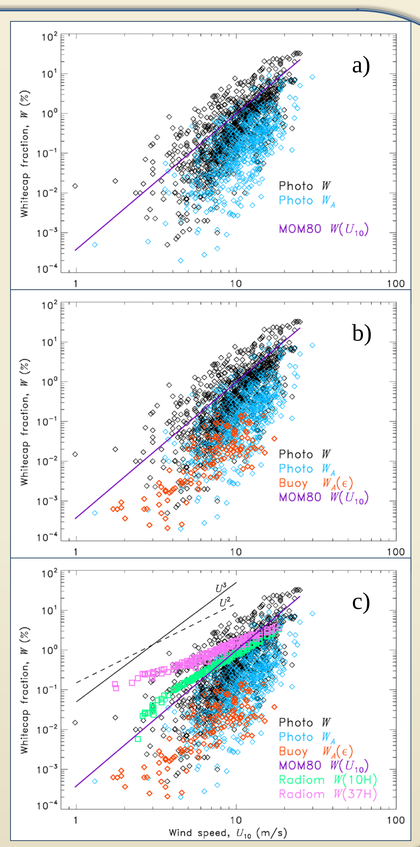
  - So that

$$(dF/dr) = W_A\,.(dF/dr)_A + W_B\,.\,(dF/dr)_B$$



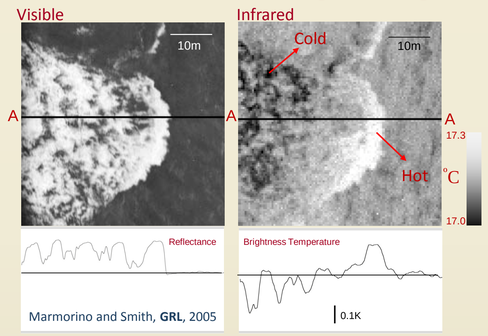
Semi-theoretical approach for W_A

- Physical basis
  - Phillips concept for breaking crest length distribution $\Lambda(c)$
  - Allows relationship $W_A(\varepsilon)$
  - Associates W_A with the dynamic (moving) part of the whitecaps
- Realization
  - Derive expression for $W_A(\varepsilon)$
  - Obtain $\langle\varepsilon\rangle$ 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

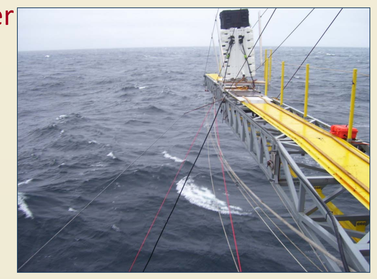


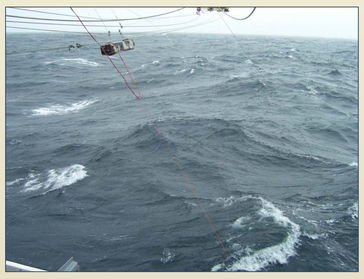
Experimental approach for W_A

- 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

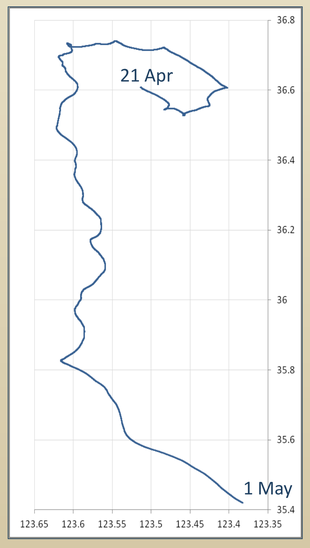


Marmorino and Smith, **GRL**, 2005

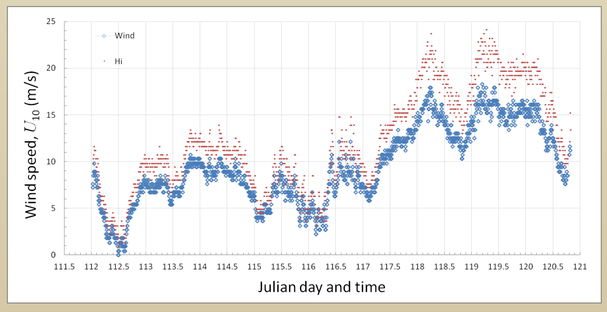




- Realization
  - Laboratory data to confirm differences of W_A and W_B in the IR region
  - Multi-instrument field campaign



FLIP drift



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?