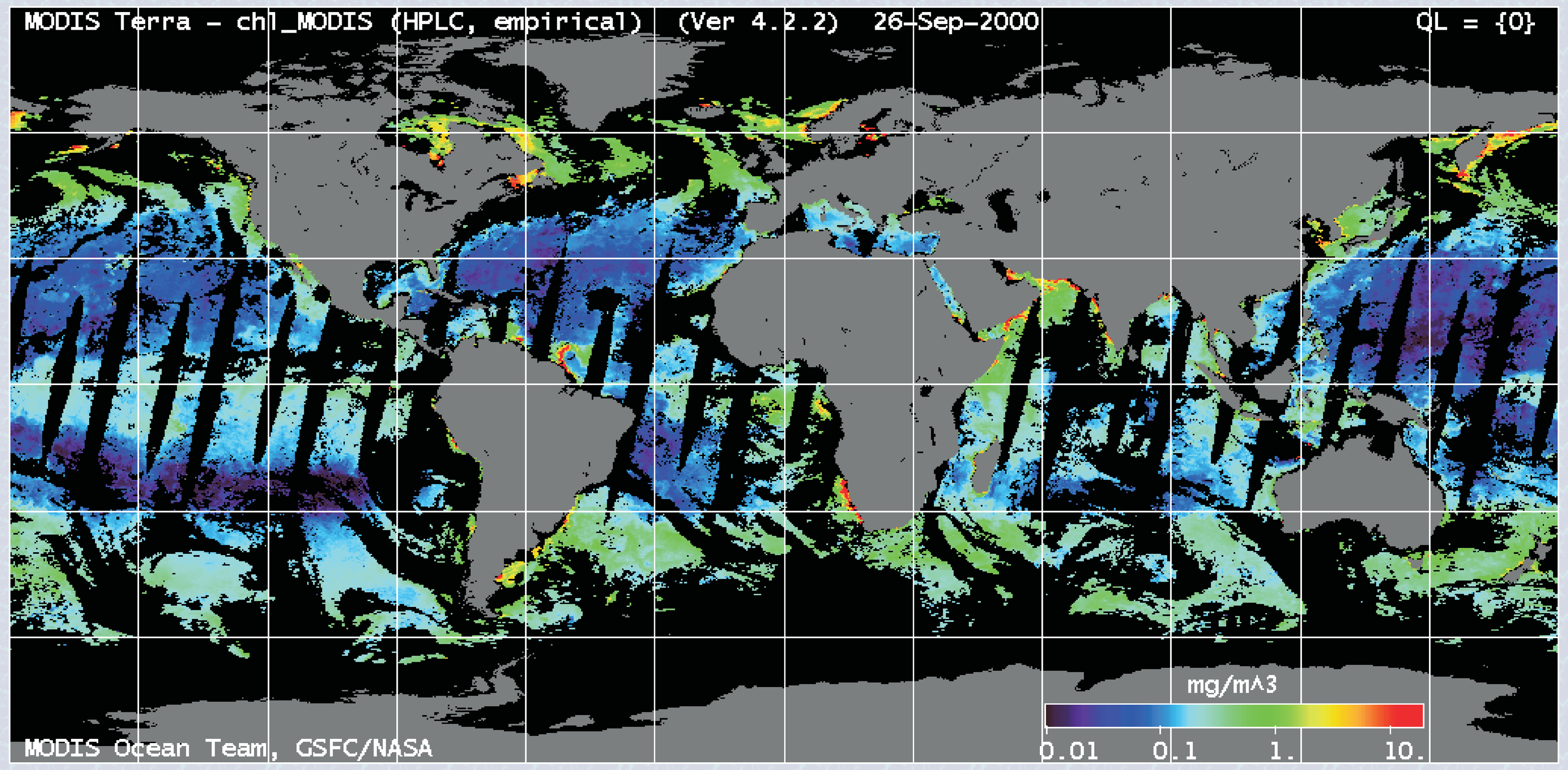
Retrievals in Presence of Sunglint: The Future is Looking Bright

H. Eide[a], *M. Ottaviani*[a], *D. Cohen*[a], *K. Stamnes*[a], *W. Wiscombe*[b], *W. Su*[c]

[a]Stevens Institute of Technology, Department of Physics and Engineering Physics,
Castle Point on Hudson, Hoboken, NJ 07030
[b]NASA Goddard, Greenbelt, MD 20771
[c]NASA Langley Research Center, Hampton, VA 23681

Sunglint: Can we do better?

- Our ability to retrieve information from the ocean and the overlying atmosphere depends on how well we can describe the ocean BRDF in our forward models.
- Sunglint only looks smooth when we average the fine structure over time and space, or look at it from great distances.
- Accurate description of ocean BRDF is becoming as important as aerosol treatment in coupled atmosphere-ocean RT models for remote sensing retrievals.
- An accurate description of sunglint together with a realistic radiative transfer model can reduce the area currently masked away as unusable data.



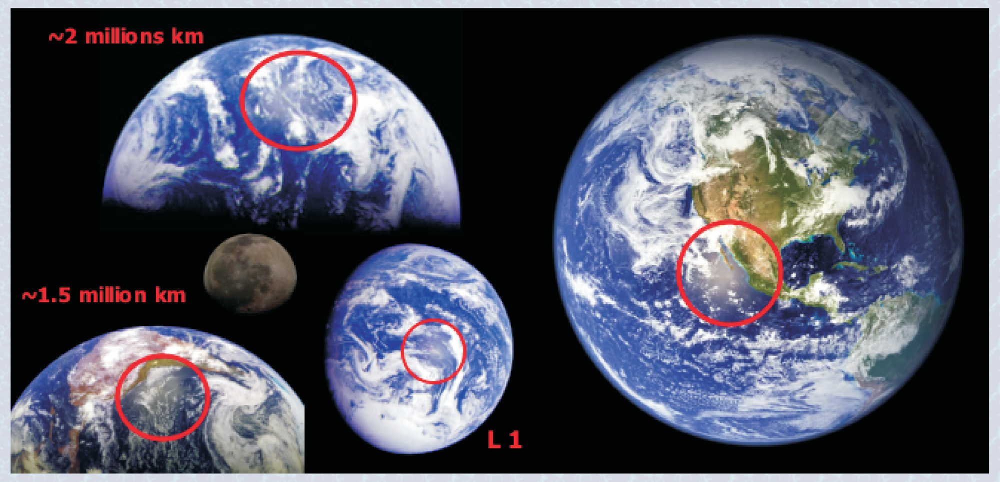
Above: Chlorophyll, 26 Sep 2000; alternate black stripes are missing data due to glint (others are gaps between swaths)

Sunglint: is it just contamination?

Sunglint is like having a bright lamp at the surface
- atmospheric spectral transmission measurements are easiest to interpret

We could use sunglint regions to retrieve:
- water vapor column (Kleidman..., 2001)
- aerosol absorption (Kaufman..., 2002)

Prerequisite: accurate description of polarized sunglint at the bottom of the atmosphere
- CO2 column amount at 1.5/2.2 μm wavelengths

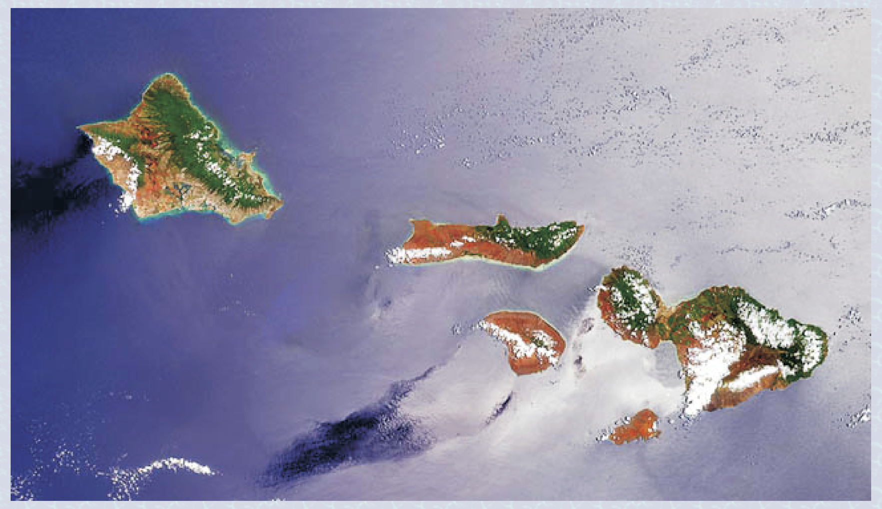


Left: Sunglint as seen from far away. Note how a significant portion of the earth's disk is in the glint region. Extra solar planets with large water bodies might one day be detected from their glint.

Right: Sunglint seen from ground level.

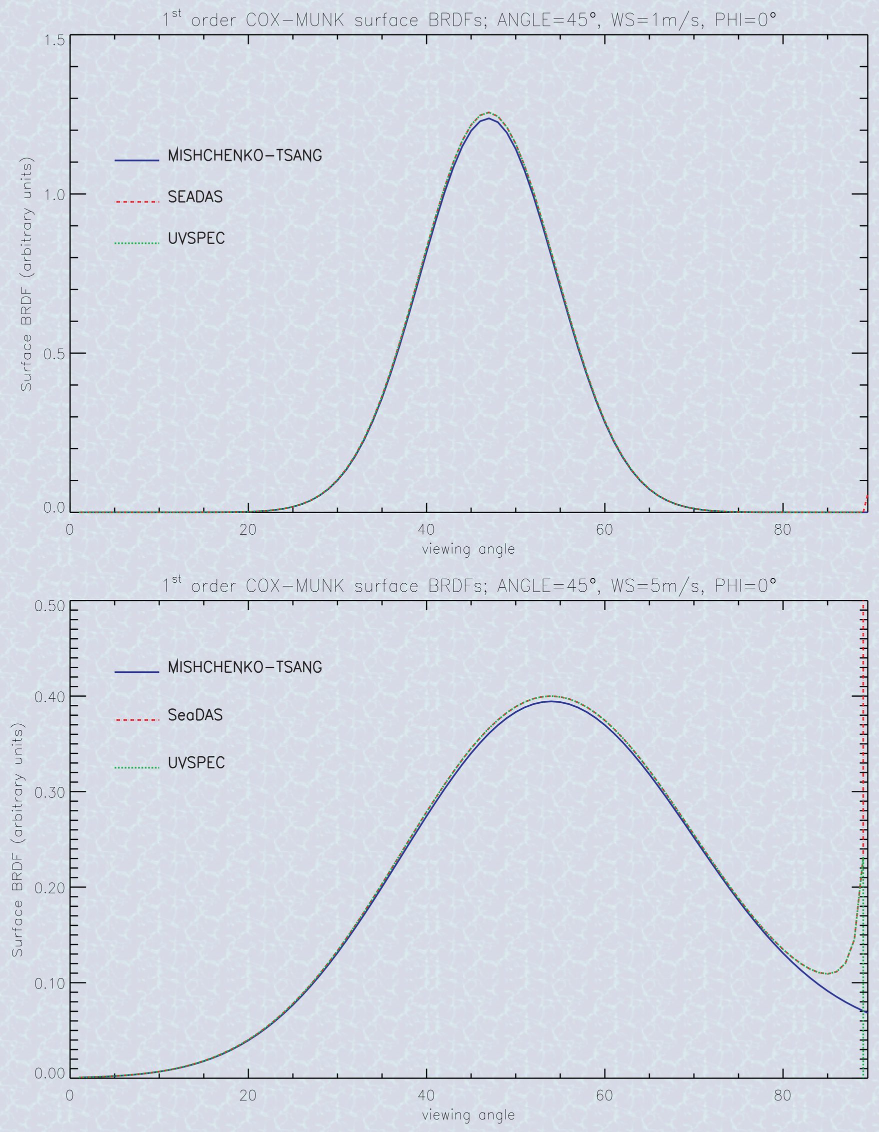
Below: Sunglint as seen from the shuttle at 800 km.

Below: Sunglint around the Hawaiian Islands as seen from 800 km up. Note the glint variation due to wind/wave conditions.



Modeling Sunglint

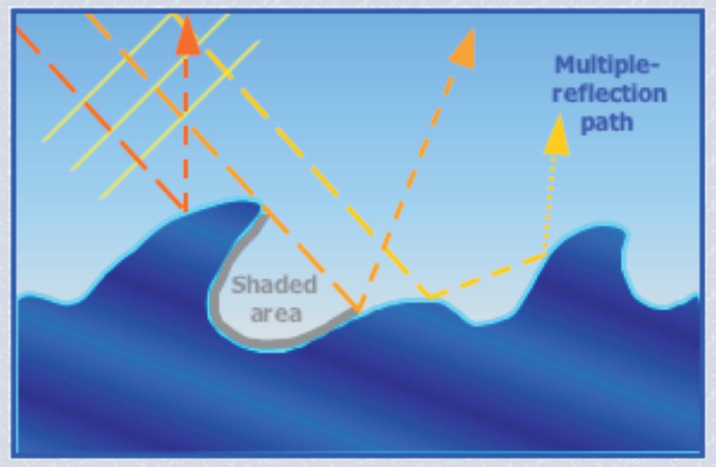
Sunglint models are usually based on the work of Cox and Munk (1954!). Techniques used:
- surface statistics combined with an electromagnetic boundary value formulation
- surface realizations (based on statistics) combined with Monte Carlo calculations



Above: Surface BRDF for a sea-surface calculated with three different models. All models use the Cox/Munk wave-slope distribution. Notable differences are only apparent for high viewing angles.

Comparisons of sunglint models

Models tested so far show small differences in
- ~ peak radiance in the specular direction
- ~ the angular direction of maximum specular reflection
- ~ the width (FWHM) of the glint region
- ~ treatment of shadowing effects
- ~ treatment of multiple reflection paths
- ~ inclusion of polarization, wind direction



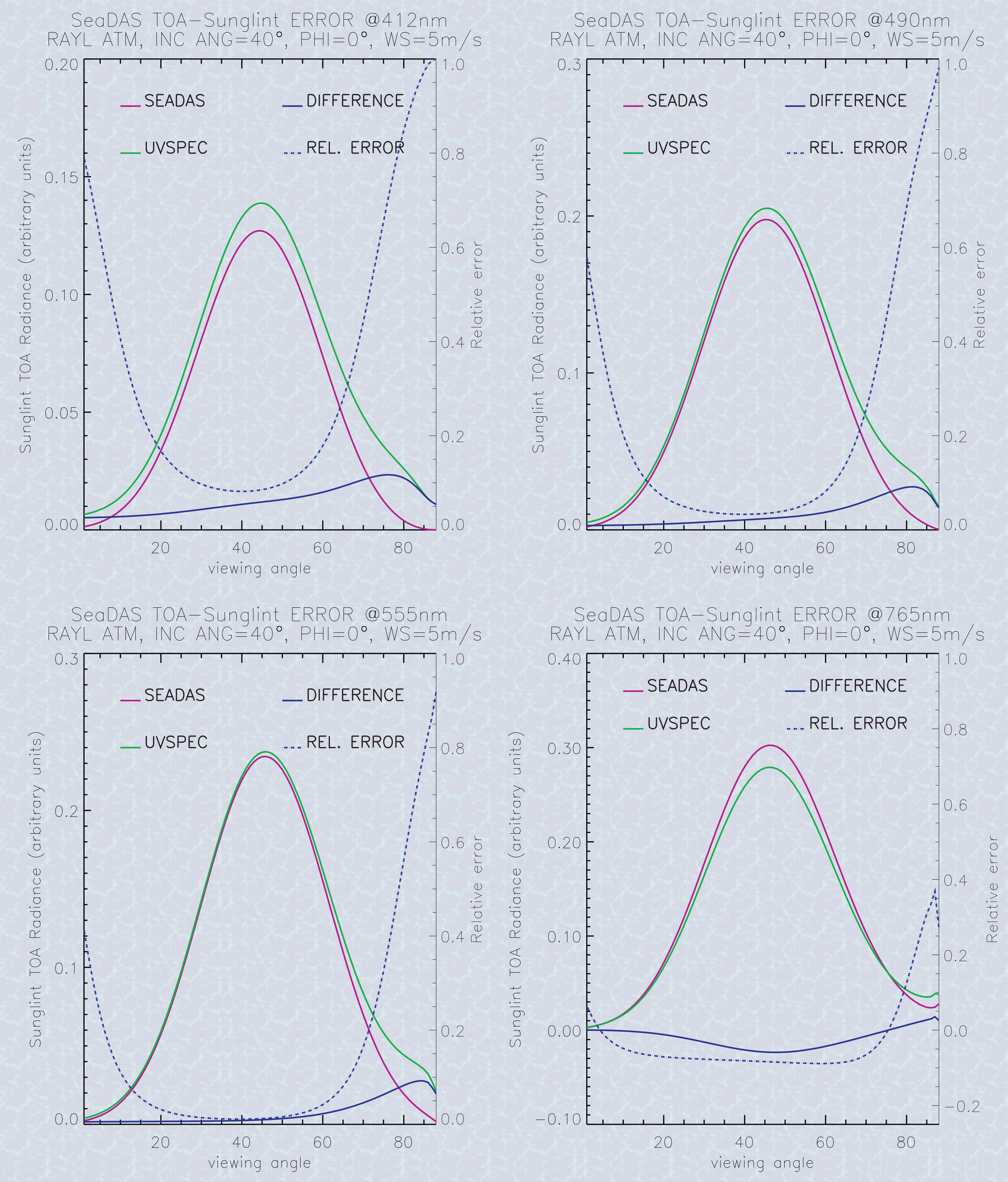
Correcting for Sunglint

Our goal is to provide algorithms that accurately will determine if glint is present, its magnitude, and polarization. This information can further
- be incorporated in forward models, enabling retrievals further into the glint contaminated region
- enable retrievals of atmospheric parameters even when the intensity of the glint is too great for accurate determination of the radiance emanating from inside the water

Sunglint correction in SeaDAS

Currently the SeaDAS sunglint correction is:
- ~ based on 1D Cox/Munk (no wind direction)
- ~ not attempted if the glint is too strong
- ~ using a simple direct transmittance calculation to determine the glint's contribution at the TOA

We are investigating a more sophisticated method that
- ~ uses accurate RT calculations to determine the glint's contribution at the TOA
- ~ will enable retrievals further into the glint region, reducing amount of wasted data
- ~ is easy to implement



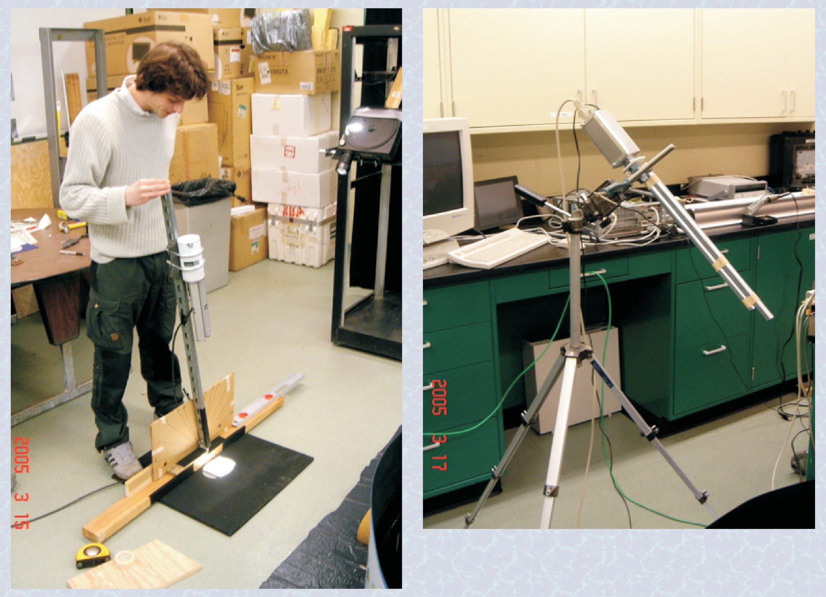
Above: Sunglint TOA calculated using UVSPEC and SeaDAS at 4 different SeaWiFS channels. The green curve is the difference between the two models.

Measuring Sunglint

There are two fundamental ways of looking at sunglint:
- time averaged (Cox/Munk) - the regime for low spatial resolution, long sampling (exposure) times
- instantaneous (time resolcved) - hyper spatial, fast sampling rates (short exposure)

Time averaged (BRDF) view of sunglint is needed for / can be used for:
- detecting departure from Gausian statistics
- input to RT models (forward models)

A dynamic view of sunglint is needed for / can be used for:
- determination of types and magnitude of shear forces (currents, wind)



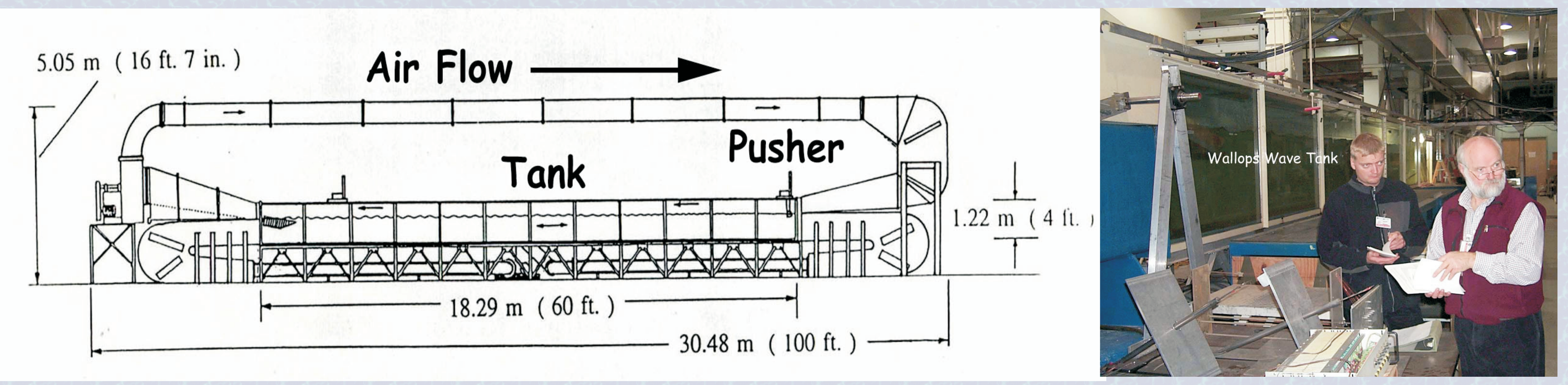
Above: Pictures from our lab showing the CIMEL sun photometer (left) and our own "glintometer". The CIMEL is capable of measuring radiances at 6 different wavelengths with polarization. Limited sampling rates prevents dynamic (time-resolved) glint measurements. Our glintometer can sample from DC to a maximum rate of 3.5kHz, enough to resolve the evolution of even the fastest "glint atoms". The glintometer measures broad-band radiances, but we plan to include filters in future versions of the instrument.

Above: Examples of the dynamic nature of glint measured by our glintometer. Top: small, wind-driven capilary waves. Bottom: large gravity waves.

Future Modeling and Measurement Plans

Development of complete Monte Carlo model with realistic surface realizations. This model will include
- shadowing effects, re-emerging photons, scattering by bubbles and foam
- plarization effects

On the experimental side we plan to utilize the Wallops Island wave tank facility to
- check the performance of current models
- investigate the effects of bubbles/foam, wind/current, thermal stability
- investigate the polarization features of the glint



Above: The NASA Wallops wave tank facility.

SUMMARY

Our sunglint studies are aimed at
- improving current methods for sunglint corrections in ocean color retrivals
- developing methods for determining atmospheric parameters using sunglint as a tool
- performing measurements of the dynamic, as well as time-averaged, sunglint
- measuring and modeling of polarized sunglint

Light and Life Laboratory — Stevens Institute of Technology