Is subsurface solar heating important for an OGCM?

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Introduction

The importance of subsurface heating on surface mixed layer properties in an ocean general circulation model (OGCM) is examined using attenuation of Photosynthetically Available Radiation (PAR) with depth below the ocean surface. The depth-dependent attenuation of subsurface heating is given by global monthly-mean fields for the diffusive attenuation of PAR (k_{PAR}). These global fields of k_{PAR} are derived from Sea-viewing Wide Field-of-view Sensor (SeaWiFS) data on the spectral diffuse attenuation coefficient at 490nm (k_{490}) and have been processed to have the smoothly-varying and continuous coverage necessary for use in OGCM applications (Rochford et al., 2001). These monthly fields provide the first complete global datasets of subsurface optical fields that can be used in OGCM applications (Figures 1 & 2).

Subsurface Solar Heating

Using the monthly-mean k_{PAR} fields and a monthly PAR climatology, the effect of including subsurface heating in the global NRL Layered Ocean Model (Hurlburt et al., 1996)

Figure 1

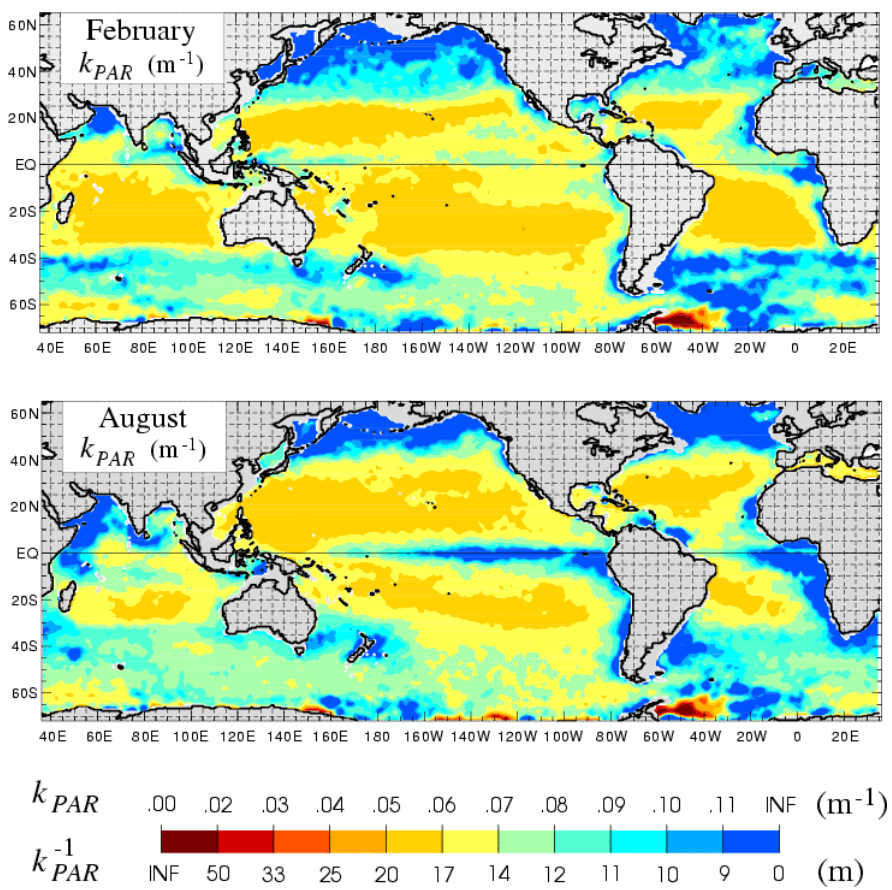

Figure 2

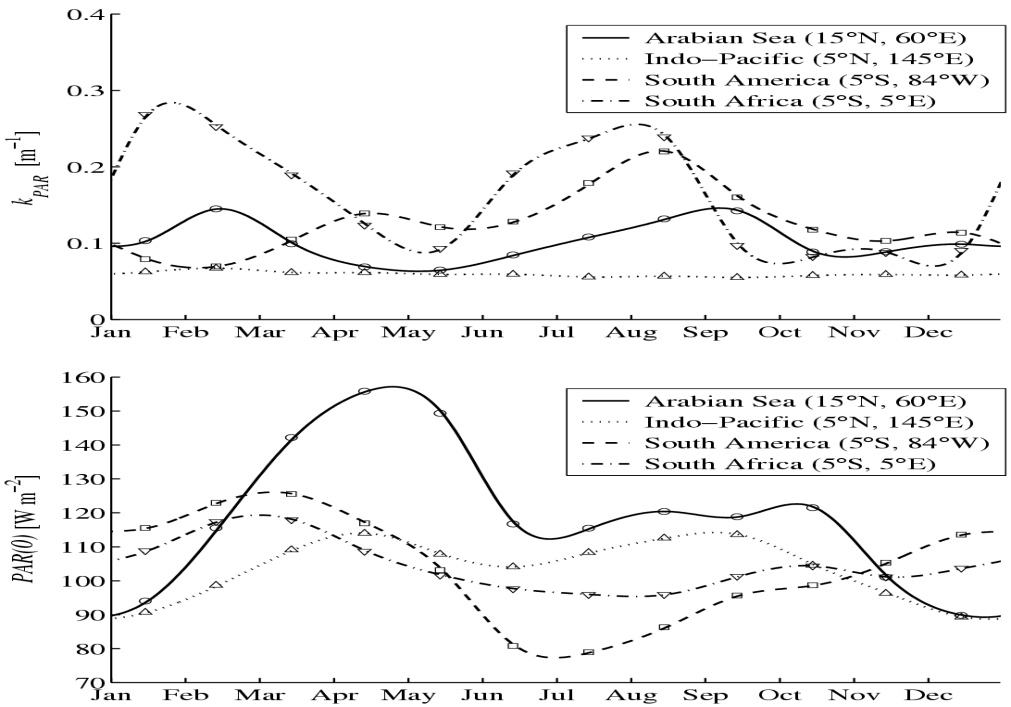

Figure 1. Diffusive attenuation coefficient (k_{PAR}) over the global ocean for the middle month of the northern hemisphere winter (February) and summer (August).

Figure 2. Time series of monthly mean k_{PAR} and PAR at four selected sites in the global ocean where there is large seasonal variability in optical attenuation.

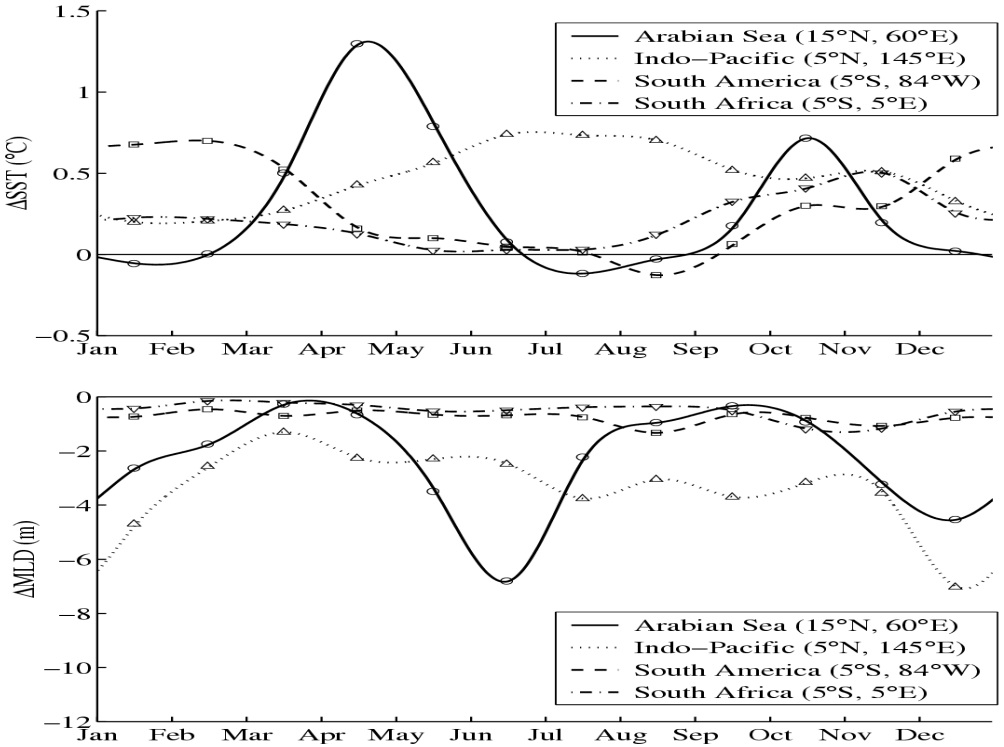

Figure 3. Seasonal differences in OGCM SST and MLD when neglecting and including subsurface heating. Shown are the results when all the PAR is absorbed within the mixed layer minus the SST when the PAR is attenuated using monthly k_{PAR}.

Is examined in terms of the model's prediction of sea surface temperature (SST) and surface mixed layer depth (MLD). The subsurface heating due to PAR is included in the OGCM by considering the surface heat flux absorbed within the mixed layer to be given by

$$Q_{abs}(z) = Q_{Net} - \mathrm{PAR}\ exp(-k_{PAR}\ h_m)\ ,$$

where Q_{Net} is the net surface heat flux, PAR is taken as a fraction of the surface solar irradiance ($0.49\ Q_{sol}$), and h_m is the MLD. The mean monthly fields from the Comprehensive Ocean-Atmosphere Data Set (COADS) (da Silva et al., 1994) are used for heat flux forcing.

To determine the consequences of subsurface heating on SST and MLD we performed 2 NLOM simulations:

1) Set k_{PAR} to a large value so the PAR is completely absorbed within the mixed layer.

2) Used the monthly k_{PAR} fields to account for the seasonal & spatial variation.

The differences between these simulations (Figure 3) reveal that changes in seasonal variability can be as large as 1-1.5°C for SST while they are only 1-6 m for MLD. These

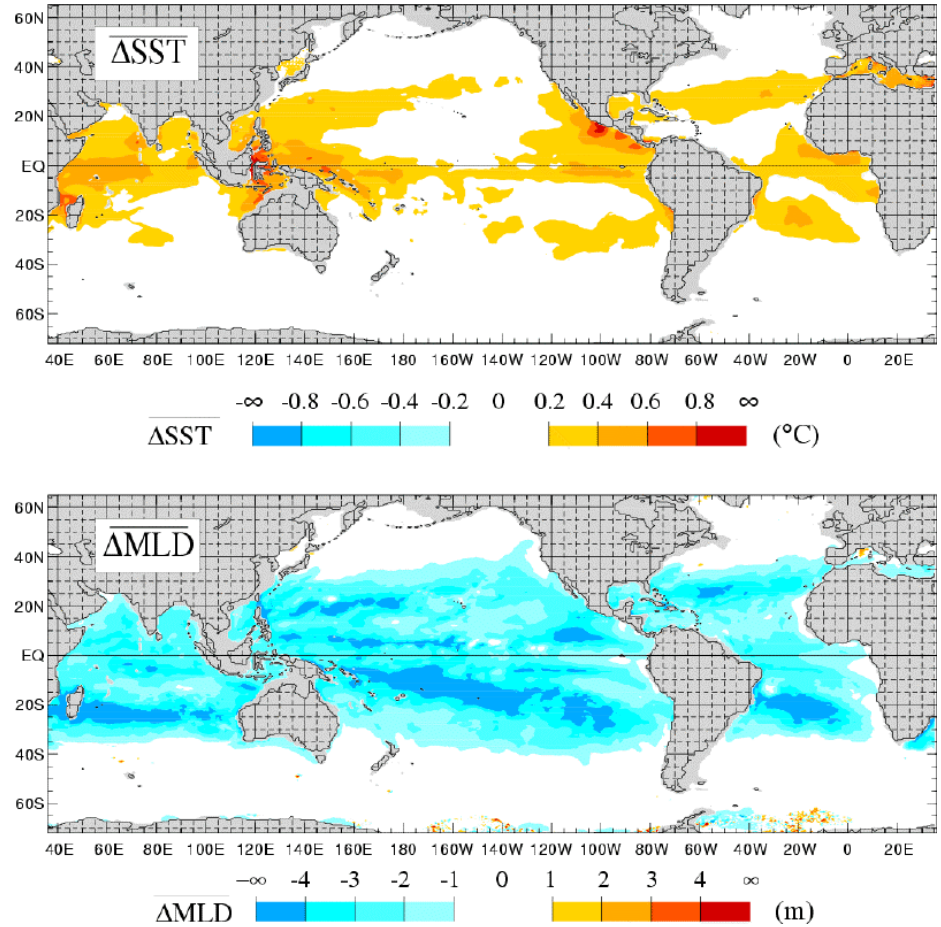

Figure 4. Annual mean differences in global OGCM SST and MLD as in Figure 3.

changes in SST and MLD are mostly confined to the low and mid latitudes (40°S-40°N).

Summary

We find that subsurface heating yields a marked increase in the SST predictive skill of the OGCM at low latitudes. Use of the monthly-mean k_{PAR} reduces the annual mean SST by up to 0.8°C, and negligibly increases MLD on climatological time scales.

References

Da Silva, A. M., C. C. Young, and S. Levitus, *NOAA Atlas NESDIS 6*, 83 pp., U.S. Department of Commerce, Washington, D.C., 1994.

Hurlburt, H. E., A. J. Wallcraft, W. Schmitz, Jr., P. J. Hogan, and E. J. Metzger, *J. Geophys. Res.*, **101**, 941-976, 1996.

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