A contribution to ocean *skin* temperature parameterization

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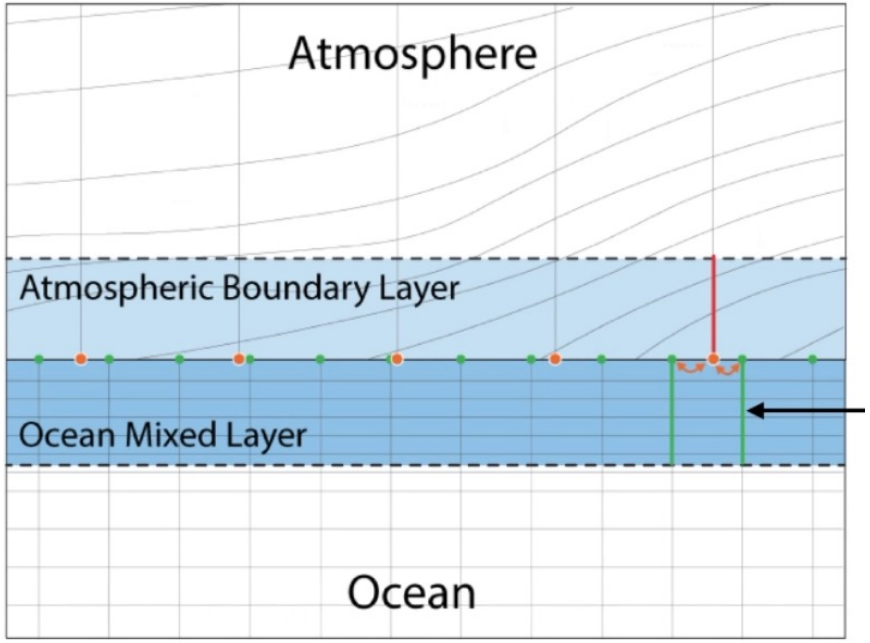
Some air-sea fluxes (sensible & latent heat, longwave radiation) depend on oceanic **skin temperature.**

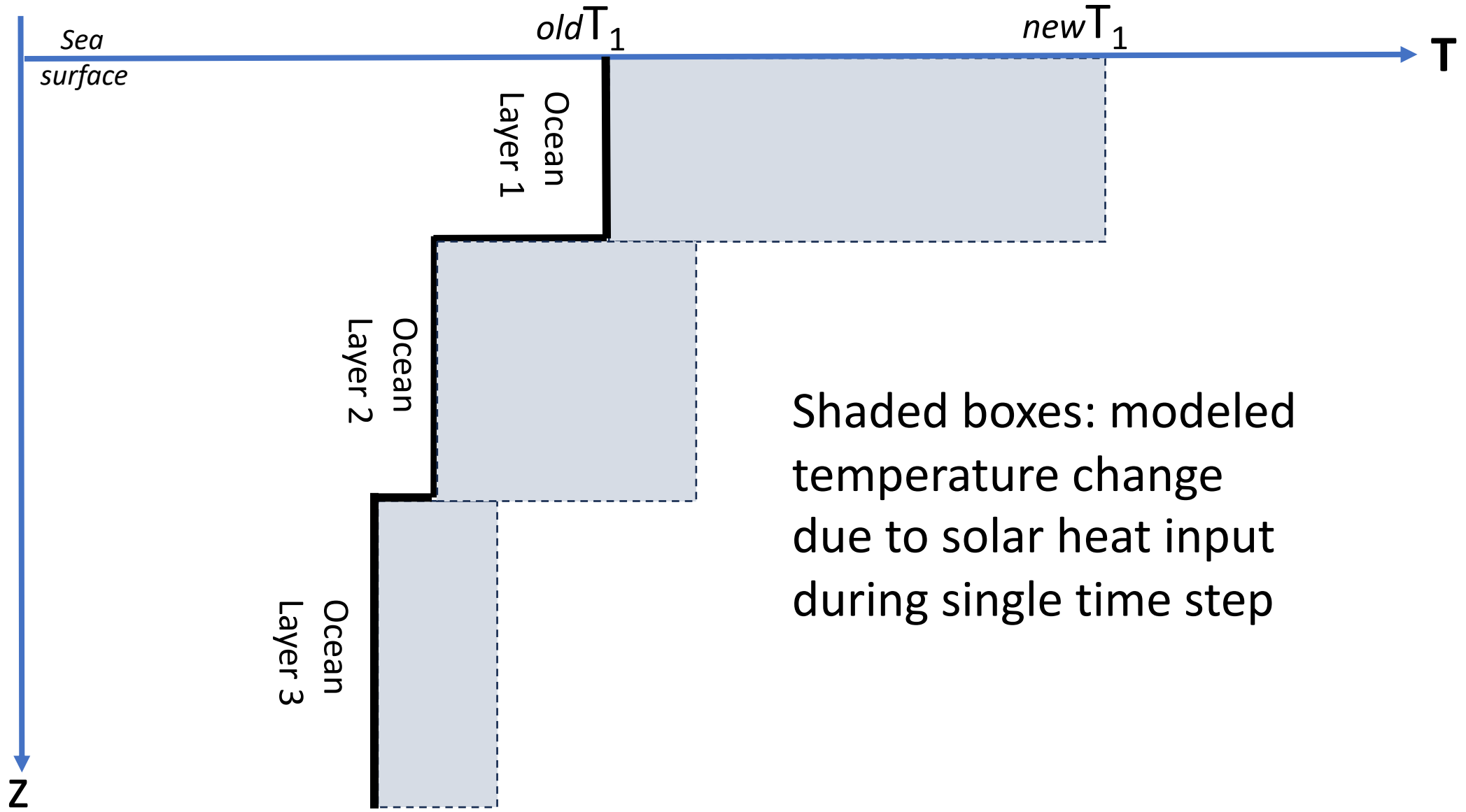
Skin temperature in ocean models typically differs from the water temperature in the uppermost coordinate layer.

Two physical processes affecting skin temperature require attention and must be parameterized:

- Buildup of daytime warm layer (this talk)
- Cool-skin effect (different topic)

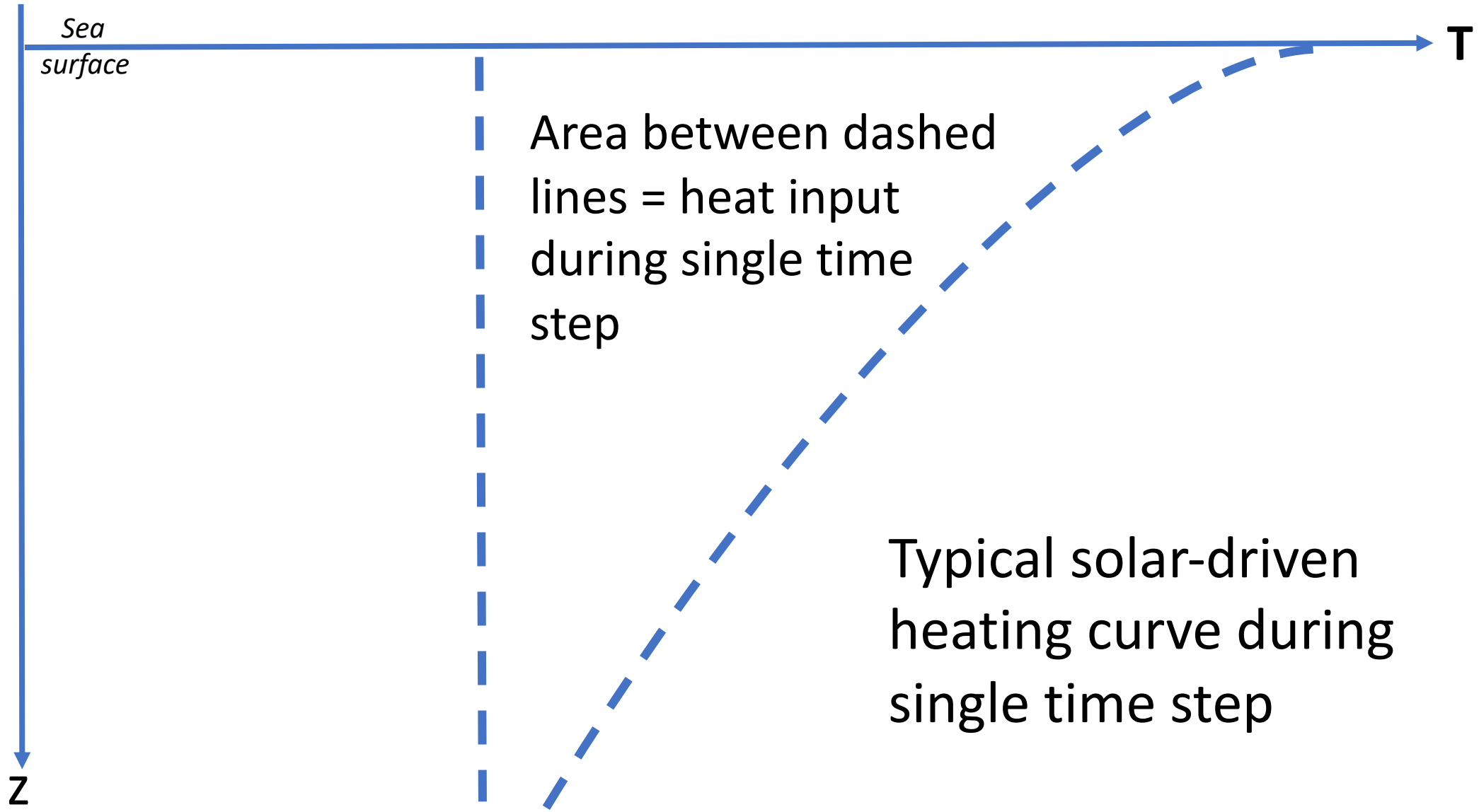


Here is how an ocean model (like MOM6) distributes the solar energy input…



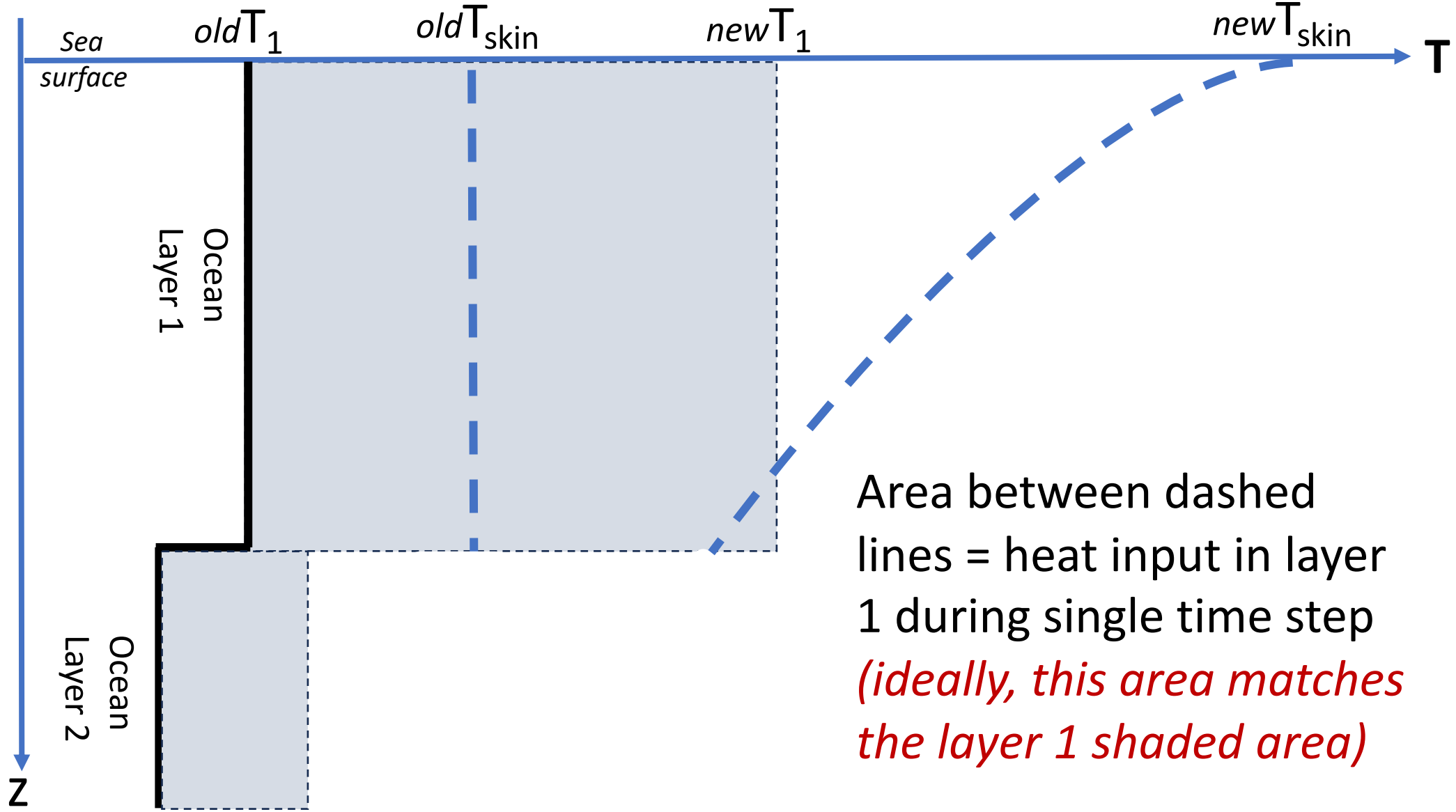
Shaded boxes: modeled temperature change due to solar heat input during single time step

In the real world, heating as a function of depth is more likely to be exponential, as shown here:


Sea
surface
T
Z
Area between dashed lines = heat input during single time step
Typical solar-driven heating curve during single time step

SkinSST attempts to reconcile the above representations of solar input (i.e. the stairstep and the exponential heating curve)….

Note that we are only interested in the outcome at z=0



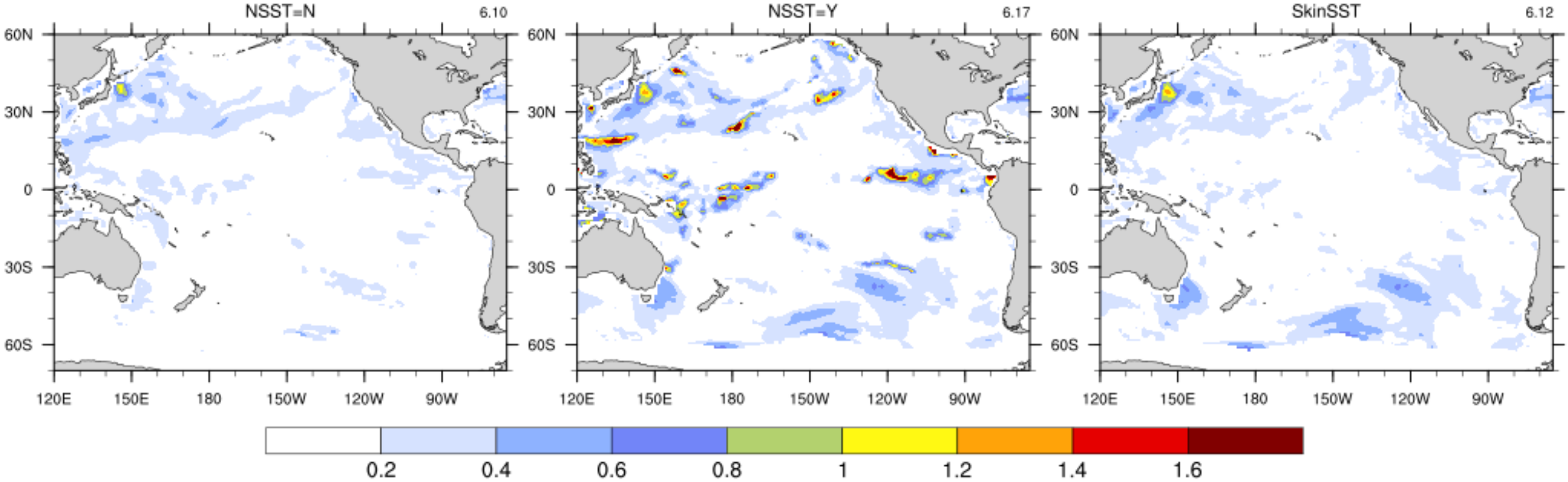
Area between dashed lines = heat input in layer 1 during single time step

(ideally, this area matches the layer 1 shaded area)

Things to note:

- SkinSST **ONLY** affects the evaluation of air-sea fluxes.
- It does **NOT** interfere with ocean/atmo mixed layer algorithms (hence, no potential violations of global conservation constraints built into ocean and atmo models).
- T_{skin} increments are cumulative and must be summed up during warm-layer lifespan. Outside that time interval, T_{skin} reverts to T_1 (minus cool-skin effect).
- Most relevant parameter: penetration depth = function of turbidity (e.g. Jerlov class or interactive bio-chem model) and solar zenith angle.
- T_{skin} approaches T_1 as model vertical resolution increases. In the high-resolution limit, warm-layer parameterization becomes superfluous.
- On the other hand, the cool-skin effect is independent of (realistic) ocean model resolution and is always required.

SST Amplitude Day 4-5

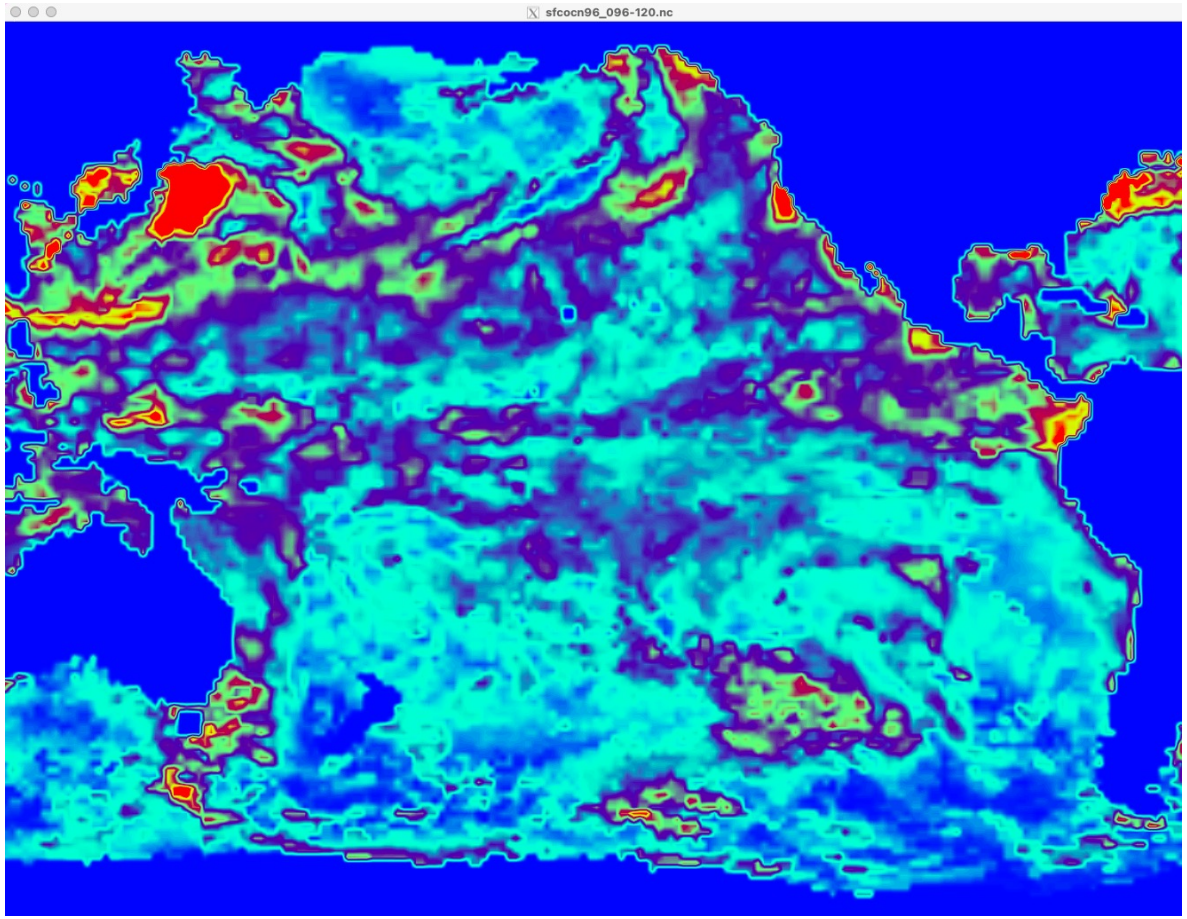


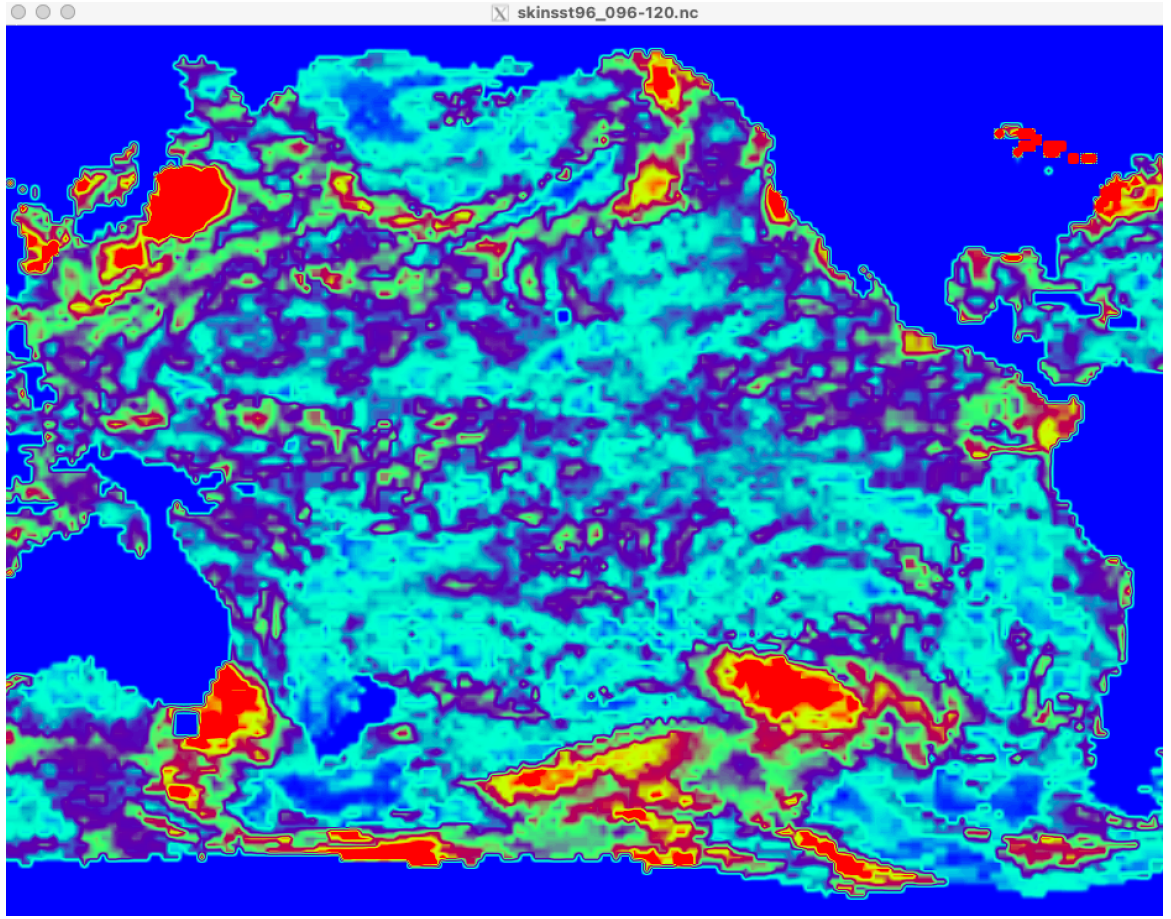
Summary

- SkinSST is a simple & easily understood scheme for estimating skin temperature in the oceanic daytime warm layer.
- SkinSST capitalizes on the discrepancy between an assumed exponential heating curve and the stairstep-like heating in layered ocean models. Algorithm is invariant to vertical resolution.
- SkinSST only has a modest effect on skin temperature in our experiments. This is to be expected, given the shallowness of the uppermost ocean layer.
- In some regions, NSST amplitudes appear to be excessive.
- https://drive.google.com/file/d/1lG0vnOa0E4OT16vt4gkxA4kw4293Pw7x/view (3-page writeup)

Reserve slides

$T_{max} - T_{min}$ during day 4.0 – 5.0. Top layer depth: 2m

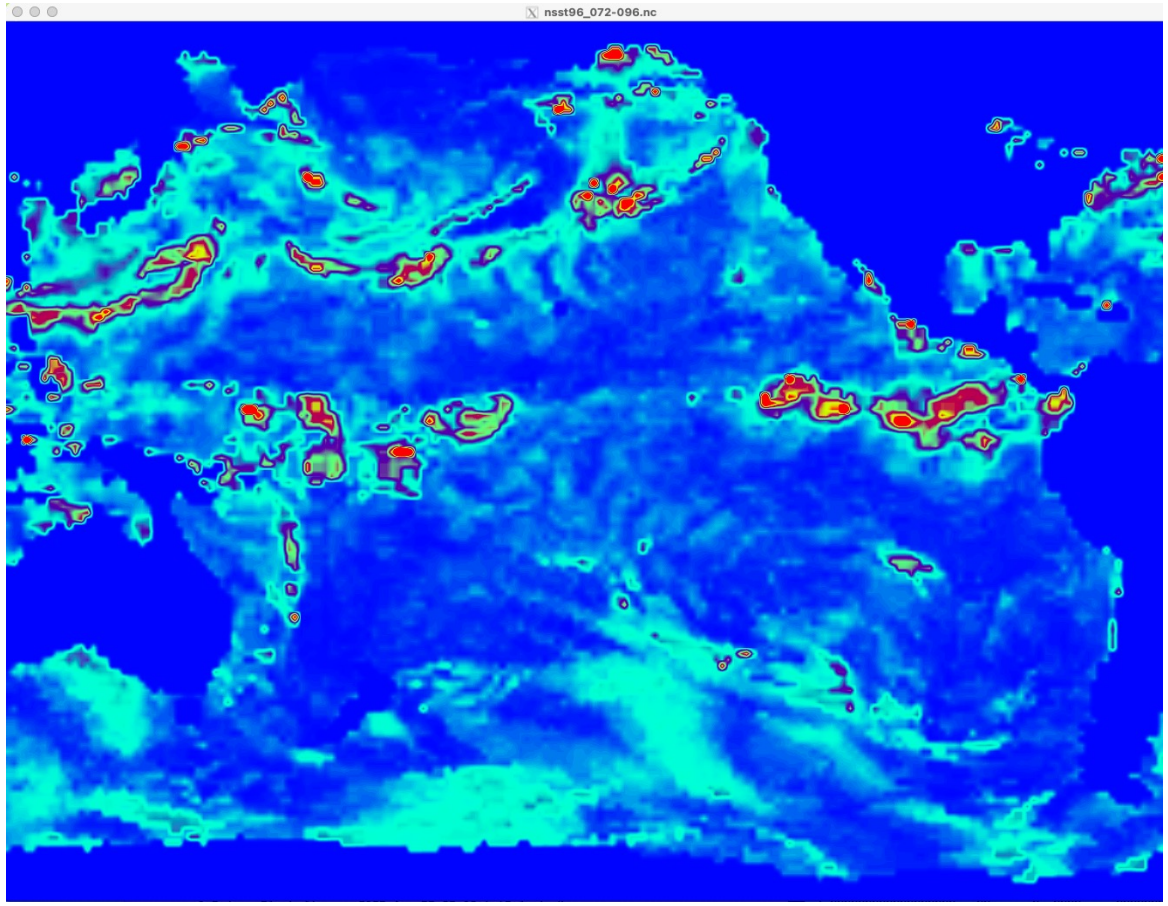


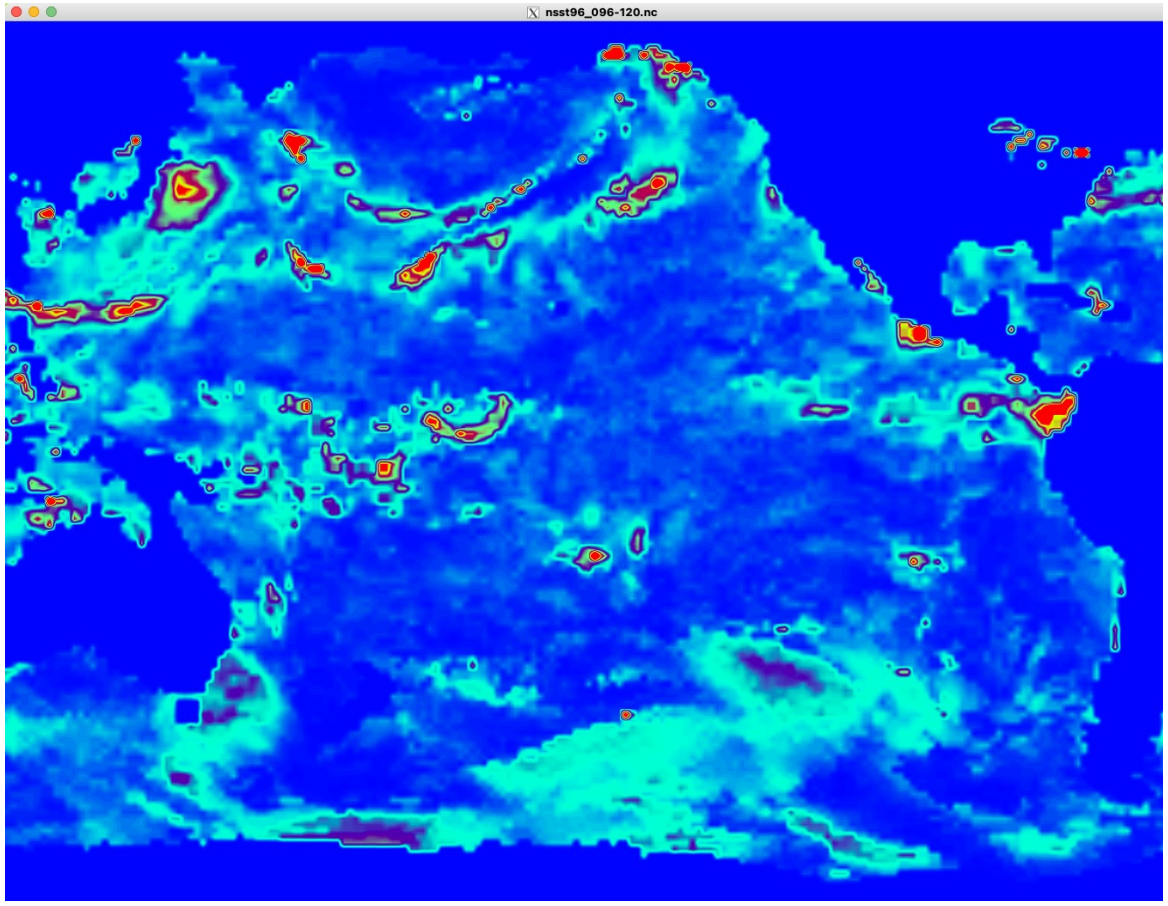


Skin temp. = top layer temp.
(i.e. no skin temp. parameterization)

Skin temp. inferred from
SkinSST parameterization

$T_{max} - T_{min}$ day 3.0 – 4.0 (left), day 4.0 – 5.0 (right) Top layer depth: 2m





different color bar

Skin temp. inferred from NSST

ABSTRACT: Ocean skin temperature is an important ingredient to bulk formulae commonly used in computing air-sea fluxes in coupled models. To arrive at unbiased estimates of this temperature, the buildup and collapse of a daytime warm layer as well as surface cooling due to outgoing longwave radiation must be accounted for.

We have been testing a scheme for parameterizing the difference between oceanic bulk layer temperature and skin temperature caused by the buildup of a shallow daytime warm layer. The scheme is meant to replace the more complex NSST scheme which was originally developed at EMC to mimic the diurnal SST cycle in atmosphere-only global models but is now used in the UFS coupled model for global predictions on medium-range to seasonal time scales.

The present scheme makes full use of information provided by the ocean model's mixed layer, thereby circumventing complexities inherited from uncoupled applications. The scheme requires knowledge of the penetration depth for shortwave radiation, top layer bulk temperature, wind speed, and the rate of solar radiation input. We are currently comparing the new scheme with NSST in areas such as long term trends in sea surface temperature patterns, the diurnal SST cycle, and global heat budget