This is well-written and a good presentation of a new model for downwelling long wave. As a reader I kept looking for but did not find the motivation for developing the model. I suggest it would improve the paper to explain the motivation.

Response: Thank you for your valuable feedback. We agree that clarifying the motivation for developing this model is essential. In short, the main motivation is to address the limitations of existing satellite-based and reanalysis products, which often struggle with accuracy under cloudy-sky conditions and have lower spatial resolution. Our new model is designed to overcome these challenges, providing improved accuracy across both clear- and cloudy-sky conditions, and at finer spatial and temporal resolutions. This makes the model more suitable for localized and high-resolution studies.

Here is the revised version of the first two paragraphs:

The downward longwave radiation (R_l) at the ocean surface is the thermal infrared (4–100 μm) radiative flux emitted by the entire atmospheric column over the ocean surface (Yu et al., 2018). The ocean-surface R_l is a critical component of the heat flux across the ocean–atmosphere interface, shaping the climate state of both the atmosphere and the ocean (Caniaux, 2005; Fasullo et al., 2009; Fung et al., 1984). Accurate estimates of R_l are essential for studying air–sea interactions and for improving our understanding of climate and oceanic systems.

Currently, R_l is routinely measured at buoy sites; however, the available buoy measurements are limited due to the sparse distribution of buoys across global oceans. Another way to obtain the R_l at the ocean surface is by using satellite-based or model reanalysis products. The ocean-surface R_l from satellite-derived products, such as the International Satellite Cloud Climatology Project (ISCCP) (Rossow & Zhang, 1995; Young et al., 2018) and Clouds and the Earth's Radiant Energy System Synoptic Radiative Fluxes and Clouds (CERES/SYN1deg) (Doelling et al., 2013; Rutan et al., 2015), is usually generated using satellite data and a radiative transfer model, which simulates the radiative transfer interactions of light absorption, scattering, and emission through the atmosphere with the input of given atmospheric parameters. However, radiative transfer models are not widely used in practice due to their complexity and the difficulties associated with collecting all essential inputs. The ocean-surface R_l provided in model reanalysis products, such as the fifth generation of the European Centre for Medium-Range Weather Forecasts atmospheric reanalysis of the global climate (ERA5) (Hersbach et al., 2020) and the Modern-Era Retrospective analysis for Research and Applications, Version 2 (MERRA2) (Gelaro et al., 2017), is produced by *assimilating various observations into an atmospheric model to get the optimal estimates of the state of the atmosphere and the surface (Gelaro et al., 2017). Previous studies indicated that R_l estimates from satellite-based products are generally in better agreement with buoy measurements than those obtained from reanalysis products (Pinker et al., 2014; Pinker et al., 2018; Thandlam & Rahaman, 2019). However, applications of the ocean-surface R_l from these two kinds of products are limited due to their coarse spatial resolutions (most of them are coarser than 1º), limited periods (especially satellite-based products), and discrepancies in accuracy and consistency (Cronin et al., 2019).*

To overcome these limitations, many parameterization and empirical models for estimating ocean-surface R_l that can easily be implemented in practical use have been established during the past few decades (Bignami et al., 1995; Josey, 2003; Zapadka et al., 2001; Zapadka et al., 2020). Most of the commonly used R_l estimation models were established using the relationship between R_l and the relevant meteorological variables (i.e., air temperature, humidity, column integrated water vapor (IWV), and cloud parameters) or oceanic parameters (i.e., bulk sea surface temperature), which are usually obtained from in situ measurements or model simulations (Li & Coimbra, 2019; Li et al., 2017; Paul, 2021). However, a significant limitation is that many of these models were originally developed for land surfaces and applied directly to the ocean, assuming similar atmospheric conditions. (Bignami et al., 1995; Clark et al., 1974; Frouin et al., 1988; Josey, 2003). This assumption introduces the uncertainty in R_l estimates, as water vapor profiles differ significantly between land and ocean surfaces (Bignami et al., 1995). Even those models specifically designed for ocean surfaces are often based on limited regional data, raising concerns about their robustness when applied globally.(Bignami et al., 1995; Josey, 2003; Zapadka et al., 2001). For example, Josey (2003) proposed a model for R_l estimation at mid-high latitude seas with a satisfactory validation accuracy, but this new model performed worse over tropical seas with a tendency to underestimate R_l by up to 10–15 W/m^2. Furthermore, most existing R_l estimation models only work under clear-sky conditions, which are especially rare over ocean surfaces. Additionally, most of these models only derive R_l at instantaneous scales, yet the R_l at the daily scale is more preferred across a range of applications.

Given these challenges, there is a clear need for a new, easily implemented model capable of providing accurate Rl estimates at the global ocean surface. Such a model should function effectively under all-sky conditions, offer flexibility in temporal scales (e.g., instantaneous and daily), and be robust enough for global application. Addressing these gaps would provide a valuable tool for improving our understanding of air–sea interactions and contribute to more accurate climate *and oceanic models. More details about the existing R_l estimation models are given in Section 2.*

What is the need for a new model? Why not use satellite based long wave radiation at the surface (As Pinker et al describe - this seems to be more accurate than the model you developed.)? Why not use surface radiation from ERA5 reanalysis or from ECMWF model - you import cloud information from ERA5, so why not just take surface radiation from that model?

Response: Thank you for this insightful question. The need for a new model arises from several limitations inherent in the existing satellite-based and reanalysis products. While satellite-derived longwave radiation products, such as those described by Pinker et al., generally perform well, they tend to have good accuracy under clear-sky conditions. However, their performance degrades under cloudy-sky conditions, where accurate cloud base temperature and height estimation remains challenging (Zeng et al., 2024). To address this, our model incorporates two cloud parameters—total column cloud liquid water and total column cloud ice water—which help improve the estimation of longwave radiation under cloudy conditions.

Similarly, while products like ERA5 provide surface radiation, they are often generated at coarse spatial resolutions, making them less suitable for local-scale studies or applications requiring finer granularity. Our new model addresses these challenges by providing high accuracy under both clear- and cloudy-sky conditions and across different temporal scales (hourly and daily). The model offers a consistent and computationally efficient method to estimate downward longwave radiation at finer resolutions.

Moreover, we conducted comparisons with ERA5 and CERES longwave radiation products, and our model consistently outperformed these products, including in land regions, where it also surpassed GLASS-AVHRR, ERA5, and CERES_SYN1deg_Ed4A products (Chen et al., 2024).

Years ago, absent satellite or model-based surface radiation, folks needed a model such as your to estimate surface long wave to force, for example, an ocean model. But now people use model or satellite fields. So will anybody utilize your new model? What was the purpose in developing it?

Response: Thank you for this comment. While satellite and model-based surface radiation products are widely used today, our model addresses a gap in applications that require higher spatial resolution and greater accuracy for estimating longwave radiation. The proposed model is designed to meet the needs of the atmospheric science and remote sensing communities (Yang et al., 2023; Jiao & Mu, 2022; Zeng et al., 2020; Chen et al., 2024; Zapadka et al., 2020), where parameterization techniques are commonly employed for generating longwave radiation products.

The computational efficiency and high accuracy of our model make it especially well-suited for operational ocean-atmosphere heat budget studies, regional climate modeling, and real-time applications, where existing longwave radiation products are subject to delays. By addressing the limitations of satellite and reanalysis products—such as coarse spatial resolution or reduced accuracy under cloudy conditions—our model provides a valuable and practical tool for researchers and practitioners who need improved, more timely estimates of downwelling longwave radiation.

Reference

Chen, Y., Jiang, B., Peng, J., Yin, X., & Zhao, Y. (2024). Evaluation of the Surface Downward Longwave Radiation Estimation Models over Land Surface. *Remote Sensing*, *16*(18), Article 18. https://doi.org/10.3390/rs16183422

Yang, J., Hu, J., Chen, Q., & Quan, W. (2023). Parameterization of downward long-wave radiation based on long-term baseline surface radiation measurements in China. *Atmospheric Chemistry and Physics*, *23*(7), 4419–4430. https://doi.org/10.5194/acp-23-4419-2023

Jiao, Z.-H., & Mu, X. (2022). Global validation of clear-sky models for retrieving land-surface downward longwave radiation from MODIS data. *Remote Sensing of Environment*, *271*, 112903. https://doi.org/10.1016/j.rse.2022.112903

Zeng, Q., Cheng, J., & Dong, L. (2020). Assessment of the Long-Term High-Spatial-Resolution Global LAnd Surface Satellite (GLASS) Surface Longwave Radiation Product Using Ground Measurements. *IEEE Journal of Selected Topics in Applied Earth Observations and Remote Sensing*, *13*, 2032–2055. IEEE Journal of Selected Topics in Applied Earth Observations and Remote Sensing. https://doi.org/10.1109/JSTARS.2020.2992472

Zeng, Q., Cheng, J., Sun, H., & Dong, S. (2024). An integrated framework for estimating the hourly all-time cloudy-sky surface long-wave downward radiation for Fengyun-4A/AGRI. *Remote Sensing of Environment*, *312*, 114319. https://doi.org/10.1016/j.rse.2024.114319

Zapadka, T., Ostrowska, M., Stoltmann, D., & Krężel, A. (2020). A satellite system for monitoring the radiation budget at the Baltic Sea surface. *Remote Sensing of Environment*, *240*, 111683. https://doi.org/10.1016/j.rse.2020.111683