**Responses to the Manuscript essd-2022-83 RC1:**

# A global dataset of spatiotemporally seamless daily mean land surface temperatures: generation, validation, and analysis

Dear reviewer #1,

The authors would like to thank you for providing us with thoughtful and outstanding comments. We have addressed all comments in detail and revised the manuscript accordingly and tracked the changes so that you can see that we have rewritten many parts of the manuscript. Point-by-point responses are provided below.

We will be very glad to receive your feedback.

Yours sincerely,

Falu Hong, Wenfeng Zhan*, Frank-M. Göttsche, Zihan Liu, Pan Dong, Huyan Fu, Fan Huang, and Xiaodong Zhang

Email: zhanwenfeng@nju.edu.cn

## I. TABLE OF CONTENTS

## II. ATTENTIONS

(1) In the following responses, texts contained within the red braces {…} are identical to those in our revised manuscript.

(2) In the following responses, the line numbers [Line XXX-XXX] refer to the clean version of the revised manuscript.

(3) Fig. 1, 2, and 3…, and Eq. 1, 2, and 3… refer to the figures and equations excerpted from our revised manuscript.

(4) In the following responses, all the related references are provided collectively in Part IV References.

## III. Responses to Reviewer #1

**Comment #1**

*This study designed an operational framework that uses the annual temperature cycle (ATC) and diurnal temperature cycle (DTC) models to generate global seamless daily mean land surface temperature (LST). The framework and generated product were validated with globally distributed in situ measurements. The validations show that the generated daily mean LST can correct the sampling bias caused by directly compositing the cloud-free MODIS LSTs. This is an interesting point for the thermal remote sensing community. Additionally, the authors discussed the uncertainties of the daily mean LST products, which are useful for further improvement. The authors clearly addressed the structure of the IADTC framework and comprehensively evaluated the generated daily mean LST product. This manuscript is generally well written and clearly organized. I recommend the paper for publication after the following issues are answered.*

**Authors' reply:**

Thanks very much for your appreciation. We have provided the point-to-point response to the concerned issues below.

**Major comments**

**Comment #2**

*The direct comparison results between the generated daily mean land surface temperature product and in situ measurements display systematically negative bias at most sites (Tables 1 and 2). The authors should provide more explanations about the negative bias.*

**Authors' reply:**

Thanks for your comment. The systematically negative bias between the *in situ* measurement and GADTC product is directly related to the systematic negative bias between instantaneous *in situ* measurement and instantaneous MODIS land surface temperature (LST) observations. The comparison results between instantaneous SURFRAD LST and MODIS LST observations (Fig. R1) show that the mean bias is negative at four overpassing times. Since the GADTC products are generated based on the instantaneous MODIS LST observations, the systematically negative bias within the instantaneous observations will be propagated to the generated daily mean LST.

The systematically negative bias between the instantaneous MODIS LST observations and *in situ* measurements could be caused by: (1) the spatial mismatch between the satellite and *in situ* measurement; (2) the differences in the observation angles; (3) the uncertainties from the LST retrieval algorithm, such as the estimation of broadband emissivity (Guillevic et al., 2018).

To avoid those uncertainties and fully reflect the accuracy of IADTC framework, we validated the IADTC framework with single source *in situ* measurements (Figs. 6 & 7). Results show that the MAEs of the IADTC framework are 1.4 K and 1.1 K for SURFRAD and FLUXNET data, respectively; and the mean biases are both close to zero.

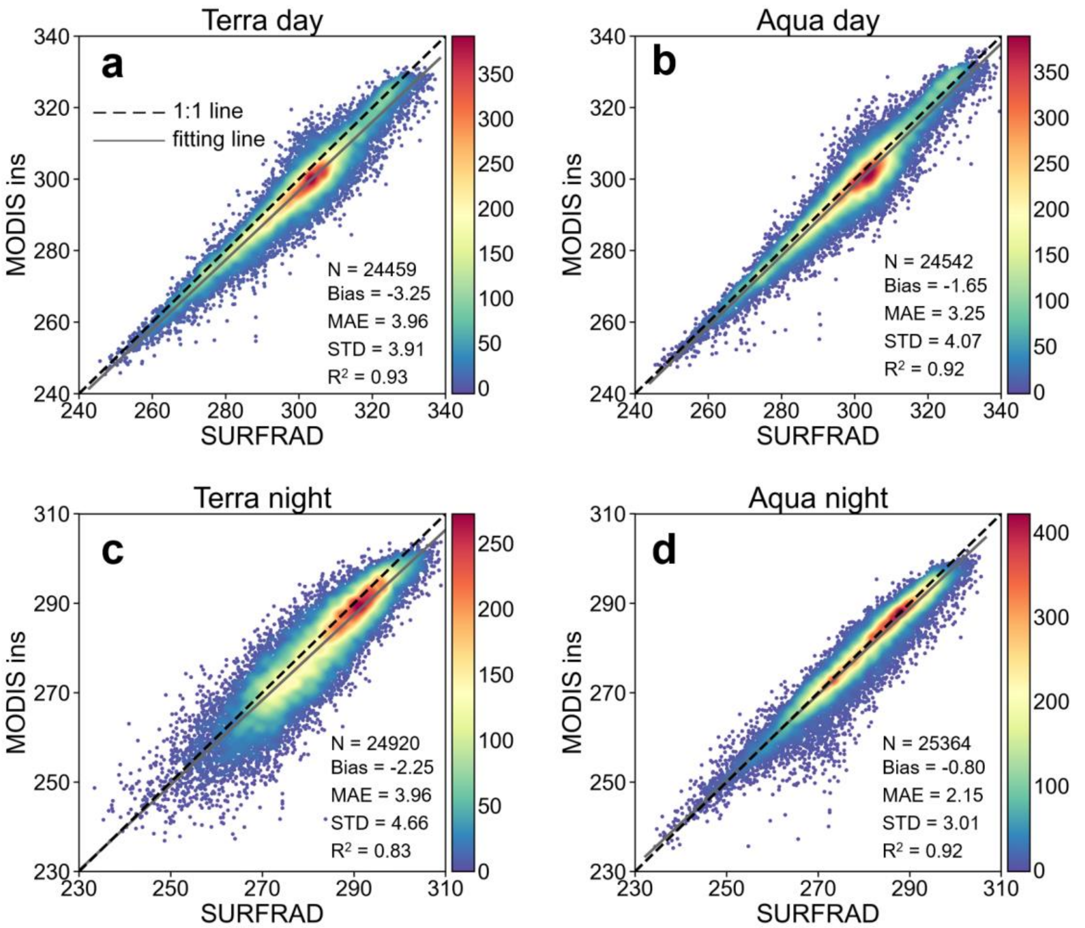


Fig. R1. Comparison between the SURFRAD instantaneous observations and MODIS instantaneous observations for the Terra day (**a**), Aqua day (**b**), Terra night (**c**), and Aqua night (**d**) overpassing times.

**Comment #3**

*The authors used the diurnal temperature range (DTR) to define different scenarios. In this paper, the calculated DTR can be affected by the accuracy of ATC model, then affecting the determination of which scenario is used to generate daily mean land surface temperature. I recommend the authors add more discussions about the uncertainties of ATC model to the daily mean LST estimation.*

**Authors' reply:**

Thanks for your comment. We agree with you that the accuracy of the ATC model can affect the determination of scenarios. We compared the proportion of three scenarios using the ATC-reconstructed under-cloud LSTs and actual *in situ* under-cloud LST observations based on the SURFRAD and FLUXNET datasets, respectively (Table R1). Table R1 proves that the accuracy of ATC model can affect the determination of scenarios. We have added discussions about the uncertainties of ATC model to the scenario determination and $T_{dm}$ estimation in Line 504-507, which was give as follows for your convenience.

Line 504-507:

{First, the currently used ATC model reconstructs under-cloud LSTs during the day (night) with small positive (negative) biases (**Error! Reference source not found.**), even though information on under-cloud air temperature has been incorporated (Liu et al., 2019b). Additionally, the errors in the ATC model can affect the determination of scenarios and consequently, the way to calculate the $T_{dm}$.}

Table R1. The percentage of each scenario using ATC-reconstructed under-cloud LST and actual *in situ* under-cloud observations for the SURFRAD and FLUXNET datasets.

| | | Scenario #1 | Scenario #2 | Scenario #3 |
|---|---|---|---|---|
| SURFRAD | $T_{ins\_cloud\_free}$ + $T_{ins\_ATC}$ | 0.2% | 95.0% | 4.8% |
| | $T_{ins\_cloud\_free}$ + $T_{ins\_obs}$ | 7.3% | 86.5% | 6.3% |
| FLUXNET | $T_{ins\_cloud\_free}$ + | 10.1% | 82.5% | 7.3% |

| | | | | |
|---|---|---|---|---|
| | $T_{ins\_ATC}$ | | | |
| | $T_{ins\_cloud\_free}$ + $T_{ins\_obs}$ | 21.1% | 67.1% | 11.8% |

**Minor comments**

**Comment #4**

*Line 138: I recommend the authors to add some descriptions about how they process the in situ measurement outliers.*

**Authors' reply:**

Thanks for your comment. We have added the descriptions of processing the outliers within the *in situ* measurement. Firstly, the minutely or half-hourly observations were aggregated into hourly values to reduce the impact from short-term LST fluctuations. Secondly, the outliers in the *in situ* measurements were further filtered using the '3σ-Hampel identifier' when validating the GADTC products (Zhang et al., 2020; Göttsche et al., 2016). You can refer to Line 139-140 and Line 299-302 for reference, which are given as follows for your convenience.

Line 139-140:

{To reduce the impacts of short-term LST fluctuations on validation, we aggregated minutely observations into hourly values.}

Line 299-302:

{Note that outliers in the *in situ* measurements were removed before performing the accuracy evaluation; here outliers are defined as the $T_{dm}$ differences between *in situ* measurements and GADTC products deviating by more than 3σ (three standard deviations) from the mean (Göttsche et al. 2016; Zhang et al., 2020).}

**Comment #5**

*Line 176-178: Please add more examples or references about the LST change in low-latitude and high-latitude regions.*

**Authors' reply:**

Thanks for your comment. We have added the references which describe the LST change in low-latitude (Cao and Sanchez-Azofeifa, 2017) and high-latitude regions (Østby et al., 2014; Westermann et al., 2012). Please refer to Line 177-180, which is given as follows for your convenience.

Line 177-180:

{However, a single sinusoidal is no longer suitable for low-latitude because there are two solar radiation peaks within a yearly cycle of low-latitude regions (Xing et al., 2020; Bechtel, 2015; Cao and Sanchez-Azofeifa, 2017); it is also inadequate for high-latitude regions where polar days and nights occur (Østby et al., 2014; Liu et al., 2019; Westermann et al., 2012).}

**Comment #6**

*Line 218: Temporal normalization is a good way to handle the overpassing time fluctuations. Please provide more discussions about the role of temporal normalization in generating consistent LST products.*

**Authors' reply:**

Thanks for your comment. We totally agree with you that temporal normalization is useful for correcting the overpassing time fluctuations and generating consistent LST products (Ma et al., 2022). We have added the discussions in Line 499-502 to emphasize the role of temporal normalization in reducing the negative impact of overpassing time fluctuation, which was given as follows for your convenience.

Line 499-502:

{Temporal normalization methods can adjust the LST observations at fluctuated overpassing time to the fixed time, which can eliminate the uncertainties in the under-cloud LST reconstruction and diurnal LST dynamics modeling (Ma et al., 2022; Liu et al., 2019; Duan et al., 2014).}

**Comment #7**

*Line 242: Moving this sentence after the introduction of DTRfour would be better.*

**Authors' reply:**

Thanks for your comment. We agree with you that moving the sentence at Line 242 to the position consequent to the introduction of $DTR_{\text{four}}$ would be better for understanding. You can refer to Line 235-238 for the revised manuscript, which was given as follows for your convenience.

Line 235-238:

{The first criterion is based on the diurnal temperature range (DTR), which was calculated as the maximum minus the minimum LSTs within a diurnal cycle. Specifically, the DTR calculated by four LSTs within the diurnal cycle (termed $DTR_{\mathrm{four}}$) was used (**Error! Reference source not found.**). Here these four daily LSTs can consist of both cloud-free observations ($T_{\mathrm{in\_cloud\_free}}$, the green circles in Fig. 1) and under-cloud LSTs reconstructed by the ATC model ($T_{\mathrm{in\_ATC}}$, the blue triangles in Fig. 1).}

**Comment #8**

*Fig. 4: I recommend the authors to add one subplot for the illustration of Scenario #1.*

**Authors' reply:**

Thanks for your comment. We have added the subplot to illustrate Scenario #1 in Fig. 4. The corresponding caption was also revised. The revised Fig. 4 and caption are attached as follows for your reference.

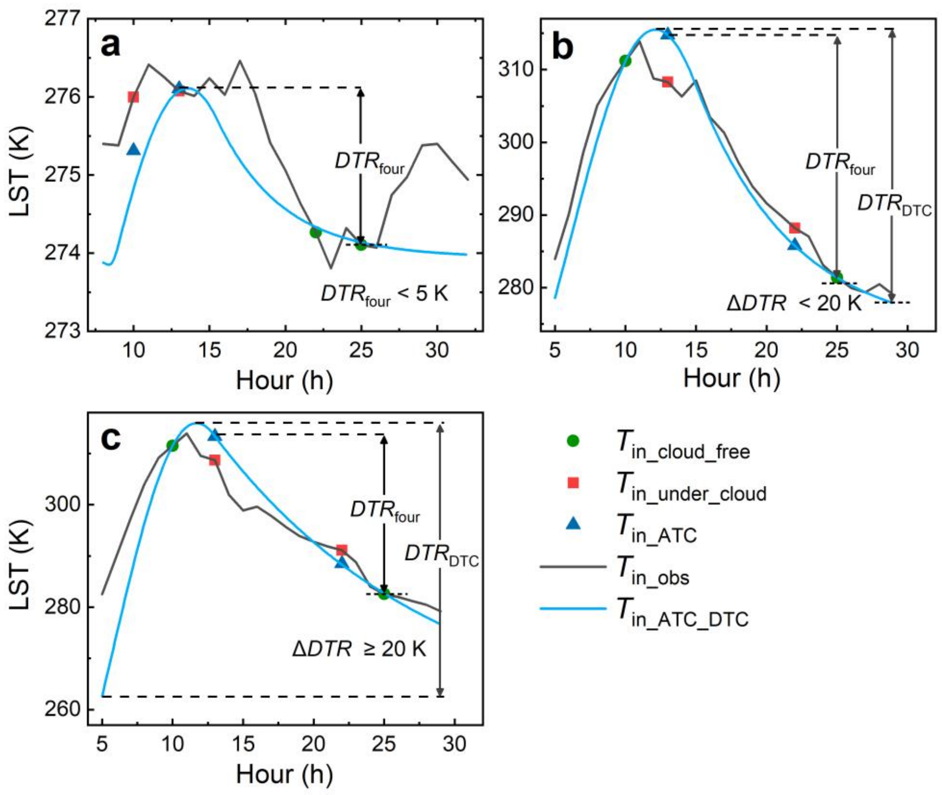


**Fig. 1. Estimation of $T_{\mathrm{dm}}$ under different conditions. (a) displays an example of estimating $T_{\mathrm{dm}}$ by averaging $T_{\mathrm{in\_cloud\_free}}$ and $T_{\mathrm{in\_ATC}}$ when $DTR_{\mathrm{four}}$ is less than 5.0 K (i.e., Scenario #1); (b) displays an example of estimating $T_{\mathrm{dm}}$ based on the DTC**

**modelling results (i.e., Scenario #2); (c) displays an example of estimating $T_{dm}$ by averaging $T_{in\_cloud\_free}$ and $T_{in\_ATC}$ when Δ*DTR* is equal or greater than 20.0 K (i.e., Scenario #3). The green circles, red rectangles, and blue triangles denote the instantaneous cloud-free LST observations, under-cloud LST observations, and under-cloud LSTs reconstructed by the ATC model, respectively. The black lines denote the *in situ* LST observations while the blue lines show the DTC-modelled values based on the cloud-free LST observations and ATC-modelled under-cloud LSTs. Noting that hours larger than 24 along the *x*-axis correspond to the next day.**

**Comment #9**

*Line 317: "Lower accuracy" being compared to what needs to be clarified.*

**Authors' reply:**

Thanks for your comment. "Lower accuracy" was compared to the accuracy of $T_{dm\_IADTC}$. This sentence indicates that the accuracy of $T_{dm\_cloud\_free}$ is lower than that of $T_{dm\_IADTC}$. It has been revised for clarification. Please refer to Line 319-320 for reference, which was given as follows for your convenience.

Line 319-320:

{By contrast, the MAEs of the $T_{dm\_cloud\_free}$ are 4.1 K and 2.5 K at the daily and monthly scales, respectively, i.e., they indicate a significantly lower accuracy compared to that of $T_{dm\_IADTC}$.}

**Comment #10**

*Line 394: Please provide more evidence about the link between ΔTsb and land cover type or DTR.*

**Authors' reply:**

Thanks for your comment. We acknowledge that our original description could be misleading and have clarified the statement with more references cited. Please refer to Line 397-400, which is given as follows for your convenience.

Line 397-400:

{We further observe that $\Delta T_{sb}$ is sensitive to land cover type and that DTR can partially explain $\Delta T_{sb}$. For instance, regions with a large DTR (e.g., deserts or bare soils) usually have a greater $\Delta T_{sb}$ (Sharifnezhadazizi et al., 2019; Hong et al., 2021; Jin and Dickinson, 2010).}

**Comment #11**

*Line 414: Please clarify what's the different information contained within the ΔTsb.*

**Authors' reply:**

Thanks for your comment. We are sorry for causing the misunderstanding. This sentence wants to claim that the slope difference between $T_{dm\_cloud\_free}$ and $T_{dm\_IADTC}$ was related to the variation of $\Delta T_{sb}$, and the variation of $\Delta T_{sb}$ is related to the cloud percentage and cloud duration among different months. For clarification, we have rephrased the original description. Please refer to Line 418-419, which was given as follows for your convenience.

Line 418-419:

{The slope difference is related to the variation of $\Delta T_{sb}$, which can be affected by the cloud percentage and cloud duration among different months.}

**Comment #12**

*Fig. 11: I am wondering about the variation of error of Tdm_ATC_DTC versus DTRfour, which can provide more solid support for the necessity of defining Scenario #1.*

**Authors' reply:**

Thanks for your comment. The variation of the error of $T_{dm\_ATC\_DTC}$ *versus* $DTC_{four}$ was displayed in Fig. R2. Results show that under scenario #1 (i.e., $DTR_{four}$ < 5.0 K), the error of $T_{dm\_ATC\_DTC}$ is close to the error of $T_{dm\_ATC\_four}$, i.e., mostly near zero, which indicates that $T_{dm\_ATC\_DTC}$ and $T_{dm\_ATC\_four}$ can be used interchangeably to achieve similar accuracy. Additionally, defining Scenario #1 can effectively avoid the outliers caused by the failed simulation case of DTC model.

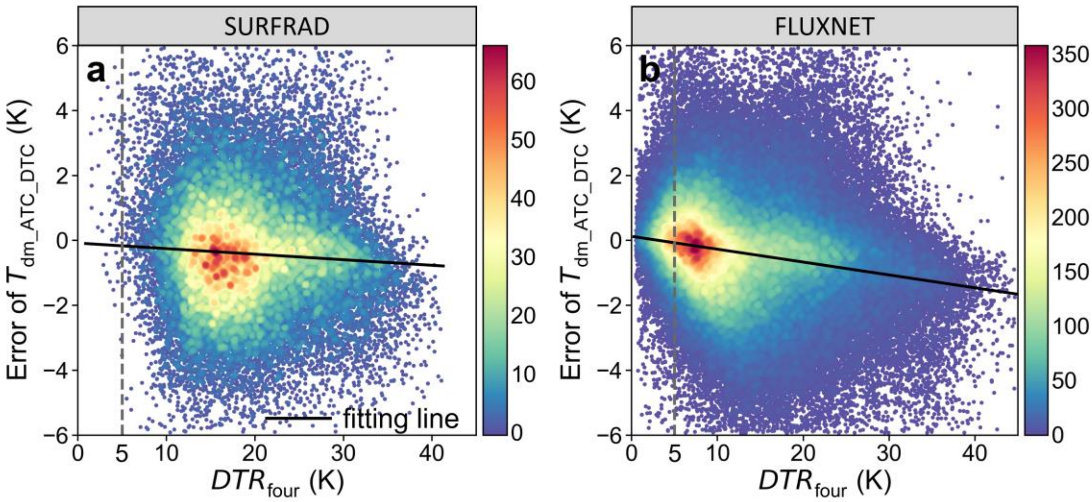


Fig. R2. The variation of $T_{dm\_ATC\_DTC}$ depends on the variation of $DTR_{four}$. (a) and (b) display the results for SURFRAD and FLUXNET, respectively.

## IV. References


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