# ReCap: Better Gaussian Relighting with Cross-Environment Captures

## Supplementary Material

In the supplementary material, we first provide detailed explanations of the HDR processing steps in Sec. A. Next, we illustrate the effects of the proposed shading function in Sec. B. Additionally, object-wise comparison and extended qualitative comparisons are presented in Sec. C and Sec. D.

## A. HDR Processing for Relighting

In Sec. 3.4, we discussed how various design choices influence the interpretation of the learned environment maps and how novel HDR maps should be processed to align with this interpretation for relighting. Fig. A summarizes the four options, with the red dotted block indicating the processing applied to standard HDR maps to obtain the relighting results presented in Tab. 1 of the main text. While omitting gamma correction during training is theoretically inconsistent with a linear light transport, it is included for completeness and to reflect common practice where it is often overlooked.

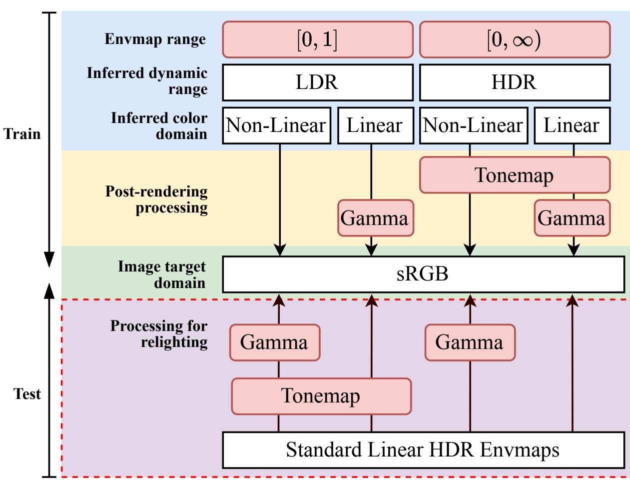


Figure A. Design choices and relevant implication on the learned environment maps. During relighting (highlighted by the red dotted block), the input HDR map are processed to match the interpretation.

Since GShader [18] and 3DGS-DR [46] do not provide official relighting code, Sec. A.1 and Sec. A.2 explain the processing applied to obtain their relighting results.

### A.1. GShader

GShader [18] constrains its learned environment maps to the range $[0, 1]$ and adopts a $y$-up coordinate convention for light querying. As illustrated in Fig. B, we perform coordinate transformations and clipping on latitude-longitude HDR environment maps for relighting. Without clipping, the rendered object appears overexposed.

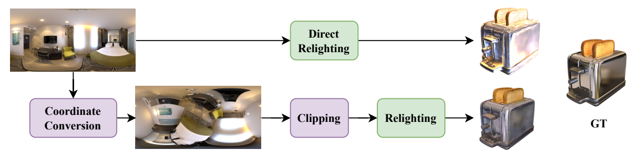


Figure B. Environment map processing for GShader.

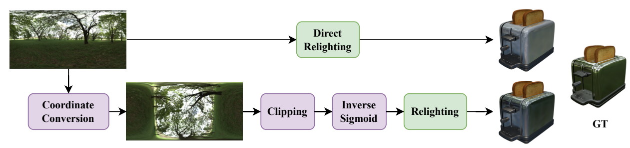


Figure C. Environment map processing for 3DGS-DR.

### A.2. 3DGS-DR

The learned environments in 3DGS-DR [46] are not range-limited and adopts a $y$-down coordinate system. Since the official implementation visualizes learned environment maps with a sigmoid function, we use an inverse sigmoid to adjust the lighting values. As shown in Fig. C, we apply coordinate transformation, clipping and inverse sigmoid on the HDR maps for relighting. Without the adjustment, the relighting output appears dull, and the highlight pattern also shifts incorrectly (from the upper surface to the front surface) due to the mismatched coordinate system.

## B. Visual Ablation of the Shading Function

The proposed shading function offers a more flexible material representation, which proves particularly advantageous for specular surfaces as shown in Fig. D. Although relighting differences are less pronounced for diffuse objects, training by the original shading function tends to misclassify non-metallic surfaces, such as the ficus leaves.

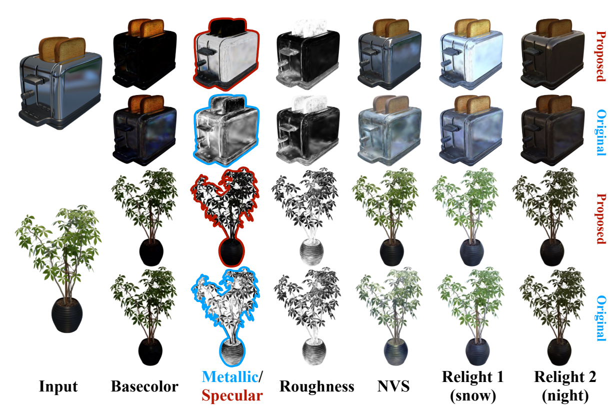


Figure D. Comparison of the original and the proposed shading function.

Table E. Object-wise relighting performance. Methods optimized over single-env (✦) and dual-env (✧) inputs differ in the choice of training split B. Best and second best results are highlighted in **bold** and *italic* respectively.

| | Relit NeRF Synthetic | | | | | | | | Relit Shiny Blender | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | **chair** | **drums** | **ficus** | **hotdog** | **lego** | **ship** | **material** | **mic** | **helmet** | **coffee** | **musclecar** | **toaster** | **teapot** |
| PSNR↑ | | | | | | | | | | | | | |
| 3DGS-DR✦[46] | 21.25 | 21.82 | 25.78 | 19.34 | 21.38 | 19.06 | 20.01 | 26.42 | 20.33 | 18.09 | 19.62 | 17.35 | 25.46 |
| GS-IR✦[26] | 20.56 | 22.53 | *27.45* | 22.22 | 24.00 | *21.79* | 21.38 | 27.58 | 19.63 | 20.40 | 22.93 | 16.51 | 26.44 |
| R3DG✦[15] | 23.67 | 21.23 | 25.60 | 24.38 | 24.13 | 20.53 | 21.55 | 26.77 | 21.17 | 17.66 | 22.47 | 16.66 | 24.54 |
| GShader✦[18] | 20.83 | 19.69 | 25.56 | 18.80 | 16.42 | 17.37 | 20.03 | 26.16 | 19.07 | 18.35 | 21.19 | 18.55 | 24.03 |
| ReCap✦ (ours) | 21.49 | *24.02* | 24.82 | 22.43 | 23.22 | 20.08 | *22.69* | 29.70 | *23.41* | 18.38 | 25.74 | 18.89 | 27.59 |
| 3DGS-DR✧[46] | 21.86 | 22.09 | 25.55 | 21.13 | 22.71 | 20.41 | 20.73 | 26.60 | 18.54 | 20.44 | 21.66 | 15.14 | 26.33 |
| GS-IR✧[26] | 21.18 | 22.70 | 27.21 | 21.74 | 24.07 | 21.51 | 21.80 | 26.84 | 19.41 | 20.27 | 22.74 | 16.05 | 26.34 |
| R3DG✧[15] | 24.08 | 21.25 | 25.17 | 23.57 | 24.50 | 18.34 | 22.17 | 25.76 | 20.74 | 18.66 | 22.09 | 17.01 | 25.33 |
| GShader✧[18] | 21.33 | 21.11 | 25.71 | 18.70 | 18.47 | 18.98 | 20.98 | 27.17 | 19.51 | 18.28 | 22.63 | 18.06 | 24.24 |
| TensoIR✧[19] | *26.32* | 20.77 | 24.29 | **26.06** | *27.08* | 21.01 | 20.69 | *29.77* | 20.11 | **25.13** | *25.83* | 15.43 | **35.89** |
| TensoIR✧$_{\text{no scale}}$[19] | 20.25 | 22.99 | 24.28 | *24.50* | **28.23** | **21.98** | 19.96 | 28.40 | 18.76 | *23.66* | 24.59 | 15.02 | 27.76 |
| GShader✧[18] + ours | 23.25 | 21.06 | 26.63 | 20.24 | 19.17 | 18.80 | 19.97 | 27.18 | 19.81 | 20.34 | 21.84 | *20.53* | 24.20 |
| ReCap✧ (ours) | **26.63** | **24.77** | **28.24** | 23.25 | 24.04 | 20.12 | **25.83** | **31.31** | **23.55** | 22.17 | **28.99** | **25.05** | *31.65* |
| SSIM↑ | | | | | | | | | | | | | |
| 3DGS-DR✦[46] | 0.920 | 0.911 | 0.958 | 0.882 | 0.867 | 0.771 | 0.875 | 0.956 | 0.885 | 0.903 | 0.882 | 0.824 | 0.974 |
| GS-IR✦[26] | 0.897 | 0.901 | 0.956 | 0.889 | 0.874 | 0.790 | 0.864 | 0.954 | 0.849 | 0.896 | 0.895 | 0.767 | 0.969 |
| R3DG✦[15] | 0.924 | 0.895 | 0.952 | 0.904 | 0.880 | 0.774 | 0.864 | 0.955 | 0.865 | 0.881 | 0.899 | 0.784 | 0.969 |
| GShader✦[18] | 0.914 | 0.891 | 0.951 | 0.885 | 0.821 | 0.777 | 0.871 | 0.956 | 0.889 | 0.908 | 0.896 | 0.824 | 0.973 |
| ReCap✦ (ours) | 0.922 | *0.928* | *0.961* | 0.900 | 0.887 | 0.801 | *0.889* | 0.970 | *0.909* | 0.910 | *0.928* | 0.824 | *0.982* |
| 3DGS-DR✧[46] | 0.925 | 0.916 | 0.957 | 0.897 | 0.884 | *0.804* | 0.876 | 0.957 | 0.862 | 0.919 | 0.896 | 0.781 | 0.976 |
| GS-IR✧[26] | 0.900 | 0.901 | 0.954 | 0.885 | 0.868 | 0.793 | 0.861 | 0.950 | 0.848 | 0.894 | 0.888 | 0.756 | 0.966 |
| R3DG✧[15] | 0.931 | 0.897 | 0.951 | 0.904 | 0.883 | 0.761 | 0.871 | 0.952 | 0.867 | 0.891 | 0.899 | 0.792 | 0.972 |
| GShader✧[18] | 0.920 | 0.901 | 0.954 | 0.892 | 0.843 | 0.794 | 0.878 | 0.961 | 0.889 | 0.909 | 0.911 | 0.820 | 0.974 |
| TensoIR✧[19] | *0.939* | 0.877 | 0.946 | 0.911 | *0.922* | 0.777 | 0.862 | *0.970* | 0.825 | 0.891 | 0.910 | 0.684 | 0.978 |
| TensoIR✧$_{\text{no scale}}$[19] | 0.920 | 0.893 | 0.946 | *0.912* | **0.925** | 0.800 | 0.870 | 0.967 | 0.818 | 0.892 | 0.901 | 0.688 | 0.977 |
| GShader✧[18] + ours | 0.935 | 0.905 | 0.960 | 0.900 | 0.855 | 0.795 | 0.888 | 0.963 | 0.903 | *0.927* | 0.906 | *0.869* | 0.975 |
| ReCap✧ (ours) | **0.951** | **0.937** | **0.972** | **0.912** | 0.908 | **0.815** | **0.921** | **0.975** | **0.920** | **0.940** | **0.943** | **0.910** | **0.988** |
| LPIPS↓ | | | | | | | | | | | | | |
| 3DGS-DR✦[46] | *0.055* | 0.056 | 0.029 | 0.110 | 0.088 | 0.173 | *0.081* | 0.025 | *0.116* | 0.149 | 0.075 | 0.143 | 0.030 |
| GS-IR✦[26] | 0.072 | 0.069 | 0.036 | 0.121 | 0.090 | 0.185 | 0.094 | 0.032 | 0.176 | 0.152 | 0.080 | 0.221 | 0.037 |
| R3DG✦[15] | 0.060 | 0.068 | 0.037 | 0.105 | 0.088 | 0.188 | 0.103 | 0.035 | 0.171 | 0.152 | 0.078 | 0.210 | 0.035 |
| GShader✦[18] | 0.078 | 0.068 | 0.038 | 0.133 | 0.119 | 0.192 | 0.089 | 0.028 | 0.134 | 0.158 | 0.075 | 0.157 | 0.037 |
| ReCap✦ (ours) | 0.060 | *0.048* | *0.028* | 0.103 | *0.081* | **0.162** | 0.082 | *0.019* | 0.118 | *0.140* | *0.057* | 0.151 | *0.023* |
| 3DGS-DR✧[46] | 0.057 | 0.055 | 0.032 | 0.102 | 0.085 | 0.187 | 0.087 | 0.028 | 0.148 | 0.150 | 0.073 | 0.185 | 0.031 |
| GS-IR✧[26] | 0.074 | 0.070 | 0.040 | 0.131 | 0.099 | 0.196 | 0.102 | 0.037 | 0.183 | 0.161 | 0.085 | 0.235 | 0.040 |
| R3DG✧[15] | 0.060 | 0.067 | 0.039 | 0.110 | 0.091 | 0.206 | 0.104 | 0.038 | 0.170 | 0.160 | 0.078 | 0.212 | 0.037 |
| GShader✧[18] | 0.076 | 0.064 | 0.038 | 0.130 | 0.106 | 0.219 | 0.090 | 0.027 | 0.135 | 0.164 | 0.068 | 0.164 | 0.038 |
| TensoIR✧[19] | 0.075 | 0.122 | 0.067 | 0.135 | 0.096 | 0.221 | 0.134 | 0.043 | 0.256 | 0.164 | 0.116 | 0.310 | 0.046 |
| TensoIR✧$_{\text{no scale}}$[19] | 0.108 | 0.119 | 0.067 | 0.144 | 0.089 | 0.208 | 0.132 | 0.046 | 0.262 | 0.165 | 0.121 | 0.308 | 0.048 |
| GShader✧[18] + ours | 0.063 | 0.062 | 0.032 | *0.100* | 0.095 | 0.205 | 0.088 | 0.024 | 0.125 | 0.146 | 0.071 | *0.124* | 0.038 |
| ReCap✧ (ours) | **0.042** | **0.042** | **0.023** | **0.091** | **0.068** | *0.165* | **0.063** | **0.016** | **0.094** | **0.120** | **0.048** | **0.088** | **0.021** |

## C. Object-wise results

We present object-wise relighting performance in Tab. E. Objects with strong self-shadowing/self-reflection (e.g., hotdog, coffee, lego as shown in Fig. E) are difficult for ReCap as we do not handle secondary rays. Ship poses a challenge for all methods with its translucent material requiring the modeling of subsurface scattering.

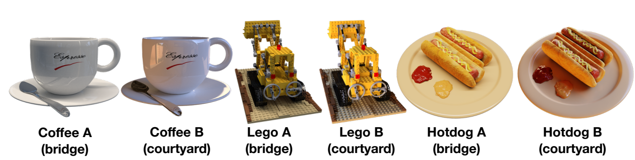


Figure E. Training views of objects with self-shadowing/self-reflection.

## D. Additional Results (Fig. F to Fig. H)

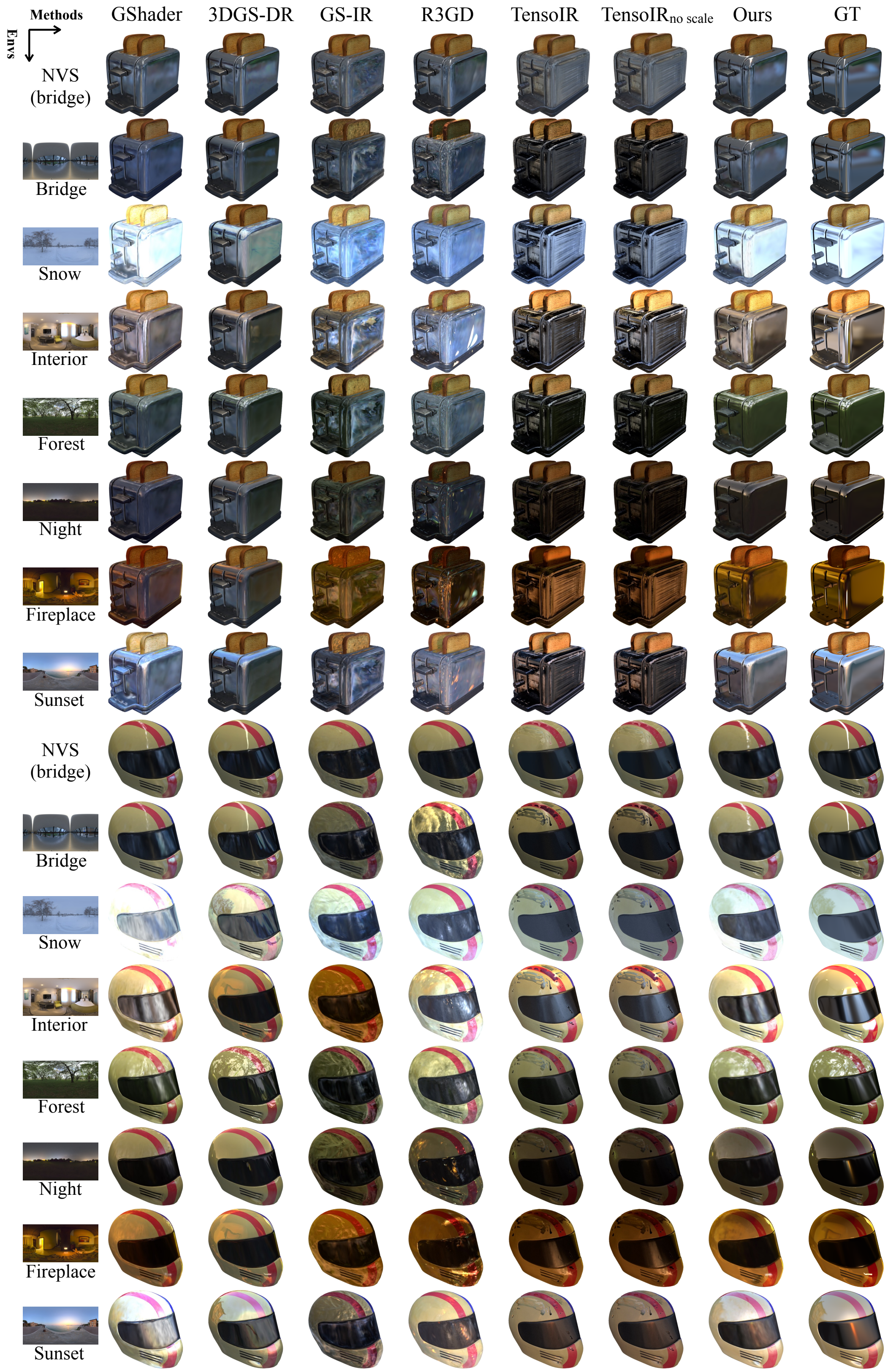

Figure F. Qualitative comparison of relighting results across different environment maps. Upper: toaster; lower: helmet.

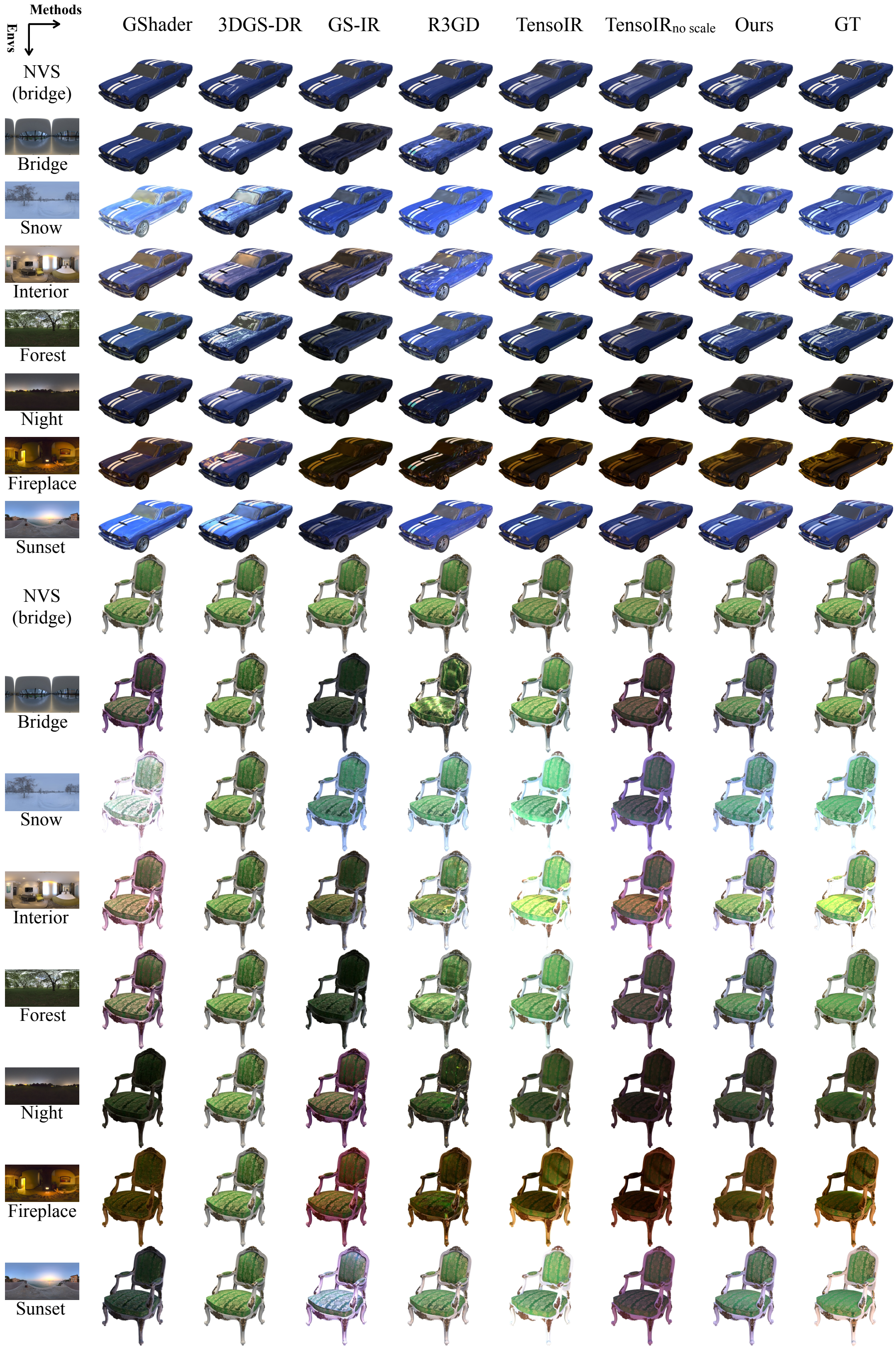


Figure G. Qualitative comparison of relighting results across different environment maps. Upper: musclecar; lower: chair.


Figure H. Qualitative comparison of relighting results across different environment maps. Upper: mic; lower: ficus.