Deep Sky.

Learning to generate photorealistic skies per user-controlled positioning of solar and atmospheric components

Ian J. Maquignaz†, Aryan Garg†, Yannick Hold-Geoffroy‡, Julien Philip‡, Jean-François Lalonde†
†Université Laval, ‡Adobe Research

Objective.

To generate visually appealing and physically accurate skies:

- Per user-controlled solar positioning.
- Per user-defined atmospheric components.
- With faithful representation of geolocation, temporality, and weather conditions.

Current Limitations To State-Of-The-ART:

- Physically based models are computationally expensive.
- Parametric models emulate only clear and overcast skies.
- ANN/DNN models offer limited resolution, realism and weather/locality variation.

Sample scenes rendered in Blender [1] with Nishita [2] Sky Textures

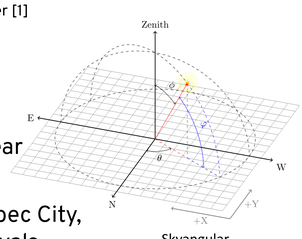
Pretham [3], Nishita [2], and Hosek/Wilkie [4]
Parametric sky textures rendered using Blender [1]

Dataset.

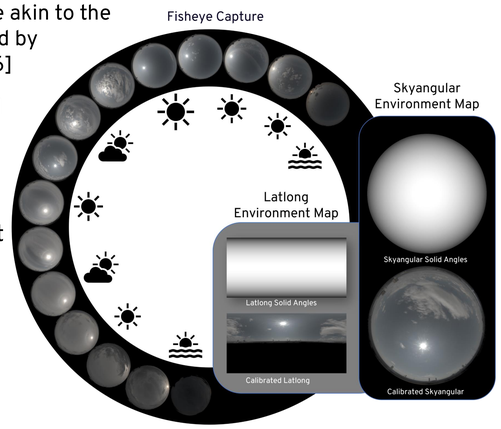
Laval HDRDB: HDR Sky Database [5]

Physically accurate and calibrated linear environment maps:

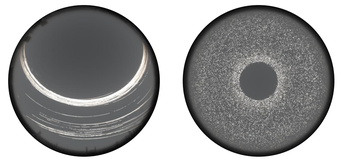
- 34K+ HDR images captured in Quebec City, Canada across varied 44-time intervals between 2015 and 2016.
- Full HDR capture akin to the method proposed by Stumpfel et al. [6]
- Rich and varied atmospheric conditions.
- Visual artifacts are few. Subject to lens flair, vignetting, and ghosting.



Skyangular Coordinate System

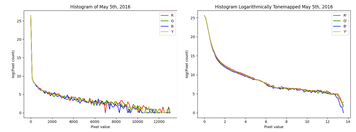


Experiments.

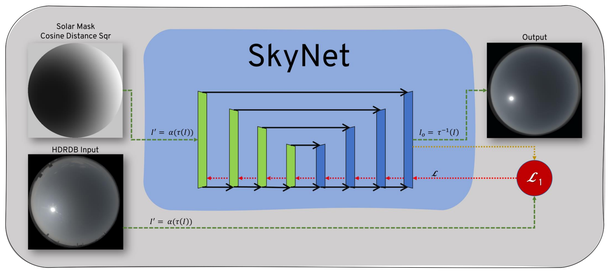


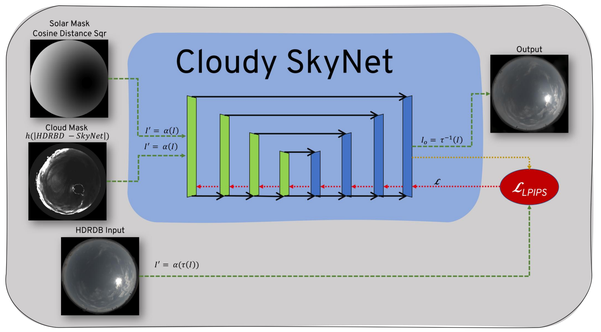
Mean of 34,968 HDRI images

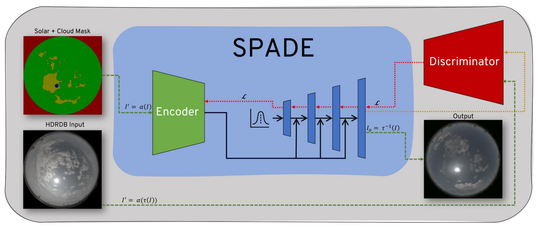
Mean of 34,968 augmented HDRI images



Mean HDR irradiance vs. mean tonemapped irradiance.
Compression of the color gamut enables GAN convergence.





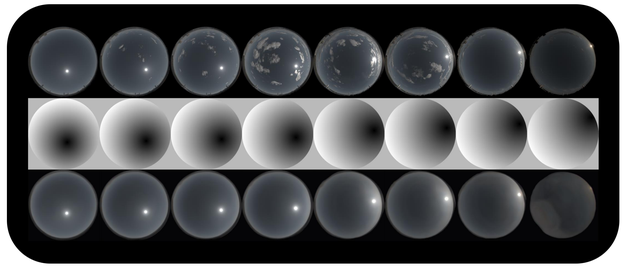


Where:

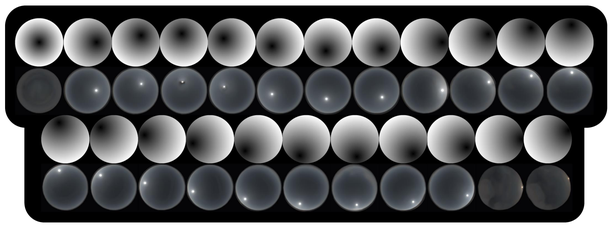
- α defines uniform random affine rotation around zenith.
- $h(I)$ defines HSV cloud segmentation.
- τ defines logarithmic tonemapping by $\tau(I) = \log_2(I+1)$ and inversely $\tau^{-1}(I) = 2^I - 1$

Sample Blender [1] scenes rendered with environment maps from HDRDB [5], paired generated environment maps from SkyNet (ours; based on [7]), and SPADE [8]

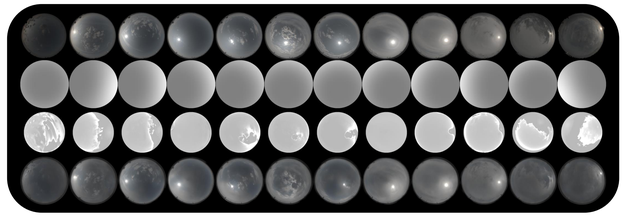
Results.



Environment maps of clear skies visually match paired images from the Laval HDR Sky Database.



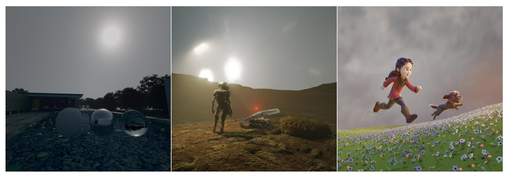
Environment maps of clear skies can be generated per artist specification for any desired time-of-day



Environment maps of cloudy skies can be generated per artist specification from a multimodal family of atmospheric components to creating a wide range of weather pattern .

Applications.

Sky models are an integral part of daylight environment simulation with various applications, including civil engineering, urban planning and visual arts.



Sample Blender creations with artistic use of environment maps [1]

Symposium IA Montréal

References:

[1] Blender Foundationn. Blender 3.1. [Online]. Available: https://www.blender.org/
[2] T. Nishita, T. Sirai, K. Tadamura, and E. Nakamae, "Display of the earth taking into account atmospheric scattering," in Proceedings of the 20th annual conference on Computer graphics and interactive techniques, 1993, pp. 175–182.
[3] A. J. Preetham, P. Shirley, and B. Smits, "A practical analytic model for daylight," in Proceedings of the 26th Annual Conference on Computer Graphics and Interactive Techniques, ser. SIGGRAPH '99. USA: ACM Press/Addison-Wesley Publishing Co., 1999, p. 91–100. [Online]. Available: https://doi.org/10.1145/311535.311545
[4] L. Hosek and A. Wilkie, "An analytic model for full spectral sky-dome radiance," ACM Trans. Graph., vol. 31, no. 4, jul 2012. [Online]. Available: https://doi.org/10.1145/2185520.2185591
[5] J.-F. Lalonde, L.-P. Asselin, J. Becirovski, Y. Hold-Geoffroy, M. Garon, M.-A.Gardner, and J. Zhang. (2016) The Laval HDR sky database. [Online]. Available: http://sky.hdrdb.com
[6] J. Stumpfel, A. Jones, A. Wenger, C. Tchou, T. Hawkins, and P. Debevec, "Direct hdr capture of the sun and sky," in ACM SIGGRAPH 2006 Courses, ser. SIGGRAPH '06. New York, NY, USA: Association for Computing Machinery, 2006, p. 5–es. [Online]. Available: https://doi.org/10.1145/1185657.1185687
[7] D. Griffiths, T. Ritschel, and J. Philip, "Outcast: Outdoor single-image relighting with cast shadows," Computer Graphics Forum, vol. 41, no. 2, pp. 179–193, 2022. [Online]. Available: https://onlinelibrary.wiley.com/doi/abs/10.1111/cgf.14467
[8] T. Park, M. Liu, T. Wang, and J. Zhu, "Semantic image synthesis with 130
spatially-adaptive normalization," CoRR, vol. abs/1903.07291, 2019. [Online]. Available: 131
http://arxiv.org/abs/1903.07291