

**THE EXPERTS**  
**Robson Forensic**

RAYMOND L. LEE JR., PH.D.  
Object Visibility, Lighting, and Meteorology

**PROFESSIONAL EXPERIENCE**

- 1992 to present **Robson Forensic, Inc.**  
*Associate*  
Provide technical investigations, analyses, reports, and testimony toward the resolution of litigation involving issues of object visibility, lighting, and meteorology.
- 1991 to present **U. S. Naval Academy, Mathematics & Science Division**  
*Research Professor*
- 1989 to 1991 **Pennsylvania State University, Meteorology Department**  
*Postdoctoral Researcher*
- 1980 to 1988 **Pennsylvania State University, Meteorology Department**  
*Graduate Lecturer and Teaching Assistant*

**FORENSIC SPECIALTIES**

Driver Reaction to Signs and Other Traffic Control Devices  
Evaluation of Glare from Sunlight and Headlights  
Nighttime and Daytime Visibility of Warning Lights and Traffic Control Devices  
Nighttime Visibility Using Headlights  
Visibility in Outdoor and Indoor Lighting  
Visibility through Windshields and through Fog, Haze, and Snow  
Photometry, Colorimetry, and Photogrammetry from Digital Images  
Evaluation of Icing and Melting Conditions  
Evaluation of Site-specific Wind Speeds and Forces  
Past Weather from Weather Radar and Surface Reports

**EDUCATION**

Ph. D., Meteorology, Pennsylvania State University, University Park, PA  
B. A. *cum laude*, Art History from Williams College, Williamstown, MA

**PROFESSION MEMBERSHIPS**

American Meteorological Society (AMS)  
Optical Society of America (OSA)  
Illuminating Engineering Society (IES)  
Sigma Xi

PUBLICATIONS

Papers in Refereed Journals

- 2020 R. L. Lee, Jr. "Analyzing colors and spectra of natural rainbows with hyperspectral imaging," *Applied Optics*, in review.
- 2017 R. L. Lee, Jr. and D. C. Mollner, "Tropospheric haze and colors of the clear twilight sky," *Applied Optics* **56**, G179-G187.
- 2017 R. L. Lee, Jr. "Spectral measurement and modeling of natural rainbows," *Applied Optics* **56**, G42-G50.
- 2015 R. L. Lee, Jr., "Measuring and modeling twilight's Belt of Venus," *Applied Optics* **54**, B194-B203.
- 2015 R. L. Lee, Jr., "Tropospheric haze and colors of the clear daytime sky," *Applied Optics* **54**, B232-B240.
- 2012 R. L. Lee, Jr. and O. R. Samudio, "Spectral polarization of clear and hazy coastal skies," *Applied Optics* **51**, 7499-7508.
- 2011 R. L. Lee, Jr. and P. Laven, "Visibility of natural tertiary rainbows," *Applied Optics* **50**, F152-F161.
- 2011 R. L. Lee, Jr., W. Meyer, and G. Hoeppe, "Atmospheric ozone and colors of the Antarctic twilight sky," *Applied Optics* **50**, F162-F171.
- 2008 R. L. Lee, Jr., "Measuring overcast colors with all-sky imaging," *Applied Optics* **47**, H106-H115.
- 2008 R. L. Lee, Jr. and D. E. Devan, "Observed brightness distributions in overcast skies," *Applied Optics* **47**, H116-H127.
- 2006 S. Johnsen, A. Kelber, E. Warrant, A. M. Sweeney, E. A. Widder, R. L. Lee, Jr., and J. Hernández-Andrés, "Crepuscular and nocturnal illumination and its effects on color perception by the nocturnal hawkmoth *Deilephila elpenor*," *Journal of Experimental Biology*, **209** (doi: 10.1242/jeb.02053), 789-800.
- 2005 M. A. López-Álvarez, J. Hernández-Andrés, J. Romero, and R. L. Lee, Jr., "Designing a practical system for spectral imaging of skylight," *Applied Optics* **44**, 5688-5695.
- 2005 R. L. Lee, Jr. and J. Hernández-Andrés, "Short-term variability of overcast brightness," *Applied Optics* **44**, 5704-5711.

RAYMOND L. LEE JR., PH.D.  
Object Visibility, Lighting, and Meteorology

- 2005 R. L. Lee, Jr. and J. Hernández-Andrés, "Colors of the daytime overcast sky," *Applied Optics* **44**, 5712-5722.
- 2004 M. V. Berry, M. R. Dennis, and R. L. Lee, Jr., "Polarization singularities in the clear sky," *New Journal of Physics* **6** (9 November, # 162, doi: 10.1088/1367-2630/6/1/162), 14 pp.
- 2004 R. L. Lee, Jr. and J. Hernández-Andrés, "Virtual tunnels and green glass: The colors of common mirrors," *American Journal of Physics* **72**, 53-59.
- 2003 R. L. Lee, Jr. and J. Hernández-Andrés, "Measuring and modeling twilight's purple light," *Applied Optics* **42**, 445-457.
- 2003 J. Hernández-Andrés, R. L. Lee, Jr., and J. Romero, "Color and luminance asymmetries in the clear sky," *Applied Optics* **42**, 458-464.
- 2001 J. Hernández-Andrés, R. L. Lee, Jr., J. Romero, and J. L. Nieves, "Color and spectral analysis of daylight in southern Europe," *Journal of the Optical Society of America A* **18**, 1325-1335.
- 2001 J. Hernández-Andrés, R. L. Lee, Jr., and J. Romero, "Colorimetric and spectroradiometric characteristics of narrow-field-of-view clear skylight in Granada, Spain," *Journal of the Optical Society of America A* **18**, 412-420.
- 1999 J. Hernández-Andrés, R. L. Lee, Jr., and J. Romero, "Calculating correlated color temperatures across the entire gamut of daylight and skylight chromaticities," *Applied Optics* **38**, 5703-5709.
- 1998 R. L. Lee, Jr., "Mie theory, Airy theory, and the natural rainbow," *Applied Optics* **37**, 1506-1519.
- 1998 R. L. Lee, Jr., "Digital imaging of clear-sky polarization," *Applied Optics* **37**, 1465-1476.
- 1994 R. L. Lee, Jr., "Horizon brightness revisited: Measurements and a model of clear-sky radiances," *Applied Optics* **33**, 4620-4628, 4959.
- 1994 R. L. Lee, Jr., "Twilight and daytime colors of the clear sky," *Applied Optics* **33**, 4629-4638, 4959.
- 1991 R. L. Lee, Jr., "What are 'all the colors of the rainbow?'" *Applied Optics* **30**, 3401-3407, 3545.
- 1990 R. L. Lee, Jr., "Green icebergs and remote sensing," *Journal of the Optical Society of America A* **7**, 1862-1874.

RAYMOND L. LEE JR., PH.D.  
Object Visibility, Lighting, and Meteorology

- 1988 R. L. Lee, Jr., "Colorimetric calibration of a video digitizing system: Algorithm and applications," *Color Research and Application* **13**, 180-186.

Invited Papers

- 2017 R. L. Lee, Jr., "Out of the blue: Hyperspectral imaging and analysis of clear daytime and twilight skies," invited talk given on 15 November at Chester F. Carlson Center for Imaging Science, Rochester Institute of Technology, Rochester, NY.
- 2000 R. L. Lee, Jr., 40 peer-reviewed entries for revised edition of the AMS *Glossary of Meteorology*.
- 2000 R. L. Lee, Jr., "Regnbuen og regndråbernes størrelse," *Aktuel Naturvidenskab*, (# 1, February/March), 10.
- 2000 R. L. Lee, Jr., "Looking at and through clear to cloudy skies: Research in mirages, glories, coronas, sky color and more, 1970-1999," in *On Minnaert's Shoulders: 20 Years of the Light and Color Conferences*, in Optical Society of America's series Classic Reprints on CD-ROM, Vol. 1.
- 1998 R. L. Lee, Jr., "Regnbuens farver," *Kvant* **9** (# 4, December), 14.
- 1990 R. L. Lee and A. B. Fraser, "The light at the end of the rainbow," *New Scientist* **127** (no. 1732, 1 September), 40-44.
- 1984 R. L. Lee, Jr., "Rainbows: An observer's guide," "God, the rainbow, and the artist," "What's at the end of the rainbow puzzle?" Published simultaneously in *The Johns Hopkins Magazine*, *Franklin & Marshall Today*, *The Wick* (Hartwick College alumni magazine), *At Rensselaer*, *The WPI Journal*, pp. I - XI (August 1984).

Scholarly Book

- 2001 R. L. Lee, Jr. and A. B. Fraser, *The Rainbow Bridge: Rainbows in Art, Myth, and Science* (ISBN 0-271-01977-8), Pennsylvania State University Press (University Park, PA) and SPIE Press (Bellingham, WA), 393 pp.

Reports and Course Development

- 1995 R. L. Lee, Jr., "Low-visibility accidents" in National Transportation Safety Board's *Highway Accident Report and Special Investigation of Collision Warning Technology*, NTSB/HAR-95/03, pp. 29-35.
- 1992 R. L. Lee, Jr., "Meteorological optics" in National Transportation Safety Board's *Proceedings: Special Public Hearing on Fog Accidents on Limited Access Highways*, NTSB/RP-92/01, pp. 87-100.
- 1991 R. L. Lee, Jr., R. S. Hostetter, and H. Leibowitz, Federal Highway Administration study Final Report # FHWA-RD-91-016, *Driver Visibility Under Wet Pavement Conditions: Size, Shape, and Spacing of Road Markers*.

RAYMOND L. LEE JR., PH.D.  
Object Visibility, Lighting, and Meteorology

1986 & R. L. Lee, Jr., "Weather and Society," Department of Independent Learning, Pennsylvania State University, 262 pp. (1st and 2nd editions).

**DISSERTATION**

"Green icebergs: A problem in geophysics and atmospheric optics." Two remote sensing techniques show that bottle-green icebergs need not be caused by extrinsic colorants. Instead, intrinsically blue-green ice containing a few black or gray scatterers *can* generate the greens observed, and these greens are especially vivid when the ice is illuminated by reddened sunlight.

**PAPERS PRESENTED AT SCIENTIFIC MEETINGS**

- 2019 "Observed and intrinsic colors and spectra of natural rainbows," paper presented at the 13th International Conference on Light and Color in Nature, Bar Harbor, ME on 16 July.
- 2016 "Tropospheric haze and twilight sky colors," paper presented at the 12th International Conference on Light and Color in Nature in Granada, Spain on 3 June.
- 2016 "Spectral imaging of spraybows and natural rainbows," paper presented at the 12th International Conference on Light and Color in Nature in Granada, Spain on 31 May.
- 2013 "Twilight's Belt of Venus: Mythology, measurements, and modeling," invited paper presented at the 11th International Conference on Light and Color in Nature, Fairbanks, AK on 8 August.
- 2013 "Measuring haze's effects on the colors and visible-wavelength spectra of clear skies," paper presented at the 11th International Conference on Light and Color in Nature, Fairbanks, AK on 7 August.
- 2010 "Spectral polarization of clear and hazy coastal skies," paper presented at the 10th International Conference on Atmospheric Optics, St. Mary's City, MD on 19 June.
- 2010 "Seasonal ozone depletion and colors of the twilight sky at Neumayer Station, Antarctica," paper presented at the 10th International Conference on Atmospheric Optics, St. Mary's City, MD on 18 June.
- 2010 "Visibility of natural tertiary rainbows," paper presented at the 10th International Conference on Atmospheric Optics, St. Mary's City, MD on 16 June.
- 2007 "Measuring overcast colors with all-sky imaging," paper presented at the 9th International Conference on Atmospheric Optics, Bozeman, MT on 25 June.

RAYMOND L. LEE JR., PH.D.  
Object Visibility, Lighting, and Meteorology

- 2007 "Observed brightness distributions in overcast skies," paper presented at the 9th International Conference on Atmospheric Optics, Bozeman, MT on 25 June.
- 2004 "Colors of clear and overcast skies," invited paper presented at the 8th International Conference on Atmospheric Optics, Bad Honnef, Germany on 16 June.
- 2004 "Temporal variability of overcast illuminances," paper presented at the 8th International Conference on Atmospheric Optics, Bad Honnef, Germany on 16 June.
- 2002 "Polarization in atmospheric optics," invited paper presented at the 3rd George Gabriel Stokes Summer School conference, Skreen, Ireland on 22 June.
- 2001 "The Rainbow Bridge: Rainbows in art, myth, and science," invited paper presented at the Topical Meeting on Meteorological Optics, National Center for Atmospheric Research, Boulder, CO on 8 June.
- 2001 "Twilight's purple light: New evidence on an old problem," presented at the Topical Meeting on Meteorological Optics, National Center for Atmospheric Research, Boulder, CO on 7 June.
- 1999 "Visibility of SMV signs during twilight," presented at National Institute for Farm Safety conference, Ocean City, MD on 21 June.
- 1997 "Mie theory, Airy theory, and the natural rainbow," invited paper presented at joint OSA/AMS topical meeting at Santa Fe, NM on 10 February.
- 1997 "Expanding the Arago neutral point: Digital imaging of clear-sky polarization," presented at joint OSA/AMS topical meeting at Santa Fe, NM on 11 February.
- 1993 "Horizon brightness revisited: Measurements and a model of clear-sky radiances," presented at OSA topical meeting at Pennsylvania State University, University Park, PA on 17 June.
- 1993 "Twilight and daytime colors of the clear sky," presented at OSA topical meeting at Pennsylvania State University, University Park, PA on 17 June.
- 1990 "Green icebergs and atmospheric optics," presented at OSA topical meeting at Georgetown University, Washington, DC on 12 July.
- 1990 "Rethinking the rainbow's colors," presented at OSA topical meeting at Georgetown University, Washington, DC on 11 July.
- 1987 "Colorimetric calibration of a video digitizing system," presented at OSA topical meeting on color appearance at St. John's College, Annapolis, MD on 30 June.

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#### GRANTS OR CONTRACTS RECEIVED

- 2016 Wrote proposal for and was awarded as principal investigator the National Science Foundation grant # AGS-1664404, "Hyperspectral imaging and analysis of natural rainbows."
- 2010 Contributed to proposal for and was awarded (with Charles Adler as principal investigator) the National Science Foundation grant # AGS-0962429, "2010 Meteorological/Light and Color in the Open Air Conference; St. Mary's City, Maryland; June 16-20, 2010."
- 2009 Wrote proposal for and was awarded as principal investigator the National Science Foundation grant # ATM-0914535, "Visual and spectral properties of tropospheric haze."
- 2007 Wrote proposal for and was awarded (with Joseph Shaw as co-principal investigator) the National Science Foundation grant # ATM-0731416, "Conference Support for the 9th International Meeting on Light and Color in Nature; Bozeman, Montana; June 25-29, 2007."
- 2006 Wrote proposal for and was awarded as principal investigator the National Science Foundation grant # ATM-0540896, "Spectral imaging of overcast skies."
- 2002 Wrote proposal for and was awarded as principal investigator the National Science Foundation grant # ATM-0207516, "Ground-based passive remote sensing of the overcast sky."
- 2001 Wrote proposal for and was awarded a National Science Foundation conference grant for the 2001 Topical Meeting on Meteorological Optics at the National Center for Atmospheric Research, Boulder, CO.
- 1999 Wrote proposal for and was awarded (with Alistair B. Fraser as co-principal investigator) the National Science Foundation grant # ATM-9820729, "Twilight's spectral and spatial structure in the visible."
- 1995 Wrote proposal for and was awarded (with Alistair B. Fraser as co-principal investigator) the National Science Foundation grant # ATM-9414290, "Twilight and the naked-eye observer: Models and high-resolution measurements."
- 1992 Awarded funding by the Naval Research Laboratory and the U. S. Naval Academy's Research Council to collaborate with NRL researchers on "Polarization and wavelength diversity of coherent SAR (Synthetic Aperture Radar) imaging."
- 1991 Consultant to Kerr-McGee Corporation on "Measured pigment colors and modeled colors of pigment spheres."

RAYMOND L. LEE JR., PH.D.  
Object Visibility, Lighting, and Meteorology

- 1989 Wrote proposal for and was awarded (with Alistair B. Fraser as co-principal investigator) renewal of the National Science Foundation grant # ATM-8917596, "The natural rainbow and passive remote sensing."
- 1988 Awarded two-year contract as principal investigator for Federal Highway Administration study # DTFH61-88-C-00118, "Driver Visibility Under Wet Pavement Conditions."
- 1986 Wrote proposal for and was awarded (with Alistair B. Fraser as principal investigator) the National Science Foundation grant # ATM-8607577, "The natural rainbow and passive remote sensing."

**SERVICE TO A PROFESSIONAL OR GOVERNMENT ORGANIZATION**

- 2016- Head of organizing committee for 13th International Conference on Light and Color in Nature at the College of the Atlantic, Bar Harbor, ME in July 2019.
- 2016- Topical editor for Optical Society of America technical papers resulting from 12<sup>th</sup> International Conference on Light and Color in Nature.
- 2015 Organizing committee for 12th International Conference on Light and Color in Nature at the University of Granada, Spain from 31 May-3 June 2016.
- 2014- Topical editor for Optical Society of America technical papers resulting from 11<sup>th</sup> International Conference on Light and Color in Nature.
- 2012- Organizing committee for 11th International Conference on Light and Color in Nature at the University of Alaska-Fairbanks, AK from 5-8 August 2013.
- 2011 Topical editor for Optical Society of America technical papers resulting from 10th International Conference on Light and Color in Nature.
- 2010 Invited panelist for public forum on "The atmosphere exposed: Photographs of meteorological optics," Boyden Art Gallery at St. Mary's College of Maryland on 16 June.
- 2009- Organizing committee for 10th International Conference on Atmospheric Optics at St. Mary's College of Maryland in St. Mary's City, MD from 16-20 June 2010.
- 2009 Invited speaker on "Forensic meteorology, visibility, and your client" at Pennsylvania Association of Criminal Defense Lawyers conference, State College, PA on 2 October.
- 2007- Topical editor for Optical Society of America technical papers resulting from 2008 9th International Conference on Atmospheric Optics.
- 2007 Organizing committee for 9th International Conference on Atmospheric Optics at Montana State University, Bozeman, MT; also served as session chair on 28 June.

RAYMOND L. LEE JR., PH.D.  
Object Visibility, Lighting, and Meteorology

- 2004- Topical editor for Optical Society of America technical papers resulting from  
2005 8th International Conference on Atmospheric Optics.
- 2004 Organizing committee for 8th International Conference on Atmospheric Optics at Bad Honnef, Germany; also served as session chair on 17 June.
- 2001 Organizing committee for Topical Meeting on Meteorological Optics at Boulder, CO; also served as session chair on 6 June.
- 1997 Session chair for OSA/AMS topical meeting on Meteorological Optics at Santa Fe, NM on 11 February.
- 1995 Invited speaker at National Transportation Safety Board Investigative Conference on “Mobile Collision Warning Technology For Low Visibility/Low Awareness Conditions,” Arlington, VA on 4 April.
- 1992- Numerous technical reports in forensic meteorology, visibility, and lighting  
Present
- 1991- Invited panel member for the National Research Council’s Highway Research  
1994 Synthesis on “Reduced Visibility on the Highway” (NCHRP Project 20-5, Topic 23-12).
- 1991 Invited speaker at National Transportation Safety Board Special Public Hearing on “Driving and Fog-related Accidents,” Knoxville, TN on 23-25 April.
- 1990 Member of technical program committee for OSA topical meeting on outdoor color and lighting.

**REVIEWS AND ADVISING**

- 2015- Ph.D. dissertation advisor for Ari R. Blenkhorn, *GPU-accelerated Rendering of*  
2018 *Atmospheric Glories* (Department of Computer Science and Electrical Engineering, University of Maryland Baltimore County).
- 1995- Supervised 14 Oceanography Department majors in their Honors Research projects;  
2017 advised Physics Department major in Honors Research project (2004); supervised 14 Oceanography Department majors on their Capstone papers.
- 1990- Reviewed 35 technical papers for *Aerosol Science and Technology*, *American Journal of*  
2017 *Physics*, *Applied Optics*, *Bulletin of the American Meteorological Society*, *Atmospheric Measurement Techniques*, *Journal of Display Technology*, *Journal of Geophysical Research – Atmospheres*, *The Observatory*, *The Physics Teacher*, *Solar Energy*, and *Journal of the Optical Society of America A*.

RAYMOND L. LEE JR., PH.D.  
Object Visibility, Lighting, and Meteorology

- 2009 Reviewed manuscript for Princeton University Press technical/popular book *A Mathematical Nature Walk*.
- 2004 Reviewed manuscript for popular-level MIT Press book *Sky in a Bottle*.
- 2002 Reviewed manuscript for popular-level Cambridge University Press book *Why the Sky is Blue*.
- 2001 Reviewed chapter manuscript for popular-level Penguin book *The Rough Guide to Weather*.
- 1994- Reviewed 5 National Science Foundation technical proposals (EPSCoR, Polar  
2003 Programs, and Physical Meteorology).
- 1996 Reviewed manuscript for AMS's Project Atmosphere book *Hands-on Meteorology*.
- 1995 M. S. thesis advisor/signatory for Michael E. Churma, *The Modeling and Remote Sensing of the Rainbow* (Department of Meteorology, Pennsylvania State University).
- 1985 Reviewed paper on the optics and colorimetry of light scattering by bubbles in water for *Applied Optics*.
- 1984- Reviewed 2 papers on meteorological optics for the *Bulletin of the American  
1985 Meteorological Society*.

**Examples of Subjects Addressed as an Expert Witness**

Driver and Pedestrian Visibility and Reactions

(1) Early one morning a car collided with a truck trailer as the truck backed onto a road. Soon after the collision the truck driver photographed the scene, including the frost-covered windshield of the striking car. Using photometric analysis of these digital images, I calculated how light diffusion by the frosted windshield reduced the car driver's ability to see the trailer lights.

(2) In foggy conditions, a van ran into the side of a school bus that was entering a road. Absent fog, the bus driver could see the van's headlights and the van driver could see the bus' side lights. Using photometric analysis of accident scene photographs, I quantified each driver's ability to detect the other vehicle and thus possibly avoid the accident.

(3) While taxiing, the wingtip of a large airplane struck the tower of a test drilling rig that was operating near the taxiway. I quantified (a) how unswept rain on the cockpit windows affected the airplane operator's visibility and (b) how airplane size, speed, and geometry affected his depth perception of the wingtip and drilling rig.

RAYMOND L. LEE JR., PH.D.  
Object Visibility, Lighting, and Meteorology

(4) A car struck and killed two pedestrians during heavy rain at night. I analyzed how rain reduced the driver's ability to see the pedestrians due to (a) scattering of headlight illumination, (b) blurring of the car's windshield, even with wipers on, and (c) creation of distracting specular reflections from nearby commercial lighting. I also photographed the accident site at night (complete with wetted road) to demonstrate a driver's poor visibility of pedestrians in the roadway, and one of these photographs was shown to the jury during trial.

(5) At night, a van struck and severely injured an elderly pedestrian in a marked crosswalk. Because the crosswalk signal was miswired, pedestrians in the median could not activate the WALK light on the far curb. I used human factors research to determine how long an elderly pedestrian who was familiar with a crosswalk typically would wait at the median before entering this *de facto* uncontrolled intersection.

(6) Late on a clear afternoon, a pickup truck traveling toward the setting sun struck two pedestrians who were walking in the roadway, killing one of them. I showed quantitatively how glare from sunlight scattered by the driver's windshield and within his eyes reduced visibility enough to make the pedestrians undetectable before impact.

(7) On a clear night, a tractor-flatbed trailer combination pulling across a dark roadway was struck by a van whose driver failed to see the trailer's marking lights and retroreflective tape. During a nighttime site visit, I used both photometers and a digital camera to record lighting levels created by exemplar vehicles. By incorporating the digital imaging data into a quantitative visibility model, I showed that lights at an adjacent business could not have caused disability glare for the van driver.

Micrometeorology

(8) A patron entered a warm bakery on a cold day and tripped over a floor fixture, subsequently blaming this on indoor fog created when he opened the bakery door. I examined indoor and outdoor atmospheric conditions and explained quantitatively (a) how much indoor fog would develop in these conditions and (b) how this fog would affect the patron's ability to see the floor fixture.

(9) While driving in darkness on a rural parkway, a driver skidded on glare ice, lost control of his vehicle and crashed (as did others following him). I analyzed the roadway's heat budget and microclimate to show how ice could have formed by melting and refreezing of plowed snow on the road shoulder, countering opposing expert's claim that the glare ice formed from nonexistent "heavy frost."

(10) A customer slipped and fell on glare ice that had formed on the sidewalk at a fast-food restaurant's entrance. I analyzed the potential for ice formation on this sidewalk based on (a) roof drainage from and shading by the restaurant building and (b) nearby weather data on air temperatures and wind speeds. My analysis showed that glare ice could form and persist under these conditions, even though sunlit portions of an adjoining parking lot were ice-free.