Fig. T-1. Mountain Wave Cloud with Cirrocumulus, 29 Nov 2020. Jan Curtis. See video at www.flickr.com/photos/79387036@N07/51715976668.

Fig. P-2. Wonders abound from the ground to the upper atmosphere. The tornado (the severe thunderstorm's umbilical cord) with hints of green, east of Cheyenne, WY 12 Jun 2017, can put the lights out. The Aurora (Fairbanks, AK) turns the lights on in the darkness of polar nights. Jan Curtis.

Wonders of the Atmosphere
Preface
Inspiration, Background, Sources, and People

Writing for Book Started 02 Jun 2024

Why this Book?

Wake the atmosphere from its background, spirit-setting slumber and it may reveal a beauty and power that rivet attention and compel reverence. Displaying and explaining the atmosphere, especially in its roused moods, is our purpose and goal in creating this book.

It is important to do this, not only for aesthetics but to wrench attention away from news on the atmosphere, which focuses almost exclusively on the negative – the havoc and destruction its storms and extremes wreak and the fractious politics of how we either have or haven't altered and polluted it, all while the science remains unambiguous.

By showcasing the atmosphere's beautiful and awe inspiring phenomena, we hope to inspire in you some measure of the lifelong sense of wonder, awe, and reverence we have felt for the natural world and the care we must take as wardens when manipulating it.

Of course, books are static whereas the atmosphere is dynamic. Because of this we have put on the Web and reference photos, videos, animations, Powerpoint Presentations, etc. of others to help make the dynamic atmosphere come alive. Our sites are,

Jan's Site: https://www.flickr.com/photos/cloud_spirit/albums/
Stan's Site: https://stanrenaissanceman.com/

Jan's site hosts thousands of photographs and videos with commentary on each. Stan's site also hosts photos but its emphasis is more academic, including lecture notes, animated simulations, and Stan's book, ***The Soul of All Scenery: A History of the Sky in Art***, briefly summarized in Chapter 15.

Our Inspiration

You might ask what were the initial moments of inspiration that set us on our life paths? We are both children of New York City, where architecture trumps and masks Nature most of the time, so during those rare times when Nature does assert itself it is all the more impressive and stunning.

Jan's first moment of inspiration occurred at the age of five when his mother took him to the roof of their apartment building in Brooklyn, NY to see a double rainbow. At six, on a trip with his father he saw lightning light up the Washington Monument and the Capitol and later, on the Blue Ridge Parkway he saw clouds from above and got overtaken by a thunderstorm on a canoe trip.

Stan's first moment of inspiration occurred at age three while walking chest deep in a snow drift in the back of his apartment building in Far Rockaway, NY from the record-breaking snowstorm of 26 Dec 1947 that dumped 26.4" on New York City in 24 hours. Blizzards, hurricanes, and the atmosphere's and ocean's light and color show have also stood out in Stan's life.

> "The March 1956 double snowstorm that paralyzed New York City for a few days brought me unbounded joy that only a few later snowstorms could match. I waited impatiently for them

all. I did not wait for Hurricane Daisy in 1958; it struck by complete surprise on the return leg of a cruise to Nassau in the Bahamas with my grandfather. The first surprise on that cruise was the gorgeous beach at Paradise Island where the ocean water on a placid, sunny day graded from turquoise to cobalt blue. That was so spectacular, so surprising, so different than the brownish beach waters at Rockaway. Hurricane Daisy had its own colors. Awesome waves that towered 10 m rocked the cruise ship. I was not afraid at all. I was transfixed. The waves, mixed with foam and bubbles had a strange pea green color I had never imagined and have never seen since. What a blessing to have color in a world of storms."

Hurricane Donna, which struck New York City on 12 Sep 1960 sealed our conversions, transforming us to future meteorologists. Stan, living in Bayswater, saw the ocean rise to submerge low-lying sections of the Rockaway Peninsula and meet Jamaica Bay. Jan, walking home in Brooklyn in gusty winds when school closed early that day,

grabbed a stop sign pole when a gust of wind lifted my legs and I was holding on for dear life like a wind-torn flag. I thought the occurrence was much more fun than dangerous.

In time, our awe of the atmosphere's power was wedded to our reverence of its beauty.

Total solar eclipses inspired both of us. Jan's experience came first.

"My first life altering event occurred on 7 March 1970, when I witnessed a total solar eclipse in Greenville, North Carolina with my dad. Until this event, which occurs somewhere on Earth on average every 360 years, few people living had actually seen this spectacle. Despite this phenomena occurring every 18 months somewhere on Earth, less than one percent of the Earth gets to see the perfect alignment of the Moon and Sun. The moment totality began, the PA speakers at the Eastern North Carolina University where I viewed this wonder of nature blared out the opening bars of Richard Strauss's ***Also Sprach Zarathustra*** (the theme of Author C Clark's ***2001: A Space Odyssey***. When I looked up after the blinding Sun was extinguished by the Moon, I felt the way the cave dwellers thousands of generations before me must have felt. My stomach had the feeling of falling in zero-G. Despite having seen countless images of totality, I was completely unprepared by my mind's inability to comprehend logically what I was witnessing. That feeling was both frightening and overwhelming."

It was almost half a century before Stan entered an umbra.

"I very much wanted to see the 07 March 1970 total solar eclipse but to my chagrin was called away to my brother's ill-timed engagement party. Five years later, in 1975, floundering around for a research topic that I would love, I chanced to see a photograph of the total solar eclipse of 15 Feb 1961 near Grenoble, France. All previous eclipse photos I had seen showed only the Sun; this photo showed the sky below the eclipsed Sun with the colors of twilight. I was stunned and thought 'This can't be. Those sky colors belong only to twilight.' That led straight to the next thought. 'I'm teaching Physical Meteorology. I should be able to explain it.' It was the first natural phenomenon I 'mastered' through math. It gave me a great sense of joy and power.

I finally got to experience a total solar eclipse on 21 August 2017, some 12 km above sea level. Joe Rao, a former student, turned professional weathercaster and lifelong eclipse aficianado, arranged seats for me and my wife on Alaska Air's dedicated flight into the eclipse. As we entered the umbra and the Moon's shadow raced eastward, sweeping across the sea surface and the clouds below, everyone on the plane was cheering but I was sorely disappointed. I did not see the vivid twilight colors I had hoped for. Instead, just outside the umbra a dull, orange-brown salmon color tinted the low clouds, a color that, along with the darkness, must have scared the wits

> out of primitive people. I was utterly baffled, perplexed, and sad. The mystery of it all consumed me; the pleasure was delayed until I was able to understand and explain it. The ability to be able to 'explain' in some way the ineffable has always given me great pleasure."

Both of us were beneficiaries of the post-Sputnick glow of Space Science in America. Jan notes that,

> In the summer of 1969 when the Apollo 11 Astronauts landed on the Moon, I was selected to attend a National Science Foundation summer astronomy program for high school seniors at the Hayden Planetarium in New York City. That was one huge factor in my decision to major in meteorology, and I suppose that opportunity set the stage that would eventually reunite me with Professor Stan more than 50 year later to co-author this book with him.

We met at the City College of New York months after the 07 March 1970 eclipse in September 1970. Jan was a freshman, majoring in Meteorology and Stan was starting his first year as Assistant Professor of Meteorology. Stan remained at CCNY, except during sabbatical years, for his entire career. Jan left CCNY for his career in the Navy after graduating in 1974. After retiring from the Navy Jan moved about, always with a view of the sky. Jan began to hone his photographic skills during his six years in Fairbanks, Alaska under the Aurora Borealis. That experience was also transformative.

> "In 2000, during solar maximum, Alaska was the place to be to observe the Northern Lights. I was living in Fairbanks at the time and this is where I experienced my second epochal connection to nature. A major solar storm reached the magnetosphere and produced a display of the aurora that changed the snow cover from green to red with shadows from the surrounding trees dancing all over the ground. Then suddenly in the isolation and quietness of the moment, nearby wolves started to howl at the sky and my skin formed goosebumps that weren't caused by the subzero temperatures.
>
> At that moment, I felt that I was privileged to be a part of nature that most never experience. That was a spiritual experience that completed my journey connecting me to nature. I learned that nature has secrets and though patience and persistence, if one is very attentive, the answers will be revealed."

Patience and persistence, indeed! For decades we had only sporadic contact. Eventually, our paths crossed again. Stan began writing articles for ***Weatherwise Magazine*** and in 1988 Pat Hughes asked Stan to be an Executive Editor. In that position, Stan became a judge in the Weatherwise Annual Photography Contest. Some years later Jan became a contestant and for more than a decade submitted prize-winning photos – in fact, too many to include in the contest.

In 2021 Stan thought it important to tell the story of Jan's inspiration and include more of Jan's photos in the pages of Weatherwise. Together we wrote an article on Jan's story and included some photos. That was an important factor that led to this book.

> "A man's got to know his limitations." Clint Eastwood, ***Magnum Force***.

Stan became a modeler of the atmosphere's optical phenomena and of cloud formations and a photographer of modest skill always looking for a nearby vantage point to see and photograph the sky. Jan, whose career as photographer began at age 10, became a persistent and excellent photographer, travelling and/or moving to greet the atmosphere when and where it puts on its shows. Thus, Jan chose homes in Fairbanks, AK to witness the aurora and on the high Plains around Cheyenne, WY to see thunderstorms and mountain wave clouds clear out to the horizon with a near pristine atmosphere mostly free of pollution and haze (except for wildfires). These choices plus our mutual love of the atmosphere and of the natural world form the basis of this collaboration, decades in the making.

Of course, no person or no two people can be everywhere at the same time or can witness, explore and delve into all things atmospheric. Both of us acknowledge, use, benefit, have learned from, been inspired by, and have collaborated with our kindred spirits. Our debts and gratitude to them are immeasurable. We must and gladly acknowledge them right up front. Their works, which have served as vital references for us, are praised and pointed out below.

The Pioneers

> "Give me a place to stand, and a lever long enough, and I will move the world. " Archimedes.

Because none of the Ancients had such a place to stand their knowledge of the atmosphere was limited to local views. As a result, scientists focused on solving problems that could be 'bottled', such as rainbows. Understanding the rainbow was based on the growing knowledge of optics in the 13th century that convex lenses magnified letters by refracting (bending) light. (This interest, which led to the invention of spectacles by 1290 CE, doubled the productive years of technical and literary workers.) In 1267 CE Roger Bacon, recognized that the rainbow was produced by spherical raindrops, each raindrop acting like a combination of a lens and a mirror. He documented that the primary rainbow appears 42° from a viewer's shadow though he couldn't explain why. Around 1308 CE, the Persian scientist, Kamāl al-Dīn al-Fārisī and the German cleric, Theodoric of Freiburg independently (we think) aimed sunbeams at glass spheres filled with water to simulate large raindrops. Both demonstrated that rainbows are caused when sunbeams suffer refractions upon entering and exiting the sphere plus either one or two reflections inside it.

The next advance in understanding the rainbow took over 300 years. In 1637, Descartes, using the newly discovered law of refraction calculated numerous rays striking all over spherical raindrops and explained mathematically why the primary rainbow appears 42° from the observer's shadow. Applying Descartes' approach to hexagonal ice crystals, Edmund Mariotte in 1676 explained the circular ice crystal halo that appears 22° from the Sun (or Moon).

Isaac Newton added color to these colorless explanations of rainbows and halos. About a century later, in 1801 Thomas Young showed that light consists of waves and used the properties of waves to explain (qualitatively) both supernumerary rainbows, which form as extra pastel-colored bands inside the primary rainbow, and coronas, which form in thin water-droplet clouds around the Sun and Moon.

About the same time, in 1802 and 1803, Jean Baptiste de Monet Lamarck in France and Luke Howard in England developed the first cloud classification and naming systems. A mere 20 years later, in 1823, Siméon Denis Poisson derived the law showing that most clouds form from the cooling due to the expansion of rising air.

Another century plus of discoveries and inventions from the telegraph to the radio, radar, computers, planes, and satellites, gave scientists the tools to see into clouds and out to large scale atmospheric phenomena including storms. The camera, movies, and videos not only recorded beautiful phenomena but added the dimension of time to see how they evolve.

With all the new tools available to study storms, research in atmospheric optics was sidelined for a generation. Knowledge at that time (1937) was summarized in Marcel Minnaert's classic, translated to English as ***The Nature of Light and Color in the Open Air*** (1954). Because of Minnaert's remarkable powers of observation and his profound insight, it still serves as a fundamental reference to anyone interested in atmospheric optics.

The Modern Epoch

During the lull in research on atmospheric optics, knowledge advanced regarding every aspect of clouds – the particles they are made of, how these particles grow, how the clouds evolve and the air

motions in and around them that give them their shapes. In Vermont, Wilson Bentley, fascinated by snow crystals since childhood, learned to capture snow crystals, rush them under a microscope and photograph them before they changed too much. A world away in Japan, Ukichiro Nakaya learned to grow and photograph snow crystals. Both of their books, laden with photographs, are classics.

Wilson Bentley, ***Snow Crystals*** (1931).
Ukichiro Nakaya, ***Snow Crystals: Natural and Artificial*** (1954).

Because Nakaya grew his snow crystals under controlled conditions, he was able to document how crystal shape e. g., (plate, pencil, or star) depends on temperature and humidity. Crystal shapes are important for understanding the various ice crystal halos. Charles Wilson invented the first cloud chamber by 1911, not to discover the value of the electric charge of an electron for which he won the Nobel Prize in Physics in 1927, but because of his fascination with the so-called Brocken Spectre (a glory) and other atmospheric optical phenomena produced by drops and crystals. Later cloud chambers or cloud wind tunnels were designed to investigate cloud particles by suspending them in mid air.

Meteorologists determined many features of clouds by flying through them. Several ice crystal halos were discovered during balloon flights. Alfred Wegener, famous for advancing the theory of continental drift, also added to the knowledge of how rain forms and at least one ice crystal halo arc. In 1938, Joachim Kuettner, an enthusiast of the atmosphere and organizer of large scale atmospheric field projects throughout his life of 101 years, flew a sailplane through mountain wave clouds, (that sometimes resemble and were the initial inspiration and model for flying saucers) and discovered the rotor (which can smash planes into the ground). Richard Scorer, trained in hydrodynamics, developed a theory of the conditions and airflow patterns that produce mountain wave clouds. Scorer also revealed the normally invisible air motions in and around all the cloud genera. This led to his landmark book on almost every aspect of clouds (and optical phenomena), ***Clouds of the World: A Complete Color Encyclopedia*** (1972)

Cloud enthusiasts abound. Gavin Pretor-Pinney, Member 001 and founder of the Cloud Appreciation Society deserves special mention. Author of ***The Cloudspotter's Guide*** (2006), Gavin turned a fascination with Australia's famous Morning Glory cloud into an abiding, active passion. His website

https://cloudappreciationsociety.org/

is a forum where sky lovers the world over view and submit photos of clouds and optical phenomena, and the collection has grown into something immense and eye watering. Even amateur sky observers can be in the right place at the right time to photograph and record some extraordinary sight.

The standard reference for clouds, which contains all the cloud forms and photographs, often accompanied by descriptions of the weather conditions under which they occur is the ***International Cloud Atlas***,

https://cloudatlas.wmo.int/en/home.html

At last, Howard (Cb) Bluestein, who has been photographing clouds as an enthusiast and professional since 1967, has assembled his best photos and insights into clouds in his long-awaited treasure book, ***The Archtecture of Clouds*** (2024).

With the benefit of all the new cloud knowledge and the computer, the next major phase in research and understanding of atmospheric optics, got going shortly before 1970. Somewhat by coincidence, this was also when serious storm chasing began, which led to detailed understanding of the structure of severe and tornadic thunderstorms.

At the dawn of the 1970's, R. A. R. Tricker published his ***Introduction to Meteorological Optics*** (1970), which presents the mathematical side of the field. Tricker revealed the difficulty of finding solutions for the colors, brightness, and even shape of optical phenomena such as rainbows, and halos. These are formidable

problems, some far too difficult and involved to solve analytically. This is where the computer enters the scene for atmospheric optics.

The computer's speed has made it possible to solve otherwise impossibly difficult problems in atmospheric optics by sheer brute force. AI (Artificial Inetlligence) is a recent culmination of computer generated solutions to complex problems.

One classical approach, the Monte Carlo technique (and used as part of AI), shoots random computerized sunbeams at computerized raindrops, cloud droplets, ice crystals, air molecules and aerosol particles and records their path through the atmosphere to an observer. In a way, that is what Descartes did to explain the rainbow. To illustrate the Monte Carlo technique, imagine the Sun as a gun shooting sunbeams at a spherical raindrop, which deflects the beams onto a target (Fig. P-3). After enough beams are shot (2 million in this simulation, which took 10 seconds on a slow PC) a pattern matching a double rainbow emerges. The Monte Carlo and other numerical bludgeoning techniques have now advanced to the point where simulations of atmospheric optical phenomena can appear photorealistic.

In 1966 Robert Greenler (with A. James Mallman) presented preliminary results of the first Monte Carlo simulations of an ice crystal halo phenomenon (a Sun pillar) at a scientific meeting in the Netherlands. This was long before the PC, and given the more primitive computers at that time, black dots were printed on a white background, but it was an impressive accomplishment for the time.

Marcel Minnaert was at that meeting, and he celebrated the presentation as a 'handing over the torch" event. Indeed, over the next decade, Greenler and colleagues produced Monte Carlo computer simulations of many different ice crystal halos, and there are many (see Chapter 11) which he presented in his now classic book, ***Rainbows, Halos and Glories*** (1980). The book is a tour de force, an eye opener at the time of its publication. It is far more than a collection of computer simulations. It also has color photographs of many of the phenomena. Greenler travelled far (from the Arctic Ocean to the South Pole) in search of unusual phenomena, and where others had better photos, he used them. These phenomena he described and explained using his keen observational skill graced by love and enthusiasm but nary an equation. Great progress has been made since the book's publication, in no small part due to the enthusiasm Greenler helped awaken in many.

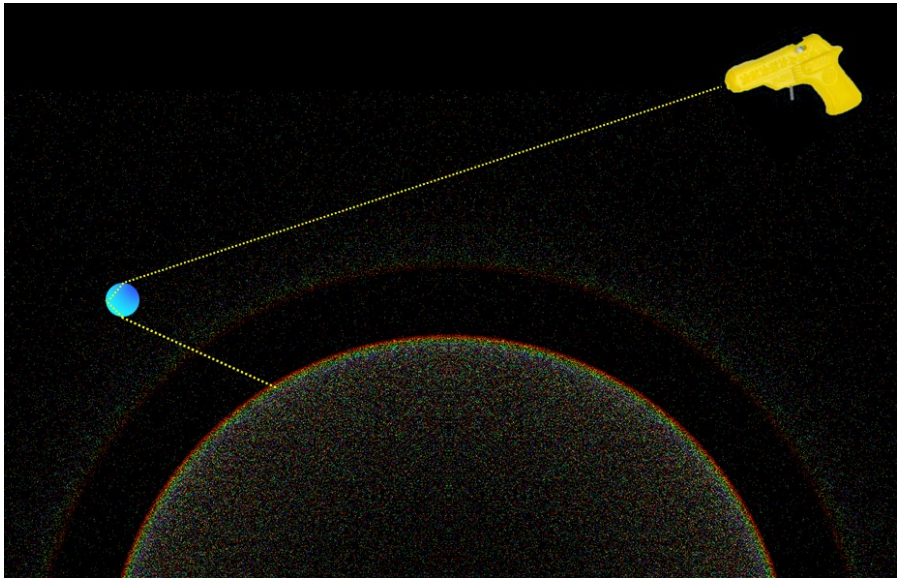

Fig. P-3. Monte Carlo dot map of a double rainbow showing one of 2 million random beams. The faint secondary bow appears outside the primary. SDG.

Greenler's lead and the success of the numerical techniques solved on the computer were important factors in reviving interest in atmospheric optics, but the time was also right. In 1968 Alistair Fraser, who had just finished his Ph. D. thesis under advisor Richard Scorer, began to prosyletize on behalf of the beauty of the atmosphere. His photographs of clouds and of optical phenomena graced the walls at the University of Washington and at the National Center for Atmospheric Research (NCAR) in Boulder, CO where they served as an inspiration to many.

Beginning in 1978, the first of a series of International Meetings on ***Light and Color in Nature*** was held to serve as a forum for

aficionados of atmospheric optics. Stan was lucky to attend many of these meetings and get to know, learn from, and even collaborate with some remarkable people and their work.

Much like storm chasers, optics enthusiasts circle the globe to capture their optical prey. Several of them have written books on various aspects of Atmospheric Optics, most with beautiful photos. The list with brief descriptions includes,

Walter Tape, rigorous in his thinking and meticulous in his photography, wrote the two definitive books on halos, ***Atmospheric Halos***, Antarctic Research Series, Volume 64 (1994) and, with Jarmo Moilanen, ***Atmospheric Halos and the Search for Angle X*** (2006).

David Lynch, a true polymath, with an eye for seeing things almost everyone misses, wrote ***Color and Light in Nature*** (2001) with astronomer William Livingston. Gunther Konnen performed wonders in revealing the subtle aspects of ***Polarized Light in Nature*** (1985).

Claudia Hinz and Wolfgang Hinz worked and lived (much of the time for more than a decade) on a mountaintop meteorological observatory, gathering the most stunning photos and assembling them with descriptions and explanations (unfortunately for many Americans in German) in ***Lichtphäniomene: Farbspiele am Himmel*** (2015).

Fellow counrtyman, Michael Vollmer, a master experimentalist and educator, wrote ***Atmosphärische Optik für Einsteiger: Lichtspiele in der Luft*** (2019), which translates to Atmospheric Optics for Beginners (but not beginners in German). Michaels latest book, ***Optics and Its Phenomena*** will soon be published in English.

Raymond L. Lee, Jr, an art history major turned scientist, collaborated with his mentor and former Ph. D. advisor, Alistair B Fraser, to write ***The Rainbow Bridge: Rainbows in Art, Myth, and Science*** (2001). Both these fine scientists rivet your attention with their bombastic lecture styles.

Craig Bohren, their prolific colleague, wrote, in addition to several technical books, two popular books on simple experiments that bring optics to light, ***Clouds in a Glass of Beer*** (1987) and ***What Light Through Yonder Window Breaks*** (1990).

Joseph Shaw, another master experimentalist and charismatic lecturer turned his plane seats into aerial laboratories in his ***Optics in the Air: Observing Optical Phenomena Through Airplane Windows*** (2017).

Other scientists have put their works on the Web. British Philip Laven seamlessly matched his photographic quality simulations with actual photos of coronas, etc on his website, http://philiplaven.com/. Fellow Brit, Les Cowley for over two decades ran the superb website, now (for the time being at least) at

https://www.atoptics.org.uk/

Frigid Finland has its own network of dedicated observers, active since the 1970's, and a host of unusual optical phenomena (e. g., complex halo displays, superior mirages, noctilucent clouds) to keep them outdoors in the most discomforting weather. Among these dedicated observer-scientist-photographers are

Marko Riikonen https://www.haloblog.net/
https://www.avaruus.fi/uutiset.html
Pekka Parviainen http://www.polarimage.fi/
https://twanight.org/profile/pekka-parviainen/confirmed-photos/

Jan can testify to some of these discomforts, photographing Auroras in temperatures down to -40°C for the love of it and for use by noted aurora scientist, Syun-Ichi Akasofu.

With storm chasing, real danger replaces freezing skin and bones. Storm chasing began as a serious profession and avocation about the same time that optics enthhusiasts began their global jaunts. Joe Golden began his landmark study of waterspouts in September 1967 as the result of a chance encounter with a line of waterspouts during a flight in a private plane to Key West, FL. That experience led him

to chasing, or more often hunting tornadoes, which in the early years proved elusive because so little was known about them and because meteorological data was inadequate and not timely.

Finally, tornado hunting hit paydirt. The massive Union City, OK Tornado of 24 May 1973, was a seminal event because it came within range of the National Severe Storms Doppler Radar system so that the storm, with all its warning signs, could be seen into through its life. That tornado proved the value of storm chasing and doppler radar for identifying developing tornadoes.

Other professional meteorologists formed the club of early Storm Chasers including Al Moller, Chuck Doswell III, whose website is laden with photos of severe storms and more,

https://www.flame.org/~cdoswell/

A few years later, Howard Bluestein, who was 4 years old when the 09 June 1953 Worcester, MA tornado struck his home town to create a lifelong memory and inspiration, began his eminent career in meteorology and severe storms. Howie's book, ***Tornado Alley: Monster Storms of the Great Plains*** (1999) and video,

https://www.youtube.com/watch?v=hyEqVrHfHUQ

cover much of tornado science and chasing.

Tom Grazulis, who has been sleuthing tornadoes for decades penned his book, ***The Tornado: Nature's Ultimate Windstorm*** (2001)

These pioneers are among the leaders in the effort to piece together a comprehensive picture of supercell storms and their attendant features such as hail, downbursts, and tornadoes, and all photographers extraordinaire, who have an uncanny instinct for being in the right place at the right time to see exceptional events.

The film, ***Twister*** (1996), inspired by the storm chasers and by Howie Bluestein's TOTO device to measure conditions inside tornadoes, unleashed the floodgates of storm chasing. Now, there are countless videos of severe storms with sometimes uncomfortable near collisions with tornadoes (or other storm chasers). Among the videos about severe thunderstorms storms and more on YouTube, those by Pecos Hank stand out. And a fine video on the history of storm chasing (with appropriate warnings has been put on the Web by Jacob Swegle

https://www.youtube.com/watch?v=uRQ-nTTCazo

Let's not forget hurricanes, described and explained by Kerry Emanuel in his book, ***Divine Wind: The History and Science of Hurricanes*** (2005)! Other professional meteorologists, many from NOAA's Hurricane Research Division, became hurricane hunters, flying into the heart and through the eye of these fearsome storms to document their structure, evolution, and awesome beauty. (Stan was lucky to join them into three hurricanes.) Information about the decades of flights into hurricanes, including photos of cosmic-feeling scale appear on the website,

https://www.aoml.noaa.gov/data-products/#hurricanedata

All these adventurers, motivated by the love of the power and beauty of the atmosphere, are heroes of sorts, and must be recognized for their dedication and persistence, involving themselves in discomfort and even danger to witness and record nature at her most spectacular.

We have been lucky and grateful to have joined in some of these adventures and to have had many of the abovementioned adventurers as colleagues and friends. Others too deserve more than the brief mentions we give them here in enriching our lives.

For Stan: Mentors and professors Harold Stolov, Victor Starr, Jule Charney, Norman Phillips, Edward Lorenz, plus many others: Long-time friends, colleagues and collaborators William Donn, Al Ehrlich, Jerome Spar, Willard Pierson, Zev Levin, Shermane Austin, George Siscoe, Nambath Balachandran, James White, Dan Smiley, Steven Richards, Tony Gordon, Mary Brady, and especially Edward

Hindman, and James Lawrence: In atmospheric optics, Alistair Fraser, David Lynch, James Lock, Michael Vollmer, Javier Hernandez Andres, Jari Pikii, and Robert Greenler: in hurricanes, Robert Burpee, Hugh Willoughby, Frank Marks, Michael Black, Peter Dodge, Jason Dunion and, John Gamache: At Weatherwise Magazine, Patrick Hughes, Jeffrey Rosenfeld, Kimbra Cutlip, Doyle Rice, Margaret Benner, and Robert Ryan: Student collaborators turned colleagues, Robert Rilling, Jeffrey Rosenbaum, Robert Arnold, Xiaoping Zhang, Elaine Lewis, and Kwan-yin Kong.

For Jan: Gerd Wendler, Carlyle Wash, Tony Bergintino, Nolan Doesken, Chris Daly, Don Day, Michael Hayes, Phil Pasteris, and Syun-Ichi Akasofu.

With all that as background…

Let's get going.

Beta Version put on Web 19 Sep 2025