

History of the Weather Service

- 1805: The Beaufort scale of force was devised by Francis Beaufort (later Rear Admiral Sir Francis Beaufort), an Irish Royal Navy officer, while serving in HMS *Woolwich*. The scale that carries Beaufort's name had a long and complex evolution from the previous work of others (including Daniel Defoe the century before) to when Beaufort was a top administrator in the Royal Navy in the 1830s when it was adopted officially and first used during the voyage of HMS *Beagle* under Captain Robert Fitzroy later to set up the first Meteorological Office (Met Office) in Britain giving regular weather forecasts. In the early 19th century, naval officers made regular weather observations, but there was no standard scale and so they could be very subjective – one man's "stiff breeze" might be another's "soft breeze". Beaufort succeeded in standardizing the scale. The initial scale of thirteen classes (zero to twelve) did not reference wind speed numbers but related qualitative wind conditions to effects on the sails of a frigate, then the main ship of the Royal Navy, from "just sufficient to give steerage" to "that which no canvas sails could withstand".
- 1849: Smithsonian Institution supplies weather instruments to telegraph companies and establishes extensive observation network. Observations submitted by telegraph to the Smithsonian, where weather maps are created.

By the end of 1849, 150 volunteers throughout the United States were reporting weather observations to the Smithsonian regularly. By 1860, 500 stations were furnishing daily telegraphic weather reports to the Washington Evening Star, and as the network grew, other existing systems were gradually absorbed, including several state weather services.

- 1860: 500 stations are making regular observations, but work is interrupted by the Civil War.
- 1869: Telegraph service, instituted in Cincinnati, began collecting weather data and producing weather charts.

The ability to observe and display simultaneously observed weather data, through the use of the telegraph, quickly led to initial efforts toward the next logical advancement, the forecasting of weather. However, the ability to observe and forecast weather over much of the country, required considerable structure and organization, which could be provided through a government agency.

- 1870: A Joint Congressional Resolution requiring the Secretary of War "to provide for taking meteorological observations at the military stations in the interior of the continent, and at other points in the States and Territories...and for giving notice on the northern lakes and on the seacoast, by magnetic telegraph and marine signals, of the approach and force of storms" was introduced. Congress passed the resolution and on February 9, 1870, President Ulysses S. Grant signed it into law.

A new national weather service had been born within the U.S. Army Signal Service's Division of Telegrams and Reports for the Benefit of Commerce that would affect the daily lives of most of the citizens of the United States through its forecasts and warnings for years to come.

- 1870-1880: Gen. Albert J. Myer serves as chief signal officer, directing the new weather service.
- 1880: Upon the death of Gen. Myer, Gen. William Babcock Hazen takes over as chief signal officer. He serves until his death in 1887.
- 1887: Upon the death of Gen. Hazen, Maj. Gen. Adolphus Greely takes over as chief signal officer. He serves until his death in 1891.

Heinrich Hertz discovers Photoelectric Effect

- May 30, 1889: An earthen dam breaks near Johnstown, Pennsylvania. The flood kills 2,209 people and wrecks 1,880 homes and businesses.
- October 1, 1890: The weather service is first identified as a civilian agency when Congress, at the request of President Benjamin Harrison, passes an act transferring the meteorological responsibilities of the Signal Service to the newly-created U.S. Weather Bureau in the Department of Agriculture.

A weather-sensitive sports event of that year: 15th running of the Kentucky Derby.

- 1891: The secretary of agriculture directs R.G. Dyrenforth to carry out rain-making experiments by setting off explosions from balloons in the air.

Weather Bureau becomes responsible for issuing flood warnings to the public; Telegraphic reports of stages of rivers were made at 26 places on the Mississippi and its tributaries, the Savannah and Potomac Rivers.

Professor Mark W. Harrington becomes the first chief of the Weather Bureau. He serves until 1895.

- 1894: William Eddy, using five kites to loft a self-recording thermometer, makes first observations of temperatures aloft.

Alexander Popov develops first RF receiver for lightning detection

- 1895: Secretary of Agriculture J. Sterling Morton appoints Professor Willis Luther Moore chief of the Weather Bureau. Moore served until his resignation in 1913.

- 1898: President William McKinley orders the Weather Bureau to establish a hurricane warning network in the West Indies.
- 1900: Cable exchange of weather warnings and other weather information begins with Europe.

September, 1900: A devastating hurricane strikes Galveston, Texas, killing more than 6,000 people. The wife of the Galveston Official-in-Charge Isaac Cline and one Weather Bureau employee and his wife are killed in the associated flooding. The Weather Bureau forecasts the storm four days earlier, but not the high tide.

- 1901: Official three-day forecasts begin for the North Atlantic.

At the Weather Bureau Conference in Milwaukee, Wis., Chief Willis Moore observed the Post Office Department was delivering slips of paper with daily forecasts, frost and cold-wave warnings, to everyone's door with the mail. The one disadvantage to the system was the mail carriers started their routes about 7:00 a.m. and that day's forecast was not issued until 10:00 a.m., so the previous night's forecasts were used.

- 1902: The Marconi Company begins broadcasting Weather Bureau forecasts by wireless telegraphy to Cunard Line steamers.

The Weather Bureau begins collecting flood damage statistics nationally.

- 1903: Weather sensitive historic events: United States and Panama sign the Canal Treaty; the first automobile trip across the United States is completed from San Francisco to New York City; The Wright brothers make first powered airplane flight at Kill Devil Hill, N.C., after consultation with the Weather Bureau several years earlier for a suitable location to conduct their experiments.
- 1904: The government begins using airplanes to conduct upper air atmospheric research.
- 1905: The SS New York transmits the first wireless weather report received on ship at sea.

Albert Einstein publishes Photoelectric Effect paper resulting in Nobel Prize 1921

- 1907: Weather sensitive historic event: Round-the-world cruise of U.S. "Great White Fleet" including 16 battleships and 12,000 men.
- 1908: Kristian Birkeland predicts atmospheric current that ultimately carries his name

- 1909: The Weather Bureau begins its program of free-rising balloon observations.

Vilhelm Bjerknes publishes Fields of Force (Bjerknes Theorem of Rotation), fluid dynamics coupled with electrodynamics

- 1910: Weather Bureau begins issuing generalized weekly forecasts for agricultural planning; its River and Flood Division begins assessment of water available each season for irrigating the West.
- 1911: The first transcontinental airplane flight, from New York City to Pasadena, Calif., by C.P. Rogers, in 87 hours and 4 minutes, air time, over a period of 18 days.
- 1912: As a result of the Titanic disaster, an international ice patrol is established, conducted by the Coast Guard; first fire weather forecast issued.
- 1913: Professor Charles F. Marvin serves as the new chief of the Weather Bureau, replacing Professor Moore. Marvin serves until his retirement in 1934.
- 1914: An aerological section is established within the Weather Bureau to meet growing needs of aviation; first daily radiotelegraphy broadcast of agricultural forecasts by the University of North Dakota.
- 1916: A Fire Weather Service is established, with all district forecast centers authorized to issue fire weather forecasts.

The Weather Bureau's fire district forecast center started at Medford, Oregon.

Einstein's Theory of Relativity is proven in solar eclipse

Kristian Birkeland dies

- 1917: Norwegian meteorologists begin experimenting with air mass analysis techniques which will revolutionize the practice of meteorology.
- 1918: The Weather Bureau begins issuing bulletins and forecasts for domestic military flights and for new air mail routes.
- 1919: Navy Aerological Service established on a permanent basis.

First Transatlantic flight by U.S. Navy sea plane, with stops in Newfoundland, Azores and Lisbon.

- 1920: Meteorologists form a professional organization, the American Meteorological Society, which is still active today.

Global Electric Circuit is proposed by C.T.R. Wilson

- 1921: The University of Wisconsin makes a radiotelephone broadcast of weather forecasts, the first successful use of the new medium for weather advisories.
- 1922: Histories of 500 river stations completed.
- 1925: Bose–Einstein condensate (BEC) predicted as a state of matter of a dilute gas of bosons cooled to temperatures very close to absolute zero, a large fraction of bosons occupy the lowest quantum state, at which point macroscopic quantum phenomena become apparent with particles acting as a collective instead of individual components
- 1926: The Air Commerce Act directs the Weather Bureau to provide for weather services to civilian aviation; fire weather service formally inaugurated when Congress provides funds for seven fire weather districts.
- 1927: The Weather Bureau establishes a West Coast prototype for an Airways Meteorological Service.

Charles Lindbergh flies alone from Long Island, non-stop, to Paris. The 3,610 mile trip is completed in 33.5 hours. As on his earlier transcontinental flight, he consulted the Weather Bureau in planning this flight. However, Lindbergh didn't wait for the final confirmation of good weather over the Atlantic. When Weather Bureau officials in New York heard that Lindbergh had left, they expressed surprise because the forecasts indicated that the flight should have been delayed by at least 12 hours. Indeed, Lindbergh ran into problems with fog and rain — as the Weather Bureau had predicted.

- 1928: The teletype replaces telegraph and telephone service as the primary method for communicating weather information.
- 1931: The Weather Bureau begins regular 5:00 a.m. EST aircraft observations at Chicago, Cleveland, Dallas and Omaha, at altitudes reaching 16,000 feet. This program spells the demise of "kite stations."
- 1933: A science advisory group apprizes President Franklin D. Roosevelt that the work of the volunteer Cooperative Observer Program is one of the most extraordinary services ever developed, netting the public more benefits per dollar expended than any other government service in the world. By 2010 the network encompasses more than 11,000 stations.

- 1934: Dr. Willis L. Gregg is named chief of the Weather Bureau, replacing Professor Marvin. He served as chief until his death in 1938.

The Weather Bureau establishes an Air Mass Analysis Section; 1934-37 "Dust Bowl" drought in southern plains causes severe economic damage.

- 1935: A hurricane warning service is established.

The Smithsonian Institution begins making long-range weather forecasts based on solar cycles; floating automatic weather instruments mounted on buoys begin collecting marine weather data.

- 1936: The Hoover Dam is completed, a weather sensitive engineering feat.
- 1937: First official Weather Bureau radio meteorograph, or radiosonde sounding made at East Boston, Mass. This program spells the end for aircraft soundings since balloons average only 50,000 feet altitude. Twelve pilots die flying weather missions.

January flood on the Ohio River is the greatest ever experienced, with Ohio River levels exceeding all previous. Cincinnati's 80 foot crest and Louisville's 81.4 foot crest have never been exceeded. Seventy percent of Louisville under water, 175,000 of its residents flee their homes; the entire city of Paducah, Kentucky, (population 40,000) is evacuated.

Neugebauer proposes Quantum Theory of Ball Lightning

Hannes Alfvén argues Plasma provides capability of carrying atmospheric electric currents

- 1938: President Franklin D. Roosevelt appoints Dr. Francis W. Reichelderfer chief of the Weather Bureau. He served as head of the nation's weather service for a quarter century — longer than anyone before or since — until his retirement in 1963.
- 1939: The Weather Bureau initiates automatic telephone weather service in New York City; radio meteorographs, or radiosondes, replace all military and Weather Bureau aircraft observations.
- 1940: The Weather Bureau is transferred to the Department of Commerce.

Both the Army and Navy establish weather centers.

President Roosevelt orders Coast Guard to man ocean weather stations.

- 1941: Dr. Helmut Landsberg, the "Father of Climatology," writes the first edition of his elementary textbook entitled, Physical Climatology.

Two women are listed among the ranks of observers and forecasters in the Weather Bureau.

- 1942: A Central Analysis Center, forerunner of the National Meteorological Center, is created to prepare and distribute master analyses of upper atmosphere; Joint Chiefs of Staff establish a Joint Meteorological Committee to coordinate wartime civilian and military weather activities.

The Navy gives the Weather Bureau 25 surplus aircraft radars to be modified for ground meteorological use, marking the start of a weather radar system in the U.S. Navy aerologists play key role as U.S. carrier-based Navy planes decimate Japanese fleet in mid-Pacific Battle of Midway Island in early June 1942, turning point in World War II.

A cooperative thunderstorm research effort is undertaken by the Weather Bureau, military services, and the University of Chicago.

- 1944: The decision to invade Normandy on June 6 was based on weather forecasts, which indicated the correct combination of tides and winds.
- 1945: More than 900 women are employed by the Weather Bureau as observers and forecasters, as a result of filling positions of men during World War II.
- 1946: The U.S. Weather Bureau selects Cincinnati, Ohio and Kansas City as locations for the nation's first hydrologist-staffed River Forecast Center. Eventually, 13 RFCs would be established to serve the United States.

Beaufort scale is extended to account for hurricanes, still in use in Pacific basin

- 1947: H.L. Jones establishes Sferics Detection Network in Oklahoma, Adcock, F., and E. Clarke publish The location of thunderstorms by radio direction finding
- 1948: USAF Air Weather Service meteorologists issue first tornado warnings from Tinker Air Force Base.

Princeton's Institute for Advanced Studies begins research into use of a computer for weather forecasting.

Dr. Richard Feynman co-authors Quantum Electro Dynamic (QED) theory of nature, the most successful theory ever developed by man.

Chicago Weather Bureau office demonstrates use of facsimile for map transmission.

Truck-mounted campers first used as mobile forecast stations in major forest fires.

- 1950: The Weather Bureau begins issuing 30-day weather outlooks; authorizes release of "tornado alerts" to the public.
- 1951: The Severe Weather Warning Center — forerunner of the National Severe Storms Center — begins operation at Tinker Air Force Base, in Oklahoma.

World Meteorological Organization established by the U.N. Bureau Chief Riechelderfer elected its first head; Bureau's New Orleans data tabulation unit moves to Asheville, N.C., to become the National Weather Records Center and later the National Climatic Data Center.

Jones, H.L., 1951: A spheric method of tornado identification and tracking, *Bull. Amer. Meteor. Soc.*, 32, 380-385.

- 1952: The Weather Bureau organizes Severe Local Storms forecasting Unit in Washington, D.C., and begins issuing tornado forecasts.

Jones, H.L., and P.N. Hess, 1952: Identification of tornadoes by observation of waveform atmospherics, *Proc. I.R.E.*, 40, 1049-1052.

- 1954: The Weather Bureau, Navy, Air Force, MIT's Institute for Advanced Study, and the University of Chicago form a Joint Numerical Weather Prediction Unit in Suitland, Maryland. This will become a twice daily routine in 1955, using an IBM 701.

The first radar specifically designed for meteorological use, the AN/CPS-9, is unveiled by the Air Weather Service, USAF.

E. M. WILKINS publishes *The Role of Electrical Phenomena Associated with Tornadoes*

- 1955: Hurricane Diane floods the Northeast resulting in 187 deaths.

Regularly-scheduled operational computer forecasts begun by the Joint Numerical Forecast Unit. The Weather Bureau becomes a pioneer civilian user of computers along with the Census Bureau in Commerce; Bureau begins development of Barotropic model, a first for numerical predictions.

H.L. Jones publishes Research on Tornado Identification

Storm Electricity Aspects of the Blackwell/Udall Storm of 25 May 1955 recorded by Montgomery and Jones

"Possible mechanism for the formation of thunderstorm electricity", B. Vonnegut, Geophys. Res. Paper No. 42, Proc. Conf. Atmos. Electr., AFCRC-TR-55-222, pp 169-181.

- 1956: The Bureau initiates a National Hurricane Research Project.

R. Gunn publishes Electric field intensity at the ground under active thunderstorms and tornadoes.

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- 1957-58: The International Geophysical year provides first concerted world wide sharing of meteorological research data.

Weather Bureau Chief Dr. Francis Reichelderfer accepts a proposal by Dr. James Brantly of Cornell Aeronautical Laboratories to modify surplus Navy Doppler radars for severe storms observation--the first endeavor to measure motion of precipitation particles by radar.

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Nobel Laureate C. T. R Wilson observes transient luminous event above thunderclouds

"Preliminary investigation of the distribution of space charge in the lower atmosphere" (1957), B. Vonnegut, C. B. Moore and M. Blume, *Artificial Stimulation of Rain*, Pergamon Press (London), pp 131-141.

- 1958: Weather-related scientific event: Explorer I is launched into space by an Army Redstone Rocket from Cape Canaveral. This satellite discovers the Van Allen Radiation Belts.

The National Meteorological Center is established; the first commercial jet passenger flight from New York to Miami by National Airlines.

"Results of an experiment to determine initial precedence of organized electrification and precipitation in thunderstorms" (1958), C. B. Moore, B. Vonnegut, and A. T. Botka, *Recent Advances in Atmospheric Electricity*, Pergamon Press (London), pp 33-360.

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- 1959: Major weather-related scientific event: The Army launches Vanguard II from Cape Canaveral, carrying two photocell units to measure sunlight reflected from clouds, demonstrating feasibility of a weather satellite.

The Weather Bureau's first WSR-57 weather surveillance radar is commissioned at the Miami Hurricane Forecast Center.

The Naval Aerological Service becomes the Naval Weather Service.

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The Thomas Jefferson and John Campanius Holm awards are created by the Weather Bureau to honor volunteer observers for unusual and outstanding accomplishments in the field of meteorological observations. Both awards still exist today.

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- 1960: The world's first weather satellite, the polar-orbiting TIROS I, successfully launches from the Air Force Missile Test Center at Cape Canaveral, Fla., on April 1. This was followed by the launch of TIROS II on November 11. The Weather Bureau and NASA invite scientists from 21 nations to participate in the analysis of weather data gathered by TIROS II. In cooperation with the Department of Health, Education and Welfare, Weather Bureau meteorologists issue first advisories on air pollution potential over the eastern United States.

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- 1961: President Kennedy, in his State of the Union address, invites all nations to join the United States in developing an International Weather Prediction Program.

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The Weather Bureau assumes full responsibility for severe weather forecasting, establishing the National Severe Storms Center in Kansas City; special training begins for Federal Aviation Authority employees to equip them to brief pilots as part of a joint FAA-Bureau program; to USAF Air Weather Service issues first official forecast of clear air turbulence; scientists from 27 countries attend NASA Weather Bureau sponsored international workshop on technique to interpret weather satellite data.

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- 1963: Dr. Robert M. White succeeds Dr. Reichelderfer as chief of the Weather Bureau. He serves in this position until 1965, when he becomes the head of the newly-formed Environmental Science Services Administration, or ESSA, the forerunner of NOAA.

The polar-orbiting weather satellite TIROS III is launched with automatic picture transmission capability, eventually to provide continuous cloud images to over 100 nations.

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- 1964: The secretary of commerce establishes the office for the Federal Coordinator for Meteorology.

The National Severe Storms Laboratory is established in Norman, Oklahoma.

The American Meteorological Society writes to the Taiwanese Ambassador to the U.S., deploring treatment accorded Mr. Kenneth T.C. Cheng, head of the Taiwan Weather Service, who had been indicted for an incorrect typhoon forecast. The AMS points out that if forecasters were indicted for an incorrect forecast there could soon be a total lack of forecasters. (Minutes of the AMS Council, October 3-4, 1964).

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The electric field of a New Mexico dust devil

W. D. Crozier

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Abstract

On August 21, 1962, a continuously recording inverted field mill, installed on an open semidesert area near the NMIMT campus, recorded the passage of a fairly large dust devil at a time when I was present to make visual observations. Its closest approach to the field mill was about 450 m, established by reference to power line poles and roads. The bulk of the visible dust cloud was contained roughly in a vertical cylinder estimated to have a diameter of 20 m and a height of 120 m. Experience acquired in observation of many other dust devils suggests that the vortex must have extended far above the height of 120 m; in this case the part above this height was not visible against the mountain background and the dust density in it was probably relatively low.

- 1965: The Environmental Science Services Administration, or ESSA, is created in the Department of Commerce, incorporating the Weather Bureau and several other agencies; Weather Bureau Chief Dr. Robert White is appointed as its first administrator.

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Dr. George Cressman is named chief of the Weather Bureau and becomes the first director of the National Weather Service, when the agency is renamed in 1970. He serves until his retirement in 1979.

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Luminescence in supersonic swirling flows

Z. Lavan and A. A. Fejer

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Abstract A luminescent region was observed near the axis of a cylindrical duct confining a supersonic swirling air flow at ambient temperature. The luminescence was identified as a glow discharge induced by a strong internal electric field, which was produced by condensed water droplets impinging on the duct wall.

- 1966: Weather officials from 25 nations meet in London for the First International Clean Air Congress.

The National Meteorological Center introduces a computer numerical model capable of making sea level predictions as accurate as those made manually.

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Tornado Detection by Pulsed Doppler Radar Rodger A. Brown, Leslie R. Lemon, and Donald W. Burgess, NSSL Norman Oklahoma 73069

Manuscript received 9 September 1977, in final form 17 October 1977

Abstract, Doppler radar measurements in the Union City, Okla. tornadic storm of 24 May 1973 led to discovery of a unique tornado vortex signature (TVS) in the field of mean Doppler velocity data. The distinct character of this signature and its association with the tornado are verified using a model that simulates Doppler velocity measurements through a tornado. Temporal and spatial variations of the TVS reveal previously unknown tornado characteristics. The TVS originates at storm mid—levels within a parent mesocyclone, descends to the ground with the tornado (extending vertically at least 10 km), and finally dissipates at all heights when the tornado dissipates. NSSL Doppler radar data from 1973 through 1976 reveal 10 signatures; eight were associated with tornadoes or funnel clouds, while no reports are available for the other two. Since the TVS first appears aloft tens of minutes before tornado touchdown, the signature has decided potential for real-time warning.

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A Nested Grid Model (NGM) becomes operational; a Global Data Assimilation System (GDAS) developed.

AFOS Computer system deployed, connecting all Weather Service forecast offices. AFOS is the most ambitious computer network created at the time, setting records for volume of data and number of entry points while supporting full range of word processing and other capabilities.

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- 1980: Mt. St. Helens, a dormant volcano in Washington state, erupts; weather satellites spot eruption and alert FAA.

"Dean of the Cooperative Weather Observers," Mr. Edward H. Stoll of Elwood, Nebraska, is honored at the nation's Capitol and meets President Jimmy Carter at the White House. Mr. Stoll had faithfully served as a Cooperative Observer since October 10, 1905.

Various "hot weather topics" become of general public concern, such as the El Niño/Southern Oscillation as a factor in U.S. weather, and global warming.

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Lightning source locations from VHF radiation data for a flash at Kennedy Space Center, PL Rustan, MA Uman, DG Childers, WH Beasley, CL Lennon
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Bendix Corporation develops computer algorithms for tornado detection by sferics on micro-processor

- 1981: Weather-related science event: World's first reusable space shuttle, Columbia, is launched, completing its mission three days later.

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Massachusetts Institute of Technology, ROGER M. LHERMITTE Rosenstie
School of Marine and Atmospheric Science University of Miami, Radar Tests of
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- 1984: The National Weather Service provides special forecast for the Olympic Games in Los Angeles.

Weather-related event: First successful solo balloon crossing of the Atlantic by pilot Joe Kittinger, 83 hours and 45 minutes.

September 11-13: The first official Air Transportable Mobile Unit (ATMU) dispatches to the Shasta-Trinity National Forest wildfire. The ATMU is dispatched by plane from Redding, California while the forecaster is flying from Sacramento, Calif. These mobile fire units are deployed nationwide in 1987. ATMUs permit NWS forecasters to set up remote observing and forecasting offices anywhere in the world within hours of a request for on-site fire weather support.

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Lightning induced voltages on power lines: Experiment, MJ Master, M Uman
Power Apparatus and Systems, IEEE Transactions on, 2502-2518

- 1985: Harvard's Blue Hill Observatory celebrates 100 years of continuous monitoring of the atmosphere.

President Ronald Reagan awards Dr. Helmet Landsberg the National Medal of Science, the most prestigious service award a civilian can receive.

"Mesoscale observations of lightning from space shuttle" (1985), B. Vonnegut, O. H. Vaughan, Jr., M. Brook, and P. Krehbiel, Bull. Amer. Meteor. Soc. 66, 1, pp 20-29.

"Nighttime observations of thunderstorm electrical activity from a high altitude airplane" (1985), M. Brook, C. Rhodes, O. H. Vaughan, Jr., R. E. Orville, and B. Vonnegut, J. Geophys. Res. 90, D4, pp 6111-6120.

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Electromagnetic Tornadoes in Earth's Ionosphere and Magnetosphere
Tom Chang, G. B. Crew, J. M. Retterer

- 1987-88 major drought experienced by nation's midsection, with some of lowest river levels in 50 years observed on the Mississippi.

Dr. Richard Hallgren retires as NWS director to become executive director of the American Meteorological Society.

Dr. Elbert W. "Joe" Friday, Jr. becomes director of the National Weather Service. He serves until 1997.

MacGorman, D. R., and W. D. Rust, An evaluation of the LLP and LPATS lightning ground strike mapping systems, *Proceedings of the 8th International Conference on Atmospheric Electricity, Inst. Of High Voltage Res., Uppsala, Sweden,*

- 1989: U.S. assists clean-up efforts following San Francisco Earthquake with mobile forecast unit.

Miami Hurricane Center plays central role in limiting loss of life from gigantic Hurricane Hugo which causes \$7 billion damage.

Eight year national plan for the modernization and restructuring of the National Weather Service is announced. The massive \$4.5 billion overhaul of the agency from will last a decade and change the way the agency operates, resulting in improved capabilities to protect lives and livelihoods. To modernize its operations, the NWS developed and implemented five major technologies:

- Automated Surface Observing System, or ASOS, which replaced manual weather observations
- Next Generation Weather Radar, or NEXRAD, a network of advanced Doppler radars that contributed to increased lead times in predicting severe weather events, such as tornadoes, hail, and flash floods

- A new series of satellites that provided improved, all-weather data for longer-term forecasting
- Advanced computer systems that increased the computing power to support National Centers tenfold
- Advanced Weather Interactive Processing System, or AWIPS, which allowed communication among forecast offices and distribution of centrally collected data as well as offered field forecasters access to the data provided by the other new technologies

Williams, E. R. and Geotis, S. G. and Bhattacharya, A. B.,: A Radar Study of the Plasma and Geometry of Lightning, *Journal of the Atmospheric Sciences*, Vol. 46, No. 9

Accidental discovery of Sprites resulting from low light level video technology

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“Comment on ‘The Electrification of Thunderstorms’” (1989), Bernard Vonnegut and Charles B. Moore, *Scientific American* 261, 1, p 8.

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"Nocturnal Photographs Taken from a U-2 Airplane Looking Down on Tops of Clouds Illuminated by Lightning" (1989), B. Vonnegut, O. H. Vaughan, Jr., and M. Brook, *Bull. Amer. Meteor. Soc.* 70, 10, pp 1263-1271.

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Methods for calculating the electromagnetic fields from a known source distribution: Application to lightning, M Rubinstein, M Uman
Electromagnetic Compatibility, IEEE Transactions on 31 (2), 183-189

Galileo launched on October 18, 1989 with Plasma Wave Subsystem (PWS)
An electric dipole antenna was used to study the electric fields of plasmas, while two search coil magnetic antennas studied the magnetic fields. The electric dipole antenna was mounted at the tip of the magnetometer boom. The search coil magnetic antennas were mounted on the high-gain antenna feed. Nearly simultaneous measurements of the electric and magnetic field spectrum allowed electrostatic waves to be distinguished from electromagnetic waves.

- 1990: The National Meteorological Center procures and installs a supercomputer, the Cray Y-MP8, to run higher resolution and more sophisticated numerical weather production models.

The National Weather Service exercises the contract option for full scale production with the Unisys Corporation for production of 165 Next General Radar (NEXRAD) units and more than 300 display subsystems. The explosive growth of technology led to the development of NEXRAD, a joint project of the Departments of Commerce, Transportation and Defense to meet their common radar needs.

- 1991: Automated Surface Observing System contract, a key element in NOAA's modernization of its NWS, awarded to AAI Corporation of Hunt Valley, Md., on February 19.

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"How the External Currents Flowing to a Thundercloud Influence Its Electrification" (1991), B. Vonnegut, *Ann. Geophysicae* 9, pp 34-36.

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"Problems for research in atmospheric electricity" (1991), B. Vonnegut, *Publ. Inst. Geophys. Pol. Acad. Sc.*, D-35, 238, pp 13-16.

MacGorman, D.R., and K.E. Nielsen, 1991: Cloud-to-ground lightning in a tornadic storm on 8 May 1986, *Mon. Wea. Rev.*, 119, 1557-1574.

- 1992: Twenty-two of the planned 115 modernized Weather Forecast Offices (WFO) were built or remodeled during the year, with 12 NWS radars installed. Of a programmed 1,700 ASOS units, 151 were installed and 13 commissioned.

Hurricane Iniki struck the Hawaiian island of Kauai killing seven and Hurricane Andrew devastates Florida and Louisiana.

"Lightning induced brightening in the airglow layer" (1992), W. L. Boeck, O. H. Vaughan, Jr., R. Blakeslee, B. Vonnegut, and M. Brook, *Geophys. Res. Lett.* 19, 2, pp 99-102.

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"Processes causing electrification of ice crystals in thunderclouds" (1992), B. Vonnegut and C. B. Moore, *Atmos. Res.* 28, pp 185-186.

- 1993: "Year of Water" — record floods inundate the Midwest; the National Weather Service earns the U.S. Commerce Department's highest award, a gold medal, for performance during the flooding.

Advanced Weather Interactive Processing System (AWIPS) contract awarded to PRC, Inc., of McLean, Va. AWIPS will rapidly analyze weather data and distribute it nationwide.

The 100th new Doppler weather radar is installed.

The blizzard of '93 deposited enough precipitation in one weekend to drastically change the spring hydrologic outlook.

An international training facility was dedicated at the National Meteorological Center.

Two scientists develop a new method of processing atmospheric data needed for global forecasting and five meteorologists from Alaska design a state-of-the-art computer network used to improve forecasting capabilities in Alaska.

Hayakawa, M., Ionospheric and magnetospheric VLF/ELF radio noises at lower latitudes, *Review, J. Atmos. Electr.*, 13, 65-93

Jonsson, H. H., and Vonnegut, B., Miniature vortices produced by electrical corona. *Journal of Geophysical Research*, Vol. 98, Issue D3, 5245-7126.

Church, C., D. Burgess, R. Davies-Jones, and C. Doswell, eds., 1993: *The Tornado: Its Structure, Dynamics, Prediction, and Hazards*. Geophys. Monogr. 79, Amer. Geophys. Un., 637 pp.

MacGorman, D.R., 1993: Lightning in tornadic storms: A review. In *The Tornado: Its Structure, Dynamics, Prediction, and Hazards*, C. Church, D. Burgess, R. Davies-Jones, and C. Doswell, eds., Geophys. Monogr. 79, Amer. Geophys. Un., 173-182.

Seimon, A., 1993: Anomalous cloud-to-ground lightning in an F5-tornado-producing supercell thunderstorm on 28 August 1990. *Bull. Amer. Meteor. Soc.*, 74, 189-203.

- 1994: Dr. Elbert W. Friday, Jr. was honored as Federal Executive of the Year.

Vice President Al Gore launches NOAA Weather Radio initiative to increase transmitter coverage to 95 percent of the population.

The new Cray C90 supercomputer was dedicated providing for faster and more accurate forecasts.

NOAA and the EPA launched an experimental Ultraviolet (UV) Exposure Index.

"The Atmospheric Electricity Paradigm" (1994), B. Vonnegut, *Bull. Amer. Meteor. Soc.* 75, 1, pp 53-61.

"Comment on 'A Review of Thunderstorm Electrification Processes'" (1994), B. Vonnegut, *J. Appl. Meteorol.* 33, 11, p 1376.

"Doppler Radar and Lightning Network Observations of a Severe Outbreak of Tropical Cyclone Tornadoes" NLDN and Doppler study of tropical storm Beryl proves no correlation with CG Lightning and Tornadoes

Observation of lightning phenomena using radio interferometry, C. T. Rhodes, X. M. Shao, Paul R. Krehbiel, Ronald J Thomas, C. O. Hayenga, New Mexico Institute of Mining and Technology, Socorro, New Mexico, United States *Journal of Geophysical Research Atmospheres* (Impact Factor: 3.43). 06/1994; 99(D6):13059-13082. DOI: 10.1029/94JD00318 ABSTRACT

A radio interferometer system is described which utilizes multiple baselines to determine the direction of lightning radiation sources with an angular resolution of a few degrees and with microsecond time resolution. An interactive graphics analysis procedure is used to remove fringe ambiguities from the data and to reveal the structure and development of lightning discharges inside the storm.

Knapp, D.I., 1994: Using cloud-to-ground lightning data to identify tornadic thunderstorm signatures and nowcast severe weather. *Natl. Wea. Assoc. Digest*, 19, 35-42.

MacGorman, D.R., and D.W. Burgess, 1994: Positive cloud-to-ground lightning in tornadic storms and hailstorms. *Mon. Wea. Rev.*, 122, 1671-1697.

Rasmussen, E., J.M. Straka, R. Davies-Jones, C.A. Doswell III, F.H. Carr, M.D. Eilts, and D.R. MacGorman, 1994: Verification of the origins of rotation in tornadoes experiment: VORTEX. *Bull. Amer. Meteor. Soc.*, 75, 995-1006.

Ziegler, C. L., and D. R. MacGorman, 1994: Observed lightning morphology relative to modeled space charge and electric field distributions in a tornadic storm. *J. Atmos. Sci.*, 51, 833-851.

Review of lightning properties from electric field and TV observations
VA Rakov, MA Uman, R Thottappillil
Journal of Geophysical Research: Atmospheres (1984–2012) 99 (D5), 10745-10750

- 1995: The National Tsunami Hazard Mitigation Program (NTHMP), the nation's community-focused program to improve tsunami mitigation and preparedness of at-risk areas within the United States and its territories is created.

NWS launches Internet Service Interactive Weather Information Network—
IWIN.

V. A. Rafalsky, A. P. Nickolaenko, and A. V. Shvets, Institute of Radio Astronomy, Ukrainian Academy of Sciences, Kharkov, Ukraine, M. Hayakawa Sugadaiza Space Radio Observatory University of Electro-Communications Chofu, Tokyo, Japan, Location of lightning discharges from a single station, *JOURNAL OF GEOPHYSICAL RESEARCH*, VOL. 100, NO. D10, PAGES 20,829-20,838, OCTOBER 20, 1995

Reynolds, D. J.,: Nocturnal Tornado Illuminated by an Electrical Discharge at Farnham, Surrey, 10 January 1994. *Journal of Meteorology, UK*, 20: 381.

"Observations of Lightning in the Stratosphere" (1995), William Boeck, Otha H. Vaughan, Jr, Richard Blakeslee, Bernard Vonnegut, Marx Brook, and John McKune, Jr., *J. Geophys. Res.* 100, D1, pp 1465-1475.

“Importance of electricity in weather?” (1995), Bernard Vonnegut, *Weather* 50, 2, pp 62-63.

"An explanation for anomalous lightning from forest fire clouds" (1995), B. Vonnegut, D. J. Latham, C. B. Moore and S. J. Hunyady, *J. Geophys. Res.* 100, D3, pp 5037-5050.

“Jovian Lightning After Comet Impacts?” (1995), Bernard Vonnegut, *Science* 268, p 1829.

“Comment on ‘Negatively charged precipitation in a New Mexico thunderstorm’ by Thomas C. Marshall and Stephen J. Marsh and ‘Charged precipitation measurements before the first lightning flash in a thunderstorm’ by Stephen J. Marsh and Thomas C. Marshall” (1995), H. H. Jonsson and B. Vonnegut, *J. Geophys. Res.* 100, D8, pp 16,867-16,868.

“Weather and Climate Changes Arising From Solar Wind Effects on Thunderstorm Electrification” (1995), B. Vonnegut and C. B. Moore, *EOS, Transactions, Amer. Geophys. Union* 76, 32, pp 315 and 327.

“Comment on ‘Trip Illumines Lightning’ by R. D. Hill” (1995), B. Vonnegut, *EOS, Transactions, Amer. Geophys. Union* 76, 50, p 516.

Bose–Einstein condensate was created by Eric Cornell and Carl Wieman and co-workers on 5 June 1995.

Galileo arrived at Jupiter on December 7, 1995, after gravitational assist flybys of Venus and Earth, and became the first spacecraft to orbit Jupiter. It launched the first probe into Jupiter, directly measuring its atmosphere. Principal investigator Martin Uman.

- 1996: NWS provides forecasting support for Atlanta Olympics.

Scientists make the first dual Doppler tornado intercept. A team of government and university scientists and student volunteers for the first time observe a tornado close-up with dual high-resolution Doppler radars, providing a never-before-seen two-dimensional view of a full-blown tornado. The team scanned the slow moving twister for 10 minutes with the two Doppler radars mounted on flatbed trucks.

OBSERVED RELATIONSHIPS BETWEEN TOTAL LIGHTNING INFORMATION AND DOPPLER RADAR DATA DURING TWO RECENT TROPICAL CYCLONE TORNADO EVENTS IN FLORIDA Scott M. Spratt, David W. Sharp, and Stephen J. Hodanish NOAA/NWS Melbourne, Florida

Relationships between Tornado Intensity and Various Wind and Thermodynamic Variables 1996 -- “Although theory and numerical studies cannot yet completely describe tornado formation in supercell thunderstorms or explain what determines tornado intensity, these sources provide evidence suggesting static stability, vertical wind shear, and helicity play important roles.” Extremely low coefficient of variation means convective processes may be result of random chance

Mach, D., D. Buechler, K. Driscoll, R. Raghavan, W. Boeck, R. Blakeslee, H. Christian, S. Goodman, and W. Koshak, 1996: A flash discrimination algorithm based on the temporal and spatial characteristics of lightning optical pulses observed from space. *Eos, Trans. Amer. Geophys. Un.*, 77, F92.

- 1997: Nationwide WSR-88D radar network is fully deployed.

Red River of the North Flood causes 11 deaths and \$3.5 billion in damages. Subsequent evaluation of NWS services led to service improvement in hydrologic products including explicit consideration of uncertainty in forecasting.

Dr. Robert S. Winokur appointed acting director of the National Weather Service.

Perez, A. H., Wicker, L. J., and Orville, R. E., 1997: Characteristics of Cloud-to-Ground Lightning Associated with Violent Tornadoes. *Weather and Forecasting*, 12: 428-437.

Krasilnikov, E. Y., 1997: Electromagnetohydrodynamic nature of tropical cyclones, hurricanes, and tornadoes. *Journal of Geophysical Research*, Vol. 102, Issue D12, 13571-13580.

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Characteristics of Cloud-to-Ground Lightning Associated with Violent
Tornadoes, *Cooperative Institute for Applied Meteorological Studies and
Department of Meteorology, Texas A&M University, College Station, Texas*

“Role of cumulus downdrafts in stratosphere-troposphere exchange and in cloud electrification” (1997), Bernard Vonnegut, *Atmospheric Research* 43, 2, pp 197-199.

“The Smell of Tornadoes” (1997), Howard G. Altschule and Bernard Vonnegut, *Weatherwise* 50, 2, pp 24-25.

MacGorman, D.R., and C.D. Morgenstern, 1997: Some characteristics of cloud-to-ground lightning in mesoscale convective systems. *J. Geophys. Res.*, 102, submitted.

Cassini spacecraft launched on October 15, 1997 with Radio Plasma Wave Science (RPWS) instrument package.

- 1998: Brig. Gen. John J. “Jack” Kelly, Jr., USAF (ret.), appointed director of the National Weather Service. He serves until his retirement in 2004.

MacGorman, D. R., and Rust, W. D.: The Electrical Nature of Storms. *Oxford University Press*, 422.

Carlisle, “Classical Comparative Analysis Procedures and Deterministic Chaos”, the limitations of Newtonian Mechanics in describing Far From Equilibrium Dynamics

“The role of the space shuttle videotapes in the discovery of sprites, jets and elves” (1998), William L. Boeck, Otha H. Vaughan, Jr., R. J. Blakeslee, Bernard Vonnegut, and Marx Brook, *J. Atmos. and Solar-Terrestrial Phys.* 60, 6-9, pp 669-677.

- 1999: Earle Williams, Bob Boldi, Anne Matlin, Mark Weber, Steve Hodanish, Dave Sharp, Steve Goodman, Ravi Raghavan, Dennis Buechler, The behavior of total lightning activity in severe Florida thunderstorms, *Atmospheric Research* 245–265
- 2000: The Advanced Weather Interactive Processing System (AWIPS), a high-tech, interactive weather computer and communications system has been installed in 152 National Oceanic and Atmospheric Administration sites across the country. AWIPS provides significant improvements in weather- and flood-related services.

With the completion of AWIPS the formal end of the NWS Modernization and associated restructuring is declared, completing a decade-long effort to revamp weather services and significantly improve weather forecasting.

StormReady®, a new national program designed to better prepare for tornadoes and other types of severe weather, is unveiled. By 2011 there are more than 1,800 StormReady sites in 48 states, as well as Puerto Rico and Guam.

Buechler, D. E., Driscoll, K. T., Goodman, S. J., and Christian, H. J.: Lightning activity within a tornadic thunderstorm observed by the optical transient detector (OTD). *Geophysical Research Letters*, Vol. 27, Issue 15, 2253-2256.

Winn, W. P., Hunyady, S. J., and Aulich, G. D.: Electric field at the ground in a large tornado. *Journal of Geophysical Research*, Vol. 105, Issue D15, 20145-20154.

Teramoto, K., and Ikeya, M.: Experimental Study of Cloud Formation by Intense Electric Fields. *Japanese Journal of Applied Physics*, Vol. 39, Issue 5A, 2876.

Biggar, D. G., 2000: A case study of a positive strike dominated supercell thunderstorm that produced an F2 tornado after undergoing a significant cloud-to-ground lightning polarity shift. *srh.noaa.gov*

- 2001: President George W. Bush issues the first presidential proclamation for the National Hurricane Preparedness week.

TsunamiReady™, a national program designed to help cities, towns, counties, universities and other large sites in coastal areas reduce the potential for disastrous tsunami-related consequences, is unveiled. By 2011 there are more than 90 TsunamiReady sites in 10 states, Puerto Rico and Guam and the Northern Mariana Islands.

R.J. Thomas, P.R. Krehbiel, W. Rison, T. Hamlin, J. Harlin, and D. Shown, Observations of VHF Source Powers Radiated by Lightning, *GEOPHYSICAL RESEARCH LETTERS*, VOL. 28, NO. 1, PAGES 143-146, JANUARY 1

Zhang, Y., Krehbiel, P., Hamlin, T., Harlin, J., Thomas, R., and Rison, W.: Electrical Charge Structure and Cloud-to-Ground Lightning in Thunderstorms during STEPS. *American Geophysical Union*, Fall Meeting , abstract #AE12A-0079.

Marshall, T. C., and Stolzenburg, M.: Voltages inside and just above thunderstorms. *Journal of Geophysical Research*, 106(D5), 4757-4768.

Cornell and Wieman share Nobel prize for Bose-Einstein condensate

- 2002: NWS partners with university and private sector meteorologists to provide accurate forecasts for athletes and spectators at 2002 Olympic Winter Games in Salt Lake City, Utah.

Krasilnikov, E. Y.: Prevention of destructive tropical and extratropical storms, hurricanes, tornadoes, dangerous thunderstorms, and catastrophic floods. *Nonlinear Processes in Geophysics*, 9: 51-59.

Electron acceleration observed by the FAST satellite within the IAR during a 3 Hz modulated EISCAT heater experiment

S. R. Cash, J. A. Davies, E. Kolesnikova¹, T. R. Robinson, D. M. Wright, T. K. Yeoman¹, and R. J. Strangeway

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Received: 7 February 2002 – Revised: 3 July 2002 – Accepted: 17 July 2002

- 2003: National Academy of Sciences report, “Fair Weather: Effective Partnerships in Weather and Climate Services” released to advise NOAA on approaches it should take to improve relationships with private sector.

Knupp, K. R., Paech, S., and Goodman, S.,: Variations in Cloud-to-Ground Lightning Characteristics among Three Adjacent Tornadoic Supercell Storms over the Tennessee Valley Region. *Monthly Weather Review*, 131: 172-188.

- 2004: Brig. Gen. David L. Johnson, USAF (ret.), appointed director of the National Weather Service. He serves until his retirement in 2007.

NOAA policy on Partnerships in the Provision of Environmental Information is adopted in response to the 2003 Academy of Science study.

Tsunami readiness in the United States is strengthened after a magnitude 9.0 earthquake strikes in the Indian Ocean and tsunami waves kill over 230, 000 people around the Indian Ocean basin.

Congress passes the Tsunami Warning and Education Act authorizing NOAA to strengthen its tsunami detection, forecast, warning and mitigation programs.

Spatial and temporal characteristics of VHF radiation source produced by lightning in supercell thunderstorms, Yijun Zhang, Qing Meng, Paul R. Krehbiel, Xinsheng Liu, Xiuji Zhou, 02/2004; 49(6):624-631. DOI: 10.1360/03wd0551
ABSTRACT The three-dimensional temporal and spatial characteristics of VHF radiation events produced by lightning discharges in three supercell thunderstorms have been analyzed based on the data measured by the lightning mapping array system with high time and space resolution. The results indicate that lightning hole (lighting free region) with about 5–6 km in diameter or lightning ring (annular lighting free region) is associated with the strong updraft in thunderstorm. The lasting time of lightning holes is either short or long, being about 20 min in a tornado-producing thunderstorm. The lightning holes appear before the occurrence of tornado.

Atmospheric Science, X-ray bursts associated with leader steps in cloud-to-ground lightning, JR Dwyer, HK Rassoul, M Al Dayeh, L Caraway, A Chrest, B Wright, E Kozak, J Jerauld, MA Uman, VA Rakov, DM Jordan, KJ Rambo, Publication date 2005/1/1 Abstract X-ray and electric field measurements were made during five nearby negative natural lightning strikes in north central Florida during the summer of 2004. The observed X-ray emission typically was detected 1 ms before the first return stroke, during the stepped-leader phase, and had energies extending up to a few hundred keV.

A ground level gamma ray burst observed in association with rocket triggered lightning, JR Dwyer, HK Rassoul, M A Dayeh, L Caraway, B Wright, A Chrest, Geophysical research letters

Messenger spacecraft was launched August 2004 to study Mercury's chemical composition, geology, and magnetic field.

- 2005: Hurricane Katrina makes landfall in southeast Louisiana on August 29, resulting in devastation and loss of life of historic proportions along the Gulf Coast. Katrina results in an estimated \$125 billion in damage/costs — making it the most expensive natural disaster in U.S. history — and approximately 1,833 deaths — the highest U.S. total since the 1928 major hurricane in southern Florida.

Hurricane Rita hits the Texas-Louisiana border coastal region in September, creating significant storm surge and wind damage along the coast, and some inland flooding. Prior to landfall, Rita reached the third lowest pressure (897 mb) ever recorded in the Atlantic basin. Rita results in an estimated \$16.0 billion in damage/costs and 119 deaths — mostly indirect.

Hurricane Wilma hits southwest Florida in October, resulting in strong, damaging winds and major flooding across southeastern Florida. Prior to landfall, as a Category 5 hurricane, Wilma sets a record for the lowest pressure (882 mb) ever recorded in the Atlantic basin. Wilma results in an estimated \$16.0 billion in damages/costs and 35 deaths.

Overall, the 2005 Atlantic hurricane season set several records. There were 28 named storms (storms with sustained winds of at least 39 miles per hour). In addition, there were an unprecedented 14 hurricanes, of which seven were major hurricanes (Category 3 or better on the Saffir-Simpson Scale). Three category 5 storms (sustained winds of 156 miles per hour or more) formed in the Atlantic Basin for the first time in a single season (Katrina, Rita, and Wilma). Four major hurricanes and three tropical storms made landfall in the U.S., with an eighth storm (Ophelia) brushed brushing the North Carolina coast.

Scherbin, M. D.,: On Possibility of Electromagnetic Nature of Atmospheric Intensive Vortices Generation. *arXiv:physics*, 0512239.

Kikuchi, H.,: EHD Approach to Tornadic Thunderstorms and Methods of Their Destruction. *American Geophysical Union*, Spring Meeting 2005, abstract #AE11B-01.

Murphy, M. J., and Demetriades, N. W. S.,: An analysis of lightning holes in a DFW supercell storm using total lightning and radar information. *Conference on Meteorological Applications of Lightning Data*, 2.3.

MacGorman, D. R., Rust, W. D., Krehbiel, P., Rison, W., Bruning, E., and Wiens, K.,: The Electrical Structure of Two Supercell Storms during STEPS. *Monthly Weather Review*, 133: 2583-2607.

Rust, W. D., MacGorman, D. R., Bruning, E. C., Weiss, S. A., Krehbiel, P. R., Thomas, R. J., Rison, W., Hamlin, T., and Harlin, J., 2005: Inverted-polarity electrical structures in thunderstorms in the Severe Thunderstorm Electrification and Precipitation Study (STEPS). *Atmospheric Research*, 76: 247-271.

R.W. Armstrong and J.G. Glenn, Role for Intra-cloud Lightning in Tornadogenesis and Possible Modification

Lightning induced disturbances in buried cables-part II: experiment and model validation, M Paolone, E Petrache, F Rachidi, CA Nucci, VA Rakov, MA Uman, *Electromagnetic Compatibility, IEEE Transactions on* 47 (3), 509-520

- 2006: Severe flooding occurs over portions of the Northeast in June due to several weeks of heavy rainfall, affecting six states and resulting in over \$1 billion in damage/costs and at least 20 deaths.

December 13 marks the 30th anniversary of the nation's only federally funded weather telecast. Known as "Alaska Weather," the program, broadcast live across the state every night at 5:30 p.m. from KAKM-TV, the PBS station in Anchorage, is a partnership between public broadcasting and NWS.

Tessendorf, S. A., Wiens, K. C., Lang, T., and Rutledge, S. A.,: STEPS 2000 Research Highlights From Colorado State University. *American Geophysical Union*, Fall Meeting 2006, abstract #AE43A-05.

Kuhlman, K. M., Ziegler, C. L., Mansell, E. R., MacGorman, D. R., and Straka, J. M.,: Numerically Simulated Electrification and Lightning of the 29 June 2000 STEPS Supercell Storm. *Monthly Weather Review*, 134: 2734-2757.

Electrical and Polarimetric Radar Observations of a Multicell Storm in TELEX
ERIC C. BRUNING, W. DAVID RUST, TERRY J. SCHUUR, DONALD R.
MACGORMAN, PAUL R. KREHBIEL, AND WILLIAM RISON Cooperative
Institute for Mesoscale Meteorological Studies, Norman, Oklahoma
NOAA/OAR National Severe Storms Laboratory, Norman, Oklahoma
New Mexico Institute of Mining and Technology, Socorro, New Mexico
Submitted to Monthly Weather Review May 11, 2006

Quasi-electrostatic field analysis and simulation of Martian and terrestrial dust
Devils, Y. Zhai,¹ S. A. Cummer,¹ and W. M. Farrell²
JOURNAL OF GEOPHYSICAL RESEARCH, VOL. 111, E06016,
doi:10.1029/2005JE002618, 2006

Received 21 October 2005; revised 6 March 2006; accepted 14 March 2006;
published 27 June 2006.

Recent experimental and modeling studies show that large quasi-static electric
fields (2–20 kV/m) can be developed in a Martian or terrestrial dust devil as a
result of contact electrification and charge separation of dust grains with different
sizes and compositions. Electric discharging occurs when the maximum electric
field reaches breakdown values (~ 20 kV/m on Mars and ~ 3 MV/m on Earth, at
surface altitudes).

- 2007: For nearly two weeks in January, overnight temperatures over a good
portion of California dipped into the 20's, destroying numerous agricultural crops;
with citrus, berry, and vegetable crops most affected. An estimated \$14 billion in
damage/costs are reported.

NWS activated its newest weather and climate supercomputers — IBM machines
capable of processing 14 trillion calculations per second at maximum
performance and ingest more than 240 million global observations daily. The new
computers increased the computational might used for the nation's climate and
weather forecasts by 320 percent.

NWS implements the Enhanced Fujita scale to rate tornadoes, replacing the
original Fujita Scale. The EF scale will continue to rate tornadoes on a scale from
zero to five, but ranges in wind speed will be more accurate with the improved
rating scale.

In response to customer demand for climate information at the local level,
NOAA's National Weather Service has launched a new local three-month
temperature outlook product for the continental United States.

NWS teams with 2007 Iditarod sled dog race to showcase for four newly
designated StormReady® communities. For the first time, mushers raced through
four trail communities — Anchorage, Wasilla, McGrath, and Nome — carrying
the StormReady distinction.

- NWS implements a new Heat/Health Watch Warning System in the cities of San Francisco, Oakland, and San Jose, as well as surrounding Bay communities of Redwood City, Palo Alto, Sunnyvale, Santa Clara, Gilroy, Fremont, Alameda, Berkeley, Richmond, and El Cerrito. They join 18 other metropolitan areas in the United States using this system as guidance for issuing excessive heat watches, excessive heat warnings and heat advisories.

Dr. John L. “Jack” Hayes appointed director of the National Weather Service.

NWS transitions from county-based to new storm-based warnings, issuing more geographically specific warnings for tornadoes, severe thunderstorms, floods, and marine hazards.

A series of three storms affected the Pacific Northwest between December 1 and 3, 2007, resulting in 11 fatalities and an estimated \$1 billion in damage.

Kikuchi, H.: Helicity or Vortex Generation in Hydrodynamic (HD), Magneto-hydrodynamic (MHD), and Electrohydrodynamic (EHD) Regimes. *Progress In Electromagnetics Research Symposium 2007, Beijing, China, March 26-30*

Steiger, S. M., Orville, R. E., and Carey, L. D.: Total Lightning Signatures of Thunderstorm Intensity over North Texas. Part I: Supercells. *Monthly Weather Review*, 135: 3281-3302.

Dehel, T. F., Dickinson, M., Lorge, F., and Startzel, F. Jr.: Electric field and Lorentz force contribution to atmospheric vortex phenomena. *Journal of Electrostatics*, Vol. 65, Issues 10-11, 631-638.

Tessendorf, S. A., Rutledge, S. A., and Wiens, K. C.: Radar and lightning observations of normal and inverted polarity multicellular storms from STEPS. *Monthly Weather Review*, 135: 3682-3706.

Kikuchi, H.: Laboratory Experiments of Helicity or Vortex Generation in an Electric Quadrupole: Simulation of Tornadoes with and without Lightning. *American Geophysical Union Spring Meeting Abstracts*, #SA54A-02.

Snow, R., Snow, M., and Kufa, N.: Lightning Signature Assessment to Forecast Tornado Formation. *International Journal of Energy and Environment*, Vol. 1, Iss. 1, 7-11.

Patton, F. S., Bothun, G. D., and Sessions, S. L.: An electric force facilitator in descending vortex tornadogenesis. *Journal of Geophysical Research*, 113, D07106, doi:10.1029/2007JD009027.

- 2008: The United States tsunami detection array is complete with 39 Dart stations positioned around the Pacific basin, western Atlantic and Caribbean Sea.

Hurricane Ike makes landfall in Texas, as the largest (in size) Atlantic hurricane on record, causing considerable storm surge in coastal Texas and significant wind and flooding damage in 10 other states. Estimated damage exceeds \$27 billion. Ike results in 112 deaths.

The Super Tuesday Tornado Outbreak of February 5-6 results in 57 fatalities in four states. It is the second largest February tornado outbreak since 1950 in terms of fatalities and the largest since May 31, 1985.

Nenana, Alaska, Receives Nation's 1,000th NOAA Weather Radio Transmitter.

Gerbeth, G., Dulikravich, G. S., and Pericleous, K.: Computational electro-magneto-hydro-dynamics (EMHD). *8th World Congress on Computational Mechanics (WCCM8), Venice, Italy*

Heene, R., Stevens, R., and Slusser, B.: Electromagnetic Fields Recorded in Mesocyclones. *National Weather Digest*, 32:1, 35-44.

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The global electrical circuit: A review

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In situ measurements of contributions to the global electrical circuit by a thunderstorm in southeastern Brazil, Jeremy N. Thomas, Robert H. Holzworth, Michael P. McCarthy, Department of Earth and Space Sciences, University of Washington, Seattle, WA, USA Geomagnetism Program, USGS Denver, CO

During its second flyby of the planet on October 6, 2008, the NASA probe MESSENGER discovered that Mercury's magnetic field shows a magnetic reconnection rate for Flux Transfer Events ten times higher than Earth's. Mercury's proximity to the Sun only accounts for about a third of the reconnection rate observed by MESSENGER and the cause of this discrepancy is not currently known.

- 2009: Drought conditions occurred during much of the year across parts of the Southwest, Great Plains, and southern Texas causing an estimated \$5 billion in agricultural losses in numerous states. The largest agriculture losses occurred in Texas and California.

NWS completed implementation of the final phase of a nine-year, \$180 million contract by installing the newest generation of IBM supercomputers for weather and climate prediction. The new supercomputers, based on IBM Power 575 Systems, are four times faster than the previous system, with the ability to make 69.7 trillion calculations per second. Higher computation speed allows meteorologists to rapidly refine and update severe weather forecasts as dangerous weather develops and threatens U.S. communities.

Devastating floods affect the southeast U.S., as copious moisture drawn into the region from the Atlantic and Gulf of Mexico produced showers and thunderstorms from September 18-23. Rainfall amounts across the region totaled 5-7 inches, with locally higher amounts near 20 inches. The northern two-thirds of Georgia, Alabama, and southeastern Tennessee were hardest hit with the southeasterly low-level winds providing favorable upslope flow. Flash flood and areal flooding were widespread, with 11 fatalities were directly attributed to this flooding.

PATRICK N. GATLIN, Earth Systems Science Center, University of Alabama in Huntsville, Huntsville, Alabama, STEVEN J. GOODMAN, NOAA/NESDIS, GOES-R System Program Office, NASA Goddard Space Flight Center, Greenbelt, Maryland, (Manuscript received 23 January 2009, in final form 14 July 2009), A Total Lightning Trending Algorithm to Identify Severe Thunderstorms

- 2010: NWS unveiled a new hurricane scale this season called the Saffir-Simpson Hurricane Wind Scale. The scale keeps the same wind speed ranges as the original Saffir-Simpson Scale for each of the five hurricane categories, but no longer ties specific storm surge and flooding effects to each category.

GOES-15, launched on March 4, 2010, from Cape Canaveral, Fla., joining three other NOAA operational GOES spacecraft that help the agency's forecasters track life-threatening weather.

Record-breaking rain struck Kentucky and the Tennessee Valley on May 1-2, resulting in widespread, devastating flash flooding across much of western and middle Tennessee, including the greater Nashville area. The heavy rain also resulted in unprecedented flooding along the Cumberland River and its tributaries. There were 26 fatalities directly attributed to the flooding, 11 of which were in greater Nashville. Preliminary estimates of property damage were in excess of \$2 in greater Nashville alone.

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Schmitter, E. D.: Modeling tornado dynamics and the generation of infrasound, electric and magnetic fields. *Natural Hazards and Earth System Sciences*, 10: 295-298.

Trostel, J. M., and Matthews, J., 2010: Application of an Improved SCIT Algorithm to Investigate Lightning Characteristics of a Tornado Outbreak in Georgia. *26th Conference on Interactive Information and Processing Systems (IIPS) for Meteorology, Oceanography, and Hydrology*

Cassini RPWS detects largest storm ever recorded in solar system in December

- 2011: A record-breaking number of 10 separate weather, water and climate disasters, each with an economic loss of \$1 billion or more. These included the Groundhog Day Blizzard of Jan 29-Feb 3, several devastating tornado outbreaks — including the one that produced an EF-5 tornado struck Joplin, Mo., which resulted in at least 160 deaths, making it the deadliest single tornado to strike the U.S. since modern tornado record keeping began in 1950 — and river flooding along the Mississippi, Missouri and Souris Rivers.

NWS launches a comprehensive initiative to build a Weather-Ready Nation to make America safer by saving more lives and protecting livelihoods as communities across the country become increasingly vulnerable to severe weather events, such as tornado outbreaks, intense heat waves, flooding, active hurricane seasons, and solar storms that threaten electrical and communication systems. The initiative is focused on helping people make better decisions with better information and will require not only improvements in the science and technology of the modernization era, but also the integration of social sciences and the improvements in partnership with other government agencies, researchers, and the private sector.

NWS ranks in the top 15 percent of federal agencies for customer satisfaction, according to a new public survey. With an essential public safety mission, the agency rated 84 on a scale of 0 to 100 – a score considered “excellent” by independent survey firm Claes Fornell International (CFI).

Hurricane Irene makes landfall over coastal N.C. before moving northward along the Mid-Atlantic Coast and causing torrential rainfall and flooding across the Northeast. Wind damage in coastal N.C., Va., and Md. was moderate with considerable damage resulting from falling trees and power lines, while flooding caused extensive flood damage across N.J., N.Y., and VT. More than seven million homes and businesses lost power during the storm.

Numerous tornadoes were also reported in several states further adding to the damage. Over \$7.0 billion in damages/costs; and at least 45 deaths were reported.

NWS began upgrading its network of Doppler radars throughout the nation with dual-polarization (Dual-Pol) capability, resulting in better estimation of heavy rainfall amounts in flooding events, improved hail detection in severe thunderstorms, and improved classification of precipitation types. Dual-Pol radar has the potential to improve forecasts and warnings and reduce the impact of hazardous weather on transportation. The upgrades are scheduled to be completed in early 2013.

NWS began using a sophisticated forecast model that substantially improves predictions of space weather impacts on Earth. Better forecasts offer additional protection for people and the technology-based infrastructure we use daily.

The National Research Council completes the first phase of a study on the NWS Modernization and Associated Restructuring effort of the 1990s. The NRC report concludes that the framework left in place from the modernization of the 1990s “allows and encourages the continued evolution of National Weather Service technology, and to some extent the workforce composition and culture.”

Development begins April 27 2011 for patented Tornado Alert Unit (TAU) using electromagnetic detection (sferics) technology

JOURNAL OF GEOPHYSICAL RESEARCH, VOL. 116, A06308,
doi:10.1029/2010JA016194, 2011

Magnetospheric injection of ELF/VLF waves with modulated or steered HF heating of the lower ionosphere

M. B. Cohen, U. S. Inan, D. Pidtyachiy, N. G. Lehtinen, and M. Gołkowski
Received 8 October 2010; revised 7 March 2011; accepted 15 March 2011;
published 16 June 2011.

- 2012: Arseniev SA, Shelkovnikov NK (2012) Electromagnetic fields in tornados and spouts. Moscow University Physics Bulletin 67: 290-295.

Relating electrified cloud properties to Wilson currents: an oceanic and continental case study, Sarah Al-Momar, Academic Affiliation, Fall 2012: Senior, Valparaiso University SOARS® Summer 2012

Research Mentors: Wiebke Deierling and Christina Kalb

Writing Mentor: Kimberly Kosmenko

Community Mentor: Carol Park

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JOURNAL OF GEOPHYSICAL RESEARCH, VOL. 117, A09306,
doi:10.1029/2012JA017577, 2012

Spatial structure of the electromagnetic field inside the ionospheric
Alfvén resonator excited by atmospheric lightning activity

A. A. Plyasov, V. V. Surkov, V. A. Pilipenko, E. N. Fedorov, and V. N. Ignatov

Received 31 January 2012; revised 27 June 2012; accepted 30 July 2012;
published 13 September 2012.

A Review of Low Frequency Electromagnetic Wave Phenomena
Related to Tropospheric-Ionospheric Coupling Mechanisms

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Greenbelt Road, Greenbelt, Maryland, 20771, USA

- 2013: Dr. Louis W. Uccellini becomes the 16th Director of the National Weather Service

FEMA issues RFI requesting solution to problems with IPAWS, withdrawn due to non response from any carriers, Morgan Schickler Senior Contracts Administrator for FEMA

S. N. Artekha and A. V. Belyan, Nonlinear Processes in Geophysics On the role of electromagnetic phenomena in some atmospheric processes Space Research Institute, Moscow, Russia Received: 19 February 2013 – Revised: 2 April 2013 – Accepted: 7 April 2013 – Published: 8 May 2013

National Academy of Public Administration for the US Congress and NWS documents mandate to integrate non-traditional environmental forecasting, and use of emerging technologies and the WFO infrastructure is aging to the point of concern. This report identifies NWS technology becoming obsolete in the near future, which could diminish NWS ability to provide critical products and services. Examples of aging infrastructure and technology at their local WFOs, a growing problem identified as possibly affecting future forecast accuracy

Monday, August 12, 2013

Lenard Effect : Spray Electrification or Waterfall Effect

The fact that exceptionally large amount of anions (negative ions) are found under waterfalls and in the seaside are contributed by the German physicist Philipp Eduard Anton von Lenard (Lénárd Fülöp in Hungarian, June 7, 1862 - May 20, 1947) who won the Nobel Prize for Physics in 1905 for his research on cathode rays and the discovery of many of their properties.

Lenard Effect: The separation of electric charges accompanying the aerodynamic breakup of water drops, first studied systematically by the German physicist P. Lenard. Experiments have shown that the degree of charge separation in spray processes depends upon the drop temperature, presence of dissolved impurities, speed of the impinging air blast, and contact with foreign surfaces.

The largest fragments of the broken drops are observed to carry positive charges (or cations) and the fine spray of drops carried off in the impinging air current carries net negative charges (anions).

Frontiers of Earth Systems Dynamics – Earth’s Global Electric Circuit Teacher’s Guide <http://sisko.colorado.edu/FESD/MeetPresentFiles/2013.GEC.3.21.pdf>

Voyager 1 detects Flux Transfer Event in interstellar space more than 100 AUs from sun.

MAVEN was successfully launched on November 18, 2013.

- 2014: Sarah M. Stough, Lawrence D. Carey, Christopher J. Schultz Total Lightning as an Indicator of Mesocyclone Behavior, XV International Conference on Atmospheric Electricity, 15-20 June 2014, Norman, Oklahoma, U.S.A.

Alexandre O. Fierro, Edward R. Mansell, Conrad L. Ziegler, and Donald R. MacGorman Explicit electrification and lightning forecast implemented within the WRF-ARW model, XV International Conference on Atmospheric Electricity, June 15-20, 2014, Norman, OK, USA Cooperative Institute for Mesoscale Meteorological Studies, Norman, Oklahoma, USA. National Severe Storms Laboratory/NOAA/OAR, Norman, Oklahoma USA, TC Isaac

Evolution of the magnetic field generated by the Kelvin-Helmholtz instability, Department of Physics, Umeå University, SE-901 87 Umeå, Sweden Department of Applied Physics, Chalmers University of Technology, SE-41296 Gothenburg, Sweden, Department of Astronomy, Stockholm University, SE-10691 Stockholm, Sweden (Received 14 February 2014; accepted 14 July 2014; published online 31 July 2014), The Kelvin-Helmholtz instability in an ionized plasma is studied with a focus on the magnetic field generation via the Biermann battery (baroclinic) mechanism. The simulations demonstrate the formation of eddies and their further interaction and merging resulting in a large single vortex.

Possible Implications of a Vortex Gas Model and Self-Similarity for Tornadogenesis and Maintenance Doug Dokken, Kurt Scholz, and Mikhail M. Shvartsman Mathematics Department, University of St. Thomas, Saint Paul, MN Pavel Belk Mathematics Department, Augsburg College, Minneapolis, MN Corey K. Potvin Cooperative Institute for Mesoscale Studies, and NOAA/OAR/National Severe Storms Laboratory, Norman, OK, USA Brittany Dahl School of Meteorology, University of Oklahoma, Norman, OK, USA Amy McGovern School of Computer Science, University of Oklahoma, Norman, OK, USA

ABSTRACT

We describe tornadogenesis and maintenance using the 3-dimensional vortex gas model presented in Chorin (1994) and developed further in Flandoli and Gubinelli (2002). We suggest that high-energy, super-critical vortices in the sense of Benjamin (1962), that have been studied by Fiedler and Rotunno (1986), have negative temperature in the sense of Onsager (1949) play an important role in the model. We speculate that the formation of high-temperature vortices is related to the helicity inherited as they form or tilt into the vertical and their interaction with the surface and boundary layer. We also exploit the notion of self-similarity to justify power laws derived from observations of weak and strong tornadoes presented in Cai (2005); Wurman and Gill (2000); Wurman and Alexander (2005). Analysis of a Bryan Cloud Model (CM1) simulation of a tornadic supercell reveals scaling consistent with the observational studies.

The physics of lightning, JR Dwyer, MA Uman Physics Reports 534 (4), 147-241

Strader SM, Ashley WS (2014) Cloud-to-ground lightning signatures of longlived tornadic supercells on 27-28 April 2011. *Physical Geography* 35: 273-296.

EF-4 electromagnetic fluxmeter for studies of geodynamic processes

V. A. Efimov , D. M. Oreshkin, P. P. Firstov, R. R. Akbashev
July 2014, Volume 50, Issue 3, pp 230-237

Electromagnetic mechanisms of forming a tornado-like whirlwind

V. L. Natyaganov , S. A. Maslov
March 2014, Volume 69, Issue 2, pp 29-34
First online: 03 May 2014

Plasmonics with a Twist: Taming Optical Tornadoes on the Nanoscale

Svetlana V. Boriskina
Date: 10 January 2014

On September 22, 2014, MAVEN reached Mars and was inserted into an areocentric elliptic orbit 6,200 km (3,900 mi) by 150 km (93 mi) above the planet's surface. The principal investigator for the spacecraft is Bruce Jakosky of the Laboratory for Atmospheric and Space Physics at the University of Colorado Boulder. Langmuir Probe and Waves (LPW) – determines ionosphere properties and wave heating of escaping ions and solar extreme ultraviolet (EUV) input to atmosphere; Magnetometer (MAG) – measures interplanetary solar wind and ionosphere magnetic fields.

- 2015 Electrical Role for Severe Storm Tornadogenesis (and Modification)
R.W. Armstrong and J.G. Glenn, Department of Mechanical Engineering,
University of Maryland, College Park, MD, USA, Munitions Directorate, Eglin
Air Force Base, FL, USA

Nishihashi M, Arai K-i, Fujiwara C, Mashiko W, Yoshida S, et al. (2015) Characterization of lightning jumps associated with a tornadic supercell on 2 September 2013. SOLA. 1: 18–22.

- 2016 – 486 documented events in the US, multiple detections in South Africa
GOES-R scheduled for launch October

Macroscopic quantum phenomena refer to processes showing quantum behavior at the macroscopic scale, rather than at the atomic scale where quantum effects are prevalent. The best-known examples of macroscopic quantum phenomena are superfluidity and superconductivity; other examples include the quantum Hall effect and concerted proton tunneling in ice. Since 2000 there has been extensive experimental work on quantum gases, particularly Bose–Einstein Condensates. Between 1996 to 2003 four Nobel prizes were given for work related to macroscopic quantum phenomena.

Cornell explains Macroscopic quantum phenomena and potential applications

<http://www.engineeringtv.com/video/2001-Nobel-Prize-Winner-Explain;Only-Engineering-TV-Videos>