# STEVEN R. HANNA, PH.D.                              Updated to Dec 2025

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Ph.D., M.S., B.S.,          Meteorology, Penn State University (1967, 1966, 1964)

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| April 1997-Present: | President, Hanna Consultants, Kennebunkport, ME |
| July 2003-Dec 2023: | Adjunct Associate Prof., Harvard School of Public Health, Boston, MA |
| July 1997- July 2003 | Research Professor, George Mason University, Fairfax, VA |
| April 1997-Dec 2000: | Research Associate, Harvard School of Public Health, Boston, MA |
| 1992-April 1997:P | Principal Meteorologist, Earth Tech, Inc., Concord, MA |
| 1985-1992: | Founder and Vice President, Sigma Research Corp., Westford, MA |
| 1981-1985: | Principal Meteorologist, Environmental Research & Technology, Inc. (ERT), Concord, MA |
| 1967-1981: | Research Meteorologist and Acting Director (1979-1981) USDOC/NOAA, Environmental Research Laboratories, Atmospheric Turbulence and Diffusion Laboratory, Oak Ridge, TN |

## AWARDS

   Dr. Hanna is the 1994 recipient of the American Meteorological Society's Award for Outstanding Contribution to the Advance of Applied Meteorology.  In 2005, he was named a Fellow of the American Meteorological Society.  In 2010, he received the AMS Helmut E. Landsberg award for "Significant novel and insightful contributions in applied meteorology and urban studies, including field work, data interpretation, model development, and model evaluation".  In 2013, he was elected a Councilor of the AMS. In 2015, he received the AMS Henry Harrison Award for Certified Consulting Meteorologists.  In 2016, he received the AMS Award for Outstanding Scientific Contributions in Meteorological Aspects of Air Pollution.

## PROFESSIONAL SUMMARY

   Dr. Hanna is a specialist in atmospheric turbulence and dispersion, in the analysis of meteorological and air quality data, and in the development, evaluation, and application of air quality models.  He is an AMS Certified Consulting Meteorologist with over 50 years of experience.  He has led several research and development projects involving, for example, the analysis of uncertainties of dispersion models, the statistical evaluations of hazardous gas dispersion models and regional ozone models, the development of models for the dispersion of emissions from tall power plant stacks, from offshore oil platforms, and from accidental and intentional releases of hazardous chemicals, and the analysis of data from large urban and regional field experiments.  From 1988-1997, Dr. Hanna was Chief Editor of the *Journal of Applied Meteorology*, and has published 189 articles in refereed journals, and five books in which he is the primary author.

**RELATED PROFESSIONAL EXPERIENCE**

*Model Evaluation, Model Uncertainty, and Concentration Fluctuations*

A statistical method for evaluating air quality models was developed by Dr. Hanna and applied to many types of source scenarios, models, and field data sets. This method is now accepted as a standard in international research on dispersion model evaluation (e.g., see www.harmo.org/kit). The U.S. Air Force, the U.S. Army, and the American Petroleum Institute supported the further development of a framework for evaluating and for estimating the uncertainty in environmental models.  During the past few years, the Department of Defense, the Department of Energy, the Environmental Protection Agency, and the Department of Homeland Security have sponsored additional studies of model evaluation methods, with emphasis on scenarios where chemical or biological agents might be released.

 From 1993 through 2006, the Electric Power Research Institute supported the development of Monte Carlo uncertainty analysis methods for photochemical grid models.  The Nuclear Regulatory Commission had Dr. Hanna review their uncertainty analysis methods for linked emissions-dispersion-exposure-risk consequence models.

From 2004 through 2007, Dr. Hanna was a lead scientist in a Defense Threat Reduction Agency (DTRA) study involving improvements of methods to account for mesoscale and regional-scale uncertainties in transport and dispersion estimates.

From 2006 through the present, Dr. Hanna has led model evaluation efforts for the HPAC-SCIPUFF model, for urban dispersion models, and for the JEM model (supported by DOD). From 2014 through 2018, he was part of the scientific advisory team in which many countries' urban puff dispersion models were being compared using the JU2003 tracer observations.  The study, UDINEE, was funded by the European Commission. From 2018-2021, he led an international model comparison exercise where 17 widely-used hazard response models for dense gases were tested with the Jack Rabbit II field trial data and the results were published in a special issue of *Atmospheric Environment*.

*Regional Air Quality Data Analysis and Model Evaluation*

Dr. Hanna was the chief scientist for analysis of field data from several regional and urban-scale ozone experiments, including the South Central Coastal Cooperative Aerometric Monitoring Program (SCCCAMP), the Lake Michigan Ozone Study (LMOS), and the Gulf of Mexico Air Quality Study (GMAQS).  From 1999 through 2005, Dr. Hanna was the chief scientist on two DOI/MMS-sponsored studies involving boundary layers and air quality in the Gulf of Mexico.  He led a ten-year effort in which the effects of uncertainties in input parameters on the uncertainties in predictions of regional air quality models were assessed using Monte Carlo methods.  This included a study of the uncertainties in the BEIS3 model, which is used to estimate biogenic emissions for input to photochemical grid models.

*Modeling of Turbulence and Diffusion*

Dr. Hanna has developed applied diffusion models for several industrial and governmental

clients, including a diffusion model for complex terrain (RTDM), a model for overwater diffusion (OCD), a cooling tower plume model (ATCOOL), a model for diffusion from tall stacks (HPDM), a hazardous gas model for chemical reactions and thermodynamics associated with $UF_6$ releases, and a baseline urban dispersion model.

From 2000 through 2015, Dr. Hanna's baseline urban dispersion model was further enhanced for use in estimating impacts of possible terrorist attacks with chemical and biological agents. It was evaluated with field data from Los Angeles, Salt Lake City, Oklahoma City, and New York City. He led the evaluation of DTRA's HPAC-Urban model with field data from Oklahoma City and New York City. He was the chief scientist of the Madison Square Garden-2005 (MSG05) tracer experiment in New York City. From 2012-2016, he analyzed the rooftop urban observations during the MID05 field experiment and developed algorithms to better estimate rooftop concentrations in city centers.

*Hazardous Gas Model Development and Analyses*

The American Institute of Chemical Engineers (AIChE) Center for Chemical Process Safety (CCPS) sponsored the writing of the Guidelines for Use of Vapor Cloud Dispersion Models in 1987, and the preparation of greatly-enhanced second edition in 1996. The AIChE/CCPS also sponsored preparation of the 2002 book entitled Wind Flow and Vapor Cloud Dispersion at Industrial and Urban Sites.

In the 1990s, an industry-government consortium supported the five-year PERF 93-16 Dispersion Modeling Project, including field and laboratory experiments, in which dense gas models were improved so that they account for high surface roughnesses, short-duration releases, and stable ambient conditions. Dr. Hanna was responsible for the planning and coordination of the technical components of the project and carried out the analysis of the Kit Fox field data and the evaluation of the HGSYSTEM 3+ model.

From 2005 through the present, Dr. Hanna has led DARPA, DHS, DTRA, and Chlorine Chemistry Council studies of emissions and dispersion of chlorine, ammonia, and other chemicals released from railcars and industrial facilities. In the DTRA study, source emission model improvements were made for Toxic Industrial Chemicals (TICs). He analyzed the observations from the DHS Jack Rabbit I chlorine and anhydrous ammonia field experiments. He has been a lead scientist for the Jack Rabbit II field experiments (in August 2015 and August 2016), where up to 20 tons of pressurized liquefied chlorine was released in each of nine trials. He was guest editor for a special issue of the journal *Atmospheric Environment,* in which 22 papers describing the results of the comparison have been presented. He is currently chief scientist of the 2022-2027 DHS/DTRA JR III field study, which involves releases of anhydrous ammonia.

*Research on Source Term Estimation*

Since 2013, Dr. Hanna has been on the scientific advisory and review panel for several large field experiments intended to improve Source Term Estimation (STE) of methane. In 2015-2016, he led an industry supported technical review of the field (including all pollutants) and published a summary article in *Atmospheric Environment*. In 2023, he completed an evaluation of the STE model in the DOD's JEM 2 model, using several sets of field observations (such as FFT07).

*Modeling of COVID-19*

From August 2020 through March 2021, Dr. Hanna was a member of a ten-scientist group at Harvard School of Public Health that developed guidance for the airlines and airline industries on how to best control COVID-19 in airplanes and airports. He analyzed observations from the TRANSCOM field study (sponsored by DARPA), where tracers were released in airplanes and concentrations sampled. He developed a basic science dispersion model and evaluated it with the TRANSCOM data. A journal manuscript on this topic was published in *Indoor Air*.

*Support of Permitting Activities for Nuclear Reactors*

From 2000 through 2020, Dr. Hanna worked on meteorological analyses and report writing as part of permits for several nuclear reactors. The plants include Callaway, Nine Mile Point, Pilgrim, Davis-Besse, Indian Point, and Seabrook. Dr. Hanna testified at the Pilgrim hearing in 2011. In all of these cases, his work focused on the NRC's MACCS2/ATMOS model. He carried out analyses of plant and other local meteorological data in the SAMA domain (50 mile radius) in order to justify use of the plant data in the ATMOS model. In addition, Dr. Hanna has been supported by BP, Mitsubishi Heavy Industries and the Japan Nuclear Agency in various studies related to the Fukushima accident. He was co-organizer of a March 2015 Workshop at Fukushima University regarding applications of transport and dispersion models to nuclear plant accidents. From 2018 through 2020, he was part of a review team for an NRC project in which NOAA's HYSPLIT model is being implemented in MACCS as an alternative to ATMOS.

*Reviews of Diffusion Research*

Dr. Hanna has been requested to prepare written reviews of various aspects of diffusion research by many national and international agencies, industries, and universities. He has been a member of peer-review panels for NRC, DOE, EPA, CDC, DHS, CARB, and DOD programs in the US. For example, in November, 1997, he chaired the Peer Review Panel for the U.S. modeling program for the Khamisiyah, Iraq, chemical releases. In 1998 he chaired the Peer Review Panel for the EPA's new AERMOD model. In 2005, he was a reviewer of the DTRA Chemical/Biological Defense Science Program. From 2014 through 2018, he was on the peer-review committee for the Barnett shale methane study and on the EPA CASAC SOx panel. In 2019, he was a member of a six-person international peer-review committee for the Swedish FOI (similar to a national laboratory in the US). He is currently reviewing fall out models for scenarios with nuclear bombs.

*Teaching Experiences at Universities*

Dr. Hanna has been a lecturer or an adjunct professor and/or research professor at four universities: Vanderbilt University and University of Tennessee while he was in Tennessee, Harvard T. H. Chan School of Public Health from 1983 through 2023, and George Mason University from 1997 through 2002. Approximately once each year throughout this period, he has taught graduate-level courses in atmospheric turbulence and dispersion. The Vanderbilt and UT lectures were used as the basis for the Atmospheric Diffusion textbook by Hanna, Briggs, and Hosker (1982), which has been widely adopted as a basic text at other universities. In addition, three or four times a year from 1987-1997, Dr. Hanna taught a two-day short course entitled "Vapor Cloud Dispersion" as part of AIChE/CCPS conferences. From 2002 through 2023, he

presented several lectures a year in Air Quality Meteorology graduate-level courses at HSPH in Boston and in their International Institute in Cyprus. The lectures include hands-on training in use of AERMOD.

*Business Experience*

In 1985, Dr Hanna was a cofounder of Sigma Research Corporation, which carried out basic and applied research on meteorology and air quality issues for a variety of clients. The company grew successfully and was purchased by Earth Tech in 1992. In 1987, Dr. Hanna founded Hanna Consultants, which initially carried out small projects such as EPA peer reviews that did not fall under SRC's scope. Since 1997, he has worked from 50 % to 100% of his time on Hanna Consultants projects. HC's work is sponsored by government agencies, national laboratories, chemical industries, environmental consulting companies, industrial associations, universities, and law firms.

*Expert Witness*

Dr. Hanna has provided testimony in depositions in several litigation cases and has testified in two trials and at two hearings. In most of these cases, he was required to apply and interpret atmospheric transport and dispersion models. He has modeled releases of methyl mercaptan, anhydrous ammonia, vinyl chloride, and chlorine from rail cars, oleum from valve ruptures, sulfuric acid from a stack, hydrogen sulfide from a missile spill, water vapor and particulates from paper mills and cooling towers, small particles and ozone from power plants over the eastern U.S., lead emissions from a smelter, pesticide dispersion, wind flows in Manhattan street canyons, and wind patterns and dispersion of potential releases from nuclear power plants and nuclear bombs.

In January 2018, Dr. Hanna organized and was main speaker and moderator of an American Meteorological Society Short Course on Forensic Meteorology.

In the past four years, Dr. Hanna has had his deposition taken twice (see below).

May 14, 2024 – Deposition taken on modeling particle concentrations in the air due to releases from burning sugar cane fields in Maui. Re: MITCHELL HARGREAVES, KATRINA HARGREAVES, LUKE HARGREAVES, FRANK FORBES, HILDA FORBES, Individually and as Next Friend for S.F., a Minor, DAVID STEIN, and NYLA NOLAN, Individually and as Next Friend for M. S., a Minor, Plaintiffs, v. 1) ALEXANDER & BALDWIN, LLC, a Delaware corporation; and 1) Does 1 to 10, 1. Defendants. IN THE CIRCUIT COURT OF THE FIRST CIRCUIT STATE OF HAWAII CIVIL NO. 1CCV-21-0001330 3. (Toxic Tort /Personal Injury). |

October 11, 2023 – Deposition taken on modeling $H_2S$ concentrations due to releases from the New Indy SC paper mill. Re: *Kennedy et al. v. New Indy Catawba LLC and New England Containerboard LLC, Case No. 0:21-cv-0174-SAL, US District Court, District of South Carolina, Rock Hill Division.*

PROFESSIONAL ORGANIZATIONS

Member of the American Meteorological Society (AMS), for whom he carried out the following volunteer activities.  Certifications and awards are also listed.
  Chief Editor, *Journal of Applied Meteorology*, 1988-1997
  Chairman, Atmospheric Turbulence and Diffusion Committee, 1977-1978
  Member, AMS/EPA Cooperative Work Group, 1979-1981
  Member, AMS Board on Urban Meteorology, 2002-2009
  Member, AMS Board of Certified Consulting Meteorologists, 2015-2019
  Chairman, 1974 Atmos. Turb. and Diff. Conference, Santa Barbara
  Co-Chairman of Urban Environment Conferences in 2004 (Vancouver) and 2006
          (Atlanta)
  AMS Certified Consulting Meteorologist (Number 361)   1983
  Recipient of 1994 AMS Award for Outstanding Contribution to the Advance of Applied
          Meteorology
  Fellow, 2005
  Co-Chairman of 2006 Forum on Managing our Physical and Natural Resources:
          Successes and Challenges, Annual Meeting, Atlanta
  Chairman of F.A. Gifford Memorial Session at AMS Annual Meeting, 2008
  Recipient of 2010 AMS Helmut E. Landsberg Award for "Significant novel and
          insightful contributions in applied meteorology and urban studies, including
          field work, data interpretation, model development, and model evaluation"
  Elected AMS Councilor, December 2013 (one year term)
  Recipient of 2015 AMS Henry Harrison Award for Certified Consulting Meteorologists.
  Recipient of 2016 AMS Award for Outstanding Scientific Contributions in
          Meteorological Aspects of Air Pollution.
Member of the Air and Waste Management Association (AWMA)
Member of American Geophysical Union (AGU)
Member of American Institute of Chemical Engineers

## INVITED AUTHOR OF BOOKS

1. Hanna, S.R., 1982:  *Review of Atmospheric Diffusion Models for Regulatory Applications*.
     World Meteorological Organization Technical Note No. 177, WMO No. 581, Geneva,
     Switzerland.

2. Hanna, S.R., G.A. Briggs and R.P. Hosker, 1982:  *Handbook on Atmospheric Diffusion*.
     DOE/TIC-11223, Department of Energy, 102 pp.

3. Hanna, S.R. and P.J. Drivas, 1987:  *Guidelines for the Use of Vapor Cloud Dispersion Models.*
     Published by CCPS/AIChE, 345 East 47th St., New York, NY 10017, 178 pp.

4. Hanna, S.R., and D.G. Strimaitis, 1988:  *Workbook of Test Cases for Vapor Cloud Source
     Emission and Dispersion Models*.  Published by CCPS/AIChE, 345 East 47th St., New
     York, NY 10017, 103 pp.

5. Hanna, S.R., P.J. Drivas, and J.C. Chang, 1996:  *Guidelines for Use of Vapor Cloud
     Dispersion Models (Second Edition)*. Published by AIChE/CCPS, 345 East 47th St.,

New York, NY 10017, 285 pages + diskette.

6.  Hanna, S.R. and R.E. Britter, 2002:  *Wind Flow and Vapor Cloud Dispersion at Industrial and Urban Sites.*  ISBN No: 0-8169-0863-X, CCPS/AIChE. 3 Park Ave., New York, NY 10016-5901, 140 pages + CD-ROM.  DOI:10.1002/9780470935613

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## PUBLICATIONS IN PEER REVIEWED JOURNALS

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2.  Hanna SR. The thickness of the planetary boundary layer.  Atmos Environ 1969; 3:519-536.

3.  Hanna SR. The formation of longitudinal sand dunes by large helical eddies in the atmosphere.  J Appl Met 1969; 8:874-883.

4.  Hanna SR, Swisher SD. Meteorological effects of the heat and moisture produced by man.  Nuclear Safety 1971; 12:114-122.

5.  Hanna SR, Hoecker WH. The response of constant-density balloons to sinusoidal variations of vertical wind speeds.  J Appl Met 1971; 10: 601-604.

6.  Hanna SR, Gifford FA. Summary of meeting on mesoscale atmospheric modeling. Bull Am Met Soc 1971;  52:993.

7.  Hanna SR. Simple methods of calculating dispersion from urban areas sources.  J Air Poll Control Assn 1971;  21:774-777.

8.  Hanna SR. Depth of boundary layer.  Discussion.  Atmos Environ 1971;  5:67-69.

9.  Hanna SR, Swisher SD. A method for calculating the size of cooling tower plumes. Atmos Environ 1972;  6:587-588.

10.  Hanna SR. Rise and condensation of large cooling tower plumes.  J Appl Met 1972: 11:793-799.

11.  Hanna SR. Comments on a comparison of wet and dry bent-over plumes and rebuttal. J Appl Met 1972;  11:1386-1387.

12.  Gifford FA, Hanna SR. Modeling urban air pollution.  Atmos Environ 1973;  7:131-136.

13.  Hanna SR. Description of ATDL computer model for dispersion from multiple sources. In:  Noll KE, Duncan JR,eds.  Industrial Air Pollution Control:  Chapter 4, 1973:23-32.

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15. Hanna SR. A simple model for the analysis of chemically reactive pollutants. Atmos Environ 1973; 7:803-817.

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23. Hanna SR, Gifford FA. Discussion of paper by Goumans and Clarenburg, a simple model to calculate the $SO_2$ concentrations in urban regions. Atmos Environ 1975; 10:564.

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25. Hanna SR. A comparison of observed and predicted cooling tower plume rise and visible plume length. Atmos Environ 1975; 10:1043-1052.

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29. Hanna SR. Comments on observations of an industrial cumulus. J Appl Met 1976; 15:1232-1233.

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