Andrew J. Annunzio, Ph.D.

Professional Overview

- Atmospheric scientist and applied mathematician with theoretical and applied research experience
- Proven track record of providing timely technical solutions to meteorological research problems
- Extensive background in numerical weather prediction, meteorological analysis, climate analysis, air pollution modeling, artificial intelligence based optimization techniques, atmospheric turbulence, and data analysis
- Four years of experience as a research meteorologist in the commodities sector
- Proficient in mathematical and statistical computer programming languages

Education

The Pennsylvania State University
Ph.D. in Meteorology 2008 - 2011
Dissertation: "Assessing the Lagrangian framework and state estimation for forward and inverse atmospheric transport and dispersion modeling"

The Pennsylvania State University
M.S. in Meteorology 2006 - 2008
Thesis: "Source characterization including atmospheric boundary layer depth"

The Ohio State University
B.S. in Geography (Atmospheric Science track) and Mathematics (minor) with honors and distinction 2002 - 2006
Thesis: "Variations in upper tropospheric temperatures and stability indices over the past 46 years in the Gulf of Mexico, and the influence the warming earth has on tropical systems"

Professional Positions

Open Systems Technologies
Consultant 06/2018 - present
- Weather consultant for Millennium Management, LLC where tasks are the same as mentioned below

Aeris, LLC
Scientist III 06/2018 - present
Consultant 06/2016 - 08/2016
- Similar role to Science and Technology in Atmospheric Research described below
- Work to date has focused on developing a wind quality control algorithm for wind measurements derived from a LIDAR to drive atmospheric transport and dispersion predictions

Millennium Management, LLC
Analyst 08/2016 - 06/2018

- A one man meteorology team whose goal is to improve the understanding of meteorological phenomenon, quantify the distributional risk inherent in subseasonal and seasonal weather prediction, and attempt to improve weather forecast skill to support investment decisions
- Build a database of atmospheric model forecasts, meteorological observations, atmospheric reanalyses, and meteorological signals for research and analysis.
- Build tools to visualize weather data pertinent to energy markets such as weather signal time series and impact on EDDs, as well as EDD forecasts from weather vendors and numerical model output
- Perform research to determine which variables have predictive power on weekly to monthly time scales. This is done for weather variables traditionally looked at by the market as well as non-traditional meteorological variables in academic literature
- Perform machine learning to develop predictive models that use the signals as input
- Read academic literature to improve understanding of meteorological phenomenon, discover state of the science forecasting signals, and apply newly published research to meteorological prediction
- Continuously communicate research findings, short to long term weather forecasts, market interpretation of forecast variables, and interpretation of weather forecasts from predictive models to portfolio managers

Citadel, LLC
Weather Analyst 08/2014 - 06/2016

- Sole meteorologist for the US natural gas team who developed a more rigorous and quantitative weather forecasting process to improve weather forecasts, and to improve the understanding of distributional forecast risks to support investment decisions
- Performed research on climate variables to better capture the distributional risk for seasonal and subseasonal weather outcomes
- Performed statistical analyses on weather vendor and numerical model forecasts to diagnose forecast skill, utility, and biases
- Communicate vendor forecasts and forecast reasoning to portfolio managers, and use research to assess the validity of these forecasts
- Build statistical models for weather prediction including national degree day and wind power forecasts

The National Center for Atmospheric Research: Applied Research Laboratory
Project Scientist I 07/2013 - 08/2014
Associate Scientist III 10/2011 - 07/2013
Associate Scientist II 10/2010 - 10/2011

- Led and assisted projects that involved meteorological and air pollution modeling for Department of Defense applications
- Created a large dataset of high-resolution flow field and pollutant transport predictions using the Weather Research and Forecasting model. These datasets were used to perform Department of Defense analyses for airborne hazards including:
  - Sensor testing and evaluation for technology investment decisions
  - Hazard assessment for human effects modeling
  - Air pollution detection algorithms for sensor networks
  - Downwind hazard prediction
- Discerned how data quantity, fidelity, and resolution impacts defense systems' analyses
- Performed verification and validation of meteorological and air pollution modeling tools

- Investigated and utilized optimization techniques to determine the initial conditions for air pollution release events
- Participated in and led programmatic meetings and teleconferences
- Presented research results to funding agency sponsors and at professional conferences

Science and Technology for Atmospheric Research
Project Scientist I 07/2013 - 08/2014
Associate Scientist III 10/2011 - 07/2013
Associate Scientist II 04/2011 - 10/2011

- Provided timely solutions in a fast paced work environment to develop, validate, and operationalize meteorological and air pollution modeling systems for Department of Defense applications
- Led and worked closely with a team of scientists and engineers to build a coupled, ensemble weather prediction and air pollution prediction systems using the Weather Research and Forecasting model
- Determined performance of ensemble modeling systems using statistical verification and validation techniques
- These modeling systems were used to generate large quantities of data to:
  - Develop signal processing techniques to better understand sensor measurements
  - Perform sensor placement optimization studies
  - Provide better uncertainty estimates for hazard assessment and prediction
- Worked closely with the sponsor to integrate the developed modeling systems into everyday operations
- Wrote technical reports and modeling system user manuals for the funding agency sponsors

Provisio Scientific, LLC
Co-Owner 08/2013 - 08/2014

- Co-founder of a start-up company for weather forecasting applications
- Applied signal processing techniques to meteorological datasets to amplify meteorological signals
- Utilized machine learning/neural network techniques to perform pattern recognition on the processed meteorological datasets for weather forecasting applications

The Pennsylvania State University and The Applied Research Laboratory
Graduate Research Assistant 06/2007 - 10/2010

- Developed and applied a novel optimization technique to better estimate the initial conditions for air pollution and meteorological modeling systems
- Developed a process to perform data denial and association to prepare data for this optimization method
- Applied artificial intelligence/genetic algorithm optimization techniques to meteorological applications
- Analyzed and utilized data assimilation methods for incorporating data into partial and ordinary differential equations to improve model solutions
- Presented research to the funding agency sponsors, and at professional conferences

The Pennsylvania State University
Graduate Teacher Assistant 08/2006 - 06/2007

- Led recitation lectures for general meteorology
- Provided guidance for students during office hours and review sessions
- Graded homework assignments

Chesapeake Energy
Summer Intern 06/2005 - 09/2005
- Assisted in providing weather forecasts and relaying meteorological information to clients in the energy and agricultural financial sectors
- Helped develop statistical meteorological products for clients

Technical Skills

Operating Systems: LINUX High Performance Computing Clusters (HPCC), LINUX, Windows

Programming Languages: Python, Matlab, R, Perl, Bash-shell scripts, FORTRAN, Minitab, Mathematica, IDL, Microsoft Office Suite, Macintosh iWork Suite

Relevant Research Interests

Artificial Intelligence, Atmospheric Turbulence, Data Analysis, Data Mining, Dynamical Systems, Fluid Dynamics, Genetic Algorithms, Long Range Forecasting, Machine Learning, Numerical Weather Prediction, Optimization, Signal Processing, Statistics, and Stochastic Processes

Academic Honors and Professional Memberships

- Phi Kappa Phi (Academic Honor Society)
- Phi Beta Kappa (Academic Honor Society)
- Chi Epsilon Pi (Meteorology Honor Society)
- American Meteorological Society

Professional Service

Department of Meteorology Graduate Advisory Council: Student Member 2009 - 2010
- Lead and participate in meetings related to events within the department of meteorology at the Pennsylvania State University

Meteorological Society's Committee on Meteorological Aspects of Air Pollution: Student Committee Member 2010 - 2011
- Serve as a judge for student presentations

Earth Explorers Science Volunteer 2012
- Participated in an outreach program to inform grade school students about careers in science

Meteorological Society's Committee on Meteorological Aspects of Air Pollution: Committee Member 2011 - 2014
- Participate in meetings to prepare for the annual meteorological conference

- Review abstracts and select relevant abstracts for presentation at the annual conference
- Serve as session chair for conference presentations

Significant Opportunities in Atmospheric Research and Science 2012 - 2014
- Research mentor for students
- Judge for student poster presentations

Tutoring Chicago 2017 - present
- Volunteer tutor for first through sixth grade students

Refereed Journal Publications and Publications in Process

Bieringer, P.E., G.S. Young, A.J. **Annunzio**, F. Vandenberghe, L.M. Rodriguez, and S.E. Haupt, 2017. Paradigms and commonalities in atmospheric source term estimation methods. *Atmospheric Environment*, **156,** 102-112.

Nelson, M.A., M.J. Brown, S.A. Halverson, P.E. Bieringer, A.J. **Annunzio,** and G. Bieberbach, 2016. A case study of the weather research and forecasting model applied to the Joint Urban 2003 tracer field experiment. Part 2: Gas Tracer Dispersion. *Boundary-layer Meteorology,* **161**, 461-490.

Nelson, M.A., M.J. Brown, S.A. Halverson, P.E. Bieringer, A.J. **Annunzio,** and G. Bieberbach, 2016. Assimilation of WRF mesoscale meteorological simulations into the QUIC atmospheric dispersion modeling system. Part 1: Wind and Turbulence. *Boundary-layer Meteorology,* **158**, 285 – 309.

Bieringer, P.E., A.J. **Annunzio**, G. Bieberbach, N. Platt, and J. Hannon, 2014. Contrasting the use of single realization versus ensemble average chemical and biological threats for defense analyses. *Journal of Applied Meteorology and Climatology.* **53**, 1399-1415.

Urban, J.T., K. Galvin, N. Platt, P.E. Bieringer, G. Bieberbach, and A.J. **Annunzio**, 2013. Comparison of hazard area and casualty predictions of a small-scale chemical attack using various toxic load toxicity models. *International Journal of Environment and Pollution.* **54**.

Haupt, S.E., A.J. **Annunzio**, and K.J. Schmehl, 2013. Evolving dispersion realizations of atmospheric flow. *Boundary-Layer Meteorology,* **149**, 197-217.

Bieringer, P.E, P.S. Ray, and A.J. **Annunzio,** 2012. The effect of topographic variability on initial condition sensitivity of low-level wind forecasts. Part I: Experiments using idealized terrain. *Monthly Weather Review,* **141**, 2137-2155.

Bieringer, P.E., P.S. Ray, and A.J. **Annunzio**, 2012. The effect of topographic variability on initial condition sensitivity of low-level wind forecasts. Part II: Experiments using real terrain and observations. *Monthly Weather Review,* **141**, 2156-2172.

Annunzio, A.J., G.S. Young, and S.E. Haupt, 2012. A multi-entity field approximation to determine the source locations of multiple atmospheric contaminant releases. *Atmospheric Environment*, **62**, 593-604.

Annunzio, A.J., G.S. Young, and S.E. Haupt, 2012. Utilizing state estimation to determine the source location for a contaminant. *Atmospheric Environment,* **46**, 580-589.

Peltier, L.J., S.E. Haupt, J.C. Wyngaard, D.R. Stauffer, A. Deng, J.A. Lee, K.J. Long, and A.J. **Annunzio**, 2010. Parameterization of NWP uncertainty for dispersion modeling. *Journal of Applied Meteorology and Climatology*, **49**, 1604-1614.

Selected Conference Proceedings, Abstracts and Presentations

Annunzio, A.J., P.E. Bieringer, R. Cabell, J. Hannon, and E. Lowenstein, 2014. An ensemble based methodology for designing CBRN sensor networks. The Defense Threat Reduction Agency/National Science Foundation Algorithms Workshop, Boulder, CO, March 10-12.

Annunzio, A.J., P.E. Bieringer, G. Bieberbach, R. Cabell, and J. Hurst, 2014. Utilizing synthetic, single realization, atmospheric transport and dispersion datasets for sensor testing and evaluation. 18th Joint Conference on the Applications of Air Pollution Meteorology with the A&WMA, 94th American Meteorological Society Annual Meeting, Atlanta, GA, February 2-5.

Annunzio, A.J., P.E. Bieringer, G. Bieberbach, and R. Cabell, 2012. An alternate approach to analyzing chemical and biological sensors and sensor detection algorithms. Defense Threat Reduction Agency/National Science Foundation Algorithm Workshop, San Diego, CA, November 26-29.

Annunzio, A.J., P.E. Bieringer, G. Bieberbach, and R. Cabell, 2012. An ensemble based method for estimating the effectiveness of standoff chemical and biological sensing technologies. 16th Annual George Mason University Conference on Atmospheric Transport and Dispersion Modeling, Fairfax, VA, July 17-18.

Annunzio, A.J., P.E. Bieringer, G. Bieberbach, and R. Cabell, 2012. Use of synthetic single realization transport and dispersion scenarios for chemical and biological defense analyses. 17th Conference on Air Pollution Meteorology and the A&WMA, 92nd American Meteorological Society Annual Meeting, New Orleans, LA, January 22-26.

Annunzio, A.J., G.S. Young, S.E. Haupt, L.M. Rodriguez, and P.E. Bieringer, 2011. A multi-entity field approximation for hazard origin estimation. 15th Annual George Mason University Conference on Atmospheric Transport and Dispersion Modeling, Fairfax, VA, July 11-14.

Annunzio, A.J., S.E. Haupt, and G.S. Young, 2010. Determining turbulence scaling variables and source characteristics from contaminant concentration data. 16th Conference on Air Pollution Meteorology, 90th American Meteorological Society Annual Meeting, Atlanta, GA, January 18-22.

Annunzio, A.J., S.E. Haupt, G.S. Young, and L.M. Rodriguez, 2010. Combined methods from entity and field frameworks to determine the source characteristics of a contaminant. 16th Conference on Air Pollution Meteorology joint session with 8th Conference on Artificial Intelligence Applications to Environmental Science, 90th American Meteorological Society Annual Meeting, Atlanta, GA, January 18-22.

Annunzio, A.J., S.E. Haupt, G.S. Young, and L.M. Rodriguez, 2009. Mixed Lagrangian/Eulerian methods to determine the source characteristics of a contaminant. Chemical and Biological Defense Science and Technology Conference, Dallas, TX, November 16-20.

Annunzio, A.J., S.E. Haupt, G.S. Young, and L.M. Rodriguez, 2009. Entity methods applied to the FFT 07 Data Set. 13th Annual George Mason University Conference on Atmospheric

Annunzio, A.J., S.E. Haupt, and G.S. Young, 2009. Methods of mitigating uncertainty in contaminant dispersion in a turbulent flow: Data Assimilation vs. Multisensor data fusion. 13th Conference on Integrated Observing and Assimilation Systems for Atmosphere, Oceans, and Land Surface, 89th American Meteorological Society Annual Meeting, Phoenix, AZ, January 11-15.

Annunzio, A.J., S.E. Haupt, and G.S. Young, 2008. Source characterization considering atmospheric boundary layer depth as a variable. 12th Annual George Mason University Conference on Atmospheric Transport and Dispersion Modeling, July 8-10, 2008.

Annunzio, A.J., S.E. Haupt, and G.S. Young, 2008. Source characterization and meteorology retrieval including atmospheric boundary layer depth using a Genetic Algorithm. 15th Joint Conference on the Applications of Air Pollution Meteorology with the A&WMA, 88th American Meteorological Society Annual Conference, New Orleans, LA, January 20-24.

Annunzio, A.J., S.E. Haupt, and G.S. Young, 2007. Comparing assimilation and sensor data fusion techniques for dispersion modeling. 11th George Mason Conference on Atmospheric Transport and Dispersion, Fairfax, VA, July 10-12.

Technical Reports

Lawrence W.G., E.C. Wack, D.C. Jamrog, J.C. Biddle, H.W. Lau, S.E. Holster, C.J. Smith, A.K. Goyal, F.D. D'Arcangelo, A.J. **Annunzio**, P.E. Bieringer, R. Cabell, and G. Bieberbach, 2013. Scientific evaluation of technologies for standoff detection of chemical and biological agents. Defense Threat Reduction Agency Final Report.

Annunzio A.J., P.E. Bieringer, G. Bieberbach, and R. Cabell, 2012. Analysis of alternatives for standoff chemical and biological detection technologies. Defense Threat Reduction Agency Final Report.

Haupt, S.E., G.S. Young, K.J. Long, A. Beyer-Lout, L.M. Rodriguez, A.J. **Annunzio**, and C.T. Allen, 2008. Assimilating concentration and wind data for dispersion modeling. Applied Research Laboratory Technical Report: ARL TR 08-005.

Invited Talks

Back-trajectory based methods for source parameter estimation, presented at the National Center for Atmospheric Research, February 23rd, 2012.

Use of synthetic single realization transport and dispersion scenarios for chemical and biological defense analyses, presented at the National Center for Atmospheric Research, February 8th, 2012.

Mixed Eulerian/Lagrangian Methods to Determine the Source Information for a contaminant, presented at The Applied Research Lab, July 9, 2010.