Dr. Kai-Lan Chang (as of November 2024)

Cooperative Institute for Research in Environmental Sciences (CIRES)
University of Colorado Boulder/NOAA Chemical Sciences Laboratory (CSL)
325 Broadway, R/CSL4, Boulder, CO 80305 USA
kai-lan.chang@noaa.gov; Tel: 303-578-0635
https://csl.noaa.gov/staff/kai-lan.chang/

Appointments

Research Scientist II, CIRES & NOAA CSL, 2021-present

Research Scientist I, CIRES & NOAA CSL, 2018-2021

National Research Council Fellow, NOAA CSL, 2017-2018

National Research Council Fellow, NOAA Global Monitoring Laboratory, 2016-2018

Research Associate, Department of Statistical Science, University College London, UK, 2016

Clerk, Directorate-General of Budget, Accounting and Statistics, Taiwan, 2007-2010

Education

University College London, UK
Ph.D., Statistics, 2011-2015
M.S., Statistics, 2010-2011

National Taiwan University, Taiwan
B.S., Public Health, minor in Mathematics, 2002-2006

Awards

CIRES outstanding performance award, 2020

US National Research Council research associateship award, 2015

Costas Goutis [dissertation] prize, Department of Statistical Science, UCL, 2013

Taiwanese government sponsorship for Ph.D. overseas study, 2009

Service

Manager, CIRES project: Atmospheric Composition Modeling

Co-convener, EGU24 session: Trends, impacts and future of tropospheric ozone

Group lead, Tropospheric Ozone Assessment Report II statistics focus working group (2021-present)

Contributor to the 2018 WMO/UNEP Scientific Assessment of Ozone Depletion

Grant reviewer for the Dutch Research Council

Journal reviewer for *Computational Statistics & Data Analysis*; *Atmospheric Chemistry & Physics*; *Atmospheric Science Letters*, *Mathematics Magazine*; *Atmospheric Environment*; *Atmospheric Measurement Techniques*; *Elementa: Science of the Anthropocene*; *Journal of Geophysical Research: Atmospheres*; *Journal of Environmental Sciences*; *Geoscientific Model Development*; *Earth and Space Science*; *Urban Climate*; *Earth System Science Data*; *Environmental Science & Technology*; *Scientific Reports*; *Atmospheric Pollution Research*; *Geophysical Research Letters*; *Scientific Data*; *Climatic Change*; *Mathematical Biosciences and Engineering*; *Environmental Science and Pollution Research*; *International Journal of Climatology*; *Environmental Technology & Innovation*

Grants

Co-I/Institutional PI, *Mapping global surface ozone concentrations through data fusion of satellite and ground observations with models for informing management of global health and agricultural impacts*, NASA ACMAP, 2023

Co-I/Institutional PI, *Solving the mystery of the disappearing low ozone values: attributing ozone trends over the Eastern Pacific Ocean and Western North America*, NASA ACCDAM, 2021

Research grant supported by University of North Carolina at Chapel Hill & NASA Health and Air Quality Applied Sciences Team, *Using sciences to inform management* [under the supervision of Prof J. Jason West], 2017

Co-Applicant, *Accelerated climate model emulation to capture uncertainties in modelling of future climate*, ReCoVER (Research on Changes of Variability and Environmental Risk) pilot study, 2015

Refereed Articles

33. Cooper OR, **Chang K-L**, Bates K, Brown SS, Chace WS, Coggon MM, Gorchov Negron AM, Middlebrook AM, Peischl J, Piasecki A, Schafer N, Stockwell CE, Wang S, Warneke C, Zuraski K, Miyazaki K, Payne VH, Pennington EA, Worden JR, Bowman, KW, and McDonald BC (2024) Early season 2023 wildfires generated record-breaking surface ozone anomalies across the U.S. Upper Midwest, *Geophysical Research Letters*, doi:10.1029/2024GL111481

32. Feinberg A, Selin NE, Braban CF, **Chang K-L**, Custódio D, Jaffe DA, Kyllönenf K, Landis MS, Leeson SR, Molepo KM, Murovec M, Mastromonaco MGN, Pfaffhuber KA, Rüdiger J, Sheu G-R, and St. Louis VL (2024) Unexpected anthropogenic emission decreases explain recent atmospheric mercury concentration declines, *Proceedings of the National Academy of Sciences*, doi:10.1073/pnas.2401950121

31. Gaudel A, Bourgeois I, Li M, **Chang K-L**, Ziemke JR, Sauvage B, Stauffer RM, Thompson AM, Kollonige DE, Smith N, Hubert D, Keppens A, Cuesta J, Heue K-P, Veefkind P, Aikin, K., Peischl, J., Thompson, C. R., Ryerson, T. B., Frost GJ, McDonald BC and Cooper OR (2024) Tropical tropospheric ozone distribution and trends from in situ and satellite data, *Atmospheric Chemistry & Physics*, doi:10.5194/acp-24-9975-2024

30. Cooper OR, Ziemke JR and **Chang K-L** (2024) Tropospheric ozone [in: "State of the Climate in 2023"], *Bulletin of the American Meteorological Society*, doi:10.1175/BAMS-D-24-0116.1

29. **Chang K-L**, Cooper OR, Gaudel A, Effertz P, Petropavlovskikh I, Morris G and McDonald BC (2024) Challenges in detecting free tropospheric ozone trends in a sparsely sampled environment, *Atmospheric Chemistry & Physics*, doi:10.5194/acp-24-6197-2024

28. Putero D, Cristofanelli P, **Chang K-L**, Dufour G, Beachley G, Couret C, Effertz P, Jaffe D, Kubistin D, Lynch J, Petropavlovskikh I, Puchalski M, Sharac T, Sive BC, Steinbacher M, Torres C and Cooper OR (2023) Fingerprints of the COVID-19 economic downturn and recovery on ozone anomalies at high-elevation sites in North America and Western Europe, *Atmospheric Chemistry & Physics*, doi:10.5194/acp-23-15693-2023

27. Becker J, DeLang M, **Chang K-L**, Serre ML, Cooper OR, Wang H, Schultz MG, Schroder S, Lu X, Zhang L, Deushi M, Josse B, Keller CA, Lamarque J-F, Lin M, Liu J, Marécal V, Strode SA, Sudo K, Tilmes S, Zhang L, Brauer M and West JJ (2023) Using regionalized air quality model performance and Bayesian maximum entropy data fusion to map global surface ozone concentration, *Elementa: Science of the Anthropocene*, doi:10.1525/elementa.2022.00025

26. Cooper OR, Ziemke JR and **Chang K-L** (2023) Tropospheric ozone [in: "State of the Climate in 2022"], *Bulletin of the American Meteorological Society*, doi:10.1175/BAMS-D-23-0090.1

25. Peischl J, Aikin KC, McDonald BC, Harkins C, Middlebrook AM, Langford AO, Cooper OR, **Chang K-L**, and Brown SS (2023) Quantifying anomalies of air pollutants in nine U.S. cities during 2020 due to COVID-19 lockdowns and wildfires based on decadal trends, *Elementa: Science of the Anthropocene*, doi:10.1525/elementa.2023.00029

24. **Chang K-L**, Cooper OR, Rodriguez G, Iraci LT, Yates EL, Johnson MS, Gaudel A, Jaffe DA, Bernays N, Clark H, Effertz P, Leblanc T, Petropavlovskikh I, Sauvage B and Tarasick DW (2023) Diverging ozone trends above western North America: boundary layer decreases versus free tropospheric increases, *Journal of Geophysical Research: Atmospheres*, doi:10.1029/2022JD038090

23. Malashock D, Delang M, Becker J Serre ML West JJ, **Chang K-L**, Cooper OR and Anenberg S (2022) Global trends in ozone concentration and attributable mortality for urban, peri-urban, and rural areas between 2000 and 2019: a modelling study, *The Lancet Planetary Health*, doi:10.1016/S2542-5196(22)00260-1

22. Wang H, Lu X, Jacob DJ, Cooper OR, **Chang K-L**, Li K, Gao M, Liu Y, Sheng B, Wu K, Wu T, Zhang J, Sauvage B, Nédélec P, Blot R and Fan S (2022) Global tropospheric ozone trends, attributions, and radiative impacts in 1995–2017: an integrated analysis using aircraft (IAGOS) observations, ozonesonde, and decadal chemical model simulations, *Atmospheric Chemistry & Physics*, doi:10.5194/acp-22-13753-2022

21. Fiore AM, Hancock SE, Lamarque J-F, Correa GP, **Chang K-L**, Ru M, Cooper OR, Gaudel A, Polvani LM and Ziemke JR (2022) Understanding recent tropospheric ozone trends in the context of large internal variability: A new perspective from chemistry-climate model ensembles, *Environmental Research: Climate*, doi:10.1088/2752-5295/ac9cc2

20. Cooper OR, Ziemke JR and **Chang K-L** (2022) Tropospheric ozone [in: "State of the Climate in 2021"], *Bulletin of the American Meteorological Society*, doi:10.1175/BAMS-D-22-0092.1

19. Malashock D, Delang M, Becker J Serre, ML, West JJ, **Chang K-L**, Cooper OR and Anenberg S (2022) Estimates of ozone concentrations and attributable mortality in urban, peri-urban and rural areas worldwide in 2019, *Environmental Research Letters*, doi:10.1088/1748-9326/ac66f3

18. Asher E, Thornberry T, Fahey DW, McComiskey A, Carslaw K, Grunau S, **Chang K-L**, Telg H, Chen P

and Gao R-S (2022) A novel network-based approach to determining measurement representation error for model evaluation of aerosol microphysical properties, *Journal of Geophysical Research: Atmospheres*, doi:10.1029/2021JD035485

17. **Chang K-L**, Cooper OR, Gaudel A, Allaart M, Ancellet G, Clark H, Godin-Beekmann S, Leblanc T, Van Malderen R, Nédélec P, Petropavlovskikh I, Steinbrecht W, Stübi R, Tarasick DW and Torres C (2022) Impact of the COVID-19 economic downturn on tropospheric ozone trends: an uncertainty weighted data synthesis for quantifying regional anomalies above western North America and Europe, *AGU Advances*, doi:10.1029/2021AV000542

16. **Chang K-L**, Schultz MG, Lan X, McClure-Begley A, Petropavlovskikh I, Xu X and Ziemke JR (2021) Trend detection of atmospheric time series: Incorporating appropriate uncertainty estimates and handling extreme events, *Elementa: Science of the Anthropocene*, doi:10.1525/elementa.2021.00035

15. DeLang M, Becker J, **Chang K-L**, Serre ML, Cooper OR, Schultz MG, Schroder S, Lu X, Zhang L, Deushi M, Josse B, Keller CA, Lamarque J-F, Lin M, Liu J, Marécal V, Strode SA, Sudo K, Tilmes S, Zhang L, Cleland S, Collins E, Brauer M and West JJ (2021) Mapping yearly fine resolution global surface ozone through the Bayesian Maximum Entropy data fusion of observations and model output for 1990–2017, *Environmental Science & Technology*, doi:10.1021/acs.est.0c07742

14. Steinbrecht W, Kubistin D, Plass-Dülmer C, Davies J, Tarasick DW, von der Gathen P, Deckelmann H, Jepsen N, Kivi R, Lyall N, Palm M, Notholt J, Kois B, Oelsner P, Allaart M, Piters A, Gill M, Van Malderen R, Delcloo AW, Sussmann R, Mahieu E, Servais C, Romanens G, Stübi R, Ancellet G, Godin-Beekmann S, Yamanouchi S, Strong K, Johnson B, Cullis P, Petropavlovskikh I, Hannigan JW, Hernandez JL, Rodriguez AD, Nakano T, Chouza F, Leblanc T, Torres C, Garcia O, Röhling AN, Schneider M, Blumenstock T, Tully M, Paton-Walsh C, Jones N, Querel R, Strahan S, Stauffer RM, Thompson AM, Inness A, Engelen R, **Chang K-L** and Cooper OR (2021) COVID-19 crisis reduces free tropospheric ozone across the Northern Hemisphere, *Geophysical Research Letters*, doi:10.1029/2020GL091987

13. Zhang Y, West JJ, Emmons LK, Flemming J, Jonson JE, Lund MT, Sekiya T, Sudo K, Gaudel A, **Chang K-L**, Nédélec P and Thouret V (2021) Contributions of world regions to the global tropospheric ozone burden change from 1980 to 2010, *Geophysical Research Letters*, doi:10.1029/2020GL089184

12. GBD 2019 Risk Factor Collaborators (2020) Global burden of 87 risk factors in 204 countries and territories, 1990–2019: a systematic analysis for the Global Burden of Disease Study 2019, *The Lancet*, doi:10.1016/S0140-6736(20)30752-2

11. **Chang K-L**, Cooper OR, Gaudel A, Petropavlovskikh I and Thouret V (2020) Statistical regularization for trend detection: an integrated approach for detecting long-term trends from sparse tropospheric ozone profiles, *Atmospheric Chemistry & Physics*, doi:10.5194/acp-20-9915-2020

10. Gaudel A, Cooper OR, **Chang K-L**, Bourgeois I, Ziemke JR, Strode SA, Omen L, Sellitto P, Nédélec P, Blot R, Thouret V and Granier C (2020) Aircraft observations since the 1990s reveal increases of tropospheric ozone at multiple locations across the Northern Hemisphere, *Science Advances*, doi:10.1126/sciadv.aba8272

9. Cooper OR, Schultz MG, Schröder S, **Chang K-L**, Gaudel A, Benitez GC, Cuevas E, Fröhlich M, Galbally I E, Molloy S, Kubistin D, Lu X, McClure-Begley A, Nédélec P, O'Brien J, Oltmans SJ, Petropavlovskikh I, Ries L, Senik I, Sjöberg K, Solberg S, Spain GT, Spangl W, Steinbacher M, Tarasick DW, Thouret V and Xu X (2020) Multi-decadal surface ozone trends at globally distributed remote locations, *Elementa: Science of the Anthropocene*, doi:10.1525/elementa.420

8. Banerjee A, Fyfe JC, Polvani LM, Waugh D and **Chang K-L** (2020) A pause in Southern Hemisphere circulation trends due to the Montreal Protocol, *Nature*, doi:10.1038/s41586-020-2120-4

7. Tarasick DW, Galbally IE, Cooper OR, Schultz MG, Ancellet G, Leblanc T, Wallington TJ, Ziemke JR, Liu X, Steinbacher M, Staehelin J, Vigouroux C, Hannigan JW, Garcìa O, Foret G, Zanis P, Weatherhead EC, Petropavlovskikh I, Worden H, Osman M, Liu J, **Chang K-L**, Gaudel A, Lin M, Granados-Muñoz M, Thompson AM, Oltmans SJ, Cuesta J, Dufour G, Thouret V, Hassler B, Trickl T and Neu JL (2019) Tropospheric Ozone Assessment Report: Tropospheric ozone from 1877 to 2016, observed levels, trends and uncertainties, *Elementa: Science of the Anthropocene*, doi:10.1525/elementa.376

6. **Chang K-L**, Cooper OR, West JJ, Serre ML, Schultz MG, Lin M, Marécal V, Josse B, Deushi M, Suto K, Liu J and Keller CA (2019) A new method (M^3Fusion v1) for combining observations and multiple models for an improved estimate of the global surface ozone distribution, *Geoscientific Model Development*, doi:10.5194/gmd-12-955-2019

5. **Chang K-L** and Guillas S (2019) Computer model calibration with large non-stationary spatial outputs: application to the calibration of a climate model, *Journal of the Royal Statistical Society: Series C*, doi:10.1111/rssc.12309
4. GBD 2017 Risk Factor Collaborators (2018) Global, regional, and national comparative risk assessment of 84 behavioural, environmental and occupational, and metabolic risks or clusters of risks for 195 countries and territories, 1990–2017: a systematic analysis for the Global Burden of Disease Study 2017, *The Lancet*, doi:10.1016/S0140-6736(18)32225-6
3. Weatherhead EC, Bodeker GE, Fassò A, **Chang K-L**, Lazo LK, Clack CTM, Hurst DF, Hassler B, English JM and Yorgun S (2017) Spatial coverage of finite monitoring stations: A climate observing system simulation experiment, *Journal of Applied Meteorology and Climatology*, doi:10.1175/JAMC-D-17-0040.1
2. **Chang K-L**, Petropavlovskikh I, Cooper OR, Schultz MG and Wang T (2017) Regional trend analysis of surface ozone observations from monitoring networks in eastern North America, Europe and East Asia, *Elementa: Science of the Anthropocene*, doi:10.1525/elementa.243
1. **Chang K-L**, Guillas S and Fioletov VE (2015) Spatial mapping of ground-based observations of total ozone, *Atmospheric Measurement Techniques*, doi:10.5194/amt-8-4487-2015

Book Chapters

- Petropavlovskikh I, Sofieva V, Firth SM, Tourpali K, Vigouroux C, Wild JD, Ball WT, Chang K-L, Davis SM, Degenstein DA, Froidevaux L, Godin-Beekmann S, Hubert D, Laeng A, Leblanc T, Maillard Barras E, Smit HGJ and Steinbrecht W (2019) Observations and model data [in: "SPARC/IO3C/GAW report on Long-term Ozone Trends and Uncertainties in the Stratosphere"]
- Damadeo R, Hassler B, Zawada DJ, Firth SM, Ball WT, Chang K-L, Degenstein DA, Hubert D, Misios S, Petropavlovskikh I, Roth CZ, Sofieva V, Steinbrecht W, Tourpali K and Zefefos CS, (2019) The LOTUS regression model [in: "SPARC/IO3C/GAW report on Long-term Ozone Trends and Uncertainties in the Stratosphere"]
- Hassler B, Damadeo R, Chang K-L, Sofieva V, Tourpali K, Firth SM, Ball WT, Degenstein DA, Godin-Beekmann S, Hubert D, Maillard Barras E, Misios S, Petropavlovskikh I, Roth CZ, Steinbrecht W, Vigouroux C, von Clarmann T, Zawada DJ and Zefefos CS (2019) Time series and trend results [in: "SPARC/IO3C/GAW report on Long-term Ozone Trends and Uncertainties in the Stratosphere"] [available at `https://www.sparc-climate.org/publications/sparc-reports`]

Other Publications

- Chang K-L, Schultz MG, Koren G and Selke N (2023) Guidance note on best statistical practices for TOAR analyses [available at `https://igacproject.org/activities/TOAR/TOAR-II`]
- Chang K-L (2022) Lecture on quantile regression, doi:10.34730/f52a5d792fbb42c3b1f1b92333d4d86e
- Frost G, Brewer A, Granier C and Chang K-L (2021) StoryMap presentations on "Atmospheric Composition, Chemistry, and Dynamics" [available at `https://storymaps.arcgis.com/stories/51ee218dec9c421c8476a81e4d71f22d`]
- Thompson C, Cooper O, Doherty S and Chang K-L (2021) StoryMap presentations on "CSL Leadership and Contributions to the Scientific Community" [available at `https://storymaps.arcgis.com/stories/ce8654fa22e946be8401406aa009ae74`]

Presentations

- TOLNet science team meeting, Boulder, CO, USA, 05/2024
- EGU general assembly, Vienna, Austria, 04/2024
- Seminar, TOAR machine learning working group, 03/2024
- AGU fall meeting, San Francisco, CA, USA, 12/2023
- EGU general assembly, Vienna, Austria, 04/2023
- TFHTAP meeting [virtual, invited], 04/2023
- TOAR workshop, Cologne, Germany, 03/2023
- IGAC conference, Manchester, UK, 09/2022
- TOAR data workshop, Julïch, Germany [invited], 06/2022
- TFHTAP meeting [virtual, invited], 05/2022
- AGU fall meeting, New Orleans, LA, USA, 12/2021
- IGAC conference [virtual], 09/2021
- HEGIFTOM (Harmonization and Evaluation of Ground Based Instruments for Free Tropospheric Ozone Measurements) workshop [virtual, invited], 03/2021
- TOAR-II kick-off workshop [virtual], 01/2021

- NOAA ESRL global monitoring annual conference [virtual], 07/2020
- AMS annual meeting, Boston, MA, USA, 01/2020
- CIRES rendez-vous, Boulder, CO, USA, 05/2019
- NOAA ESRL global monitoring annual conference, Boulder, CO, USA, 05/2018
- NOAA ESRL global monitoring annual conference, Boulder, CO, USA, 05/2017
- LOTUS workshop, Paris, France, 03/2017
- AGU fall meeting, San Francisco, CA, USA, 12/2016
- CliMathNet conference, Exeter, UK, 07/2016
- SIAM conference on uncertainty quantification, Lausanne, Switzerland, 04/2016
- Computational and data challenges in environmental modelling, Cambridge, UK, 02/2016
- International conference on uncertainty quantification in computational sciences and engineering, Crete Island, Greece, 05/2015
- Calculating and communicating uncertainty, London, UK, 01/2015
- Latsis symposium on atmosphere and climate dynamics, Zurich, Switzerland, 06/2014
- CCMI workshop, Lancaster, UK, 05/2014
- SIAM conference on uncertainty quantification, Savannah, GA, USA, 04/2014
- Seminar, University College London, UK, 10/2013