

ENRICO CAMPOREALE

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www.mlspaceweather.org



CURRENT POSITION

- 2019 – present** Research Associate, Cooperative Institute for Research in Environmental Sciences, University of Colorado, Boulder & NOAA, Space Weather Prediction Center (Boulder, CO, USA)
- 2014 – present** Scientific Staff Member, Multiscale Plasma Dynamics Group
Center for Mathematics and Computer Science (CWI), Amsterdam, NL

EDUCATION

- 2005 – 2008** PhD in Space Plasma Physics
Queen Mary University of London (UK)
Thesis title: Kinetic aspects of Solar Wind turbulence
- 1998 – 2004** Master of Science (Laurea) in Nuclear Engineering
Politecnico di Torino (Italy)
Thesis title: Model of bifurcated current sheets in the Earth's magnetotail: equilibrium and stability
Grade: 110 / 110 cum laude

RESEARCH EXPERIENCE

- 2010 – 2013** Postdoctoral Research Assistant
Los Alamos National Laboratory (USA)
- 2008 – 2010** Postdoctoral Research Assistant
Queen Mary University of London (UK)
- 2004 – 2005** Graduate Research Assistant (post-Master)
Los Alamos National Laboratory (USA)

RESEARCH INTERESTS

Space Weather, Solar-Terrestrial Physics, Machine Learning, Computational Methods for Space Plasma Physics.

FUNDING

- PI of NWO – VIDI grant (personal grant from the Dutch Agency for Scientific Research) ***Real-time forecasting of killer electrons on satellite orbits***. Period: 11/2017 – 11/2022. Value: €860,000 www.mlspaceweather.org
- PI of the project ***Data-Enhanced simulations for Space Weather predictions*** within the CWI–INRIA collaboration in Computational Sciences. Period: 09/2015 – 09/2019. Value: €233,000 <https://project.inria.fr/inriacwi/projects/mdg-tao>
- PI of NASA grant ***Machine Learning in Heliophysics*** (NNH19ZDA001N-TWSC:Topical Workshops, Symposia, and Conferences). Value: \$20,000
- co-PI of the Horizon-2020 (EU) project ***AIDA (Artificial Intelligence Data Analysis)***. Period: 09/2018 – 09/2021 PI: Prof. Lapenta. Total Value: €1,500,000. PI of the work package Machine Learning (value: €220,000). Website: <http://www.aida-space.eu>
- co-PI of the Horizon-2020 (EU) project ***ESCAPE (European Science Cluster of Astronomy & Particle Physics)***. Total Value: €16M. Website: <https://projectescape.eu/>
- co-I of the NASA grant ***A machine learning based specification and forecast model of the inner magnetospheric radiation environment*** (PI: Bortnik, NASA Heliophysics Research Program NNH18ZDA001N-HSWO2R)
- co-I of the NWO (Netherlands Organisation for Scientific Research) ***Let CO2 spark! Understand breakdown dynamics for high voltage technology and lightning***. Period: 02/2017 – 09/2021. PI: Prof. Ebert, Total Value: €950,000. Website: <https://www.narcis.nl/research/RecordID/OND1362478/Language/en>
- co-I of Marie Skłodowska-Curie Action – Innovative Training Network (ITN) ***SAINT Science and Innovation with Thunderstorms*** Coordinator: Danmarks Tekniske Universitet. Total Value: €3,996,874. Website: <https://www.saint-h2020.eu/>
- co-PI of NASA grant ***Global Evolution and Local Dynamics of the Kinetic Solar Wind*** (under evaluation, PI: Velli, NNH19ZDA001N-HTMS:Heliophysics Theory, Modeling, and Simulations)
- co-I of NASA grant ***Solar Storms and Terrestrial Impacts Center (SOLSTICE)*** (under evaluation, PI: Gombosi, NNH18ZDA001N-DRIVE:Heliophysics Phase I DRIVE Science Centers)

I have actively participated in the formulation of the following successful proposals, where I have played the role of co-applicant, co-I, co-PI, or external advisor (during my postdoc at LANL I was not allowed to act as PI for internal proposals).

- Leverhulme Trust grant. *From geometry to kinetic-fluid systems (and back)* (2015) PI: Dr. Tronci. Value: £252,676
- London Mathematical Society – Research in Pairs (2014) PI: Dr. Tronci. Value: £530 (travel grant)
- Los Alamos National Lab – Institute of Geophysics, Planetary Physics (2013) *Wave-particle interaction in the radiation belt: beyond quasi-linear diffusion*. PI: Dr. Delzanno. Value: \$75,000.

- Los Alamos National Lab – Laboratory Directed Research and Development (LDRD) (2012) *A new approach to multiscale Plasma Physics Simulations*. PI: Dr. Delzanno. Value: \$1,170,000.
- Los Alamos National Lab – Laboratory Directed Research and Development (LDRD) (2011) *Multiscale Spacecraft Charging Simulations in support of New Space Missions*. PI: Dr. Delzanno. Value: \$1,170,000.
- Science and Technology Facilities Council (UK) grant. *Kinetic plasma turbulence in plasma and astrophysical flows*. (2010) PI: Prof. Burgess. Value: £332,010

ACADEMIC SUPERVISION

Current/upcoming students and postdocs

- Mandar Chandorkar: day-to-day supervision of **PhD project** on the use of *Machine Learning for Space Weather simulations* (graduation November 2019)
- Rakesh Sarma: **postdoc** on VIDI project, working on *Bayesian parameter estimation in radiation belts simulations*.
- Carl Shneider: **postdoc** on VIDI project, working on *Deep Learning from solar images*.
- Andong Hu: **postdoc** on AIDA project, working on *Machine Learning python package AIDApv*.

Past students and postdocs

- Amin Taziny (summer 2019): undergraduate SOARS student (<https://www.soars.ucar.edu/>) on *Modeling electron auroral precipitation with machine learning*
- Bala Poduval (Sep 2018 – Feb 2019): postdoc of H2020 AIDA project.
- George Wilkie (Jan 2019 – Jun 2019): postdoc on *Real-time forecasting of radiation belt electrons*.
- Casper Rutjes (CWI): supervision of a project (part of PhD programme) on *numerical solution of the Poisson equation on adaptive mesh*.
- Ashuthosh Agnihotri (CWI): supervision of a project (part of PhD programme) on *sampling techniques for uncertainty quantification*.
- Marina Gruet (Onera, France): PhD internship at CWI on *Machine Learning to forecast geomagnetic indices*.
- Algo Carè (ERCIM fellow, 2017): postdoc on *Uncertainty Quantification* project.
- Emanuele Cazzola (U. Surrey): long-term postdoc visit on *neutral Vlasov model* project.
- Marleen Rijkssen (U. Amsterdam): supervision of BSc thesis *Using Convolutional Neural Networks for Solar Wind Classification*.
- Martijn Dortmond (U. Amsterdam): supervision of BSc thesis *Deep Learning classification of solar images using MXNet*.
- Simon Wing: co-supervisor of the PhD thesis *Pathways for solar wind plasma and energy transfer to the Earth's magnetosphere* (Eindhoven University of Technology, Sep 2016).
- Anissa Rebzani: main supervisor of MSc thesis *Calibration of a Computer Simulation of the Earth's Radiation Belts* (Ecole Normale Supérieure Cachan, France, Sep 2016).

- Christopher Haynes: collaborator of PhD project *Simulations of Electron Kinetics in Solar Wind Turbulence* (Queen Mary University of London, Jul 2014).
- Martina Giraudo: co-supervisor of MSc thesis *Plasma-material interaction for magnetic fusion and space applications* (Los Alamos National Lab).

INTERNATIONAL CONFERENCES ORGANIZATION

- Convener at the 2019 AGU Fall Meeting (San Francisco, CA) of the session ***Machine Learning in Space Weather***
- Convener at the 2019 European Space Weather Week (Liege, Belgium) of the session ***Machine Learning and statistical inference techniques applied to space weather***
- Chair of the Scientific Organizing Committee for the 1st Conference ***Machine Learning in Heliosphere*** (September 2019)
- Co-organizer of the International Space Science Institute (ISSI) working team ***Novel Approaches to Multiscale Geospace Particle Transfer: Improved Understanding and Prediction through Uncertainty Quantification and Machine Learning*** (2019-2020)
- Convener at the 2019 IUGG General Assembly (Montreal, Canada) of the session ***Space Weather Throughout the Solar System: Bringing Data and Models Together***
- Convener at the 2018 AGU Fall Meeting (Washington, DC) of the session ***Machine Learning in Space Weather***
- Convener at the 2018 European Space Weather Week (Leuven, Belgium) of the session ***Unveiling current challenges in Space Weather forecasting***
- Member of the Scientific Organizing Committee for the workshop ***Exploring Systems Science Techniques for the Earth's Magnetosphere-Ionosphere-Thermosphere*** (Los Alamos, July 2018)
- Main organizer of the Lorentz Center Workshop ***Space Weather: a multi-disciplinary approach*** (Leiden, September 2017)
- Convener at the 2017 AGU Fall Meeting (New Orleans) of the session ***Frontier Solar-Terrestrial Science Enabled by the Combination of Data-Driven Techniques and Physics-Based Understanding.***
- Convener at the 2017 IAGA (International Association of Geomagnetism and Aeronomy) Scientific Assembly (South Africa) of the session ***Space weather from Sun to Earth: bringing data and models together.***
- Convener at the 2017 European Space Weather Week (Oostende, Belgium) of the session ***System Science: Application to space weather analysis, modelling and forecasting.***
- Convener at the 2016 European Space Weather Week (Oostende, Belgium) of the session ***Machine Learning and statistical inference techniques.***
- Convener at the 2015 AGU Fall Meeting (San Francisco) of two sessions: ***Field-aligned currents: 40 years after Iijima and Potemra [1976]***, and ***The Role of Coulomb Collisions in Space Plasmas: What Do We Know and How Well Do We Model Them?***

OTHER ACADEMIC ACTIVITIES

Editorial roles

Editor of the book *Machine Learning Techniques for Space Weather*

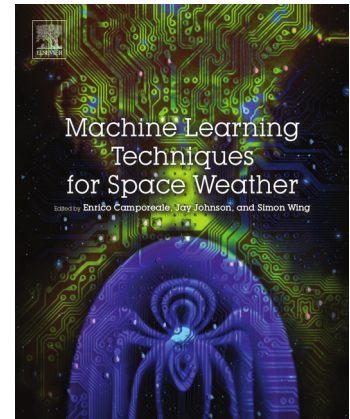
<https://www.elsevier.com/books/machine-learning-techniques-for-space-weather/camporeale/978-0-12-811788-0>

Associate Editor for the *Journal of Space Weather and Space Climate*

www.swsc-journal.org

Editor of the Research Topic *Machine Learning in Heliophysics*
(*Frontiers in Astronomy and Space Science*)

<https://www.frontiersin.org/research-topics/10384/machine-learning-in-heliophysics>



Co-Editor of the topical issues (*Journal of Space Weather and Space Climate*):

- *System Science: Application to Space Weather Analysis, Modelling, and Forecasting*
- *Space Weather research in the Digital Age and across the full data lifecycle*

Peer and grants review

Referee for the following journals: Space Weather, Physical Review Letters, Journal of Geophysical Research, Geophysical Research Letter, Physics of Plasmas, Astrophysical Journal, Journal of Computational Physics, Computer Physics Communication, Space Science Reviews, Solar Physics, Astronomy & Astrophysics, Journal of Plasma Physics, Europhysics Letter, European Physical Journal D, New Journal of Physics, Nonlinear Processes in Geophysics, Scientific Reports, Astronomy & Computing, Earth, Moon & Planets, Nature Astronomy, EOS, Earth Moon & Planets, 34th AAAI Conference on Artificial Intelligence, Thirty-sixth International Conference on Machine Learning.

Reviewer of book proposals for Elsevier.

Reviewer for the National Science Foundation (USA), Czech Republic Science Foundation, Natural Environment Research Council (NERC).

Institute of Physics (IOP) 2016 **Outstanding Reviewer Award**.

PhD committees

- Supervisor: Mandar Chandorkar, Eindhoven University of Technology, November 2019.
- Co-supervisor: Dr. S. Wing, Eindhoven University of Technology, September 2016; A. Agnihotri, Eindhoven University of Technology (June 2018); C. Rutjies Eindhoven University of Technology (Mar 2018)
- Member of the jury: O. Pezzi, A. Tommasi, University of Calabria, Italy, March 2017
- Member of the reading committee: Andong Hu, RMIT University, Melbourne, Australia.

Teaching

Guest Lecturer in the graduate course **Remote Sensing Data Analysis** (ASEN 6337) at the University of Colorado, Boulder (academic year 2019/20)

SCIENTIFIC PRESENTATIONS

- 2019 AGU Fall Meeting (San Francisco, CA). Invited oral: *All models are wrong, but some Machine-Learned models are useful*. Oral: *A gray-box model for a probabilistic estimate of regional ground magnetic perturbations: Enhancing the NOAA operational Geospace model with machine learning*
- 2019 1st Conference on Machine Learning in Heliophysics (Amsterdam, NL). Oral: *On the generation of probabilistic forecasts from deterministic models*
- 2019 Lorentz center workshop: Ensemble Forecasts in Space Weather: Science and Operations (Leiden, NL). Invited oral: *Uncertainty Quantification and Machine Learning*
- 2019 Physics of the Magnetosphere Workshop (Italy). Oral: *Estimation of radiation belts' phase space density using Bayesian inference and deep learning*
- 2019 Space Weather Workshop (Boulder, CO). Oral: *Machine Learning in Space Weather*
- 2019 Chapman conference on Scientific Challenges Pertaining to Space Weather Forecasting Including Extremes (Pasadena, CA). Invited oral: *A Deep Learning Approach to forecasting solar wind properties*
- 2018 AGU Fall Meeting (Washington, DC). Oral: *Accurate and Reliable Probabilistic Forecast Generated from a Deterministic Model*
- 2018 Solar Wind 15 (Brussels, BE). Oral: *Coherent structures and spectral energy transfer in turbulent plasma: a space-filter approach*. Poster: *Classification of Solar Wind with Machine Learning*
- 2018 EGU General Assembly (Vienna, AT). Poster: *Coherent structures and spectral energy transfer in turbulent plasma: a space-filter approach*
- 2017 AGU Fall Meeting (New Orleans, USA). Posters: *Probabilistic Space Weather forecasting: a Bayesian perspective; Bayesian inference of radiation belt loss timescales*
- 2017 Lorentz Center Workshop Space Weather (Leiden, NL): a multi-disciplinary approach. Oral: *A Bayesian approach to Space Weather predictions*
- 2017 IAGA Joint Assembly (Cape Town, South Africa). Oral: *Uncertainty quantification of radiation belts dynamics*. Oral: *A space filter approach to study the energy cascade associated with coherent structures in Kelvin-Helmholtz turbulence*
- 2016 Vlasovia Fifth International Workshop on the Theory and Applications of the Vlasov equation (Copanello, Italy). Invited Oral: *A quasi-neutral kinetic model for collisionless plasma*.
- 2016 13th European Space Weather Week (Oostende, Belgium). Oral: *Gaussian Process Models for Prediction of the Dst Index*.
- 2016 SHIELDS: Shielding Society From Space (Santa Fe, USA). Oral: *A probabilistic framework for radiation belt simulations*.

- 2015 AGU Fall meeting (San Francisco, USA). Oral: *Wave-Particle Interactions with Whistlers: Comparison Between Particle-in-Cell and Quasi-Linear Simulations.*
- 2015 Eindhoven Multiscale Institute Annual Symposium (Netherlands).
Invited Oral: *Multiscale simulations for Space Weather modeling.*
- 2015 Turbulence and Dissipation in Collisionless Astrophysical Plasmas (Cargese, France).
Invited Oral: *Quantifying the role of coherent structures in the cross-scale energy transfer: a space-filter approach.*
- 2015 UCLA Inner Magnetosphere Coupling - III meeting. Poster: *Wave-particle interactions with whistler waves: PIC and quasi-linear simulations.*
- 2015 Nonlinear Dynamics in Natural Systems Workshop (U. Twente, NL)
Invited Oral: *Multiscale simulations for space weather modeling.*
- 2015 The next generation of Dutch HPC infrastructure (Leiden, NL).
Invited Oral: *Space Weather simulations: steps towards a data-driven approach.*
- 2014 Physics@FOM (Veldhoven, NL). Invited Oral: *Probing the earth's magnetosphere with an electron gun.*
- 2014 ISSI (Bern) Solar wind turbulence working team. Invited Oral: *Implicit PIC simulations. Decaying turbulence and the role of reconnection.*
- 2014 Lorentz workshop: Modeling TLEs and TGFs (Leiden, NL). Invited Oral: *Whistler waves: magnetosphere and lightning related phenomena.*
- 2014 Symposium on Plasma Physics and Radiation Technology (Lunteren, NL).
Invited Oral: *Linear mode conversion between cold plasma waves mediated by a density inhomogeneity in the ionosphere*
- 2014 General Scientific Meeting of the Belgian Physical Society. Invited Oral: *A spectral discretization of a kinetic plasma model: comparison with the Particle-in-Cell method*
- 2014 Geospace revisited (Rhodes, Greece). Poster: *Particle-in-cell simulations of whistler-particle interactions: an assessment of the quasi-linear paradigm.*

SKILLS

Computer: C, C++, Fortran, MPI, Python, MATLAB, Mathematica, CUDA, TensorFlow

Languages: English (fluent), Italian (native), Dutch (basic)

Italian qualification for the profession of Nuclear Engineer (Esame di Stato).