

Bulletin of the UFS Community

Space Weather: The Next UFS Frontier

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By Jose-Henrique Alves and Linda Taylor

UFS Communications and Outreach Celebrating a Great Year Ahead

This edition of community bulletin marks the end of 2021 and the transition of NOAA co-chairs in the UFS Communications & Outreach (C&O) working group. After a year and a half co-leading this incredible team alongside Susan Jasko, our fabulous community co-chair, Jose-Henrique Alves (NOAA Research) is handing the NOAA co-chair post to Linda Taylor (National Weather Service). In our editorial, Jose-Henrique and Linda share a celebration of successes from an exciting interaction with a team that did not balk in the face of adversity after another unusual year, as the UFS C&O moves into an exciting New Year.

The UFS C&O manages a range of channels to promote engagement representing all community members. Our team creates content facilitating dialogue and sustaining community identity, working with several comms and outreach offices in partner organizations. Our products currently include the UFS Portal, a UFS knowledge base, the UFS Graduate Student Test (GST), and the quarterly Bulletin of the UFS Community,

Over the last year, our team changed from having a centralized UFS C&O coordinator from NOAA to a partnership between co-chairs representing equally Government and Community. We achieved great outcomes such as bridging communication gaps between UFS community members, unifying communication platforms, and aggregating scattered foundational documents into a centralized archive with easier access. We also substantially increased community engagement with a redesigned website and social media campaigns.

Our commitment to the UFS community reestablished levels of trust and facilitated consensual decisions to solve everyday problems. A revitalized UFS Portal strengthened the UFS community branding and cohesion: our website had more than 10,000 new users in 2021. Our social media following saw a five-fold increase, with tens of thousands of impressions that made the UFS community message accessible, building a diverse and inclusive membership.



Jose-Henrique and Linda, former and current UFS C&O NOAA Co-Chairs

2022 started with new UFS C&O leadership as Linda took up the NOAA co-chair post, and exciting new challenges to tackle. Although encouraging community engagement by providing robust products and services is a primary focus, the UFS C&O now needs a formalized, strategic work plan with identified resources, roles, and responsibilities. This collaborative plan, vetted by community members and having effective buy-in from all UFS organizations, will guide future team activities.

To date, we've been fortunate enough to build a great team with a strong track record and will continue the momentum by expanding and diversifying its membership. We are confident that the 2022 UFS C&O team, with continued support from the UFS Community and all its member organizations, will reach greater heights propelled by the inevitable success of the UFS.

Learn more about what's new with the UFS at ufscommunity.org.

*Linda Taylor is the NOAA Co-Chair for the UFS C&O Team and Senior Communications Specialist for the National Weather Service
Dr. Jose-Henrique Alves is the Bulletin of the UFS Community Editor and Project Manager for EPIC at the Weather Program Office (WPO), NOAA Research.*

Editorial Board: Jose-Henrique Alves, Susan Jasko and Linda Taylor.

Collaborators: Patrick Britt, Todd Christenson, and Peter Roohr.

We are thankful for the support from the UFS Steering Committee and the UFS Communications & Outreach Team.

Thank you, and forgive us if we forgot someone!



UFS Community Events at the 102nd AMS Meeting, 23-27 Jan 2022

The 102nd Annual Meeting of the American Meteorological Society (AMS) starts Sunday, January 23rd. The virtual meeting will host a large number of presentations and events showcasing the Unified Forecast System (UFS) and community modeling efforts to advance Earth prediction systems, which are highlighted in a [comprehensive list](#) prepared by the UFS Community.

The AMS meeting this year features, for the first time, the [Symposium on Earth Prediction Innovation and Community Modeling](#), coordinated by UFS Community members. The Symposium is an opportunity for the broad research community to share information about the latest developments and how innovations advance community models for Earth prediction applications.

Symposium presentations and events will discuss open innovation, observation impact, model code development, software engineering, computing architectures, and societal benefits. Participants represent public, private, and academic sectors working to advance community modeling systems, like the Unified Forecast System (UFS), partnering through initiatives such as NOAA's [Earth Prediction Innovation Center \(EPIC\)](#).

Highlights of the Symposium include a session "[Honoring the Life, Legacy, and Accomplishments of William 'Bill' Lapenta](#)", hosted by the 31st Conference on Weather Analysis and Forecasting (WAF), the Symposium's [Core Science Keynote talks](#) and the [UFS Community Modeling Forum](#). Check the meeting website for the [full Symposium program](#).

Leaders from Government, Academia and Industry Discuss Community Modeling, Innovation and Society

The First Symposium on Earth Prediction Innovation and Community Modeling invited Mary Erickson, Acting Director of NOAA's National Weather Service (NWS), Dr. Everett Joseph, Director of the National Center for Atmospheric Research (NCAR), and Dr. Peter Neilley, Director of Weather Forecasting Sciences, Technologies and Operations at IBM's The Weather Company, to discuss their visions about the importance of community modeling to the future of weather and climate forecasting. Ms. Erickson will provide a Government perspective on the importance of community modeling to accelerate innovation, whereas Dr. Joseph will present current and future capabilities of NCAR's community Earth system model development efforts, and Dr. Neilley will describe how community modeling has influenced weather services for society. The keynote talks will be followed by a panel open to AMS meeting participants.



Mary Erickson (NOAA), Everett Joseph (NCAR) and Peter Neilly (IBM)

By Patrick Britt

The Epic Vision that Strengthened the UFS Community



Neil Jacobs is a pioneer in community-driven weather modeling

Numerical Weather Prediction (NWP) is the cornerstone of modern environmental forecasting. The United States uses a large variety of NWP for its operational weather forecasting activities at the National Oceanic and Atmospheric Administration (NOAA), ranging from large synoptic-scale models such as the Global Forecast System (GFS), and short-range convection-allowing models such as the High-Resolution Rapid Refresh (HRRR). Such a wide range of modeling systems and products have been a challenge to streamline community innovations and advance operational NWP. Former NOAA Acting Administrator Neil Jacobs spearheaded a vision to address existing challenges, by unifying weather models in an open-source framework that is overhauling modern forecasting capabilities leveraging the Unified Forecast System (UFS).

Jacobs recently recounted the history of his efforts in establishing the Earth Prediction Innovation Center (EPIC) in support of the UFS in his American Meteorological Society paper titled 'Open Innovation and the Case for Community Model Development'. The paper describes the ideas that led to the NOAA and National Center for Atmospheric Research (NCAR) memorandum, along with the Weather Research and Forecasting Innovation Act of 2017, which set in motion "the most significant

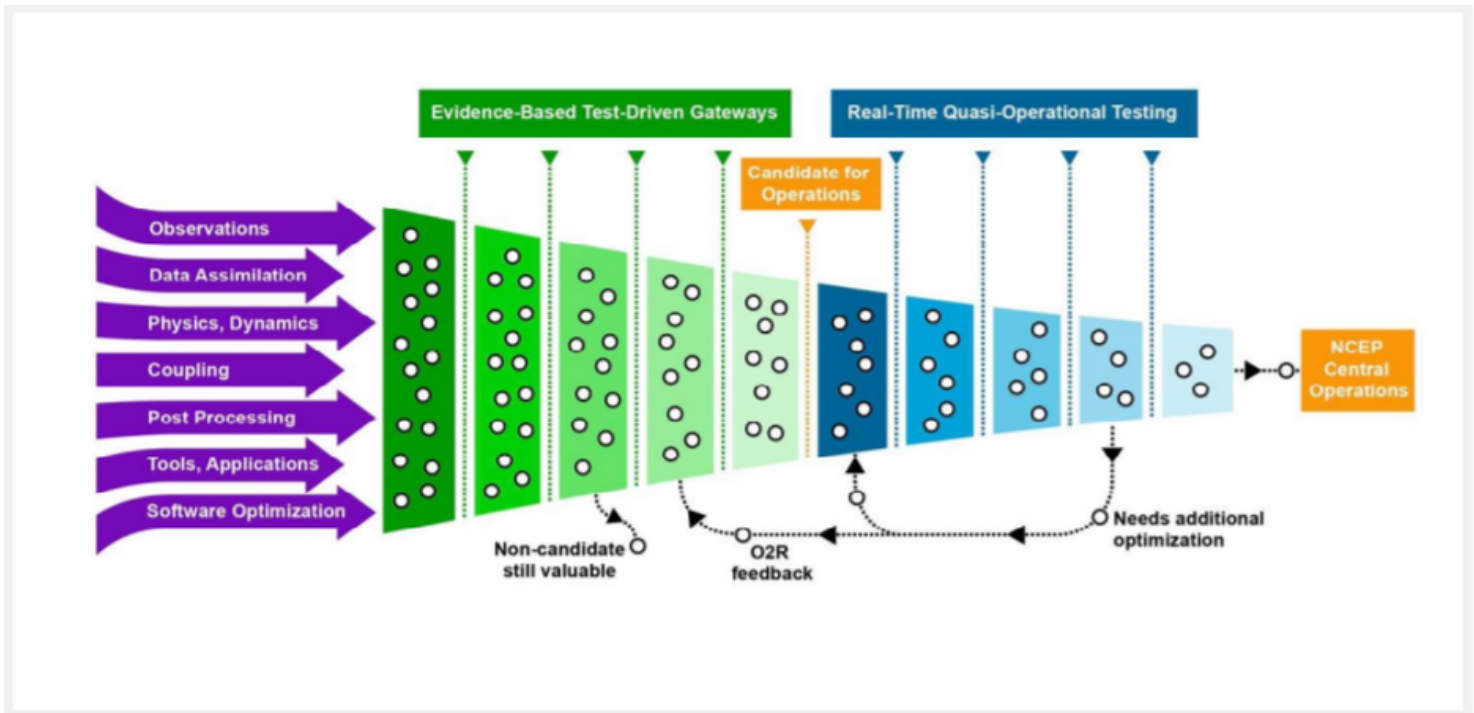
restructuring of coordination efforts among federal agencies since [1964]". Jacobs' paper also discusses the challenges that will be faced in restructuring the models and the need for close integration of the government with the broader weather modeling community, including universities, research centers, and private industry.

The baseline challenge of modern government NWP, as the paper describes, is how the models were created. The GFS was designed using specific code to work only under NOAA's high-performance computing (HPC) system. Due to this constraint, NOAA models and operations are isolated from the private sector and academia. Government policies, such as requiring a security clearance to work on the models, only exacerbated the problem. This has created a disfunction in the weather modeling world, where industry and academic modeling efforts and NOAA's projects would compete for funding from the federal government.

The solution described in the paper originated from an unprecedented collaboration between NOAA and the community, opening government modeling systems and data to open-source development and collaboration, better allowing the private and academic sectors to collaborate with the Federal government.



The idea on a napkin that led to the UFS community and EPIC



New additions to the UFS are vetted in a series of tests from the UFS community, and gradually transition into higher operational readiness levels before becoming operational.

Jacobs' paper states the ultimate goal of open-sourced unified forecasting where all stakeholders are able to contribute and benefit. The ability to parallel-test a needed feature in the cloud, and eventually be able to implement it into NOAA's operational source code allows all parties involved to achieve several benefits from the unified model. This allows for a wide range of stakeholders to diversify features in the unified model, which allows even more users to access desired features and accelerate the rate of scientific innovations into operational forecast systems and products.

Open-source software and the proposed open-development approach allow for greater community outreach and collaboration. As pointed out in the paper, UFS community members from high school students to professionals using cloud HPC compiled and ran the UFS model, and gave feedback directly to Jacobs, leading him to realize that open-source development is not perfect and a process is needed to allow for efficient and stable modeling, that is where the Earth Prediction Innovation Center (EPIC) comes in.

EPIC is a program that will support the development of the UFS bringing the community together using cloud resources. Jacobs expects that EPIC will accelerate the flow of community innovations to operational NOAA models, through a

process that can be roughly illustrated as a funnel where new additions to the UFS are vetted in a series of tests from the UFS community, and gradually transition into higher operational readiness levels before becoming operational.

The vision described in Neil Jacobs' paper, built through open collaboration with community scientists and NOAA, lays the groundwork to strengthen the UFS and leverage the awesome capabilities of the American Earth sciences community, the largest in the world. This unique open-development modeling vision will tool the UFS to be suited to any government, private sector, and academic needs. When realized, the shared vision of the UFS leveraged by EPIC, championed by Neil Jacobs, will change the modeling landscape forever.

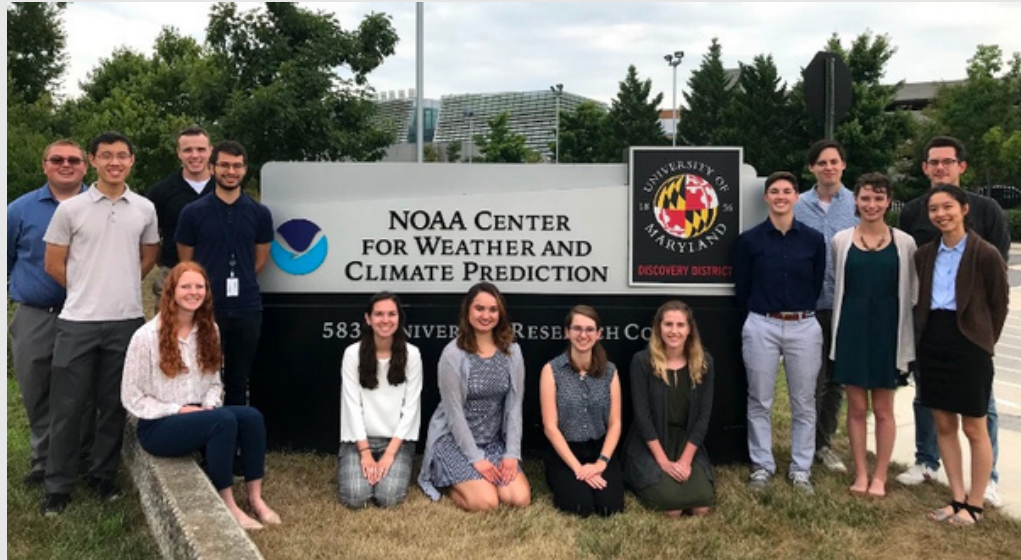
Read more in Neil Jacobs' [original paper](#).

Neil Jacobs is the former acting NOAA administrator and early pioneer in EPIC and Unified modeling. He holds a BS in Mathematics and Physics from the University of South Carolina and a PhD. in atmospheric science from North Carolina State University and has worked in both the public and private sectors for the past 15 years, most notably for Panasonic. He served as the chair of forecasting improvement for the American Meteorological Society, and was affiliated with the World Meteorological Association.

Supporting the Next Generation of Scientists

By Todd Christenson and Peter Roehr

The William M. Lapenta NOAA Student Internship Program provides an opportunity to train the next generation of researchers, modelers and forecasters for the benefit of the broader weather community through hands-on experiences at the National Weather Service (NWS), Office of Oceanic and Atmospheric Research (OAR) and National Environmental Satellite and Data Information Service (NESDIS) facilities. Approximately 50 interns are supported annually.



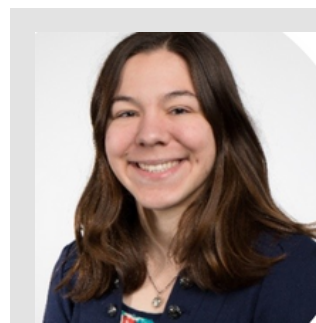
2019 Summer Interns at the NOAA Center for Weather and Climate Prediction building, College Park, Maryland.

The focus of these projects is on forecasting, modeling, prediction and decision support systems and other operational tools in high demand in the weather, climate and Earth system science communities. Several interns over the past two years have contributed to the further development of the Unified Forecast System (UFS), a community-based, coupled, comprehensive Earth modeling system with applications spanning local to global domains and predictive time scales from sub-hourly analyses to seasonal predictions. The UFS is designed to support the Weather Enterprise and to be the source system for NOAA's operational numerical weather prediction applications (learn more about the UFS here).

Improving Smoke Forecasts

Currently, several components of the UFS remain under development. One example is the UFS smoke forecast model. This summer, University of Wisconsin PhD Student Maggie Bruckner used her 10-week internship at the OAR Global Systems Lab to verify the High Resolution Rapid Refresh (HRRR)-Smoke Model using Aerosol Robotic Network (AERONET) aerosol optical depth (AOD) data. Preliminary results indicate the HRRR-smoke model tends to underestimate AOD over the continental US, likely due to non-fire sources and a lack of a chemistry component in the model. However, as

smoke begins to dominate the aerosol component, AOD forecasts from HRRR-Smoke and AERONET increasingly agree. The project also found that significant enhancement in AOD can be more dependent on the direction of plume transport than on distance between the AERONET site and the fire. Maggie will present these results at the American Geophysical Union (AGU) meeting in December. Her mentors, Ravan Ahmadov and Georg Grell are optimistic that this methodology can be applied to demonstrate improved smoke forecasting capabilities of the new RRFS-smoke model versus the current HRRR-Smoke model.



Maggie Bruckner is an atmospheric science PhD student at the University of Wisconsin working with Dr. Brad Pierce. She earned her bachelor's degree in

science from the University of Portland. In her spare time she enjoys a variety of activities including playing ultimate frisbee, hiking, and reading novels.



Sam Ephraim is a senior at the University of Michigan majoring in meteorology and computer science. He is from the Chicago area and has loved to observe the weather

since a young age. He is excited to learn new skills in addition to applying his knowledge while at NCEP. Sam loves to sail. He is on the University of Michigan Sailing Team.

Migrating Components to the Cloud

Two interns over successive years in OAR's Weather Program Office (WPO) have worked on the migration of the UFS components to a cloud-based platform to improve its accessibility. In 2020, Donald Long, an MS student in Atmospheric Science at the University of North Dakota conducted comparative case studies on the UFS Medium-Range Weather (MRW) application on an on-site High Performance Computing (HPC) platform using Amazon Web Services (AWS) cloud architecture. Working with mentors Krishna Kumar and DaNa Carlis, Donald demonstrated the viability of AWS as a lower-cost alternative for running the UFS, a significant benefit to schools and others without access to HPC resources. Since his internship, Donald has transferred to the Atmospheric Science MS program in the NOAA Center for Atmospheric Science and Meteorology (NCAS-M) at Howard University. He plans to pursue a PhD in emergency management.

Samuel Ephraim, a rising senior in meteorology and computer science at the University of Michigan, worked this summer with Jose-Henrique Alves and Krishna Kuman in WPO to document running the UFS Graduate Student Tests (GST) in the cloud. Sam's project seeks to expand the UFS community by running GSTs with only an internet connection rather than requiring HPC resources. He created a step-by-step guide for users, a FAQs page and made the MRW application more user-friendly, also enhancing its data visualization capabilities. Sam will present his work at the 2022 American Meteorological Society (AMS) meeting. After graduating, Sam plans to pursue a master's degree in meteorology before seeking work in government or the private sector.

Understanding Community Modeling

Michael Michaud, a PhD student at the University of Delaware, worked with Leah Dubots and Gina Eosco from WPO. Mike conducted a social science analysis of the community modeling approach for the Earth Prediction Innovation Center (EPIC). The results of his project will be presented at the AMS meeting in January 2022. After graduation, he wants to work at the nexus of atmospheric and social science.

Mike shared some thoughts about his work: "I had an influential experience this summer as a Lapenta Intern with the EPIC team. I was able to learn more about the earth systems modeling community and see first hand what community modeling entails. Through interviews with key UFS and EPIC stakeholders, I conceptualized the social aspects of what it means to be part of a community, and heard perspectives on how the public, private, and academic sectors approach the UFS. In the future, I want to continue bringing social science into the weather enterprise to improve how weather information is collected and disseminated to stakeholders and communities."



Mike Michaud is a PhD student at the University of Delaware studying Disaster Science and Management. Trained first as an atmospheric scientist, and now as a social scientist, he enjoys

bridging the gap to better incorporate social science into the physical sciences. He is an avid kayaker and boater, enjoys cooking, and is usually giving attention to his adorable dog.

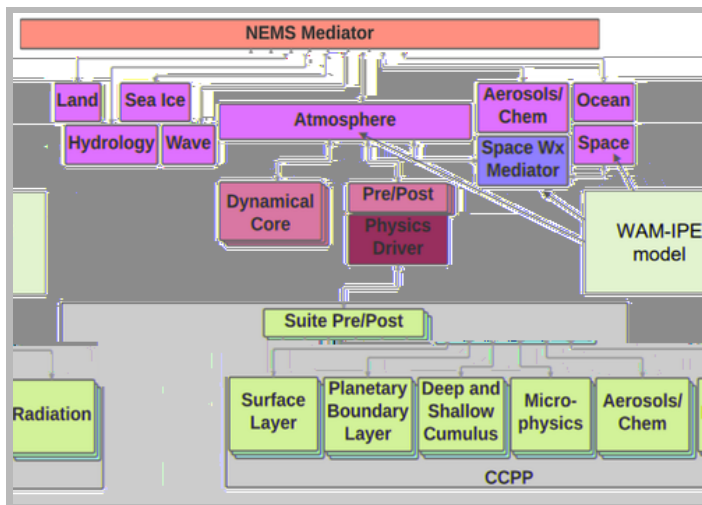
Maggie, Donald, Sam, and Michael represent only a handful of the brilliant students that join NOAA every summer to participate on a variety of projects that advance NOAA's mission. With new hiring authorities afforded to the Lapenta Summer Intern Program, we hope that this student opportunity continues to provide a pathway for the next generation of scientists, researchers, and managers to engage with NOAA and continue to diversify our workforce.

Interested in learning more about the William M. Lapenta NOAA Student Internship Program? Please contact Peter Roohr (peter.roohr@noaa.gov) (NWS), Todd Christenson (todd.christenson@noaa.gov) (OAR), or Christopher Brown (christopher.w.brown@noaa.gov) (NESDIS) or visit www.weather.gov/lapenta_studentinternships

By Patrick Britt

NOAA's First-Ever Operational Coupled Space-Atmosphere Weather Model

On July 21, 2021 the National Weather Service began operations on a new and groundbreaking space weather model known as the Whole Atmosphere Model and Ionosphere Plasmasphere Electrodynamics Model (WAM-IPE). The new model operations allow the Space Weather Prediction Center (SWPC) to provide better forecasting capabilities of ionospheric and space weather conditions. The model utilizes couplings with the neutral atmosphere, and the ionosphere and plasmasphere. Henry Juang, a recently retired research scientist from NCEP, who has spent much time working on the project says: "It took more than 10 years from research to operation (R2O)." Juang continues, "It started from model development of WAM (Whole Atmosphere Model) in EMC and IPE (ionosphere-plasmasphere-Electrodynamics) in SWPC and CIRES [Cooperative Institute for Research in Environmental Sciences]."



Model coupling Infrastructure: NOAA Environmental Modeling System (NEMS). Interoperable physics Infrastructure: Common Community Physics Package (CCPP).

As the name suggests, the WAM and IPE are two separate parts of the same model. The WAM is an extension of the Global Forecasting System's (GFS) Global Spectral Model (GSM). The GSM did not include the thermosphere or represent its constituents. Because of this, Juang says he and his team augmented the GFS's global spectral model with "atmospheric constituents of O, O₂, O₃, and N₂, then extended original GSM vertical domain from

below 100km to up to 500-600 km to cover thermosphere, and implemented thermosphere-related model physics, as a whole atmosphere model (WAM)."

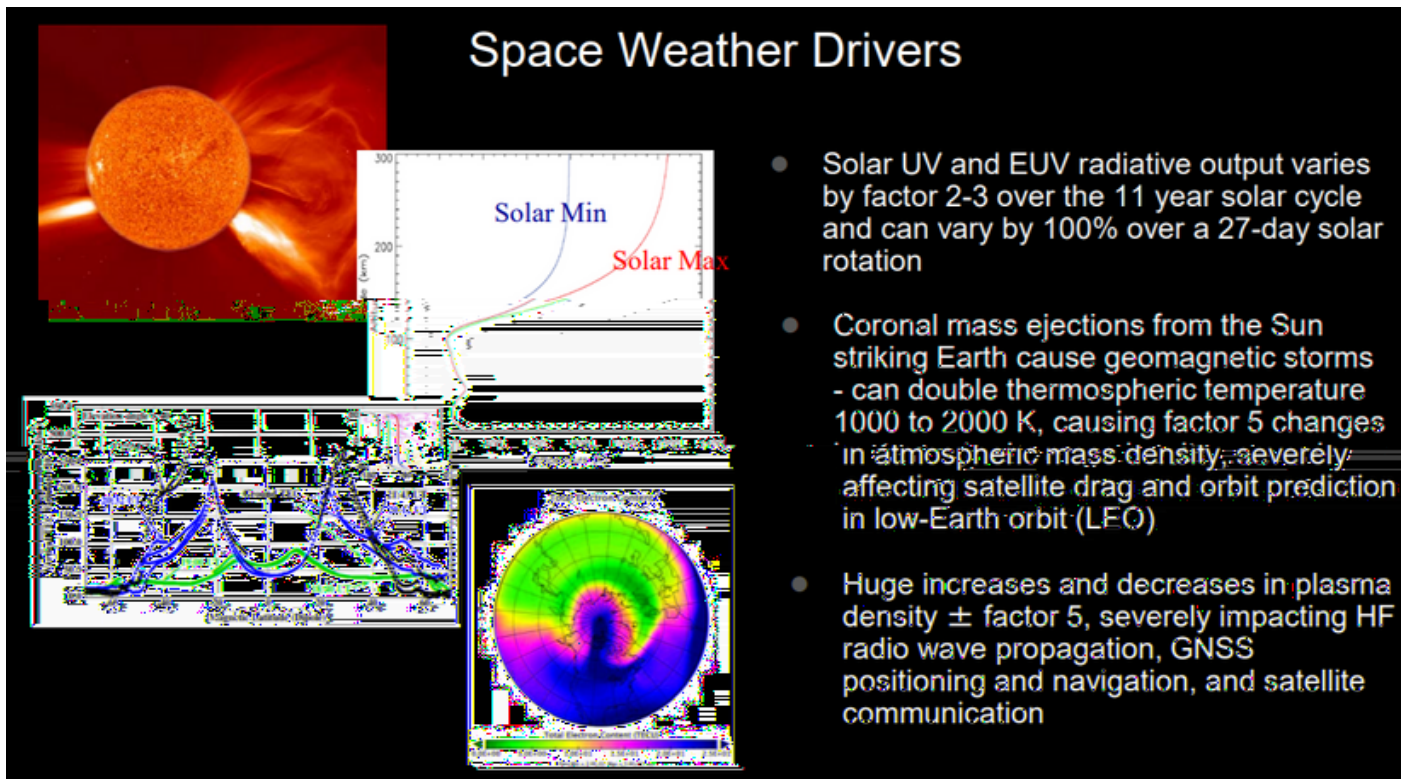
The IPE is a time-dependent, 3-dimensional model of the ionosphere and plasmasphere. These systems are coupled together, which allow the model to forecast the impact the neutral atmosphere (wind, temperature, chemistry, etc) has on the ionosphere and plasmasphere. Key features of the IPE include accurate magnetic field lines (flux tubes). The coupling is done through a special space weather mediator, which allows information to be exported between WAM and IPE.

The coupling of these two systems into one model was one of much research and time. Henry Juang said the main challenge of creating the combined model was finding a way to couple them so that they can interact with each other. Juang explains that a 3-dimensional model must have a vertical domain up to the thermosphere in order to cover most of the neutral atmosphere, which Juang says "connects and covers the lower model domain of IPE for coupling [the WAM and IPE]".

The WAM-IPE, alongside existing models, allows the SWPC to have greater capabilities to forecast through its introduction of new products that can vastly improve warning times and accuracy. The first ionospheric product provided by the WAM-IPE is the total electron content (TEC). The TEC is the number of electrons in a one-meter squared area, that is between two heights in the atmosphere. The next ionospheric product is the maximum usable frequency (MUF), which is the maximum electromagnetic frequency that can be used for communication by bouncing the EM waves off the ionosphere.



Dr. Henry Juang is a renowned NOAA scientist who led the development of WAM



Space Weather Drivers, adapted from Fuller-Rowell et al. (2020), "WAM-IPE Review Status of transition of WAM-IPE to operations."

The WAM-IPE also ships with products that describe the neutral atmosphere. The first is the density of the atmosphere at 400km, and the second is the anomaly of the density at 400km. The last product is the elemental oxygen to nitrogen ratio which helps the SWPC forecast using atmospheric chemistry. All neutral atmospheric and ionospheric products are valid for 48 hours.

These new products and features are breakthroughs in space weather modeling and computing, as this is the first NCEP operational model ever to forecast upper atmospheric conditions both influenced by space, and by the lower atmospheric conditions and perturbations. The products described allow for better advising and forecasting for private sector communications and aviation that has not previously been done. The 400km density will allow for the most precise orbit prediction ever for space traffic, as orbital decay effects from atmospheric drag is modeled more accurately.

All of these innovations come with the cost of computing and large amounts of data. Juang explains: "We spent lots of time developing the WAM data assimilation and 3D coupling process between WAM and IPE, and lots of time in tuning the model results to be satisfied among us."

In the official NOAA press release, it is explained that more satellite observations and data collection will contribute to the model's continued success. All of this is possible because of modern high-performance computing.

The WAM-IPE is a breakthrough model that will allow for better forecasting and warning in space weather. Because of researchers like Henry Juang, we now have the capability to create a more space weather-ready nation, one that is powered by research and community.

The Space Weather Application is part of the Unified Forecast System. Current plans call for the development of a non-hydrostatic, FV3-WAM (using the finite volume dynamical core (FV3)) at a 50 km resolution. The FV3-WAM development will proceed in parallel with enhancement in the IPE component, including increased resolution, transport scheme, and parallel-processing grid decomposition. The model improvement will enable the development of ionospheric irregularity space weather products utilizing the enhanced resolution and wave spectrum of FV3-WAM.

*Dr. Henry Juang is a retired NOAA scientist who recently received a Marquis Lifetime Achievement Award
Mr. Patrick Britt is a Meteorology Major student at the University of Michigan.*

Announcing Retirement, NOAA Leaders Celebrate Great Accomplishments



Louis Uccellini, global leader in meteorology, and renowned expert on U.S. winter storms

Louis W. Uccellini, Director, National Weather Service

Dr. Uccellini has enjoyed a 43-year illustrious career in public service as a research scientist, day-to-day operational leader and senior executive. He has served as the NWS director for nearly nine years, and previously as director at NOAA's National Centers for Environmental Prediction for 14 years, dedicating more than 50 years to the field of meteorology.

"For more than half a century, Louis has been a force throughout the field of meteorology. He is someone I consider both a friend and a professional colleague," said NOAA Administrator Rick Spinrad, Ph.D. "Louis is a legend whose legacy will have a lasting and positive influence for generations to come."

Uccellini's career path spans academia, research, research-to-operations, leading forecasting operations, and serving as a senior executive. He is leaving a legacy of more accurate and extended weather forecasts and a nation that is more ready and responsive to extreme weather, water and climate events.

"Through teamwork, we have advanced forecast skill and improved public resilience in the face of extreme weather beyond anything in my wildest imagination," he said. "We continued the work of research giants from previous decades and built off the success of the NWS modernization in the 1990s and into the 21st century. Everything we accomplished together was possible because of the hard work and determination of our employees and the tremendous partnerships they cultivated with emergency managers and water resource managers at every level of government."

[\(Read the full article\)](#)



Craig McLean speaks about the importance of the ocean. Aspen Ideas Festival, 2018.

Craig McLean, Assistant Administrator, NOAA Research

Mr. McLean is a champion of ocean exploration, scientific integrity, and ocean diplomacy who began his NOAA career as a uniformed officer in the NOAA Corps four decades ago and rose to lead the agency's research division.

"Craig has been a passionate leader aboard our ships and more recently a champion of NOAA research to advance our mission to serve the nation," said Rick Spinrad, Ph.D., NOAA Administrator. "Like the best of ship captains, Craig has steered NOAA through rough waters, always upholding scientific integrity, advancing science and technology, forging strong partnerships at home and abroad."

As leader of NOAA Research, McLean has raised the public profile of NOAA's ocean, weather, climate and Great Lakes research. He has strengthened collaboration with NOAA's National Weather Service and across NOAA, and quickened the pace of using new research to improve NOAA's forecasts. He also served as U.S. representative to the Intergovernmental Oceanographic Commission of UNESCO, helping to lead the UN Decade of Ocean Science

"I have been proud to wear the NOAA jersey for 40 years and work with so many amazing people who perform tirelessly to understand and protect our planet," said McLean. "What I learned from my experiences early in my career is that leadership has the responsibility to do everything you can for your people, advocate for your people, and when you have chosen the right people, the mission will flow."

[\(Read the full article\)](#)