**CIMSS/NESDIS: Passive Retrievals of 3D Optical Flows with Information Leveraged from Environmental Sounders (PROFILES)**

A Proposal to

The National Oceanic and Atmospheric Administration

National Environmental Satellite Data and Information Service

Program: NESDIS GeoXO Program

For the Period

1 September 2025 – 30 June 2026

Support Requested: $125,000

Total Task I: $4,460

Total Task II: $120,540

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
|  |  | **Project Funds** | **Task 1 Funds** | **Total** |
| Task 2.1 |  | $120,540 | $4,460 | $125,000 |
| **TOTAL** |  | **$120,540** | **$4,460** | **$125,000** |

Submitted by the

University of Wisconsin-Madison

On behalf of

The Cooperative Institute for Meteorological Satellite Studies (CIMSS)

Space Science and Engineering Center (SSEC)

at the University of Wisconsin-Madison

1225 West Dayton Street

Madison, Wisconsin 53706

David Santek Dr. Tristan L’Ecuyer

Principal Investigator Director, CIMSS

Brenda Egan, Managing Officer Pre-award

Research and Sponsored Programs

May 2025

**NOAA’s Mission: Science, Service, and Stewardship**

To understand and predict changes in weather, oceans, and coasts,

To share that knowledge and information with others, and

To conserve and manage coastal and marine ecosystems

**NOAA’s Long-Term Goals:**

**Weather-Ready Nation:** Society is prepared for and responds to weather-related events

**NOAA Strategic Plan-Mission Goals**

* Serve society’s needs for weather and water
* Support the nation’s commerce with information for safe, efficient and environmentally sound transportation
* Provide critical support for the NOAA mission

**Cross-Cutting Priorities**

1. Accurate and reliable data from sustained and integrated earth observing systems
2. An engaged and educated public with an improved capacity to make scientifically informed environmental systems

**CIMSS Research Themes**

Theme 1. Satellite Meteorology Research and Applications

Theme 2. Satellite Sensors and Techniques

Theme 3. Environmental Models and Data Assimilation

**CIMSS Tasks**

Task I: Administrative Activities – CIMSS Management, Education, Outreach

Task II: Research involving direct collaboration with NOAA scientists, including research collaborations with locally-stationed NOAA scientists

**NOAA Funding Source:** Andrew Heidinger NOAA/NESDIS

Contact Information: andrew.heidinger@noaa.gov / 608-263-6757

**NOAA Funding POC #2**: Jaime Daniels NOAA/NESDIS/STAR

Contact Information: jaime.daniels@noaa.gov / 301-683-3587

**Brief Summary:**

Over the next decade a new class of Geostationary hyperspectral IR sounders (GeoHIS), will provide a large domain of high-cadence, fine-spatial-resolution profile retrievals of temperature, water vapor, and trace gases, which in turn yield traceable textures, also known as optical flow, that can also be used to infer the 3D structure of atmospheric winds. Such 3D winds are essential for generating accurate forecasts by improving the assumed initial atmospheric state in numerical weather prediction models. The proposed research will develop, test, and demonstrate novel 3D wind derivation by tracking features from GeoHIS retrievals of humidity and ozone, enabled by advancements in computational hardware and artificial intelligence, to improve upon current capabilities. This study takes advantage of GeoHIS proxy datasets developed via numerical modeling and imagery from more temporally coarse sounders already in-orbit, with truth data for validation acquired from balloon soundings and model-estimated winds.

This research will be conducted in collaboration with the Cooperative Institute for Research in the Atmosphere (CIRA), who will submit a companion proposal (PI: Jason Apke). CIRA will be responsible for updating and testing established dense optical flow retrieval approaches to function on GeoHIS proxy datasets produced at CIMSS, testing methods against routine-generated 3D wind retrieval approaches, and publishing code on open-source repositories. CIMSS will provide model-derived GeoHIS proxy datasets, generate new wind retrieval datasets using the heritage winds algorithm (Santek et al. 2019) and a deep learning/optical flow method (Vandal et al. 2022), and explore methods to generate improved uncertainty estimates that would be useful for future data assimilation efforts.

**Table of Contents**

Introduction 5

CIMSS CA Task I: CIMSS management support, including General Education and Outreach Activities 5

Project Lead: Wayne Feltz 5

Total Task I Budget: $4,460 5

CIMSS Support: Maria Vasys and Leanne Avila 5

CIMSS CA Task II: Research involving direct collaboration with NOAA scientists, including locally-stationed NOAA scientists 5

Task 2.1: CIMSS/NESDIS: Passive Retrievals of 3D Optical Flows with Information Leveraged from Environmental Sounders (PROFILES) 5

Project Lead: David Santek 5

Budget $120,540 5

NOAA Collaborators: Andy Heidinger, Jaime Daniels 5

Management, Facilities and Reporting 12

UW-Madison CIMSS Data Sharing Plans 16

Task 2.1: CIMSS/NESDIS: Passive Retrievals of 3D Optical Flows with Information Leveraged from Environmental Sounders (PROFILES) 16

# Introduction

# CIMSS CA Task I: CIMSS management support, including General Education and Outreach Activities

### Project Lead: Wayne Feltz

### Total Task I Budget: $4,460

### CIMSS Support: Maria Vasys and Leanne Avila

**Project Description**

Task I activities are related to the overall management of CIMSS, as well as general education and outreach activities. These are activities that support the operation of CIMSS; provide outreach platforms to transmit CIMSS science to varied audiences; train and develop future scientists in the workforce, and provide capabilities requested under the Federal Funding Opportunity Federal Funding Opportunity NOAA-NESDIS-CIPO-2025-29886, but which are not tied to a specific project or projects. Task I funding includes partial funding/salary support for the CIMSS PI/Director, Tristan L’Ecuyer, and other CIMSS management support staff, travel, and visiting researcher support. Also, inclusive of Task I are educational and outreach activities including support of post-docs and graduate students within CIMSS not assigned to specific projects or research; support of undergraduate research interns; development of community outreach, education, and training programs; and support for CIMSS education and outreach staff. The inclusion of Task I for all CIMSS submissions are based on NOAA requirement as part of the FY25 Funding Guidance Memo directive, with a provided target value of ~3.7% of Task II and III activities.

# CIMSS CA Task II: Research involving direct collaboration with NOAA scientists, including locally-stationed NOAA scientists

## Task 2.1: CIMSS/NESDIS: Passive Retrievals of 3D Optical Flows with Information Leveraged from Environmental Sounders (PROFILES)

### Project Lead: David Santek

**CIMSS Support Scientists: Jason Otkin, Tom Rink, and Tim Olander**

### Budget $120,540

### NOAA Collaborators: Andy Heidinger, Jaime Daniels

**2.1.1) Project description**

Wind observations in the troposphere provide critical insights towards diagnosis and prediction in cloud processes, aerosol transport, energy management, weather forecast modeling, and general circulation. Such observations are typically limited to in-situ measurements (i.e., surface anemometers and rawinsondes) and localized remote sensing tools (i.e., wind profiling radars and lidars), though satellite cloud- and water-vapor-drift motions also play a key role by providing information over sparsely sampled areas of the globe such as the oceans or near the poles. The Geostationary hyperspectral IR sounders (GeoHIS) will significantly expand upon that capability, providing drift motions over large domains from fine spatial and temporal resolution passive retrievals of temperature, moisture, and trace gas profiles in clear air (Lindsey et al. 2024*)*. The “Passive Retrievals of 3D Optical Flows with Information Leveraged from Environmental Sounders” (PROFILES) project aims to develop, test, and demonstrate novel methods to produce 3D winds from GeoHIS imagery using so-called Dense (every-image-pixel) Optical Flow (DOF) retrieval methods enabled by advancements in computational hardware and artificial intelligence.

CIRA, CIMSS, and NASA-AMES have already begun exploring novel DOF retrieval approaches to enhance GOES-R Advanced Baseline Imager products with cloud- and water-vapor-drift motions (Stettner et al. 2019; Apke et al. 2020). The “Optical flow Code for Tracking, Atmospheric Motion Vector, and Nowcasting Experiments” (OCTANE) product renders motions within imagery sequences by mimicking human vision with a penalty function minimization technique, where the penalties are designed to ensure an input guess optical flow follows consistent brightness and brightness gradients in time (Apke et al. 2022). The flow is then retrieved from a first guess motion field that is iteratively updated to reduce the penalty with a gradient descent method. Similarly, the WindFlow algorithm renders motions via image-to-image translation with machine learning, using training datasets produced by water vapor grids from large reanalysis datasets (Vandal et al. 2022). An example of WindFlow applied to the ECO1280 Nature Run (NR) humidity grids is shown in Figure 2.1.1. Both techniques follow decades of development by the computer vision community and are robust in their demonstrated capabilities to handle difficult-to-track scenes, including low textures, multi-layer motions, deformations, and discontinuities. Such scenes are common in satellite imagery, including products provided by GeoHIS, and provide notable wind coverage increases over operational Atmospheric Motion Vectors (AMVs) alone. DOF retrieval approaches are now being explored as an alternative for 3D wind retrieval, with early techniques demonstrating encouraging validation results from open-source-retrieval methods that were not originally designed for sounder information (e.g., Ouyed et al. 2023).

A map of the world

Description automatically generated

Figure 2.1.1: Derived AMVs using WindFlow applied to a pair of ECO1280 grids from 01 June 2016 at 00 and 03 UTC on the 500 hPa surface. Color shading is humidity and vector length is based on pixel displacement of the feature motion.

CIRA and CIMSS will work collaboratively to establish a 3D winds retrieval approach for the GeoHIS imagery. Using proxy datasets from previous research at CIMSS (NOAA/GeoXO; PI: Z. Li), and further proxy dataset development by CIMSS during this project, CIRA will develop DOF approaches that take advantage of the 3D environmental information to be provided by GeoHIS. Such research involves updating the current OCTANE methodology to use 3D texture information, ingest multiple “channels” (e.g. temperature, moisture, and ozone), ignore missing data in the case of clouds, and even exploring the value of physically-based constraints such as mass continuity or adiabatic thermodynamics (Héas et al. 2007). Further, CIRA will explore the value of the latest in state-of-the-art machine learning techniques for comparison to OCTANE, such as VideoFlow, which uses specially designed deep learning networks to take advantage of temporal cues in imagery sequences to render accurate motions (Butler et al. 2012). Such algorithms may exploit textures which are not yet considered in approaches like OCTANE, further improving our ability to render 3D motions.

Developed techniques will be tested using routine-generated AMVs and WindFlow (produced by CIMSS) with validation information from background model winds and, where appropriate, the wind field from a model NR. Further experimentation will also be performed on relevant data from low-earth-orbiting sensors such as AIRS, IASI, and CRIS (Santek et al. 2019), which provide GeoHIS-like imagery at a lower-refresh cadence. Winds rendered from such proxy datasets will be validated with ancillary truth information acquired from regional balloon rawinsondes. Validations will include standard error metrics for AMVs (e.g., root-mean-squared-error) which are essential for their effective assimilation into numerical weather prediction models.

With validation established, we also plan to experiment with the value of predictive uncertainty towards improving the output and identifying where the most useful winds for forecast models exist. Simple methods such as image triplet acceleration checks and objective corner and salt-and-pepper detection will be employed here, though additional experiments are planned on adding quality-control-based constraints to the OCTANE retrievals themselves. Development will follow performance-to-truth datasets to guide inferred best practices.

Finally, we plan to demonstrate the developed algorithms on new proxy datasets produced by CIMSS as well as any available geostationary sounder datasets which may come online as soon as 2026 (e.g. Meteosat Third Generation InfraRed Sounder; IRS). We also plan to release developed code and relevant datasets to open-source repositories, enabling further downstream research to engage and improve upon any appropriate 3D winds approaches.

**2.1.2) Benefit to the Public and Non-NOAA Users**

* The outcome of this project will complement the current *cloud-tracked* satellite wind products, by providing 3D wind information in tropospheric data void regions of *clear-sky and above clouds*, and by extending into the lower stratosphere. The assimilation of the 3D winds into numerical weather prediction (NWP) models in future projects will benefit the general public through improved weather forecasts disseminated by NOAA. Moreover, the 3D winds could also be used by other federal agencies that have similar weather models, such as the Navy (Fleet Numerical Meteorology and Oceanography Center (FNMOC)) and NASA (Global Modeling and Assimilation Office (GMAO)).
* Private sector companies developing NWP models with specialized forecasts serving various industries, such as aviation (e.g., Delta and Southwest Airlines, which have a staff of meteorologists) would also immediately benefit from a 3D winds product.

**2.1.3) Background and Previous Work**

The Targeted Observable (TO) 3D winds in the Decadal Survey are best realized by direct measurement (e.g., Doppler Wind Lidar) of the wind in the troposphere and stratosphere. The Aeolus mission was successful because it provided this type of observation that had a significant impact on weather forecasts (Rennie et al. 2021). An alternate approach to derive 3D winds uses time-separated hyperspectral IR retrievals of humidity and ozone, which is described in detail in Santek et al. (2019). In three NASA ROSES awards to the Space Science and Engineering Center (SSEC) under the “The Science of Terra and Aqua” program, a 3D winds product was developed by tracking moisture features (troposphere) and ozone gradients (stratosphere) from the Aqua Atmospheric Infrared Sounder (AIRS) retrieved vertical profiles of temperature, humidity, and ozone. A 6-week NWP model experiment was run to determine the impact of the AIRS 3D winds on forecasts using the 2013 version of the 3DVar GEOS-5. Although the forecast impact was not statistically significant, it was positive, especially in forecast days 4.5 to 6.5. This is encouraging as the vertical and spatial density of winds is low for that product and the winds were only in the high latitudes, but they had a positive impact in the northern hemisphere Anomaly Correlation Coefficient (ACC) scores.

More recently, we have begun exploring the utility of a machine learning system known as WindFlow (Vandal et al. 2022) for deriving AMVs for use with both IR hyperspectral retrieved data and model NR grids. There are several advantages to this system over the heritage winds code. Because WindFlow operates with a pair of images rather than an image triplet, the spatial coverage extends equatorward for overlapping orbits of LEO satellites. For the JPSS satellite series, the overlap is continuous over the entire orbit, resulting in daily global coverage. Another advantage is that the optical flow algorithm results in a much higher density of winds. The WindFlow package was pre-trained with data from the GEOS-5 NR. Modifications were made to the code to import data from CrIS and are depicted in Figure 2.1.2.

**2.1.4) Proposed Activities for 2025-2026**

The proposed CIMSS activities are detailed below and complement the efforts of CIRA (described in the companion proposal). The CIMSS effort leverages the products, software, and processes developed under previous grants, with the goals of this proposal being to 1) support research at CIRA by providing proxy GeoHIS datasets, 2) generate baseline wind retrieval datasets using the heritage winds algorithm, 3) generate 3D winds using the WindFlow optical flow method, 4) develop a method to estimate AMV errors, which is currently lacking in operational satellite-derived wind products, and 5) if necessary, develop new model-derived proxy GeoHIS datasets for use by the CIRA and CIMSS project team.

GeoHIS proxy: The GeoHIS proxy datasets were produced and available from CIMSS[[1]](#footnote-1). Currently, the dataset includes 158 hours for the continental U.S. (CONUS) and 18 hours for the Sounding Disk (SD), for a satellite located at -105° longitude. Both CONUS and SD datasets are available every 15 minutes with a nadir resolution of 4-km. The datasets are in netCDF format; variables include air temperature, water vapor mixing ratio, zonal and meridional wind components, skin temperature, emissivity, surface pressure, cloud fraction, latitude, longitude, satellite zenith and azimuth angles, solar zenith and azimuth angles, all-sky brightness temperature, observation noise, cloud top pressure, cloud optical thickness, cloud particle size, and phase. We will provide this dataset to collaborators at CIRA and also use it to derive AMVs with the heritage wind algorithm that, in turn, will be used in comparisons to the optical flow derived wind fields. If needed, based on consultation with our CIRA collaborators, we will develop a new model-derived proxy dataset to meet the goals of this project. Co-lead Otkin has extensive experience developing state-of-the-art proxy datasets for satellite research and demonstration activities (Otkin et al. 2007; Otkin et al. 2009), including AMVs (Bormann et al. 2013).

A map of different colored squares

Description automatically generated

**Figure 2.1.2:** Winds derived with WindFlow at 300 hPa from a scattering of CrIS retrieval granules over the Atlantic on 13 September 2023. Hurricane Lee is evident in the lower left granule; Hurricane Margot is near 30°N/40°W. These winds were not screened by cloud height or quality controlled.

Heritage winds algorithm: The heritage winds algorithm, known as WINDCO, developed and maintained at CIMSS for over two decades, will be used as a baseline for 3D AMV generation (Santek et al. 2019). It has been supported by several grants from NASA and NOAA for deriving 3D winds from CrIS retrievals and nature run grids. For example, the algorithm has been used to generate AMVs by tracking specific humidity features on tropospheric pressure levels from the GEOS-5 and the ECO1280 Nature Runs, to simulate wind generation from hyperspectral IR sounder retrievals of humidity. The wind field in the nature run provides a validation for the motion derived from feature tracking.

Uncertainty estimation: Typical satellite-derived wind products provide a measure of *quality* for each AMV, which is based on the spatial consistency of nearby derived winds. However, there is no *error estimate* for the wind vector and its assigned pressure level. To help address this issue, we will explore development of uncertainty estimations from neural network architecture-based models (Gawlikowski et al. 2023), e.g. Windflow-RAFT[[2]](#footnote-2). Uncertainty can arise from noise in the training data (aleatoric) and/or noise in the model’s internal parameters (epistemic). While the former cannot be reduced, the latter can be reduced by increasing the data size and/or improving the model’s ability to represent the data. This project will use synthetic data from a global nature run, where the ‘truth’ is known so the aleatoric error can be neglected. Bethell et al. (2024) described three methodologies to quantify uncertainty: Bayesian Neural Networks (BNNs), Monte Carlo Dropout (MC Dropout), and Quantile Regression. After a preliminary investigation of these, we chose the quantile regression because it is more robust to outliers and deviation from a normal distribution. Quantile regression trains the model on multiple conditional quantiles to provide an estimation of the central tendency and statistical dispersion. This requires implementing a custom loss function and training the model for each quantile: upper bound, lower bound, and central median regression. For a given input, we can treat the upper and lower bound as a confidence interval for the prediction.

**2.1.5) Milestones**

* Algorithm developments and updates (Quarter 1)
  + Import GeoHIS proxy datasets into the 3D winds heritage algorithm
  + Adapt WindFlow for use with GeoHIS proxy datasets
* 3D winds retrieval (Quarter 1)
  + Generate AMV dataset using WINDCO with an NR and GeoHIS proxy datasets
  + Generate AMV dataset using WindFlow with an NR and GeoHIS proxy datasets
* 3D winds validation (Quarters 2 and 3)
  + Produce validation statistics for each AMV dataset
  + Produce comparison statistics between WINDCO and WindFlow
* Investigate uncertainty estimates (Quarters 3 and 4)
  + Experiment with predictive uncertainty measures for WindFlow NR AMVs, where the truth field is known and as compared to WINDCO quality metrics.
  + Apply methodologies to determine uncertainty estimates developed from the NR, to the GeoHIS proxy-derived AMVs.
* 3D winds from current satellites (Quarter 4)
  + As time permits, apply WindFlow (and uncertainty estimates) to operational IR hyperspectral data (e.g., CrIS, and if available, MTG-IRS)
* Reports and presentations (Quarters 3 and 4)
  + Summarize overall findings
  + Present findings at scientific meetings (e.g., AGU or AMS)

**References**

Apke, J. M., K. A. Hilburn, S. D. Miller, and D. A. Peterson, “Towards objective identification and tracking of convective outflow boundaries in next-generation geostationary satellite imagery,” *MURI Special Edition Issue: Atmospheric Measurement Techniques,* vol. 13, pp. 1593–1608, 2020, [Online]. Available: https://doi.org/10.5194/amt-13-1593-2020

Apke, J. M., Y. J. Noh, and K. Bedka, “Comparison of Optical Flow Derivation Techniques for Retrieving Tropospheric Winds from Satellite Image Sequences,” *J Atmos Ocean Technol*, vol. 39, no. 12, pp. 2005–2021, 2022, doi: 10.1175/JTECH-D-22-0057.1.

Bethell, D., Gerasimou, S., & Calinescu, R. (2024). Robust Uncertainty Quantification Using Conformalised Monte Carlo Prediction. *Proceedings of the AAAI Conference on Artificial Intelligence*, *38*(19), 20939-20948. https://doi.org/10.1609/aaai.v38i19.30084

Bormann, N., A. Hernandez-Carrascal, R. Borde, H.-J. Lutz, J. A. Otkin, and S. Wanzong, 2013: Atmospheric motion vectors from model simulations. Part I: Methods and characterization as single-level estimates of wind. *J. Appl. Meteor. Climatol*., **53**, 47-64.

Butler, D. J., J. Wulff, G. B. Stanley, and M. J. Black, “A naturalistic open source movie for optical flow evaluation,” *Lecture Notes in Computer Science (including subseries Lecture Notes in Artificial Intelligence and Lecture Notes in Bioinformatics)*, vol. 7577 LNCS, no. PART 6, pp. 611–625, 2012, doi: 10.1007/978-3-642-33783-3\_44.

Gawlikowski, J., Tassi, C.R.N., Ali, M. et al. A survey of uncertainty in deep neural networks. Artif Intell Rev 56 (Suppl 1), 1513–1589 (2023). https://doi.org/10.1007/s10462-023-10562-9

Héas, P., E. Mémin, N. Papadakis, and A. Szantai, “Layered estimation of atmospheric mesoscale dynamics from satellite imagery,” in *IEEE Transactions on Geoscience and Remote Sensing*, Dec. 2007, pp. 4087–4104. doi: 10.1109/TGRS.2007.906156.

Lindsey, D., et al., “GeoXO NOAA’s Future Geostationary Satellite System,” *Bull Am Meteorol Soc*, vol. 105, no. 3, pp. E660–E679, Mar. 2024, doi: 10.1175/BAMS-D-23-0048.1.

Otkin, J. A., T. J. Greenwald, J. Sieglaff, and H.-L. Huang, 2009: Validation of a large-scale simulated brightness temperature dataset using SEVIRI satellite observations. *J. Appl. Meteor. Climatol*., **48**, 1613-1626.

Otkin, J. A., D. J. Posselt, E. R. Olson, H.-L. Huang, J. E. Davies, J. Li, and C. S. Velden, 2007: Mesoscale numerical weather prediction models used in support of infrared hyperspectral measurements simulation and product algorithm development. *J. Atmos. Ocean. Technol*., **24**, 585-601.

Ouyed, A., Smith, N., Zeng, X., Galarneau, T. Jr., Su, H., and Dixon, R. D, “Global three-dimensional water vapor feature-tracking for horizontal winds using hyperspectral sounder data from overlapped tracks of two satellites,” in *Geophysical Research Letters*, vol. 50, 2023, doi: 10.1029/2022GL101830.

Rennie, M. P., Isaksen, L., Weiler, F., de Kloe, J., Kanitz, T. & Reitebuch, O. (2021) The impact of Aeolus wind retrievals on ECMWF global weather forecasts. *QJR Meteorol Soc*, **147**, 3555–3586. https://doi.org/10.1002/qj.4142

Santek, D., S. Nebuda, and D. Stettner, "Demonstration and Evaluation of 3D Winds Generated by Tracking Features in Moisture and Ozone Fields Derived from AIRS Sounding Retrievals" *Remote Sensing* 11, no. 22, 2019. https://doi.org/10.3390/rs11222597

Stettner, D., C. Velden, R. Rabin, S. Wanzong, J. Daniels, and W. Bresky, “Development of Enhanced Vortex-Scale Atmospheric Motion Vectors for Hurricane Applications,” *Rem. Sens*., vol. 11, no. 17, p. 1981, 2019, doi: 10.3390/rs11171981.

Vandal, T. J., K. Duffy, W. McCarty, A. Sewnath, and R. Nemani, “Dense Feature Tracking of Atmospheric Winds with Deep Optical Flow,” KDD ’22: *Proceedings of the 28th ACM SIGKDD Conference on Knowledge Discovery and Data Mining*, no. 1, pp. 1807–1815, 2022, doi: 10.1145/3534678.3539345.

# Management, Facilities and Reporting

**Management and Personnel**

The Cooperative Institute for Meteorological Satellite Studies (CIMSS) is a scientific research unit within the Space Science and Engineering Center (SSEC). Dr. Santek, Principal Investigator, has a successful research career working in the atmospheric sciences in studies pertaining to radiation, radiative transfer, and remotely sensed atmospheric wind research. Dr. Santek’s research has involved the extensive use of NOAA weather satellite data. Dr. Santek will be responsible for overseeing and managing the activities described above. The CIMSS Deputy Director, Wayne Feltz, will also provide oversight to the project. Mr. Feltz oversees the day to day operations of SSEC scientific research, and provides management and coordination for the more than 50 current CIMSS research grants and contracts. The Project Leaders provide the important expertise to the research components of this proposal. Project Leaders are responsible to the Director for their individual research tasks, presenting their results at meetings and conferences, and submitting reports on their findings.

**Facilities**

CIMSS was established through a partnership between NOAA and the University of Wisconsin-Madison (UW-Madison) to conduct research that maximizes the value of meteorological satellite data for meeting the nation’s weather needs. CIMSS is a world-class center for research on the interpretation and uses of meteorological satellite observations for a wide variety of atmospheric and oceanographic studies. University-based Cooperative Institutes like CIMSS have proved to be very cost-effective organizations for conducting research and development programs. CIMSS was awarded to the UW-Madison following an open competition in 2020 and successfully completed a 5-year renewal review in 2025.

CIMSS resides within the Space Science and Engineering Center (SSEC), a research facility within the Office of the Vice Chancellor for Research (OVCR) of UW-Madison. CIMSS position within SSEC at UW-Madison furnishes its scientists with access to undergraduate and graduate students and subject matter expertise in a wide variety of disciplines as well as programs from other agencies including National Aeronautics and Space Administration (NASA), Department of Energy (DoE), Department of Defense (DoD), and the National Science Foundation (NSF).

SSEC is housed within a 15-story building on the UW-Madison campus providing facility support for:

* **Technical Computing** provides a unique set of shared research computing services to meet the high performance computing and data storage needs of the UW–CIMSS research staff. This includes the design, construction, and maintenance of a high performance data processing and storage facility to a customized science software application stack. These services provide the users with cost effective powerful tools they could not otherwise access while maximizing the available resources (labor and equipment). As noted above, SSEC currently has one of the largest computing clusters on campus with 4,160 cores approximately 15 petabytes of total data storage.
* **The Atmospheric Oceanic and Space Sciences (AOSS) Library** at SSEC/UW–CIMSS serves as an important resource for UW–CIMSS scientists and AOS students. SSEC fully supports the AOSS Library activities.
* **SSEC Rooftop Instrument Suite and *SSEC Portable Atmospheric Research Center (SPARC)*.** SSEC supports an instrument validation site on the roof of its 15-story building. A UW–Madison grant funded the purchase and installation of high quality basic meteorological measurements (temperature, moisture, wind, pressure, solar radiation.) and installation of remote sensing instruments. To bring all this information to scientists and other users, UW–Madison SSEC has funded the development of a data collection, management and Web-based delivery system for this instrument site. SSEC also maintains a mobile research facility called the SPARC (*SSEC Portable Atmospheric Research Center)* to study the atmosphere. Several instruments are integrated into a 36-foot trailer that is configured for remote operation either by using internal generators, or by connection to virtually any electrical power source found in the field. The current complement of instruments in the SPARC includes an Atmospheric Emitted Radiance Interferometer (AERI), High-Spectral Resolution Lidar (HSRL), a Halo Doppler Wind Lidar (DWL), a ceilometer, a meteorology surface station, a radiosonde launch receiver, and a GPS total precipitable water instrument. SSEC acquired the facility in 2013 and it has provided great benefit to UW–CIMSS to support field experiments and satellite Cal/Val activities.
* **Engineering -** SSEC maintains a significant engineering research support capability that has a long and successful history working collaboratively with a diverse group of researchers and disciplines to help define, design, implement, test, and document cutting-edge hardware and software projects. SSEC’s instrument development capability involves and integrates the disciplines of mechanical, thermal, optical, electro-optical, electrical software, and systems engineering, as well as program management and quality assurance. We have developed both small and large-scale scientific research instruments for terrestrial, aircraft, and space applications across a broad range of science disciplines.
* **Quality Assurance -** SSEC/CIMSS has developed an advanced quality and safety program to address project needs. All SSEC processes are designed to be scalable to adjust to the size of the project as appropriate. The QA program includes procedures on document management, project development, training, project and employee safety, test equipment calibration, quality records and complaint handling.

***Interactive Computing and Visualization***

The Man computer Interactive Data Access System (McIDAS) was first developed at SSEC over 50 years ago. During that period, it has continued to evolve with advances in technology. McIDAS-X is an integral element in meteorological support for launches at Johnson Space Center and Cape Canaveral, in converting many satellite data formats into data for AWIPS at NWS locations, in staging data from NOAA CLASS, and in many other NASA and NOAA centers and systems.

SSEC is a national leader in on-going research into better data visualization techniques for the physical sciences. The VisAD software package developed at SSEC has been distributed worldwide to hundreds of research organizations interested in high-performance visualization techniques required for large, complex data sets.  VisAD is used as the software core for the next generation of McIDAS, McIDAS-V.   McIDAS-V is freely available from the McIDAS website and via EUMETCast and is being used worldwide for integrating different meteorological data types into 2- and 3-D displays.

***SSEC Data Center***

The SSEC Data Center's Satellite Data Services receives real-time, full resolution data from the GOES-16/17/18/19, EWS-G2, Himawari, COMS, METEOSAT, and MTSAT geostationary satellites, and NOAA, METOP, JPSS, Suomi NPP, and EOS polar orbiting (POES) meteorological satellites. It also receives the GEOnetcast, NWS NOAAport data streams and other alphanumeric, grid, model and radar data feeds. The Data Center has been archiving GOES data since 1978, and has access to all GOES imager and sounding data since that time.  Over 8 TBs of data are ingested daily, of which, approximately 1TB of the geostationary data are archived.  The current archive of geostationary data exceeds 4 PBs, all of which are online and accessible by UW CIMSS researchers.

**Reporting**

An Annual Progress Report will be provided via GEMS/eRA Commons to the NOAA Grants Management Division and to the NOAA/NESDIS Technical Program Manager (TPM) as part of the CIMSS Cooperative Agreement reporting requirements.

**Curriculum Vitae**

|  |
| --- |
| NAME: Santek, David A. |
| Persistent Identifier (PID): https://orcid.org/0000-0003-4020-7156 |
| POSITION TITLE: Scientist, Space Science & Engineering Center |
| Organization: University of Wisconsin-Madison, Madison, WI USA |

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| INSTITUTION AND LOCATION | DEGREE (if applicable) | START DATE  MM/YYY | END DATE MM/YYYY | FIELD OF STUDY |
| University of Wisconsin-Madison, Madison, WI, USA | PHD | 01/1999 | 08/2007 | Atmospheric and Oceanic Sciences |
| University of Wisconsin- Madison, Madison, WI, USA | MS | 01/1976 | 08/1978 | Meteorology |
| University of Michigan, Ann Arbor, MI, USA | BS | 01/1974 | 12/1975 | Atmospheric and Oceanic Sciences |

**Scientific Appointments and Positions**

|  |  |
| --- | --- |
| 2008 – | Scientist I, SSEC, UW-Madison, Madison, WI |
| 2004 – 2008 | Program Manager/Researcher, SSEC, UW-Madison, Madison, WI |
| 1996 – 2004 | Software Development Manager, SSEC, UW-Madison, Madison, WI |
| 1991 – 1996 | Team Leader, SSEC, UW-Madison, Madison, WI |

**Products: Recent Publications**

1. Lukens K. E., K. Garrett, K. Ide, D. Santek, B. Hoover, D. Huber, R. N. Hoffman, H. Liu: System for Analysis of Wind Collocations (SAWC): A Novel Archive and Collocation Software Application for the Intercomparison of Winds from Multiple Observing Platforms. *Meteorology*. 2024; 3(1):114-140.
2. Lukens, Katherine E., K. Ide, K. Garrett, H. Liu, D. Santek, B. Hoover, and R. N. Hoffman, 2022: Exploiting Aeolus level-2b winds to better characterize atmospheric motion vector bias and uncertainty. Atmospheric Measurement Techniques, Volume: 15, Issue: 9, pp. 2719-2743.
3. Santek, D., S. Nebuda, D. Stettner, 2019: Demonstration and Evaluation of 3D Winds Generated by Tracking Features in Moisture and Ozone Fields Derived from AIRS Sounding Retrievals. Remote Sens., 11, 2597.
4. Santek, D., R. Dworak, S. Nebuda, S. Wanzong, R. Borde, I. Genkova, J. García-Pereda, R. Galante Negri, M. Carranza, K. Nonaka, K. Shimoji, S.M. Oh, B.-I. Lee, S.-R. Chung, J. Daniels, J., W. Bresky, 2019: 2018 Atmospheric Motion Vector (AMV) Intercomparison Study. Remote Sens., 11, 2240.
5. Posselt, Derek J.; L. Wu, K. Mueller, L. Huang, F. W. Irion, S. Brown, H. Su, D. Santek, C. S. Velden, 2019: Quantitative assessment of state-dependent atmospheric motion vector uncertainties.Journal of Applied Meteorology and Climatology, Volume 58, Issue 11, 2019, pp.2479-2495.

# UW-Madison CIMSS Data Sharing Plans

## Task 2.1: CIMSS/NESDIS: Passive Retrievals of 3D Optical Flows with Information Leveraged from Environmental Sounders (PROFILES)

**1. Principal Investigator contact and types of environmental data and information to be created during the course of the project**

David Santek, Task Lead, Cooperative Institute for Meteorological Satellite Studies (CIMSS), University of Wisconsin-Madison, dave.santek@ssec.wisc.edu, 608-263-7410

This project will not generate publicly available environmental information.

**2. Type of collection method**

N/A

**3. Tentative date by which data will be shared**

N/A

**4. Standards to be used for data/metadata format and content**

N/A

**5. Policies addressing data stewardship and preservation**

N/A

**6. Procedures for providing access to data and prior experience in publishing such data**

N/A

1. https://www.ssec.wisc.edu/geo-ir-sounder/proxy-data-demonstration/ [↑](#footnote-ref-1)
2. Recurrent All-Pairs Field Transforms (RAFT): Deep learning model designed for optical flow estimation. [↑](#footnote-ref-2)