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Computational and Information Sciences & Technology Office

Sciences and Exploration Directorate, Goddard Space Flight Center

In This Issue

Computational Technologies Project

Field Tests Unite Weather and Climate Models

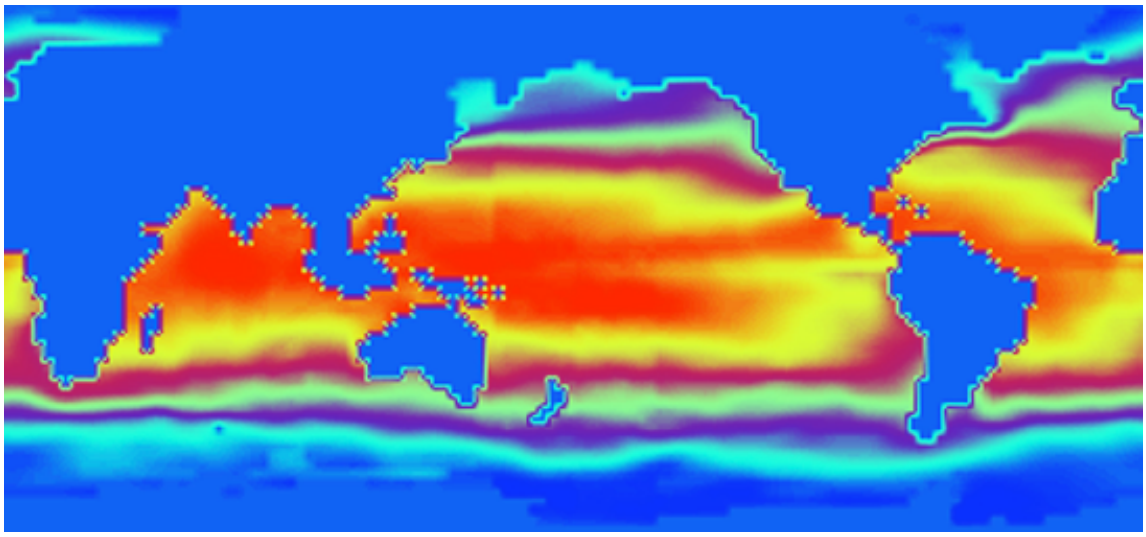
Researchers from Goddard Space Flight Center (GSFC) and seven other government and academic institutions have created four new supercomputer simulations that for the first time combine their mathematical computer models of the atmosphere, ocean, land surface, and sea ice. These simulations are the first field tests of the new Earth System Modeling Framework (ESMF), a shared software infrastructure that promises to accelerate research aimed at improving U.S. predictive capability ranging from short-term weather forecasts to century-long climate change projections and more rapidly move the results of that research into operational prediction systems.

Under a partnership, groups from NASA, the National Science Foundation (NSF), the National Oceanic and Atmospheric Administration (NOAA), the Department of Energy (DOE), the Department of Defense, and research universities are using ESMF as the standard for coupling their weather and climate models to achieve a realistic representation of the Earth as a system of interacting parts. Having a standard will unify much of the modeling community. ESMF makes it easier to share and compare alternative scientific approaches from multiple sources, uses remote sensing data more efficiently, and eliminates the need for individual agencies to develop their own coupling software.

"The development of large Earth system applications often spans initiatives, institutions, and agencies and involves the geoscience, physics, mathematics, and computer science communities. With ESMF, these diverse groups can leverage common software to simplify model development," said NASA ESMF principal investigator Arlindo da Silva, a scientist in GSFC's Global Modeling and Assimilation Office.

NASA's Earth-Sun System Technology Office/Computational Technologies (ESTO/CT) Project funds the field tests and overall ESMF development. The partners on the field tests are DOE's Los Alamos National Laboratory (LANL), the Massachusetts Institute of Technology (MIT), NASA's Jet Propulsion Laboratory (JPL), NOAA's Geophysical Fluid Dynamics Laboratory (GFDL) and National Centers for Environmental Prediction (NCEP), NSF's National Center for Atmospheric Research (NCAR), and the University of California, Los Angeles (UCLA).

Experimental details. The newly completed field tests, known as interoperability experiments, show that this new approach in coupling models works as envisioned. For instance, ESMF enables an NSF-NASA



Using ESMF, researchers have coupled an atmosphere model and an ocean model that had not interacted before. This image depicts sea surface temperatures after five iterations of the simulation. The collaborators on this field test are the Geophysical Fluid Dynamics Laboratory (GFDL) and the Massachusetts Institute of Technology (MIT) (Image credit: Shep Smithline, GFDL; Chris Hill, MIT).

atmosphere model to ingest conventional and satellite observations from NCEP's data analysis system. The coupling then produces global temperature and wind outputs similar to those from NCEP's operational coupled models. Although most of the experiments would require exhaustive tuning and validation to be scientifically sound, they already show that ESMF can be used to assemble coupled applications quickly, easily, and with technical accuracy.

"These interoperability experiments illustrate the role ESMF can play in integrating the national Earth science resources," da Silva said. "Using existing data assimilation technology from NCEP, the finite-volume Community Atmosphere Model, or fvCAM, was able to ingest conventional and satellite observations, a capability that could open the door to using the fvCAM for weather as well as climate prediction." The fvCAM, which includes land surface capabilities, was developed by NCAR, with key components from GSFC.

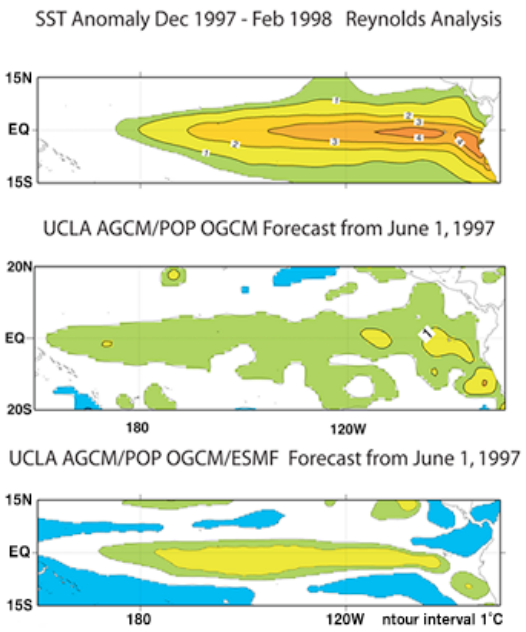
The second experiment again uses NCEP's data assimilation technology but this time couples it with the Aries atmosphere model originally developed by the NASA Seasonal-to-Interannual Prediction Project. Aries is typically also coupled with an ocean model to run experimental forecasts of phenomena such as El Niño and its effects on precipitation. Because they both use ESMF, these two interoperability experiments enable the intercomparison of systems for satellite data assimilation.

The third experiment, combining a GFDL atmosphere-land-ice model with an MIT ocean-sea ice model (known as MITgcm), may ultimately bring new insights into ocean uptake of carbon dioxide and other important atmospheric gases and how this process affects the climate.

In an early independent adoption of ESMF technology, UCLA researchers have successfully coupled their Atmospheric General Circulation Model to the MITgcm for the first time and inserted ESMF into an existing coupling of their model to the LANL Parallel Ocean Program model. They made experimental predictions of the El Niño/Southern Oscillations with the coupled

models using initial states provided by JPL's Estimating the Circulation and Climate of the Ocean (ECCO) project. These preliminary results validate ESMF performance in terms of scientific fidelity, thereby demonstrating the software's ability to serve in a production modeling system. Scientists can then use the ESMF-enabled couplings to compare the forecasting skills between different model combinations. The results also support the importance of ECCO products for improving short-term climate forecasts.

Spreading the word. Demonstrations of the software and the field tests took place at the 4th ESMF Community Meeting, held at MIT in July. It attracted more than 100 attendees from the United States and several other countries. This year's meeting kicked off with the first ESMF on the Grid Workshop on July 20. Shujia Zhou of the CT Project and Northrop Grumman IT, Chris Hill of MIT, and Cecelia DeLuca of NCAR organized the workshop. The event included presentations on grid software and grid implementations of ESMF and other Earth and space science software frameworks.

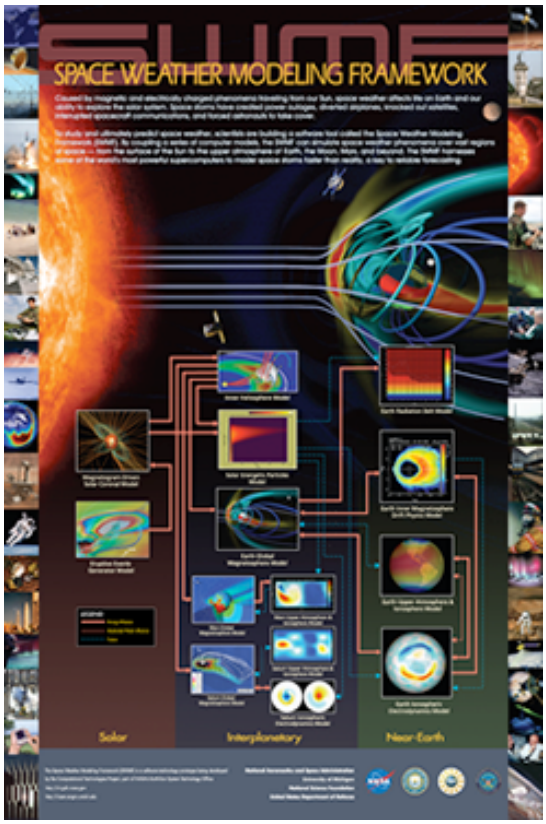


In an early independent adoption of ESMF technology, University of California, Los Angeles (UCLA) researchers have coupled their atmosphere model to two ocean models. This result is from a simulation using a Los Alamos National Laboratory (LANL) ocean model. The visualization shows the stress of sea surface winds on the ocean; this stress influences the ocean's circulation (Image credit: Joe Spahr, C. Roberto Mechoso, UCLA; Phil Jones, LANL; Shujia Zhou, Northrop Grumman IT/GSFC).

The Community Meeting's main session on July 21 demonstrated the maturation ESMF has undergone over the past year. CT Project Manager Jim Fischer noted that ESMF "is graduating from NASA development funding to multi-agency coordinated funding." On the technical front, ESMF now allows concurrent execution of models, as explained by NCAR's Nancy Collins. This capability enables ensemble forecasting: running multiple models with slightly different starting conditions. In addition to the field tests, presenters from GFDL, MIT, the Naval Research Laboratory, NCAR, and NCEP detailed efforts to replace their organizations' coupling software with ESMF. Max Suarez of GSFC described development of the GEOS-5 atmosphere model, the first model completely implemented with ESMF. As related by Don Anderson of NASA Headquarters, GEOS-5 and two other NASA models are being tested for hurricane forecasting in the Florida State University Superensemble. The Community Meeting concluded on July 22 with a hands-on tutorial and an industry partners forum.

Reaching beyond the NASA-funded partnership, the ESMF development team distributes the software to the scientific community via the Internet. NCAR, home of the core implementation team, released ESMF Version 2.2.0 on July 13.

http://ct.gsfc.nasa.gov/
http://www.nasa.gov/centers/goddard/news/topstory/2005/esmf.html



The front side of the new Space Weather Modeling Framework poster shows connections between 14 component models (Image credit: Laurie Graham, GST, Inc.).

New Space Weather Poster Available

A new 24" by 36" wall poster showcases the Space Weather Modeling Framework (SWMF), a CT Project investigation led by the University of Michigan (UM). The front side's dramatic central image links an observation of the Sun with a simulation image showing the effects of a solar storm on Earth's magnetic field. Data visualizations represent the 14 SWMF component models, with color-coded lines indicating the multiple connections between the models. Images along the sides of the poster illustrate real-world impacts on Earth and in space. The back side of the poster includes a feature story about applying the SWMF to the biggest space weather event in recent history, descriptions of the component models and U.S. space weather programs, and science activities for the home or classroom.

The SWMF poster debuted at the 2005 Earth-Sun System Technology Conference, held June 28–30 at the University of Maryland, College Park, MD. SWMF Principal Investigator Tamas Gombosi (UM) featured the poster in his luncheon lecture on the conference's opening day.

Copies of the poster are available free of charge for educational purposes to individuals and groups in the United States. Please send your name, mailing address, and numbers of copies requested to jcohen@pop900.gsfc.nasa.gov.

http://ct.gsfc.nasa.gov/swmf.poster.html

Land Information System Named 2005 NASA Software of the Year

The ESTO/CT-funded Land Information System (LIS) is co-winner of the 2005 NASA Software of the Year award. Co-Principal Investigators Paul Houser of George Mason University (formerly of GSFC) and Christa Peters-Lidard of GSFC received the award in a September 6 ceremony at NASA Headquarters. The award consists of a medal and $43,400. The other 2005 recipient is the Autonomous Sciencecraft Experiment software from NASA JPL.

LIS is a software suite capable of modeling the global land surface at 1-kilometer resolution faster than real time (see "Data Drives Land Surface Modeling," *ESDCD News*, Summer 2004). It currently has more than 150 users from 30 countries, including science teams for NASA satellite missions and a variety of government agencies. LIS co-investigators sharing the award are James Geiger, Susan Olden, and Luther Lighty of GSFC and Sujay Kumar and Yudong Tian of the Goddard Earth Sciences and Technology Center of the University of Maryland, Baltimore County.

The NASA Inventions and Contributions Board, which administers the award, noted that LIS has "helped advance the Earth-Sun System Division's software engineering principles and practices, while promoting portability, interoperability, and scalability." The Software of the Year Review Panel comprises experts from each NASA Center. The Offices of the Chief Engineer, Safety and Mission Assurance, and Chief Information Officer co-sponsor the award.

http://icb.nasa.gov/nasaswy.html

CISTO Updates

Large-Scale Team Science Demonstrated Over 10 Gbps Coast-to-Coast Network

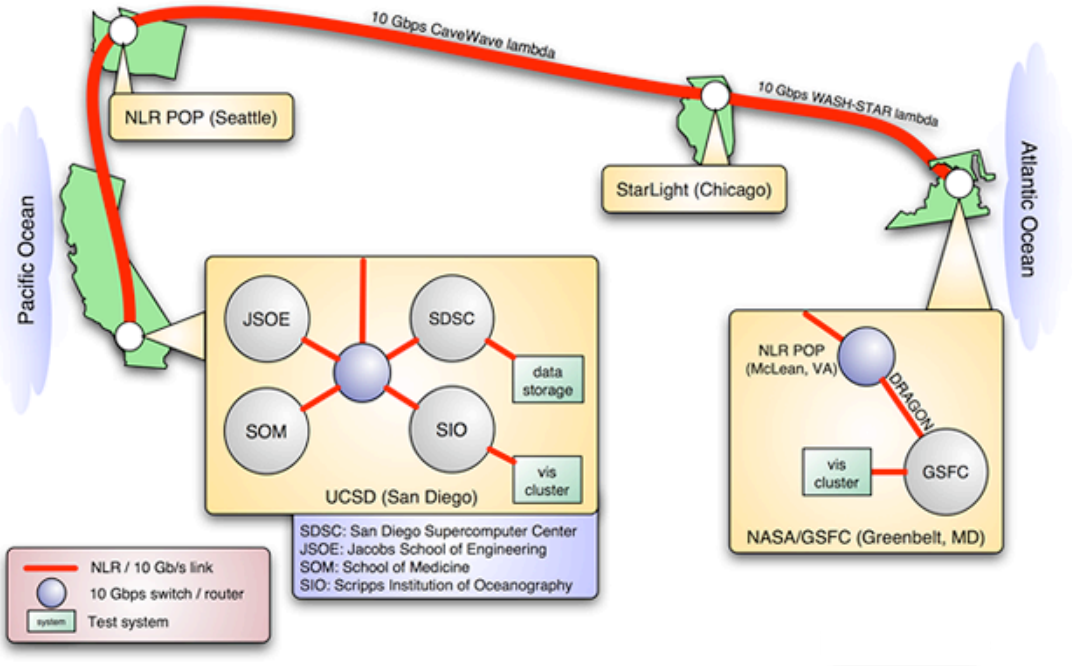
Using its recently installed direct connection to the National LambdaRail (NLR), GSFC joined the University of California, San Diego (UCSD) to demonstrate science applications over the 10 gigabit-per-second (Gbps) network. GSFC hosted "A Demonstration of Large-Scale Team Science in the 21st Century" on August 8. The event was a tribute to Al Diaz, outgoing NASA associate administrator, Science Mission Directorate, who funded CISTO's NLR effort when he was GSFC director in 2004.

"The demo exceeded every expectation I had when I initiated the program for information technology at Goddard," Diaz said. "At that time I hoped that this project would serve as a demonstration of the value of IT investments in the conduct of NASA-sponsored science, particularly Earth science. Not only did it do that, but I hope the demonstration served to promote further investment."

On July 28, engineers from CISTO's Lambda Network (L-Net) Project installed the last link between GSFC and the NLR Point of Presence (POP) in McLean, VA. This link goes through DRAGON, a Washington, DC-region 10 Gbps optical network funded by the National Science Foundation. The coast-to-coast CAVEwave lambda connects a growing collection of computing, visualization, and data storage resources at GSFC, UCSD, and the University of Illinois at Chicago (UIC) into a national-scale OptIPuter (see "GSFC Among First 10 Users of the National LambdaRail," *ESDCD News*, Winter 2005).

The OptIPuter organizations and Ames Research Center (ARC) collaborated on the demonstration, which took place in the Software Integration and Visualization Office's Scientific Visualization Studio (SVS) facility. Serving as master of ceremonies was Milt Halem, GSFC emeritus scientist affiliated with the University of Maryland, Baltimore County (UMBC) and chair of GSFC's IT Pathfinder Working Group. The presentation featured a variety of technologies that take advantage of the NLR.

The demonstration was a tribute to Al Diaz (right), recently retired NASA associate administrator, Science Mission Directorate. Sitting nearby were (from right to left) Tsengdar Lee, program manager, Science Mission Directorate; Gail McConaughy, senior information systems architect, GSFC; and Franco Einaudi, director, Earth-Sun Exploration Division, GSFC (Photo credit: Chris Gunn, INFONETIC).



The 10 gigabit-per-second National LambdaRail now connects resources at GSFC and the University of California, San Diego (Image credit: Kevin Fisher, GSFC).

Larry Smarr, director of UCSD's California Institute for Telecommunications and Information Technology (Calit2) and OptIPuter principal investigator, spoke with attendees from UCSD via high-definition videoconferencing in a partition of the SVS's nine-screen HyperWall. Exploiting the UIC/Electronic Visualization Laboratory (EVL)-developed TeraVision software running over the NLR, this capability will enable closer collaboration between GSFC and UCSD's Scripps Institution of Oceanography. Scientific data sets and videoconferencing can co-exist on a HyperWall or on a scientist's desktop. Later in the program, Scripps' V. Ramanathan and Bernard Minster used the videoconferencing capability to describe plans for accessing petabytes of Earth science data.

The HyperWall at GSFC displayed Land Information System (LIS) 1-kilometer-resolution data sets residing on an OptIPuter storage cluster at UCSD. GSFC hydrologist Christa Peters-Lidard spoke about LIS advancements such as resolving small cities as well as advantages of using the NLR. Using UIC/EVL's SAGE and JuxtaView software, Randall Jones of the SVS/GST, Inc., sitting at GSFC, panned and zoomed on visualizations of the eastern United

Christa Peters-Lidard, a GSFC hydrologist, points out features of Land Information System (LIS) data products. Using the National LambdaRail, the HyperWall behind her displays LIS 1-kilometer data sets fed from an OptIPuter cluster at the University of California, San Diego (Photo credit: Chris Gunn, INFONETIC).

States to show how the views get updated over 2,000 miles of the LambdaRail with only a slight delay.

At the nearby Lambda Display, a two-screen set-up possible for a scientist's office, Kevin Fisher of GSFC called up MAP '05 hurricane data sets employing GrADS-DODS software from across the continent. This technology will also serve the Coordinated Enhanced Observing Period (CEOP) collaboration involving GSFC, Scripps, and other organizations. Arlindo da Silva, a GSFC data assimilation scientist, said that CEOP scientists will soon be analyzing hydrological data sets from 10 national meteorological centers as part of the World Climate Research Program.

A fourth application involved NASA finite-volume General Circulation Model (fvGCM) forecasts of Hurricane Irene running on the Columbia supercomputer at ARC. As a movie loop of fvGCM output appeared on a wall-sized screen, ARC's Chris Henze explained how 2-D MPEG visualizations from every time-step were being assembled in real time and then compressed and continuously delivered over an Internet2 connection. Horace Mitchell of the SVS explained that ARC's forthcoming NLR connection will enable sharing of 3-D, uncompressed visualizations.

More than 50 contributors made the demonstrations possible. CISTO participants included L-Net Project members Pat Gary and Bill Fink of GSFC and Paul Lang and Aruna Muppalla of ADNET Systems, Inc.

http://cisto.gsfc.nasa.gov/IRAD_Lambda.html

CISTO Engineer Receives Patent and GSFC IS&T Award

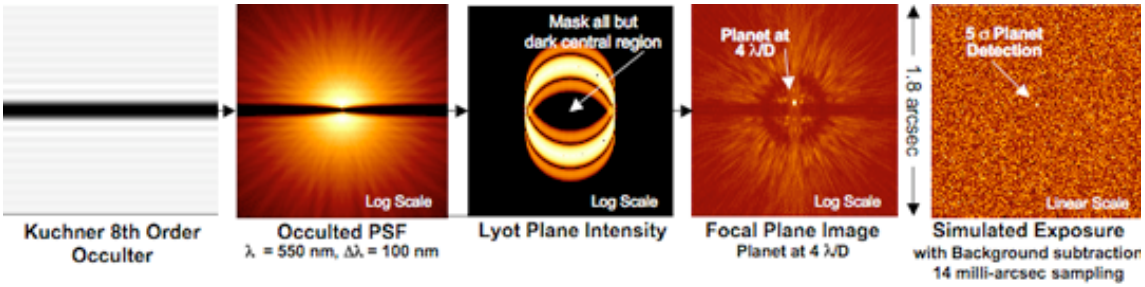
James C. Tilton, a member of CISTO's Information Sciences and Technology (IS&T) Research group, recently received notice that the United States Patent and Trademark Office has issued patent US

Deputy Center Director Chris Scolese (left) presents Jim Tilton (right) with the 2005 Excellence in Information Science and Technology Award (Photo credit: Pat Izzo).

6,895,115 B2, "Method for Implementation of Recursive Hierarchical Segmentation (RHSEG) on Parallel Computers," to NASA for his invention. This patented innovation enables the efficient parallel implementation of the pre-processing software that Tilton developed for hierarchical segmentation (HSEG) analysis of single band, multispectral, or hyperspectral imagery data at resolutions up to 8000 x 8000 pixels.

Originally developed for improving the analysis of Earth sciences and remote sensing imagery, Tilton's work also has applications for aircraft and satellite remote sensing, medical imaging, drug development, x-ray imaging, data mining, facial recognition, and thermal imaging. Tilton has worked with GSFC's Office of Technology Transfer and Office of Patent Counsel to disseminate the RHSEG software to other organizations inside and outside NASA, such as Bartron Medical Imaging, LLC, of New Haven, CT. The company uses RHSEG in their commercial product, the Medical Segmentation (MED-SEG) HSEG System, for the diagnosis and management of disease through enhanced medical imaging.

Tilton also received the Fifth Annual Excellence in Information Science and Technology Award in May 2005. The award



The Coronagraphic Exploration Camera (CorECam) study was recently awarded as a science instrument for the Terrestrial Planet Finder Instrument Concept Study. CorECam collects light from the output of the coronagraphic starlight suppression system of NASA's Terrestrial Planet Finder, which uses a series of specialized optical occulting masks (far left). A mask is placed over the image of the bright central source (2nd from left), and the telescope's primary mirror is re-imaged (PSF = point-spread function). The resulting intensity pattern is shown in the center figure. A Lyot mask is applied to block the cat's eye-shaped bright regions, and the light is brought back to focus thereby collecting the planetary image within CorECam. This has the net effect of suppressing the starlight but not the planetary light (4th figure from left). The residual pattern, known as speckle, is due to optical errors, misalignments, and scatter (far right) (Image credit: Richard Lyon).

is presented annually to the GSFC employee(s) who best exhibits broad, significant contributions to GSFC programs or projects in IS&T.

http://techtransfer.gsfc.nasa.gov/RHSEG/index.html
http://www.bartron.ws/
http://isandtcolloq.gsfc.nasa.gov/awards/award.html

CISTO Scientist is Co-investigator on Successful TPF-C Concept Studies

CISTO scientist Richard Lyon is a co-investigator on three of five successfully competed instrument concept studies for the Terrestrial Planet Finder-Coronagraph (TPF-C). The Terrestrial Planet Finder (TPF) is a suite of two complementary observatories that will study all aspects of planets outside our solar system. TPF observatories will measure the size, temperature, and placement of planets as small as the Earth in the habitable zones of distant solar systems.

The TPF-C will use visible light coronagraphy and occulting techniques in conjunction with active optical control to suppress the stellar light with respect to the planetary light, increasing the contrast and enabling planetary detection and characterization. Lyon contributed to three awarded studies for the GSFC-led coronagraphic camera (CoreCAM), the JPL-led general astrophysics instrument, and the University of Arizona-led imaging spectrometer study.