The Modified Gerchberg-Saxton (MGS) algorithm is an image-based wavefront-sensing method that can turn any science instrument focal plane into a wavefront sensor. MGS characterizes optical systems by estimating the wave-front errors in the exit pupil using only intensity images of a star or other point source of light. This innovative implementation of MGS significantly accelerates the MGS phase retrieval algorithm by using stream-processing hardware on conventional graphics cards.

Stream processing is a relatively new, yet powerful, paradigm to allow parallel processing of certain applications that apply single instructions to multiple data (SIMD). These stream processors are designed specifically to support large-scale parallel computing on a single graphics chip. Computationally intensive algorithms, such as the Fast Fourier Transform (FFT), are particularly well suited for this computing environment. This high-speed version of MGS exploits commercially available hardware to accomplish the same objective in a fraction of the original time. The exploit involves performing matrix calculations in NVIDIA graphic cards. The graphical processor unit (GPU) is hardware that is specialized for computationally intensive, highly parallel computation.

From the software perspective, a parallel programming model is used, called CUDA, to transparently scale multicore parallelism in hardware. This technology gives computationally intensive access to the processing power of the NVIDIA GPUs through a C/C++ programming interface. The AAMGS (Accelerated Adaptive MGS) software takes advantage of these advanced technologies, to accelerate the optical phase error characterization. With a single PC that contains four NVIDIA GTX-280 graphic cards, the new implementation can process four images simultaneously to produce a JWST (James Webb Space Telescope) wavefront measurement 60 times faster than the previous code.

This work was done by Raymond K. Lai, Catherine M. Ohara, Joseph J. Green, Siddhuraju P. Bikkannavar, Scott A. Basinger, David C. Redding, and Fang Shi of Caltech for NASA’s Jet Propulsion Laboratory. For more information, contact iaooffice@jpl.nasa.gov. The software used in this innovation is available for commercial licensing. Please contact Daniel Broderick of the California Institute of Technology at danielb@caltech.edu. Refer to NPO-47101.
mixing, additional small-scale terms, one in the momentum and one in the energy conservation equations, were identified as requiring modeling. These additional terms were due to the tight coupling between dynamics and real-gas thermodynamics. It was inferred that if these terms would not be modeled, the high density-gradient magnitude regions, experimentally identified as a characteristic feature of these flows, would not be accurately predicted without the additional term in the momentum equation; these high density-gradient magnitude regions were experimentally shown to redistribute turbulence in the flow. And it was also inferred that without the additional term in the energy equation, the heat flux magnitude could not be accurately predicted; the heat flux to the wall of combustion devices is a crucial quantity that determined necessary wall material properties.

The present work involves situations where only the term in the momentum equation is important. Without this additional term in the momentum equation, neither the SGS-flux constant-coefficient Smagorinsky model nor the SGS-flux constant-coefficient Gradient model could reproduce in LES the pressure field or the high density-gradient magnitude regions; the SGS-flux constant-coefficient Scale-Similarity model was the most successful in this endeavor although not totally satisfactory. With a model for the additional term in the momentum equation, the predictions of the constant-coefficient Smagorinsky and constant-coefficient Scale-Similarity models were improved to a certain extent; however, most of the improvement was obtained for the Gradient model. The previously derived model and a newly developed model for the additional term in the momentum equation were both tested, with the new model proving even more successful than the previous model at reproducing the high density-gradient magnitude regions. Several dynamic SGS-flux models, in which the SGS-flux model coefficient is computed as part of the simulation, were tested in conjunction with the new model for this additional term in the momentum equation. The most successful dynamic model was a “mixed” model combining the Smagorinsky and Gradient models.

This work is directly applicable to simulations of gas turbine engines (aeronautics) and rocket engines (astronautics).

This work was done by Jovette Bellan and Ezgi Taşkınoğlu of Caltech for NASA's Jet Propulsion Laboratory. For more information, contact iaoffice@jpl.nasa.gov. NPO-47040

Tropospheric Correction for InSAR Using Interpolated ECMWF Data and GPS Zenith Total Delay
This technique could be used in environmental remote sensing applications.

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To mitigate atmospheric errors caused by the troposphere, which is a limiting error source for spaceborne interferometric synthetic aperture radar (InSAR) imaging, a tropospheric correction method has been developed using data from the European Centre for Medium-Range Weather Forecasts (ECMWF) and the Global Positioning System (GPS).

The ECMWF data was interpolated using a Stretched Boundary Layer Model (SBLM), and ground-based GPS estimates of the tropospheric delay from the Southern California Integrated GPS Network were interpolated using modified Gaussian and inverse distance weighted interpolations. The resulting Zenith Total Delay (ZTD) correction maps have been evaluated, both separately and using a combination of the two data sets, for three short-interval InSAR pairs from Envisat during 2006 on an area stretching from north-east from the Los Angeles basin towards Death Valley. Results show that the root mean square (rms) in the InSAR images was greatly reduced, meaning a significant reduction in the atmospheric noise of up to 32 percent. However, for some of the images, the rms increased and large errors remained after applying the tropospheric correction. The residuals showed a constant gradient over the area, suggesting that a remaining orbit error from Envisat was present. The orbit reprocessing in ROI_pac and the plane fitting both require that the only remaining error in the InSAR image be the orbit error. If this is not fulfilled, the correction can be made anyway, but it will be done using all remaining errors assuming them to be orbit errors. By correcting for tropospheric noise, the biggest error source is removed, and the orbit error becomes apparent and can be corrected for.

After reprocessing the InSAR images using re-estimated satellite orbits, the overall rms reduction (using both tro-