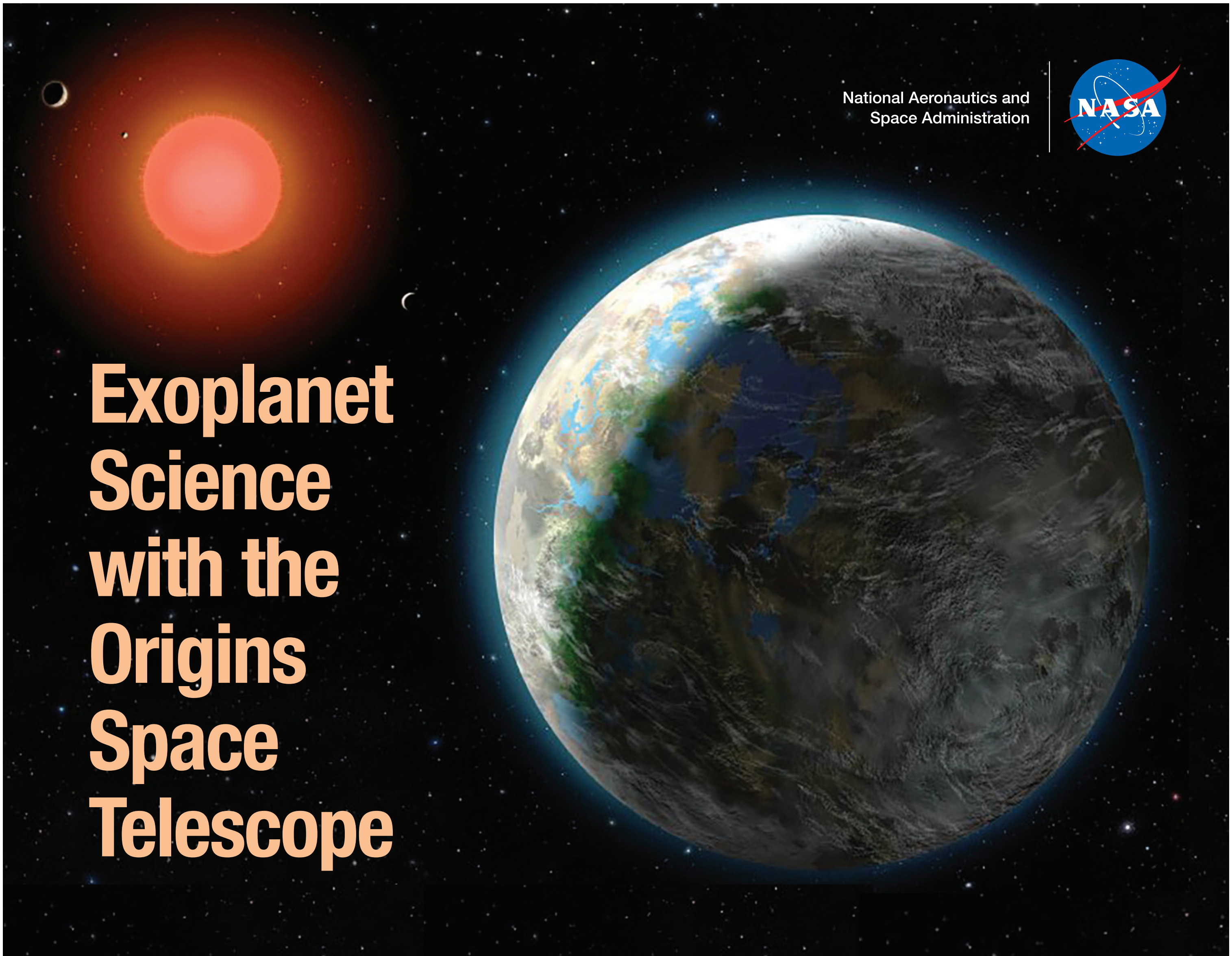
National Aeronautics and Space Administration

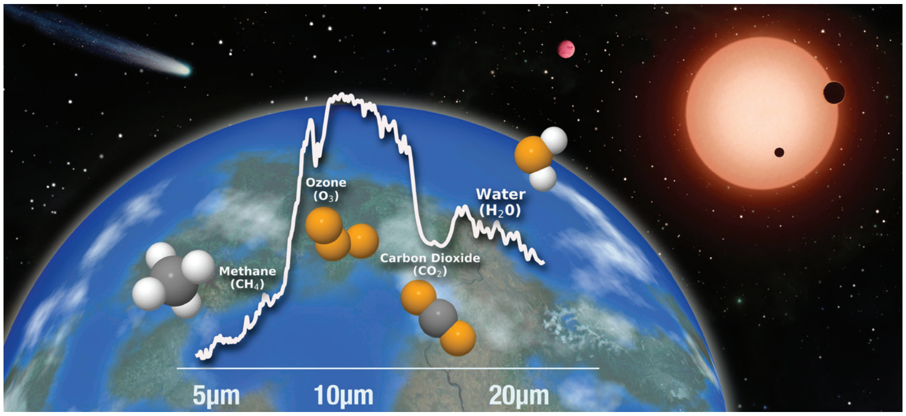


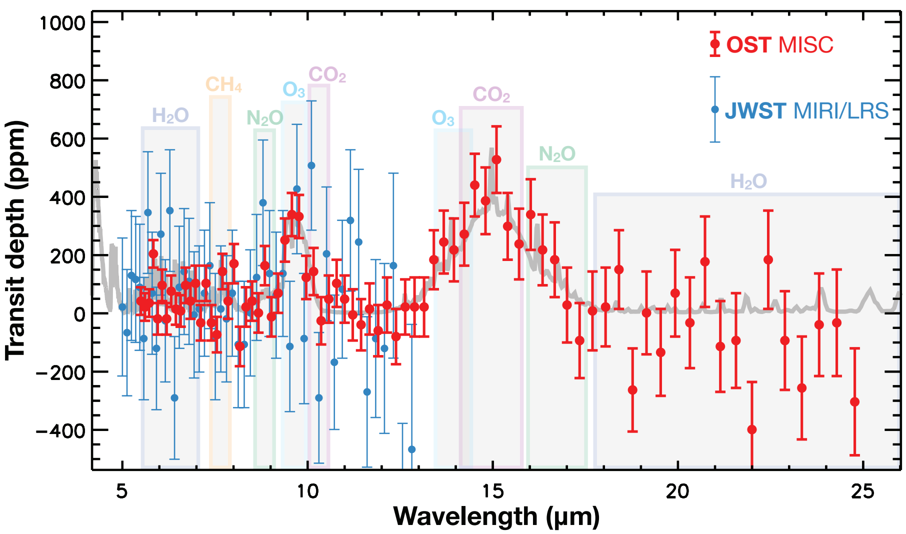
Exoplanet Science with the Origins Space Telescope

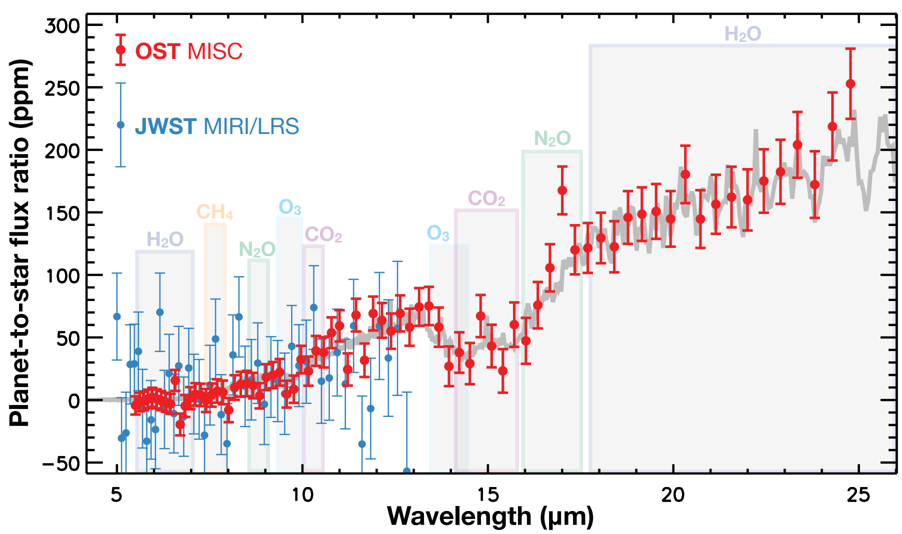
MEASURING HABITABILITY AND BIOSIGNATURES OF TERRESTRIAL EXOPLANETS

The Origins Space Telescope (OST) is the mission concept for the Far-Infrared Surveyor in NASA’s Astrophysics Roadmap. OST is one of four large mission concepts currently being studied by NASA in preparation for the Astrophysics 2020 Decadal Survey. With active cooling (~4 K), OST will be extraordinarily sensitive in mid- to far-IR wavelengths, and will use imaging and spectroscopy to probe the universe deeply, trace the path of water through star and planet formation, and characterize the atmospheres of exoplanets ranging in size from Jupiter to Earth.

Visit our website at: origins.ipac.caltech.edu







OST will detect biosignatures and characterize habitable planets. Model transmission (top) and emission (bottom) spectra of TRAPPIST-1e (0.92 R_E, 250 K) with simulated JWST (blue) and OST (red) data. The panels indicate bandwidths of detectable molecular features. Uncertainties are derived for a Kmag = 8 star using 30 transits/eclipses. The JWST+MIRI/LRS simulations assume an optimistic noise floor of 30 ppm. The OST simulations assume a 9-meter aperture.

A Comprehensive Understanding of Potentially Habitable Worlds

Detecting Biosignatures

OST will expand upon the legacy of exoplanet science with the Hubble Space Telescope, Spitzer Space Telescope and the upcoming James Webb Space Telescope (JWST) by conducting transmission and emission (dayside and phase-resolved) spectroscopy of exoplanets, with a particular focus on Earth-sized exoplanets transiting in the habitable zones of M-dwarf stars. By leveraging mass, radius, and density measurements of this population of planets, OST can preselect those that are definitively rocky to search for and detect biosignatures, including ozone (O_3) and/or nitrous oxide (N_2O) with methane (CH_4).

Measuring Climate

Potentially habitable planets have blackbodies that peak in the mid-IR — the wavelengths over which OST can probe. Due to its low estimated noise floor, observations will be sufficiently sensitive to measure phase-resolved thermal emission of rocky planets, which will help distinguish between planets with thin or substantial atmospheres. Because these measurements will be conducted spectroscopically, rocky planet atmospheres can be constrained in both longitude and altitude, providing a heretofore unseen look at the global thermal structure of potentially habitable planets. These thermal measurements will enable direct determination of habitability.

Directly Imaging Exoplanets

With a detectable contrast ratio of 10^{-6} and an inner working angle of ~0.6 arcsec at 25 microns, OST will be able to directly image and characterize the atmospheres of true exoplanet analogs of Jupiter and Saturn, critical for understanding the origin and evolution of exoplanetary systems like our own. OST will enable quantitative abundance determinations of molecules prominent in the mid-IR such as carbon dioxide and many nitrogen-bearing species not accessible with current direct imaging facilities. OST will also be capable of imaging young gas giants and ice giants, including those that are temperate (~300 K).

Technology Advancements

OST will include an instrument designed to obtain spectra of both transiting and directly imaged exoplanets. The Mid-Infrared Imager, Spectrometer, and Coronagraph (MISC) instrument is being designed in collaboration with JAXA. The Transit Spectroscopy Module uses a densified pupil spectrometer to generate multiple spectra on the detector plane that are more stable against telescope pointing jitter and mirror deformation. Using modern data analysis techniques (e.g. independent component analysis on the collection of spectra) and by advancing detector technology, we expect to achieve <10 ppm performance (with a goal of <5 ppm). MISC will use three Si:As detectors to provide simultaneous wavelength coverage from 5 – 25 microns at a resolution R = 100 – 300.

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