Description of the EPOCh Earth Observations

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Updated by Tim Livengood, 2 September 2010, for EPOCh Earth Polar observations in 2009.

EPOCh Earth Equatorial Observations in 2008

The 2008 EPOCh Earth equatorial observations comprise imaging in seven optical narrow-band filters, as well as infrared (1.05 to 4.8 micron) spectroscopy. The optical images used a 512x512 subarray of the visible HRIV CCD detector at a scale of 0.4 arcsec per pixel, and each frame acquired by the HRII infrared spectrometer is 512 pixels (wavelength) x 128 pixels (spatial, with a scale of 2 arcsec per pixel). Because the HRI telescope used for both optical and infrared wavelengths is defocused, the spatial resolution as observed is about 4 arcsec in each case, but can be improved by deconvolution (see below).

The optical filters are centered in wavelength at approximately 350, 450, 550, 650, 750, 850 and 950 nanometers, and have FWHM bandpasses of 100 nanometers. HRIV CCD images were taken hourly in all filters, for a duration of approximately 24 hours, at three epochs (18-19 March, 28-29 May, and 4-5 June, 2008, UT, see Table 1). The 450, 550, 650, and 850 nanometer filters were imaged more frequently, at a 15-minute cadence. Infrared spectroscopy was obtained every two hours, by scanning the slit of the HRII spectrometer over the Earth, using three scans to ensure that the entire disk of Earth would be covered. The slit of the IR spectrometer was aligned to be perpendicular to the Earth's terminator during the scans; during the March campaign the MRI CCD was used to acquire images of Earth as context for the IR spectra. The spacecraft orbit was approximately in the plane of the ecliptic; therefore the view of Earth is approximately from the equator. During the 28 May observation, the Moon transited Earth as seen from the spacecraft.

Table 1. Summary of the 2008 EPOCh Earth observations.

Start Date/Time (UT)	***End Date/Time (UT)***	***Range (AU)***	***Illumination Fraction***
18 March 2008 18:19:19	19 March 2008 18:19:17	0.183	76.7%
28 May 2008 20:03:52	29 May 2008 20:03:50	0.332	62.8%
4 June 2008 16:57:30	5 June 2008 16:57:28	0.337	61.5%

The units of the archived raw optical images as well as the raw IR spectroscopy are raw data counts while the units of the archived calibrated optical images and calibrated IR

spectra are Watts per square meter per steradian per micron. (Both raw and calibrated data files are archived at MAST and PDS.) The calibrated HRIV CCD images have been bias-subtracted with removal of electronic crosstalk and transfer smear and nominally flat-fielded, using flat-field calibration exposures of an integrating sphere made on the ground before launch. The CCD detector response has changed in space. The most precise photometry (e.g., for exoplanet transits) has to account for those changes, but the EPOCh team has not corrected the Earth images for changes in the CCD. The calibrated HRII spectra were linearized and dark corrected; electronic crosstalk was also removed. The CCD images were flux-calibrated using observations of standard stars, and the IR spectra were flux-calibrated using lunar observations.

The EPOCh team used the optical images from 2008 to construct videos of the rotating Earth, using observations of standard stars to deconvolve the out of focus PSF of the telescope. Those videos are available on the EPOXI mission and MAST websites and may be archived at PDS.

EPOCh Earth Polar Observations in 2009

The EPOCh Earth observations at high subspacecraft latitude ("polar") comprise imaging in seven optical narrow-band filters, as well as infrared (1.05 to 4.8 micron) spectroscopy. The optical images used a 512x512 pixel subarray of the visible HRIV CCD detector at a scale of 2 microradian per pixel (0.413 arcsec per pixel). Each frame acquired by the HRII infrared spectrometer is 512 pixels (wavelength) x 128 pixels (spatial, with a scale of 10 microradian per pixel or 2.06 arcsec per pixel). Because the HRI telescope used for both optical and infrared wavelengths is defocused, the spatial resolution as observed is about 4 arcsec in each case, but can be improved by deconvolution (see below).

The optical filters are centered in wavelength at approximately 350, 450, 550, 650, 750, 850 and 950 nanometers, and have FWHM bandpasses of 100 nanometers. HRIV CCD images were taken hourly in all filters, for a duration of approximately 24 hours. The 450, 550, 650, and 850 nanometer filters were imaged more frequently, at a 15-minute cadence. Infrared spectroscopy was obtained every two hours, by scanning the slit of the HRII spectrometer over the Earth, using three scans to ensure that the entire disk of Earth would be covered. The slit of the IR spectrometer was aligned to be perpendicular to the Earth's terminator during the scans. The MRI medium-resolution instrument CCD was used to acquire images of Earth as context for the IR spectra. Data were collected in two epochs (27–28 March and 4–5 October, 2009, UT, see Table 2); a small amount of data (one HRIV imaging set) was collected in an aborted observation of Earth on 27 September 2009 UT that was terminated prematurely by spacecraft fault-protection systems. The view of Earth in these observations was from high subspacecraft latitude, for a view dominated by either the north or south polar region near equinox.

Table 2. Summary of the 2009 EPOCh Earth observations.

Start Date/Time (UT)	*End Date/Time (UT)*	*Range (AU)*	*Illumination Fraction*	*Sub-spacecraft latitude*
27 March 2009 16:19	28 March 2009 16:37	0.114	53.5%	+62.0°
27 September 2009 16:10	27 September 2009 16:10	0.115	52.7%	–73.8°
4 October 2009 09:37	5 October 2009 09:57	0.114	53.1%	–73.8°

The units of the archived raw optical images as well as the raw IR spectroscopy are raw data counts while the units of the archived calibrated optical images and calibrated IR spectra are Watts per square meter per steradian per micron. Both raw and calibrated data files are archived at PDS. The calibrated HRIV CCD images have been bias-subtracted with removal of electronic crosstalk and transfer smear and nominally flat-fielded, using flat-field calibration exposures of an integrating sphere made on the ground before launch. The CCD detector response has changed in space. The most precise photometry (e.g., for exoplanet transits) has to account for those changes, but the EPOCh team has not corrected the Earth images for changes in the CCD. The calibrated HRII spectra were linearized and dark corrected; electronic crosstalk was also removed. The CCD images were flux-calibrated using observations of standard stars, and the IR spectra were flux-calibrated using lunar observations.

The EPOCh team used the optical images to construct videos of the rotating Earth, using observations of standard stars to deconvolve the out-of-focus PSF of the telescope. Those videos are available on the EPOXI mission website and will be archived at PDS and MAST.