Introduction for EPIC

This simple information website contains three documents to help you become familiar with the major characteristics of the two Earth Science instruments EPIC and NISTAR. If there are additional questions, they may be addressed to the Project Scientist, Associate Project Scientist, or either of the two Instrument Scientists. The appropriate email addresses are listed on the three of the five documents (2 for EPIC and 3 for NISTAR).

As of this writing, the plan is to launch the DSCOVR spacecraft during January 2015. It will take approximately 6 months before the spacecraft reaches Lagrange-1 (L-1) and achieves a stable orbit. In order to avoid contamination, the doors on EPIC and shutters on NISTAR will not be opened until the major rocket firings are completed.

The first month in the planned orbit about L-1 will be devoted to stabilizing the spacecraft operations, initial calibration, and instrument checkout. Earth data will also be obtained, but there may be some interruptions for lunar calibration and other check-out operations.

After the first month, the operation of DSCOVR will go onto a regular schedule. For EPIC, this will mean approximately 10 images approximately every 1.5 hours in order to conform to the available telemetry rate of 5 hours of downlink time at Wallops Island, Virginia. The official life time of this mission is two years. There is enough onboard fuel for 5 years.

Because of the unstable nature of the L-1 orbit, and because of lunar perturbations, there will be periodic orbit correction maneuvers to maintain the orbit within specified parameters. The plane of the perturbed Lissajous orbit about L-1 is tilted relative to the ecliptic plane of the Earth. This means that the effective distance from the Earth will go from a maximum to a minimum every 3 months. The Earth size as viewed from L-1 is a nominal 0.5 degrees.

The spacecraft will rotate slowly on it axis with a period of 6 months, but its optical axis will remain aligned with the Earth. Occasionally, the spacecraft will be slewed to view the Moon (a maximum of once per month) for about 20 minutes to perform lunar calibration and to check radiometric stability. Lunar calibration will be performed only on days when a full moon is seen from the Earth. At no time will the slew be more than 4 degrees from the Earth's center to stay within the transmission cone of the spacecraft antenna. This is to make sure that we receive continuous real-time solar weather data.

The project will produce geolocated "calibrated" measured radiances as a function of latitude and longitude. Each of the 10 wavelengths channels corresponding to a single measurement cycle will be aligned on a common grid. The conversion from counts to radiances will be obtained by using the data from lunar measurements as compared to the US Geological Survey's ROLO data for full moon conditions as seen from the Earth's surface. This will be approximately the same view as EPIC has from L-1.

It may be possible to obtain a better lunar calibration using Lunar Reconnaissance Orbiter data, since it does not need to be corrected for atmospheric aerosols and absorbers.

The DSCOVR data will be archived for access on the Langley ASDC website in HDF5 format: https://eosweb.larc.nasa.gov/ At the moment the specific directory structure for the data location is not known. This document will be updated with the latest information.

CORRECTIONS

1. *There is an omission in the DSCOVR Earth Science Algorithms announcement (A.22) released on April 14, 2014.*

In the primary application of the spectral band 779.5 nm (last row in the Table on page A.22-2) should be both Clouds and Vegetation. It should read:

Wavelength (nm)	Full Width (nm)	Primary Application
317.5 ± 0.1	1 ± 0.2	Ozone, SO 2
325 ± 0.1	2 ± 0.2	Ozone
340 ± 0.3	3 ± 0.6	Ozone, Aerosols
388 ± 0.3	3 ± 0.6	Aerosols, Clouds
443 ± 1	3 ± 0.6	Aerosols
551 ± 1	3 ± 0.6	Aerosols, Vegetation
680 ± 0.2	2 ± 0.4	Aerosols, Vegetation, Clouds
687.75 ± 0.2	0.8 ± 0.2	Cloud Height
764 ± 0.2	1 ± 0.2	Cloud Height
779.5 ± 0.3	2 ± 0.4	Clouds, Vegetation

2. The filter description document, EPIC filter.xls, has been corrected for the 340 nm filter. The values for 325 nm were accidentally copied into the 340 nm column
3. The ROSES AO has a sentence on page A22-1 as follows:

   EPIC images radiances from the sunlit face of the Earth on a 2048 x 2048 pixel CCD in 10 narrowband channels (ultraviolet [UV] and visible) with a nadir sampling field of view of approximately 8 km and an estimated resolvable size of 17 km for visible wavelengths.

   The word visible should be changed to "all".

   Recently, the DSCOVR project made a decision to average 2x2 pixels onboard the spacecraft for 9 out of the 10 channels and to use an optimized form of lossy compression. One channel, 443 nm, will be transmitted at full 2048x2048 resolution to help with cloud detection algorithms. This was done to compensate for the limited telemetry capability arising from only using 1 antenna located at Wallops Island, Virginia for 5 hours per day. The change permits a full set of 10 images every 90 minutes. The lossy compression has been tested on simulated radiance data, and found to produce very small differences in retrievals (e.g., ozone error < 1 DU) compared to lossless compression. The new photographic resolution (resolvable size) for the 1024 x 1024 images is 24 km. The small change between 17 and 24 km is caused by the point spread function limiting the resolution at 2048x2048 pixels.

   May 5 2014: There are new files on AVDC.GSFC.NASA.GOV

   May 19, 2014 A preliminary version of the Level 1 DSCOVR EPIC data format control book has been added to the documentation. <u>This document will be replaced by a final version.</u>

Questions Asked and Answers as of 6/5/2014

What kind of accuracy and precision requirements are expected from the EPIC instrument?
The accuracy and precision varies with the desired product. However, as an example, the retrieval of O3 should result in an error of approximately 1%. An error of 10% would be useless. 2% would still be quite useful.

In this document that I had found, you mention that stray light is mitigated as a correction to the raw detector signal, where an inversion is done to try and remove the stray light component from the signal to leave behind the desired signal. Has this correction been studied under a barrage of geophysical conditions? How were the ozone retrievals affected in regions of low ozone?
There has been no data obtained with EPIC under real conditions. The efficacy of the stray light correction will not be known until EPIC is in orbit. The stray light correction worked quite well using simulated radiances. O3 retrievals worked better in cloudy regions and worse in dark regions because of the reduction in SNR in dark regions. Low ozone values compared to high ozone values (280 DU compared to 450 DU) had almost no effect on the retrieval of O3.

Main question: From your perspective, would there be a need for such a capability in your program?
If you can improve the stray light correction over the current method, it would be valuable.

You said that the ozone retrievals are worse for “darker” pixels and good for “brighter” pixels with cloud fields in them. Could you clarify what a dark pixel is? Could it be a clear sky pixel over ocean perhaps? Also, could you give me an estimate as to the size of a typical pixel SNR for the "dark” and "brighter” cases?

Darker pixels are those viewing cloud-free and aerosol-free scenes. Typical scenes that include clouds have reflectivities that are about 30%. Typical clouds have reflectivities ranging up to to 60% with the brightest clouds reaching about 80% usually high thick clouds at low latitudes. The very brightest scenes are clear-sky over fresh snow, which can reach over 90% reflectivity. The reflectivity of the earth's surface ranges from 2 to 4% in the UV range, but is higher in the visible wavelengths (20% over vegetation). In the UV wavelengths needed for ozone retrieval, the situation is complicated by Rayleigh scattering. This reduces the contrast from 20 to 1 down to about 5 to 1. The intrinsic SNR of the DSCOVR detector is derived from the CCD well depth of about 95,000 electrons or approximately SNR = 300. However, to avoid blooming on the CCD, we anticipate only filling the wells to 80% or a SNR of about 275 for the brightest scenes and 125 for the darkest scenes. We plan on binning at least 4 pixels for 9 of the 10 channels, so that the SNR will be about 550 and 250, respectively. The 443 nm channel is currently planned to be downlinked at 2048x2048 for cloud discrimination with improved spatial resolution. The size of a single pixel projected on the Earth is about 8 km (1 arc second) at the sub-satellite point, however the photographic resolution is about 17 km because of the optical point-spread function. If the CCD output is binned by averaging 2x2 pixels, then the photographic resolution is about 24 km.

I presume there exists an instrument (optical) model of EPIC, whereby an incident radiance field entering the instrument can be transmitted through the optical chain (lens, mirrors, slit, grating) and imaged onto the CCD, correct?

We do have a ZEMAX optical model of the telescope that is moderately accurate compared to laboratory measurements for a uniform light source illuminating the entire entrance aperture.

I am sure simulated data does exists, but would it be available to me for use in developing a proposal?

There are no simulated Earth radiances for observations from the Lagrange-1 viewpoint. The closest one could come would be to use data from other satellites (MODIS and OMI) at the appropriate phase angles.

Can ROSES algorithms be run on GSFC computers where they have access to the data?

There are 2 possibilities: 1) the GSFC NCCS super computer, or 2) as part of the level 1 pipeline on the same node.

For the first case, ROSES winners could apply for access to the NCCS. (http://www.nccs.nasa.gov/account_info.html).

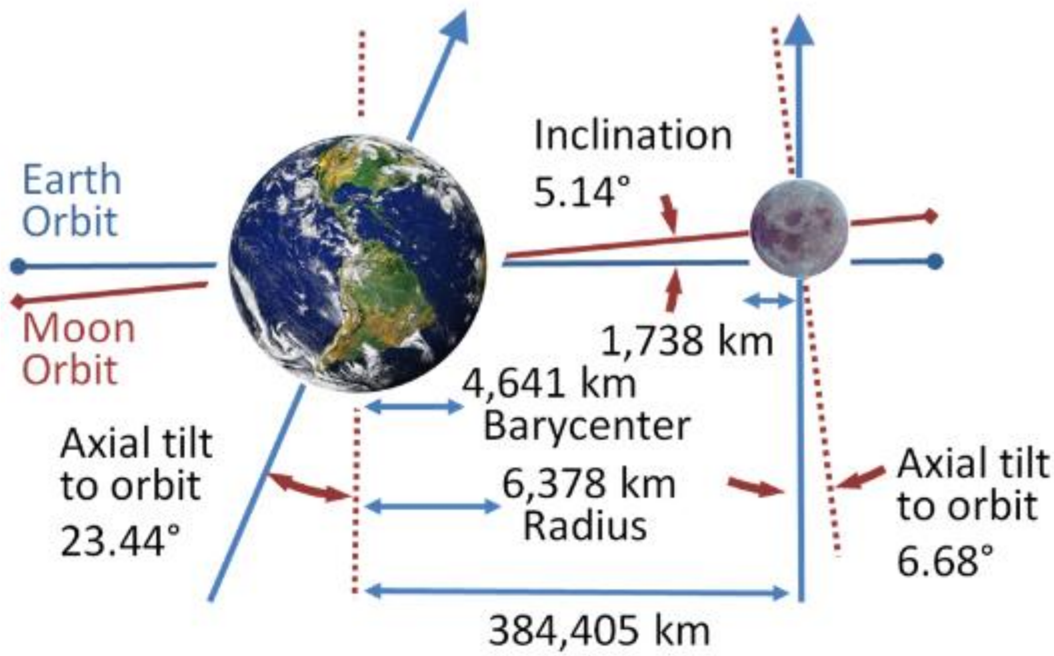
The data could be obtained from the SPOCC, as there is already a connection between it and the NCCS, or via the ASDC. They would be responsible for all software development, and the only support we would supply would be in terms of data access to the level 1 data.

In the second case, it would require a collaboration with the project to vet/develop their software to production quality and insert it into the pipeline. However, there is no funding on from the project for this.

NCCS = NASA Center for Climate Simulation
SPOCC = Science and Planetary Operations Control Center ("the ground processing facility archive")
ASDC = Atmospheric Science Data Center

What will be the conditions for Lunar Calibration?

EPIC will look at the Moon when it is behind the earth as viewed from L-1. Since the Moon's orbit is tilted (5.15 degrees) relative to the plane of the ecliptic, the Moon will be frequently visible to EPIC. However, the spacecraft will only use look angles that are 4 degrees of less from the center of the Earth (up to 8 Earth diameters). The maximum tilt viewed from L-1 will be 2.7 Earth diameters requiring a spacecraft tilt of no more than 1.8 degrees. The critical period for calibration is when the Moon appears as full disk when viewed from the Earth. Under these conditions, the Moon will occasionally have approximately the same viewing angles from both Earth and L-1. This is important, since the lunar albedo is a strong function of phase angle. The USGS ROLO data will be used to determine the lunar albedo. Then fraction of solar irradiance reflected from the Moon will be calculated and adjusted for the distance between the Moon and the EPIC spacecraft at L-1. Using the total lunar irradiance as seen by EPIC for each filter, total EPIC counts will be converted to energy units, which constitute calibration for each filter channel.



Max Earth Diameters = 5.15*(3.14159/180)*384405/(6378*2) = 2.7086865

Is there sun glint in the data obtained from EPIC?

Yes. Sunglint will be evident in the EPIC data as shown in a similar image obtained from the Galileo flyby of L-1