EDITORIAL
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Editorial: DSCOVR EPIC/NISTAR: 5Years of Observing Earth From the First Lagrangian Point

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Editorial on the Research Topic

DSCOVR EPIC/NISTAR: 5 Years of Observing Earth From the First Lagrangian Point

The Deep Space Climate Observatory (DSCOVR) was launched in February 2015 to a Sun-Earth Lagrange-1 (L1) orbit, approximately 1.5 million kilometers from the sunlit side of the Earth. In many regards, the DSCOVR is a unique mission: for the first time, it delivers well-calibrated and multi-spectral measurements of Earth from the L1 point. This unique location allows near-hourly views of the entire illuminated disk of the Earth, multiple times a day. The moderately high observational cadence results in cloud-free views of nearly the entire Earth land surface and global ocean with significantly higher frequency than is available to the operational polar orbiters, and at a near-global scale inaccessible to geostationary sensors.

In addition to providing continuous solar wind measurements for accurate space weather forecasting, DSCOVR operates two Earth science instruments: the Earth Polychromatic Imaging Camera (EPIC) and the NIST Advanced Radiometer (NISTAR). EPIC has a 2048 × 2048 pixel CCD with sensitivity to UV, visible, and near IR (NIR) wavelengths. The filter wheel contains 10 narrow-band filters from 317.5 to 779.5 nm. The spatial resolution is about 10 km at nadir. The Earth-observing geometry of the EPIC instrument captures a nearly constant scattering angle between 168° and 178°. NISTAR measures the absolute irradiance integrated over the entire sunlit face of the Earth in four broadband channels every minute covering visible and IR wavelengths.

The unique near-backscatter view geometry of EPIC led to creation of several new Earth science products. The diurnal course of "sunlit leaf area index" SLAI is one of them (Yang et al., 2017). It characterizes the area of green leaves at a given time intercepting the direct sunlight and depends on canopy structural organization. Because sunlit and shaded leaves exhibit different photosynthetic response to incident Photosynthetically Active Radiation (400–700 nm; Mercado et al., 2009; Stenberg, 1998), SLAI is important addition to the standard total leaf area index (LAI) that has long been provided by polar orbiting sensors like MODIS or VIIRS. By virtue of its unique view geometry, EPIC became the first sensor providing SLAI required for better characterization of ecosystem productivity and carbon/nitrogen cycles (Bonan et al., 2003; Dai et al., 2004; Mercado et al., 2009; He et al., 2013).

Other new land surface products are the Directional Area Scattering Factor (DASF), the Earth Reflector Type Index (ERTI) and Canopy Scattering Coefficient (CSC) at 443, 551, 680 and 780 nm (Knyazikhin and Myneni, 2021). DASF provides information critical to accounting for structural contributions to measurements of leaf biochemistry from remote sensing (Smolander and Stenberg, 2003; Knyazikhin et al., 2013; Stenberg et al., 2016). ERTI is an estimate of the recollision probability. This index was developed to discriminate between signals originating from clouds, cloud-free ocean, bare and vegetated land (Song et al., 2018). SCS is an estimate of the fraction of intercepted radiation that has been reflected

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from, or diffusively transmitted through, the vegetation (Smolander et al., 2003; Lewis and Disney, 2007). This coefficient for example is useful to detect changes in leaf chlorophyll content of equatorial forests (Sun et al., 2022). The land products use EPIC surface reflectance which is provided by MAIAC atmospheric correction algorithm along with cloud detection and aerosol retrieval (Lyapustin et al., this issue).

Even casual glimpses at EPIC images (https://epic.gsfc.nasa.gov/) reveal bright colorful spots near the image center. The analysis of observation geometry and collocated EPIC data suggests that these bright spots are caused by specular reflection from ice crystals that float inside clouds in a horizontal orientation (Marshak et al., 2017; Li J. -Z.et al., 2019; Varnai et al., 2020b). Glint studies over the ocean found that cloud glints are small but bright (Varnai et al., 2020a). Most recently (Kostinski et al., 2021) it was found that cloud glints were used to gauge the accuracy of geolocation in EPIC operational products and to examine the physical processes and instrumental considerations that affect EPIC glints caused by specular reflection from small lakes. It has been a general assumption that the ice crystals in the high-altitude ice clouds are randomly orientated. Orientation of crystals affects reflection of the incoming Sun light and its transmission to the Earth surface, and thus an improved understanding of the number, or proportion of oriented ice particles has a potential to bring improvement in modeling of the Earth cloud radiation budget. The first operational glint product was released recently (https://epic.gsfc.nasa.gov/science/products/glint).

EPIC and NISTAR have continuously operated until 27 June 2019, when the spacecraft was placed in an extended safe hold due to degradation of gyroscopes. With development of the software patch for spacecraft attitude determination based solely on the star trackers, DSCOVR returned to full operations on 2 March 2020. Since then, DSCOVR has been able to maintain pointing accuracy similar to that with gyroscopes keeping the Earth fully in the field-of-view of EPIC. After March 2020 the range of scattering angle has substantially increased towards backscattering reaching 178°. This provided a unique opportunity to study angular variations of the Earth reflectivity in the vicinity of the exact backscattering, or hotspot (Marshak et al.). All EPIC and NISTAR observations show a strong increase of reflectance towards the hotspot. For NISTAR, which data are used to study the Earth radiation budget, this limits angular resolution of the angular distribution models to 1°–3° near the backscattering angle.

For aerosol science, a near-backscattering view geometry of EPIC has both merits and drawbacks. Increase of the land surface brightness at this geometry results in decreasing sensitivity of observations to the atmospheric aerosol variations, e.g. of the aerosol optical depth (AOD). On the other hand, the high observational cadence and near-global coverage enhances our capability for a high-quality characterization of the surface reflectance, and based on that, characterization of the high-AOD mega-events such as forest wildfires or dust storms when the surface brightness becomes less important.

Based on well-calibrated EPIC UV-vis observations, Lyapustin et al. developed an algorithm to simultaneously retrieve both AOD and spectral aerosol absorption. The latter, in turn, allows to peek into aerosol composition based on spectrally distinct absorption properties of dominant absorbers, namely black and brown carbon in biomass burning smoke, and hematite and goethite in airborne mineral dust (Go et al., 2022). The developed speciation algorithm has been integrated in MAIAC v2 EPIC algorithm. Thus, while the fundamentals of such decomposition were developed earlier for AERONET (Holben et al., 1998; Schuster et al., 2016) and later applied for POLDER/PARASOL (Li L. et al., 2019), EPIC is becoming the first operational imager to provide such speciation information in support of both climate modeling and the air quality communities.

This special issue of Frontiers in Remote Sensing titled “DSCOVR EPIC/NISTAR: 5 years of observing Earth from the first Lagrangian point” has 23 papers that provide an integral holistic view of the Earth science from DSCOVR. Topics range from the sensors’ description, data calibration, and geolocation to the processing algorithms and official products, to the science data analysis and applications.

There are four papers on EPIC data calibration, covering EPIC geolocation strategies (Blank, et al.), raw data calibration (Cede et al.) and calibration of EPIC visible and NIR channels (Geogdzhaev et al.; Haney et al.). Eight papers describe different official EPIC products, including ocean surface photosynthetically available radiation (PAR) (Frouin et al.), total and tropospheric ozone (Kramarova et al.), aerosol height (Lu et al.), aerosol optical depth and atmospheric correction (Lyapustin et al.; Lyapustin et al.), vegetation (Ni et al.), clouds (Zhou et al.) and solar glint (Varnai et al.). Two papers discuss cloud height from EPIC: Davis et al. reviews cloud height remote sensing using atmospheric oxygen absorption spectroscopy while Delgado-Bonal et al. talks about daily variability in cloud height around the globe. Variability of the Earth’s planetary albedo is investigated in three papers by Carlson et al., Lacis et al. and Penttilä et al. If the first two deal mostly with GCM and distribution of clouds, the third one discusses a new method to derive the Earth spherical albedo from EPIC data and provides it at fine temporal resolution. Finally, Su et al. discusses the relationships between EPIC radiances and the reflected shortwave fluxes and compares EPIC- derived fluxes with those from CERES.

Phase angles between Sun illumination and EPIC observations have an important effect on estimating Earth reflectance near the backscattering (Marshak et al.). Valero et al. reviewed the history behind the current DSCOVR mission and discussed the opportunity of future Earth observations from Lagrange points while Gorkavyi et al. highlighted Earth observations from the Moon surface with an EPIC-like instrument, as a part of the future Artemis mission. In addition, EPIC observations were used to estimate the reduction of spectral radiance during solar eclipse of 21 June 2020 (Wen et al.). Finally, Pisek et al. explores the potential of retrieving clumping vegetation index using DSCOVR EPIC data.

AUTHOR CONTRIBUTIONS

All authors listed have made a substantial, direct, and intellectual contribution to the work and approved it for publication.

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