ICAP, ESA/ESRIN
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Overview of the Earth Science Instruments on the NASA DSCOVR mission

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History and current status

1998 Triana mission initiated; involvement of Al Gore; launch planned for 2001

2001 Mission postponed

2003 Mission renamed to Deep Space Climate ObserVatoRy (DSCOVR); still one space weather system (PlasMag) and two Earth viewing instruments (NISTAR and EPIC)

2006 Mission terminated; satellite in storage

2009 Refurbishment of DSCOVR initiated; decision to change the filters in EPIC

2011 Finished refurbishment and laboratory calibration of EPIC; all instruments integrated on satellite; satellite electronics are being refurbished at GSFC

2012 DSCOVR mission is secured; possible launch 2014-2015; <u>it is uncertain whether there is support for the Earth Science instruments.</u>

Al Gore promoting DSCOVR at AGU Fall meeting 2011, San Francisco


DSCOVR assembled at GSFC in Dec 2011

Earth Observation from Lagrange 1 point

The Earth viewing instruments on DSCOVR have a continuous view of the entire sunlit face of the Earth.

The NIST Advanced Radiometer (NISTAR) measures the absolute irradiance integrated over the entire sunlit face of the Earth in 4 broadband channels minute-by-minute.

The Earth Polychromatic Imaging Camera (EPIC) images the irradiance from the sunlit face of the Earth on a 2048 x 2048 pixel CCD in 10 narrowband channels (UV and visible). Its temporal resolution will depend on the final schedule of the data-downlink for all instruments on DSCOVR. It may range from a maximum of 19 channels/hour to 10 channels/90-minutes.

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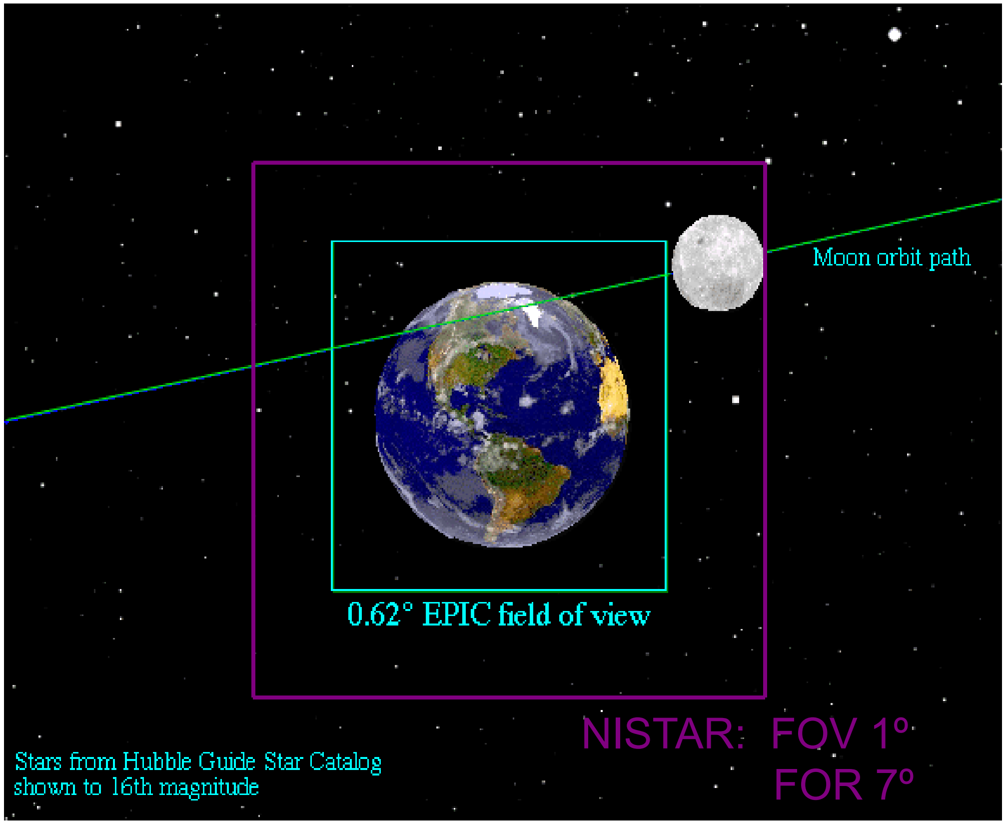
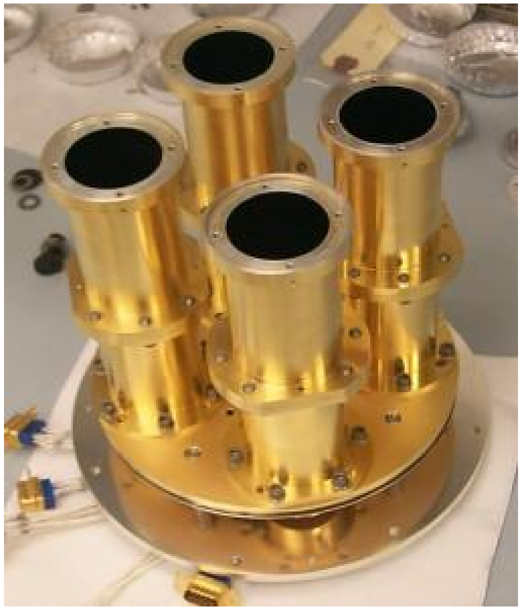
This talk is based on the publically available materials contained in the posters and presentations of the session 'Earth Observations From the L1 (Lagrangian Point No. 1)' at the AGU 2011 fall meeting, San Francisco.



NIST Advanced Radiometer - NISTAR



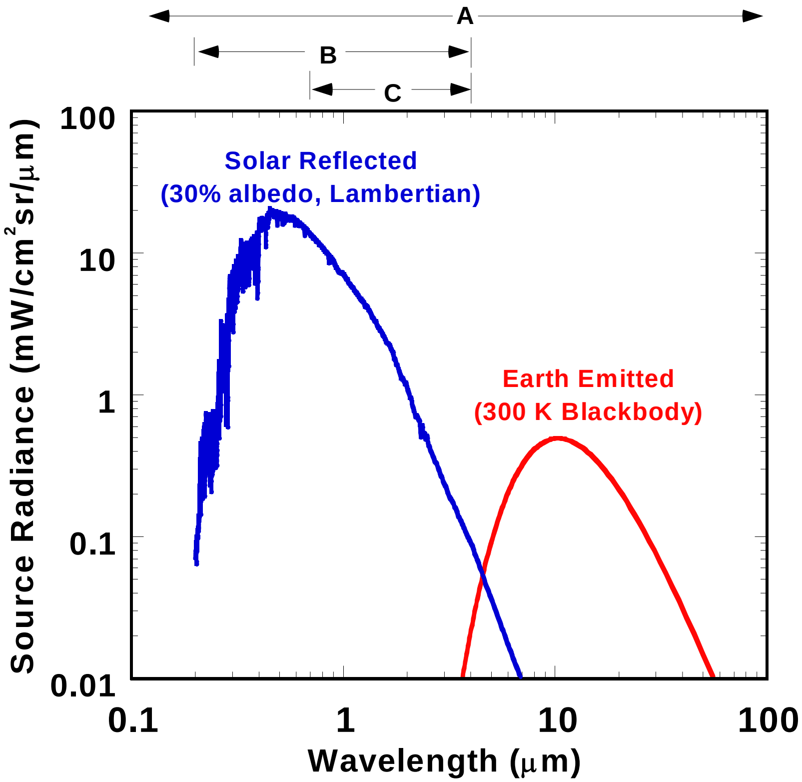
NISTAR is a cavity radiometer designed to measure the absolute irradiance from the entire sunlit face of the Earth. It will measure the Earth radiation budget at high accuracy (0.1%).

3 broadband channels:

A) 100nm to 100µm
B) 200nm to 4µm
C) 700nm to 4µm

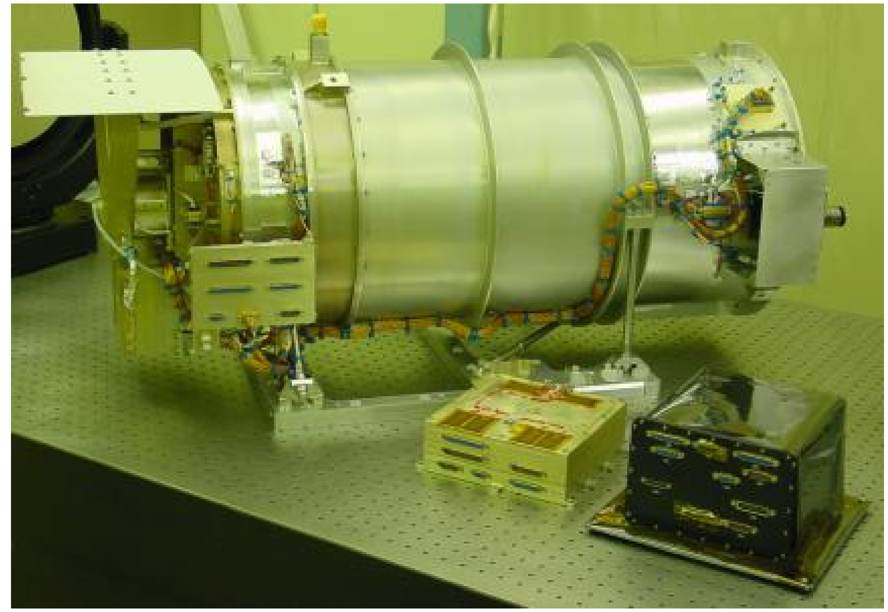
+ Photodiode (300nm to 1000nm)

Field of view 1º, parallel to EPIC.



Figures from: Joseph Rice et al., NISTAR: The NIST Advanced Radiometer, AGU Fall Meeting 2011, San Francisco, CA, USA, December 5-9, 2011.

Earth Polychromatic Imaging Camera - EPIC

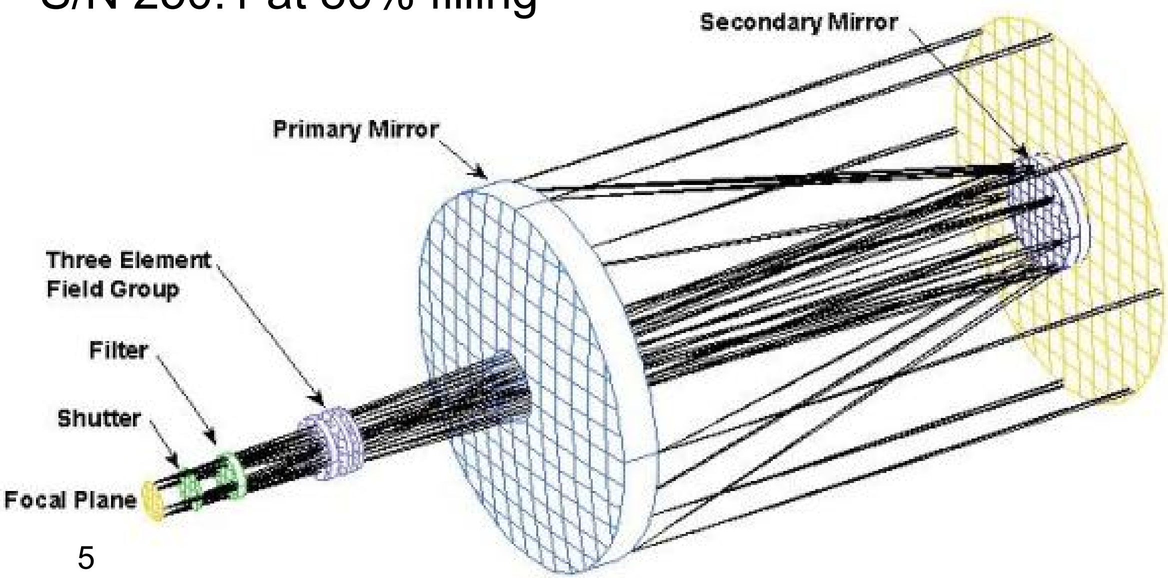


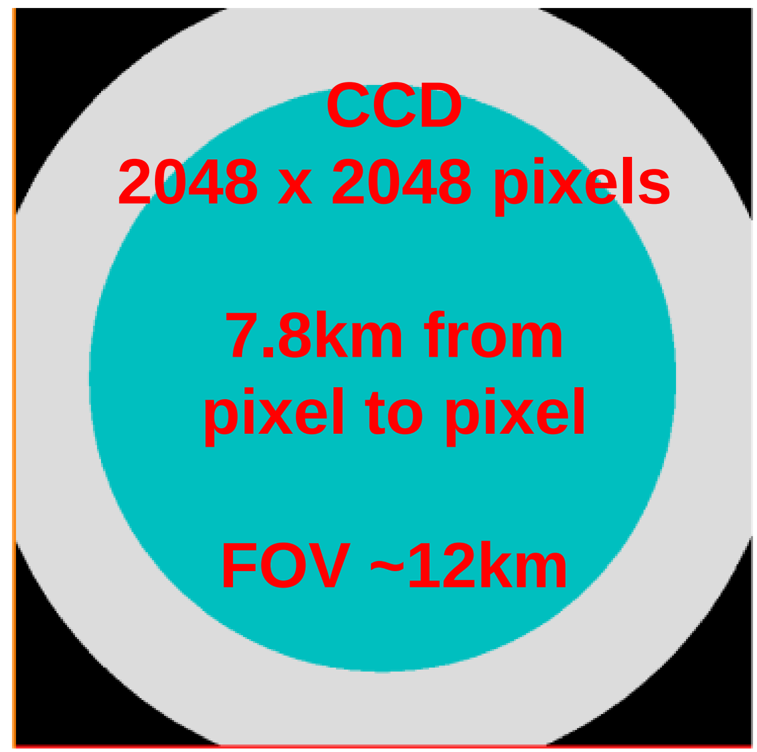
Cassegrain telescope

2 filterwheels with 6 positions each (open hole plus 5 spectral filters) → 10 channels

2048 x 2048 pixel CCD stabilized at -40ºC

Exposure time ~40ms for each channel
S/N 250:1 at 80% filling





Expected EPIC data products

Ozone: total column
Aerosol properties: aerosol index, aerosol optical thickness, aerosol height
Cloud & surface properties: cloud fraction, cloud height, surface albedo
Vegetation properties: vegetation index and Leaf Area Index (LAI)
RGB: colored image of the Earth's sunlit face

Center [nm]	FWHM [nm]	Primary purpose
317	1	Ozone
325	1	Ozone
340	3	Ozone, Aerosols, Reflectivity
388	3	Aerosols, Reflectivity
443	3	Aerosols, Reflectivity, Vegetation, RGB
552	3	Aerosols, Reflectivity, Vegetation, RGB
680	2	Aerosols, Reflectivity, Vegetation, LAI, O_2B-Band Reference, RGB
688	0.8	O_2B-Band Cloud Height
764	1	O_2A-Band Cloud Height, Aerosol Height
779	2	Aerosols, Reflectivity, Vegetation, LAI, O_2A-Band Reference

EPIC channels - overlap with other instruments

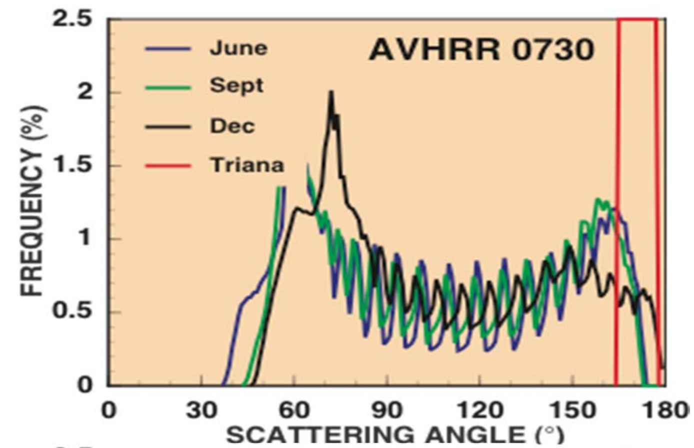
Aa – AATSR
Av – AVHRR
G – GEOSat
Go – GOME
GR – GOES-R
Me – MERIS
Mi – MODIS
Mo – MODIS
N - VIIRS (NPP)
O - OMI
P - POLDER
V – VIRS

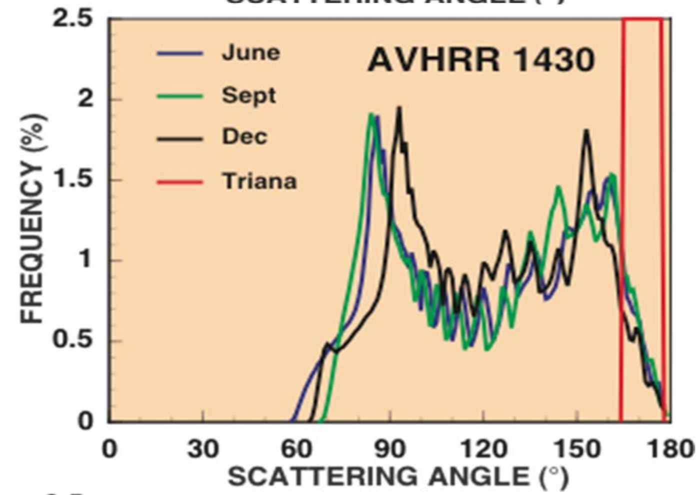
Filter	Center Wavelength (CWL) (nm)	
1	317.5	O, Go
2	325.0	O, Go
3	340.0	O, Go
4	388.0	O, Go
5	443.0	Go, GR, Me, Mi, Mo, N, O, P
6	551.0	Aa, Go, Me, Mi, Md, N, P
7	680.0	Aa, Av, G, GR, Go, Me, Mi, Mo, N, P, V
8	687.75	
9	764.0	Me, P
10	779.5	Me

From: Patrick Minnis et al., Improved Cloud and Surface Properties By Combining Conventional and L-1 Satellite Imager Data AGU Fall Meeting 2011, San Francisco, CA, USA, December 5-9, 2011.

EPIC scattering angles

There is minimal overlap between EPIC's & other satellites' scattering angles. Therefore EPIC'S observations from L1 would provide a unique angular perspective and can be combined with other measurements to obtain particle shape, phase selection, optical depth, 3-D effects, and stereo heights.





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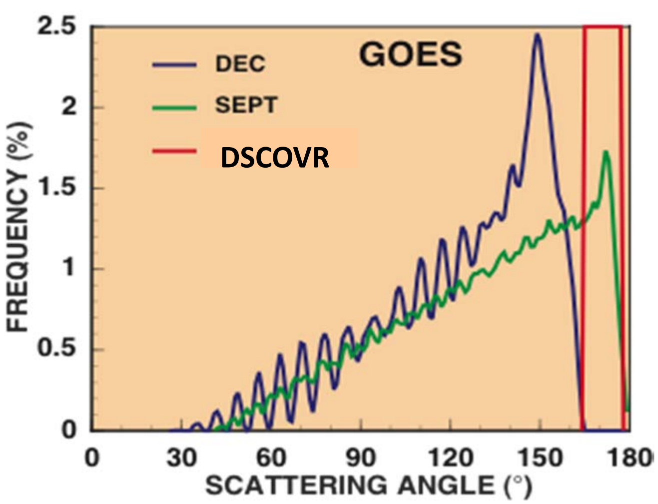
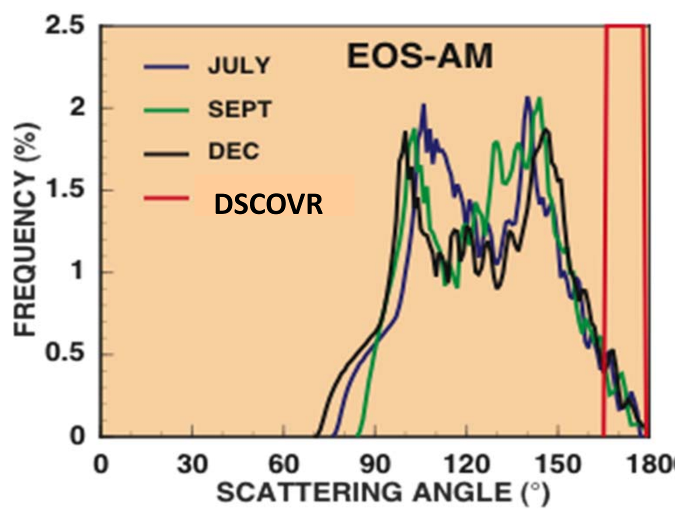
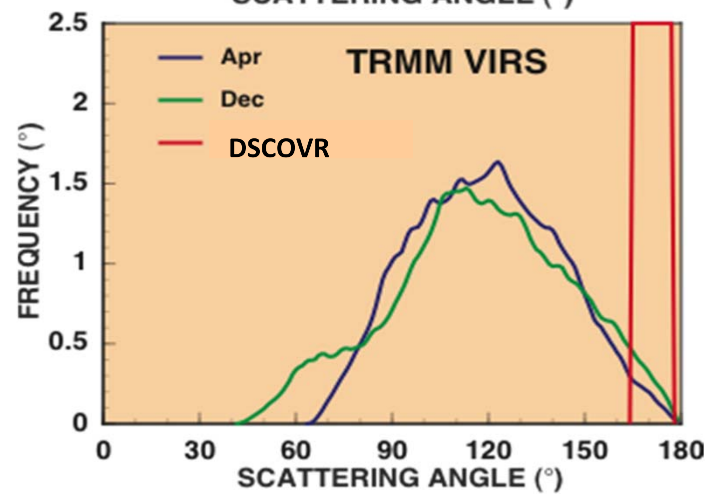
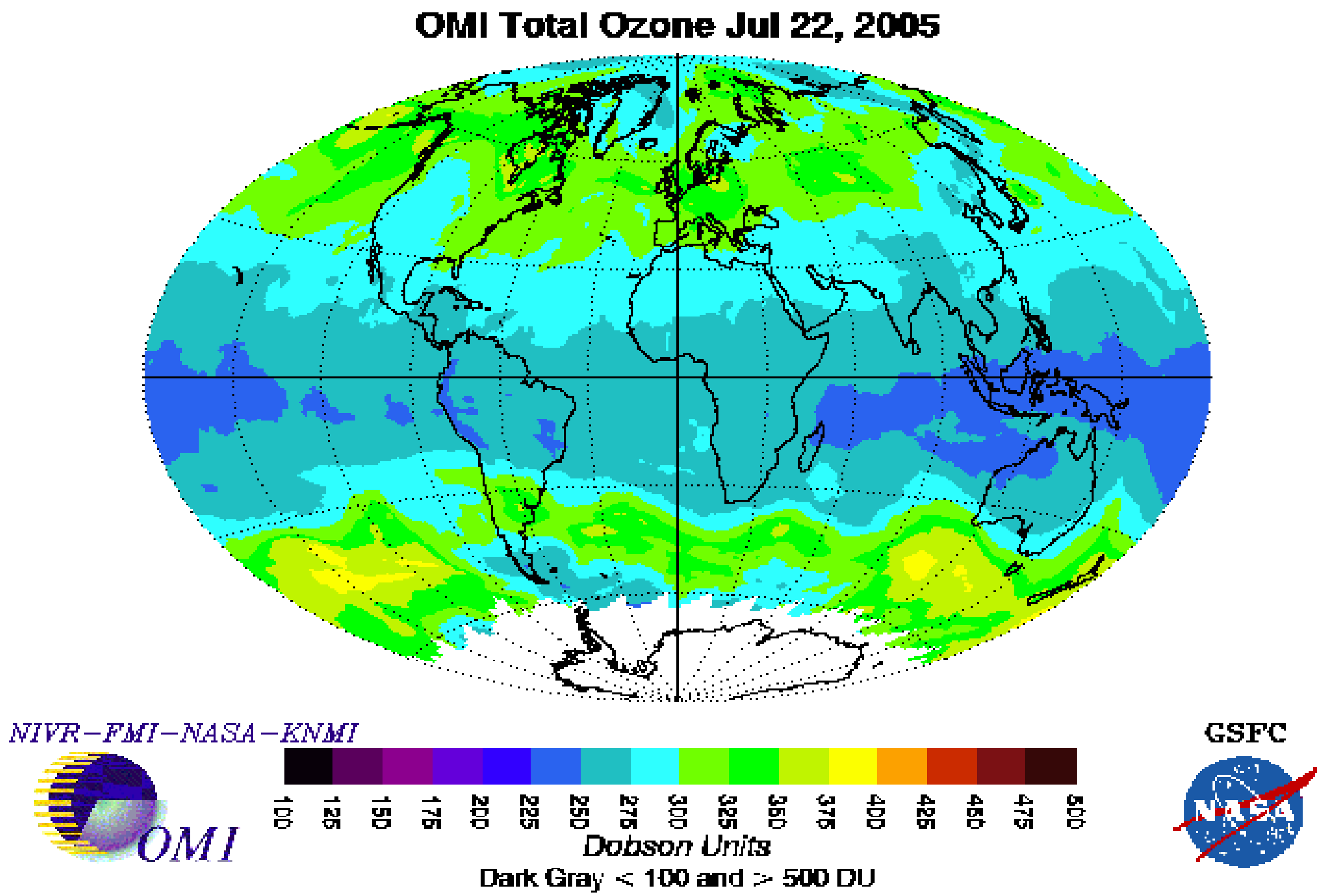






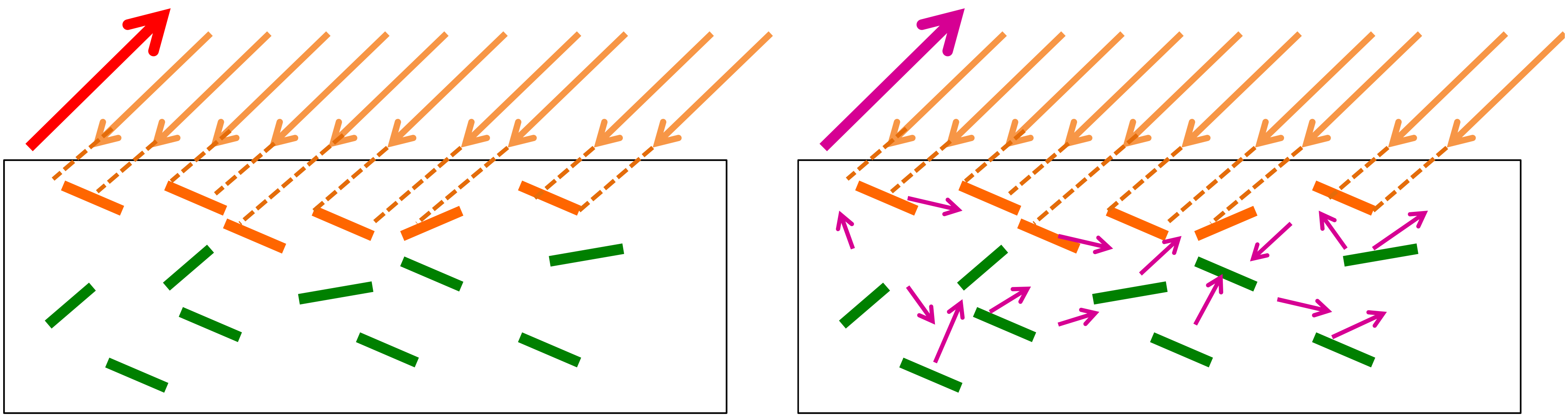
EPIC Ozone

The ozone algorithm uses 3 wavelengths 317.5, 325, and 340 nm and is based on the TOMS/OMI ozone algorithm.



EPIC Vegetation properties using 680 and 780 nm channels

Leaf Area Index (LAI): one-sided green leaf area per unit ground area



680 nm: strong absorption; single scattering dominates; conveys information about **SUNLIT leaf area**

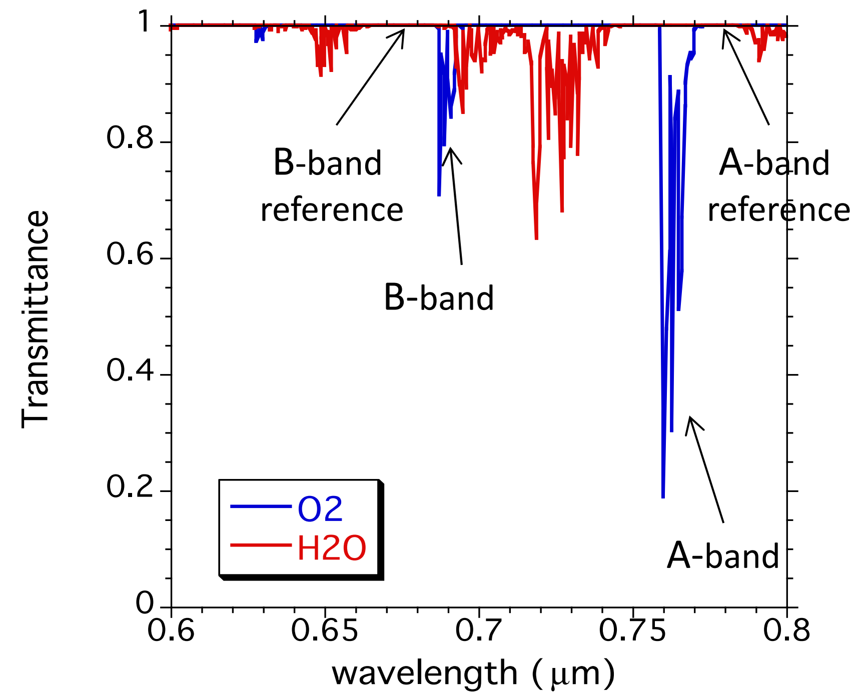
780 nm: weak absorption; multiple scattering dominates; conveys information about **TOTAL leaf area**

- Sunlit and shaded leaves exhibit different photosynthetic response to incident PAR;
- Key variable in many global models of climate, hydrology, biogeochemistry and ecology.

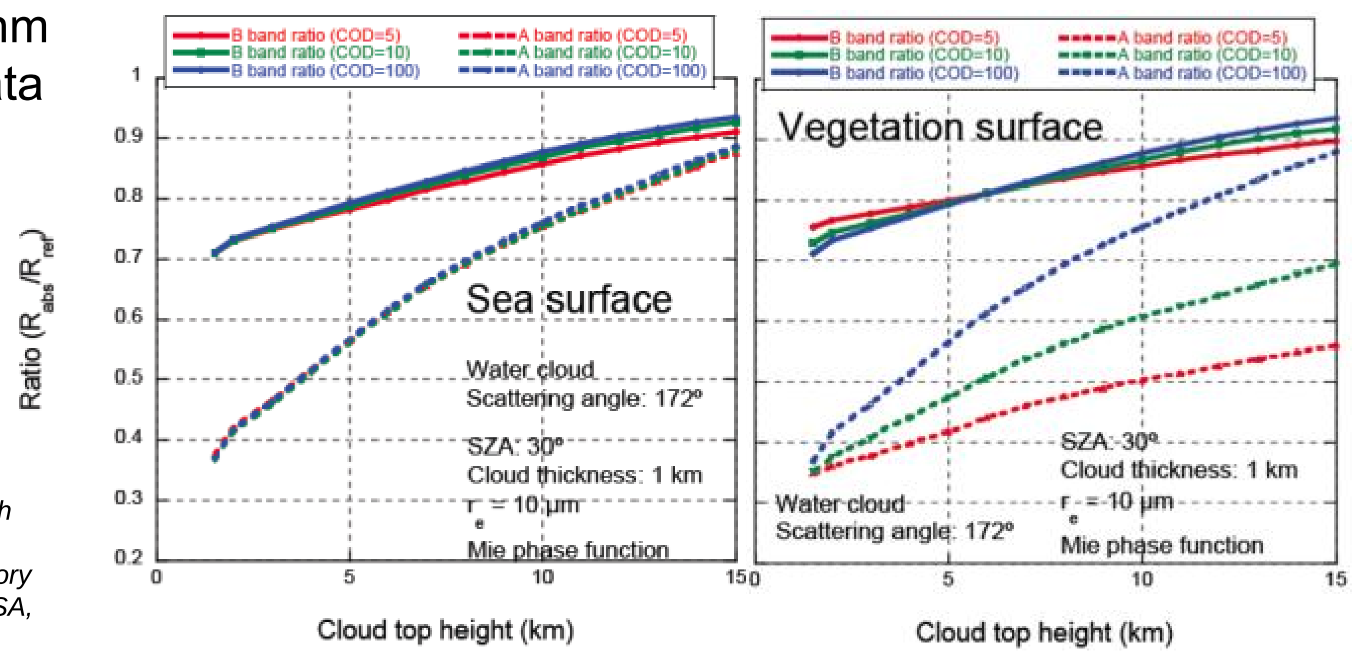
EPIC Cloud height

The oxygen absorption is proportional to the altitude of the reflection layer.

The A-band is more sensitive to the cloud height (~0.5% per 100m) than the B-band (~0.5% per 500m), but it is more sensitive to the higher surface reflectivity. Therefore the A-band will mostly be used over the ocean and the B-band over vegetation.



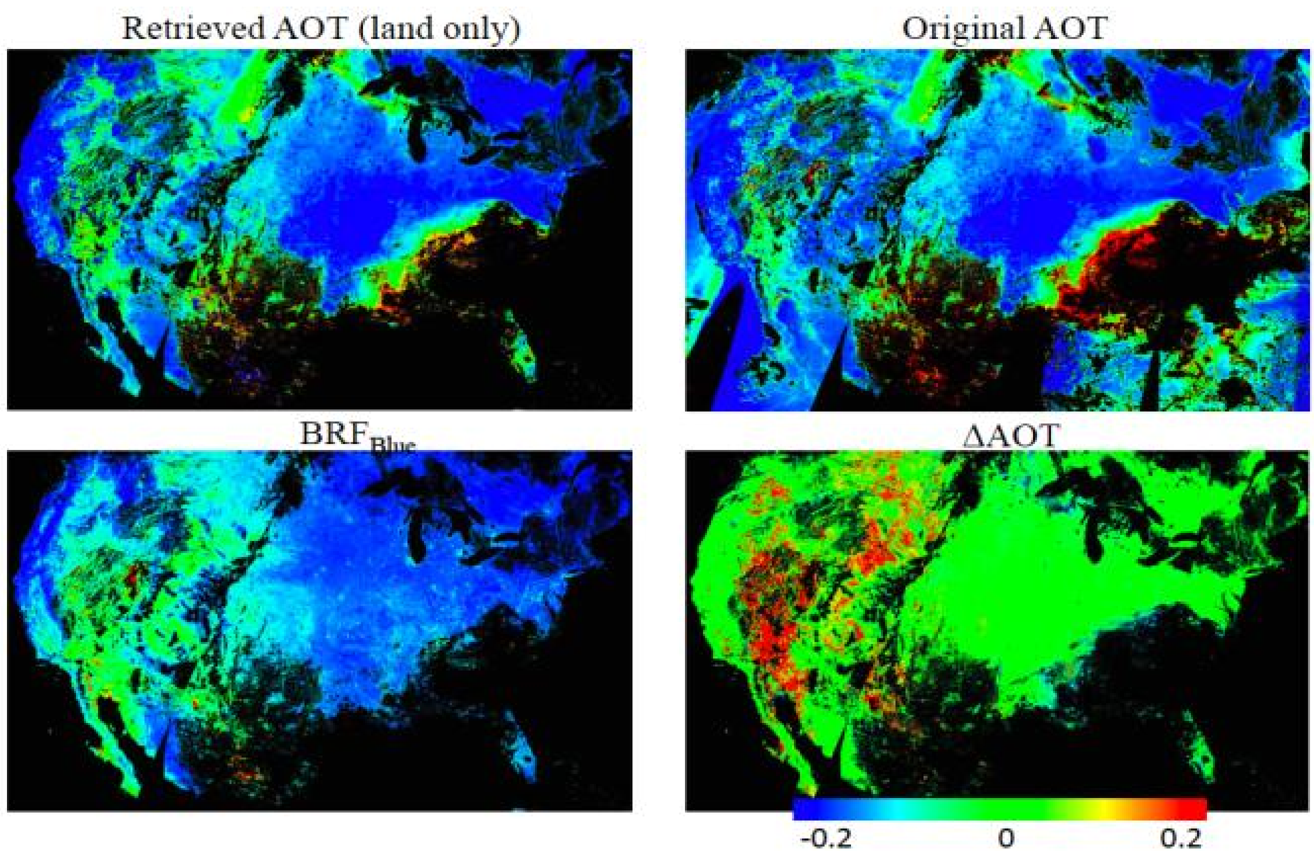
The EPIC cloud height algorithm will be a combination of the data from A-band and B-band.



Figures from: Yuekui Yang et al., Cloud Height Retrieval with Oxygen A and B bands for the Earth Polychromatic Imaging Camera (EPIC) onboard the Deep Space Climate Observatory (DSCOVR), AGU Fall Meeting 2011, San Francisco, CA, USA, December 5-9, 2011.

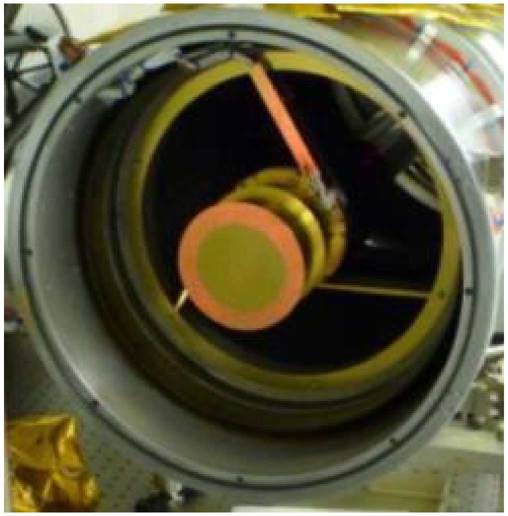
EPIC aerosol products

- Aerosol Index (based on TOMS/OMI experience)
- Aerosol Optical Thickness and surface BRF (based on TOMS/OMI and MODIS experience)
- Aerosol Height using the Oxygen A-pair (complementary information to other satellites, e.g. TROPOMI)



Examples of the retrieved AOT using EPIC simulator

EPIC challenges

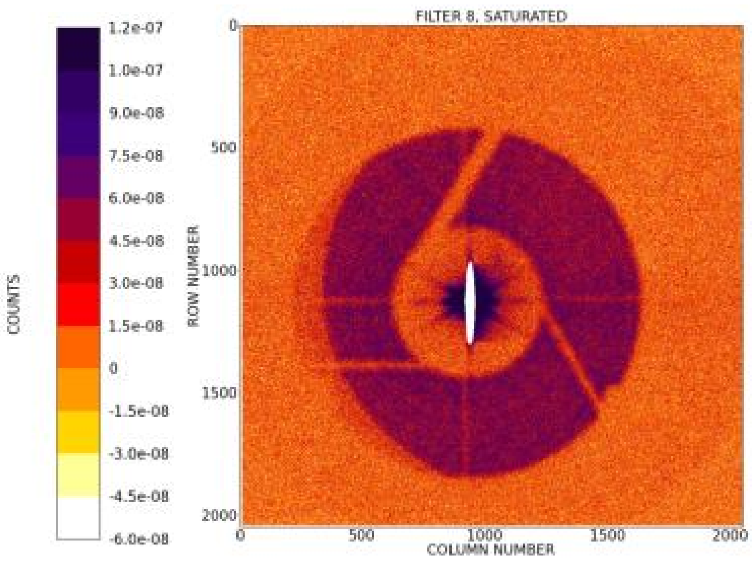


Geolocation

The spacecraft jitter is expected to be on the order of 1 pixel. This increases EPIC's effective field of view. The 'edge' of the Earth and the outline of the continents will have to be used to exactly geo-locate the images. This is especially important for the algorithms based on ratios of channels.

Stray light

EPIC's (spatial) stray light is significant and must be corrected. A very complex stray light correction algorithm is being developed. It is based on laboratory measured point spread functions and calculations of an optical model.



Instrument stability

The radiometric stability of EPIC will be tracked using the measured reflectivity over ice-covered surfaces and by periodic images of the Moon's sunlit face at a nearly constant phase angle when it is furthest from the Earth as seen from L1.