Juhan Ross Legacy Symposium

Ispra, Italy

Dudelstatd, Germany, Oct. 1989

National Aeronautics and Space Administration

Using the EPIC/DSCOVR O2 B-band for monitoring vegetation

Alexander Marshak (NASA GSFC)
and
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Many thanks to
the DSCOVR Project and
the DSCOVR Science Team

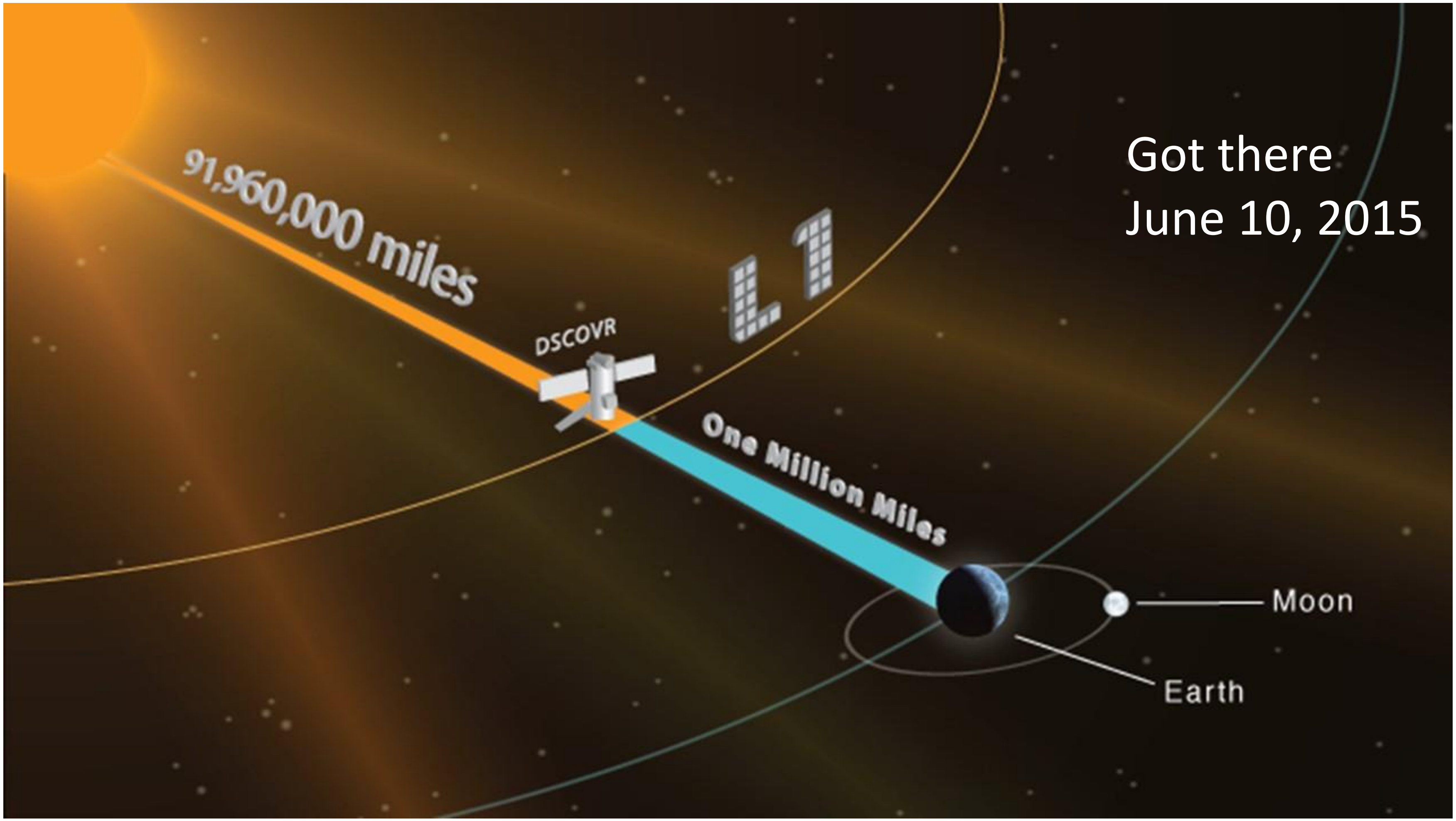
DSCOVR

DEEP SPACE CLIMATE OBSERVATORY

advanced warning of approaching solar storms

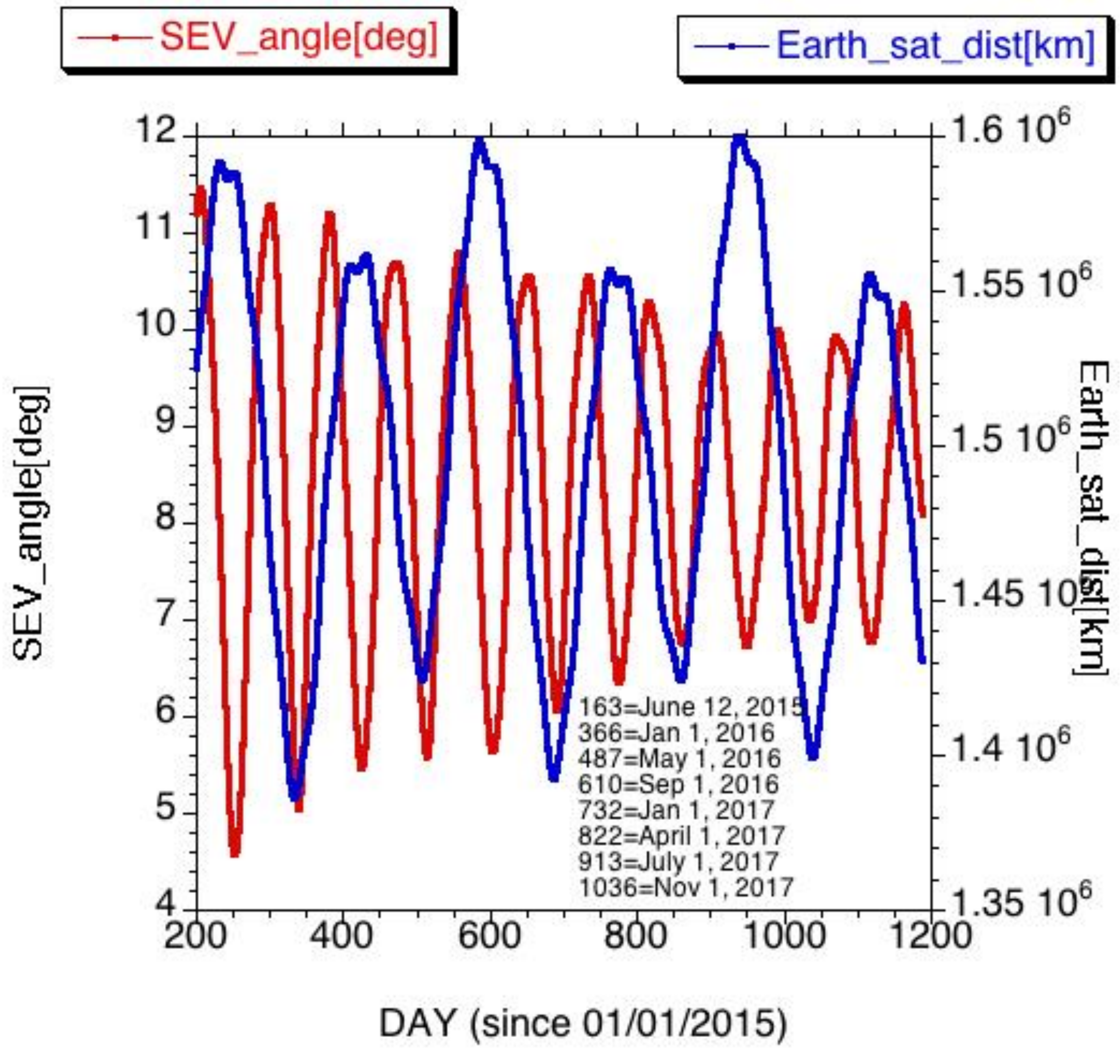
Courtesy of Space X

DSCOVR at Lagrange-1



At L1, the neutral gravity point between the Sun and the Earth, DSCOVR will remain near the same position relative to the Earth and Sun

Lissajous Orbit



August 25; 11 GMT:

968.46 day since 01/01/2015

dist. from Earth = 1.577 10^6 km

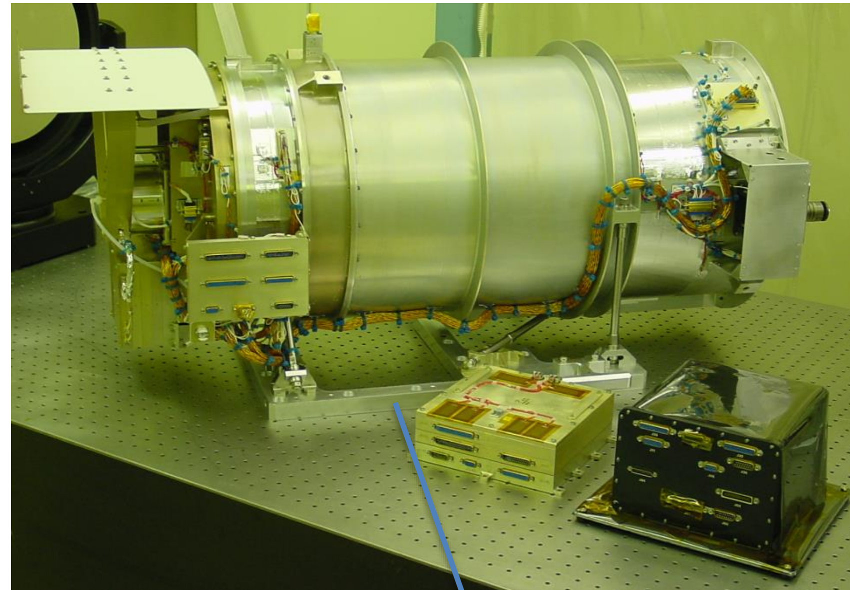
SEV = 7.94°

Velocity = 0.241 km/sec

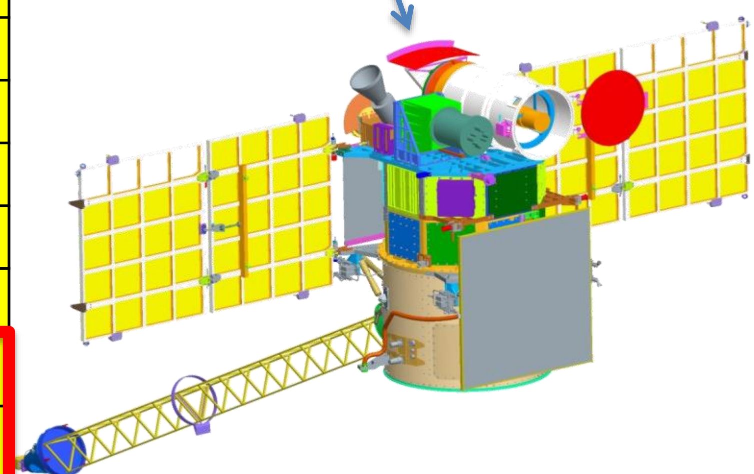
Earth Polychromatic Imaging Camera (EPIC)

- 2048 x 2048 pixel CCD;
- 8 km pixel size;
- One full set of images

13/day in winter
22/day in summer



Wavelength (nm)	Full width (nm)	Primary Applications
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*	*Aerosol, Vegetation, Clouds*
687.75 ±0.2	*0.8 ±0.2*	*Cloud Height*
764.0 ±0.2	*1 ±0.2*	*Cloud Height*
779.5 ±0.3	*2 ±0.4*	*Clouds, Vegetation*



Lunar calibration of the O2 abs. channels

Assumptions:

- Lunar reflection is constant relative to the adjacent pairs: 680 and 688; 764 and 780;

- The ratio between two neighboring channels doesn't depend on Solar and Viewing geometry;

Lunar calibration of the O2 abs. channels

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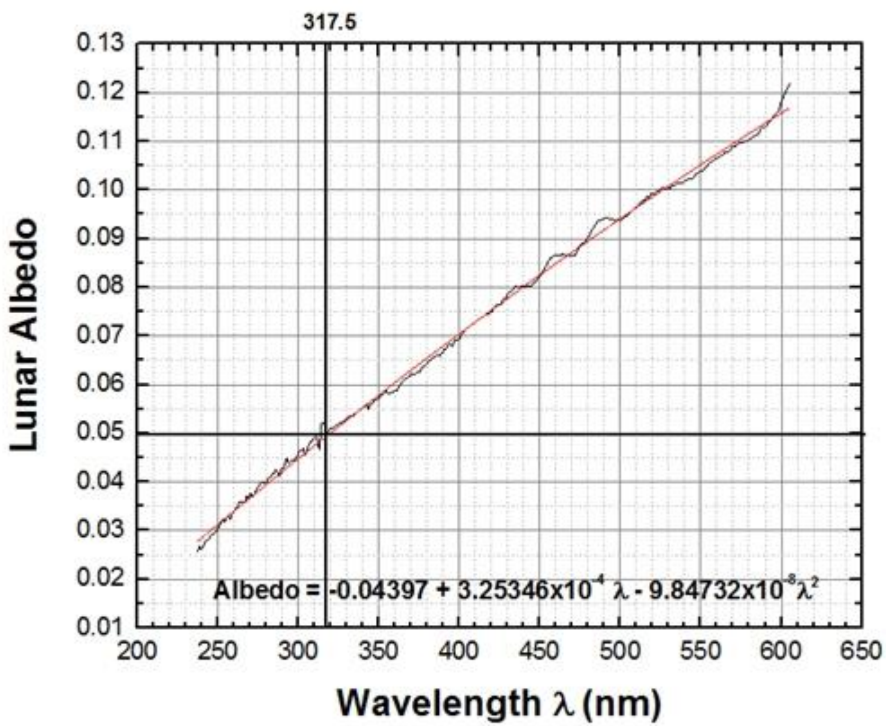
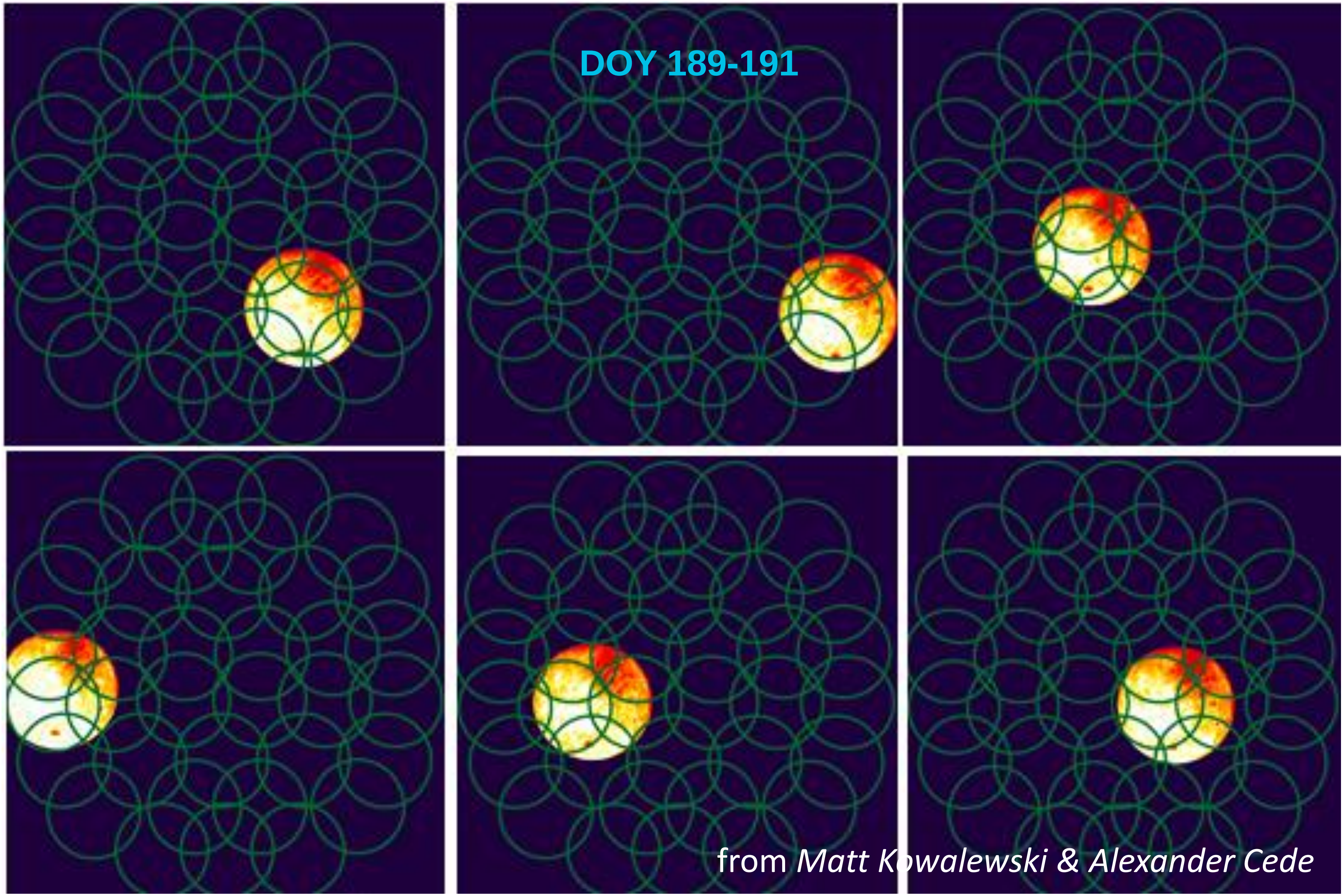
- Lunar reflection is constant relative to the adjacent pairs: 680 and 688; 764 and 780 nm



Using GOME Lunar Albedo:
10 nm difference ~ 0.5% increase

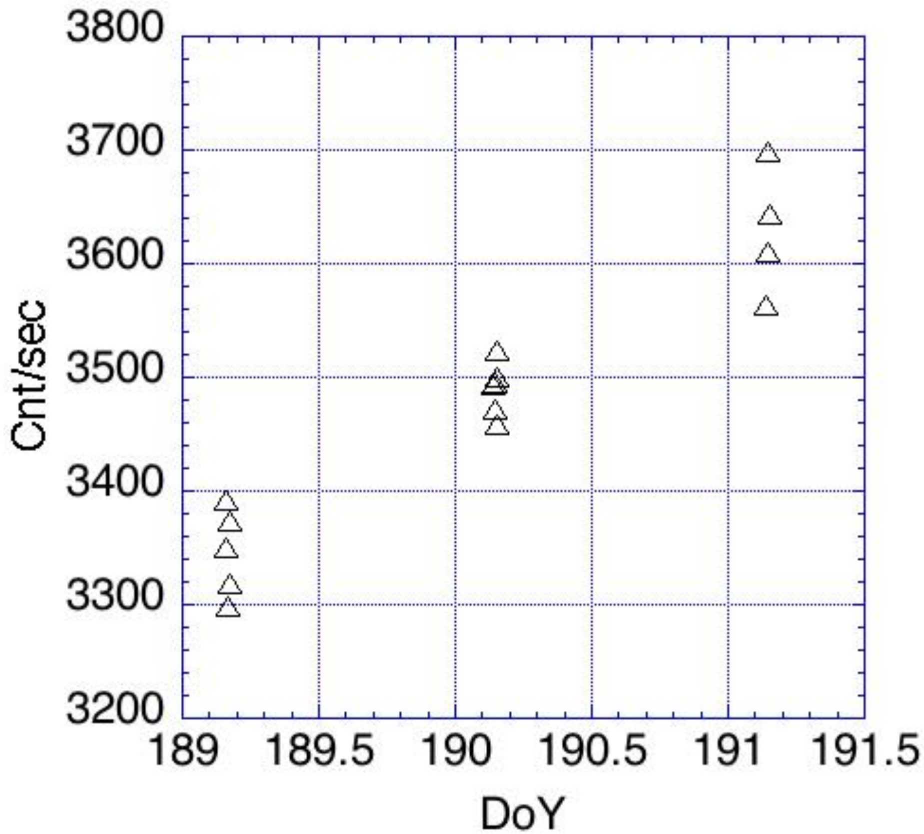
Lunar calibration of the O2 abs. channels

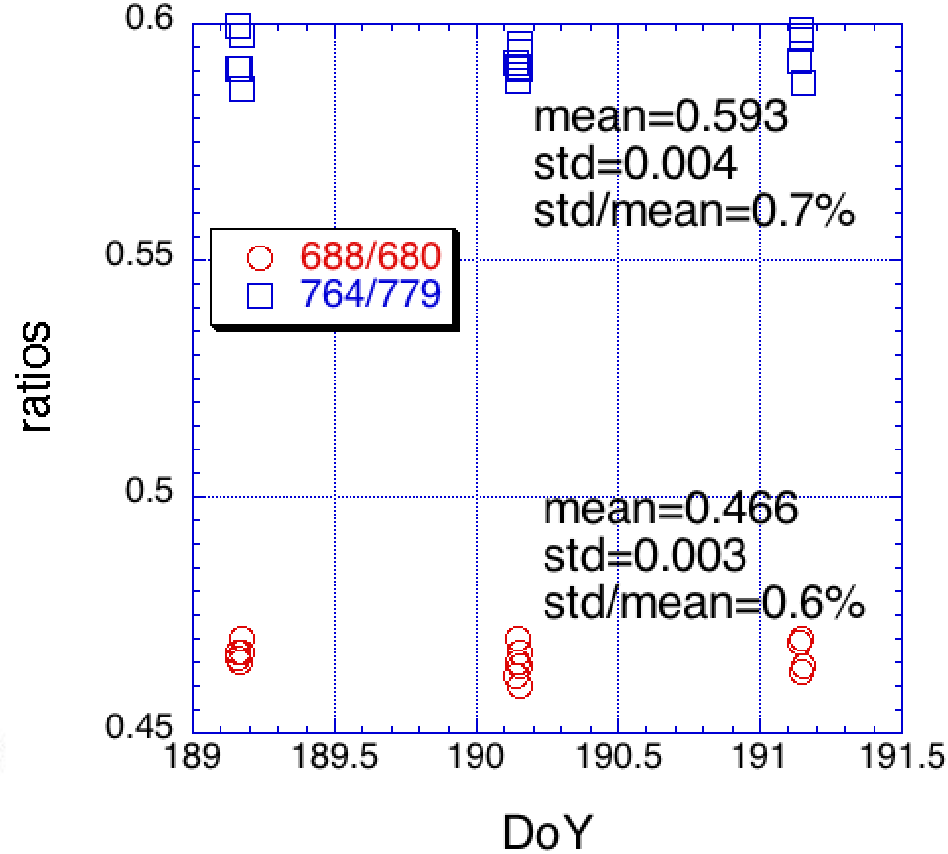


from *Matt Kowalewski & Alexander Cede*

Lunar calibration of the O2 abs. channels

779 nm





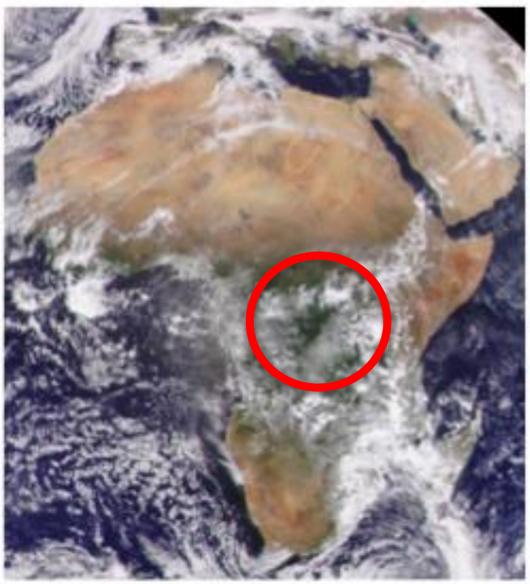
~ 10%

< 1%

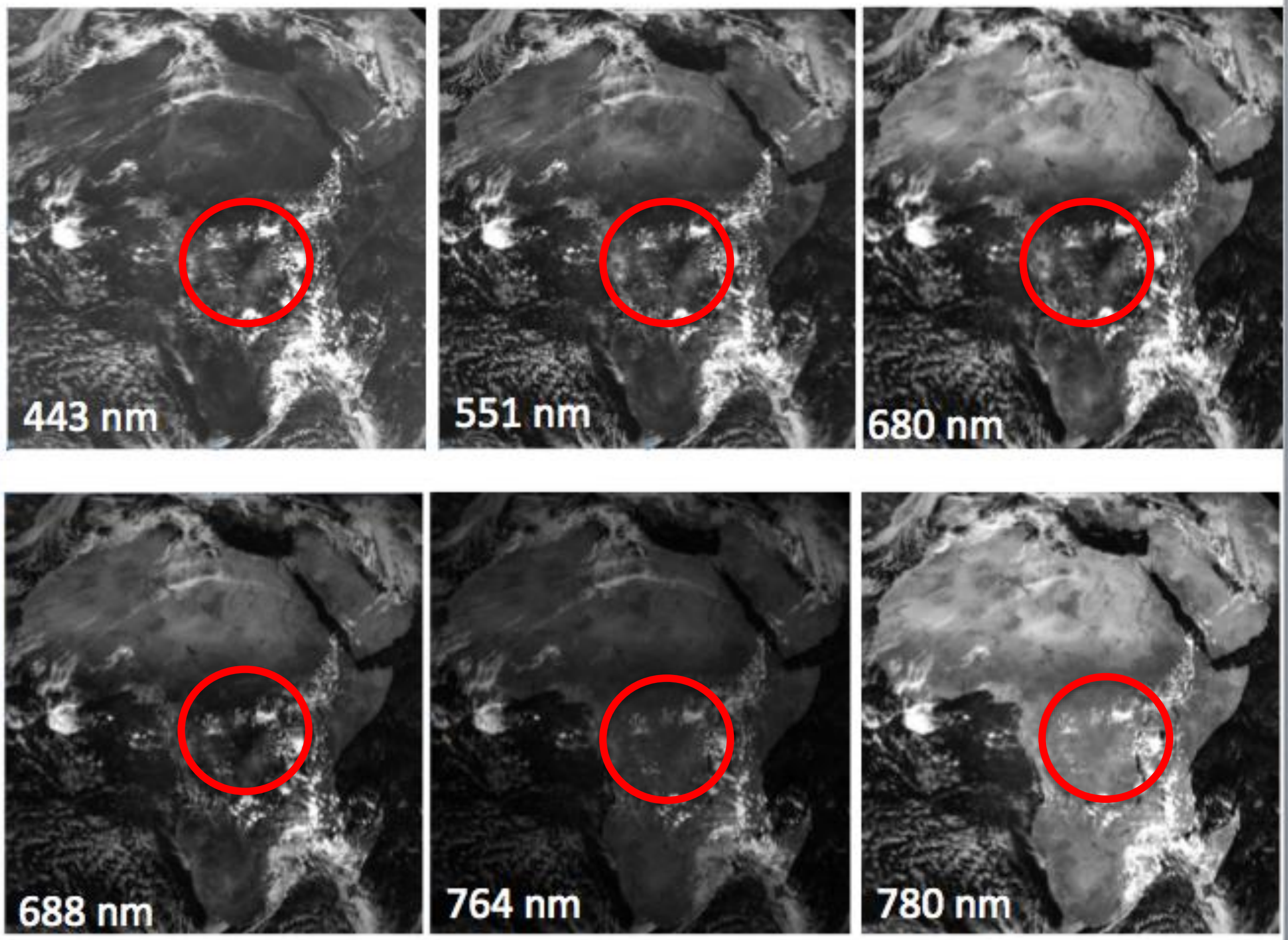
Using the EPIC/DSCOVR O2 B-band for monitoring vegetation

EPIC reflectance at six bands measured on March 22, 2016 at 10:52 GMT

SZA=6.4±0.5, $|\mu_0|$=0.994±0.001; VZA=12.7±0.5, μ=0.976±0.002; scattering angle is 171.5°.

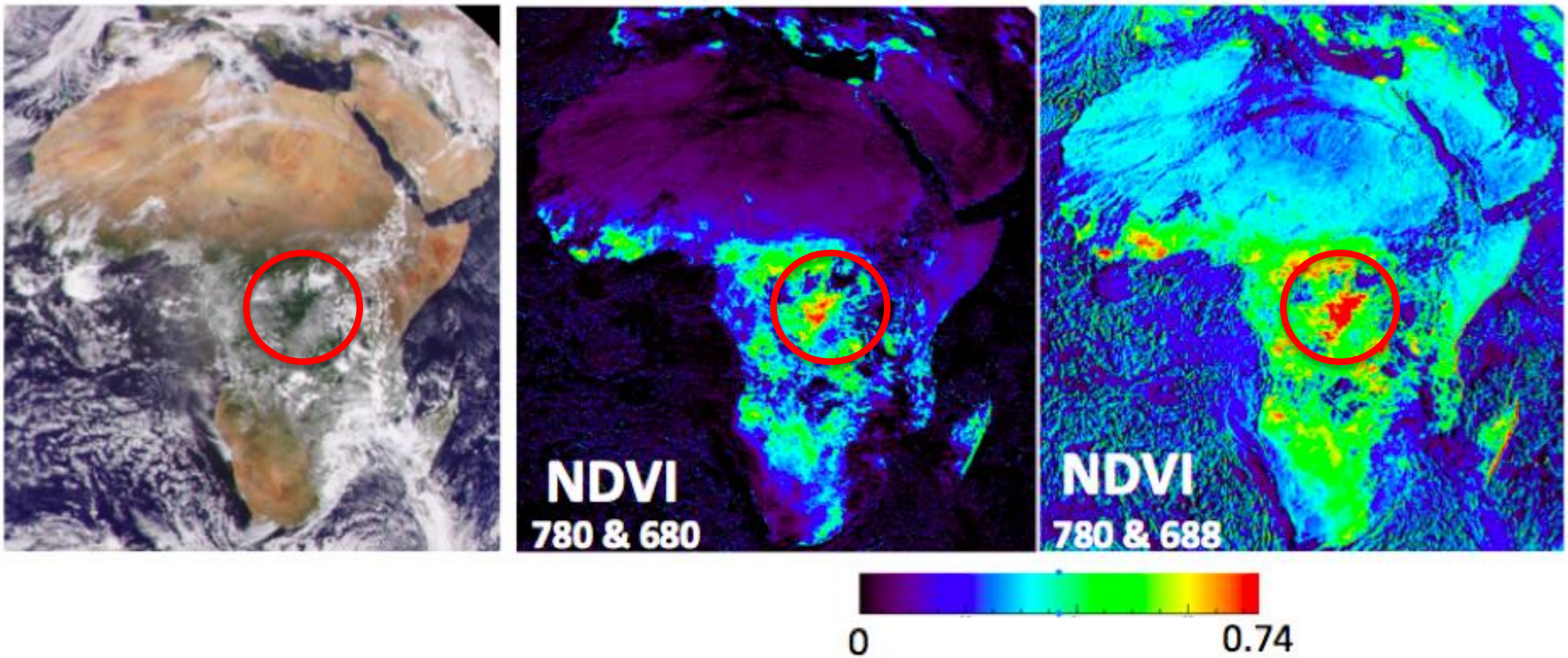


Enhanced and Rayleigh corrected RGB image



Two EPIC NDVIs from March 22, 2016

SZA=6.4±0.5, $|\mu_0|$=0.994±0.001; VZA=12.7±0.5, μ=0.976±0.002; scattering angle is 171.5°.



Some technical justification

$$R_\lambda(\Omega, \Omega_0) = \exp(-\frac{\tau_\lambda}{|\mu_0|})\,\rho_\lambda(\Omega, \Omega_0)\exp(-\frac{\tau_\lambda}{\mu}) + D_\lambda$$

$D_\lambda \approx 0$

(λ=688 nm; O2 B-band)

$\Omega_0 \approx -\Omega$

(back scattering direction)

Spectral Invariant Approximation

$$R_\lambda(\Omega,\Omega_0) = \exp(-\frac{\tau_\lambda}{|\mu_0|})\,\rho_\lambda(\Omega,\Omega_0)\exp(-\frac{\tau_\lambda}{\mu}) + D_\lambda$$

$$\rho_\lambda(\Omega,\Omega_0) = K(\Omega,\Omega_0)W_\lambda$$

K is determined entirely by canopy geometrical properties while W_λ by leaves optical properties

Levis&Disney, 2007

$$W_\lambda = \omega_{0\lambda}\frac{1-p}{1-p\omega_{0\lambda}}$$

$$\omega_{0\lambda} = \exp(-A_\lambda) = \exp[-(\alpha k_{Ch,\lambda} + \beta)]$$

$k_{Ch,\lambda}$ is the chlorophyll absorption spectrum,
α is its concentration and
β represents the total absorption coefficient of dry matter.

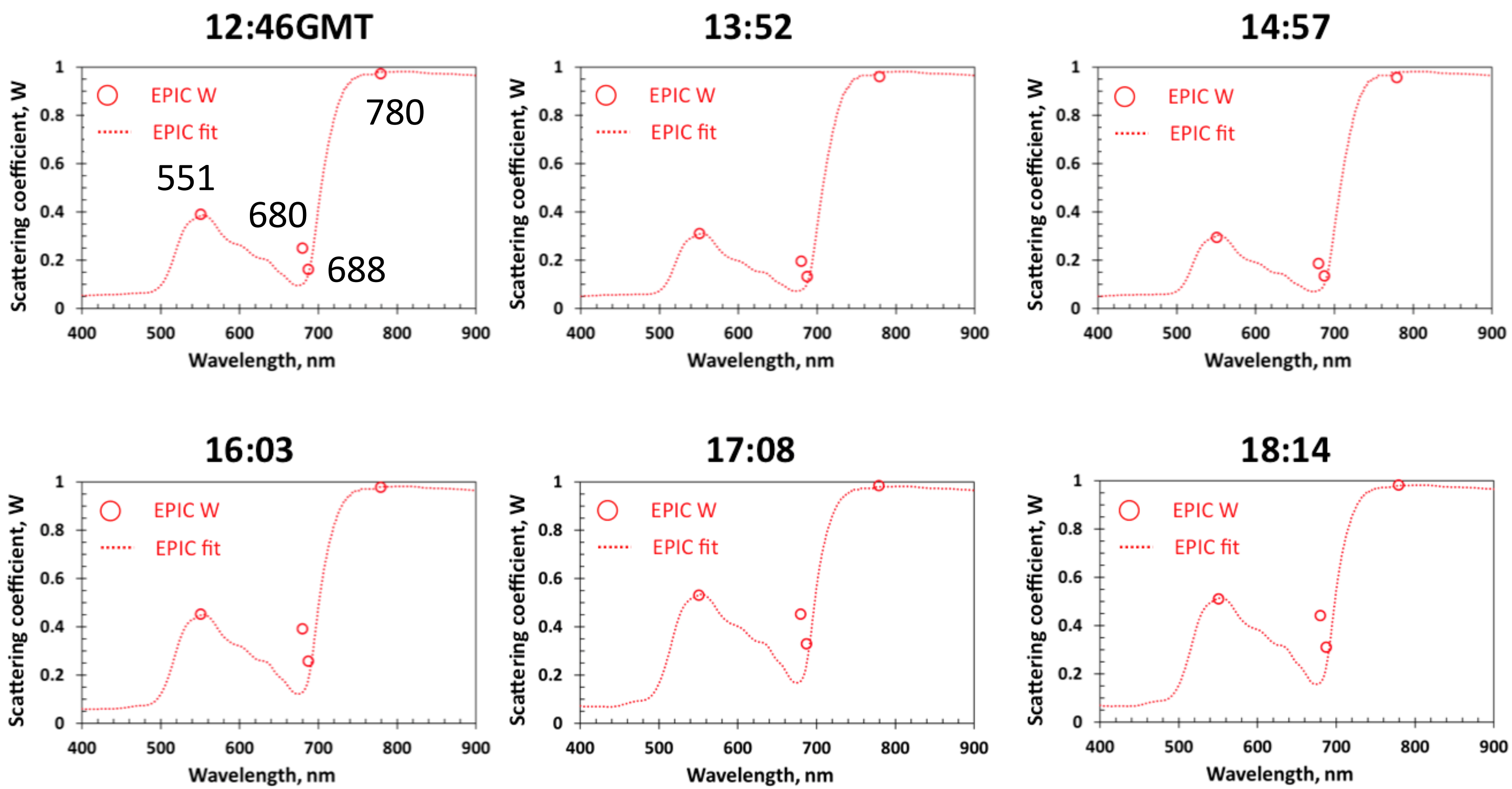
$$\frac{W_\lambda}{\omega_{0\lambda}} = pW_\lambda + (1-p)$$

$$\frac{\rho_\lambda}{\omega_{0\lambda}} = p\rho_\lambda + K(1-p)$$

Huang et al., 2007; Knyazikhin et al., 2011

$$\frac{R_\lambda(\Omega,\Omega_0)}{\omega_{0\lambda}} = pR_\lambda(\Omega,\Omega_0) + b(\Omega,\Omega_0)\exp\left(-\frac{2\tau_\lambda}{\mu}\right) + D_{A\lambda}$$

Spectrally variable scattering coefficient W_λ obtained from EPIC observations



W_λ obtained from EPIC observations in Amazonian rainforests.

The approximated values of W_λ mimic the shape of the spectral scat. coefficient over dense vegetation although its magnitudes are overestimated.

It always fits the scattering coefficient at λ = 551, 688 and 780 nm independently of atmospheric conditions while its value at λ = 680 nm fails to be fitted.

Summary

If the EPIC O2 B-band (688 nm) is used instead of the red band, the effect of atmosphere (the diffuse radiation) on surface reflectance *will be reduced* and the residual uncertainties in atmospheric correction can be better tolerated.

This is due to two factors:

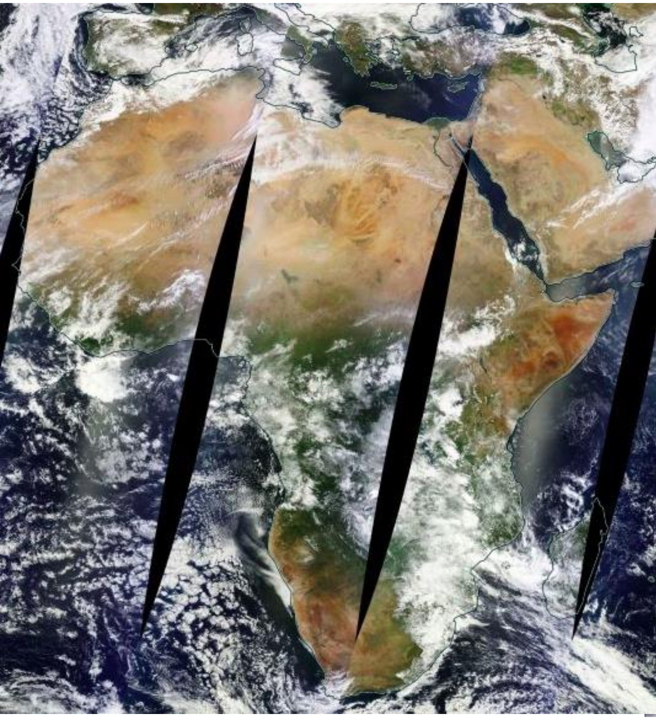
(i) vegetated surface is yet sufficiently dark at 688 nm and

(ii) the O2 absorbing atmosphere substantially reduces multiple scattering.

The spectral invariant approximation supports this statement.

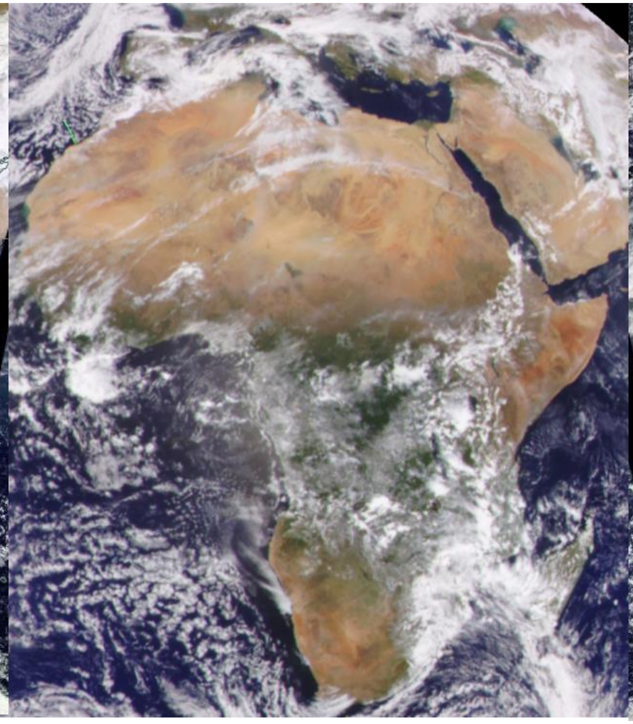
Sig
Gerstl

MODIS/Terra&Aqua and EPIC/DSCOVR



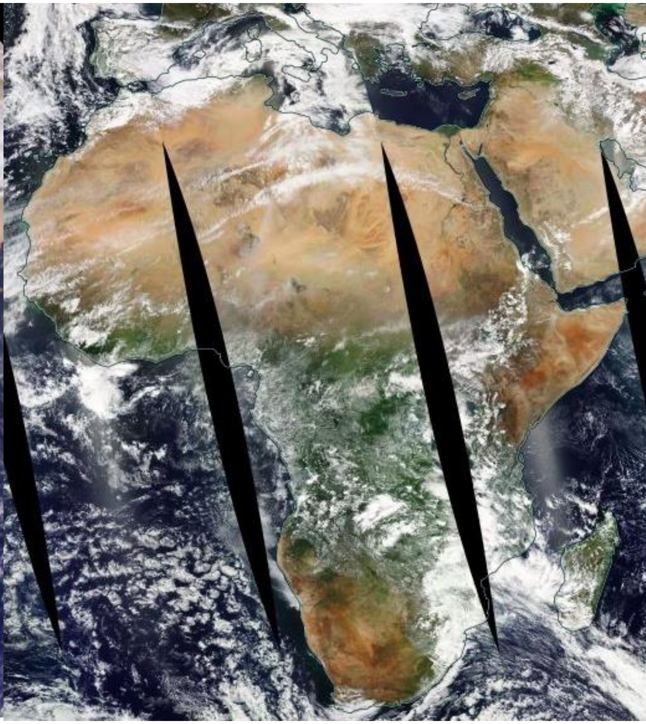
MODIS Terra

10:30 equatorial crossing time



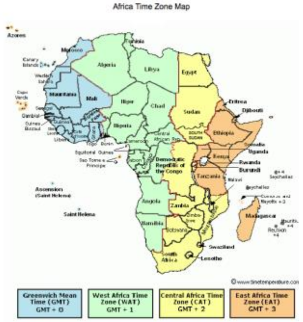
EPIC

10:56 UTC



MODIS Aqua

13:30 equatorial crossing time



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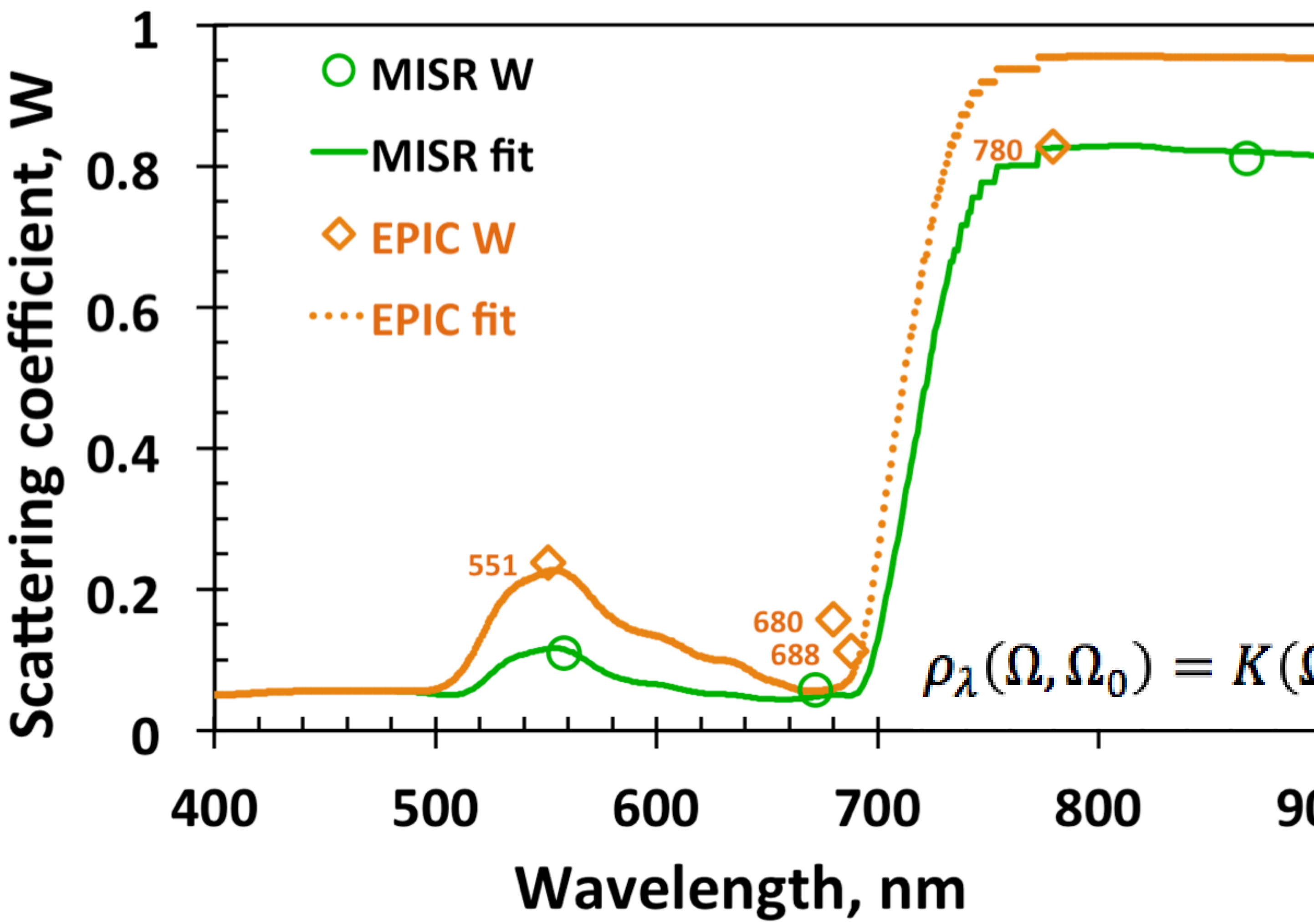
Example with MISR and EPIC



$$\rho_\lambda(\Omega, \Omega_0) = K(\Omega, \Omega_0) W_\lambda$$

To summarize, the scattering coefficient W_λ at λ = 551, 688 and 780 nm (but not at λ = 680 nm) can be well approximated by the chlorophyll absorption spectrum.