EPIC L2 Cloud Products Update

Cloud Products Team:

Investigators: Yuekui Yang, Yaping Zhou, Kerry Meyer, Galina Wind

Collaborators: Steven Platnick, Wenying Su, Qilong Min, Anthony Davis

DSCOVR EPIC&NISTAR Science Team Meeting

Oct. 06-08, 2020, Online

List of updates (work since last STM in Sept. 2019)

- NCCS *discover* operating system change from SLES11 to SLES12 (libraries used in the cloud product algorithms: hdf4, hdf5, nc4, fortran and c++)

- Algorithm development and implementation:

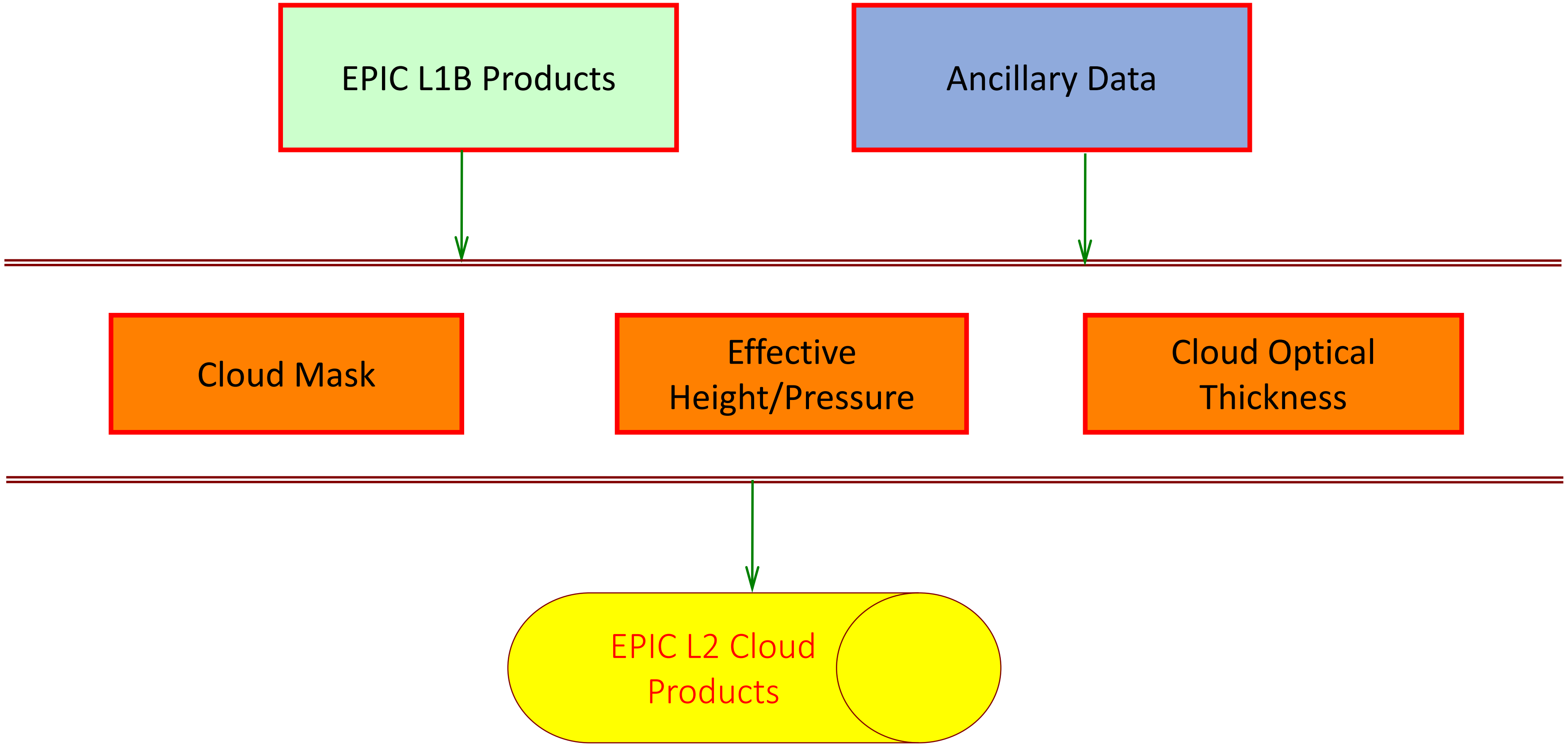
  -- cloud mask over ice and snow (paper published)

  Zhou, Y., Y. Yang, M. Gao, P. Zhai, 2020: Cloud Detection over Snow and Ice with Oxygen A- and B-band Observations from the Earth Polychromatic Imaging Camera (EPIC), *Atmos. Meas. Tech.*, 13, 1575–1591, https://doi.org/10.5194/amt-13-1575-2020.

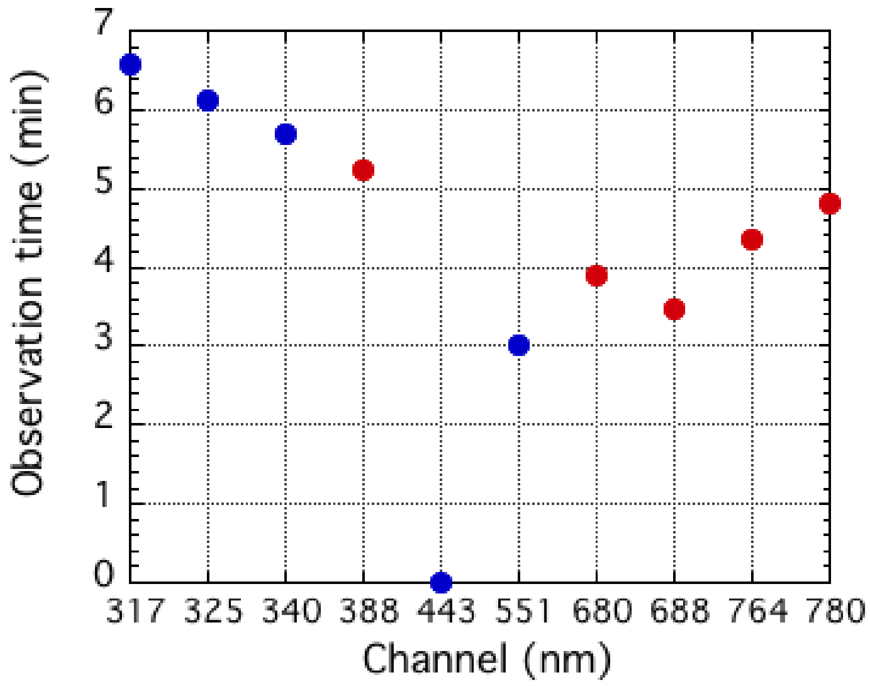
  -- cloud mask over sun glint regions: implemented

- Thresholds tuning and improvements: cloud mask over snow-free land
- Surface type and pressure from GEOS FPIT near real time
- Other small fixes

EPIC Standard L2 Cloud Product System



EPIC Channels Used for Cloud Retrievals



Product	Resolution	Description	EPIC Data Used
Cloud Mask	Original pixel size	Each EPIC pixel is classified as clear/cloudy with high/low confidence.	388 nm, 680 nm, and the 780 nm relectances, the 764/780 nm and the 688/680 nm ratios.
CEP/CEH	Original pixel size	Cloud effective pressure (CEP) is retrieved for both O2 A- and B-bands	O_2 A-band (780 nm and 764 nm), and B-band (680 nm and 688 nm), EPIC cloud mask
COT	Original pixel size	Cloud optical thickness is retrieved using a single-channel approach (680 nm over land and 780 nm over ocean)	680 nm, 780nm, EPIC cloud mask, EPIC CEP

Observation time for each EPIC channel starting from the 443 nm channel. Red dots are the channels used for cloud retrievals.

EPIC cloud products and required EPIC observations

EPIC L2 Major Cloud Product List

1) EPIC Cloud Mask
2) Oxygen A-band Cloud Effective Pressure
3) Oxygen A-band Cloud Effective Height
4) Oxygen B-band Cloud Effective Pressure
5) Oxygen B-band Cloud Effective Height
6) Cloud Optical Thickness – assuming liquid phase
7) Cloud Optical Thickness – assuming ice phase
8) Cloud Effective Temperature
9) Most likely cloud thermodynamic phase

EPIC Cloud Product Version Naming Convention

Versions 01

DSCOVR_EPIC_L2_CLOUD_01_20190627131403_02.nc4

16,676 granules
05/12/2016 – 06/27/2019

Cloud Product Version

L1b Version

Versions 02

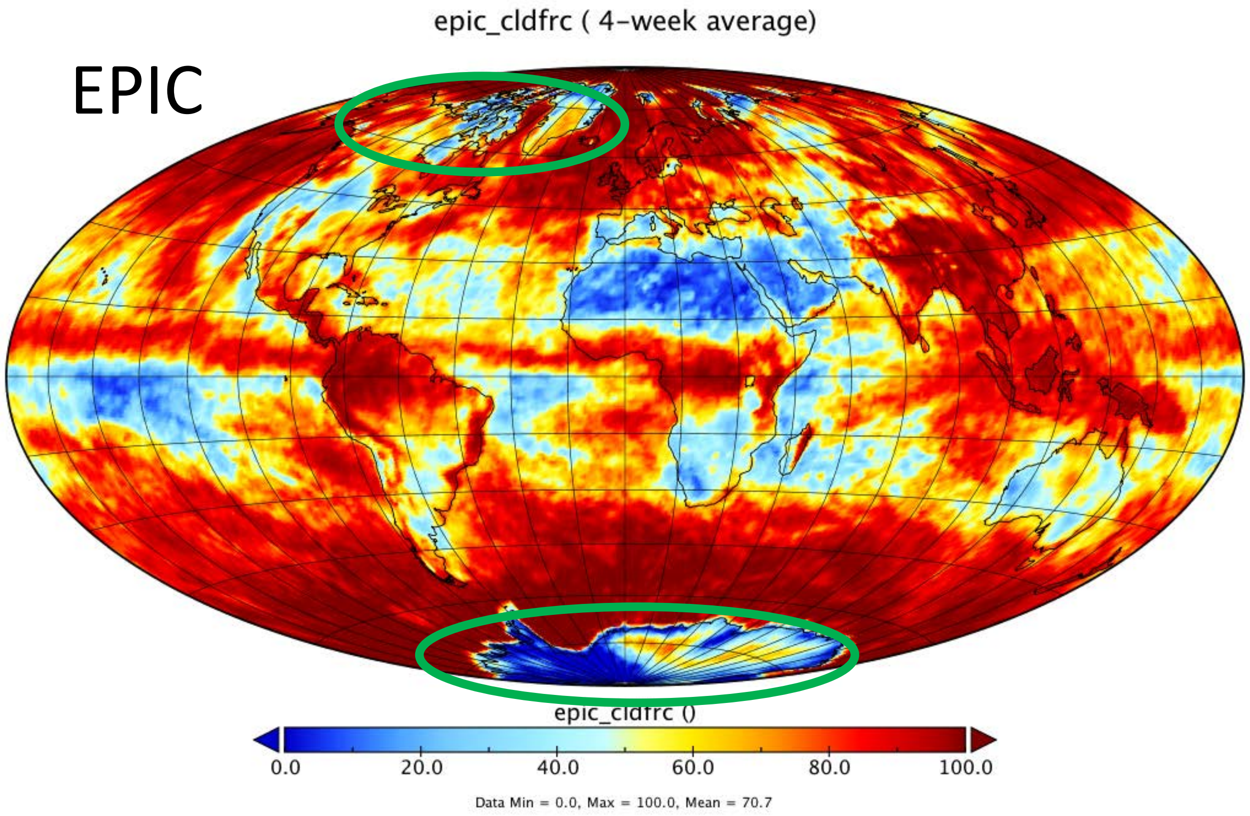
DSCOVR_EPIC_L2_CLOUD_02_20190627131403_03.nc4

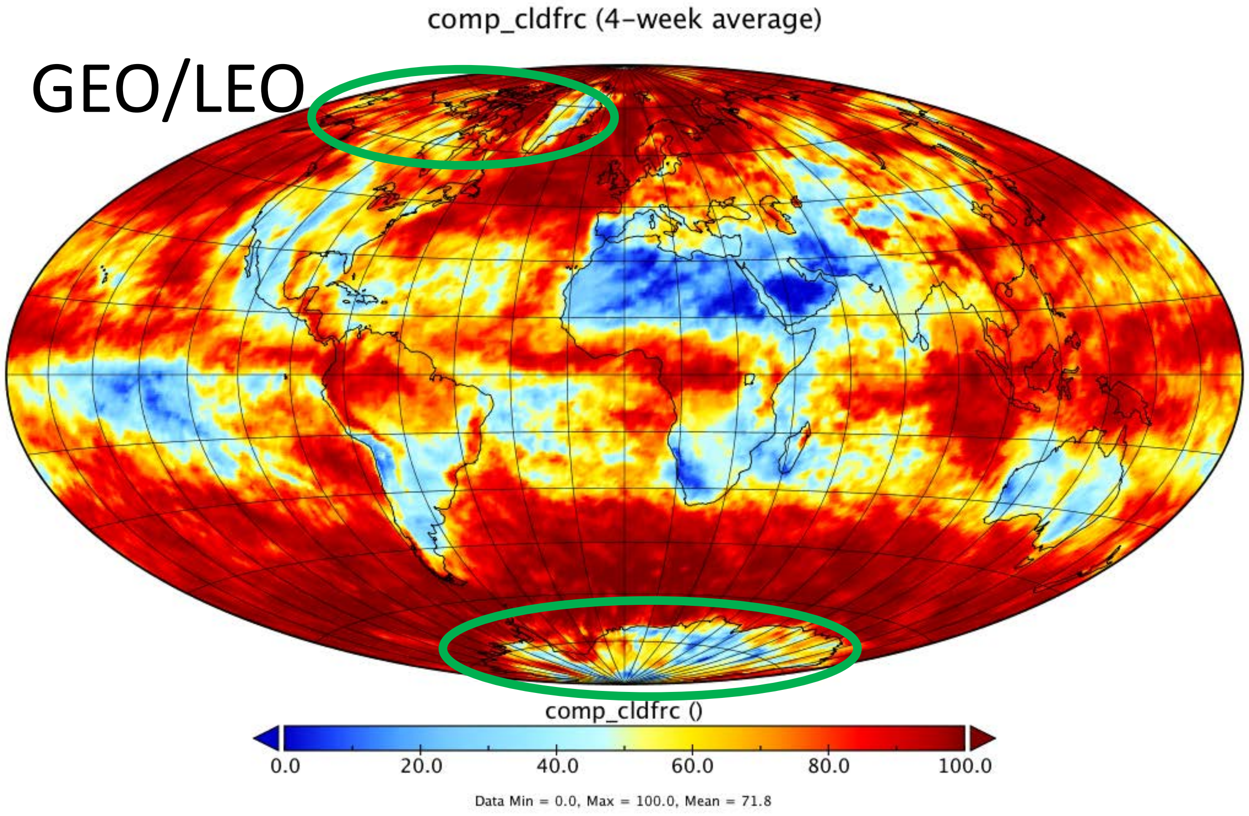
23,301 granules
05/12/2016 – present

Next: Versions 03

DSCOVR_EPIC_L2_CLOUD_03_20190627131403_03.nc4

Issues with Version 1 EPIC L2 Cloud Products





- Comparison used four weeks of data from 2016 with one week for each season.
- General patterns agree well, but problems exist over
  - -- snow/ice covered areas
  - -- sunglint areas

Improvements of cloud mask over snow/ice

Atmos. Meas. Tech., 13, 1575–1591, 2020
https://doi.org/10.5194/amt-13-1575-2020

Atmospheric Measurement Techniques
Open Access
EGU

Cloud detection over snow and ice with oxygen A- and B-band observations from the Earth Polychromatic Imaging Camera (EPIC)

Yaping Zhou[1,2], Yuekui Yang[1], Meng Gao[1,3], and Peng-Wang Zhai[4]

[1]NASA Goddard Space Flight Center, Greenbelt, MD, USA
[2]The Joint Center for Earth Systems Technology, University of Maryland Baltimore County, Baltimore, MD, USA
[3]SSAI/NASA Goddard Space Flight Center, Ocean Ecology Laboratory, Greenbelt, MD, USA
[4]The Joint Center for Earth Systems Technology, Department of Physics, University of Maryland Baltimore County, Baltimore, MD 21250, USA

Another paper supported by this project just published:

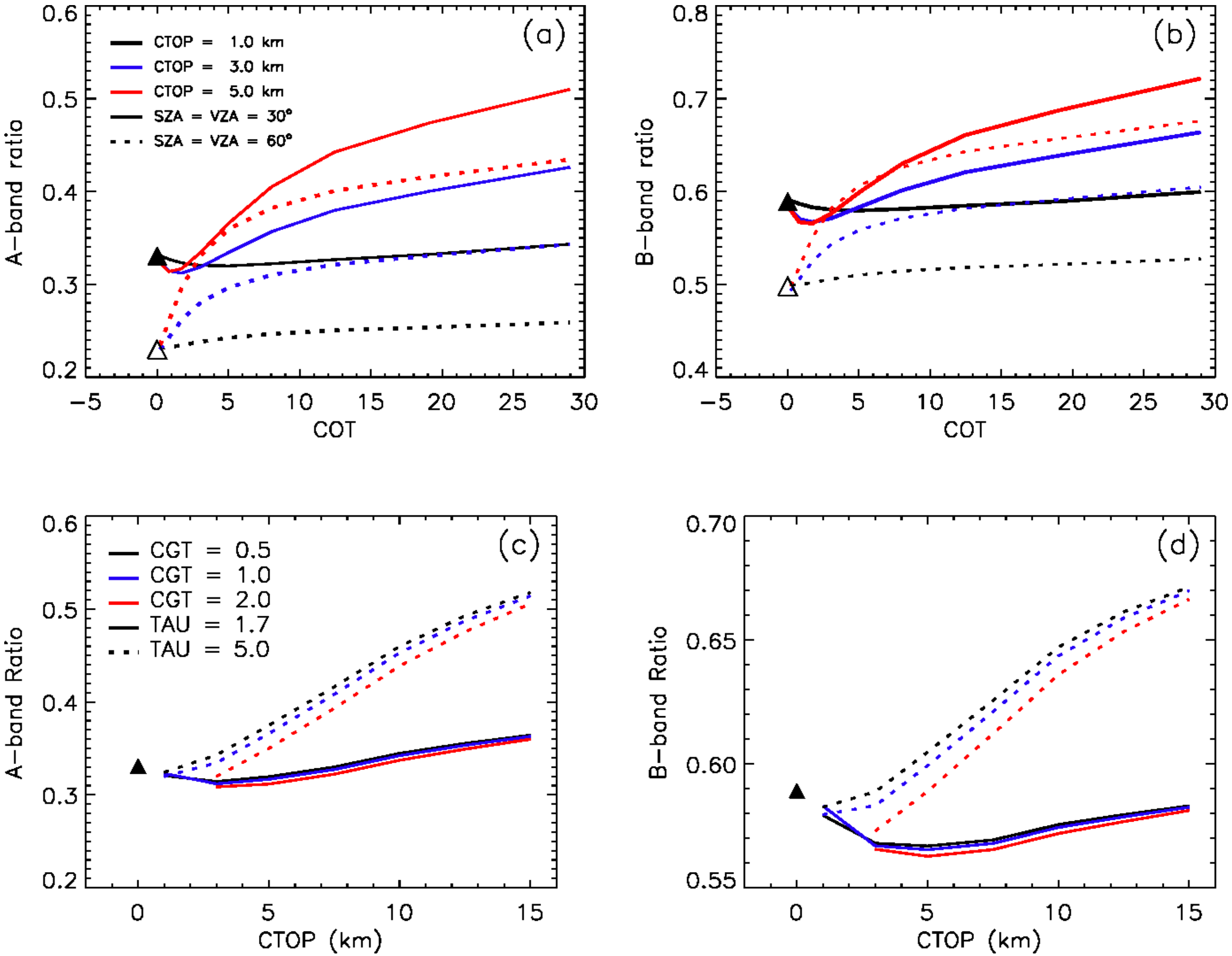
Yin, B., Min, Q., Morgan, E., Yang, Y., Marshak, A., and Davis, A. B., 2020: Cloud-top pressure retrieval with DSCOVR EPIC oxygen A- and B-band observations, Atmos. Meas. Tech., 13, 5259–5275, https://doi.org/10.5194/amt-13-5259-2020.

Cloud detection over snow/ice with O_2 bands

Model simulated Oxygen band ratios as a function of cloud optical thickness (COT) with cloud top height at 2.5 km (black), 5.0 km (blue) and 7.5 km (red) and solar zenith angles at 30° (solid line) and 60° (dotted lines), respectively.

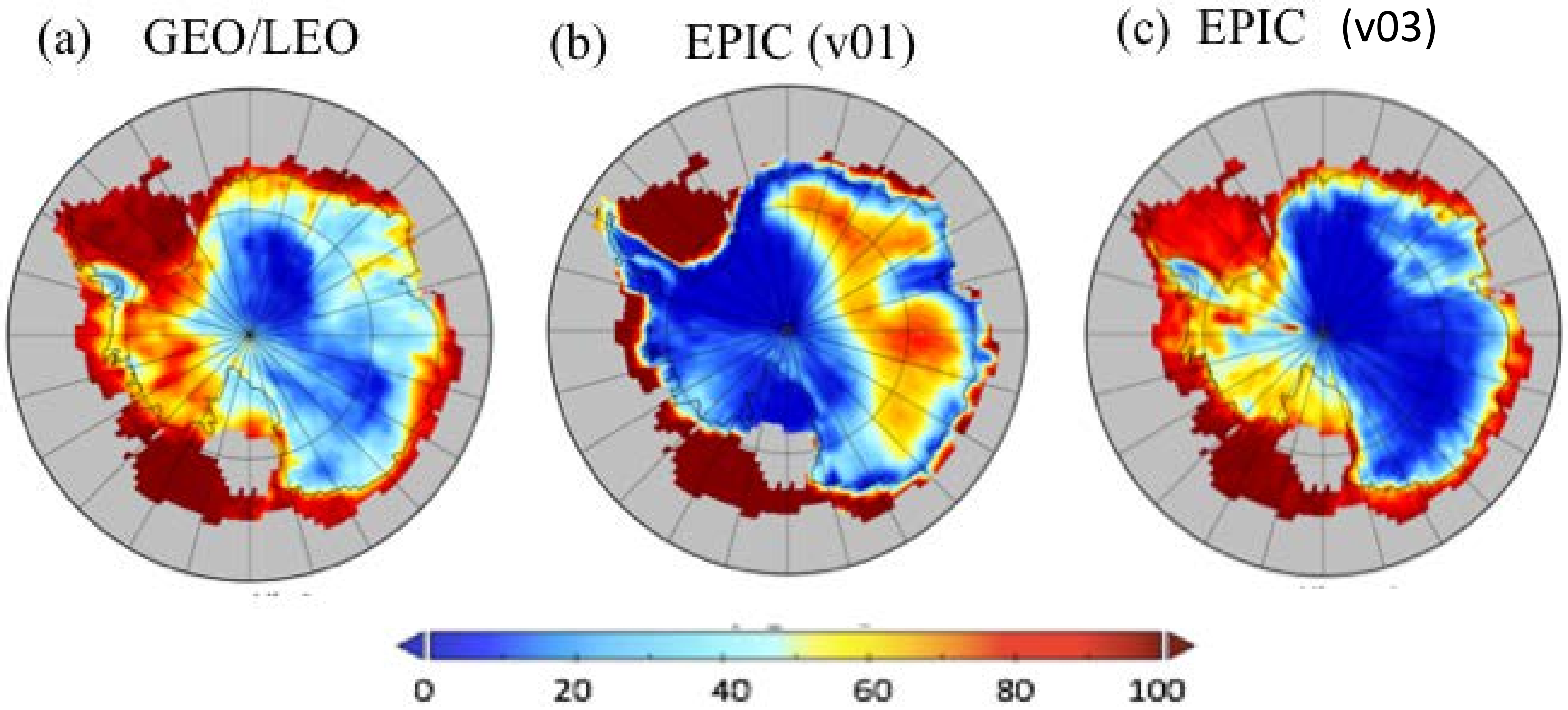
Thresholds are developed as a function of surface height, solar zenith and view zenith angles.

Zhou et al., AMT, 2020



Improvements of cloud mask over snow/ice

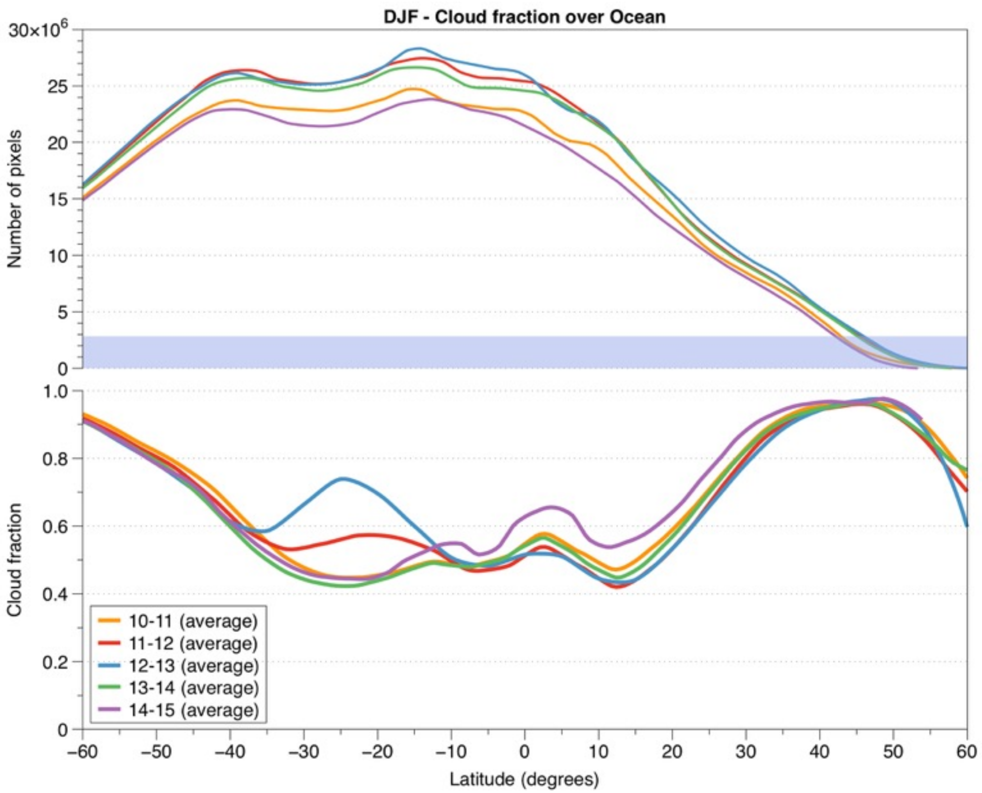
Cloud Fractions derived from (a) composite GEO/LEO retrievals, (b) original EPIC cloud mask, (c) new EPIC cloud mask over Antarctic in January 2017

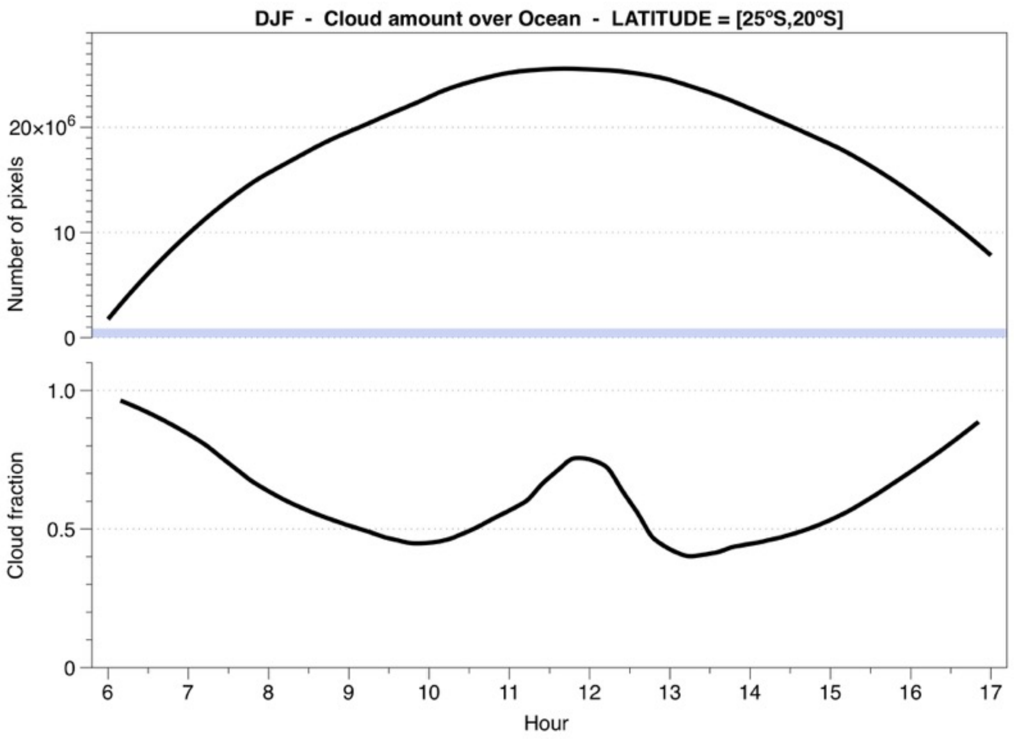


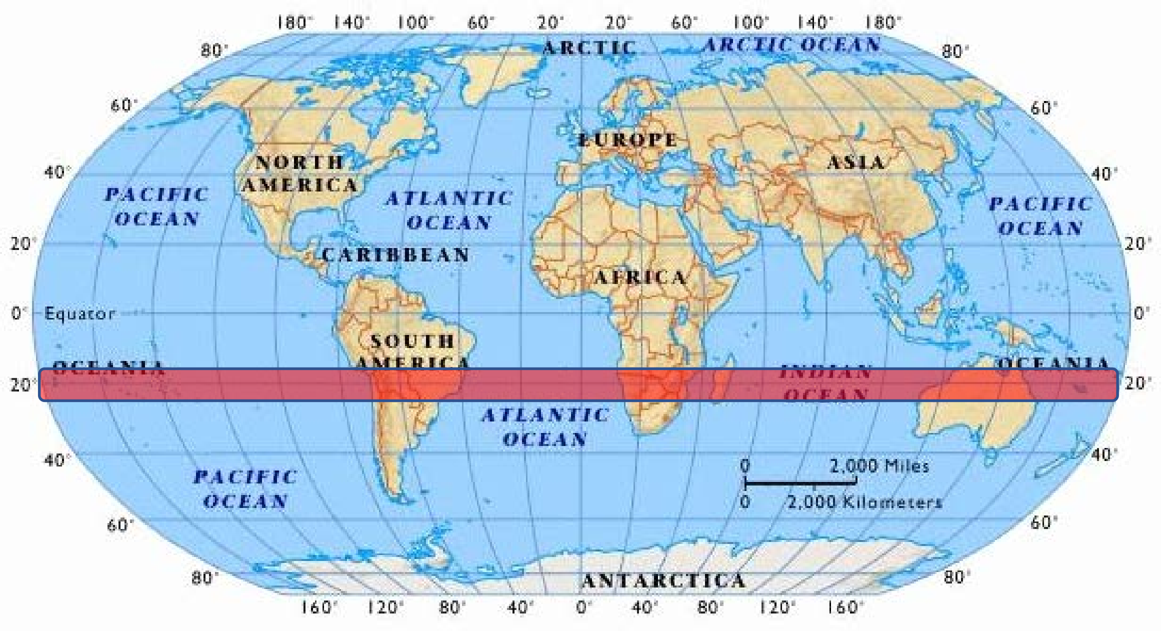
Zhou et al., AMT, 2020

Problems around sunglint

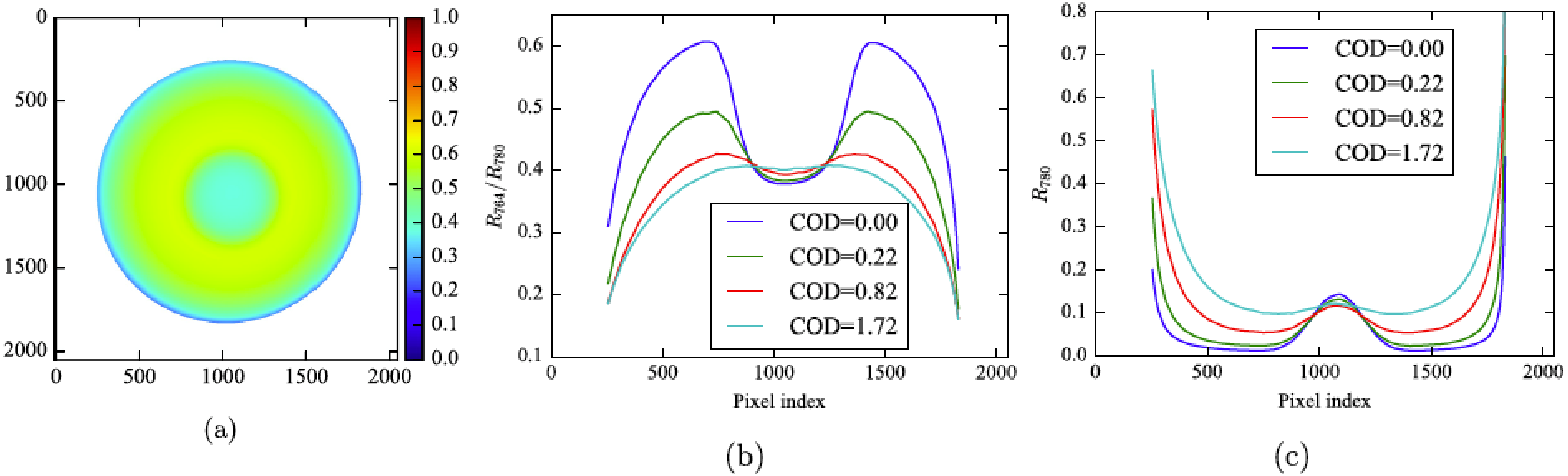
Courtesy of Alfonso







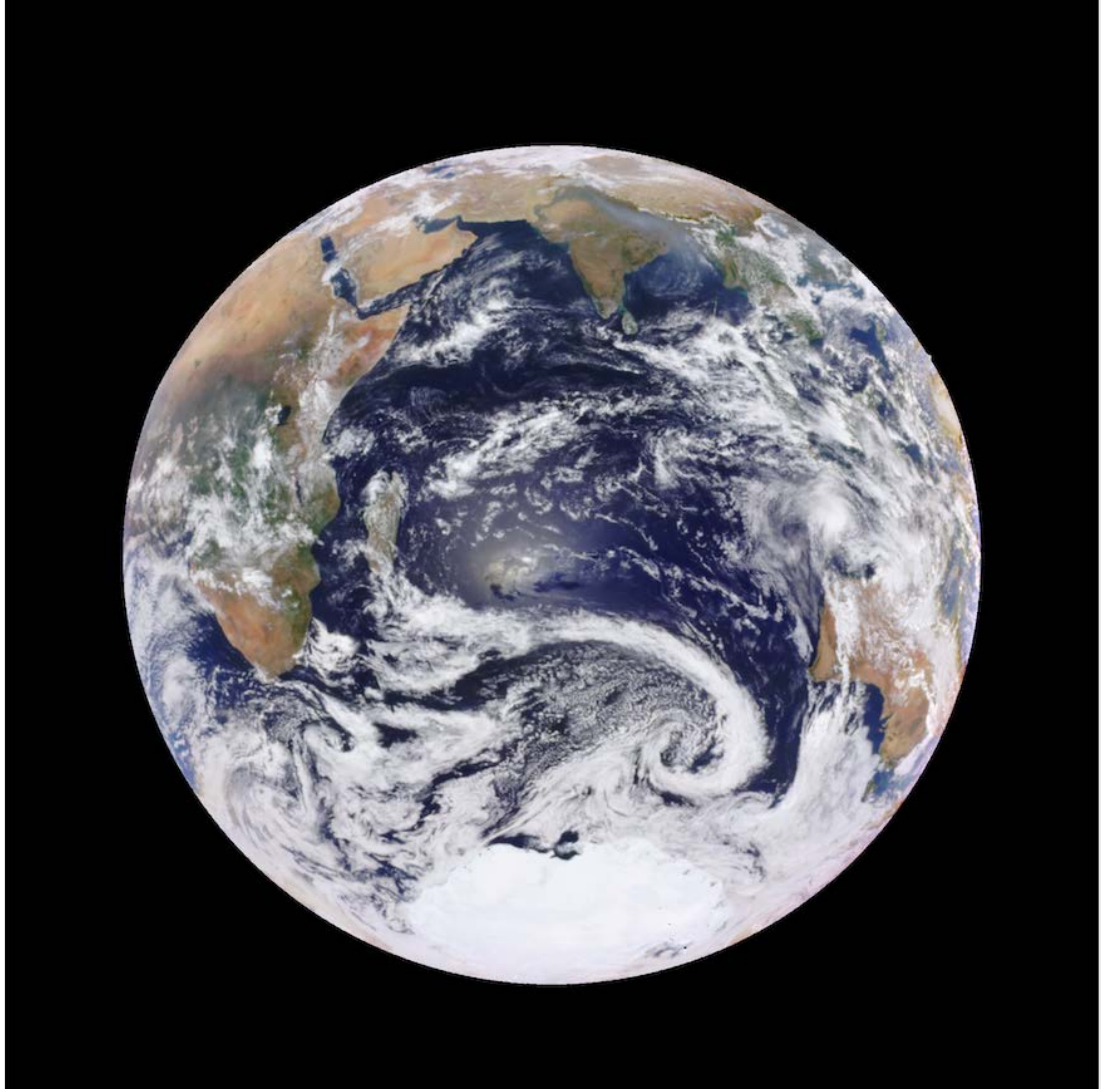
Cloud detection over sung lint

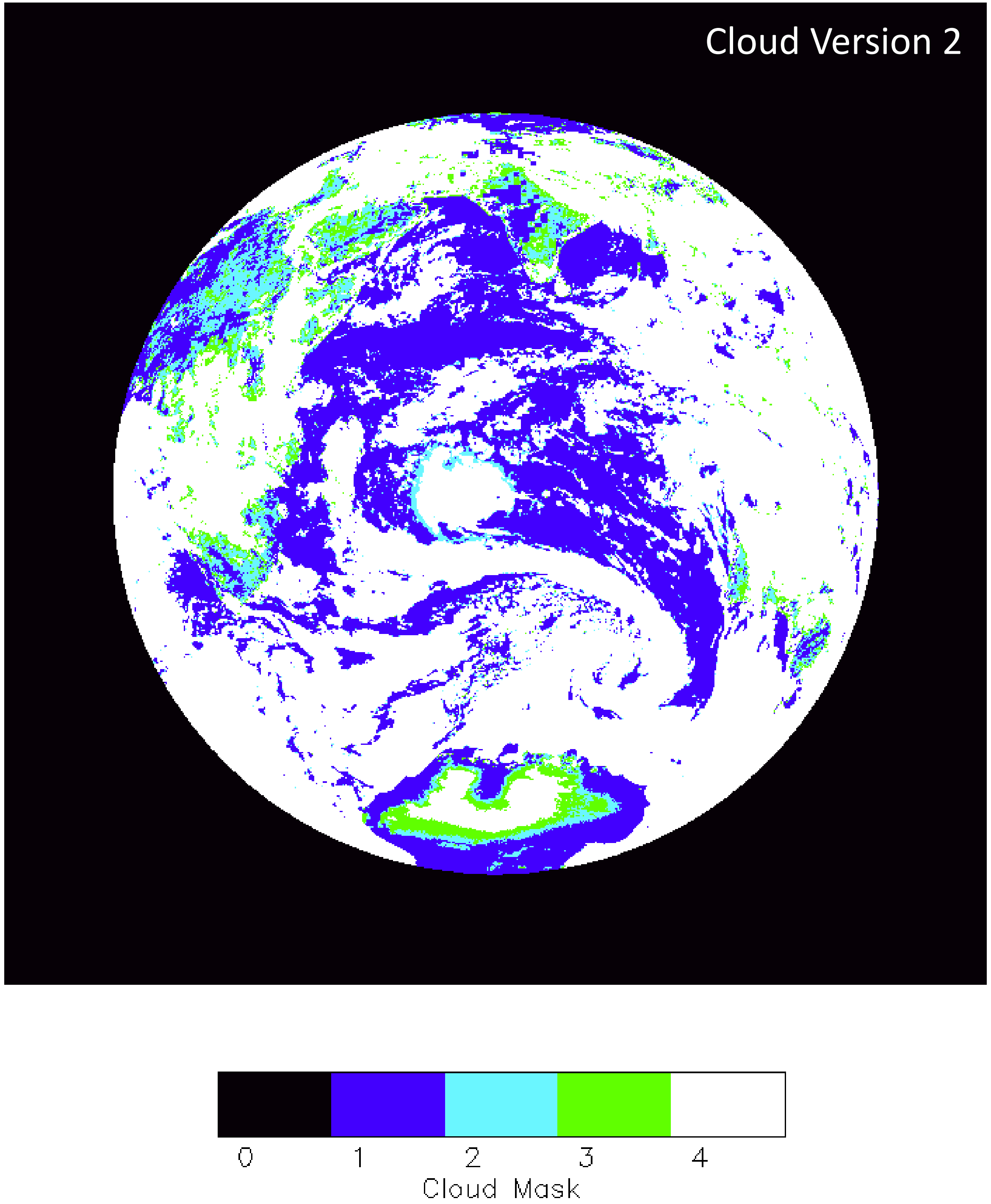


(a) *R* 764 / *R* 780 of a clear sky case for a typical Earth viewing geometry from EPIC. (b) *R* 764 / *R* 780 as a function of the pixel index on the horizontal line which intercept the image at y = 1024, where y is the vertical pixel index. CTH and CGT are 2.5 and 1 km, respectively. (c) *R* 780 on the same horizontal line

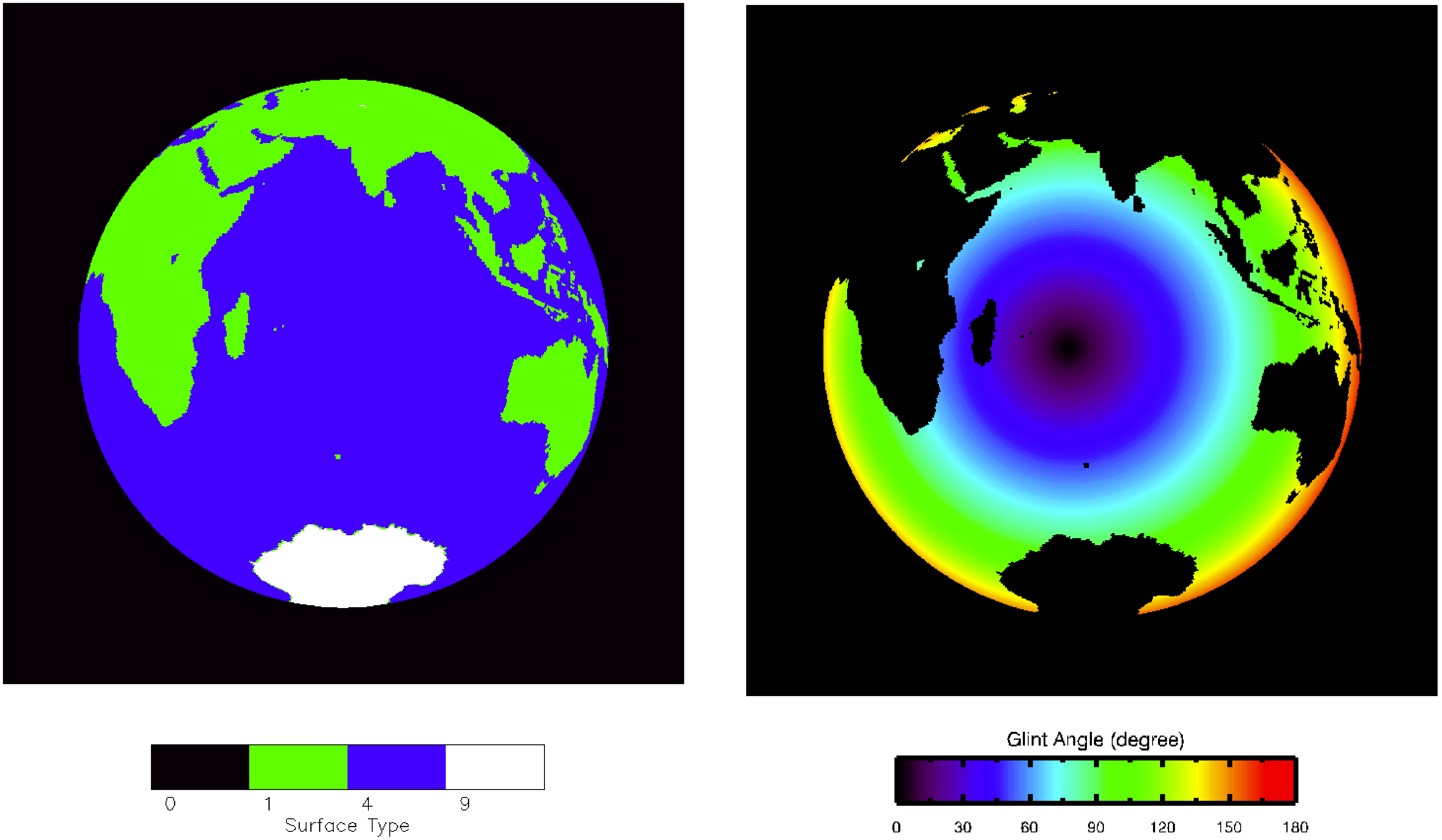
Gao et al., JQSRT, 2019

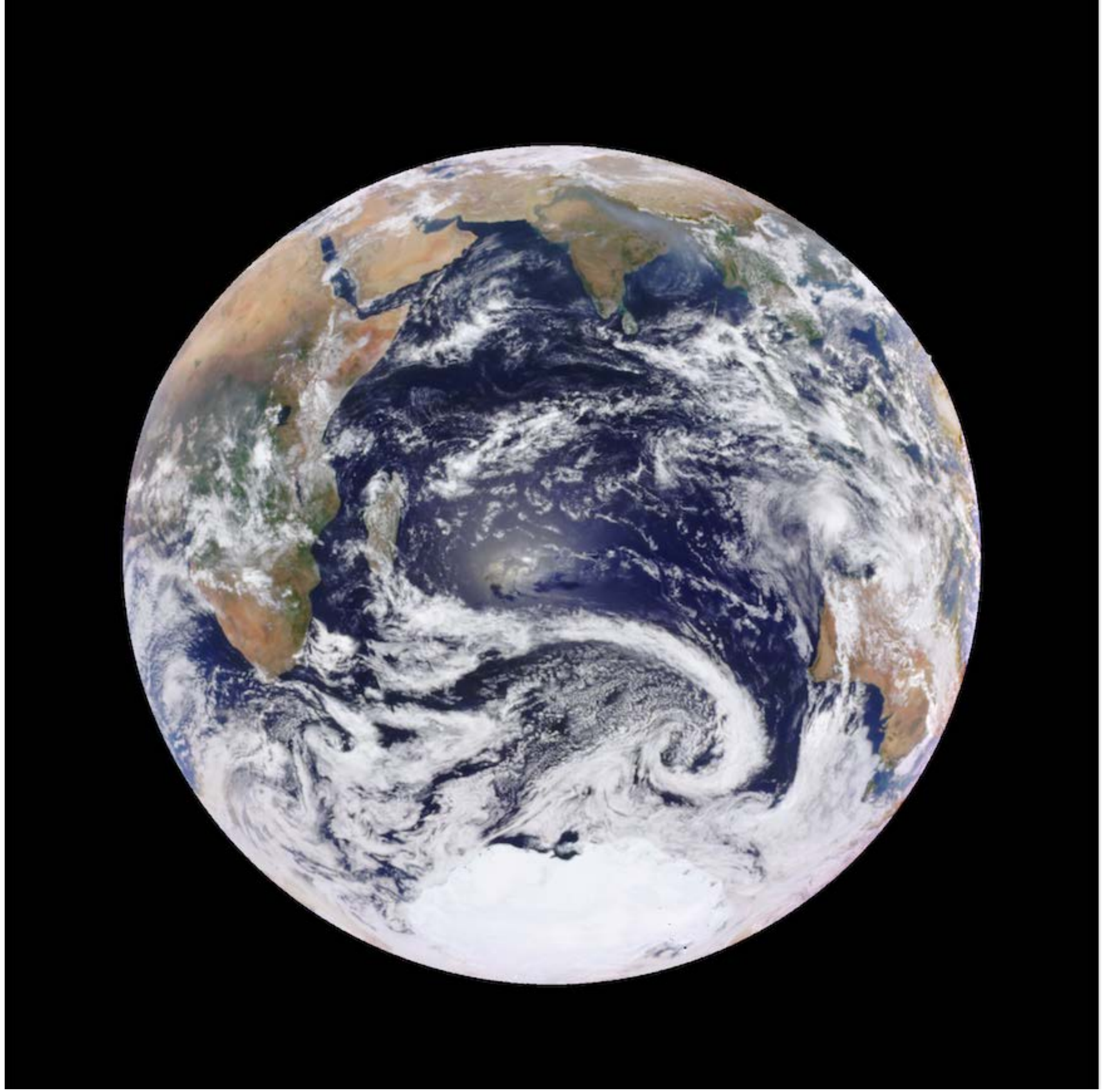
Thresholds are derived as a function of glint angle using O_2 A-band ratio and 780nm reflectance

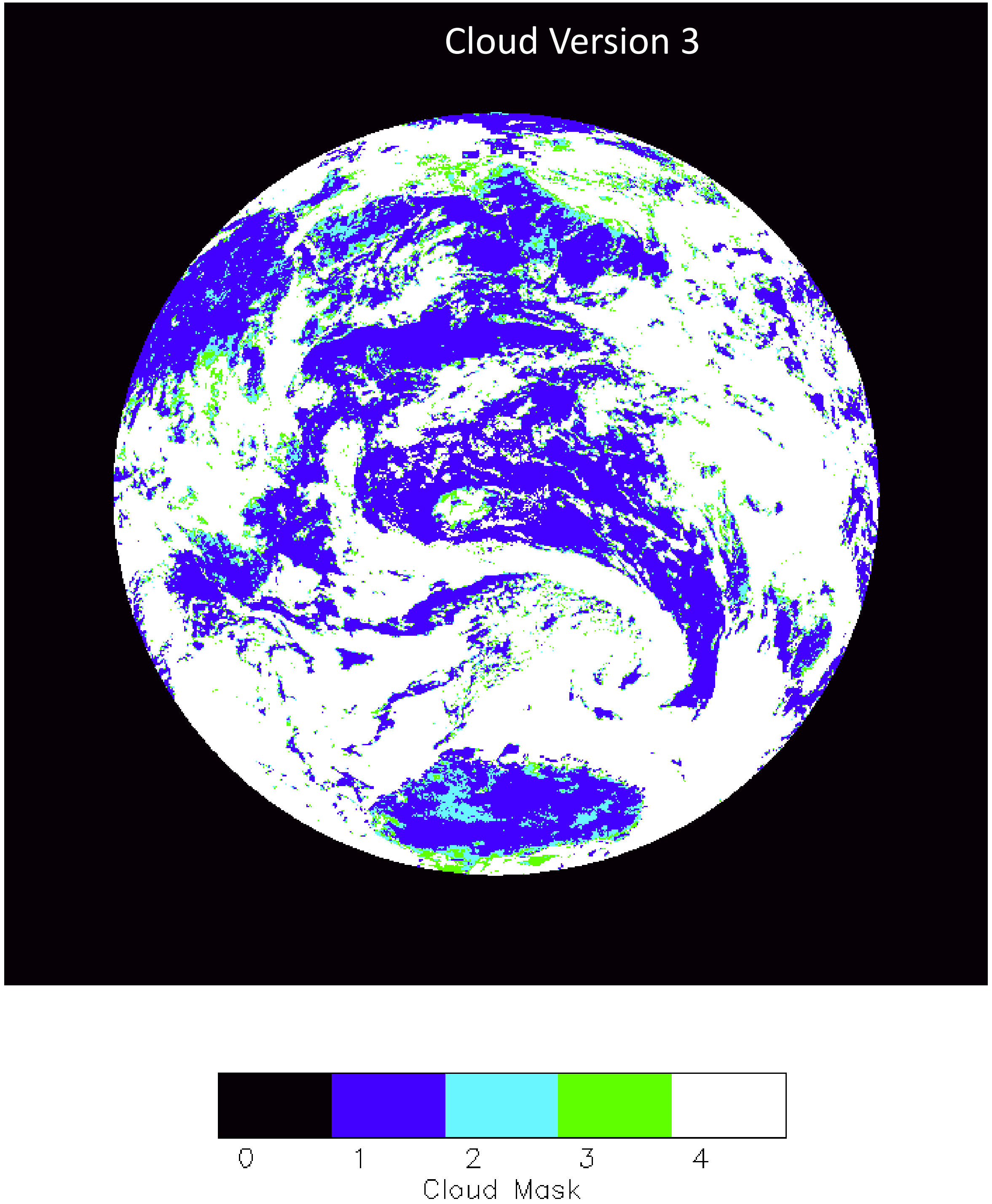




Example:
DSCOVR_EPIC_L2_CLOUD_03_20161222075806_03.nc4


0
1
4
9
Surface Type
Glint Angle (degree)
0
30
60
90
120
150
180





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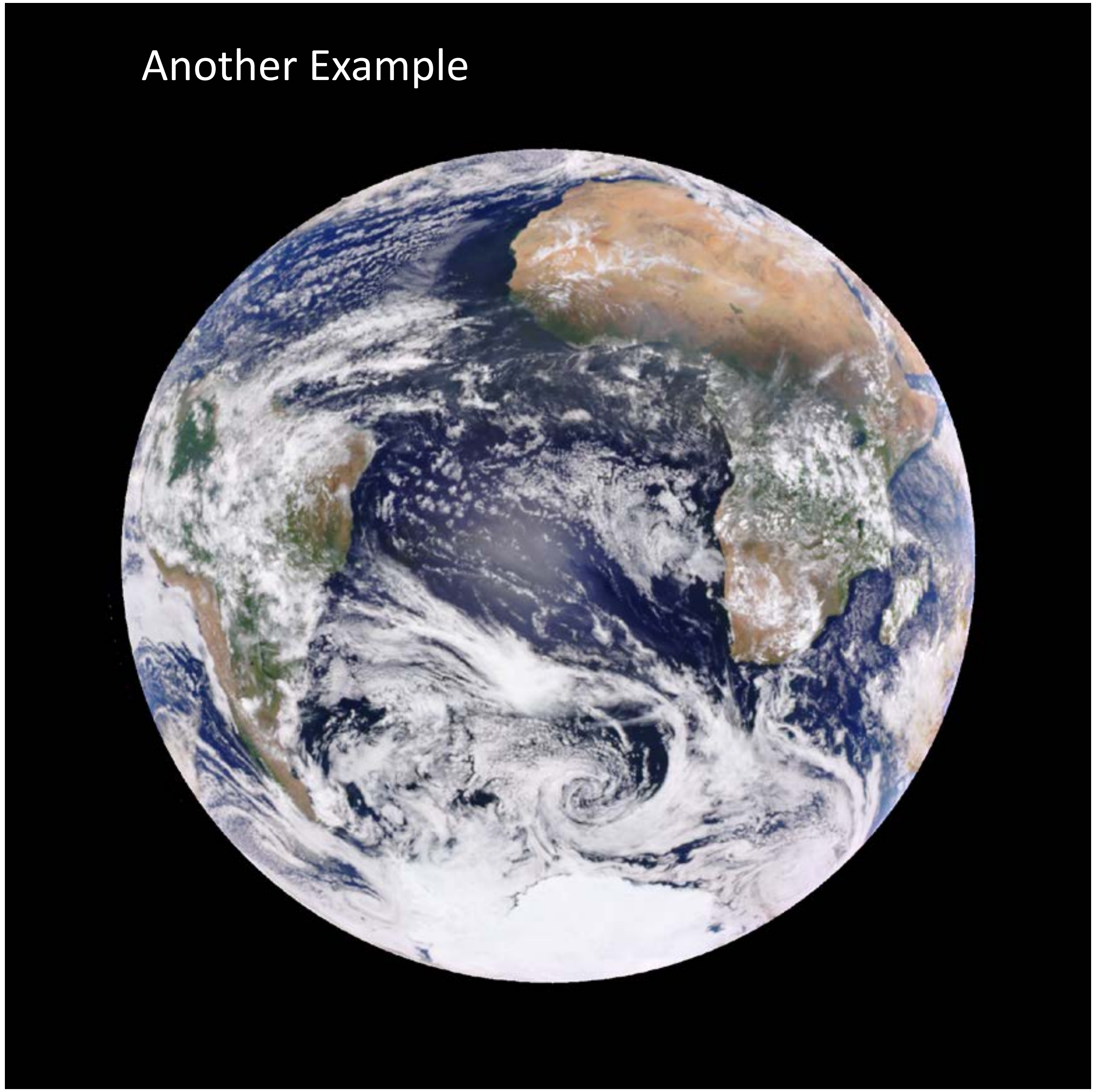
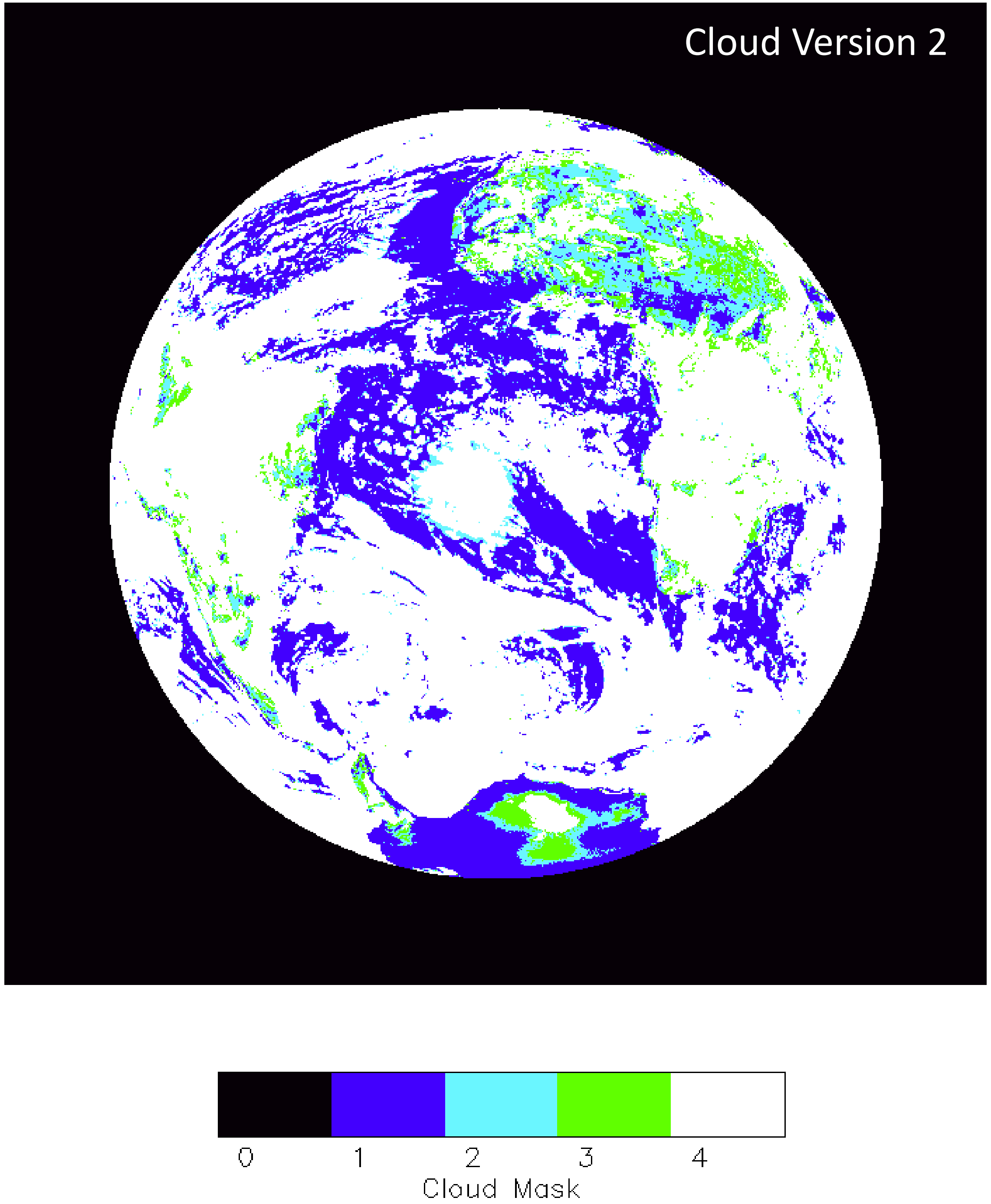
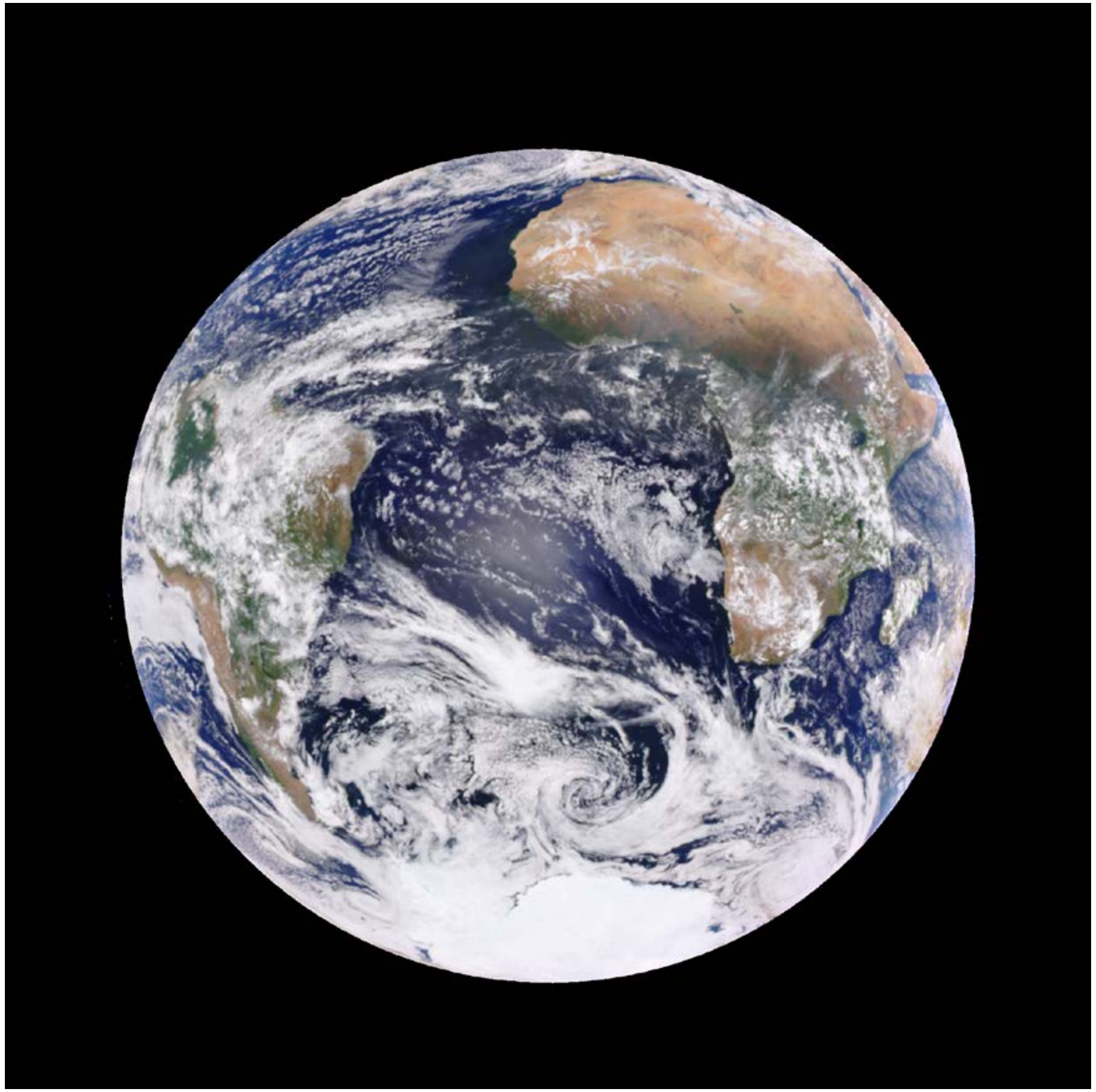
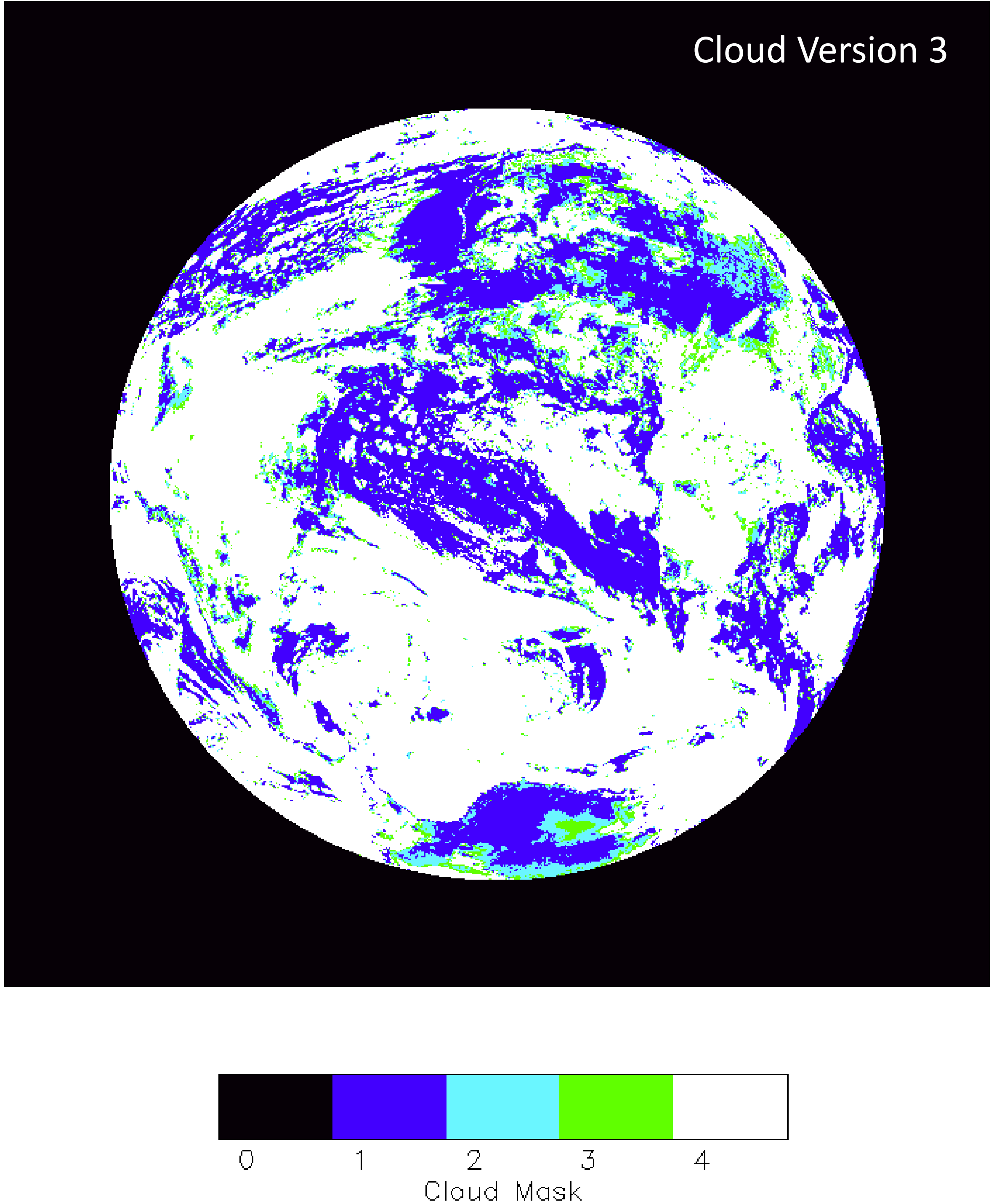
DSCOVR_EPIC_L2_CLOUD_03_20161222075806_03.nc4





Example:
DSCOVR_EPIC_L2_CLOUD_02_20160101133135_03.nc4





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EPIC Cloud Product Application Examples

- Kramarova, Huang, et al. Ozone retrieval corrections
- Kai Yang's products

EPIC Cloud Product Application Examples (Cont.)

JGR Atmospheres

RESEARCH ARTICLE
10.1029/2019JD031488

Key Points:

- EPIC observes the sunlit side of the Earth with a frequency between 1 and 2 hr providing information on cloudiness at different local times
- Four years of EPIC global cloud fraction was analyzed as a function of season and latitude
- The daytime evolution of cloudiness over ocean exhibits a clear convex shape, while it has less pronounced features over land

Supporting Information:

- Supporting Information S1

Daytime Variability of Cloud Fraction From DSCOVR/EPIC Observations

A. Delgado-Bonal[1,2], **A. Marshak**[1], **Y. Yang**[1], **and L. Oreopoulos**[1]

[1]Earth Sciences Division, NASA Goddard Space Flight Center, Greenbelt, MD, USA, [2]Universities Space Research Association, Columbia, MD, USA

Abstract The location of the Earth Polychromatic Imaging Camera (EPIC) aboard the Deep Space Climate Observatory (DSCOVR) offers a global view of the Earth and captures its atmosphere at different locations and time of the day. In this paper, we take advantage of that unique feature to study the daytime variability of cloud fraction in a seasonal and zonal context. We observe that the ensemble behavior over ocean has a distinctive convex shape, with higher cloud fractions at early morning and late afternoon, while no such pattern is seen over land. Unique perspectives are obtained by analyzing the cloud fraction of the globe as a whole and separately for each hemisphere, and by studying the effect of the viewing zenith angle on cloud fraction retrievals.

EPIC Cloud Product Application Examples (Cont.)

Remote Sensing of Environment 232 (2019) 111320

Contents lists available at ScienceDirect

Remote Sensing of Environment

journal homepage: www.elsevier.com/locate/rse

ELSEVIER

Estimating hourly land surface downward shortwave and photosynthetically active radiation from DSCOVR/EPIC observations

Dalei Hao[a,b,e], Ghassem R. Asrar[b], Yelu Zeng[c], Qing Zhu[d], Jianguang Wen[a,e], Qing Xiao[a,e], Min Chen[b,*]

[a] State Key Laboratory of Remote Sensing Science, Institute of Remote Sensing and Digital Earth, Chinese Academy of Sciences, Beijing 100101, China
[b] Joint Global Change Research Institute, Pacific Northwest National Laboratory, College Park, MD 20740, USA
[c] Department of Global Ecology, Carnegie Institution for Science, Stanford, CA 94305, USA
[d] Earth Science Division, Lawrence Berkeley National Lab, Berkeley, CA 94720, USA
[e] University of Chinese Academy of Sciences, Beijing 100049, China

EPIC Cloud Product Application Examples (Cont.)

Earth Syst. Sci. Data, 12, 2209–2221, 2020
https://doi.org/10.5194/essd-12-2209-2020

Open Access Earth System Science Data

DSCOVR/EPIC-derived global hourly and daily downward shortwave and photosynthetically active radiation data at 0.1° x 0.1° resolution

Dalei Hao[1,2,3], Ghassem R. Asrar[4], Yelu Zeng[1], Qing Zhu[5], Jianguang Wen[2,3], Qing Xiao[2,3], and Min Chen[1]

[1]Joint Global Change Research Institute, Pacific Northwest National Laboratory, College Park, MD 20740, USA
[2]State Key Laboratory of Remote Sensing Science, Aerospace Information Research Institute, Chinese Academy of Sciences, Beijing 100101, China
[3]University of Chinese Academy of Sciences, Beijing 100049, China
[4]Universities Space Research Association, Columbia, MD 21046, USA
[5]Earth Science Division, Lawrence Berkeley National Lab, Berkeley, CA 94720, USA

Correspondence: Min Chen (min.chen@pnnl.gov)

Received: 31 January 2020 – Discussion started: 6 April 2020
Revised: 15 July 2020 – Accepted: 3 August 2020 – Published: 15 September 2020

Summary

- Since last STM, the cloud detection algorithm upgrade has been implemented. Results over ice, snow, snow-free land, and sung lint are improved.
- EPIC L2 cloud products have seen some exciting applications, including trace gas corrections, surface solar energy calculation, and cloud diurnal cycle studies.
- Future work include:

  -- Oxygen A- and B-band absorption look up table update
  -- Version 3 cloud product, testing, processing and validation.

Publications

Yin, B., Min, Q., Morgan, E., Yang, Y., Marshak, A., and Davis, A. B., 2020: Cloud-top pressure retrieval with DSCOVR EPIC oxygen A- and B-band observations, Atmos. Meas. Tech., 13, 5259–5275, https://doi.org/10.5194/amt-13-5259-2020.

Zhou, Y., Y. Yang, M. Gao, P. Zhai, 2020: Cloud Detection over Snow and Ice with Oxygen A- and B-band Observations from the Earth Polychromatic Imaging Camera (EPIC), *Atmos. Meas. Tech.,* 13, 1575–1591, https://doi.org/10.5194/amt-13-1575-2020.

Delgado-Bonal, A., A. Marshak, Y. Yang, L. Oreopoulos, 2020: Daily variability of cloud amount from EPIC observations, *J. Geophys. Res.,* 125(10), https://doi.org/10.1029/2019JD031488

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Marshak, A., J. Herman, A. Szabo, K. Blank, A. Cede, S. Carn, I. Geogdzhayev, D. Huang, L-K, Huang, Y. Knyazikhin, M. Kowalewski, N. Krotkov, A. Lyapustin, R. McPeters, O. Torres, and **Y. Yang**, 2018: Earth Observations from DSCOVR/EPIC Instrument, *Bull. Amer. Meteor. Soc.99(9), 1829-1850,* https://doi.org/10.1175/BAMS-D-17-0223.1

Xu, X., J., Wang, Y., Wang, J., Zeng, O., Torres, Y., Yang, A., Marshak, J., Reid, and S., Miller, 2017: Passive remote sensing of altitude and optical depth of dust plumes using the oxygen A and B bands: first results from EPIC/DSCOVR at Lagrange-1 point*, Geophys. Res. Lett.,* 44, doi:10.1002/2017GL073939.

Meyer, K., Y. Yang, and S. Platnick, 2016: Uncertainties in cloud phase and optical thickness retrievals from the Earth Polychromatic Imaging Camera (EPIC), *Atmos. Meas. Tech.,* 9, 1785-1797, doi:10.5194/amt-9-1785-2016.

Holdaway, D. and Y. Yang, 2016: Study of the Effect of Temporal Sampling Frequency on DSCOVR Observations Using the GEOS-5 Nature Run Results (Part II): Cloud Coverage. *Remote Sens. 8*(5), 431, doi:10.3390/rs8050431.

Holdaway, D. and Y. Yang, 2016: Study of the Effect of Temporal Sampling Frequency on DSCOVR Observations Using the GEOS-5 Nature Run Results (Part I): Earth's Radiation Budget. *Remote Sens. 8(2), 98, doi:10.3390/rs8020098.*