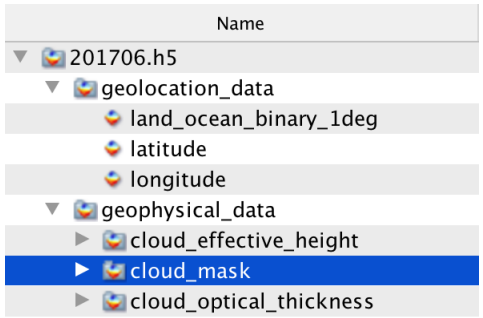
Global daily variability of cloud amount from EPIC observations

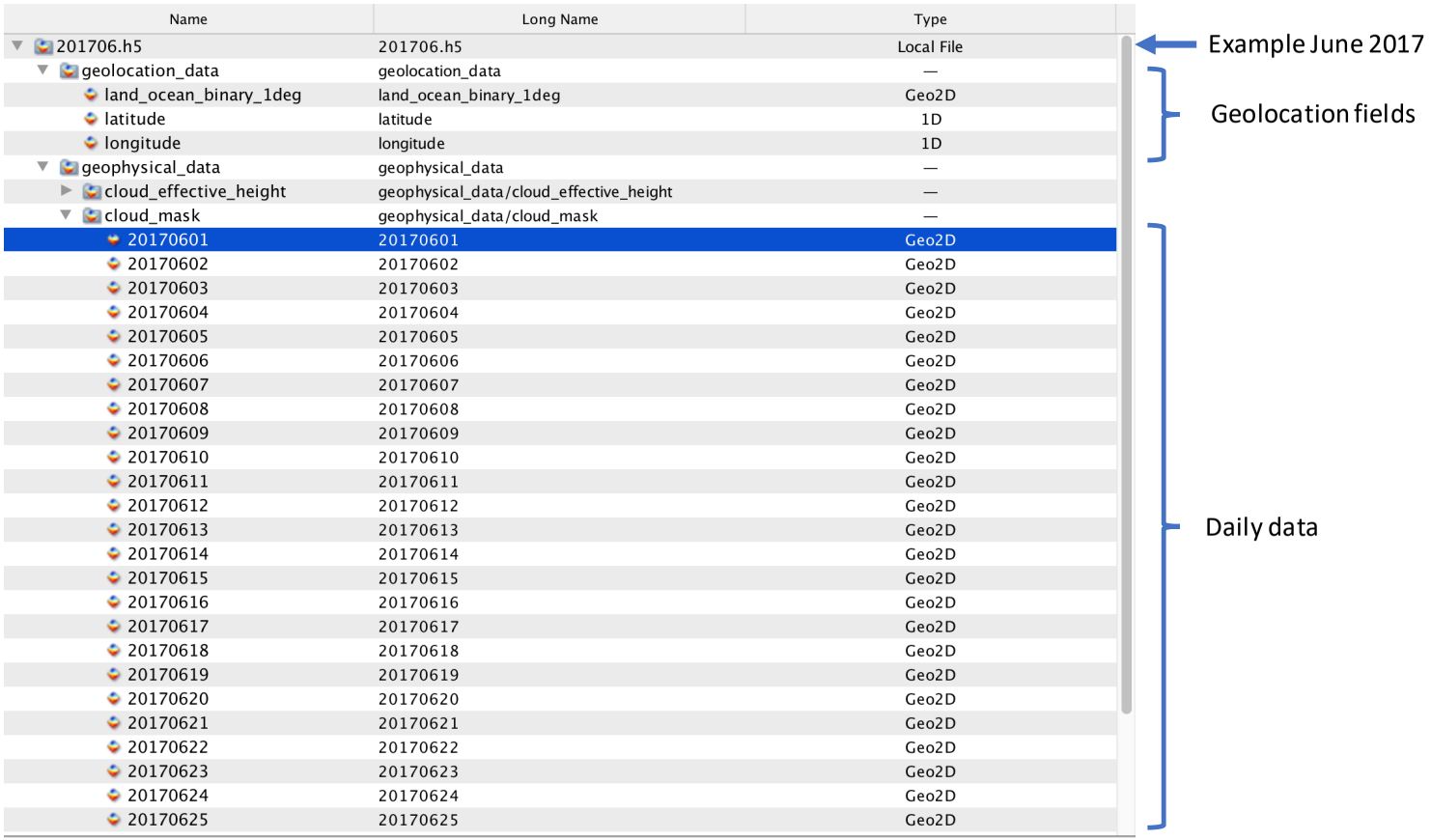
A. Delgado-Bonal, A. Marshak, Y. Yang and L. Oreopoulos

DSCOVR STM 2020 – Oct 6-8

Level 3 – Cloud products

- 1° by 1° grid.
- HDF5 format (NASA Earth Science Data format system)
- Monthly files (~ 200MB each) containing daily data for:
  - Cloud height
  - Cloud mask
  - Cloud optical thickness

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Type
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201706.h5
Local File
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geolocation_data
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land_ocean_binary_1deg
Geo2D
latitude
latitude
1D
longitude
longitude
1D
geophysical_data
geophysical_data
—
cloud_effective_height
geophysical_data/cloud_effective_height
—
cloud_mask
geophysical_data/cloud_mask
—
20170601
20170601
Geo2D
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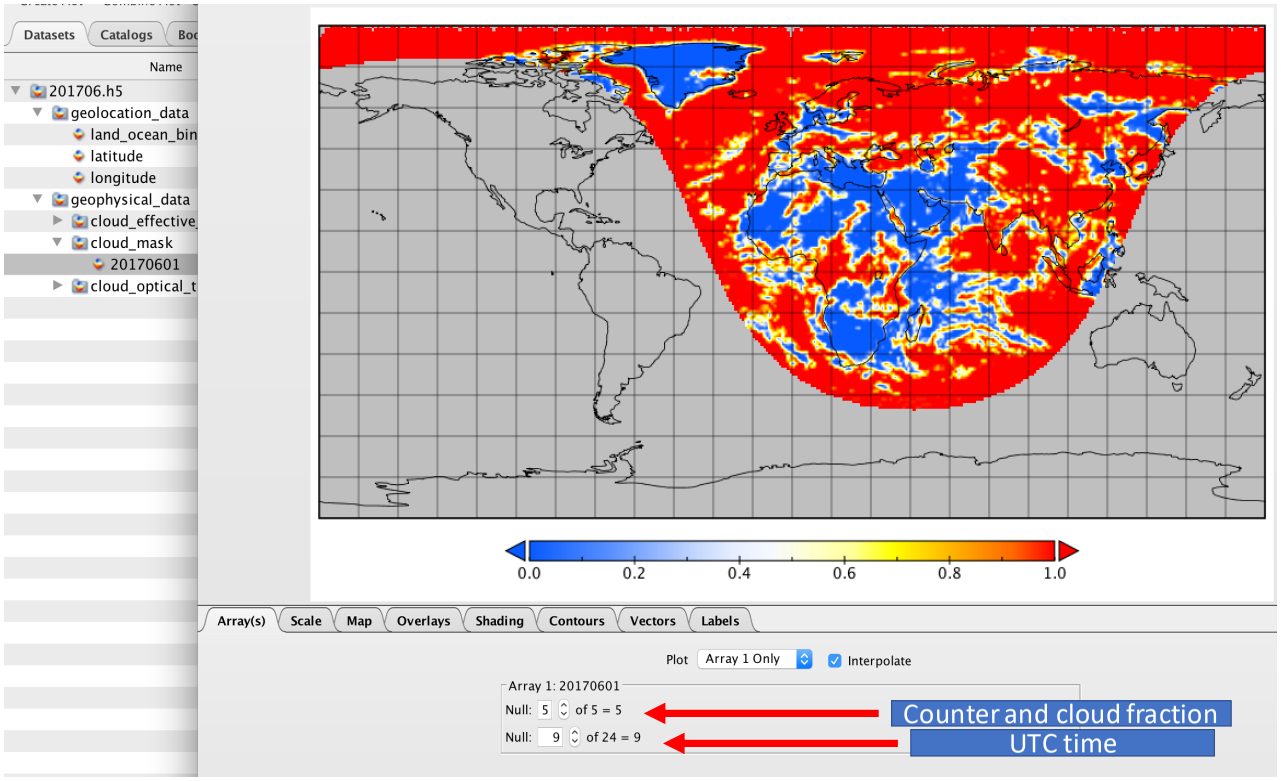
Geo2D
Example June 2017
Geolocation fields
Daily data

Cloud fraction



Counter:

1 = Clear sky
2 = Probably clear
3 = Probably cloudy
4 = Cloudy

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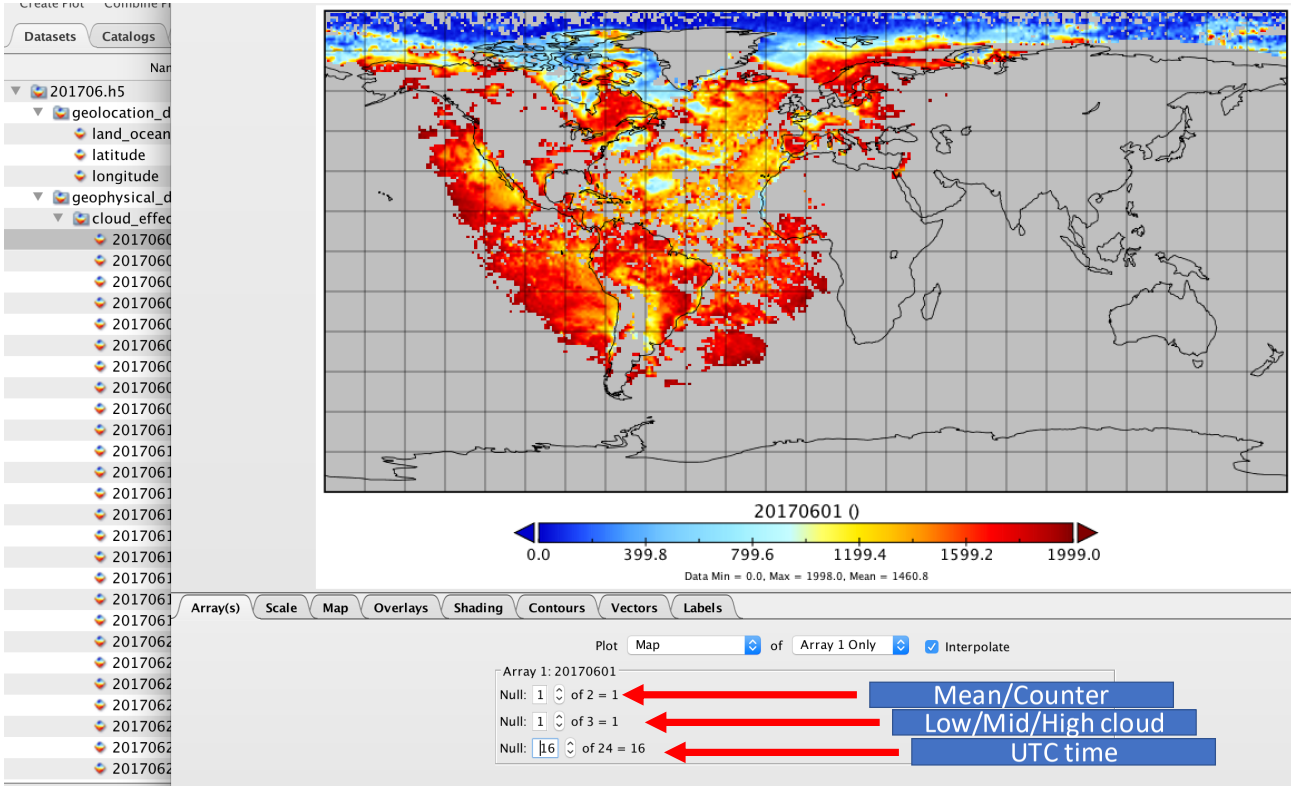
5 = Cloud Fraction

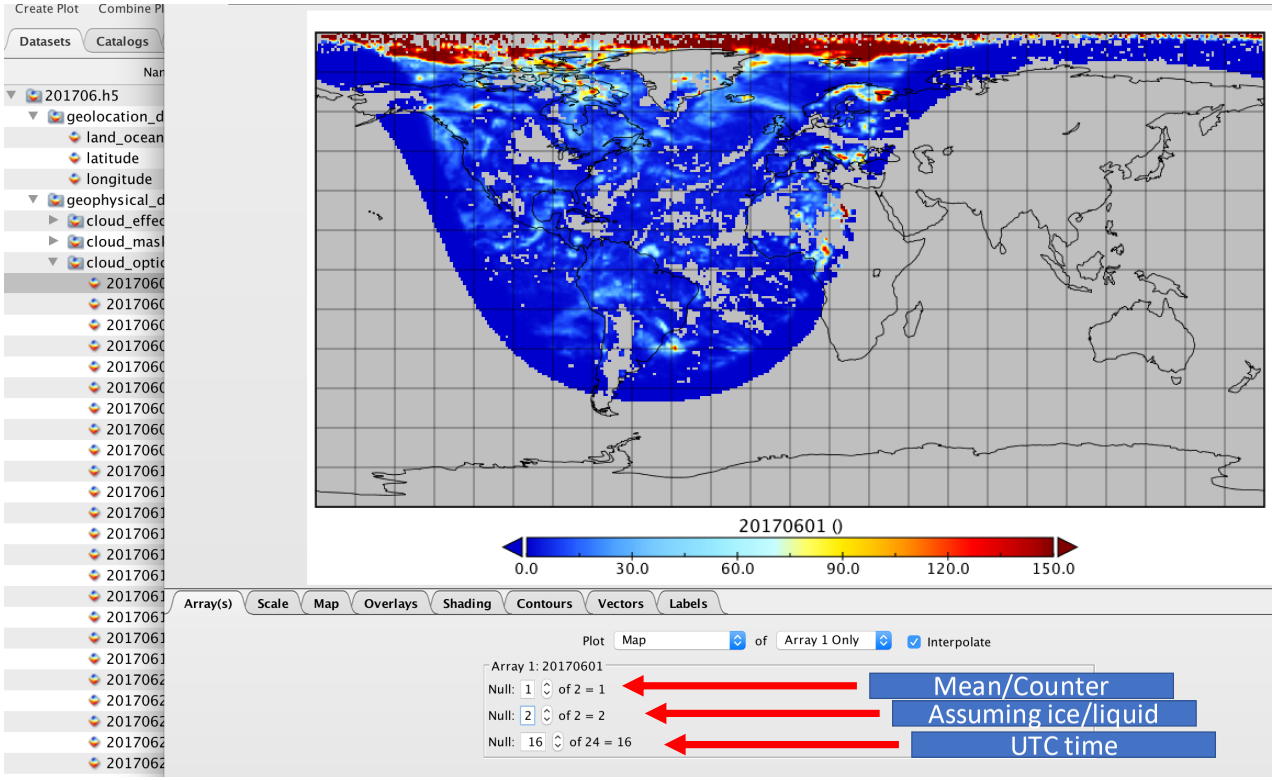
Cloud height



Cloud height:

1 = Low (0-2000m)
2 = Mid (2000-6000m)
3 = High (> 6000m)

Cloud optical thickness



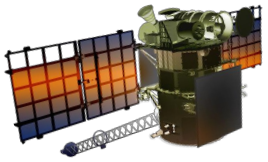
Assuming:

1 = Ice cloud
2 = Liquid Cloud

Cloud fraction

- Seasonal variability (UTC)
- Daily variability (UTC)

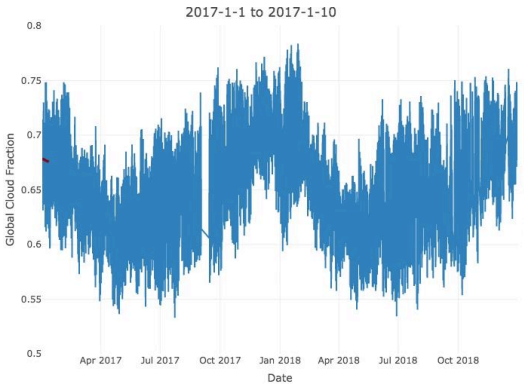
Seen from DSCOVR

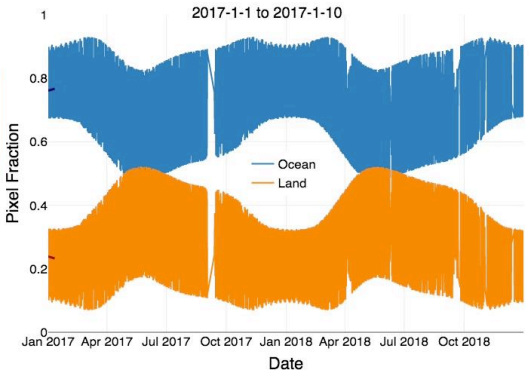


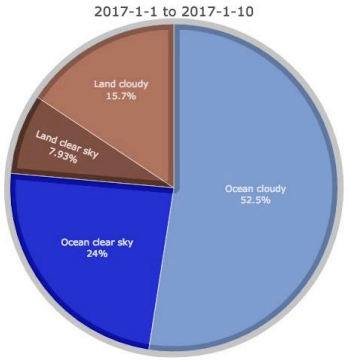
- Daytime variability zonally-averaged (Local Time)
- Global daytime variability (Local Time)

Seen from Earth

Seasonal variability (UTC)







- Variations because the Earth's axis is tilted 23.5°
- Important for shortwave radiation

Daily variability (UTC)

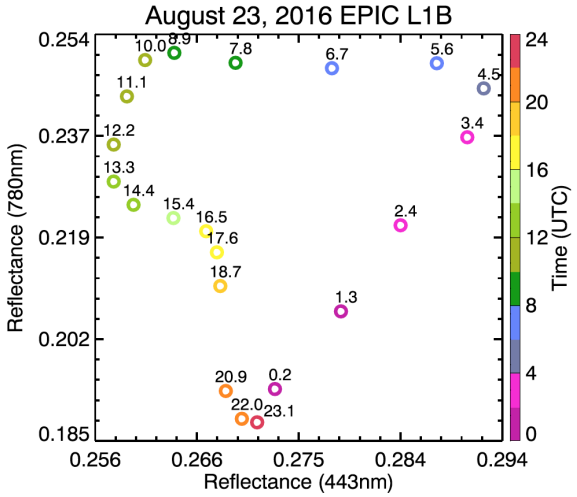
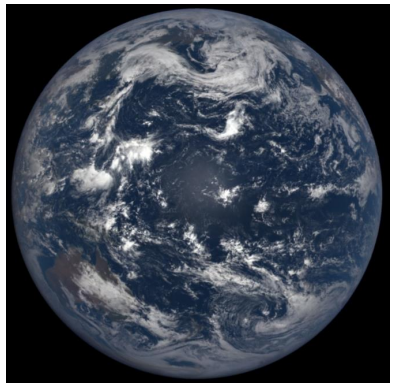


Figure 3. The relationship between blue (443 nm) and near-infrared (780 nm) global average reflectance with observation time (UTC) indicated. There are 21 EPIC observations. EPIC = Earth Polychromatic Imaging Camera.

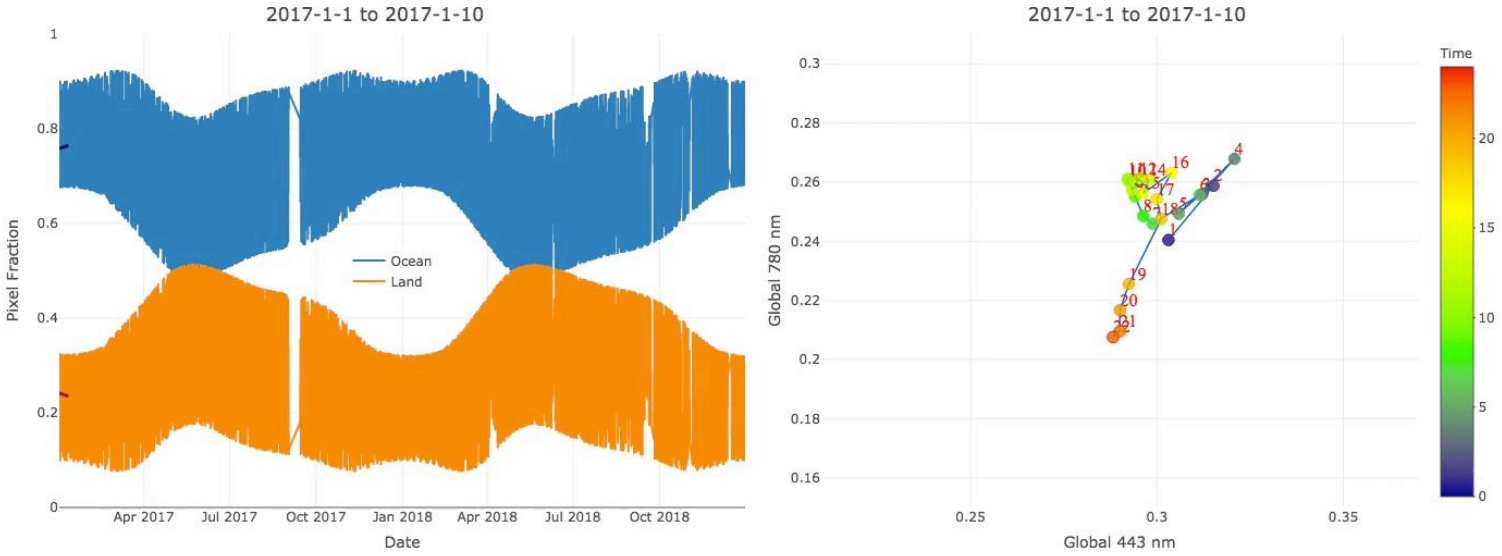


2016 08 23 00:08:30

2016 08 23 09:57:39

Wen, G., A. Marshak, W. Song, et al. 2019.
"A Relationship between Blue and Near-IR Global Spectral Reflectance and the Response of Global Average Reflectance to Change in Cloud Cover Observed from DSCOVR EPIC."
Earth and Space Science, 6: 1416-1429

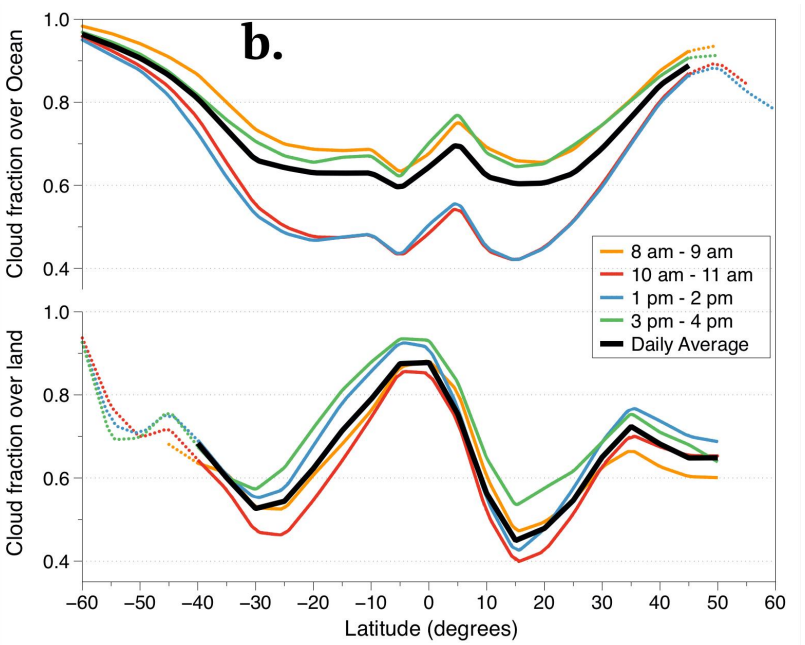
Daily variability (UTC) throughout the year



Depending on the surface cover, the correlation changes in shape and daily variability

Daytime variability (Local Time)

EPIC image with an overlapped colored mask at selected time zones



Zonally-averaged cloud fraction over land and ocean at those local times (yearly averaged values)

A. Delgado-Bonal, A. Marshak, Y. Yang, and L. Oreopoulos, Daytime variability of cloud fraction from DSCOVR/EPIC observations, Journal of Geophysical Research: Atmospheres, 125, e2019JD031488, (2020) https://doi.org/10.1029/2019JD031488

Global daily variability: motivation

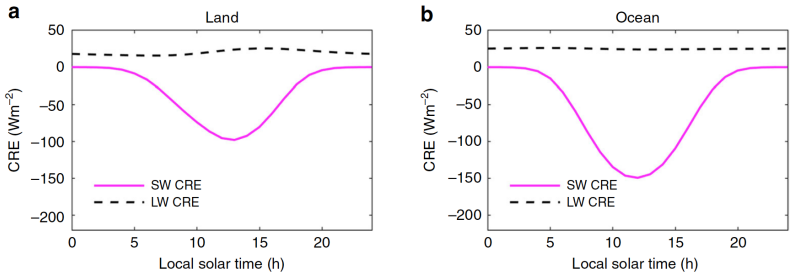
nature COMMUNICATIONS

ARTICLE

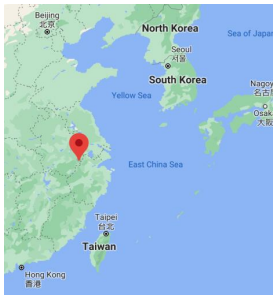
DOI: 10.1038/s41467-017-02369-4 OPEN

Diurnal cloud cycle biases in climate models

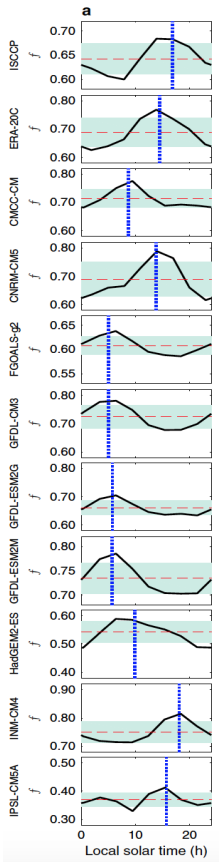
Jun Yin [1,2] & Amilcare Porporato [1,2]



Guangde, Anhui, China (30.7N, 119.2E)



- These errors are sometimes compensated between ocean and land obtaining better matching global values
- Other times, the underestimation of cloud fraction is compensated by a higher albedo to match the radiative effects
- Diurnal variability has an important effect on SW radiation



Global daily variability: motivation

Orbit Characteristics and View Angle Effects on the Global Cloud Field

Brent C. Maddux[1,2]
Steven A. Ackerman[1]
Steve Platnick[3]
Paul Hubanks[4]

[1]Cooperative Institute for Meteorological Satellite Studies
[2]Department of Atmospheric and Oceanic Sciences-U of Wisconsin
[3]NASA Goddard Space Flight Center, Greenbelt, Maryland
[4]Wyle Information Systems, McLean, VA 22102

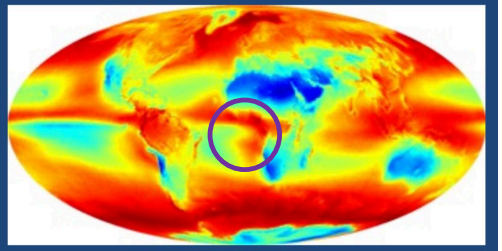
- Polar-orbiting satellites can't capture daytime variability
- Geosynchronous satellites can capture only a region
- GCMs may have different biases

- ISCCP (combination of sources)
- MERRA2 (reanalysis)

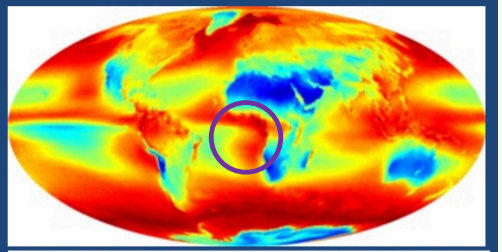
Global Means

- Daytime Cloud Fraction
- Coast lines evident
- Differences where expected: maritime stratocumulus decks, SH land, etc.

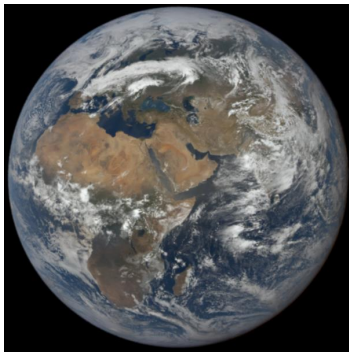
Aqua 7 Year Mean

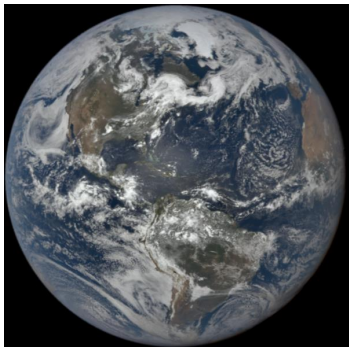


Terra 9 Year Mean

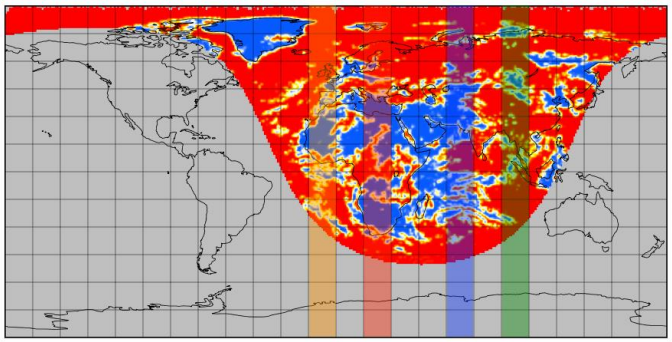


Global daily variability: methodology

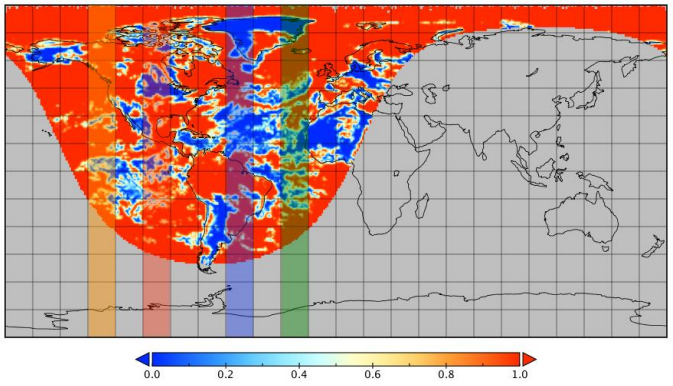




EPIC Cloud Fraction: 2017-07-01 09:38:56



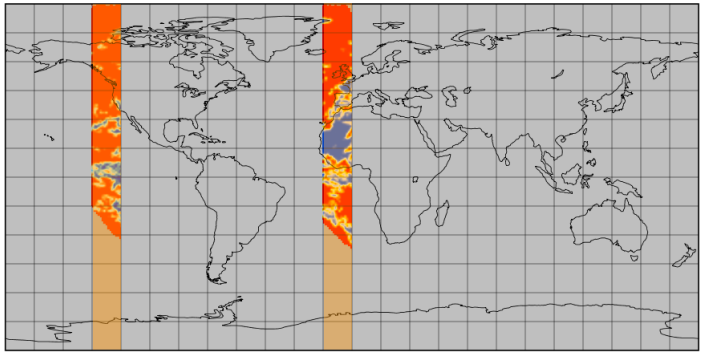
EPIC Cloud Fraction: 2017-06-01 17:07:51



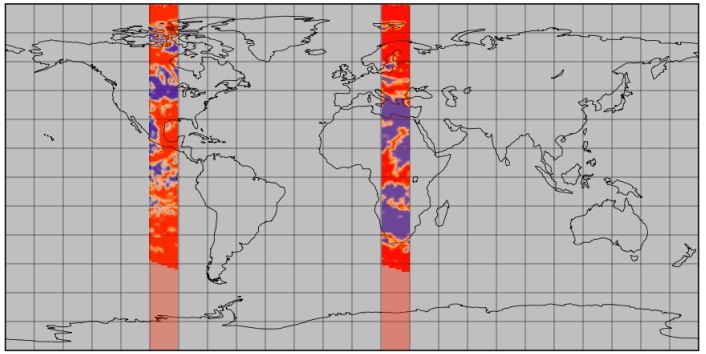
Local Times

8:00 to 9:00 : orange
10:00 to 11:00: red
13:00 to 14:00: blue
15:00 to 16:00: green

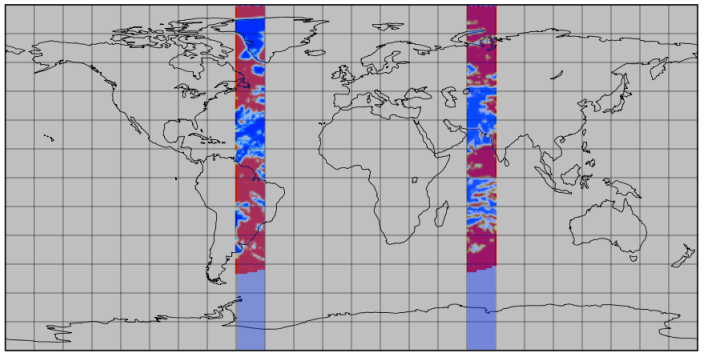
EPIC Cloud Fraction: Local Time 8:00 to 9:00



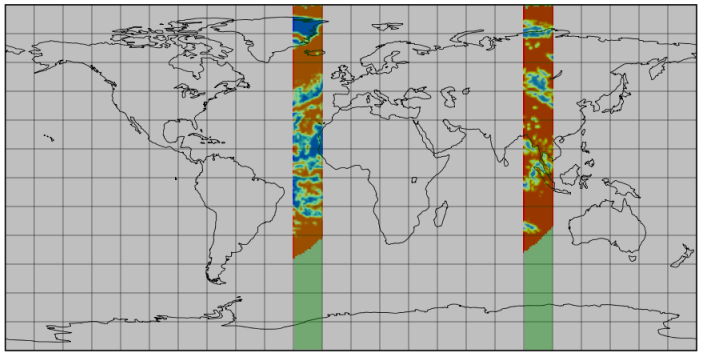
EPIC Cloud Fraction: Local Time 10:00 to 11:00



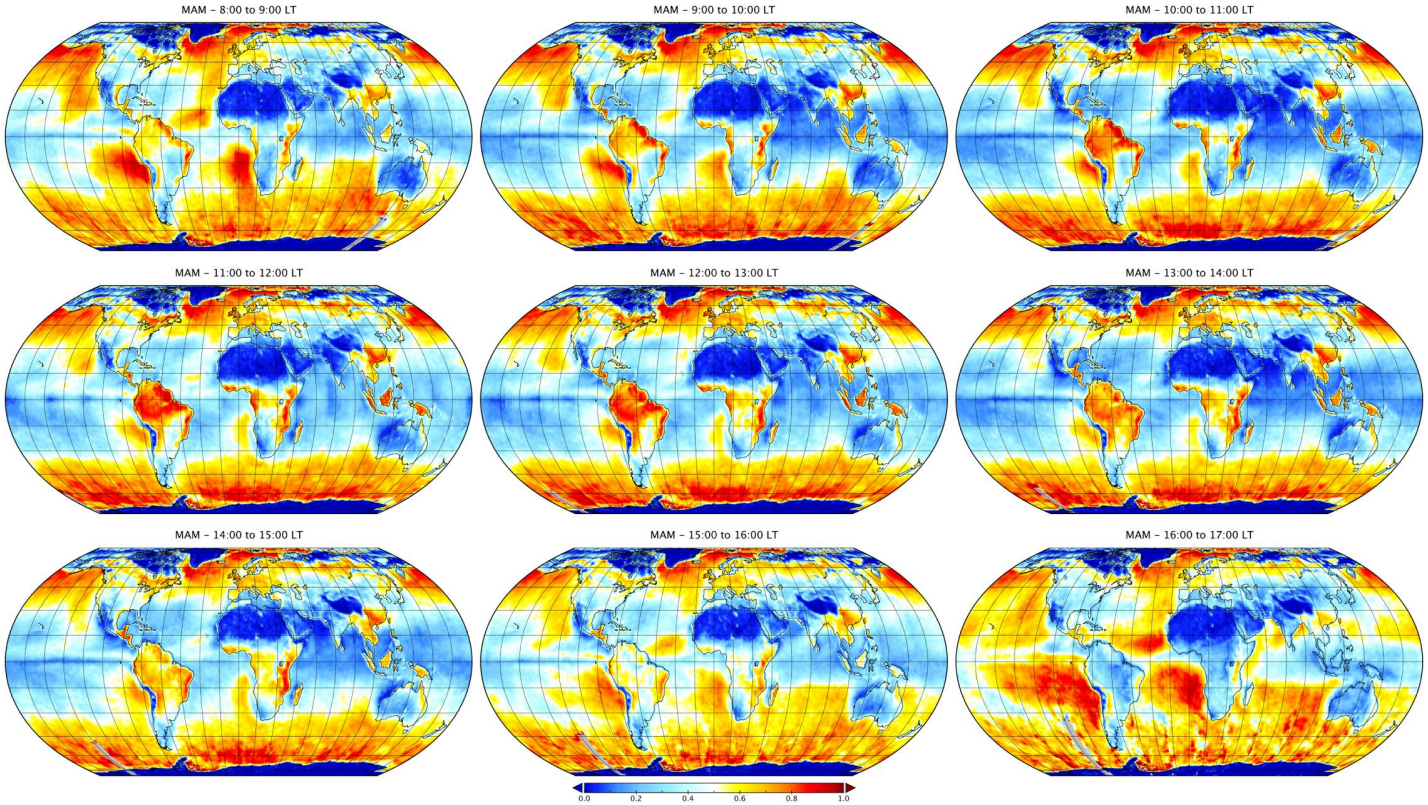
EPIC Cloud Fraction: Local Time 13:00 to 14:00



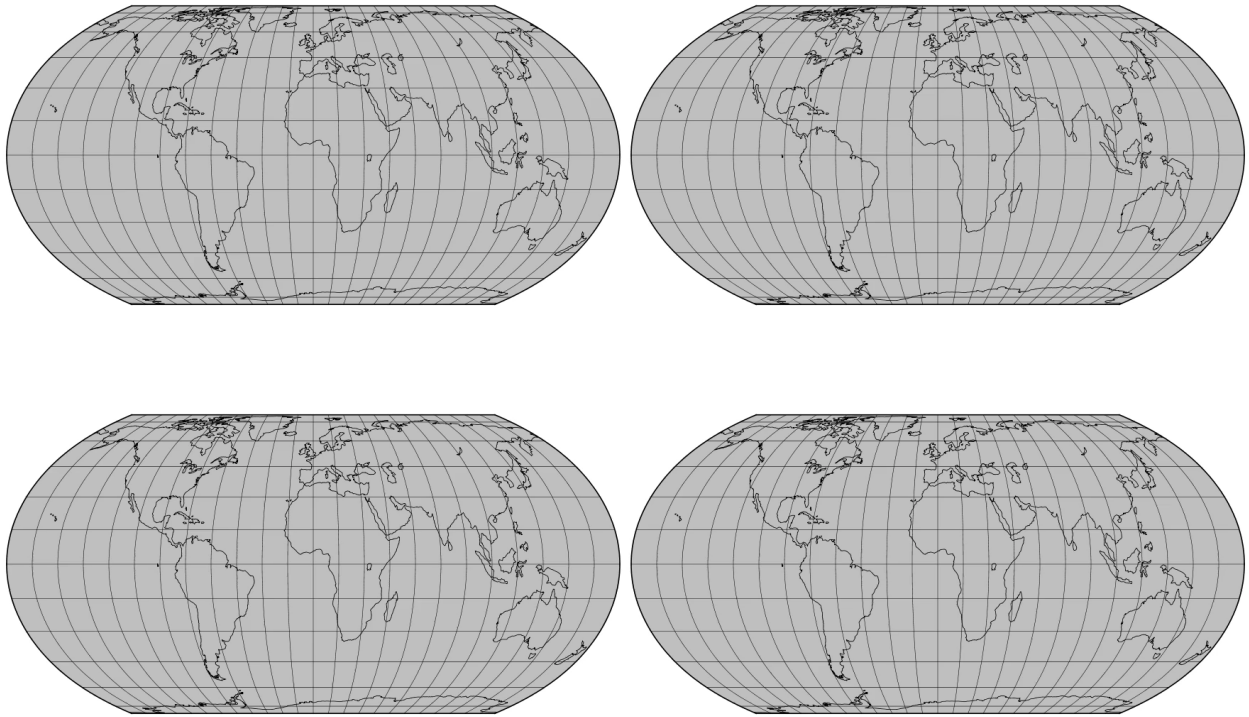
EPIC Cloud Fraction: Local Time 15:00 to 16:00



Liquid Clouds Hourly Values - MAM



Liquid Clouds Hourly Values – all seasons



Liquid clouds Morning time variability:

cloud fraction at 8 am - cloud fraction at 12 pm

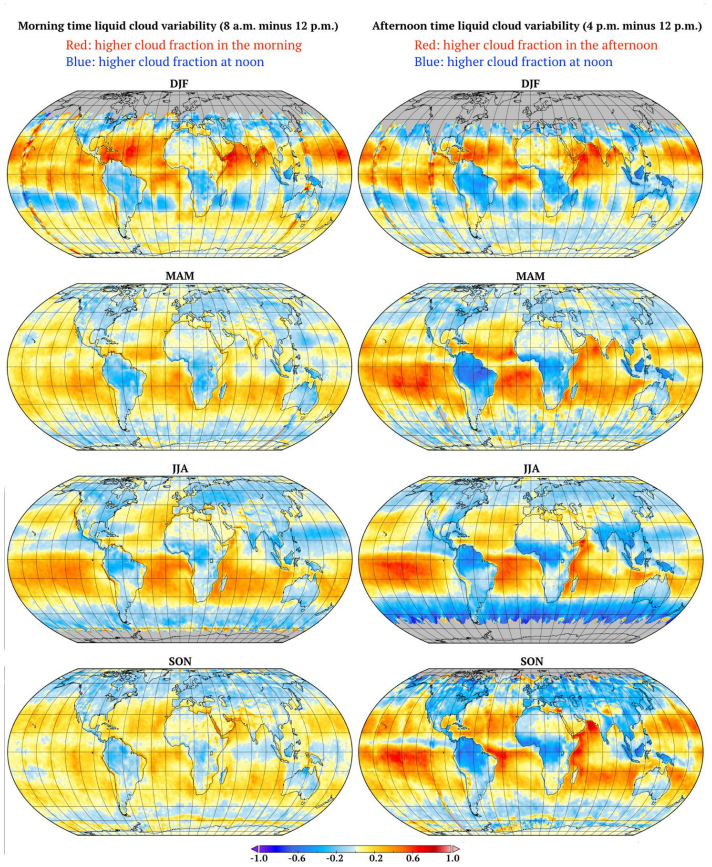
Red: higher cloud fraction in the morning
Blue: higher cloud fraction at noon

Liquid clouds Afternoon time variability:

cloud fraction at 4 pm - cloud fraction at 12 pm

Red: higher cloud fraction in the afternoon
Blue: higher cloud fraction at noon

Liquid cloud fractions have opposite daytime evolution between land and ocean, reaching a maximum and minimum around noon, respectively



Ice clouds Morning time variability:

cloud fraction at 8 am - cloud fraction at 12 pm

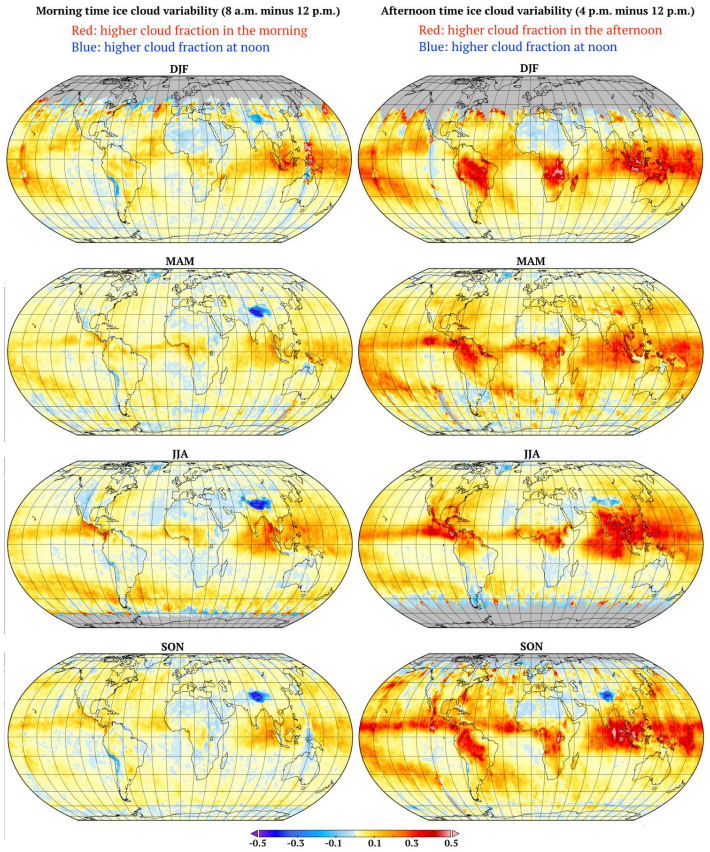
Red: higher cloud fraction in the morning
Blue: higher cloud fraction at noon

Ice clouds Afternoon time variability:

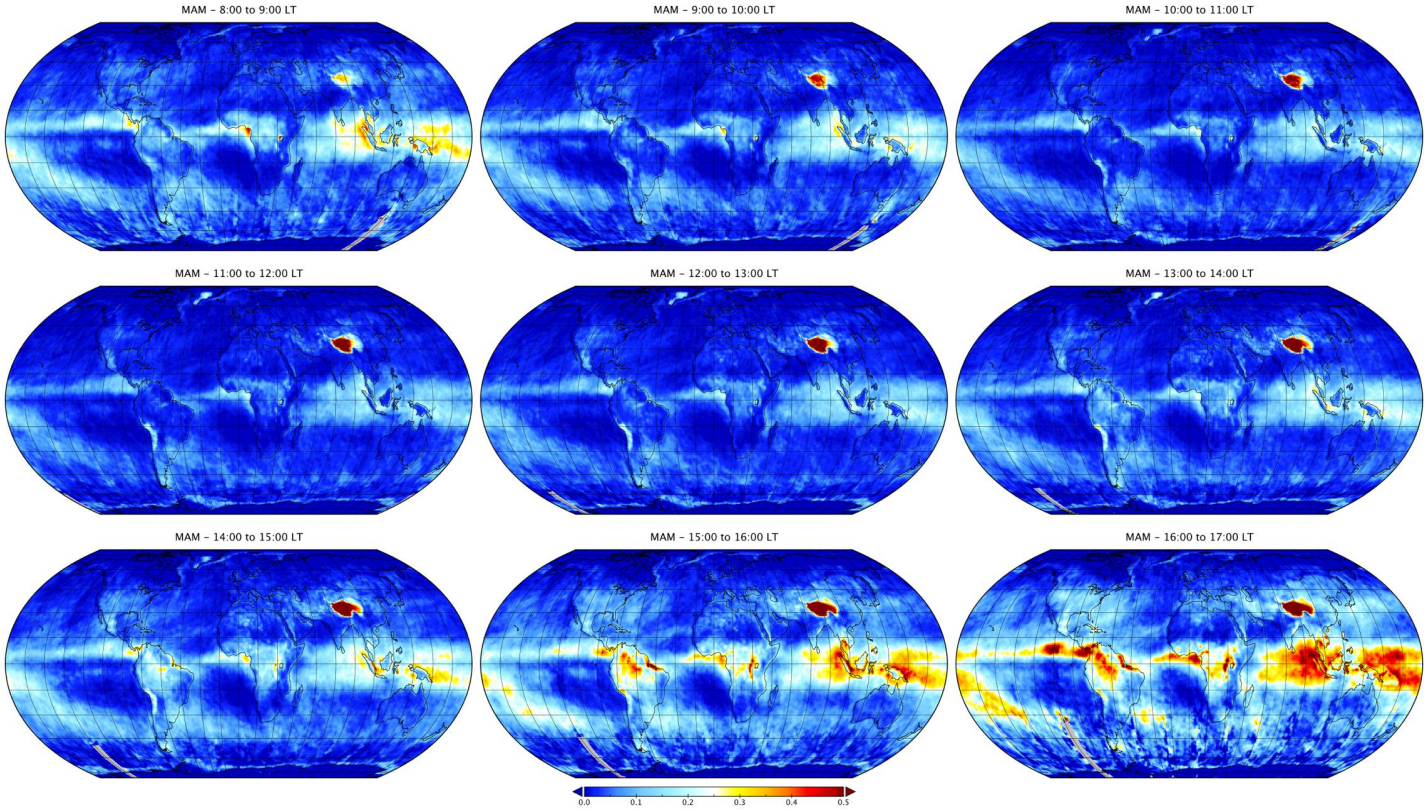
cloud fraction at 4 pm - cloud fraction at 12 pm

Red: higher cloud fraction in the afternoon
Blue: higher cloud fraction at noon

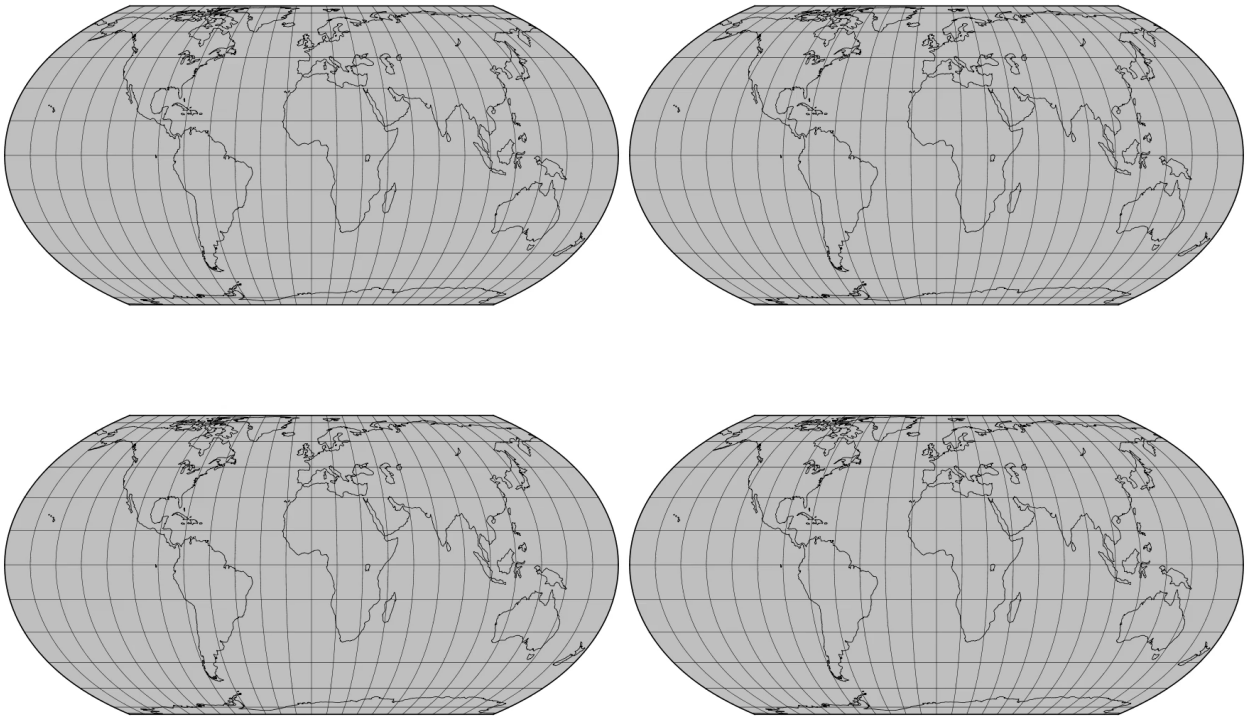
Daytime evolution of ice cloud fractions is independent of the type of underlying surface, with higher values in the morning and afternoon and minimum around noon

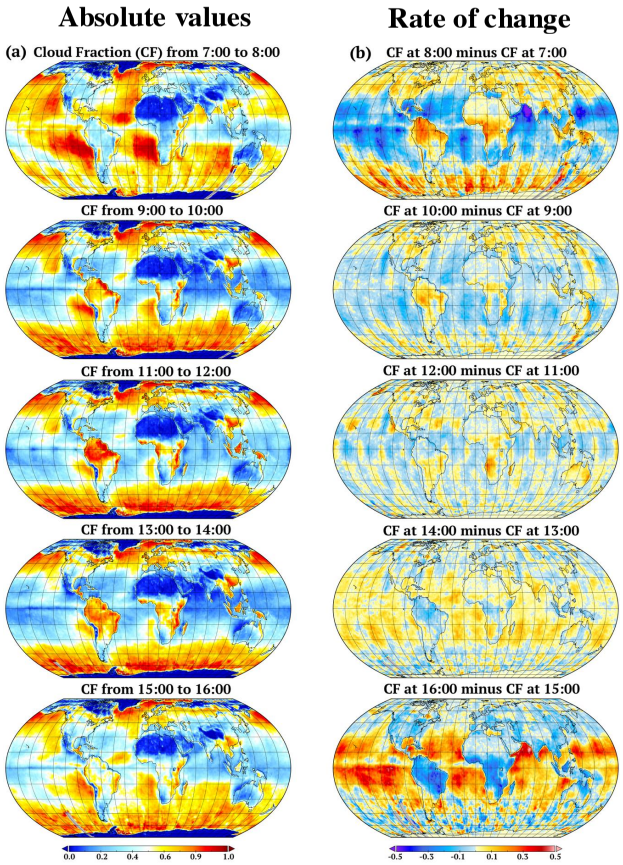


Ice Clouds Hourly Values - MAM



Ice Clouds Hourly Values – all seasons





Liquid Clouds - MAM

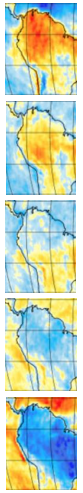
Rate of change:

Red: higher cloud fraction than the previous hour
Blue: lower cloud fraction than the previous hour

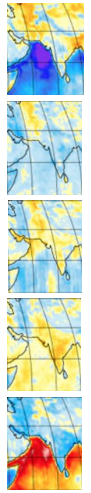
- The intensity of the daytime cycle is not constant (it accelerates during the hours closer to sunrise and sunset).

- This view allows us to identify the areas where daytime changes are neither symmetric nor monotonic:

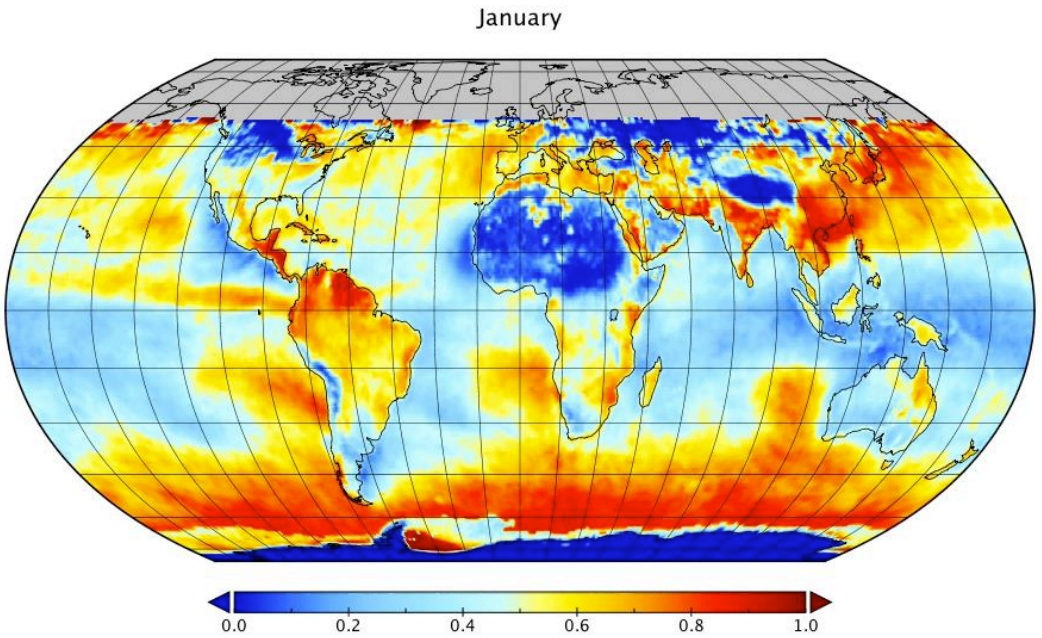
Amazonia:

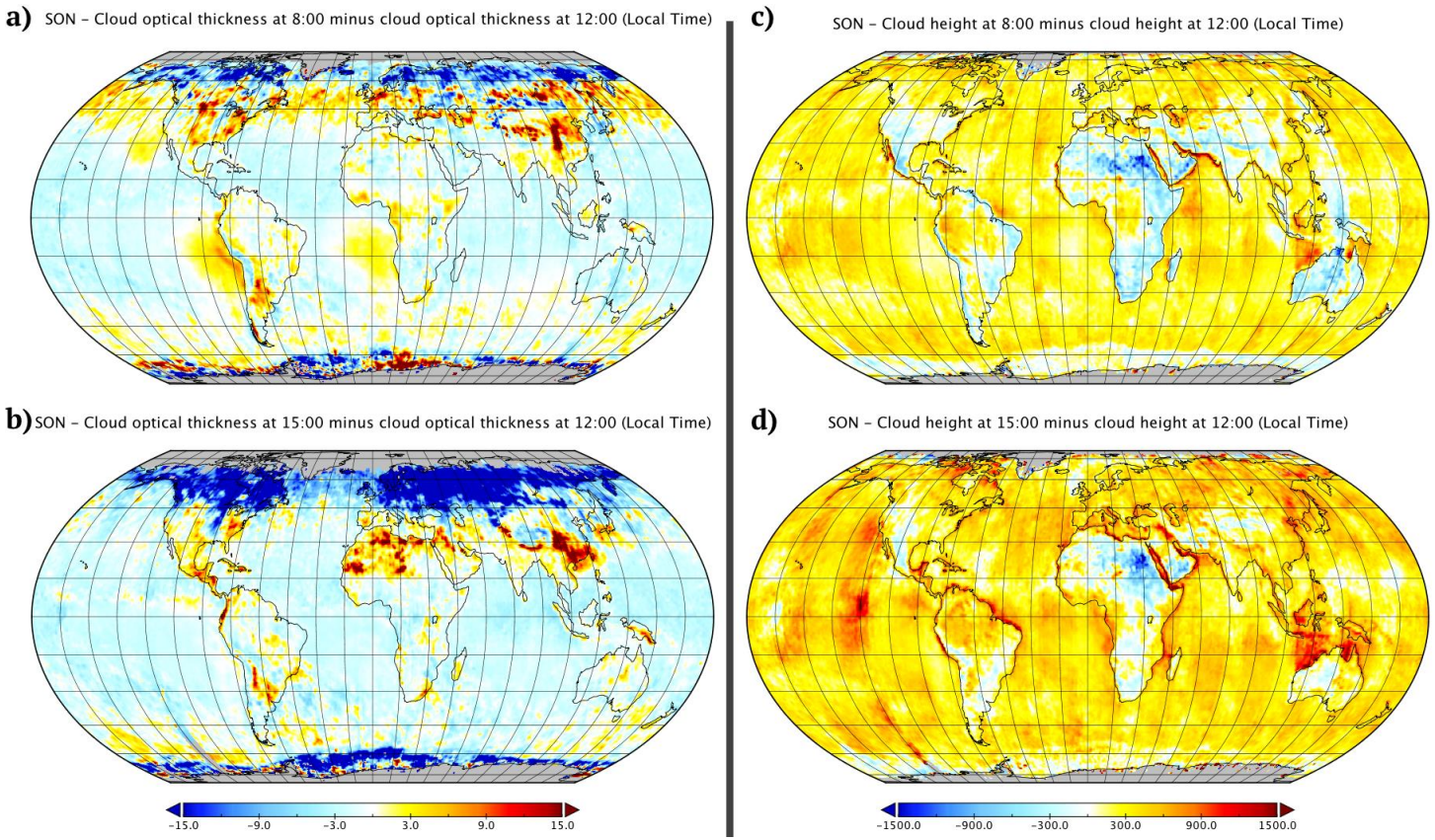


Indian region:



Monthly daytime average liquid cloud fraction




a)
SON – Cloud optical thickness at 8:00 minus cloud optical thickness at 12:00 (Local Time)
b)
SON – Cloud optical thickness at 15:00 minus cloud optical thickness at 12:00 (Local Time)
-15.0
-9.0
-3.0
3.0
9.0
15.0
c)
SON – Cloud height at 8:00 minus cloud height at 12:00 (Local Time)
d)
SON – Cloud height at 15:00 minus cloud height at 12:00 (Local Time)
-1500.0
-900.0
-300.0
300.0
900.0
1500.0

Conclusions

- DSCOVR/EPIC provides information about daily cycles in UTC but also about local time daytime cycles

- We developed an analysis with high spatial and temporal frequency (1-hour plots) with results in agreement with ISCPP and regional studies

- Liquid cloud fractions have opposite daytime evolution between land and ocean, reaching a maximum and minimum around noon, respectively

- Daytime evolution of ice cloud fractions is independent of the type of underlying surface, with higher values in the morning and afternoon and minimum around noon

- This methodology can be applied to study other properties (cloud optical thickness or cloud height) but also to other products.