

The Weather of the Blue Marble

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9 **Abstract**

10 *The Blue Marble* is one of the most famous photos of the Earth. It was captured on
11 7th December 1972 by the Apollo 17 crew as they were travelling toward the moon, being
12 one of the first images to show the entire Earth from the outer space. The picture not only
13 showed the beauty of our world but also illustrated through the clouds the great diversity of
14 meteorological structures that occur on the Earth on any given day. Here I describe the
15 different cloud arrangements and the atmospheric dynamics visible in the image, from
16 tropical convection to polar clouds including both tropical and extratropical cyclones,
17 showing the atmospheric richness of our world.

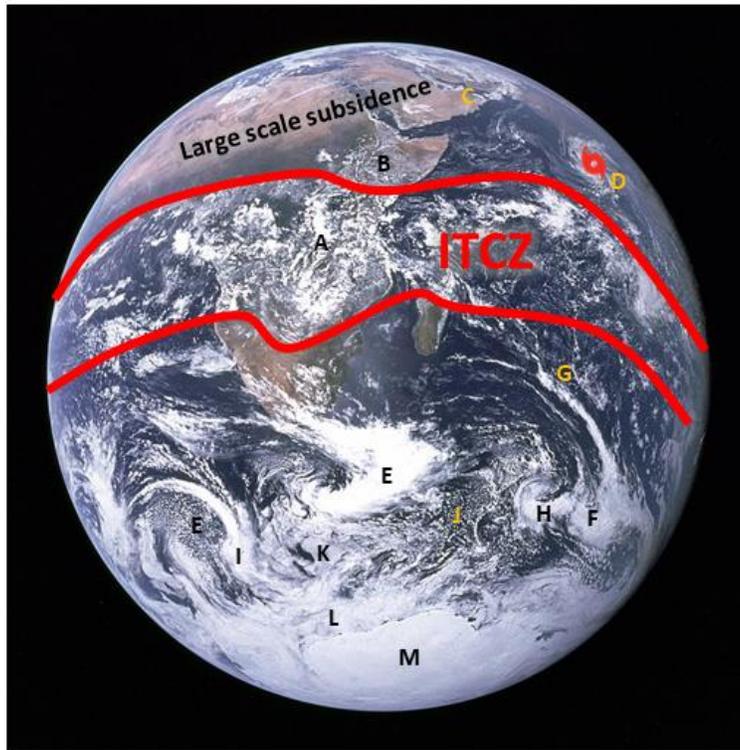
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19 **Keywords:** Blue Marble, photography, historic weather, meteorological structures

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Graphical Abstract



- A:** Tropical deep moist convection
- B:** Mountain induced shallow cumulus
- C:** Low stratus
- D:** Tropical Cyclone Tamil Nadu
- E:** Saphiro-Keyser cyclone
- F:** Cyclone
- G:** Tropical-Extratropical Cloud Band
- H:** Comma-shaped polar low
- I:** Cyclone
- J:** Open-cell clouds
- K:** Low stratus or fog
- L:** Stratus
- M:** Polar free cloud areas

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The Blue Marble shows cloud structures associated with the different weather systems.

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The picture displays features ranging from tropical convection to polar clouds

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including both tropical and extratropical cyclones, showing the atmospheric richness

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of our world.

27 **Introduction**

28 Nearly half a century ago, one of the most iconic images of the Earth was captured
29 by the crew of the Apollo 17 spacecraft on its way to the moon (Figure 1). The photograph,
30 called *The Blue Marble*, was taken in 1972. At the time, satellite imagery was not widely
31 available to the public and, although *The Blue Marble* is not the first clear picture of the full
32 illuminated face of the Earth, the photo rapidly became a symbol of the environmental
33 activism (Petsko, 2011). It is said that thanks to this photograph, humanity realized that Earth
34 was a lonely planet in the middle of the vastness of space, as 18 years later Carl Sagan
35 illustrated in another famous picture of the Earth called a *Pale Blue Dot*. However, unlike the
36 Voyager’s photograph taken from afar, the *Blue Marble* shows a great diversity of clouds and
37 meteorological systems that we describe in this article (Figure 2).

38

39 **The photograph**

40 The *Blue Marble*, or AS17-148-22727 as officially designated by NASA, was shot on
41 7th December 1972 at 10:39 UTC by the Apollo 17 crew (Eugene Cernan, Ronald Evans and
42 Harrison Schmitt) using a 70-millimeter Hasselblad camera with an 80-millimeter Zeiss lens
43 (NASA, 1974). The photo was taken at about 5:06 hours after launch from a distance of about
44 45,000 km from the Earth’s surface. The *Blue Marble* is a cropped, reoriented and
45 chromatically adjusted version of the original capture shown in Figure 1. Until 2015, when
46 the DSCOVR mission was launched, it was the last photo of the entire sunlit side of the Earth.

47 The projection of the picture is interesting. Although not intentional, the photograph
48 is centred on an Earth’s hemisphere rarely used by the first world. The image shows the south
49 of Africa and Madagascar in the middle, the Sahara and the Arabian Peninsula in the north,
50 Antarctica in the south, the South Atlantic in the west and the Indian Ocean in the east. Notice

51 that as the date is near to the December solstice, all Antarctica is illuminated. Figure 2(b)
52 shows a cloudless projection of the picture.

53 When the photo was shot, weather was the subject of most of the conversations as
54 revealed from the voice transcripts (NASA, 1972; CC: Capsule communicator; CDR:
55 Commander; CMP: Command module pilot; LMP: Lunar module pilot):

56 *CC: [...] Have you gotten a good look at any of that weather down there on the*
57 *Antarctic?*

58 *CDR: Well, on Ton's window number 1 – maybe he can tell you a little about it.*

59 *CMP: You know, it is real funny there in Antarctica the – You can see the snow, but*
60 *there isn't any weather at all in it. All of the weather's around it in the water.*

61 *CC: Roger.*

62 *LMP: That's where moisture is. [...]*

63

64 **Meteorological description of the *Blue Marble***

65 One of the most characteristic features of our planet as viewed from space is the
66 clouds that stand out above the dark oceans and forests. They shine white in a visible image
67 because the large cloud droplets within clouds backscatter the sunlight, which is also white.
68 Clouds are an important part of the atmospheric system and are found where the water vapour
69 condenses where there is ascent, which is related with the dynamic processes of the
70 atmosphere (Brimacombe, 1981). When clouds are observed from far above, we can identify
71 the weather systems on the Earth. On 7th December 1972, many synoptic scale features can
72 be appreciated in the *Blue Marble* (Figure 2a).

73 As usual during the austral summer, a broken band of deep, moist convection (Fig.
74 2a, A) associated to the Intertropical Convergence Zone (ITCZ) is centred few degrees south

75 of the equator between 5°N and 15°S. As usual in the boreal winter, no significant African
76 easterly waves, tropical troughs which move from east to west near the ITCZ, can be
77 observed in this image. Equatorial convection indicates the ascending branch of a well-
78 developed Hadley cell over the Southern Hemisphere with a descending branch around 25°N.
79 This descent is inferred from the large free-cloud areas over the Sahara, the Sahel and the
80 Arabian Peninsula. This picture is broken by some shallow cumulus over the Ethiopian
81 mountains (Fig. 2a, **B**) where topography plays a role in the cloud formation. An attentive
82 person will see the Great Rift Valley and the Afar Triple Junction highlighted by the clouds
83 (Fig. 2c). Low stratus can be observed over the Persian and Oman Gulf (Fig. 2a, **C**). Over
84 the Indian coast in the north-eastern side of the picture a tropical cyclone can be seen (Fig 2a,
85 **D** and Fig. 2d). This cyclone, named Tamil Nadu after the worst affected region, killed 80
86 people and rendered 30,000 people homeless (Das et al. 1973).

87 Between the ITCZ and the Antarctic continent in the Southern hemisphere, a belt of
88 extratropical cyclones shows the position of the Antarctic Circumpolar Trough. This is one
89 of the most active cyclonic areas of the world, and that fact is evidenced in the image. Low-
90 pressure systems were located relatively far north on this day, around 40°S, evidencing the
91 expansion phase of the Semi-Annual Oscillation in summer (van Loon, 1967). The low-
92 pressure system located south of Africa in the centre of the picture attracts the most of the
93 attention (Fig. 2a, **E**). The system displays features of the Shapiro-Keyser cyclogenesis
94 process (Shapiro and Keyser, 1990), a conceptual model of cyclones that explains some types
95 of cyclogenesis that do not fit in the classical Norwegian cyclone model. A “T-bone” structure
96 with a frontal fracture and a prominent cloud hook associated with the back-bent front can
97 be seen. At the east of this low, two cyclonic vortices can be observed. The main one (Fig.
98 2a, **F**) exhibits a well-developed cold front connected to the subtropical areas near

99 Madagascar (Fig. 2a, **G**). The secondary vortex (Fig. 2a, **H**) is a polar low with a comma
100 shape (Rasmussen, 2003) and was probably developed by a cold air outbreak behind the **F**
101 cyclone. The open-cell clouds in the area suggest that possibility, but the lack of previous
102 images does not allow us to observe how it was formed. One more cyclone can be appreciated
103 at the south-west of the picture (Fig. 2a, **I**). Between the individual cyclones, large areas with
104 open-cell clouds (Fig. 2a, **J**) are caused by equatorward cold advection over a relatively warm
105 ocean. Closed-cell cloud areas and low stratus or fog are observed where warm tropical
106 advection reaches to the cold sub-Antarctic waters (Fig. 2a, **K**). Both features show the
107 different regimes of thermal advection on the opposite flanks of the extratropical cyclones.
108 Near the Antarctic coasts, shallow clouds composed by stratus, stratocumulus or fog (Fig. 2a,
109 **L**) hides from view any sea ice remaining from the cold season. Over the Antarctic continent,
110 areas devoid of cloud or with only a thin veil of cirrus (Fig. 2a, **M**) permit a view of the polar
111 ice shelf.

112

113 **Conclusions**

114 *The Blue Marble* is an image full of weather. This photograph shows a vast richness
115 of meteorological systems including tropical convection, tropical cyclones, mid-latitude
116 cyclones and polar clouds. Since the photo was taken, our knowledge of the atmosphere has
117 dramatically improved through satellite images, in-situ and remote sensing observations and
118 atmospheric simulations. Recently, this image has been used by the ECMWF to demonstrate
119 the accuracy of ERA5 analyses back to 1972 (Lopez, 2019) bridging the past with the present.
120 However, the most important value of this image is that it first showed us the majesty of our
121 world which, at the time of writing, is the only planet we know of with thick white-water
122 clouds over the dark blue oceans, greenish and yellowish earth and white ice caps.

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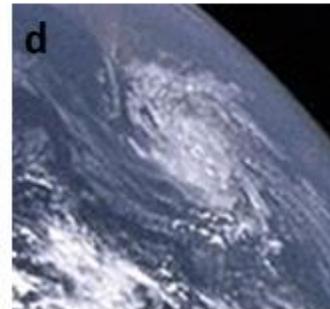
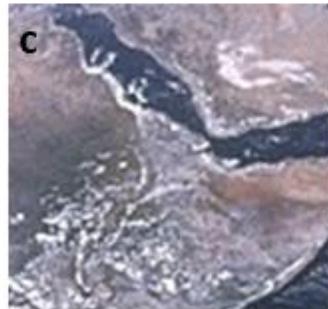
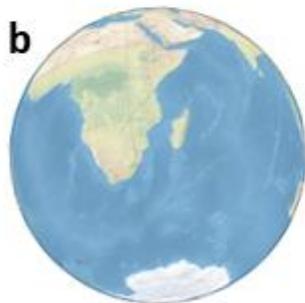
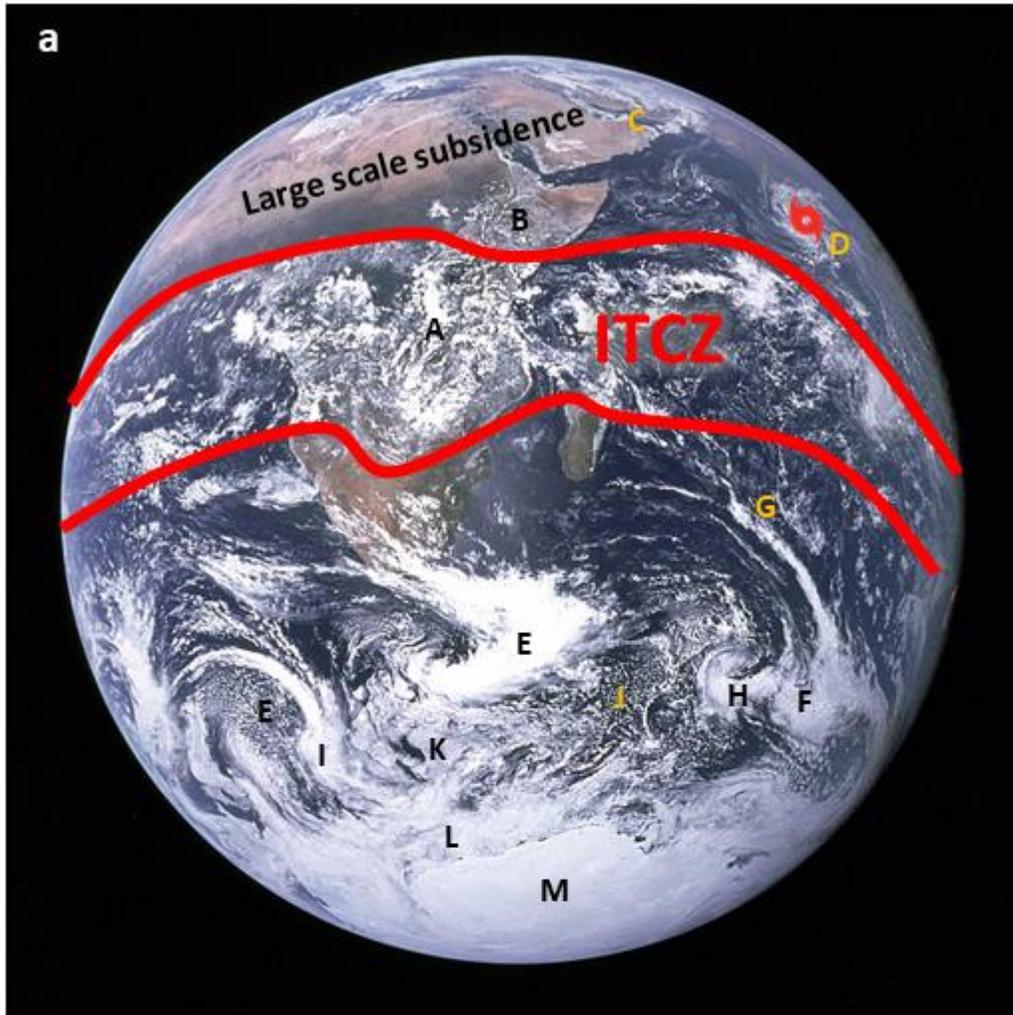
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152 Figure 1. The original AS17-148-22727 photograph captured from the Apollo 17 traveling
153 toward the moon by the crew (Eugene Cernan, Ronald Evans and Harrison Schmitt). Notice
154 that the image was taken upside down compared with the conventional view of *The Blue*
155 *Marble*. Credit: NASA Johnson Space Center.



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| D: Tropical Cyclone Tamil Nadu | K: Low stratus or fog |
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| F: Cyclone | M: Polar free cloud areas |
| G: Tropical-Extratropical Cloud Band | |

157 Figure 2. Atmospheric features observed in *The Blue Marble*. (a) Remarkable atmospheric
158 structures discussed in the text. (b) Cloudless projection of the picture. (c) Zoom into the the
159 Great Rift Valley and the Afar Triple Junction. (d) Zoom into the Tamil Nadu cyclone.
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