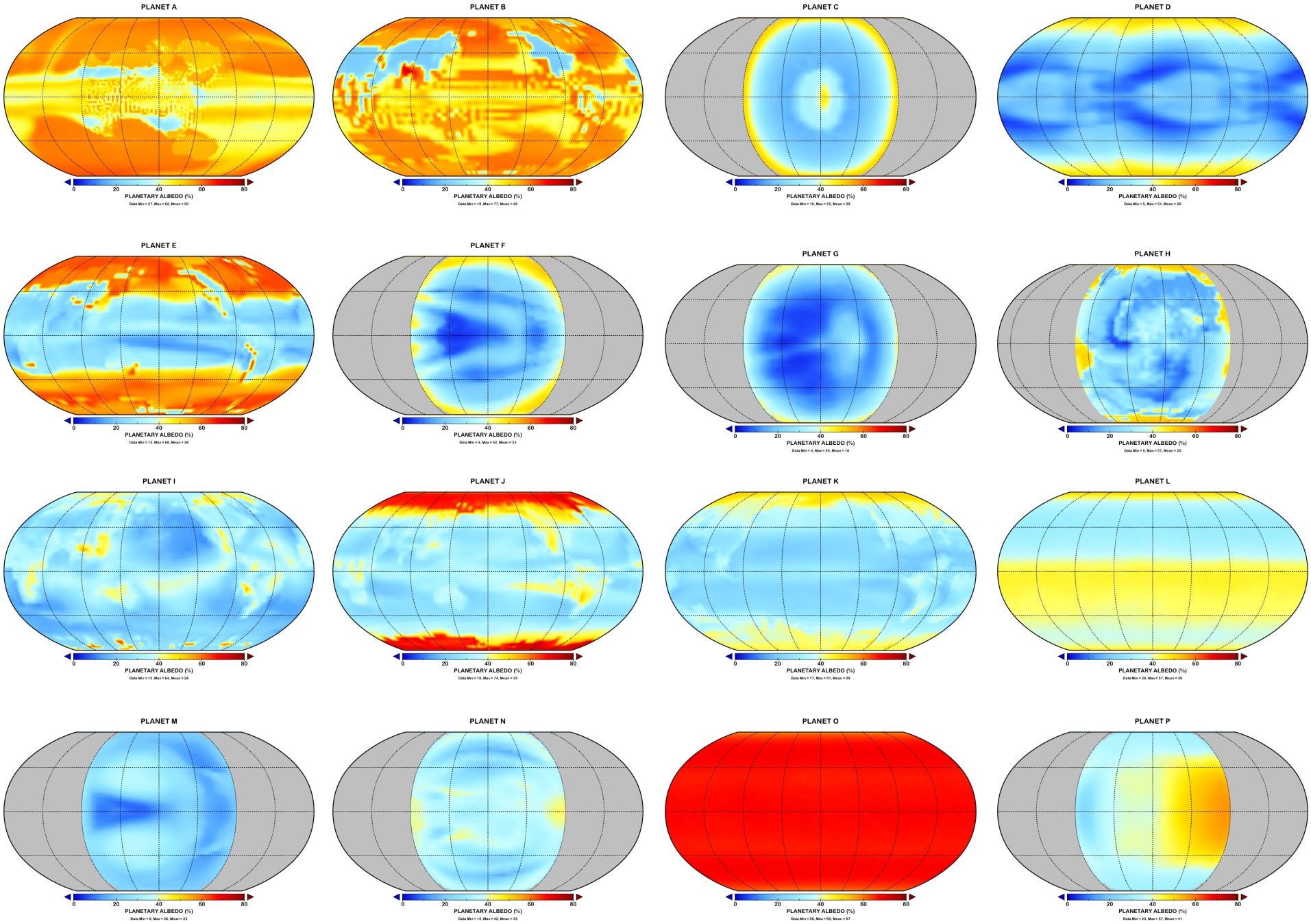
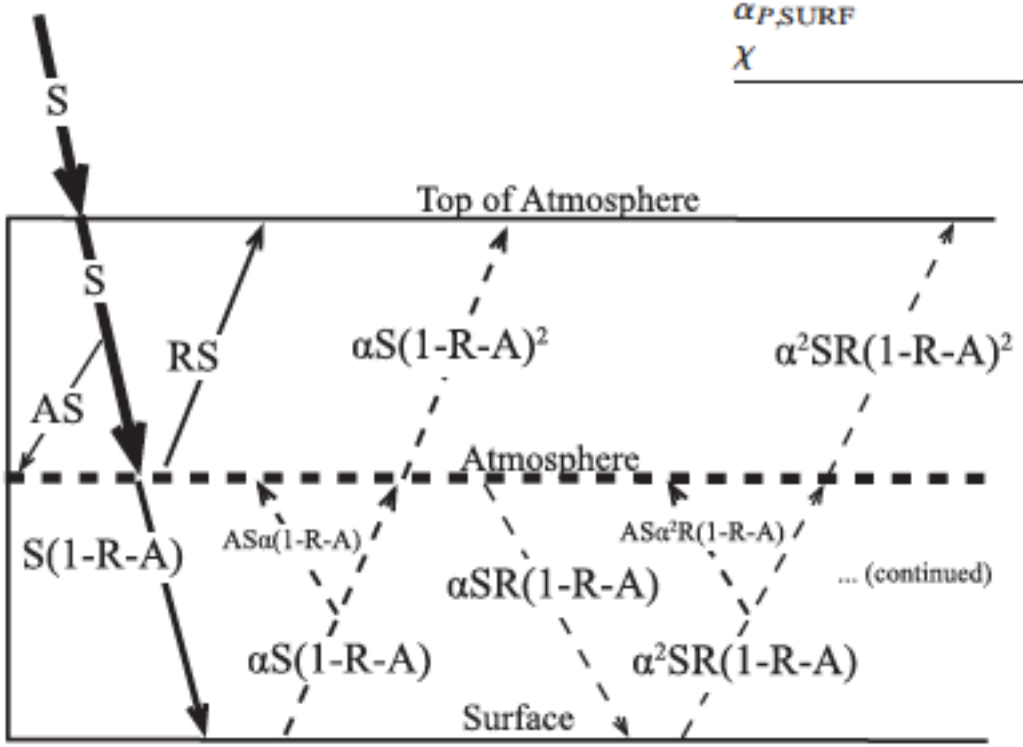


(gray = undefined)

Atmosphere vs. surface contribution to Bond albedo (= planetary albedo)

TABLE 1. Variables used in this study.

Symbol	Meaning
α	Surface albedo
α_P	Planetary albedo = TOA albedo
A	Percentage of absorption during each pass through the atmosphere
R	Percentage of reflection during each pass through the atmosphere
$\alpha_{P,\mathrm{ATMOS}}$	Atmospheric contribution to planetary albedo
$\alpha_{P,\mathrm{SURF}}$	Surface contribution to planetary albedo
χ	Atmospheric attenuation of surface albedo



(Donohoe and Battisti, 2011)

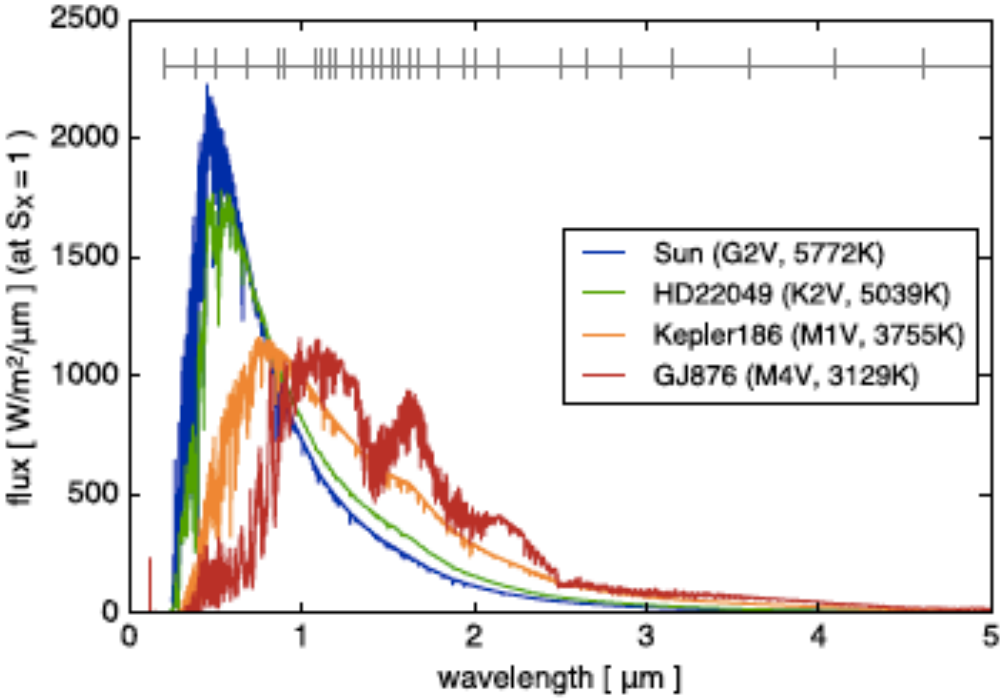
$$\alpha_{P,\mathrm{ATMOS}} = R, \quad \text{and}$$

$$\alpha_{P,\mathrm{SURF}} = \alpha \frac{(1-R-A)^2}{1-\alpha R}.$$

Earth: 88% atmosphere, 12% surface

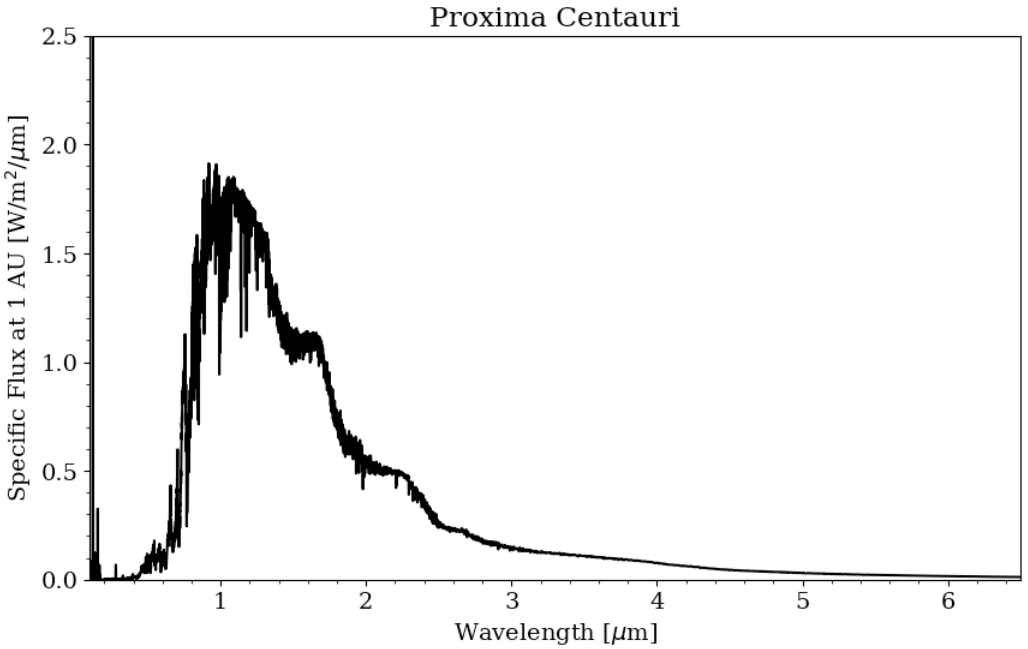
Venus: 99.96% atmosphere, 0.04% surface

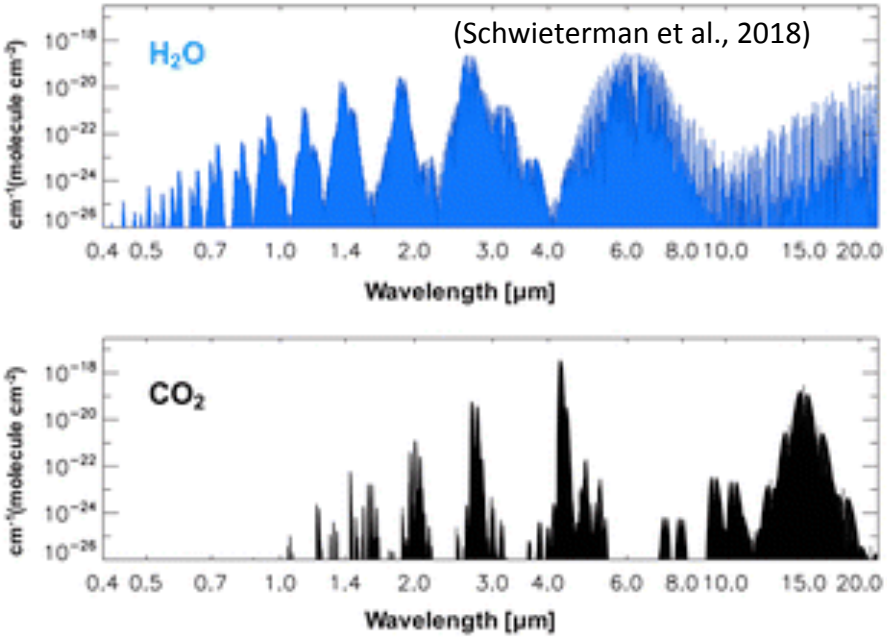
Stellar spectra

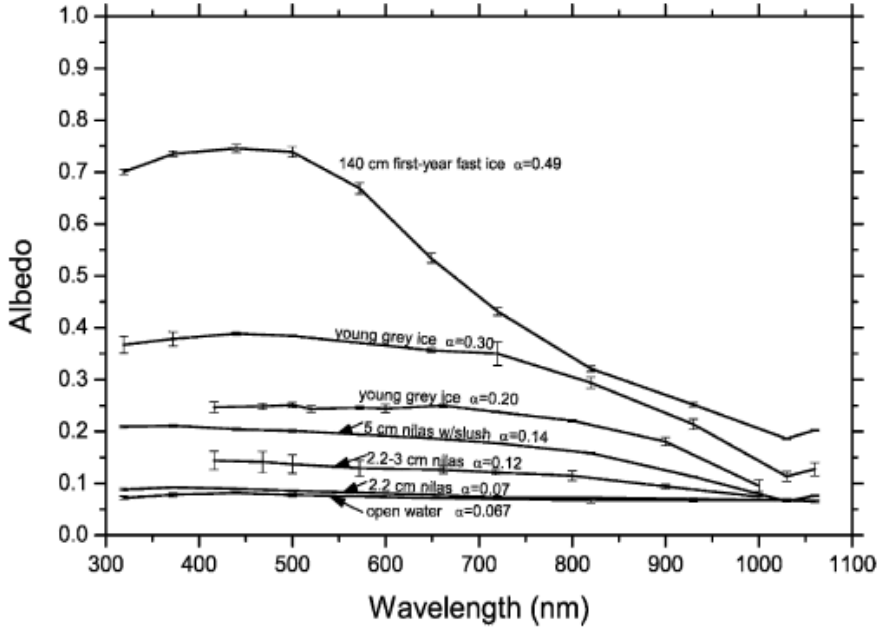


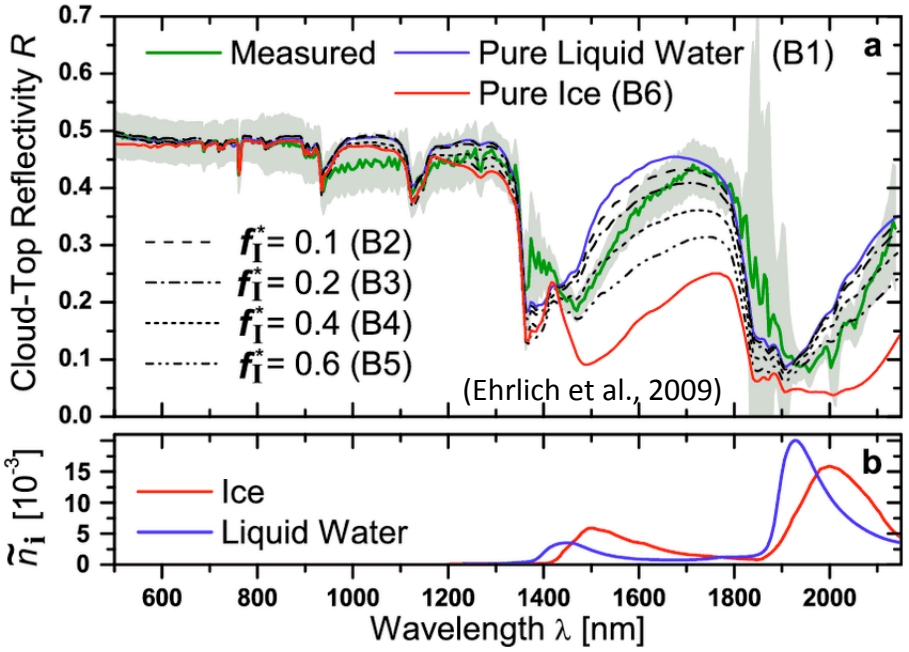
(Fujii et al., 2017)

(Meadows et al., 2016)

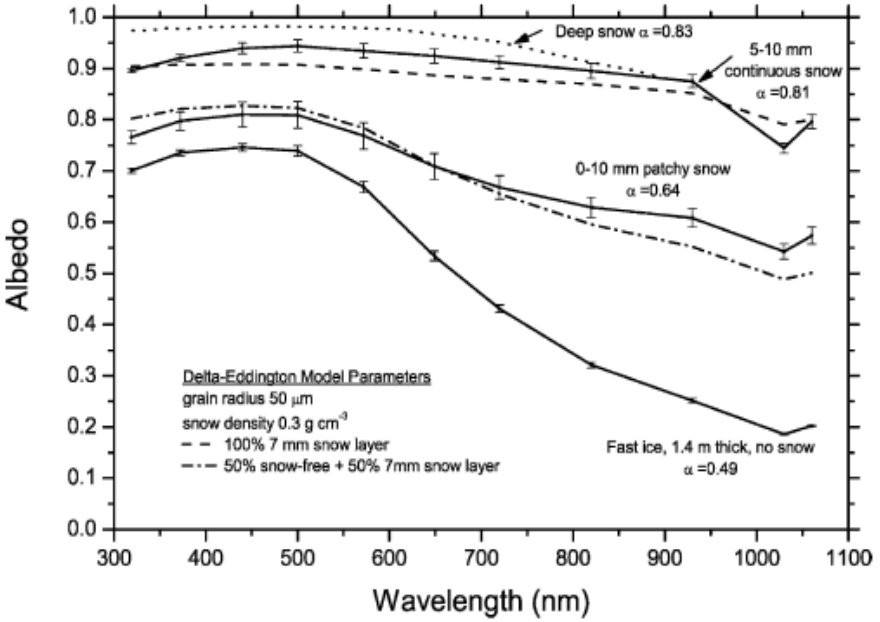








(Brandt et al., 2005)



Some hints to guide you:

- Separate the synchronously rotating planets from the asynchronous planets (note: albedo is only defined where there is incident starlight available)
- Separate the aquaplanets (all ocean at surface) from the planets with exposed land
- Surface contribution to Bond albedo is largest when R is minimum, A is minimum, and α is maximum
- The mission is partly impossible (I think), but that's one of the points of the exercise
- What general statements can we make about the Bond albedos of "Earth-like" planets, e.g., high vs. low insolation or orbiting G vs. M stars?
- If you need more information, go to

  https://data.giss.nasa.gov/rocke3d/maps/

National Aeronautics and Space Administration
Goddard Institute for Space Studies

Goddard Space Flight Center
Sciences and Exploration Directorate
Earth Sciences Division

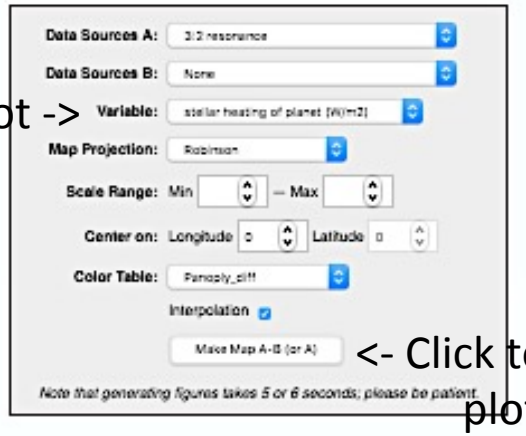
Simulations of Planetary Climates with ROCKE-3D

The ROCKE-3D general circulation model (GCM), an outgrowth of the parent GISS Earth GCM ModelE, is designed to study different points in the history of our own planet and other Solar System terrestrial planets, as well as exoplanets. Our research supports NASA's objective to search for life elsewhere by determining which types of planets are most likely to be habitable and what NASA might do to characterize these planets and eventually find evidence of life. On this page we provide results obtained from simulations of several planets and various time periods.

The user can select parameters on the form below to create maps of a variety of climate variables for a planet chosen in Data Source A. If two different time periods or planet configurations for a given planet are chosen as Data Sources A and B, the resulting figure will be the difference between A and B. Brief descriptions of each planet or time period are given below. Please take note of comments regarding the continent outlines for the Huronian and Archaean Earth simulations.

Select planet ->

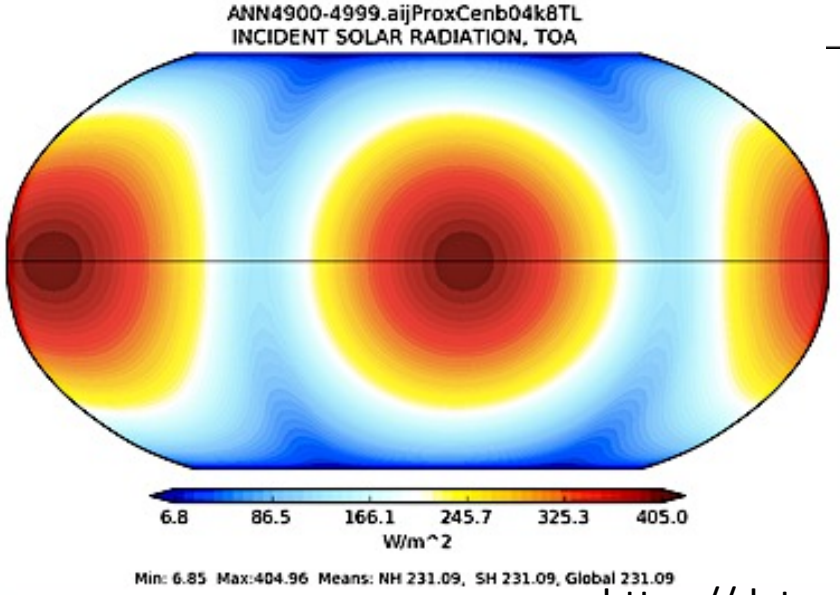
Select parameter to plot ->



<- Click to make plot

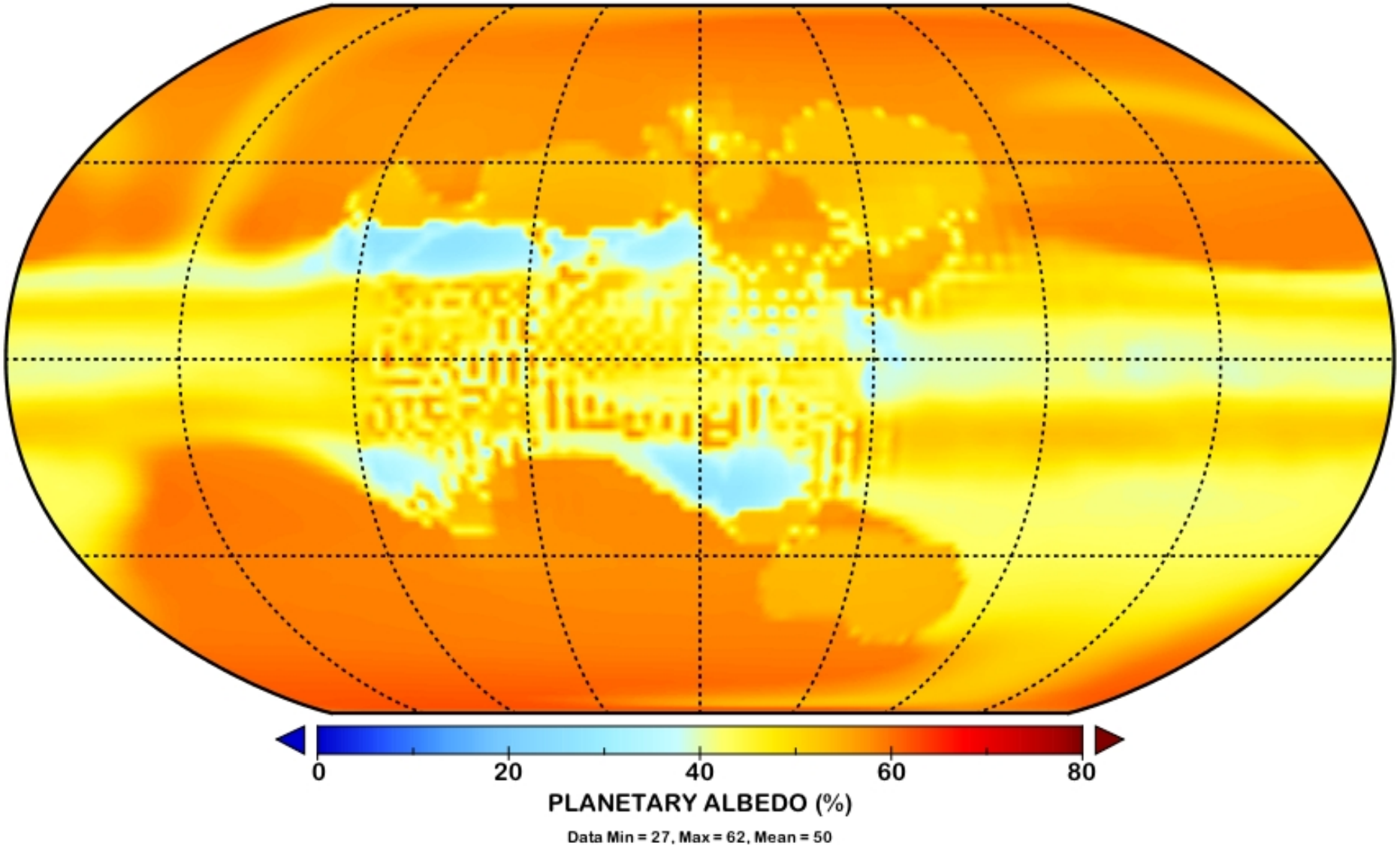
topography (m)
stellar heating of planet (W/m2)
surface temperature (deg. C)
precipitation (mm/day)
sea ice fraction (%)
snow depth (mm)
soil moisture (kg/m2)
column water vapor (mm)
sea level pressure (mb - 1000)
500 mb height (m - 5600)
planetary albedo (%)
absorbed starlight (W/m2)
emitted heat (-W/m2)
cloud cover (%)

Proxima Centauri b
synchronous, Earthlike atmosphere
synchronous, CO2 atmosphere
3:2 resonance
Ancient Earth
Cretaceous, 4×CO2
Sturtian
Huronian
Archean
Venus
Ancient
Modern Earth
Pre-industrial
2x CO2
4x CO2

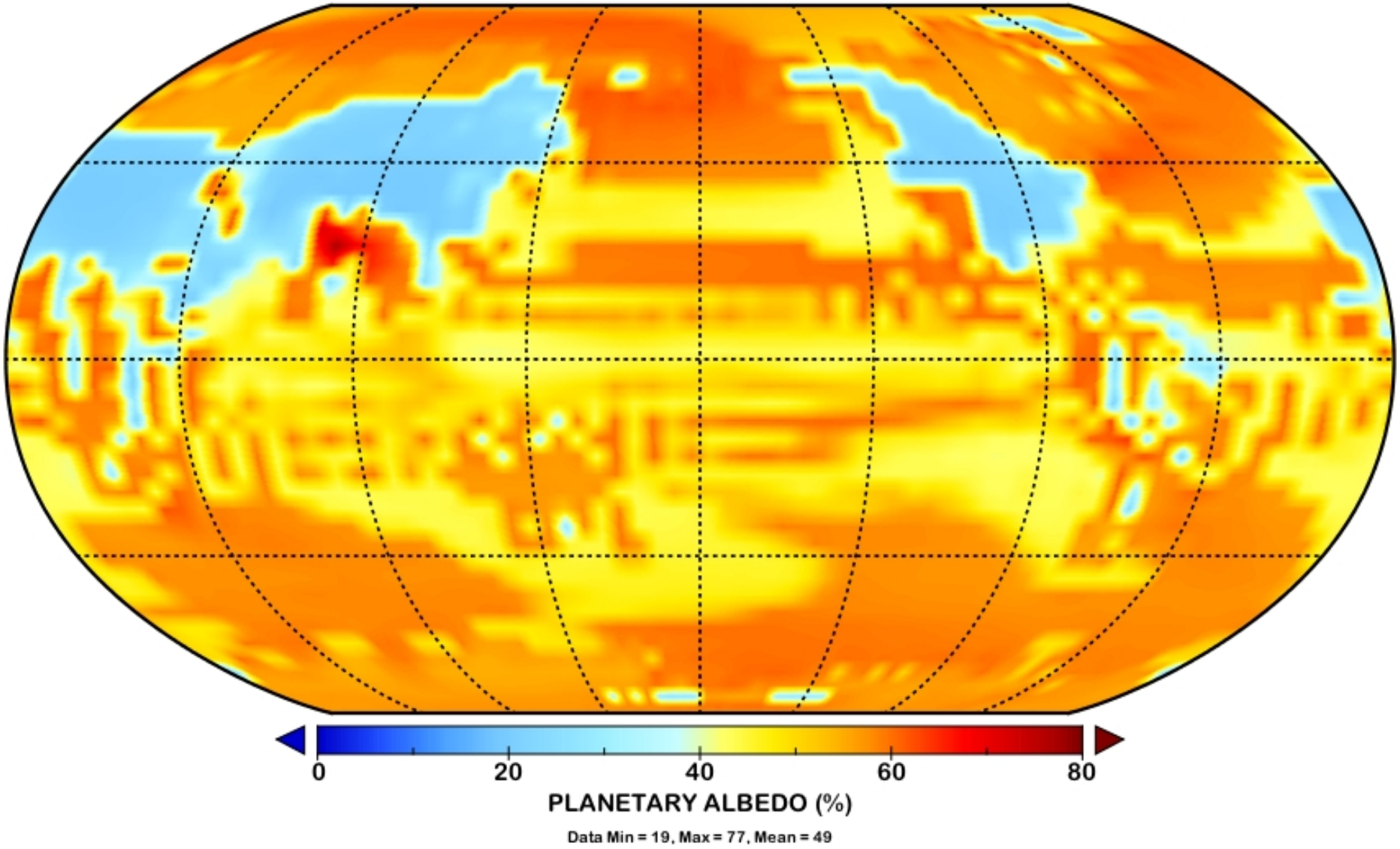


https://data.giss.nasa.gov/rocke3d/maps/

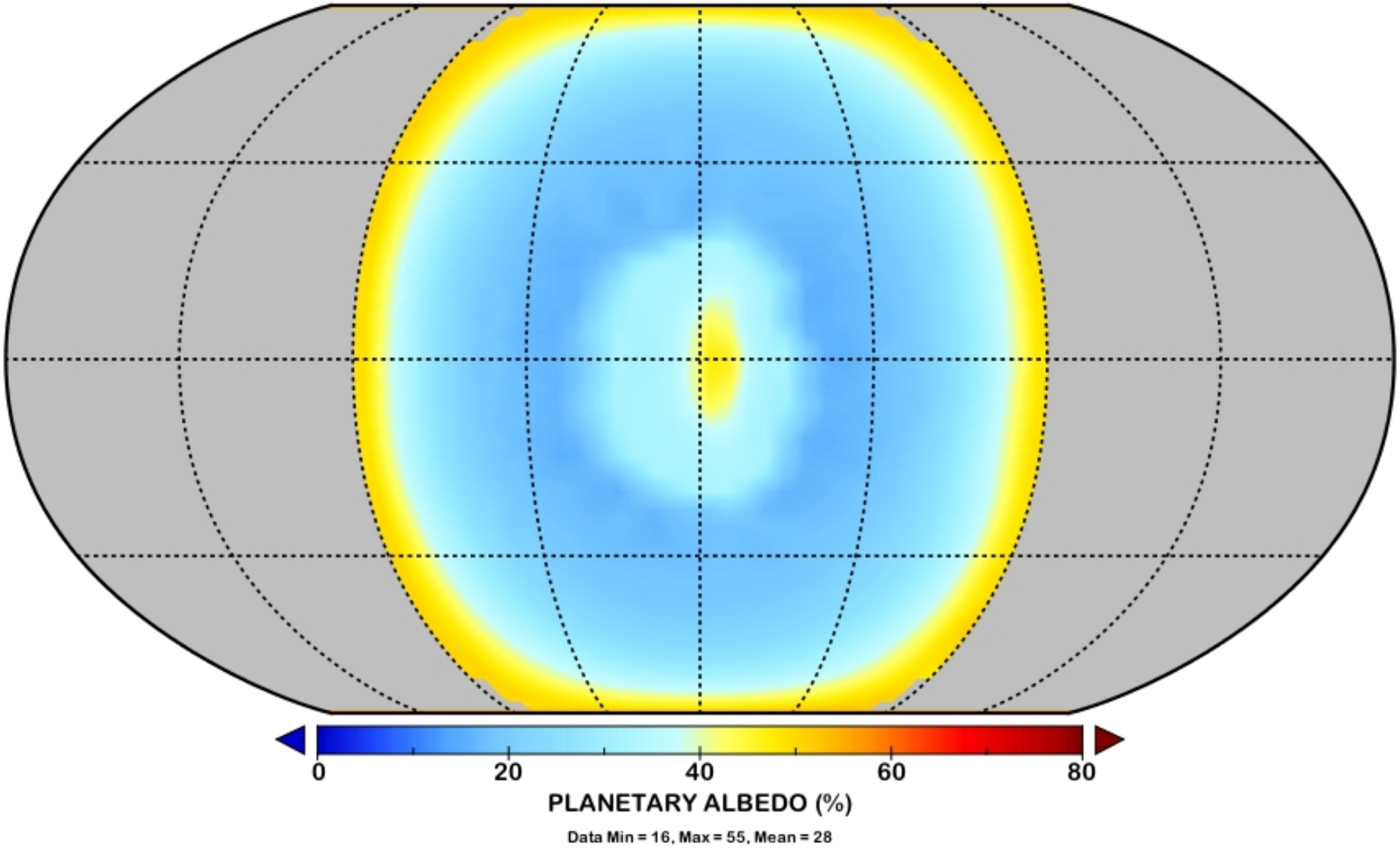
PLANET A



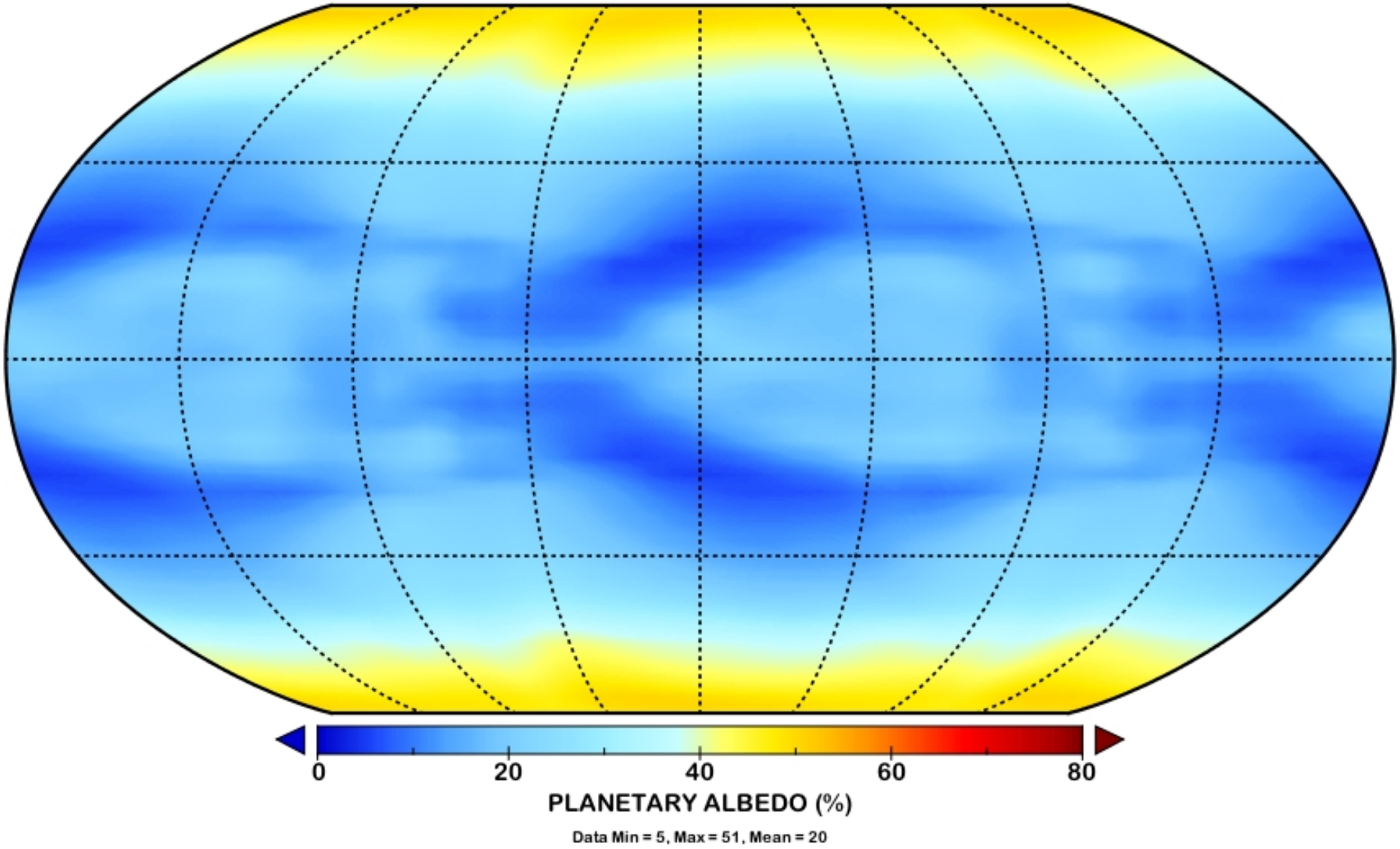
PLANET B



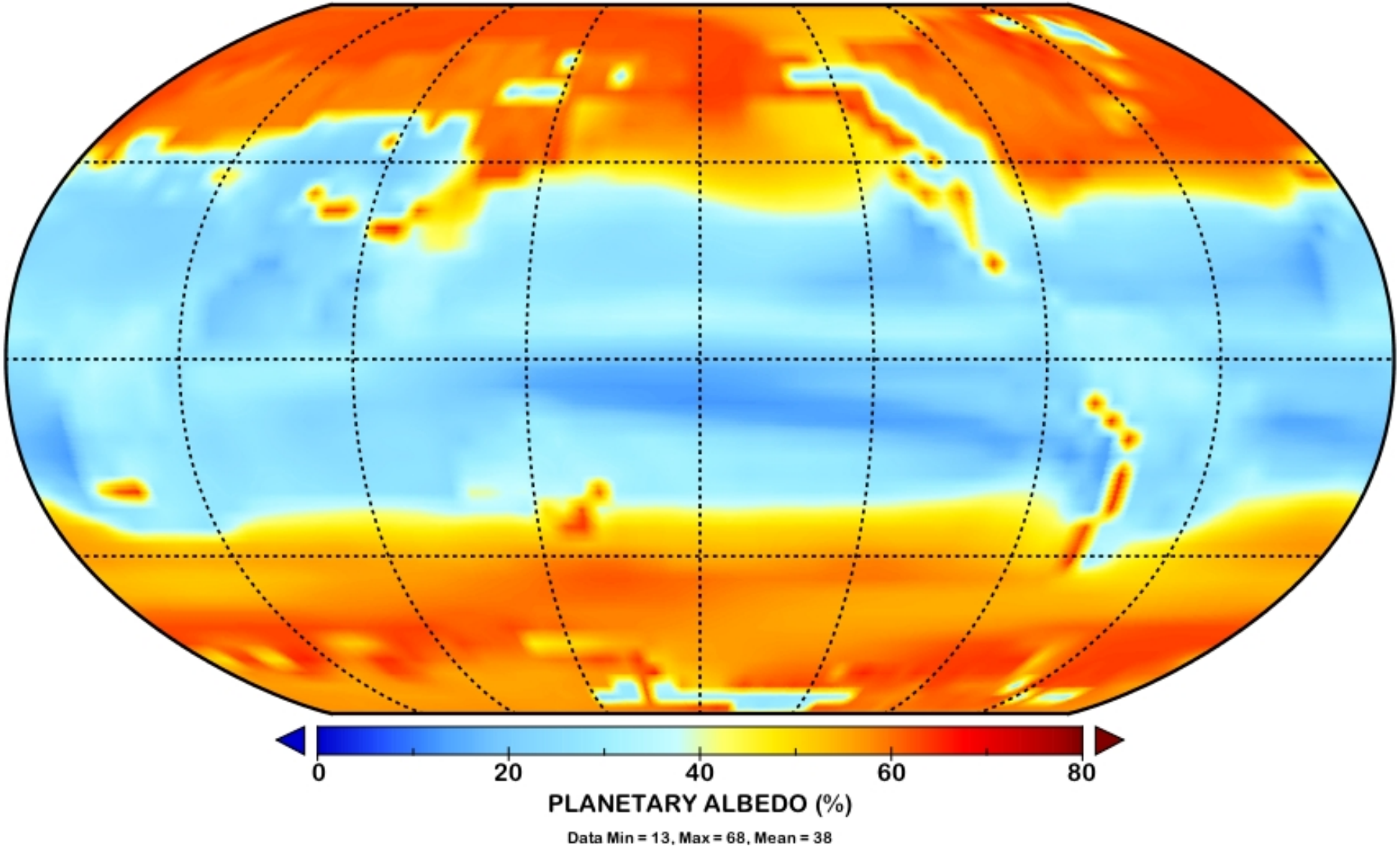
PLANET C



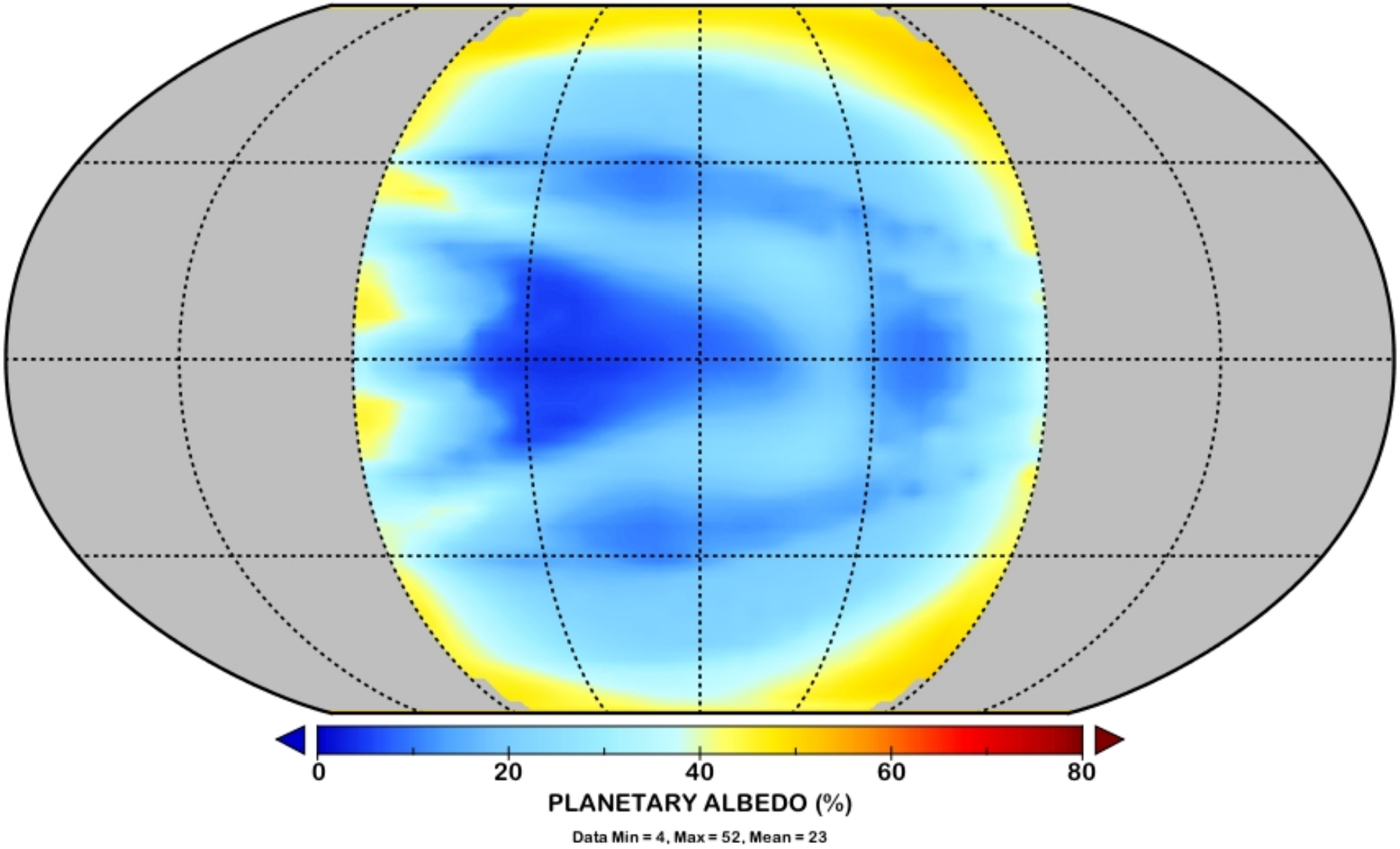
PLANET D



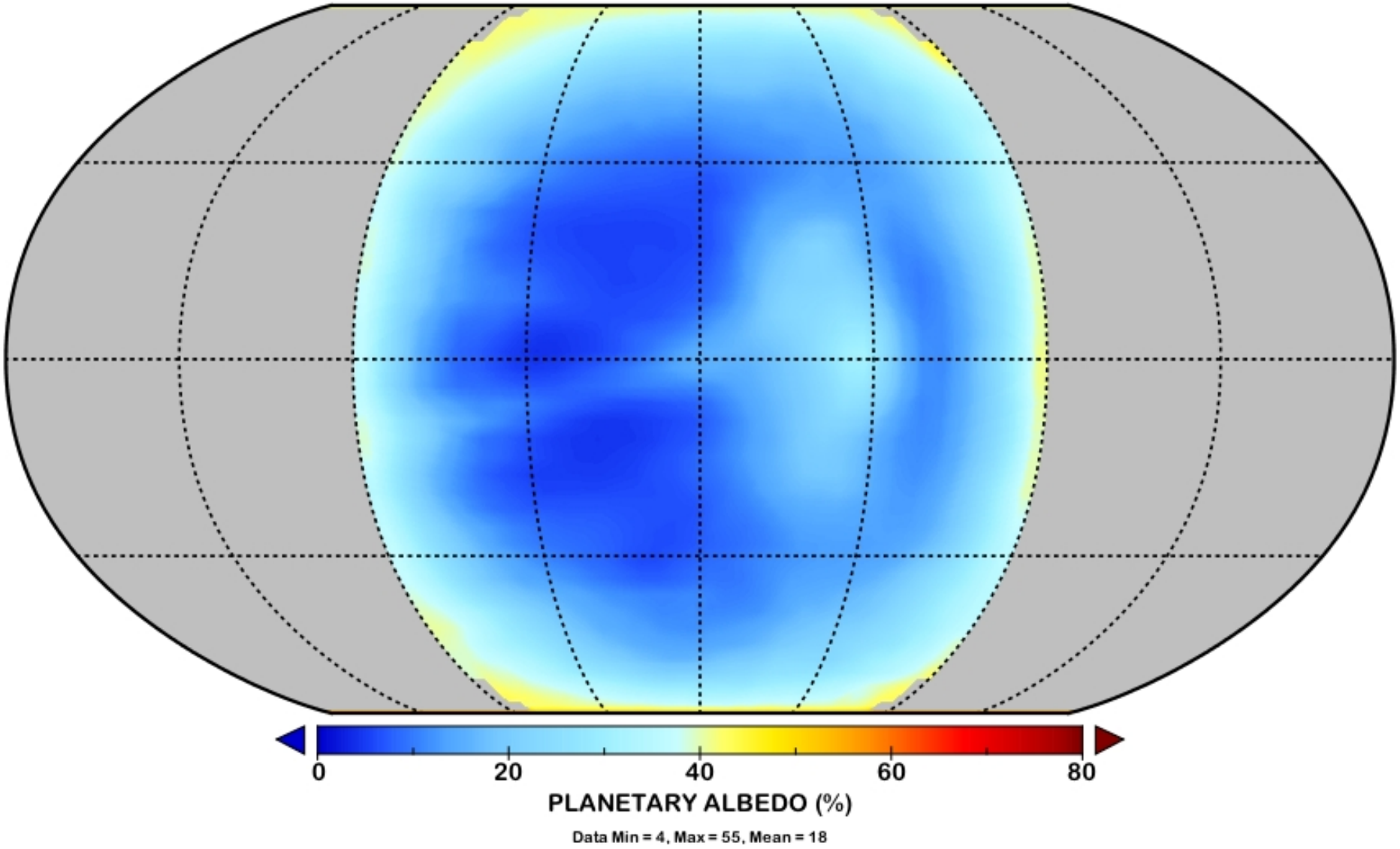
PLANET E



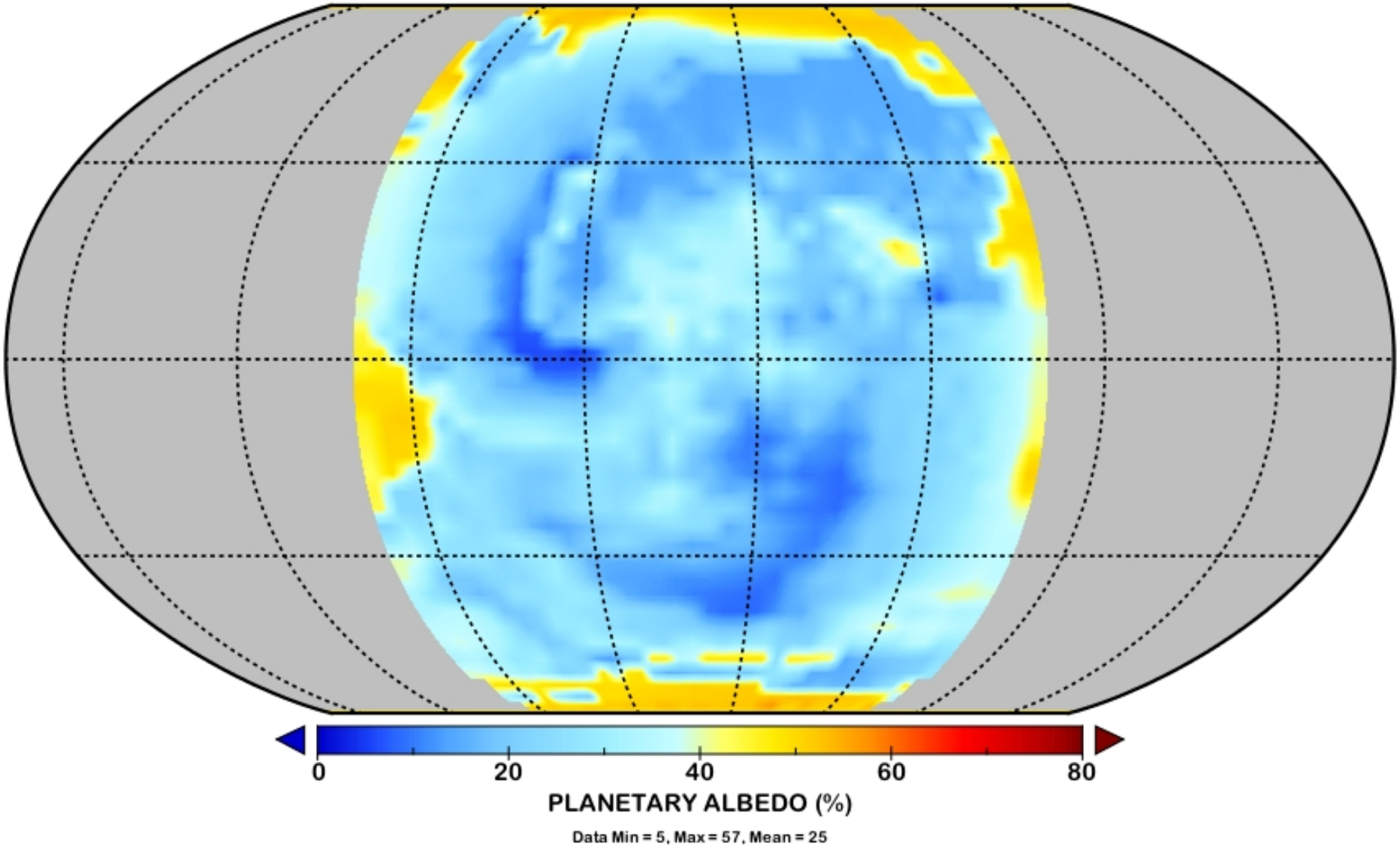
PLANET F



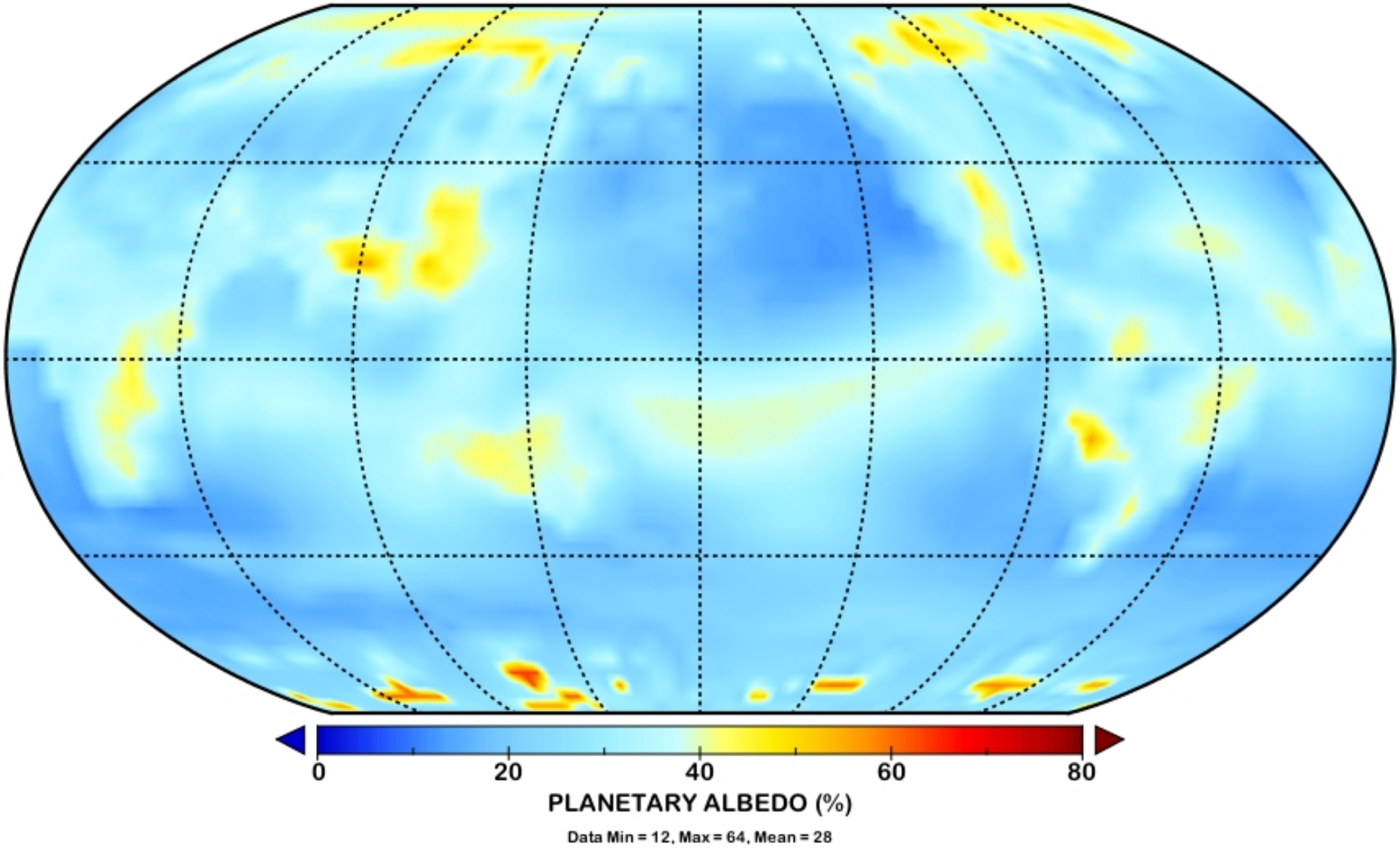
PLANET G



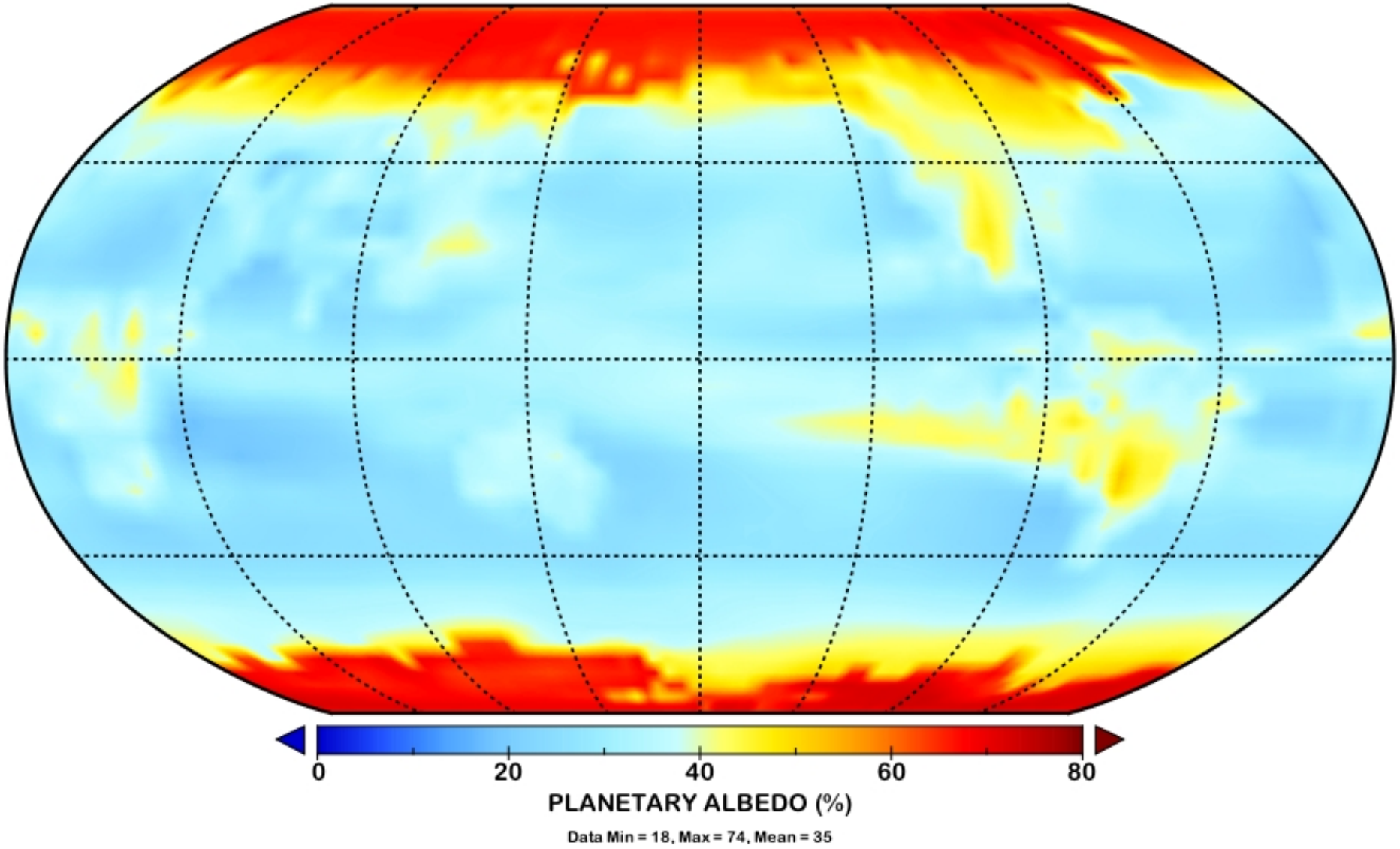
PLANET H



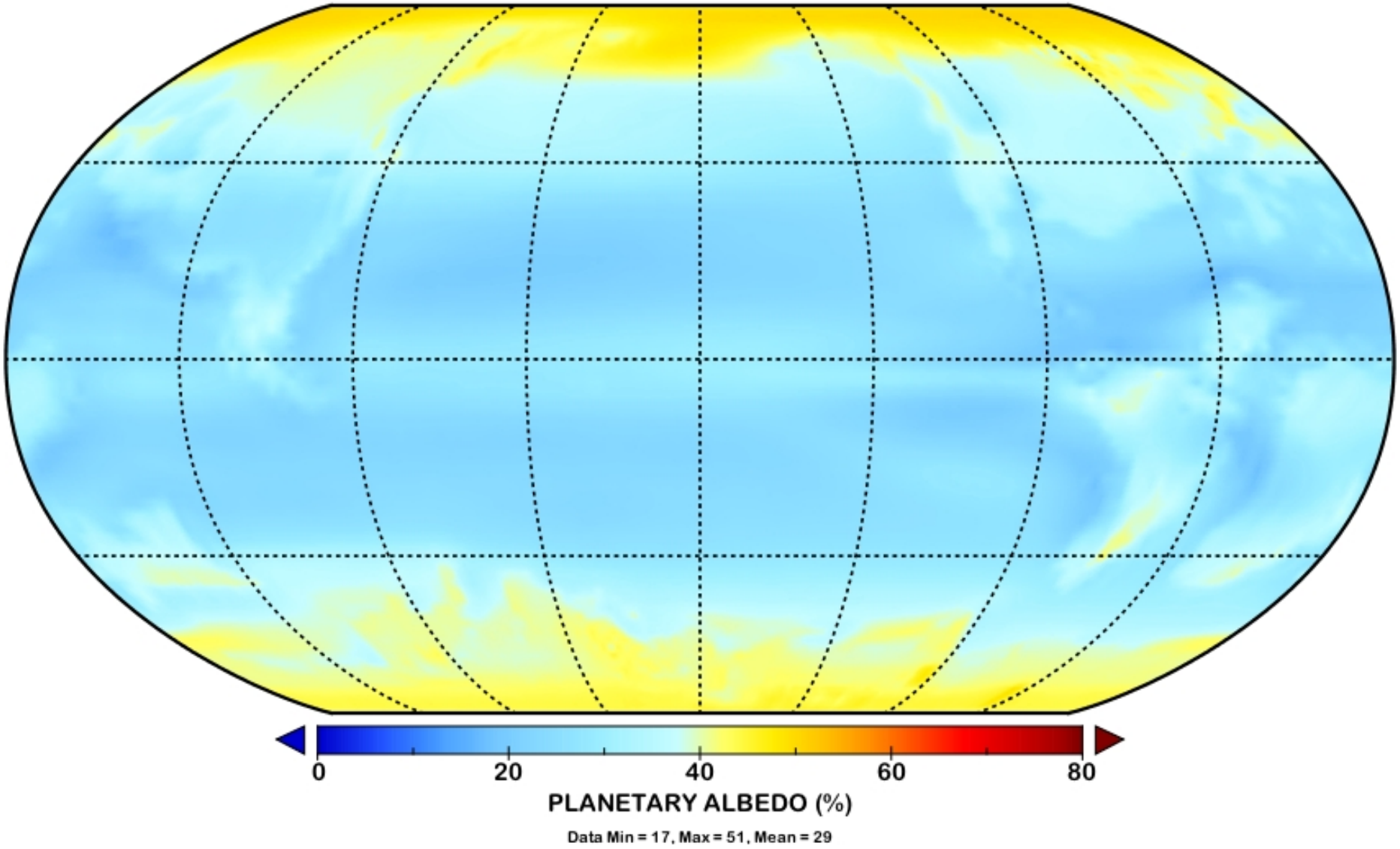
PLANET I



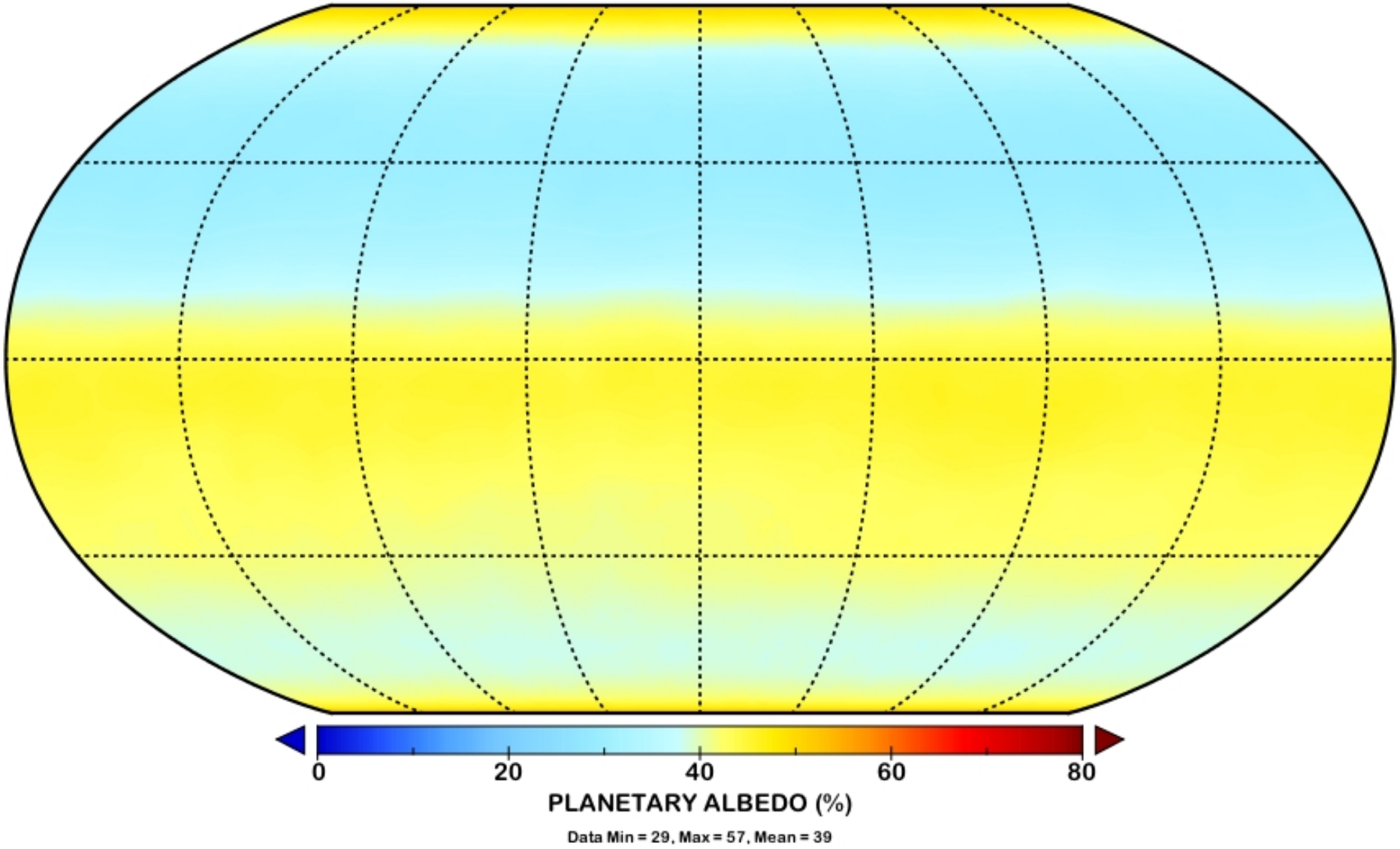
PLANET J



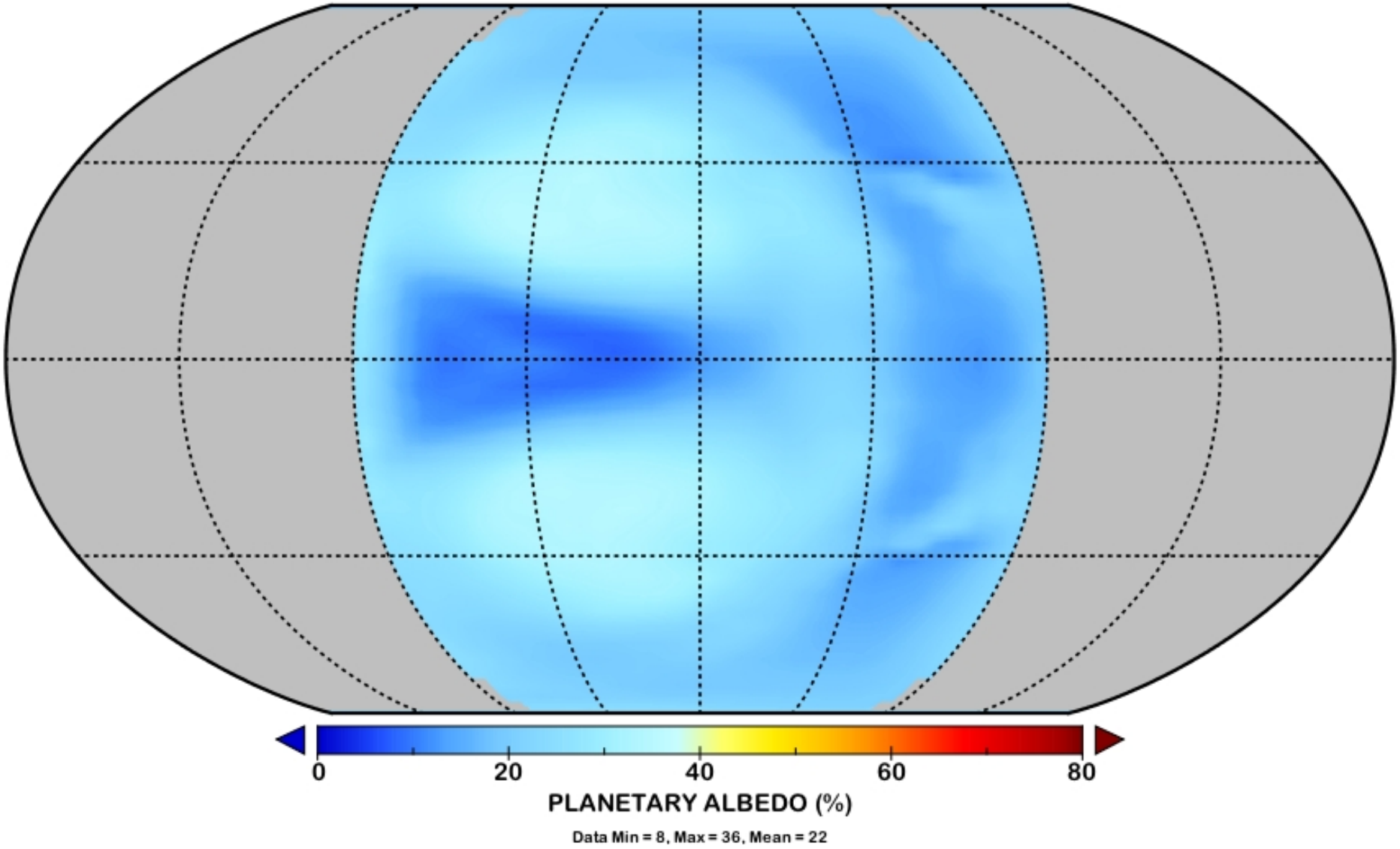
PLANET K



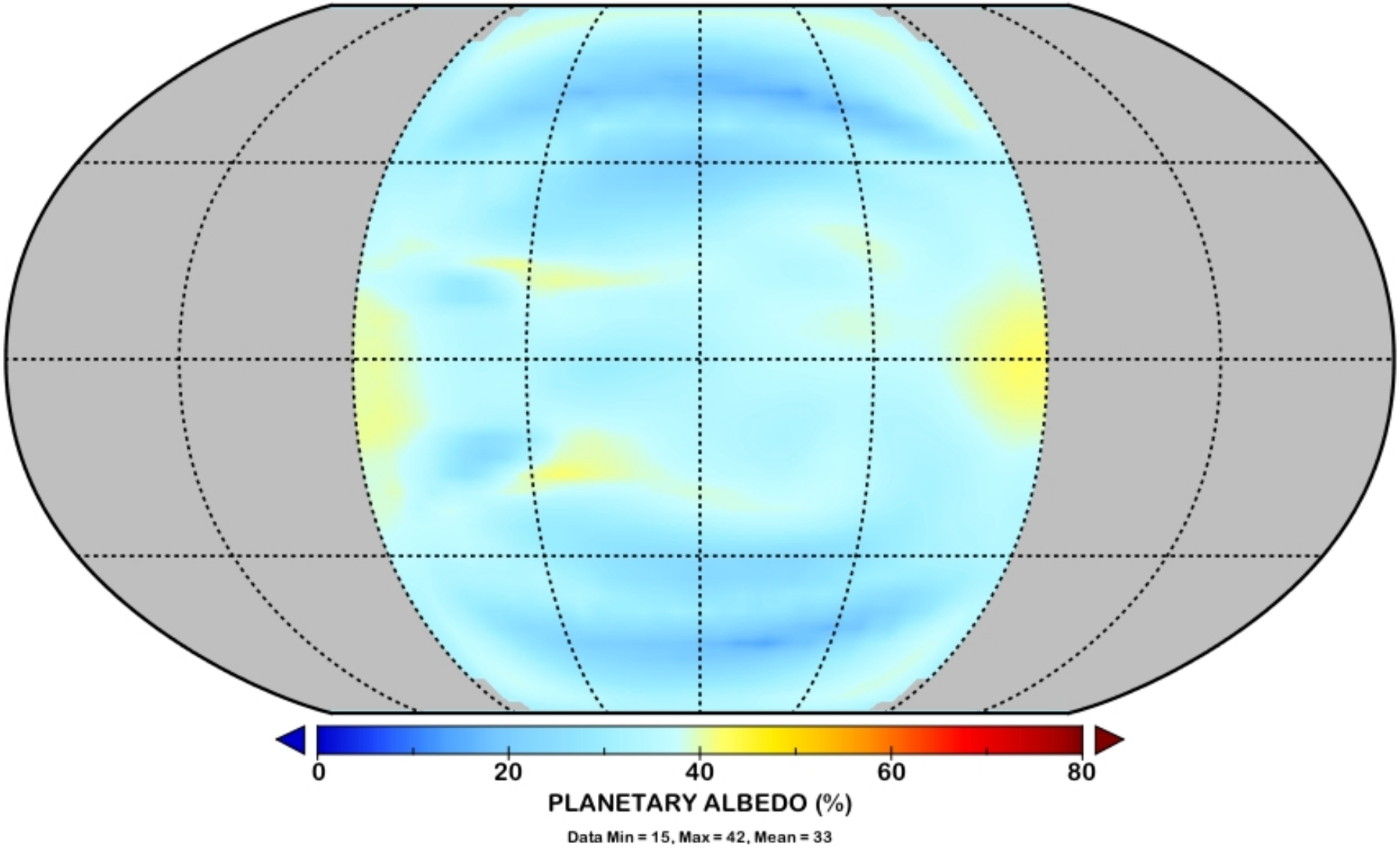
PLANET L



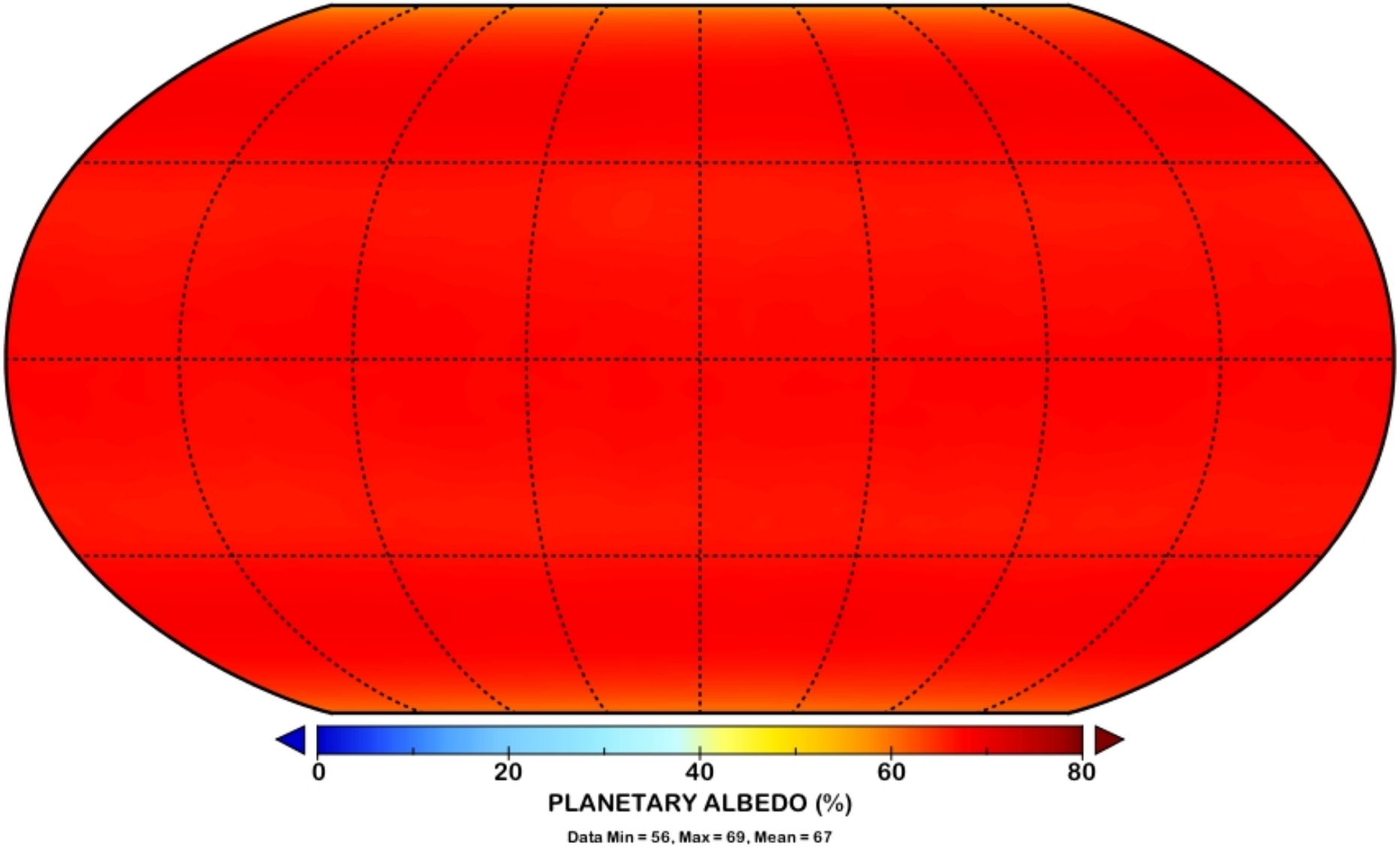
PLANET M



PLANET N



PLANET O



PLANET P