

# Climate of Terraformed Mars

A Simulation Study using DCPAM

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2017/02/21

# Mars

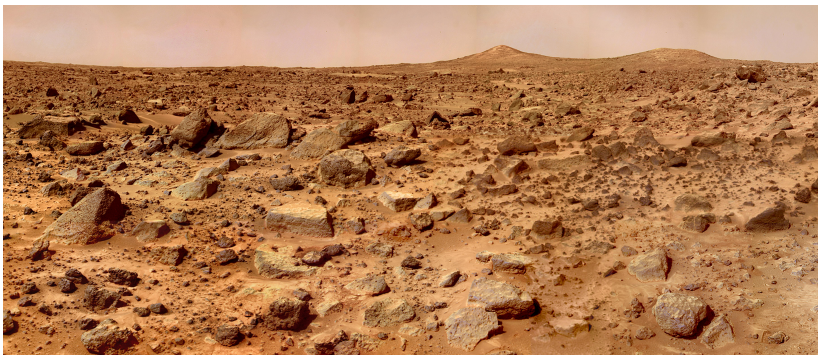


Image Credit: <http://photojournal.jpl.nasa.gov/jpeg/PIA02406.jpg>

The martian surface is presently cold and dry.

- ▶  $T_s = 210 \text{ K}$ ,  $P_s = 6 \text{ hPa}$

# Terraformed Mars

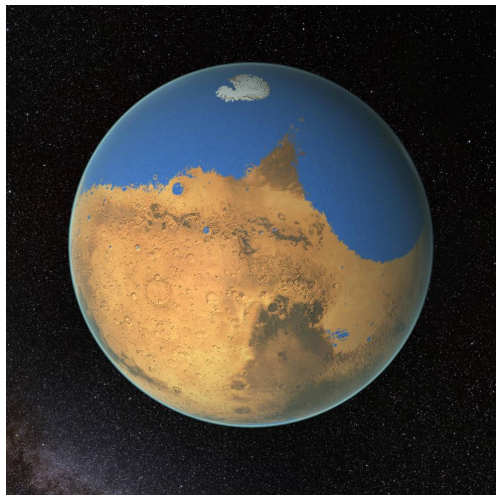


Image Credit: <https://www.nasa.gov/press/2015/march/nasa-research-suggests-mars-once-had-more-water-than-earth-s-arctic-ocean>

Terraformed mars is warm and partially covered with ocean.

- ▶ We do not discuss how to terraform the Mars.

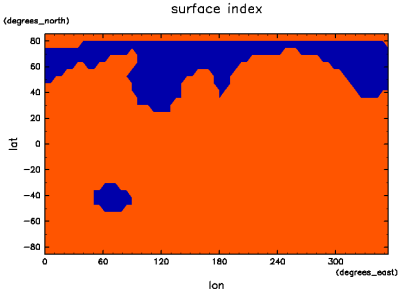
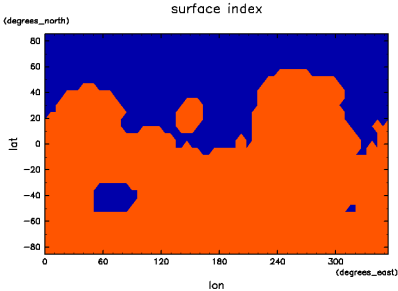
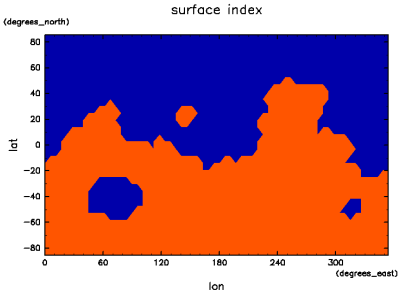
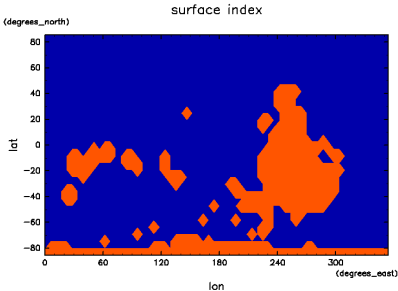
# Terraformed Mars

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Radius	3396 (km)	Mars
Gravity	3.72 (m/s <sup>2</sup> )	Mars
Rotational period	24.66 (hour)	Mars
Obliquity	25.19 (deg)	Mars
Eccentricity	0.0935	Mars
Orbital period	669 (Mars day)	Mars
Solar constant	1370 (W/m <sup>2</sup> )	Earth
Atmospheric composition	N <sub>2</sub> , O <sub>2</sub> , +minor	Earth
Surface pressure	1 (atm)	Earth
Coverage of ocean	85, 51, 35, 14 (%)	

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# Coverage of Ocean



# Model and Experimental Setting

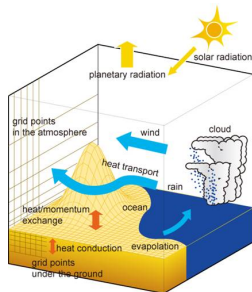
## DCPAM5 ver20161021

(Dennou-Club Planetary Atmospheric Model Project)

- ▶ Dynamics : Primitive equations
- ▶ Radiation : Chou et al. (1999)
- ▶ Large scale condensation : Manabe (1965)
- ▶ Cumulus convection : Relaxed Arakawa-Schubert
- ▶ Turbulent mixing : Mellor and Yamada (1982)
- ▶ Land surface process : Manabe (1969)

## Experimental Setting

- ▶ Ocean : Slab ocean (60 m)
  - ▶ Thermodynamic sea ice model
- ▶ Resolution : T21L26
- ▶ Integration time : 25 Martian years
  - ▶ The last 3 years are analyzed.

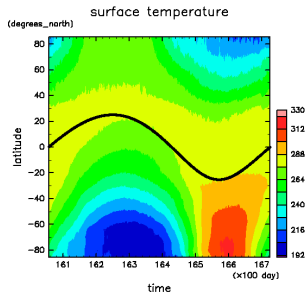
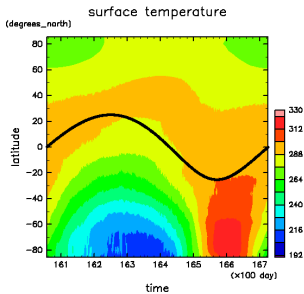
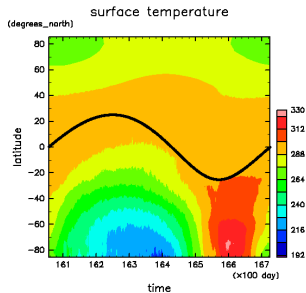
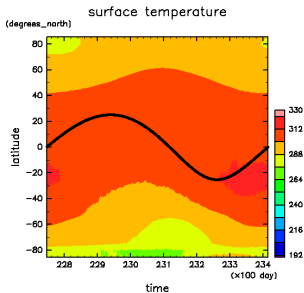


# Global Mean

Coverage of ocean	85%	51%	35%	14%
Surface temperature (K)	304	285	281	267
SW heating at TOA ( $\text{W}/\text{m}^2$ )	242	225	222	209
Effective Temperature (K)	256	251	250	246
Greenhouse effect (K)	48	34	31	21
Precipitable water (mm)	153	40	29	5

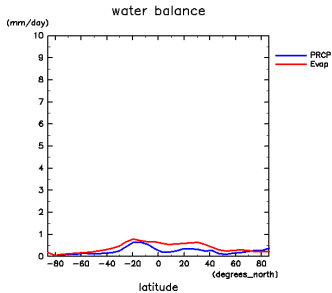
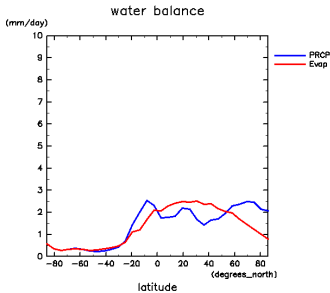
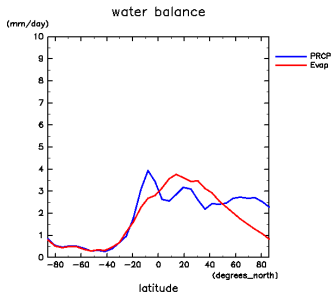
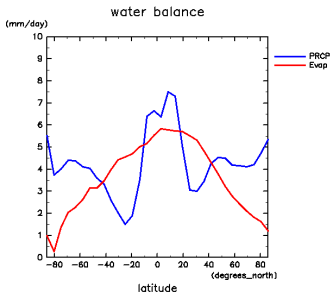
- ▶ Ocean albedo < Land albedo

# Surface Temperature

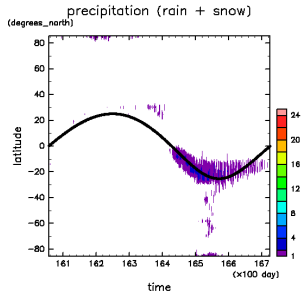
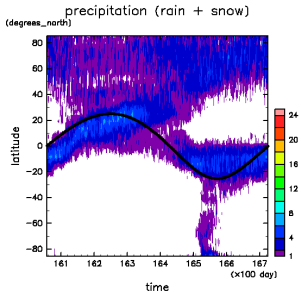
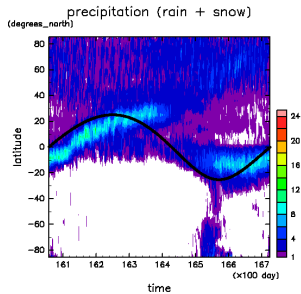
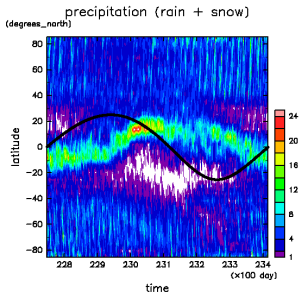




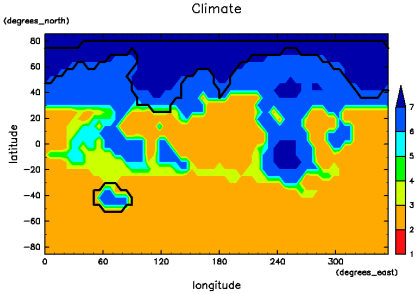
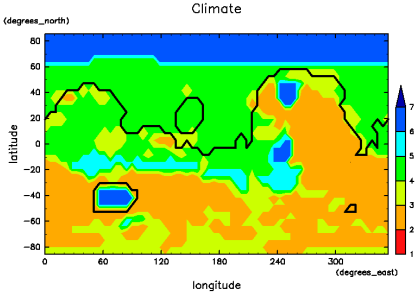
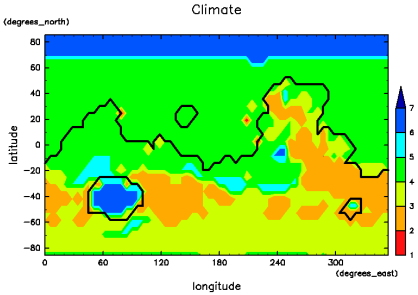
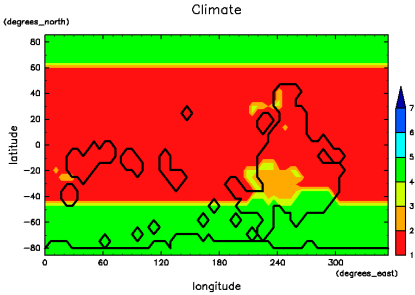
# Precipitation and Evaporation



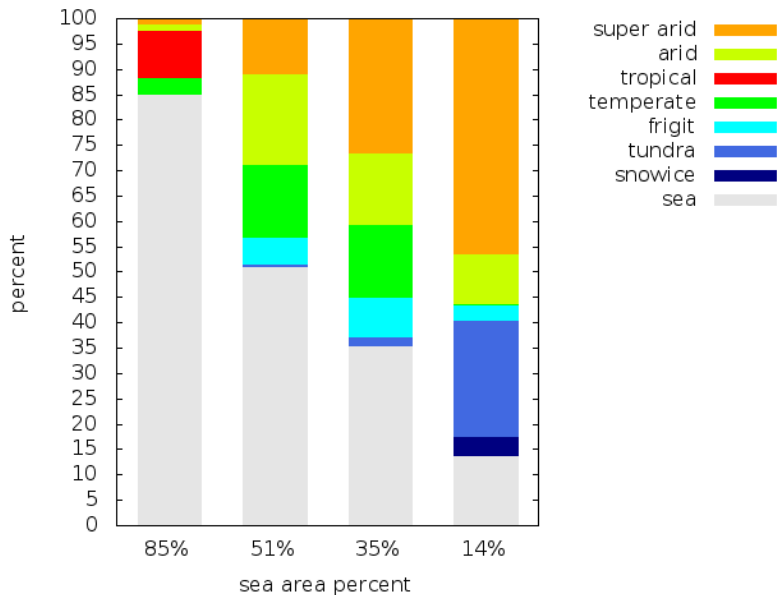
# Precipitation



# Climate Classification



# Habitability



# Summary

We simulated a climate of terraformed Mars with four different sea levels.

- ▶ Global mean surface temperature increases, as the sea level rises.
  - ▶ Albedo of sea surface is smaller than that of land surface.
- ▶ Global mean precipitation increases, as the sea level rises.
- ▶ Large area of southern hemisphere become arid, when the area of ocean is less than 50%.
  - ▶ Since the martian two hemispheres' geography differ in elevation, the southern hemisphere become a large continent.