Here, we propose a new scenario to explain the chemical transition of surface water from neutral to acidic pH. Ferrous iron has two stable dissolved species; Fe^{2+} and $Fe(OH)^{+}$. Both the species are oxidized by UV irradiation. But, $Fe(OH)^{+}$ is also oxidized with irradiation of visible lights. In a thick CO_2 atmosphere with several ppms of SO_2, UV light is shielded by the SO_2. In this case, photo-oxidation of $Fe(OH)^{+}$ proceeds in surface water, but that of Fe^{2+} does not. In surface water, photo-oxidation of $Fe(OH)^{+}$ acidifies the water. However, the concentration of $Fe(OH)^{+}$ drastically decreases around pH~6.5 via the conversion into Fe^{2+}. The decrease in $Fe(OH)^{+}$ concentration, in turn, results in dampening acidification. On the other hand, in an atmosphere with less SO_2, UV light reaches to the surface, leading to photo-oxidation of both Fe^{2+} and $Fe(OH)^{+}$. In this case, even if the concentration of $Fe(OH)^{+}$ decrease down to pH~6.5, acidification continues via photo-oxidation of Fe^{2+}. As a result, a runaway acidification to highly acidic surface water occurs.

We discuss the above possibility quantitatively using the previous laboratory data on photo-oxidation rates of Fe^{2+} and $Fe(OH)^{+}$. We calculate the total production rate of H^{+} both via the photo-oxidation of $Fe^{2+}$and $Fe(OH)^{+}$ for various atmospheric compositions and pressures. Based on our sensitivity study, the critical atmospheric compositions to drive the runaway acidification are discussed.

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6. **PS12-D4-PM2-311B(L3N)-006** (PS12-A002)

Climate and Habitability of Kepler 452b

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The discovery of Kepler 452b marks a milestone of searching for habitable exoplanets. While simple estimation indicates that Kepler 452b is located in the habitable zone of a Sun-like star, the climate state and habitability of Kepler 452b require detailed studies. Using a three-dimensional fully coupled atmosphere-ocean climate model and assuming an aqua-planet, we perform simulations to demonstrate climate states of Kepler 452b for different greenhouse effects and ice-albedo feedbacks. Our simulations show that sea ice can only invade from poles to about 45 degree in latitude for extremely low levels of CO_2 (5 ppmv), and that surface temperature near the equator remains as high as 300 K. For high level of CO_2 (0.2 bars), the exoplanet becomes ice free, and tropical surface temperature reaches about 335 K. The results suggest that Kepler 452b is very close to the inner edge of the habitable zone, and that its climate state can readily reach the runaway greenhouse limit as greenhouse concentration is higher.

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7. **PS12-D4-PM2-311B(L3N)-007** (PS12-A007)

A Numerical Experiment on Occurrence Condition of the Runaway Greenhouse State with an Atmospheric General Circulation Model

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The runaway greenhouse state is an important concept for considering the existence condition of the ocean, and hence habitability of planets. The runaway greenhouse state is defined as a state in which incident flux given to the atmosphere exceeds the radiation limit (Nakajima et al., 1992). Recent studies utilizing atmospheric general circulation models (AGCMs) discuss that atmospheric circulation and cloud albedo significantly affect the occurrence condition of the runaway greenhouse state (e.g., Leconte et al., 2013). However, our speculation is that the runaway greenhouse state emerges when global mean absorbed solar flux exceeds the maximum values of OLR. In order to confirm our speculation, we perform a numerical experiment with an AGCM. We examine the response of modeled atmospheric states to the increase of solar flux considering two spatial and temporal distributions: one for synchronously rotating planets with fixed dayside and nightside, and the other for an Earth-like, non-synchronously rotating planets with diurnal and seasonal changes. We use the AGCM developed by our research group, DCPAM (http://www.gfd-dennou.org/library/dcpam). Subgrid physical processes are parameterized with standard methods used in terrestrial Meteorology. The amount of cloud water is calculated with a simple model adopting a fixed cloud extinction time. Heat capacity of the surface is assumed to be zero. The results of our experiments show that horizontal deviation of OLR decreases with increasing solar constant regardless the radiation scheme (grey scheme or non-grey scheme), existence of clouds, and solar flux distribution. It seems that runaway greenhouse state appears when global mean absorbed solar radiation flux exceeds the maximum values of OLR. Our results suggest that the occurrence condition of the runaway greenhouse state is determined by a common mechanism, although the maximum value of OLR differs among runs with different conditions.

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10. **PS12-D4-PM2-311B(L3N)-008** (PS12-A011)

Observation of Land Vegetation on Habitable Planets Around M Dwarfs

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After the confirmation of the habitability of exoplanets, these planets will become the main targets for the search of exoplanet life. One of the signatures of life on the Earth is the vegetation red edge (VRE) signal. M dwarfs are thought to be the 'fast-track' for the search for habitable exoplanets. But habitable planets of M dwarfs are likely to be tidally locked, which potentially limits the distribution of vegetation. In this work we study the growth of vegetation on exoplanet GJ667Cc by using the climate data of an exoplanet GCM model in the Denitrification and Decomposition model (DNDC) model and calculate the reflection spectra of the planet. We find that the VRE signal is on the order of 1% without considering clouds. The VRE signal is reduced to 0.1% or less when considering the occultation effect of clouds. When considering only photon noise and perfect stellar light repression, observation time of ~200 hours will be required for a 6.5-m size telescope to detect the potential VRE signal on GJ667Cc.

Poster Presentations

PS12-D5-PM2-P-009 (PS12-A004)

Study on Interaction Between Diurnal Tide and Atmospheric Aerosols Observed by the Mars Climate Sounder

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The increased local time coverage observed by Mars Climate Sounder (MCS) on board Mars Reconnaissance Orbiter (MRO) can enable direct extraction of thermal tides in Mars middle atmosphere with reduced aliasing. Using temperature profiles from Mars year (MY) 30 to 32, we study the latitudinal and seasonal variations of tides and stationary planetary waves with zonal wave numbers s = 1-3. The amplitude of the migrating diurnal tide (DW1) has strong semiannual variations both in the equatorial region and in the Southern Hemisphere (SH) middle latitudes. Aerosols widely distributed in the atmosphere of Mars, namely, dust and water ice also show apparent diurnal variations, which may be caused by a dynamical process of tidal vertical wind. Tidal response in dust abundance indicates an annual variation with maximum amplitude in aphelion seasons while the background abundance of dust peaks in perihelion seasons when global dust storm occurs frequently, which suggests that extremely large abundance of dust may restrain its own tidal response. Water ice abundance in the middle latitudes has a semiannual variation which is similar to the thermal diurnal tide. In addition, the diurnal heating rate of aerosols is calculated and Hough decomposition is performed to estimate the radiative effect of aerosols on diurnal tide.

PS12-D5-PM2-P-010 (PS12-A006)

Modeling the Evolution of Pluto's Ice-Rich Surface

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Recent discoveries made available through NASA's New Horizon mission revealed a new world on Pluto with a plateau of "young" surface. We endeavor to explore various possibilities that may have contributed to this phenomena, including atmospheric condensation, ice sheet evolution, etc.

The first perspective would require a 3D GCM adapted for Pluto's exceptionally thin atmosphere, while the later one could be studied by introducing an ice sheet model with revised nitrogen ice parameters, gravity and bottom features.

The co-existence of nitrogen- and water-ice on Pluto may hold the key to answering our question. Some initial simulations have revealed that nitrogen ice sheet could deform to flatten out under its own weight, smoothing craters. Though awaiting further verification, model experiments suggested that this mechanism is workable on a timescale of a million years.

PS12-D5-PM2-P-011 (PS12-A009)

On the Detection of Carbon Monoxide as an Anti-Biosignature in Exoplanetary Atmospheres

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Recent works suggest that oxygen can be maintained on lifeless exoplanets in the habitable zones of M dwarfs as the results of photochemical reactions. However, the same photochemical models also predict high concentrations of carbon monoxide (CO) in the corresponding atmospheres. A line-by-line radiative transfer model is used to investigate observation requirements of O2 and CO. We find that abiotically produced O2 is detectable at 0.76 μm, in agreement with previous findings. More interestingly CO in the corresponding atmospheres is also detectable at NIR. We suggest that future missions aiming at characterization of exoplanetary atmospheres consider detections of CO as an anti-biosignature.

PS12-D5-PM2-P-012 (PS12-A013)

Distinguishing Habitable Exoplanet from Planets Rapidly Losing Water Through Observations

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Habitable Planets by definition are capable of maintaining liquid water on their surfaces. Thus the amount of water vapor in their atmospheres is limited, with the Earth as the only confirmed example. Planets could start to lose their water rapidly when surface temperature is increased above certain threshold, which drives water into the middle atmosphere where photo dissociation readily convert water vapor into hydrogen and oxygen. We used a 1-D line-by-line radiative transfer model (LT model) to calculated reflectance spectra of the Earth and exoplanets losing water more and more rapidly. The exoplanets are modeled using the CESM model by applying enhanced stellar radiation in comparison to that received by the Earth. The results show that the two spectra can be easily distinguishable without considering cloud effects. In this work we will explore the effect of clouds and its impact on the feasibility to distinguish habitable exoplanet from planets rapidly losing water observationally.

PS12-D5-PM2-P-014 (PS12-A016)

Numerical Simulation of Topographic Effects on Wind Flow Fields Over Mountainous Area of Mae Moh District