How to make an ocean planet habitable

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Since the first discovery in 1995, over 3,500 exoplanets have been identified so far. Some of them are known to have the similar sizes as the Earth and be located in the “habitable zones” around the central stars. These exoplanets could have water on the surface—they are called “ocean planets.” Even though we have found many ocean planets, however, we do not know whether they are *really* habitable or not. Earth, the only planet known to harbor life, has ocean on the surface, but the amount of water is subtle (~0.023 wt% of the Earth). Recent studies insisted that the proper amount of water—not too much, not too little—is essential to generation and evolution of life. Therefore, it is important to understand why Earth has got such a small amount of water to answer the question “how to make an ocean planet habitable?” I will review the general water supply process to terrestrial planets, and discuss the existence and observability of habitable exoplanets.

Keywords: Earth, ocean, exoplanet, habitable

Near-Surface Salinity Stratification from Satellite SSS Observations and Numerical Models

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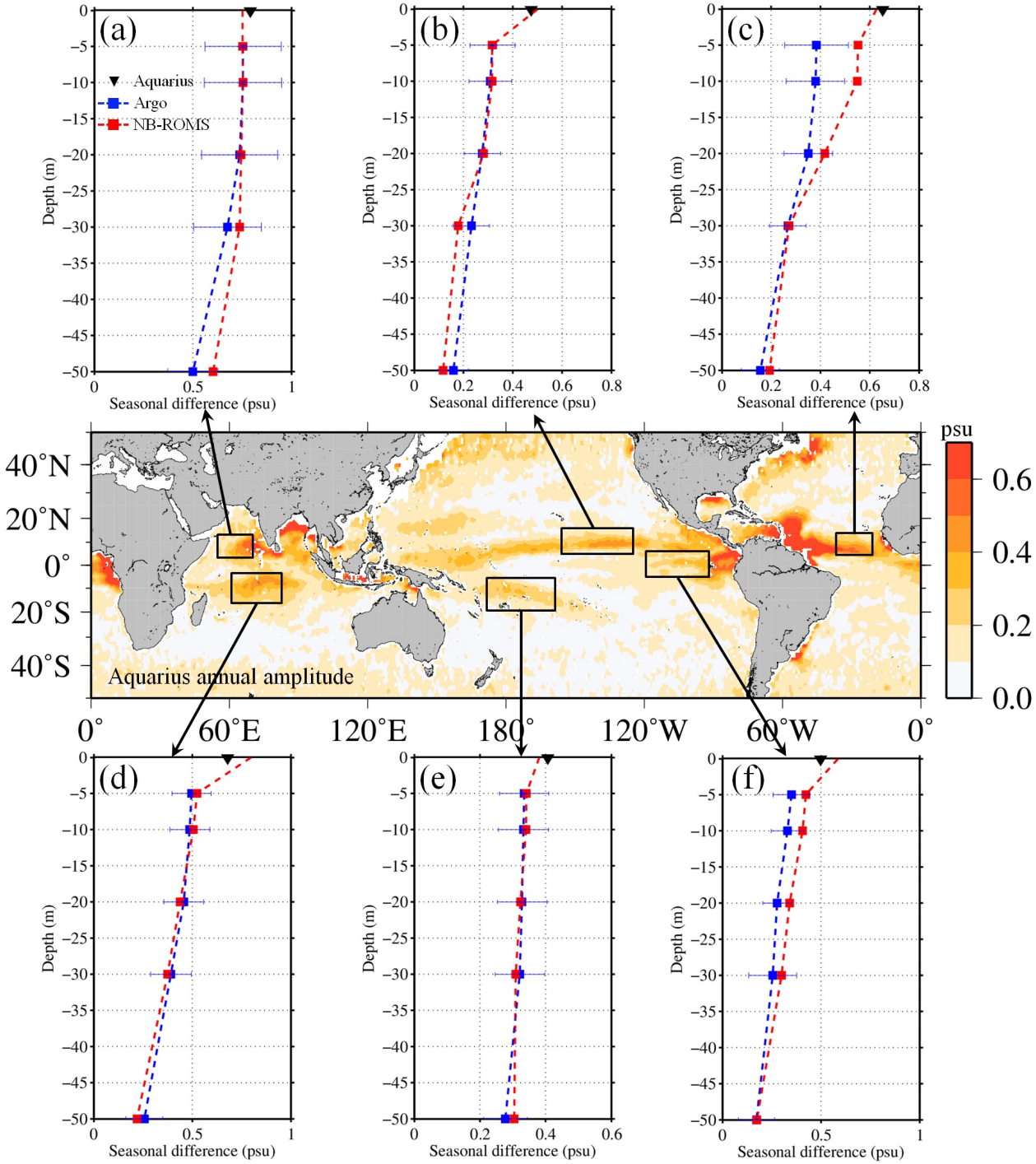
Using a recently developed ESSL (extended surface-salinity layer) model [Song et al., JGR, 2013], we have examined the near-surface salinity stratifications with emphasis on understanding of the dynamical processes that differ from one region to another. It is shown that the seasonal SSS variability at skin layer differs/agrees regionally in their amplitude from/with Argo-measured salinity at 5 m depth and model salinity at the top layer, indicating various characteristics of near-surface salinity stratifications. Our model-data comparisons show that for regions with river runoff and/or surface freshwater, significant differences due to near-surface stratification can be found between the Aquarius, Argo and model. Differently for well-mixed regions, like the southern Arabian Sea due to seasonally reversing currents driven by monsoons, the surface water can be mixed down quickly to the depth of 5 m, resulting in an agreement among the datasets. The modeling study suggests that dynamical differences can lead to different vertical salinity stratifications locally.

Keywords: Satellite observation , Sea surface salinity, River runoff



The role of vegetation as feeder of precipitation on a continental scale

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Precipitation in a continent reduces with increasing the distance from the ocean. However, there is an exception; in the continents covered with forests as in Amazon, Congo and the northern Eurasia precipitation is constant or increases with the distance from the ocean over a few thousands of kilometers. Makarieva and Gorshkov (2007, HESS) and Makarieva et al. (2013, Theor Appl Climatol) hypothesized that forest transports water vapor from the ocean to inland continents (the biotic pump), although they did not specify the hydrological processes.

Evaporation of canopy interception, CI, typically some 20% of annual precipitation, makes forest the greatest evaporative surface on the earth. CI is proportional to the amount of rainfall due to evaporation of splash produced by raindrops impacting onto the canopy (Murakami, 2006, J Hydrol; Murakami and Toba, 2013, HRL).When it is raining around 20% of rain water on the forest cover gets back into the atmosphere in the form of water vapor that can feed constant amount of rainfall over the continents.

Nevertheless, CI is not peculiar to forest, and some studies show ca. 20% of CI was observed in field crops and artificial trees with heights of about 2 m. Though most studies reported that CI declined after thinning of forest stand, on the contrary, Murakami and Toba (2013) observed increase in CI after thinning of an artificial tree stand with a height of 1.1 m (2.3 m above the ground).

These results imply that not only forest but also field crops or shrubs can work as the biotic pump, though it is unknown how the vegetation structure affects CI. Even such short vegetation may contribute increase in precipitation if the vegetation coverage is large enough.

Keywords: canopy interception, biotic pump, vegetation, rainfall, precipitation, splash droplet

Impact of extreme river discharges on coastal ocean environment on example of the North-Eastern Pacific coast of Japan in JCOPE-T ocean model

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As show simple estimations (Troselj et al., submitted), extreme outflow of Japanese rivers caused by passing typhoons and related precipitations can bring monthly climatological amount of fresh water to the oceans just in 2-3 days. Impact of discharged fresh water masses on the coastal ocean environment was analyzed by us using the regional JCOPE-T ocean circulation model nested to the basin scale JCOPE2 model and forced by tides, realistic meteorological fluxes and different presentations of freshwater discharges. In the "base" case the monthly mean climatological river discharges were used. It was compared with the “extreme" case when real-time hourly fresh water discharges from rivers flowing to the north-eastern Pacific coast of Japan for the period of typhoon Roke passage over this part of Japan in September 2011 were applied. Comparison showed significant differences in simulation results for the “extreme" case. Differences could be considered as local and remote. For example, the salinity in proximity of river mouths dropped quickly (in couple of hours) on up to 10-12 PSU and then slowly restored to mean climatology (base case) during more then 15-20 days of model integration. It generated peculiarities in local ocean circulation. Further, lowered salinity waters spread all along the north-eastern coast of Japan, were transported southward and traced along the Kuroshio extension current. Considering an importance of information on detailed realistic river discharges, the Kyoto University group developed hydrological model for selected rivers which would be coupled with the JCOPE real-time ocean prediction systems for improvement of ocean forecasting.

Keywords: Extreme river discharges, Ocean modeling, Coastal ocean environment

Basin scale coupled ocean-shelf ecosystem modelling

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The biogeochemistry and ecosystems of the open-ocean and shelf seas are intimately connected. For example, continental shelves can receive a substantial fraction of their nutrients from the wider ocean, while exporting carbon at depth, sequestering it from atmospheric exchange. Similarly rivers transport substantial quantities of terrestrial nutrients and dissolved organic carbon into the coastal zone. The ultimate fate of this material is dependent on its recycling within and transport across the continental shelves. In both cases the open-ocean to shelf sea coupling is mediated by the complex dynamical processes at the shelf-break and on-shelf. Basin scale, hydrodynamic ecosystem models that merge the modelling approaches of the global scale and the coastal ocean scale, provide an important window into these processes. We draw of results from a 1/12° basin-scale NEMO-ERSEM model of the Northern North Atlantic (Holt et al 2014) with specific features relevant to shelf seas (e.g. tides and advanced vertical mixing schemes). This model is eddy resolving in the open-ocean, and well resolves barotropic scales on-shelf. We use this model to explore the ocean shelf nutrient transport and its relation to wider scale oceanic and atmospheric variability (e.g. sub-polar gyre variability and the North Atlantic Oscillation). We compare the performance of this model with its parent global ocean model and global climate models from the CMIP5 ensemble; demonstrating a marked improvement. We go beyond this North Atlantic work to introduce new basin-scale and global-scale coupled ecosystem modelling efforts focusing in the western Indian Ocean and South East Asian seas, and we explore how the capabilities developed in this context can be translated to global models (Holt et al 2017).

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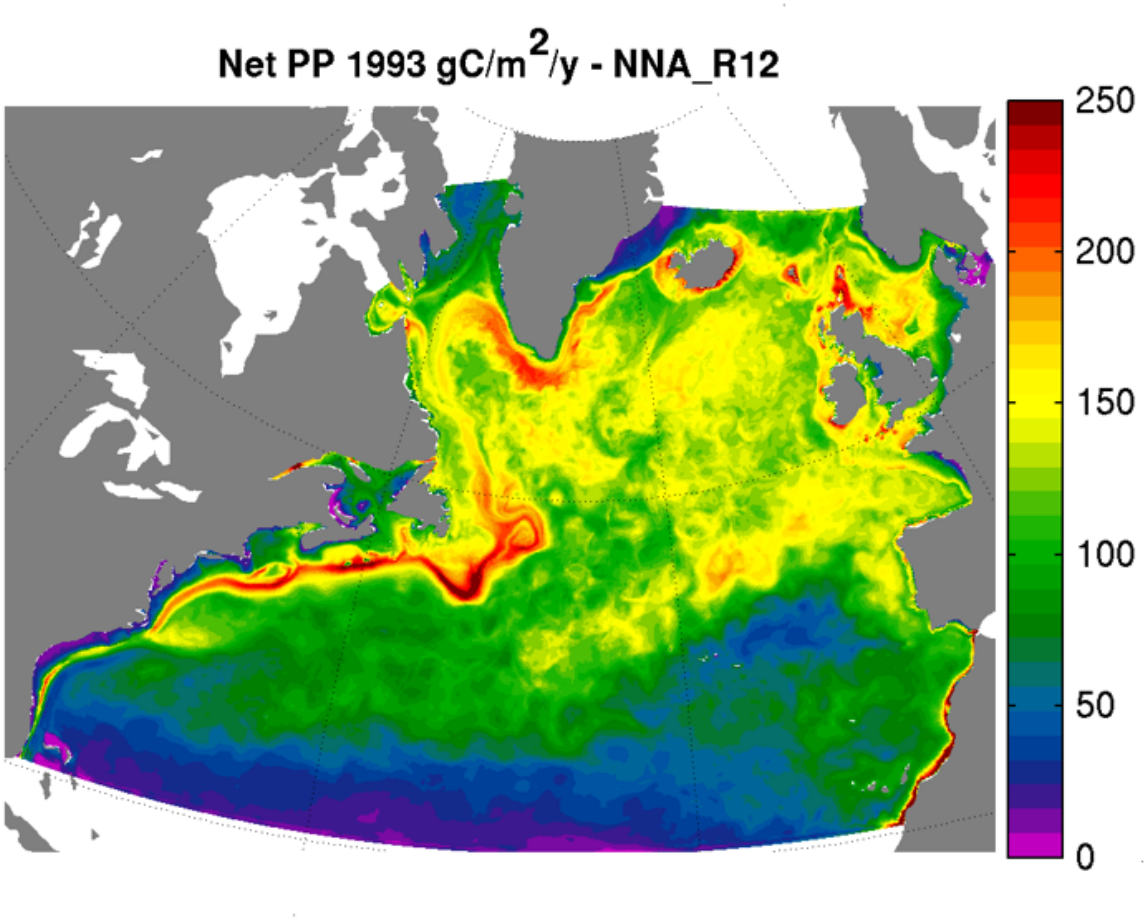
Keywords: ocean-shelf coupling, coupled hydrodynamic-ecosystem modelling, shelf edge and shelf sea processes, Global coastal ocean modelling



Relationship between pollen distribution and marine environment in Northern South China Sea

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Then pollen records from the tropical West Pacific indicate that the tropical vegetation is much sensitive to the environment and climate change. But, for the marine pollen record, the source area and distribution of pollen grains is the key information for data analysis. Through the high density sample collection in the northern South China Sea, the distribution of the pollen grains show that, much high concentration is mainly along the coast line within 30 km away from the land, especially the estuary area. Then, with the distance between the land and the deposition point increasing, the value of the pollen drops sharply. Among that, the content of the *pinus* and spores is much high when the deposition points is 40-100 km range and 80-110 km range offshores, respectively. That indicates the very different transport path and ability among the pollen groups. Combined the topography and the grains size analysis result, it present that the pollen grains deposit in the terrain slope break and the less hydrodynamic areas when they are transported by the sea current.

Keywords: pollen distribution, marine environment, northern South China Sea

Possibility of water on the surface of the Moon

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When we see the Moon by ground-based telescopes or photos of the Moon taken by spacecraft or the Apollo astronauts, we just see very dry desert. However now we have some evidences of existence of water on the surface of the Moon by lunar explorations. It is a very interesting issue that whether water exists on the surface of the Moon or not, from the point of not only the planetary science but also the utilization of the lunar surface such as lunar-base. In this presentation, we will review the results obtained by previous lunar explorations, and show some possibilities for future explorations.

The possible existence of ice in the permanently shadowed craters at the Moon's poles has been said for long time. Chandrayaan-1, which was launched by India in 2008, observed spectral absorption by water molecule or hydroxyl group mainly in the polar region of the Moon. This indicated the existence of water on the surface of the Moon. In the mission of LCROSS (Lunar Crater Observation and Sensing Satellite) launched by NASA in 2009, the attached tank was separated and it hit the surface of the Moon. Then a debris cloud was made and the spacecraft observed it. Also water or hydroxyl group was confirmed to exist. However, there are many unknown things such as in what form the water exists or how much water exists.

Several theories are put forward to explain the origin of the water on the Moon: (1) originated from the interior of the Moon, (2) brought by asteroids or comets, (3) created by protons in the solar wind by colliding to oxygen in the regolith. Anyhow, since it is indicated that water exists on the surface or the Moon, there are some discussions for future explorations to study the water on the Moon both in Japan and in abroad. We hope such missions will be realized in the near future.

Keywords: water, Moon, exploration

First True Gamma-ray Spectroscopic Imaging of Contamination near Fukushima Plant and Extension to the Whole Area in Fukushima

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We have developed Electron-Tracking Compton Camera (ETCC), which provides a well-defined Point Spread Function (PSF) by reconstructing a direction of each gamma as a point, and hence can measure both brightness and energy of incoming gammas within PSF simultaneously. Then obtained images give the emissivity and energy-spectrum of any point, independently of its distance, which no other instruments can give.
Here we present the results of our on-site pilot gamma-imaging-spectroscopy with ETCC, carried out at several contaminated and decontaminated areas around the Fukushima Daiichi Nuclear Power Plant in Japan in 2014, after the major accident of the plant. Obtained brightness (or radioactivity) distributions were directly transferred to the dose on the ground with no ambiguity. The dose distribution was quantitatively consistent with that taken by mapping measurements with a dosimeter, which verifies the complete reproducibility of radioactivity in observed area by ETCC. In addition, imaging spectroscopy reveals quantitatively the complex radioactive features around each target point under intense background of scattered gammas. Notably, the ETCC imaging spectra free of Compton edges enabled us to spot both a “micro hot spot” of remaining caesium, even in a decontaminated area and dominant scattered low-energy gammas from sky in all areas. Thus, ETCC provides the performances expected from geometrical optics completely, which guarantees the universality and general versatility of ETCC. This success enables us to measure directly a distribution of the essential parameter of the radioactivity, which can be coarsely inferred from the dose distribution so far.
Here using this excellent feature of the ETCC, we have simulated the possibility of the detailed spectroscopic imaging for whole contaminated area in Fukushima Prefecture using the improved ETCC which is being developed for the balloon experiment for astronomy in 2018, and will show the possible survey using the airship at the altitude of 100 with a 10 m x 10 m resolution. Then the whole contamination area in Fukushima prefecture (about 20 km x 50 km) may be be mapped with this area resolution during a few months, assuming the working time of 8 hours per day. Some of the spectra obtained in this survey might be found out to be generated by the gammas scattered by something, such as trees in woods, within the grid. Our survey will efficiently detect a hint for those areas, which can be then studied in more detail with on-site measurements, such as ones by backpacks. No successful large-scale survey has been yet performed to monitor the radioactivity in Fukushima. Our upgraded ETCC will be capable of revolutionizing the situation.

Keywords: gamma-ray imaging spectroscopy, Fukushima, Nuclear Power Plant

Effect of irrigation water withdrawals on water and energy balance in the Mekong River Basin using an improved VIC land surface model

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We present a detailed analysis of the effect of agricultural irrigation water abstraction on surface water, energy state and flux, using a model simulation to predict changes in Bowen Ratio, surface temperature and water resources within the Mekong River Basin. Using the Variable Infiltration Capacity (VIC) macroscale hydrological model including the infiltration, surface runoff, subsurface runoff, drainage from the soil layer, and irrigation scheme, together with the most recently available and accurate geophysical, geological and meteorological forcing datasets, we carried out the hydrological simulation on three calibration parameters. The multi-objective complex evolution (MOCOM-UA) optimizer was used to calibrate the model, which revealed a significant decrease in Bowen Ratio due to irrigation water withdrawal: this in turn affected surface temperature. We conclude that (1) the performance of the improved
model was generally good, with an overall Nash–Sutcliffe Efficiency of 0.86 for the validation period 1986–1993; (2) the volume-based total Net Irrigation Water Requirement was about 24×109m3/year for the period 1979–2000; (3) including the irrigation water withdrawals from runoff, river channels and dams decreases the total monthly runoff by 32% compared to the “no irrigation” baseline; (4) the period-averaged Bowen Ratio decreased by 6.8% in the dry season as a result of irrigation effects; (5) this significant decrease in Bowen Ratio resulted in a decrease in average surface temperature of 9.3×10−2% and a maximum of 4.8% over irrigated areas during the dry season.

Keywords: Irrigation water withdrawals, Runoff, Mekong River

Numerical simulations of debris flow by the smoothed particle hydrodynamics

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The debris flows are an important phenomenon since it can threaten the human lives.
Since the laboratory experiment of debris flows in real scale is hard to perform, numerical simulations play an important role to evaluate their impact.
Among several candidates, the smoothed particle hydrodynamics (SPH) is an attractive numerical method for this purpose.
SPH is a particle-based numerical hydrodynamic method, which is originally developed in the astrophysical field and then extended to elastic bodies.
Several works have been already published which tested the applicability of SPH to the debris flow.
We, however, state that the accurate treatment of the elastic bodies tends to be computationally expensive.
Thus, we have developed a massively parallel SPH code with various state-of-the-art numerical flavours.
Our code can work on up to the full nodes of Japanese supercomputer K.
We will show the comparison between numerical simulations and laboratory experiments.

Introduction of canopy component into Isopycnal-layered model for hydrological calculation

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Isopycnal-layered model (Kida and Yamashiki, 2014) was proven to be an innovative river-ocean interactive model capable for handling both land-ocean and ocean-land interaction without creating specific physical component. According to their modeling, calculated discharge at each subbasin showed good agreement with gauged data without making any specific adjustment. At the same time, the original model was, since established for oceanographic usages, no component was prepared to trace hydrological processes.
In this study, we introduced how to develop basic hydrological component in the model and performed several testing calculation comparing the original model output and revised model scheme. The infiltration ratio and storage ratio in each canopy is set and included in hydrological processes in forest zone.
By introducing this basic hydrological component with necessary arrangement, this Isopycnal-layered model can be applicable for all different basins with minimum requirement (DEM and Land-use), which may facilitate significantly for the continental-oceanic integrated calculation.

Keywords: Isopycnal-layered model, Canopy model

