O-1111-04

Influence of climate changes on mangrove ability to fix and store CO2

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Mangroves are forested ecosystems developing in the intertidal zone of tropical and subtropical coastlines. They cover up to 140,000 km² worldwide, and extend from 30°N to 38°S (1). They are amongst the most productive ecosystems in the world (2). Furthermore, they have been suggested to be enhancers of heterotrophic secondary production and offshore fisheries. In addition, it is well recognized that tropical mangrove ecosystems provide a high abundance of food, shelter, and breeding and nursery habitats for a diverse community of terrestrial, aquatic and aerial organisms, including many endangered species (3). At a larger scale, the high net primary productivity of mangroves and low decomposition rates results in global atmospheric CO2 sinks (4). In addition, mangroves are crucially important ecologically and economically, supporting a wide variety of ecosystem services (5). For example, mangroves stabilize the shoreline and serve as barriers against erosion. One of the most dramatic examples of the efficiency of this biological system as protection from catastrophic climatic events was demonstrated in 2004, when a large-scale tsunami devastate most coastal areas, but mangrove forested shorelines were significantly less affected (6). The annual economic value of mangroves, including products and services has been estimated to be US$ 200,000-900,000 ha-1 (7). Mangrove ecosystems have been decreasing dramatically worldwide, mainly due to habitat destruction. Once mangroves covered more than 200,000 km2 worldwide (8). However, human population growth and urbanization of coastal areas, expansion of industrial activities, and exploration and exploitation of natural resources have resulted in a current decrease in mangrove area of 1 to 2% per year. This declining rate is equivalent or even higher than that of other threatened ecosystems, such as coral reefs or primary rainforests (9). Mangrove ecosystems also are also threatened by climate change. However, the responses of mangrove ecosystems to climate changes are not well understood (10). Relative sea-level rise may be the greatest threat to mangroves because most mangrove sediment surface elevations are not keeping pace with sea-level rise (11). Additionally, the increases of temperature and atmospheric CO2 concentrations may also modify their functioning and distribution. Reduced mangrove area and health will increase the threat to human safety and shoreline development from coastal hazards, such as erosion, cyclonic events, and tsunamis (12). Mangrove habitat loss also may reduce coastal water quality, biodiversity, and fish and crustacean breeding and nursery habitats. Such ecological deterioration may have direct and indirect adverse effect on adjacent coastal habitats, and may eliminate a major resource for human communities that rely on mangroves for numerous products and services. Mangrove destruction also has the potential to release large quantities of stored carbon, which can have dramatic global implications (13). A synthesis of the current knowledge will be proposed, and our project of mangrove monitoring in the Indo-pacific area will be presented.

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Evolution of dengue epidemics in the south pacific in the present and the future

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Dengue fever is the most important mosquito-borne viral disease, with 390 million people being infected each year and 2.5 billion people living in areas at risk of dengue worldwide. The rapid global spatial spread over the past 40 years is likely to be due to recent socio-economic changes such as global population growth and uncontrolled urbanisation but these factors need to be associated with suitable climatic conditions before dengue fever can establish itself in a given country, for it is transmitted by a number of mosquito species, mainly Aedes aegypti, whose life cycle is influenced by temperature, rainfall and humidity. In the following contribution, we focus on the South Pacific region, a vast, oceanic region where dengue epidemics are recurrent, aiming at disentangling socio-economic factors from climate factors.

We first analyse an original dengue database covering the 1971-2009 period across the South Pacific. In the Pacific region, dengue epidemics occurred every 3 to 6 years, with each epidemic wave caused by the regional circulation of 1 of the 4 dengue virus serotypes, with very limited serotype co-circulation. There are no apparent spatial propagation patterns in the region, and countries such as French Polynesia and New Caledonia are the most regularly affected. There is a weak anti-correlation between the major El Niño climate variability and the annual number of countries experiencing an epidemic, suggesting a link between climate and dengue epidemics. However, while the South Pacific has experienced a weak + 0.5°C trend in temperature, there is no detectable overall/regional long-term trend in the evolution of the number of affected countries for the past 40 years. However, local trends exist: New Caledonia is experiencing a positive trend whereas dengue epidemic frequency is decreasing in some smaller islands. We then analyse dengue epidemic profiles per country (endemic, regular epidemics, or sporadic epidemics). We identify variables linked to the different profiles by fitting a statistical model based on variables characterizing the socio-economic situation (e.g. GDP) or climate (e.g. temperature) in each country. These statistical models are able to reproduce the major epidemic profiles. Assuming the socio-economic variables to remain constant over time, we project these models for the next 100 years using models of the IPCC-AR5 under RCP8.5.

Finally, we focus on the case of New Caledonia where very high quality data allows a more quantitative analysis. At present, dengue epidemics there occur approximately every 6 years. Using spatial statistical modelling, we show that the primary variables explaining the spatial distribution of incidence rates are the mean temperature and a variable highly correlated with people's way of life. Using this model, we show that by the end the 21st century, with temperature increasing by approximately 3°C as projected by 6 IPCC-AR5 models in New Caledonia, mean incidence rates will be multiplied by two, with areas currently at low risk of dengue fever being highly exposed in the future. In terms of dengue epidemics recurrences, we also build a temporally dynamic model at weekly time scales allowing the detection of the beginning and length of dengue epidemics. One key variable is the number of days where temperature exceeds 32 °C. As this number will increase substantially over the next 100 years in the IPCC-AR5 models, we show that the proportion of dengue epidemic years will rise from 17 % at present to 100 % in the RCP8.5 scenario and 66 % in the RCP4.5 scenario, with the duration of dengue epidemics substantially increasing compared to the present day. Implications for the future of dengue virus circulation in the South Pacific are discussed on the basis of our results

1111-POSTER PRESENTATIONS

P-1111-01

Mass mortality events in atoll lagoons: present environmental control and increased future vulnerability with climate change

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Several geomorphologically closed atolls of the Pacific Ocean have experienced in recent decades mass benthic and pelagic lagoonal life mortalities, that are due to unusual calm weather conditions lasting for several weeks. These events, although poorlyknown and characterized, pose a major threat for resource sustainability for islanders, and need to be taken into account for long-term resource management. A sample of eleven mortality events on eight atolls from the central South Pacific occurring between 1993 and 2012 were revisited to estimate the environmental thresholds required to trigger such events. We investigated thresholds and spatial patterns of sea surface temperature, significant wave height and wind stress satellite data. Then, using these thresholds, spatial maps of present-day potential risk are produced for the central South Pacific region. The highest risk zone lies north of the Tuamotu Archipelago in French Polynesia. To assess future risks in a climate change era, a regional climate model is used to downscale the projected future climate and to estimate the potential change in risk by the end of the 21st century. This process highlights a relative risk increase of up to 60% for the eastern Tuamotu atolls/ However, caution is required given the limited number of case-studies available to train the analysis and identify thresholds. This study suggests that long-term monitoring of the biophysical conditions of the lagoons at risk is needed to precisely identify the physical thresholds and better understand the biological processes involved in these rare, but consequential, mass mortality events.

P-1111-02

Mesopelagic heterotrophic N2 fixation related to organic matter composition in the Solomon and Bismarck Seas (Southwest Pacific)

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The oceans play a key role in absorbing carbon dioxide (CO2) emitted by human activities. This absorbing power depends largely on the activity of microalgae, which take up CO2 using nutrients and sunlight. The availability of nutrients is thus essential for maintaining life in the oceans and balancing global CO2 levels. In open ocean areas nitrogen is mainly provided through nitrogen fixation, a process performed by specific microorganisms called diazotrophs. Primary production in the oceans is strongly limited by the availability of fixed nitrogen. In open ocean nutrient-impoverished areas, which make up ~50% of the global ocean surface, nitrogen is mainly provided through the process of biological atmospheric nitrogen (N2) fixation. N2 fixation is carried out by the so termed diazotrophs, marine microorganisms that may belong to the cyanobacteria, bacteria or archaea. For many years, autotrophic diazotrophs were thought to be the most abundant diazotrophs in the ocean. Autotrophic diazotrophs need light to fix carbon dioxide via photosynthesis, and therefore are constrained to the sunlit layer of the ocean, which is generally less than 100 m deep. Recent investigations have revealed that heterotrophic diazotrophs, which cannot photosynthesize, are present in greater abundance than autotrophic diazotrophs in the world's oceans. Heterotrophic diazotrophs are not constrained by the availability of light and therefore are able to live in the dark ocean, the largest and less studied habitat on Earth. This discovery significantly expands the boundaries where N2 fixation was though to be possible and theoretically increases the inputs of fixed nitrogen to the ocean, which remain unaccounted for. The diazotrophs inhabiting mesopelagic dark waters are heterotrophic and depend on organic matter for their nutrition. In this habitat, these microorganisms can live in association with oxygen minimum zones or local oxygen deficit microzones like organic particles. However, the relationship of heterotrophic diazotrophic activity and diversity with organic matter is unknown. We investigated N2 fixation along two transects in the Bismarck and Solomon Seas (Southwest Pacific, Transects 1 and 2 respectively). In Transect 1, transparent exopolymer particles (TEP) where higher and oxygen concentrations lower than in Transect 2. The presence of N- and P-containing dissolved organic matter (DOM) compounds was also higher in Transect 1 than in Transect 2, as revealed by Fourier transform ion cyclotron mass spectrometry. N2 fixation rates (0.09-1 nmol N L-1 d-1) were higher in Transect 1 than in Transect 2, and correlated positively with TEP and negatively with oxygen, reflecting the dependence of mesopelagic heterotrophic diazotroph activity on organic matter. The scores of the multivariate ordination of DOM samples (principal coordinate analysis) were negatively correlated with bacterial abundances and positively correlated with N2 fixation rates. We interpret these results as an active bacterial exploitation of the DOM pool and its use to sustain diazotrophic activity. Phylogenetic analyses of the nifH gene detected γ-, δ-, α- and β-proteobacteria (Cluster I), Cluster III and Cluster IV. The relative importance of anaerobic Cluster III phylotypes in our clone library (26% of sequences), suggests that N2 fixation was partially supported by diazotrophs with a particle-attached lifestyle. Custom-designed quantitative PCR primer-probe sets were designed for three selected phylotypes. The abundances of a phylotype close to Cluster III ranged from undetectable to 1000 nifH gene copies L-1. Altogether, our results provide new insights into the mysterious ecology of heterotrophic diazotrophs and suggest that in situ organic matter sustains their N2 fixation activity. The input of fixed N2 by these organisms is significant and potentially contributes significantly to nutrient replenishment and primary production in the SW Pacific.

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Autonomous observations with Bio-Argo floats in the Southern Ocean

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The Southern Ocean (SO) is the most remote and the least understood of the world's oceans, although it plays a crucial role in past and present climate state and changes. It is unique in being the only zonally unbounded ocean. For this reason, it is the major link by which water properties are exchanged among the other oceans. Moreover, the SO is a major source of natural CO2 due to the upwelling of CO2-rich deep waters and a major sink of anthropogenic CO2 due to the formation of intermediate and bottom waters. The SO also largely contributes to supply nutrients from the deep ocean to the upper water layer everywhere in the world ocean. For all these reasons, the SO plays a critical role in the control of the Earth's climate. In turn it is very sensitive to climate variability. Given its critical

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ABSTRACT BOOK

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