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RESEARCH

Boosting the Earth's "Immune System": the Development of an "Ocean Mission Architecture Optimization"

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Abstract

Since the 1960s, researchers have studied catastrophes and have predicted that the Earth's Systems are moving towards a new equilibrium. We are heading towards a new Ice Age. The question is whether mankind can withstand it. Eighty-two percent of the world's largest cities are situated on coastal areas cf. (Creel in Ripple effects: population and coastal regions, PRB. https://www.prb.org/resources/ripple-effects-population-and-coastal-regions/, 2003). Urbanization and deterioration of mangroves, the marine ecology and coastal environments bring cities in the front line of impact with the climate crises. While, ever since the 1970s, oceans have absorbed 93% of the excess atmospheric heat from greenhouse gas emissions cf. (Ocean Warming in IUCN. https://www.iucn.org/resources/issues-briefs/ocean-warming, 2017), megacities continue to grow over a boiling pot. What comes next remains to be seen, yet this paper proposes the development of an "Ocean Mission Architecture Optimization" (OMAO) as a step forward in combining interconnected proactive plans for future Ocean and land-use sustainability.

Keywords Earth Systems · Ocean sustainability · Optimization · Architecture · Coastal areas · Climate change · Renewable energy

1 Introduction

In the 1960s, the French Mathematician and father of Catastrophe Theory René Frédéric Thom cf. [1] managed to classify effects and identify parameters that through equations could calculate how behavioral changes can be related with sudden or unpredictable life-threatening events, such as landslides. About a decade later, in 1979, the Hungarian-American Theoretical Physicist and father of the Hydrogen Bomb Edward Teller wrote in his book *Energy from Heaven and Earth* that we are heading towards the next Ice Age, which is expected to occur in 5000 years [14]. Action orchestration is needed; or

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else, our actual existence will be under threat, he described. Teller also added that: “No single prescription exists for a solution to the energy problem. Energy conservation is not enough. Petroleum is not enough. Coal is not enough. Nuclear energy is not enough. Solar energy is not enough. New ideas and developments will not be enough by themselves. Only the proper combination of all these will suffice” [14].

Remarkably, while researchers have been stressing out the unpredictable and disastrous consequences of the upcoming crises, no combined actions were effectuated on time to mitigate the results of global warming. Technological methods were developed to predict—through artificial intelligence and machine learning—various changes. Interpreting, for instance, the vastness of ocean movements is a complex task requiring sensors to be installed in different locations of the Atlantic Ocean in order to collect data, useful for climate-ocean modeling cf. [12] in order to optimize future living.

The ever growing man-made global warming is unfortunately expected to bring more frosts and more heat waves over the course of the years ahead cf. [2, 5]. University of Columbia NASA Climate Specialist Dr. J. E. Hansen has predicted also that a significant rise in the sea levels is expected [6] posing a direct threat on coastal living.

2 Alarming Facts and International Agreements

Water covers 71% of the earth’s surface. Out of this, oceans cover 96.5% cf. [16]. This means that water and ocean-related environmental sustainability is essential. However, since the 1970s the Intergovernmental Panel on Climate Change (IPCC) announced that the oceans have absorbed more than 90% of the excess heat from greenhouse gas emissions (see 5th Assessment Report [11]. As oceans absorb large amounts of excess atmospheric heat keeping the earth cool, Imperial College researchers [17] have estimated that from 1971 to 2010, the earth received an amount of 274ZJ heat energy, of which the ocean absorbed 90%. This immense level of heat energy absorption seems to have increased the oceans’ temperature by 0.09 °C. This drastic figure reminds us that without the high heat absorption capacity of the oceans, the atmosphere would have warmed up much more significantly and the global temperature would in fact have risen to 36 °C [17], or more.

While the 0.09 °C increase in the oceans’ temperature might falsely seem rather small, it is not. Global warming from 1.3 to 1.5 °C has been calculated to bring a rise in the sea level by around 48 cm by 2100 [8]. A rise from 1.3 to 2.0 °C is expected to bring the sea surface up to around 56 cm [8]. Increasing temperatures to 1.5 °C, 2.0 °C, and 3.5 °C is expected to bring respectively 16, 23, and 41 times more marine heat waves annually. Such alarming temperature increases are expected to create an exponential rate of ice melting, the acceleration of which is estimated to cause multi-meter sea level increase [3]. This is expected to have a direct impact on communities dwelling coastal areas who might be forced, within this century, to evacuate their areas and relocate to new ones that might or might not be hospitable.

The 2014 Paris Agreement [15] thus included 196 parties endorsing targets aiming for a global transition to halving the greenhouse gas emissions by 2030. It was agreed also that the global temperature rise (since the pre-industrial period) should be limited to up to 2.0 °C, a figure that seems challenging to meet. That is because in 2020, calculations suggested that, since the pre-industrial period, the global temperature rose to + 1.3 °C and that this figure is expected to reach + 3.9 °C by 2100, should no action is taken [13].

While the oceans are heating up, about 2 decades ago, PRB stated that 14 out of 17 largest cities of the world are located on coastal areas [4]. Urbanization has led also 40% of the cities with up to 10 million people to live near coastlines [4]. In 2003, PRB also stated that absorbing nutrients of the marine life and destroying coastal ecosystems have lead urbanized coastal areas to become finally the direct receptors of storms. The degradation of the coastal ecosystems through the loss of a majority of over 70% of the total mangroves of areas such as in Puerto Rico and the Philippines has led weather interactions with human settlements to become ever more severe [4]. The interface between the coastal cities and the respective sea fronts is potentially the first receptor of the raging impact of the Earth's Climate Systems destabilization.

While oceans seem to act as the "first line of defense" in Earth's "immune system," global warming causes the melting of ice sheets that further lead to the development of ocean currents, which impact coastal regions [12]. Steadily converting oceans into "a hot soup," as vividly stated by Joe McCarthy (Global Citizen environmental writer) [9], is expected to boil the marine ecosystems causing local food scarcity, poverty, and global insecurity.

3 Ocean Mission Architecture Optimization (OMAO): Interconnection Plans for the Defense of the Earth's Systems

There is one important case embedded in the challenge of limiting global temperature that the earth's climate systems respond rather slowly to change and therefore there is an inertia (which might take a few decades) associated with the transitioning of the climate systems to a new equilibrium state [10]. Nowadays, IMO [7], NASA, EC (cf. Green Deal), and other global organizations act towards influencing research communities, but also the general public in working together to preserve and proactively optimize the environment and its conditions. Various sectors, such as shipping, combine applied mathematics, new technologies, and environmental analytics to try sailing large cargo vessels using "greener" fuels. Urban analytics are performed also in port areas and more environmentally friendly designs are considered.

Developing an Ocean Mission Architecture Optimization (OMAO) requires the transition of a large array of research missions and interdisciplinary strategies in creating synergies that can span in a broad spectrum, such as (i) environmental and energy-related, (ii) social innovation, (iii) new eco and user-friendly technological developments, (iv) port-related and coastal architectural design, (v) oceanographic, (vi) marine and maritime, and (vii) legislation and global policy-making, to name just a few.

Below, four OMAO interconnected plans that could be combined with each other or with other plans are outlined. These are used herewith, as an example of ways to design simple yet multifaceted and replicable missions aiming to (i) face the multiplicities of the effects to come and at the same time (ii) optimize conditions for a safer and more sustainable future.

3.1 OMAO Interconnected Plan 1: Coastal Cities to Tackle Marine Pollution Sustainably

- Coastal areas are makers and receivers of ocean debris. Identifying the movement of floating and sinking debris into the oceans and coastal areas is crucial. The use of technology and other tracking systems could be helpful.
- Find the debris, “fish it,” and re-use it sustainably (the case of up cycling). Collecting debris is not sufficient alone.

3.2 OMAO Interconnected Plan 2: Attract Social Engagement to Diffuse Sustainable Plans

- Create maker-spaces to engage communities into converting the debris into usable infrastructure, objects, tools, and elements for sustainable living.
- Create awareness on how to co-create and join missions with technologists and/or scientists who can supervise the production of the elements of living for a more sustainable future.
- Use social innovation models for social engagement and inclusion that could be applicable in each case.

3.3 OMAO Interconnected Plan 3: Energy Conservation Through Coastal and Port Cities

- Wind and solar energy is incremental. Combining these renewable sources of energy with biogas, biofuels and wave energy could create 100% zero emission communities.
- Wave energy can be produced in coastal areas or offshore and thereafter be used for the coastal area’s electrification.
- Biogas can be developed in agricultural areas and be shipped through electrified freight trains to coastal areas to support port and shipping related-operations.
- Biofuels and biogas could be created to minimize carbon footprints from landfills but also to power the sailing of sea vessels and the operation of ports as well as coastal cities. Biogas can be purified and applied in natural gas networks. It can also offer a possible replacement to natural gas.

3.4 OMAO Interconnected Plan 4: Make Technology User-Friendly and Solutions Replicable

- Connecting new technologies with the users who can interact with them can be of actual assistance not only on mitigation plans, e.g., before the occurrence of a storm, but could also offer useful information to the scientific world by the users, thus making the users an integral part for the creation of a vast database to be used and analyzed from the scientific community.

- Invite different sectors of scientific endeavor and practice to communicate with each other in order to provide different viewpoints and experiences, which will be of use in order to examine data in a multifaceted manner.
- Add architectural values and human values in technological advancements.
- Interconnect OMAO plans 1, 2, 3, and 4 with other existing strategies as well as future plans.

Overall, the above-mentioned are outlines of the actual interoperability between different sectors (e.g., marine, maritime, environmental, oceanographic, architectural, mathematical, technological, and socio-economic). More is being analyzed and joint proactive plans could be developed in promoting an overarching "Ocean Mission Architecture Optimization" (OMAO).

4 Conclusion

This paper discusses action plans in developing an overarching "Ocean Mission Architecture Optimization" (OMAO), which we have coined as a strategy to co-design, communicate and co-create sustainable futures. OMAO's mission is to introduce new ideas as well as combine them with established ideas and research results, aiming to provide what E. Teller suggested in his book "Energy from heaven and earth" [14]:

> The proper combination of all.

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Declarations

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References

1. Britannica, René Frédéric Thom: French mathematician. https://www.britannica.com/biography/Rene-Frederic-Thom. Accessed 23 Aug 2022

2. Center for Climate and Energy Solutions (C2ES) Heat waves and climate change. https://www.c2es.org/content/heat-waves-and-climate-change/. Accessed 7 July 2022
3. Climate Citizen (2012) Is climate change causing an exponential rate of ice sheet mass loss, sea level rise?. https://takvera.blogspot.com/2012/12/is-climate-change-causing-exponential.html. Accessed 7 Aug 2022
4. Creel L (2003) Ripple effects: population and coastal regions, PRB. https://www.prb.org/resources/ripple-effects-population-and-coastal-regions/. Accessed 8 Sept 2022
5. Gammelby PF (2020) Global warming means more frost damage to trees in Europe and Asia, Aarhus University. https://nat.au.dk/en/about-the-faculty/news/show/artikel/global-opvarmning-giver-traeer-i-europa-og-asien-flere-frostskader-1. Accessed 1 Sept 2022
6. Hansen J, & Sato M, Updating the climate science: What path is the real world following?. http://www.columbia.edu/~jeh1/. Accessed 23 Aug 2022
7. IACS IMO POLARIS: IACS overview, IACS: 4th PAME Shipping Best Practices Information Forum, London. https://pame.is/images/03_Projects/Forum/4th_meeting/Presentations/Session_4_-_James_Bond.pdf. Accessed 8 Oct 2022
8. Lindsey R (2022) Climate change: global sea level NOAA Climate.gov: Science & Information for a Climate-Smart Nation. https://www.climate.gov/news-features/understanding-climate/climate-change-global-sea-level. Accessed 23 Aug 2022
9. McCarthy J (2021) Climate crisis: what's the difference between a rise of 1.5, 2, and 3 degrees celsius?, Global Citizen. https://www.globalcitizen.org/en/content/the-difference-in-global-warming-levels-explained/. Accessed 18 July 2022
10. NASA Earth Observatory, Bad news, good news. https://earthobservatory.nasa.gov/features/HeatBucket/heatbucket4.php. Accessed 18 Sept 2022
11. Ocean Warming (2017) IUCN. https://www.iucn.org/resources/issues-briefs/ocean-warming. Accessed 18 Sept 2022
12. RACE-Synthesis, Global Change Ocean and climate modelling. https://race-synthese.de/ocean-and-climate-modelling. Accessed 20 July 2022
13. Schleussner CF, The Paris Agreement 1.5C temperature goal, Climate analytics. https://climateanalytics.org/briefings/15c/. Accessed 1 Oct 2022
14. Teller E (1979) Energy from Heaven and Earth, W. H. Freeman and Company, San Francisco.
15. United Nations Treaty Collection (2015) Paris Agreement Chapter XXVII Environment. https://treaties.un.org/pages/ViewDetails.aspx?src=TREATY&mtdsg_no=XXVII-7-d&chapter=27&clang=_en. Accessed 10 July 2022
16. Water Science School (2019) How much water is there on Earth? USGS Science for a Changing World. https://www.usgs.gov/special-topics/water-science-school/science/how-much-water-there-earth. Accessed 7 June 2022
17. Whitmarsh F, Zika J, & Czaja A (2015) Ocean heat uptake and the global surface temperature record Imperial College London: Grantham Institute Briefing Paper No14. https://www.imperial.ac.uk/media/imperial-college/grantham-institute/public/publications/briefing-papers/Ocean-heat-uptake---Grantham-BP-15.pdf. Accessed 7 June 2022