Bluerise harnessing the ocean's power

TU Delft Energy Initiative

EUROPEAN SPACE WEEK CONNECTING THE FUTURE

MARINE and MARITIME PARALLEL SESSION
Using and preserving our marine environment

Space as a tool supporting the energy package

Dr Adam Candy

with Maria Lems–de Jong, Berend Jan Kleute, Rémi Blokker, Paul Dinnissen, Julie Pietrzak, Laurence Crosnier and Copernicus Marine Environment Monitoring Service (CMEMS) team

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Copernicus Europe's eyes on Earth

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Motivation: What drives the need to support our future energy security? Why now?

Existing traditional energy generators

e.g. carbon fuels: gas, oil, coal fire powered,
nuclear fission ⟶ steam turbines

- Location-agnostic
- Continuous (all day, all night, 24/7)
- Instantaneous (to meet demand)
- Linear (fuel in ⟶ energy out)
- Effectively unlimited
  (assuming fuel provided)

Transitioning towards

New sustainable approaches to energy generation

e.g. wind, solar, ocean, hydro, biomass,

- Local resource dependence
- Different locations demand different technology
- Conversion technology unrefined ⟶ energy out?
- Variability in resource availability (over varying timescales)
- Local environment inter-dependence

NEGATIVES

- Dangerous by-products (CO2, SO2, radioactive)
- Fuel transport & sourcing
- Questionable security

NEW CHALLENGES

- Understanding variability of renewable resources
- Forecasting short-term for energy grid management
- Long term trend changes in resource
- Impact of extraction on environment and availability
  - Lack of data

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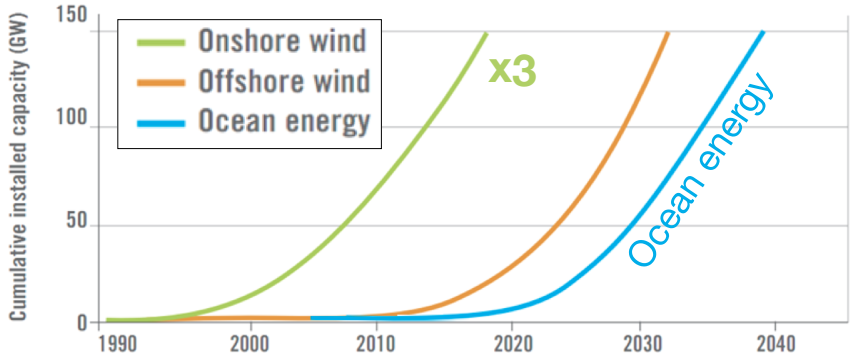
Why Ocean Energy?

The transition to sustainable energy sources is underway.

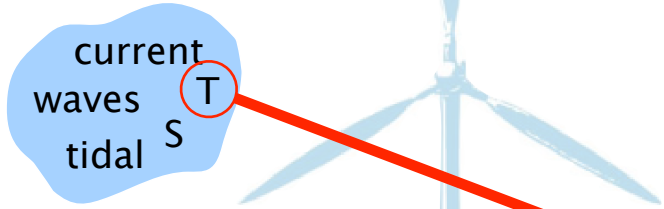
Diverse mix is central to its success.

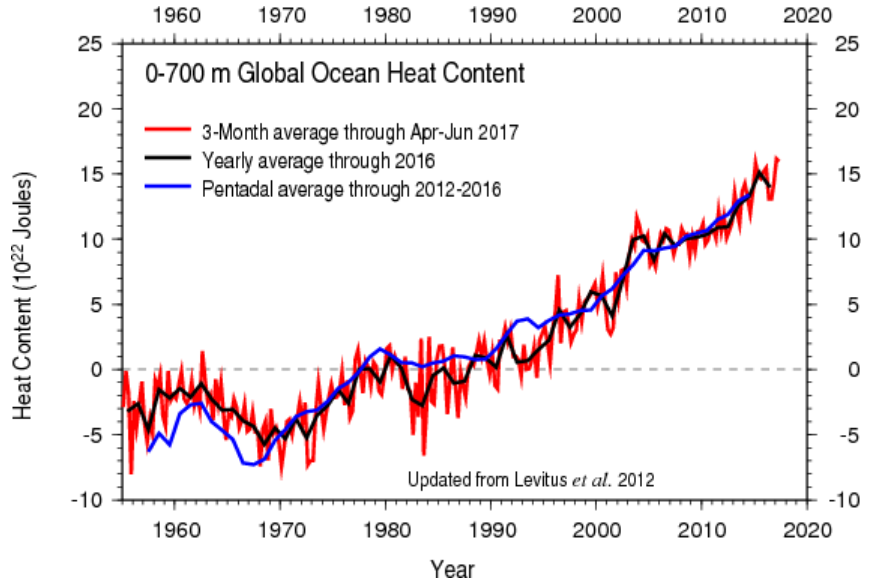


* Source: European Ocean Energy Association

Significant advantages:

- **Space:** Oceans cover more that 70% of the Earth's surface
- **Access:** 80% of populations live within 100km of the ocean
- **Resource:** Vast store of energy relative to our global demand
- **Diversity** of energetic physical ocean processes to tap into
- **Continuity** of supply
- **Density:** of energy is high
- **Unobtrusive**





Bluerise OTEC
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OTEC

Ocean Thermal Energy Conversion

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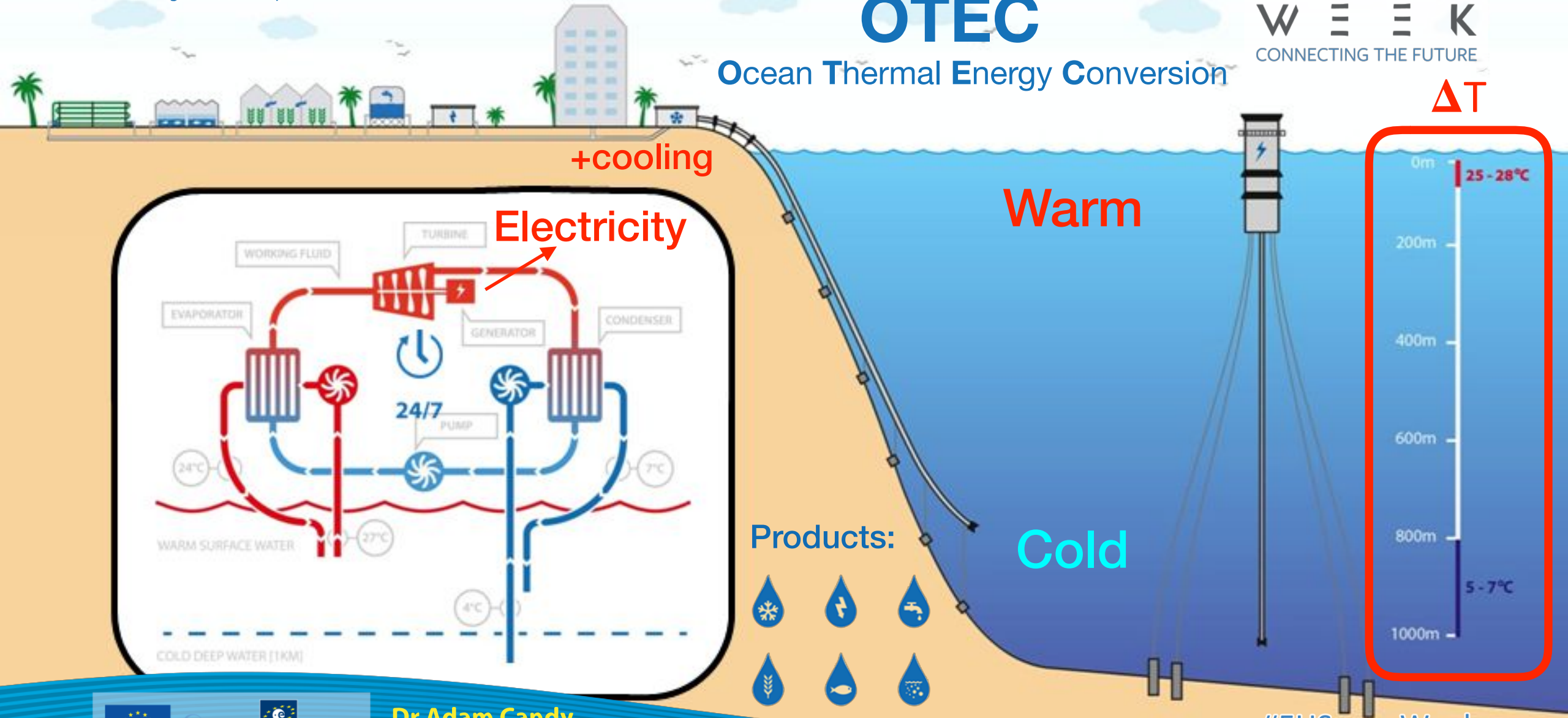

Products:

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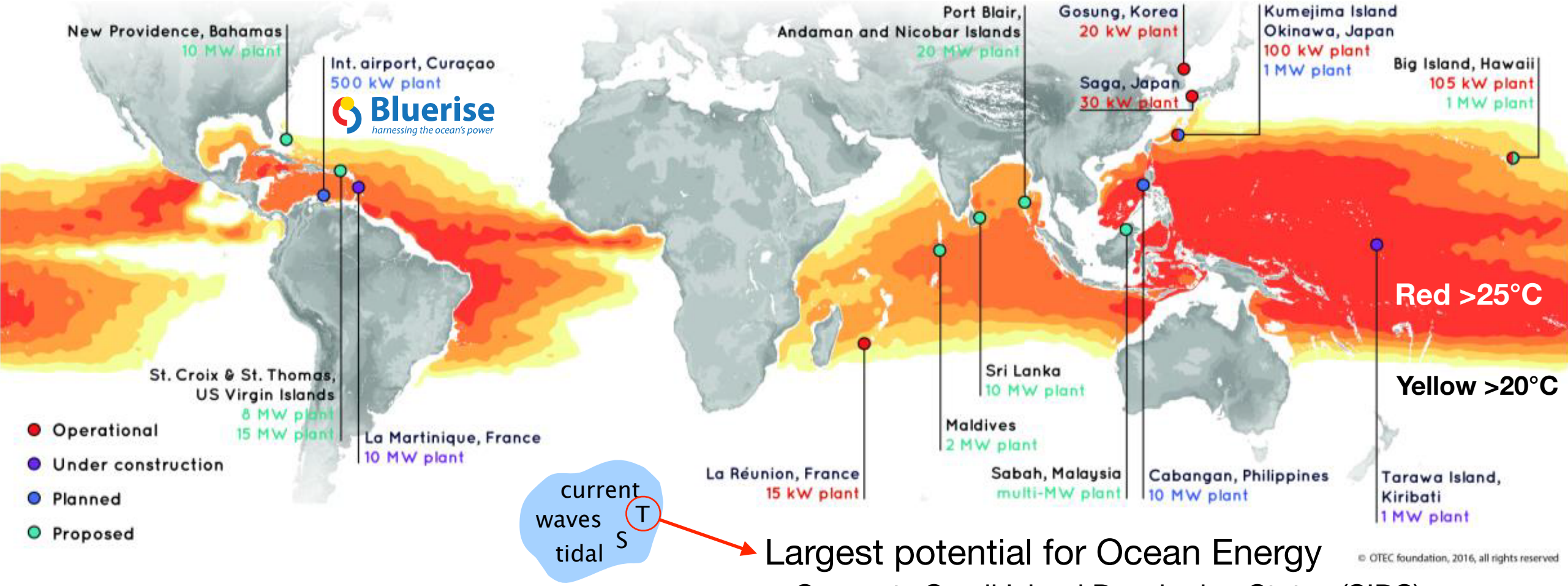
Worldwide operational, planned and proposed OTEC and its potential



Largest potential for Ocean Energy

Supports Small Island Developing States (SIDS)

My.oceanpotential.com powered by Bluerise #EUSpaceWeek

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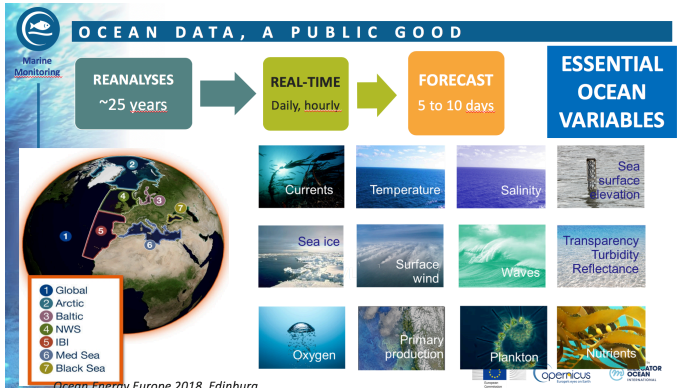
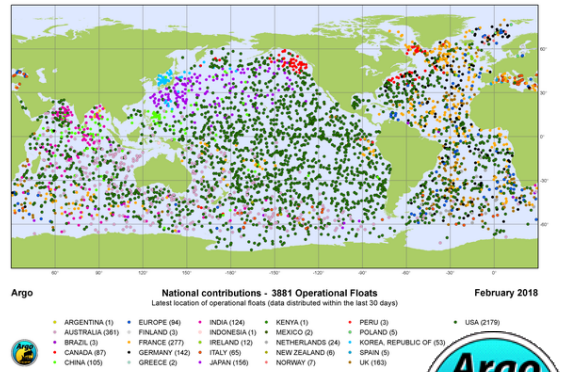
Motivation: Why is space now important for our future energy security?

NEW CHALLENGES

- Understanding variability of renewable resources
- Forecasting short-term for energy grid management
- Long term trend changes in resource
- Impact of extraction on environment and availability
- Lack of data

Dutch Research Vessel Pelagia, docked at Pointe-à-Pitre, Guadeloupe, Aug 2016





Importance of ensemble and data assimilation for assessment and forecasting of the resource

⟶ Space as a tool supporting Supercomputing Science

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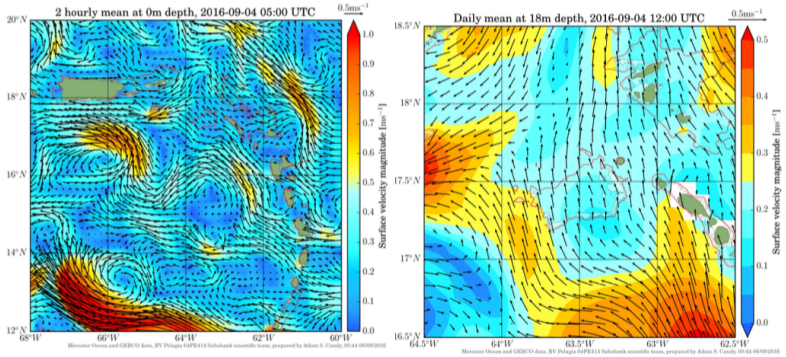
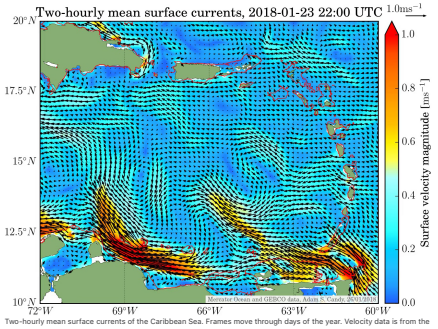
Mercator Ocean 7-day short term forecasts used during sea research expedition



Nightly-updated forecast outputs

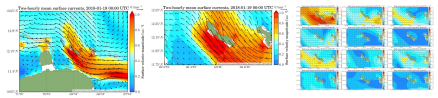


Two-hourly mean surface currents of the Caribbean Sea. Frames move through days of the year. Velocity data is from the Mercator operational 1/12° global ocean physics and analysis data set (Mercator Ocean, 2017). Bathymetry and coastlines determined from GEBCO (2014). To identify the location of shallower waters, a red line marks the 100m depth contour. Available to download here. A forecast of the daily mean surface velocity is also available here.

Regions of the Caribbean Sea

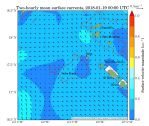
Further analysis for regions of the Caribbean Sea, including daily-updated current conditions and longer-term annual datasets.

- CaribbeanWatch: Curaçao



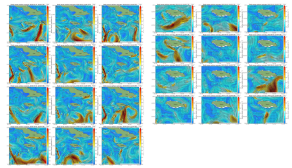
Conditions in Curaçao this week, and longer term reviews. Follow the link for more details.

- CaribbeanWatch: Sababank



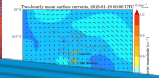
Conditions in Sababank this week, and longer term reviews. Follow the link for more details.

- CaribbeanWatch: Jamaica



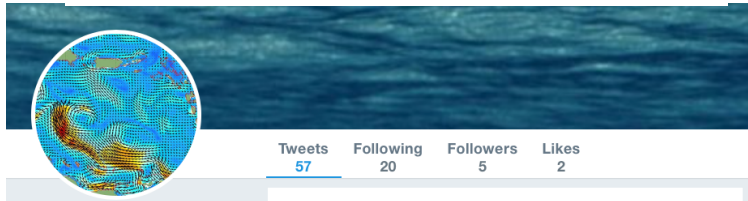
Conditions in Jamaica over the past year 2017 and 2016. Follow the link for more details.

- CaribbeanWatch: Sint Maarten



http://candylab.org/caribbeanwatch/

@caribbean_watch



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Caribbean Watch
@caribbean_watch Follows you

Up-to-date daily mean surface currents of the regional Caribbean Sea. By @dradamcandy @tudelft with @NIOZnieuws using data assimilation @MercatorOcean @CMEMS_EU

Delft, Nederland
candylab.org/caribbeanwatch/
Joined November 2017
Born on November 27

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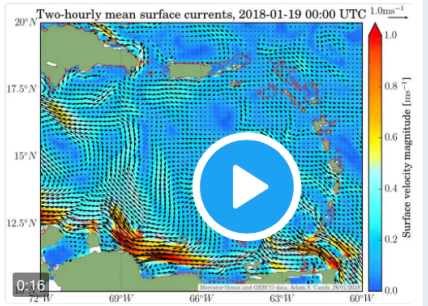
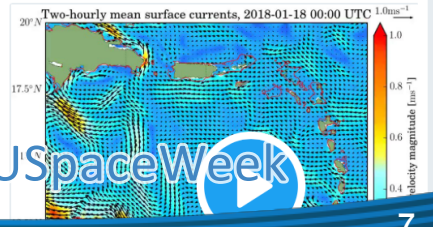
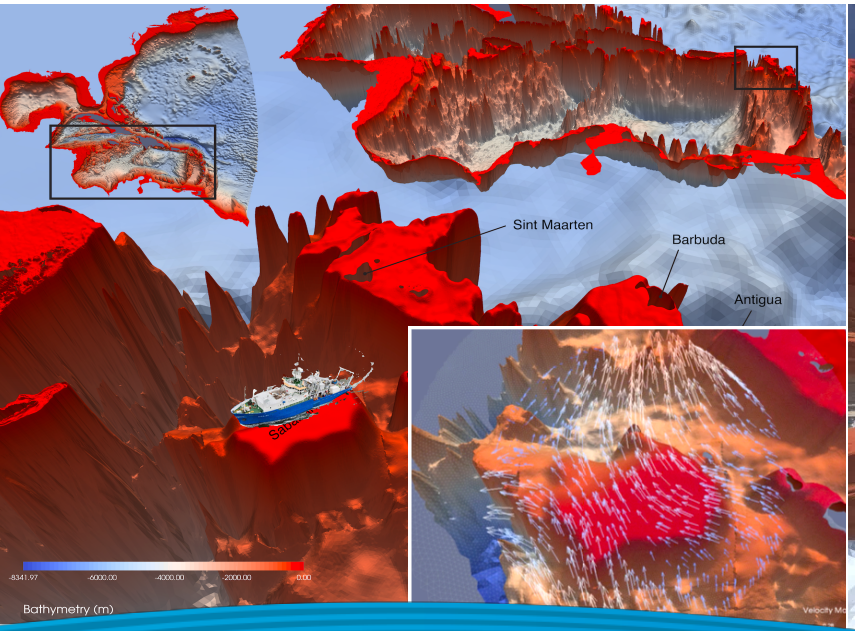
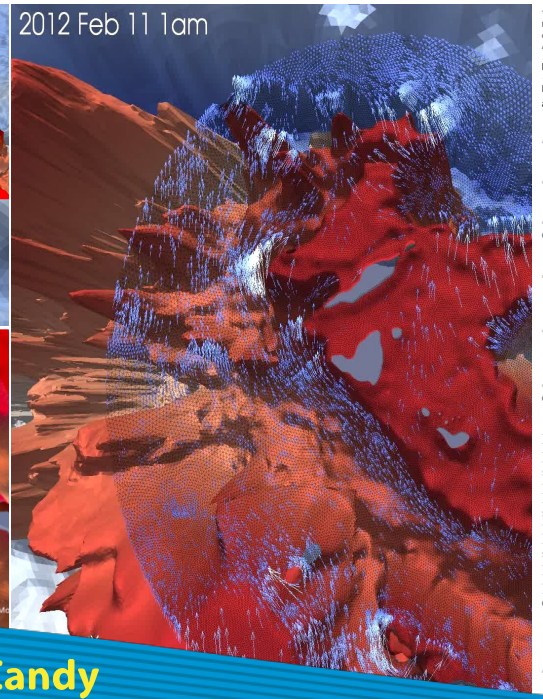
Caribbean Watch @caribbean_watch · 3h
Up to date two-hourly mean surface currents of the regional Caribbean Sea, either side of today 26th Jan 2018: from a week ago on 19th Jan 2018 and forecast ten days ahead to 5th Feb 2018. candylab.org/caribbeanwatch/



Caribbean Watch @caribbean_watch · Jan 25
Up to date two-hourly mean surface currents of the regional Caribbean Sea, either side of today 25th Jan 2018: from a week ago on 18th Jan 2018 and forecast ten days ahead to 4th Feb 2018. candylab.org/caribbeanwatch/







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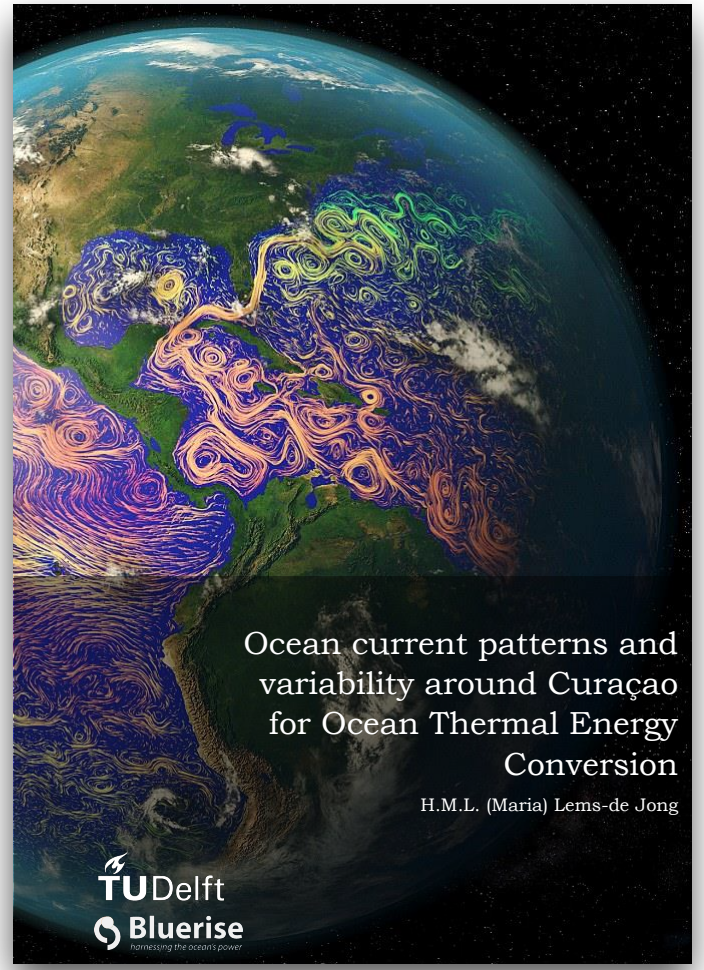
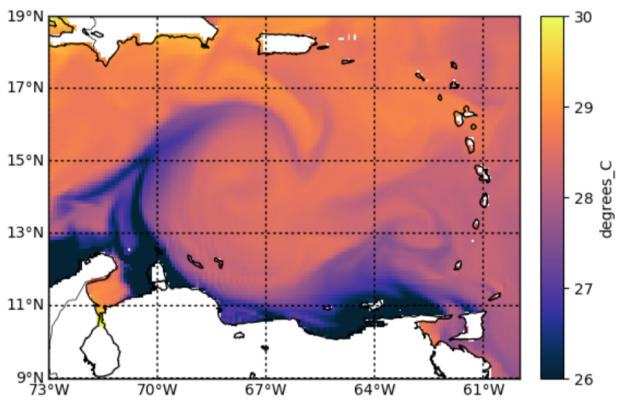
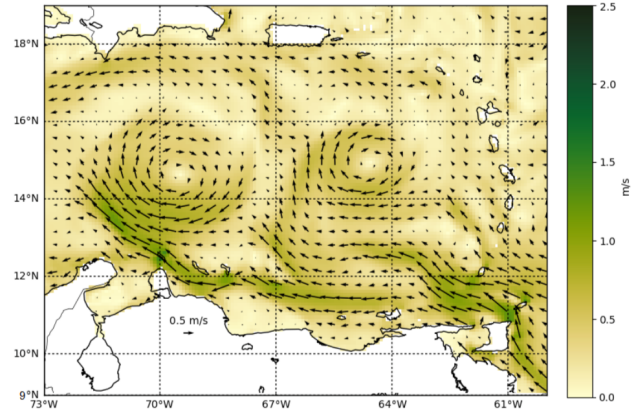
Research into variability using Mercator Ocean data-data-assimilated space products





(a) Sea surface temperature on July 13th, 2007, when a large cold-water ligament extended up to 17°N.



(b) Sea surface currents on July 10th, 2016, when current velocity was up to 1.5 m/s.

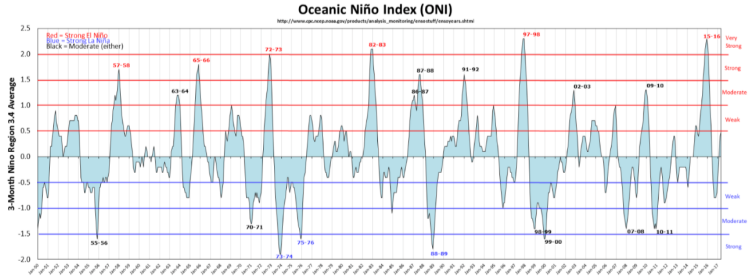


Figure 2.3: Overview of the ONI values from 1950 up to 2016. Three months average values are used. From NOAA Climate Prediction Center [2017]

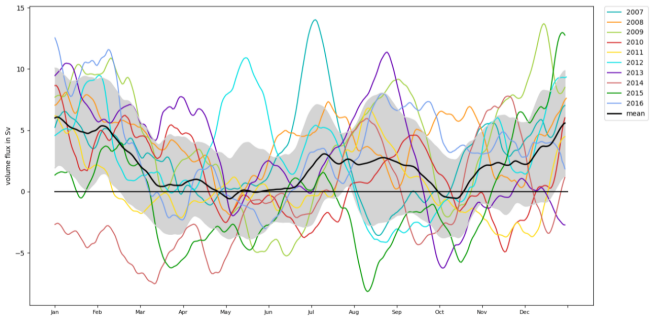
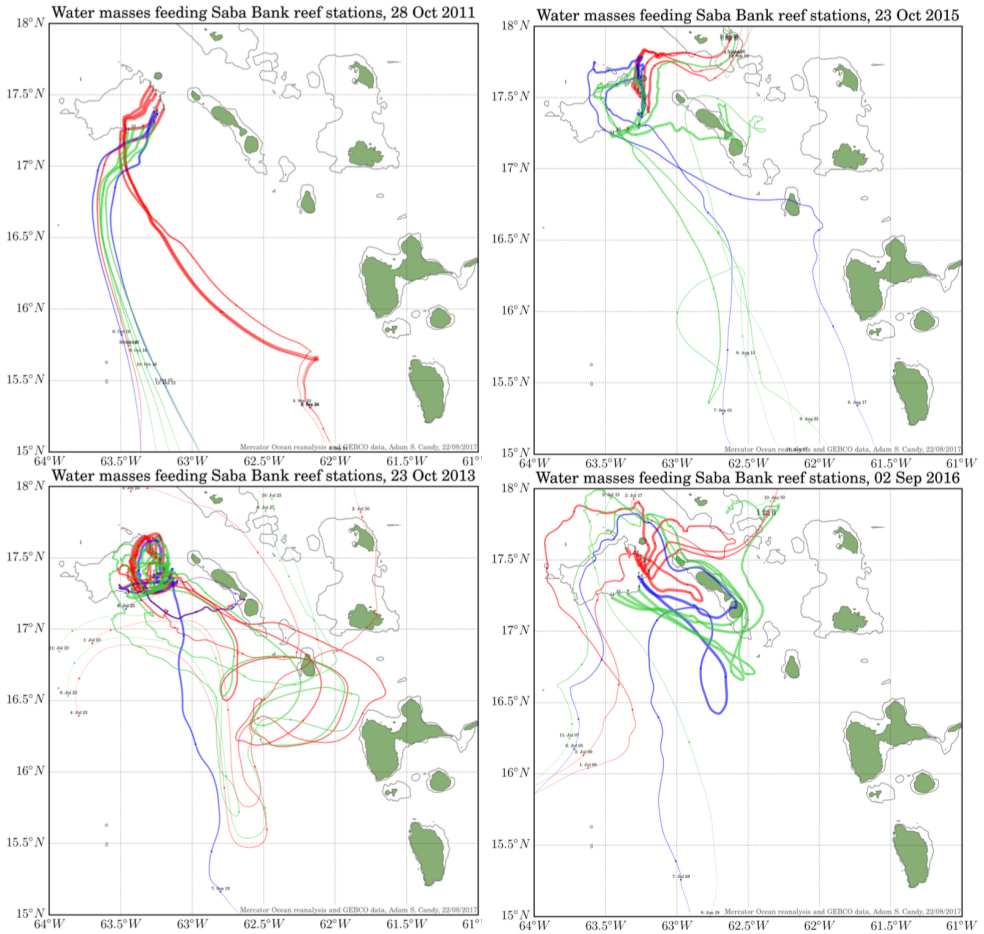


Figure 6.1: Volume flux for the years 2007 to 2016 over the transect line in the channel and sheltered region. The mean is plotted in black and the grey areas indicate the magnitude of the standard deviation. A rolling average of eight days was used to smooth the lines. Plots per year can be found in Figures I.1 to I.10.

Ocean Current Patterns and Variability around Curaçao: An Analysis for Ocean Thermal Energy Conversion, Lems-de Jong HML, Candy AS, Hoving JS, Kleute BJ and Pietrzak JD, 2017, 5th International Ocean Thermal Energy Conversion Symposium, La Réunion, 7-9 Nov 2017

Space as a tool supporting the energy package

Future work and use of space products



Journal of Marine Science and Engineering
MDPI
Article

An Evaluation of the Large-Scale Implementation of Ocean Thermal Energy Conversion (OTEC) Using an Ocean General Circulation Model with Low-Complexity Atmospheric Feedback Effects

Yanli Jia [1,*], Gérard C. Nihous [2] ar

expresses horizontal atmospheric transport. This produces lower steady-state OTEC power maxima (8 to 10.2 TW instead of 14.1 TW for global OTEC scenarios, and 7.2 to 9.3 TW instead of 11.9 TW for OTEC implementation within 100 km of coastlines). When power production peaks, power intensity remains practically unchanged, at 0.2 TW per Sverdrup of OTEC deep cold seawater,

⟶ **Power output is 56% originally predicted**

⟶ **Demand for model integrated with atmosphere and larger ocean**

Requirements to make OTEC viable, especially for deploying large scale.

- Investigating the effect of OTEC on the environment
- Two-way feedbacks
- Impact of a changing climate, lifecycle, 2050 timeframe
- Lagrangian advection to accurately determine water sources, large variability in Caribbean
- Ecosystem impacts

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Space as a tool supporting Small Island Developing States

Get in touch!

Dr Adam Candy

candylab.org/OceanEnergy

candy@cantab.net @DrAdamCandy