



Presentation template for the 5 teams:  
BOUSSOLE (F), Crete (GR), El Hierro (E),  
Lampedusa (I), and Madeira (P)

# Climatological Characterisation of candidate Ocean Sites for Copernicus OC-SVC infrastructure placement

Site: **Madeira (P)**



# Site/s geography

970 km SW Europe

520 km W Africa

500 km from Canary islands

**Area** 741 km<sup>2</sup>,

**length** 54 km,

**widest length**. 23 km;

Mountain ridge along the centre of the island:

- Reaching 1862 m
- Several peaks, all reaching over 1500 m.

Table 4.1: Observed characteristics for the potential Madeira OC-SVC sites. Compliance matrix from SOW (Table 1.1).



SOW location (32.25N, 17.00W)	OPT (32.62N, 17.27W)
----------------------------------	-------------------------

Dist. to land: 24 nm

Dist. to Harbour: 24 nm

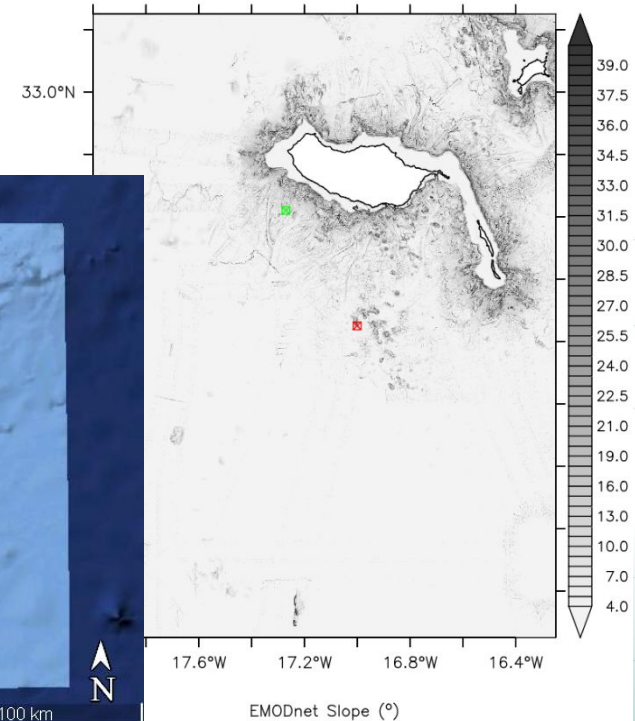
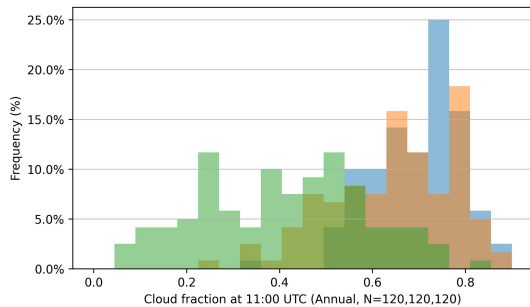
Slope: possibly high, should be confirmed locally

Dist. to land: 8 nm

Dist. to Harbour: 18.5 nm

Slope: possibly high, should be confirmed locally

Cloud fraction histograms from month averages in the 2010-2019 decade in the three areas / locations of interest: full area (blue), SOW site (32.25N,17W) (orange)



# Relevant local measurements and infrastructures

## FUNCHAL/Observatório in WMO Region I - Africa

<https://oscar.wmo.int/surface/#/search/station/stationReportDetails/0-620-2001-08522>



Front and West sides



Back and West sides



Back and West sides



Cars entrance



Meeting room



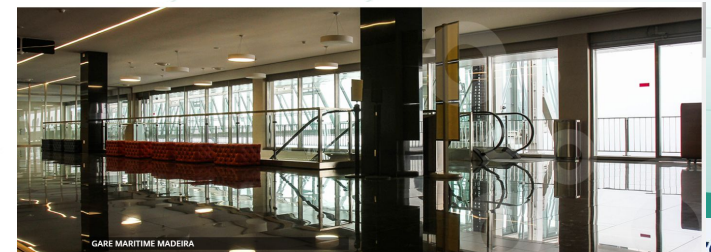
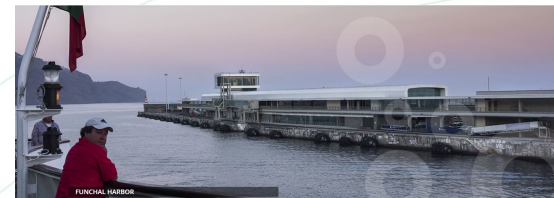
Meteorological park

- Atmosphere > Clouds
- Atmosphere > Humidity
- Atmosphere > Past weather
- Atmosphere > Present weather
- Atmosphere > Pressure
- Atmosphere > Radiation
- Atmosphere > Temperature
- Atmosphere > Visibility
- Atmosphere > Wind
- Ocean > Basic Physical Properties (SST)
- Terrestrial > Soil

## Site logistics

### FUNCHAL Harbour

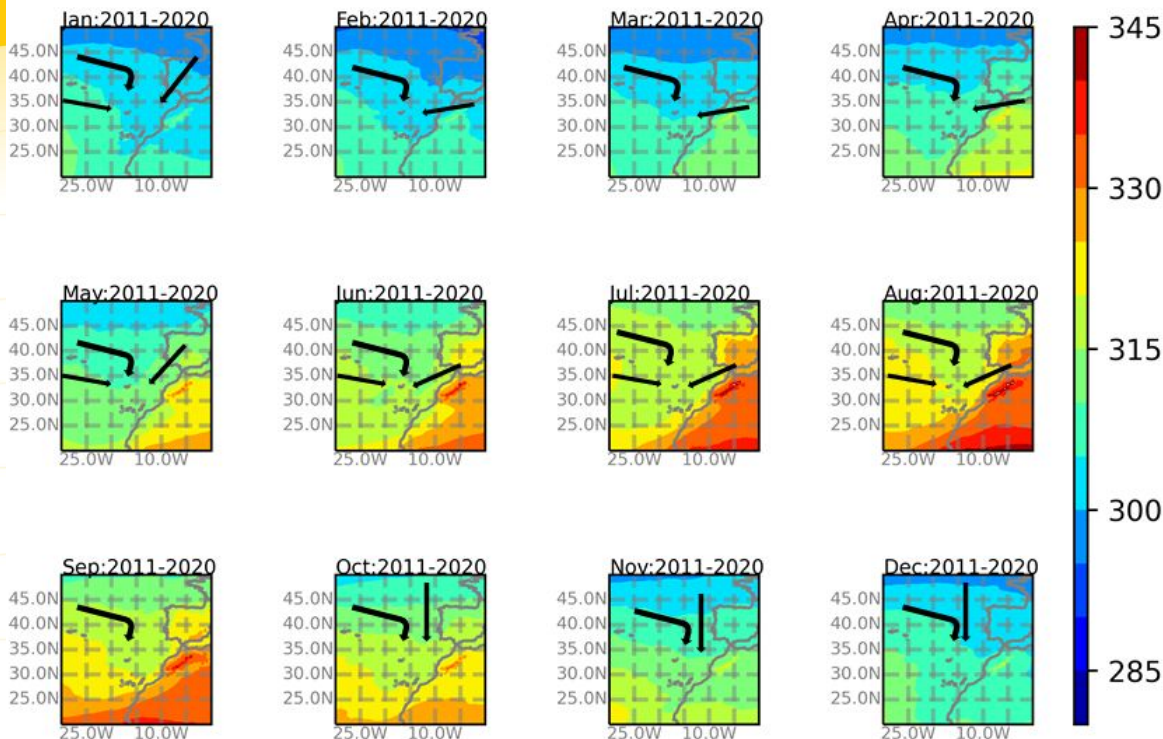
<http://www.apram.pt/site/index.php/en/>



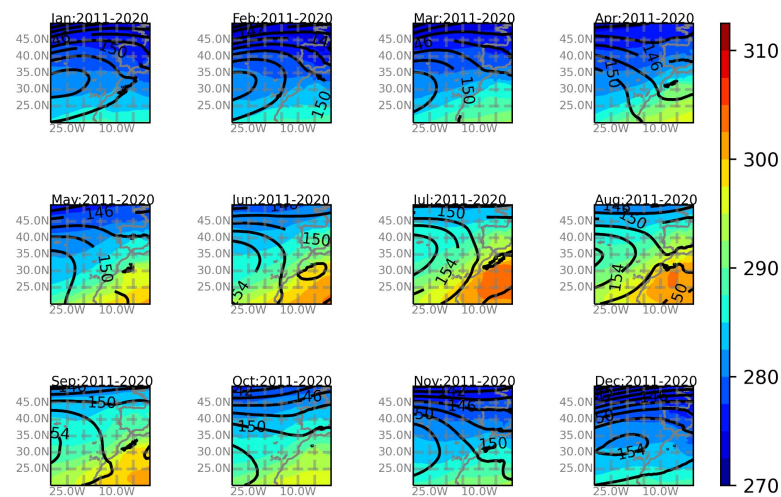
# Prevailing meteorological circulation patterns

source: ERA5 2011-2020

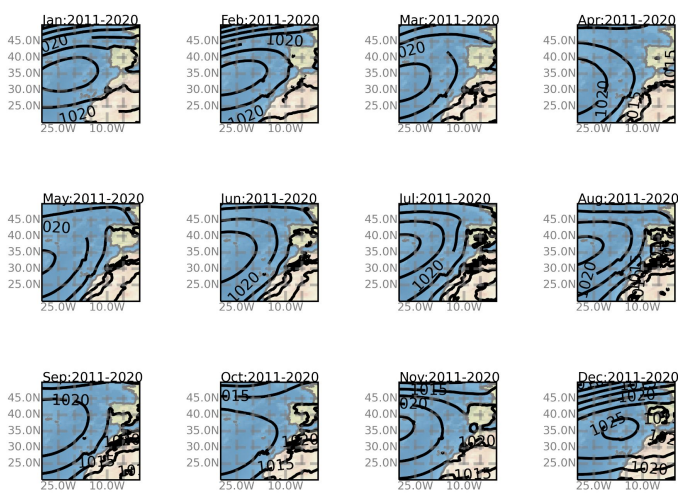
## equivalent potential temperature (K)



## 850 hPa potential temperature (K), Z (100 m)



## MSLP (hPa)



Courtesy Ângela Lourenço

**Dec, Jan:** mT or returning mT. Sometimes mP (moist and mild) and fewer times cP (less dry and warmer).

**Feb to May:** returning mT (sometimes cT for short periods 3 to 7 days and not so dry).

**Jun to Aug:** mT (sometimes returning mT) and cT (short periods 3 to 7 days).

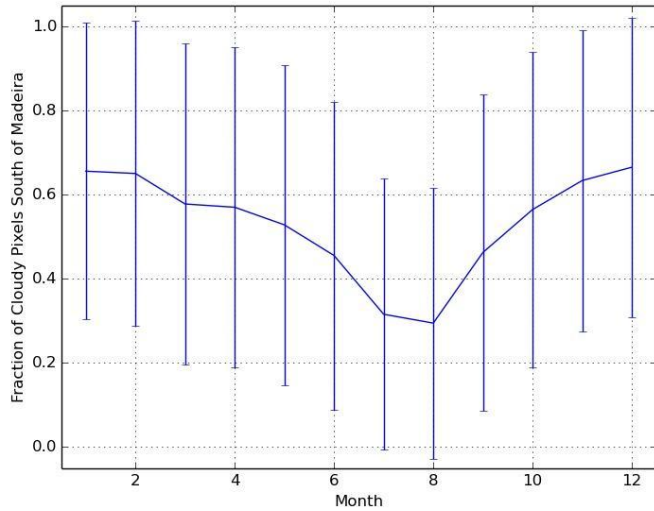
**Sep to Oct:** returning mT and mP (moist and mild).

# Cloudiness and solar illumination

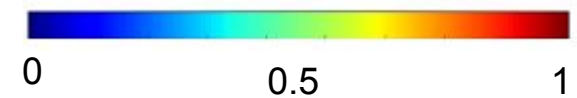
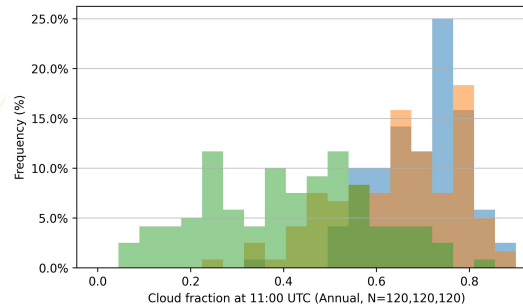
source: SEVIRI Cloud Mask product NWC/LSA SAF

GEO software- 15min from 2005 to 2020

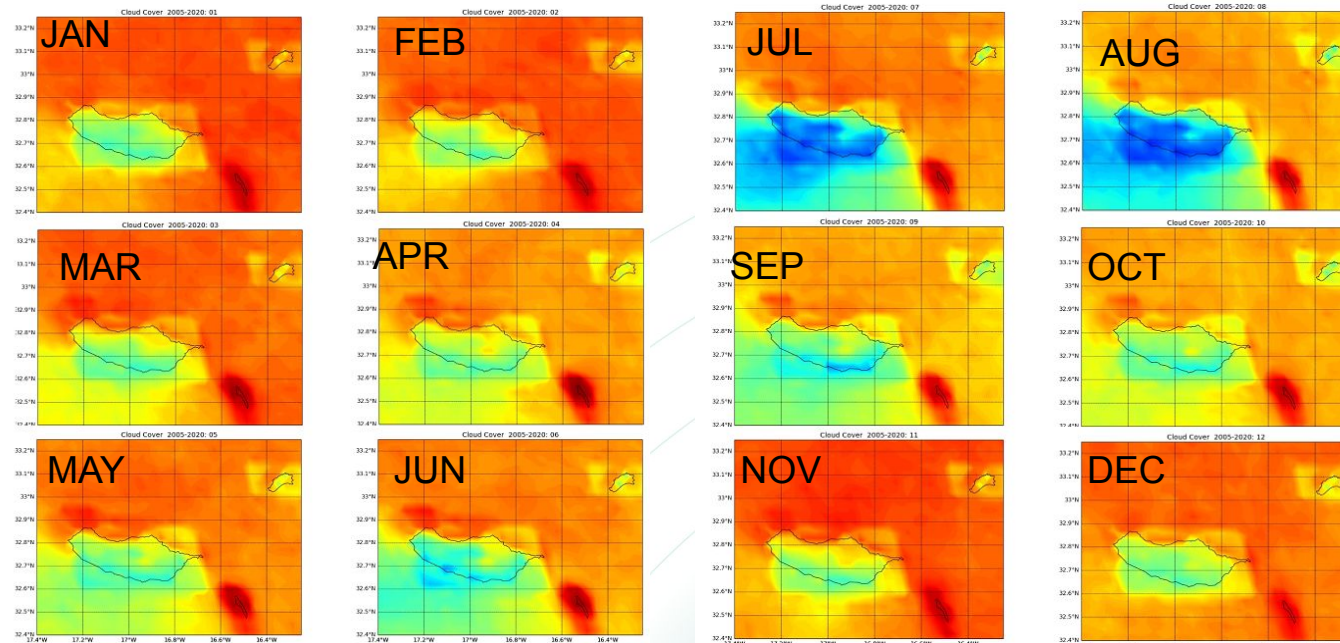
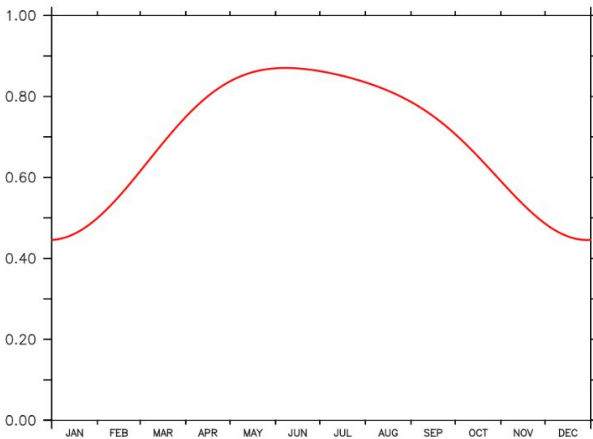
## Monthly fraction of cloudy pixels 2005-2020 period .



Cloud fraction histograms from month averages in the 2010-2019 decade in the three areas / locations of interest: full area (blue), SOW site (32.25N,17W) (orange)



Plot of cosine of Sun zenith angle at 10AM Local Solar Time (LST) per day of year

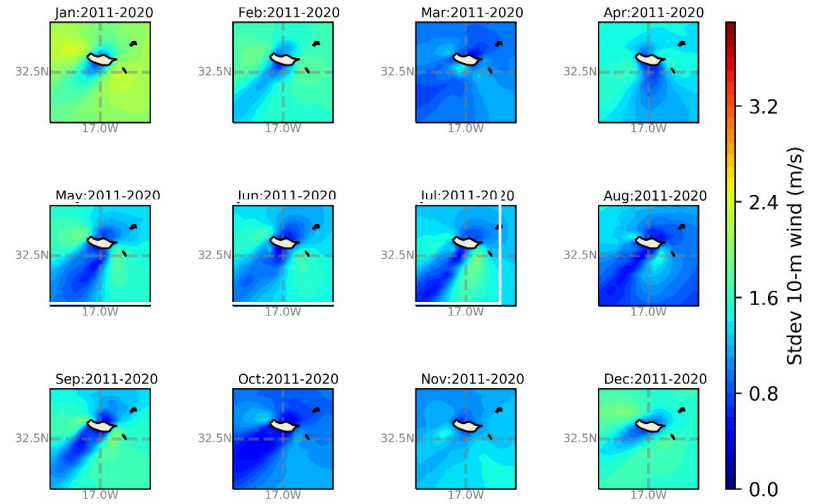
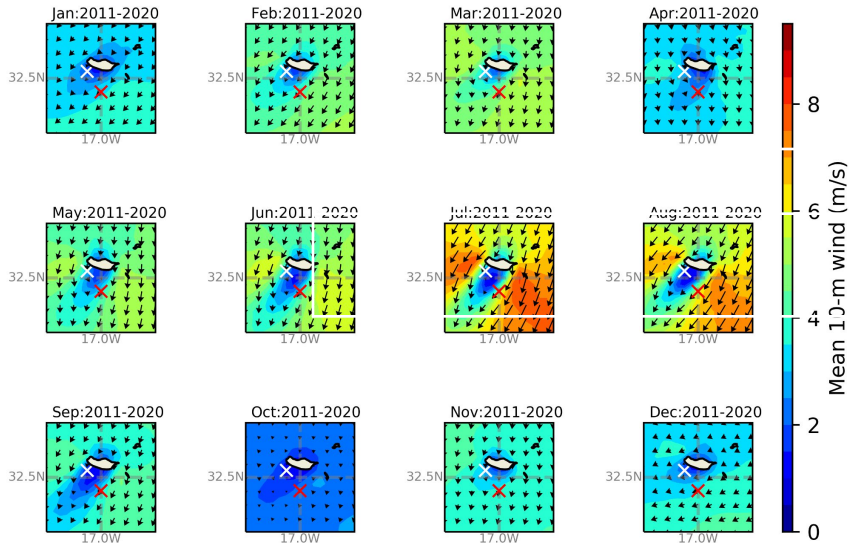


# Winds

data source: ECMWF/HRES 2011-2020. ~9 km grid resolution  
reprojected regular 0.125°x0.125° grid

## mean 10-m wind (m/s)

## stdv 10-m wind (m/s)

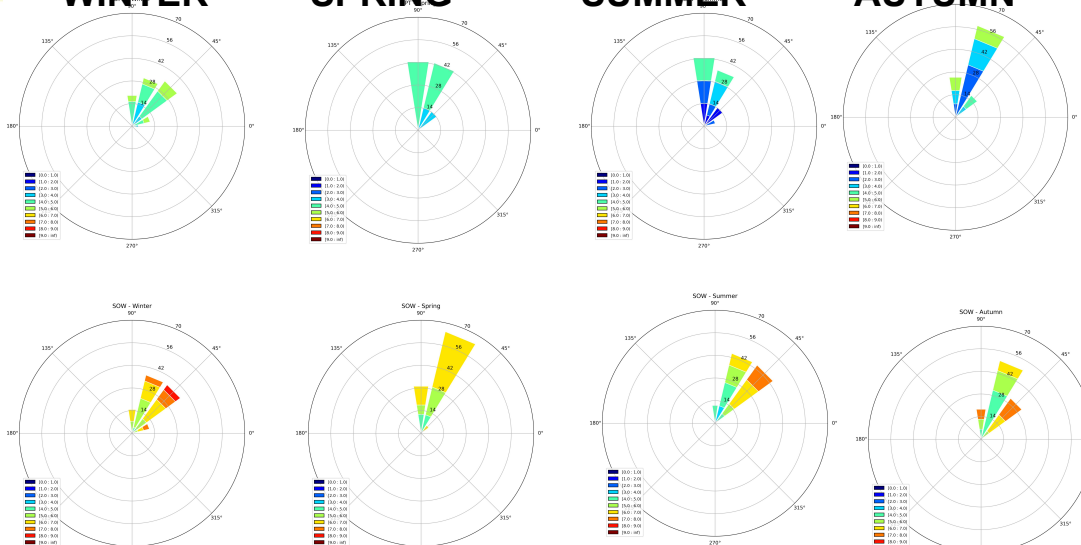


### WINTER

### SPRING

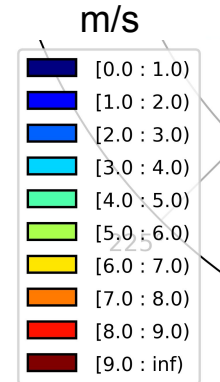
### SUMMER

### AUTUMN



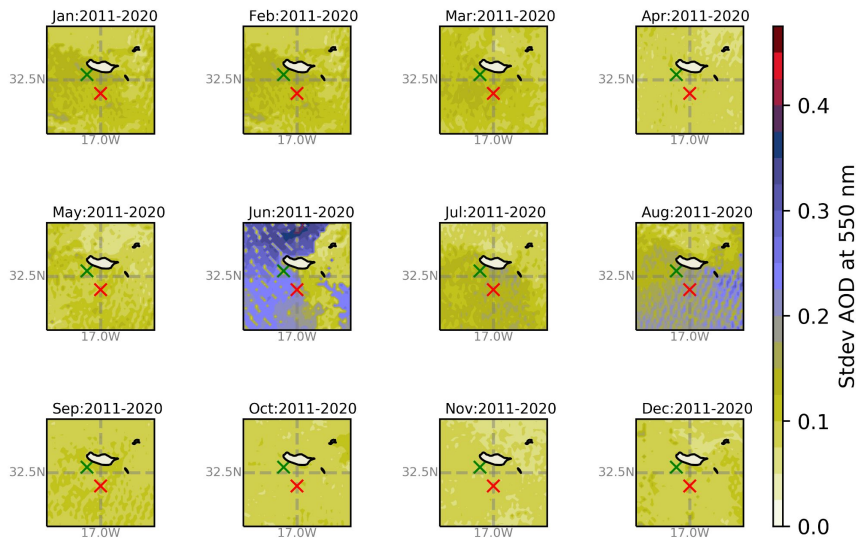
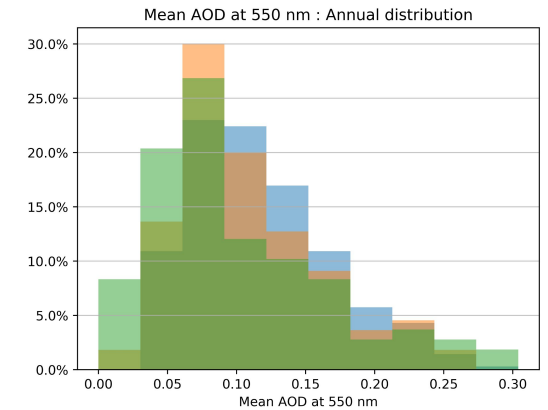
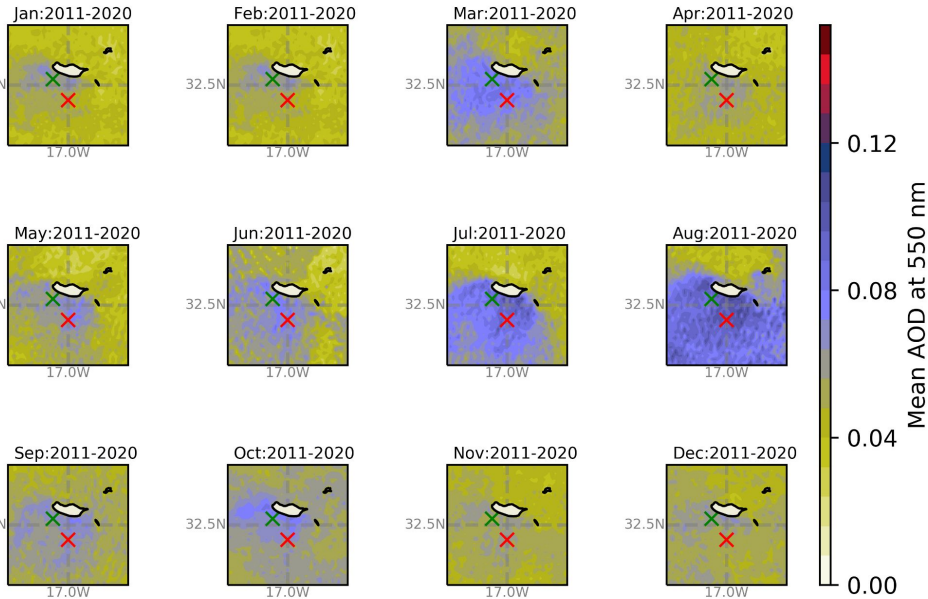
OPT

SOW



# Aerosols and AOT

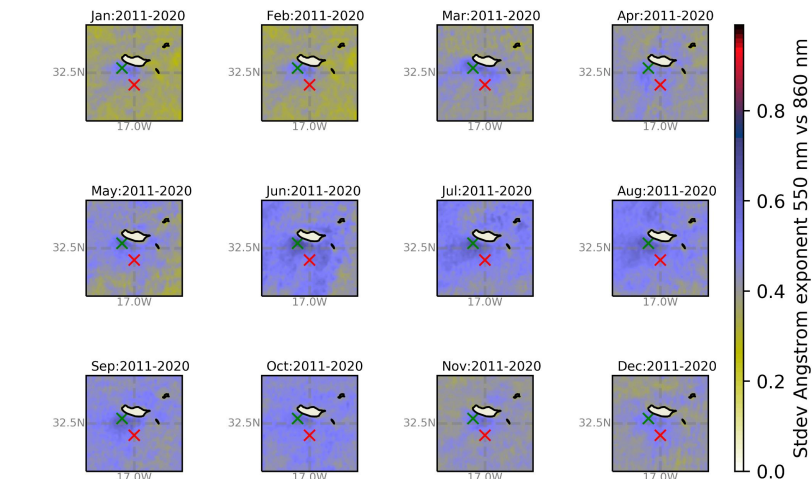
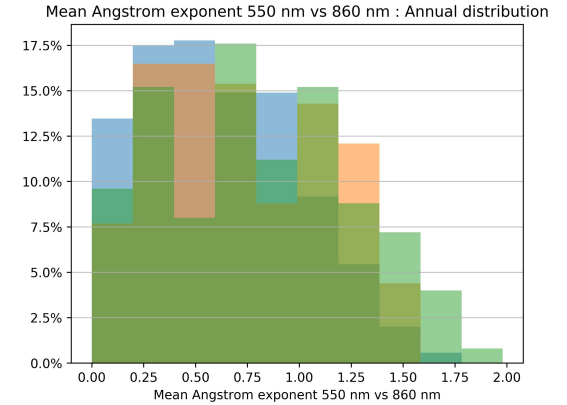
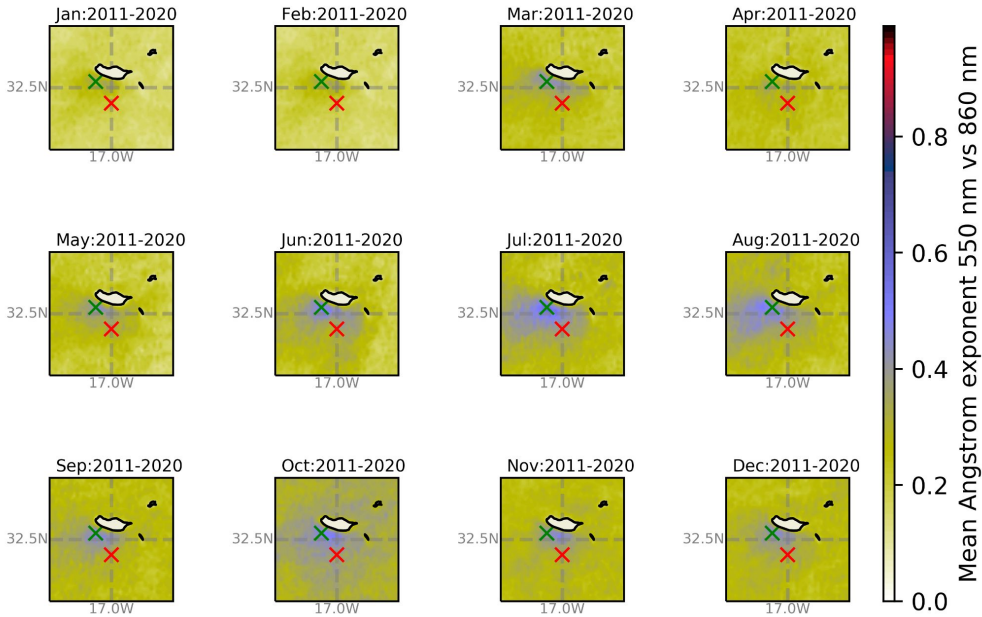
data source: MODIS Aerosol products (MOD04\_3K) 2011-2020  
3 km spatial resolution, reprojected to a regular 0.05°x0.05°



ALL MODIS passes	Desert Dust		Biomass Burning		$\alpha > 1$	
	SOW	OPT	SOW	OPT	SOW	OPT
January	23	21	4	15	4	15
February	20	24	5	13	5	13
March	27	35	2	15	2	15
April	25	20	4	7	4	7
May	23	18	8	15	8	15
June	29	15	5	21	5	21
July	28	26	5	27	5	27
August	41	35	4	15	4	15
September	27	30	3	15	3	15
October	27	29	1	10	2	10
November	24	24	2	6	2	6
December	14	22	2	12	2	12
10 Years	308	299	45	171	45	171

# Aerosols and Angstrom

data source: MODIS Aerosol products (MOD04\_3K) 2011-2020  
3 km spatial resolution, reprojected to a regular 0.05°x0.05°

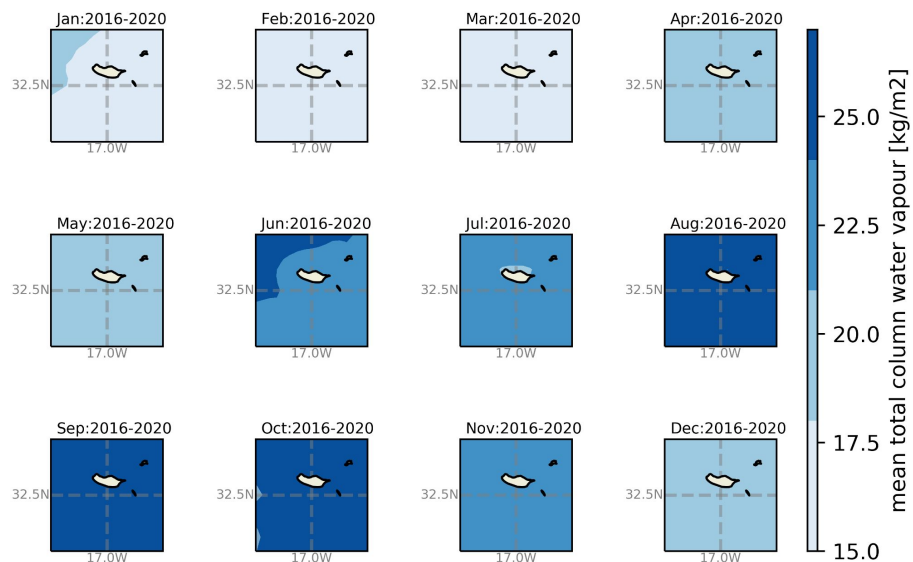
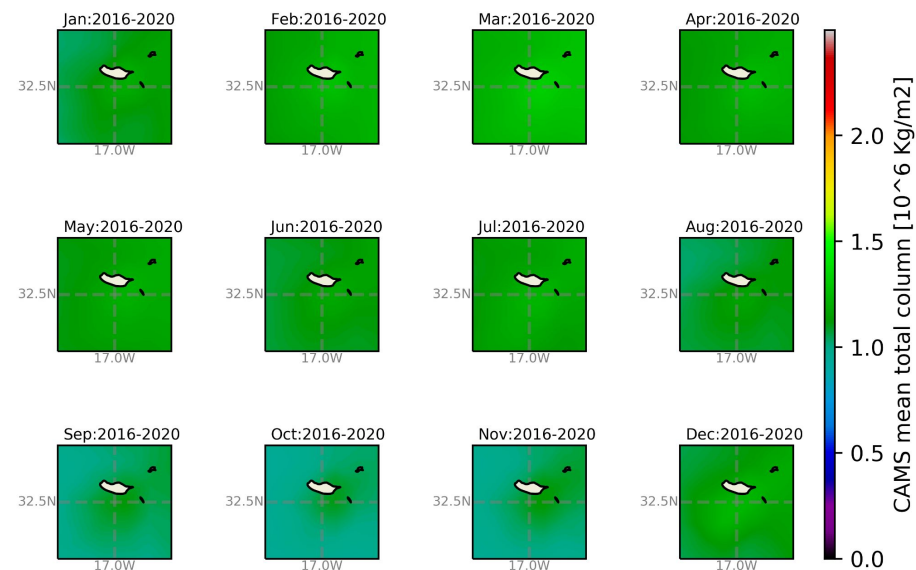
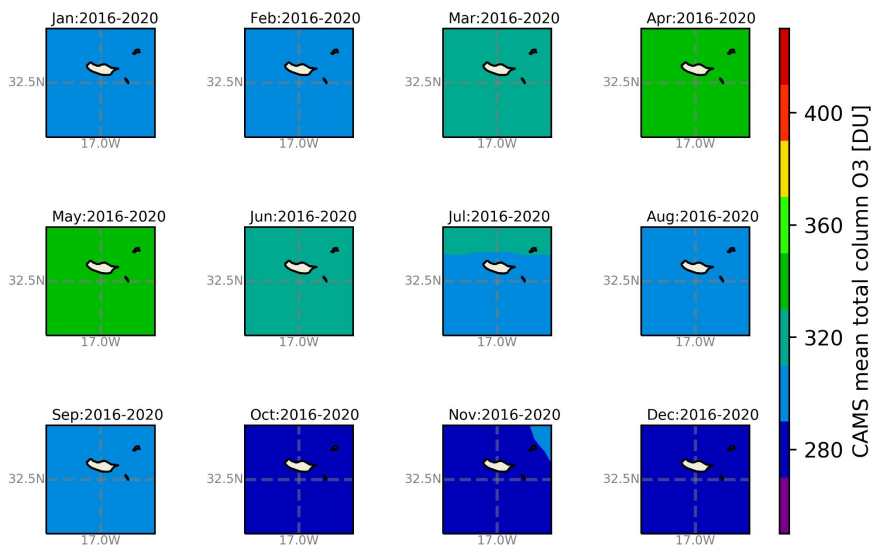


Aerosol Type	Continental	Moderate Absorption Fine	Strong Absorption Fine	Weak Absorption Fine	Dust Coarse
N cases	3	4231	0	1427	0
Frequency (%)	0	75%	0	25%	0



# Absorbing gases

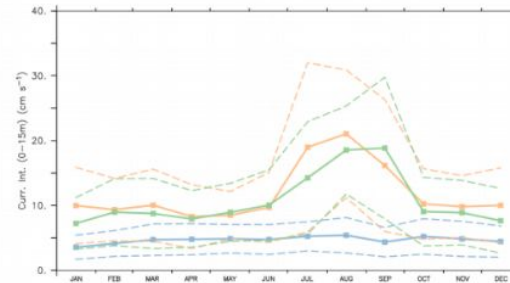
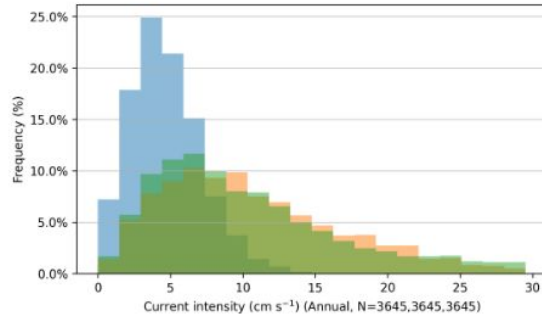
data source: CAMS reanalysis products in a 0.75°x0.75° regular grid



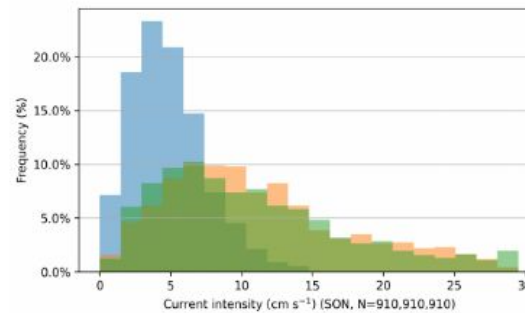
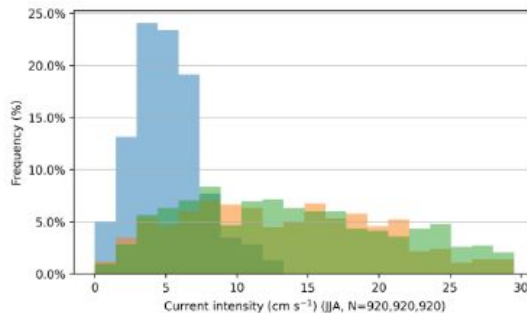
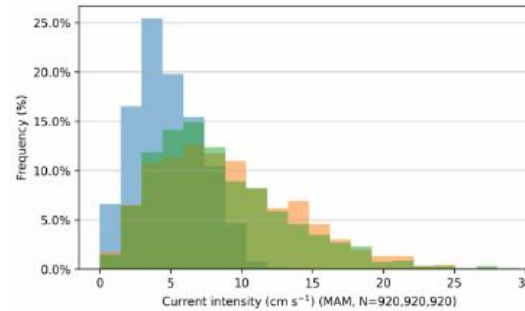
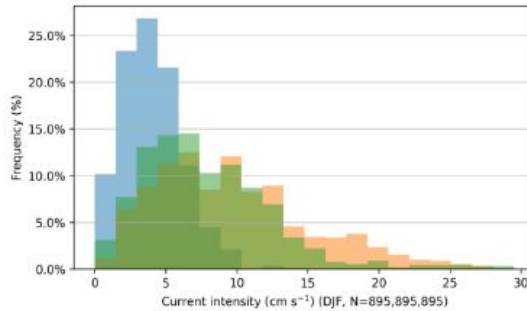
# Oceanog. cond. - currents

data source: daily CMEMS IBI-reanalysis in a 1/12° grid

Average current intensity in the top 15 m ( $\text{cm s}^{-1}$ ) histogram for a year, mean current intensity and standard deviation per month.



Average current intensity in the top 15 m ( $\text{cm s}^{-1}$ ) histogram for each season.



# Oceanog. cond. - currents

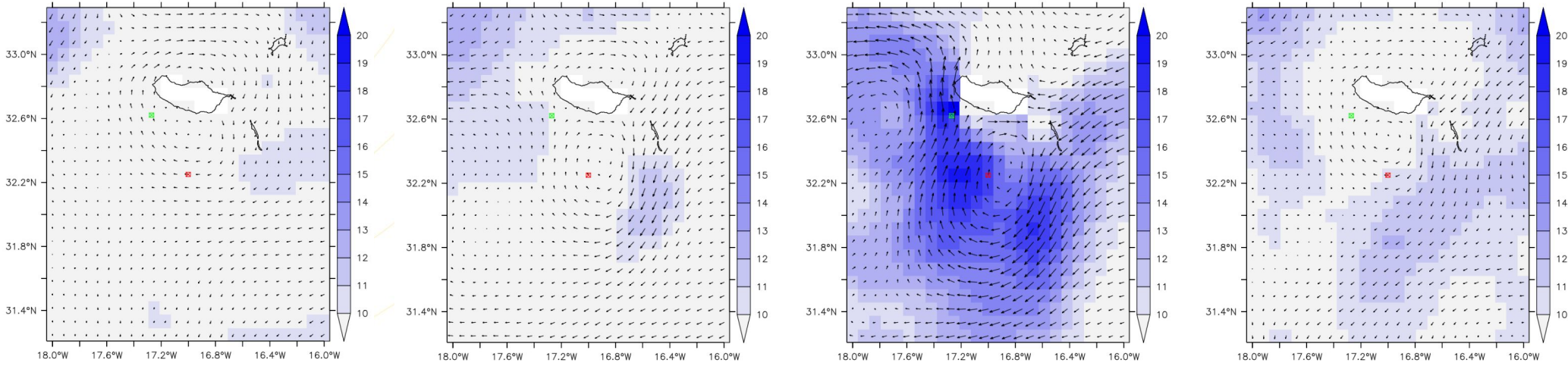
data source: daily CMEMS IBI-reanalysis in a 1/12° grid

JFM: 2010–2019

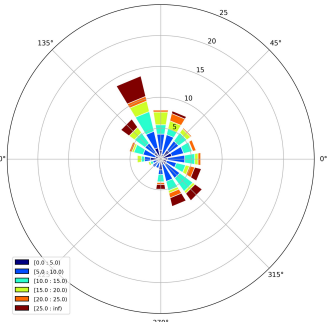
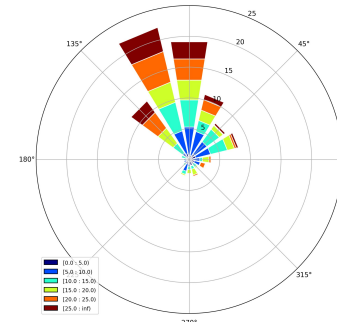
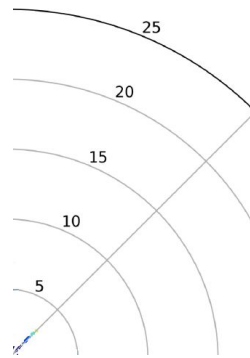
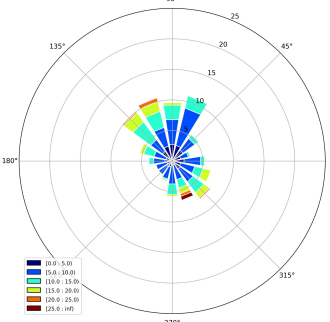
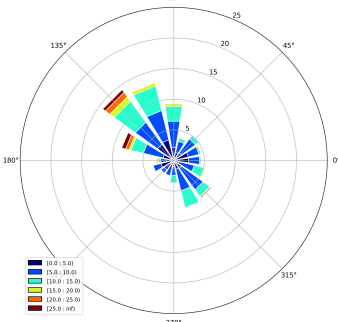
AMJ: 2010–2019

JAS: 2010–2019

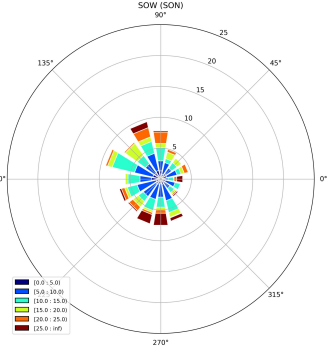
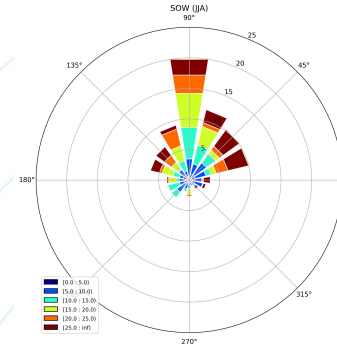
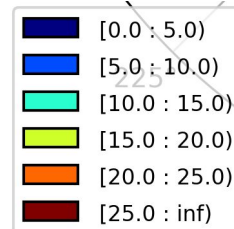
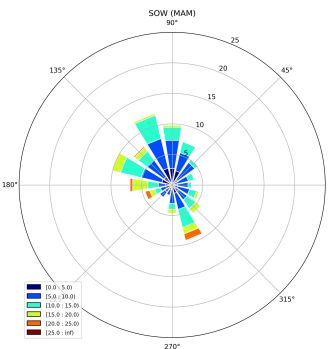
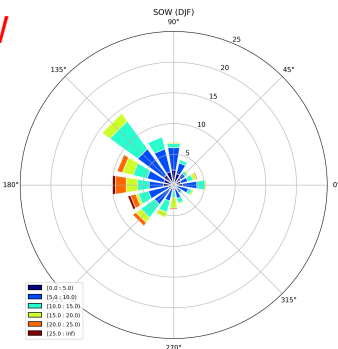
OND: 2010–2019



OPT



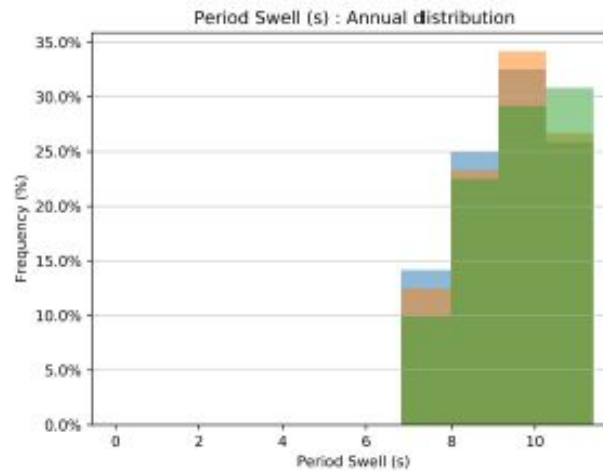
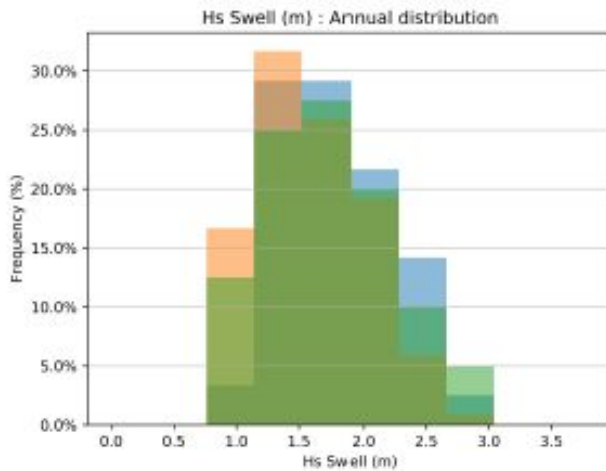
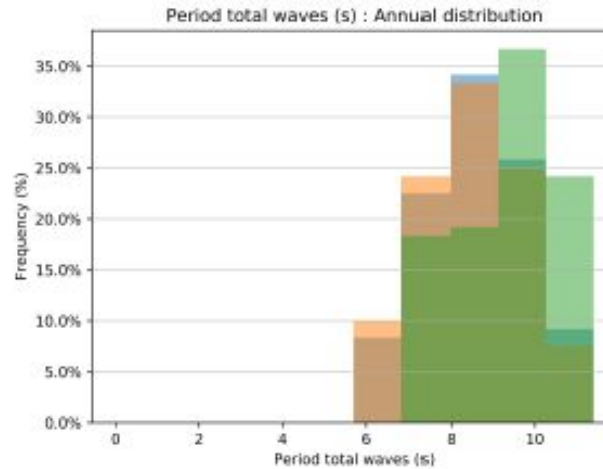
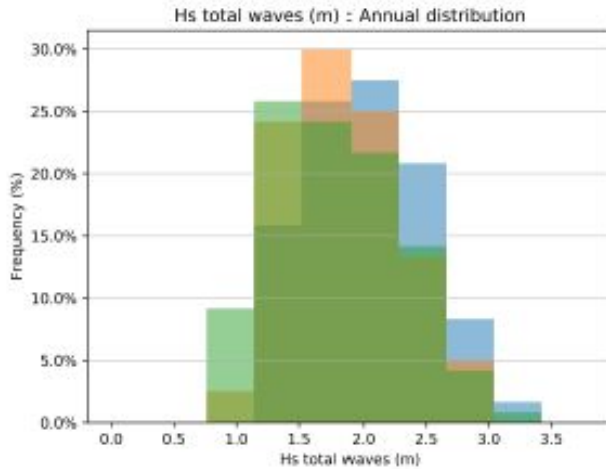
SOW



# Oceanog. cond. - waves

data source: ECMWF/HRES-WAM 2011-2020. ~14 km grid resolution, reprojected in a 0.125°x0.125° regular grid

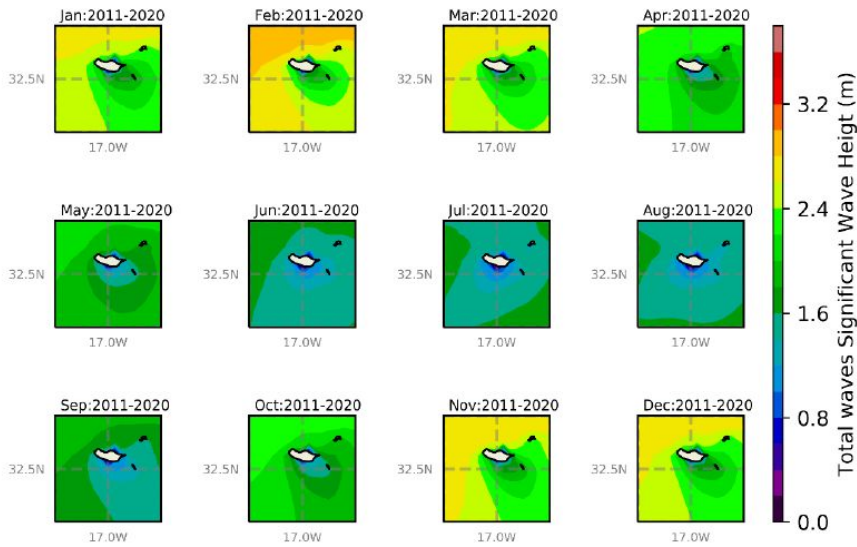
Significant wave height (m, left) and wave period (s, right) histograms for total area (blue), SOW site (orange) and the OPT site (green), total waves (top) and swell (bottom).



# Oceanog. cond. - waves

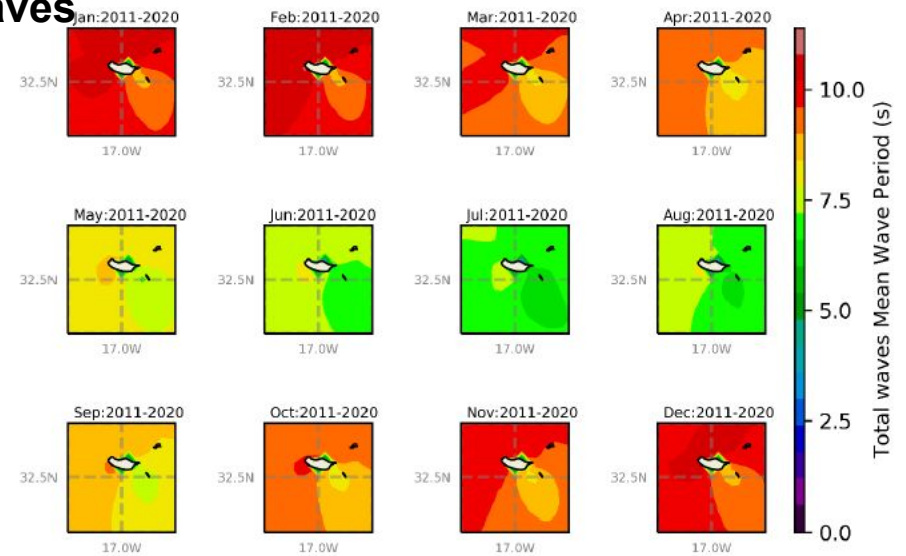
data source: ECMWF/HRES-WAM 2011-2020. ~14 km grid resolution, reprojected in a 0.125°x0.125° regular grid

Figure 3.3.20: Monthly mean Total waves significant wave height (m) map.

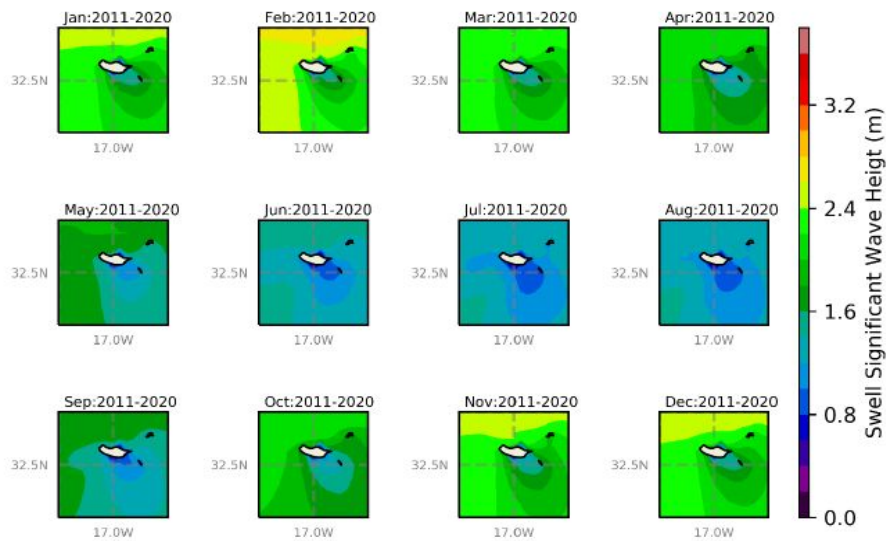


## total waves

Figure 3.3.21: Monthly mean wave period maps.

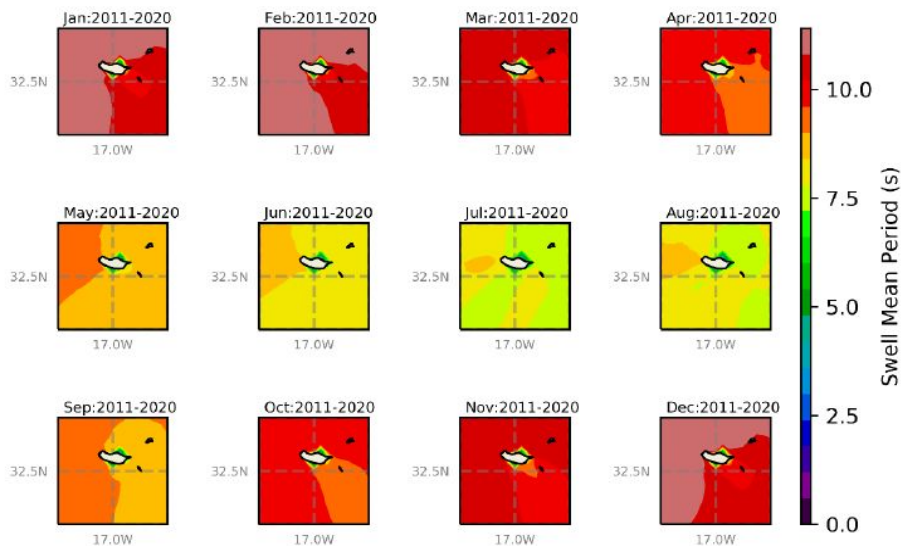


Monthly mean swell significant wave height (m).



## swell

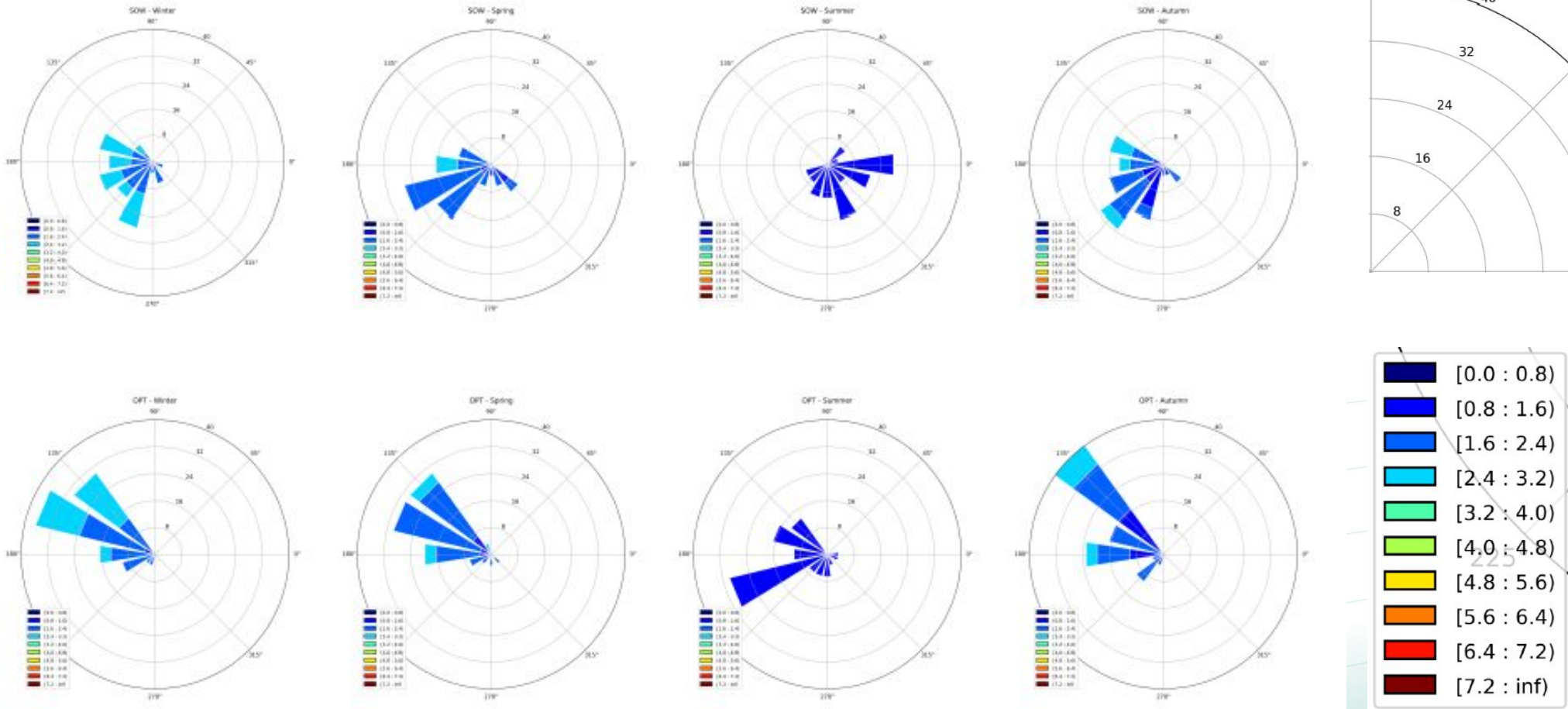
Monthly mean swell period (s).



# Oceanog. cond. - waves

data source: ECMWF/HRES-WAM 2011-2020. ~14 km grid resolution, reprojected in a 0.125°x0.125° regular grid

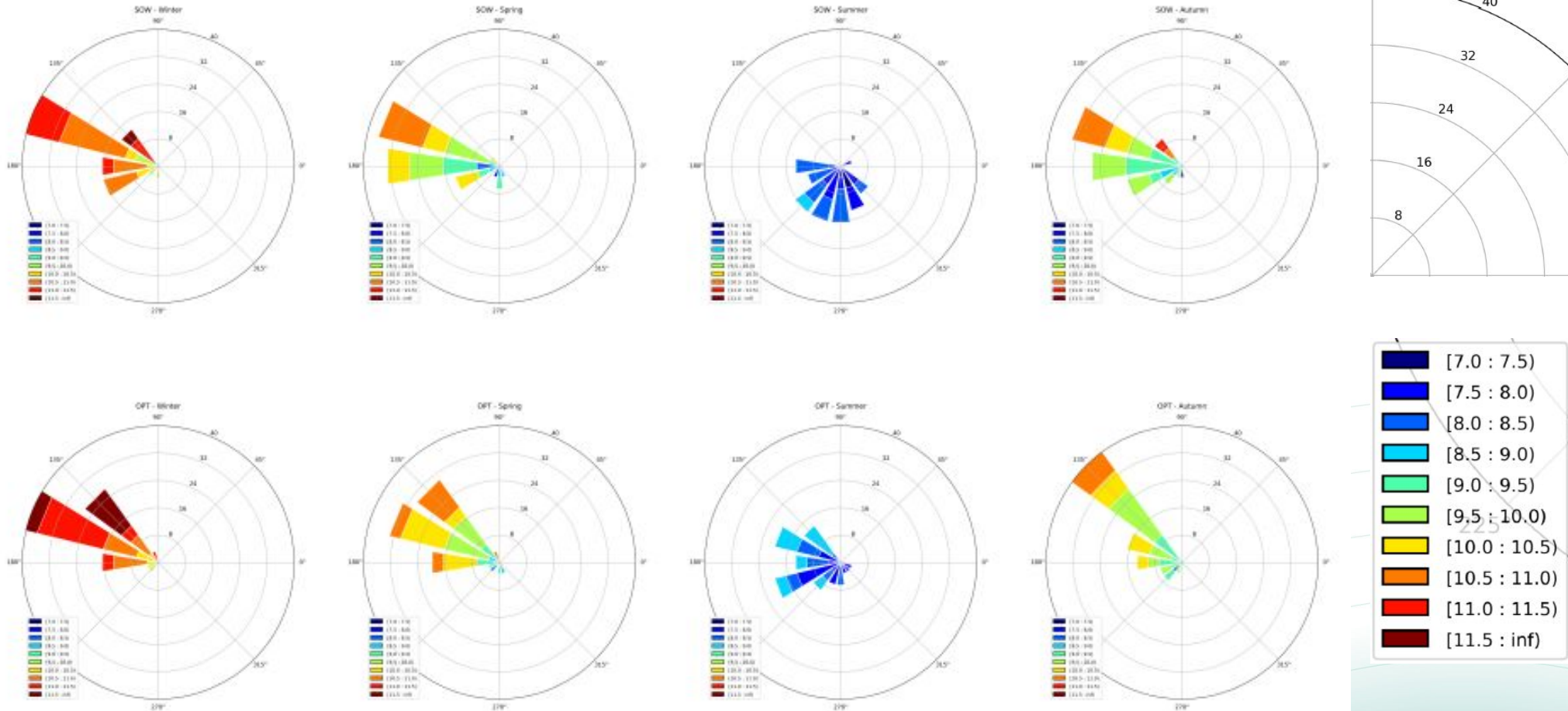
Significant Wave Height and direction distribution rose diagrams for each season (oceanographic convention) for SOW (top) and OPT (bottom).



# Oceanog. cond. - waves

data source: ECMWF/HRES-WAM 2011-2020. ~14 km grid resolution, reprojected in a 0.125°x0.125° regular grid

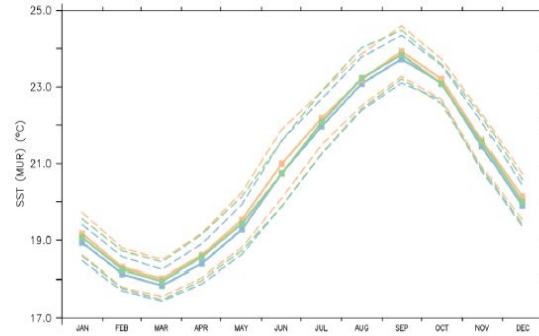
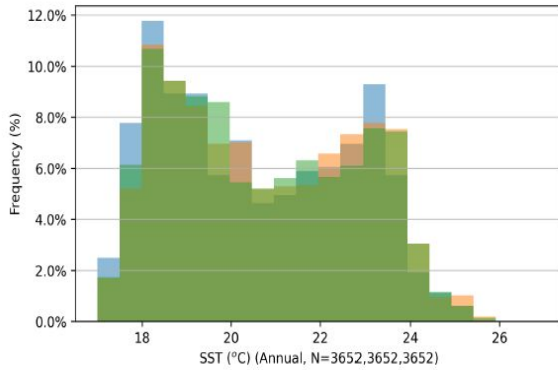
*Swell Period and direction distribution rose diagrams for each season (oceanographic convention) for SOW (top) and OPT sites (bottom).*



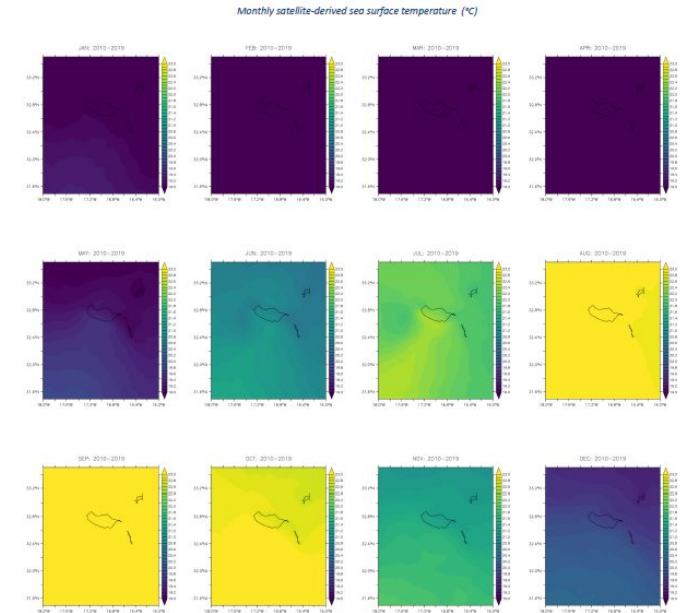
# SST and SSS

data source: daily CMEMS IBI-reanalysis in a 1/12° grid

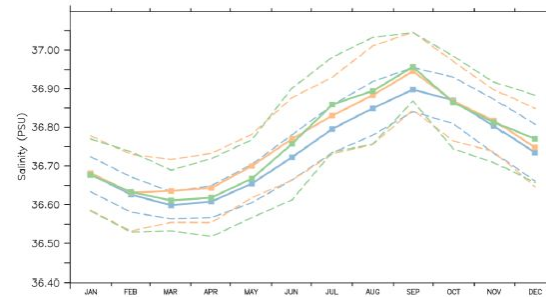
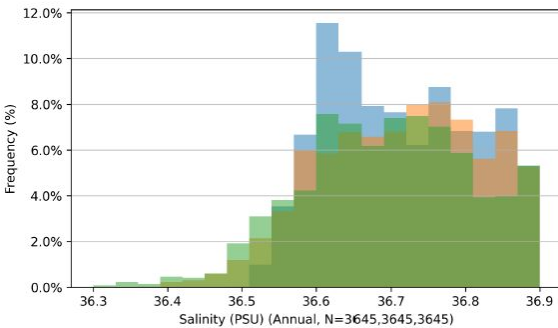
Average satellite-derived sea surface temperature (°C) histogram for a year, mean temperature and standard deviation per month.



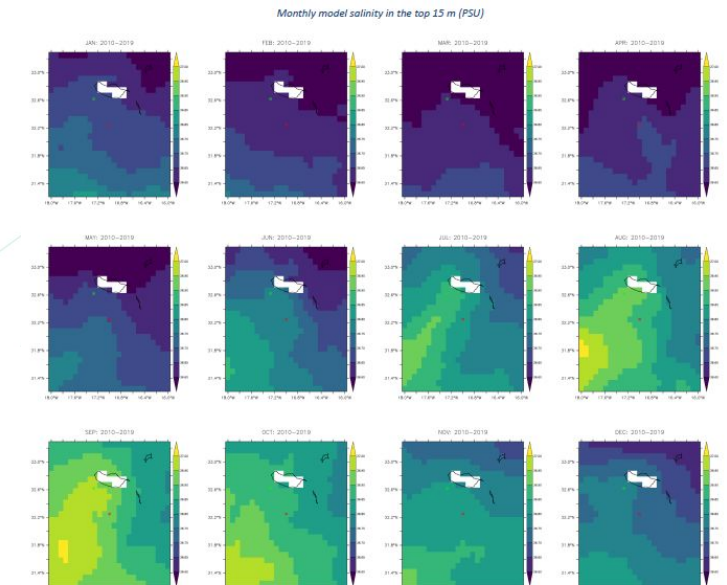
## SST



Average model salinity in the top 15 m (PSU) histogram for a year, mean salinity and standard deviation per month.



## SSS

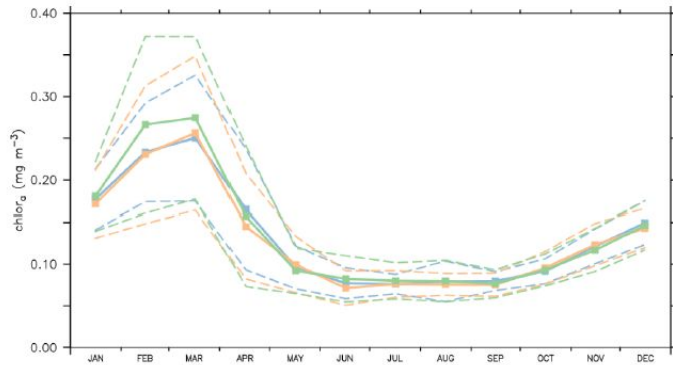
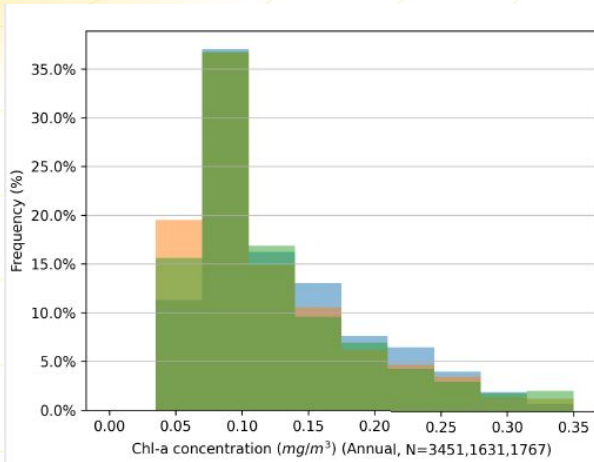




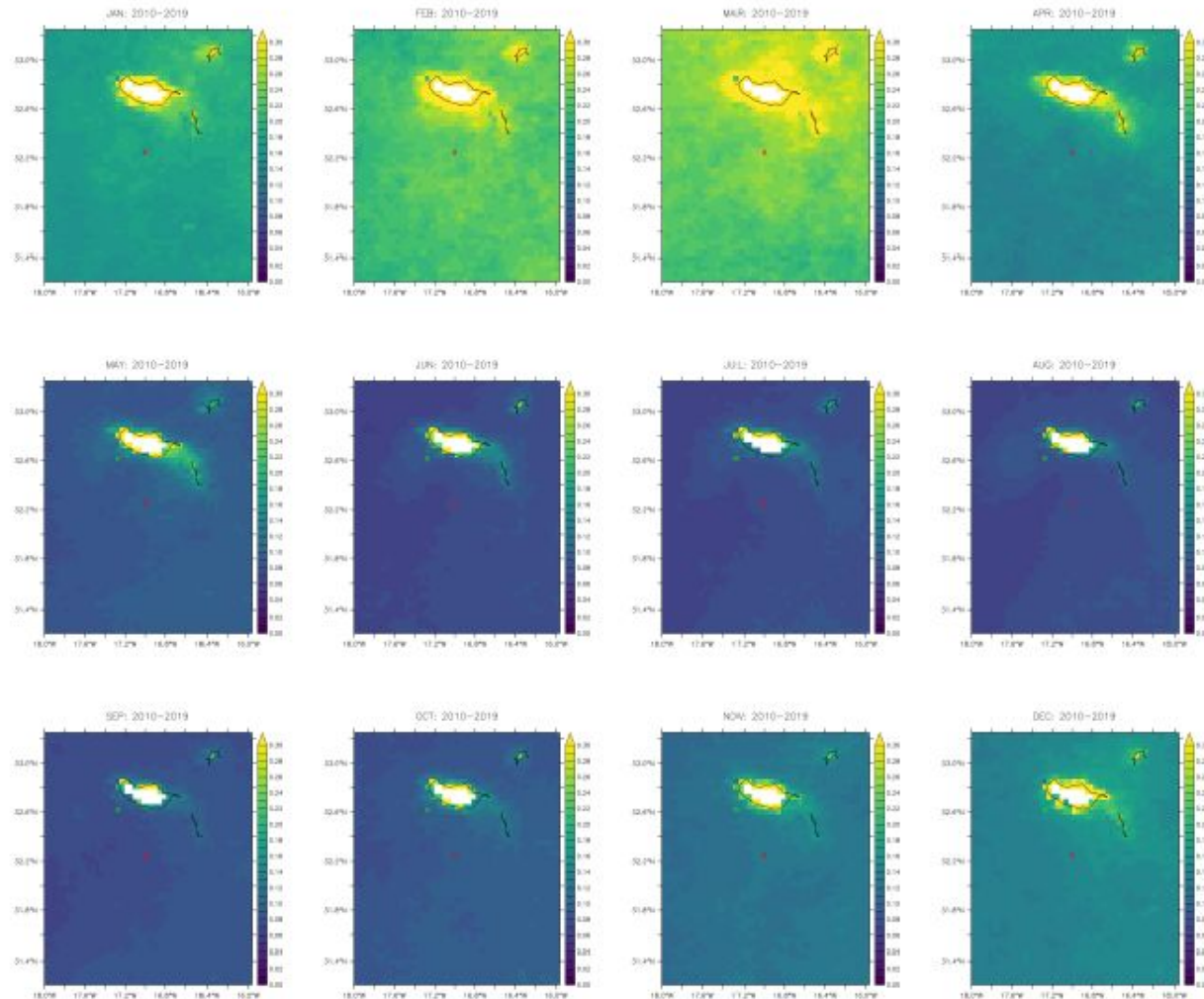
# Chlorophyll

data source: OC-CCI (CCI\_ALL-v5.0-DAILY) in 4x4 km grid

Chlorophyll-A (Chl-a) concentration ( $mg\ m^{-3}$ ) histogram (left); mean Chl-a concentration and standard deviation per month (right). The number of available Chl-a retrievals is presented on the x-axis histogram label.



Monthly mean Chlorophyll-A (Chl-a) concentration ( $mg\ m^{-3}$ )

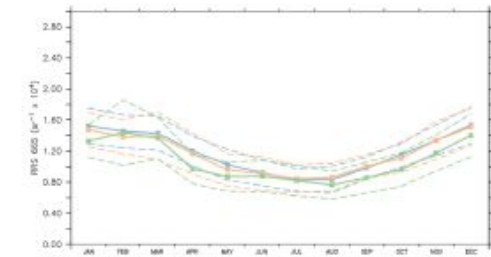
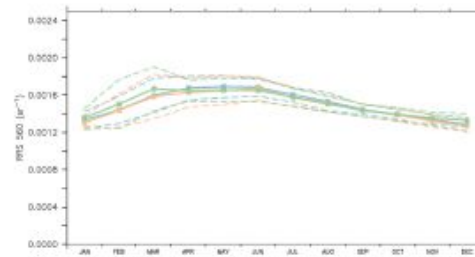
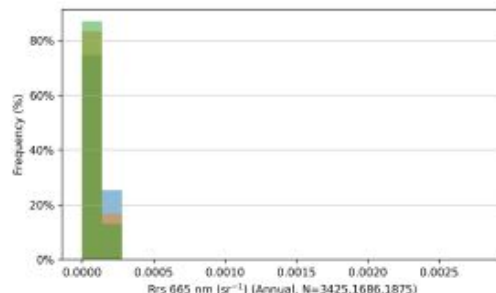
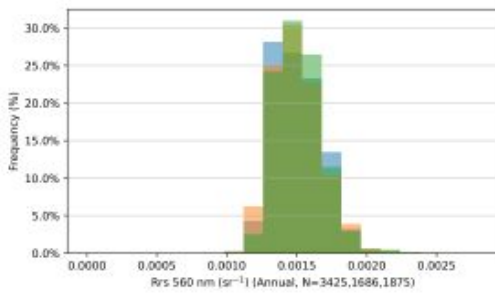
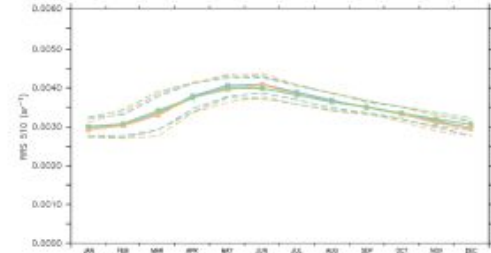
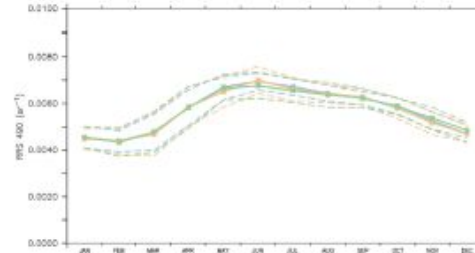
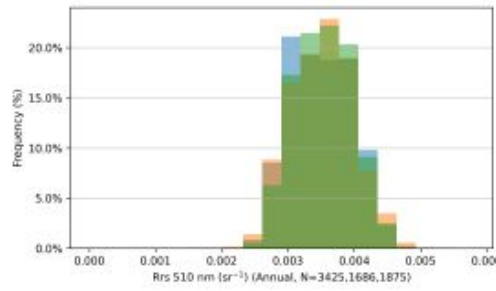
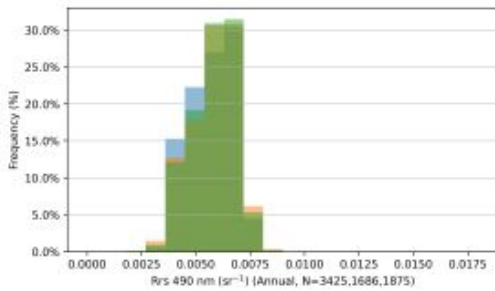
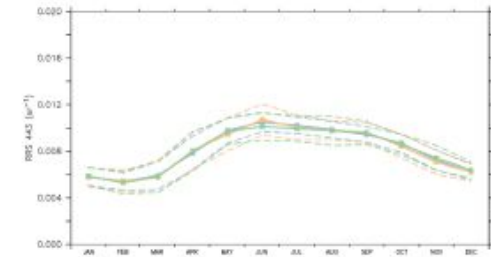
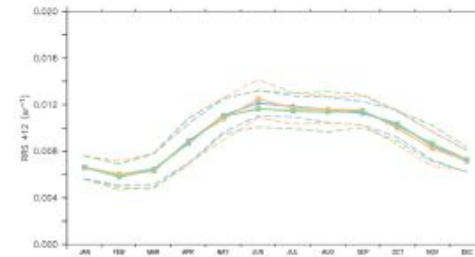
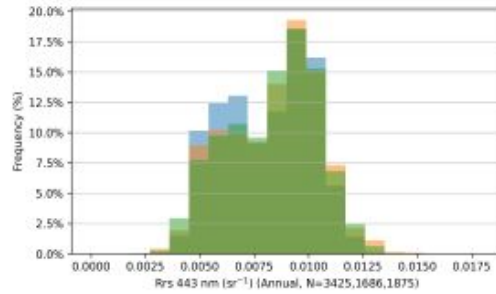
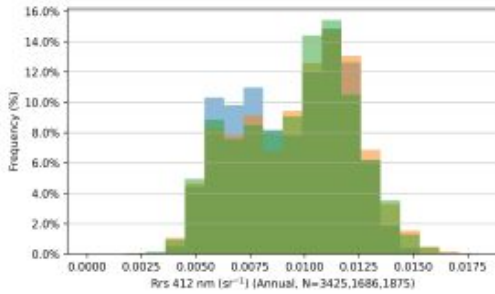


# Remote sensing reflectances

data source: OC-CCI (CCI\_ALL-v5.0-DAILY) in 4x4 km grid

Remote sensing reflectance ( $R_{rs}$ ,  $sr^{-1}$ ) at 412, 443, 490, 510, 560 and 665 nm histograms from all daily L3 images.

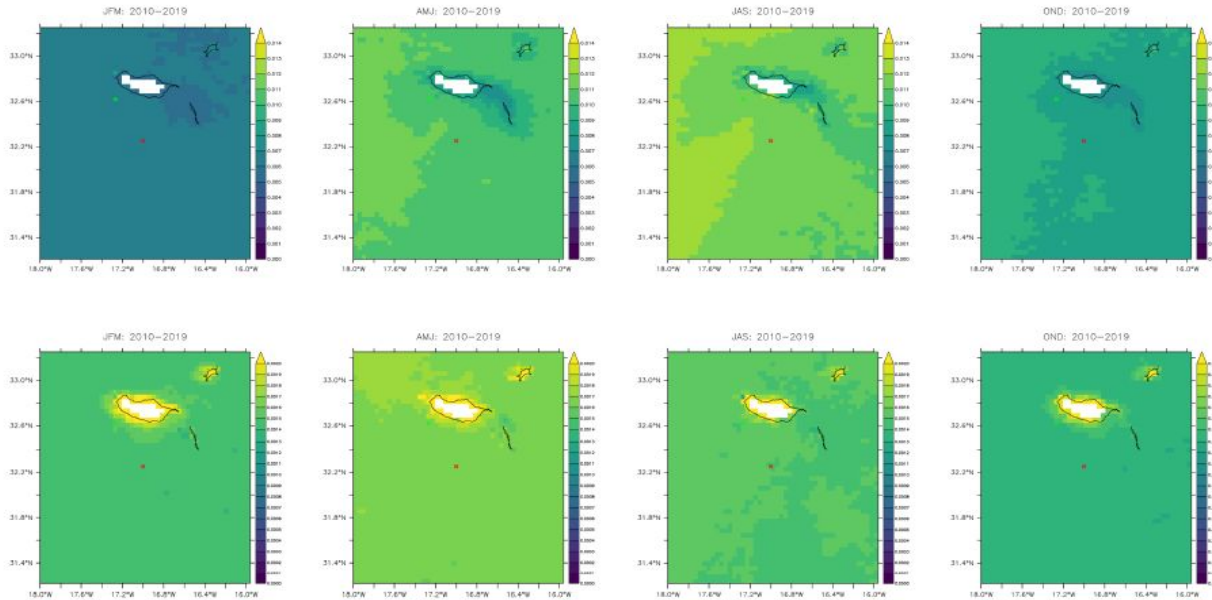
Remote sensing reflectance ( $R_{rs}$ ,  $sr^{-1}$ ) mean and standard deviation per month at 412, 443, 490, 510, 560 and 665 nm from all daily L3 images.



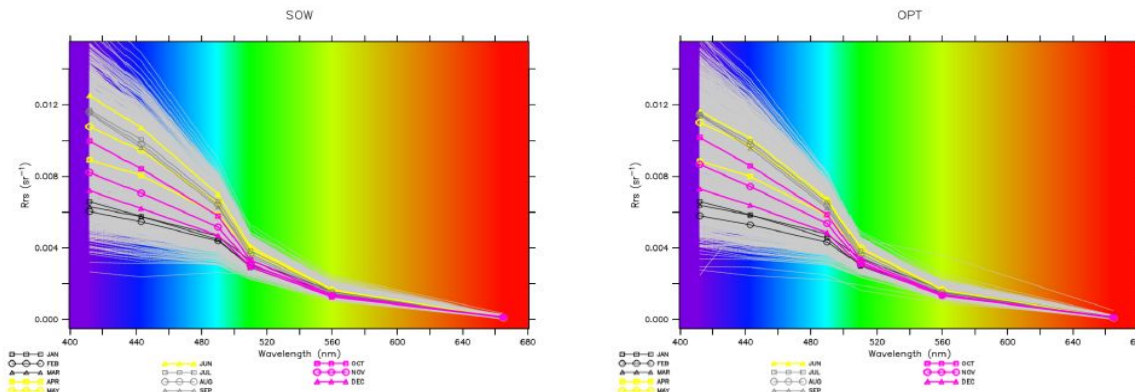
# Remote sensing reflectances

data source: OC-CCI (CCI\_ALL-v5.0-DAILY) in 4x4 km grid

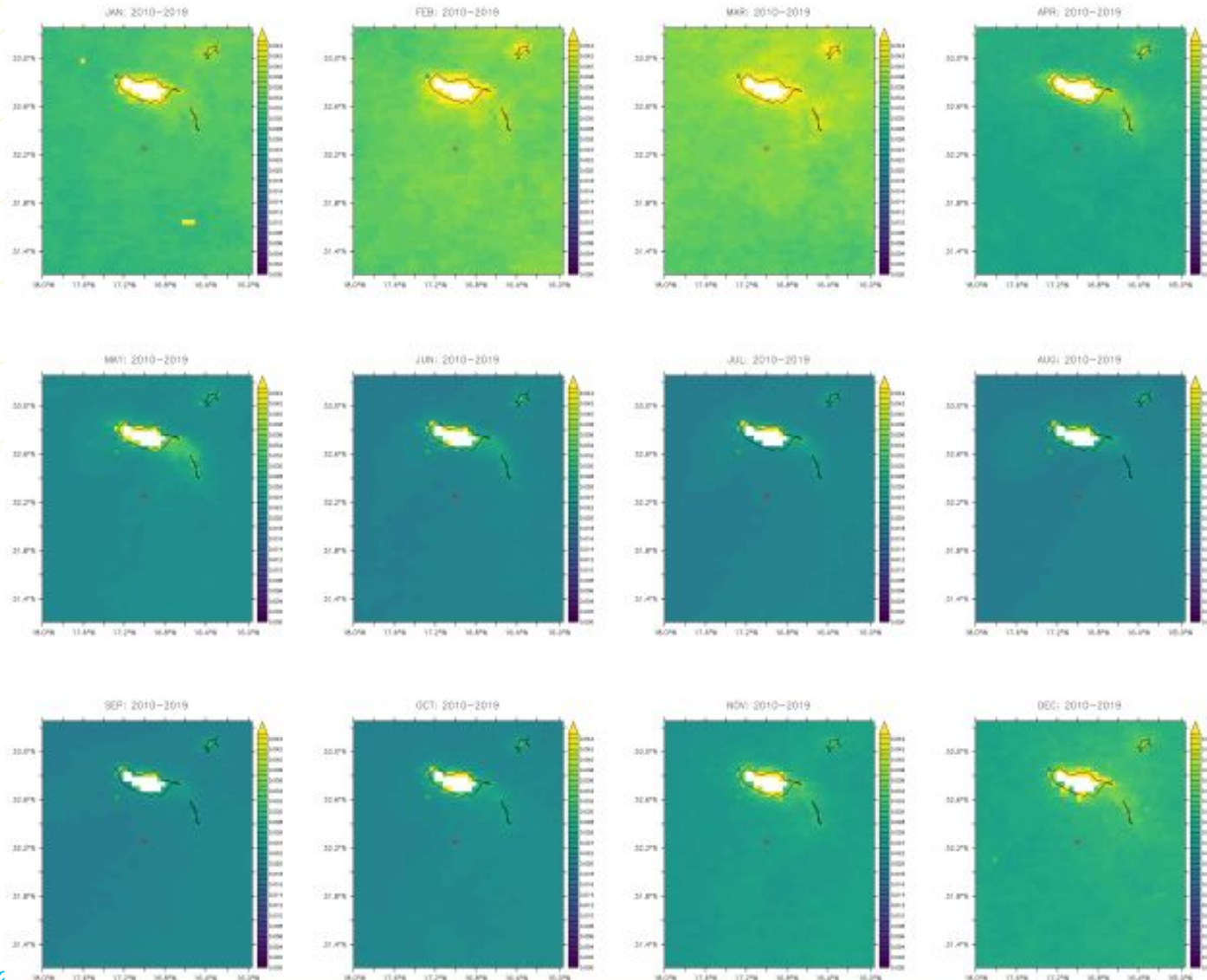
Remote sensing reflectance ( $R_{rs}$ ) ( $sr^{-1}$ ) mean maps for each season at 443 (top) and 560 nm (bottom).



Monthly mean Remote sensing reflectance ( $R_{rs}$ ) ( $sr^{-1}$ ) spectra for the sites SOW (left) and OPT (right). Light grey-unlabeled lines represent the spectra for each daily retrieval.



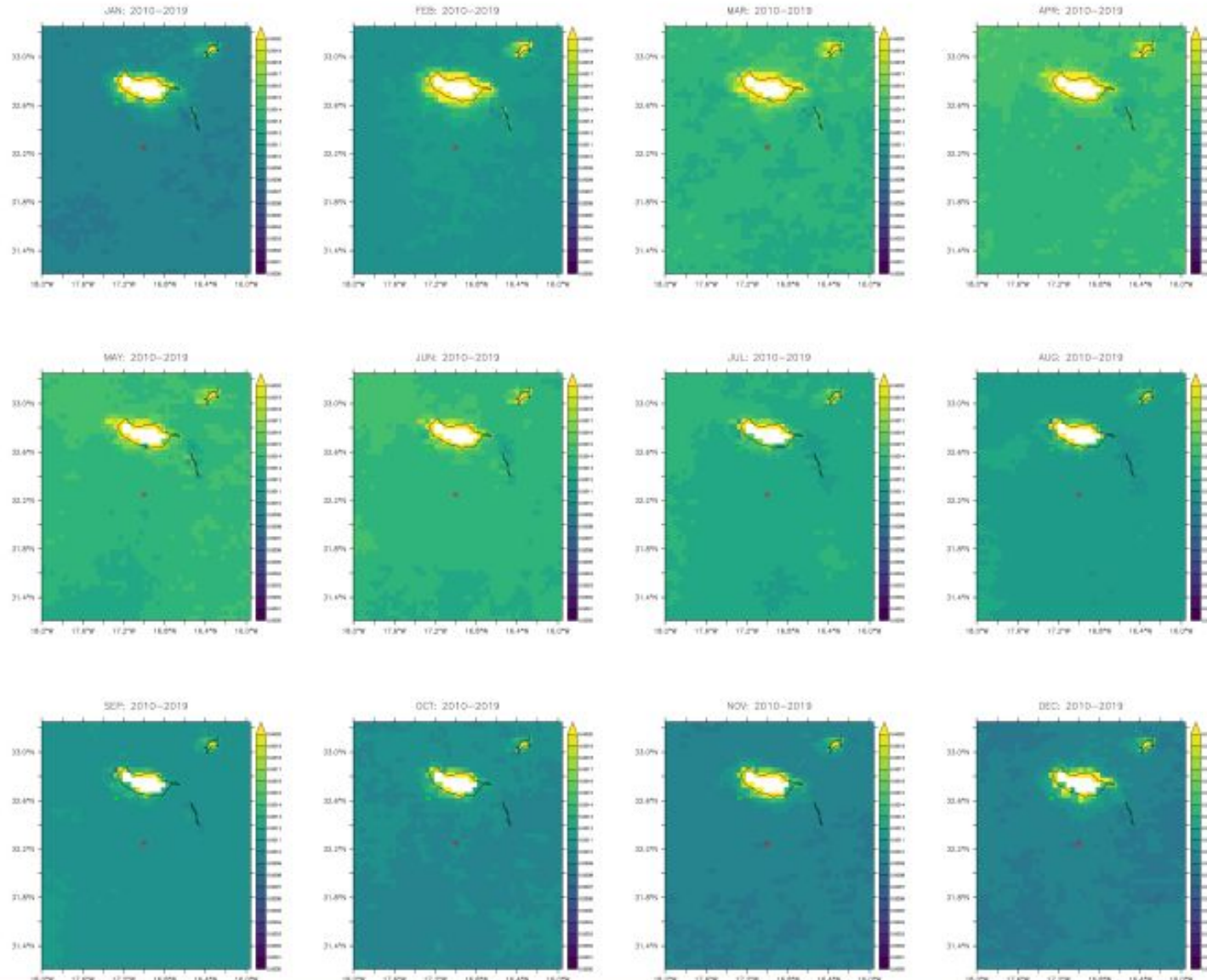
Monthly mean maps of Coloured Dissolved Organic Matter (CDOM) absorption at 443 nm [ $a_{CDOM}(m^{-1})$ ].



# IOPs – particulate backscatter

data source: OC-CCI (CCI\_ALL-v5.0-DAILY) in 4x4 km grid

Monthly mean maps of particulate backscatter at 560 nm bbp ( $m^{-1}$ ).

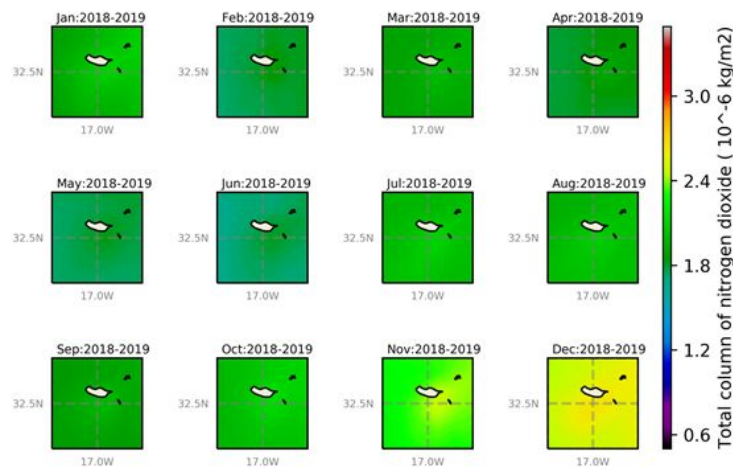


# Shipping, airline and fire

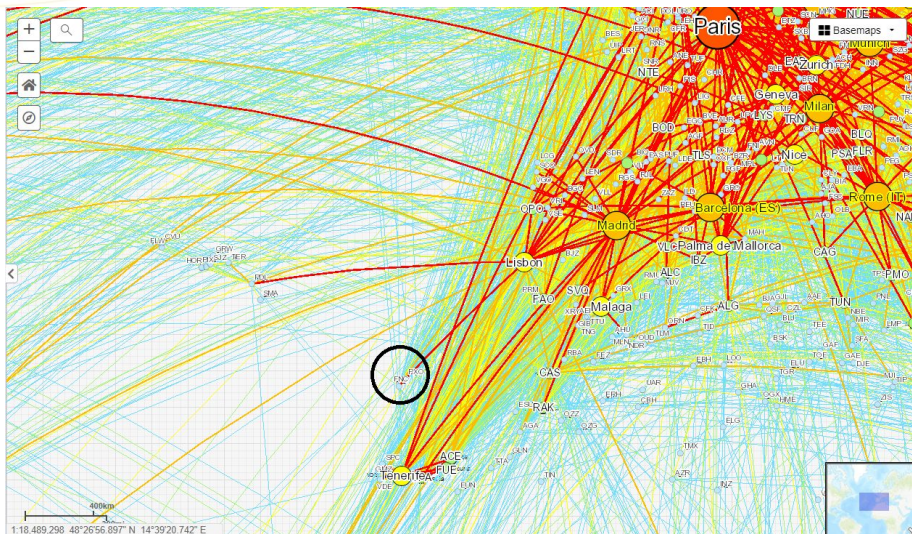
source: [EMODnet Human activities portal](https://emodnet.eu/)

CAMS reanalysis

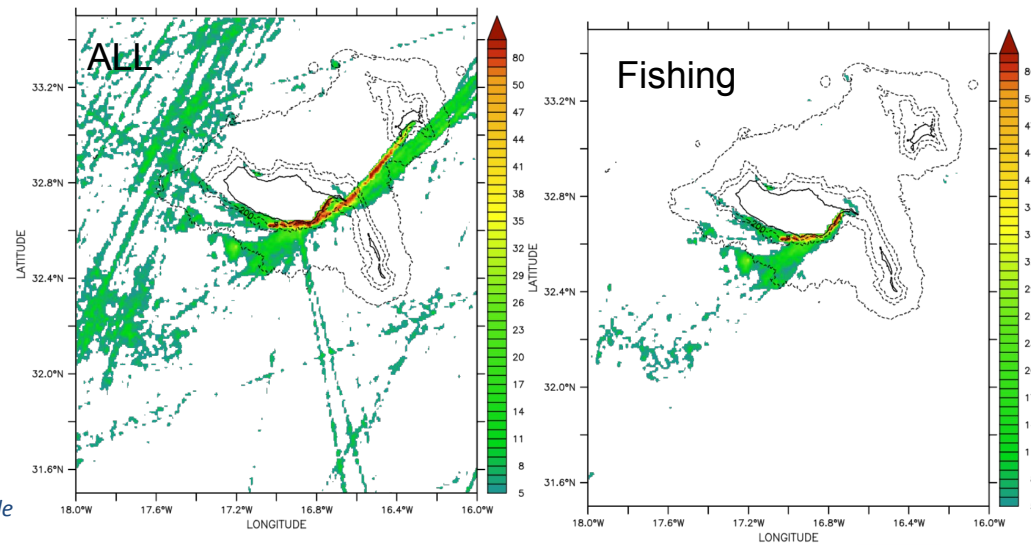
source: <https://gis.icao.int/icaoaviation/?locale=en-gb#/-12.8979/38.2963/5>



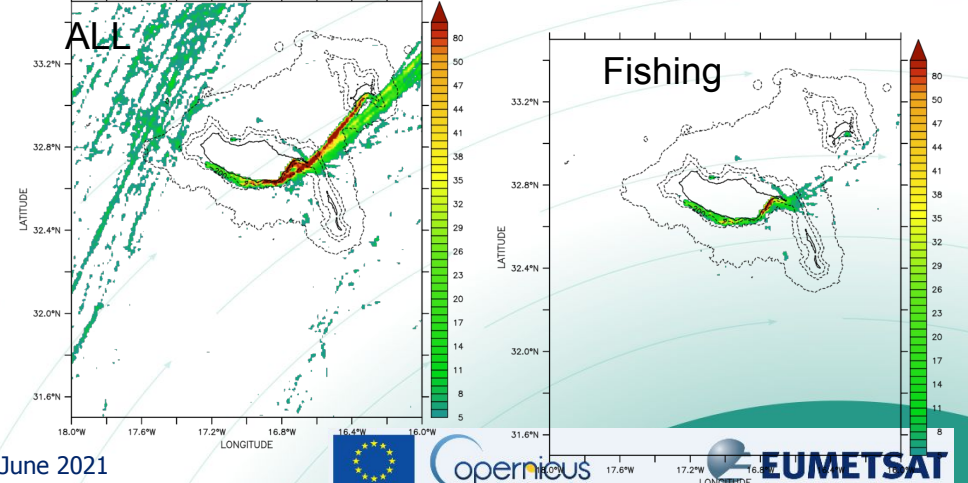
Air traffic routes for Europe for 2018 and 2019, Madeira region is identified by the black circle



Shipping activity (hours per square km per month) for summer 2019



Shipping activity (hours per square km per month) for summer 2020



# Site highlights

OC-SVC\_Madeira.kmz

The screenshot displays the Google Earth Pro interface. The main map shows the Madeira Islands with a highlighted area in yellow and orange. Labels on the map include 'Madeira', 'Funchal', 'Harbour', 'OPT', and 'SOW'. The left sidebar contains the 'Places' and 'Layers' panels. The 'Places' panel lists several locations, with 'OC-SVC-Madeira' selected. The 'Layers' panel shows various map features like 'Primary Database', 'Announcements', 'Borders and Labels', 'Places', 'Photos', 'Roads', '3D Buildings', 'Weather', 'Gallery', 'More', and 'Terrain'. The bottom status bar shows the imagery date as 12/14/2015 and coordinates: 32°33'31.55" N, 16°36'02.22" W, with an elevation of -675 m and eye alt of 350.68 km. The Windows taskbar at the bottom shows the search bar and system tray with the time 09:37 on 24/06/2021.

Google Earth Pro

File Edit View Tools Add Help

Search

Search

ex: 37 25' 19.1"N, 122 05' 06"W

Get Directions History

Places

- The London Eye  
Localizada em Londres, Inglaterra
- Titanic  
Localizado no Atlântico Norte
- Cidade Proibida  
Localizada em Pequim, China
- Monte Fuji  
Localizado perto de Tóquio, Japão
- Sede da Google  
Localizada em Mountain View, Califórnia
- Carabean Sea
- Marcador de local sem título

Temporary Places

- OC-SVC-Madeira

Layers

- Primary Database
  - Announcements
  - Borders and Labels
  - Places
  - Photos
  - Roads
  - 3D Buildings
  - Weather
  - Gallery
  - More
  - Terrain

© 2021 Google  
Data SIO, NOAA, U.S. Navy, NGA, GEBCO

Google Earth

Imagery Date: 12/14/2015 32°33'31.55" N 16°36'02.22" W elev -675 m eye alt 350.68 km

Type here to search

IPMA Apps 09:37 24/06/2021

# Site highlights

## Atmosphere and Logistics

Parameter	SOW location (32.25N, 17.00W)	OPT (32.62N, 17.27W)
fractional cloud cover <i>low, per season/month/day, high persistence of cloud free conditions</i>	Monthly average [0.49, 0.80] Month @ min,max [AUG, FEB] Stdev @ mon min,max [0.11, 0.08] Nb. Chla L3: 1686 (46%)	Monthly average [0.17, 0.60] Month @ min,max [AUG, FEB] Stdev @ mon min,max [0.04, 0.12] Nb. Chla L3: 1875 (51%)
aerosol type and optical thickness <i>stable and spatially uniform maritime aerosol, Aerosol Optical Thickness (AOT) &lt; 0.15, only quantified and limited episodes of dust, biomass burning, pollution etc</i>	AOD < 0.15, 82% of the occurrences. DD episodes ~15 days/year BB episodes ~4.5 days/year	AOD < 0.15, 78% of the occurrences DD episodes ~15 days/year BB episodes ~17.1 days/year
atmospheric gases <i>quantified and limited absorbing gases: ozone, stratospheric &amp; tropospheric NO2 from cities &amp; ship emissions), H2O</i>	Low atmospheric gases emission No paths associated with ship routes can be identified in the NO2 spatial patterns	Low atmospheric gases emission. No paths associated with ship routes can be identified in the NO2 spatial patterns
wind speed and direction spectrum <i>low surface wind, per season/month/day</i>	below 4 m/s, 50% of the occurrences	below 4 m/s, 80% of the occurrences
distance from land <i>Should be maximised within the site logistic constraints</i>	~23 nautical miles from main island	~7 nautical miles from main island
solar illumination conditions <i>Maximising light availability per season/month/day</i>	Cosine of Sun Zenith Angle at 10AM in the range [0.44, 0.87]	Cosine of Sun Zenith Angle at 10AM in the range [0.44, 0.87]
bathymetry <i>depth &gt; 800m [mean,max-min] in 0.01x0.01 box</i>	3733m [3714, 409]	2865m [2814, 265]

## Ocean

Parameter	SOW location (32.25N, 17.00W)	OPT (32.62N, 17.27W)
chlorophyll concentration <i>stable and spatially uniform low concentration &lt; 0.2 mg.m-3, daily/monthly/season</i>	Monthly average [0.07, 0.26] Month @ min,max [SEP, MAR] Stdev @ mon min,max [0.01, 0.09] Nb. days < 0.2: 1459 (86%)	Monthly average [0.08, 0.27] Month @ min,max [SEP, MAR] Stdev @ mon min,max [0.01, 0.1] Nb. days < 0.2: 1596 (85%)
water bio-optical properties <i>stable and spatially uniform Inherent Optical Properties (IOPs), uniform within buoy depth</i>	aCDOM: - Month average [0.02, 0.04] - Month @ min,max [SEP, MAR] - Stdev @ mon min,max [<.01,<.01] - Nb. days < 0.03: 1346 (80%) Bbp 560 nm: - Month average [0.0009, 0.0014] - Month @ min,max [DEC, JUN] - Stdev @ mon min,max [<.001,<.001] - Ndays < 0.0012: 1004 (59%)	aCDOM: - Month average [0.02, 0.04] - Month @ min,max [SEP, MAR] - Stdev @ mon min,max [<.01,<.01] - Nb. days < 0.03: 1468 (78%) Bbp 560 nm: - Month average [0.0009, 0.0014] - Month @ min,max [DEC, MAR] - Stdev @ mon min,max [<.001,<.001] - Ndays < 0.0012: 1033 (55%)
currents, significant wave height <i>low to minimise buoy tilt, low frequency of swells, low hydrosol advection</i>	Monthly curr. average [8, 21] Month curr @ min,max [APR, AUG] Curr. Stdev @ mon min,max [5, 10] Nb. days curr. < 20 cm/s: 3153 (86%)	Monthly curr. average [7, 19] Month curr @ min,max [JAN, SEP] Curr. Stdev @ mon min,max [4, 11] Nb. days curr. < 20 cm/s: 3205 (88%)
sea surface temperature, salinity <i>stable and spatially uniform</i>	SST (°C): - Month average [18.0, 23.9] - Month @ min,max [MAR, SEP] - Stdev @ mon min,max [0.5, 0.6] Salinity 0-15m (PSU): - Month average [36.63, 36.95] - Month @ min,max [FEB, SEP] - Stdev @ mon min,max [0.1, 0.1]	SST (°C): - Month average [17.9, 23.8] - Month @ min,max [MAR, SEP] - Stdev @ mon min,max [0.5, 0.6] Salinity (PSU): - Month average [36.61, 36.96] - Month @ min,max [MAR, SEP] - Stdev @ mon min,max [0.1, 0.1]