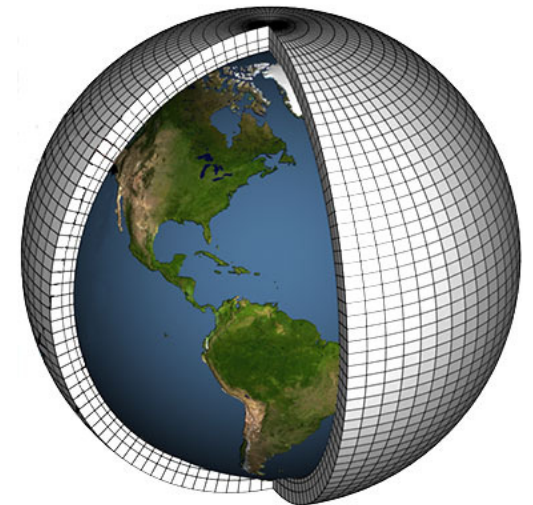


Module 15/16/17 Oceans

- Module 15
 - Ocean variability in seasonal models
 - SST and Sea Level
 - Climate drivers and the ocean
 - Past and future coastal flooding for Pacific Small-Island Nations
- Module 16
 - Marine Applications of Ocean Outlooks
- Module 17
 - ACCESS-S Ocean Outlooks and websites
 - ACCESS-S Ocean Skill



Module 15: Ocean Dynamics



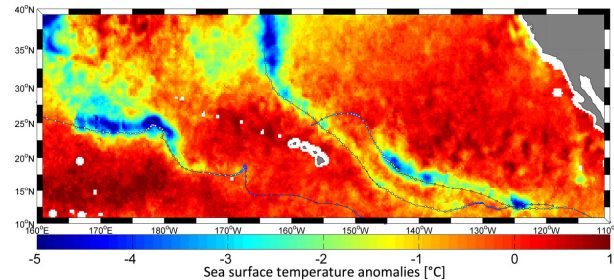
Australian Government

Department of Foreign Affairs and Trade

Bureau of Meteorology

Ocean variability in seasonal models

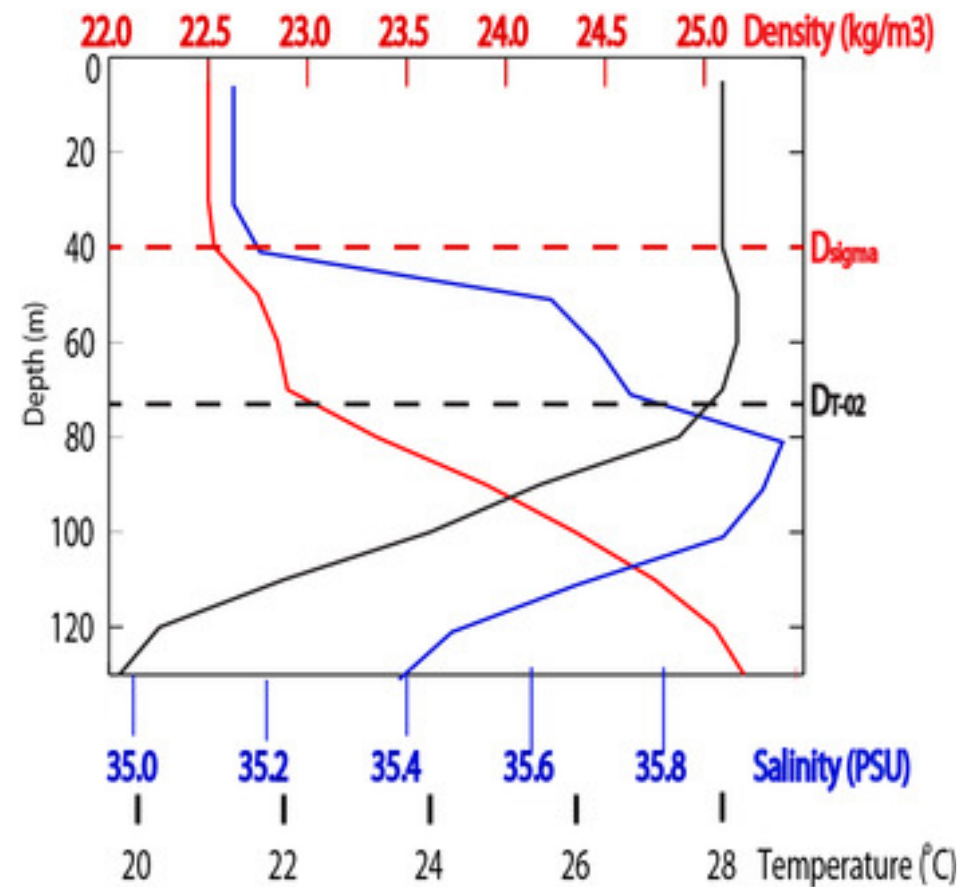
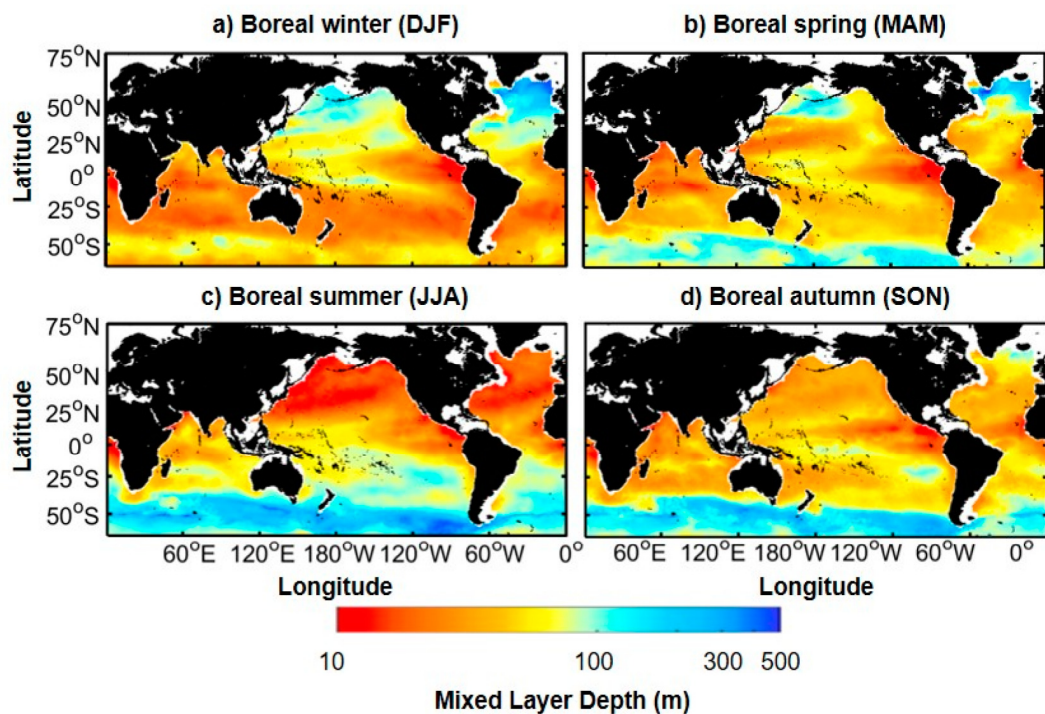
- Sea surface temperature
 - Current changes (wind and density driven)
 - Wind changes impacting mixing (cyclones)



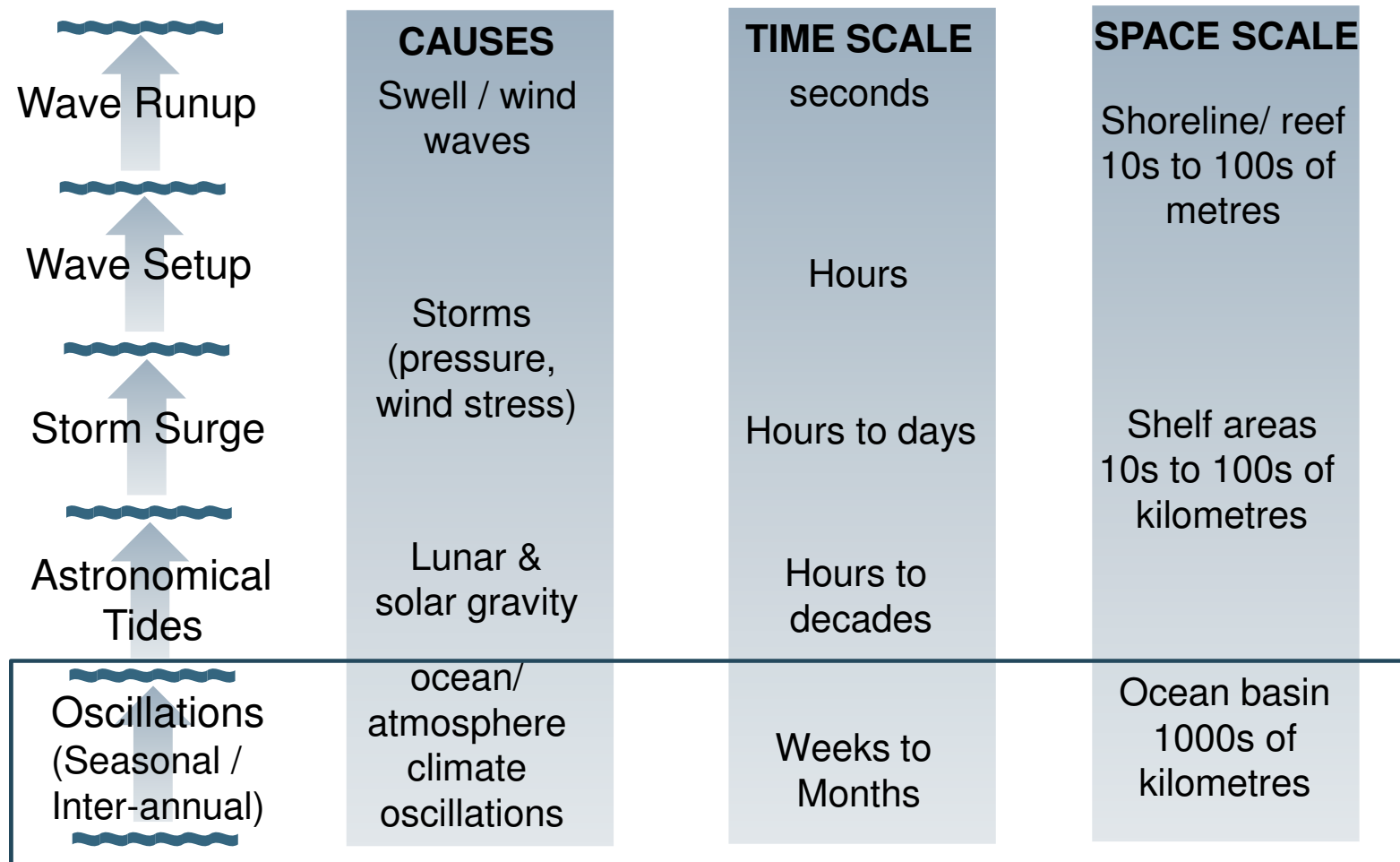
- Subsurface downwelling/upwelling movements
- Cloudiness/Rainfall

Ocean variability in seasonal models

- Mixed Layer Depth



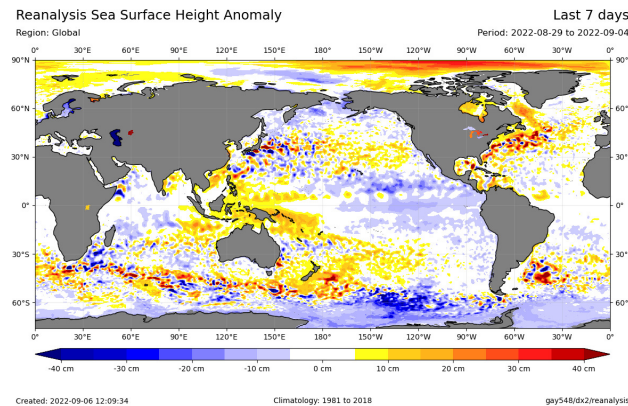
Sea Level Modelled in ACCESS-S



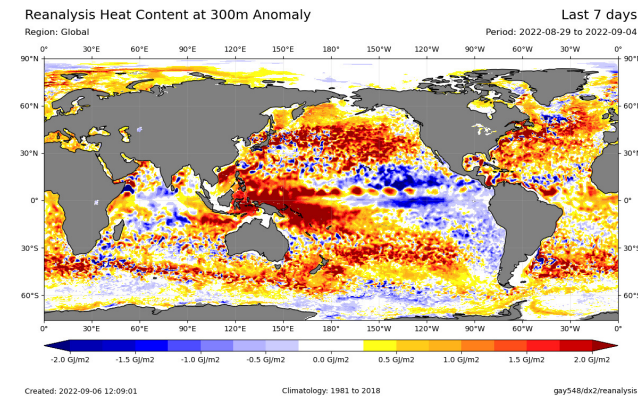
Ocean variability in seasonal models

- Sea level

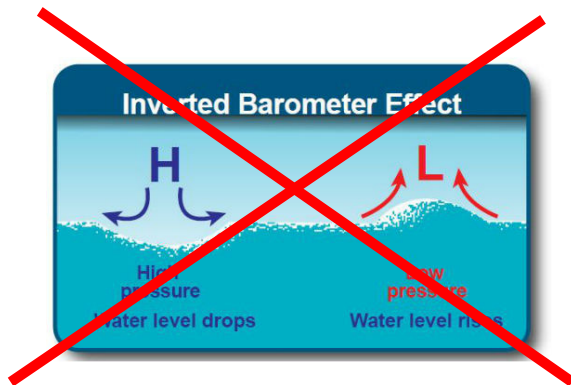
- Subsurface density changes from temperature and salinity variation
- Sea level mainly attributed to subsurface warming in most places



Sea level anomaly



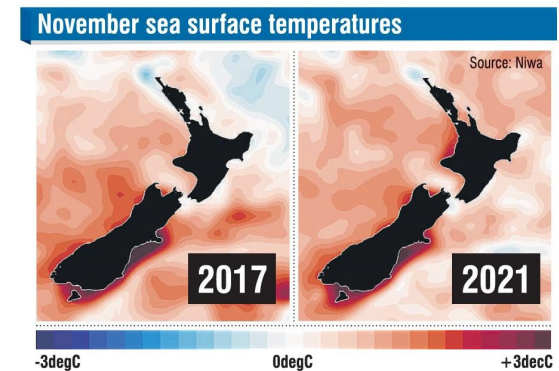
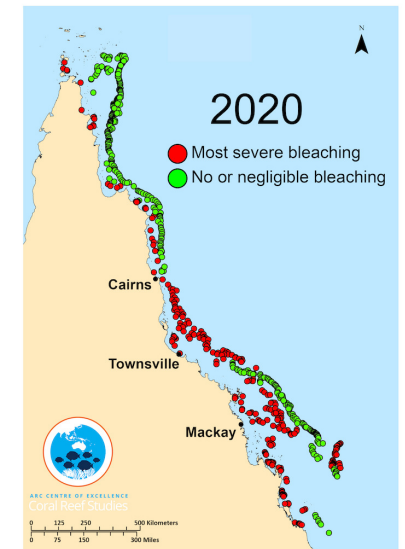
Heat Content Anomaly (300 m)



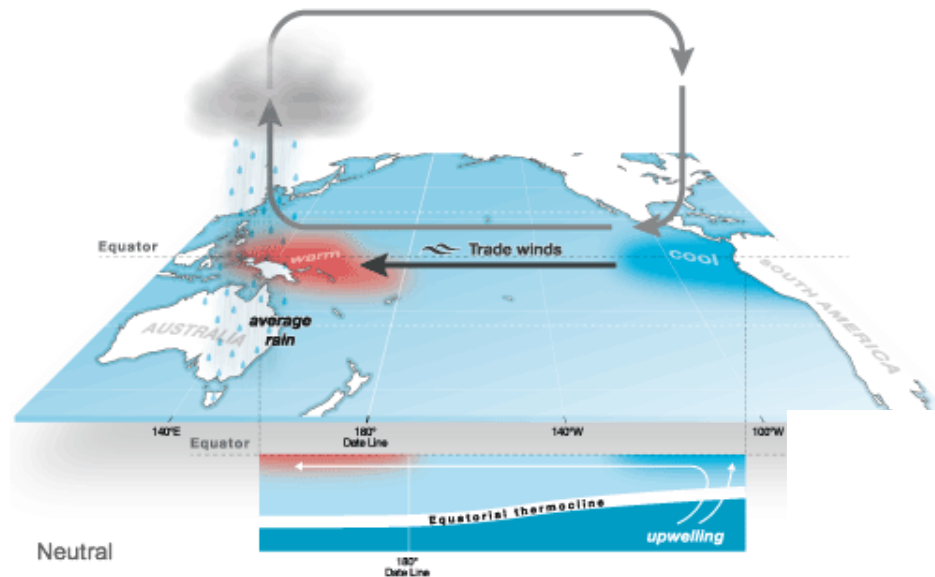
- Not included: Inverse Barometer effect

Ocean variability: climate drivers

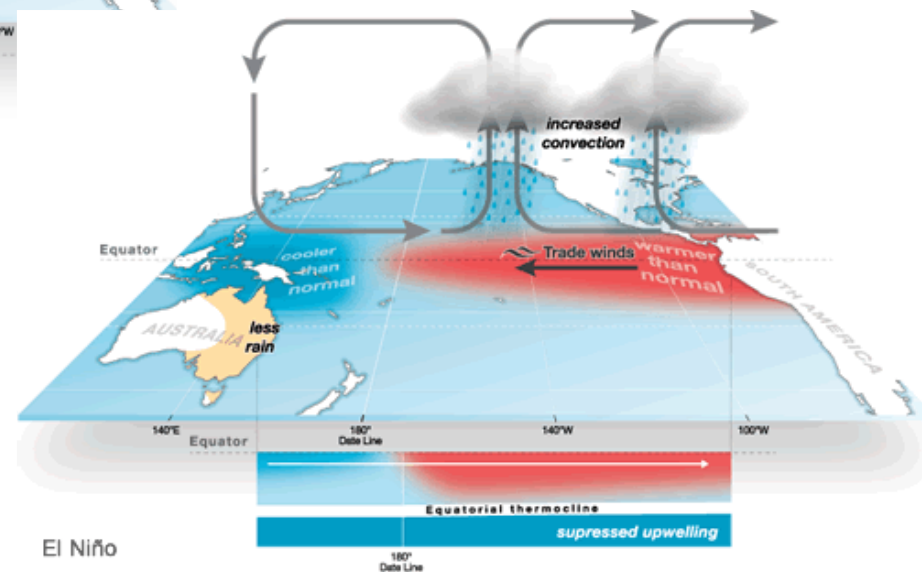
- El Niño Southern Oscillation (ENSO)
 - SST and Sea level changes in the tropics
- MJO
 - Rainfall/Cloudiness and wind impacts on SST
- ITCZ/SPCZ
 - Cloudiness decreases insolation (sun shining on the ocean)



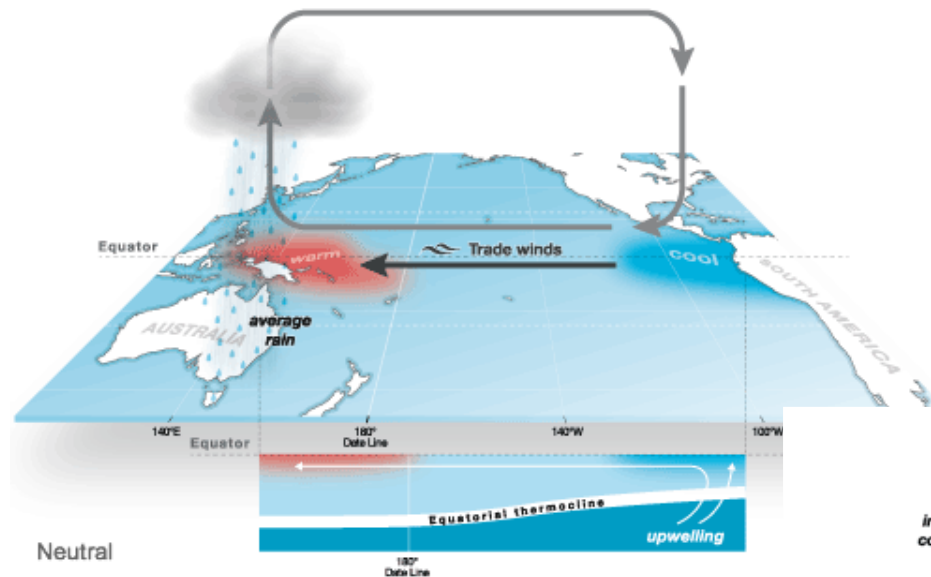
El Niño Southern Oscillation (ENSO): El Niño Events



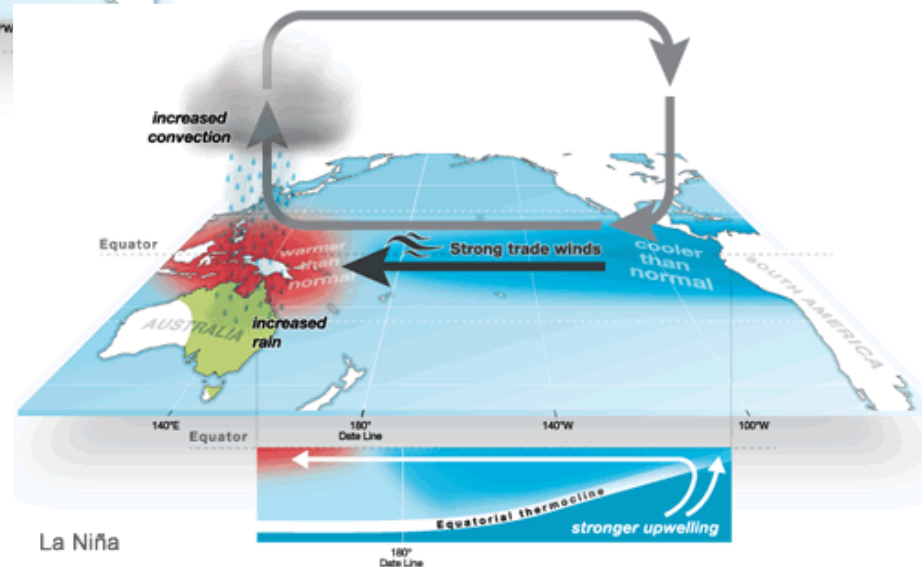
<http://www.bom.gov.au/climate/enso/history/In-2010-12/three-phases-of-ENSO.shtml>



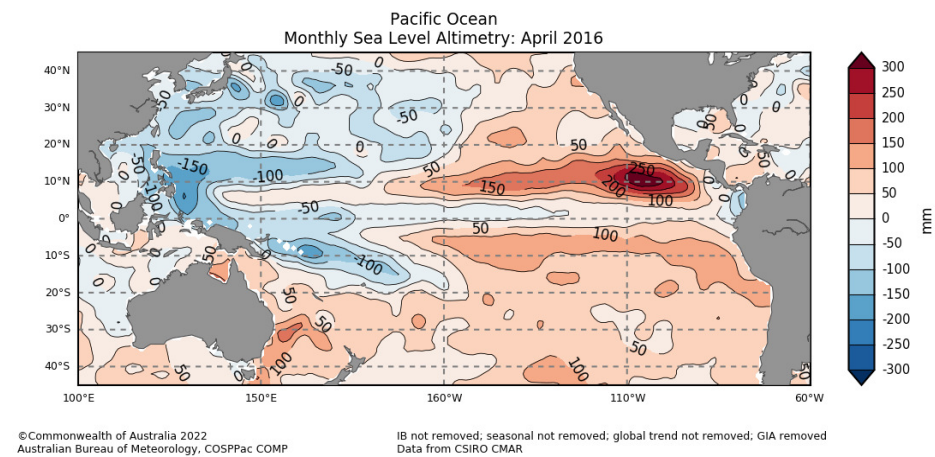
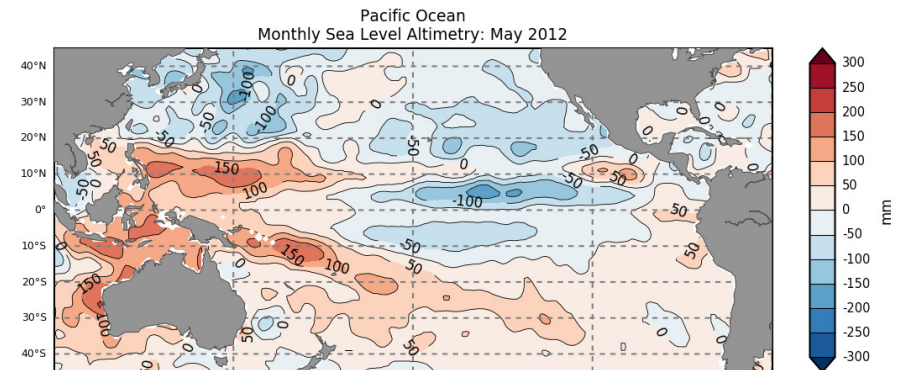
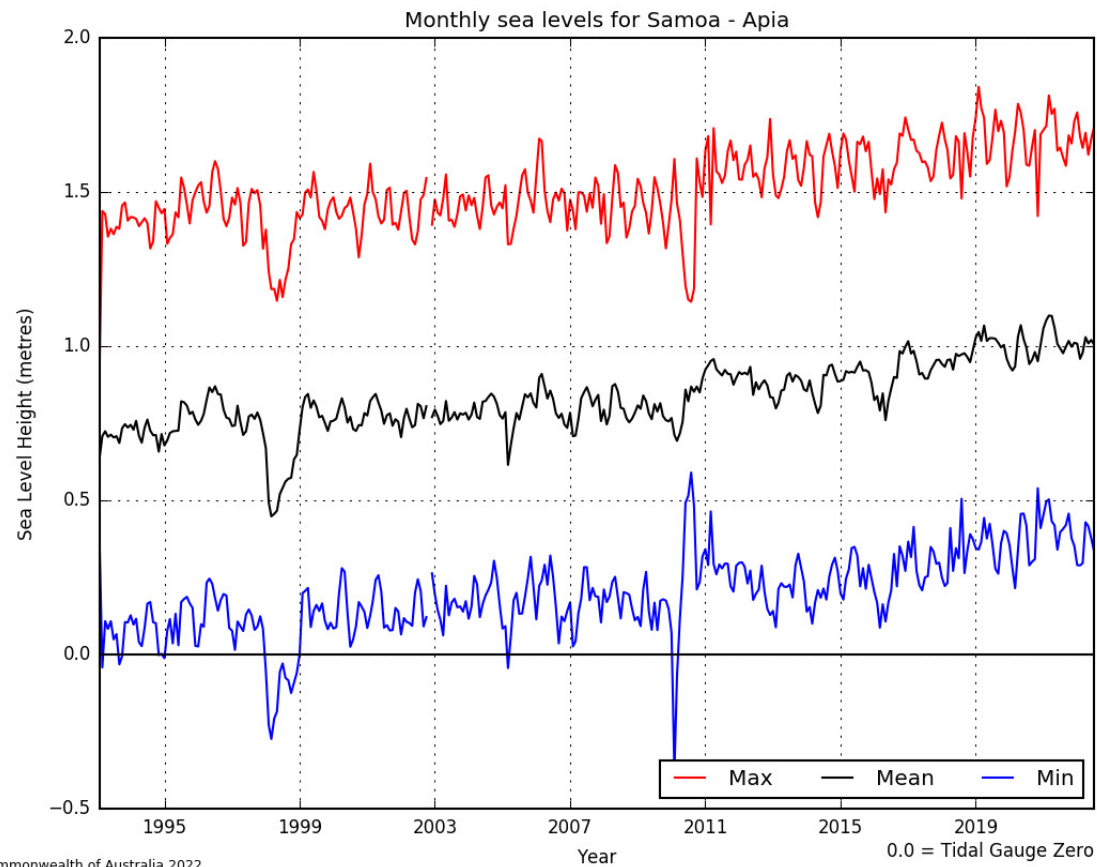
El Niño Southern Oscillation (ENSO): La Niña Events



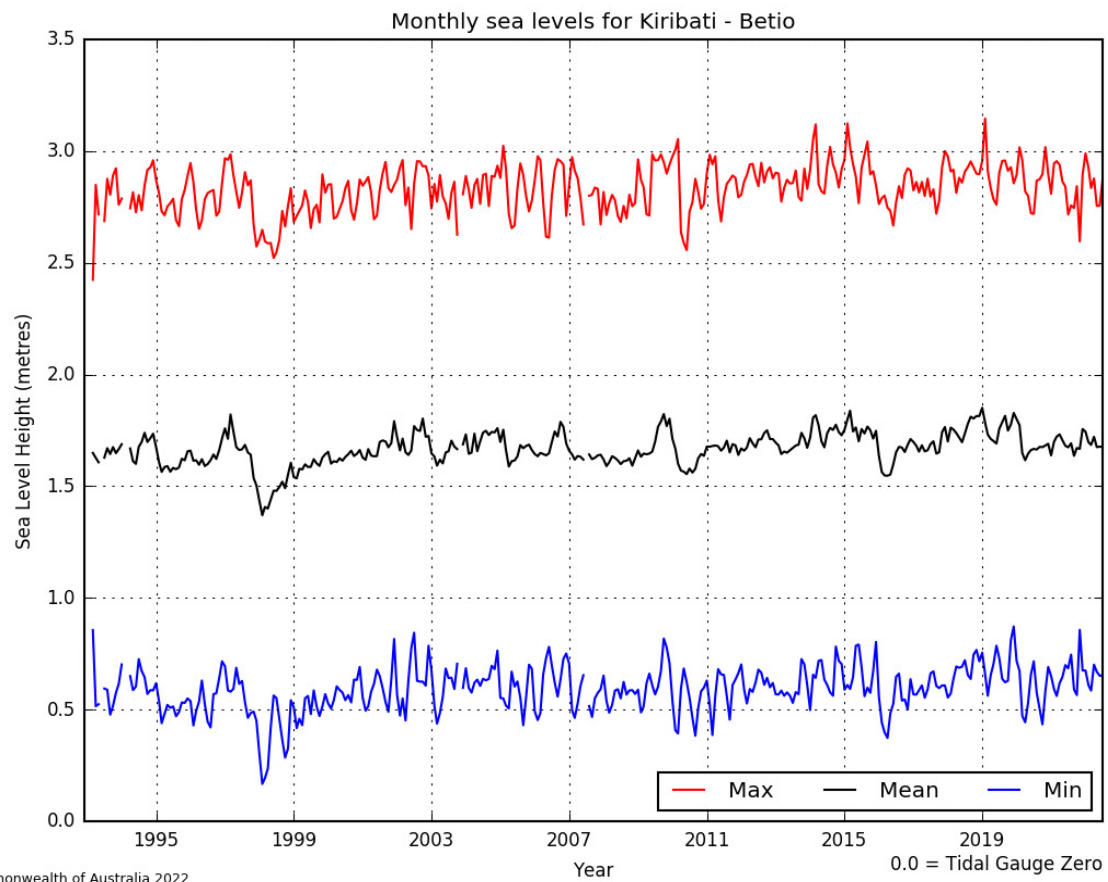
<http://www.bom.gov.au/climate/enso/history/In-2010-12/three-phases-of-ENSO.shtml>



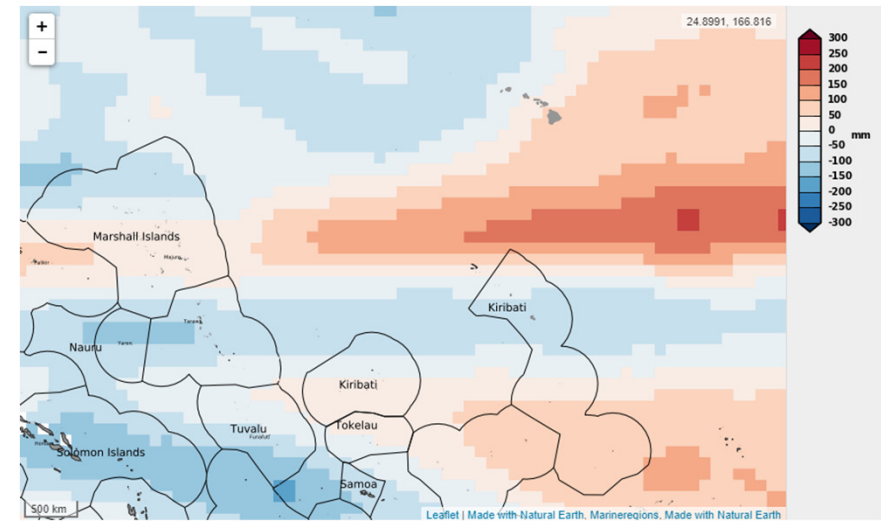
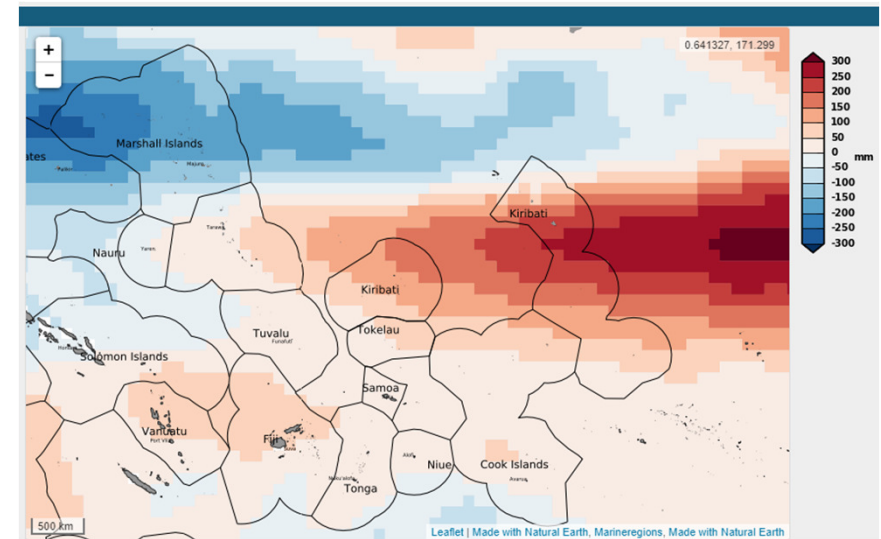
ENSO cycles and Sea Level



ENSO cycles and Sea Level

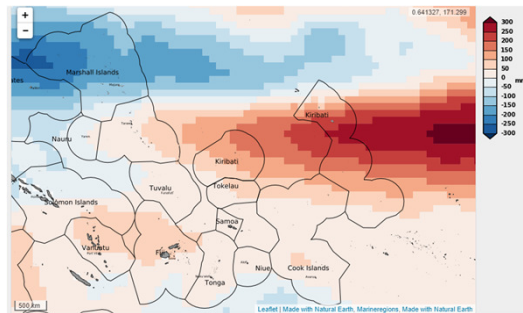


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Australian Bureau of Meteorology, COSPPac COMP

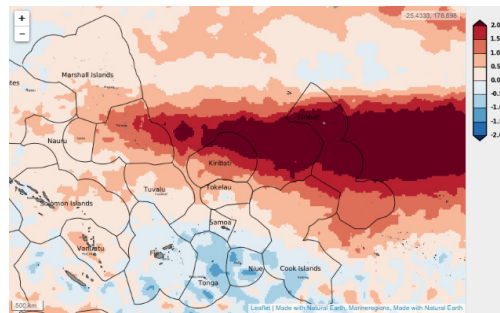


ENSO cycles and Sea Level

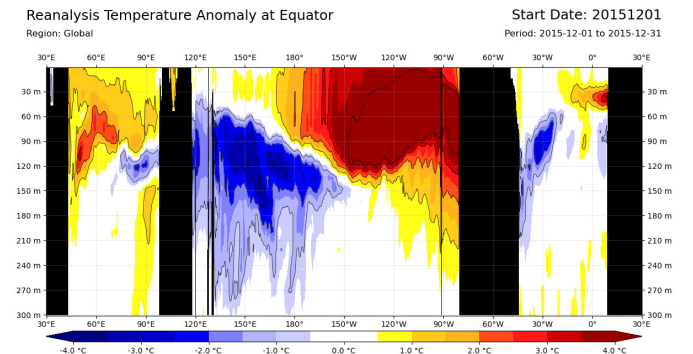
Sea Level Anomaly



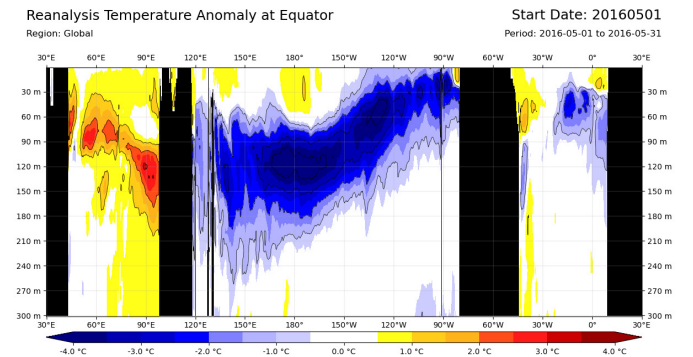
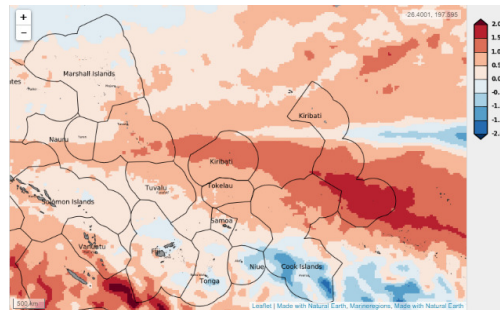
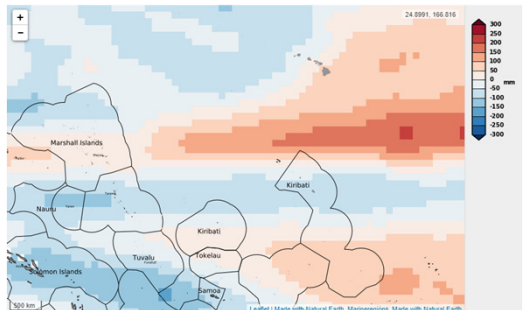
SST Anomaly



Subsurface Anomaly



December 2015

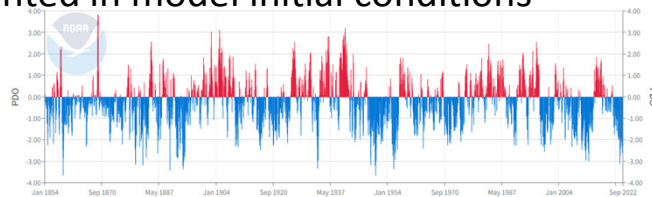


April 2016

Ocean Variability: Years to decades

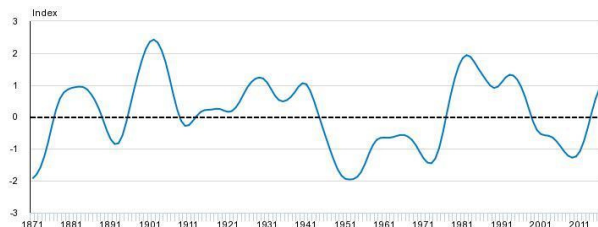
- PDO – Pacific Decadal Oscillation

- Index compares North Pacific SST patterns to equatorial Pacific
- Usually oscillates around 5 to 10 year intervals
- Represented in model initial conditions

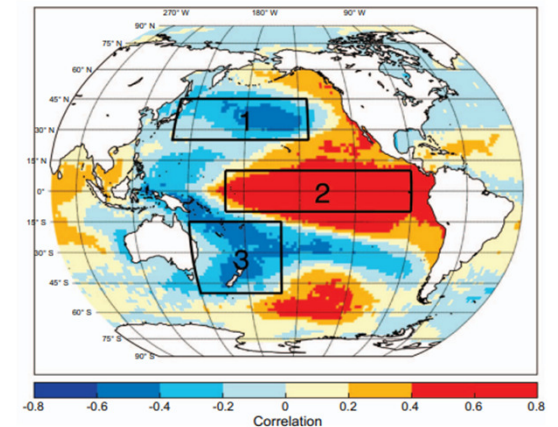
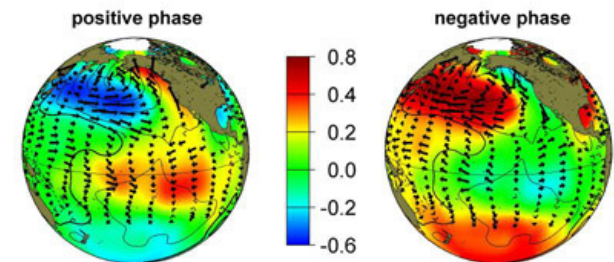


- IPO – Interdecadal Pacific Oscillation

- Index compares both north and south Pacific SST to equatorial Pacific
- 15 to 30 year oscillations
- Represented in model initial conditions

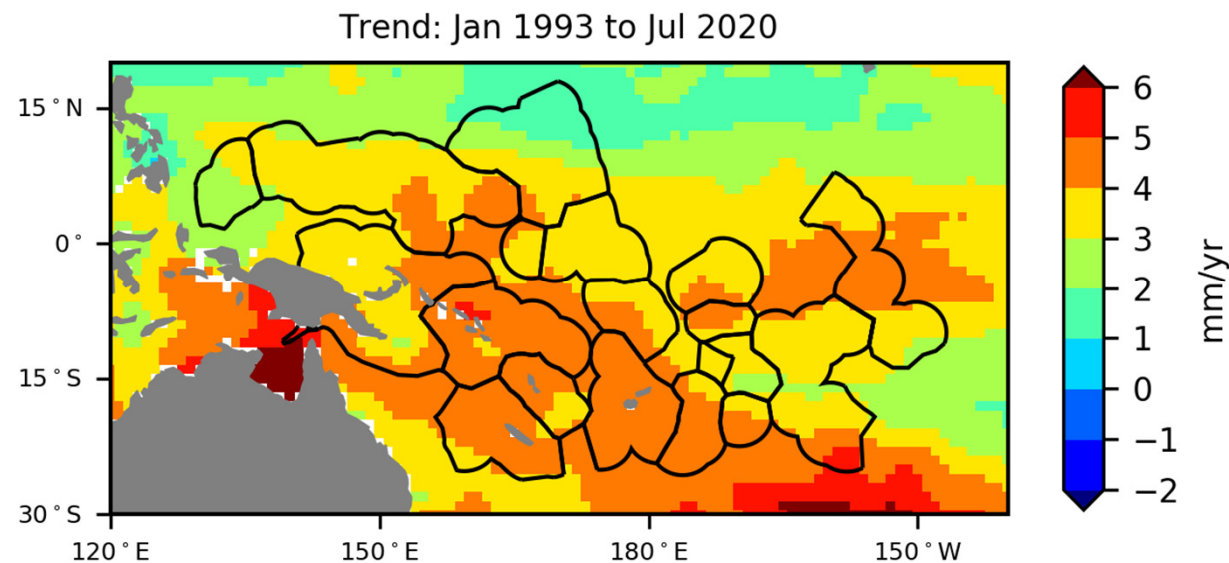


Pacific Decadal Oscillation



Ocean Variability: Years to decades

- Climate Change – Sea Level Rise
 - Current global trend is +3.40 mm/year
 - Sea level observations not part of ACCESS-S initial conditions
 - Removed ACCESS-S2 post processing (detrended)



Past and future coastal flooding for Pacific Small-Island Nations

Mathilde Ritman

Module 16: Marine Applications



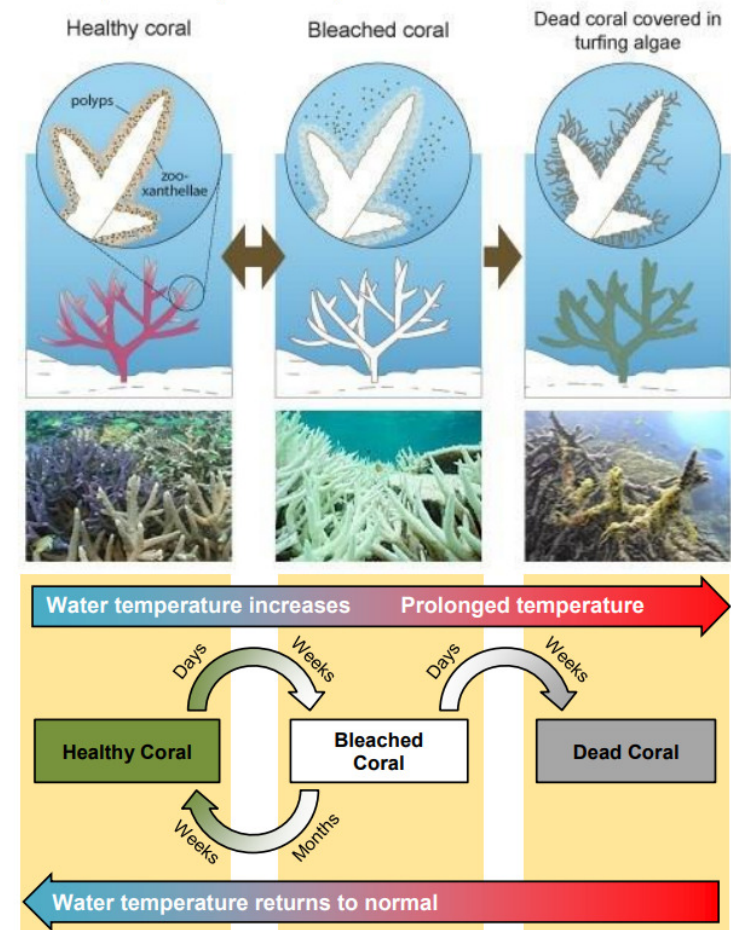
Australian Government

Department of Foreign Affairs and Trade

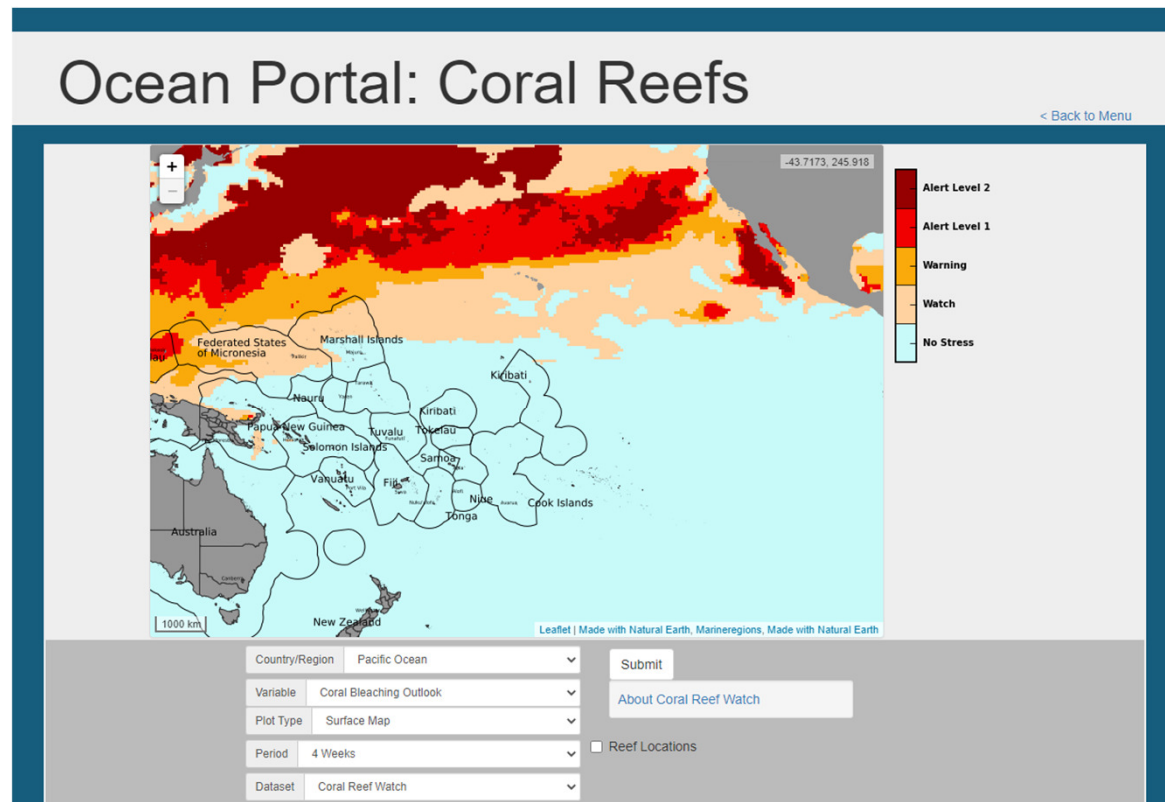
Bureau of Meteorology

Sea Surface Temperature

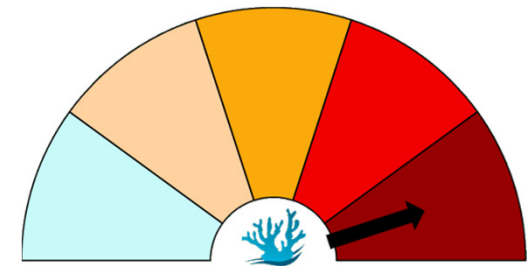
- Environmental health
 - Coral bleaching
 - Lagoon health (deoxygenation)
- Fisheries/Aquaculture
 - Pelagic fish migrations
 - Aquaculture site selection & management



Sea Surface Temperature: Coral bleaching

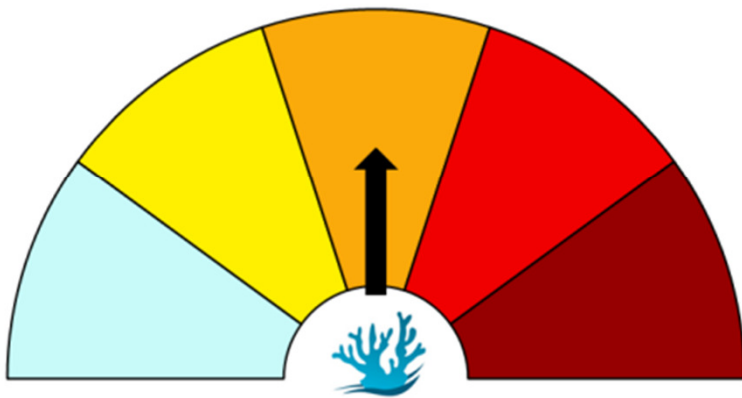


- Coral Bleaching outlooks available in the ocean portal
- Derived from SST outlooks from NOAAs CFSv2

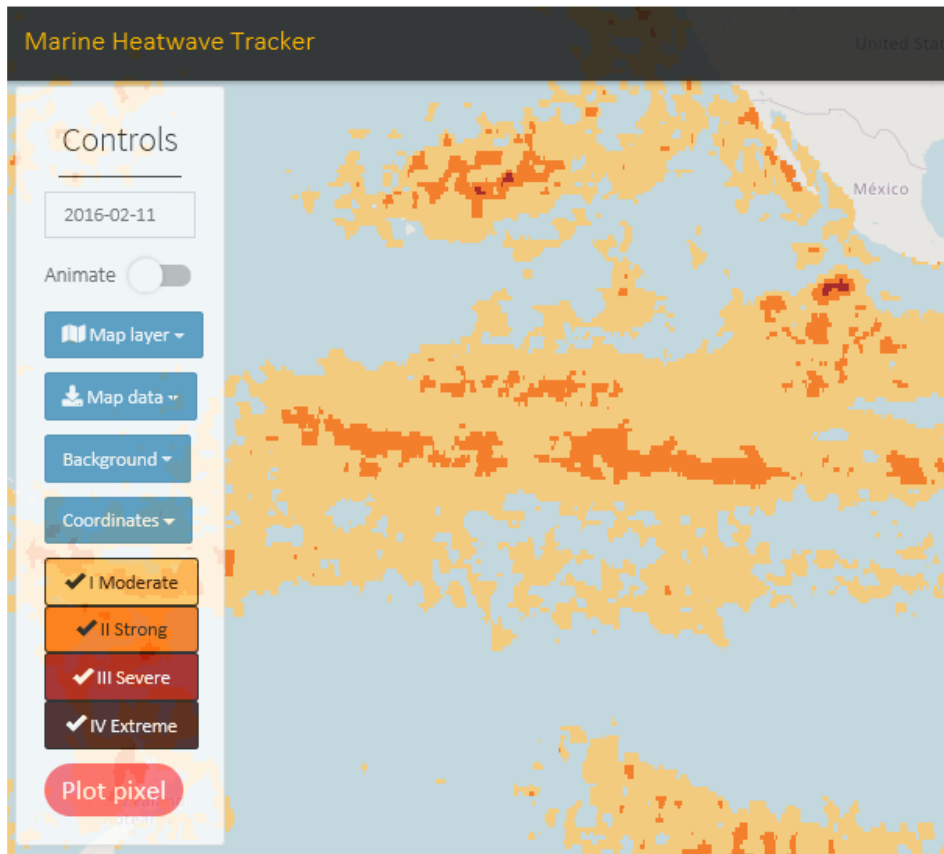


Sea Surface Temperature: Coral bleaching

Alert Level	Level Definition	Effect
No Stress	HotSpot ≤ 0.0	No thermal stress
Bleaching Watch	Watch $0.0 < \text{HotSpot} < 1.0$	Low-level thermal stress
Bleaching Warning	$1.0 \leq \text{HotSpot}$ and $0.0 < \text{DHW} < 4.0$	Coral bleaching possible
Bleaching Alert Level 1	$1.0 \leq \text{HotSpot}$ and $4.0 \leq \text{DHW} < 8.0$	Coral bleaching likely
Bleaching Alert Level 2	$1.0 \leq \text{HotSpot}$ and $8.0 \leq \text{DHW}$	Coral mortality likely

Alert Level	Effect	Coral Bleaching Alert 
No Data	No alert data available	
No Stress	No thermal stress	
Bleaching Watch	Low-level thermal stress	
Bleaching Warning	Coral bleaching possible	
Bleaching Alert Level 1	Coral bleaching likely	
Bleaching Alert Level 2	Coral mortality likely	

Marine Heatwaves: Impacts (Kiribati)



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Coral Bleaching Subsiding After 3 Extreme Years, but Recovery Could Take Decades

"Overall warming has pushed corals closer to their critical threshold," NOAA's Mark Eakin said. Another extreme warming event will set them back again.

BY BOB BERWYN, INSIDECLIMATE NEWS
JUN 21, 2017

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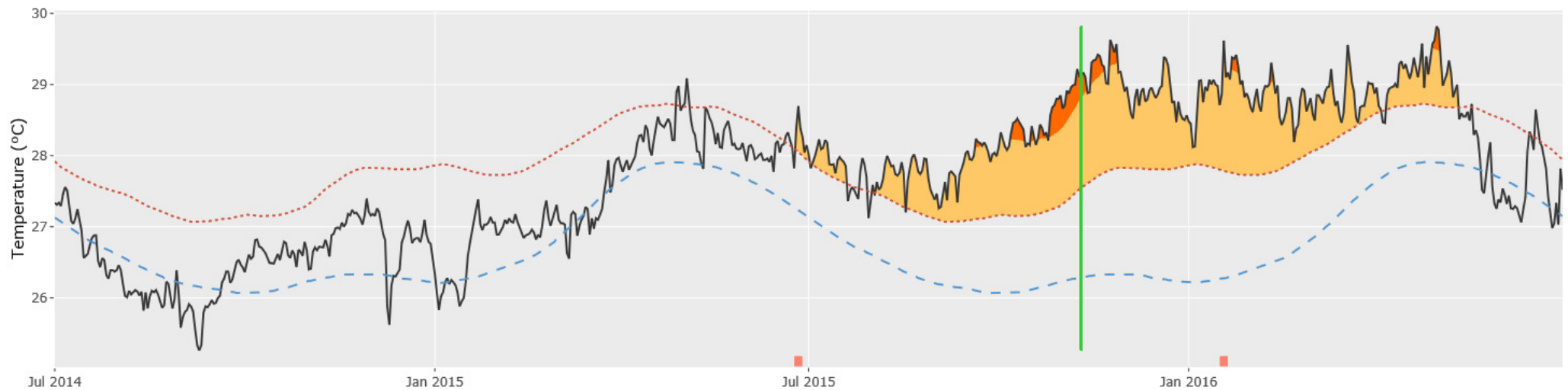
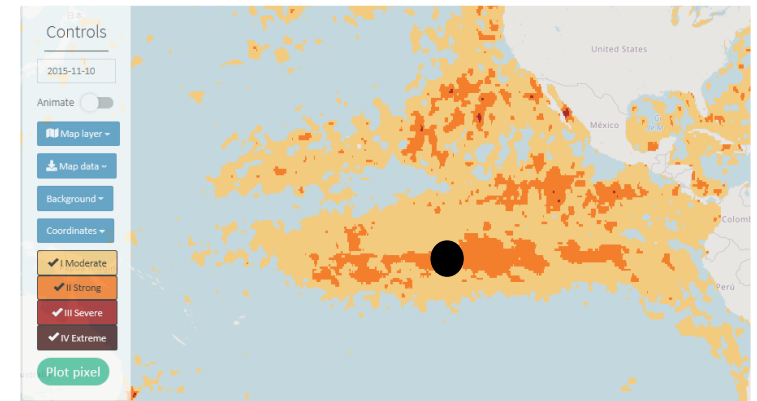
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Marine Heatwaves: Impacts

- Almost 3 years of anomalously warm temperatures
- Peaking during the 2015-2016 El Niño at Category 2 - Strong



Marine Heatwaves: Impacts

HUFFPOST

NEWS CORONAVIRUS POLITICS 2020 ELECTIONS ENTERTAINMENT LIFE PERSONAL VIDEO SHOPPING

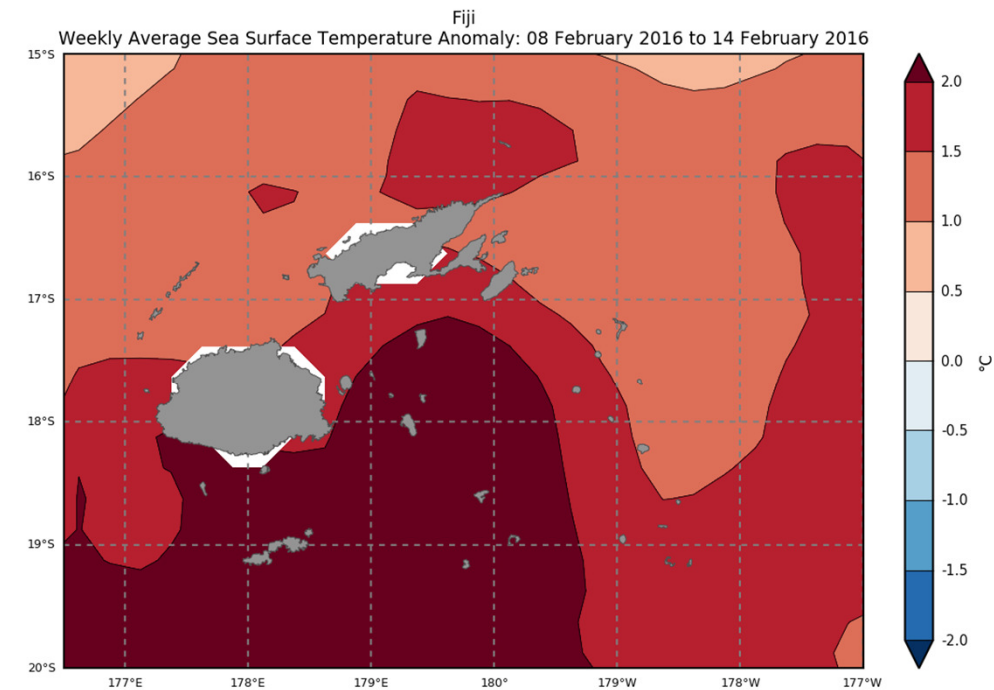


Lagipolva Cherele Jackson, Contributor
Independent Samoan Writer

Fish Kills Reported in Fiji and Vanuatu

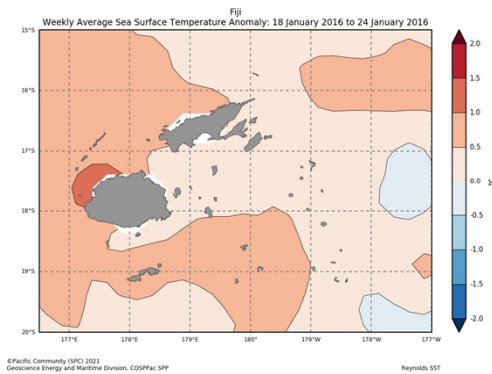
02/15/2016 03:43 pm ET | Updated Dec 06, 2017

You know how we talk about worst case scenario of climate change impacts? Well, it's happening now in some Pacific islands. All across the Pacific, high temperatures have been recorded and residents reported the hottest months they have ever experienced. For some islands however, the impacts have gone beyond a daily nuisance to a serious marine threat. Last week reports from Vanuatu and Fiji showed fish kills by the thousands as a result of the temperatures.

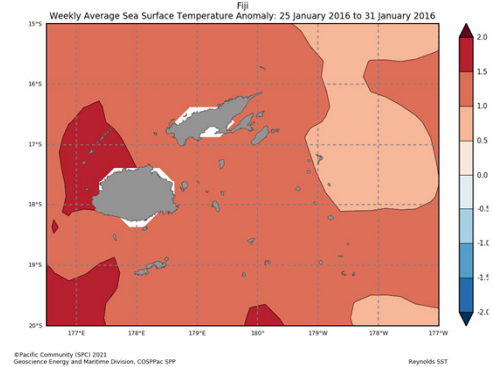


Marine Heatwaves: Impacts (Fiji)

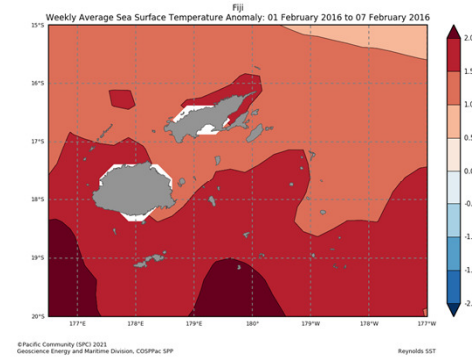
- 21 January 2016



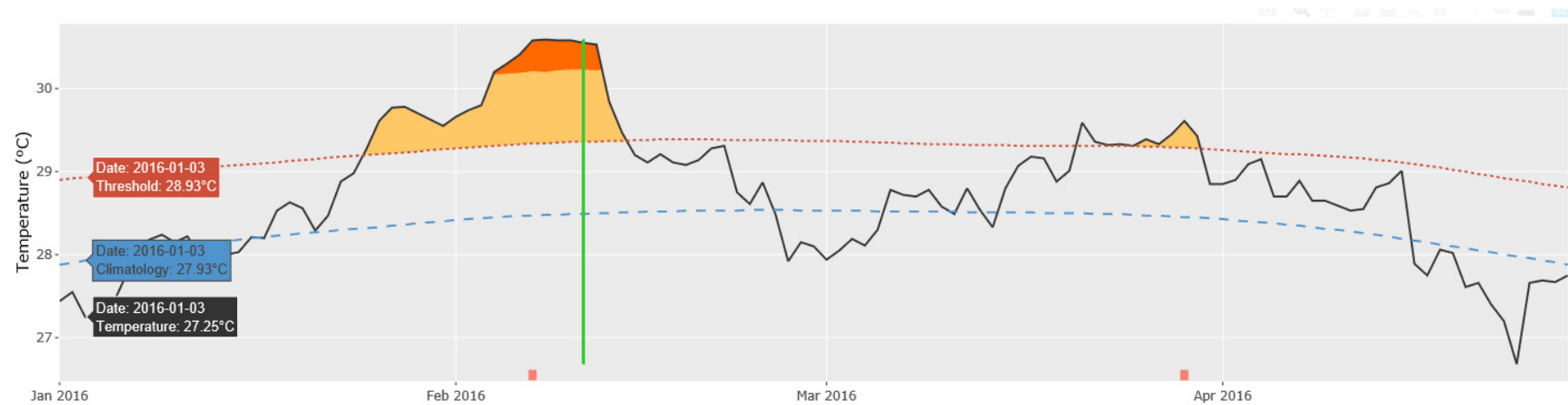
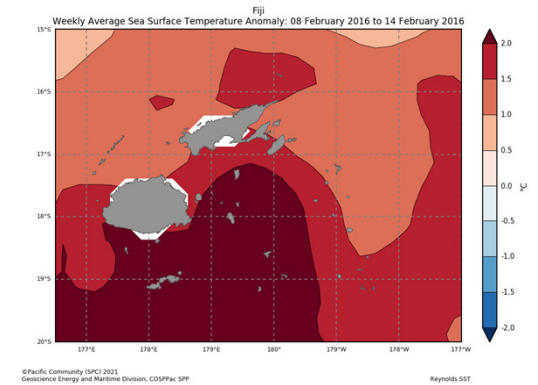
28 January 2016



4 February 2016



11 February 2016



Fisheries in the Pacific

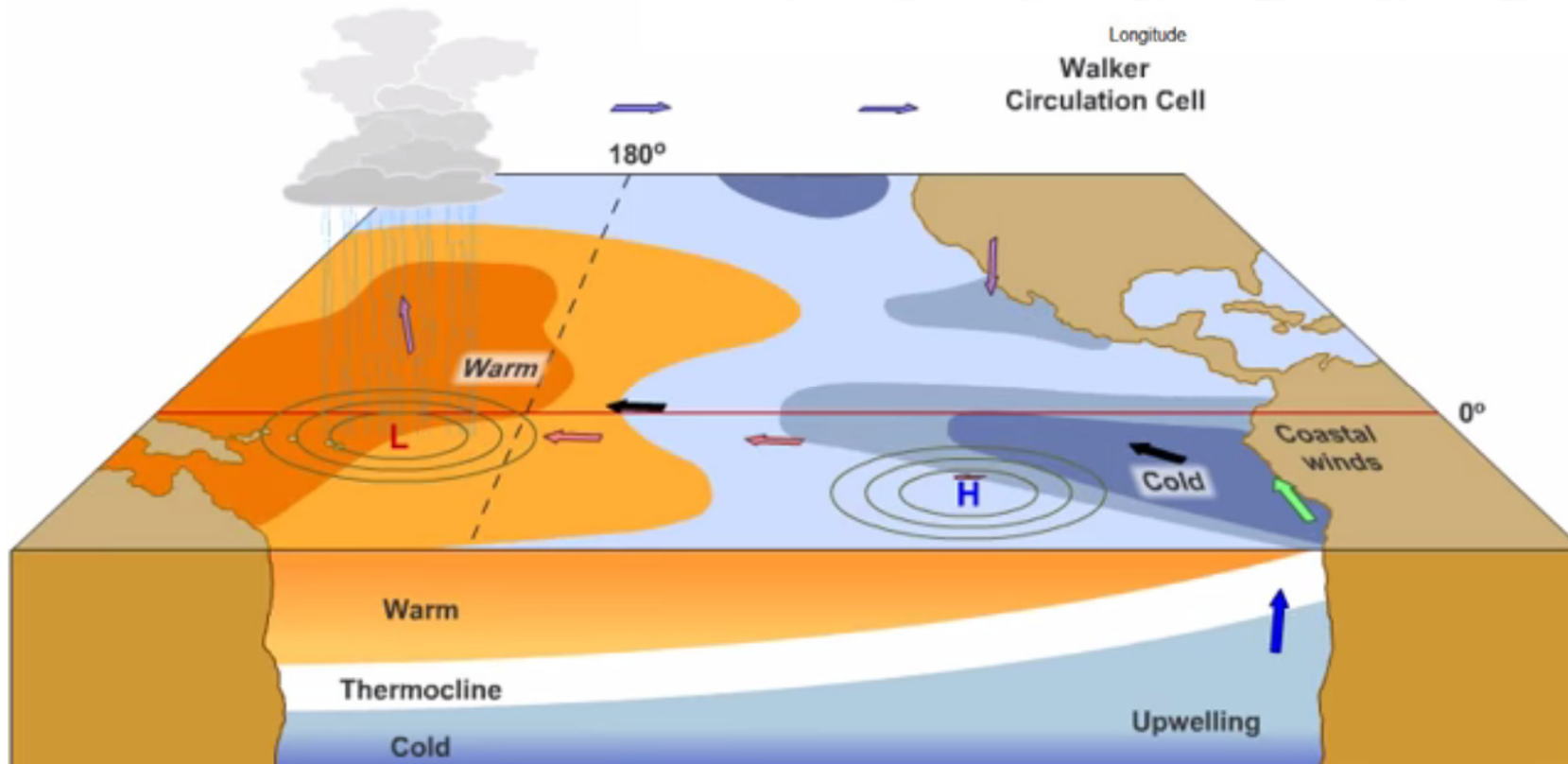
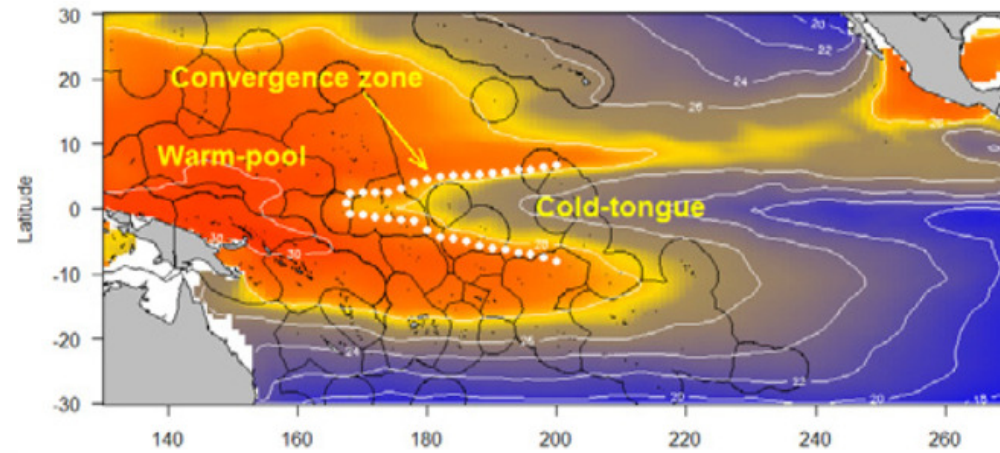
- Major source of animal protein in the diet of most Pacific Islanders (1 billion people worldwide)



- Primary source of cash income (tuna)
- Primary source of food security (tuna and reef fish)

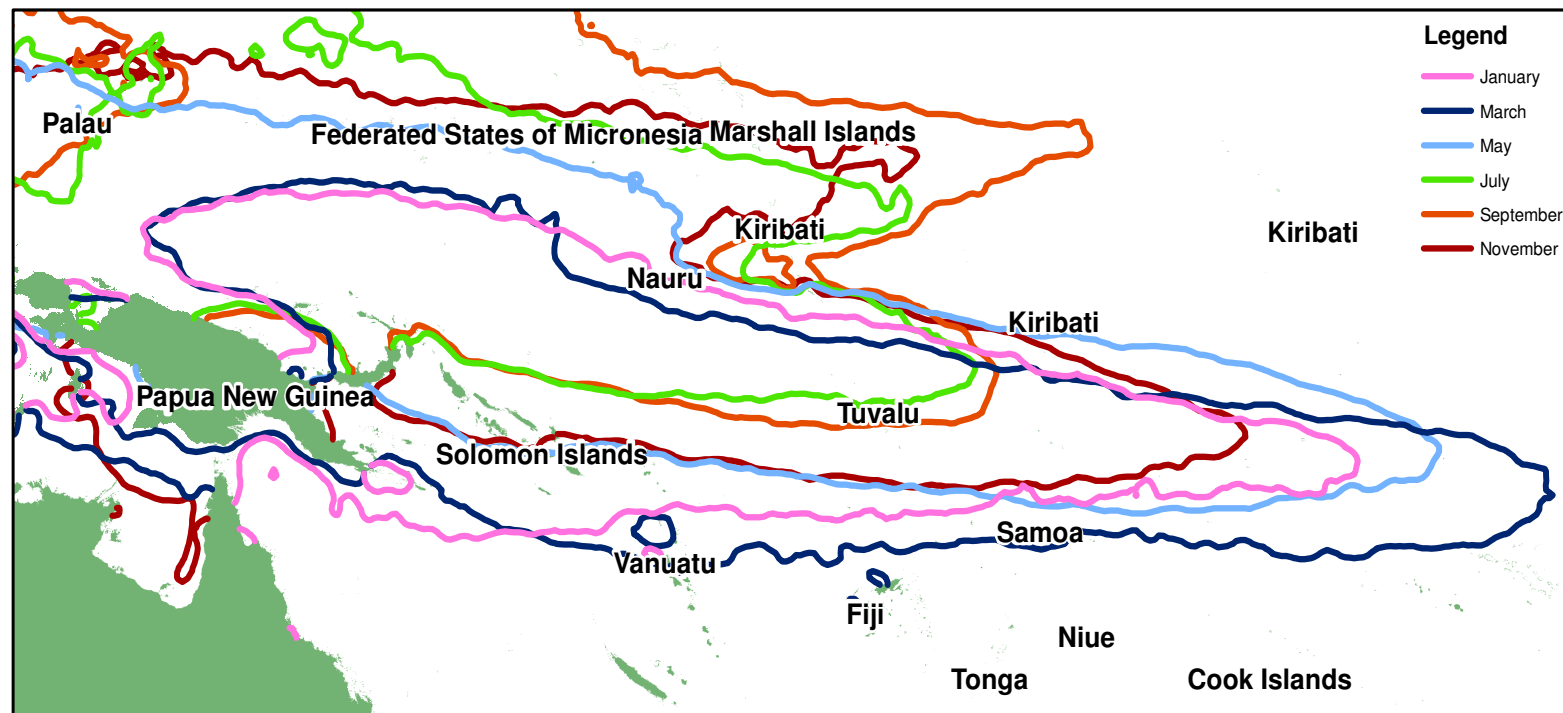


Distribution of Tuna

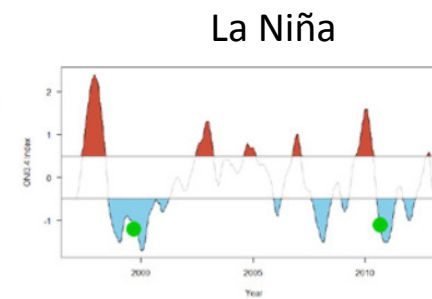
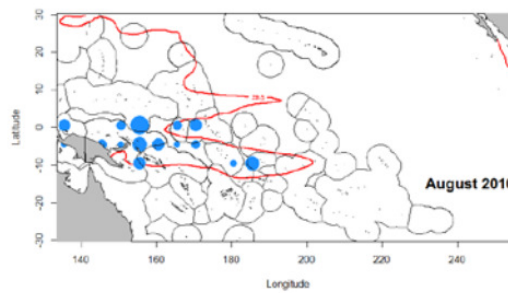
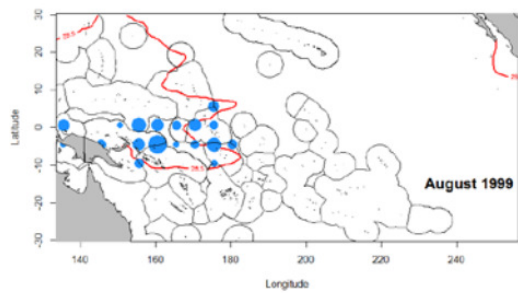
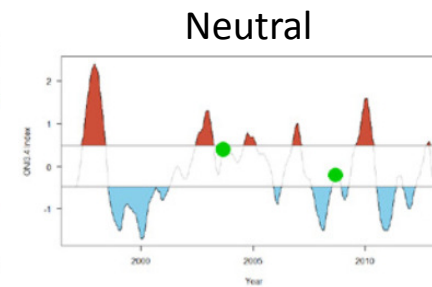
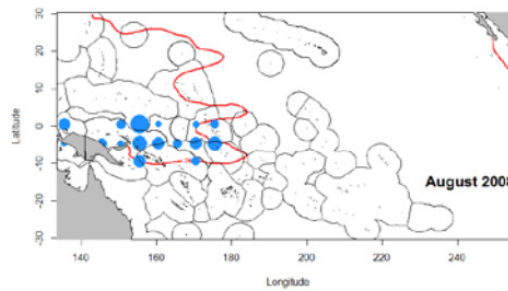
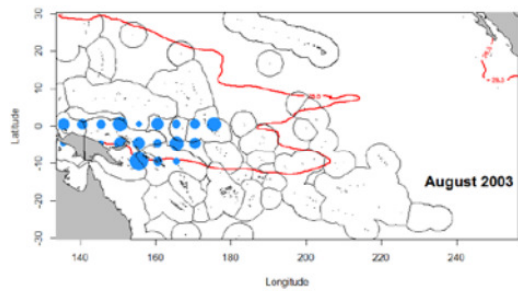
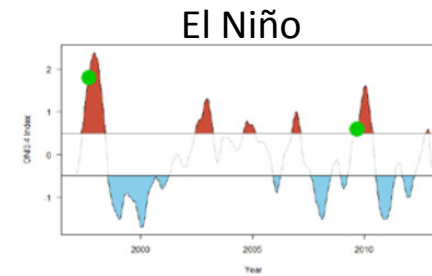
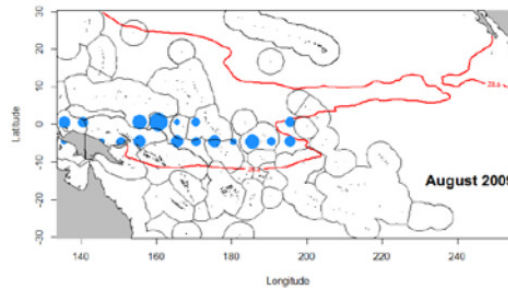
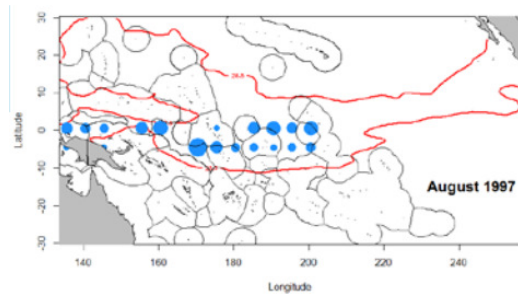


Fisheries: Convergence Zone

- The convergence zone is a well-defined salinity front that surrounds the western Pacific warm pool.



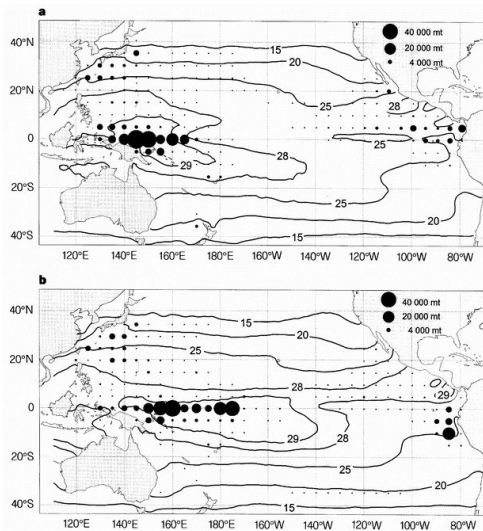
SPC Tuna factsheet



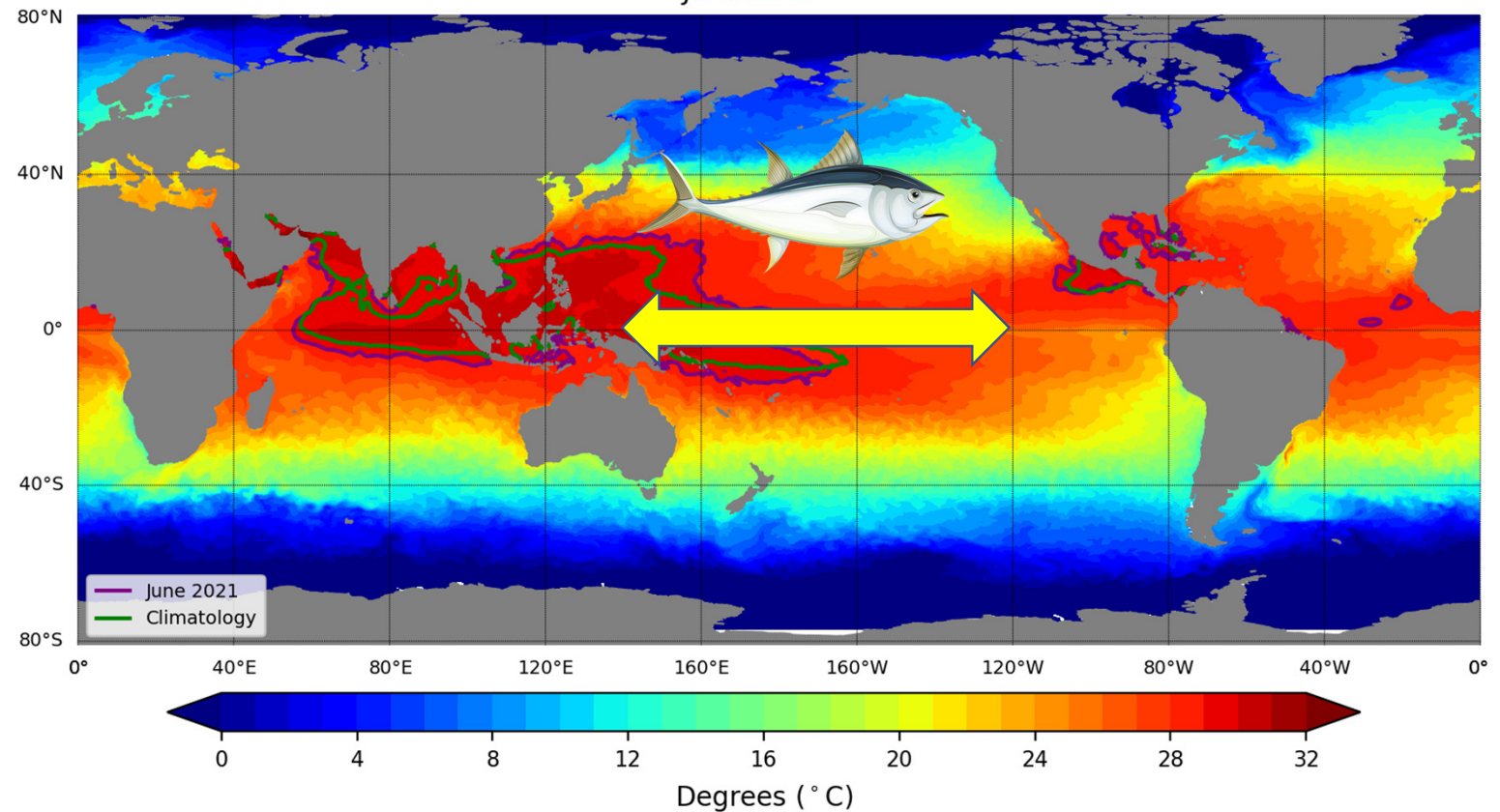
Seasonal Outlooks For Fisheries



- Tuna (skipjack in below example) drifts with the Western Warm Pool boundary



Sea surface temperature forecast for
June 2021



© Commonwealth of Australia 2021
Bureau of Meteorology

Model: ACCESS-S1
Base Period: 1990-2012

Model Run: 03/05/2021
Issued: Map not issued

Sea Surface Temperature: Management of aquaculture


Ocean temperature is an important environmental condition that affects pearl oyster reproduction, pelagic larval duration, and growth. Optimal operating temperature range for growth and reproduction has been defined as 23-34°C. Sub-seasonal to seasonal outlooks of SST from the Bureau of Meteorology's ACCESS-S model can be used to inform management decisions to mitigate the effect of warm ocean temperatures, such as increasing the proportion of spat produced in hatcheries under controlled temperature and harvesting pearls during the cooler months of the year.

Climate Information needed to salvage the demise of the Black Pearls: Case study for the Cook Islands

Arona Ngari¹ and Grant Smith²
¹Cook Islands Meteorological Service
²Climate and Oceans Support Program for the Pacific (COSPPac)

Introduction

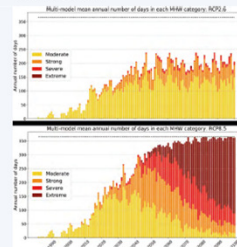
Solar radiation and sea surface temperatures (SST) are two important climate features of the Pacific islands' climate. Although sunshine is good for agriculture production in many Small Island Developing States (SIDS) via photosynthesis, excessive solar radiation is detrimental to the marine life and ecosystems that can deprive niche markets for sustainable growth. Prolonged periods of above normal SST from excessive solar radiation can be devastating in shallow lagoons of these atolls. This can deplete marine life, and could also be exacerbated by severe weather, resulting in the economic loss of millions of dollars and could face depopulation.



A worker cleans new foreign growth on the oyster shells on a regular basis in preparation for seeding or harvesting

Changing ocean waters

Climate data and recent observations have significantly shown some trends in these climate parameters to be of negative impact on the Pacific Islands and especially atolls. These are the loss of certain lagoon fishes, the migration of the crown of thorns that normally peaks at El Niño episodes and the more than abundance of oyster spat in some lagoons that cannot be sorted for aquaculture farming and eventually harvesting. Marine heatwaves days and severity in the Cook Islands are projected to increase over this century.




Multi-model mean annual number of days in each MHW category, 2021-50
Multi-model mean annual number of days in each MHW category, 2021-50

Marine heatwave intensity and duration projected to increase in the Cook Islands source: <https://www.rccanp.org/library/item/61fc956b7492a>
CSIRO and SPREP 2022

Assessing status of and impacts to the Black Pearl Sector

Through the collaboration with other National Meteorological Services and scientific communities, user-friendly and tailored products and services for aquaculture and marine ecosystems have been used to gauge the status of this sector. This work is aligned also to the findings of IPCC for more extreme tropical cyclones and ocean acidification.

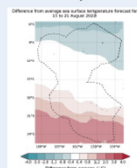
In the case of the Cook Islands this involves providing CSIRO with data on the number of black pearl farms on the island of Manihiki, with the Cook Islands Meteorological Service working closely with the Marine Resources of the Cook Islands and some pearl farmers. Data were collected by a team that shone some light on the fate of the black pearls on Manihiki.



Farm workers remove pearl shells from lines which are cleaned on the boat and returned immediately instead of taking them to farm houses, for efficiency and cost savings

Outlooks for Black Pearl Management

Ocean temperature is an important environmental condition that affects pearl oyster reproduction, pelagic larval duration, and growth. Optimal operating temperature range for growth and reproduction has been defined as 23-34°C. Sub-seasonal to seasonal outlooks of SST from the Bureau of Meteorology's ACCESS-S model can be used to inform management decisions to mitigate the effect of warm ocean temperatures, such as increasing the proportion of spat produced in hatcheries under controlled temperature and harvesting pearls during the cooler months of the year.

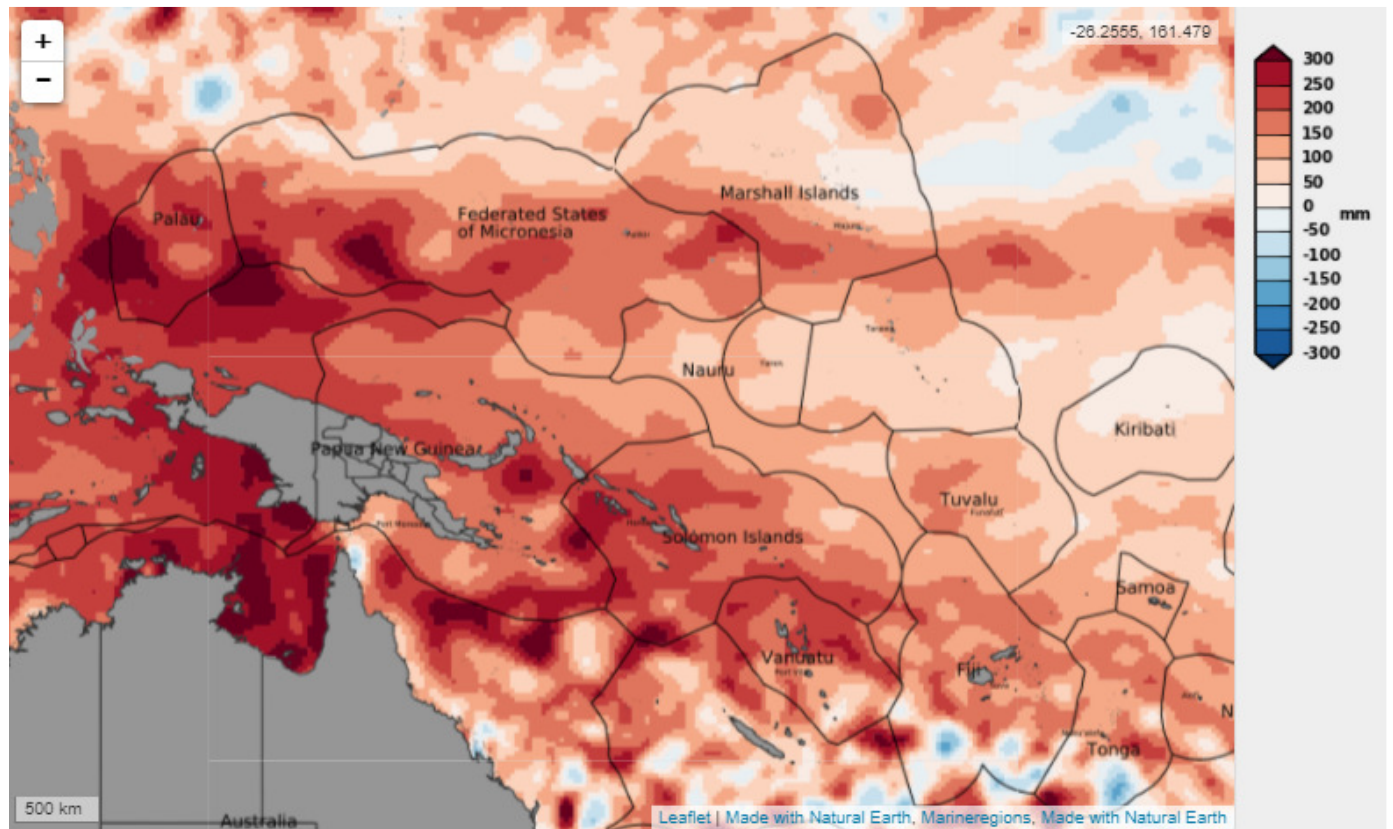


Sub-seasonal and seasonal outlooks can be used as part of Black Pearl Management Practices

Sea level: Coastal hazards

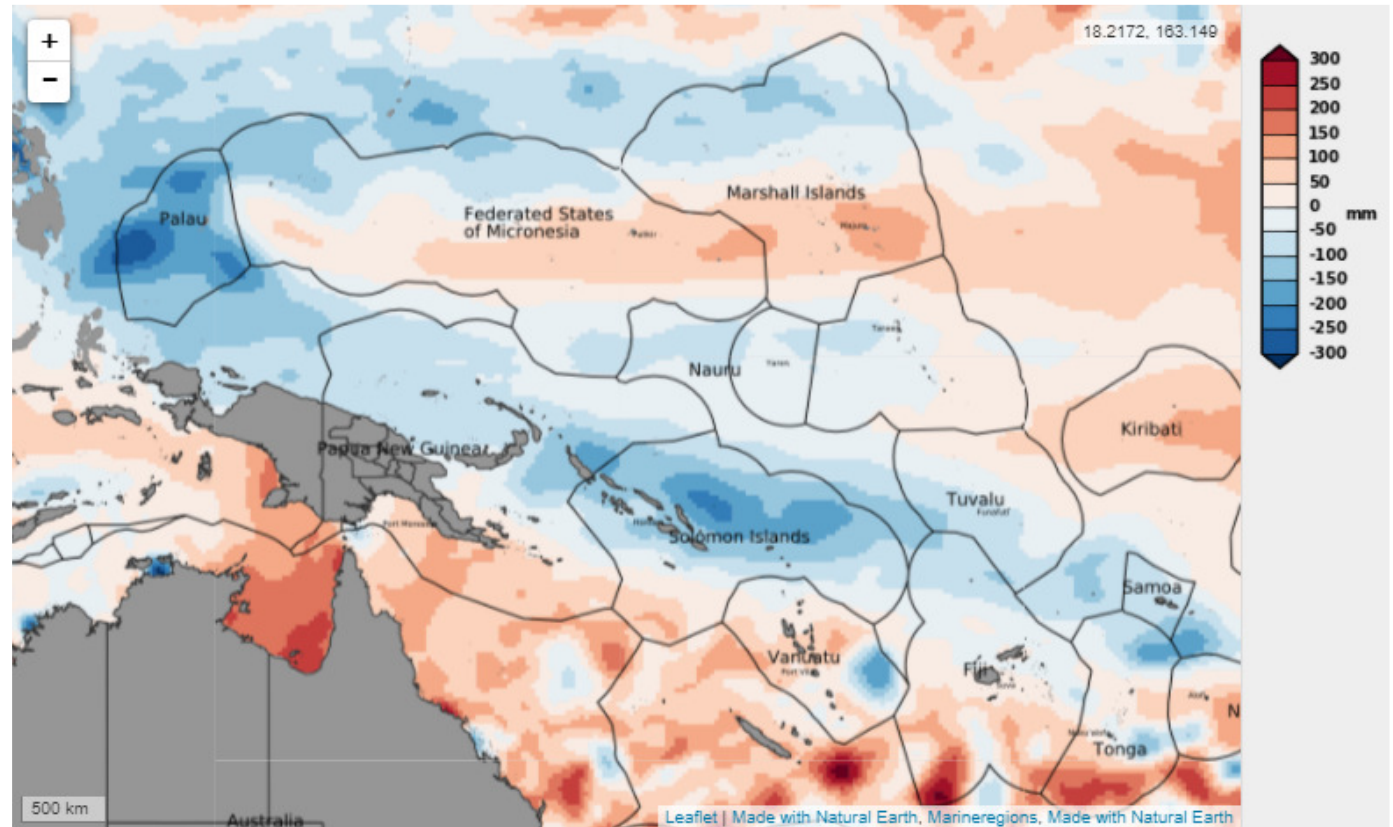


Pictured Above: An island suffers from saltwater inundation

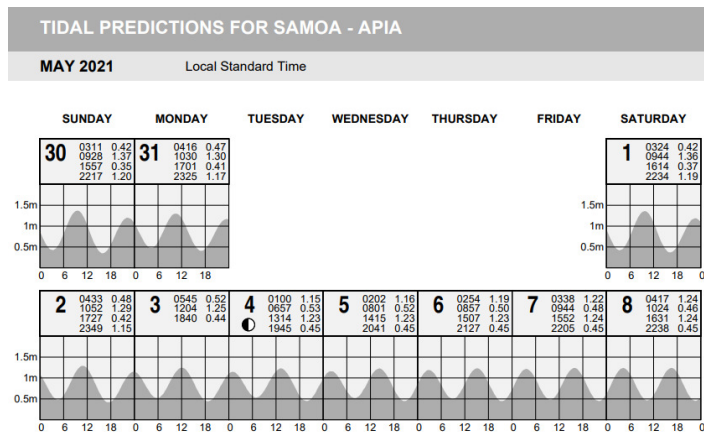


Sea level: Low water standings

- Taimasa

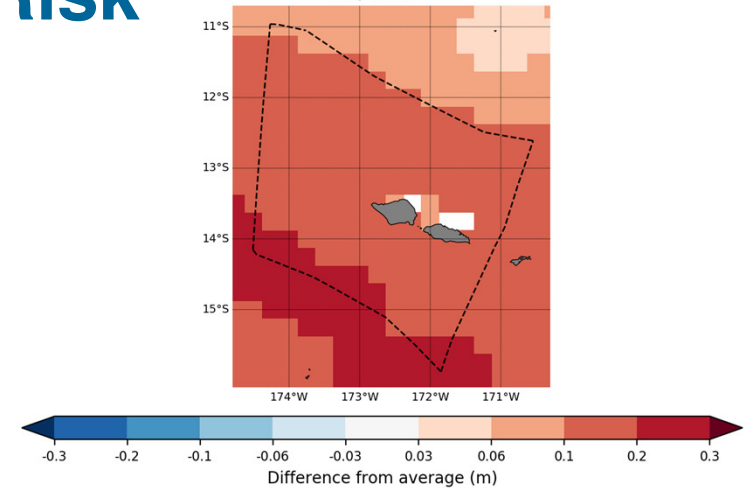


Inundation or Reef Exposure Risk

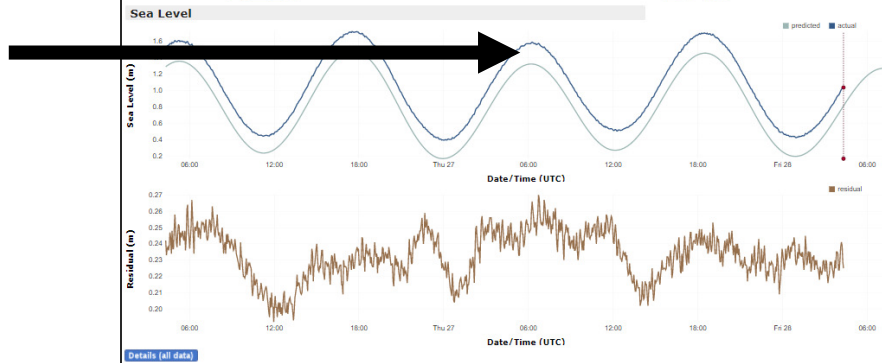


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Difference from average sea surface height forecast for May 2021



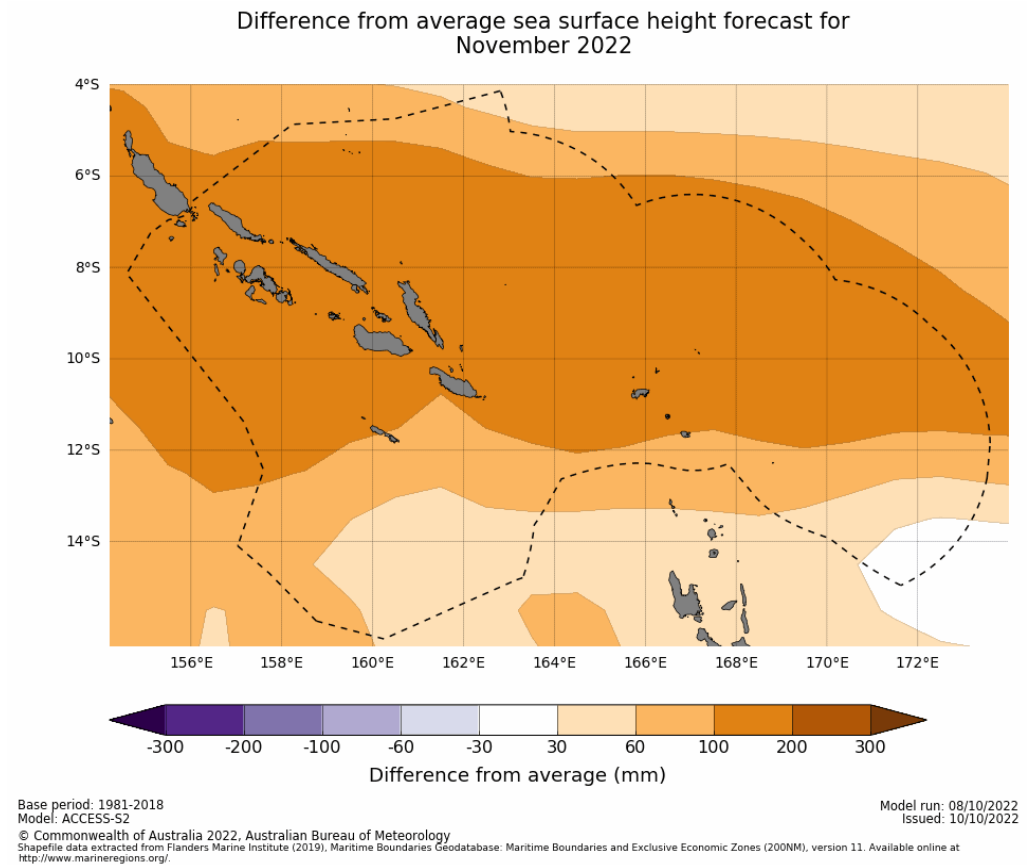
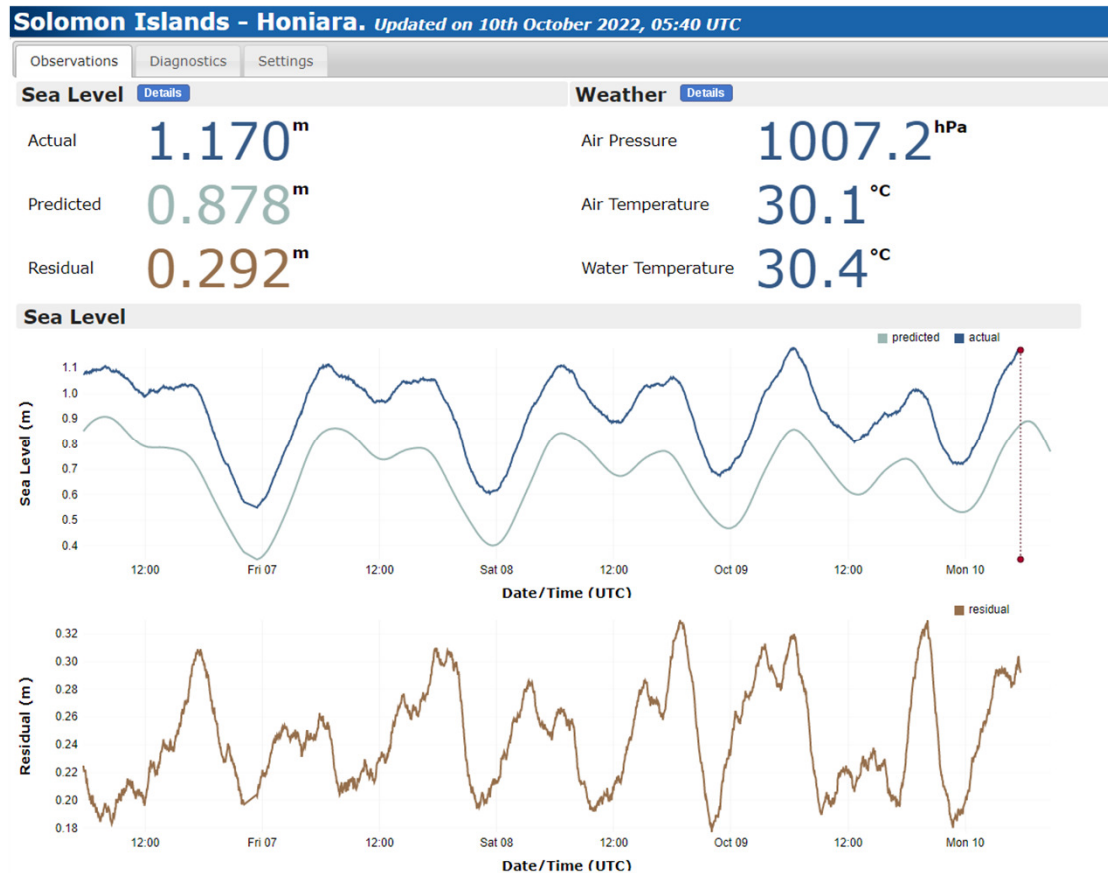
=



&



How good is the tides + anomaly method?



PNG Case Study: December 2021



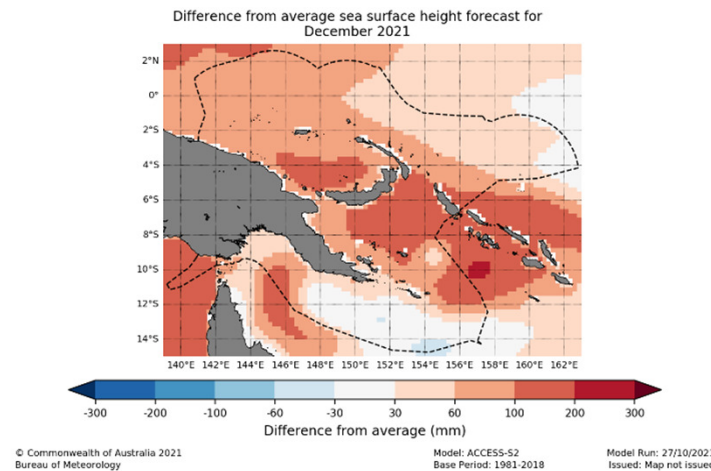
PNG Case Study

2021

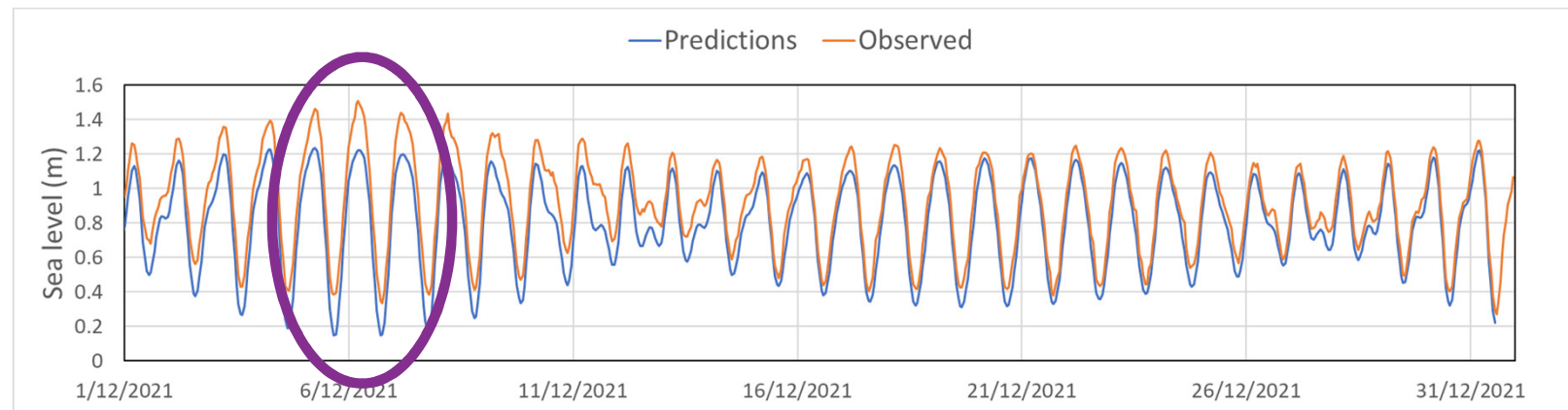
Time Zone -1000

DECEMBER

Time	m	Time	m
1 0409 0.82		16 1504 1.09	
0807 0.72			
WE 1505 1.13	TH		
2306 0.50			
2 0610 0.84		17 0011 0.38	
0809 0.83		1413 1.10	
TH 1512 1.17	FR		
2347 0.37			
3 1522 1.20		18 0037 0.34	
FR		1341 1.13	
		SA	
4 0035 0.26		19 0106 0.32	
1534 1.23		1346 1.16	
SA		SU	
●		○	
5 0128 0.18		20 0137 0.31	
1544 1.24		1407 1.18	
SU		MO	
6 0224 0.14		21 0213 0.32	
1526 1.22		1432 1.18	
MO		TU	
7 0323 0.14		22 0253 0.33	
1445 1.20		1454 1.17	
TU		WE	

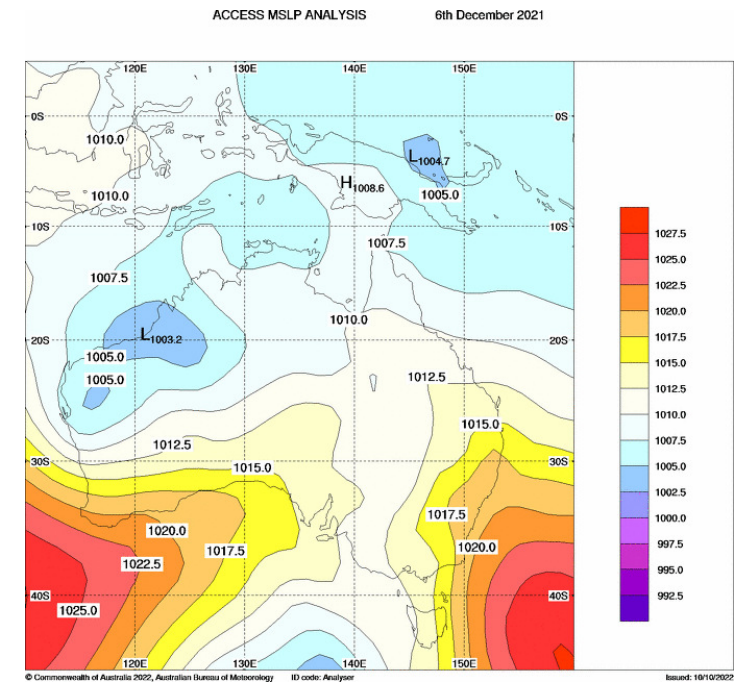
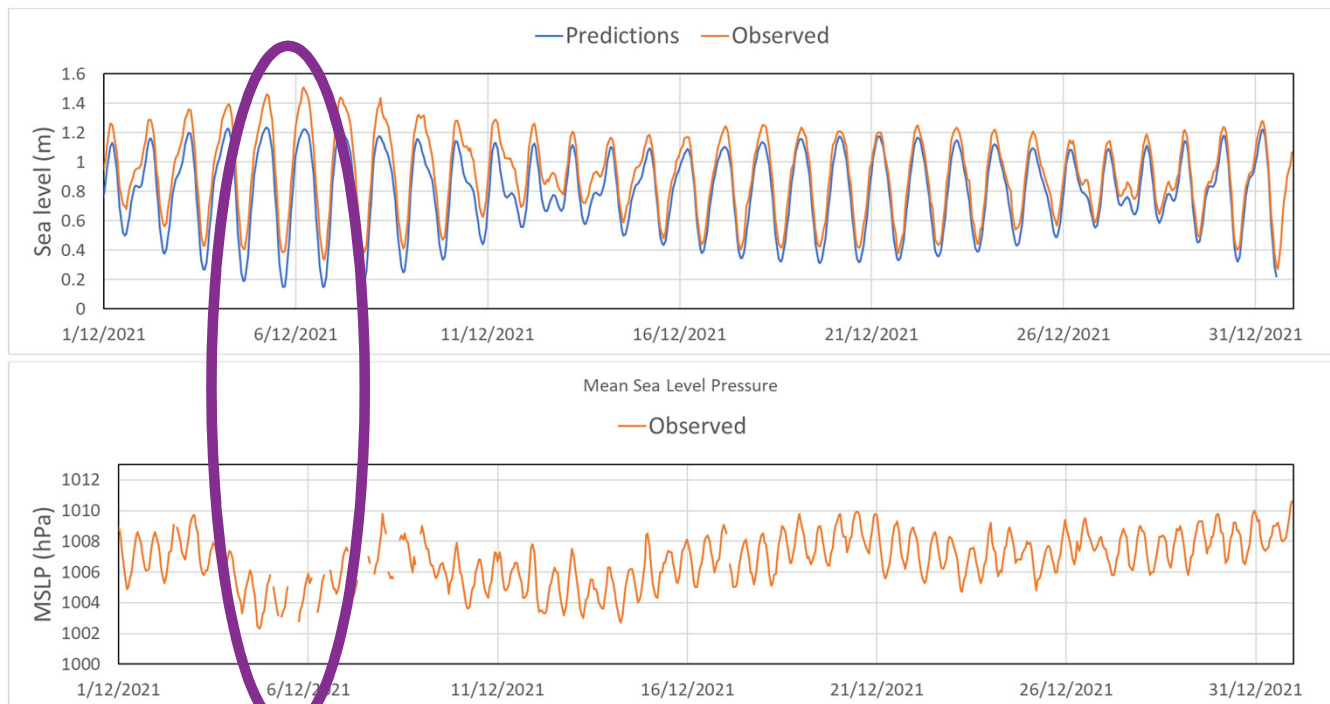
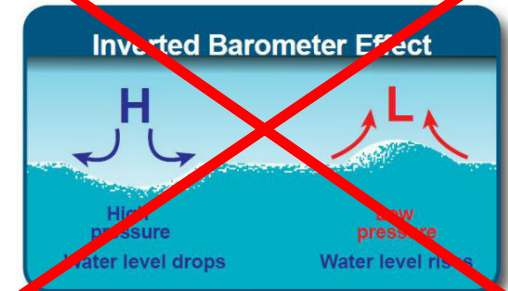


1.24m tide +
~0.1m = 1.34m
Measured SL
was 1.48m

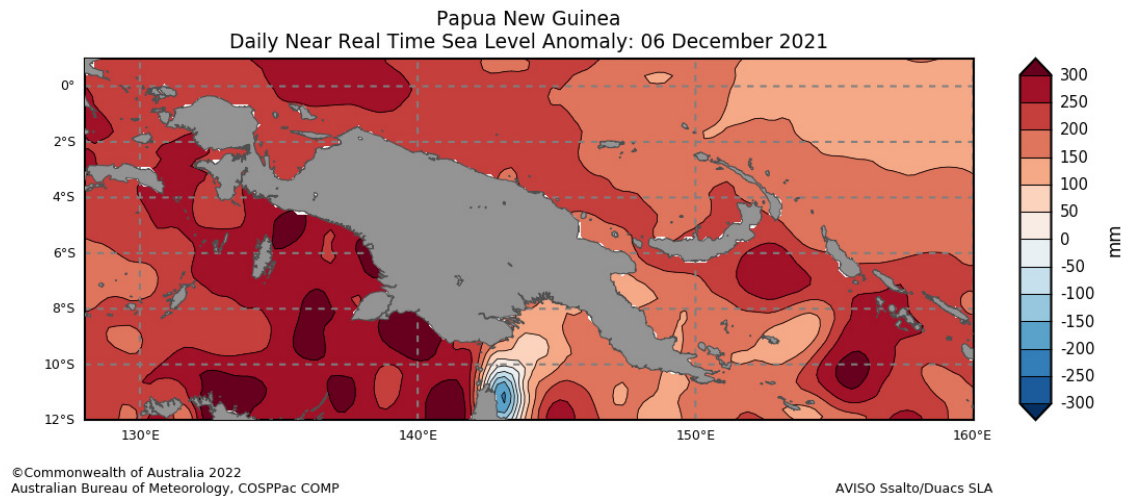


Inverse Barometer effect

- IB accounts for several centimetres of sea level, approximately **1 cm** per hPa below average.
- About 10 cm still remains unaccounted for.
- The forecast is monthly, which averages the daily data over the month, lessening the peaks.



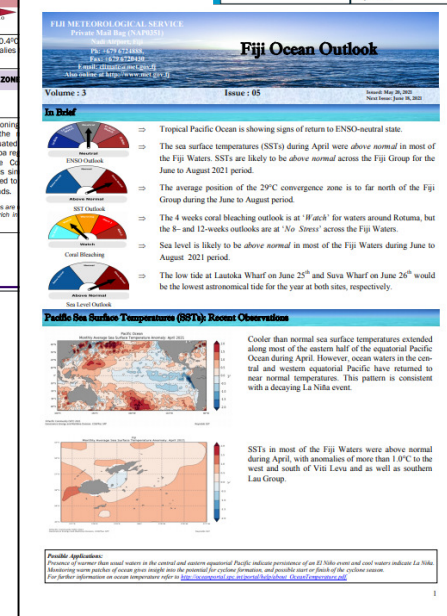
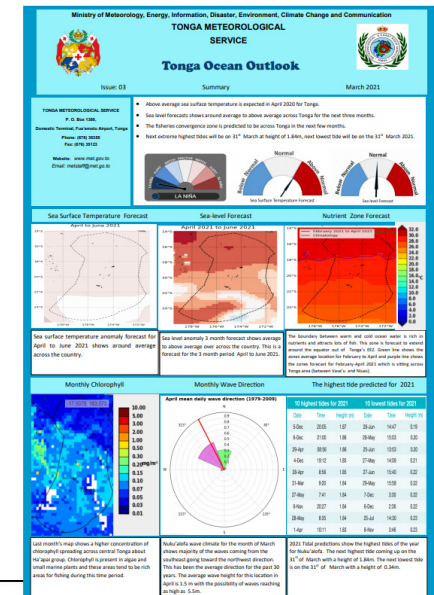
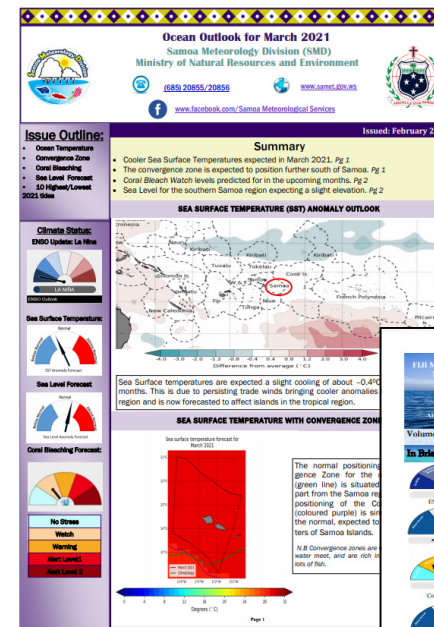
PNG Case Study: Conclusion



- In hindsight looking at satellite observations, we'd expect a total sea level of 1.44 m, which is still 4 cm below the tide gauge observations.
- Limitations in forecasting the full scale of the inundation event
- Monthly average forecasts lessen the daily peaks
- Inverse Barometer effect not included in ACCESS-S
- Small scale local coastal amplification effects

Ocean Outlooks

- Seasonal outlooks for Ocean Outlook Bulletins
- Commonly use SST Anomaly, Sea Level, Coral Bleaching, SST for Fisheries
- Released on monthly or 3-monthly timeframes
- Also include recent observations and tide predictions



Module 17: ACCESS-S Ocean Outlooks & Skill

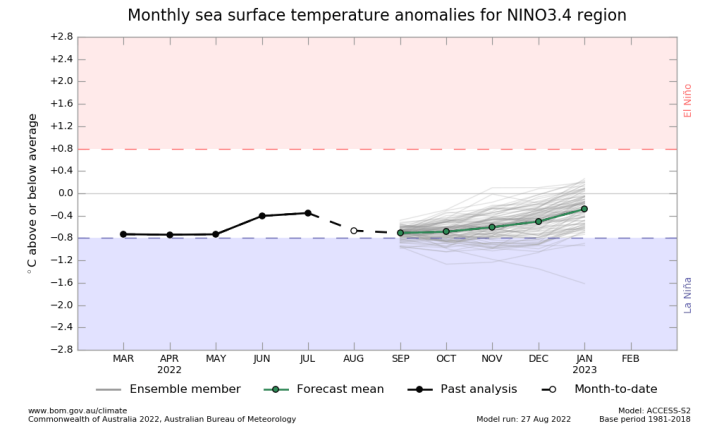


Australian Government

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ACCESS-S Skill Information



- Ocean outlook maps from ACCESS-S are an **ensemble mean** anomaly
- An ensemble mean is an average of all model ensembles
- Ocean parameters such as SST and Sea Level usually have good skill in tropical pacific when showing outlooks as the ensemble mean
- Different types of forecasts need different methods of verification
- Skill metrics used are **Correlation Coefficient** and **Root Means Squared Error**

Operations with the mean

$$\text{mean} = \frac{\text{Sum of all the observations}}{\text{Number of all observations}}$$

Means can be added if variable is cumulative (like rainfall)

$$\text{Mean Jan to March rainfall} = \text{Jan mean} + \text{Feb mean} + \text{March mean}$$

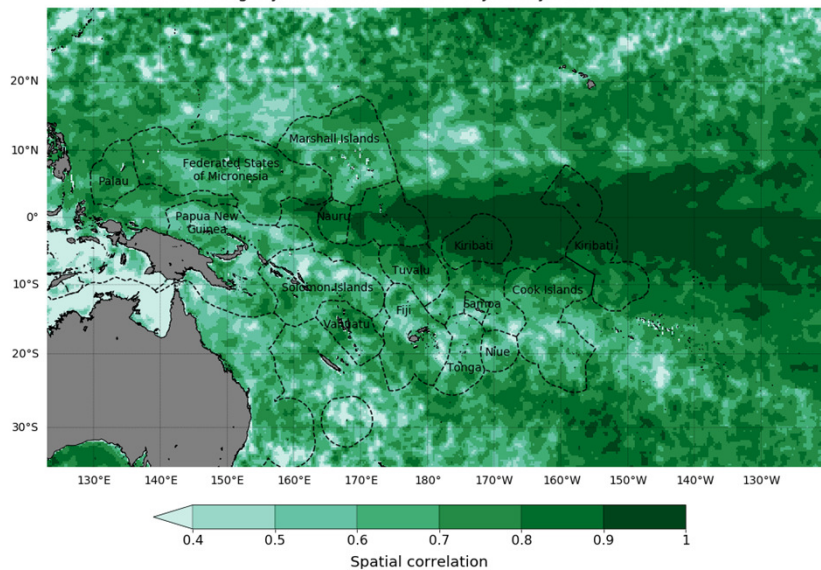
Means can be averaged if variable is not cumulative (like temperature)

$$\text{Mean Jan to March maximum temperature} = \frac{\text{Jan mean} + \text{Feb mean} + \text{March mean}}{3}$$

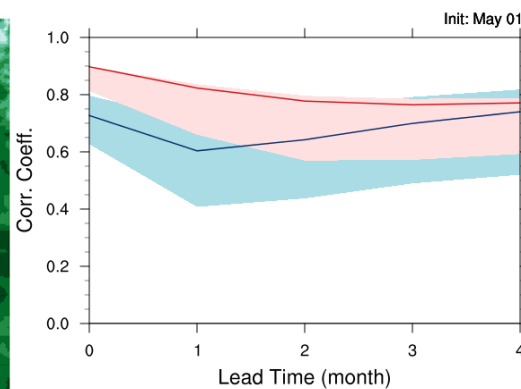
Hindcast skill: How good is ACCESS-S at prediction?

Different types of forecasts need different methods of verification

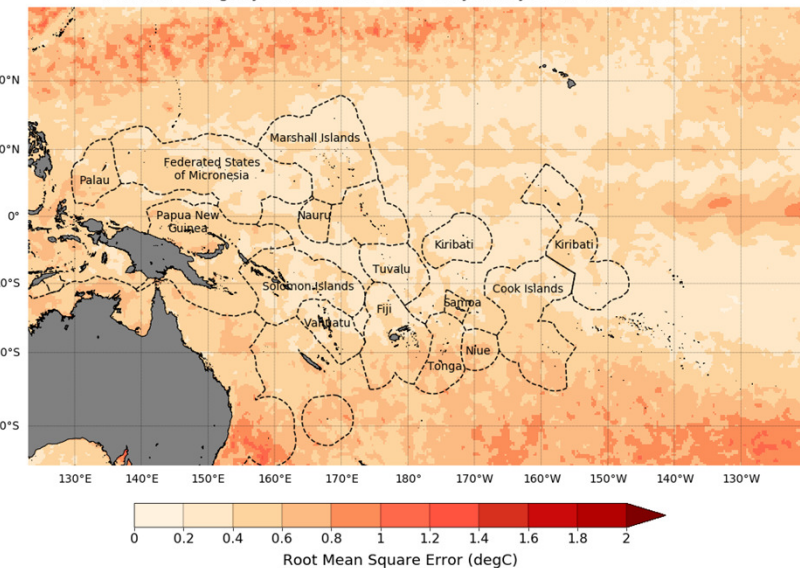
Sea surface temperature anomaly spatial correlation.
Period: Fortnightly. Initialisation date: 9th January. Lead time: 1 week



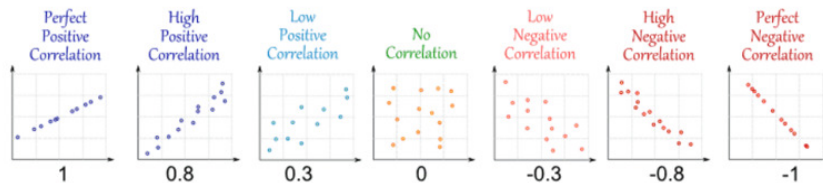
nino34



Sea surface temperature anomaly Root Mean Square Error (RMSE).
Period: Fortnightly. Initialisation date: 9th January. Lead time: 1 week



Correlation coefficient: measures how strong a relationship is between the model and real world over time

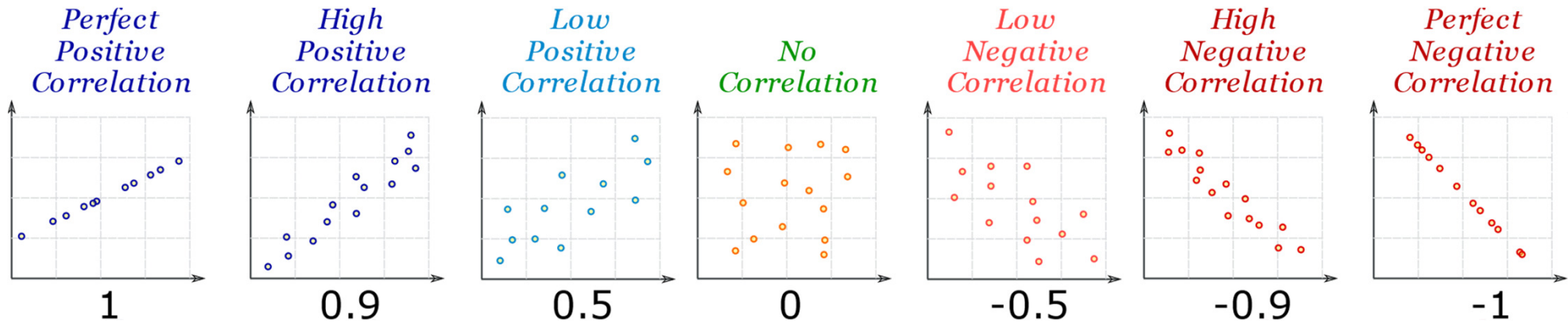


Root Mean Squared Error: often used alongside correlation, it's a measure of the average magnitude of the forecast error, *i.e.* how concentrated the data is around the line of best fit between the model and observed.

Correlation – how related are two variables?

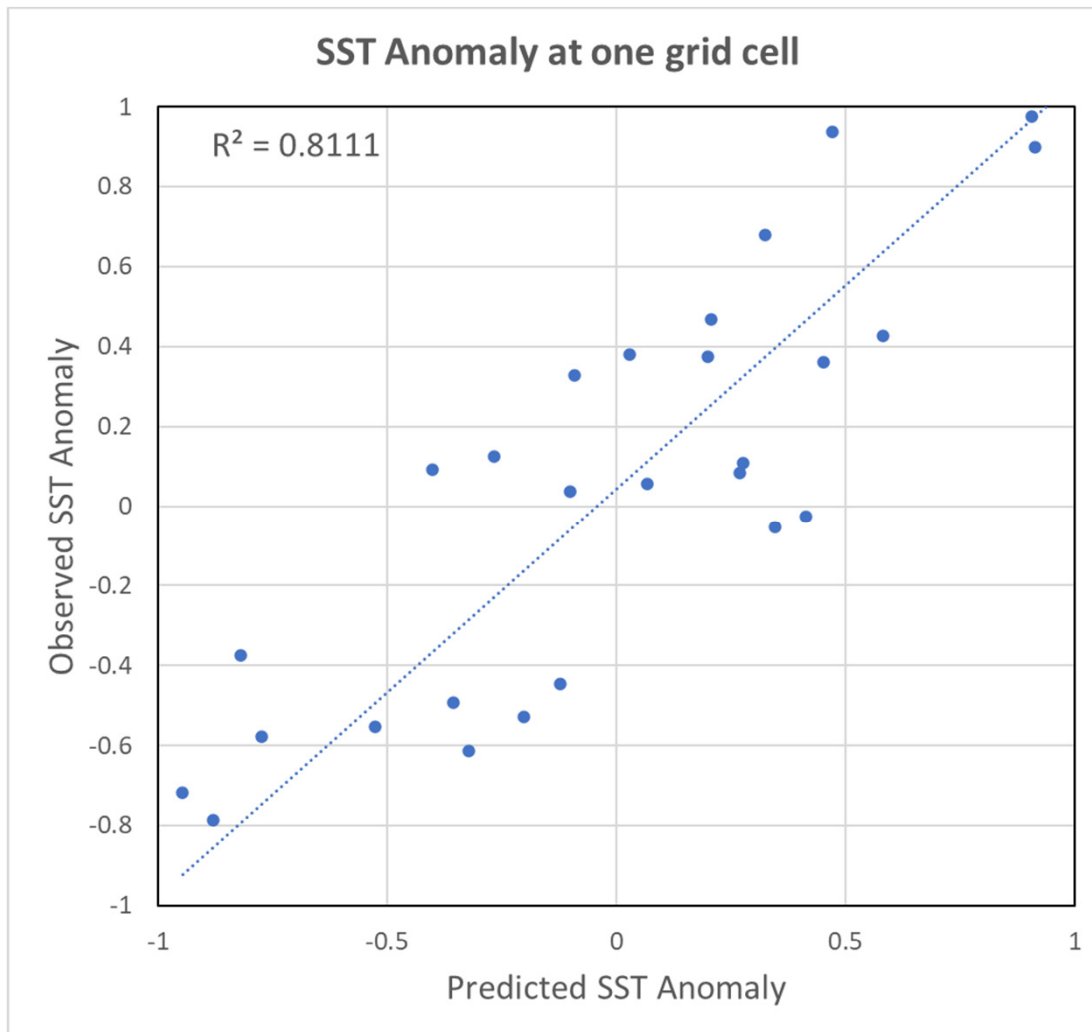
- We test a **dependent** variable's relationship with an **independent** variable
- The **Correlation Coefficient (r)** measures the strength of the relationship – it can vary between –1 and +1
- Values of –1 and +1 are **perfect** in which all the observations lie on a straight line
- **Positive** correlation: dependent variable increases as the independent variable increases
- **Negative** correlation: dependent variable decreases as the independent variable increases
- **r** relates to the **scatter** of observations about the regression line of best fit
- Correlation does **not** imply Causation
- Correlation can be used to calculate model skill

Correlation coefficient examples



The number below each graph is the value of r , the correlation coefficient

Using excel to calculate the correlation



What is the correlation between SST predicted by ACCESS-S and satellite observations of SST

Use Excel to test the correlation. To calculate the correlation coefficient between two arrays of numbers: the formula is **=Correl(array1:array2)**

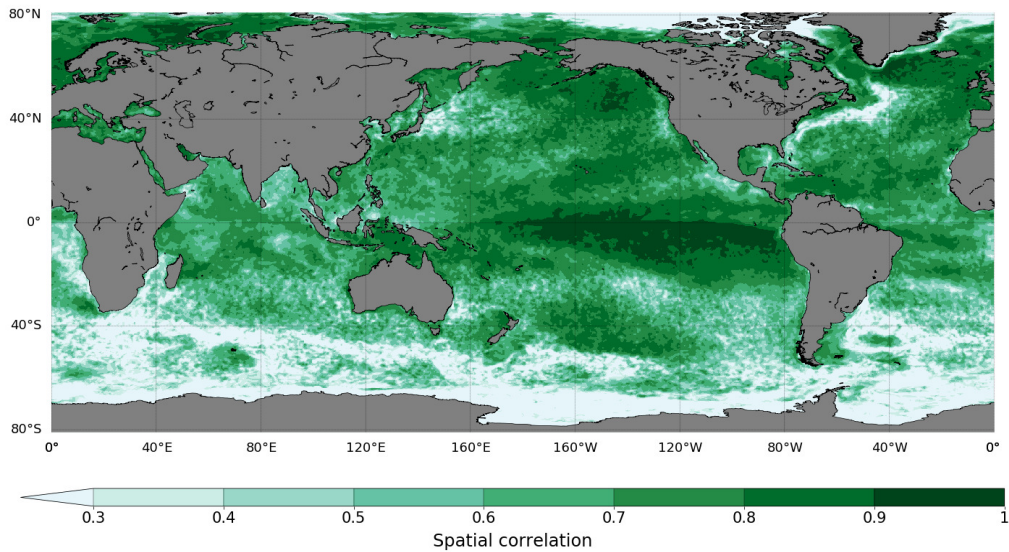
There is a positive correlation between the two datasets, very good news for a model (a negative correlation would mean the model is well underperforming).

Excel calculates 0.9 for **r**. If we square this, we get the **R²** value shown on the graph.

But is it **statistically significant**?

Statistical significance

Spatial correlation of fortnightly sea surface temperature anomaly
for October. Lead time: 1 week



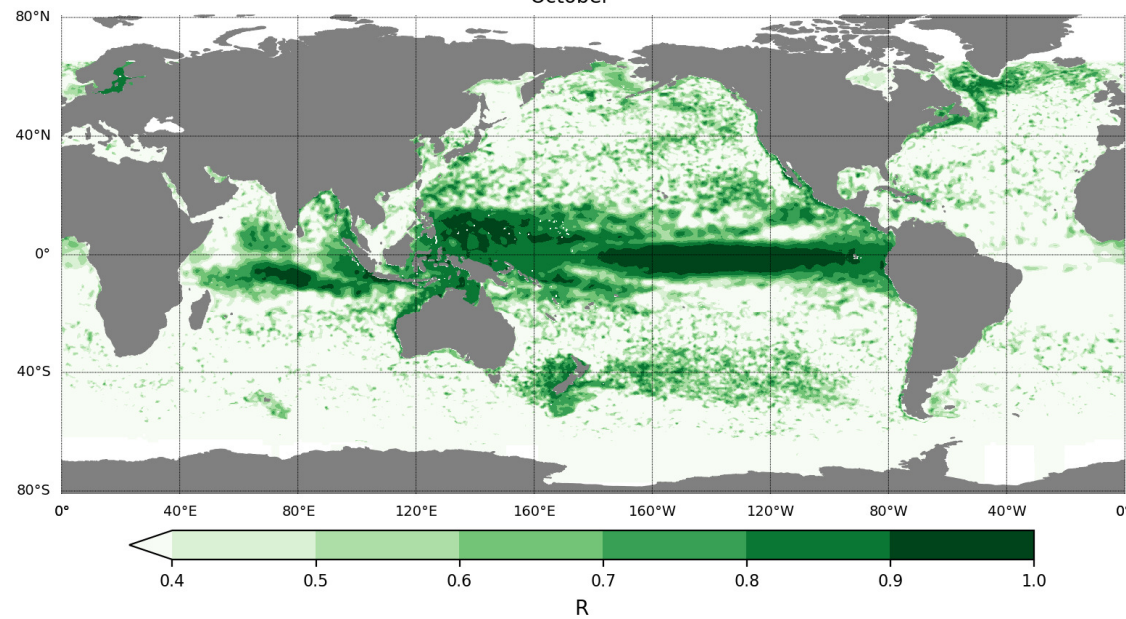
Run date: October

Base period: 1981-2018

Issued: 09/02/2022

Data source: ACCESS-S2 and NOAA OISST V2
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Disclaimer: Contains NOAA OISST V2 data provided by NOAA/NCEI, Asheville, North Carolina, USA, from their website <https://www.ncdc.noaa.gov/oisst>.

Difference from average sea surface height spatial correlation
October



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Model: ACCESS-S2
Base Period: 1993-2018

Hindcast Date: 01/10/2022
Created: 05/10/2022

Using significance tables for correlation significance

The correlation coefficient (r) can be checked against a table of **critical r** values for **different levels of significance** [e.g. 0.05 (5%) or 0.01 (1%)] and **degrees of freedom (df)**

degrees of freedom (df) = $n - 1$, where n is the number of points on the graph, i.e. the sample size

df \ α	0.2	0.1	0.05	0.02	0.01	0.001
1	0.951057	0.987688	0.996917	0.999507	0.999877	0.999999
2	0.800000	0.900000	0.950000	0.980000	0.990000	0.999000
3	0.687049	0.805384	0.878339	0.934333	0.958735	0.991139
4	0.608400	0.729299	0.811401	0.882194	0.917200	0.974068
5	0.550863	0.669439	0.754492	0.832874	0.874526	0.950883
6	0.506727	0.621489	0.706734	0.788720	0.834342	0.924904
7	0.471589	0.582206	0.666384	0.749776	0.797681	0.898260
8	0.442796	0.549357	0.631897	0.715459	0.764592	0.872115
9	0.418662	0.521404	0.602069	0.685095	0.734786	0.847047
10	0.398062	0.497265	0.575983	0.658070	0.707888	0.823305
11	0.380216	0.476156	0.552943	0.633863	0.683528	0.800962
12	0.364562	0.457500	0.532413	0.612047	0.661376	0.779998
13	0.350688	0.440861	0.513977	0.592270	0.641145	0.760351
14	0.338282	0.425902	0.497309	0.574245	0.622591	0.741934
15	0.327101	0.412360	0.482146	0.557737	0.605506	0.724657
16	0.316958	0.400027	0.468277	0.542548	0.589714	0.708429
17	0.307702	0.388733	0.455531	0.528517	0.575067	0.693163
18	0.299210	0.378341	0.443763	0.515505	0.561435	0.678781
19	0.291384	0.368737	0.432858	0.503397	0.548711	0.665168
20	0.284140	0.359827	0.422714	0.492001	0.536800	0.652378
21	0.277411	0.351531	0.413247	0.481512	0.525620	0.640230
22	0.271137	0.343783	0.404386	0.471579	0.515101	0.628710
23	0.265270	0.336524	0.396070	0.462221	0.505183	0.617769
24	0.259768	0.329705	0.388244	0.453413	0.495808	0.607360
25	0.254594	0.323283	0.380863	0.445078	0.486932	0.597446
26	0.249717	0.317223	0.373886	0.437184	0.478511	0.587988
27	0.245110	0.311490	0.367278	0.429693	0.470509	0.578956
28	0.240749	0.306057	0.361007	0.422572	0.462892	0.570317
29	0.236612	0.300898	0.355046	0.415792	0.455631	0.562047
30	0.232681	0.295991	0.349370	0.409327	0.448699	0.554119

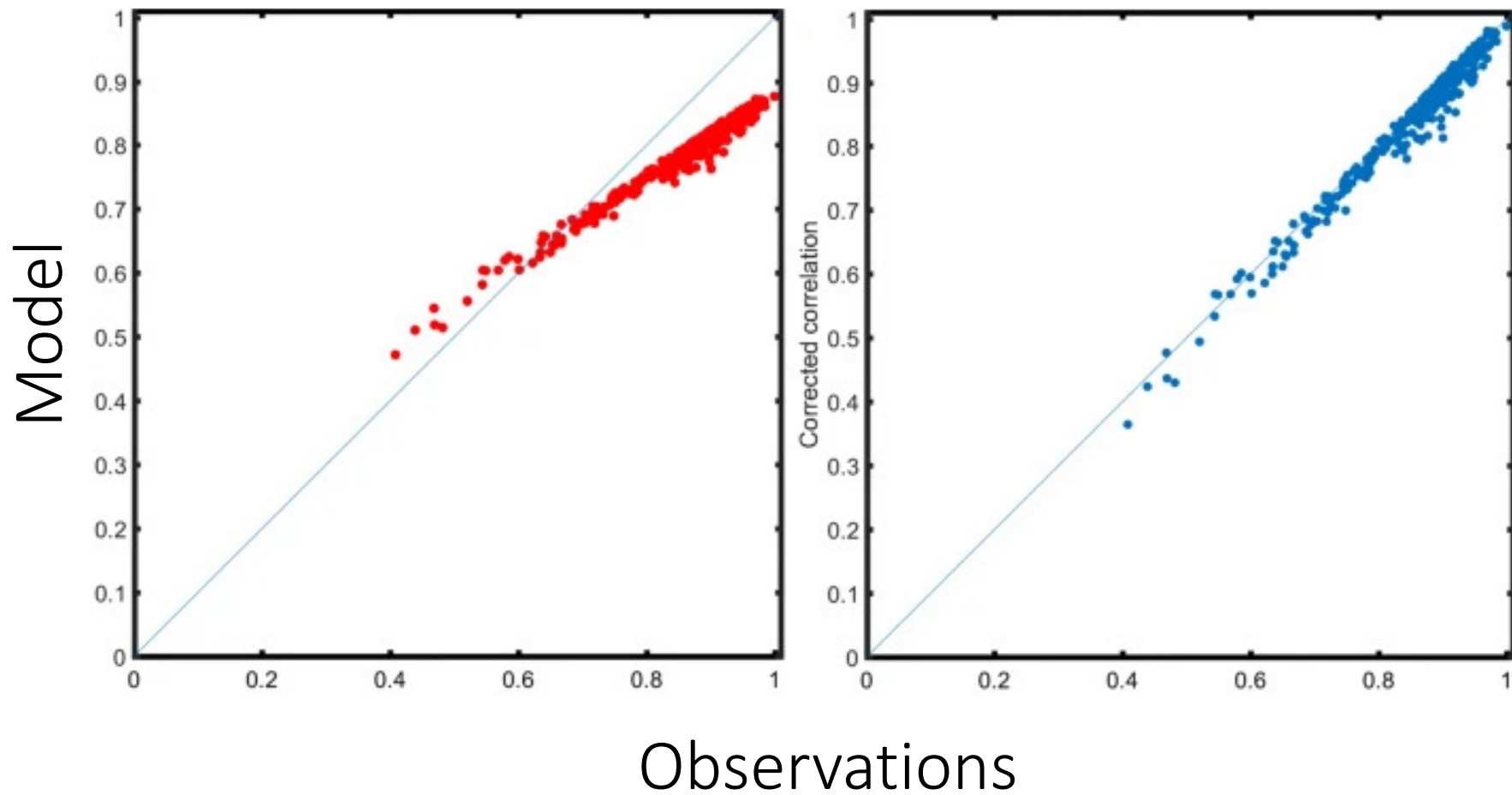
df \ α	0.2	0.1	0.05	0.02	0.01	0.001
35	0.215598	0.274611	0.324573	0.380976	0.418211	0.518898
40	0.201796	0.257278	0.304396	0.357787	0.393174	0.489570
45	0.190345	0.242859	0.287563	0.338367	0.371442	0.464673
50	0.180644	0.230620	0.273243	0.321796	0.354153	0.443261
60	0.164997	0.210832	0.250035	0.294846	0.324818	0.407865
70	0.152818	0.195394	0.231883	0.273695	0.301734	0.379799
80	0.142990	0.182916	0.217185	0.256525	0.282958	0.356816
90	0.134844	0.172558	0.204968	0.242227	0.267298	0.337549
100	0.127947	0.163782	0.194604	0.230079	0.253979	0.321095
125	0.114477	0.146617	0.174308	0.206245	0.227807	0.288602
150	0.104525	0.133919	0.159273	0.188552	0.208349	0.264316
175	0.096787	0.124036	0.147558	0.174749	0.193153	0.245280
200	0.090546	0.116060	0.138098	0.163592	0.180860	0.229840
250	0.081000	0.103852	0.123607	0.146483	0.161994	0.205677
300	0.073951	0.094831	0.112891	0.133819	0.148019	0.188431
350	0.068470	0.087814	0.105132	0.123957	0.137131	0.174657
400	0.064053	0.082155	0.097824	0.115997	0.128339	0.163520
450	0.060391	0.077466	0.092248	0.109397	0.121046	0.154273
500	0.057294	0.073497	0.087528	0.103808	0.114870	0.146436
600	0.052305	0.067103	0.079920	0.094798	0.104911	0.133787
700	0.048427	0.062132	0.074004	0.087789	0.097161	0.123935
800	0.045301	0.058123	0.069234	0.082135	0.090909	0.115981
900	0.042721	0.054782	0.065281	0.077430	0.085727	0.109385
1000	0.040520	0.051993	0.061935	0.073484	0.081340	0.103800
1500	0.033086	0.042458	0.050582	0.060022	0.066445	0.084822
2000	0.028654	0.036772	0.043811	0.051990	0.057557	0.073488
3000	0.023397	0.030027	0.035775	0.042457	0.047006	0.060027
4000	0.020262	0.026005	0.030984	0.036773	0.040713	0.051996
5000	0.018123	0.023260	0.027714	0.032892	0.036417	0.046512

ACCESS-S2 (1981-2018)
38 years – 2 = N = 36

ACCESS-S1 (1990-2012)
23 years – 2 = N = 21

ACCESS-S2 (1993-2018)
25 years – 2 = N = 23

Correlation can be misleading....



Root Mean Square Error

$$RMSE = \sqrt{\sum_{i=1}^n \frac{(\hat{y}_i - y_i)^2}{n}}$$

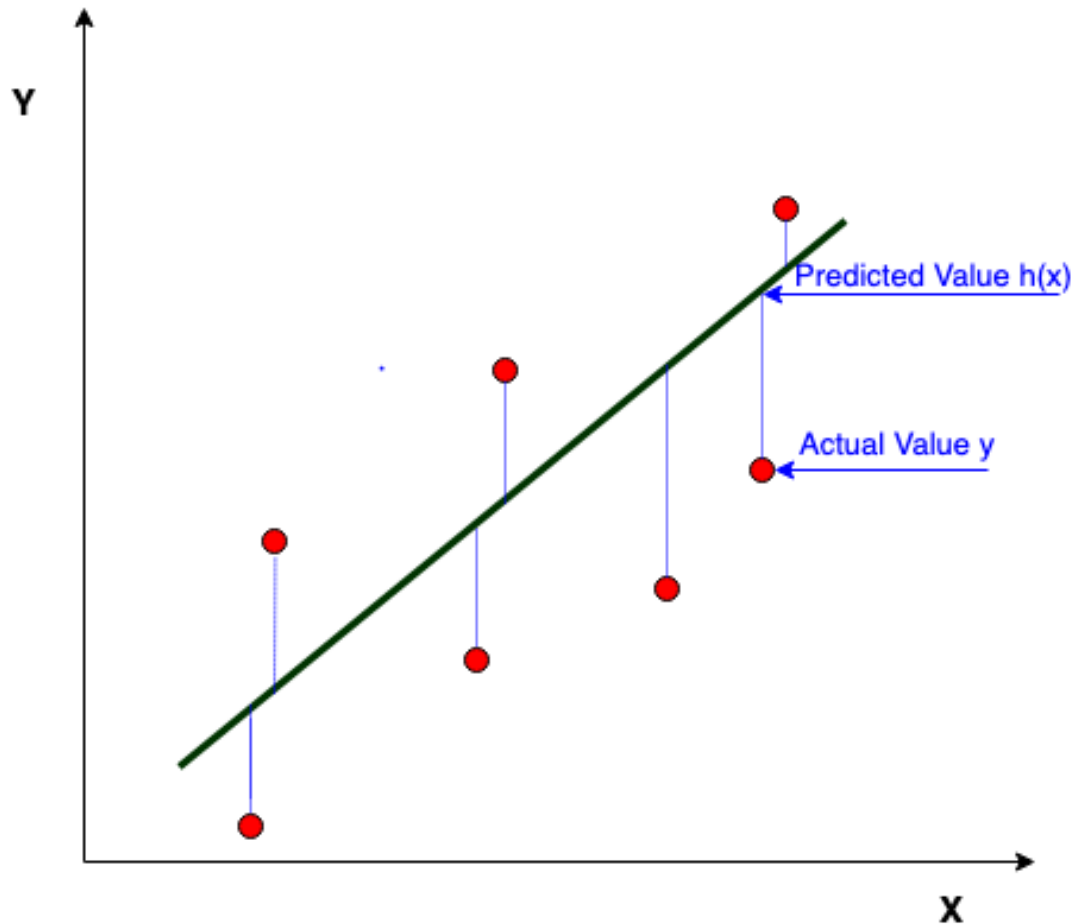
$\hat{y}_1, \hat{y}_2, \dots, \hat{y}_n$ are predicted values

y_1, y_2, \dots, y_n are observed values

n is the number of observations

- RMS stands for **Root Mean Squared**
 - It looks similar to the Standard Deviation
 - Measures the error of a **model** in **predicting** data
 - n = Sample size
 - $\hat{y}_i - y_i$ is the **error** (anomaly or residual) between the model prediction and the observation
 - Each error is **squared**
 - We calculate the **sum** (Σ) of all the squared errors
 - This sum is divided by the number of observations to create the **mean** of the squared errors
 - Finally, calculate the square **root** of the mean
-
- This is a common method used in ACCESS-S model verification

ACCESS-S Skill: Root means squared error



Tells you how different the outlooks are on average to reality in the parameters actual units ($^{\circ}\text{C}$ for SST and mm for Sea Level)

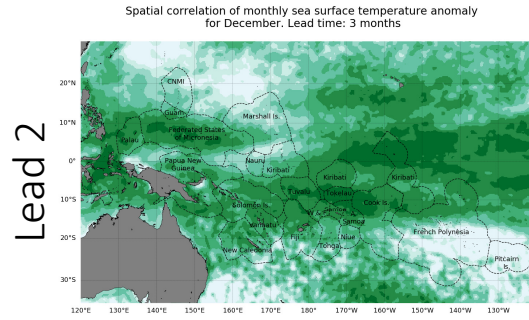
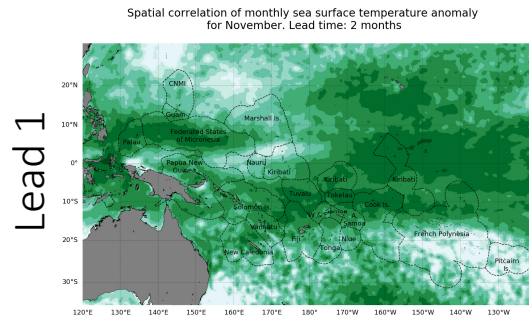
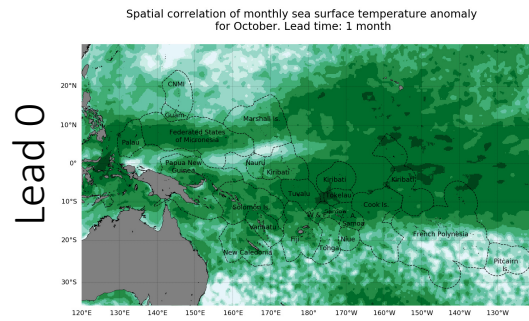
$$RMSE = \sqrt{\frac{\sum_{i=1}^N (\text{Predicted}_i - \text{Actual}_i)^2}{N}}$$

ACCESS-S Skill Calculations

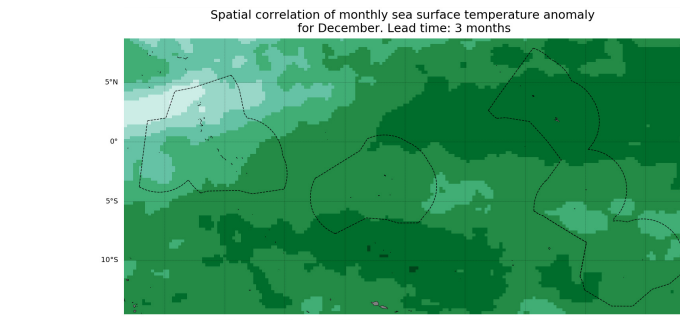
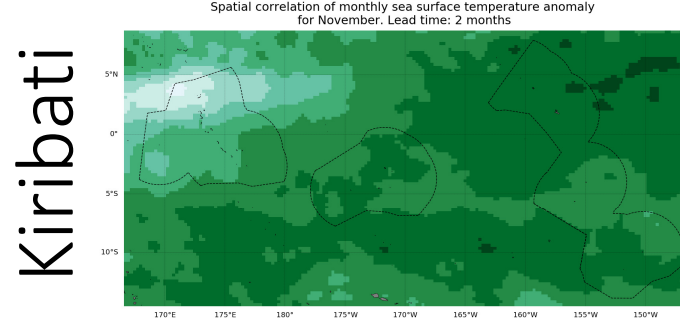
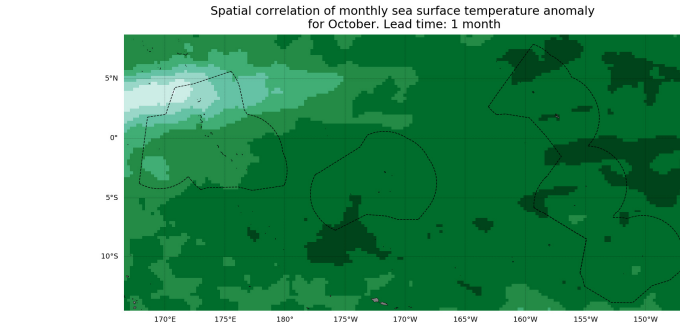
- ACCESS-S has a 38-year hindcast
- A hindcast is a set of retrospective forecast over the past few decades
- We use the hindcast to assess how good the model forecasts because we know what happened
- The model forecasts are compared to observations
- For SST, we used satellite observations (1982 to 2018)
- For Sea Level, we used satellite altimetry (1993 to 2018)



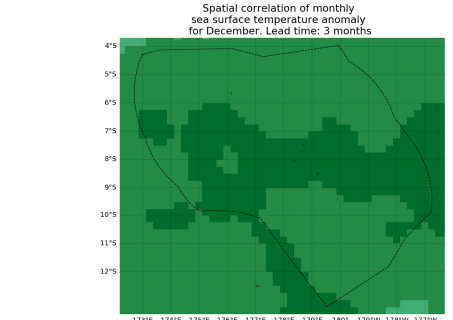
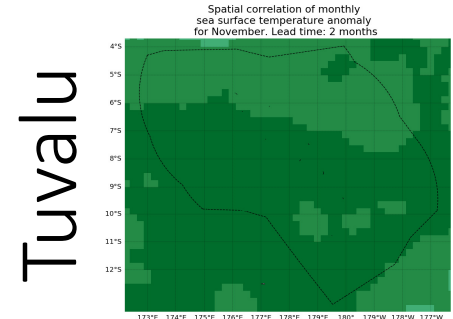
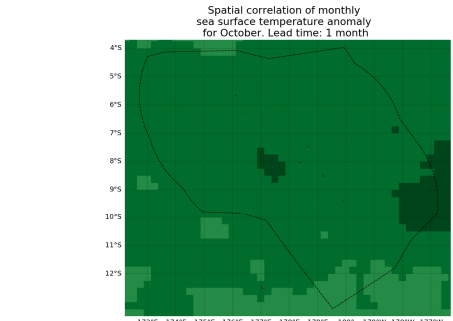
Model skill reduces with lead time...



Run date: 1st September
Data source: ACCESS-S2 and NOAA OISST V2
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Shapfile data extracted from Flinders Marine Institute (CSI), Maritime Boundaries Coordination: Maritime Boundaries and Exclusive Economic Zones (2008), version 11. Available online at <http://www.maritime.gov.au>



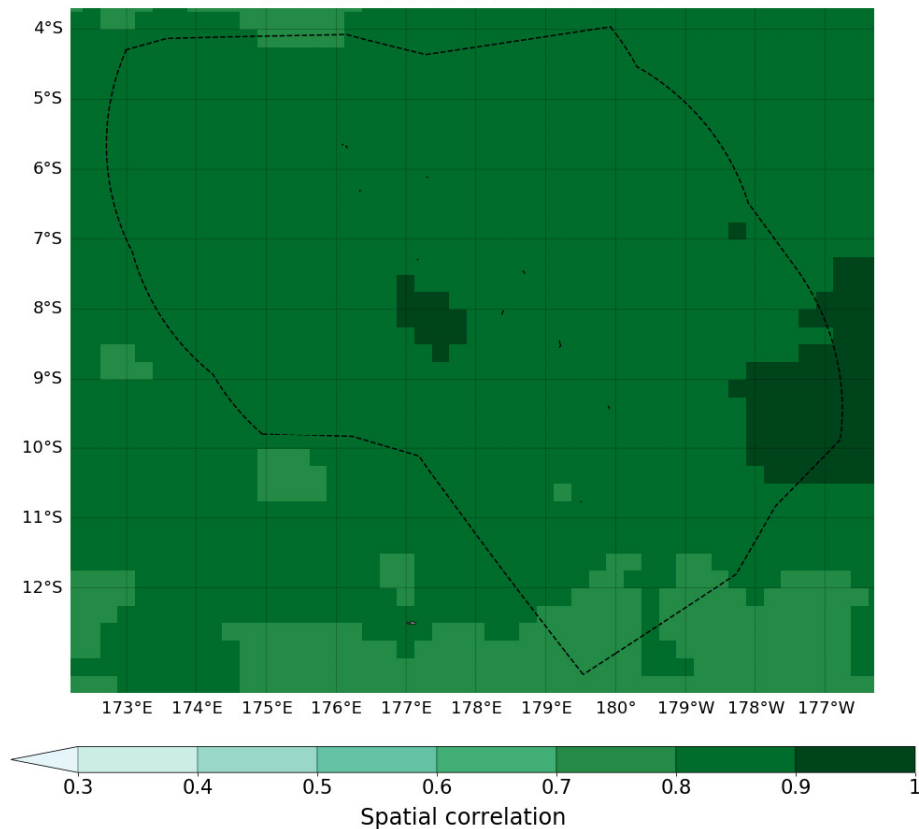
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Shapfile data extracted from Flinders Marine Institute (CSI), Maritime Boundaries Coordination: Maritime Boundaries and Exclusive Economic Zones (2008), version 11. Available online at <http://www.maritime.gov.au>



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Tuvalu SST Skill Example

Spatial correlation of monthly
sea surface temperature anomaly
for October. Lead time: 1 month



Run date: 1st September

Base period: 1981-2018

Issued: 02/02/2022

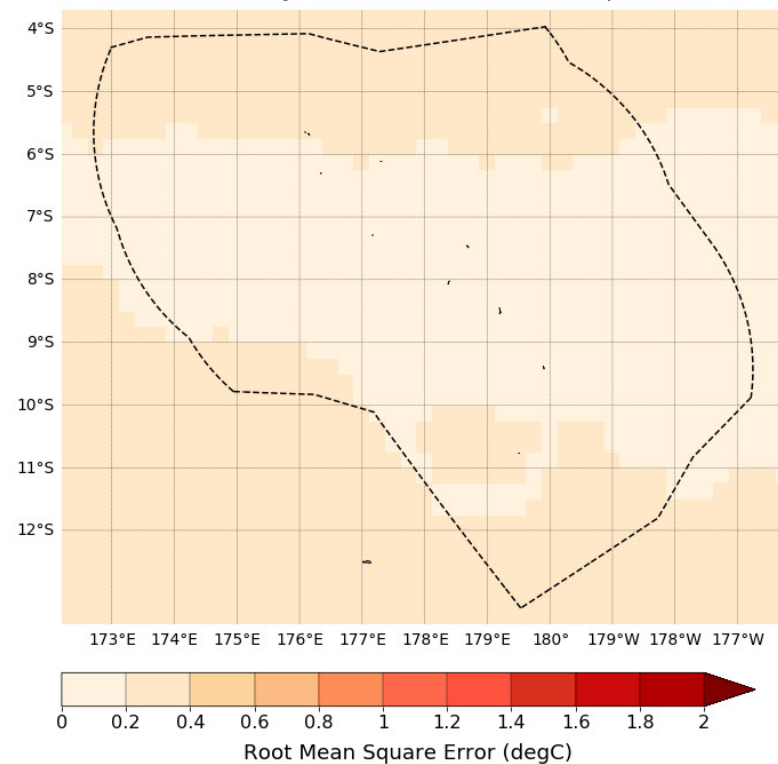
Data source: ACCESS-S2 and NOAA OISST V2

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Disclaimer: Contains NOAA OISST V2 data provided by NOAA/NCEI, Asheville, North Carolina, USA, from their website <https://www.ncdc.noaa.gov/oisst>

Shapefile data extracted from Flanders Marine Institute (2019), Maritime Boundaries Geodatabase: Maritime Boundaries and Exclusive Economic Zones (200NM), version 11. Available online at <http://www.marineboundaries.org/>

October sea surface temperature anomaly Root Mean Square Error (RMSE)
Period: Monthly. Initialisation date: 1st September



Source: ACCESS-S2 and NOAA OISST V2

Supported by Climate and Oceans Support Program in the Pacific

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Hindcast period: 1981-2018

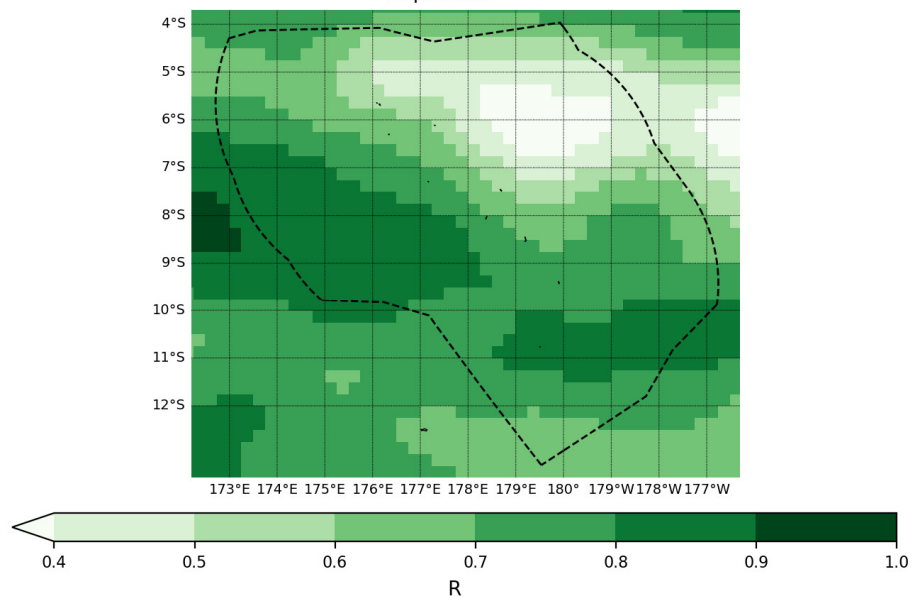
Created: 14/10/2021

Disclaimer: Contains NOAA OISST V2 data provided by NOAA/NCEI, Asheville, North Carolina, USA, from their website <https://www.ncdc.noaa.gov/oisst>

Shapefile data extracted from Flanders Marine Institute (2019), Maritime Boundaries Geodatabase: Maritime Boundaries and Exclusive Economic Zones (200NM), version 11. Available online at <http://www.marineboundaries.org/>

Tuvalu Sea Level Skill Example

Difference from average sea surface height spatial correlation
September

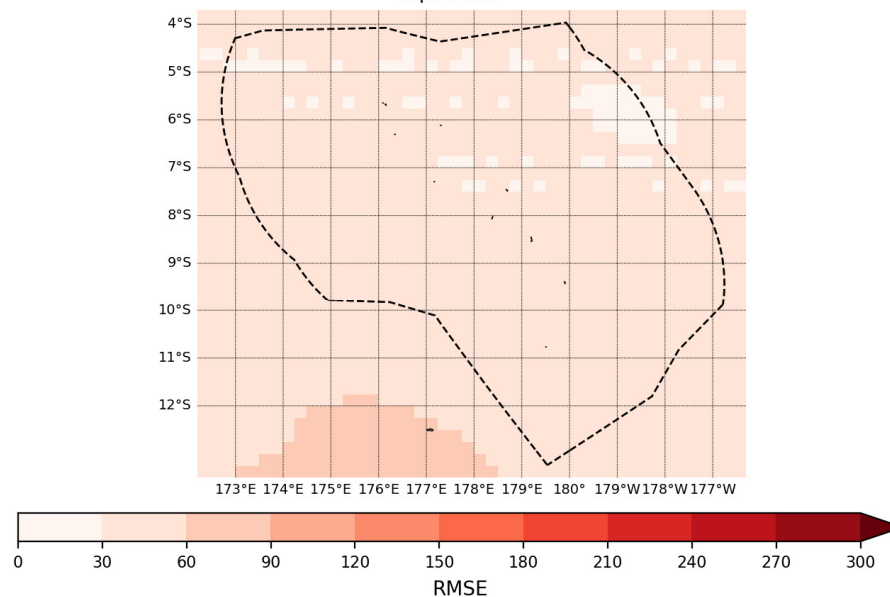


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Model: ACCESS-S2
Base Period: 1993-2018

Hindcast Date: 01/09/2022
Created: 06/09/2022

Difference from average sea surface height Root Mean Square Error
September



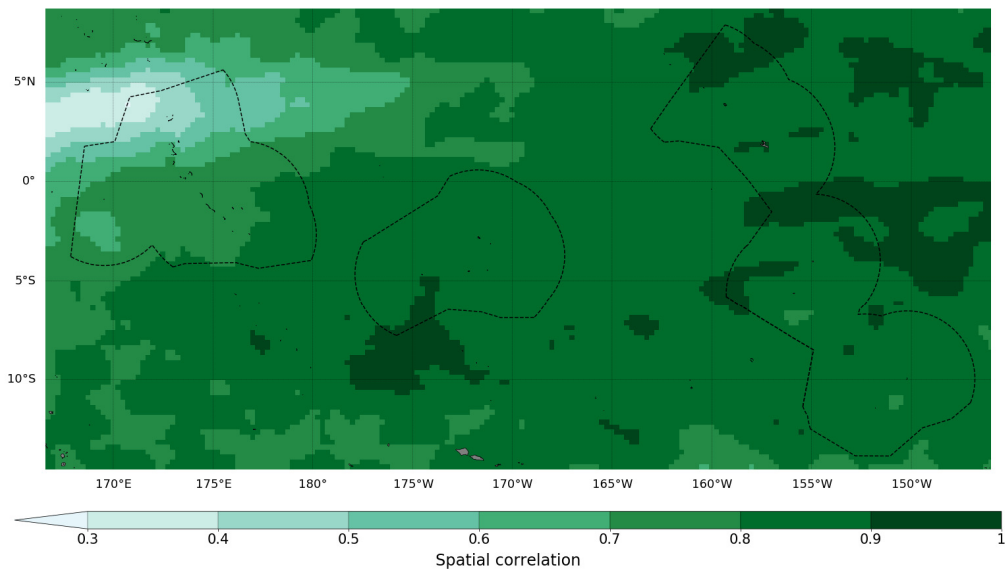
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Model: ACCESS-S2
Base Period: 1993-2018

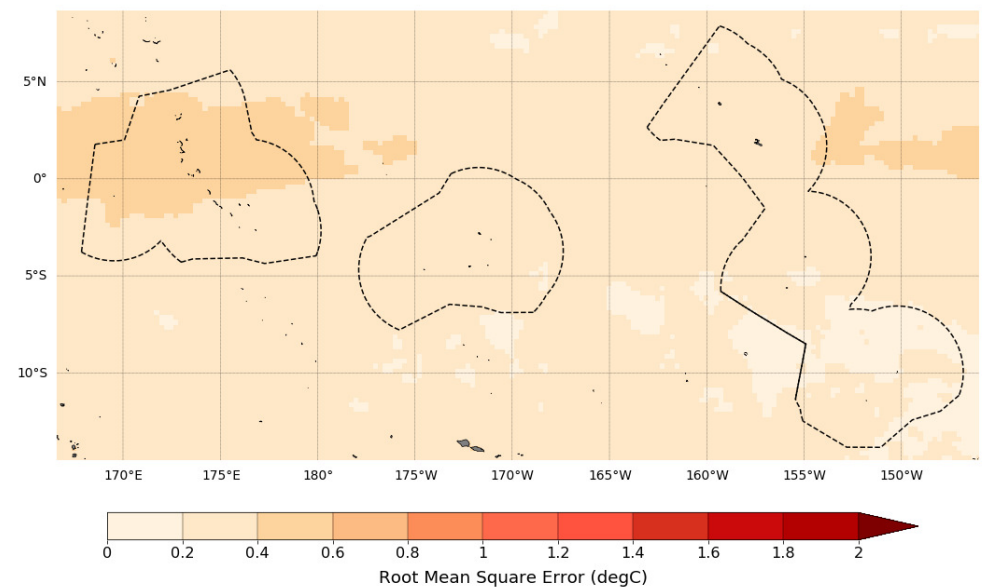
Hindcast Date: 01/09/2022
Created: 06/09/2022

Kiribati SST Skill Example

Spatial correlation of monthly sea surface temperature anomaly
for October. Lead time: 1 month



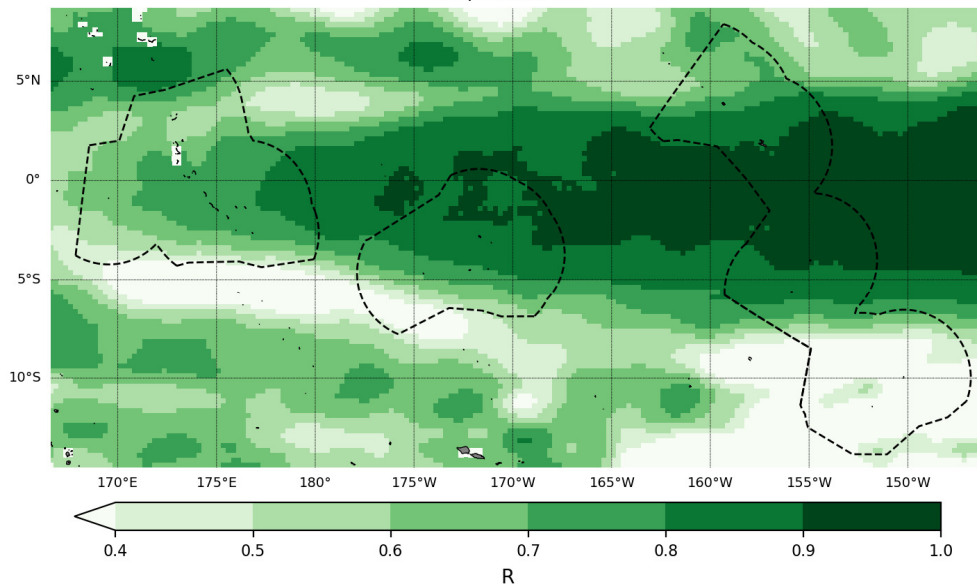
Sea surface temperature anomaly Root Mean Square Error (RMSE).
Period: Fortnightly. Initialisation date: 1st September. Lead time: 1 week



Hindcast period: 1981-2018
Created: 17/10/2021

Kiribati Sea Level Skill Example

Difference from average sea surface height spatial correlation
September

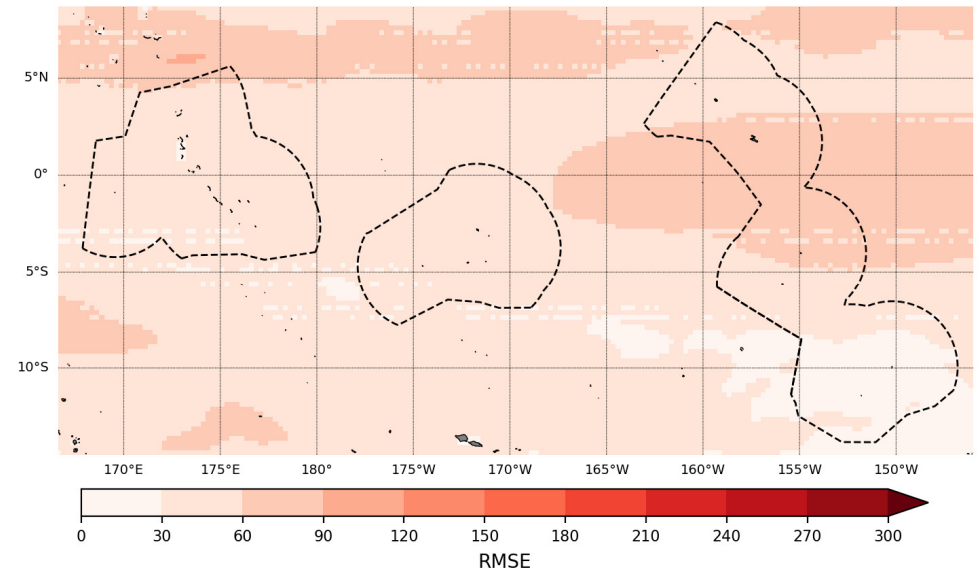


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Bureau of Meteorology

Model: ACCESS-S2
Base Period: 1993-2018

Hindcast Date: 01/08/2022
Created: 03/08/2022

Difference from average sea surface height Root Mean Square Error
September

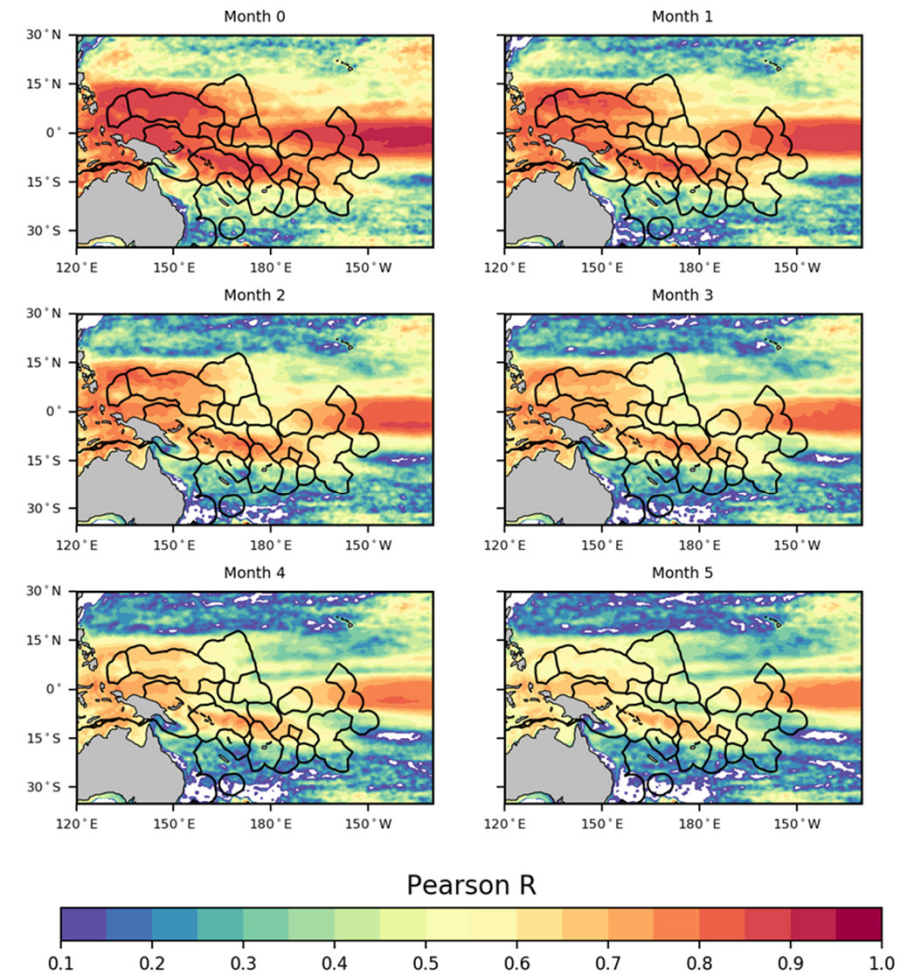
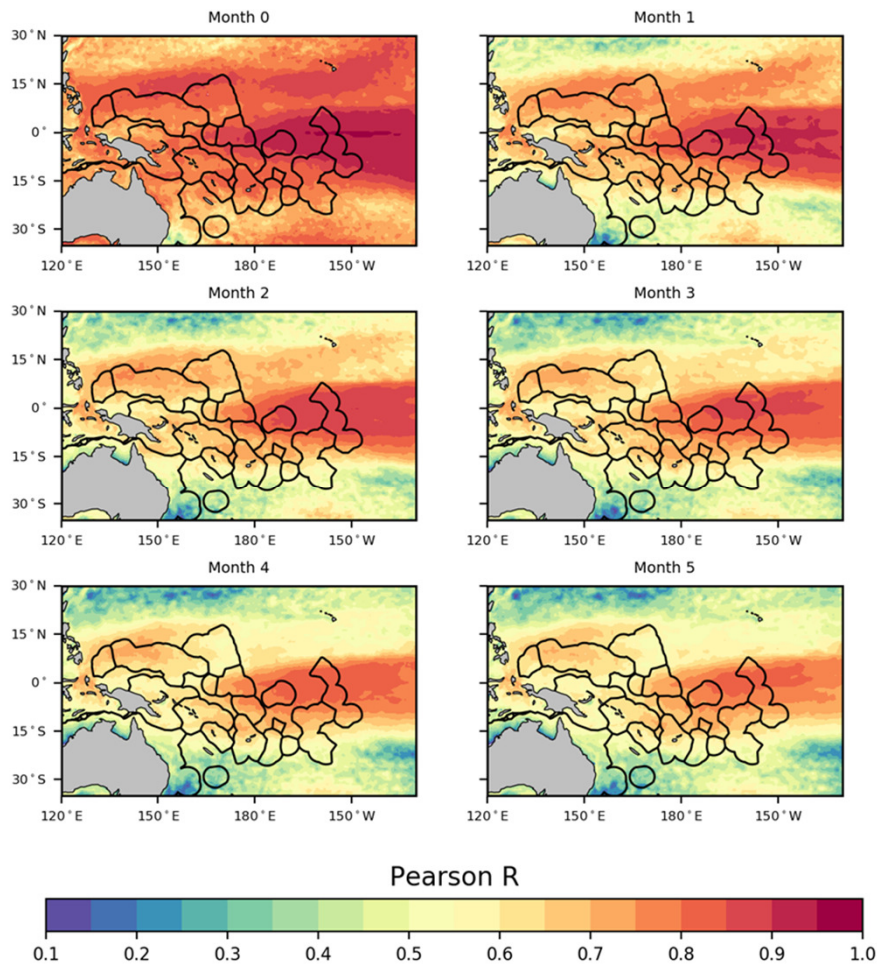


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Model: ACCESS-S2
Base Period: 1993-2018

Hindcast Date: 01/09/2022
Created: 06/09/2022

Skill in Ocean Portal Help Files

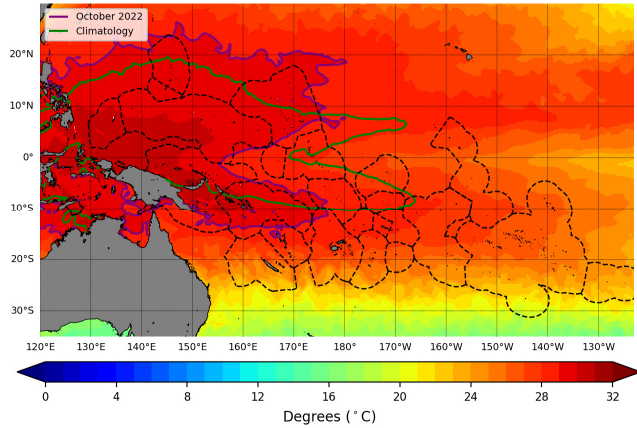


Important take home messages...

- Three main products: SST anomaly, sea level anomaly, SST with convergence zone.
- The most comprehensive resource for outlooks is the ACCESS-S webpage which includes regional/national maps and skill for all time scales.
- Pacific Ocean Portal provides an interactive view of monthly outlooks
- Model skill is represented by correlation with observations, and root means squared error.
- Use correlation to determine if there is skill, and use RMSE to see how different the model is to observations on average.
- Check skill for your country when issuing outlooks to ensure outlooks are trustworthy.

Pacific Forecasts – oceanic variables

Sea surface temperature forecast for
October 2022

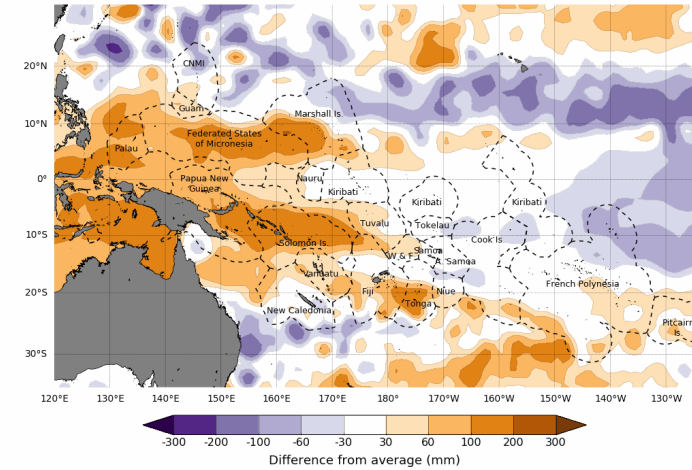


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Model: ACCESS-S2
Base Period: 1981-2018

Model Run: 01/10/2022
Issued: 05/10/2022

Difference from average sea surface height forecast for
November 2022

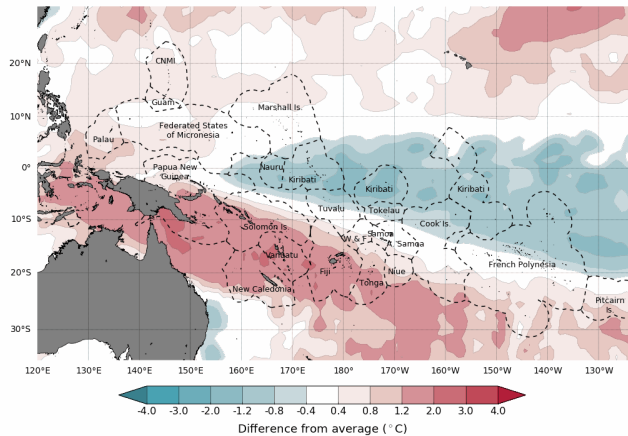


Base period: 1981-2018
Model: ACCESS-S2
© Commonwealth of Australia 2022, Australian Bureau of Meteorology

Model run: 08/10/2022
Issued: 10/10/2022

Shapefile data extracted from Flanders Marine Institute (2019), Maritime Boundaries Geodatabase: Maritime Boundaries and Exclusive Economic Zones (200NM), version 11. Available online at <http://www.maritimesegions.org/>

Difference from average sea surface temperature forecast for
15 to 21 October 2022



Base period: 1981-2018
Model: ACCESS-S2
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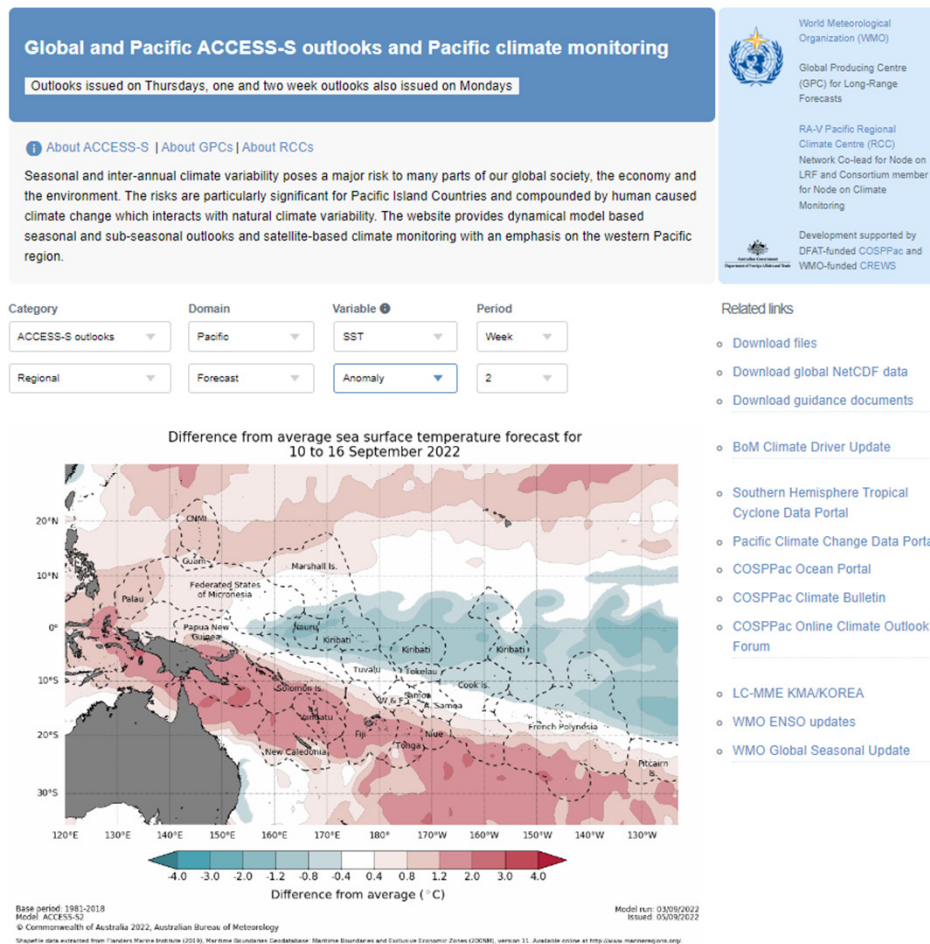
Model run: 08/10/2022
Issued: 10/10/2022

Shapefile data extracted from Flanders Marine Institute (2019), Maritime Boundaries Geodatabase: Maritime Boundaries and Exclusive Economic Zones (200NM), version 11. Available online at <http://www.maritimesegions.org/>

Outputs for:

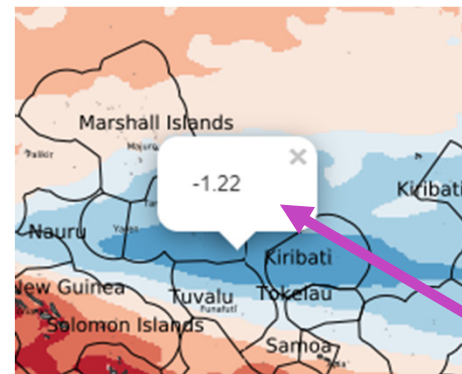
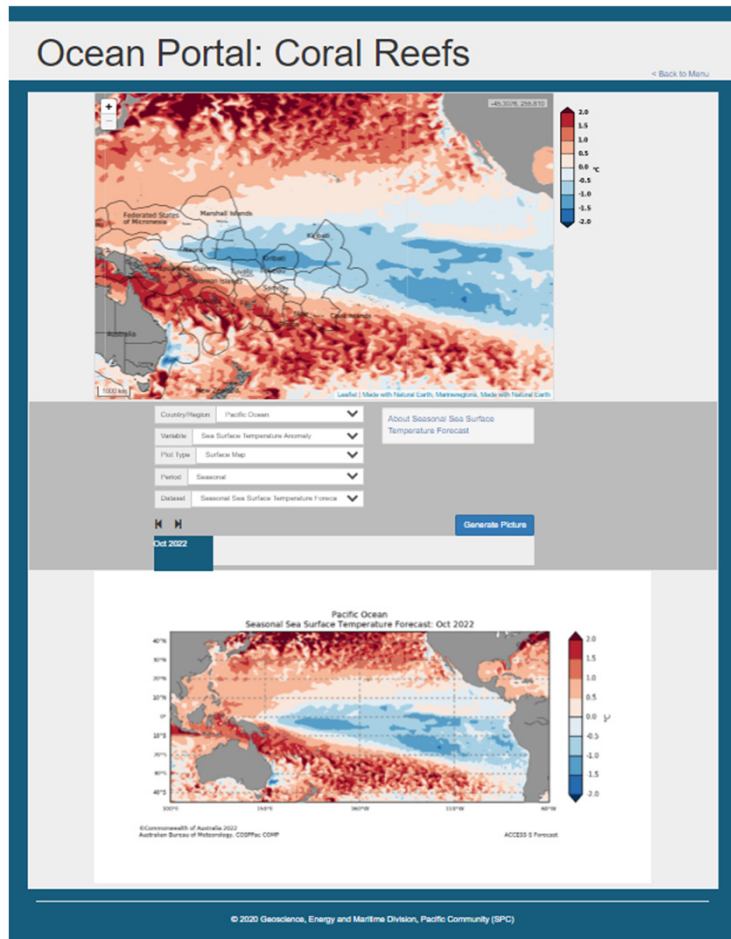
- Sea surface temperature (both full field and anomaly)
- Sea surface height

ACCESS-S Ocean Outlooks: website

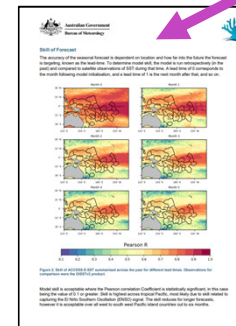


- <http://www.bom.gov.au/climate/pacific/outlooks/>
- Weekly/fortnightly/monthly/seasonal available for SST anomaly
- Skill maps
- Forecast out to 3 weeks, 3 fortnights, 3 months, 2 seasons

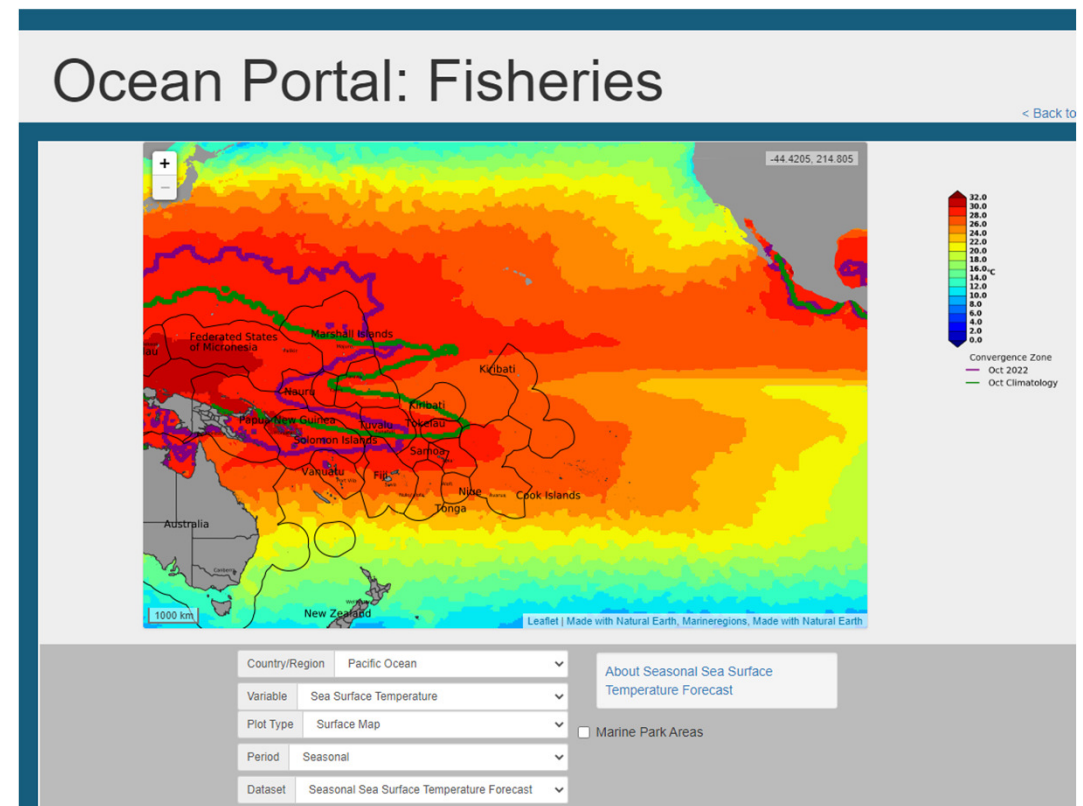
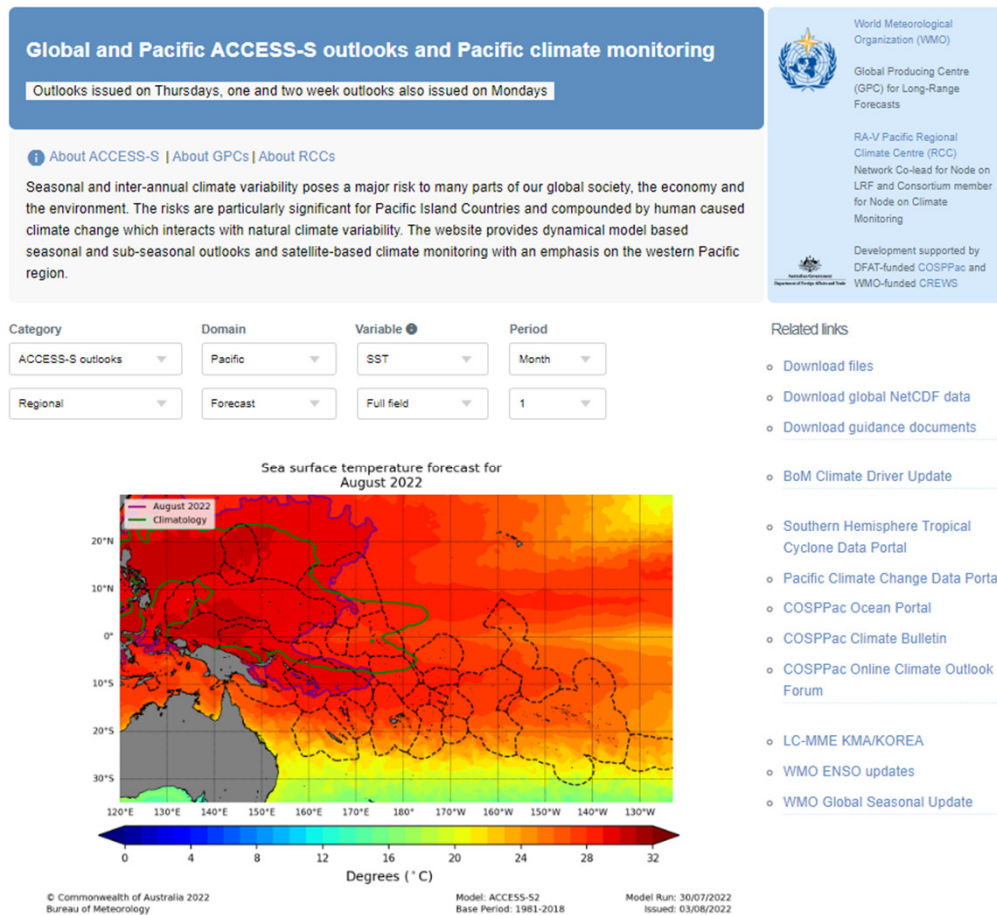
ACCESS-S Ocean Outlooks: Ocean Portal



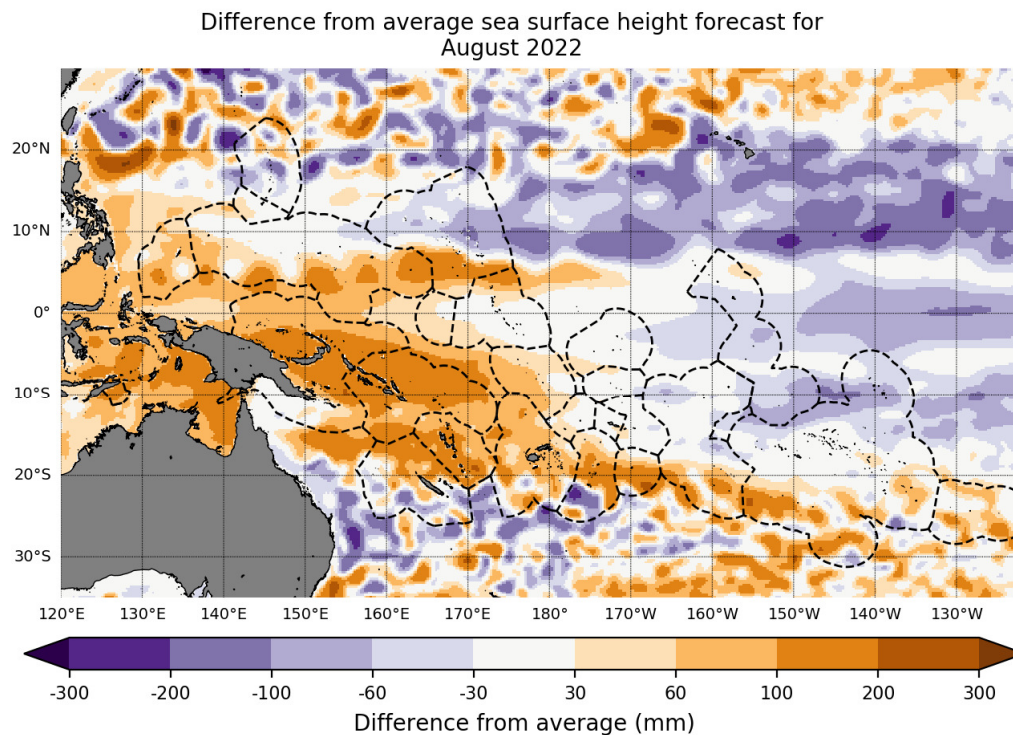
- <http://oceanportal.spc.int/portal/ocean.html>
- Monthly only
- Right click to discover real values down to two decimal places
- Help files available (with monthly skill maps included)
- Interactive map window
- Available out to six months



ACCESS-S Ocean Outlooks: SST full field



ACCESS-S Ocean Outlooks: Sea level



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Model: ACCESS-S2
Base Period: 1981-2018

Model Run: 28/07/2022
Issued: 03/08/2022

- <http://www.bom.gov.au/climate/pacific/outlooks/>
- Only available on the website (will be available in the ocean portal soon)
- Difficult to find sea level outlooks from global seasonal climate models (only other one available is NOAA CFSv2....)

CFSv2 and ACCESS-S MME



Data Network Research Products GLOSS About

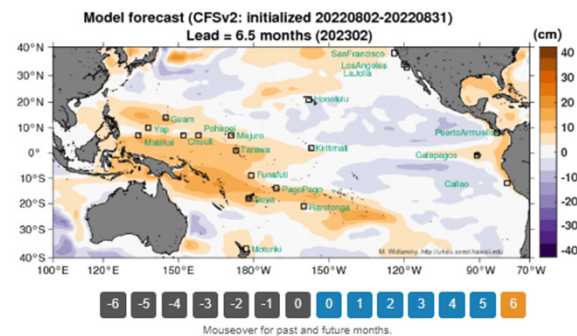
Sea Level Forecasts



This product provides an outlook of monthly sea level anomalies for the next one to two seasons. We combine sea level forecasts with astronomical tide predictions to provide more accurate predictions of coastal water level compared to tide predictions alone.

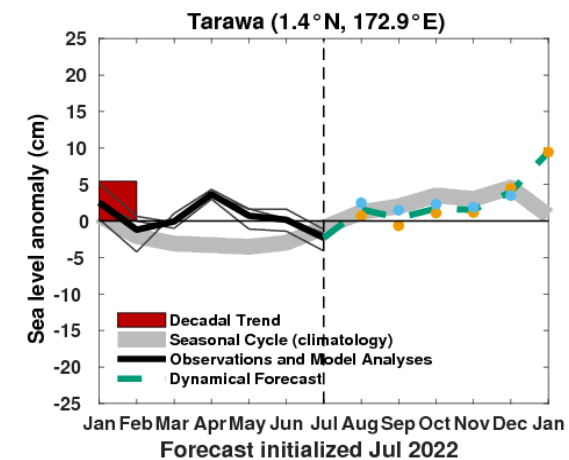
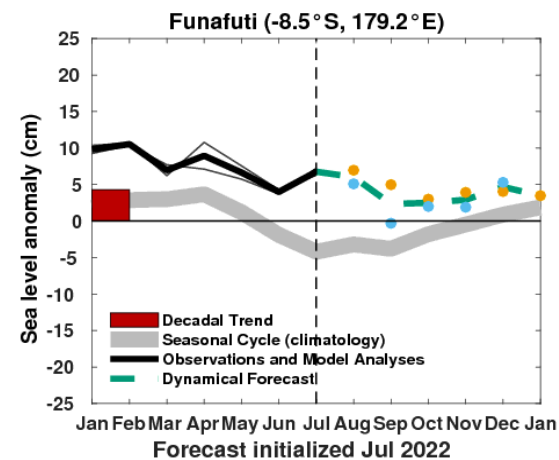
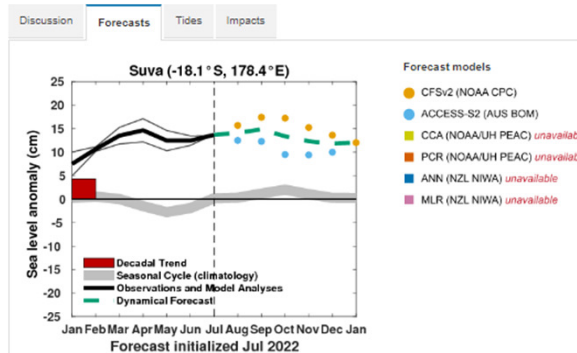
READ MORE

This seasonal forecast product is experimental. For short-term forecasts (daily to weekly), please see the High Sea Level Forecast for your region. Neither the seasonal nor the weekly product is accurate when a tsunami or tropical cyclone threatens your coastline.



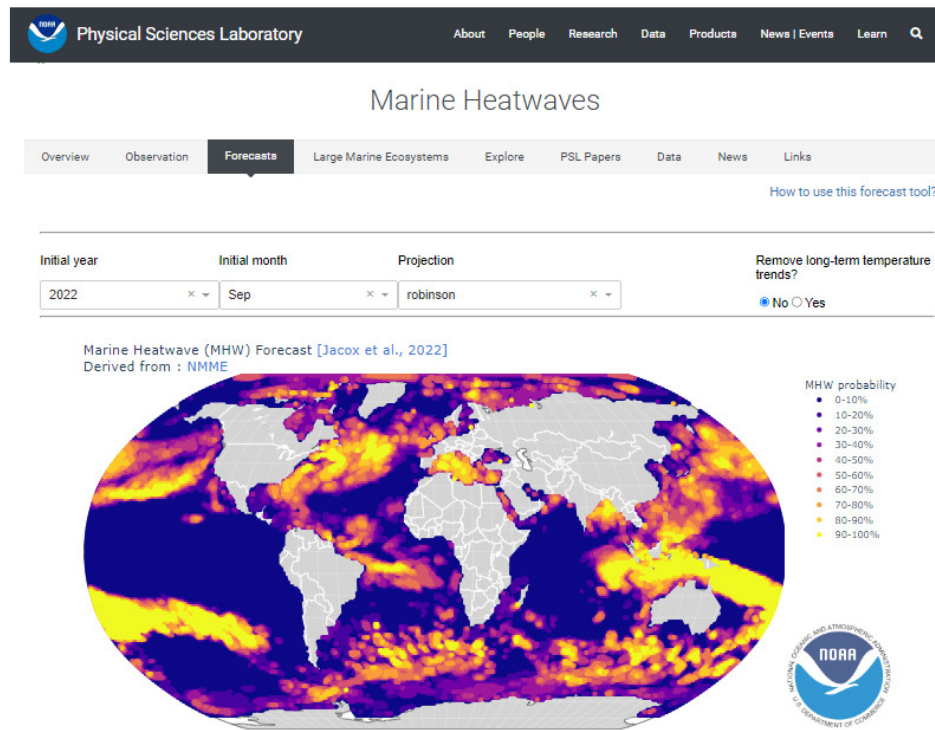
How to use this page ...

- Visualize recent sea level observations from satellites (past 6 months) and predictions from one model (next 6 months) by moving the mouse over the row of numbers below the map.
- View multi-model forecasts for many islands in the tropical Pacific by clicking tide gauge station labels on the map.
- Click on the "Tides" or "Impacts" tabs to see how the predicted relative sea level anomaly is likely to alter the astronomical tide cycle and affect the coastline.



- <https://uhslc.soest.hawaii.edu/sea-level-forecasts/>
- Time series available (one location per Pacific country only)

Marine Heatwaves Outlooks



- <https://psl.noaa.gov/marine-heatwaves/>
- Marine Heatwave outlooks on a monthly time scale
- Probabilistic outlooks
- From NOAA's North American Multi-Model Ensemble
- Includes skill maps