

International Climate Change Adaptation Initiative



Tropical cyclones in the Western Pacific

Yuriy Kuleshov
Australian Bureau of Meteorology



Australian Government
Bureau of Meteorology

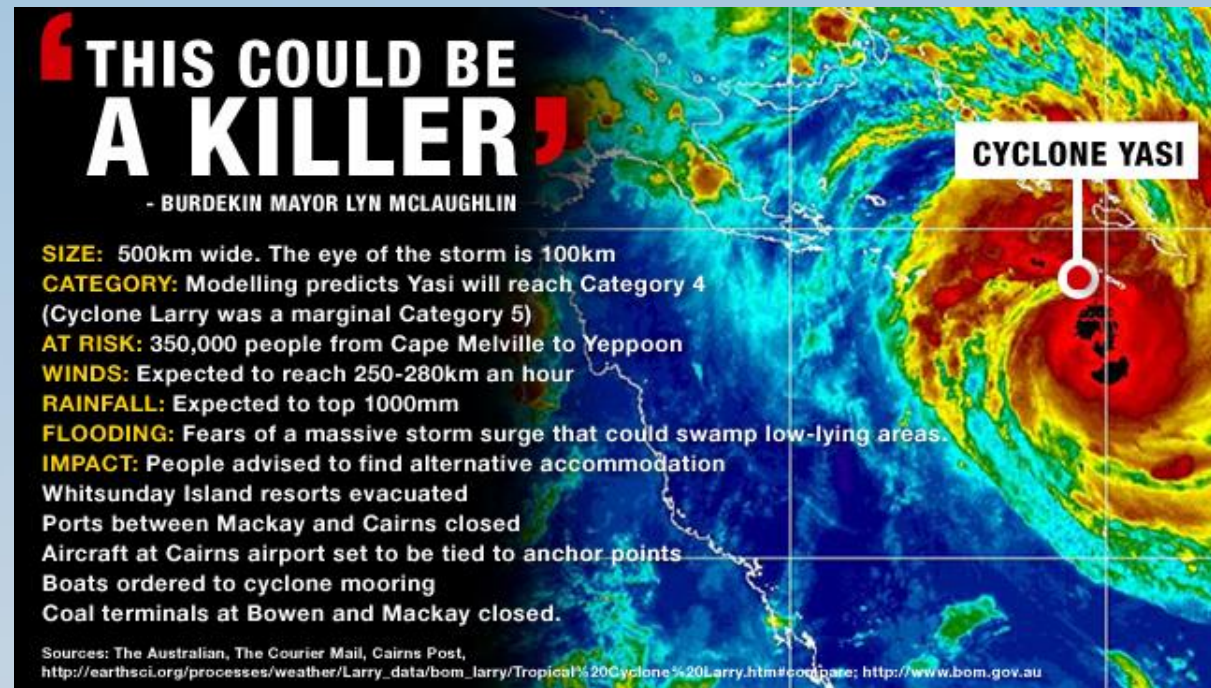
Outline

- Tropical cyclones – impacts
- Climate Change and Southern Hemisphere tropical cyclones international initiative
- International Climate Change Adaptation Initiative
- Effective response to disasters and adaptation



Tropical cyclones

Tropical cyclones are the most extreme severe weather events which impact coastal communities and island nations.



There is an ongoing research

- (i) on accurate analysis of observed trends in tropical cyclone occurrences, and
- (ii) how to improve skill of tropical cyclone forecasting, including seasonal prediction of cyclone activity to assist with preparedness and risk reduction for coastal communities.

Cyclone Tracy, Darwin, Australia, 1974

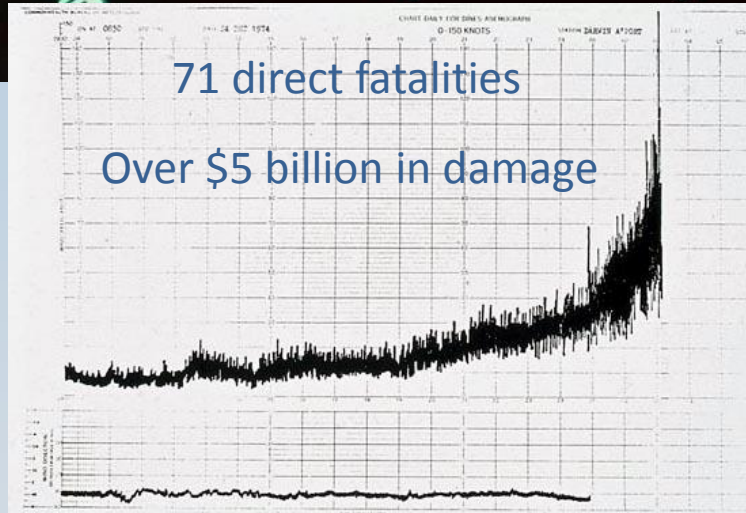
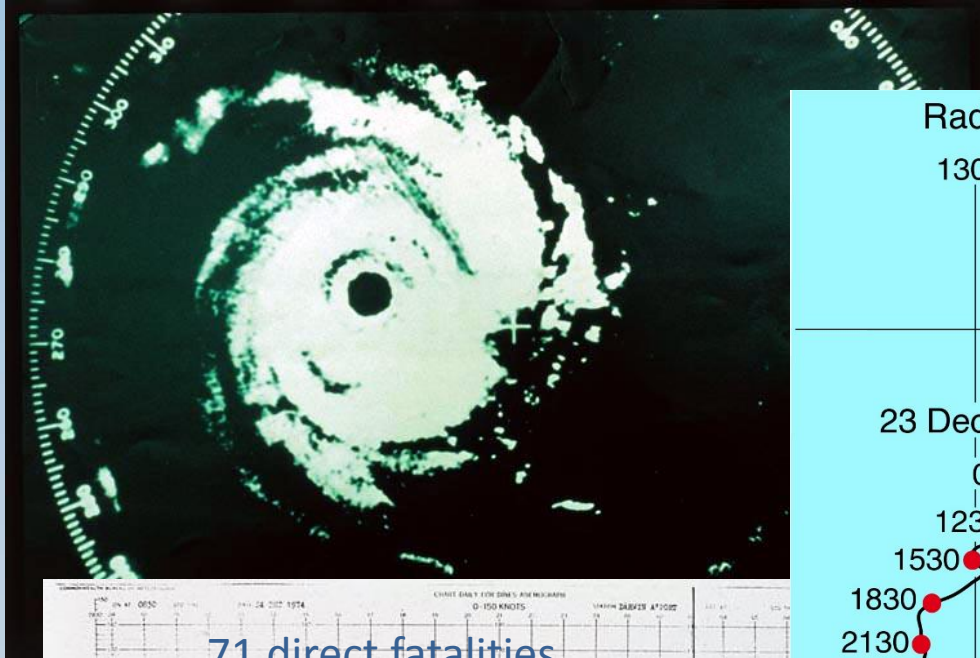


Fig 11 An approximate reproduction of the Dines anemograph record, reproducing only the information which is known to be inferred. The wind speeds may be low by as much as 6 km per h. (3 knots) because of a possible zero error. The maximum gust is subject to verification.



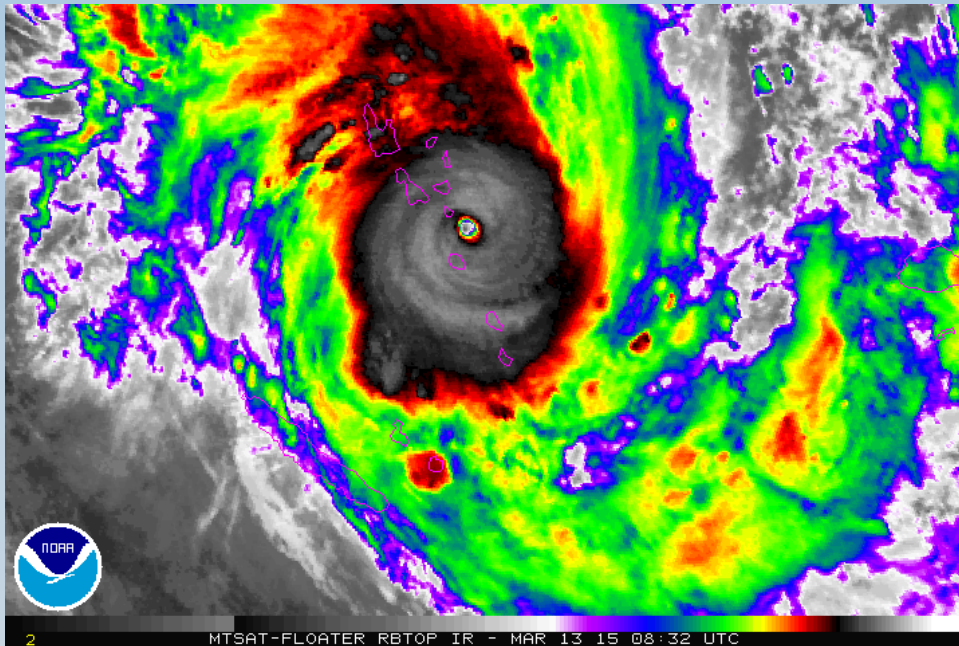
Cyclone *Tracy*, Darwin, Australia, 1974



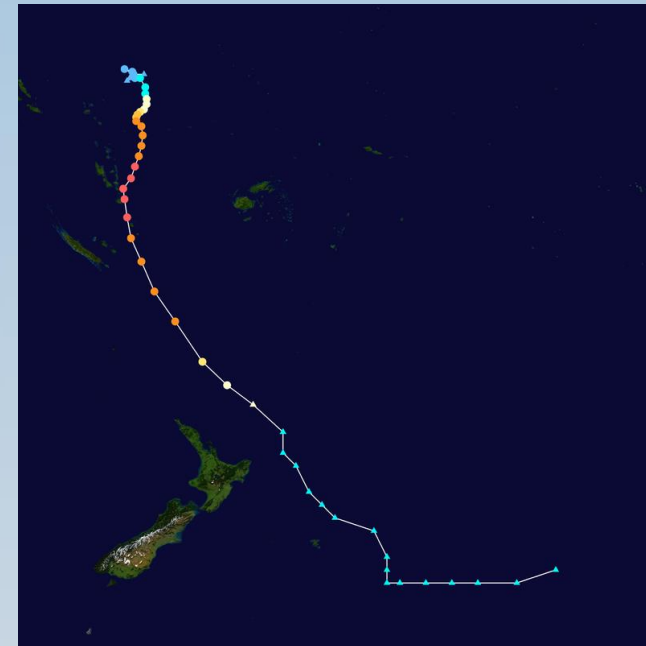
- 70% of Darwin's buildings were destroyed
- *Tracy* was described as “disaster of the first magnitude ... without parallel in Australia's history”.

Cyclone *Pam*, March 2015

Severe tropical cyclone *Pam* was considered to be the worst natural disaster in the history of Vanuatu. A tropical depression developed on 6 March 2015 east of Solomon Islands. On 13-14 March *Pam* attained category 5 cyclone intensity with highest winds 250 km/h and lowest pressure 896 hPa.



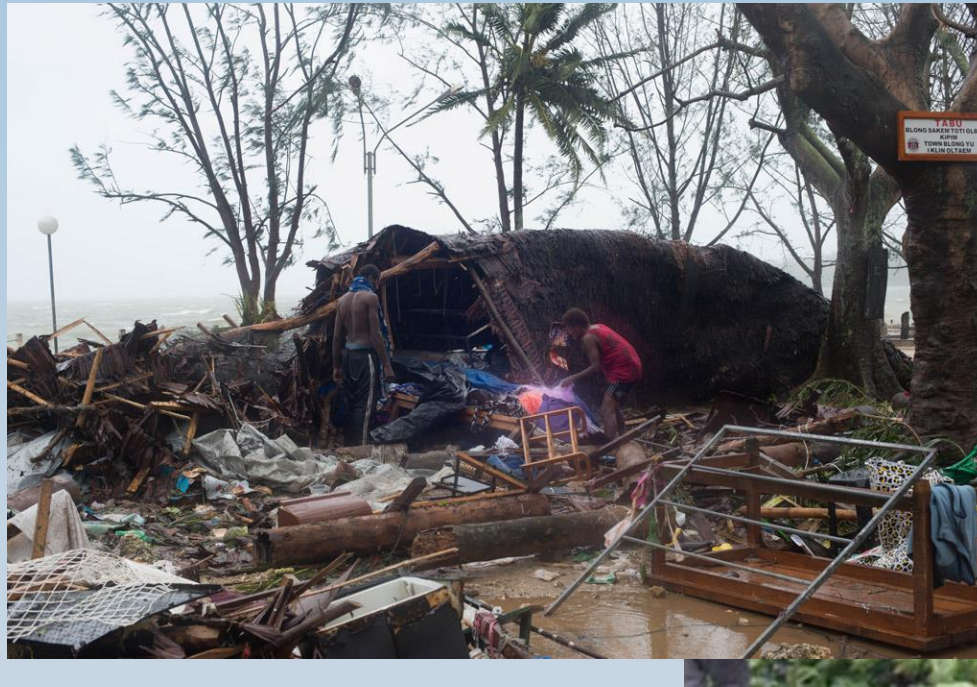
Satellite image of category 5 tropical cyclone *Pam* on 13/3/2015



Track of tropical cyclone *Pam*

Cyclone Pam, March 2015

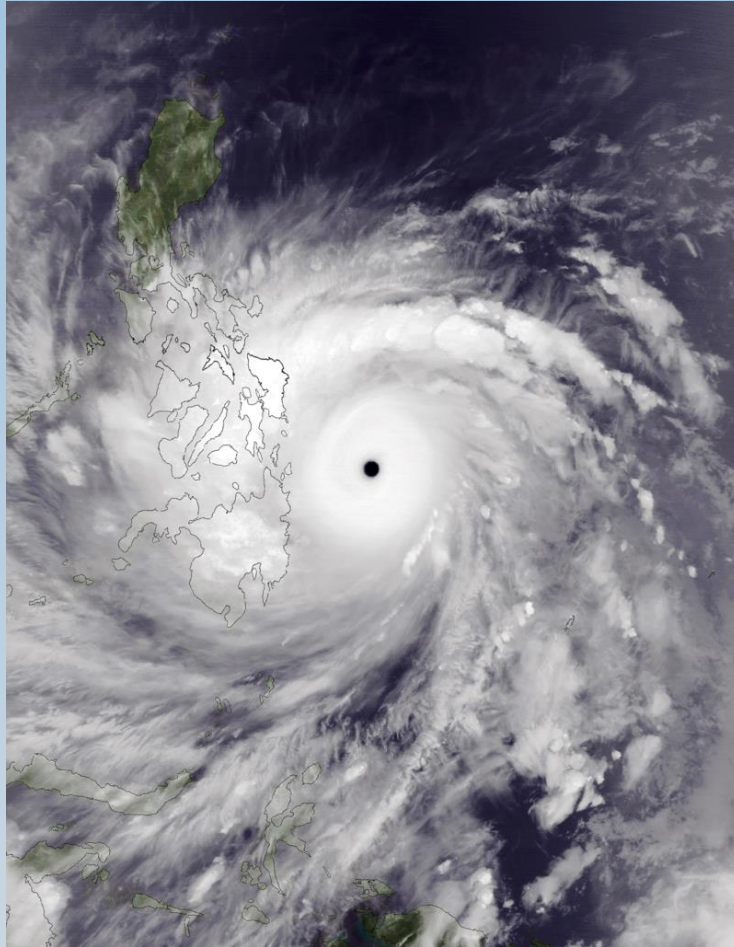
After all the development we have done for the last couple of years and this big cyclone came and just destroyed... all the infrastructure the government has... built. Completely destroyed. Vanuatu President Baldwin Lonsdale.



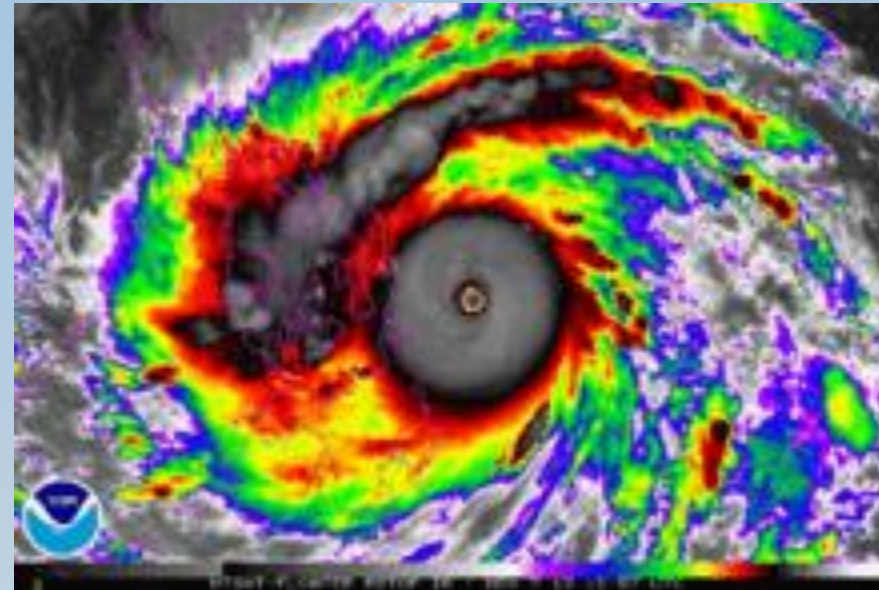
At least 16 people are confirmed to have died, and 30 others were reported injured; at least 132,000 people have been impacted (Vanuatu population is estimated at 267,000, July 2014)

~ 70% of houses destroyed

Typhoon *Haiyan* (*Yolanda*), November 2013



TC *Haiyan* (*Yolanda*) at peak intensity
approaching the Philippines on Nov 7, 2013
Winds: 230 km/h;
Pressure: 895 hPa



An enhanced infrared satellite loop of Typhoon *Yolanda* from 15:57 UTC to 22:57 UTC on November 7, 2013. These images show the storm at peak intensity and making landfall over the islands of Samar and Leyte in the Philippines.

Typhoon *Haiyan (Yolanda)*, November 2013



Typhoon *Yolanda*, was one of the strongest TCs ever recorded. It is the deadliest Philippine typhoon recorded in modern history, killing at least 6,300 people. It is also the strongest storm recorded at landfall.



Fatalities: 6,340 confirmed; 1,061 missing

Damage: \$2.86 billion (2013 USD), the costliest Philippine typhoon.

How climate change affects tropical cyclone activity – globally and regionally?



IPCC Fifth Assessment Report (AR5): Climate Change 2013

Climate is changing on a global scale and consequently it is important to monitor changes in global and regional tropical cyclone frequencies, intensities and tracks.

Phenomenon and direction of trend	Assessment that changes occurred	Likelihood of further changes (Late 21st century)
Increases in intense tropical cyclone activity	<i>Low confidence</i> in long term (centennial) changes <i>Virtually certain</i> in North Atlantic since 1970	<i>More likely than not</i> in the Western North Pacific and North Atlantic

Trend in tropical cyclone occurrences

1 OCTOBER 2015

KLOTZBACH AND LANDSEA

7625

TABLE 1. Number and percentage of category 4–5 hurricanes by TC basin by pentad since 1970.

Basin	1970–74	1975–79	1980–84	1985–89	1990–94	1995–99	2000–04	2005–09	2010–14
	No. of category 4 and 5 hurricanes								
NA	2	6	4	6	2	12	11	12	7
EP	6	13	11	12	25	16	9	9	14
WP	27	21	27	26	42	28	41	38	31
NI	0	0	1	0	3	4	0	4	5
SI	5	6	8	6	13	19	20	15	15
SP	1	3	1	5	10	6	5	9	10
NH	35	40	43	44	72	60	61	63	57

Ten years ago, Webster et al. documented a large and significant increase in both the number as well as the percentage of category 4 and 5 hurricanes for all global basins from 1970 to 2004, and this manuscript examines whether those trends have continued when including 10 additional years of data. In contrast to that study, as shown here, the global frequency of category 4 and 5 hurricanes has shown a small, insignificant downward trend while the percentage of category 4 and 5 hurricanes has shown a small, insignificant upward trend between 1990 and 2014. Accumulated cyclone energy globally has experienced a large and significant downward trend during the same period. The primary reason for the increase in category 4 and 5 hurricanes noted in observational datasets from 1970 to 2004 by Webster et al. is concluded to be due to observational improvements at the various global tropical cyclone warning centers, primarily in the first two decades of that study.

Klotzbach, P. J. and C. W. Landsea, 2015: Extremely intense hurricanes: Revisiting Webster et al. (2005) after 10 years, *Journal of Climate*, 28, 7621–7629.



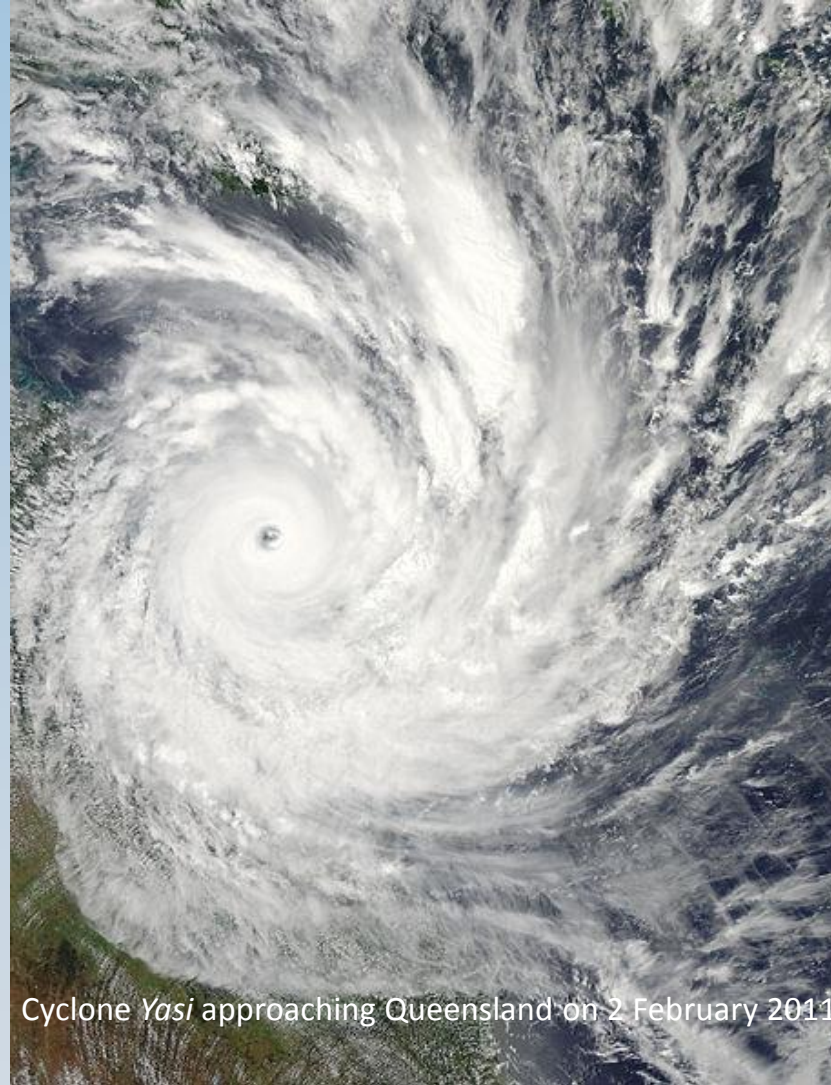
Australian Government
Bureau of Meteorology

Tropical cyclones – projections

- Trend detection is further impeded by substantial limitations in the availability and quality of global historical records of tropical cyclones. Therefore, it remains uncertain whether past changes in tropical cyclone activity have exceeded the variability expected from natural causes.
- However, future projections based on theory and high-resolution dynamical models consistently indicate that greenhouse warming will cause the globally averaged intensity of tropical cyclones to shift towards stronger storms, with intensity increases of 2–11% by 2100.
- Existing modelling studies also consistently project decreases in the globally averaged frequency of tropical cyclones, by 6–34%. Balanced against this, higher resolution modelling studies typically project substantial increases in the frequency of the most intense cyclones.



Climate Change and Southern Hemisphere Tropical Cyclones International Initiative



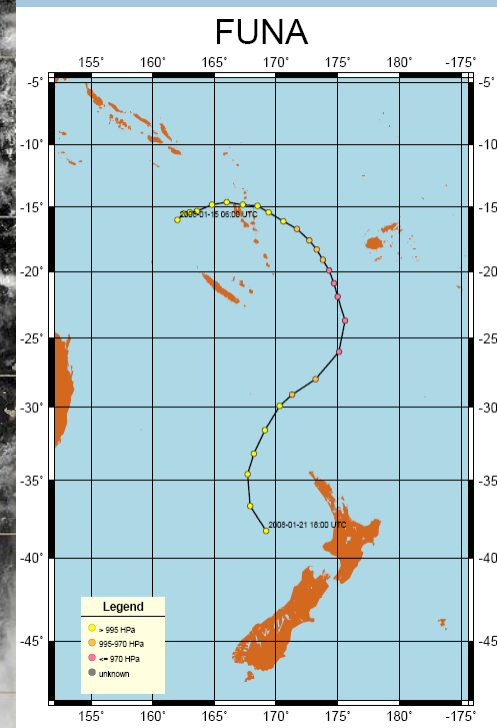
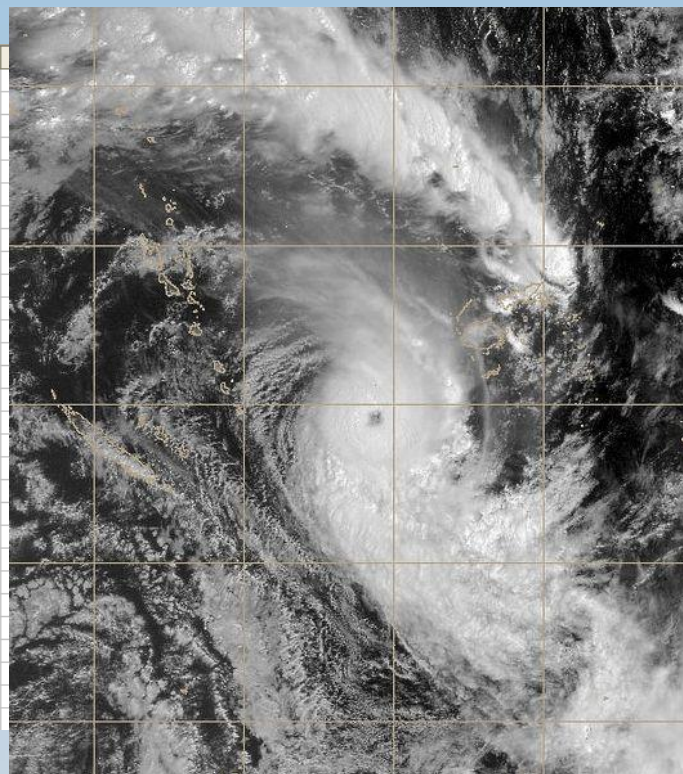
Cyclone *Yasi* approaching Queensland on 2 February 2011

"Climate Change and Southern Hemisphere Tropical Cyclones" international initiative

- High-quality tropical cyclone database for the South Pacific and the South Indian Oceans, covering tracks and intensity.
- Tropical cyclone archive extended to the Western North Pacific (in collaboration with RSMC Tokyo).
- Tropical cyclone climatology for the Southern Hemisphere.
- Web-based information tools to support the use and dissemination of data and analyses.
- Statistical and dynamical climate model-based seasonal tropical climate prediction.

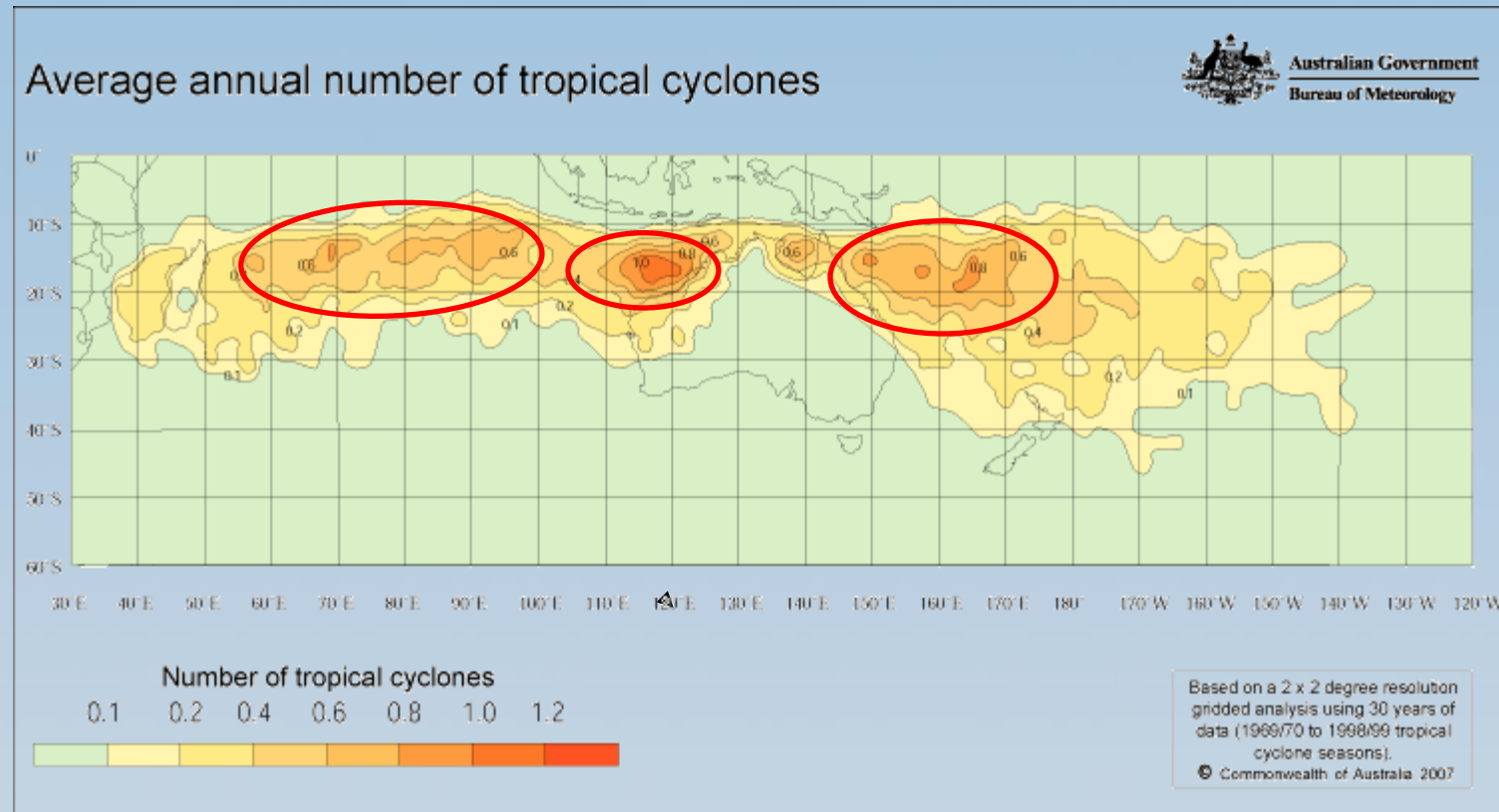
Tropical cyclone archive for the Southern Hemisphere and the Western Pacific Ocean

	A	B	C	D	E	F	G
1	year	seq	name	datetime	lat	lon	pressure
2	2007	12	FUNA	15/01/2008 6:00	-16	162	999
3	2007	12	FUNA	15/01/2008 12:00	-15.5	162.5	997
4	2007	12	FUNA	15/01/2008 18:00	-15.4	163	997
5	2007	12	FUNA	16/01/2008 0:00	-15.3	163.6	995
6	2007	12	FUNA	16/01/2008 6:00	-14.8	164.8	990
7	2007	12	FUNA	16/01/2008 12:00	-14.6	166	987
8	2007	12	FUNA	16/01/2008 18:00	-14.8	167.3	980
9	2007	12	FUNA	17/01/2008 0:00	-14.9	168.5	970
10	2007	12	FUNA	17/01/2008 6:00	-15.4	169.4	970
11	2007	12	FUNA	17/01/2008 12:00	-16.1	170.6	970
12	2007	12	FUNA	17/01/2008 18:00	-16.7	171.7	965
13	2007	12	FUNA	18/01/2008 0:00	-17.6	172.7	960
14	2007	12	FUNA	18/01/2008 6:00	-18.3	173.3	960
15	2007	12	FUNA	18/01/2008 12:00	-19.1	173.8	955
16	2007	12	FUNA	18/01/2008 18:00	-19.9	174.3	945
17	2007	12	FUNA	19/01/2008 0:00	-20.9	174.7	935
18	2007	12	FUNA	19/01/2008 6:00	-21.9	175	930
19	2007	12	FUNA	19/01/2008 12:00	-23.7	175.6	930
20	2007	12	FUNA	19/01/2008 18:00	-26	175.1	945
21	2007	12	FUNA	20/01/2008 0:00	-28	173.2	950
22	2007	12	FUNA	20/01/2008 6:00	-29.1	171.3	965
23	2007	12	FUNA	20/01/2008 12:00	-29.9	170.3	970
24	2007	12	FUNA	20/01/2008 18:00	-31.6	169.1	975
25	2007	12	FUNA	21/01/2008 0:00	-33.2	168.2	981
26	2007	12	FUNA	21/01/2008 6:00	-34.6	167.7	987
27	2007	12	FUNA	21/01/2008 12:00	-36.7	167.9	987
28	2007	12	FUNA	21/01/2008 18:00	-38.3	169.2	992
29							



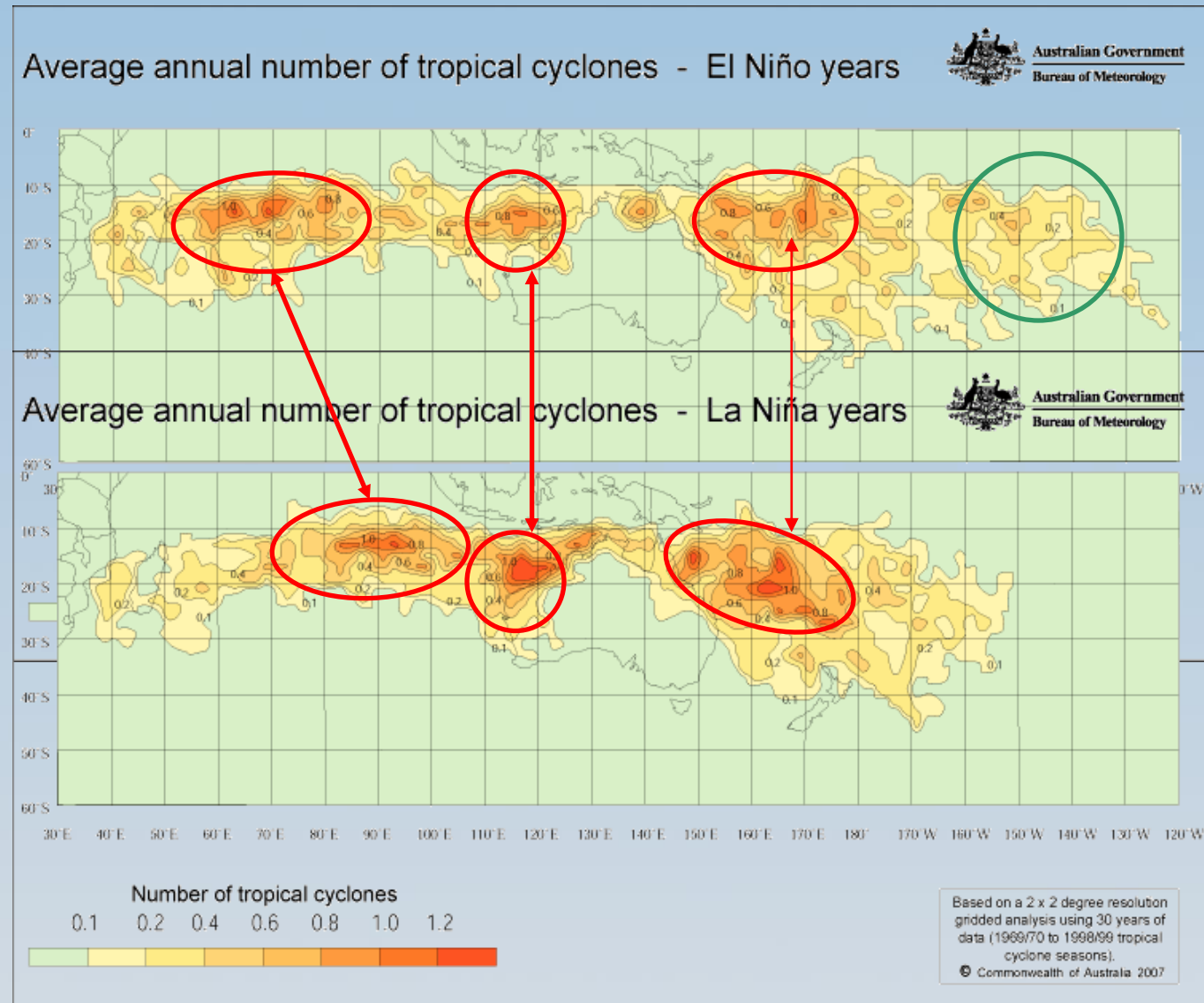
- Historical tropical cyclone best track data have been examined and a new satellite-era data set has been prepared to be subsequently displayed through the enhanced tropical cyclone data portal for the Southern Hemisphere and the Western Pacific Ocean.

Tropical cyclones climatology – maps

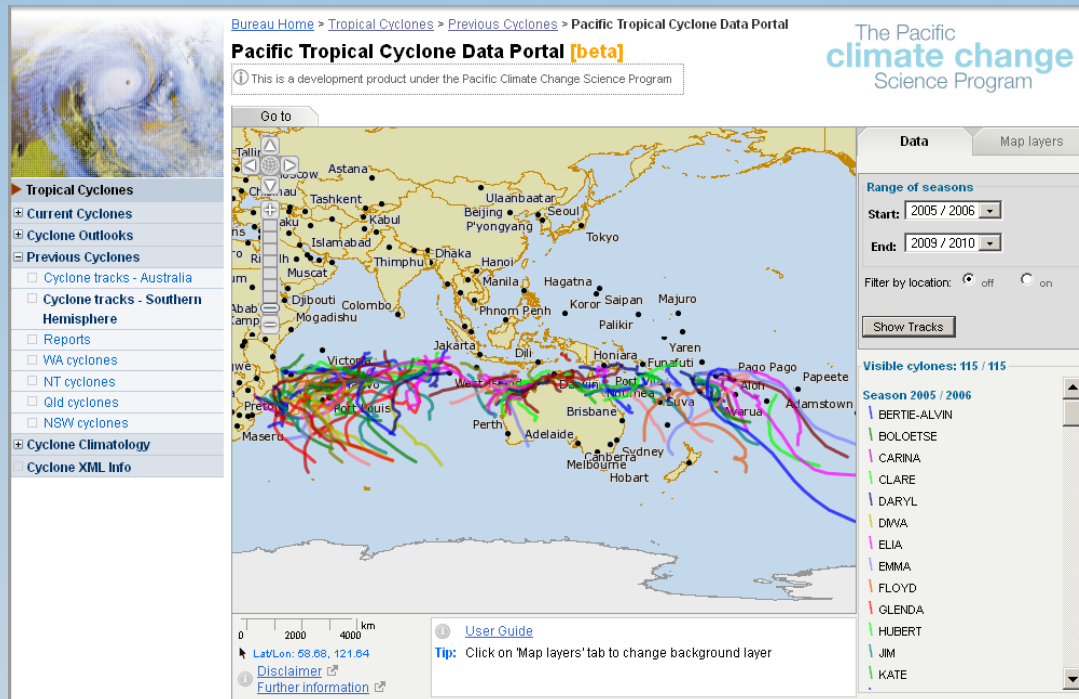


Kuleshov, Y., L. Qi, R. Fawcett, and D. Jones, 2008: On tropical cyclone activity in the Southern Hemisphere: Trends and the ENSO connection, *Geophysical Research Letters*, **35**, L14S08, doi:10.1029/2007GL032983.

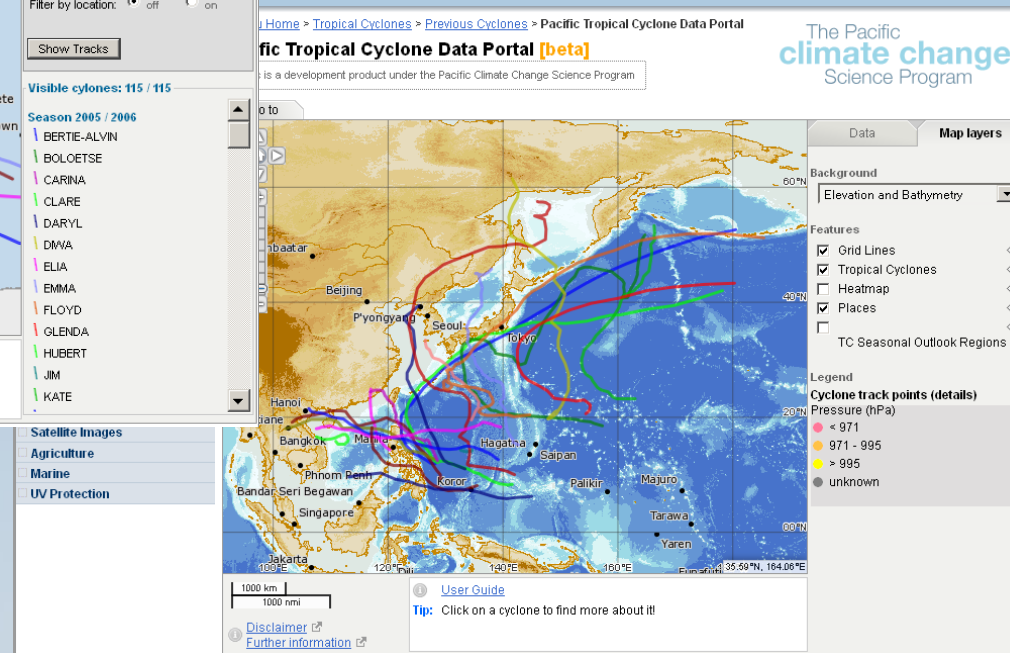
Tropical cyclones climatology – maps



Tropical cyclone data portal




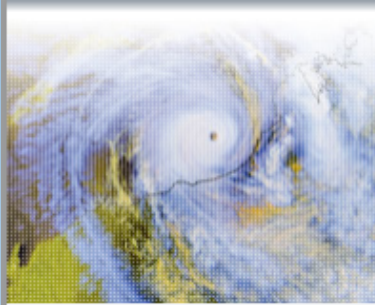
- South Pacific
- Western North Pacific



Kuleshov, Y., 2012: *Southern Hemisphere tropical cyclone climatology*, Chapter 1, in book "*Modern Climatology*", Intech, ISBN 979-953-307-337-7, pp. 1-44.

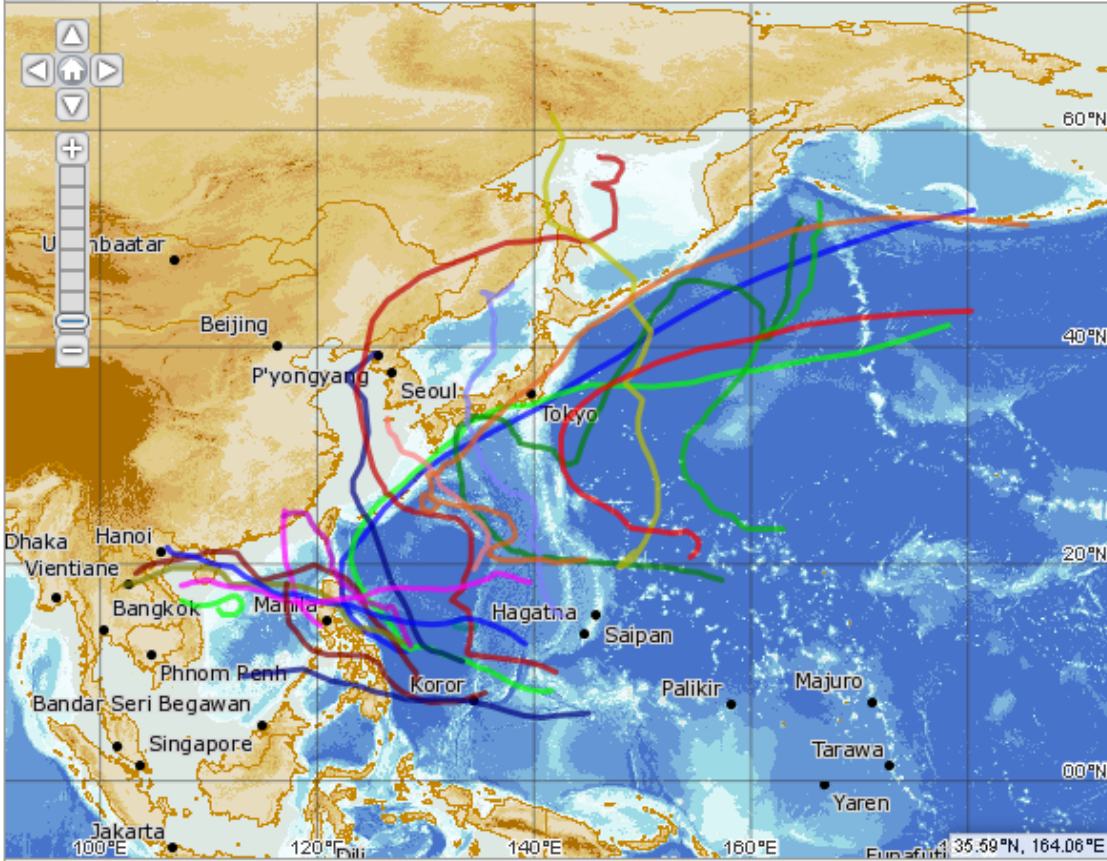

Pacific Tropical Cyclone Data Portal [beta]

 This is a development product under the Pacific Climate Change Science Program



- Tropical Cyclones**
 - Current Cyclones
 - Cyclone Outlooks
 - Previous Cyclones
 - Cyclone Climatology
 - Cyclone XML Info
- National Weather Services**
 - Weather & Warnings
 - Radar Viewer
 - Tsunami Warnings
 - Weather Maps
 - Satellite Images
 - Agriculture
 - Marine
 - UV Protection

Go to



Data | **Map layers**

Background
Elevation and Bathymetry

Features

- Grid Lines
- Tropical Cyclones
- Heatmap
- Places
- TC Seasonal Outlook Regions

Legend

Cyclone track points (details)

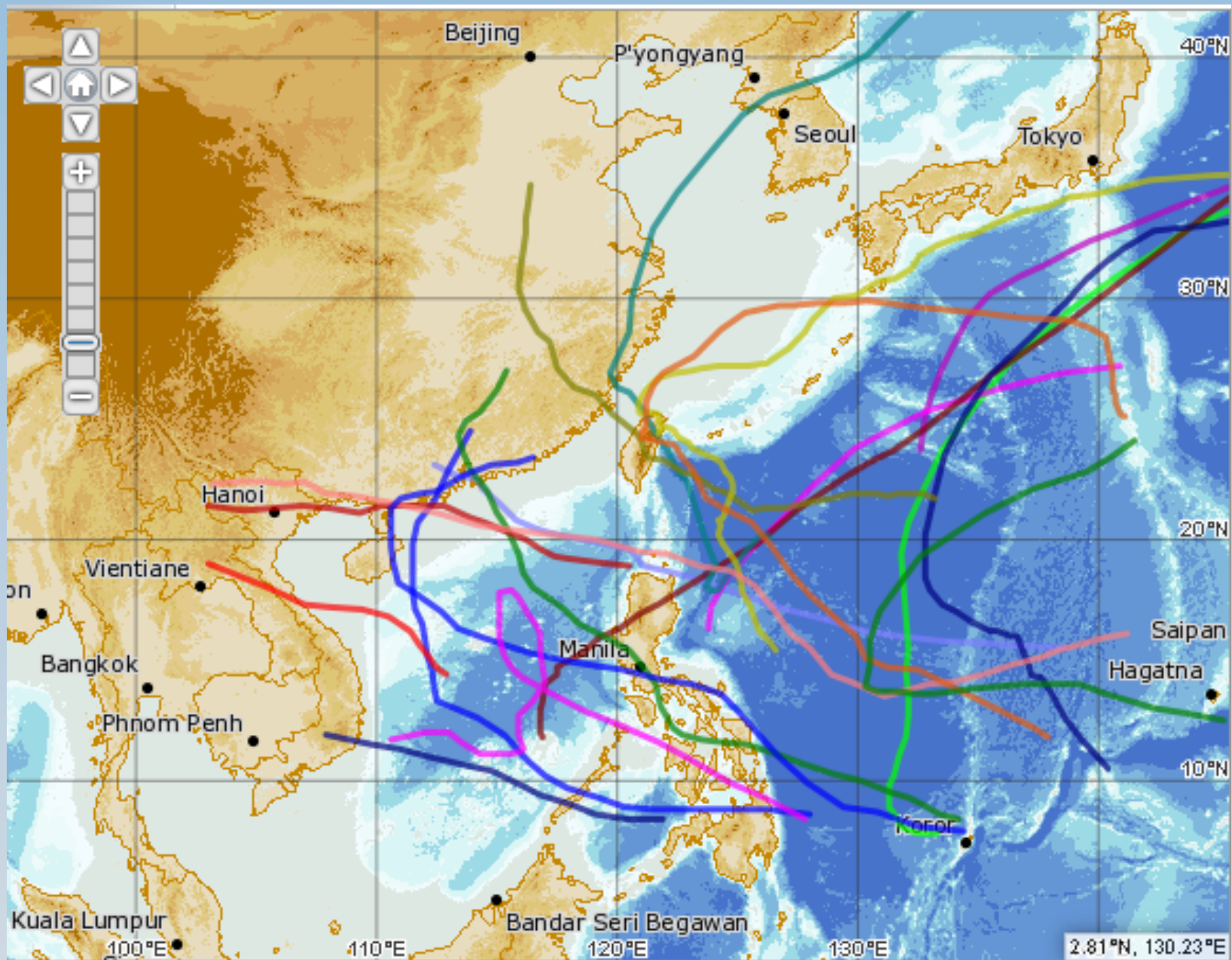
Pressure (hPa)

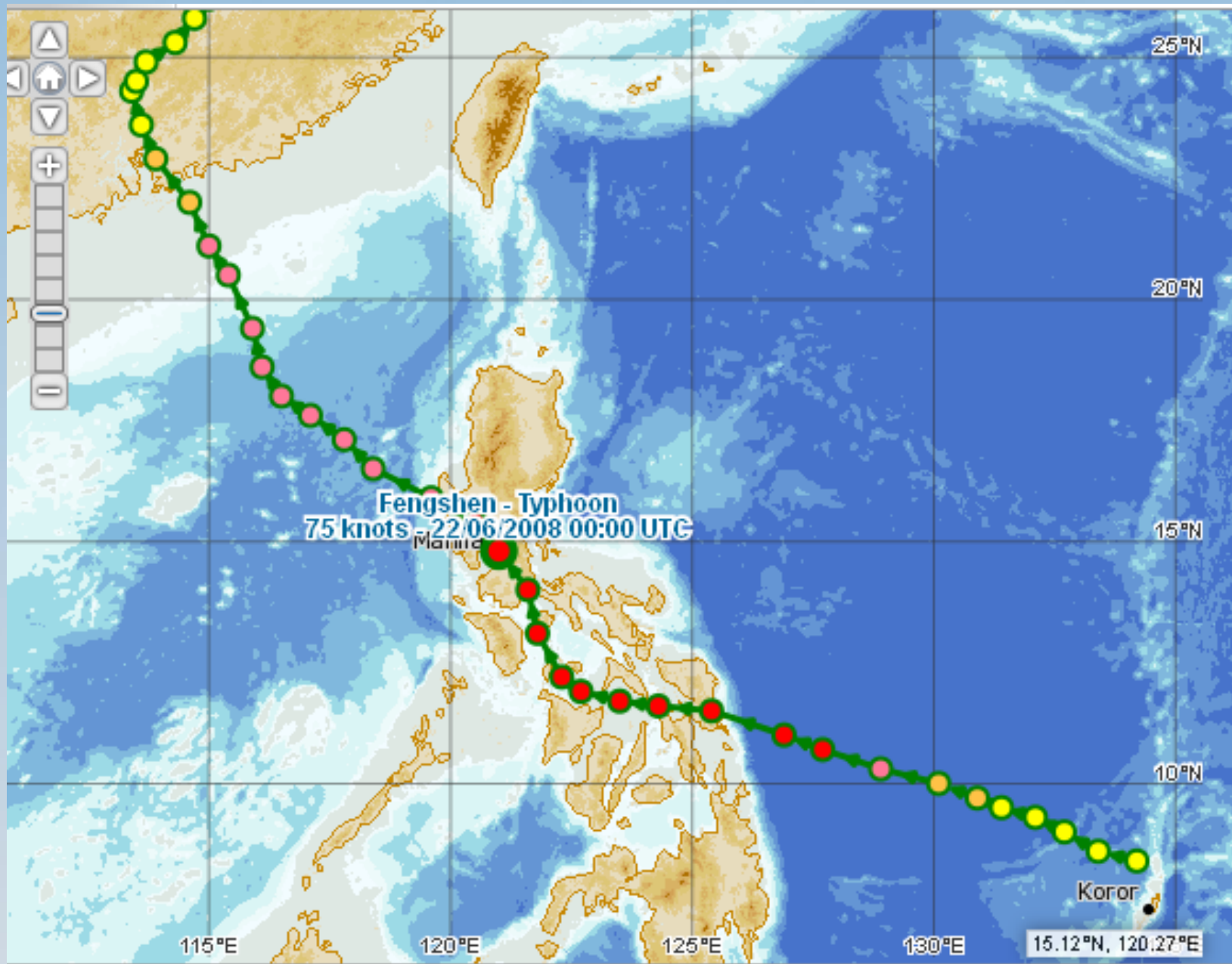
- < 971
- 971 - 995
- > 995
- unknown

[User Guide](#)

Tip: Click on a cyclone to find more about it!

[Disclaimer](#) | [Further information](#)

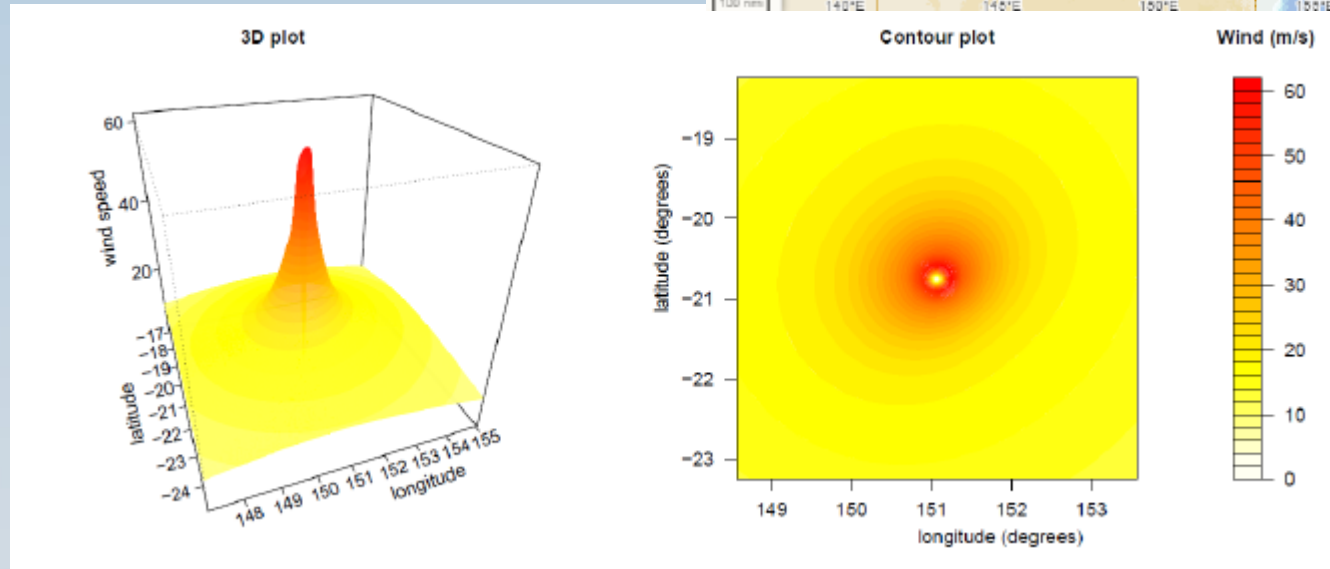
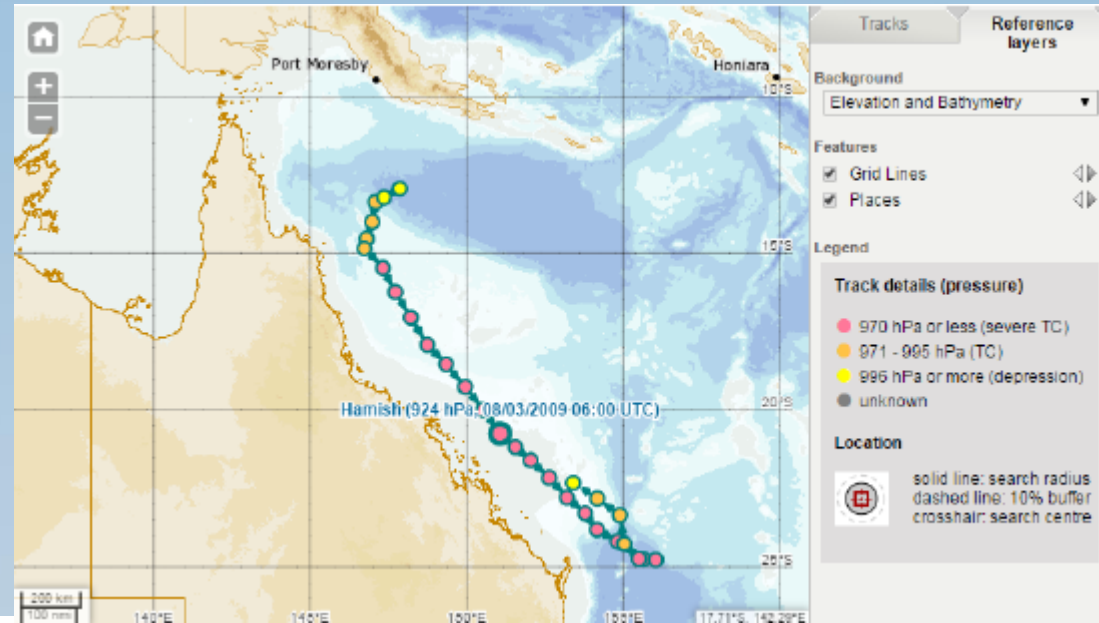




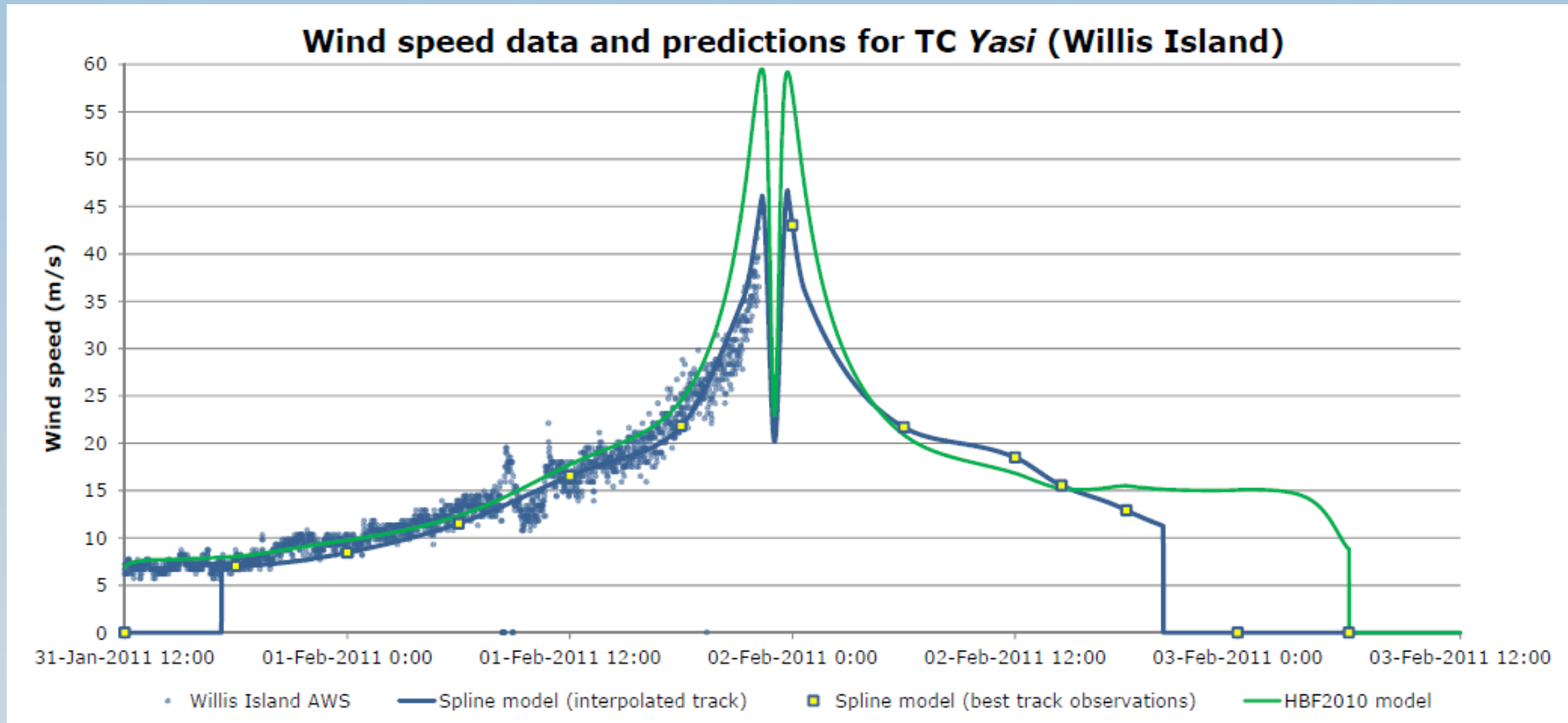
Wind field model

Best track of tropical cyclone *Hamish*

Tropical cyclone *Hamish* as a category 5 cyclone at peak intensity (central pressure 924 hPa).

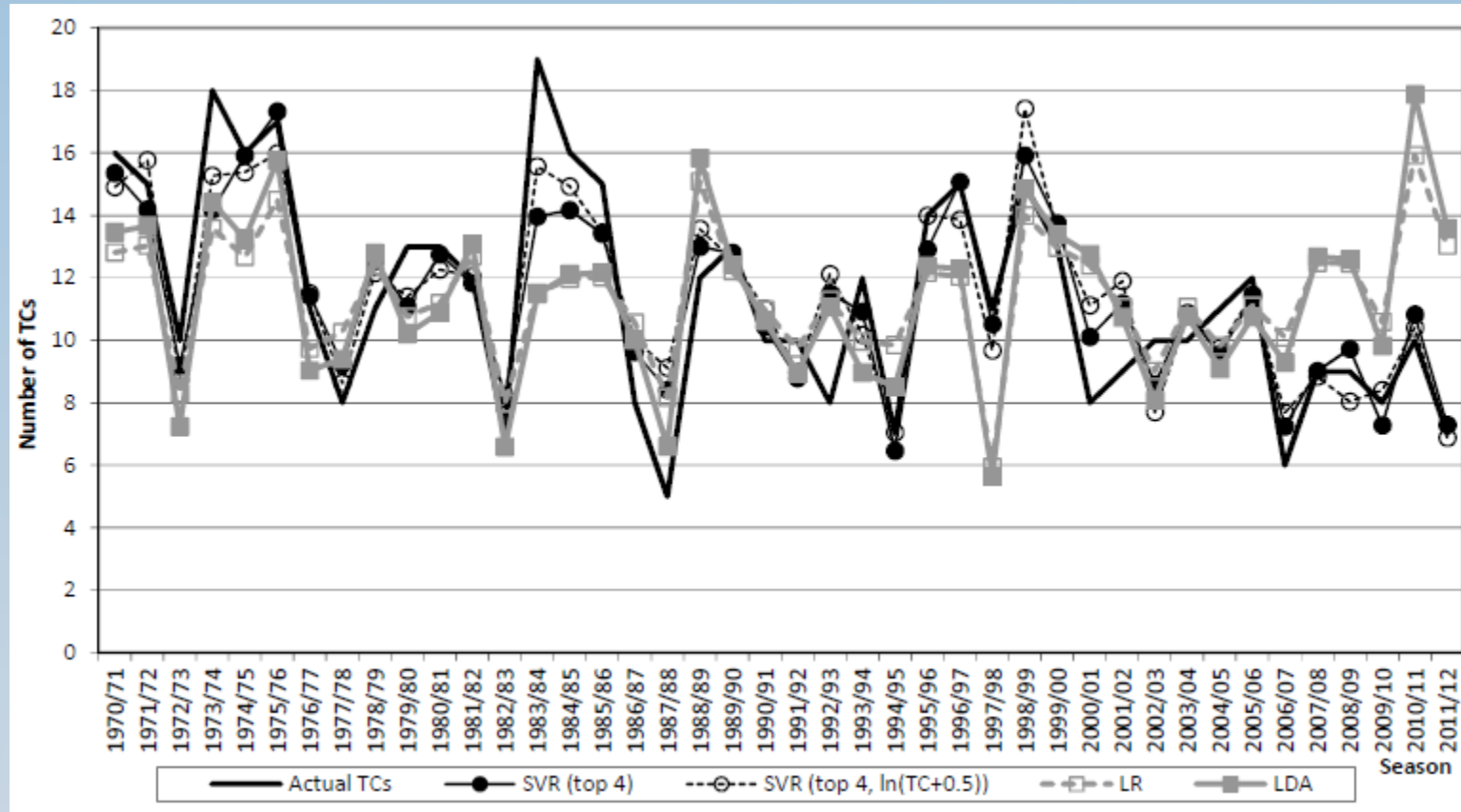


Wind field model



Comparison of modelled wind speeds of the spline model and HBF2010 model at Willis Island when tropical cyclone *Yasi* passed the AWS

Seasonal prediction of tropical cyclones – statistical methodology



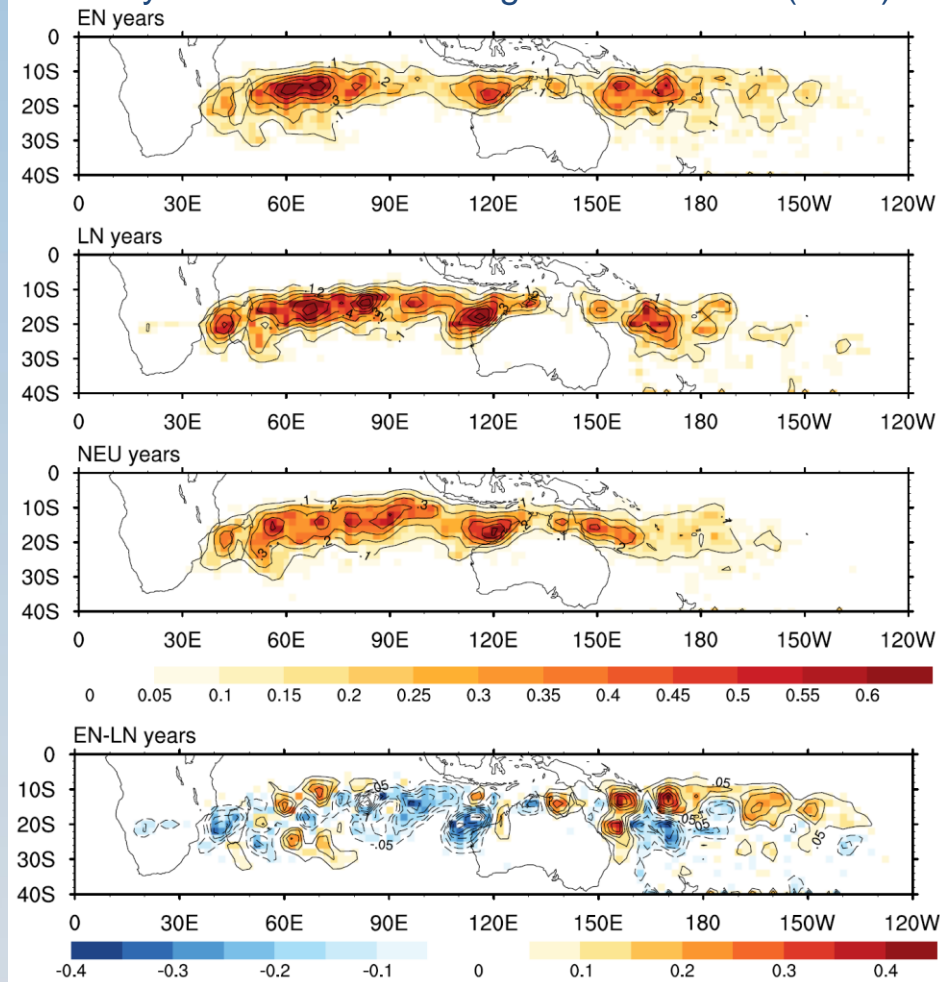
Seasonal forecast for tropical cyclones in the Australian region

Wijnands, J.S., Qian, G., Shelton, K.L., Fawcett, R.J.B., Chan, J.C.L., and Kuleshov, Y., 2015: *Seasonal forecasting of tropical cyclone activity in the Australian and the South Pacific regions*, Mathematics of Climate and Weather Forecasting, pp. 21-44.

POAMA – tropical cyclones & ENSO

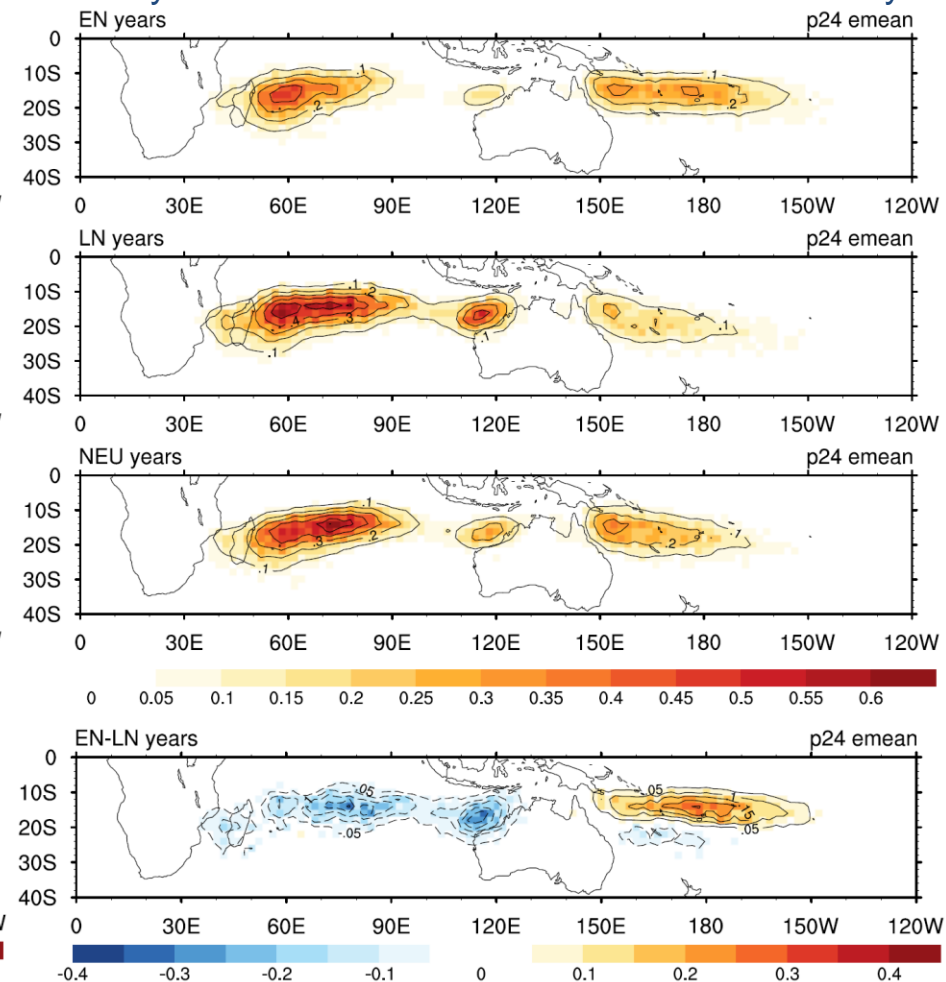
Observations

ENSO years defined following Kuleshov et al. (2008).

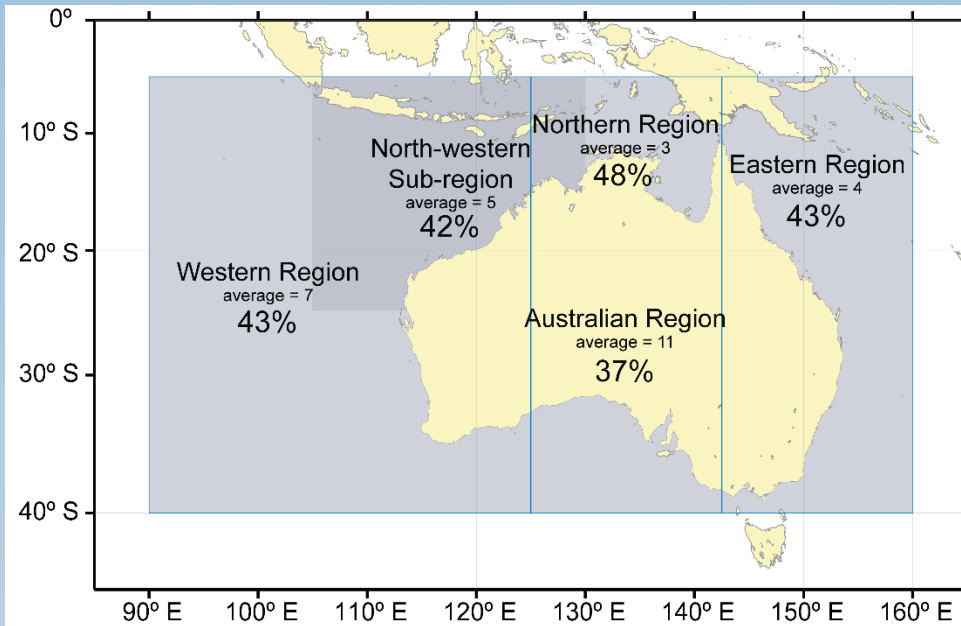


POAMA

ENSO years defined member Niño 3.4 SST anomaly

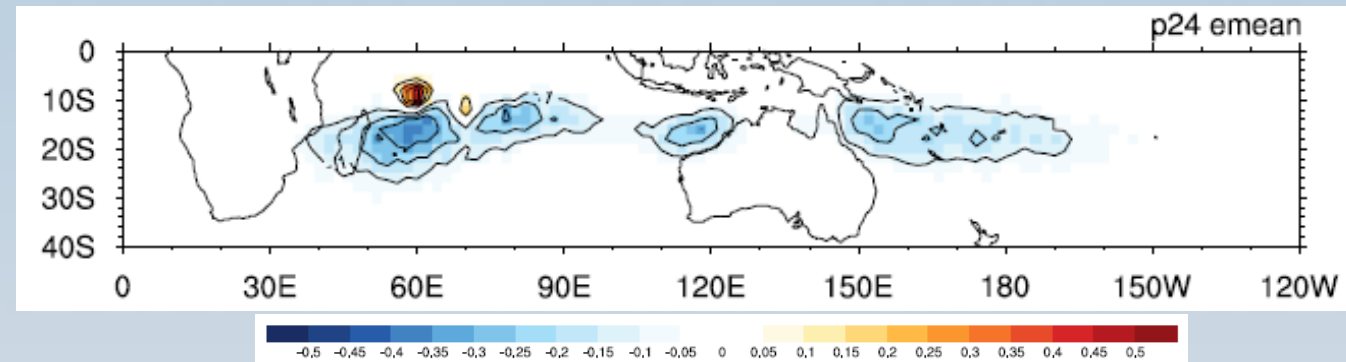


Tropical cyclone predictions



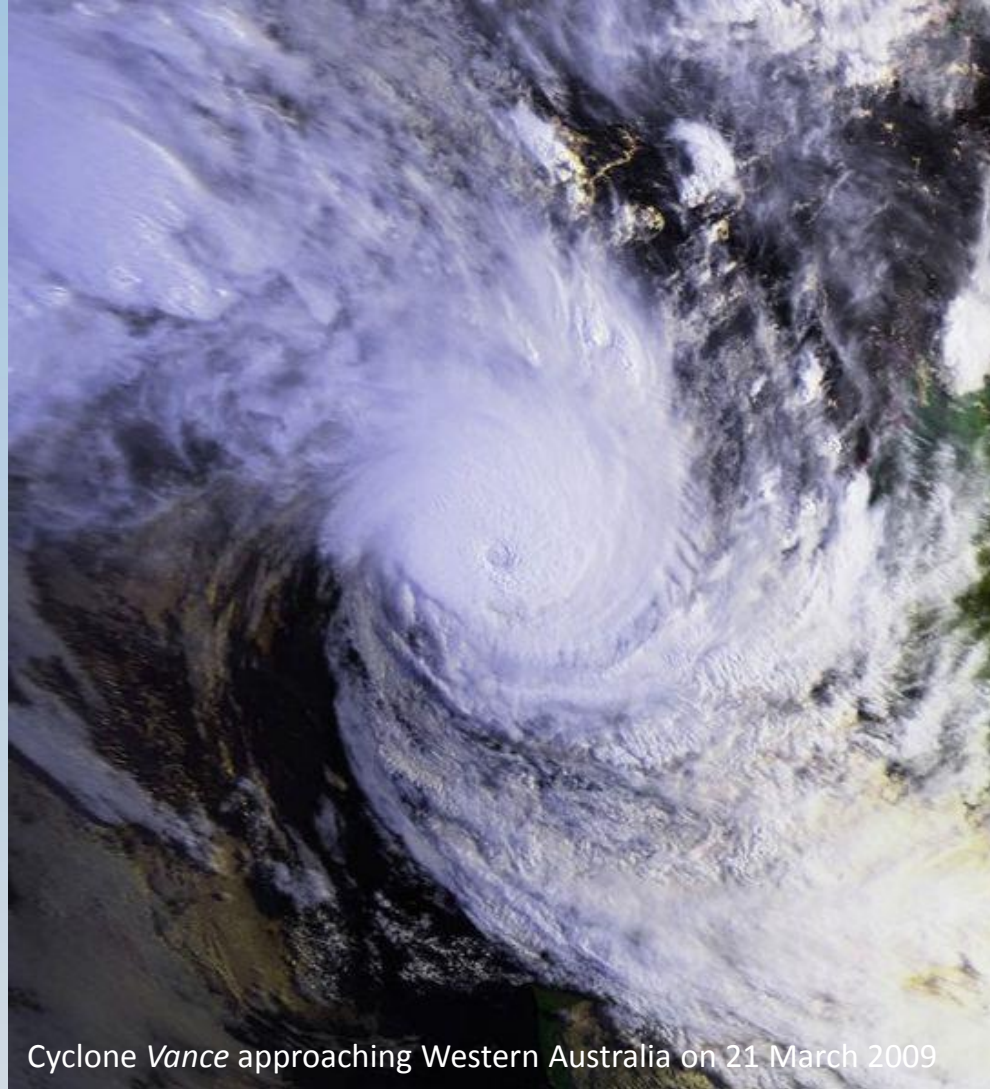
Based on climate model outputs, we can provide

- Regional probabilistic tropical cyclone predictions.
- Geographic distribution of tropical cyclone activity.



Kuleshov, Y., Y. Wang, J. Apajee, R. Fawcett and D. Jones, 2012: Prospects for improving the operational seasonal prediction of tropical cyclone activity in the Southern Hemisphere. *Atmospheric and Climate Sciences*, 2(3), 298-306, doi:10.4236/acs.2012.23027.

International Climate Change Adaptation Initiative



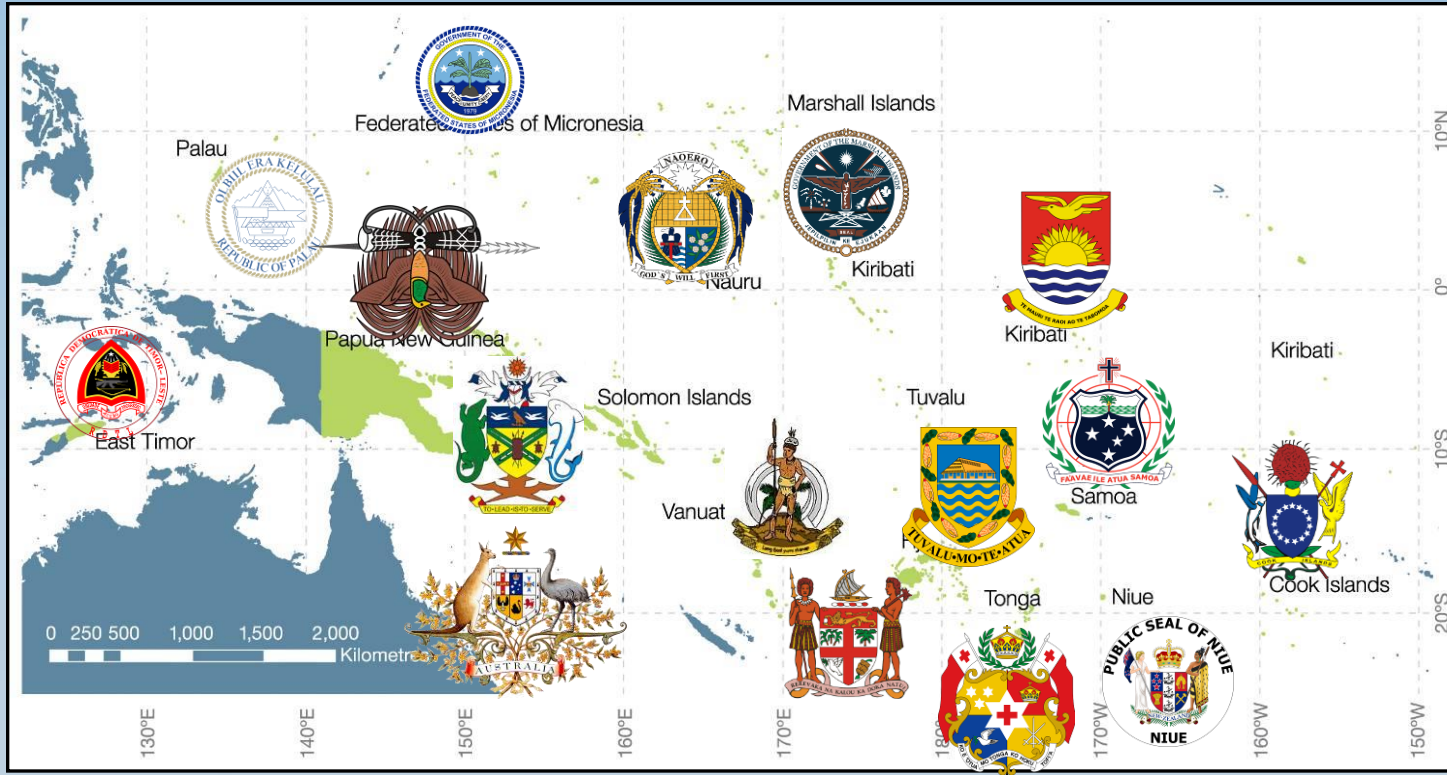
Cyclone *Vance* approaching Western Australia on 21 March 2009

International Climate Change Adaptation Initiative (ICCAI)

- Australia supports high priority climate change adaptation needs in vulnerable countries in our region.
- The primary geographic emphasis of the AusAID–DCCEE jointly–managed International Climate Change Adaptation Initiative (ICCAI, \$350 M , 2008-2013) is on Australia's neighbouring island countries.
- The Pacific Climate Change Science Program (PCCSP) and the Pacific Adaptation Strategy Assistance Program (PASAP), 2009–2011, helped Pacific island countries and East Timor better understand how climate change will impact on them.
- The Pacific Australia Climate Change Science and Adaptation Planning (PACCSAP) Program, 2012-2013, was a continuation of the PASAP and PCCSP, with a focus on climate extremes.



PACCSAP Partner countries



Cook Islands

Niue

Samoa

East Timor

Palau

Solomon Islands

Federated States of Micronesia

Papua New Guinea

Tonga

Fiji

Republic of Marshall Islands

Tuvalu

Kiribati

Republic of Nauru

Vanuatu

Climate extremes in the Western Pacific

Little knowledge about current climate of the Pacific Island Countries and climate projections prior to PCCSP research.

Climate extremes have a major impact on Pacific Island countries, and their changes over the coming decades are expected to drive many of the most significant effects of climate change.

Of particular concern are tropical cyclones, hydrological extremes (droughts and floods), sea level extremes and unusually warm ocean temperatures, and their impacts through severe weather, coastal inundation and coral bleaching.



ICCAI web-based information tools

<http://www.bom.gov.au/climate/pacific/projects.shtml>

A range of web-based information tools have been developed to assist National Meteorological and Hydrological Services of 15 island countries in the Western Pacific with climate change adaptation:

- Climate Data for the Environment (CliDE)
- Pacific climate change data portal
- Seasonal climate prediction portal (currently WMO GPC portal)
- Pacific tropical cyclone data portal
- Sea level anomalies
- Ocean temperature extremes

Pacific Climate Change Data Portal

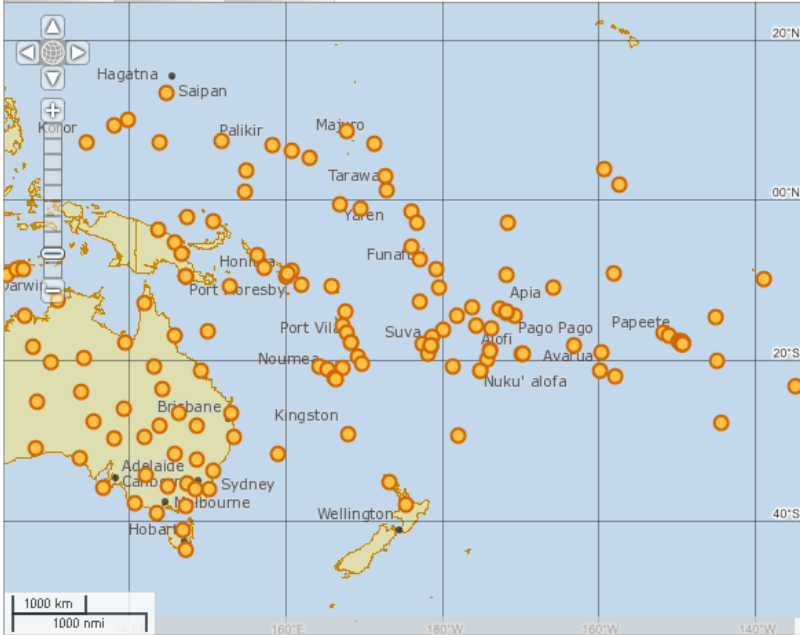
[Bureau Home](#) > [Climate](#) > Pacific Climate Change Data Portal

Pacific Climate Change Data Portal

[About Pacific Climate Change Data Portal](#)

This website provides historical climate information and trends from individual observation sites across the Pacific region and East Timor. The Pacific Climate Change Data portal has been developed through the [Pacific Climate Change Science Program](#) (PCCSP) and Pacific-Australia Climate Change Science and Adaptation Planning (PACCSAP) Program.

[Home](#) [Go to](#) [Bookmark](#)



Related links

- [Climate Data Uploader Login](#)
- [Climate Data Removal Login](#)

Data **Map layers**

I would like

- Select a data type -

Time-series period

Monthly

Country of interest

- Select a country -

[Start again](#)

[Disclaimer](#)

Tip: Click on a weather station for information.
Tip: Hold down the Shift key and drag the mouse pointer to zoom in

Currently, 92 station records for 23 countries and territories (excl. the Aust. and NZ mainland)

Pacific Climate Change Data Portal - Functionality

Bureau Home > Climate > Climate Change > Pacific climate change data portal > Pacific climate change site data

Pacific climate change site data

[About data](#) | [About climate extremes](#) | [Contacts for data](#)

Site information
 Site name: Honiara
 WMO number: 91517
 Country: Solomon Islands
 Latitude: 9.42°S Longitude: 159.97°E

Nearest alternative sites
 Henderson - Solomon Islands (8 km)
 Tulagi - Solomon Islands (40 km)
 Auki - Solomon Islands (109 km)

Download daily time-series (restricted)
 Consecutive dry days [Download]

Time-series Period: Monthly Daily
 Data Source: Raw Homogeneous


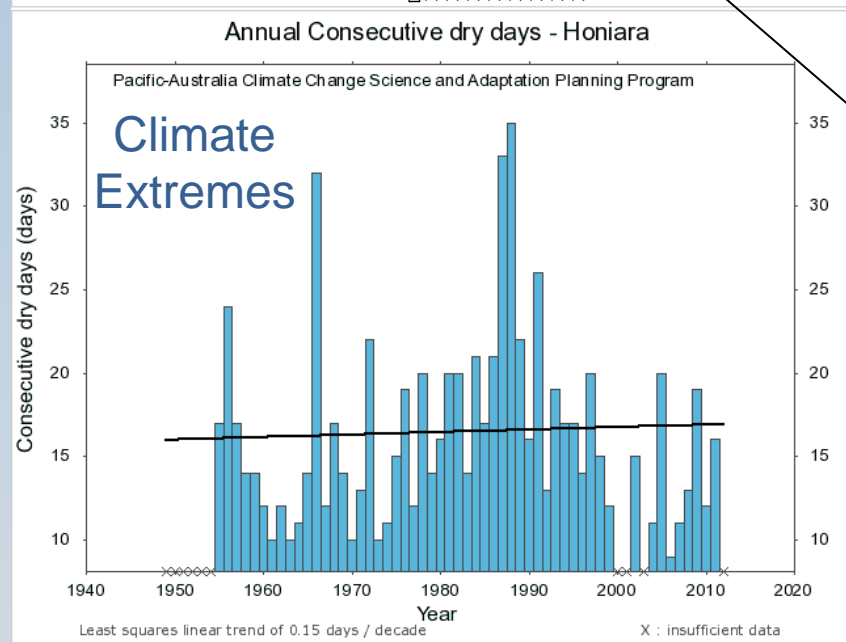
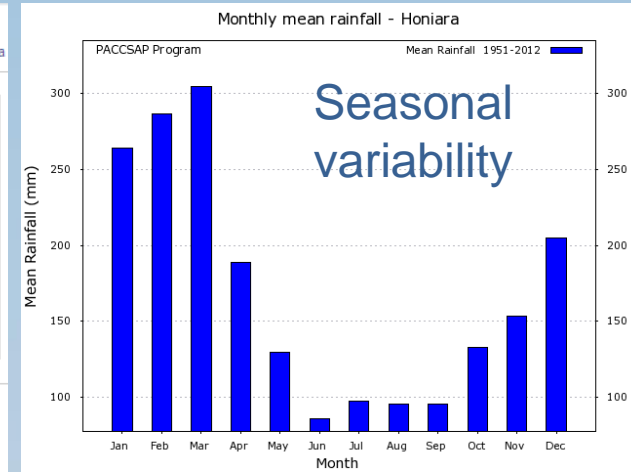
Variable: Consecutive dry days

Reporting Period: Annual

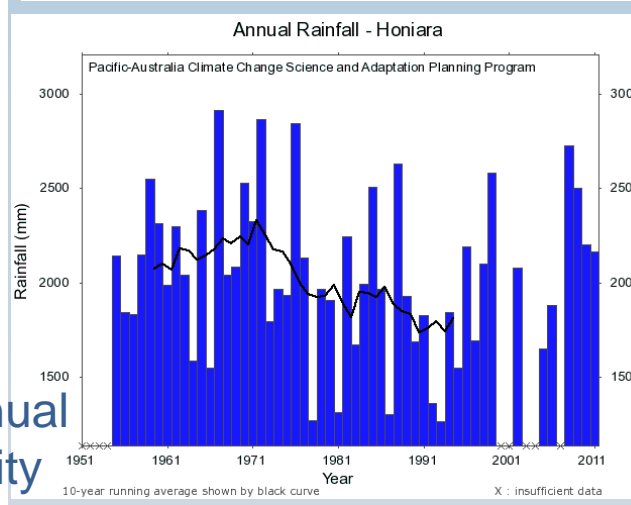
Start year: 1949 End year: 2012 [Plot]

Years of running average: T [Full]

(T=linear trend; A=average)
 T A 3 5 7 9 11 13 15

Station & data selection



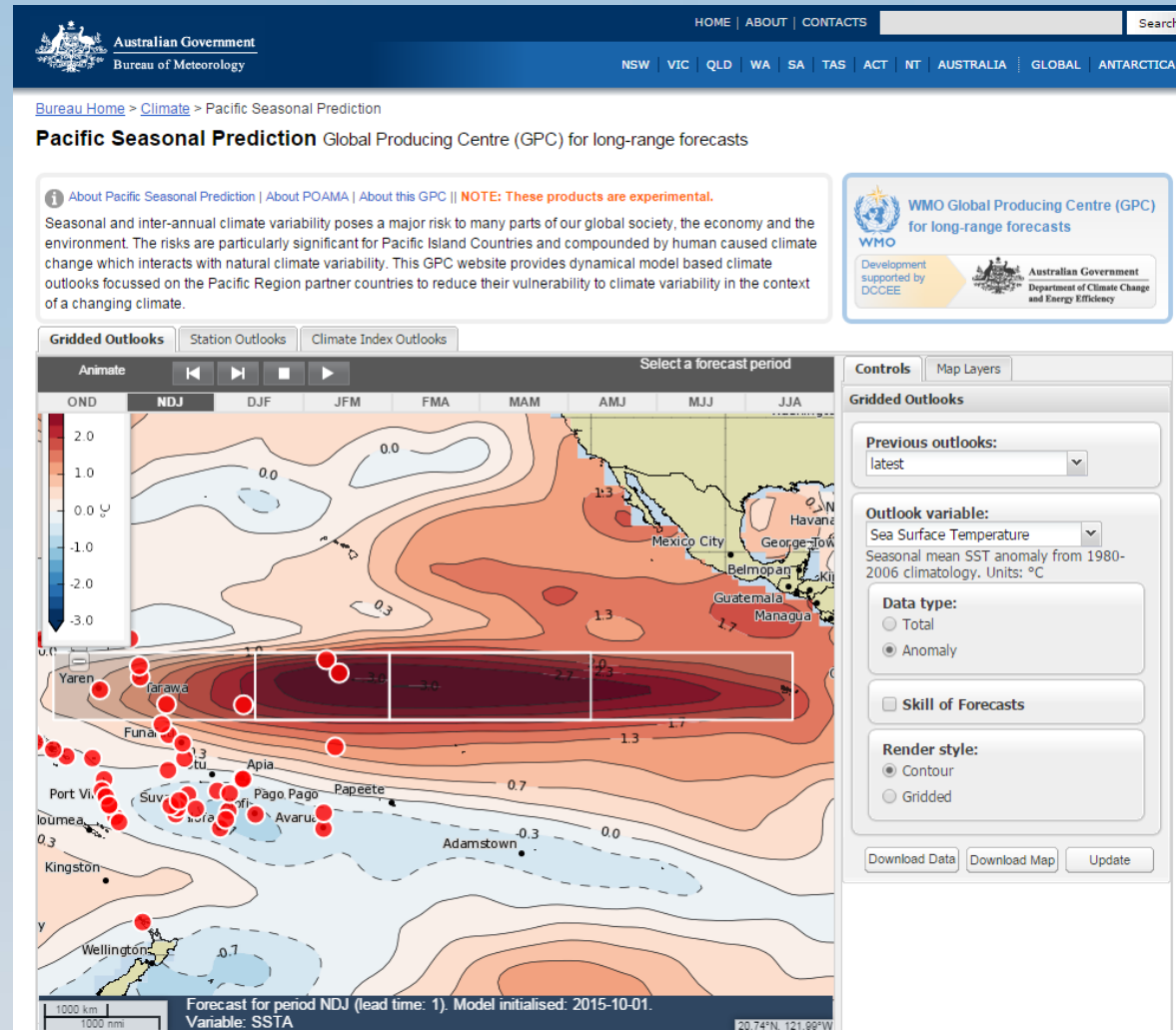
Inter annual variability and trends

WMO GPC Melbourne

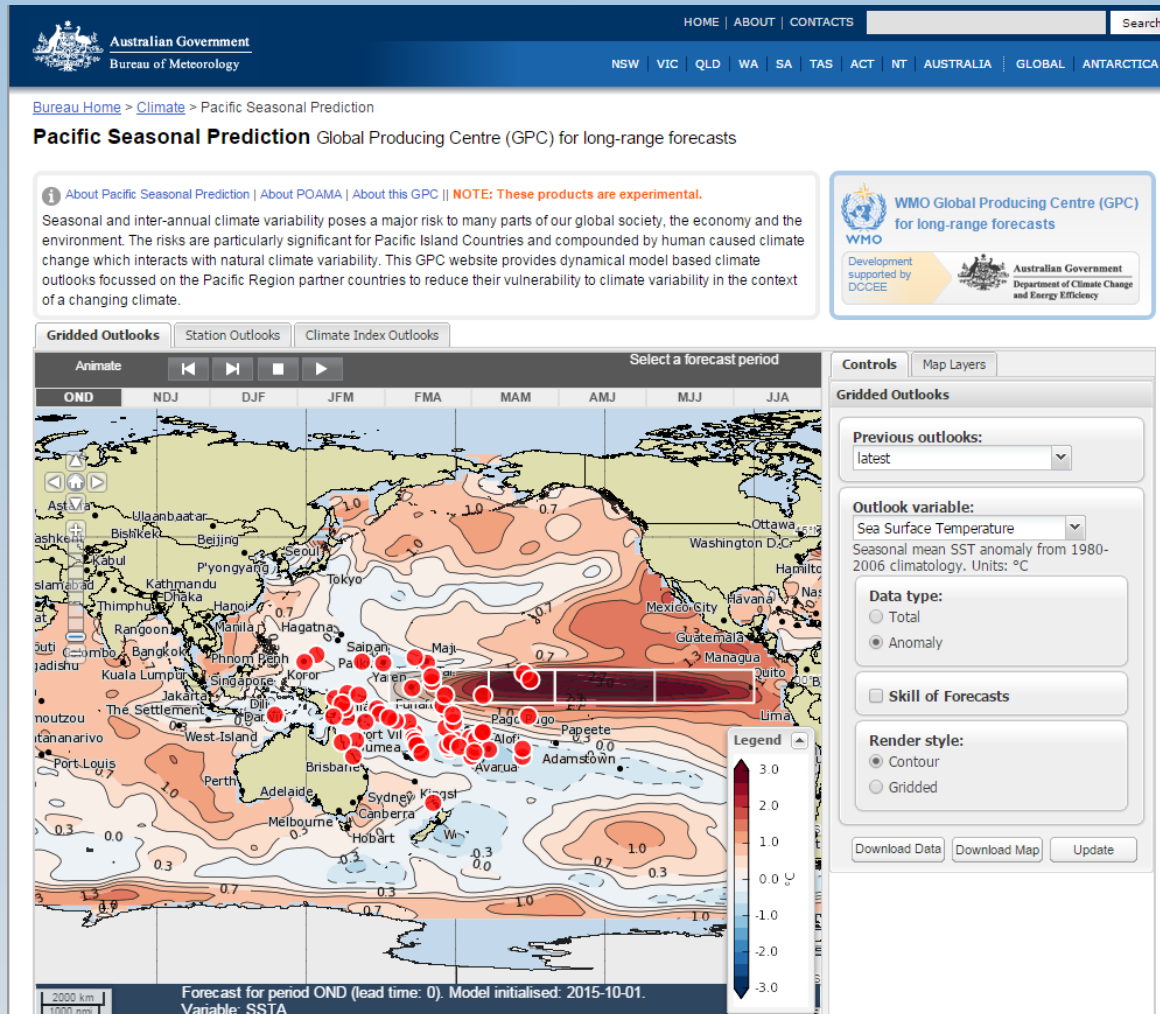
WMO Global Producing Centre (GPC) for long-range forecasts, Melbourne, Australia

Developed as part of the ICCAI, Pacific Adaptation Strategy Assistance Program (PASAP)

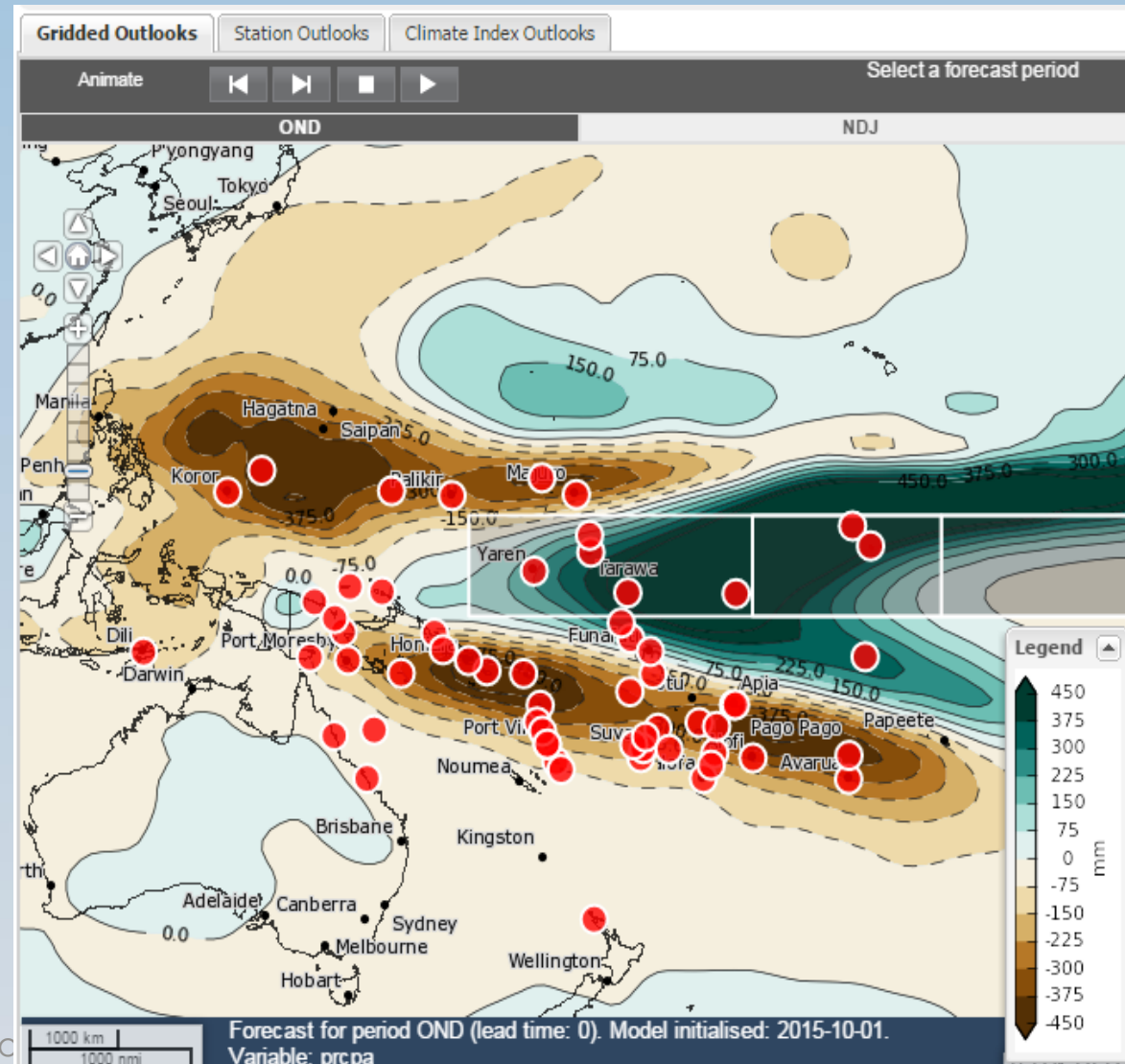
<http://poama.bom.gov.au/experimental/pasap/>



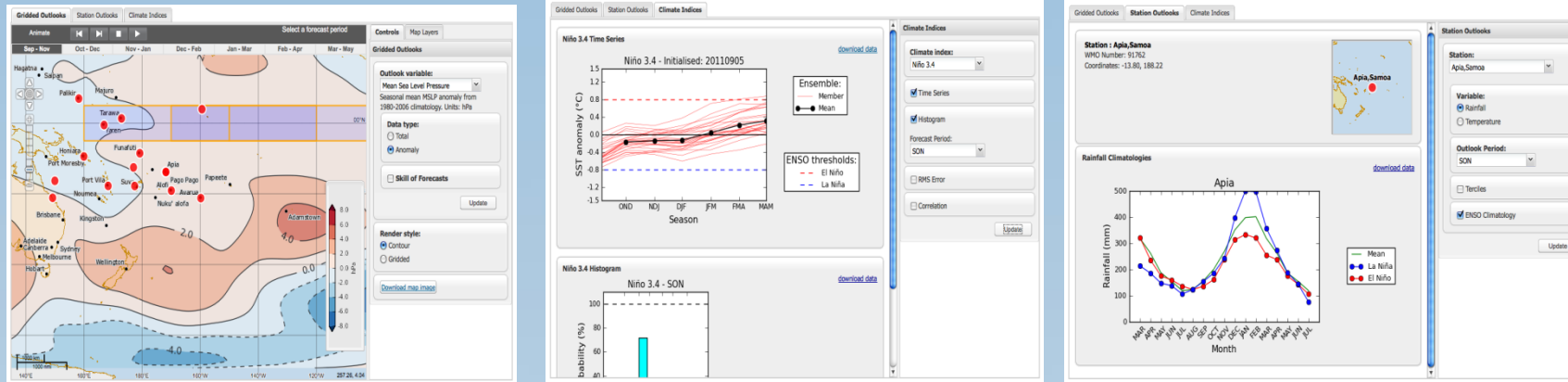
October to November 2015 climate outlook: SSTs



October to December climate outlook: Accumulated Rainfall



The Pacific Seasonal Climate Prediction Portal

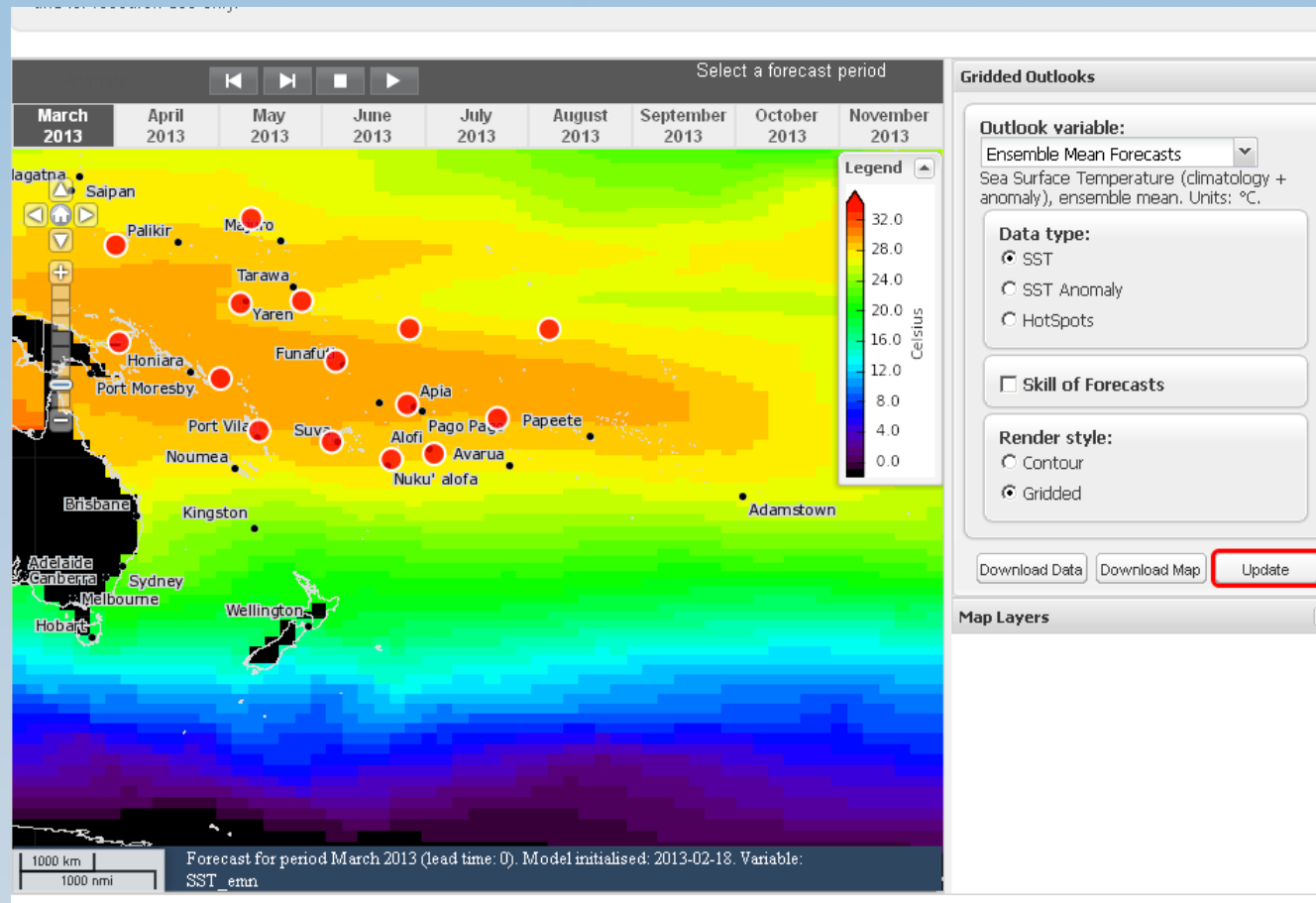


The Pacific Seasonal Climate Prediction Portal provides access to outlooks for

- Broad scale fields
- Climate drivers (ENSO)
- Rainfall and temperature tercile probabilities for selected sites
- Hindcast skill scores for all outlooks

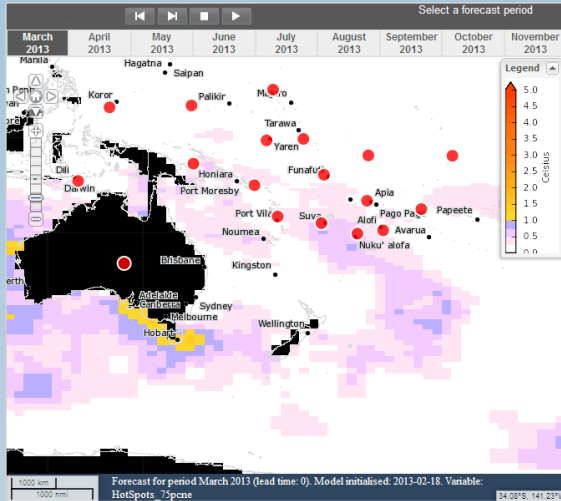
Outlooks are based on the Bureau of Meteorology's POAMA seasonal forecasting system.

Sea Surface Temperature Seasonal Prediction



Seasonal prediction of extreme ocean temperatures and associated coral bleaching ports - provides seasonal forecasts of ocean temperature and coral bleaching risk.

Sea Surface Temperature Seasonal Prediction

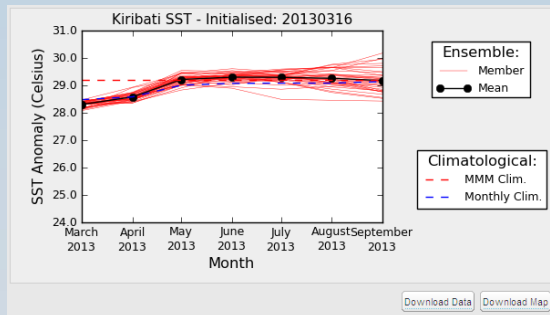


coral
risk
metrics

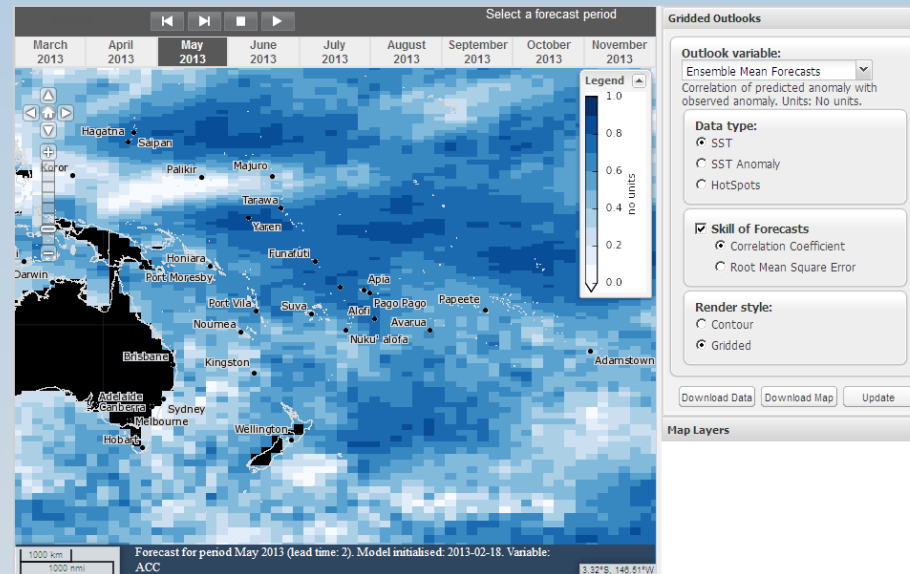
probabilistic
forecasts

- Data type:**
- SST - 75%
 - SST - 50%
 - SST - 25%
 - SST Anomaly - 75%
 - SST Anomaly - 50%
 - SST Anomaly - 25%
 - HotSpots - 75%
 - HotSpots - 50%
 - HotSpots - 25%

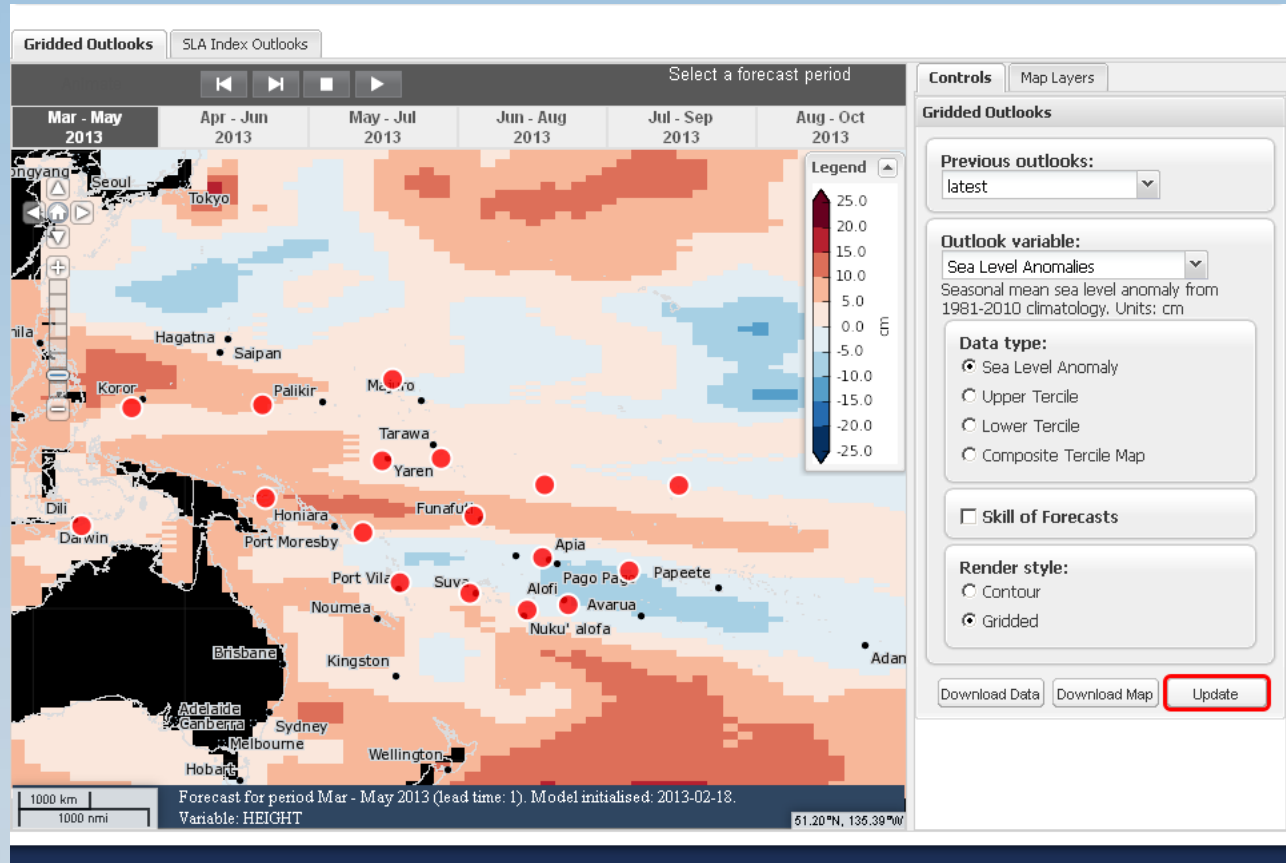
time-series for countries



skill
scores



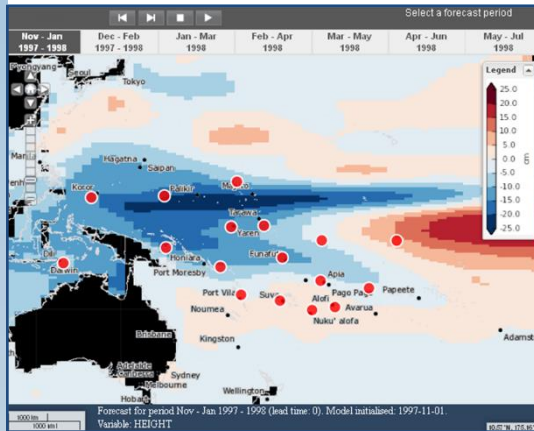
Sea Level Seasonal Prediction



Seasonal prediction of sea-level anomalies in the Western Pacific portal – provides seasonal forecasts for sea level for Pacific Partner Countries.

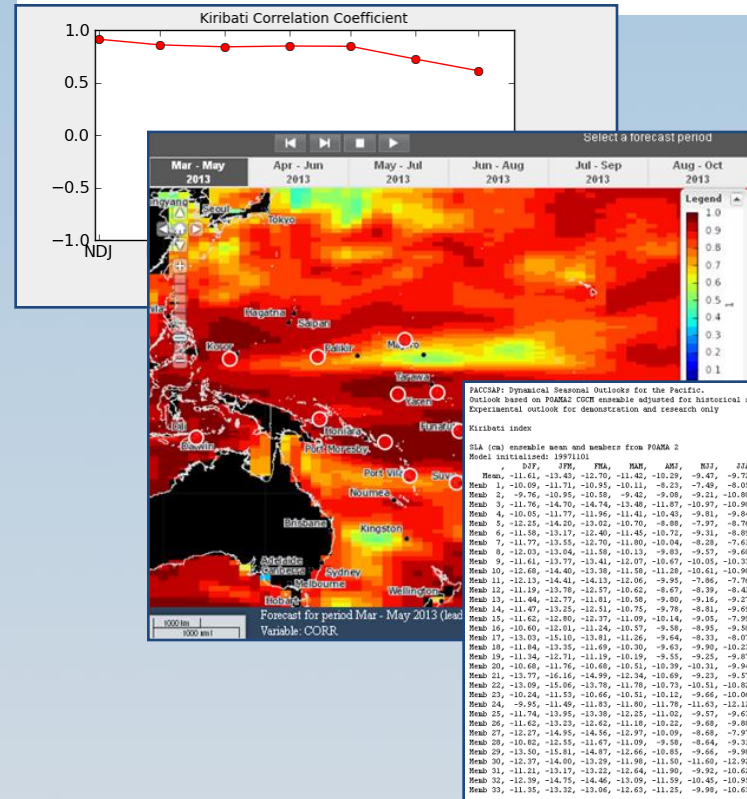
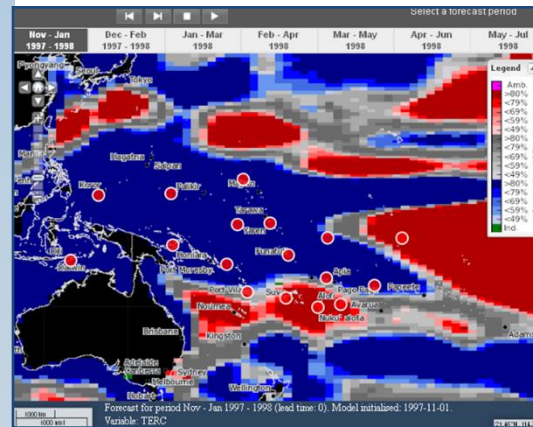
Sea Level Seasonal Prediction

Sea level anomaly forecasts

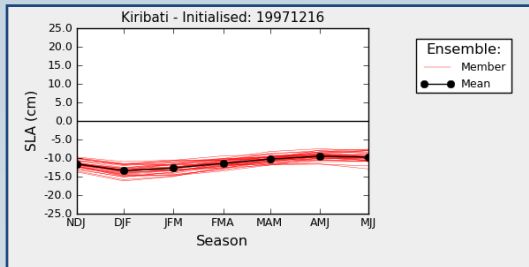


Skill scores for all forecasts
Data available in netcdf and text format

Tercile predictions



Timeseries for Exclusive Economic Zones of Partner Countries



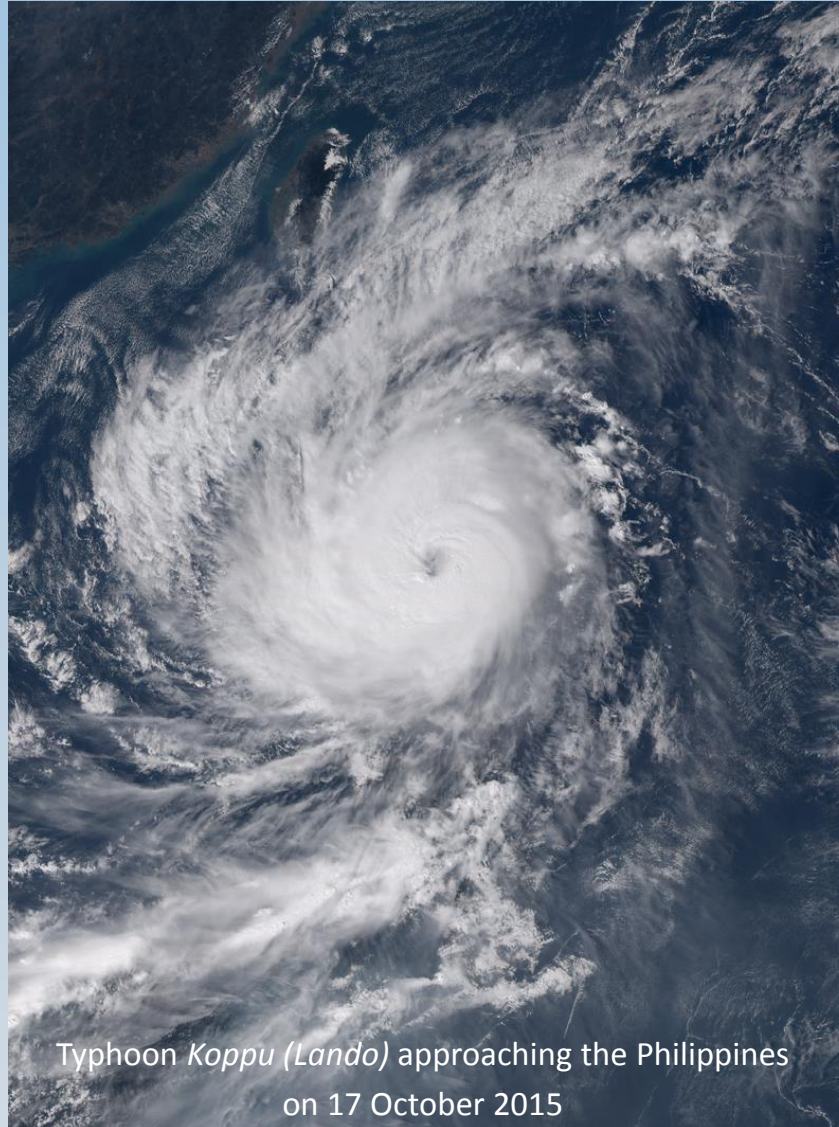
Capacity development



- Extensive training of the Pacific National Meteorological Services personnel during in-country visits
- Pacific Science Programs numerous workshops



Effective Response to Disasters



Typhoon *Koppu (Lando)* approaching the Philippines
on 17 October 2015

Climate Risk Early Warning System (CREWS) for developing nations



New York, 29 Sept 2015

France's Secretary of State for Development Ms. Annick Girardin speaks about the CREWS initiative, as Ms. Rachel Kyte, World Bank Group vice president and special envoy for climate change and World Meteorological Organization Secretary-General Mr. Michel Jarraud listen to her remarks (Photo: UNISDR)

- Plans to bring early warning systems to some of the world's poorest countries and thereby curb the risk of disasters have cleared a new milestone, thanks to a French-spurred initiative unveiled at the United Nations.
- The objective is provide access to real-time weather and climate updates, public information and communications technology, as well as improve risk knowledge and ensure that all arms of the administration are on the same page when it comes to issuing warnings.
- “The goal is that by 2020, all of the most vulnerable countries are equipped with such a system,” said France’s Secretary of State for Development Ms. Annick Girardin.
- “Natural disasters are a real impediment to sustainable development,” said WMO Secretary-General Mr. Michel Jarraud, who compared over-stretched meteorological services to hospitals with almost no doctors.

<http://www.unisdr.org/archive/45967>

International Climate Change Adaptation Initiative



Australian Government
Bureau of Meteorology

Pacific urged to lead against complacency



Suva, Fiji, 26 October 2015

More than 200 senior representatives are examining how to implement the Sendai Framework in the Pacific (Photo: UNISDR)

- The Pacific region was urged to use its respected voice on the global stage to rally against complacency over the mounting level of disaster and climate related risk.
- The Special Representative of the UN Secretary-General for Disaster Risk Reduction, Ms. Margareta Wahlström, said the Pacific needed to maintain the influence “that has contributed to the significant progress of the global community made over the past 10 years” in disaster risk reduction.

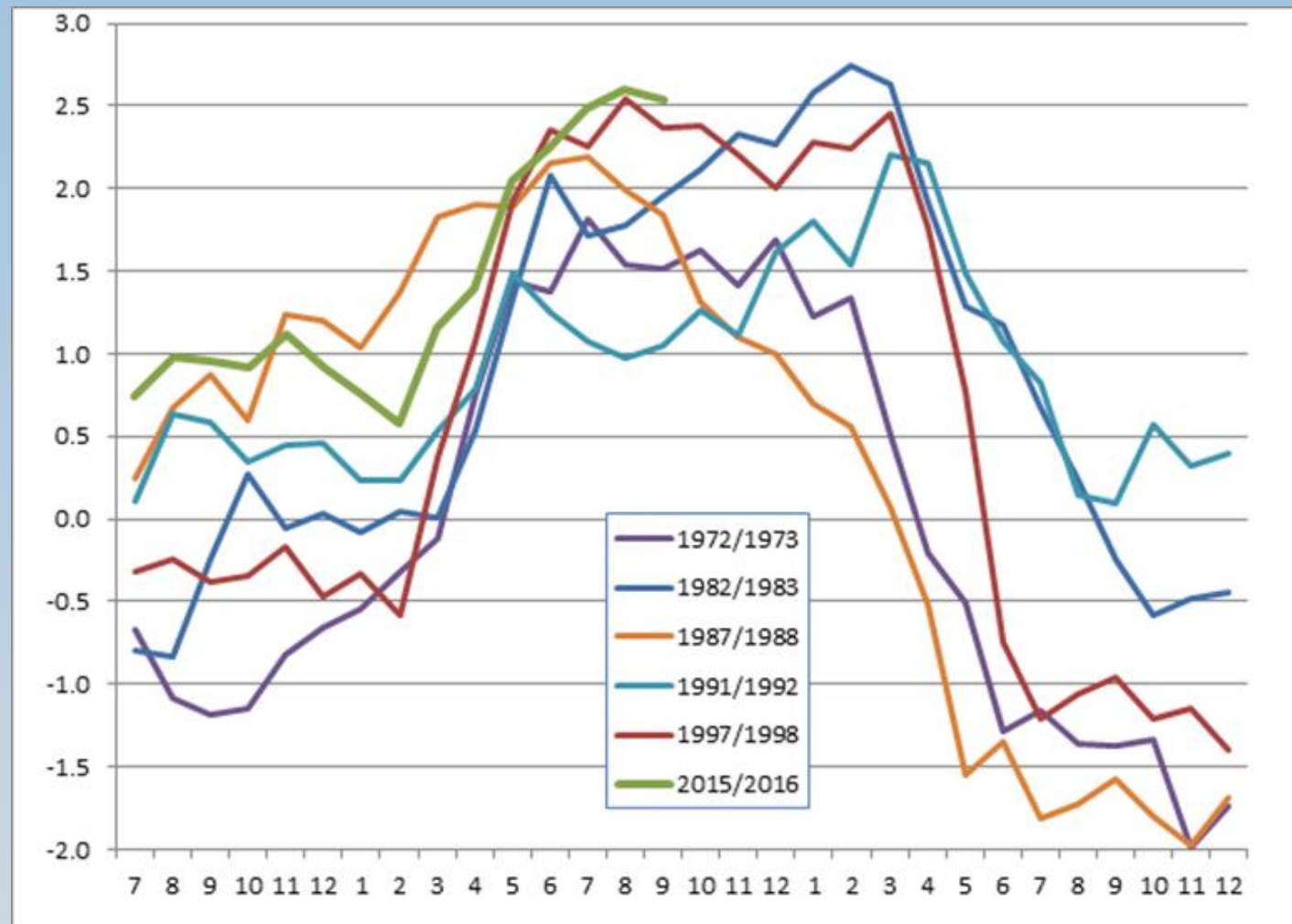
- Fiji’s Acting Permanent Secretary for Rural and Maritime Development and National Disaster Management, Mr. Setareki Tale, said the Pacific needed to do even more because “climate change is now the new normal”.
- “For most, if not all, Pacific countries, the Sendai Framework will be another testing instrument for our resolve to strengthen disaster risk reduction and how to effectively respond to disasters.”

<http://www.unisdr.org/archive/46383>

Summary

- Improved knowledge of extreme climatic events, with the assistance of tailored forecast tools, will enhance the resilience and adaptive capacity of SIDS and LDCs under climate change.
- Outcomes of ICCAI's climate projects provide National Meteorological Services in the Pacific with valuable information and tools which contribute significantly to capacity building to support adaptive responses to climate variability and change.
- This approach of providing quality scientific tools, coupled with training and ongoing support, appears a highly effective capacity building model which could be recommended for future GFCS projects.

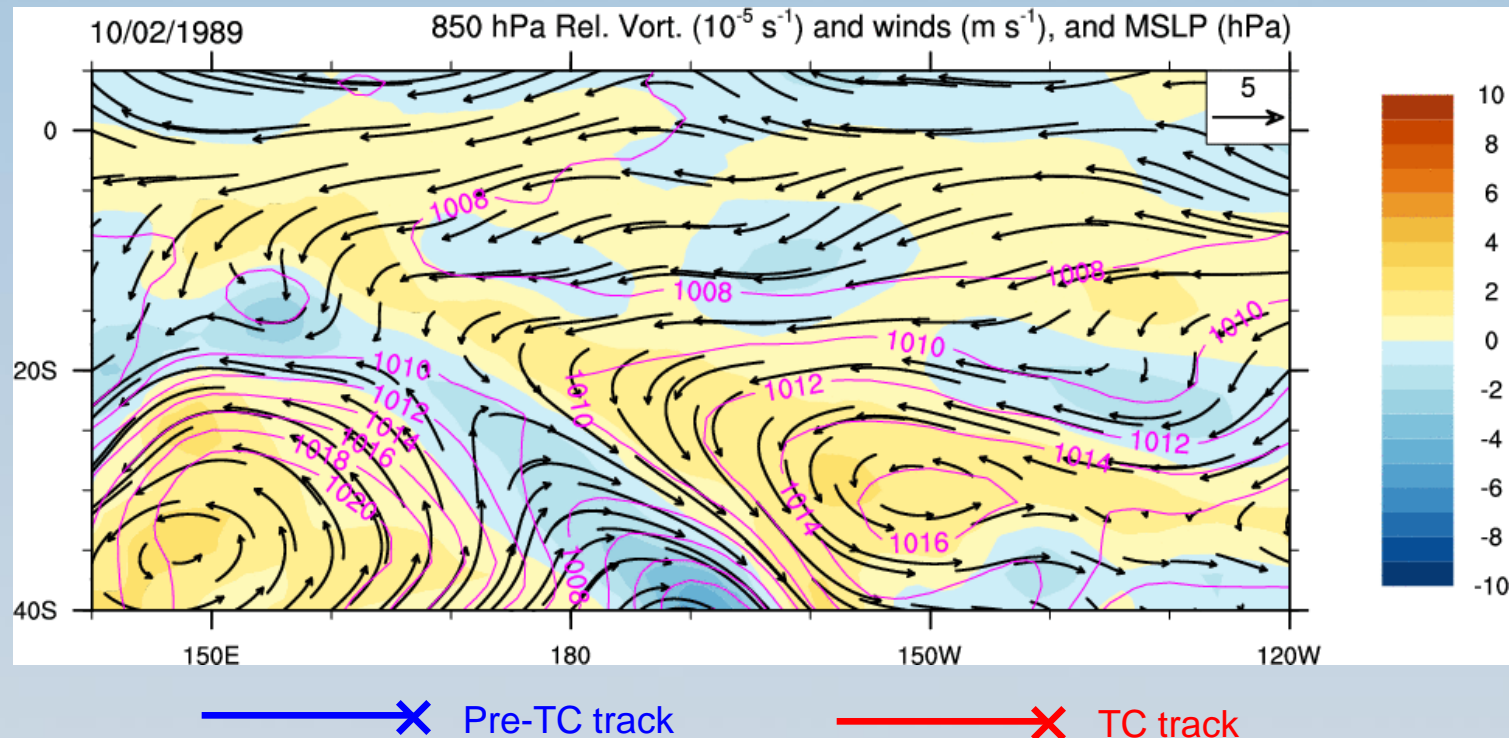
Intensity of the 2015 El Niño



The current event has topped 1997/1998 for peak intensity, but not 1982/1983.

Tropical cyclone seasonal prediction

- Tropical cyclones are tracked every day for the entire Southern Hemisphere tropical cyclone season (Nov-Apr) in each member of the climate model ensemble.

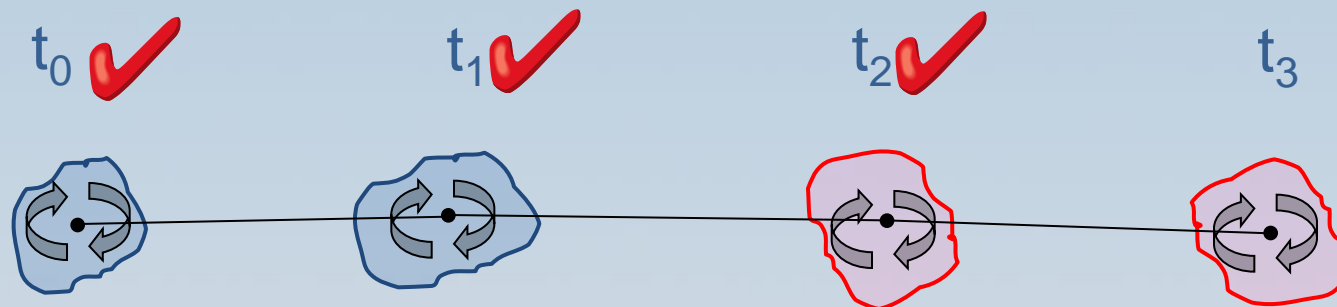


Kuleshov, Y., C. Spillman, Y. Wang, A. Charles, R. de Wit, K. Shelton, D. Jones, H. Hendon, C. Ganter, A. Watkins, J. Apajee, and A. Griesser, 2012: Seasonal prediction of climate extremes for the Pacific: Tropical cyclones and extreme ocean temperatures, *Journal of Marine Science and Technology*. Vol. 20, No. 6, pp. 675-683, doi: 10.6119/JMST-012-0628-1.

Tropical cyclone seasonal prediction

Use dynamical climate model and objective cyclone tracking scheme:

- Identify disturbances in the model at each time,
- Join these disturbances together to form a track,
- When certain threshold criteria have been met for 3 successive times, the disturbance is declared a tropical cyclone.



Thank you

