



Climate and Oceans Support
Program in the Pacific

Module 4: Satellite rainfall monitoring and MSWEP

Zhi-Weng Chua

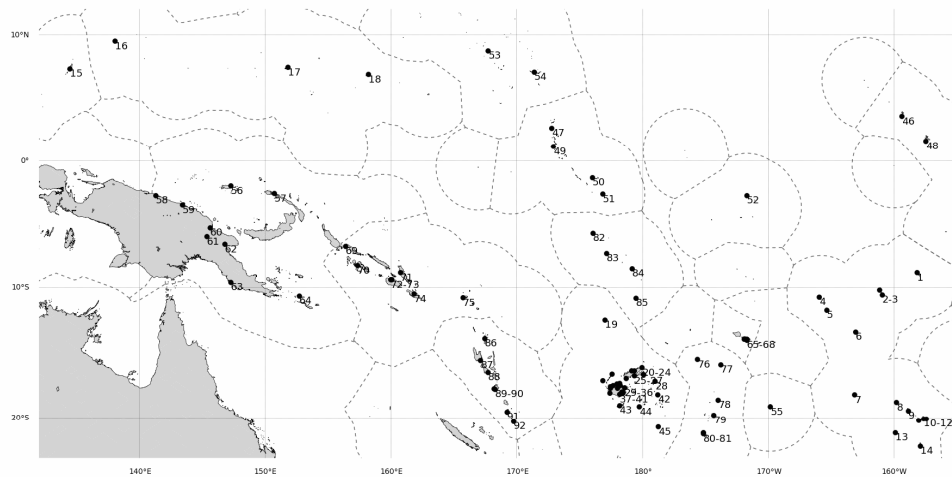




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Introduction – Existing monitoring

- Rainfall data from stations, rainfall values converted to percentiles/SPI, which are then converted to a drought status



Perryth 1, Rakahanga 2, Manihiki 3, Pukapuka 4, Nassau 5, Suvarow 6, Palmerston 7, Aitutaki 8, Manua 9, Mitaro 10, Mauke 11, Atiu 12, Rarotonga 13, Mangaia 14, Koror 15, Yap 16, Chuuk 17, Pohnpei 18, Rotuma 19, Udu Point 20, Labasa 21, Senoaga 22, Yasawai 23, Matei 24, Savusavu 25, Nabouwalu 26, Viwa 27, Vanuabalavu 28, Pengmi 29, Newara 30, Dobulevu 31, Karawai 32, Laurim 33, R.K.S. Lodon 34, Nadi 35, Mohasavu 36, Nason 37, Koromiva 38, Nacocovevu 39, Laucaia 40, Tokoroko 41, Lakeba 42, Vanuisea 43, Matuku 44, Ono-Laba 45, Tabuaren 46, Butaritari 47, Kirimati 48, Tavea 49, Beru 50, Arorua 51, Kanton 52, Kwalekeni 53, Majuro 54, Aloi 55, Momoke 56, Ravang 57, Vanimo 58, Wewak 59, Madang 60, Goroka 61, Nadzab 62, Port Moresby 63, Misima 64, Asau 65, Apia 66, Nafanua 67, Alahamiti 68, Taro Island 69, Munda 70, Auki 71, Henderson 72, Honiara 73, Kira Kira 74, Santa Cruz 75, Anuafoou 76, Niukoputapu 77, Vavau 78, Heapa 79, Auku alofa 80, Fua amotu 81, Nanumea 82, Nui 83, Funafuti 84.

"Drought" series for 3mth Percentile Drought method
Coloured by 3 Phase SOI Values & Rank by Integral(*)

	Date	SOI 3-mnth mean	NINO 3.4 SSTA	Funafuti Mar 1933 to Jul 2022 n=1073 3mth Per...	Nanumea Mar 1941 to Jul 2022 n=977 3mth Per...	Niulakita Mar 1953 to Jul 2022 n=833 3mth Per...	Nui Mar 1946 to Jul 2022 n=917 3mth Per...
1042	Dec 2019	-6.8		50.00	49.37	44.62	47.95
1043	Jan 2020	-4.5		81.82	51.90	90.62	63.01
1044	Feb 2020	-2.1		93.18	97.47	93.94	91.78
1045	Mar 2020	-2.0		85.39	97.47	88.24	76.32
1046	Apr 2020	-2.6		66.29	97.47	62.32	72.37
1047	May 2020	-1.0		29.21	59.49	7.35	34.21
1048	Jun 2020	-2.4		51.69	35.00	55.88	35.53
1049	Jul 2020	-0.9		53.93	35.00	85.29	71.05
1050	Aug 2020			60.23	36.71	92.65	81.33
1051	Sep 2020			69.32	44.30	94.12	78.67
1052	Oct 2020			69.32	31.65	61.76	40.00
1053	Nov 2020			32.95	20.25	62.12	20.00
1054	Dec 2020			15.91	5.06	58.46	27.40
1055	Jan 2021			2.27	0.00	70.31	23.29
1056	Feb 2021			43.18	11.39	96.97	34.25
1057	Mar 2021			33.71	11.39	86.76	19.74
1058	Apr 2021			83.15	35.44	92.75	39.47
1059	May 2021			31.46	26.58	16.18	32.89
1060	Jun 2021			38.20	26.25	67.65	40.79
1061	Jul 2021			23.60	23.75	45.59	19.74
1062	Aug 2021			67.05	30.38	82.35	25.33
1063	Sep 2021			78.41	36.71	72.06	26.67
1064	Oct 2021			88.64	32.91	58.82	36.00
1065	Nov 2021			72.73	25.32	51.52	36.00
1066	Dec 2021			92.05	16.46	35.38	26.03
1067	Jan 2022			89.77	30.38	62.50	17.81
1068	Feb 2022			86.36	24.05	37.88	10.96
1069	Mar 2022			74.16	22.78	50.00	18.42
1070	Apr 2022			15.73	1.27	21.74	14.47
1071	May 2022			46.07	1.27	35.29	31.58
1072	Jun 2022			10.11	1.25	10.29	17.11
1073	Jul 2022			16.85	0.00	10.29	9.21

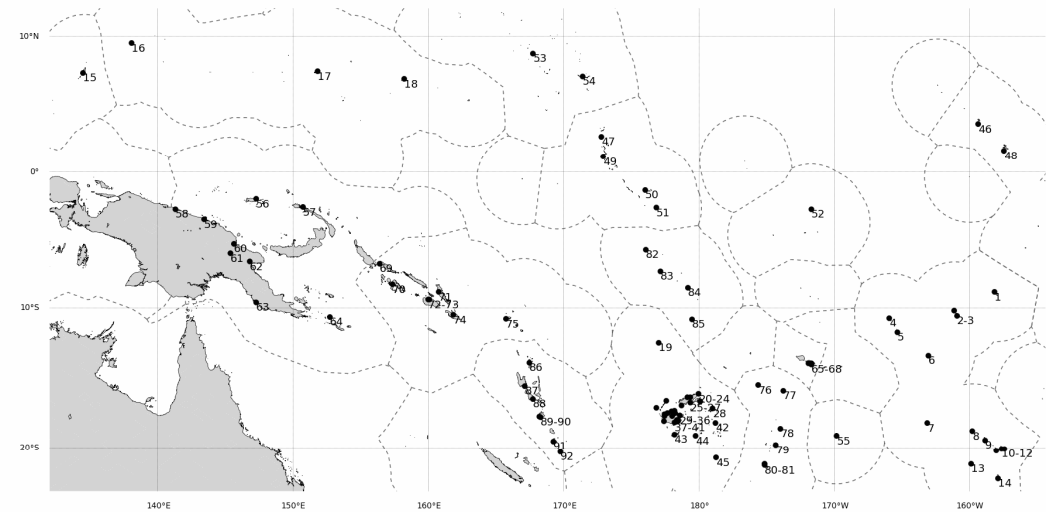
La Nina El Nino Neutral Watch Warning Drought



Stations

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- Directly measures rainfall through what is collected
- In most circumstances, it is the most reliable
- Greatest limitation is coverage



Penrhyn 1, Rakahanga 2, Manihiki 3, Pukapuka 4, Nassau 5, Suvarrow 6, Palmerston 7, Aitutaki 8, Manuae 9, Mitaro 10, Mauke 11, Atiu 12, Rarotonga 13, Mangaia 14, Koror 15, Yap 16, Chuuk 17, Pohnpei 18, Rotuma 19, Udu Point 20, Labasa 21, Seqaqa 22, Yasawai 23, Matei 24, Savusavu 25, Nabouwalu 26, Viwa 27, Vanuabalavu 28, Pengmili 29, Yawara 30, Dobuilevu 31, Karawaei 32, Lautimil 33, R.K.S. Lodon 34, Nadi 35, Monasavi 36, Nauson 37, Koroniva 38, Macrotilevu 39, Laucala 40, Tokotoko 41, Lakeba 42, Vanisea 43, Matuku 44, Ono-Lau 45, Tabuaeran 46, Butaritari 47, Kiritimati 48, Tarawa 49, Beru 50, Arorae 51, Kanton 52, Kwajalein 53, Majuro 54, Alofi 55, Momote 56, Kavieng 57, Venimo 58, Wewak 59, Madang 60, Guroka 61, Nadzaba 62, Port Moresby 63, Misima 64, Asau 65, Apia 66, Nafanua 67, Afamalu 68, Taru Island 69, Munda 70, Auki 71, Henderson 72, Honiara 73, Kira Kira 74, Santa Cruz 75, Niuafoou 76, Niuaotupou 77, Vavau 78, Haapai 79, Nuku alofa 80, Fua'amotu 81, Nanumea 82, Nui 83, Funafuti 84.

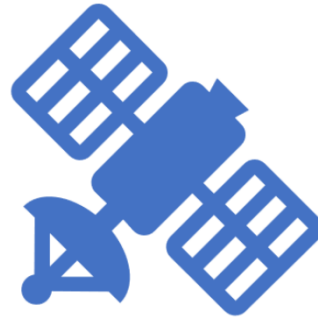


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Other ways of estimating rainfall



Gauge



Satellite



Model Reanalysis



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Remote sensing through satellites

- Satellites can produce a gridded dataset on close to a global domain.
- Detect changes in scattering and emission of microwaves and convert this to a rain rate.

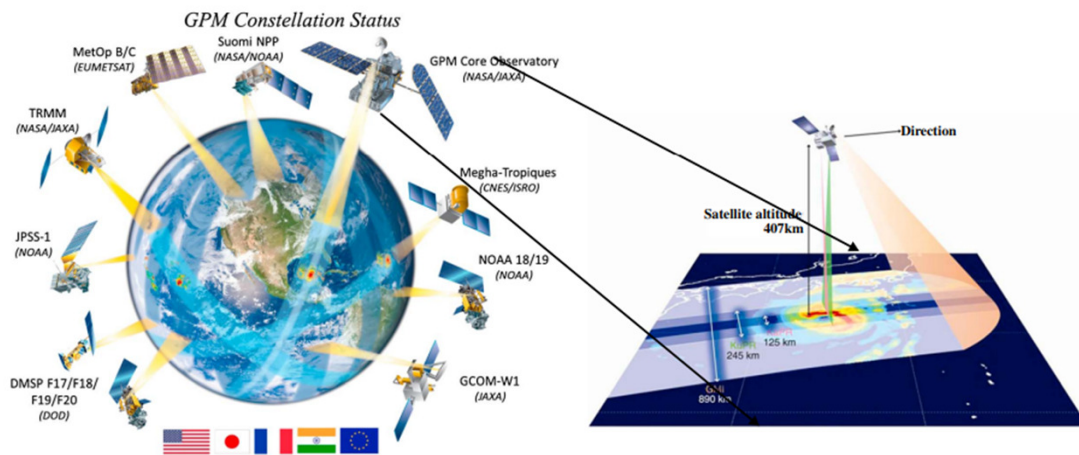
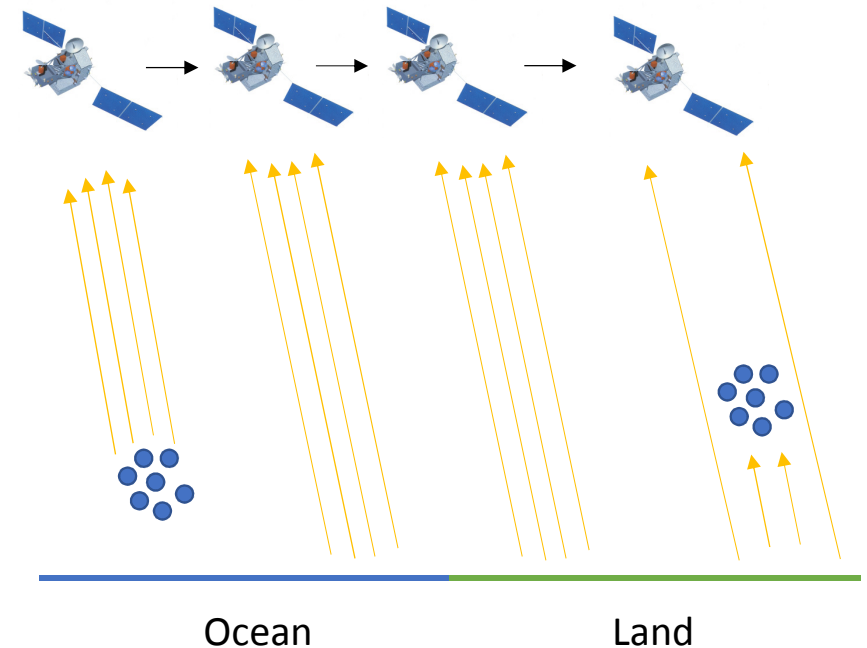


Figure 3. Conceptualization of precipitation observations from the GPM core satellite. Figure adapted from Hou et al. (2014) and GPM/DPR special site (http://global.jaxa.jp/countdown/f23/overview/gpm_e.html).



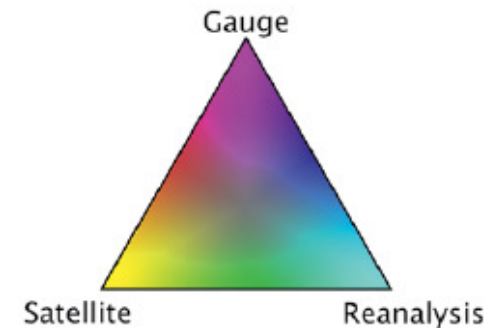
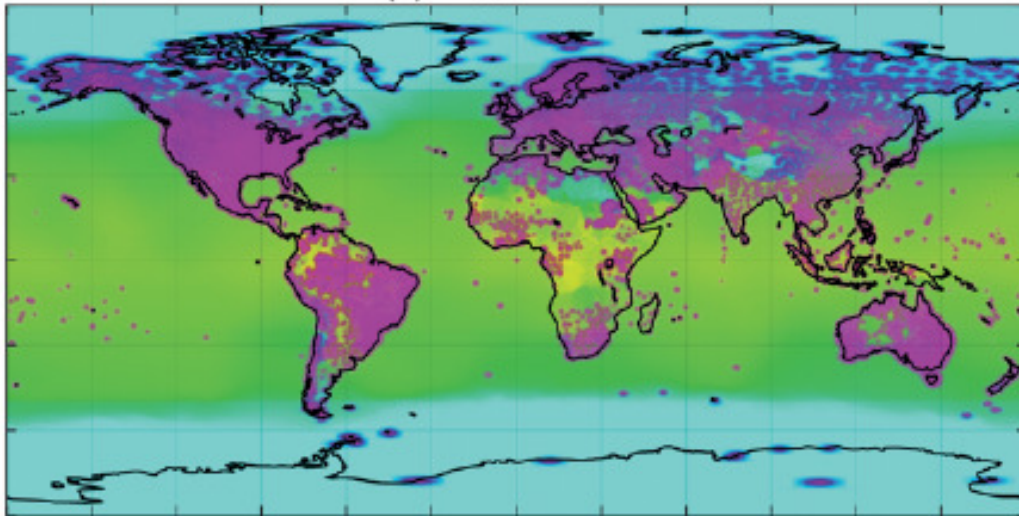


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Multi Source Weighted Ensemble Precipitation (MSWEP)

- Blend of gauge, satellite and model reanalysis data, weighted by their accuracy to gauges.
- Stations from GHCN-D database (Menne et al. 2012), the GSOD database, the Latin American Climate Assessment and Dataset (LACA&D) database, the Chile Climate Data Library, and national databases for Mexico, Brazil, Peru, and Iran are used.

(c) 2000-2017



Left to right: Relative accuracy of rainfall estimates as indicated by their weight into the Multi-Source Weighted Ensemble Precipitation (MSWEP) dataset (Beck et al., 2019)



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Validation and why MSWEP?

- Studies have shown it to be one of the best performing datasets available (Beck et al. 2017; Beck et al. 2019)
- Did our own validation study comparing station data, MSWEP, ERA5 and GSMaP covering:
 - Solomon Islands
 - PNG
 - Kiribati
 - Tuvalu
 - Marshall Islands
 - Cook Islands
 - Fiji
- MSWEP performed the best, ERA5 was a close second.
- GSMaP performance is not bad, but shorter record is an obstacle.



Basic validation of data against stations

- Compared gridded data from 2001 to 2020 to 14 stations over Fiji.
- R = Linear correlation (closer to 1 is better) – when station values are large, are values from the gridded dataset also large?
- MAE = Mean Absolute Error (based on average error).

Dataset	R	MAE (mm/month)
GSMaP	0.78	95.49
ERA5	0.77	82.58
MSWEP	0.85	64.27



Basic validation of data against stations

- Compared gridded data from 2001 to 2020 to 32 stations over the Pacific.
- R = Linear correlation (closer to 1 is better) – when station values are large, are values from the gridded dataset also large?
- MAE = Mean Absolute Error (based on average error).

Dataset	R	MAE (mm/month)
GSMaP	0.70	104.05
ERA5	0.69	91.36
MSWEP	0.76	75.53



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Advantages and limitations for gridded maps

Advantages

- Provides estimate of rainfall where stations cannot.
- Consistent over space and time.
- Data updated relatively quickly.

Limitations

- Greater uncertainty than station data.
- Record only extends back to 1980.

Station and remote sensing data are complementary. Gridded maps used in EAR WATCH but station data is still useful for verification and ground-truthing.



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Why are there differences?

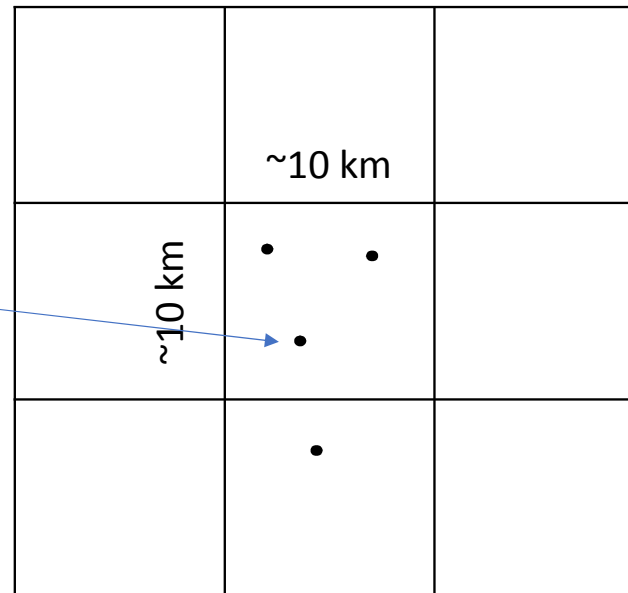
Stations

- Direct measurement.
- Rainfall value at a point.

Remote-sensing

- Indirect estimation
- Value averaged over a grid square
- Does not include all stations

230 mm



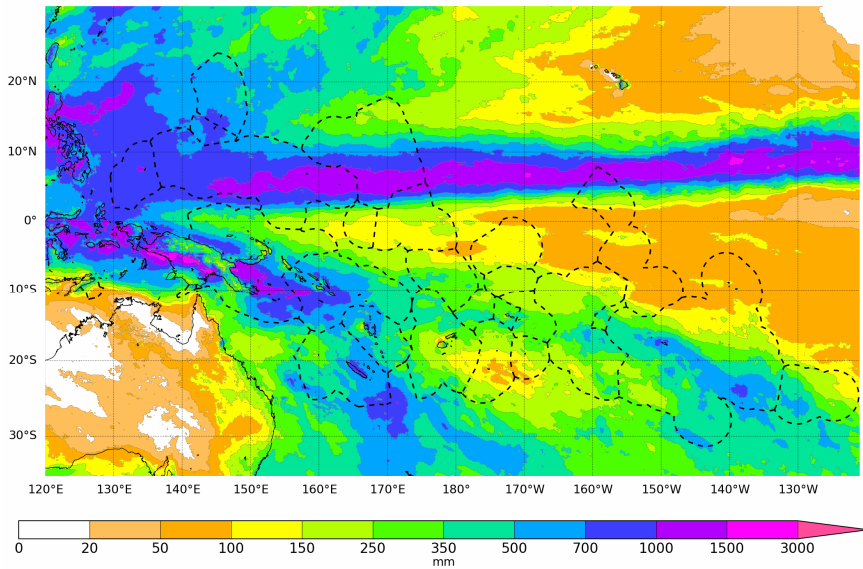


Percentile maps

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- At each grid point, use rainfall values from MSWEP to calculate percentile.
- Use the climatology of MSWEP; record goes back to 1980.

3-month total rainfall ending August 2022



Source: MSWEP

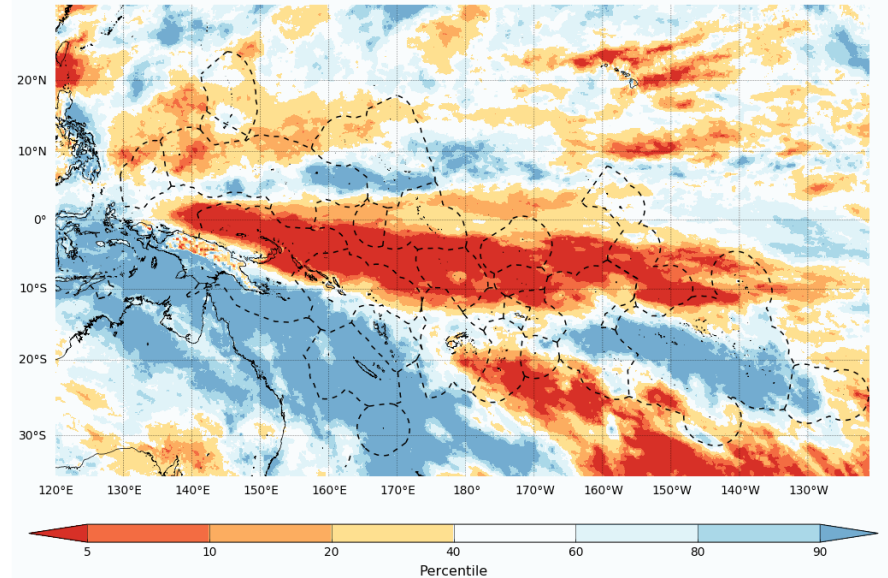
Map created: 07/09/2022 (UTC)

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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.marineregions.org/>.

Convert to
percentiles



3-month Percentile to end of August 2022



Data source: MSWEP

Run: 01/08/2022
Base period: 1980-2021

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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.marineregions.org/>.

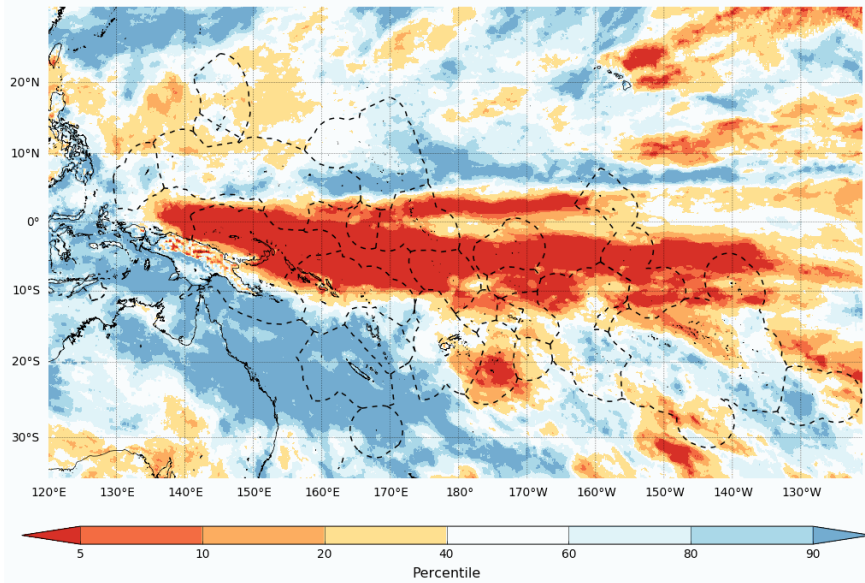


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Drought status maps

Percentiles

3-month Percentile to end of July 2022



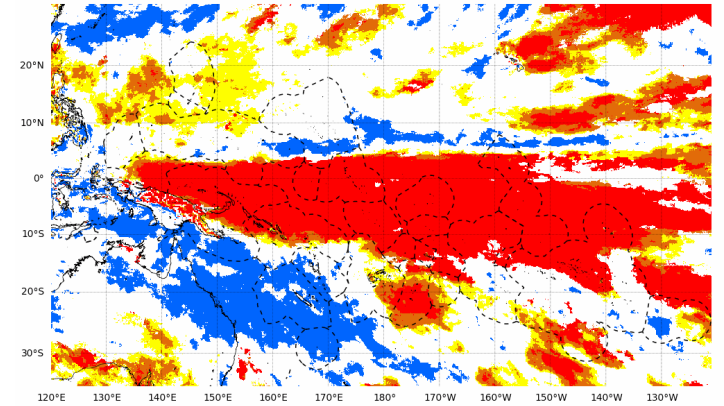
Data source: MSWEP
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Shapellie data extracted from Flanders Marine Institute (2019), Maritime Boundaries Geodatabase: Maritime Boundaries and Exclusive Economic Zones (200NM), version 11. Available online at <http://www.maritimeresources.org/>
Run: 01/07/2022
Base period: 1980-2021

Convert
percentile to a
status



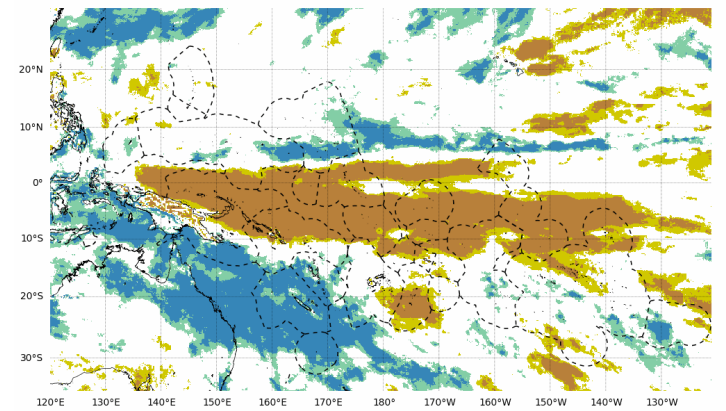
Rainfall status

3-month rainfall status to end of July 2022



Data source: MSWEP
Method: Percentile
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Shapellie data extracted from Flanders Marine Institute (2019), Maritime Boundaries Geodatabase: Maritime Boundaries and Exclusive Economic Zones (200NM), version 11. Available online at <http://www.maritimeresources.org/>
Run: 01/07/2022
Base period: 1980-2021

3-month rainfall status to end of July 2022



Data source: MSWEP
Method: Percentile
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Run: 01/07/2022
Base period: 1980-2021



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Drought status for multiple timescales

1-month

3-month

6-month

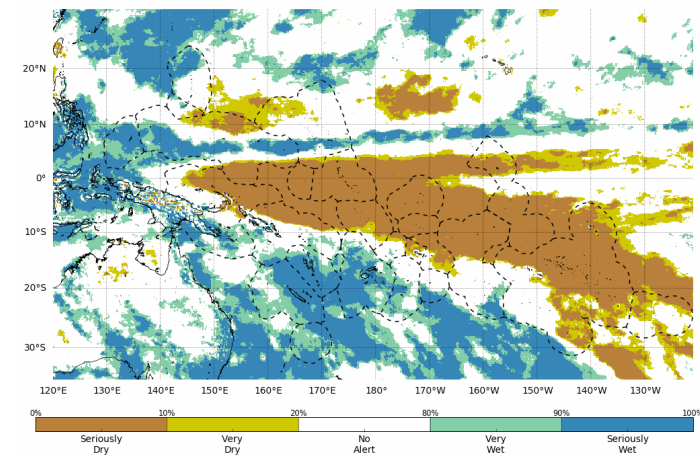
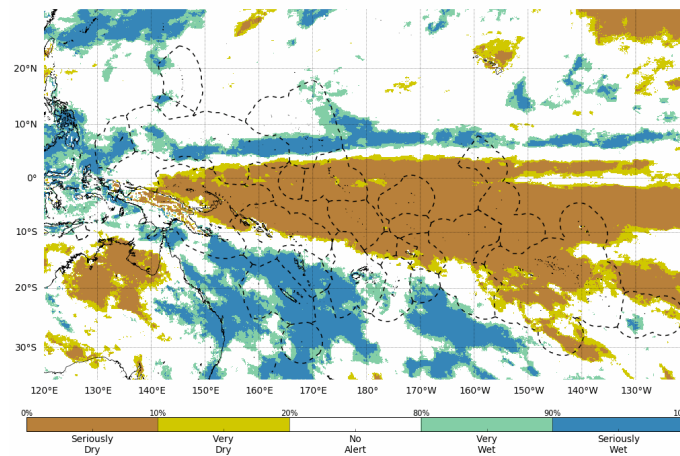
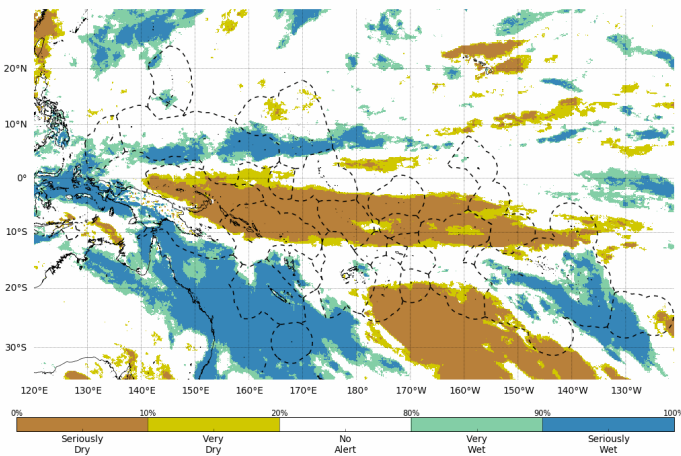
12-month

24-month

Rainfall status for July 2022

6-month rainfall status to end of July 2022

24-month rainfall status to end of July 2022



Data source: MSWEP
Method: Percentile
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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.maritimerregions.org/>

Data source: MSWEP
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Closing remarks

Thank you!

Products available at: <http://www.bom.gov.au/climate/pacific/outlooks/>