SEA-POL Radar Data - Version 1.0

1. Data Set Description

This dataset contains radar moments data in CfRadial format, collected by the SEA-POL radar during the Prediction of Rainfall Extremes Campaign In the Pacific (PRECIP). During PRECIP, SEA-POL was located at the west end of Yonaguni (24.4567 N, 122.943 E, 0.007 km altitude) and collected data from 9 June to 22 August 2022. For more information on PRECIP see https://www.eol.ucar.edu/field_projects/precip. This release contains both Level 2 and Level 3 products.

2. Instrument description

The CSU Sea-Pol ship- and land-deployable radar measures dual-polarization data over a range in excess of 200 km. The radar operates at C-band and has a 4.3m stabilized antenna system. The inertial navigation unit (INU) and platform stabilization, which correct for ship movement in sea deployments, can be disabled for land deployments as was done for PRECIP. The radar operates in simultaneous transmit and receive mode, as well as horizontal-only mode, with a sensitivity of -7 dBZ at 100 km. A variety of pulse widths and PRFs are supported, within a 0.12% duty cycle limit.

For more information on SEA-POL, please visit https://seapol.colostate.edu/.

SEA-POL Radar Characteristics	
Transmitter	5.535 GHz
Pulse Width	0.67 μs
PRF	1200 Hz
Peak Power	250 kW
Radar Noise Figure	< 3.5 dB
Dynamic Range	> 99 dB
Minimum detectable signal	-7 dB at 100 km
Polarization Switching	HV
Gain	45 dBi
Diameter	4.3 m
Beamwidth	1.0°
First sidelobe	< -27 dB (typ. < -30 dB)
Scan rate	1º/s for RHIs, 14-16º/s for PPIs
Wind Limit	115 mph/185 km/h windspeed
Number of range gates	1197
Gate Spacing	100 m
Number of Samples	2 – 1024 pulses

Clutter filter	Adaptive (GMAP), > 50 dB clutter suppression
Time Series (I/Q) capability	Yes

3. Data Collection and Processing

SEA-POL scanned on a 12-minute cycle that coordinated with SPol and ran nearly continuously over the project. The 12-minute cycle consisted of a curtain RHI scan beginning at 281º and ending at 101º, a surveillance scan that consisted of elevation angles from 0.5º to 17º, a dedicated RHI scan pattern that scanned over the cardinal and ordinal directions and a nearby disdrometer, and a user-selected scan that consisted either of RHI scans centered on nearby precipitation or a shallower surveillance scan. Birdbath scans were performed at the direction of the radar scientist when rain was suspected directly over the radar.

On 9 June 2022, SEA-POL was granted a license to operate and data collection began. Any files collected before June 9 were removed from the finalized dataset. Per a request from the JSDF, SEA-POL's transmitter was re-tuned to 5.535 GHz. SEA-POL was nominally blocked from 110-198ª at all elevations due to a Japanese military request beginning on 0300 UTC 15 July through the end of the project. This request was occasionally lifted for IOPs, such as on 0300 UTC 29 July until 0300 UTC 30 July.

Regular antenna position calibration was performed in the field. There was no long-term drift in the antenna pointing accuracy and errors remained within 0.1º the entire time the radar was up. The automatic internal receiver calibration was performed in May and August, however the change in the radar frequency in May meant the original calibrations were no longer valid. The transmit power only changed by 0.1 dB.

Files were converted to CfRadial by RadxConvert.

Two QC procedures were performed to 1) remove the lowest quality signal and correct any measurement errors (Level 2) and 2) remove low-quality and non-weather echoes from the data and add value-added products (Level 3).

3.1 Level 2: high-quality radar measurements retained

To remove the lowest-quality signal, any gates where SQI < 0.2 and SNR < 0.0 dB were removed. This QC was applied to all variables using Python.

We identified an average ZDR bias of -0.9 dB over the full campaign after examination of high-elevation RHI1 data, SUR scans above the melting level, and select birdbath scans. This bias is corrected and saved to the ZDR data.

Level 2 data contain bias-corrected and high-quality radar signals, which include both meteorological and non-meteorological echoes. These data are for experienced radar users who want access to the full radar measurements. For most meteorological applications, users should consider using the Level 3 data.

3.2 Level 3: high-quality meteorological data, including value-added products

The RHOHV field provided by the IRIS software removes noise from the variable, which causes a high bias in low-SNR regions, per correspondence with Jim George. This RHOHV field is preferred for microphysical interpretation, but not for quality control. The raw RHOHV field is stored in the field ‘UNKNOWN_ID_82.’ RadxConvert handles the type conversion by applying a bias of 128, then subtracting 32768 to convert to a signed integer. To calculate raw RHOHV, we apply a 32640 offset, subtract 1, and then divide by 65533 (original uint16 linear scale: 0 = no data, 1 = 0.0, 65534 = 1.0, 65535 = reserved). The raw RHOHV field is called RHOHV_NNC in this dataset and is used to remove non-meteorological echoes.

Low-quality and non-meteorological echoes were removed from the dataset based on polarimetric values, the CSU RadarTools despeckling algorithm, and non-weather categories from the NCAR PID algorithm in RadxRate. Polarimetric variables used for thresholding included RHOHV_NNC, SNR, smoothed SQI (using a 2D Gaussian smoother), and the standard deviation of PHIDP.

KDP was calculated using RadxRate, with a FIR filter length of 10 gates and using the Hubbert and Bringi (1995) method to handle phase shift on backscatter. KDP is only considered valid in regions where the standard deviation of PHIDP is less than 20 and RHOHV is above 0.9.

Although the NCAR PID was used to censor non-weather echoes, there were issues with excessive graupel, so the CSU RadarTools HID was used to identify hydrometeor types due to extensive development for C-band radars in tropical environments. Soundings for the HID were obtained from the 6-hourly GFS model analysis. The summer HID algorithm (Dolan et al. 2013; Rutledge et al. 2019) uses RHOHV, attenuation-corrected DBZ and ZDR, and KDP.

Attenuation-corrected DBZ and ZDR are calculated using the default C-band coefficients available in RadxRate. These Level 3 products are labeled DBZ and ZDR in the final dataset; the variables prior to attenuation correction are referred to as DBZ_ATTEN_UNCORRECTED and ZDR_ATTEN_UNCORRECTED.

Rain rates are estimated using the blended Tropical Rainfall Algorithm from CSU RadarTools, which uses the attenuation-corrected DBZ and ZDR, and KDP fields (Lang et al. 2019). Rain rate coefficients come from Table 1 of Thompson et al. (2018).

These Level 3 products have removed the majority of non-meteorological echoes and are recommended for general use. Users who want more control over the quality control processing are recommended to use the Level 2 data.

Processing scripts and parameter files are available on GitHub.

4. Data Format

The moments data described here are available at https://data.eol.ucar.edu/dataset/621.001 in CfRadial format. For more information on CfRadial see https://www.eol.ucar.edu/system/files/CfRadialDoc-v2.0-20180430.pdf.

The primary data products for scientific use are listed in the table below.

Variable	**Dimensions Unit**	**Long Name**
time	time s	Seconds since volume start
range	range m	Range from instrument to center of gate
azimuth	time deg	Ray azimuth angle
elevation	time deg	Ray elevation angle
DBZ_L2	n_points dBZ	Level 2 Reflectivity
VEL_L2	n_points m/s	Level 2 Doppler velocity
WIDTH_L2	n_points m/s	Level 2 Spectrum width
ZDR_L2	n_points dB	Level 2 Bias-corrected differential reflectivity
PHIDP_L2	n_points deg	Level 2 Differential phase
DBZ	n_points dBZ	Level 3 Attenuation-corrected reflectivity
ZDR	n_points dB	Level 3 Attenuation-corrected and bias-corrected differential reflectivity
DBZ_ATTEN_UNCORRECTED	n_points dBZ	Level 3 Reflectivity
ZDR_ATTEN_UNCORRECTED	n_points dB	Level 3 Bias-corrected differential reflectivity
VEL	n_points m/s	Level 3 Doppler velocity
WIDTH	n_points m/s	Level 3 Spectrum width
PHIDP	n_points deg	Level 3 Differential phase
KDP	n_points deg/km	Level 3 Specific differential phase
RHOHV	n_points none	Level 3 Cross correlation ratio
RHOHV_NNC	n_points none	Level 3 Cross correlation ratio, without noise correction
PID_FOR_QC	n_points	Hydrometeor particle ID from RadxRate

HID_CSU	n_points	Hydrometeor ID from CSU RadarTools
RATE_CSU_BLENDED	n_points mm/h	Rain rate from CSU RadarTools

5. Data Remarks

5.1 Known problems

The ZDR bias was considered as a system bias over the entire field project. If examining case studies or an event where rain was occurring (or had occurred recently), an additional ZDR bias correction may be necessary. It did not rain frequently over SEA-POL, but we suspect SEA-POL will have a wet radome problem during and after periods of rainfall, which would produce biases in ZDR that are unaccounted for in our ZDR bias correction.

5.2 Data time-gaps

The following table lists data gaps of more than 30 minutes, based on the surveillance scan data files.

Gap start time	Gap end time	Gap secs	Gap hours	Reason
2022-06-11T01:11:34Z	2022-06-11T01:37:16Z	1543	0.428548	Not logged.
2022-06-20T22:54:03Z	2022-06-21T00:20:57Z	5214	1.44845	Negative fault error (also referred to as negative elevation limit in logs) thrown on mandatory RHI.
2022-06-23T21:17:58Z	2022-06-24T00:13:19Z	10520	2.92231	Negative fault error.
2022-06-25T08:18:00Z	2022-06-25T09:31:55Z	4434	1.23178	Negative fault error.
2022-06-25T23:29:59Z	2022-06-26T00:15:07Z	2709	0.752452	Negative fault error.
2022-06-28T16:05:51Z	2022-06-29T00:30:21Z	30270	8.40838	Negative fault error and problem with the antenna status.
2022-07-06T19:03:53Z	2022-07-07T00:15:33Z	18700	5.19439	SEA-POL offline, possible power outage.
2022-07-11T18:29:50Z	2022-07-12T00:01:30Z	19900	5.52783	SEA-POL stopped scanning, negative fault error suspected.
2022-07-12T04:23:46Z	2022-07-12T04:49:31Z	1545	0.429131	SEA-POL taken offline to allow for tour of the radome.
2022-07-17T21:30:09Z	2022-07-18T00:01:35Z	9085	2.52371	Negative fault error.
2022-07-24T00:23:45Z	2022-07-24T00:52:03Z	1698	0.471683	SEA-POL stopped to provide a tour for visiting scientists.
2022-07-27T23:23:47Z	2022-07-28T03:13:29Z	13783	3.82854	SEA-POL stopped scanning due to a request from Japanese government.
2022-07-28T17:23:45Z	2022-07-28T23:29:22Z	21937	6.09363	SEA-POL stopped scanning, reason unknown.
2022-07-29T20:11:46Z	2022-07-29T21:11:30Z	3585	0.995713	SEA-POL stopped scanning, reason unknown.

2022-07-30T11:08:49Z	2022-08-03T02:20:25Z	313896	87.1934	SEA-POL stopped scanning, antenna receiver connection issue, water intrusion found.
2022-08-04T04:54:10Z	2022-08-04T05:50:13Z	3363	0.934097	SEA-POL mechanical issue.
2022-08-04T06:28:14Z	2022-08-04T07:14:59Z	2805	0.779041	SEA-POL antenna unstable, mechanical issue.
2022-08-04T08:20:07Z	2022-08-06T05:29:52Z	162585	45.1625	SEA-POL mechanical issue.
2022-08-06T05:53:54Z	2022-08-06T06:38:46Z	2692	0.747775	SEA-POL mechanical issue.
2022-08-06T07:23:05Z	2022-08-06T07:54:35Z	1890	0.525005	SEA-POL mechanical issue.
2022-08-06T08:28:36Z	2022-08-07T00:13:13Z	56677	15.7437	SEA-POL mechanical issue.
2022-08-07T01:08:02Z	2022-08-07T07:02:11Z	21249	5.90259	SEA-POL mechanical issue.
2022-08-07T23:05:52Z	2022-08-07T23:54:45Z	2933	0.814771	SEA-POL mechanical issue.
2022-08-07T23:54:51Z	2022-08-08T05:05:10Z	18620	5.17209	SEA-POL mechanical issue.
2022-08-08T08:41:48Z	2022-08-08T09:41:06Z	3558	0.988204	SEA-POL mechanical issue.
2022-08-08T09:45:41Z	2022-08-08T23:49:02Z	50601	14.0559	SEA-POL mechanical issue.
2022-08-09T05:48:31Z	2022-08-09T06:26:50Z	2299	0.638647	SEA-POL mechanical issue.
2022-08-09T06:43:34Z	2022-08-09T07:36:15Z	3161	0.878098	SEA-POL mechanical issue.
2022-08-09T07:41:25Z	2022-08-10T00:07:28Z	59163	16.4342	SEA-POL mechanical issue.
2022-08-10T05:06:22Z	2022-08-10T07:15:55Z	7773	2.15915	SEA-POL mechanical issue.
2022-08-10T07:16:03Z	2022-08-10T10:53:21Z	13038	3.62171	SEA-POL mechanical issue.

6. References

6.1 Data Citation

Colorado State University SEA-POL Team. 2023. PRECIP: SEA-POL radar moments data. Version 1.0. Colorado State University. https://doi.org/. Accessed <insert data download date>.

6.2 References

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