RETRIEVALS OF DOPPLER WIND DIVERGENCE PROFILES FROM SMART-R AND TOGA RADARS DURING DYNAMICS OF THE MADDEN JULIAN OSCILLATION (DYNAMO): DATA SUMMARY

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1.0 Dataset Overview:

The profiles of wind divergence

Time period:
    SMART-R: *02 October 2011 – 31 January 2012*
    TOGA (3 time legs): 1st October 2011-30th October 2011; November 07-December 08 2011; December 16 2011-January 02, 2012
Location:
    SMART-R: 0.6075°S, 73.0995°E (Located on Addu Atoll, Maldives)
    TOGA Radar: 0°, 80.5 °E (on Revelle ship platform)

2. Instrument description:

The profiles of wind divergence are retrieved from the SMART-R and TOGA Doppler radars during the DYNAMO using velocity-azimuthal display methodology at hourly resolution.

Radar Specifications	SMART-R	TOGA
Wavelength	5.5 cm	5.35 cm
Location (lat/lon)	0.6075^{o}S/73.0995^{o}E	0° / 80.5 ^{o}E
Site/Platform	Continental/Diesel pedestal	Ocean/Ship-based Platform
PRF (Hz)	300-3000	1000
Beam Width (deg)	1.5^{o}	1.65^{o}
Scan cycle (mins)	10	10
Nyquist velocity (m/s) for volume scans	13.38	13.3
Unambiguous range (for volume scans)	150 km	150 km
Scan elevations (deg)	13 elevations between 0.5^{o} to 29.5 ^{o}(33°)	22 elevations between 0.8 ^{o} to 21.5 ^{o}

Table 1: Specifications and site locations of SMART-R and NASA TOGA Radars during the DYNAMO field campaign

3. Description of Wind Divergence Retrieval and Quality Control

The methodology of wind divergence retrieval can be subdivided into tasks such as, pooling and binning of radar data, velocity de aliasing/unfolding, VAD calculation and uncertainty estimates.

3a. Pooling of the radar data

The volume scans performed by the radar measured the data in spherical coordinate system. We have chosen a cylindrical coordinate system to pool the data stream binned into hourly histograms in a coarse 12 x 24 x 36 (range x azimuth x altitude) cylindrical grid (as shown in Figure 1). The histograms of reflectivity values carried out at 1-dBZ resolution from 0 to 60 dBZ. Reflectivities over 60 counted as 60, radar echoes below 2 dBZ counted in bin 1 and the bin 0 is incremented when there are no echoes reported.

The important quantity for the velocity-azimuthal display (VAD) technique is the mean radial velocity V_r in each spatial grid cell. The histogram

of V_r is carried out between -1 to 1 times of Nyquist velocity as listed in table 1), which will be used in velocity unfolding of Vr.

To increase the number of available divergence estimate at the upper levels, the data are further pooled from 500-m height layers from 500-m height layers to 50-hPa pressure layers with a total of 19 pressure levels.
The data is further pooled in horizontal range with 8-km range interval augmented by data from one or two adjacent range intervals.
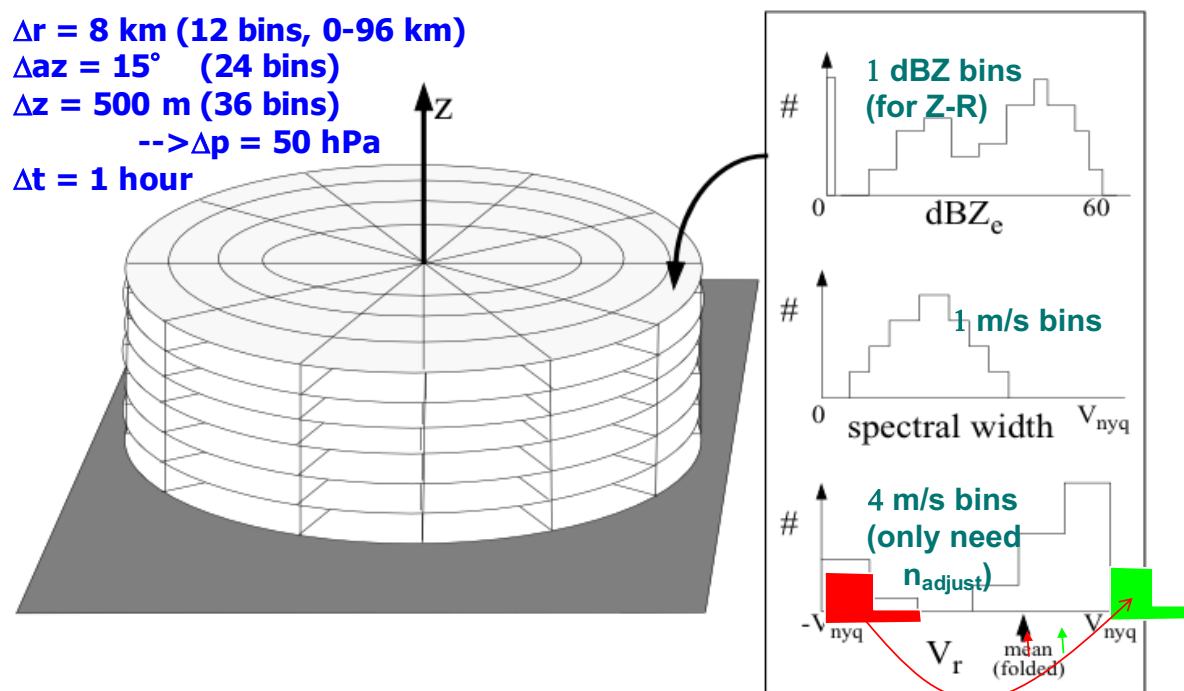
Cylindrical data binning for VAD

Δr = 8 km (12 bins, 0-96 km)
Δaz = 15°   (24 bins)
Δz = 500 m (36 bins)
        --> Δp = 50 hPa
Δt = 1 hour

Figure 1: Pooling and data binning of radar data.

3b. Velocity unfolding

A simple two-step method is devised to correct for aliased or folded radial velocities: i) histogram of raw V_r is used for relative unfolding of partly folded V_r values with in each spatial cell (refer to Figure 1). ii) first guess wind/azimuthal structure is used for absolute unfolding of the adjusted grid cell-mean V_r values. The mean wind profile is calculated by VAD method using grid cells with at least 20 % echo coverage by pooling 40-96 km horizontal ranges, in order to maximize the azimuthal coverage and statistical robustness.
At every height, the cell mean V_r values at each azimuth are shifted by +/-2nV_{nyq} to lie within V_{nyq} of that guess, and then fed into the harmonic-curve fitting

routine. The fitted result with highest goodness of fit value defines the best fit VAD wind at that height.

3c. VAD methodology

After the unfolding process, to estimate a mean *horizontal* wind and wind divergence at each altitude, the fall velocity contribution to the V_r is removed by estimating its value from the mean grid cell's reflectivity and air density. No correction is made to account for the vertical motions and overcorrection of the fall speeds below the melting layer where the reflectivity tends to be large due to wet aggregated ice particles, which shows as a distinct kink in the divergence profile.

The VAD method is applied by fitting a harmonic curve with a weighted least square fit using 3 parameters: azimuthal component of Vrh and amplitude and phase of wavenumber 1. The sum of squares of these normalized deviations is minimized in the fit. Once the harmonic fit accomplished, the divergence theorem is used to compute area-averaged horizontal divergence.
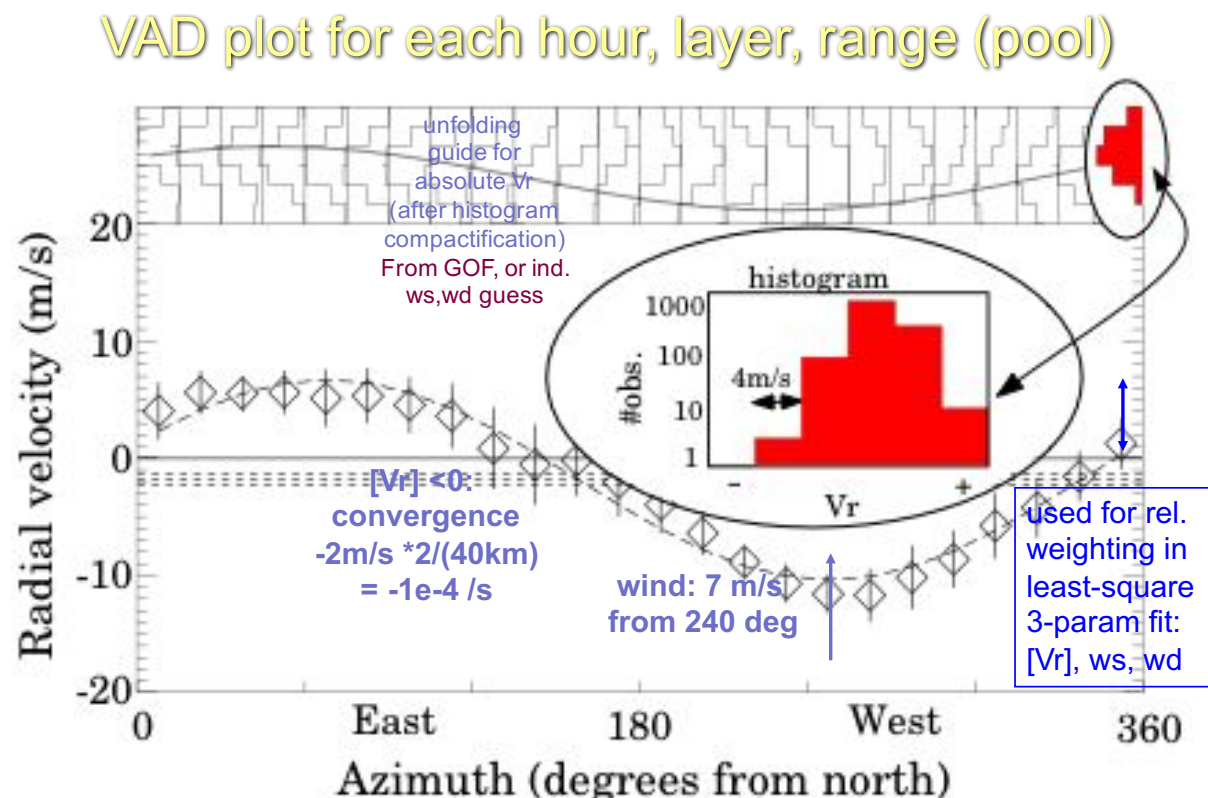

Figure 2: Sample demonstration of VAD methodology

4. Divergence output format

Output Files:

Output Format: All in NETCDF/IDL output format (.sav files)

Output Files:
CYLBIN_output_SMARTR_legs_all.sav / CYLBIN_output_SMARTR_legs_all.nc

CYLBIN_output_TOGARADAR_cruise_all.sav/CYLBIN_output_TOGARADAR_cruise_all.nc

Output frequency: 1 hourly
Data version and date: Version: 1.0 and 26 May 2017.

This file contains the output from the CYLBIN processing for the SMARTR data for the DYNAMO period

The descriptions of the variable stored in the output file is given below:

Time strings: time string in format YYYYDDMMHH

range: radius from the center where the divergence estimates are made, in km [size: 12 ranges]

Pressure: pressure in mb [size: 19 levels]

Divergence: divergence estimates in per sec [size: #hours x 12 x 19]

Divergence_stdev: uncertainty in the divergence estimates in per sec units [size: #hours x 12 x 19]

U: zonal winds estimated at each range radius, in m/s [size: #hours x 19]

V: meridional winds estimated at each range radius, in m/s [size: #hours x 19]

U_stdev: uncertainty in zonal winds zonal winds estimated at each range radius, in m/s [size: #hours x 19]

V_stdev: uncertainty in meridional winds estimated at each range radius, in m/s [size: #hours x 19]

chi_uv: chi-square coefficient of VAD fitted winds to the data at each range radius, in m/s [size: #hours x 19]

chi_div: chi-square coefficients of VAD divergence estimates in per sec [size: #hours x 12 x 19]

 EchoCover_0db: Fractional coverage of reflectivity bins containing values > 0 dBZ at a given range radius [# hours x 12 x 19]

EchoCover_15db: Fractional coverage of reflectivity bins containing values > 15 dBZ at a given range radius [# hours x 12 x 19]

EchoCover_30db: Fractional coverage of reflectivity bins containing values > 30 dBZ at a given range radius [# hours x 12 x 19]

Arearain_GATEZR: area rain averaged with in the given range radius using GATE Z-R relation[# hours x 12]

Arearain_localZR; area rain averaged with in the given range radius using GATE Z-R relationship[# hours x 12]

stratiform_fraction: stratiform rain fraction with in the given range radius [# hours x 12]

All_data_matrix /v01: Master array containing 29 variables (listed below) stored in detail in a single array: [size: 29 x 12 x 19 x # hours]

```
All_data_matrix = ['cover total'        ,'dbz (db)'          ,'Ze (mm^6/m^3)'      ,$
   'rwc (kg/m^3)'        ,'iwc (kg/m^3)'       ,'rain_gate (kg/m^2/s)',$
   'rain_local (kg/m^2/s)','spectral width (m/s)','u_7r (m/s)'         ,$
   'v_7r (m/s)'          ,'wspd_7r (m/s)'     ,'div_1r (1/s)'       ,$
   'div_3r (1/s)'        ,'div_5r (1/s)'      ,'std_div_1r (1/s)'   ,$
   'std_div_3r (1/s)'    ,'std_div_5r (1/s)'  ,'chi_fit_1r'         ,$
   'chi_fit_3r'          ,'chi_fit_5r'        ,'az_obs_1r (deg)'    ,$
   'az_obs_3r (deg)'     ,'az_obs_5r (deg)'   ,'gapmax_1r (deg)'    ,$
   'gapmax_3r (deg)'     ,'gapmax_5r (deg)'   ,'std_u_7r (m/s)'     ,$
   'std_v_7r (m/s)'      ,'chi_fit_7r']
```

5. Data remarks:

Divergence estimates over larger areas provides accurate estimates as spatial averaging with the divergence theorem is accurate and a bigger area average has less contribution by electronic noise. Also, the horizontal scans with lower elevation angles have less influence from the necessary fall speed correction assumptions, which might be in error.

The uncertainties of the divergence estimates are given in term of the chi-square coefficients. If the magnitude of the uncertainties in the divergence/wind estimates are greater than the mean quantities, they will be flagged as an outliers (recommendation).

6. List of references:

Mapes, B.E. and J. Lin, 2005: Doppler Radar Observations of Mesoscale Wind Divergence in Regions of Tropical Convection. *Mon. Wea. Rev.,* **133**, 1808–1824,https://doi.org/10.1175/MWR2941.1