

CAMEX-3 EDOP Reprocessed Dataset Documentation

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1. Introduction

This document provides relevant information for the reprocessed ER-2 Doppler Radar (EDOP) data collected during the Third Convection and Moisture Experiment (CAMEX-3) field campaign, which took place in August and September 1998. The CAMEX series of field campaign focused on expanding our understanding of dynamics and thermodynamics of tropical deep convection, including tropical cyclones. The field campaign collected observations using the NASA ER-2, NASA DC-8, and UND Citation aircraft in coordination with the NOAA P-3s and ground observations. In addition to EDOP, the ER-2 payload during CAMEX-3 included AMPR, LIP, MAMS, NAST-I, NAST-MTS, and MIR. A journal article describing the CAMEX-3 and CAMEX-4 field campaigns is available at <https://doi.org/10.1175/JAS3607.1>. CAMEX-3 was flown in collaboration with the Texas Florida Underflights Experiment – B (TEFLUN-B).

EDOP is an X-band (9.6 GHz) Doppler radar built and maintained by NASA Goddard Space Flight Center that flew aboard the NASA ER-2 aircraft during several field campaigns that took place between 1993 through 2007. The EDOP instrument mounts both a nadir-pointing antenna and a forward-angled antenna, both of which are located in the nose of the ER-2. During CAMEX-3, the forward antenna pointed at approximately 33° forward of nadir. By using a dual pulse repetition frequency set up, the instrument avoids issues with Doppler velocity folding due to the platform motion. The table below provides a quick reference for the radar characteristics.

EDOP Characteristics

Frequency	9.60 GHz	Beamwidth	3°
Peak Power	25 kW	Nadir surface footprint	1.1 km diameter
Duty Cycle	0.44% max	Forward antenna tilt	33°
Pulse Width	0.25, 0.5, 1.0 μ s	Nyquist Velocity	34 m s ⁻¹
PRF	2200 Hz, 4400 Hz	Gate Spacing	37.5 m

The current reprocessing efforts are limited to the previously processed data files and did not delve into reprocessing the data from the raw files. Below is a list of flights during which EDOP successfully collected data:

Flight Date	EDOP File Time Range (UTC)	Description of Flight
5 August 1998	14:55 – 18:56	Ferry flight
8 August 1998	16:07 – 19:34	Sea breeze convection
13 August 1998	19:32 – 22:31	Coastal convection
15 August 1998	20:34 – 22:47	Sea breeze convection
23 August 1998	18:49 – 22:54	Hurricane Bonnie
24 August 1998	19:58 – 22:58	Hurricane Bonnie
26 August 1998	11:21 – 17:39	Hurricane Bonnie
2 September 1998	19:38 – 23:46	Hurricane Earl
5 September 1998	19:47 – 22:32	Coastal convection
13 September 1998	23:26 – 02:26	Calibration flight
17 September 1998	18:23 – 22:07	Oceanic convection
21 September 1998	14:44 – 17:39	Hurricane Georges
22 September 1998	18:29 – 01:43	Hurricane Georges
25 September 1998	13:02 – 20:20	Hurricane Georges
27 September 1998	18:28 – 19:23	Hurricane Georges

2. Reprocessing Methods

The data file used to produce the L1B reprocessed files were the Universal Format (UF) binary files containing the publicly available processed data (https://www.eol.ucar.edu/sites/default/files/files_live/private/UfDoc.txt). The processing applied to produce these original files included computing reflectivity and Doppler velocity from the raw moments data as well as removing the aircraft motion from the Doppler velocity and calibrating the reflectivity values. The spectrum width was also computed from the raw data during the original processing. The additional work performed as part of the modern reprocessing effort was to remove the effects of non-uniform beam filling (NUBF) from the Doppler velocities and to package the data in a netcdf4 format, complete with meta data. While the data collected by the nadir and forward-angled antenna are stored in separate files, the time stamps for data from each antenna are matched such that the pair of files will contain the exact same time stamps.

For a nadir-pointing beam, the effect of NUBF on the Doppler velocity is to produce an apparent upward motion where reflectivity increases in the along-track direction and an apparent downward motion where reflectivity decreases in the along-track direction. As such, the NUBF correction for the nadir antenna data set is a function of the along-track gradient in reflectivity. For the forward-angled antenna, however, the vertical gradient in reflectivity must also be considered. The equation we use for computing the NUBF correction, v_N is as follows:

$$v_N = v_P \frac{\beta^2 R \ln(10)}{160 \ln(2)} (\nabla_y(dBZ_e) \cos^2 \phi_0 + \nabla_z(dBZ_e) \cos \phi_0 \sin \phi_0),$$

where v_P is the aircraft ground speed, y is oriented in the along-track direction, z is oriented in the vertical (positive upwards), β is the angular beam width in radians, ϕ_0 is the along-track angle of the beam center from nadir, R is the range from the antenna (positive away from the antenna), and dBZ_e is the reflectivity in logarithmic units. Note, for the nadir-pointing antenna, the vertical reflectivity gradient term drops out. For CAMEX-4, we computed the along-track gradient using a convolution of the kernel $[-1, 0, 0, 0, 1]$, which covers two seconds of data collection, and the along-beam gradient using a convolution of the kernel $[-1, 0, 0, 0, 0, 1]$. The vertical reflectivity gradient can then be computed by the following equation:

$$\nabla_z(dBZ_e) = \frac{\nabla_y(dBZ_e) \sin \phi_0 - \nabla_B(dBZ_e)}{\cos \phi_0},$$

where $\nabla_B(dBZ_e)$ is the along-beam gradient (positive away from the antenna).

Additionally, because time stamps were stored with integer seconds and EDOP recorded data twice per second, a time correction was applied. For each pair of identical time stamps in the record, the time correction add 0.5 seconds to the latter of the pair. 0.5 seconds is added to the initial time only if the initial time is unique (i.e., the file record starts on what would have been the latter time step of a pair had the file started earlier). Occasionally, there are more than the two expected duplicates. We first attempt to fit all the data into the time line at no greater than 0.5 second intervals. In instances where there is no way to fit all the data into the timeline without resorting to sub-half second intervals, we simply spread the data points linearly in time.

3. Known Issues

1. Lack of noise estimate – Due to thresholding applied in the original processed data used to produce the reprocessed data, we were unable to estimate the noise level. Instead, we use a power threshold of -120 dBm to mask the data arrays.

4. Change Log

The following is a record of changes that occurred in each version of this data set, listed in reverse chronological order such that the most recent data version is at the top.

RevA	Made correction to forward-antenna NUBF correction and added some missing metadata.
Rev-	Initial release of reprocessed data files.

5. Netcdf4 Format

The following is a copy of the output of `ncdump -h` for the nadir and forward-angle 17:08 – 17:21 UTC 8 August 1998 files:

5.1 Nadir antenna file

```
netcdf CAMEX3_EDOP_Nadir_L1B_RevA_199808081708_199808081721 {

// global attributes:
    :Title = "Level1B processed EDOP airborne Doppler radar nadir antenna data collected during
CAMEX-3" ;
    :Institution = "NASA Goddard Space Flight Center, Mesoscale Atmospheric Processes Lab (Code
612), High Altitude Radar Group" ;
    :Radar = "EDOP" ;
    :AntennaDescriptor = "Nadir Antenna" ;
    :Aircraft = "NASA ER-2" ;
    :Experiment = "CAMEX-3" ;
    :FlightID = "98-042" ;
    :FlightDate = "19980808" ;
    :FlightLegName = "" ;
    :FlightLegCode = "" ;
    :ExperimentPI = "" ;
    :InstrumentPI = "Gerald M. Heymsfield, NASA/GSFC" ;
    :DataContacts = "Charles N. Helms, UMD/ESSIC & NASA/GSFC, charles.n.helms@nasa.gov;
Matthew L. Walker McLinden, NASA/GSFC, matthew.l.mclinden@nasa.gov" ;
    :Rawdata_filename = "980808_1708-1721" ;
    :UFfilename = "980808_1708-1721.uf.2.1" ;
    :UFprocessDate = "11/01/**" ;
    :UFlastModificationDate = "11/01/**" ;
    :L1B_processDate = "2025-04-04 19:17:29.004531+00:00" ;
    :L1B_revision = "RevA" ;
    :L1B_revisionNote = "Made correction to forward-antenna NUBF correction and added some
missing metadata. Please reach out to the data contacts with any questions or concerns regarding the
data." ;
    :L1B_revisionHistory = "Revision History:\nRevA :: Made correction to forward-antenna NUBF
correction and added some missing metadata.\nRev- :: Initial release of the reprocessed CAMEX3
data.\n" ;
    :NavigationSource = "ER-2 aircraft GPS/INS Hybrid with altitude taken from ER-2 GPS" ;
    :AirfieldName = "Patrick AFB, Florida, USA" ;
    :AirfieldLatitude = 28.24f ;
    :AirfieldLongitude = -80.61f ;
    :TiltFromNadir_degrees = 0.8f ;
    :AzimuthFromHeading_degrees = 0.f ;
    :GateSpacing_m = 37.5f ;
    :PulseWidth_Hz = 0.5f ;
    :PRF_Hz = 2200.f, 4400.f ;
    :PRT_usec = 454.5f, 227.3f ;
    :NyquistVelocity_m_s-1 = 33.86f ;
    :ReflIntegrationTime_sec = 0.5f ;
    :DopIntegrationTime_sec = 0.f ;
```

```

:RadarConstant_dB = 87.19f ;
:IFbandwidth_MHz = 0.f ;
:Frequency_GHz = 9.72f ;
:Wavelength_cm = 3.109375f ;
:Beamwidth_degrees = 3.f ;
:TransmitPower_dBm = 68.f ;
:ReceiverBandwidth_MHz = 0.f ;
:TransmitRecievePolarization = "VV" ;
:ReceiverGain_dB = 0.f ;
:PeakPower_dBmW = 68.f ;
:AntennaGain_dB = 36.09f ;
:PulseLength_usec = 0.32f ;
:UFdumpFilename = "C3_EDOP_UFdump_980808_1708-1721.uf.2.1.nc" ;

```

```

group: Products {
  dimensions:
    Range = 729 ;
    TimeUTC = 1515 ;
  variables:
    float Range(Range) ;
      Range:_FillValue = NaNf ;
      Range:correctionFromUF_meters = 299.f ;
      Range:units = "meters" ;
      Range:description = "Along-beam range in meters from antenna" ;
    double TimeUTC(TimeUTC) ;
      TimeUTC:_FillValue = NaN ;
      TimeUTC:source = "Aircraft INS time" ;
      TimeUTC:units = "seconds since 1970-01-01 00:00 UTC" ;
      TimeUTC:correctionFromUF_seconds = 0.f ;
      TimeUTC:description = "UTC profile time in unix epoch format (seconds since 00 UTC 1 January
1970)" ;
    float dBZeCoPol(Range, TimeUTC) ;
      dBZeCoPol:_FillValue = NaNf ;
      dBZeCoPol:UF_fieldName = "ZN" ;
      dBZeCoPol:description = "Equivalent reflectivity factor in dB for the co-polarization channel" ;
      dBZeCoPol:units = "10*log10(mm^6/m^3)" ;
      dBZeCoPol:calibration_constant_dB = 0.f ;
    float dBZeSfcCh(Range, TimeUTC) ;
      dBZeSfcCh:_FillValue = NaNf ;
      dBZeSfcCh:units = "10*log10(mm^6/m^3)" ;
      dBZeSfcCh:description = "Equivalent reflectivity factor in dB for the surface channel" ;
      dBZeSfcCh:calibration_constant_dB = 0.f ;
      dBZeSfcCh:gateShift_gates = 0s ;
      dBZeSfcCh:UF_fieldName = "ZS" ;
    float VelocityCorrectedCoPol(Range, TimeUTC) ;
      VelocityCorrectedCoPol:_FillValue = NaNf ;

```

```

    VelocityCorrectedCoPol:description = "Co-polarization channel Doppler velocity corrected to
account for both non-uniform beam filling and aircraft motion. Note, the MaskCoPol mask is applied
during the NUBF correction." ;
    VelocityCorrectedCoPol:units = "m/s" ;
    VelocityCorrectedCoPol:signConvention = "Away from antenna is positive" ;
    VelocityCorrectedCoPol:equation = "VelocityCorrected = VelocityUncorrected +
DopplerCorrectionNUBF" ;
    float VelocityUncorrectedCoPol(Range, TimeUTC) ;
    VelocityUncorrectedCoPol:description = "Co-polarization channel Doppler velocity with only
the aircraft motion correction applied" ;
    VelocityUncorrectedCoPol:equation = "VelocityCorrected = VelocityUncorrected +
DopplerCorrectionNUBF" ;
    VelocityUncorrectedCoPol:UF_fieldName = "VN" ;
    VelocityUncorrectedCoPol:_FillValue = NaNf ;
    VelocityUncorrectedCoPol:units = "m/s" ;
    VelocityUncorrectedCoPol:signConvention = "Away from antenna is positive" ;
    float PowerCoPol(Range, TimeUTC) ;
    PowerCoPol:_FillValue = NaNf ;
    PowerCoPol:description = "Recieved power for the co-polarization channel" ;
    PowerCoPol:units = "dBm" ;
    PowerCoPol:UF_fieldname = "MN" ;
    float PowerSfcCh(Range, TimeUTC) ;
    PowerSfcCh:_FillValue = NaNf ;
    PowerSfcCh:description = "Recieved power for the surface channel" ;
    PowerSfcCh:units = "dBm" ;
    PowerSfcCh:gateShift_gates = 0s ;
    PowerSfcCh:UF_fieldname = "MS" ;
    float SpectrumWidthCoPol(Range, TimeUTC) ;
    SpectrumWidthCoPol:description = "Doppler spectrum width estimate for the co-polarization
channel" ;
    SpectrumWidthCoPol:units = "m/s" ;
    SpectrumWidthCoPol:UF_fieldname = "WN" ;
    SpectrumWidthCoPol:_FillValue = NaNf ;
    float SpectrumWidthSfcCh(Range, TimeUTC) ;
    SpectrumWidthSfcCh:_FillValue = NaNf ;
    SpectrumWidthSfcCh:description = "Doppler spectrum width estimate for the surface channel"
;
    SpectrumWidthSfcCh:units = "m/s" ;
    SpectrumWidthSfcCh:gateShift_gates = 0LL ;
    SpectrumWidthSfcCh:UF_fieldname = "WS" ;
} // group Products

group: Information {
    dimensions:
        Range = 729 ;
        TimeUTC = 1515 ;
    variables:
        byte MaskCoPol(Range, TimeUTC) ;

```

```

MaskCoPol:description = "Mask for removing noise. Noise was set to a missing value in original
data, so mask is generated based on that missing value." ;
MaskCoPol:key = "0 = Signal, 1 = Noise" ;
byte MaskSfcCh(Range, TimeUTC) ;
MaskSfcCh:description = "Mask for removing noise. Noise was set to a missing value in original
data, so mask is generated based on that missing value." ;
MaskSfcCh:key = "0 = Signal, 1 = Noise" ;
short OceanGateIndex(TimeUTC) ;
OceanGateIndex:_FillValue = 0s ;
OceanGateIndex:description = "Range index of gate at expected zero altitude above mean sea
level based on radar geometry and aircraft attitude." ;
float DopplerCorrectionAircraftMotion(TimeUTC) ;
DopplerCorrectionAircraftMotion:_FillValue = NaNf ;
DopplerCorrectionAircraftMotion:description = "Estimated aircraft motion correction to
Doppler velocity" ;
DopplerCorrectionAircraftMotion:units = "m/s" ;
DopplerCorrectionAircraftMotion:note = "Correction is already applied to both
VelocityCorrected and VelocityUncorrected" ;
float DopplerCorrectionCoPolNUBF(Range, TimeUTC) ;
DopplerCorrectionCoPolNUBF:_FillValue = NaNf ;
DopplerCorrectionCoPolNUBF:description = "Estimated non-uniform beam filling correction to
co-polarization channel Doppler velocity accounting for horizontal reflectivity gradients" ;
DopplerCorrectionCoPolNUBF:units = "m/s" ;
DopplerCorrectionCoPolNUBF:horizontalGradientKernal = -1s, 0s, 0s, 0s, 1s ;
DopplerCorrectionCoPolNUBF:note = "Correction is already applied to both VelocityCorrected
and VelocityUncorrected" ;
float dxdr(TimeUTC) ;
dxdr:_FillValue = NaNf ;
dxdr:description = "Data cross-track distance from aircraft per unit range" ;
dxdr:units = "m/m" ;
dxdr:convention = "Positive is in the starboard direction" ;
float dydr(TimeUTC) ;
dydr:_FillValue = NaNf ;
dydr:description = "Data along-track distance from aircraft per unit range" ;
dydr:units = "m/m" ;
dydr:convention = "Positive is in the direction of aircraft travel" ;
float dzdr(TimeUTC) ;
dzdr:_FillValue = NaNf ;
dzdr:description = "Data vertical distance from aircraft per unit range" ;
dzdr:units = "m/m" ;
dzdr:convention = "Positive is in the upward direction" ;
float horizontalResolution6dB(Range) ;
horizontalResolution6dB:_FillValue = NaNf ;
horizontalResolution6dB:description = "Approximate horizontal resolution defined as width of
spatial weighting after averaging as a function of radar range" ;
horizontalResolution6dB:units = "meters" ;
} // group Information

```

```

group: Navigation {
  dimensions:
    TimeUTC = 1515 ;
  variables:
    float NominalDistance(TimeUTC) ;
      NominalDistance:_FillValue = NaNf ;
      NominalDistance:description = "Nominal aircraft travel distance estimated by cumulatively
summing the instantaneous velocities" ;
      NominalDistance:units = "meters" ;
      NominalDistance:source = "TimeUTC and GroundSpeed" ;
    float Latitude(TimeUTC) ;
      Latitude:_FillValue = NaNf ;
      Latitude:description = "Latitude" ;
      Latitude:units = "degreesNorth" ;
    float Longitude(TimeUTC) ;
      Longitude:_FillValue = NaNf ;
      Longitude:description = "Longitude" ;
      Longitude:units = "degreesEast" ;
    float Altitude(TimeUTC) ;
      Altitude:_FillValue = NaNf ;
      Altitude:description = "Aircraft height above sea level" ;
      Altitude:units = "meters" ;
    float GroundSpeed(TimeUTC) ;
      GroundSpeed:_FillValue = NaNf ;
      GroundSpeed:description = "Aircraft total horizontal speed" ;
      GroundSpeed:units = "m/s" ;
    float NorthVelocity(TimeUTC) ;
      NorthVelocity:_FillValue = NaNf ;
      NorthVelocity:description = "Aircraft northward component of velocity" ;
      NorthVelocity:units = "m/s" ;
    float EastVelocity(TimeUTC) ;
      EastVelocity:_FillValue = NaNf ;
      EastVelocity:description = "Aircraft eastward component of velocity" ;
      EastVelocity:units = "m/s" ;
    float UpVelocity(TimeUTC) ;
      UpVelocity:_FillValue = NaNf ;
      UpVelocity:description = "Aircraft upward component of velocity" ;
      UpVelocity:units = "m/s" ;
    float Track(TimeUTC) ;
      Track:_FillValue = NaNf ;
      Track:description = "Direction of motion in degrees from north with 90 degrees indicating
eastward motion" ;
      Track:units = "degrees" ;
    float Heading(TimeUTC) ;
      Heading:_FillValue = NaNf ;
      Heading:description = "Direction towards which aircraft nose is pointing in degrees from north
with 90 degrees indicating eastward pointing" ;
      Heading:units = "degrees" ;

```

```

        Heading:correctionFromUF_degrees = 0.f ;
float Drift(TimeUTC) ;
    Drift:_FillValue = NaNf ;
    Drift:description = "Difference between track and heading" ;
    Drift:units = "degrees" ;
    Drift:equation = "Drift = Track - Heading" ;
float Roll(TimeUTC) ;
    Roll:_FillValue = NaNf ;
    Roll:description = "Roll about along-aircraft axis. Positive values correspond to the starboard
(right) wing dipping" ;
    Roll:units = "degrees" ;
    Roll:correctionFromUF_degrees = 0.f ;
float Pitch(TimeUTC) ;
    Pitch:_FillValue = NaNf ;
    Pitch:units = "degrees" ;
    Pitch:description = "Pitch about across-aircraft axis. Positive values correspond to a nose up
position" ;
    Pitch:correctionFromUF_degrees = 0.f ;
float VerticalAcceleration(TimeUTC) ;
    VerticalAcceleration:_FillValue = NaNf ;
    VerticalAcceleration:units = "m/s/s" ;
    VerticalAcceleration:description = "Vertical acceleration of aircraft" ;
float FlightLevelWindDirection(TimeUTC) ;
    FlightLevelWindDirection:_FillValue = NaNf ;
    FlightLevelWindDirection:description = "Observed wind direction at flight level" ;
    FlightLevelWindDirection:units = "degrees" ;
    FlightLevelWindDirection:source = "INS" ;
float FlightLevelWindSpeed(TimeUTC) ;
    FlightLevelWindSpeed:_FillValue = NaNf ;
    FlightLevelWindSpeed:description = "Observed wind speed at flight level" ;
    FlightLevelWindSpeed:units = "m/s" ;
    FlightLevelWindSpeed:source = "INS" ;
} // group Navigation
}

```

5.2 Forward-angle Antenna File

```

netcdf CAMEX3_EDOP_Forward_L1B_RevA_199808081708_199808081721 {

// global attributes:
    :Title = "Level1B processed EDOP airborne Doppler radar forward antenna data collected during
CAMEX-3" ;
    :Institution = "NASA Goddard Space Flight Center, Mesoscale Atmospheric Processes Lab (Code
612), High Altitude Radar Group" ;
    :Radar = "EDOP" ;
    :AntennaDescriptor = "Forward Antenna" ;
    :Aircraft = "NASA ER-2" ;

```

:Experiment = "CAMEX-3" ;
:FlightID = "98-042" ;
:FlightDate = "19980808" ;
:FlightLegName = "" ;
:FlightLegCode = "" ;
:ExperimentPI = "" ;
:InstrumentPI = "Gerald M. Heymsfield, NASA/GSFC" ;
:DataContacts = "Charles N. Helms, UMD/ESSIC & NASA/GSFC, charles.n.helms@nasa.gov;
Matthew L. Walker McLinden, NASA/GSFC, matthew.l.mclinden@nasa.gov" ;
:Rawdata_filename = "980808_1708-1721" ;
:UFfilename = "980808_1708-1721.uf.2.1" ;
:UFprocessDate = "11/01/**" ;
:UFlastModificationDate = "11/01/**" ;
:L1B_processDate = "2025-04-04 19:17:29.012246+00:00" ;
:L1B_revision = "RevA" ;
:L1B_revisionNote = "Made correction to forward-antenna NUBF correction and added some
missing metadata. Please reach out to the data contacts with any questions or concerns regarding the
data." ;
:L1B_revisionHistory = "Revision History:\nRevA :: Made correction to forward-antenna NUBF
correction and added some missing metadata.\nRev- :: Initial release of the reprocessed CAMEX3
data.\n" ;
:NavigationSource = "ER-2 aircraft GPS/INS Hybrid with altitude taken from ER-2 GPS" ;
:AirfieldName = "Patrick AFB, Florida, USA" ;
:AirfieldLatitude = 28.24f ;
:AirfieldLongitude = -80.61f ;
:TiltFromNadir_degrees = 33.9f ;
:AzimuthFromHeading_degrees = 0.f ;
:GateSpacing_m = 37.5f ;
:PulseWidth_Hz = 0.5f ;
:PRF_Hz = 2200LL, 4400LL ;
:PRT_usec = 454.5, 227.3 ;
:NyquistVelocity_m_s-1 = 33.86f ;
:ReflIntegrationTime_sec = 0.5f ;
:DopIntegrationTime_sec = 0.f ;
:RadarConstant_dB = 88.48f ;
:IFbandwidth_MHz = 0.f ;
:Frequency_GHz = 9.72f ;
:Wavelength_cm = 3.109375f ;
:Beamwidth_degrees = 3.f ;
:TransmitPower_dBm = 68.f ;
:ReceiverBandwidth_MHz = 0.f ;
:TransmitRecievePolarization = "VV, VH" ;
:ReceiverGain_dB = 0.f ;
:PeakPower_dBmW = 68.f ;
:AntennaGain_dB = 35.5f ;
:PulseLength_usec = 0.32f ;
:UFdumpFilename = "C3_EDOP_UFdump_980808_1708-1721.uf.2.1.nc" ;

```

group: Products {
  dimensions:
    TimeUTC = 1515 ;
    Range = 729 ;
  variables:
    double TimeUTC(TimeUTC) ;
    TimeUTC:_FillValue = NaN ;
    TimeUTC:source = "Aircraft INS time" ;
    TimeUTC:units = "seconds since 1970-01-01 00:00 UTC" ;
    TimeUTC:correctionFromUF_seconds = 0.f ;
    TimeUTC:description = "UTC profile time in unix epoch format (seconds since 00 UTC 1 January
1970)" ;
    float Range(Range) ;
    Range:_FillValue = NaNf ;
    Range:correctionFromUF_meters = 296.f ;
    Range:units = "meters" ;
    Range:description = "Along-beam range in meters from antenna" ;
    float dBZeCoPol(Range, TimeUTC) ;
    dBZeCoPol:_FillValue = NaNf ;
    dBZeCoPol:description = "Equivalent reflectivity factor in dB for the co-polarization channel" ;
    dBZeCoPol:units = "10*log10(mm^6/m^3)" ;
    dBZeCoPol:calibration_constant_dB = 0.f ;
    dBZeCoPol:UF_fieldName = "ZF" ;
    float dBZeCrPol(Range, TimeUTC) ;
    dBZeCrPol:_FillValue = NaNf ;
    dBZeCrPol:description = "Equivalent reflectivity factor in dB for the cross-polarization channel" ;
    dBZeCrPol:units = "10*log10(mm^6/m^3)" ;
    dBZeCrPol:calibration_constant_dB = 0.f ;
    dBZeCrPol:gateShift_gates = 0s ;
    dBZeCrPol:UF_fieldName = "ZX" ;
    float VelocityCorrectedCoPol(Range, TimeUTC) ;
    VelocityCorrectedCoPol:_FillValue = NaNf ;
    VelocityCorrectedCoPol:description = "Co-polarization channel Doppler velocity corrected to
account for both non-uniform beam filling and aircraft motion. Note, the MaskCoPol mask is applied
during the NUBF correction." ;
    VelocityCorrectedCoPol:units = "m/s" ;
    VelocityCorrectedCoPol:signConvention = "Away from antenna is positive" ;
    VelocityCorrectedCoPol:equation = "VelocityCorrected = VelocityUncorrected +
DopplerCorrectionNUBF" ;
    float VelocityUncorrectedCoPol(Range, TimeUTC) ;
    VelocityUncorrectedCoPol:equation = "VelocityCorrected = VelocityUncorrected +
DopplerCorrectionNUBF" ;
    VelocityUncorrectedCoPol:_FillValue = NaNf ;
    VelocityUncorrectedCoPol:description = "Co-polarization channel Doppler velocity with only
the aircraft motion correction applied" ;
    VelocityUncorrectedCoPol:units = "m/s" ;
    VelocityUncorrectedCoPol:signConvention = "Away from antenna is positive" ;
    VelocityUncorrectedCoPol:UF_fieldName = "VF" ;

```

```

float PowerCoPol(Range, TimeUTC) ;
    PowerCoPol:_FillValue = NaNf ;
    PowerCoPol:description = "Recieved power for the co-polarization channel" ;
    PowerCoPol:units = "dBm" ;
    PowerCoPol:UF_fieldname = "MF" ;
float PowerCrPol(Range, TimeUTC) ;
    PowerCrPol:_FillValue = NaNf ;
    PowerCrPol:description = "Recieved power for the cross-polarization channel" ;
    PowerCrPol:units = "dBm" ;
    PowerCrPol:gateShift_gates = 0s ;
    PowerCrPol:UF_fieldname = "MX" ;
float SpectrumWidthCoPol(Range, TimeUTC) ;
    SpectrumWidthCoPol:description = "Doppler spectrum width estimate for the co-polarization
channel" ;
    SpectrumWidthCoPol:units = "m/s" ;
    SpectrumWidthCoPol:UF_fieldname = "WF" ;
    SpectrumWidthCoPol:_FillValue = NaNf ;
float SpectrumWidthCrPol(Range, TimeUTC) ;
    SpectrumWidthCrPol:_FillValue = NaNf ;
    SpectrumWidthCrPol:description = "Doppler spectrum width estimate with aircraft motion
removed for the cross-polarization channel" ;
    SpectrumWidthCrPol:units = "m/s" ;
    SpectrumWidthCrPol:gateShift_gates = 0LL ;
    SpectrumWidthCrPol:UF_fieldname = "WX" ;
float LDR(Range, TimeUTC) ;
    LDR:_FillValue = NaNf ;
    LDR:description = "Linear depolarization ratio (CrPol/CoPol)" ;
    LDR:units = "dB" ;
} // group Products

group: Information {
    dimensions:
        Range = 729 ;
        TimeUTC = 1515 ;
    variables:
        byte MaskCoPol(Range, TimeUTC) ;
            MaskCoPol:description = "Mask for removing noise. Noise was set to a missing value in original
data, so mask is generated based on that missing value." ;
            MaskCoPol:key = "0 = Signal, 1 = Noise" ;
        byte MaskCrPol(Range, TimeUTC) ;
            MaskCrPol:description = "Mask for removing noise. Noise was set to a missing value in original
data, so mask is generated based on that missing value." ;
            MaskCrPol:key = "0 = Signal, 1 = Noise" ;
        short OceanGateIndex(TimeUTC) ;
            OceanGateIndex:_FillValue = 0s ;
            OceanGateIndex:description = "Range index of gate at expected zero altitude above mean sea
level based on radar geometry and aircraft attitude." ;
        float DopplerCorrectionAircraftMotion(TimeUTC) ;

```

```

    DopplerCorrectionAircraftMotion:_FillValue = NaNf ;
    DopplerCorrectionAircraftMotion:description = "Estimated aircraft motion correction to
Doppler velocity" ;
    DopplerCorrectionAircraftMotion:units = "m/s" ;
    DopplerCorrectionAircraftMotion:note = "Correction is already applied to both
VelocityCorrected and VelocityUncorrected" ;
    float DopplerCorrectionCoPolNUBF(Range, TimeUTC) ;
    DopplerCorrectionCoPolNUBF:_FillValue = NaNf ;
    DopplerCorrectionCoPolNUBF:description = "Estimated non-uniform beam filling correction to
co-polarizontaion channel Doppler velocity accounting for both horizontal and vertical reflectivity
gradients" ;
    DopplerCorrectionCoPolNUBF:units = "m/s" ;
    DopplerCorrectionCoPolNUBF:horizontalGradientKernal = -1s, 0s, 0s, 0s, 1s ;
    DopplerCorrectionCoPolNUBF:alongBeamGradientKernal = -1s, 0s, 0s, 0s, 0s, 0s, 1s ;
    DopplerCorrectionCoPolNUBF:note = "Correction is already applied to both VelocityCorrected
and VelocityUncorrected" ;
    float dxdr(TimeUTC) ;
    dxdr:_FillValue = NaNf ;
    dxdr:description = "Data cross-track distance from aircraft per unit range" ;
    dxdr:units = "m/m" ;
    dxdr:convention = "Positive is in the starboard direction" ;
    float dydr(TimeUTC) ;
    dydr:_FillValue = NaNf ;
    dydr:description = "Data along-track distance from aircraft per unit range" ;
    dydr:units = "m/m" ;
    dydr:convention = "Positive is in the direction of aircraft travel" ;
    float dzdr(TimeUTC) ;
    dzdr:_FillValue = NaNf ;
    dzdr:description = "Data vertical distance from aircraft per unit range" ;
    dzdr:units = "m/m" ;
    dzdr:convention = "Positive is in the upward direction" ;
    float horizontalResolution6dB(Range) ;
    horizontalResolution6dB:_FillValue = NaNf ;
    horizontalResolution6dB:description = "Approximate horizontal resolution defined as width of
spatial weighting after averaging as a function of radar range" ;
    horizontalResolution6dB:units = "meters" ;
} // group Information

```

```

group: Navigation {
    dimensions:
        TimeUTC = 1515 ;
    variables:
        float NominalDistance(TimeUTC) ;
        NominalDistance:_FillValue = NaNf ;
        NominalDistance:description = "Nominal aircraft travel distance estimated by cumulatively
summing the instantaneous velocities" ;
        NominalDistance:units = "meters" ;
        NominalDistance:source = "TimeUTC and GroundSpeed" ;
}

```

```

float Latitude(TimeUTC) ;
    Latitude:_FillValue = NaNf ;
    Latitude:description = "Latitude" ;
    Latitude:units = "degreesNorth" ;
float Longitude(TimeUTC) ;
    Longitude:_FillValue = NaNf ;
    Longitude:description = "Longitude" ;
    Longitude:units = "degreesEast" ;
float Altitude(TimeUTC) ;
    Altitude:_FillValue = NaNf ;
    Altitude:description = "Aircraft height above sea level" ;
    Altitude:units = "meters" ;
float GroundSpeed(TimeUTC) ;
    GroundSpeed:_FillValue = NaNf ;
    GroundSpeed:description = "Aircraft total horizontal speed" ;
    GroundSpeed:units = "m/s" ;
float NorthVelocity(TimeUTC) ;
    NorthVelocity:_FillValue = NaNf ;
    NorthVelocity:description = "Aircraft northward component of velocity" ;
    NorthVelocity:units = "m/s" ;
float EastVelocity(TimeUTC) ;
    EastVelocity:_FillValue = NaNf ;
    EastVelocity:description = "Aircraft eastward component of velocity" ;
    EastVelocity:units = "m/s" ;
float UpVelocity(TimeUTC) ;
    UpVelocity:_FillValue = NaNf ;
    UpVelocity:description = "Aircraft upward component of velocity" ;
    UpVelocity:units = "m/s" ;
float Track(TimeUTC) ;
    Track:_FillValue = NaNf ;
    Track:description = "Direction of motion in degrees from north with 90 degrees indicating
eastward motion" ;
    Track:units = "degrees" ;
float Heading(TimeUTC) ;
    Heading:_FillValue = NaNf ;
    Heading:description = "Direction towards which aircraft nose is pointing in degrees from north
with 90 degrees indicating eastward pointing" ;
    Heading:units = "degrees" ;
    Heading:correctionFromUF_degrees = 0.f ;
float Drift(TimeUTC) ;
    Drift:_FillValue = NaNf ;
    Drift:description = "Difference between track and heading" ;
    Drift:units = "degrees" ;
    Drift:equation = "Drift = Track - Heading" ;
float Roll(TimeUTC) ;
    Roll:_FillValue = NaNf ;
    Roll:description = "Roll about along-aircraft axis. Positive values correspond to the starboard
(right) wing dipping" ;

```

```
    Roll:units = "degrees" ;
    Roll:correctionFromUF_degrees = 0.f ;
float Pitch(TimeUTC) ;
    Pitch:_FillValue = NaNf ;
    Pitch:units = "degrees" ;
    Pitch:description = "Pitch about across-aircraft axis. Positive values correspond to a nose up
position" ;
    Pitch:correctionFromUF_degrees = 0.f ;
float VerticalAcceleration(TimeUTC) ;
    VerticalAcceleration:_FillValue = NaNf ;
    VerticalAcceleration:units = "m/s/s" ;
    VerticalAcceleration:description = "Vertical acceleration of aircraft" ;
float FlightLevelWindDirection(TimeUTC) ;
    FlightLevelWindDirection:_FillValue = NaNf ;
    FlightLevelWindDirection:description = "Observed wind direction at flight level" ;
    FlightLevelWindDirection:units = "degrees" ;
    FlightLevelWindDirection:source = "INS" ;
float FlightLevelWindSpeed(TimeUTC) ;
    FlightLevelWindSpeed:_FillValue = NaNf ;
    FlightLevelWindSpeed:description = "Observed wind speed at flight level" ;
    FlightLevelWindSpeed:units = "m/s" ;
    FlightLevelWindSpeed:source = "INS" ;
} // group Navigation
}
```