Package ‘radar’

October 14, 2022

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Title Fundamental Formulas for Radar
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Description Fundamental formulas for Radar, for attenuation, range, velocity, effectiveness, power, scatter, doppler, geometry, radar equations, etc.
Based on Nick Guy’s Python package PyRadarMet
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ApertureWeightingFunctionsAntenna

Description

ApertureWeightingFunctionsAntenna has Antenna Characteristics for Aperture Weighting Functions

Usage

ApertureWeightingFunctionsAntenna

Author(s)

Jose Gama
**AttenuationAbsCoeff**

**Source**

**References**

**Examples**
```python
data(ApertureWeightingFunctionsAntenna)
str(ApertureWeightingFunctionsAntenna)
```

---

**AttenuationAbsCoeff** Absorption coefficient of a spherical particle

**Description**
AttenuationAbsCoeff Absorption coefficient of a spherical particle. From Doviak and Zrnic (1993), Eqn 3.14a or Battan (1973), Eqn 6.6

**Usage**
AttenuationAbsCoeff(D, lam, m)

**Arguments**
- **D** Particle diameter (m)
- **lam** Radar wavelength (m)
- **m** Complex refractive index (unitless)

**Value**
- **Qa** Absorption coefficient [unitless]

**Author(s)**
Jose Gama

**Source**
Doviak, R.J. and Zrnic, D.S., 1993 Doppler radar and weather observations, Academic Press


References

Doviak, R.J. and Zrnić, D.S., 1993 Doppler radar and weather observations, Academic Press

AttenuationExtCoeff

Extinction coefficient of a spherical particle

Description

AttenuationExtCoeff Extinction coefficient of a spherical particle. From Doviak and Zrnic (1993), Eqn 3.14a or Battan (1973), Eqn 6.5

Usage

AttenuationExtCoeff(D, lam, m)

Arguments

D       Particle diameter (m)
lam    Radar wavelength (m)
m      Complex refractive index (unitless)

Value

Qe      Extinction coefficient [unitless]

Author(s)

Jose Gama

Source

Doviak, R.J. and Zrnić, D.S., 1993 Doppler radar and weather observations, Academic Press

References

Doviak, R.J. and Zrnić, D.S., 1993 Doppler radar and weather observations, Academic Press
AttenuationScatCoeff  Scattering coefficient of a spherical particle

Description

AttenuationScatCoeff Scattering coefficient of a spherical particle. From Doviak and Zrnic (1993), Eqn 3.14a or Battan (1973), Eqn 6.5

Usage

AttenuationScatCoeff(D, lam, m)

Arguments

D  Particle diameter (m)

lam  Radar wavelength (m)

m  Complex refractive index (unitless)

Value

Qs  Scattering coefficient [unitless]

Author(s)

Jose Gama

Source


Doviak, R.J. and Zrnić, D.S., 1993 Doppler radar and weather observations, Academic Press


References


Doviak, R.J. and Zrnić, D.S., 1993 Doppler radar and weather observations, Academic Press

Conversion from dBZ (log) units to linear Z units

**Description**

ConversiondBZ2Z Converting from dBZ (log) units to linear Z units

**Usage**

ConversiondBZ2Z(dBZ)

**Arguments**

- dBZ logarithmic reflectivity value

**Value**

- Z linear reflectivity units

**Author(s)**

Jose Gama

**Source**


**References**


Conversion from linear Z units to dBZ (log) units

**Description**

ConversionZ2dBZ Converting from linear Z units to dBZ (log) units

**Usage**

ConversionZ2dBZ(Zlin)

**Arguments**

- Zlin linear reflectivity units
DopplerDilemma

Value
   dBZ      logarithmic reflectivity value

Author(s)
   Jose Gama

Source

References

DopplerDilemma returns the Doppler dilemma From Rinehart (1997), Eqn 6.12

Usage
   DopplerDilemma(inFloat, lam, speedOfLight)

Arguments
   inFloat      Nyquist Velocity [m/s] or Maximum unambiguous range [m]
   lam          Radar wavelength [m]
   speedOfLight speed of light

Value
   Rmax        Maximum unambiguous range [m]

Author(s)
   Jose Gama

Source
DopplerFmax

References


---

**DopplerFmax**

*Maximum frequency given PRF*

---

**Description**

DopplerFmax returns the PRF for a maximum frequency From Rinehart (1997), Eqn 6.8

**Usage**

DopplerFmax(PRF)

**Arguments**

| PRF | Pulse repetition frequency [Hz] |

**Value**

| f   | Maximum frequency [Hz] |

**Author(s)**

Jose Gama

**Source**


**References**


**DopplerFreq**  
*Frequency given wavelength*

---

**Description**

DopplerFreq Converts from wavelength to frequency

**Usage**

DopplerFreq(lam, speedOfLight)

**Arguments**

- `lam`  
  Wavelength [m]
- `speedOfLight`  
  speed of light

**Value**

- `f`  
  Frequency [Hz]

**Author(s)**

Jose Gama

**Source**


**References**


---

**DopplerPulseDuration**  
*Pulse duration from pulse length*

---

**Description**

DopplerPulseDuration Converts from pulse length to pulse duration

**Usage**

DopplerPulseDuration(tau, speedOfLight)
DopplerPulseLength

**Arguments**

- tau: Pulse length [m]
- speedOfLight: speed of light

**Value**

- pDur: Pulse duration [s]

**Author(s)**

Jose Gama

**Source**


**References**


---

DopplerPulseLength  
*Pulse length from pulse duration*

**Description**

DopplerPulseLength Converts from pulse duration to pulse length

**Usage**

DopplerPulseLength(pDur, speedOfLight)

**Arguments**

- pDur: Pulse duration [s]
- speedOfLight: speed of light

**Value**

- tau: Pulse length [m]

**Author(s)**

Jose Gama
**DopplerRmax**

**Source**


**References**


---

**Description**

DopplerRmax returns the maximum unambiguous range From Rinehart (1997), Eqn 6.11

**Usage**

DopplerRmax(PRF, speedOfLight)

**Arguments**

- **PRF**
  - Pulse repetition frequency [Hz]
- **speedOfLight**
  - speed of light

**Value**

- **Rmax**
  - Maximum unambiguous range [m]

**Author(s)**

Jose Gama

**Source**


**References**


DopplerVmax

Nyquist velocity, or maximum unambiguous Doppler velocity (+ or -)

Description

DopplerVmax returns the Nyquist velocity, or maximum unambiguous Doppler velocity (+ or -).

From Rinehart (1997), Eqn 6.8

Usage

DopplerVmax(PRF, lam)

Arguments

PRF Pulse repetition frequency [Hz]

lamb Radar wavelength [m]

Value

Vmax Nyquist velocity [m/s], +/-

Author(s)

Jose Gama

Source


References


DopplerVmaxDual

Doppler velocity from dual PRF scheme radar (+ or -)

Description

DopplerVmaxDual returns Doppler velocity [m/s] from a mobile platform. From Jorgensen (1983), Eqn 2

Usage

DopplerVmaxDual(lam, PRF1, PRF2)

Arguments

- **lam**: Radar wavelength [m]
- **PRF1**: First Pulse repetition frequency [Hz]
- **PRF2**: Second Pulse repetition frequency [Hz]

Value

- **Vmax**: Doppler velocity [m/s]

Author(s)

Jose Gama

Source


References


**DopplerVshift**

**Description**

DopplerVshift returns Adjusted Doppler velocity from a mobile platform. From Jorgensen (1983), Eqn 2

**Usage**

DopplerVshift(GS, psi)

**Arguments**

<table>
<thead>
<tr>
<th>Argument</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>GS</td>
<td>Gound speed [m/s]</td>
</tr>
<tr>
<td>psi</td>
<td>Angle between actual azimuth and fore/aft angle [deg]</td>
</tr>
</tbody>
</table>

**Value**

<table>
<thead>
<tr>
<th>Value</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Vshift</td>
<td>Shift in Doppler velocity from mobile aspect [m/s]</td>
</tr>
</tbody>
</table>

**Author(s)**

Jose Gama

**Source**


**References**


**DopplerWavelength**

*Wavelength given frequency*

---

**Description**

*DopplerWavelength* Converts from frequency to wavelength

**Usage**

*DopplerWavelength*(freq, speedOfLight)

**Arguments**

<table>
<thead>
<tr>
<th>Argument</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>freq</td>
<td>Frequency [Hz]</td>
</tr>
<tr>
<td>speedOfLight</td>
<td>speed of light</td>
</tr>
</tbody>
</table>

**Value**

<table>
<thead>
<tr>
<th>Value</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>lam</td>
<td>Wavelength [m]</td>
</tr>
</tbody>
</table>

**Author(s)**

Jose Gama

**Source**


**References**


---

**Electronic Warfare Frequency Bands**

*Electronic Warfare Frequency Bands*

---

**Description**

*ElectronicWarfareFrequencyBands* has Electronic Warfare Frequency Bands

**Usage**

*ElectronicWarfareFrequencyBands*

---
**Author(s)**

Jose Gama

**Source**


**References**


**Examples**

```matlab
data(ElectronicWarfareFrequencyBands)
str(ElectronicWarfareFrequencyBands)
```

---

**GeometryBeamBlockFrac**  
Partial beam blockage fraction

**Description**

GeometryBeamBlockFrac returns the partial beam blockage fraction From Bech et al. (2003), Eqn 2 and Appendix

**Usage**

```matlab
GeometryBeamBlockFrac(Th, Bh, a)
```

**Arguments**

- `Th`  
  Terrain height [m]
- `Bh`  
  Beam height [m]
- `a`  
  Half power beam radius [m]

**Value**

- `PBB`  
  Partial beam blockage fraction [unitless]

**Author(s)**

Jose Gama
Geometry\texttt{HalfPowerRadius}

Source

References

\begin{verbatim}
Geometry\texttt{HalfPowerRadius}

    \textit{Half-power radius}

\end{verbatim}

Description
Geometry\texttt{HalfPowerRadius} returns the half-power radius Battan (1973)

Usage
Geometry\texttt{HalfPowerRadius}(r, bwhalf)

Arguments
\begin{itemize}
    \item \texttt{r} \hspace{1cm} Range [m]
    \item \texttt{bwhalf} \hspace{1cm} Half-power beam width [degrees]
\end{itemize}

Value
\begin{itemize}
    \item \texttt{Rhalf} \hspace{1cm} Half-power radius [m]
\end{itemize}

Author(s)
Jose Gama

Source
GeometryRangeCorrect

References

GeometryRangeCorrect  *Half-power radius*

Description
GeometryRangeCorrect returns the half-power radius From CSU Radar Meteorology AT 741 Notes

Usage
GeometryRangeCorrect(r, h, E)

Arguments

- **r**  
  Distance to sample volume from radar [m]
- **h**  
  Height of the center of radar volume [m]
- **E**  
  Elevation angle [deg]

Value

- **r_{new}**  
  Adjusted range to sample volume [m]

Author(s)
Jose Gama

Source
CSU Radar Meteorology AT 741 Notes

References
CSU Radar Meteorology AT 741 Notes
GeometryRayHeight

Description


Usage

GeometryRayHeight(r, elev, H0, R1=kConstantR43)

Arguments

r        Range from radar to point of interest [m]
elev     Elevation angle of radar beam [deg]
H0       Height of radar antenna [m]
R1       Effective radius [m]

Value

h        Radar beam height [m]

Author(s)

Jose Gama

Source


References

GeometryReffective

Effective radius calculation

Description

GeometryReffective returns the effective radius From Rinehart (1997), Eqn 3.9, solved for R’

Usage

GeometryReffective(dNdH=-39e-6, earthRadius)

Arguments

dNdH Refraction [N x10^-6/km]
earthRadius earth radius [m]

Value

R Effective radius [m]

Author(s)

Jose Gama

Source


References


GeometrySampleVolGauss

Sample volume assuming transmitted energy in Gaussian beam shape

Description

GeometrySampleVolGauss returns the sample volume assuming transmitted energy in Gaussian beam shape. From Rinehart (1997), Eqn 5.4

Usage

GeometrySampleVolGauss(r, bwH, bwV, pLength)

Arguments

- $r$: Range from radar to point of interest [m]
- $bwH$: Horizontal beamwidth [deg]
- $bwV$: Vertical beamwidth [deg]
- $pLength$: Pulse length [m]

Value

- $sVol$: Sample Volume [$m^3$]

Author(s)

Jose Gama

Source


References


GeometrySampleVolIdeal

Sample volume (idealized) assuming all power in half-power
beamwidths

Description

GeometrySampleVolIdeal returns the sample volume (idealized) From Rinehart (1997), Eqn 5.2

Usage

GeometrySampleVolIdeal(r, bwH, bwV, pLength)

Arguments

r          Range from radar to point of interest [m]
bwH        Horizontal beamwidth [deg]
bwV        Vertical beamwidth [deg]
pLength    Pulse length [m]

Value

sVol       Sample Volume [m^3]

Author(s)

Jose Gama

Source


References


**Constant Speed of Light**

**Description**

- kConstantSpeedOfLight is "c" the constant speed of light [m/s].
- kConstantSLP Sea-level Pressure [hPa].
- kConstantP0 Reference pressure [hPa].
- kConstantRe Earth's radius [m].
- kConstantR43 4/3 Approximation effective radius for standard atmosphere [m].
- kConstantBoltz Boltzmann's constant [m^2 kg s^-2 K^-1].

**Usage**

```python
print(kConstantSpeedOfLight)
```

**Author(s)**

Jose Gama

**Examples**

```python
print(kConstantSpeedOfLight)
```

**System Antenna Effective Area**

**Description**

SystemAntEffArea returns the antenna effective area From Rinehart (1997), Eqn 4.5

**Usage**

```python
SystemAntEffArea(G, lam)
```

**Arguments**

- **G** Antenna Gain [dB]
- **lam** Radar wavelength [m]

**Value**

- **Ae** Antenna effective area [unitless]
SystemFreq

**Description**

SystemFreq converts from wavelength to frequency.

**Usage**

`SystemFreq(lam, speedOfLight)`

**Arguments**

- `lam`: Wavelength [m]
- `speedOfLight`: Speed of light

**Value**

- `f`: Frequency [Hz]

**Author(s)**

Jose Gama

**Source**


**References**


**SystemGainPratio**

*Antenna gain via power ratio*

---

**Description**

SystemGainPratio returns the antenna gain via power ratio From Rinehart (1997), Eqn 2.1

**Usage**

SystemGainPratio(P1, P2)

**Arguments**

- **P1**  
  Power on the beam axis [W]
- **P2**  
  Power from an isotropic antenna [W]

**Value**

- **G**  
  Gain [dB]

**Author(s)**

Jose Gama

**Source**


**References**


SystemNormXsecBscatterSphere

Normalized Backscatter cross-sectional area of a sphere using the Rayleigh approximation

**Description**

SystemNormXsecBscatterSphere returns the normalized Backscatter cross-sectional area of a sphere using the Rayleigh approximation From Rinehart (1997), Eqn 4.9 and 5.7 and Battan Ch. 4.5

**Usage**

SystemNormXsecBscatterSphere(D, lam, K=0.93)

**Arguments**

- **D** Diameter of target [m]
- **lam** Radar wavelength [m]
- **K** Dielectric factor [unitless]

**Value**

- **sigNorm** Normalized backscatter cross-section [unitless]

**Author(s)**

Jose Gama

**Source**


L. J. Battan, 1973 Radar observation of the atmosphere The University of Chicago Press

**References**


L. J. Battan, 1973 Radar observation of the atmosphere The University of Chicago Press
SystemPowerReturnTarget

*Power returned by target located at the center of the antenna beam pattern*

Description

SystemPowerReturnTarget returns Power returned by target located at the center of the antenna beam pattern From Rinehart (1997), Eqn 4.7

Usage

SystemPowerReturnTarget(Pt, G, lam, sig, r)

Arguments

- **Pt**: Transmitted power [W]
- **G**: Antenna gain [dB]
- **lam**: Radar wavelength [m]
- **sig**: Backscattering cross-sectional area of target [m^2]
- **r**: Distance to sample volume from radar [m]

Value

- **Pr**: Power returned by target [m]

Author(s)

Jose Gama

Source


References


SystemPowerTarget  

*Power intercepted by target*

**Description**

SystemPowerTarget returns the power intercepted by target From Rinehart (1997), Eqn 4.3

**Usage**

\[ \text{SystemPowerTarget}(Pt, G, Asig, r) \]

**Arguments**

- **Pt**: Transmitted power [W]
- **G**: Antenna gain [dB]
- **Asig**: Area of target [m^2]
- **r**: Distance to sample volume from radar [m]

**Value**

- **Psig**: Power intercepted by target [m]

**Author(s)**

Jose Gama

**Source**


**References**


**SystemRadarConst**

**Radar constant**

**Description**

SystemRadarConst returns radar constant From CSU Radar Meteorology notes, AT 741

**Usage**

SystemRadarConst(Pt, G, Tau, lam, bwH, bwV, Lm, Lr)

**Arguments**

- **Pt**: Transmitted power [W]
- **G**: Antenna gain [dB]
- **Tau**: Pulse Width [s]
- **lam**: Radar wavelength [m]
- **bwH**: Horizontal antenna beamwidth [degrees]
- **bwV**: Vertical antenna beamwidth [degrees]
- **Lm**: Antenna/waveguide/coupler loss [dB]
- **Lr**: Receiver loss [dB]

**Value**

- **C**: Radar constant [unitless]

**Author(s)**

Jose Gama

**Source**


CSU Radar Meteorology notes, AT 741

**References**


CSU Radar Meteorology notes, AT 741
SystemSizeParam  Size parameter calculation

**Description**

SystemSizeParam returns the size parameter calculation From Rinehart (1997), Eqn 4.9 and 5.7 and Battan Ch. 4.5

**Usage**

SystemSizeParam(D, lam)

**Arguments**

- **D**  Diameter of target [m]
- **lam**  Radar wavelength [m]

**Value**

- **alpha**  Size parameter [unitless]

**Author(s)**

Jose Gama

**Source**


L. J. Battan, 1973 Radar observation of the atmosphere The University of Chicago Press

**References**


L. J. Battan, 1973 Radar observation of the atmosphere The University of Chicago Press
**SystemThermalNoise**

| **Thermal noise power** |

**Description**

SystemThermalNoise returns the thermal noise power. From CSU Radar Meteorology notes, AT741

**Usage**

SystemThermalNoise(Bn, Units, Ts=290, k=kConstantBoltz)

**Arguments**

- **Bn**: Receiver bandwidth [Hz]
- **Units**: String of units desired, can be ’W’ or ’dBm’
- **Ts**: Receiver noise temperature [K]
- **k**: Boltzmann’s constant

**Value**

- **nt**: Thermal noise power [W or ’dBm’]

**Author(s)**

Jose Gama

**Source**


CSU Radar Meteorology notes, AT741

**References**


CSU Radar Meteorology notes, AT741
**Systemwavelength**  
*Wavelength given frequency*

**Description**  
Systemwavelength Converts from frequency to wavelength

**Usage**  
Systemwavelength(freq, speedOfLight)

**Arguments**  
- freq  
  Frequency [Hz]
- speedOfLight  
  speed of light

**Value**  
- lam  
  Wavelength [m]

**Author(s)**  
Jose Gama

**Source**  

**References**  

**SystemXsecBscatterSphere**  
*Backscatter cross-sectional area of a sphere using the Rayleigh approximation*

**Description**  
SystemXsecBscatterSphere returns Backscatter cross-sectional area of a sphere using the Rayleigh approximation From Rinehart (1997), Eqn 4.9 and 5.7
Usage

SystemXsecBscatterSphere(D, lam, K=0.93)

Arguments

D  Diameter of target [m]
lam  Radar wavelength [m]
K  Dielectric factor [unitless]

Value

sig  Backscattering cross-section [m^2]

Author(s)

Jose Gama

Source


References


VariablesCDR  Circular depolarization ratio

Description

VariablesCDR returns the circular depolarization ratio From Rinehart (1997), Eqn 10.2

Usage

VariablesCDR(Zpar, Zorth)

Arguments

Zpar  Reflectivity in the parallel channel [mm^6/m^3]
Zorth  Reflectivity in the orthogonal channel [mm^6/m^3]
Value

CDR Circular depolarization ratio [dB]

Author(s)
Jose Gama

Source

References

VariablesHDR

Differential reflectivity hail signature

Description
VariablesHDR returns the differential reflectivity hail signature From Aydin et al. (1986), Eqns 4-5

Usage
VariablesHDR(dBZh, ZDR)

Arguments

dBZh Horizontal reflectivity [dBZ]
ZDR Differential reflectivity [dBZ]

Value
ZDP Reflectivity difference [dB]

Author(s)
Jose Gama

Source
Aydin et al., 1986
VariablesLDR

Description

VariablesLDR returns the linear depolarization ratio From Rinehart (1997), Eqn 10.3

Usage

VariablesLDR(Zh, Zv)

Arguments

Zh  Horizontal reflectivity [mm^6/m^3]
Zv  Vertical reflectivity [mm^6/m^3]

Value

LDR  linear depolarization ratio

Author(s)

Jose Gama

Source


References


**Description**

VariablesRadVel returns the radial velocity From Rinehart (1993), Eqn 6.6

**Usage**

VariablesRadVel(f, lam)

**Arguments**

- **f**
  - Frequency shift [Hz]
- **lam**
  - Radar wavelength [m]

**Value**

- **Vr**
  - Radial velocity [m/s]

**Author(s)**

Jose Gama

**Source**


**References**


Description

VariablesReflectivity returns the radar reflectivity From Rinehart (1993), Eqn 5.17 (See Eqn 5.14-5.16 also)

Usage

VariablesReflectivity(Pt, G, Tau, lam, bwH, bwV, Lm, Lr, Pr, r, K=0.93)

Arguments

<table>
<thead>
<tr>
<th>Argument</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pt</td>
<td>Transmitted power [W]</td>
</tr>
<tr>
<td>G</td>
<td>Antenna gain [dB]</td>
</tr>
<tr>
<td>Tau</td>
<td>Pulse Width [s]</td>
</tr>
<tr>
<td>lam</td>
<td>Radar wavelength [m]</td>
</tr>
<tr>
<td>bwH</td>
<td>Horizontal antenna beamwidth [degrees]</td>
</tr>
<tr>
<td>bwV</td>
<td>Vertical antenna beamwidth [degrees]</td>
</tr>
<tr>
<td>Lm</td>
<td>Antenna/waveguide/coupler loss [dB]</td>
</tr>
<tr>
<td>Lr</td>
<td>Receiver loss [dB]</td>
</tr>
<tr>
<td>Pr</td>
<td>Returned power [W]</td>
</tr>
<tr>
<td>r</td>
<td>Range to target [m]</td>
</tr>
<tr>
<td>K</td>
<td>Dielectric factor [unitless]</td>
</tr>
</tbody>
</table>

Value

Ze  Radar reflectivity [unitless]

Author(s)

Jose Gama

Source


References


VariablesZDP  

**Description**

VariablesZDP returns the reflectivity difference From Rinehart (1997), Eqn 10.2

**Usage**

VariablesZDP(Zh, Zv)

**Arguments**

<table>
<thead>
<tr>
<th>Argument</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Zh</td>
<td>Horizontal reflectivity [mm^6/m^3]</td>
</tr>
<tr>
<td>Zv</td>
<td>Vertical reflectivity [mm^6/m^3]</td>
</tr>
</tbody>
</table>

**Value**

<table>
<thead>
<tr>
<th>Name</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>ZDP</td>
<td>Reflectivity difference [dB]</td>
</tr>
</tbody>
</table>

**Author(s)**

Jose Gama

**Source**


**References**


VariablesZDR

Differential reflectivity

Description

VariablesZDR returns the differential reflectivity From Rinehart (1997), Eqn 10.3 and Seliga and Bringi (1976)

Usage

VariablesZDR(Zh, Zv)

Arguments

<table>
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<tr>
<th>Zh</th>
<th>Horizontal reflectivity [mm^6/m^3]</th>
</tr>
</thead>
<tbody>
<tr>
<td>Zv</td>
<td>Vertical reflectivity [mm^6/m^3]</td>
</tr>
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Value

| ZDR | Differential reflectivity [dB] |

Author(s)

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Source


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