Interactive discussion for amt-2018-302:

## The Disdrometer Verification Network (DiVeN): a UK network of laser precipitation instruments

#### **Response to Reviewer 1**

The authors thank the reviewer for their time and consideration given to this manuscript.

The reviewer's comments have been listed below in **bold** and responded to individually in *red italics*.

#### **General Comments:**

The reviewer fist thought that the purpose of the paper is to use Theis Laser Precipitation Monitor (LPM) to evaluate the radar-based precipitation phase algorithm over United Kingdom. The manuscript is actually evaluated Their LPM phase algorithm with human observer. The manuscript also deals with the technical aspects of the data collection process from Theis LPM in near real time. The manuscript includes quite a bit information regarding precipitation measurements which are not relevant to this study. What is the relevance of tipping bucket gauges if the main purpose is related to the precipitation phase. The authors mentioned about dual-pol radar-based hydrometeor classification algorithm which was not used in this study. The section 1.1 is misleading regarding the main content/purpose of the study.

Perhaps, the key issue of the study is the Theis LPM precipitation phase algorithm which was disclosed by the manufacturer. As expected Theis LPM uses fall velocity versus particle size to determine the phase of the hydrometeor. In that regard, what is the accuracy of size and fall velocity. Is there any literature where the fall velocity has been presented? Even accurate fall velocity measurements, the study cannot comment on the error sources on the precipitation phase algorithm since this is not available. The title of the manuscript is quite general and it is hard to extract the content of the paper from the title.

The authors dedicated a section on the installation and cost of DiVeN. The text is written in quite detail and perhaps too much detail information. The price of the each element of the network is given in pounds. It is expected that the price is fluid, changes with time and should not be included in peer-reviewed journal.

Section 4.2 describes the second case study. Unlike 4.1 and 4.3, this section deals with the size distribution measurements and rain intensity. The reader is get confused since this is not expected in this study. The reader would like to know more about the performance of Theis for precipitation phase. Section 4.3 was quite useful. It is understandable that the Theis and similar instruments can confuse light snow from drizzle since the fall speed are similar in this size regime. Going back to section 4.2, what is the purpose of presenting raindrop size distribution comparison. It is feasible that Theis may have splash drops but Joss-Waldvogel disdrometer and PWS100 are not standard and cannot be used as a reference. It is likely that they both underestimate small drops severely. Thurai and Bringi (2018, Journal of Applied Meteorology and Climatology) introduced Meteorological Particle Spectrometer which is sensitive to the small drops. The author should consider this study as a reference.

The manuscript is well written and has original aspects. Sections 2.2, 4.1, and 4.3 have useful information for future Theis LPM users. With a major revision, basically shortening the manuscript, the study has a potential to be published.

#### General comments response:

The purpose of the paper is to describe and introduce a new network of commercially available Thies LPM disdrometers in the UK. As such, the focus of the paper is on the discussions of the creation of the network, the details of the instruments that have been provided by the manufacturer and demonstrate the use of the dataset through the examination of some initial cases. The paper is not trying to critically evaluate the Thies or the internal algorithm that it uses for Present Weather type. Nor is it introducing the instrument as a new device — which the authors agree would require rigorous laboratory

experiments to justify the standalone skill of the instrument. The Thies LPM has been a commercially available product for over 10 years and the algorithms it utilizes are provided by the manufacturer.

The authors accept that, as originally presented, the introduction could cause a misinterpretation of the paper's purpose. The paper's focus is intended to be a description of a network and the dataset it is creating which has been created due to the need for a data set that could be used to compare to a surface radar hydrometeor type product. However, there are further uses for the network within the research community, which this paper seeks to encourage. Several changes have been made throughout the text to clarify the purpose of the paper. The notable changes are shown below.

1.1 Precipitation Instruments

changed to:

1.1 Motivation for DiVeN

2.2 paragraph 3 removed first sentence.

Abstract:

Here we describe the Disdrometer Verification Network and subjectively discuss the skill of the Thies LPM for hydrometeor type identification using specific cases from the first year of observations.

changed to:

Here we describe the Disdrometer Verification Network and present specific cases from the first year of observations.

Section 1.3:

This paper describes DiVeN and attempts to subjectively analyse the abilities of the Thies LPM instruments being used.

changed to:

This paper describes DiVeN and demonstrates the data products of the Thies LPM instruments being used.

Section 1.3

These events will provide a subjective analysis of the accuracy for the disdrometer instruments and thus determine the qualitative abilities of the network for HCA verification.

Changed to:

These events will provide an illustrative analysis of the observations being produced by all the individual disdrometer instruments within DiVeN.

**Special Comments:** 

1) Page 2, line 6, what is the reference for moderate rainfall? The Glossary of American Meteorological Society defines the boundaries of rain intensities.

The authors have removed the word "moderate" as descriptor as it is rightly identified by the reviewer as an ambiguous definition.

2) Page 2, line 17, single polarization radar may or may not have the Doppler capability. Please clarify.

The authors agree with the reviewer and have removed all mentions of "Doppler" from the paragraph.

3) Page 2, line 20, what does it mean for composition?

The authors agree with the reviewer that the use of the word "composition" is misleading. It has now been removed.

"...requires additional knowledge about the size distribution and type of hydrometeors being observed."

4) Page 2, line 21, The manuscript quotes hydrometeor or precipitation type. Perhaps, phase rather than type is more suitable. Folks use type for stratiform and convective rainfall in the literature.

The authors agree with this comment and, all instances of "precipitation type" are now altered to "hydrometeor type". "Phase" would not encapsulate the different solid hydrometeors the instrument is able to detect.

#### 5) Page 3, line 5, what is FAAM stands for?

The authors have added the definition of the acronym to page 3, line 2:

"Instrumented aircraft flights such as the Facility for Airborne Atmospheric Measurements (FAAM) take a swath volume..."

6) Page 3, line 15, the bin width is related to the accuracy of particle size not resolve differences between smaller drops.

This has been corrected in the text.

7) Page 3, lines 27-28, Please specify Parsivel as Parsivel-1.

This has been corrected in the text.

MC3E was for two months not two weeks. Also, please use a bigger city name (e.g. Ponca City, Oklahoma) rather than Tonkawa. Despite the fact that I participated the field campaign, I never heard Tonkawa.

This has been corrected in the text.

8) Page 4, line 14, Perhaps the sentence needs to be modified since Loffler-Mang and Joss (2000) paper describes Parsivel not Theis. While they are sister instruments, there are differences in their operation.

The authors agree with this comment and have changed the sentence to:

*"Figure 1 in Löffler-Mang and Joss (2000) describes a similar instrument (Parsivel-1) with the same observing principle and is an excellent visualisation of the technique which is employed by the Thies LPM."* 

9) Page 4, line 30, the authors says that the exact method of derivation does not need to be known. I disagree with this statement. This is one of the deficiencies of the study.

The study is not trying to point out specific problems with the Thies internal algorithm for *PW* Type and correct for them. The data will be taken as-is and not corrected since the internal algorithm is the intellectual property of Adolf Thies GMBH & CO. KG. We are simply trying to identify in which meteorological conditions the algorithm does a poor job so we can know when to trust it and when not to, in future work using this data. Phrasing has been changed to better reflect the reality of the situation.

Section 4 of this paper will qualitatively test the skill of the present weather code regardless of the algorithm it uses, such that the exact method of derivation does not need to be known.

#### changed to

Section 4 of this paper will qualitatively test the skill of the present weather code regardless of the algorithm it uses, since the exact method of derivation is not known.

10) Page 5, lines 1-2, Personal communication should be more explicit. Who is the person to be communicated with and what is his/her affiliation?

This has been corrected in the text.

#### Also, please correct Section 44.1 to 4.1

#### This has been corrected in the text.

11) Page 5, lines 4-7, the paragraph talks about the aircraft probes. What is the relevance? The aircraft probes are the sole source for the hydrometeor phase aloft

but cannot be observed continuously. They are research instrument, not operational.

The authors accept that the aircraft probes are off-topic and have removed the discussion describing the FAAM aircraft instruments.

12) Page 6, section 3.1. While it is important to report the challenges of the DiVeN sites, the section is quite long. For somebody who is not familiar with UK geography, it is easy to get lost. This section is subject to be shortened.

following this suggestion, the authors have removed the paragraph describing Scottish mountain sites and their relation to future radar HCA verification work.

13) Page 7, section 3.3 is perhaps the least favorite section of the manuscript. I am not frequent reviewer of the Atmospheric Measurement Techniques, so I am not sure if the detailed information on DiVeN costs are welcome. For a science paper, it is not. Before reading the manuscript, I could never imagine to read this kind of detailed information in the paper. Specifically, I am not sure what is the relevance of electricity cost in UK for a reader outside the country. I would say nearly 2/3 of the manuscript does not related to evaluation of the Theis LPM hydrometeor phase algorithm.

The authors wish to keep these technical details. The low-cost installation and continued low running costs of DiVeN are key aspect of the network's success, as the network would not be possible were the costs higher. There has also been considerable attention within the atmospheric science community about "low cost" sensors and we hope to contribute to this larger discussion. The authors leave the decision of the applicability of this material in an AMTD article to the Associate Editor.

#### 14) Page 11, last line, gauge resolution should be 0.01 mm.

The authors have reviewed the Lambrecht technical details <u>https://www.lambrecht.net/upload/productDocuments/rain[e] Leaflet EN 1.pdf</u> which state a resolution of 0.001 mm is made but only reported at 0.01 mm resolution. We have changed the text to state:

"A high-resolution Lambrecht gauge (recorded resolution of 0.01 mm) on the site".

Further personal communication with Stephen Burt (30th March 2019):

"You and your referee are both right. In theory the gauge has a resolution of 0.001 mm, but in reality surface tension limits the flow of droplets this small into the funnel and thus into the weighed 'bucket' - gravity is insufficient to overcome surface tension until the droplet volume is somewhat larger. (I have made this point to Lambrecht...) The smallest resolvable drop is about 0.01 mm, and that's what I've set the resolution of my unit to. Even this resolution is only achievable once the funnel has been wetted - a dry funnel seems to require about 5 droplets to find their way in before anything happens. Even so, it's much more precise than a normal 0.2 mm TBR." Interactive discussion for amt-2018-302:

# The Disdrometer Verification Network (DiVeN): a UK network of laser precipitation instruments

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81	\Author[3]{Dawn}{Harrison}	
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84 85	\affil[2]{National Centre for Atmospheric Science, 71-75 Clarendon Rd, Leeds, Yorkshire, UK. LS2 9PH}	
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116 117 118 119 120 121 122 123 124 125 126 127 128 129 130 - 131 132 133 134 135 137	relationships, the instrument classifies precipitation into one of L1 possible hydrometeor classes in the UKMT and maked based to be a subset within a marked the UKMT and maked based to be a subset within a marked the UKMT and maked based to be a subset within a marked the UKMT and maked based to be a subset within a marked the UKMT and maked based and be a subset within a marked the UKMT and maked based and be a subset within a marked the UKMT and maked based and be a subset within a marked the UKMT and maked based and be a subset within a marked the ukmt be and the united kingdom inherently, due to internal processing. The present weather code subility index is shown to have be skill within the supplementary sensor recommeded by the mundaturer. Overall the thies the is a useful tool for detecting hydrometeor type at the surface and prove provides a novel dataset not previously observed for the united kingdom. Used abstruct the supplementary sensor recommeded by the mundaturer. Overall the thies the is a useful tool for detecting hydrometeor type at the surface and prove provides a novel dataset not previously observed for the united kingdom. Used abstruct the surface and proves and proves and the surface and proves and the surface and proves and precipitation into a bucket which the subsection (betrated for Divec). Subsection(betratefore proves and precipitation into a bucket which the sund ensemble value are and the surface and proves and precipitation into a bucket which the sund ensemble value and therefore and the subsect and precipitation into a bucket which the sund ensemble value and therefold volume is reached. The threshold volum	APR 8, 2019 3:05 PM • You         ✓ Reject       ✓ Accept         ✓ Changed Precipitation Mea         APR 8, 2019 5:05 PM • You         ✓ Reject       ✓ Accept         ✓ Sold PM • You         ✓ Sold PM • You         ✓ Sold PM • You         ✓ Changed Precipitation Mea         ✓ Sold PM • You         ✓ Sold PM • You         ✓ Accept         ✓ Deleted defined as moderate by         Apt R. 2019 5:27 PM • You         ✓ Reject       ✓ Accept         Obleted defined as moderate by         Apt R. 2019 4:07 PM • You         ✓ Reject       ✓ Accept         Apr R. 2019 4:07 PM • You         ✓ Reject       ✓ Accept         Apr R. 2019 4:05 PM • You         ✓ Reject       ✓ Accept         Apr R. 2019 4:05 PM • You         ✓ Reject       ✓ Accept         Apr Deleted and Deppler velocity Apr R. 2019 4:05 PM • You         ✓ Reject       ✓ Accept         Apr Deleted -composition, Mar 30, 2019 1:01 PM • You         ✓ Reject       ✓ Accept         Apr Deleted -composition, Mar 30, 2019 1:01 PM • You         ✓ Reject       ✓ Accept

139	Starting in mid-2012 and completing early-2018, every radar in the UK Met Office network was upgraded from single to dual-polarisation using in-house design and off-the-shelf components, re-using the pedestal and reflector from the original radar systems. To take advantage of the new information and to improve precipitation estimates, an operational HCA was developed within the Met Office, based on work at M\'et\'eo France \citep{Al-Sskta2013}. While significant amounts of literature have been published on the technical improvement of HCAs \citep{Chandrasekar2013}, the verification of HCA skill has not been discussed as widely. There is a need for more rigorous validation of HCAs and DiVeN was created specifically for the verification of the UK Met Office radar network HCA.	Added (FAAM) Mar 30, 2019 1:07 PM • You * Reject
140		all)
141	Typically in-situ aircraft are used to verify radar HCA \citep{Liu2000,Lim2005,Ribaud2016}. Instrumented aircraft flights such as the Facility for Airborne	Apr 8, 2019 3:31 PM • You
	Atmospheric Measurements (FAAM) take a swath volume using 20 Hz photographic disdrometer instruments \citep{abel2014}. However there is no fall speed	🗙 Reject 🛛 🗸 Accept
	information, which distinguishes hydrometeor type with high skill due to distinct particle density differences \citep{locatelli1974}. The lack of fall speed	Added , with the notable
	information on FAAM instruments means that the 1,200 images collected in every minute of flight must be visually analysed manually or with complex image	🔗 exceptions of Canada (show all)
	recognition algorithms. The major disadvantage with FAAM data is the sparsity of cases due to the expense of operating the aircraft.	Apr 22, 2019 4:52 PM • You
142		🗙 Reject 🛛 🗸 Accept
143	Therefore, in-situ surface observations must be utilised to expand the quantity of comparison data. A larger dataset allows bulk verification statistics to	<ul> <li>Changed However n to N</li> </ul>
	be performed on radar HCAs. Here we introduce a new surface hydrometeor type dataset and examine the skill of the dataset, independently of any radar	Apr 22, 2019 4:54 PM • You
	instruments.	🗙 Reject 🛛 🗸 Accept
144		
145		Added -1
146		V Peiect Accent
147 -	(subsection(Precipitation Measurement with Disarometers)	
T40	A disurbancer is an instrument which measures the drop size distribution of precipitation over time. The drop size distribution (nenceforth obs) of	Changed Tonkawa, Oklahoma to
	precipitation is the function of arop size and arop frequency. (citeJameson2001) provides an in-depth discussion on the definition of a 050. Disdometers	Ponca City, Oklah (show all)
149	cypicarty record drop sizes into bins or nonrinearly increasing which due to the acturacy reducing with increasing values.	M Deject
150	The disdrometer is also a useful tool for verifying radar hydrometeor classification algorithms. Hydrometeor type can be empirically derived using	
200	information about the diameter and fall speed of the particle, which the Thies Laser Precipitation Monitor (LPM) instrument used in June is able to	Changed two to six
	measure. The Gunn-Kinzer curve \citep{Gunn1949} describes the relationship between raindrop diameter and fall speed. As diameter increases, the velocity of	<ul> <li>Apr 8, 2019 4:20 PM • You</li> </ul>
	a raindrop increases asymptotically. Other velocity-diameter relations have been shown in the literature for snow, hail, and graupel which are well	🗙 Reject 🛛 🗸 Accept
	described in \cite{locatel]i1974}.	A Changed on to with
151		Apr 8, 2019 4:24 PM • You
152	As of the time of writing this publication, operational networks of disdrometers are uncommon, with the notable exceptions of Canada \citep{sheppard1990}	🗙 Reject 🛛 🗸 Accept
	and Germany. Networks of disdrometers solely for research purposes have been frequently deployed for short periods of time. From March 2009 to July 2010 (16	Changed attempts to subio
	months), 16 disdrometers were placed on rooftops within a 1 km by 1 km on the campus of the Swiss Federal Institute of Technology in Lausanne to study the	(show all) to demonstrates
	inter-radar pixel variability in rainfall \citep{Jaffrain2011}. Another example of research using networked disdrometers is the Midlatitude Continental	Apr 8, 2019 5:40 PM • You
	Convective Clouds Experiment (MC3E) \citep{jensen2016} which utilised 18 Parsive]-1 disdrometers and 7 ZDVDs (2-Dimensional Video Disdrometers) within a 6	🗙 Reject 🛛 🗸 Accept
	km radius of a central facility near Ponca City, Oklahoma. The project lasted for six weeks (22 April through 6 June 2011). Diven has an initial deployment	Channed a billiblica to data
	phase of 3 years with a high expectation of renewal, which enables unique long-term research to be conducted with the data.	Products
153		Apr 17, 2019 2:08 PM • You
154		🗙 Reject 🛛 🗸 Accept
155		Channel There exercise 111
150 -	\subsection(Paper structure)	<ul> <li>(show all) to These events will</li> </ul>
121	In spaper describes Diven and demonstrates the data products of the intes LPM instruments being used. Ine first part of the paper provides a technical description of the did demonstrates used in the notice the location of the distruments of the theory of the theory of the technical determines and distruments in the notice of the distruments of the distrument of the distruments of the distruments of the distruments of the distrument of the distru	(show all)
	description of the discriments used in the network, the locations chosen to nost the instruments, and data management in the network, tase	Apr 22, 2019 2:46 PM & You
	security see sufficient of manyon operations are then discussed. The case studies include rain shew transitions in the 2017 named winter storm	Api 22, 2017 3.40 Pivi • Tou
	studies from the first 12 months of Diven observations are then discussed. The case studies include fain-show transitions in the 2017 named winter storm ports a convertive rainfall event and rained how the studies of the observations the being nordinged by all	× Reject ✓ Accept
	studies from the first 12 months of Diven observations are then discussed. The case studies include fain-show transitions in the 2017 named winter storm Doris, a convective rainfall event, and graupel observations. These events will provide an illustrative analysis of the observations being produced by all the individual discometer instruments within Diven. Einhanced scrutiny will be placed on the performance of the present weather code because this variable.	Added describes a similar
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158	studies from the first 12 months of Diven observations are then discussed. The case studies include rain-show transitions in the 2017 named winter storm Doris, a convective rainfall event, and graupel observations. These events will provide an illustrative analysis of the observations being produced by all the individual disdrometer instruments within Diven. Enhanced scrutiny will be placed on the performance of the present weather code because this variable will be used to verify the Met Office radar HCAs.	★ Reject     ✓ Accept       Added describes a similar <i>I</i> Arstwell, (show all) Apr 8, 2019 3:52 PM • You
158 159	studies from the first 12 months of Diven observations are then discussed. The Case studies include rain-show transitions in the 2017 named winter storm Doris, a convective rainfall event, and graupel observations. These events will provide an illustrative analysis of the observations being produced by all the individual disdrometer instruments within DiVeN. Enhanced scrutiny will be placed on the performance of the present weather code because this variable will be used to verify the Met Office radar HCAs.	★ Reject     ✓ Accept       Added describes a similar       instrument (Parsivel (show all))       Apr8,2019.352 PM × You       ★ Reject     ✓ Accept
158 159 160	Studies from the first 12 months of Diven observations are then discussed. The case studies include fain-show transitions in the 2017 named winter storm Doris, a convective rainfall event, and graupel observations. These events will provide an illustrative analysis of the observations being produced by all the individual disconderter instruments within DiveN. Enhanced scrutiny will be placed on the performance of the present weather code because this variable will be used to verify the Met Office radar HCAs.	× Reject     ✓ Accept       Added describes a similar       instrument (Parsivel (show all))       Apr8.2019.352 PM • You       × Reject     ✓ Accept
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158 159 160 161 - 162 163 - 164	<pre>studies from the first 12 months of Diven observations are then discussed. The case studies include rain-show transitions in the 2017 named winter storm Doris, a convective rainfall event, and graupel observations. These events will provide an illustrative analysis of the observations being produced by all the individual disdometer instruments within DiveN. Enhanced scrutiny will be placed on the performance of the present weather code because this variable will be used to verify the Met Office radar HCAs.  <pre>\section{Thies Clima Laser Precipitation Monitor}\label{instrument} <pre>\subsection{Specification}\label{spec} The instruments used in DiveN (see Figure \ref{fig:weybourne}) are the Thies Laser Precipitation Monitor (LPM), model number 5.4110.00.200,</pre></pre></pre>	× Reject ✓ Accept     Added describes a similar     instrument (Parsivel, (show all)     Apr 8, 2019 3:52 PM • You     × Reject ✓ Accept     Ab Deleted -measurement     Apr 8, 2019 3:52 PM • You     × Reject ✓ Accept     Changed used to which is     employed
158 159 160 161 ~ 162 163 ~ 164	<pre>studies from the first 12 months of Diven observations are then discussed. The case studies include rain-show transitions in the 2017 named winter storm Doris, a convective rainfall event, and graupel observations. These events will provide an illustrative analysis of the observations being produced by all the individual discometer instruments within DiveN. Enhanced scrutiny will be placed on the performance of the present weather code because this variable will be used to verify the Met Office radar HCAS. \section{Thies Clima Laser Precipitation Monitor}\label{instrument} \subsection{Specification}\label{spec} The instruments used in DiveN (see Figure \ref{fig:weybourne}) are the Thies Laser Precipitation Monitor (LPM), model number 5.4110.00.200, which are described in detail in \cite(Thies2011). To make observations the instrument utilises an infrared (785 nm) beam with dimensions 228 mm x 20 mm x</pre>	Apt 22,232 - 352 PM + You Added describes a similar Added describes a similar instrument (ParsiveL., (show all) Apr 8, 2019 3:52 PM + You Keject Ab Deleted measurement Apr 8, 2019 3:52 PM + You Keject Changed used to which is employed Apr 8, 2019 3:52 PM + You
158 159 160 161 ~ 162 163 ~ 164	<pre>studies from the first 12 months of Diven observations are then discussed. The case studies include rain-show transitions in the 2017 named winter storm Doris, a convective rainfall event, and graupel observations. These events will provide an illustrative analysis of the observations being produced by all the individual discometer instruments within DiveN. Enhanced scrutiny will be placed on the performance of the present weather code because this variable will be used to verify the Met Office radar HCAS.  <pre>section{Thies Clima Laser Precipitation Monitor}\label{instrument} <pre>subsection{Specification}\label{spec} The instruments used in DiveN (see Figure \reffig:weybourne}) are the Thies Laser Precipitation Monitor (LPM), model number 5.4110.00.200, which are described in detail in \cite{Thies2011}. To make observations the instrument utilizes an infrared (785 m) beam with dimensions 228 mm x 20 mm x 0.75mm, a total horizontal area of 45.6cm\$&gt;25. The infrared beam is emitted from one end of the instrument and is directed to the other. A photo-diode and</pre></pre></pre>	Apple 12:2037500 MM et dd       ★ Reject     ✓ Accept       Added describes a similar instrument (ParsiveL. (show all) Apr8, 2019 3:52 PM • You       ★ Reject     ✓ Accept       Ab     Deleted -measurement Apr8, 2019 3:52 PM • You       ★ Reject     ✓ Accept       Changed used to which is employed Apr8, 2019 3:52 PM • You       ★ Reject     ✓ Accept
158 159 160 161 - 162 163 - 164	<pre>studies from the first 12 months of Diven observations are then discussed. The case studies include rain-snow transitions in the 2017 named winter storm Doris, a convective rainfall event, and graupel observations. These events will provide an illustrative analysis of the observations being produced by all the individual disdometer instruments within DiveN. Enhanced scrutiny will be placed on the performance of the present weather code because this variable will be used to verify the Met office radar HCAs. \section{Thies Clima Laser Precipitation Monitor}\label{instrument} \subsection{Specification}\label{spec} The instruments used in DiveN (see Figure \ref{fig:weybourne}) are the Thies Laser Precipitation Monitor (LPM), model number 5.4110.00.200, which are described in detail in \cite{Thies2011}. To make observations the instrument utilises an infrared (785 nm) beam with dimensions 228 mm x 20 mm x 0.75mm, a total horizontal area of 45.6cm\$^25. The infrared beam is emitted from one end of the instrument and is directed to the other. A photo-diode and signal processor determine the optical characteristics including optical intensity which is reduced as a particle falls through the beam. The diameter of the budgeteres residue of the backward of the other of the budgeteres of the the maximum and bit doe the other.</pre>	Added describes a similar       Added describes a similar       instrument (Parsivel (show all)       Apr.8. 2019 3:52 PM + You       X Reject     ✓ Accept       Ab Deleted -messurement Apr.8. 2019 3:52 PM + You       X Reject     ✓ Accept       Changed used to which is       employed Apr.8. 2019 3:52 PM + You       X Reject     ✓ Accept       Changed used to which is       ✓ Accept       ✓ Accept       ✓ Accept
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158 159 160 161 - 162 163 - 164	<pre>studies from the first 12 months of Diven observations are then discussed. The case studies include rain-show transitions in the 2017 named winter storm Doris, a convective rainfall event, and graupel observations. These events will provide an illustrative analysis of the observations being produced by all the individual disdometer instruments within DiveN. Enhanced scrutiny will be placed on the performance of the present weather code because this variable will be used to verify the Met Office radar HCAs.  <pre>\section{Thies Clima Laser Precipitation Monitor}\label{instrument} \subsection{Specification}\label{spec} The instruments used in DiveN (see Figure \ref{fig:weybourne}) are the Thies Laser Precipitation Monitor (LPM), model number 5.4110.00.200, which are described in detail in \cite{Thies2011}. To make observations the instrument utilises an infrared (785 nm) beam with dimensions 228 nm x 20 mm x 0.75mm, a total horizontal area of 45.6cm\$^25. The infrared beam is emitted from one end of the instrument and is directed to the other. A photo-dioe and signal processor determine the optical characteristics including optical intensity which is reduced as a particle falls through the beam. The diameter of the hydrometer is inferred by the maximum amplitude of the signal reduction and the speed of the hydrometer is estimated by the duration of the signal reduction. Figure 1 in \cite{Ioffler-Mang2000} describes a similar instrument (Parsive]-1) with the same observing principle and is an excellent visualisation of the terphinue which is emolyced by the Thies Number Similar instrument (Parsive]-1) with the same observing principle and is an excellent visualisation of the terphinue which is enduced by the the signal reduction. Figure 1 in \cite{Ioffler-Mang2000} describes a similar instrument (Parsive]-1) with the same observing principle and is an excellent visualisation of the terphinue which is emolyced by the Thies Number Sime to cheare and is directed to the other of the other of the ot</pre></pre>	× Reject     ✓ Accept       Added describes a similar instrument (Parsivel(show all) Apr.8. 2019 3:52 PM • You       × Reject     ✓ Accept       Apr.8. 2019 3:52 PM • You       × Reject     ✓ Accept       Apr.8. 2019 3:52 PM • You       × Reject     ✓ Accept       Apr.8. 2019 3:52 PM • You       × Reject     ✓ Accept       Changed used to which is employed Apr.8. 2019 3:52 PM • You       × Reject     ✓ Accept       Changed Precipitation typ (show all) to Hydrometeor type Apr.8. 2019 4:01 PM • You
158 159 160 161 - 162 163 - 164	<pre>studies from the first 12 months of Diven observations are then discussed. The case studies include fain-snow transitions in the 2017 named winter storm Doris, a convective rainfall event, and graupel observations. These events will provide an illustrative analysis of the observations being produced by all the individual discometer instruments within DiveN. Enhanced scrutiny will be placed on the performance of the present weather code because this variable will be used to verify the Met Office radar HCAS. \section{Thies Clima Laser Precipitation Monitor}\label{instrument} \subsection{Specification}\label{spec} The instruments used in DiveN (see Figure \ref{fig:weybourne}) are the Thies Laser Precipitation Monitor (LPM), model number 5.4110.00.200, which are described in detail in \cite{Thies2011}. To make observations the instrument utilises an infrared (785 nm) beam with dimensions 228 mm x 20 mm x 0.75mm, a total horizontal area of 45.6cm\$x25. The infrared beam is emitted from one end of the instrument and is directed to the other. A photo-diode and signal processor determine the optical characteristics including optical intensity which is reduced as a particle falls through the beam. The diameter of the hydrometer is inferred by the maximum amplitude of the signal reduction and the speed of the hydrometor is estimated by the duration of the signal reduction. Figure 1 in \cite{Loffler-Mang2000} describes a similar instrument (Parsive]-1) with the same observing principle and is an excellent visualisation of the technique which is employed by the Thies LPM. The signal processing claims to detect and remove particles that fall on the edge of the beam: The measured values are processed by a signal processing claims to detect and remove particles that fall on the edge of the beam: The measured values are processed by a signal processing claims to detect and remove particles that fall on the edge of the beam: The measured values are processed by a sional processor (DSP), and checked for nal</pre>	Apple 12:12:13:13:00 million       ★ Reject     ✓ Accept       Added describes a similar       instrument (ParsiveL., (show all)       Apr8, 2019 3:52 PM + You       ★ Reject     ✓ Accept       Ab     Deleted -measurement       Apr8, 2019 3:52 PM + You       ★ Reject     ✓ Accept       Changed used to which is       employed       Apr8, 2019 3:52 PM + You       ★ Reject     ✓ Accept       Changed used to which is       employed       Apr8, 2019 3:52 PM + You       ★ Reject     ✓ Accept
158 159 160 161 - 162 163 - 164	<pre>studies from the first 12 months of Diven observations are then discussed. The case studies include fain-show transitions in the 2017 named winter storm Doris, a convective rainfall event, and graupel observations. These events will provide an illustrative analysis of the observations being produced by all the individual disdometer instruments within DiveN. Enhanced scrutiny will be placed on the performance of the present weather code because this variable will be used to verify the Met Office radar HCAS. \section{Thies Clima Laser Precipitation Monitor}\label{instrument} \subsection{Specification}\label{spec} The instruments used in DiveN (see Figure \ref{fig:weybourne}) are the Thies Laser Precipitation Monitor (LPM), model number 5.4110.00.200, which are described in detail in \cite{Thies2011}. To make observations the instrument utilizes an infrared (785 nm) beam with dimensions 228 nm x 20 nm x 0.75mm, a total horizontal area of 45.6cm\$&gt;25. The infrared beam is emitted from one end of the instrument and is directed to the other. A photo-diode and signal processor determine the optical characteristics including optical intensity which is reduced as a particle falls through the beam. The diameter of the hydrometeor is inferred by the maximum amplitude of the signal reduction and the speed of the hydrometeor is estimated by the duration of the signal reduction. Figure 1 in \cite{Loffler-Mang2000} describes a similar instrument (Parsive]-1) with the same observing principle and is an excellent visualisation of the technique which is employed by the Thies LPM. The signal processing claims to detect and remove particles that fall on the edge of the beam: "The measured values are processed by a signal processor (DSP), and checked for plausibility (e.g. edge hits).'' No further details are given by manufacturer. The instrument is able to allocate individual hydrometeor is informed to signal box 20.2 m</pre>	Apple 12:1203 / South Merked       ★ Reject     ✓ Accept       Added describes a similar instrument (Parsivel (show all) Apr.8. 2019 3:52 PM × You       ★ Reject     ✓ Accept       Ab     Deleted -messurement Apr.8. 2019 3:52 PM × You       ★ Reject     ✓ Accept       Changed used to which is employed Apr.8. 2019 3:52 PM × You       ★ Reject     ✓ Accept       Changed Precipitation typ (show all) to Hydrometeor type Apr.8. 2019 4:01 PM × You       ★ Reject     ✓ Accept       Changed Precipitation typ (show all) to Hydrometeor type Apr.8. 2019 4:01 PM × You       ★ Reject     ✓ Accept
158 159 160 161 - 162 163 - 164	<pre>studies from the first 12 months of Diven observations are then discussed. The case studies include fain-show transitions in the 2017 named winter storm Doris, a convective rainfall event, and graupel observations. These events will provide an illustrative analysis of the observations being produced by all the individual disdometer instruments within DiveN. Enhanced scrutiny will be placed on the performance of the present weather code because this variable will be used to verify the Met office radar HCAs. \section{Thies Clima Laser Precipitation Monitor}\label{instrument} \subsection{Specification}\label{spec} The instruments used in DiveN (see Figure \ref{fig:weybourne}) are the Thies Laser Precipitation Monitor (LPM), model number 5.4110.00.200, which are described in detail in \cite{Thies2011}. To make observations the instrument utilises an infrared (785 nm) beam with dimensions 228 mm x 20 mm x 0.75mm, a total horizontal area of 45.6cm\$^2\$. The infrared beam is emitted from one end of the instrument and is directed to the other. A photo-diode and signal processor determine the optical characteristics including optical intensity which is reduced as a particle falls through the beam. The diameter of the hydrometeor is inferred by the maximum amplitude of the signal reduction and the speed of the hydrometeor is estimated by the duration of the signal reduction. Figure 1 in \cite{Loffler-Mang2000} describes a similar instrument (Parsive1-1) with the same observing principle and is an excellent visualisation of the technique which is employed by the Thies LPM. The signal processing claims to detect and remove particles that fall on the edge of the beam: "The measured values are processed by a signal processor (DSP), and checked for plausibility (e.g. edge hits).'' No further details are given by the manufacturer. The instrument is able to allocate individual hydrometeors into 20 diameter bins from 0.125 mm to \$&gt;\$ 8 mm, and 22 speed bins from \$&gt;\$ 0.2 m s\$A(-1)\$.</pre>	Apple 12: 2017 Star Mer Rd       ★ Reject     ✓ Accept       Added describes a similar instrument (Parsivel (show all) Apr.8. 2019 3:52 PM + You       ★ Reject     ✓ Accept       Ab Deleted -measurement Apr.8. 2019 3:52 PM + You       ★ Reject     ✓ Accept       Changed used to which is employed Apr.8. 2019 3:52 PM + You       ★ Reject     ✓ Accept       Changed Precipitation typ (show all) to Hydrometeor type Apr.8. 2019 4:01 PM + You       ★ Reject     ✓ Accept       Changed Precipitation typ (show all) to hydrometeor type Apr.8. 2019 4:01 PM + You       ★ Reject     ✓ Accept
158 159 160 161 - 162 163 - 164	<pre>studies from the first 12 months of Diven observations are then discussed. The case studies include rain-show transitions in the 2017 named winter storm Doris, a convective rainfall event, and graupel observations. These events will provide an illustrative analysis of the observations being produced by all the individual disdrometer instruments within DiveN. Enhanced scrutiny will be placed on the performance of the present weather code because this variable will be used to verify the Met Office radar HCAs.  <pre>\section{Thies Clima Laser Precipitation Monitor}\label{instrument} \subsection{specification}\label{spec} The instruments used in DiveN (see Figure \ref{fig:weybourne}) are the Thies Laser Precipitation Monitor (LPM), model number 5.4110.00.200, which are described in detail in \cite{Thies2011}. To make observations the instrument utilises an infrared (785 nm) beam with dimensions 228 nm x20 mm x 0.75mm, a total horizontal area of 45.6cm\$^25. The infrared beam is emitted from one end of the instrument and is directed to the other. A photo-diode and 0.75mm, a total horizontal area of 45.6cm\$^25. The infrared beam is emitted from one end of the hydrometeor is estimated by the duration of the signal reduction. Figure 1 in \cite{Loffler-Mang2000 describes a similar instrument (Parsivel-1) with the same observing principle and is an excellent visualisation of the technique which is semployed by the Thies LPM. The signal processing claims to detect and remove particles that fall on the edge of the beam: ``The measured values are processed by a signal processor (DSP), and checked for plausibility (e.g. edge hits).'` No further details are given by the manufacturer. The instrument is able to allocate individual hydrometeors into 20 diameter bins from 0.125 mm to \$&gt;\$ 8 mm, and 22 speed bins from \$&gt;\$ 0.2 m s\$^{-1}\$ to \$&gt;\$ 20 m s\$^{-1}\$.</pre></pre>	Apple 12, 1247 3540 Mer Rd       ★ Reject     ✓ Accept       Added describes a similar instrument (Parsivel (show all) Apr.8, 2019 3:52 PM + You       ★ Reject     ✓ Accept       Apr.8, 2019 3:52 PM + You       ★ Reject     ✓ Accept       Apr.8, 2019 3:52 PM + You       ★ Reject     ✓ Accept       Changed used to which is employed Apr.8, 2019 3:52 PM + You       ★ Reject     ✓ Accept       Changed Precipitation typ (show all) to Hydrometeor type Apr.8, 2019 4:01 PM + You       ★ Reject     ✓ Accept       Changed precipitation typ (show all) to hydrometeor type Apr.8, 2019 4:02 PM + You       ★ Reject     ✓ Accept
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158 159 160 161 - 162 163 - 164	<pre>studies from the first 12 months of Diven observations are then discussed. The case studies include rain-snow transitions in the 2017 hamed winter storm poris, a convective rainfall event, and graupel observations. These events will provide an illustrative analysis of the observations being produced by all the individual disdrometer instruments within DiveN. Enhanced scrutiny will be placed on the performance of the present weather code because this variable will be used to verify the Met Office radar HCAs. \section{Thies Clima Laser Precipitation Monitor}\label{instrument} \subsection{Specification}\label{spec} The instruments used in DiveN (see Figure \ref{fig:weybourne}) are the Thies Laser Precipitation Monitor (LPM), model number 5.4110.00.200, which are described in detail in \cite{Thies2011}. To make observations the instrument utilises an infrared (785 mm) beam with dimensions 228 mm x 20 mm x 0.75mm, a total horizontal area of 45.6cm%25. The infrared beam is emitted from one end of the instrument and is directed to the other. A photo-diode and signal processor determine the optical characteristics including optical intensity which is reduced as a particle falls through the beam. The diameter of the hydrometeor is inferred by the maximum amplitude of the signal reduction. Figure 1 in \cite{Loffler-Mang2000} describes a similar instrument (Parsivel-1) with the same observing principle and is an excellent visualisation of the technique which is employed by the Thies LPM. The signal processing claims to detect and remove particles that fall on the edge of the beam: "The measured values are processed by a signal processor (DSP), and checked for plausibility (e.g. edge hits).'' No further details are given by the manufacturer. The instrument is able to allocate individual hydrometeors into 20 diameter bins from 0.125 mm to \$&gt;\$ 8 mm, and 22 speed bins from \$&gt;\$ 0.2 m s\$A{-1}\$. The Thies disdrometer performs additional calculations on the incoming data which it attaches to the Telegram 4</pre>	Apple 12:1237 Journal of Market       ★ Reject     ✓ Accept       Added describes a similar     instrument (ParsiveL., (show all))       Apr. 2019 3:52 PM + You       ★ Reject     ✓ Accept       Ab     Deleted -measurement       Apr. 2019 3:52 PM + You       ★ Reject     ✓ Accept       Changed used to which is       employed       Apr. 2019 3:52 PM + You       ★ Reject     ✓ Accept       Changed Precipitation typ       (show all) to Hydrometeor type       Apr. 8, 2019 4:01 PM + You       ★ Reject     ✓ Accept       Changed Precipitation typ       (show all) to hydrometeor type       Apr. 8, 2019 4:02 PM + You       ★ Reject     ✓ Accept
158 159 160 161 - 162 163 - 164	<pre>studies from the first 12 months of Diven observations are then discussed. The case studies include rain-snow transitions in the 2017 named winter storm poris, a convective rainfall event, and graupel observations. These events will provide an illustrative analysis of the observations being produced by all the individual disdrometer instruments within DiveN. Enhanced scrutiny will be placed on the performance of the present weather code because this variable will be used to verify the Met office radar HCAs.  <pre>\subsection{Specification}\label{spec} The instruments used in DiveN (see Figure \ref{fig:weybourne}) are the Thies\texttrademark{Laser Precipitation Monitor (LPM), model number 5.4110.00.200, which are described in detail in \cite{Thies2011}. To make observations the instrument utilises an infrared (785 nm) beam with dimensions 228 mm x 20 mm x 0.75mm, a total horizontal area of 45.6cm/S23. The infrared beam is emitted from one end of the instrument and is directed to the other. A photo-diode and signal processor determine the optical characteristics including optical intensity which is reduced as a particle falls through the beam. The diameter of the hydrometeor is inferred by the maximum amplitude of the signal reduction and the speed of the hydrometeor is estimated by the duration of the signal reduction. Figure 1 in \cite{Loffler-Mang2000} describes a similar instrument (Parsivel-1) with the same observing principle and is an excellent visualisation of the technique which is employed by the thies LPM. The signal processing claims to detect and remove particles that fall on the edge of the beam: `The measured values are processed by a signal processor (OSP), and checked for plausibility (e.g. edge hits).'' No further details are given by the manufacturer. The instrument is able to allocate individual hydrometeors into 20 diameter bins from 0.125 mm to \$&gt;\$ 8 mm, and 22 speed bins from \$&gt;\$ 0.2 m s\$A{-1}\$ to \$&gt;\$ 20 m s\$A{-1}\$.</pre></pre>	Apple 12:1237 Jose Weil Red       ★ Reject     ✓ Accept       Added describes a similar instrument (Parsivel (show all) Apr.8. 2019 3:52 PM + You       ★ Reject     ✓ Accept       Ab Deleted -messurement Apr.8. 2019 3:52 PM + You       ★ Reject     ✓ Accept       Changed used to which is employed Apr.8. 2019 3:52 PM + You       ★ Reject     ✓ Accept       Changed Precipitation typ (show all) to Hydrometeor type Apr.8. 2019 4:01 PM + You       ★ Reject     ✓ Accept       Changed precipitation typ (show all) to hydrometeor type Apr.8. 2019 4:02 PM + You       ★ Reject     ✓ Accept       Changed such that to since Apr.8. 2019 4:02 PM + You       ★ Reject     ✓ Accept
158 159 160 161 - 162 - 163 - 164	<pre>studies from the first 12 months or biven observations are then discussed. The case studies include rain-snow transitions in the 2017 named winter storm Doris, a convective rainfall event, and graupel observations. These events will provide an illustrative analysis of the observations being produced by all the individual disdrometer instruments within Diven. Enhanced scrutiny will be placed on the performance of the present weather code because this variable will be used to verify the Met office radar HCAs. \section{Thies Clima Laser Precipitation Monitor}\label{instrument} \subsection{Specification}\label{spec} The instruments used in Diven (see Figure \ref{fig:weybourne}) are the Thies Laser Precipitation Monitor (LPM), model number 5.4110.00.200, which are described in detail in \cite{Thies2011}. To make observations the instrument utilises an infrared (785 mm) beam with dimensions 228 mm x 20 mm x 0.75mm, a total horizontal area of 45.6cm%25. The infrared beam is emitted from one end of the instrument and is directed to the other. A photo-diode and signal processor determine the optical characteristics including optical intensity which is reduced as a particle falls through the beam. The diameter of the hydrometeror is inferred by the maximum amplitude of the signal reduction and the speed of the hydrometer is estimated by the duration of the signal reduction. Figure 1 in \cite{Loffler=Mang2000} describes a simil ar instrument (Parsivel-1) with the same observing principle and is an excellent visualisation of the technique which is employed by the Thies LPM. The signal processing claims to detect and remove particles that fall on the edge of the manufacturer. The instrument is able to allocate individual hydrometeors into 20 diameter bins from 0.125 mm to \$&gt;\$ 8 mm, and 22 speed bins from \$&gt;\$ 0.2 m s\$A(-1)\$ to \$&gt;\$ 20 m s\$A(-1)\$. The Thies disdrometer performs additional calculations on the incoming data which it attaches to the Telegram 4 serial output. Table \ref{Tab:var} provides de</pre>	Apple 12, 203 / 500 MM + Nd       ★ Reject     ✓ Accept       Added describes a similar instrument (Parsivel (show all) Apr.8, 2019 3:52 PM + You       ★ Reject     ✓ Accept       Ab Deleted -messurement Apr.8, 2019 3:52 PM + You       ★ Reject     ✓ Accept       Changed used to which is employed Apr.8, 2019 3:52 PM + You       ★ Reject     ✓ Accept       Changed Precipitation typ (show all) to Hydrometeor type Apr.8, 2019 4:01 PM + You       ★ Reject     ✓ Accept       Changed Precipitation typ (show all) to hydrometeor type Apr.8, 2019 4:02 PM + You       ★ Reject     ✓ Accept       Changed greetheteor type Apr.8, 2019 4:02 PM + You       ★ Reject     ✓ Accept       Changed greetheteor type Apr.8, 2019 4:02 PM + You       ★ Reject     ✓ Accept       Ø Apr.9, 2019 3:30 PM + You       ★ Reject     ✓ Accept
158 159 160 161 - 162 163 - 164	<pre>studies from the first 12 months of Diven observations are then discussed. The case studies include rain-snow transitions in the 2017 named winter storm Doris, a convective rainfall event, and graupel observations these events will provide an illustrative analysis of the observations being produced by all the individual disdrometer instruments within Divex. Enhanced scrutiny will be placed on the performance of the present weather code because this variable will be used to verify the Met Office radar HCAS. \section{Thies Clima Laser Precipitation Monitor}\label{instrument} \subsection{Specification}\label{spec} The instruments used in DiveN (see Figure \ref{fig:weybourne}) are the Thies Laser Precipitation Monitor (LPM), model number 5.4110.00.200, which are described in detail in \cite{Thies2011}. To make observations the instrument utilises an infrared (785 nm) beam with dimensions 228 mm x 20 mm x 0.75mm, a total horizontal area of 45.6cm\$^25. The infrared beam is emitted from one end of the instrument and is directed to the other. A photo-diode and theydrometeor is inferred by the maximum amplitude of the signal reduction and the speed of the hydrometeor is estimated by the duration of the signal reduction. Figure 1 in \cite{Infler-Mang2000} describes a similar instrument (Parsivel-1) with the same observing principle and is an excellent visualisation of the technique which is employed by the Thies LPM. The signal processing claims to detect and remove particles that fall on the edge of the beam: "The measured values are processed by a signal processor (DSP), and checked for plausibility (e.g. edge hits).'' No further details are given by the manufacturer. The instrument is able to allocate individual hydrometeors into 20 diameter bins from 0.125 mm to \$&gt; 8 mm, and 22 speed bins from \$&gt; 0.2 m s\$4(-1)\$ to \$&gt; 20 m s\${-1}\$. The Thies disdrometer performs additional calculations on the incoming data which it attaches to the Telegram 4 serial output. Table \ref{Tabivar} provides details o</pre>	Apple 2019 000 MM + Kd       ★ Reject     ✓ Accept       Added describes a similar instrument (ParsiveL., (show all)) Apr 8, 2019 352 PM + You       ★ Reject     ✓ Accept       Ab     Deleted measurement Apr 8, 2019 352 PM + You       ★ Reject     ✓ Accept       Changed used to which is employed Apr 8, 2019 352 PM + You       ★ Reject     ✓ Accept       Changed Used to which is employed Apr 8, 2019 352 PM + You       ★ Reject     ✓ Accept       Changed Precipitation typ (show all) to Hydrometeor type Apr 8, 2019 402 PM + You       ★ Reject     ✓ Accept       Changed greecipitation typ (show all) to hydrometeor type Apr 8, 2019 402 PM + You       ★ Reject     ✓ Accept       Changed such that to since Apr 9, 2019 330 PM + You       ★ Reject     ✓ Accept
158 159 161 - 162 163 - 164	<pre>studies from the first 12 months of Diven observations are then discussed. The case studies include rain-snow transitions in the 2017 named winter storm Doris, a convective rainfall event, and graupel observations. These events will provide an illustrative analysis of the observations being produced by all the individual disdrometer instruments within Diven. Enhanced scrutiny will be placed on the performance of the present weather code because this variable will be used to verify the Met Office radar HCAs. \section{These Clima Laser Precipitation Monitor}\label{instrument} \subsection{Specification}\label{spec} The instruments used in Diven (see Figure \ref{fig:weybourne}) are the Thies Laser Precipitation Monitor (LPM), model number 5.4110.00.200, which are described in detail in \cite{Thies2011}. To make observations the instrument utilises an infrared (785 mm) beam with dimensions 228 mm x 20 mm x 0.75mm, a total horizontal area of 45.6cm525. The infrared beam is emitted from one end of the instrument and is directed to the other. A photo-diode and signal processor determine the optical characteristics including optical intensity which is reduced as a particle falls through the beam. The diameter of the hydrometeor is inferred by the maximum amplitude of the signal reduction and the speed of the hydrometeor is estimated by the duration of the signal reduction. Figure 1 in \cite{Loffler-Mang2000} describes a similar instrument (Parivel-1) with the same observing principle and is an excellent visualisation of the technique which is employed by the Thies LPM. The signal processing claims to detect and remove particles that fall on the edge of the beam: "The measured values are processed by a signal processor (DSP), and checked for plausibility (e.g. edge hits)." No further details are given by the manufacturer. The instrument is able to allocate individual hydrometeors into 20 diameter bins from 0.125 mm to \$55 8 mm, and 22 speed bins from \$55 0.2 m \$5A(-1)\$ to \$55 20 m \$5A(-1)\$. The Th</pre>	Apple 12:1237564 We fed       ★ Reject     ✓ Accept       Added describes a similar       instrument (ParsiveL., (show all))       Apr8, 2019:352 PM + You       ★ Reject     ✓ Accept       Ab Deleted -measurement       Apr8, 2019:352 PM + You       ★ Reject     ✓ Accept       Changed used to which is       employed       Apr8, 2019:352 PM + You       ★ Reject     ✓ Accept       Changed Precipitation typ       (show all) to Hydrometeor type       Apr8, 2019:4:01 PM + You       ★ Reject     ✓ Accept       Changed precipitation typ       (show all) to Hydrometeor type       Apr8, 2019:4:02 PM + You       ★ Reject     ✓ Accept       Changed such that to since       Apr9, 2019:3:02 PM + You       ★ Reject     ✓ Accept       Changed does not need to       (changed does not need to       (changed does not need to
158 159 160 161 - 162 163 - 164 165 166	<pre>studies from the first 12 months of Diven observations are then discussed. The case studies include rain-show transitions in the 2017 named winter storm Doris, a convective rainfall event, and graupel observations. These events will provide an illustrative analysis of the observations being produced by all the individual disdrometer instruments within DiveN. Enhanced scrutiny will be placed on the performance of the present weather code because this variable will be used to verify the Met Office radar HCAS. \subsection{Specification}\label{spec} The instruments used in DiveN (see Figure \ref{fig:weybourne}) are the Thies Laser Precipitation Monitor (LPM), model number 5.4110.00.200, which are described in detail in \cite{thies2011}. To make observations the instrument utilises an infrared (785 nm) beam with dimensions 228 mm x 20 mm x 0.75mm, at total horizontal area of 45.6mSv25. The infrared beam is emitted from one end of the instrument and is directed to theoter. A photo-diode and signal processor determine the optical characteristics including optical intensity which is reduced as a particle falls through the beam. The diameter of the hydrometeor is inferred by the maximum amplitude of the signal reduction and the speed of the hydrometeor is estimated by the duration of the signal reduction. Figure 1 in \cite(toffier-Man2000) describes a similar instrument (Parsivel-1) with the same observing principle and is an excellent visualisation of the technique which is employed by the Thies LPM. The signal processing claims to detect and remove particles that fail on the edge of the beam: "The massured values are processed by a signal processor (DSP), and checked for plausibility (e.g. edge hits)." No further details are given by the manufacturer. The instrument is able to allocate individual hydrometeors into 20 diameter bins from 0.125 mm to \$&gt;\$ 8 mm, and 22 speed bins from \$&gt;\$ 0.2 m s\$A(-1)\$ to \$&gt;\$ 20 m s\$A(-1)\$. The Thies disdrometer performs additional calculations on the incoming data</pre>	Apple 12:1237 Journal Weildd       ★ Reject     ✓ Accept       Added describes a similar instrument (Parsivel (show all) Apr8, 2019 3:52 PM + You       ★ Reject     ✓ Accept       Ab     Deleted -measurement Apr8, 2019 3:52 PM + You       ★ Reject     ✓ Accept       Changed used to which is employed Apr8, 2019 3:52 PM + You       ★ Reject     ✓ Accept       Changed Precipitation typ (show all) to Hydrometeor type Apr8, 2019 4:01 PM + You       ★ Reject     ✓ Accept       Changed precipitation typ (show all) to hydrometeor type Apr8, 2019 4:02 PM + You       ★ Reject     ✓ Accept       Changed such-that to since Apr8, 2019 3:30 PM + You       ★ Reject     ✓ Accept       Changed such-that to since Apr8, 2019 3:30 PM + You       ★ Reject     ✓ Accept       Changed does not need to (show all) to is not Apr17, 2019 2:24 PM + You
158 159 160 161 - 162 163 - 164	<pre>studies from the first 12 months of Diven opervations are then discussed. The case studies include rain-show transitions in the 2017 named winter storm Doris, a convective rainfall event, and graupel observations. These events will provide an illustrative analysis of the observations being produced by all the individual disdrometer instruments within Diven. Enhanced scrutiny will be placed on the performance of the present weather code because this variable will be used to verify the Met Office radar HCAs. \subsection{Specification}\label{spec} The instruments used in Diven (see Figure \ref{fig:weybourne}) are the Thies Laser Precipitation Monitor (LPM), model number 5.4110.00.200, which are described in detail in <cite{thies2011}. (785="" 20="" 228="" an="" beam="" dimensions="" infrared="" instrument="" make="" mm="" mm)="" observations="" the="" to="" utilises="" with="" x="" x<br="">0.75mm, a total horizontal area of 45.6mm\$x25. The infrared beam is emitted from one end of the instrument and is directed to the other. A photo-diode and signal processor determine the optical characteristics including optical intensity which is reduced as a particle falls through the beam. The diameter of the hydrometeor is inferred by the maximum amplitude of the signal reduction and the speed of the hydrometeor is unterred by the maximum amplitude of the signal processing claims to detect and remove particles that fall on the edge of the easa: The measured values are processed by a signal processor (OSp), and checked for plausibility (e.g. edge hits).''' No furth details are given by the manufacturer. The instrument is able to allocate individual hydrometeors into 20 diameter bins from 0.125 mm to \$&gt;\$ 0 m s\$A{-1}\$. The Thies disdrometer performs additional calculations on the incoming data which it attaches to the Telegram 4 serial output. Table \ref{Tab:var} provides details of the variables and the range of possible values that the instrument is capable of recording. The usation Monitor is capable of recording. The present weather code is encoded as a n</cite{thies2011}.></pre>	Apple 12:1237-0500 MM + Rd       ★ Reject     ✓ Accept       Added describes a similar instrument (Parsivel(show all) Apr.8. 2019:352 PM + You       ★ Reject     ✓ Accept       Ab Deleted -messurement Apr.8. 2019:352 PM + You       ★ Reject     ✓ Accept       Changed used to which is employed Apr.8. 2019:352 PM + You       ★ Reject     ✓ Accept       Changed Precipitation typ (show all) to Hydrometeor type Apr.8. 2019:401 PM + You       ★ Reject     ✓ Accept       Changed precipitation typ (show all) to hydrometeor type Apr.8. 2019:402 PM + You       ★ Reject     ✓ Accept       Changed such that to since Apr.9. 2019:3:30 PM + You       ★ Reject     ✓ Accept       Changed des-not need to (show all) to is not Apr.17. 2019:2:4 PM + You       ★ Reject     ✓ Accept
158 159 160 161 - 162 163 - 164 165 166	<pre>scueres rrum the rist 12 months of Diven observations are then discussed. The Case Studies include rain-snow trainsitions in the 2017 named winter storm Doris, a convective rainfall event, and graupel Observations. These events will provide an illustrative analysis of the observations being produced by all the individual disdrometer instruments within Diven. Enhanced scrutiny will be placed on the performance of the present weather code because this variable will be used to verify the Met Office radar HCAS. /section{Thies Clima Laser Precipitation Monitor}/label{instrument} /subsection{Specification}/label{spec} The instruments used in Diven (see Figure \ref[fig:weybourne]) are the Thies Laser Precipitation Monitor (LPM), model number 5.4110.00.200, which are described in detail in /cite{Thies2011}. To make observations the instrument utilises an infrared (785 mm) beam with dimensions 228 mm x 20 mm x 0.78mm, a total horizontal area of 45.6m5/23. The infrared beam is emitted from one end of the instrument and is directed to the other. A photo-idde and signal processor determine the optical characteristics including optical intensity which is reduced as a particle falls through the beam. The diameter of the hydrometeor is inferred by the maximum amplitude of the signal reduction and the speed of the hydrometeor is estimated by the duration of the signal reduction. Figure 1 in /cite{Loffler-Mang2000} describes a similar instrument (Parsivel-1) with the same observing principle and is an excellent visualisation of the technique which is employed by the Thies LPM. The signal processor (DSP), and checked for plausing claims to detect and renove particles that fail on the edge of the manufacturer. The instrument is able to allocate individual hydrometeors into 20 diameter bins from 0.125 mm to \$5 8 mm, and 22 speed bins from \$5 0.2 m s\$4(-1)\$ to \$5 2 0 m s\$4(-1)\$. The this disdrometer performs additional calculations on the incoming dat which it attaches to the Telegram 4 serial output. Table \</pre>	Apple 12, 123 - 0500 MM + Rd       ★ Reject     ✓ Accept       Added describes a similar instrument (Parsivel (show all) Apr.8. 2019 3:52 PM + You       ★ Reject     ✓ Accept       Ab Deleted -measurement Apr.8. 2019 3:52 PM + You       ★ Reject     ✓ Accept       Changed used to which is employed Apr.8. 2019 3:52 PM + You       ★ Reject     ✓ Accept       Changed Precipitation typ (show all) to Hydrometeor type Apr.8. 2019 4:01 PM + You       ★ Reject     ✓ Accept       Changed precipitation typ (show all) to hydrometeor type Apr.8. 2019 4:02 PM + You       ★ Reject     ✓ Accept       Changed such that to since Apr.9. 2019 3:03 PM + You       ★ Reject     ✓ Accept       Changed such that to since Apr.9. 2019 3:03 PM + You       ★ Reject     ✓ Accept       Changed does not need to (show all) to is not Apr.17, 2019 2:24 PM + You       ★ Reject     ✓ Accept
158 159 160 161 - 162 163 - 164 165 166	<pre>scues rrum the rinst 12 months or Divem observations are then discussed. The Case studies include rain-snow transitions in the 2017 handed winter storm Doris, a convective rainfail event, and graupel observations. These events will be placed on the performance of the present weather code because this variable will be used to verify the Met Office radar MCAS. /section{Thies Clima Laser Precipitation Monitor}\label{instrument} /subsection{Specification}\label{spec} The instruments used in Divem (see Figure \ref{fig:weybourne}) are the Thies] Laser Precipitation Monitor (LPM), model number 5.4110.00.200, which are described in detrichies2011. To make observations the instrument utilises an infrared (785 mm) beam with dimensions 228 mm x 20 mm x 0.75mm, a total horizontal area of 45.6cm\$A25. The infrared beam is emitted from one end of the instrument and is directed to the other. A photo-diode and signal processor determine the optical characteristics including optical intensity which is reduced as a particle fails through the beam. The dimeter of the hydrometer is inferred by the maximum amplitude of the signal reduction and the speed of the hydrometer is estimated by the duration of the signal reduction. Figure 1 in Loffler-Mang20000 describes a signal processor (DSP), and checked for plausibility (e.g. edge hits).'' No further details are given by the manufacturer. The instrument is able to allocate individual hydrometeors into 20 diameter of the S0 m S&gt;6 20 m S&gt;6 20 m S&gt;6 20.2 m SA(-1) 5 to S&gt;6 20 m S&gt;(-1).</pre>	Added describes a similar         Added describes a similar         Instrument (ParsiveL., (show all))         Apr8, 2019 352 PM × You         X Reject       ✓ Accept         Added describes a similar         Instrument (ParsiveL., (show all))         Apr8, 2019 352 PM × You         X Reject       ✓ Accept         Changed used to which is         employed         Apr8, 2019 352 PM × You         X Reject       ✓ Accept         Changed Precipitation typ         (show all) to Hydrometeor type         Apr8, 2019 4:01 PM × You         X Reject       ✓ Accept         Changed precipitation typ         (show all) to hydrometeor type         Apr8, 2019 4:02 PM × You         X Reject       ✓ Accept         Changed such that to since         Apr9, 2019 3:30 PM × You         X Reject       ✓ Accept         Changed does not need to         (show all) to is not         Apr17, 2019 2:24 PM × You         X Reject       ✓ Accept         Changed does not need to         (show all) to is not         Apr17, 2019 2:24 PM × You         X Reject       ✓ Accept         Changer, all
158 159 160 161 - 163 - 164 165 166	<pre>scueics irom the irist 12 months or Divem observations are then discussed. The Case studies include rain-snow transitions in the 2017 handed winter storm Doris, a convective rainfail event, and graupel observations. These events will be placed on the performance of the present weather code because this variable will be used to verify the Met Office radar HCAs. \section(Thies Clima Laser Precipitation Monitor)\label{instrument} \subsection{Specification}\label{spec} The instruments used in Divem (see Figure \ref{fig:weybourne}) are the Thies Laser Precipitation Monitor (LPM), model number 5.4110.00.200, which are described in detail in \cite{Thies201}. To make observations the instrument utilises an infrared (785 mm) beam with dimensions 228 mm x 20 mm x 0.78m, a total horizontal area of 45.6cm\$^25. The infrared beam is emitted from one end of the instrument and is directed to the other. A photo-diode and signal processor determine the optical characteristics including optical intersum (Parsive1-D) with the same observing principle and is an excellent visualisation of the technique which is employed by the Thies LPM. The signal processing claims to detect and remove particle stat fall on the edge of the baam. The instrument is able to allocate individual hydrometeors into 20 diameter bits from 0.125 mm to \$5.8 mm, and 22 speed bits from \$5.0 .2 m s\$4(-1)5 to \$5.2 0 m s\$4(-1)5. The Thies disdometer performs additional calculations on the incoming data which it attaches to the Telegram 4 serial output. Table \ref{Tab:var} provides details of the variables and the range of possible values that the instrument is capable of recording. The quantity, intensity, and type of precipitation (dirize), rai, snow, ice, grains, soft hall, hall a well as combinations of multiple types) are calculated. Mydrometeor type is precorded as a present weather code. Table \ref{Tab:war} of busible Values that the instrument is capable of recording. The quantity, intensity, and type of precipitation (dirize), rai,</pre>	Apple 12:1237 Jour We Red       ★ Reject     ✓ Accept       Added describes a similar instrument (Parsivel (show all) Apr8, 2019 3:52 PM + You       ★ Reject     ✓ Accept       Ab     Deleted -measurement Apr8, 2019 3:52 PM + You       ★ Reject     ✓ Accept       Changed used to which is employed Apr8, 2019 3:52 PM + You       ★ Reject     ✓ Accept       Changed Precipitation typ (show all) to Hydrometeor type Apr8, 2019 4:01 PM + You       ★ Reject     ✓ Accept       Changed precipitation typ (show all) to hydrometeor type Apr8, 2019 4:01 PM + You       ★ Reject     ✓ Accept       Changed such that to since Apr8, 2019 3:30 PM + You       ★ Reject     ✓ Accept       Changed design the You       ★ Reject     ✓ Accept       Changed Jos Shat to since Apr8, 2019 3:30 PM + You       ★ Reject     ✓ Accept       Changed does not need to (show all) to is not Apr17, 2019 2:24 PM + You       ★ Reject     ✓ Accept       Changed fto with Marc Hilleb (show all) Apr8, 2019 3:27 PM + You       ★ Reject     ✓ Accept
158 159 160 161 - 163 - 164 165 166 167 168	<pre>scueres rrom the infsile work of gruppel observations are then discussed. The case studies native analysis of the observations hint within provide an illustrative analysis of the observations being produced by all the individual disdometer instruments within proves. Enhanced scrutiny will be placed on the performance of the present weather code because this variable will be used to verify the Met Office radar HCAs. /section(Thies Clima Laser Precipitation Monitor)\label{instrument} /subsection(Specification)\label{spec} The instruments used in Divek (see Figure \ref(fig:weybourne}) are the Thies\texttrademark() Laser Precipitation Monitor (LFM), model number 5.4110.00.200, which are described in detail in \citeKinetiescoll). To make observations the instrument utilises an infrared (785 mg) beam with dimensions 228 mm x 20 mm x 0.75mm, a total horizontal area of 45.6cm%v25. The infrared beam is emitted from one end of the instrument and is directed to the other. A photo-diode and signal processor determine the optical characteristics including optical intensity which is reduced as a particle falls through the beam. The diameter of the hydrometeor is inferred by the maximum amplitude of the signal reduction and the speed of the hydrometeor is estimated by the duration of the isgnal reduction. Figure 1 in \citeL(offier-wang2000) describes a similar instrument (Parsivel-1) with the same observing principle and is an excellent visualisation of the ischnique which is melyosed by the Thies LFM. The signal Processing claims to detect and remove particles that fall on the edge of the beam: "The measured values are processed by a signal processor (DSP), and checked for plausibility (e.g. edge hits)." No further details are given by the manufacturer. The instrument is able to allocate individual hydrometeors into 20 diameter birs from 0.125 mm to \$5.8 m, and 22 speed bins from \$5.0.2 m SA(-1)5.           The thiss disdometer performs additional calculations on the incoming data which it att</pre>	Appl 21:23756401401 Md Md       ★ Reject     ✓ Accept       Added describes a similar instrument (ParsiveL., (show all)) Apr8, 2019 3:52 PM + You       ★ Reject     ✓ Accept       Ab     Deleted -messurement Apr8, 2019 3:52 PM + You       ★ Reject     ✓ Accept       Changed used to which is employed Apr8, 2019 3:52 PM + You       ★ Reject     ✓ Accept       Changed Precipitation typ (show all) to Hydrometeor type Apr8, 2019 4:01 PM + You       ★ Reject     ✓ Accept       Changed precipitation typ (show all) to hydrometeor type Apr8, 2019 3:02 PM + You       ★ Reject     ✓ Accept       Changed such-that to since Apr9, 2019 3:30 PM + You       ★ Reject     ✓ Accept       Changed does not need to (show all) to hydrometeor type Apr17, 2019 3:30 PM + You       ★ Reject     ✓ Accept       Changed does not need to (show all) to is not Apr17, 2019 2:24 PM + You       ★ Reject     ✓ Accept       Changed does not need to (show all) to is not Apr17, 2019 2:24 PM + You       ★ Reject     ✓ Accept       Changed such-that to since Apr9, 2019 3:20 PM + You       ★ Reject     ✓ Accept       Changed does not need to (show all) to is not Apr8, 2019 3:27 PM + You       ★ Reject     ✓ Accept
158 159 160 161 - 162 163 - 164 165 166 167 168 169 170	<pre>scueres rrom the infsile work, and graupel observations are then discussed. The case studies include rain-show transitions in the 2017 named winter storm poris, a convective rainfail event, and graupel observations. These events will provide an illustrative analysis of the observations being produced by all the individual disdometer instruments within Dives. Enhanced scrutiny will be placed on the performance of the present weather code because this variable will be used to verify the Met Office radar HCAS. /section(Thies Clima Laser Precipitation Monitor)\label{instrument} /subsection(Specification)\labelspec) The instruments used in DiveN (see Figure \ref[fig:weybourne]) are the Thies] Laser Precipitation Monitor (LPM), model number 5.4110.00.200, which are described in detail in \cite{Thies2011}. To make observations the instrument utilises an infrared (785 m) beam with dimensions 228 mm x 20 mm x 0.75mm, a total horizontal area of 45.6m5/23. The infrared beam is emitted from one end of the instrument and is directed to the other. A photo-diode and signal processor determine the optical characteristics including optical intensity which is reduced as a particle falls through the beam. The diameter of the hydrometeor is inferred by the maximum amplitude of the signal reduction and the speed of the hydrometeor is estimated by the duration of the signal reduction. Figure 1 in \citet(cliffle=radur2000) describes a similar instrument (Farsivel-1) with the same observing principle and is an excellent visualisation of the technique which is employed by the Thies LPM. The signal processory (DSP), and checked for plausibility (e.g. edge hits).'' No further details are given by the manufacturer. The instrument is able to allocate individual hydrometeors into 20 diameter bins from 0.125 mm to 55 8 mm, and 22 speed bins from 55 0.2 m signal processory (DSP), and checked for plausibility (e.g. edge hits).'''. No further details are given by the manufacturer. The instrument is able to allocate individu</pre>	Apple 12: 123 - 0500 MM + Nd       ★ Reject     ✓ Accept       Added describes a similar instrument (Parsivel (show all) Apr.8. 2019 3:52 PM + You       ★ Reject     ✓ Accept       Ab Deleted messurement Apr.8. 2019 3:52 PM + You       ★ Reject     ✓ Accept       Changed used to which is employed Apr.8. 2019 3:52 PM + You       ★ Reject     ✓ Accept       Changed Precipitation typ (show all) to Hydrometeor type Apr.8. 2019 4:01 PM + You       ★ Reject     ✓ Accept       Changed precipitation typ (show all) to hydrometeor type Apr.8. 2019 4:02 PM + You       ★ Reject     ✓ Accept       Changed such that to since Apr.9. 2019 4:02 PM + You       ★ Reject     ✓ Accept       Changed des-not needto (show all) to hydrometeor type Apr.17. 2019 2:24 PM + You       ★ Reject     ✓ Accept       Changed does not needto (show all) to is not Apr.17. 2019 2:24 PM + You       ★ Reject     ✓ Accept       Changed r, to with Marc Hilleb (show all) Apr.8. 2019 3:27 PM + You       ★ Reject     ✓ Accept
158 159 160 161 - 163 - 164 165 166 166 166 168	<pre>scuere rrom the risk 12 months or Diven observations are then discussed. The Case Studies include rain-snow transitions in the 2017 hand winter storm Doris, a convective rainfall event, and grapel observations. These events will provide an illustrative analysis of the observations being produced by all the individual disdometer instruments within Divek. Enhanced scrutiny will be placed on the performance of the present weather code because this variable will be used to verify the Met Office radar HCAS. \section{These Clima Laser Precipitation Monitor}\label{instrument} \subsection{Specification}\label{spec} The instruments used in Divek (see Figure \ref[figureybourne)) are the Thies\texttrademark() Laser Precipitation Monitor (LPM), model number 5.4110.00.200, which are described in detail in \cite(Thies2011). To make observations the instrument ufilises an infrared (785 mg) beam with dimensions 228 mm x 20 mm x 0.77mm, a total horizontal area of 45.6cm\$25. The infrared beam is emitted from one end of the instrument and is afforced to ther. A photo-Idode and signal processor determine the optical characteristics including optical intensity which is reduced as a particle falls through the beam. The diameter of the hydrometeor is inferred by the maximu amplitude of the signal reduction and the speed of the hydrometeor is estimated by the duration of the signal reduction. Figure 1 in \cite(Infler=Ama)OU describes a similar intrument (ArisVel-1) with the same observing principle and is an excellent visualisation of the instrument is able to allocate individual hydrometeors into 20 diameter bins from 0.125 mm to \$55 mm, and 22 speed bins from \$5.0.2 m s\$6(-1)5 to \$5 20 m s\$6(-2)5. The Thies disdometer performs additional calculations on the incoming data which it attaches to the relegram 4 serial output. Table \ref[Tab:var] provides details of the variables and the range of possible values that the instrument codes that the Thies Laser Foreipitation Monitor is capable of recording. The present weather code is</pre>	Apple 12:0270000000000000000000000000000000000
158 159 160 161 - 163 - 164 165 166 167 168 169 170	<pre>studies rrom the inst 12 months or Diven observations are then discussed. The Case studies include rain-snow transitions in the 2017 hand winter storm Doris, a convective rainfall event, and graupel observations. These events will provide an illustrative analysis of the observations being produced by all the individual disdometer instruments within Divek. Enhanced scrutiny will be placed on the performance of the present weather code because this variable will be used to verify the Met Office radar HCAS. \section(Thies Clima Laser Precipitation Monitor)\label{instrument} \subsection(Specification)\label(spec) The instruments used in Divek (see Figure \ref(figurewybourne)) are the Thies\texttrademark() Laser Precipitation Monitor (LPM), model number 5.4110.00.200, which are described in detail in \cite(Thies2011). To make observations the instrument utilises an infrared (785 mm) beam with dimensions 228 mm x 20 mm x 0.75mm, a total horizontal area of 45.6mx42. The infrared beam is emitted from one end of the instrument and is directed to the other. A photo-diode and signal processor determine the optical characteristics including optical intensity which is reduced as particle fails through the beam. The dimense of the hydrometeor is inferred by the maximum amplitude of the signal processing claims to detect and remove particles that fail on the edge of the beam: "The masured values are processed by a signal processing claims to detect and remove particles that fail on the edge of the manufacturer. The instrument is able to allocate individual hydrometeors into 20 diameter bins from 0.125 mm to \$55 8 mm, and 22 speed bins from \$55 0.2 m sis(-1)5 to 55 20 m 55(-1)5. The Thies disdrometer performs additional Calculations on the incoming data which it attaches to the Telegram 4 serial output. Table \ref[Tabivar] provides details of the variables and the range of possible values that the instrument tis capable of recording. The quantity, intensity, and type of precipitation details of the variables</pre>	Apple 12:12:37:00:00 MM + Noi       ★ Reject     ✓ Accept       Added describes a similar instrument (ParsiveL., (show all)) Apr8, 2019:352 PM + You       ★ Reject     ✓ Accept       Ab     Deleted -measurement Apr8, 2019:352 PM + You       ★ Reject     ✓ Accept       Changed used to which is employed Apr8, 2019:352 PM + You       ★ Reject     ✓ Accept       Changed Precipitation typ (show all) to Hydrometeor type Apr8, 2019:4:01 PM + You       ★ Reject     ✓ Accept       Changed precipitation typ (show all) to Dydrometeor type Apr8, 2019:4:01 PM + You       ★ Reject     ✓ Accept       Changed guerkthat to since Apr8, 2019:3:01 PM + You       ★ Reject     ✓ Accept       Changed desenst needto (show all) to is not Apr17, 2019:2:24 PM + You       ★ Reject     ✓ Accept       Changed rowith Marc Hilleb (show all) to is not Apr17, 2019:2:24 PM + You       ★ Reject     ✓ Accept       Changed rowith Marc Hilleb (show all) Apr8, 2019:3:27 PM + You       ¥ Reject     ✓ Accept       Changed rowith Marc Hilleb (show all) Apr8, 2019:3:27 PM + You       ¥ Reject     ✓ Accept       Deleted \ref[case_studies] Mar30, 2019:1:22 PM + You       ¥ Reject     ✓ Accept
158 159 160 161 - 162 163 - 164 165 166 167 168 169 170	<pre>studies from the first 12 months of Diven Observations are then discussed. The Case studies include rain-snow transitions in the 2017 maned whiter storm Doris, a convective rainfall event, and graupel observations. These events will provide an illustrative analysis of the observations being produced by all the individual disconnecter instruments within Diven. Enhanced scrutiny will be placed on the performance of the present weather code because this variable will be used to verify the Met Office radar MCAs.</pre>	Apple 12: 203 / South Merked       ★ Reject     ✓ Accept       Added describes a similar instrument (Parsivel (show all) Apr8, 2019 3:52 PM + You       ★ Reject     ✓ Accept       Ab     Deleted measurement Apr8, 2019 3:52 PM + You       ★ Reject     ✓ Accept       Changed used to which is employed Apr8, 2019 3:52 PM + You       ★ Reject     ✓ Accept       Changed Precipitation typ (show all) to Hydrometeor type Apr8, 2019 4:01 PM + You       ★ Reject     ✓ Accept       Changed precipitation typ (show all) to hydrometeor type Apr8, 2019 4:02 PM + You       ★ Reject     ✓ Accept       Changed such that to since Apr9, 2019 3:30 PM + You       ★ Reject     ✓ Accept       Changed desent need to (show all) to hydrometeor type Apr8, 2019 3:30 PM + You       ★ Reject     ✓ Accept       Changed for with Marc Hilleb (show all) to is not Apr17, 2019 2:24 PM + You       ★ Reject     ✓ Accept       Changed for with Marc Hilleb (show all) Apr8, 2019 3:27 PM + You       ★ Reject     ✓ Accept       Ab     Deleted Veffease_studies] Mar 30, 2019 12:29 PM + You       ★ Reject     ✓ Accept
158 159 160 161 - 162 163 - 164 165 166 167 168 169 170	<pre>studies from the first 12 months or Diven Observations are then discussed. The Case studies include rain-snow transitions in the 2017 maned whiter storm Doris, a convective rainfall event, and graupel observations. These events will provide an illustrative analysis of the observations being produced by all the individual disdometer instruments within Diven. Enhanced scrutiny will be placed on the performance of the present weather code because this variable will be used to verify the Met Office radar MCAS.</pre>	Apple 12: 123 - 0500 MM + Noi       ★ Reject     ✓ Accept       Added describes a similar instrument (ParsiveL., (show all) Apr8, 2019 3:52 PM + You       ★ Reject     ✓ Accept       Ab     Deleted -messurement Apr8, 2019 3:52 PM + You       ★ Reject     ✓ Accept       Changed used to which is employed Apr8, 2019 3:52 PM + You       ★ Reject     ✓ Accept       Changed Precipitation typ (show all) to Hydrometeor type Apr8, 2019 4:01 PM + You       ★ Reject     ✓ Accept       Changed precipitation typ (show all) to hydrometeor type Apr8, 2019 3:02 PM + You       ★ Reject     ✓ Accept       Changed such that to since Apr9, 2019 3:30 PM + You       ★ Reject     ✓ Accept       Changed desend need to (show all) to hydrometeor type Apr8, 2019 3:20 PM + You       ★ Reject     ✓ Accept       Changed does not need to (show all) to is not Apr17, 2019 2:24 PM + You       ★ Reject     ✓ Accept       Changed does not need to (show all) Apr8, 2019 3:27 PM + You       ★ Reject     ✓ Accept       Apr8, 2019 3:27 PM + You       ★ Reject     ✓ Accept       Changed such thar chilleb (show all) Apr8, 2019 3:27 PM + You       ★ Reject     ✓ Accept       Ab     Deleted Veffease_studies] Mar 30, 2019 1:227 PM + You       ★ Reject     ✓ Accept       Ab     Deleted Veffease_studies] Mar 30, 2019
158 159 160 161 - 162 163 - 164 165 166 167 168 169 170 171 172	<pre>suures runs use runs 12 months or piven observations are then discussed. The class studies includes influence train-show trainsitions in the 2017 named winter storm boris, a convective rainfall event, and grangel observations. Hese events will provide an illustrative analysis of the observations being produced by all the individual disdometer instruments within Diven. Enhanced scrutiny will be placed on the performance of the present weather code because this variable will be used to verify the Met Office radar HCAS. \section(Thies Clima Laser Precipitation Monitor)\label{instrument} \subsection(Specification)\label{spec}) The instruments used in Diven (see Figure \reff(figureybourne)) are the Thies/texttrademark() Laser Precipitation Monitor (LPM), model number 5.4110.00.200, which are described in detail in \cite(Thies/COLL). To make observations the instrument utilises an infrared (735 m) beam with dimensions 228 mm x 0.75mm, a total horizontal area of 45 GenX43. The infrared beam is mitted from one end of the instrument and is directed to the other. A photo-clide and signal processor determine the optical characteristics including optical intensity which is reduced as a particle falls through the beam. The diameter of the hydrometeor is inferred by the maximu applitude of the signal reduction and the speed of the hydrometeor is estimated by the duration of the estimal reduction. Figure 1 th. <cli>Cliff(figureybourne) describes a similar instrument Grassvel-1) with the sam observing principle and is an excellent visualisation of the lechnique with the simple of the signal processor (DS7), and checked for plausibility (e.g. edge hits).'' No further details are given by the manufacturer. The instrument is able to allocate individual hydrometors into 20 diameter bins from 0.125 mm to 35 m, and 22 speed bins from 53.0 m sS4-clifs. The files disdometer performs additional calculations on the incoming data which it attaches to the Telegram 4 serial output. Table \reff(Tab:var) provides details of the variab</cli></pre>	Apple 12: 237 5500 MM × Nod       ★ Reject     ✓ Accept       Added describes a similar instrument (Parsivel. (show all) Apr.8. 2019 3:52 PM × You       ★ Reject     ✓ Accept       Ab     Deleted messurement Apr.8. 2019 3:52 PM × You       ★ Reject     ✓ Accept       Changed used to which is employed Apr.8. 2019 3:52 PM × You       ★ Reject     ✓ Accept       Changed Precipitation typ (show all) to Hydrometeor type Apr.8. 2019 4:01 PM × You       ★ Reject     ✓ Accept       Changed precipitation typ (show all) to hydrometeor type Apr.8. 2019 4:02 PM × You       ★ Reject     ✓ Accept       Changed such that to since Apr.9. 2019 4:02 PM × You       ★ Reject     ✓ Accept       Changed such that to since Apr.9. 2019 3:30 PM × You       ★ Reject     ✓ Accept       Changed such that to since Apr.9. 2019 3:32 PM × You       ★ Reject     ✓ Accept       Changed such that to since Apr.9. 2019 3:32 PM × You       ★ Reject     ✓ Accept       Changed such that to since Apr.9. 2019 3:32 PM × You       ★ Reject     ✓ Accept       Ø     Changed for with Marc Hilleb (show all) Apr.8. 2019 3:32 PM × You       ★ Reject     ✓ Accept       Ø     Deleted As with optical probes aboard aircraft w (show all) Apr.8. 2019 3:42 PM × You       ★ Reject     ✓ Accept
158 159 160 161 - 163 - 164 165 166 166 166 169 170 171 172 173	<pre>subset run up inst 2 months or piven observations are then discussed. The class studies includes influes rain-show transitions in the 2017 named winter storm poris, a convective rainfall event, and grangel observations. Hese events will provide an illustrative analysis of the observations being produced by all the individual disdrometer instruments within Diven. Enhanced scrutiny will be placed on the performance of the present weather code because this variable will be used to verify the Met Office radar MCAs.</pre>	Added describes a similar         Added describes a similar         Instrument (ParsiveL., (show all))         Apr 8, 2019 352 PM × You         X Reject       ✓ Accept         Added describes a similar         Instrument (ParsiveL., (show all))         Apr 8, 2019 352 PM × You         X Reject       ✓ Accept         Changed used to which is         employed         Apr 8, 2019 352 PM × You         X Reject       ✓ Accept         Changed Precipitation typ         (show all) to Hydrometeor type         Apr 8, 2019 4:01 PM × You         X Reject       ✓ Accept         Changed genercipitation typ         (show all) to hydrometeor type         Apr 8, 2019 4:02 PM × You         X Reject       ✓ Accept         Changed such that to since         Apr 9, 2019 4:02 PM × You         X Reject       ✓ Accept         Changed does not need to         (show all) to is not         Apr 17, 2019 2:24 PM × You         X Reject       ✓ Accept         Changed 4:0 with Marc Hilleb         (show all) to is not         Apr 17, 2019 2:24 PM × You         X Reject       ✓ Accept         Ab       Dele

175	L	Deleted This paper focuses on
176	<pre>\cite{Tapiador2016} performed a physical experiment with 14 laser disdrometers (Parsive]-1) placed in close proximity (within 6 m\$^25) on the roof of a building in Toledo, Spain. Precipitation characteristics were calculated for one disdrometer's data, then for two instrument's combined data and so on until all 14 disdrometer's data were used. The aim was to test how many disdrometer's data were needed for the precipitation parameters to asymptote towards a stable value. It was found that a single disdrometer could underestimate instantaneous rain rate by 70\%. \cite{Tapiador2016} proposed that large drops contribute disproportionately to the rain rate and that instantaneous measurements have a lower chance of measuring large drops because they are sparsely populated. The DiVeN disdrometers have a shortest temporal resolution of 1 minute which alleviates some of the sampling issues by allowing time for larger droplets to be observed.</pre>	AB the hydrometeor ty (show all) Apr 8. 2019 3:11 PM • You X Reject
178 179 180 181	<pre>index index in the sample size of the instrument were larger and thus could count more particles at a faster rate, other limitations would occur. The instrument relies of speed observations. If two hydrometeor spet at the optical intensity which the signal processor must account for. Similarly for diameter, if two hydrometeor sample at a count of the sample area is thus limited to reduce the possibility of overlapping particles. The sample area is the user wave the sample area is the user wave the sample area is the user wave the particle in the user and the sample area is the user the user and the</pre>	Changed precipitation typ (show all) to hydrometeor type Apr.8.2019-402 PM × Vou ★ Reject ★ Accept Changed precipitation typ (show all) to hydrometeor type Apr.8.2019-402 PM + Vou ★ Reject ★ Accept Changed snow aggregate to ice crystal Mar 30, 2019 12:30 PM + You ★ Reject ★ Accept Changed lets to s Apr.8.2019-628 PM + You ★ Reject ★ Accept
182	Ayam, righte i millitetetetetetetetetetetetetetetetetete	· Deleted 2
183	The chance of two drops being in the disdrometer at the same time is unlikely except in extremely high precipitation rates. To examine this, a Poisson distribution test is applied using the sampling volume of the disdrometer with increasing drop concentrations. Figure \ref{fig:poisson_test} shows that precipitation rates of greater than 10,000 drops mins^{-1}s are required before the probability of simultaneous drops in the beam occurring becomes non-negligible. There is a 0.05% chance of 2 or more drops in the beam simultaneously for 105A45 drops mins^{-1}s observed by the disdrometer; 1 in every 1,075 drops. For a 105A55 drops mins^{-1}s observed by the disdrometer here is a 7% chance of 2 or more drops in the beam simultaneously; 1 in every 14 drops. For context, a drop count of 12,000 observed by the disdrometer located at NFARR Atmospheric observatory, chilbolton, England in March 2017 (see Section ref{violent_rain}) was equivalent to 22 mm hfs^{-1}s. Rain rates approaching 100 mm hfs^{-1}s would be necessary for the chance of 2 drops existing in the beam simultaneously to be non-negligible. Such rainfall rates are extremely rare in the UK.	Ab         Deleted 3 Apr 8, 2019 6:28 PM • You           X         Reject         ✓ Accept           Ab         Deleted -2 Apr 8, 2019 6:28 PM • You         ×           X         Reject         ✓ Accept           Ab         Deleted -2 Apr 8, 2019 6:28 PM • You         ×           X         Reject         ✓ Accept           Ab         Deleted -Yref(case_studies) Mar 30, 2019 12:31 PM • You         ×
184		🗙 Reject 🛛 🗸 Accept
185 186 187 - 188 - 189	<pre>\section{Description of the Network}\label{description} \subsection{Diven Locations} Disdrometers have similar site specification requirements as other precipitation instruments. Ideally a flat site with no tall objects or buildings nearby that can cause shadowing, and steps taken to minimise the splash of liquid droplets from the surrounding ground into the instrument. To this end, Thies recommends that the instrument be mounted on a 1.5 m pole above a grassy surface. A grassy surface also minimises convective upwelling from solar heating of the ground - a particular problem for concrete surfaces - which can slow hydrometeor fall speeds and create turbulence. Turbulence from buildings should</pre>	
100	also be avoided if possible since it acts to break larger particles into smaller particles, resulting in skewed drop size distributions.	
190 191 192	The locations chosen for DiVeN cover a variety of geophysical conditions such as mountain peaks, valleys and flat regions, as well as inland and coastal sites. The locations also cover the full breadth of the climatology of precipitation totals and hydrometeor types in the UK \citep{Fairman2015} with sites in wetter (Wales) and drier (East Anglia) regions as well as sites in warmer (southern England) and colder (northern Scotland) climates.	Deleted <b>Cairngorm Ski Centre is</b> Ab situated in a va (show all) Apr 8, 2019 1:51 PM • You
193	The typical range at which the Met Office radar HCA product will need to perform is \$<\$ 120 km (maximum range used to produce surface rainfall rate composite). For the disdrometers to be representative when verification work is performed, the instruments in DiveN are located at varying ranges from Met Office radars. Figure \ref{fig:DiveN_Map} shows the DiveN site locations and the Met Office radar locations for comparison. Table \ref{Tab:locations} gives an overview of each site in DiveN, including the coordinates, height a.m.s.l. and terrain characteristics.	X Reject     ✓ Accept       Apr8, 2019 1:50 PM + You       X Reject     ✓ Accept
195		Deleted <del>, which represent every</del>
196 197	Two instruments are located 10 m apart at NFARR Atmospheric Observatory in Chilbolton. These two instruments form part of an extended observational period of 12 months where their performance will be assessed against several other precipitation sensors located at the same site. A separate paper will be produced to address the results of this dual-instrument study.	AB possible method (show all) Apr 8, 2019 1:50 PM • You
198		Apr 8, 2019 1:51 PM • You
200		X Reject V Accept
201 <del>-</del> 202	\subsection{Installation} The main installation campaign occurred in February 2017 for 9 instruments. The Holme Moss site was installed shortly after in March, followed by Cairngorm and Feshie in June 2017. Dunkeswell is a Met Office installed site which was added to the network via a Raspberry Pi with 3G dongle being appended in July 2017. The last instrument to be installed was at Coverhead Estate in the Yorkshire Dales in December 2017, as a collaboration with Water@Leeds \url{http://water.leeds.ac.uk}.	
203 204	Installation took around 2 hours at each site and consisted of: anchoring the tripod to the ground; attaching the disdrometer and data logging box; plugging the disdrometer cables into the power strip and the Raspberry Pi; cutting the power strip cable to length for the site. The installation was designed to be `as plug and play as possible'. Wiring of plugs, data and power cables onto the disdrometer and coding of the Raspberry Pi were all completed in a lab before arriving at the site.	
205 206 207 208 -	\subsection{DiVex Costs and Environmental Impact}	
209	Each site required the following components to support the disdrometer: Davis Instruments\textsuperscript{\textregistered} tripod (\pounds100, \url{http://www.davisnet.com/product_documents/weather/manuals/07395-299_IN_07716.pdf]); IP67-rated box (\pounds25, \url{http://www.timeguard.com/products/safety/weathersafe-outdoor-power/outdoor-multi-connector-box}); Raspberry Pi 3 Model B (\pounds30, \url{http://www.timeguard.com/products/raspberry-pi-3-model-b/}) and a generic RS-485 to USB converter (\pounds12). Therefore the total cost per site for hardware was \pounds167. 200 m of power/data cable and tools required for the installation cost an additional \pounds270 and \pounds00 respectively. Some sites rely on a 3G dongle to upload data. The dongles themselves were free when purchased with a single-use data allotment. The total cost of hardware and equipment to build DiVeN amounted to \pounds2,500.	

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- 211 The Thies Clima instrument is power rated at a maximum of 750 mA @ 230 v. No typical usage has been measured but should the maximum be continuous, then the annual consumption would be 1,500 kwh per year, or \pounds190 p.a. at average UK electricity costs (valid March 2018). In reality the power consumed is subjectively known to be much less than the maximum rating.
- 212
- 213 Most sites use existing networks at their sites for uploading data to the NCAS server, but those with 3G dongles have an ongoing cost of \pounds75 per year for a yearly data plan. There are 8 sites using 3G dongles hence the ongoing annual cost is \pounds600.
- 214
- 215 The emissions from the first 2,300 mile journey in a diesel van were approximately 966 kg of COS\_25 and 1.74 kg of NOS\_X5 + PMs (nitrogen oxides + particulate matters). Ongoing power consumption for 13 sites (the Druim nam B0 (Feshie) site is powered off-grid by solar and wind) at the aforementioned maximum rating would be 7,150 kg of COS\_25 annually (using the UK average of 0.367 kg kwh5^{-1}\$, valid October 2017). In reality the power consumption is less and the UK average kg kwh5^{-1}\$ is gradually decreasing over time. Computational energy consumed by DiveN is near-unquantifiable; the data hosting, processing and analysis were carried out on shared systems (National Centre for Atmospheric Science server, JASMIN server), so the fractional consumption is difficult to estimate.
- 216 217
- 218
- 219 \subsection{Data Acquisition and Management}\label{data\_management}
- The disdrometer data is read through a serial port by a Raspberry Pi which executes a Python script to receive and digest the Telegram 4 format data. The Python code performs file management with timestamps taken from the Raspberry Pi internal clock (set over IP) and backs up files to a memory card into a directory specific to the date. Separate programming triggers the uploading of new files in the 'today' directory to an NCAS server every 5 minutes over SFIP. At 01 UTC each day, the Raspberry Pi attempts to upload any remaining files in the directory of the previous day. At 02 UTC each day, the Raspberry Pi attempts to upload files from the directory for 7 days ago as a backup command in the event that no connection could be made at the time. Only new files that do not already exist on the NCAS server are uploaded to avoid duplication. The entire directory of data for a single day is compressed using tar gunzip, 8 days after it is recorded. A support script exists to keep the processing and uploading scripts running and self-regulating. The support script checks that the processing script is running; if not, it will issue a command to start the processing script again. This means that the data acquisition script will be reattempted if an exit error occurs. In the event of a power loss the Raspberry Pi will startup and initiate all of the required scripts itself when power is restored, without user intervention.
- 221
- 222 Each disdrometer produces 3.2 MB of ASCII .txt files per day but this can be compressed significantly. 10 years of continuous minute-frequency disdrometer data (5.3 million minutes) can be compressed to as small as 400 MB.
- 223
- 224 225
- 226 \subsection{Open Access Website}
- 227 Data is uploaded to an NCAS server every 5 minutes. One minute after the upload, plotting scripts are initiated. An additional minute later, a <u>quicklook</u> system indexes the target directories for new images and displays them on the public website.
- The public website can be accessed here: \url{https://sci.ncas.ac.uk/diven/}. Data can currently be downloaded from NCAS upon request to the lead author. At the end of the first DiveN deployment phase (early 2020) all data collected by DiveN will be archived into netCDF at the Centre for Environmental Data Analysis (CEDA).
- 230
- 231

#### 232 - \subsection{DiVeN Users}

- 233 Although the data from DiveN will be used for radar verification, there are many other uses for the data. Several stakeholders have used DiveN data. Met Office operational forecasters are able to see live hydrometeor type data and compare with numerical weather preciction forecasts to adjust their guidance. Second, there are some research projects at the University of Leeds being carried out. This includes research on DSD characteristics in bright band and non-bright band precipitation, calibration work with the NACAS X-band polarimetric (NXPO1) radar in Cumbria, England for the Environment Agency (EA) and flood forecasting research with the Water@Leeds project. Other institutions have used DiVeN data also; The University of Dundee and the Scottish Environment Protection Agency (SEPA) are conducting work on snow melt and the University of Reading may use DSD information from the Reading University Atmospheric Observatory (RUQO) disdrometer to study aerosol sedimentation rates. Finally, the wind turbine manufacturer Vestas have used annual DSD data to evaluate models of blade-tip drag to improve turbine efficiency. The applications of disdrometer data are broad and cover many fields. The authors intend that this publication combined with the open accessibility of data will inspire new uses of DiveN observations.
- 234 235
- 236
- 237 \subsection{Performance of DiVeN in the First Year}
- Figure \ref{fig:uptime} shows the uptime of each site in DiVeN in the order that they were installed. Generally the uptime of the network has been good for the period shown, with most sites uploading more than 95\% each day. A few sites have not been as good but this was mostly anticipated. In particular the Druim nam Bo site at 900m a.m.s.l. in the Scottish Highlands has poor upload percentages. 3G signal is weak at the site and a signal booster was added in January 2018. Furthermore the site is powered by a small wind turbine and solar panel, which became rimed in ice during the winter (Figure \ref{fig:rime}). Although these issues were anticipated, the site was still chosen because it can provide cases of solid hydrometeors nearly all year round, in a terrain which is notoriously difficult for radar performance. Radar hydrometeor classification will be particularly difficult at this location and thus the site will provide a `wost-case scenario' for radar HCA verification work.
- 239
- 240 Holme Moss is a remote site at relatively high altitude and uses satellite broadband which has been somewhat unreliable, however the amount of data stored on the Raspberry Pi may be higher than depicted in Figure \ref{fig:uptime} which was created based from data successfully uploaded to the NCAS server. Furthermore, the data is being archived on the University of Manchester's system at Holme Moss and this is known to be a much more complete dataset, which will be transferred to the NCAS servers in the future.
- 241
- 242 There were several unanticipated downtime periods. Weybourne had to be moved for construction work at the field site and was without power for approximately 1 month in March 2017. In late April 2017, the NGAS server blacklisted all disdrometer IP addresses and these had to be manually whitelisted. This was detected and resolved within 8 days. The 7-day backup upload filled in the majority of the missing data but the 8th day prior to the issue being fixed was never reattempted because of the design of the code discussed in Section \ref[data\_management].
- 243
- 244 The largest unanticipated downtime occurred in September 2017. An issue arose with the disdrometers being unable to record any new data, in the order that they were installed. 2 GB of free space remained on the SD cards, however there was a (previously unknown) limit to the number of files that can be saved to certain card formats irregardless of the space remaining. The issue was fixed by the creation of a new script which merged old files together. The script had to be added to all of the Raspberry Pis in the network. The issue was detected after the first 4 DiveN disdrometer installations failed sequentially, so the failure of other sites in the network was anticipated and mitigated. This can be seen on Figure \ref{fig:uptime} as a stepped-failure starting with the chilbolton 1 instrument in September 2017.
- 245
- 246 Some further issues occurred which were avoidable. Laurieston was disconnected from power whilst closing the datalogger box after the installation which meant it was offline for the first 2 months until the site could be visited again. Similarly during the Dunkeswell installation in July 2017 the serial data cable was damaged which could not be fixed until November 2017. The Raspberry Pi at Lancaster was not reconnected after the aforementioned file number problem in September 2017.
- 247
- Although several problems have arisen with the Disdrometer Verification Network in the first 12 months, the network manager and site owners have been, on the whole, quick to respond to these issues which has minimised downtime. DiveN is in an ideal state for long-term data collection as it has been designed with few potential failure points and with several backup methods in place in the event of a failure.
- 250

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251		
252 <del>-</del> 253 254	\section(case Studies)\label{case_studies} The following sections subjectively analyse the skill of the disdrometer instrument for classifying hydrometeor type. Three types are discussed here: snow from named winter storm Doris; an intense rainfall event at NFARR Atmospheric Observatory and a graupel shower at the Reading University Atmospheric Observatory. NFARR Atmospheric Observatory instrument data were sourced from \cite{Chilbolton_JWD} and \cite{Chilbolton_PWS100}.	Changed precipitation typ (show all) to hydrometeor type Apr 8, 2019 4:02 PM • You X Reject  Accept
255 <del>-</del> 256	\subsection{Rain-Snow Transition}\label{doris} During the first disdrometer installation trip in February 2017, the Met Office-named winter storm Doris impacted the UK. The disdrometer at Lancaster was installed on 22nd February, and Edinburgh was scheduled for installation on 24th February. Storm Doris was forecast to bring heavy snowfall to the central belt of Scotland on the morning of the 23rd. Therefore a decision was made to leave Lancaster early on the evening of the 22nd, to arrive in Gladhouse Reservoir before the expected snowfall. An opportunity arose to temporarily operate a disdrometer at Gladhouse Reservoir (55.7776, -3.1173). Observations began at 01:00 UTC, by which time light rain had begun precipitating.	
257		
258	The opportunistic observations made during storm Doris provide a unique dataset by which to evaluate the skill of the disdrometer for prescribing hydrometeor type. Several transitions between rain and snow occurred that were also observed by a qualified meteorologist. The following section compares the disdrometer present weather codes and the eyewitness observations taken by the lead author during the event. An important consideration is the fact that the disdrometer was setup in a suboptimal observing environment which had approximately 2005A{\circ}\$ of tall objects in close proximity. Figure \ref{fig:gladhouse_map} shows the instrument operating at cladhouse Reservoir. There were tall evergreen trees to the east and west, and a two-floor building to the south. Telecoms cables were also overhead and associated poles are visible to the NNE behind the disdrometer in Figure \ref{fig:gladhouse_map}. This was unavoidable given the impromptu circumstances of deployment.	
260	Despite the suboptimal observing conditions, the disdrometer performed well at diagnosing the correct present weather code during the storm Doris event. Table \ref{Tab:Doris_Dbs} and Figure \ref{fig:doris_HCA} show that the disdrometer correctly output a present weather code of rain initially, followed by an unverified `mixed precipitation' from 01:24 to 01:50. From 01:50 onwards a consistent snowfall PW code was observed, which agrees with visible observations made within 01:50-03:55. At 03:55 the precipitation became light and was described as drizzle by the disdrometer.	
262	From 06:00 onwards the precipitation intensified and the present weather code changed between drizzle and rain. By 06:45 the PW code was switching between only rain and a rain/snow mix. From 07:24 onwards the present weather code was constant snow, which continued with varying intensity until 15:28. The eyewitness observation at 15:39 is of individual ice crystals which the disdrometer perceived as low precipitation rates of 0.293 mm hr\$^{-1}5 misclassified as drizzle. Weak precipitation continued until 17:13 where no precipitation is observed by the disdrometer, concluding the IOP.	
264	Table \ref{Tab:Doris_Obs} shows that the Thies LPM has good skill with regard to determining the present weather type. Every disdrometer-diagnosed present weather code is in agreement with the eyewitness observations throughout the IOP, with the exception of 15:39. The difference in fall velocity between drizzle particles and individual ice crystals is small and as such the disdrometer struggled to identify the precipitation correctly.	
265	Figures \ref{fig:doris_hca_1} and \ref{fig:doris_hca_2} show the periods of constant hydrometeor type observed by the disdrometer in Figure \ref{fig:doris_HCA}, normalised for particle count. There are clear differences between rain, snow and rain/snow mix periods. Rain follows the curve shown by \cite{Gunn1949}. The rain/snow mix periods in b) and f) retain the Gun-Kinzer relationship but with additional, larger particles with slower fall velocities. The snow categories in c) and g) are markedly different with broader distributions of particle size and a shifted fall velocity distribution. The drizzle and ice crystal periods however, are very similar. Both are characterised by distributions of particle fall speed and diameter peaking at approximately 1.4 m s54-135 and 0.375 mm respectively. The distribution similarities of drizzle and pristine ice crystals on Figures \ref{fig:doris_hca_1} and \ref{fig:doris_hca_2} illustrates the difficulty in distinguishing between these two types by fall speed and diameter alone, without additional information. A temperature sensor added to the disdrometer may have aided the PW code classification. The misidentification described here is not a major concern since pristine ice crystal precipitation is a) uncommon in the UK and b) contributes negligible amounts to total rainfall as indicated during this	Changed precipitation typ (show all) to hydrometeor type Apr 8, 2019 4:02 PM + You X Reject Accept
267	event.	Ab Deleted ! Mar 30, 2019 12:36 PM • You
268	The present weather code quality index shown in Figure \ref{fig:doris_HCA} demonstrates that the Thies LPM is able to detect when recording conditions are challenging. The PW code quality index decreases, showing a poor quality measurement, during times of weak precipitation rates and in mixed precipitation phases.	× Reject     ✓ Accept     Added -derived surface     Apr 8, 2019 6:37 PM • You
270	The opportunistic data collected in the storm Doris event is unusual in its number of transitional periods and will be a valuable case by which to compare the performance of radar-derived surface hydrometeor classification schemes.	× Reject ✓ Accept → Changed <del>nominal</del> to recorded
271 272 -	\subsection{Intense Convective Rainfall}\label{violent_rain}	Mar 30, 2019 12:13 PM • You
273	Storm Doris also brought an interesting event to another site; a high rainfall rate observed by the NFARR Atmospheric Observatory pair of disdrometers (Chilbolton 1 \& 2). The event was synoptically characterised by a narrow swath of intense precipitation oriented meridionally. The high intensity precipitation moved west to east across the UK, associated with a cold front originating from the low associated with named winter storm Doris. 30 km NE of NFARR Atmospheric Observatory in Stratifield Mortimer, a private weather station managed by Stephen Rurt also observed the intense precipitation of a constraint of the state o	Added of Mar 30, 2019 12:13 PM • You X Reject
	communication, 20th October 2017). A high-resolution Lambrecht gauge (recorded resolution of 0.01 mm) on the site observed a 75.6 mm hr\$^{-1}\$ rain rate over 10 seconds at 07:51 UTC. The 1-minute rain rate at 07:51 was 54.6 mm hr\$^{-1}\$ and the 5-minute rain rate ending 07:52 was 30.6 mm hr\$^{-1}\$. The event was described by a trained observer as ``rain ouickly became heavy then torrential''.	Ab Deleted 0 Mar 30, 2019 12:13 PM • You
274 275 276	The event was particularly outstanding from a DiVeN point of view due to the drop count measured by the Thies LPMs situated at NFARR Atmospheric Observatory, Chilbolton, which peaked at around 12,000 drops in a single minute (200 per second) at 07:39 UTC on 23rd February 2017. Both disdrometers observed a similar evolution of drop count over the short 26-minute rainfall event. This does not prove that the instruments are recording accurately; conversely it may be a signal of a systematic issue with the measurement technique used in every Thies LPM.	
277	Figure \ref{fig:heavy_DSD_DVD} shows an anomalously large left-tailed DSD from both of the Thies LPMs when compared against the Joss Waldwogel RD-80 and Campbell Scientific PWS100 disdrometers. A high concentration of small drop sizes suggests that splashing is occurring, where larger drops breakup on impact with either the instrument itself, or the surroundings. Earlier versions of the Thies LPM did not have shields on top of the sensor, which the manufacturer acknowledged were added because of splashing issues. It is possible that in very high rainfall rates, splashed droplets are still reaching the instrument beam and are being erroneously recorded. The drop velocity distribution (OVD) from the Thies LPM is also in disagreement with the PWS100. The PWS100 uses a similar optical technique to the Thies LPM with the addition of having 4 vertically stacked beams versus 1 on the Thies LPM, which should increase the accuracy of fall velocity measurements. Furthermore, the Thies LPM categorises the highest velocity particles into the smallest diameter particle bins, which is unphysical. Finally. The total drop court per metre is significantly bridner for both of the Thies LPM.	Ab Deleted ¥ Mar 30, 2019 12:38 PM • You ★ Reject
278	The second provide the second per metric to significancily ingret for over of the fiftes tends	

279	The DVD during the event is very wide. A noteworthy observation from the Stratfield Mortimer observatory is the wind characteristics. Marking the passage of the cold front at 07:45, winds became increasingly gusty and 10-minute wind mean ending 07:40 was 20 knots. A strong surface wind is associated with turbulent eddies which have some vertical component. The intermittent vertical wind acts to widen the drop velocity distribution. Furthermore, turbulence breaks up droplets thus skewing the drop size distribution. Finally, winds tangent to the beam (N-S oriented beam, westerly wind) as was the case here.	Changed The fall speed of (show all) to A strong surface (show all)
280 281	increase the number of beam-edge hits which reduce the quality of the data.	Apr 22, 2019 5:04 PM • You ★ Reject    ✔ Accept
202	the Thies LPMs overestimate the rainfall during 07:35 to 07:40 where the rain rate is heavy. In total, chilbolton 1 and chilbolton 2 recorded 120(% and 149(% of the rainfall measured by the PWS100. The JWD is expected to underestimate slightly due to the range of observable diameters (0.3 mm to 5 mm) being smaller than true raindrop sizes, and smaller drop sizes being undetectable in the presence of large droplets due to sensor oscillation.	
282	It appears that in these conditions the hydrometeors were not correctly measured by the Thies LPM. However, the hydrometeor type is still correctly identified despite these shortcomings in rain rate, particle diameter and particle velocity.	
285 <del>-</del> 286	\subsection{Graupel Shower} Graupel (rimed ice crystals) are important signatures of convection for the UK, where hail is relatively uncommon. The Thies instrument does not have a graupel category because the category does not exist within the WMO Table 4680 which it uses to convey hydrometeor type. Codes 74, 75, 76 (light / moderate / heavy soft hail / ice grains) are presumed to be equivalent to what is commonly described as graupel.	Changed precipitation typ f (show all) to hydrometeor type
287 288	On the 25th April 2017 a shower containing conical-shaped graupel passed over Reading University 'between 16:30 and 16:45 UTC' as observed by Dr Chris Westbrook (personal communication, 25th April 2017). Figure \ref{fig:ruao_HCA} shows the temporal evolution of hydrometeor type identified by the Diven instrument during the event. The disdrometer observed only a single minute (16:36) of 'soft hail / ice grains' PW code (indicating graupel) during the entire 21 minutes of precipitation detected. Between 16:30 and 16:50 UTC inclusively, the following codes were also observed: 7 minutes of code 68 (moderate / heavy rain and / or drizzle with snow); 12 minutes of codes 61 / 62 (light / moderate rain); 1 minute of code 72 (moderate snow fall). Clearly the instrument struggled to diagnose graupel in this particular event.	Apr 8, 2019 4:02 M + You ★ Reject ✓ Accept
290	Figure \ref{fig:ruao_grids} shows the particle size and velocity information grouped by hydrometeor type prescribed by the Thies LPM. Throughout the graupel shower the instrument observed a bimodal distribution in both velocity and diameter for all hydrometeor types which is indicative of both rain and graupel precipitating simultaneously. Furthermore in the rain/snow, snow, and graupel periods, a few hydrometeors exist below the Gunn-Kinzer curve which are misidentified as snow. Although the accumulated drop characteristics for the rain and rain/snow minutes are indicative of a rain/graupel mixture, in a single minute only a few particles may fall through the disdrometer beam versus several hundred raindrops. The ratio of rain to graupel may therefore be insufficient for the PW code to change to graupel. No PW code exists in the WMO Table 4680 for a rain/graupel mixture or rain/ soft hail' mixture. The false detection of snow hydrometeors may be attributed to graupel particles bouncing off nearby surfaces or the instrument itself, slowing the fall velocity and thus appearing to the disdrometer as a lower density particle such as an ice aggregate.	
291 292 293	For future work with DiVeN data it is important to note 1-minute observations of `soft hail / ice grain' PW codes when longer time periods are being analysed. For example, radar hydrometeor classification will be performed with DiVeN data at 5-minute intervals. If in one of the five minutes soft hail or snow grains are observed, this must be highlighted. Graupel likely existed for longer than one minute but it was either not the dominant hydrometeor or the instrument was unable to correctly identify it.	
294 <del>-</del> 295 295	\section{Summary} The Disdrometer Verification Network is the largest network of laser precipitation measurements in the UK. Here we have fully described the network and discussed three specific observation cases to subjectively discuss the accuracy of the Thies LPM with a focus on hydrometeor type diagnosis.	
297	In summary, the instruments are able to correctly identify changes between snow and rain during storm Doris even with the suboptimal observing conditions. Snow is easily detected by the disdrometer and it is also able to accurately signal a mixture of hydrometeor types when transitioning between rain and snow.	Changed precipitation typ (show all) to hydrometeor type
298	Yet, the Thies LPM appears to have difficulty with measuring heavy rainfall events, where droplet breakup may be occurring due to instrument design. Distributions of drop size are skewed, such that small particle counts are significantly enhanced when compared with the Joss waldv\"ogel RD-80 and the Campbell Scientific PWS100. The hydrometeor type variable was unaffected by the distribution discrepancies in the case studied.	× Reject ✓ Accept
300 301 302	The Thies LPM also struggled to detect graupel in the event studied here. This shortcoming can be somewhat compensated for by flagging individual minutes of present weather codes 74, 75 and 76 within larger datasets but there will be graupel cases that the Thies LPM fails to detect entirely.	<ul> <li>✓ (show all) to hydrometeor type Apr 8, 2019 4:02 PM • You</li> <li>★ Reject</li> <li>✓ Accept</li> </ul>
303	A factor affecting the Thies LPM for hydrometeor classification is that empirical relationships do not account for instrument errors or the design of the instrument which may interfere with the precipitation being measured. The hydrometeor type signatures should be derived using data from the instrument to which they will be applied. Furthermore, by using the present weather code to describe hydrometeor type, the Thies LPM is restricted in it's ability to express the true nature of the observations being made, particularly noted in instances of graupel.	Changed precipitation typ (show all) to hydrometeor type Apr 8, 2019 Act PM + You Apr 8, 2019 Act PM + You
305	DiveN offers open-access data in near-real-time at 5 minute updates. 1 minute frequency data is available upon request from the authors or via the Centre for Environmental Data Analysis (CEDDA) from 2020. Data has been made publicly accessible in the hope that the Disdrometer Verification Network will be used for research beyond the original scope of the network.	
306 307 308	%% The following commands are for the statements about the availability of data sets and/or software code corresponding to the manuscript. %% It is strongly recommended to make use of these sections in case data sets and/or software code have been part of your research the article is based on.	
310 311 311	%\codeavailability{TEXT} %% use this section when having only software code available	
313	\dataavailability{Data plots are available in near-real-time here: \url{https://sci.ncas.ac.uk/diven/}. Original data is available upon request to the corresponding author and will be available through the Centre for Environmental Data Analysis (CEDA) in <u>NEtCOF format in 2019.</u> <i>XX use this section when having only data sets available</i>	Changed <del>2020</del> to <b>NetCDF format</b>
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319 320	%\sampleavailability{TEXT} %% use this section when having geoscientific samples available	
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323	X  XX Appendix A	c.
325 326 - 327	%  %% Appendix A1, A2, etc.	>

328		
329	% \noappendix %% use this to mark the end of the appendix section	
331	%% Regarding figures and tables in appendices, the following two options are possible depending on your general handling of figures and tables in the manuscript environment:	
332 333	%% Option 1: If you sorted all figures and tables into the sections of the text, please also sort the appendix figures and appendix tables into the	
334	respective appendix sections. %% They will be correctly named automatically.	
336 337	%% option 2: If you put all figures after the reference list, please insert appendix tables and figures after the normal tables and figures. %% To rename them correctly to A1, A2, etc., please add the following commands in front of them:	
338 339 340	%\appendixfigures  %% needs to be added in front of appendix figures	
340 341 342	%\appendixtables   %% needs to be added in front of appendix tables	
343 344	%% Please add \clearpage between each table and/or figure. Further guidelines on figures and tables can be found below.	
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347	%\authorcontribution{TEXT} %% optional section	
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350	interests are present	
351 352	%\disclaimer{TEXT} %% optional section	
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354	% ACNOWLEDGMENTS	
355	x	
357 -	\begin{acknowledgements}	
358	\textit{\\The lead author wishes to thank the following people and institutions for contributing to the creation of the Disdrometer Verification Network}	
359 360	\textit{The United Kingdom Meteorological Office for loaning the Thies LPM instruments used in DiVeN, Thies for advice and communication regarding the instrument, and the National Centre for Atmospheric Science (NCAS) for all other supporting hardware.}	
361		
362	\textit{Morwenna Cooper (Met Office), Dan Walker (NCAS), James Groves (NCAS) and Darren Lyth (Met Office) for technical advice regarding the data acquisition design of Diven.}	
363	The contacts at each site hosting a disdrometer for Diven. Judith Jeffery (NEARB) Andrew Lomas (University of Reading). Reherca Carling (Eacility	
501	for Atmospheric Measurements), Grant Forster (University of East Anglia), David Hooper (NFARR), James Heath (University of Lancaster), Richard Essery	
	(University of Edinburgh), Geeff Monk (Mountain Weather Information Service), Michael Flynn (University of Manchester), Louise Parry (Scottish Environment	
	Protection Agency), Jim confloot (Natural Retreats), Chris Taylor (Natural Retreats), Andrew Black (University of Dundee), Darren Lyth (Met Office), Megan	
265	Klaar (University of Leeds), Stephen Mawle (Coverhead Farm)}	
365	\textit{Jack Giddings, Ashley Nelis, Scott Duncan and Daniel Page for providing accommodation and sanity during the month-long installation trip.}	
368 369	\textit{Philip Rosenberg (NCAS) for advice on statistical tests.}	
370	Also: Stephen Best (Met Office), James Bowles (Met Office), Dave Hazard (NFARR), Darcy Ladd (NFARR), Stephen Burt (University of Reading), Chris Westbrook (University of Reading).}	
371	\end{acknowledgements}	
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379	%% authors experienced with BibTeX only have to include the following two lines:	
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404	%% FIGURES	
405 406	%% when figures and tables are placed at the end of the MS (article in one-column style), please add \clearpage	
407 408	%% between bibliography and first table and/or figure as well as between each table and/or figure.	
409 -	\begin{figure}[t]	
410	<pre>A Diven Thies LPM located at Weybourne Observatory in Weybourne, East Anglia, UK, which is an Atmospheric Measurement Facility (AMF) site, part of the National Centre for Atmospheric Science (MCAS) } \label{fig:weybourne}</pre>	
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417	\includegraphics[width=8.3cm]{poisson_test.pdf}	
418	<pre>Probability of \$X\$ number of drops residing in within the disdrometer beam for a given drop concentration. If two or more drops are within the beam simultaneously, data quality can be reduced. More than 12,000 drops m\$^{-3}\$ (equivalent to 10,000 drops min \$^{-1}\$ recorded by the disdrometer*) are required before the probability of 2 or more drops occurring in the beam simultaneously becomes non-negligible. As such, any events with more than 10,000 drops observed per minute should be treated as less reliable. *Drops falling through the disdrometer beam assumes a 3 m s\$^{-1}\$ fall velocity, which from \cite{Gun1949} is a particle of approximately 0.8 mm diameter, typically the average size observed for a moderate rainfall event. Droplet breakup on the housing of the Thies LPM is not factored into this test.} \label{fig:poisson_test}</pre>	
419 420	\end{figure}	
421	\clearpage	
422 423 <del>-</del>	\begin{figure}[t]	
424 425	\includegraphics[width=8.3cm]{Diven_Map.png} Instrument locations that make up the Disdrometer Verification Network (Diven) as of September 2018. Grev icons are the operational Met Office	
426	radars as well as the Met Office research radar at Wardon Hill. Map data \textcopyright2018 GeoBasis-DE/BKG (\textcopyright2009), Google, Inst. Geogr. Nacional.}\label{fig:Diven_Map} \end{figure}	
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430 <del>-</del> 431	<pre>\trighters[t] \includegraphics[width=8.3cm]{Diven_Data_Flow.png}</pre>	
432	<pre>Flow chart of the sequence of data in the Disdrometer Verification Network. The instrument outputs a Telegram 4 format serial ping every minute, which is then captured by a Raspberry Pi (v3) running a Python script. The Python script then saves the file to the built-in SD card as an ASCII .txt. Separate BASH scripts upload the new files every 5 minutes (xx:05, xx:10, xx:15) to an NAS server, which JASMIM then reads to plot the data (xx:06, xx:11, xx:16). The website indexes for new images at xx:07, xx:12, xx:17 and so on. Thus the time taken for the xx:00 to xx:05 data to reach the website is 2 minutes.} \label{fig:Diven_Data}</pre>	
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438	<pre>\includegraphics[width=8.3cm] {uptime.pdf}</pre>	
439	\caption{Daily upload performance of DiVeN in the first 365 days of operation. Black indicates 100\% upload (1440 files in a day), and white indicates 0\% upload. } \label{fig:uptime}	
440 441	\end{figure}	
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443 444 -	\heain{figure}[t]	
445	<pre>\includegraphics[width=8.3cm]{rime.jpg}</pre>	
446	\caption{Disdrometer at Druim nam Bo, Scotland covered in rime in January 2018. The instrument was still receiving power and recording nullified (no beam received by optical diode) data which it interpreted as a `sensor error' (-1) present weather code.} \label{fig:rime}	
447	\end{figure}	
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451 <del>-</del> 452	\u00edrachics[width=8.3cm]{gladhouse_map.pdf}	
453	Maps, satellite images and ground images of the disdrometer location and setup for named winter storm Doris at Gladhouse Reservoir House, Scotland.	
	<pre>/label{fig:gladhouse_map}</pre>	
454 455	\end{figure}	
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457 458 <del>-</del>	\begin{sidewaysfigure}[t]	
459	<pre>\includegraphics[width=20.5cm]{Doris_HCA_quality_RR.pdf}</pre>	
460	Caption(Rain rate, hydrometeor type, and present weather code quality index during the storm Doris event on 25rd February 2017, which occurred over approximately 16 hours at Gladhouse Reservoir, Scotland. Rain rate is liquid equivalent for periods of snow and is recorded by a Thies LPM disdrometer. Hydrometeor type is shown from both the disdrometer and impromptu from a trained meteorologist. The meteorologist observations at 05:00 and 07:00 UTC are	
461	approximate use to a fack of acturate time information. The disprometer mistoentified individual ice crystals at 15:39 as drizzle.} \rabel{fig:doris_HCA} \end{sidewaysfigure}	
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467	\caption{Accumulated particle information for each hydrometeor class period described in Figure \ref{fig:doris_HCA}. The centre grid shows particle counts	
	binned by size and fall velocity. The y-axis histogram shows particle velocity distribution (DVD) and the x-axis histogram shows particle size distribution (DSD) for the time period described, Since the time periods between each subplot are inconsistent in length, the color scale and histograms have been	
	normalised for the total precipitation over each period. The periods are as follows: a) 0055-0124 (Rain) b) 0124-0150 (Rain/Snow) c) 0150-0355 (Snow) and d)	
468	0355-0600 (Drizzle).} \label{fig:doris_hca_1} \end{figure}	
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<pre>visity during the set of a set of</pre>	481	Caption(urop characteristics of a neavy rain event at NEAK Atmospheric observatory, Childoton, England on the 2srd March 2017, Distributions are accumulated from 07:25 to 07:50 UTC inclusively for a 26 minute summation. The left panel shows drop osize distribution and the right panel shows drop	
<pre>bit indths. Total drop count is listed in the top "right of each plot. Both of the Thise LHB have a higher total drop count, as well as significantly higher counts of suall, fast mving droplets.) (Lakel(fig:have_JDDL_PK) indtreased counts of null, fast mving droplets.) (Lakel(fig:have_JDDL_PK) indtreased counts of null relations of the theorem indtreased by indtrease</pre>		velocity distribution. The Joss-Waldvogel RD-80 (JWD) does not provide drop velocity information. Each instrument has been normalised for sampling area and	
<pre>costs of sall and high velocity particles compare with the Peg and 100. The frame of the Thes LPM may be splashing droplets into the Beam leading to increased courts of sall. Task into version of the Peg and 100. The frame of the Thes LPM may be splashing droplets into the Beam leading to increased courts of sall. Task into version of the Peg and 100. The Per and Per and Per and Per and 100. The Per and 100. T</pre>		bin widths. Total drop count is listed in the top right of each plot. Both of the Thies LPMs have a higher total drop count, as well as significantly higher	
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<pre>total accumulated rain depth over the 26 minutes for each instrument is as follows: oilbothon 1 (1.43 m); chiloblon 2 (1.847 ms); msilo (1.837 msilo (1.837 ms); msilo (1.837 msilo (1.837 ms); msilo (1.837 ms</pre>	488	Rain rate measured by 4 instruments during a heavy rain event at NFARR Atmospheric Observatory, Chilbolton, England on the 23rd March 2017. The	
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524 %%% TABLES 525 %%% %%% The different columns must be seperated with a & command and should 526 %%% end with \\ to identify the column brake. 527 528 529 \clearpage 530 531 - \begin{table}[t] 532 \caption{Variables output from the Thies Laser Precipitation Monitor (LPM).}\label{Tab:var} 533 - \begin{tabular}{ccccrrcrc} 534 \hline\hline 535 Output & Units & Resolution & Range \\ 536 \hline Particle Diameter & 0.125 mm (max) & \$\geq\$ 0.125 \$-\$ \$>\$ 8 mm \\ 537 & mm 538 Particle Velocity & m s  $^{-1}$  & 0.2 m s  $^{-1}$  (max) & 5> 0 - 5> 20 m s  $^{-1}$  \\ 539 Particle Count & Counts & 1 Count // 0000 2-2 0 3 & mm hr\$^{-1}\$ & 0.001 mm hr\$^{-1}\$ & 0.000 \$-\$ 999.999 mm hr\$^{-1}\$ \\ Rainfall Rate 540 Precipitation Visibility & m & 1 m & O \$-\$ 99999 m \\ 541 Radar Reflectivity Factor & dBZ & 0.1 dBZ & -9.9 \$-\$ 99.9 dBZ \\ 542 543 PW Code Quality Index & \% & 1 \% & 0 \$-\$ 100 \% \\ 544 \hline \end{tabular} 545 546 \end{table} 547 548 \clearpage 549 550 - \begin{table}[t] 551 \caption{world Meteorological Organization (WMO) synoptic present weather codes (Table 4680) output by the Thies Laser Precipitation Monitor (LPM) } \label { Tab: pw\_codes } 552 - \begin{tabular}{ccccrrcrc} 553 \hline\hline 554 SYNOP (Tab.4680) & Description \\ 555 \hline -1 & Sensor error \\ 556 41 & Light / moderate unknown precipitation \\ 557 558 42 & Heavy unknown precipitation \\ 559 0 & No precipitation \\ 51, 52, 53 & Light / moderate / heavy drizzle \\ 560 57 & Light drizzle with rain \\ 561 562 58 & Moderate / heavy drizzle with rain  $\backslash\backslash$ 563 61, 62, 63 & Light / moderate / heavy rain \\ 67 & Light rain and / or drizzle with snow \\ 564 565 68 & Moderate / heavy rain and / or drizzle with snow \\ 566 71, 72, 73 & Light / moderate / heavy snow fall \\ 567 74, 75, 76 & Light / moderate / heavy soft hail / ice grains \\ 568 77 & Snow grains \\ 89 & Hail \\ 569 570 \hline 571 \end{tabular} 572 \end{table} 573 574 \clearpage 575 576 - \begin{sidewaystable\*} 577 \caption{Site location descriptions of disgrometers in the Disdrometer verification vetwork.}\label{Tab:locations} Added d Mar 30, 2019 12:41 PM • You 578 - \begin{tabular}{p{1.5cm}p{1.1cm}p{1cm}p{1.2cm}p{14cm}}%{ccccrrcrc} 579 \hline\hline 🗙 Reject 🛛 🖌 Accept 580 Site Name & Lat/Lon & Altitude (a.m.s.].) & Install Date & Description \\ Changed et to D 581 \hline Mar 30, 2019 12:39 PM + You Chilbolton & 51.1455,-1.4396 & 83 m & 10th Feb 2017 & NFARR Atmospheric Observatory. 2 instruments, 10 m apart. Land type: flat, agricultural fields for 582 🗙 Reject 🗸 Accept \$>\$ 500m in all directions. Nearby objects: 25 m diameter radar dish antenna 100 m ESE; 2-floor building 25 m SSW. \\ RUAO & 51.4415, -0.9376 & 63 m & 13th Feb 2017 & Reading University Atmospheric Observatory. Land type: open grass in vicinity; campus with lake and trees 🖉 Changed 🕶 to V 583 Mar 30, 2019 12:39 PM • You situated within a wider suburban area. Lake 100 m W-NW, 3-floor building 50 m SSE. Shed 30 m ENE. \\ 🗙 Reject 🛛 🗸 Accept 584 cranfield & 52.0744, -0.6252 & 105 m & 15th Feb 2017 & Facility for Airborne Atmospheric Measurements. Land type: 2-floor rooftop observatory within a cluster of buildings at a university airport. Nearby objects: stairwell NW, hangar ESE. Above most nearby buildings.\\ Changed n to N 585 Weybourne & 52.9505, 1.1218 & 8 m & 17th Feb 2017 & NCAS Atmospheric Measurement Facility. Land type: military base, mostly grass. Sandy beach and ocean Mar 30, 2019 12:41 PM • You 100 m NNE. Nearby objects: small 1-floor building ESE, 4-floor scaffold tower E. 🗙 Reject 🛛 🗸 Accept Aberystwyth & 52.4248, -4.0045 & 44 m & 20th Feb 2017 & NFARR / NERC (Natural Environment Research Council) Mesosphere-Stratosphere-Troposphere (MST) radar 586 site. Land type: agricultural fields in a WSW-ENE valley. Nearby objects: single tree and 1-floor building SSE, hedgerow N-SSE. \\ 587 Lancaster & 54.0138, -2.7749 & 94 m & 22nd Feb 2017 & Hazelrigg Weather Station, University of Lancaster. Land type: agricultural fields. Nearby objects: 100 m tall wind turbine 150 m WSW, meteorological mast 10 m NW. Road and trees 30 m E.\\ Edinburgh & 55.9217, -3.1745 & 105 m & 24th Feb 2017 & GeoSciences Weather Station, University of Edinburgh. Land type: roof of 6-floor James Clark Maxwell 588 Building. Urban campus W-N-E, with golf course S. Nearby objects: rooftop above all surrounding buildings. \\ 589 Laurieston & 54.9614, -4.0605 & 67 m & 28th Feb 2017 & Mountain Weather Information Service. Land type: rural village, undulating agricultural terrain beyond. Nearby objects: 1-floor buildings 10 m SE, trees 30 m S-W \\ Holme Moss & 53.5335. -1.8574 & 522 m & 10th Mar 2017 & Holme Moss transmitting station. Land type: hilltop moorland. Nearby objects: 228 m transmitting 590 mast 40 m SW with anchoring cables overhead. Cabin 10 m SW, wire mesh fence NW-N. \\ 591 Cairngorm & 57.1269, -3.6628 & 781 m & 12th Jun 2017 & CairnGorm Mountain Ski Resort with Scottish Environment Protection Agency (SEPA) collaboration. Land type: arctic tundra, frequently snow-covered valley, facing NM. Nearby objects: road and power outbuilding uphill (SE) 20 m.\\ 592 Feshie & 57.0063, -3.8550 & 882 m & 13th Jun 2017 & Druim nam Bo weather station owned by University of Dundee. Land type: arctic tundra, frequently snow-Covered, rounded mountain ridge oriented SW-NE, sloping SW. Nearby objects: weather station 10 m N.\\ 593 Dunkeswell & 50.8603, -3.2398 & 255 m & 14th Jul 2017 & Met Office official observatory at Dunkeswell Aerodrome. Land type: flat in all directions. Runway N-E-S with surrounding agricultural fields and forest SW-N. Nearby objects: 1-floor building 20 m NW. \\ Coverhead & 54.2038. -1.9849 & 316 m & 15th Dec 2017 & Coverhead Estate with Water@Leeds collaboration. Land type: NW slope of SW-NE valley, agricultural 594 fields. Nearby objects: mounted on a small outhouse facing S. Telegraph pole 10 m NW and trees E-SW. \\ 595 \hline 596 \end{tabular} \end{sidewaystable\*} 597 598

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601 - \begin{table}[t]
602 \caption{Present Weather code evolution throughout the named winter storm Doris event on 23rd February 2017. All times in UTC.}\label{Tab:Doris_Obs}
603 - \begin{tabular}{p{1.9cm}p{4cm}p{1.9cm}p{3.1cm}}%{ccccrrcrc}
604 \hline\hline
605 Time & Disdrometer Present Weather Code & Time & Qualified Meteorologist Observation \\
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     \hline
607
      00:55 to 01:24 & Rain & 00:30 to 01:05 & Rain \\
608
      01:24 to 01:50 & Rain or Mixed Precipitation & & \backslash\backslash
      01:50 to 03:55 & Snow & 02:31 to 02:40 & Snow \\
609
      03:55 to 06:00 & Light / Moderate Drizzle & Approx. 05:00 & Drizzle \\
610
      06:00 to 06:45 & Drizzle or Rain & & \\
611
612
      06:45 to 07:24 & Rain or Mixed Precipitation & Approx. 07:00 & Mixed Precipitation \\
613
      07:24 to 15:28 & Moderate / Heavy Snow & 09:49 to 14:31 & Moderate / Heavy Snow \\
      15:28 to 17:13 & Light / Moderate Drizzle & 15:39 & Pristine Ice Crystals \\
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    %%% MATHEMATICAL EXPRESSIONS
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667 %%% All papers typeset by Copernicus Publications follow the math typesetting regulations
668 %%% given by the IUPAC Green Book (IUPAC: Quantities, Units and Symbols in Physical Chemistry,
669 %%% 2nd Edn., Blackwell Science, available at: http://old.iupac.org/publications/books/gbook/green_book_2ed.pdf, 1993).
670 ***
671 %%% Physical quantities/variables are typeset in italic font (t for time, T for Temperature)
    %%% Indices which are not defined are typeset in italic font (x, y, z, a, b, c)
672
    %%% Items/objects which are defined are typeset in roman font (Car A, Car B)
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674
    XXX Descriptions/specifications which are defined by itself are typeset in roman font (abs, rel, ref, tot, net, ice)
    %% Abbreviations from 2 letters are typeset in roman font (RH, LAI)
675
676 %%% Vectors are identified in bold italic font using \vec{x}
677 %%% Matrices are identified in bold roman font
678 XXX Multiplication signs are typeset using the LaTeX commands \times (for vector products, grids, and exponential notations) or \cdot
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679 %%% The character \* should not be applied as mutliplication sign

680 🕺 681 🕺 682 %%% EQUATIONS 683 \* 684 %%% Single-row equation 685 🕺 686 %\begin{equation} 687 🕺 688 %\end{equation} 689 🕺 690 %%% Multiline equation 691 % 692 %\begin{align} 

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737 \end{document} 738

