

LISST *in situ* Particle Sizer data series for cruises: Challenger CH140, Pelagia PE136, Mitra MT0499 and Belgica BG9912

Co-Principal Investigators

Dr. Colin Jago and Dr. Sarah Jones, University of Wales (UWB), Bangor, UK.

Data Originator

Rebecca Latter – UWB.

Content of data series

Parameter	Unit	Parameter code	Comment
Suspended particle size distribution by volume in 32 size-classes (1.25 to 250 μm)			ASCII files
Volume Scattering Function in 32 angles (0.0018 to 0.3032 radian)			ASCII files
Pressure	dbar	PRESR01	none
Temperature	deg. C	TEMPR01	none
Attenuance	per m	ATTNSR01	none
Particle size mode	μm	MOGSISXX	see text
Proportion of total particle volume in mode class	%	PRSCISMO	see text
Total suspended particle volume	$\mu\text{l l}^{-1}$	SVCTISGA	see text
Mean particle size	μm	MNGSISXX	see text
Standard deviation of mean particle size	μm	SDGSISXX	see text
Median particle size	μm	MDGSISXX	see text
95 th Percentile (*)	μm	PC95ISXX	see text
75 th Percentile (*)	μm	PC75ISXX	see text

(*) cumulated frequency distribution sorted in order of decreasing size classes.

Instrumentation

The *in-situ* laser particle sizer LISST-100B instrument manufactured by Sequoia Instruments, Redmond, USA (<http://www.sequoiasci.com>) was used to obtain *in-situ* observations of particle size distribution. The LISST uses laser diffraction principles (eg. Agrawal and Riley 1984, Agrawal et al. 1991). This technique is based on particles of a given size diffracting light through a given angle which increases with decreasing particle size. The LISST records scattering at 32 angles. This primary measurement is mathematically inverted to get the size distribution, and also scaled to obtain the volume scattering function (VSF). The size distribution is presented as concentration ($\mu\text{l l}^{-1}$) in each of 32 log-spaced size bins. The LISST-100 used during PROVCESS was a "type B" instrument and thus operated in the size range 1.25-250 microns.

The LISST-100 also records the optical transmission, pressure and temperature. The instrument is fully self-contained with battery and data-logger.

Sampling strategy

LISST deployments were carried out during four of the PROVCESS cruises: Challenger CH140 in the northern North Sea, and Pelagia PE136, Mitra MT0499 and Belgica BG9912 in the southern North Sea. The LISST was attached to the CTD frame, generally for the whole duration of a cruise. The sampling pattern was therefore similar to that adopted for CTD stations.

The instrument was mounted horizontally on the CTD frame in order to prevent settling of particles on the detector windows. Lowering rate was no faster than 0.5 m s^{-1} . Sampling rate was approximately 4 scans per second. The final number of profiles of particle size spectra obtained for each cruise was 59 for CH140, 123 for PE136, 158 for MT0499 and 41 for BG9912.

Originator's data processing and data file format

The data were converted from raw counts to calibrated units using the manufacturer's software. Despiking was performed by removing points that were more than two standard deviations away from the previous point. The data were then averaged by using a running mean over 3 points. The data were submitted to BODC as a series of ASCII files containing individual downcast profiles. These files are available from the PROVESS CD-ROM Disk 2 (directory Lisst).

Each file contained one datacycle per row with the following elements per row:

Elements	Parameter
1-32	Volume concentration (in µl/l) for size class 1 though to 32
33	Laser transmission sensor
34	Battery voltage in calibrated units
35	External auxiliary input 1 in calibrated units
36	Laser reference sensor in calibrated units
37	Pressure in calibrated units
38	Temperature (in °C)
39	Minutes or hour at which data were taken (see below for explanations)
40	Seconds or minutes at which data were taken (see below for explanations)
41	Computed % optical transmission over path
42	Computed beam-c in units of 1/m
43-74	Volume scattering function for 32 angles from small to large

For CH140: element 39 is in minutes and 40 is in seconds.

For PE136: from cast 15 to 139, element 39 is in minutes and 40 is in seconds; from cast 140 to 260 they are hours and minutes respectively.

For MT0499 and BG9912: element 39 is in hours and 40 is in minutes.

The 32 size ranges are in logarithmic progression from 1.25 to 250 µm (the upper size in each bin is 1.18 times the lower). Definition of the 32 size classes and angles together with additional information about the ASCII files can be found in Appendix to this document.

BODC's data processing

Because of the impracticality of loading large frequency distributions into a relational database, a number of particle size distribution parameters were derived at BODC from the data submitted by the originators. These parameters provide an easily accessible summary of the particle size distribution measured by the LISST particle sizer. However it should be stressed that, in doing so, no attempt was made to "correct" the data for potential instrument-specific or sampling-specific bias in the particle size distribution. The parameters derived from the originator's data should therefore be used as relative quantities only. A comparative analysis of the LISST instrument with two other laser particle sizers can be found in the paper cited in reference (Latter et al., 2002).

The processing steps applied to each datacycle of each file were as follows:

1. Construct the 'Originator Identifier' (OID) for each cast based on originator's file names.
2. Read pressure, temperature and beam attenuation.
3. Read particle volume concentrations V_i for each size class (as represented by its median size).
4. Calculate the total particle volume V_t by summing particle volume from each size class.
5. Calculate frequency distribution by volume F_i :

$$F_i = \frac{V_i * 100}{V_t}$$

6. Extract the particle size mode taken as the centre of the size class with the greatest percentage frequency.

7. Calculate mean particle size \bar{S} :

$$\bar{S} = \frac{Fi * Si}{100}$$

where Si is the centre of each size class and Fi is its associated percentage frequency by number.

8. Calculate the arithmetic standard deviation of the distribution:

$$sdev = \sqrt{\frac{Fi * (Si - \bar{S})^2}{100}}$$

9. Calculate the particle size median.

The particle size median was determined by linear interpolation between the two frequencies closest to 50 percent.

10. Extract the 95th and 75th percentile of the distribution.

These were extracted from the cumulative frequency distribution with the size classes sorted in order of decreasing particle sizes (coarse to fine). They represent the centre of the size class for which the cumulated frequency was lower than 95, 75 and 25% respectively.

The information extracted from each file was then compiled into a file containing one record per datacycle. The records were loaded into a database under the Oracle Relational Database Management System. Quality checks were only carried out on the metadata and on the overall aspect of the profiles for each cruise. No attempt was made to check or calibrate hydrographic and attenuation data from the LISST instrument against the corresponding calibrated CTD data series.

Comments on data quality from data originator

- LISST cannot resolve particles coarser than 250 μm and such particles are included in the 250 μm class.
- For cruise Mitra MT0499: the attenuation channel was very noisy and should be used with caution.
- For further information regarding data quality see Latter et al. 2002.

Accessing the data from the database on the CD-ROM

Oracle Explorer Data submenu: Profile

Cruise: select only one cruise at a time as volume of data can be large.

Gear Code: LISST

Data Categories: Hydrography (HYDR)
Particulate load (spm + composition) (SPM)
Sediment properties (SEDM)

References

Latter RJ, Jones SE, Bale AJ (2002) Comparison of three particle size analysers under field and laboratory conditions. Submitted to Journal of Sea Research (PROVESS Special Issue).

Agrawal YC, McCave IN, Riley JB (1991) Laser diffraction size analysis. In: Syvitski JPM (ed) Principles, methods and applications of particle size analysis. Cambridge University Press, UK, 119-128.

Agrawal YC, Riley JB (1984) Optical particle sizing for hydrodynamics based on near forward scattering. Ocean optics VII, SPIE, 489, 68-76.

Appendix

Additional information about originator's ASCII files

The originator's ASCII files are available from the PROVESS CD-ROM Disk 2 (directory Lisst). The file name structure for each cruise is as follows:

BODC Data Documentation
PROVESS Project MAS3-CT97-015

MT0499: m+digits.dav where 'digits' is the cast number.
 BG9912: bv+digits.dwn where 'digits' is the cast number.
 PE136: pe+digits.dav where 'digits' is the cast number.
 CH140: ch140+digits.dav where 'digits' is the cast number.

Note that the cast number matches CTD cast number for all cruises but for PE136 where CTD casts numbers were used to identify CTD stations while cruise station numbers were used to identify LISST casts. There are also a number of CTD casts with no corresponding LISST profile. These were:

MT0499: no LISST profile data corresponding to CTD048.
 BG9912: no LISST profile data between 19/5/99 14:59 and 19/5/99 20:01 (corresponding to CTD casts 26 to 31).
 PE136: no LISST profile data associated with CTD091 (cruise station number 160).
 CH140: no LISST profile corresponding to CTD02.

Definition of the 32 size classes and Volume Scattering Function (VSF) angles of the LISST instrument as used during PROVESS

Size and angle rank	Size class median μm	lower boundary μm	upper boundary μm	VSF angles radian
1	1.36	1.25	1.47	0.0018
2	1.60	1.47	1.74	0.0022
3	1.89	1.74	2.05	0.0026
4	2.23	2.05	2.42	0.0030
5	2.63	2.42	2.86	0.0036
6	3.11	2.86	3.37	0.0042
7	3.67	3.37	3.98	0.0050
8	4.33	3.98	4.70	0.0059
9	5.11	4.70	5.54	0.0069
10	6.03	5.54	6.53	0.0082
11	7.11	6.53	7.71	0.0097
12	8.39	7.71	9.10	0.0114
13	9.90	9.10	10.74	0.0135
14	11.69	10.74	12.67	0.0159
15	13.79	12.67	14.95	0.0188
16	16.27	14.95	17.65	0.0221
17	19.20	17.65	20.83	0.0261
18	22.66	20.83	24.58	0.0308
19	26.74	24.58	29.01	0.0364
20	31.56	29.01	34.23	0.0429
21	37.24	34.23	40.40	0.0506
22	43.95	40.40	47.67	0.0597
23	51.86	47.67	56.25	0.0704
24	61.2	56.25	66.38	0.0830
25	72.22	66.38	78.33	0.0979
26	85.22	78.33	92.44	0.1154
27	100.57	92.44	109.07	0.1359
28	118.67	109.07	128.71	0.1600
29	140.04	128.71	151.89	0.1882
20	165.26	151.89	179.25	0.2210
31	195.02	179.25	211.53	0.2592
32	230.14	211.53	250.00	0.3032