

Bilfinger Noell GmbH
Alfred-Nobel-Straße 20, 97080 Würzburg, Germany



BILFINGER

Prof. Benjamin Murray
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England

Technologies

Contact person	Department	Reference	Phone	E-Mail
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Subject: Upgrade of PINE instrument
Our Offer Number: 210.671.0005

30.01.2020

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VAT No. DE211420259
Finance Office Würzburg

Dear Prof. Murray,

We are glad to provide you with an offer for the upgrade of the PINE instrument, which is part of the collaboration agreement between KIT, University of Leeds and NOELL.

In case of questions, please do not hesitate to contact us.

We are looking forward to your order.

Best regards,

Bilfinger Noell GmbH

i.V. Wolfgang Walter
Head of Magnet Division

i.V. Michael Gehring
Head of Sales, Magnet Technologies

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Page 2 / 6
Reference: 210.671.0005
Bilfinger Noell GmbH

Table of Content

1	Basis of the offer	3
2	Content of the offer	3
3	Scope of supply	3
4	Terms of Delivery/Transport packaging	3
5	Price	4
6	Terms of payment	4
7	Schedule	4
8	Liability	4
9	Warranty	4
10	Applicable Law, Dispute Resolution	5
11	Validity of the offer	5
12	Further conditions	5

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60



BILFINGER

Page 3 / 6
Reference: 210.671.0005
Bilfinger Noell GmbH

1 Basis of the offer

Basis of our offer is

- This offer
- Technical description PINE Version 2001
- Our Standard terms of delivery of the Bilfinger Noell GmbH (NOELL) Edition 10/2017.

Within the binding period, the purchaser has the right to accept this offer by unilateral declaration in writing (purchase order) for the whole scope of supply and performance.

2 Content of the offer

We offer according to the above mentioned basis:

Upgrade of one PINE instrument

3 Scope of supply

Scope of supply according to the enclosed PINE manufacturer description PINE Version 2001.

The following components and services are excluded and will be supplied by the University of Leeds in due time free of charge:

- 1x Humidity sensor with sampling cell DMT143 G1C1A1A3A1ASX
- 2x Agilent Pumps IDP3D01
- 2x Dryer 24" PPMD-700-24S-1
- 1x OPC - Palas
- 3x MFC
 - MFC1 F-201CV-10K-AGD-00-V
 - MFC2 F-201CV-10K-AGD-00-V
 - MFC3 F-201CV-10K-AGD-HH-V
- - 1x Pressure Controller PC P-702CV-1K1A-AGD-00-V
- Calibration of the instrument by KIT.

4 Terms of Delivery/Transport packaging

NOELL will supply the PINE according to Incoterms 2010.

Incoterms Code: EXW Würzburg

The PINE shall be packed by NOELL suitable for transportation by truck/airplane.

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Page 4 / 6
Reference: 210.671.0005
Bilfinger Noell GmbH

5 Price

The price for the a.m. scope is as follows:

56,000.00 Euro net

License fees are not included in the price.

Any customs, import duties, tariffs, taxes, fees, etc. charged outside Germany are not included in the above mentioned prices. If applicable, VAT will be charged additionally according to the regulations stipulated by applicable law.

6 Terms of payment

50 % of the contract price upon signature of the order

50 % of the contract price upon notification of readiness for shipment

All payments have to be made within 14 days after presentation of the invoice.

7 Schedule

The expected delivery time is **six months** until "ready for shipment", after confirmation of order, receipt of the down payment at Noell and BAFA clearance.

We assume that the University of Leeds supplied components arrive at Noell latest on 26.03.2020.

After the expiry of the validity of the offer we expect a longer delivery time, according to the current state of knowledge.

8 Liability

Bilfinger Noell GmbH is liable for the delivery as follows:

- Any liability from whatever legal reason for indirect, consequential or incidental damages for example, loss of profit, loss of production or increase of costs is generally excluded.
- All liability for damages in contract or tort in connection with this contract is limited to 100 % of the contractual value
- No limitation of liability will be claimed by us for damages resulting out of acts of wilful misconduct.

The Supplier's statutory product liability shall remain unaffected by this agreement.

9 Warranty

Bilfinger Noell GmbH warrants the execution of the scope of supply in a careful and proper way as well as obeying all legal rules.

The warranty period is 12 months upon notification of readiness for shipment.

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BILFINGER

Page 5 / 6
Reference: 210.671.0005
Bilfinger Noell GmbH

The Warranty for repaired or exchanged parts shall in any case expire latest 12 months after expiry of the regular Warranty period.

In case of deficiencies in the supply, the Supplier shall have the right to select the way of remedy (repair or substitute the goods). The transportation cost of warranty related shipments are to be borne by the purchaser.

10 Applicable Law, Dispute Resolution

Place of fulfilment for both parties is the principal place of business of the Bilfinger Noell GmbH.

Place of jurisdiction is the seat of the court competent for the principal place of business of the Bilfinger Noell GmbH.

All legal relations between the purchaser and Bilfinger Noell GmbH are governed exclusively by the German Law as it applies to the legal relations between domestic parties.

Application of the UN Convention on Contracts for the International Sale of Goods (CISG) is excluded.

11 Validity of the offer

This offer is valid until 28.02.2020.

12 Further conditions

Our offer is subject to the granting of an export clearance for the contract from the German authority "Bundesamt für Wirtschaft und Ausfuhrkontrolle". (Federal Office of Economics and Export Control)

Until now, we do not expect any problems in obtaining this permission.

Bilfinger Noell GmbH shall retain title to the goods until such time as the purchase price thereof has been paid in full.

Except of conditions stipulated above our offer is based on our enclosed "Standard terms of delivery of the Bilfinger Noell GmbH Edition 10/2017"

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BILFINGER

Page 6 / 6
Reference: 210.671.0005
Bilfinger Noell GmbH

Würzburg, 30.01.2020

Bilfinger Noell GmbH

i.V. Wolfgang Walter
Head of Magnet Division

i.V. Michael Gehring
Head of Sales, Magnet Technologies

Enclosures:

- Manufacturer description PINE: Version 2001
- "Standard terms of delivery of the Bilfinger Noell GmbH Edition 10/2017"

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Walter

Standard Terms of Delivery of Bilfinger Noell GmbH
1. Scope of Application

1.1. These terms of delivery shall be exclusively applicable to all present and future supplies and services provided to our contractual partners (hereinafter referred to as "Purchasers"). Any differing provisions, especially the Purchaser's terms and conditions shall not apply even if we do not object to them expressly in each individual case. Even if we refer to a letter which contains the Purchaser's or a third party's terms and conditions or refers to such terms and conditions, this does not imply acceptance of the application of these terms and conditions. They shall not become part of this agreement neither by acceptance of the order nor by any other action implying intention. These terms shall be deemed accepted, at the latest, upon receipt of the delivery item.

1.2. We would like to point out that for particular services, special terms and conditions shall apply which may complement or modify the terms of sale and delivery.

2. Offer, Scope of Delivery

2.1. Our offers are non-binding. Any orders, conclusion of contracts and other arrangements shall not become binding until confirmed by us in writing. The scope of delivery is determined solely by the written order confirmation.

2.2. All contracts on the provision of supplies and services by us which do not fulfil the written form requirement are only valid if confirmed by us in writing and hand-signed or by telefax. Unilateral declarations on legal transactions regarding the contractual relationship, in particular termination of contract must be made in writing and hand-signed in order to be valid. The written declaration may also be sent by telefax.

2.3. Details regarding the delivery item or service (e.g. weights, dimensions, performance characteristics, load-bearing capacity, tolerance values and technical data) as well as representations thereof are descriptions or characterizations. Liability may not be derived from these details unless they have been expressly marked in writing as binding. Variations that are customary in the trade and variations which are the result of legal provisions or which represent technical improvements are permissible insofar as they do not affect the usability for the contractually stipulated purpose.

2.4. We are reserving all rights in offers and cost estimates submitted by us, in tools, auxiliary means, samples, illustrations, descriptions, models, calculations, majorities of data sets (also from different contracts) and other documentation provided by us or third parties and put at the disposal of the Purchaser. These items must neither be disclosed nor made accessible by the Purchaser to third parties without our consent, either as such or in their contents, nor may they be published or copied or applied for the Purchaser's proper or third parties' use. Upon our request the Purchaser is obliged to return these items and any copies in their entirety if they are no longer needed by him in the regular course of business or if negotiations have not resulted in the conclusion of a contract.

2.5. In the event that the Purchaser requires changes deviating from the delivery contract these must be jointly agreed upon taking into account possible extra costs and delays.

2.6. The Purchaser assumes full responsibility for the information and for the documentation provided to us such as drawings, models, samples and suchlike.

2.7. Agreements based on our offers and cost estimates shall be treated as confidential.

3. Prices, Payment and Setting-off

3.1. All prices are quoted in Euros unless otherwise expressly agreed. Unless otherwise agreed, prices shall be understood for delivery ex store or works including loading, but excluding packing, freight, postage and insurance. The applicable legal amount of value-added tax shall be added to the prices.

3.2. Unless otherwise agreed, payment shall be due immediately after receiving the invoice and shall be effected in cash without any deduction, free stated payment office.

3.3. Partial deliveries are invoiced immediately.

3.4. Payment default occurs latest 30 days after due date. In case the time of receipt of the invoice is under dispute, payment default occurs latest 30 days after receipt of the supply. In case of delay in payment, statutory interest on arrears will be charged without requiring a separate reminder and in reservation of the assertion of further rights, especially any further damage caused by delay. Article 353 Commercial Code (HGB) remains unaffected.

3.5. Any retention of payments and the setting-off against possible counterclaims by Purchaser is only admissible to the extent such counterclaims are uncontested, admitted by us or determined by final judgement.

3.6. Payment default and circumstances brought to our knowledge after signature of the contract which might affect Purchaser's credit standing so that enforcement of our claims for payment may appear in jeopardy, entitles us to withhold the performance of due deliveries until receipt of advance payment or customary bank securities or to rescind the contract after expiry of a reasonable notice period and to claim damages for non-fulfilment. Furthermore in this case we shall be entitled to prohibit resale of the goods delivered under reservation of title (section 6 of these terms).

4. Delivery Period

4.1. Delivery periods and dates are not binding unless they have expressly been confirmed in writing.

4.2. The delivery period shall begin with the dispatch of the confirmation of order, however, not before obtaining the documents, approvals, releases to be provided by the Purchaser nor before receipt of a stipulated down-payment. If the Purchaser fails to cooperate or requests modifications the delivery periods and dates are appropriately extended. The delivery period shall be considered observed when the delivery item has left the works, or its readiness for shipment has been advised, by the end of said period.

4.3. The delivery period will be duly extended in the event of actions under labour disputes, mainly strike and lockout, as well as on occurrence of unforeseen obstacles which are not our fault, such as force majeure, action by governmental authorities, faultless delay in the production of parts from subcontractors, plant failure/operational breakdown, the failure of subcontractors to perform, provided that it can be proven that such obstacles notably affect the completion or deliv-

ery of the delivery item. This shall be applicable irrespective of said circumstances occurring at our shops, those of our sub-contractors or any of their sub-suppliers. Such circumstances shall not be our responsibility even if they occur while a delay has already been suffered. We will inform the Purchaser, as soon as possible, about the start and end of such circumstances.

4.4. If the Purchaser suffers a loss as a result of a delay on our part, in cases of minor negligence we shall only be liable to an amount not exceeding 5% of the agreed purchase price. Any further claims arising from delay shall be based exclusively upon Clause 8.

4.5. Observance of the delivery period is conditional upon fulfilment of Purchaser's contractual obligations. After futile expiry of stipulated periods, especially at the end of any call periods provided, we shall be entitled, without prejudice to our other rights, to cancel all or part of the goods not yet accepted or to withdraw from the contract as a whole or part of it, without incurring the liability to pay damages, while being at liberty to claim compensation for loss occasioned by default.

4.6. If shipping is delayed at Purchaser's request, he shall be charged the expenses incurred by storage, starting one month after notification of readiness for dispatch. If the goods are stored in any of our own works, at least half a percent of the invoice amount shall be charged as storage costs for each month. After granting a reasonable period and its futile expiry we shall, however, be entitled to otherwise dispose of the delivery item and provide for substitute delivery to Purchaser within a reasonably extended period or withdraw from the contract.

5. Dispatch, Passing of Risk and Acceptance

5.1. For the interpretation of the delivery clauses the Incoterms in force on the day of order confirmation apply.

5.2. The risk shall pass to Purchaser, at the latest on dispatch of the delivery items ex works (EXW), even in cases of partial delivery or of our exceptionally having assumed additional obligations such as cost of transportation or carting and installation.

5.3. In the event that our staff assist in loading operations, they are deemed to be acting at the sole risk of the Purchaser and not on our behalf.

5.4. Even if it has been expressly agreed in the contract that transportation of the goods shall be carried out by us, the risk shall nonetheless pass to the Purchaser at the beginning of the loading process, at the latest upon the goods leaving our factory or warehouse, unless the Purchaser's place of business has been expressly agreed as the place of performance. The above shall also apply if partial deliveries are made or if we have agreed to take over other services such as shipping costs.

5.5. In the event that we have expressly agreed to bear the freight costs, the following shall apply: any increase in freight costs following the conclusion of the contract as well as extra costs resulting from obstruction or delay of transport attributable to circumstances beyond our control shall be borne by the Purchaser.

5.6. If there is a requirement of acceptance, such acceptance determines the passing or risk. It shall be declared immediately on the acceptance date or in the alternative following our notification as to acceptance readiness. Acceptance is considered as granted, if the Purchaser does not carry out an agreed acceptance test within three months following our notification as to acceptance readiness. Likewise, acceptance is considered as granted if the Purchaser puts our supply into operation or otherwise uses them without our consent and before having expressly declared acceptance.

5.7. Delivered items shall be accepted by the Purchaser irrespective of the rights under section 7 of these terms even if they show minor defects. Packaging and dispatch are done according to the best judgement but without further liability on our behalf. The Purchaser shall notify us in writing of any discrepancies arising from dispatch immediately after receipt of the goods.

5.8. Partial deliveries are reasonably permitted. If shipping is delayed for reasons which are Purchaser's responsibility, the risk shall pass to Purchaser as of the date of notification of readiness for dispatch.

5.9. Only at the express request and at the expense of the Purchaser shall we obtain insurance against theft, breakage, damage caused by transport, fire and water and other insurable risks.

6. Reservation of Title

6.1. All goods shall remain our property (reserved goods) until all claims arising from our business relationship with the Purchaser on whatever legal grounds have been satisfied, including future or qualified claims, also those raised under contracts signed at the same time or later. This shall also be applicable to payments expressly attributed to specific claims. In this respect all deliveries are deemed to be a connected delivery transaction.

6.2. Without our consent the Purchaser must neither pledge the reserved goods nor assign them by way of security. In the event of attachments, seizure or other interventions by third parties, the Purchaser shall inform us without delay in writing.

6.3. Machining and processing of reserved goods shall take place for us as manufacturers in the meaning of Article 950 of the German Civil Code (BGB), but without exposing us to any obligations. Processed goods shall be considered as reserved goods as defined in these terms.

6.4. If reserved goods are processed or inseparably mixed by the Purchaser with other items owned by others, we will acquire proportionate co-ownership in the new goods within the meaning of Article 947 Clause 1 of the German Civil Code (BGB) and the Purchaser retains the object for us in custody. In the event that our goods are combined or inseparably mixed with other movable property forming a single object and this object is considered the main object, Purchaser shall assign proportionate co-ownership to us, provided the main object is owned by him. Our rights in items delivered by us which are not an essential part of an object are not affected by this regulation.

6.5. As long as the Purchaser is willing and in a position to duly meet his obligations towards us, he may use the goods in our ownership or part ownership for the purpose of ordinary business. More specifically, the following provisions shall apply:

- a) If the Purchaser allows delayed payment of the purchase price towards his customer, he must reserve right of ownership over his customer to the modified goods. Without such reservation, the Purchaser shall not be entitled to dispose of the reserved goods.
 - b) Purchaser herewith assigns to us already now any claims which may arise from the sale of the reserved goods including drafts and cheques in order to secure our claims from the business relationship. In the event of sale of goods co-owned by us, the assignment of claims shall refer to the co-owned shares. In the event of processing of the goods within the framework of a contract for services, the wage claim shall be assigned to us already now in the pro rata amount of the Purchaser's invoice for the processed reserved goods. The Purchaser shall be entitled to resell or otherwise utilize the reserved goods only if it is assured that the resulting claims will pass over to us.
 - c) In the event that the assigned claims are included in a current invoice, the Purchaser immediately assigns to us that part of the balance which is equivalent to the amount of such claims, including the final balance from current account operations. If interim balances are drawn and it is agreed that they will be carried forward, then the claims from the interim balance to which we are entitled according to the above provision shall be treated as assigned to us for the next balance.
 - d) Purchaser shall have the right to collect claims under resale until revoked by us. We are entitled to revoke the collection authority for good reason, such as delayed payment, suspension of payment, significant deterioration in the assets of the Purchaser. Upon our request, he is obliged to inform his customers of any assignment to us and to make available to us the information and documents required to assert the claim.
- 6.6. Breach of contract by the Purchaser, any significant deterioration in the assets of the Purchaser or the opening of insolvency proceedings entitle us to prohibit the treatment and processing as well as the resale of the reserved goods. Our taking back or seizure of the reserved goods is only deemed to be a rescission of the contract, if expressly so declared by us.
- 6.7. Should the value of the securities provided for us exceed our claims overall by more than 20 percent, we shall be obliged to disclaim, at Purchaser's request, securities to this extent at our discretion.
- 6.8. If the Purchaser or a third party applies for insolvency proceedings to be opened over the assets of the Purchaser, or insolvency proceedings against the Purchaser are opened by court order or the opening of such proceedings is denied due to lack of assets, we are entitled to rescind the contract and to demand the immediate return of the reserved goods.
- 7. Warranty Claims**
- 7.1. The Purchaser must immediately check whether the goods delivered or the services provided are of the contractually agreed quality and fit for the intended purpose.
- 7.2. Regarding deficiencies of the delivery we shall be liable, under exclusion of any further claims, notwithstanding Clause 8 of these terms, exclusively in such a way that we will repair or replace, at our discretion, all parts which prove defective as the result of circumstances having occurred before the passing of the risk.
- 7.3. The warranty shall expire, at the latest, within 12 months of the passing of risk. Purchaser's right to assert claims due to deficiencies shall be statute barred in all cases within 6 months of the Purchaser having notified a defect, at the earliest, however, at the end of the warranty period. As an exception to this, the normal statutory limitation periods apply for defects in a building or for delivery items which were used in a building in accordance with their normal destination and caused such building's deficiency. The provisions of Clause 9 remain unaffected.
- 7.4. Should the Purchaser or third parties proceed to improper modifications or repair work without our consent, our liability for the resulting consequences is excluded.
- 7.5. Should the repair or delivery of replacement fail for reasons for which we are responsible or should we fail to observe the grace period granted to us for the repair or delivery of replacement by our fault, Purchaser may claim a reduction of remuneration (reduction of purchase price) or rescind the contract.
- 7.6. Our action taken upon any notification by Purchaser of an alleged defect, no matter in what form, under no circumstances shall represent acknowledgement of the justification of Purchaser's claim.
- 7.7. We are entitled to demand compensation from the Purchaser for costs to the extent a notice of defect proves to be unjustified.
- 7.8. Further contractual and non-contractual claims of the Purchaser, especially any claim for compensation of losses not represented by the delivery item itself shall be excluded, subject to the provision in Clause 8.2.
- 7.9. If production and supply of our services are due to instructions of the Purchaser, the Purchaser guarantees that industrial property rights of third parties hereby will not be infringed. If third parties assert claims concerning industrial property rights, the Purchaser is obligated to indemnify us from our arising loss and costs, provided that he is responsible for the infringement.
- 7.10. If use of the delivery item by our fault leads to the infringement of third party's industrial property rights within the Federal Republic of Germany, we shall, in principal at our costs acquire for the Purchaser the right to make further use of the delivery item or modify it for the Purchaser in an acceptable manner so that the infringement of property rights no longer exists. If this is not possible under economically justifiable conditions or within an appropriate period of time, we

are as well as the Purchaser entitled to rescind the contract. The obligations under Sentence 1 are final, subject to the provisions under Clause 8.2. Our liability particularly is excluded, if the Purchaser not immediately informs us about asserted infringements of industrial property rights, not supports us in the defense against asserted claims to the appropriate extent respectively enables us to take measures of modification. Our liability also is excluded if the Purchaser caused the infringement by arbitrarily changing the delivery item or using it in breach of contract or is otherwise responsible for the infringement of the industrial property right.

8. Liability

- 8.1. In case the delivered item, due to our fault, cannot be appropriated by the Purchaser in accordance with the contract as a result of failure or defectiveness of proposals made and advice given before or after the conclusion of contract or infringement of other contractual collateral duties – particularly instructions for operating and maintenance of the delivery item - the provisions under Clauses 7. and 8.2 of these terms apply accordingly, to the exclusion of further claims of the Purchaser.
- 8.2. For damage not represented by the delivery item itself we shall, for whatever legal grounds, only be liable in the event of intent, gross negligence by our organs or executives, culpable injury to life, body and health, defects we have deceitfully kept hidden or the absence of which we guaranteed and defects of the delivery item concerning liability under product liability law for personal injury or damage to property to privately used objects. In case of culpable infringement of material contractual obligations we shall also be liable for gross negligence of non-executives and for slight negligence, in the latter case limited to the typical contractual, reasonably foreseeable damage, limited to a maximum extent of 100.000,00 Euros for each claim, in case of different claims limited to a total maximum extent of 300.000,00 Euros. Apart from that, Purchaser's claims for damages and reimbursement of expenses particularly due to infringement of contractual duties and tortuous act, regardless for whatever legal grounds, are excepted.

9. Miscellaneous

- 9.1. No verbal side agreements have been concluded. Any modifications of and supplements to these provisions are only valid if made in writing.
- 9.2. If and insofar as software is included in the scope of delivery, the Purchaser shall be granted the non-exclusive right to use the supplied software including its documentation. It is provided for use on the intended delivery item. The software must not be used on more than one system. The Purchaser commits not to remove or change producer's information – particularly copyright marks. Particularly Articles 69 ff. of German Copyright Law (UrhG) shall be observed in this context. Granting of sub-licenses is inadmissible. All claims of the Purchaser – for whatever legal grounds – are subject to a limitation of 12 months. As an exception to this, the statutory limitation periods prevail upon claims for damages in accordance with Clause 8.2 as well as to defects in a building or to delivery items appropriated in accordance with their normal use for a building and causing its defectiveness.

10. Place of Fulfilment, Place of Jurisdiction, Governing Law

- 10.1. Place of fulfilment for both parties is the principal place of business of Bilfinger Noell GmbH.
- 10.2. Place of jurisdiction is the seat of the court competent for the principal place of business of the Bilfinger Noell GmbH. We are, however, also entitled to take legal action at the principal place of business of the Purchaser.
- 10.3. All legal relations between the Purchaser and us are governed exclusively by the German Law as it applies to the legal relations between domestic parties. Application of the UN Convention on Contracts for the International Sale of Goods (CISG) is excluded.

11. Severance Clause

- 11.1. Should a term of these provisions or any other agreements that have been concluded be ineffective or become ineffective, the validity of the remainder of the contract shall not be affected. This shall not apply, however, if adherence to the contract would constitute unreasonable hardship for one of the parties to the contract. The parties to the contract shall replace the ineffective provision by a provision following as closely as possible the economic intent of the previous provision.



PINE: the instrument that revolutionizes the field of atmospheric ice nucleating particle concentration measurement allowing researchers to perform unattended, fully automated campaigns and long-term monitoring down to -60°C .

Overview

Ice nucleating particles (INP) are the source for primary ice formation in clouds, hence their concentration has a critical impact on the temporal and spatial distribution of precipitation as well as a major impact on climate. PINE enables the accurate measurement of the INP concentration, thus providing researchers and meteorologists with a unique and valuable insight into INP properties. PINE is the first automated online INP counter and requires minimal user input. This makes it suitable for INP monitoring since it measures continuously and can be operated and maintained by non-experts. It is thereby able to detect atmospheric INP concentrations over a wide range of concentrations and temperatures at high time resolution and at conditions relevant for many cloud types. In addition, PINE provides information on the overall aerosol concentration.

Applications

- Cloud physics research
- Observation and monitoring of ice nucleating particles
- Systematic laboratory investigation of the ice nucleation activity of different aerosol species



BILFINGER NOELL GMBH

PINE is the result of a collaboration between Bilfinger Noell GmbH, the Karlsruhe Institute of Technology and University of Leeds.



PINE: the first instrument to automatically measure long-term series of INP concentrations at high sensitivity, time resolution and in a wide range of temperatures.

How it works

The core element of PINE is an air tight vessel, several liters in volume, which can be cooled to a specified temperature. Air is drawn into the chamber through a valve at the top, and pulled through by a pump below. For a cloud formation experiment, the pressure within the chamber is reduced, causing the gas temperature to drop by expansion cooling. The chamber walls are temperature controlled, allowing to start cloud expansion runs at any pre-selected temperature between 0°C and -60°C

The frost point of the air sampled into the chamber is controlled to be low enough for preventing frost formation at the cold chamber walls, but high enough for allowing cloud droplet activation and ice formation during the expansion runs. Varying the temperature and humidity determines which nucleation mode will occur within the chamber, and therefore which cloud types the measurements are relevant for.

When the chamber is operated in the immersion mode (relevant for mixed-phase clouds), a large number of supercooled water droplets are formed during the expansion run. Only a minor fraction of those droplets containing an INP freezes, and ice crystals are formed and grow to larger size.

To access cirrus cloud conditions, the chamber is operated at ice super saturation, but below water saturation. This leads to deposition ice nucleation as the temperature within the chamber decreases and the ice supersaturation increases. The resulting ice particles rapidly grow into the detection range of the optical particle counter (OPC).

The OPC (fidas-100, Palas GmbH, Germany) detects large aerosol particles, cloud droplets, and ice crystals and differentiates by optical size between the different particle types.

Features

- Expansion chamber with operating temperatures between 0°C and -60°C.
- Refrigeration system based on thermal conduction (no fluids).
- Integrated control system.
- Fully automated operations.
- Plug and play instrument (connect only power).
- Compact rack design.

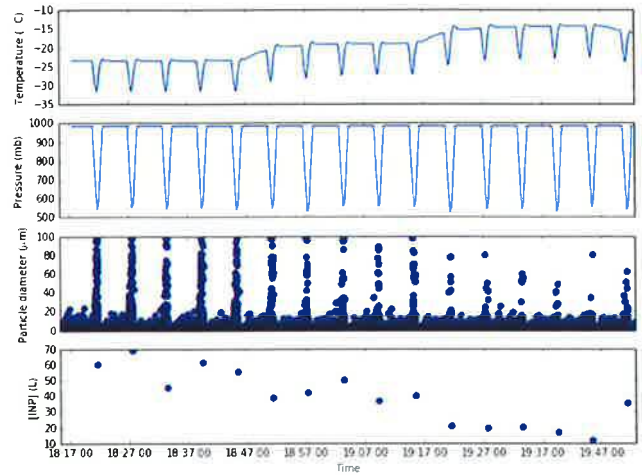
Included items

- » PINE instrument
- » Operator manual
- » Email and phone technical support

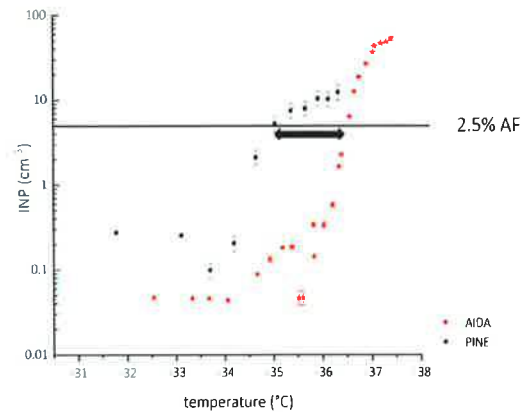
Detailed specifications:

INP concentration range..... 0.1 to 1000 L⁻¹
 Sampling temperature..... < 35 °C
 Wall temperature..... 0 to -60 °C
 OPC particle detection range ... 0.2 to 200 µm

Dimensions 0.80 m X 0.60 m X 1.83 m
 Weight..... < 200 kg
 Power requirements < 1 kW, 110-240 VAC



Preliminary results of the prototype PINE chamber during the HyICE test campaign at the Hyytiälä (Finland) field station in 2018.



Validation experiment: the temperature for homogeneous freezing of sulfuric acid particles agrees within 1.5°C to AIDA measurements

Add on

The PINE instrument will be validated for temperature and INP concentration measurements at the KIT cloud facility before delivery. The validation will be documented and is part of the operation manual.

For the operation of PINE, a free as-is software is available from KIT. The software allows setting temperature ramps as well as defining measuring cycles.

Technologies

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In cooperation with

