Printed Optical Particle Spectrometer

A small, sensitive, light-weight, and disposable aerosol spectrometer for balloon and UAV applications



Hagen Telg

Cooperative Institute for Research in Environmental Sciences NOAA Earth System Research Laboratory May 20, 2014 start

motivation

now POPS works

how POPS performs O field test O

Motivation



Why aerosols

 $\Rightarrow\,$ large uncertainty about effect on radiative forcing

Scientific questions that are difficult to address with existing tools

- Aerosol profiles inside the Asian Monsoon \rightarrow no aircraft excess
- Fire plume sampling → no aircraft excess
- Volcanic aerosol and ash quantification → no aircraft excess, monitoring needed
- $\bullet \ \ \text{Geo-engineering} \rightarrow \text{monitoring needed}$
- \Rightarrow A small, light-weight, low cost, low power optical particle counter will help greatly

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⇒ Printed Optical Particle Spectrometer

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start	motivation O	how POPS works	how POPS performs O	field test O	fine 00
Ho	w POPS works				
			light-source	e 405 nm laser diode	
	РМТ		beam shaping	aspherical, and cylindrical lenses shape laser to line	
	spherical mirror		light collectior	n spherical mirror image scattered light on Photo m ultiplier T ube	
			stray ligh	t multiple slits suppress stray light	
	parter A single Participants A single A	an Den han	signal processinç		
		15 cm	sizinç	g intensity of scattered light depends on particle size	DOBB



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Но	w POPS works				
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	• • • •	Laser	light collection	spherical mirror image scattered light on Photomultiplier Tube	
		• mirror	stray light	multiple slits suppress stray light	
	Exact Parage Barbar Ba	Lure norm	signal processing		
		15 cm	sizing		



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stray light	multiple slits suppress stray light
signal processing	$\begin{array}{l} PMT \text{ output current} \\ converted to voltage \rightarrow \\ amplified \rightarrow digitized \ (4 \\ MHz; 16 \ bit) \rightarrow \\ analyzed on \\ single-board computer \\ \rightarrow \ communicate via \\ serial port \end{array}$



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How POPS	Sworks				



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sizing	intensity of scattered light depends on particle size	
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how POPS works

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dimensions	15x6x6 cm
weight	< 1 kg
cost*	~2500 \$
power	3 W
* labor exclude	ed

light-source	405 nm laser diode
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R. S. Gao et al., Aerosol Sci. Technol. 2013, 47, 137

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how P	OPS performs	3			
	raw data	Diameter (nm) ● ● 180	 single particles are r good diameter resol ∆d/d ≈ 15 % 	esolved ution	
			 minimum measurable <150 nm 		
			agreement with theo		
	Time (a	**************************************	 comparison to UHS/ agreement in absolu 190 nm) 	AS shows good te counts (down to	



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start	motivation	how POPS works	how POPS performs	field test
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how PC	OPS performs			
(i, i)	raw data	Diameter (nm)	• single particles are • good diameter resol $\Delta d/d \approx 15\%$	resolved lution

- minimum measurable diameter <150 nm
- agreement with theory
- comparison to UHSAS shows good agreement in absolute counts (down to 190 nm)



Signal intensity (arb.



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how POPS porforms





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how POPS performs	
Time (arb. u.)	 single particles are resolved good diameter resolution ∆d/d ≈ 15 % minimum measurable diameter <150 nm agreement with theory comparison to UHSAS shows good agreement in absolute counts (down to 190 nm)
peak height histogram 10^{-10} 0.16 0.16 0.12 0.08 0.08 0.02	exp. versus theo.

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how POPS performs





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fine

start	motivation	how POPS works	how POPS performs	field test	fine
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field test	t on Manta U	AV			



package

- POPS
- Condensation Nuclei Counter
- 3 wavelengths aerosol absorption abotometer \rightarrow like CLAP
- aerosol filter sampler \rightarrow 6 filters
- Radiometer

outcome

- POPS functional
- but interference with UAV communication and other instruments \rightarrow bursts of noise

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 \Rightarrow improve shielding





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summary					

Printed Optical Particle Spectrometer

low cost \sim 2500 \$ \Rightarrow disposable

diameter range 150 - 2500 nm

tested Manta UAV

POPS will be fully functional in a couple of months!



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- Ru-Shan Gao
- Laurel Watts
- Steven Ciciora
- Richard McLaughlin
- Matt Richardson
- Joshua Schwarz
- Anne Perring
- Charles Brock
- Nick Wagner



- Tim Bates
- James Johnson

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