# New detectors for unmanned aircraft systems (and GOAHEAD)

Ru-Shan Gao

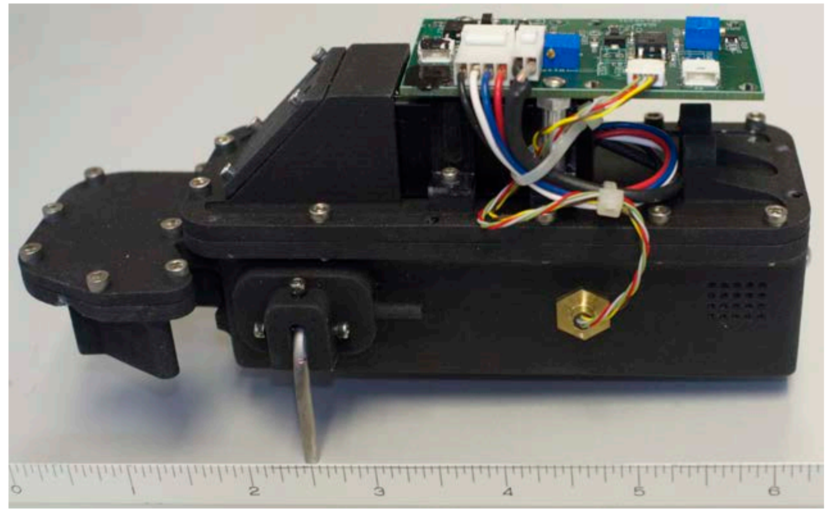
- There is a strong need in CSD to use unmanned aircraft systems (UASs) to reach places difficult or dangerous for manned aircraft
  - Small UASs demand small and light instruments
  - Time is ripe for miniature instruments – Tools just become available now
    - 3D printing
    - Other rapid manufacturing facilities
- CSD is strong in instrument development
  - Catalyst: The NOAA OAR Special Early-Stage Experimental or Development (SEED) grant in 2013 (Ru-Shan Gao, CSD, and Tim Bates, Pacific Marine Environment Laboratory, Co-PIs)
  - Current focus: Aerosol and radiation
  - Goal: Small, light, and inexpensive instruments of science quality that can be easily duplicated

New instruments developed at NOAA/CSD

Printed Optical Particle Spectrometer (POPS)

- Single-particle detection
- 140 – 3000 nm diameter range
- 800 g, 7 Watts
- $2500 per copy, lose-able

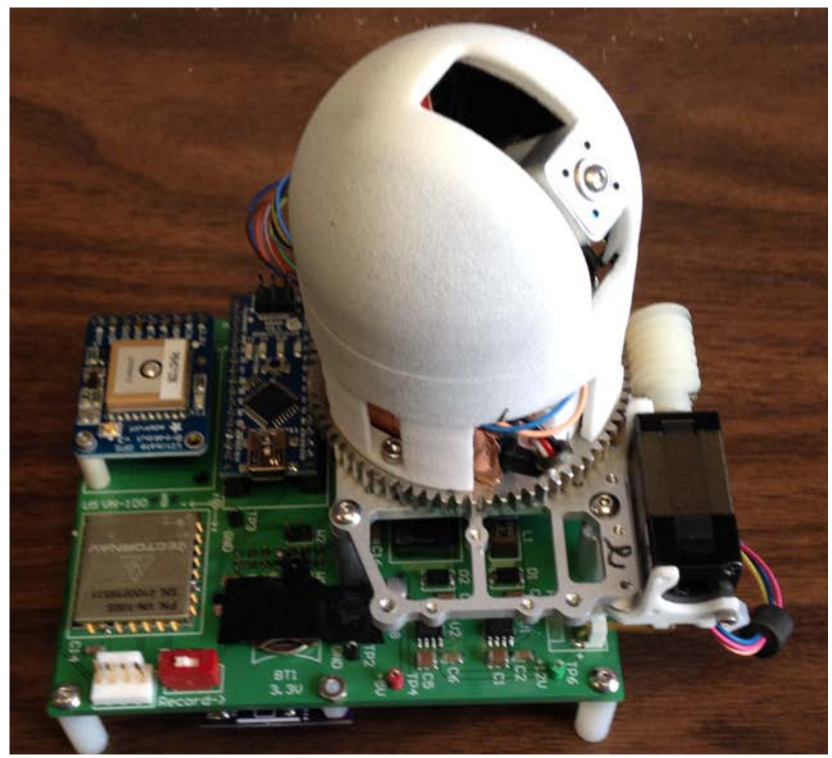
Ru-Shan Gao et al.



Upward Looking Radiometer (ULR)

- 4 wavelength (460, 550, 670, 860 nm)
- 0.02 AOD detection limit
- 350 g, 2 Watts
- $1500 per copy, lose-able

Dan Murphy et al.



Research to Application: Generated significant amount of scientific and commercial interest

UAS implementation

The NOAA Pacific Marine Environment Laboratory (PMEL) Manta UAS

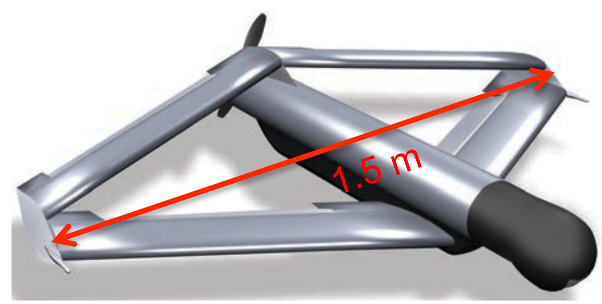

- POPS and ULR have been fully integrated
- Successful test flights in January 2015
- First field mission in April 2015 – Svalbard, Norway in collaboration with PMEL


The University of Colorado Pilatus UAS

- POPS integration in February 2015
- Test flight in March 2015
- First field mission in April 2015 – Oliktok Point, AK in collaboration with Dept. of Energy, University of Colorado, and Physical Sciences Division (PSD)

The Laboratory for Atmosphere and Cyclone (LACy, Reunion, France) $R^2$ Drone

- POPS integration in July 2015
- Test flight in July – August 2015
- First field mission in August - December 2015 Indian Ocean in collaboration with LACy



- New instruments provide new opportunities

The Global Ozone and Aerosol profiles and Aerosol Hygroscopic Effect and Absorption optical Depth ($GOA^2HEAD$) Network Initiative

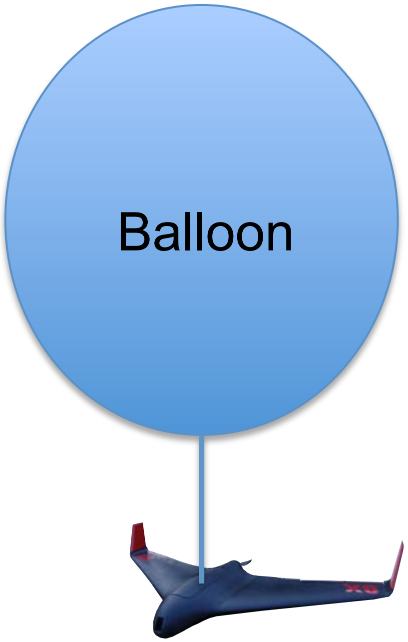
A CSD-led project

Chemical Sciences Division and Global Monitoring Division, Earth System Research Laboratory,
and
Cooperative Institute for Research in Environmental Sciences, University of Colorado

In close collaboration with the NOAA Aircraft Operation Center and UAS Office

- Addressing the desire of frequent global observations of $O_3$, aerosol, aerosol hygroscopicity, and aerosol absorption profiles, aerosol optical density (AOD), and aerosol absorption optical density (AAOD)

- Key criteria for achieving such a important goal:
  - Low equipment cost
  - Low operation cost
  - Reliable measurements of known uncertainty.




Instrumented auto-homing glider

• Weather balloon based glider system, < 6 lbs.
  - FAA regulation on small gliders might be less restrictive: Ease of operation

• Inexpensive instruments ($Ks per instrument, "lose-able")
  - Low equipment cost

• Autonomously homing gliders or parafoils
  - Low operation cost ($350 per launch)
  - 5-km ceiling for easy recovery

Instrument package 1 (developed):

• Deliverables:
  - $O_3$, dry aerosol, relative humidity (RH), and aerosol optical depth (AOD) profiles
  - Dry aerosol AOD (derived)
  - AOD
  - RH effect on AOD

Package 2: (under development with GMD, see poster)

• Deliverables:
  - RH, Aerosol, and aerosol absorption coefficient (AAC) profiles
  - Aerosol AOD (derived)
  - Derived dry aerosol absorption optical density (AAOD)

• All instruments are robust and uncertainties can be quantified
  -Reliable measurements of known uncertainty