Long-Term Monitoring of Aerosols and Cloud Properties using Unmanned Aerial Vehicles (UAVs)

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Aerosol

GOETHE UNIVERSITÄT FRANKFURT AM MAIN

NOAA

The Cyprus Institute

ISARRA 2017

Oban, Scotland
23rd May 2017

UNMANNED SYSTEMS RESEARCH LABORATORY

EEWRC

Outline

Infrastructure

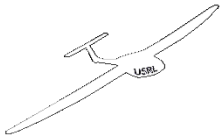
- Laboratory & Permanent Runway / Airspace
- Fleet of UAVs
- Mobile GCS

Long-Term Monitoring of Aerosols and Cloud Properties

- Routine Monitoring Activities (2017)
- Experimental setup
  - Instrumentation
  - Flight strategy
  - Preliminary results

Future Work

- AQABA Campaign
- Stratosphere UAV release from balloon



Infrastructure

- 100 m^2 Laboratory
- Equipped for unmanned systems research and development
- Next to the CyI instrumentation laboratory for atmospheric sciences
- Next to the CyI chemistry analytical laboratory

Our fleet of UAVs

Fixed wing

4 UAVs

1 UAV

1 UAVs

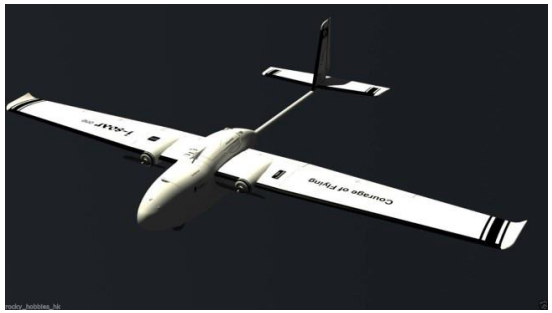
9 UAVs

Cruiser
Medium Size: 35 Kg
Payload: 12 Kg
Endurance: 4 hours
Ceiling: 4 Km

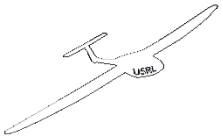
Mini Cruiser
Small Size: 11 Kg
Payload: 4.5 Kg
Endurance: 3 hours
Ceiling: 4 Km

Skywalker EVE
Small Size: 5.5 Kg
Payload: 2.5 Kg
Endurance: 2hours
Ceiling: 3 Km

Skywalker 1680
Small Size: 4 Kg
Payload: 1.5 Kg
Endurance: 1.5 hours
Ceiling: 3 Km



I-Soar 2 UAVs
Small Size: 6 Kg
Payload: 2 Kg
Endurance: 1.5 hours
Ceiling: 3 Km



Rotary Wing

Logo 800
Small Size: 12 Kg
Payload: 5 Kg
Endurance:~30 minutes
Ceiling: 3 Km

Dji S1000+
Small Size: 11Kg
Payload: 4 Kg
Endurance: ~20 minutes
Ceiling: 1 Km

Mobile Ground Control station (GCS)

GCS / Mobile Laboratory

Truck with GCS

Monitoring & Control of
UAV, Payload, Camera

Portable GCS

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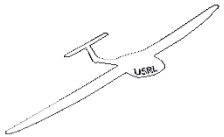


UAV routine monitoring activities



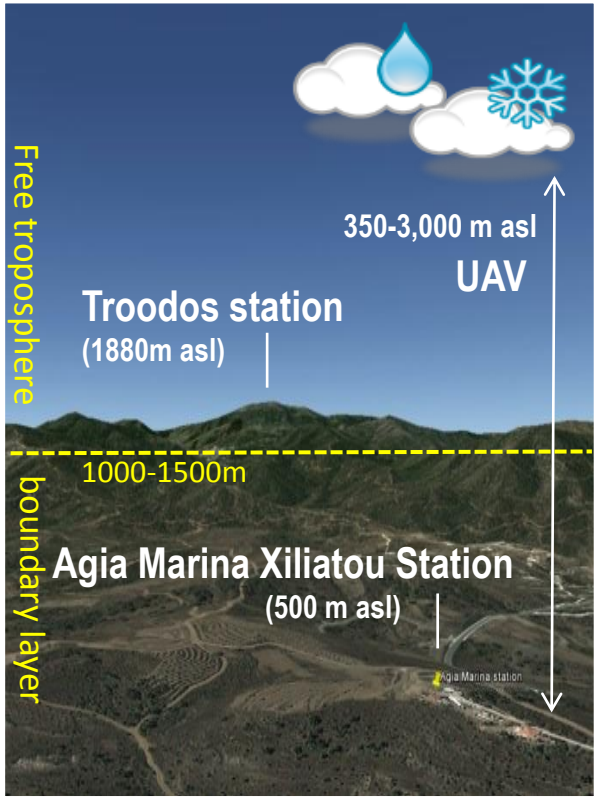

- **1-year routine (January 2017 – December 2017) observation of the vertical composition of the atmosphere with weekly UAV flights (Absorption, Size distribution, AOD, Ice Nuclei, etc.) completing similar 1-year co-located (Cyprus) remote sensing observations (TROPOS).**

Scientific motivations:

- ✓ **Building of a unique atmospheric database in the Mediterranean with boundary layer and free tropospheric in-situ observations**
- ✓ **Investigation of atmospheric processes within and above the atmospheric boundary layer, and in-situ observations of dust layers from different source regions**
- ✓ **In-situ constrain of remote sensing (sunphotometer, lidar) retrieval algorithms of aerosol optical properties and IN parametrization**
- ✓ **Demonstration of the added-value of UAV platforms in long-term routine observations of the atmosphere (ACTRIS ESFRI)**

UAV monitoring activities : Experimental setting

(January 2017 – December 2017)



Payload: NO_2, O_3, BC, STAP

Payload: DWP

Payload: IN sampler

Payload: miniSASP, POPs, OPCs (MetOne, Palas)

T, RH, Video

Flight Strategy – Focus on contrasted situations

- Clean (Med.) vs Polluted (Europe/Turkey/Middle East)
- Dust (Africa) vs Dust (Middle East)
- Aerosol layer (boundary layer) vs aerosol layer (Free troposphere)
- Aircraft campaigns (April, July-August, September 2017)

Instrumentation

OPC, Palas, Fly100

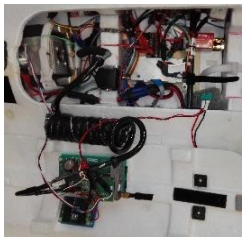
- Size distr., 0.18-40 µm (64 ch.)
- Time res. 1 s

Printed Optical Particle Spectrometer, (POPS), NOAA prototype

- size distr. 0.14-30 µm (14 ch.)
- 550 g, 5 W, lose-able (2000 $)
- Gao et al., 2016

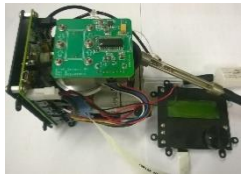
Dual Wavelength Prototype (DWP), Aerosol d.o.o.

- 2-λ absorption photometer
- (370 and 880nm)
- Up to 2 lpm inlet flow rate



STAP, Brechtel

- 3-λ absorption photometer (467, 528, 652 nm)



Mini Scanning Aerosol Sun Photometer, (miniSASP), NOAA prototype

- 460, 550, 670, 860 nm
- 0.02 AOD detection limit
- 350g, 2 W, lose-able (1000 $)
- Murphy et al., 2015

Ice Nuclei sampler (IN), Goethe Uni. Prototype

- 5-15 min collection time / sample
- Schrod et al., 2017

NO_2 / O_3 sensors, CairPol

- 55g, 1min resolution
- 2 separate sensors

T, RH and video on all flights

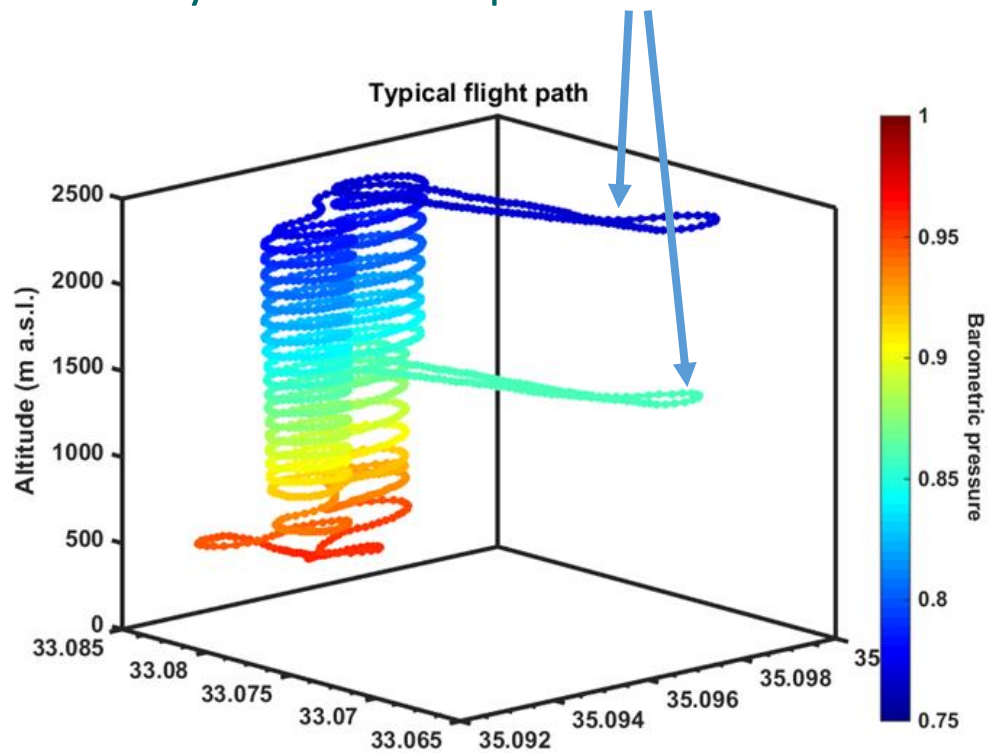
Flight planning

- Flights are planned to overlap with satellite overpass and / or with different pollution / dust source region.
- Boundary layer height and possible dust layers are identified from lidar data at Limassol (TROPOS).

Level flight above and within the boundary layer for IN sampler and miniSASP

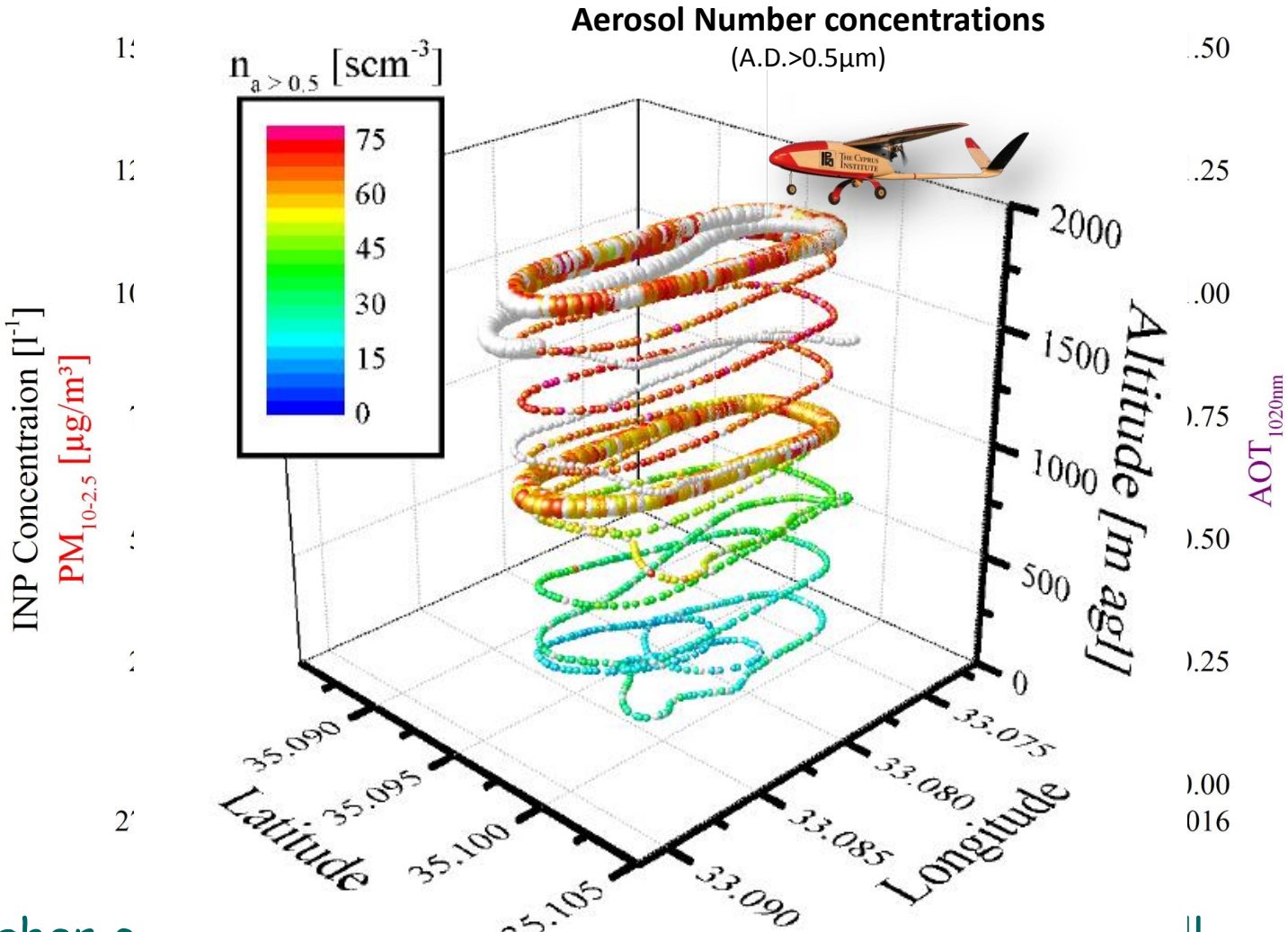
Flights ascend on a spiral path to desired altitude (within or above boundary layer).

Continue to ascend, or descend back to home with similar path.



Ice Nuclei Particle concentration = f(altitude, time)

BACCHUS
Field Campaign
Cyprus, April 2016

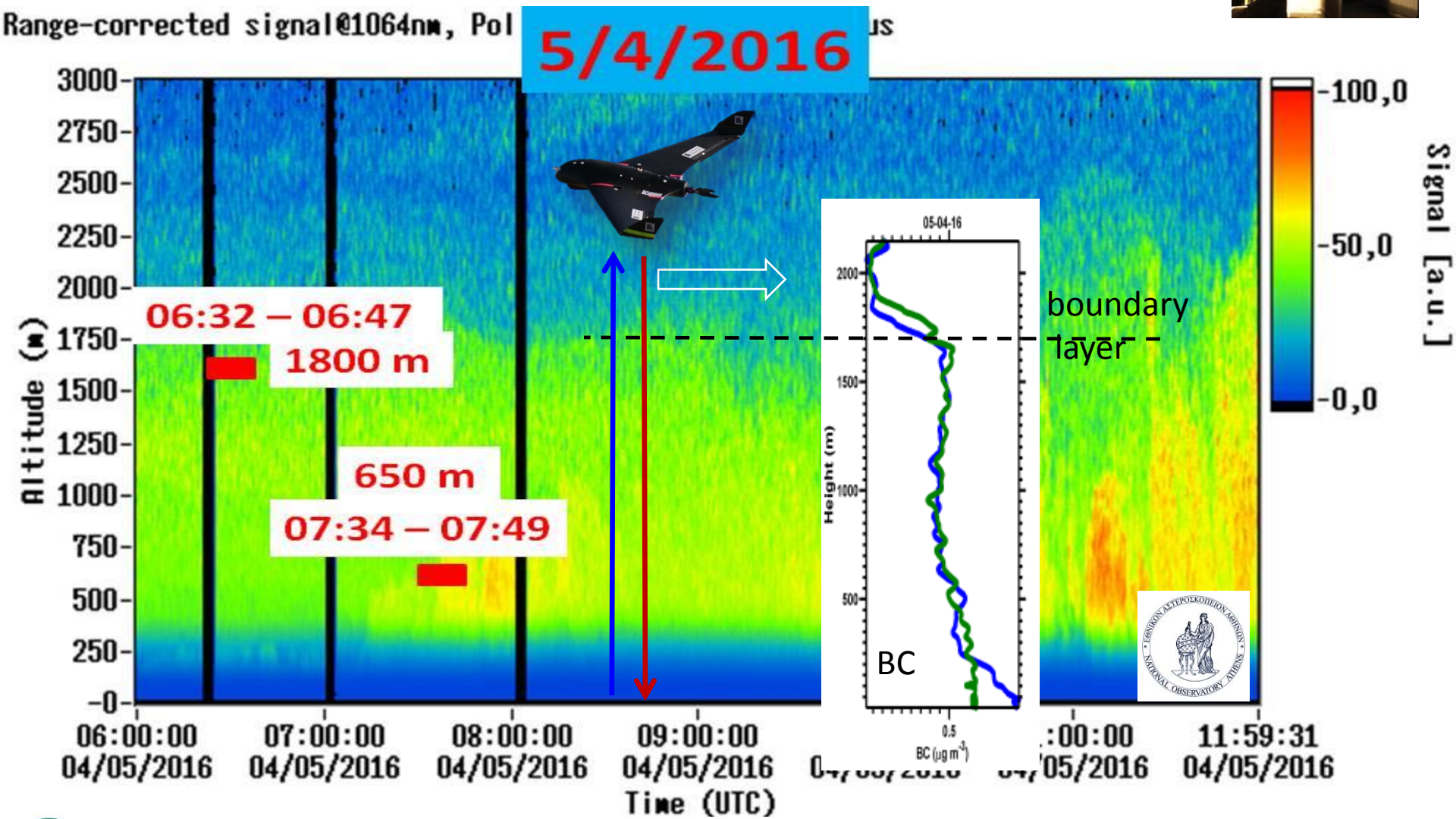


Higher c[illegible] !!

Schrod et al., Atmos. Chem. Phys. 2017

Investigating the atmospheric column:

Synergy between remote sensing (Lidar) and in-situ (UAV)



INUIT – BACCHUS - ACTRIS

Cyprus (April 2016)

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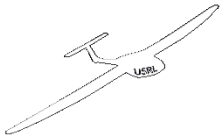
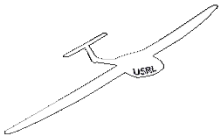


Air Quality & Climate in the Arabian Basin (AQABA) Campaign – June-August 2017

MAX PLANCK INSTITUTE FOR CHEMISTRY

- Multiphase chemical interactions of gaseous and particulate air pollutants with desert dust and sea salt aerosols
- Life cycle of natural and anthropogenic aerosols and oxidants: impacts on air quality, clouds, climate and biogeochemical cycles

Ship measurement campaign around the Arabian Peninsula from Malta to Kuwait (Roundtrip)



Ecole Nationale de l'Aviation Civile

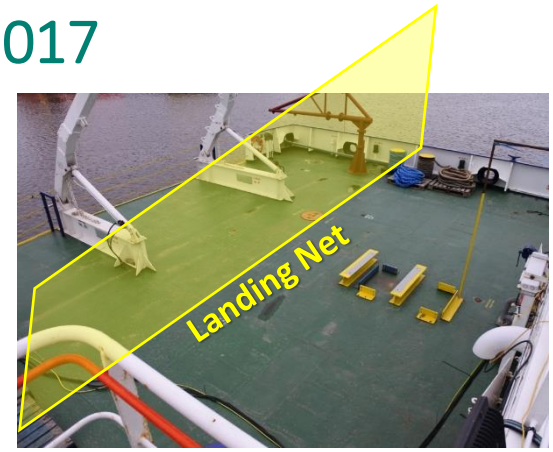
National School of Civil Aviation, Toulouse, France

Experimental Setup

- Ship: Kommandor Iona
- UAS: Skywalker 2015 (USRL-ENAC)
- Aerial Measurements: Optical Particle Counter (OPC), **O_3, NO_2**, Temperature, Relative-Humidity, Pressure

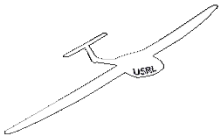
AQABA Flight Plan

Air Quality & Climate in the Arabian Basin (AQABA) Campaign – June-August 2017



Hand-Launch

Net Landing Attempts



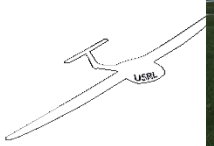
New Tools for Long-term monitoring of the atmospheric composition of the upper troposphere/lower stratosphere

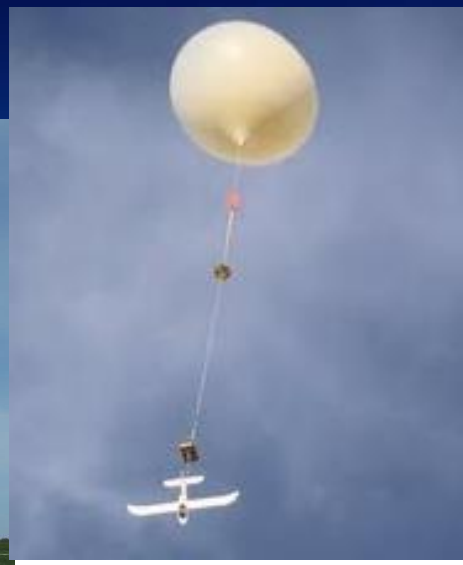
Instrumented auto-homing glider

In collaboration with

EARTH SYSTEM RESEARCH LABORATORY

Serving Society through Science





Thank you !

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