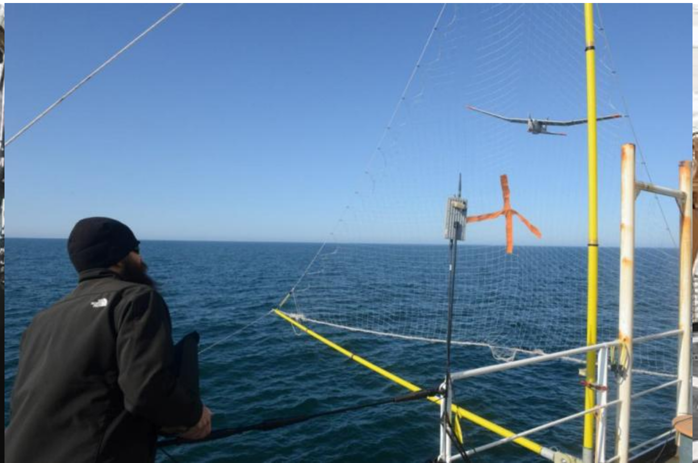
NAVY/NSF-UNOLS SCOAR April 13-15, 2015, U.Miami/RSMAS, Miami, Fl.

US Coast Guard PACAREA Aircraft Ops, 2014-2015

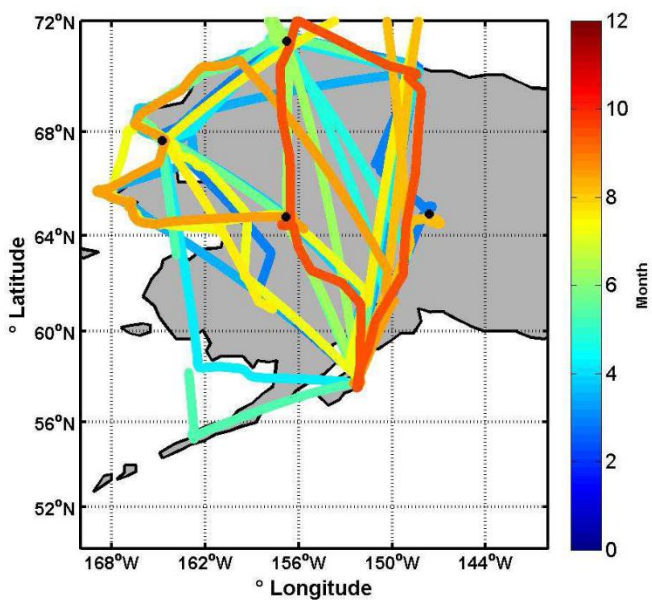
Dr. Phil McGillivary, USCG Science Liaison, email: philip.a.mcgillivary@uscg.mil



2014 CG C130 NOAA Support

Gas Sampling (Colm Sweeney, NOAA/ESRL)

- 2014: 5 monthly flights, 11 days total
- Each Two days over land, and
- Two days over ocean
- CH4, CO2, CO, O3, water vapor, temp
- Joint w NASA & DoE begins June 2015



2014 CG C130 NAVY SIZRS* Support

(PI: Jamie Morison, UW/APL)

[*Seasonal Ice Zone Reconnaissance Surveys]

- Objective: measure inter-annual variability atmospheric forcing of ocean/ice cover
- Improve forecasts of seasonal ice zone variability, especially along shipping routes
- Conduct repeated sections to capture monthly changes using CG Arctic Domain Awareness flights

2014 CG C130 NAVY SIZRS* Support

(PI: Jamie Morison, UW/APL)

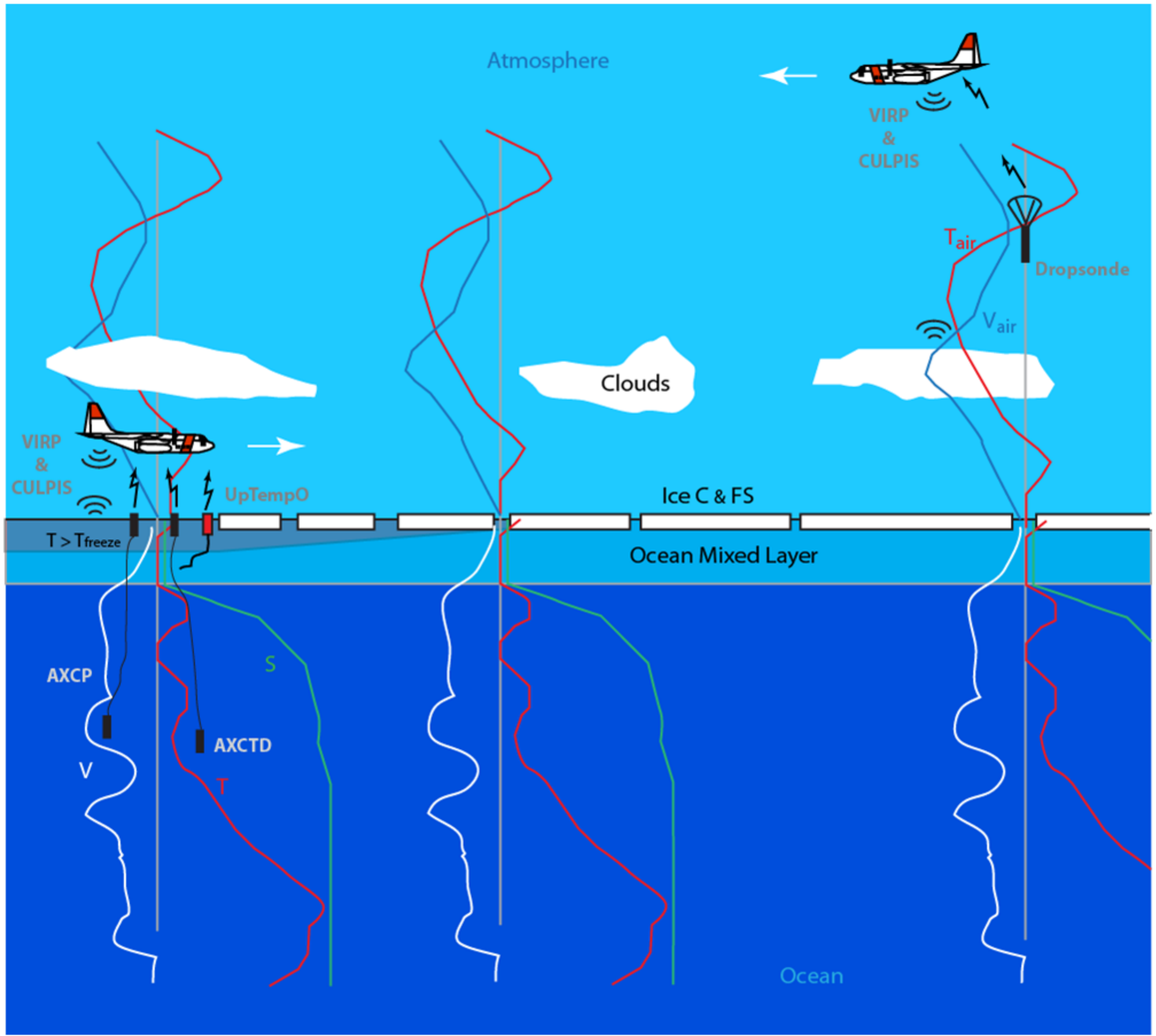
[Seasonal Ice Zone Reconnaissance Surveys]

- Buoy deployments for International Arctic Buoy Program (IABBP);
- Typically 6 stations/flight deploying: Airborne eXpendable Ice Beacons (AXIBs); 1000m Aircraft Expendable Conductivity, Temperature, Depth probes (AXCTDs); and, Aircraft Expendable Current Profilers (AXCPs); and, Dropsondes for atmospheric temperature profiles
- Deploy UpTempO (Upper Ocean Temperature Drifters) to measure time series of upper 60m of water column: 3 deployed in 2014

Fulfilling Coast Guard Arctic Strategy, released May 2013, to:
"Assist government-sponsored scientific exploration to develop a greater understanding of the changing Arctic environment."

2014 CG C130 NAVY SIZRS Support

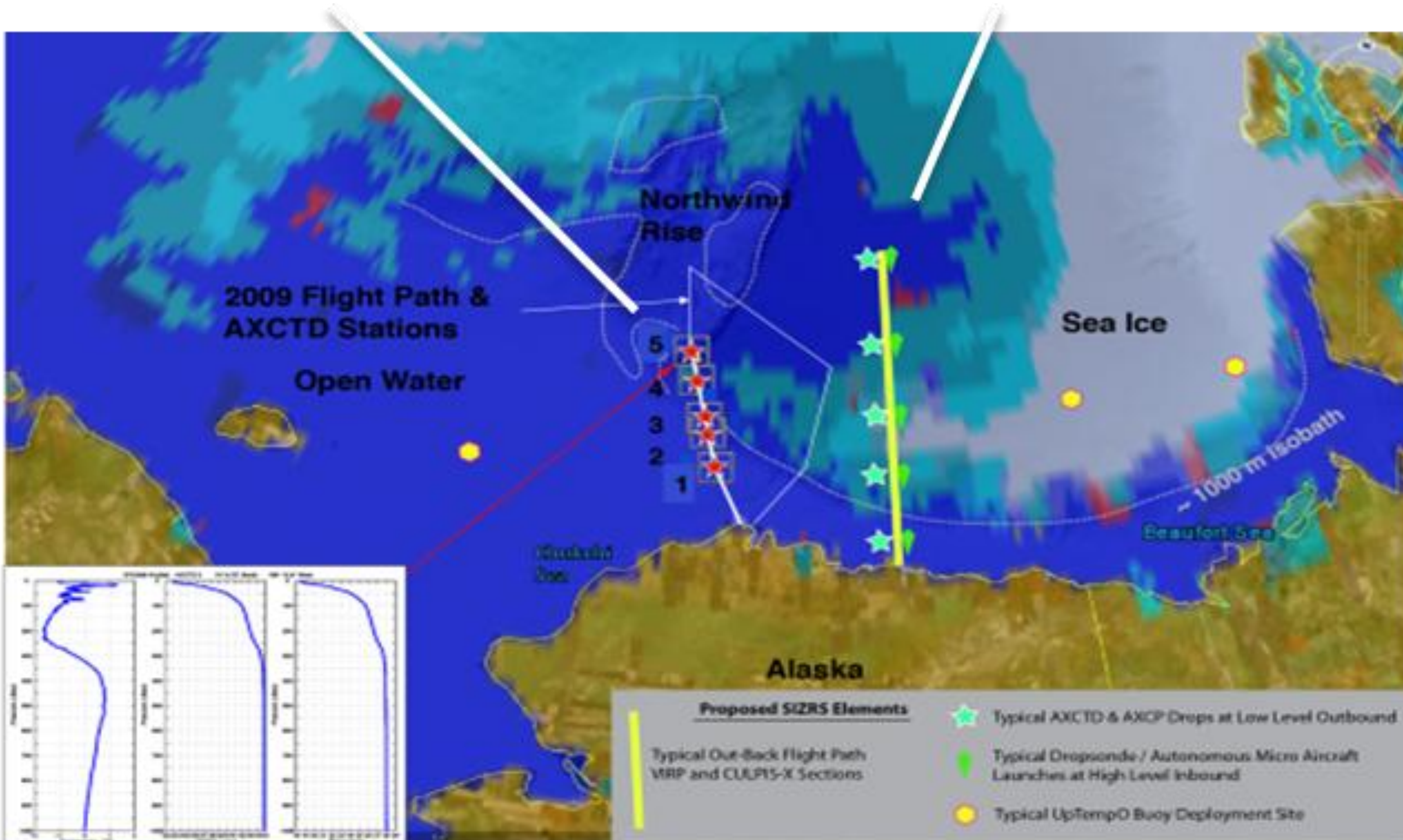
Atmospheric dropsondes, AXCTDs, AXCPs,
UpTempO buoys, IABP buoys, IR video collection



2014 CG C130 NAVY SIZRS* Support

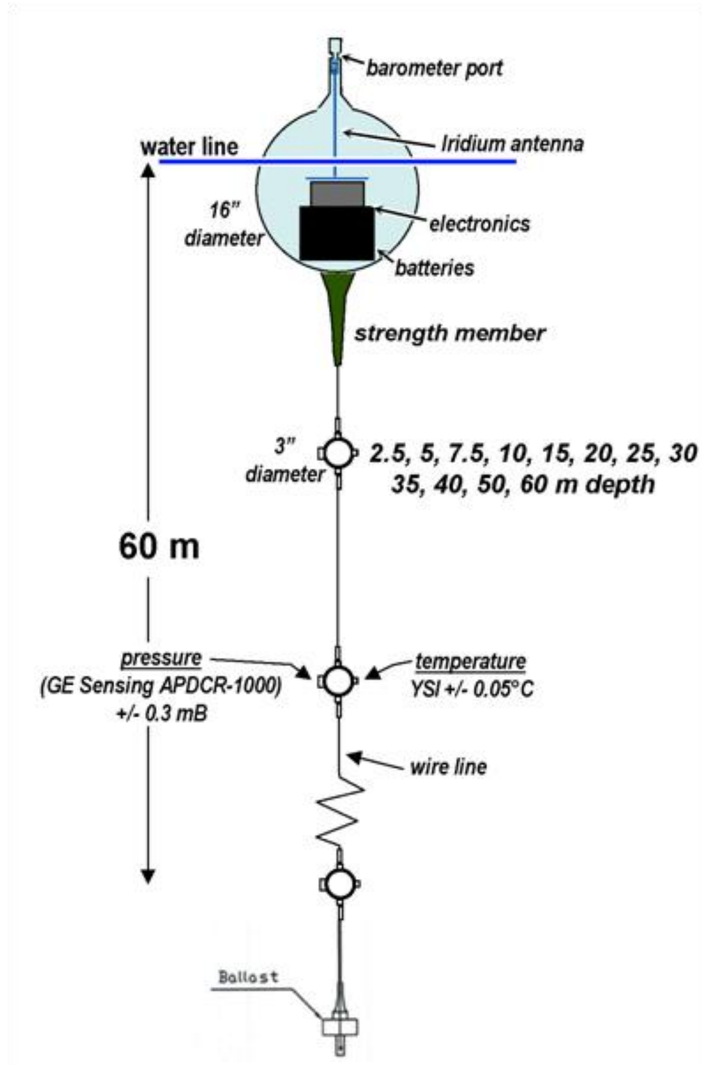
(PI: Jamie Morison, UW/APL)

[Seasonal Ice Zone Reconnaissance Surveys]



2014 CG C130 NAVY SIZRS Support

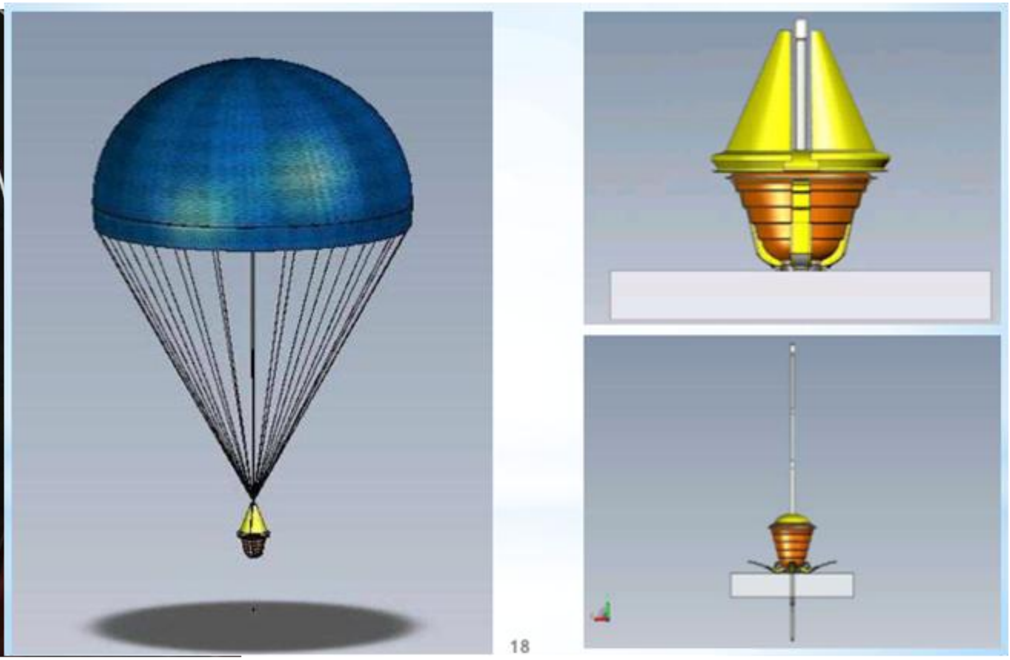
UpTempO Buoy



2014 CG C130 NAVY SIZRS Support

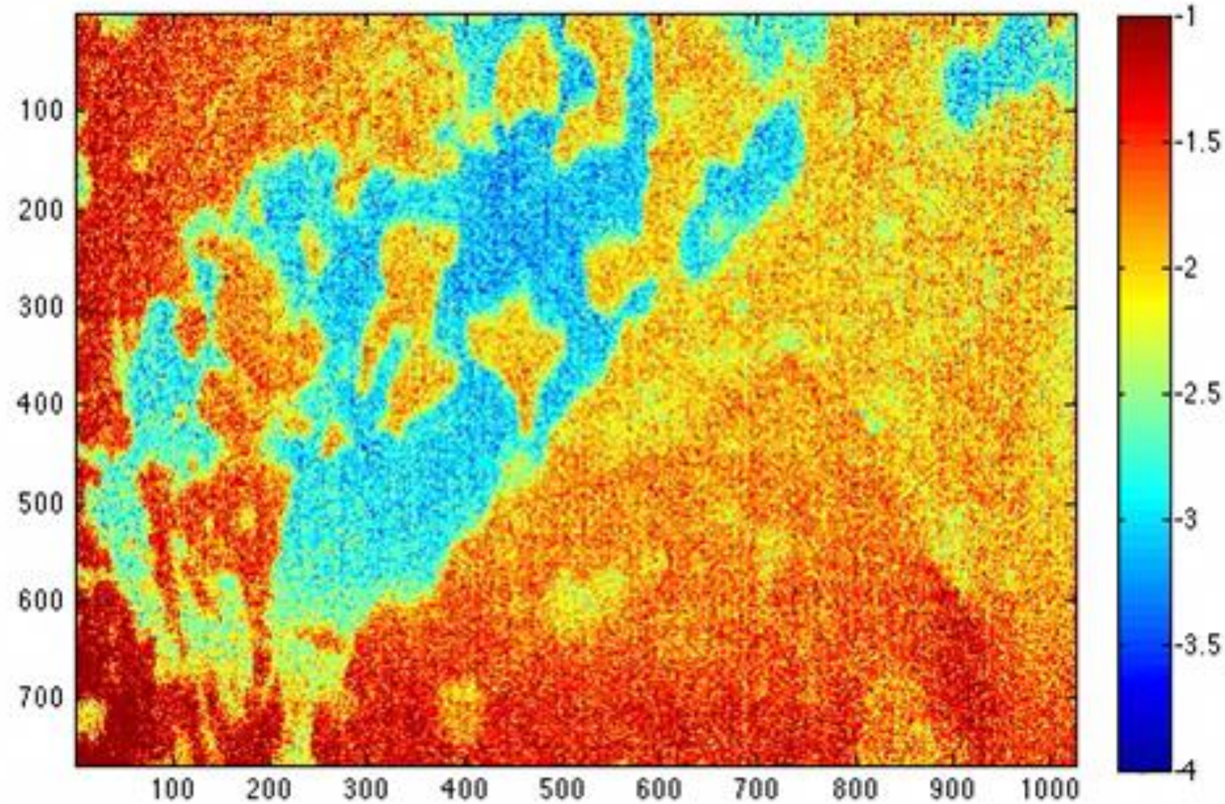
International Arctic Buoy Program (IABP) & self-erecting Aircraft Expendable Ice Buoys (AXIB) deployments

U.Colo. Chickadel/Lindsay IR camera location approved 2014



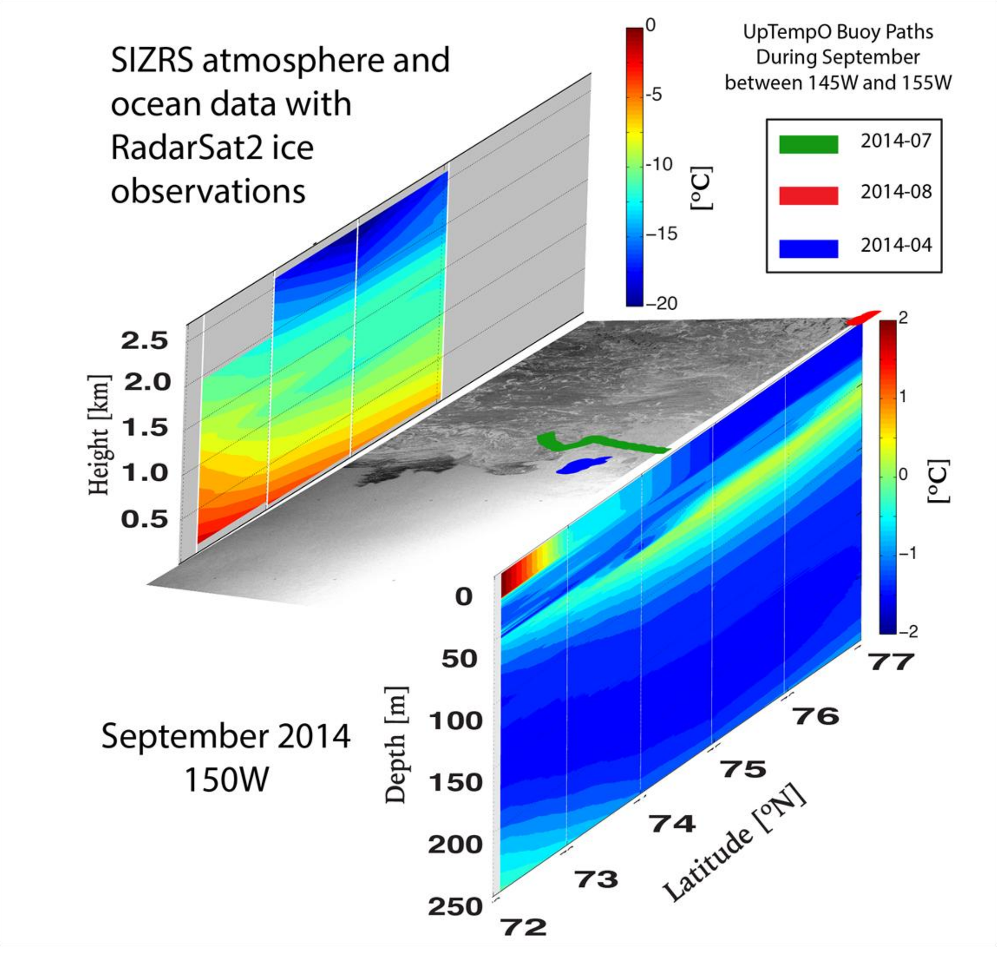
2014 CG C130 NAVY SIZRS Support

IR video camera (still frame image) of SS/Ice Temperature



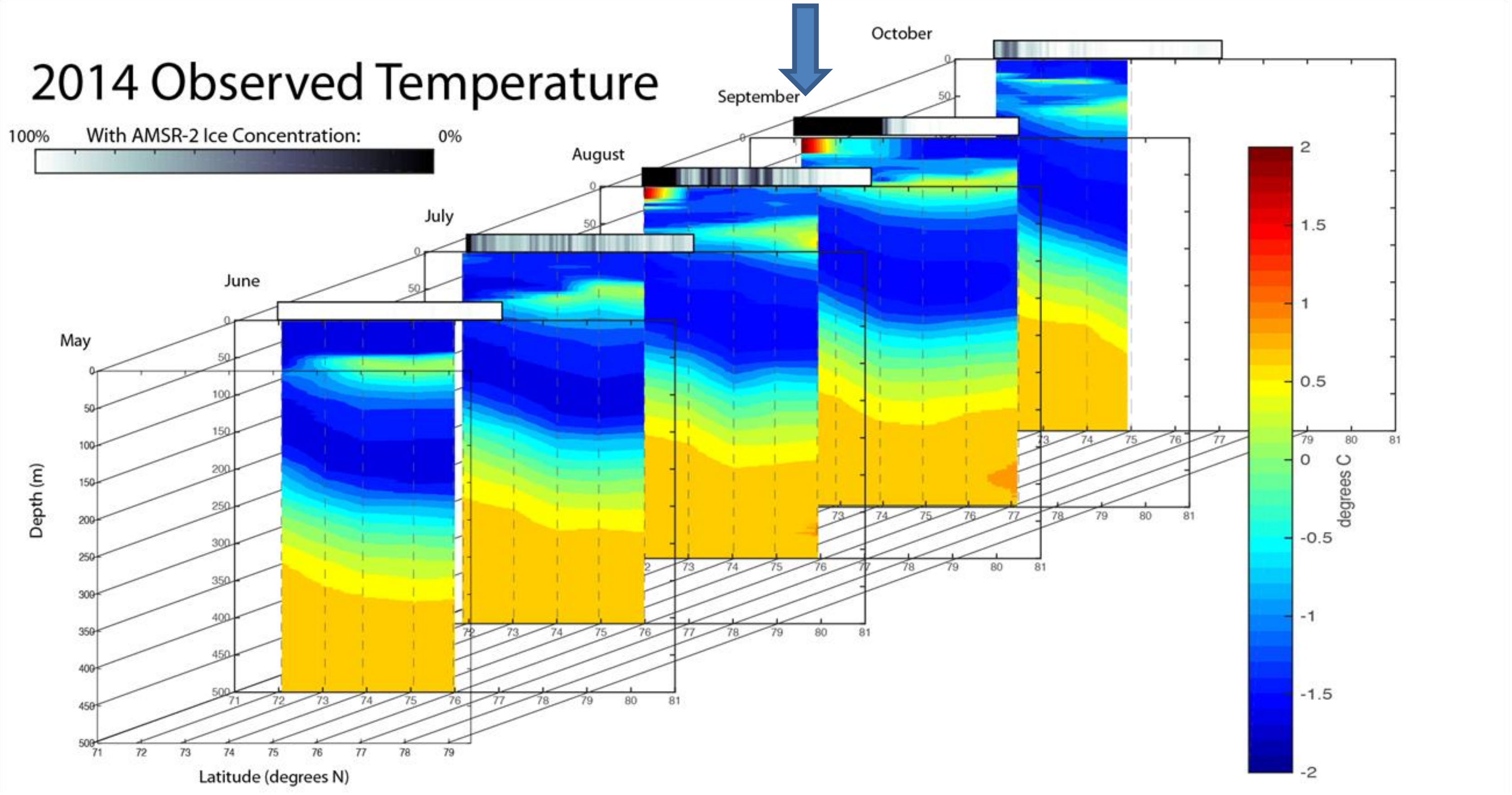
2014 CG C130 NAVY SIZRS Support

Combined Air/Ocean profiling Results, compare w satellite ice data



2014 CG C130 NAVY SIZRS Support

Warming & freshening at melting ice edge as season progresses



2015 CG C130 NAVY SIZRS Support

Experience has reduced fail rates of AXCTD, AXCP deployments to @10% (from @30%)

Future Plans:

Now 3 years of monthly data, ONR funding 4 more years of SIZRS flights, June to October for all instruments

Looking for atmospheric 'SmartSonde' deployment approval & improved IR camera

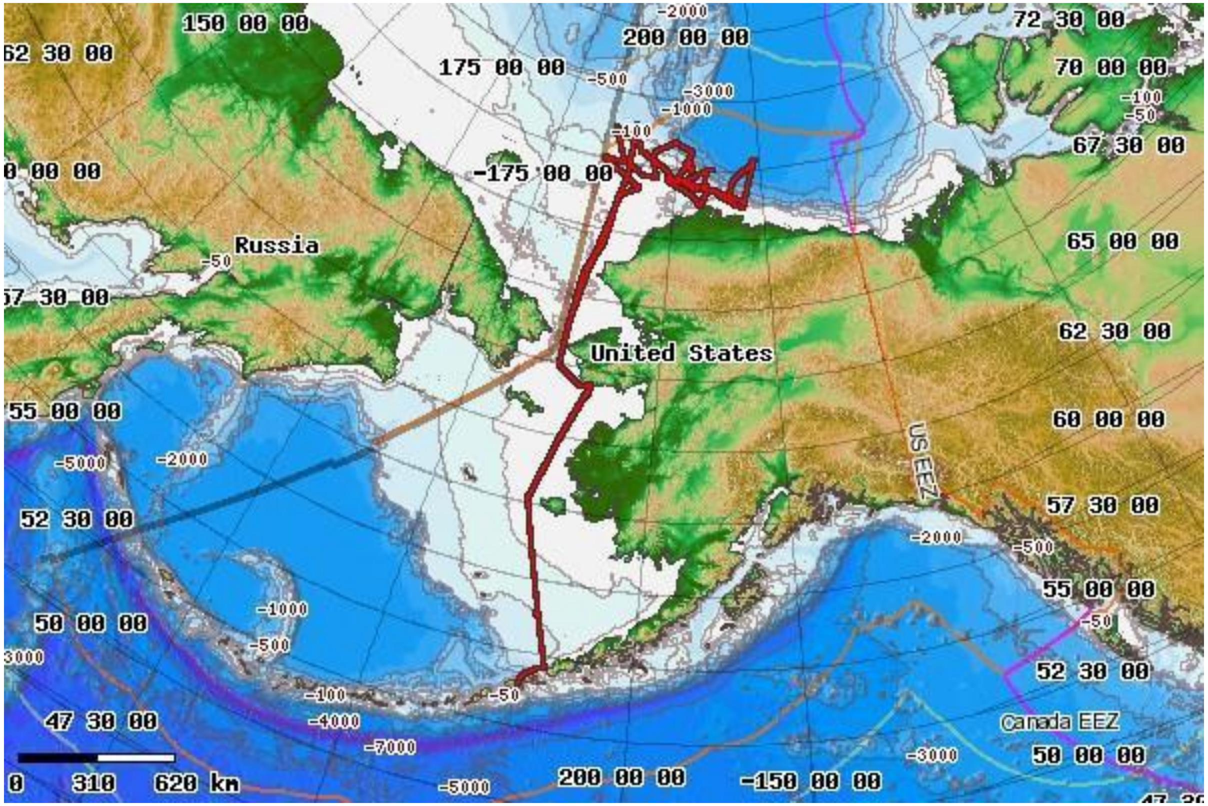
2015 flights: June 9; July 14-17;

Aug 11-13; Sept. 8-11; and, Oct. 6

2015 CG C130 NAVY SIZRS Support

CULPIS-X Lidar in CG C130 FLIR tube…approval pending for external detector (basically telescope) about @4-6” cube. Allows ice ridge detection and mapping by laser. Project started 2010, will finally be approved & operational 2015.

2014 NOAA/CG RDC Oil Spill in Ice Support on HEALY:



2014 NOAA/CG RDC Oil Spill in Ice Support on HEALY:

Aerostat Imaging/Comms to Ship

2014 NOAA/CG RDC Support on HEALY:

Aerostat Comms w WaveRelay wireless on aerostat (2015 also onPUMA UAS)

Range to @27mi at 500’, @25Mbs (4 video streams), weight 1.1lb w/o batteries (ie integrated w UAS battery); 2lbs w batteries

Wave Relay® is a Mobile Ad Hoc Networking System (MANET) designed to maintain connectivity on the move. It is a scalable, peer-to-peer network which provides data, video, and voice even in the most challenging applications. With user throughput of 41 Mbps UDP and 31.1 Mbps TCP, Wave Relay® provides a dynamic, reliable, and secure wireless networking solution beyond mesh.

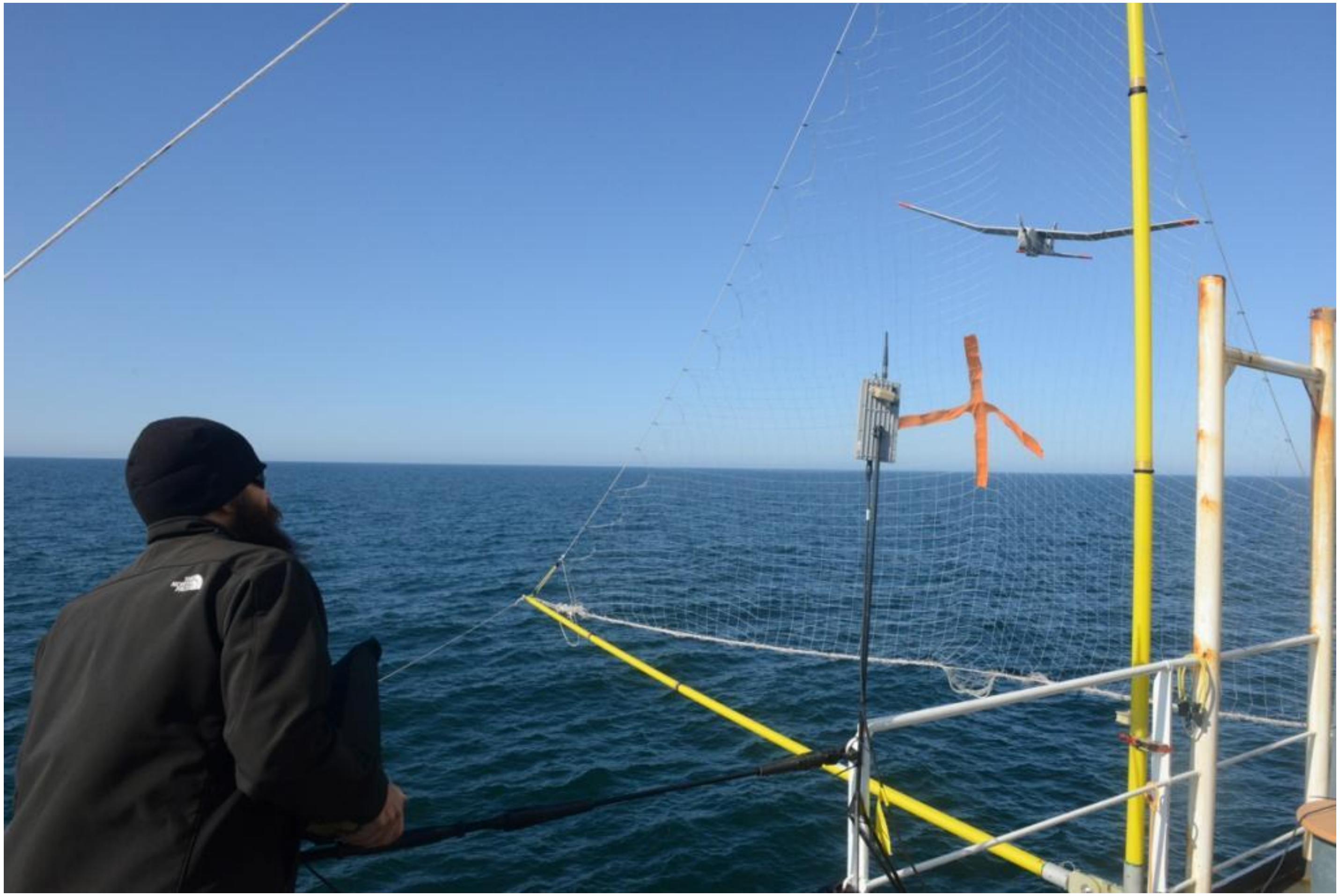
THE MPU4 BRINGS THE WAVE RELAY® MOBILE AD HOC NETWORK (MANET) CAPABILITY DIRECTLY TO THE DISMOUNTED USER.

Seamless Layer-2 Ethernet connectivity facilitates plug-and-play operation of cameras, video encoders, IP sensors, and other devices. In addition, the MPU4 is the smallest, lightest and most portable wireless MANET solution from the Wave Relay® product family. The MPU4 is compatible with 3-pin twist lock batteries providing up to 14 hours of run-time. The MPU4 connects to Android™ phones and tablets through a high speed secure cable which also powers the device from the standardized battery.

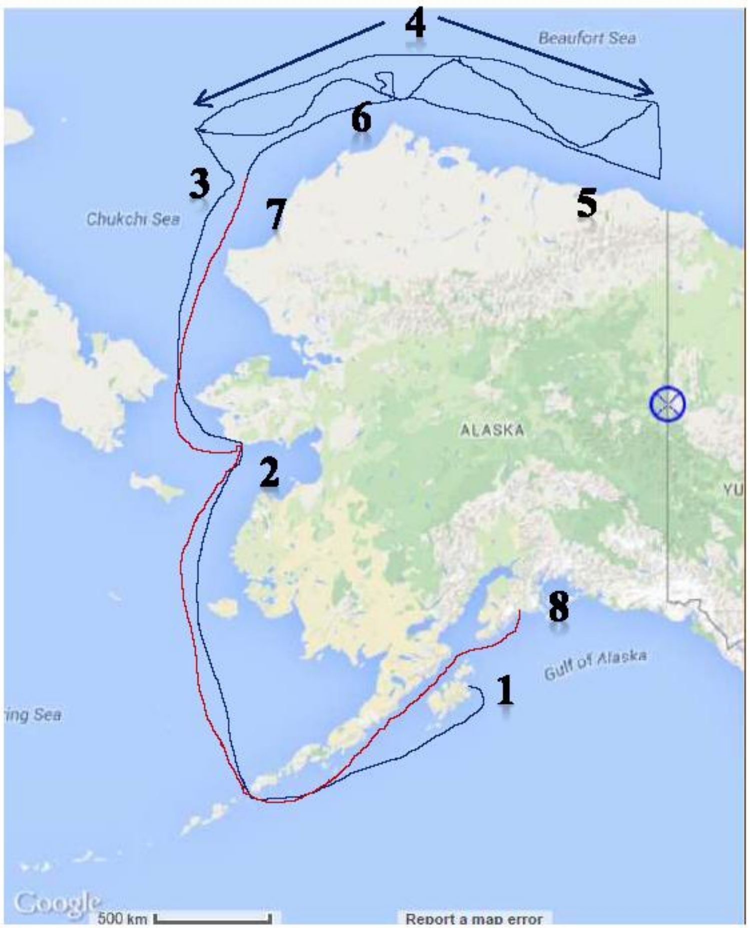
- Peer-to-Peer Mobile Ad Hoc Network (MANET)
- Secure High Bandwidth Data
- Transfers Data, Video, & Voice
- Multiple Video Streams
- Real-time Position Location
- Push To Talk (PTT) Voice
- 27Mbps Multicast Throughput
- Cloud Relay™ Compatible

2014 NOAA/CG RDC Support on HEALY:

PUMA manual net recovery; will test automated recovery in 2015



HEALY 2015 CG RDC Ops, July 3-26



[Not yet final]

1. Depart Kodiak 3 July
2. Personnel on-load in Nome on 7 July
3. NOAA ops off Fairbanks
4. Cruise EEZ
   a) Comms checks throughout
   b) Unmanned vehicle launches as we go.
5. Possible Pitch and catch of Scan Eagle UAS near Prudhoe Bay
6. Buoy ops north of Barrow
7. Cruise for Nome personnel off-load 21 July
8. Equipment and personnel off-load in Seward 26 July

HEALY 2015 CG RDC Shipboard UAS Ops

RDC Arctic Operations Support(FY14)

Key Points

A Collection of Technology Evaluations

Provide direct support to four different RDC projects:

- Arctic Craft Improvements
- Communication testing
- Next Generation Navigation Safety
- Oil Spill Tracking

Independent technologies evaluations:

- Unmanned systems testing
- Ice radar performance
- ERMA

HEALY 2015 CG RDC Shipboard UAS Ops

Objectives (New Data packages)

- Stream near real time full motion video between two Pumas and Puma and Aerostat to demonstrate increased range
- Integrate WaveRelay high bandwidth comms onto PUMA
- Launch and recover with High res camera system onboard

Objectives (Other)

- Demonstrate automated net landings
- Compare UAS's visual verses IR capability to identify ice verse open water leads
- Develop IFC for low visibility & high wind flights
- Coat PUMA and test carbon nanotube anti-icing coating
- Improve manned aircraft de-confliction protocols (and standardize)

HEALY 2015 CG RDC Shipboard UAS Ops

2015: Successful Development & Testing of Carbon Nano-tube Anti-icing Coating for UAS

- Work by Kim Sorensen, PhD Student of Tor-Arne Johansen, NTNU
- Collaborative work and testing at NASA Ames under Matt Fladeland
- Talk & Publication: IEEE Aerospace2015 Conf., March 7-14, Big Sky, Montana
- Field Testing, March 30-April 3, Anchorage, Alaska
- Further field testing aboard CGC HEALY, summer 2015
- Additional Anchorage field testing, Oct. 2015

Carbon Nanomaterial-Based Wing Temperature Control System for In Flight Anti-Icing and De-Icing of Unmanned Aerial Vehicles

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Tor Arne Johansen, Norwegian University of Science and Technology
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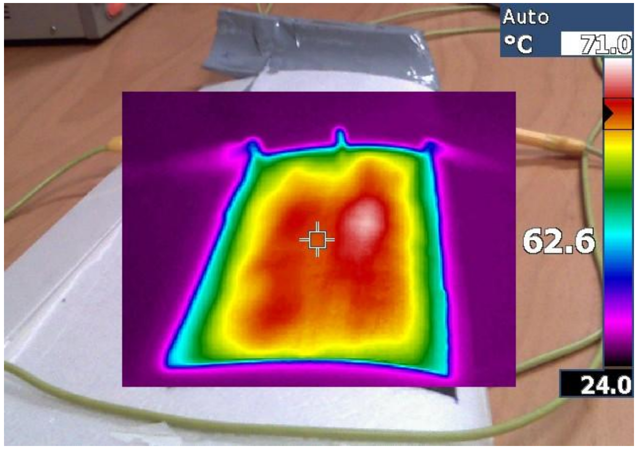
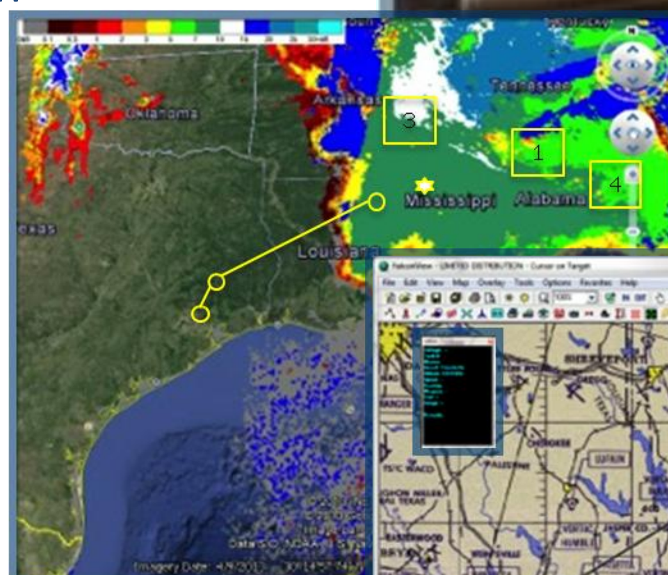


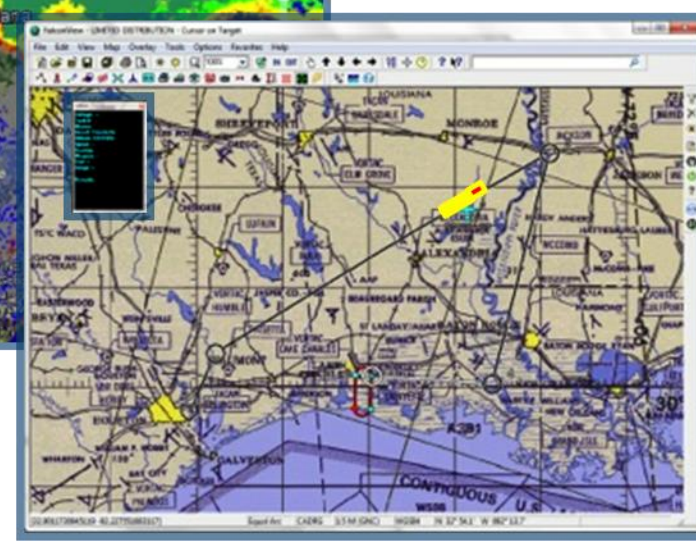
HEALY 2015 CG RDC Shipboard UAS Ops

PEMDAS ASAP Ice Warning/Detection System for UAS

www.pemdastechnologies.com

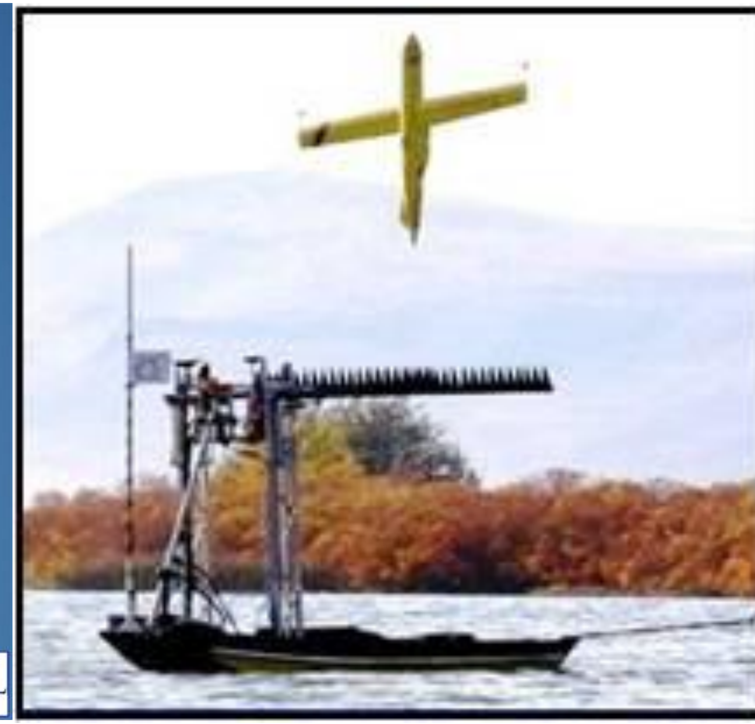
- Make Atmospheric Sensing & Prediction System (ASAP) which monitors conditions for icing, and provides alerts in real-time with Warning 9 min in advance, and Alert 1 min in advance
- System weighs <1 lb; intended for use on small UAS, including PUMA
- NOAA hopes to test from PUMAs summer 2015 off HEALY; fits in front of aircraft





HEALY 2015 CG RDC Shipboard UAS Ops

CG R&D Center will test fly the Aerovel FlexRotor UAS



HEALY 2015 CG RDC Shipboard UAS Ops

Automatic Notification System Testing

Current ship UAS ops along North Slope of Alaska include de-confliction of NOAA Marine Mammal observation flights requiring use of phone calls to numbers on a 'phone tree' prior to each flight.

We will try to simplify and standardize routine UAS flight notifications by testing use of automated electronic notifications possible through mutual use of NASA freely available [UAS] Mission Tools Suite software that allows UAS position displays on Google Earth maps in real time.

HEALY 2015 CG RDC Shore-based UAS/Aircraft Ops

w Conoco-Phillips & InSitu Scan Eagles (via CRADA)

Objectives

- Produce digital elevation maps of ice ridges
- Demonstrate Oil Platform Surveillance capability
- Relay FMV sensor data beyond line of sight
- Shore-to-Ship Hand-off UAS control of operation
- Will include interaction w D17 & ERA helicopters

Location Requirements

- DeadHorse, AK
- Chukchi Sea (Land-based launch and recovery)

(Possible/ Not Confirmed)

HEALY 2015 CG RDC Ops, July 3-26

Overview for FY 15

Equipment on-load :
- Seattle on June 19
- Kodiak on July 2

Equipment off- load:
- Seward on July 26
- Seattle in October

Personnel on-load location:
- Kodiak July 2
- Nome July 7

Personnel off-load
- Nome July 21
- Seward July 26

Total as of March 4th 40 personnel & 10 Technologies onboard

RDC Staff -	7
UAS support staff -	13
DHS Intern	1
High School Interns	2
Cadets	6
Wave Glider staff	3
University of Alaska	3
ROV-CG dive locker	2
D-17 PA	1
NOAA rider	1
CG HQ Rider	1

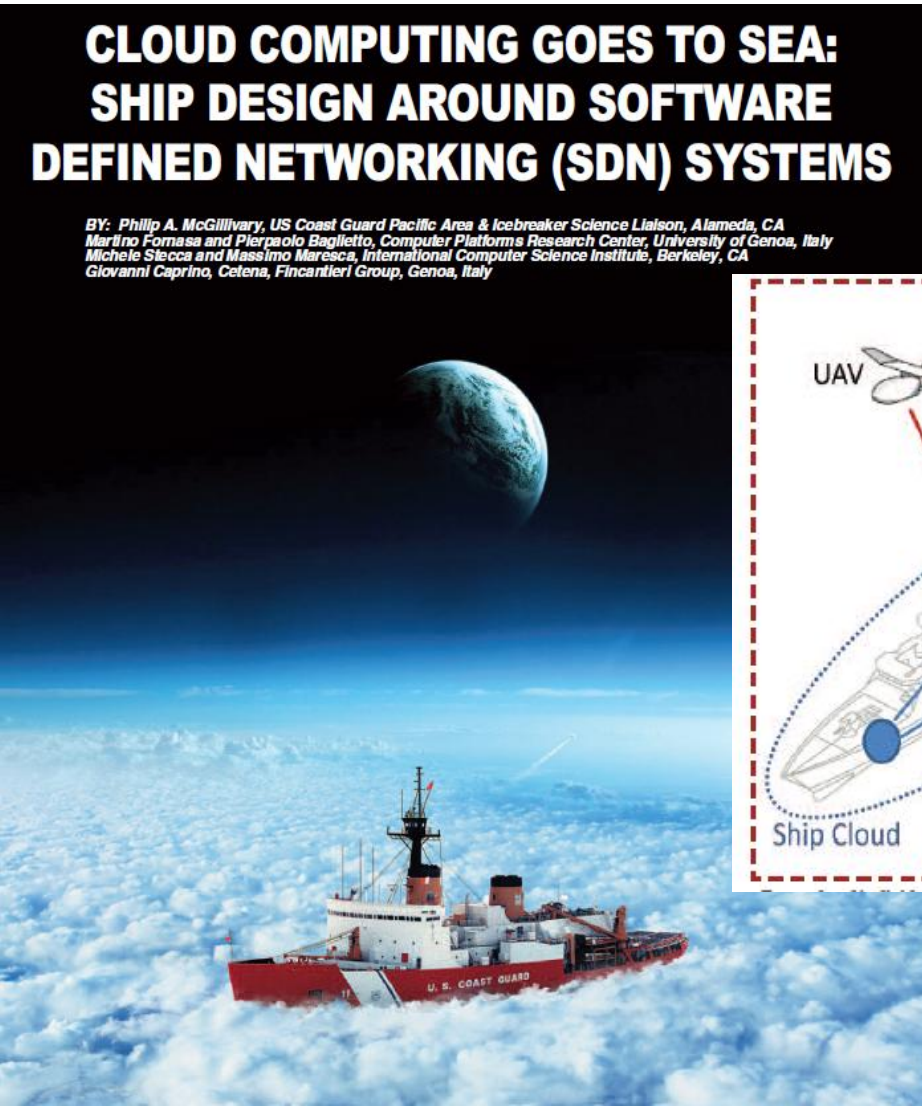
Puma UAS	3
ROV	1
Wave Glide	3
NOAA Buoys	?
Scan Eagle Controller	1 *
Flex Rotor	1 *
Isotope Detector	1
Buoy Refurb Gear	1
C-worker	1 *
UHAC	1 *

* - Tentative

CG PACAREA UAS Tech Development

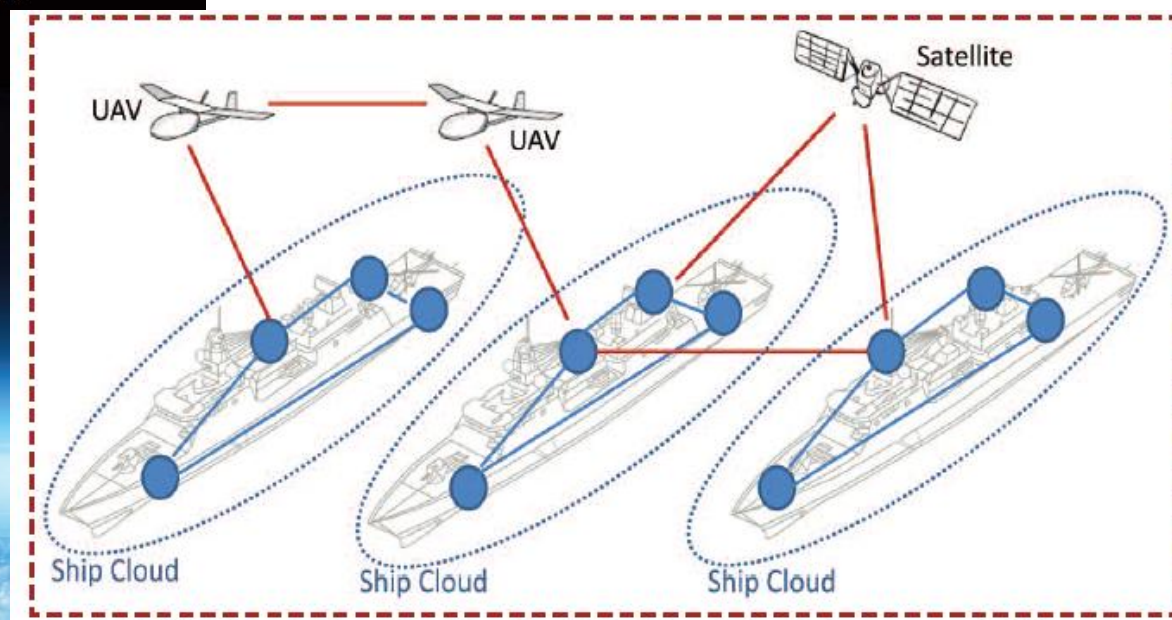
Ocean News & Technology, Sept. 2014

McGillivary, et al., p.30-32.


CLOUD COMPUTING GOES TO SEA: SHIP DESIGN AROUND SOFTWARE DEFINED NETWORKING (SDN) SYSTEMS

BY: Philip A. McGillivary, US Coast Guard Pacific Area & Icebreaker Science Liaison, Alameda, CA
Martino Fornasa and Pierpaolo Baglietto, Computer Platforms Research Center, University of Genoa, Italy
Michele Stecca and Massimo Maresca, International Computer Science Institute, Berkeley, CA
Giovanni Caprino, Cetena, Fincantieri Group, Genoa, Italy

Cloud computers on ships can integrate data from multiple UAS.



CG PACAREA UAS Tech Development

Cloud Computers on ships:

Nebula Cloud Computing System installed on RV FALKOR Nov. 2014, operational Jan. 2015. Multiple UAS ops summer 2016.

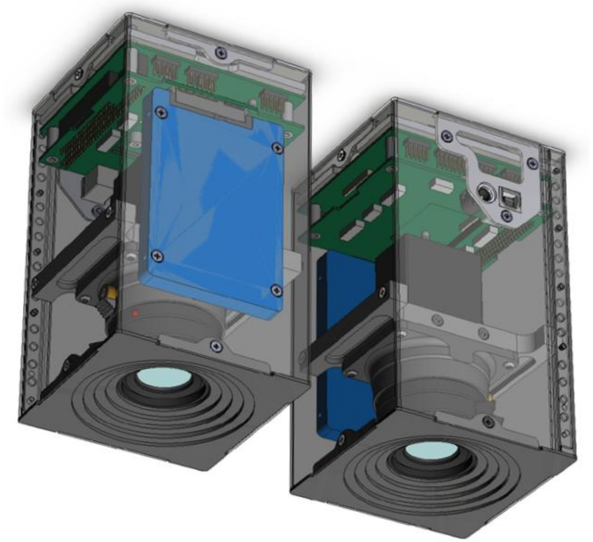
First ever ship install of cloud computer.

This is the start of a new capability for management of concurrent multiple UAS from ships, with real-time data fusion.

CG PACAREA UAS Tech Development

Continued UAS Fluid Lensing work with application for SAR & Whale observations, Ved Chirayath, Stanford University & NASA Ames

- NASA Earth Science Technology Office stereo cameras on UAS can provide high resolution imagery for application of Fluid Lensing software.
- NASA software allows automated recognition of whales in video image streams.
- UAS so equipped can then use Fluid Lensing methods to very accurately measure dimensions of whales sited, which is particularly useful to gauge health of young whales.



CG PACAREA UAS Tech Development

Working with Schmidt Ocean Institute to evaluate use of the Arca Aerospace Explorer High Altitude Long Endurance UAS designed as a communications node for broadband comms in remote regions.

See: http://www.airstrato.com/en/explorer.html

Such systems can potentially deliver high bandwidth data comms at costs significantly less than existing satellites.

CG PACAREA UAS Tech Development

UAS Fish Tracking Technology

Continuing collaboration with U. Porto for UAS use for fish tracking; beginning collaboration with US researchers with similar interests.

This tracking is done automatically by the UAS using recognition software, and operates without human interaction, while however allowing human control.

See U. Porto Dec. 2014 AGU poster showing shark and mola mola (sunfish) tracking in next slide.

Building oceanographic and atmospheric observation networks by composition: unmanned vehicles, communication networks, and planning and execution control frameworks

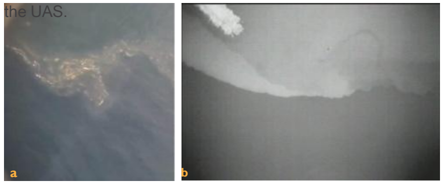
lsts.pt

João Sousa, Filipe Ferreira, Maria Costa, Marina Oliveira

Final Paper Number:
OS41A-1181

Observing coastal fronts with UAS [1]

In 2013, experiments were conducted in coastal waters of Sesimbra (Portugal), where riverine fronts were detected with a UAS equipped with an Infra-Red (IR) camera. The fronts had a steep thermal gradient, which was detected by the UAS.

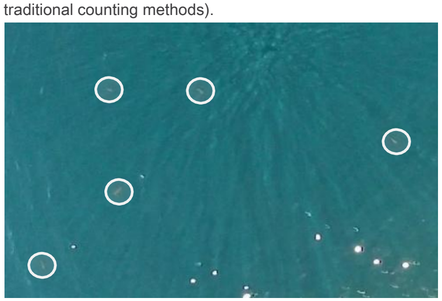


a Aerial imagery extracted from real time video feed of a riverine front.
b IR picture of coastal front taken onboard of a UAS.

UAS tracking hammerhead sharks [2]

Mission ***SharkFly*** took place in August 2013 on the island of Faial, on the Portuguese archipelago of the Azores. The main aim was to demonstrate the use of low cost UAS to monitor aggregations of large pelagic predators such as sharks.

This method to detect hammerhead sharks enabled unprecedented accuracy that led to higher counts (w.r.t. traditional counting methods).



Hammerhead sharks (highlighted) found with on-board video camera.

Designing, Building And Operating Unmanned Underwater, Surface And Air Vehicles

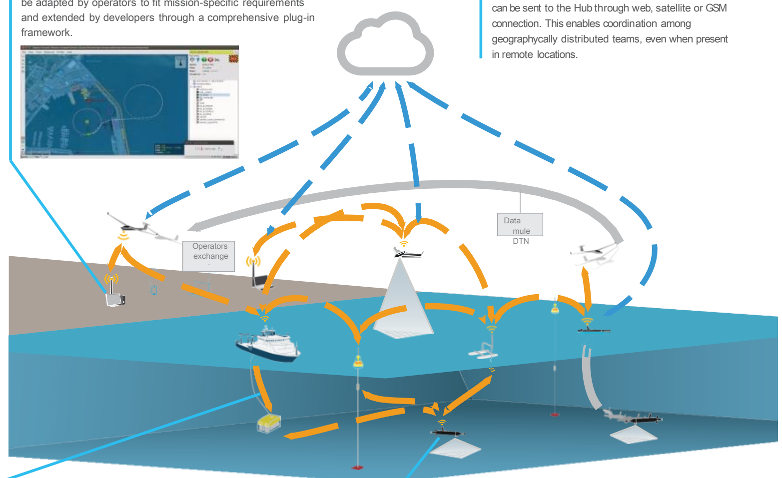
Tools And Technologies For The Deployment Of Networked Vehicle Systems

Neptus *(Off Board)*

Distributed Command and Control Infrastructure for the operation of all types of unmanned vehicles. Neptus supports the different phases of a typical mission life cycle: planning, simulation, execution and post-mission analysis. Neptus can be adapted by operators to fit mission-specific requirements and extended by developers through a comprehensive plug-in framework.

HUB

Webservice in charge of centralizing data. It gathers different types of information (oceanographic conditions, vehicle positions, etc) and makes it available through a Web API or Iridium messages. Data can be sent to the Hub through web, satellite or GSM connection. This enables coordination among geographically distributed teams, even when present in remote locations.



IMC *(Communtication Protocol)*

Defines a common control message set understood by all types of vehicles and computers nodes in networked environments.

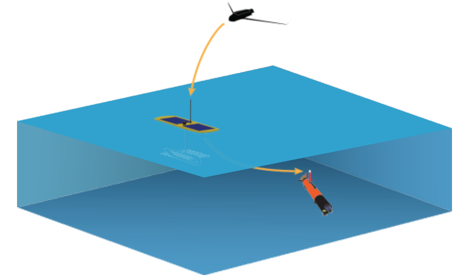
DUNE *(On Board)*

Embedded software at the heart of the vehicle: modules for control, navigation, simulation, networking, sensing, and actuation.

OS and CPU architecture independent.

UAS commanding UUV

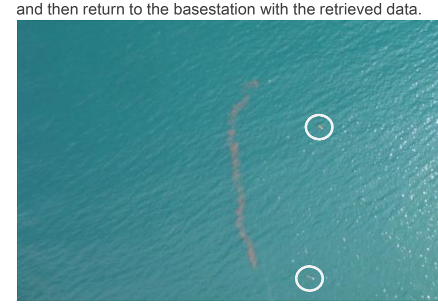
In July 2014, offshore near Sesimbra (Portugal), a UAS was used to command a submerged UUV. In this experiment, a USV was used as a communication gateway between the UAS and the UUV and the commands to the UUV were sent from the basestation to the UAS.



Vehicles used in the experiment described above.

UAS as communication relay

In September 2014, trials involving UUV and UAS working together were carried out in Marjan peninsula, Split (Croatia). The UAS mission required the UAS to fly from shore to the trial location, gather information from the UUV and then return to the basestation with the retrieved data.



Aerial picture taken from UAS while syncing data from the different UUVs.

References

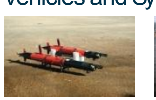
[1] M. Faria, J. Pinto F. Py, J. Fortuna, H. Dias, R. Martins, F. Leira, T. A. Johansen, J. Sousa, K. Rajan, "**Coordinating UAVs and AUVs for Oceanographic Field Experiments: Challenges and Lessons Learned**". IEEE Int. Conf. Robotics and Automation, Hong Kong, 2014.

[2] J. Fortuna, F. Ferreira, R. Gomes, S. Ferreira, J. Borges de Sousa, "**Using low cost open source UAVs for marine wild life monitoring - Field Report**", 2nd RED-UAS 2013 Workshop on Research, Education and Development of Unmanned Aerial Systems, Compiegne, France, Nov 20-22, 2013.

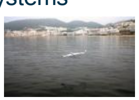
Toolchain User Community:

Portugal, Spain, France, Norway, Greece, Croatia, USA, Netherlands, Sweden, Italy, Germany, Russia, India

Vehicles and Systems



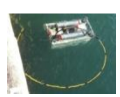
Light AUV
Light Autonomous Underwater Vehicle



UAS X8
Unmanned Aircraft System

Wavy Drifter
Drifter Buoy

Manta Gateway
Communications Gateway



ROV Adamator
Remotely Operated Vehicle

ASV Swordfish
Autonomous Surface Vehicle

U.PORTO
FEUP FACULDADE DE ENGENHARIA UNIVERSIDADE DO PORTO

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Voip: +351 22 041 32 23
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lsts.pt

CG PACAREA UAS Tech Development
UAS for Polar Meteorological Measurements

Polar meteorological forecasting suffers from a lack of data in athe Arctic & Southern Oceans.

One way to improve polar met data collection is through use of UAS. This is a focus of ISARRA, the Intl. Soc. for Atmos. Res. using Remotely Piloted Aircraft (http://www.isarra.org)

PACAREA is working with ONR-G, NOAA & Dr. John Selker of OSU (funded by NSF) to field use of UAS with suspended fiber optic cables in the polar regions to provide near-ocean surface meteorological profiles to improve polar forecast models.

See: http://www.auvsi.org/blogs/auvsi-news/2015/04/06/oregonatmos

CG PACAREA UAS Tech Development

CG-NAVY Operation Coastal Trident

(Port Hueneme, June 8-19, 2015)

Use of WAM-V ASV w FAA-approved InstantEye UAS

(UH, Ted Ralston) (also WaveGlider)

Objectives:

1 – Develop technologies for federal, state and local maritime awareness & emergency response

2 - Test new sensors, data links

3 - Test decision support software (including imagery integration)

4 – Test new ship firefighting capabilities

CG PACAREA UAS Tech Development

CG-UH UAS SAR Coordination

Charleston (SC) Race Week, April 16-19, 10am-4pm

Use of InstantEye UAS (Ted Ralston, UH) for sailboat man-overboard tracking jointly w CG & tracking/cueing w CG SAR helos

CG PACAREA UAS Tech Development UAS for Emergency Response

- **Inter-agency Conference, NASA Ames, Nov. 14, 2014: "Recent UAS Developments and Concepts for Operation"**
- Included UAS presentations by: NASA, NOAA, USCG, NAVSEA, Cal Fire, USGS, USDA, DHS, Marine Corps
- Included Concept of Operations for not only single, but also multiple UAS in emergency scenarios, and data-sharing protocols

CG PACAREA UAS Tech Development

New UAS products of note: 3D cameras

360Fly camera, 4.2oz, $450 see: http://eyesee360.com/

V.360 HD camera, @6x10cm; 8.1 oz; waterproof, <$500, see: http://www.vsnmobil.com/products/v360

CG PACAREA UAS Tech Development
New UAS products of note

Peregrine 3D Flash Lidar Camera, < 1 lb., for UAS, see:

http://www.advancedscientificconcepts.com/products/peregrine.html

Headwall Photonics, <1.5 lbs. NanoHyperspec UAS camera

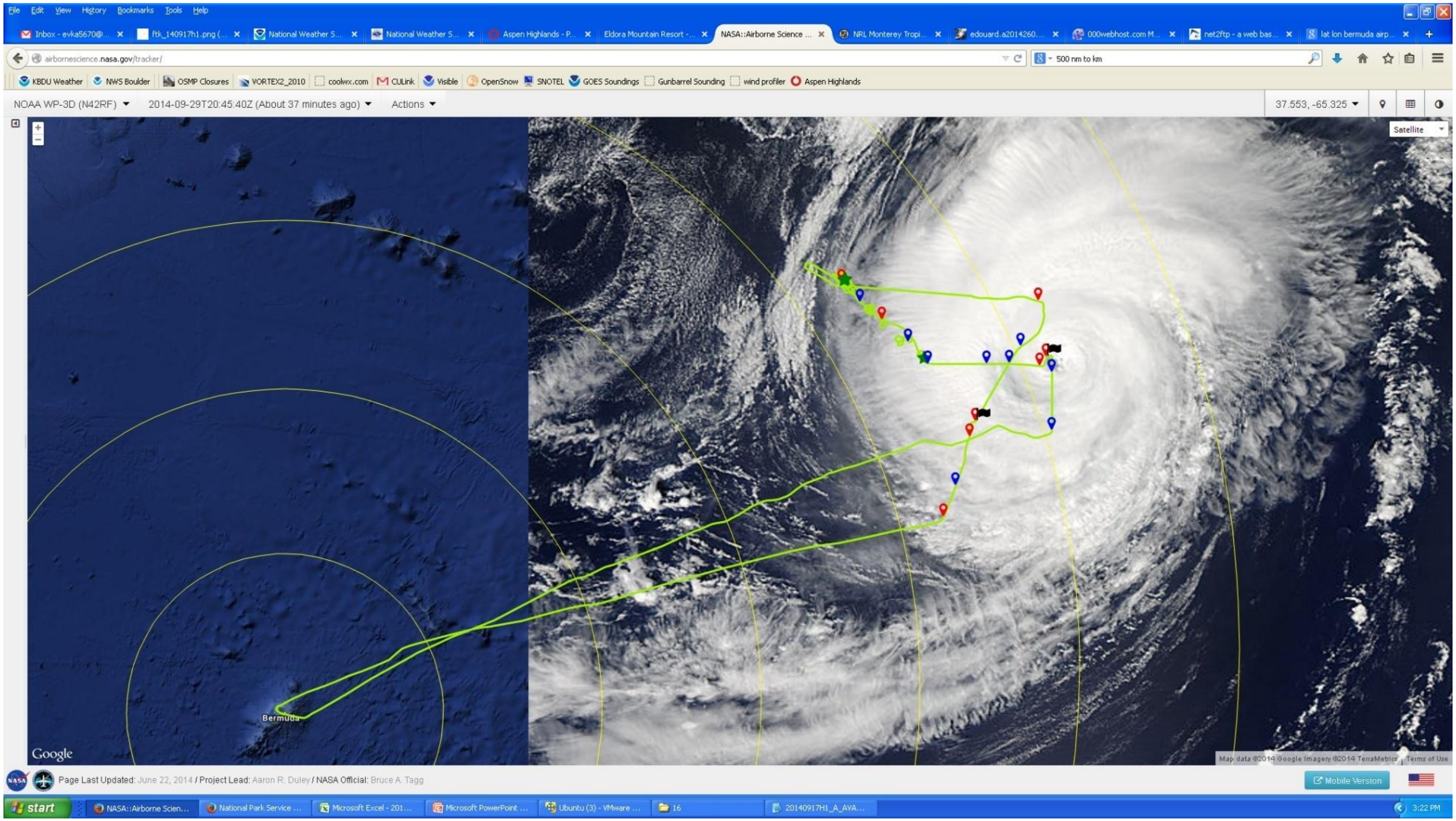
http://www.headwallphotonics.com/spectral-imaging/hyperspectral/nano-hyperspec/

NOAA AOML WP-3D Orion w Coyote UAS

Deployment in Hurricane Edouard Sept., 2014 (Joe Cione, HRD)

NOAA AOML WP-3D Orion w Coyote UAS

Deployment in Hurricane Edouard, Sept. 2014 (Joe Cione, HRD)



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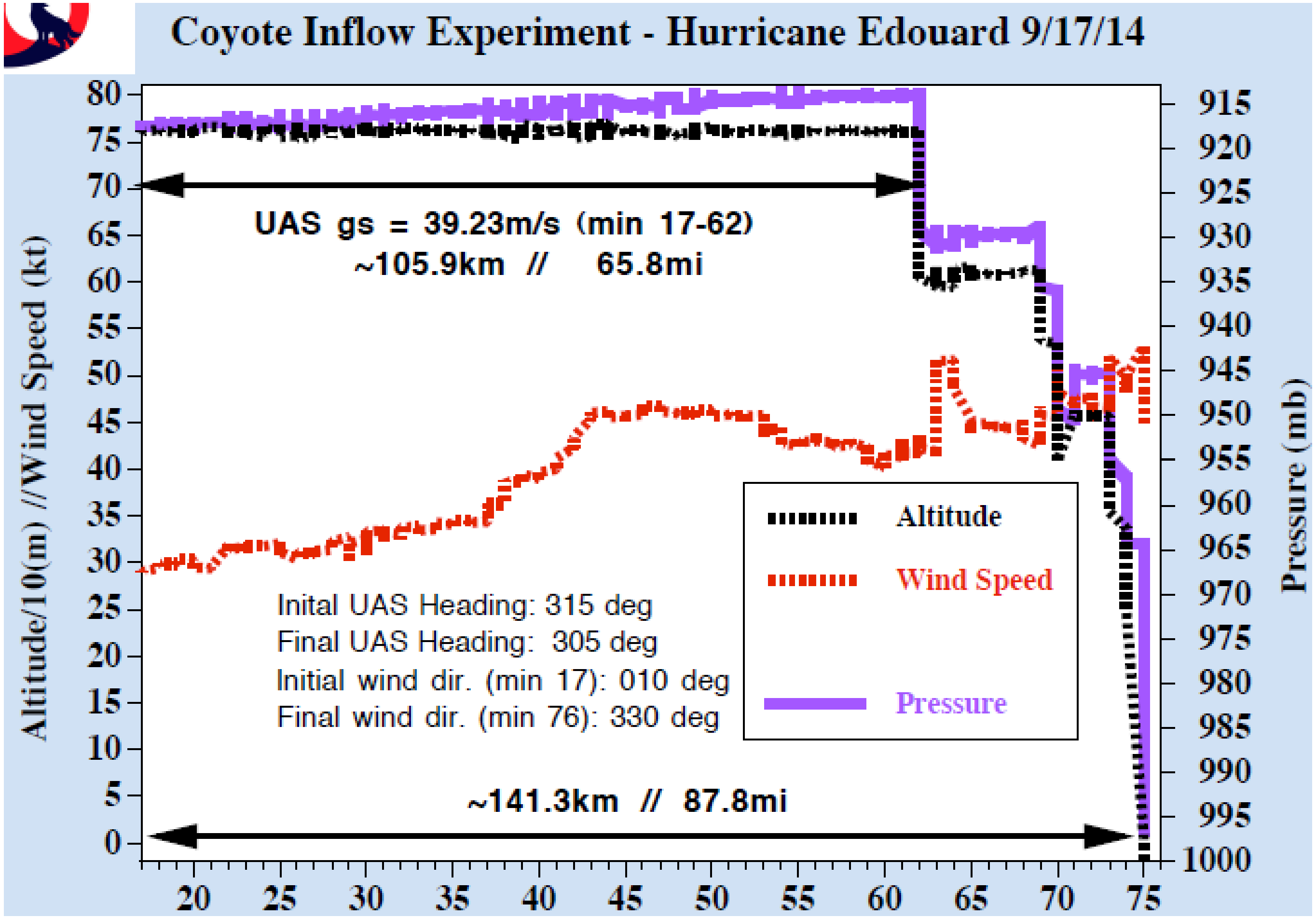

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Results:

1 – Coyote survived fine in hurricane to 53kt winds;
    68 min endurance dropped from 400m altitude

2 – Data collected helped evaluate performance of models

3 – Coyote data compared well w Dropsonde data

4 – Eye: model too warm/moist
    Inflow: model too cool/dry, 0-750m too unstable
    Surface humidity too low, fluxes too high

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Plans for 2015:

1 – Improve comms between aircraft & UAS; longer range antenna

Change signal from 900MHz to 350MHz, amplify signal. Expect increase from 60mi to 100mi.

2 – Improve ‘awareness’ by having P3 Data visualization of UAS position – software completed

3 – Improve sensors (higher temporal resolution); include IR SST sensor

4 – Deliver Coyote wind speed & direction data in real time to hurricane centers