Unmanned Aircraft Systems (UAS): Potential Benefits and Current Status

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Outline

- What are UAS?
- Why use UAS?
- What has been done so far?
- What is being planned?
- What are the current challenges?
- Next steps.

What are UAS?

- Unmanned Aircraft Systems include:
  - Aircraft, communications systems and pilot.
- A variety of UAS are currently available; many more are under development.

- Scientists: What can they do?
- Engineers: What do you want them to do?

Why use UAS?

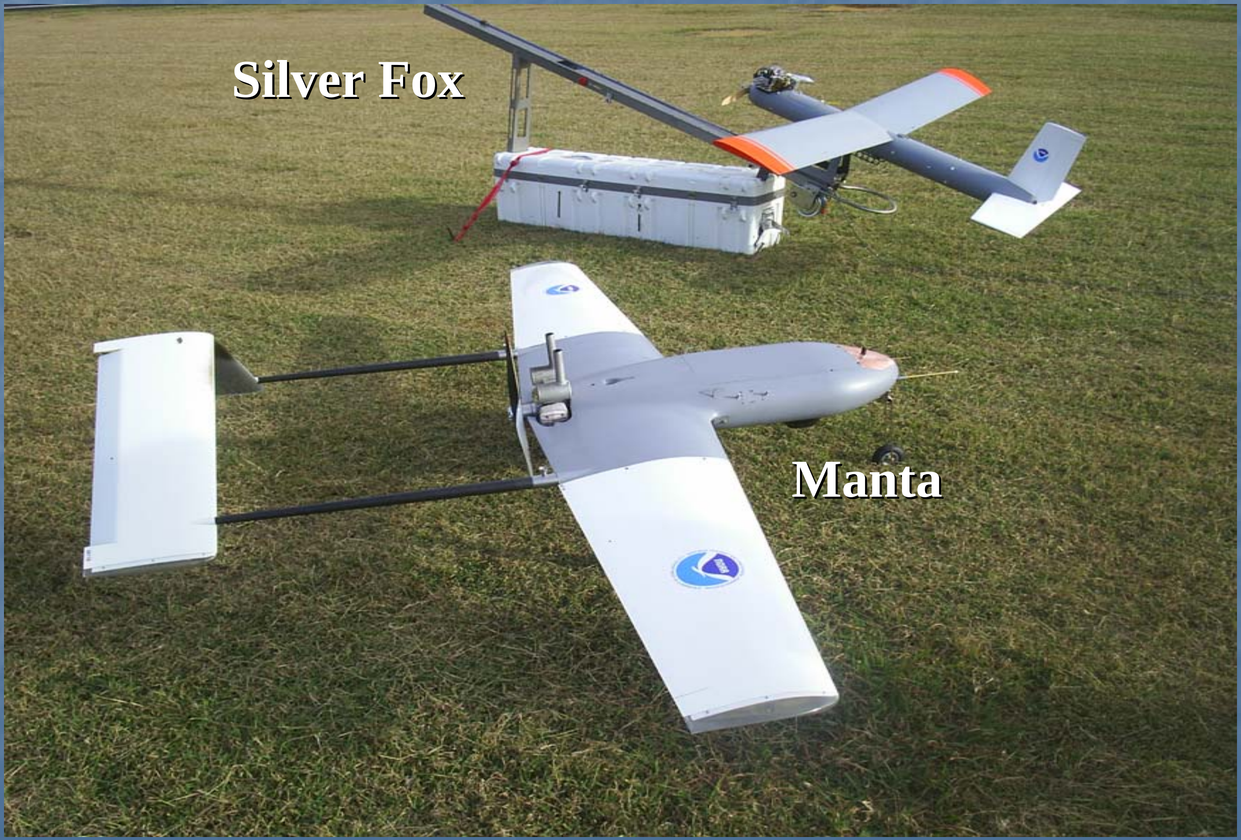
- The technology is evolving and is likely to produce unique capabilities.
- From the military:
  - Dull
  - Dirty
  - Dangerous
- In the beginning, applications are likely to be very expensive.

Silver Fox & Manta UAS Evaluation Project
Upolu Point, Hawaii, March 15, 2006

A United States Navy Special Clearance Team 1 program
NOAA Ocean Service, Marine Sanctuaries Progam Objectives

Silver Fox
equipped with fixed (20 degree offset) EO/IR Cameras

Manta
Equipped with gyro-stabilized, turret mounted gimbaled camera system



Silver Fox & Manta UAS Evaluation Project
Upolu Point, Hawaii, March 15, 2006

NOAA Project Objectives

To evaluate these platforms for their surveillance potential for use in National Marine Sanctuaries

Determine whether systems can be used to spot and/or identify individual whales and pods of whales

Evaluate potential to control and/or launch from a vessel

Determine whether these systems can be used to identify vessels, activity aboard vessels and to document precise locations of above – NOAA Fisheries Enforcement

Maldives AUAV Campaign, Island of Hanimaadhoo
March 05 – 31, 2006

Scripps Institution of Oceanography, UC at San Diego

Objectives: to observe Aerosol-Cloud-Radiation-Climate Interactions Simultaneously from three Stacked Autonomous Unmanned Aerial Vehicles (AUAVs)

Groupings of 3 aircraft flew 18 flights in synchronous vertical formation, which allowed onboard instruments to observe conditions below, inside and above clouds simultaneously

Determine how the microphysics of clouds can affect the radiative properties.

NOAA provided support

NASA/USDA-FS Fire Mission

Summer 2006

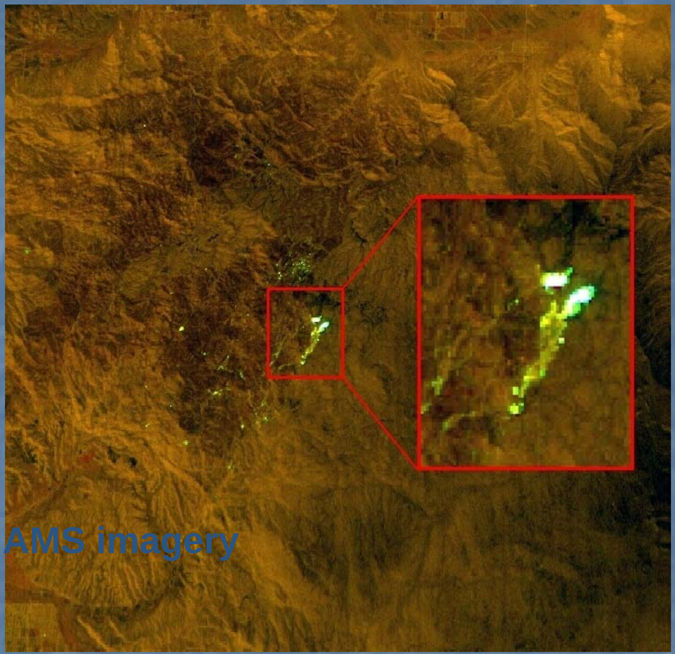
Esperanza Fire Rapid Response 28-29Oct 2006

An extension of the recently-completed Western States Fire Mission.

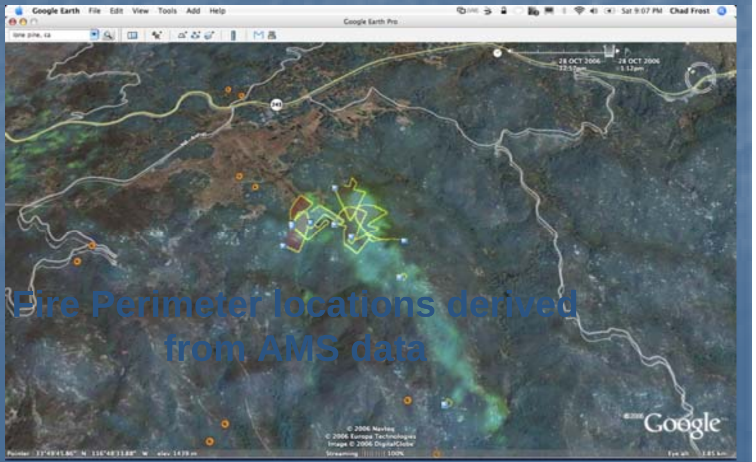
FAA approved a COA in less 9 hours.

Fire mission teams from NASA Ames and NASA Dryden mobilized 10/27 to upload the AMS.

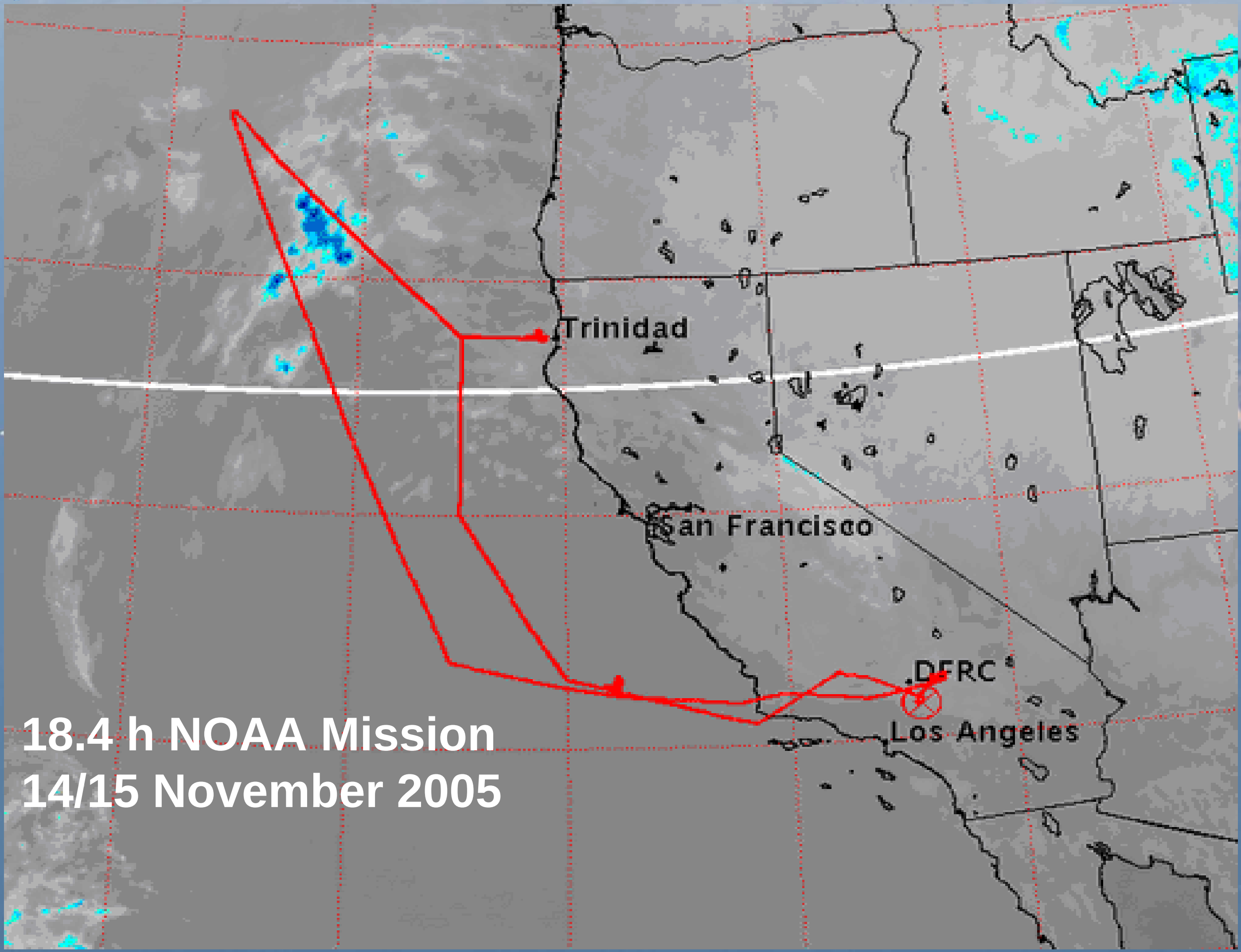
The AMS sensor fed real-time IR imagery of hot spots to the California offices. Altair flew for 16.6 hours. Multi-spectral infrared images were remotely processed on board the aircraft, and broadcast in near real-time via satellite for dissemination to the fire community.



30 meter resolution

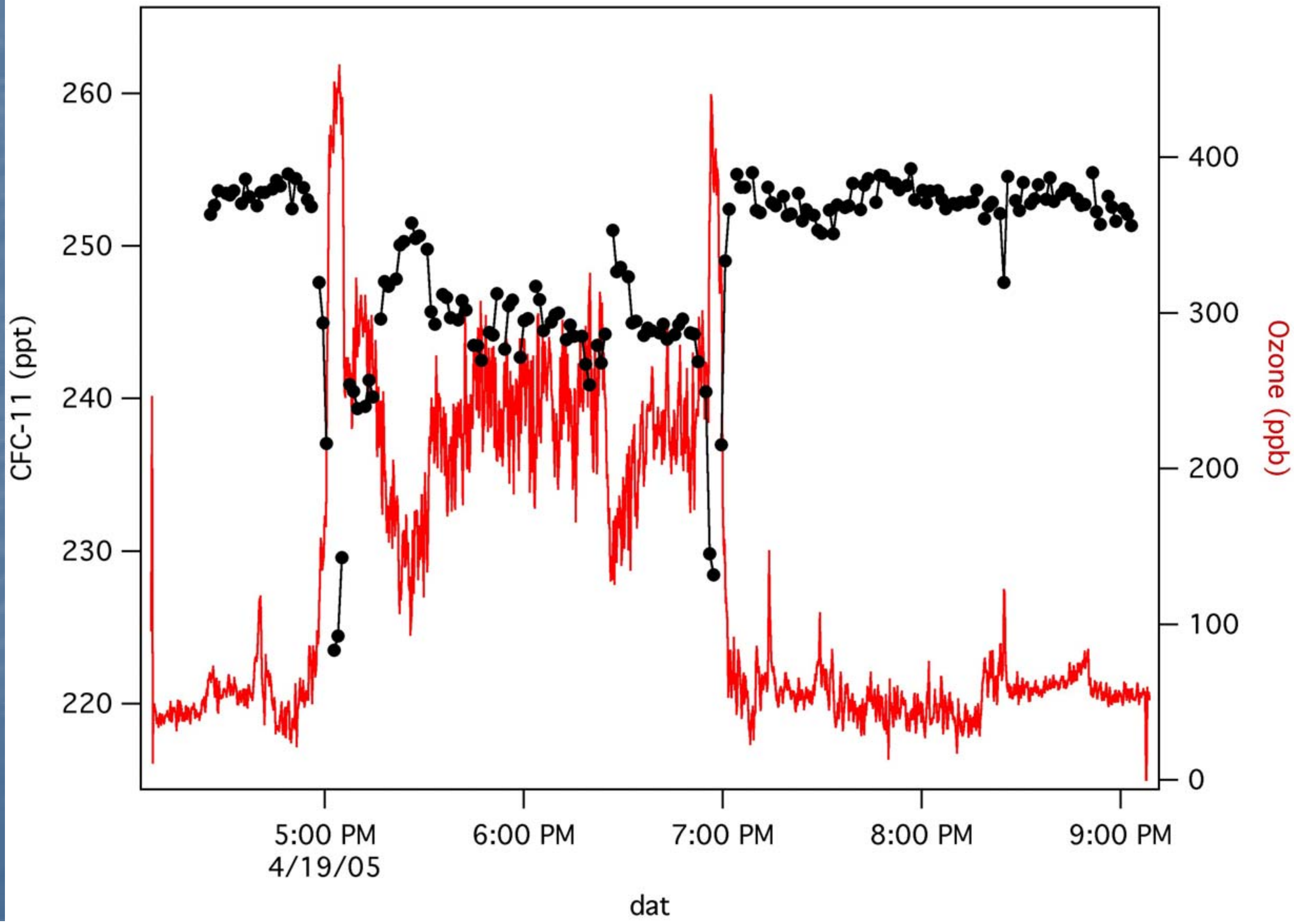


Altair Demonstration 2005



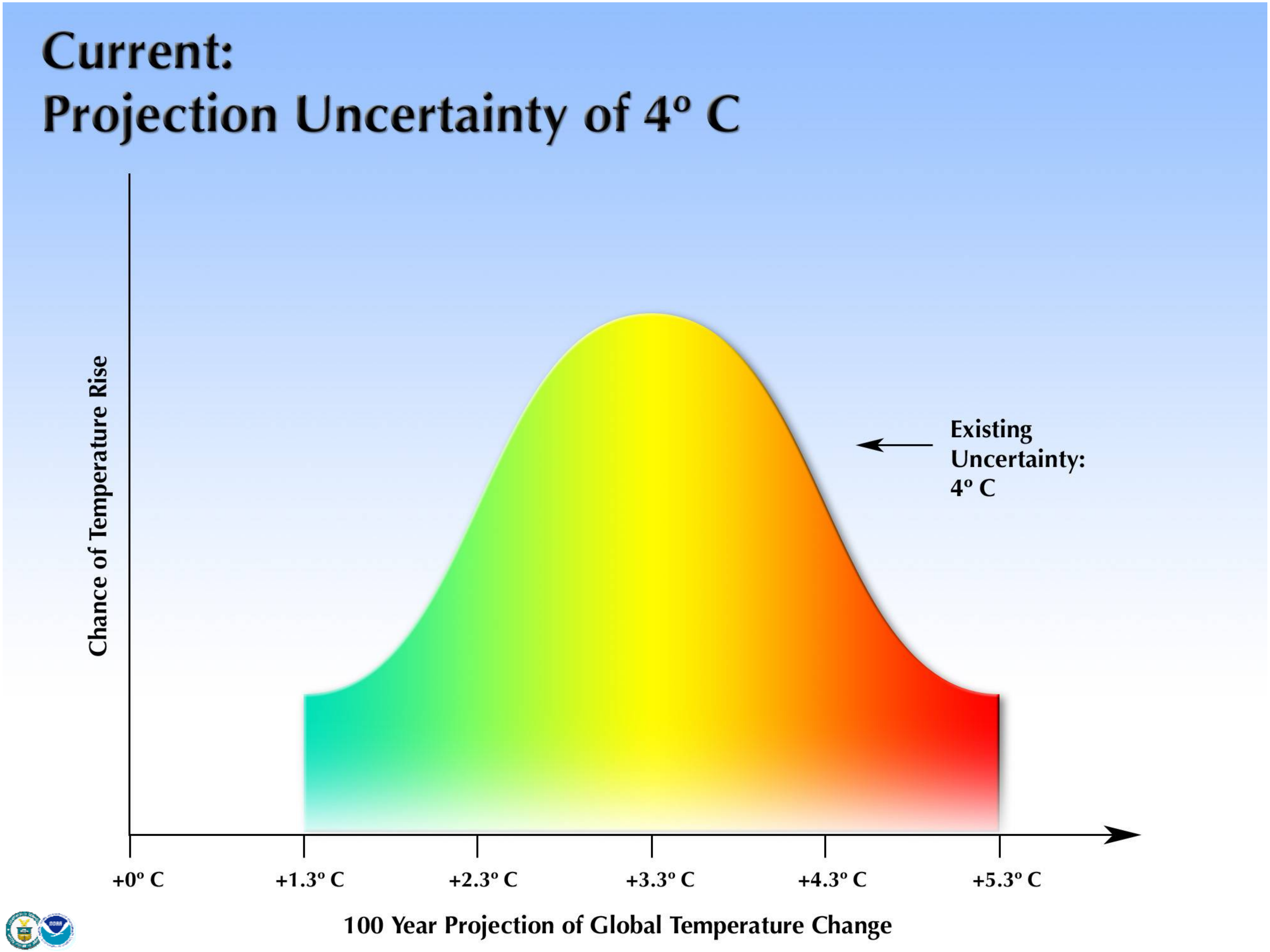
18.4 h NOAA Mission
14/15 November 2005

Initial Results from UAS

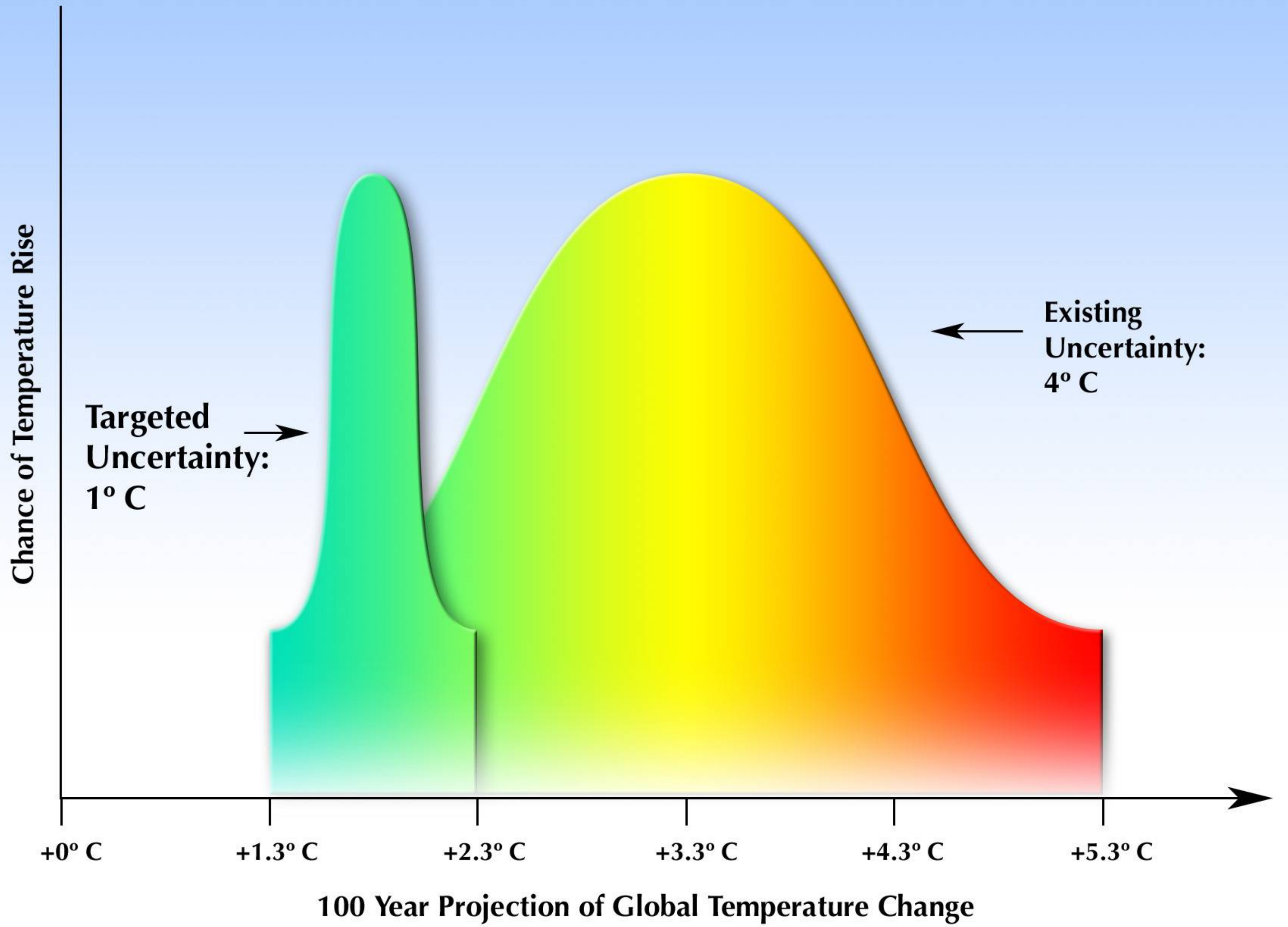


Future Direction of UAS

- In the long-term:
  Improve weather and climate predictions.
- In the short-term:
  Develop capabilities and demonstrate benefits.


Current:
Projection Uncertainty of 4º C
Chance of Temperature Rise
Existing Uncertainty: 4º C
+0º C
+1.3º C
+2.3º C
+3.3º C
+4.3º C
+5.3º C
100 Year Projection of Global Temperature Change

Requirement:
Limit Projection Uncertainty to 1º C



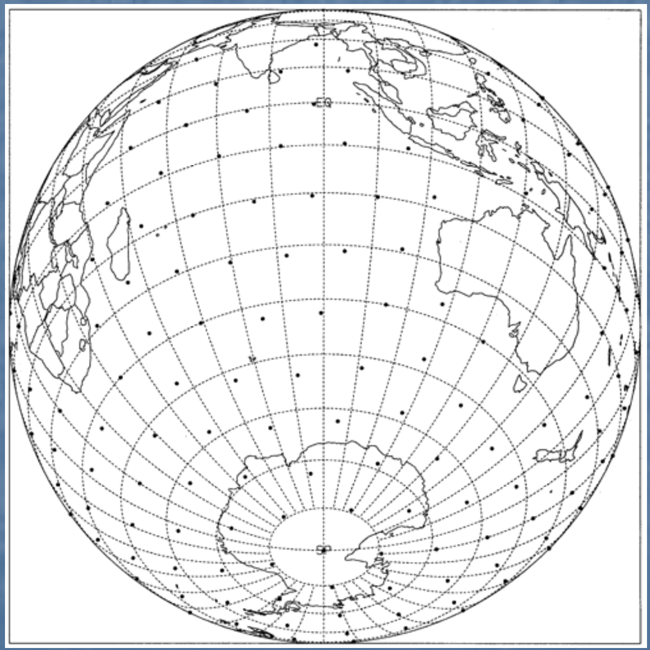
Long-term vision

Oceans comprise ~70% of Earth's surface *Dr. Alexander MacDonald*

Climate: Accurate climate sondes at every "climate point" (240 points equally distributed over oceans and polar regions) every three days.

Weather: Adaptive observations over the globe every 72 hours, including storms.

Buoys or AXBT's at each ocean point, measuring temperature, current and salinity down to about 2000 meters.



Idea is to use a HALE UAV (e.g. Global Hawk) to take the most accurate possible profiles from the stratosphere to deep in the ocean over as much of the earth as possible.

State variables, forcing, chemistry - correlated with ocean measurements from buoys

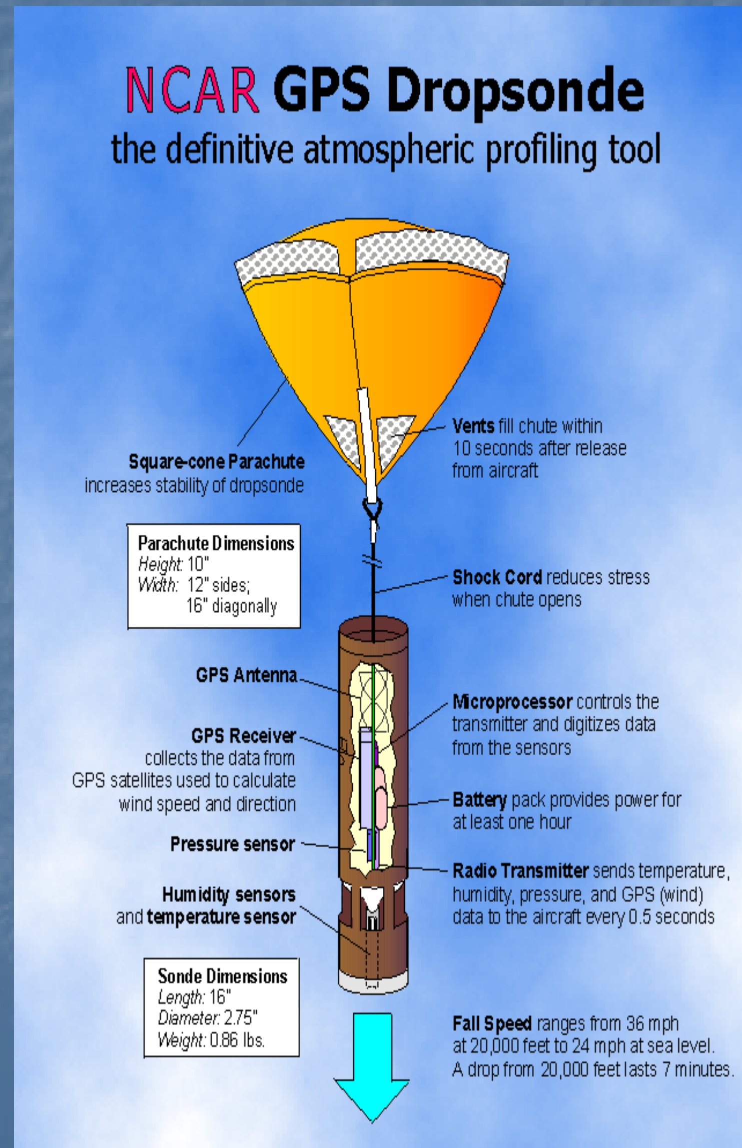
Global Hawk could be the Unmanned Aerial Vehicle platform:

* Range:	14,000 miles
* Speed:	350 knots
* Altitude:	60,000 feet
* Payload:	1960 lbs
* Prime: Northrop	

Dropsonde

GPS Dropwindsonde Specifications

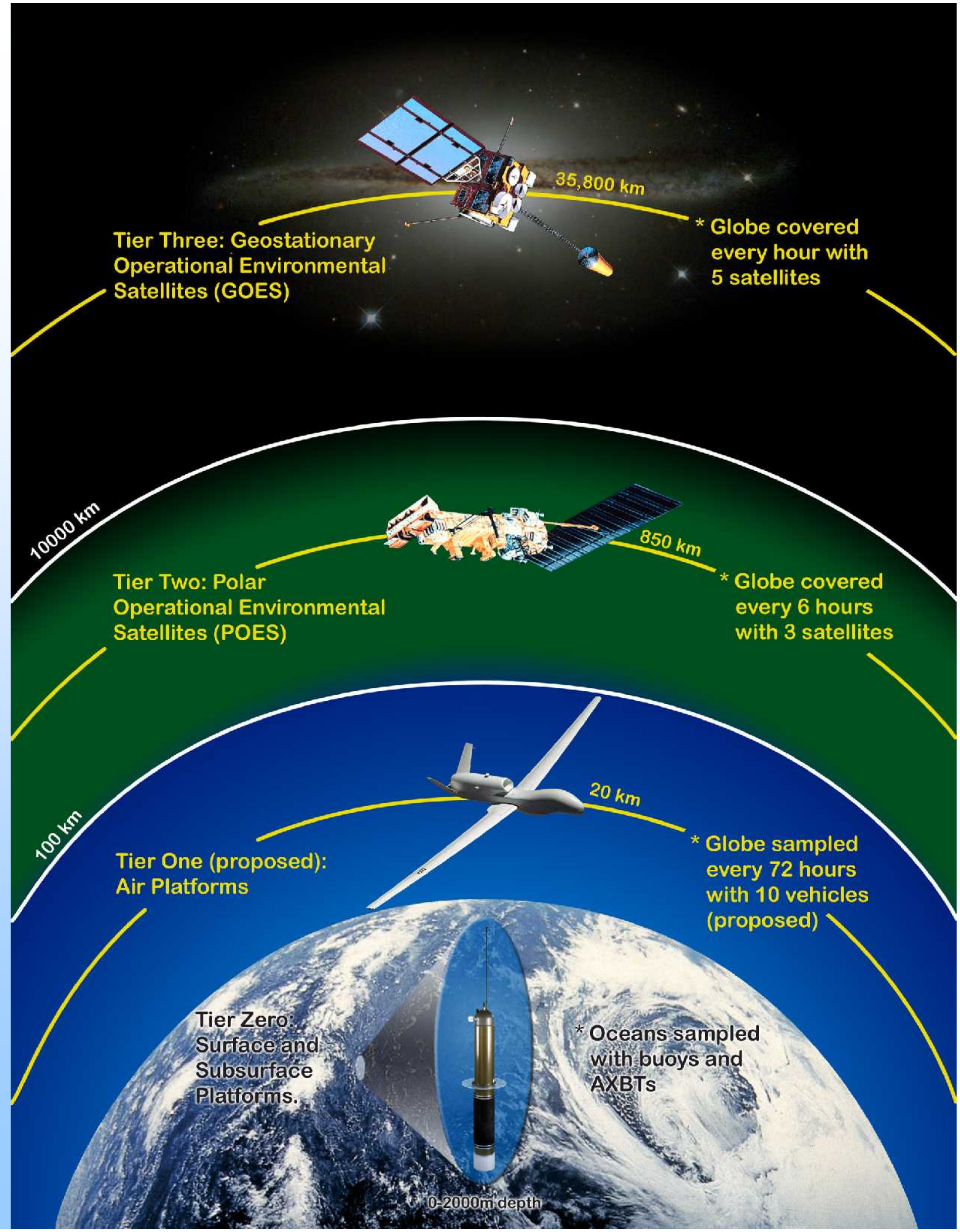
	Operate	Accur-acy	Resolu-tion	Time Const.	Typ. Error
Pressure	1060-20mb	0.5mb	0.1mb	<0.01 sec	1.0mb
Temperature	-90 to 45°C	0.2°C	0.1°C	2.5 to 3.7 s	0.2°C
Humidity	0 to 100%	2.0%	0.1%	0.1 to 10 sec	<5%
Winds	0 to 150 m/s	0.5 m/s	0.1 m/s		0.5 to 2.0ms



Starting from the existing dropwindsondes, a sonde can be developed that has the extremely high accuracy and time continuity needed for climate trends.

Void between satellites and surface-based sensors

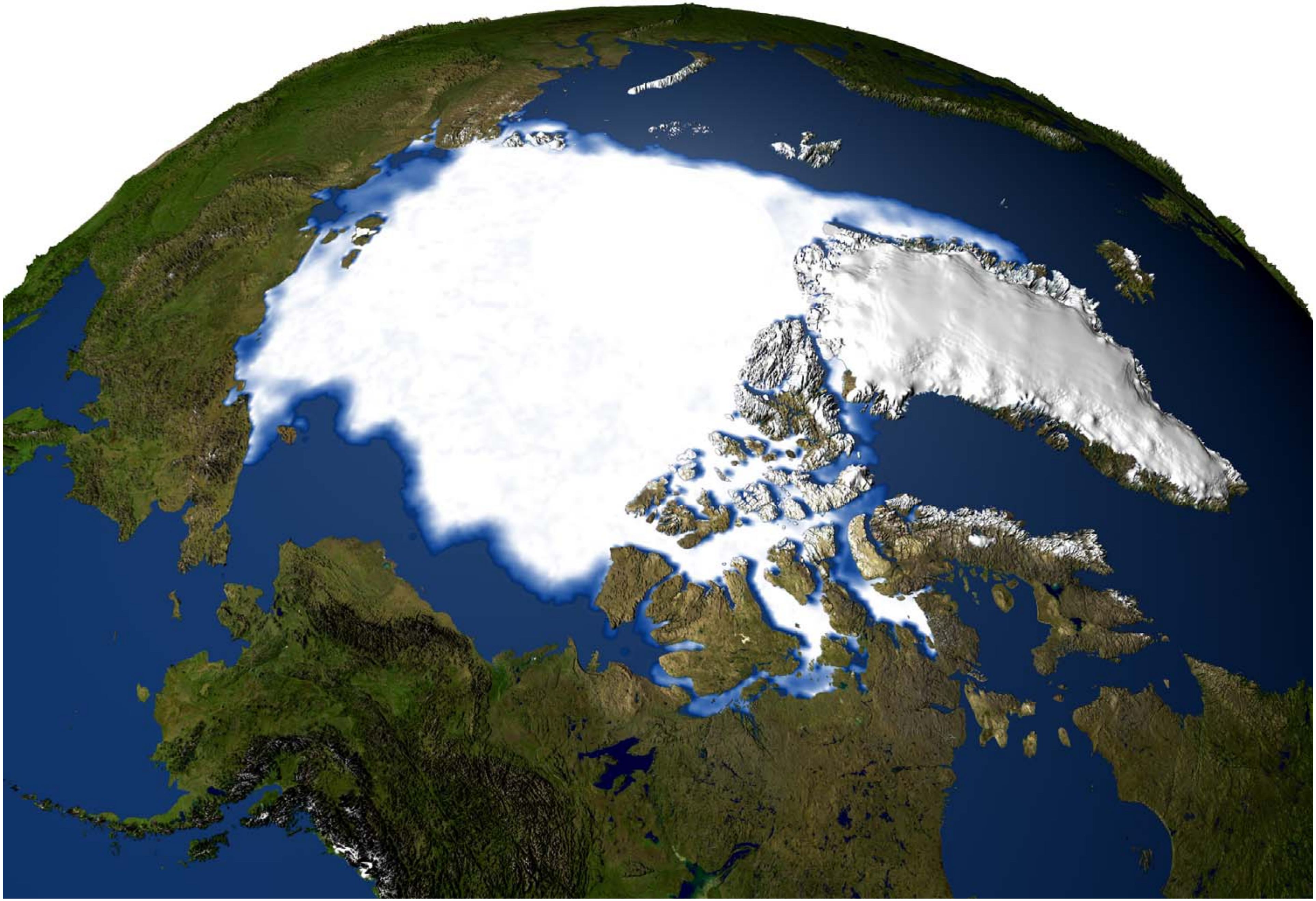
Unmanned Aircraft Systems have great potential to fill this void

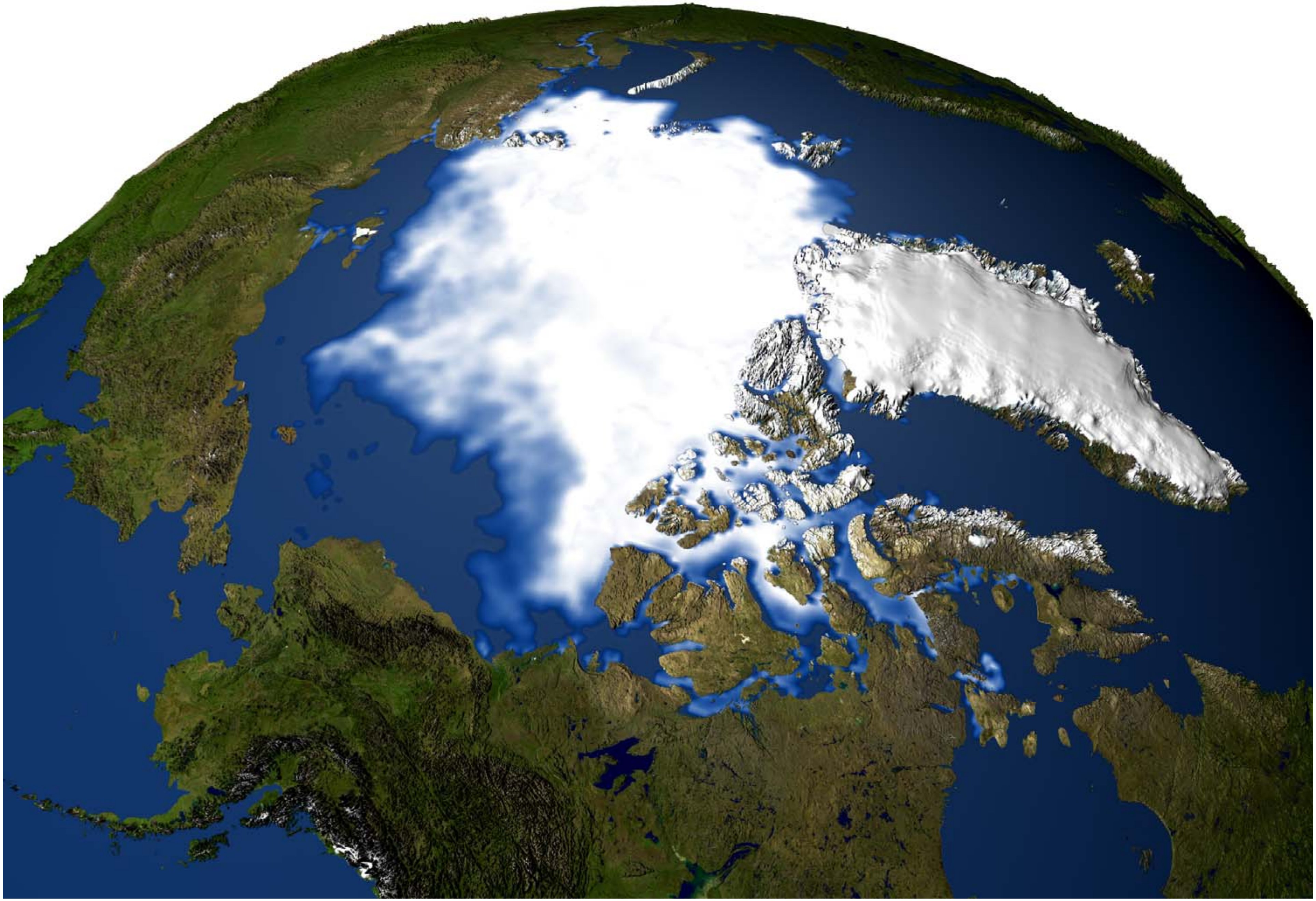


NOAA's Proposed UAS Stations

UAS in Alaska and the Arctic

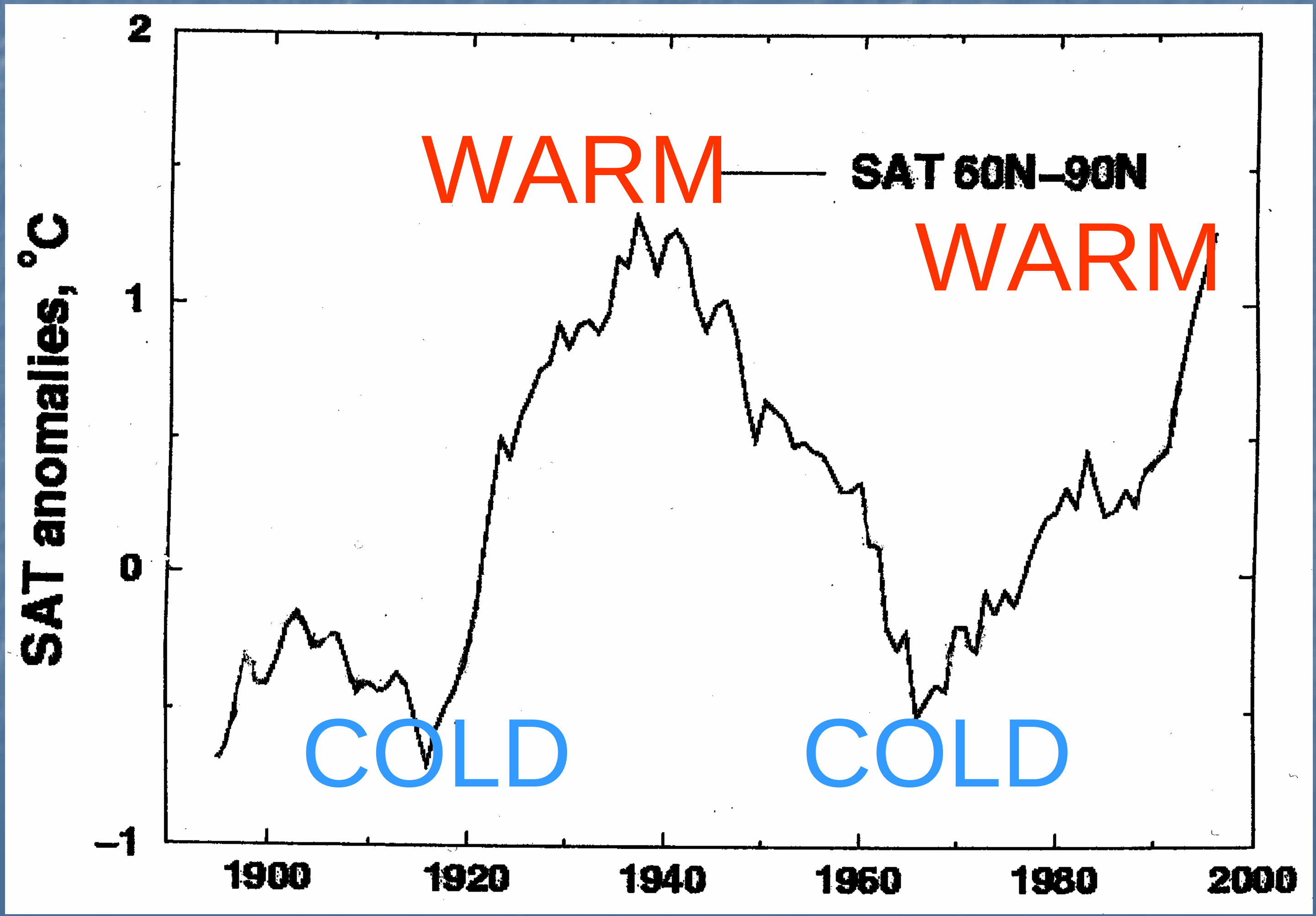
- Dull, dirty and dangerous often apply to the Arctic
- Unique advantages:
  - Sparsely populated
  - Scientifically important
  - Poor monitoring capabilities
  - Many uses beyond environmental measurements.





Decadal Temperature Change

Arctic temperature during the 20th century

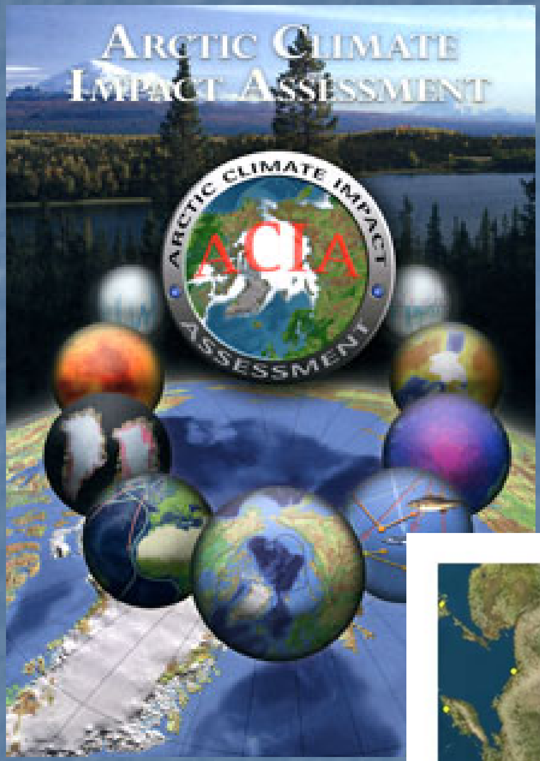


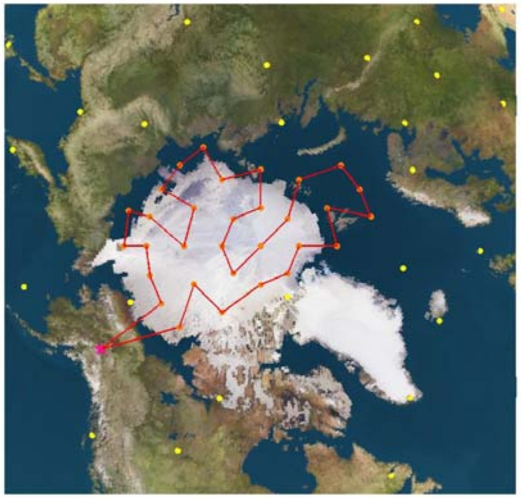
Unmanned Aircraft can offer a unique capability to Alaska

- Weather and Climate Measurements
- Long-endurance flights (greater than 30 hours).
- Dangerous situations
- Search and Rescue
- Homeland Security
- Volcanic emissions and pollution plumes
- Marine Mammal inventories
- Fisheries Enforcement
- Pipeline monitoring

Arctic Climate and Weather: Changes and Impacts

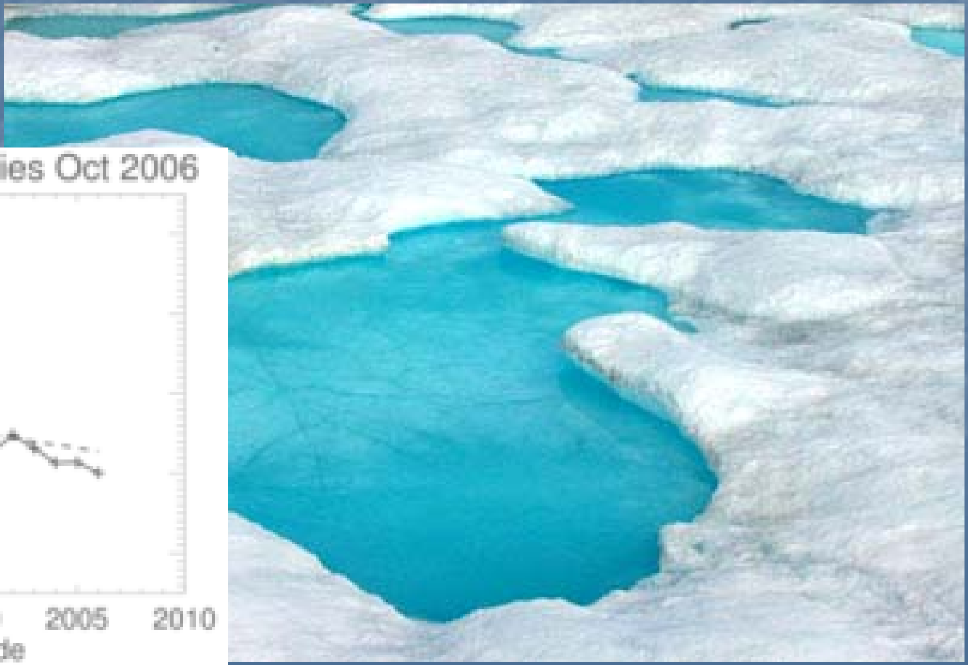
- Some of the strongest changes of the past two decades have been observed in the Arctic.
- These changes have been complex geographically and temporally.
- Native Alaskans talk about how the weather has changed, becoming more unpredictable.
- Changes in Arctic climate can effect the entire globe.
- Attribution is still the big question.

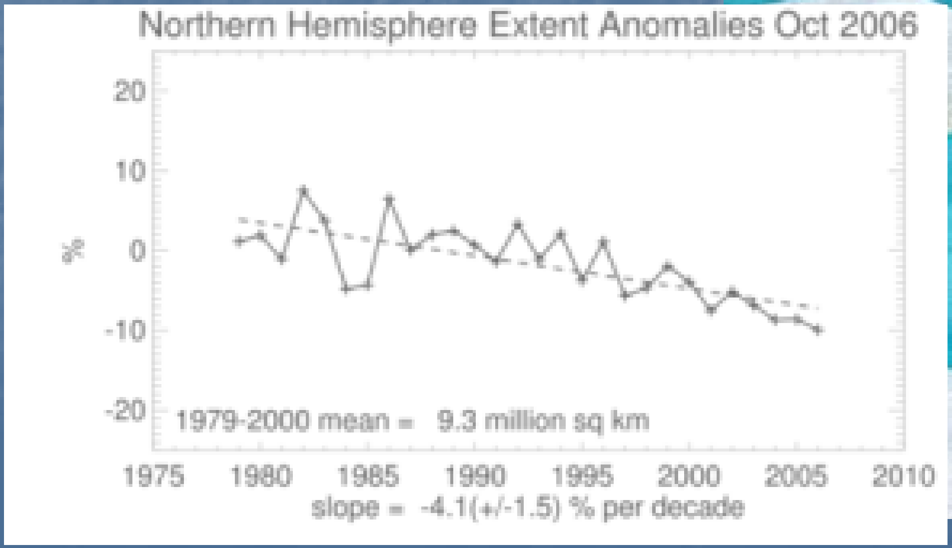




SEA ICE:

Amount and quality of sea ice can change rapidly in the Arctic. Current monitoring is inadequate to understand changes and make short or long-term predictions about conditions of the ice.



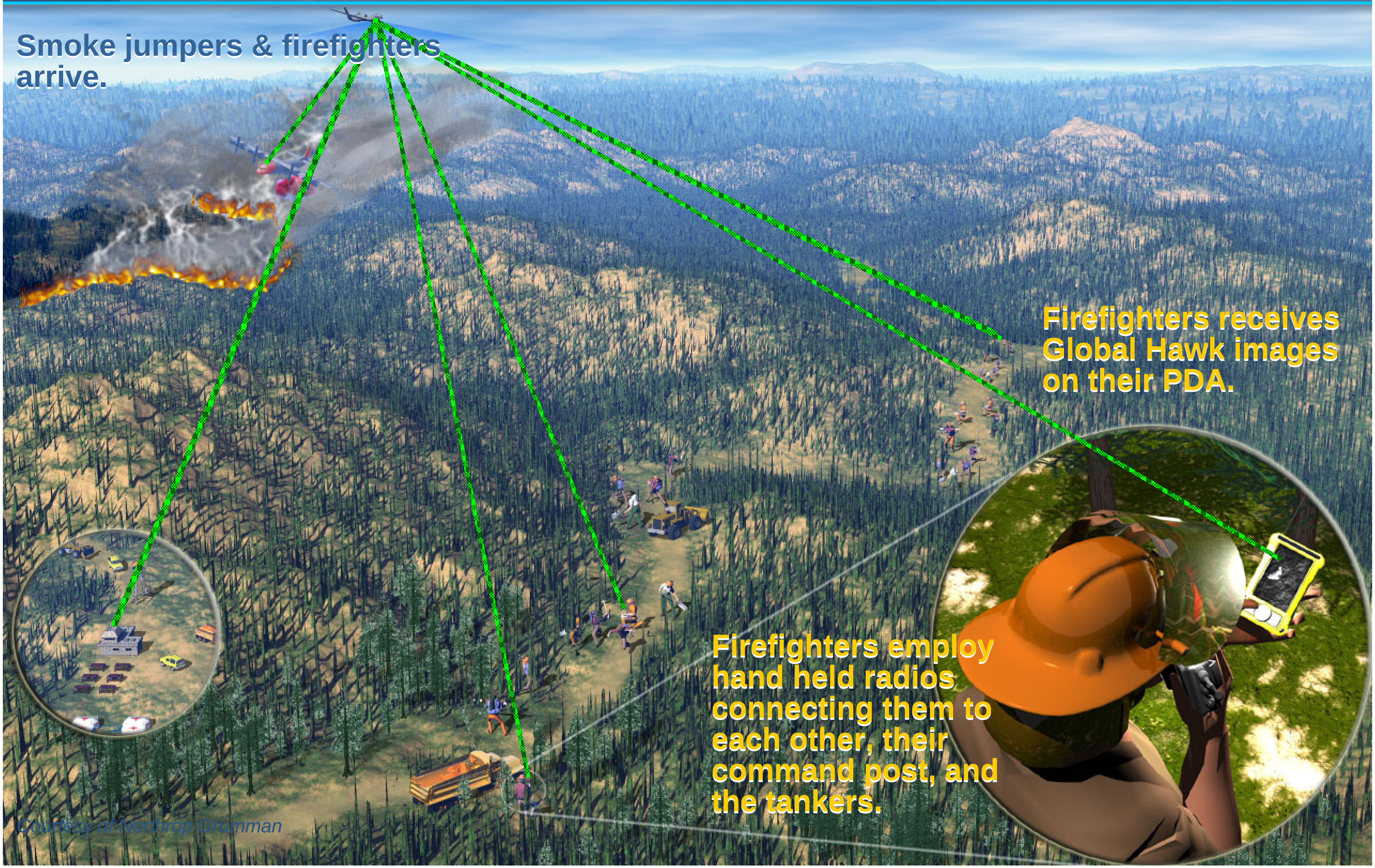


Wildlife Monitoring

Long migration paths can require Long-range monitoring capabilities.

Alaska's coasts and marine sanctuaries are so large in area and geographically diverse that a UAS would greatly increase the knowledge of what is happening in these sanctuaries.

Search and Rescue: UAS can offer a unique capability to communicate over land and ocean. UAS can go into dangerous situations and can fly low for long periods of time.



Homeland Security

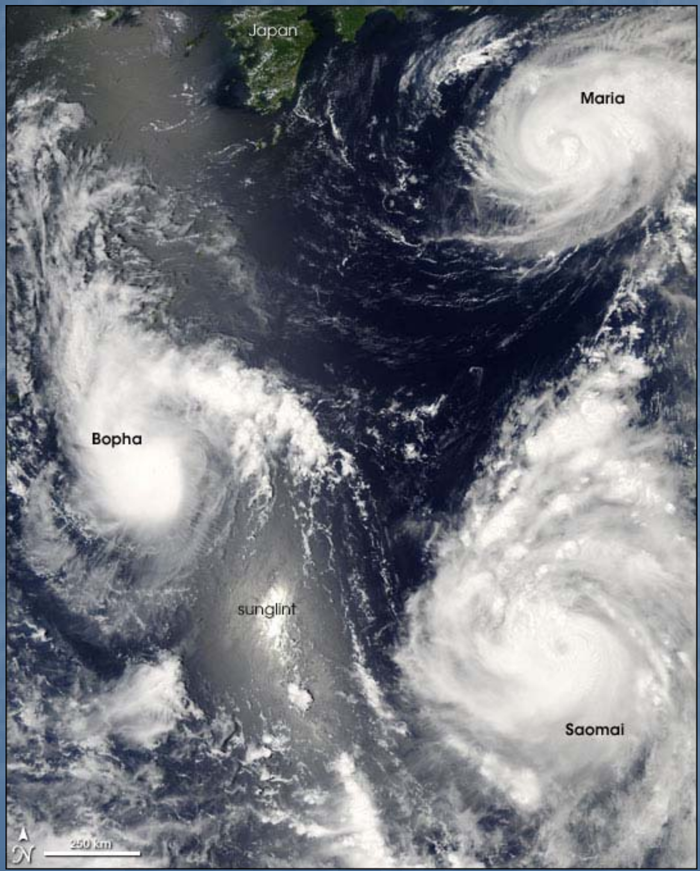
Monitoring of the Alaska pipeline –Routine flights could fly along the entire pipeline route, allowing early detection of pipeline hazards, potential spills, or terrorist attacks. The UAS, flying in the stratosphere with high resolution visible and infrared sensors, is not discernable from the ground, and thus is particularly valuable for detecting potential sabotage.

Sensitivities

- Flying over Alaska requires FAA approval.
- Flying over the Arctic Ocean should be accompanied by multi-national support.
  - Good press
  - Need for emergency landing support
- Native Alaskans and Inuit need to be consulted:
  - Flying low over some settlements may not be welcome.
- Flying low over some ecosystems may have currently unknown impacts.
- Failures, disappointments

UAS and the Pacific

- Lack of measurements over the Pacific limit weather predictions.
- Ecosystem monitoring, fisheries enforcement are currently untractable



Pacific Typhoon (August 7, 2006)

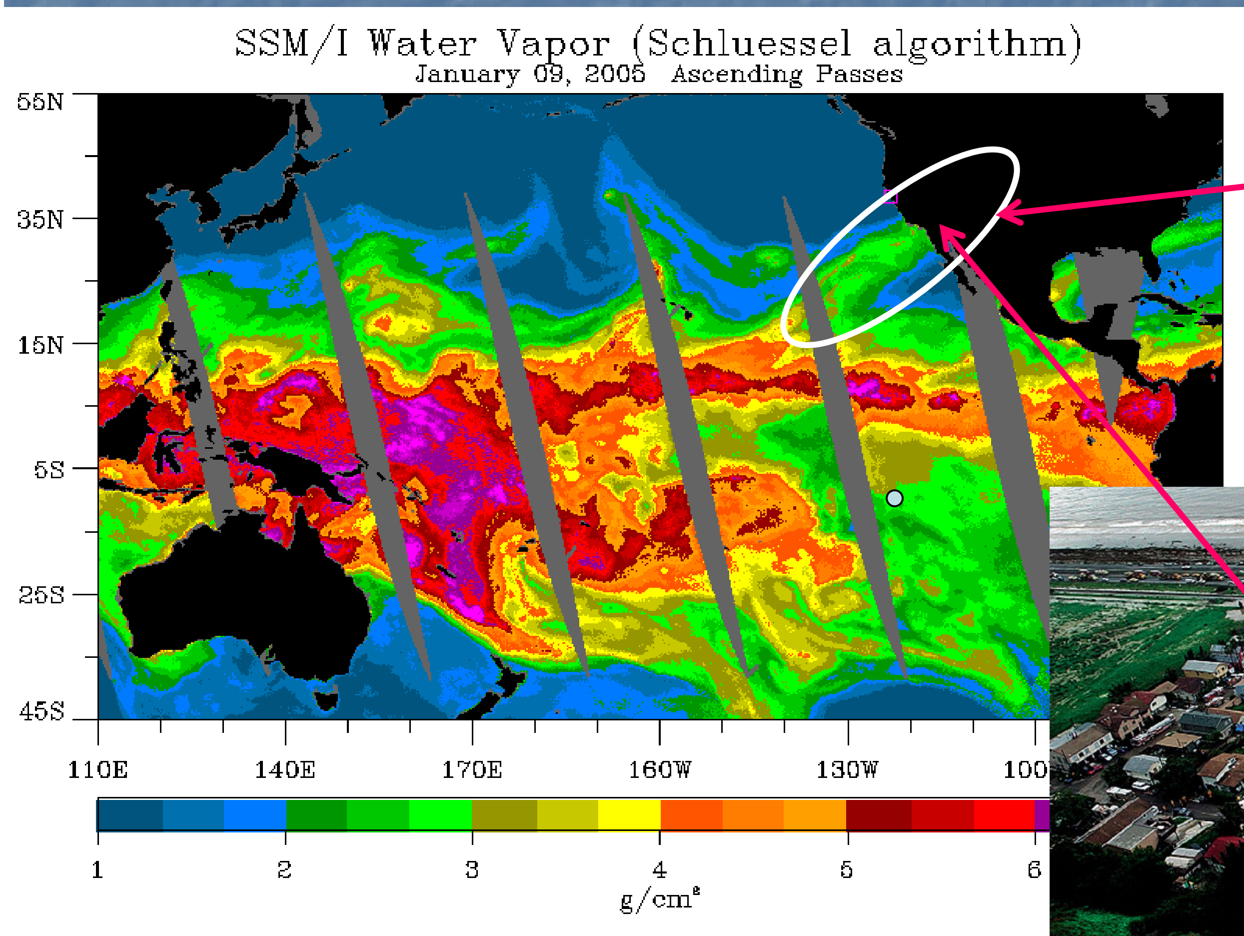
UAS Applications in the Pacific
(35% of earth's surface)

Northwest Hawaiian Islands National Monument - 1400 miles from the mainHawaiian Islands. World's largest marine sanctuary This area is one of the most pristine marineecosystems in the world, nearly untouched by humans. It is home to morethan 7,000 species, many seen nowhere else in the world

Ghost nets

Atmospheric Rivers – California Landfall Storms

Satellite Observations of Water Vapor



Atmospheric river on 9 Jan 2005

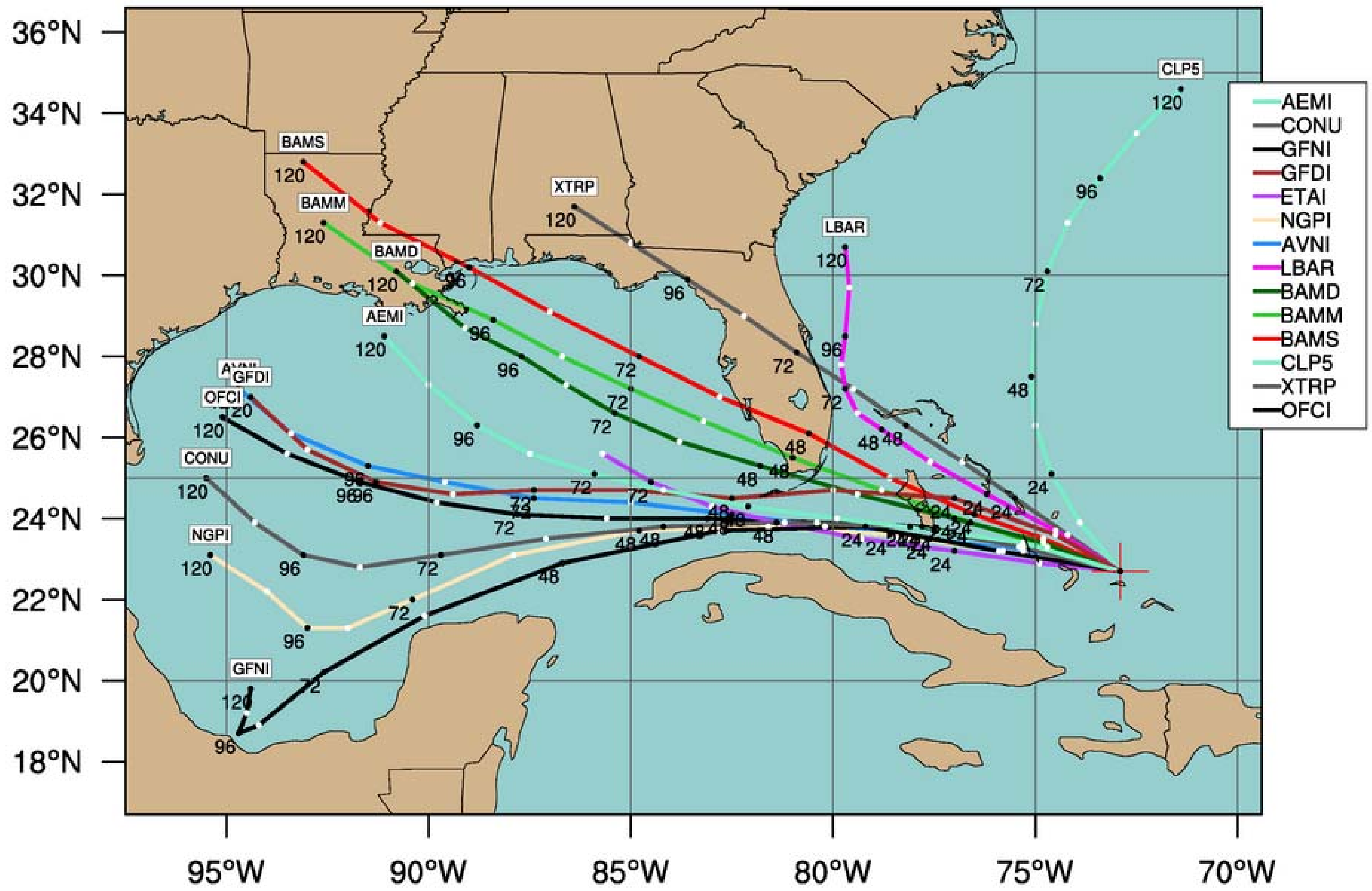
Fatal mudslides and floods on 10 Jan 2005

UAS and Cyclogenesis

- Progress has been made with hurricane predictions
- More progress is needed, particularly for several day forecasts.

AL18

Early-cycle track guidance valid 0000 UTC, 19 September 2005



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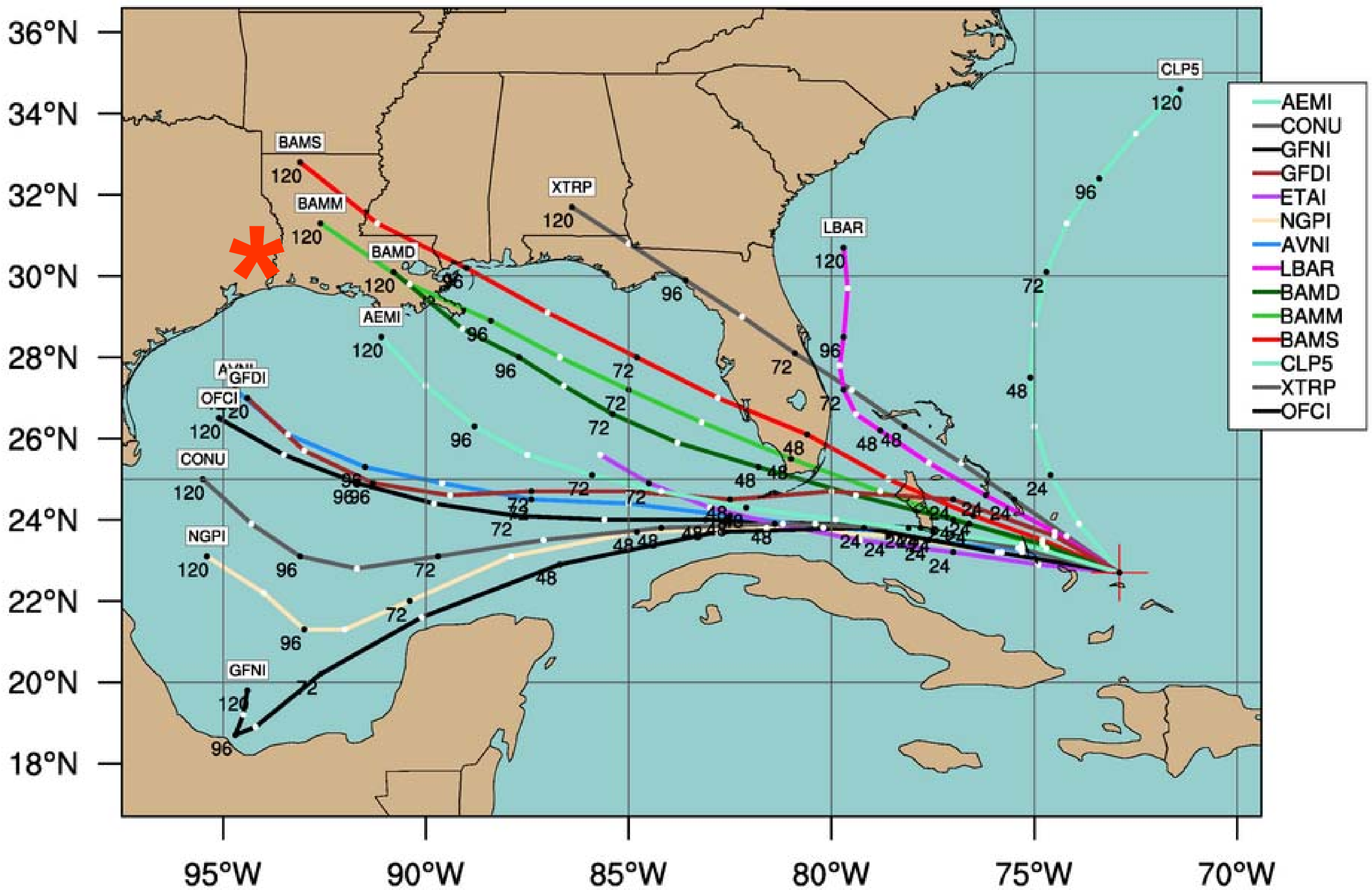
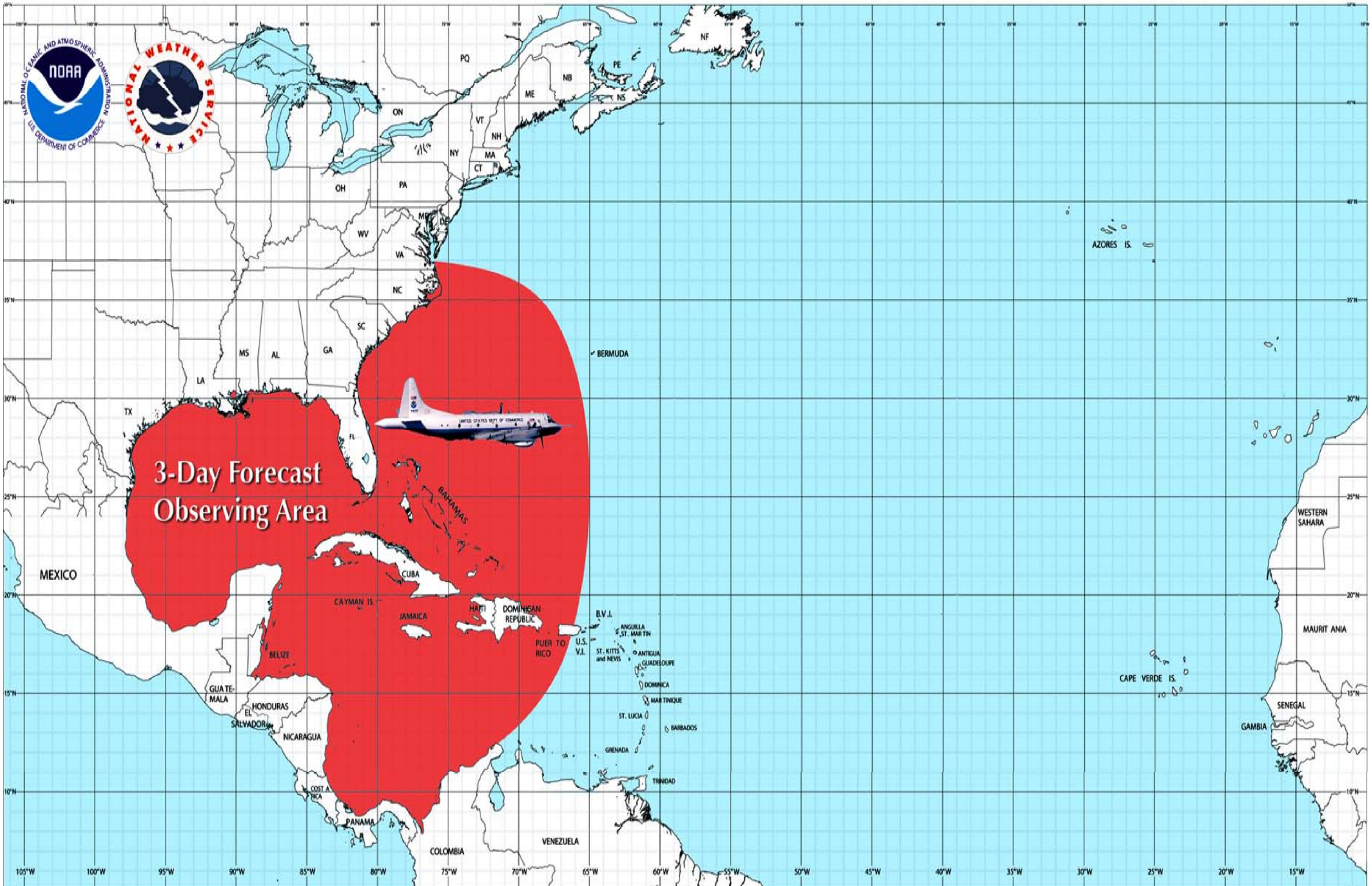
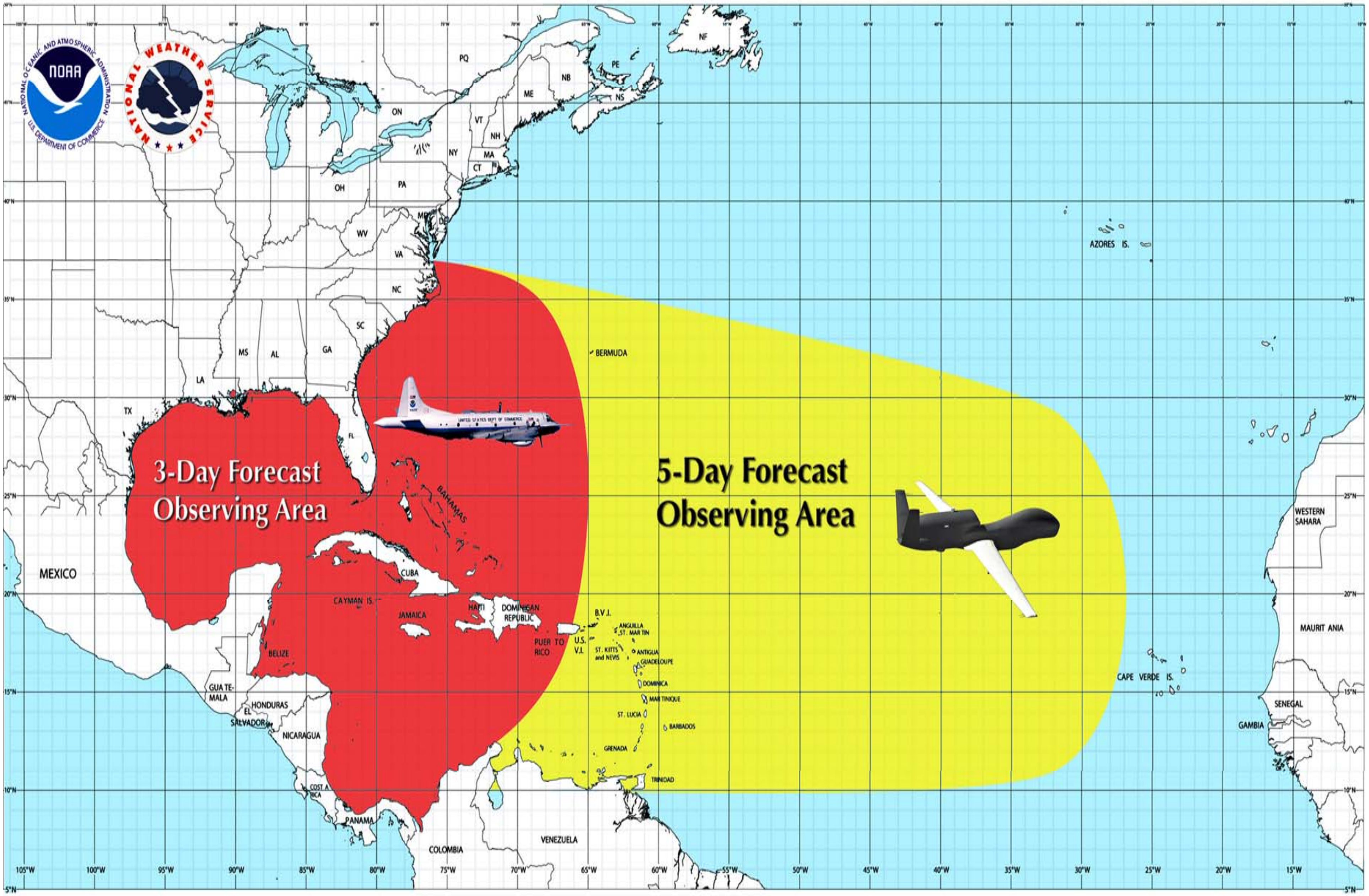


Landfall Sept 24, 2005

Extending Hurricane Prediction Lead Time



Extending Hurricane Prediction Lead Time



Current Challenges

- FAA Approval
  - FAA wants to make sure UAS are as safe as conventional aircraft systems
  - Demonstrate safety
  - “Sense and Avoid”
- Meeting in Boulder: April 4, 2007
- Partnership

Current Challenges

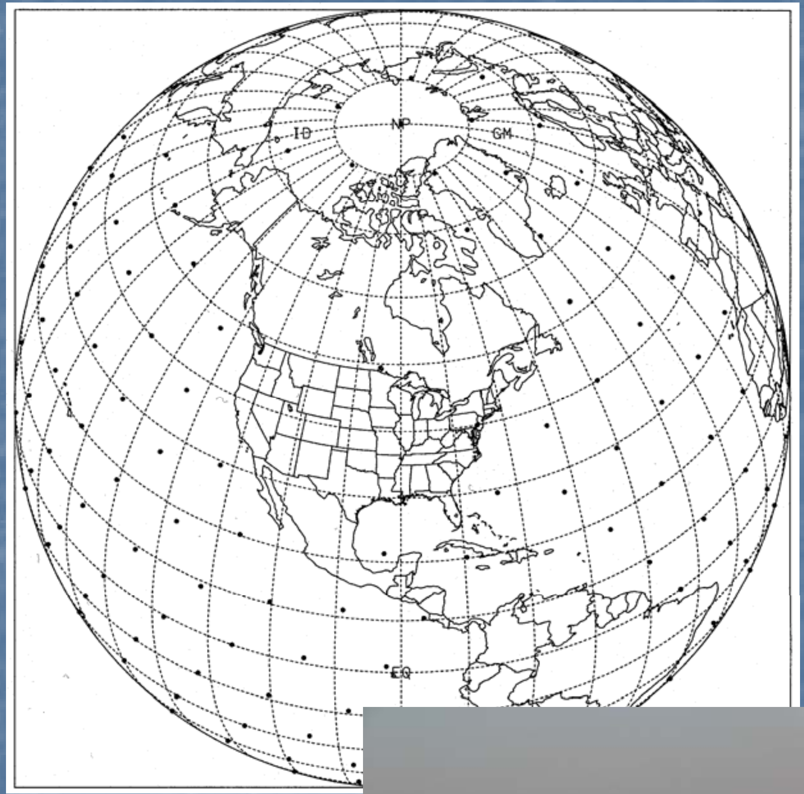
- Communication
  - Beyond Horizon adds to complexities and costs
- Long-distance coverage will require this challenge to be met.

Current Challenges

- Cost:
  - UAS are very expensive at this point.
  - All new technologies have been expensive at the beginning
- Cost of climate change effects and mitigation are larger.
- Comparable to current satellite costs.

Current challenges

- National and international acceptance.
  - FAA is only one component
- Global vision requires agreement of international communities.



Next Steps

- Define initial goals
- Continue instrument development
- Carry out test missions
- Work with the FAA
- Work with the UAS manufacturers
- Work with all interested parties
- Evaluate results and redefine goals