

NOAA and UAS



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1985 Hurricane Elena taken from the Space Shuttle

Motivation



“We must move new but proven observing systems into an operational environment and redirect associated resources and research toward exploring new technologies, such as unmanned aerial vehicles, to meet future requirements.”

**Æ VADM Conrad C. Lautenbacher,
August 2005**



Global Earth Observing System of Systems GEOSS



A top NOAA Priority

**Acquiring political
legitimacy**

**Requires international
collaboration**



Improved Observations Hold the Key to Saving Lives, Property and Resources



Examining the state of the planet's natural resources

Improving weather forecasts

Understanding global climate change

Understanding the rate of Arctic Ice melt

Improved hurricane track and intensity predictions

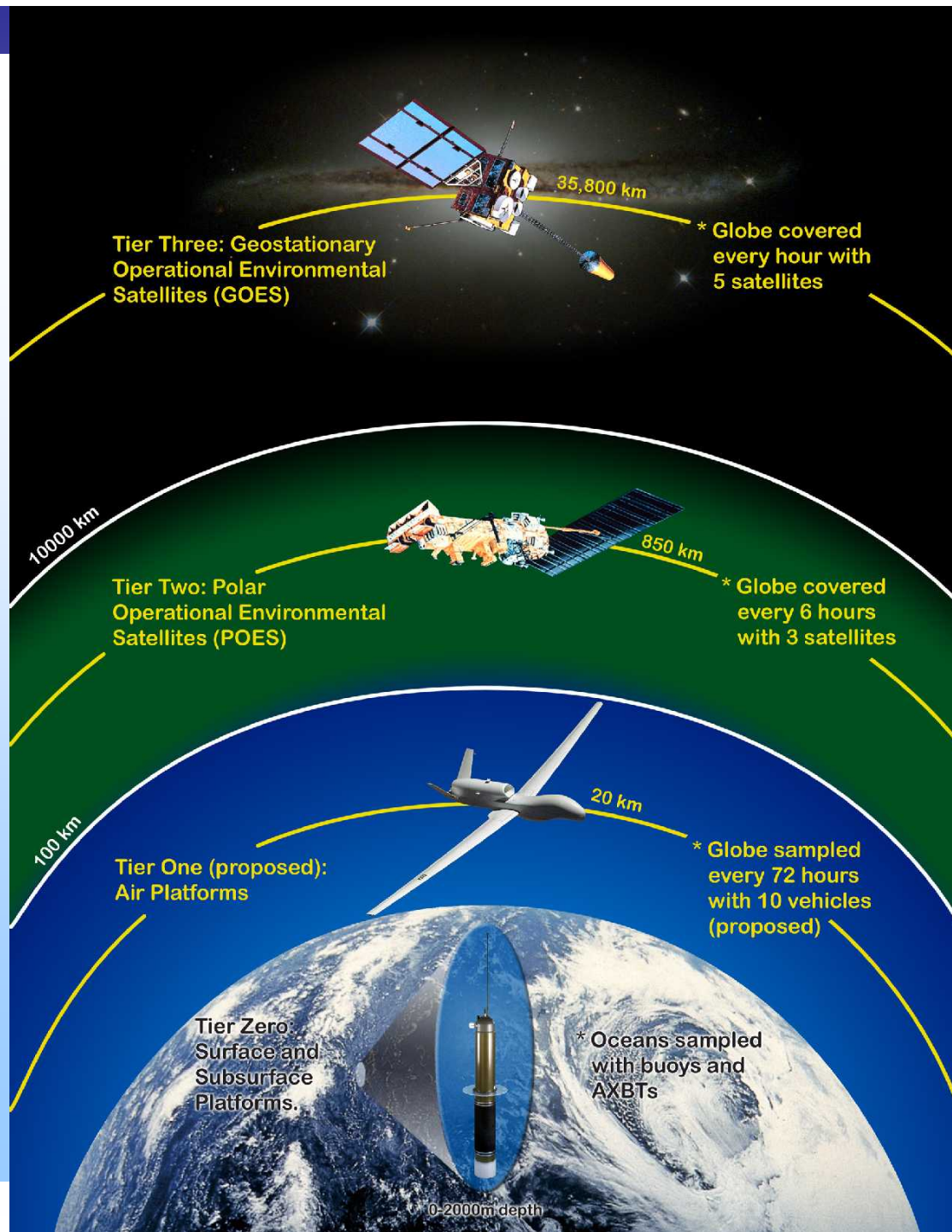
Fire Weather



GAP between satellites and surface-based sensors

Unmanned Aircraft Systems have great potential to fill this gap and take observations to complement our existing platforms

What are the gaps ?



The UAS “System”

System is comprised of Subsystems

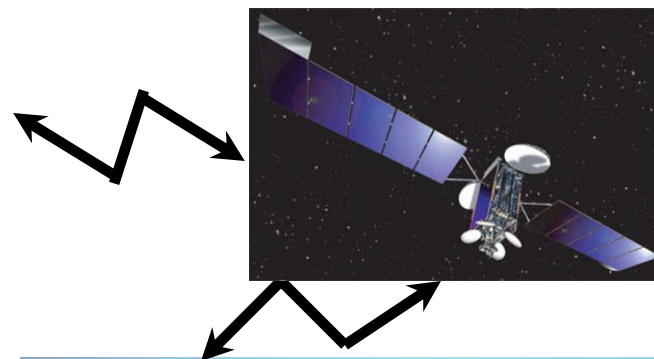


- **Airframe (Platform)**
 - **Avionics (electronic equipment that controls aircraft)**
 - **Communication:**
 - * **Line of Site (LOS)**
 - * **Satellite (OTH)**
 - **Ground Control:**
 - * **Fixed**
 - * **Mobile:**
 - **Vehicle**
 - **Vessel**
 - **Hand**
 - **Launch and recovery**
 - **Payload:**
 - * **Communications relays**
 - * **Sensors:**
 - **Scientific**
 - **Operational**
- Scientific:**
- **Remote**
 - **In situ**
- Operational:**
- **Optical**
 - **Infrared**
 - **Radar**
 - **Hyperspectral**
 - **AIS**
 - **Etc...**



UAS "System"

Altair/Predator B Communications and Control



Equipped with C- Band: transmits line-of-sight signals short distances
Ku-band satellite data link to provide over- the-horizon mission capabilities
(>150 miles)



High Altitude Long Endurance (HALE) UAS



Global Hawk

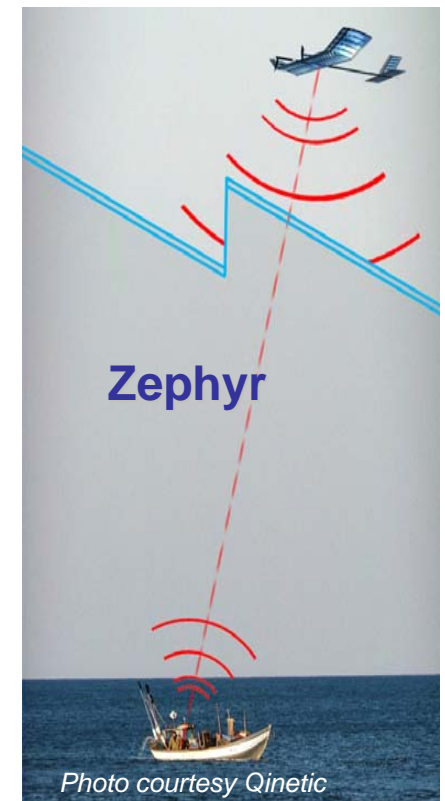
HA = High Altitude: working altitudes > 45k feet

LE = Long Endurance, i.e. airborne for 25 hours or more

Loitering capability allows us to track the evolution of systems, e.g. a weather system, forest fire, volcanic plume, etc

Payload capability varies; large payloads can support broad sensor suite.

Examples: Global Hawk, Zephyr, Altair



Medium Altitude Long Endurance (MALE) UAS



MA = Medium Altitude: working altitudes to 25k feet

LE = Long Endurance, i.e. airborne up to 20+ hours

Similar capabilities to HALE UAS

Because MALE UAS are operating at lower altitudes, they can transmit more detailed imagery of targets

Examples: GA-ASI Gnat, Predator B

Gnat 750



Photo courtesy Sandia Labs

Predator B



Photo courtesy General Atomics Aeronautical Systems Inc



Low Level UAS

Working altitudes 150-1000 feet AGL

Endurance up to 5+ hours

Cruise speeds 20-50 mph, increasing with weight

Operating Radius about 10 miles

Fly low and slow, inexpensive, may be expendable

Good for missions not needing large payloads or long endurance

No runway needed; can be launched/recovered from anywhere – by hand or catapult or from bow of ship

Inadequate payload capacity for digital datalinks

Examples: Aerosonde, Scan Eagle, Sierra, Silver Fox, Mantra



Aerosonde release from its transport vehicle on the runway at the NASA Wallops flight Facility



APPLICATIONS

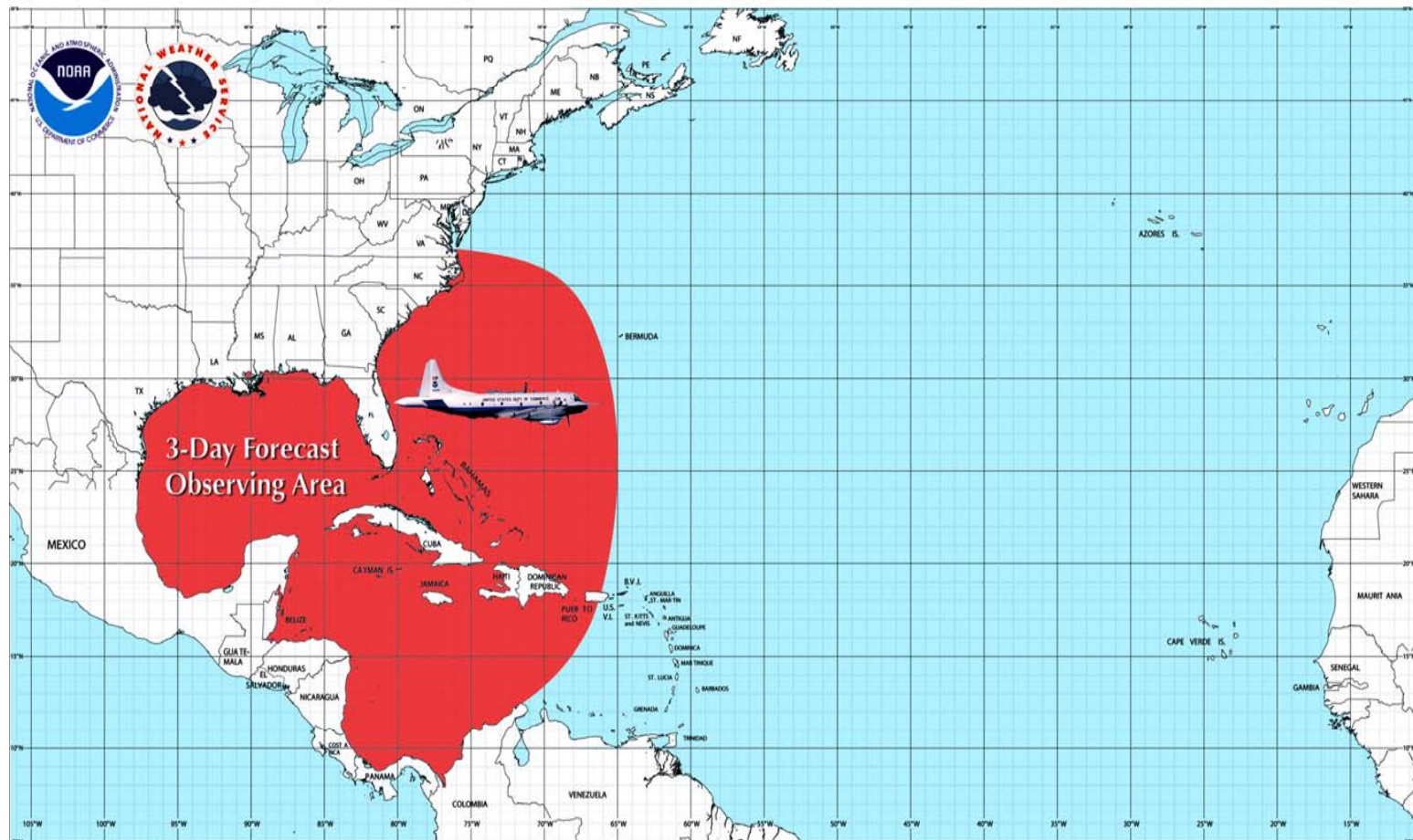
"dull, dirty & dangerous"



Hurricane Prediction



Extending Hurricane Prediction Lead Time

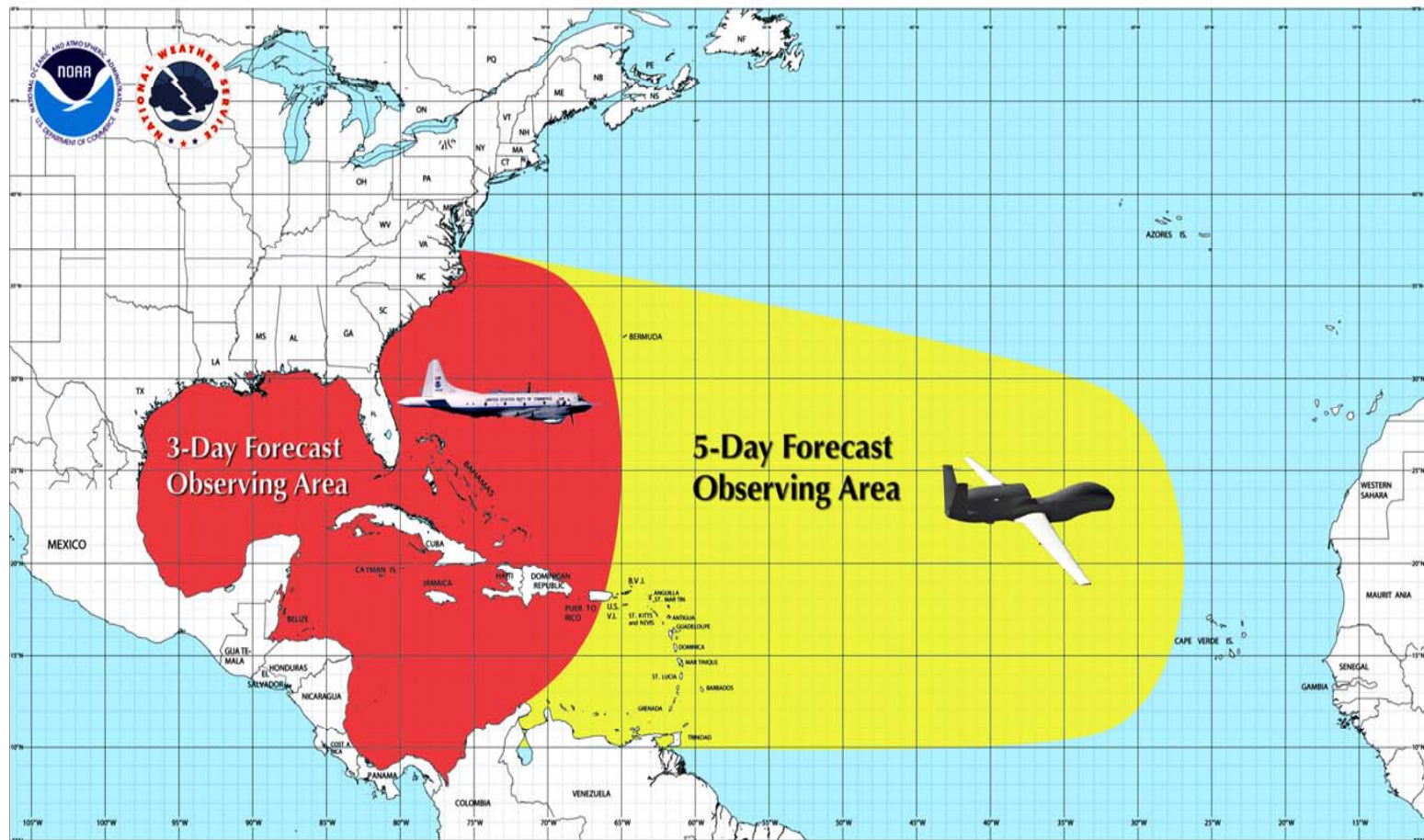


NO.

Hurricane Prediction



Extending Hurricane Prediction Lead Time



“Aerosonde” in Ophelia, 9/16/05



NASA Wallops Flight
Facility, Wallops Island,
VA. 7:30-5:30 EDT

NOAA satellite image of Tropical Storm
Ophelia taken on Sept. 16, 2005, at 9:15
a.m. EDT



“Aerosonde” in Ophelia, 9/16/05

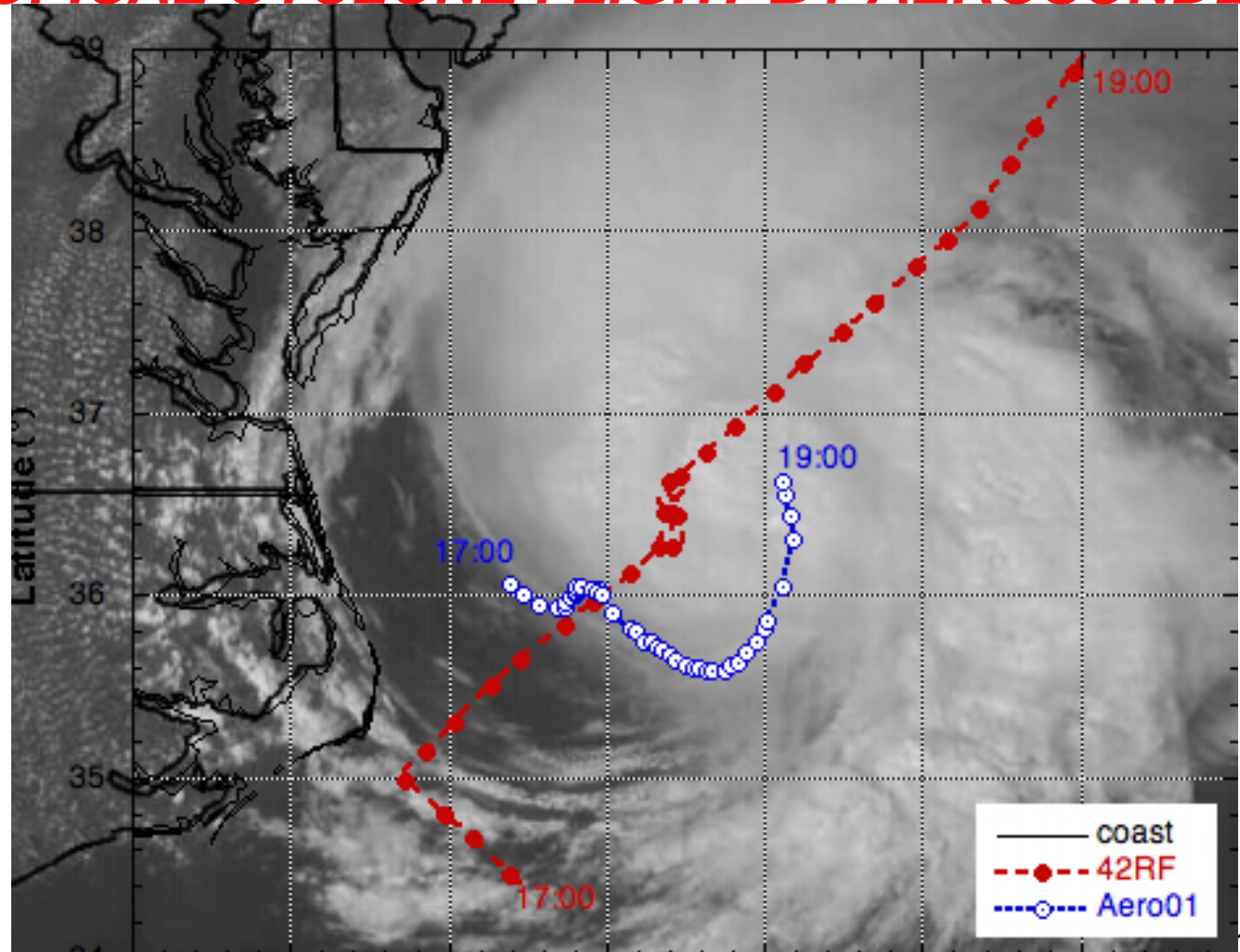


FIRST EVER TROPICAL CYCLONE FLIGHT BY AEROSONDE

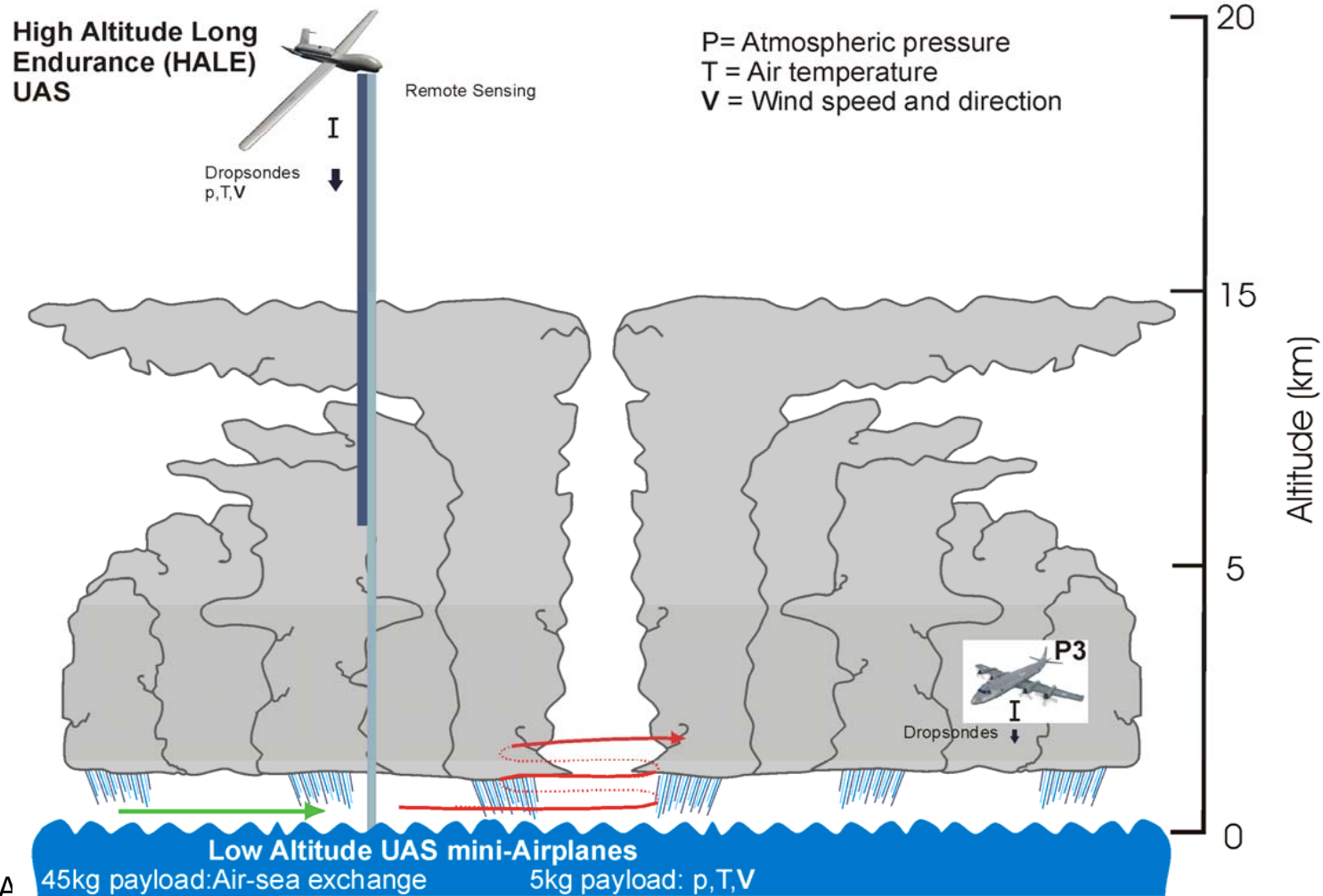
Satellite image of Tropical Storm Ophelia (intensity = 55 kt), with flight tracks shown:

Aerosonde (blue) just after WP-3D Orion (red) penetration across the eye

Courtesy of Joe Cione and Frank Marks (OAR/AOML)



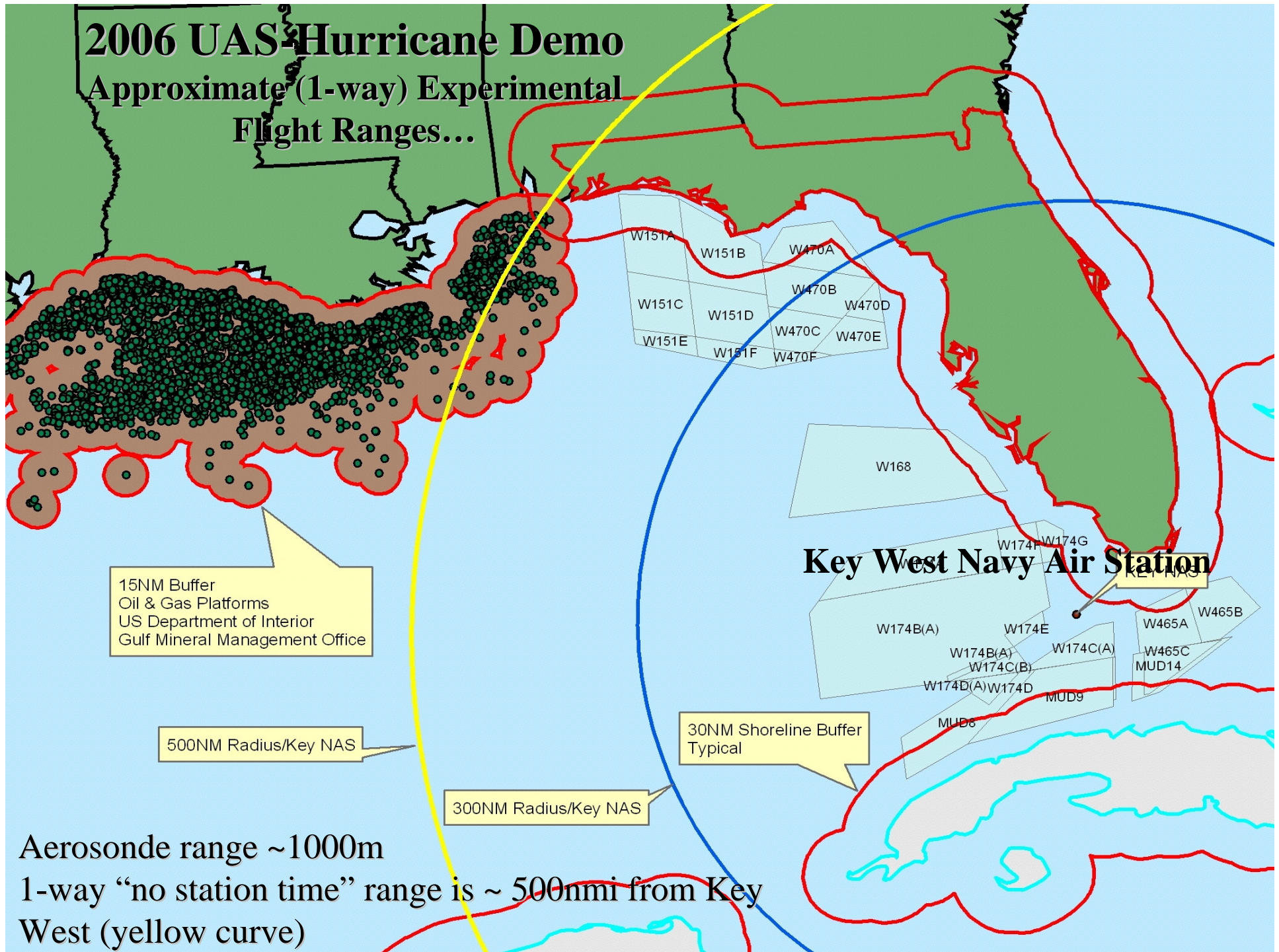
Hurricane Prediction



NOA

2006 UAS-Hurricane Demo

Approximate (1-way) Experimental Flight Ranges...



15NM Buffer
Oil & Gas Platforms
US Department of Interior
Gulf Mineral Management Office

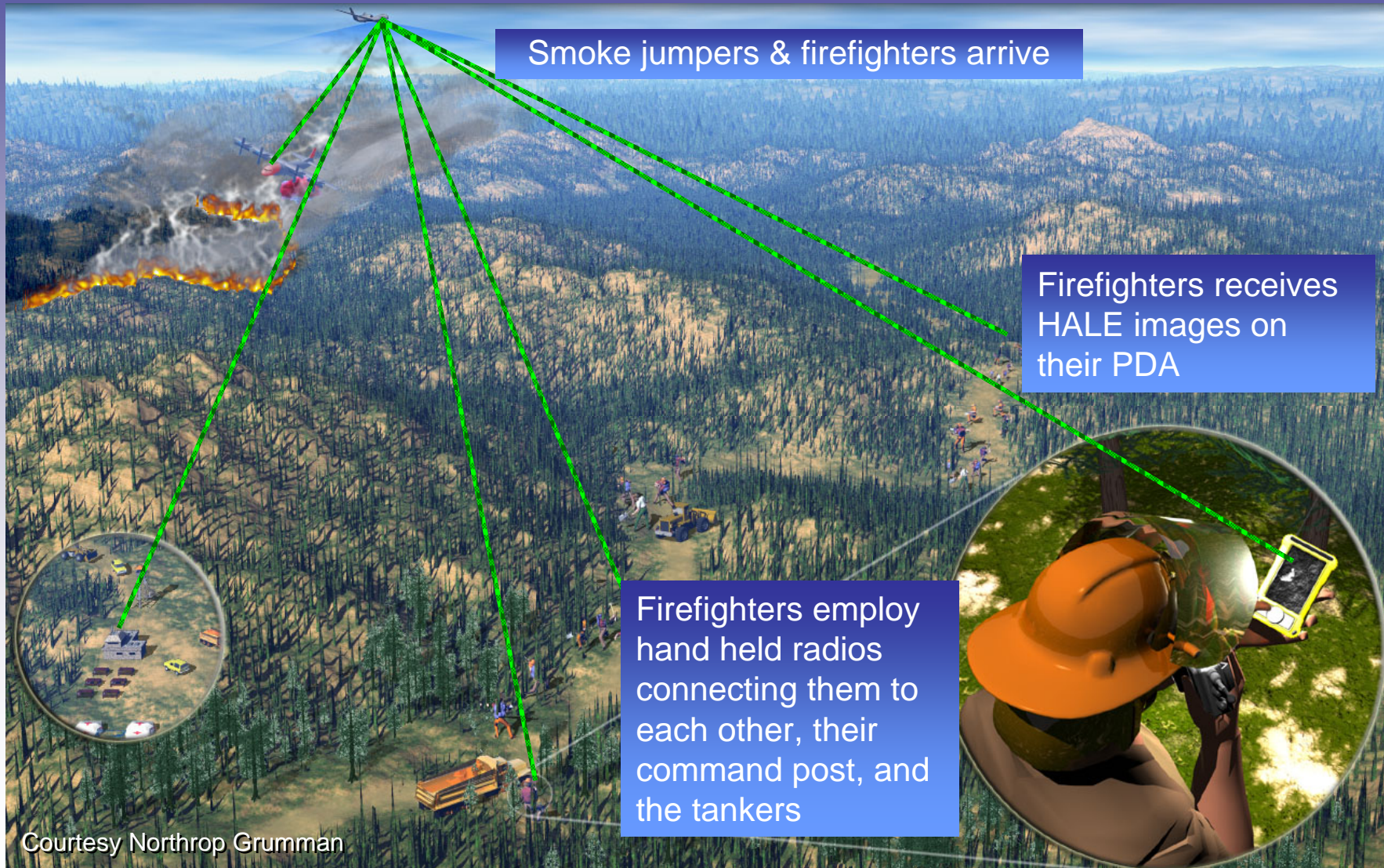
500NM Radius/Key NAS

300NM Radius/Key NAS

30NM Shoreline Buffer
Typical

Aerosonde range ~1000m
1-way "no station time" range is ~ 500nmi from Key West (yellow curve)

Fire Fighting Capability & Prediction



Smoke jumpers & firefighters arrive

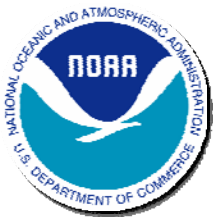
Firefighters receives HALE images on their PDA

Firefighters employ hand held radios connecting them to each other, their command post, and the tankers

Courtesy Northrop Grumman



NASA/USDA-FS Fire Mission



Summer 2006



NOAA's Inter

NASA/USDA-FS Fire Mission



- 23 hour flight **with** pod, 43K ft.
- 21 hour flight **without** pod, 48K ft. altitude
- continental NAS with FAA COA under new rules.

Mobilized for the October 28 **Esperanza, California fire which covered 40,200 acres- a category 1 fire (top priority). Four firefighters lost their lives**

The emergency flight was requested by the Incident Command Team, the State of California Office of Emergency Services, and the Governor's Office.





 **A UAS base would address Alaska's unique environmental threats.**
NOAA's International Arctic Campaign

Arctic Ice Melt



Existing Network:

Sparse network of **surface observations** in the Arctic

Satellite observations:

Geostationary ~38,000km above the equator

Instruments have constant view of mid-lats and tropics, but a limited view of the poles.

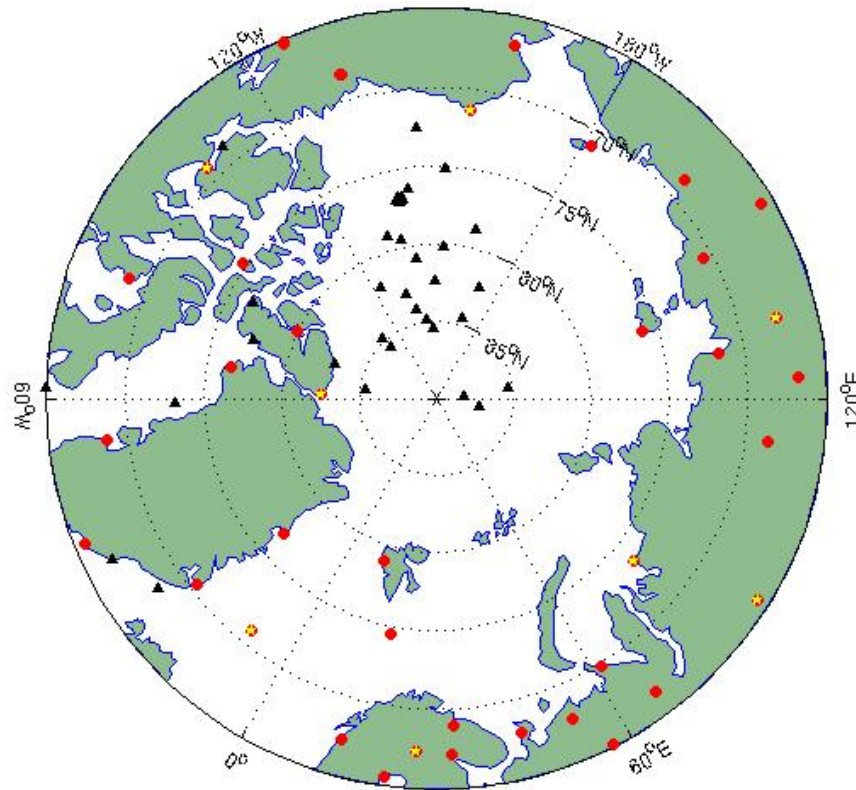
Polar orbiting ~800km

Capture more detail because of lower altitude but complete coverage takes time.

But difficulty in distinguishing between clouds and ice because radiative properties are similar – clouds and snow/ice have similar temperatures and similar albedos.



Arctic Surface Observing Stations and Buoys



Black Triangles: International Arctic Buoy Program (IABP) Buoys
Red Dots: Global Climate Observing System (GCOS) points



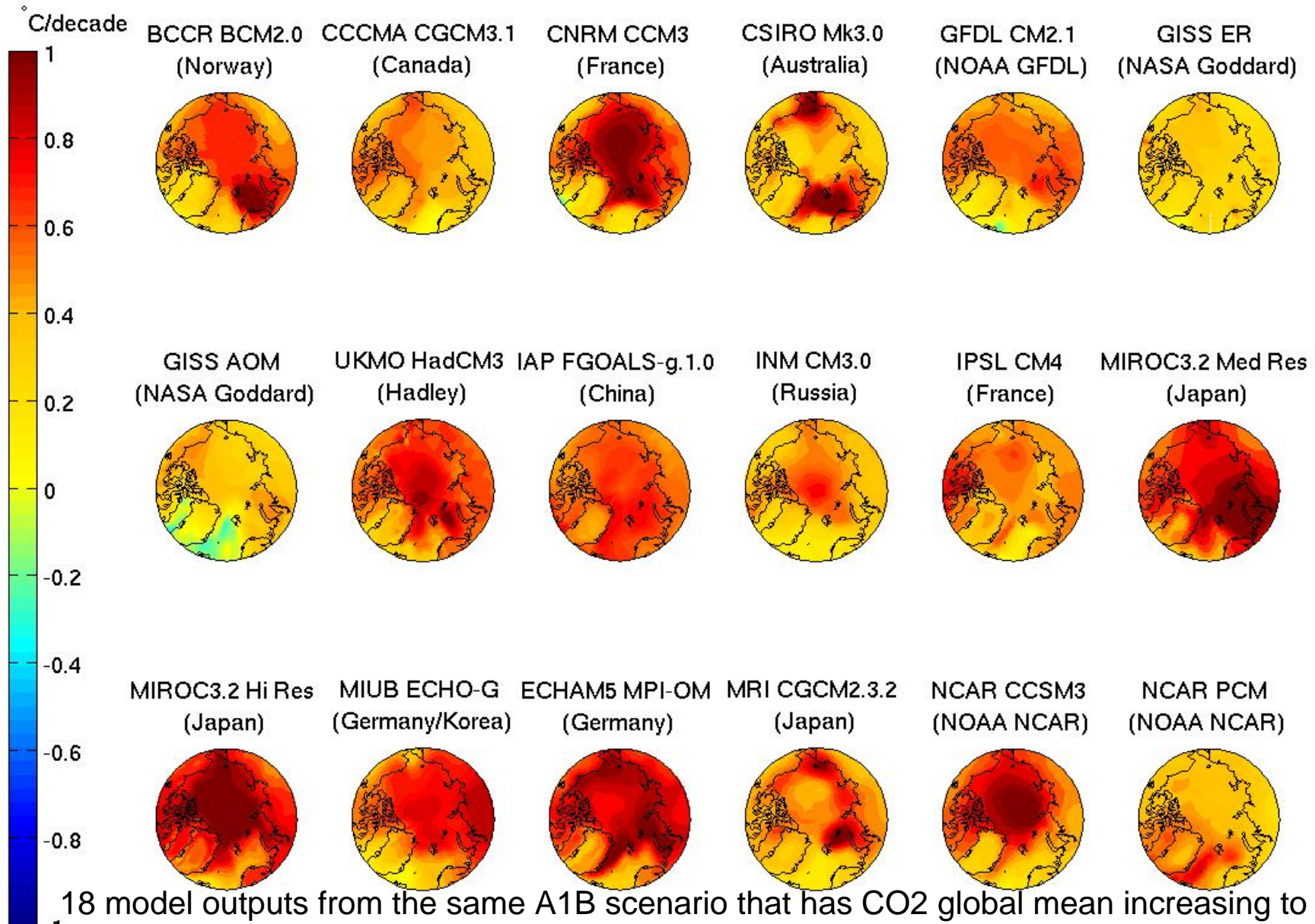
Ice Thickness Remains a Problem



5-10 cm

much thicker

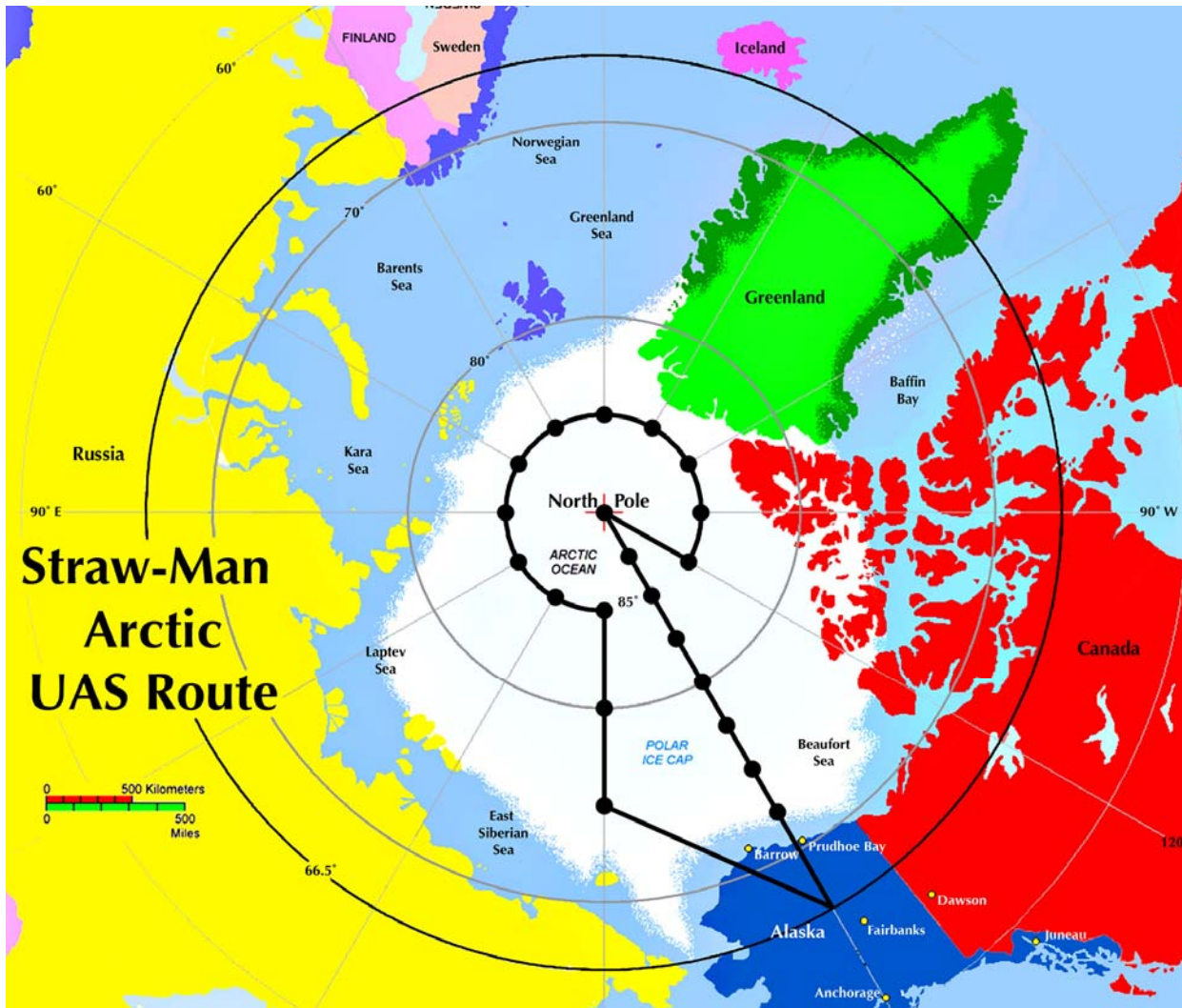
Surface Temperature increase in C/decade, from 2000-2100



18 model outputs from the same A1B scenario that has CO₂ global mean increasing to 720 ppm by 2100 (current global mean ~ 380ppm).

Darkest red = 1 C/decade (10C/century), Yellow = 0; green is slightly negative, and due to ocean circulation changes.

Arctic Ice Melt



“Strawman” route for HALE UAS over the Arctic ice. Profiles of state variables and forcing are made at the 20 points shown. Under each point is a AUV to observe the temperature, salinity and ice depth at the same geographic point.

Unmanned Aircraft Systems

UAS Test Beds



Arctic



Pacific



Hurricanes



UAS Research Applications in Alaska



Fisheries



**Arctic Ice monitoring
strawman route**



Mammal Monitoring



**Transboundary Air
Pollution from Asia**



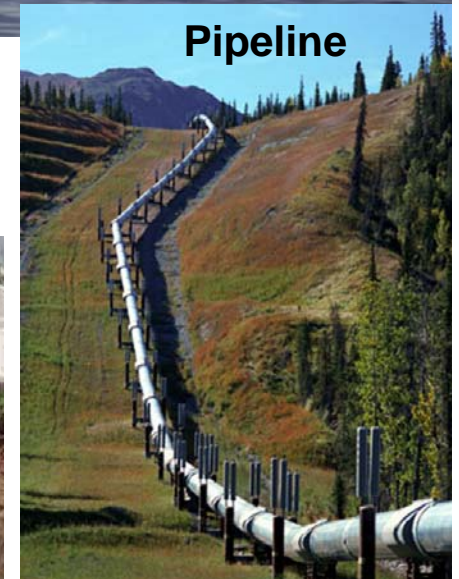
Wild Fires



Coastal Erosion



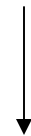
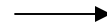
Pipeline



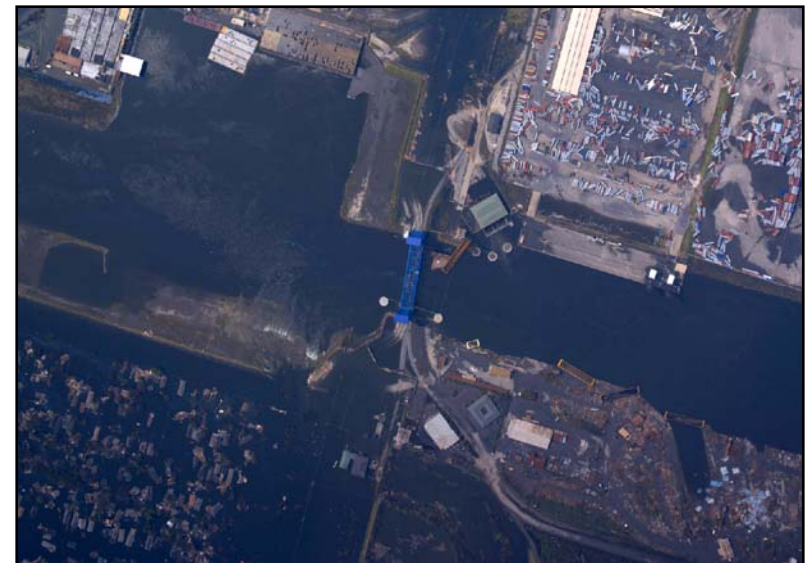
UAS Applications in the Gulf Region



Hurricane
Forecasting



Hurricane aftermath
Katrina (New Orleans)



Oil Platforms



Dead Zone

(harmful algal blooms)

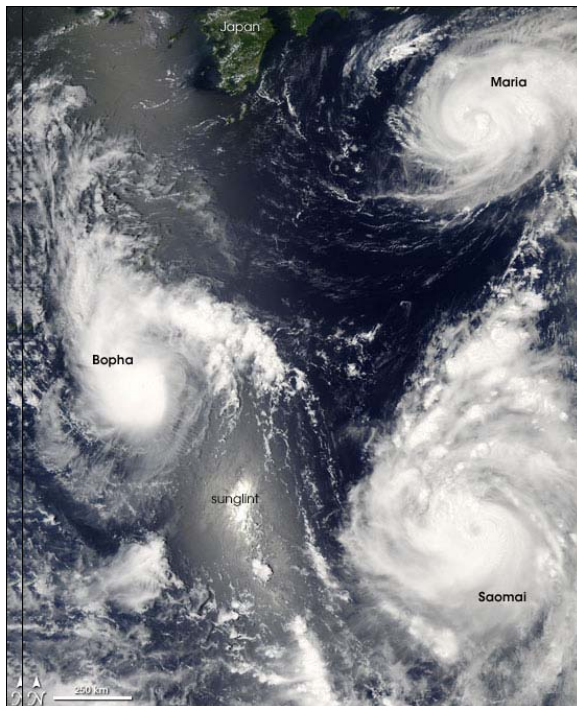


NOAA's International Arctic Campaign

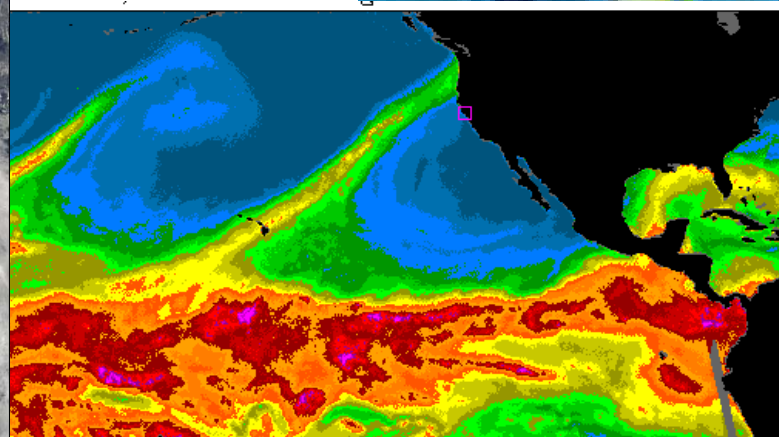
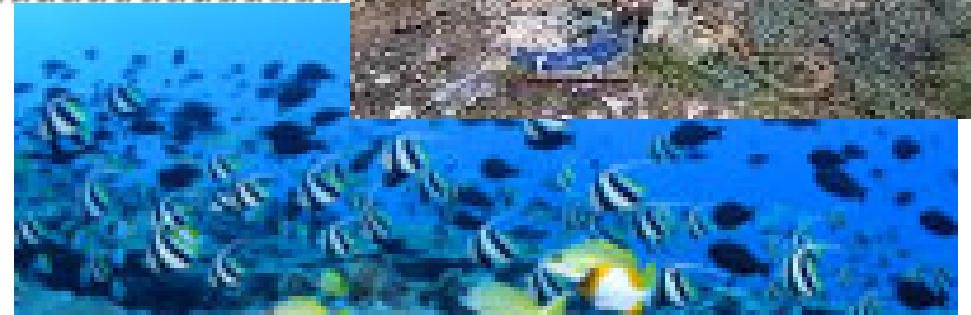
UAS Applications in the Pacific (35% of earth's surface)



Northwest Hawaiian Islands Marine National Monument: world's largest marine sanctuary and one of the most pristine marine ecosystems in the world, nearly untouched by humans. 1,400 miles long, 100 miles wide, and home to more than 7,000 species, many seen nowhere else in the world



**Pacific Typhoon
(August 7, 2006)**



Atmospheric River

Feb 2006, Point Upolu,
Hawaii, NOAA NMSP
Silver Fox and Manta
Project to monitor marine
mammals

TESTS



Tropical Storm
Ophelia Sept 2005,
NASA Wallops
Aerosonde launch



Altair Mission, Channel Islands and
eastern Pacific, 2005



3M in 2008
President's budget



QUESTIONS ?



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