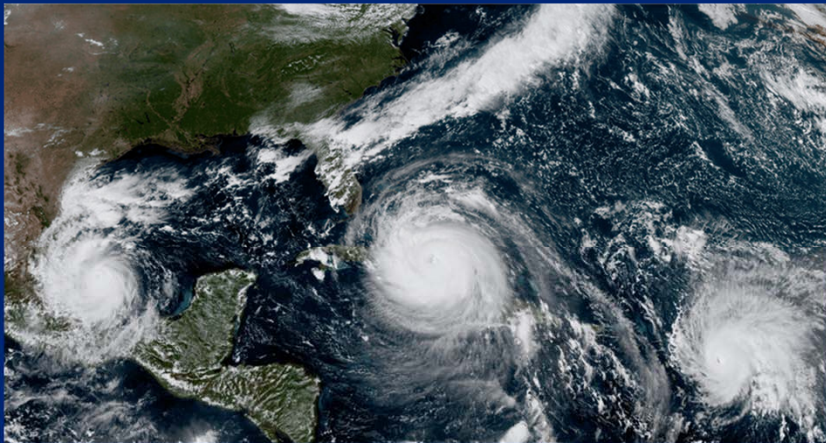


2017 Hurricane Season: How NOAA Reduced Risk, Saved Lives, & Aided in Recovery



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Introduction

- First thank you to our sponsor, **Senator Thune, Chairman** of the Senate Commerce Committee and each of you for joining us today.
- Purpose of today's conversation is to share some of the critical **data, products and services NOAA provides to your constituents before, during, and after a storm**. To illustrate the value of those services, we will focus on the recent **Atlantic** hurricane season.
- Because NOAA's **partners** are absolutely essential to our work, I've **invited** several colleagues to join me for today's panel discussion.

■INTRODUCE AND THANK THE PANEL

■**Jeffry Evans**, Meteorologist-in-Charge, NWS Houston/Galveston Weather Forecast Office

■**CDR Chris Kerns**, NOAA Corps Hurricane Hunter Pilot

■**Bryan Koon**, Vice-President, Innovative Emergency Management (former Florida emergency-management director)

■**Rear Admiral Peter W. Gautier**, Director of Governmental and Public Affairs, US Coast Guard

- Our plan is to **talk for about 40 minutes** and then leave ample time for questions and discussion.

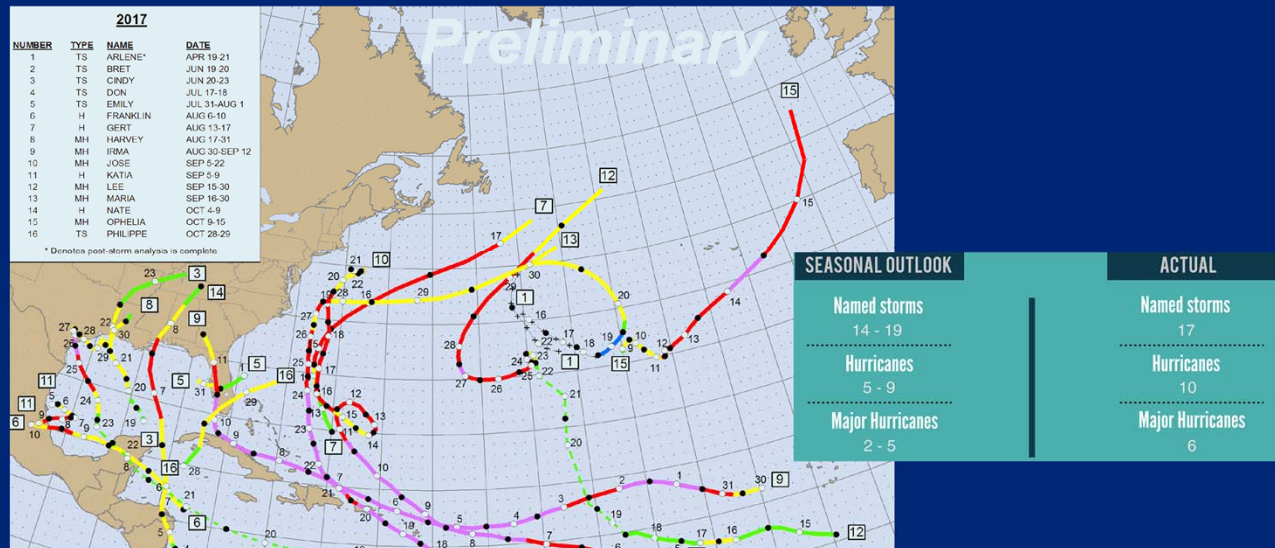
- Before we start talking about NOAA's services, I want to acknowledge that despite the best efforts of local communities, the 2017 hurricanes and their aftermath claimed the **lives of hundreds of individuals.**
- There is an ongoing humanitarian crisis in Puerto Rico and US Virgin Islands where the situation remains dire: only about **half of Puerto Rico residents have seen power restored. Our thoughts are with those** are still struggling to get food, water and shelter, and I assure you that NOAA continues to strive to help communities across our Nation to respond to the 2017 season and become better prepared and more resilient.
- **I personally empathize from my Katrina experience**

Key Message

I want to thank you and the members of Congress who have helped in so many ways to improve over the last 5 years after Hurricane Sandy

hope is that you walk away today with a better understanding of the critical role NOAA plays in keeping people safe and protecting livelihoods during and in the aftermath of natural disasters such as hurricanes. From preparedness to response to recovery, NOAA strives to save lives and property and get the economies moving again. The services we provide as a valued partner, that are recognized and depended upon by other agencies such as FEMA, U.S. Coast Guard, and state and local agencies.

2017 Hurricane Season



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Active 2017 Atlantic Hurricane Season

- The 2017 hurricane season produced
- **17 named storms of which**
- **10 became hurricanes, and**
- **6 became major hurricanes.**
- **Our seasonal outlook in May was close (right)**
- **Highest ACE on record**
- **A lot of Purple and Red**
- **Red Hurricane**
- **Purple lines in the left image were the Major Hurricanes (Category 3 or higher)**
- Throughout this devastating hurricane season, dedicated NOAA employees – spanning multiple lines and offices – provided live coverage of the storms and vital forecasts and data that helped save many lives.
- The proof is in the results -- As an example, this year **NWS successfully launched new Storm Surge Watches and Warnings in 2017 for the Atlantic and Gulf** coasts of the U.S. Despite three landfalling category 4 hurricanes, there are currently **no known deaths resulting from storm surge** in the United States.

Reducing Risk

Restored Marsh



Habitat Conservation & Restoration



- **Almost half of the nation's population lives near the coast**, and these areas are at **more risk from severe weather** such as hurricanes and floods. Communities are looking for more safe, effective, and affordable approaches to coastal protection.
- Compared to **2012 when Sandy hit**, **5 million more people live in** the coastal communities of the Gulf and Atlantic states

Shoreline Restoration Reduces Damages

- According to a new **study in *Scientific Reports***, conserving and restoring coastal reefs, wetlands, and mangroves can prevent flooding and save hundreds of millions of dollars in storm damage. It reports that **wetlands protected areas of the East Coast from more than \$625 million in direct flood damages from Hurricane Sandy in 2012**. Wetlands **reduced damages by more than 22 percent in half of the affected areas and by as much as 30 percent in some states**.
- **NOAA has an extraordinary team of environmental engineers, conservation biologists, and ecological experts who are running Programs to rebuild marshes, beaches, and breakwaters**

- **and I've seen the success of these efforts first hand**, here's me with NMFS' habitat conservation team in Bayou Dupont LA in Dec, standing on a restored marsh that was underwater 4 years ago - obviously a more effective Hurricane storm surge barrier
- Since **1995, NMFS and partners have implemented over 300 wetland and coastal habitat restoration projects in the Caribbean, South Florida and Gulf of Mexico - all areas that were impacted by 2017 hurricanes.**
- When compared to adjacent sites that were not stabilized, **NOAA restoration sites a mitigated further erosion** which reduced additional sedimentation of coral reef habitats while **also protecting adjacent infrastructure (i.e., roads).**
 - **Texas** restoration projects in the path of Hurricane Harvey generally sustained little to no damage.
 - In **Louisiana**, **ten recent large-scale coastal wetland protection** projects implemented through the **Coastal Wetlands Planning, Protection and Restoration Act** Program sustained little or no damage during Hurricanes Harvey and Nate.
 - The third landfall of Harvey passed over the Louisiana **Oyster Bayou project during construction**; however, only a small amount of material was lost and construction was able to quickly resume.
 - In the **Caribbean**, the paths of both Hurricanes **Irma** and **Maria** crossed multiple (up to **100**) **watershed restoration projects** located throughout the US Virgin Islands and Puerto Rico. These projects are focused on stabilizing steep and eroding terrain to prevent sedimentation to nearshore habitats and generally appear to have sustained minor to no damage.
- **It's also important to note: most hurricane deaths are due to storm surge, so this work also saves lives, which gets me to my next slide**

Saving Lives

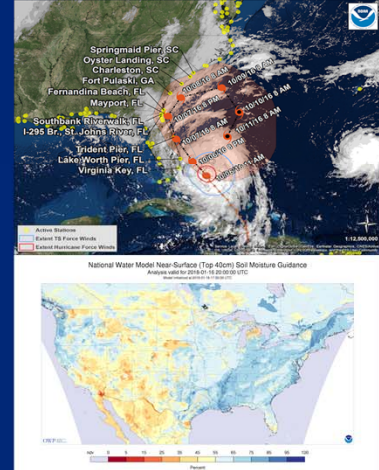
Embedding With EMs



Critical Observations



Advanced Warnings



Saving lives is a core NOAA mission

And every NOAA line office had a hand in doing this this year

- Left: NWS WFO Houston is co-located in the county EM Building and that connection resulted in many early life saving evacuations Benefits of co-location include:
 - We can address the media through **joint press conferences** which enhanced clarity of message.
 - We can provide **more timely weather predictions during natural hazards such as floods, tornadoes, and man made disasters such as chemical plant releases or train derailments.**
 - We are better able to support first responders with information through the emergency management channels.
 - I met these EMs in Houston when I visited last week, and heard **nothing but praise for that WFO's forecasters, who I also met**
 - i also met, **Jeff Evans, MIC** from the Houston/Galveston WFO will **speak more about the integral work at that forecast office in a few minutes.**
 - Another extraordinary example of our improved relationship with EMs, or Irma, **FL Governor declared a state of emergency 6 days in advance**

- Middle: **NESDIS' GOES-16 (launched in FY17) Already Providing Crucial Data**
 - **It's also important to note: most hurricane deaths are due to storm surge** conducting **operational checkout**, data from NOAA's GOES-16 satellite proved vital in forecasting operations for Hurricane **Maria** as it neared **Puerto Rico** on September 20, 2017. **Two FAA doppler radar** in San Juan were disabled at 5:50 a.m. EDT, just before Maria made landfall, forecasters were able to utilize data from GOES-16, to track the storm in real-time.
 - Google GOES-13 vs GOES-16 and you will understand we call **GOES-16 a 4-dimensional imaging spacecraft**
 - With higher resolution information from GOES-16, NWS forecasters in **Corpus Christi, Texas, tracked the eyewall of Hurricane Harvey** to alert emergency managers when they would have a **safe window of opportunity** (as the eyewall was passing over the region) to evacuate **200 people** before the back end of the hurricane struck.
 - **OMAO flight crews and scientists flew a combined 622.7 hours and flew nearly 40,000 miles - equal to flying cross country and back 17 times - in 2017** to provide vital data to scientists for improved modeling and forecasting, ensuring an accurate forecast provided to the public.
 - **This data reduces hurricane track error by 15-20%**
 - **CMDR Chris Kerns is here today to tell you a little more about the great work of our Office of Marine and Aviation Operations**
- Right: These **satellite and aircraft data fed our models, which were used by the NWS NHC and our WFOs**
 - Upper right, you see a **storm surge quick look from NOS for Hurricane Irma** which depicts the NHC track and storm surge predictions for key locations on the FL coast
 - **First, let's talk about NHC track forecasts: Preliminary data show that 2017 NHC Atlantic track forecasts set record low errors at all time frames** and, for the **three landfalling category 4 hurricanes, the track errors were about 25 percent below the most recent 5-year mean errors.**
 - We are still working on improving forecasts of **intensification** but did see some notable success. One such case occurred about **36 hour before Harvey's** landfall, when the NHC forecast Harvey to become a high-end category 3 hurricane before reaching the Texas coast. This forecast captured Harvey's rapid intensification and was only **5 kt below the landfall intensity** -- a remarkable forecast for such a quickly changing situation.

- Lower right: here we have a depiction of **NOAA's National Water Center's recently**
It's also important to note: most hurricane deaths are due to storm surge
National Water Model
 - It's used to **compute river flows and critical water budget** variables (e.g. snowpack, soil moisture) across the continental United States.
 - This was a **huge development** in view of **Harveys** record setting flooding **20,000 year flood**
 - New flood maps provided to FEMA by the National Weather Service using
 - the National Water Model for the inland areas where river flooding dominated
 - and NOS storm surge quicklooks for the coasts
 - Both were improved by data from GOES-16 and NOAA-NASA Suomi NPP,
 - allowed **local officials and teams** on the ground to quickly determine where to employ limited resources, plan for **evacuations**, and determine where to focus their recovery efforts.
 - They also help local officials determine **when it is safe for people to** return home.
- In November, the National Water Center released its preliminary version of volume 11 of NOAA's Precipitation Frequency Atlas #14 for Texas for peer review. NOAA scientists calculate precipitation frequency estimates using the statistical analysis of historical precipitation data. The updated estimates in Volume 11 contain the latest data from Hurricane Harvey, and will supersede those currently available for Texas from the 1960s and 1970s. These estimates are used by **engineers and planners** for a wide variety of **design and planning activities** under federal, state, and local regulation. NOAA Atlas 14 is also used to **delineate and manage development in floodplains** for the **National Flood Insurance Program**. These updates follow **policies set forth by FEMA -billion-dollar decisions for states and counties**

Aiding Recovery

Aerial Surveys



Waterborne Rescues



Debris Removal



Coral Triage



NOAA Programs are in the sky, on the ground, and on the water helping communities recover

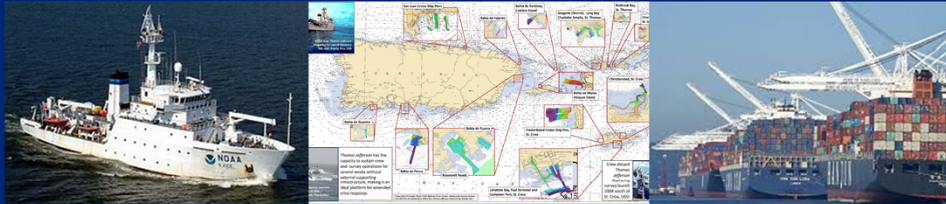
- Left: I visited our King Air aircraft last week in Austin during AMS that performed aerial surveys in TX, FL, PR, and USVI used by EMs and citizens to know when and by what routes they could access their residences and places of business
- Middle: **not only did we help guide EMs** in rescues with our weather and water information, we actually had 6 NOAA employees in **NMFS' Galveston Lab** use their boats to **rescue 24 people, (and a pig!)** I was thrilled to meet them last week.
- Right:
 - The **Florida Keys and the Florida peninsula** were hit hard by Hurricane Irma. NOAA initiated several rapid response efforts to help communities recover, including a **Florida Sea Grant project to recover commercial lobster** traps in the Florida Keys and a project to recover misplaced and sunken vessels. NOAA is tracking more than **3,500 recreational vessels and large debris items in Florida, Puerto Rico and U.S. Virgin Islands** that pose potential navigation and hazardous material threats.
 - NOAA quickly assessed coral reefs after the storm and identified where emergency restoration could save the reefs. We improved the chances of recovery of severely damaged reefs through rapid triage, selective stabilization of storm generated coral fragments (for example, nearly 1000

Elkhorn coral have been rescued), and uprighting of large coral heads tumbled by storms. We were able to do this thanks to **NFWF support of \$250K to rapidly assess and stabilize coral reefs in Florida, Puerto Rico, and USVI.**

- NOAA also formed a unique partnership with **Force Blue**, which gives former combat divers and Special Operations veterans a chance to learn about and explore coral reefs and to adapt their training to aid in their protection. This new partnership took root in **Florida** during initial coral assessment and emergency restoration activities in October 2017. This effort was very successful and NOAA asked the group to join teams working on reefs in **Puerto Rico**. Force Blue began that portion of the mission in early November and concluded in December 2017.

Economic Impacts

Opening Ports and Reestablishing Maritime Commerce



Assisting with the Restoration of Coastal Economies



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Ports Back in Business More Quickly With NOAA Support

- NOAA provided crucial information and expertise before, during and after all of the storms.
- **As soon as weather permitted, NOAA began aerial survey missions to assess damages to areas affected by the hurricanes. The data we collected were rapidly processed and provided to emergency responders and coastal managers, often within hours of collection. Hurricanes Harvey, Irma, and Maria more than 65,000 images were collected, covering the same area as the State of Maryland (9774 sq miles).**
- NOS also provided **emergency hydrographic services** at affected port areas. This data was used to detect potential hazards that could delay the delivery of emergency supplies and maritime commerce and help the U.S. Coast Guard to make decisions on reopening ports. **I visited Port Houston last week, and they lose \$670M a day when fog or hurricane debris blocks the channel, they are one of In total, NOAA helped reopen over 26 ports OCS biggest fans, Corpus Christi and Miami \$100M / day**
- **All told, 26 ports**

Restoring Coastal Economies

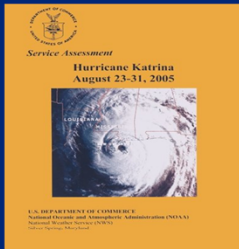
- I visited **Grand Bay, MS National Estuarine Research Reserve** the day the photo on the left was taken. More than 2M people annually visit the NERRS, providing

\$20M annually in direct benefits, and another \$10M in science and research economic impacts. NERRS contributes about \$5M in education relief offsets, educating over 83,000 children; and offsets more than \$13M in training for more than 66,000 people.

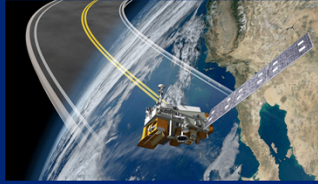
- Across all **national marine sanctuaries**, **about \$8 billion annually** is generated in local coastal and ocean dependent economies from diverse activities like commercial fishing, research and recreation/tourism-related activities. The bottom middle photo is from **Florida Keys National Marine Sanctuary**, which like over 700,000 people per year, I enjoyed an opportunity to dive and contribute nearly **\$500M** to the local economy.
- NOAA Fisheries worked with fishermen to relieve some reporting requirements after the hurricanes.
 - **Federal dealers in affected areas were released from weekly ticket reporting** requirements, and individual fishing quota participants who did not have access to electronic reporting were allowed to submit paper forms.
 - After Harvey and Irma the requirements were suspended for about a month.
 - NOAA Fisheries is assisting state agencies in **Texas, Florida and the USVI with a rapid appraisal of impacts** to fishing communities. Fieldwork in Florida (over **1600 interviews** conducted) and Texas (**over 800 interviews** conducted) has been completed. The USVI and Puerto Rico assessments are ongoing. Additionally NOAA Fisheries has initiated a comprehensive **assessment of aquaculture operations at the request of FEMA and Florida Department of Agriculture**.

Improving Performance

Post Storm Assessments



NOAA Satellites



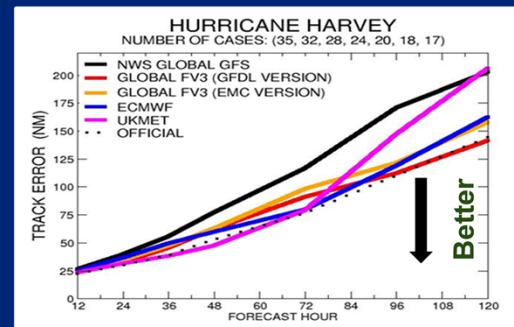
UxS observations



Fleet & Aircraft Recapitalization



FV3: Next Generation Weather Model



Post Storm Assessments

- After major storms, we collect information to continually improve our operations and services. We focus on **best practices and learn from missed opportunities**. Recent assessments have shown the need for increased **social sciences** integration into operations.

NOAA Satellites

- NOAA **GOES S Launch** March 1, 2018.
- This new satellite can deliver vivid images of severe weather as often as every 30 seconds,
 - **scanning the Earth 5 x t faster, with**
 - **4 x greater image resolution and**
 - **3 x spectral channels.**
- The first, **GOES-R (now GOES-East)**, keeps an eye on the continental United States and the Atlantic Ocean.
- **GOES-S will be operational as GOES-West**, providing coverage of the western U.S., Alaska, Hawaii and the Pacific Ocean.
- Together, GOES-East and GOES-West will observe Earth from the **west coast of Africa all the way to Guam**

Unmanned Systems:

- These new technologically advanced tools are expanding our knowledge of the environment while minimizing the potentially harmful human footprint that we leave behind when studying remote areas and the sensitive plants and animals that live there.
- NOAA Researchers **deployed unmanned aircraft and underwater gliders** this hurricane season to gather data that could potentially **boost forecast skill**.
- This hurricane season, NOAA joined with NASA to fly the unmanned **NASA Global Hawk ahead of and above Hurricanes Franklin and Harvey**.
- Scientists also launched six small drones, called **Coyote, from a NOAA WP-3D Orion Hurricane Hunter** during Hurricane **Maria** to collect unique data from **within the eyewall** in the **lower part of the storm where** it gains strength from the **ocean**.
- NOAA also launched underwater gliders in the waters north and south of Puerto Rico to better understand how the upper ocean contributes to hurricane intensity
- Over the next months and beyond, scientists will analyze data from these unmanned systems in an effort to improve prediction and preparedness for future hurricane seasons.

Fleet and Aircraft Recapitalization

- NOAA's fleet of research ships, managed by the Office of Marine and Aviation Operations, currently comprising 16 ships, is expected to decline to untenable numbers over the upcoming decade due to aging ships reaching their end of expected service life. The ability of NOAA to meet at-sea data requirements utilizing NOAA ships will diminish **50 percent by 2028, based** on the current composition of the NOAA fleet. Several concurrent fleet recapitalization efforts are underway to address this issue and maximize NOAA observational infrastructure capabilities.
- NOAA operates a fleet of nine aircraft that perform NOAA's prioritized airborne data collection requirements in support of weather research, air chemistry, water research, hydrology forecasting, protected species management, and emergency response. Aircraft recapitalization is required due to the aging aircraft fleet, single points of failure critical to the Nation's products and services including hurricane tracks, and increasing emergency response and water resource data requirements. NOAA is in process of clearing for release the Aircraft Recapitalization Plan, outlining NOAA's current and future airborne observational infrastructure needs.

Research and Development Continues To Build Next Generation Weather Models

- Experimental models being developed at NOAA Research labs produced impressive results this hurricane season and promise for important gains in future years. These models will be further tested, refined and transitioned to day-to-day operations.
- NOAA's experimental Global Forecast System, or fvGFS, exceeded all other global models in forecasting the track of Hurricane Maria. FvGFS is powered by the NOAA Research-developed Finite-Volume Cubed-Sphere **Dynamical Core or FV-3, which**

is transitioning to operations to become the heart of NOAA's next generation Global Forecast Model.

- The **experimental**, basin-scale version of the operational Hurricane Weather Research and Forecasting (HWRF) model, supported by HFIP, was run in real time for Hurricane Harvey. **Tail Doppler radar wind data** collected from the NOAA P-3 aircraft was assimilated into this system for the first time. Apart from near-perfect track predictions, the basin-scale HWRF accurately captured the rapid intensification of Harvey over several cycles in advance of the system's landfall.
- The NOAA Research experimental High Resolution Rapid Refresh model, HRRRx, also showed great promise for future improvements to NOAA's only high resolution, hourly updating forecast model that can resolve weather down to the level of individual thunderstorms. Preliminary evaluations showed that HRRRx, developed by NOAA's Earth System Research Lab, accurately predicted the path of Hurricane Harvey as well as the location and amount of record rainfall from the storm. It also predicted the timing and location of Hurricane Irma's landfall 28 hours in advance.
- While these models come to the forefront of discussions during hurricane season, it is important to note that NOAA scientists are working around the year and around the clock to improve weather prediction models by increasing the accuracy of hurricane intensity forecasting and tracking over even longer timescales.

Summary



Reducing
Risk

Saving
Lives

Aiding
Recovery

Improving
Performance

- To conclude, I want to point out that **its not just supercomputers, satellites, ships and aircraft**
- it's about the **most extraordinary team of professionals in the Federal Government** .
- Left to Right:
 - Ms. Pat Montanio of NMFS leads a dedicated and passionate team to restore habitat that protects animals and people from storm surge; these people do the heavy lifting of making marshes, breakwaters, and beaches
 - Mr. Greg Mandt, Director of the Joint Polar Satellite System, is overseeing procurement of four next generation polar orbiting satellites and ground system supporting these plus multiple other polar satellites. These new platforms are revolutionizing the way we understand and predict weather.
 - Dr. Ed Rappaport, the Acting Director of the National Hurricane Center, spearheaded a tremendous effort by the entire NWS team that was directly responsible for saving countless lives through their forecasts and warnings and work with media and emergency managers.
 - CAPT Nancy Hann, Aircraft Operations Center Commanding Officer, who led the crews that flew into the storms to provide data that was critical for forecasters to issue warnings, but also the aerial surveys I talked about earlier
 - Rear Admiral Shepard M. Smith, Director of the Office of Coast Survey,

which surveyed 18 port facilities and conducted emergency repairs to three tide and weather stations to assure safe passage of commerce.

- Dr. “Ram” Ramaswamy, Geophysical Fluid Dynamics Laboratory (GFDL) Director -- Under Dr. Ramaswamy's scientific research leadership, GFDL produced one of the world's most innovative weather and climate modeling systems.

- All told, the **NOAA Team hit a grand slam at what was a true world series of a hurricane season**
- **I thank you and your members for the support and appropriations** that enabled NOAA to serve Americans in harm's way,
- and that will **allow us to get even better in the future.**