The Department of Defense (DoD) & CEDAR

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UNITED STATES MILITARY ACADEMY
WEST POINT

PURPOSE/AGENDA

DEPARTMENT OF PHYSICS AND NUCLEAR ENGINEERING
UNITED STATES MILITARY ACADEMY

Purpose: Provide the students of CEDAR a brief introduction to opportunities within the DoD focused on the service academies, military graduate schools and one of many military units.

Service Academies

- United States Military Academy
- United States Naval Academy
- United States Air Force Academy
- United States Coast Guard Academy

Military Graduate Schools

- Naval Post Graduate School
- Air Force Institute of Technology

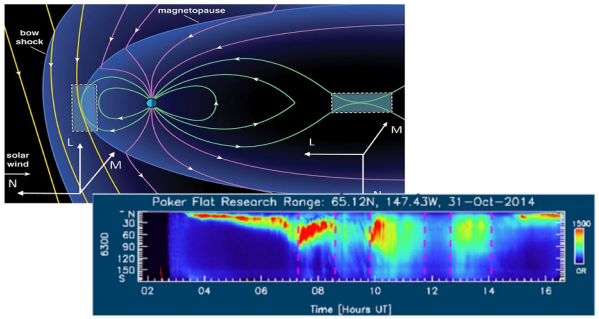
Military Units

- 557th Weather Wing
  - 2nd Space Weather Squadron
- Fleet Numerical Meteorological and Oceanographic Center (FNMOC)

United States Military Academy, West Point

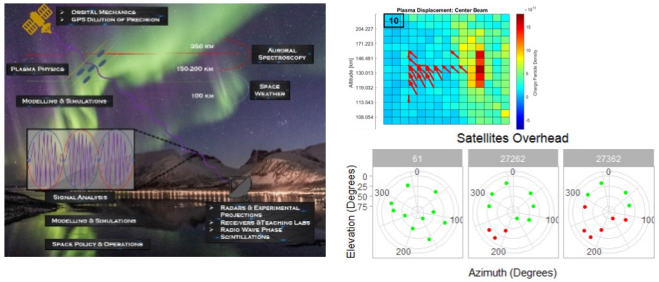
Sun vs Earth:

Can we determine the timing of the onset of field aligned current flow? Is it by dayside magnetic merging or nightside magnetic reconnection?



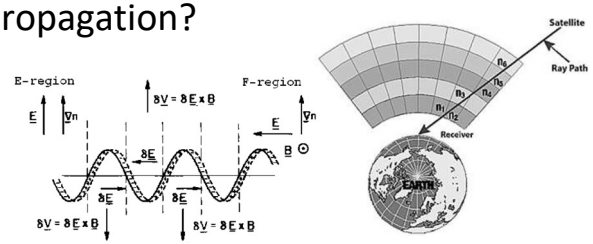
GPS vs the Aurora

What is the physics of GPS scintillations in the auroral oval and can we devise a global metric for GPS signal scintillations, akin to the Richter Scale?



Modeling the GDI:

Can we use an approximate Riemann solver to model plasma structuring caused by Gradient Drift Instability (GDI) to more accurately understand the effects on radio wave propagation?



Other Space at West Point

- Balloon Satellites
- Cube Satellites
- Debris Mitigation*
- Sounding and Hypersonic Rockets
- Geospatial Information Sciences
- Bioastronautics
- Lunar Rover Robotics

Opportunities

1. Developing leaders
2. Lead your own research
3. Scholarship and teaching
4. National and international collaboration
5. Conferences and travel
6. Community outreach
7. Leading faculty and undergraduate research
8. Hosting summer internships
9. Space Experiments Review Board (SERB) presentations

POC: Colonel Diana Loucks, diana.loucks@westpoint.edu

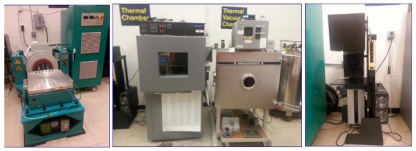
U.S. NAVAL ACADEMY SMALL SATELLITE PROGRAM (NASSP)

Mission

- Provide midshipmen full-range of hands-on space system development experiences
  - Satellite Design
  - Bus and payload development, integration, and testing
  - Mission Operation
- Guide students regulatory/validation procedures
- Research for future space technology

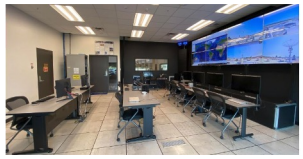
Facilities

Satellite Fabrication/Qualification



Shaker Table | Thermal & Thermal Vacuum Chambers | Solar Simulation

Satellite Mission Operations Center



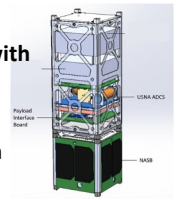
Rooftop Antenna Farm

12-meter Antenna

Recent Projects

USNA-16

- Modular CubeSat with 1U standard bus
- ADCS payload
- Payload integration

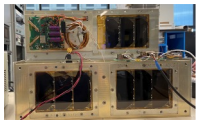


RSAT

- 3U CubeSat in ISS Microgravity Science Glovebox
- Demonstrate on-orbit robotic assembly and repair of spacecraft

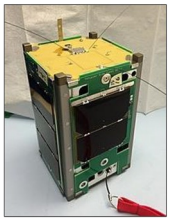
PSAT-3

- Integrated APRS command and control
- PPOD size payload, on upper stage rocket body



BRICSAT-2

- Amateur radio transponder
- Micro-cathode electrical thrusters from George Washington University

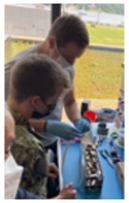


CDIO (Conceiving – Designing – Implementing – Operating (CDIO)

USNA Satellite Mission Operations

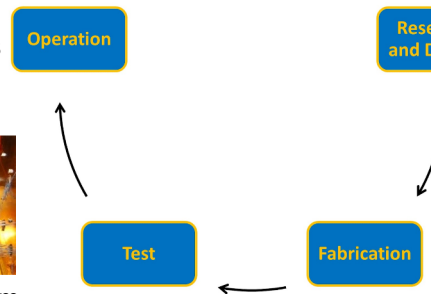
RSat Concept

RSat Prototyping



RSat Build

Thermal Vacuum Testing



Concluding Remarks

- Naval Academy Small Satellite Program developed a USNA standard bus geared towards student education
- Students are still students: challenges are there, but we have some good practices
- Amateur radio a critical component to student projects
- Certain lower-tech, but more-robust design features can greatly benefit student satellite development experiences
- Having data relay transponders in space enables other remote- sensing student projects in other engineering disciplines

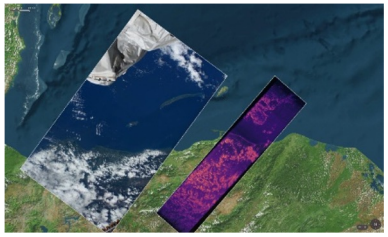
Ocean/Arctic Buoys (Naval Architecture)

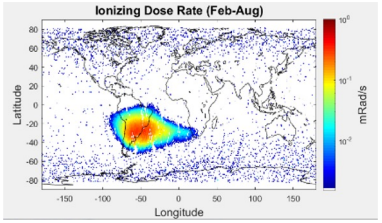
Original Presentation:
https://www.nasa.gov/sites/default/files/atoms/files/kang_bruninga_nassp_presentation_s3vi_webinar_series_14_nov_2019.pdf

U.S. AIR FORCE ACADEMY – SPACE PHYSICS & ATMOSPHERIC RESEARCH CENTER (SPARC)

- **Mission**
  - Provide cadets the "ah-ha" moment in learning by working on a "real" DoD space research project
  - Revolutionize science payloads with aggressive miniaturization
  - Maximize cadet involvement in Project
  - Spaceflight: Space science payloads
  - Laboratory: Plasma discharge
  - Field: Aurora, Sprites
  - Basic research tied to solutions for real USAF/USSF needs

- **Spaceflight Experiments**
  - SPARC has flown 25 science missions since 2003 inception
  - All rides provided by DoD Space Test Program (STP)
  - Cadets brief Space Experiments Review Board (SERB) to get ranked
  - Favorite ride is the ISS
  - Science includes
    - Miniaturized plasma sensors
    - Ionospheric physics
    - Use of AI for "big data" sets
    - Space radiation dosimetry
    - Neuromorphic imagery of lighting and sprites

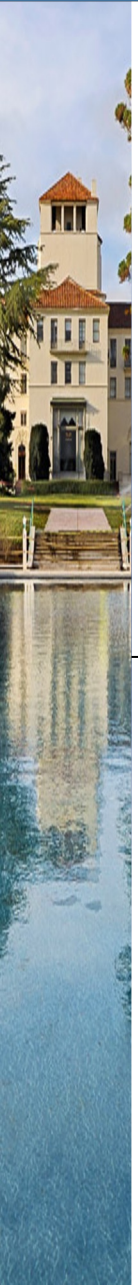




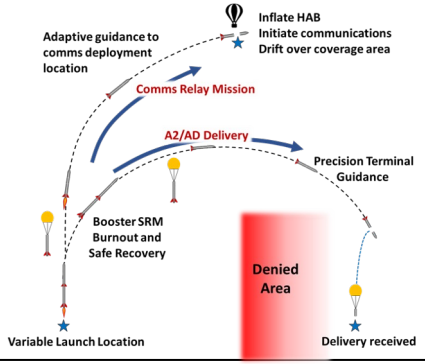
- **Laboratory and Field Experiments**
  - High-altitude weather balloon flights
  - Neuromorphic camera mounted on telescope to track satellites
  - Auroral effects on ionosphere using high speed cameras and photometers
  - Ground support of NASA sounding rocket
  - Testing Hall thrusters in plasma chamber
  - Dynamics and energetics of sprites & lightning

- **Outreach Programs**
  - The Air Force has number of programs eligible for new PhDs
    - Air Force Office of Scientific Research (Basic Research) runs them (see details in URL)
    - Young Investigator Program
    - Historically Black Colleges and Universities and Minority Program
    - Center of Excellence Program
    - Summer visiting faculty
  - National Research Center Post Doc and visiting faculty
    - SPARC is eligible for both

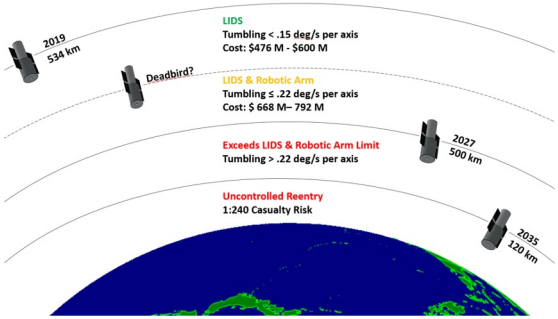
NAVAL POSTGRADUATE SCHOOL



- **Rocket Propulsion Laboratory:**
  - **Designing and developing 2-stage rocket system to achieve maximum altitude and deploy comms relay in situations for anti-access/areal denial (A2/AD) environments. It is considering altitudes above the Karman line, and therefore, analyzing space weather effects against the comm relay.**

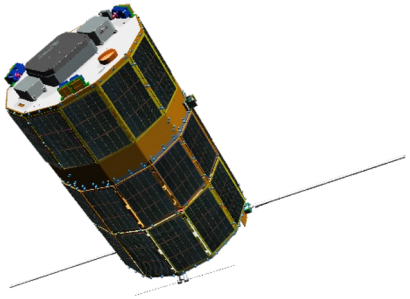


- **Space Systems Simulations:**
  - **Effects of spacecraft and space debris due to space weather are analyzed. As an example, the Hubble Space Telescope's End of Life (EOL) trajectory is currently under multiple simulations as it expected that the telescope will breakup but not completely burn up upon re-entry. The casualty risk is assessed to be approximately 1:240 (significantly below the NASA threshold of 1:10000)[1].**



- **CubeSat Laboratory:**
  - **NPS continues to conduct small satellite projects as part of DoD to test spacecraft technology, investigate space weather, evaluations of radio communications, and rocket test platforms to deliver CubeSats at near-space altitudes.**

The NPSAT1 mission is a small satellite project manifested for launch aboard a Falcon Heavy launch vehicle in 2019 as part of the Department of Defense (DOD) Space Test Program's STP-2 mission.



https://nps.edu/web/ssag/research

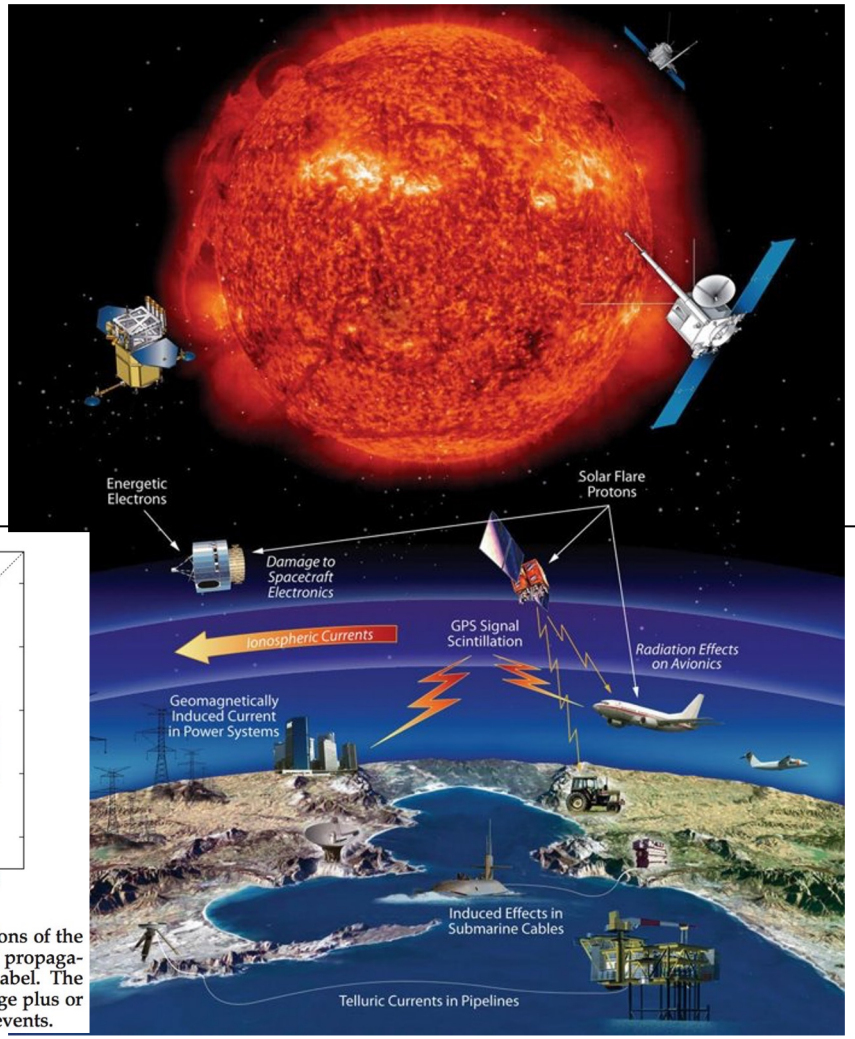
Space Weather Research:

NPSAT1 Mission Objectives:

1. Provide a "vehicle" for graduate education in Space Systems Engineering and Space Systems Operations
2. Provide a platform for space weather experimentation in ionospheric physics
3. Provide a platform for spacecraft technology demonstration

AIR FORCE INSTITUTE OF TECHNOLOGY (AFIT)

- **Graduate school for the Air Force**
  - Awards both PhD and MS degrees
  - Located at Wright Patterson Air Force Base, OH
    - Mostly military but has civilians
  - MS Applied Physics - Space Physics Track
  - Graduates Typically work at:
    - 557th Weather Wing Space Weather Operations Center (SpaceWOC)
    - NOAA Space Weather Prediction Center (SWPC)
    - Joint Space Operations Center (JSpOC)
    - Air Force Research Laboratory (AFRL)
    - Radio Solar Telescope Network (RSTN)



SPACE WEATHER, VOL. 11, 95–106, doi:10.1002/swe.20019, 2013

Ensemble forecasting of coronal mass ejections using the WSA-ENLIL with CONED Model

D. Emmons,[1,2] A. Acebal,[1] A. Pulkkinen,[3,4] A. Taktakishvili,[3] P. MacNeice,[3] and D. Odstrcil[3,5]

Received 8 October 2012; revised 8 December 2012; accepted 14 December 2012; published 4 March 2013.

[1] The combination of the Wang-Sheeley-Arge (WSA) coronal model, ENLIL heliospherical model version 2.7, and CONED Model version 1.3 (WSA-ENLIL with CONED Model) was employed to form ensemble forecasts for 15 halo coronal mass ejections (halo CMEs). The input parameter distributions were formed from 100 sets of CME cone parameters derived from the CONED Model. The CONED Model used image processing along with the bootstrap approach to automatically calculate cone parameter distributions from SOHO/LASCO imagery based on techniques described by Pulkkinen et al. (2010). The input parameter distributions were used as input to WSA-ENLIL to calculate the temporal evolution of the CMEs, which were analyzed to determine the propagation times to the L_1 Lagrangian point and the maximum K_p indices due to the impact of the CMEs on the Earth's magnetosphere. The Newell et al. (2007) K_p index formula was employed to calculate the maximum K_p indices based on the predicted solar wind parameters near Earth assuming two magnetic field orientations: a completely southward magnetic field and a uniformly distributed clock-angle in the Newell et al. (2007) K_p index formula. The forecasts for 5 of the 15 events had accuracy such that the actual propagation time was within the ensemble average plus or minus one standard deviation. Using the completely southward magnetic field assumption, 10 of the 15 events contained the actual maximum K_p index within the range of the ensemble forecast, compared to 9 of the 15 events when using a uniformly distributed clock angle.

Citation: Emmons, D., A. Acebal, A. Pulkkinen, A. Taktakishvili, P. MacNeice, and D. Odstrcil (2013), Ensemble forecasting of coronal mass ejections using the WSA-ENLIL with CONED Model, *Space Weather*, *11*, 95–106, doi:10.1002/swe.20019.

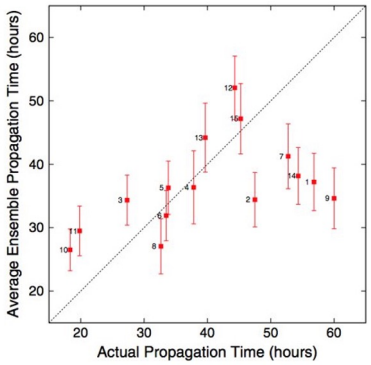


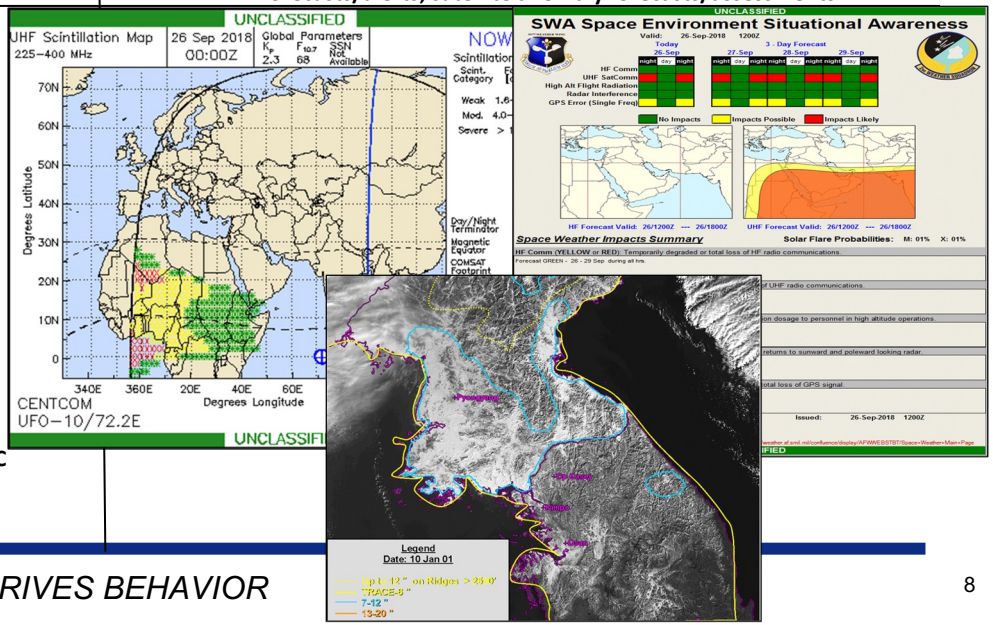
Figure 8. The averages and standard deviations of the propagation time ensembles versus the actual propagation times, with the event number as the label. The actual propagation time was within the average plus or minus one standard deviation for 5 of the 15 events.

2ND WEATHER SQUADRON

- Civilian Positions Overview
  - Positions at the 2 WS Space Weather Operations Center (SpWOC), Offutt AFB, Nebraska
    - DoD counterpart to the Space Weather Prediction Center (SWPC)
  - Currently four GS-12 level 1301 Series (Physical Scientist) positions
    - Expect to add two additional positions
    - Degree requirements: B.S. in physical science, engineering, or mathematics
      - Prefer space physics, space weather, or atmospheric physics background
    - Duty Title: Space Weather Operations Senior Duty Officer (SDO)
      - Leads DoD-driven space environmental forecasting and assessment operations floor
      - Conducts real-time and after-the-fact space environment anomaly assessments
      - Utilizes expertise to research and develop new capabilities for space weather support

- Four Duty Positions
  - Battle Management (BatMan), Electromagnetic Spectrum Operations (EMSO), and Orbital Warfare (OW) are filled primarily by Active Duty (AD) military personnel
  - Senior Duty Officer (SDO) filled primarily by Civilian personnel
    - SDO is trained and certified on all duty positions
- Senior Duty Officer
  - Area of Responsibility (AOR): Surface of the Sun to just outside GEO orbit
  - Equips the SpWOC BatMan, EMSO, & OW positions with the space environmental information necessary to tailor products in support of the warfighters
  - Responsibilities: Solar feature forecast coordination; solar wind forecast; SWPC coordination; system troubleshooting; product development/refinement

- Battle Management (BatMan)
  - Governing Sciences: Ionospheric Physics/Geophysics (HF propagation, geomagnetic storming)
  - Responsibilities: Geomagnetic forecasts/alerts; ionospheric forecasts; HF Electromagnetic Interference (EMI) forecasts/alerts; Over-The-Horizon Radar (OTHR) support.
- Electromagnetic Spectrum Operations (EMSO)
  - Governing Sciences: Electrodynamics/Wave Physics/Atmospheric Physics
  - Responsibilities: UHF EMI forecasts/alerts; EMI assessments; ground station/signal health forecasts; regional space/EM forecasts/analysis
- Orbital Warfare (OW)
  - Governing Science(s): Particle Physics/Astrodynamics (orbits, SEPs, spacecraft)
  - Responsibilities: SEP impact forecasts/alerts; satellite charging forecasts/alerts; satellite anomaly forecasts/assessments

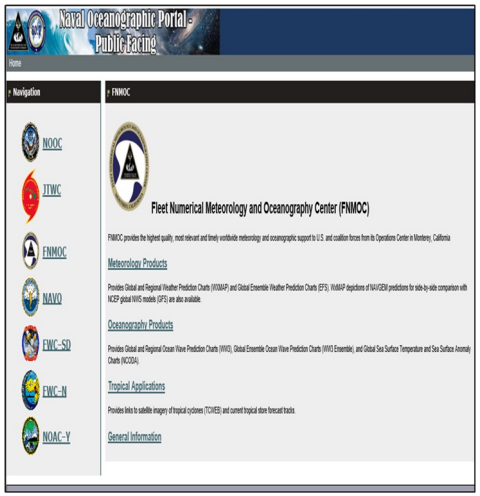


UNCLASSIFIED

WEATHER DRIVES BEHAVIOR

Fleet Numerical Meteorology and Oceanography Center (FNMOC)

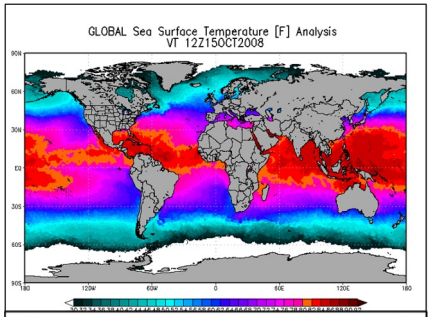
- **Purpose: Primary distributor of weather data for Navy and Marines**
  - Web-based products
  - Meteorology
  - Oceanography
  - Tropical Conditions
  - Navy Ice Center
  - Download afloat

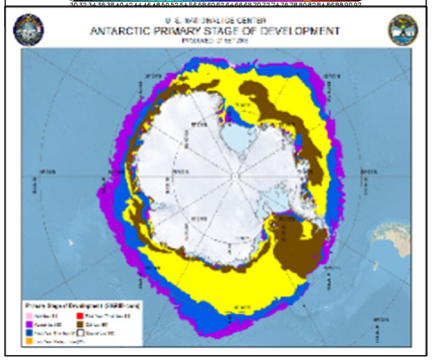


http://www.fnmoc.navy.mil

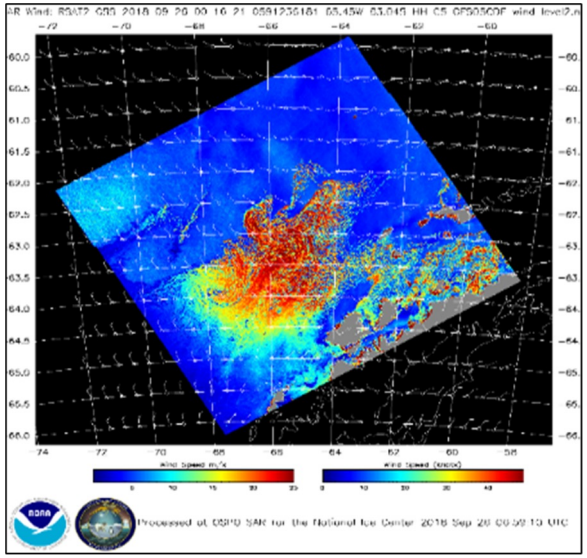
Forecast carrier operations, amphibious operations, and air operations.

- Wind speed analysis from satellites using SAR
- Snow and ice forecasts, particularly in the polar regions
- Ducting effects on RADAR
- Global sea surface temperatures
- Typhoon warnings globally

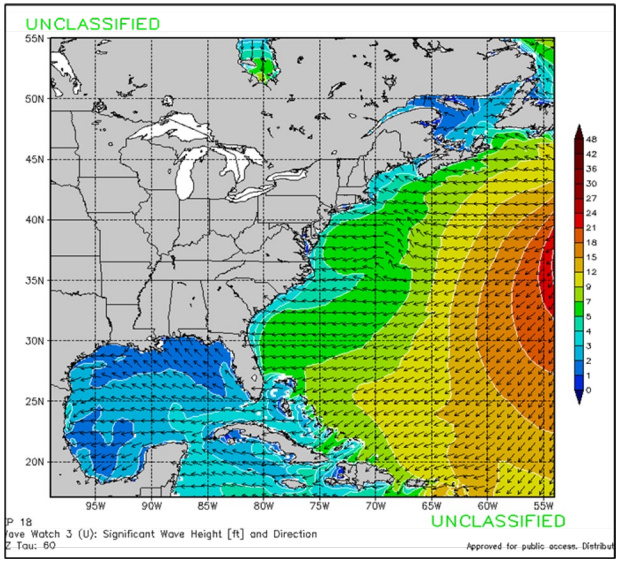




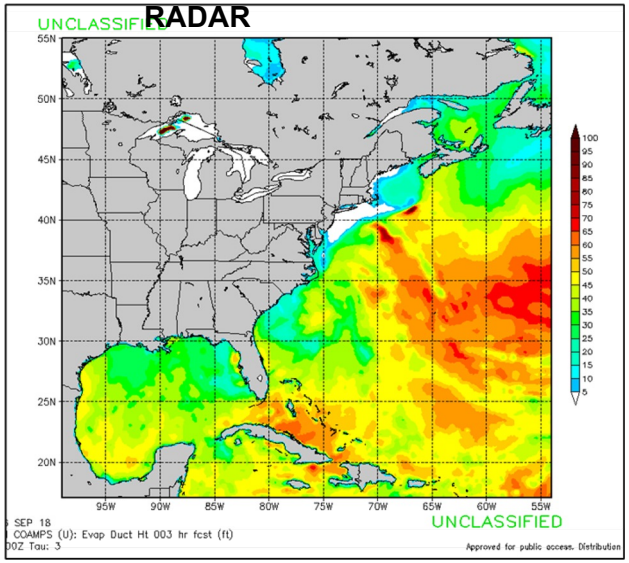
Wind Speed



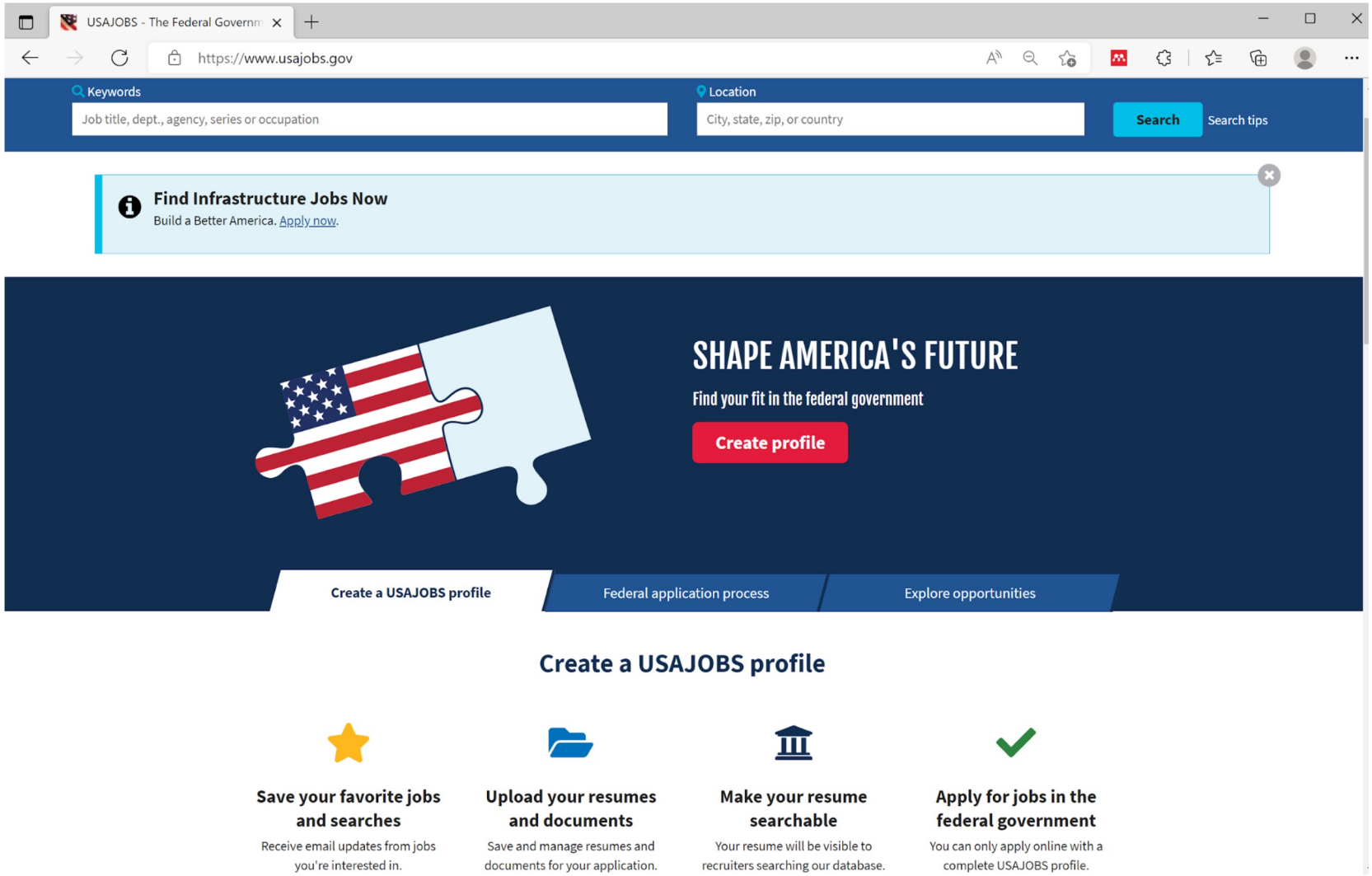
Wave Height



Ducting Effects on RADAR



USAJobs – your gateway



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