



Staff Meteorology Branch



AFLCMC... Providing the Warfighter's Edge



U.S. AIR FORCE

Weather for Acquisitions and RDT&E

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RPA Icing



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- **Icing is a serious problem for RPAs**
- **In 2012 the AF contracted 2 companies to design anti-icing equipment for retrofit on AF RPAs**
 - **Both companies got 2 rounds of SBIR funding at a cost to the AF of ~ \$1M**
 - **Retrofit would/will cost tens of millions**
 - **No solution has been found**
- **A Staff Meteorologist could have highlighted the icing threat early in the life cycle of the Predator or Global Hawk and the programs could have mitigated the icing threat during the design phase and avoided a costly retrofit!**



Overview



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- **Weather Parameters of Interest**
- **Weather Impacts**
- **Guidance**
- **XZIG Mission**
- **Staff Meteorologist (Staffmet) Services**
- **Available Weather Datasets**
- **Support Examples**
- **Staffmet Needs**



Weather Parameters Of Interest



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- **Terrestrial Weather**
 - Temperature
 - Humidity
 - Wind
 - Turbulence
 - Icing
 - Precipitation
 - Thunderstorms
 - Obscurants: dust, clouds, volcanic ash, etc.
 - Atmospheric Chemicals
- **Space Weather**
 - Radiation and charged particles



The Impacts Of Temperature



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- **Hot temperatures**

- Thermal aging, reduced viscosity, expansion
- Insulation failure, structural changes/stresses
- Thermal protective systems for re-entry and hypersonic flight



- **Cold temperatures**

- Ice formation
- Increased viscosity
- Physical contraction – structural stress/failure



- **Freeze / thaw cycling**

- Mechanical stress, seal leaks/damage, cracking



The Impacts Of Humidity



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- **Impact EO/IR sensor performance, directed energy transmission**
- **Special coatings may have limited ability to operate in areas of high humidity/precipitation**
- **Ice FOD occurs at high humidity/low temperatures i.e. F-16, B-1**
- **Carburetor icing at high humidity/low temperatures in Army unmanned aircraft**
- **Contrails give away aircraft locations**



The Impacts of Wind



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- **Wind shear**
 - Change in speed and/or direction horizontally and/or vertically impact flight performance
 - Space launch impacted by wind shear
- **Cross-wind**
 - Aircraft operationally limited on takeoff/landing
- **Wind can impact fuel load, loiter time**
- **Space launch operations limited by wind speed**





The Impacts of Turbulence



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- **Mechanical stress**
- **Structural failure**
- **Impacts stability of ISR sensors**
- **Impacts flight performance**



During Desert Storm this KC-135 lost both left wing engines after encountering wake-turbulence from an aircraft departing ahead of it.

The Impacts of Aircraft Icing

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- **Disrupts airflow over wings**
 - Increasing drag and decreasing lift
- **Interferes with control surfaces**
- **Damage engines as FOD**



B-1 on the ramp at Ellsworth, 2011.
De-icing required for bombers to
take off and strike Libya during OP
Odyssey Dawn.



The Impacts of Precipitation



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- **Freezing rain and drizzle**
 - Moderate to severe icing
 - Decreases flight performance
 - Can prevent take-off/landing
 - Can cause aborts/diverts
 - Impairs ground movement and activity
- **Frozen precip – snow, ice pellets**
 - Reduces traction for take-off/landing
 - Delays take-off/landings
 - Impairs ground movement and activity
- **Liquid precipitation**
 - Impacts composites
 - Reduces traction for take-off/landing
 - Impacts on-board radar and EO/IR ISR sensors
 - Impairs ground movement and activity





The Impacts of Thunderstorms



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- **Lightning**
- **Hail**
- **Precipitation**
- **Wind**



Army helo at Aviano after Severe Thunderstorm

- High speed/gusts, updrafts, downdrafts, microbursts, wind shear, dust storms
- **Turbulence**
 - Severe assumed in thunderstorms
- **Icing**
 - Severe assumed in thunderstorms



Tinker AFB 1948. Damage after first successful tornado warning

- **Tornadoes**
- **Visibility**

The Impacts of Lightning Strikes

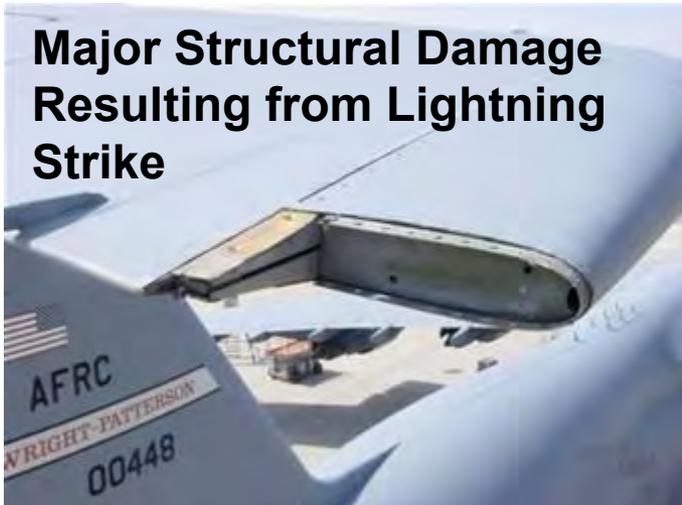
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**GOV Struck at Robins AFB
- 2012**



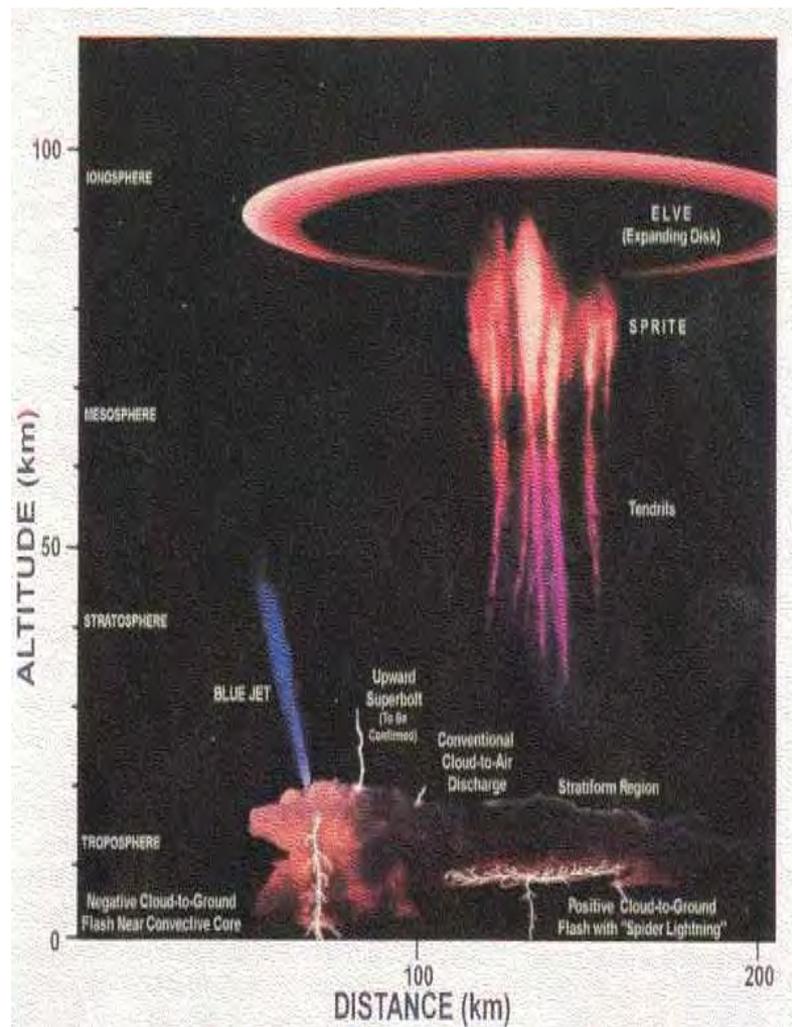
- **Physical Damage**
- **Laminate and composite construction require lightning mitigation systems due to differing conductivity of the materials used**

**Major Structural Damage
Resulting from Lightning
Strike**



- **HH-60 required demagnetization after lightning strike**

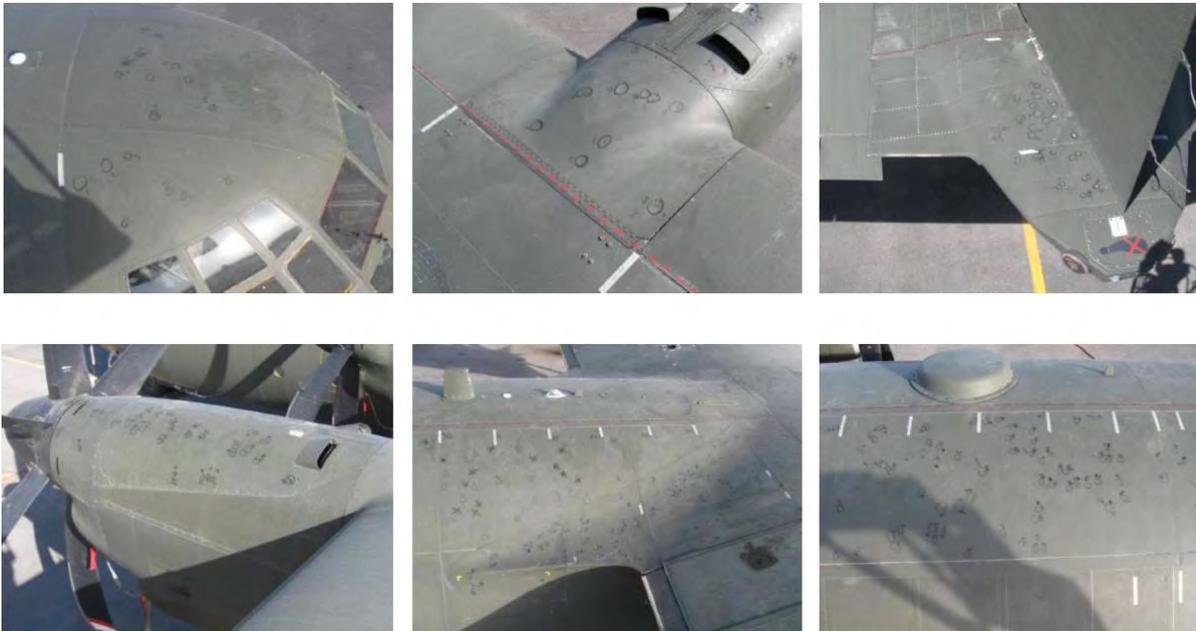
- **Blue jet similar to cloud to ground lightning bolts**
- **Sprites and Elves are visual phenomena**
 - **Potential sensor issues**



The Impacts of Hail

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- **Physical Damage**
 - Metal surfaces dent
 - Composite/laminate surfaces crack/are punctured
- **Impacts on-board radar and EO/IR ISR sensors**



Airmen testing an E-3 aileron for hail damage after 40 aircraft were damaged at Tinker AFB in 2008

5 UK C-130J damaged in Afghanistan 2013 ~\$16 M damage. Metal surfaces dented; composites penetrated



The Impacts of Obscurants



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- **Visibility reduction**
- **Degradation of EO/IR Sensing**
- **Degradation of directed energy weapons**
- **Engine wear**



C-17 on the ramp in Iraq, 2010.
Dust storm stopped all air traffic.



B-1 on the ramp at Ellsworth, 2011.
Fog lifted allowing bombers to strike
Libya during OP Odyssey Dawn.



The Impacts of Obscurants

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Brownout

MV-22 Hover taxi



MV-22 Brownout Landing





The Impacts of Obscurants



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- **Volcanic Ash**
 - Ash can seize engines causing loss of thrust
 - Poisonous gases
 - Ablation
 - Reduction to visibility/invisible at night



2009 Deployed to Holloman after Red Flag due to volcanic activity in AK

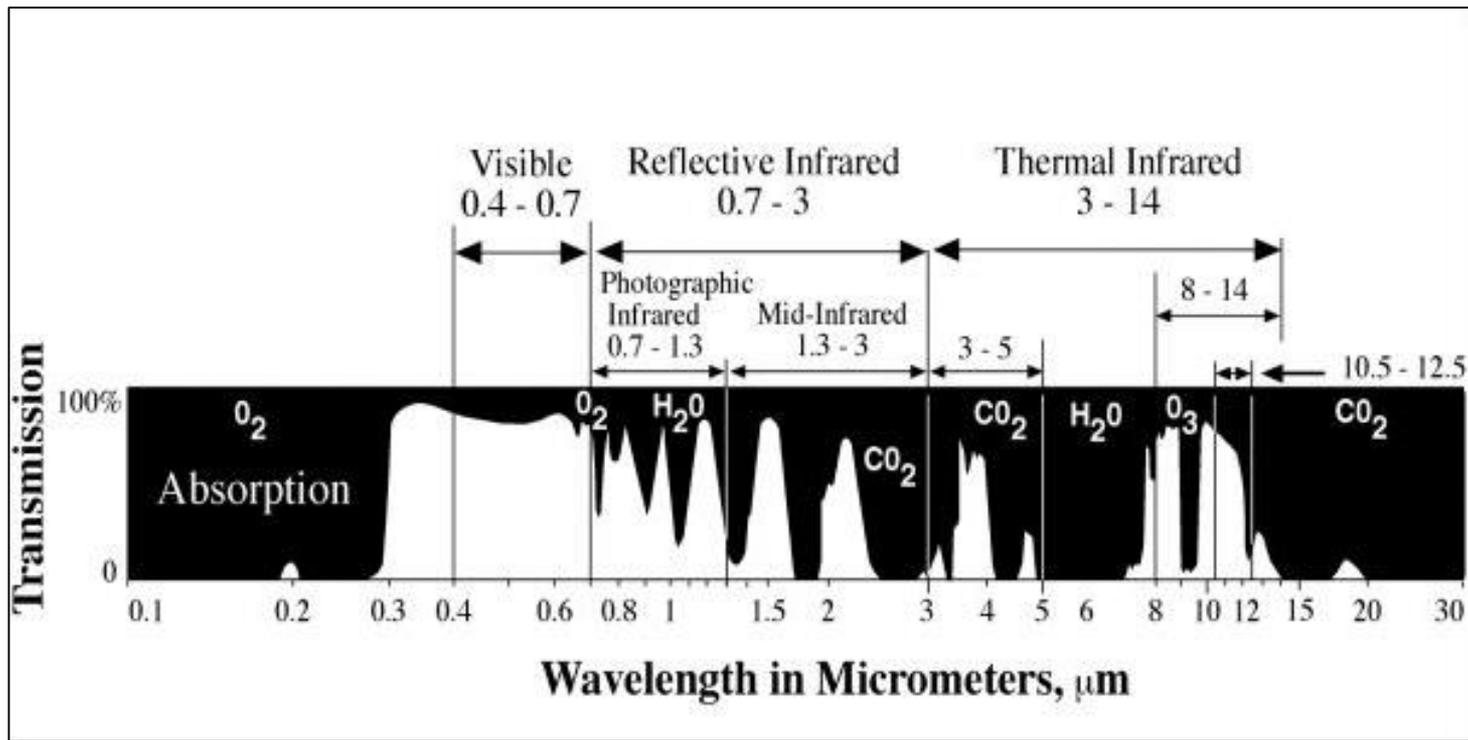


The Impacts of Atmospheric Chemicals



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- Determine atmospheric transmission of directed energy
- Degrades UV sensor performance (Ozone)
- Degrades materials (Oxygen, Ozone)



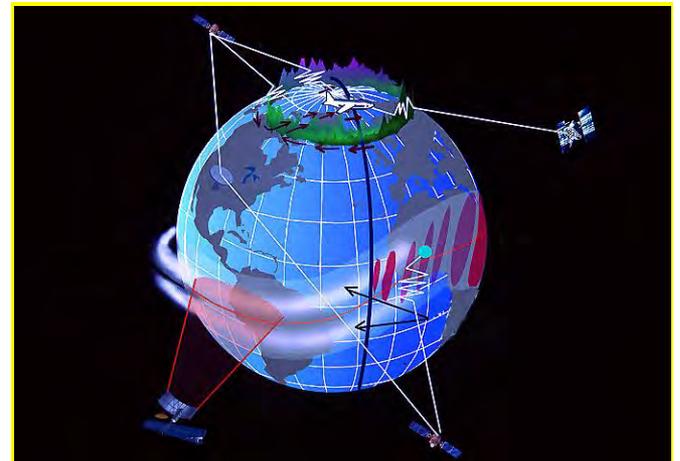


The Impacts of Space Weather



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- **Signal Fades and Interference**
 - HF COMM (tactical), SATCOM (data links/voice)
- **GPS degradation**
 - Dual-Freq signal lock loss (Navigation, PGMs)
 - Single Freq location errors (Mines, Mapping)
- **Radar Interference and tracking errors**
 - Missile Warning



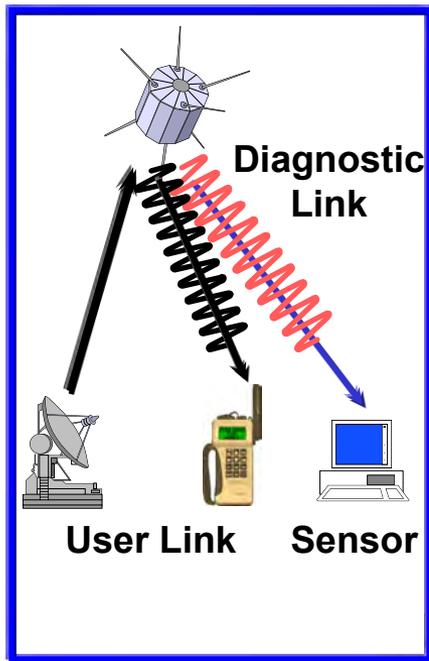
The Impacts of Space Weather

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- **Space Situational Awareness: Enemy or Environment**

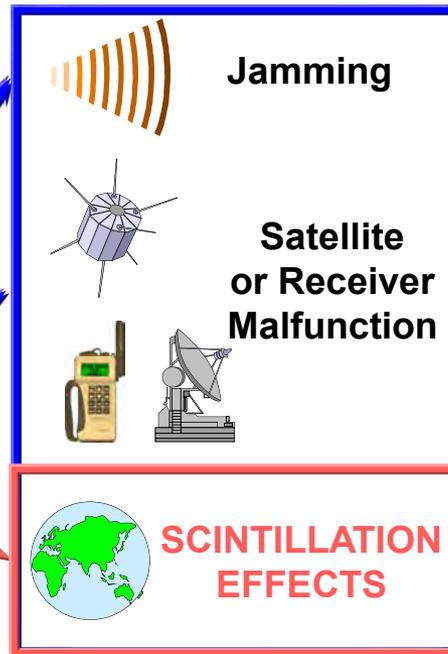
USER LINK

Data Losses or SATCOM Outages



PROBLEM SOURCES

Enemy, Equipment, or **ENVIRONMENT**



ALTERNATIVES

Mitigation of Ionospheric Effects





Guidance



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- **Defense Acquisition Guidebook, Ch 4**
 - “...natural environmental conditions...should be considered in system design.”
- **AFPAM 63-113, Program Protection Planning for Life Cycle Management**
 - PM’s will “develop a comprehensive threat picture evaluating all threats both natural and manmade.”
- **AFPD 63-1, Integrated Life Cycle Management**
 - “The AF shall apply standard systems engineering processes and practices to ensure the integrity, mission assurance, operational safety, suitability, and effectiveness (OSS&E) of each system throughout the life cycle from concept development through disposal.”
- **AFI 63-101/20-101, Integrated Life Cycle Management**
 - “The PM will: Ensure and preserve the OSS&E throughout the life cycle of systems...”
 - Preservation of OSS&E includes consideration of “natural environmental effects and impacts” in the “environment planned or expected” for operational employment



Guidance



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- **AFMCI 15-102, Weather Support to the Acquisition System**
- **RDAT&E leaders* are responsible for:**
 - Consulting with assigned Staffmets to ensure terrestrial and space weather effects are considered in capability requirements development, planning, and processes
 - Providing Staffmets access to technical details, requirements and capabilities of your effort so they can plan for and prepare operational weather forces for capability deployment

*** PMs, Single Managers, Product Directors, Technology Directors, Development Planning Team Leaders, and/or Initiative Leads**



XZIG Mission

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- **Provide meteorological guidance and support to Research, Development, Acquisition, Testing, and Evaluation (RDAT&E)**
 - **Ensures RDAT&E leaders consider weather effects on warfighting capabilities to avoid/mitigate impacts to cost, schedule, and performance**
 - **Ensures operational weather units are aware of the weather needs of future warfighting capabilities**



Staffmet Services



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- **Expertise**
 - If you aren't sure, call and we can help
- **Identify weather impact(s) to new, modified, and legacy capabilities**
- **Identify ways to mitigate weather impact(s) to new, modified, and legacy capabilities**
- **Document Terrestrial Weather and Space Weather Sensitivities**
- **Document Terrestrial Weather and Space Weather Support Requirements**



Staffmet Services



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- **Conduct Acquisition Document Reviews**
- **Modeling & Simulation Liaison**
- **Obtain/interpret weather data**
- **Interpret meteorological references (MIL-HDBK-310)**
- **Develop algorithms and software**
- **Prepare Technical Reports**
- **Provide Expertise to Mishap Review Boards**



Staffmet Services



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- **Test Planning Support**
- **Range Observing Support**
- **Suggest appropriate weather sensors/sensing strategy for tests/ops**
- **Mission Planning and Execution Forecasts**
- **Coordinate weather support (T&E, Operational)**



Available Data Sets



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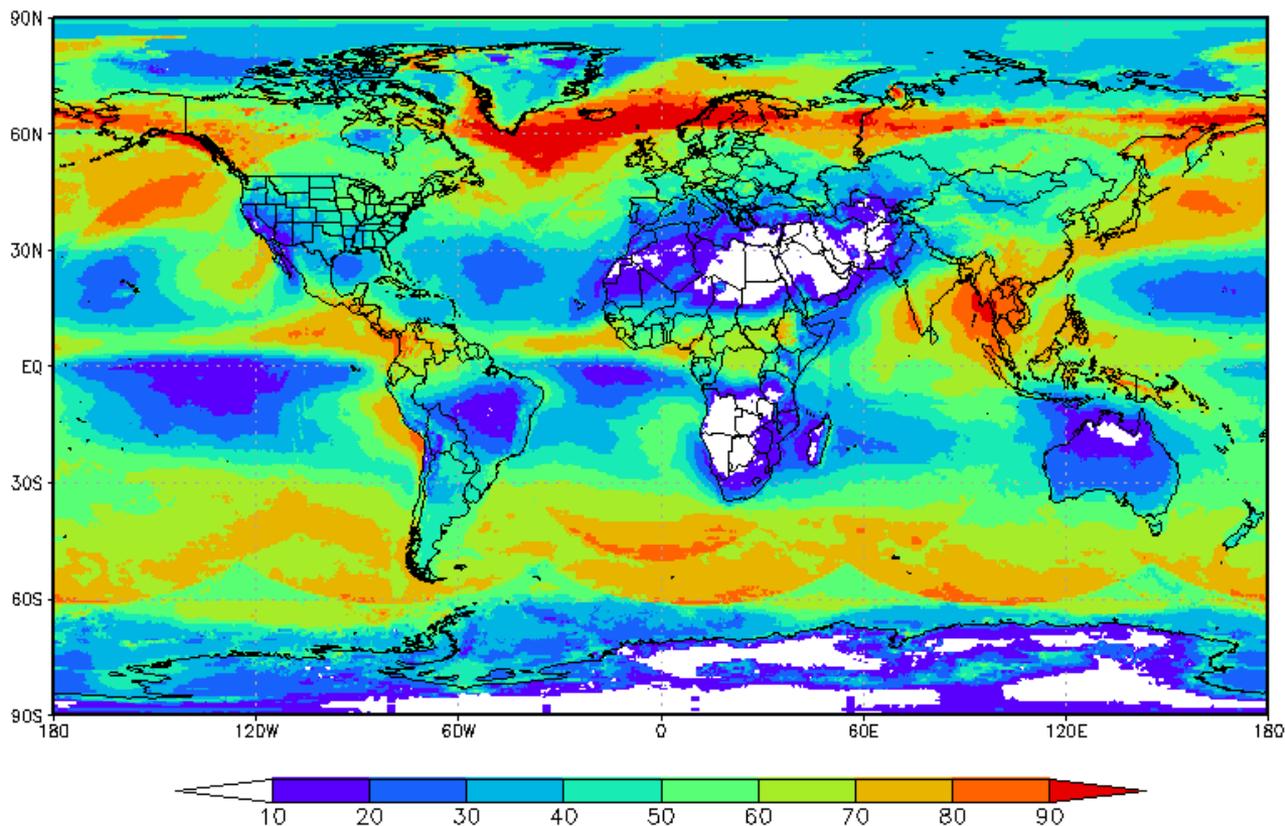
- **Clouds**

Mean_Total_Cloud_Amount_[%]

(VT: All Hours JUN)

Cloud Climatology Image

14WS (557 WW)
151 Patten Ave, Rm 120
Asheville, NC 28801-5002



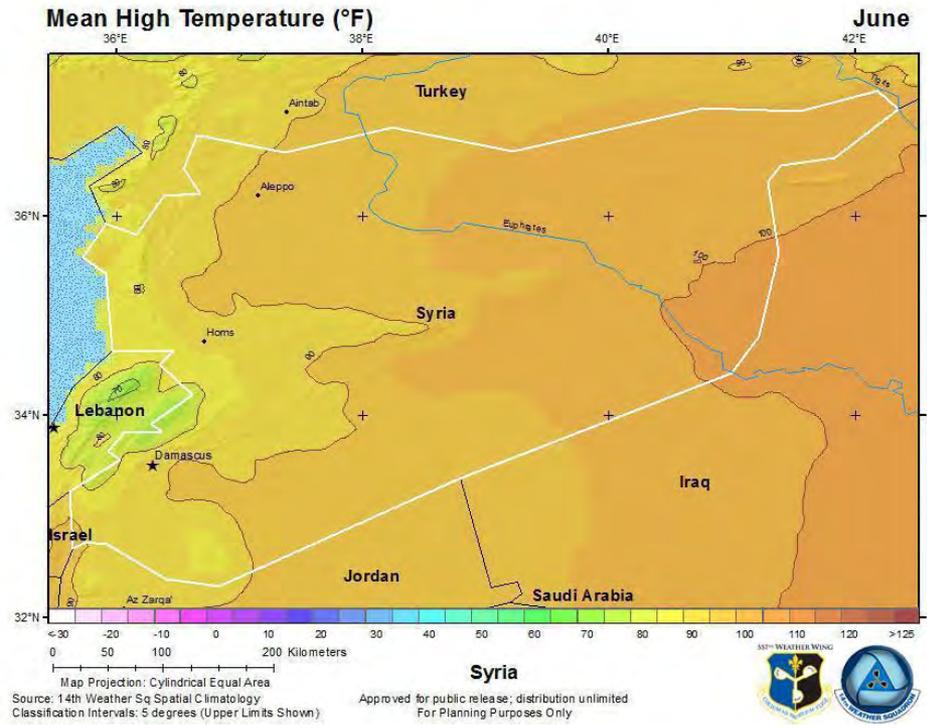
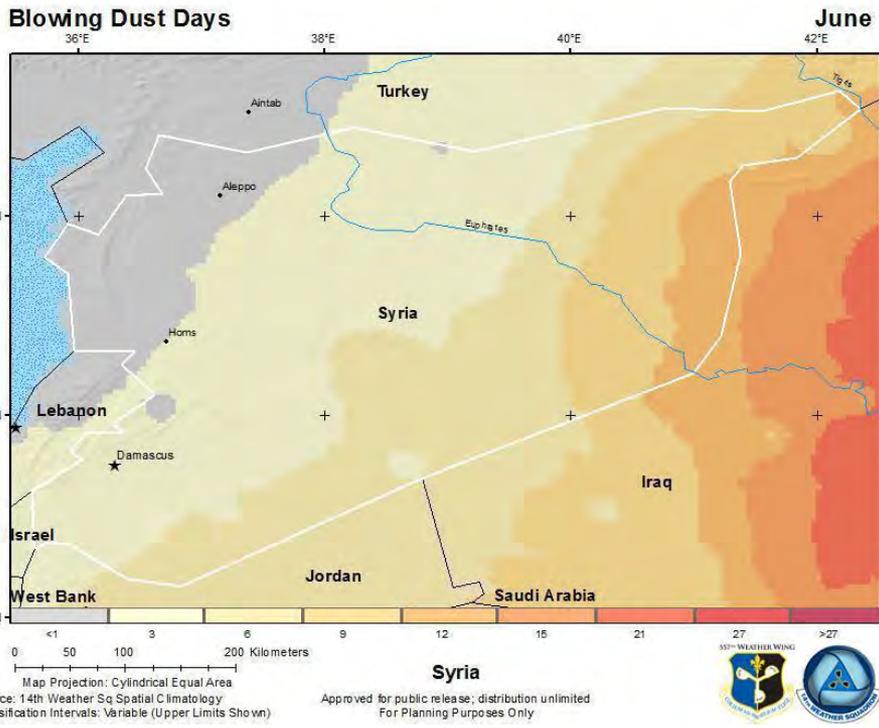


Available Data Sets

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- **Climatology**

- Winds, Temperature, Humidity, Precipitation, etc.

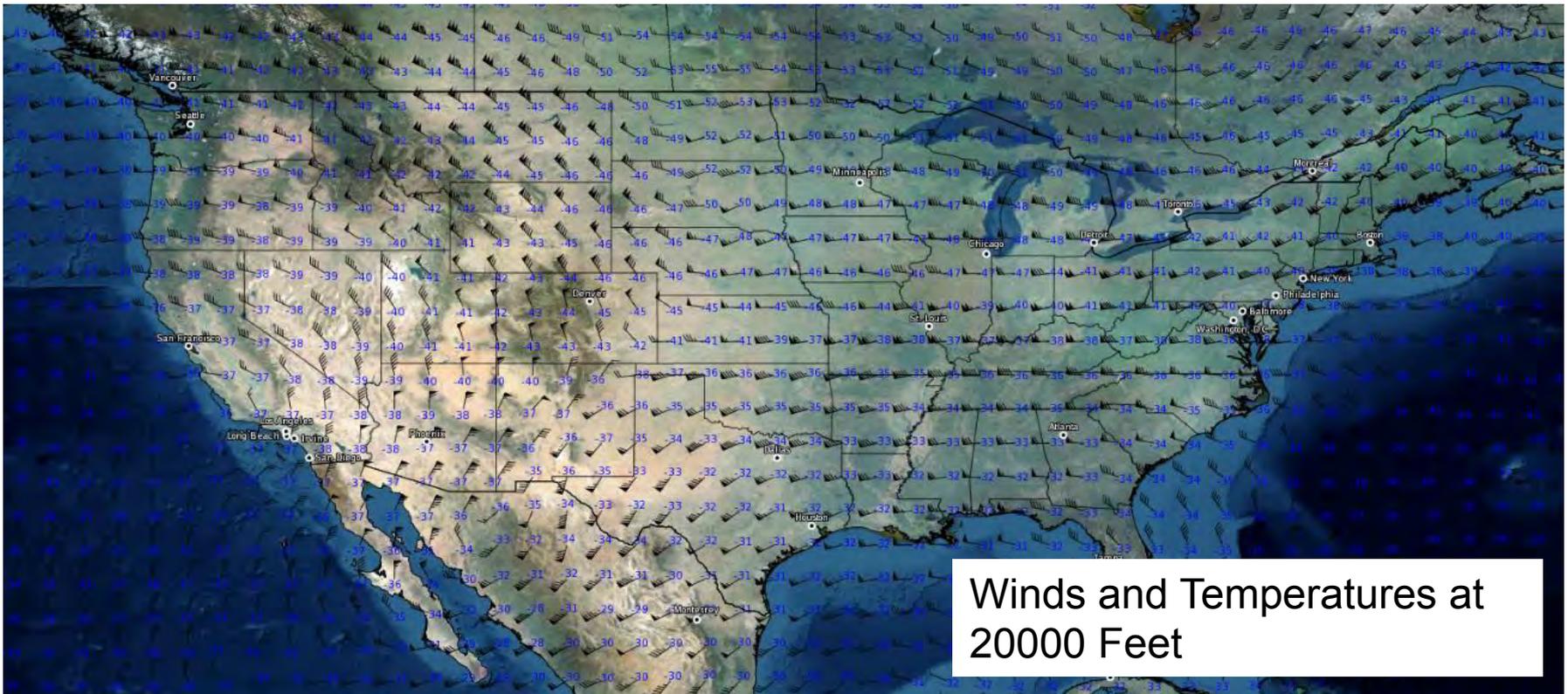




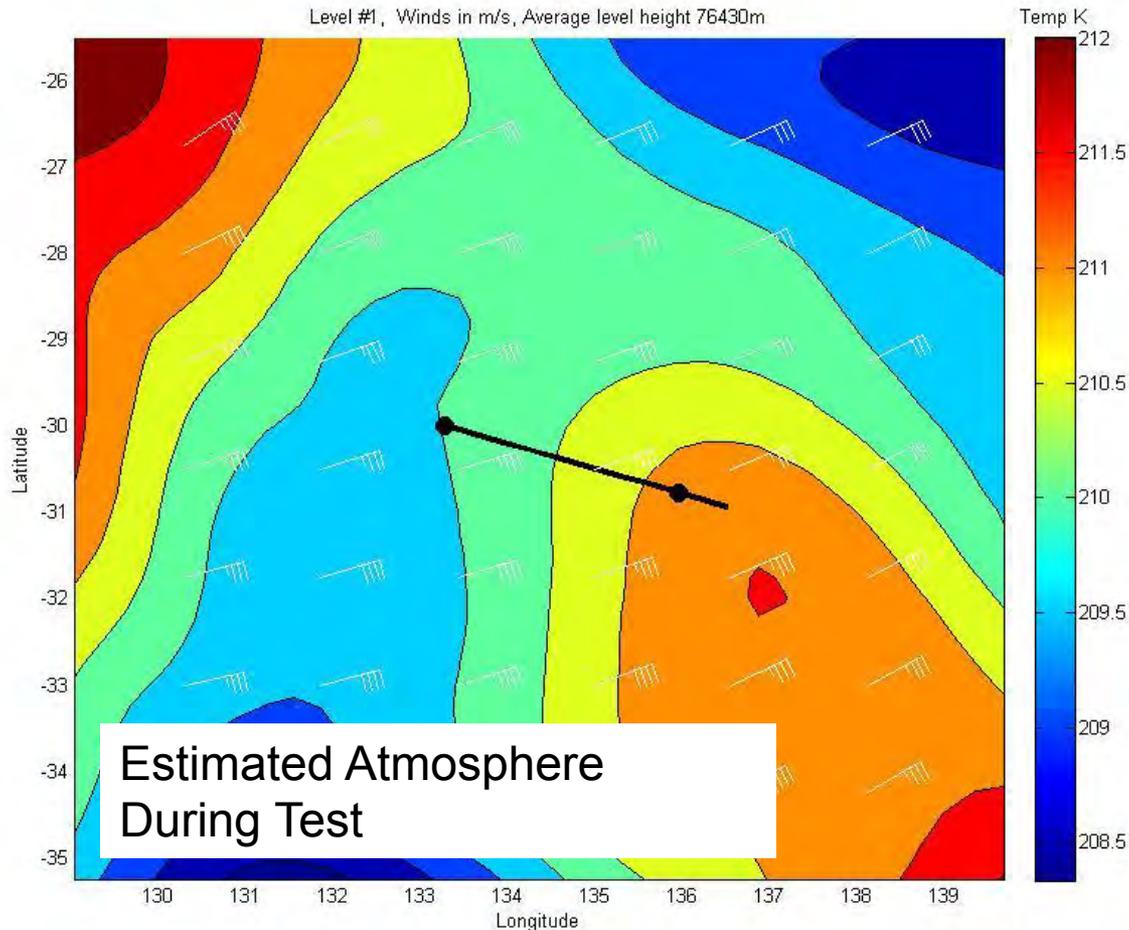
Available Data Sets

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- **Operational Forecasts**
 - Winds, Temperature, Humidity, Precipitation, etc.



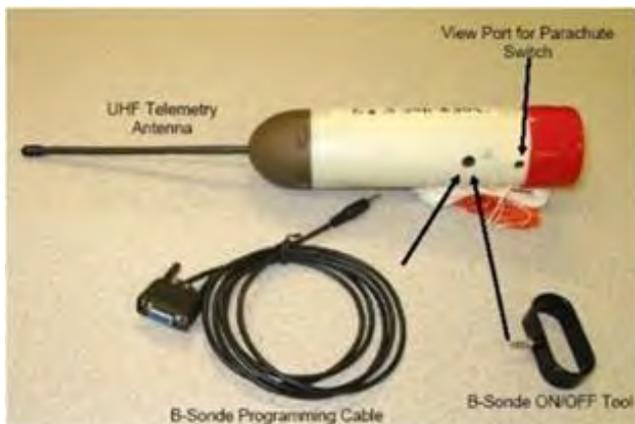
- **Data Analysis**



Support Examples

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- **Joint Precision Airdrop System (JPADS)**
 - Conducted JPADS dropsonde accuracy comparison
 - Assured program of sensor performance
 - Provided forecast for precision airdrop wind sensing test
 - Tests completed in time allotted: no schedule or cost overruns
 - Avoided loss of three days/expenditure of \$30K
 - Avoided ~\$50K labor cost to program to hire weather contractor



Support Examples

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• Hypersonic Vehicle Support

- Provided Forecasts for HTV-2 tests
 - Allowed for safe test and weather data collection strategy
- Provided Best Estimate Atmosphere (BEA) model along Best Estimate Trajectory (BET) in post test flight analysis
 - Allows engineers to better study heating of vehicles
- **Avoided ~\$120K weather contractor cost to program**
- Supported Joint AFRL/NASA/Australian DoD Program: Hypersonic International Flight Research Experiment (HIFiRE)
 - Test Flight 7 (Mar 2015) Andoya, Norway AFLCMC/XZIG provided upper atmospheric climatological data along flight trajectory
 - Will perform Best Estimate Atmosphere (BEA) post flight analysis to validate flight conditions





Support Examples



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- **Aircraft Signatures Testing**

- Provided forecasts for 11 tests over a two week period
 - Tests completed in time allotted: no schedule/cost overruns.
- Weather Consulting
 - Sets up/tear down weather observing equipment for tests
 - Consults on all weather matters to program
 - PM estimates cost savings of \$1-2M in last 6 years



- **F-22 Scientific Advisory Board Quick-Look Study on Aircraft Oxygen Generation**

- Provided weather data for all incidents
 - Weather ruled not a factor which led investigators to discover the real issue
 - Saved the SAB 300-400 Man-Hours of time by providing the appropriate data



Staffmet Needs



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- **Integration into the RDAT&E team**
 - **Access** to other team members
 - **Access** to system design documents
 - **Access** to test results
 - **Access** to programs that don't yet have our support, but need it



Your Perspective May Be:

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- **“My program doesn’t need weather.”**
 - **If it is in contact with the atmosphere it probably does**
 - **Everything from the Base picnic to D-Day gets a weather brief at some point**
- **“I’ll just look up the weather I need in a book like MIL-HDBK-310 or online.”**
 - **What book or resource? Does the data apply globally across all seasons? How good was the data that was used to fill the book or resource? Are you using the information correctly?**



Your Perspective May Be:



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- **“My contractor is providing weather.”**
 - What does that cost you? Working with us may have avoided that cost.
 - Is the contractor supplying the same kind of information/data that is provided by operational weather forces? Is the data they are providing suitable for your problem?
- **“Weather has its own funding lines – you shouldn’t need my dollars.”**
 - We will likely not cost you anything
 - We may request TDY funds or raise issues that drive program cost, but if we do so early large costly gaps later may be avoided.



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Questions?

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