



# AFLCMC/XZIG

## Staff Meteorology Branch

*AFLCMC... Providing the Warfighter's Edge*



# U.S. AIR FORCE

## Weather for Acquisition 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

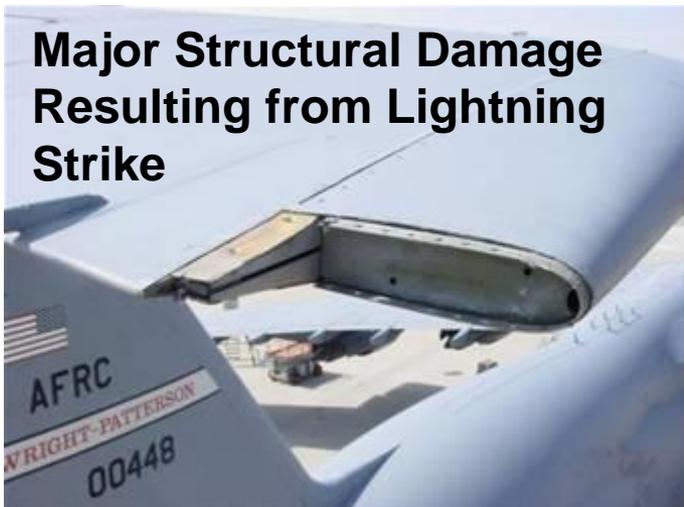
- **Tornadoes**
- **Visibility**

**GOV Struck at Robins AFB  
- 2012**



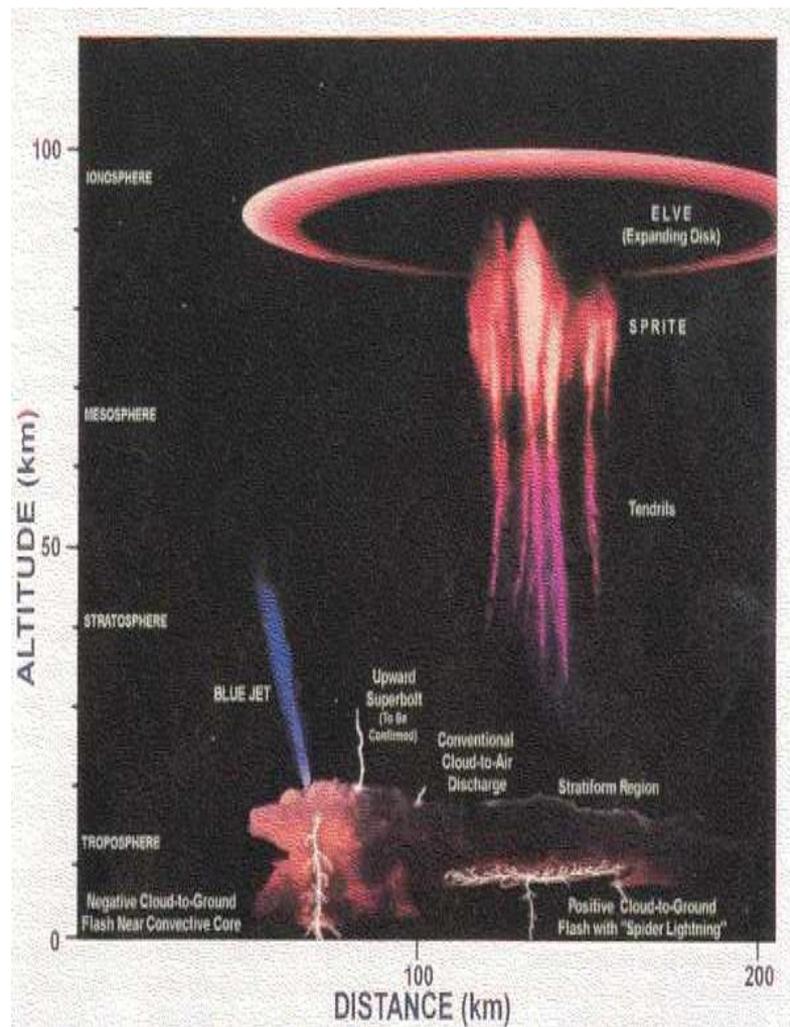
- **Physical Damage**
- **Laminate and composite construction require lightning mitigation systems due to differing conductivity of the materials used**

**Major Structural Damage  
Resulting from Lightning  
Strike**



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

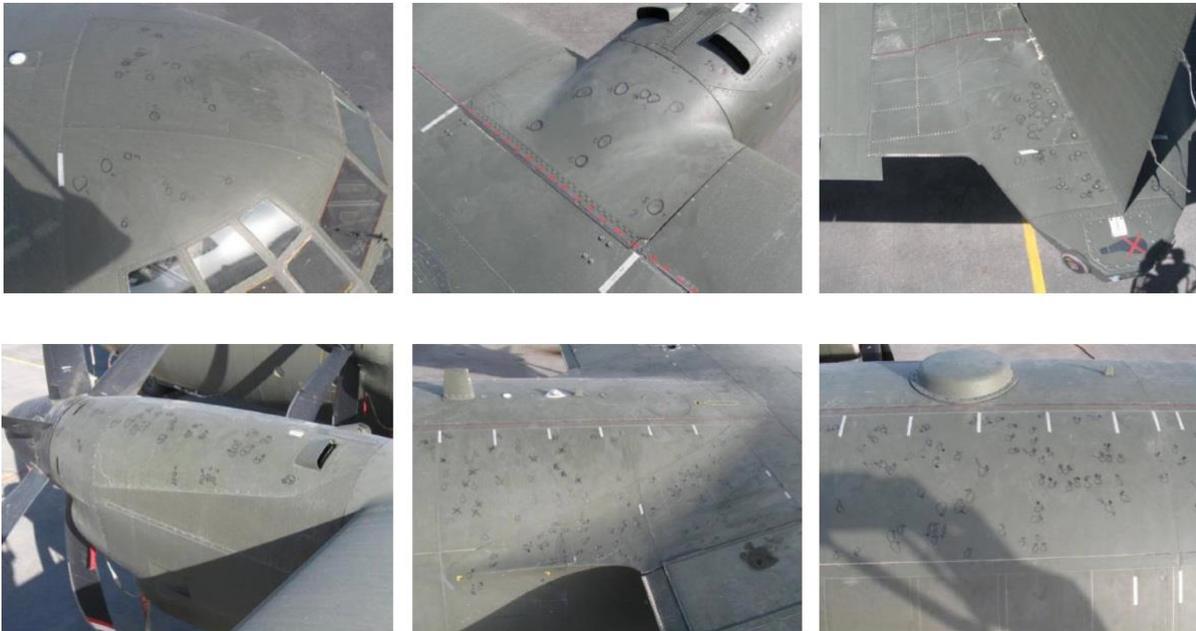
- Blue jet similar to cloud to ground lightning bolts
- Sprites and Elves are visual phenomena
  - Potential sensor issues



# 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

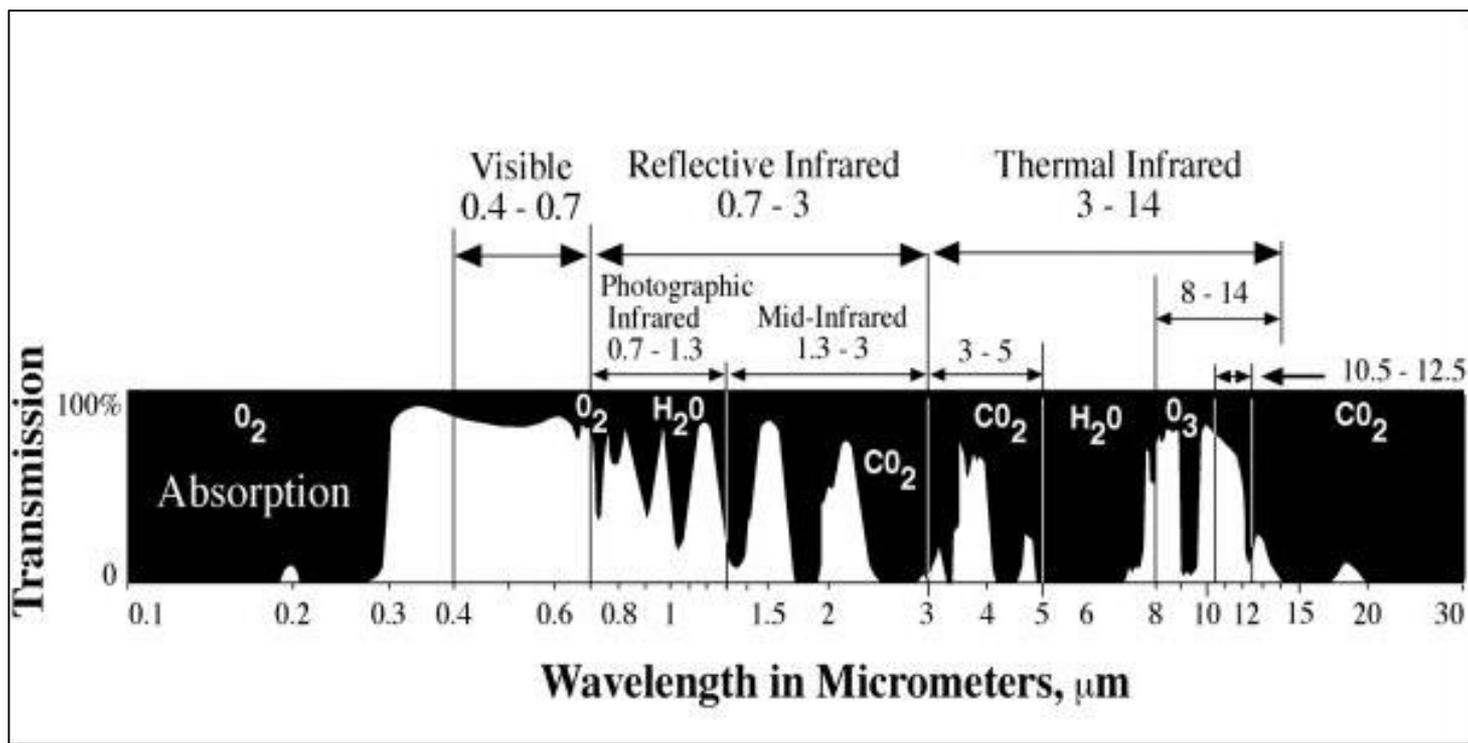


1989 KLM FLT 867 lost all 4 engines at 27,900ft near Mt. Redout Volcano  
2009 Deployed to Holloman after Red Flag due to volcanic activity in AK

# 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
- **Power Grid Failure**
  - Induced Currents
    - March 13, 1989 Quebec, Canada
    - 6 million people no power for 9 hours



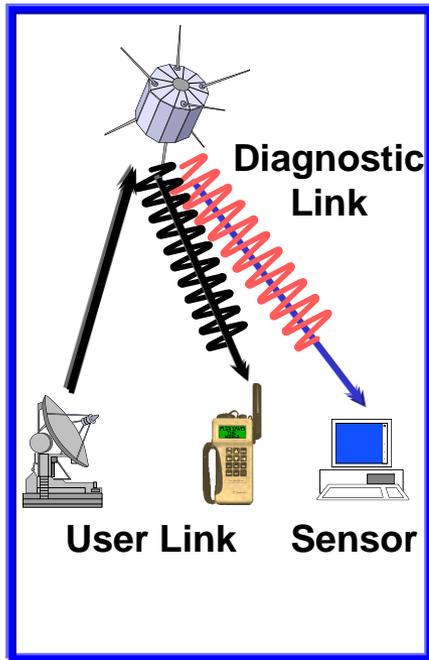
# The Impacts of Space Weather

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

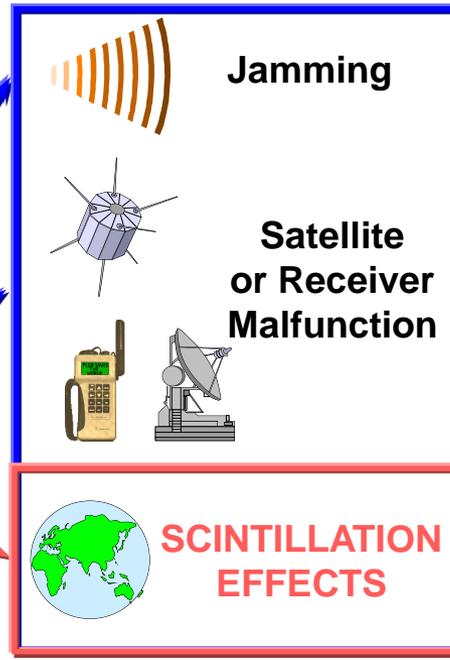
## USER LINK

Data Losses or SATCOM Outages



## PROBLEM SOURCES

Enemy, Equipment, or ENVIRONMENT



## ALTERNATIVES

Mitigation of Ionospheric Effects





# Overview Update



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# 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 63-1/20-1, 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**
- **Serve as Modeling & Simulation liaison**
- **Obtain, analyze, and interpret weather data**
- **Interpret meteorological references (e.g., MIL-HDBK-310)**
- **Develop algorithms and software**
- **Prepare technical reports**
- **Provide expertise to Mishap Review Boards**



# Staffmet Services



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- **Suggest appropriate weather sensors and/or sensing strategy for tests/ops**
- **Support long-range test planning**
- **Provide mission-planning forecasts**
- **Coordinate weather forecast and/or range observing support (T&E, Operational)**

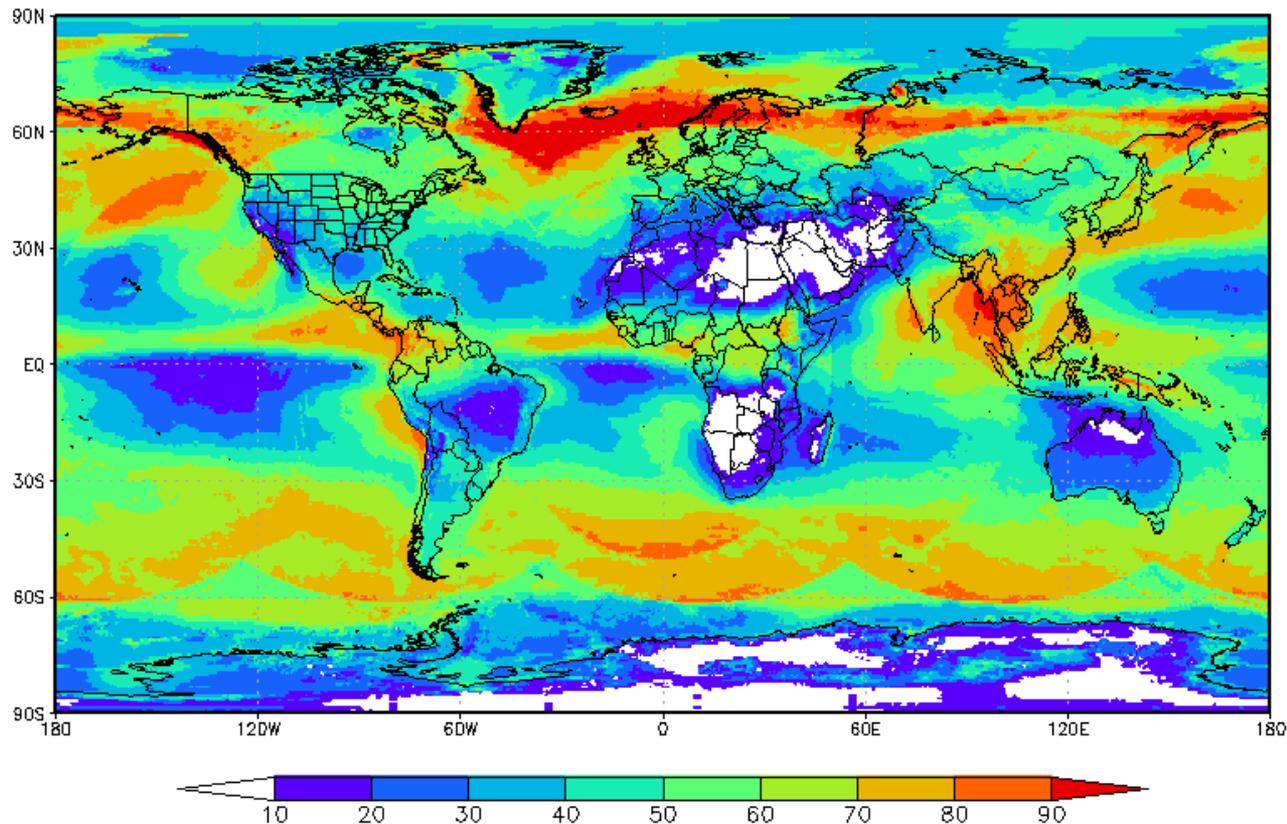
- **Clouds**

Mean\_Total\_Cloud\_Amount\_[%]

(VT: All Hours JUN)

Cloud Climatology Image

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





# Available Data Sets



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- **Historical Weather**
  - Winds, Temperature, Humidity, Precipitation, etc.

14 WS

WEATHER OBSERVATIONS  
WHITEMAN AFB, MO

WMO:724467  
ICAO: KSZL

Approved for Public Release: Distribution is unlimited

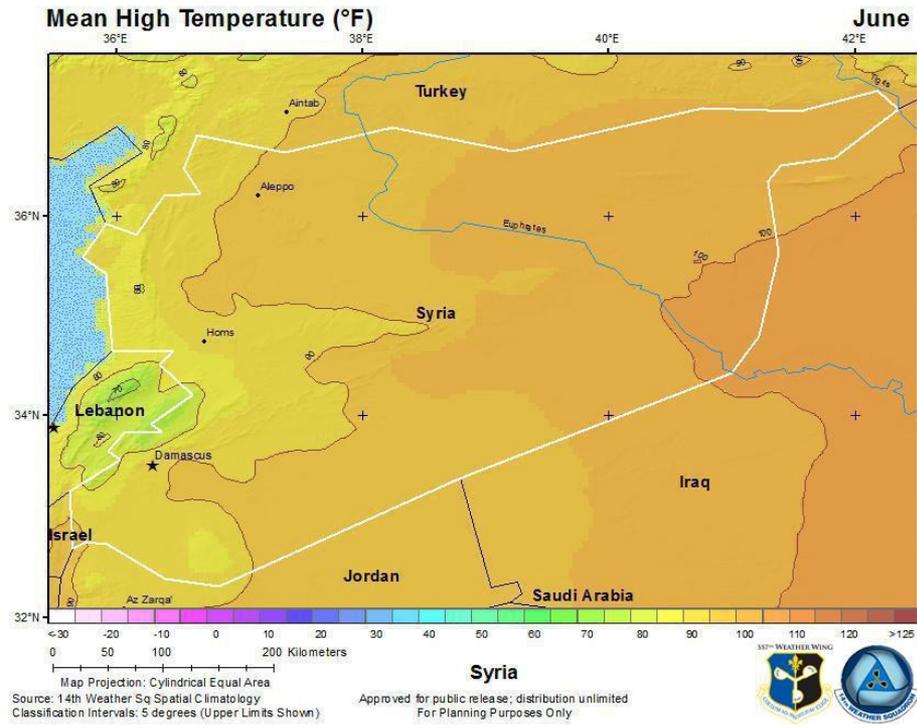
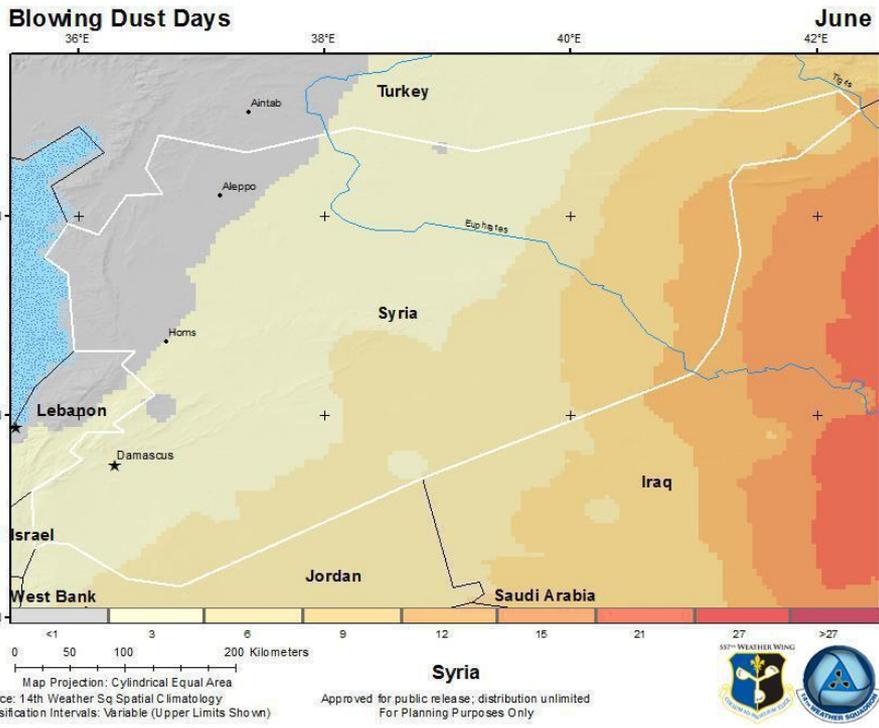
Date	Time (UTC)	Wind Direction	Wind Speed	Wind Gust	Temp F	Dewpt F	Relative Humidity	Absolute Humidity	Visibility	Weather or Obstructions to Vision	Station Pressure	Solar Data BTUs
20140801	0358	0	0		67	51	57%	9.40	7SM		29.123	
20140801	0458	0	0		65	53	65%	10.08	7SM		29.123	
20140801	0558	200	2		63	52	68%	9.92	7SM		29.115	
20140801	0658	0	0		62	51	67%	9.36	7SM		29.123	
20140801	0758	0	0		65	50	60%	9.25	7SM		29.123	
20140801	0858	0	0		63	50	64%	9.28	7SM		29.123	
20140801	0958	0	0		60	51	72%	9.58	7SM		29.123	
20140801	1058	0	0		62	53	73%	10.22	7SM		29.123	
20140801	1158	0	0		62	55	77%	10.83	7SM		29.135	
20140801	1258	260	3		67	57	71%	11.76	5SM	HZ	29.144	21
20140801	1358	300	5		69	56	66%	11.49	7SM		29.164	79
20140801	1452	350	5		68	54	60%	10.36	7SM		29.164	115
20140801	1558	70	4		71	53	52%	9.97	7SM		29.164	194
20140801	1658	70	5		71	53	53%	10.09	7SM		29.164	204
20140801	1758	40	6		77	53	42%	9.79	7SM		29.155	271
20140801	1858	80	4		81	49	33%	8.61	7SM		29.144	284
20140801	1958	40	5		81	49	33%	8.45	7SM		29.135	297
20140801	2058	990	3		83	48	30%	8.19	7SM		29.135	291
20140801	2158	990	3		82	47	30%	7.93	7SM		29.123	193
20140801	2258	990	2		83	46	28%	7.66	7SM		29.115	204



# Available Data Sets

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- **Climatology**
  - Winds, Temperature, Humidity, Precipitation, etc.



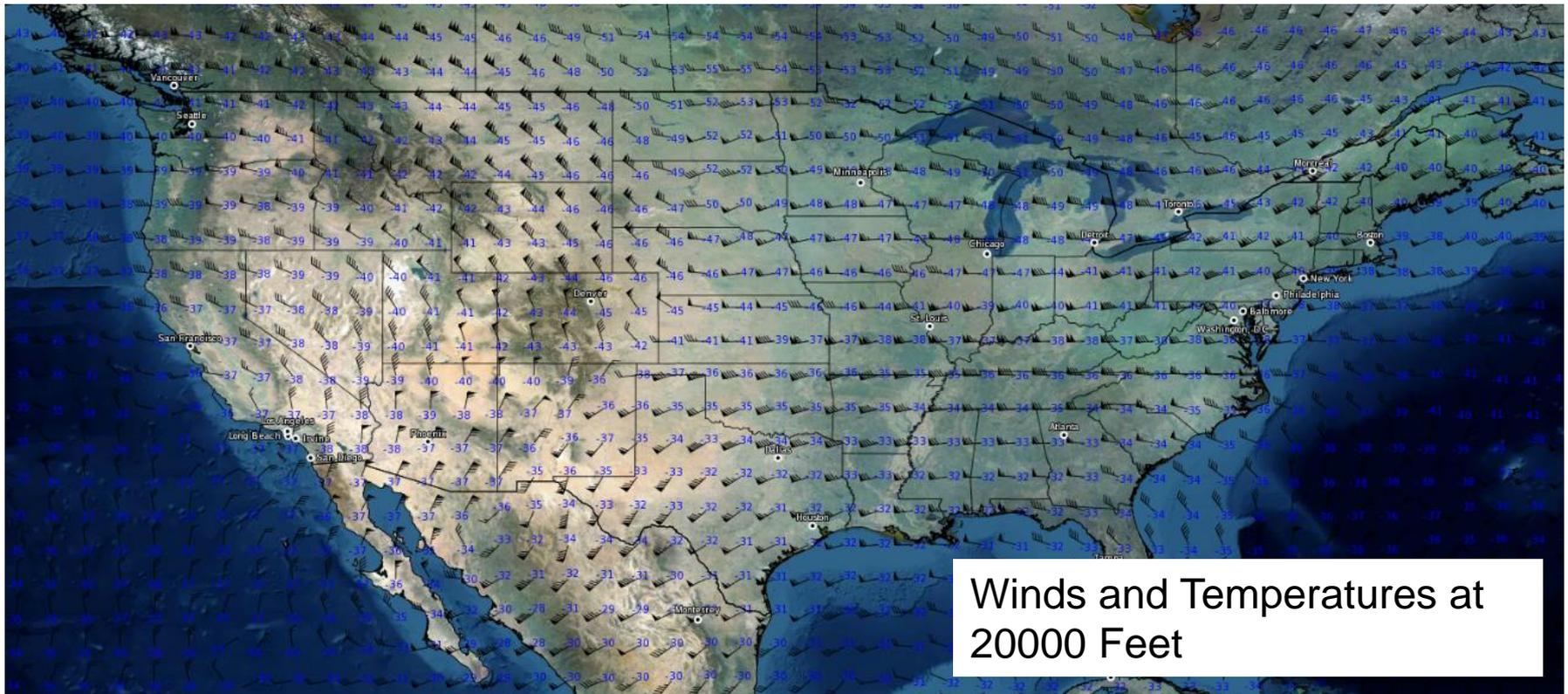


# Available Data Sets

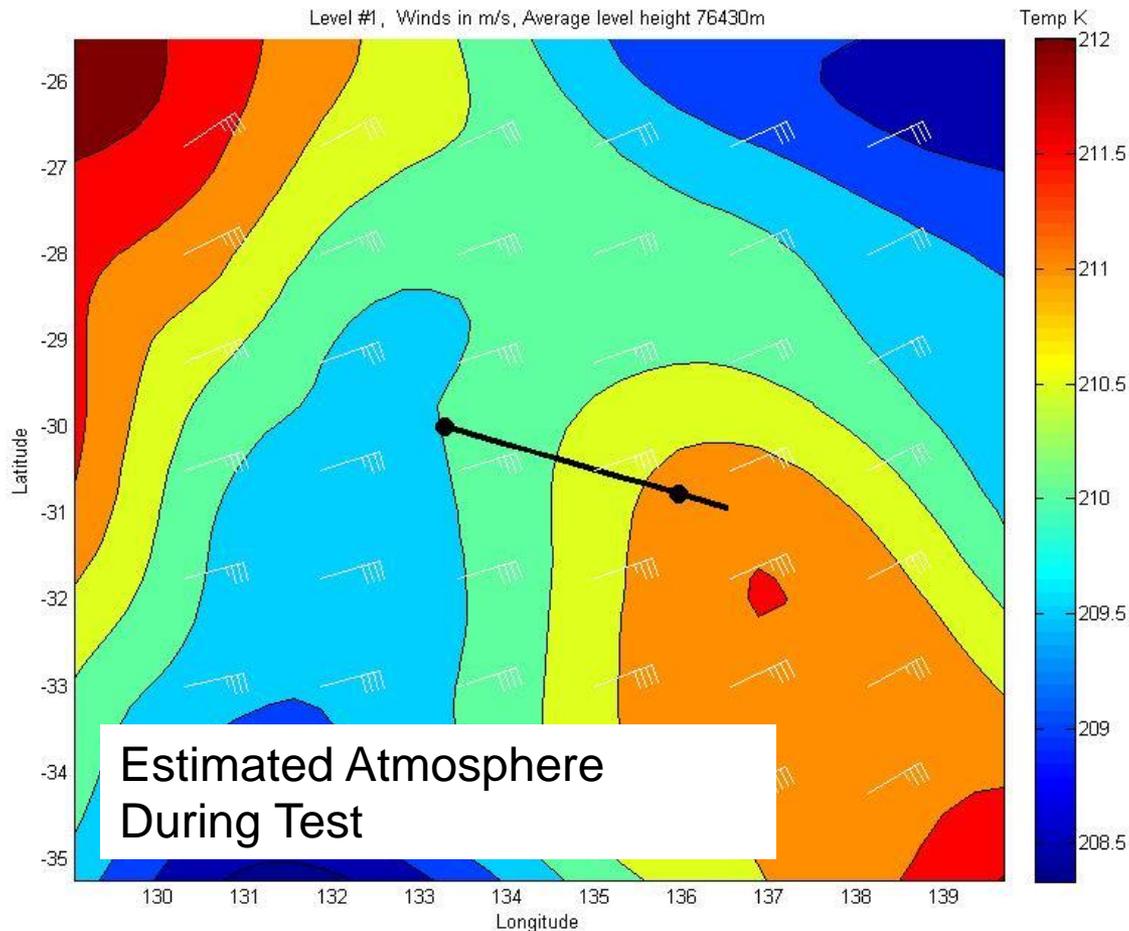


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- **Operational Forecasts**
  - **Winds, Temperature, Humidity, Precipitation, etc.**



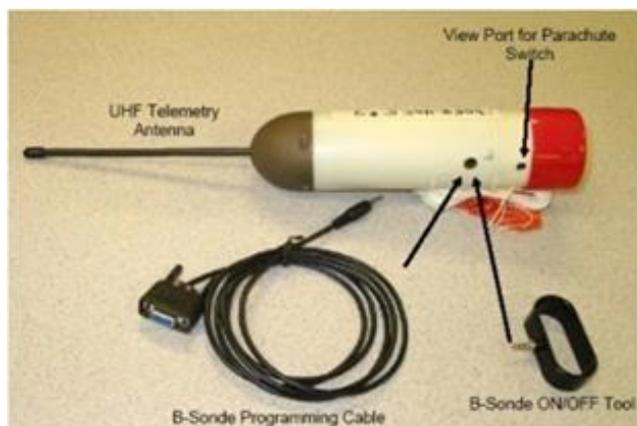
- **Data Analysis**



# 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



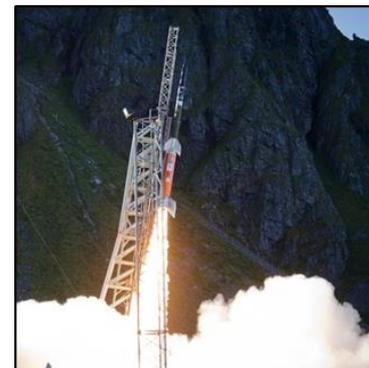


# Support Examples

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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 or data that is provided by operational weather forces? Are 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?

## **AFLCMC/XZIG**

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