Air Force Weather Agency

Fly - Fight - Win

USAF JCSDA Overview

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27 January 2009

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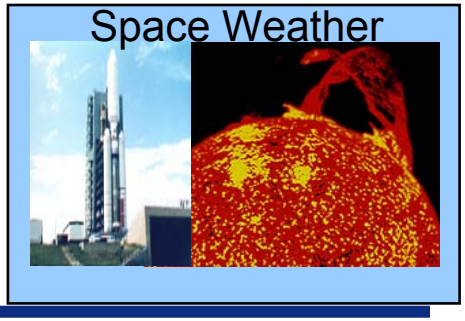
Overview

- Mission
- Products and services
- Operational models
- Perspective on JCSDA
- JCSDA initiatives
  - Cloud Optical Properties assimilation
  - LIS data assimilation enhancements and coupling with WRF
  - WRF data assimilation enhancements
- Our DA future - AFWA Coupled Analysis & Prediction System (ACAPS)

Mission

Focus on the Joint Warfighter

"Air Force Weather enables Joint Warfighters to anticipate and exploit the weather...for air, space, cyberspace, and ground operations"



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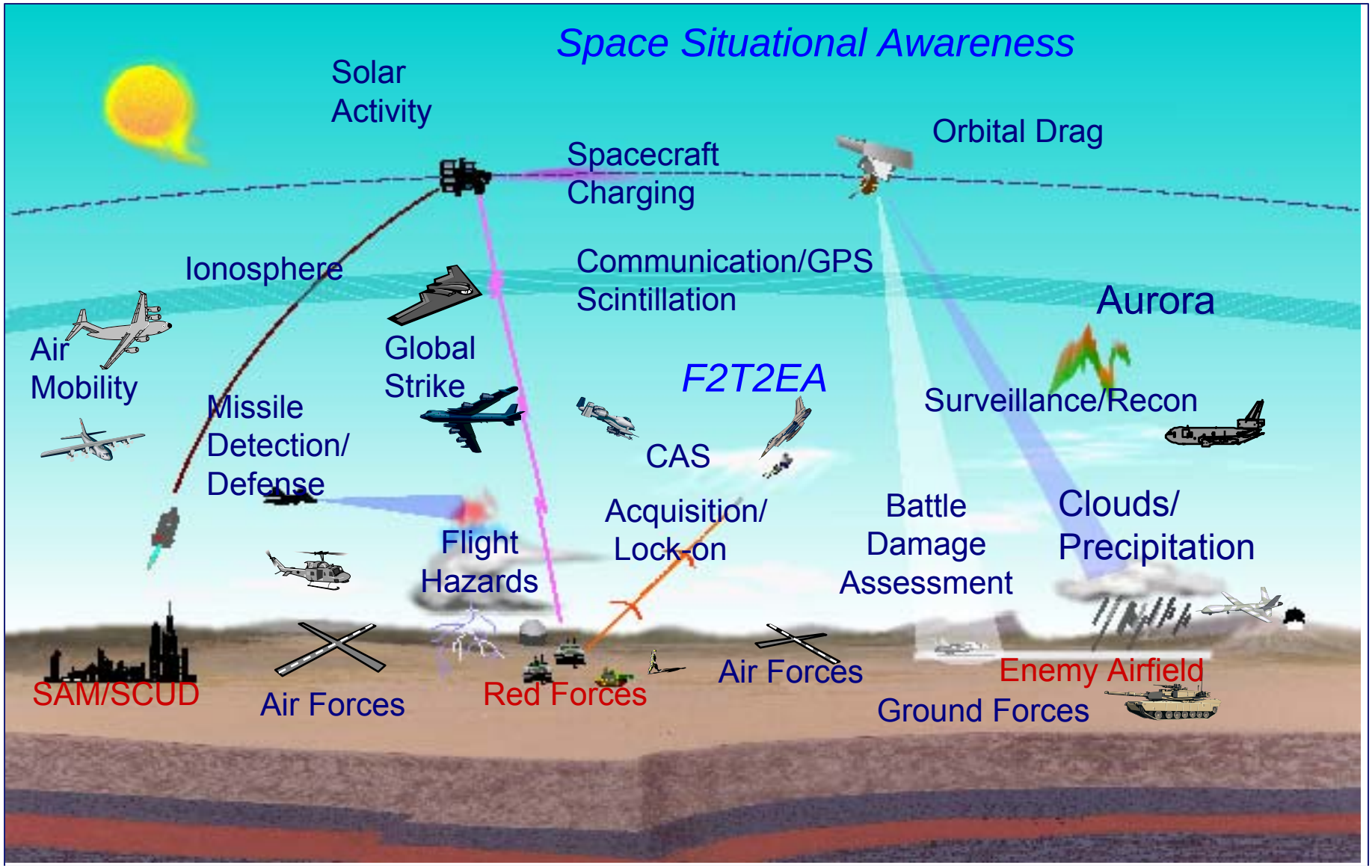
Mission Areas

"From the Mud to the Sun"



Products and Services

Terrestrial Weather

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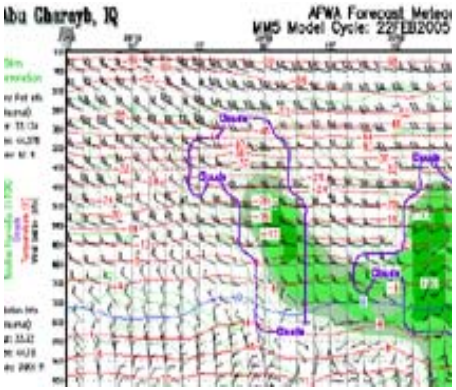

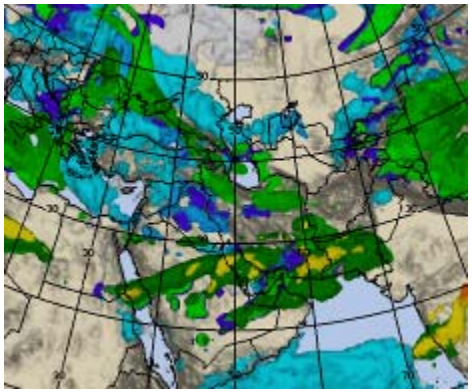

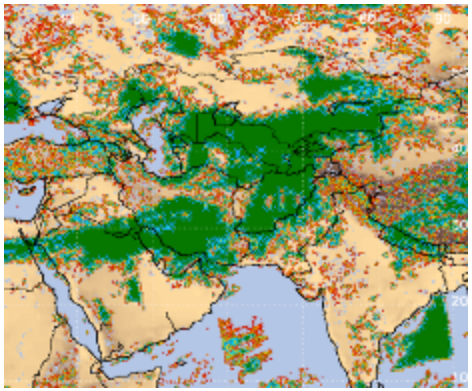

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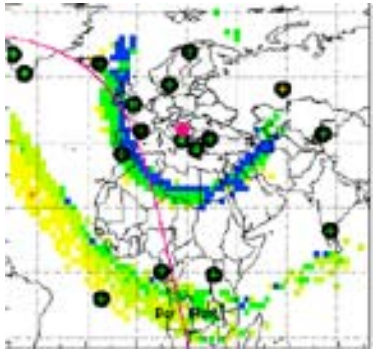
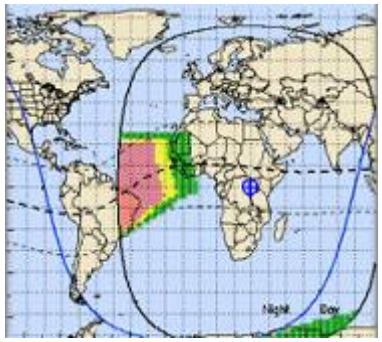
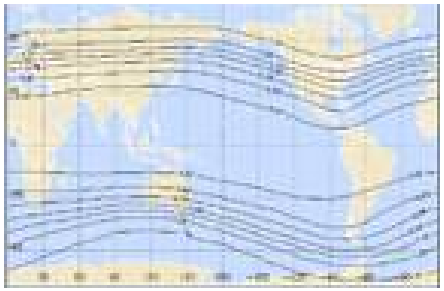
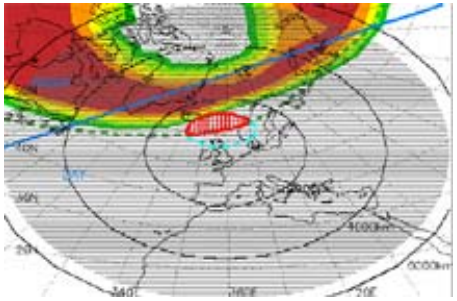
Products and Services

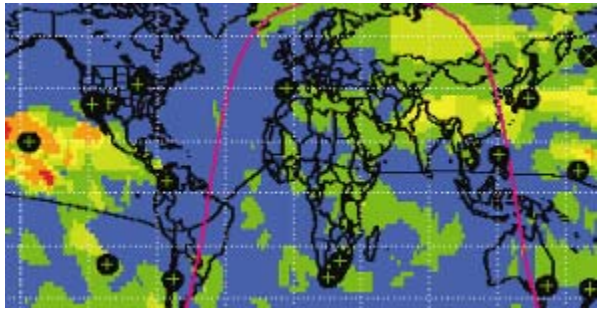
Space Weather

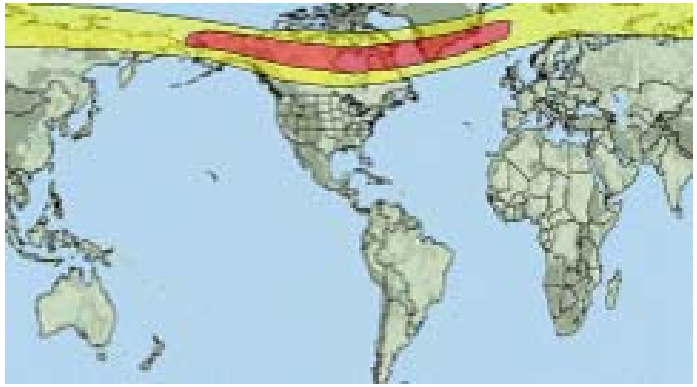












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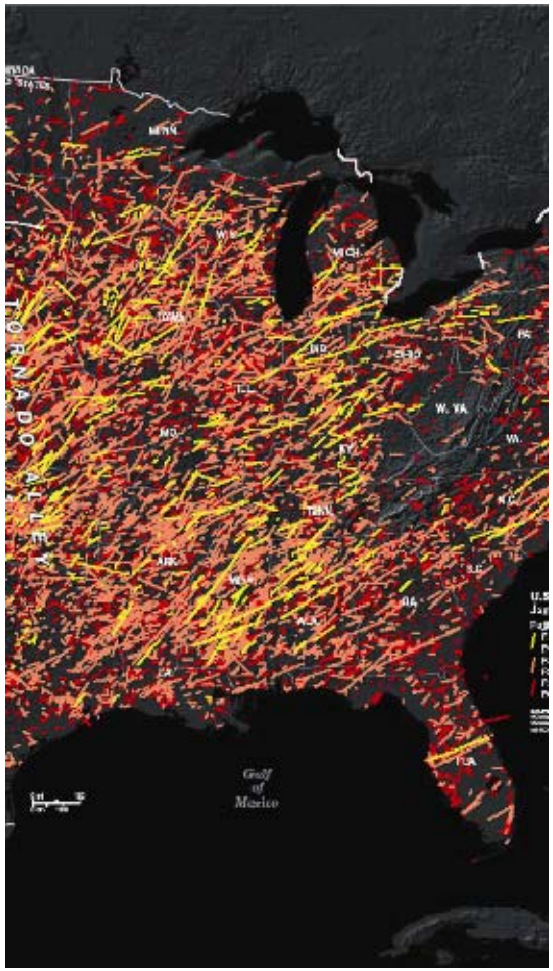
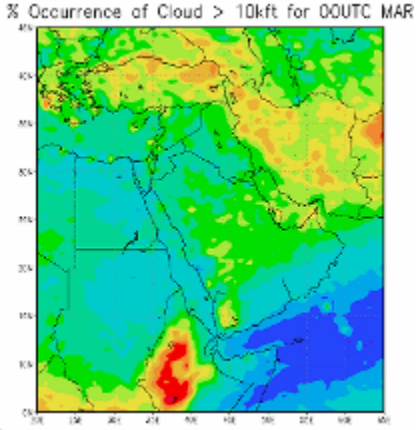
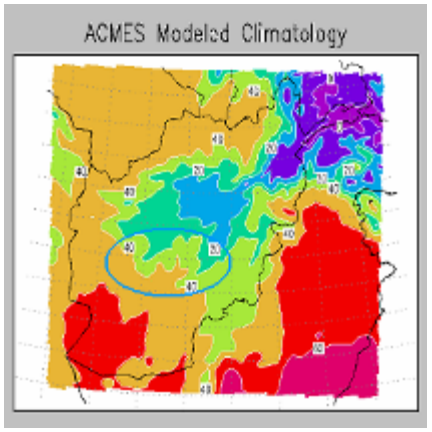
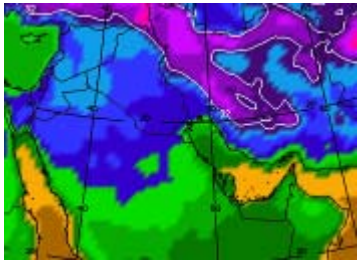
Products and Services

Climatology









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Meteorological Models

Assimilating Satellite Data

- **Global cloud model**
  - **Cloud Depiction and Forecast System (CDFS) II**
  - **World-wide Merged Cloud Analysis (WWMCA)**
  - **Produces cloud forecasts to 84 hours**
- **Surface characterization (Land Information System)**
  - **Global snow depth analysis**
  - **Soil moisture analysis**
  - **Geostationary Infra-Red Precipitation (GEOPRECIP)**
  - **Surface Temperature (SFCTMP)**
- **NWP**
  - **AFWA runs WRF model (ARW core) for regional DoD support**
  - **NCEP's GFS used for global operations and to initialize WRF**

Global Cloud Model

Cloud Depiction and Forecast System Version II

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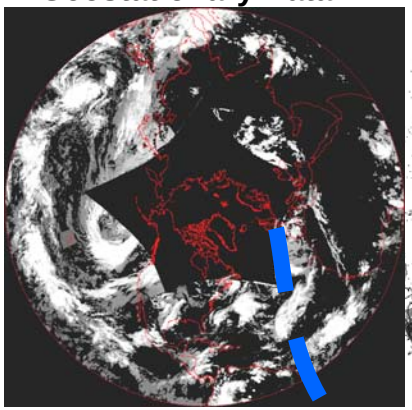
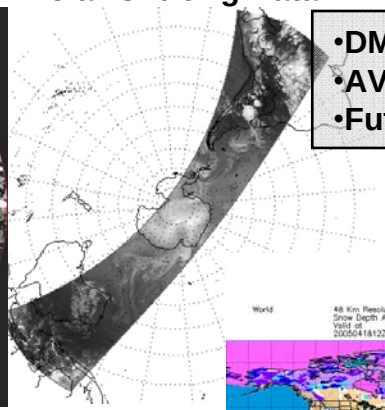
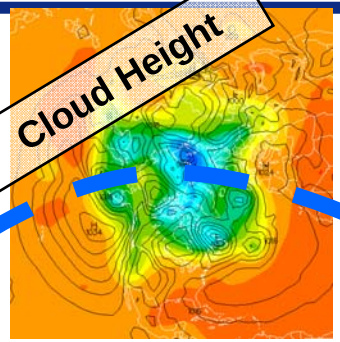
Geostationary Data



Polar Orbiting Data

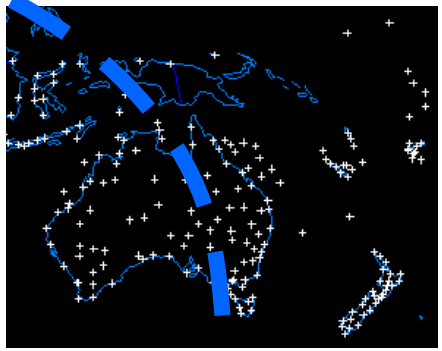


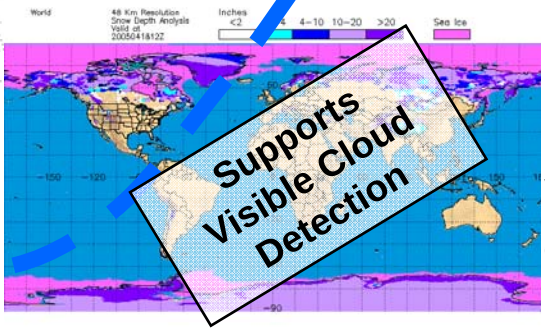
- DMSP
- AVHRR
- Future NPOESS



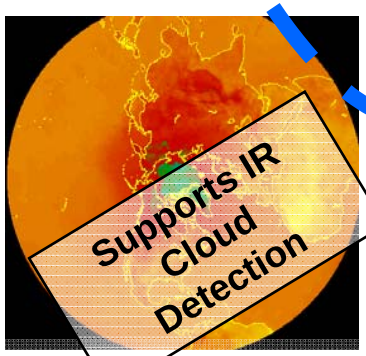
GFS
Upper Atmos. Temp
Near Surface Temp/RH/Wind

Surface Observations





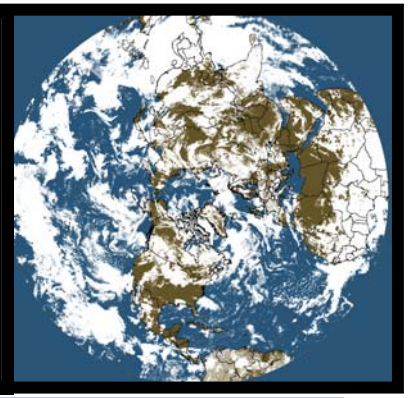
Snow Analysis
Resolution: 12 nm
Obs: Surface, SSM/I
Freq: Daily, 12Z



Surface Temp Analysis
Resolution: 12 nm
Obs: IR imagery, SSM/I Temp
Freq: 3 Hourly

World-Wide Merged Cloud Analysis (WWMCA)
Hourly, global, real-time, cloud analysis @12.5nm

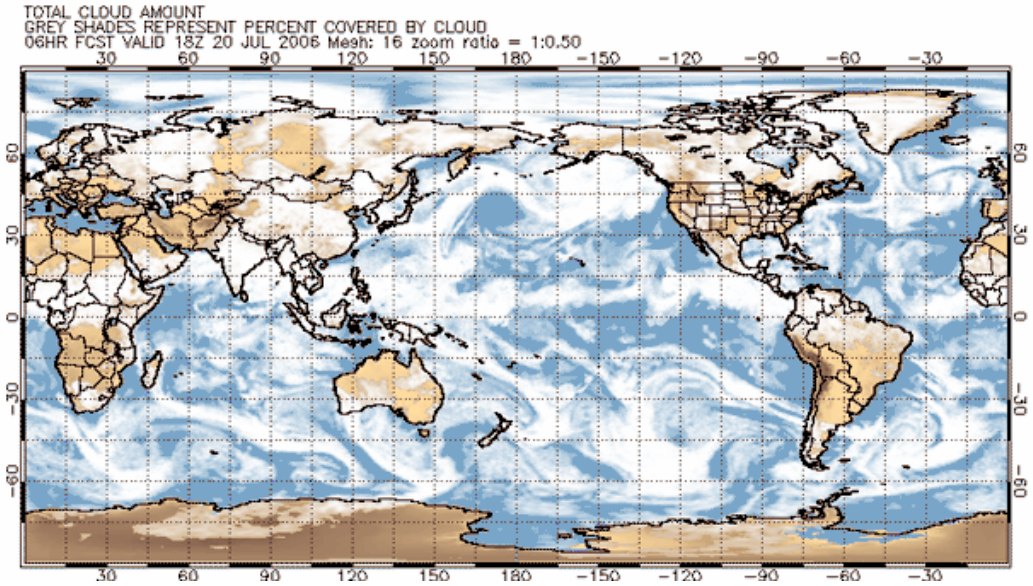
Total Cloud **and** ***Layer Cloud*** **data supports National Intelligence Community, cloud forecast models, and global soil temperature and moisture analysis.**



Cloud Forecast Models

Long Range Global Cloud Forecast

MODEL: Stochastic Cloud Forecast Model (SCFM) produces LRCF



SCFM

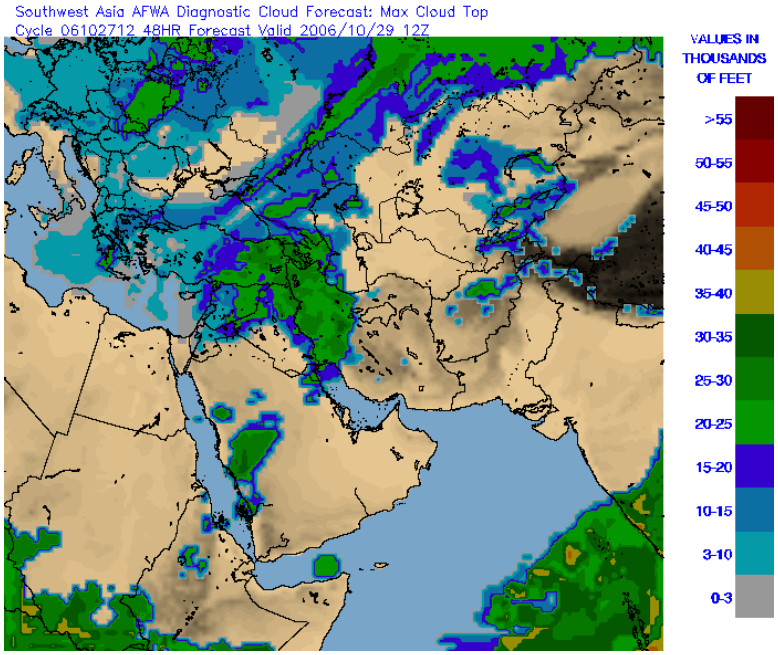
- ***Global*** **cloud cover model developed by 2 WXG/WE (Dr. Dave McDonald)**
- **Pairs GFS Temp, RH, VV, and Surface Press. with WWMCA cloud amounts**
- **16th mesh Polar Stereographic projection**
- **5 vertical layers**
- **3-hr time step**
- **84 hr forecast**

SCFM products:

- **Total fractional cloud coverage**
- **Layer coverage (5-layers)**
  - **500 meter AGL, 850mb, 700mb, 500mb, 300mb layers**

Cloud Forecast Models

Regional Cloud Forecasts



DCF products:

- Total fractional cloud coverage
- layer coverage (5-layers)
- layer top height & thickness
- layer type

DCF

- *Regional* cloud cover model developed by AFRL (Don Norquist)
- Pairs AFWA WRF output with CDFS-II WWMCA analysis
- Statistically "chooses" which clouds best correlate with WRF "predictors"
- 45/15/5 km WRF grids & global ½ degree GFS grid
- 3-hr time step
- 30 to 80 hr forecast (depends on grid)

5km DCF Forecast Images

Available for Evaluation via JAAWIN

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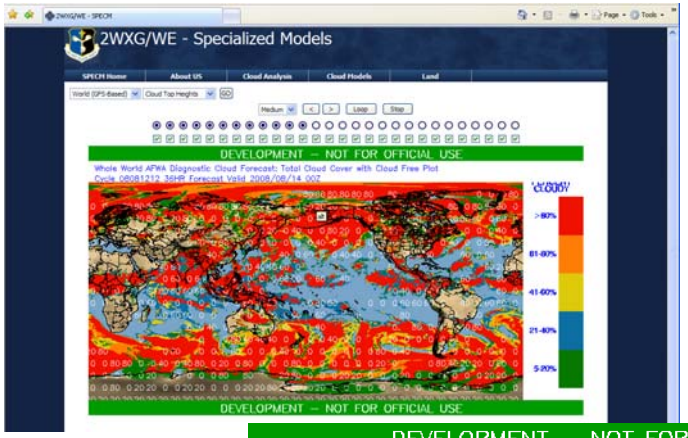
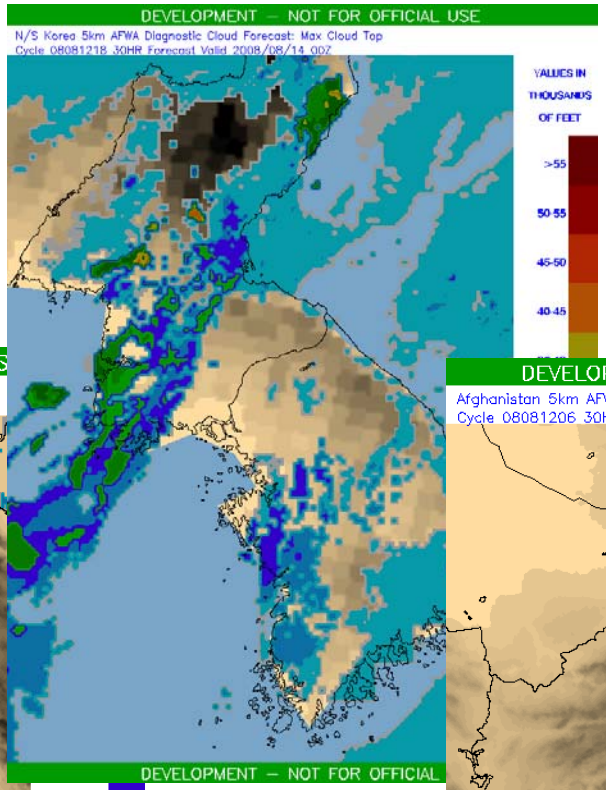
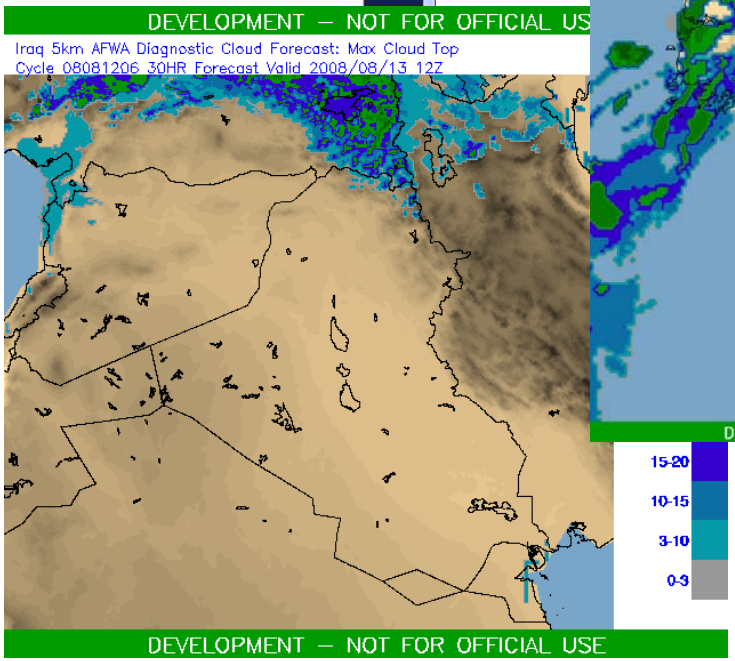
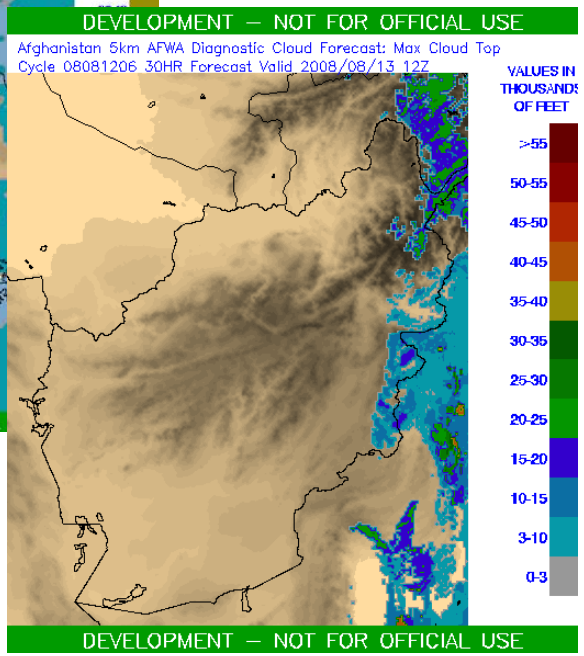


LINK: https://weather.afwa.af.mil/host_home/DNXM/SPECM/dcf.html







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Land Information System

Collaborative Development with NASA

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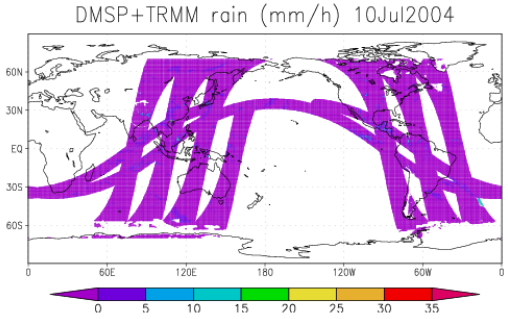
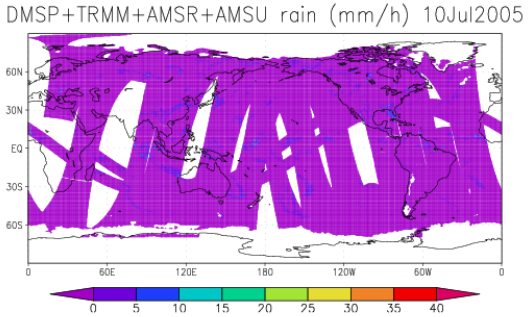
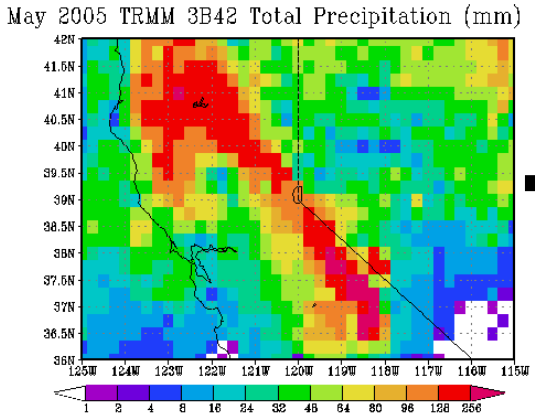
- **Increasing reliance upon space-based precipitation observations**

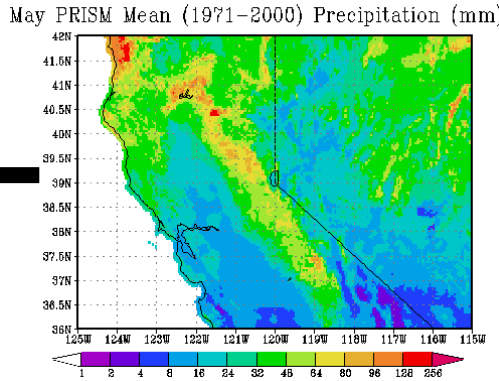




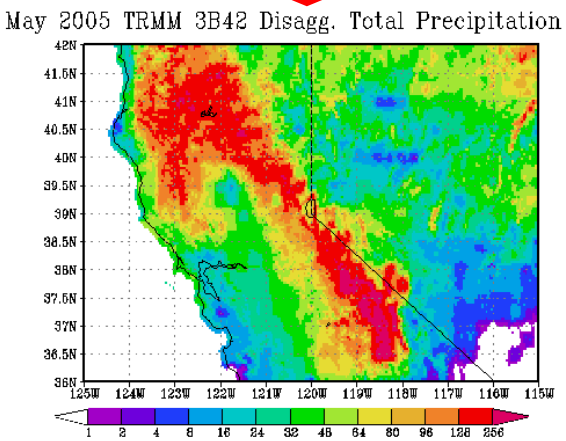
TRMM Estimate



High-Resolution Climatology



- **Use high-resolution climatology (PRISM*) to constrain satellite precipitation observations**



Downscaled precipitation analysis

*PRISM Group on the web– http://www.prism.oregonstate.edu

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Regional NWP Model

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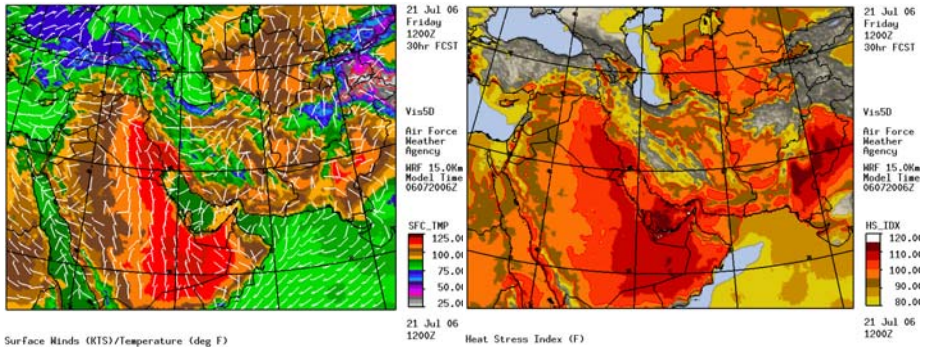
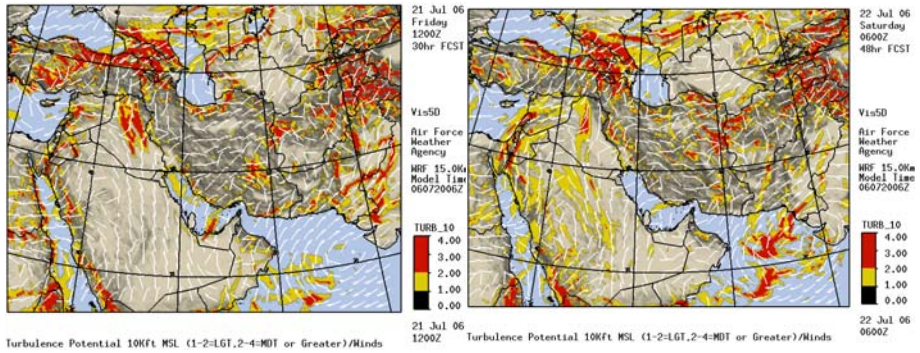
Surface temperature and heat stress forecasts,



10,0000 FT MSL Turbulence forecasts,

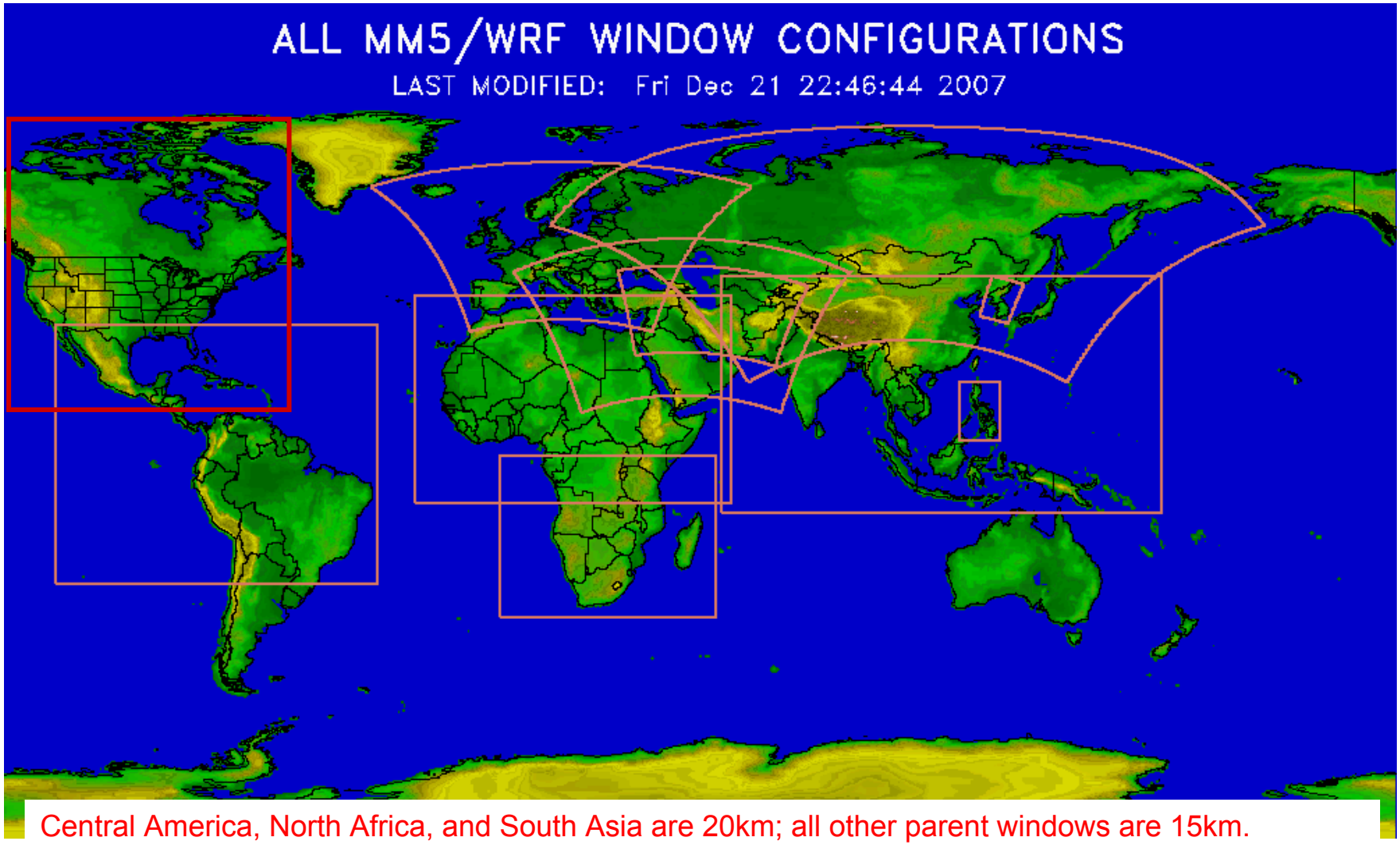


Weather Research and Forecast (WRF) model

- Development agent is NCAR
- Improved forecast capability over MM5 to better meet warfighter requirements
  - Implemented in classified enclave Jul 06
  - Unclassified transition ongoing for all theaters
- Current DA system is WRF 3D-Var (aka “WRFVAR”)
  - Beginning transition to GSI

WRF Windows

Proposed Configuration



Central America, North Africa, and South Asia are 20km; all other parent windows are 15km.

Our Perspective on JCSDA

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- **USAF formally joined JCSDA in 2001**
  - **Commitment was lacking for several years**
  - **Renewed commitment from AFW leadership ~2006**
- **AF now sees JCSDA as a highly effective approach for shared development and R2O of assimilative methods**
- **Primary development bed for NPP/NPOESS data assimilation capability is/will be the JCSDA**
- **Increasing resource commitments to JCSDA**
  - **Visiting Scientist funding increased from 1 to 3 positions**
  - **In-kind projects increased from $1.5M (FY08) to $1.9M (FY09)**
  - **Working to improve collaboration between JCSDA and NCAR for greater unity of effort on 4D-Var development**

JCSDA Projects

High Fidelity Cloud & Aerosol Characterization are the Driving Requirements

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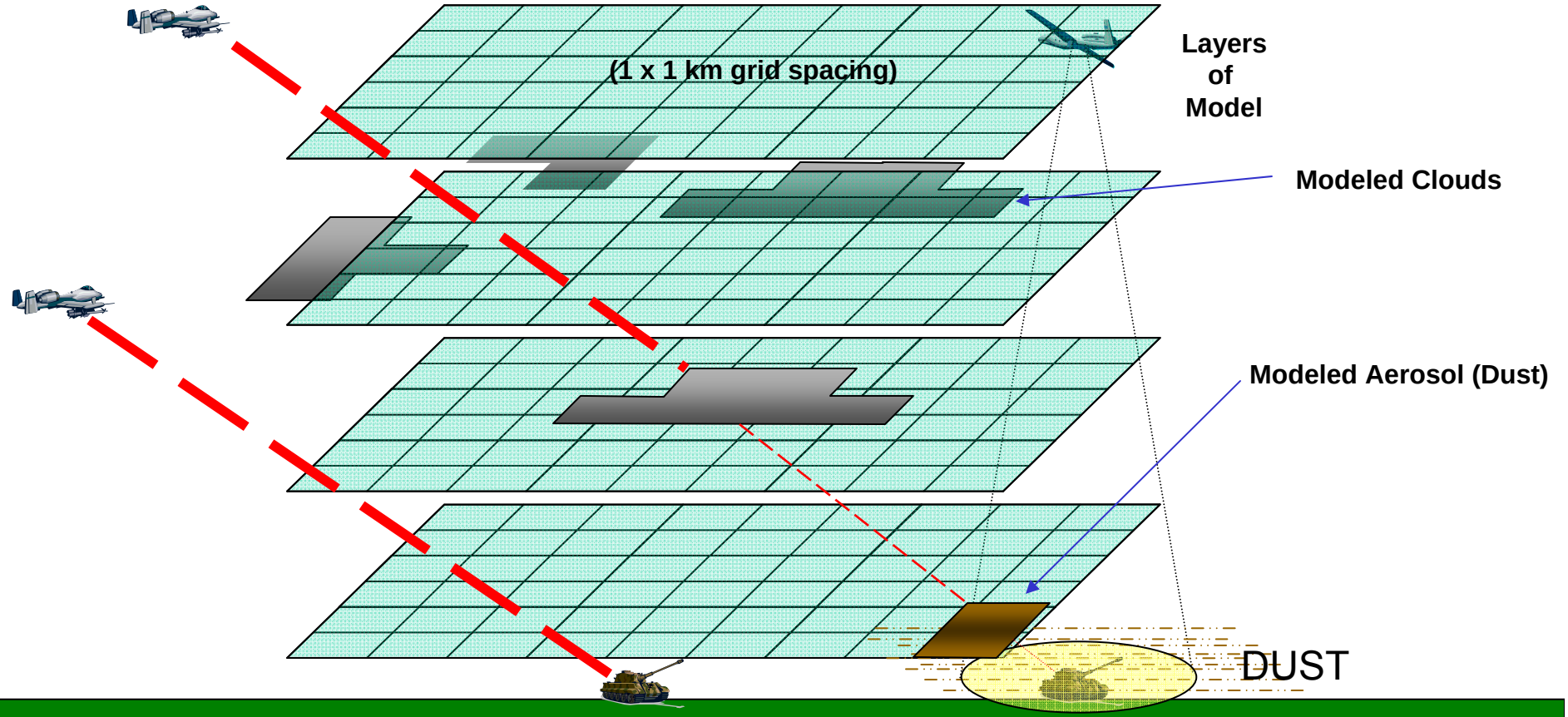

- Spatial resolution: Horizontal: 1 x 1 km, Vertical: # of layers in model (SFC to 10mb)
- Temporal resolution: 1hr steps for 0-12hrs, 3hr steps for 12-24hrs, 12hr steps for 24-72hrs
- Quantify aerosol/cloud "amount" on 1km grid for each layer of model
    - Predict slant path (visible/IR) detection by integrating layered cloud/aerosol forecasts
        - For visual acquisition, output defaults to CFLOS-like product that accounts for aerosols as well as clouds.
        - For IR acquisition, output defaults to TDA product since we must account for sensor type, target temp, background temp, etc. in addition to slant path clouds, aerosols.

JCSDA Projects

Cloud Optical Properties - AIRS Cloud Retrieval

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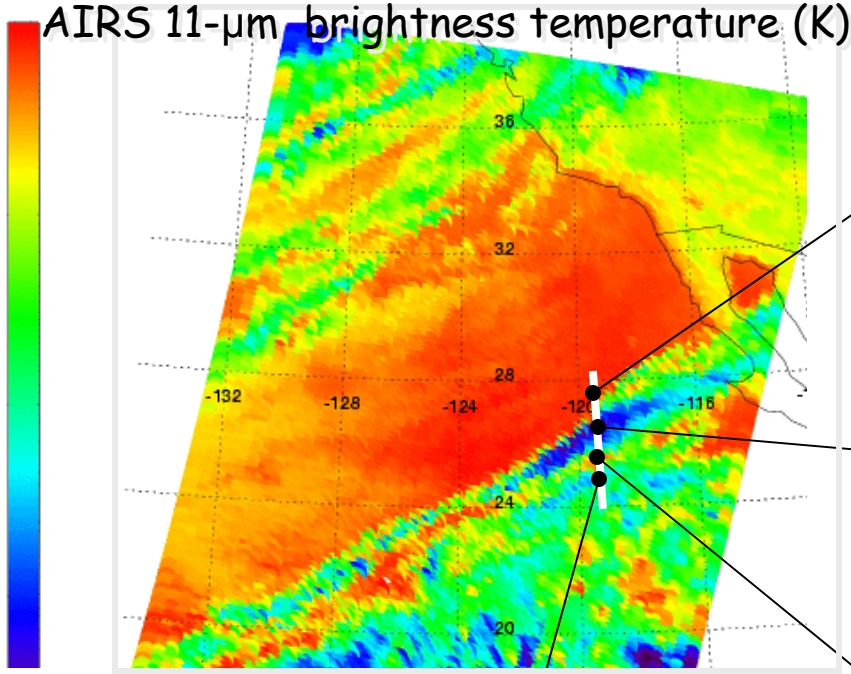
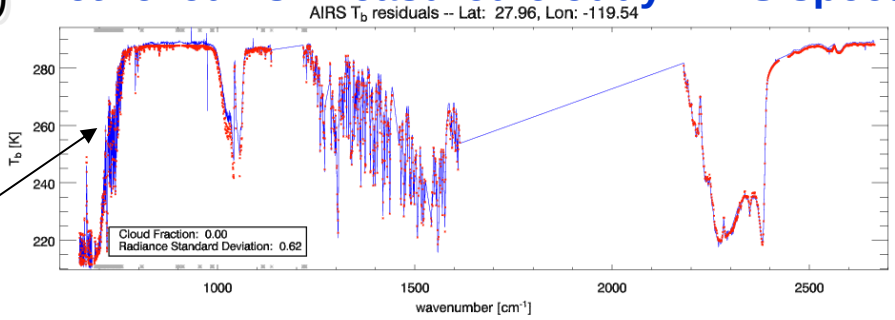
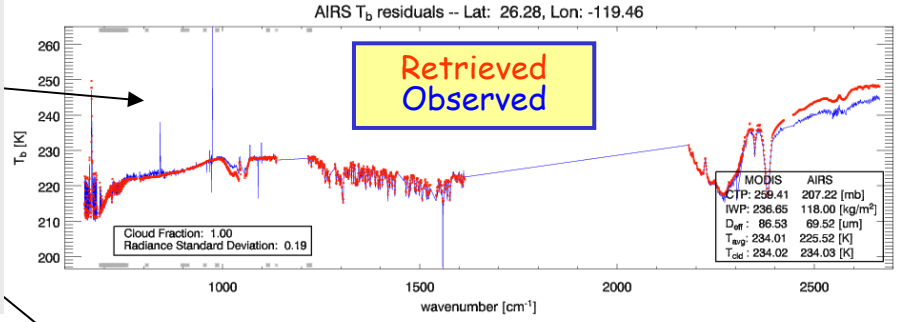
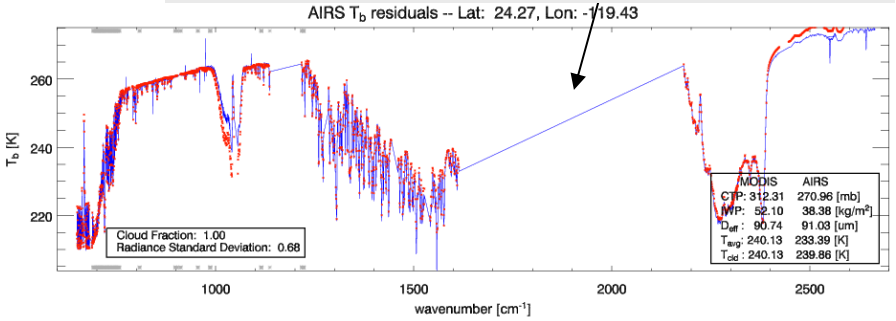
AIRS 11-μm brightness temperature (K)

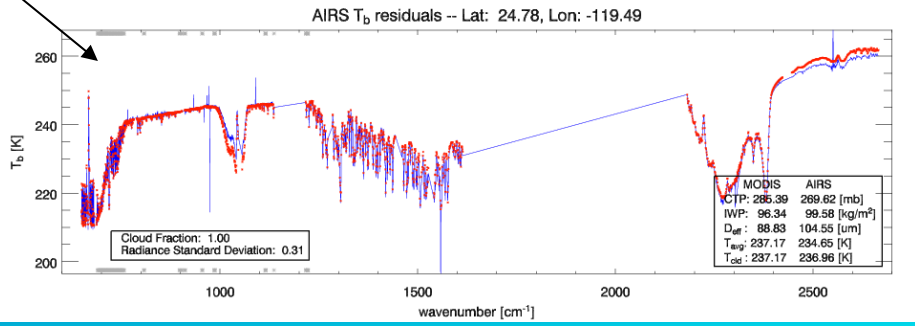


Retrieved vs. measured cloudy AIRS spectra







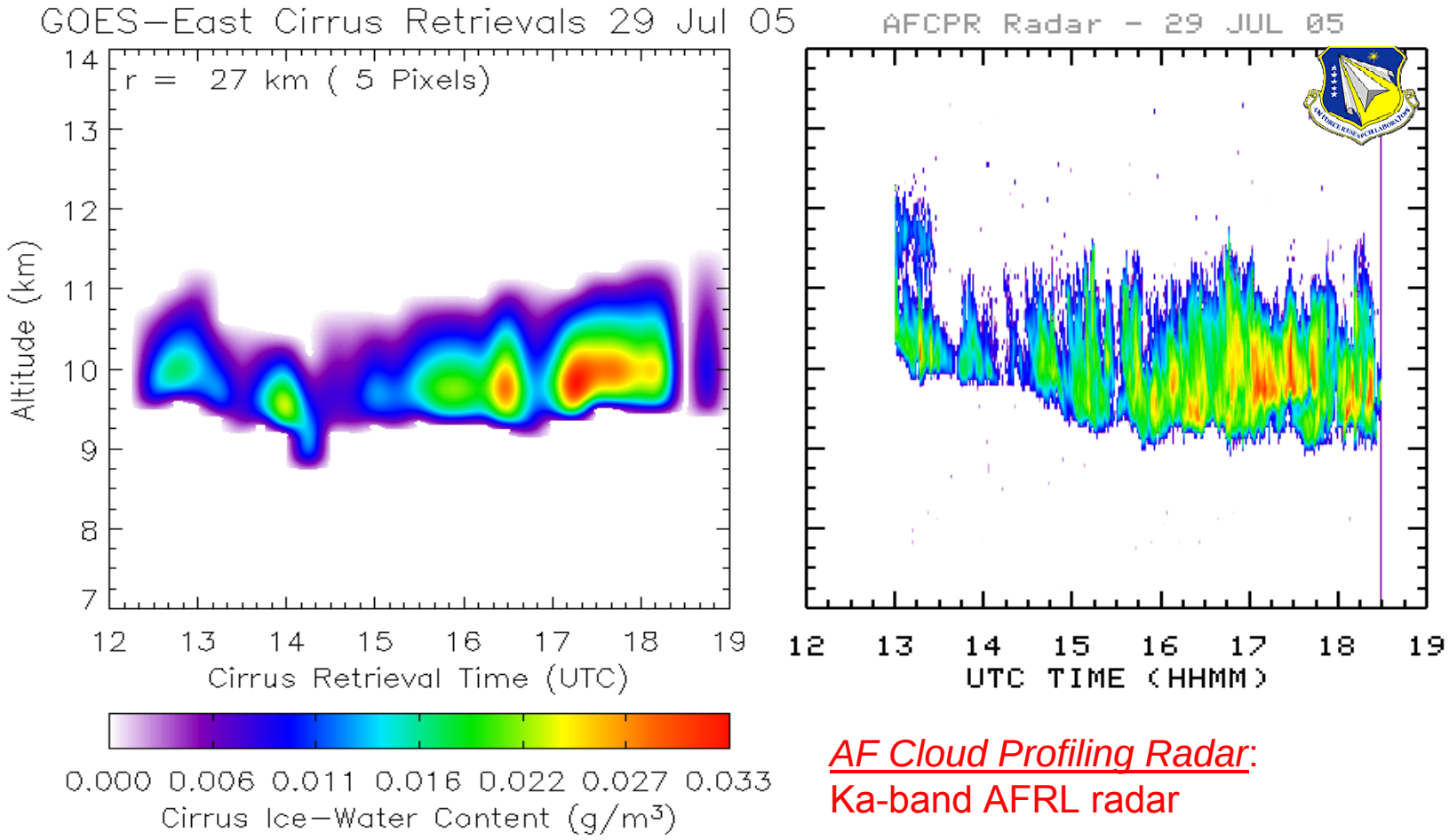


Retrieval with RTM achieves close match with measurements *Tracks transition from clear to cloudy*

JCSDA Projects

Cloud Properties Validation

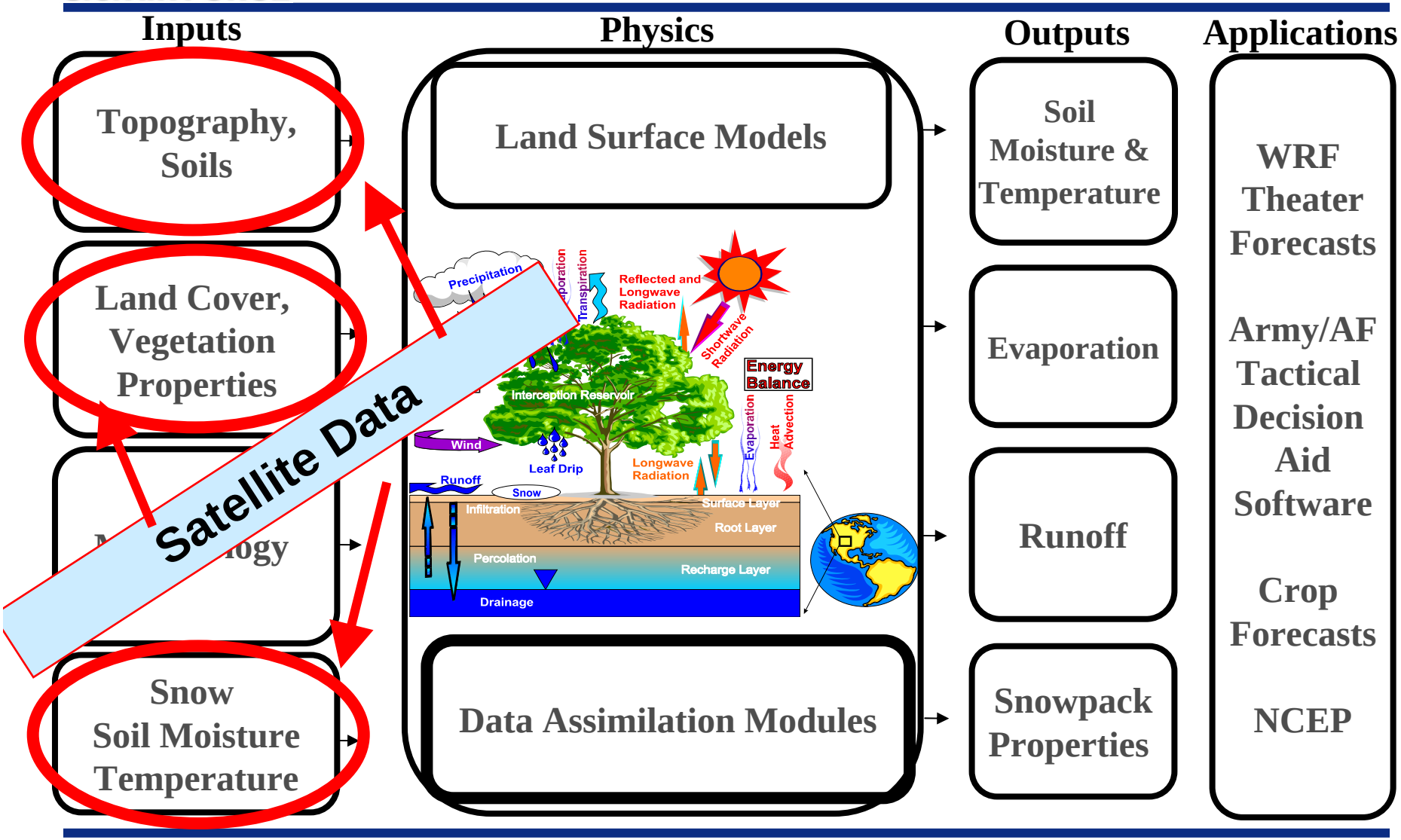
AER, Inc. Ice Water Content using AIRS compared to Radar Returns



AF Cloud Profiling Radar:
Ka-band AFRL radar

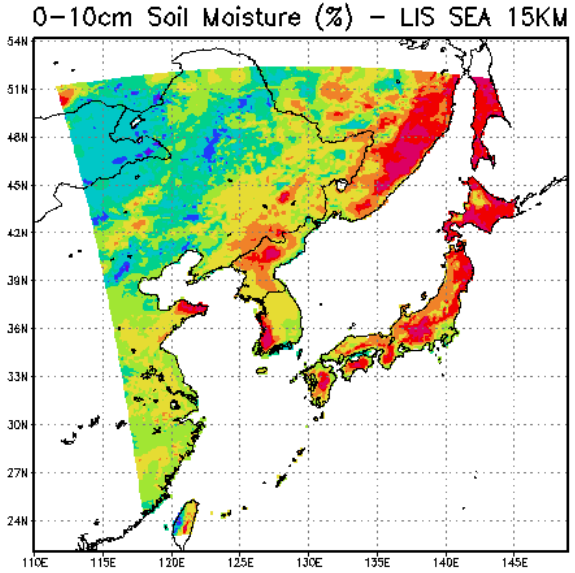
JCSDA Projects

LIS Data Assimilation Enhancement

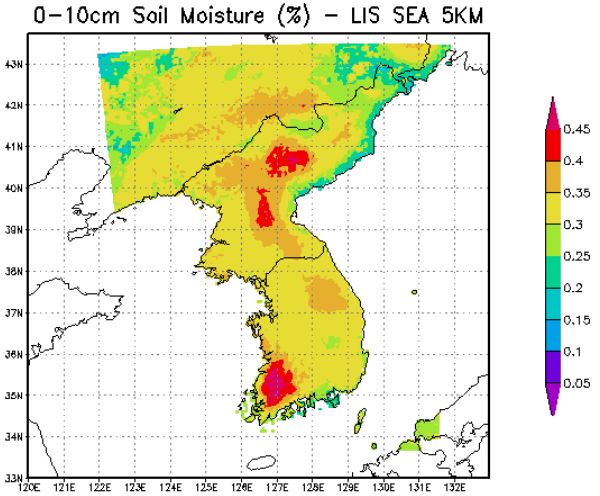


JCSDA Projects

LIS Coupling with WRF

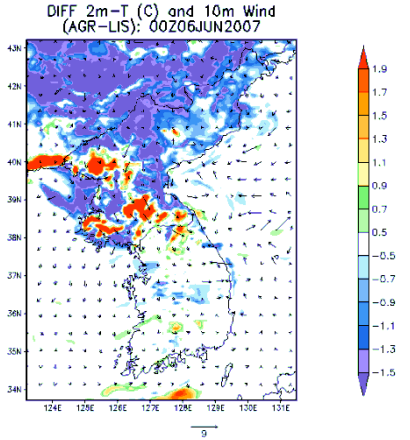


- **Demonstrate and evaluate using LIS to initialize WRF (ARW) SE Asia domain**
- **4 seasonal test case periods**



STUDY RESULTS:

- **LIS initialized runs were able to reduce WRF warm bias**
- **LIS affected 0-48 hour fcst variables of surface weather, boundary layer, cloud, and precipitation**
- **LIS soil and snow fields capture fine scale surface features, reflecting important role in high resolution NWP**

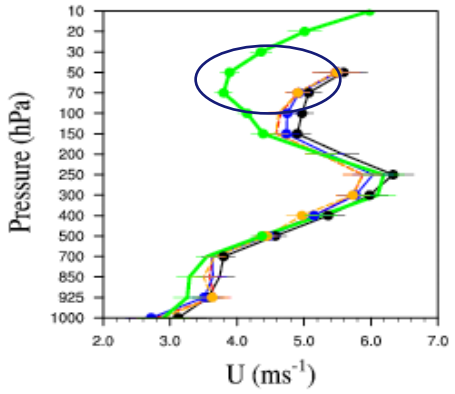


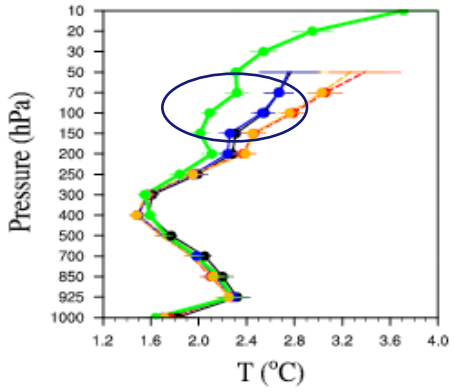
JCSDA Projects

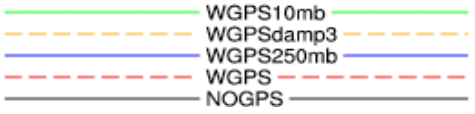
WRF Data Assimilation Enhancement

RMSE of 36hr Forecasts over SWA w.r.t. Sondes

- **WGPS_10mb** vs. **WGPS**: Moving the model top to 10mb decreases the RMSE of U and T forecasts in the stratosphere.
- **WGPS_250mb** vs. **WGPS** & **WGPS_250mb** vs. **NOGPS**: Assimilation of COSMIC data only in troposphere sustains positive impacts in troposphere and decreases the RMSE of T forecasts in stratosphere as shown in WGPS.
- **WGPS_damp3** vs. **WGPS**: The enhanced damping at the model top only marginally changes the RMSE of T(U) forecasts.



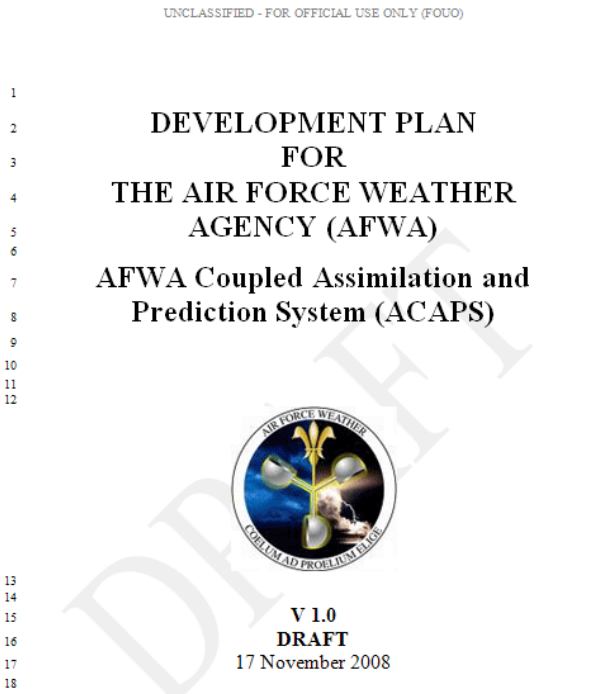




Assimilation of COSMIC data in WRF substantially reduces stratospheric wind and temperature errors (results for SWA theater)

The Future

ACAPS and 4D-VAR



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DEVELOPMENT PLAN
FOR
THE AIR FORCE WEATHER
AGENCY (AFWA)

AFWA Coupled Assimilation and
Prediction System (ACAPS)

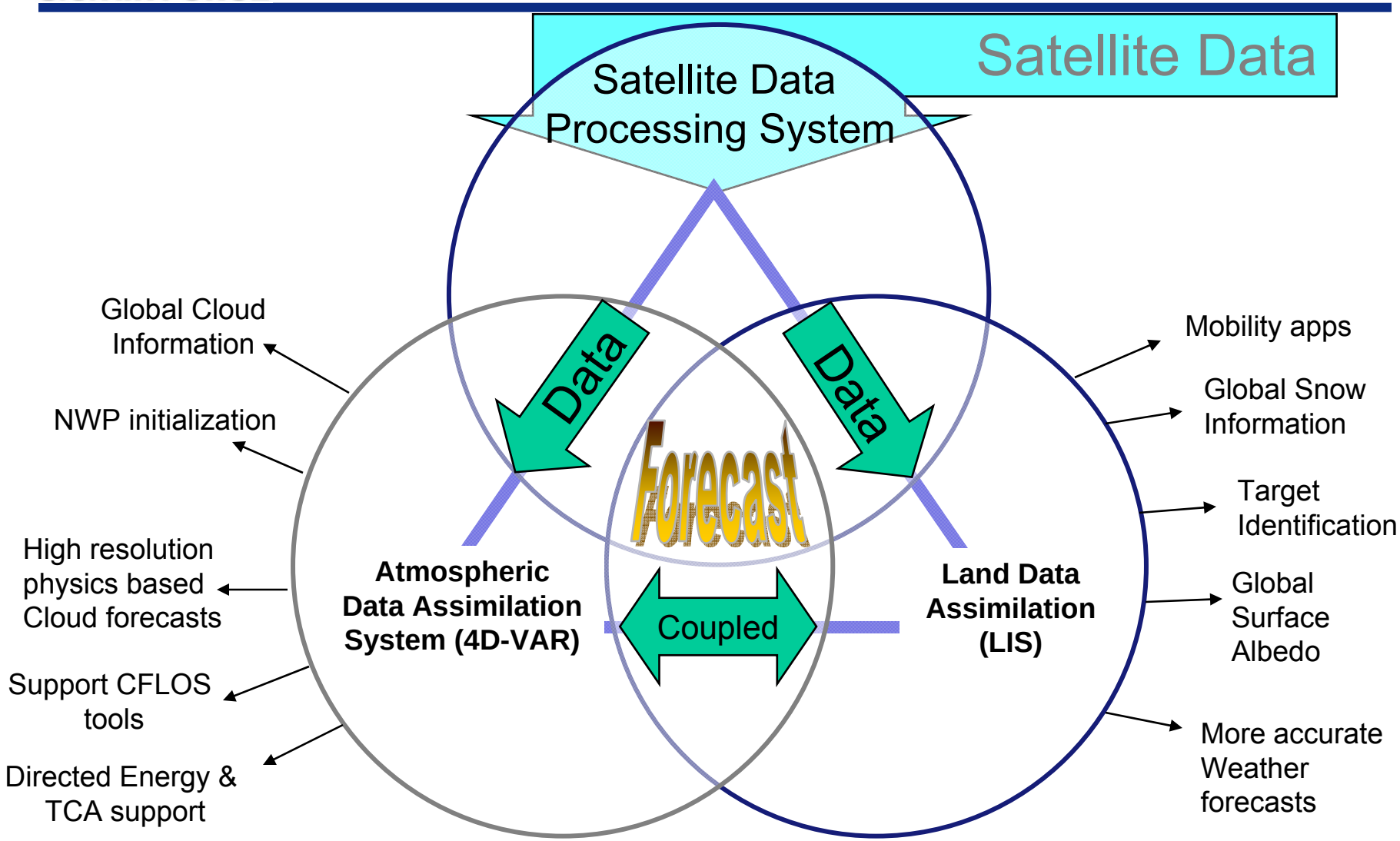
V 1.0
DRAFT
17 November 2008

UNCLASSIFIED - FOUO 1

- **ACAPS – AFWA Coupled Assimilation and Prediction System**
  - **Combines CDFS-II and WRF data assimilation strengths**
- **AFWA and NCAR have FY09 statement of work to begin ACAPS R&D**
  - **5 NCAR FTEs (PhD level)**
  - **Includes research conducted at Colorado State University and University of Colorado (CG/AR)**
- **Cloud properties research (via AER Inc.)**
- **4D variational assimilation essential for clouds**

The Future

ACAPS Conceptual Design



Questions