

# ***AF Life Cycle Management Center***

*Providing the Warfighter's Edge*

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## **USAF Overview and Plans**

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# Overview



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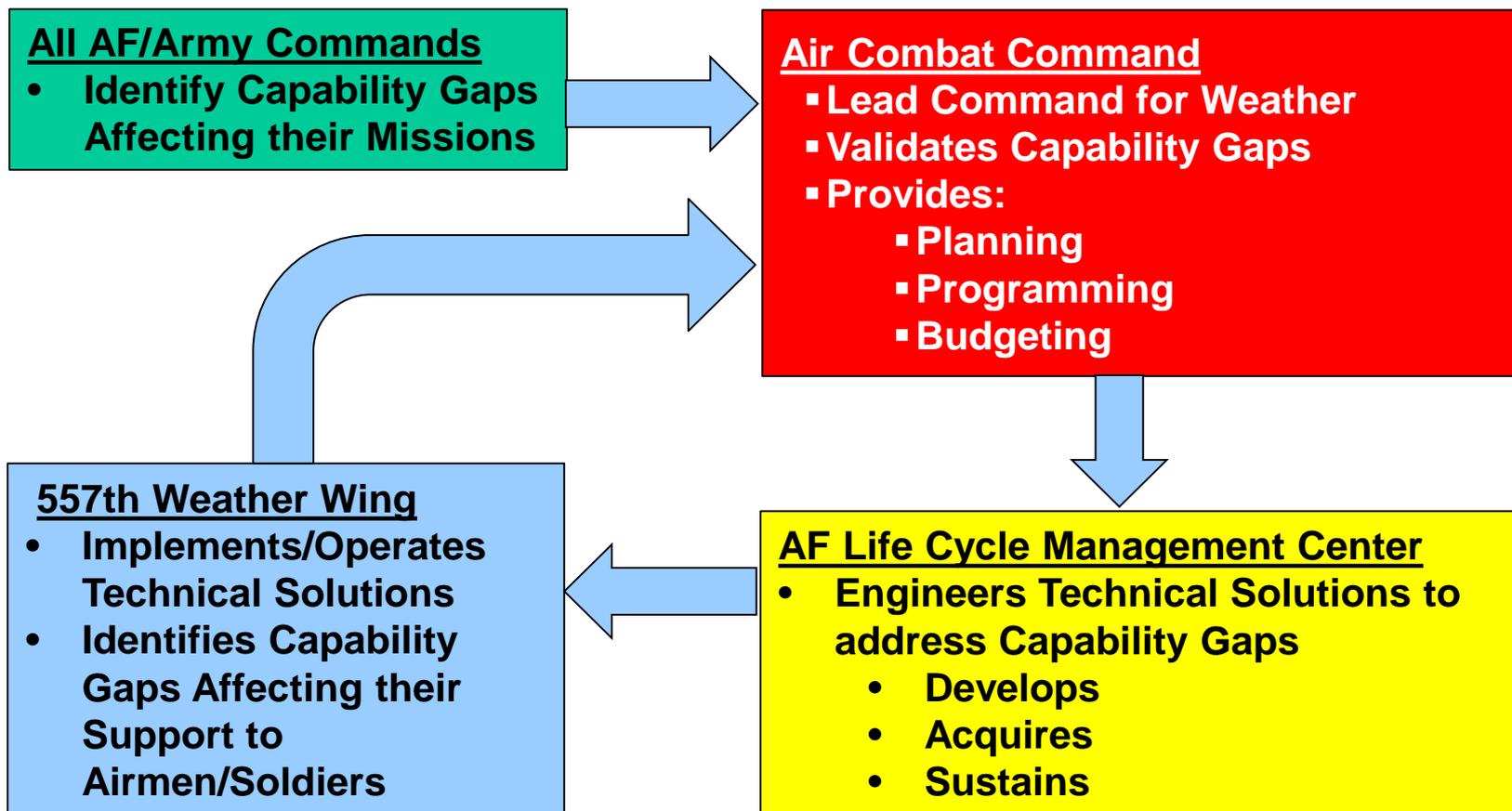
- **USAF Weather Data Assimilation and Cloud Requirements and Process**
- **USAF Weather Modeling Transition Update**
- **Satellite Data Assimilation for Cloud Analysis and Forecasts**



# AF Weather Capability Development



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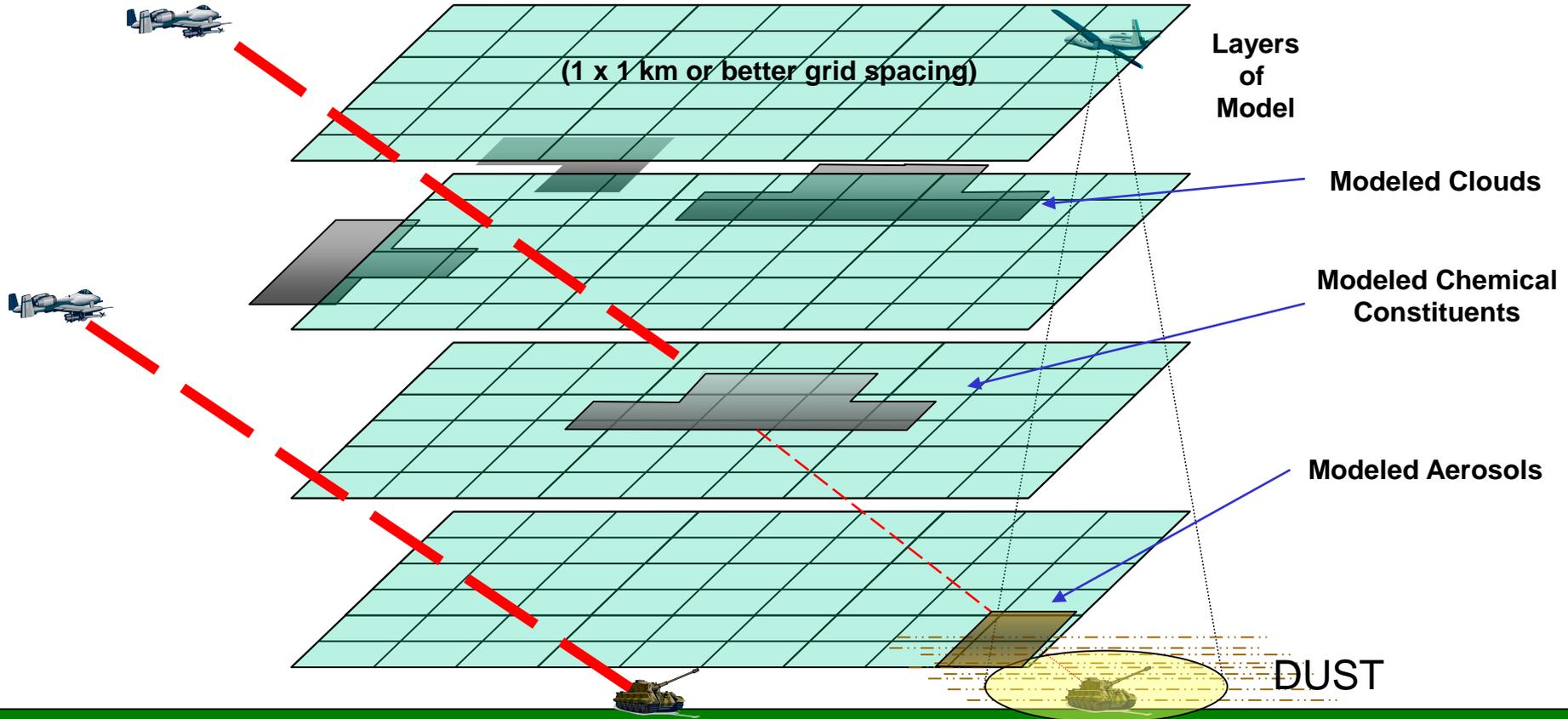


# Modeling Requirements

High Fidelity Clouds & Aerosols are the Driving Requirements



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- Spatial resolution: Horizontal: 1 x 1 km, Vertical: 100m (SFC 5000') 1km above
- Temporal resolution: 1hr steps for 0-24hrs, 3hr steps for 12-72hrs, 6hr steps for 72-144hrs
- 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 clear line of sight that accounts for aerosols as well as clouds.
    - For IR acquisition, output chemical constituent dependencies per sensor type, target temp, background temp, etc. in addition to slant path clouds, aerosols.



# USAF Modeling Transition Status



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- **Currently operationally running 17-km 70 level version of the UKMO's Unified Model named the Global Air-Land Weather Exploitation Model (GALWEM)**
- **Instantiating a version of UKMO Hybrid 4D-Var data assimilation system at the 557 WW**
  - **Expect to be running operationally sometime in 2017 when new HPC hardware is available**
  - **Will initially mimic UKMO data inputs**
  - **Will eventually use some USAF specific sources such as NASA's Land Information System (LIS) and theater obs**



# USAF Modeling Transition Plans



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- **Initiate GALWEM ensembles based on Met Office Global and Regional Ensemble Prediction Systems (MOGREPS)**
- **Upgrading to 12-km 85 Level version of GALWEM in late 2017**
  - **120+ Levels possible in 2018 or beyond**
- **Evaluating GALWEM regional windows**
  - **Still identifying the Data Assimilation need**
- **Will migrate to UM-based dust/aerosol capability**
  - **GALWEM for dust**
  - **UK Chemistry/Aerosol (UKCA)**



# USAF – UKMO Collaboration Processes



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- **USAF will rely on UKMO to manage GALWEM baselines for**
  - **Data Assimilation**
  - **Forecast Model**
- **USAF requested improvements will need to be approved and implemented by UKMO**
  - **USAF to join UM Partnership**
- **USAF will continue to develop functionality and code outside the UKMO baseline**
  - **E.g., LIS, Post-processors**
  - **Ingest theater observations**



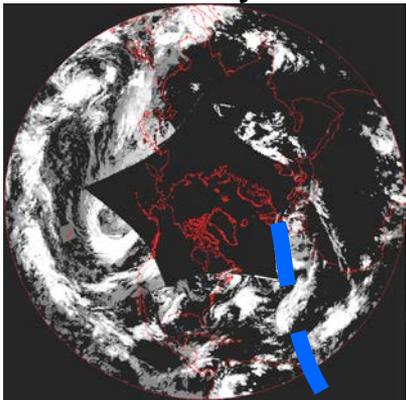
# Global Cloud Analysis System

## CDFS II is Heavily Reliant on Satellite Data

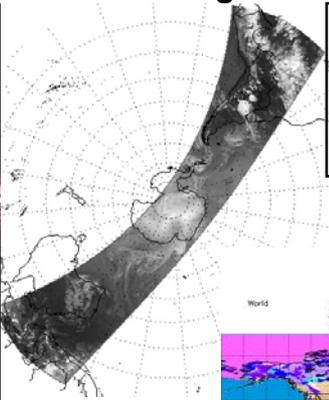
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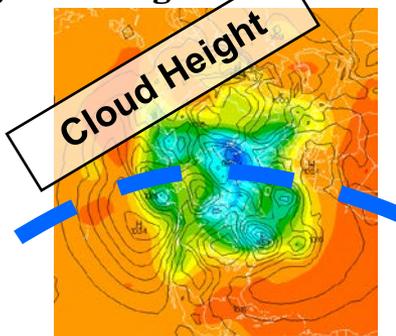
Geostationary Data



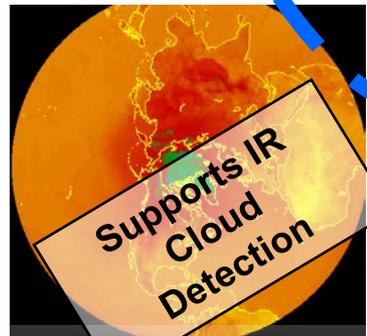
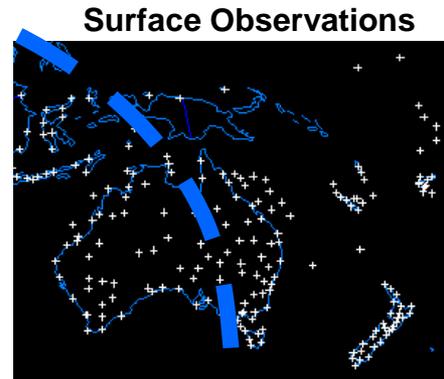
Polar Orbiting Data



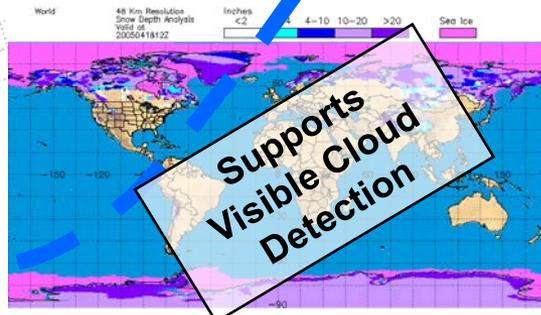
- DMSP
- AVHRR
- MODIS
- VIIRS



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



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

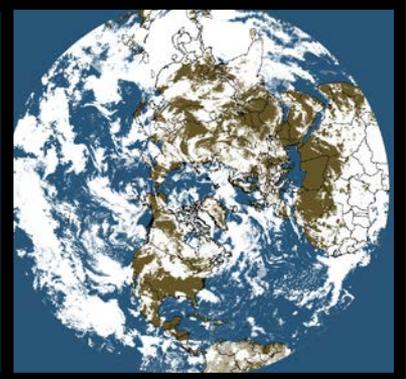


Snow Analysis  
Resolution: 12 nm  
Obs: Surface, SSM/I  
Freq: Daily, 12Z

### World-Wide Merged Cloud Analysis (WWMCA)

Hourly, global, real-time, cloud analysis @12 nm

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





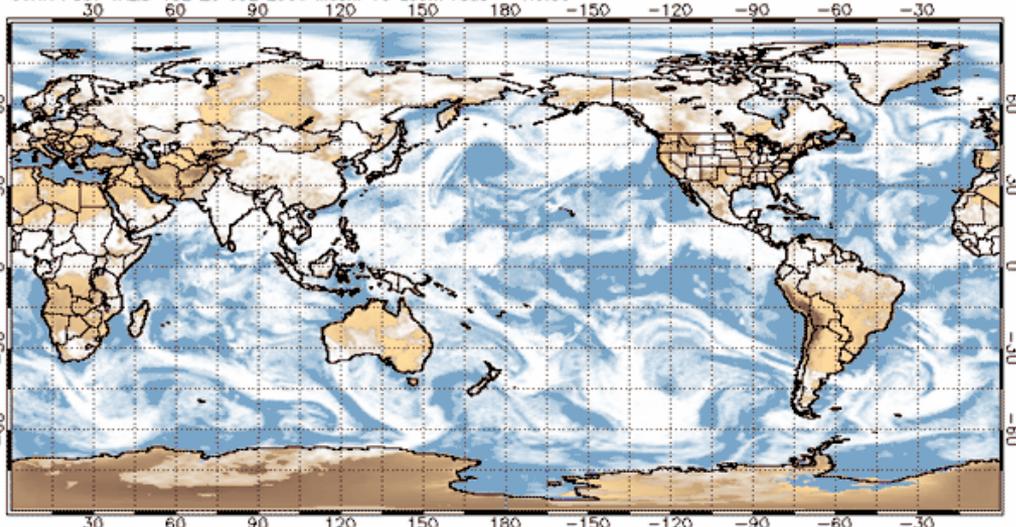
# Cloud Forecast Models

## Short Term Advective and Longer Term Statistical

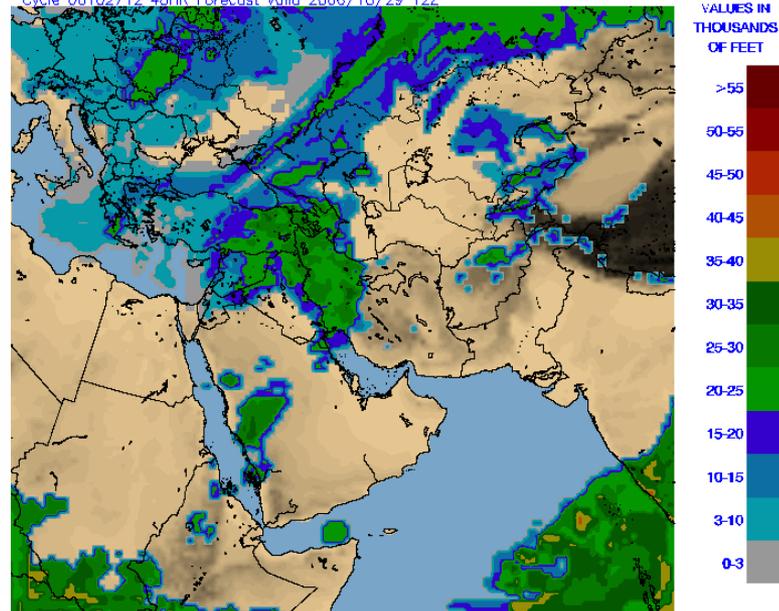


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TOTAL CLOUD AMOUNT  
GREY SHADES REPRESENT PERCENT COVERED BY CLOUD  
06HR FCST VALID 18Z 20 JUL 2006 Mesh: 16 zoom ratio = 1:0.50



Southwest Asia AFWA Diagnostic Cloud Forecast: Max Cloud Top  
Cycle 06102712 48HR Forecast Valid 2006/10/29 12Z



### Short Range Cloud Forecast:

- Primary for hours 1 – 6
- 24 km resolution
- Total fractional cloud coverage
- Layer coverage (5-layers)

### Diagnostic Cloud Forecast:

- Primary beyond 6 hours
- Down to 5 km resolution
- Total fractional cloud coverage
- Layer coverage (5-layers)

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# USAF Cloud Analysis and Forecasting Future Direction



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- **Objective is to directly assimilate and forecast explicit clouds using NWP models**
- **Many technical hurdles to address**
  - **Assimilate all sky radiances**
  - **Improved cloud microphysics**
  - **Rapid update cycling**

**USAF expects to be a leader in the development of this capability**



# Explicit Cloud Analysis & Forecast Approach – Near Term



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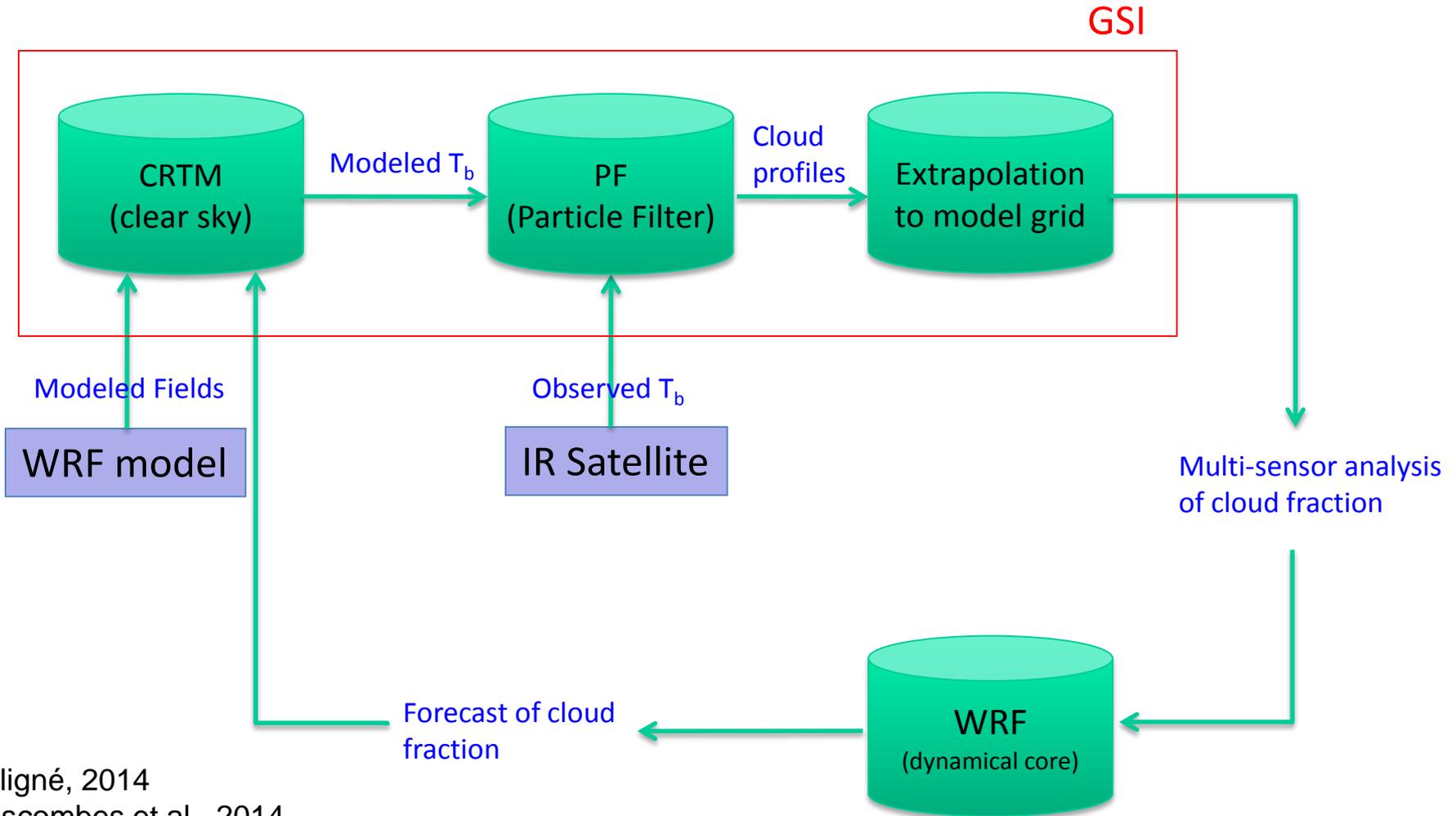
- **Evaluating WRF-based MADCast developed by NCAR**
  - **GSI assimilation**
  - **WRF Dynamics to advect and diffuse clouds**
  
- **NCAR to develop and deliver a MPAS version of MADCast**
  - **Will be evaluated to replace current short-term cloud forecasting product**
  - **Will implement to operations if evaluation is positive**



# MADCast 2.X



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Auligné, 2014  
Descombes et al., 2014  
Wu et al., 2016

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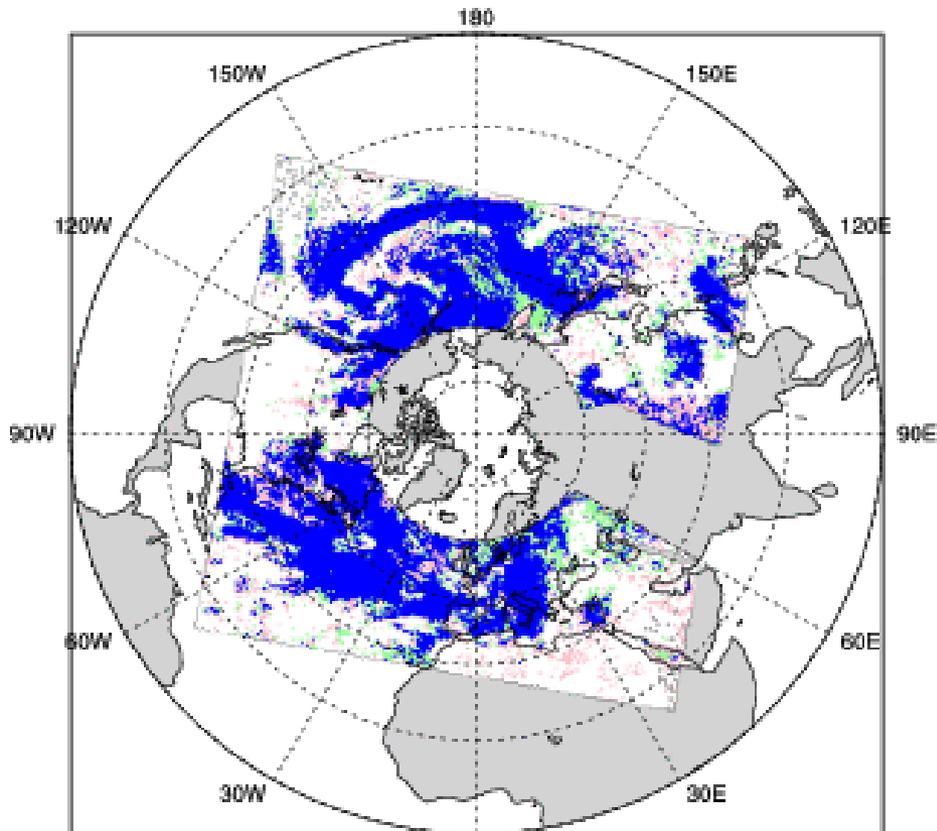


# Evaluation

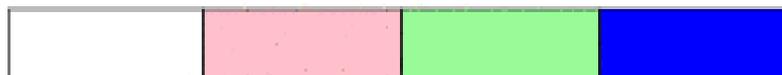


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# Long – Term Plan



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- **Continue to enhance NWP-based cloud analysis and forecasting**
  - **Enhance assimilation of clouds from satellites**
  - **Work towards full physics forecasting**
  
- **USAF would prefer a model-agnostic, community-based next generation data assimilation system**
  - **Allows flexibility in the choice of next-generation model**
  - **Maximizes leverage of community efforts**
  - **Intend to participate in JCSDA's Joint Effort for Data assimilation Integration (JEDI) project**



# Summary



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- **By 2018 USAF will be executing a state-of-the-art global model suite**
  - Hybrid 4DVAR data assimilation
  - 12-km 85-level deterministic forecast model
  - 20+ member ensemble
- **USAF will continue to look to upgrade its aerosol/dust forecast needs with UM-based solutions**
- **USAF long-term goal is to have cloud analysis and forecasting done by NWP models**
  - Looking at initial steps now with MADCast
  - Long-term plan is to achieve goal in middle of next decade as part of the next generation models and data assimilation



# References



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- **Auligne, T., 2014: Multivariate Residual Method for Cloud Retrieval. Part I: Theoretical Aspects and Simulated Observation Experiments. Mon. Wea. Rev. 142, 4383-4398.**  
<http://journals.ametsoc.org/doi/abs/10.1175/MWR-D-13-00172.1>
- **Descombes, G., T. Auligné, H-C. Lin, D. Xu,, and C. Schwartz, 2014: Multisensor Advection Diffusion nowCast (MADCast) for cloud analysis and short-term prediction. NCAR Technical Note, NCAT/TN 509+STR, 21 pp.**  
<http://nldr.library.ucar.edu/collections/technotes/TECH-NOTE-000-000-000-878.pdf>
- **Wu, D., T. Auligne, G. Descombes, and C. Snyder, 2016: A Method for Retrieving Clouds with Satellite infrared radiances using the Particle Filter. Unpublished Manuscript.**