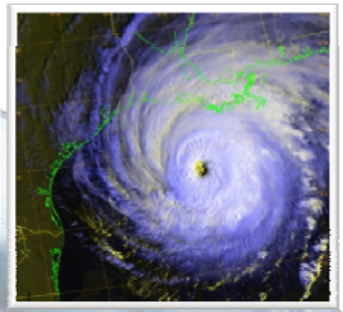
Atmospheric and Environmental Research

Surface Solar Irradiance: Cloud Observations and Radiative Transfer Modeling

A Research Perspective on Solar Forecast Issues



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Atmospheric and Environmental Research

- Provide basic and applied research services to government and industry
  - We enable the effective integration of leading research capabilities across all environmental and weather disciplines to develop data, operational systems, and critical communications for organizational response and management initiatives.
- Leaders in across the spectrum (UV, EO, IR, RF) radiative transfer (RT) simulation modeling for sensor systems (satellite/airborne/ground based)
- Leaders in numerical modeling, analysis, and prediction of the environment
- Scientific integrity of a major research institution coupled with the programmatic experience and efficiency of an ISO-9001 certified contractor
- Worldwide capabilities include:
  - Weather/climate predictions
  - Energy demand forecasting
  - Hurricane forecasting
  - Air quality assessments and predictions
  - Radiative transfer modeling
  - Satellite remote sensing
  - Cloud property determination and forecasting
  - Flood monitoring
  - Space weather observations/forecasting
  - Oceanography

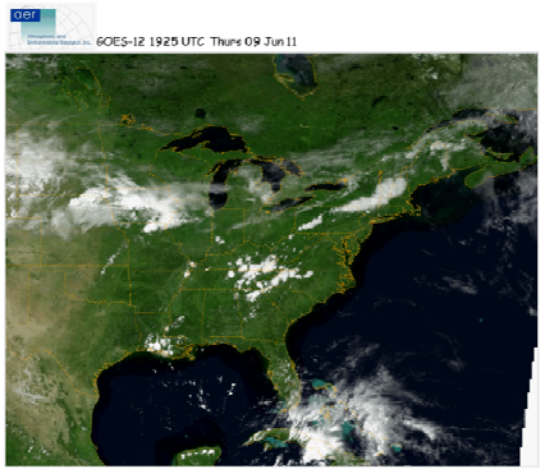
The role of satellite data in cloud detection and analysis

- Environmental satellites provide an optimal platform for observing global cloud cover
  - Hemispheric to global coverage
  - High spatial resolution: on the order of a few km
  - Sufficient spectral coverage
    - Sensor channel wavelengths selected to provide high information content on clouds and surface characteristics
    - New/planned sensors provide additional channels/information content
  - Polar and Geostationary orbits highly complementary
    - Polar provides most frequent updates and greatest overlap at high latitudes
    - Geostationary distortion is minimized and overlap greatest at low latitudes

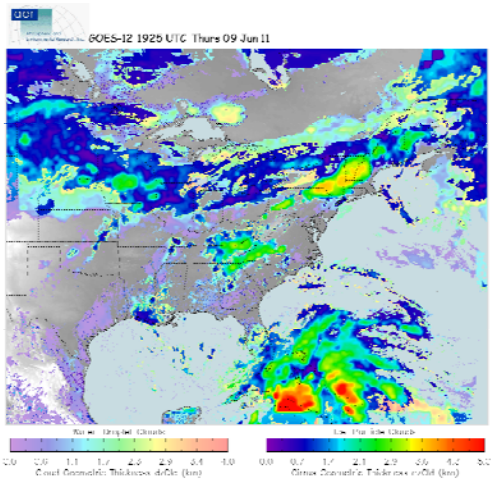
Clouds impact numerous systems and missions

- AER has 20+ years experience developing satellite-based cloud detection, analysis and forecast algorithms for the Air Force (AFRL and AFWA)
  - Cooperative Research and Development Agreement (CRDA) provides access to all unclassified satellite and weather data
  - AER developed the current Air Force operational cloud analysis and forecasting algorithms
  - Current versions operational at AER provide real-time cloud optical properties
    - Physical retrieval approach using multispectral data
    - Applied to GOES, Meteosat, and MTSat data

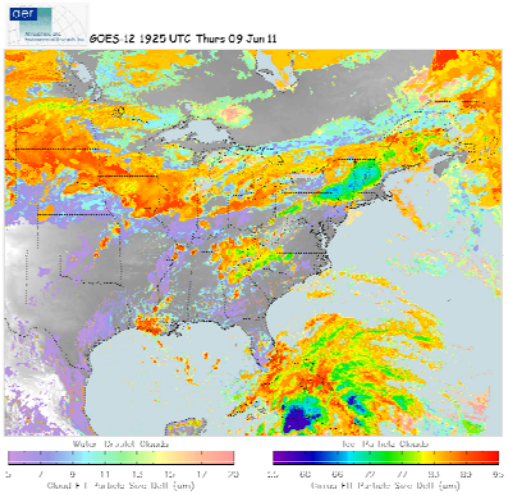
Cloud optical property modules: microphysics necessary for radiative transfer calculations



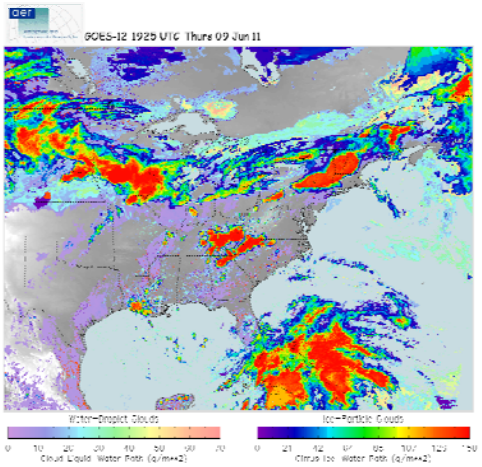
Composite Imagery



Cloud Thickness



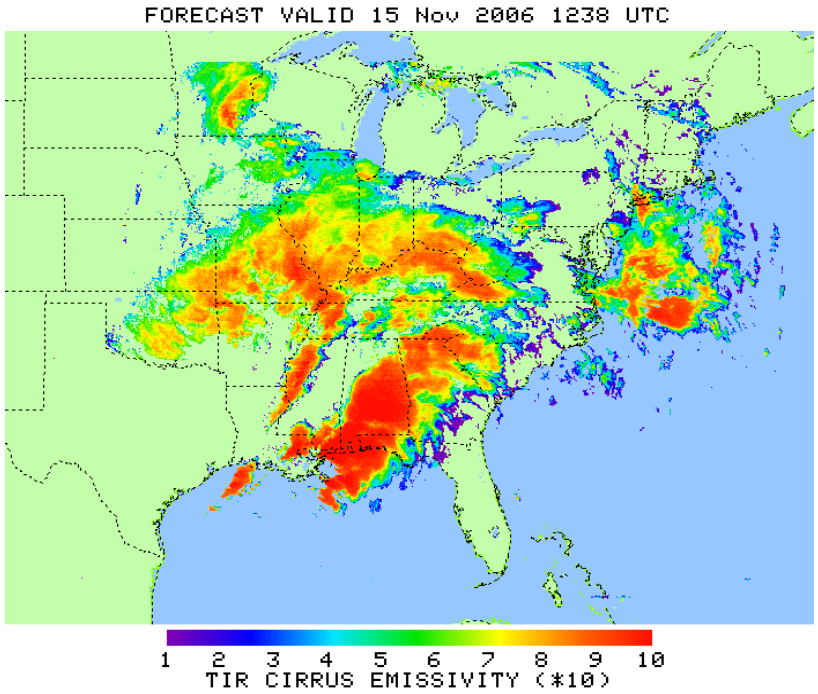
Particle Size

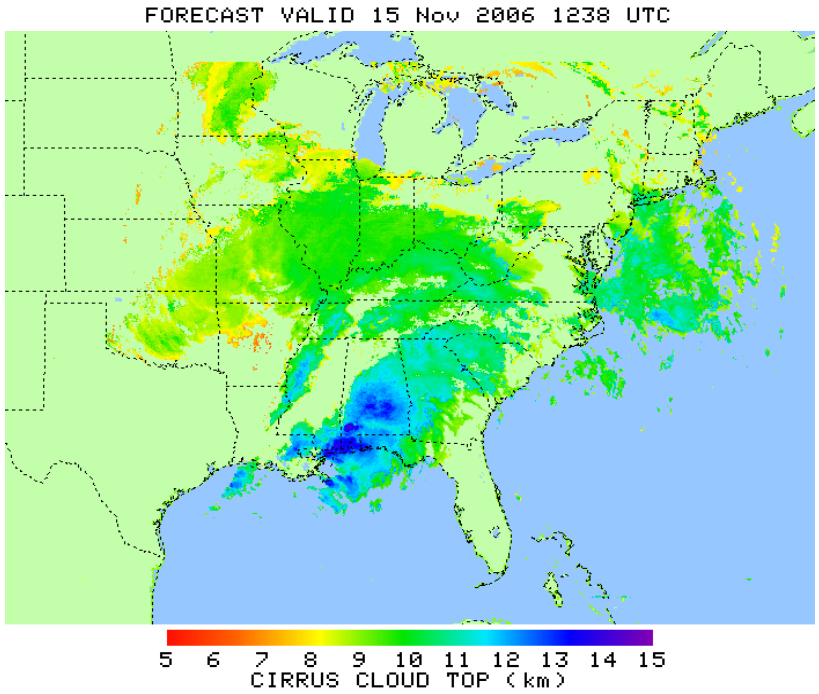


LWP/IWP

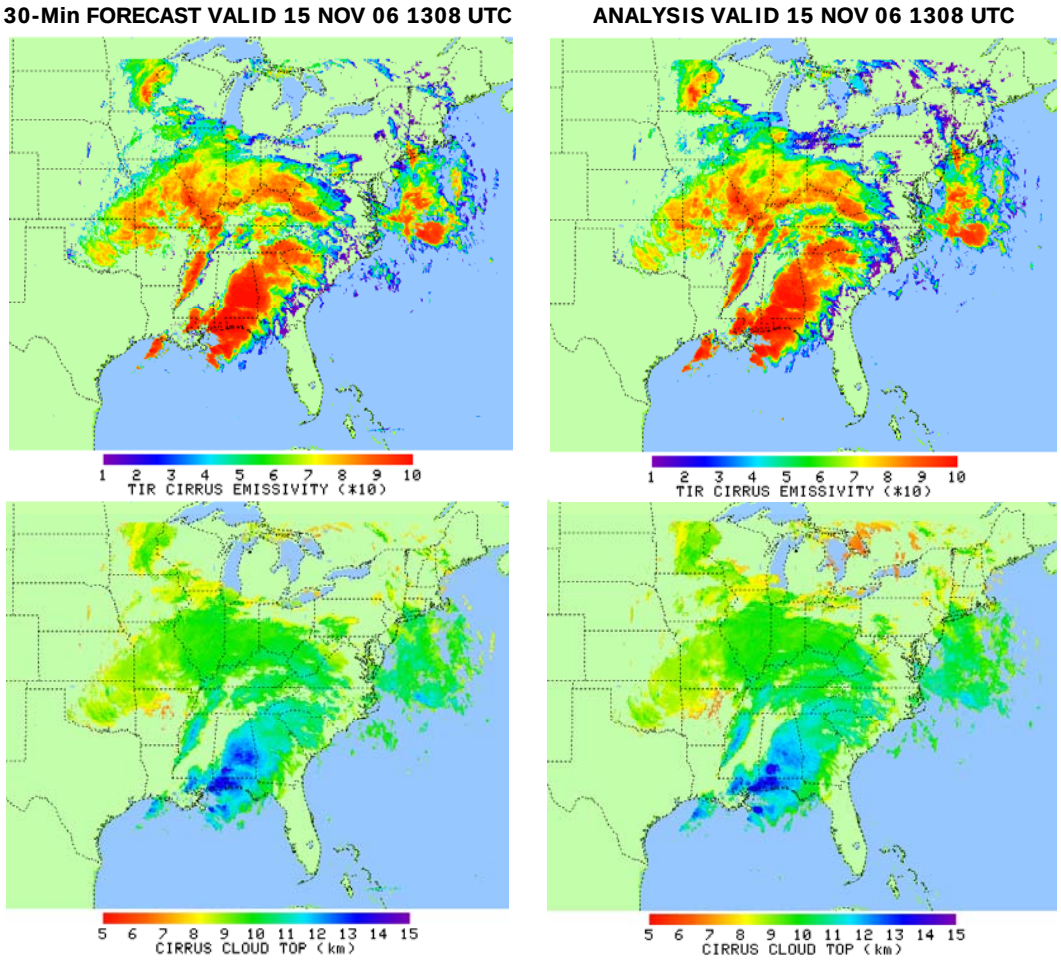
Forecasts of 3D Cloud Distribution

- **Uses back-trajectory approach to forecast cloud movement for specified time period**
  - **2-minute intervals out to 30 minutes**



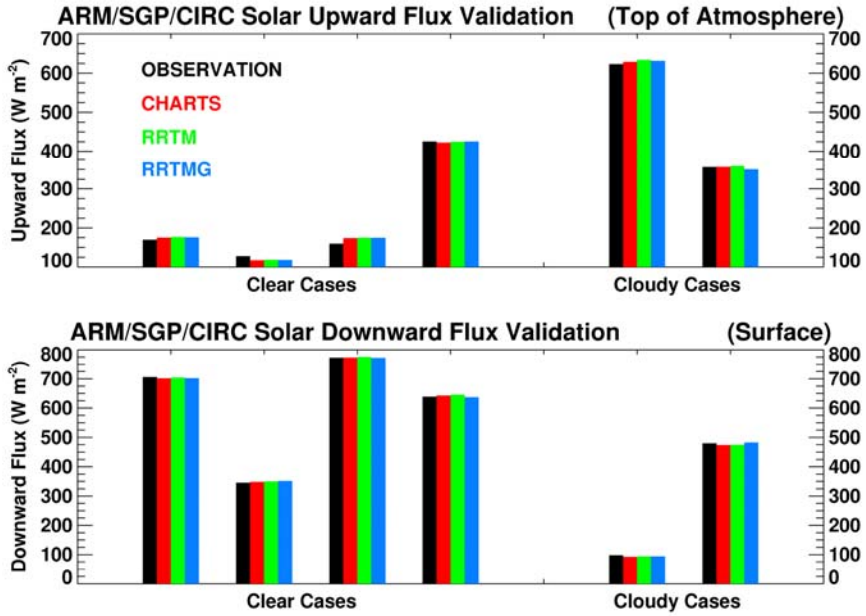


Cloud forecast validation using subsequent cloud analysis



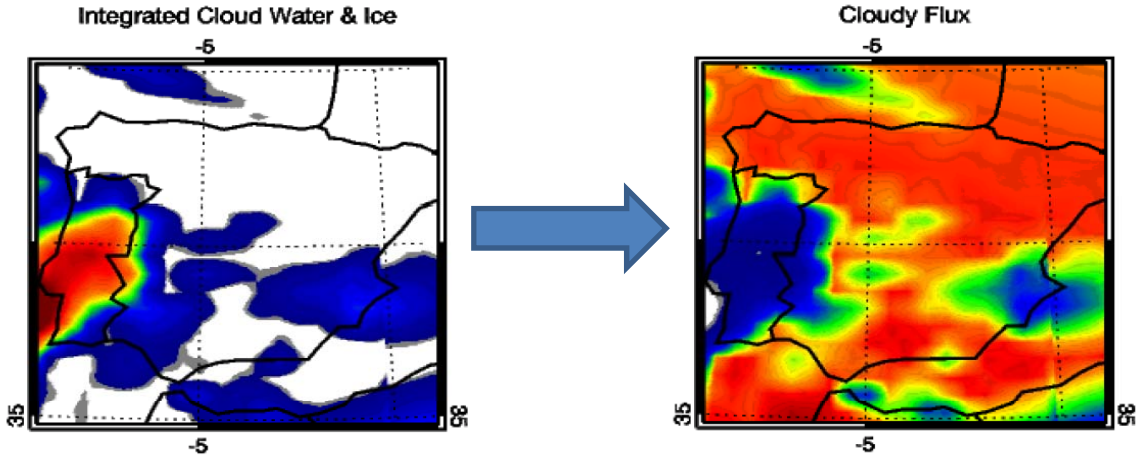
State-of-the-Science Radiation Code: RRTMG

- RRTMG developed as part of DOE ARM program
- Best fast RT code in existence as shown in peer-reviewed RT model intercomparisons
- Used in prediction codes worldwide: RUC, WRF, NCEP GFS and CFS, NCAR CESM/CAM5, ECMWF IFS

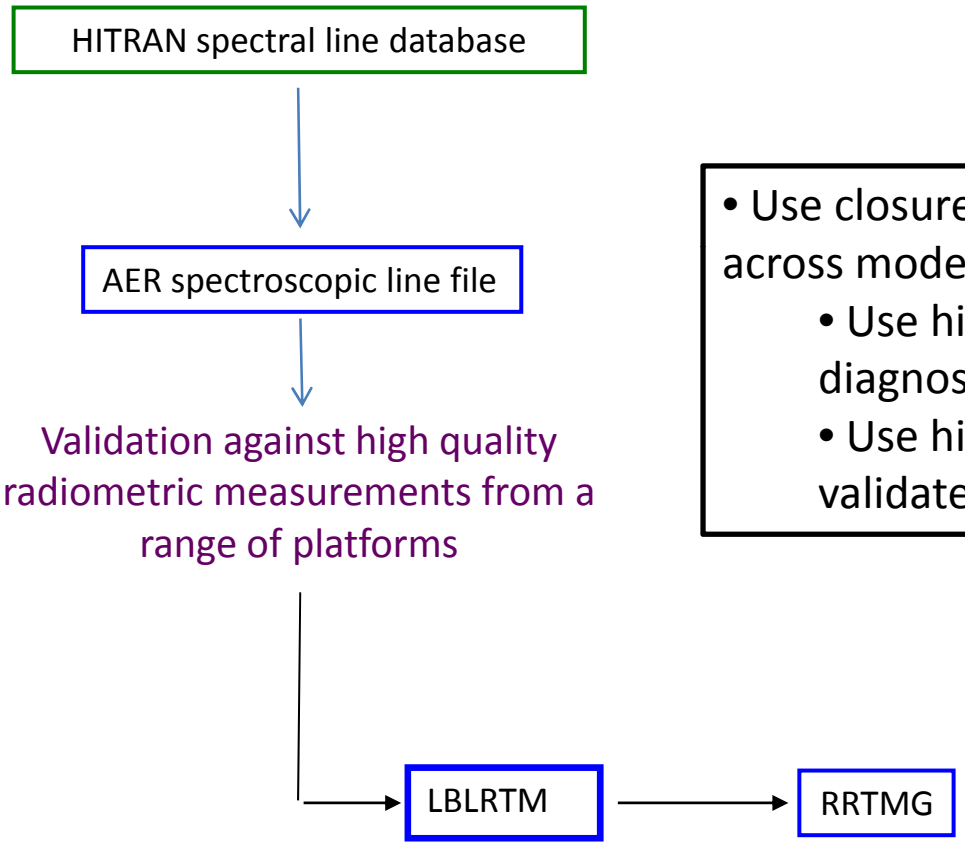


Use RT model to compute surface solar irradiance from atmospheric information

- Perform radiative transfer calculation to compute irradiance reaching the surface
  - Can generate broadband as well as narrow-band irradiances
  - Could be tuned to specific spectral response of panels
- NASA and DOE funding to port AER RT models (including RRTMG) to graphical processing unit (GPU)



RRTMG validated against high spectral resolution model



- Use closure studies to maintain accuracy across model domains
  - Use high spectral resolution models to diagnose overall accuracy
  - Use high spectral resolution models to validate fast model parameterizations

Conclusions

- Advanced cloud analysis techniques provide enhanced utility for satellite data
  - Physical retrieval approach for cloud optical properties
  - Near global coverage ~15 minutes, improving with new systems
  - AFWA archive datasets and algorithms, with AER updates for cloud optical properties could be used to reprocess historical data

- Need a better understanding of radiative transfer as applied to the solar forecast problem
  - Radiative closure studies to validate models used and better understand uncertainties and limitations
    - Forecast errors should be limited by the uncertainties, not the radiation calculation