High Resolution Coupled RAQMS/WRF-Chem Ozone and Aerosol Simulations for GOES-R Research

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GOES-R: Next Generation GOES

First launch scheduled for FY2015

GOES-R offer many improved capabilities over the current GOES

*Advanced Baseline Imager (ABI) - Improved resolution (4x), faster coverage (5X), more bands (2X) and more coverage simultaneously

- 6 bands in visible
- 10 bands in IR

Much research underway to ensure optimal use of ABI data when it becomes available

GOES Algorithm Working Group (AWG) Proxy ABI Dataset Team

Purpose: Generate proxy ABI datasets

Datasets to be used by GOES-R team members for algorithm development, testing and demonstration activities.

Current Research

-Augment the current GOES-R AWG WRF ABI proxy data set capabilities through addition of ozone and aerosols.

- Perform high temporal and spatial resolution WRF/Chem simulations over CONUS to provide ozone and aerosols

-Addition of aerosol and ozone distributions allows generation of more realistic proxy radiances for all ABI bands

ABI Proxy Simulation

Needed: 24 hour high temporal and spatial resolution radiance datasets over CONUS for all 16 ABI bands.

- 06Z August 24 - 06Z August 25, 2006
  - -Forest fires and sulfate event
  - -Chemical initial conditions and lateral boundary conditions available
    (*2x2 degree global analyses)

First step: WRF/Chem simulation*

1) 36km resolution 00Z August 20 – 00Z August 23

2) 12 km resolution 00Z August 23 -00Z August 24

3) 4 km resolution 00Z August 24 – 06Z August 25

15 minute resolution 06Z Aug. 24 – 06Z Aug. 25
5 minute resolution 06-09Z and 15-18Z Aug. 24

40 vertical layers, top=50mb

Models Used for Proxy ABI Dataset Generation

WRF-Chem V3.0.1

Chemistry

•GOCART RACM - KPP (chem_opt = 301)

(ozone, SO4, hydrophobic OC, hydrophilic OC, hydrophobic BC, hydrophilic BC, dust, sea-salt)

-Simple aerosol treatment

•Anthropogenic emissions – high resolution (4km) NEI-99, version 3

(including March 2004 revisions)

•Biomass burning emissions produced from Wild Fire Automated

Biomass Burning Algorithm (WF-ABBA) wildfire products

Real-time Air Quality Modeling System (RAQMS)

Pierce et al. (2007) JGR

- developed by UW-Madison and NASA Langley
- unified (stratosphere-troposphere) online global chemical and aerosol assimilation/ forecasting system
- 2x2 degree global analyses
- 35 vertical layers (top ~60km)
- assimilate -MLS ozone, TES CO and MODIS aerosols
- uses GOCART model
- global analyses available at 6 hour intervals for Feb. – Oct. 2006

-provided chemical initial conditions and lateral boundary conditions

-used to provide ozone and temperature profiles above 50mb (top of WRF/Chem) in CRTM

JCSDA CRTM

- ABI sensor specifications are included in the CRTM
- Appropriate satellite viewing geometry used in the generation of radiances
- IR version of CRTM for ABI channel forward modeling has been available for some time.
- Beta version of CRTM used which includes forward modeling capabilities for ABI visible channels (including aerosols).

WRF-Chem Simulation

Meteorology initialized 00Z Aug. 20 from NCEP GDAS 1x1 degree data
-updated every 24 hours at 00Z, except 00Z Aug. 25

Chemistry initialized at 00Z Aug. 20 from RAQMS 2x2 global analyses
-never updated

Chemical lateral boundary conditions (ozone and aerosols) – each time step from 6 hour RAQMS analyses

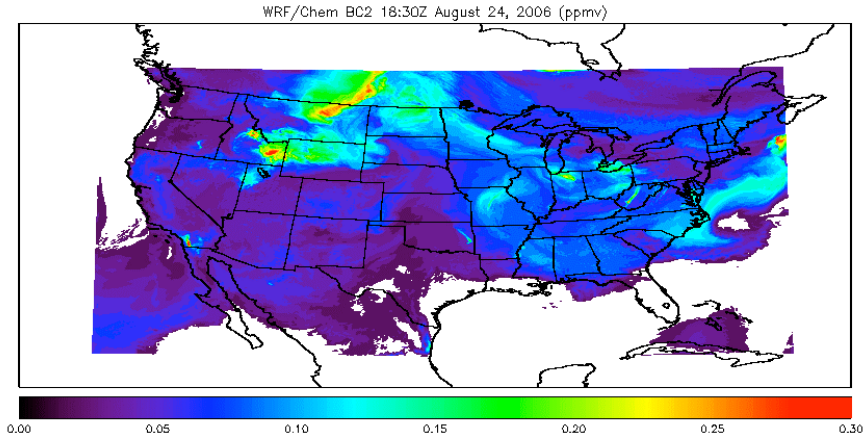
Calculation of Proxy ABI Radiances

Atmospheric structure → CRTM forward model → Radiances

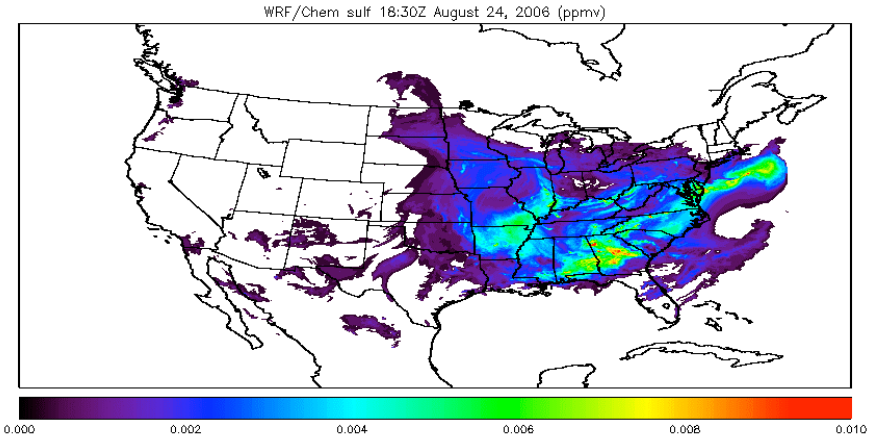
WRF/Chem input to CRTM:

- vertical profiles of T, q, O_3, cloud water, ice, snow and graupel
- SO4, OC1, OC2, BC1, BC2, Dust (5 bins), Sea Salt (4 bins)
- surface parameters (e.g., soil temperature, vegetation fraction, land use)
- RAQMS profiles of T and O3 above the top of WRF/Chem (above 50mb)

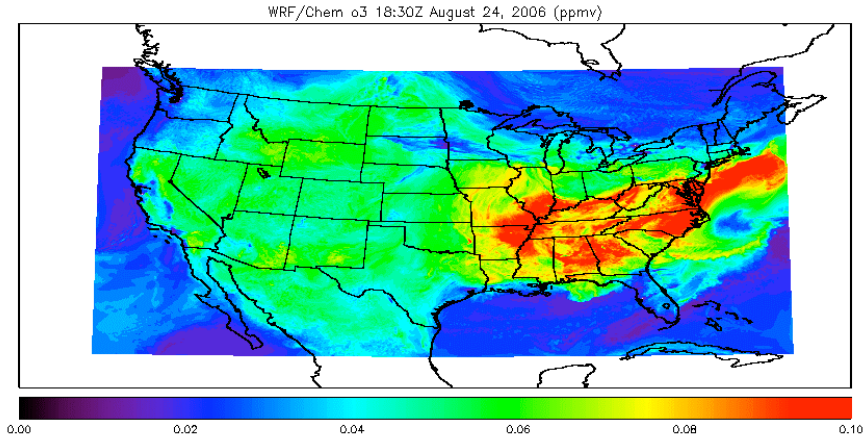
WRF/Chem 4km
18:30Z August 24, 2006 - Lowest layer



Hydrophilic Black Carbon (BC2)



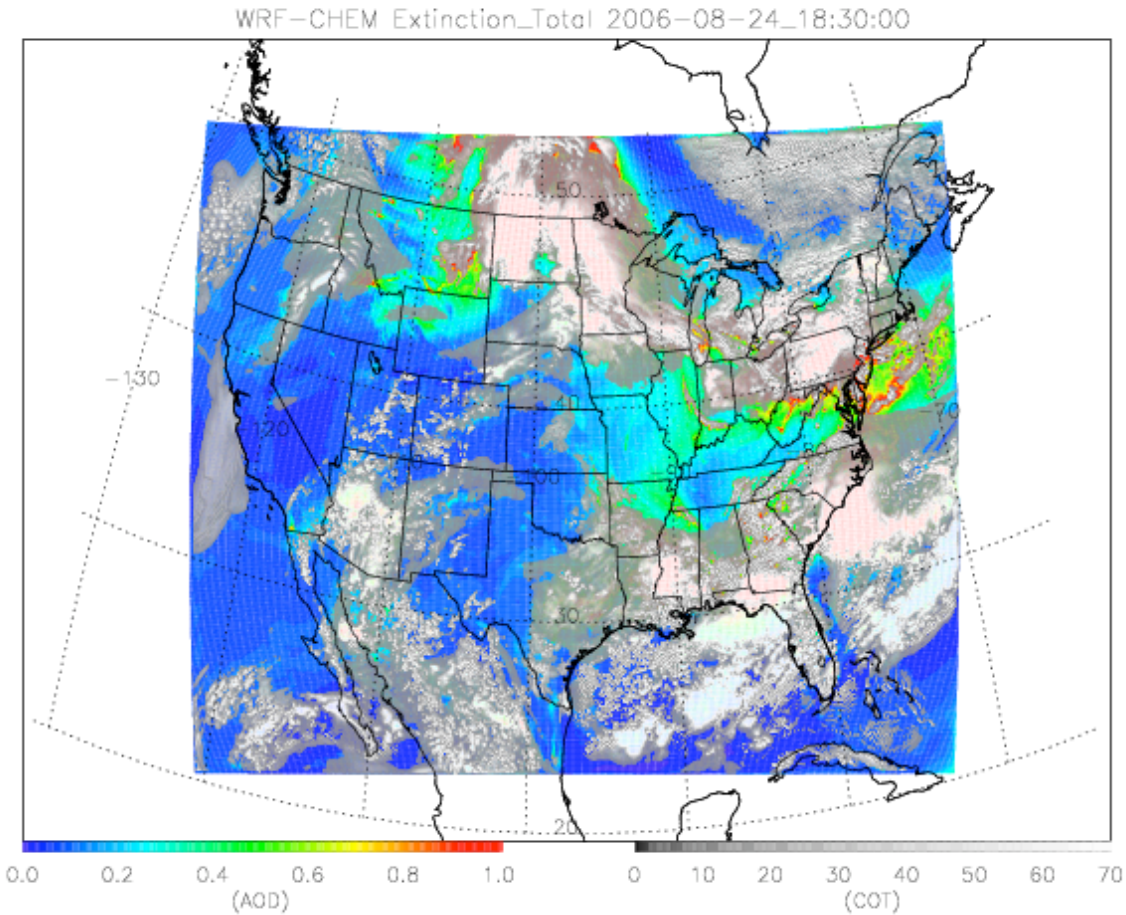
Sulfate



Ozone

Aerosol Optical Depth and Cloud Optical Thickness
WRF/Chem simulation

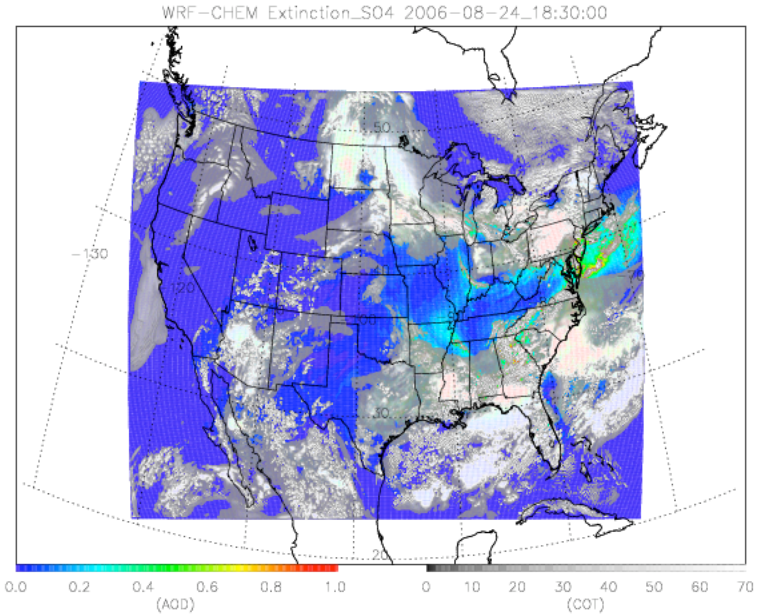
18:30Z August 24



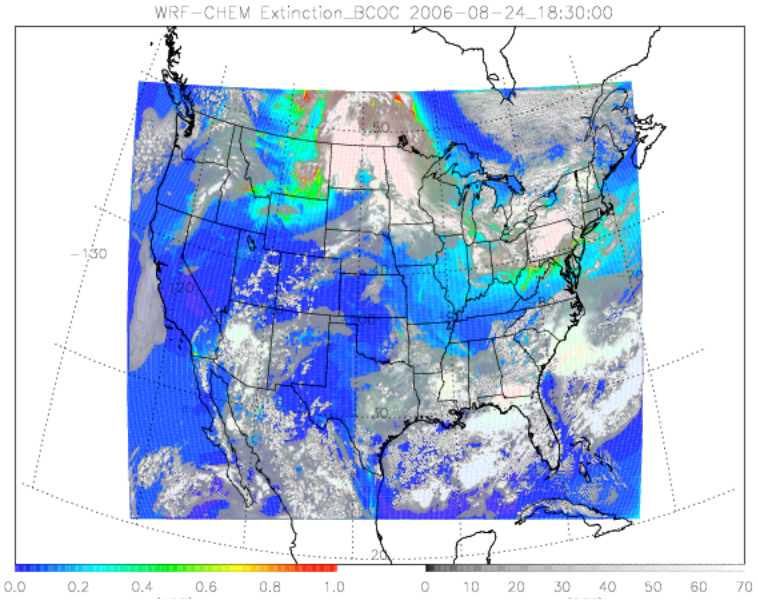
AOD COT

Component AOD

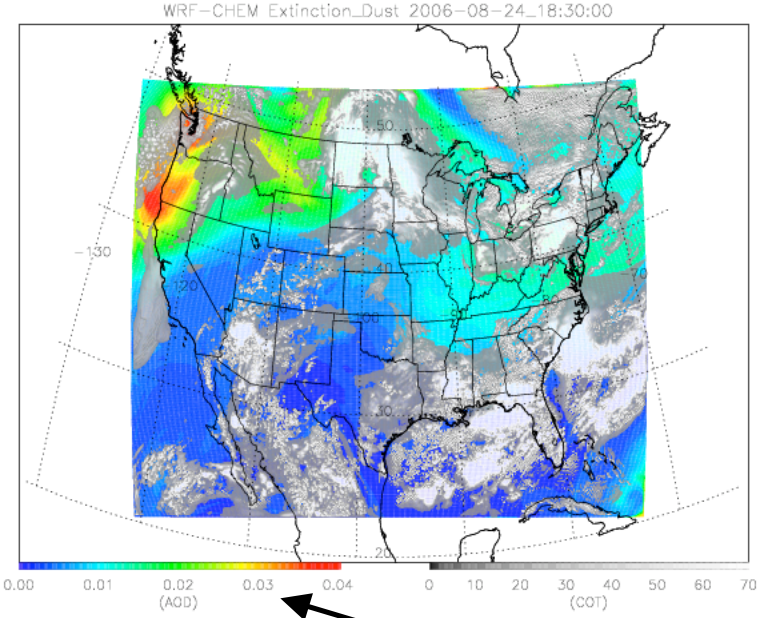
SO4



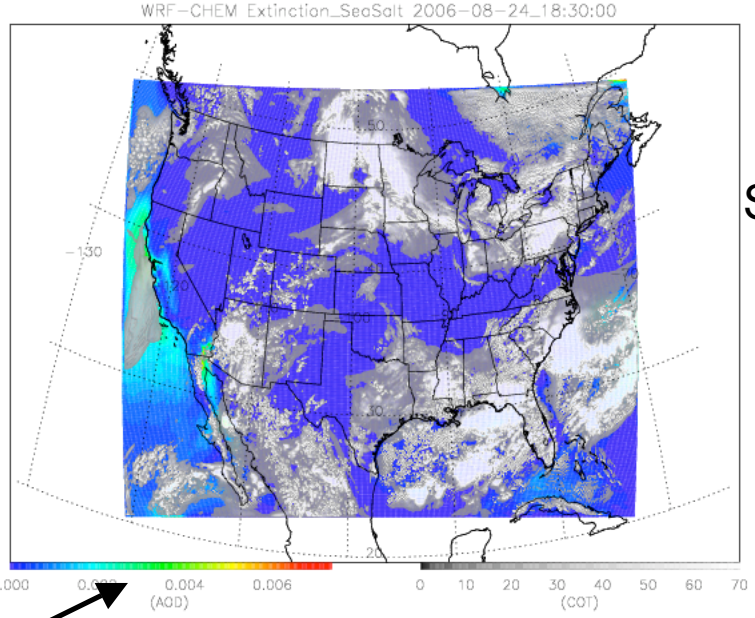
BCOC



Dust



SeaS

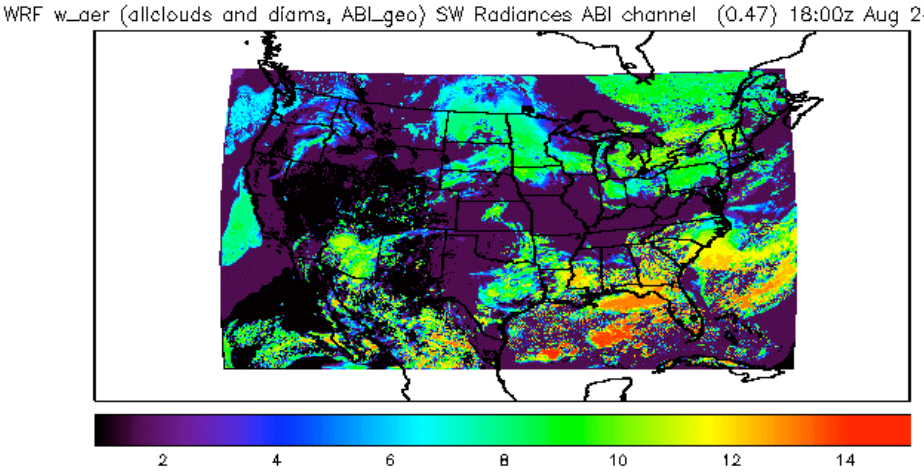


Note different scale

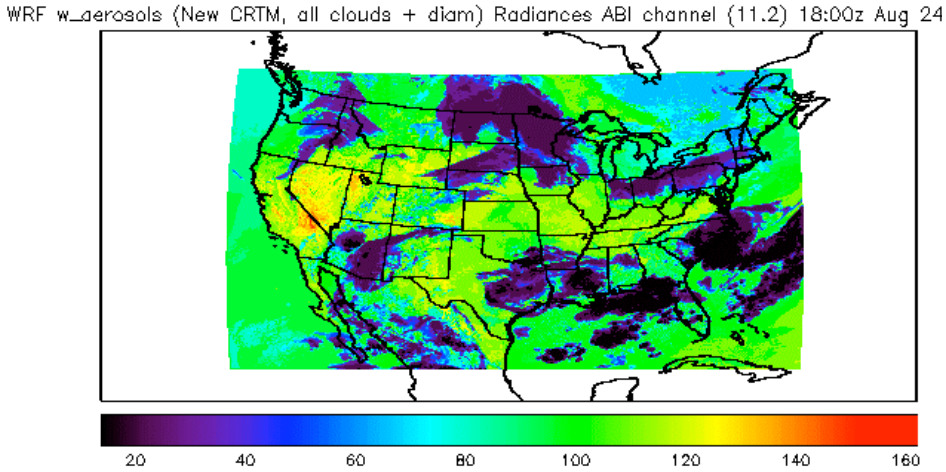
Sample Proxy Radiances

WRF/Chem 4km - 18Z August 24, 2006

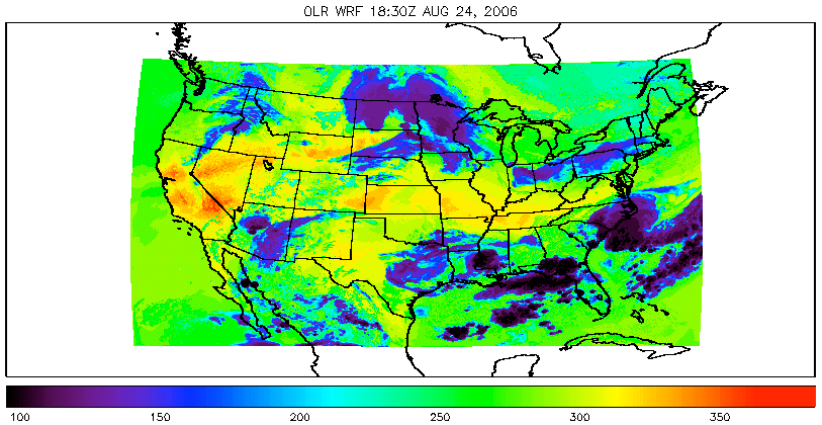
Proxy ABI radiance
0.47 micron (visible)



Proxy ABI radiance
11.2 micron (IR)



WRF OLR



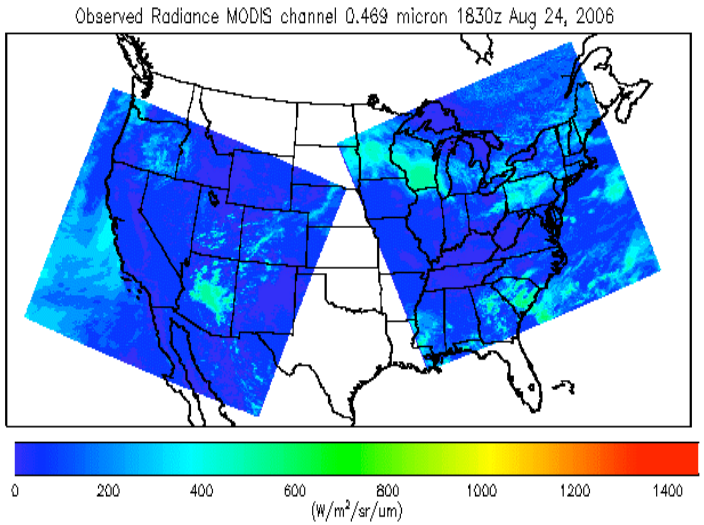
Preliminary
comparisons with MODIS

18:30Z August 24, 2006
MODIS AQUA and TERRA overpasses

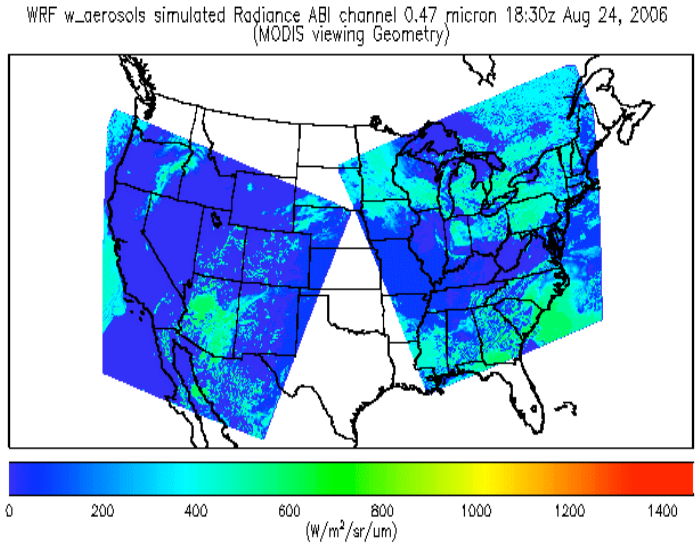
MODIS viewing geometry used in CRTM

Visible Band

MODIS 0.469 um

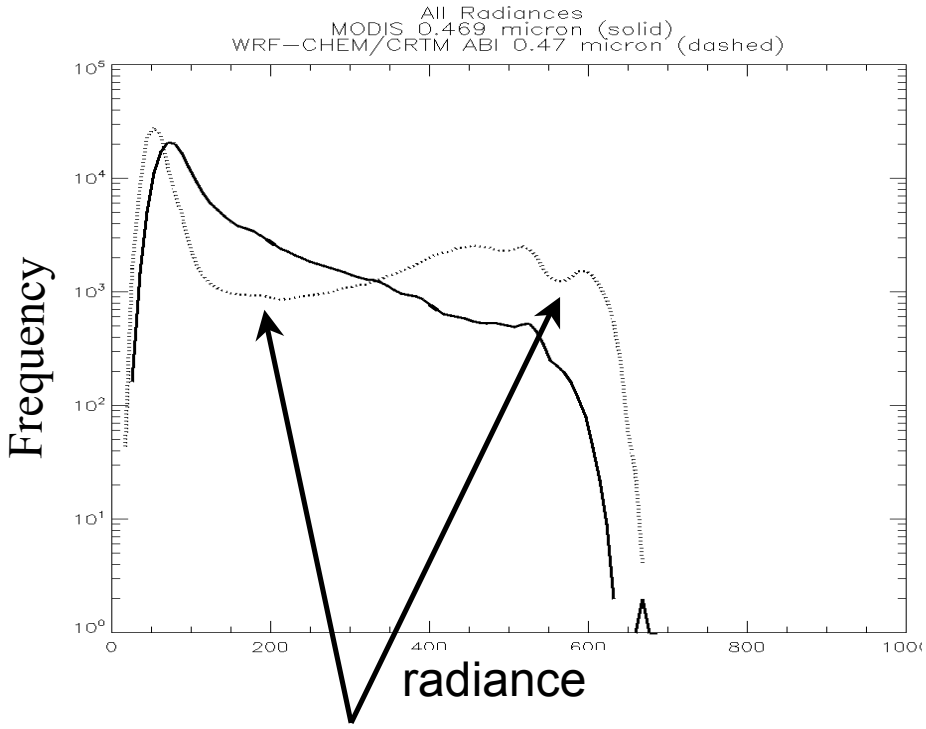


Proxy 0.47 um



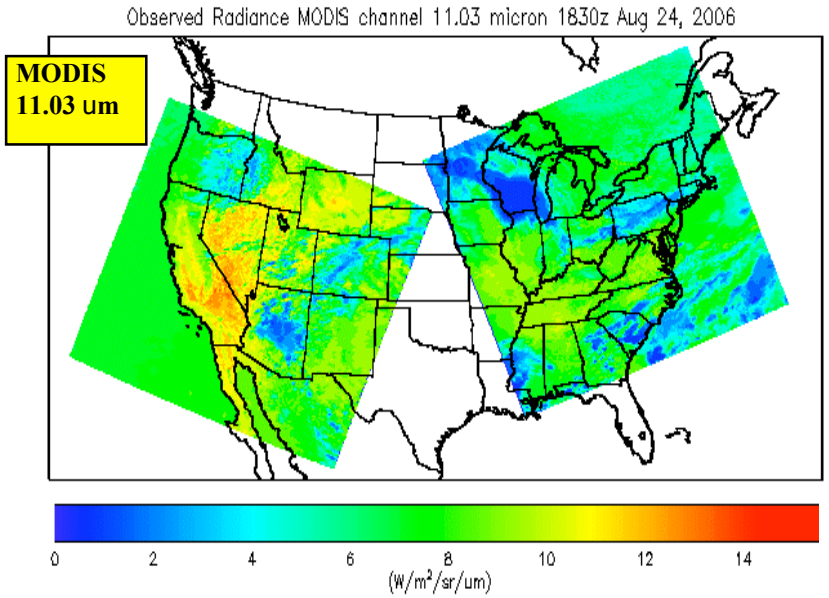
MODIS 0.469 um **MODIS – solid**

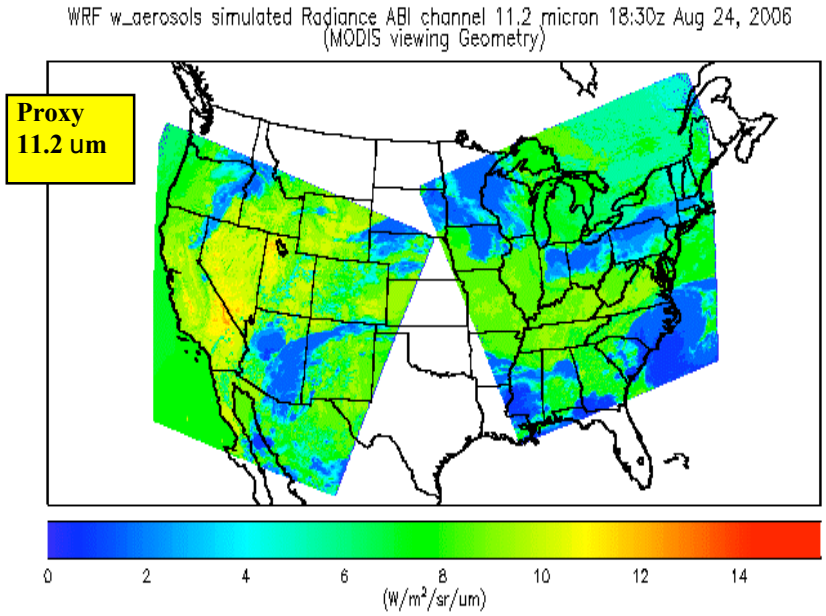
Proxy 0.47 um **Proxy ABI - dashed**



Proxy – larger areal extent of convective and low-level clouds

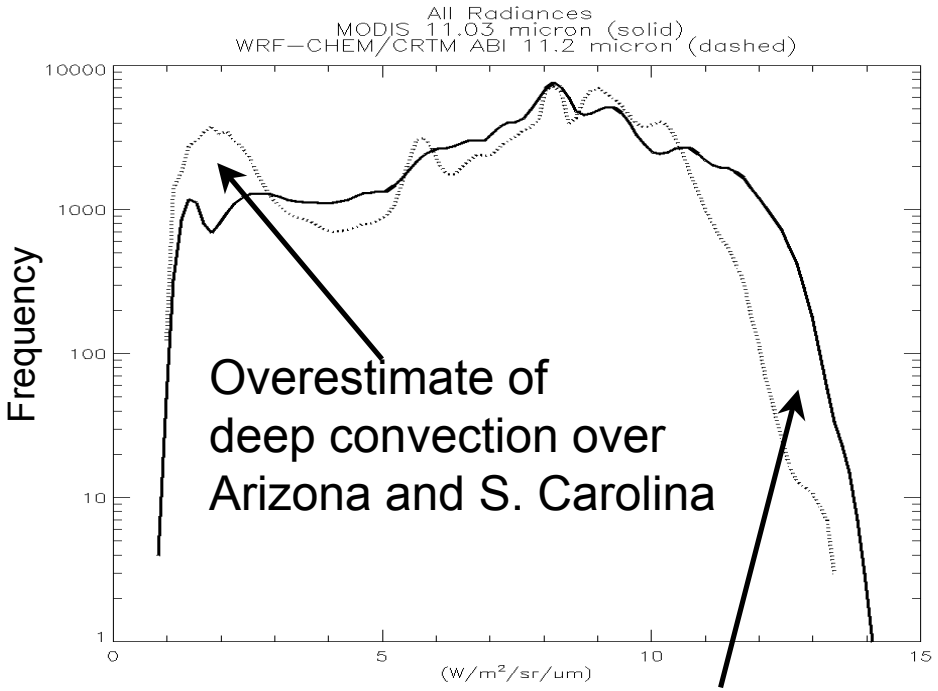
IR Band





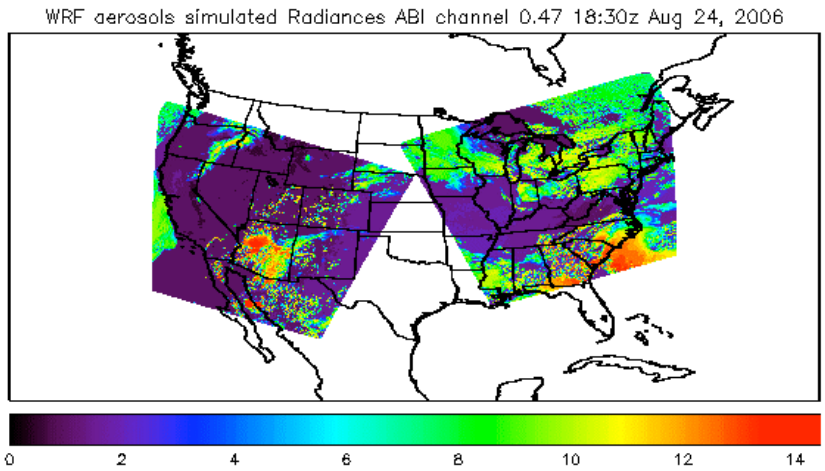
MODIS 11.03 um **MODIS – solid**

Proxy 11.2 um **Proxy ABI - dashed**

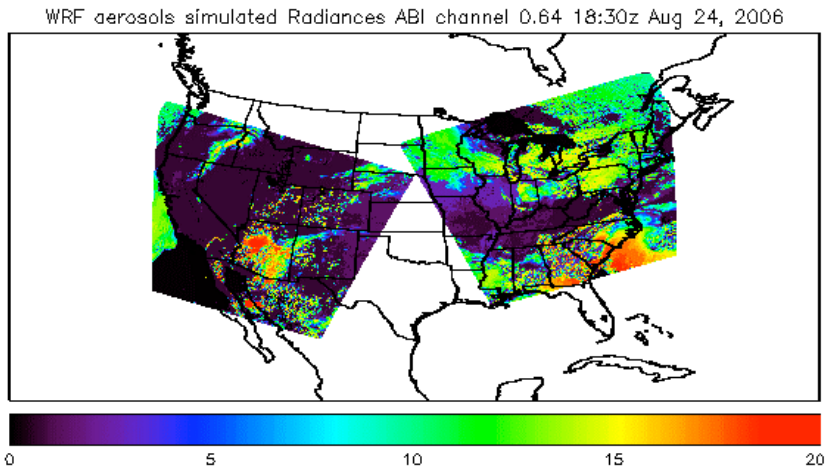


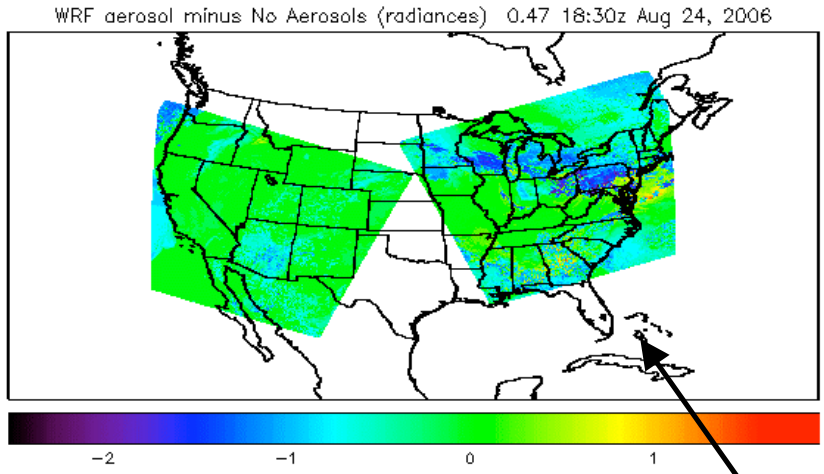
Impact of Aerosols on TOA Radiance 18:30Z Aug. 24

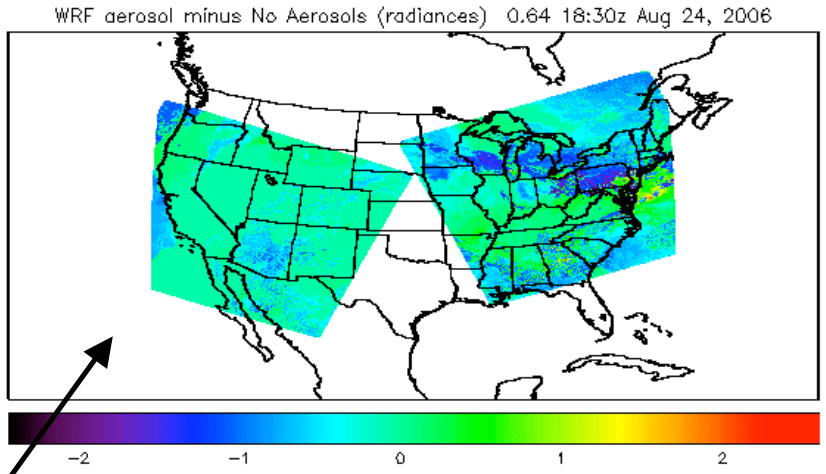
0.47 microns



0.64 microns







BC - absorb
diff < 0

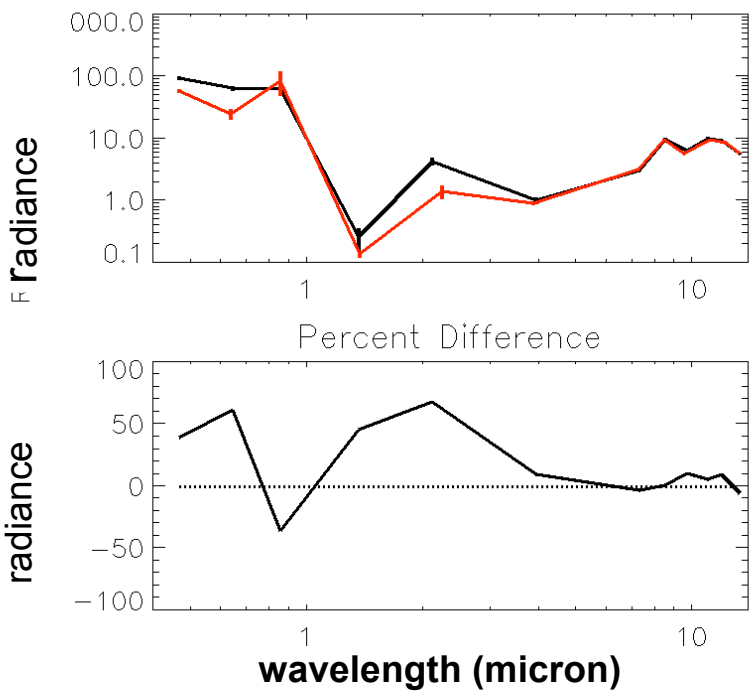
With aerosols minus no aerosols

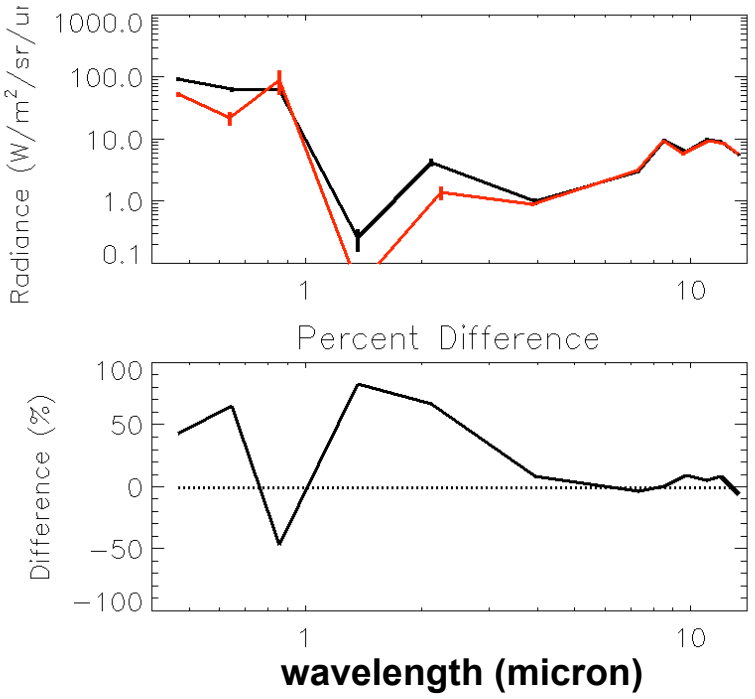
sulfate - scatter, reflect
diff > 0

Cloud cleared radiances; AOD > 1.0

MODIS – black; Proxy - red

Full domain comparison of 12 similar bands





With aerosols

No aerosols

Conclusions and Future Work

Realistic distributions of visible and IR radiances have been achieved

Comparison between the MODIS and Proxy ABI channels show reasonable agreement

- largest differences arise from timing, location and areal extent of deep convective and low level clouds, and likely problems with surface emissivity and reflectivity (possible surface temperature errors)

- agreement better in the IR than in the visible bands.

Research effort is in early stages of validation. Validation will continue.

Impact experiments will be run to assess the role of clouds and total and component aerosols on top of the atmosphere (TOA) radiances.

Proxy ABI radiances will be calculated for all ABI bands for 06Z August 24 to 06Z August 25, 2006.
-datasets will be used by GOES-R team members for algorithm development and demonstration activities.

END