WRF Model Simulated Proxy Datasets Used for GOES-R Research Activities

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Outline

• Describe the end-to-end modeling procedure
  – Generate model-simulated proxy datasets
  – Generate TOA radiances and other products
• Describe hardware resources
• Discuss WRF model characteristics and capabilities
• Present results from case study simulations
  – ATREC
  – FULLDISK
  – OCEAN-WINDS
• Discuss future plans
End-to-End Processing

• Use WRF model to generate physically realistic simulated atmospheric profile datasets with high spatial and temporal resolution

• Simulated fields used by the GIFTS forward model include the surface temperature, atmospheric temperature and the mixing ratios for water vapor and various hydrometeor species

• Estimate effective particle diameter for each species

• Calculate total liquid and ice water paths

• Calculate liquid and ice cloud top pressures
End-to-End Processing

• Interpolate simulated 3-d data from the model coordinate system to the isobaric levels used by the forward model

• Use temperature profiles from NESDIS 1200 dataset to fill the levels above the model top

• Ozone data from the LBLRTM are used to create representative ozone profiles

• Simulated datasets subsequently passed through the GIFTS forward model to generate simulated TOA radiances
Processing Resources

- 32 CPU SGI Linux cluster
- 192 Gb of physical memory
- 6.4 Gb/sec interconnect
- 10 Tb of external disk storage

- Allows us to perform very large memory-intensive model simulations with fine horizontal resolution in a reasonable amount of time
WRF Model Characteristics

• Integrates fully compressible non-hydrostatic Euler equations cast in flux form

• Uses a mass-based terrain-following coordinate with vertical stretching allowed

• Can be run for idealized or real-data cases

• Options for one and two-way interactive nests
WRF Model Characteristics

• Employs a 3rd order Runge-Kutta temporal integration scheme

• Option to use 2nd to 6th order horizontal and vertical advection schemes

• Minimal implicit and explicit smoothing of data (better preserves high resolution of simulations)

• Effective resolution is ~ 7 * x
WRF Model Characteristics

• Uses the Noah land surface model to calculate surface moisture and energy fluxes

• Somewhat limited choice of parameterization schemes

• FDDA (analysis nudging) available soon

• Contains basic 3DVAR and EnKF data assimilation package
WRF Model Benefits

• Flexible Domain Configuration
  – Geographic location
  – Model output frequency
  – Spatial resolution

• Dataset Consistency
  – Data available at regular intervals over entire domain (compare to global orbiters or aircraft)
**ATREC Extratropical Cyclone Case**

- Intense extratropical cyclone developing over the Gulf Stream
- Significant cloud shield with extensive region of stratiform precipitation
- Scattered convection along trailing cold front
ATREC Extratropical Cyclone Case

WRF Model Configuration:
• 1070x1070 grid point domain with 2 km grid spacing and 50 vertical levels
• Initialized at 00 UTC on 05 December with 1° GFS data and then run for 24 hours
• WSM6 microphysics
• Yonsei University (YSU) planetary boundary layer
• RRTM/Dudhia radiation
• Noah land-surface model
• Explicit cumulus
ATREC Extratropical Cyclone Case

- Cyclone develops along strong baroclinic zone
- Broad region of warm air advection
- Weak shortwave trough in the upper levels
ATREC Extratropical Cyclone Case

- Upper-level trough in western portion of domain
- Diffuent flow above surface cyclone
- Cyclone deepened slightly and moved northward along baroclinic zone
ATREX Extratropical Cyclone Case

- WRF simulation contains a realistic representation of the main cloud features

- Very fine scale structure evident in the simulated cloud fields
ATREC Extratropical Cyclone Case

- 11.1 micron brightness temperatures calculated with the GIFTS forward model
ATREC Extratropical Cyclone Case

- Clear-sky retrievals compare favorably to simulated fields
- Widespread cloud cover limits retrievals in lower levels
- Improved coverage in upper levels illustrates importance of above cloud top retrievals
FULLDISK Simulation

WRF Model Configuration:

• 1580 x 1830 grid point domain with 8-km grid spacing and 50 vertical levels
• Initialized at 00 UTC on 24 June with 1° GFS data and then run for 30 hours
• WSM6 microphysics
• Yonsei University (YSU) planetary boundary layer
• RRTM/Dudhia radiation
• Noah land-surface model
• Explicit cumulus
FULLDISK Simulation

- Thunderstorm complex develops over central U.S.
- Meridional cloud band over western Atlantic
- Widespread low-level cloud cover over eastern Pacific
- Tropical convection along ITCZ
FULLDISK Simulation

- Dry air wrapping into cyclone over central U.S.
- Dry air over eastern Pacific
- Cutoff cyclones over eastern Atlantic
FULLDISK Simulation

- Cellular stratus over eastern Pacific
- Very fine cloud structures over both oceans
- Diurnally-driven convection over southeastern U.S.
FULLDISK Simulation

- Very warm airmass across eastern U.S.
- Sharp temperature contrast across central U.S.
- Strong temperature gradients associated with ocean currents
- Fine structure in mountainous areas
FULLDISK Simulation

- Amplified flow pattern across North America
- Weak winds over the tropics
- Strong jet stream across southern portion of the domain
FULLDISK Simulation

- Plentiful moisture along the ITCZ
- Moisture streaming northward into the central U.S.
- Significant fine-scale structure evident in many regions
- Dry air present over much of the southern oceans
FULLDISK Simulation

- Vertically-integrated cloud microphysical content
- Very fine-scale cloud structure
- Cellular stratus over the oceans
- Deep convection over Northern Plains
- Tropical convection along the ITCZ
FULLDISK Simulation

- Deep convection along ITCZ and over the Northern Plains
- Low cloud cover over northeastern Pacific Ocean
- Mid-level cloud cover over southern Pacific Ocean
FULLDISK Simulation

- Simulated brightness temperatures calculated using GIFTS forward model
- Simulated brightness temperatures contain substantial fine-scale detail
- Simulated cloud features are very realistic compared to the observed clouds
FULLDISK Simulation

- Simulated top of atmosphere brightness temperatures
- Water vapor weighting function peaks at successively lower levels
FULLDISK Simulation

- Simulated GOES sounder TOA radiances

24 June 2003 0600 UTC Simulated GOES Sounder Band 1

- Sounder Band 1: CO₂ (Upper)
- 14.7 μm (681 cm⁻¹)
FULLDISK Simulation

- Simulated GOES sounder band 8 TOA radiances
OCEAN-WINDS Simulation

- Case study was chosen for its relatively clear conditions over the eastern Atlantic
- Primary goal was to generate a high quality dataset for AMV algorithm development
OCEAN-WINDS Simulation

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OCEAN-WINDS Simulation

- Large cut-off cyclone located over western Atlantic Ocean
- Weak flow field and temperature gradients across most of the domain
OCEAN-WINDS Simulation

- Band of enhanced moisture to SE of cyclone
- Fine-scale structure evident in the convective regions
- Dry air over the eastern U.S.
OCEAN-WINDS Simulation

- Large clear region along the eastern U.S. coast
- Scattered convection associated with the cut-off cyclone
OCEAN-WINDS Simulation

- Mostly clear conditions along the East Coast
- Cirrus drifting in from the northern boundary
- Low clouds around the cut-off cyclone
OCEAN-WINDS Simulation

- Generate simulated AMVs by tracking water vapor gradients
- A cloud mask is applied
- Potential targets that have passed preliminary quality control are shown in the top panel
- Simulated AMVs are shown in the bottom panel
Future Plans

• Generate additional datasets for various GOES-R AWG and GOES-R3 activities

• Employ the sophisticated Seifert and Beheng double-moment microphysics scheme for high-resolution (< 2 km) simulations
  – Includes prognostic equations for the mixing ratio and number concentration of each species
  – Improves parameterization of various cloud processes such as sedimentation and collisional interactions
  – Early results are promising
Future Plans

• Implement other versions of the WRF model
  – NMM version developed by NCEP
  – Tropical WRF

• Perform data assimilation studies using simulated GOES-R radiances
  – Most likely employ the Ensemble Kalman Filter method
  – Benefits include flow-dependent and time-varying background error covariances and ease of implementation