Model study of waves generated by convection with direct validation via satellite

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Gravity waves

- Common in middle atmosphere
- Transport energy and momentum
- Variety of sources
- Convection important in tropics due to deep convection and lack of topography
- Source variation produces broad spectrum of wave scales, frequencies, and phase speeds
Talk outline

- AIRS satellite
- Meteorology
- Model description
- Model results
- Rainfall and heating profile
- Results
AIRS scan pattern
Channel 75 Kernel Function
AIRS Radiance perturbations
AIRS Radiance perturbations
Model description

- 3D, non-linear, non-hydrostatic, cloud resolving
- Temperature over domain of 760x760x70km
- Horizontal grid is 2kmx2km
- Vertical levels every 0.25km
- Rayleigh damping above 55km

Model Inputs

- Heating profiles
- Initial horizontal winds
- Initial potential temperature
Input profiles: Potential temperature, zonal and meridional winds
Heating profiles

- Vary at each location over the model domain
- Vary with time
- Depth of column from radar cloud height
- Column heating from rainfall rates
- Column heating $= \frac{(RR \cdot \rho \cdot Lc)}{(Cp \cdot M)}$
- Vertical profile – use sine shape approximation appropriate for convective rainfall
Darwin rainfall

Green: total rainfall, Red: convective, Blue: stratiform
C-pol heating and cloud altitude
Model output temperature at 41km
Heating from rainfall

- Different time scales 1 min -vs- 10 min
- Non-uniform rainfall
- Radar scanning pattern
- Drop-size distribution
- Conversion algorithm – ice phase neglected
Darwin rainfall

Rain Gauge

C-pol
Nearest grid point rain rate

Black = rain gauge  Red = nearest point C-pol
Influences on heating profile

Solid=moist rain
Dashed=ice above melting layer
Dotted=30% of rain evaporates below 5km
• Juelich Rapid Spectral Simulation Code
• Radiances output on AIRS grid
• Error much smaller than AIRS measurement
Results

Model

AIRS
Conclusions

- Linked a specific convective event to observed waves in the stratosphere
- Model results agree well with observed wave: wave pattern and wavelengths
- Source region consistent with region of maximum heating and high clouds during storm
- Amplitude of modelled waves too small
- Reference: Grimsdell et al. JAS 67, May 2010, 1617-1631
JURASSIC

- Juelich Rapid Spectral Simulation Code
- Computes radiative transfer using Curtis-Godson approximation and Emissivity Growth Approximation
- Flexible ray-tracing algorithm allows determination of exact lines-of-sight for individual AIRS footprints.
- Radiances output on AIRS grid
- Error much smaller than AIRS measurement noise