Global Analysis and Characterization of AIRS/MOIDS Cloud-Clearing

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Characterization of Infrared Imager/Sounder and Infrared/Microwave Sounder Synergistic Cloud-Cleared Infrared Radiances

Summary
• To evaluate the characteristics of these cloud-cleared radiances and their potential for improvements of numerical weather prediction and cloudy sounding applications.
• Preliminary results have shown that these two approaches, though quite different in character, and processing methodology, are both effective and have certain unique characteristics and deficiencies.

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Case Granule Dataset Used

- 4 Granules of Collocated AIRS & MODIS Data
- MODIS 1-km Cloud Mask
- AIRS C.M. (from MODIS)
- No ancillary data used

2 Sep. 2002 AIRS Focus Day

Wisconsin Granule

17 Sep. 2003

Australia Granule

South Africa Granule

Hurricane Isabel Granule
Aqua MODIS IR SRF Overlay on AIRS Spectrum
MODIS/AIRS Synergistic Single-Channel $N^*$ Cloud-Clearing General Principal

After Smith

\[ R_c(\nu) = \frac{R_1(\nu) - N^* R_2(\nu)}{1 - N^*} \]

Where;
\[ N^* = \frac{N_1}{N_2}. \]

\[ N^* = \frac{srf[R_1(w)] - R_c(w)}{srf[R_2(w)] - R_c(w)} \]

\[ srf[R_i(w)] = \int \theta(w, \nu) R_i(\nu) d\nu \]

\[ \Sigma \{ srf[R_c(\delta\nu_j)] - R_c(\delta\nu_j) \}^2 \leq \varepsilon \]
MODIS/AIRS Synergistic Multi-Channel N* Cloud Clearing

General Principal

\[ J(N^*) = \sum_i \frac{1}{\sigma_i} [(R_{M_i}^{clr} - f_i(R_v^{cc}))^2] \]

\[ J(N^*) = \sum_i \frac{1}{\sigma_i} [(R_{M_i}^{clr} - f_i(R_v^1 - R_v^2 N^*)][1 - N^*])^2] \]

\[ \frac{\partial J(N^*)}{N^*} = 0 \]

\[ N^* = \frac{\sum_i \frac{1}{\sigma_i^2} [f_i(R_v^1) - R_{M_i}^{clr}][f_i(R_v^1) - f_i(R_v^2)]}{\sum_i \frac{1}{\sigma_i^2} [f_i(R_v^2) - R_{M_i}^{clr}][f_i(R_v^1) - f_i(R_v^2)]} \]

Li et al, 2005, IEEE-GRS
Global AIRS/MODIS Cloud Clearing Analysis

45 Days (1 Jan. to 15 Feb. 2004):

• Used by John Le Marshall in his AMS bulletin paper while only thinned and selected channels of “clear” only AIRS were assimilated

• Collocated MODIS and AIRS level 1 data

• Collocated MODIS cloud mask
Day Time

AIRS/MODIS C.C. BIAS
Day Time

AIRS Cloud clearing Global Statistics on day 20040113

Day & Land

Day & Ocean

Day & Mixed

AIRS/MODIS C.C. BIAS

Land

Ocean

Mixed
Day Time

AIRS Cloud clearing Global Statistics on day 20040121

Land

Ocean

Mixed

AIRS/MODIS C.C. BIAS
Day Time

AIRS/MODIS C.C. BIAS

Land

Ocean

Mixed
Day Time

AIRS Cloud clearing Global Statistics on day 20040207

Land

Ocean

Mixed

AIRS/MODIS C.C. BIAS
Night Time

AIRS Cloud clearing Global Statistics on day 20040104

Land

Ocean

Mixed

AIRS/MODIS C.C. BIAS
Night Time

AIRS/MODIS C.C. BIAS

Night & Land

Night & Ocean

Night & Mixed

Land

Ocean

Mixed
Night Time

AIRS/MODIS C.C. BIAS

Land

Ocean

Mixed

AIRS/MODIS C.C. BIAS
Night Time

AIRS Cloud clearing Global Statistics on day 20040124

Night & Land

Night & Ocean

Night & Mixed

AIRS/MODIS C.C. BIAS

Land

Ocean

Mixed
Night Time

AIRS Cloud clearing Global Statistics on day 20040206

Land

Ocean

Mixed

AIRS/MODIS C.C. BIAS
Night Time

AIRS/MODIS C.C. BIAS

Land

Ocean

Mixed
Global AIRS FOV Processing Statistics

AirS Cloud clearing Global Statistics on day (20040101 – 20040215)

Land

Ocean

Mixed
Global AIRS FOV Processing Statistics

AIRS Cloud clearing Global Statistics on day (20040101 – 20040215)

![Bar charts for Land, Ocean, and Mixed](image-url)

- **Land**
- **Ocean**
- **Mixed**
Global AIRS FOV Processing Statistics
(1-1-2004 to 2-15-2004)

Date (2004)

Percentage (%)

Clear  Cloud-Cleared  CC Failed  Overcast
Global AIRS FOV Processing Statistics
(1-1-2004 to 2-15-2004)

Percentage (%)

Date (2004)

Clear (13.26%)  Cloud-Cleared (20.60%)  CC Failed (17.78%)
Global AIRS FOV Processing Statistics
(1-1-2004 to 2-15-2004)

- Cloud-Cleared: 20.60%
- CC Failed: 17.78%

Date (2004):

- 1-15 Jan
- 3-15 Feb
Global AIRS Cloud Clearing Statistics (20040101 -- 20040215) over land

Bias [K]

std. dev. [K]

RMSD [K]

Wavenumber [cm⁻¹]

total number = 3,568,088
Global AIRS Cloud Clearing Statistics (20040101 -- 20040215) over water

Bias [K]

total number = 4,234,135

Std. Dev. [K]

RMSD [K]

Wavenumber [cm⁻¹]
Global AIRS FOV Processing Statistics
(1-1-2004 to 2-15-2004)
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Summary

45 days of collocated AIRS/MODIS global data are analyzed:
- To characterize the synergistic AIRS/MODIS cloud-clearing performance in terms of bias and RMS error using collocated MOIDS clear and near by AIRS clear data
- The performance is consistent in terms of daily statistics of successful (~21%) and unsuccessful (~18%) cloud-clearing percentage
- The performance is consistent over land or water surface when FOV to FOV scene variation is taking into account.
- The performance is also consistent at day and night time when MODIS cloud mask characteristic is taking into account.
- Quantitative cloud clearing errors (bias & RMS) are derived for assimilation and retrieval applications.
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Future Work

- Deliver cloud-cleared datasets (including the associated bias & RMSE) to JCSDA and GMAO for potential assimilation of AIRS cloud-clearing radiances.
- Perform cloud-cleared radiance sounding retrievals.
- Continue to refine cloud-clearing error processing procedure to include the calculate clear radiances as the “reference truth” and to remove FOV to FOV scene in-homogeneity from the errors estimate when using near-by clear as the independent reference truth.
- Reanalyze cloud-clearing characteristic using Ver. 5 MODIS cloud mask and new AIRS/MOIDS collocation routine.
- Using Ver. 5 MOIDS cloud phase and height info to improve cloud-clearing Q.C.
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Madison, WI, University of Wisconsin-Madison, Space Science and Engineering Center,