Experimental processing of the AIRS hyperspectral measurements to estimate the cloud absorption vertical profiles for Hurricane Ioke on August 28, 2008

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Abstract

AIRS granules covering Hurricane Ioke on August 28, 2008 were selected and processed. A multi-level cloud model for approximating cloud spectral effects on outgoing spectral radiation in the "surface –atmosphere' system was used in the physical interpretation of AIRS measurement. Cloud spectral effects in the model are represented by an effective cloud absorption vertical profile (CAVP). Spatial distribution of cloud absorption in 3D was obtained. The internal structure of Hurricane Ioke was reconstructed. The CAVP estimates were compared with coincident CALIOP measurements

Model

$$\left.\begin{aligned} J(\nu) &= (1-\sum_{k=1}^{K}\alpha_k(\nu))J(\nu,p_S)+\sum_{k=1}^{K}\alpha_k(\nu)J(\nu,p_k)\\ J(\nu,p_k) &= \mathrm{B}_\nu[T(p_k)]\tau_\nu^{\uparrow}(p_k)+\int_{\tau_\nu^{\uparrow}(p_k)}^{1}\mathrm{B}_\nu[T(p)]d\tau_\nu^{\uparrow}(p)\\ 0 &< \sum_{k=1}^{K}\alpha_k(\nu)\le 1,\quad 0<\alpha_k(\nu)\le 1,\ k=1,\dots K\\ A_{ik} &= J(\nu_i,T(p_k))-J(\nu_i,T_S) \end{aligned}\right\}$$

Solution

$$\hat{\alpha}=\arg\min_{\alpha'}\left\{\frac{1}{M}\sum_{i=1}^{M}\sigma_i^{-1}\left|\tilde{f}_i-\sum_{k=1}^{K}A_{ik}\alpha_k'\right|\right\}$$

$$\alpha_k'(\nu)=\begin{Bmatrix}0 & \alpha_k(\nu)<\Delta_k\\ \alpha_k(\nu) & \alpha_k(\nu)\ge\Delta_k\end{Bmatrix}$$

$$0<\sum_{k=1}^{K}\alpha_k'(\nu)\le 1$$

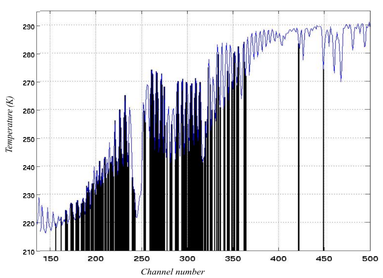
Spectral channels

Selected channels : (a) not sensitive to atmospheric moisture and ozone, $\tau_\nu^{\uparrow}(p_S,\Theta)\le 0.4$

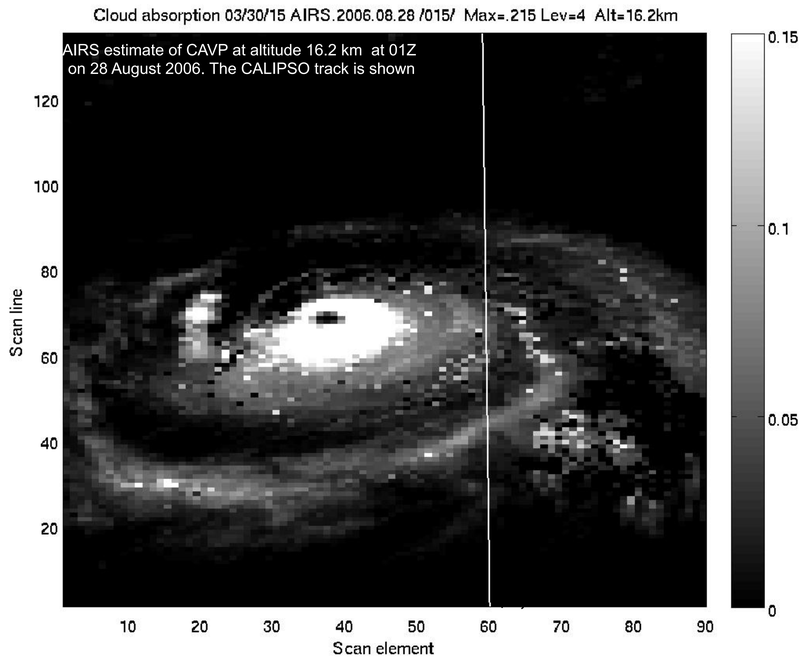
(b) having insignificant contribution from the surface: $\tau_\nu^{\uparrow}(p_C,\Theta)\ge 0.6$

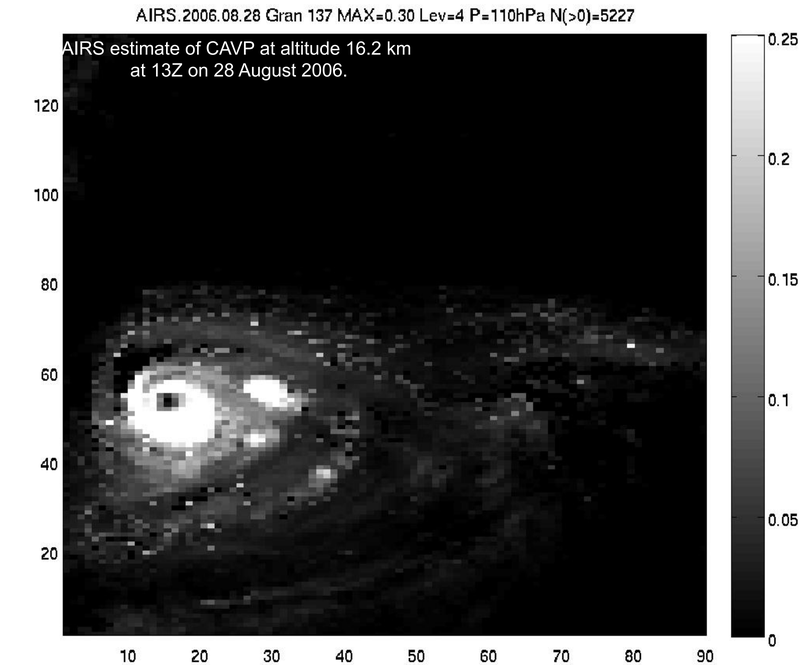
(c) with significant contribution from the cloud atmosphere:

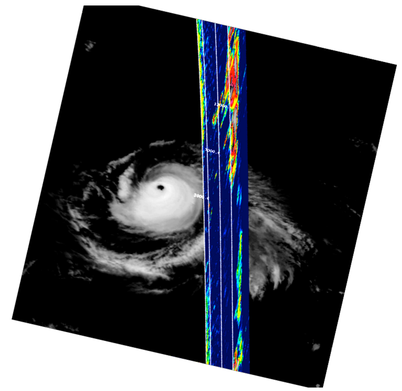
Removed channels showing (d) spectral-spatial inconsistencies temporal instability (processing with feedback), and (f) poor performance in the radiative transfer model (processing with feedback).



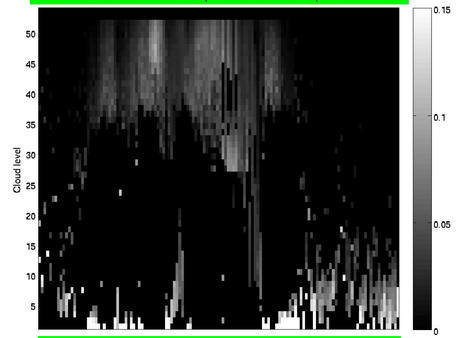
Vertical bars indicate the location of the 131 spectral channels selected for CAVP estimation over the granule 015 of 08.28.2006
The first channel N156: 694.4cm^{-1} & 110hPa; the last channel N449 : 791.8cm^{-1} & 715hPa



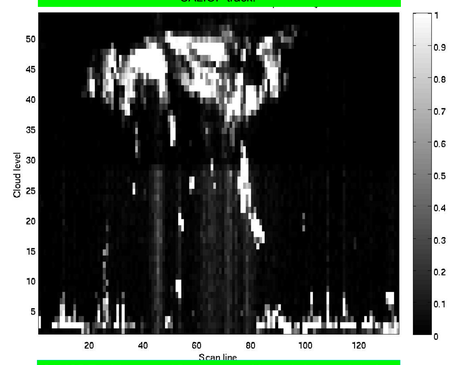




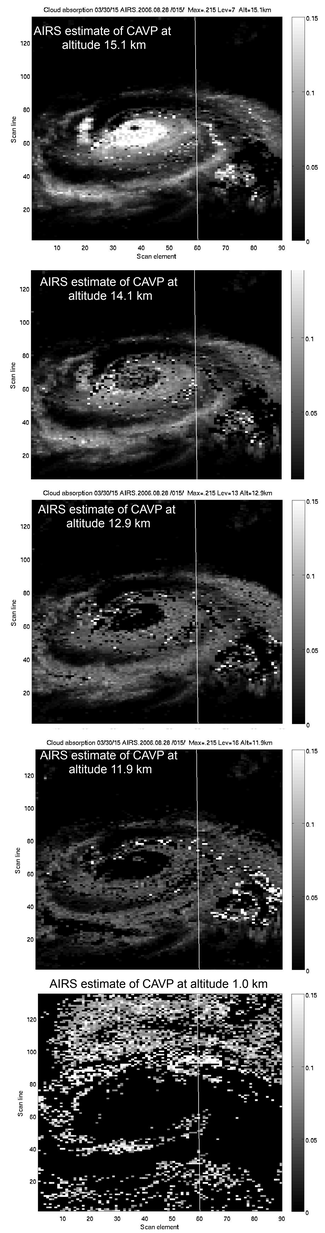
GOES image of Hurricane Ioke at 00Z on 28 August 2006. The CALIPSO backscatter path is shown for spatial context



AIRS Cloud Absorption Vertical Profile (relative units) along CALIOP track.



CALIOP Total Attenuated Backscatter 532 mm (relative units) after spatial horizontal and vertical integration to fit AIRS spatial horizontal and vertical resolution; there are 54 counts of CALIOP measurements per AIRS scan line.



Conclusions

- Stated inverse problem of estimation of cloud absorption vertical profile is applied to AIRS hyperspectral measurements. The inverse problem generates a physically meaningful solution.
- The derived estimates of CAVP is compared with coincident CALIOP measurements. Comparison shows that the estimate exhibits high spatial-temporal correlation with the lidar measurements reproducing cloud vertical structures similar to those observed in the lidar measurements.
- The CAVP estimate contains the information about cloud vertical structure. Spatial distribution of cloud absorption in 3D allows to reconstruct and to monitor the hurricane internal structure.
- AIRS instrument provides IR hyperspectral information that is effective for the identification of cloud vertical structure.

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