Validation of T/q Profiles and Greenhouse Gases Retrieved from Satellite-Based and Ground-Based Measurements with Aircraft and Radiosonde Observations

Tae-Young Goo, Shin-Hoo Kang, Yeon-Jin Jung, Mi-Lim Ou and Sang-Boom Ryoo
National Institute of Meteorological Research, 45 Gisangcheong-gil, Dongjak-gu, Seoul, KOREA

INTRODUCTION AND MEASUREMENTS

Since May 2010, the National Institute of Meteorological Research (NIMR) has performed intensive observation at Anmyeondo (36.32N, 126.19E), Korea. The observation site, Anmyeondo, is the sixth largest island (87.96 km²), located at the west coast of Chungnam province, Korea. Anmyeondo had a population of about 125,000 as of 2006 and had no significant anthropogenic sources within a radius of about 30 km. During the period of observations, T/q profile and greenhouse gases retrieved from a ground-based Atmospheric Emitted Radiance Interferometer (AERI) and satellites (MetOp/IASI, AQUA/AIRS and GOSAT) were validated against T/q profiles from radiosonde observations and greenhouse gases from aircraft sampling measurements (Figure 1).

The AERI was developed by Wisconsin university and manufactured by ABB Inc. (Figure 2). Spectrum coverage is from 520 to 3020 cm⁻¹ and spectral resolution is 1 cm⁻¹. Primary product is downwelling infrared spectra and secondary product is retrieved parameter like T/q profiles. T/q profiles were retrieved from the AERI by AERIPROF algorithm (Feltz et. Al, 1998) which has an accuracy of 1 K for temperature and 10% for humidity. For the validation of the AERI T/q retrievals, the vertical distribution of temperature and dew point temperature were observed by radiosonde from surface to around 30 km.
Aircraft sampling measurements were carried out to measure carbon dioxide (CO₂), methane (CH₄), nitrous oxide (N₂O), surfer hexafluoride (SF₆) and carbon monoxide (CO). The observation was performed from 0700 to 1800 LST (0700, 1000, 1300, 1500, and 1800 local time (UTC + 9)), from the surface to an altitude of 5 km (surface, 0.15, 0.3, 0.5, 1, 3, and 5 km above the ground). Sampled air was collected into pre-vacuumed and pre-purged 7-L stainless steel canisters using a diaphragm pump (KNF). After sampling, CO₂, CH₄, and SF₆, and CO were measured in the laboratory using various instruments such as: a cavity ring-down spectrometer (Picarro, G1301) for CO₂ and CH₄, a gas chromatograph (Agilent, 6890N) for N₂O and SF₆, and a residual gas analyzer (Ametec, Ta3000) for CO.

RESULTS

It was found that AERI T/q retrievals have better agreement with radiosonde observation than satellite T/q retrievals from Aqua/AIRS (Figure 3) and MetOp/IASI. In particular, atmospheric inversion structures from 1000 to 900 hPa on 26 May and from 800 to 700 hPa on 4 November 2010 were well described by AERI retrievals. Although AERI retrievals for dew point temperature showed large difference against those of radiosonde observations from time to time, the variations as function of altitude were somewhat described. However, satellite retrievals for dew point temperature look like averaged profiles. That is, satellite retrievals couldn’t captured well the sharp variation of moisture with altitude.

Generally, averaged RMSE profiles for AERI T/q retrievals show better scores than those of Aqua/AIRS and MetOp/IASI from 1000 to 700 hPa (Figure 4). In particular, the performance of temperature retrievals from AERI is significantly better than those from Aqua/AIRS and MetOp/IASI. Moisture retrievals from AERI has also some skill less. vertically averaged RMSEs for AERI T/q retrieval are 1.15 K and 0.71 g/kg while those for AIRS and IASI are 2.43 K and 1.16 g/kg, and 2.04 K and 0.91 g/kg, respectively.
Figure 3: Plot of ambient temperature (solid) and dew point temperature (dashed) profiles of AERI (red) in comparison with those of radiosonde (Navy) and satellite (Aqua/AIRS and MetOp/IASI (gray)) at 1705 UTC on 26 May 2010 (left) and at 1206 UTC on 4 November 2010 (right).

Figure 4: Root Mean Square Errors (RMSEs) for T/q profile retrieved from AERI (Thick solid lines), Aqua/ AIRS (thin dotted lines) and MetOp/IASI (thin solid lines) against radiosonde profiles.
**Figure 5**: Correlation plots between satellite-based CO$_2$ and CH$_4$ retrievals and their observation from aircraft sampling measurements. Circles indicate Aqua/AIRS and squares describe MetOp/IASI.

CO$_2$ and CH$_4$ retrievals from IASI and AIRS are mostly underestimated as compared with aircraft sampling measurements (Figure 5). However, CO$_2$ and CH$_4$ measured from aircraft observation were column-averaged concentration from surface to 5 km while the retrievals from satellites have a strong sensitivity from 5 to 15 km. Therefore the feature of underestimation is likely to be reasonable. Fundamentally, CO$_2$ and CH$_4$ retrievals from AIRS and IASI can't provide well description in the lower troposphere. Therefore, greenhouse gases retrievals from a ground-based AERI play a key role to compensate on the weakness of satellite retrievals in the lower troposphere. In this regard, the NIMR is working on CH$_4$ retrievals from the AERI using modified SFIT2 algorithm (v.3.93) in collaboration with the university of Toronto.

**SUMMARY AND CONCLUSIONS**

The NIMR has carried out the intensive observations since May 2010 using a ground-based AERI, radiosonde and aircraft sampling. In validation, AERI T/q retrievals show better skill than space-based retrievals from 1000 to 700 hPa. In particular, the AERI retrievals well captured the atmospheric inversion structure. Dew point temperature retrievals from AERI show significant errors compared with temperature retrievals. However, vertical variation of dew point temperature observed by radiosonde was better described by AERI retrievals than by satellite retrievals.

Since greenhouse gas retrievals from AIRS and IASI are focusing on CO$_2$ and CH$_4$ in the middle troposphere, it is not enough to obtain comprehensive understanding on the features of them in the lower troposphere. In this study, that is investigated again in the validation between satellite retrievals and aircraft sampling measurements. In this regard, the NIMR has a plan to retrieve CH$_4$ from the AERI using modified SFIT2 algorithm.

**REFERENCES**


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