TECHNICAL MEMORANDUM

757

# Assessment of AMVs from COMS in the ECMWF system

Sihye Lee[1], Kirsti Salonen and Niels Bormann

Research Department

July 2015

[1] Korea Institute of Atmospheric Prediction Systems (KIAPS), Seoul, Republic of Korea



European Centre for Medium-Range Weather Forecasts
Europäisches Zentrum für mittelfristige Wettervorhersage
Centre européen pour les prévisions météorologiques à moyen

Series: ECMWF Technical Memoranda

A full list of ECMWF Publications can be found on our web site under:
http://www.ecmwf.int/en/research/publications

Contact: library@ecmwf.int

**Abstract**

This study evaluates Atmospheric Motion Vectors (AMVs) from the Korean geostationary Communication, Ocean and Meteorological Satellite (COMS) in the European Centre for Medium-Range Weather Forecasts (ECMWF) system for a 6-month period. The monitoring statistics of the COMS AMVs have been compared to those of the operational Multifunction Transport Satellite (MTSAT) AMVs because both satellites cover a similar region around East Asia.

The First Guess (FG) departure statistics for the MTSAT and COMS AMVs have consistent features geographically, although the quality characteristics for both satellites are slightly different. Height assignment errors of COMS AMVs have also been estimated based on model best-fit pressure statistics, suggesting height assignment errors that are broadly in line with those of other AMV products.

Assimilation experiments have been performed to assess the impact of COMS AMVs in a system that uses all operationally assimilated conventional and satellite observations. New quality control criteria for COMS AMVs are investigated, designed to improve the impact on ECMWF model analyses and forecasts. As a result, the use of COMS AMVs in the ECMWF system shows a positive impact on the forecast quality in the absence of AMVs from MTSAT. When COMS AMVs are added in the presence of MTSAT AMVs the forecast impact is more neutral.

# 1 Motivation and background

The Meteorological Satellite Center of the Korean Meteorological Agency (KMA) has started to produce hourly AMVs from imagery obtained from COMS on 1st April 2011. COMS is a geostationary satellite, positioned at 128.2°E over the equator. It provides coverage similar to the Japanese MTSAT-2, positioned at 145°E above the equator. COMS AMVs have been disseminated in real time since 22 January 2015 via the Global Telecommunication System (GTS). It is therefore of interest to start near-real time processing of COMS AMVs at ECMWF.

The assimilation of high spatial and temporal resolution AMVs in numerical weather prediction (NWP) models has provided benefits to operational forecasts (Bormann et al., 2012). Wind is a primary variable for describing the atmospheric state. An accurate wind field in areas with no conventional data is essential for initialization of NWP models. Wind products from geostationary satellites including COMS can provide near continuous data where conventional observations are lacking, particularly over the ocean.

In the present study, we have evaluated the COMS AMVs in the ECMWF assimilation system in terms of comparisons against the ECMWF FG and in terms of forecast impact. In the first step, the COMS AMVs are passively monitored in the ECMWF assimilation scheme, which allows to derive statistics against the model FG without these vectors impacting the analyses. After the characteristics of COMS AMVs have been evaluated, data assimilation experiments are performed to investigate the impact on model analyses and forecasts.

# 2 Characteristics of COMS AMVs

COMS AMVs are derived from the infrared (IR; 10.8 µm), water vapour (6.7 µm), visible (0.67 µm), and short-wave IR (SWIR; 3.7 µm) channel (e.g., Sohn et al. 2012). COMS produces full disk images every 3 hours and extended Northern Hemisphere images (to 10°S) every 15 minutes. AMVs are derived by tracking cloud and water vapor features in subsequent images. The tracking algorithm is based on cross-correlation. The target selection to estimate COMS AMVs uses 24 x 24 pixels (i.e., 96 x 96 km at the sub-satellite point), which will be changed to 16 x 16 pixels (i.e., 64 x 64 km) in the near future. The dynamic search area is 80 x 80 pixels (i.e., 320 x 320 km at the sub-satellite point) centered on the target box. Height assignment is performed using the Equivalent Black Body Temperature (EBBT) and $H_2O$ intercept methods (Nieman et al., 1993; Szejwach, 1982). The latter step includes the use of a short-range forecast, obtained from the operational global NWP system of KMA (i.e., the Unified Model of The Met Office).

## 2.1 Quality indicators

For COMS AMVs, quality information for each AMV is available in the form of a Quality Indicator (QI), similar to what is provided by other AMV producers. The QI is based on temporal and spatial consistency checks of the derived wind field (Holmlund, 1998), and has values between 0% and 100% with 100% indicating the best quality. Two QI values are supplied: one forecast independent one (referred to as QI_nofc), and one which includes in addition a comparison to a short-term forecast (referred to as QI_fc). This forecast test is based on the vector difference between the 6-hour forecast of the current KMA operational model and the derived AMV.

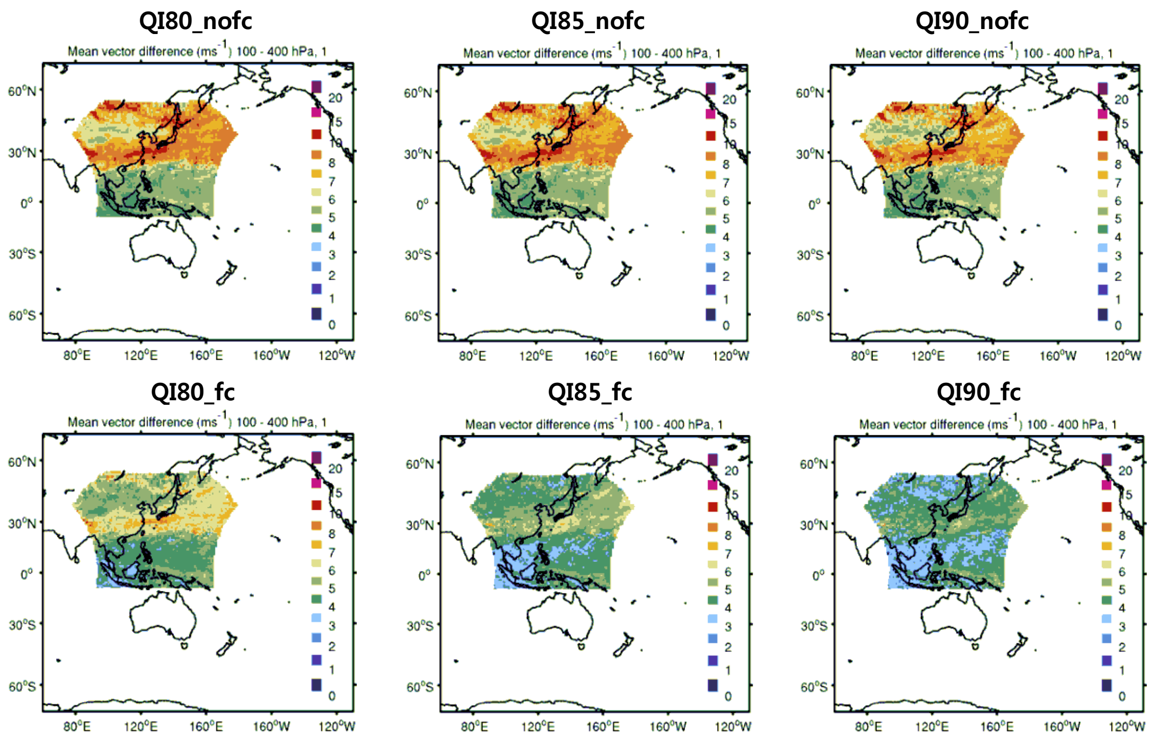


*Figure 1: Maps of mean vector difference for high-level COMS AMVs from the IR channel in different QI_nofc (upper) and QI_fc (lower) for January to March 2013.*

In NWP systems, the QI is used to select a sample of winds with appropriate error characteristics. Figure 1 shows the mean vector difference for the high-level (100-400 hPa) COMS AMVs from the IR channel for different QI thresholds for the two types of QI provided. For both types of QI, the mean vector difference is larger over the region of the Northern Hemisphere, but the magnitude of the vector difference is different for QI_nofc and QI_fc. Interestingly, the monitoring statistics for the COMS AMVs are quite similar to each other for different thresholds of the QI_nofc, suggesting that this type of QI is not suitable for identifying higher quality AMVs. However, it is possible to improve the monitoring statistics such as the mean vector difference of AMVs when instead the QI_fc threshold is applied (see the lower maps in Figure 1).

The choice of QI threshold is a trade-off between AMV quality (and forecast-dependence in the case of the QI_fc) on the one hand, and the number of winds on the other. Figure 2 presents the fraction of the number of data for high-level IR AMVs as a function of QI. The rate of reduction in the available number of AMVs above QI80 is faster for the QI_fc than the QI_nofc. In Figure 1, the vector difference for COMS AMVs dramatically decreases with increasing QI_fc, but Figure 2 shows that the number of available COMS AMVs becomes extremely small.

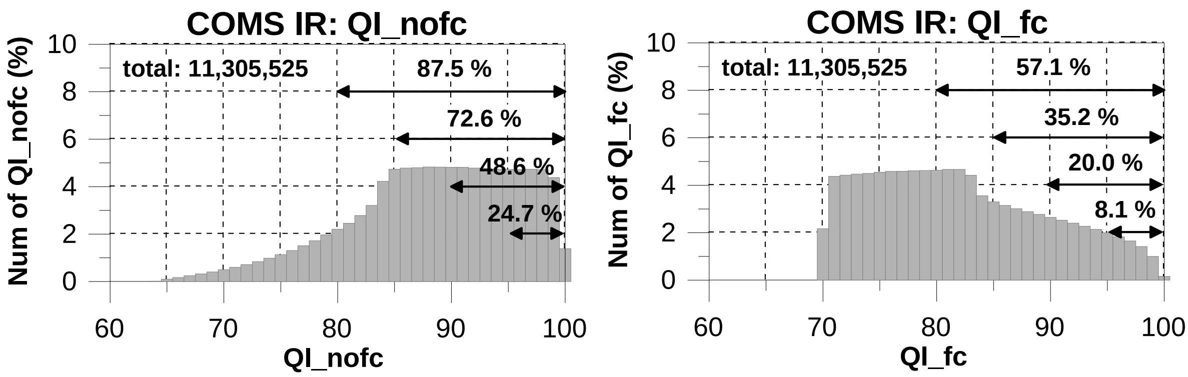


*Figure 2: Percent fraction of the number of data for high-level IR AMVs from COMS as a function of different QIs for January to March 2013.*

In this study, we use a QI_fc threshold of 80% for passive monitoring of COMS AMVs for all channels, and this will be used in any subsequent analysis. While all channels show benefits in terms of departure statistics for a higher QI threshold (Figure 3), this is at the expense of limiting the data sample and increasing the dependence on the forecast used in the AMV processing. Using the QI_fc for the data selection is in contrast to the preferred approach of selecting the data without the aid of the forecast used in the AMV processing. This has been chosen, as the characteristics of the COMS AMVs do not improve with a QI_nofc.

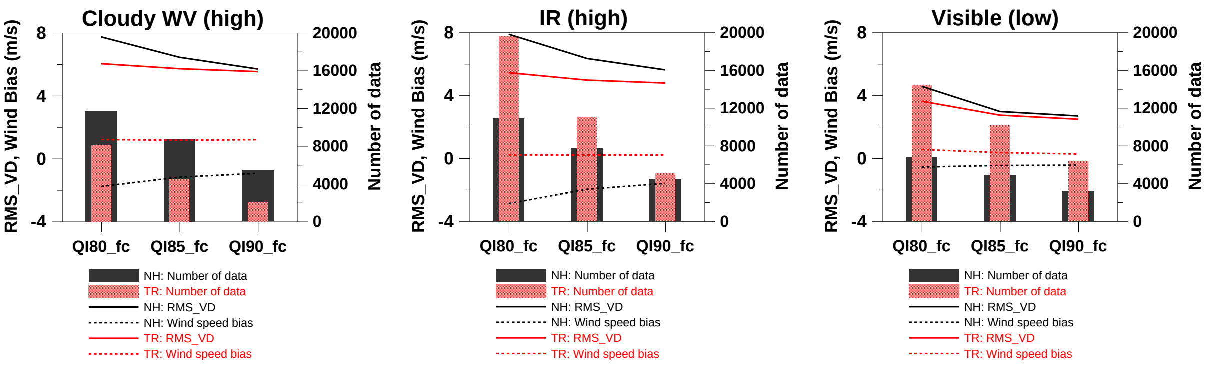


*Figure 3: RMS vector difference (solid line), wind speed bias (dashed line), and number of data (bar graph) for high-level cloudy water vapor AMVs (left), high-level IR (middle), and low-level visible AMVs (right) from COMS after applying different thresholds for QIs_fc for January to March 2013. Black shows results for the Northern Hemisphere, red results for the tropical region.*

## 2.2 Comparison of MTSAT and COMS AMVs

In the following, we will compare the monitoring statistics for COMS AMVs with those obtained from MTSAT. MTSAT AMVs are normally assimilated in the operational assimilation system at ECMWF, but for the present comparisons, the departure statistics are obtained from an experiment in which MTSAT winds are excluded from the analysis. This is to make the comparison more equal for both datasets.

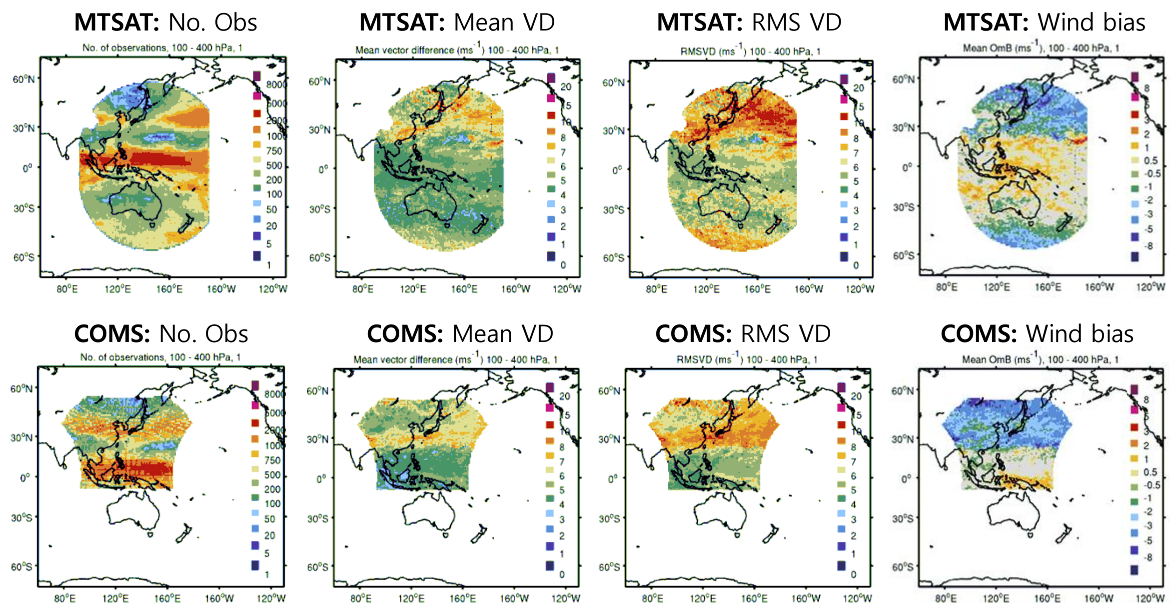


*Figure 4: Maps of number of observations, mean vector difference, RMS vector difference, and wind speed bias for high-level IR AMVs from MTSAT (upper row) and COMS (lower row). AMVs from both satellites have QI_fc > 80 for January to March 2013.*

Figure 4 shows the global maps of monitoring statistics of the MTSAT and COMS high-level AMVs derived from the IR channel. Although the regional coverage of MTSAT is larger than that of COMS, the monitoring statistics of both satellites present similar results in the overlapping region. In the tropical region (20°N ~ 20°S), the number of observations is relatively high, and the mean vector difference, root-mean-square (RMS) vector difference, and wind speed bias are relatively low, compared to the extra-tropical region. For the Northern extra-tropics, the speed biases are relatively large for both satellites for this winter season. Note that for this reason, IR winds from MTSAT are blacklisted north of 20°N in the operational ECMWF system. Such geographical blacklisting for COMS AMVs from the IR channel may need to be considered as well.

Overall, the monitoring statistics suggest that the general quality of COMS AMVs is similar to that of MTSAT AMVs. This is, for instance, highlighted in Figure 5, which compares the mean vector differences of COMS and MTSAT AMVs at different vertical levels. Note that COMS AMVs show relatively poor departure statistics for low-level AMVs over land, and these AMVs should be excluded from the assimilation. For MTSAT, such AMVs are not available.

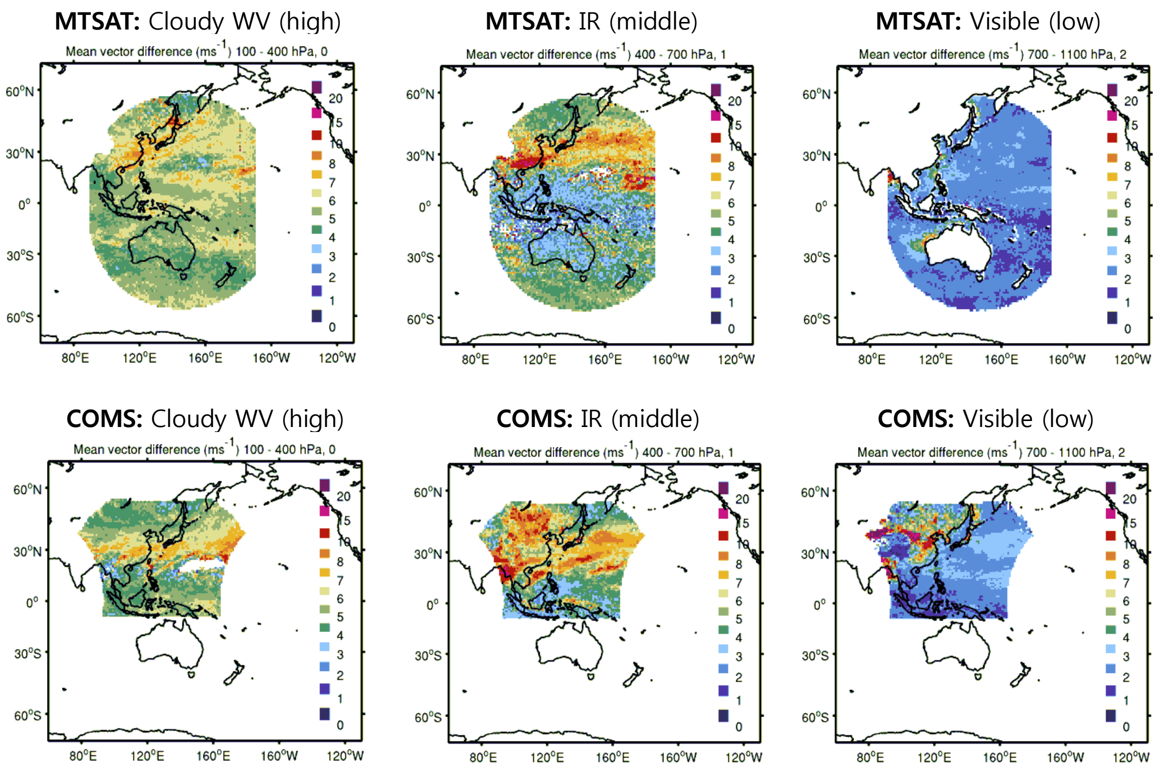


*Figure 5: Maps of mean vector difference for high-level (100-400 hPa) cloudy water vapor AMVs (left), middle-level (400-700 hPa) IR, and low-level (700-1100 hPa) visible AMVs from MTSAT (upper row) and COMS (lower row). AMVs from both satellites have QI_fc > 80 for January to March 2013.*

## 2.3 Shortwave infrared AMVs

In addition to long-wave IR, water vapor and visible winds, COMS also provides AMVs derived from the 3.7 µm SWIR channel at nighttime, which are not available from MTSAT. The visible and SWIR channels provide good contrast between clouds and ocean, which is very helpful to track the low-level cumulus form clouds motions (Ottenbacher et al., 1997). These AMVs supplement the available data from the other channels, in particular the visible AMVs which are only available at daytime.

In Figure 6, the monitoring statistics of COMS AMVs from the SWIR channel have been compared to those of other channels for low-level AMVs. Fortunately, the number of observations, mean vector difference, RMS vector difference, and wind speed bias of SWIR channel are very similar to those of the IR and visible channels. AMVs from all three channels show relatively large RMS vector differences over land and land-masking is likely to be needed for the assimilation of the data.

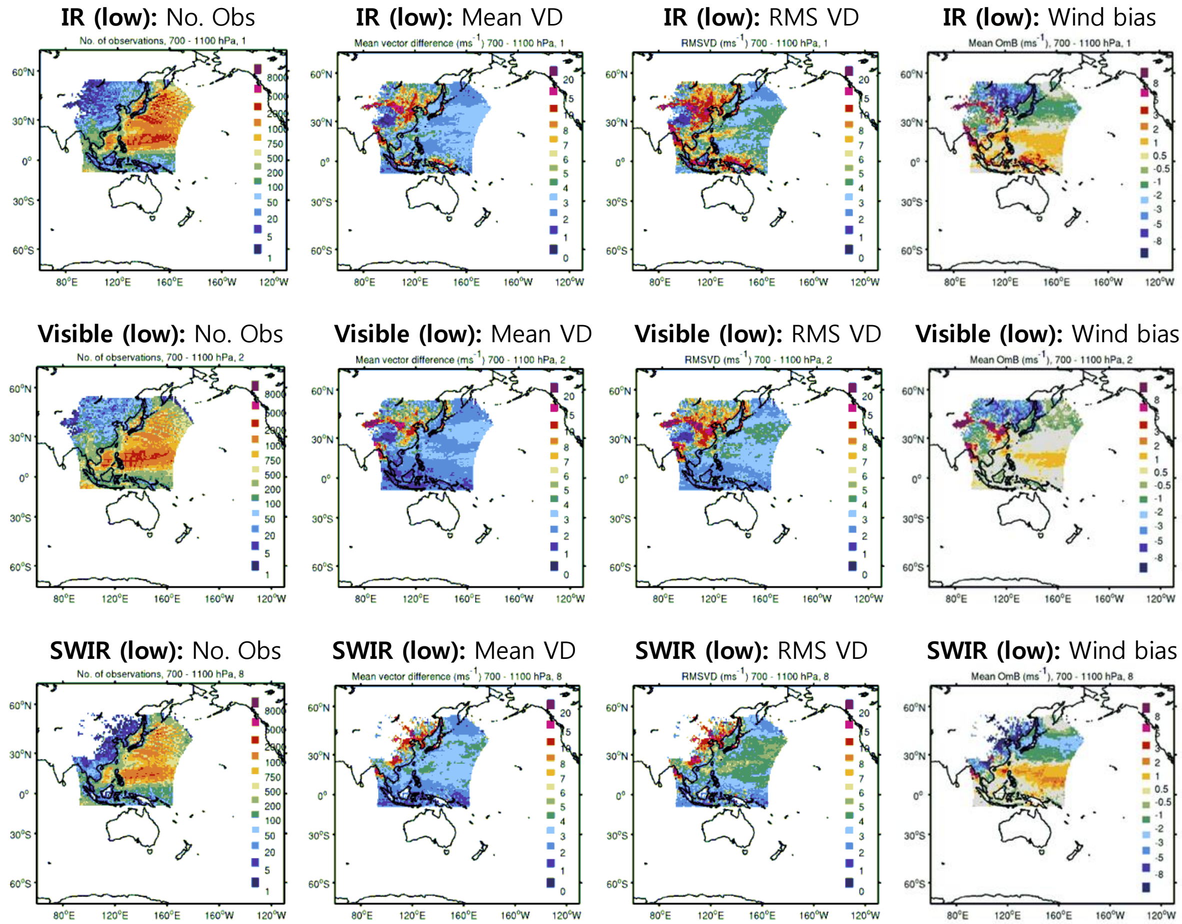


*Figure 6: Maps of number of observations, mean vector difference, RMS vector difference, and wind speed bias for low-level COMS AMVs from the IR (upper row), visible (middle row), and SWIR channels (lower row). COMS AMVs have QI_fc > 80 for January to March 2013.*

Zonal means of the monitoring statistics for COMS AMVs further show consistent features for the AMVs from the four channels (Figure 7), suggesting that the quality of the SWIR AMVs is comparable to that of the AMVs from the other channels. Interestingly, the SWIR AMVs cover a similar vertical range as the IR AMVs, which was not expected. The plots provide further input for blacklisting decisions for COMS, which will be discussed later.

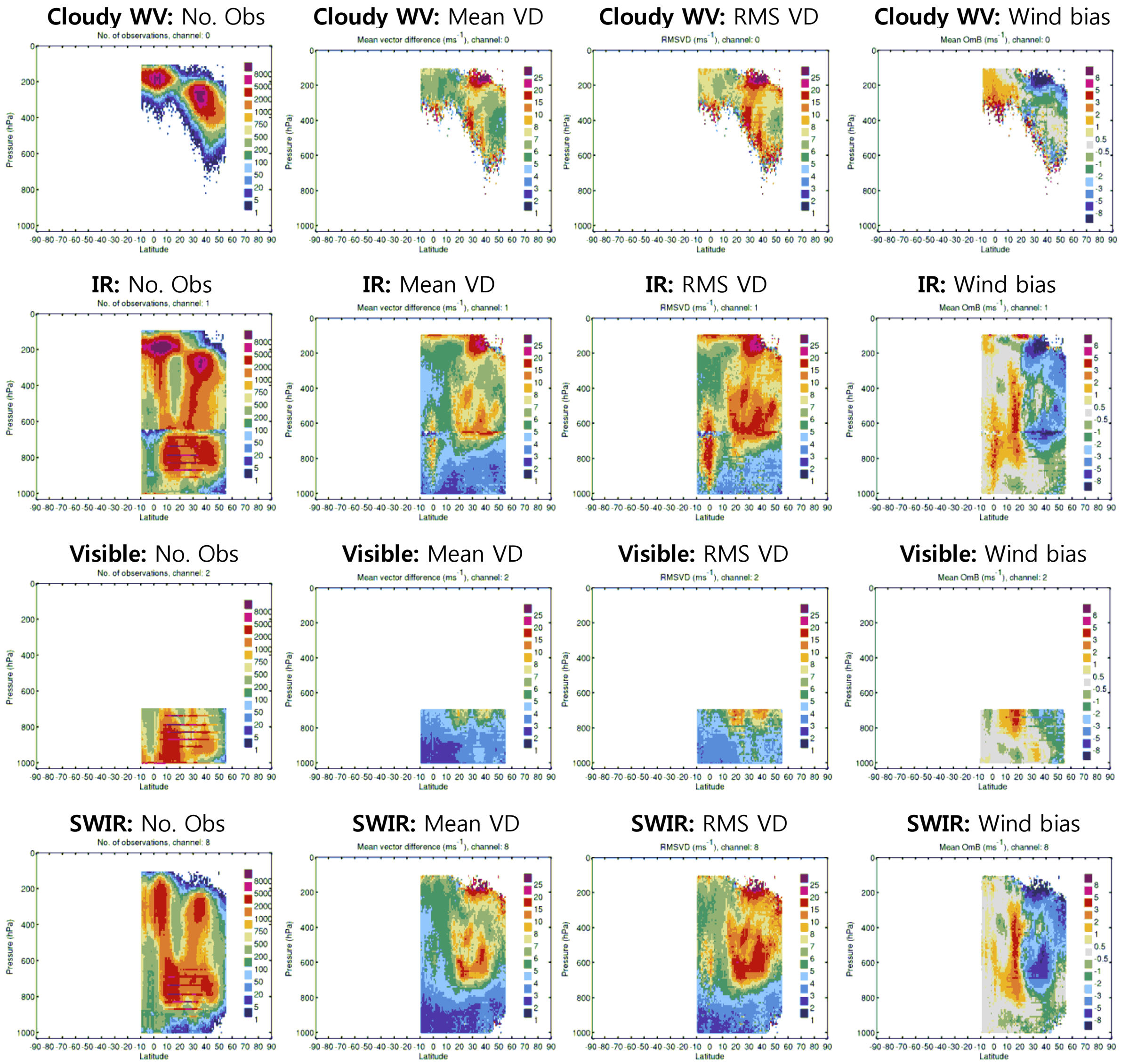


*Figure 7: Zonal plots of number of observations, mean vector difference, RMS vector difference, and wind speed bias for the COMS AMVs in cloudy water vapor (1st panel), IR (2nd panel), visible (3rd panel), and SWIR channels (4th panel). COMS AMVs have QI_fc > 80 for January to March 2013.*

## 2.4 Temporal consistency

Figure 8 shows the daily time-series of monitoring statistic for MTSAT and COMS AMVs during the winter and spring seasons. Both satellites with different number of data show a relatively strong negative bias of wind speed over the Northern Hemisphere (latitude > 25°N) in winter. This is linked to the strength of the jet-stream during these months, and in spring, the negative biases of both satellites are improved. In the MTSAT AMVs, slightly positive and negative biases are consistently remaining in the tropics (25°S ≤ latitude ≤ 25°N) and Southern Hemisphere (latitude < 25°S), respectively. However, it should be noted that the MTSAT AMVs over the Northern Hemisphere are not used operationally at ECMWF due to these biases, and similar blacklisting of these areas with the winter bias may need to be included in the ECMWF system for COMS AMVs.

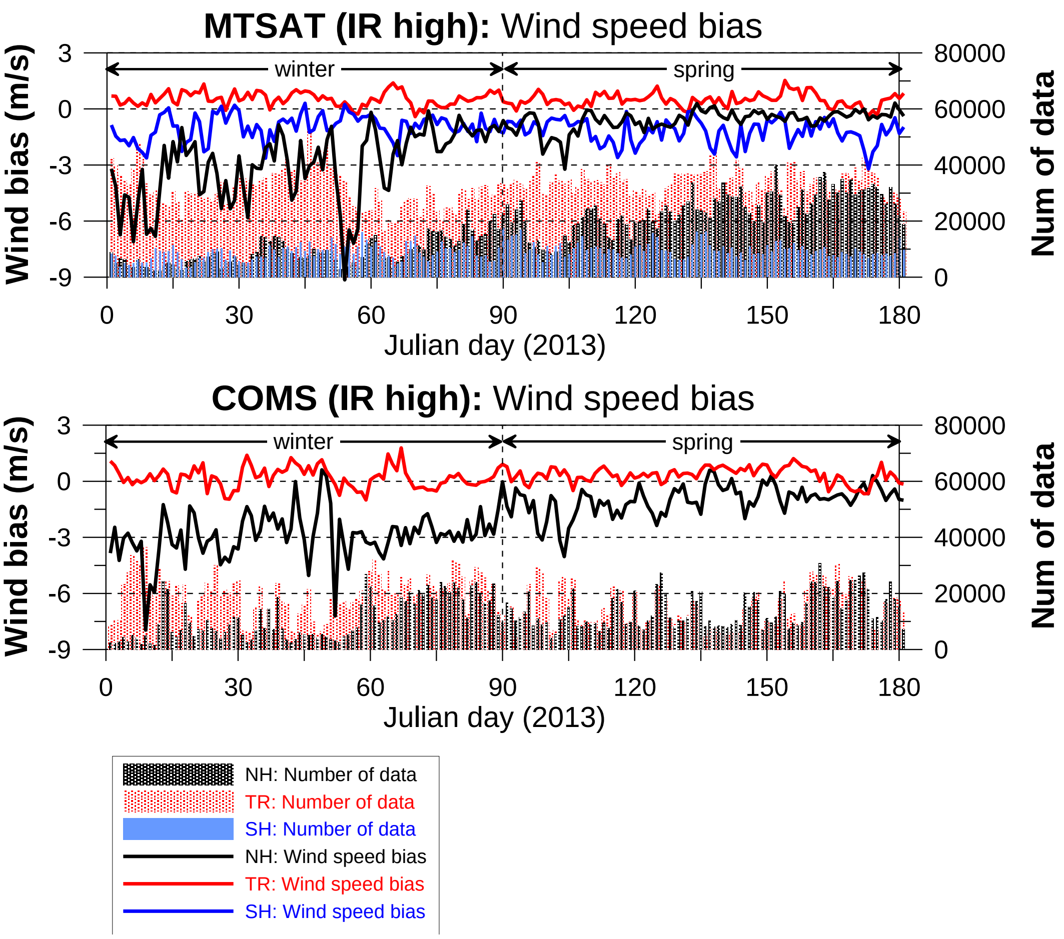


*Figure 8: Daily time-series of the number of data (bar graph) and wind speed bias (solid line) for high-level IR AMVs from MTSAT (top) and COMS (bottom). AMVs from both satellites have QI_fc > 80 for January to June 2013. Black shows results for the Northern Hemisphere, red results for the tropical region, and blue results for the Southern Hemisphere.*

COMS AMVs appear to have different characteristics for certain times of the day. Figure 9 shows monitoring statistics as a function of the hour of the day, with clear 3-hourly spikes for the COMS data. A similar feature can be seen for MTSAT AMVs, albeit 6-hourly. The phenomenon is similar for AMVs from other channels (not shown). It is clearly a characteristic of the AMVs, rather than the short-range forecast. For MTSAT AMVs, the pattern has been linked to the scanning schedule of the satellite, which means that the 6-hourly data uses a different imaging interval. It is likely that a similar explanation holds for COMS AMVs, as 3-hourly data (e.g., 0200, 0500, 0800, 1100, 1400, 1700, 2000, and 2300) is derived from a global scan with a longer imaging interval. Such inconsistent data characteristics are undesirable, and their origin should be further investigated. In the ECMWF system, the MTSAT AMVs showing the 6-hourly spikes are blacklisted, to improve the homogeneity of the data characteristics. A similar approach may be needed for COMS AMVs. For COMS, the data from the 3-hourly spikes show relatively better statistics for the wind speed bias over the Northern Hemisphere compared to the data from the other times. The relatively strong negative wind speed bias of COMS AMVs over the Northern Hemisphere for the other time-slots is related to the seasonal bias discussed earlier (see Figure 8). Additional investigations would be beneficial to resolve the winter bias and 3-hourly spikes for COMS AMVs.

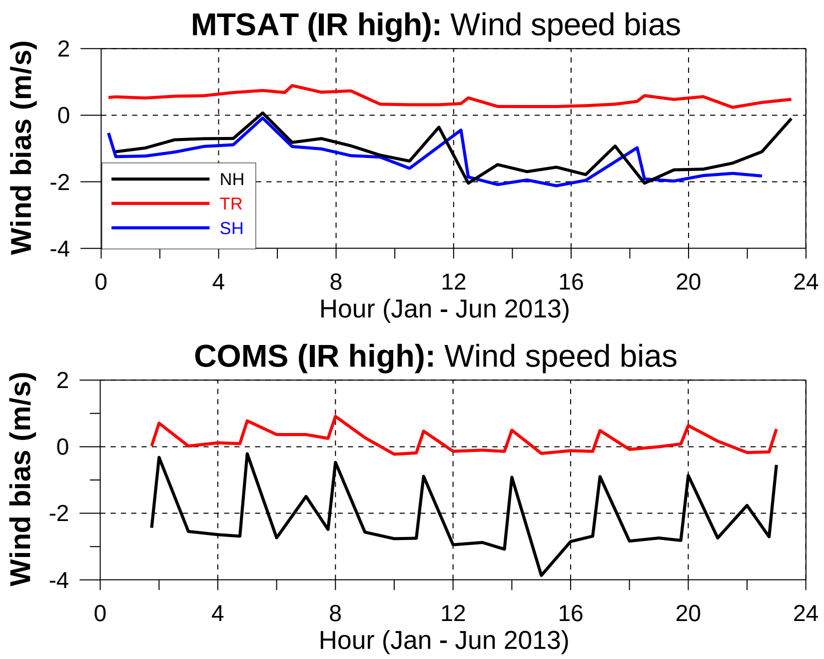


*Figure 9: Wind speed bias (observation minus FG) as a function of time-of-day for high-level IR AMVs from MTSAT (top) and COMS (bottom). AMVs from both satellites have QI_fc > 80 for January to June 2013. Black shows results for the Northern Hemisphere, red results for the tropical region, and blue results for the Southern Hemisphere.*

## 3 Impact assessment of COMS AMVs

Given the encouraging results from the investigation of monitoring statistics for COMS AMVs, we will now investigate their impact in the ECMWF assimilation system. To do so, we will first need to assign an observation error to represent the uncertainties involved in the use of the AMVs, and then conduct a range of assimilation experiments.

### 3.1 Observation errors

AMV errors originate mainly from two sources: height assignment and wind vector tracking. The impact of errors in height assignment is highly situation dependent, and it is very significant in areas where wind shear is strong (Forsythe and Saunders, 2008). In the ECMWF system, the height assignment errors of COMS AMVs have been estimated based on model best-fit pressure statistics separately for all channels and height assignment methods (as described in Salonen and Bormann, 2013). The tracking errors have been estimated from FG departure statistics from cases where the wind error due to error in height assignment is small.

Figure 10 shows the zonal plots of the mean difference of assigned height minus model best-fit pressure for COMS AMVs in each channel for different QIs. The statistics present a similar pattern for QI80_nofc and QI80_fc with good agreement between the assigned and the best-fit pressure above about 300 hPa height. Below 300 hPa there is a strong positive bias in the tropics for IR and SWIR channels with more significant bias for QI80_nofc.

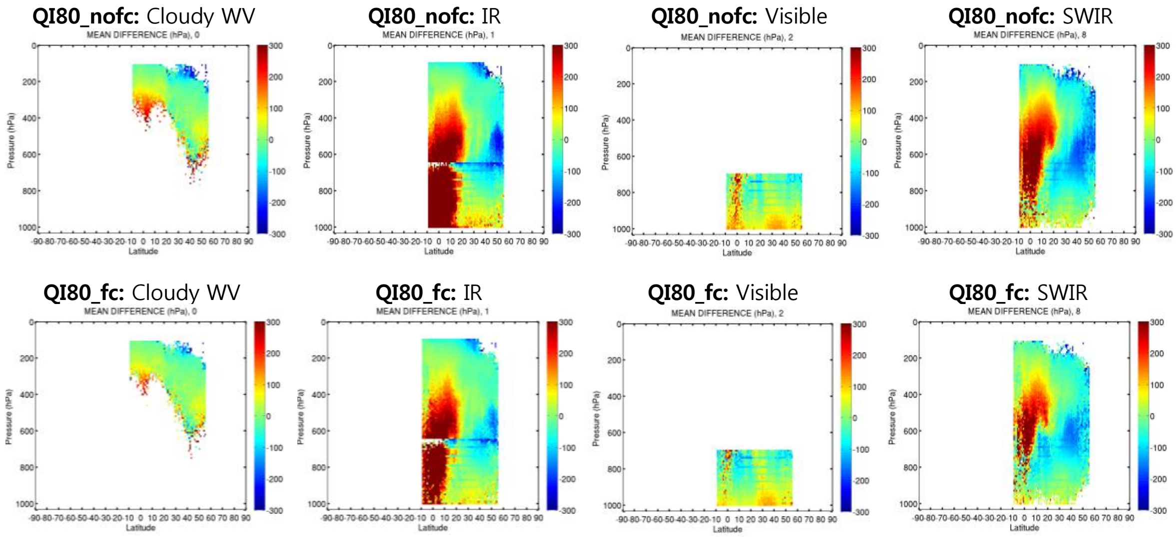


*Figure 10: Zonal plots of the mean difference (hPa) of assigned observation height minus model best-fit pressure for the COMS AMVs of cloudy water vapor, IR, visible, and SWIR channels. COMS AMVs have QI_nofc > 80 (upper) and QI_fc > 80 (lower) for January to March 2013.*

Figure 11 shows the pressure error estimated from best-fit pressure statistics for COMS AMVs in each channel. The used height assignment methods for COMS AMVs are Equivalent Black Body Temperature (EBBT) and $H_2O$ intercept (Nieman et al., 1993; Szejwach, 1982). Overall, the pressure errors of COMS AMVs are lower when the QI_fc is used for quality control compared to when the QI_nofc is used. The difference is up to 90 hPa for low-level (800-1000 hPa) IR AMVs using EBBT. For low-level IR AMVs, the pressure error of COMS AMVs is relatively high, even when a QI_fc threshold is applied, about 200 hPa. In the ECMWF system, the pressure errors for operational MTSAT AMVs are in the range of 40 to 135 hPa for different channels at each level (not shown), and the typical pressure errors of operational satellites AMVs are of the order of 70 to 110 hPa (Salonen and Bormann, 2013).

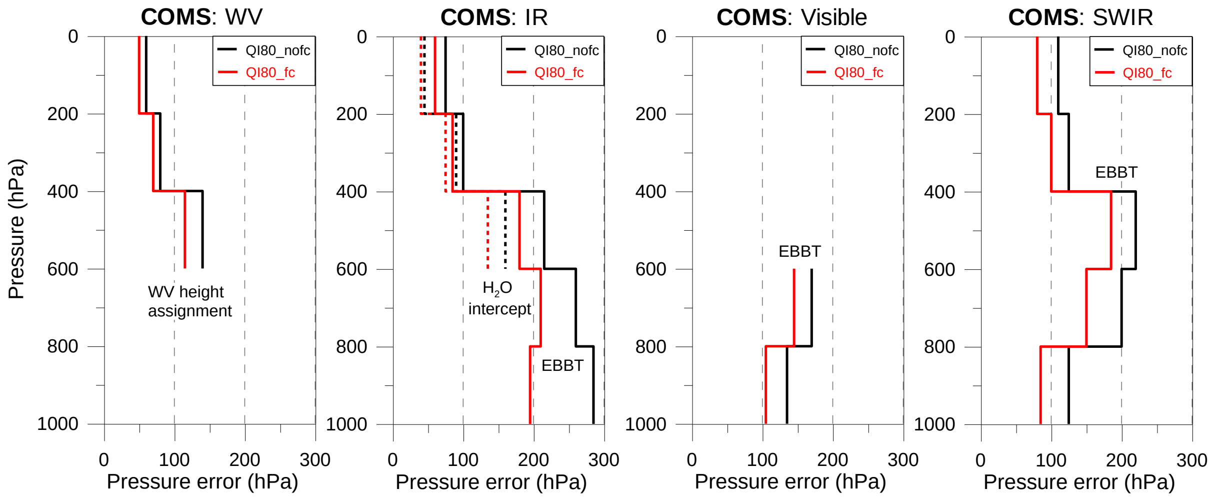


*Figure 11: Pressure error estimated from best-fit pressure statistics for COMS AMVs by QI80_nofc (black) and QI80_fc (red) in cloudy water vapor, IR, visible, and SWIR channels utilizing EBBT (solid line) and $H_2O$ intercept height assignment methods (dashed line).*

## 3.2 Experiments with COMS AMVs

A set of assimilation experiments has been conducted to evaluate different blacklisting choices for COMS AMVs. We use the ECMWF Integrated Forecasting System (IFS) cycle 41r1 at a T511 resolution, 137 levels, and 12-hour 4D-Var over the period 1st January to 30th June 2013. In the control experiment (CTL), all operationally assimilated conventional and satellite observations except MTSAT AMVs are used. To compare the assimilation of COMS AMVs with that of MTSAT AMVs, we also run an experiment similar to the CTL, but with MTSAT AMVs added as used in operations.

Table 1 lists the experiments to investigate the quality control criteria for COMS AMVs. In all these experiments, MTSAT AMVs are not used. All COMS experiments presented here include geographical blacklisting of COMS AMVs, that is, IR and SWIR AMVs are excluded between 400 and 800 hPa south of 35°N. This is because monitoring shows large positive biases in wind speed and pressure in these regions (e.g., Figures 7 and 10). Additional assimilation experiments without this geographical blacklisting show a degradation of forecast scores as shown in Figure 12. In addition, all experiments apply further geographical blacklisting similar to that applied to other AMVs, that is, water vapor AMVs are used above 400 hPa only and visible AMVs are assimilated below 700 hPa only. No AMVs are used over land over the Northern Hemisphere extra-tropics, whereas elsewhere they are used only above 500 hPa over land.

*Table 1. Experiments to investigate the quality control criteria for COMS AMVs.*

| Experiment | Used QI | Timeslot blacklisting | Used SWIR | Seasonal blacklisting | Geographical blacklisting |
|---|---|---|---|---|---|
| COMS_QI80_nofc | QI80_nofc | 3-hourly (worse) | No | No | Yes |
| COMS_QI80_fc | QI80_fc | 3-hourly (worse) | No | No | Yes |
| COMS_SWIR_nofc | QI80_nofc | 3-hourly (worse) | Yes | No | Yes |
| COMS_SWIR_fc | QI80_fc | 3-hourly (worse) | Yes | No | Yes |
| COMS_Seasonal | QI80_fc | 3-hourly (worse) | No | Yes | Yes |
| COMS_3hourly_nofc | QI80_nofc | 3-hourly (better) | Yes | Yes | Yes |
| COMS_3hourly_fc | QI80_fc | 3-hourly (better) | Yes | Yes | Yes |
| COMS_1hourly_fc | QI80_fc | 1-hourly | Yes | Yes | Yes |

In addition, the experiments presented in Table 1 consider the following blacklisting options:

***Choice of QI:*** COMS_QI80_nofc and COMS_QI80_fc are the experiments to compare the forecast impact of using the forecast-independent or forecast-dependent QI, in both cases using a threshold of 80%. This affects the characteristics of the assimilated AMVs (Figure 1), but also the number of data used, with fewer assimilated AMVs when the forecast-dependent QI is used for data selection (see Figures 2 and 3).

***Time-slot blacklisting:*** This considers using the AMVs only for certain time-slots with consistent characteristics, following the finding that certain slots show different departure characteristics (Figure 9). The experiment COMS_3-hourly uses time-slots 0200, 0500, 0800, 1100, 1400, 1700, 2000, and 2300 which show the best departure statistics (marked as “3-hourly (better)” in Table 1). In contrast, COMS_1-hourly uses all other time-slots. All other experiments use time-slots 0145, 0445, 0745, 1045, 1345, 1645, 1945, and 2245, that is, they use 3-hourly COMS AMVs, but from time-slots with poorer departure characteristics. This selection was done unintentionally, but the experiments are still used here to evaluate the sensitivity to the other blacklisting choices.

***Seasonal blacklisting:*** COMS_Seasonal is the experiment to investigate the forecast impact of seasonal blacklisting, which is applied to IR and SWIR channels over the Northern Hemisphere north of 20°N in January to March because large biases were found for IR winds during this time (see Figure 8).

***Use of SWIR AMVs:*** COMS_SWIR_fc and COMS_SWIR_nofc are assimilation trials in which the SWIR AMVs are used to further improve the forecast impact, using an 80% threshold on the QI_fc and the QI_nofc, respectively. The monitoring statistics of SWIR AMVs are similar to the IR ones (see Figures 6 and 7), so the same data selection is applied.

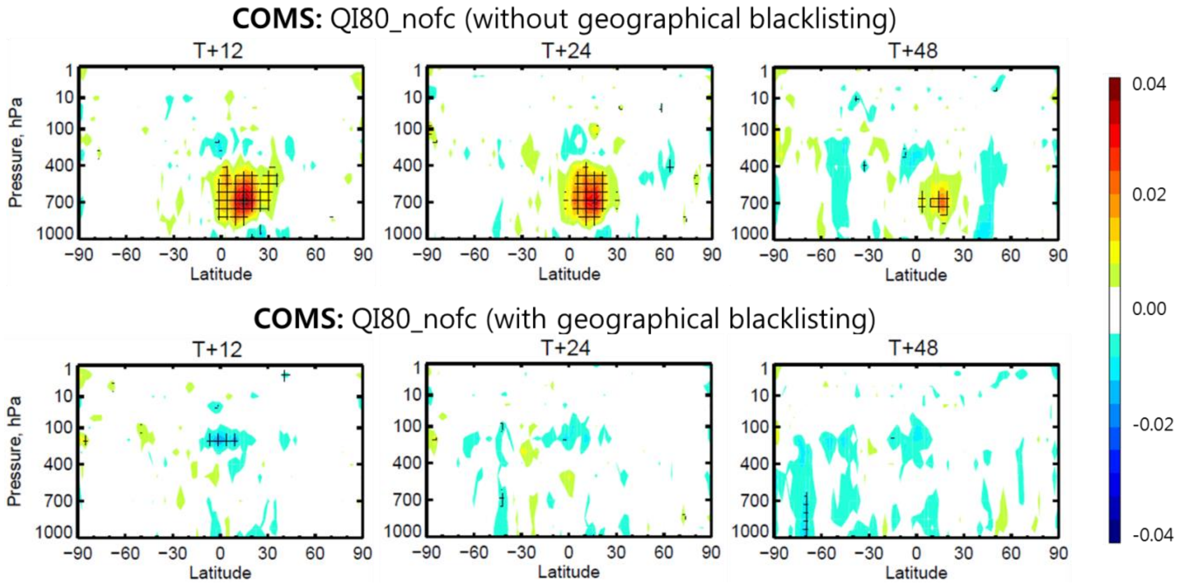


*Figure 12: Zonal plots of the normalized difference (experiment minus CTL) of the RMS error for the 12-, 24-, and 48-hour wind forecasts. The top row shows results for an experiment without geographical blacklisting, whereas the bottom row shows results for the COMS_QI80_nofc experiment with geographical blacklisting experiments. Verification is against the own analysis, and the statistics cover January to June 2013. Blue shades indicate positive impact and green and red shades negative impact from using the COMS AMVs, and cross-hatching shows statistical significance at the 95% level.*

## 3.3 Mean wind analysis

MTSAT and COMS AMVs have a significant impact on the tropical mean wind analysis, especially over the western Pacific Ocean. Figure 13 shows the mean wind analysis at 200 hPa for the CTL, whereas Figure 14 shows the vector difference of the mean wind analysis between the experiments (operational MTSAT and COMS_QI80_nofc) and CTL. The differences for other COMS experiments are similar. The vector differences in the mean wind analysis at 200 hPa are seen mainly in areas where the mean wind analysis of CTL is extremely small. Changes to the mean wind analysis over the tropics are a common finding when AMVs are assimilated (e.g., Payan and Cotton, 2012), and they are thought to primarily correct model biases resulting from weaker constraints for the tropical wind field. Interestingly, while the adjustments of the mean wind analysis are consistent for the assimilation of MTSAT AMVs and COMS AMVs in some regions (e.g., around the equator at 150°E), there are also differences, hence suggesting different bias characteristics in the assimilated data. The changes to the mean wind analysis for the lower levels are weaker, typically less than 0.3 m/s (not shown).

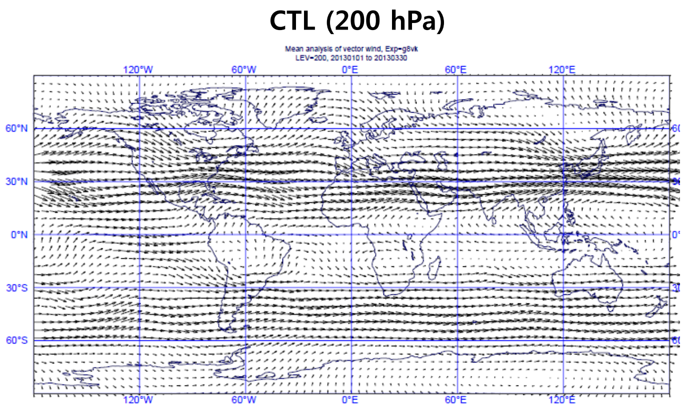


*Figure 13: The mean wind analysis for the CTL at 200 hPa for January to March 2013.*

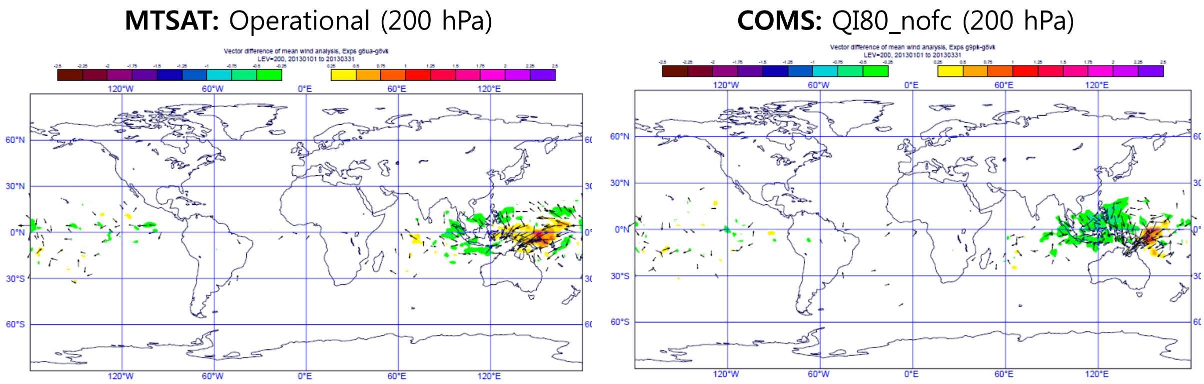


*Figure 14: The vector difference of the mean wind analysis at 200 hPa between the MTSAT experiment and the CTL (i.e., experiments minus CTL, left), and the COMS_QI80_nofc experiment and the CTL (right).*

## 3.4 Forecast verification

COMS AMVs have a small, but positive forecast impact for all blacklisting choices considered here, as long as the lower- and mid-level IR (and SWIR) AMVs are excluded. Figure 15 shows the zonal plots of the normalized difference (i.e., different experiments minus CTL) in the RMS error for 72-hour wind forecasts for six-months. Here, the experiments are the operational MTSAT AMVs and COMS AMVs with different blacklisting. The impact on the 72-hour forecast is shown here as a representative example, as it tends to be more robust against different choices of verifying analysis than shorter-range forecasts, but is also more reliable than forecast impact at longer lead times. The most consistent impact for the different COMS experiments is found for the higher levels in the tropics. When the COMS SWIR AMVs are included, the forecast impact is broadly comparable to that of MTSAT (compare Figures 15a and e-i), except over the Southern Hemisphere extra-tropics which are not covered by COMS.

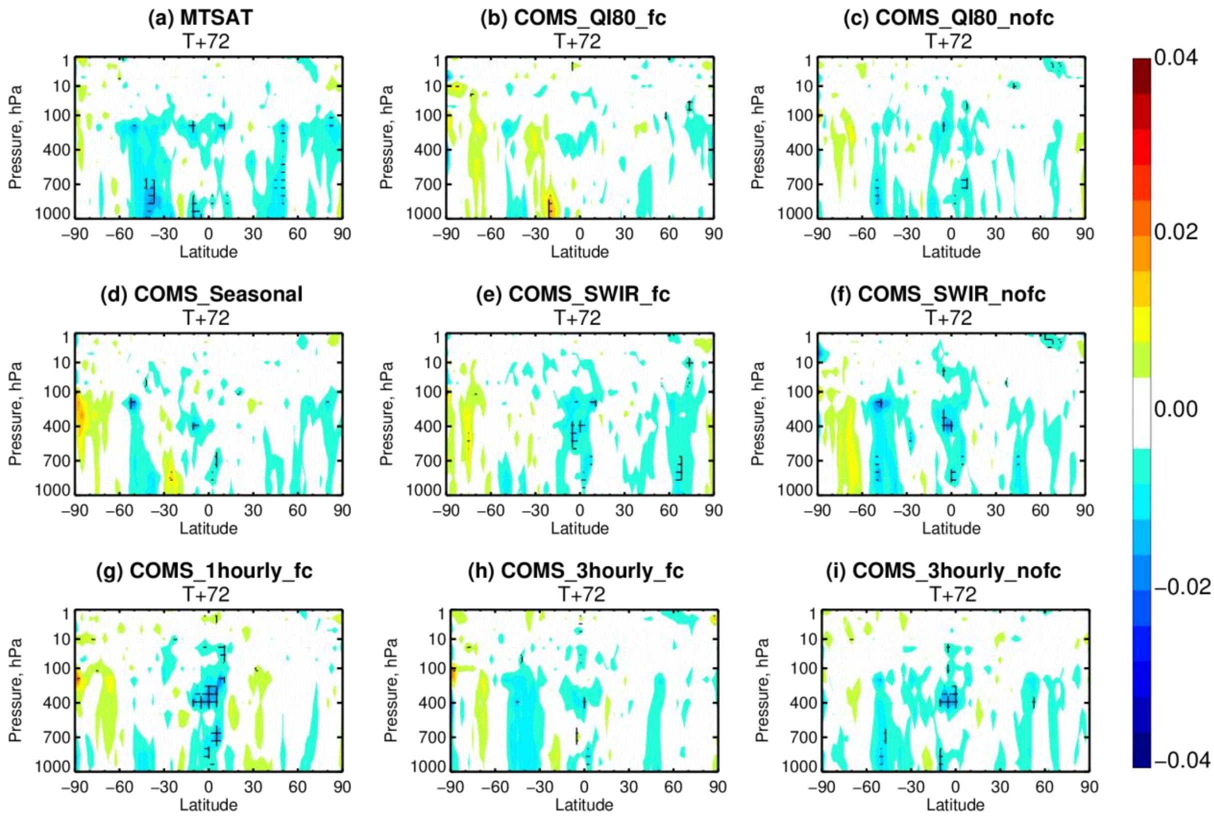


*Figure 15: The same as Figure 12, but for the experiment with MTSAT AMVs (upper left) and the experiments with COMS AMVs with different blacklisting choices for January to June 2013, as indicated above each panel.*

The consistent impact at higher levels in the tropics is also confirmed when considering background departure statistics for other assimilated wind observations (e.g., Figure 16). Statistically significant reductions in the standard deviations of observation minus background (OmB) statistics can be seen from 150 hPa to 400 hPa levels. This indicates that the other wind observations fit better the model FG when the COMS AMVs are used, suggesting that the short-range forecast is more accurate. In Figure 16 only the results for the COMS_QI80_fc and the COMS_QI80_nofc experiments are shown as an example, but the pattern is present for all COMS experiments considered here, with only small and mostly not statistically significant variations.

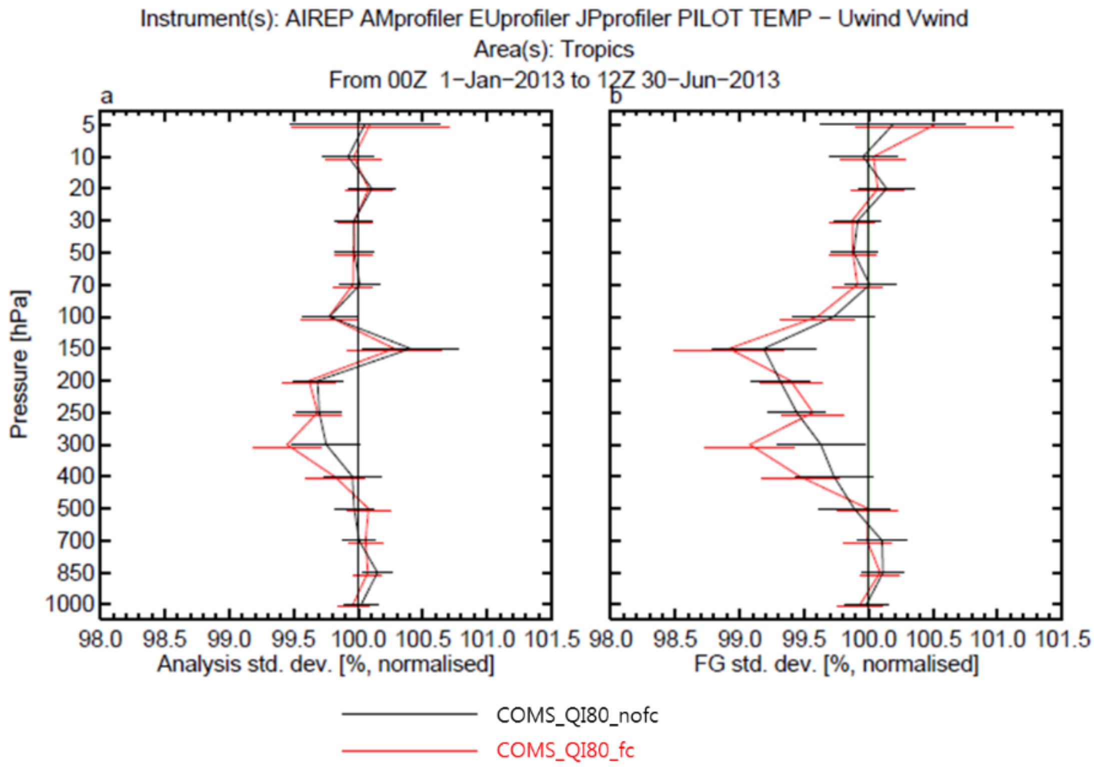


*Figure 16: Normalized change in standard deviation of analysis (left) and first-guess (right) differences from wind observations from radiosondes, pilots, aircraft reports and wind profilers with respect to the CTL in the tropics for January to June 2013. Values less than 100% indicate beneficial impacts from the use of COMS AMVs. The horizontal bars indicate 90% confidence range.*

Adding the SWIR AMVs from COMS appears to give a small benefit (compare experiments COMS_QI80_fc and COMS_SWIR_fc, or COMS_QI80_nofc and COMS_SWIR_nofc in Figure 15). This can also be seen in Figure 17 which shows a map of the normalized RMS differences between the experiments (COMS_QI80_fc and COMS_SWIR_fc) and CTL for 72-hour wind forecast at 850 hPa level. The impact over the western Pacific is on average neutral to slightly positive when the COMS AMVs are used. The COMS_SWIR_fc experiment shows a more positive impact over the COMS coverage area at low levels (see the right map in Figure 17), but also the tropics at all pressure levels (see Figure 15).

Although the choice of QI has a significant impact on the monitoring statistics of COMS AMVs, the effect on the forecast impact appears less clear. Figure 15 suggests a small benefit from using the QI_nofc (compare COMS_QI80_nofc and COMS_QI80_fc, or COMS_SWIR_fc and COMS_SWIR_nofc, or COMS_3hourly_fc and COMS_3hourly_nofc), but the differences are not statistically significant. In contrast, Figure 16 shows a slightly better improvement in terms of the standard deviations of background departures for the COMS_QI80_fc experiment, but the differences are only statistically significant at 300 hPa.

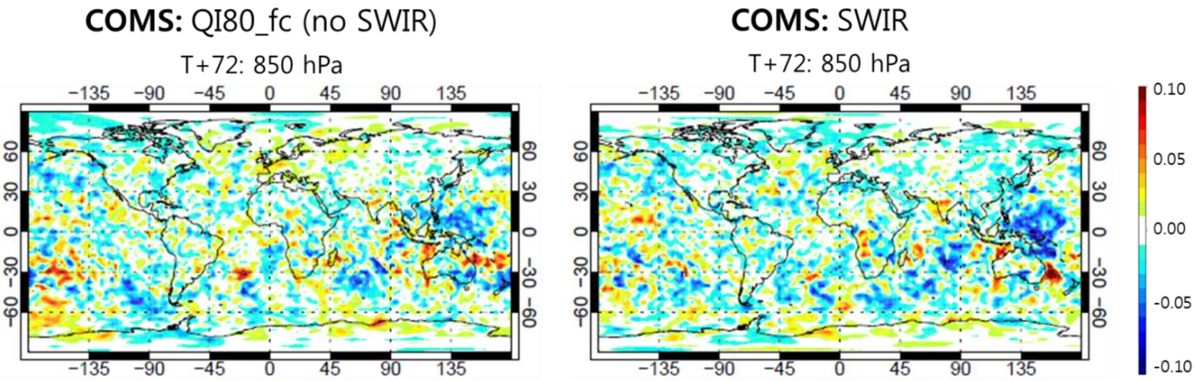


*Figure 17: Global maps of the normalized RMS difference between experiment and CTL for 72-hour wind forecasts at 850 hPa level. Experiments are COMS_QI80_fc (left) and COMS_SWIR_fc (right) for January to June 2013. Blue shades indicate positive impact and green and red shades negative impact from using the COMS AMVs.*

The choice of assimilated time-slots for the COMS AMVs appears to lead to different responses over different regions (Figure 18). While the assimilation of the AMVs from the time-slots which show smaller biases over the extra-tropics leads to somewhat better forecast impact over the extra-tropics, the benefits are mostly not statistically significant. In contrast, the use of the AMVs from the other time-slots gives a better forecast impact over the tropics, with statistically significantly better results at high levels. The latter finding may reflect the use of a larger number of AMVs, together with smaller speed biases for these winds over the tropics (Figure 9).

Finally, Figure 19 shows the forecast impact at 200 hPa of using COMS AMVs with seasonal blacklisting. As mentioned before, seasonal blacklisting is applied over the Northern Hemisphere extra-tropics only for the first 3 months. Although no significant improvement is seen for the COMS_seasonal experiment, regions with negative forecast impact are reduced over the Southern Hemisphere. As the seasonal blacklisting is applied over the Northern Hemisphere, it is unclear whether this is a result of the seasonal blacklisting or an artifact of the sample size.

In summary, we found a small, but positive forecast impact from the assimilation of COMS AMVs, particularly when the SWIR AMVs are included. The clearest impact on the wind forecasts can be found for the upper troposphere in the tropics. As expected, the impact is primarily confined to the COMS area, but it is measureable in statistics that consider all longitudes. The choice of assimilated time-slots or whether a forecast dependent or independent QI is used for blacklisting appears less clear.

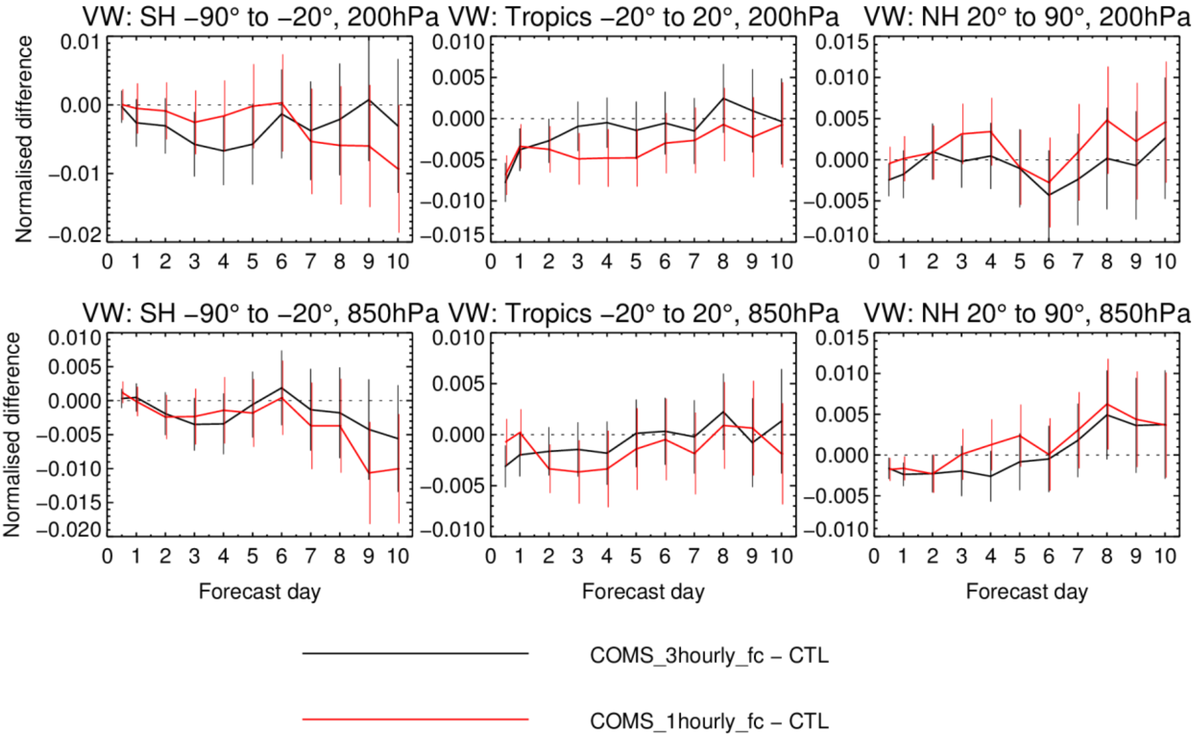


*Figure 18: Normalized difference of the 200 hPa (upper) and 850 hPa (lower) RMS wind forecast error as a function of the forecast range for the Southern Hemisphere extra tropics (left), tropics (middle), and the Northern Hemisphere extra tropics (right). The difference is calculated as COMS_3hourly_fc minus the CTL (black) and COMS_1hourly_fc minus CTL (red), so negative values indicate an improvemed forecasts. Each experiment has been verified against its own analysis. The vertical bars indicate 90% confidence range. The statistics cover the 6-month period January to June 2013.*

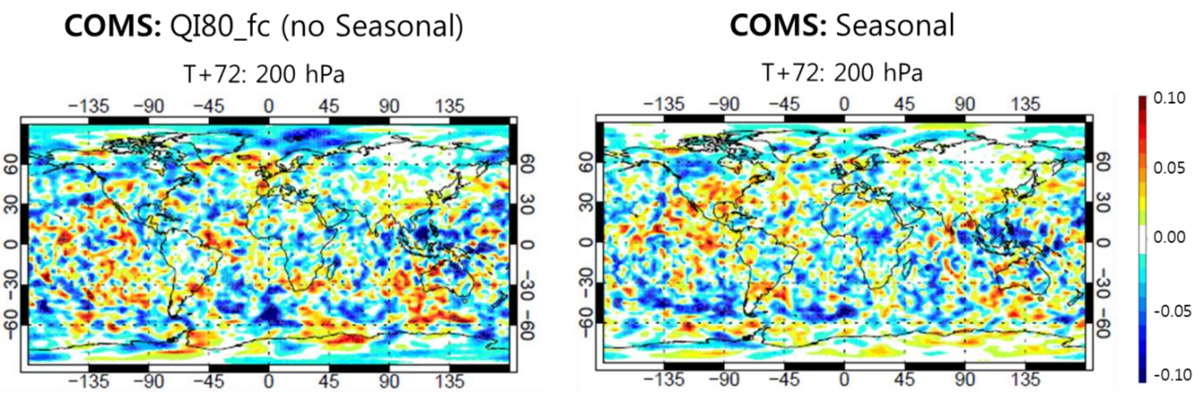


*Figure 19: The same as Figure 16 but for the 200 hPa level. Experiments are COMS_QI80_fc (left) and COMS_Seasonal (right) for January to March 2013 (winter season).*

## 3.5 Impact of MTSAT and COMS AMVs

So far, we have considered the assimilation of COMS AMVs as an alternative to MTSAT AMVs, as they cover a similar area. This is useful to establish the quality of the data and to put it in the context of the rest of the observing system. Given the benefits shown from the assimilation of COMS AMVs, the question arises whether there is a benefit from assimilating COMS AMVs in addition to MTSAT AMVs. As the observations originate from different satellites with different derivation algorithms, using both datasets together potentially adds further information to the assimilation system. However, this is not guaranteed, as both datasets may be affected by similar errors, and such correlations between errors are not taken into account in the assimilation system.

To investigate the combined used of MTSAT and COMS AMVs, we have conducted a further assimilation experiment over the same period, in which the MTSAT as well as the COMS AMVs are assimilated. This experiment uses the configuration of the COMS_1hourly_fc experiment for the assimilation of the COMS AMVs. Other quality control choices for the COMS AMVs could have been considered, but they are not expected to lead to overall significantly different results.

In the combined experiment, COMS and MTSAT AMVs are thinned together, with a spatial thinning scale of 200 km, applied to ½-hourly timeslots and vertical layers defined by standard pressure levels. As can be seen from Figure 20, the use of the two AMV datasets is nevertheless almost additive. Globally, there are roughly half the number of AMVs assimilated from COMS than for MTSAT – mostly due to the lack of coverage over the Southern Hemisphere for COMS.

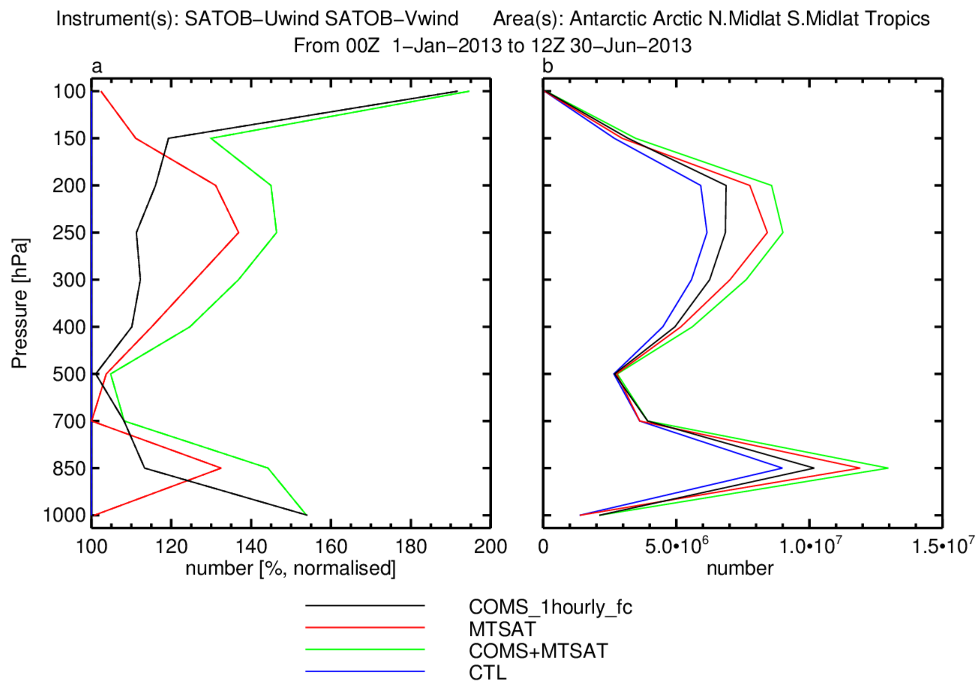


*Figure 20: Total number of AMVs assimilated globally (right), and relative change to the CTL experiment (left) for the COMS_1hourly_fc experiment (black), the MTSAT experiment (red), and the COMS+MTSAT experiment (green).*

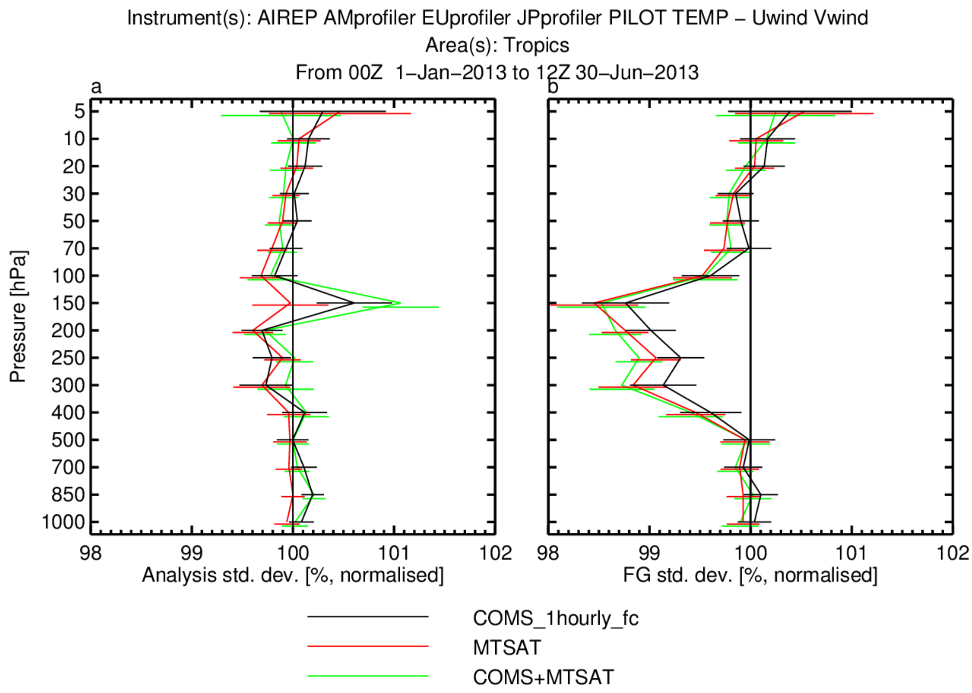


*Figure 21: As Figure 16, but for the experiments COMS_1hourly_fc (black), MTSAT (red) and COMS+MTSAT (green).*

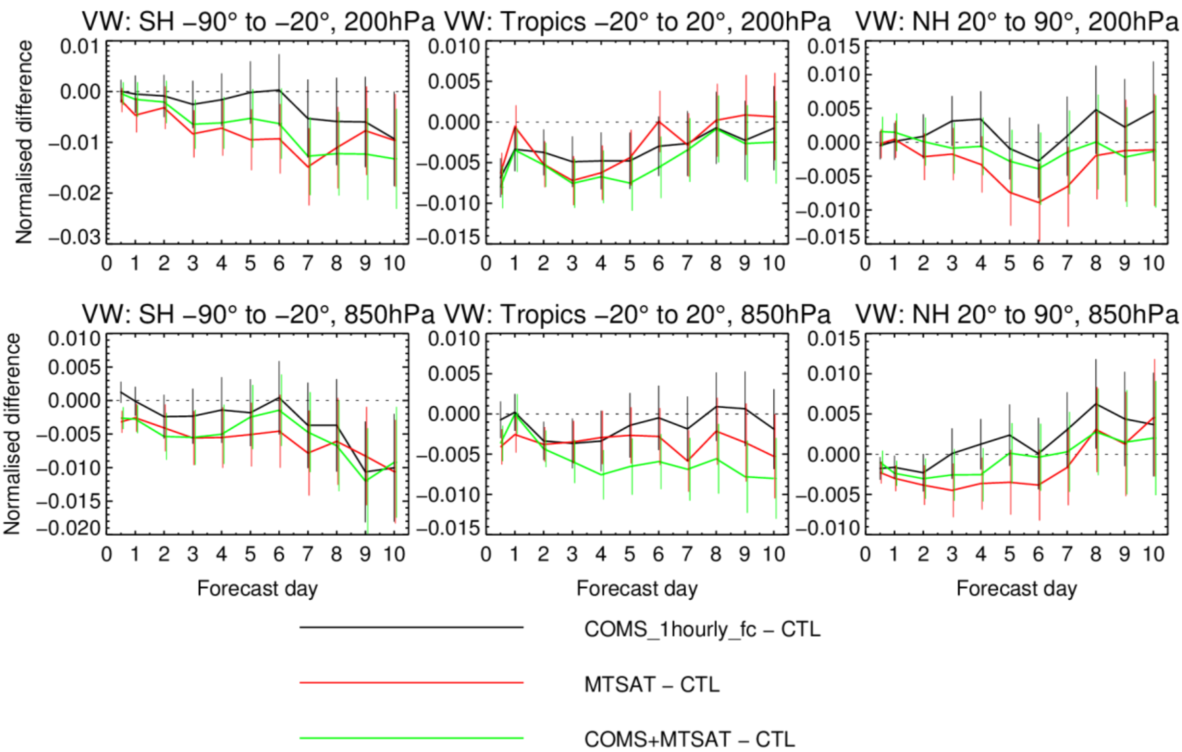


*Figure 22: As Figure 18, but for the COMS_1hourly_fc experiment (black), the MTSAT experiment (re d), and the combined COMS+MTSAT experiment (green).*

The additional forecast impact of COMS AMVs in the presence of MTSAT AMVs is less clear. Standard deviations of background departures for other wind observations in the tropics show a similar level of improvement at high levels when MTSAT and COMS AMVs are added individually, but the combined result does not lead to statistically significant further benefits (Figure 21). The most significant benefit from assimilating the combination of COMS and MTSAT AMVs in terms of forecast scores is over the low levels in the tropics, where the combined experiment leads to smaller forecast errors than when COMS and MTSAT AMVs are assimilated individually (compare the green line versus the black or red line in Figure 22). In other regions, the forecast impact of adding COMS AMVs in addition to MTSAT AMVs is mostly neutral. Some degradation relative to an experiment that uses MTSAT AMVs alone can be found over the extra-tropics, but this is not statistically significant.

# 4 Conclusions and future work

COMS AMVs have been investigated in the ECMWF system in terms of FG departure statistics and assimilation experiments, and the results have been compared to operational MTSAT AMVs. The main findings from the passive monitoring of COMS AMVs are:

(1) The FG departure statistics of COMS and MTSAT AMVs show consistent features geographically, indicating broadly similar quality in most regions.

(2) The choice of a forecast-dependent QI threshold is a trade-off between the quality of AMVs (and the dependence on a short-range forecast) and the number of winds. We found little indication for improved quality with higher values of the forecast-independent QI supplied with COMS AMVs.

(3) The monitoring statistics for the SWIR AMVs are comparable to those of IR winds at all levels.

(3) COMS AMVs show different monitoring characteristics for certain time-slots, with better FG departure statistics for 3-hourly COMS winds at 0200, 0500, 0800, 1100, 1400, 1700, 2000, and 2300. The different characteristics for certain time-slots are likely to be an artefact of the scanning schedule and should be investigated further.

(4) COMS AMVs have a relatively strong negative bias of wind speed over the Northern Hemisphere in winter.

The assimilation of COMS AMVs has a notable impact on the mean wind analysis in the tropics at high levels. COMS AMVs have a positive forecast impact in this region, regardless of the detailed blacklisting choices investigated here. However, geographical blacklisting for lower- and mid-level IR and SWIR AMVs is considered necessary, as the assimilation of these winds leads to a small forecast degradation. The forecast impact of COMS AMVs is broadly comparable to that of operational MTSAT AMVs when the SWIR AMVs of COMS are used. When MTSAT and COMS AMVs are assimilated together the additional benefit of COMS AMVs is small, and confined to the lower levels in the tropics.

There are some areas in which the use of COMS AMVs could be improved further. Currently, the height errors of COMS AMVs have been derived from the sample of AMVs after applying a QI threshold, but without taking the geographical blacklisting into account. This means that height errors used for COMS AMVs may be overestimated, and revised height errors may be more beneficial. Also, the quality control applied to the AMVs from MTSAT and COMS could be refined further when both datasets are used together, in order to optimise the benefits from both datasets.

## 5 References

Bormann, N., Salonen, K., Peubey, C., McNally, T., and Lupu, C., 2012: An overview of the status of the operational assimilation of AMVs at ECMWF. Proceedings of the 11th International Wind Workshop. Auckland, New Zealand, 20-24 February 2012.

Forsythe, M., and Saunders, R., 2008: AMV errors: a new approach in NWP. Proceedings of the 9th International Wind Workshop. Annapolis, Maryland, USA, 14-18 April 2008, EUMETSAT P.51.

Holmlund, K., 1998: The utilization of statistical properties of satellite-derived atmospheric motion vectors to derive quality indicators. Wea. Forecasting, 13, 1093-1104.

Nieman, S. J., Schmetz, J., and Menzel, W., P., 1993: A comparison of several techniques to assign heights to cloud tracers. J. Appl. Meteor., 32, 1559-1568.

Ottenbacher, A., Tomassini, M., Holmlund, K., and Schmetz, J., 1997: Low-level cloud motion winds from Meteosat high-resolution visible imagery. Wea. Forecasting, 12, 175-184.

Payan, C., and Cotton, J., 2012: Collaborative Satellite Winds Impact Study. Report of a study conducted by the International Winds Working Group. Available from: http://cimss.ssec.wisc.edu/iwwg/Docs/windsdenial-synthesisV1-1.pdf

Salonen, K., and Bormann, N., 2013: Winds of change in the use of Atmospheric Motion Vectors in the ECMWF system. ECMWF Newsletter, 136, 23-27.

Sohn, E., Chung, S.-R., and Park, J.-S., 2012: Current status of COMS AMV in NMSC/KMA. Proceedings of the 11th International Wind Workshop. Auckland, New Zealand, 20-24 February 2012.

Szejwach, G., 1982: Determination of semi-transparent cirrus cloud temperature from infrared radiances: Application to Meteosat. J. Appl. Meteor., 21, 384-393.

## Acknowledgements

The National Meteorological Satellite Centre of KMA is gratefully acknowledged for providing a sample dataset of COMS AMVs for the present study.