Operational Generation And Assimilation Of Himawari-8

Atmospheric Motion Vectors

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Overview

• Importance of EOS
• Improvements in specification of the mass and wind field
• AMVs- MTSat -1R, -2 Himawari – 8, Himawari – 9
• Future
• Conclusions
The Importance of EOS (in the SH)

Observing System Experiments (OSEs)

With and Without Satellite Data

• Systems Examined
    – 28 October to 30 November 2011
    – 15 August to 30 September 2010
Fig. 8(c). SH 500hPa height anomaly correlation for the control (SAT) and no satellite (NOSAT), 28 October to 30 November 2011 using ACCESS and verifying against the control analysis

Fig. 8(f). NH 500hPa height anomaly correlation for the control (SAT) and no satellite (NOSAT), 28 October to 30 November 2011 using ACCESS and verifying against the control analysis
ACCESS-G 48 to 72 hour rainfall forecast for 9 November 2011 using satellite data.

ACCESS-G 48 to 72 hour rainfall forecast for 9 November 2011 using no satellite data.

Daily rain gauge analysis for 9 November 2011.

<table>
<thead>
<tr>
<th>9 November 2011</th>
<th>NOSAT</th>
<th>SAT</th>
</tr>
</thead>
<tbody>
<tr>
<td>Correlation between observed and forecast rainfall (Aust. Region)</td>
<td>0.282</td>
<td>0.699</td>
</tr>
<tr>
<td>Hanssen and Kuipers (Aust. Region)</td>
<td>0.360</td>
<td>0.596</td>
</tr>
</tbody>
</table>

Daily rainfall values.
Atlantic basin mean hurricane track errors for the control (all data) and no satellite data case, 15 August to 30 September 2010 using GFS and verifying against the control (all data) analysis.
Global 24-hour forecast error reduction from each of the observation types assimilated in ACCESS

- Three months: April, May and June 2016. Himawari-8 AMVs included in full period.
- All types of observations are beneficial, i.e. reduce the forecast error.
- **Total impact (LH panel)** is dominated by satellite instruments (e.g. the IASI, AMSU and CrIS sounding instruments carried on polar orbiters and AMVs) - due to large numbers & global coverage.
- Greater **impact per observation (RH panel)** comes from balloon upper air measurements plus surface measurements from drifting and fixed buoys.
MTSAT-1R and 2 Himawari-8 Himawari-9

THE GENERATION AND ASSIMILATION OF CONTINUOUS ATMOSPHERIC MOTION VECTORS WITH 4DVAR
## Specification of “Himawari-8/9” Imager (AHI)

<table>
<thead>
<tr>
<th>Band</th>
<th>Central Wavelength [μm]</th>
<th>Spatial Resolution</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>0.43 - 0.48</td>
<td>1Km</td>
</tr>
<tr>
<td>2</td>
<td>0.50 - 0.52</td>
<td>1Km</td>
</tr>
<tr>
<td>X</td>
<td>3 0.63 - 0.66</td>
<td>0.5Km</td>
</tr>
<tr>
<td>X</td>
<td>4 0.85 - 0.87</td>
<td>1Km</td>
</tr>
<tr>
<td>X</td>
<td>5 1.60 - 1.62</td>
<td>2Km</td>
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<tr>
<td>6</td>
<td>2.25 - 2.27</td>
<td>2Km</td>
</tr>
<tr>
<td>X</td>
<td>7 3.74 - 3.96</td>
<td>2Km</td>
</tr>
<tr>
<td>X</td>
<td>8 6.06 - 6.43</td>
<td>2Km</td>
</tr>
<tr>
<td>X</td>
<td>9 6.89 - 7.01</td>
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<td>X</td>
<td>10 7.26 - 7.43</td>
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<td>X</td>
<td>11 8.44 - 8.76</td>
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<td>X</td>
<td>12 9.54 - 9.72</td>
<td>2Km</td>
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<tr>
<td>X</td>
<td>13 10.3 - 10.6</td>
<td>2Km</td>
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<tr>
<td>X</td>
<td>14 11.1 - 11.3</td>
<td>2Km</td>
</tr>
<tr>
<td>X</td>
<td>15 12.2 - 12.5</td>
<td>2Km</td>
</tr>
<tr>
<td>X</td>
<td>16 13.2 - 13.4</td>
<td>2Km</td>
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</table>

MTSAT-1R/2

<table>
<thead>
<tr>
<th>Band</th>
<th>Central Wavelength [μm]</th>
<th>Spatial Resolution</th>
</tr>
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<tbody>
<tr>
<td>1</td>
<td>0.55 – 0.90</td>
<td>1Km</td>
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<tr>
<td>2</td>
<td>3.50 – 4.00</td>
<td>4Km</td>
</tr>
<tr>
<td>3</td>
<td>6.50 – 7.00</td>
<td>4Km</td>
</tr>
<tr>
<td>4</td>
<td>10.3 – 11.3</td>
<td>4Km</td>
</tr>
<tr>
<td>5</td>
<td>11.5 – 12.5</td>
<td>4Km</td>
</tr>
</tbody>
</table>

MTSAT-1R/2 Full Disk Image every 10 minutes

- RGB Composited True Color Image
- Water Vapour
- SO2
- O3
- Atmospheric Windows
- CO2

1.3 μm for GOES-R
NEAR RT TRIAL
OPERATIONAL SYSTEM

27 January – 23 February 2011

Used

- Real Time Local Satellite Winds MTSAT-2 (EE, hourly since 96, TDB)
- 2 sets of quarter hourly motion vectors every six hours.
- Hourly motion Vectors
- Operational Regional Forecast Model (ACCESS-R) and Data Base (Inc JMA AMVs)
Fig. 6(a). The RMS difference between forecast and verifying analysis geopotential height (m) at 24 hours for ACCESS-R (green) and ACCESS-R with hourly AMVs (red) for the period 27 January to 23 February 2011.

Fig. 6(b). The RMS difference between forecast and verifying analysis geopotential height (m) at 48 hours for ACCESS-R (green) and ACCESS-R with hourly AMVs (red) for the period 27 January to 23 February 2011.
Table 6: The SI skill scores for the hourly IR and VIS CDW assimilation (CLAPS2) and matching control Forecasts (CLAPS1) for the period and 05 September to 08 December 1995

<table>
<thead>
<tr>
<th>Period</th>
<th>05 September to 25 September 1995</th>
<th>03 December to 08 December 1995</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Level</strong></td>
<td>MSLP</td>
<td>850 hPa</td>
</tr>
<tr>
<td><strong>Assim. Type</strong></td>
<td>CLAPS1</td>
<td>CLAPS2</td>
</tr>
<tr>
<td><strong>No. of cases</strong></td>
<td>16</td>
<td>16</td>
</tr>
<tr>
<td><strong>Skill score</strong></td>
<td>27.1</td>
<td>26.1</td>
</tr>
<tr>
<td><strong>Period</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Level</strong></td>
<td>MSLP</td>
<td>850 hPa</td>
</tr>
<tr>
<td><strong>Assim. Type</strong></td>
<td>CLAPS1</td>
<td>CLAPS2</td>
</tr>
<tr>
<td><strong>No. of cases</strong></td>
<td>6</td>
<td>6</td>
</tr>
<tr>
<td><strong>Skill score</strong></td>
<td>29.0</td>
<td>28.3</td>
</tr>
</tbody>
</table>
GENERATION AND ASSIMILATION OF CONTINUOUS (10 Minute) ATMOSPHERIC MOTION VECTORS FROM MTSAT-1R (HIMAWARI-6) USING 4DVAR
Fig. 1 A selection of Himawari-6 Atmospheric Motion Vectors over North-Eastern Australia generated from 10 min imagery between 0010 UTC and 0050 UTC 28 January 2014.
Fig. 13 Bureau of Meteorology Analysis for 12 UTC on 27 January 2014.

Fig. 14 Bureau of Meteorology Analysis for 12 UTC on 30 January 2014.

Fig. 15 The Bureau of Meteorology operational three-day MSLP (hPa) forecast valid 1200 UTC 30 January 2014, shown remapped over an MTSat infrared image, valid at the same time.

Fig. 16 The Bureau of Meteorology three-day MSLP (hPa) forecast valid, 1200 UTC 30 January 2014 using the next generation operational regional forecasting system with ten, fifteen and sixty minute AMV data from MTSat-1R and MTSat-2. The forecast remapped over the 1200 UTC MTSat image.
RECENT GENERATION AND ASSIMILATION OF CONTINUOUS (10 Minute) H-8 (9) ATMOSPHERIC MOTION VECTORS, With GEOCAT AND 4DVAR
Himawari-8 Operational AMV Generation

Uses all image triplets (separated by 10 min in HSF format).

Employs modified GEOCAT (Geostationary Cloud Algorithm Testbed) software in initial processing.

Height assignment methods similar to GOES-R ABI ATBD For Cloud Height (Heidinger, A. 2010)

AMV estimation is similar to GOES-R ABI ATBD for Derived Motion Winds (Daniels, 2010) / BoM system

Error characterization, data selection, QC via EE, QI, ERR etc. (Le Marshall et al., 2004, 2015)

Height assignment verification Cloudsat/Calipso, RAOBS
(System also used for H-7)
Fig. 7 AMVs generated around Australia 0000UTC 29 April 2015 – Note box around Australia.

Fig. 8 AMVs generated around Australia 0000UTC 29 April 2015 – View from the south.

Fig. 9 AMVs generated around Australia 0000UTC 29 April 2015 – View from the west.

Fig. 10 AMVs generated around Australia 0000UTC 29 April 2015 – Slant view from southwest.
**Table 1 Verification Table for Himawari-8 IR (Channel 14) AMVs compared to radiosondes 1 March - 31 March 2017**

<table>
<thead>
<tr>
<th>AMV Type</th>
<th>Category</th>
<th>m/s</th>
<th>NOBS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Low Sep</td>
<td>MMVD</td>
<td>2.5161</td>
<td>660</td>
</tr>
<tr>
<td></td>
<td>RMSVD</td>
<td>2.9618</td>
<td></td>
</tr>
<tr>
<td></td>
<td>BIAS</td>
<td>-0.0991</td>
<td></td>
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<tr>
<td>High Sep</td>
<td>MMVD</td>
<td>3.2834</td>
<td>2958</td>
</tr>
<tr>
<td></td>
<td>RMSVD</td>
<td>3.9624</td>
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</tr>
<tr>
<td></td>
<td>BIAS</td>
<td>-0.4998</td>
<td></td>
</tr>
</tbody>
</table>

**Processing every 10 minutes**

**Table 2 Verification Table for Himawari-8 VIS (Channel 3) AMVs compared to radiosondes 1 March - 31 March 2017**

<table>
<thead>
<tr>
<th>AMV Type</th>
<th>Category</th>
<th>m/s</th>
<th>NOBS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Low Sep</td>
<td>MMVD</td>
<td>2.4808</td>
<td>473</td>
</tr>
<tr>
<td></td>
<td>RMSVD</td>
<td>2.8381</td>
<td></td>
</tr>
<tr>
<td></td>
<td>BIAS</td>
<td>0.2875</td>
<td></td>
</tr>
<tr>
<td>High Sep</td>
<td>MMVD</td>
<td>2.9777</td>
<td>710</td>
</tr>
<tr>
<td></td>
<td>RMSVD</td>
<td>3.6743</td>
<td></td>
</tr>
<tr>
<td></td>
<td>BIAS</td>
<td>-0.8148</td>
<td></td>
</tr>
</tbody>
</table>
The correlation function used was the second order auto-regressive (SOAR) function (Daley 1991), namely

\[ R(r) = R_{00} + R_0 (1 + r/L) e^{r/L} , \]

where \( R(r) \) is the error correlation, with fitting parameters \( R_{00}, R_0 \) (greater than 0), and \( L \) is the length scale, and 'r' is the separation of the correlates.

Initial parameter estimates derived using the methods referenced in Le Marshall, 2004 (for example for low level Ch14 AMVs; \( L=128, R_0=0.56 \) and \( R_{00}= 0.01 \)) are not inconsistent with the current analysis method. These estimates are still being improved as the match database being used is expanding rapidly.
Fig. 3  Thinned Himawari-8 AMVs tracked using tracers from channel 14, 9 and 2 images at 00 UTC 24 July 2017.

Fig. 4. Measured error (m/s) vs Expected Error (m/s) for low-level Himawari-8 IR winds (131 August –29 2016).

Fig. 5 Coverage of AMVs from Himawari-8 in the tropics to the north of Australia around 0000 UTC 29 April 2015.

Fig. 6 Himawari-8 level of best fit height assignment statistics for CH.14 AMVs for September 2015 (see text).
Fig7 Himawari-8 level of best fit height assignment statistics for CH.14 830-870 Hpa AMVs for September 2017 (see text)

Fig8 Himawari-8 level of best fit height assignment statistics for CH.14 230-270 Hpa AMVs for September 2017 (see text)
Australian BoM ACCESS–R  Received observations coverage
Satwind  20180412 0000 UTC
Total number of obs = 410349

4424 GOES  0 ESAC  208805 AUS  175997 JMA  21123 MSG

Issue time 01UTC 12 Apr 2018
Australian BoM ACCESS-R  Accepted observations coverage
Satwind  20180412 0000 UTC
Total number of obs = 17609
Fig. 13 MSLP anomaly correlation coefficients for the Northern Hemisphere Annulus for the operational system (blue) and for the operational test system for 4 – 26 March 2016.
FSOI for major observation types & instruments

2017 Jun - Aug

Satellite
Upper-air
Surface
Figure 10(a) shows Channel 14 (IR) low level AMVs (yellow) with expected errors less than 2.6m/s and upper level AMVs (red) with expected errors less than 6.0m/s generated by one image triplet.

Figure 10(b) shows Channel 14 (IR) low level AMVs (yellow) with expected errors less than 2.6m/s and upper level AMVs (red) with expected errors less than 6.0m/s generated by six image triplets.
Fig. 8(a) Thinned IR Channel 14 10 minute AMVs from Himawari-8 images at 00UTC 1 May 2017

Fig. 8(b) IR plus Visible Channel 2 10 minute AMVs from Himawari-8 images 00UTC 1 May 2017
Fig 9(c) IR Channel 14 (yellow) and Visible Channel 2 (Beige) 10 minute AMVs from Himawari-8 images at 00UTC 18 October 2017

Fig. 9(d) IR Channel 14 (yellow) and Visible Channel 2 (Beige) 10 minute AMVs from Himawari-8 images near 00UTC 18 July 2017
Visible image on April 29 at 06:35 UTC (2:35 a.m. EDT) from the MODIS instrument on NASA's Aqua satellite of Tropical Cyclone Quang in the Southern Indian Ocean.

Credit: NASA Goddard MODIS
TC Quang Himawari-8 AMV Generation

Used all Vis/IR image triplets (separated by 10 min/HSF format). (2km ch 14 IR, 1km ch 2 VIS)

Employs modified GEOCAT software in initial processing.

Height assignment methods similar to GOES-R ABI ATBD

AMV estimation is similar to GOES-R ABI ATBD / BoM system

Error characterization, selection, QC via EE, QI, ERR etc.
TC Quang Himawari-8 AMV Assimilation

Used operational TCX system over Timor Sea.

Used all Vis/IR image triplets (separated by 10 min/HSF format). (2km IR, 1km VIS) plus full operational data base.

TCX is a nested TC model (nested in APS-2 ACCESS-G) of 4km resolution and has 70 levels.

Forecast start time 00UTS 29 April 2015
TC "Quang"

997

H 1035

National Operations Centre
Bureau of Meteorology

MSLP Analysis (hPa)
Valid: 0000 UTC 29 Apr 2015
10AM EST 29/Apr/2015
Fig. 14(a) The forecast track of tropical cyclone Quang from 00 UTC 29 April 2015 (red) and the best track (Black), both in six hour intervals
Fig. 14(b) Forecast position of tropical cyclone Quang and 6hr accumulated rainfall at 12 UTC 1 May 2015
Fig. 15 The original forecast track error of tropical cyclone Quang from 00 UTC 29 April 2015 (yellow) and the final track error (Blue), both in six hour intervals (see text).
Summary and Conclusions

10-minute winds are being operationally continuously generated and assimilated in the Australian region with 4D Var

H-8 10 minute DMVs have provided an improved spatial and temporal resolution database for analysis and forecasting.

The quality of these higher spatial, temporal and spectral density data is of a level which renders them beneficial for NWP.

If the data is thinned to equal spatial density, the quality of the H-8 data exceeds that of the operational H7 data.

Data assimilation tests showed successful transfer of data into operations and successful use of the data by the NWP system.

Further quantification of the impact of these data in our current operational prediction system is underway. This also involves use of all 10 minute data in the prediction of TC activity and severe weather.
Future

Optimisation of the provision, use and error characterization of AMV data for NWP data at high temporal and spatial resolution.

Optimisation of use of the AMV data in NWP in concert with other components of the database (such as clear radiances) at high temporal and spatial resolution.

Increasing benefits will continue to accrue from current and next generation advanced instruments, which represent considerable investment by the international community. (eg. CrIS, IASI, VIIRS,EPS-SG ,ABI, AHI, MTG, FY-4, …GK-2A….). This will need co-investment in staff, infrastructure, research and R2O.
Looking Down

Is

Looking Up

TC LAURENCE - Dec. 2009