Assimilation of GOES Clear Air Water Vapor Atmospheric Motion Vectors in the NCEP Global Forecast System

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Investigate the use of CAWV AMVs from GOES-13/15 for GFS DAS

• Description and Motivation
• Quality Control
• Observation Error
• Analysis Impact
• Forecast Skill Impact
Clear Air Water Vapor AMVs

Description:

Motion derived by tracking moisture gradients in clear target scenes using GOES 13/15 Channel 3 with center frequency at 6.5 µm. Height is assigned using a cold sample of pixels in the scene which are compared to the forecast temperature profile for a height estimate.
Motivation: Improve data coverage in the tropics

GOES IR & Cloud Top WV AMV above 500 hPa

No Clear Air WV AMVs

18Z 15 Aug 2014
Motivation: Improve data coverage in the tropics

GOES IR & Cloud Top WV AMV above 500 hPa

With Clear Air WV AMVs

18Z 15 Aug 2014
Motivation: Improve data coverage in the tropics

GOES IR & Cloud Top WV AMV above 500 hPa With Clear Air WV AMV

Features that need to be in the analysis
Regions where QC is needed
How can consistency be improved?
CAWV are located lower than IR and CTWV

Location of GOES AMVs

AMVs with Speed > 10m/s

Data Count

Number in the Lat/Prs Bin

6-21 Aug 2014
Quality Control

Quality Indicator (QI) without the forecast component and Expected Error (EE)
High values of QI and low values of EE should indicate better quality AMV data
Neither parameter show skill in predicting AMV departure from the GFS first guess

Vector Difference = $\sqrt{ (U_{AMV}-U_{GFS})^2 + (V_{AMV}-V_{GFS})^2 }$
Color indicates number of data in the 2d histogram bin
Black line shows average value for the given x bin

6-21 Aug 2014
Quality Control

Minimum speed requirement: 10 m/s. Conservative, could be relaxed for GOES-R
Maximum direction departure: 50°
Near surface check over land
Apply the Log Normal Vector Difference (LNVD) constraint: LNVD < 3

\[
LNVD = \sqrt{\left(U_{AMV}-U_{GFS}\right)^2 + \left(V_{AMV}-V_{GFS}\right)^2} \quad < 3
\]

LN (Speed\_AMV)

More about LNVD:

• LNVD was first introduced for MODIS AMV QC
• As AMV speed increases, allowed speed departure increases while allowed direction departure decreases
• For slow AMVs, less speed departure allowed but larger direction departure is allowed
• Should reevaluate limit for regional or hurricane applications or remove entirely
• With a speed minimum of 10 m/s, the LNVD<3 also limits the direction departure to less than 50°
Observation Error  Current settings for AMV observation errors in GFS

GOES IR and CTWV AMV error profiles
Increased to account for the higher data volume when temporal frequency increased to hourly winds
Observation Error
Justify using same error settings by comparing OMB statistics of IR and CTWV with CAWV

OMB Departures for CAWV are largest in the Eastern Pacific where current operational data is sparse.
Observation Error

Mean Speed OMB m/s as a function of Latitude

CAWV have larger positive speed bias but similar behavior

Setting the minimum speed to 10 m/s increases the mean speed OMB for all AMV types but similar relationship exists

Positive bias could be due to height assignment for the layer movement
Observation Error

RMS Vector Difference OMB as a function of Latitude

CAWV have similar RMS vector difference largest in the tropics and is much lower than the 12-14 m/s error specified For GOES IR and CTWV AMVs
Analysis and Forecast Skill Impact

GFS Hybrid ENKF T670-T254 - 2 seasons

1. July-Sep 2015 Experiment wve1, Control wvc1
2. Feb-Mar 2015 Experiment wve2, Control wvc2

Results show changes to the analysis circulation ~350 hPa in the tropics

Short term impact ~24 hours on the wind forecast skill otherwise neutral impact in global and regional statistics
Sept Mean U and V at 350 hPA

**U (m/s) 350 hPa**

*Time Average*

00z01sep2015 to 18z30sep2015

**V (m/s) 350 hPa**

*Time Average*

00z01sep2015 to 18z30sep2015

wve1

wve1 - wvc1 ave = -0.00269288

wve1 - wvc1 ave = 0.00285992
March Mean U and V at 350 hPa

U (m/s) 350 hPa
Time Average
00z01mar2015 to 18z31mar2015

V (m/s) 350 hPa
Time Average
00z01mar2015 to 18z31mar2015

wve2

wve2 - wvc2 ave=0.0352907

wve2 - wvc2 ave=-0.00844479
200 hPa Tropical Wind Bias

200 hPa Tropical Wind RMSE

500 hPa Tropical Wind Bias

500 hPa Tropical Wind RMSE

July-Sep 2015

Forecast validated with Experiment Analysis
200 hPa Tropical Wind Bias

500 hPa Tropical Wind Bias

200 hPa Tropical Wind RMSE

500 hPa Tropical Wind RMSE

Feb-Mar 2015

Forecast validated with Experiment Analysis
Summary

Clear Air Water Vapor AMVs provide data coverage in locations which currently do not have other AMVs

GOES CAWV AMV data is already available

QC changes for GFS use were straight forward

Analysis impact largest in tropics at 350hPa

Forecast skill impact was neutral
Extra slides
Feb Mean U & V at 350 hPA

U (m/s) 350 hPa
Time Average
00z01feb2015 to 18z28feb2015

V (m/s) 350 hPa
Time Average
00z01feb2015 to 18z28feb2015

wve2

wve2 - wvc2 ave = 0.0263047

wve2

wve2 - wvc2 ave = -0.00738774
Aug Mean U & V at 350 hPa

U (m/s) 350 hPa
Time Average
00z01aug2015 to 18z31aug2015

V (m/s) 350 hPa
Time Average
00z01aug2015 to 18z31aug2015

wve1

wve1 - wvc1 ave=0.00270459

wve1

wve1 - wvc1 ave=0.000161056
July Mean U & V at 350 hPA

U (m/s) 350 hPa

Time Average
00z01Jul2015 to 18z31Jul2015

V (m/s) 350 hPa

Time Average
00z01Jul2015 to 18z31Jul2015

wve1 - wvc1 ave=0.00968218

wve1 - wvc1 ave=0.00467656
July OMA GOES CAWV, CTWV, IR

Mean (Speed OMA)/Speed AMV

Mean Speed OMA

Count

RMS VD OMA