Recommendations from CGMS33
and
a 'Fresh Look' at AMV Research and Development

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1.   Introduction

This paper summarises a presentation to the plenary at the 8th International Winds Workshop by Jean-Noël Thépaut, invited expert from ECMWF as representative of the NWP community, and J. Schmetz, CGMS Rapporteur on Satellite Derived Winds. The purpose of the presentation to the plenary at the workshop was to provide relevant background for discussions in the three Working Group on 'AMV Extraction Methods (WG-I)', 'Data Assimilation (WG-II)' and 'AMV Characteristics (WG-III). Specifically the presentation did:

a) recall highlights of the 7th International Winds Workshop, which should help maintaining coherent progress from workshop to workshop. With regard to future research and development the presentation also recalled the topics labeled as 'Pending Advances' in a recent paper by Velden et al. (2005).

b) present the recommendations from CGMS 33 (held in November 2005) as request and guidance to IWW8

c) elaborate on the requirements from NWP with regard to open areas for research and development of AMVs

2.   Highlights from the 7th International Winds Workshop

The highlights from the 7th International Winds Workshop are summarised as follows:

a) The first satellites of new series had started operational services on orbit, namely Kalpana-1, a dedicated Indian meteorological geostationary satellite and Meteosat-8. Early results from both systems were encouraging and showed performances superior to predecessors.

b) As in previous winds workshops, the height assignment of AMVs was identified as an area promising substantial improvement in the overall quality of AMVs.

c) Therefore it was suggested to carefully select appropriate technique for the situation, e.g. CO_2 slicing is the preferred technique for thin cirrus. It was clearly stated that averaging of results from different methods should be avoided.

d) A better characterisation of AMV errors was identified as bearing great potential for NWP applications. This should include height assignment.

e) The use of AMVs in regional numerical modelling should be expanded

f) It was stated that the (then novel) MODIS winds were used by three NWP centers (status in June 2004)

g) IWW7 expressed deep concern about the potential gap in polar winds products because the imagers on the future operational polar satellites (MetOp and NPOESS) do not carry imagers with channels in the 6.2 µm water vapour band. Efforts were suggested to close the potential gap with a new mission in a Molniya orbit.

h) Scatterometer winds are an established and important ingredient in the analysis for NWP.

i) The workshop welcomed the outlook to novel wind products from space-based lidar and from hyper-spectral sounders, respectively.

3. Salient Points from 'Pending advances' in Velden et al. (2005)

In a recent paper in the Bulletin of the American Meteorological Society Velden et al. (2005) depict some salient issues that underscore the importance of securing a sustained capability growth of the space based system to derive winds from satellite observations (here AMVs from MODIS) and to enhance the space-based system by novel geostationary sounding missions:

a) Observing system simulation experiments (OSSEs) (e.g. by NASA GMAO) show substantial impact of space-based wind lidar
b) CIMSS/University of Wisconsin has pioneered R&D work to study wind profile information from hyperspectral imagers/sounders in geostationary orbit. Aircraft measurements along with radiative transfer calculations provide the basis for studies.
c) The goal is to produce 'altitude resolved' AMVs providing vertical profiles of wind vectors from tracking water vapour features at different altitudes. The approach also takes care of the current problem of adequate height assignment.

4. Recommendations from CGMS 33

At the annual meetings of the Coordination Group for Meteorological Satellites (CGMS) has a working group on 'Satellite Products Including Satellite Derived Winds'. This working group discusses development and implementation into operations as well as the need for and potential of new ideas to improve operational applications. The working group recommendations are presented to the CGMS plenary for approval and formal adoption. At the 33rd CGMS meeting in November 2005 the following recommendations to IWW8 were formulated:

a) Exploit satellite constellations which provide novel opportunities to explore critical issues for AMV derivation (accurate height assignment of cloud tracers with active instruments, e.g. Calipso)
b) Use of geometric approaches to height assignment as independent reference methods and for validation of operational cloud heights
c) AMV quality is an integrated result of many steps, starting with navigation. It is suggested to revisit the individual processing steps. (CMA is an example on how to progress through a comprehensive approach considering all processing steps).
d) Target identification should be revisited considering the errors due to pattern evolution in time.
e) Potential to utilise derivatives from AMVs (e.g. divergence and vorticity) should be further explored.
f) Better ways to derive the atmospheric motions at different scales are needed, however CGMS 33 did not feel in the position to propose a particular method.
g) Good AMVs often get rejected in the pre-processing for NWP models because of too large a difference to the model background. Better description of AMV errors and a better accuracy per se would help.
h) CGMS 33 (WG II) concluded that other items for future research on AMVs, as listed in a working paper from EUMETSAT (EUM-WP-16), should also be considered in the specific working groups at IWW8. Those items are listed in the following in section 4.1 and 4.2.

4.1   Further Suggestions for AMV Research

a) Improve the height assignment of AMVs, especially for mid- and high-level. SEVIRI on MSG provides the opportunity to test established methods of height assignment (CO_2-slicing and water vapour intercept) with a consistent data set => *IWW8 could organise a comparison*
b) Efforts should be made to understand the physical reasons for discrepancies between e.g. CO_2-slicing and other methods
c) Use radiative transfer simulation tools to investigate the height assignment of AMVs (with cloud microphysics and vertical variability)
d) Investigate the error characteristics of AMVs and develop a quality indicator for the height assignment. Also: *Reduce height assignment dependence on forecast*
e) High-resolution NWP models provide the possibility to calculate synthetic spectral satellite images => Tracking could be performed in those images to investigate AMVs algorithms
f) Efforts of JMA and EUMETSAT in support of re-analysis projects at NWP centres were commended. Other satellite operators are invited to conduct similar activities

4.2   General topics

a) IWW8 to critically review AMV progress with the goal to identify areas where the AMV products have most to offer; i.e. where the return on investment is highest.
b) With regard to the transfer of research into operations: Experience showed that R&D work benefits from a close proximity to the operational system/code. Ideally R&D should 'share' a software system with operations.
c) The AMV-community is relatively small and CGMS with its bi-annual International Winds Workshop pretty much embraces all relevant players => revive the international collaboration through concrete projects.

5.   NWP Requirements for AMV Research & Development

Numerical Weather Prediction centres are the main users of AMV products. The following issues constitute a consolidated view presented by Jean-Noël Thépaut from ECMWF.

5.1   General points expected for winds producers from NWP:

a) Continuation of coverage is important
   -   counteract the threat of losing polar winds
   -   there is an urgent need the to confirm impact of IR winds and develop such products from AVHRR
b) Harmonisation of AMV processing is desirable (as far as possible and practical), as accounting for different characteristics is tedious and time-consuming, and beyond the resources of most NWP centres.
c) Use of forecast data for quality control should be left to NWP centres.
   -   Can the dependence on forecast data be reduced in general in the processing?
   -   QI (forecast independent) should still indicate something about wind quality!

d) Winds producers should endeavour to provide more automated information on quality for each wind, especially to characterise:
- Quality of height assignment.
- Tracer/scene quality (e.g., poorer quality in scenes with multi-layer cloud).

e) More research is needed to reduce ad-hoc adjustments in the derivation (e.g. speed increase to balance a speed bias, autoeditor). Influence of new developments need to be evaluated with and without such adjustments.

f) Reprocessing activities are encouraged (i.e. actions should be taken by all satellite operators to re-process AMVs with current AMV retrieval schemes from old geostationary and polar satellites using archived image data).

5.2 Areas Requiring Effort from Winds Producers and NWP

a) Error inventory:
- Study errors of all aspects of winds derivation, to identify largest uncertainties.
- Assess in particular errors entailed by original biases in radiances and if possible, remove them.

b) Observation operator for AMVs are needed:
- With regard to cloudy AMVs the question is: Can we do better than claiming: "The cloud motion represents the wind at a single height, which is an estimate of the cloud top/base (layer averaging)"?
- With regard to clear-sky WV AMVs: These are not assimilated from geostationary satellites. Can we provide an observation operator?

c) Evaluation of AMVs derived from simulated imagery:
This offers a framework to better characterise clear *and* cloudy-sky AMVs, height assignment, a better error inventory, observation operator.

d) Evaluation of AMVs using ancillary data (ADM-AEOLUS, Calipso)

References:
Velden, Ch., Daniels, J., Stettner, D., Santek, D., Key, J., Dunion, J., Holmlund, K., Dengel, G., Bresky, W., Menzel, P., 2005: Recent innovations in deriving troposheric winds from meteorological satellites. Bulletin of the American Meteorological Society, 205-223