Accounting for the situation-dependence of the AMV observation error in the ECMWF system

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Motivation

- AMV observation errors are highly situation dependent.
- Errors originate mainly from two sources:
  - errors in the wind vector derivation (tracking error)
  - errors in the height assignment
- Significant especially in regions where wind shear is strong.
- Met Office has introduced an approach to estimate situation dependent observation errors. The method is investigated in the ECMWF system.

Height errors in the ECMWF system

- Height errors have been estimated from best-fit pressure statistics (Feb – Mar 2010, May – June 2010).

- Defined separately for all satellites, channels and height assignment methods.
Wind error due to error in height

- Typical value for the height error is 70 – 120 hPa.
- Default value set to 80 hPa.
- Height error estimates are translated to wind error using the model first guess wind profile

\[ E_{vp} = \sqrt{\sum W_i(v_i - v_n)^2 / \sum W_i}, \quad W_i = \exp\left(-\frac{(p_i - p_n)^2}{2E_p^2}\right) \times dP_i \]

\( p_i \) and \( v_i \): pressure and wind on model level
\( p_n \) and \( v_n \): pressure and wind at observation location
\( E_p \): error in height assignment
\( dP_i \): layer thickness

Wind error due to error in tracking

- The tracking errors have been estimated from cases where the error due to error in height is small.
- Defined for geostationary and polar AMVs.
- Varies between 2 and 3.2 m/s
- Default value set to 2.5 m/s.

\[ [\text{Total } u/v \text{ error}]^2 = [\text{Tracking error}]^2 + [\text{Error in } u/v \text{ due to error in height}]^2 \]
Situation dependent observation errors

Example: Meteosat 9, WV channel, CO2 slicing
Example: Cloudy WV, 100 – 400 hPa, 25 Aug 2010, 12 UTC

Observation - Background

Situation dependent observation errors

Mean Omb, WV cloudy, 100 hPa - 400 hPa

Mean obs error, WV cloudy, 100 hPa - 400 hPa
Experimentation

- Set of data assimilation experiments for 07 – 08 / 2010
  - How should the first guess check be modified?
  - How to use observation error due to error in height assignment to exclude suspicious observations?
  - What is the impact?

- Results
  - Control, operational setup
  - Experiment:
    - Situation dependent observation errors
    - Simplified and relaxed first guess check
    - Criteria $\sigma_{\text{due to error in height}} < 2 \sigma_{\text{tracking}}$
Model first guess check

- Observation $y$ is compared to the model counterpart $Hx_b$.

\[
\frac{1}{2} \left( \frac{(Hx_b - y)^2}{\sigma_b^2 + \sigma_o^2} \right)_u + \left( \frac{(Hx_b - y)^2}{\sigma_b^2 + \sigma_o^2} \right)_v \leq L
\]

- Current operational implementation
  - Asymmetric: additional penalty applied to observations which under-report the wind speed compared to model background
  - Geographical dependence in the rejection limit $L$

- Under investigations
  - Remove asymmetry and geographical dependence
  - Define the rejection limit
First guess check example: Met-9 WV 100-400 hPa

After blacklisting

After first guess check

$\sigma_{\text{due to error in height}} < 2 \sigma_{\text{tracking}}$

Operational

Under investigations

11th International Winds Workshop 2012
Vector difference of mean wind analysis

EXP – Control, 200 hPa level, 1.7.2010 – 31.8.2010
Normalised difference in VW RMS error

EXP – control, verified against own analysis

VW: \(-90^\circ \text{ to } -20^\circ, 700\text{hPa}\)

VW: \(20^\circ \text{ to } 90^\circ, 700\text{hPa}\)
Normalised difference in VW RMS error

EXP – No AMVs, verified against own analysis

11th International Winds Workshop 2012
Summary

● Development towards using situation dependent AMV observation errors in the ECMWF system.
  ▪ Tracking error
  ▪ Error due to error in height assignment, highly situation dependent

● Situation dependent observation errors are on average of the same magnitude than the old observation errors.

● Agreement with the OmB standard deviation is good.
Summary

- Results from the data assimilation experiments show encouraging results.
  - Simplifying the first guess check is possible without degrading the quality of the model analysis and forecasts.
  - Situation dependent observation errors down-weight observations with large first guess departures.
  - $\sigma_{\text{due to error in height}} < n \sigma_{\text{tracking}}$ is an effective criteria to reject suspicious observations.

- Ongoing work
  - Define $n$
  - FSO (Forecast sensitivity to observation) experimentation