Revised observation uncertainties for bending angle assimilation

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Desroziers’ method

• If $H$, $R$ and $B$ are correctly specified, then:
  \[
  E(d_a^o (d_b^o)^T) = R
  \]
  \[
  d_b^o = y - H(M(x_b))
  \]

• If they are not correctly specified, then:
  \[
  E(d_a^o (d_b^o)^T) = R(HBH^T + R)^{-1}E(d_b^o (d_b^o)^T)
  \]
  Correction term – would apply to background errors as well
Desroziers’ method uses innovations and residuals to determine the observation and background uncertainties.

- It can only provide a correction to the input covariances.
- Calculated using 1m trialing (16th Dec 2017 – 16th Jan 2018).
- Assimilating all normal satellites + FY-3C and COSMIC-6.

- Not using Hollingsworth and Llionberg, or the three-cornered hat method.
Current observation uncertainties

- Errors relative to observed bending angle
- Minimum of 3 $\mu$rad (applies above 40km)
- No dependence on satellite ID
- All 1.5% above 10km
Variation with satellite

• Note: oscillations above 15km due to interpolation between model levels
Variation with satellite – Above 35km

- Metop A/B: Smaller standard deviations above 45km
- FY-3C: Slightly larger standard deviations
- TerraSAR-X: Not assimilated above 40km
- All uncertainties smaller than operational (3µ rad assumed minimum)
Variation with satellite – Core region

- **FY-3C**: Large jump in standard deviations below 25km – smoothing
- **Metop A/B**: Larger standard deviations than others – smoothing!
- **Operational uncertainties** generally too large
Variation with satellite – Troposphere

- **Metop A/B**: Smaller standard deviations in the upper troposphere
- **TerraSAR-X + FY-3C**: Smaller standard deviations in the lower troposphere
- Operational uncertainties closer to diagnosed
Variation with latitude

- Complicated!
Variation with latitude

- Large uncertainties in troposphere
  - Small uncertainties in upper troposphere
- Large uncertainties in lower stratosphere
- Small (relative) uncertainties above 40km
Variation with latitude

- Small uncertainties in troposphere
- Small uncertainties throughout stratosphere
- Differences in relative errors above 40km – climatology of observed bending angles
Early trial results
Trial setup

- Obs uncertainties used in two steps
  - Quality control
  - Data assimilation
- Initially keep old uncertainties for QC
- Low-resolution mimic of operational NWP system (Forecast model: 640x480)
- Winter: Dec 2017 – Feb 2018
- Summer: 15 Jul 2018 – 15 Oct 2018
First trial

- General benefit from new observation uncertainties
- Largest changes in SH
- Negatives in temperature at 50hPa
Inflated observation uncertainties

- Observation uncertainty standard deviation inflated by 1.2
- Tropical temperatures at 50hPa more negative
Bump removal

• UTLS increase in diagnosed uncertainties
  • Cause of negative results?
• Interpolate between nearest minima
Inflated uncertainties – remove bump

• Much better performance at 50hPa
• Maximum in UTLS is model error
Alternatives to latitude
Summer season results

- Obs uncertainties diagnosed in winter
- Less good results in summer (e.g. Scherllin-Pirscher et al., 2011)
- Latitude not an atmospheric quantity
Variation with Vertically Integrated WV

- Some variation with IWV
- Not as good separation as latitude
Average temperature diagnosis

- Average model temperature surface – 20km
- Smooth variation with latitude
  - Somewhat affected by orography
Average temperature trial

- Good performance for most variables
- Replicated for second season
- Will be implemented next year
Conclusion

- New observation uncertainties calculated using the method of Desroziers et al. (2005)
- Improvement in forecast performance
- Allow uncertainties to depend on average temperature below 20km

- Diagnosed increase in UTLS area degrades forecast – removed
- Benefits related to smoother variation (with latitude) and variation with satellite
Extra slides
Integrated Water Vapour

• Small benefits for some variables – no big degradations
Tropopause height

General benefit, but with some negative for temperature at 100 hPa.

% difference (new Obs Errors x 2 Tropopause - removed bump vs control) - overall 0.9%
Tropopause height – data assimilation stats

- Check assimilation stats to confirm forecast performance
- Increase in RMS innovations point to problems with obs uncertainties based on tropopause height
Tropopause height

- Tropopause height as diagnosed from a short-range forecast
- Shows interesting variation with weather system
- Sharp gradients are seen
Average temperature – data assimilation stats

• Check assimilation stats to confirm forecast performance
• Reductions in RMS innovations point to benefits of new uncertainties
No variation with satellite

- Large reductions in benefit in SH-ET
- Small increase in benefit in NH-ET
Crude variation with latitude (and no sat)

- As current model, observation uncertainties in 30 degree bands
  - No interpolation
- Further reductions in benefit across all regions