Effects of a special filtering on assimilation of RO bending angle by NWP model

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Outline

• Introduction
• Estimate the systematic errors
• Impact of a special filtering of RO BA on assimilation by WRF
• Summary
Inconsistent vertical resolutions of NWP models with RO data

• Model/height: 1km, 2km, 3km, 5km, 10km
  - WRF: 180m, 300m, 440m, 540m, 480m
  - ECMWF: 180m, 250m, 320m, 420m, 430m

• Both model configurations have coarser vertical resolutions than the RO observations (AtmPrf format, 100m) in the lower troposphere
Two RO BA profiles with sharp structures

Many NWP models’ configurations can not resolve the sharp structures.
Estimation of the representative errors

• Modeling BA using the down-sampled RO refractivity data at NWP model grids (WRF and ECMWF here)
• Compare modeled BA with raw RO BA data (both sampled onto a fixed 200-meters vertical grid)
• The AtmPrf profiles with 100m physical resolution are used as raw observation
Comparison of modeled BA and Obs for two RO profiles

The modeled BA can not resolve the sharp spikes of BA at 2km and 5km.

Will this result in systematic errors in stable PBL and ITCZ?
Monthly mean bias of bending angle (Obs - Model) on WRF grid (at 2km & 5km, April, 2012)

Mean diff. of Obs - modeled BA (%), 2km

Bases, up to 2% at 2km exist where sharp PBL prevails.

Mean diff. of Obs - modeled BA (%), 5km

Biases, up to 1%, at 5km exist where moist convection (ITCZ) prevails.
A low-pass filtering of RO bending angle

- A low-pass filter is applied to smooth out the RO BA sharp structures to fit to the NWP vertical resolutions
- The special filtering is performed on AtmPrf BA data (with 10-meter interval)
  - WRF:
    - 0 - 1.5 km: 260 m
    - 1.5 - 4.0 km: 400 m
    - 4 – 10 km: 400 m
  - ECMWF model:
    - 0 - 1.5 km: 220 m
    - 1.5 - 4 km: 300 m
    - 4 - 10 km: 540 m
- The coarser WRF grid needs stronger filtering of BA
- For comparison, a constant low-pass filtering of 200m is also tested
Comparison of modeled BA and Obs for two RO profiles

The modeled BA is closer to the filtered RO BA

The Bufr format filtering is not strong enough to filter out the sharp structures
Bias of bending angle (Obs – Modeled BA) on WRF grid
(at 2km, April 1-30, 2012)

Mean diff. of Obs - modeled BA (%, 2km)

The large biases are substantially reduced, particularly by the special filtering.
Bias of bending angle (Obs – Modeled BA) on WRF grid
(at 5km, April 1-30, 2012)

The large biases located in ITCZ are mostly removed by the special filtering
Daily averaged biases of BA (Obs – modeled BA) (at 2km, tropics)

The large biases are reduced by the special filtering of RO bending angle, especially the WRF grid.
Impact of the low-passing filtering on BA assimilation by WRF

- Assimilations are done over W Pacific (active moist convection) for April 1-14, 2012
- Raw or filtered BA are sampled at fixed 200m intervals and assimilated
- **BA run**: assimilate conventional observations and raw bending angle
- **BAB run**: Same as BA run but assimilate the Bufr format (200-meter resolution) bending angle
- **BAF run**: Same as BA run but assimilate the specially filtered bending angle
- The WRF analyses and 6-hour forecasts are verified to the BA observations assimilated, respectively

- It is noted that the “implicit smoothing” from assimilation of the RO BA data is very weak at the “cut-off” window of 300m-400m, due to the RO data assimilated at 200m
Biases of WRF analyses against raw and filtered RO BA

(Obs-Analysis, 3km, April, 1-15, 2012, W. Pacific)

The biases are mostly reduced by the special filtering of RO bending angle.
The biases at ~2.5km are reduced by the special filtering of bending angle.
The radiosonde Q data used for verification of WRF forecasts
Averaged Errors of WRF 6h forecasts to radiosonde Q data
(April, 1-14, 2012, W. Pacific)

The biases at 850 hPa are reduced by the special filtering
Summary

• Substantial representative biases can exist in tropical lower troposphere where stable PBL and ITCZ exist, when the RO bending angle is assimilated by lower vertical resolution NWP models.

• Proper filtering of the RO BA data, consistent with the NWP model’s vertical resolution, can reduce the biases and improve assimilation of RO data by NWP.
There exist evident biases in the entire lower troposphere