Assimilation of observations from the Microwave Humidity Sounders on board China’s FY-3B and FY-3C Meteorological Satellites

ITSC-20

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William Bell
Nigel Atkinson

Met Office
*now at ECMWF

October 28, 2015
Introduction: Who we are

The Met Office (MO) Satellite Radiance Assimilation Group (SRAG)

- Manage Infrared and Microwave sounding data from: AIRS, ATOVS, ATMS, CrIS, IASI, and SSMIS.
- Maintain processing system for operational assimilation into the MO models.
- Carry out research to improve and extend data applications.
- Investigate the introduction of new instruments. Here, the MicroWave Humidity Sounders (MWHS) on board China’s FY-3 platforms.

This work is supported by the European Horizon-2020 GAIA-CLIM project and the CSSP:China program, in collaboration with the NSMC-CMA.
**Introduction: Source of data**

Sounding missions supporting NWP and climate monitoring.

FY-3 polar orbiting satellites will become a major source of data for NWP and climate monitoring over the next decades.
Content

1. Presentation of MWHS-1 and -2
2. NWP-based assessment outlines
3. Assimilation experiments outlines
4. Concluding remarks
Presentation: FY-3B MWHS-1

<table>
<thead>
<tr>
<th>Channel Number</th>
<th>Frequency (GHz)</th>
<th>MWHS-1</th>
<th>MWHS-2</th>
<th>ATMS</th>
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<td>118.75 ± 0.3 (V)</td>
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<td>118.75 ± 0.8 (V)</td>
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<td>118.75 ± 1.1 (V)</td>
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<td>118.75 ± 3.0 (V)</td>
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<td>-</td>
<td>-</td>
<td>118.75 ± 5.0 (V)</td>
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<tr>
<td>1-2</td>
<td>10</td>
<td>17</td>
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<td>150 (H)</td>
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<td>183 ± 1.0 (V)</td>
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<td>183 ± 7.0 (V)</td>
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FY-3B equator crossing time: ~14:20 local time ascending.
## Presentation: FY-3C MWHS-2

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<th>Channel Number</th>
<th>Frequency (GHz)</th>
<th>MWHS-1</th>
<th>MWHS-2</th>
<th>ATMS</th>
<th>MWHS-1</th>
<th>MWHS-2</th>
<th>ATMS</th>
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<tr>
<td>1</td>
<td>89 (H)</td>
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<td></td>
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<tr>
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<td>118.75 ± 0.3 (V)</td>
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<td></td>
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<tr>
<td>4</td>
<td>118.75 ± 1.1 (V)</td>
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<td>118.75 ± 2.5 (V)</td>
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<tr>
<td>5</td>
<td>118.75 ± 3.0 (V)</td>
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<tr>
<td>6</td>
<td>118.75 ± 4.5 (V)</td>
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<td></td>
<td></td>
</tr>
<tr>
<td>7</td>
<td>118.75 ± 7.0 (V)</td>
<td></td>
<td>150 (V-H)</td>
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<td>150 (H)</td>
<td></td>
<td>165.5 (H)</td>
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<td>183 ± 1.0 (V)</td>
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<td>183 ± 1.0 (H)</td>
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<td>183 ± 4.5 (H)</td>
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<tr>
<td>12</td>
<td>183 ± 7.0 (V)</td>
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<td>183 ± 7.0 (V)</td>
<td></td>
<td>183 ± 7.0 (V)</td>
<td></td>
<td>183 ± 7.0 (H)</td>
</tr>
</tbody>
</table>

FY-3C equator crossing time: ~10:20 local time descending.
Assessment: August 2015 (MWHS-1, -2, and ATMS)

First guess departure from raw observations (O-B), corrected observations (C-B) and 1σ standard deviation

<table>
<thead>
<tr>
<th>Channel Number</th>
<th>First Guess Departure (O-B) ±1σ (K)</th>
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<td>MWHS-1</td>
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<td>-1.416±2.346</td>
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<td>4</td>
<td>-1.254±1.417</td>
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<tr>
<td>5</td>
<td>-0.034±1.509</td>
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</table>
Assessment: Corrected observations

August 2015 corrected observations from 1D-Var static bias correction

<table>
<thead>
<tr>
<th>Channel Number</th>
<th>First Guess Departure (C-B) ±1σ (K)</th>
</tr>
</thead>
<tbody>
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<td>MWHS-1</td>
<td>MWHS-2</td>
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<tr>
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<td>14</td>
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<td>5</td>
<td>15</td>
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</table>

Apr-Jun 2015* corrected observations from 4D-Var VarBC

<table>
<thead>
<tr>
<th>Channel Number</th>
<th>First Guess Departure (C-B) ±1σ (K)</th>
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<tbody>
<tr>
<td>MWHS-1</td>
<td>MWHS-2</td>
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<td>3</td>
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<td>14</td>
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<td>5</td>
<td>15</td>
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</tbody>
</table>

* two different trials: 62 days for MWHS-1 and 79 days for MWHS-2 and ATMS
Assimilation experiments

MWHS-1 and -2 are integrated into a full system, low resolution (N320), for assimilation experiments in the MO global system.

- Exp 1 MWHS-2 with static bias correction scheme . . . . . . . . . . 49 days long
- Exp 2 MWHS-2 with variational bias correction scheme . . . . . 23 days long
- Exp 3 MWHS-1 with variational bias correction scheme . . . . . 62 days long

<table>
<thead>
<tr>
<th>Channel number</th>
<th>Observation errors (K)</th>
<th>Assimilated channels</th>
<th>Cloud screening</th>
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<tbody>
<tr>
<td></td>
<td>MWHS-1</td>
<td>MWHS-2</td>
<td>MWHS-1</td>
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<td>5</td>
<td>15</td>
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* only for MWHS-2
Assimilation experiments

Change in standard deviation of the fit to the model background for MHS-NOAA19 (relative to the control).

Exp 1
(MWHS-2 with static bias correction)

Exp 2
(MWHS-2 with VarBC)

Exp 3
(MWHS-1 with VarBC)
Assimilation experiments: Exp 1 (MWHS-2 with static BC)

Similar improvement for other sounders in Exp 1 (and 2) ...
Assimilation experiments: Exp 3 (MWHS-1 with VarBC)

... But mixed picture in Exp 3.

Significant degradation in Relative Humidity in lower and mid-troposphere.
Assimilation experiments: Exp 3 (MWHS-1 with VarBC)

Could we indirectly introduce bad data? (Hypothesis)

1D-Var RH – RH\textsubscript{bg}
Concluding remarks

▶ MWHS-2 (likely) to be operationally assimilated in the next MO system update.
▶ MWHS-1 operational use postponed until we work out RH issues.

Future work

▶ Further investigate MWHS-1 impact on relative humidity.
▶ Test the assimilation of MWHS-1 and -2 183 GHz over land.
▶ Test MWHS-2 118 GHz channels.
## Supplementary material: Errors

<table>
<thead>
<tr>
<th>Channel Number</th>
<th>NEΔT (K)</th>
<th>Observation errors (K)</th>
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<tbody>
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<td>MWHS-1 (2x2)</td>
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</table>
Supplementary material: Humidity Jacobian

![Graph showing humidity Jacobian and pressure levels for Ch.11 to Ch.15.](image)
Supplementary material: RH correlation

RH - RH background in analysis
Supplementary material: Long term variability
Supplementary material: Recent variability