FY-3E Microwave Sensors Evaluation at ECMWF

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Presentation outline

Presentation will focus on two sounders aboard Feng-Yun 3E:

- Micro-Wave Humidity Sounder 2 (MWHS-2)
- Micro-Wave Temperature Sounder 3 (MWTS-3)

1) Quality of MWHS-2 data from FY-3E, compared to FY-3C and FY-3D

2) Impact of assimilating FY-3E MWHS-2 data into the Integrated Forecasting System (IFS)

- Assimilation experiments have been performed for almost 5 months
- Data have been assimilated operationally at ECMWF since 22 February 2023

3) Potential benefits of the early-morning orbit of FY-3E

4) Initial investigation of MWTS-3 data

MWHS-2 experiments overview

FY-3E: First CMA satellite in the early-morning orbit – important element of the 3-orbit CGMS baseline, complementing the 9:30 Metop and 13:30 JPSS orbits

Control

- Uses the current operational IFS cycle at Tco399 resolution
- FY-3C and FY-3D MWHS-2 data are assimilated in ECMWF's "all-sky" system using RTTOV-SCATT v13
- Assimilate six 118 GHz and five 183 GHz channels
- Data thinned onto N128 Gaussian grid, but not averaged

FY-3E assimilation

- As control, but with the additional assimilation of FY-3E MWHS-2 data

Experiments performed between 14 Oct 2022 – 28 Feb 2023, with the first week used to spinup VarBC
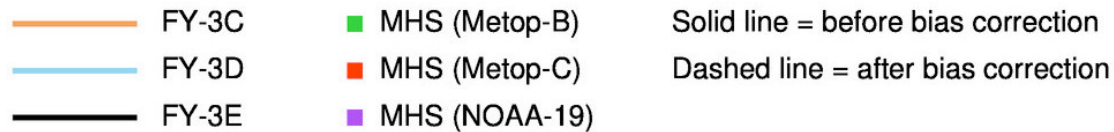
118 GHz

183 GHz
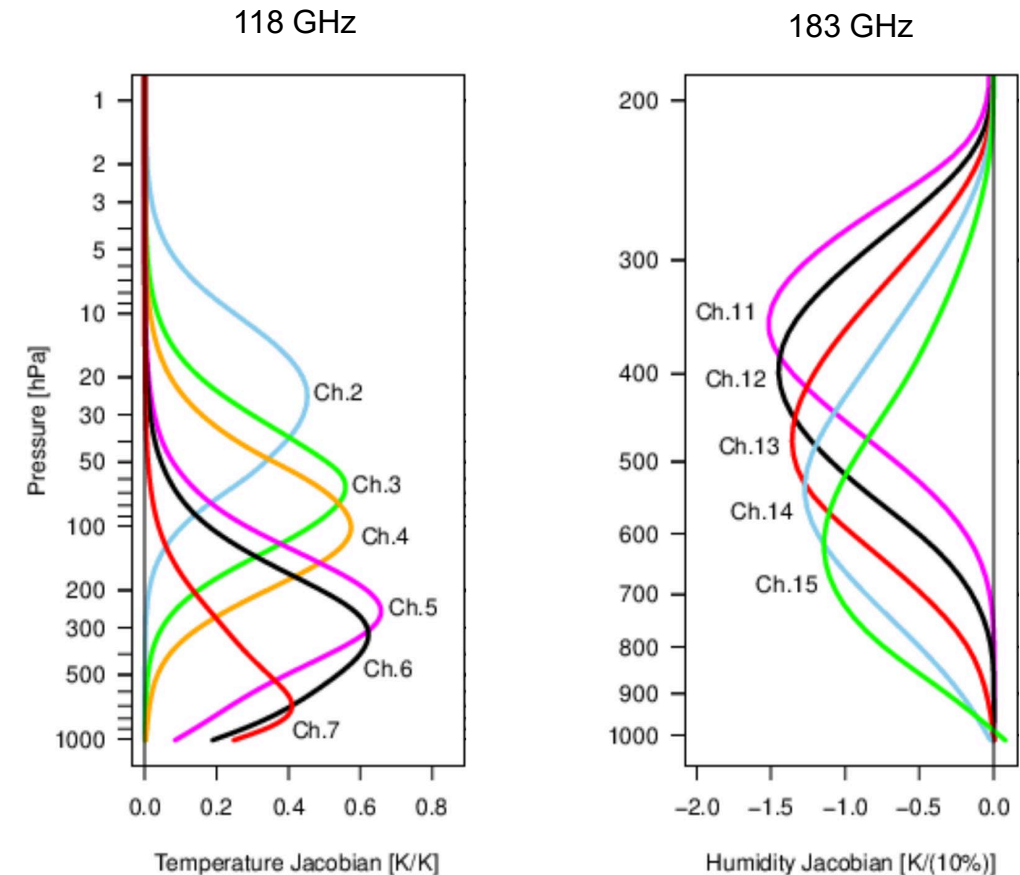
MWHS-2 data quality

Use the mean and standard deviation of 'O – B' to assess the data quality across different instruments

Data selection criteria:
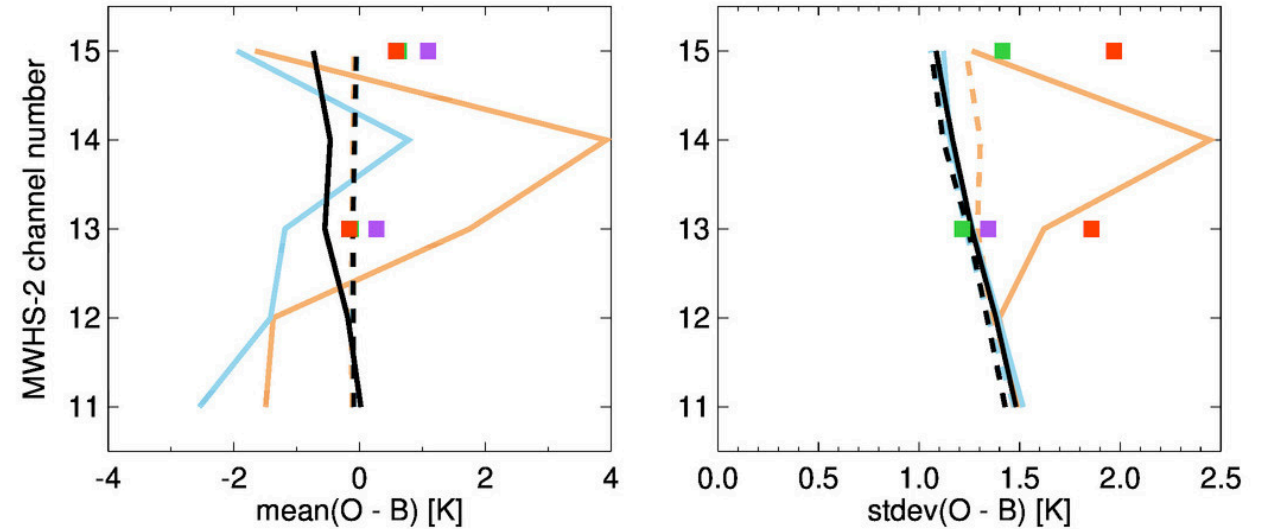
- Feb 2023
- Clear sky (Scattering index < 5 K)
- Over ice-free ocean
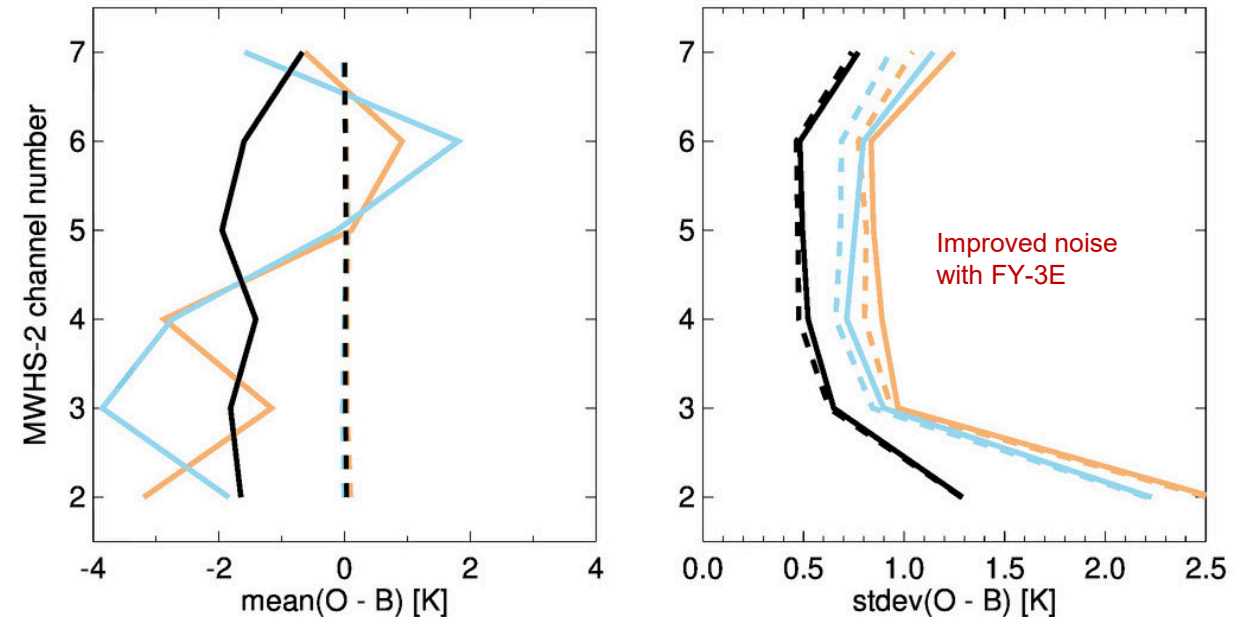- Instrument zenith < 60°
- abs(latitude) < 60°

MWHS-2 on FY-3E has smaller and more consistent bias, and lower obs error compared to FY-3C and FY-3D. Compares well against MHS

FY-3C	■ MHS (Metop-B)	Solid line = before bias correction
FY-3D	■ MHS (Metop-C)	Dashed line = after bias correction
FY-3E	■ MHS (NOAA-19)	

Humidity channels (183 GHz)

Temperature channels (118 GHz)

Improved noise with FY-3E

# Short-range forecast impact against other observations

Statistics combined over a 4 month period, from 287 twelve-hour forecasts

Black line is the 'control': an experiment not including FY-3E MWHS-2 data (but including FY-3C and FY-3D MWHS-2 data)

Red line is an experiment assimilating FY-3E MWHS-2 data

Improvements seen when assimilating FY-3E MWHS-2:

- Most noticeable for humidity-sensitive observations
- Improvements can also be seen for temperature and wind

EUROPEAN CENTRE FOR MEDIUM-RANGE WEATHER FORECASTS
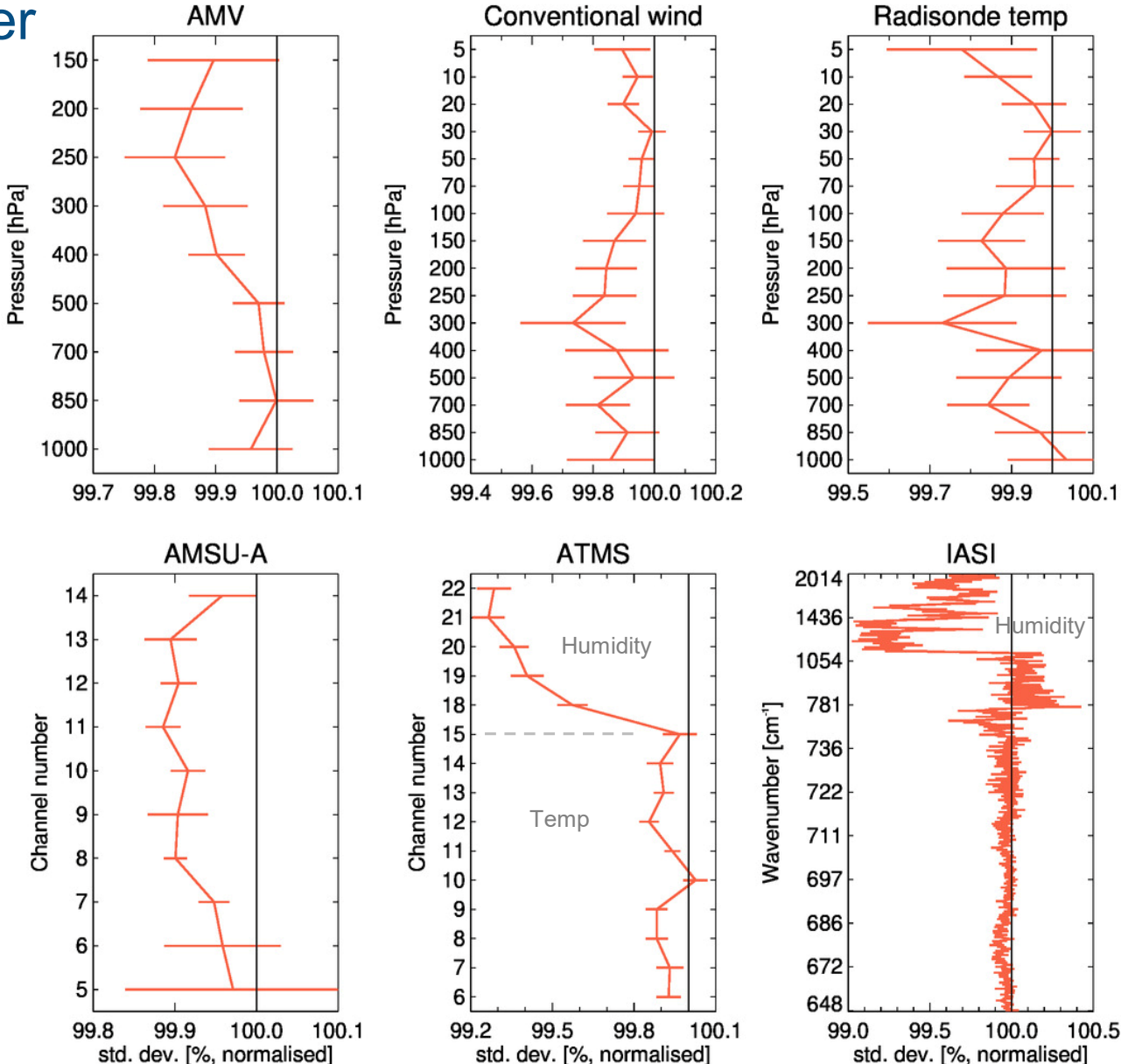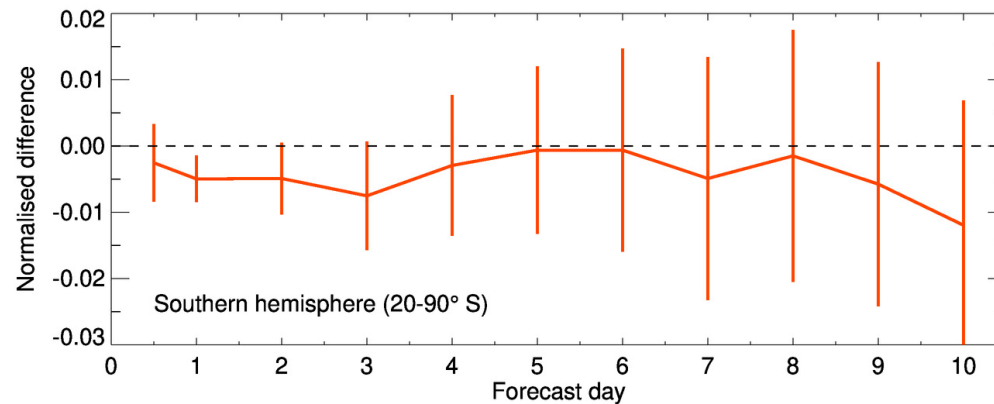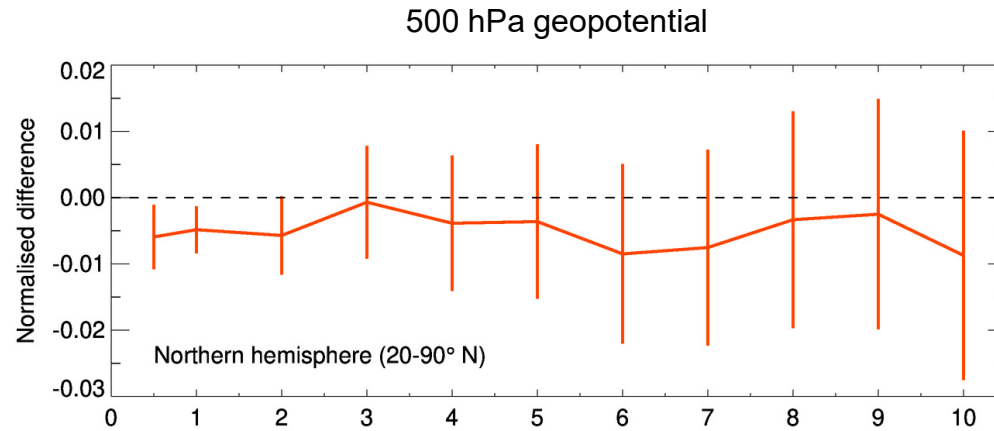
Medium-range forecast impact

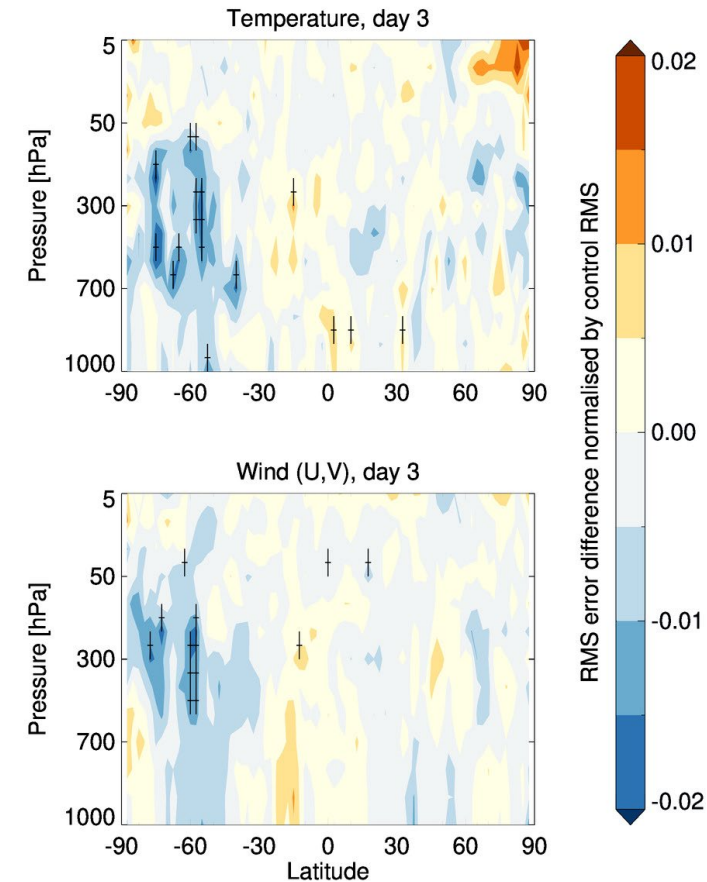Evaluation of data from 20 Oct 2022 – 28 Feb 2023

Forecast day plots

Inclusion of FY-3E MWHS-2 data leads to improved 500 hPa geopotential forecast

Zonal plots

Statistically-significant differences (hatching) generally show that assimilating FY-3E MWHS-2 data leads to improved temperatures and winds

500 hPa geopotential

Vertical bars = 95% confidence range

Cross-hatching indicates regions with 95% confidence

Assessing the potential benefit of the FY-3E early morning orbit

To attempt to assess the benefit of the early morning FY-3E orbit, three additional experiments were performed for the same period (14 Oct 2022 – 28 Feb 2023):
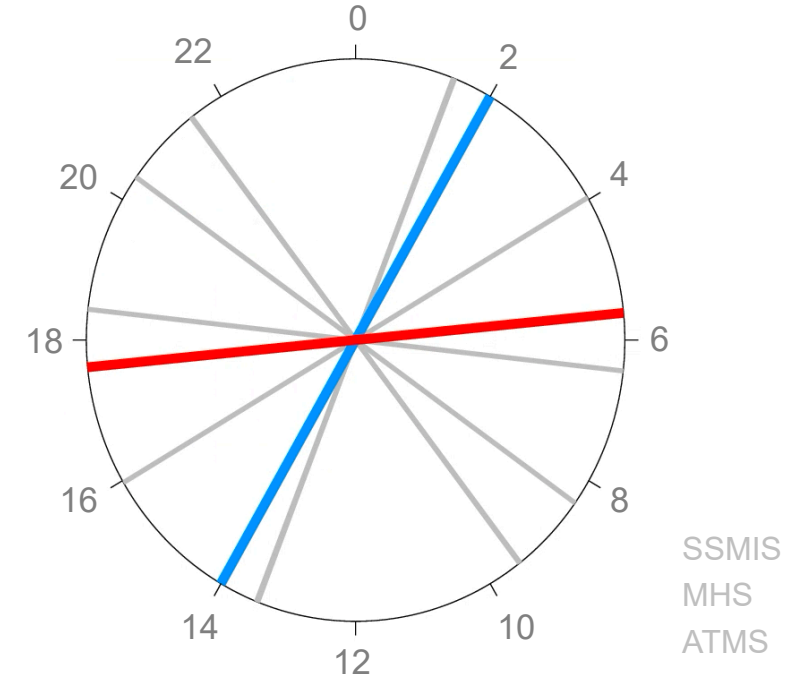
- **Control**

Uses the current operational IFS cycle at Tco399 resolution
Has no MWHS-2 data assimilated

- **FY-3D assimilation**

As control, but with assimilation of FY-3D MWHS-2 data
Local ECT ~ 2:00 am/pm

- **FY-3E assimilation**

As control, but with assimilation of FY-3E MWHS-2 data
Local ECT ~ 05:40 am/pm

To keep the number of observations similar between the FY-3D and FY-3E assimilations, data from the two outermost scan positions (1,2 and 97,98) were removed

SSMIS
MHS
ATMS

Short-range forecast impact against other observations (FY-3E vs FY-3D)

Black line: control

Blue line: assimilate FY-3D MWHS-2 data

Red line: assimilate FY-3E MWHS-2 data

Humidity: improvements appear greatest when assimilating FY-3E data

Temperature: assimilation of FY-3E data shows greater improvements against satellite data, but is more mixed for radiosondes

Wind: less clear signal, possibly due to poorer sampling

There appears a generally greater improvement from assimilating FY-3E MWHS-2 data, but it's not possible to say if this is due to the early-morning orbit or the better noise performance of the 118 GHz channels


ECMWF
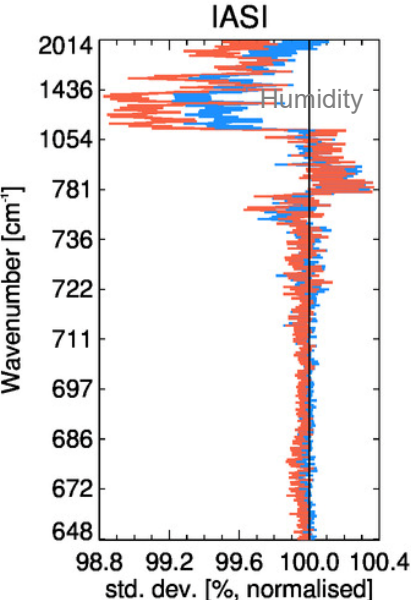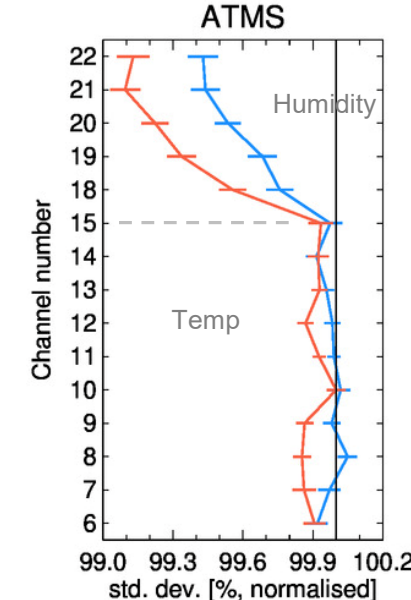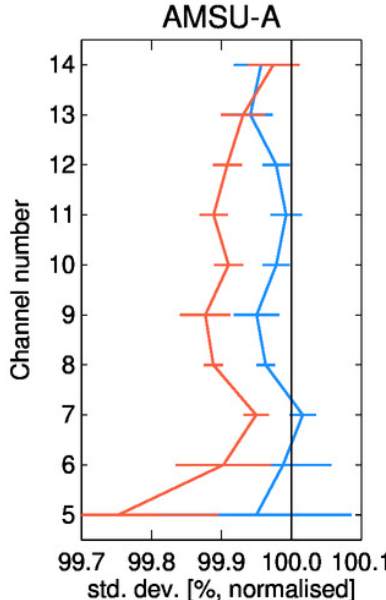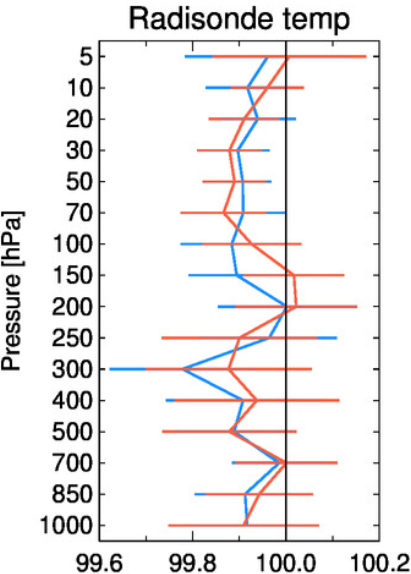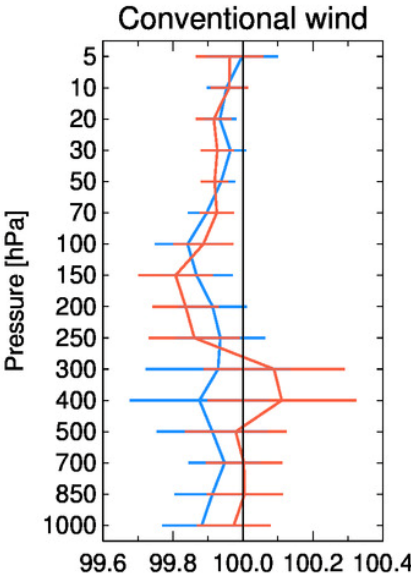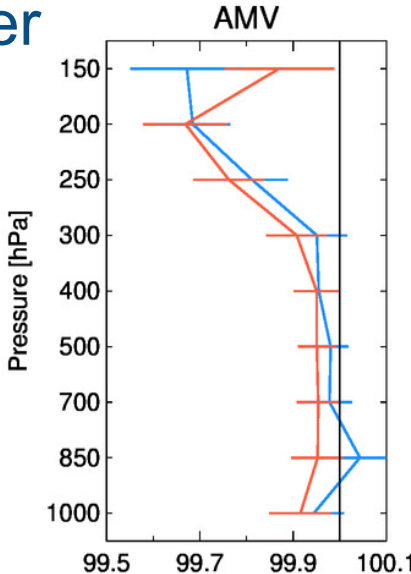
MWTS-3 data quality

Use the mean and standard deviation of 'O – B' to assess the data quality across different instruments

Data selection criteria:

- Nov 2022 and Feb 2023
- Clear sky (LWP < 0.3 mm)
- Over ice-free ocean
- Instrument zenith < 60°
- abs(latitude) < 60°

Channels 7 and 8 were improved in mid December

Improvements seen after bias correction, but standard deviation is still larger than for AMSU-A (Metop-C)
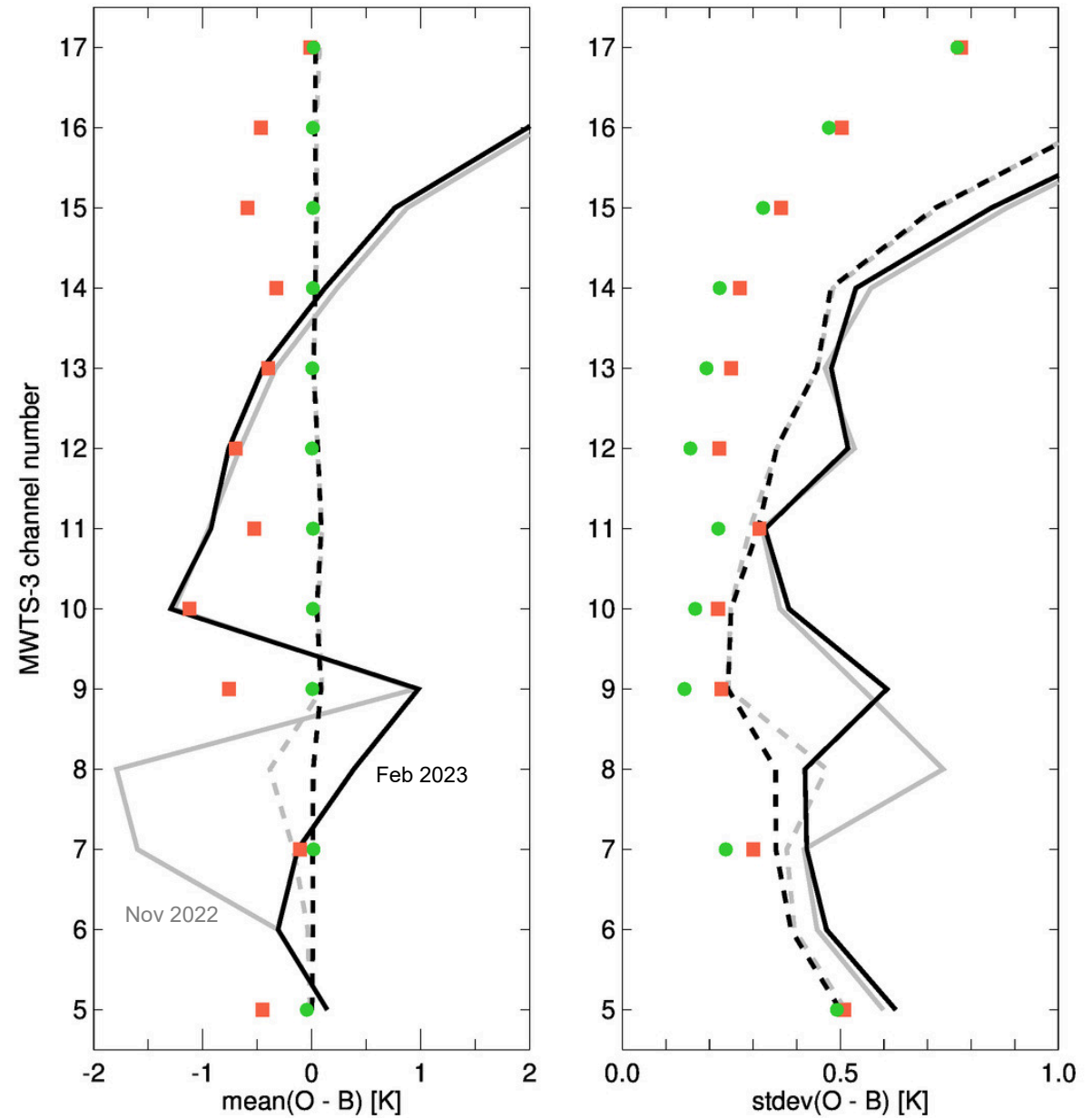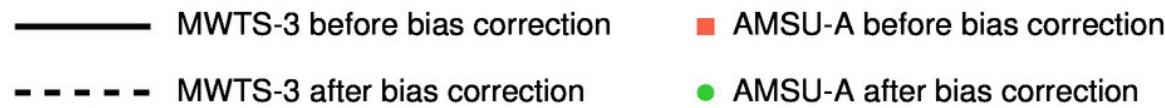

MWTS-3 before bias correction

- - - - MWTS-3 after bias correction

■ AMSU-A before bias correction

● AMSU-A after bias correction

MWTS-3 vs AMSU-A

Structure present in the MWTS-3 swaths that is not present in AMSU-A:

- Land-sea contrast in non-surface-sensitive channels

- Striping, but less noticeable with 3x3 averaging applied

- Scan position biases in some channels, even after bias correction (partly related to our bias correction model)

Work continuing to investigate potential future assimilation

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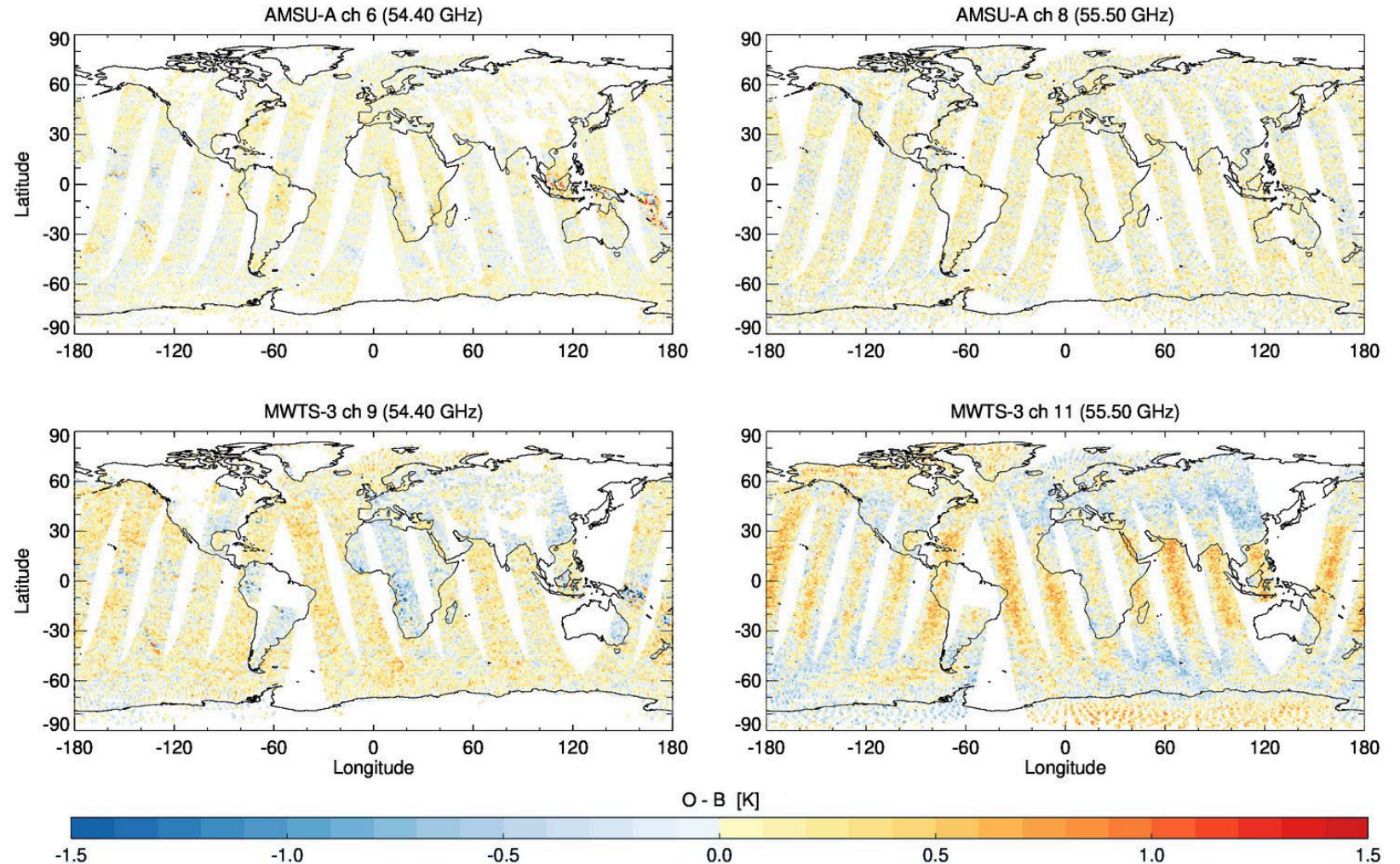
Conclusions

FY-3E MWHS-2

- Tests for clear sky conditions show smaller biases and errors compared to FY-3C and FY-3D
- Improvements to the forecast are observed when assimilating the data for the Oct - Feb period
- Observations are operationally assimilated as of 22 Feb 2023

FY-3E MWTS-3

- Data have issues similar to MWTS-2
- Land-sea contrasts, striping and scan biases evident in some channels
- We are currently investigating the potential for assimilation (e.g. averaging data, performing strict selection criteria)

Additional instruments on FY-3E, with evaluation to commence soon

- HIRAS-2 (Hyperspectral Infrared Sounder) - gained access to observations in late Feb 2023
- WindRAD (Wind Radar)
- GNOS-2 (Radio Occultation Sounder)