Operational use of ATOVS at the Met Office

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Met Office NWP system

- Global
  - 3D-var FGAT cut-off 1h50 mins (7 hour update for background)
  - 0.86° x 0.56° (~60 km) 38L
- Regional and mesoscale models
  - 0.11° (~12 km) 38L; similar "Euro" configuration, and mesoscale system run for several model domains (UK, Middle East etc.)
  - Cut off 1h30m
  - See presentation by Candy (given by me)
- 3D-var with FGAT and 1D-var preprocessor for ATOVS and SSM/I(S)
- AAPP to map all ATOVS radiances to HIRS. Assimilate radiances for ATOVS, 1D-var windspeed for SSM/I.

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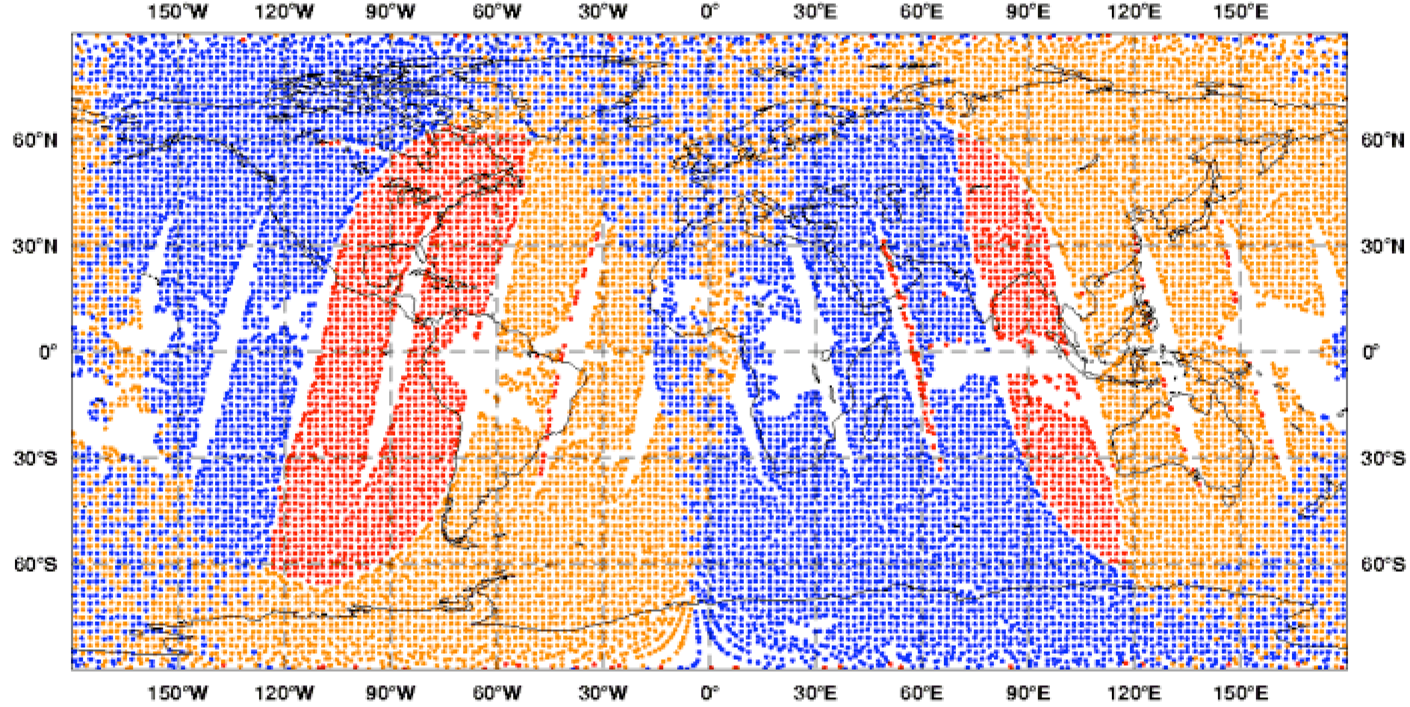
Current use in global model

- NOAA-15 AMSU-A and AMSU-B
- NOAA-16 and NOAA-17 HIRS, AMSU-A and AMSU-B
  - HIRS Chs 4-8, 10-12, 15; AMSU-A Chs. 4-11; AMSU-B Chs. 18-20
  - AMSU-A Chs. 7, 11 and AMSU-B Ch.19 rejected on NOAA-15; AMSU-A Ch 7 rejected on NOAA-17, Ch 9 on NOAA-16.
- SSM/I F13 and F15 Windspeed (through 1D-var)

Data Coverage: ATOVS
(10/4/2003, 12 UTC, qs12)

0 NOAA-14 TOVS (green), 1975 NOAA-15 ATOVS (red), 6538 NOAA-16 ATOVS (blue), 6410 NOAA-17 ATOVS (orange)

Total number of observations assimilated: 14923



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Science

- Use of ATOVS over land
  - best approach?
- New bias correction
  - Following Kelly and Harris
- RTTOV-7

- Microwave cloud and precipitation
  - - see poster (English, O'Keeffe, Doherty and Sreerekha)
- Mesoscale assimilation
  - - see talk by Candy and English

ATOVS over land

- Three approaches are being evaluated
  - Emissivity atlas (Prigent et al. JGR 1997) fitted to coefficients for an empirical model
  - Land surface class approach (using re-mapped 1km surface type classification) with fixed emissivities for each class
  - Use of NWP surface fields (e.g. snow cover)

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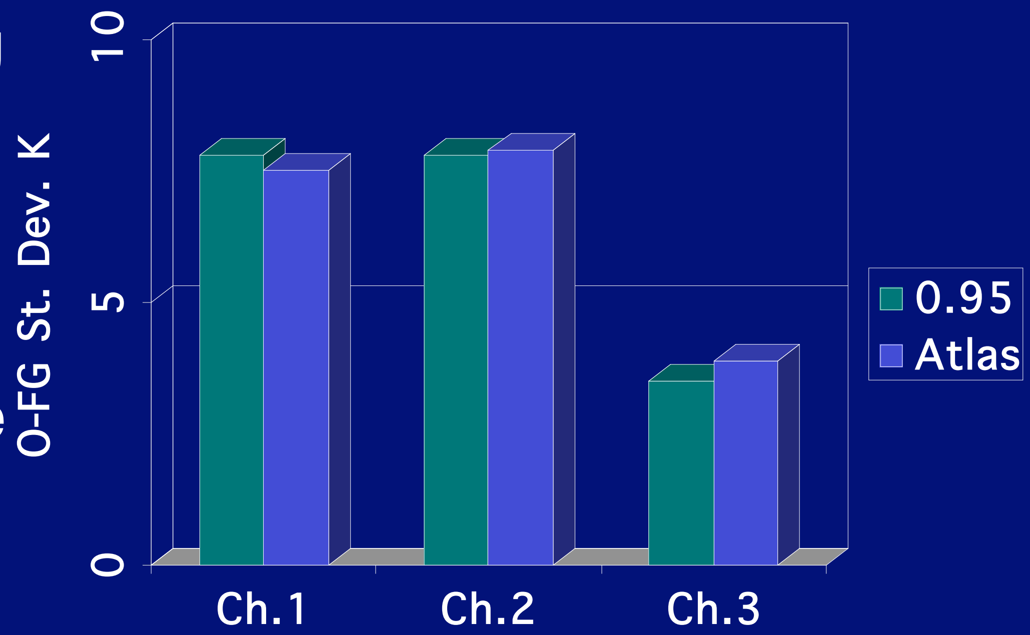
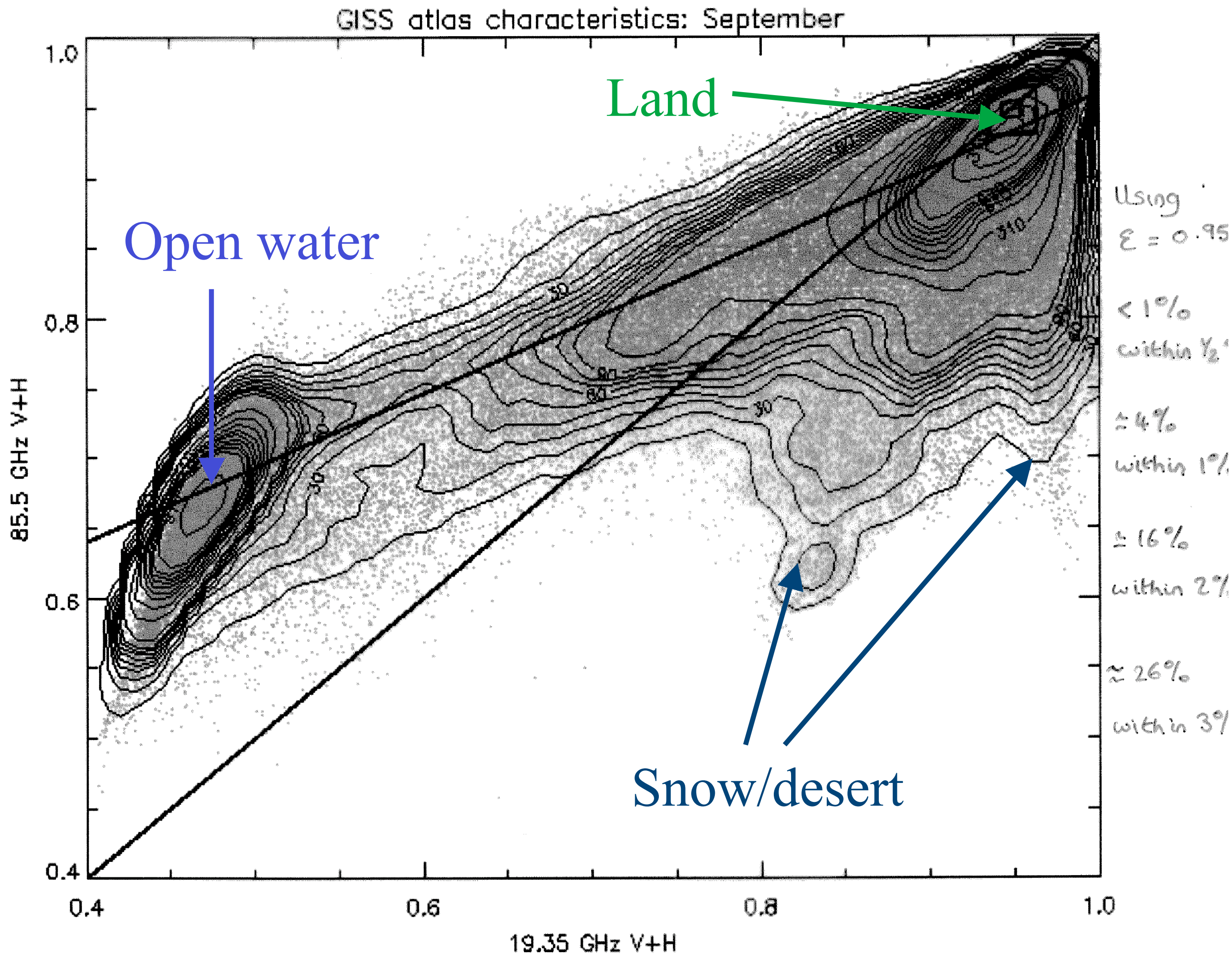
Emissivity atlas

- Results disappointing
- First guess fit to AMSU window channels actually degraded
- "Retrieved emissivities" very close to 0.95 most of the time, so it does not make much difference




GISS atlas characteristics: September
Land
Open water
Snow/desert
85.5 GHz V+H
19.35 GHz V+H
1.0
0.8
0.6
0.4
0.4
0.6
0.8
1.0
Using
ε = 0.95
< 1%
within ½'
≃ 4%
within 1%
≃ 16%
within 2%
≃ 26%
within 3%

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Issues with atlas approach

- Most of variance explained by variations in fractional water coverage, surface wetness, snow cover. An atlas at 25 km resolution is not good at representing this.
- High percentage of non-convergence when snow present i.e. snow does not fit the empirical model very well.
- Spectral signatures for some surfaces rather different to emissivity estimates from airborne and ground based radiometer studies – not understood.

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Alternative?

- We will look at using snow analysis and high resolution (1 km) fraction of open water to derive first-guess emissivity.
- Use fraction of each, and fixed emissivities for each (possibly more sophisticated treatment of snow later).

- Similar to existing sea ice scheme (water, new ice, multi-year ice)

Bias correction

- Wish to replace scheme of Eyre[1] with scheme based on Kelly and Harris[2]
- Evaluated a range of predictors (layer thicknesses, background BTs, skin temperature, total column water vapour, lapse rate)
- Initial trial using two mean layer thicknesses (200-50 hPa and 850 To 300 hPa) and calculated BT from background.
- Impact over 2 weeks neutral in extra-tropics, but slight increase in tropical moisture.
- Slight positive impact from using additional observations where previous scheme using observed AMSU Ch.5 and 9 did not work (high land).
- New runs using only two thicknesses underway and giving much better results.

[1]ECMWF Tech. Memo. **186**, 1992

[2]Q. J. Royal Meteorol. Soc., **127**, 2001

RTTOV-5 -> RTTOV-7

- RTTOV-7 several improvements/changes cf. RTTOV-5
  - Improved accuracy for several channels, esp. water vapour
  - More instruments supported
  - New and improved surface emissivity models
  - Cloud liquid water profile included
  - Better treatment of ozone

- For us also a change in vertical levels (40 to 43)

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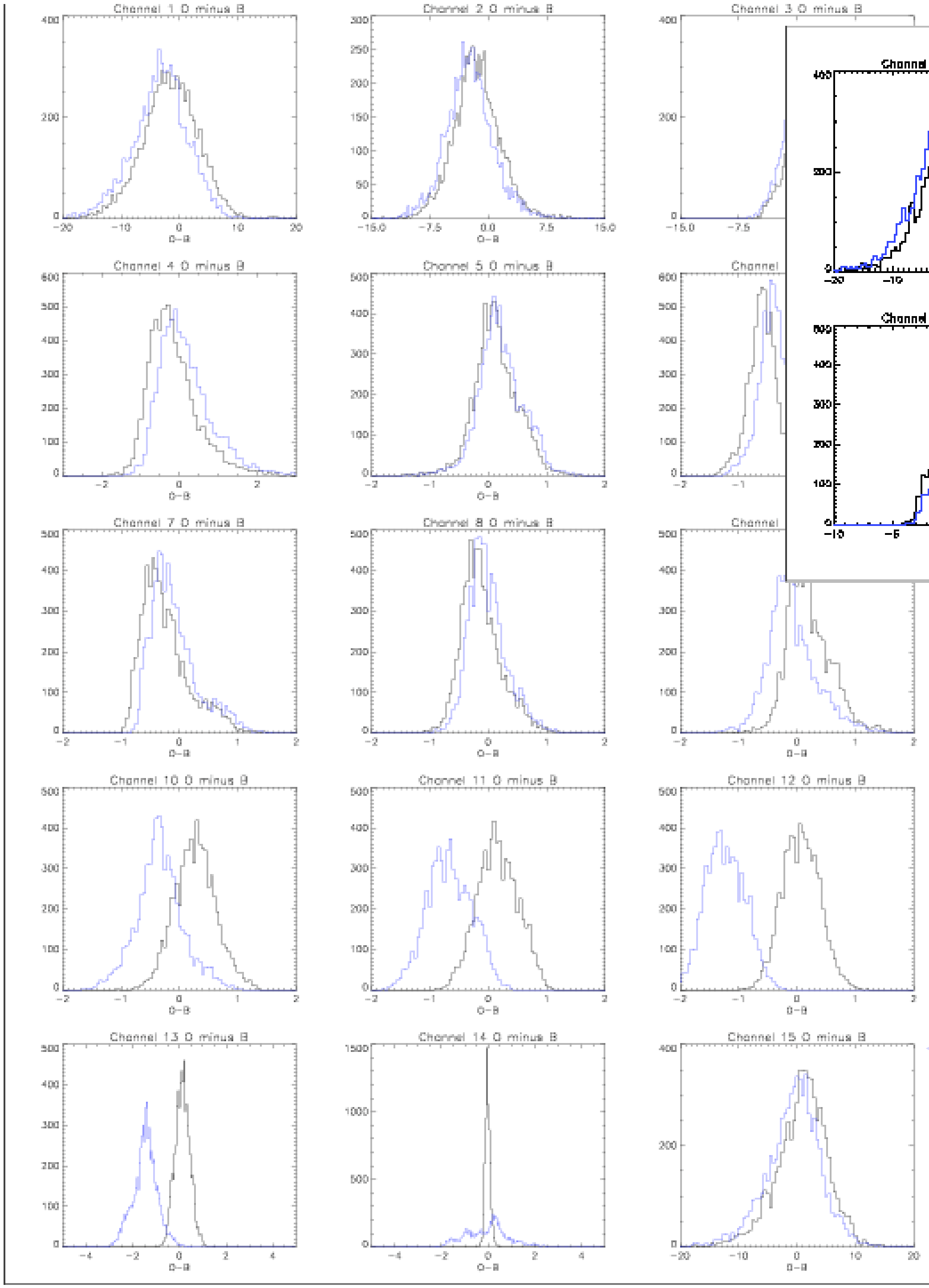
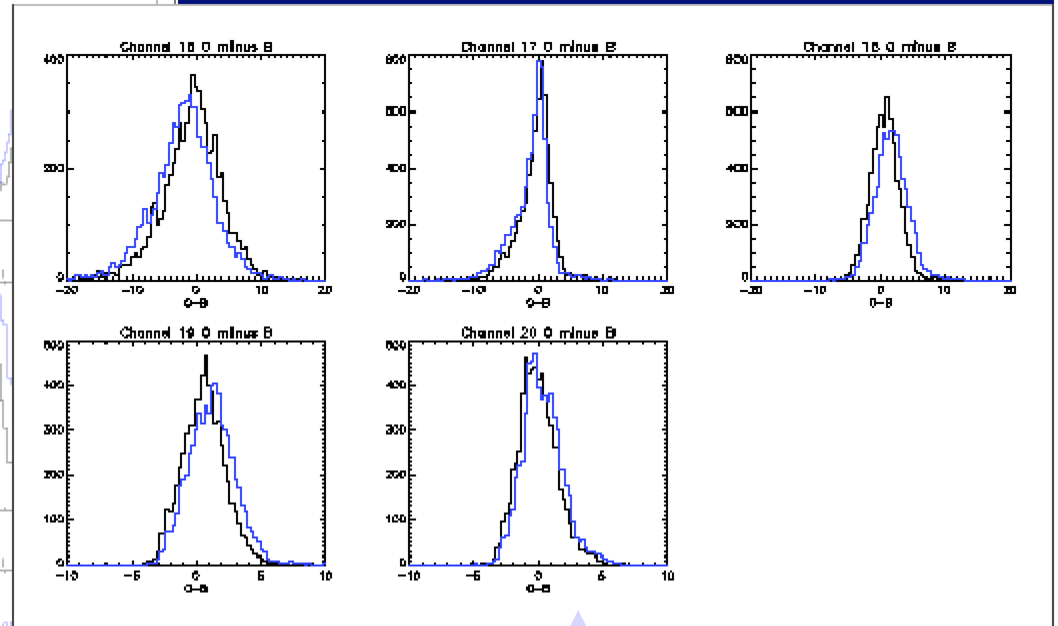
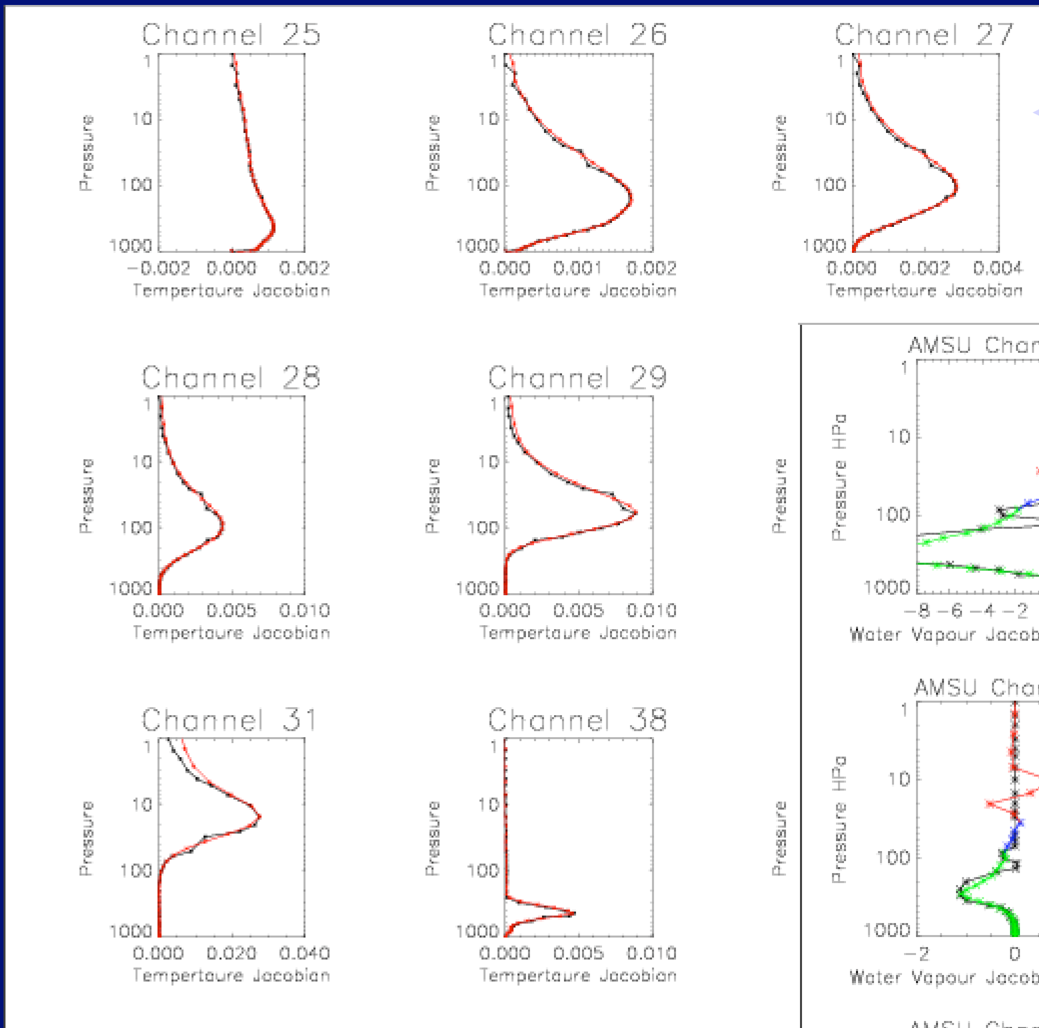


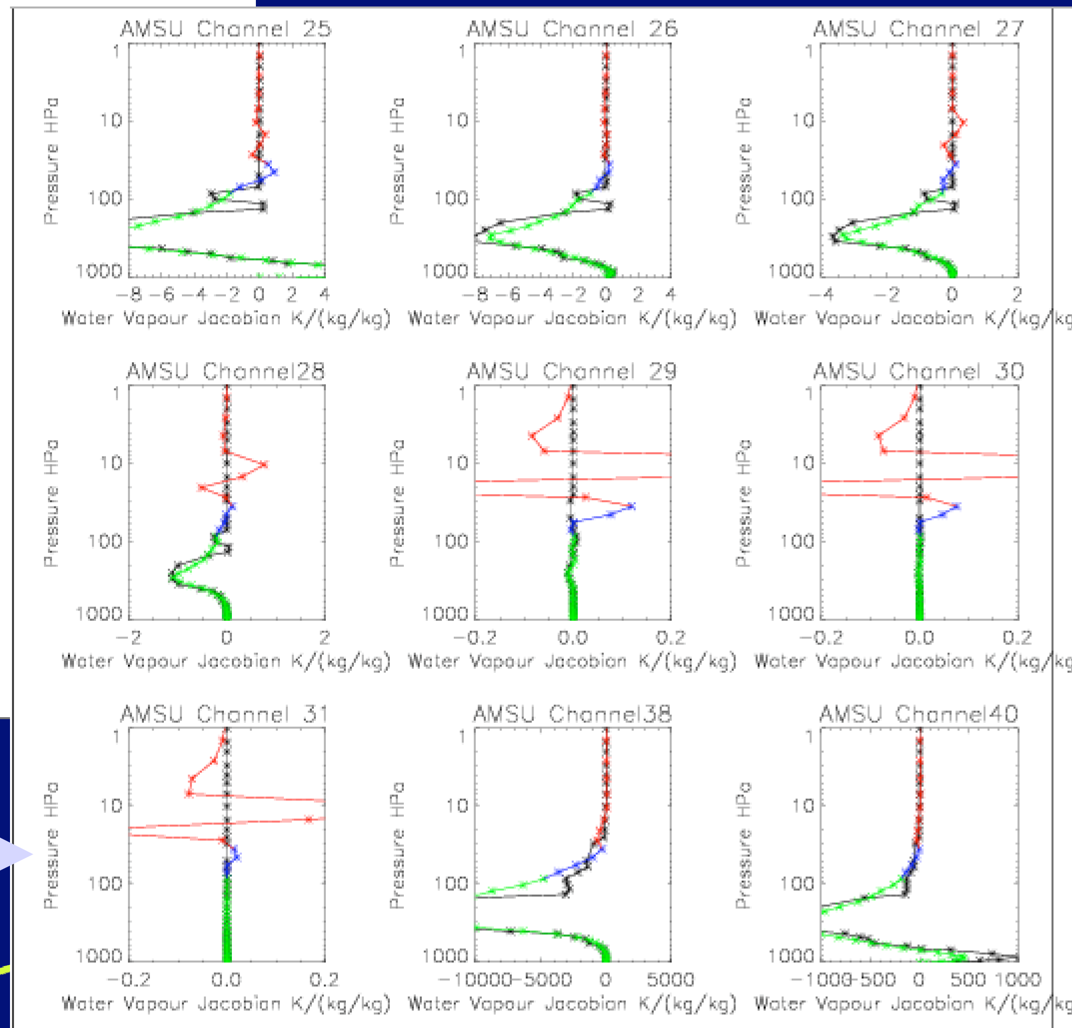


AMSU-B (above): very little difference, RTTOV-5 (black) slightly more Gaussian and lower St.Dev. Than RTTOV-7.

AMSU-A (left): Large biases for highest peaking channels. RTTOV-7 (blue) slightly more Gaussian and lower St.Dev. Biases slighly better with RTTOV-7.



Temperature Jacobians



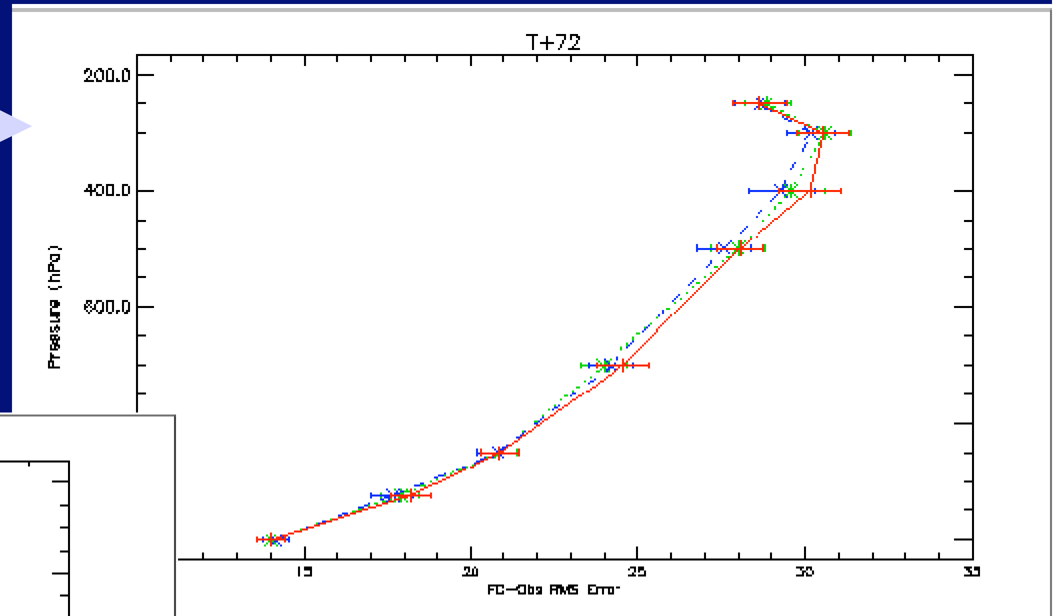
Humidity Jacobians

Relative humidity 850 hPa SH 3 days

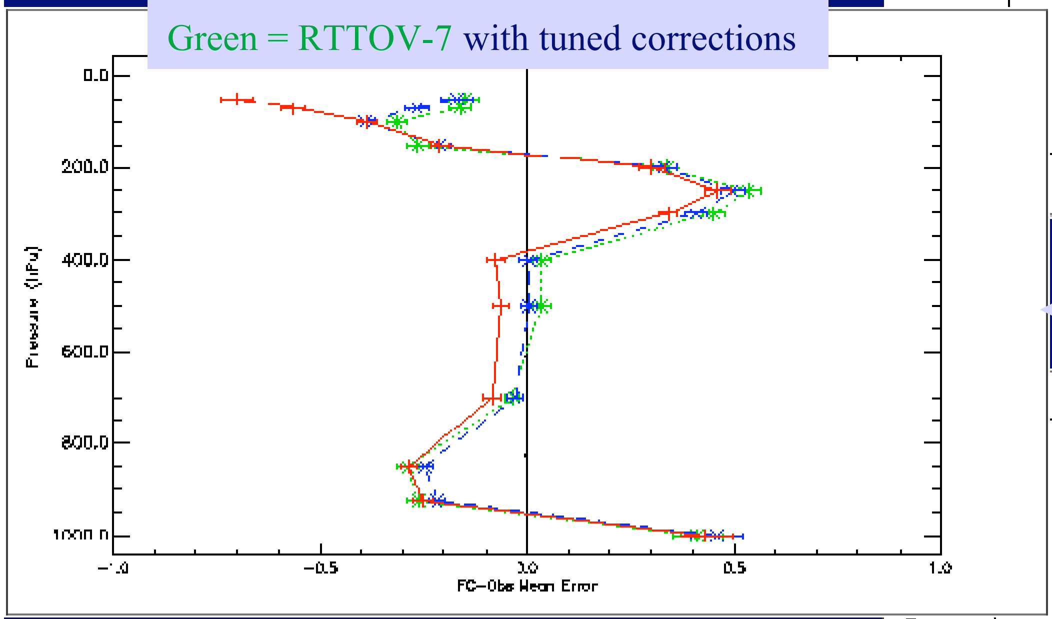
Red = RTTOV-5

Blue = RTTOV-7 without retuning bias corrections

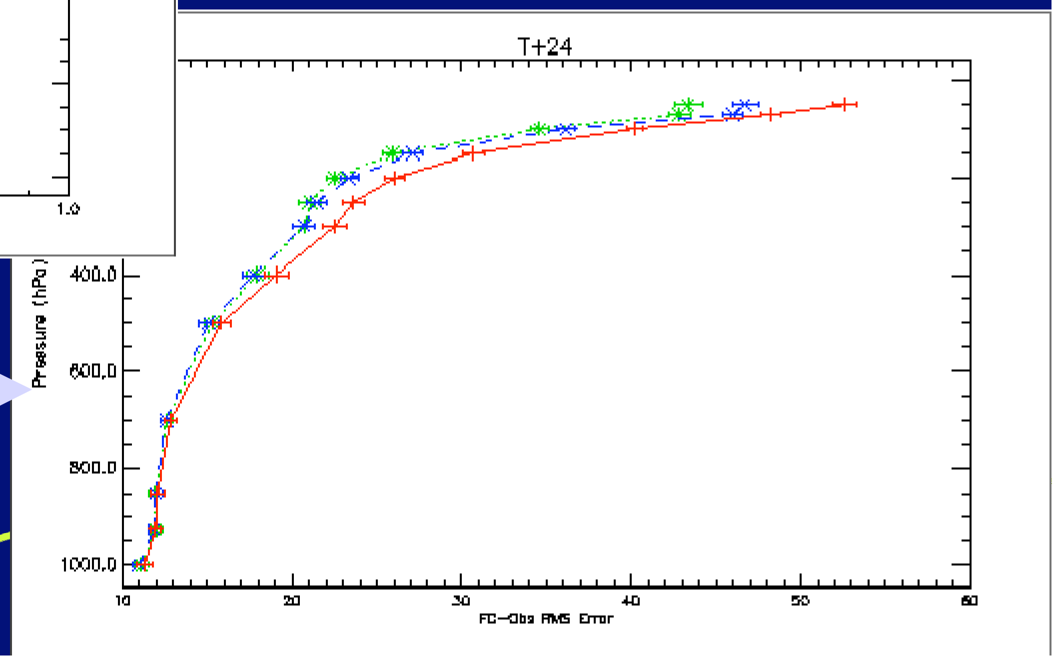
Green = RTTOV-7 with tuned corrections



Mean temperature SH 1 day



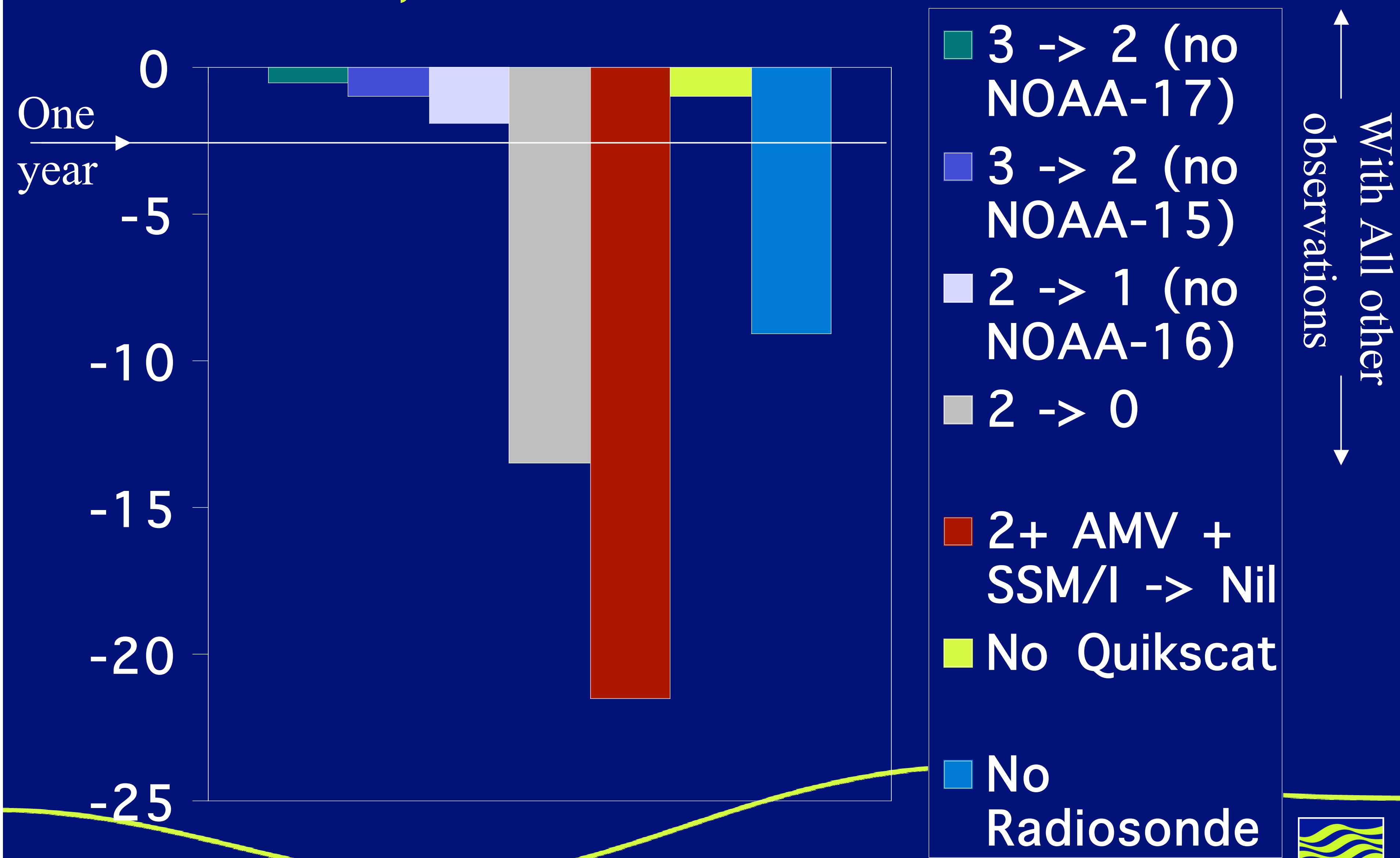
Geopotential height 500 hPa SH 1 day



RTTOV-7 - conclusions

- Some forecast improvements from using RTTOV-7 as a direct replacement for RTTOV-5 (note we are not exploiting new capabilities of RTTOV-7 here).
- Much more expensive to run – prior to local optimisation 3-4x longer – an issue we must be careful with.
- Many small but time consuming scientific and technicial difficulties (e.g. 40 -> 43 levels) can we learn from this to make RTMs easier to implement?

1, 2 or 3 satellites?



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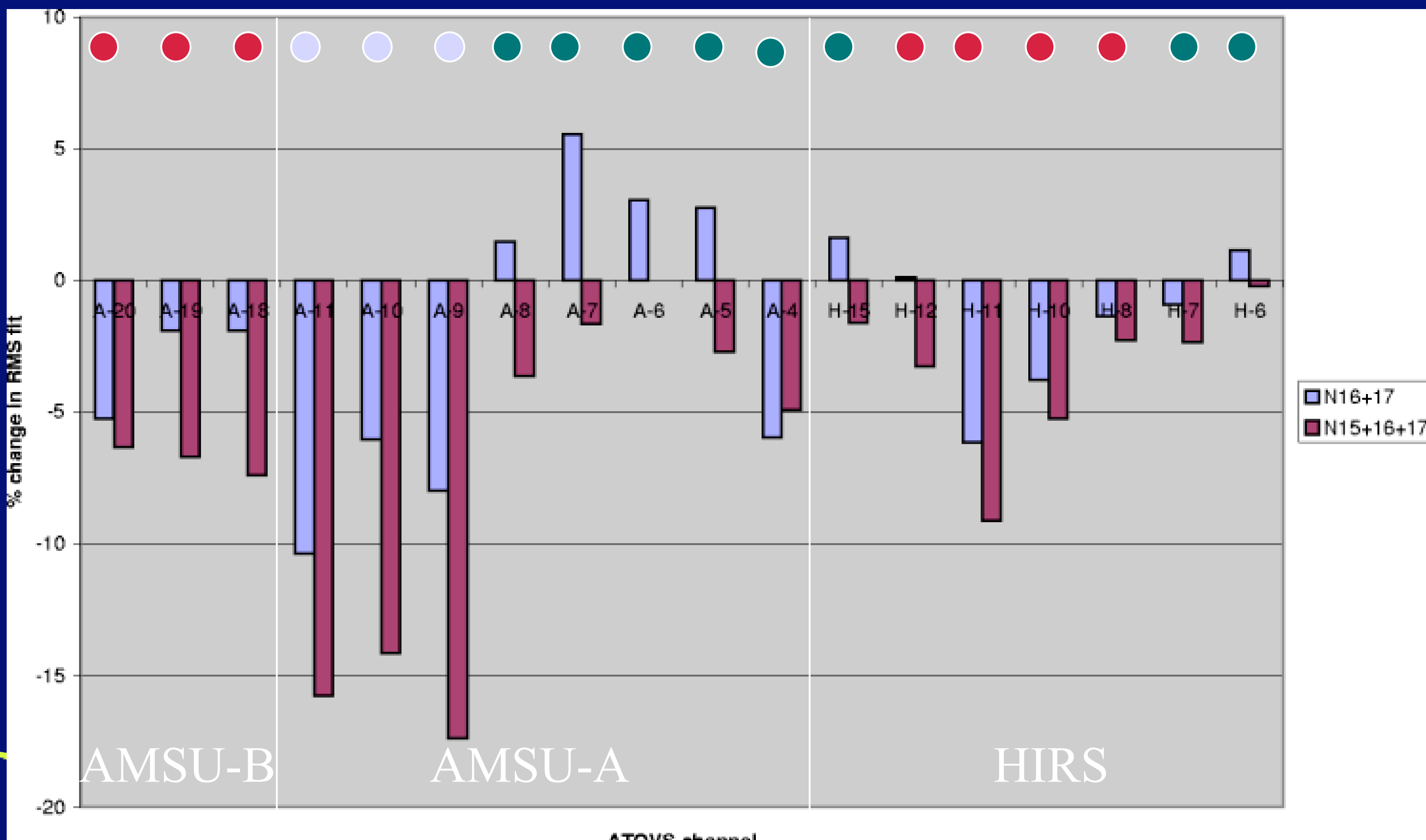
% change in T+6 RMS fit to NOAA-16 BTs vs N15+N16

- Humidity channels – OK to replace N15 with N17 but 3 sat system more skillful
- Stratospheric temperature channels – Also OK to replace but 3 sat system best
- Tropospheric temperature channels – Replacing N15 with N17 degrades fit but 3 sat system performs best



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SSM/I and SSMIS

- Biases in SSM/I data carefully re-examined leading to increased confidence in inter-sensor calibration (but not absolute calibration).
- New SSM/I TPW experiments - same result (still too much tropical convection).
- Met Office defined BUFR for SSMIS
- Processing sample data – aiming to implement SSMIS fast track post launch October 18 2003.

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Conclusions

- Use of data over land – alternatives to emissivity atlas approach?
- Bias correction – Running with two thicknesses only is giving better results than existing scheme, and running with background BT predictor not as effective.
- Implementation of RTTOV-7 was technically much more difficult than expected (but positive in the end) Lessons to be learnt for fast RT development? Issues for RT WG?
- The current three satellite operational system is beneficial to NWP compared to two satellite, both in impact and robustness. What is the optimal design for Global Observing System?
- Biggest success was the positive introduction of AMSU in regional and mesoscale data assimilation – see talk prepared by Brett Candy (but to be given by me).

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