The current forecast impact of surface-sensitive microwave radiances over land and sea-ice in the ECMWF system

Niels Bormann, Cristina Lupu, Alan Geer, Heather Lawrence, Peter Weston and Stephen English

Research Department, ECMWF, Reading, United Kingdom; email: n.Bormann@ecmwf.int

1 Introduction

The poster gives an overview of the status of the operational assimilation of surface-sensitive microwave sounding observations over land and sea-ice at ECMWF. We use an approach that relies on surface emissivities retrieved from window channel observations (Karbou et al 2006). The retrieval is a simple inversion of the radiative transfer equation (assuming specular reflection at the surface) for a single channel, with the terms (incl. skin temperature) specified by model background information.

Following a number of gradual enhancements over the years, the poster aims to:
- assess the present impact of these observations
- highlight short-comings and possible improvements in certain areas

More details can be found in Bormann et al. (2017).

2 Data and Experiments

Table 1: Channels considered in this study (subject to orography screening over land):

Type	Instrument, clear/all-sky	Channel	Snow-free land	Snow	Sea-ice
T	AMSU-A, clear-sky (6 sats)	5 6-7	Yes Yes	Yes Yes	N.Hem only Yes
	ATMS, clear-sky (1 sat)	6-8	Yes	Yes	No
q	ATMS, clear-sky (1 sat)	18-22	Yes	No	No
	MHS, all-sky (4 sats)	3 4 5	Yes Yes Yes	Yes No No	Yes Yes No
	SSMIS, all-sky (1 sat)	9 10-11	Yes Yes	No Yes	No Yes

Experiments for 2 June - 30 September 2014 and 2 December 2014 - 31 March 2015:

Base: No surface-sensitive MW sounder data used over land and sea-ice, but otherwise the full operational set of observations is assimilated.

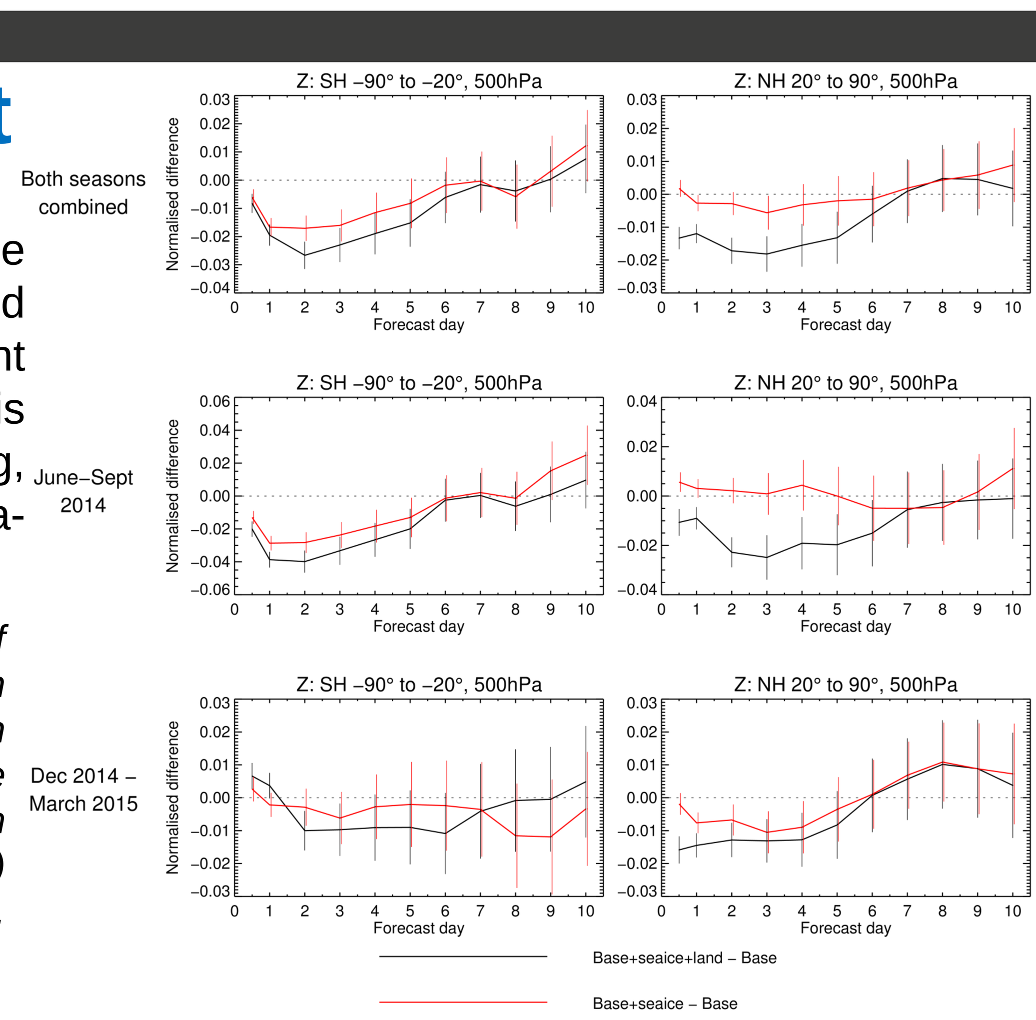
Base+seaice: As Base, but with surface-sensitive MW sounder data added over sea-ice.

Base+seaice+WV land: As Base+seaice, but with MW humidity sounder data added over land.

Base+seaice+land: As Base+seaice+WV land, but with MW temperature sounder data added over land. The observation usage is hence equivalent to the operational system in IFS cycle 43r1.

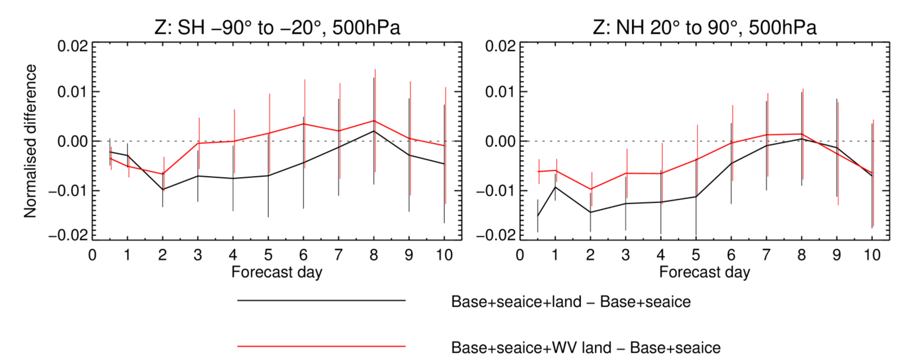
3 Forecast Impact

The sea-ice data, as well as the further addition of data over land provide statistically significant positive forecast impact. There is some seasonal dependence, relating, for instance, to the presence of sea-ice and snow.



Normalised difference in RMSE of 500 hPa geopotential for Southern Hemisphere (left) and Northern Hemisphere (right). Negative values show an improvement from adding the data over sea-ice (red) and land and sea-ice (black).

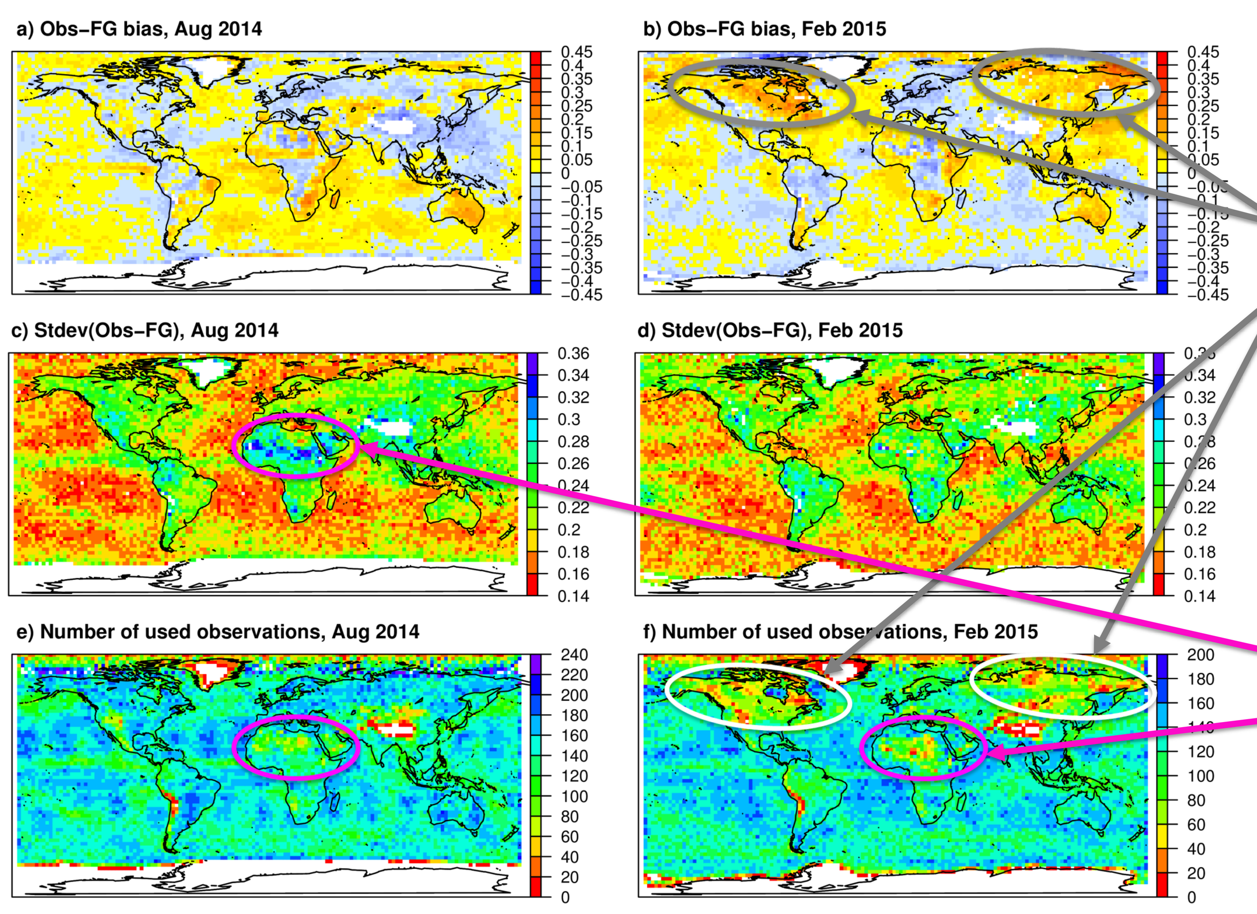
The humidity sounding and the temperature-sounding observations contribute similarly to the positive forecast impact of the data over land.



As above, but for adding the humidity-sounding data over land (red) and adding temperature and humidity-sounding data over land (black).

4 Issues

Departure and data usage statistics nevertheless show short-comings in certain areas, particularly for deserts and snow, for instance for AMSU-A channel 5 (used data):

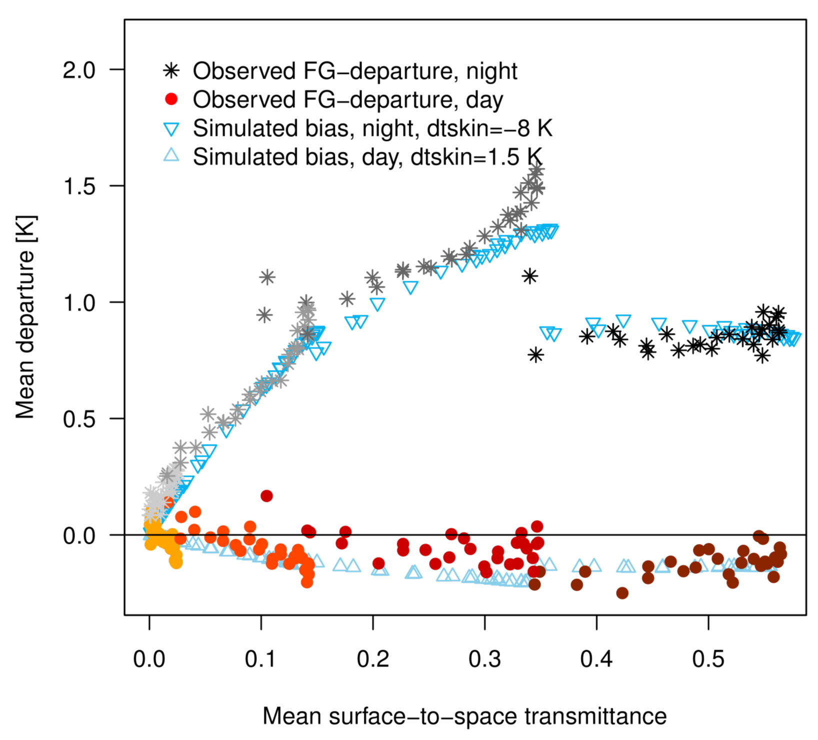


Snow: Larger biases [K], fewer observations used

Deserts: Larger stdev (o-b) [K], fewer observations used

4a Deserts

Departure statistics over desert regions show strong day/night biases (see dots and stars for day and night statistics, respectively). Also shown are simulations of the emissivity retrieval and subsequent forward calculations (blue triangles). They suggest that the bias pattern are consistent with an 8 K cold bias in the used skin temperature at night-time, and a 1.5 K warm bias at day-time. This is most likely due to a combination of two effects: 1) neglecting surface penetration for the model skin temperature used, even though this effect can be significant over deserts (a more appropriate skin temperature would have a dampened diurnal cycle, e.g., Prigent et al 1999), 2) under-estimation of the day-time peak of the diurnal cycle in the model skin temperature (found, for instance with IR data).

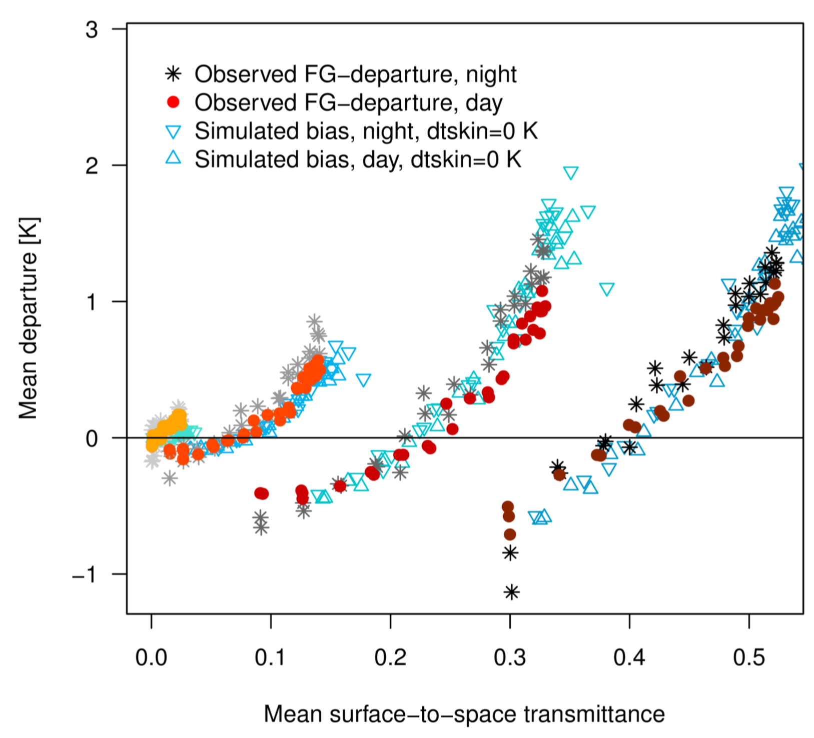


Mean background departures (dots and stars) for all observations in a 2°x2° region over the Eastern Sahara, binned by scan-position for ATMS channels 4-7 for June-August 2014 (over-pass times: 1:30am/pm). Blue triangles depict biases that would be expected from a -8 K and 1.5 K bias in the model skin temperature, respectively.

4b Snow

Statistics over selected snow regions show bias pattern as shown in this example. For each channel (different shading of stars/dots), the different surface-to-space transmittances are linked to the different viewing geometry of the ATMS cross-track scanner. The biases appear to be linked to the viewing geometry, in addition to the surface-to-space transmittance.

The behaviour is consistent with pattern that would be expected from using the specular assumption in the emissivity retrieval and subsequent forward calculations, when in reality the surface shows Lambertian reflection. Blue triangles show simulations of this using an approximation of Lambertian behaviour. The approach has been proposed before by Guedj et al (2010) and others.



Mean background departures (dots and stars) after bias correction for all observations in a 2°x2° snow-covered region in Eastern Russia, binned by scan-position for ATMS channels 4-7 for January-March 2015.

5 Conclusions

- Surface-sensitive MW data over land and sea-ice show significant positive forecast impact in the ECMWF system.
- There are, however, issues with the current approach that relies on a simple emissivity retrieval, particularly over desert and snow-covered surfaces.
- Approaches that allow a better treatment of skin temperature as well as catering for Lambertian behaviour over snow offer promising avenues.

References

Bormann, N., C. Lupu, A. Geer, H. Lawrence, P. Weston and S. English, 2017: Assessment of the forecast impact of surface-sensitive microwave radiances over land and sea-ice, ECMWF Tech. Memo 804, available online.

Guedj, S., F. Karbou, F. Rabier, and A. Bouchard, 2010: Toward a better modeling of surface emissivity to improve AMSU data assimilation over Antarctica. *IEEE Trans. Geosci. Remote Sensing*, **4**, 1,976—1,985.

Karbou, F., E. Gérard, and F. Rabier, 2006: Microwave land emissivity and skin temperature for AMSU-A and -B assimilation over land. *Q.J.R.Meteorol.Soc.*, **132**, 2333—2355.

Prigent, C., W. Rossow, E. Matthews, and B. Marticorena, 1999: Microwave radiometer signatures of different surface types in deserts. *J.Geophys.Res.*, **104**, 12,147—12,158.