Status of ATOVS and SSM/I data in the operational assimilation system at Météo-France and perspectives towards the use of microwave surface sensitive channels from ATOVS and SSM/I instruments over land

Elisabeth Gérard*, Fatima Karbou*§, Florence Rabier*, and Zahra Sahlaoui¶

*CNRM/GAME, Météo-France, Toulouse, France

¶ Maroc-Météo, Casablanca, Morocco

§ F. Karbou acknowledges financial support from CNES

The operational global model at Météo-France benefits now from the assimilation of AMSUA, AMSUB and HIRS data on board NOAA15, NOAA16, NOAA17, NOAA18 and AQUA satellites, but all three instruments are not used on each platform. The assimilation of SSM/I radiances in clear sky over sea is now operational as a positive impact of those data has been revealed in research experiments. The impact of those data on the first guess and analysis fields is presented as well as on the forecast scores.

Efforts are performed at Météo-France to use AMSUA, AMSUB and SSM/I channels over land when the surface (emissivity and/or skin temperature) is reliably described. Indeed, three land surface schemes have been developed at Météo-France, where (scheme 1) the emissivity is derived from an atlas obtained over 15 days prior to the assimilation period; (scheme 2) the emissivity is dynamically derived from only one channel of each instrument; (scheme 3) the emissivity is derived from the atlas as in scheme 1 and the skin temperature is dynamically computed from only one channel of each instrument. Encouraging results obtained from these schemes on observation departure from first guess, analysis field and forecast performances are presented.

The assimilation of clear sky SSM/I radiances over sea

Conditions of use of SSM/I channels over sea

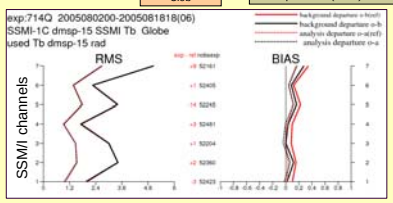
Frequency [GHz] Polarisation	19.35 V	19.35 H	22.235 V	37.0 V	37.0 H	85.5 V	85.5 H
Notation	19V	19H	22V	37V	37H	85V	85H
Channel number	1	2	3	4	5	6	7
Horizontal resolution [km]	25	25	25	25	25	12.5	12.5
Noise equivalent NeΔT [K]	0.8	0.8	0.8	0.6	0.6	1.1	1.1
Observation error [K]	3.0	4.5	4.0	3.5	4.0	4.0	6.0
Background error [K]	1.5	2.6	2.3	1.2	2.3	1.5	3.4

Quality control

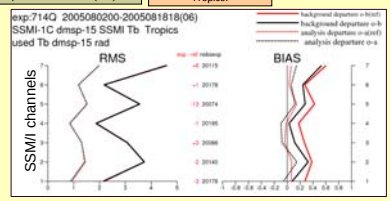
- Observed and simulated Tbs should within an acceptable range (50 K < Tb < 350 K)
- Observations over land or sea ice are rejected
- Cloudy observations are rejected ($CLWP_{f(22V,37V)}$ > 0.1 kg.m^{-2})
- Rainy observations are rejected (Tb_{37V} - Tb_{37H} < 40 K)
- Observations too far from simulations are rejected: | observation – simulation | ≤ sqrt (6.25 (s_o^2+s_b^2))

Fit to SSM/I observations
Experiment (black) versus operational model (red)

Glob



Tropics:



Impact of SSM/I (sea/ clear sky) on analysis and forecast skills ?

Better fit to the observations
to wind observations (TEMP, PILOT, AIREP, SATOB, AM/EU PROFILER)
to temperature (TEMP, AIREP)
to ATOVS radiances
Increase of the number of assimilated observations

Impact on analysed humidity
Impact on strato-cumulus distribution (more clouds in the tropics)
Impact on rain distribution (less rain in north Africa)
Impact on humidity
Scores: Positive for Europe (Z, T, V, RH) by comparison to radiosondes

Towards the assimilation of AMSU and SSM/I radiances over land

Conditions of use of SSM/I channels over land

Frequency [GHz] Polarisation	19.35 V	19.35 H	22.235 V	37.0 V	37.0 H	85.5 V	85.5 H
Notation	19V	19H	22V	37V	37H	85V	85H
Used* ?	No	No	Yes	Yes	Yes	Yes	Yes
Observation error [K]	3.0	4.5	4.0	3.5	4.0	4.0	6.0

* Other conditions are considered for the selection of channels : Orography, latitudes, clouds, sea/ice, …

Conditions of use of AMSU-A & AMSU-B channels over land

Frequency [GHz]	23.8	31.4	50.3	52.8	53.59	54.4	54.9	55.5	f=57.29	f±0.217	f±0.322±0.048	f±0.322±0.022	f±0.322±0.01	f±0.322±0.045	89	89	150	183±1	183±3	183±7
Notation	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
Used* ?	Yes	Yes	No	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	No	No	No	No	Yes	Yes	Yes	Yes
Observation error [K]	4.0	4.0	2.34	1.0	0.45	0.35	0.35	0.35	0.35	0.35	0.50	0.80	1.2	1.4	4.0	4.0	4.0	3.0	2.5	4.0

AMSU-B

* Other conditions are considered for the selection of channels : Orography, latitudes, clouds, sea/ice, …

Overview

Assimilation experiments have been conducted from August 15th to September 14th 2005 to test the assimilation of surface sensitive channels from AMSU or SSM/I sensors within the ARPEGE system.

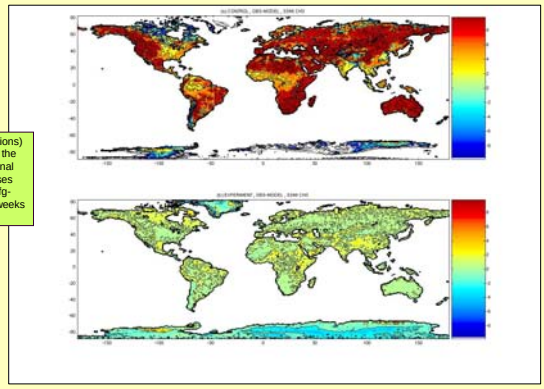
- **For AMSU-A & AMSU-B** : New surface parameterisations have been used to determine the emissivity and/or the skin temperature (Karbou et al. 2006a).
  - **Parameterisation 1**: the emissivity is taken from an atlas made using the last 2 weeks prior to the assimilation period
  - **Parameterisation 2**: the emissivity is dynamically calculated at one channel (channel 3 for AMSU-A and channel 16 for AMSU-B). These two channels are discarded from any other calculation or diagnostic. For each sensor, the emissivity at the other channels is taken equal to the dynamic emissivity.
  - **Parameterisation 3**: the emissivity is taken from an atlas (same as parameterisation 1) and the skin temperature is dynamically calculated at only one channel (channel 3 for AMSU-A and channel 16 for AMSU-B). These two channels are discarded from any other calculation or diagnostic. For each sensor, the obtained skin temperature is taken as a guess for the other channels.
- **For SSM/I** : We used the **parameterisation 2** to determine dynamically the emissivity at channels 1 and 2. Emissivity from channel 1 is taken for channels with a vertical polarisation. Emissivity from channel 2 is taken for channels with a horizontal polarisation.

Results are given for the experiments that use a dynamical approach for calculating the emissivity (parametrisation2). The assimilation experiments show that positive impacts on both analysis and forecast skills are obtained when assimilating surface sensitive channels. The three surface parameterisations give equivalent results. The results are being further analysed to derive final conclusions (Gérard et al. 2006, Karbou et al. 2006b).

Gérard, E., F. Karbou, F. Rabier, and Z. Sahlaoui, 2006: Assimilation of SSM/I radiances over sea and over land at Météo-France, Q. J. R. Meteorol. Soc. To be submitted.

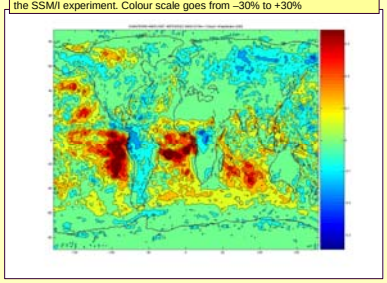
Karbou, F., E. Gérard, and F. Rabier, 2006a: Microwave Land Emissivity and Skin Temperature for AMSU-A & -B Assimilation Over Land, Q. J. R. Meteorol. Soc. To appear.

Karbou, F., E. Gérard, F. Rabier, E. Bazile, 2006b: Impact of Microwave Land Emissivity from AMSU Measurements in the 4D-Var system at Météo-France, Q. J. R. Meteorol. Soc. To be submitted.

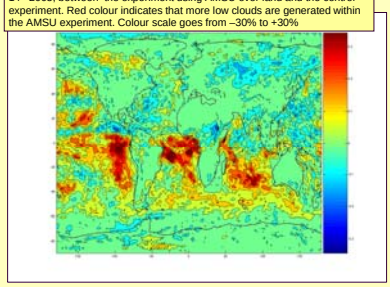


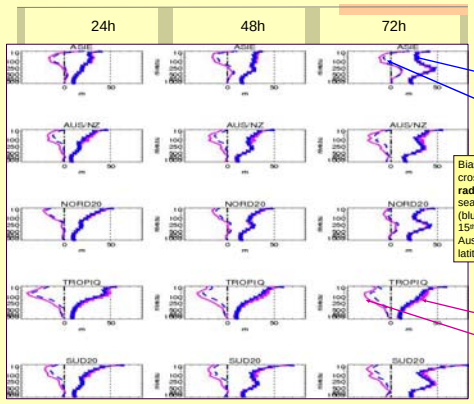
fg-departure (observation-simulations) maps for the SSM/I channel 3 for the control experiment (Top: operational model) and an experiment that uses the parameterisation 2 (Bottom). fg-departures are averaged over 2 weeks in August 2005

Low cloud difference (cumulated over 24h) from August 15th to September 14th 2005, between the experiment using SSM/I over land and the control experiment. Red colour indicates that more low clouds are generated within the SSM/I experiment. Colour scale goes from –30% to +30%



Low cloud difference (cumulated over 24h) from August 15th to September 14th 2005, between the experiment using AMSU over land and the control experiment. Red colour indicates that more low clouds are generated within the AMSU experiment. Colour scale goes from –30% to +30%





RMS errors, Exp. (SSM/I over land) / radiosondes

Bias, Exp. (SSM/I over land) / radiosondes

Bias (solid and dashed lines) and RMS errors (curves with crosses) of geopotentiel height, **with respect to the radiosondes**, for the control (operational model+ SSM/I over sea) (pink) and an experiment with SSM/I over land and sea (blue colour). Statistics correspond to 16 cases from August 15th to September 2nd 2005. Results are given for Asia, Australia, North20: latitudes > 20°, tropics, and South20: latitudes < -20° and for 24h, 48h, and 72h forecasts.

RMS errors, Control / radiosondes

Bias, Control / radiosondes