Impact of whitecap coverage derived from a wave model on the assimilation of radiances from microwave imagers

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The EUMETSAT Network of Satellite Application Facilities
NWP SAF
Numerical Weather Prediction

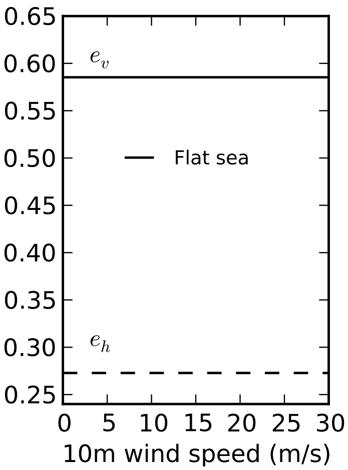
Impact of the whitecap coverage on microwave imagers observations

- Microwave imagers are very sensitive to the surface emission and consequently the surface emissivity
- In RTTOV, over seas, FASTEM is used

Emissivity calculation in FASTEM

1. Flat specular sea water
2. Small-scale correction
3. Large-scale correction
4. Foam partial cover
5. Azimuthal angle correction

19Ghz, T_s=283K, θ=53°



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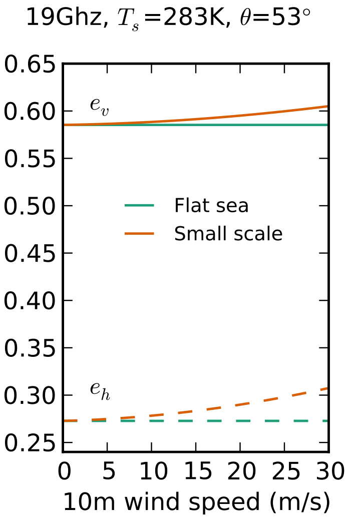

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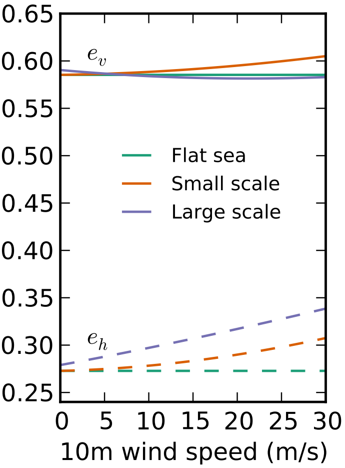

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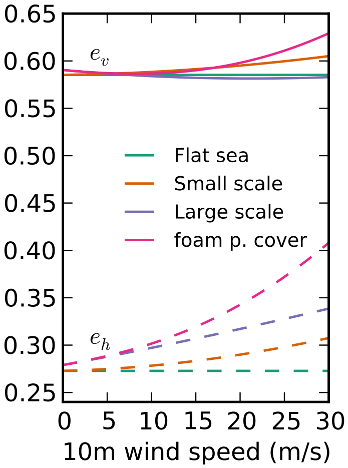

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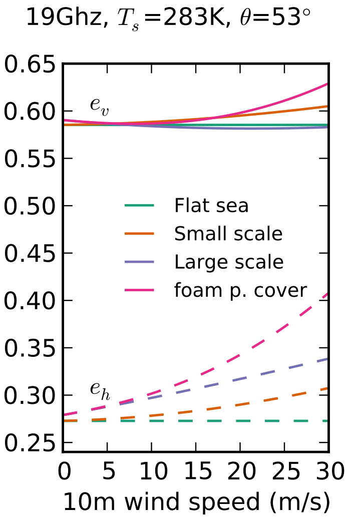
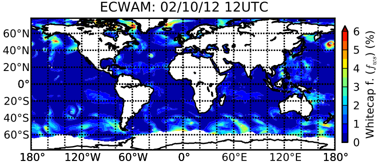


Whitecap coverage parametrisation

- Bottom friction set aside, wave breaking is the dominant energy dissipation mechanism for ocean waves
- The energy dissipation flux (Φ_{oc}) is calulated by the wave model and can be used to diagnose the whitecap fraction



Whitecap fraction (W) (see [Kraan et al., 1996])

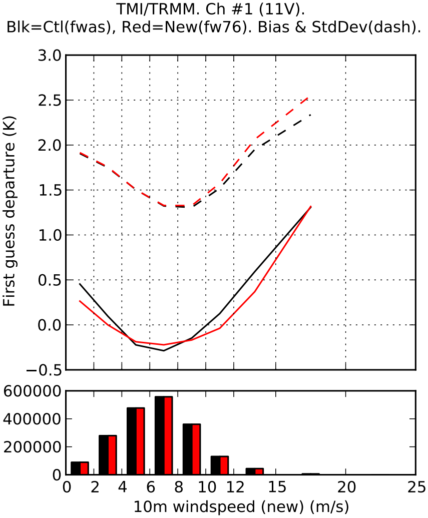
$$W = \frac{-\Phi_{oc}}{\gamma \rho_w g \omega_p E}$$

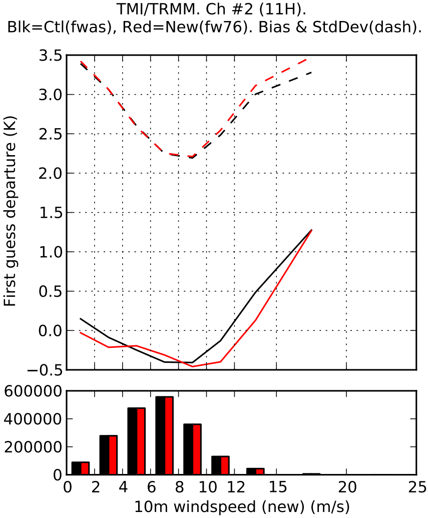
- E is the total wave energy,
- ω_p is the peak angular frequency,
- γ is the fraction of the total wave energy dissipated per whitecapping event

Assimilation experiments setup

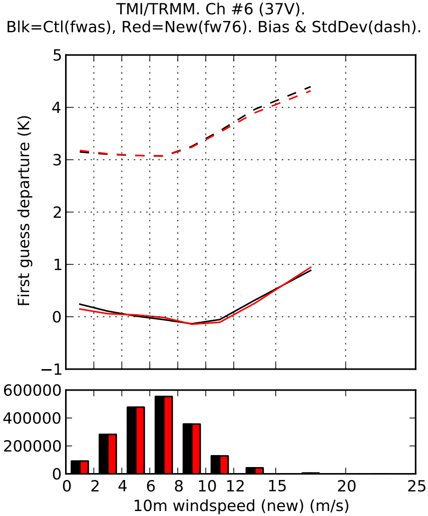
- Two experiments:
  - fwas (control): FASTEM uses the current formulation of the whitecap fraction (based on 10 m wind speed)
  - fw76 (new): FASTEM uses the whitecap fraction calculated by the wave model
- Both experiments are based on cy38r2 of IFS. Microwave imagers are asssimilated in allsky conditions
- The two experiments have ran from 1 October 2012 00UTC to the 14 December 2012 12UTC. The results shown later on are computed from the 10 October 2012 00UTC in order to allow the variational bias correction to adjust
- Heavy precipitation areas are excluded from the statistics shown later on

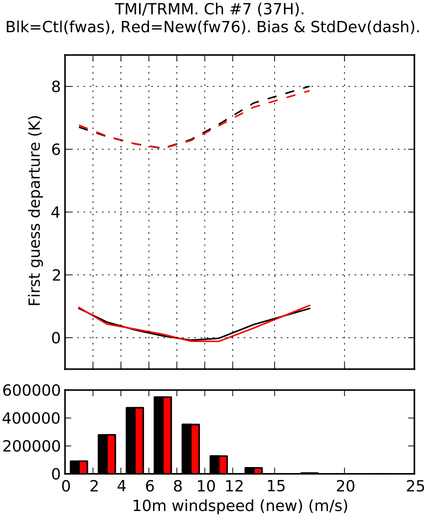
TMI 11Ghz: First guess departures w.r.t. windspeed





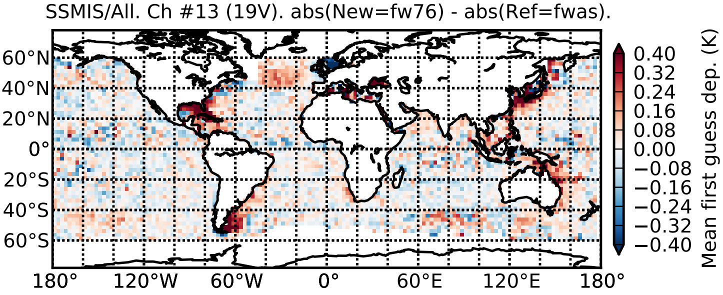
TMI 37Ghz: First guess departures w.r.t. windspeed



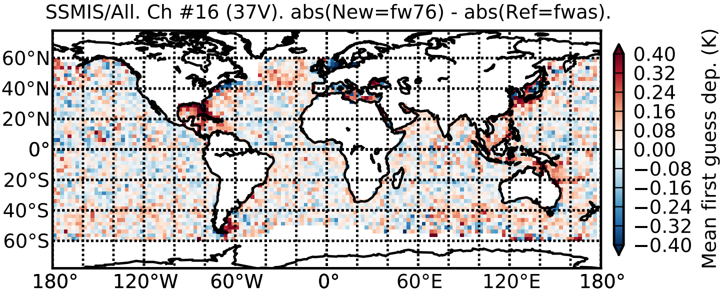


SSMIS: First guess departure bias (abs. difference)

19GHz V:



37GHz V:



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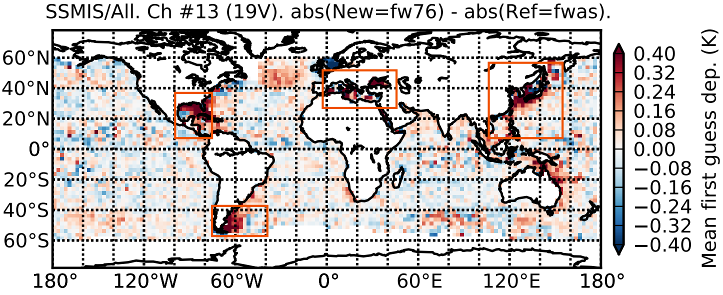

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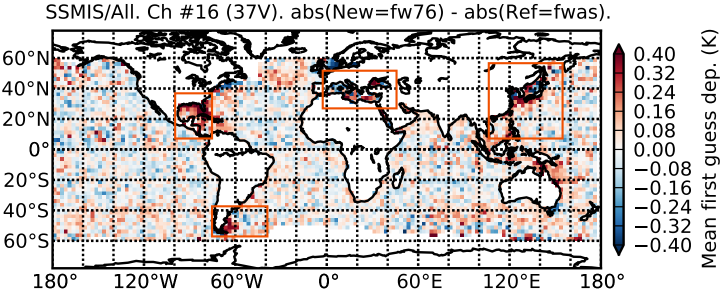


Tentative conclusion

- Overall the impact of the new parametrisation is negative at low frequiencies but slightly positive at higher frequencies
- The need for a bias correction predictor based on the wind speed is less with the new parametrisation (not shown)
- The amount of whitecap generated by the new parametrisation in closed sea, some sheltered area and shallow waters seems to be excessive

Lack of validation data for the whitecap fraction parametrisation

This led us to calculate a whitecap fraction retrieval (see [Anguelova and Webster, 2006])

Whitecap fraction retrieval method

FASTEM-5 calculates the sea emissivity as follows:

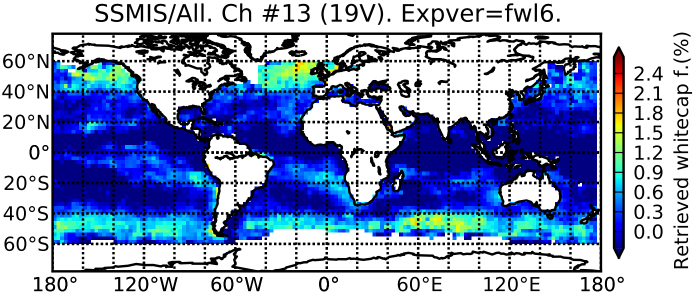
$$e = (1 - W)\, e_{foamfree} + W\, e_{foam}$$

How to retieve W ?

- $e_{foamfree}$ and e_{foam} are calculated within FASTEM-5
- e can be estimated from the observed brightness temperature (see [Prigent et al., 2005], [Karbou et al., 2005])

This method has been applied on an assimilation experiment similar to our “control” experiment (except that the wind speed predictor was turned off in the bias correction). The same period is considered (from 10 October 2012 00UTC to 14 December 2012 12UTC)

Mean retrieved whitecap fraction at low frequency



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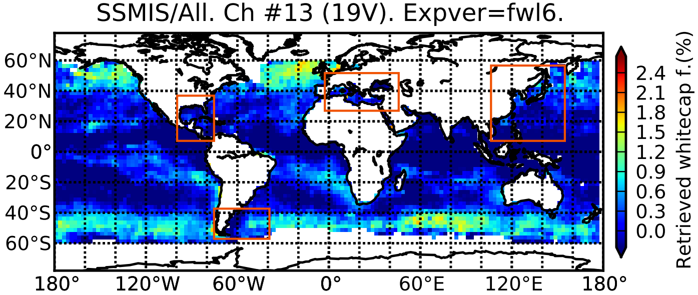
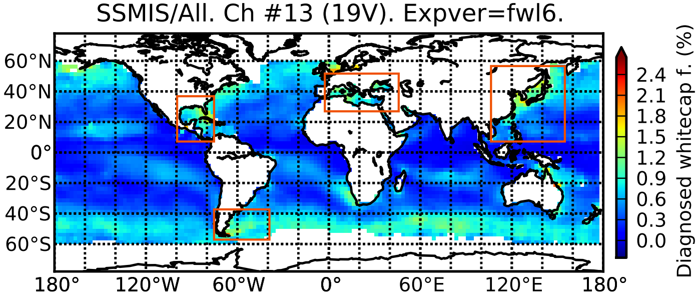
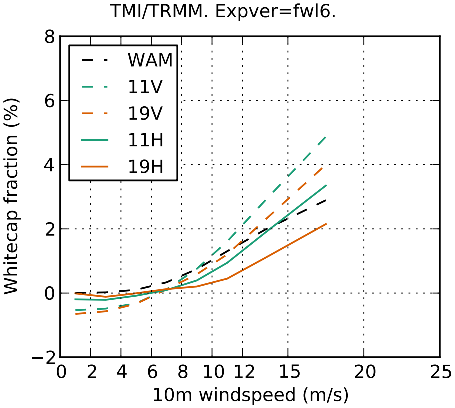




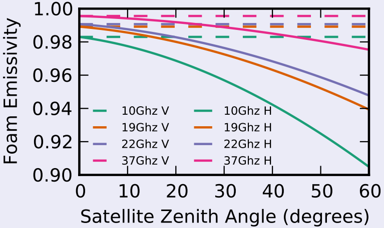
Retrieved whitecap fraction using TMI



How to explain the differences ?

The emissivities prescribed by FASTEM-5 during the retrieval ($e_{foamfree}$ and e_{foam}) may not be correct...

FASTEM-5 foam emissivity:



Conclusion

Our first results show:

- At low frequencies, a degradation of the standard deviation of the first guess departures when the new parametrisation is used. At higher frequency the impact is neutral to slightly positive.
- A positive impact on the bias correction.

Perspectives

- The whitecap parametrisation should be improved along the coasts, in the closed sea and shallow water areas.
- The emissivity model of the foam should be modified in order to correct the inconsistencies between H and V polarisations.
- The retrieved whitecap fraction may be used to tune the whitecap fraction parametrisation.

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