Potential benefit of a microwave sounder on-board a geostationary satellite onto Numerical Weather Prediction with meso-scale model

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Introduction

The idea of a radiometer observing the Earth in the microwave spectrum from a geostationary orbit has been put forth since a long time. Such a mission would add to the high observation rate offered by a geostationary orbit the sounding capability of the current observing system.

Technologies used for sounders like AMSU/MHS/APHIR/HRMW2 are not well suited to the GEO orbit (very large antennas to obtain reasonably good horizontal resolutions). Recent technical advances permit to use the microwave radiometry that was initially proposed in terms of scientific or operational objectives (e.g. GOMAS, Biscaye, 2005). Different instrument concepts are emerging mostly on interferometry.

This kind of technology may lead to reasonably good horizontal resolutions, but potentially at the cost of less accurate observations than technologies used for LEO orbit.

The mission concept considered in this study includes observations of different accuracies, within the 183.31 GHz water vapour absorption band, and aims to assess their potential impact onto humidity and precipitation forecasts for fine-scale Numerical Weather Prediction. Within the context of this broader ESA project, the selected method to estimate the contribution of a future microwave geosounder is to conduct Observing System Simulation Experiments (OSSE).

Operational observations

Synthetic observations

Observation errors consistent with the current observing system (IRS+MWGEO) have been simulated from the NR on the period from 01/01/2015 to 31/01/2015. Only ground radar observations are not simulated (e.g. satellite pass, no geostationary interferometric microwave radiometer (GIMS) demonstrator). In this configuration as below compared to the operational AROME (cy41T1):

- Selection of 25 water vapour channels
- Observations of different accuracies: 2.5K and 5K (MHS/AMSUB have a 2K error in Météo France DAS)
-Warnings are added to the cloud screening scheme.

The true atmospheric state is called the Nature Run (NR). It is a free-run, long and unobserved forecast performed with the global WRF ARPEGE model.

The NR is used to simulate the synthetic observations and to compute forecast skill scores at the hourly scale.

Data assimilation system

The convective scale AROME-France model covers Western Europe. The selected configuration is as below compared to the operational AROME (cy41T1):

- 4D-Var Data Assimilation System
- Diurnal scale configuration to the Nature Run for the period from July 1st to July 31st. This example shows that the OSSE configurations characterized by errors on relative humidity are comparable to forecasts of the operational AROME model.

Conclusion

- Assimilation of a MWGEO instrument (6 channels around 183.31 GHz) could lead to positive changes in the NR forecast environment as the OSSE configuration.
- However, these positive impacts strongly depend on the accuracy of this potential instrument.

Perspectives and improvements:

- Include ground radar simulations
- Perform the same experiments over longer periods and in different seasons
- Use active observations

References

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Duruisseau, F., Chambon, P., Guedj, S., Guidard, V., Fourrié, N., Taillefer, F., Brousseau, P., Mahfouf, J.-F. 2021. Observation errors consistent with IRS and MWGEO. 2021-like observing system (MHS/AMSUB have a 2K error in Météo France DAS) and to the Nature Run for the period from July 1st to July 31st. This example shows that the OSSE configurations characterized by errors on relative humidity are comparable to forecasts of the operational AROME model.

Conclusions

- Assimilation of a MWGEO instrument (6 channels around 183.31 GHz) could lead to positive changes in the NR forecast environment as the OSSE configuration.
- However, these positive impacts strongly depend on the accuracy of this potential instrument.

Perspectives and improvements:

- Include ground radar simulations
- Perform the same experiments over longer periods and in different seasons
- Higher horizontal resolution (6K-5K), MWGEO(25 to 52 km)
- Use a 4D-Var Data Assimilation System

Precipitation scores

No statistically significant differences can be found between all the experiments.

Forecast skill scores results

Daily Fraction Skill Scores between precipitation forecasts from each experiment and the NR are computed and a monthly average before computing confidence intervals at the 95% confidence level

FSS compared to the NR on 12 h accumulated precipitation forecasts:

Neighbouring of 40 km

Neighbouring of 120 km

Introduction

This study was funded by the ESA/ESTRAC contract N° 4000113023/13/NL/MV. This work would like to thanks Dr. Paul King for his support and his recommendations for concluding this work. Pascal Brunel is also acknowledged for providing RITM configurations for the IRS in-circuit.