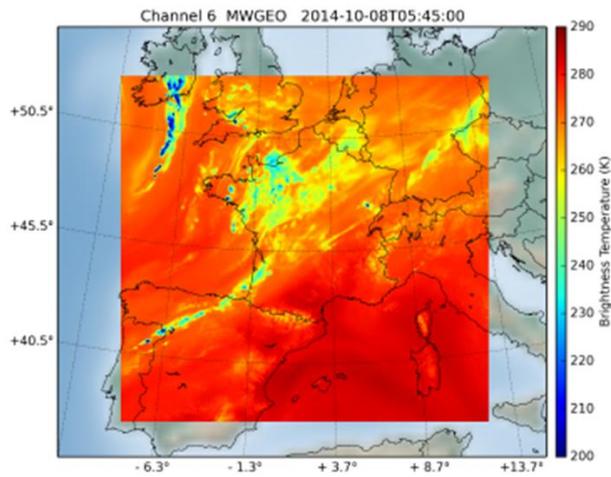# Executive Summary
for
ESA/ESTEC Contract Nr. 4000113023/13/NL/MV
"Geosounder requirements consolidation study"

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Introduction

This executive summary synthetises the outcome of the various work packages that were all achieved and delivered during the course of the contract and formulates recommendation based on the Geosounder mission concept.

Workpackages summaries

The consolidation study was designed around 3 productive tasks and one synthetis task which are
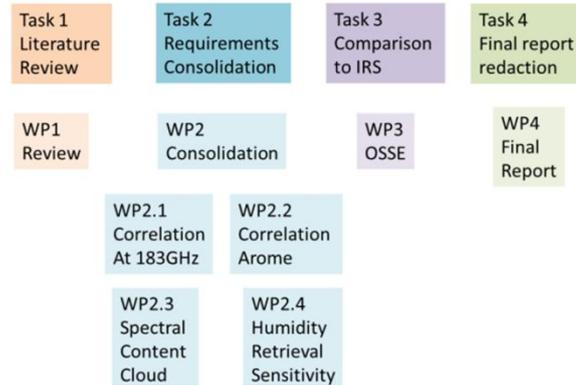

Figure 1 Outlook of the WP for the consolidation study

recalled in Figure 1 and are fully detailed in the Proposal. The names of the various leaders and groups can also be found in the Proposal and are recalled in each of the individiual reports and not recalled here. In short the study is articulated around two main types of investigations beyond the literature review. The first group of analysis can be portrayed as "basic investigations" and the second group as "advanced analysis". The first WP, so called literature review, was successful in confirming the need for the various WPs as well as initiating discussions between the French and German teams. Also it provided the needed elements to feed the various WPs investigations.

Basic investigations

This corresponds to WP 2.1, 2.2 and 2.4 and covers spatial resolution , spatial sampling and temporal sampling as well as radiometric noise aspects.

WP 2.1 "Correlation at 183 GHz" This WP relies upon using the latest version of the AROME model of Meteo-France to simulate *total sky* radiances in a Geosounder geometry using 183GHz channels similar to SAPHIR. Then classical geostatistics tools (variograms computations) are used to evaluate the space time autocorrelation of the simulated instrument for various configurations.

The results suggest that if a resolution better than 50km cannot be achieved for the MW Geosounder, 15 min resolution Level 1 products are likely to be highly correlated and to have low information content. The study further emphasized the large variability observed in the analysis of the variograms depending on the rain event characteristics

WP 2.4 "Humidity retrievals" This WP relies upon using a clear sky relative humidity profile retrieval to establish the sensitivity of such retrievals to specification of radiometric noise. The outcomes indicates that adapted training (i.e., including noise in the training step) can only partially compensate for radiometric errors, and, by consequence, degraded Level-2 products shall be

expected if radiometric errors of the MW Geosounder are large with respect to current generation MW sounders.

WP 2.2 Correlation Arome This WP elaborates on a new technique to replicate idealized fast cycle assimilation experiments (clear sky only) that permits to explore the information content of the Geosounder at high refresh rates for various specifications of the instrumental noise. The results indicates that in all experimental configuration tested, there is a clear benefit in assimilating observations at higher temporal frequency despite larger values of radiometric noises. This is a stand-alone perspective and does not account for the other available instruments for the NWP system. See next WP 3.

Advanced information content analysis

This corresponds to WP 2.3 and 3. It covers the information content under all skies for various hydrometeors as well as a comparative study with IRS in terms of impact on forecast in a realistic environment.

WP 2.3 Information Content Analysis for Cloudy Sky This WP is built on the usage of hydrometeor profiles derived from ICON with a two-moment microphysical scheme and on calculations from the line-by-line radiative transfer model ARTS. Optimal estimation theory and classical statistical tools were employed as metrics for the information content. The results show the strong dependence of cloudy Jacobians on the atmospheric composition and for rain also a dependence on the surface emissivity. In general the information content is high. For the liquid phases (cloud water and rain), the complete set of frequencies gives the highest information content, whereas for snow and ice the combination of the 183 GHz channel with either of the window channels results in an equally high information content as the full set of channels. The inclusion of the second window channel does not add more information about snow and ice.

WP 3 OSSE with the Météo-France NWP system This WP is based on the AROME data assimilation system and MF observing system simulations capabilities. The OSSE permits to evaluate the impact of the Geosounder in a realistic NWP environment both in terms of model and in terms of actual data ingested by the assimilation scheme. The set up used here benefitted from an update of the Météo-France system in the course of the study and hence is based on a NWP system with a much more rapid refresh cycle that initially anticipated (1h instead of 3h) further in lines with the scientific objectives of this WP. A so-called "MWGEO2K" (GEOsounder with NEdT equivalent to current LEO sounders) was assimilated within Arome, as well as a "MWGEO5K" instrument (GEOsounder with NEdT less accurate than the current LEO sounders). Both Relative Humidity and Precipitation scores reveal that improvements on forecasts, up to +15h (resp. +24h), can be expected when either MWGEO2K or an IRS-like instrument is assimilated. All the scores indicate that the MWGEO5K have a very little added value, even with respect to the current observing system without MTG. In a multi-Geo environment including MTG, only an accurate Geosounder would bring some slight added value with respect to IRS and for short range forecasts (up to +3h/+6h), due to the lowest cloud contamination of microwave observations

Recommendations

The results of all of the study have been projected in terms of recommendation for ESA about Geosounder based on the available specifications of the mission. It has been summarized in the Table.

	Specifications from ESA		Our study
	Threshold	Breakthrough	
Footprint size	50 km at mid lat	15-20 km at mid lat	15km should be the goal
Revisit time	30 minutes	15 minutes	15min should be the goal
NEdT	1K	0.5K	0.5K

In summary, **our study suggests that such a mission, with enhanced characteristics, could bring in additionnal information. A strong impact in NWP is not expected in a foreseen very busy operational environment over Europe.**

Conclusions and possible future works

The study relied on various state-of-the-art numerical tools (RT model, assimilation OSSE and NWP forecast systems) to explore the possible impact of a Geosounder mission on the retrieval of humidity and forecast. The study showcases that some specifications are valid for such an endeavor and some needs to be refined.

Future works should be directed towards a more complex information content analysis with an all sky OSSE set up and maybe a multispectral/hyperspectral perspective on the channel selection.

The group would like to thank ESA and in particular Paul Ingmann for proposing such an interesting investigation despite various programmatic complexities and for the high level of courtesy in our exchange that in our opinion warrant further cooperation.