Engineering and the Environment

UNIVERSITY OF Southampton

A Constellation Concept for Microwave Interferometric Radiometry from Geostationary Orbit

Astronautics Research Group
Mr. Ahmed Kiyoshi Sugihara El Maghraby, Dr. Adrian Tatnall and Dr. Angelo Grubišić

Introduction and Aim

Microwave radiometry has been successfully providing a variety of environmental and climate information including surface temperature, soil moisture and ocean salinity, precipitation, tropospheric temperature and humidity from LEO.

In LEO, the temporal resolution (frequency) of measurements are limited by the satellites' revisit frequency, typically in days. Placing the instrument on a geostationary orbit would reduce this to minutes, and would also enable real-time measurement. However, due to the distance to GEO, spatial resolution suffers.

To improve the spatial resolution at a given wavelength, two interferometer concepts with formation-flight are proposed.

$$\text{Spatial Resolution} \propto Range \frac{Wavelength}{Aperture\ Size}$$

Placing a Radiometer in GEO

- GEO is approximately 50 times further from the ground than a typical LEO. Thus to maintain the spatial resolution, the angular resolution (λ/D) must be improved by a factor of 50.
- The wavelength (λ) is already specified by the application (e.g. sounding of Tropospheric temperature).
- Therefore the aperture dimension (D) must be increased to a few tens of metres.
- No single satellite can achieve this. Two concepts using formation-flying satellites are proposed.

Validation by Simulation

The beam performance of the two concepts presented have been estimated by simulation and are tabulated below (53 GHz). These simulations are performed without imperfections to illustrate the potential of the free-flying interferometers.

	Concept 1	Concept 2
-3dB Beam Efficiency	46.1%	
Null Beam Efficiency	98.6%	
-3dB Beam Width	17.3 km	8.6 km
Null Beam Width	42.1 km	21.0 km
Side Lobe Level	-29 dB	

Estimated performance at 53 GHz

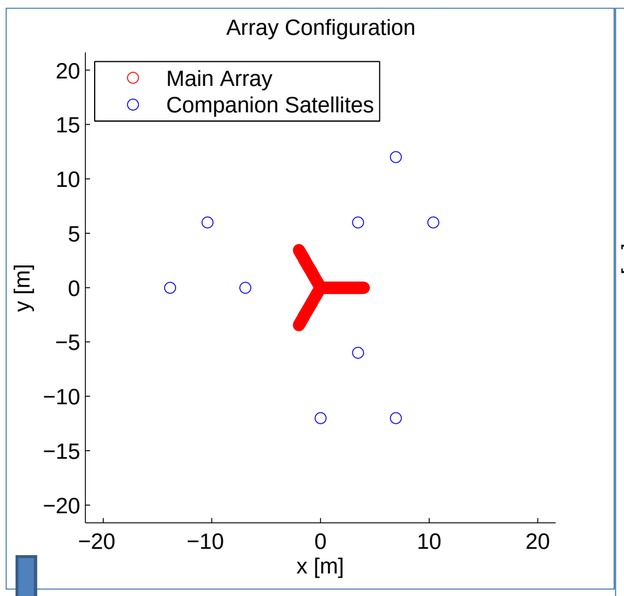
Conclusion

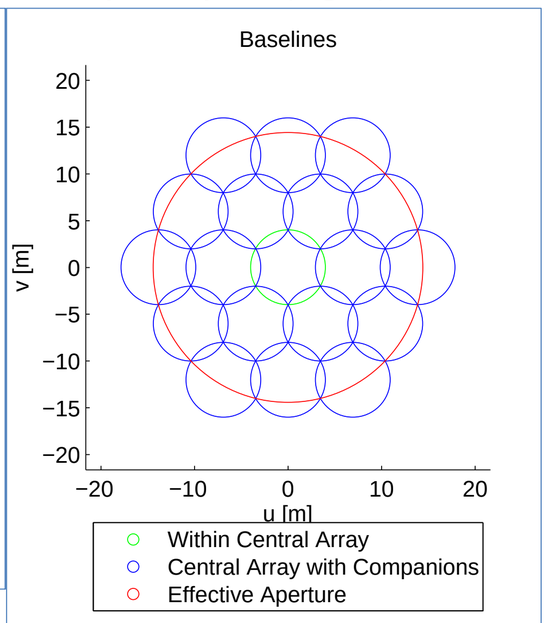
Both concepts produce apertures in excess of ten metres. Such apertures may enable microwave radiometry at lower frequencies (< 53 GHz) from the geostationary orbit.

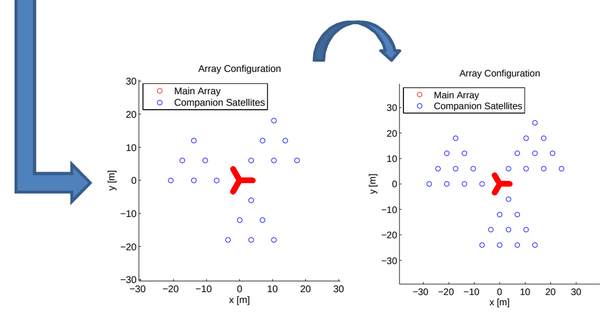
Geostationary radiometry is suitable for measuring global and rapidly evolving parameters as precipitation and temperature.

Concept 1

Single rotating Y-shaped interferometer (4 m arms) with nine (or more) accompanying microsatellites.
Constellation layout (left) and its visibility samples (right)







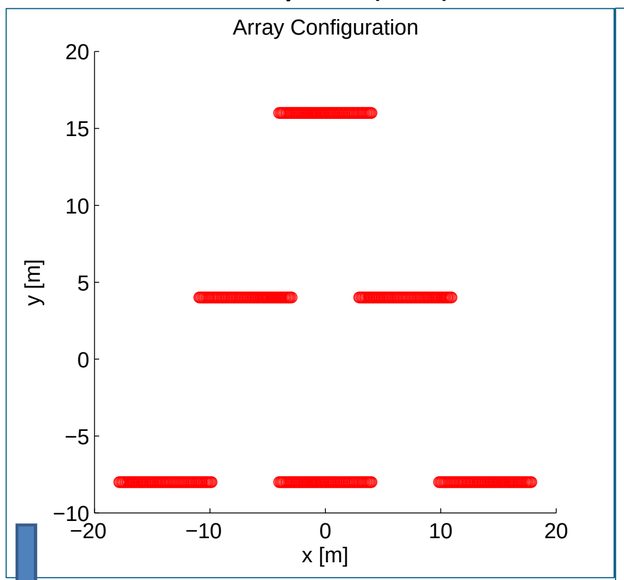
Constellation scalable

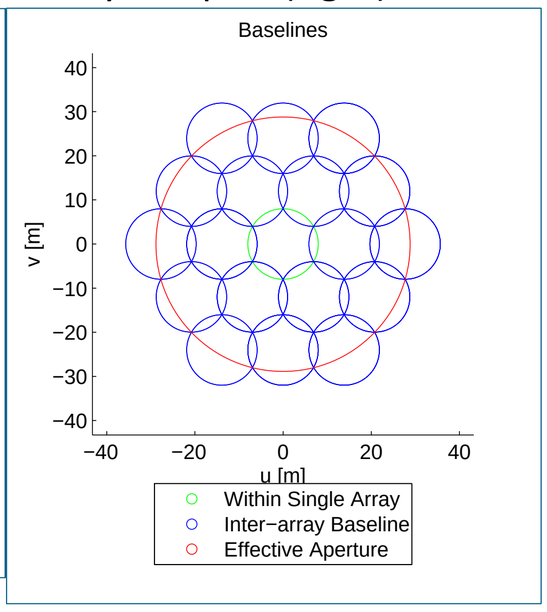
Companions	Aperture	Mass
3	8.0 m	868 kg
9	14.4 m	1288 kg
18	20.0 m	1918 kg
30	32.0 m	2758 kg

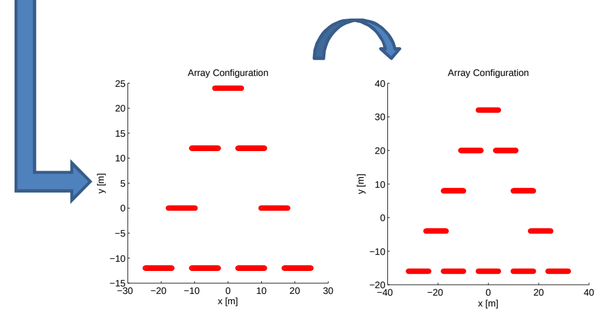
Scaling of the constellation

Concept 2

Six (or more) rotating two-boom interferometers (4 m arms).
Constellation layout (left) and its visibility samples (right)







Constellation scalable

Satellites	Aperture	Mass
3	16.0 m	1974 kg
6	28.8 m	3948 kg
9	40.0 m	5922 kg
12	64.0 m	7896 kg

Scaling of the constellation

References

Cover image: 3-D view of Hurricane Arthur in July 2014, taken from instruments aboard the NASA/JAXA GPM observatory (image credit: NASA)

www.southampton.ac.uk | e-mail: asem1g14@soton.ac.uk

Astronautics Research Group, Aeronautics and Astronautics, The Faculty of Engineering and the Environment
University of Southampton, SO17 1BJ UK