Sea Ice Flooding Observations via Remote Sensing

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Introduction

- Passive instruments detect energy which is either emitted or reflected from an object [1].
- They comprise various types of radiometers and spectrometers and operate in the visible, infrared, thermal infrared, and microwave parts of the EM spectrum [1].
- Snow ice is formed when sea water floods the basal layers of the snowpack on sea ice and freezes [2].
- When sea ice has the oxygen isotopic signature close to snow, it is assumed to be snow ice [2].

Case Studies

- Study 1 in the Weddell Sea Area: IMBs installed for sea ice temperature monitoring [3]
- Each IMB – 5 m temperature sensor string, sensors spaced every 2 cm [3]
- The sensor chain was heated once a day to determine surrounding medium – ocean, sea ice, or snow – via temperature response [3]
- Flooding detected through variations in heating rate profile at base of the snow layer [3]

- Study 2 in Western Pacific: Radar data + field measurements of snow density, thickness, wetness, layering, including snow packs with flooding, hard crusts, and icy layers [4]
- Flooding found at first snowpit at Station 10 with coordinates taken from SIPEX data provided by this project's supervisors: – 65.94167, 119.13605

Hypothesis

Passive microwave sensors detect the microwave energy that a snowpack emits [5]. Brightness temperatures (TB) are calibrated from documented microwave energy [5]: $T_b = \varepsilon T_s$

Volume scattering within snow affects microwave radiation emitted from ice below + TB measured at the snow surface. Scattering reduces surface TB at snow surface; therefore, TB is lower at higher frequencies [6]. As snow deepens, more scattering occurs and brightness temperature drops with increasing frequency, so a negative gradient ratio (GR) could be observed with thicker snow cover [6].

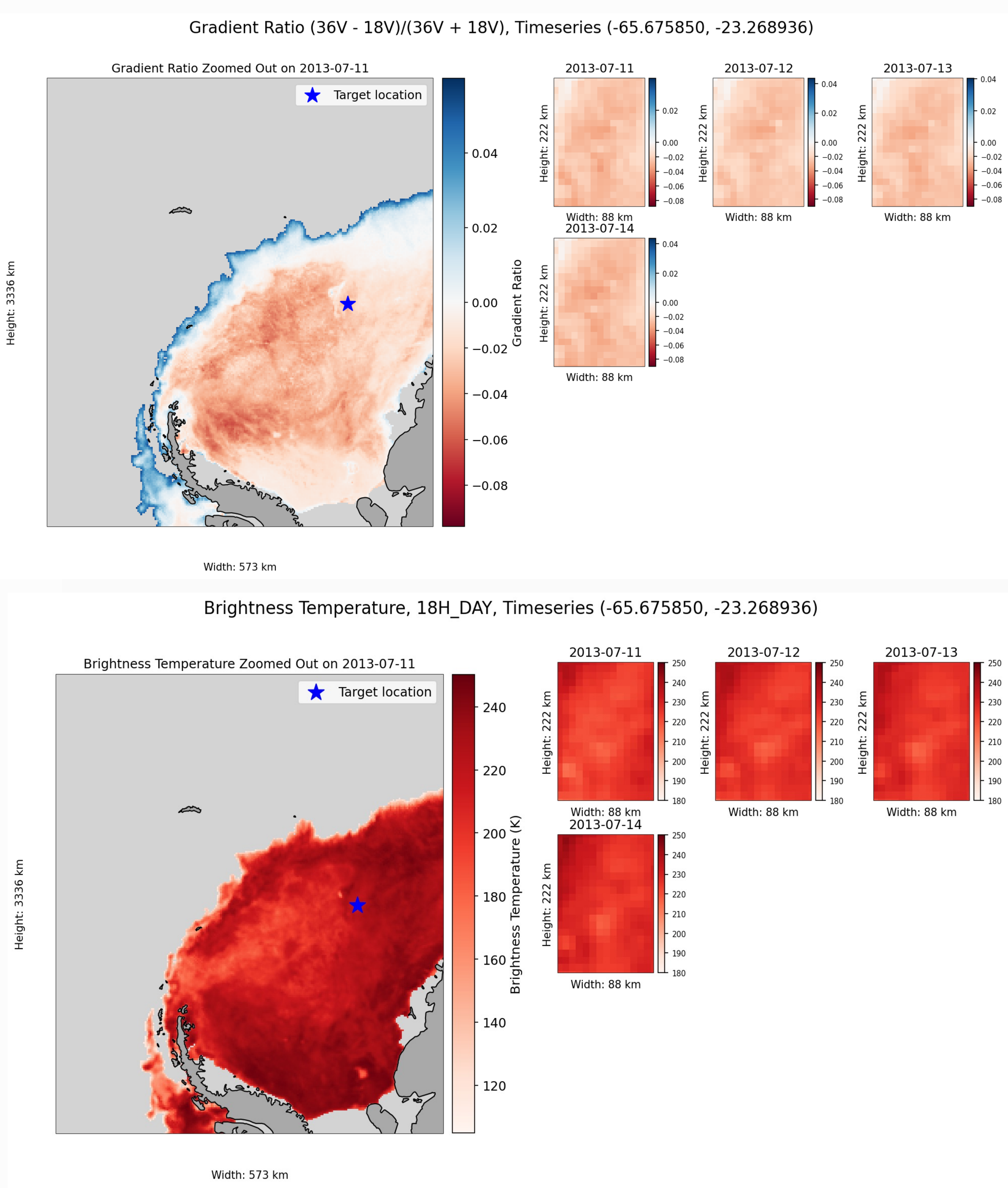
Hypothesis: After a flooding event, brightness temperature ↑. Once the water layer refreezes, brightness temperature ↓. Moreover, the GR for flooded/wet snow is near 0, because liquid water in the snowpack absorbs microwave energy which decreases backscatter [7].

Methods

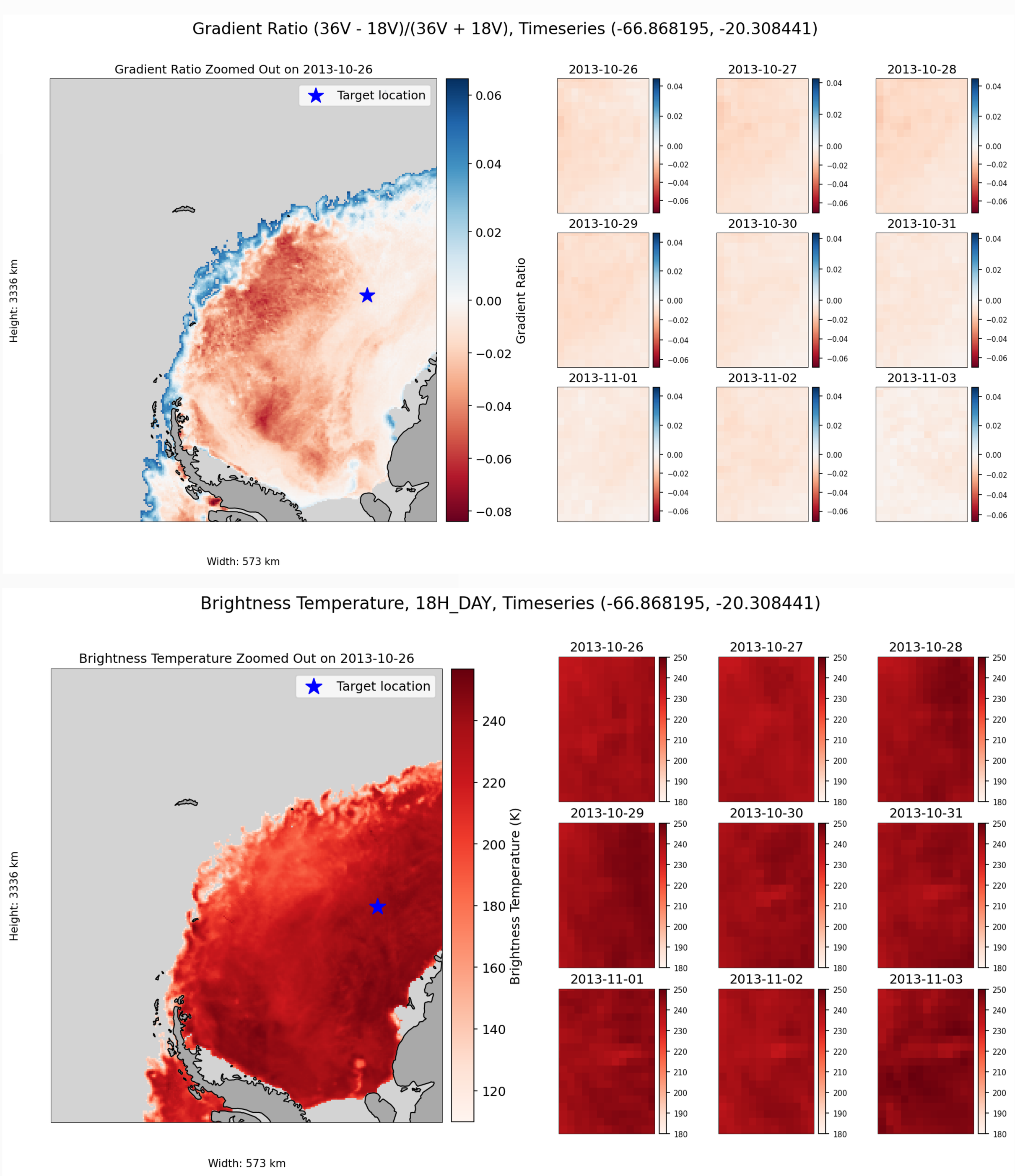
Dataset: AMSR-E/AMSR2 Unified L3 Daily 12.5 km Brightness Temperatures, Sea Ice Concentration, Motion & Snow Depth Polar Grids V001 [8]
Focus: Take dates + coordinates of ice floes where flooding was detected in situ (case study 1 and 2) and see if flooding can be detected via remote sensing using the dataset

Results

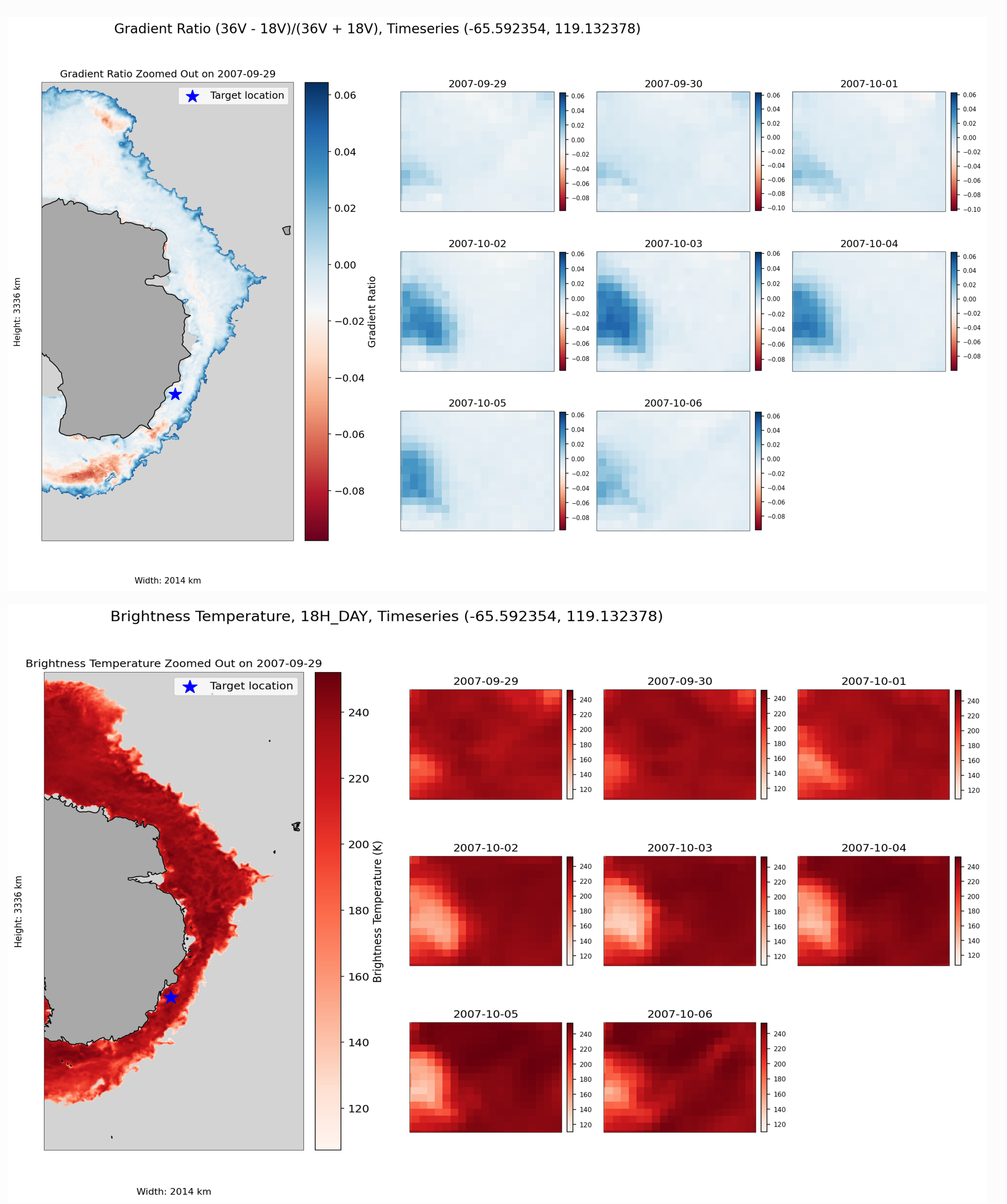
Base Case



Case 1



Case 2



Discussion and Conclusion

- Base case for flooding – the period when an ice floe station was installed in July 2013. The TB cartopy plots from this period are considerably lighter than those from Oct and Nov 2013, when flooding was observed in situ in case study 1. The base case plots are also lighter than case 2 (September 2007). These results are consistent with the hypothesis that flooding leads to an increase in brightness temperature, which would make the plots appear darker.
- The base case gradient ratio plots from July 2013 are predominantly red, with values approaching the negative end of the colorbar – consistent with a thicker snow cover. In case 1, the GR plots from Oct and Nov 2013 become lighter and move toward zero. In case 2, the plots are blue, with small positive values that also lie close to zero. In both cases, this could suggest that the snow during these periods is wet or flooded.
- An important next step would be to look at meteorology data and see whether in the periods of interest it rained or snowed.

Key References

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