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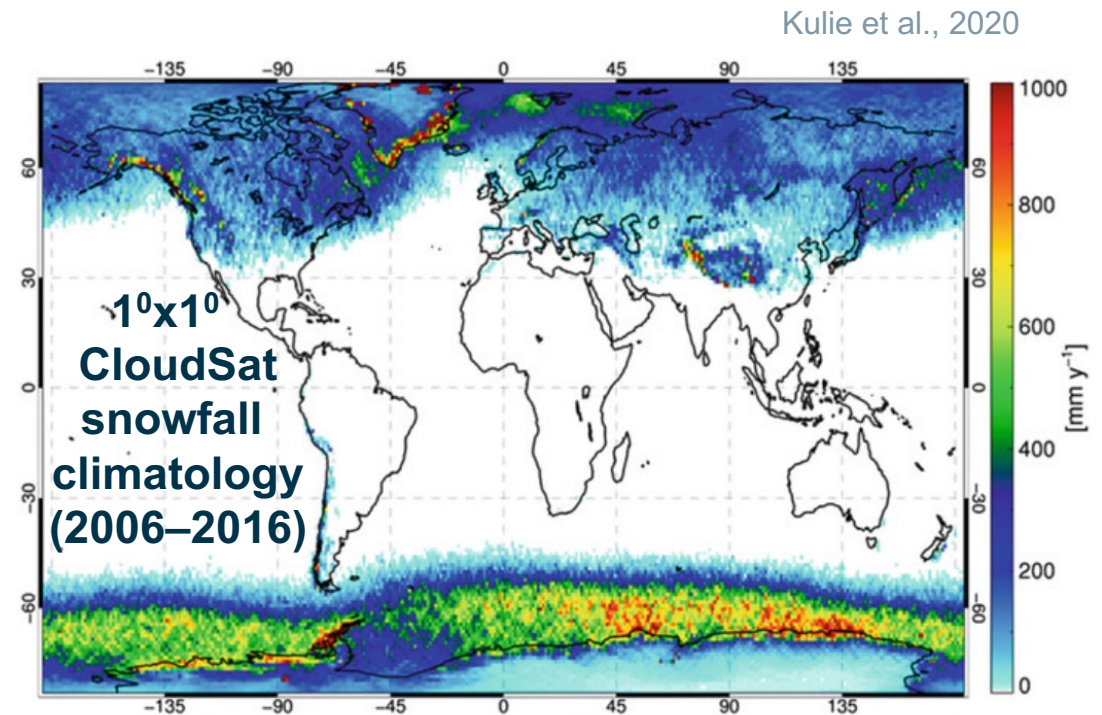
HOW CAN GLOBAL SNOWFALL ESTIMATES BE IMPROVED BY ESA'S PROPOSED EARTH EXPLORER 11 WIVERN MISSION?

Maximilian Maahn, Alessandro Battaglia, Marco Coppola, Sabine Hörnig, Pavlos Kollias, Stef Lhermitte, Nina Maherndl, Mario Montopoli, Filippo Scarsi, Frederic Tridon, and Anthony Illingworth



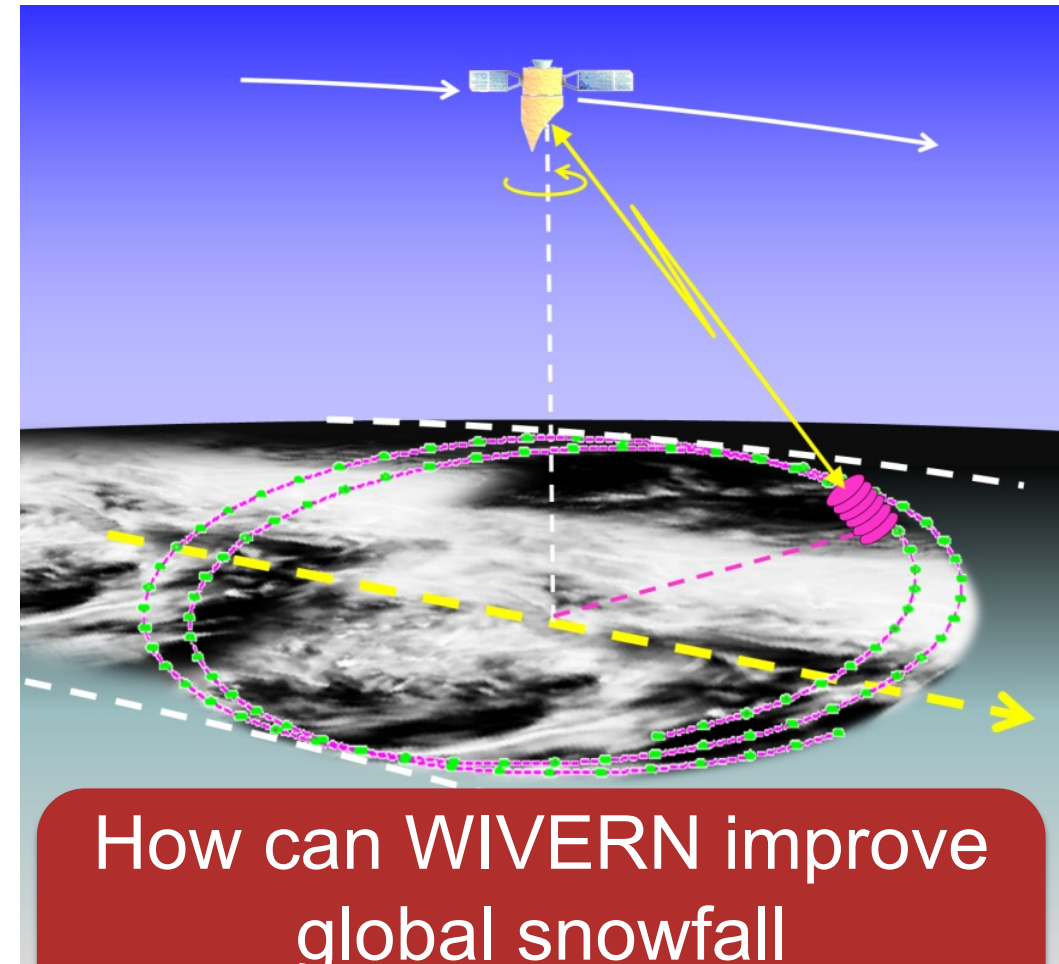
STATE OF THE ART: MEASURING SNOWFALL FROM SPACE

- Snowfall one of the most challenging climate variables to measure
- CloudSat's radar was the best source for snowfall climatology
- Snowfall radar retrievals based on well established empirical power-laws
- Significant random errors
- Poor sampling
- EarthCARE has same limitations



WHAT IS WIVERN?

- One of two remaining ESA Earth Explorer 11 candidates
- WInd VElocity Radar Nephoscope
- Will carry a *scanning* polarimetric 94 GHz Doppler cloud radar measuring at 38° off-nadir
- Will provide, for the first time, the global vertical profiles of winds in cloudy and precipitating areas
- Will fill a major gap in the global observing system
- Will improve a 72 hour forecast (T & RH at 850 hPa) by 1 hour

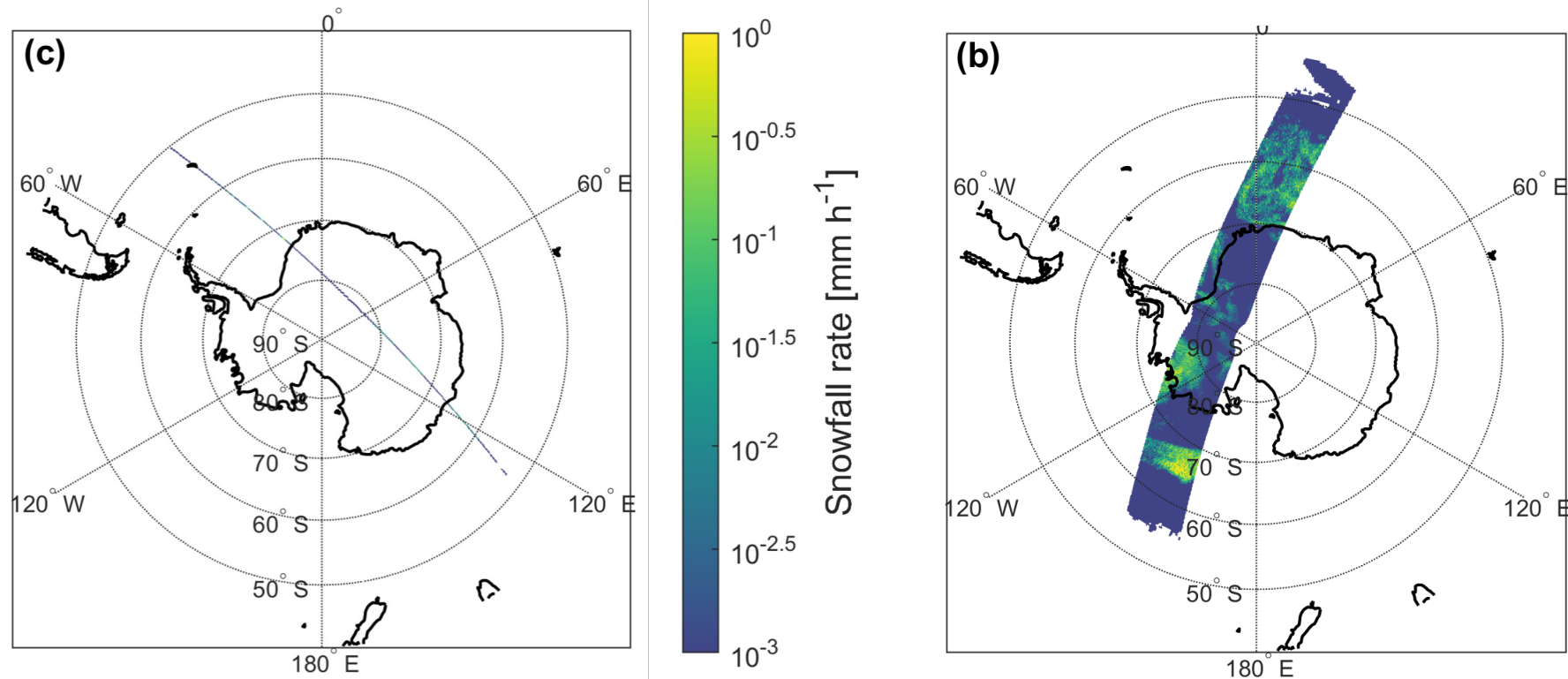




Scarsi et al., 2024

1) BETTER SAMPLING

- CloudSat and EarthCARE are pencil beam observations
- WIVERN has a 800 km swath - > 70x more observations

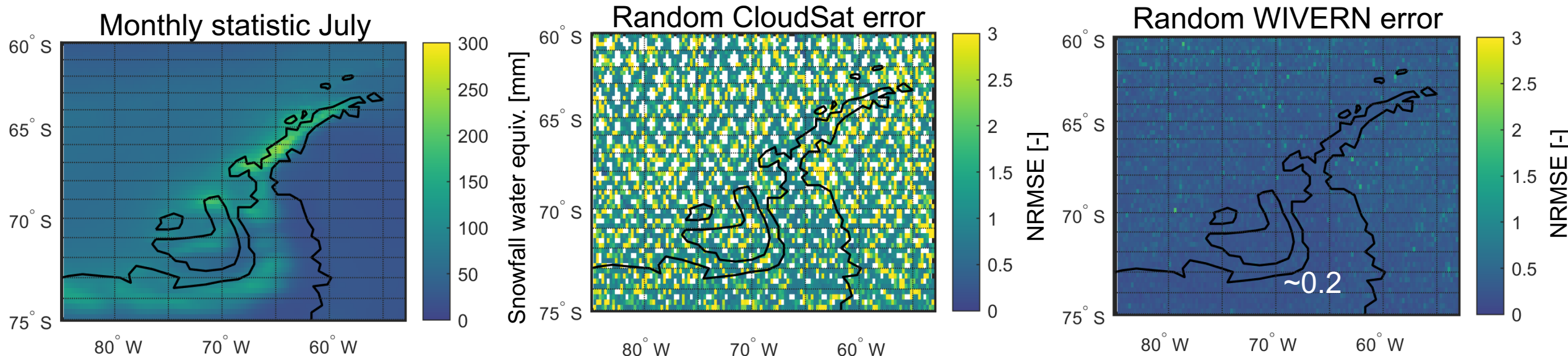




Scarsi et al., 2024

1) BETTER SAMPLING

- Investigate impact on monthly 0.25° snowfall statistic
- Consider random retrieval error, radar sensitivity (CloudSat -27, WIVERN -21 dBz)
- For CloudSat, sampling error more important than retrieval error
- WIVERN can provide monthly snowfall statistics!

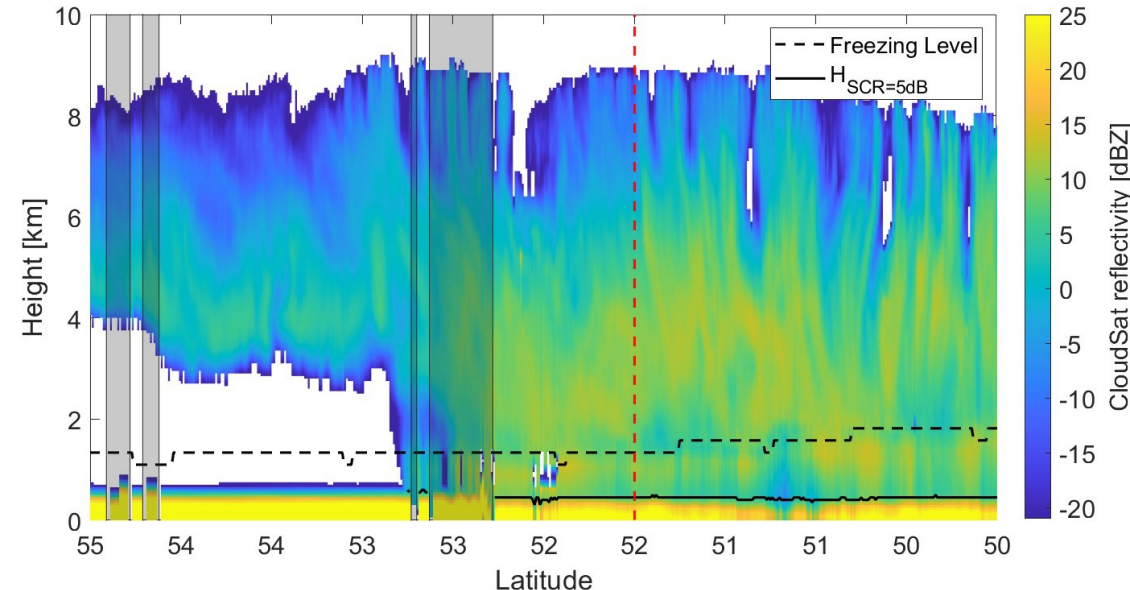




Coppola et al.,
2025

2) REDUCED BLIND ZONE

- Ground Clutter prohibits observations close to the ground
- Typical values for CloudSat: 1200 m over land & 600 m over ocean

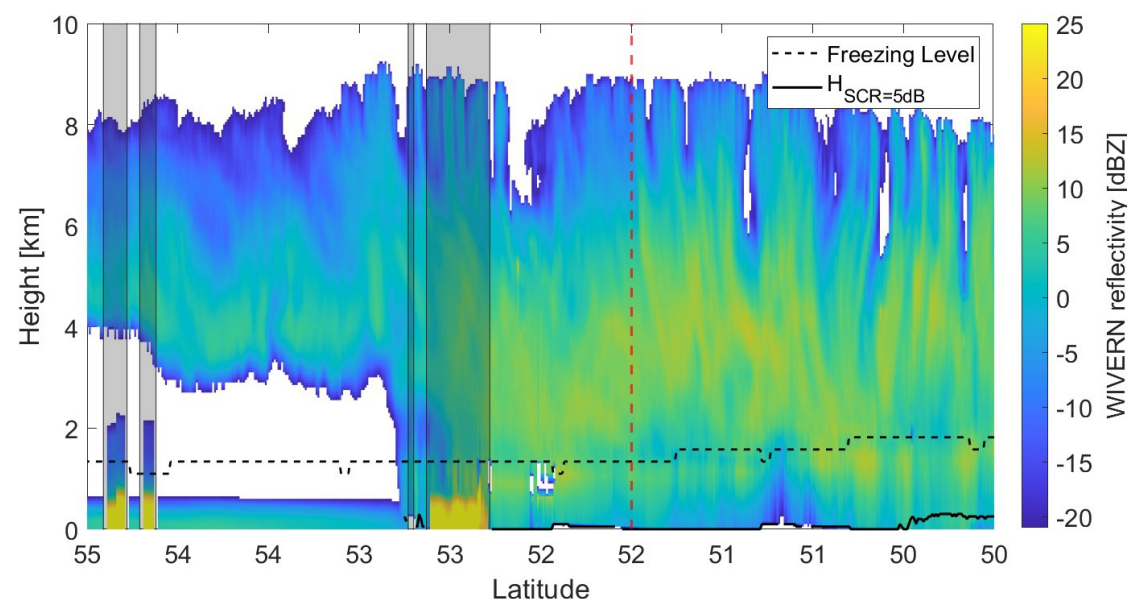




Coppola et al.,
2025

2) REDUCED BLIND ZONE

- Ground Clutter prohibits observations close to the ground
- Typical values for CloudSat: 1200 m over land & 600 m over ocean
- For WIVERN, ocean return reduced by 30 dB due to slanted angle
- Over ocean, WIVERN can see light precipitation often to the surface



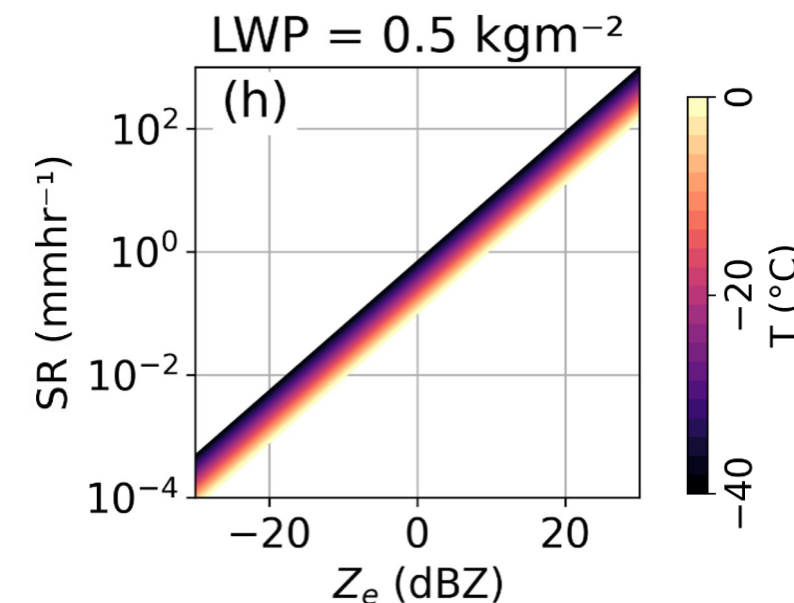


Maherndl et al.,
2025

3) BETTER RETRIEVALS

- WIVERN will provide collocated 94 GHz brightness temperatures for liquid water path (LWP) retrievals over ocean
- LWP is a proxy for riming
- Retrieval for snowfall rate (SR) considering LWP:

$$SR = a \cdot z_e^b \cdot 10^{c \cdot T} \cdot LWP^d$$
- Retrieval outperforms literature relations
- WIVERN will also (though quite noisy) polarimetric observations



Thank you!

SUMMARY

Even though designed as a mission for measuring in-cloud winds, WIVERN will improve global snowfall estimates by

1. Better sampling (Scarsi et al. 2024)
70 times better sampling allows for monthly snowfall statistics at 0.25°
2. Reduced Blind zone (Coppola et al. 2025)
Light precipitation can be often observed all the way to the ocean surface
3. Better retrievals (Maherndl et al. 2025)
Including passive observations over ocean reduces retrieval random error



Please cross your fingers for the mission selection in 7/2025!

