Airborne UWB Radar for Alpine Snow Measurements

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Abstract

An airborne 2-18 GHz frequency-modulated continuous wave (FM-CW) radar was developed for fine-resolution measurements of snow. The radar was deployed to the alpine region near Grand Mesa, CO to collect snow depth data. The radar is capable of measuring snow as thin as 3 cm and up to more than 10 m. Snow depth retrieved from the radar data agrees well with the in-situ data reported by nearby SNOTEL stations.

Introduction

The radar was developed for the Naval Research Laboratory to measure snow thickness over sea ice in Alaska.

Test flight opportunities were available in the early spring of 2016 and 2017 to deploy the radar to the alpine region near Grand Mesa to conduct airborne snow thickness measurements.

The radar operates from 2 to 18 GHz which provides the possibility of snow depth measurements with 1.5 cm range resolution.

In addition to nadir sounding mode, the system supports side-looking SAR imaging mode, offering a potential for estimating snow-water equivalent (SWE) from radar backscattered data.

Radar System Design

- **FMCW based architecture**
- **Parameter** | **Value** | **Unit**
  - Frequency band: 2-18 GHz
  - Bandwidth: 16 GHz
  - Chirp length: 240 µs
  - PRF: 3.9 kHz
  - Transmit power: 20-30 dBm
  - ADC sampling rate: 125 MSPS
  - ADC resolution: 14 bit
  - Range resolution: 1.5 cm
  - No. of TX channel: 2
  - No. of RX channel: 10

Data Collected near Grand Mesa, CO

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Conclusions

- A new multichannel 2-18 GHz FMCW airborne radar was developed to enable fine-resolution snow measurements.
- The radar was flown over the alpine region in Grand Mesa, CO.
- The radar has a vertical resolution of 1.5 cm, enabling measurement of thin snow (<10 cm), which was previously not feasible.
- Radar-derived snow depth shows a very good agreement to ground truth data.

Future Directions

- **Radar miniaturization**
  - Smaller radar package will enable UAS integration and potentially lower cost in snow monitoring
- **Side-looking SAR data**
  - SWE estimates can be obtained from multi-frequency SAR imaging data
  - Example SAR image collected:

Bibliography