Sensor synergy to detect clouds and precipitation: results of the first HALO-HAMP flight campaign.

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1. Introduction

Clouds and precipitation play an important role in the atmospheric water cycle and radiation budget. Unfortunately, the understanding of the processes involved in cloud and precipitation formation and their description in global and regional models are still poor. Not only models poorly describe such processes, also satellites retrievals often show discrepancies in surface precipitation estimates. To improve our understanding of these processes and to reduce model and retrieval uncertainties, new observation and retrieval techniques exploiting the synergy between active and passive sensors are needed.

With these foci the German research aircraft HALO (High Altitude Long-range Aircraft) took part to the NARVAL (Next-generation Aircraft Remote-sensing for VALidation studies) campaigns in December 2013 and January 2014.

2. HALO payload

- **HAMP (HALO Microwave Package)**
  - Radiometer: 26 channels spanning from 22 to 183 GHz, sensitive to water vapor, temperature and hydrometeor concentrations
  - Footprint at 13 km: from 1.2 km (K-band) to 0.6 km (183 GHz)
- **Radar:**
  - Pulsed Doppler radar at 36 GHz
  - 130 m footprint at 13 km
  - -38 dBZ sensitivity @ 5 km
- **WALES lidar:**
  - Water vapor absorption lidar
  - Four wavelength, three in the 935 nm H$_2$O absorption band
- **Dropsonde dispenser**
- **HALO SR (Solar Radiation)**
  - UVVIS and NIR spectrometer
- **Mini DOAS**
  - Trace gas, water vapor and ice detection

3. NARVAL campaigns

- **NARVAL-South**
  - 10 – 21 December 2013
  - 8 flights over tropical and subtropical Atlantic
  - 75 dropsondes released
  - Tropical boundary layer cloud formation and evolution

- **NARVAL-North**
  - 7 – 21 January 2014
  - 5 flights over North Atlantic
  - 2 transfer flights with several ground-based super-site overpasses
  - 42 dropsondes released
  - Investigate North Atlantic postfrontal shallow convection
  - Validate satellite precipitation retrievals

4. Sensor synergy

- **Radar – radiometer – lidar:** Liquid water and snow content profiles
- **Radar – radiometer:** Precipitation
- **Lidar – radiometer:** Water vapor profiles
- **Radiometer – dropsonde:** Temperature profiles (see poster n. 11 in session ‘Calibration techniques and methods’)

Figure 5 shows data collected during three pre-campaign flights which took place over Germany on the 7 and 11 June and 24 July 2013 to test the in-flight performance of the HALO payload.

5. Liquid water and water vapor column retrieval

- **K-band used to retrieve precipitable water (PW) and liquid water path (LWP)**
- **K-band allows retrievals for the whole atmospheric column also in the presence of thick clouds**
- **Comparison with dropsonde:**
  - RMS = 0.6 mm for precipitable water
  - High sensitivity of LWP retrieval will be used for satellite comparison/validation
  - Combine radar-radiometer-lidar to retrieve liquid water content profiles

6. Conclusion and future work

- The German research aircraft HALO successfully accomplished two measurements campaigns with its remote sensing suite on-board.
- NARVAL-South investigated trade wind shallow cumulus convection.
- NARVAL-North explored frontal and post-frontal convection over North Atlantic.
- Precipitable water retrieval has been developed and shows good agreement with dropsonde measurements (RMS = 0.6 mm).
- Liquid water path retrieval shows high sensitivity to thin clouds.
  - Multiple sensor retrieval for water vapor and hydrometeor concentration profiles are under development.
  - Data collected will be used for satellite retrieval validation and process studies.

7. Bibliography and Acknowledgments

- C. Klepp, S. Bakan and H. Grewe, 2005, Missing North Atlantic cyclonic precipitation in ECMWF numerical weather prediction and ERA-40 data detected through the satellite climatology HOAPS, Met. Zeit.
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