Motivation: operational profiling by ground-based remote sensing (RS)

• NWP and climate modelers require continuous profile measurements of the atmospheric thermodynamic state for model evaluation and initialization.
• Ground-based remote sensing stations (GRSS) equipped with a microwave profiler (NWP), a cloud radar and a lidar ceilometer possess the potential of continuously profiling temperature (T), humidity (q) and liquid water content (LWC).
• The IPT combines such measurements together with a priori information within an optimal estimation based retrieval scheme.

Motivating questions:
• How accurate are GRSS T & q profiles w.r.t. radiosondes? How accurate are LWC profiles?
• How important is the a priori knowledge? What type of a priori is needed for optimal retrieval performance?
• Can operationally implemented GRSS complement the existing radiosonde network?
• Can GRSS replace the role of radiosondes (e.g. in remote areas)?

IPT accuracies:

Description
• IPT (der) RMS is the theoretical error given by the IPT method.
• The reg algorithm is empirical: based on linear regression

Discussion
• blue minus red RMS lines indicate the information gain through RS, which is observed up to 4km (average: T = -0.4K; q = -0.4gm^-3)
• similarity of IPT (calc) and IPT (der) indicate satisfactory retrieval performance
• IPT outperforms reg

Description:
• The shown results are the accuracies averaged over the lowest 4 km of the profile
• The x-axis shows the distance between RS site and radiosonde site
• blue minus red bars indicate the information gain (IG) through RS

Discussion:
• accuracy is best at small distances, however IG is enhanced at greater distances
• For both T & q, RMS accuracies show “saturation” effect around 400km (1.0K / 0.7gm^-3) as accurate as statistical a priori
• IPT can, to a certain degree, minimize BIAS errors contained in the a priori

IPT accuracies: the cloudy skies → LWC, in-cloud humidity & in-cloud temperature as a function of height above cloud base

• IPT and a priori RMS & BIAS errors for in-cloud humidity
• IPT RMS behavior very satisfactory (~ 0.5gm^-3 average) due to saturation constraint
• a priori BIAS: cloudy cases contain more moisture than clear cases on average

• LWC: IPT RMS error (calc), theoretical error (der) and, RMS error of simple 2-LWC relation scaled with 1,4-wave derived LWP; also: mean LWC profile for orientation
• On average, IPT values are 17% more accurate than scaled 2-LWC values
• IPT and a priori RMS & BIAS errors for in-cloud temperature
• IPT RMS behavior very similar (~ 0.7K on average) as in the clear & cloudy cases
• Reasons for positive BIAS (a priori & IPT) have not yet been identified

Conclusions and implications
• GRSS can provide continuous profiles of T & q with accuracies better than 1.1K, respectively 0.7gm^-3 on average in the lowest 4km.
• The information gain through RS can be as high as 3K and 1gm^-3.
• IPT T & q performance can be significantly improved if operational radiosonde profiles launched within a 400km radius of the RS site are used as a priori.
• In-cloud IPT T & q performance is as accurate as outside the cloud.
• Adequately equipped GRSS allow, in contrast to radiosondes, the continuous retrieval of LWC profiles with accuracies of 30% on average.
• Once installed a GRSS can complement an existing radiosonde network by adding extra spatial and temporal information.
• In a dense radiosonde network (100-200km), GRSS may be able to replace existing radiosonde launch sites; overall accuracies of 0.5K and 0.5gm^-3 seem possible.
• Need further studies to quantify possible systematic retrieval errors due to microwave absorption uncertainty!