The GlobVapour Project is developing multi-annual global water vapour data sets based on calibrated and inter-calibrated satellite radiance for long-term series satellite observations. On the other hand, integrated Water Vapour (IWV) estimations derived from ground-based Global Navigation Satellite Systems (GNSS) observation networks such as the International GNSS Service (IGS) network are also very promising, with continuous observations spanning over the last 15 years. Additionally, the AERONET (Aerosol Robotic Network) (AERONET) also provides long-term and continuous ground-based observations of the IWV performed with standardized and well-calibrated sun photometers. Finally, radiosonde measurements offer long time series of IWV, but suffer from inhomogeneities due to changes in the used humidity sensors throughout time.

The aim of the present study is to set up an inter-technique comparison of IWV measurements from satellite devices (CIMEL, GOME(2), OMEC(2)/SCIAMACHY) and the ground-based methods to resolve the above mentioned ground- and in-situ instruments. To this end, we selected 26 sites worldwide for which GNSS observations were directly compared with simultaneous satellite IWV observations, together with sun photometer and radiosonde measurements, if available. In particular, we investigate the inter-technique biases, the influence of the presence of clouds on the IWV inter-technique comparison and the geographical dependency of the property of the IWV scatter plots between all those different instruments.

2. INTER-TECHNIQUE COMPARISONS

As a first step, this study focused on Leuven, Brussels, Belgium (50°44’N, 4°21’E, 100m a.s.l.) presenting the following advantages:

- The site is equipped with 3 CIMEL instruments and the automatic weather station (time resolution 10 min) is newly located at the same site, so the horizontal and vertical separation of the different devices is not an issue.
- All instruments are available for this site.
- We dispose of all metadata of the different instruments, so that we are aware of any instrumental change that might give rise to an inhomogeneity of the instruments data series.
- The availability of auxiliary weather data is a major advantage.

From Fig. 2, we note:

- The different instruments have different observation periods.
- We have 2 radiometers types: Vaisala’s FS90 and R925/960/980.
- The GPS IGSS IWV is a good candidate for reference device because of the data daily (or since 1998), only minor data gaps, homogenous data (no processing by IGS).

The degree of scatter does not make it possible to determine the sources of the scatter.

EXPLORATION OF THE IWV DATASETS @ BRUSSELS

We conducted scatter plots of simultaneous (Δt = 10 min for CIMEL, Δt = 30 min for RS and GOME(2)/SCIAMACHY) IWV measurements between the different devices (using the GNSS data as reference, see Fig. 3). These plots show that:

- The mean bias between the different techniques is between -0.6 mm (GOME(2)/SCIAMACHY to 0.6 mm (FS90).
- The best correlation and lowest dispersion (Δt = 10 min) points are reached for the CIMEL vs. GNSS comparison.
- Vaisala’s state-of-the-art radiosonde type (R925/960/980) provides better accuracy than the preceding FS80 type.
- The temporal resolution of free w.i.t. GNSS is closer to 1 for other all-weather devices (FS90) than for instruments demanding a partly clear sky (GOME(2)/SCIAMACHY, A small study incorporating the available cloud cover data demonstrated that the presence of clouds leads to higher IWV values, in particular for the GNSS observations, compared to the simultaneous CIMEL measurements.

3. CONCLUSIONS AND PERSPECTIVES

- CIMEL sun photometers and GNSSs are very valuable ground-based techniques and therefore good candidates to evaluate/calibrate the long-term for datasets provided by satellite devices: they correlate very well (their mean R² is 0.984) and typically agree at the level of 0.3 mm ± 1.5 mm of IWV.
- Influence of clouds: for large IWV values, the GNSS instrument measures higher amounts of IWV than the CIMEL does. This can at least partly be explained by the observation bias of the CIMEL instrument: it requires a clear sky in the direction of the sun. But the larger the IWV values, the higher the probability to have clouds, which would directly impact the CIMEL IWV observations.
- Both ground-based techniques are very promising to build up long time series for climate applications, as long as the data homogeneity can be guaranteed. For the CIMEL photometers belonging to the AERONET, a regular calibration of the instrument is required. IGS GNSS data were retrieved based on microwave (MMR) from 1994 on in April 2011.

As a first example, we evaluated the GOME(2}/SCIAMACHY satellite IWV dataset. The GOME(2)/SCIAMACHY IWV measurements are susceptible to a similar observation bias as the CIMEL (almost cloud free skies are needed), which is also reflected in the low mean value of the regression line slope for these satellite data. The largest (but apparently random) geographical variability of the IWV measurements relative to the co-located GNSS observations is obtained.

At this point of our research, there is no clear geographical pattern (e.g. related to the climate type) in the inter-technique comparisons at the selected sites worldwide.

* This research might be extended to other (e.g. IR) satellite devices measuring IWV.

REFERENCES