Integrated Water Vapour Measurement at Jungfraujoch

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Introduction

Water vapour feedback in the mid-troposphere (400-700 hPa) is expected to play a crucial role in climate change. We present integrated water vapour (IWV) data from the Global Positioning System (GPS) receiver at Jungfraujoch (mean annual pressure 655 hPa) and use it to develop an altitude correction for the 31 stations in the Swiss GPS network (see Figure 1).

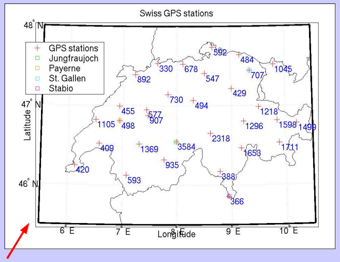

Figure 1 – Stations in the AGNES (Automated GPS Network of Switzerland) run by swisstopo.

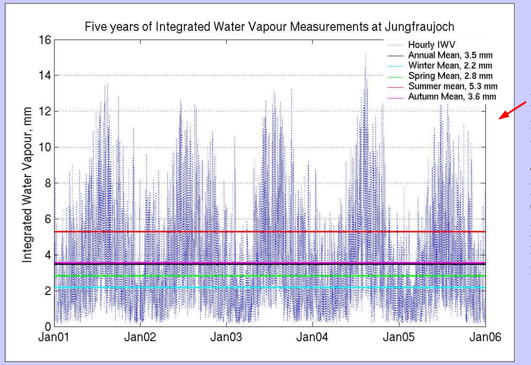

Figure 2 – The five year IWV time series at Jungfraujoch produced from GPS, sun photometer and radiation measurements.

Water vapour data at Jungfraujoch

The Jungfraujoch data consist of hourly GPS observations[1]. At this altitude the IWV can be as low as 0.2 mm. However, the GPS has an accuracy of ± 0.7 mm and unrealistic negative measurements occasionally occur. When the GPS records less than 1 mm water vapour, it is supplemented by IWV estimates from sun photometer[2](2 % of time) and radiation measurements[3,4](15 % of time). Figure 2 shows five years of IWV measurements.

Change in IWV with altitude

The IWV is higher in summer than in winter. It also decreases with increasing altitude in an exponential manner, as shown in Figure 3.

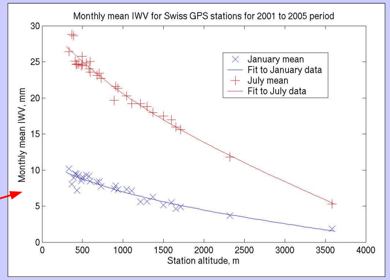

Figure 3 : The exponential fit to the monthly mean IWV data is calculated using Equation 1.

Topographical differences dominate the GPS IWV measurements. We correct IWV at the station height h to a standard height of 500 m, *IWV(0.5),* using Equation 1 where a is a dimensionless factor (annual mean, 1.02) and H is the scale height (annual mean 2.1 km)[4].

$$IWV(0.5) = a * IWV(h) * \exp\frac{(h-0.5)}{H}$$

Equation 1

Figure 4 shows that the scale height is related to the ratio of IWV at Jungfraujoch to that measured at Payerne.

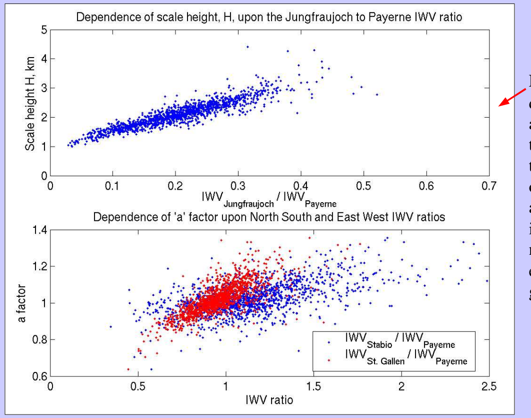

Figure 4 – GPS data from 2004 are used to show that H is related to the gradient of IWV with altitude while a is related to the north-south and east-west IWV gradients.

Five year IWV climatology for Swiss GPS stations

IWV measured at all Swiss GPS stations was corrected to a standard height of 500 m using Equation 1. Five years of seasonally averaged IWV(0.5) data are shown in Figure 5. Jungfraujoch has a similar IWV(0.5) to surrounding stations in the winter but is 2 to 5 mm drier in other seasons.

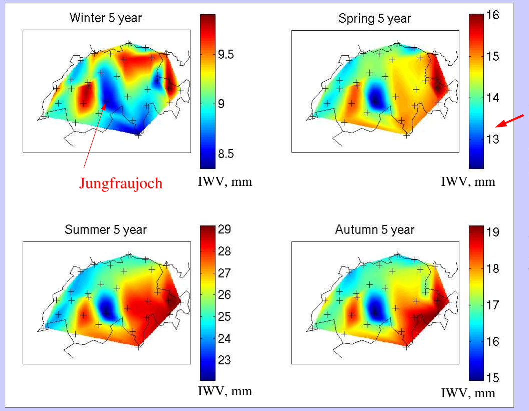

Figure 5 – Station averages of IWV(0.5) for the winter, spring, summer and autumn months in the 2001 to 2005 period.

Conclusions

- Jungfraujoch is a key station for developing an altitude correction for IWV measured by the Swiss GPS network.
- When equivalent altitudes are considered, the Alps are moister than the Swiss plains and the Jura in all seasons except winter.
- A dry IWV bias is observed at Jungfraujoch in the warmer months but not in winter. Is this due to the predominance of convection versus advection?

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Data and more information: Data and more information at

http://www.iapmw.unibe.ch/research/projects/STARTWAVE/startwave_dbs.html

References: (1) J. Morland, M. A. Liniger et al. (2006), Comparison of GPS and ERA40 IWV in the Alpine region, including correction of GPS observations at Jungfraujoch (3584 m), *J. Geophys. Res., 111, D04102, doi:10.1029/2005JD006043.* (2) S. Nyeki, L. Vuilleumier et al. (2005), A 10-year integrated atmospheric water vapor (IWV) record using precision filter radiometers (PFR) at two high-alpine sites, *Geophys. Res. Lett., 32, L23803, doi: 10.1029/2005GL024079.* (3) C. Ruckstuhl and R. Philipona (2005), Observed relationships between surface humidity, integrated water vapour and longwave downward radiation, poster presented at the *4th International NCCR Climate Summer School, Grindelwald, Switzerland, 27 August - 2 September, 2005.* (4) J. Morland and C. Mätzler (2006), Spatial interpolation of GPS integrated water vapour measurements made in the Swiss Alps, submitted to *Meteorological Applications*.