Water vapour dynamics over Switzerland during severe precipitation in August 2005

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1. Motivation

Water vapour is a natural greenhouse gas. An increase in air temperature of 1°C due to global warming results in an increase of approximately 6% in water vapour, leading to further warming (1). Monitoring of water vapour is therefore essential.

Here, we present a preliminary analysis of water vapour during a severe precipitation episode which affected Switzerland in August 2005 - one of the most costly weather disasters in Swiss history (2).

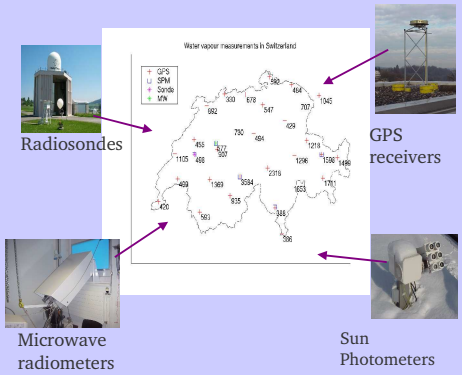


Figure 1: The water vapour observing network of Switzerland, showing the location microwave radiometers, radiosonde station, sun photometers and 31 GPS receiving stations.

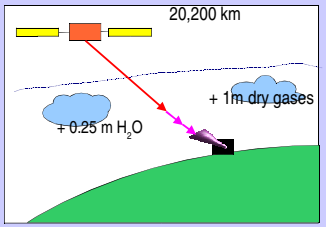
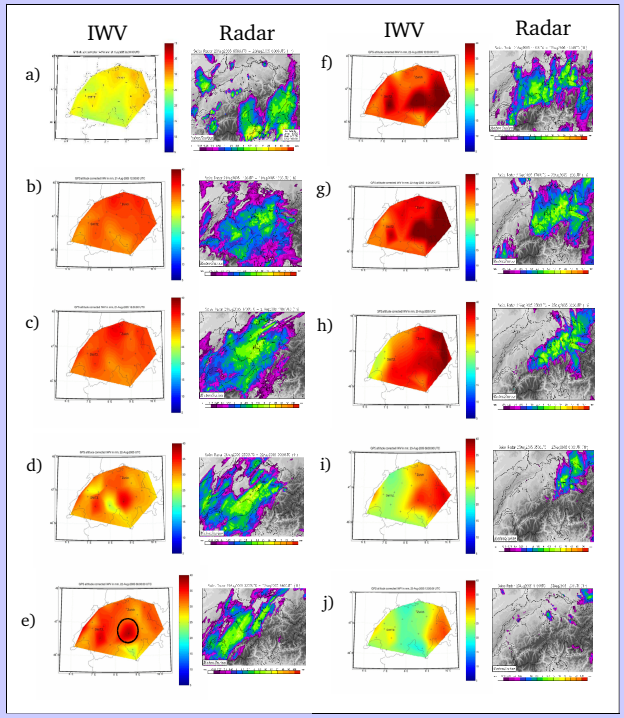


Figure 2: The GPS satellites orbit at at an altitude of 20,200 km and emit microwave signals which are captured by ground receivers. These signals are delayed as they pass through the atmosphere, the delay being expressed as an extra distance (metres). Part of the delay is due to nitrogen and oxygen (dry gases). The rest is due to water vapour.

2. Methodology

A comprehensive water vapour observing network exists for Switzerland. The system includes Global Positioning System (GPS) receivers, microwave radiometers and radiosonde measurements (Figure 1).

The 31 GPS receivers are favourably situated at altitudes ranging from 330 to 3600 metres. Estimates of integrated water vapour can be made using them (Figure 2). When combined with measurements made by the microwave radiometers and radiosondes, a good picture of the water vapour distribution over Switzerland is obtainable.



Figures 3 (a-j): GPS integrated water vapour (IWV) maps for Switzerland during the period 21-23 August 2005 (corrected to a height of 500 metres), at 6-hourly periods from 0600 GMT on 21/8/2005 to 1200 GMT on 23/8/2005. Also shown alongside is the MeteoSwiss rainfall radar for the same time. Andermatt GPS station is circled in image (e).

3. Case study of August 2005 floods in Switzerland

Severe floods and landslides followed prolonged precipitation over the northern Alps during the period 21-23 August 2005.

Hourly integrated water vapour (IWV) maps of the event have been created using the GPS data and are shown in Figure 3. The rainfall radar maps for the same time are also shown alongside. Since water vapour normally decreases with height (the relationship is approximately exponential) and because Switzerland is a mountainous country, it has been necessary to correct these maps to a standard height of 500 metres above sea level (3).

4. Results

(i) Integrated water vapour exceeds 40mm at the peak of the precipitation

(ii) The largest values occur consistently above the GPS station which is closest to the region of heaviest precipitation (black circle in figure 3e).

(ii) Integrated water vapour values remain high during the precipitation, indicating that supply of water vapour by advection equals or exceeds that lost by precipitation

5. Further work and information

We plan to undertake a mass balance study to confirm whether the flux of water vapour into Switzerland (including evaporation) is equal to the flux out of the country (minus what is lost by precipitation). Work is currently in progress to increase the GPS water vapour network to include over 100 European stations.

The complete water vapour database is known as STARTWAVE (4) and is available for researchers on the world wide web at http://www.iapmw.unibe.ch/research/projects/STARTWAVE/

References: (1) IPCC (2001): Climate Change: The Scientific Basis, Cambridge University Press. (2) Guy Carpenter and Company Ltd. (2005), European Flood Report 2005-Central and Eastern Europe. (3) Morland J. and C. Mätzler (2006): Spatial interpolation of GPS integrated water vapour measurements made in a mountainous terrain, submitted to Meteorological Applications. (4) Morland J., B. Deuber, D. G. Feist, L. Martin, S. Nyeki, N. Kämpfer, C. Mätzler, L. Vuilleumier (2005): The STARTWAVE atmospheric water vapour database, Atmospheric Chemistry and Physics Discussions 5, 10839-10879, 2005, and under review in Atmospheric Chemistry and Physics. Acknowledgements: Funding for this project is provided by NCCR-Climate. The GPS data is provided by the Swiss Federal Office of Topography (SwissTopo). For further information, please contact: eddie.graham@mw.iap.unibe.ch