GPS derived integrated water vapor in aLMo: impact study with COST 716 near real time data

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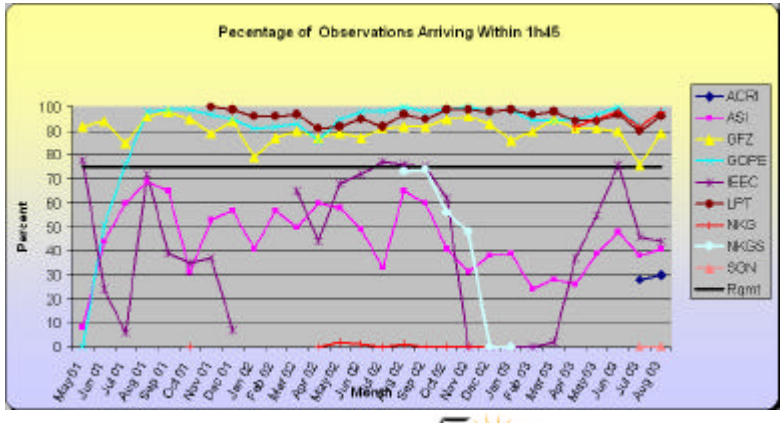
COST 716 near real time project

- About 250 european sites
- Seven processing centres, using different algorithms
- Hourly zenith tropospheric delays (ZTD) files in COST format delivered at UK Met Office

- Goal is data delivery within 1h 45
- At least three centers capable of delivering more than 90% of data in this time window:
  - GFZ - Potsdam, Germany (two obs. per hour)
  - GOPE - Pency, Czech Republic (hourly obs.)
  - LPT - Wabern, Switzerland (hourly obs.)
- These three centers represent about 140 stations



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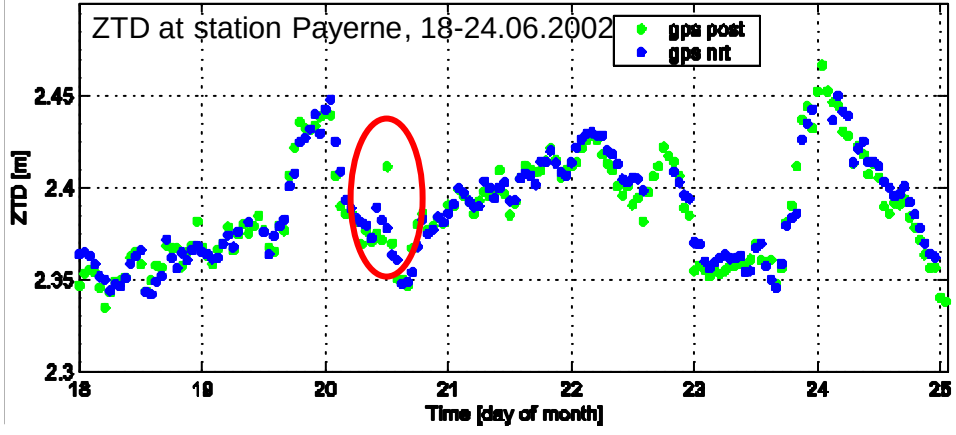
Quality of GPS data

- It has been demonstrated that the integrated water vapor can be retrieved using ground based GPS with the same level of accuracy as radiosondes and microwave radiometers

- A good agreement between near real time and post-processed data is observed
  - over Switzerland for 7 days in June: ZTD bias of 2.3 mm, ZTD std. dev. of 8 mm
- Strong discrepancy can however occur, due to smoothing by near real time algorithm
  - ZTD bias of 35 mm the 20th of June at Payerne, due to passage of a cold front



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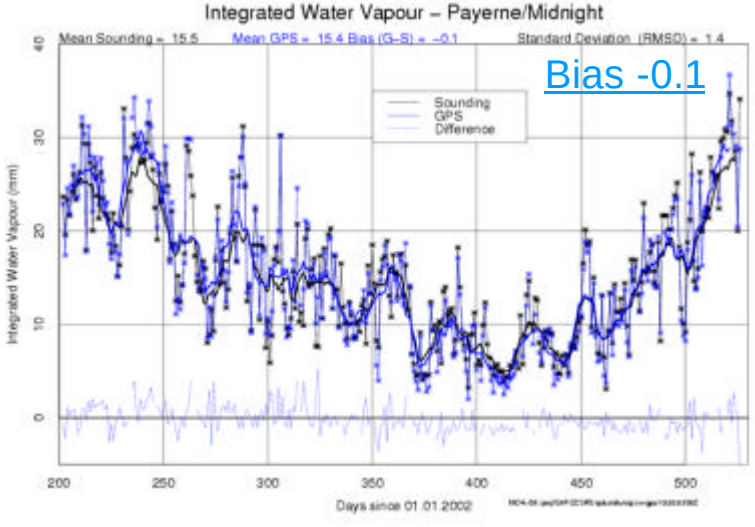
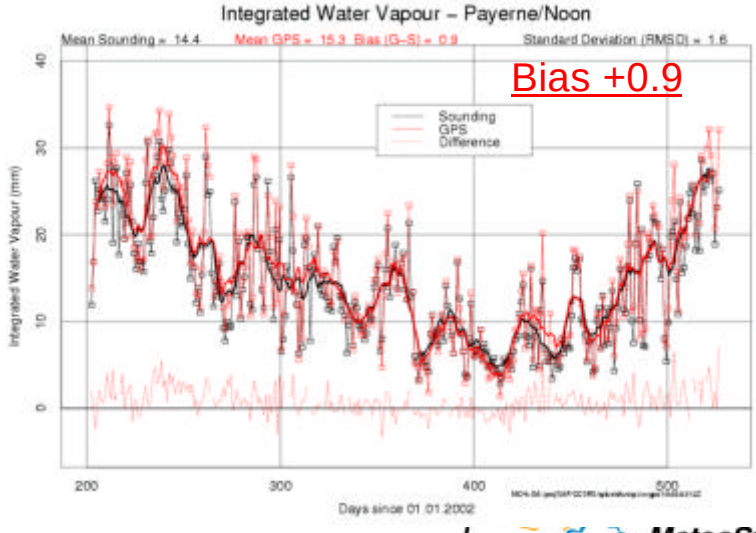
GPS versus radiosonde

- A dry radiosonde bias in mid day observations has been reported
- Hasse et al. 2002 submitted to Bull Am. Meteor. Soc.
  - „From over two years of data, the difference between radiosonde and GPS ZTD has standard deviation of 12 mm and bias of 7 mm. […] The bimodal distribution of residuals, with a higher bias for daytime launches, indicates these biases may be due to radiosonde day-night measurement biases.“
  - „This day-night bias of radiosondes has been documented in simultaneous flight tests comparing many standard radiosondes against a reference radiosonde.“
- A similar feature is observed at Payerne (Switzerland)





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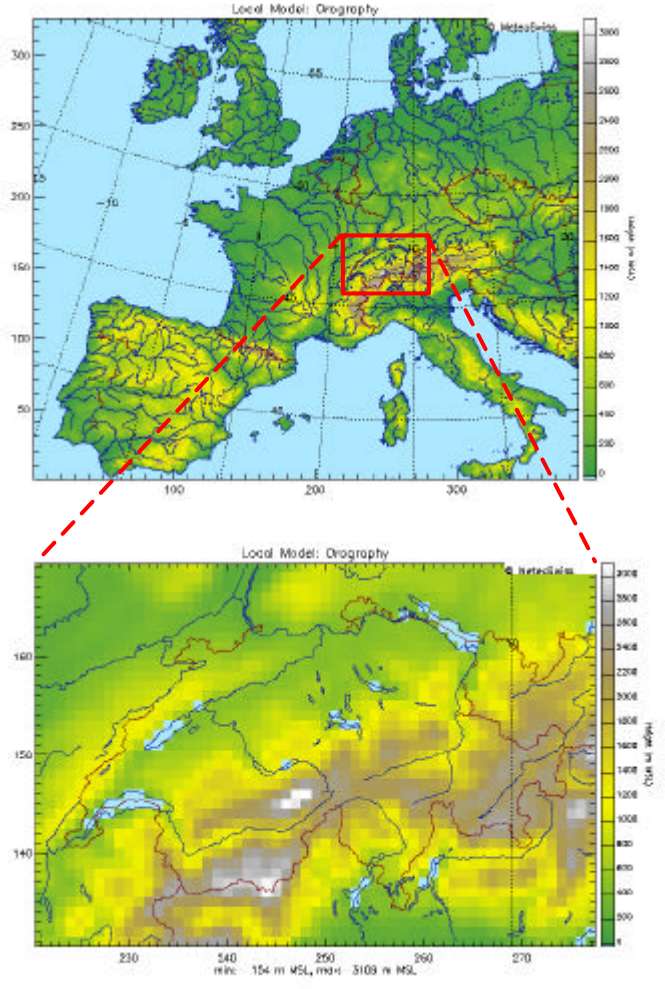
MeteoSwiss NWP model (aLMo)

- Nonhydrostatic fully compressible model based on COSMO code
- Domain covers most of western Europe
- Grid resolution is 1/16º (~ 7km); 45 terrain following hybrid layers
- Lateral boundary conditions from ECMWF model
- Own nudging based assimilation cycle; only conventional data used:
  - Ship, Synop, Buoy
  - Pilot, Temp
  - Amdar, Airep



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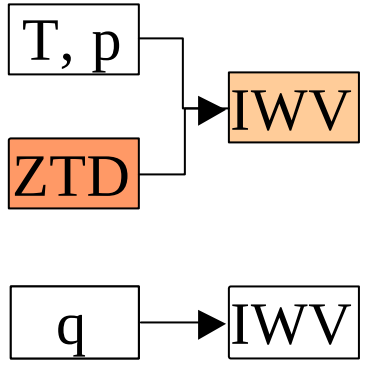
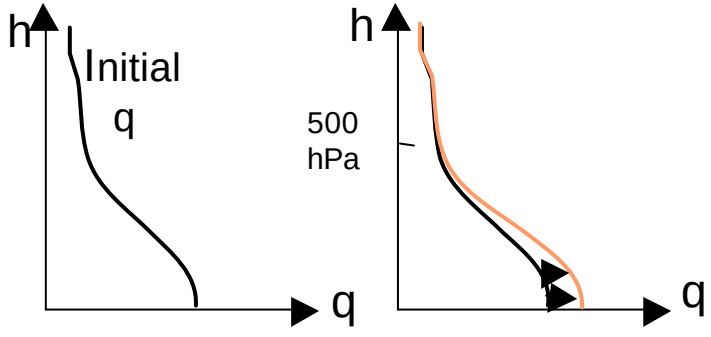
GPS assimilation with the nudging method

- ZTD is converted in integrated water vapour (IWV) using the model temperature and surface pressure
- GPS IWV is compared with aLMo IWV and an IWV ratio (GPS versus aLMo) is calculated



$$\frac{IWV}{IWV} = K$$

- using this ratio the model specific humidity profile is scaled from the surface up to 500 hPa
- the model specific humidity increments are spread laterally using an autoregressive horizontal weight function with a typical scale of 35 km



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Experimental setup

- Observing system experiments based on aLMo operational configuration
- 2 configurations are defined
  - reference: only conventional data are assimilated
  - gps: in addition, GPS derived IWV is also assimilated
- 4 periods are considered
  - 9 - 23 September 2001 (preliminary study)
  - 9 - 13 September 2001 (advective weather regime)
  - 10 - 14 January 2002 (winter stratus)
  - 18 - 24 June 2002 (summer convection)
- For each period and for each configuration
  - continuous assimilation cycle
  - 2 daily 30 hour forecast, starting at 00 and 12 UTC

- Data from GFZ, GOP and LPT are used
- French GPS sites only available for the June 2002 period

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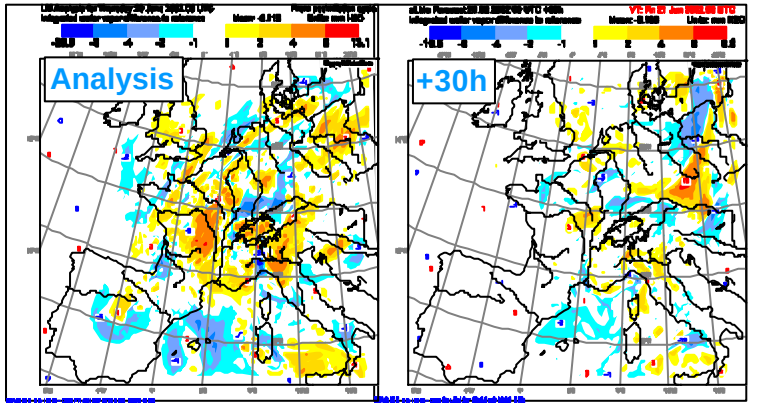
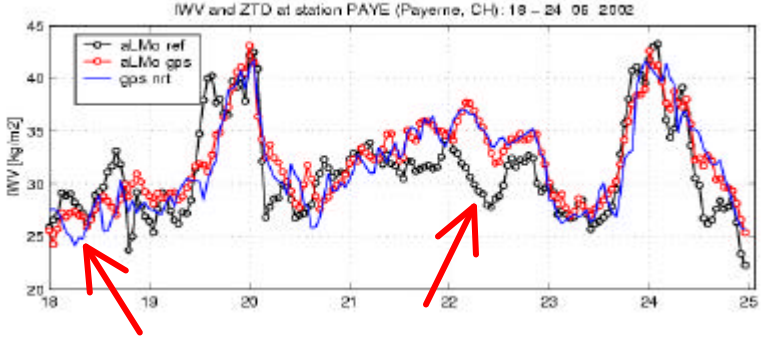
Impact on humidity field

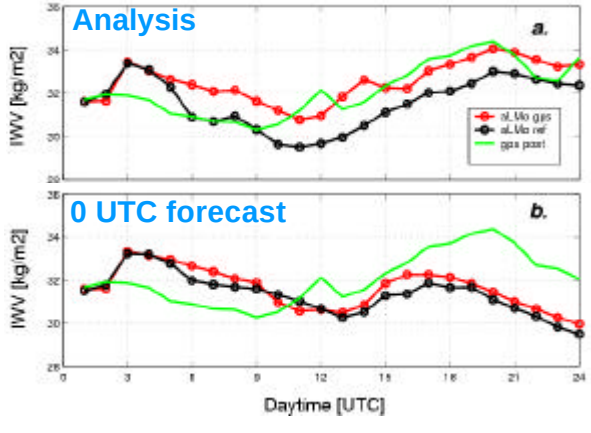
- Dependent on weather regime/season; impact on IWV analysis is
  - January: ±10% (average IWV 10mm)
  - September: ±20% (average IWV 20mm)
  - June: ±30% (average IWV 32mm)
    ±20% up to +30h forecast



- The implemented scheme corrects a large part of IWV deficiencies observed in the reference experiment
  - stronger forcing with shorter time scale could be beneficial



- Over Switzerland a dry bias of the reference analysis is observed during day time, well corrected in GPS experiment
  - std is also reduced by 50% in the GPS exp.
  - a small positive impact is still present in the 24h forecast



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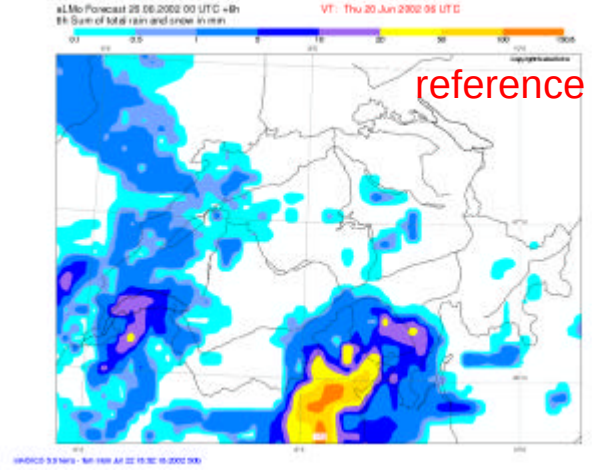
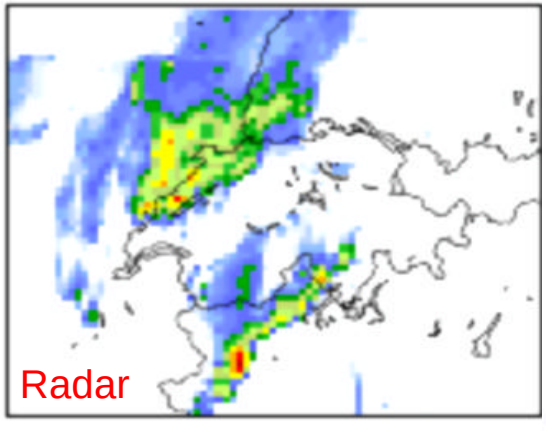
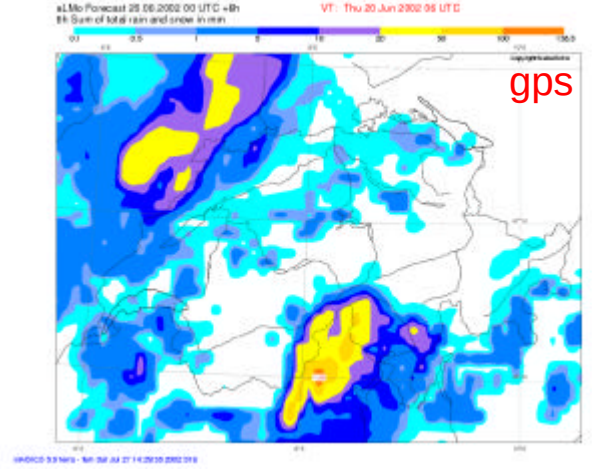
Impact on precipitation

- Weak impact both on January and September experiments
- Both positive and negative impact on the June experiment
  - the considered period was characterized by intense precipitation events (¡ 20mm/6h)
  - one case with overestimated analyzed precipitation south of Alps aggravated
  - one case with a missing structure in the 6h reference forecast has been clearly improved (20/06/2002 00 UTC)







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Conclusion and outlook

- Data coverage is unequal, from good (CH, DK,…) to pretty poor (ES, FR, …)
  - operational use of GPS depends on future data availability (agreement with geodetic community)
- Prescribed data availability is reached for 95% of the sites inside aLMo domain
- Data quality is similar to radiosonde data, with occasional smoothing caused by near real time processing

- Model water vapor benefits from GPS data - in summer an impact is visible up to the end of the forecast (+30h)
  - a model dry bias during day time (against GPS) could be related to a similar TEMP bias
- Occasional positive impact on precipitation and cloud pattern in the short range forecast (6 h) – negative impact on precipitation quantity also observed
- Otherwise mainly neutral impact
  - Small positive impact on analyzed 2m temperature and dew point (both bias and std)

- Following tuning of the nudging scheme could be envisaged
  - stronger forcing with shorter time scale
  - GPS derived water vapour gradient to improve horizontal spreading of data
  - reconstruction of vertical profile is the weakest point of the method; combining GPS with other data (e.g. clouds) or using tomographic methods could improve this point

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