Fog forecast impact studies for Sofia Airport: Numerical Weather Prediction simulation and use of GNSS tropospheric products

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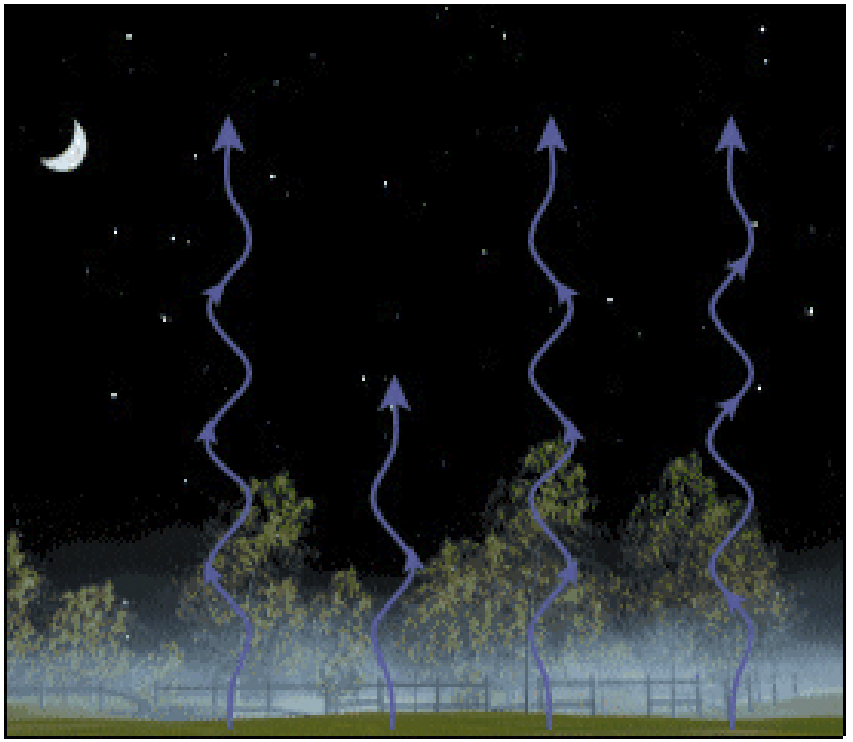
Motivation

- fog: low level phenomenon dependent on temperature, humidity and wind
- fog: visibility under 1 km, relative humidity over 90-95 %, light wind (below 2 m/s), temperature in the range $\pm$ 10 °C
- fog: three main types - radiation fog, advection fog, upslope fog
- critical importance for transportation in particular aviation

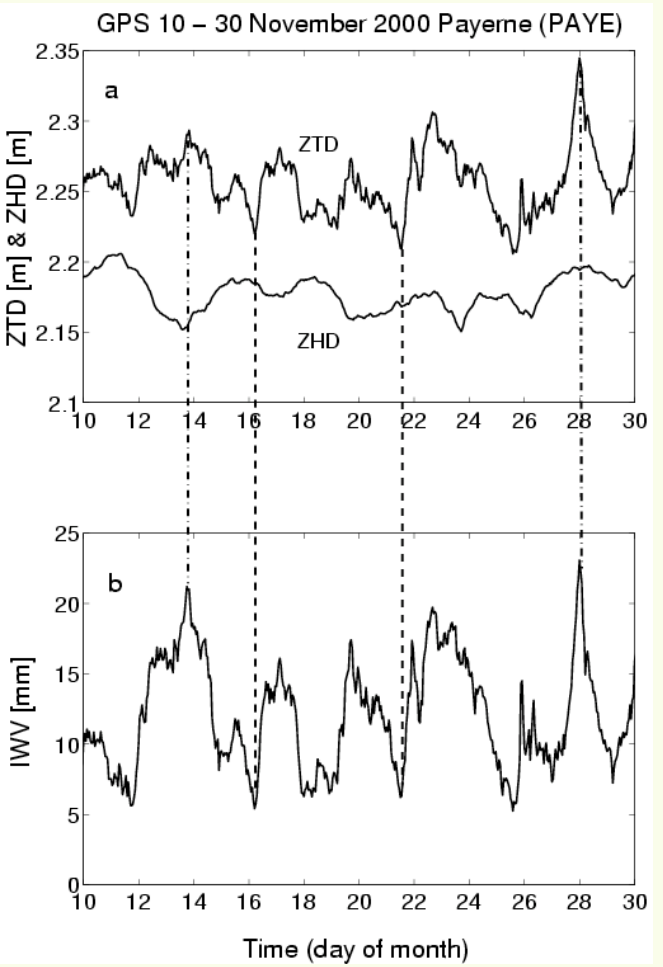
Radiation fog

- Radiation fog forms at night under clear skies with calm winds when heat absorbed by the earths surface during the day is radiated into space. As the earths surface continues to cool, provided a deep enough layer of moist air is present near the ground, the humidity will reach 100% and fog will form.



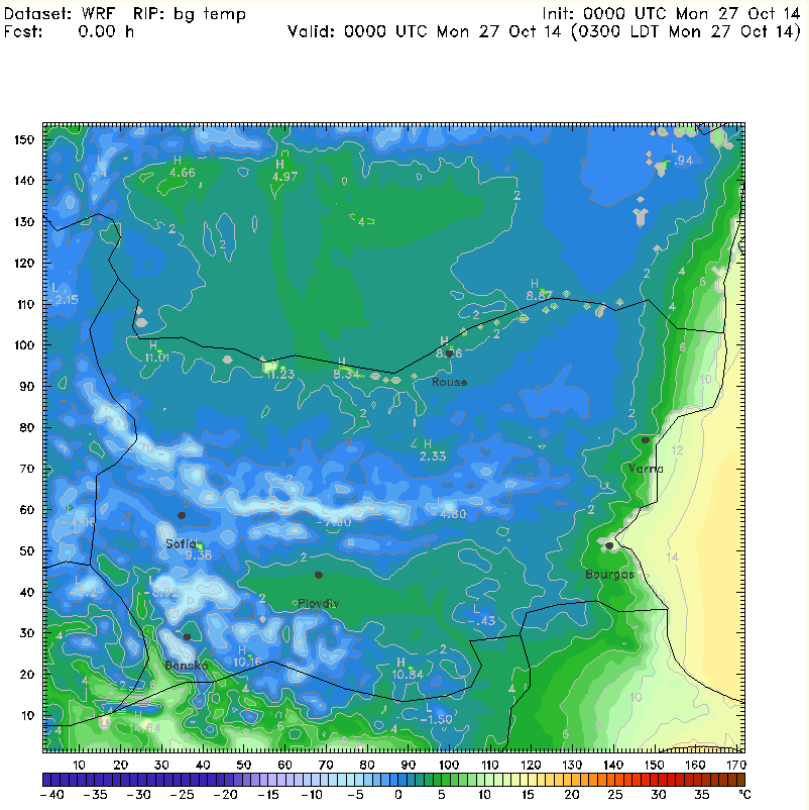
GNSS tropospheric products: ZTD, ZHD, IWV

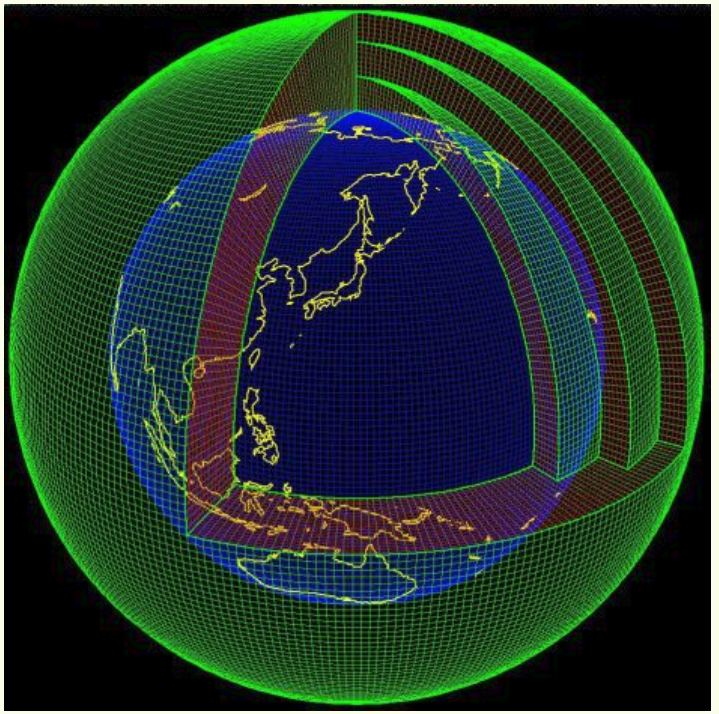
- Bulipos GNSS network - Sredec station, altitude 601 m asl.
- Bernese software v 5.0 - ZTD derived every 1h
- ZHD and IWV computed using surface pressure and temperature from the WRF model
- GNSS Meteorology explained: https://www.youtube.com/watch?v=t1inZaRdWY4



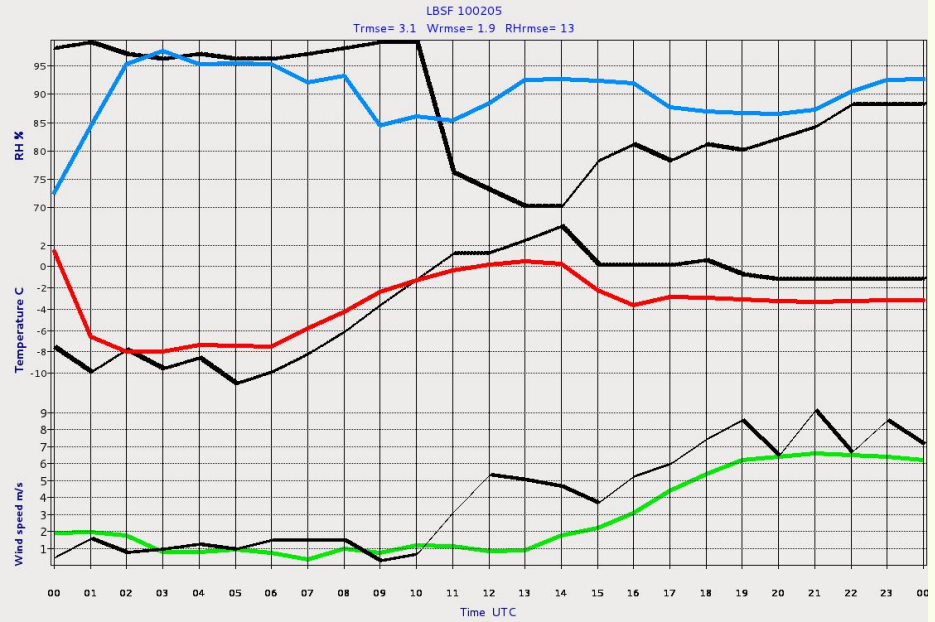
Numerical Weather Prediction (NWP) model: WRF

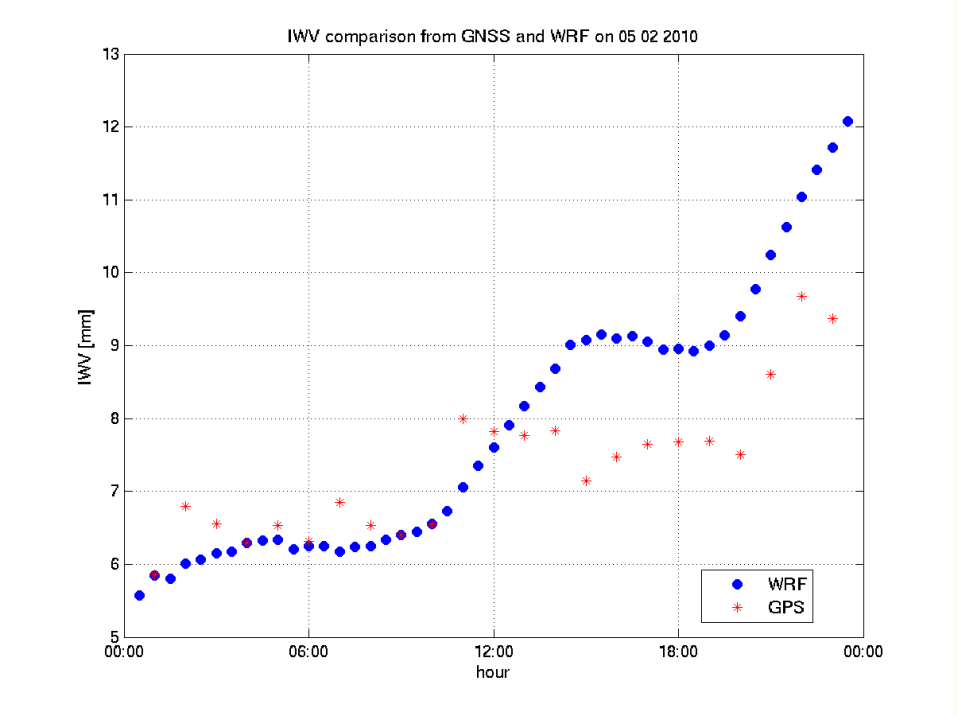
- WRF Numerical Weather Prediction model simulations for Bulgaria
- horizontal resolution 9 km, 44 vertical levels
- altitude closest grid point 601 m asl.
- temporal resolution 30 min.





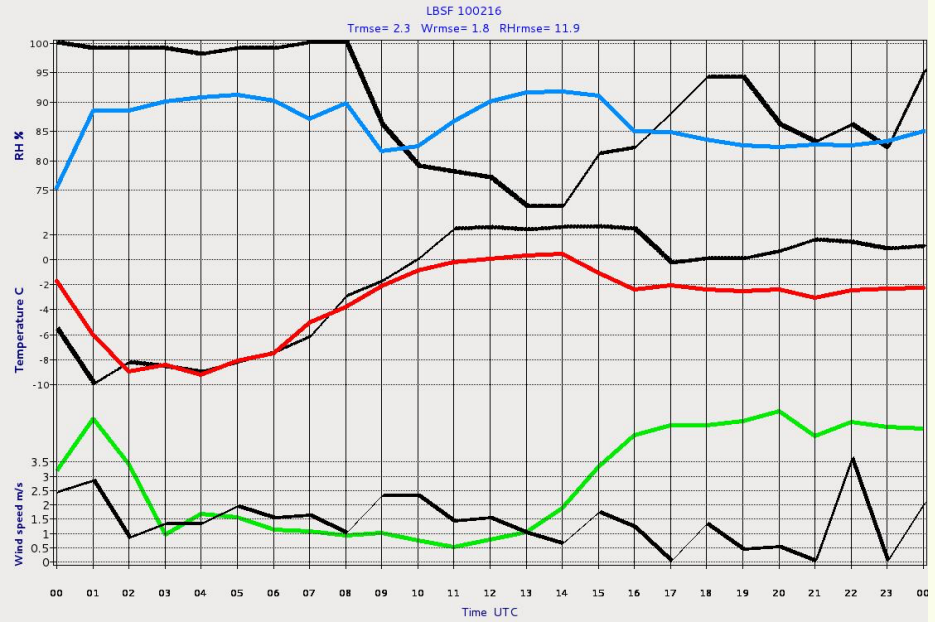
Radiation fog: 5 February 2010

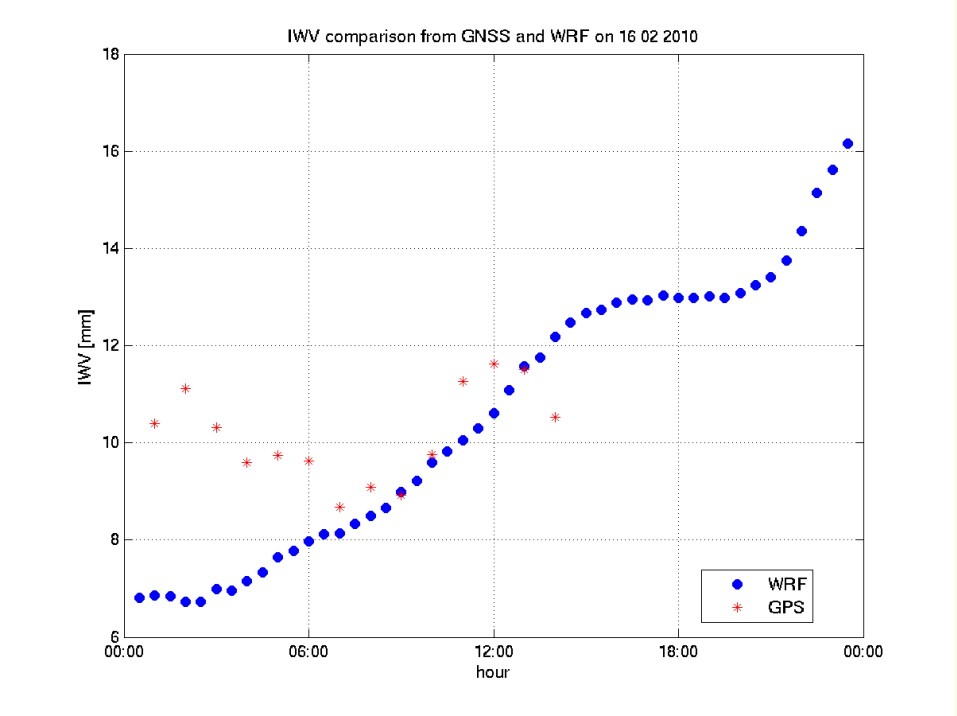




- from 00 to 10 UTC - relative humidity (RH) above 95 % - fog
- 11 UTC - RH drop to 75 %
- from 00 to 10 UTC - Integrated Water Vapour (IWV) 6 to 7 mm
- 11 UTC - increase of IWV to 8 mm
- IWV increase is due to transition from liquid water to water vapour and this is clear indication that the fog is dispersing
- very good timing between RH and IWV

Radiation fog: 16 February 2010

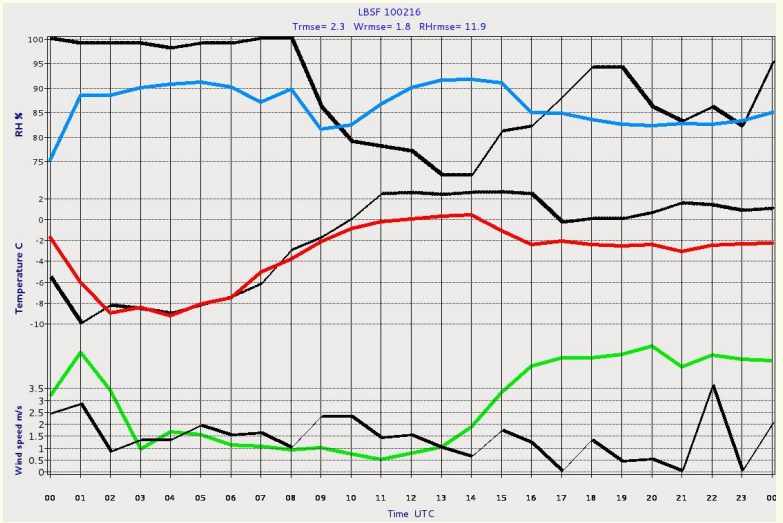


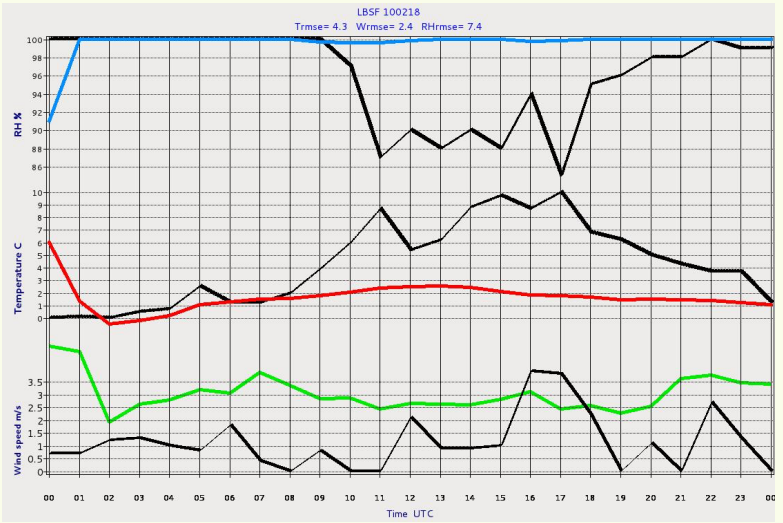


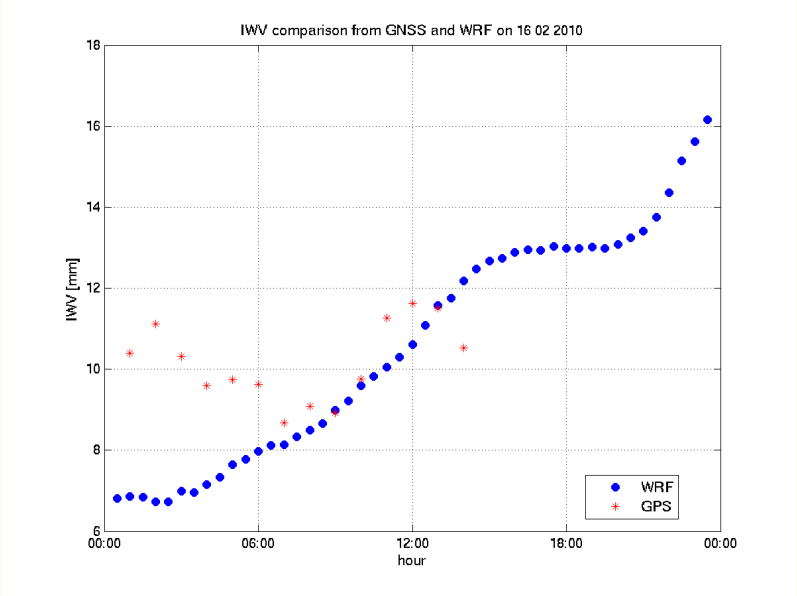
- from 00 to 8 UTC - relative humidity (RH) above 95 % - fog
- 9-11 UTC - RH drop to 75 %
- from 00 to 8 UTC - Integrated Water Vapour (IWV) decreases from 11 to 9 mm
- 9-11 UTC - increase of IWV from 8 mm to 12 mm
- slower IWV increase compared with 5 February
- very good timing between RH and IWV

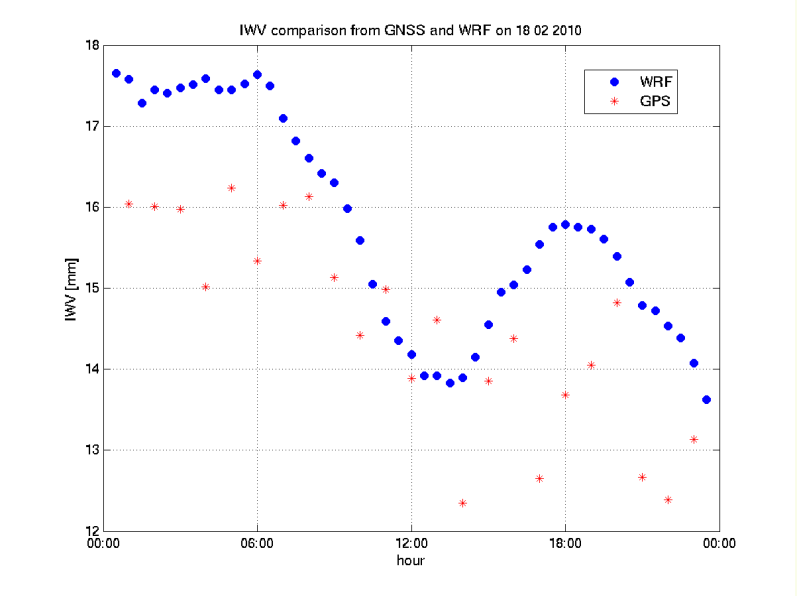
Fog: 16 & 18 February 2010

- Radiation fog (16) versus fog in dynamic conditions (18)



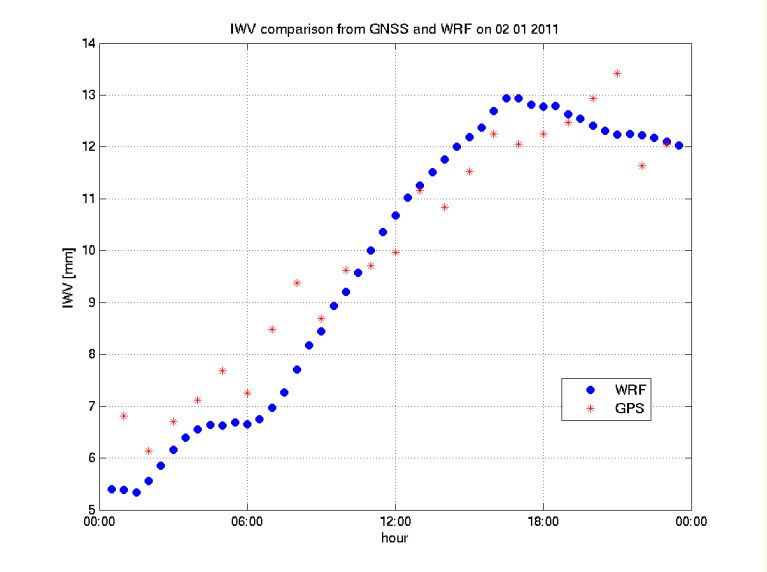


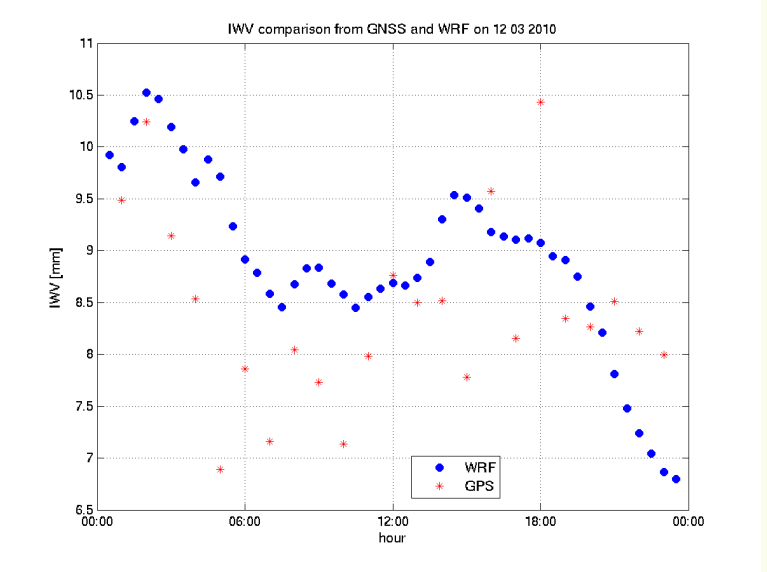


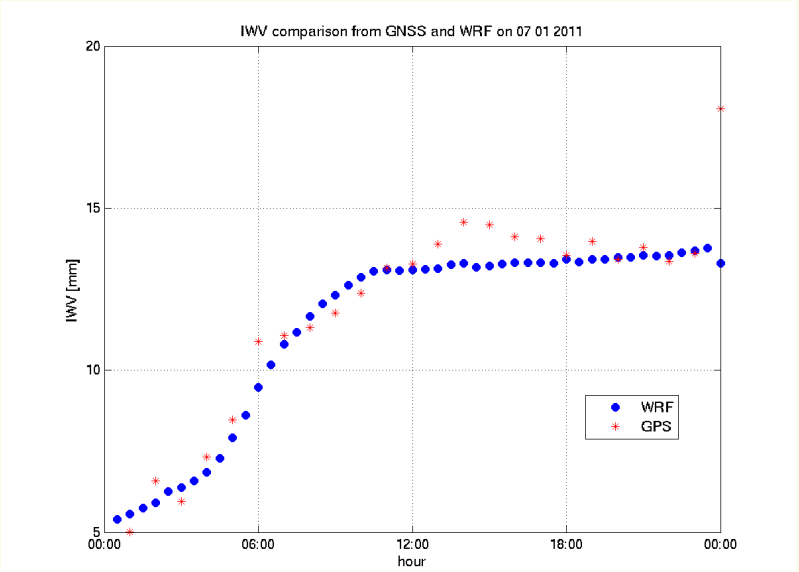


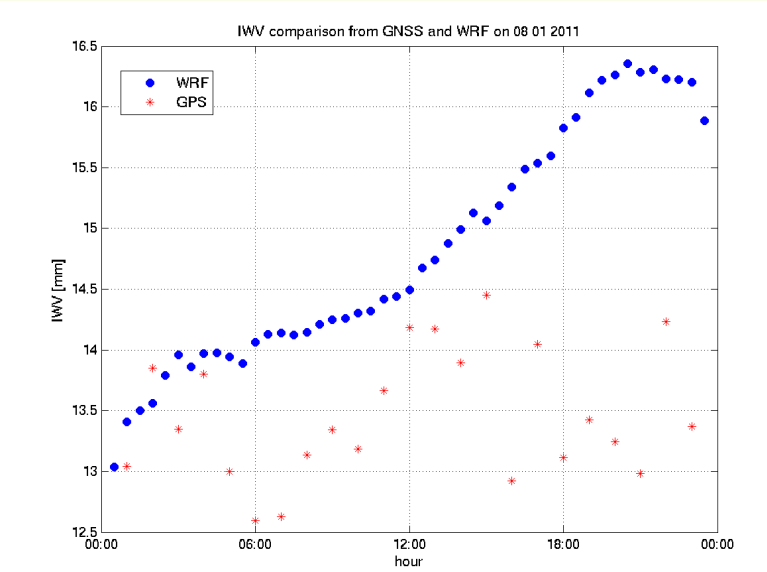
IWV comparison WRF (blue) and GNSS (red)

- diurnal cycle of IWV very well captured by WRF model (left)
- large differences in diurnal cycle of IWV (right)









Conclusion

- hourly and sub-hourly GNSS tropospheric products give a new insight in fog dynamics
- case studies with radiation fog suggests that synergy between surface observations and GNSS-IWV can be used in forecasting (nowcasting) of fog dissipation
- GNSS-IWV suitable for NWP model validation during fog episodes
- future work will continue with detail study of different fog types
- WRF model simulations with assimilation of GNSS tropospheric products will be considered

THANK YOU!