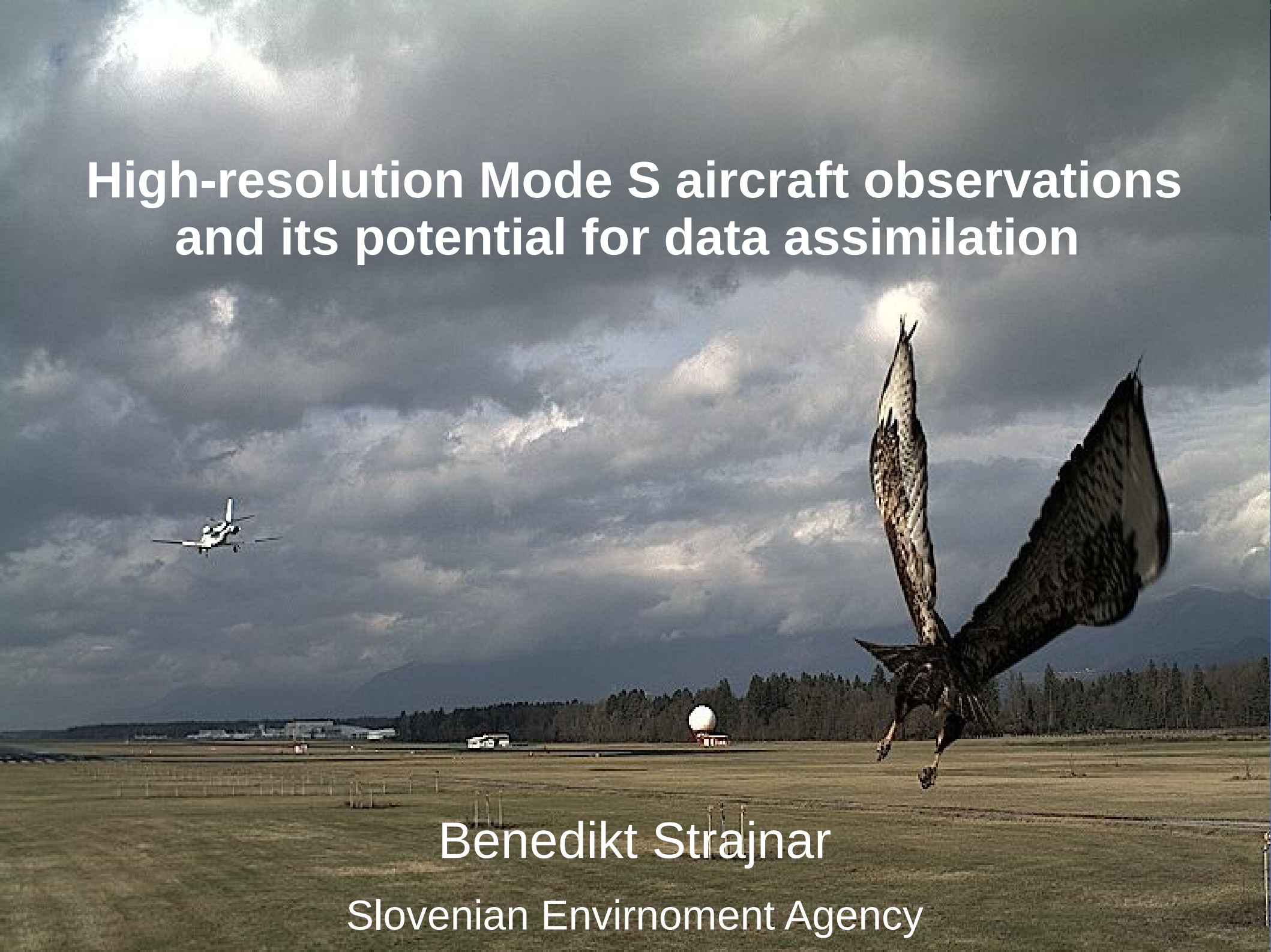
High-resolution Mode S aircraft observations and its potential for data assimilation



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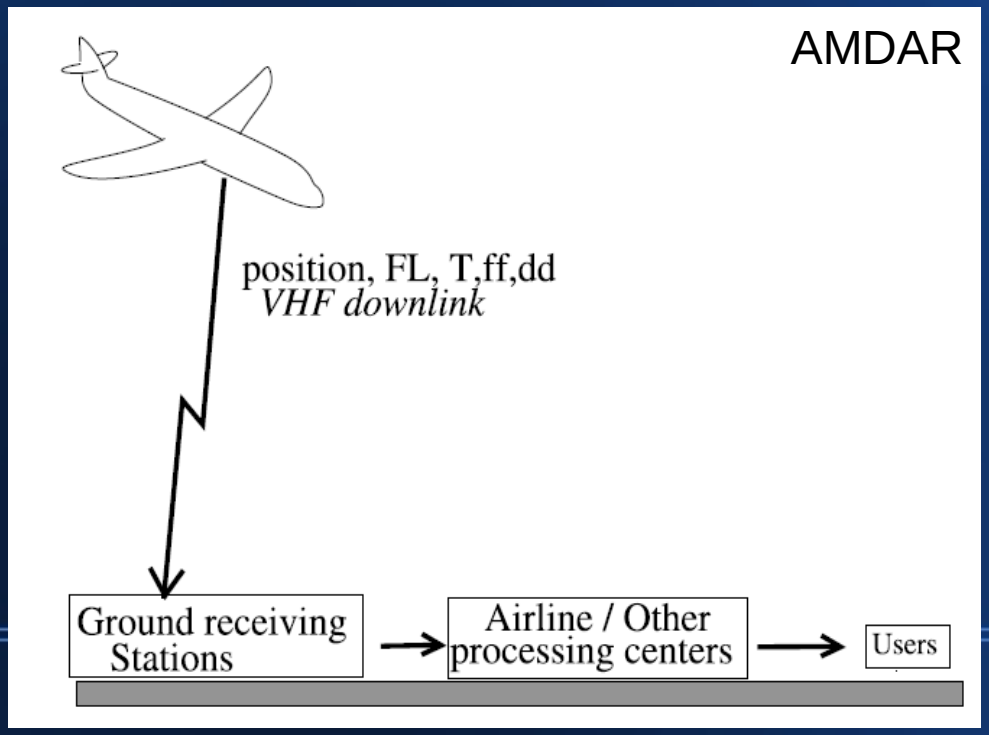
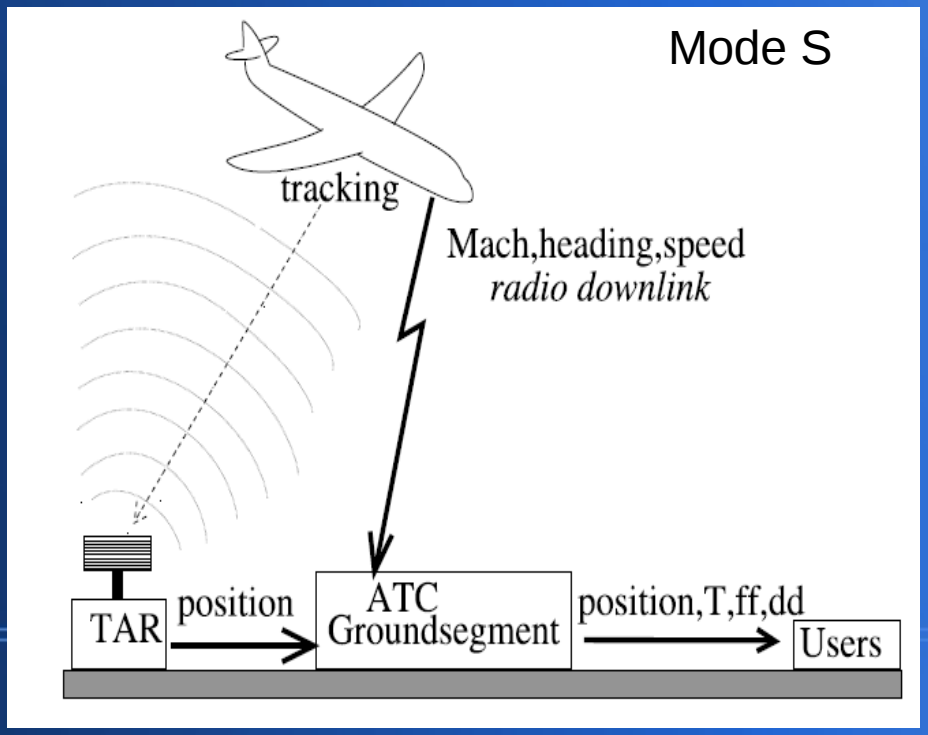
AMDAR and Mode S

- AMDAR (Aircraft Meteorological Data Relay, WMO, specially equipped aircraft, initiated in 1968)
- Mode S: On request from TAR radar, the transponder sends out information
  no additional cost on meteorological side & little latency

from de Haan, 2011



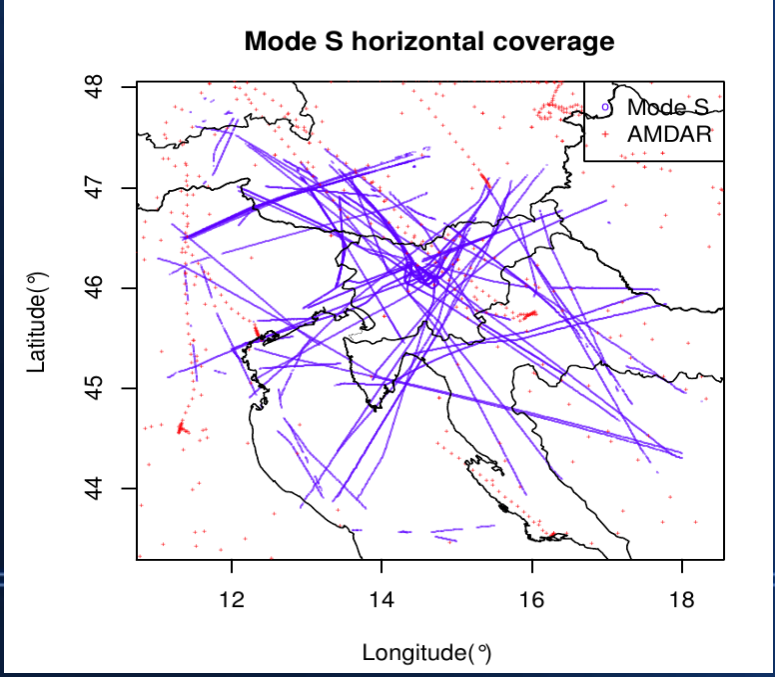


Mode S coverage and resolution

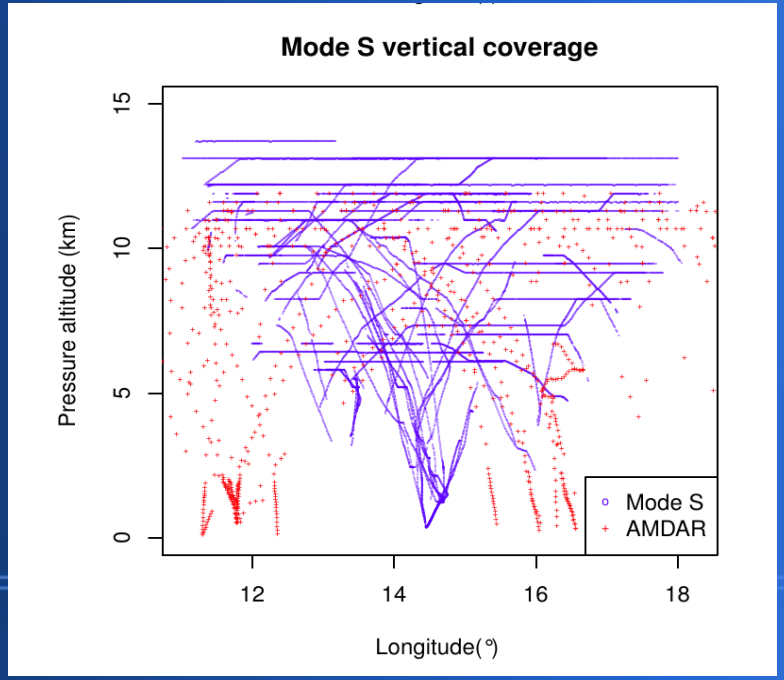
- range ~ 250 km
- frequency: 4 s
- dh: 1 FL ~ 30 m

altitude layer (km)	Mode-S wind	Mode-S temperature	AMDAR wind	AMDAR temperature
0 - 2	139.958	162.262	8.547	8.547
2 - 4	160.003	206.249	3.523	3.523
4 - 6	184.996	277.199	2.793	2.793
6 - 8	202.298	256.239	3.416	3.416
8 - 10	168.256	189.009	7.725	7.725
10 - 12	134.307	136.4	28.981	28.981
12 - 14	52.882	54.723	602	602
Total	1042.7	1282.081	55.587	55.587

[a] Period is 19 February 2011 - 1 March 2012.



6-hourly coverage



measurements & sensors

- Basic measurements:
  - Pitot–static head (total and static air pressure)
  - temperature probe (total air temperature)
- Delivered data:
  - pressure altitude (in FL), with respect to MSL 1013.25 hPa or MSL at airport (QNH)
  - static air temperature (using Mach number, computed from pressures)
  - wind (ground speed – true air speed difference)
    - true airspeed = f (Mach number, temperature)
    - ground speed from GPS

Mode S time-series: landing

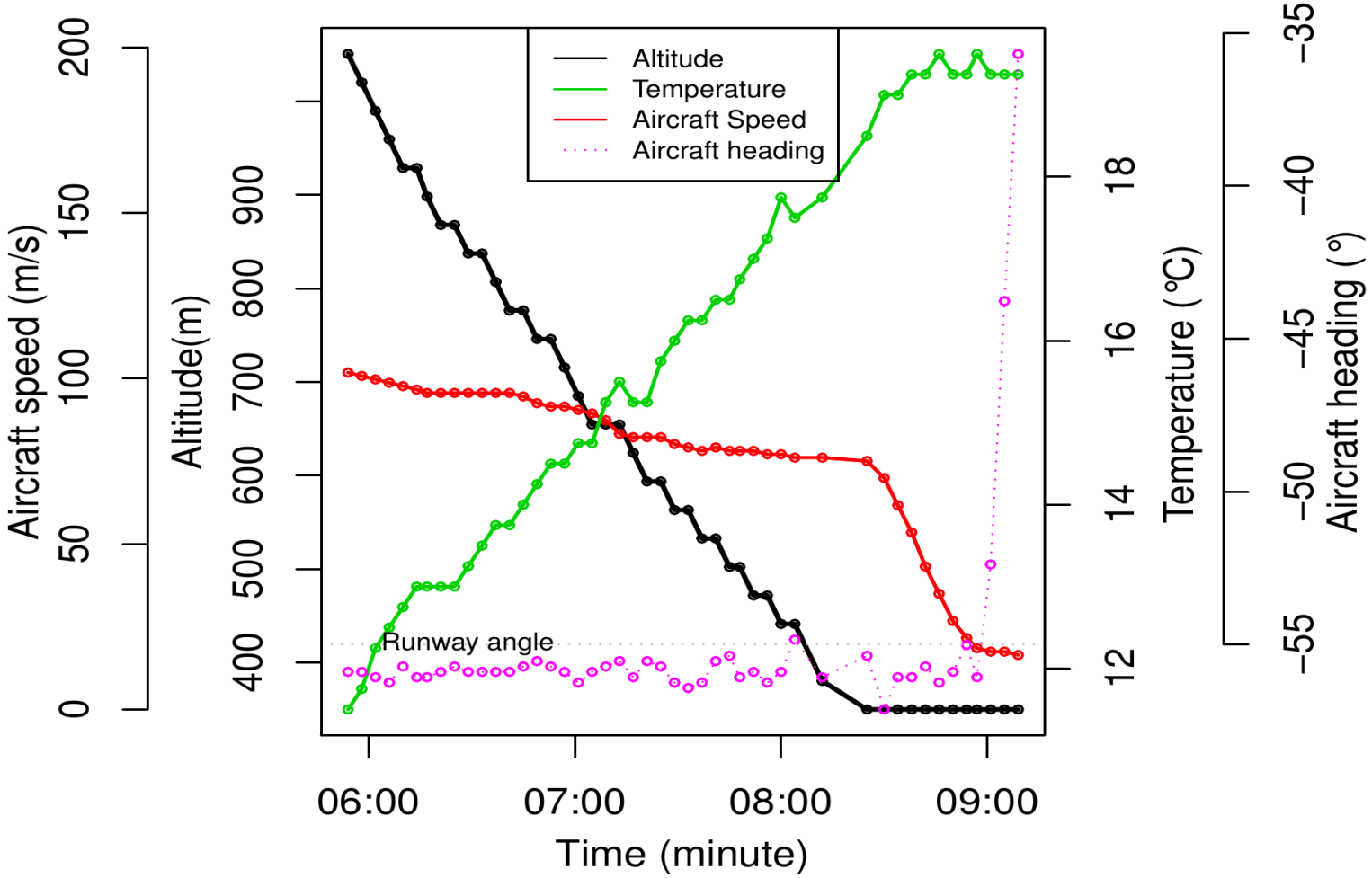
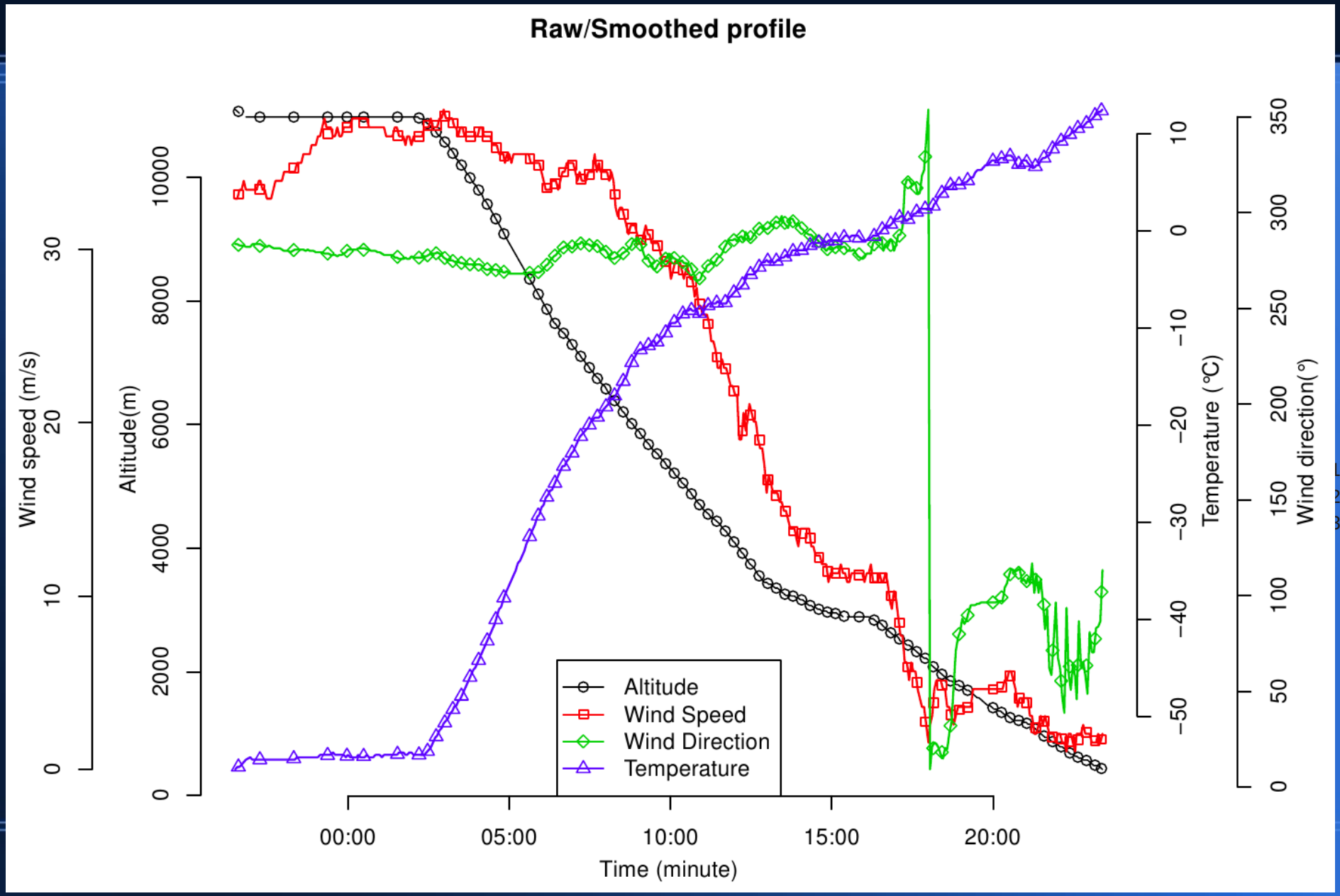


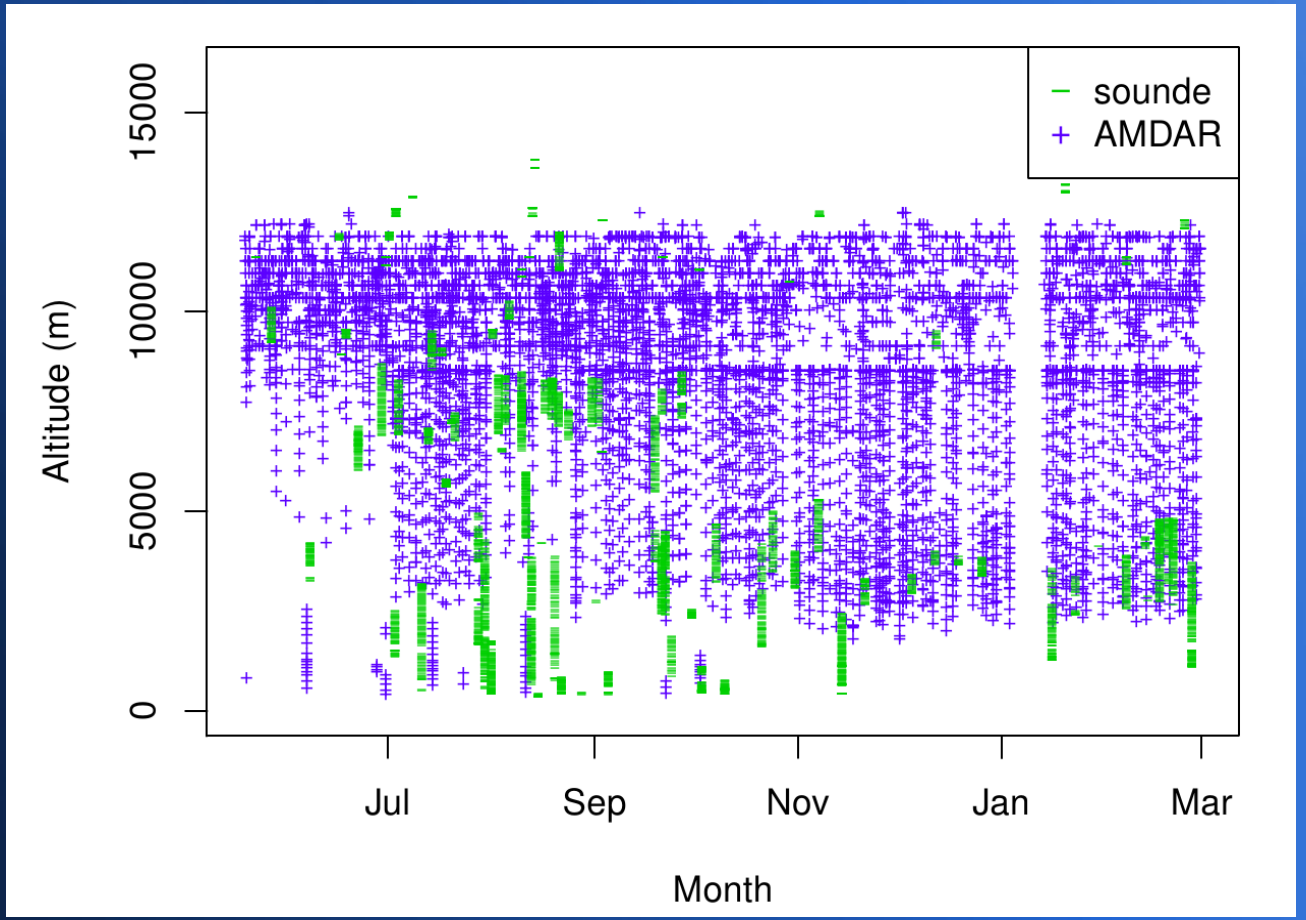
Figure 3. Profile of Mode S parameters during landing at Ljubljana airport at around 12:25 UTC, March 21 2011. Aircraft type is Canadair Regional Jet 900.

Smoothing of Mode S



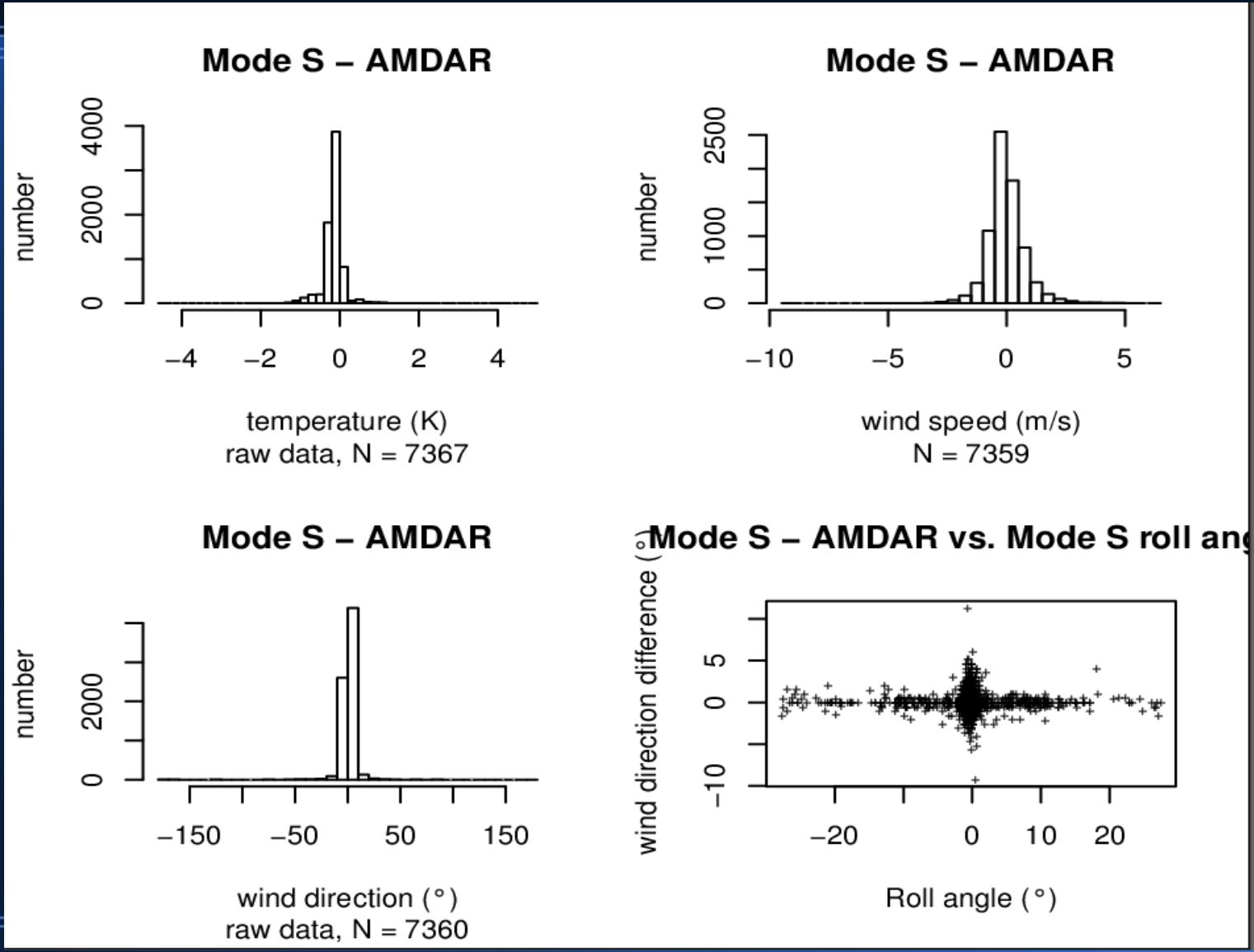
Validation by collocations – vertical distribution

- period: 19th May – 1 March 2012
- AMDAR (more high-level comparison):
  - dx=5 km
  - dt=5 min
  - dh=100 m
- Radiosoundes (more low-level):
  - dx=25 km
  - dt=15 min



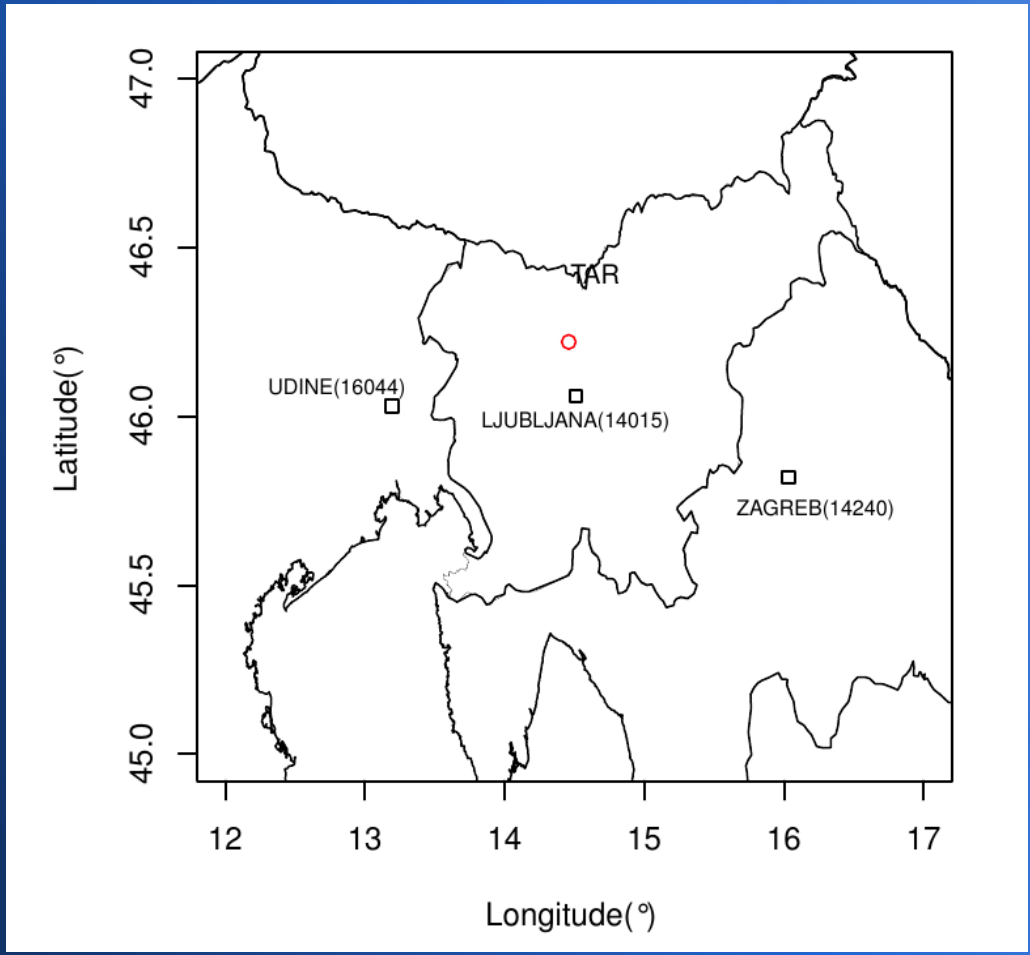
Collocation of Mode S and AMDAR

- very good agreement with AMDAR
- small std. of temperature compared to de Haan (2011)
- differences can be explained by averaging procedure
- slightly more spread at high roll angle (remove < 3°)



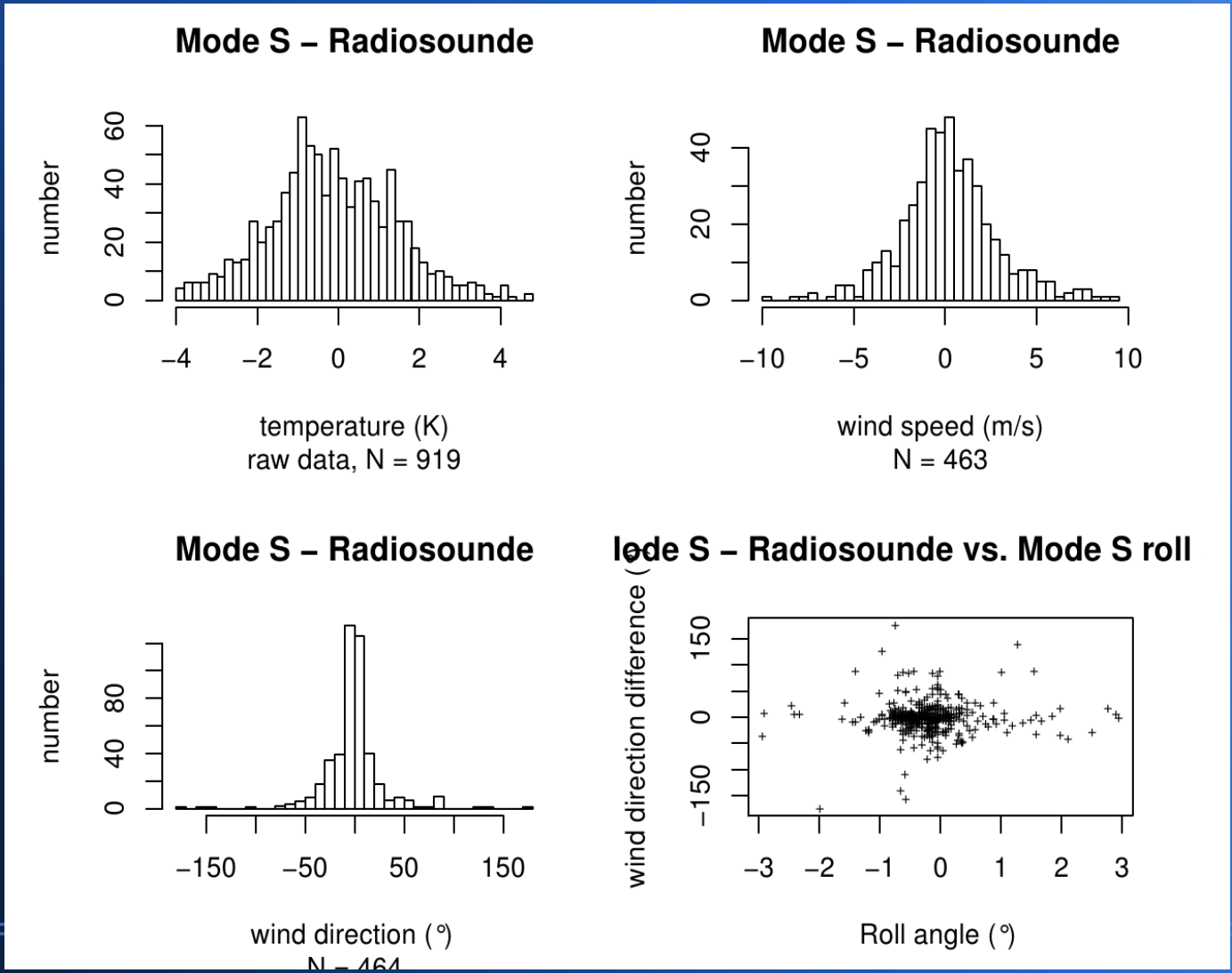
Collocations of Mode S with soundings

- evaluation period: 19th May – 1 March 2012
- mostly low-level collocations
- UDINE: 00 and 12 UTC
- LJUBLJANA: only at 3 UTC, few flights to Ljubljana at that time



Collocation with radiosoundes

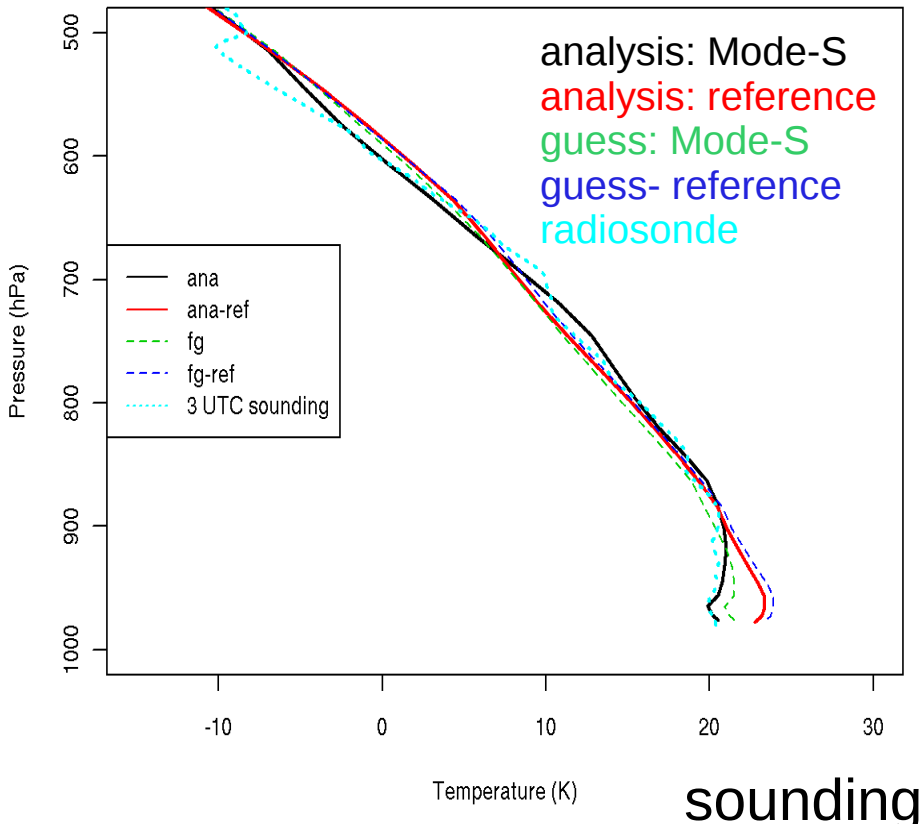
- Increased spread, little bias
- standard deviation 1.7 K, 2.7 m/s, still less that estimated error of AMDAR
- little problems with small roll angles

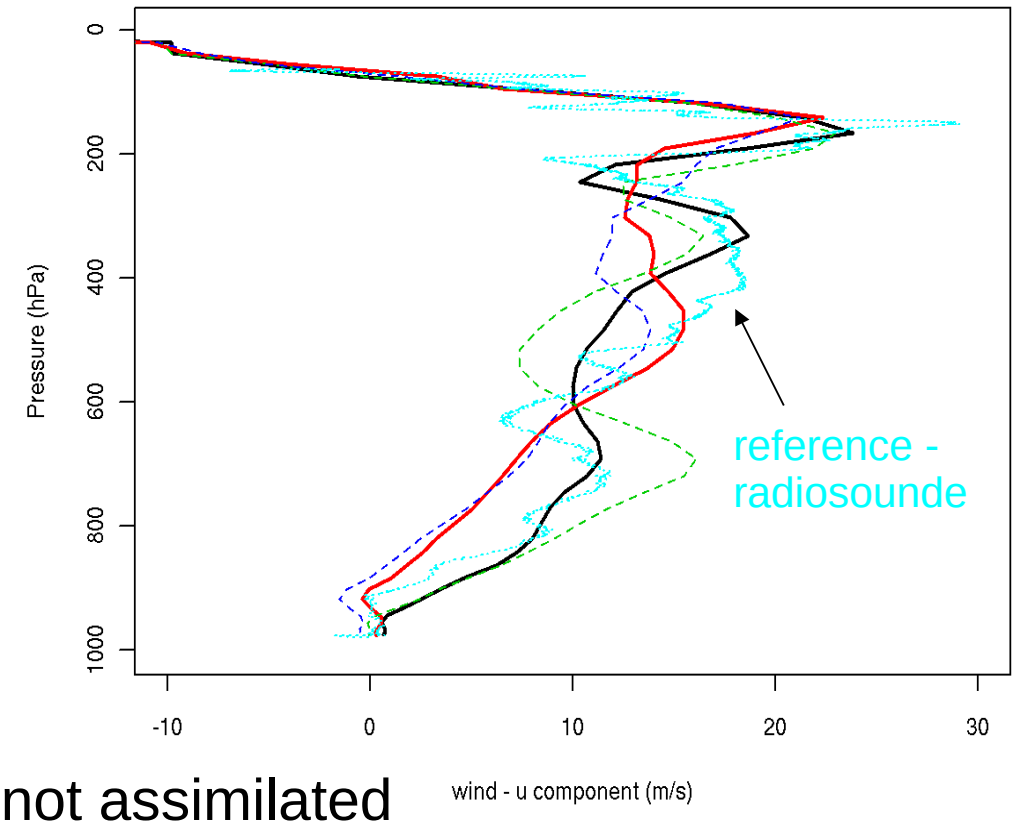


PART 2:
Data assimilation of Mode-S in ALADIN

Impact on analysis: summer (well-mixed atmosphere)

13th July 2011 6 UTC



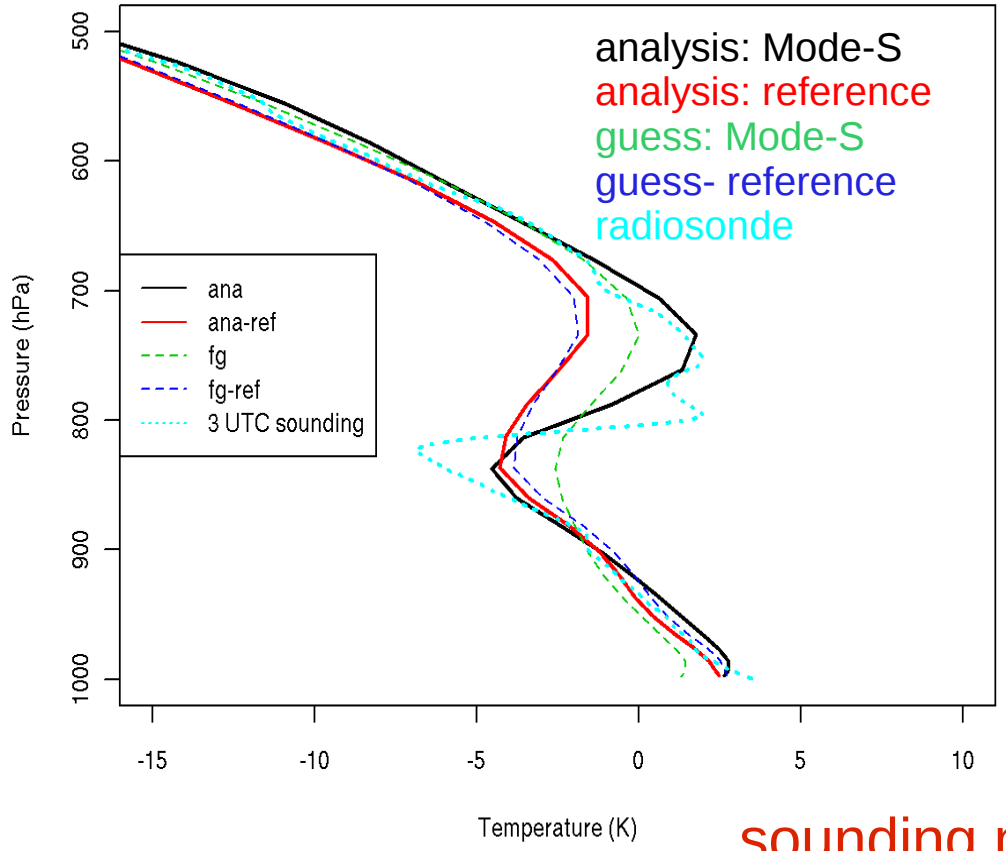


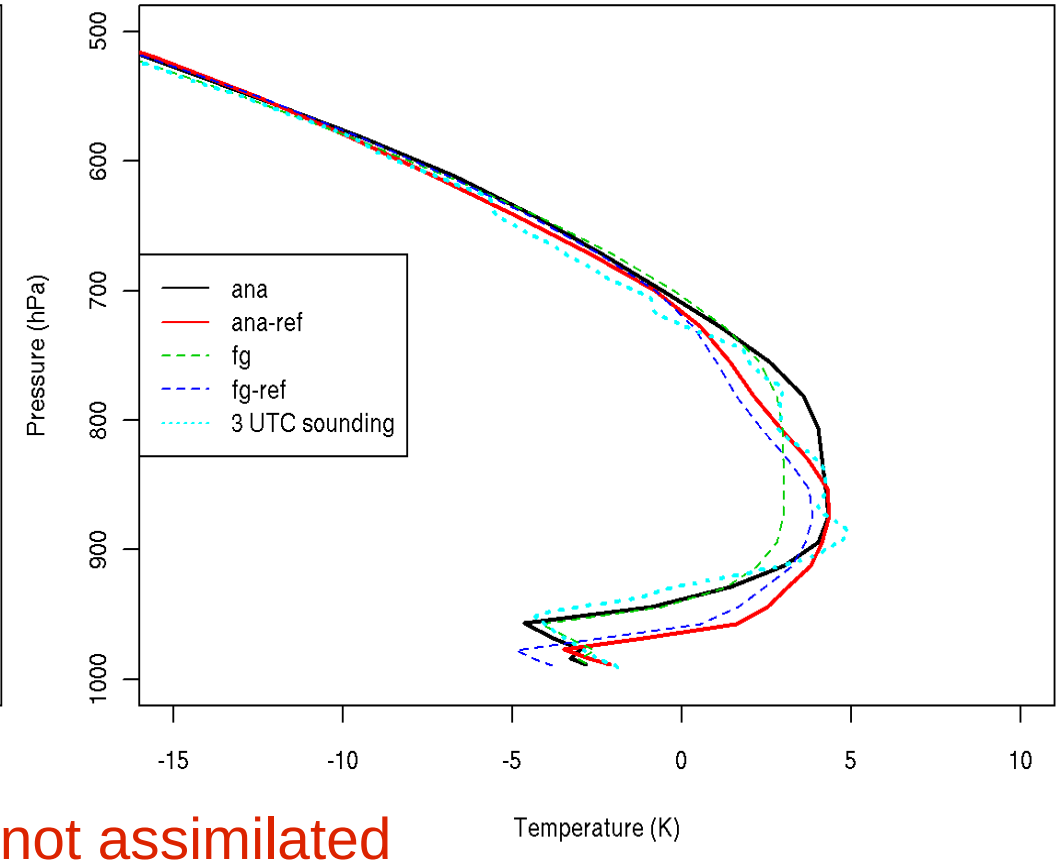
sounding not assimilated

Impact on analysis: winter (temperature inversion)

12th November 6 UTC

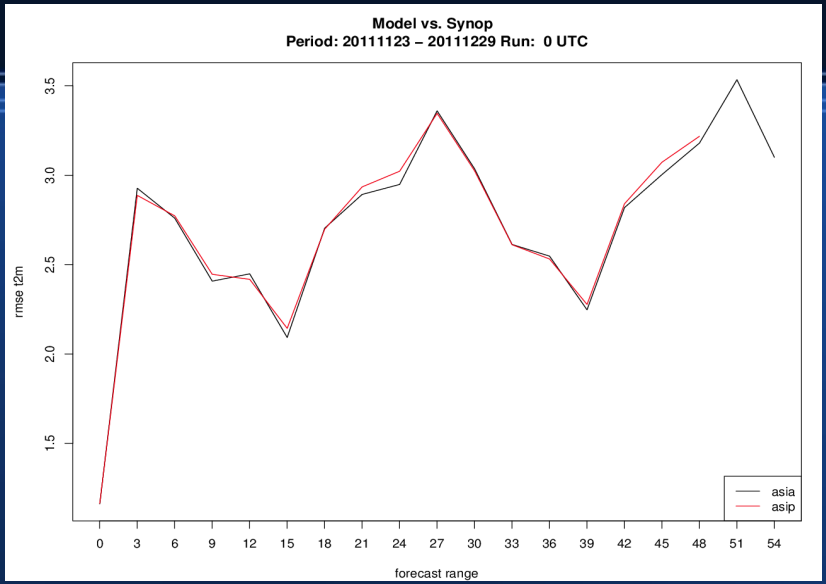
19th November 6 UTC

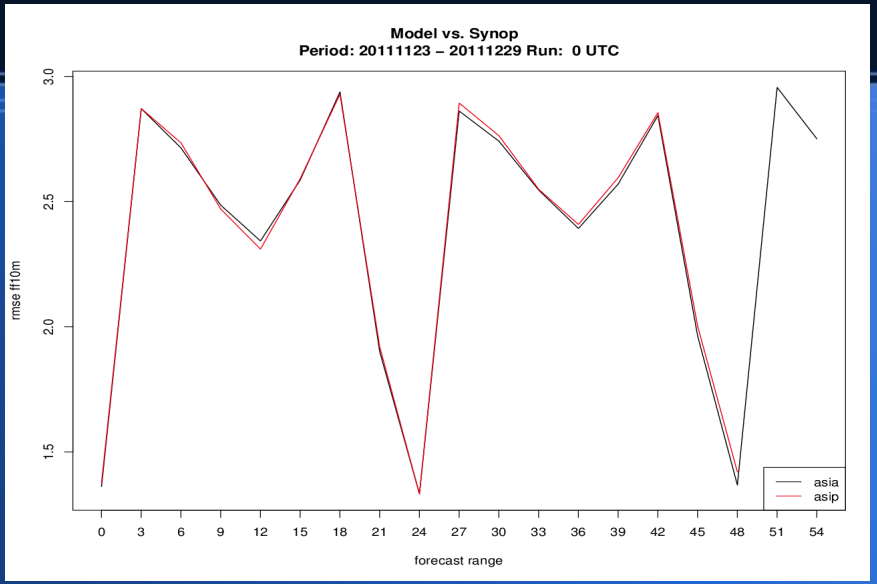


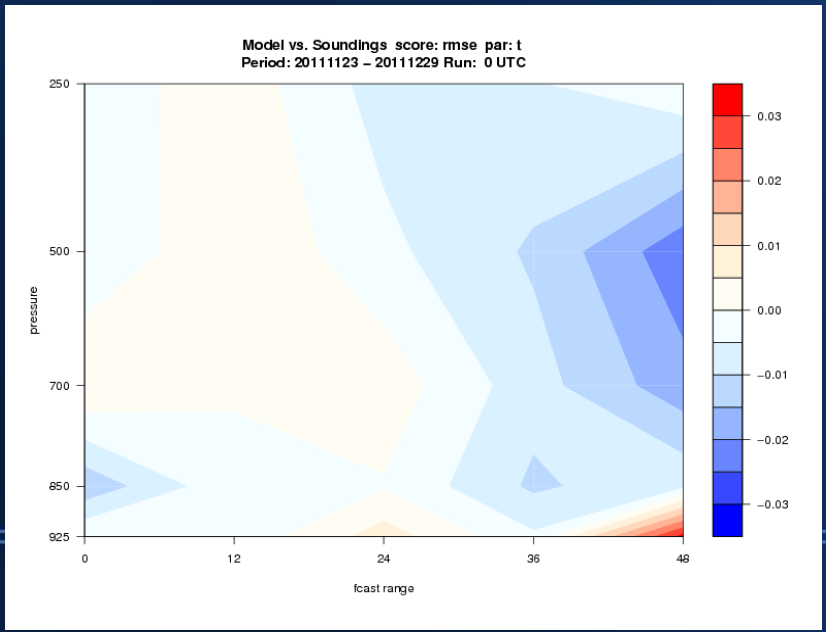


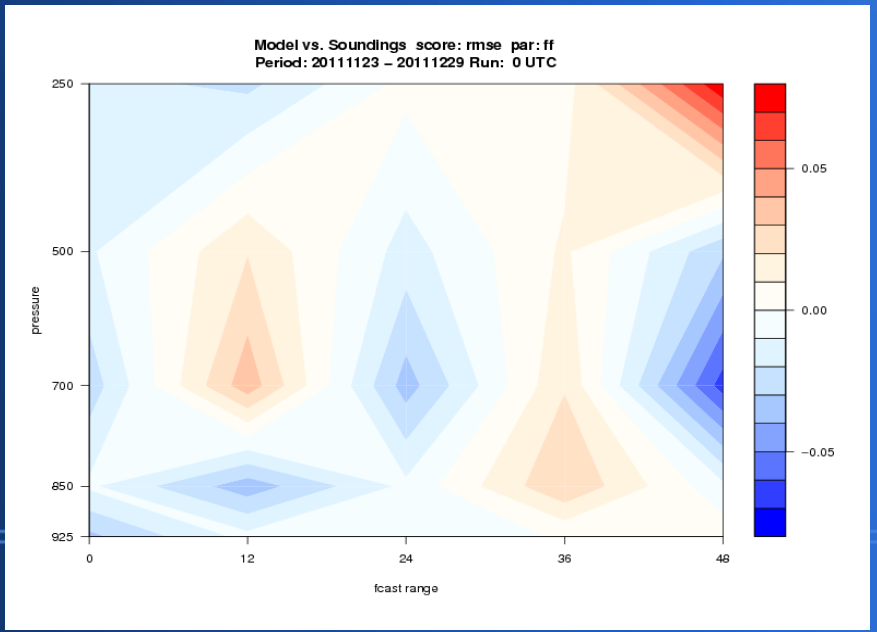
sounding not assimilated

Impact on forecasts: winter (neutral so far)









Preliminary conclusions

- local Mode S data is available for NWP in Slovenia, with little latency
- the quality of Mode S data is comparable to AMDAR, temperature and wind
- the Mode S data have impact on temperature and wind profiles in the analysis over Slovenia, especially during situations with temperature inversion

Future work

- impact on analysis to be further verified (DFS,...)
- impact on forecasts
- more quality control, super observations
  - determination of observation errors (now AMDAR's)
- using more observations
  - reducing thinning distance
  - test with cycle frequency (RUC)
  - increasing vertical resolution (also planned at ARSO)
  - tests with 3D-FGAT ? ...