Regional Cooperation for
Limited Area Modeling in Central Europe

LACE
nwp central europe

Collection and assimilation of Mode-S MRAR observations in Slovenia

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Outline

- What Mode-S observations are?
- Validation study
- Pre-processing
- Data assimilation experiments
- Conclusions

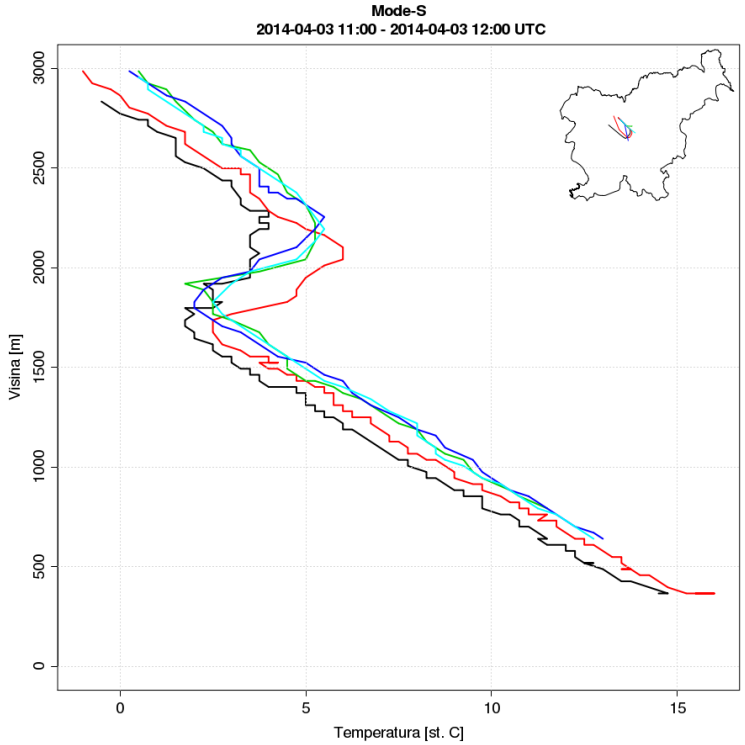
Mode-S system

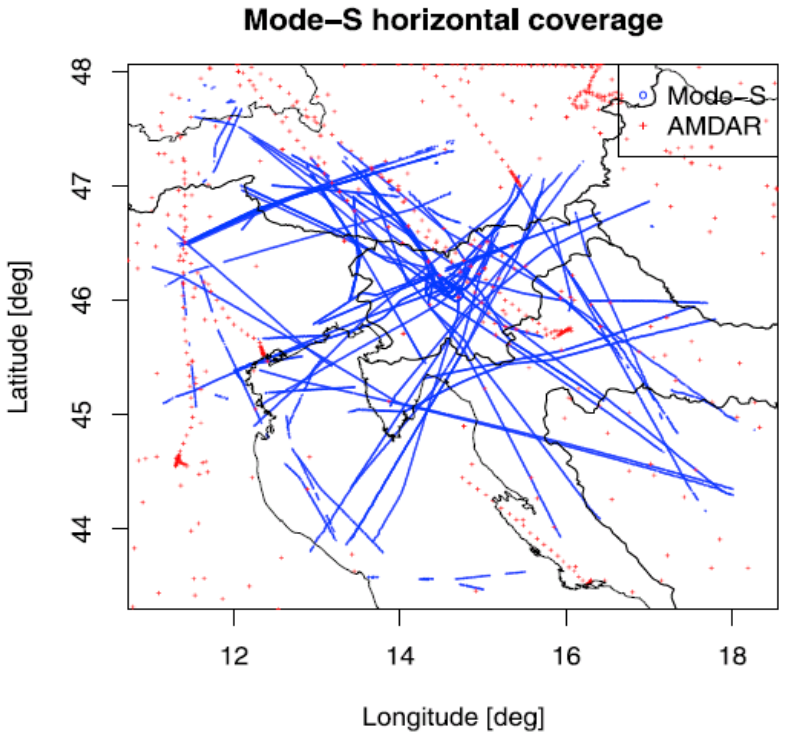
- Primary radars
  - a pulse is reflected back by the aircraft, enabling its position to be computed
- Secondary radar systems
  - transponder on board the aircraft transmits its identity, as well as the aircraft's altitude
- Mode-S
  - selective communication between airframe and ground station (possibility to transmit various 56-bit data registers, up to 5 for a standard system).

Types of Mode-S met. data

name	MODE-S MRAR *Meteorological routine air report*	MODE-S EHS *Enhanced surveillance (report)*
data	▫ (BDS 4,4) – met. routine air report wind speed, direction, temperature, turbulence, humidity ▫ (BDS 4,5) – met. hazard report (turbulence, wind shear, microburst, icing)	▫ (BDS 4,0) selected vertical intent (selected altitude) ▫ (BDS 5,0) track and turn report - roll angle, true track angle and rate, ground speed and true air speed ▫ (BDS 6,0) heading and speed report indicated air speed and mach, barometric altitude rate, magnetic heading
type	Direct data	Indirect (temperature) data
rep. by	around 5 % of all Mode-S equipped aircraft (depends on the transponder configuration)	all Mode-S equipped aircraft
	Strajnar 2012, Hrastovec and Solina 2013	*de Hann 2011, de Haan and Stoffelen 2012*

Mode-S data from Ljubljana airport

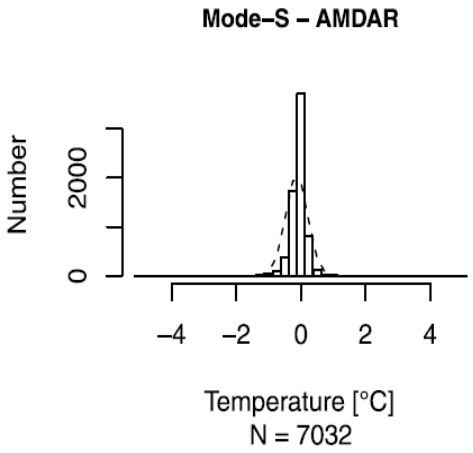


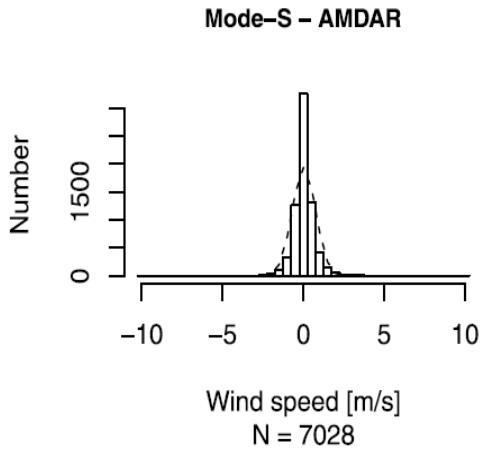


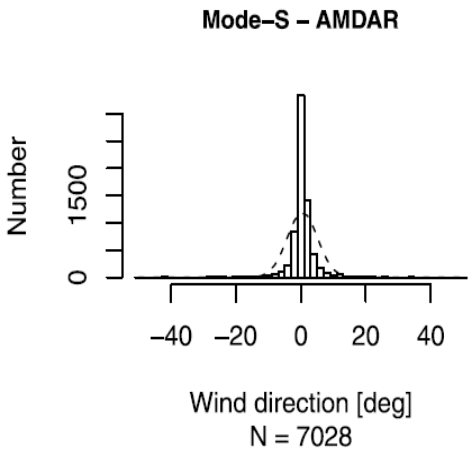
- ½ of all data from national carrier (Adria Airways)
- Mostly smaller airplanes (CRJ) and corporate jets (some possiblly problematic), little data from bigger Airbus and Boeing airplanes

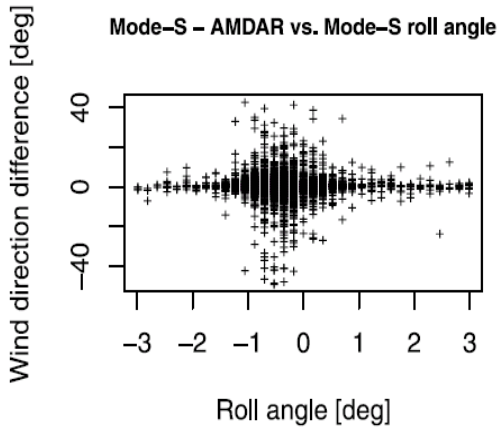
Validation (1)

- Comparison with AMDAR and radiosondes over 9 months
- Match with AMDAR (on the same aircraft) very good (std. difference 0.35 K,0.8 m/s and 10 deg.)
- No significant bias



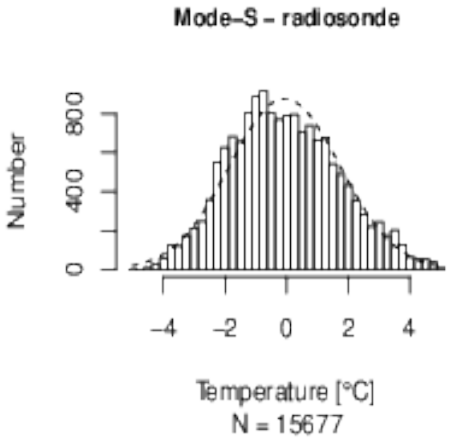


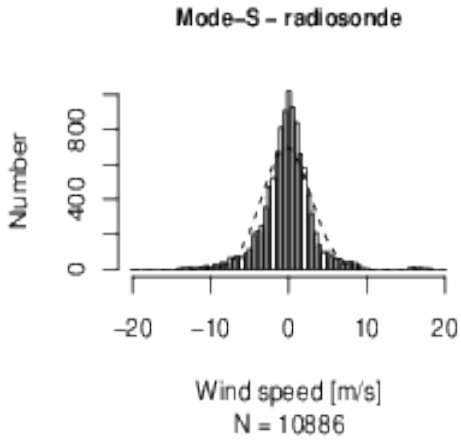


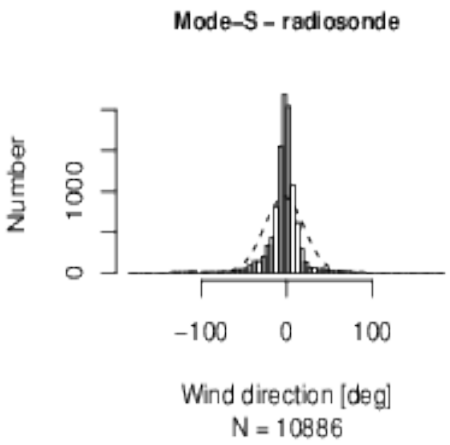


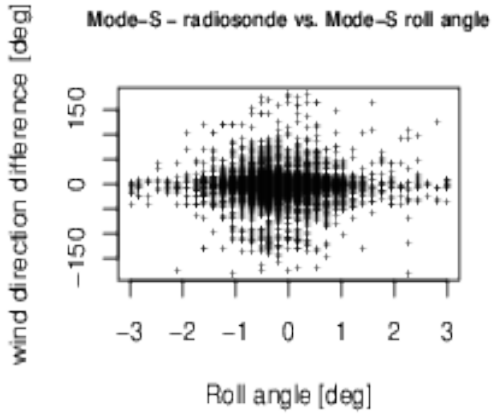
Validation (2)

- Comparison with hi-res radiosondes from Ljubljana, Zagreb, Zadar and Udine
- Std. deviations larger (1.7 K,3 m/s and 25 deg.)
- But still no significant bias



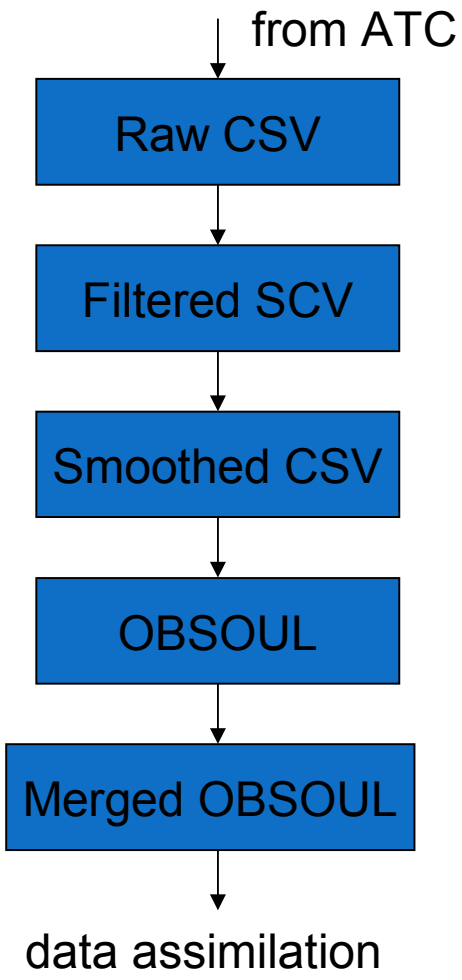






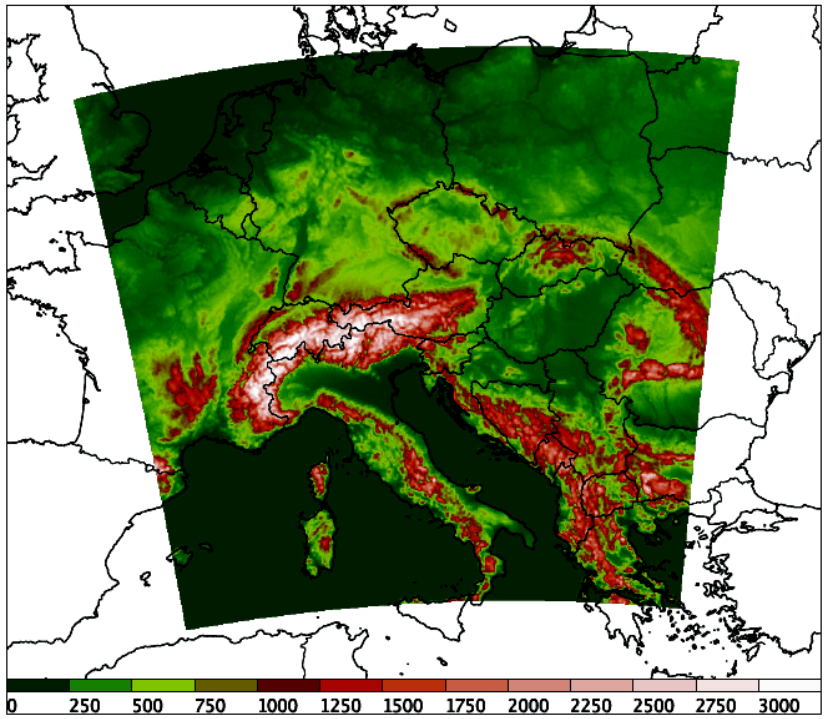
Preprocessing and quality control

- Temporal smoothing (12s / 60 s)
- Whitelist approach
  - Generated from comparison of Mode-S with operational NWP over a period of 22 months
  - Airplanes with high mean or sd with respect to model flagged
- Coding to OBSOUL format



Assimilation experiments - model

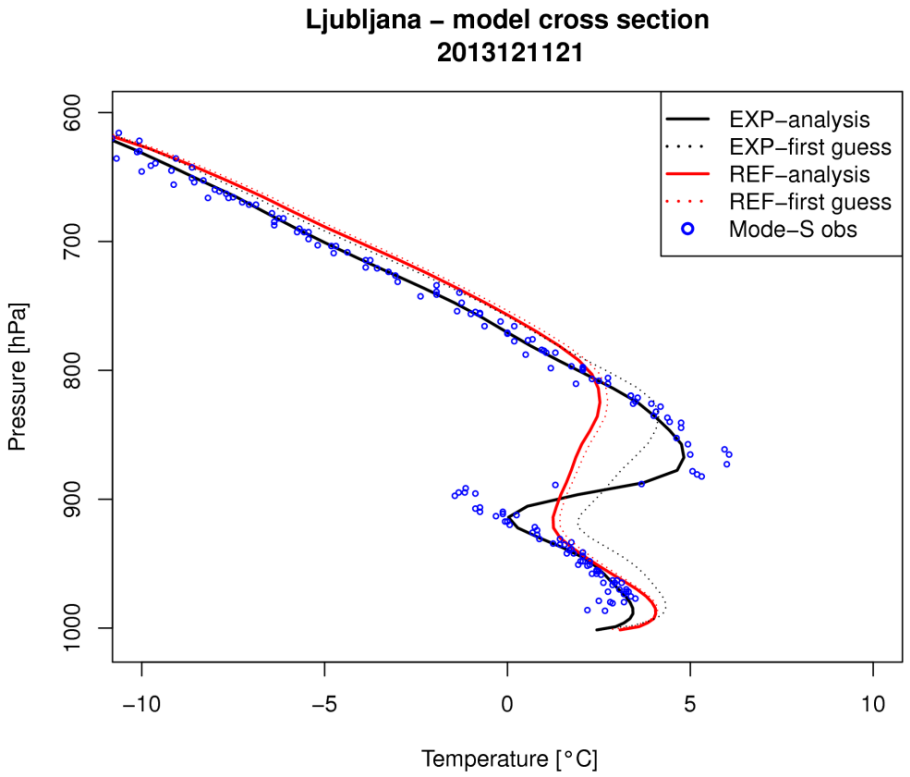
- ALARO - model cycle 38t1
- 4.4 km resolution, 87 levels
- 3-hourly 3d-Var data assimilation
- SYNOP+AMP, TEMP, AMDAR, AMV, NOAA, METOP, MSG
- ECMWF LBC

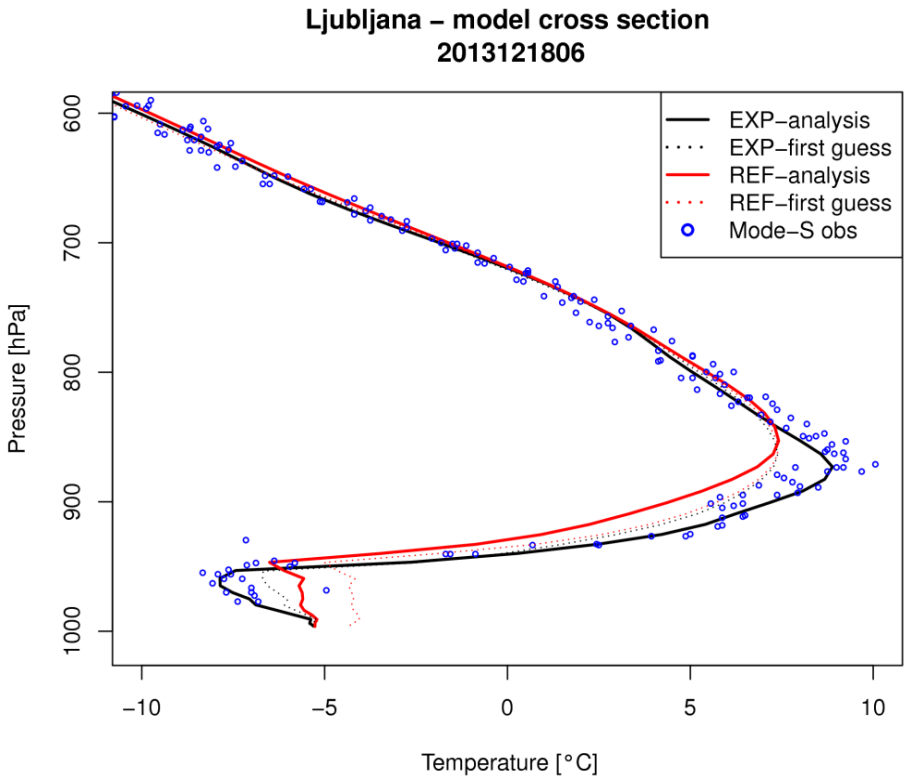


- 2 evaluation periods
  - 18 Dec 2013 – 10 Jan 2014
  - 18 Jun 2013 – 10 Jul 2013

Winter period – impact on analysis

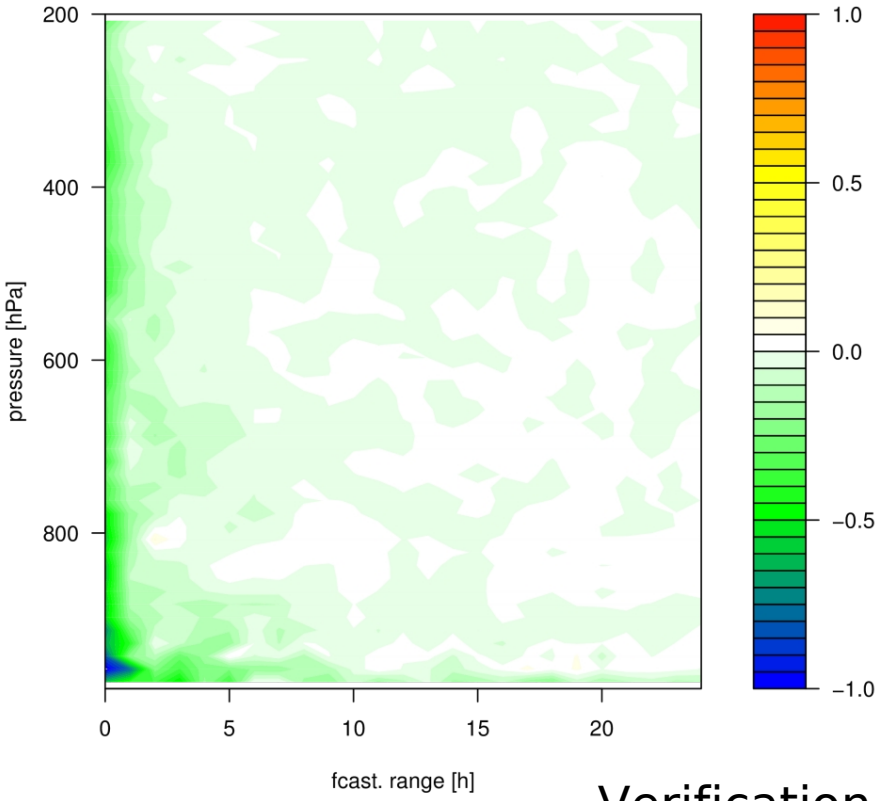
- Temperature inversions locally much better captured in the analysis due to assimialted Mode-S



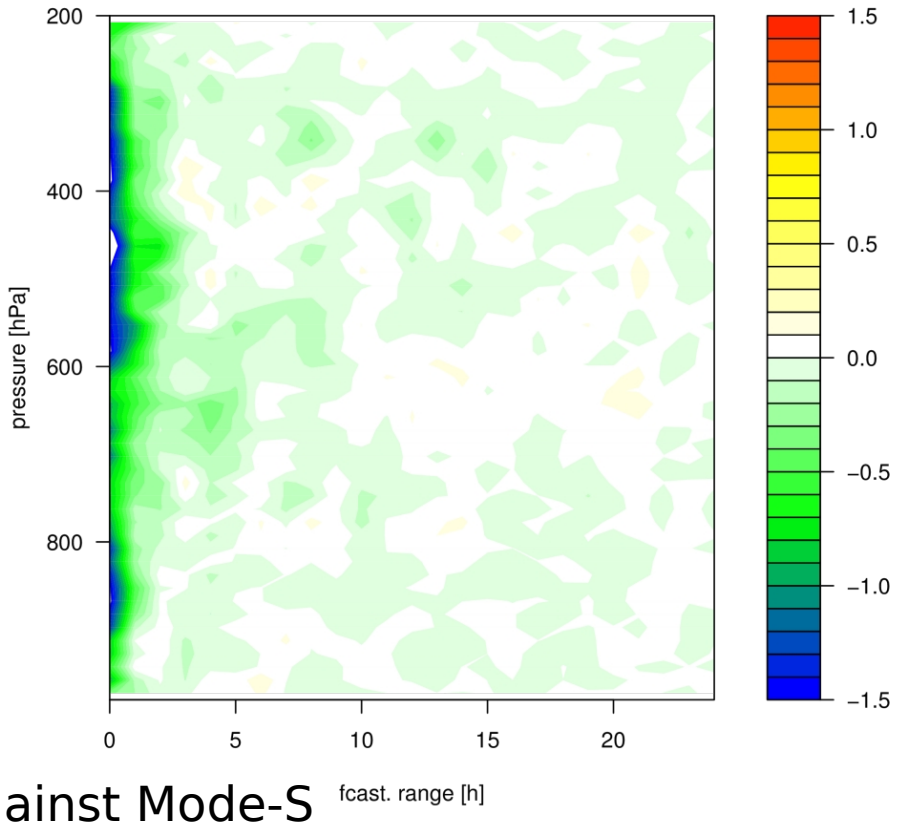


Winter period – Impact on forecasts

Temperature RMSE reduction



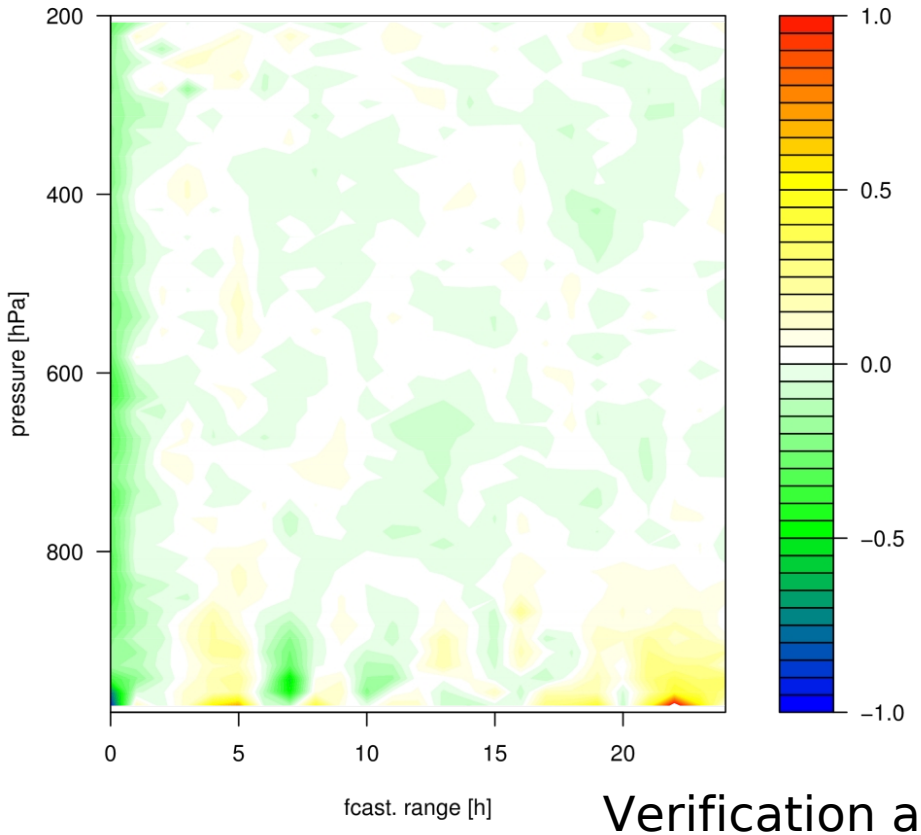
Wind speed RMSE reduction (same for dir.



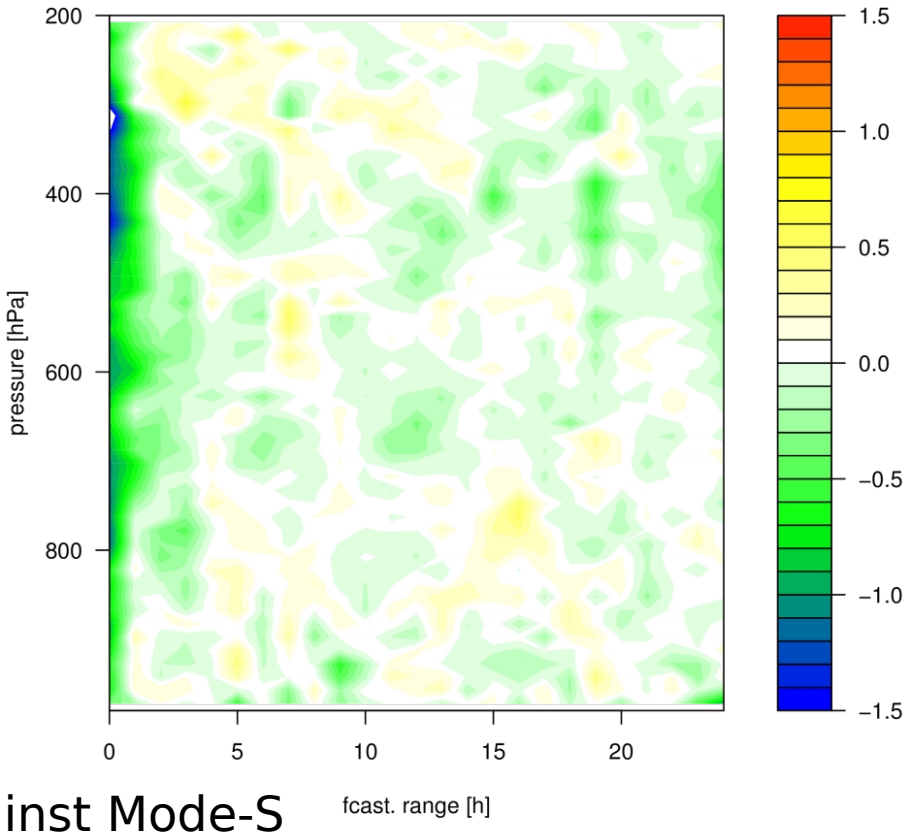
Verification against Mode-S

Summer period – impact on forecasts

Temperature RMSE reduction



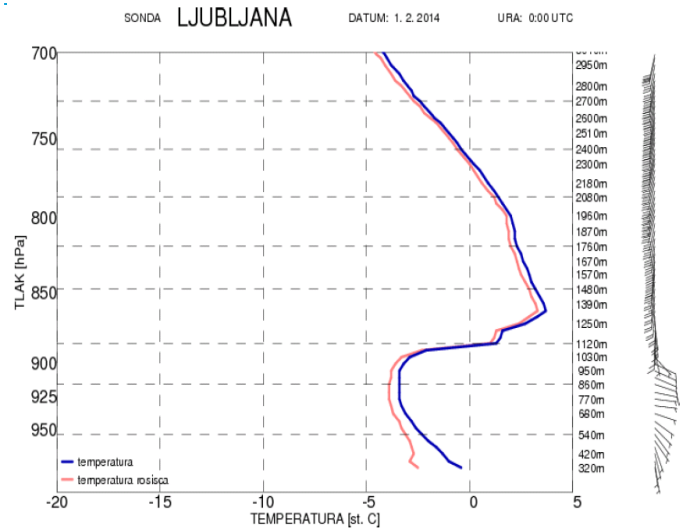
Wind speed RMSE reduction



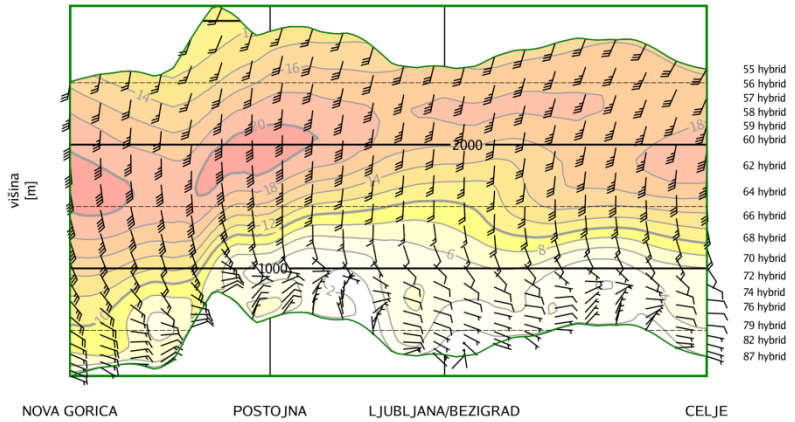
Verification against Mode-S

Severe freezing rain case (1)

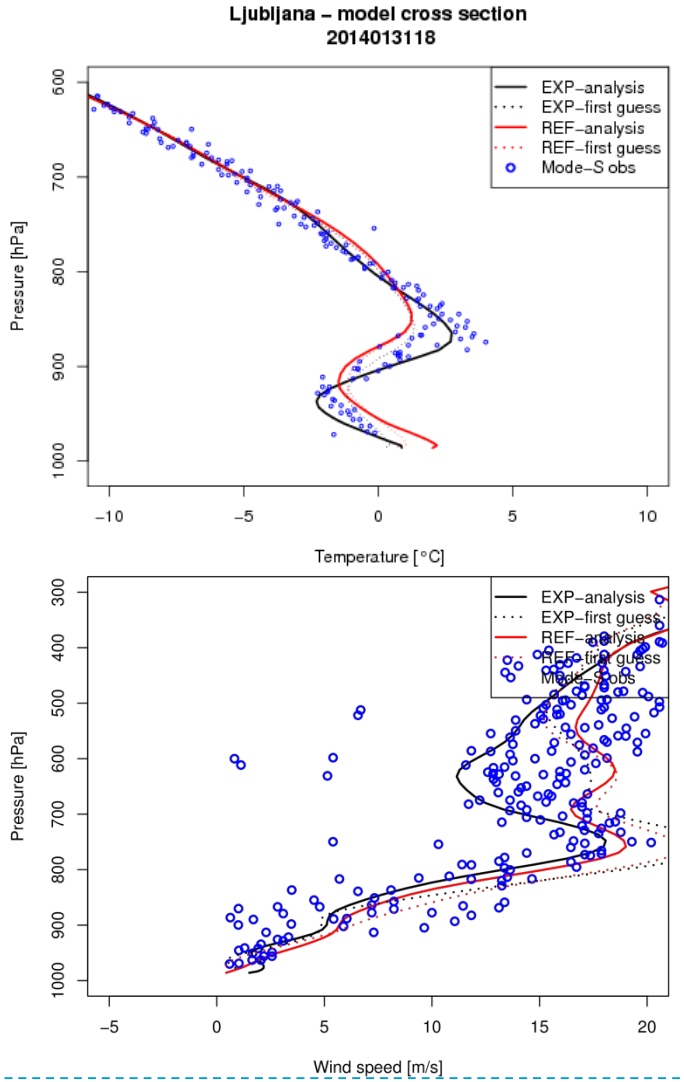
- end of January 2014

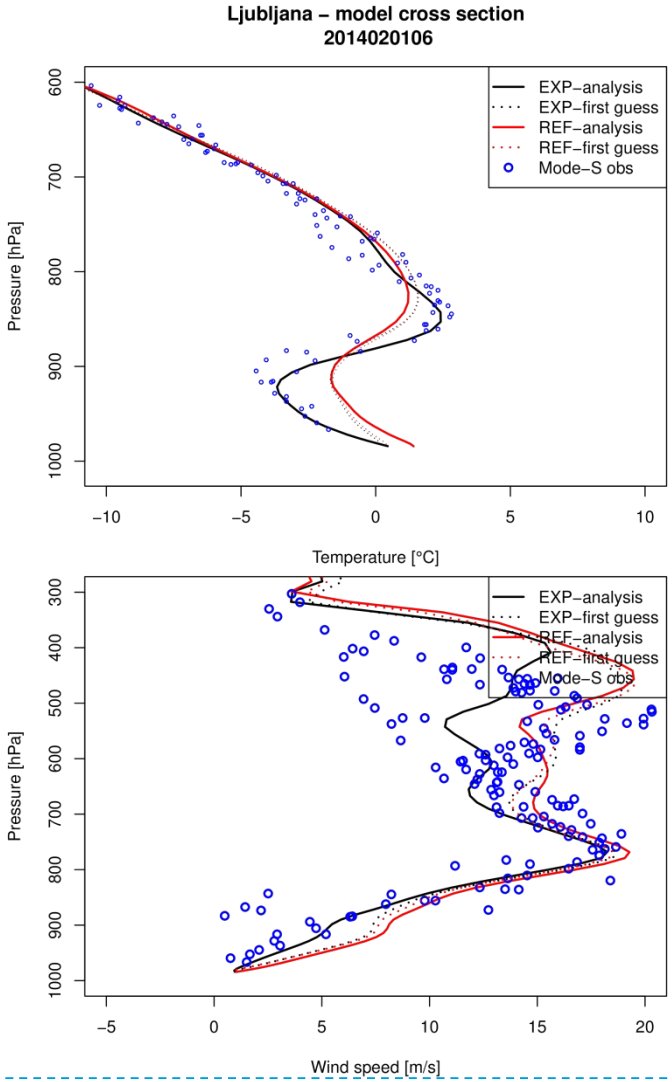


VERTIKALNI KRAJEVNI PRESEK
01.02.2014 06:00
Napoved modela ALADIN/SI DA: hitrost vetra (m/s), horizontalni veter

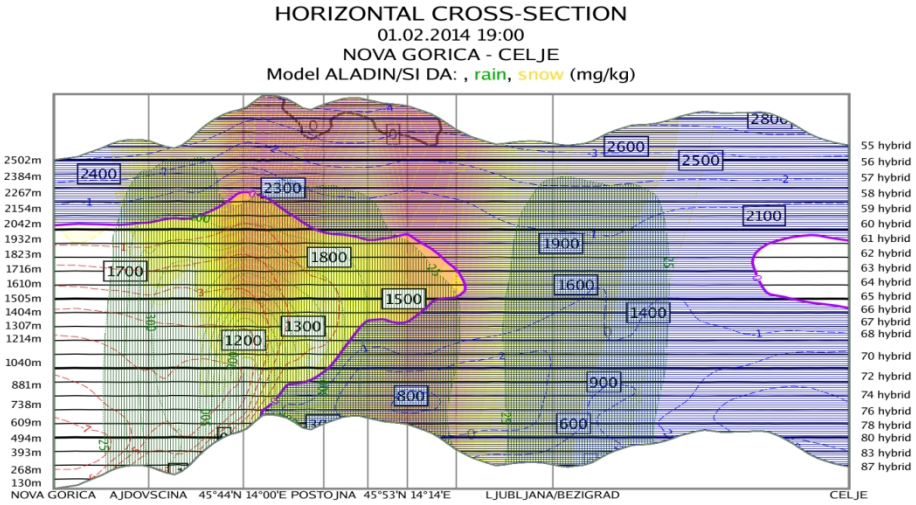


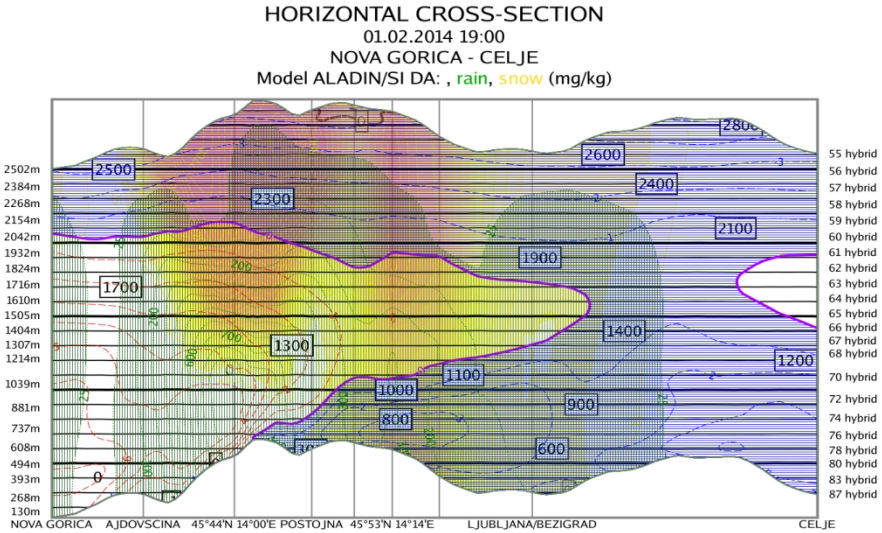
Severe freezing rain case (2)

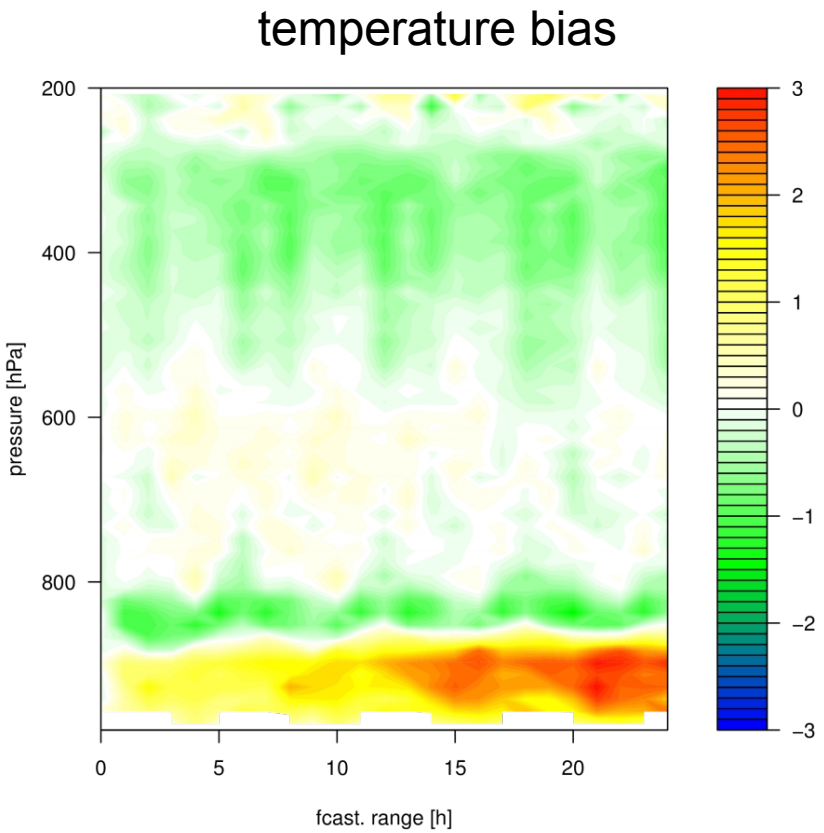




Severe freezing rain case (3)







With Mode-S

Conclusions

- Mode-S MRAR are (on average) very good observations
- Only a small percentage of all aircraft responding with temperature and winds
- Quality control very important
- Clear impact on analysis and short-range forecasts even with data from a single radar
  - Longer impact in winter (inversions)

Future

- Use Mode-S MRAR operationally
- Automatic/adaptive creation of whitelists (important to accept new aircraft)
- New Mode-S radar sites (Korlape in Austria, another near Ljubljana
- Promote Mode-S MRAR
- Use Mode-S EHS (winds)