Assimilation of Mode-S observations in COSMO-DE-KENDA

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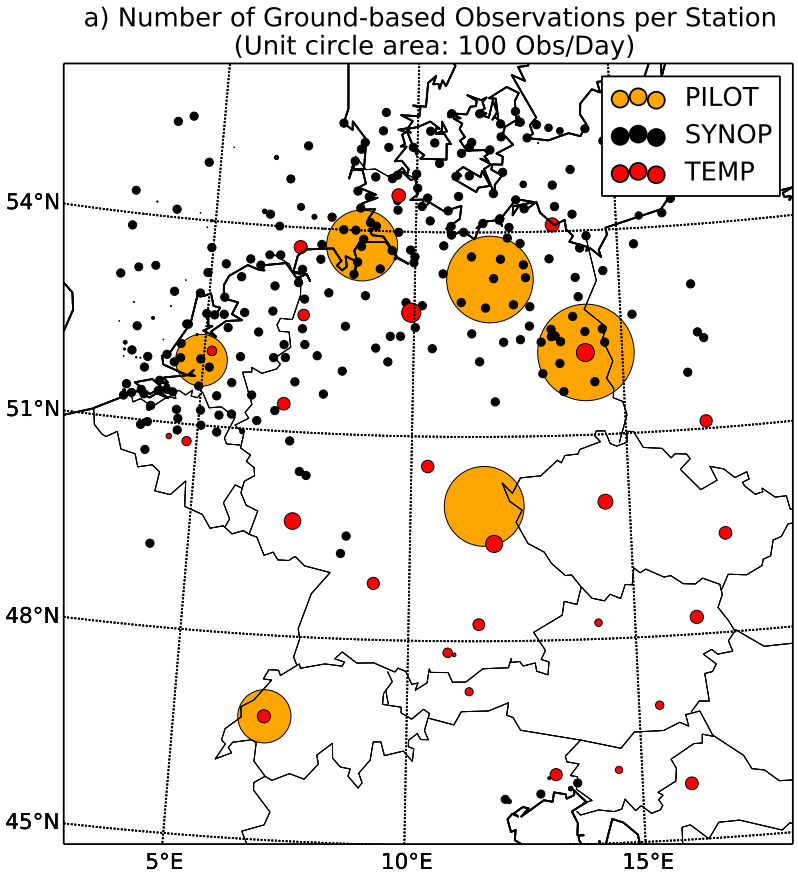
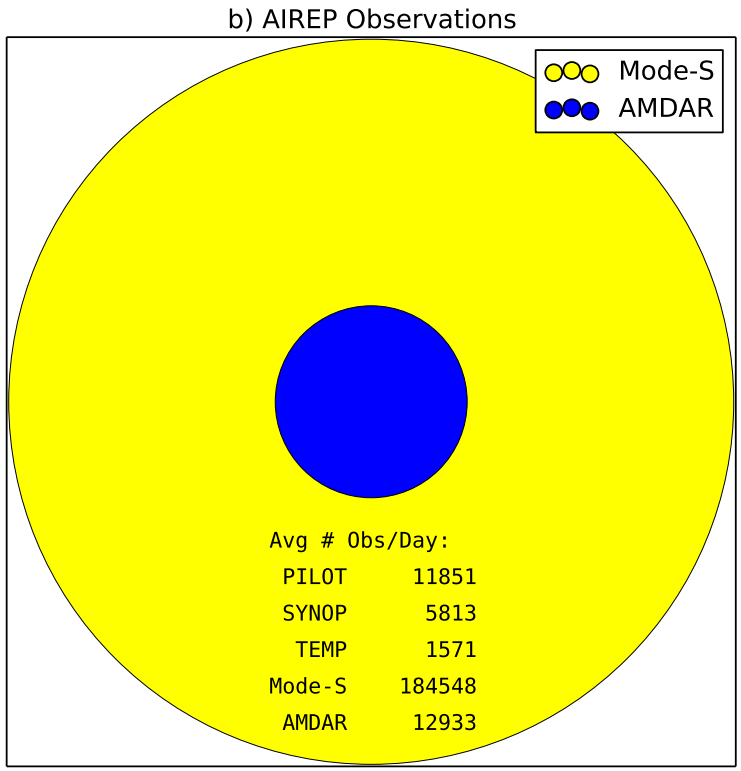
COSMO-MUC Meeting, Offenbach, 06.11.2014

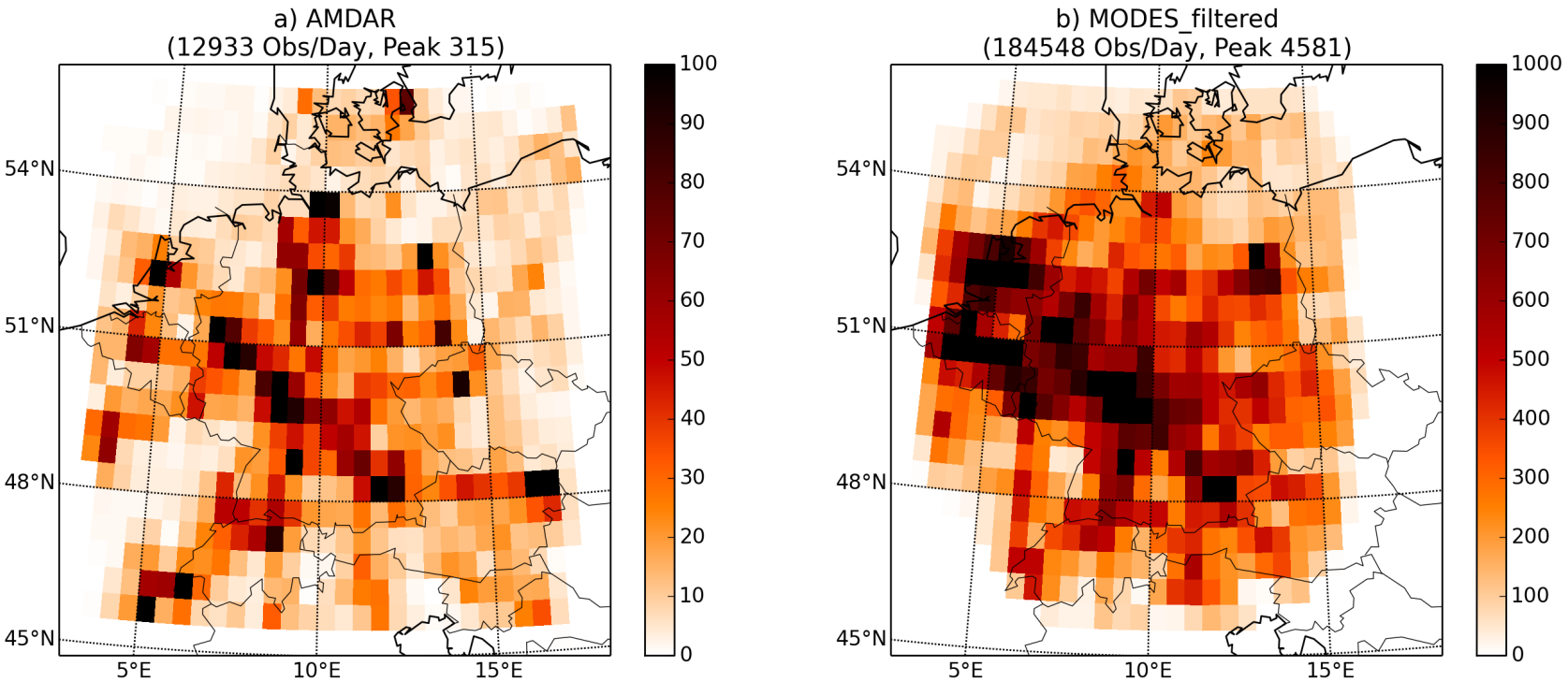
Outline

Conventional observations and AIREP





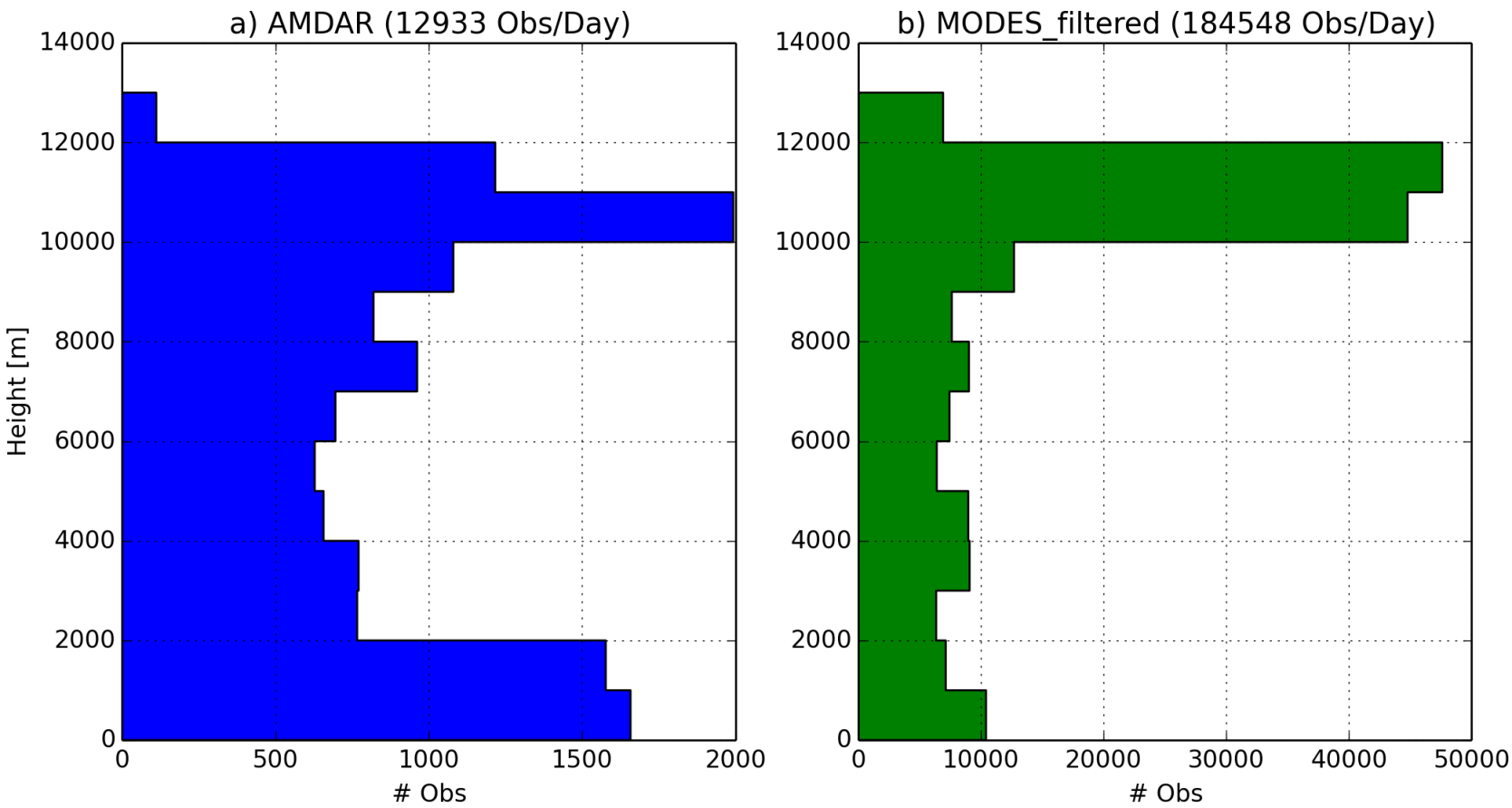
AMDAR and Mode-S observation density



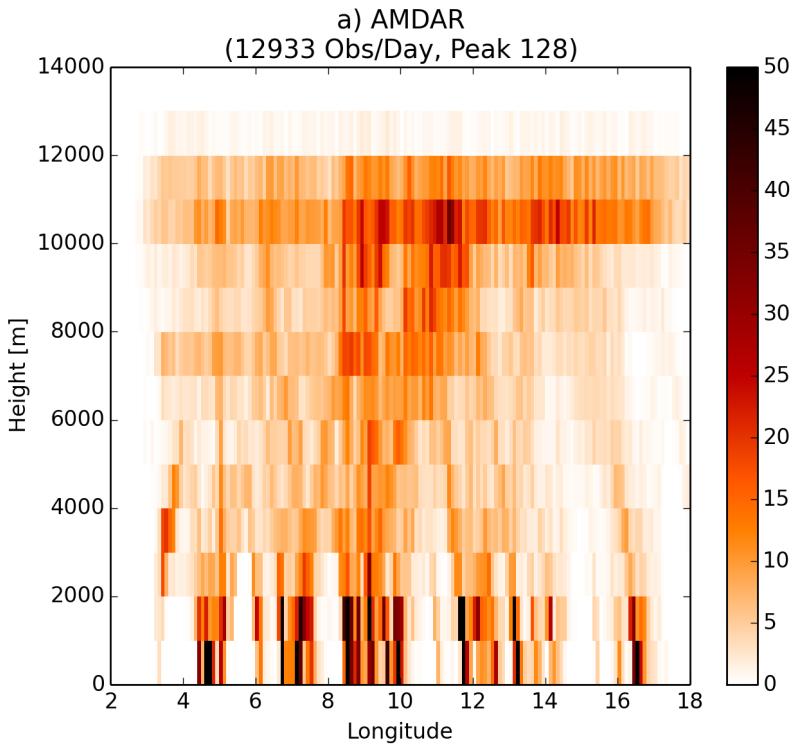
AMDAR and Mode-S observation density

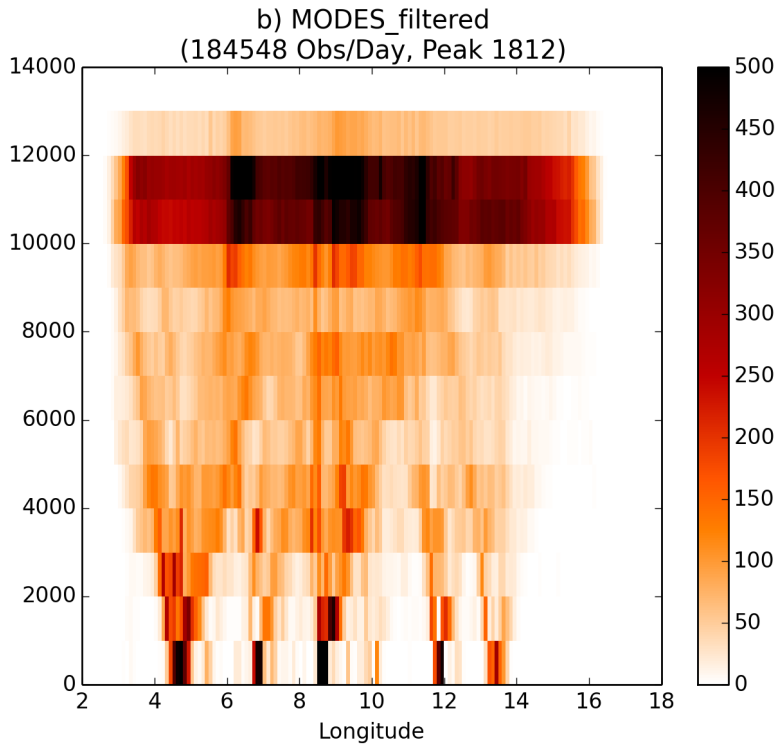
- Mode-S original resolution: **every** aircraft **every** 4 sec
- Mode-S flighttrack-superobbed in AMDAR-fashion:
  1. Ascending flight phase
     - first 9 observations 10 hPa apart
     - after that: 50 hPa apart
  2. Level flight phase
     - Consecutive obs 60 sec apart
  3. Descending flight phase
     - p $<$ 900 hPa: 50 hPa apart
     - p $>$ 900 hPa: 10 hPa apart
  4. Resulting reduction factor: 1/20
- 15 x times more flights in Mode-S than in AMDAR

AMDAR and Mode-S observation density

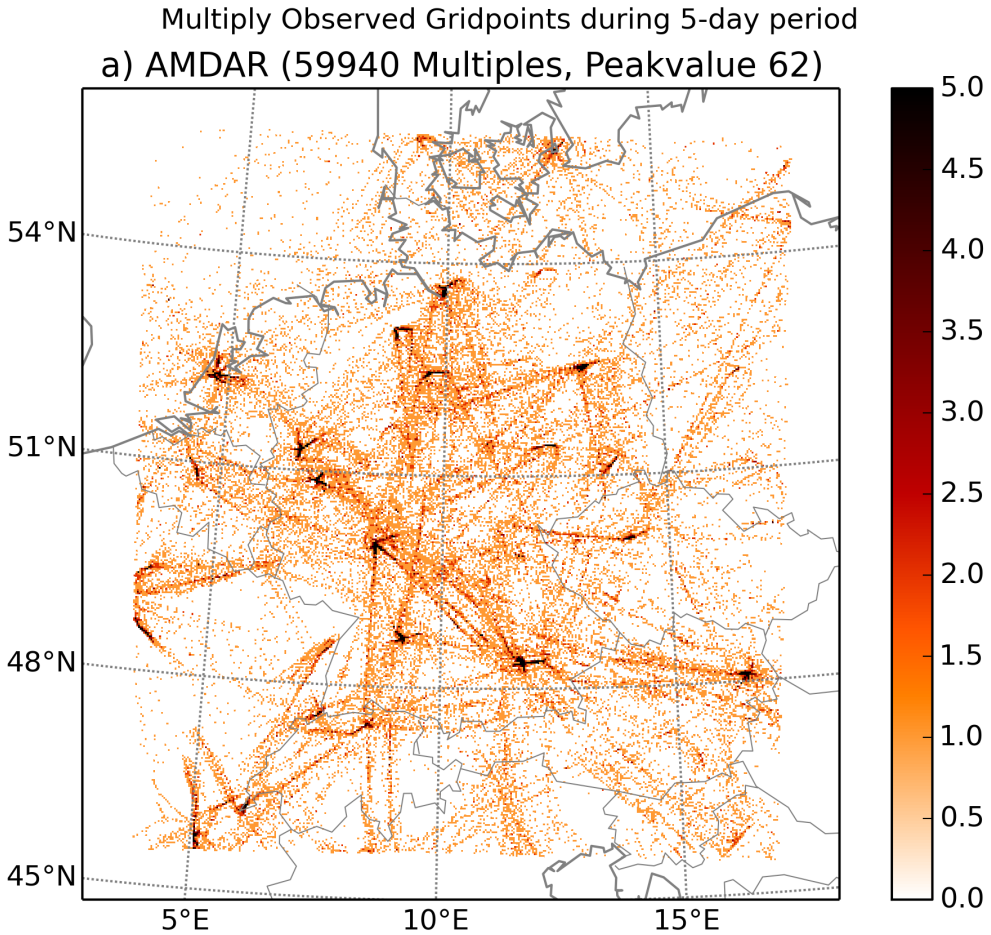


AMDAR and Mode-S observation density

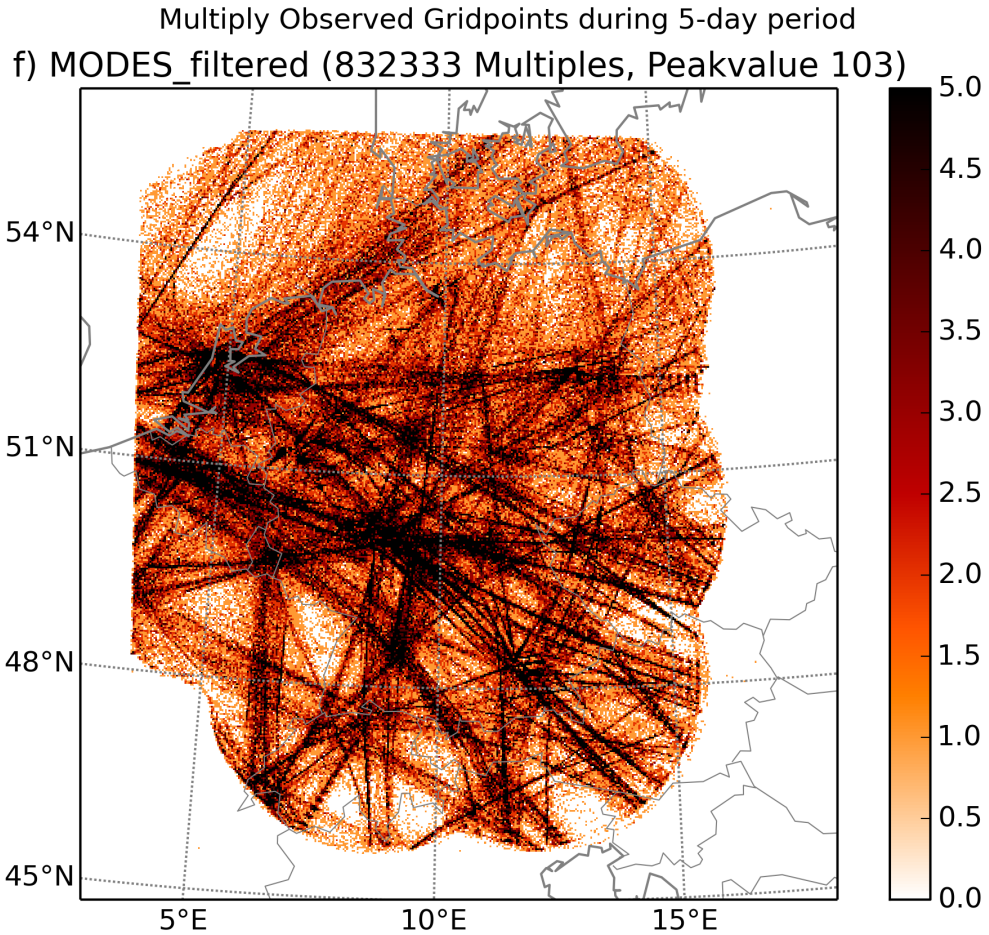




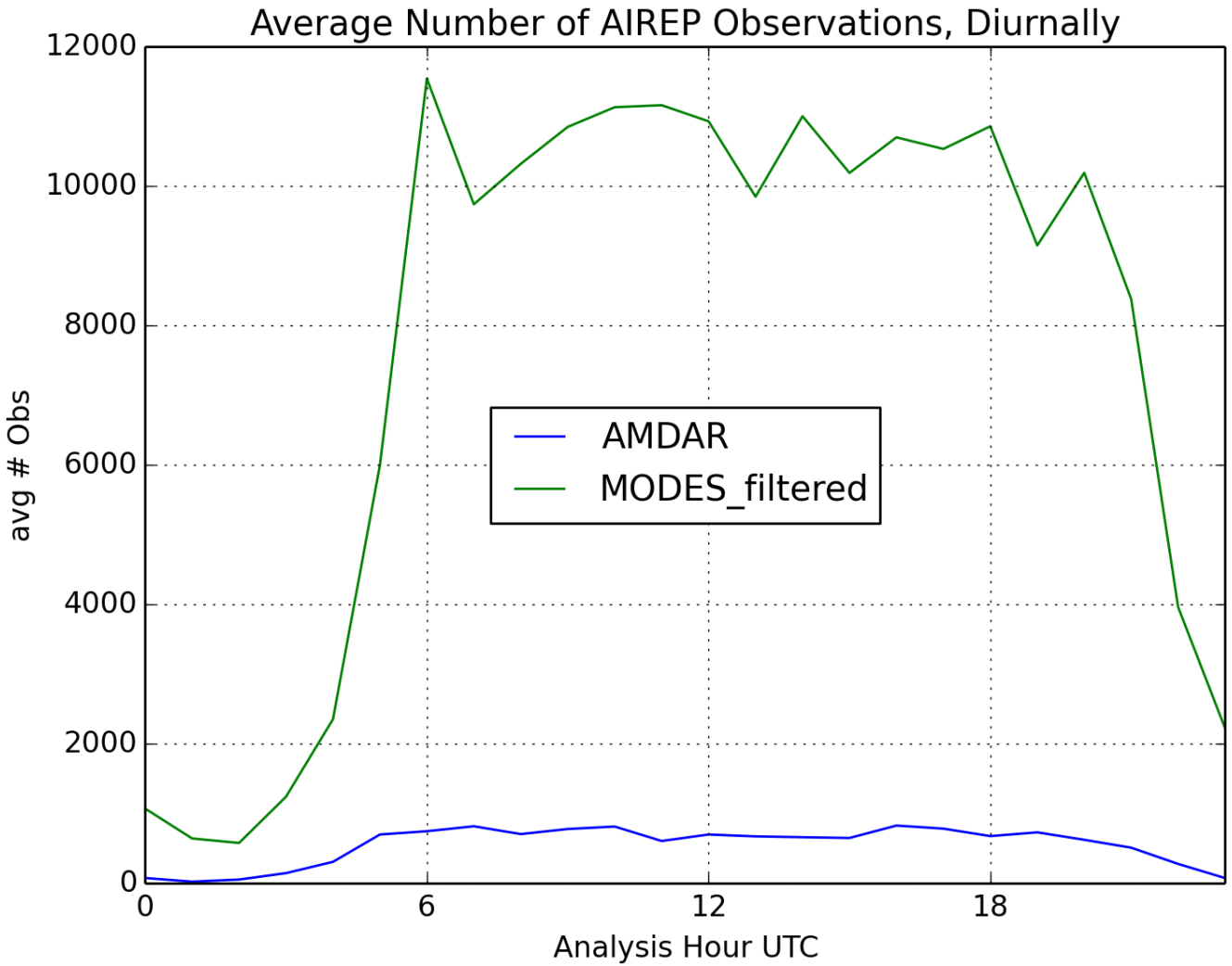
AMDAR redundancy



Mode-S redundancy



Temporal density



COSMO-DE-KENDA Setup

Basic Cycling (BaCy) setup:

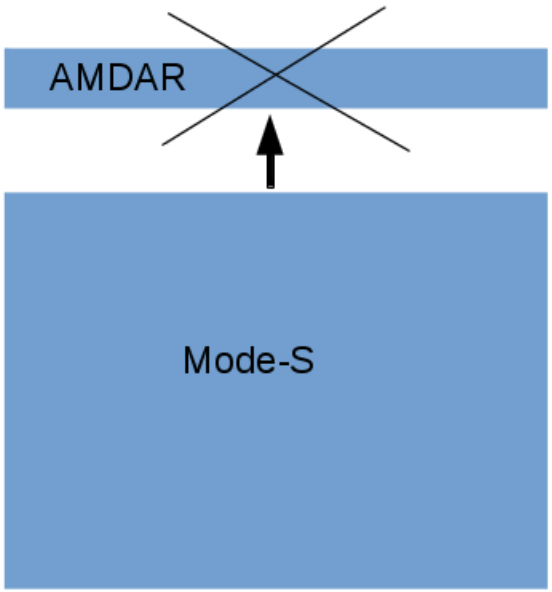
- 40 Member Ensemble of COSMO-DE + 1 Deterministic Run
- Initial and boundary data:
  - 40 global ICON Members + 1 Deterministic Run
  - Period: 06.05.2014 – 12.05.2014
- LETKF:
  - 1-hourly cycling
  - conventional observations:
    - SYNOP
    - PILOT
    - AIREP (AMDAR **or** Mode-S)
    - TEMP (passive)

Goals/Experiments

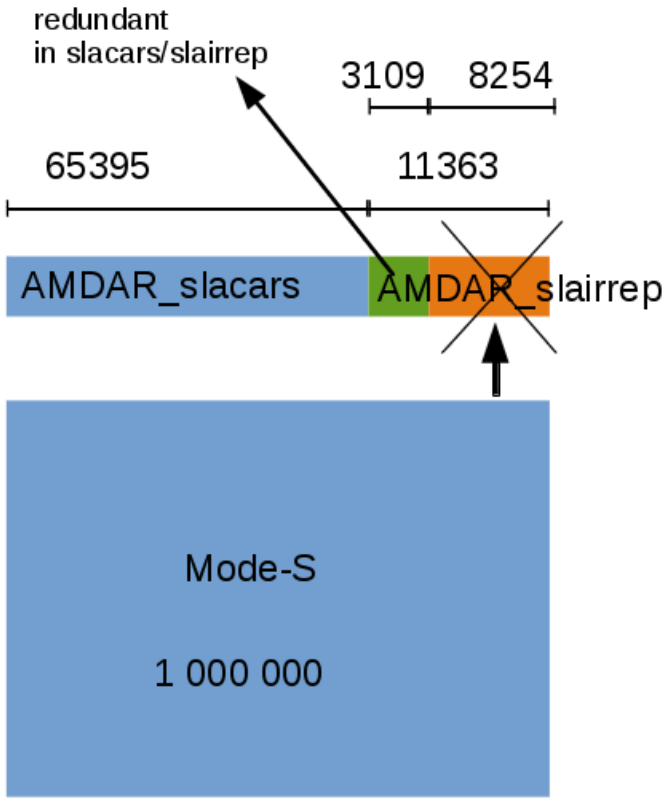
1. Swap AMDAR with Mode-S
2. Monitor quality of Mode-S vs. AMDAR
3. Mode-S 1-hourly vs. 15 minute cycling
4. Thinning of Mode-S (3 hour forecasts)
5. Diagnose observation error of Mode-S

Mode-S swap with AMDAR

a) Plan of AIREP data-change



b) actual AIREP data-change

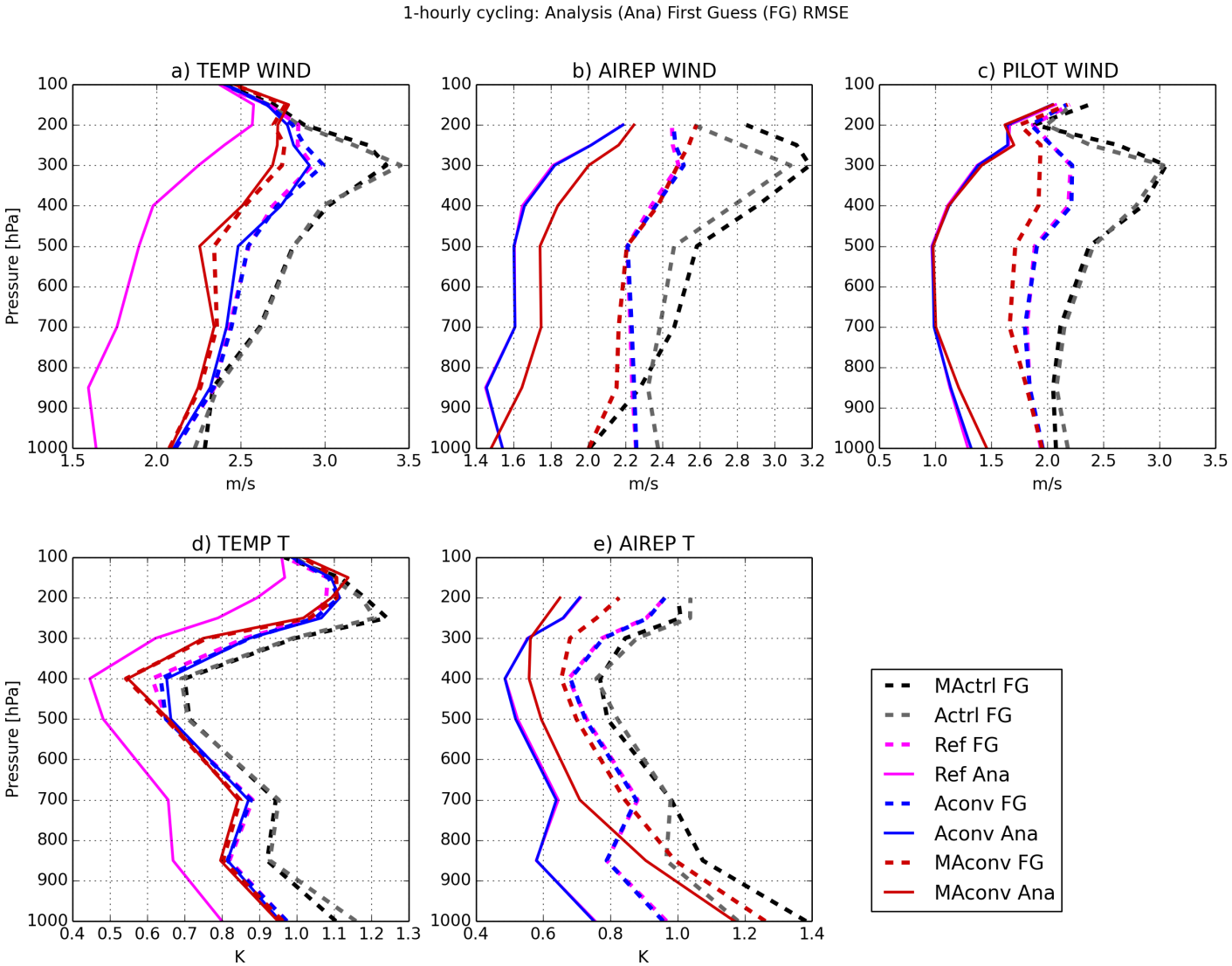


Experiments table

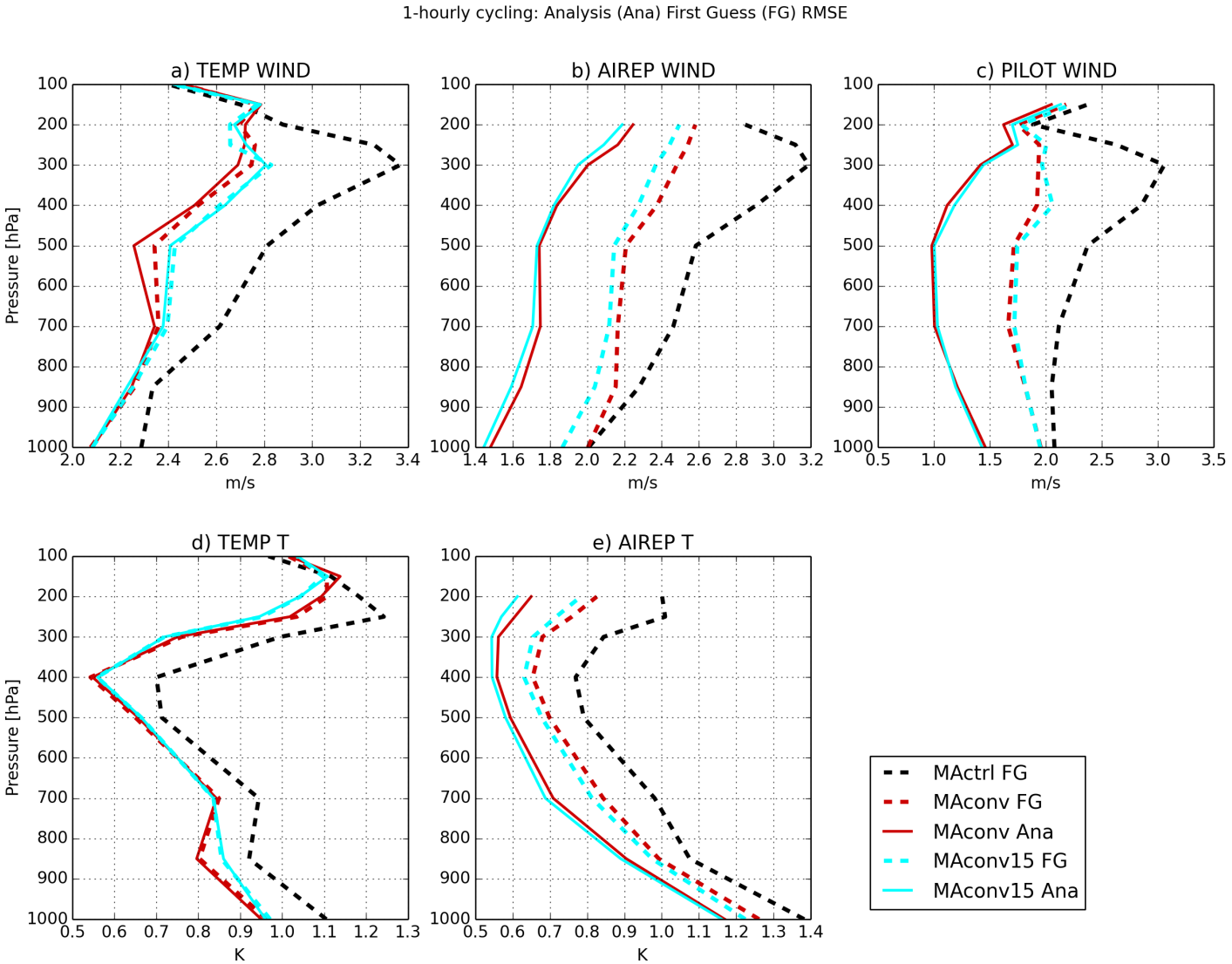
Experiments performed with Mode-S and AMDAR data

	TEMP	SYNOP	PILOT	AMDAR	Mode-S	DDHH 0	Ini	ΔT (min)	% AIREP
Actrl	P	P	P	P (ac+ar)	-	0600	ICON	60	1
MActrl	P	P	P	P (ac)	P	0600	ICON	60	1
Ref	A	A	A	A (ac+ar)	-	0700	Mctrl	60	1
Aconv	P	A	A	A (ac+ar)	-	0700	Mctrl	60	1
MAconv	P	A	A	A (ac)	A	0700	Mctrl	60	1
MAconvTh10	P	A	A	A (ac)	A	0700	Mctrl	60	0.10
MAconvTh20	P	A	A	A (ac)	A	0700	Mctrl	60	0.20
MAconvTh50	P	A	A	A (ac)	A	0700	Mctrl	60	0.50
MAconv15	P	P	P	A (ac)	A	0700	Mctrl	15	1
MAconvR1,2	P	A	A	A (ac)	A	0700	Mctrl	60	1

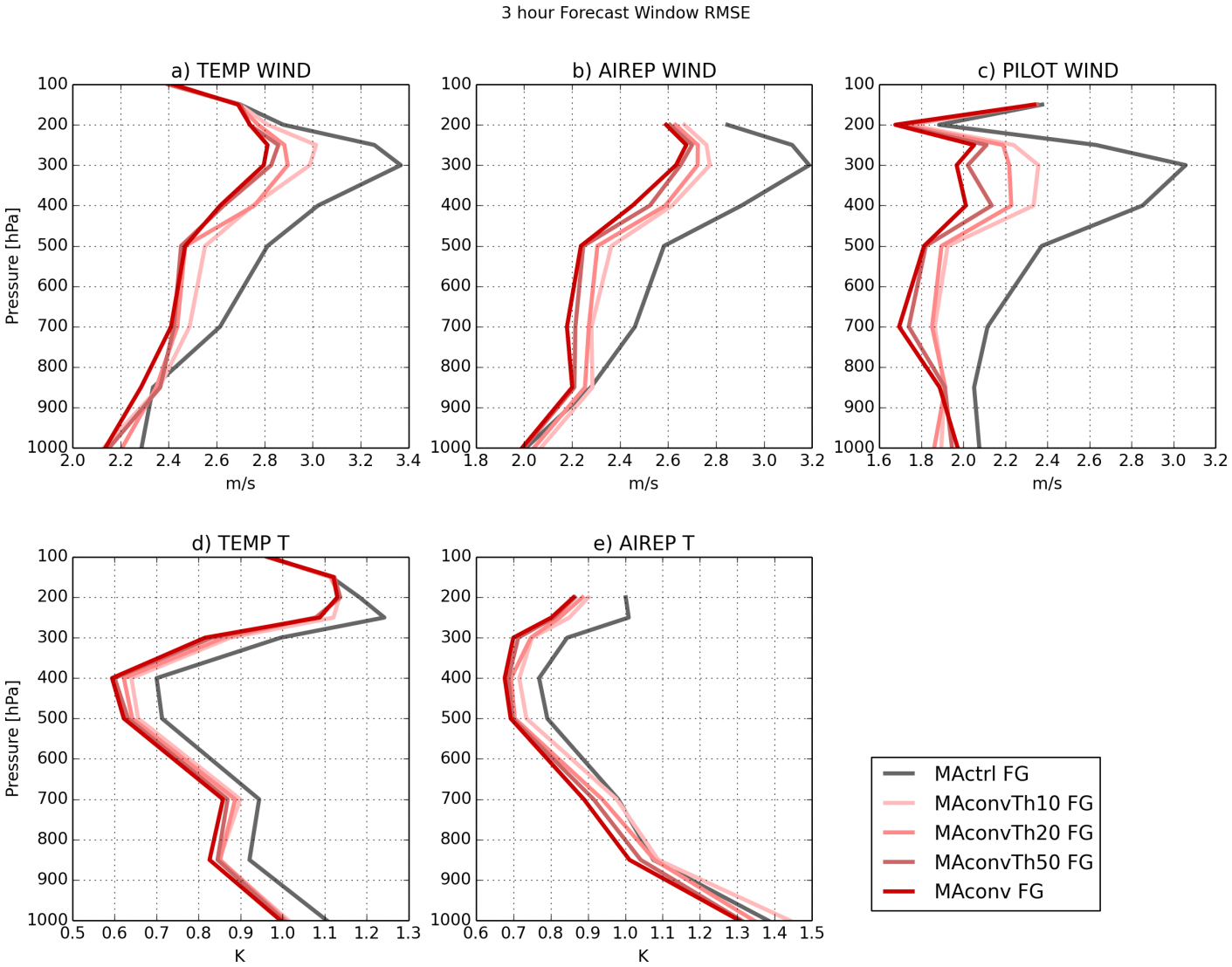
Mode-S vs. AMDAR



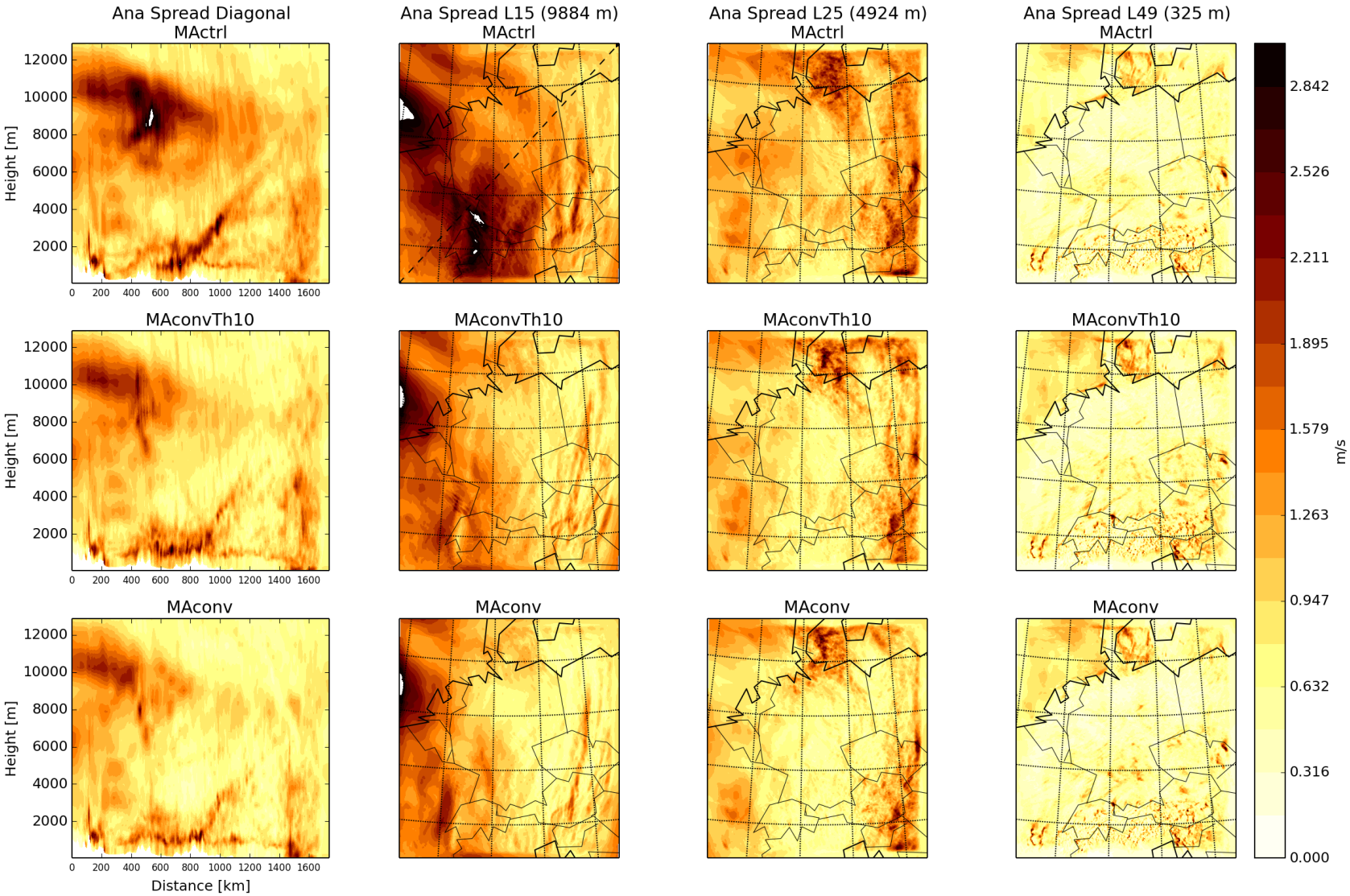
Mode-S: 1-hourly vs. 15 Minute Cycling



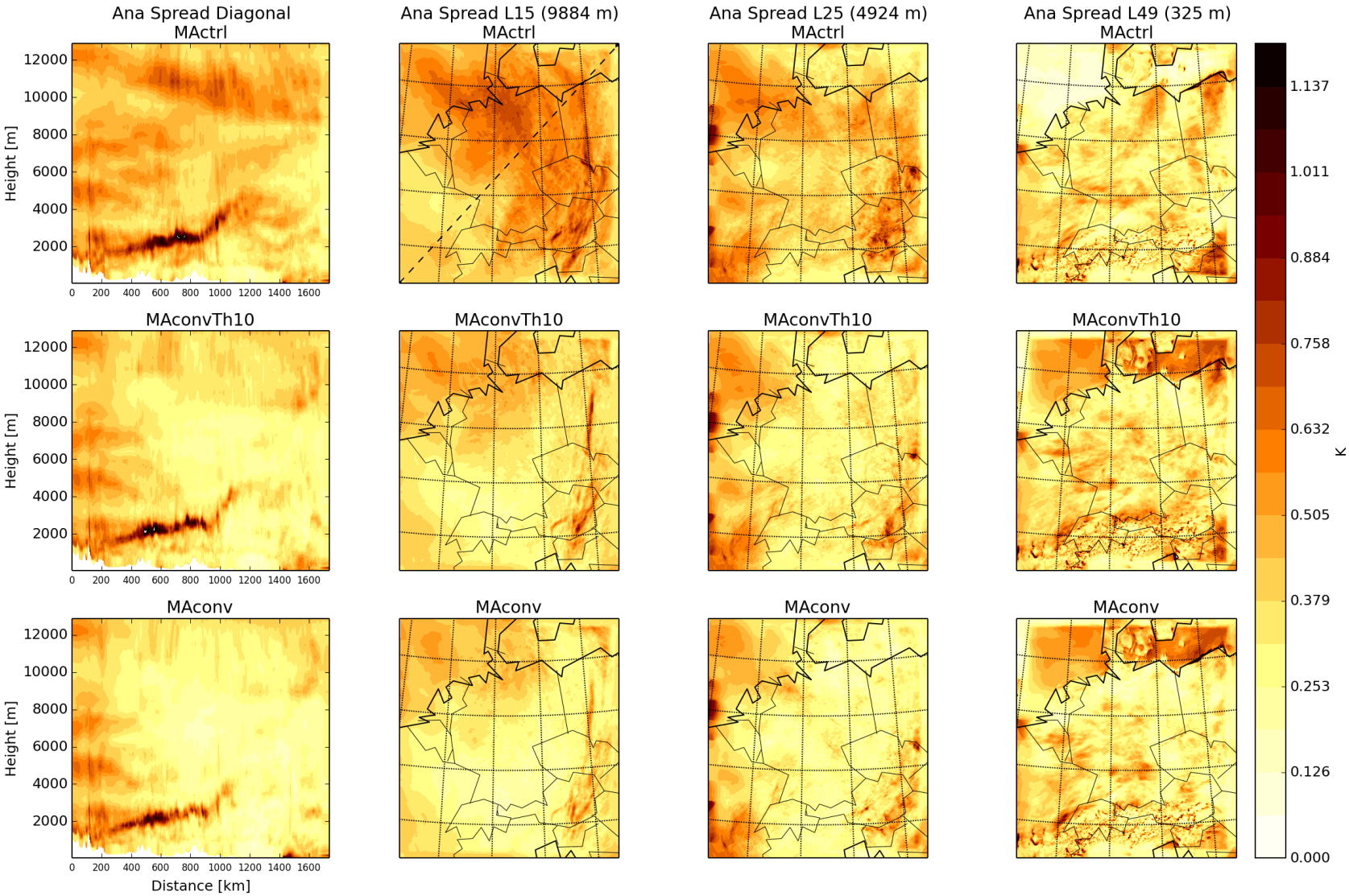
Mode-S: Thinning (3 Hour Forecast Window)



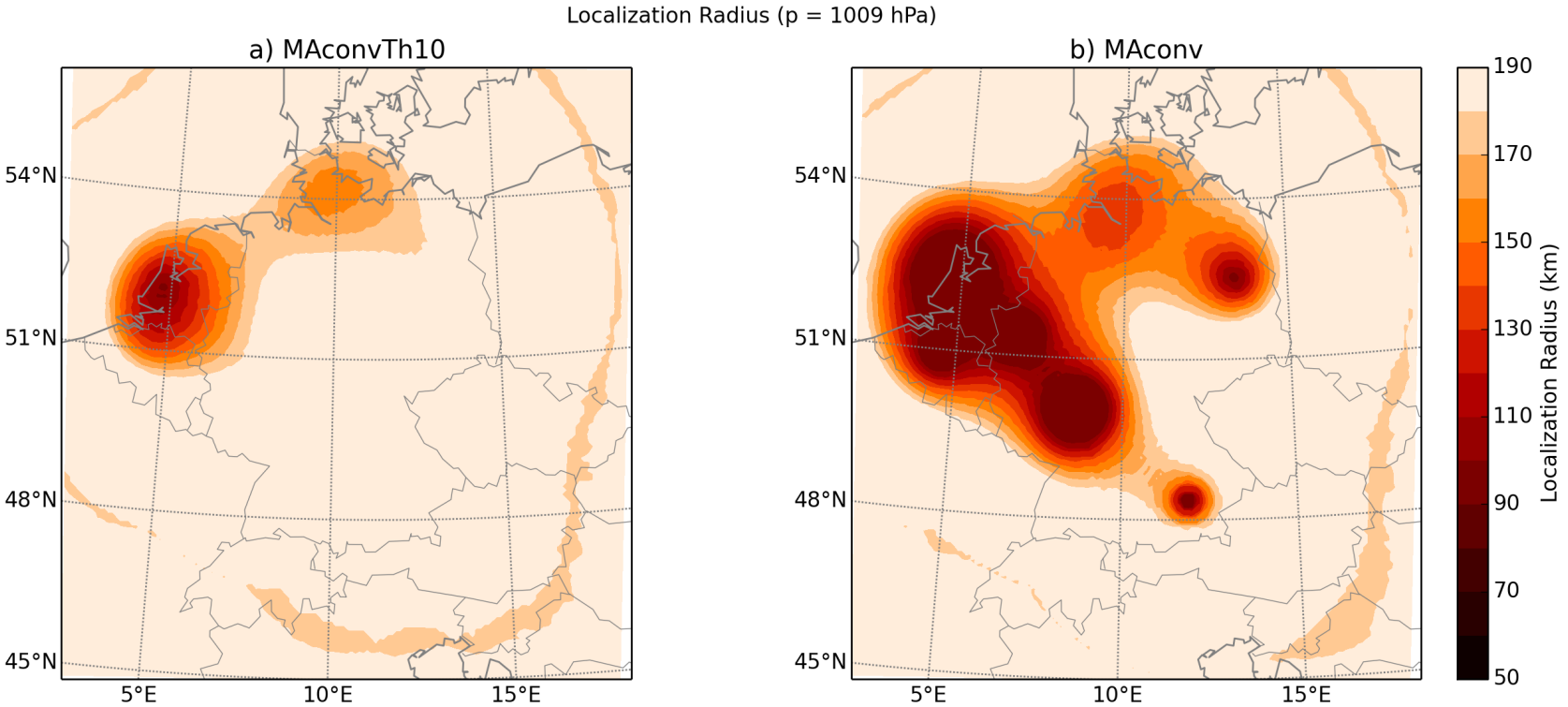
Mode-S: Thinning Analysis Spread (Zonal Wind U)



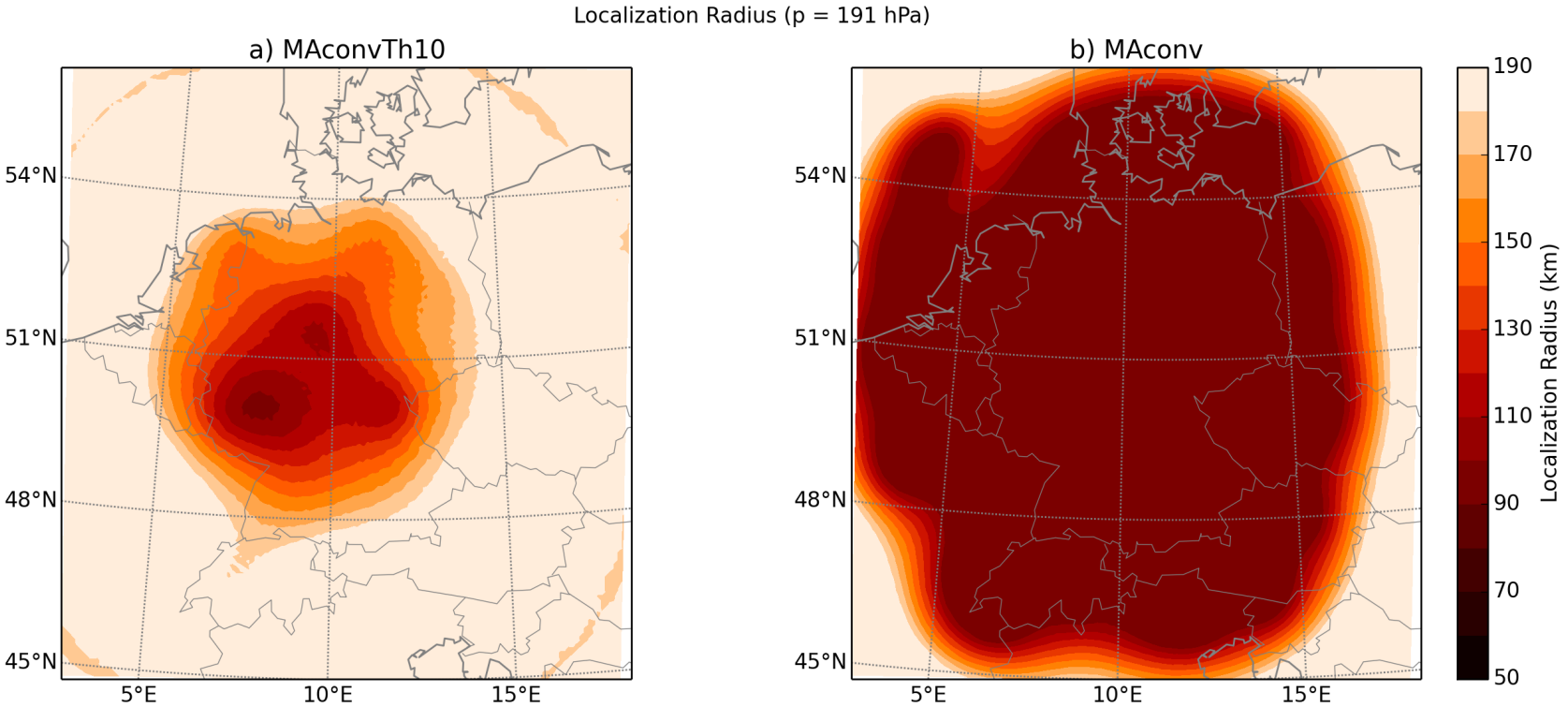
Mode-S: Thinning Analysis Spread (Temperature T)



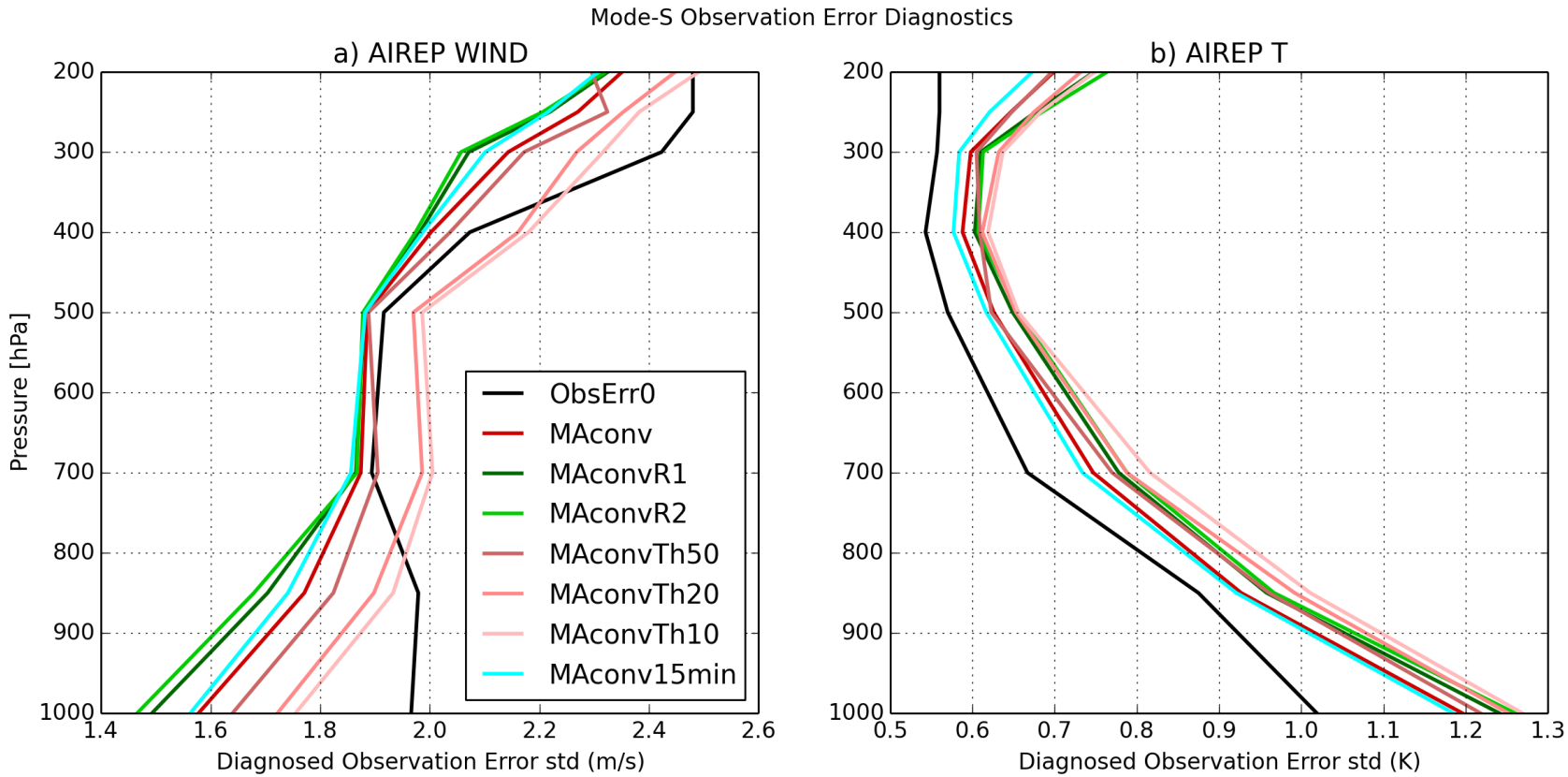
Mode-S: Localization Radius Surface Level



Mode-S: Localization Radius Upper Air



Mode-S: Error Diagnostics (Desroziers Statistics)



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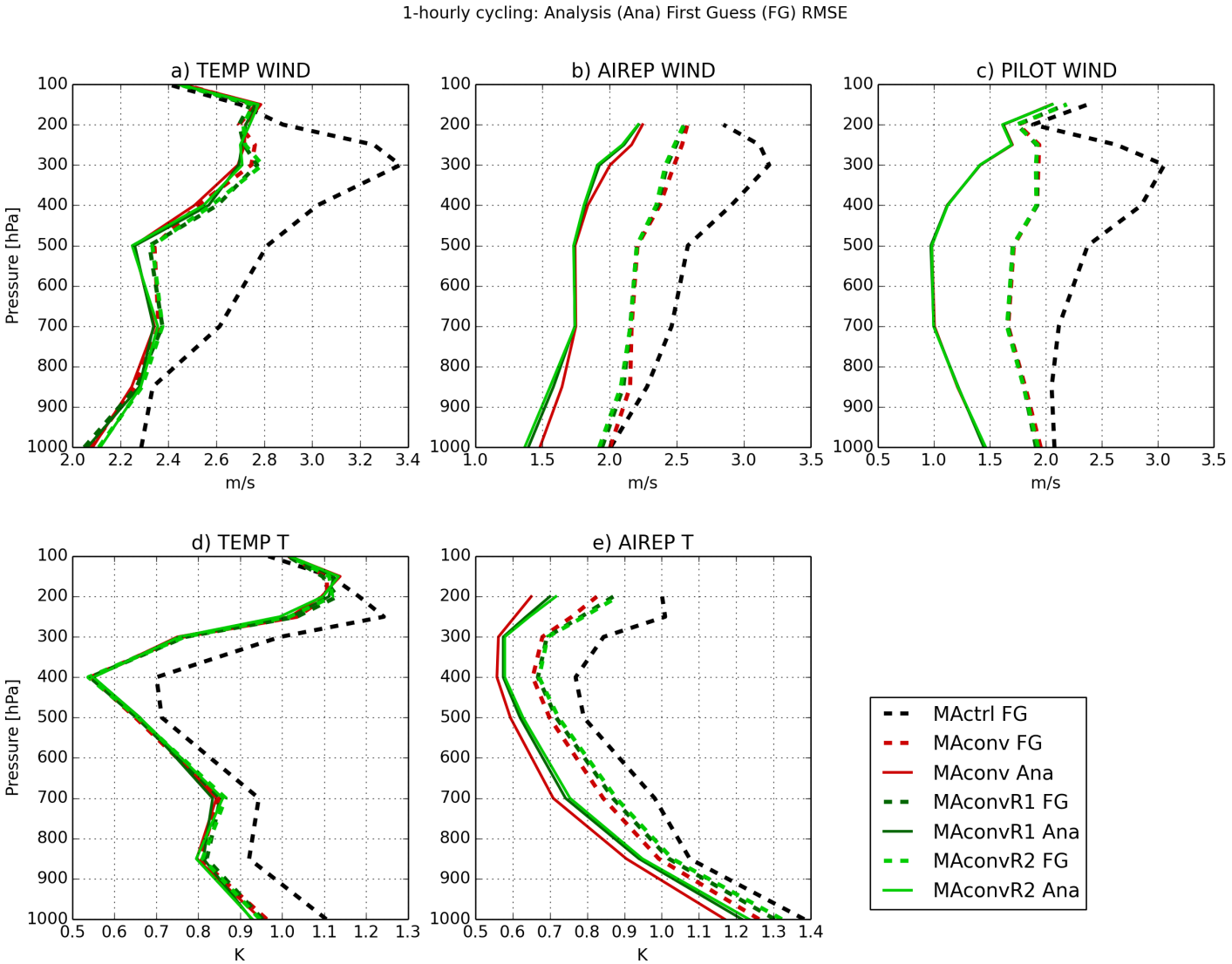

Conclusions

Data Quality of Mode-S:

- Wind error comparable to AMDAR
- Temperature error larger than AMDAR for low levels
- EnDA insensitive to small tunings of observation error

Ensemble Data Assimilation:

- Mode-S data strongly improves analyses and forecasts
- COSMO-KENDA can handle the amount of additional data, no further thinning required
- Ensemble Spread conserved by Relaxation-to-Prior and Adaptive Localization

LETKF-Settings

Namelist-Paramter	Value	Effect
k_enkf	40	Number of ensemble members
det_run	1	Compute deterministic analysis
excl_bnd (deg)	0.67	Distance: Obs excluded if too close to lateral boundaries
height_t (hpa)	100.	Top pressure: Obs excluded if close to model top
rho	1.1	Covariance inflation factor
adap_loc, nobs_gp	True, 100	Adaptive horizontal localization, # Obs/Gridpoint
lh_min, lh_max,	50., 100.	Min/Max Horizontal localization length scale
lv_surf, lv_top	0.075, 0.5	Bottom/Top Vertical localization length scale
apply_rtpp, rtpp_alpha	True, 0.75	Relax to prior perturbation, relaxation factor
rf, nzr	3, 30	Horizontal coarse grid factor, vertical analysis levels
adap_rho (_u,_l)	True, 0.5, 3.	Adaptive background covariance inflation (upper/lower bound)
q_bound, sat_ad	True, True	Positive analysis humidity, saturation adjustment
hyd_bal, bal_var	True, PP	Hydrostatic balancing, balanced variable (pressure perturbation)