Regional Cooperation for
Limited Area Modeling in Central Europe

LACE
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Data assimilation activities at CHMI

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Progress summary since last DAWD

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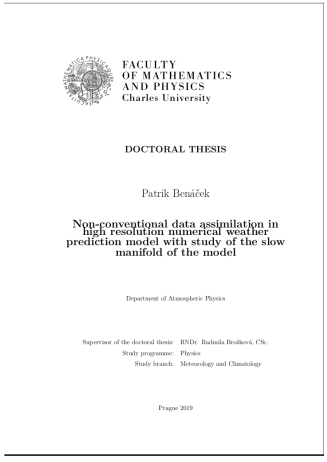
- **Increase of the model resolution to 2.3km - implemented in February 2019**
- **Czech Mode-S MRAR data - made available to RC LACE members from June 2019**
- **Quality of "new" observations (national SYNOP, wind profiler, HRWIND) is investigated and a new approach for the local blacklisting is under evaluation - talk tomorrow**
- **Research on satellite variational bias correction (VarBC) approaches in LAM ended. PhD defended in June - Benáček (2019):** *"Non-conventional data assimilation in high resolution numerical weather prediction model with study of the slow manifold of the mode"* **& article was published in MWR: Benáček and Mile (2019)**



FACULTY
OF MATHEMATICS
AND PHYSICS
Charles University

DOCTORAL THESIS

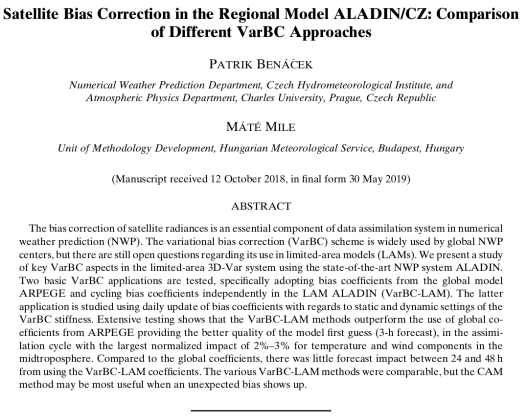
Patrik Benáček

Non-conventional data assimilation in high resolution numerical weather prediction model with study of the slow manifold of the model

Department of Atmospheric Physics

Supervisor of the doctoral thesis: RNDr. Radmila Brožková, CSc.
Study programme: Physics
Study branch: Meteorology and Climatology

Prague 2019



Satellite Bias Correction in the Regional Model ALADIN/CZ: Comparison of Different VarBC Approaches

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ABSTRACT

The bias correction of satellite radiances is an essential component of data assimilation system in numerical weather prediction (NWP). The variational bias correction (VarBC) scheme is widely used by global NWP centers, but there are still open questions regarding its use in limited-area models (LAMs). We present a study of key VarBC aspects in the limited-area 3D-Var system using the state-of-the-art NWP system ALADIN. Two basic VarBC applications are tested, specifically adopting bias coefficients from the global model ARPEGE and cycling bias coefficients independently in the LAM ALADIN (VarBC-LAM). The latter application is studied using daily update of bias coefficients with regards to static and dynamic settings of the VarBC stiffness. Extensive testing shows that the VarBC-LAM methods outperform the use of global coefficients from ARPEGE providing the better quality of the model first guess (3-h forecast), in the assimilation cycle with the largest normalized impact of 2%–3% for temperature and wind components in the midtroposphere. Compared to the global coefficients, there was little forecast impact between 24 and 48 h from using the VarBC-LAM coefficients. The various VarBC-LAM methods were comparable, but the CAM method may be most useful when an unexpected bias shows up.

Operational Setup at CHMI

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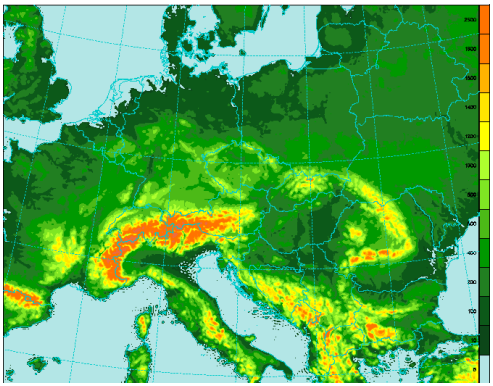
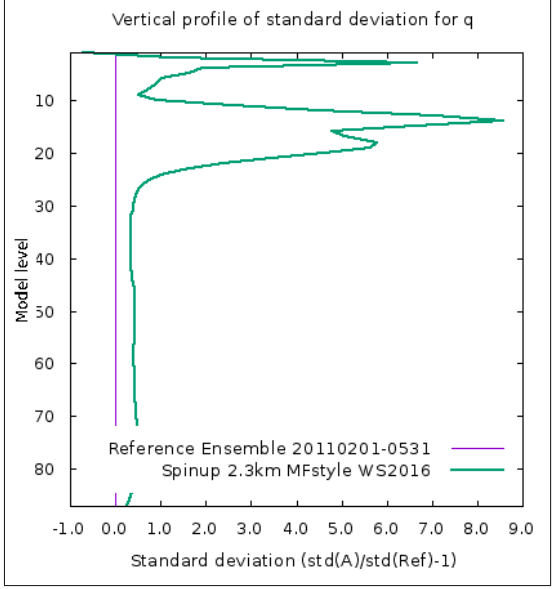


- ALARO NH-v1B cy43t2pt_op1:
  - domain: $\triangle$x 2.3km, 1069x853GP
  - 87 vertical levels, mean orography
  - time step 90s
  - 3h space consistency coupling ARPEGE synchronous
  - forecasts up to +72/+54h at 00, 06, 12 and 18 UTC
  - weak IDFI of short cut-off production analysis
- Upper air analysis – BlendVar scheme
  - BlendVar = DF Blending (filter. at trunc. E102x81) followed by 3D-Var
  - 6h assim cycle, no IDFI in the next +6h assim guess
  - REDNMC=0.5, spin-up ensemble B matrix based on AEARP
  - $\pm$1.5h assim window, VARBC 24h cycling
  - Assimilated observations - SYNOP (Ps), TEMP (t, q, u, v), AMDAR (t, u, v), AMV, SEVIRI (channels: 2, 3), Mode-S MRAR CZ (t, u, v), Mode-S EHS from KNMI (t, u, v)
  - SIGMAO_COEF=.67, SIGMAO_COEF(AMDAR)=2.8, SIGMAO_COEF(RADIANCE)=1.15
- Surface analysis – OI based on SYNOP (T2m, RH2m)
  - SST from ARPEGE

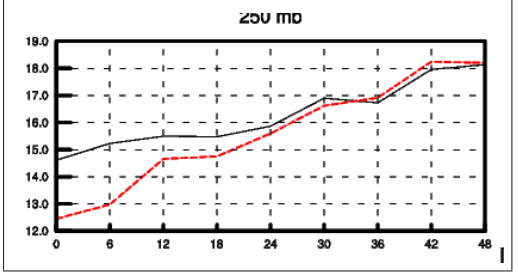
DA aspects of resolution increase

- **Increase of the model resolution from 4.7 to 2.3km**
- **New B matrix**
  - **Computed by dynamical adaptation of 6 memb of AEARP**
  - **The period was 2 weeks in winter and 2 weeks in summer**
- **Tuning: SIGMAO_COEF(RADIANCE)=1.15 and REDNMC=0.5**
  - **Due to performance issues with SEVIRI observations**

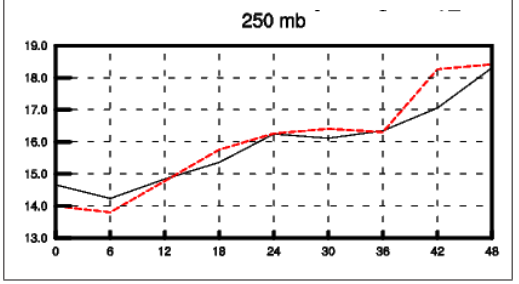
Relative vertical profile of q stde (B matrix diagnostics)



RMSE RH250hPa before tuning of B matrix, ALADIN 4.7km (red), ALADIN 2.3km (black)



RMSE RH250hPa after tuning of B matrix



ALARO-NH 2.3km

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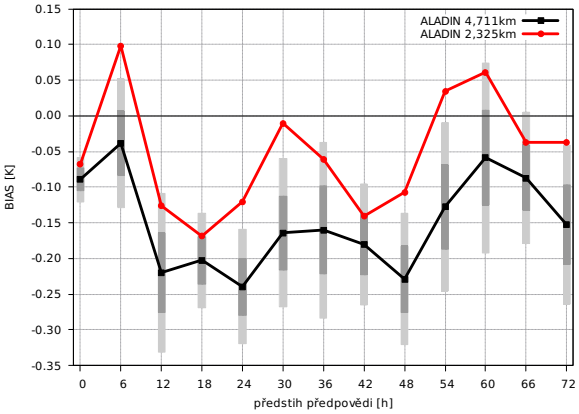
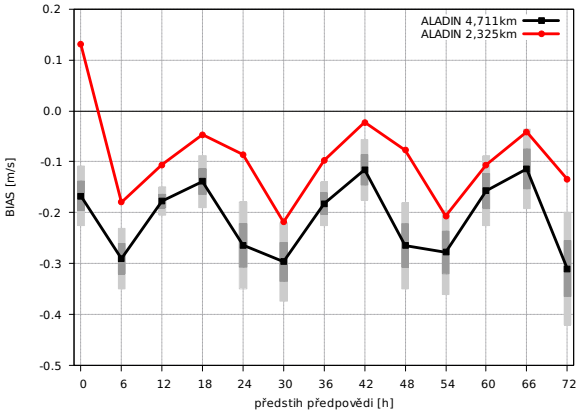
- **Scores** - positive effect on screen level parameters compared to old resolution
  - High resolution 2.3km (**red**), old resolution 4.7km (black)

bias t2m

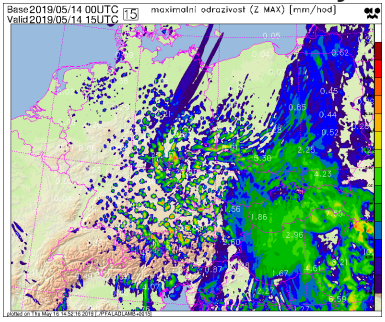


bias v10m

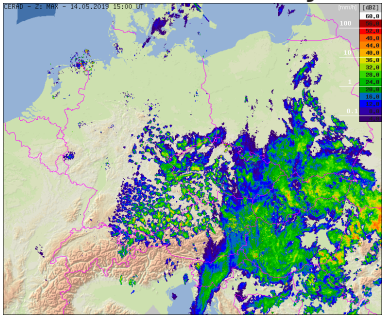


- **New products**

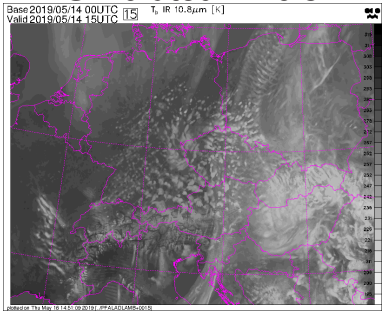
Simulated reflectivity



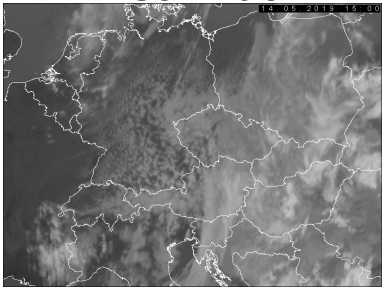
Radar reflectivity



Simulated IR10.8



MSG IR10.8

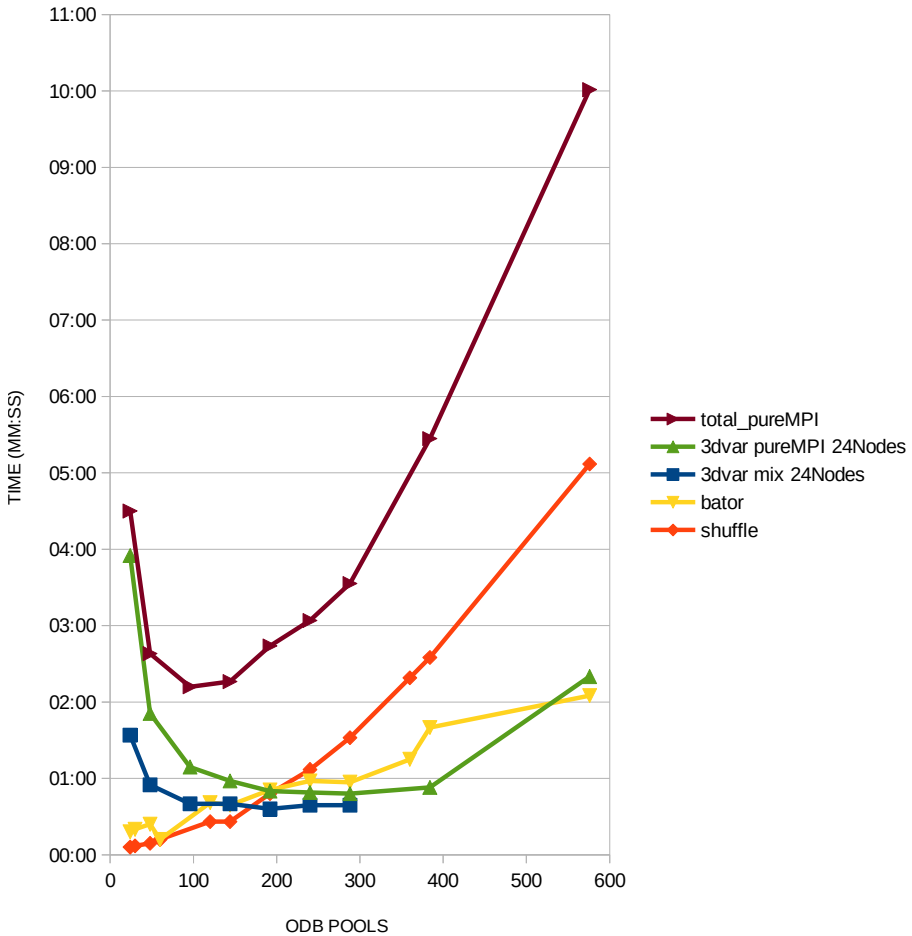


Scalability tests

- Scalability of 3D-Var on 24 Nodes, Node=24 cores of Intel Broadwell
- Execution time of Bator and off-line merge of ODB bases (shuffle) increases almost linearly with number of ODB Pools

  Nodes * MPIperNode = Pools
- Minimization with pureMPI is best on not fully loaded nodes (green)
- Minimization with mix OpenMP/MPI is slightly better on fully populated nodes (blue)
- OPER setup: pure MPI, 24 Nodes * 6 MPIperNode = 144 Pools

  Only 1/4 of cores is used!



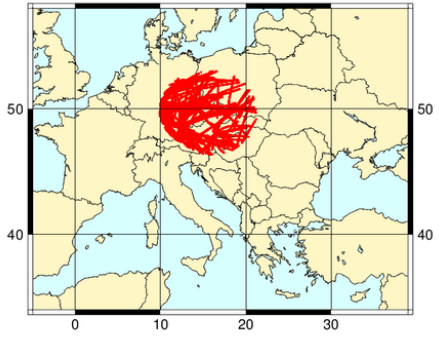
Czech Mode-S aircraft observation

- **quality of Mode-S aircraft data from modern air surveillance system reassessed**
- **good measurements were selected based on 3 months statistics (March-June 2019) with respect to ALARO/CZ NWP model separately for each aircraft (whitelist) following Strajnar (2012)**
- **only aircraft without systematic errors and with standard deviation comparable with other observations selected**

var	number of obs	mean	std
temperature	3000	<1K	<2K
wind speed	3000	<1m/s	<5m/s
wind direction	3000	<10	<100

Table 1: Thresholds used to generate Czech MRAR whitelist of aircraft

- **Czech Mode-S MRAR data - made available to RC LACE members from 8 June 2019**
- **Czech MRAR data has subtype=141 to be distinguishable from AMDAR (subtype=144) or EHS (subtype=145)**



VarBC approaches in LAM

- **VarBC-LAM methods outperform use of global coefficients from ARPEGE**
- **VarBC-LAM provides better quality of the model first guess (3h forecast) in the assimilation cycle with the largest normalized impact of 2%-3% for temperature and wind components in the mid troposphere.**
- **compared to the global coefficients, little forecast impact up to 24h from using the VarBC-LAM coefficients**
- **more details Benáček and Mile (2019)**

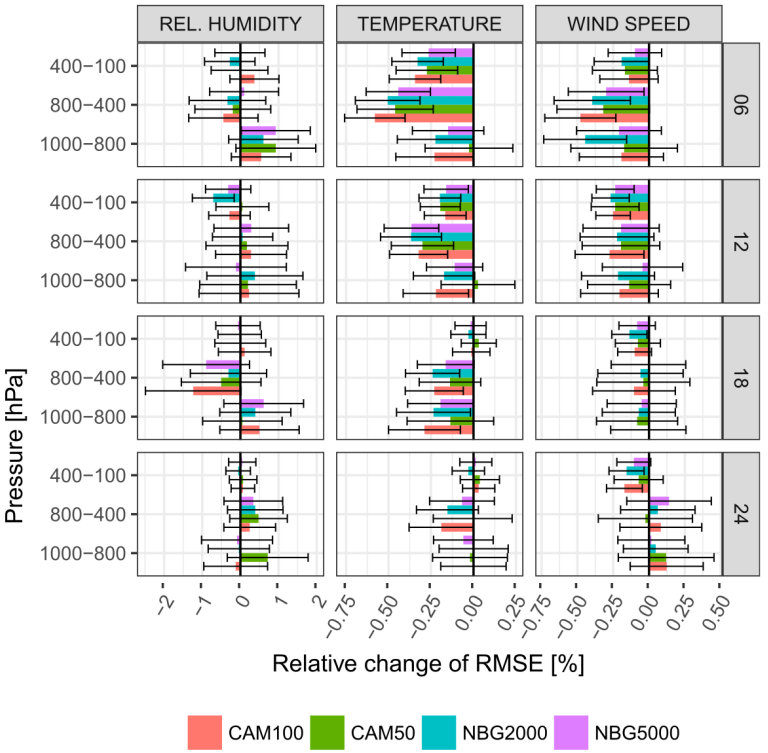


FIG. 8. The normalized RMS impact of various VarBC-LAM methods NBG5000, NBG2000, CAM100, and CAM50 on the 6–48-h forecast for humidity, temperature, and wind speed. The VarBC-global (ARP) is used as a reference. The forecast scores are evaluated from 1 Dec 2015 to 31 Jan 2016 with respect to AMDAR and TEMP measurements separated into three vertical layers. Error bars represent 95% significance level.

Future Plans

- Increase BlendVar cycling frequency from 6h to 3h
- Improve representation of B matrix
- Extend use of existing observations:
  - national synoptic observations
  - wind observations (HRWIND, wind profilers,scatterometers)
  - radar data
  - radiances from polar satellites
- Investigate hourly RUP (non-cycled) NWP based nowcasting system up to +12h

End

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Thank you for your attention !

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References

Patrik Benáček. *Non-conventional data assimilation in high resolution numerical weather prediction model with study of the slow manifold of the model*. PhD thesis, Charles University, Prague, 2019. http://hdl.handle.net/20.500.11956/108243.

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