Numerical Weather Prediction @ Czech Hydrometerological Institute

Joint 27th ALADIN Workshop & HIRLAM All Staff Meeting 2017, 3-7/04/2017, Helsinki, Finland

NWP system

ALADIN/CHMI couples hydrostatic dynamics and the set of ALARO-1 physical parameterizations suited for modeling atmospheric motions from planetary up to the meso-gamma scales:

- domain 529x421 grid points, Δx~4.7km
- linear truncation E269x215
- 87 vertical levels, mean orography
- time step 180 s
- 3h coupling interval
- 00, 06, 12/18 UTC forecast to +72/54h
- hourly analysis system VarCan Pack
- ALADIN cycle **38t1tr_op6** **(ALARO-1vA+)**

Figure 1: Orography of model domain

Data assimilation includes surface analysis based on an optimal interpolation (OI) and **BlendVar** analysis for upper air fields, which consists of the digital filter spectral blending (Brozkova et al., 2001) followed by 3DVAR analysis based on the incremental formulation originally introduced in the ARPEGE/IFS global assimilation (Courtier et al., 1994, doi: 10.1002/qj.49712051912).

- digital filtering at truncation E87x69; space consistent coupling
- no DFI in long cut-off 6h cycle; incremental DFI in short cut-off production analysis

Major operational changes during 2016

26 Jan 2016 - prolongation of forecast to +72h

16 Jun 2016 - new 2m diagnostics

26 Sep 2016 - new cloud base of the non-precipitating convection in TOUCANS
- new cloud geometry (exponential-random overlap)
- improved diagnostics of sunshine duration

Developments of longwave radiation scheme ACRANEB2

Shortwave part of **ACRANEB2 radiation transfer scheme** was published in QJRMS (Mašek et al. 2016, doi:10.1002/qj.2653), paper describing the longwave part is in the review process in the same journal. Evaluating accuracy of the NER (Net Exchanged Rate) technique with bracketing required construction of independent narrowband reference with full inclusion of scattering. It confirmed that in the longwave part of spectrum grey treatment of aerosols and clouds is fully justified, and gaseous transmissions are the only quantities whose broadband optical saturation must be parameterized.

Figure 1 demonstrates accuracy of bracketing technique, making the cost of EBL (Exchange Between Layers) computation linear in number of levels. Figures 2 and 3 show accuracy of ACRANEB2 and of narrowband reference, respectively. In NWP environment, broadband approach combined with selective intermittency leads to an optimal share between cost and accuracy, making ACRANEB2 outperforming traditional approach that compromises high accuracy of k-distribution method by using rather crude full intermittency in order to make the computational cost affordable.

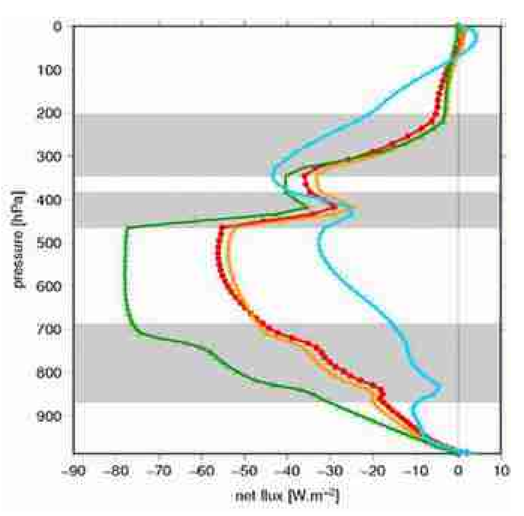


Figure 1: EBL flux calculated by narrowband reference and by bracketing technique, interpolating between minimum and maximum EBL estimates. The case shown is a waving cold front on 01-Jul-2012 at 18 UTC in Prague. Cloud layers are denoted by grey shading.

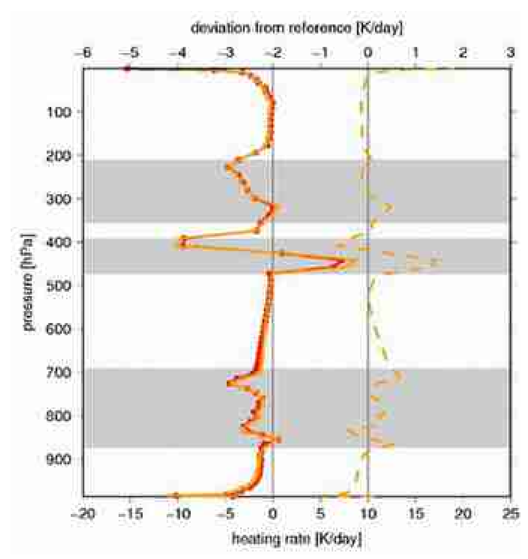


Figure 2: Longwave heating rate computed by narrowband reference and by ACRANEB2 for the same case as on figure 1. Dashed line denotes error of ACRANEB2 with respect to narrowband reference (upper scale).

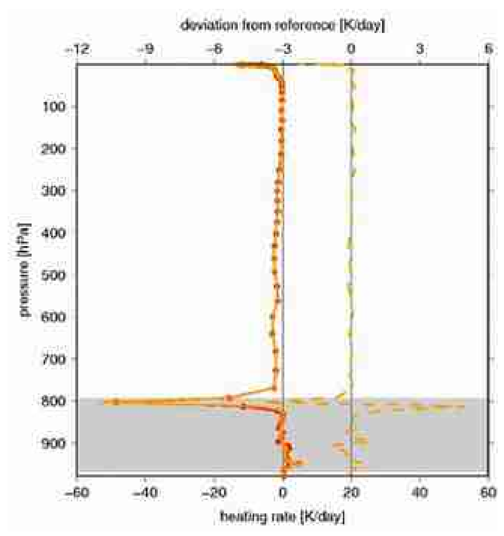


Figure 3: Longwave heating rate delivered by line by line calculation and by narrowband reference for CIRC (Continual Intercomparison of Radiation Codes) benchmark case 6. Dashed line denotes error of narrowband reference with respect to line by line calculation (upper scale).

Major operational changes in detail

The new **diagnostics of 2m temperature and humidity** (LACE stay of M. Dian)

- still based on Monin-Obukhov similarity theory (following Geleyn 1988, doi:10.1111/j.1600-0870.1988.tb00352.x)
- in stable conditions, more realistic stability function for heat inspired by SHEBA experiment is used (after Kullmann 2009)
- insertion of elimination parameter was revised, removing spurious oscillations and discontinuous behavior seen in the limit of very strong stability
- the new diagnostics affects surface analysis via obs operator
- it reduces diurnal amplitude of 2m temperature and humidity bias

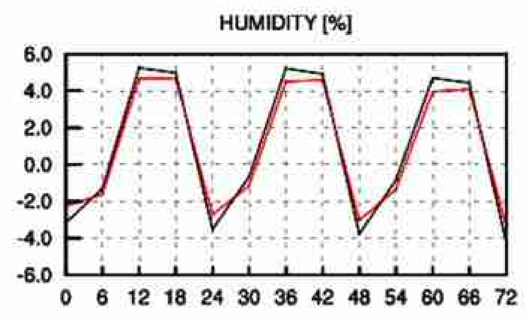


Figure 1: RH2m BIAS for **OPER**, **e-suite** for 12 May–15 Jun 2016.

The new scheme of the **non-precipitating convection in TOUCANS** based on:

- mass-flux type approach
- recent works on moist Brunt-Väisälä frequency formulation
- fit to LES data
- operational in ALARO-1 within the turbulence scheme TOUCANS (Bašták Ďurán et al., 2014, doi:10.1175/JAS-D-13-0203.1)

The scheme reduces a weak rain spread present in the reference:

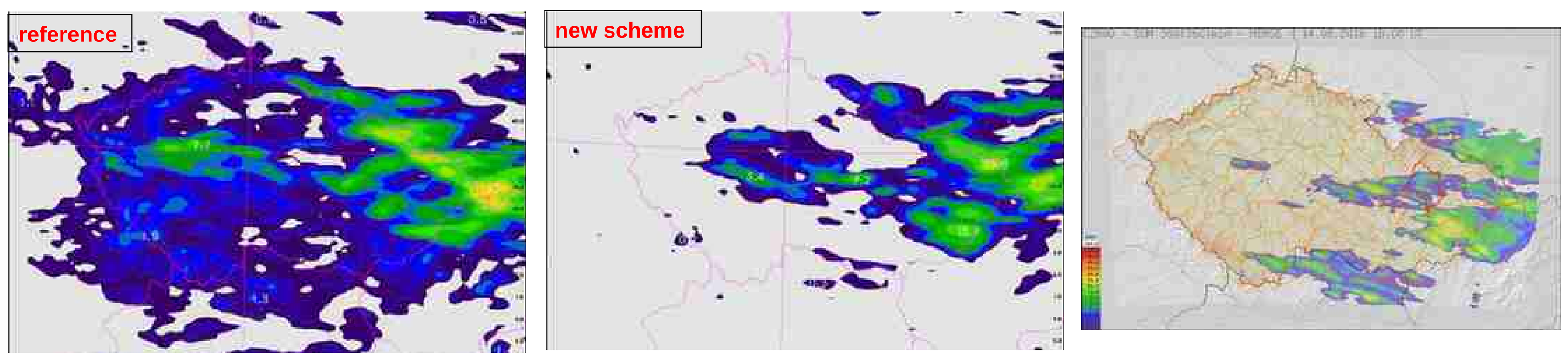


Figure 2: 6h precipitation forecast for 14 August 2016 00UTC for lead time of +18h for reference (left), the new scheme (middle) and observations – radar and rain gauges based quantitative precipitation estimate (right).

Radiation scheme originally assumed maximum-random **cloud overlap**:

- unrealistic for deep clouds
- replaced by a more realistic exponential-random cloud overlap
- decorrelation depth depending on latitude and solar declination (inspired by Oreopoulos et al. 2012, doi:10.5194/acp-12-9097-2012)

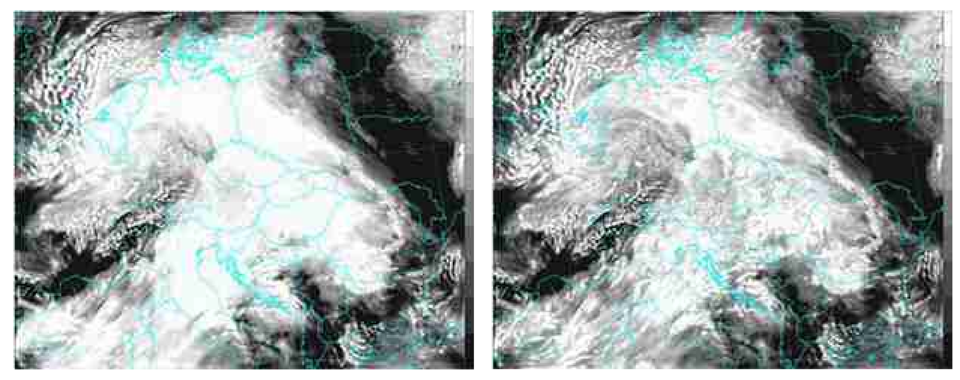
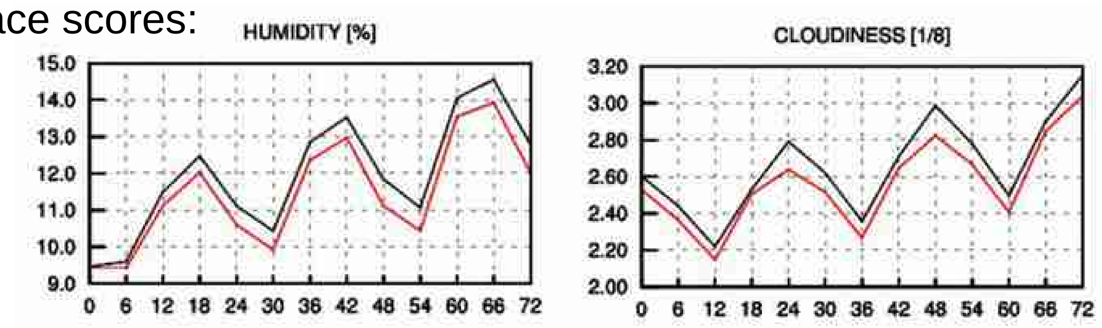


Figure 3: Total cloud cover in radiation for 14 October 2015 for lead time +12h (case of C. Wittmann). Exponential-random (left) and maximum-random overlap (right).

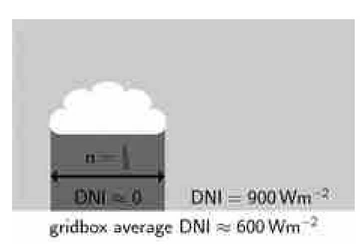
More realistic cloud overlap hypothesis together with the new parameterization of shallow convection lead to improved surface scores:

Figure 4: STD of RH2m (right) and cloudiness (right) for **OPER** and **e-suite** for 22 Jul – 25 Sep 2016.



Problems with **sunshine duration**:

- strong overestimation in situations with partial cloud cover, even when model DNI (Direct Normal Irradiance) is realistic
- same syndrome is visible in ECMWF deterministic forecast
- it is incorrect to evaluate sunshine condition (DNI > 120W/m2) using gridbox average DNI
- subgrid variability of the surface DNI must be taken into account:



gridbox average DNI => sunshine during whole Δt

reality => sunshine only during 2/3 of Δt

- new approach evaluates sunshine condition separately below cloud and in the clearsky part of gridbox, weighting the result by total cloud cover
- impact of the new diagnostics on scores is impressive

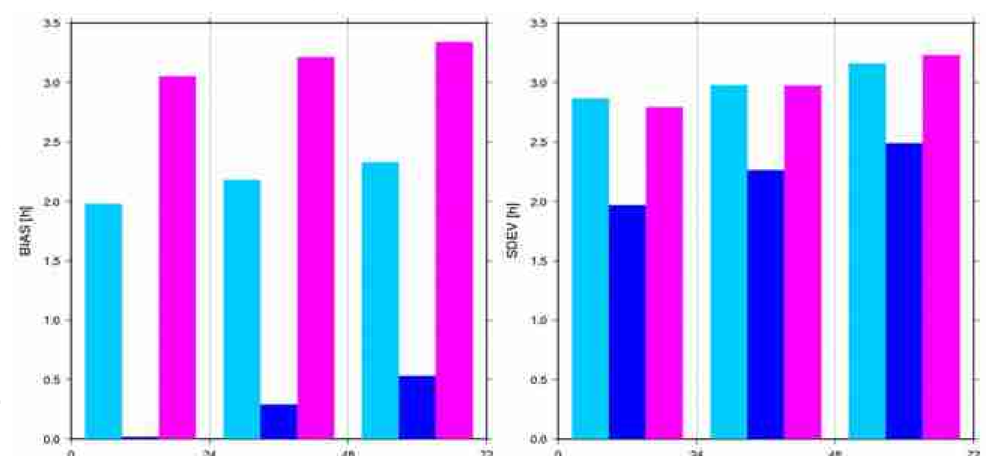


Figure 5: BIAS (left) and STD (right) scores of sunshine duration for **OPER**, **e-suite** and **ECMWF** over 19 stations in the Czech Republic from period 30 Jun 2016 to 26 Sep 2016.

Testing parameters of iterative time schemes

When setting the **iterative time scheme (PC scheme)** we may choose the time discretization used in the research of SL trajectory (SETTLS or NESC) and the time discretization of non-linear terms used in the predictor step, while in all corrector steps the non-extrapolating (NESC) scheme is used. Furthermore, we decide if the SL trajectories will be recalculated in corrector steps or not. The trajectories are kept for corrector steps unchanged in case the “CHEAP” version of the iterative scheme is used.

An orographic wave over the mountainous Czech western boundary on 27 January 2008 has been simulated using 1km horizontal resolution and 87 vertical levels with integration for 24 hours from 00UTC. Tests have been performed with ALARO-1 physics and various configurations of the iterative time scheme with one iteration. An enhanced time step of 50s was used to see the difference in the stability and accuracy of distinct configurations. The appropriate choice would rather be 40s, but differences in results are then less pronounced.

The results were compared to the reference experiment with short time step of 20s (not shown). We may conclude from the experiments performed that SETTLS scheme may be beneficial in the trajectory calculations while the calculation of SL trajectories through NESC could be dangerous since serious oscillations in the prognostic fields may occur (compare EXP3 with EXP2) with big impact on the precipitation field (40mm in 6 hours of spurious precipitation). Best results are obtained if SL trajectories are calculated in the predictor step only and through SETTLS (see EXP1). Regarding calculation of non-linear terms, the combination of SETTLS in the predictor and NESC in the corrector steps gives extremely noisy results (see EXP4), while pure SETTLS without corrector step is unstable.

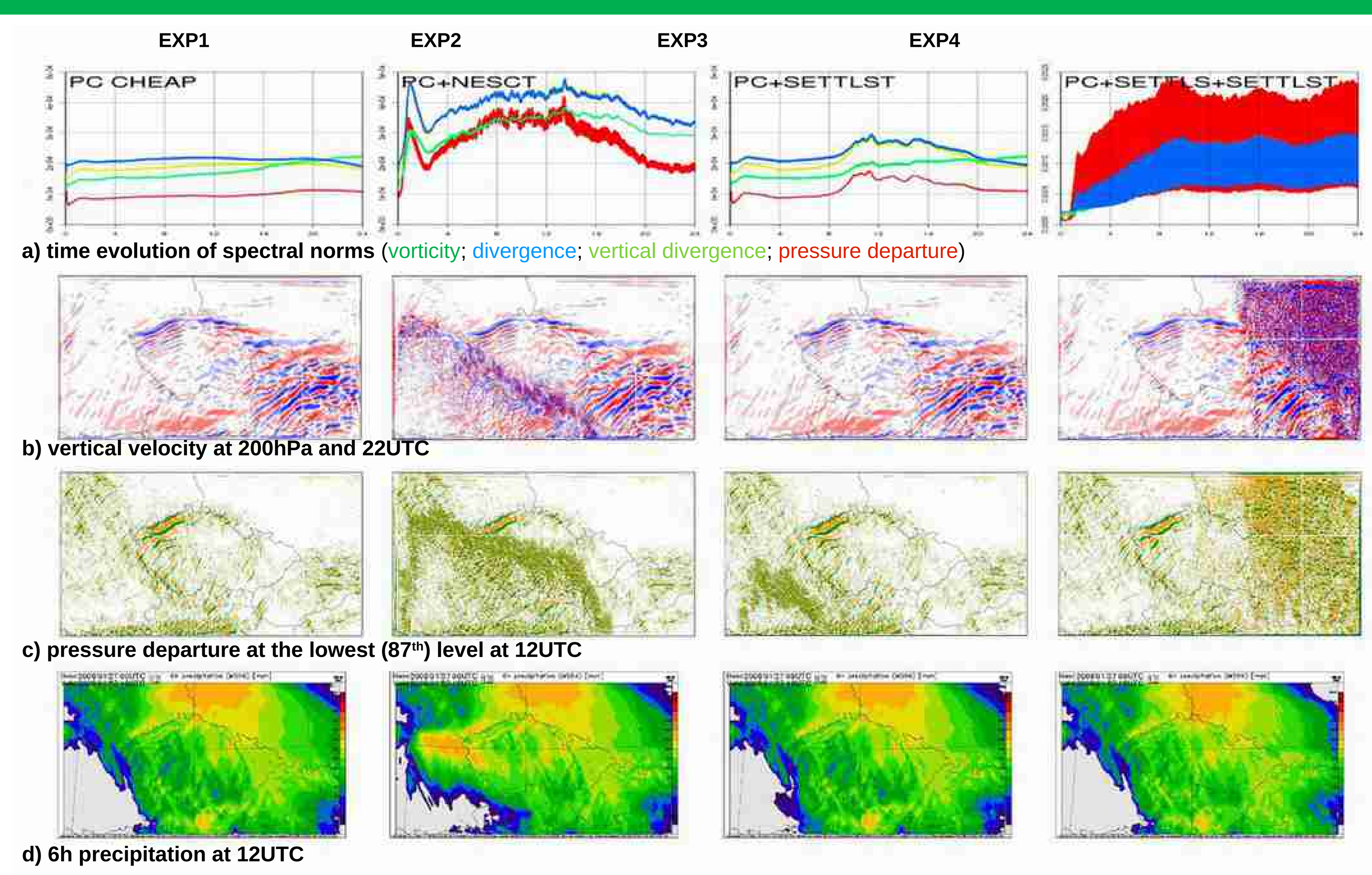


Figure 1: The choices in the iterative time scheme:
EXP1: cheap version of PC scheme - SL trajectories calculated only in the predictor step (LSETTLST=true);
EXP2: SL trajectories calculated in all steps with NESC (NESCT=true);
EXP3: SL trajectories calculated in all steps with SETTLS (LSETTLST=true);
EXP4: SETTLS used in the predictor step for non-linear terms, while NESC is used in corrector step and SL trajectories are calculated with SETTLS (LSETTLST=true) - notice 5 times larger scale for spectral norms.