ACRANEB2 - current status and plan

Ján Mašek, CHMI

Introduction

- at previous ALARO-1 working days, all key ACRANEB2 components were finished
- focus in ALARO-1 developments has moved to cloud, turbulence and surface parameterizations
- this year, ACRANEB2 presentation will be **short**

Addressing of previous challenges (set in September 2016)

- using microphysical condensates and layer cloud fractions in radiation **[ongoing, preparatory steps started in 2018]**
- improving gaseous transmissions in the stratosphere **[postponed, low priority]**
- parameterizing impact of clouds on the broadband surface albedo **[postponed]**
- parameterizing 3D cloud effects in 1D radiative transfer **[put aside, questionable at cloud resolving scales]**
- parameterizing optical properties of falling hydrometeors **[postponed, weak expected impact]**
- taking into account orographic effects on surface radiation budget **[waiting for ALARO-1 with SURFEX]**
- using near real time aerosol distribution and optical properties **[postponed]**

Novelties since the last ALARO-1 Working Days

- **optimized last model timestep** when intermittency is on, available in cy43t2_export and since cy45t1

- **new products** on APLPAR side, available since cy46t1:

parameter	activation key and namelist		structure	default FA name
global normal irradiance	LRAYS	NAMCFU	GFP_CGNI	'SURFGLB NORM IRR'
mean radiant temperature	LXMRT	NAMXFU	GFP_XMRT	'CLSMEAN.RAD.TEMP'

- discussed better way of diagnosing **apparent direct solar flux** (P. Räisänen)

- first steps done towards **unified cloud treatment** (ACNEBN versus ACNEBCOND)

- verification against measurements of CHMI radiation network extended by **hourly scores** (so far only daily totals were verified)

Publications

- ACRANEB2 scheme is now described by two papers in QJRMS, that can serve as scientific documentation:
  - shortwave ACRANEB2 paper published in January 2016 (DOI:10.1002/qj.2653)
  - longwave ACRANEB2 paper **published in April 2017** (DOI:10.1002/qj.3006)
- moreover, Ph.D. thesis devoted to ACRANEB2 developments was **defended in December 2017** at Charles University:

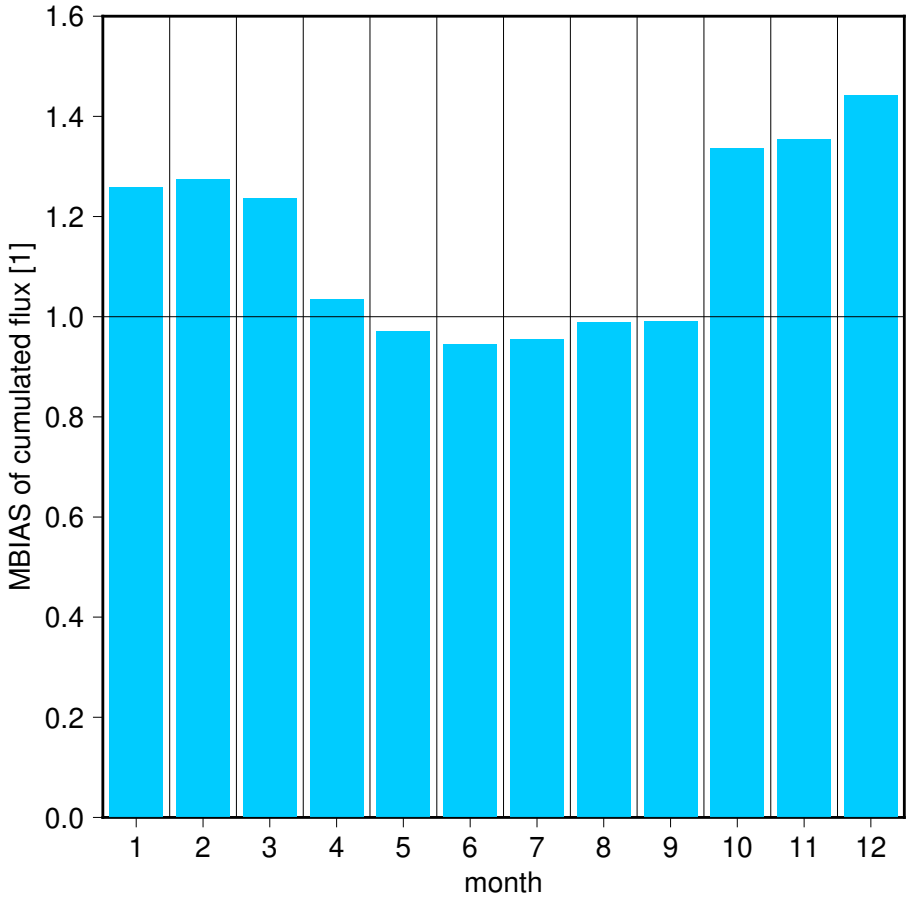
  https://dspace.cuni.cz/bitstream/handle/20.500.11956/94155/140061419.pdf

ACRANEB2 performance in ALADIN/CHMI operational suite

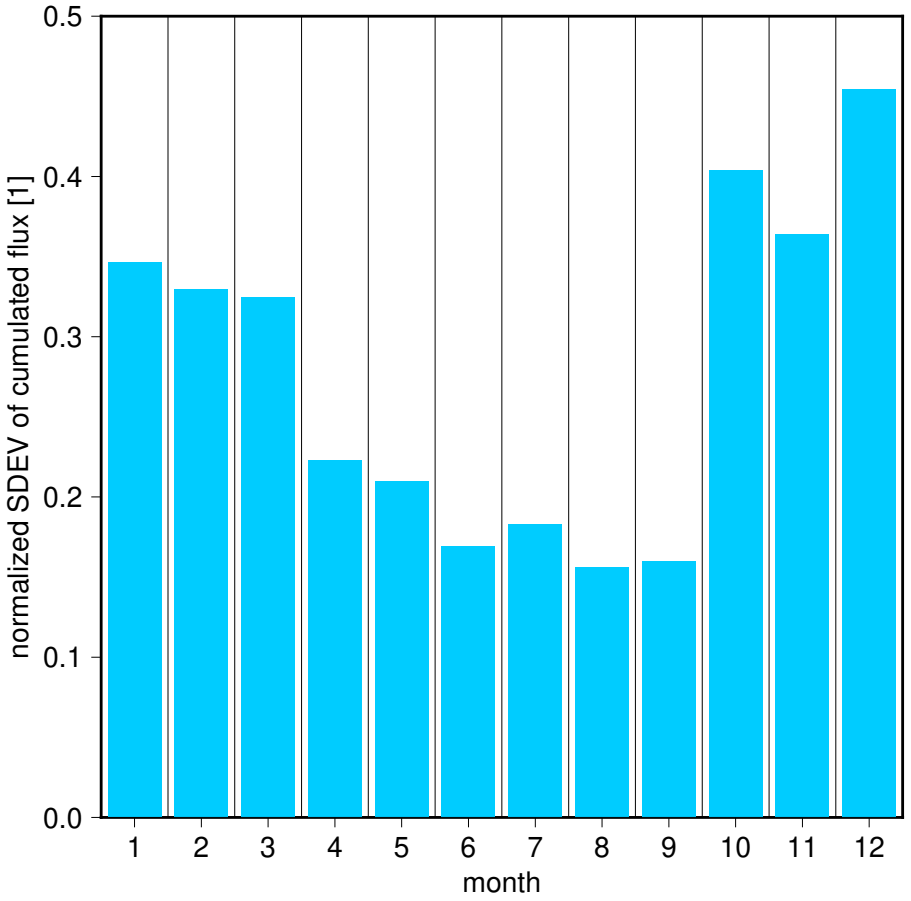
- daily downward surface fluxes are regularly verified against CHMI radiation network
- scores from the last 3 years show persisting problem during cold season in the Czech basin – strong bias and increased random error of global radiation
- overestimated global radiation indicates insufficient cloud cover
- problem is caused by **lacking low sub-inversion clouds**

Scores of daily global radiation (year 2016, day 1, 19 CZ stations)

multiplicative BIAS



normalized SDEV



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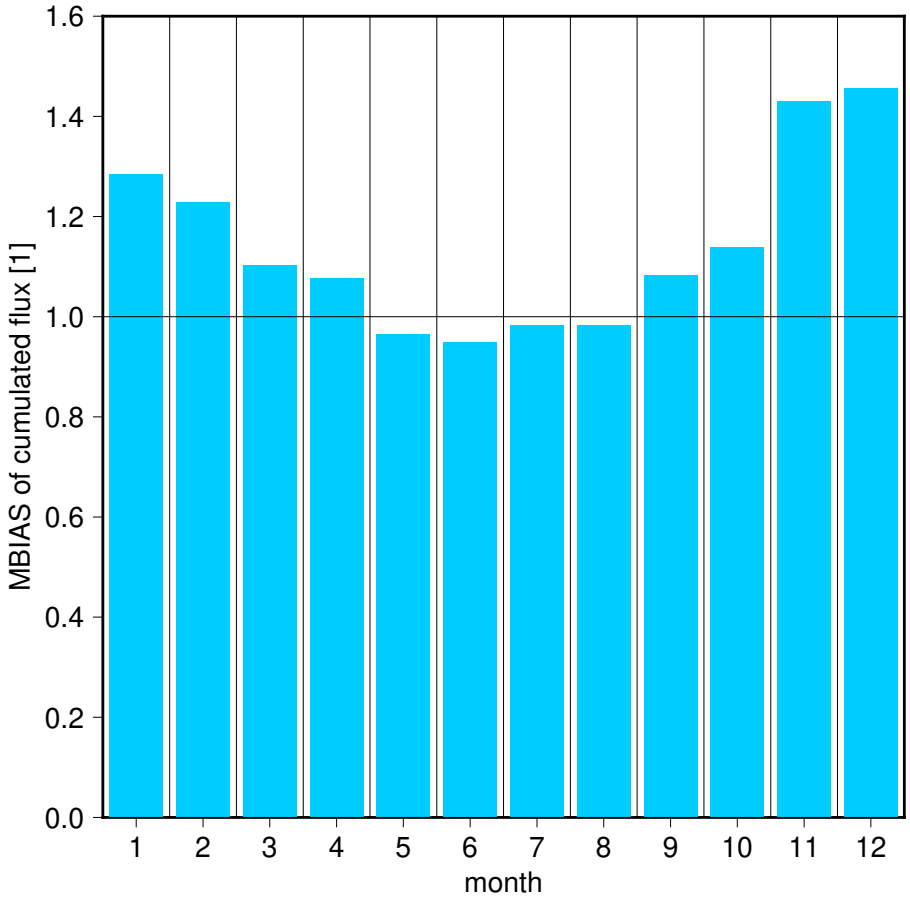

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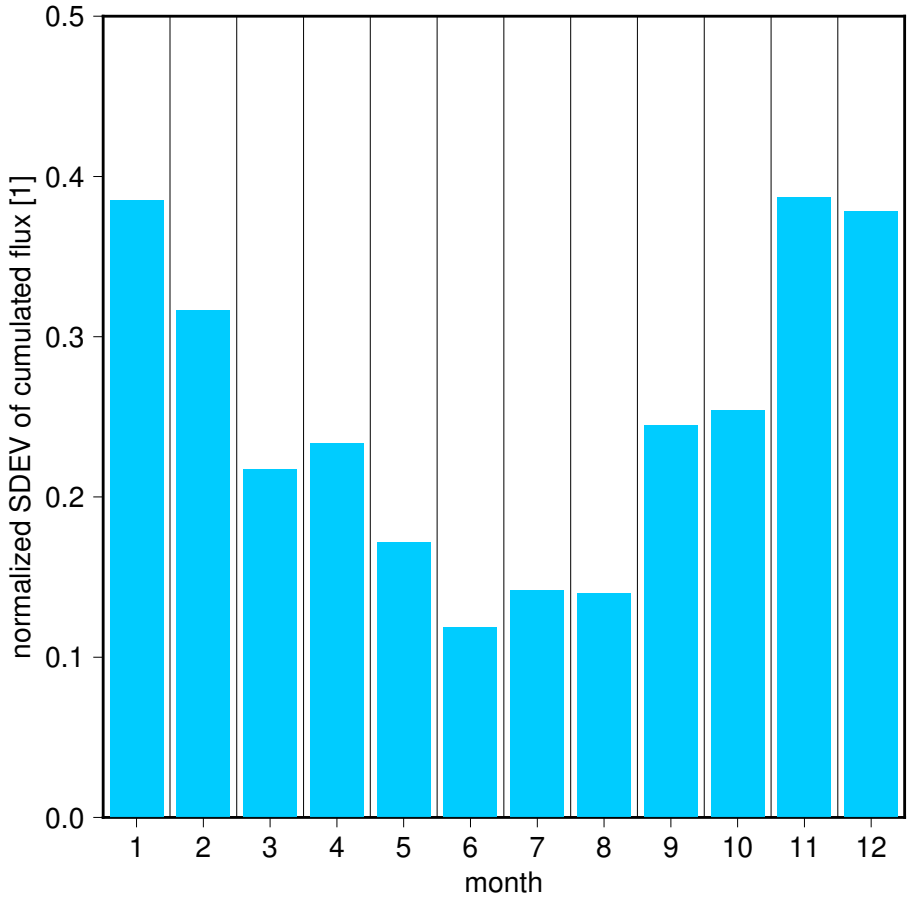

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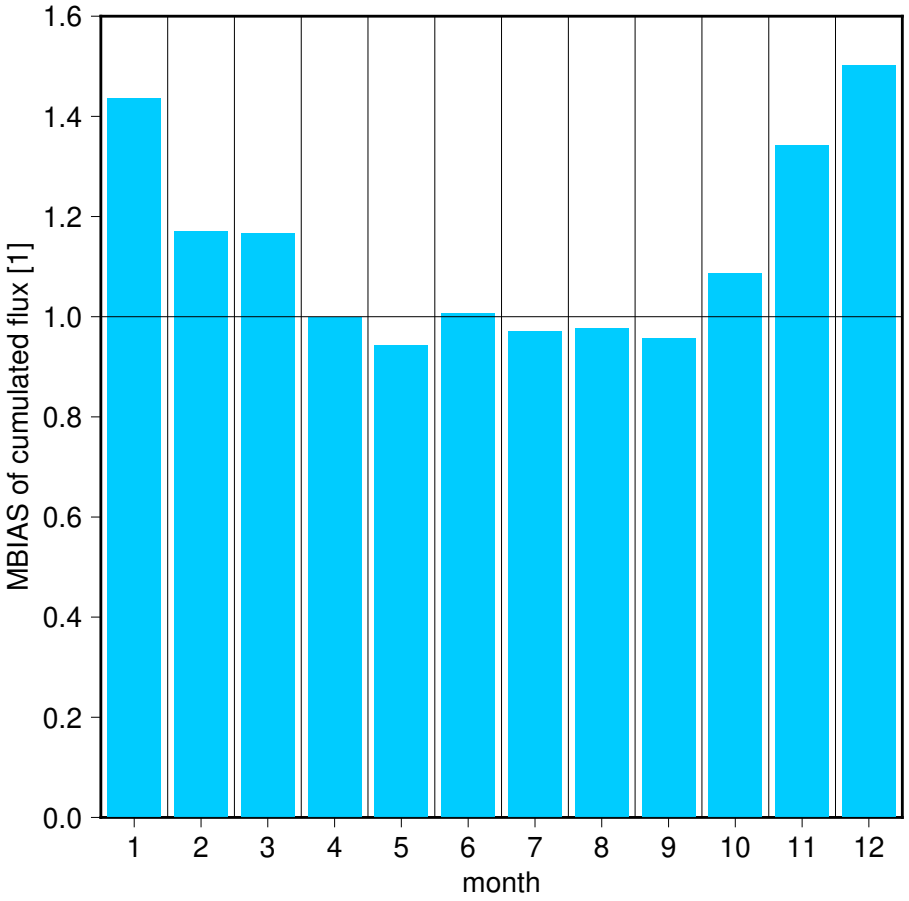

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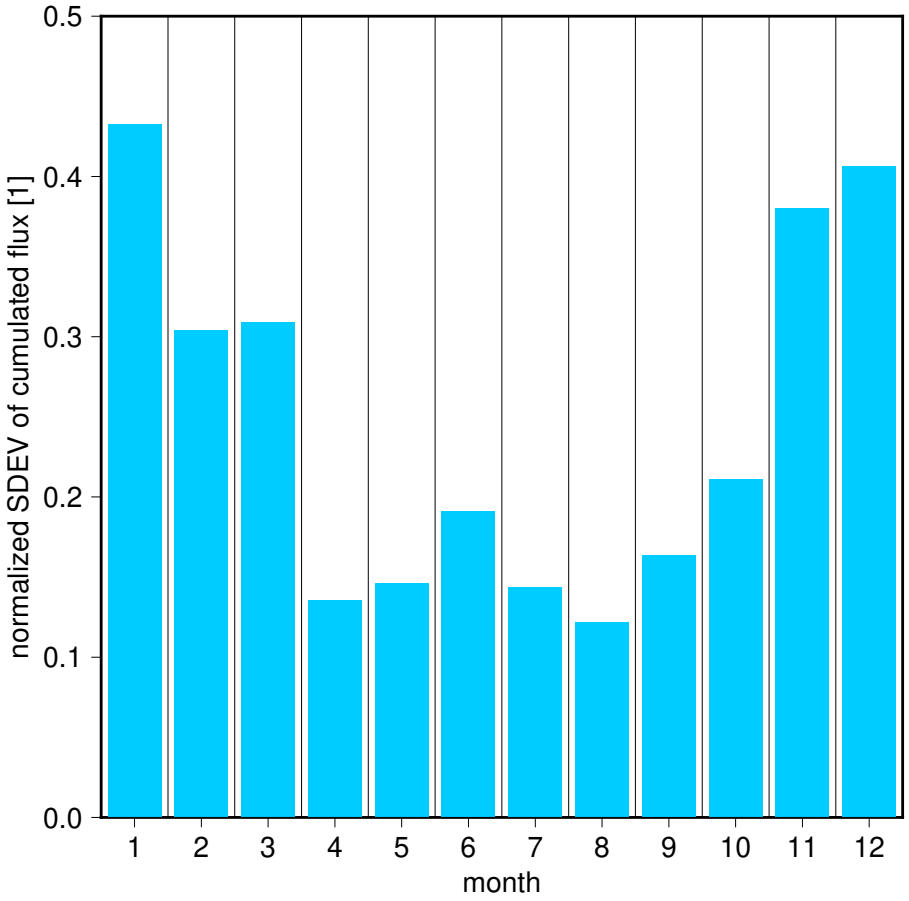
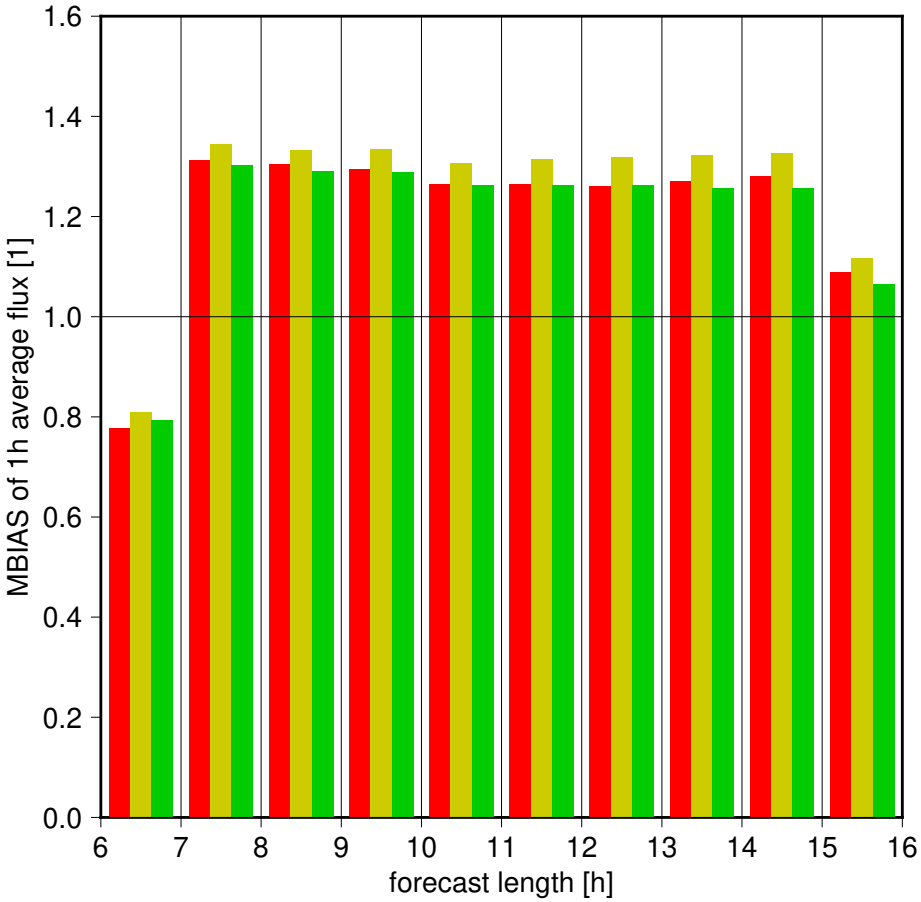


ACRANEB2 performance in ALADIN/CHMI high resolution parsuite

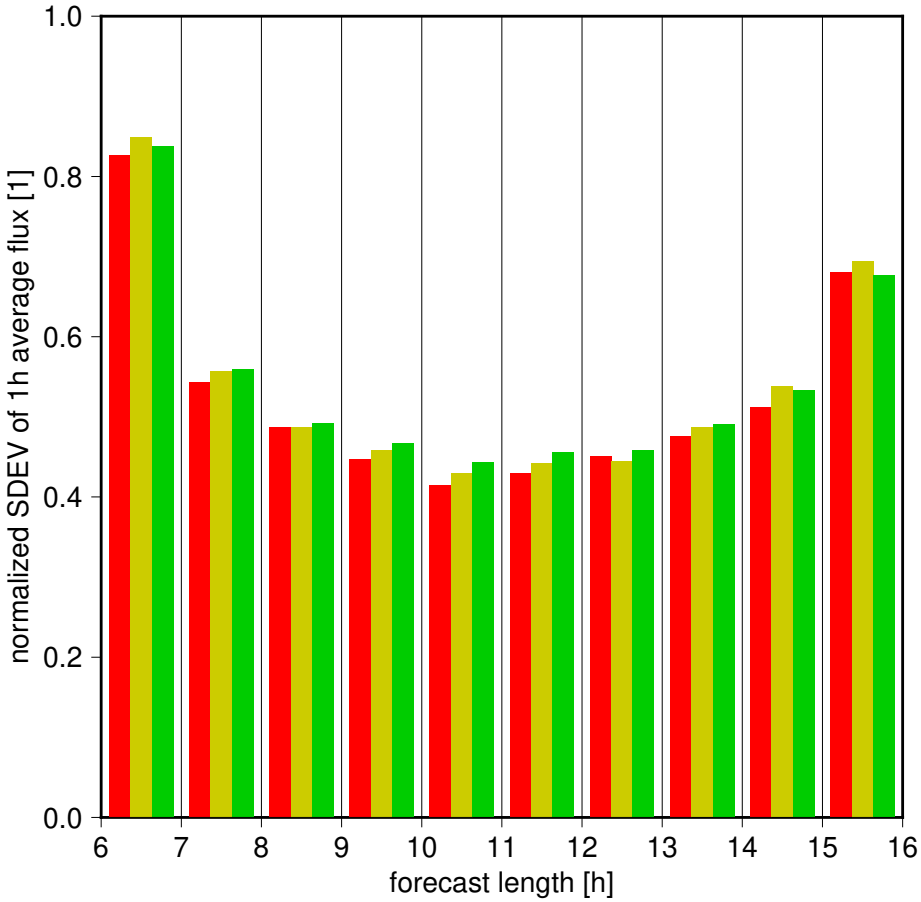
- in January 2019, parsuite on 2.3 km horizontal resolution was started
- hourly radiation scores were evaluated and compared against 4.7 km oper suite
- they revealed increased positive bias and slightly higher random error of global radiation
- retuned cloud scheme supporting sub-inversion clouds on ACNEBN side reduced bias to original level
- higher random error remains, its origin is not yet understood

Scores of hourly global radiation (10.1.–6.2.2019, day 1 forecast, 19 CZ stations)

multiplicative BIAS



normalized SDEV



- 4.7 km oper suite
- 2.3 km double suite
- 2.3 km double suite, retuned cloud scheme

Cost reevaluation on the new CHMI computer

- ACRANEB2 scheme saves CPU cost by **intermittent update** of gaseous transmissions, while keeping timely update of clouds

- intermittency significantly reduces the amount of ACRANEB2 calculations, but it requires **memory storage** of several 3D fields

- efficiency of intermittent approach is restricted by **memory latency**, therefore it depends on machine architecture and topology

- in January 2018, CHMU switched operations from vector NEC SX-9 to scalar NEC LX platform (full installation available since May 2018):

platform	nodes	CPUs /node	processor type	cores	memory /node
NEC SX-9	2	16	single chip vector	—	1 TB
NEC LX	320	2	Intel Broadwell	12	64 GB

- gain due to selective intermittency must be reevaluated

Gain due to selective intermittency

- CHMI oper suite uses 1 h/3 h update of gaseous transmissions
- on NEC SX-9 machine, it reduced cost of radiation by factor **21.7**
- on NEC LX machine, similar reduction by factor **20.6** is reached:

Δx	Δt	update frequency of gaseous transmissions		relative CPU cost	
		shortwave	longwave	radiation (% of model)	model
4.7 km	180 s	1 h	1 h/3 h	1.00 (14.2%)	1.00
		180 s	1 h/3 h	1.16	1.02
		180 s	180 s	**20.6**	3.77
2.3 km	90 s	1 h	1 h/3 h	1.00 (5.5%)	1.00
		90 s	1 h/3 h	1.62	1.03
		90 s	90 s	**34.1**	2.81

- move to horizontal resolution 2.3 km (keeping 87 levels) increases saving factor to **34.1**
- due to activation of NH dynamics, radiation in 2.3 km ALARO-1 takes only **5.5%** of the model cost

Alternatives to ACRANEB2 radiation

- old **ACRANEB** scheme
  - simple gaseous transmissions, intermittency not applied
  - not developed any longer, remains part of ALARO-0

- old ECMWF radiation (**FMR** in shortwave, **RRTMG** in longwave)
  - longwave part based on CKD method, requires full intermittency
  - still used in ARPEGE (hourly) and AROME (every 15 min)
  - 15 min use in 2.3 km ALARO-1 takes **4.6%** of the model cost
  - not developed any longer

- new ECMWF radiation (**McRad** and recently **ecRad**)
  - based on CKD method (RRTMG), requires full intermittency
  - not yet interfaced to MF physics
  - ecRad is most advanced scheme, modular and optimized

- old HIRLAM radiation scheme **HLRADIA**
  - cheap and simple scheme, intermittency not applied
  - available in h-cycles, but not yet in t-cycles

Short term plan

- further modularization of ACRANEB2 solver, enabling diagnostics of clearsky fluxes with little computational overhead (promised for cy46t1, delayed)
- calculation of apparent direct solar flux according to idea of Mauno et al. (2011)
- impact of clouds on the broadband surface albedo following Gardner and Sharp (2010)
- radiative effect of falling hydrometeors
- development of ACRANEB2 single precision version

Longer term challenges

- unified cloud treatment in ALARO-1 (ongoing)
- improved stratospheric gaseous transmissions
- use of near real time aerosols in radiation
- pilot study of **resolved** 3D radiative effects and their relevance for cloud resolving NWP