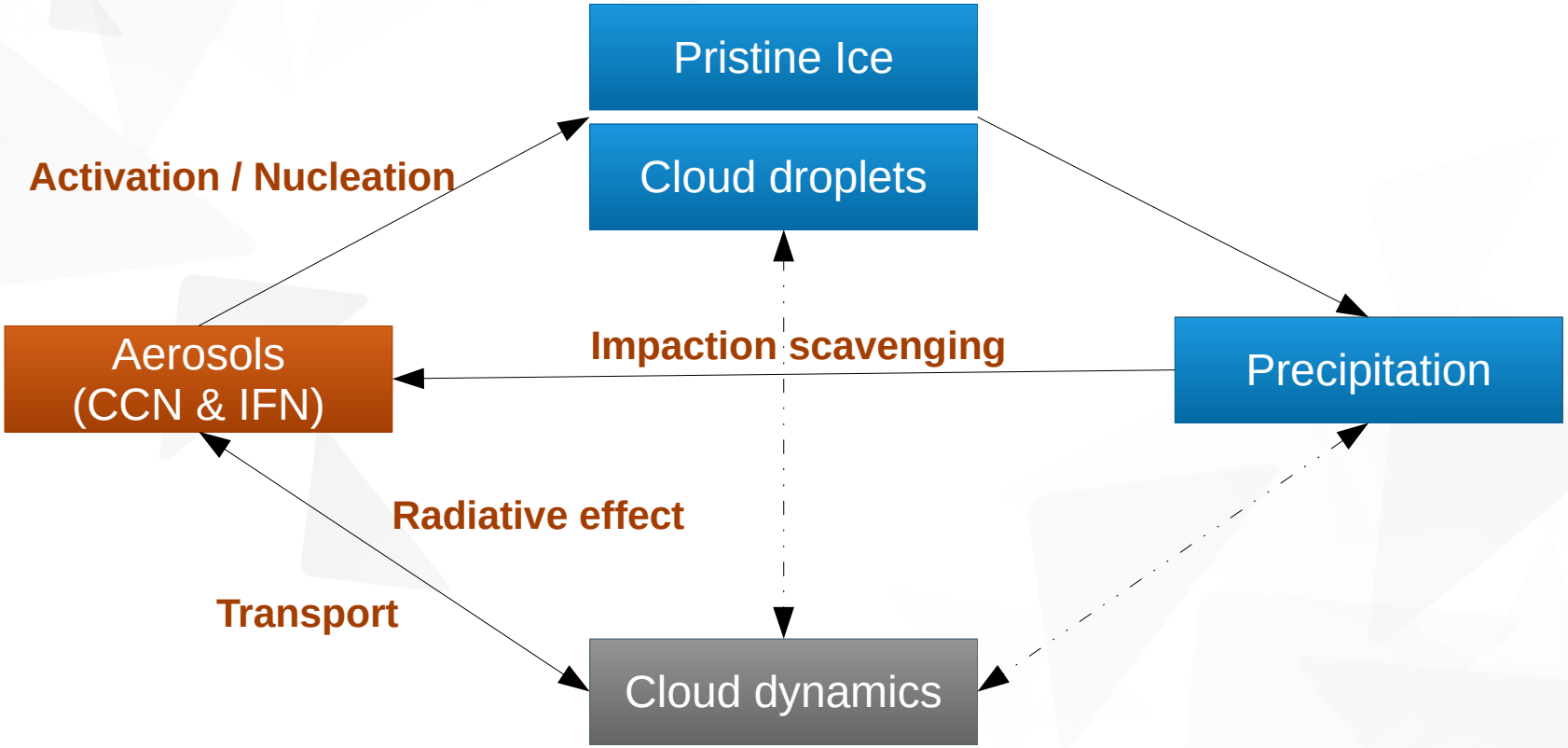
Two-moment microphysics for AROME

- B. Vié, CNRM, Météo-France/CNRS, Toulouse
- J.-P. Pinty, LA, University of Toulouse/CNRS, Toulouse

Motivations

- Complex aerosols – clouds – precipitations interactions



LIMA: Liquid Ice Multiple Aerosols

- 2-moment, mixed-phase microphysical scheme

Droplets	Drops	Ice	Snow	Graupel	Hail
r_c N_c	r_r N_r	r_i N_i	r_s	r_g	r_h

r: mass mixing ratio ($kg.kg^{-1}$) N: number conc. ($\#.kg^{-1}$)

- Derived from ICE3, with improved representation of some processes
  - Explicit deposition of water vapour on ice crystals
  - Improved pristine ice ⟶ snow conversion

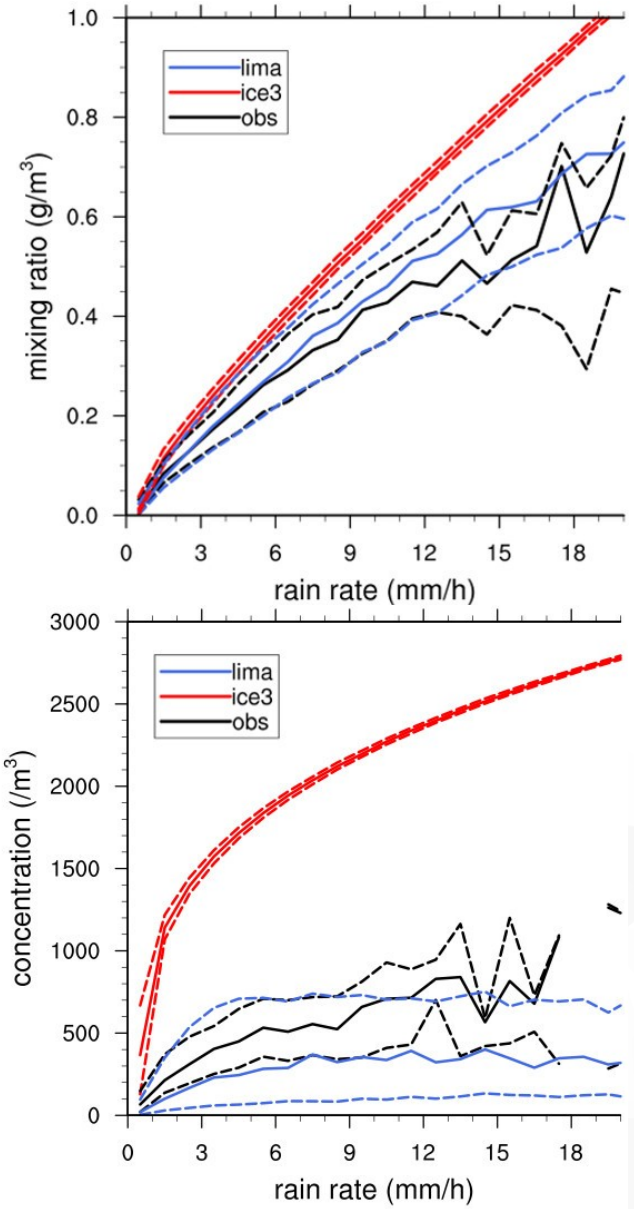
- Vié *et al.*, 2016: *LIMA (v1.0): a two-moment microphysical scheme driven by a multimodal population of cloud condensation and ice freezing nuclei*, GMD, doi:10.5194/gmd-9-567-2016.

LIMA: Prognostic aerosols

- Prognostic evolution of a realistic aerosol population
  - Multimodal (lognormal psd), 3D externally mixed aerosols
  - Distinction between several types of CCN / IN / coated IN
- Aerosol treatment
  - Transport by the resolved flow and turbulence
  - CCN activation (Cohard and Pinty, 2000) $\longrightarrow$ cloud droplets
  - IFN nucleation (Phillips *et al.* 2008, 2013) $\longrightarrow$ ice crystals
  - Below-cloud aerosol washing-out by rain (Berthet *et al.* 2010)

LIMA: Evaluation

- HyMeX: heavy precipitation
  - PhD thesis, Marie Taufour
- Lanfex: LES of fog and impact on visibility
  - PhD thesis, Léo Ducongé
- Sesar: Application to aircraft icing



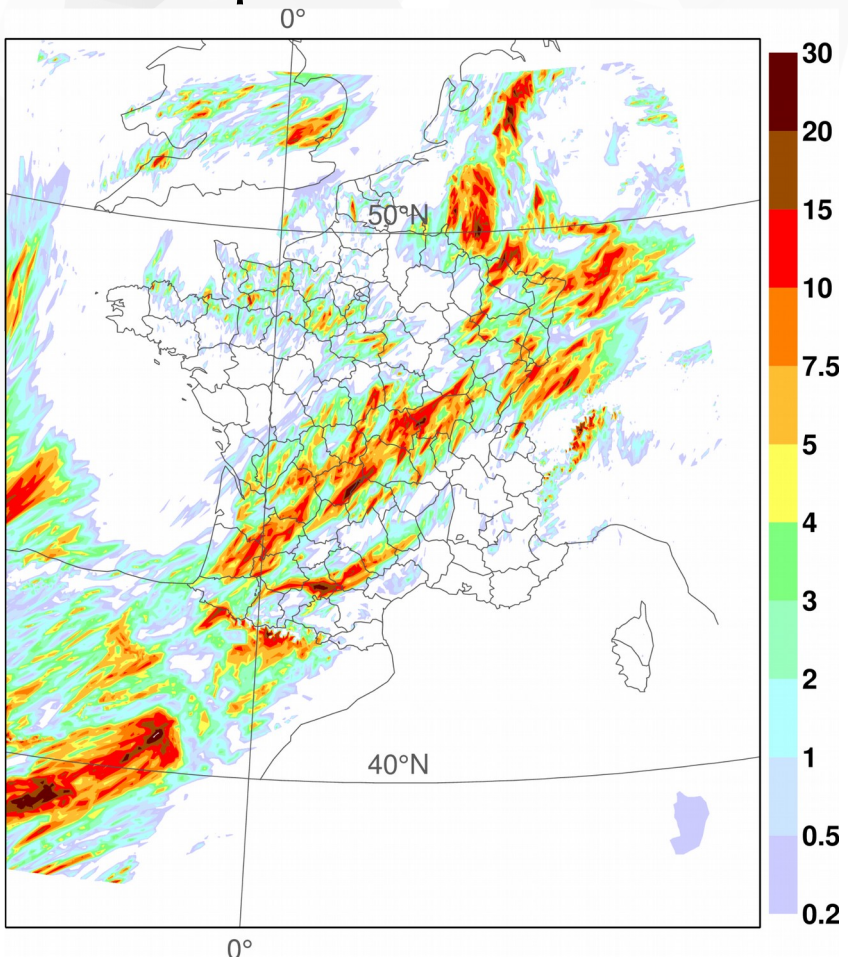
Comparison of simulated rain characteristics to disdrometer observations, HyMeX IOP 16, 2012/10/26

Current implementation of LIMA

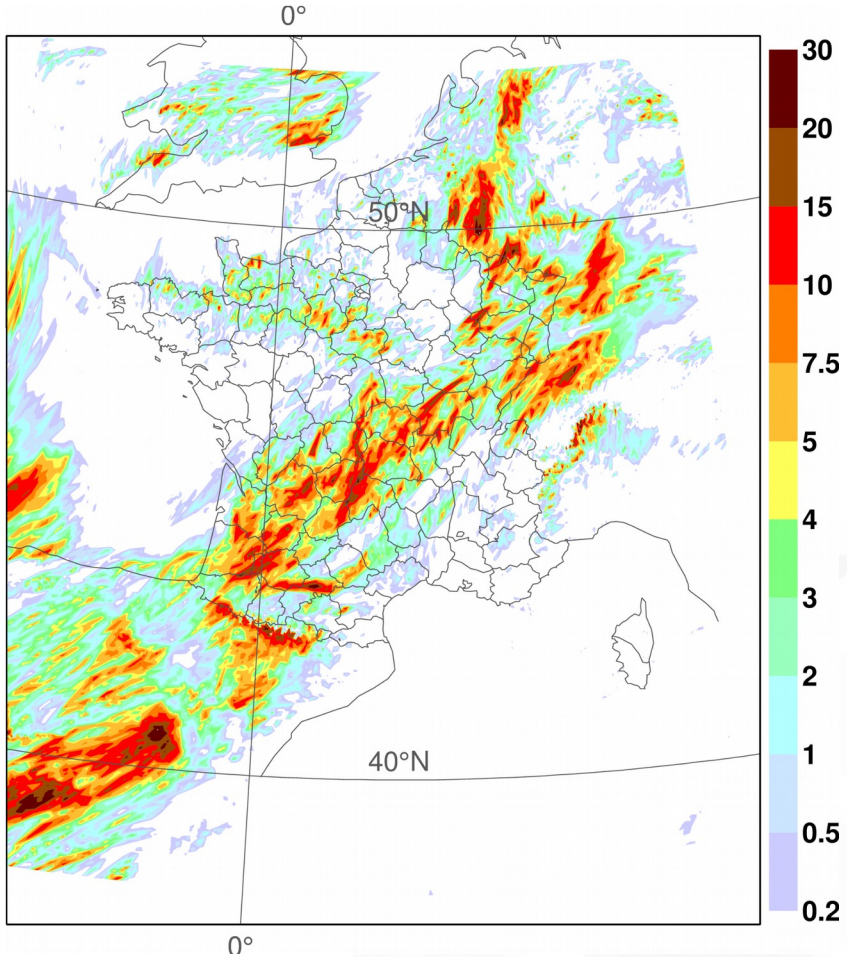
- LIMA was integrated in AROME (cycle 42)
  - New GFL variables for number concentrations
  - Complete microphysical parameterization
  - Homogeneous initial aerosol concentration
- First evaluation of LIMA in AROME
  - 33 days from March 16, 2016 to April 17, 2016
  - One 24-h forecast each day, initialized at 00 UTC, using the operational resolution and domain
  - Exact same configuration for 2 runs, using ICE3 and LIMA
  - LIMA simulations were 29.9% longer on average (384 procs were used on 48 nodes, + 2 nodes for IO)

AROME & LIMA : First test

- 00UTC April 13th, 2016, 12-h accumulated rainfall (mm)



ICE3

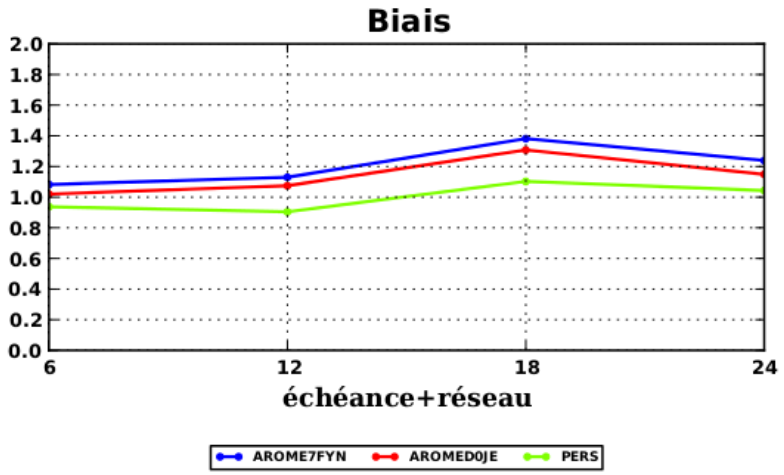


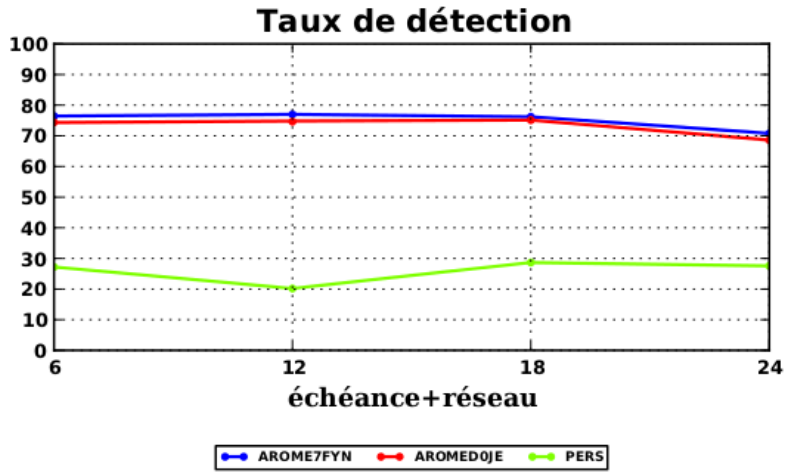
LIMA

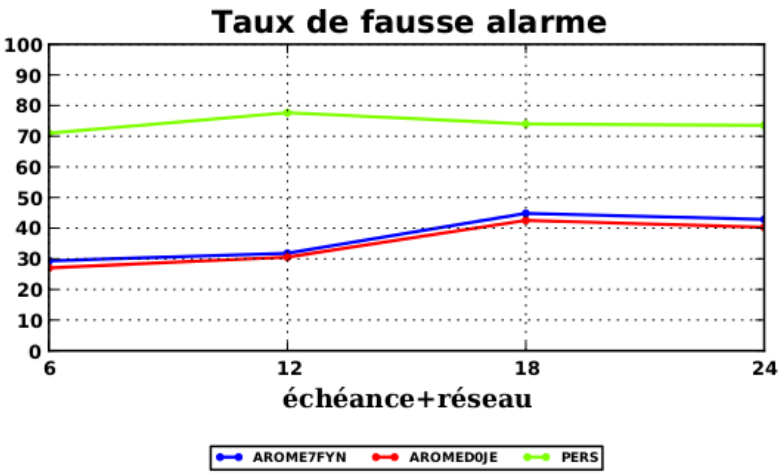
AROME & LIMA : First test

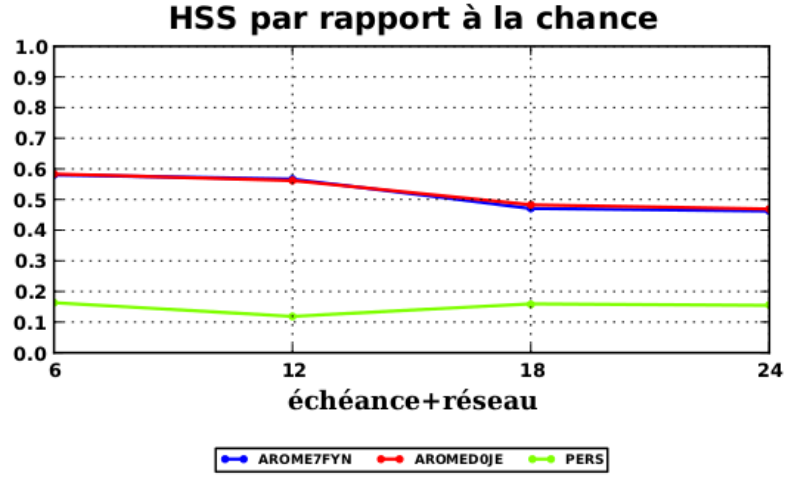
LIMA

ICE3









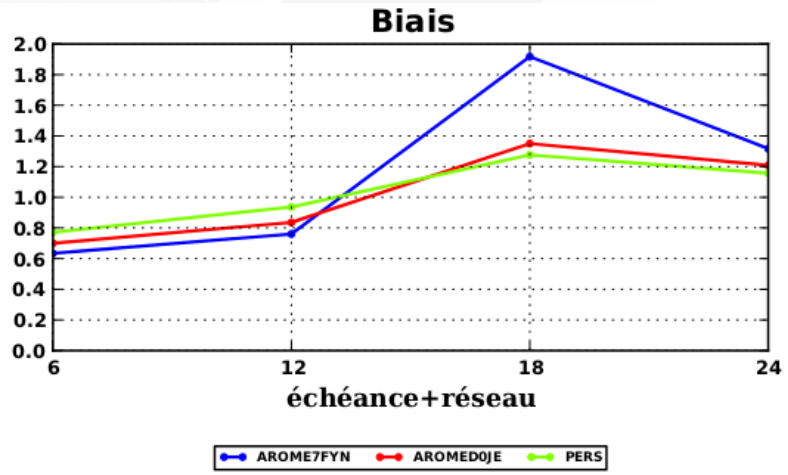
DPREVI/COMPAS 11-January-2017

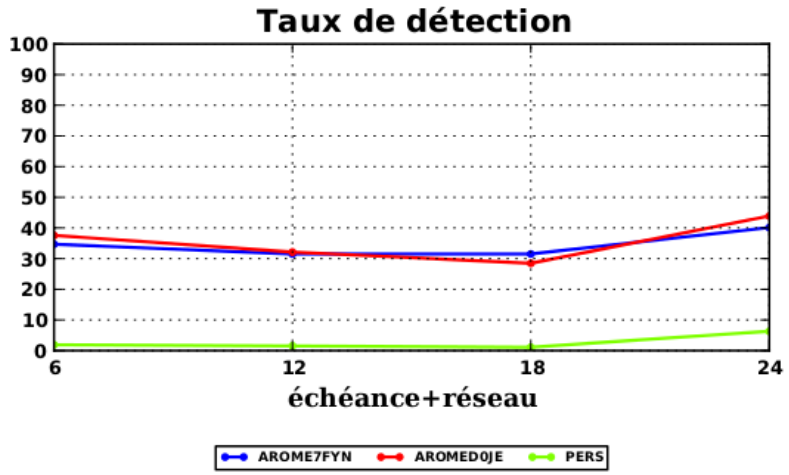
20160316-20160417, 6-h accumulated precipitation, 5mm threshold

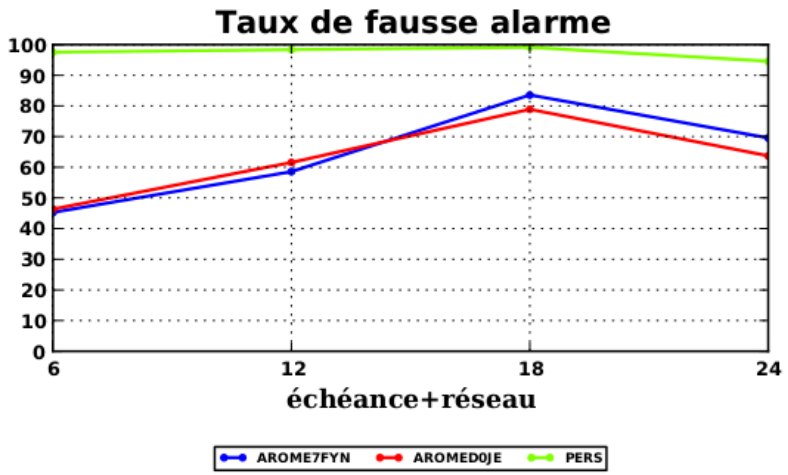
AROME & LIMA : First test

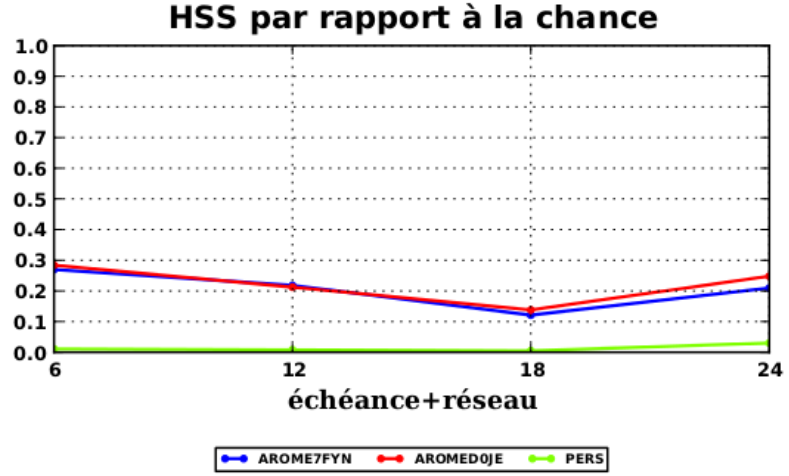
LIMA

ICE3









DPREVI/COMPAS 11-January-2017

20160316-20160417, 6-h accumulated precipitation, 10mm threshold

AROME & LIMA : First test

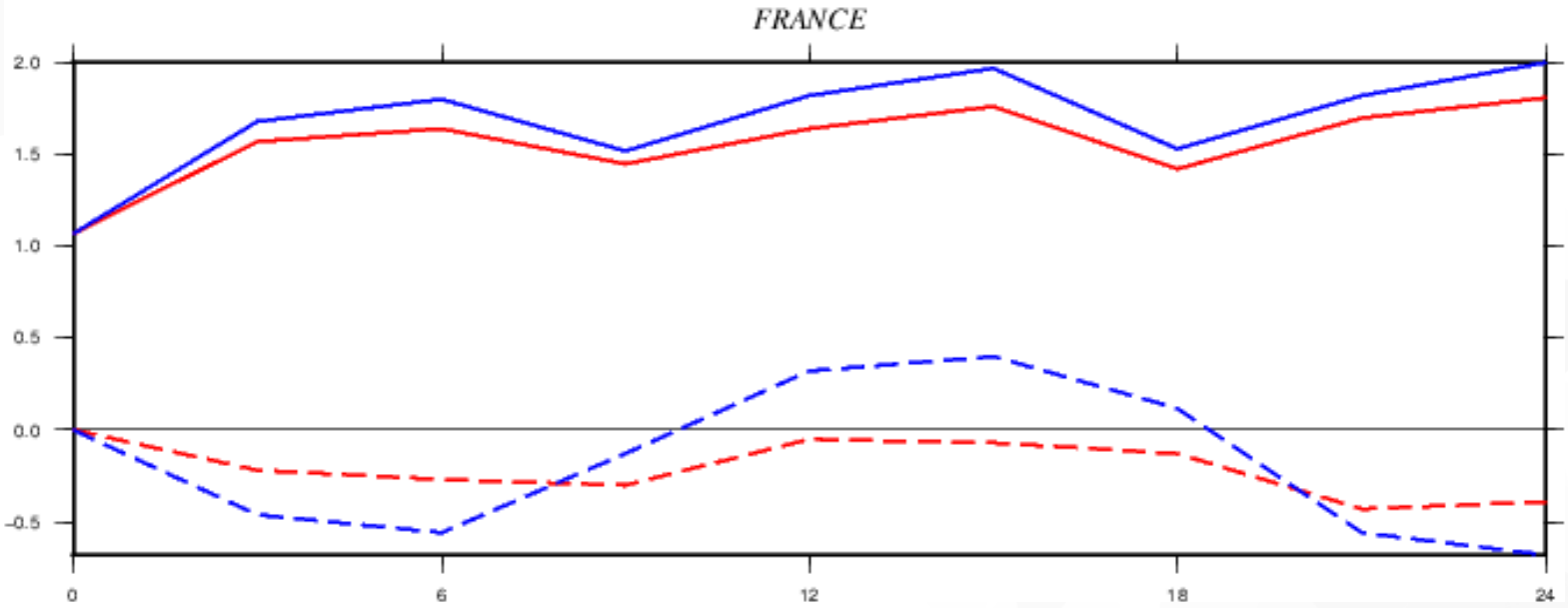
ICE3 **LIMA**

___ Eqm PD0JE.r 00/SYNOP+RADOME ___ Eqm P7FYN.r 00/SYNOP+RADOME

– – BiaisPD0JE.r 00/SYNOP+RADOME – – BiaisP7FYN.r 00/SYNOP+RADOME

RMSE

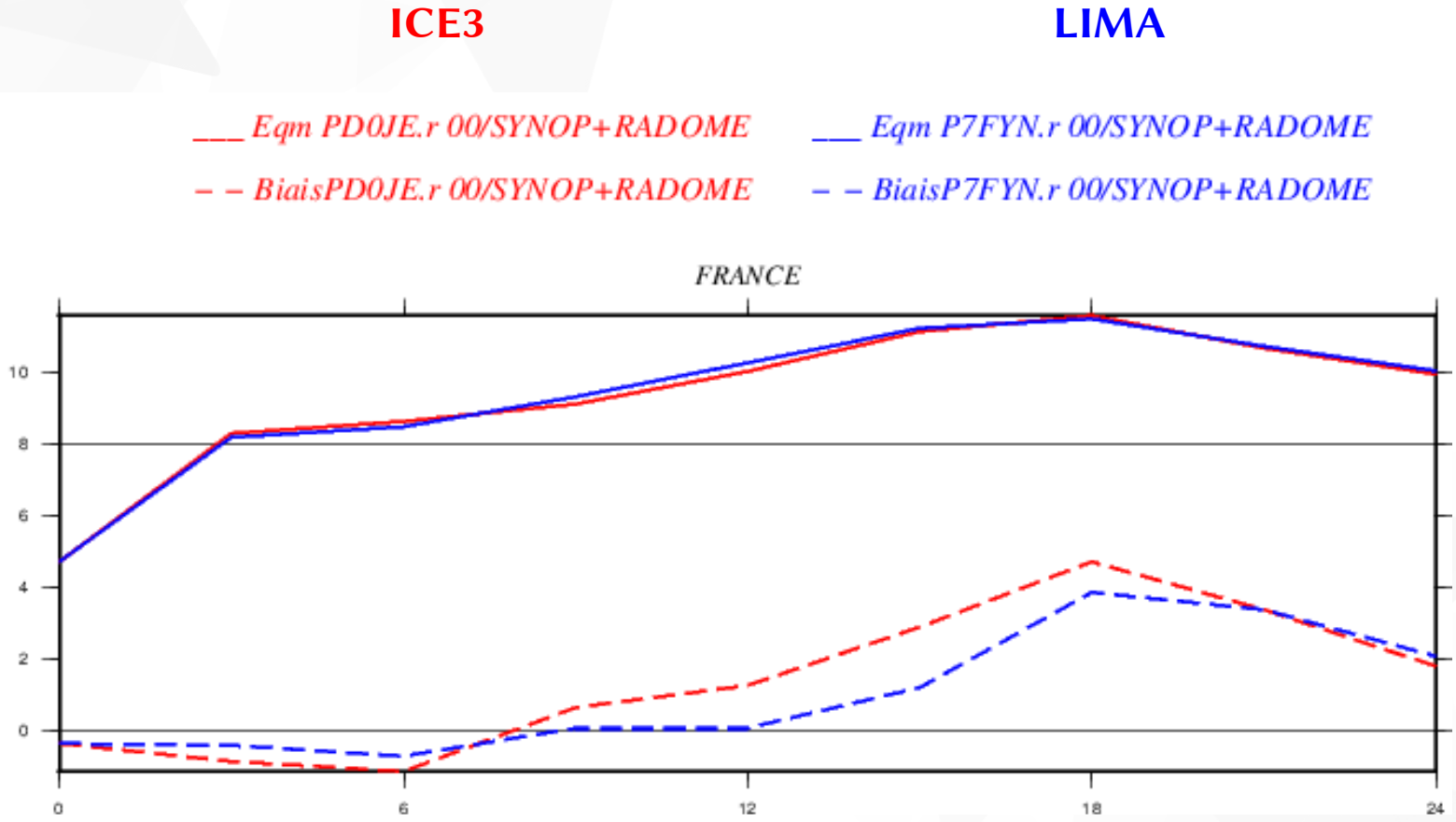
BIAS



20160316-20160417, 2-m temperature (K) bias and RMSE

AROME & LIMA : First test

ICE3 **LIMA**



RMSE

BIAS

20160316-20160417, 2-m relative humidity (%) bias and RMSE

LIMA: To-Do list

- Computation cost analysis & Choice of an optimal configuration
  - Minimal number of additional variables, simplify the representation of time-consuming processes if necessary
- Some more technical work (DDH, fullpos, radar simulator...)
- Sedimentation scheme ?
- Subgrid cloud fraction
- Microphysics sensitivity to the time step
- Other scheme improvements

Radiation parameterization

- In AROME, the radiative transfer parameterization is currently unaware of the aerosols and hydrometeors number concentrations

- In Meso-NH:
  - The cloud droplets and pristine ice number concentrations are used in the computation of cloud optical properties
  - The radiative effect of aerosols is accounted for using the detailed scheme by Aouizerats et al. (2010) and the prognostic aerosol population from LIMA.

Aerosols representation

- LIMA accounts for aerosol-cloud interactions (nucleation, scavenging)
- What precision in the representation of aerosols do we need ?
  - Homogeneous initial population ?
  - Realistic aerosol population ?
    - MACC analyses can be used to provide realistic 3D initial and lateral boundary conditions for aerosols (under development)
    - Including data assimilation / nudging ?
  - Complete aerosol scheme, including sources, ageing... ?
    - Emission schemes for dust and sea-salt
    - Complete chemistry-aerosol module ORILAM (Tulet *et al.* 2005, Meso-NH)

To be continued...

2016 05 12, Low clouds in front of the Pyrénées