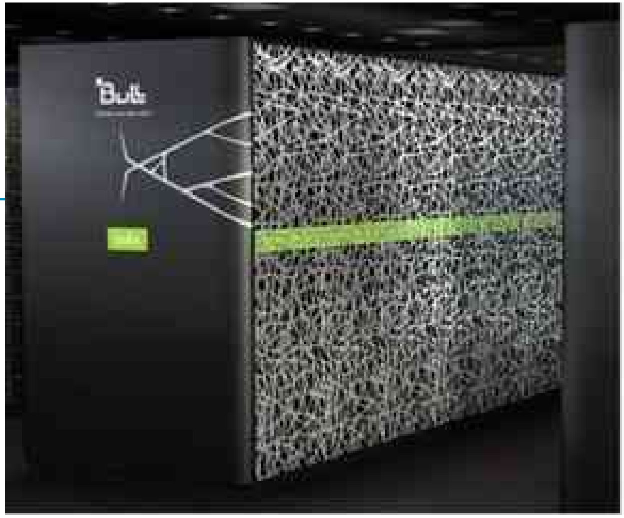
Progress and plans on numerical aspects and parametrization in Arpège and Arome-France

C. Fischer, Météo-France/CNRM/GMAP

EWGLAM/SRNWP 2016, Rome, Italy

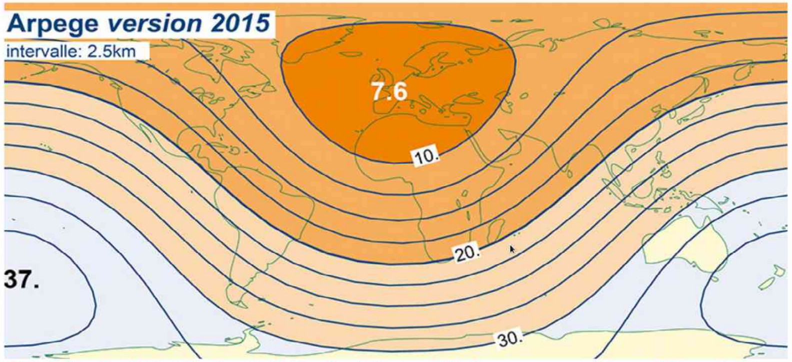
The MF operational NWP system,
a wide range of spatial and temporal scales



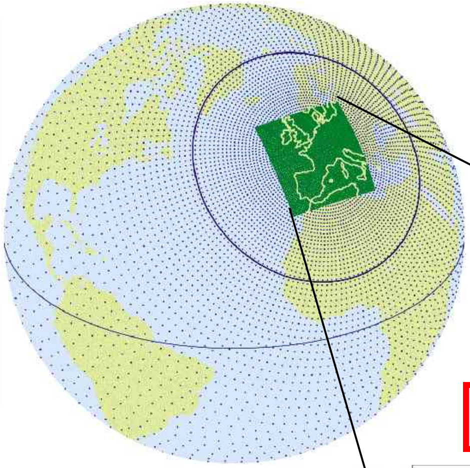
BULLX B700 DLC

513TFlops 990 nodes

NWP systems are based on IFS/ARPEGE software developed in collaboration with ECMWF and the ALADIN/HIRLAM NWP Consortia.



Nouvelle résolution horizontale (en km) du modèle Arpege en version « déterministe »

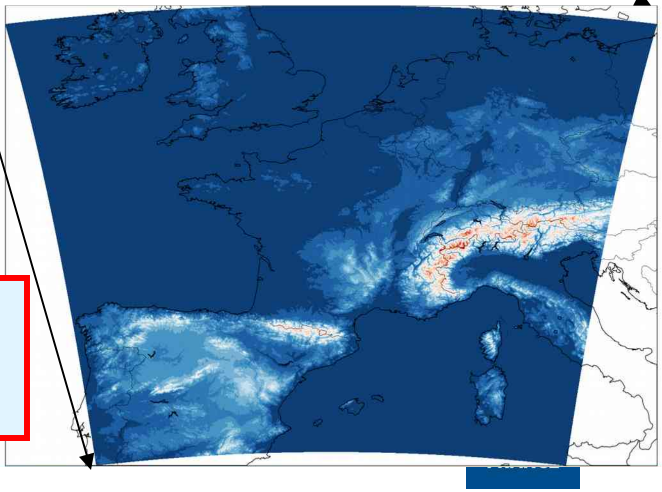


Global ARPEGE-IFS:forecasts every 6 hours up to 114h. dx=7.5 km over France, and 35 km over Australia

T1198 with stretching factor c=2. 2.
L105 with first model level at 10m

4DVar Inc Data Assimilation system 135km and 50km

AROME 1.3km



AROME 1.3km

L90 (1536 x 1440 points)

3DVar (1h cycle)

Physics packages in ARPEGE and AROME

	ARPEGE & LAM	ARPEGE & LAM (2017)	Physics for the convective scale model(AROME)
Surface	ISBA(Noilhan,Planton (89), Giard, Bazile(2000))	SURFEX (Masson et al., 13): surface modelling platform	
Radiation	RRTM (Mlawer, 97) + SW6* (Fouquart 80, Morcrette 01)		
Turbulence	1.5 order scheme prognostic TKE (Cuxart et al., 00)		
Mixing length	Non local, buoyancy based (Bougeault-Lacarrère, 89)		
PBL thermals/shallow	KFB (Bechtold et al. 2001)	New scheme PCMT	PMMC09 (Pergaud et al., 09)
Clouds	PDF based: (Smith, 90) or (Bougeault, 82)		
Microphysics	Bulk scheme with 4 prog. var. (Lopez, 02)		Bulk scheme** 5 prog. var. (Pinty and Jabouille, 98)
Convection	Moisture Convergence (Bougeault 85)	New scheme PCMT (5 prog. var) (Piriou et al., 07) and (Gueremy, 11)	x
Sub oro. effects	Catry-Geleyn (08)		x

Outline of talk

- The problem of low level cloud forecasts in AROME and ARPEGE
- Other R&D efforts for AROME
- ARPEGE global model: new convection scheme and SURFEX

The problem of low level (LLV) cloud forecasts in AROME and ARPEGE

Y. Seity, E. Bazile (CNRM/GMAP)

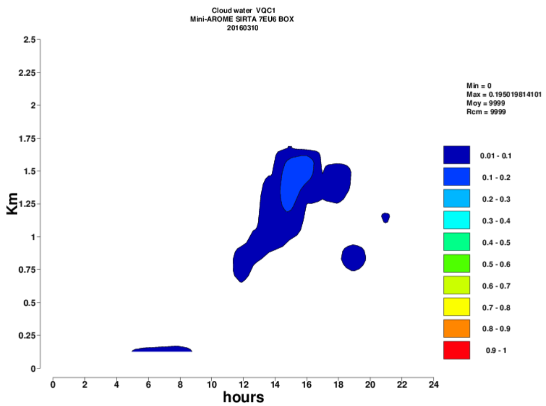
Experimental evidence and operational feedback

- Low level (LLV) clouds are under-estimated in AROME-France, both over land and over sea
- Same for ARPEGE since April 2015 (effect of hor/vert resolution, other ?)
- ALADIN and HIRLAM partners running AROME-type of configurations rather report the opposite ! (too many LLV clouds esp. Over sea)
- A specific WG was created (MF, KNMI, SMHI) and met in Nov 2015 at SMHI:
  - KNMI use a different shallow convection scheme, which can explain the over-estimation over sea (North Sea cases)
  - tests at KNMI with an alternative turbulence scheme are under way
- And at MF/CNRM : assess impact of different formulations for entrainment or closure assumption in shallow convection scheme
- Comparisons with KNMI model outputs over France

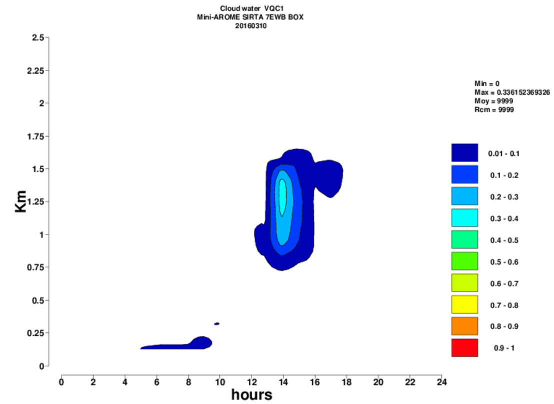
An illustration of LLV clouds in AROME and ARPEGE (case of 10 March 2016)

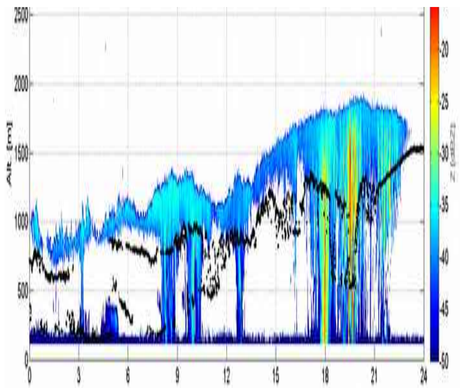
- Total cloud water content (Site = SIRTA profile measurement site)

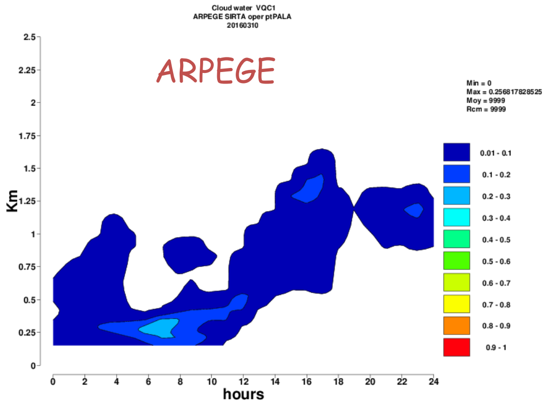
AROME-Site

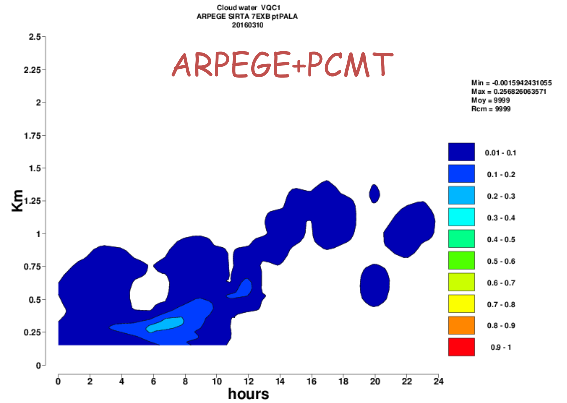


AROME-Site no EDMF

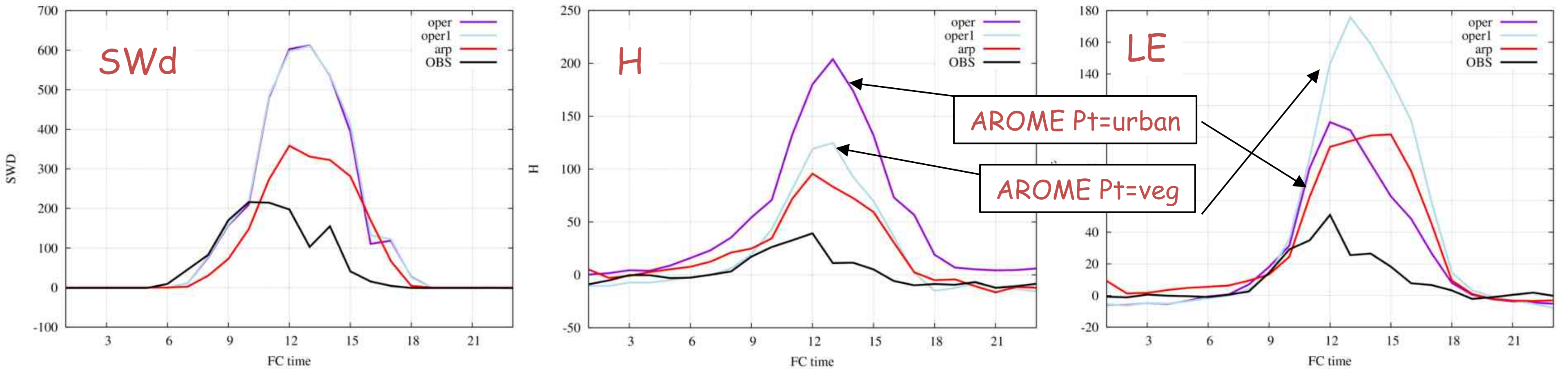


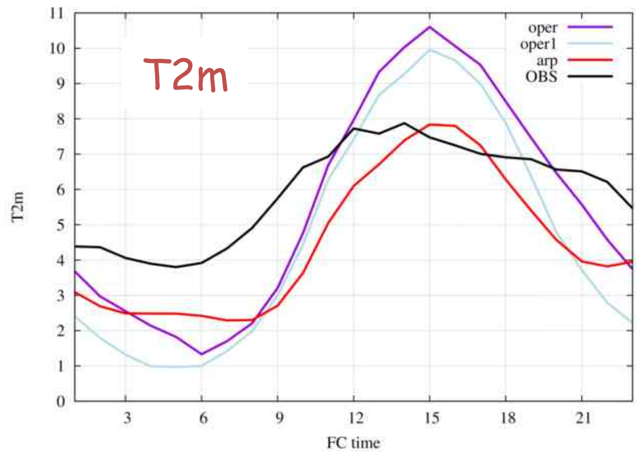






LLV clouds in AROME and ARPEGE (10/03/16): daily cycle of fluxes and T2m

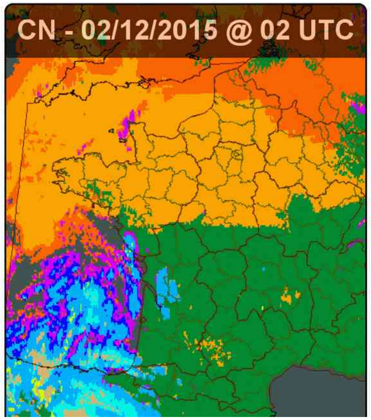




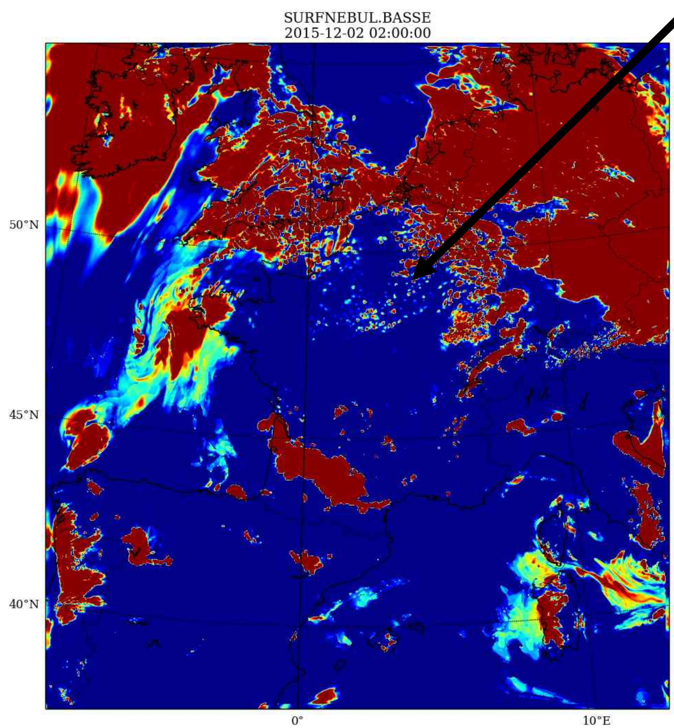
Budget SWd – (H+LE) =
Obs at site= ~100W/m2
ARPEGE= ~120W/m2
AROME = ~300W/m2.

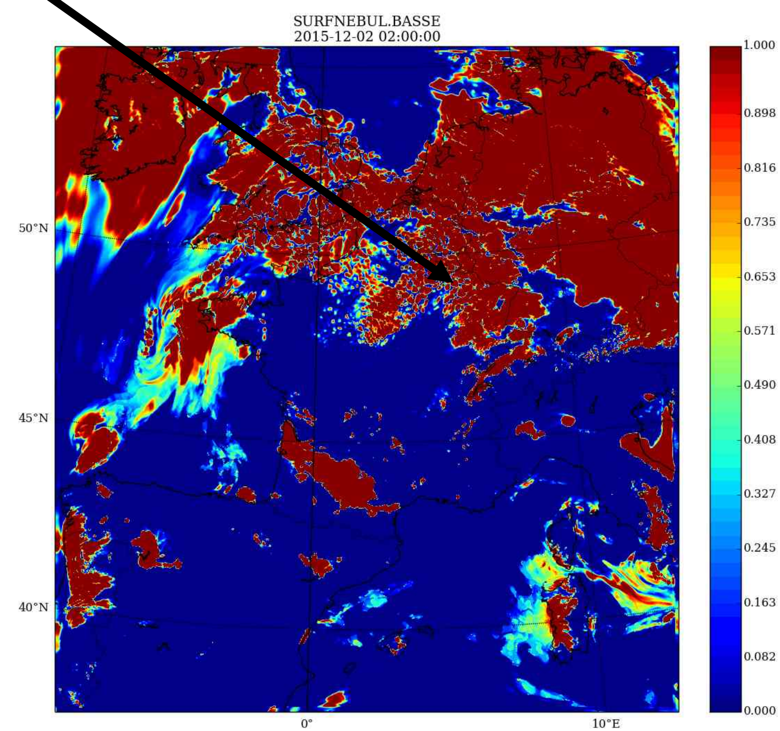
Max of ARPEGE T2m is correct but for *wrong* reasons ! Too strong SWd is counterbalanced by LE+H.

Impact of assimilation: removal of LLV clouds in the very short range and initial time

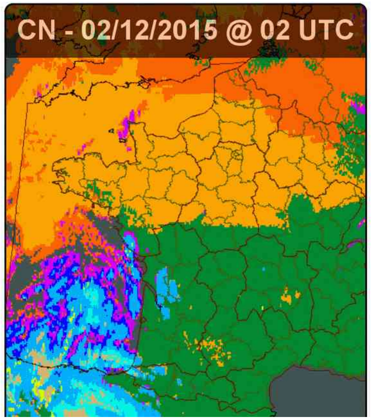


Less deterioration when avoiding to dry the LLV by assimilating dry profile retrievals (from the Bayesian 1D+3D reflectivity assim)



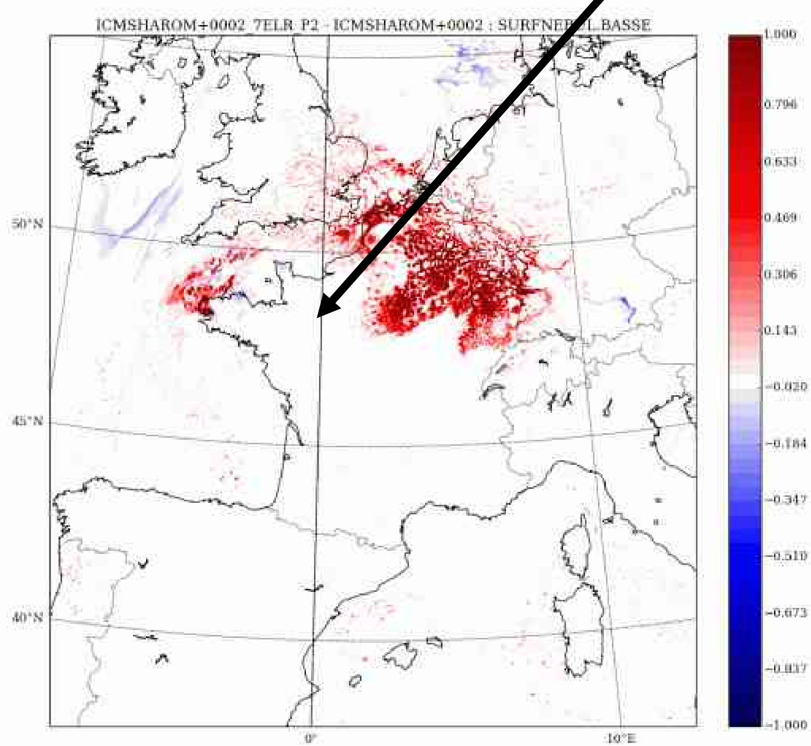


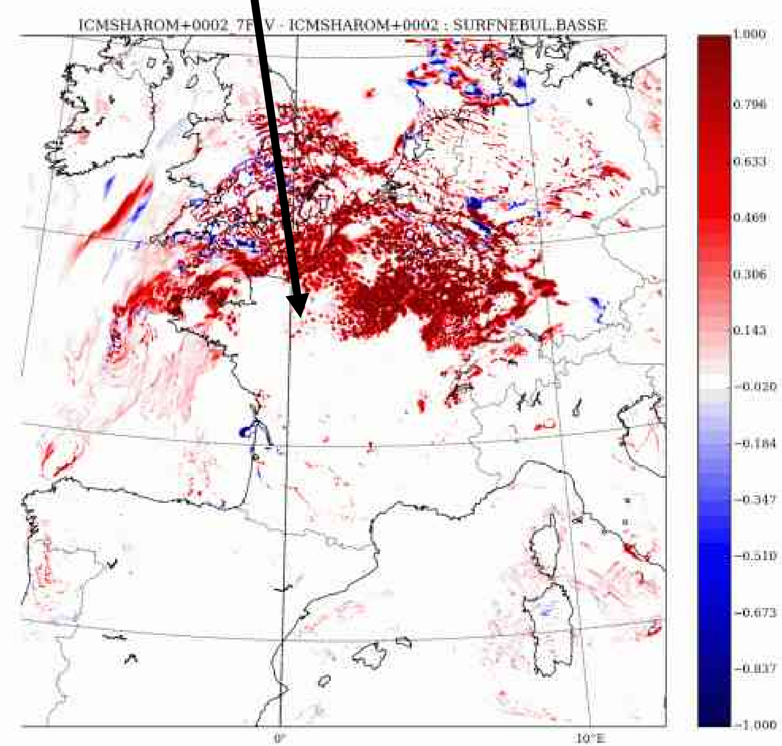
Removal of LLV clouds in assimilation: avoid spurious LLV precipitation in AROME model



Less deterioration with changing the autoconversion threshold:

$$0.5 \cdot 10^{-3} g/kg \rightarrow 10^{-3} g/kg$$





Current status of brainstorming and experimental trials

The observed under-estimation of LLV clouds in AROME may have several reasons:

- problem of initialization of PBL below 500 m
- problem when assimilating radar reflectivity (via model profile retrievals):
  * re-assess the detection threshold for light rain ?
  * avoid short range light rain in the model (while not observed) => re-assess the value of the auto-conversion threshold
- problem of too active sedimentation in microphysics ? Too weak content of Ql and Qi ?
- problem of too active mixing in day time ? (shallow convection v/s TKE)

A dedicated workshop (January 2017, Toulouse) is under discussion

Other R&D efforts for AROME

- new **two-moment microphysics scheme LIMA** (first version developed and tested with Méso-NH, Vié *etal*. GMD 2016, now available in AROME for testing)
- **towards a 3D turbulence** scheme: implementing the 3D version of the CBR scheme of Méso-NH in AROME (Cuxart *etal*. QJRMS 2000)
- evaluation of **fog forecast** in AROME, impact of vertical resolution (PhD by A. Philip, paper accepted in WAF DOI: 10.1175/WAF-D-16-0074.1)
- **alternative formulations of the non-hydrostatic dynamical core**:
    - moving away from the spectral SI: test high-order finite differences (FD) on the horizontal, replacing the spectral SI solver (direct) by an iterative gridpoint solver (multi-grid or Krylov).
    - Z-grid versus A-grid: real model experiments based on FD reveal that the A-grid (unstaggered with U,V) is favorable over the Z-grid (unstaggered with divergence-vorticity). PhD by S. Caluwaerts.
    - assess the potential of the HEVI approach (PhD study, C. Colavolpe)

ARPEGE: new convection scheme and SURFEX

- new convection scheme PCMT: Piriou *etal.* (JAS 2007), Guérémy (Tellus 2011), Lopez (QJRMS 2002)
- switch surface scheme from ISBA to SURFEX
- both are currently under evaluation in the 2016 autumn E-suite, with an expected switch to operations in the first quarter of 2017
- for ARPEGE/SURFEX: LBC files from E-suite will be tested by ALADIN partners

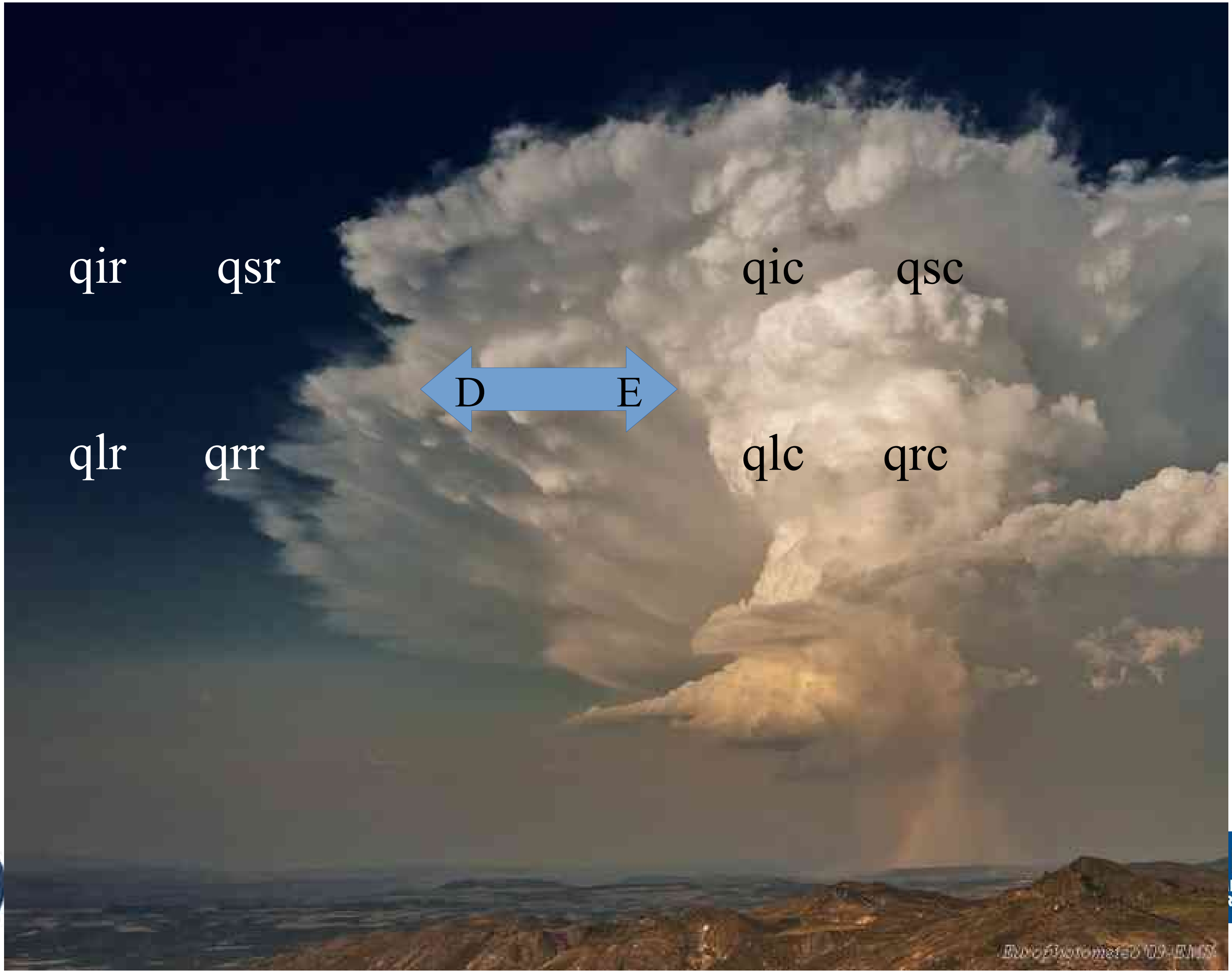
PCMT convection scheme

Jean-Marcel Piriou, Jean-François Guérémy, Yves Bouteloup, François Bouyssel, Ryad El Khatib, GMAP, GMGEC, ENM, ...

PCMT convection scheme: overview

- PCMT : Prognostic Condensates Microphysics and Transport
- Prognostic microphysics : liquid water, ice water, rain, snow : transport / icing of updraft water vapour, autoconversion, collection, sedimentation / evaporation of precipitation, etc
- Symmetric geometry : (i) updraft / (ii) its environment. Microphysics called in each area, conservative entrainment / detrainment between these two areas

PCMT convection scheme



PCMT equations

Convective liquid water (or ice)

$$
\begin{aligned}
\frac{\partial}{\partial t}\overline{q_{lc}} \;=\;& \mathrm{Advec}(\overline{q_{lc}}) \\
& -\frac{1}{\rho}\frac{\partial}{\partial z}\rho\left[\alpha_u w_u + \alpha_d w_d\right] q_{lc} \\
& +\left(E_u + E_d\right) q_{lr} - \left(D_u + D_d\right) q_{lc} \\
& +\mathrm{CondensEvap}_c - \mathrm{AutoconvColl}_c + \mathrm{MeltingIcing}_{lc}
\end{aligned}
$$

Resolved liquid water + Smith (or ice)

$$
\begin{aligned}
\frac{\partial}{\partial t}\overline{q_{lr}} \;=\;& \mathrm{Advec}(\overline{q_{lr}}) \\
& -\frac{1}{\rho}\frac{\partial}{\partial z}\rho\left[-\alpha_u w_u - \alpha_d w_d\right] q_{lr} \\
& -\left(E_u + E_d\right) q_{lr} + \left(D_u + D_d\right) q_{lc} \\
& +\mathrm{CondensEvap}_r - \mathrm{AutoconvColl}_r + \mathrm{MeltingIcing}_{lr}
\end{aligned}
$$

PCMT equations

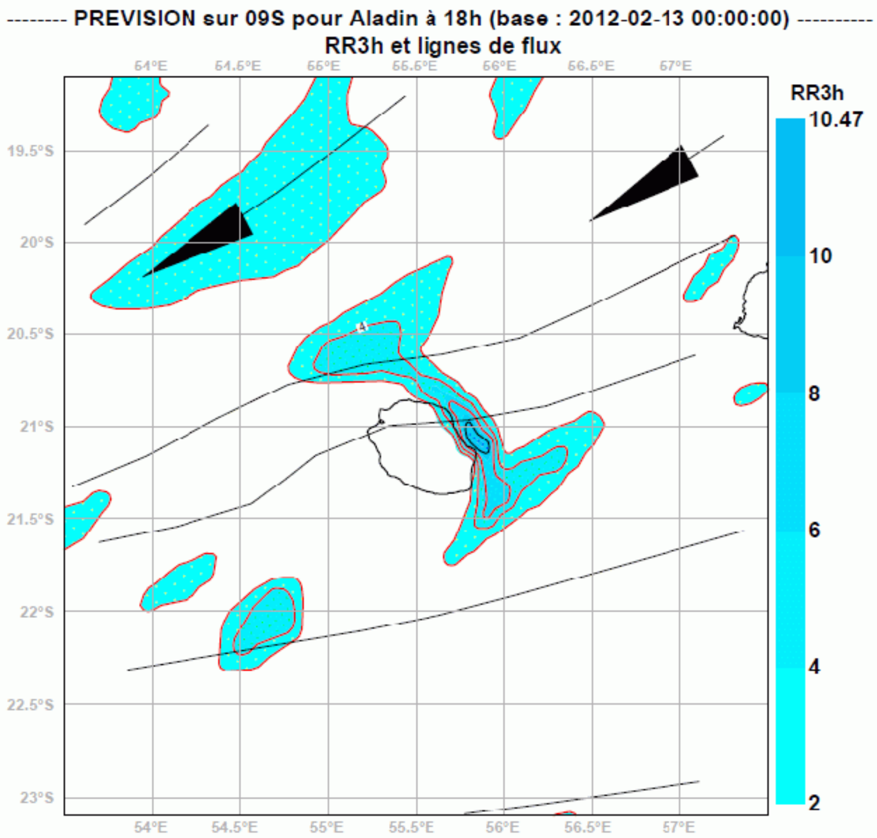
Convective rain (or snow)

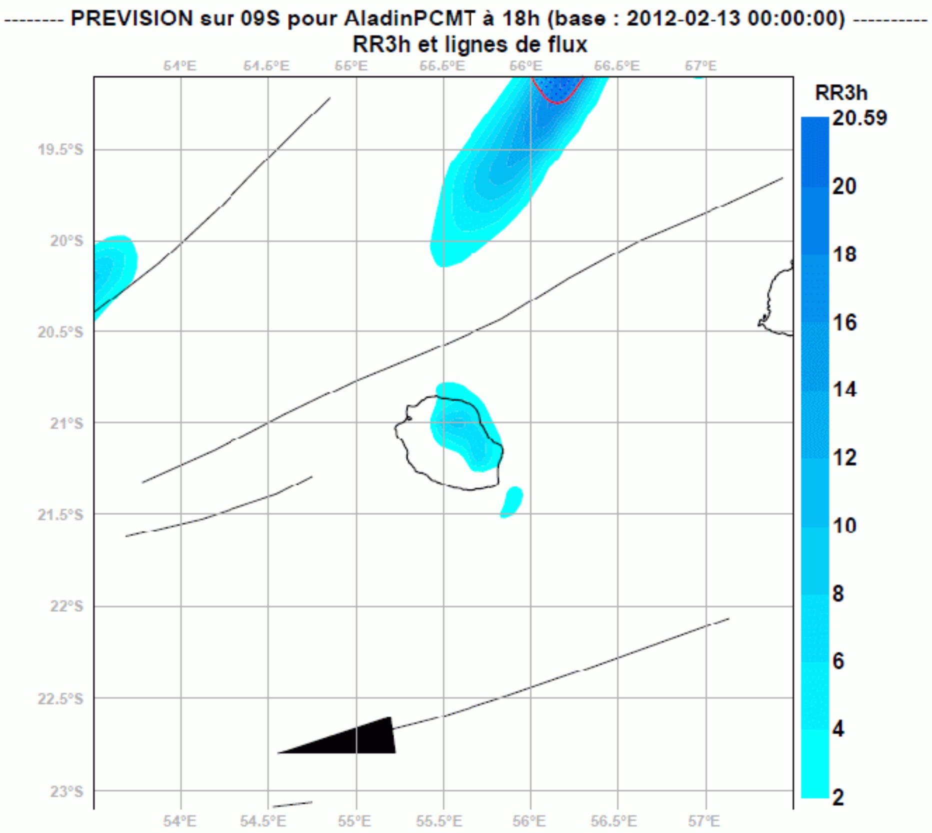
$$
\begin{aligned}
\frac{\partial}{\partial t}\overline{q_{rc}} &= \mathrm{Advec}(\overline{q_{rc}}) \\
&-\frac{1}{\rho}\frac{\partial}{\partial z}\rho\left[\alpha_u(w_u+w_s)+\alpha_d(w_d+w_s)\right]q_{rc} \\
&+(E_u+E_d)\,q_{rr}-(D_u+D_d)\,q_{rc} \\
&+\mathrm{AutoconvColl}_c-\mathrm{Evap}_{rc}+\mathrm{MeltingIcing}_{rc}
\end{aligned}
$$

Resolved rain (or snow)

$$
\begin{aligned}
\frac{\partial}{\partial t}\overline{q_{rr}} &= \mathrm{Advec}(\overline{q_{rr}}) \\
&-\frac{1}{\rho}\frac{\partial}{\partial z}\rho\left[-\alpha_u w_u-\alpha_d w_d+(1-\alpha_u-\alpha_d)w_s\right]q_{rr} \\
&-(E_u+E_d)\,q_{rr}+(D_u+D_d)\,q_{rc} \\
&+\mathrm{AutoconvColl}_r-\mathrm{Evap}_{rr}+\mathrm{MeltingIcing}_{rr}
\end{aligned}
$$

PCMT : precipitation and orography : île de La Réunion





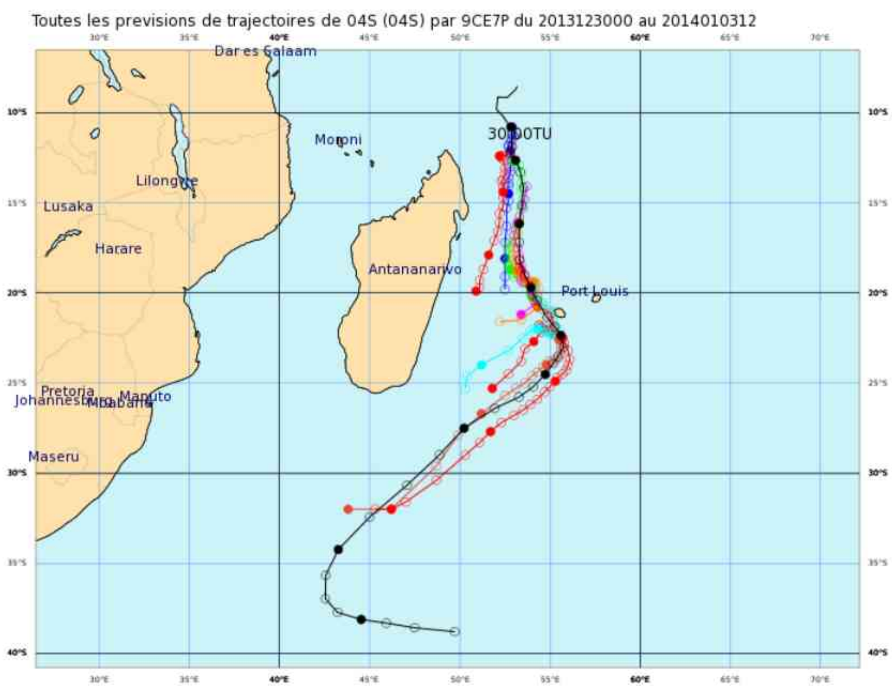
ARPEGE
standard

ARPEGE
PCMT

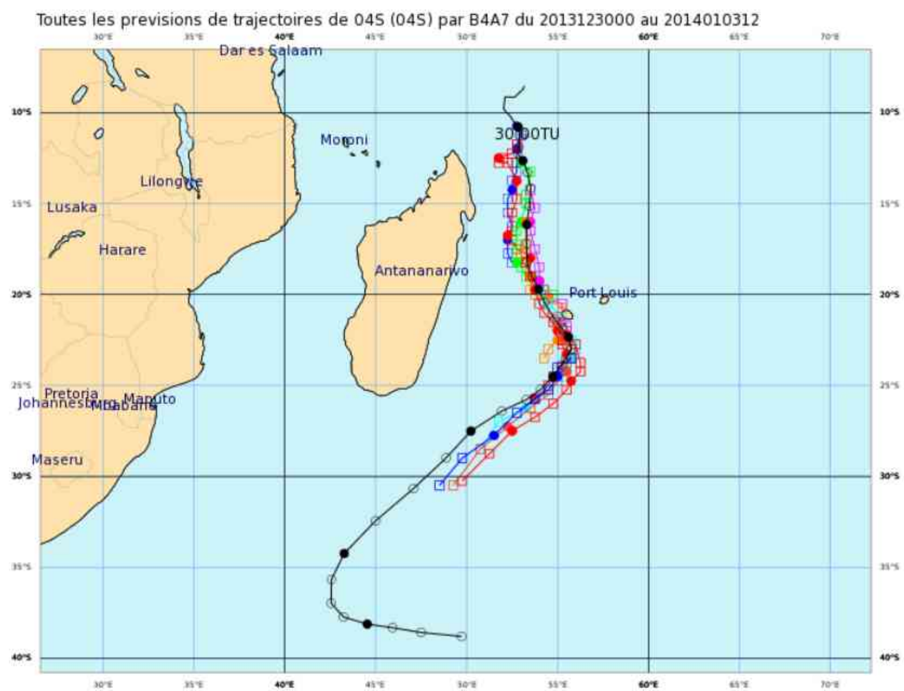
Courtesy David Barbary, Météo-France La Réunion

Tropical cyclones prediction (Jérémy Guerbette's PhD)

ALADIN-Réunion 8km



Physique oper

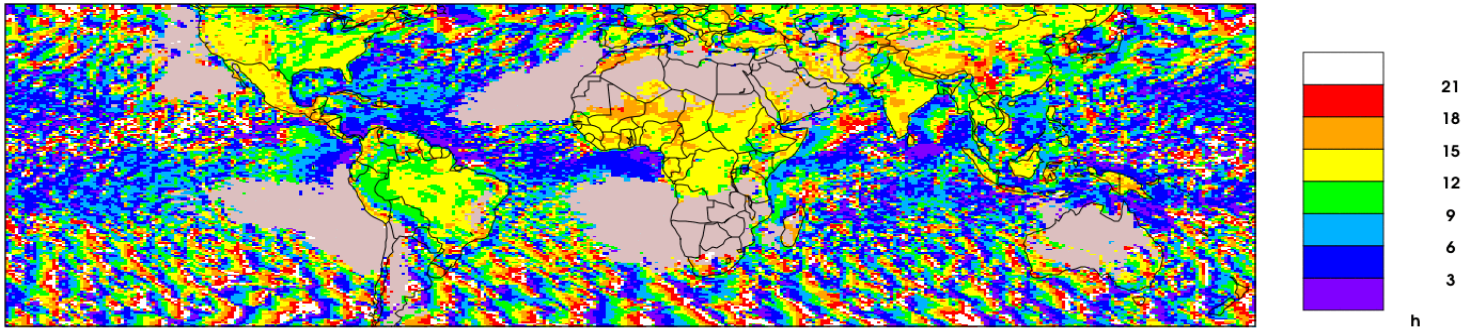


Nouvelle physique
« PCMT + PMMC09 »

- Speed too low (ref and exp)
- Improved stormtrack and deepening

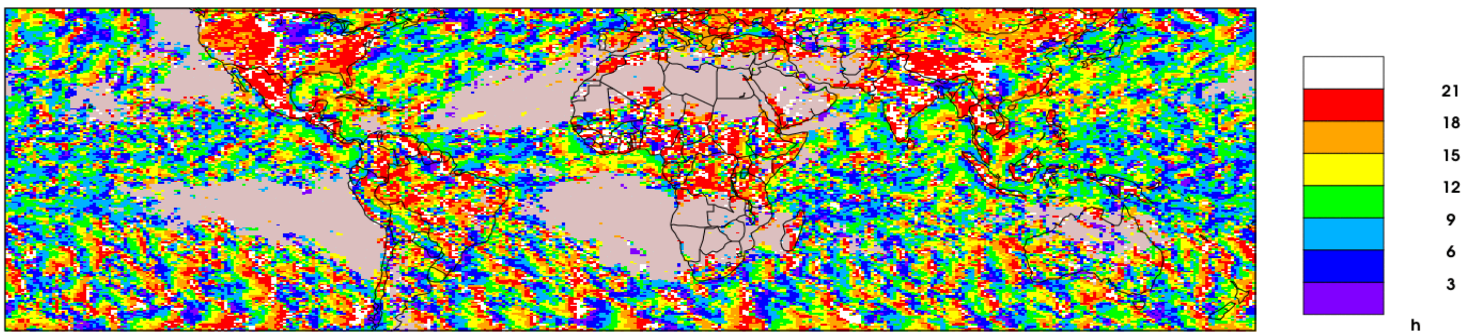
Diurnal cycle of precipitation

Local solar time max. diurnal precipitation wave , oper
20150501-20150731.oper
Min=0.0513 Max=23.9 Moy=10.3 Ect=5.46 Rcm=11.7



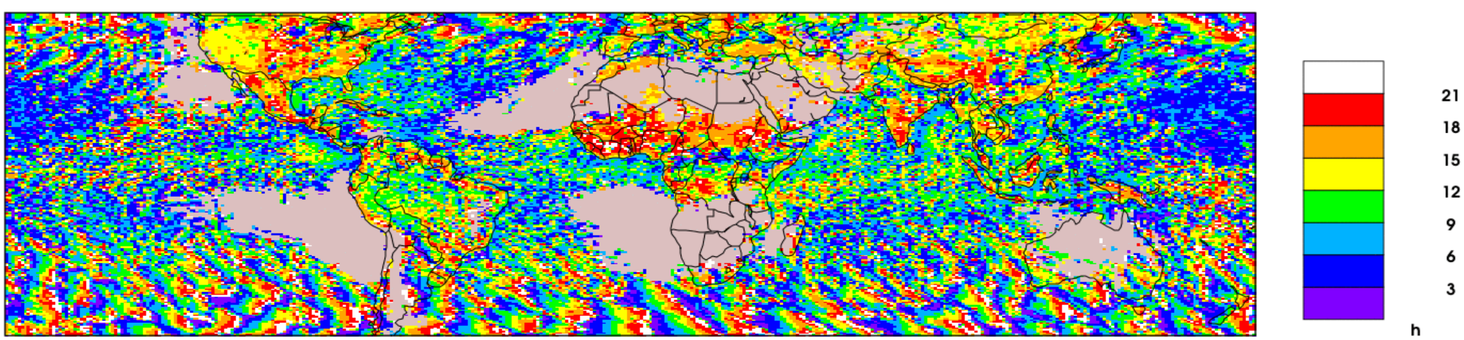
ARPEGE oper.

Local solar time max. diurnal precipitation wave , trmm
20150501-20150731.trmm
Min=0.0306 Max=24.0 Moy=11.9 Ect=5.58 Rcm=13.2



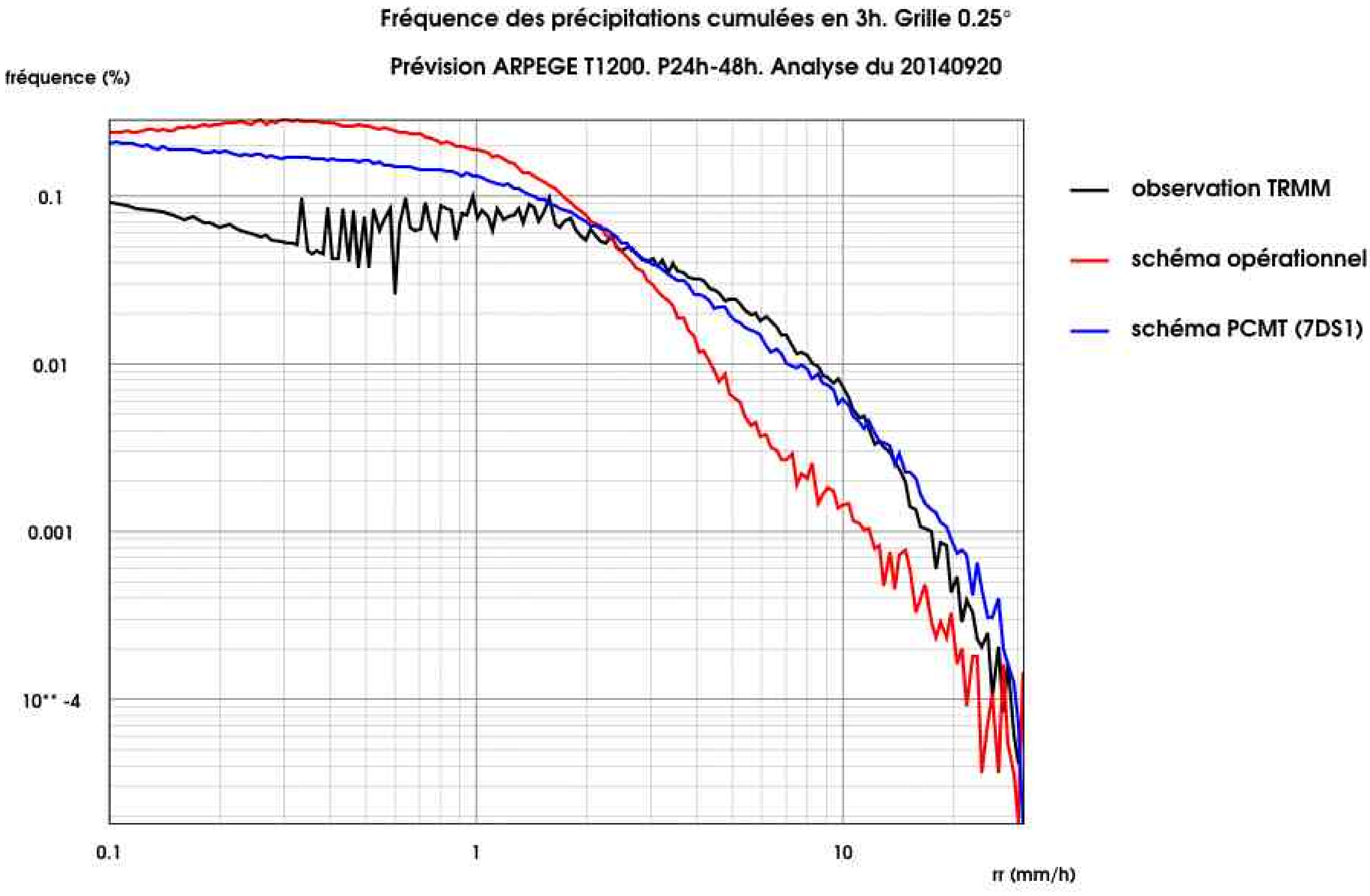
TRMM analysis

Local solar time max. diurnal precipitation wave , 7E7S
20150501-20150731.7E7S
Min=6.11E-3 Max=23.9 Moy=10.6 Ect=5.41 Rcm=11.9



ARPEGE PCMT

PDF of 3-hourly precipitation rate versus TRMM data



Further plans (2017-2018)

Arpège :

- higher resolution (5km over Western Europe),
- improvements in the assimilation of observations : AMDAR-hum, VarBC/aircraft, hyperspectral sounders inter-channel error correlations, additional GSP-RO, additional microwave radiances, etc.

PEARP (global EPS) : 4 runs/day, surface perturbations

Arome-France :

- progress on LLV,
- reduce spin-up for dynamical adaptation models,
- test new microphysics scheme LIMA,
- diagnose visibility and cloud bottom height,
- assimilate more X-band radar, assimilate OPERA-type data

PEARO (convection-permitting EPS) : 4 runs/day, increase ensemble size ?

FINE

la ringrazio molto per l'attenzione e per le vostre domande!

thank you very much for your attention and for your questions!