Overview of the ARPEGE/AROME 1D simulations run at Meteo-France within the EUCLIPSE project

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The ARPEGE/AROME 1D model MUSC (Unified Model, Single Column) has been used to simulate two Sc-Cu transition cases: the ASTEX lagrangian case, built from the ASTEX field campaign conducted in June 1992 near the Azores (De Roode and Dussen, 2010) and three composite transition cases based on the observational study of the boundary layer clouds (Sandu et al., 2010).

Three physics packages have been tested: the physics used in NWP ARPEGE model, the physics used in the NWP non-hydrostatic LAM AROME and that of the CM5.1 global climate model.

After a short description of the tested physics packages, the implementation and preliminary results of the studied cases are presented and first analyses are provided.

ARPEGE/ALADIN/AROME/IFS/HARMONIE/MUSC
A NWP unified software

GLOBAL (variable mesh or not) or LAM (choice made by NAMELIST) or 2D

Two dynamical cores (choice made by namelist)

Hydrostatic

Non hydrostatic

A set of physical packages (choice made by NAMELIST)

Hirlam

ALARO

ARPEGE-NWP
ARPEGE/CLIMAT
ALADIN

AROME

IFS

3D/4D
Variational
Algorithmic
structure

Obs
operators

OI assimilation scheme
Used only for surface

Thanks to Y. Bouteloup.

1D MODEL MUSC : Current status

- **<u>1D cases already available in MUSC</u>**:

 Cumulus: **ARM (21/06/1997)**, **BOMEX**

Stable Boundary Layer : GABLS cases (**GABLS 1, 2 et3**)

- **For the EUCLIPSE project : 3 cases have been added**

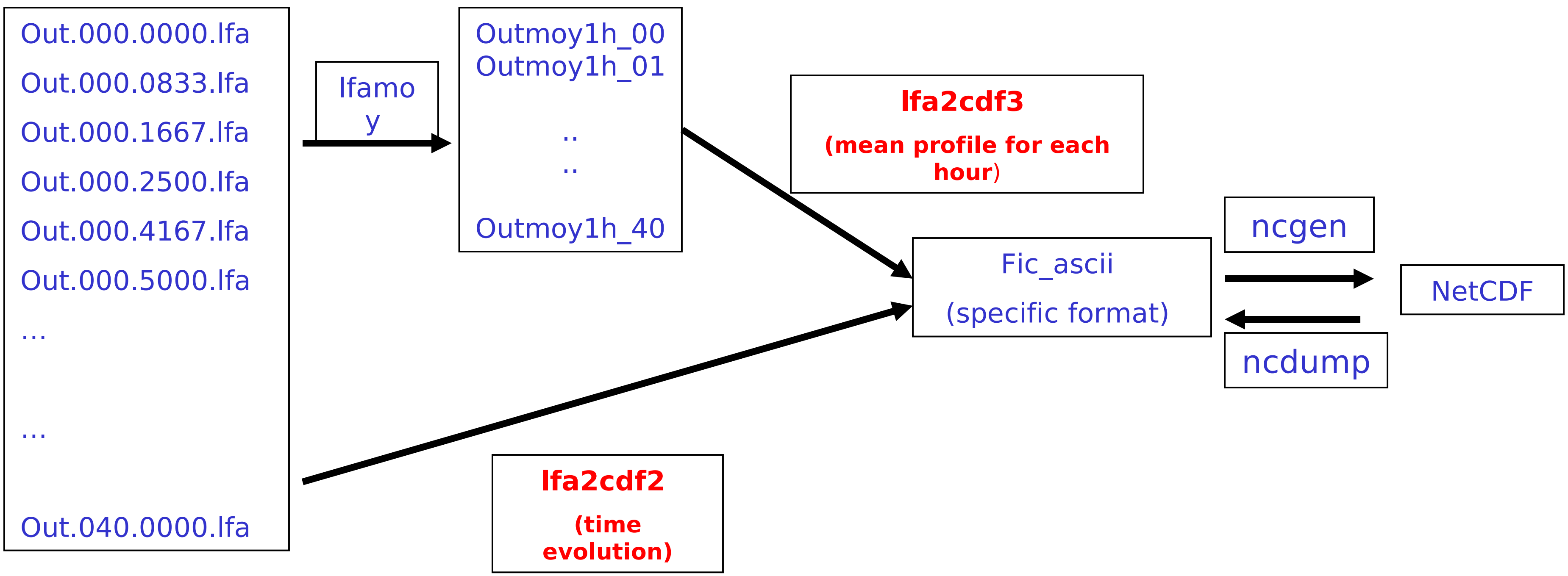
 Sc-Cu transition <u>ASTEX</u> Lagrangian and <u>COMPOSITE, RADIATION CASE.</u>

- **Several forcing types are now available :**
  - **Geostrophic wind, advection for T, Q, U/V, nudging for T, Q, U/V, vertical advection (from W)**

- **For the surface, with SURFEX surface scheme:**
  - **By sensible and latent heat fluxes**
  - **By Ts/qs over land or by a varying SST**
  - **New albedo option Marat Khairoutdinov for the COMPOSITE case.**

Output files:

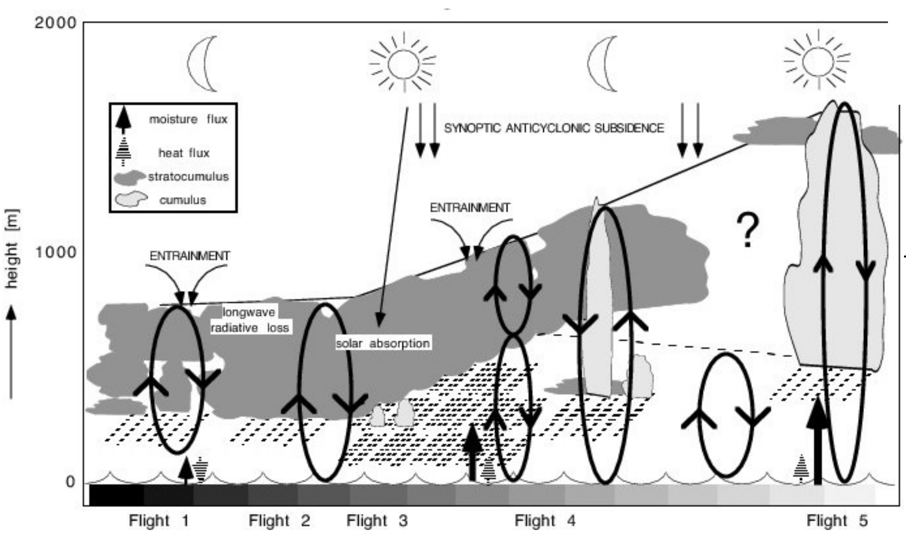
- **To provide NetCDF files for the EUCLIPSE project from the LFA files, some converters have been written:**



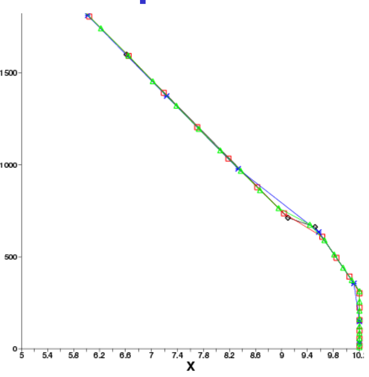
Physics in MUSC

	ARPEGE/ALADIN	AROME	ARPEGE/CLIMAT GIEC AR5	ALARO0
Coeff K diffusion	TKE –Cuxart et al (2000) (HL) modified for Ku	TKE –Cuxart et al (2000) (FL) modified for Ku	TKE-2.0/Mellor-Yamada 82 (Ricard Royer-93)	E-TKE
L Mixing length	Bougeault and Lacarrère 89		Quadratic profile (Lenderink and Holtslag, 2004)	Int. HCLA Ayotte
Shallow convection	Bechtold et al (2000) so called KFB	Pergaud et al (2009) so called EDKF	TKE-2.0/Mellor-Yamada 82 (Ricard Royer-93)	Geleyn 87 With e-TKE
Clouds	Smith(90)	f0, f1, f2 Bougeault (82)	PDF/f0,f1, f2; Bougeault (82)	Xu & Randall
Micro-Physics	Lopez modified ql,qi,qr,qs (PCS)	Ice3 ql,qi,qr,qs,qg	Kessler-Smith (1990)	ql,qi,qr,qs (PCS)
Convection	Bougeault 85 with modifications	No	Bougeault, 85 (V3: cycle 18)	3MT-deep
Radiation	ECMWF: LW=RRTM SW=Morcrette (93)			New-Geleyn

ASTEX lagrangian (13th, June 1992, +40 h)



Qv (g/kg) Initial profile

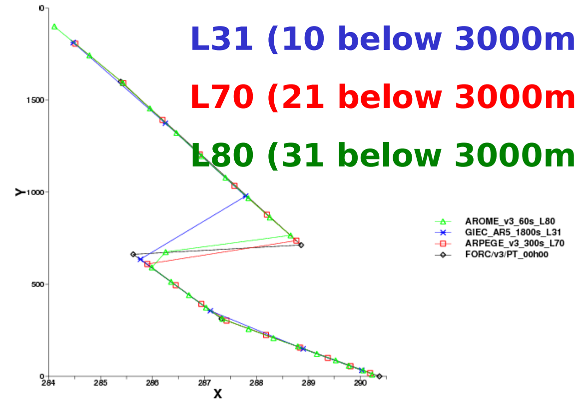


T (K) Initial profile

L31 (10 below 3000m)

L70 (21 below 3000m)

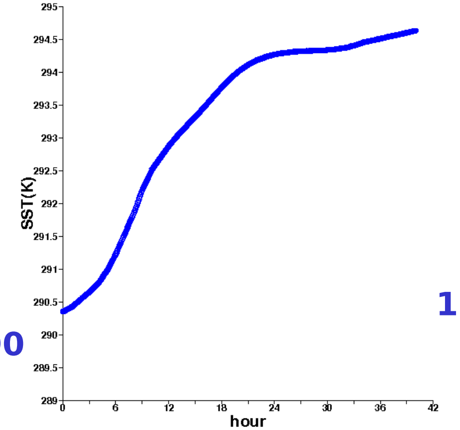
L80 (31 below 3000m)



SST forcing (K)

295

290

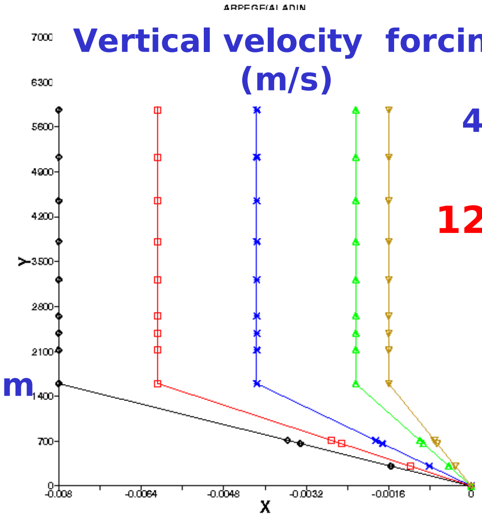


Vertical velocity forcing (m/s)

4000m

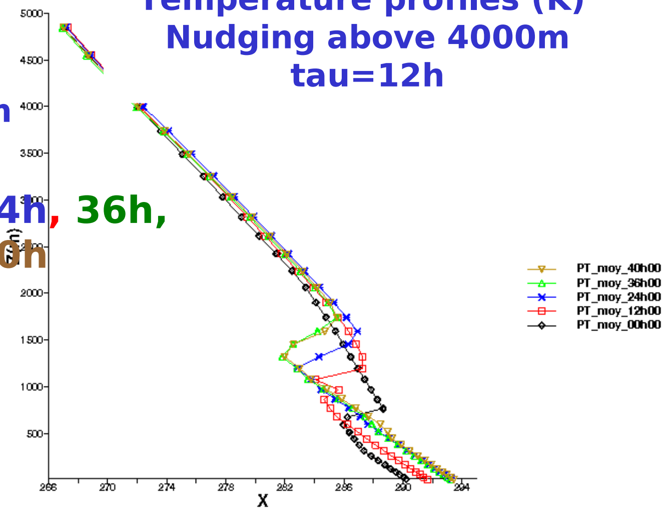
1500m

-8mm/s



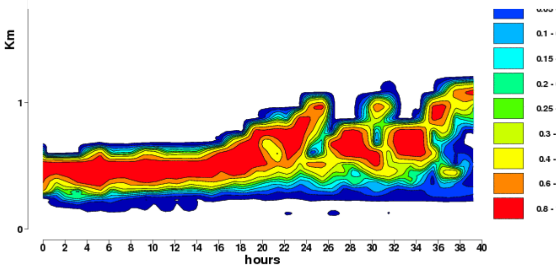
Temperature profiles (K) Nudging above 4000m tau=12h

12h, 24h, 36h, 40h

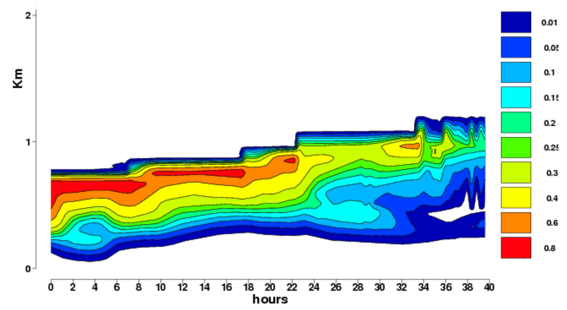


ASTEX Lagrangian

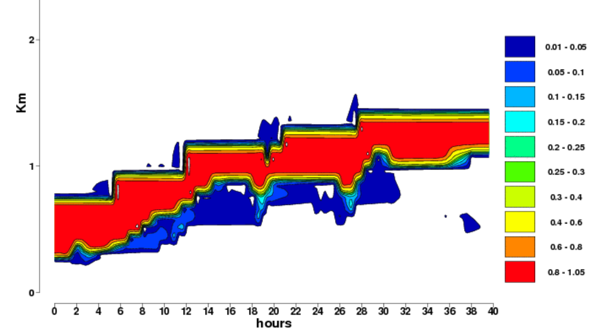
Cloud Cover ARPEGE-CLIMAT L80 300s



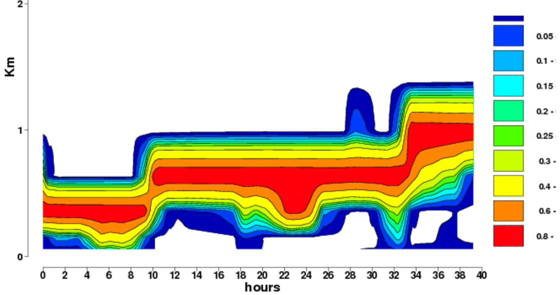
Cloud Cover ARPEGE NWP L80 300s



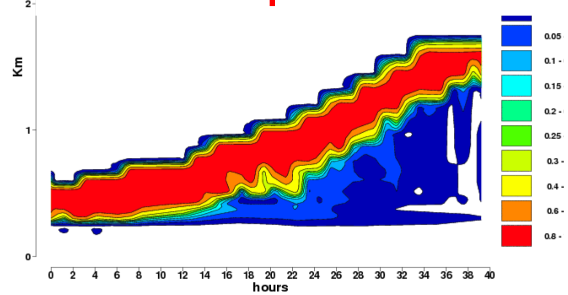
Cloud Cover AROME L80 60s



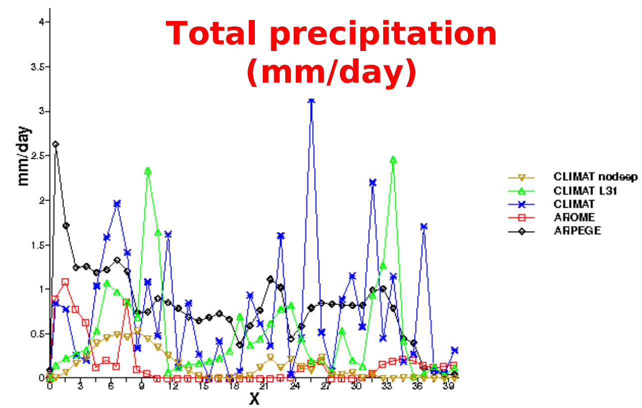
Cloud Cover ARPEGE-CLIMAT L31 300s



Cloud Cover ARPEGE-CLIMAT Nodeep L80 300s



Total precipitation (mm/day)

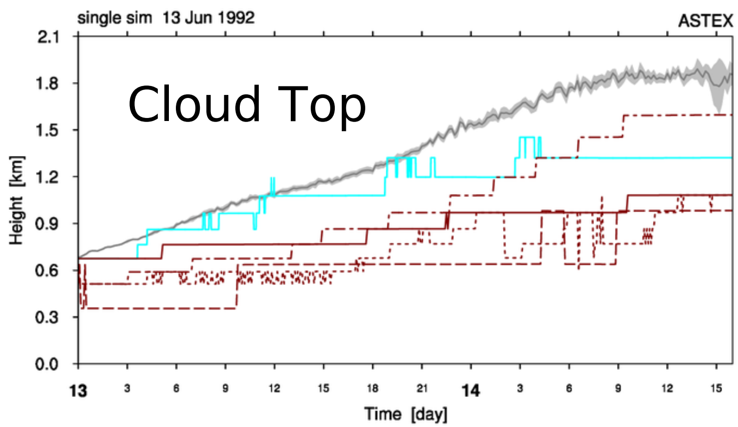


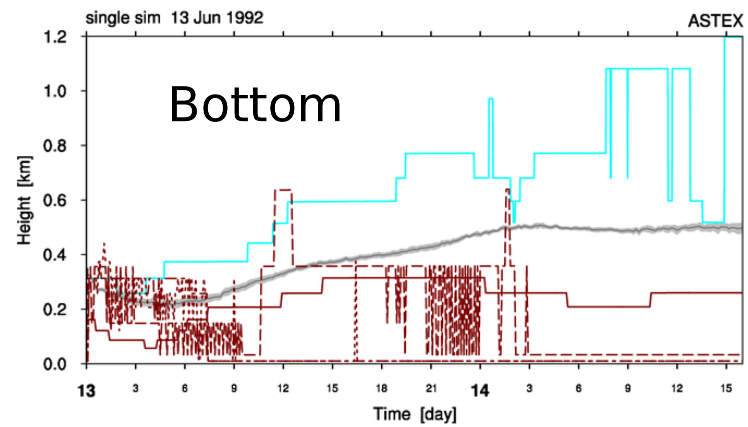
Relatively good behaviour of the Climate version with only 31 levels. ARPEGE-NWP and CLIMAT underestimate the cloud top and the cloud base rising is not sufficient. The AROME cloud development seems reasonable.

Suppressing the deep convection scheme in the climate version has surprisingly an important and positive impact.

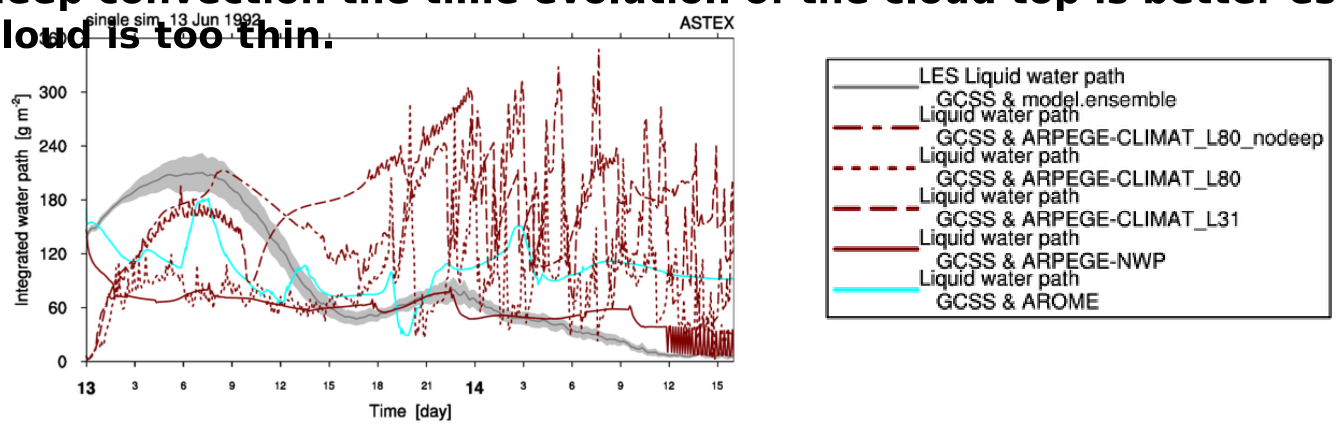
ASTEX Lagrangian

http://www.knmi.nl/samenw/rico/RICO/index_inter_tim.php





Cloud top is generally underestimated, to a less extent for AROME. Without the deep convection the time evolution of the cloud top is better estimated. AROME cloud is too thin.

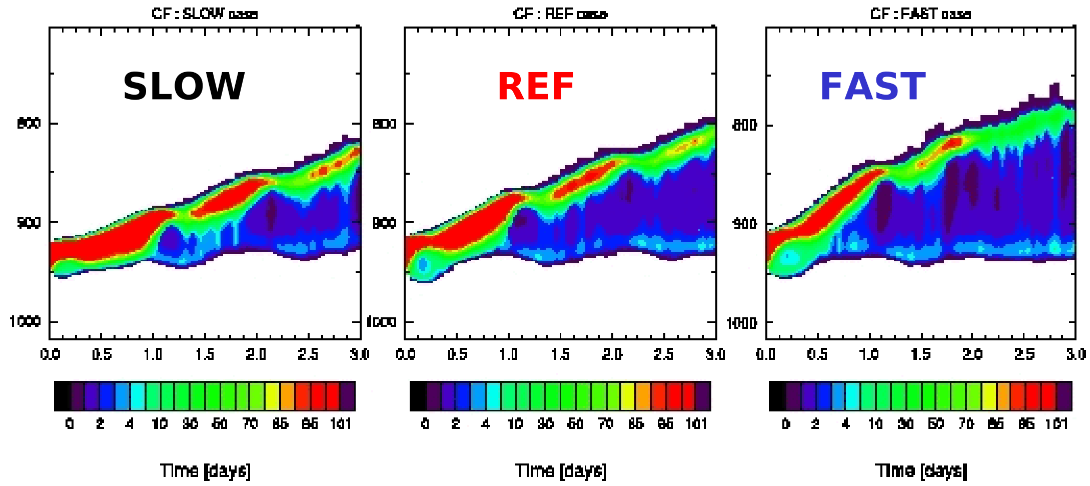


ARPEGE NWP: small variations of LWP, clear underestimation at the beginning .

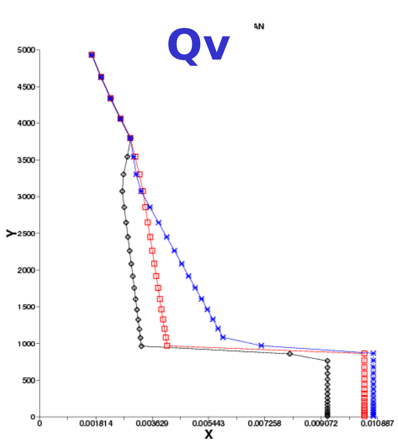
AROME: underestimation at the beginning, overestimation at the end.

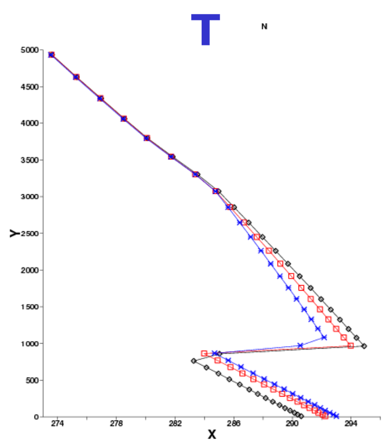
ARPEGE-CLIMAT: too strong values and oscillations during the second part of the simulation. Underestimation at the beginning of the run with L80 + deep convection scheme.

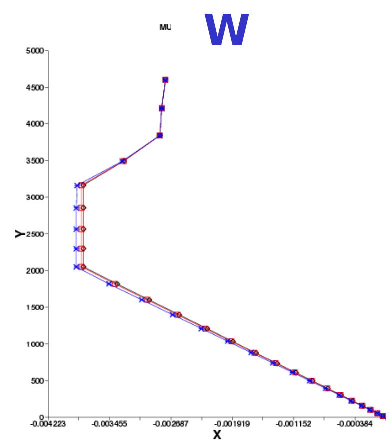
COMPOSITE Case (15th July, 3 days forecast)

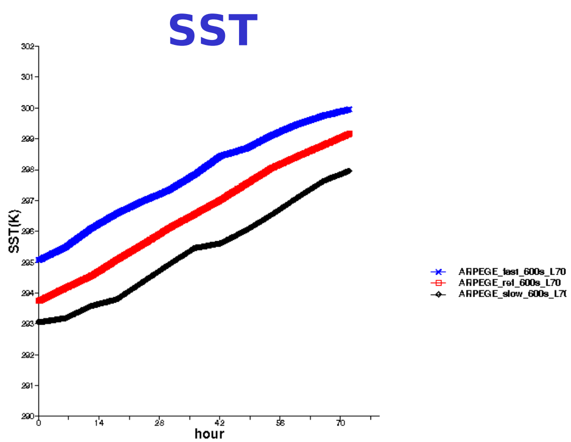


LES (UCLA) Cloud cover evolution for the 3 transitions slow, ref and fast



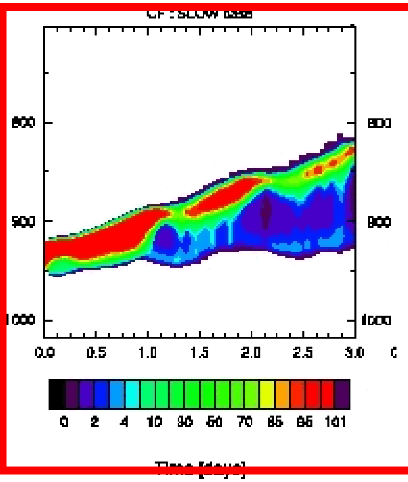


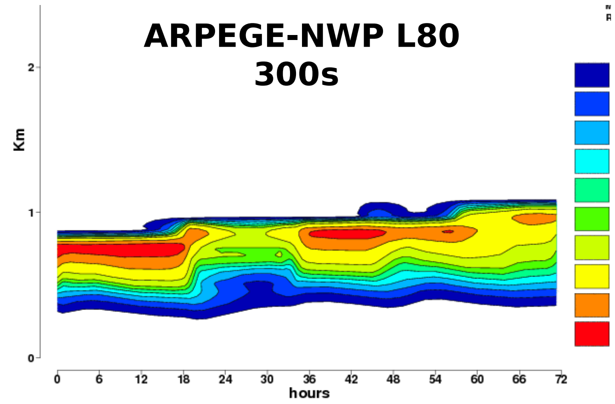


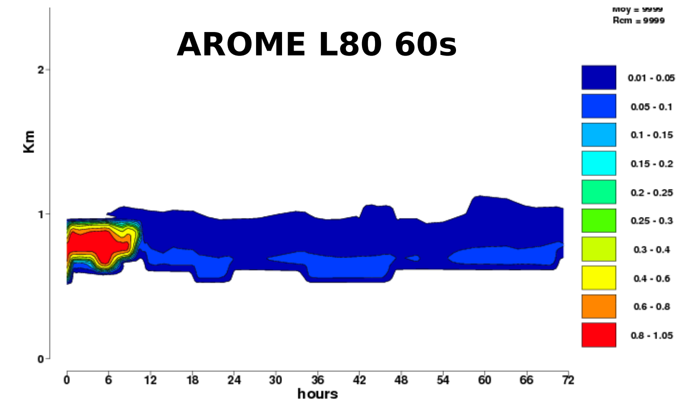


COMPOSITE Case (15th July, 3 days forecast)

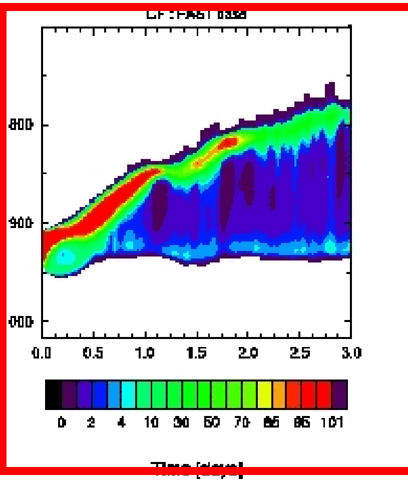
SLOW

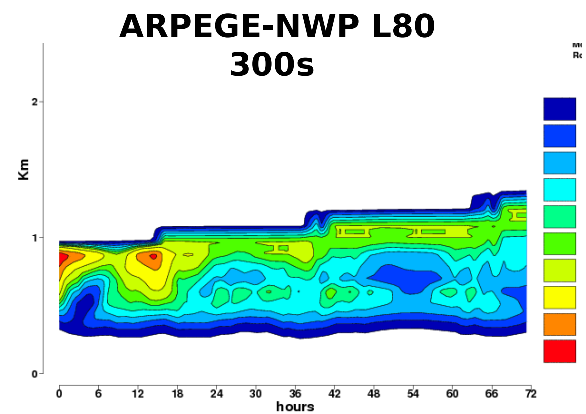


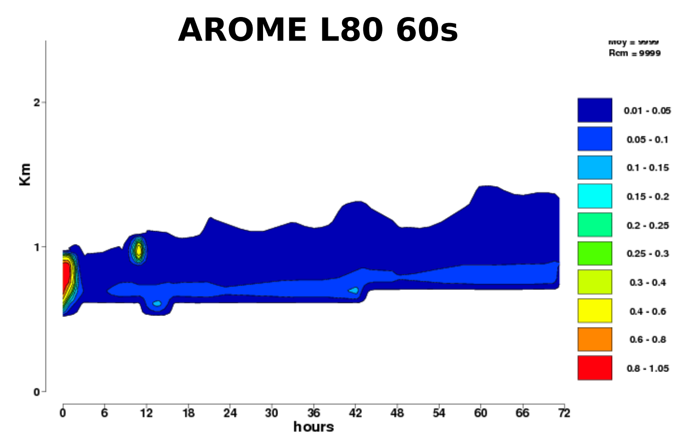




FAST





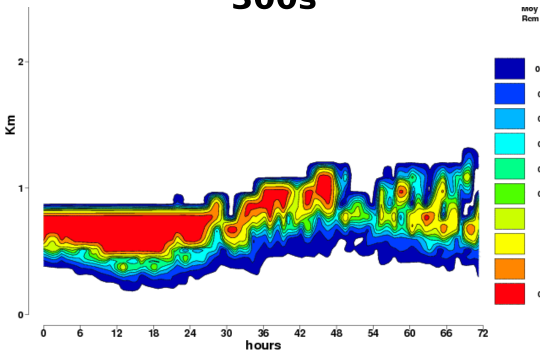


ARPEGE NWP/AROME Cloud Cover: insufficient vertical development (top&bottom), too small cloud fraction (particularly true for AROME). Too small sensitivity between the slow and the fast case.

COMPOSITE Case (15th July, 3 days forecast)- ARPEGE-Climat Sensitivity tests

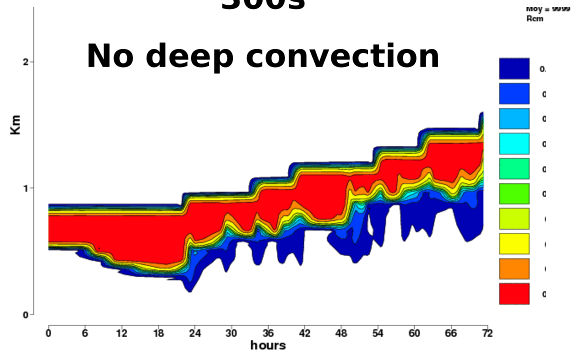
SLOW

ARPEGE-CLIMAT L80 300s

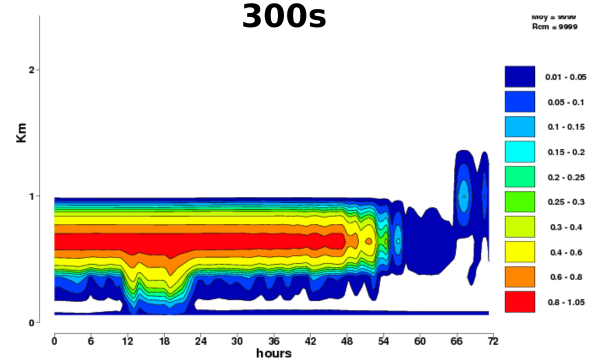


ARPEGE-CLIMAT L80 300s

No deep convection

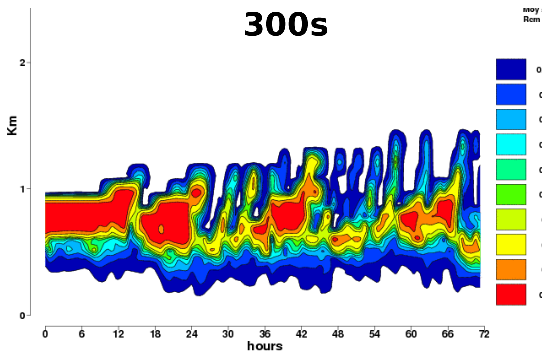


ARPEGE-CLIMAT L31 300s



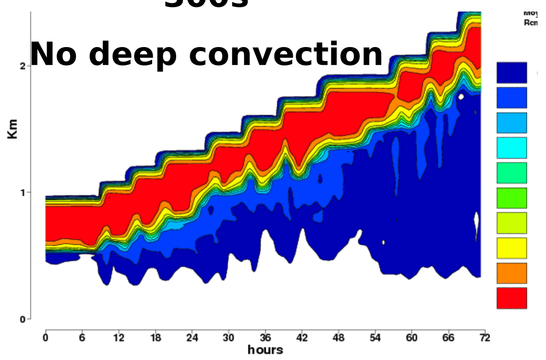
FAST

ARPEGE-CLIMAT L80 300s

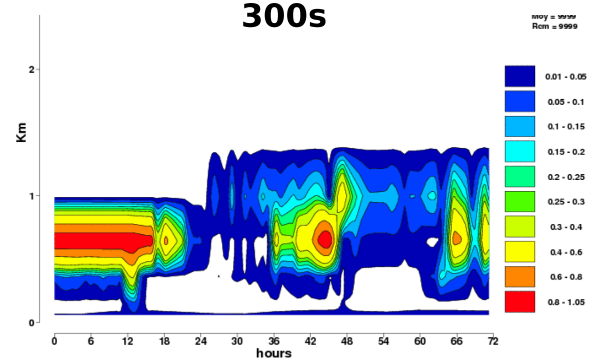


ARPEGE-CLIMAT L80 300s

No deep convection



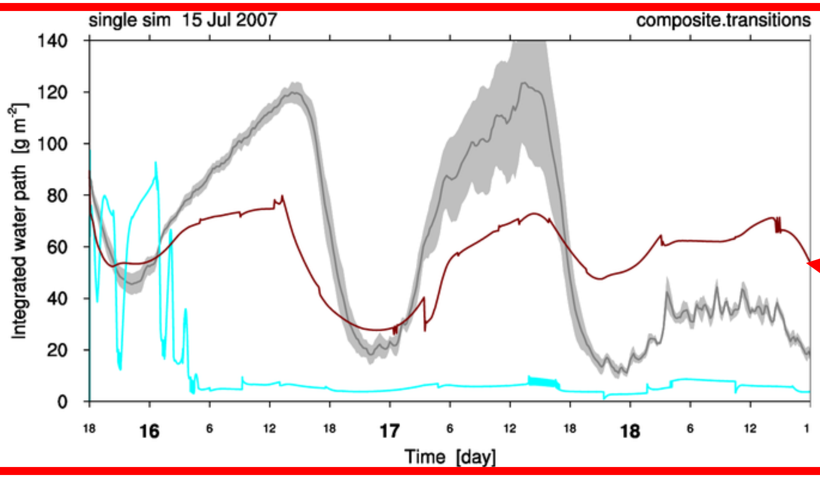
ARPEGE-CLIMAT L31 300s

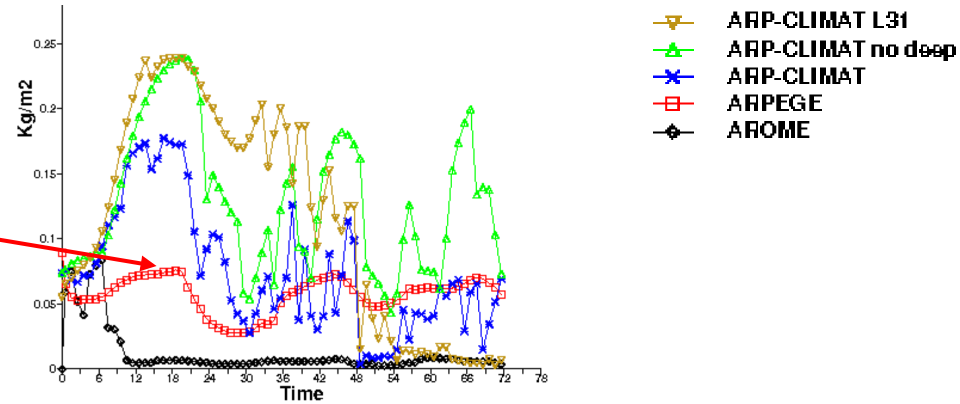


Without the deep convection scheme (L80), more satisfactory cloud vertical development (top/bottom), as found in the ASTEX case, and good sensitivity to the transition case. With 31 vertical levels, badly simulated vertical development in the slow case, a little better in the fast case.

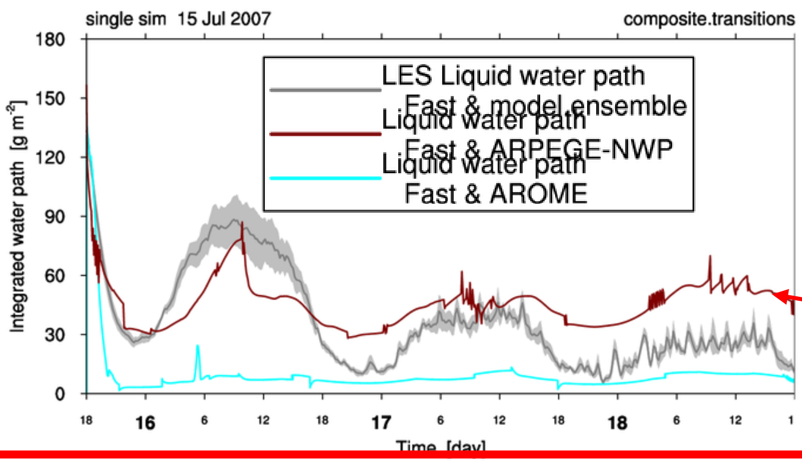
COMPOSITE Case (15th July, 3 days forecast) Liquid Water Path

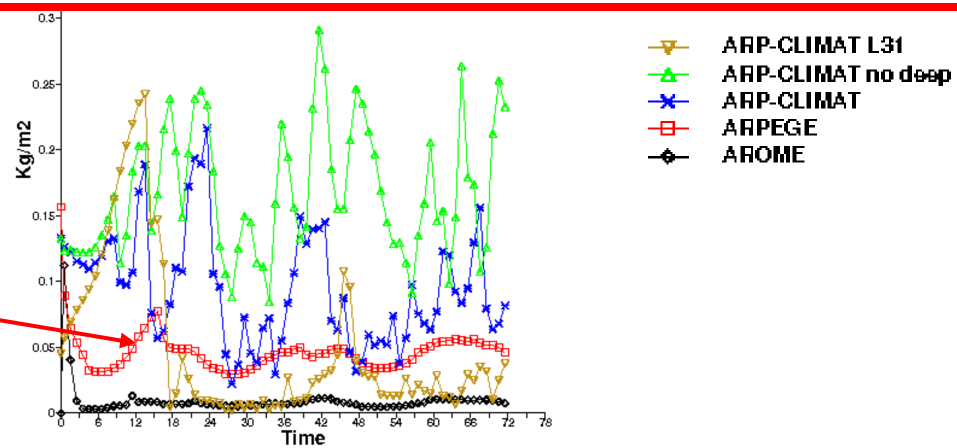
SLOW





FAST





AROME: Underestimation of LWP.

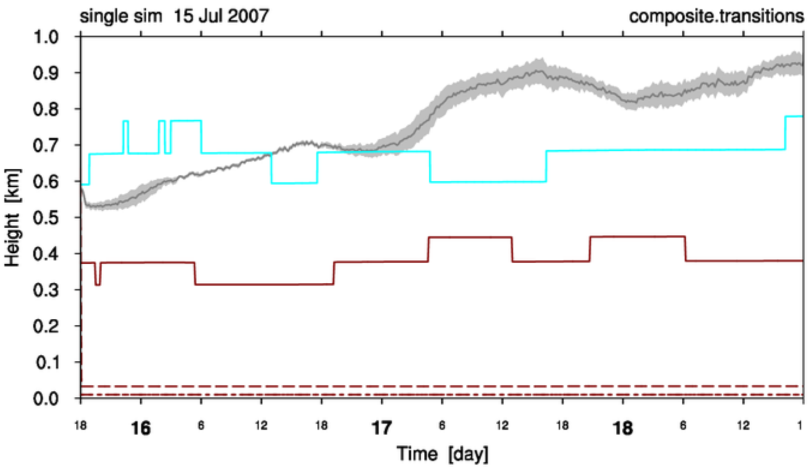
ARPEGE NWP: in phase with the LES variations.

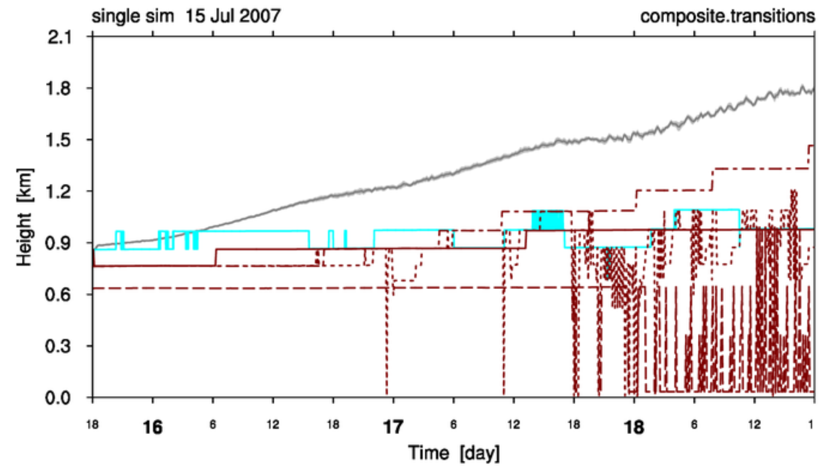
Overestimation of LWP by ARPEGE-CLIMAT excepted for the L31 simulation.

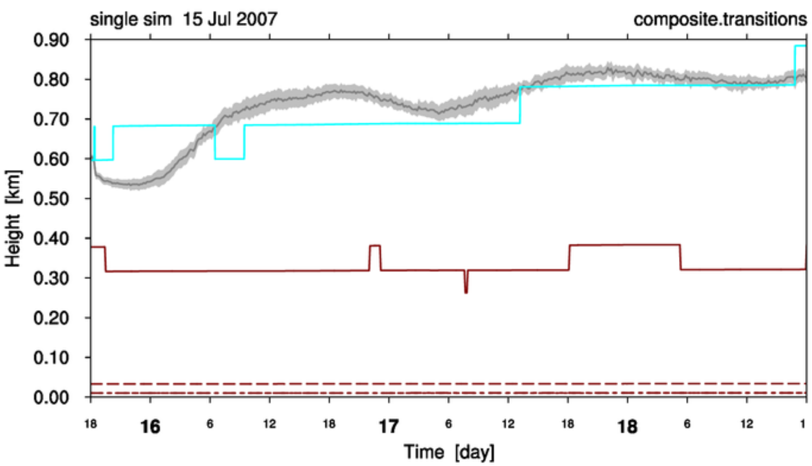
COMPOSITE Case (15th July, 3 days forecast)

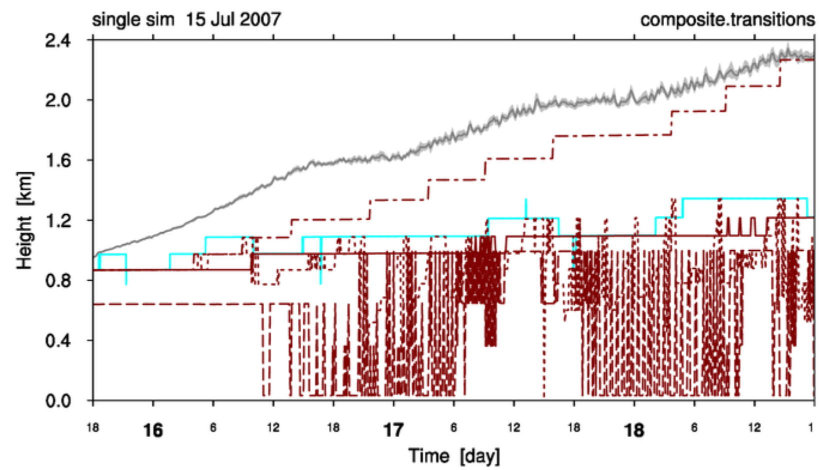
Base

Top









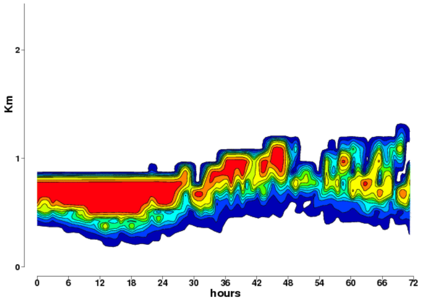
AROME cloud is too thin as in the ASTEX case. ARPEGE-NWP lacks of sensitivity to the forcing (transition). Without the deep convection scheme, the ARPEGE-CLIMAT cloud time evolution is well represented as in the ASTEX case, nevertheless a GCM NEEDS a deep convection scheme.

Sensitivity to the deep convection scheme (L80, 300s)

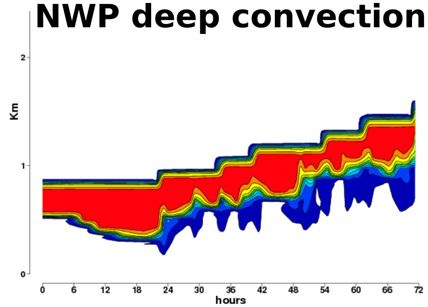
COMPOSITE CASE

SLOW

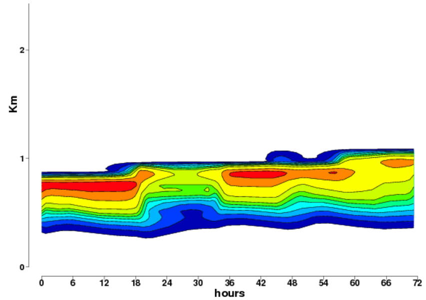
ARPEGE-CLIMAT



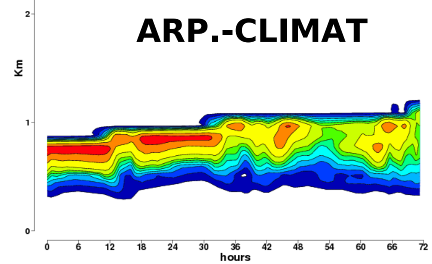
ARPEGE-CLIMAT with NWP deep convection



ARPEGE-NWP

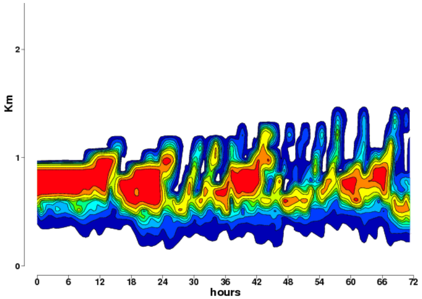


ARPEGE-NWP with deep convection from ARP.-CLIMAT

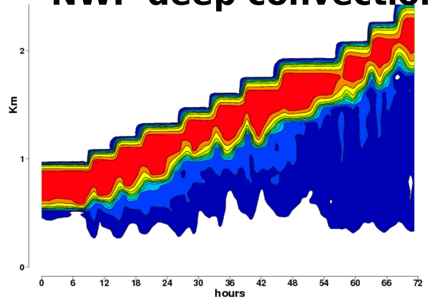


FAST

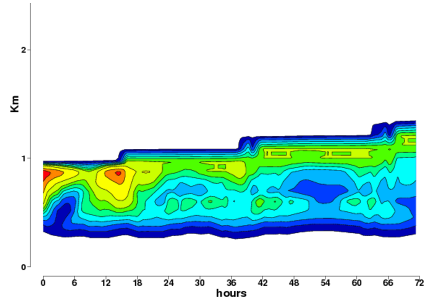
ARPEGE-CLIMAT



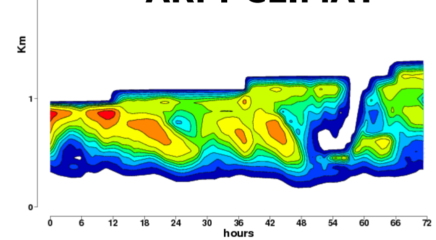
ARPEGE-CLIMAT with NWP deep convection



ARPEGE-NWP



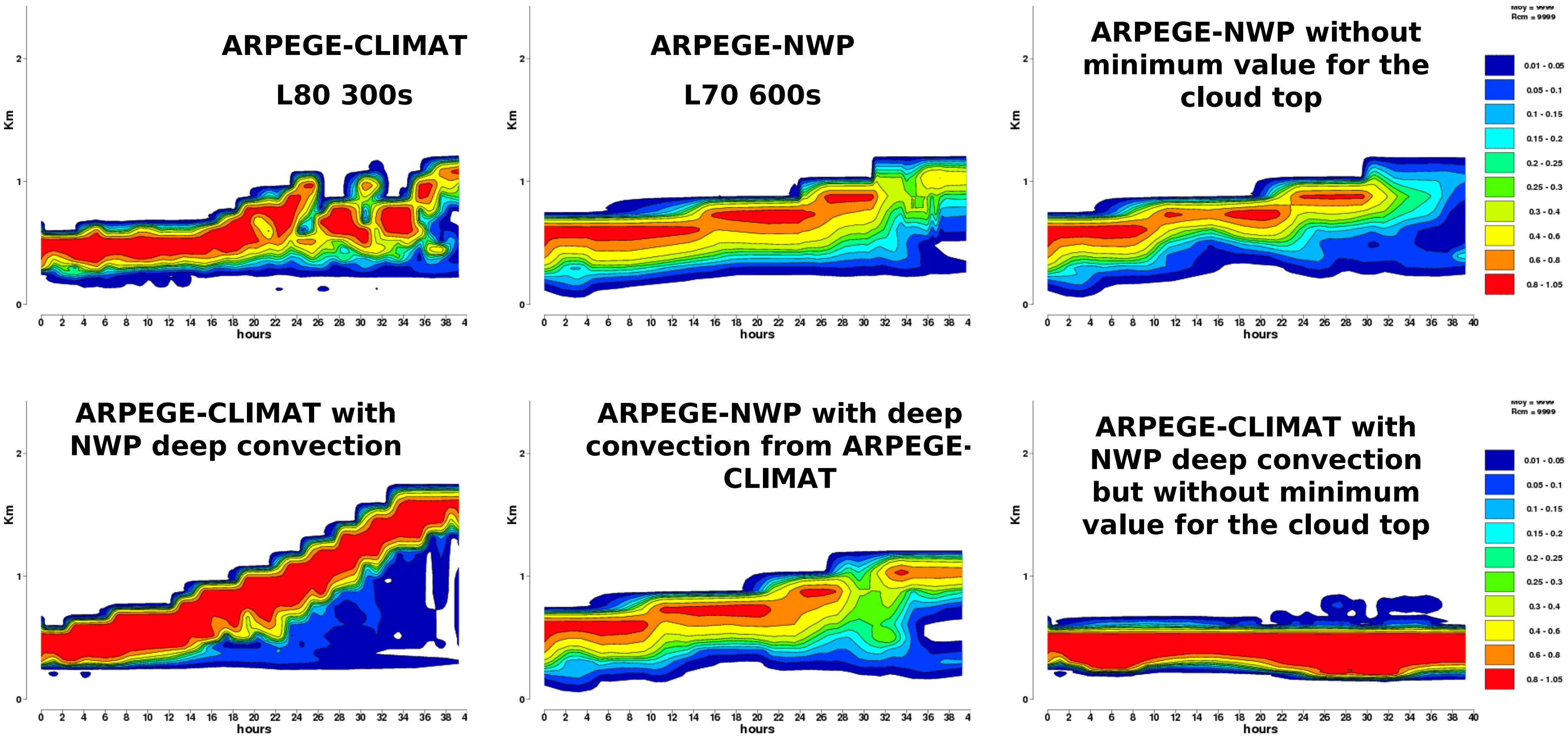
ARPEGE-NWP with deep convection from ARP.-CLIMAT



Implementation of the NWP scheme allows the cloud vertical development in ARPEGE-CLIMAT but the ARPEGE-CLIMAT deep convection has a smaller impact in ARPEGE-NWP.

Sensitivity to the deep convection scheme

ASTEX LAGRANGIAN CASE



Same sensitivity than the COMPOSITE Case . Very different responses of the two models to the deep convective schemes.

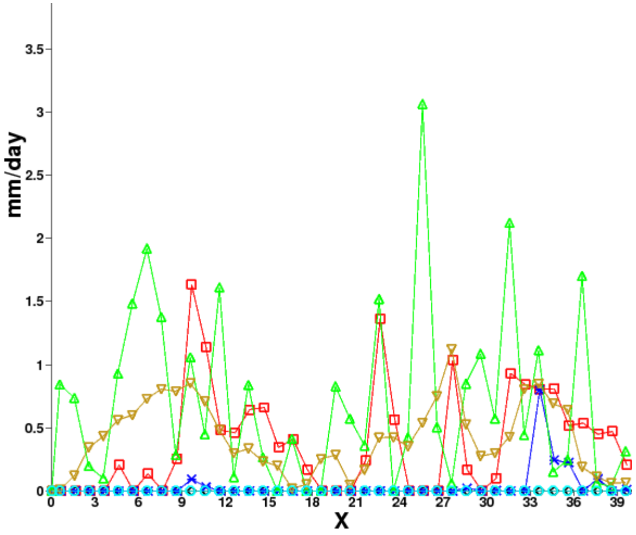
Is it a triggering or a convective intensity problem ?

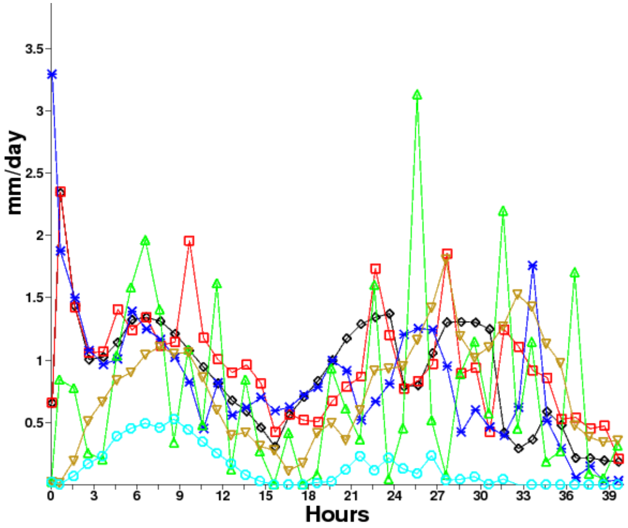
Is it the result of the interaction between the BL and deep convective schemes ?

Sensitivity to the deep convection scheme

ASTEX LAGRANGIAN CASE

In the NWP scheme, a minimum value for the top of the deep convective cloud (3000m) has been introduced when the boundary layer schemes (Prognostic TKE + mass flux shallow convection) have replaced the Louis's scheme (Feb. 2009).





	Total	Deep Conv.	Shallow + Resolved
CLI. DEEP NWP	0.13	0.0	0.13
CLI. DEEP NWP NO MIN VALUE	0.75	0.41	0.34
CLI.REF	0.73	0.70	0.03
ARP DEEP CLI	0.85	0.04	0.81
ARP NO MIN VALUE	0.97	0.38	0.59
ARP REF	0.89	0.0	0.89

Excepted the ARPEGE-CLIMAT model with the NWP deep convection scheme, all the models tend to have too high precipitation rate in the first part of the simulation and keep this weakness till the end whereas no precipitation occurs in the LES. The ARPEGE-NWP precipitation rate is mainly due to the shallow + resolved part, contrary to the ARPEGE-CLIMAT model where the deep convection part is predominant.

CONCLUSIONS

- **The NWP models (ARPEGE and AROME) tend to underestimate the vertical development with a lack of sensitivity to transition characteristics.**
- **ARPEGE-CLIMAT: the deep convection scheme is too active; by introducing a minimum value for the top of the deep cloud, the sensitivity to the transition characteristics and the vertical development of the cloud are improved.**
- **The simulated precipitation rates are generally overestimated, to a less extent with the ARPEGE-CLIMAT model using the NWP deep convection scheme.**
- **Comparing the two previous results, it seems that a correct vertical extension is linked with an improved precipitation rate. This overestimation of precipitation may probably be explained by the fact that the auto-conversion threshold is reached, because the LWP is too high whereas the simulated cloud is too thin.**
- **For the future: more sensitivity tests to understand the weak response of the NWP models to the transition and 3D tests of ARPEGE-CLIMAT with the NWP deep convection scheme.**