Recent developments in AROME dynamics

Pierre Bénard, F. Rabier, F. Bouyssel, Y. Seity, L. Auger, and many others (CNRM/GMAP)

HIRLAM-ALADIN ASM 7-10 May 2012 - Marrakech

INSTABILITIES IN OPERATIONAL AROME-FRANCE

(in December 2011)

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INTRODUCTION

What happened ?

- 5-7 Dec.: NH AROME-FRANCE operational forecasts became unstable.
- Automatic safety procedure : reduce Dt

→ no effect (as well as increase HDiff, Spc.relax)

- Decision to run Hydrostatic for 2 days;

INTRODUCTION

What happened ? (cont'd)

- 25-31 Dec. : AROME-FRANCE unstable again
- decision to run Hydrostatic until things become clearer (and fixed)
- Situation not very comfortable…

INTRODUCTION

What happened ? (cont'd)

- 25-31 Dec. : AROME-FRANCE unstable again
- decision to run Hydrostatic until things become clearer (and fixed)
- Météo-France's Président-Directeur Général, in New Year Ceremony talk:

"…We are very proud that MF has TWO operational HYDROSTATIC systems, but … "

- return to NH mode on 16 Feb 2012.

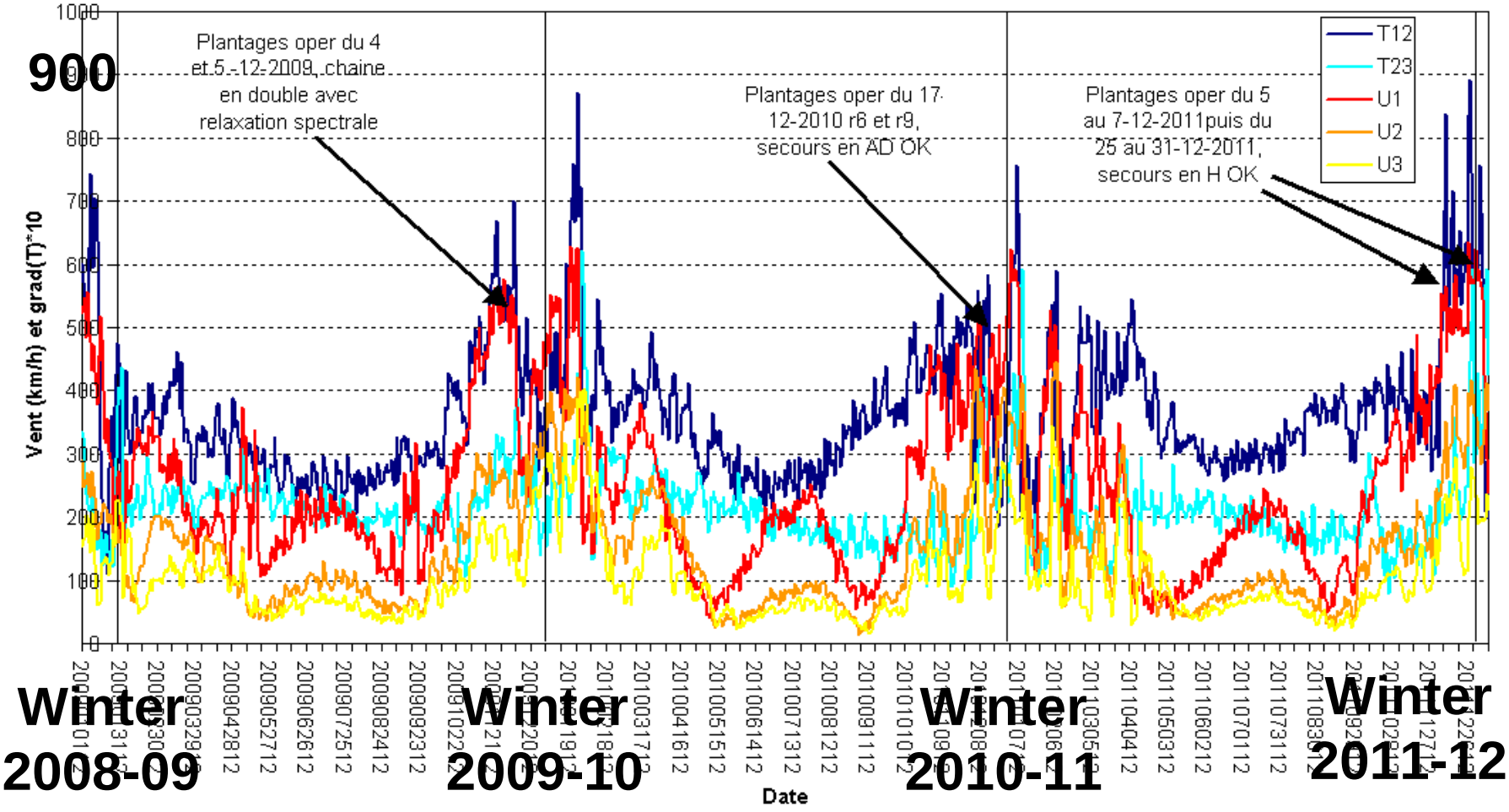
INTRODUCTION

What happened ? (cont'd)

- Coupling model's (ARPEGE) profiles near top were immediately identifed as potentially problematic (fig.)
- Wind velocity around 190 m/s in jets at stratopause
- Wind jump 100 m/s between AROME's levels 1 and 2.
- Temp. jump 90 K between AROME's levels 1 and 2.
- ... However IFS had similar values/profiles as ARPEGE
- so what ? : stupid profiles, bad AROME model, or... ?

INTRODUCTION

Max wind1 and 10x(T2-T1) (period 2008-12)



INTRODUCTION

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- However IFS had similar profiles/values as ARPEGE
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SITUATION

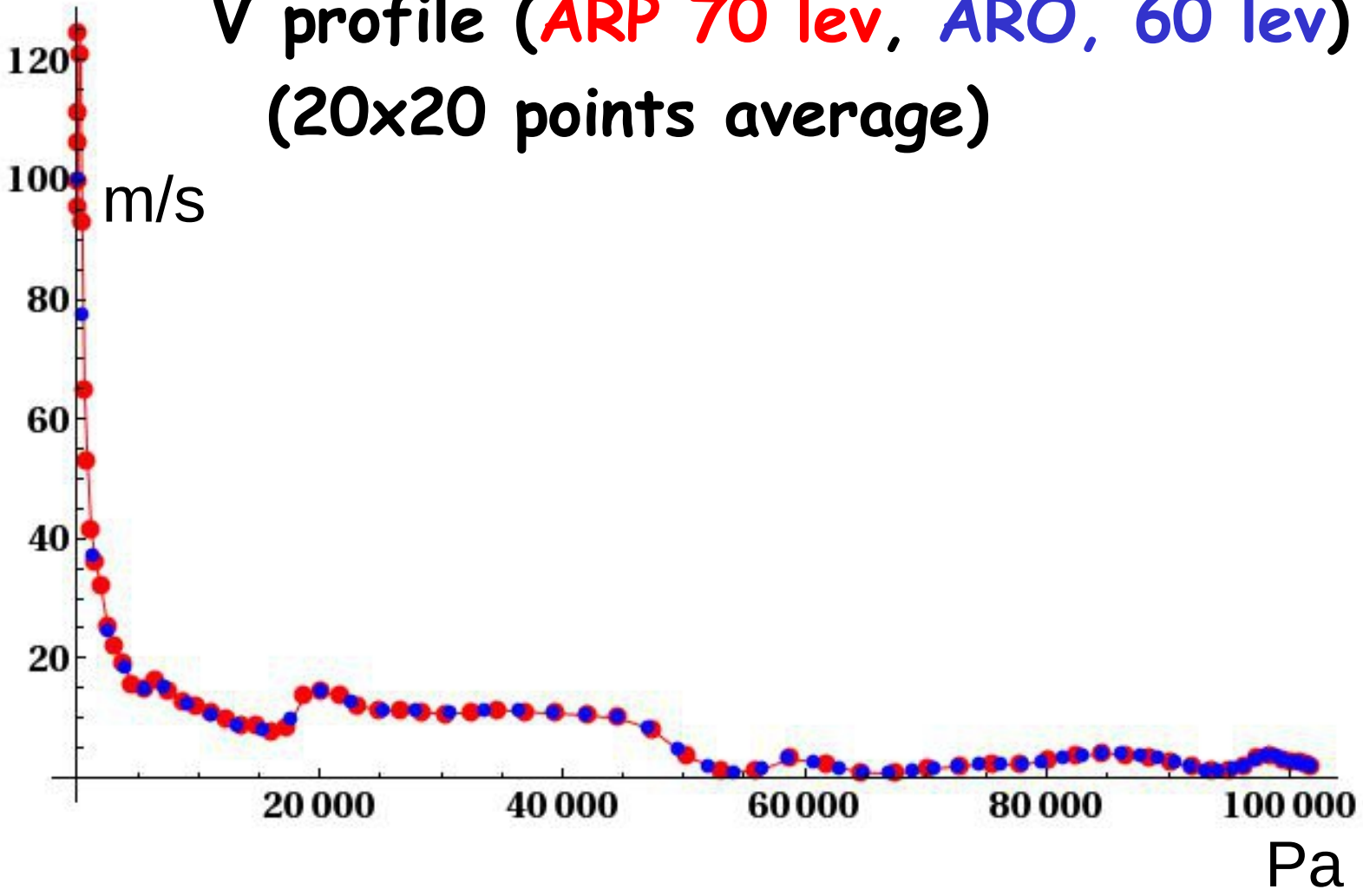
The situation

- Very fast jet at stratopause (50 km <=> 1 hPa) with limited georaphic extension for huge V's
- Quite good vertical resolution there in ARPEGE
- Poor vertical resolution in AROME (15 km)

- Profiles look pretty bad sampled

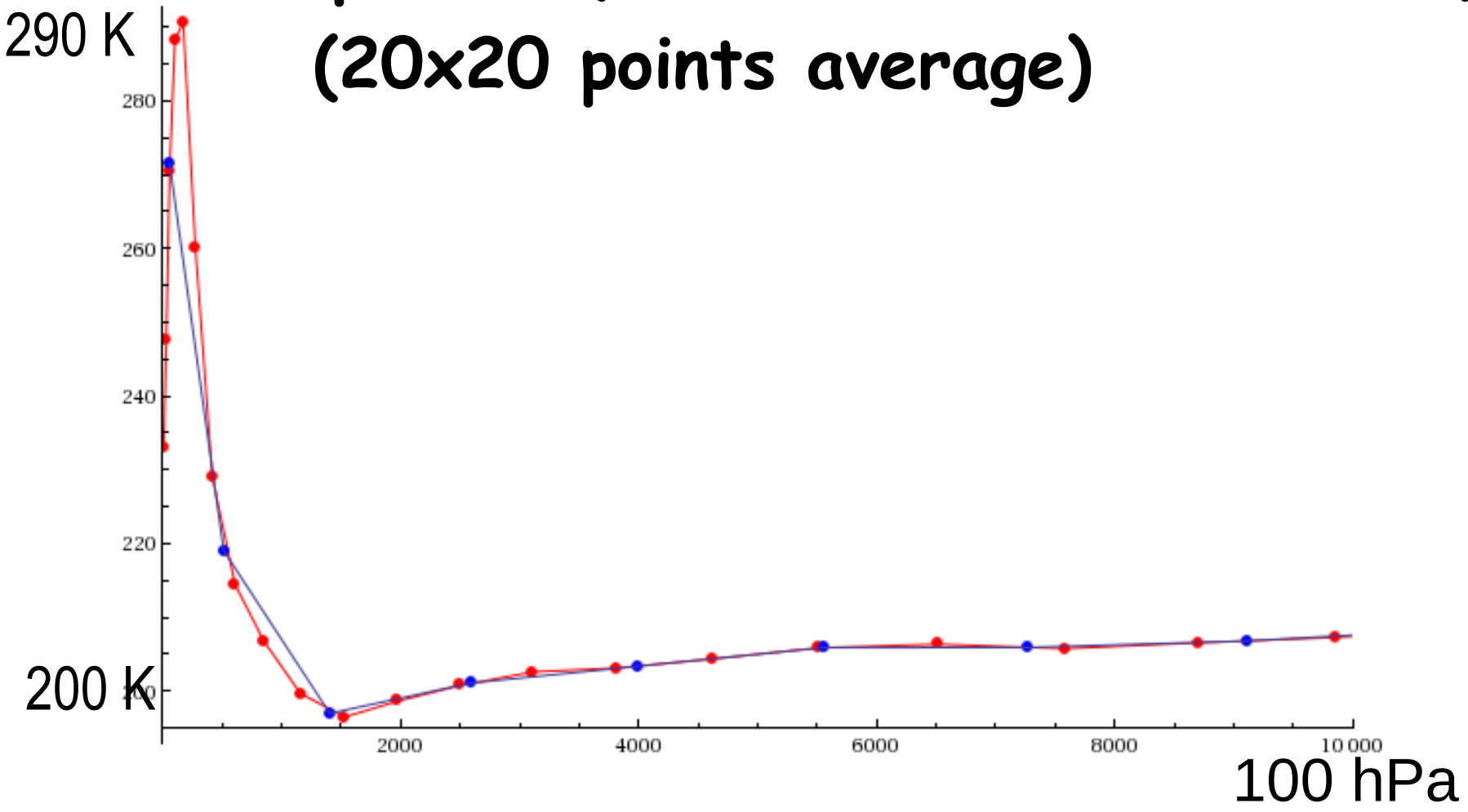
SITUATION

V profile (ARP 70 lev, ARO, 60 lev)
(20x20 points average)



SITUATION

T profile (ARP 70 lev, ARO, 60 lev)
(20x20 points average)



SITUATION

Two decisions :

- Explore "fixers" in operational-like framework
- Try to reproduce and study of the problem in academic mode

SITUATION

Explore "fixers":

- Usual damping processes confirmed no effect

  (~ consistent with "guilty profiles")
- Arbitrarily limiting V to 120 m/s was the most effective (all cases OK)
- Arbitrarily limiting (T_2 - T_1) less effective.

ACADEMIC STUDIES

ADS:

- By the way, there is an academic version of AROME (3D or 2D Vert. Plane).
- Thanks to gmkpack you can run on your PC/HPC.
- Just needs to prepare initial/coupling files

(…it's very easy, for more information come and see me)

ACADEMIC STUDIES

hypotheses

- Absolute values of V ?
- Absolute values of jumps of V, T at top ?
- Poor sampling ?

questions

- More levels with same profiles would be simply OK ?
- Are coupling profiles absurds (i.e. may it happen ?)
- Should we act on the coupling model ?
- Other

ACADEMIC STUDIES

Are coupling profiles realistics ?

- No observations there : sat. soundings provide only T (not V), and only in clear sky areas…
- In the doubt we will assume that the coupling profiles and values are realistics.
- Hence we should not intent to modify the dynamics of the coupling model at high levels in order to avoid such profiles to occur

ACADEMIC STUDIES

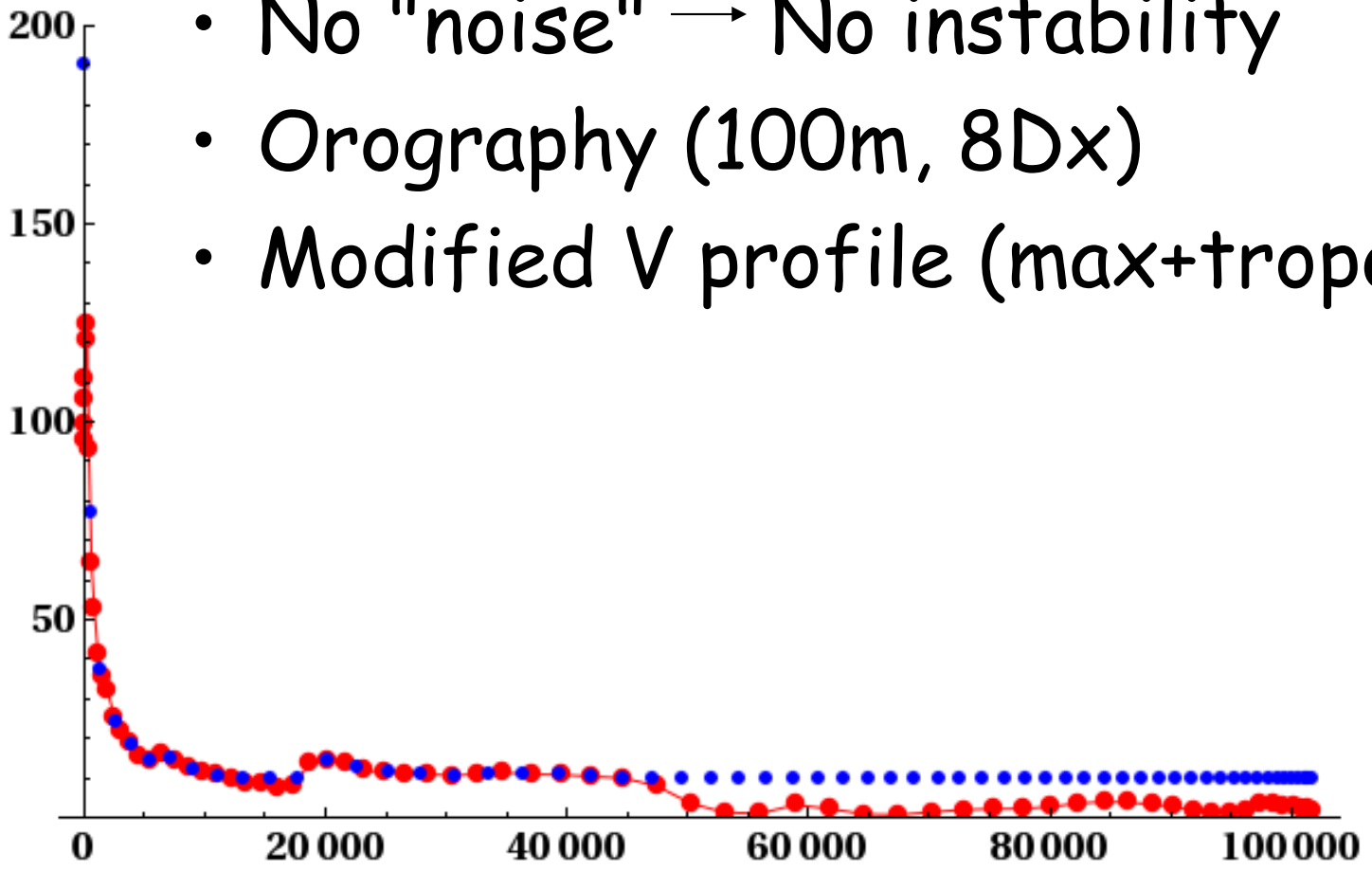
Reproduce instability (principle):

- Use 2D vertical plane model
- Introduce the severe V,T profiles
- Try to trigger instability
- Try to convince that instability is similar to operational one

ACADEMIC STUDIES

Reproduce instability:

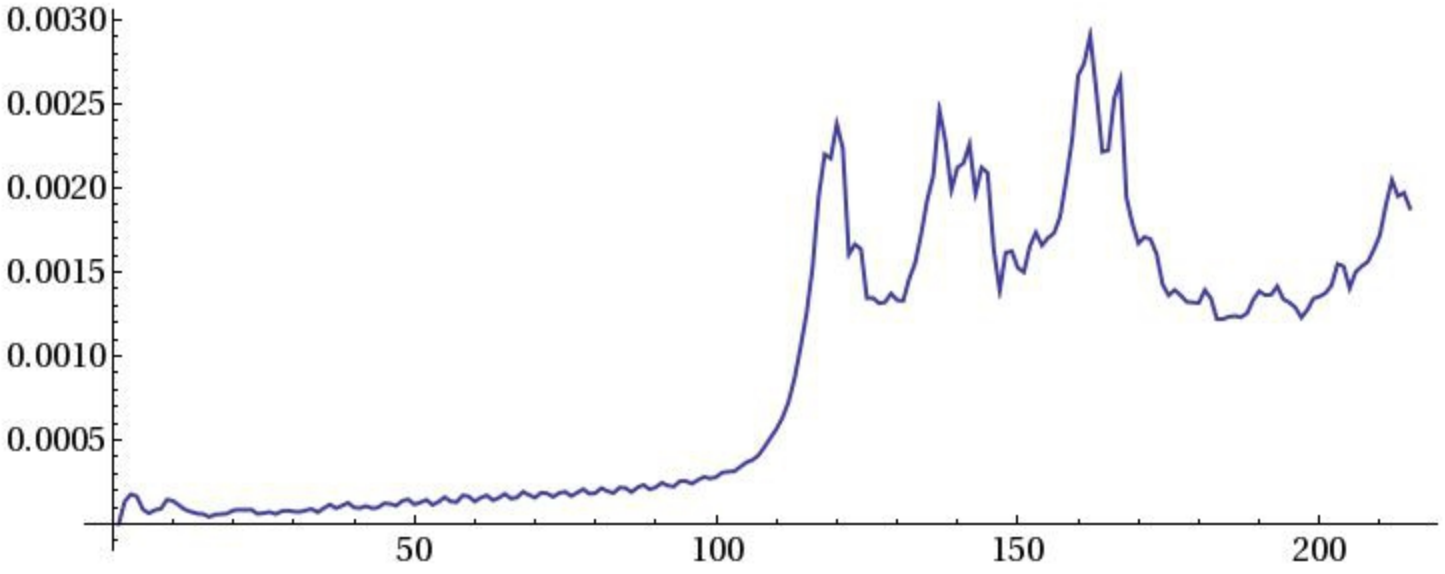
- No "noise" → No instability
- Orography (100m, 8Dx)
- Modified V profile (max+tropo)



ACADEMIC STUDIES

Reproduce instability:

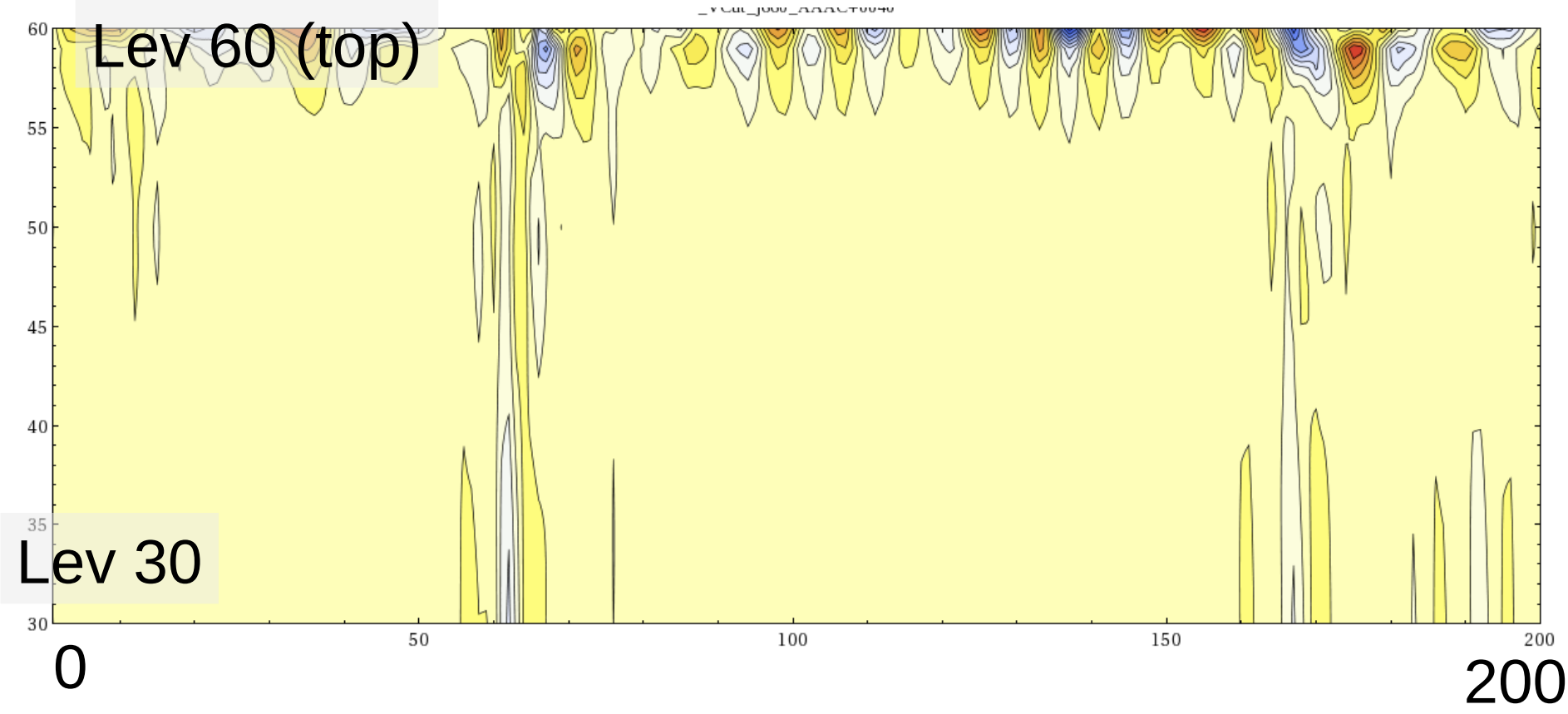
- Needs 600 points (slow instability)



ACADEMIC STUDIES

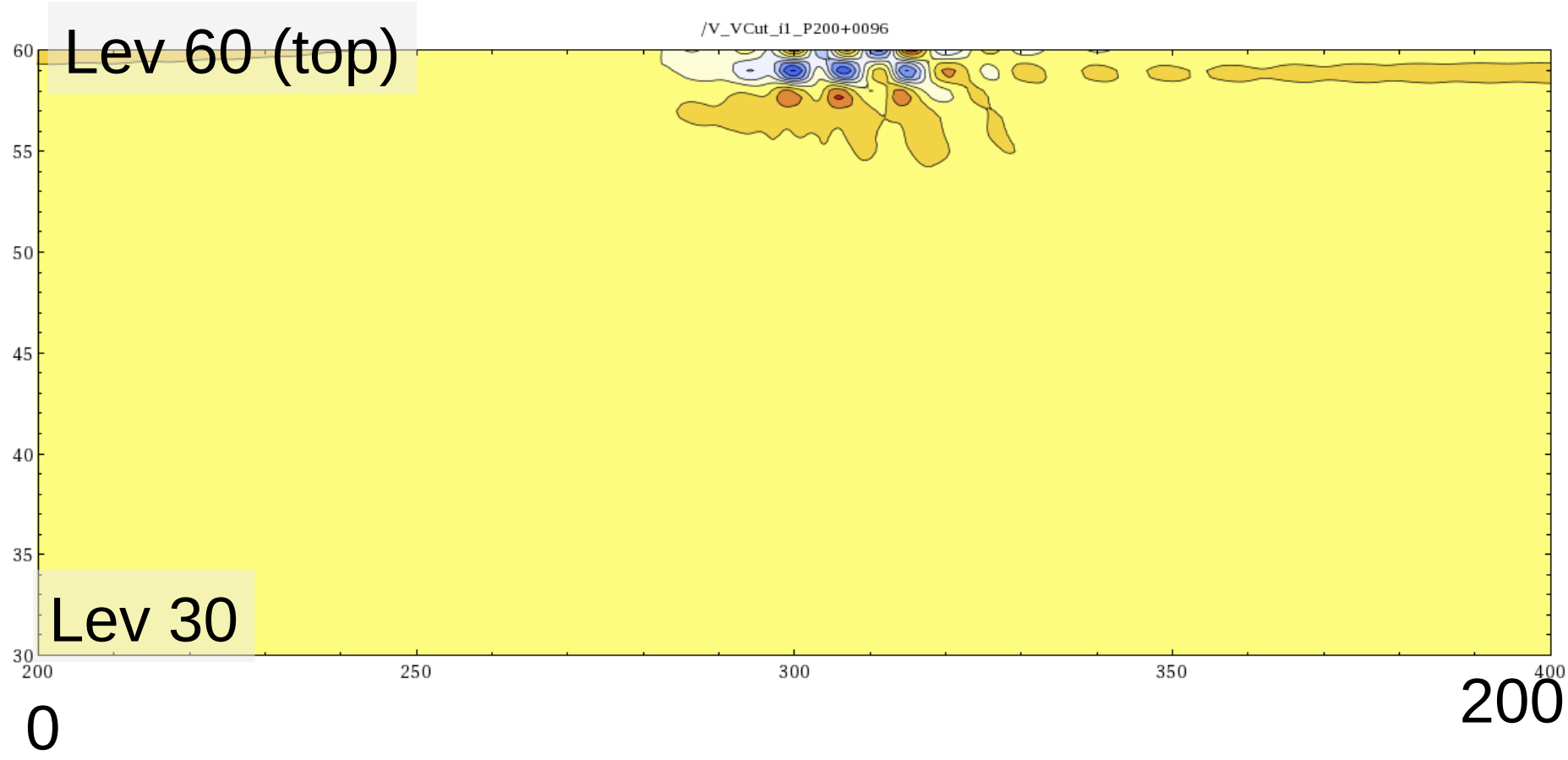
AROME oper (V Cross section):

- 2012/12/27/00UTC+0040



ACADEMIC STUDIES

AROME acad (vert plane):



ACADEMIC STUDIES

Reproduced instability can be interpreted in simple framework

- Adiab, frictionless, unrotating,
- Better identification of "main cause"
- Not a "complex" interaction, etc…

ACADEMIC STUDIES

AROME acad behaves similarly to oper

- HD, SC : no effect
- Decrease Dt : quite small effect
- Decrease V2-V1, 100 to 80 m/s → stable
- Incr. #lev to 81 (same profiles) → stable
- Iterative implicit (P/C) scheme → stable

ACADEMIC STUDIES

Several level configurations then tested in the real NWP AROME:

- Decrease the height of first lev: 0.6 to 5 hPa
- Use the L70 of ARPEGE (better resol at 1 hPa)
- Use a L81 (first lev at 2 hPa)

Solve all problems except 26/12 in last case (solved by e.g. larger Spectral Coupling)

Lack of vertical resolution in an area with large variations of fields (sampling problem).

ACADEMIC STUDIES

Another problem detected:

- Gravity waves amplitude is growing with height
- Should break and dissipate energy in high stratosphere (at all scales, even resolved/large)
- It seems this is not the case in the model
- Dynamics will certainly not do that
- Physics (turb) is not acting there

--> Big GW amplitude adding to already big jet velocities (becomes too much)

Conclusion

- Instability well understood, not interesting in itself since it is the consequence of a deeper sampling problem.
- Use of current AROME's L60 should not be recommended (at least without proper fixers)
- We should think to a mechanism for breaking GW in high-stratosphere
- Decision at MF for next winter : use "V fixer"

  $V_{near\ top} = Min[V, 120m/s]$ (for "time-table" reasons)
- then for 2013-14 : clever L90~L100~L105

Thank you for your attention