# International collaboration on Limited Area Modelling (LAM) over the past decades

# The example of the ALADIN R&D activities within an evolving pan-European landscape for Numerical Weather Prediction (NWP)

*J.-F. Geleyn*

***Hungarian Meteorological Society***
***Budapest, 28/3/2011***

# Scope of the talk

- This presentation will try and analyse how science-policy issues and international co-operation structures do influence the way along which national scientific teams:
  - (i) agree to collaborate at the international level;
  - (ii) structure their methods of work for profiting from the critical mass created by the said collaborations.
- The examples will mainly come from the ALADIN, RC LACE and HARMONIE frameworks.
- I better know those … and by the way, within their scope, this is my 12th visit to Hungary (92, 94, 96, 97, 02, 03, 06, 07, 08, 10 [2x], 11), for 37 days.

# Raised issues

- We shall try to address the following issues:
  – what is the minimum amount of scientific agreement for launching a common effort?
  – why is the ‘collaboration-competition’ model so stable in the long-term?
  – what drives the true NWP innovation for high resolution modelling?
  – why are the ‘science logistic’ issues so important here?
  – where may we be currently heading to, ‘politically’ and ‘scientifically’, at the pan-European level?

# About scientific collaboration

# The <u>history</u> of ALADIN (1/4)

- 16-10-90: Launch of the idea by A. Lebeau
- 13-11-90: Presentation of the concept and of the financing to 6 C-E European visitors in Toulouse
- March 91: Exploratory work in Paris with Cz, Hu & Ro
- May 91: The connection with LACE starts (Vienna)
- September 91: The actual work starts in Toulouse; confirmed Partners: At, Bg, Cz, Fr, Hu, Pl, Ro
- October 91: S. Malardel invents the ALADIN acronym
- November 92: First complete run of an ALADIN test
- 31-5-94: First quasi-operational run in Toulouse with products dissemination to 8 partners (Ma, Si, Sk joined in between)
- December 94: Signing of the 'RC LACE' agreement and of a partnership with M-F for ALADIN
- 1996: Ma, Si & Ro start the first 'deported' applications
- July 96: First ALADIN-LACE oper runs (in Toulouse)

# The history of ALADIN (2/4)

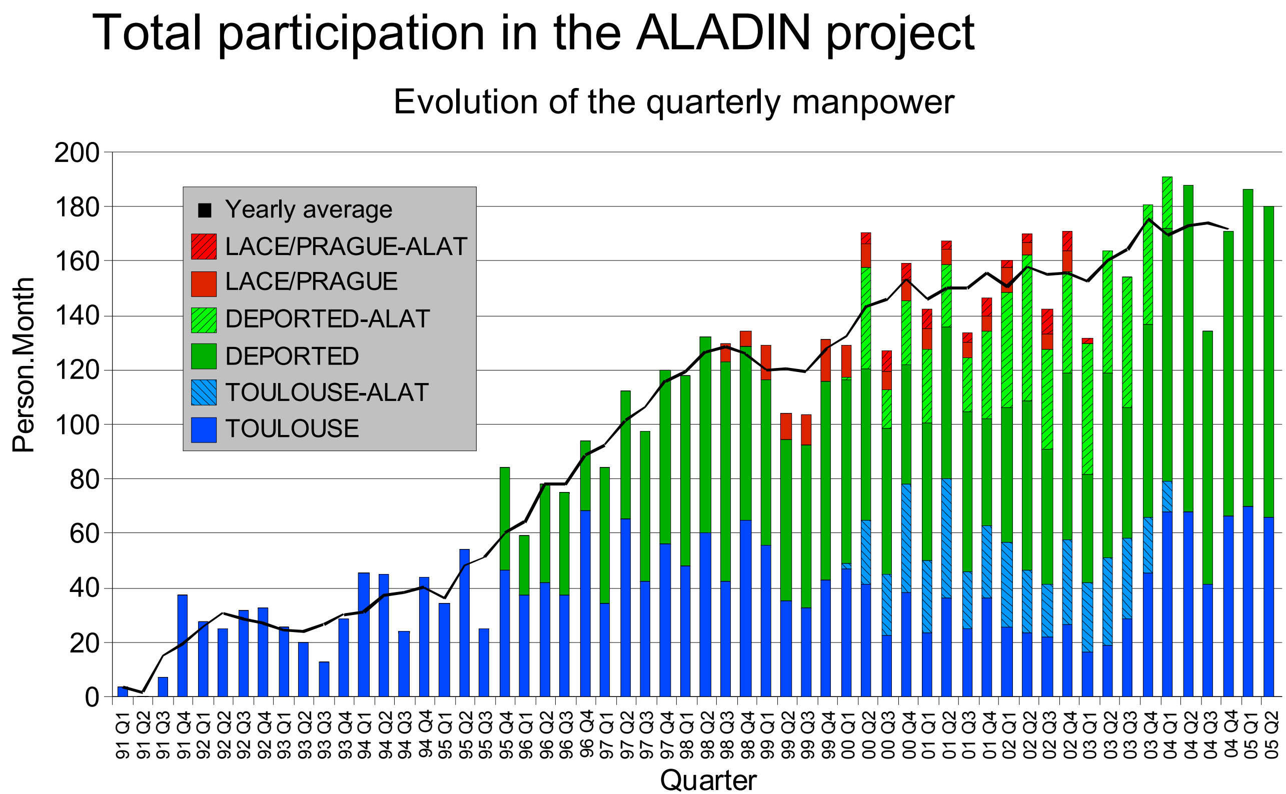
- 26-11-96: Signing of the first ALADIN MoU in Paris by At, Be, Bg, Cz, Fr, Hr, Hu, Ma, Pl, Ro, Si, Sk
- April 97: Joining in of Pt / April 01: Joining in of Tn
- July 98: The ALADIN-LACE application goes to Prague
- 31-5-01: 10$^{th}$ anniversary ceremonies in Paris, signing of the 2$^{nd}$ ALADIN MoU, the (not yet named) 'AROME' problematics starts to touch the project
- 13-12-02 / 14-4-03 / 12-2-04 / 19-1-05: Cascade of meetings to 'stabilise' the relationships of AROME and ALADIN. In parallel LACE goes for a decentralised mode
- 29-09-03: First contact about a HIRLAM-ALADIN meso-scale partnership
- January 05: First joint workshop with HIRLAM (Tartu)
- 21-10-05: Signing of the third ALADIN MoU (Dz joins in). J.-F. Geleyn becomes the first ALADIN PM
- 6-12-05: Signing of the HIRLAM-ALADIN agreement

# The <u>history</u> of ALADIN (3/4)

- 15-19/5/06: First joint ASM + Workshop in Sofia
- 6/2/2008: Approval of the ALADIN Strategy
- 6/11/2008: Turkey becomes officially the 16th ALADIN Full Member (membership already ongoing for one year in practice)
- 27/05/2009: Final approval of the first version of the ALADIN 4-year plan
- 15/12/2010: Signing of the 4th ALADIN-MoU. Approval of the first joint workplan between HIRLAM and ALADIN. Piet Termonia becomes the new ALADIN PM.

# The <u>history</u> of ALADIN (4/4)

- A matter of step-wise but controlled growth

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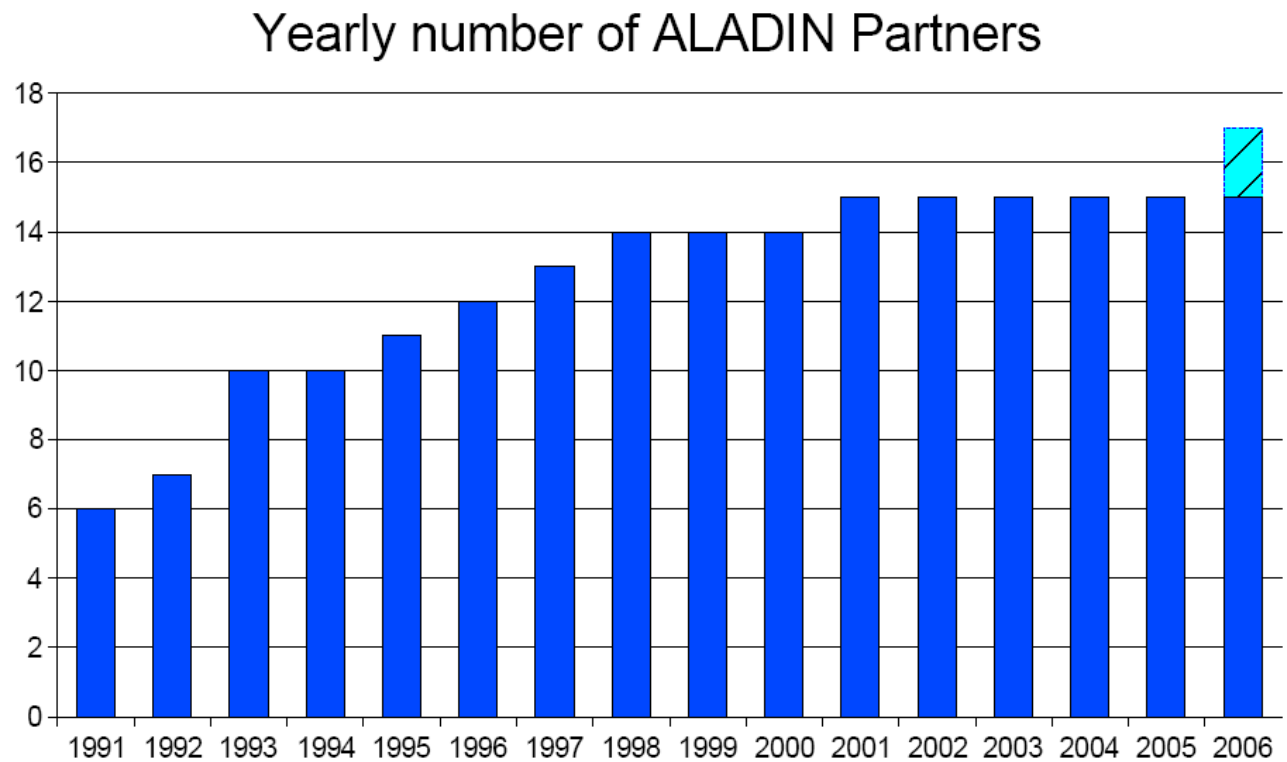


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# ALADIN transversal workshops

- Bratislava (1996) => All purpose
- Ljubljana (1996) => ‘W-S’ versions
- Budapest (1997) => Applications
- Toulouse (1998) => Scientific and Technical
- Prague (1998) => Applications and Science
- Bucharest (1999) => All purpose
- Ljubljana (1999) => Applications
- Krakow (2000) => Science and Application
- Bruxelles (2000) => Application
- Toulouse (2001) => Science
- Lisbonne (2001) => Applications
- Medulin (2002) => All purpose
- Budapest (2002) => Maintenance & Training
- Prague (2003) / Innsbruck (2004) / Bratislava (2006) => All purpose
- Sofia (2006) / Oslo (2007) / Bruxelles (2008) / Utrecht (2009) / Krakow (2010) => all purpose and jointly organised with HIRLAM ‘All Staff Meetings’

# ALATNET (ALADIN Training NETwork 2000-2004) main events

Seminar on LAM modelling, Radostovice, Cz, 16-27/4/00

Seminar on data assimilation, Gourdon, Fr, 11-22/6/01

Mid-term Review, Brussels, Be, 22-23/4/02

Seminar on numerical methods, Kranjska Gora, Si, 27-31/02

Concluding Workshop, Kiralyret, HU, 15-17/10/03

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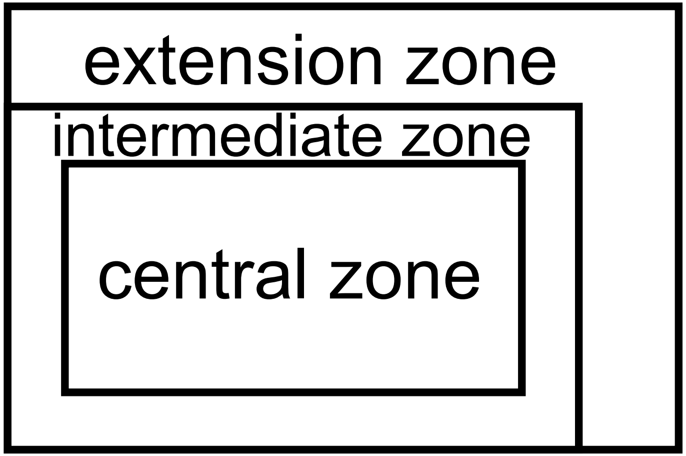
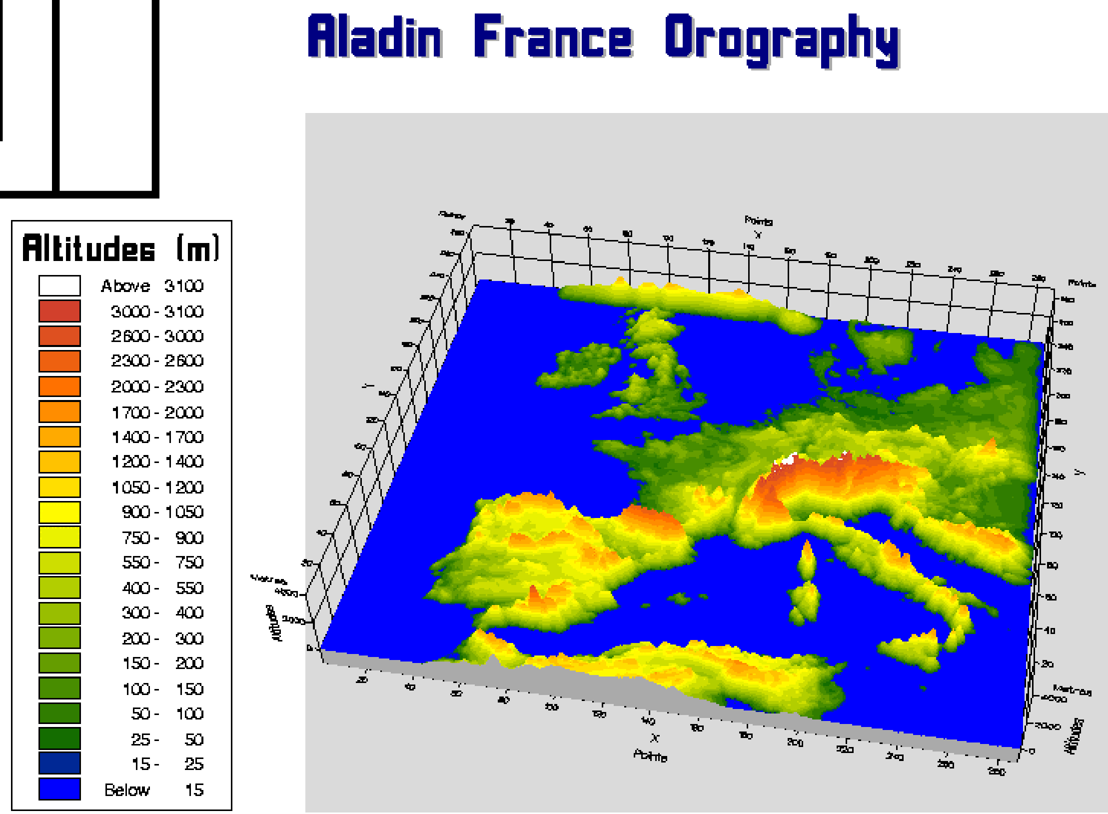
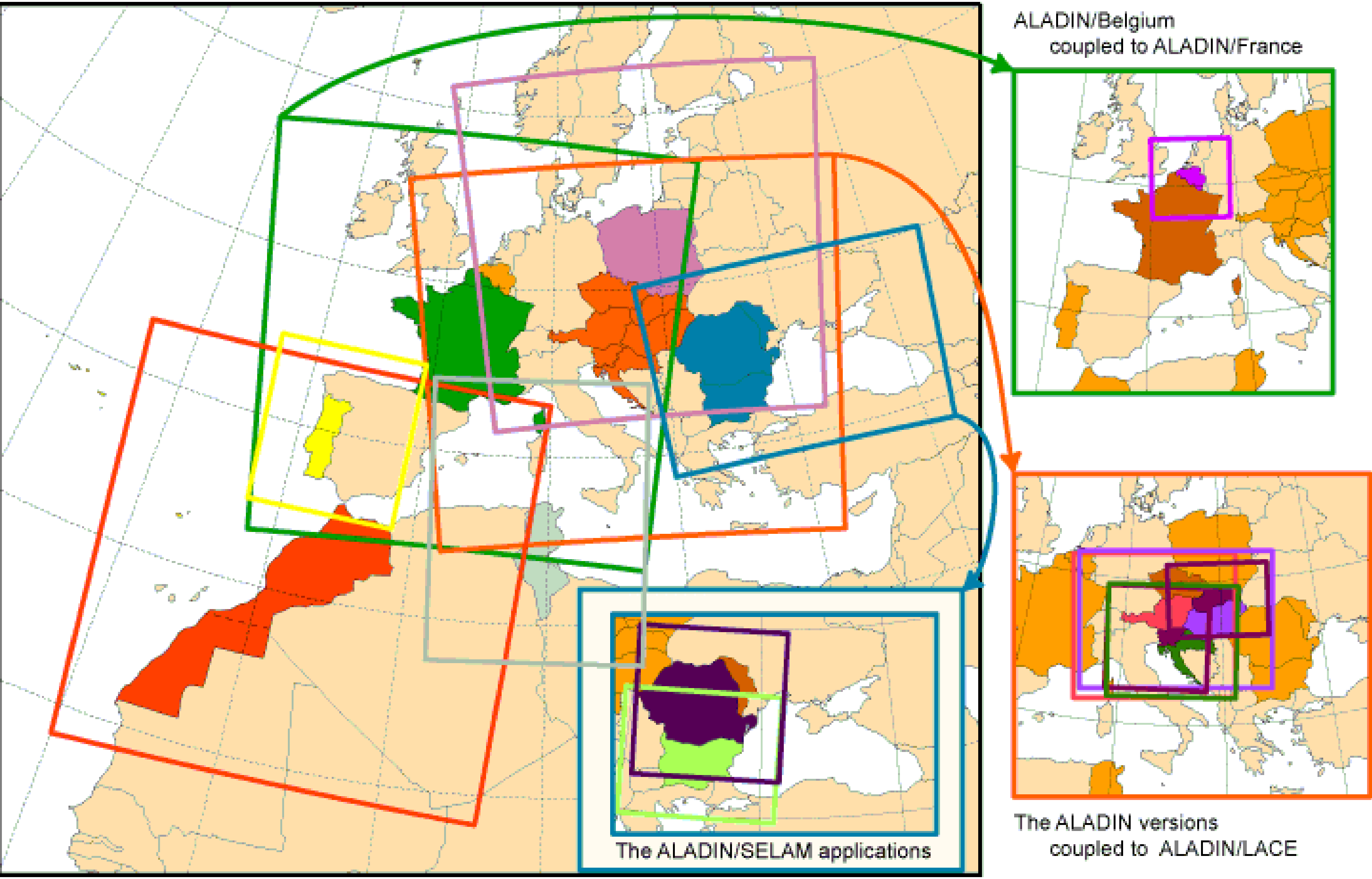
  - **In**
  - **Euromed**

# Machenhauer-Haugen biperiodicisation (HIRLAM's main link)



# ALADIN : 14 operational domains (situation at the end of 2002)



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- Full compatibility with IFS => **I**ntegration-**F**lexibility-**M**odularity-**G**enerality rules
- System specifically organised to be able to run on remote sites from the coupling model, with unique code- and file-structure
- No full distinction (outside M-F) in terms of teams' organisation between:
  - (i) upstream research;
  - (ii) applied R&D;
  - (iii) operational meteorological constraints;

    [Some 'operational support' missing here]
  - (iv) operational technical constraints.

# The <u>central issue</u> about ALADIN

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- The above-described ‘model’ of ALADIN development is:
  - Neither fully plug-compatible with the complex internal structure of its ‘anchor’ NMS (Météo-France);
  - Nor in symbiosis with the more direct management practices of most of its other Partners.

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  - Neither fully plug-compatible with the complex internal structure of its ‘anchor’ NMS (Météo-France);
  - Nor in symbiosis with the more direct management practices of most of its other Partners.
- **Here is both the main strength of ALADIN (when things go well) and its main weakness (when they evolve in a more chaotic way) => dilemma**

# Principles of the ALADIN collaboration
## *The concept*

How to build a mutually benefiting cooperation between 'big' and 'small' NMSs ?

=

One completely integrated international team (***1/3 of the work 'abroad' at the beginning, diminishing share now***)

**&**

Freedom of detailed operational choices adapted to anyone's needs (***thanks to numerical efficiency***)

⇓

**The central idea => no 'hot line' on any 'black-box'**

# Principles of the ALADIN collaboration
## *The system*

ALADIN systematically phased with respect to IFS/ARPEGE

Heavy maintenance constraint ⇒ Cycles about every 9 months with rather strict rules

⇓

Allows a rapid familiarisation of 'newcomers' …

but …

Requires a strong investment of 'key-people'

# Principles of the ALADIN collaboration
## *The applications*

- By nature ‘mixed-type’ between research and (pre)-operational
- This allows access to an advanced tool even for small teams but it has drawbacks at both ends of the spectrum
- Nevertheless quite good results were obtained in terms of:

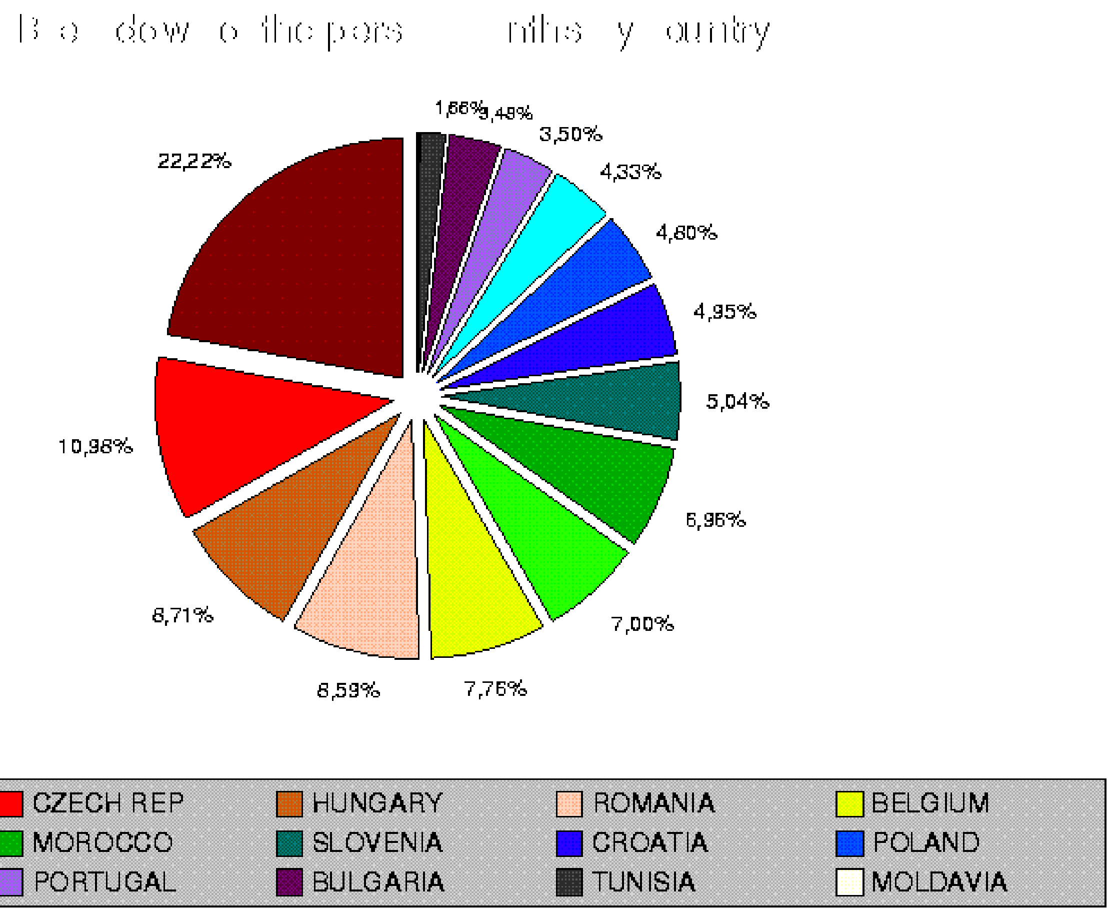
  - training (applied as well as ‘through research’ => 18 PhDs in 3 Research and Training Networks)

  - networking (evergrowing number of interdependent applications)

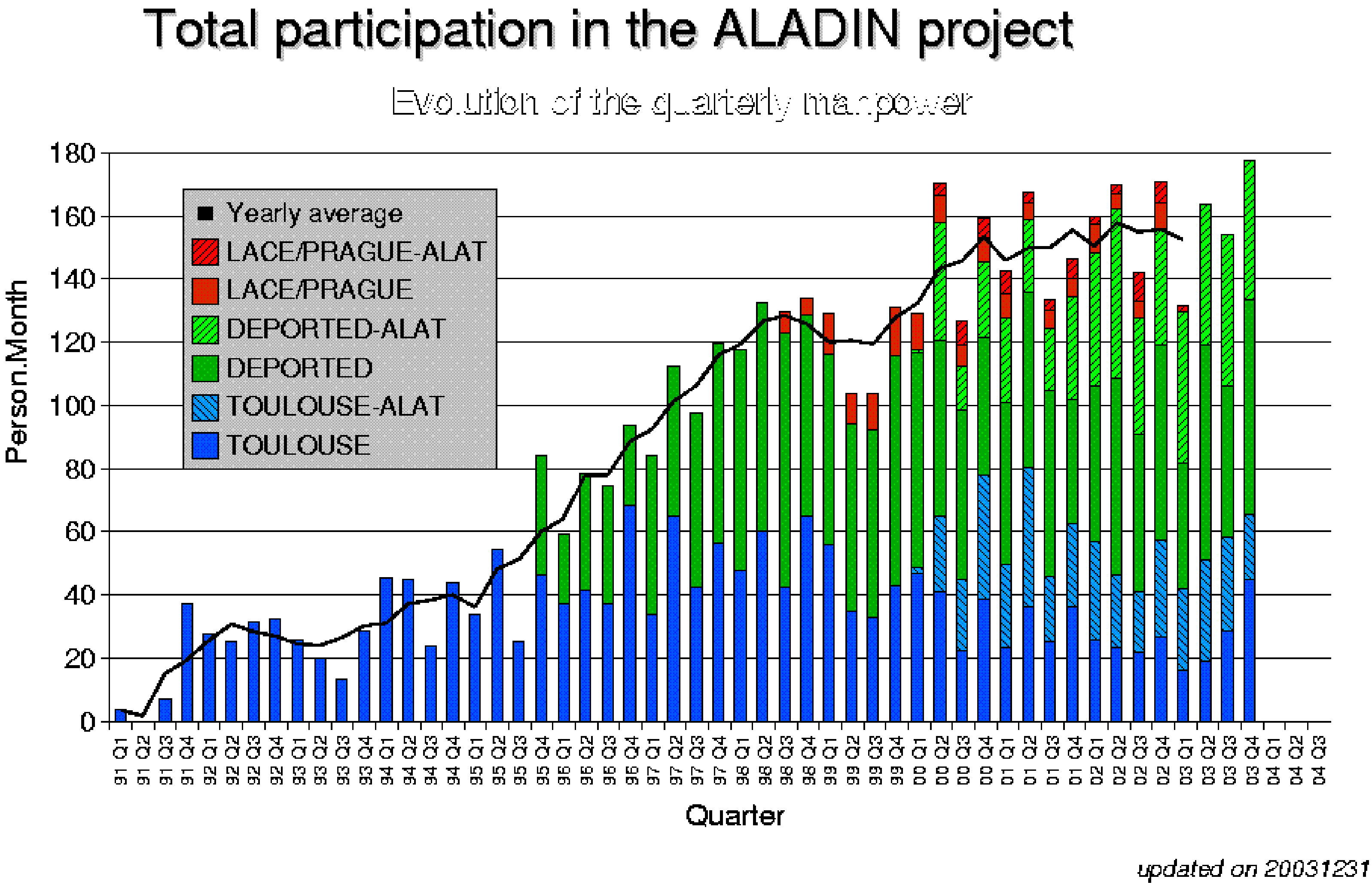
  - innovation (NH-version of dynamics and 3D/Var)

# ALADIN statistics

## Total participation in the ALADIN project



# ALADIN statistics



# Caracterisation of family types in Europe (*after 'L'invention de l'Europe' of E. Todd*)

| | Shared inheritage: diversity of successions | First born right: protection of possession |
|---|---|---|
| Separate parents – adult children dwelling | **Nuclear-egalitarian family** **(Paris area, Italian Piemont, Castilla, …)** | **Fully nuclear family** **(Around the North Sea)** |
| Common parents – adult children dwelling | **Communautary family** **(Eastern Europe, Finland, Toscana, …)** | **Root Family** **(Germanic world)** |

# Cooperation ‘topology’ of SRNWP entities

| | Options oriented maintenance | Basic version oriented maintenance |
|---|---|---|
| Diversity of development threads | **Arp./ALADIN** | **HIRLAM** |
| Unicity of development threads | **ECMWF-IFS** | **COSMO-LM** |

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**MO-UM**

# A bit of ‘philosophy’

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- From the previous viewgraph we have a choice between two paradigms:
  - Maintenance concepts 'frame' the scope of developments;
  - The choice of 'valid' developments dictates maintenance choices.
- On top of that there is the problem of how to articulate upstream research and NWP R&D => next viewgraph.

# A bit of ‘philosophy’ (bis)

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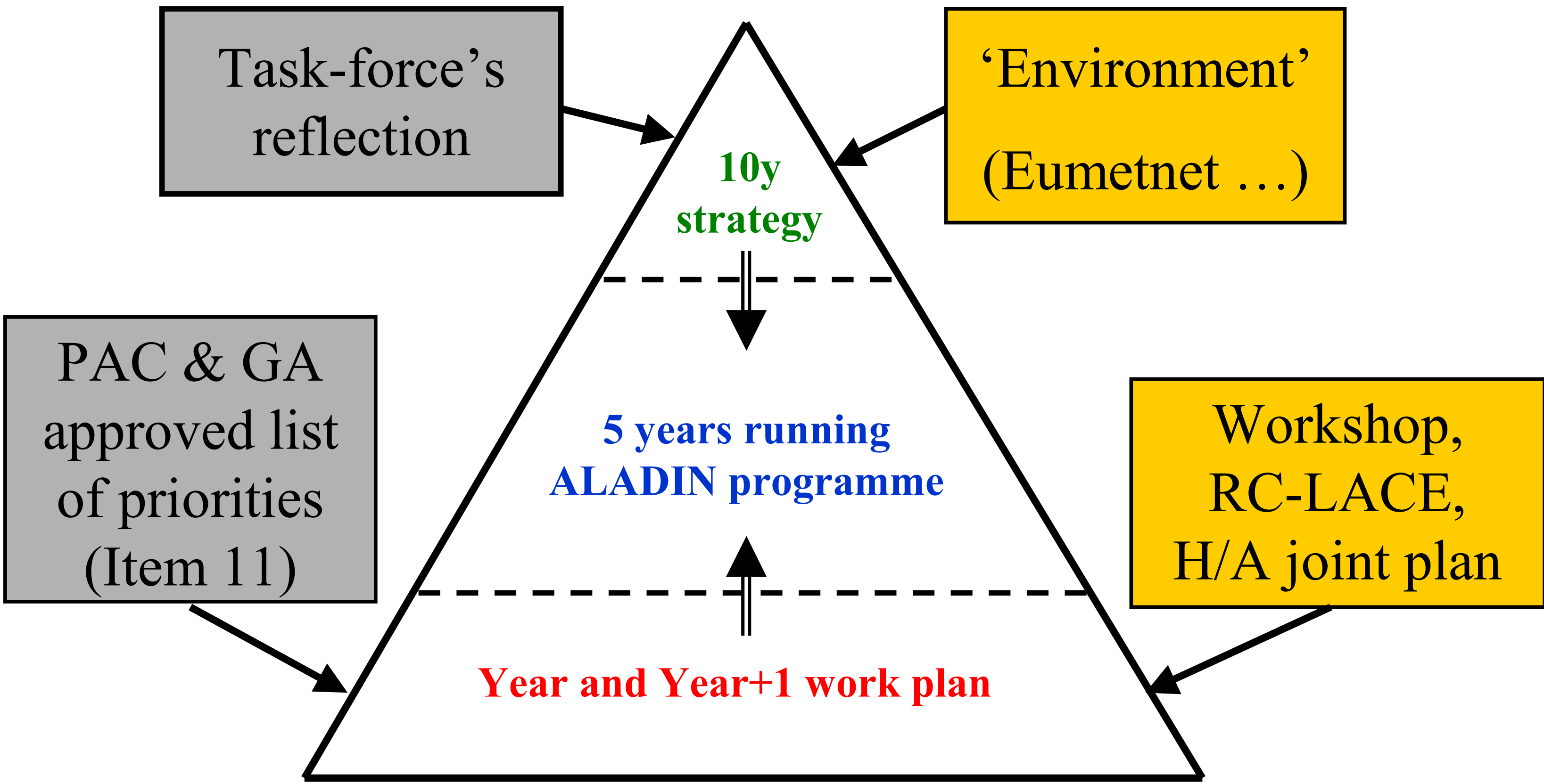
- NWP R&D is about converting simple ideas (e.g. biper-spectral-LAM or DFI) into an enormously complex operational machinery!

- No wonder it's not easy to handle meaningfully the links between the two!!!

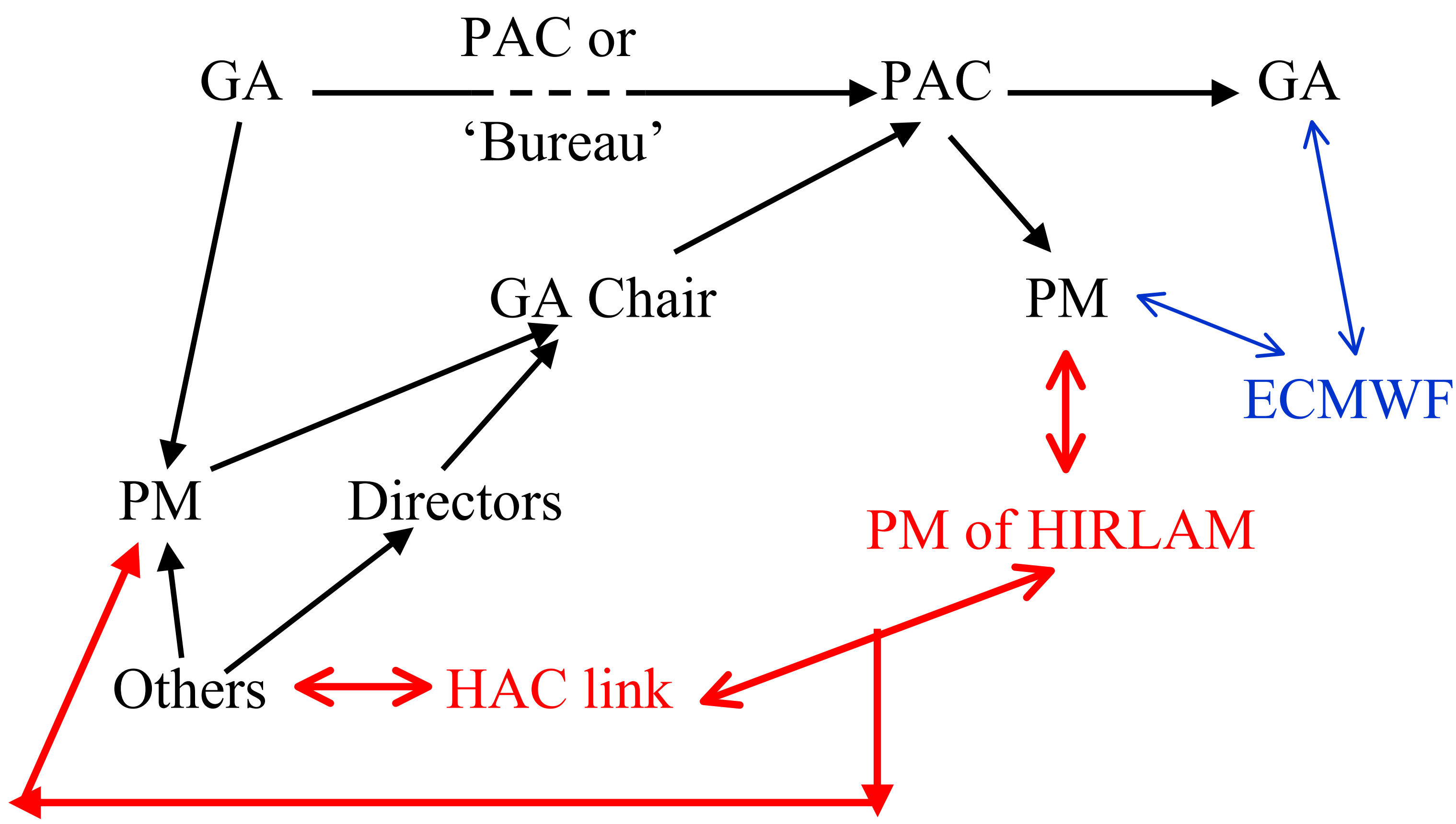
And where does this lead to ?

# ALADIN Strategy and Planning

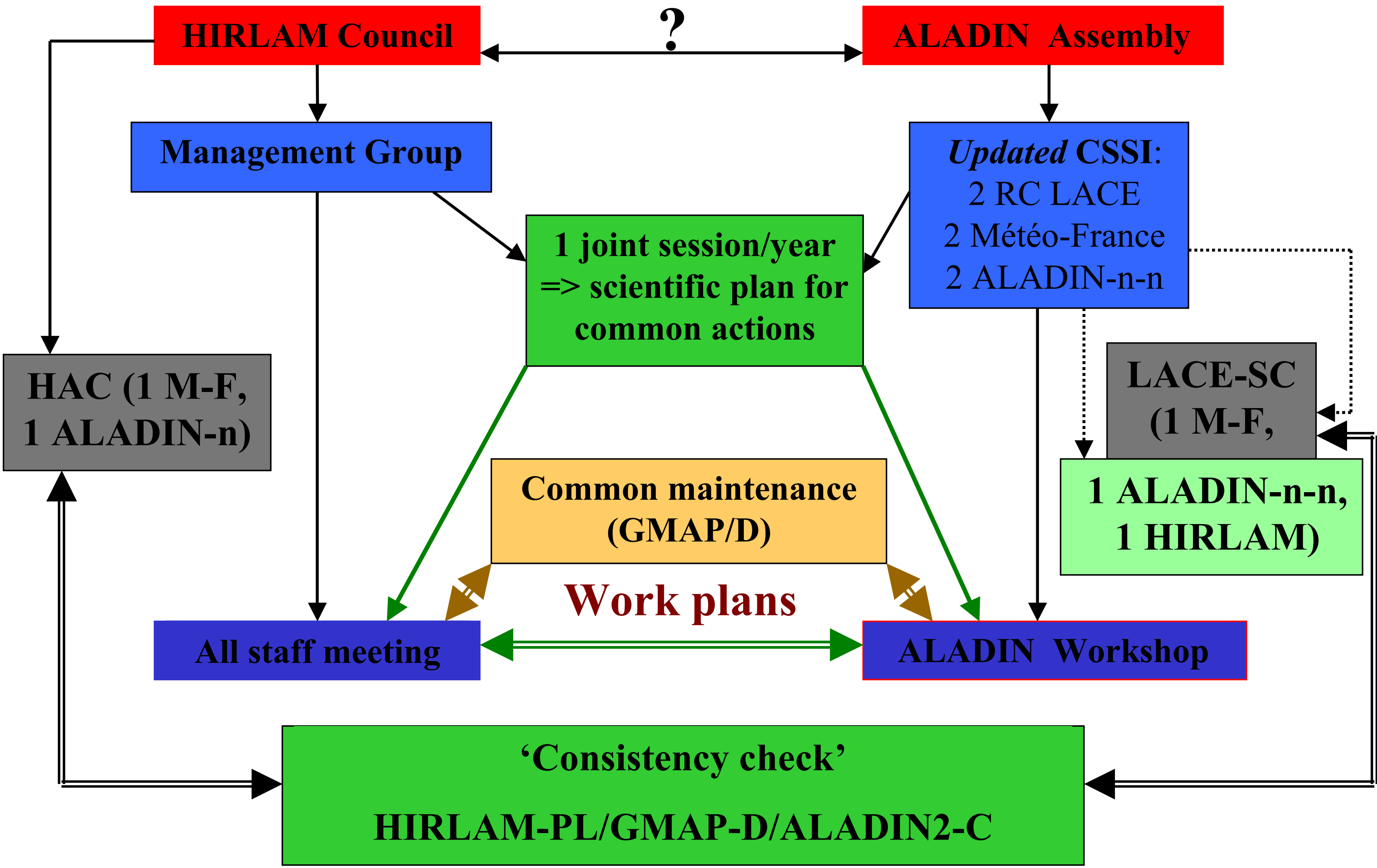



Programme aggregation step

# Working schedules and practices around the year



# H-A working schedules and practices



EWGLAM => SRNWP => C-SRNWP => EUMETNET-forecasting

The strength of the ‘collaboration-competition’ concept

# History of the Consortia and their grouping

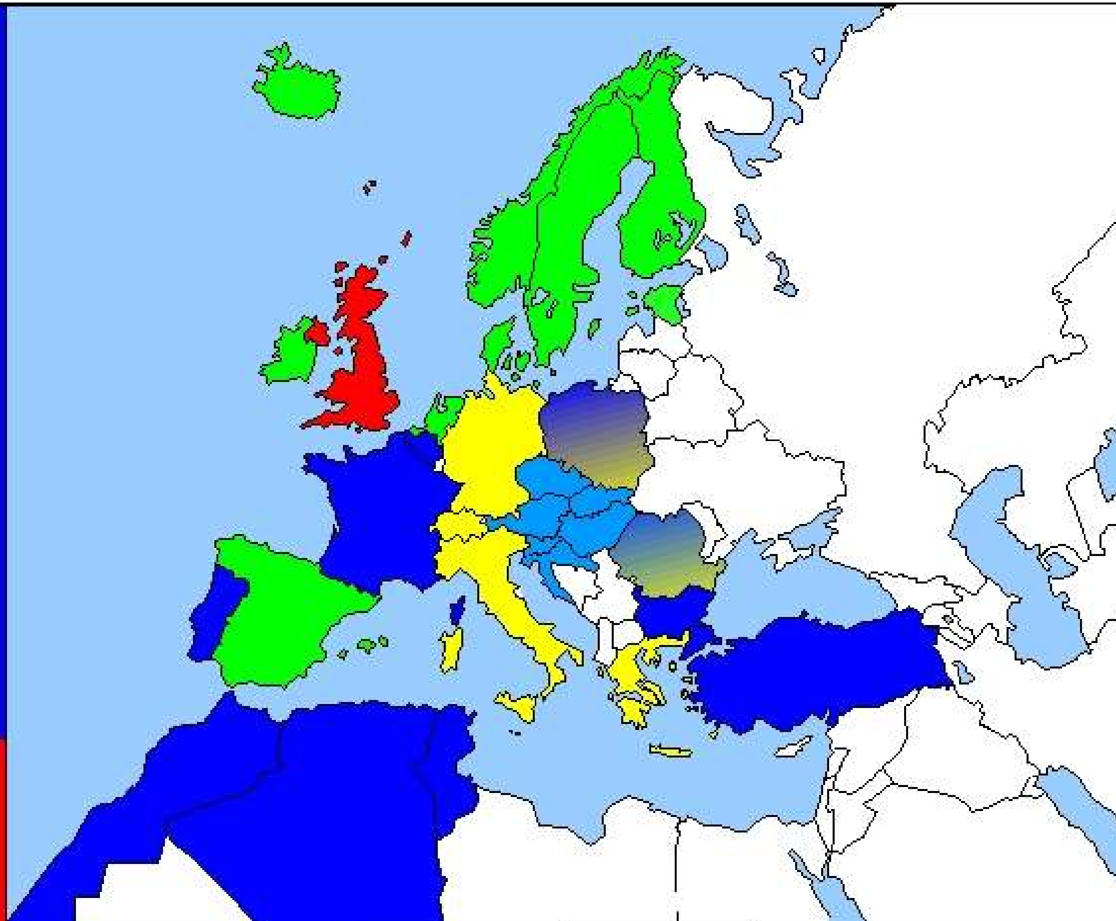
- 1979: First ECMWF operational forecast & first EWGLAM meeting (for LAM NWP)
- 1985: Birth of HIRLAM
- 1988: Birth of COSMO (German-Swiss only at that stage)
- 1991: Birth of ALADIN
- 1993-1994: Launching of SRNWP
- 1994: Official birth of RC LACE
- 1998: EUMETNET takes SRNWP under its umbrella
- 2005: Signing of the HARMONIE agreement

# SRNWP Consortia in Europe

**ALADIN**
Algeria
Belgium
Bulgaria
France
Morocco
Poland
Portugal
Tunisia
Turkey

Austria
Croatia
Czech Rep.
Hungary
Romania
Slovakia
Slovenia
LACE

**UKMO**
United
Kingdom



**HIRLAM**
Denmark
Estonia
Finland
Iceland
Ireland
Netherlands
Norway
Spain
Sweden

**COSMO**
Germany
Greece
Italy
Poland
Romania
Switzerland

*Updated on 13/05/08*

# SRNWP CONSORTIA (5) and MODELS (4)

| CONSORTIA | MODEL |
|---|---|
| ALADIN | ALADIN |
| COSMO | COSMO |
| HIRLAM | HIRLAM |
| LACE | ALADIN |
| MetOffice | Unified Model |

**Remark**: ALADIN (LACE) and HIRLAM are working on code collaboration around the IFS/ARPEGE/ALADIN/ALARO/AROME code

# EXPERT TEAMS

1. Diagnostics, validation and verification
2. Dynamics and lateral boundary coupling
3. Link with applications
4. Physical parameterisation
5. Predictability and EPS
6. Surface and soil processes
7. System aspects
8. Data assimilation and use of observations

# The ‘quintessence’ of the concept: Kiralyret 2003

ALATNET Seminar KIRÁLYRÉT, October 15-17, 2003



## INTRODUCTION

- The ALATNET EU project is going to be finished at the end of February 2004. There was an idea raised during the ALATNET mid-term Review (spring, 2002, Brussels) that an opportunity should be sought for the young researchers for meeting and presenting their work carried out in the framework of the project. This last ALATNET seminar will be held in Hungary (Királyrét, 60 km North from Budapest, www.kiralyret.hu) with the organisation of the Hungarian Meteorological Service.

# The ‘quintessence’ of the concept: Kiralyret 2003

- **PROGRAMME**

- Steluta Alexandru (Romania): Scientific strategy for the implementation of a 3d-var data assimilation scheme for a double-nested limited area model
- Gianpaolo Balsamo (Italy): Coupling a variational assimilation of gridpoint surface fields with a 4d variationalassimilation of upperair spectral fields
- Margarida Belo-Pereira (Portugal): Improving the assimilation of water in a NWP model
- Martin Gera (Slovakia): Improved representation of boundary layer
- Ilian Gospodinov (Bulgaria): Reformulation of the physics-dynamics interface for a non-hydrostatic high resolution model
- Raluca Radu (Romania): Extensive study of the coupling problem for a high resolution limited area model
- Andre Simon (Slovakia): Study of the relationship between turbulent fluxes in deeply stable PBL situations and cyclogenetic activity
- Christopher Smith (United Kingdom): Stability analysis and precision aspects of the boundary condition formulation in the non-hydrostatic dynamics and exploration of the alternatives for discrete formulation of the vertical acceleration equation both in Eulerian and Semi-Lagrangian time marching schemes
- Cornel Soci (Romania): Sensitivity studies using a limited-area model and its adjoint for the mesoscale range
- Klaus Stadlbacher (Austria): Systematic qualitative evaluation of high-resolution non-hydrostatic model
- Malgorzata Szczech (Poland): Use of IASI/AIRS data over land
- Jozef Vivoda (Slovakia): Application of the predictor-corrector method to non-hydrostatic dynamics

# The ‘quintessence’ of the concept: Kiralyret 2003

## TRAINING ACTIVITIES, WORKSHOPS and SEMINARS at the SRNWP CONSORTIA

ALADIN: Jean-Francois Geleyn
COSMO: Jean Quiby
HIRLAM: Per Unden
LACE: Radmila Brozkova
UKMO: Nigel Wood

# Research and Training Networks

| Network | RTN N°1 | RTN N°2 | RTN N°3 |
|---|---|---|---|
| Financing | Fr (Min. of Research) | Fr (Min. of Research) | EU (TMR Programme) |
| Centres | Toulouse | Toulouse | T/B/P/B/L |
| Target | 4 PhD | 5 PhD | 9PhD/3PDr |
| Application | 02/92 | 11/95 | 05/99 |
| Acceptance | 08/92 | 02/96 | 10/99 |
| Start | 11/92 | 08/96 | 03/00 |
| First defense | 04/95 | 11/98 | 04/03 |
| End of grant | 12/95 | 02/99 | 02/04 |
| Last defense | 11/96 | 09/03 | ???? |

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- => ~8 equivalent persons (including ALATNET) currently on training !
- The training effort is mostly 50/50 (home/visit) => a trend now also fostered by EU
- Out of the 14 Toulouse PhDs, 5 to 6 are or were in ‘co-tutelle’

# NWP innovation outside global modelling

(starting with three quite differing Hungarian examples)

# There are always beautiful 'Columbus egg solutions' that have been overseen by others

3122 MONTHLY WEATHER REVIEW VOLUME 123

**Comments on "A Spectral Limited-Area Formulation with Time-Dependent Boundary Conditions Applied to the Shallow-Water Equations"**

GÁBOR RADNÓTI

*Hungarian Meteorological Service,* Budapest, Hungary*

18 August 1994 and 8 February 1995

$$(\mathbf{I} - \Delta t\mathcal{L})\Psi_{t+\Delta t} = \Psi_{t+\Delta t_{\exp}} + \Delta t\mathcal{L}(\Psi_{t-\Delta t} - 2\Psi_t), \tag{1}$$

$$\Psi^C = (1-\alpha)\Psi^I + \alpha\Psi^{LS}, \tag{2}$$

**The operators of (1) and (2) do not commute in a 'static' classical way**

**BUT …**

a new solution that allows the coupling to be done at the end of the gridpoint computations on time level $t + \Delta t$ and therefore does not require any gridpoint computations in the extension zone or coupling of any derivative fields. In other words, after the right-hand side of Eq. (1) is gained, it is coupled with $(\mathbf{I} - \Delta t\mathcal{L})\Psi^{LS}_{t+\Delta t}$, where the superscript LS stands for large scale.

# The ‘upstream’ part: PhD thesis ultimately leading to the establishment of the Var aspects of ALADIN

# => Data Assimilation and EPS

**Andras HORANYI defended his thesis**

**"Sensitivity studies of frontal waves using the adjoint method"**

**in Budapest in November 1996.**

The thesis is dealing with the study of the dynamics of frontal waves using the adjoint method.

The dynamics of the frontal waves areexplained in the first chapter.

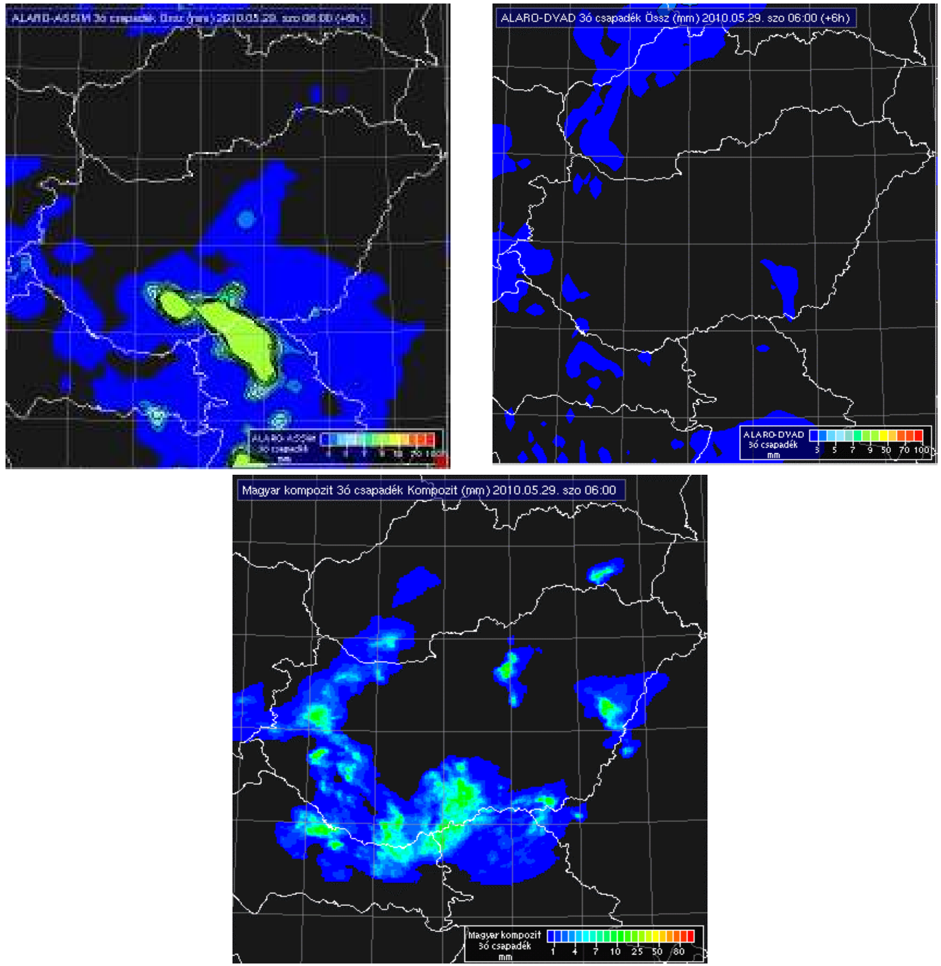
The second chapter is dealing with the applied models i.e. the ARPEGE/ALADIN model and its tangent linear and adjoint versions.

Chapter 3 recalls the basic principles of sensitivity studies using the adjoint models, i.e. how sensitivities of a given characteristic of the frontal waves with respect to initial conditions can be calculated with the integration of the non-linear and adjoint models.

The last chapter describes the experiments performed (including the description of the idealized frontal waves used for the experiments) and the obtained results with the relevant conclusions.

The thesis is in Hungarian, therefore in case of interest it is recommended to read the reference (Horanyi A. and A. Joly, 1996: Some aspects of the sensitivity of idealized frontal waves. Contributions to Atmospheric Physics (Beitrage zur Physik der Atmosphere), Vol. 69., No. 4. 517-533) or contact directly the author

# LAM data assimilation within RC LACE (coordinated by G. Bölöni)




**Case study (29.05.2010) demonstrating the improvement of the short-range (+6 h) precipitation forecast (3 hour accumulation) by data assimilation. Top-left: run with assimilation, Top-right: run without assimilation, Bottom: Radar**

# Simplifying the RSM models to a tractable set of equations for turbulence

- The next two viewgraphs show a spectacular reduction of complexity for Reynolds Stress Modelling equations, obtained within the work to go from p-TKE to e-TKE for ALARO.
- The advantages are multiple:
  - The stability dependency functions can be inverted => possibility to parameterise shallow convection via a single modification of the Brunt-Vaisala frequency;
  - The inclusion of Third Order Moment (TOMs) terms can be performed at relative little computing expense;
  - The novel QNSE spectral theory can be well

# Original equations



$$\overline{u^2} = \frac{1}{3}q^2 - \frac{\tau}{3}\left[(\lambda_2 + 3\lambda_3)\frac{\partial U}{\partial z}\overline{uw} - 2\lambda_3\frac{\partial V}{\partial z}\overline{vw} + 2\lambda_4 g\alpha\overline{w\theta}\right] \quad (15a)$$

$$\overline{v^2} = \frac{1}{3}q^2 - \frac{\tau}{3}\left[(\lambda_2 + 3\lambda_3)\frac{\partial V}{\partial z}\overline{vw} - 2\lambda_3\frac{\partial U}{\partial z}\overline{uw} + 2\lambda_4 g\alpha\overline{w\theta}\right] \quad (15b)$$

$$\overline{w^2} = \frac{1}{3}q^2 + \frac{\tau}{3}\left[(3\lambda_3 - \lambda_2)\left(\frac{\partial U}{\partial z}\overline{uw} + \frac{\partial V}{\partial z}\overline{vw}\right) + 4\lambda_4 g\alpha\overline{w\theta}\right] \quad (15c)$$

$$\overline{uv} = -(\lambda_2 + \lambda_3)\frac{\tau}{2}\left(\frac{\partial V}{\partial z}\overline{uw} + \frac{\partial U}{\partial z}\overline{vw}\right) \quad (15d)$$

$$\overline{uw} = -\frac{\tau}{2}\frac{\partial U}{\partial z}\left[\frac{1}{2}\left(\lambda_1 - \frac{4}{3}\lambda_2\right)q^2 + (\lambda_2 - \lambda_3)\overline{u^2} + (\lambda_2 + \lambda_3)\overline{w^2}\right] - (\lambda_2 - \lambda_3)\frac{\tau}{2}\frac{\partial V}{\partial z}\overline{uv} + \lambda_4\tau g\alpha\overline{u\theta} \quad (15e)$$

$$\overline{vw} = -\frac{\tau}{2}\frac{\partial V}{\partial z}\left[\frac{1}{2}\left(\lambda_1 - \frac{4}{3}\lambda_2\right)q^2 + (\lambda_2 - \lambda_3)\overline{v^2} + (\lambda_2 + \lambda_3)\overline{w^2}\right] - (\lambda_2 - \lambda_3)\frac{\tau}{2}\frac{\partial U}{\partial z}\overline{uv} + \lambda_4\tau g\alpha\overline{v\theta} \quad (15f)$$

$$\overline{u\theta} = -\lambda_5^{-1}\tau\left[\frac{\partial\Theta}{\partial z}\overline{uw} + \frac{1}{2}(\lambda_6 + \lambda_7)\frac{\partial U}{\partial z}\overline{w\theta}\right] \quad (15g)$$

$$\overline{v\theta} = -\lambda_5^{-1}\tau\left[\frac{\partial\Theta}{\partial z}\overline{vw} + \frac{1}{2}(\lambda_6 + \lambda_7)\frac{\partial V}{\partial z}\overline{w\theta}\right] \quad (15h)$$

$$\overline{w\theta} = -\lambda_5^{-1}\tau\left[\frac{\partial\Theta}{\partial z}\overline{w^2} + \frac{1}{2}(\lambda_6 - \lambda_7)\left(\frac{\partial U}{\partial z}\overline{u\theta} + \frac{\partial V}{\partial z}\overline{v\theta}\right)\right] \times \left[1 + \lambda_5^{-1}\lambda_8 g\alpha\tau^2\frac{\partial\Theta}{\partial z}\right]^{-1}. \quad (15i)$$

Equations (15a)–(15i) can be solved using symbolic algebra. The results are

$$(\overline{uw}, \overline{vw}) = -K_M\left(\frac{\partial U}{\partial z}, \frac{\partial V}{\partial z}\right) \quad (16a)$$

$$\overline{w\theta} = -K_H\frac{\partial\Theta}{\partial z} \quad (16b)$$

$$K_M = e\tau S_M, \qquad K_H = e\tau S_H \quad (16c)$$

$$S_M = \frac{1}{D}(s_0 + s_1 G_H + s_2 G_M) \quad (17a)$$

$$S_H = \frac{1}{D}(s_4 + s_5 G_H + s_6 G_M), \quad (17b)$$

where $G_H$ and $G_M$ are defined as

$$G_H \equiv (\tau N)^2, \qquad G_M \equiv (\tau S)^2 \quad (18a)$$

$$N^2 \equiv g\alpha\frac{\partial\Theta}{\partial z}, \qquad S^2 \equiv \left(\frac{\partial U}{\partial z}\right)^2 + \left(\frac{\partial V}{\partial z}\right)^2 \quad \text{and} \quad (18b)$$

$$D = 1 + d_1 G_H + d_2 G_M + d_3 G_H^2 + d_4 G_H G_M + d_5 G_M^2 \quad (18c)$$

$$d_1 = \lambda_5^{-1}\left(\frac{7}{3}\lambda_6 + \lambda_8\right)$$

$$d_2 = \left(\lambda_3^2 - \frac{1}{3}\lambda_2^2\right) - \frac{1}{4}\lambda_5^{-2}(\lambda_6^2 - \lambda_7^2),$$

$$d_3 = \frac{1}{3}\lambda_4\lambda_5^{-2}(4\lambda_6 + 3\lambda_8)$$

$$d_4 = \frac{1}{3}\lambda_4\lambda_5^{-2}[\lambda_2\lambda_6 - 3\lambda_3\lambda_7 - \lambda_5(\lambda_2^2 - \lambda_3^2)] + \lambda_5^{-1}\lambda_8\left(\lambda_3^2 - \frac{1}{3}\lambda_2^2\right)$$

$$d_5 = -\frac{1}{4}\lambda_5^{-2}\left(\lambda_3^2 - \frac{1}{3}\lambda_2^2\right)(\lambda_6^2 - \lambda_7^2), \qquad s_0 = \frac{1}{2}\lambda_1$$

$$s_1 = -\frac{1}{3}\lambda_4\lambda_5^{-2}(\lambda_6 + \lambda_7) + \frac{2}{3}\lambda_4\lambda_5^{-1}\left(\lambda_1 - \frac{1}{3}\lambda_2 - \lambda_3\right) + \frac{1}{2}\lambda_1\lambda_5^{-1}\lambda_8$$

$$s_2 = -\frac{1}{8}\lambda_1\lambda_5^{-2}(\lambda_6^2 - \lambda_7^2), \qquad s_4 = \frac{2}{3}\lambda_5^{-1},$$

$$s_5 = \frac{2}{3}\lambda_4\lambda_5^{-2}$$

$$s_6 = \frac{2}{3}\lambda_5^{-1}\left(\lambda_3^2 - \frac{1}{3}\lambda_2^2\right) - \frac{1}{2}\lambda_1\lambda_5^{-1}\left(\lambda_3 - \frac{1}{3}\lambda_2\right) + \frac{1}{4}\lambda_1\lambda_5^{-2}(\lambda_6 - \lambda_7). \quad (18d)$$

# Resulting set of phenomenological equations

$$R_{if} = C_3 R_i \frac{\phi_3(R_i)}{\chi_3(R_i)}$$

***$C_3$*** : inverse Prandtl number at neutrality

$$\chi_3(R_i) = \frac{1 - R_{if} / R}{1 - R_{if}}$$

***$R$*** : parameter characterising the flow's anisotropy

$$\phi_3(R_i) = \frac{1 - R_{if} / R_{ifc}}{1 - R_{if}}$$

***$R_{ifc}$*** : critical flux-Richardson number (***$R_{if}$*** at $+\infty$)

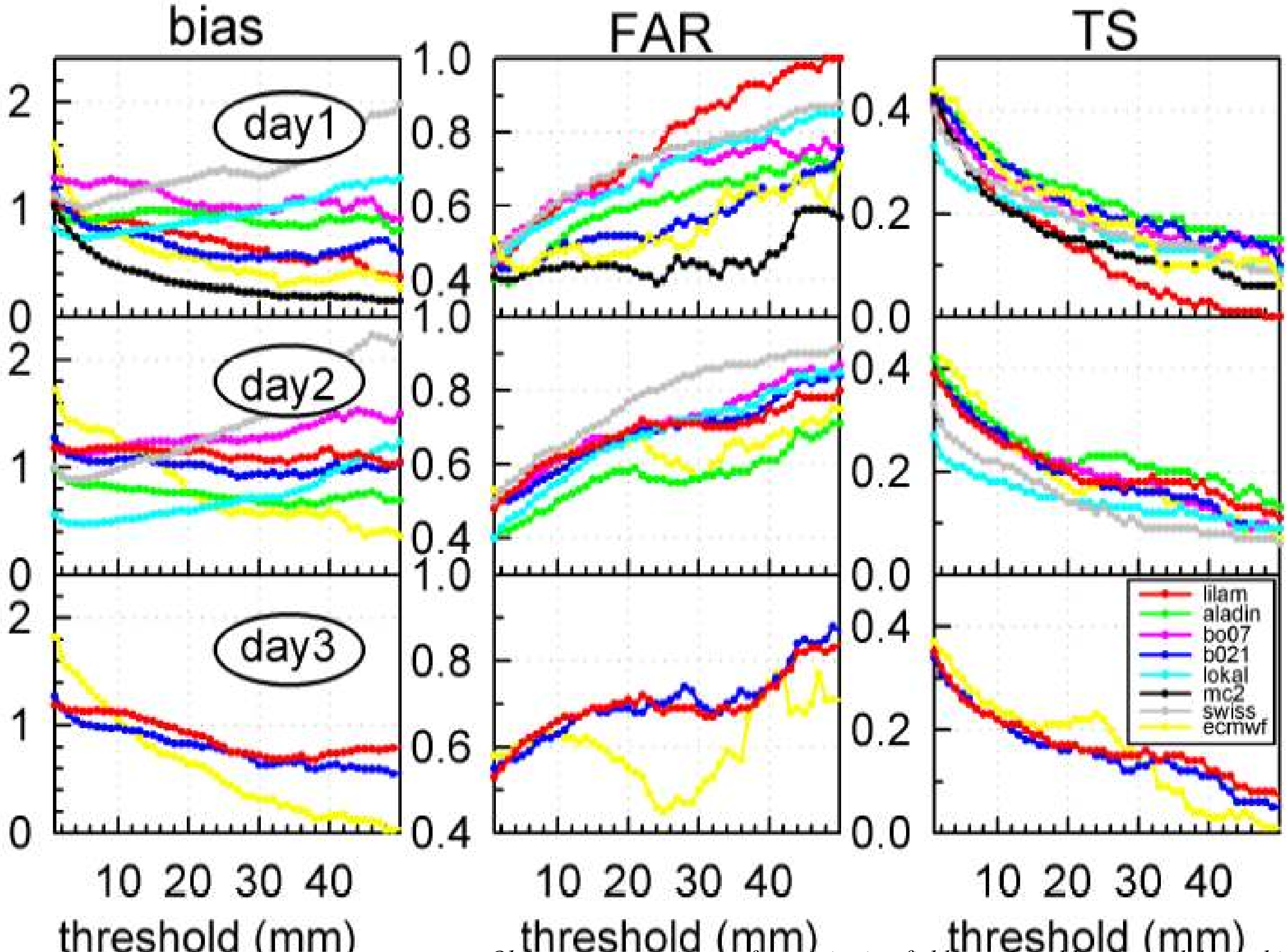
***Plus the 'developed' prognostic TKE equation (for 'E')***

$$\frac{\partial E}{\partial t} = A_{dv}(E) + \frac{1}{\rho}\frac{\partial}{\partial z}\frac{\rho K_m}{\sqrt{C_K C_\varepsilon}}\frac{\partial E}{\partial z} + K_m\left[\left(\frac{\partial u}{\partial z}\right)^2 + \left(\frac{\partial v}{\partial z}\right)^2\right] - \frac{g}{\theta}K_h\frac{\partial \theta}{\partial z} - \frac{C_\varepsilon E^{3/2}}{L}$$

$$K_m = C_K L \chi_3(R_i)\sqrt{E} \quad K_h = C_3 C_K L \phi_3(R_i)\sqrt{E}$$

$L$ *length scale* $\quad C_K$ & $C_\varepsilon$ *tuning parameters*

# Motivation by good results!




*Objective comparisons of precipitation fields produced by the models used in operational support during the 99 MAP campaign. ALADIN only 0=>48h.*

Pedemonte et al., 2003

# The logistic of cooperative projects

# Balances of power in a former version of the ALADIN governance

| | Long-term Impuls | Medium-term Issues | Short-term actions | Planification | Budgetary aspects | Manpower | Maintenance | Harmonisat. |
|---|---|---|---|---|---|---|---|---|
| Assembly of Partners | | | | | | | | |
| ‘PL’ (COOPE/D) | | | | | | | | |
| ‘Co-ordinator’ | | | | | | | | |
| GMAP/D + maintenance animation | | | | | | | | |
| CSSI | | | | | | | | |
| LACE Council | | | | | | | | |
| PL LACE | | | | | | | | |
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Complementarities

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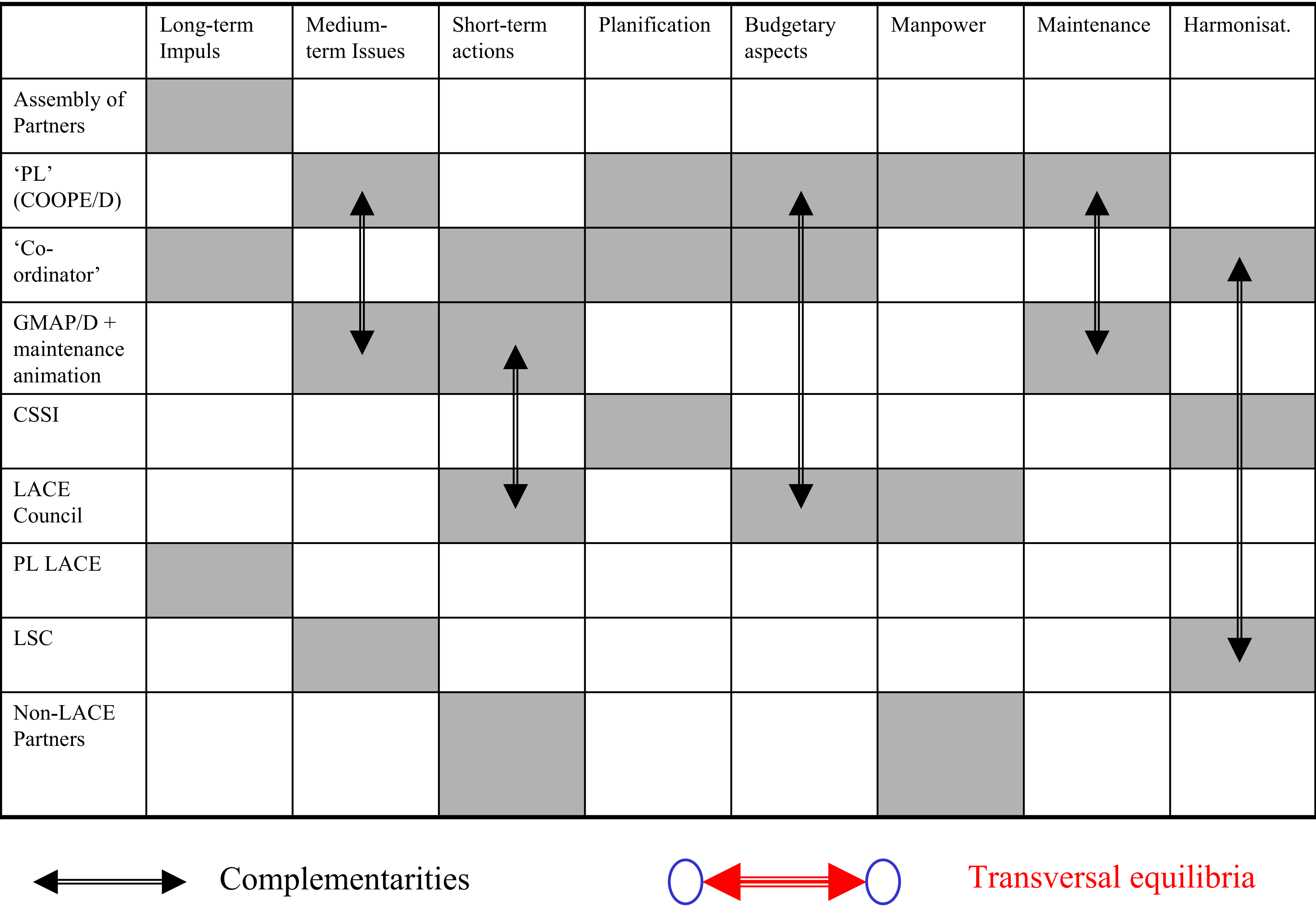

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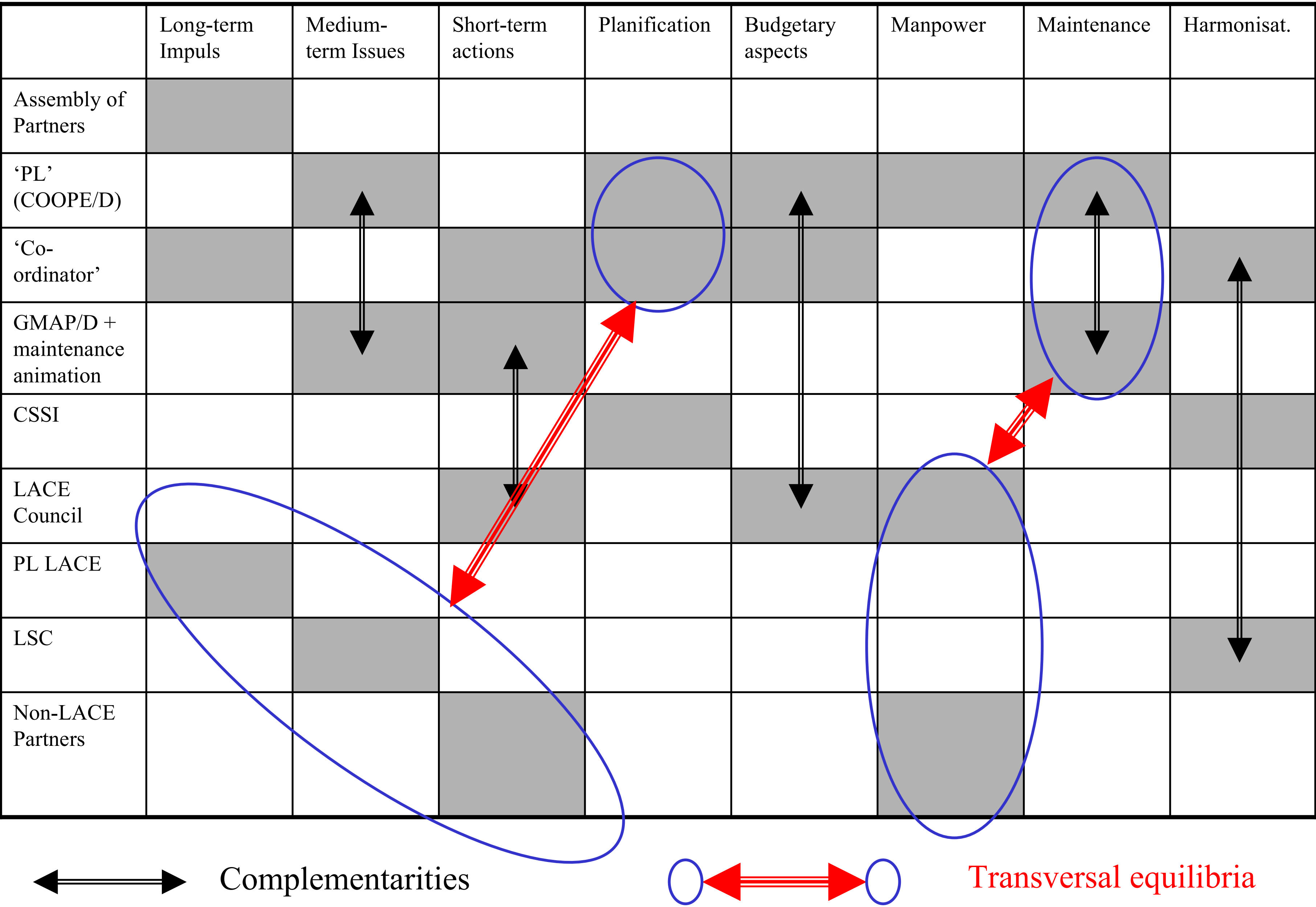
Complementarities

Transversal equilibria

# Balances of power in a former version of the ALADIN governance



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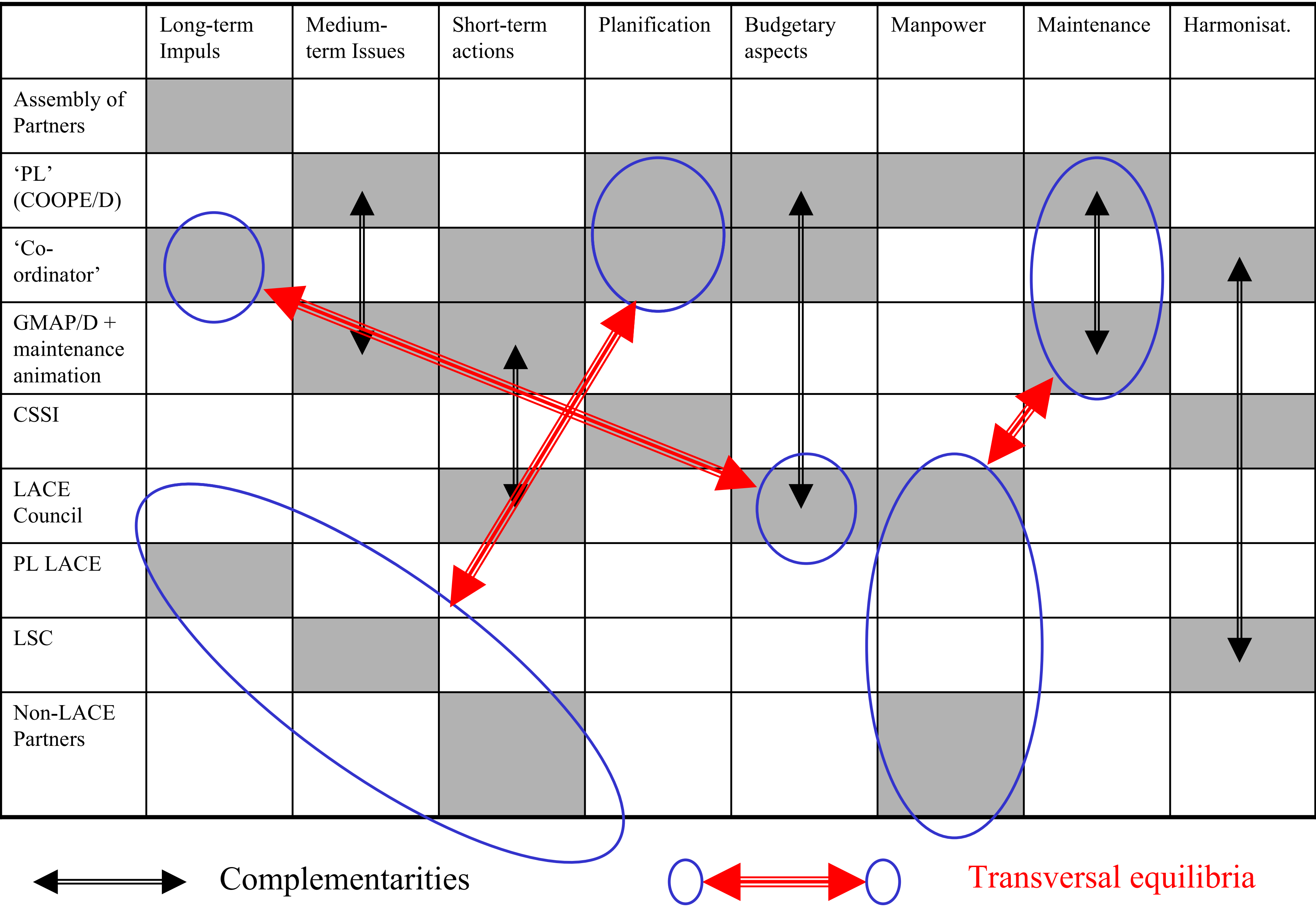

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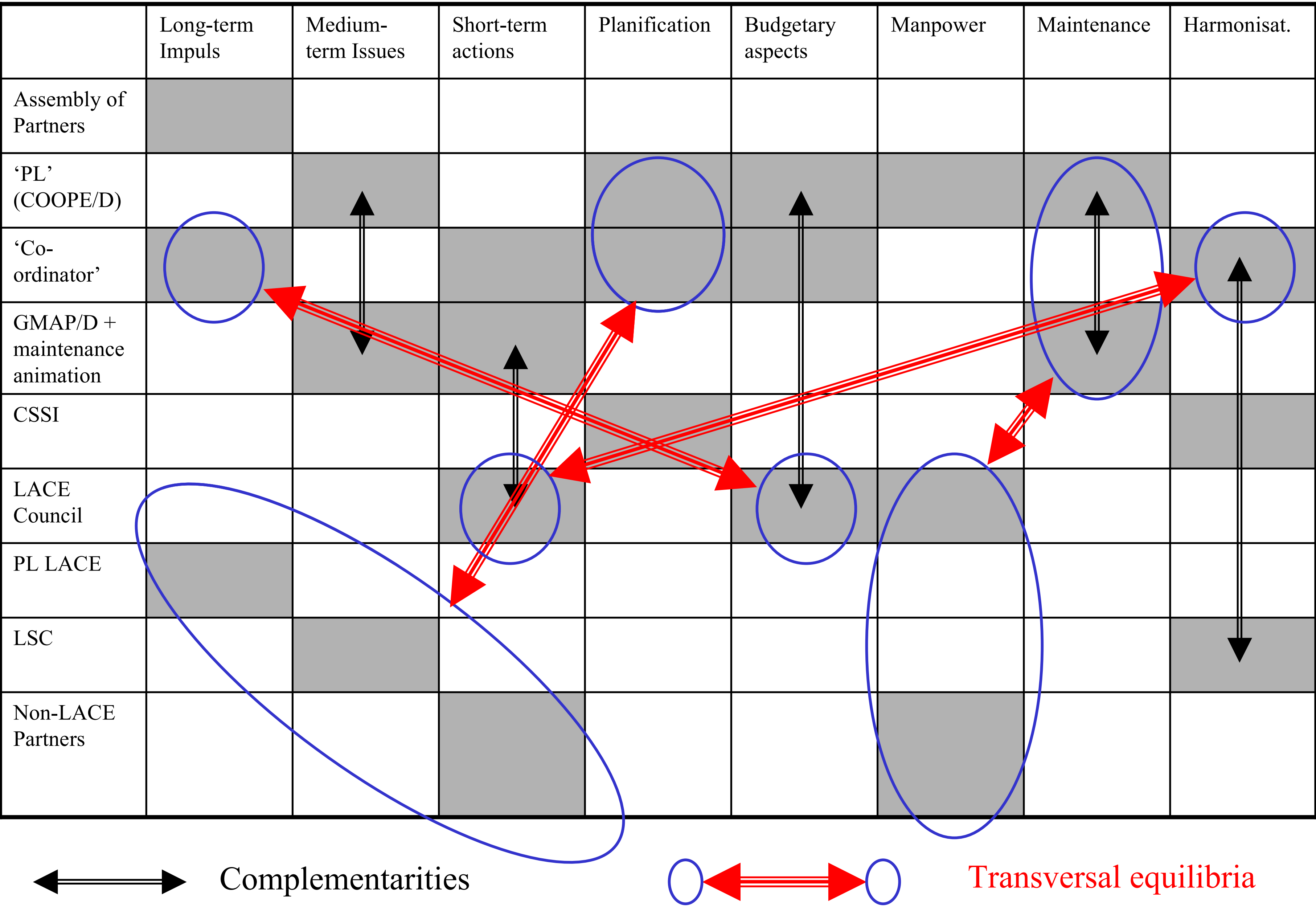

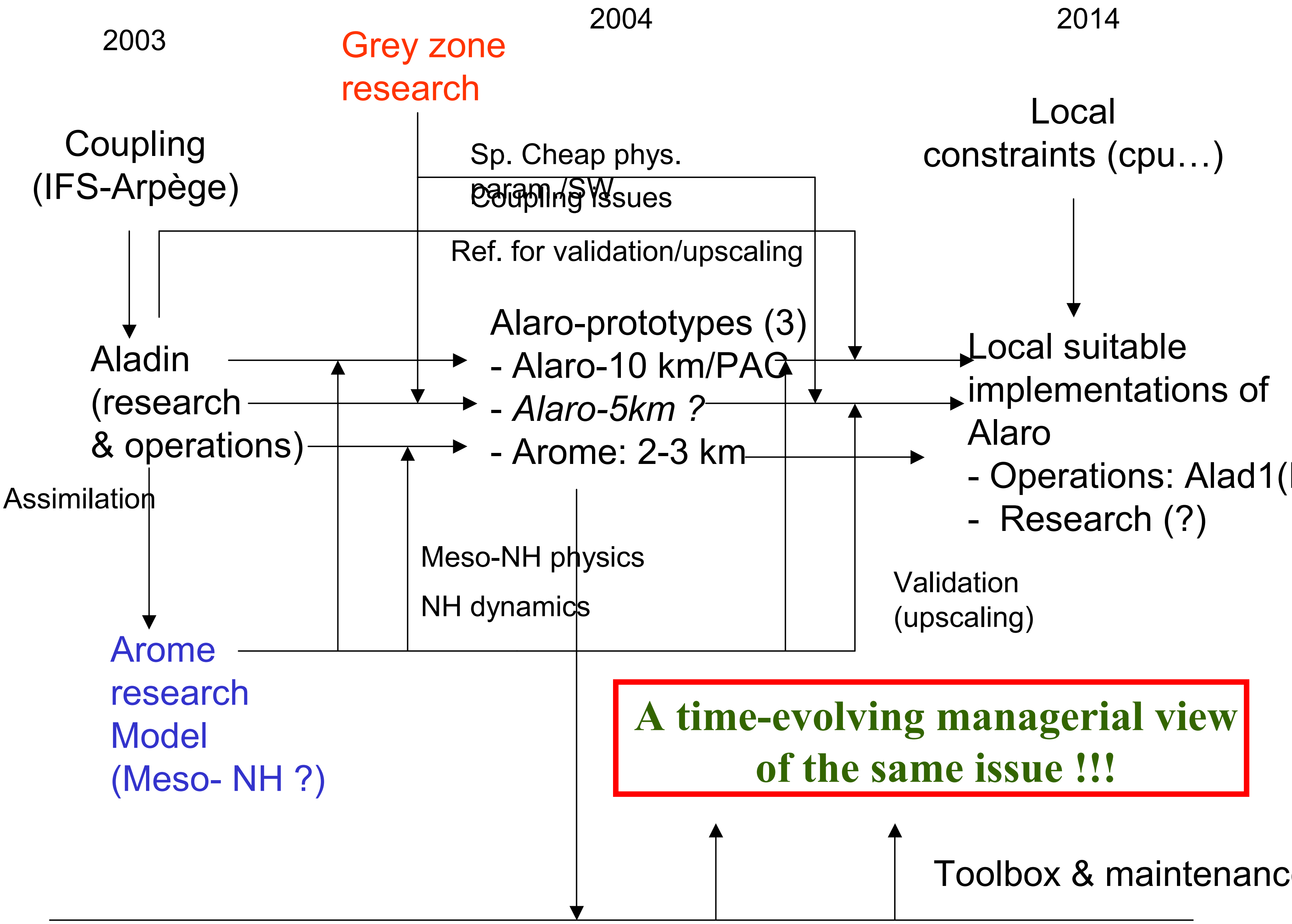
2003
2004
2014
Grey zone research
Coupling (IFS-Arpège)
Sp. Cheap phys. param./SW
Coupling issues
Local constraints (cpu…)
Ref. for validation/upscaling
Aladin (research & operations)
Alaro-prototypes (3)
- Alaro-10 km/PAC
- *Alaro-5km ?*
- Arome: 2-3 km
Local suitable implementations of Alaro
- Operations: Alad1(
- Research (?)
Assimilation
Meso-NH physics
NH dynamics
Validation (upscaling)
Arome research Model (Meso- NH ?)
A time-evolving managerial view of the same issue !!!
Toolbox & maintenanc

# The coordination problem

| | | At | Be | Bg | Cz | Fr | Hr | Hu | Ma | Pl | Pt | Ro | Si | Sk |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| EE927 | | Y | Y | Y | Y | - | Y | Y | Y | Y | Y | Y | Y | Y |
| Data Bank (obs) | | Y- | N | N | Y | Y+ | N | Y | Y+ | (Y) | Y | Y- | (Y) | N |
| Cycle | 09 | | | | | | | | | **X** | | | | |
| | 10 | | | | | | | | | | | | | |
| | 11 | **X** | | **X** | | | | | | | | | **X** | |
| | 12 | | **X** | | **X** | | **X** | **X** | | | **X** | **X** | | **X** |
| | 13 | | | | | | | | **X** | | | | | |
| | 14 | | | | | | | | | | | | | |
| | 15 | | | | | **X** | | | | | | | | |
| Phys | pre-C. | | | **x** | | | | | | **x** | | | **x** | |
| | Cycora | **x** | | | | | **x** | **x** | | | | | | |
| | C.-bis | | **x** | | **x** | | | | **x** | | **x** | **x** | | **x** |
| | C.-ter | | | | | **x** | | | | | | | | |
| Relative δt | | 1.32 | 0.90 | 0.95 | 0.98 | 0.99 | 0.86 | 1.05 | 0.84 | 0.70 | 0.90 | 1.03 | 0.85 | 0.99 |
| Vor. H-diff. intensity | | 1.00 | 1.00 | 1.05 | 1.00 | 1.00 | 0.71 | 0.98 | 1.02 | 1.24 | 1.17 | 1.00 | 0.99 | 1.00 |
| Div. H-diff. intensity | | 1.80 | 1.00 | 1.05 | 1.00 | 1.00 | 1.30 | 1.77 | 1.83 | 1.24 | 2.10 | 1.00 | 1.01 | 1.00 |
| Resolution's influence knowledge | | Y | Y+ | Y- | Y+ | Y+ | N | Y- | Y | Y | Y | Y | Y+ | Y- |

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- Backphasing is a good way to protect the operational credibility of the project but the worse practice in terms of long term code quality
- When code-users have a pure research perspective and no maintenance awareness, one is preparing future (impossible) choices between frustration and domino-cascade-type problems
- When operational aspects become too paramount, the implementation of common progress is either deified or diabolised!

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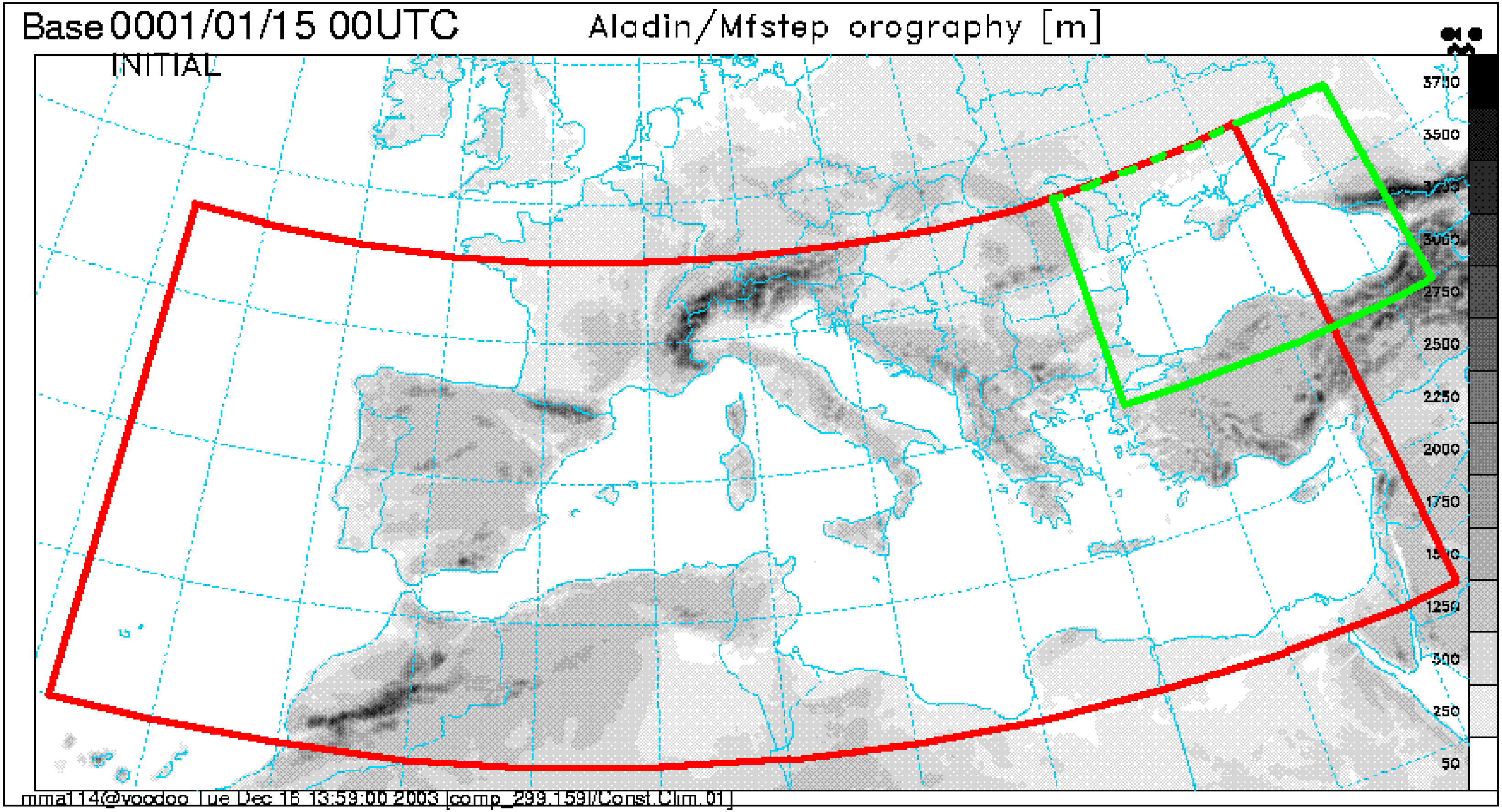
- It does not avoid coordination but facilitates it
- It is unfortunately doubly unpopular!!

The current challenges (organisational ones; one assumes that the scientific ones will [*higher resolution, more physical sophistication, more remote-sensed data and additional need for stochasticity*] remain roughly unchanged)

# Promoting the diversity of application: oceanography by CE teams (Cz, Sk, Si) !

ALADIN/MFSTEP domain



# Looking at ‘integrated downstream use’ aspects

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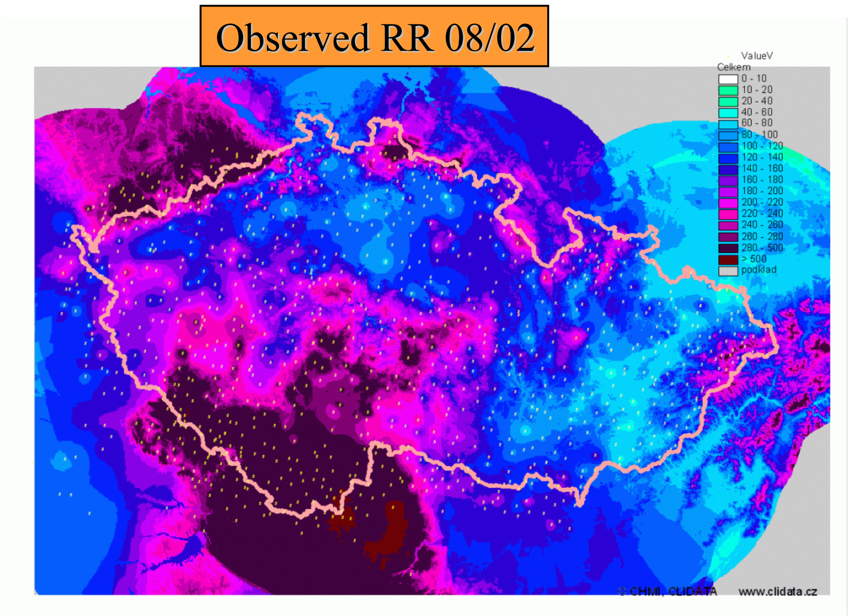

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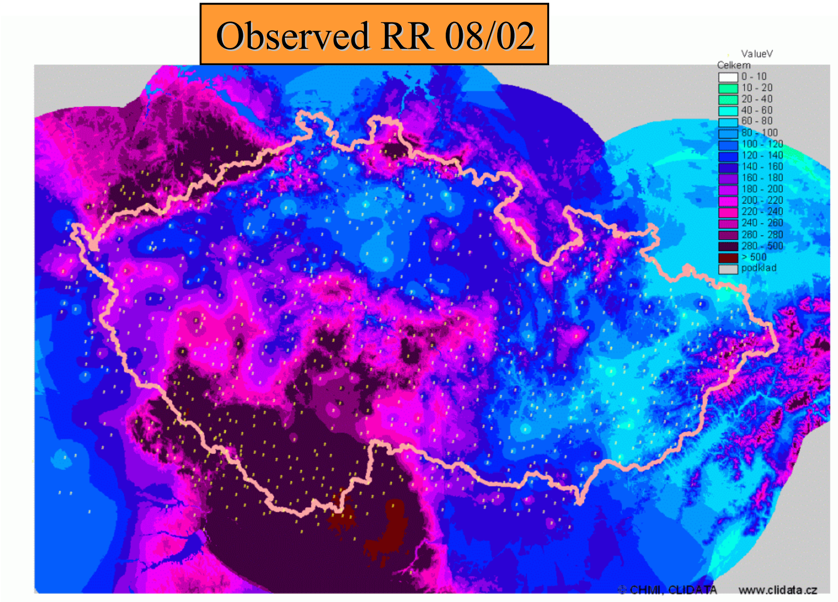
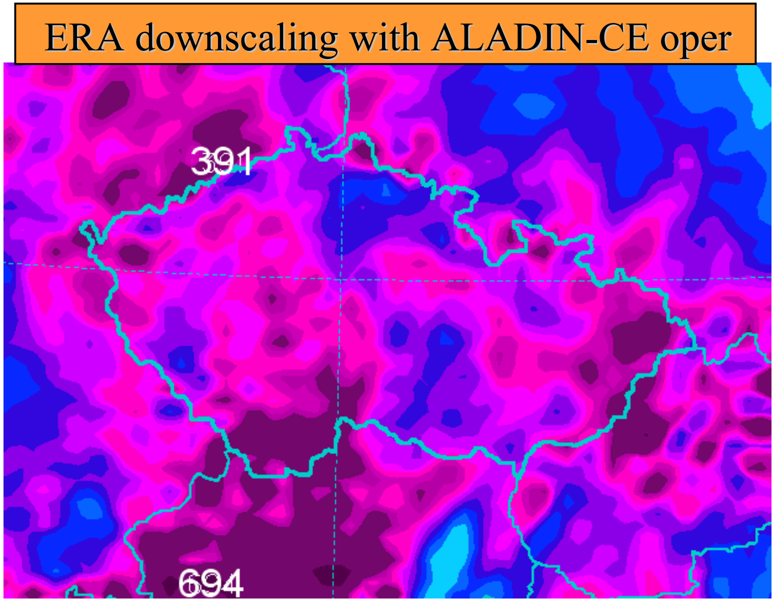
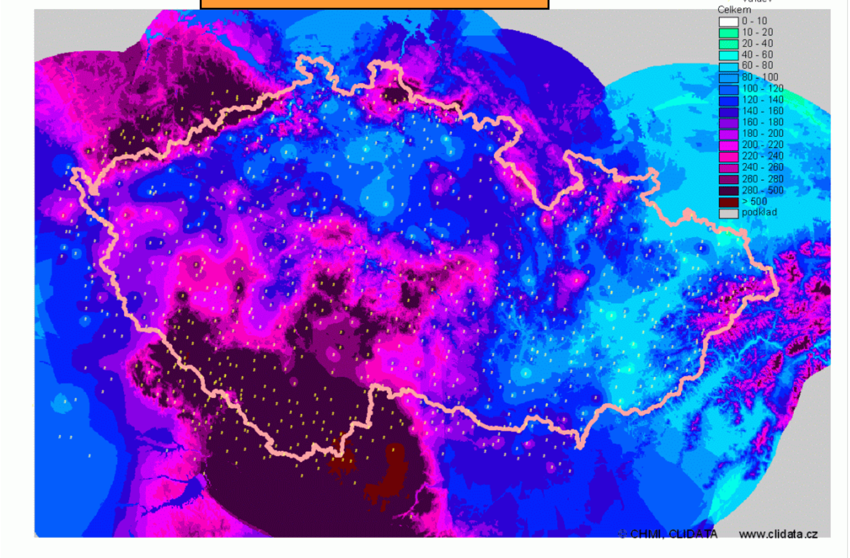


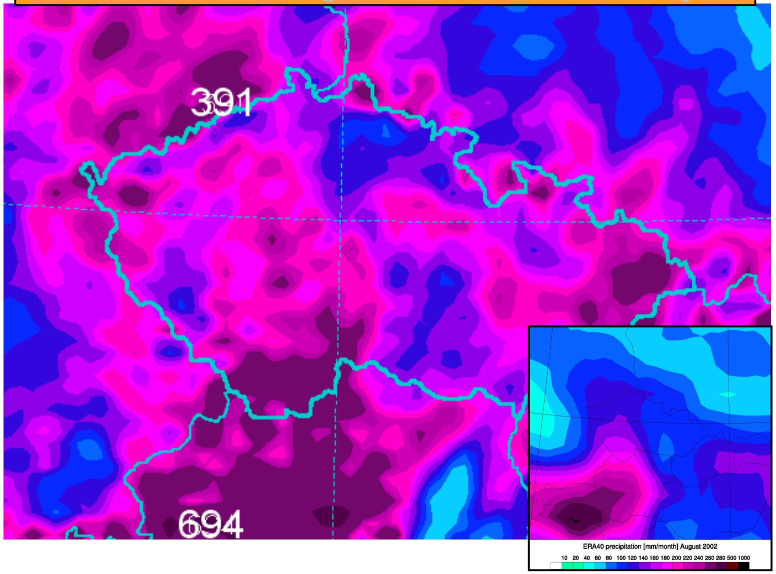



# Looking at ‘integrated downstream use’ aspects

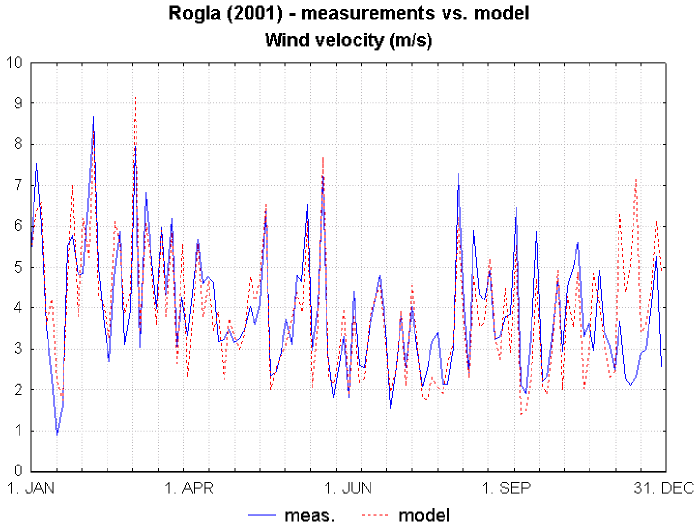
Observed RR 08/02

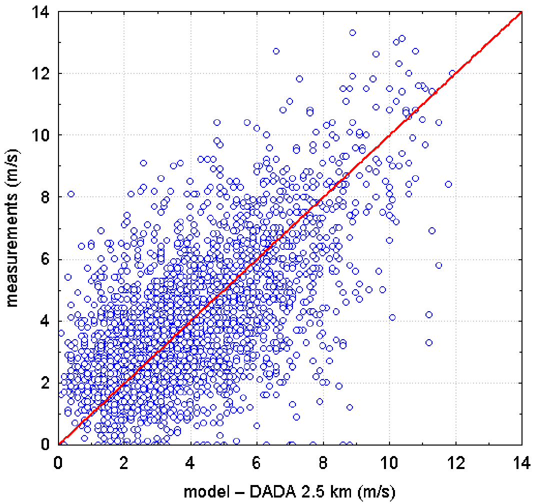


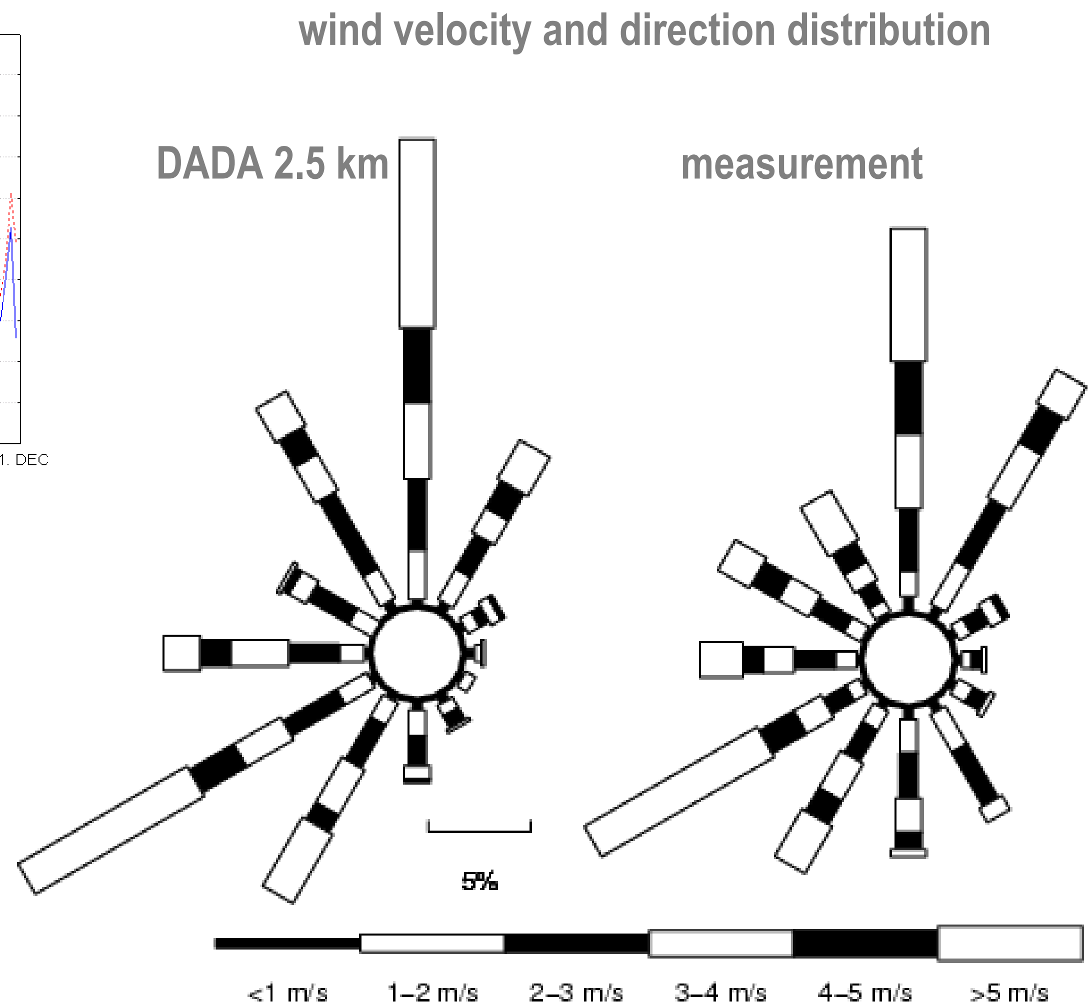

ERA downscaling with ALADIN-CE oper



# Using ‘dynamical downscaling for innovative applications



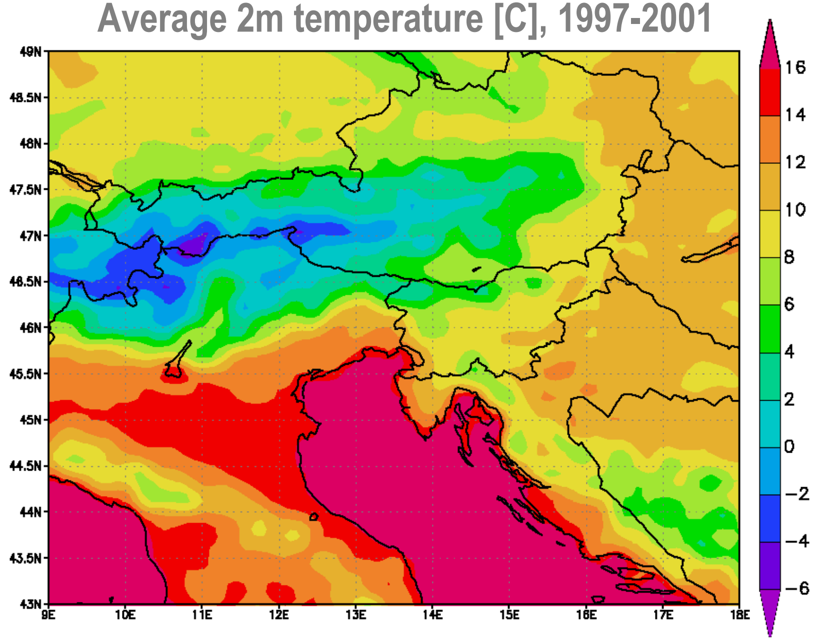




Analysis by R. Bertalanic, EARS

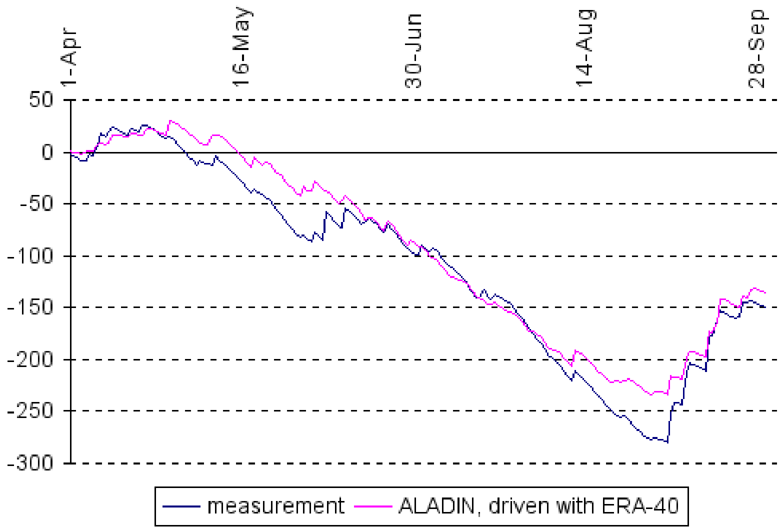
# Using ‘dynamical downscaling for innovative applications

## 2m Temperature and Evapotranspiration

Average 2m temperature [C], 1997-2001




Water balance in Murska Sobota, summer 2001 drought (precipitation + evapotranspiration) [mm]




Analysis by B. Kurnik, EARS

# The current legacy of ALADIN

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- A powerful ‘model’ of (Toulouse based) common maintenance and training
- A principle of ‘no hot-line’ for operational applications

# Where are we heading to? (1/3)

- Constraints:
  - NWP-type applications are more and more important in day-to-day meteorology, they rely on codes that are more and more difficult to master and they are driven to incorporate more and more multidisciplinarity.
  - The latter aspect drives towards '***high level modularity***', while the scientific challenges would rather push for '***low level modularity***'.
  - The evolution of HPC (High Performance Computing) also interfers with this dilemma.
  - Budgetary constraints force to make choices and to rank priorities.

# Where are we heading to? (2/3)

- Consequences:
  - The dreams of 'full interoperability' (external *or even internal*!) are difficult to reach or even to pursue.
  - This puts the need for coherency within each 'software-driven endeavour' higher and higher on the agenda.
  - But, at wider and wider size of the teams, this is a constraint that most scientists do not like (the justification by downstream applications becomes a rare resource).
  - The system must therefore remain faithful to its principles but should evolve in the way to apply them.

# Where are we heading to? (3/3)

- Solutions:
  - Diversification of the forms of support to the NWP science (the ‘climate issue’ may help here a bit).
  - More consensus needed between scientific risk assessment and science-policy planning.
  - We are still all in the same boat (at European level), even if it is a bit more shaky than it used to be. The empirical rules that gave it its shape are still very valid. We must trust them =>

**Consolidate the structure, make its working a bit more ‘vertical’, search for new forms of financing (for upstream actions) and still have strong solidarity in the direct NWP concretisation steps.**