A tribute to Jean-François Geleyn

Toulouse, 6 February 2020

Works with Jean-François about the *moist-air thermodynamics*

By Pascal MARQUET

Météo-France. CNRM-GMAP-Proc

It started in 1990…

Pascal MARQUET

MÉTÉO FRANCE / E.E.R.M.

L.M.D. POLYTECHNIQUE / C.N.R.S. (with D. Cadet)

Feb. / March 1990

PURPOSE : ENERGETICS OF THE AFRICAN MONSOON CIRCULATION

$$a_h = (h - h_r) - T_r (s - s_r)$$

POSSIBLE GENERALIZATIONS :

MOIST AVAILABLE ENTHALPY ?

- How to generalize dry-air exergy to **moist-air?**

- My "FCPLR" internship (1987-90) at LMD-X
- Generalize the APE into the **dry-air exergy,**
- with both **enthalpy** and **entropy…**

- Jean-François missed my talk at the CRMD-Alma
- but he went to LMD-X … and gave me an answer: see the paper of **Hauf and Höller (JAS, 1987)!**

1990

- I have then rapidly done the job : **thanks J.-F.!**
- I join the ARPEGE-Project in 1990 (Prévi-Num) and prepare a communication for the AMA-90 →

L'exergie de l'atmosphère
Définition et propriétés de l'enthalpie utilisable humide.

Pascal MARQUET
Météorologie nationale, SCEM/PREVI/NUM

Octobre 1990

$$\theta^* = T\left(\frac{p^0}{p_{00}}\right)^{-R^0/c_p^*}\left(\frac{p^1}{p_{00}}\right)^{-R^1 r^1/c_p^*}\exp\left(-\frac{r^2\, l_{21}+r^3\, l_{31}}{c_p^*\, T}\right)$$

- with this by-product: a **more "symmetric"** entropy potential temperature than in Hauf and Höller (1987)
- and Jean-François loved this quantity!
- **because Jean-François loved clean thermodynamics!**

then 1992

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SUBROUTINE PPWETPOINT ( KIDIA,KFDIA,KLON,PAPRS,PT,PQV,PQL,PQI,PWETPOINT )
!-----------------------------------------------------------------------
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- **Jean-François then used it to compute the wet-bulb potential temperature in ARPEGE (1992), still at used!**

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!****  *PPWETPOINT*  CALCUL DU "POINT BLEU".

!                COMPUTATION OF THE WETPOINT TEMPERATURE.

FULLY GENERAL ROUTINE COMPUTING THE ABOVE-MENTIONED
TEMPERATURE FOR WHATEVER ATMOSPHERIC "INPUT" STATE (P,T,QV,QL,QI
ARE INDEPENDENT VARIABLES) AND WHETHER OR NOT THE "LNEIGE=.T."
OPTION HAS BEEN ACTIVATED.
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$$\theta^* = T\left(\frac{p^0}{p_{00}}\right)^{-R^0/c_p^*}\left(\frac{p^1}{p_{00}}\right)^{-R^1 r^t/c_p^*}\exp\left(-\frac{r^2\, l_{21}+r^3\, l_{31}}{c_p^*\, T}\right)$$

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AUTHOR.
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 92-09, J.F. Geleyn.
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      THREE IMPLICIT EQUATIONS ARE SOLVED BY NEWTON METHODS :
         - SEARCH OF THE SATURATION POINT OF EQUAL ENTROPY UNDER A
    REVERSIBLE TRANSFORM ;

         - FOR THE FIRST STEP THE SYMETRIC FORM OF THE MOIST ENTROPY
    PROPOSED BY P. MARQUET IS USED IN ORDER TO ALLOW A MIX OF LIQUID
    AND ICE WATER IN THE ATMOSPHERIC STATE ;
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then 1992 … 2009

Then our activities drifted appart

- Jean-François was the head of GMAP (→2003), then PM of ALADIN…
- I joined the Climate-ARPEGE team (Michel Déqué, 1995-2008) and then the "Laboratory of Forecasting" (Patrick Santurette, 2008-2014)

- but Jean-François was against all what was done in the Climate version of ARPEGE…

- **one can say that J.-F. was as great at <u>helping his friends</u> as he was at <u>fighting the thoughts of his enemies</u>… sometimes the darker side of J.-F.'s force!**

Why these fights: the Shallow convection?

Short- and Medium-Range Numerical Weather Prediction
Collection of Papers Presented at the WMO/IUGG NWP Symposium, Tokyo, 4-8 August 1986

Use of a Modified Richardson Number for Parameterizing the Effect of Shallow Convection

By JF. Geleyn (1987)

Direction de la Météorologie Nationale, EERM/CRMD Paris, France

(Manuscript received 4 November 1986, in revised form 3 February 1987)

One of the rare J.-F.'s paper

2. The problem

During the last ten years several parameterizations of the vertical exchange in the planetary boundary layer have been developed that make explicit use of the local Richardson number R_i to compute vertical exchange coefficients K following:

$$K=l^2(z)\left|\frac{\partial \vec{u}}{\partial z}\right| f(R_i) \qquad (1)$$

with

$$R_i=\frac{g}{C_pT}\frac{\partial s/\partial z}{|\partial \vec{u}/\partial z|^2} \qquad (2)$$

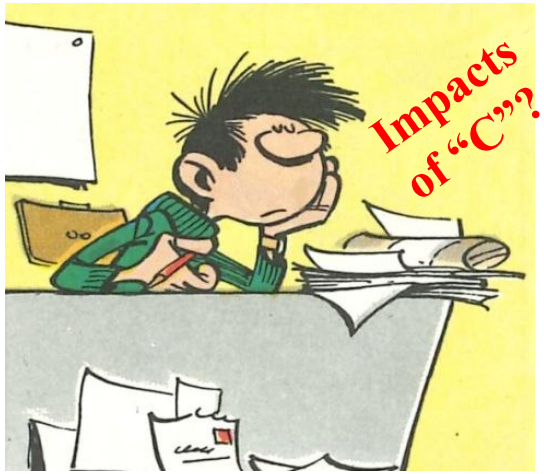
s being the dry static energy C_pT+gz.

Even if the cloud is only covering a partial area in the ratio C, the replacement of s by $C_pT+gz+CLq_s$ will also be consistent, *but only as long as C remains constant with height.*

4. Proposal

All the above mentioned properties are obtained by the following formulation:

$$R_i^*=\frac{g}{C_pT}\frac{\partial s/\partial z+L\cdot\min(0,\partial(q-q_s)/\partial z)}{|\partial \vec{u}/\partial z|^2}$$



… january 2010 …

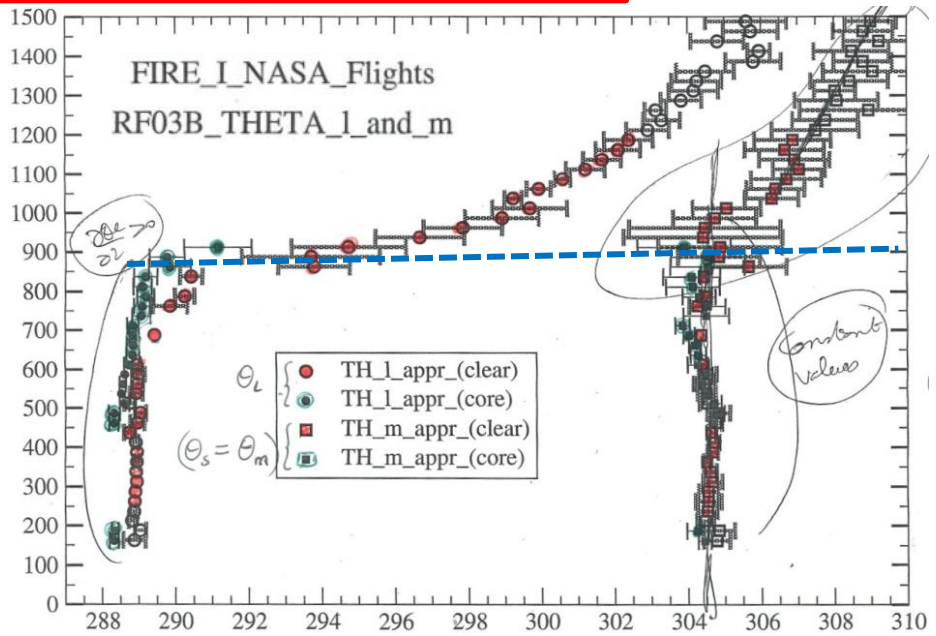
$$\theta_m = \theta \exp\left(-\frac{L_{vq}}{c_{pd}T}\, r_{sat}\right) \left(\frac{T}{T_r}\right)^{\kappa_{dry}} \left(\frac{p_r}{p}\right)^{\kappa_{dry}} \left(\frac{q_v}{q_r}\right)^{-r_{dry}} \left(\frac{1+\eta\, q_v}{1+\eta\, q_r}\right)^{\kappa(1+\delta_{dry})}$$

14 dec. 2009

2010: me at the LABO & J.-F. not so far…

- I showed him my new results, and he was so enthusiast! (*more than expected:* **old 1990 works!**

- convinced at once that **"entropy = Cste" in PBL**!
- he saw this a great news for the **turbulence!**
- and **a need to compute C and Ri (moist)** for the **Turbulent-Shallow convection…**



QJRMS-2013

On a general definition of the squared Brunt–Väisälä frequency associated with the specific moist entropy potential temperature

Q. J. R. Meteorol. Soc. 139: 85–100, January 2013 A

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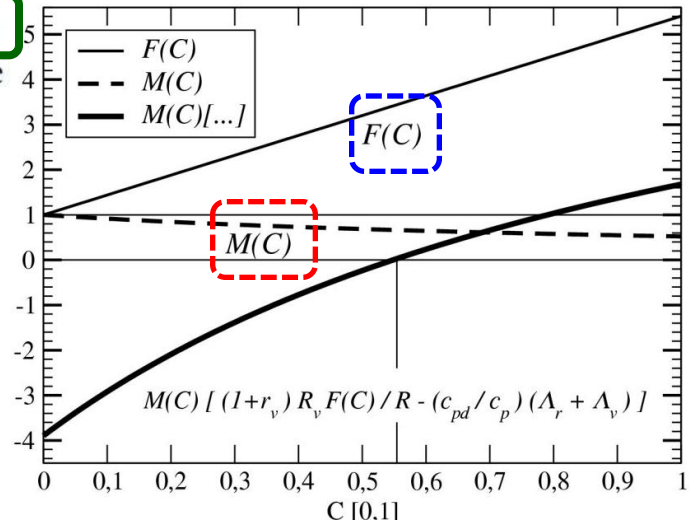


2010-2012: nights and week-ends to make ugly moist-air thermodynamic computations!

- Jean-François was still proud of that paper in 2014

$$N_1^2(C) = g\,M(C)\left(\frac{\partial \ln(\theta_s)_1}{\partial z}\right)_E + g\left(\frac{\partial \ln(q_d)}{\partial z}\right)_E + g\,M(C)\left[(1+r_v)\frac{R_v}{R}F(C) - \Lambda_r\right]_E\left(\frac{\partial q_t}{\partial z}\right)_E$$

- Jean-François still searched for the **"cloudiness" parameter "C"** via M(C) and F(C) for a (pTKE) **moist-Ri + Shallow Convection** (like in the 1987 paper)

COST-ES0905 / 2010-2014

I was not in this EU program, **but Jean-François convinced people to accept me**

- Many talks by him about the "application of the moist-air entropy to turbulence"
- **Many thanks Jean-François!**

Moist thermodynamics and moist turbulence for modelling at the non-hydrostatic scales

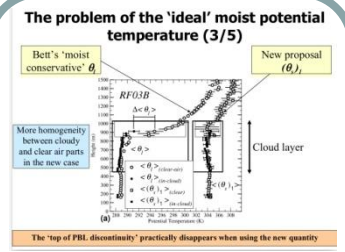
J.-F. Geleyn and P. Marquet

Météo-France, Toulouse

with thanks to R. Brožková and I. Bašták-Ďurán for their input

ECMWF Workshop on *'Non-hydrostatic modelling'*
Reading, 8/11/2010

The problem of the 'ideal' moist potential temperature (3/5)



Brac, Croatia, 2010

Filtering the condensation/evaporation aspects of moist turbulence parameterisation via an a-priori definition of shallow convection cloudiness and the simplest analytical translation of moist-entropy conservation

J.-F. Geleyn, P. Marquet, I. Bašták-Ďurán, F. Váňa and R. Brožková

COST ES0905 WG3 meeting, Offenbach/Main, 28-29/11/2011

ALADIN

A year of preparation EWGLAM/SRNWP, Exeter, 4/10/10

On the possible use of moist entropy gradients in the modelling of turbulent and convective mixing

Introduction of a topic (already touched by Emanuel (1994)), for an open discussion

J.-F. Geleyn (Météo-France)

2010 Session of WG3 of the COST ES0905 action, Prague, 18-19/11/10

Interest of doing clean thermodynamics in models: rules, conditions of their application and a few (present and anticipated) examples

Jean-François GELEYN

CNRM, Météo-France, Toulouse

(many thanks to P. Marquet, B. Catry, R. Brožková, I. Bašták-Ďurán and M. Van Ginderachter)

COST ES0905 WG1+2 meeting
Reading, 14/01/2013

Unification of thermodynamics

or

Unification steps via thermodynamics ?

in fact the presentation will oscillate between the two meanings …

Jean-François GELEYN

CNRM, Météo-France, Toulouse

(many thanks to P. Marquet, B. Catry, and M. Van Ginderachter)

COST ES0905 annual meeting
Palma de Mallorca, 20/03/2013

On the use of moist entropy in the parameterization of the moist turbulence

Pascal MARQUET
Laboratory of Forecasting.

Jean-François GELEYN
CNRM.

EMS, NWP2 session
Łódź, Poland, 13/09/2012

EMS Annual Meeting Abstracts
Vol. 8, EMS2011-613, 2011
11th EMS / 10th ECAM

Enthalpy and entropy:

J.-F. Geleyn and P. Marquet
Météo-France, TOULOUSE, France

COST-ES0905 / 2010-2014

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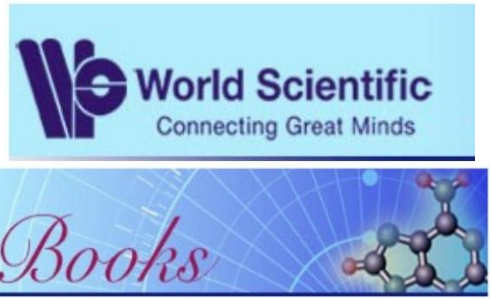
- Many talks by him about the "application of the moist-air entropy to turbulence"
- **Many thanks Jean-François!**

- Jean-François **tried to convince people** via workshops and meetings
- while **I preferred to write papers**: this was a clear difference between us
- and my goals was on **all applications** of moist entropy:

  surface fluxes, free-air turbulence, PV + moist enthalpy as well, …

Our last chapter: Marquet & Geleyn / October 2015

P. Marquet, J.-F. Geleyn (**2015-c**). Formulations of moist thermodynamics for atmospheric modelling. In: R. S. Plant and J.-I. Yano, editors, "Parameterization of Atmospheric Convection", Volume 2: Current Issues and New Theories, chapter 22, pages 221-274. World Scientific, Imperial College Press. Free acces at: http://arxiv.org/abs/1510.03239
http://www.worldscientific.com/doi/abs/10.1142/9781783266913_0026



After 2015 ? My research programs

- I'm so sorry that Jean-François is no longer here, because he dared to ask fundamental questions!

1) Why setting $K_h = K_w$? (i.e. turbulence acts in the same way for "heat" and "water")

Answer: ***no good reasons, it's just that it's easier!***

2) By the way, why using Richardson numbers depending on θ_v?

Answer: ***a need to make a "back to basic"***
a mix of 1990 (exergy) - Obukhov (1947) and 2010 (entropy) - Richardson (1920) →

The Supply of Energy from and to Atmospheric Eddies.
By Lewis F. Richardson.
(Communicated by Sir Napier Shaw, F.R.S. Received March 9, 1920.)

$$\left(\frac{\partial \bar{v}_x}{\partial h}\right)^2 + \left(\frac{\partial \bar{v}_y}{\partial h}\right)^2 > \frac{g}{\gamma_p}\frac{\partial \sigma}{\partial h}$$

$\propto \partial s/\partial z$ ...

s = *entropy !*

we miss you!