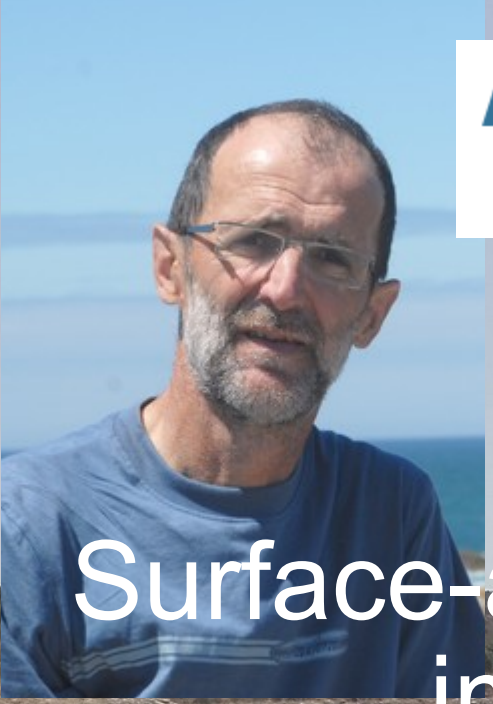


A Tribute to Joël Noilhan 21-22 March 2019

Centre International de Conférences - Météo-France - Toulouse - France

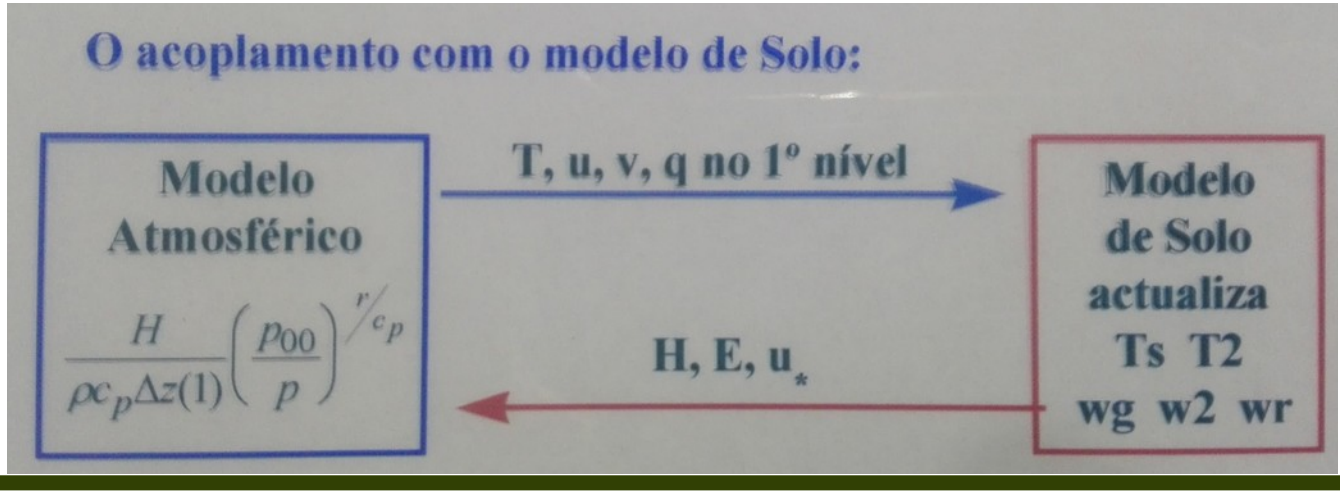
Surface-atmosphere interactions and the impact of lakes on climate

Rui Salgado
Instituto de Ciências da Terra, Universidade de Évora
with: Pedro Miranda, Pierre Lacarrère, Patrick Le Moigne, Silvie Donniers, Miguel Potes, Maria João Costa, Carlos Policarpo, Maksim Iakunin, Pedro Soares, ...

UNIVERSIDADE DE ÉVORA

1. Coupling ISBA with NH3D

- NH3D – NonHydrostatic-3Dimensional – model developed by Pedro Miranda (Miranda and James, 92)
  - essentially dynamics: No radiative scheme, no cloud microphysics, **no surface**
  - 3D turbulence
  - sigma pressure vertical coordinate
- Coupled to ISBA (Noilhan and Planton, 1988) in 1994 (Salgado, master thesis, 1996), in order to participate in the study of the climate impact of a projected dam and more generally to study atmospheric circulations induced by surface heterogeneities
  - One month intern-ship with **Joël, Pierre Lacarrère and Florence Habets**
- Explicit coupling



Digitalization of part of a slide from the defense of my master's thesis.

Coupling ISBA with NH3D - Validation

- Quasi 1D simulation with NH3D + ISBA (9x9)
- Comparison against EFEDA91 data
  - site Tomelloso 2 (Castilla la Mancha, Spain); day 23/06/1991; initialization (surface and vertical) from observations at 6 UT (extracted from Giordani, 1993).
  - Geostrophic wind forced and updated each 6H
  - radiation imposed from obs
  - 24 hours of simulation
- good net radiation representation
- partition H / LE is also well represented
- Problems at night: model do not give the observed negative fluxes.
- results are similar to those obtained with ARPEGE 1D + ISBA
- Data and ARPEGE results provided by Pierre Lacarrère

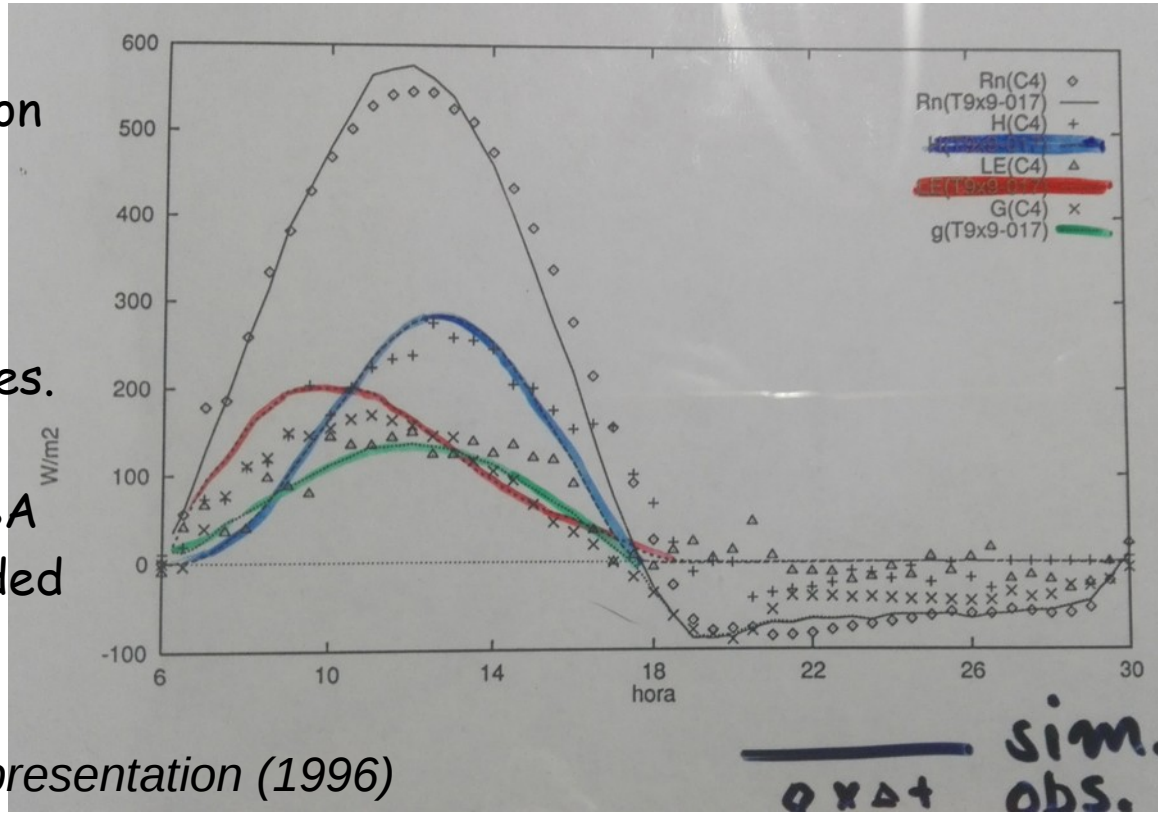


Figure from master thesis presentation (1996)

Report on the Environmental Impact of Alqueva

- NH3D+ISBA was the base of the estimations of the Climate impact
  - PI: Pedro Miranda; I was his master student
  - Done in 1994, before the construction of the dam (the gates closed in 2012)

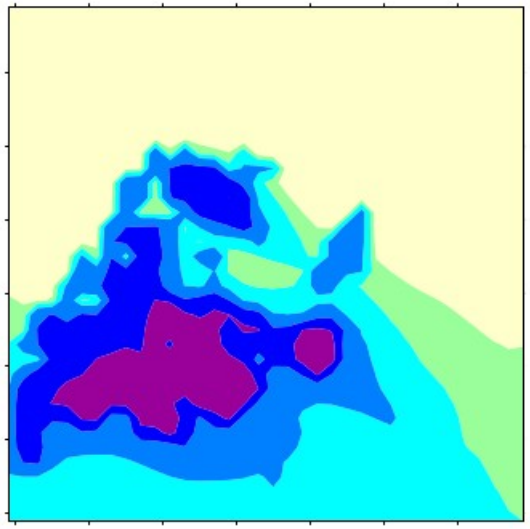
  - An important national project, first projected in the fifties, with many issues and controversies, finally build in the transition of the century
  - first (and unique?) project to have an autonomous climate impact study

Report cover

ESTUDO DE IMPACTE AMBIENTAL DO ALQUEVA

CLIMA

Relatório Final



Pedro M. A. Miranda
Francisco Abreu
Rui Salgado

Relatório Técnico do ICAT
Janeiro 1995

Report on the Environmental Impact of Alqueva: 3D simulations and results.

- NH3D+ISBA Simulations
  - reservoir
  - irrigation map
  - 37x37x60 grid-points (4 km resolution)
- very simplified surface characteristics
- imposed downward radiative fluxes
- Initialization with one vertical profile

Impact on 2m air temperature for a typical July day

- Conclusion: realistic results,
- To go further it was necessary to use a model with more "physics": Meso-NH

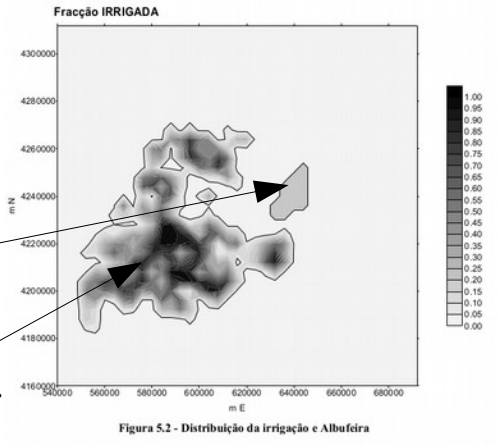


Figura 5.2 - Distribuição da irrigação e Albufeira

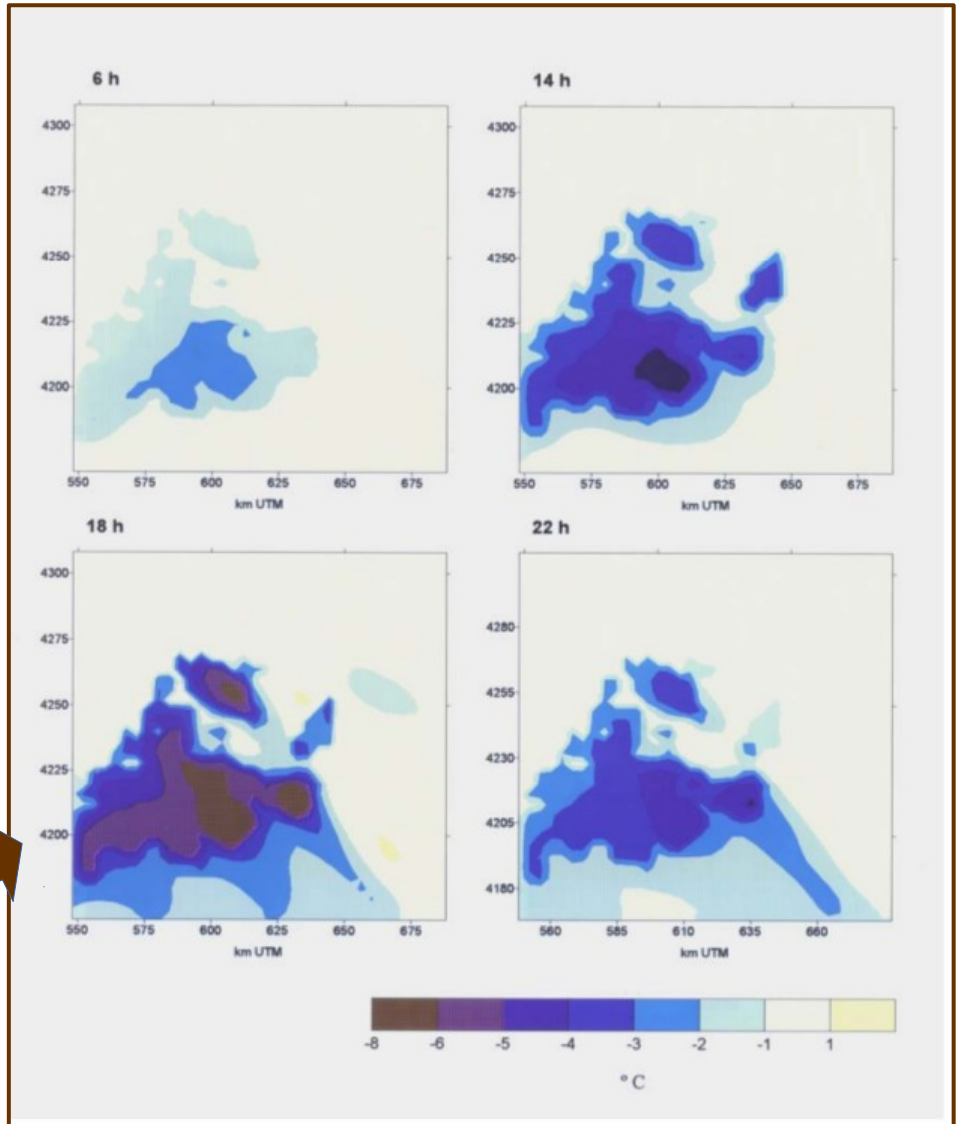
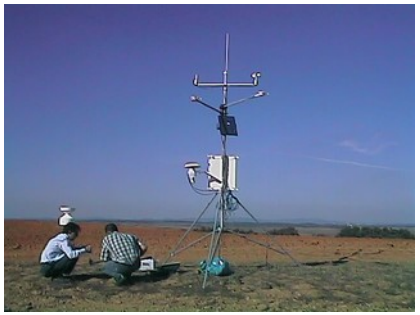
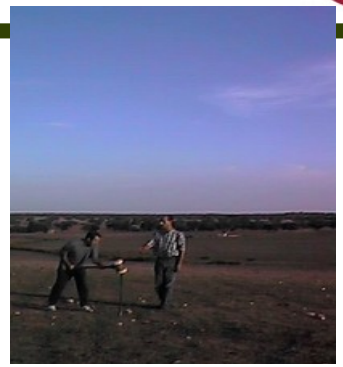


Figura 5.3 – Anomalia da Temperatura do ar aos 2m em simulações correspondentes ao mês de Julho. Forçamento atmosférico e radiativo com base em observações realizadas em Julho de 1994 na Mitra. Experiências R1(A5-35) eS1 (A6-35).

2. CICLUS field campaign

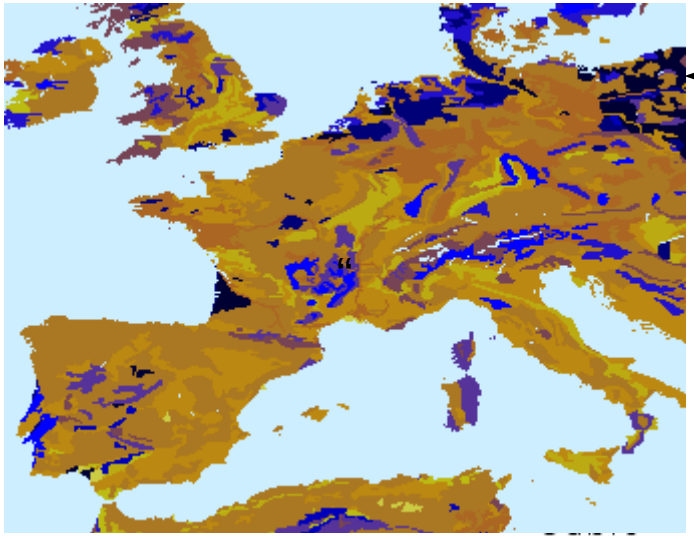




- A Portuguese national project (FCT),
  - PI: Pedro Miranda,
  - advisor: Joël Noilhan
- Continuous surface observations (2 years)
  - October 1997 - September 1999
  - Total of 13 weather stations
- Intensive observation periods
  - **24 and 25 July 1998**
  - May 2000
  - Radiosondes (3 in 3 hours)
  - Sodar
  - Eddy covariance system
- CICLUS experiment provide data for my PhD co-supervised by Joël

3. Global maps of sand and clay fractions

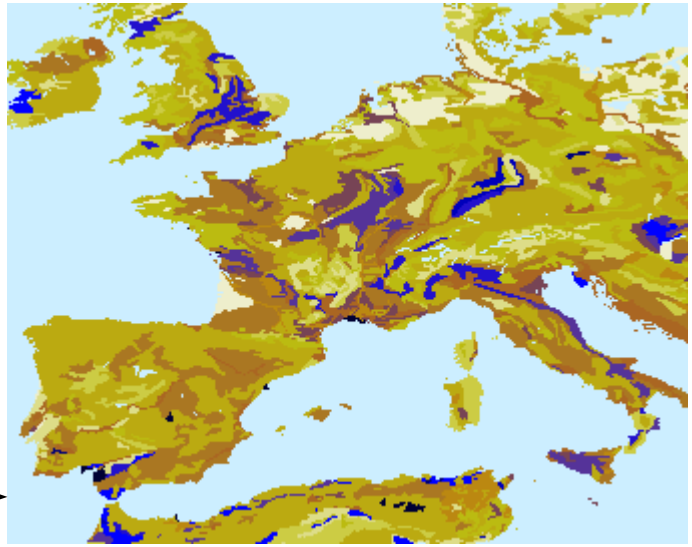
- Noilhan and Lacarrère (1995) proposed expressions to calculate the thermal and water parameters of the soil from the percentage of clay and sand present in the soil
- It was necessary to build global maps in order to use these expressions anywhere inside ISBA/Meso-NH
- As proposed by Joel, the FAO Soil Digital Map (1998) was used
  - based on the World Soil Map published by FAO between 1974 and 1978 at the 1: 5000000 scale
  - comprised 4930 different cartographic units
  - resolution of 5'× 5'
- The methodology to compute the textural fractions from the FAO units described in Salgado (1999), as a proceeding to the "Atelier ISBA", 6 mai 1999



sand_fao.dir

Files based on FAO (1998) used by Meso-NH until 3/4 years ago

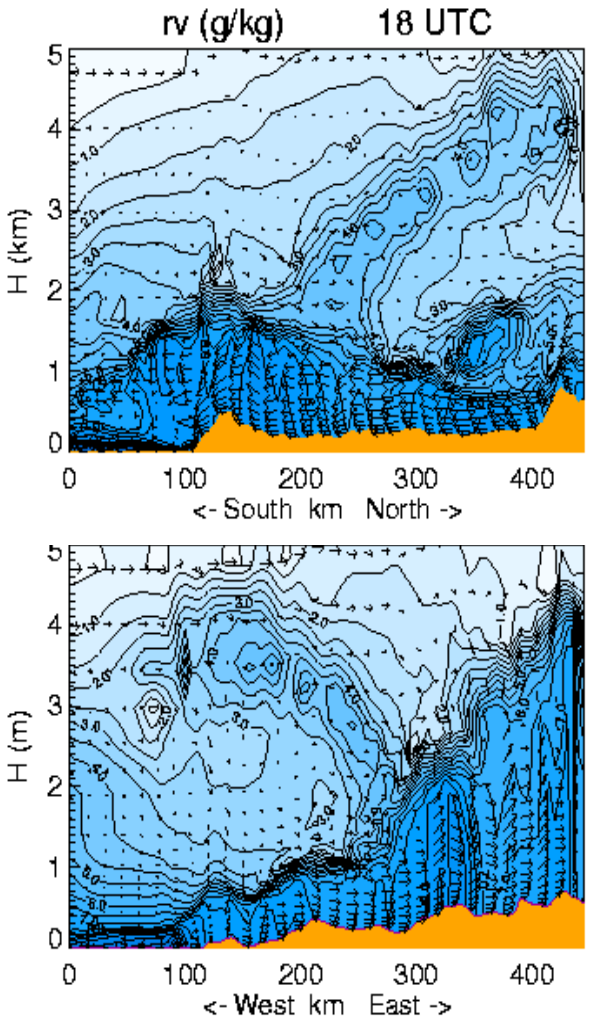
clay_fao.dir



4. Boundary layer development and summer circulation in Southern Portugal

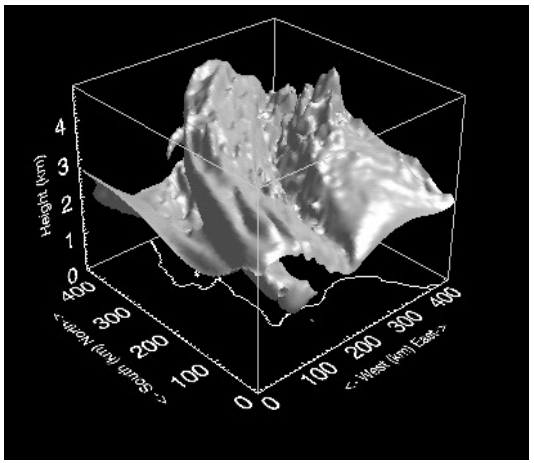
slide presented at Réunion Meso-NH 2001

24 / 25 July 1998

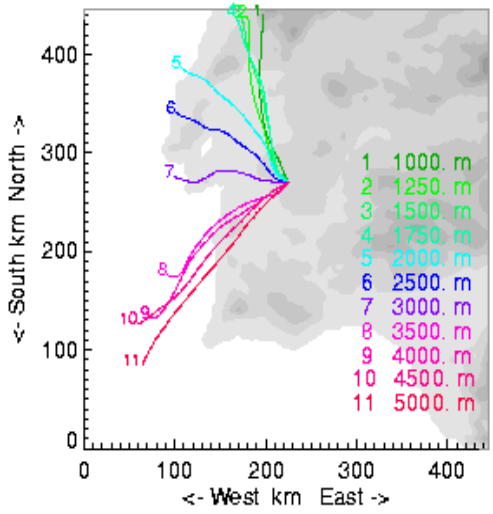


Cross-sections of wind and humidity

3D Projection of a mixing ratio iso-surface (3.5 g kg-1) at 18 UTC



Surface projection of Simulated trajectories of air parcels that reach the vertical over Évora at 18 UTC at several levels



Boundary layer development and summer circulation in Southern Portugal

Later published in Tethys (Salgado et al. 2015)

- The simulations permits a better understanding of the dynamics and a quantification of the magnitude of the peninsular (Iberia) scale see breeze effects.
- The summer circulation generated by the land-sea contrasts is organized by the Iberian thermal low system, well away from the direct effect of the sea breezes.
- The evolution of the BL in the interior of the Peninsula is strongly influenced by the horizontal transport of heat and moisture in the sea-breeze circulation, even in locations at more than 100 km from the coast; This influence occurs in the form of a bulk cooling of the BL in mid to late afternoon, depending on the distance from the coast.
- Evidence of complex 3D transport of humidity in the Iberian region, linking the coastal source to the mid troposphere where it interacts with the large-scale subsidence, associated with anticyclonic circulation in upper levels.

Tethys

Journal of Mediterranean Meteorology & Climatology

Tethys 2015, 12, 33–44
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ISSN-1697-1523
eISSN-1139-3394
DOI:10.3369/tethys.2015.12.03
Journal edited by ACAM

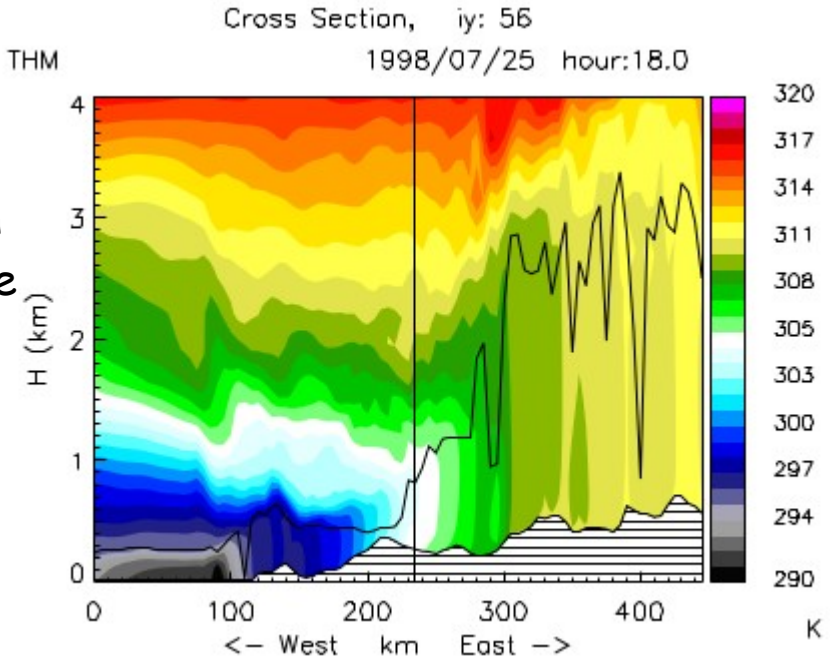
Boundary layer development and summer circulation in Southern Portugal

R. Salgado[1], P. M. A. Miranda[2], P. Lacarrère[3] and J. Noilhan[3]
[1]Instituto de Ciências da Terra, Universidade de Évora, Portugal
[2]Instituto Dom Luiz, Universidade de Lisboa, Portugal
[3]CNRM-GAME, Météo-France, France
Received: 15-VII-2015 – Accepted: 04-XII-2015 – **Original version**

Correspondence to: rsal@uevora.pt

Abstract

The summer circulation in Southwest Iberia is studied using data from a field experiment and numerical simulations by the non-hydrostatic mesoscale model, Meso-NH. The model is initialized and forced by the ARPEGE numerical weather prediction model. Surface fields and parameters were obtained from a number of different sources and validated against observations and long period integrations of the land surface model. The numerical simulations capture most

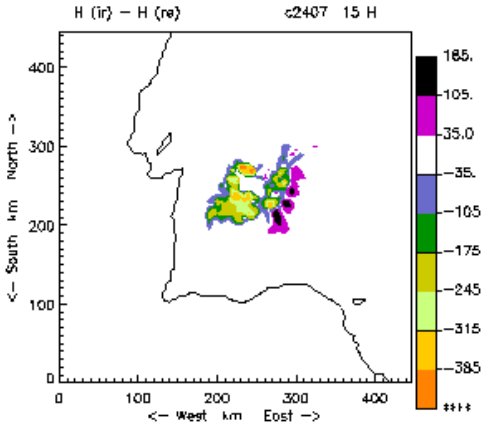


W-E cross section of potential temperature

5. Returning to the impact of Reservoir and Irrigation

- First based on one case study: the *ciclus* IOP

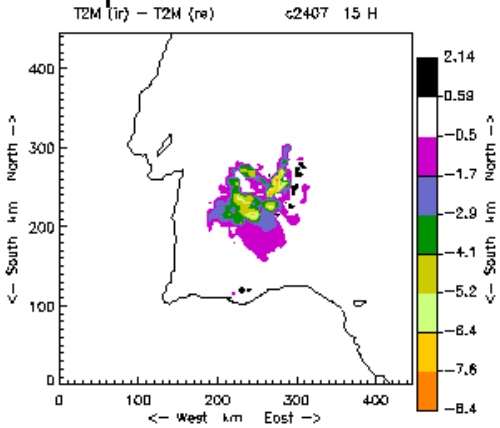
24 / 25 Juillet 1998



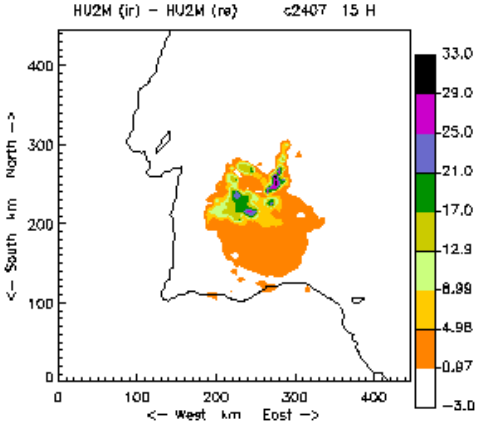
Flux de chaleur sensible à surface (W m^{-2})

Impact de l'irrigation différences entre le cas irriguée e le cas de contrôle (15 UT)

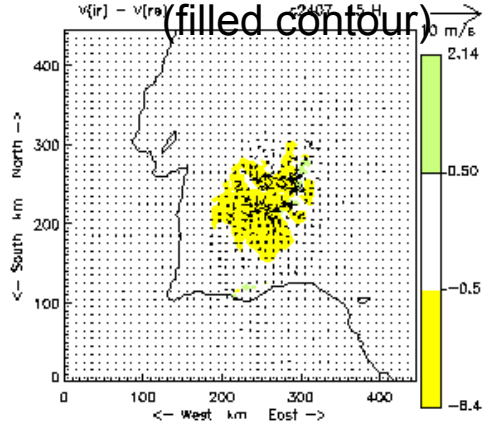
Température de l'air à 2 m



humidité de l 'air à 2 m



Vent horizontale (vecteurs) sur la température de l'air (filled contour)



slide presented at Réunion Meso-NH 2001

Impact of Reservoir and Irrigation on temperature

- The results of this case study confirm the initial estimates but have much more detail
- The impact on Tmax can reach -8°C
- The impact on Tmin is negative over irrigated areas (~- 2°C) and positive over reservoir (~+2°C)

Figure from Salgado (2006) PhD thesis

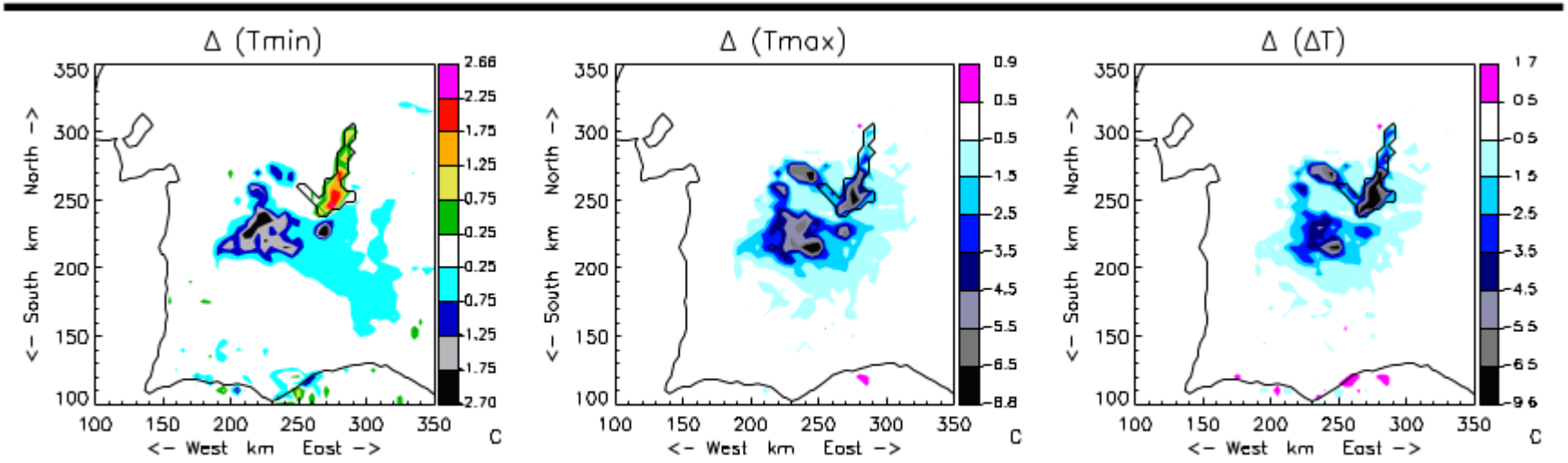
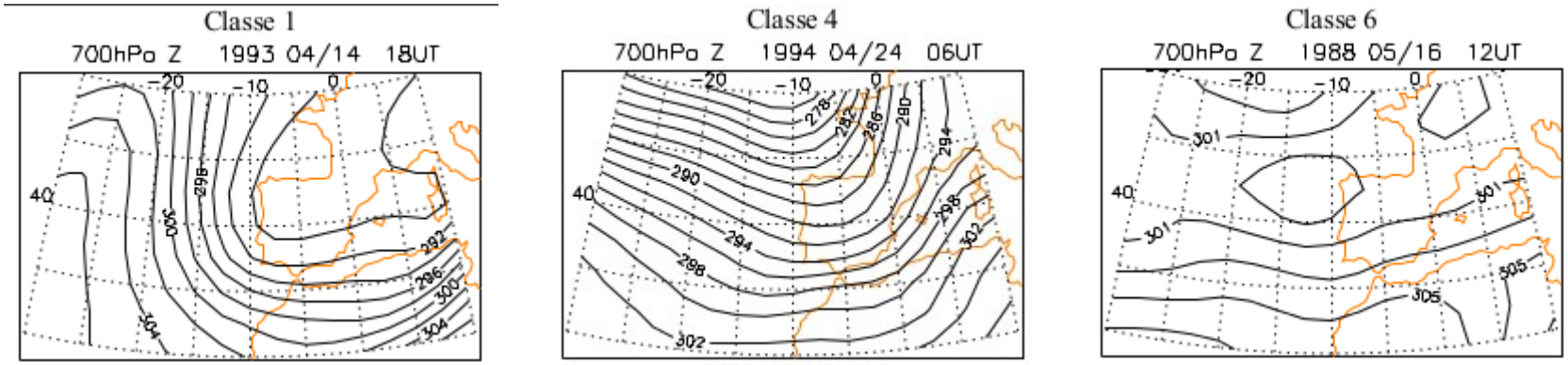


Figura 4.10 Anomalia nos campos da temperatura mínima diária do ar, temperatura máxima diária do ar e amplitude térmica diária. Foram considerados os resultados dos 2 dias simulados.

Objective classification of weather states

- In order to generalize the conclusions for the whole spring and summer period
- Following a suggestion of Joël, Silvie Donnier perform the classification
  - based on the 700hPa geopotential field, using a cluster analysis algorithm following Champeaux et al (1990)
  - using ECMWF reanalysis 1979-1999 at 2.5° resolution
  - April to December
  - considering 10 classes, each with one gravity centre and one *étalon* (the element closest to the centre)
  - Each class has a frequency



The 3 more frequent classes

Average impact of irrigation

- A case study representative of each weather regime were selected and simulated.
- Each case was analysed and discussed
- Based on the frequencies of each state, an average impact was calculated.

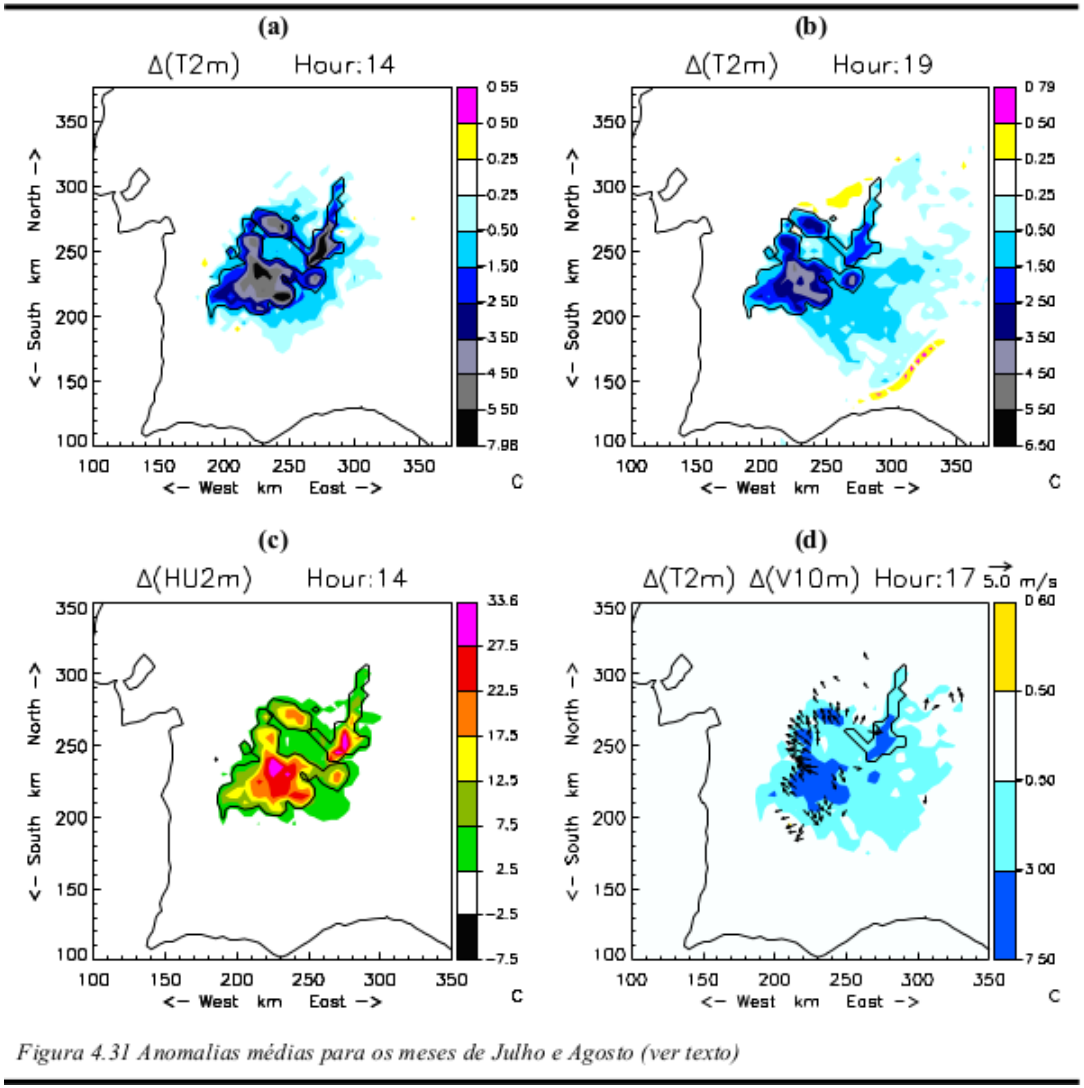


Figura 4.31 Anomalias médias para os meses de Julho e Agosto (ver texto)

Figure from Salgado (2006) PhD thesis

Average impact of irrigation in July and August PhD thesis

Impact on precipitation

- Case studies of late spring and summer convective precipitation events
- the impact is marginal

Figures from Salgado (2006) PhD thesis

Dia 21 de Maio

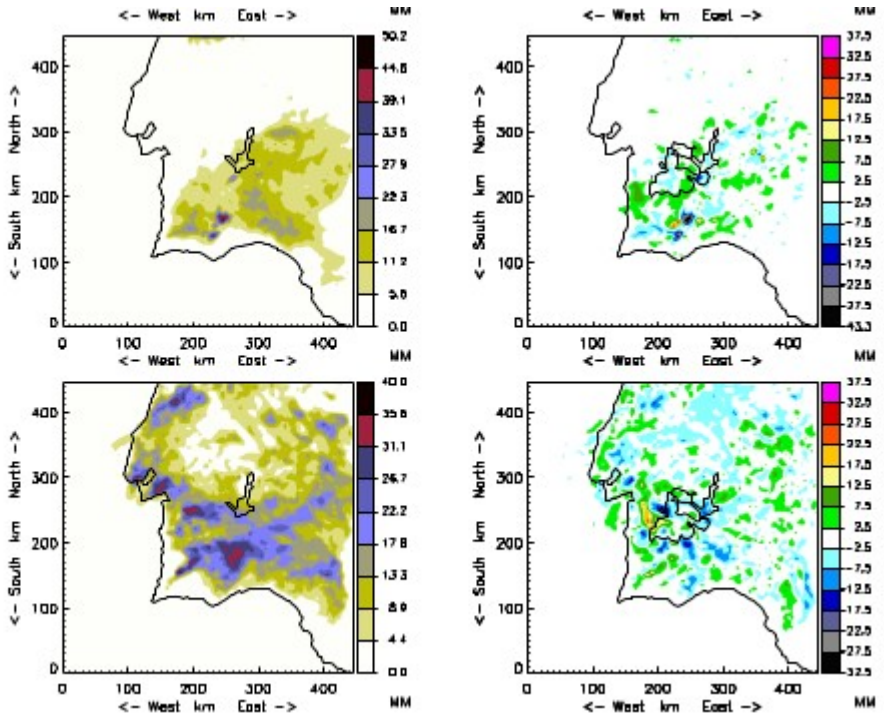
	MNH	MNH_ir
C	4.9	5.1
Ir	7.7	7.0
Al	9.6	8.0

Dia 22 de Maio

	MNH	MNH_ir
C	10.3	9.9
Ir	16.1.	15.6
Al	11.8	5.6

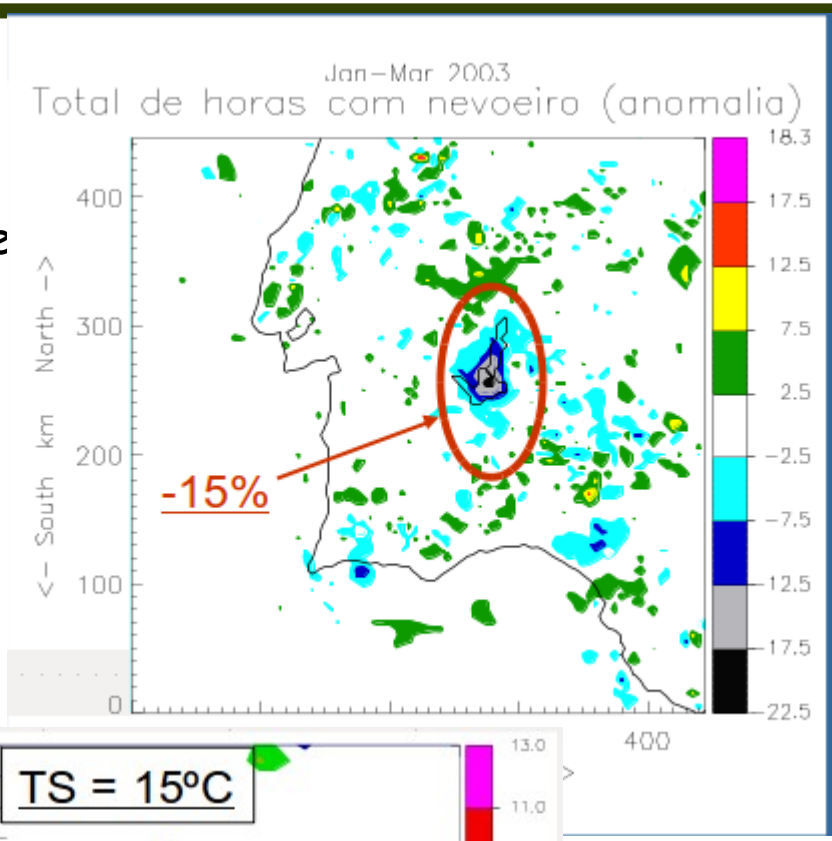
CONTROL

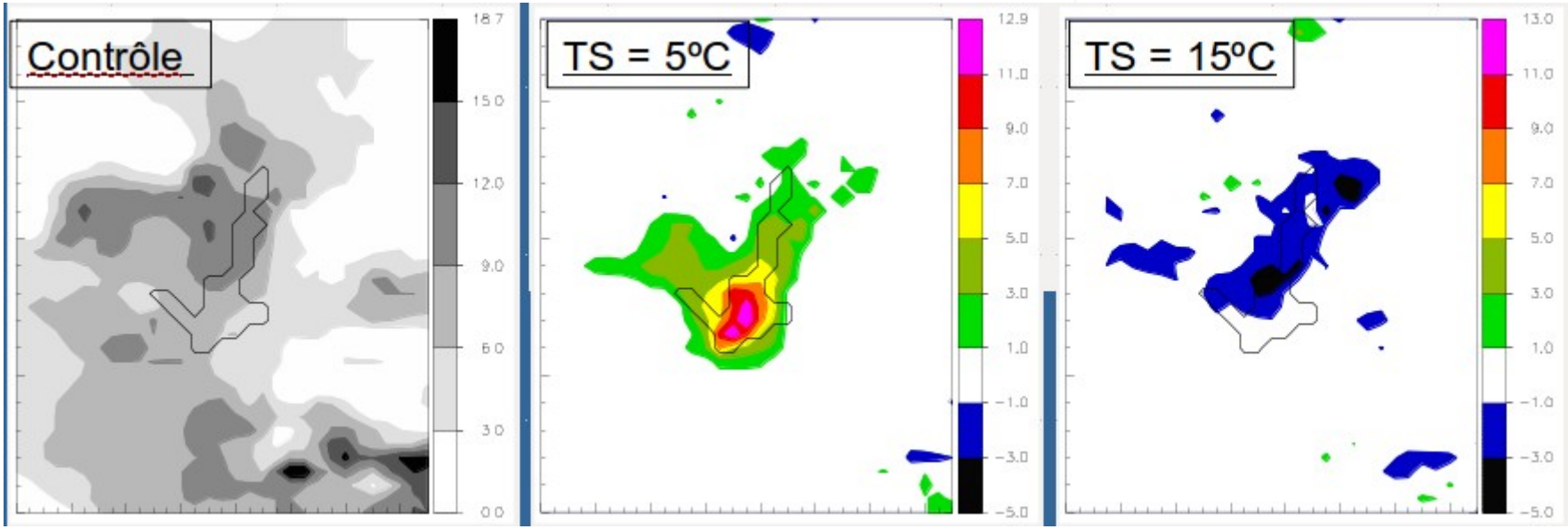
Anomaly
Irr - Contr



Impact on fog

- Significant reduction in the number of fog hours over the reservoir
- Increase around
- The impact of the lake on fog depends strongly on the difference between the surface water temperature and the daily minimum air temperature :
- When the water is warmer relatively to air, the impact is negative on fog;
- When the water is colder, the lake induces more fog
- **Need of a better representation of lake temperature**



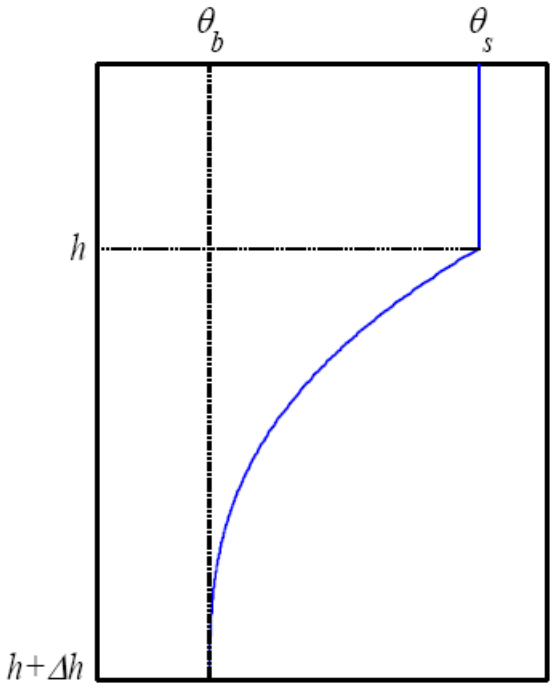


6. Interactive lakes in NWP models?

- In 2007/2008 different groups were working on this issue
- Joël proposed that I link a lake model (FLake) to SURFEX, together with Patrick Le Moigne.

FLake model (Mironov, 2008)

- Surface or mixed layer temperature, θ_s
- Bottom temperature, θ_b
- Mixed layer depth, h
- Shape factor , C_T



The evolution are based on 4 equations:

- 2 Equations for conservation of energy
- Evolution of h
- Evolution of C_T

Coupling of the FLake model to the Surfex

- Published in BER: Salgado and Le Moigne (2010)
- Describes a validation of the coupled system Surfex-FLake based on measurements carried out on the Alqueva reservoir in southern Portugal

BOREAL ENVIRONMENT RESEARCH 15: 231–244
ISSN 1239-6095 (print) ISSN 1797-2469 (online)

Helsinki 30 April 2010

Coupling of the FLake model to the Surfex externalized surface model

Rui Salgado[1)] and Patrick Le Moigne[2)]

[1)] *Centro de Geofísica de Évora, University of Évora, P-7000 Évora, Portugal*
[2)] *CNRM/GAME, Météo-France/CNRS, F-31057 Toulouse, France*

Received 17 Feb. 2009, accepted 9 Sep. 2009 (Editor in charge of this article: Veli-Matti Kerminen)

Coupling of the FLake model to the Surfex

- Published in BER: Salgado and Le Moigne (2010)
- Describes a validation of the coupled system Surfex-FLake based on measurements carried out on the Alqueva reservoir in southern Portugal
- Shows how the use of FLake in the Surfex system improves surface temperature and turbulent fluxes at the water–atmosphere interface
- adapt the FLake model to warm lakes

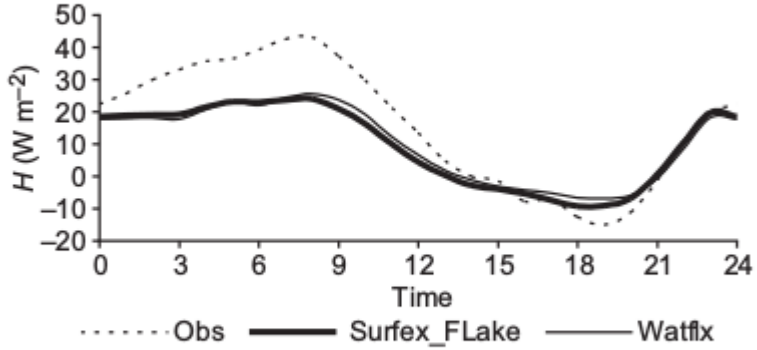


Fig. 10. Mean daily cycles of observed and modelled (FLake and Watflx) sensible heat fluxes.

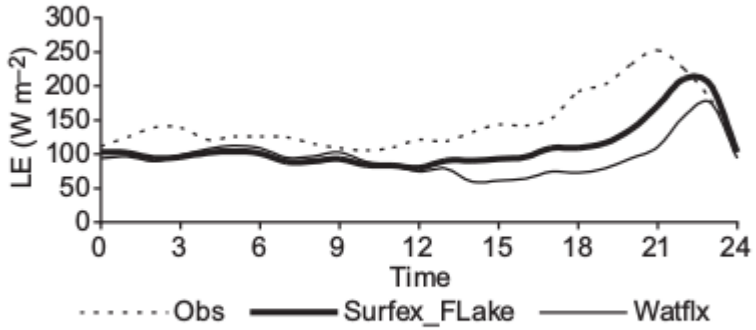


Fig. 11. Mean daily cycles of observed and modelled (FLake and Watflx) latent heat fluxes.

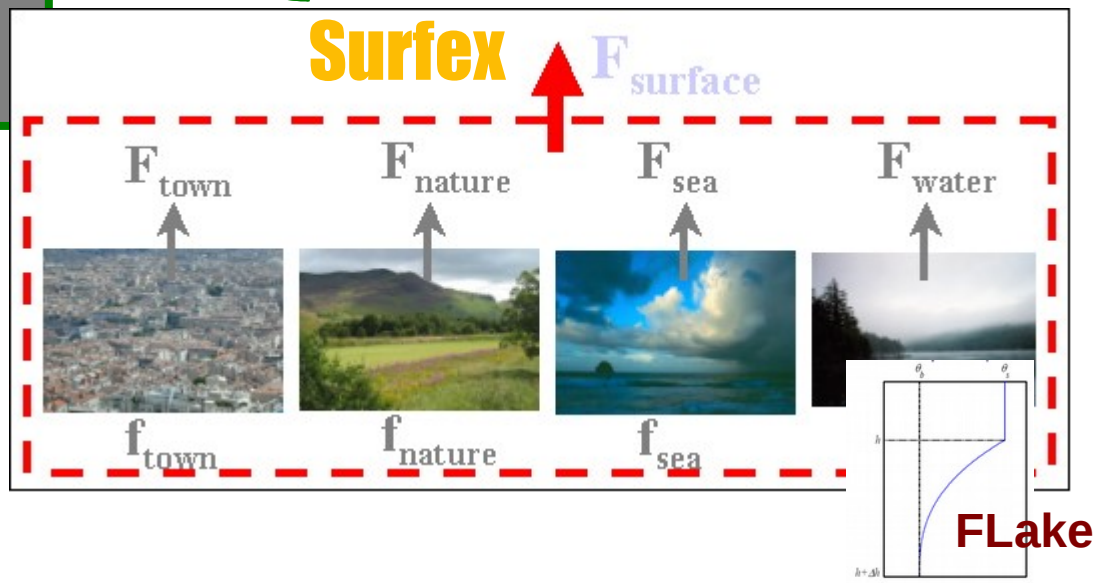
Coupling FLake to SURFEX

Méso-NH
AROME
Arpège / Aladin

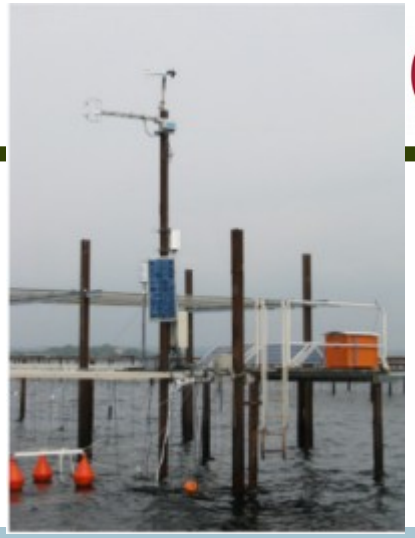
albedo
emissivity
radiative temperature

momentum flux
sensible heat
latent heat
CO2 flux
Chemical fluxes

Atmospheric forcing
Sun position
Downward radiative fluxes



Evaluated using THAUMEX data



- Later validated against THAUMEX (2011) data
- Coordinated by Patrick Le Moigne
- Participation of R. Salgado and M. Potes (Uevora)
  - Determination of the extinction coefficient of light in water
  - Potes et al., 2013, Tellus

Le Moigne et al., 2013

Tellus SERIES A DYNAMIC METEOROLOGY AND OCEANOGRAPHY
PUBLISHED BY THE INTERNATIONAL METEOROLOGICAL INSTITUTE IN STOCKHOLM

Evaluation of the lake model FLake over a coastal lagoon during the THAUMEX field campaign

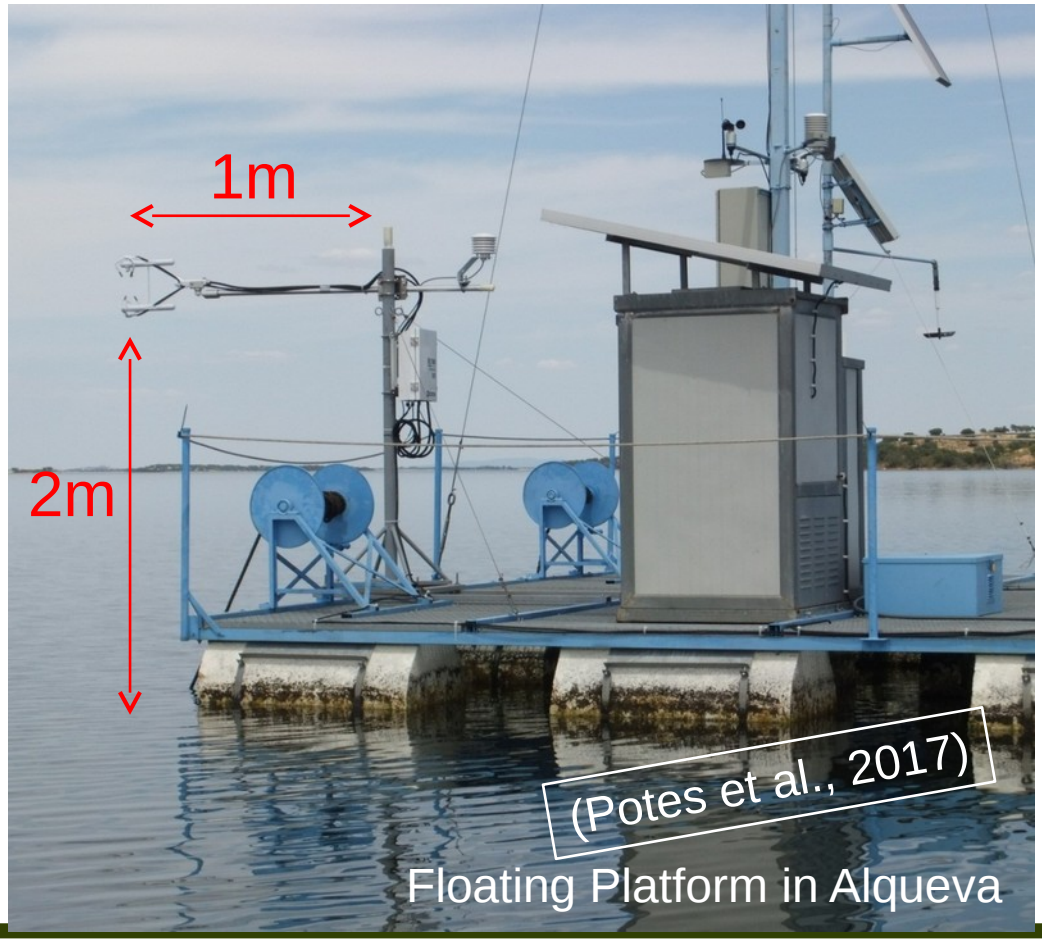
By PATRICK LE MOIGNE[1]*, DOMINIQUE LEGAIN[1], FRANCK LAGARDE[2], MIGUEL POTES[3], DIANE TZANOS[1], ERIC MOULIN[1], JOEL BARRIÉ[1], RUI SALGADO[3], GRÉGORY MESSIAEN[2], ANNIE FIANDRINO[2], SYLVIE DONIER[1], OLIVIER TRAULLÉ[1] and MARIA JOÃO COSTA[3], [1]*CNRM-GAME, Météo-France/CNRS UMR 3589, 42 Avenue Gustave Coriolis, 31057 Toulouse Cedex, France*; [2]*IFREMER, B.P. 171, Bd Jean Monnet, 34203 Sète Cedex, France*; [3]*Centro de Geofísica de Évora, Universidade de Évora, Rua Romão Ramalho, 59, 7000 Évora, Portugal*

(Manuscript received 26 March 2013; in final form 10 September 2013)

Following the example of Joel and his legacy, we continue

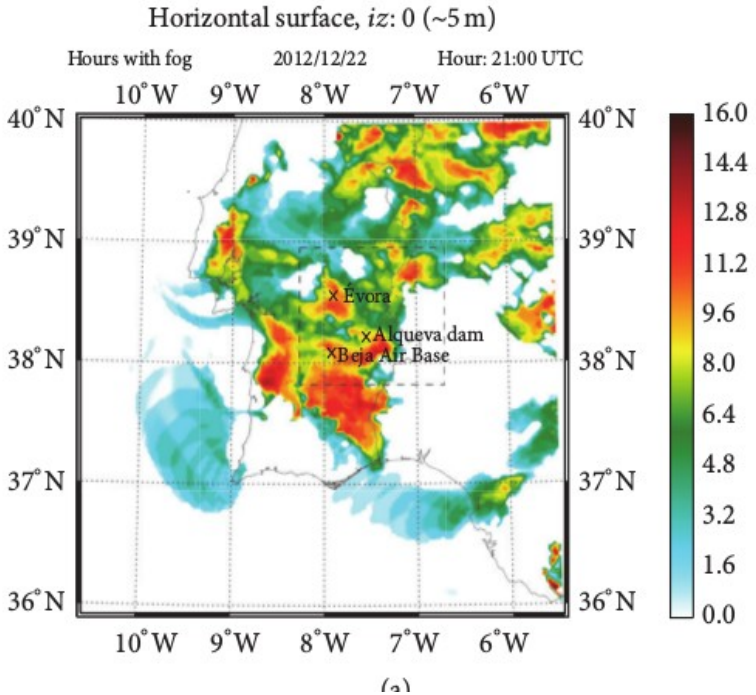
Observing the Surface-Atmosphere transfers

- Eddy covariance measurements
- Energy fluxes (radiative and sensible and latent heat), CO2 and H2O over the reservoir

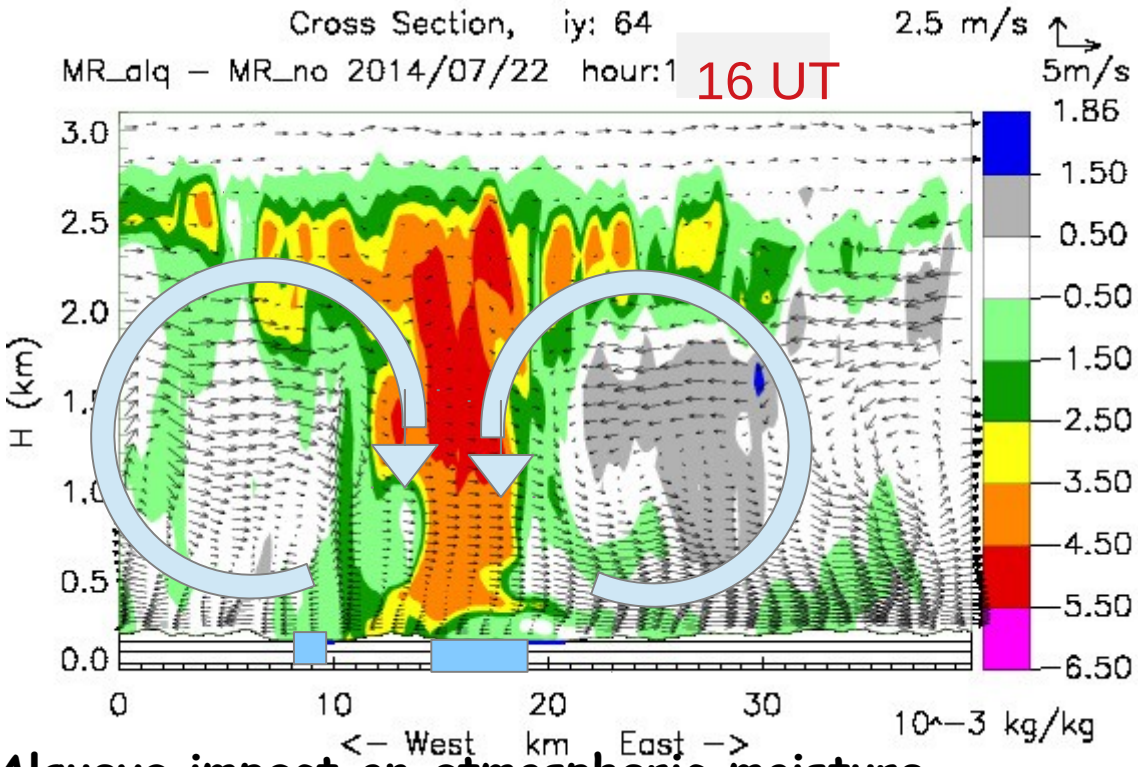


- Boundary Layer characterization

Modelling



Simulation of the "number of hours with fog" between 21:00 and 15:00 UTC



Alqueva impact on atmospheric moisture

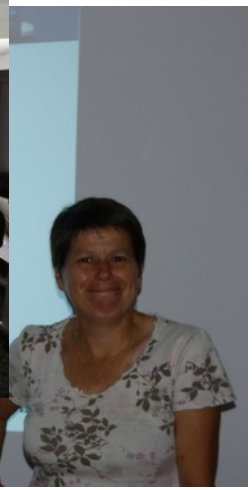
- Alqueva – NoAlqueva water vapor anomaly and wind in Alqueva case
- 250 m resolution, West-Est crosssection, crossing the reservoir
- Afternoon decrease of mixing ratio over the water reservoir

(Iakunin et al., 2018)

Collaborating and teaching young scientists

ALEX Summer School 2014 with Patrick Le Moigne

Meso-NH Tutorial in Évora (2016) with Christine Lac



ALOP Summer School 2018 with Florence Habets and Gianpaolo Balsamo

Co-orientation of Flavio Couto's thesis with Véronique Ducrocq
Couto *et al.*, 2016 and 2017

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Understanding significant precipitation in Madeira island using high-resolution numerical simulations of real cases

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