Actividades e interesses do Instituto de Ciências da Terra relacionados com a Previsão Numérica do Tempo

Rui Salgado com
ICT – Grupo 1 – Atmospheric Sciences, Water and Climate

Models

Models in use in Evora (ICT)

- NWP in mesoscale: BRAMS, WRF, AROME, MESO-NH
- Surface (coupled or stan-alone): SURFEX platform
- Lake models: FLake and LAKE
- Radiation: Ecrad and LibRadtran

Observations

- Atmosphere
  - Évora Observatory, Meteorological and radiometric networks, Field campaigns
- Lake (Alqueva reservoir)
  - floating platform, field campaigns

Computational infrastructure

- Terra Cluster:
  - 128 processing cores (32 per node)
  - 157.1GB. total RAM memory
  - The processors are Xeon(R) CPU E5-2660 0 @ 2.20GHz
- Khromeleque Cluster:
  - 16 nodes with 4 AMD Opteron 6376 (64 cores 64 bits a 2.3 GHz)
  - 1 head node (2 x Intel Xeon E5 2650, 32 GB)
  - node 2 x Intel Xeon E5 2640v2, 64 GB, com 2 Xeon Phi 7210
  - node 2 x Intel Xeon E5 2690v2, 128 GB, com 1 nVidia Tesla K20
  - Infiniband backbone FDR 4x (56 Gbps)
  - distributed filesystem 100 TB

Meso-NH
mesoscale non-hydrostatic model

- A state-of-art" non-hydrostatic non-hydrostatic mesoscale atmospheric model developed by the Laboratoire d'Aérologie and by CNRM/Météo-France.
- Incorporates a non-hydrostatic system of equations, for dealing with scales ranging from large (synoptic) to small (large eddy) scales;
- Has a complete set of physical parameterizations, which are particularly advanced for the representation of clouds and precipitation;
- Allows a multi-scale approach through a grid-nesting technique;
- Is a versatile code, vectorized, parallelized, operating in 1D, 2D or 3D designed to handle real situations as well as academic cases;
- Is coupled with a chemistry module and a lightning module;
- Is coupled to a Forest Fire propagation model (FOREFIRE)
- Has observation operators that compare model output directly with satellite observations, radar, lidar and GPS.

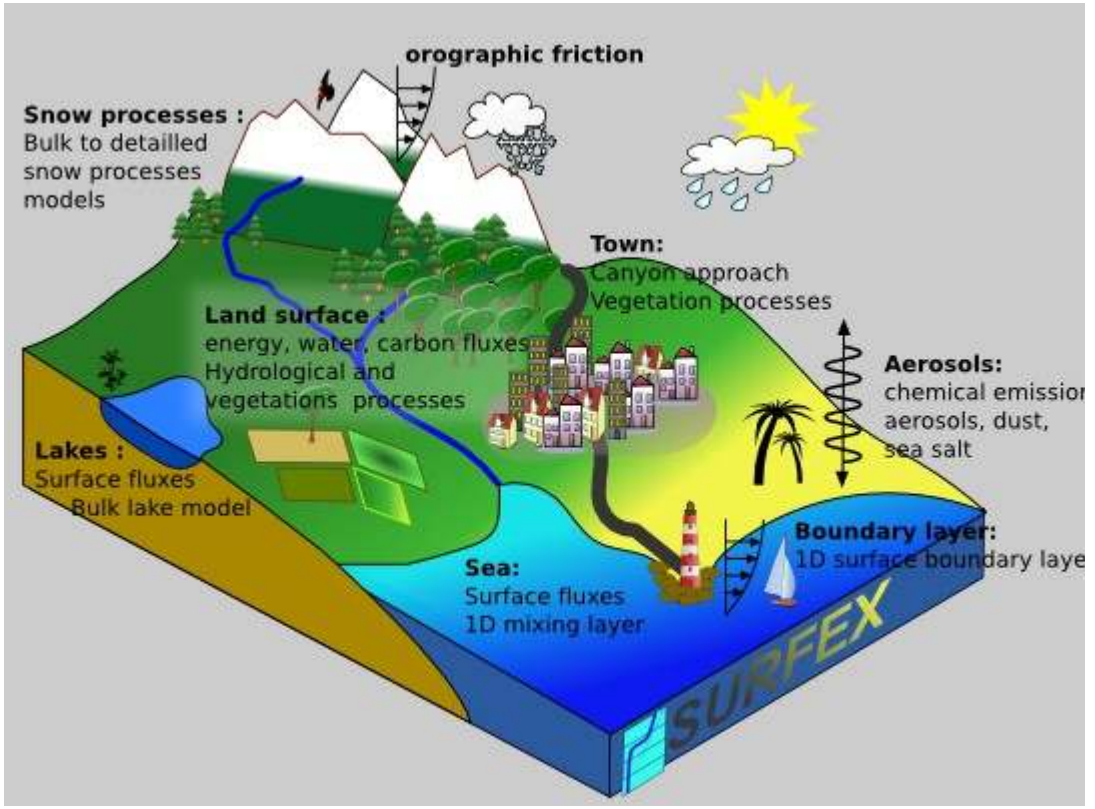
Reference: *Lac, C. et al., 2018*

Meso-NH
mesoscale non-hydrostatic model

- Is coupled to the SURFEX platform of surface models for the representation of surface atmosphere interactions
  - SURFEX is used in AROME, HARMONIE, …
- Share the *Physics* with AROME (runs operationally in IPMA)
- Share the radiative code of IFS (now EcRAD)
- Is the research model of Météo-France: new developments may be included in the operational versions.
- participation in the steering committee and in biennial meetings

SURFEX

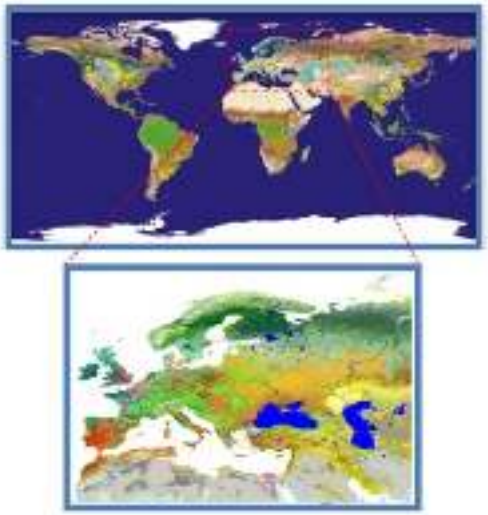
- SURFEX (Surface Externalisée, in French, *Masson et al., 2013*) is a surface modelling platform developed by Météo-France in cooperation with the scientific community.
- SURFEX is composed of various physical models for **natural land** surface, **urbanized areas**, **lakes** and **oceans**.
- It also simulates chemistry and aerosols surface processes and can be used for assimilation of surface and near surface variables.
- SURFEX can be used in
  - stand alone mode
  - coupled to an atmospheric model.



- **SURFEX is used in the NWP models of the ALADIN – HIRLAM consortiums**

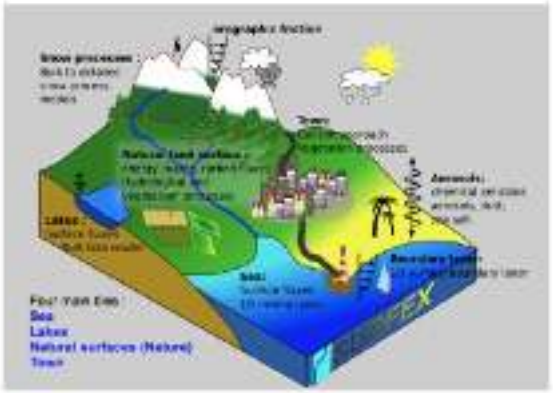
SURFEX basis

Land cover database

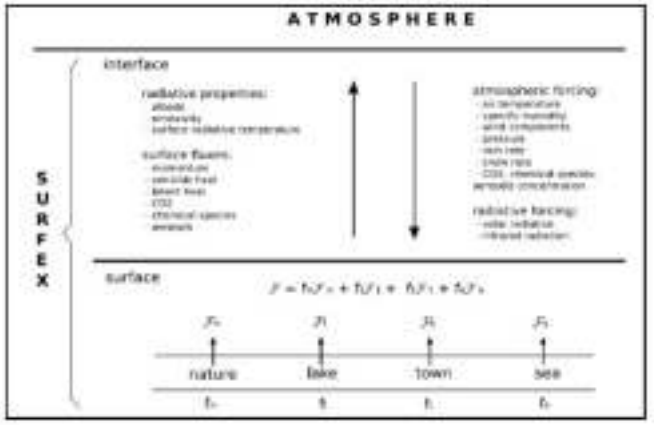


Tile %

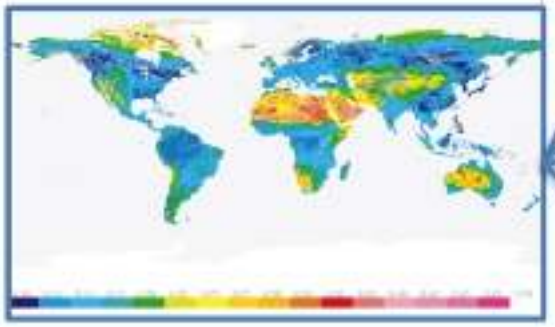
Tiling approach



Flux calculation



Model parameters



Models

Seas and oceans:
Prescribed SST, Charnock formulation
ECUME (multi-campaign parameterization), 1D Ocean Mixed Layer model

Lakes :
Prescribed LST, Charnock formulation
FLake lake model

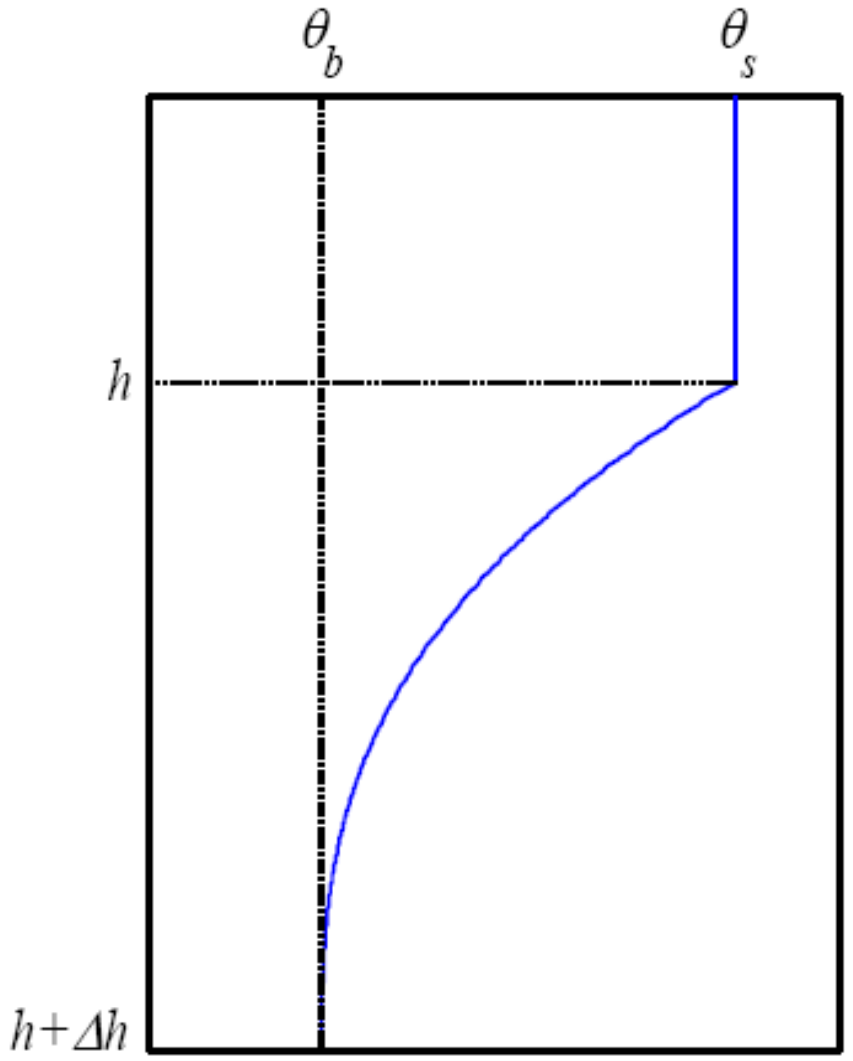
Soil and vegetation: ISBA
Force restore or diffusion for heat and water transfers in the soil

Town: TEB
Canyon concept, detailed radiative scheme
Vegetated buildings, impact of trees in canyon

Patrick Le Moigne et al., 2018

FLake

- Water temperature profile, two layers:
  - Mixed Layer (Constant Temperature)
  - thermocline (temperature profile is defined by a shape factor)
  - 4 variables (Ts, Tb, h and c)
  - important parameters:
    - lake depth
    - **Extinction Coefficient**
- Computationally cheap and good representation of Surface temperature evolution
- In use in SURFEX / AROME / Meso-NH and in ECMWF, DWD and MetOffice

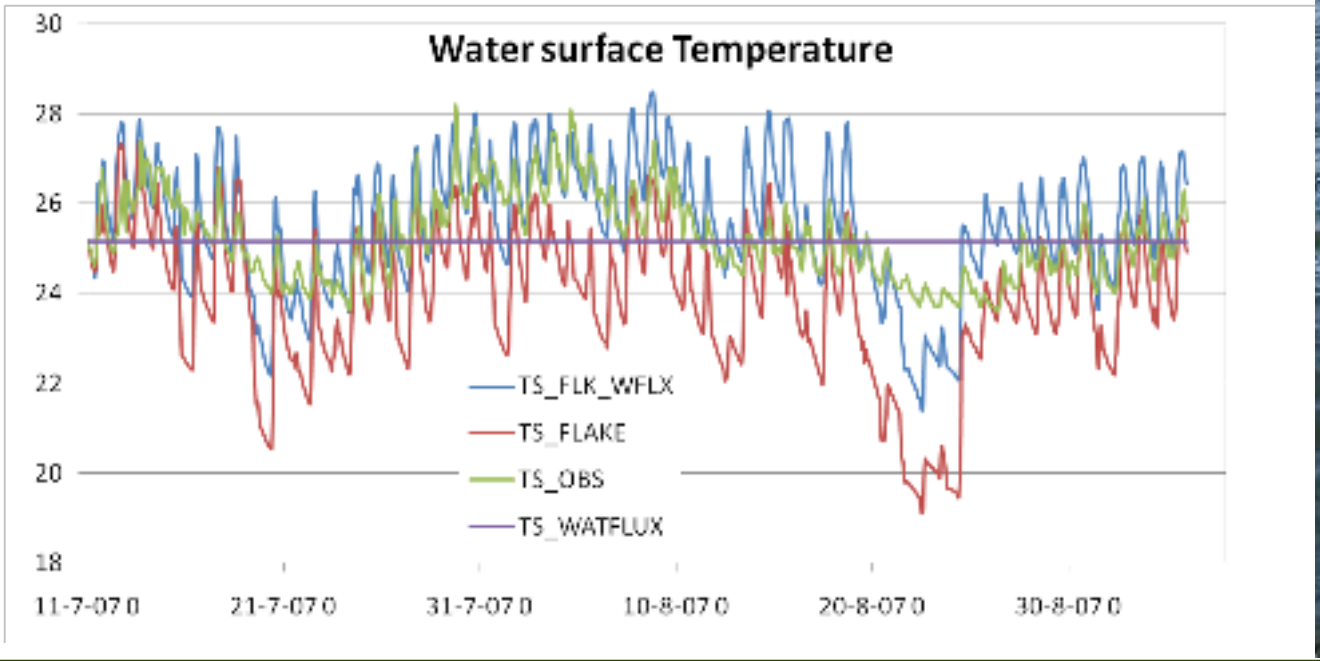


FLake

- Flake was tested with data from Alqueva, measured on a floating platform
- The tests were used to link FLake into SURFEX

  Salgado and Le Moigne (2010)
- Colaboration in IFS implementation

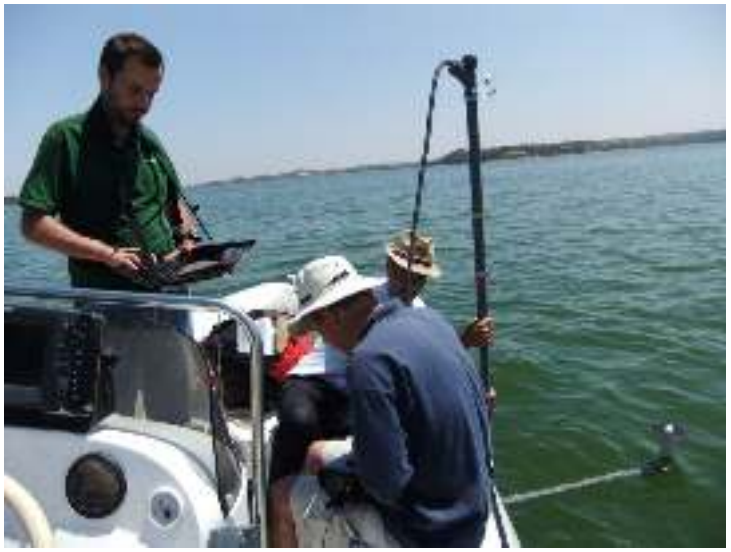
  Balsamo et al. (2012)



Extinction Coefficient: measurements

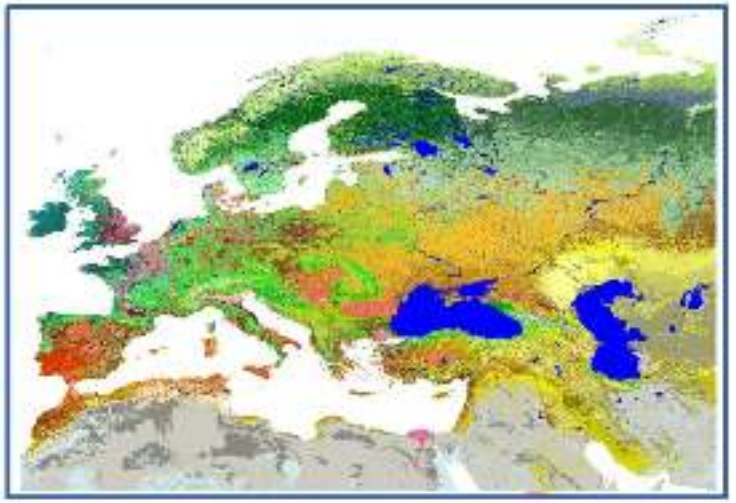
- Measurements of:
  - Underwater irradiation
  - Extinction coefficient
- Locals:
  - Alqueva reservoir (Potes et al., 2013, 2017)
  - Thau lagoon (Thaumex, LeMoigne et al., 2013)

- Development of a FieldSpec UV/VNIR da ASD coupled to an optical cable and a cosine receptor
- Apparatus developed by Miguel Potes (PhD thesis)



Ecoclimap

- Global land cover map of ecosystems (273 in version 2)
- Dataset of surface parameters associated for each grid mesh in tabular form:
  - albedo, LAI, % of vegetation cover, z_0, minimum stomatal resistance, and root zone.
- Now (Second Generation) is at 300m resolution
- Used by NWP models to produce physiographic maps ("climatologies")

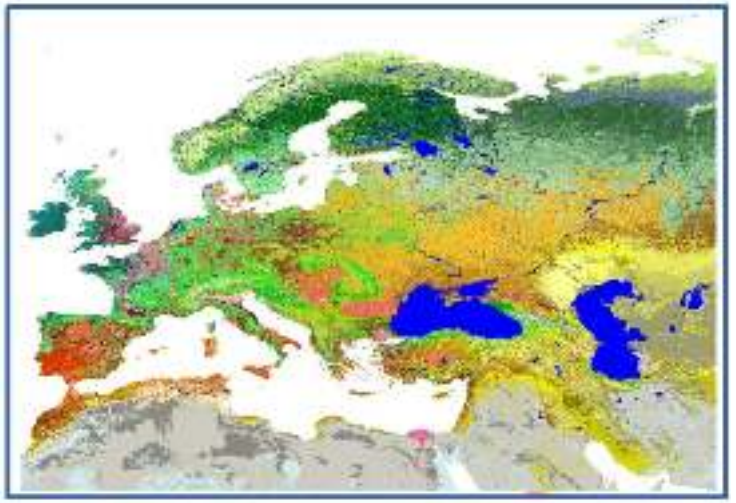


Ecoclimap-II map over Europe

Faroux et al., 2013

Ecoclimap

- Operational version used at IPMA don't included Alqueva
- The ALqueva was inserted in the Ecoclimap database by Carlos Policarpo et al (2017)
- and was implemented and tested by Sónia Assunção (Master thesis, 2017) e Maria Monteiro in a collaboration ICT/IPMA (see poster)



Ecoclimap-II map over Europe

Faroux et al., 2013

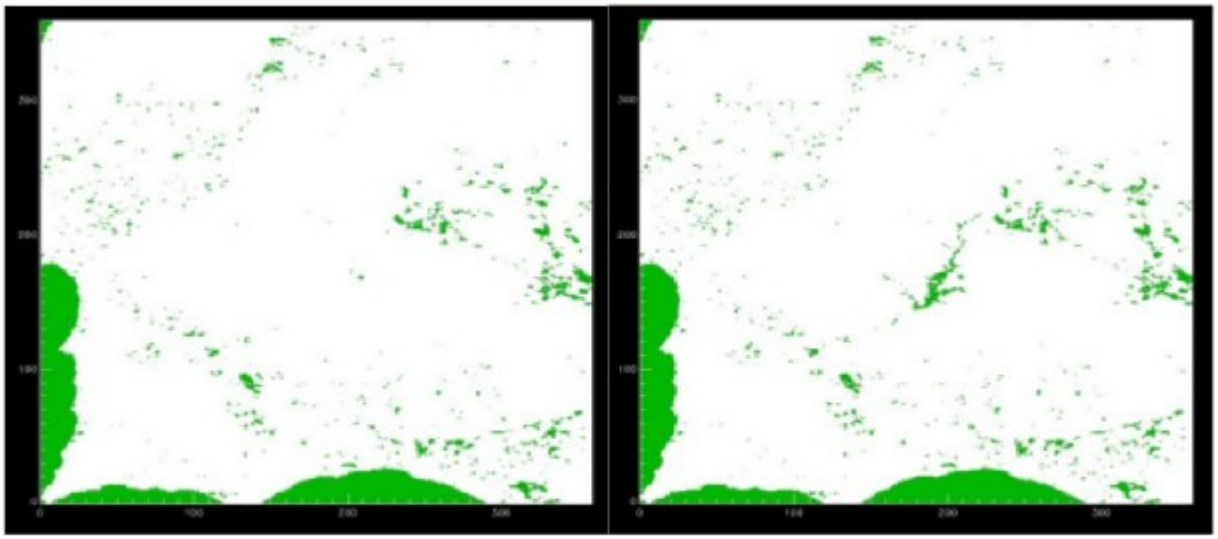
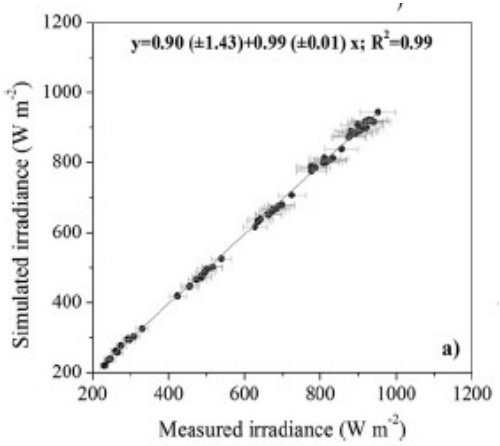


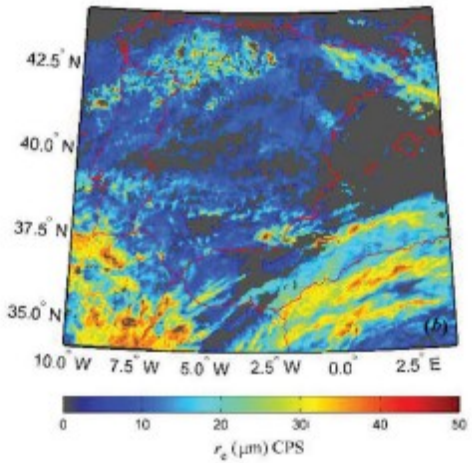
Figura 3 – Representação da base de dados ECOCLIMAP_II_v2.3 sem a fisiografia da albufeira de Alqueva (à esquerda) e com a fisiografia (à direita). As áreas a verde representam superfícies com água.

libRadtran

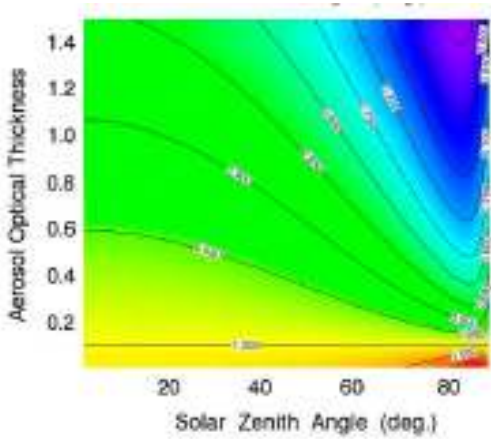
- library for radiative transfer http://libradtran.org
- Set of C and Fortran routines to compute solar and thermal radiation in the atmosphere (3D). Free under GNU GPL.
- Several examples of works done in ICT

Global irradiation: aerosols radiative forcing

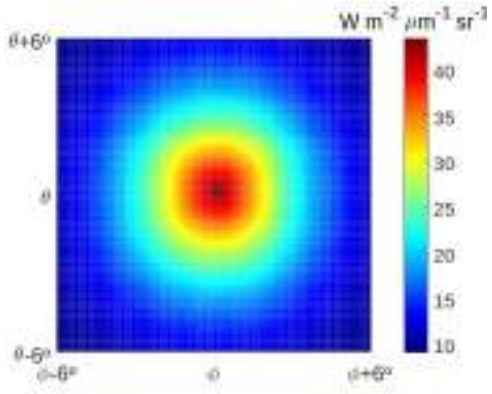




Remote sensing of cloud properties

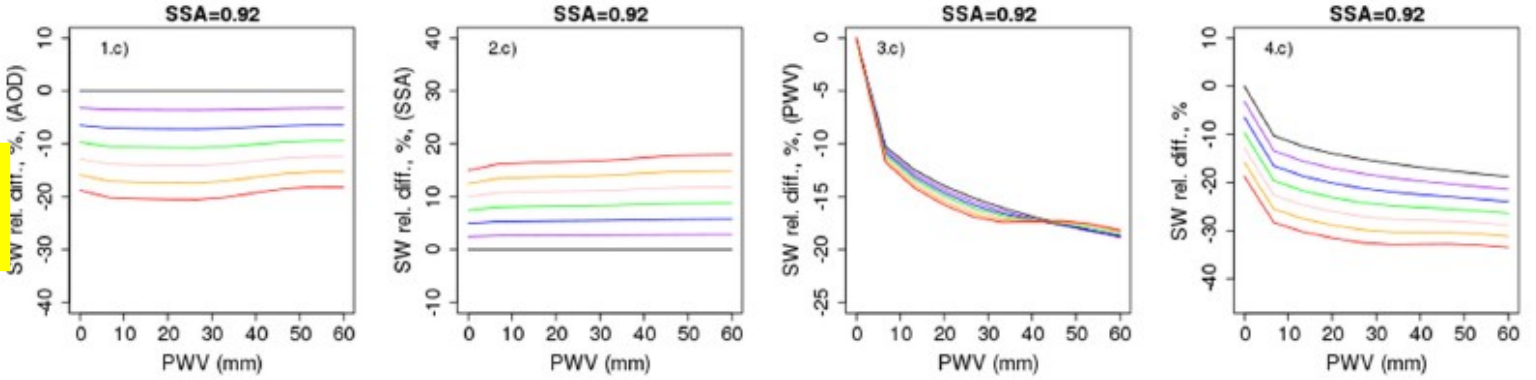


clear sky irradiation at the surface



diffuse irradiation in the circumsolar region

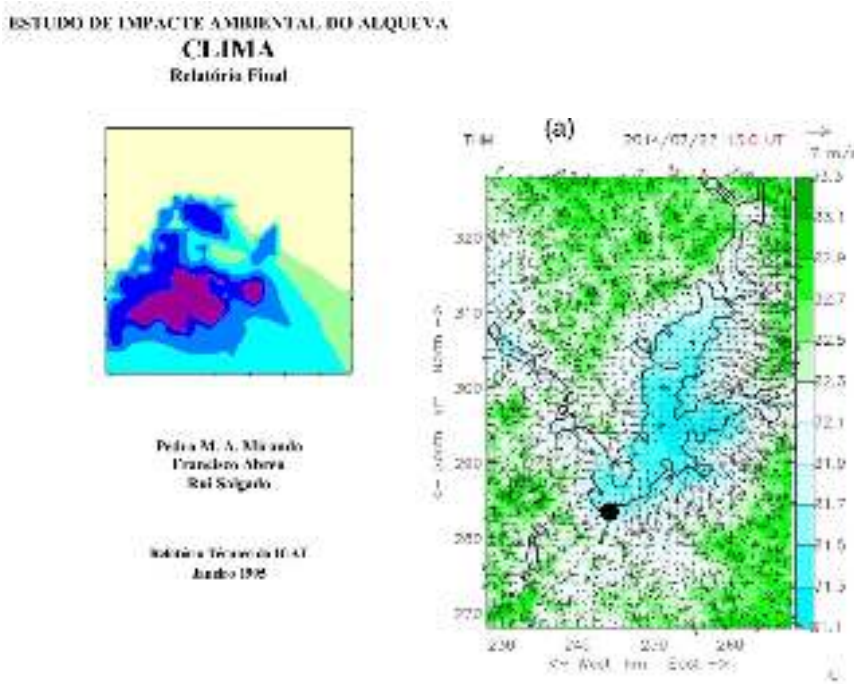
sensitivity tests to: aerosols and water vapour

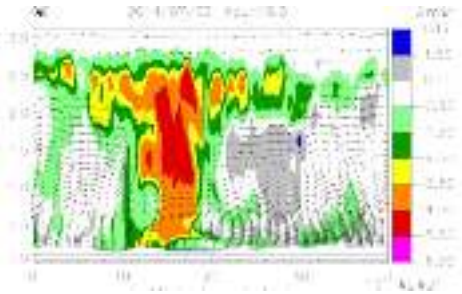


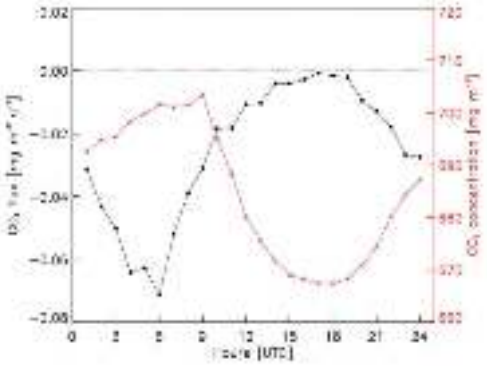
Applications

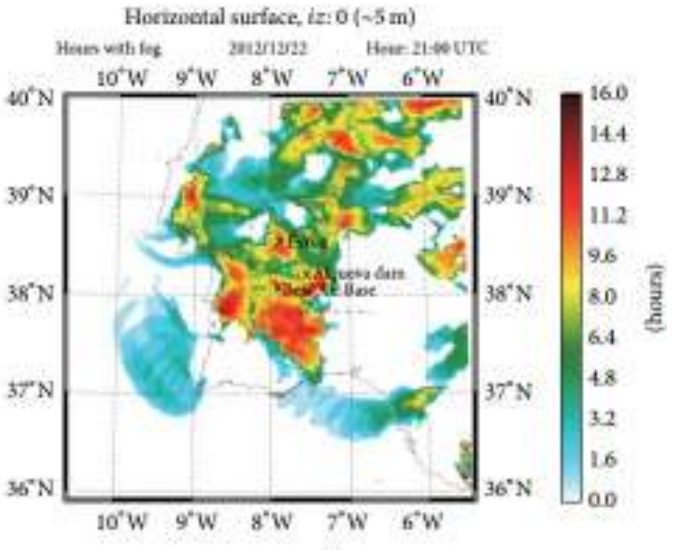
Climate impact of Alqueva

- Effects on Temperature and humidity (Miranda et al., 1995, Salgado, 2006)
- Effects on fog (Salgado, 2006, Policarpo et al., 2017)
- Characterization of the Lake Breeze (Iakunin et al., 2018)
- Effects in the atmospheric electrical field Lopes et al., 2016; Nicol et al., 2018
- Heat, water vapour and CO_2 fluxes (Potes et al., 2017)









Representation of lakes in NWP

Improvement of lake parameterization in MF models

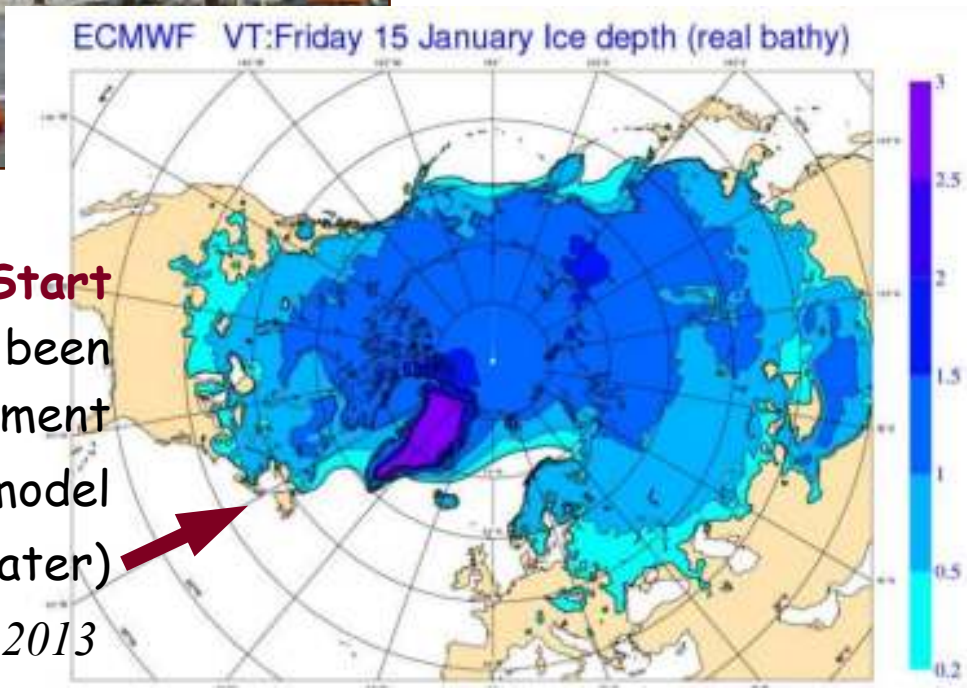
Due to the increase of horizontal resolution in models
Need to improve the diurnal cycle over lake areas
A step forward to data assimilation

SURFEX implementation of FLake model

Salgado and Le Moigne, 2010

Field Campaigns validations

THAUMEX, South-France : Le Moigne et al., 2013



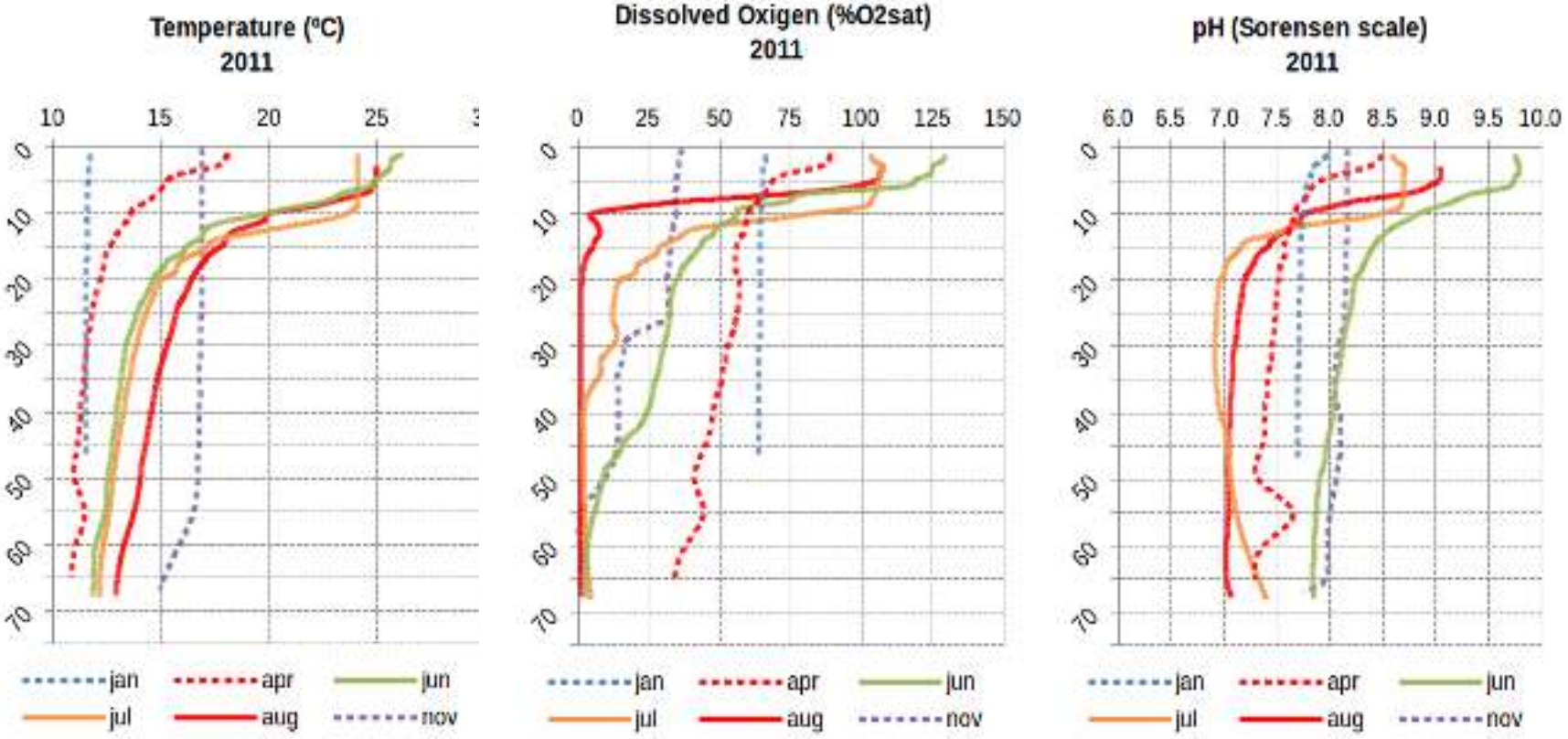
Cold Start

- A monthly climatology of FLake variables has been created using a Lake Planet experiment
  - This climatology is used by the ECMWF model
  - Example: Climatological Ice Depth (Above water)

Balsamo et al. 2013

Water quality forecast

- Forecast of water quality parameters using NWP
  - In-line or post-processing
- Using a Flake type approach (EcoFlake)
- Try a more physical (and chemical) based model (LAKE)
  - see Maksim's presentation



pattern of the profiles are similar.

Solar Radiation Forecast

- The use of solar energy in electricity generation is growing
- There are many new projects in Portugal, namely in Alentejo
- There is a need to improve solar radiation predictions based on NWP
  - Global Radiation
  - Direct Normal Radiation, for

DNI Predictions

- Concentrating solar photovoltaic (CPV) and thermal (CST) technologies require direct normal irradiance (DNI) forecasts
- DNI is a new ECMWF output, not validated
- New Radiative code (2017): EcRad
- 1st step: Access the quality of ECMWF forecast of DNI
  - Francisco Lopes et al. (2018)
    See his presentation

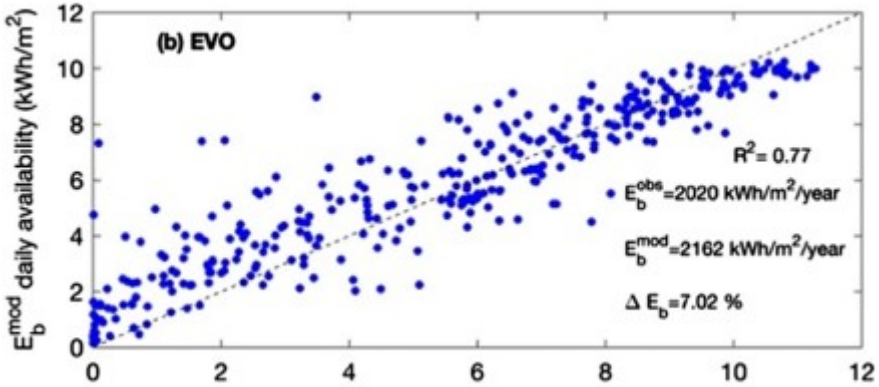

Contents lists available at ScienceDirect

Solar Energy

journal homepage: www.elsevier.com/locate/solener

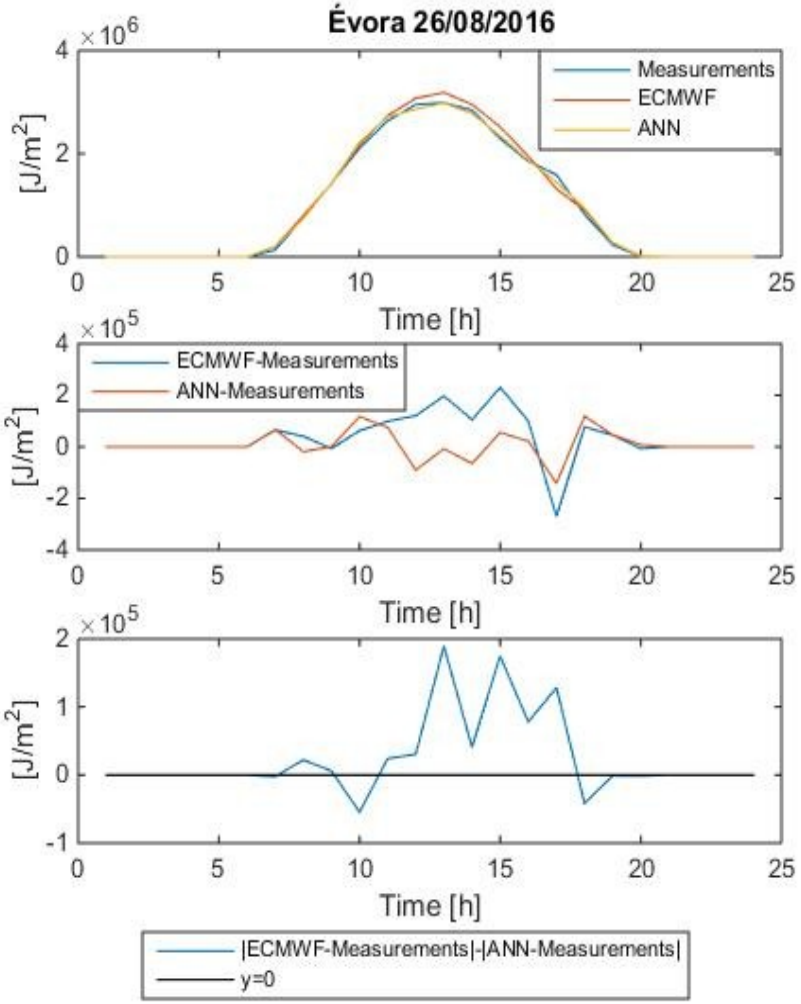
Short-term forecasts of GHI and DNI for solar energy systems operation: assessment of the ECMWF integrated forecasting system in southern Portugal

Francis M. Lopes[a,b,*], Hugo G. Silva[a,b,c], Rui Salgado[b,c], Afonso Cavaco[d], Paulo Canhoto[b,c], Manuel Collares-Pereira[a,b,c,d]



Improve Global Radiation prediction

- Study and development of a solar radiation predicting algorithm based on ECMWF's forecasts and ANNs
  - Sara Pereira et al. (2018) (See her presentation)
- Pos-processing technique
- ANN was trained and validated using data from ICT and IPMA stations



Orographic Precipitation - Madeira

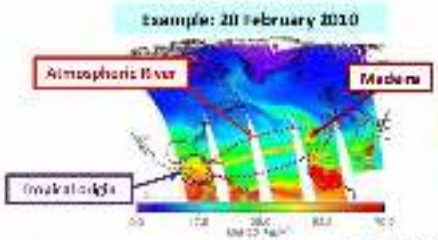
1. Introduction

Starting point

HPE in the 2009/2010 winter and the disaster on February 2010.

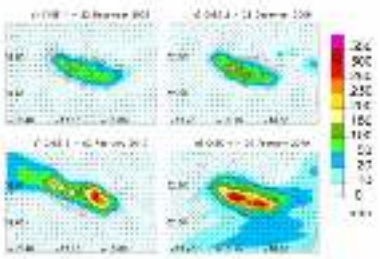
LARGE SCALE

A cyclone and frontal systems affecting the island.



MESOSCALE

MESO-NH simulations at 1 km resolution showed the **orographic effect** for HPE over the island, and maximum of accumulated precipitation in the highlands.

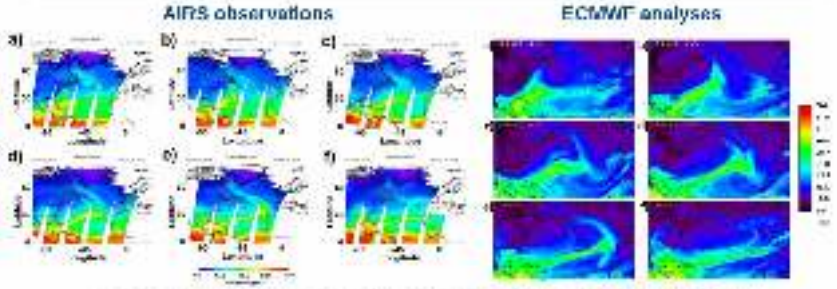


Couto et al. (2012)

3. Results

Large scale environment

The meridional water vapour transport through the Atmospheric Rivers (ARs) may be identified from the Aqua-AIRS or ECMWF analyses, as shown for the episode of 20 February 2010.



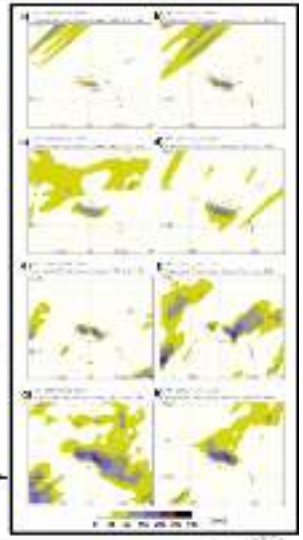
From an operational point of view, this information helps the HPE forecast, since this transport may be easily identified over the ocean several hours before it reaches the island.

3. Results

Local effects: Part I – AROME results for precipitation distribution

=> **The model captures the orographic signature** in the accumulated precipitation, as well as **the different rainfall patterns**. This result is evidenced by comparing the AROME outputs with those obtained with the MESO-NH model.

AROME outputs at 2.5 km resolution for four periods considered by **Couto et al. (2016)**



4. Conclusions and perspective

Conclusions

The satellite data may support the monitoring of water vapour transport over the Atlantic Ocean.

From the AROME analysis, at least when the orographic effects lead to quasi-stationary orographically induced precipitating systems, it is able to reproduce satisfactorily the different rainfall patterns in a short-range forecast.

For the season, the AROME captured the main significant precipitation periods in the three regions considered, despite some under or overestimation of the local values.

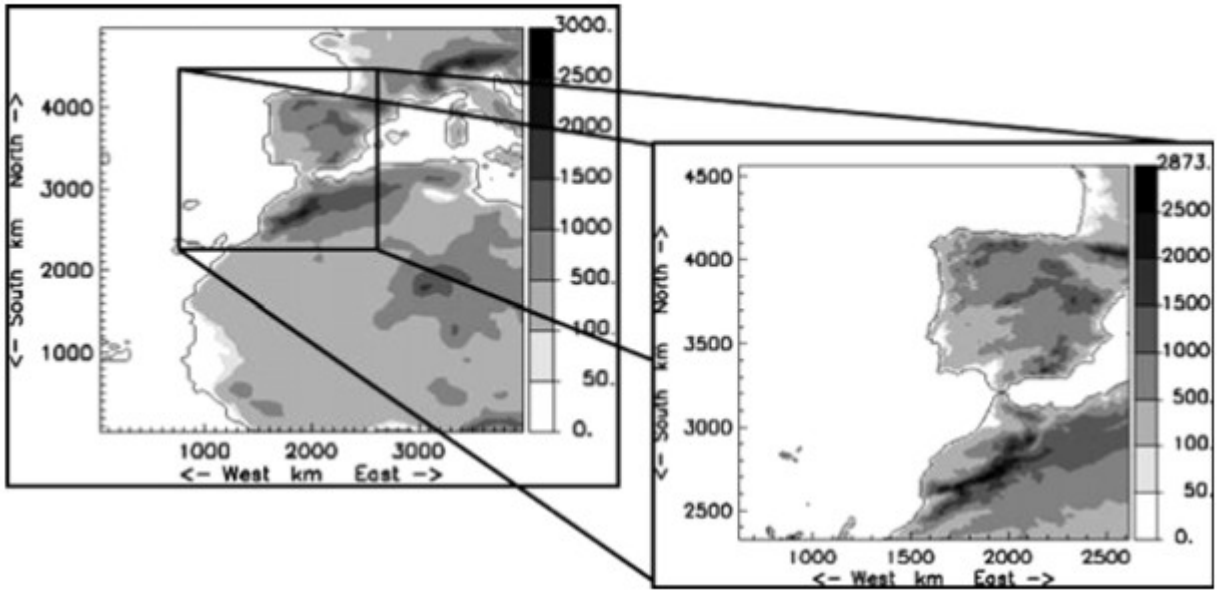
Perspective

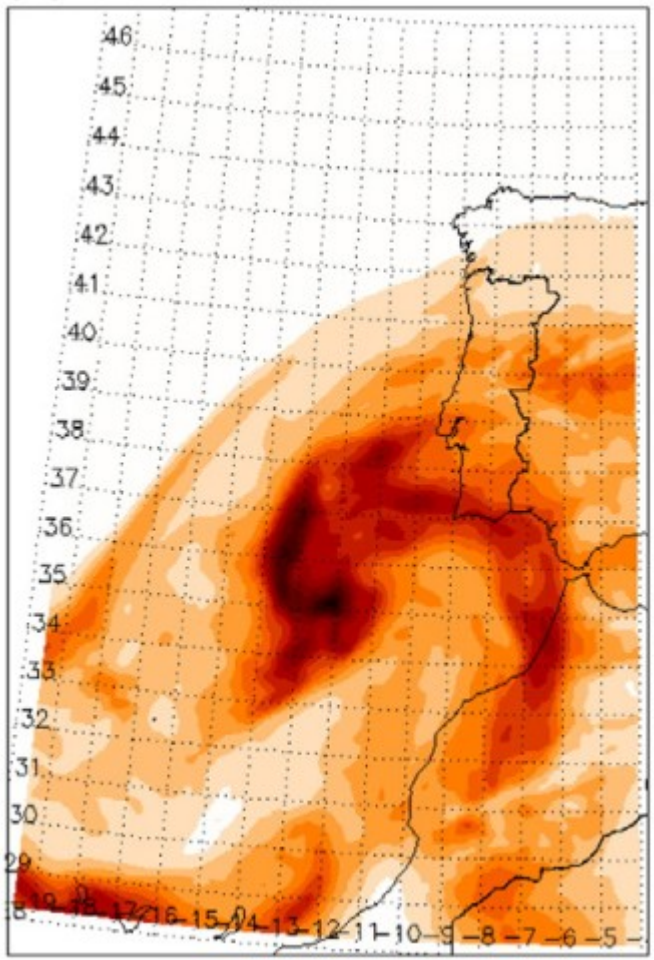
Besides the orographic signature or location of the accumulated precipitation, a more detailed analysis about the AROME performance is suggested for future works, also considering other situations.

- Flavio Couto slides
- based on Couto et al. (2012, 2015, 2016 and 2017)
- Last work in collaboration with IPMA

Dust emission, diffusion and transport

- Simulation of dust events from the emission to the effects on cloud
- Case studies using Meso-NH
- Work done by Dina Santos et al. (2011, 2013)





Simulated aerosol optical depth

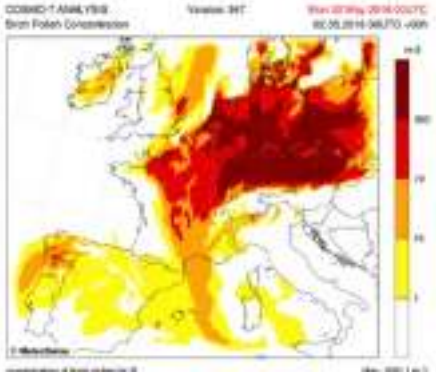
Pollen monitoring and forecast

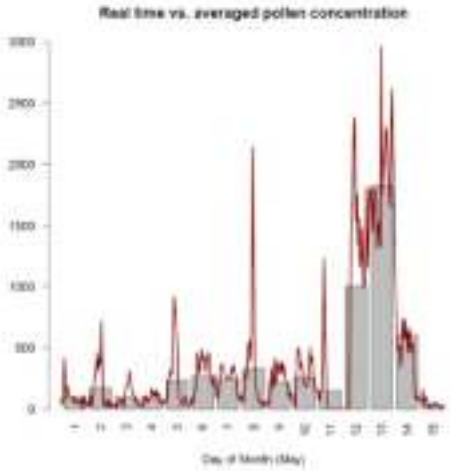
- AutoPollen: Automatic Pollen Detection Network
  - support of EUMETNET and MeteoSwiss
- We want to participate
- It should be good if IPMA join us
- More than 100 million Europeans suffer from allergic rhinitis and 70 million from asthma
- Pollen forecasting are necessary to prevent pollen allergy
- It will be a new forecast product

EUMETNET

Benefits of real-time pollen monitoring

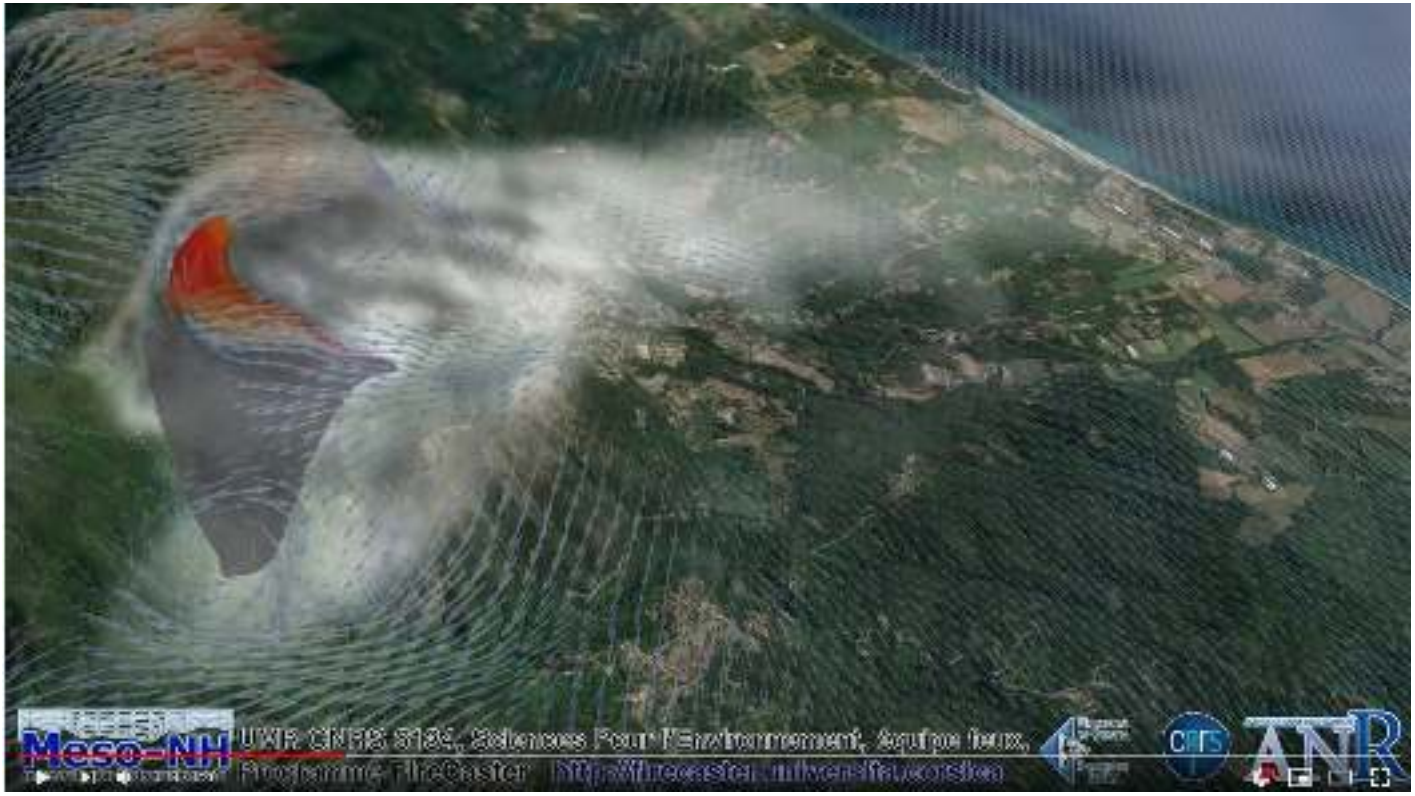
- Timely information
- Input for forecasts and models
- Improve the quality, e.g. of information and forecasts
- Partnerships, convergence with aerosol and air quality measurements
- New products and services





Forest Fire

- **Meso-NH – ForeFire** coupled model can be used to simulate and predict fine- to large-scale effects of wildfires
  - *Fillipi et al. (2018)*
- Operational at Corsica
- Maybe coupled to AROME
- To be tested in near future during CILIFO (ITERREG Project)



https://youtu.be/zsuFhA6ZvOQ

Atmospheric Science Observatory

Sun-sky photometer CIMEL

Temperature and humidity profilerMicrowave Radiometer

Raman Lidar System

IRGASON, integrated eddy covariance system to access fluxes of momentum, energy, vapour and CO2

Ceilometer VAISALA CL31

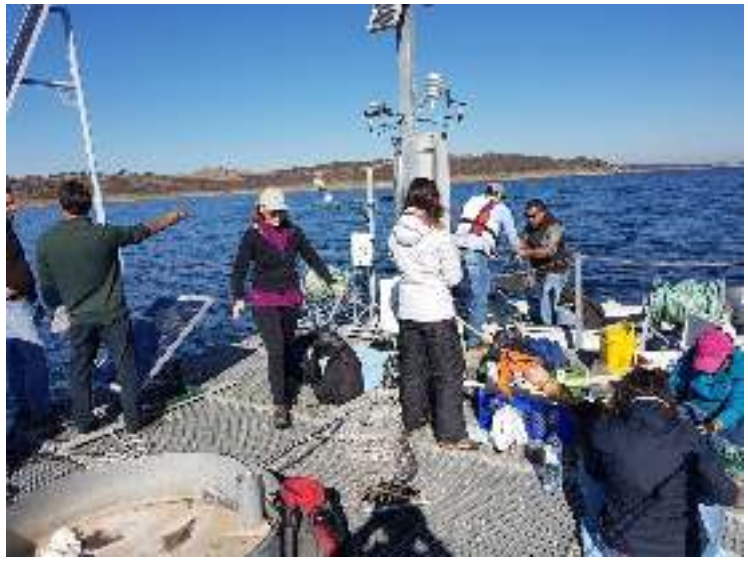
ALOP Field Experiment

- Observação simultânea da qualidade da água e do estado da atmosfera









Agradecimentos

COMPETE 2020 através do ICT (UID / GEO / 04683/2013) com a referência POCI-01-0145-FEDER-007690 e dos projectos ALOP (ALT20-03-0145-FEDER-000004) e DNI-A (ALT20-03-0145-FEDER-000011).

References

References

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