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Looking for gypaetus barbatus : bearded vulture in Crete



- I. The CarboEurope project
- II. The CarboEurope Regional Experiment campaign
- III. [CO₂]modeling with Meso-NH

The CarboEurope EU Project : Elucidate the European Carbon Balance

Component 1: Carbon fluxes over representative ecosystems : long term CO₂ fluxes measurements over forest, grasslands, crops

Component 2: Atmospheric Observations network for [CO₂]

Component 3: Regional Experiment

- Regional CO2 budget over SW of France : the Hapex-Mobilhy area

- Database of fluxes, concentrations, remote sensing for local to regional modeling

Component 4: Spatial integration and assimilation : inverse modeling to retrieve carbon sources and sinks

Why CNRM was involved in carbon budgeting?



Credit: Office of Biological and Environmental Research of the U.S. Department of Energy Office of Science.

- Atmospheric CO₂ in interaction with land cover through photosynthesis: vegetation is a sink
- Anthropogenic emissions are the main sources
- CO_2 and H_2O fluxes are linked through the stomata aperture

-> improving CO_2 fluxes to improve H_2O fluxes



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Why CNRM was involved in carbon budgeting?

- -> the HAPEX-MOBILHY Experiment (Andre et al., 1986) !
- -> South-West of France :
 - well known for met. modeling
 - a good candidate for the Regional Experiment



- Noilhan and Planton, 1989
- Noilhan et al., MWR, 91
- Noilhan and Lacarrère, J. Climate, 1995
- Noilhan et al., J. hydrology, 1997



The CarboEurope Regional Experiment



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The CarboEurope Regional Experiment IOPs

Types of Observations	MAY-JUNE 2005	APRIL 2007	SEPTEMBER 2007
Number of IOP	22 days	6 days	8 days
RS	128 RS + 11 BVC Toulouse + La Cape Sud	19 RS Toulouse	22 RS Toulouse + La Cape Sud
Piper-Aztec : [CO2] & dyn	23 flights	0	0
Dimona : [CO2] & dyn	10 flights	3 flights South 8 flights Landes	3 flights South 8 flights Landes
Sky Arrow Ibimet Flux measurements	52 flights	11 flights	4 days of measurements
Sky Arrow Alterra Flux measurements	0	11 flights	7 days of measurements
Sky Arrow Isafom	15 flights	0	0
[CO2] Towers	2 Biscarosse, Marmande	3 Biscarosse, Bellegarde, Marmande	3 Biscarosse, Bellegarde, Marmande
Flux Stations	10 (St Sardos, Le Fauga from CNRM)	8 (St Sardos, Le Fauga from CNRM)	8 (St Sardos, Le Fauga from CNRM)

Meso-scale modeling : MESO-NH configuration

- ECMWF analysis for LB forcing, met. and surface moisture initialisation.
- CO₂ anthropogenic emissions from Stuttgart Univ. at 10 km
- Land use : Ecoclimap_v3 (Champeaux et al., 2005)
- Grid nesting 2 ways with 2 domains at 10 and 2 km resolution



62 classes of vegetation: Ecoclimap processed from CORINE 2000 and Vegetation NDVI.



Landes

Atmospheric CO₂ modelling

Online coupling between Meso-NH and the surface scheme ISBA-A-gs :

- CO₂ surface fluxes = assimilation + respiration + anthropogenic emissions+oceanic exchanges from the surface to the atmosphere
- * Feedback : CO₂ concentrations from the atmosphere interacts with the surface



Meso-NH Case study may 27, 2005 (Sarrat et al., 2007a)



Improving surface scheme using CO₂ data (Sarrat et al., 2008b)

- 19-23 April : 5 days of simulation de 30H, re-initialized every day at 18UTC
- 8 km de resolution
- East-West gradient every day
- Underestimation of the CO₂ concentrations near Toulouse due to too high LAI and CO₂ assimilation in the model





101.0

190.0

389.0

385.0

184.0

383.0

382.0 381.0

380.0

379.0 378.0

177 D 176.0

175.0

374.0

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171.0

ONE

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395

390

385

380

375

Improving surface scheme using CO₂ data



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Intercomparison of 5 met. models (Sarrat et al., 2007b)

Participation of 5 models: RAMS from Amsterdam Vrije Univ., RAMS from Alterra, RAMS from CEAM, WRF from MPI, Meso-NH from CNRM

Experimental Protocol agreed on:

- Domain of simulation at 2km resolution
- ECMWF analysis for initialization and lateral boundaries forcing
- Ecoclimap land cover including 62 surface classes, summer crops/winter crops

CO₂ anthropogenic emissions at 10 km





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First mesoscale inversion of CO₂ sources and sinks (Credit: T. Lauvaux)



2005: State-of-the-art CO_2 inversions only performed at global to continental scales Introduction of the first mesoscale system (PhD LSCE-CNRM: T. Lauvaux)



Conclusion

- The CarboEurope Regional Experiment campaigns were a great success with a huge database for surface fluxes and atmospheric obs.

- Allowing validation of the modeling activities :

- improvement of surface and atmospheric scheme
- intercomparisons with other meso-scale models like RAMS or WRF
- First regional inversion
- CarboEurope allowed to determine that continental carbon sinks (forests, grassland) are offset by GHG emissions from croplands, peatlands and inland waters (Schulze et al., 2010)
- Recent publication shows that the carbon sequestration decreases because:
 - the land-surface carbon sink is decreasing with temperature increase
 - the CO₂ fertilizing effect slows down due to nutrient limitation effect (Peñuelas et al., 2017)





ECOCLIMAP Cover Class

Fraction of winter crops reduced for the cover: MODISLA

- SW_GARDENING_CROPS,
- SW_MIXED_CROPS,
- SW_WINTER_CROPS
- Increase of the summer crops fraction Decrease of LAI near Toulouse







Lagrangian Experiment (Sarrat et al., 2008a)

CO₂ Regional Budget Estimation using modeling & observations





ABL vertical profiles of [CO₂] and TH from the Piper-AZTEC

RS LACS june-06 14H







