Hiatus Investigation Attribution Thorough Understanding, Sensitivity experiments

A grant request from **BARCELONA SUPERCOMPUTING CENTER-CENTRO NAICONAL DE SUPERCOMUTACIÓN (BSC)**

For the Climate Initiative programme of the BNP Paribas Foundation

Print PDF

Description of the project

Producing trustworthy interannual to decadal climate predictions constitutes a societal challenge with numerous socio-economic applications (energy, health, insurance). Climate is, for example, one of the key factors that influences grape and wine production affecting the suitability of certain grape varieties to a particular region as well as the type and quality of the wine produced, which will be the main application of interest of this project. Taking up the challenge of predicting the climate on interannual to decadal timescales relies on both the predictability of the internally generated climate variability and the externally forced rate of global warming. Whereas most of the climate oscillations around the long-term warming trend over the last 50 years are relatively well understood, the early XXIst century has been marked by an intriguing pause of the near surface global warming despite a sustained buildup of atmospheric greenhouse gas levels. This so-called hiatus has triggered an intense scientific debate on its causes and has drawn considerable media attention. Changes in the Earth's radiative budget through the solar activity, the stratospheric water vapor and the stratospheric and tropospheric aerosols have been hypothesized to have canceled out, at least partially, the greenhouse effect during this hiatus. Internal climate system variability has also been suggested to be a main contributor via an increased ocean heat uptake (OHU) which would have compensated for the Earth's total (top-of-atmosphere) heat storage. The applying team has recently achieved a robust identification of the enhanced OHU as a main cause, published in Nature Climate Change, through the exploitation of successful retrospective climate predictions of the hiatus until 5 years ahead. However, these retrospective climate predictions were not fully explored to understand the complete mechanisms leading to the recent hiatus, and part of the recent hiatus signal was not captured. The HIATUS project proposes to: 1) investigate the mechanisms behind the early XXIst century hiatus and their regional fingerprints, 2) to evaluate whether this hiatus is expected to last in the coming decade or we could observe a rebound effect with an intensified global warming, 3) to assess the impact of decadal temperature variability on agriculture yield, with a focus on the wine sector. The research is organized in 6 Work Packages (WP). A deeper investigation of the simulations published in Nature Climate Change and similar climate predictions generated with a newer model version will be carried out within WP1. Complete regional heat budgets and thorough dynamical analyses are planned, combined with a validation against innovative observational data sources within WP2 as well as information-denial sensitivity experiments within WP3. Other hypotheses suggested in the literature, such as the role of stratospheric aerosol concentrations, will additionally be explored to explain the uncaptured part of the hiatus signal within WP4. The knowledge gathered during the HIATUS project will allow us to determine within WP5 whether the early XXIst century hiatus should be expected to last in the coming decade or whether we should observe a rebound effect with an intensified global warming, through the generation of an exceptionally large ensemble of climate predictions for the next decade sampling all the known sources of uncertainty. Finally, the impact of decadal temperature variability on wine yield over the last 50 years and the coming decade will be estimated within WP6, exploiting the most reliable climate information that can be provided within the HIATUS project. This project will build on the expertise of the Barcelona Supercomputing Center (BSC, Spain) on climate predictions and on the XXIst century hiatus, as well as the expertise of the Laboratoire d'Etudes en Géophysique et Océanographie Spatiales (LEGOS, France) on novel observational data sources.

Project attributes

Localisation

This project focuses on the evolution of the global mean surface temperature. Therefore, all geographical regions of the world will be considered, with a special interest in the oceans, according to previous results. Sources of informations

Partners:

https://www.bsc.es/earth-sciences http://www.legos.obs-mip.fr/

Publications:

Guemas V., Doblas-Reyes F. J., Andreu-Burillo I., Asif M., 2013, Retrospective prediction of the global warming slowdown in the past decade. Nature Climate Change, 3, 649-653, doi : 10.1038/nclimate1863 Major milestones 2017

By month 6 of the project, user-needs will be documented to feed WP1 and WP5 data producers. By month 12, new experiments similar to those published in Nature Climate Change, but with a newer model version, will have been carried out, to assess whether the hiatus signal is better captured (part of the hiatus signal remained uncaptured in this article

Major milestones 2018

By month 18, the analyses of the article published in Nature Climate Change will have been reproduced on the new simulations produced within WP1, detailed regional heat budgets and validation against novel observational data, such as sea level, will have been carried out, as well as sensitivity experiments to stratospheric aerosols.

By month 24, information-denial experiments, that are sensitivity experiments by applying constraints toward climatology to oceanic quantities in a restricted region, will have been conducted to identify key regions in the hiatus mechanism. By month 24 as well, two publications will have been submitted: one on the identification of the playing a key role in the increased OHU during the hiatus and one on the role of stratospheric aerosols on the hiatus.

Major milestones 2019

By month 30, the role of ocean dynamics on the increased OHU will have been assessed and sensitivity experiments to the role of atmospheric quantities on the mechanisms of increased OHU will have been conducted. One or more publication(s) will be submitted on the dynamical changes responsible for the increased OHU during the hiatus.

By month 33, an exceptionally large ensemble (70 members) of climate predictions will have been generated for the coming decade to sample all known sources of uncertainties, including aerosols and internal variability, and integrate all the knowledge generated during the HIATUS project.

By month 36, the climate service for agriculture, with a focus on the wine sector will be delivered and a publication will be submitted on the range of possibilities for the climate of the next decade. Scientific interest

HIATUS plans a robust identification of the dynamical mechanisms behind the increased ocean heat uptake and the induced hiatus of the early XXIst century. A deep understanding of these mechanisms, only partially understood so far, is essential to reach confidence in climate predictions for the next decade. HIATUS will also produce refined climate predictions for the coming decade containing an exceptionally large number of members to sample widely all possible sources of uncertainties. Added-value of the HIATUS climate simulations on prediction of grape and wine yied will be assessed and predictions will be produced for the coming decade. At least 5 publications will be written based on the results of HIATUS. International scope

This project will contribute to the international Decadal Climate Prediction Project (DCPP) from the Sixth Phase of the Coupled Model Intercomparison Project (CMIP6), as well as to the Decadal climate variability and predictability and the Consistency between planetary energy balance and ocean heat storage research foci of CLIVAR (Climate and Ocean Variability Predictability and Change), closely monitored by Virginie Guemas, coordinator of HIATUS, as part of her responsibilities as a member of the CLIVAR Scientific Steering Group. On top of partners officially involved in HIATUS (BSC and LEGOS), the delivery of the objectives will also rely on on-going collaborations on this topic with various institutes around the world: ECMWF (Magdalena Balmaseda, UK), KNMI (Geert Jan van Oldenborgh, Holland), the University of Reading (Jon Robson, UK), Meteo-France (Herve Douville, France) and the CERFACS (Christophe Cassou, France).

Organisation of the team and profiles involved

The HIATUS project will be carried out jointly by the Earth Sciences Department of the Barcelona Supercomputing Center (BSC, Spain) and the Laboratoire d'Etudes en Géophysique et Océanographie Spatiales (LEGOS, France). Virginie Guemas, head of the climate prediction group at BSC and coordinator of HIATUS, is currently PI of 6 national and international projects and has been PI of one national project in the past. She is the first author of the Nature Climate Change, which forms the base hypothesis of HIATUS. Isadora Jimenez (BSC) is an expert on climate services, Roberto Fernandez (BSC), Eleftheria Exarchou (BSC) and Neven Fuckar (BSC) are early career scientists and oceanographers, Oriol Mula (BSC) and IT support and Mar Rodriguez (BSC) is project manager. Benoit Meyssignac (LEGOS) is an expert on sea level changes and its regional and Remy Roca, senior researcher (LEGOS), is an expert on satellite data. Outreach

Given the substantial interest of the large public for the reasons behind the past hiatus, as seen by the large success of the Nature Climate Change article with more than 8000 citations in articles in the international (New York Times, ABC Sciences, Le Figaro ...), national (La Vanguardia, El Periodico ...) and local media, we expect a large enthusiasm for the results of the HIATUS project. The climate information that HIATUS plan to provide for the next decade will be of substantial socio-economic interests for applications such as in the energy sector. Applications in the agriculture sector will be directly tackled by HIATUS. To respond to the demand of the large public on information about the hiatus and the climate of the next decade, at least two presentations will be organized at the local library intended to non-specialists, as already organized by BSC in the past. A webpage intended to non-specialists will also be setup to present the main results of the HIATUS project.

Project timeframe

The first HIATUS year will be devoted to extending the analyses performed in the Nature Climate Change article, to identify regions playing a key role in the enhanced OHC and its dynamical reasons. In parallel, these experiments will be reproduced with a newer model version. During the second HIATUS year, sensitivity experiments to the aerosol will be conducted and mechanism analyses will be extended to the new simulations. By the middle of the project, conclusions about mechanisms should have been reached and sensitivity experiments to demonstrate these mechanisms will start. During the third HIATUS year, a large ensemble of climate predictions for the coming decade will be produced. Climate services for the wine sector will be developed all along the project, with a user-survey in the first months, followed by analyses of the HIATUS climate simulations as they are produced and finally predictions of wine yield for the coming decade based on the large ensemble of climate predictions.

Impact of the fundings

This project has already been submitted and approved by the Spanish Ministery of Economy and Competition which has committed to fund only 20% of the total requested budget (100,000 euros). Additional funding will be requested to CNES via a post-doctoral grant to cover another 20% (100,000 euros). The team would therefore need BNP-Paribas to fund the remaining 60% of the total budget (500,000 euros), i.e. 300,000 euros, to be able to carry out its activities.

Synthesis

Producing trustworthy interannual to decadal climate predictions constitutes a societal challenge with numerous socio-economic applications (agriculture, health). The early XXIst century has been marked by an intriguing pause of the near surface global warming despite a sustained buildup of atmospheric greenhouse gas levels. This has triggered an intense scientific debate on the causes and has drawn considerable media attention. Through the combination of innovative observational data and original sensitivity experiments, HIATUS offers to disentangle the reasons behind this global warming slowdown. A deep understanding of the underlying mechanisms, only partially understood so far, is essential to reach confidence in climate predictions for the next decade. HIATUS will also produce refined climate predictions for the coming decade together with an evaluation of climate impact on crop yield, in particular for grapes and wine.

Project team

RODRIGUEZ, Mar

Project manager

BARCELONA SUPERCOMPUTING CENTER-CENTRO NAICONAL DE SUPERCOMUTACIÓN (BSC)

Mar Rodriguez will be in charge of the administrative and financial coordination of HIATUS.

E: <u>mar.rodriguez@bsc.es</u> M: T: +34 93 413 75 66

Carrer Jordi Girona, 31 08034 Barcelona Spain

Exarchou, Eleftheria

Research Scientist

Barcelona Supercomputing Center-Centro Naiconal de Supercomutación (BSC)

Eleftheria Exarchou will be involved in WP1, 2 and 3: mentoring a post-doctoral scientist, running new experiments, reproducing the analyses performed within Nature Climate Change, furthering these analyses and carrying out sensitivity experiments.

E: <u>eleftheria.exarchou@bsc.es</u> M: T:

Carrer Jordi Girona, 31 08034 Barcelona Spain

Fuckar, Neven

Research Scientist

Barcelona Supercomputing Center-Centro Naiconal de Supercomutación (BSC)

Neven Fuckar will be mostly involved in WP4, mentoring a postdoctoral scientist, running and analyzing sensitivity experiments to the aerosols, as well as contributing to WP5 to generate a reliable and trustworthy climate prediction for the next decade.

E: <u>neven.fuckar@bsc.es</u> M: T: Carrer Jordi Girona, 31 08034 Barcelona Spain

Jiménez, Isadora Christal

Communication specialist

Barcelona Supercomputing Center-Centro Naiconal de Supercomutación (BSC)

Isadora Jiménez will lead WP6 on application of climate information to the agriculture sector and mentor a post-doctoral scientist working on this topic.

E: <u>isadora.jimenez@bsc.es</u> M: T:

Carrer Jordi Girona, 31 08034 Barcelona Spain

<u>Mula, Oriol</u>

Software engineer

Barcelona Supercomputing Center-Centro Naiconal de Supercomutación (BSC)

Oriol Mula-Valls will provide technical support for the maintenance of machines, running experiments, performing heavy data analysis and make the most of resources.

E: <u>oriol.mula@bsc.es</u> M: T:

Carrer Jordi Girona, 31 08034 Barcelona Spain

Meyssignac, Benoit

Research Scientist

Laboratoire d'Etudes en Géophysique et Océanographie Spatiales (LEGOS)

Benoit Meyssignac will focus mostly on WP2 and WP3, mentoring a post-doctoral scientist working at LEGOS, exploiting innovative observational data, such as sea level pressure, to validate climate model and close the Earth's energy budget

E: <u>benoit.meyssignac@legos.obs-mip.fr</u> M: T:

14 avenue Edouard Belin 31400 Toulouse France

Roca, Remy

Senior scientist

Laboratoire d'Etudes en Géophysique et Océanographie Spatiales (LEGOS)

Remy Roca is a senior scientist. He will contribute to advising HIATUS team members, participate in project meetings and comment on advances, results, experimental design etc...

E: <u>remy.roca@legos.obs-mip.fr</u> M: T:

14 avenue Edouard Belin 31400 Toulouse France

BSC, BSC

Institute

Barcelona Supercomputing Center-Centro Naiconal de Supercomutación (BSC)

BSC members will perform climate model experiments that will be combined with LEGOS innovative data to investigate the reasons behind the global warming slowdown of the last decade.

E: M: T:

Carrer Jordi Girona, 31 08034 Barcelona Spain

LEGOS, LEGOS

Institute

Laboratoire d'Etudes en Géophysique et Océanographie Spatiales (LEGOS)

LEGOS members will contribute to HIATUS by providing innovative observational data to confront and validate climate model simulations performed at BSC

E: M: T:

14 avenue Edouard Belin 31400 Toulouse France

Budget of the project

- Budget entered
- <u>Budget group by account</u>
- Budget group by year

Spendings

Benoit Meyssignac 2 month time PRIMAVERA -2017 13,826.00€ 110 Human ressources : Permanent staff H2020 project -Grant Agreement: Benoit Meyssignac 3 month time 2018 20,739.00€ 641727 110 Human ressources : Permanent staff 300 Public Benoit Meyssignac 3 month time 2019 20,739.00€ financing 110 Human ressources : Permanent staff **GEOSSHUB** -BSC postdoctoral researcher 2017 48,000.00€ H2020 project * 120 Human ressources : Non-permanent staff 300 Public LEGOS postdoctoral researcher financing 2017 65,000.00€ 120 Human ressources : Non-permanent staff PRIMAVERA -LEGOS postdoctoral researcher H2020 project -65,000.00€ 2018 120 Human ressources : Non-permanent staff Grant Agreement: LEGOS postdoctoral researcher 641727 2018 65,000.00€ 120 Human ressources : Non-permanent staff 300 Public BSC postdoctoral researcher financing 48,000.00€ 2018 120 Human ressources : Non-permanent staff PRIMAVERA -H2020 project -BSC postdoctoral researcher 2018 48,000.00€ Grant Agreement: 120 Human ressources : Non-permanent staff 641727 BSC postdoctoral researcher 2019 48,000.00€ 300 Public 120 Human ressources : Non-permanent staff financing BSC postdoctoral researcher 2019 48,000.00€ **GEOSSHUB** -120 Human ressources : Non-permanent staff H2020 project * LEGOS postdoctoral researcher 2019 65,000.00€ 300 Public 120 Human ressources : Non-permanent staff financing LEGOS supercomputer amortization : 3% of total cost of **BNP-Paribas BSC** 45000 euros 2017 1,500.00€ grant * 210 Purchases : Equipment 500 Grant LEGOS 2 screens requested from the 1,400.00€ 2017 210 Purchases : Equipment **BNP** Paribas LEGOS 2 desktops Foundation

Fundings

2017

2018

2018

2019

2019

2017

75,000.00€

65,000.00€

75.000.00€

70.000.00€

65,000.00€

71,117.60€

210 Purchases : Equipment	2017	3,000.00€	BNP-Paribas		
BSC 3 disk cabinets : 1 head node and 2 JOBS wich cost 7000			LEGOS grant *		
euros each to extend storage space	2017	21,000.00€	500 Grant	2017	81,329.86€
210 Purchases : Equipment			requested from the		
BSC 126 4Tb disks which cost about 220 euros each to extend			BNP Paribas		
storage space	2017	27,720.00€	Foundation		
220 Purchases : Consumables			BNP-Paribas BSC		
LEGOS travels : one week visit to BSC			grant *		
300 Travels and related expenses	2017	1,000.00€	500 Grant	2018	114.535.20€
RSC travels : one travel per year for each team member to			requested from the	2010	11,000.200
attend summer schools or international workshops or			BNP Paribas		
conferences related to HIATUS	2017	9,260.00€	Foundation		
300 Travels and related expenses			BNP-Paribas		
LECOS travels , one week visit to DSC			LEGOS grant *		
200 Travels and related expenses	2018	1,000.00€	500 Grant	2018	86.021.29€
500 Travels una retatea expenses			requested from the	2010	00,021.29 0
BSC travels : one travel per year for each team member to			BNP Paribas		
attend summer schools or international workshops or	2018	9,260.00€	Foundation		
200 Turnels and related surrange			BNP-Paribas BSC		
500 Travels and related expenses			grant *		
LEGOS travels : attending the EGU General Assembly	2018	1,500.00€	500 Grant	2019	121 535 20€
300 Travels and related expenses		,	requested from the		121,000.200
LEGOS travels : one week visit to BSC	2019	1 000 00€	BNP Paribas		
300 Travels and related expenses	2017	1,000.000	Foundation		
BSC travels : one travel per year for each team member to			BNP-Paribas		
attend summer schools or international workshops or	2019	9.260.00€	LEGOS grant *		
conferences related to HIATUS	2019	9,200.00€	500 Grant	2019	14.426.29€
300 Travels and related expenses			requested from the		1.,.20.29 0
LEGOS travels : attending the AGU General Assembly	2010	2,000,00,6	BNP Paribas		
300 Travels and related expenses	2019	2,000.00€	Foundation		
LEGOS publication			Benoit Meyssignac		
420 Communication : Advertising and publishing	2018	1,500.00€	2 months	2017	13.826.00€
BSC 2 publications			800 In-kind		,
420 Communication : Advertising and publishing	2018	4,000.00€	support		
LEGOS publication			Benoit Meyssignac		
420 Communication : Advartising and publishing	2019	1,500.00€	3 months	2018	20 739 00€
PSO 2 - 11' - d' - a			800 In-kind	2010	20,757.000
BSC 3 publications	2019	6,000.00€	support		
420 Communication : Advertising and publishing			Benoit Meyssignac		
BSC overheads		80,275.20€	3 months	2019	20 739 00€
600 Management fees		,	800 In-kind	2017	20,757.000
BSC overheads	2017	40 137 60€	support		
600 Management fees	2017	10,137.00 C	Total Fundings		894,269.44€
LEGOS overheads	2017	0 420 86 E			
600 Management fees	2017	9,429.80€			
BSC overheads	2010	00.075.00.0			
600 Management fees	2018	80,275.20€			
LEGOS overheads	• • · · -				
600 Management fees	2018	17,021.29€			
LEGOS overheads					
600 Management fees	2019	9,926.29€			

Total Spendings

894,269.44€

* Non confirmed funding

Spendings			Fundings			
110 Human ressou	urces : Permanent staff	55,304.00€	300 Public financi	350,000.00€		
120 Human ressou staff	urces : Non-permanent	500,000.00€	500 Grant requested from the BNP Paribas Foundation		488,965.44€	
210 Purchases : E	Equipment	26,900.00€	800 In-kind support		55,304.00€	
220 Purchases : C	Consumables	27,720.00€	Total Fundings		894,269.44€	
300 Travels and r	elated expenses	34,280.00€				
420 Communication publishing	on : Advertising and	13,000.00€				
600 Management	fees	237,065.44€				
Total Spendin	gs	894,269.44€				
Spendings			Fundings			
	80,275.20€		2017	241,273.46€		
2017	241,273.46€		2018	361,295.49€		
2018	361,295.49€		2019	291,700.49€		
2019	211,425.29€		Total Fundings 894,269.44€			
Total Spendin	gs 894,269.44€					

Our organisation

BARCELONA SUPERCOMPUTING CENTER-CENTRO NAICONAL DE SUPERCOMUTACIÓN (BSC)

Creation year :2005

The Barcelona Supercomputing Center – Centro Nacional de Supercomputación (BSC-CNS) is the National Supercomputing Facility of the Spain. BSC-CNS manages MareNostrum III with 48,128 cores and 1.1 Pflops capacity, one of the most powerful supercomputers in Europe located in the former Torre Girona chapel in Barcelona. BSC-CNS also hosts other high-performance computing (HPC) systems such as MinoTauro, one of the most energy efficient supercomputers in the world. The mission of BSC-CNS is to research, develop and manage information technology in order to facilitate scientific and technological progress. At the BSC-CNS, more than 350 researchers and students from more than 40 different countries perform research in Computer Sciences, Life Sciences, Earth Sciences and Computational Applications in Science and Engineering. This multi-disciplinary approach and the combination of world-leading researchers and HPC experts with state-ofthe-art HPC resources make BSC-CNS a unique research institution.

BSC-CNS is located on a campus of the Technical University of Catalonia (Universitat Politecnica de Catalunya - UPC) and has an agreement with the UPC to use university facilities and services. Furthermore, many of the group leaders at BSC-CNS are also university professors with broad knowledge and experience in advance research and teaching, i.e., the BSC-CNS substantially contributes to and benefits from UPC higher educational environment. The BSC-CNS is a key element of, and it coordinates, the Spanish Supercomputing Network, which is the main framework for granting competitive HPC time to Spanish research institutions. Also, BSC-CNS is one of six hosting nodes in France, Germany, Italy and Spain that form the core of the Partnership for

Advanced Computing in Europe (PRACE) network. PRACE provides competitive computing time on world-class supercomputers to researchers in the 25 European member countries. BSC-CNS has been accredited as one of the first eight Severo Ochoa Centers of Excellence. This award is given by the Government of Spain as recognition of leading research centers in Spain that are internationally well known institutions in their respective areas. Specifically, BSC-CNS received Severo Ochoa Center of Excellence support and accreditation starting in January 2012, and now renovated, based on accomplishments in scientific research and engineering, applying exascale supercomputers and big data management to tackle major societal problems in areas such as human health and biomechanics, and environment and climate

Web site :

Organisation :

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Project leader

Guemas Virginie Job title :Head of the climate prediction group E-mail :virginie.guemas@bsc.es Phone :+34 934 137 679 Mobile :+34 934 137 679 Organisation :Barcelona Supercomputing Center Carrer Jordi Girona, 31 08034 Barcelona Spain

Contribution to the project :

Virginie Guemas will coordinate scientifically the HIATUS project, mentor the three post-doctoral scientists hired at BSC and contribute mostly to WP5, integrating the new knowledge generated within HIATUS to generate a reliable future climate prediction.

Main area of research

Virginie Guemas is an expert in climate prediction, with a background in oceanography and sea ice processes. She is currently head of the climate prediction group at BSC which counts 18 members. She is Principal Investigator (PI) of 6 on-going national or international projects, WP leader in another one and was PI of another project in the past. She is supervising one Marie Curie and one Juan de la Cierva fellowships. She is the author of 37 articles, among which 6 in high impact journals, including a famous study in Nature Climate Change attributing the recent global warming slowdown to an increased ocean heat uptake, mainly in the Tropics. She is a member of the Scientific Steering Group of the WCRP/WMO CLIVAR project. Main publications

Guemas V., Doblas-Reyes F., Andreu-Burillo I., Asif M., 2013, Retrospective prediction of the global warming slowdown in the last decade. Nature Climate Change, 3, 649-653, doi:10.1038/nclimate1863.

Guemas V., Doblas-Reyes F., Germe A., Chevallier M., Salas y Mélia D., 2013, September 2012 Arctic sea ice minimum: Discriminating between sea ice memory, the August 2012 extreme storm and prevailing warm conditions [in "Explaining Extreme Events of 2012 from a Climate Perspective"]. Bull. Amer. Meteor. Soc., 94 (9), S20-S22.

Guemas V, Auger L, Doblas-Reyes FJ, Rust H, Ribes A, 2014, Dependencies in Statistical Hypothesis Tests for Climate Time Series. Bull. Amer. Meteor. Soc, 95 (11), 1666-1667.

Doblas-Reyes F., Andreu-Burillo I., Chikamoto Y., García-Serrano J., Guemas V., Kimono M., Mochizuki T., Rodrigues L. R. L., van Oldenborgh G. J., 2013, Initialized near-term regional climate change prediction. Nature Communications, 4, 1715, doi:1038/ncomms2704.

<u>Awards</u>

2015-2020 Ramon y Cajal fellowship: This highly competitive fellowship (2% success) is granted by the MINECO, and commits the institute welcoming the Ramon y Cajal fellow to hire him/her permanently when the fellowship ends, in case of positive evaluation.

2010 Adrien Gaussail PhD prize: This prize is awarded every 2 years to a scientific PhD Thesis by the Académie des Sciences Inscriptions et Belles Lettres (

http://academie-sciences-lettres-toulouse.fr/attribution-des-prix-en-2010/)

2012 Young Scientist Travel Award: This prize is awarded by the European Meteorological Society to support participation of outstanding students and young scientists at EMS-co-sponsored conferences (<u>http://www.emetsoc.org/awards/travel-awards-ystas</u>)

2005 Excellence scholarship for Master students: This €4000 scholarship is awarded by the Université Paul Sabatier to their best students in exchange for a commitment to do a PhD.