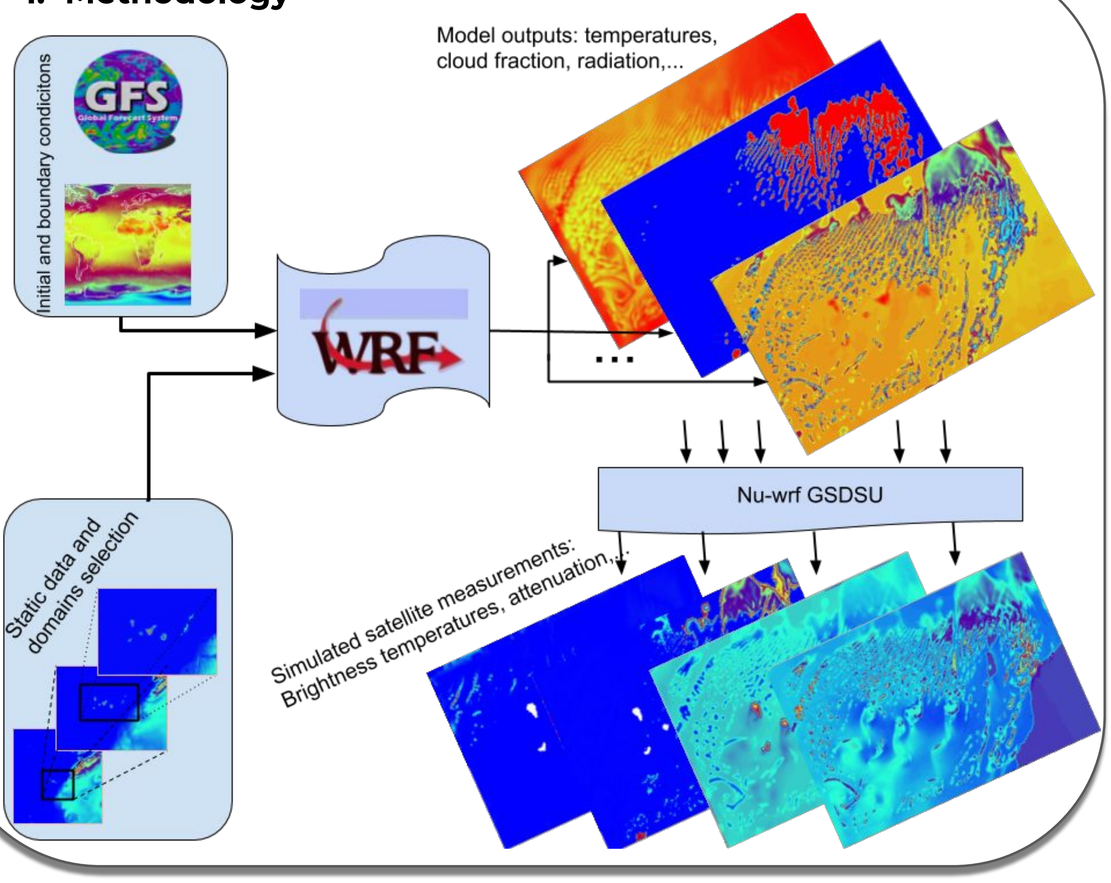
Sensitivity study of Boundary layer cloud modelling using WRF

Juan C. Pérez[1], Albano González[1], Juan P. Díaz[1], Francisco Expósito[1] and Manuel Luis[1]
1. Universidad de La Laguna (ULL), Canary Islands, Spain

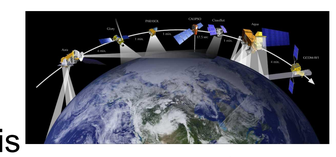
In this work, a detailed study of the ability of limited area numerical models to characterize boundary layer clouds is performed. Particularly, a sensitivity study was carried out to evaluate the ability of WRF model simulations in reproducing the properties of marine stratocumulus clouds in the North Atlantic subsidence regime. To this end, a wide set of experiments was designed to analyze both, the physical parameterizations implemented in the model to simulate the different processes, such as PBL, microphysics and radiation schemes, and the model configuration, that is, initial and boundary conditions, vertical resolution or vertical nesting.

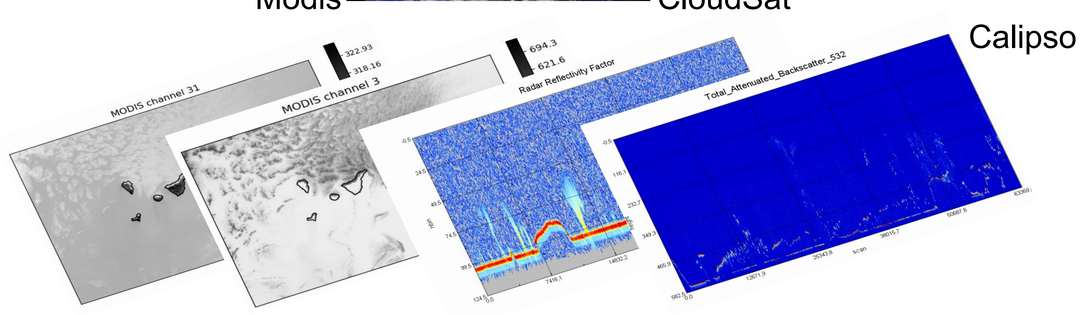
Simulations were conducted for some case studies and a region located to the North of the Canary Islands was selected to compare model results with observational data retrieved from satellite sensors. In particular, data from the A-Train satellite constellation have been used (multispectral radiation from MODIS sensor, radar data from CloudSat platform and the attenuated backscatter from Calipso lidar instrument). From these measurements, information such as the cloud vertical structure or cloud radiative properties were derived and used to evaluate the strengths and weakness of the different parameterizations to model these kind of clouds.

1. Methodology



2. Data





MODIS Product L1-B:
- Channel 3 radiances
- Channel 31 brightness temperatures

CloudSat. Product 2B-GEOPROF:
- Radar Reflectivity Factor (dbZe)

Calipso. Product L1-Lidar Standard v4.0
- Total_attenuated backscatter_532

CCCM - CERES CALIPSO CloudSat MODIS
- Cloud Height
- Optical thickness

Selected dates:
- A-train data available for the region of interest (Canary Islands)
- Low level clouds

3. WRF Simulations

- Version 3.9.1
- 3 nested domains (27, 9 and 3 kms). Results from innermost domain
- 48 hours simulations (24 hrs. spin-up)
- Cumulus parameterization in outermost domain

4. Experiments

Several experiments were conducted to evaluate the skills of WRF model to simulate the vertical structure of Marine Boundary Layer cloud formed in the North Atlantic subsidence region.

Special attention was paid to the number of vertical levels considered. Several configurations were tested increasing the total number of levels up to 100, with higher resolution in the lowest levels, and the new option of vertical grid nesting (WRFv3.8) was also tested.

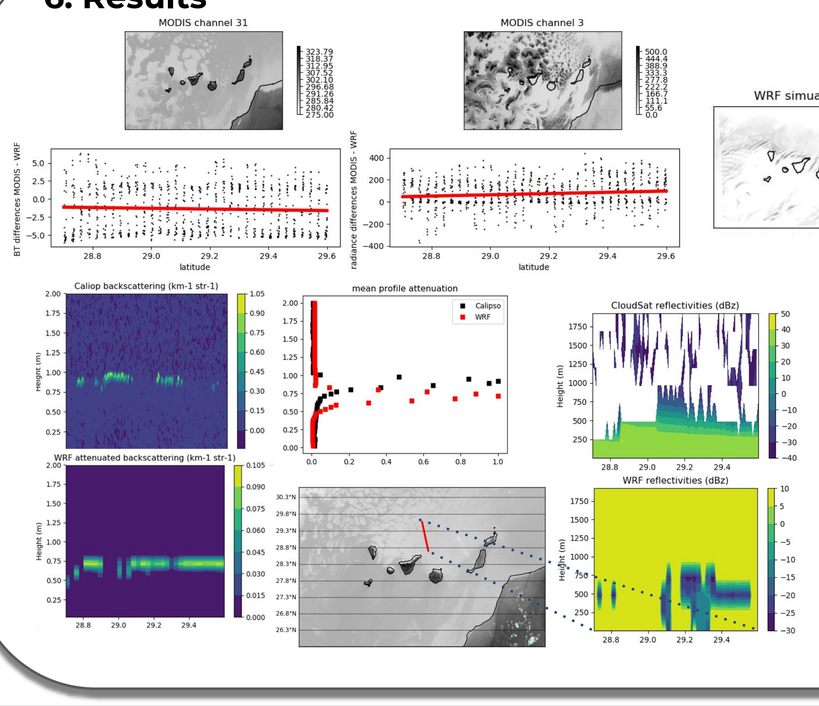
Parameterization /Strategy	Options
Lateral and boundary input	Interim
	FNL
Vertical levels	33
	60
	80
	100
	Vertical grid nesting (33,45,80)
Radiation	CAM
	RRTMG

Parameterization /Strategy	Options
PBL/surface layer	YSU/
	MYJ
	QNSE
	MYNN2/3
	ACM2
	BOULAC
	UW
	TEMF
Microphysics	Thompson
	Morrison
	WDM6

5. Postprocessing

To compare the results of WRF simulations with satellite data, the satellite simulator software included in the NASA-Unified Weather Research and Forecasting (NU-WRF) model was used. From it, visible and thermal radiances of MODIS were simulated, so as radar reflectivity factor from Cloudsat platform and total attenuated backscatter at 532 nm as measured by Calipso in the same vertical resolution as provided by the different sensors (Peters-Lidard et al., 2015)

6. Results



Microphysics			
	Thomp	Morris.	WDM6
Ch31 Temp (K)	0.34	**-0.28**	0.67
Ch3 rad (Wm^{-2})	33.14	59.74	**30.0**
Cloud top height (km)	-0.45	-0.72	**-0.44**
Optical thickness	-4.14	-3.85	**-3.66**

Planetary Boundary Layer						
	acm2	bou	myj	qnse	uw	ysu
Ch31 Temp (K)	0.69	0.56	0.85	-0.66	**-0.50**	1.22
Ch3 rad (Wm^{-2})	**0.39**	23.23	23.13	64.16	58.40	12.47
Cloud top height (km)	-0.40	-0.41	-0.47	-0.85	-0.57	**-0.37**
Optical thickness	-3.57	-2.93	-3.22	-5.13	-4.78	**-2.69**

Vertical levels		
	67	nesting
Ch31 Temp (k)	**0.34**	0.54
Ch3 rad (Wm^{-2})	33.14	**25.26**
Cloud top height (km)	-0.45	**-0.44**
Optical thickness	-4.14	**-3.59**

Lateral and boundary		
	INTERIM	FNL
Ch31 Temp (K)	**0.34**	0.73
Ch3 rad (Wm^{-2})	33.14	**21.63**
Cloud top height (km)	-0.45	**-0.16**
Optical thickness	**-4.14**	-5.61

radiation		
	CAM	RRTMG
Ch31 Temp (K)	**0.34**	0.54
Ch3 rad (Wm^{-2})	33.14	**25.26**
Cloud top height (km)	-0.45	**-0.44**
Optical thickness	-4.14	**-3.59**

Grupo de Observación de la Tierra y la Atmósfera

Contact information:
Juan C. Pérez
jcperez@ull.edu.es

Projects:
- CGL2015- 67508-R (MCIU)
- CLI05 (CajaCanarias)