

A 3-D comparison of WRF forecasts with observations during the RHUBC-II campaign

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Outline

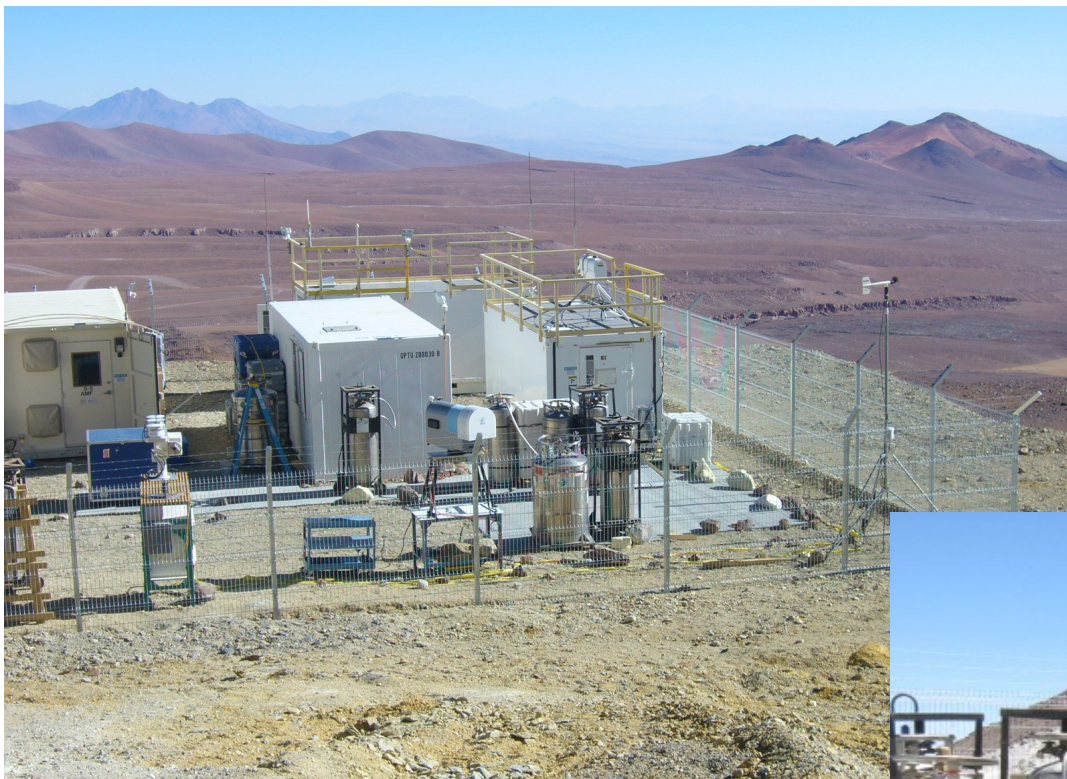
- *Introduction*
- *Objectives*
- *WRF configuration*
- *Observations*
- *Preliminary analysis*
- *Conclusions*
- *Future plans*

Introduction

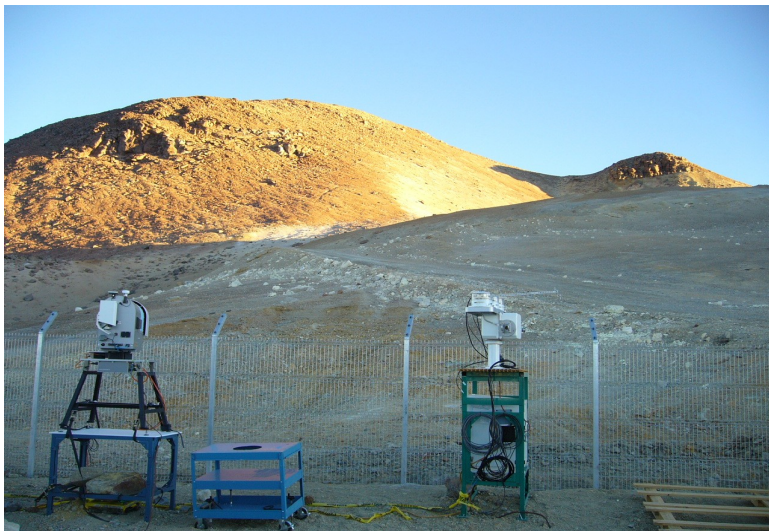
The Atacama Desert in Chile is a region relatively little studied where meteorological observations are scarce.



Several astronomical observatories operating there need accurate forecasts.



RHUBC-II campaign
was held at Cerro Toco
(5322 m of altitude) from
August to October 2009.



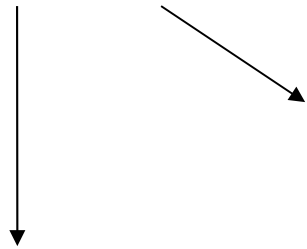
A great opportunity to assess numerical weather forecasts over this region!!!!

Objectives

- *Assess WRF forecasts with RHUBC-II and satellite observations at and above the boundary layer.*

WRF configuration

Four nested domains:

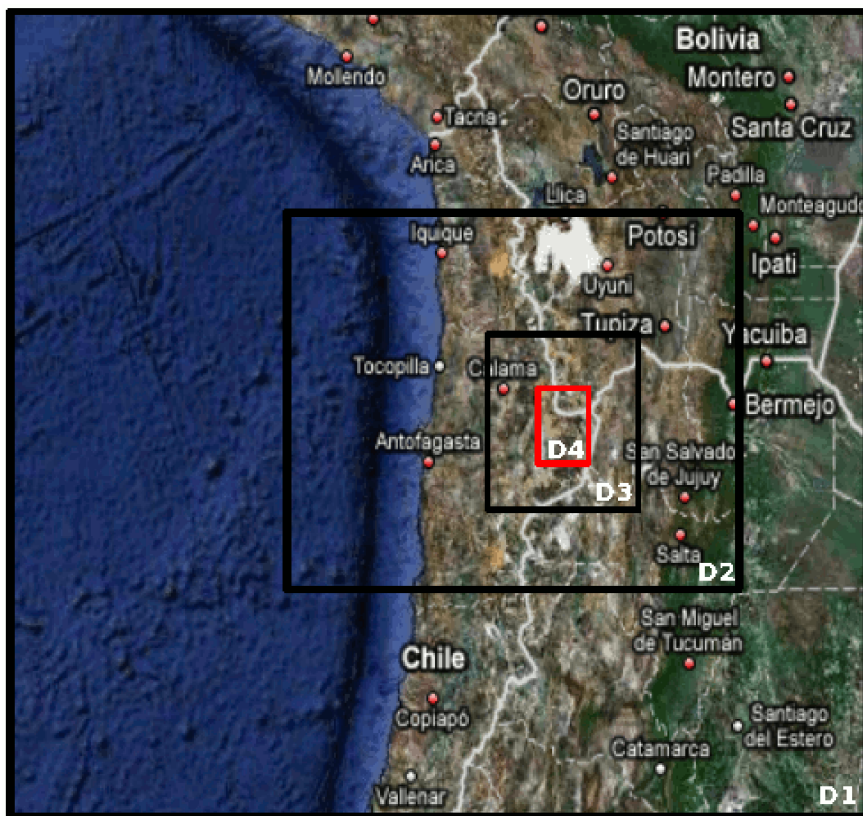


Domains	Nx	Ny	Grid space [km]	Area [km ²]
D1	70	53	27	1890 × 1431
D2	82	93	9	738 × 657
D3	97	97	3	291 × 291
D4	112	112	1	112 × 112

Initial and boundary conditions:
GFS forecasts 1° x 1° horiz. resolution

Simulations started everyday at 12 UTC.
72 h run

Only D4 is compared with observations.



WRF configuration

WRF	Sim1	Sim2
Microphysics	WRF Single-Moment 3-class	
Cumulus	Kain-Fritsch	
LW Radiation	RRTM	
SW Radiation	Dudhia	
PBL	Eta scheme: MYJ	
Surface Layer	Eta similarity	
Land surface	5-layer thermal diffusion	Noah LSM
Land-use data	USGS 5-min (~9 km)	MODIS 30 sec. (~1km)

All other parameters remained unchanged

Values from WRF at the nearest grid point to RHUBC-II

$dz = 29.9 \text{ m}$

$Distance = 504 \text{ m}$

Observations

RHUBC-II

Surface Variables

- Temp. 2m
- qv 2m

Radiosondes

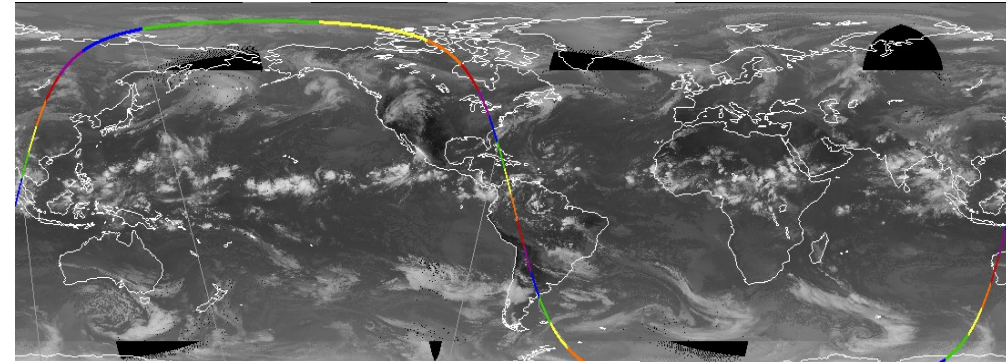
- Temperature
- Dew Point
- RH
- PWV

CloudSat

Vertical profiles

- Cloud water
- Ice water

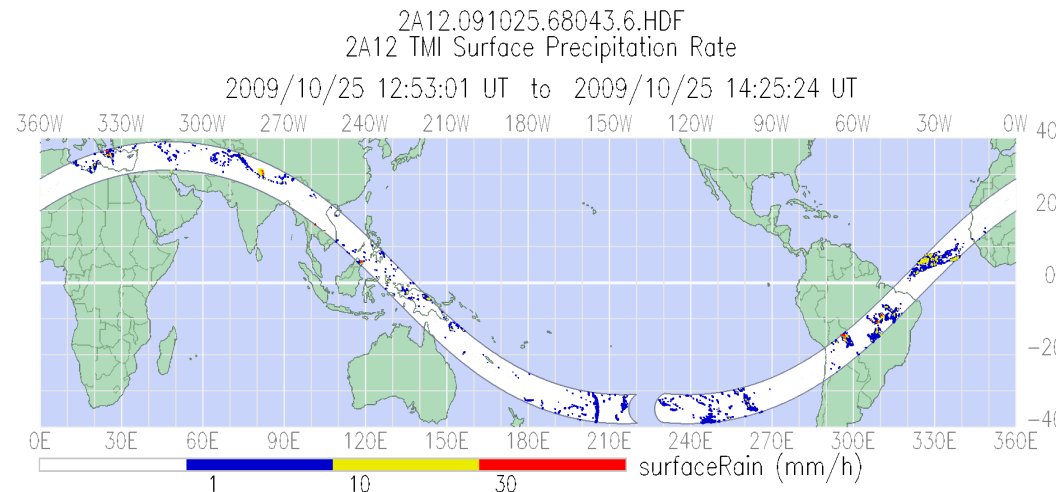
8 Granules selected



TRMM

Vertical profiles

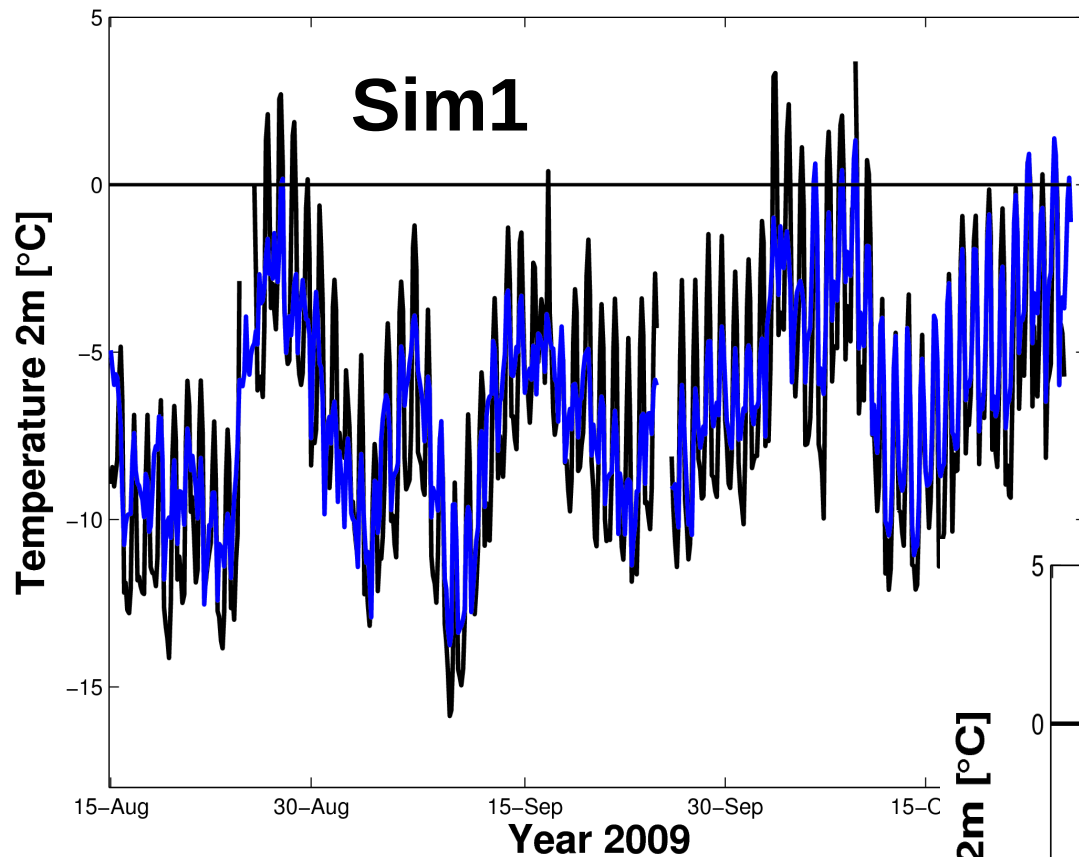
- Cloud water
- Ice water



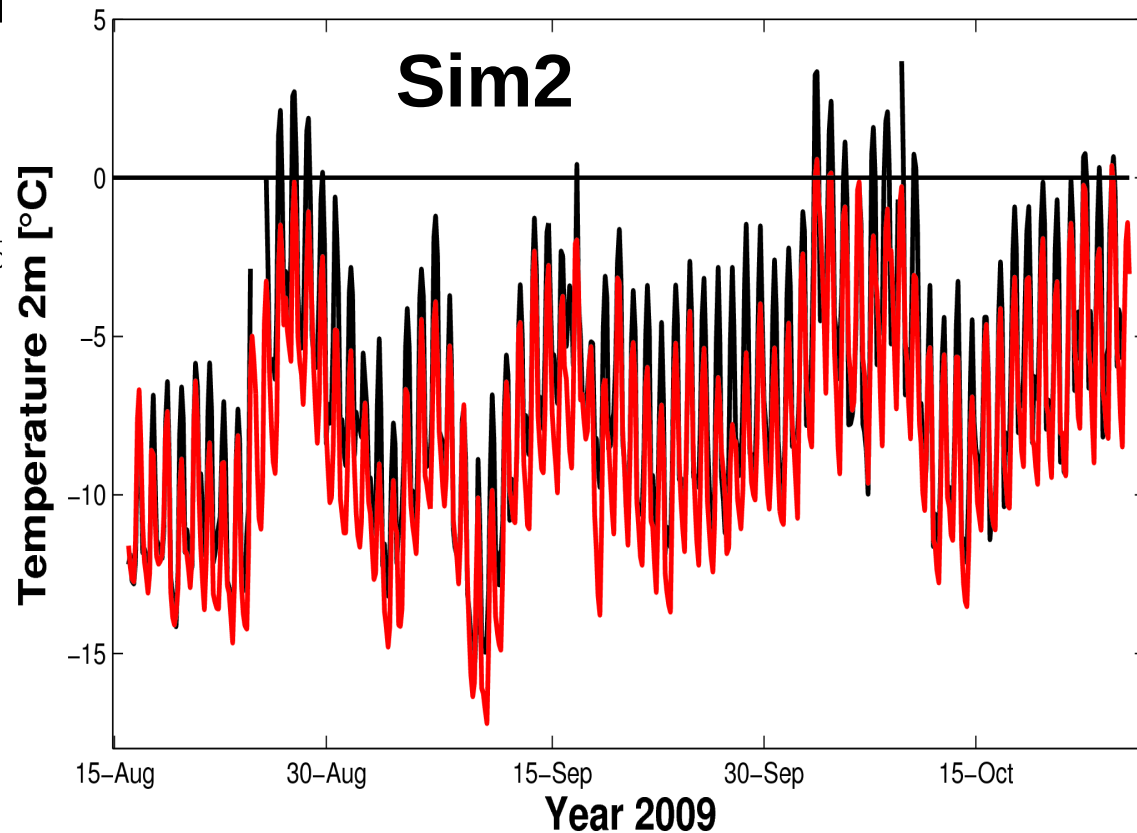
104 orbits selected

Preliminary analysis

Surface Variables: Temp. 2m

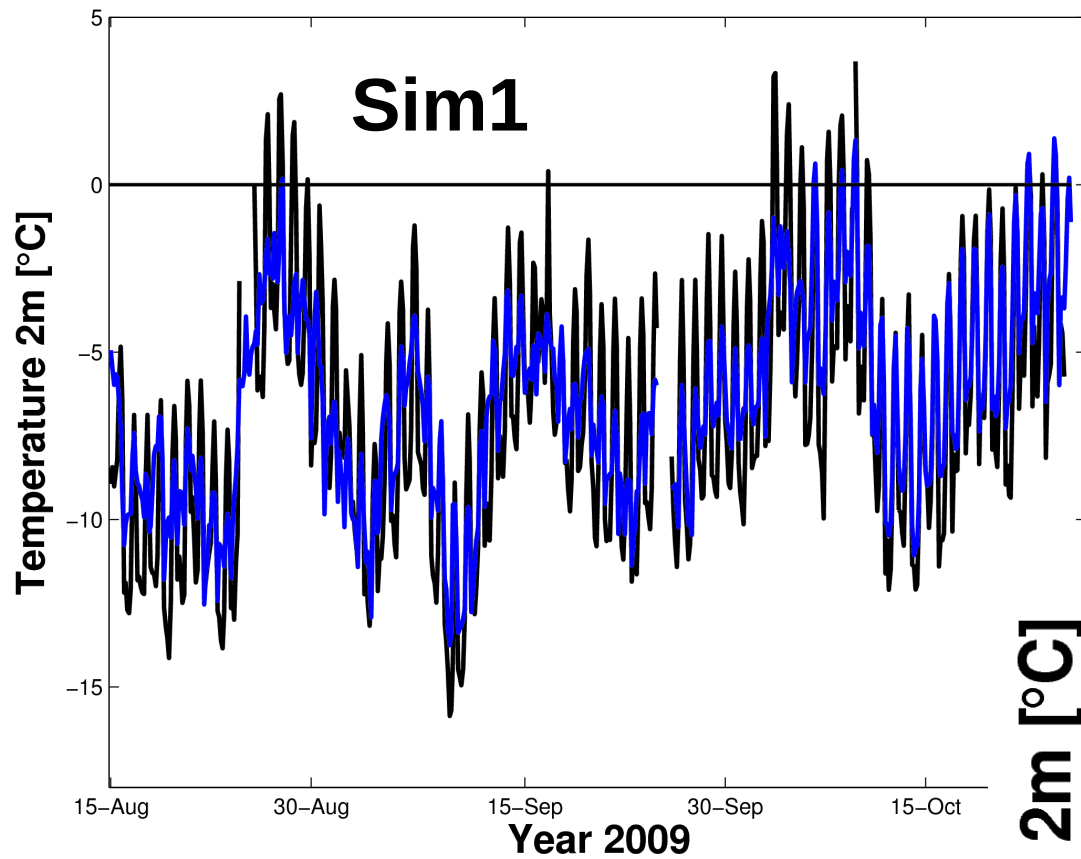


<i>WRF</i>	<i>RMSE</i> [°C]	<i>Mean Bias</i> [°C]
<i>Sim1</i>	2.0	0.3
<i>Sim2</i>	1.9	-1.4



Both simulations do a good job reproducing the day-to-day variations in 2m temperature BUT

Preliminary analysis

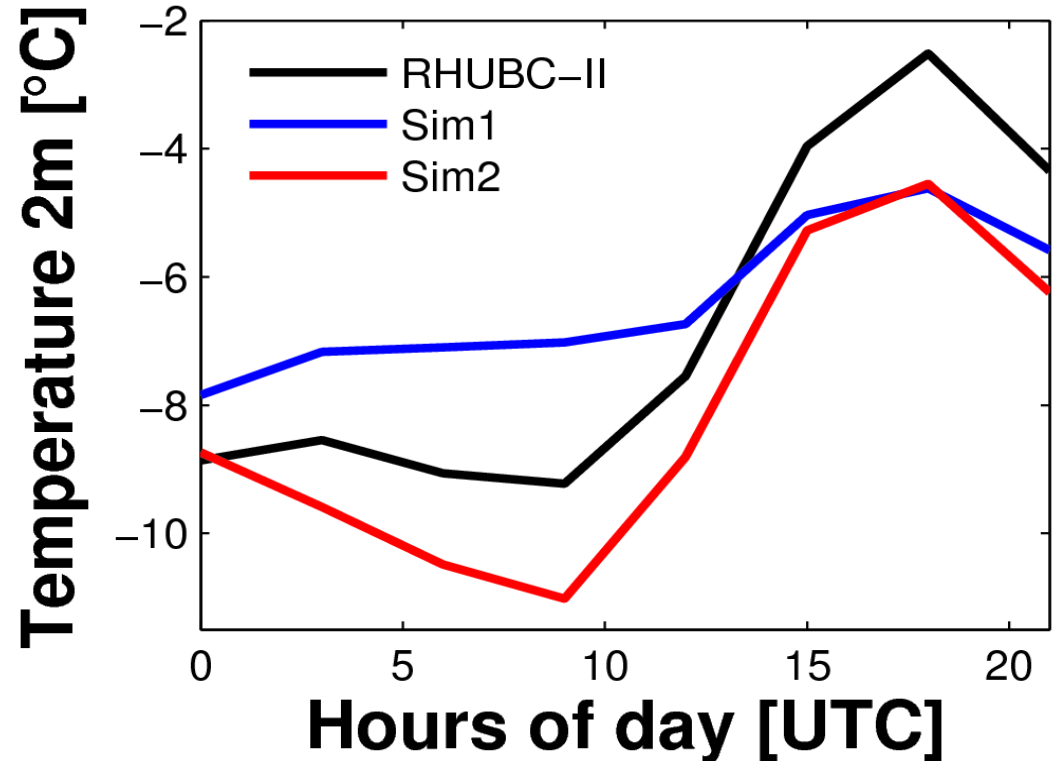


Surface Variables: Temp. 2m

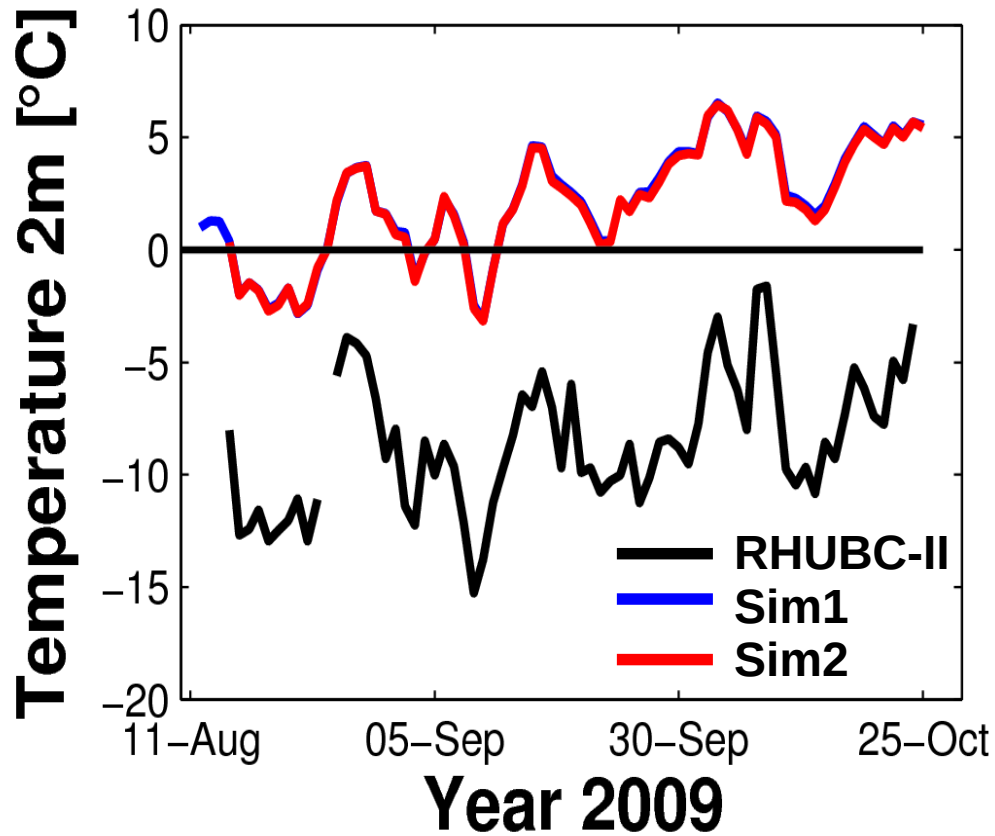
<i>WRF</i>	<i>RMSE</i> [$^{\circ}\text{C}$]	<i>Mean Bias</i> [$^{\circ}\text{C}$]
<i>Sim1</i>	2.0	0.3
<i>Sim2</i>	1.9	-1.4

Diurnal cycle underestimated
in absolute values in **Sim1**

Evident negative bias in **Sim2**



Preliminary analysis

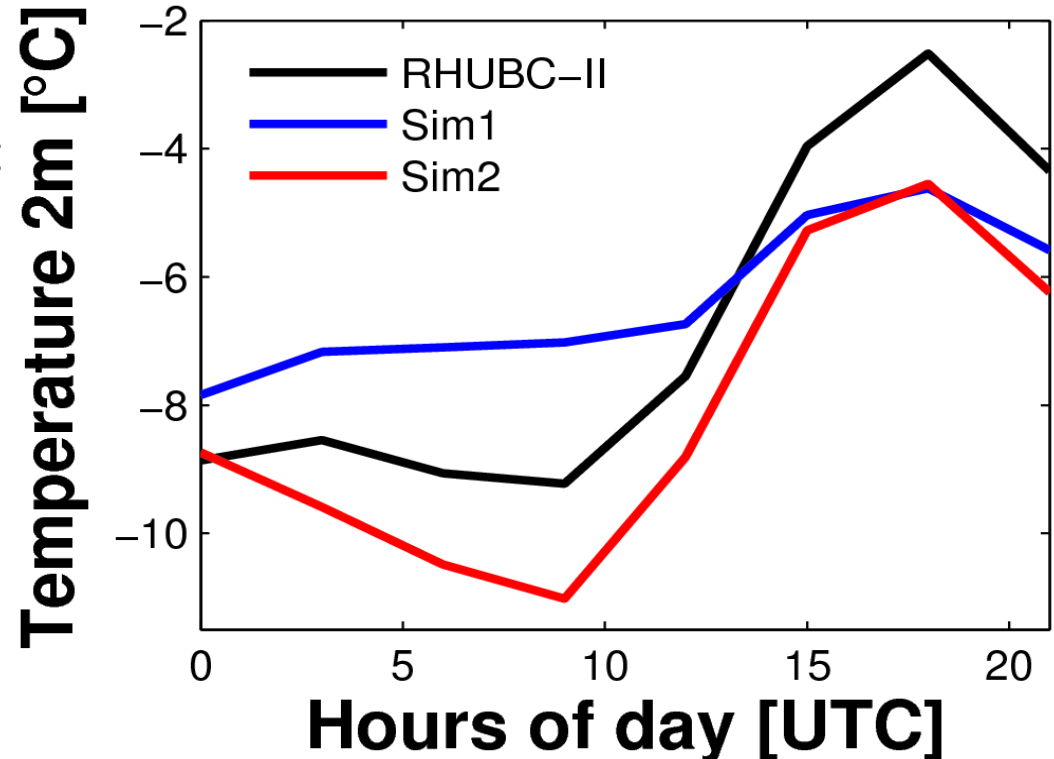


2m temp. at the initial conditions (12 UTC) in D4

RMSE (Temp 2m) = 10 °C

Surface Variables: Temp. 2m

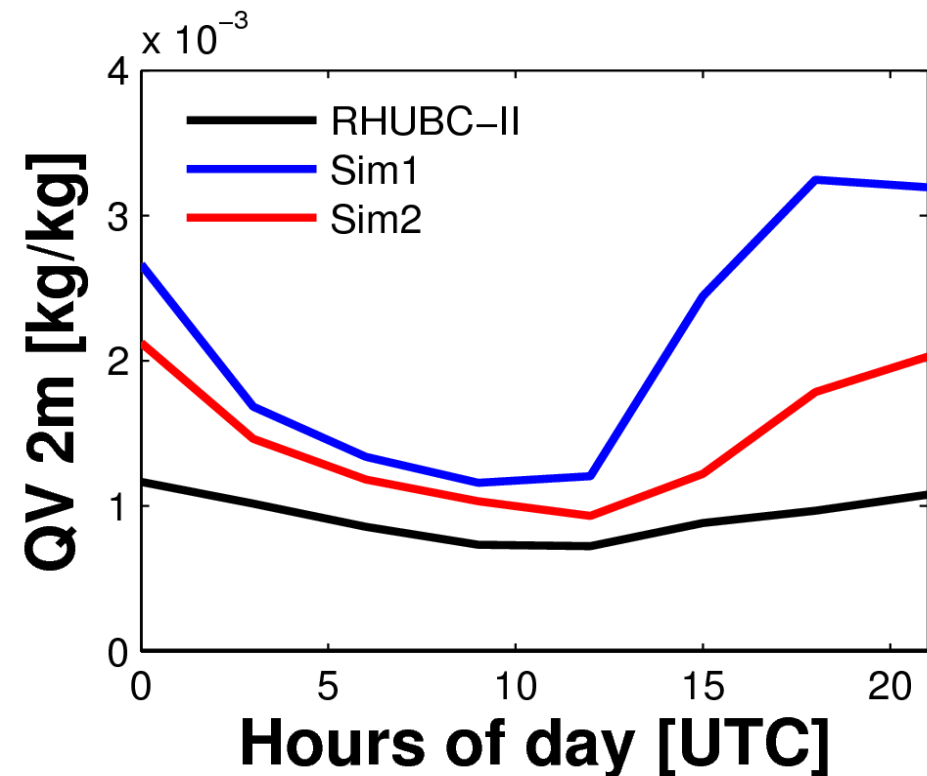
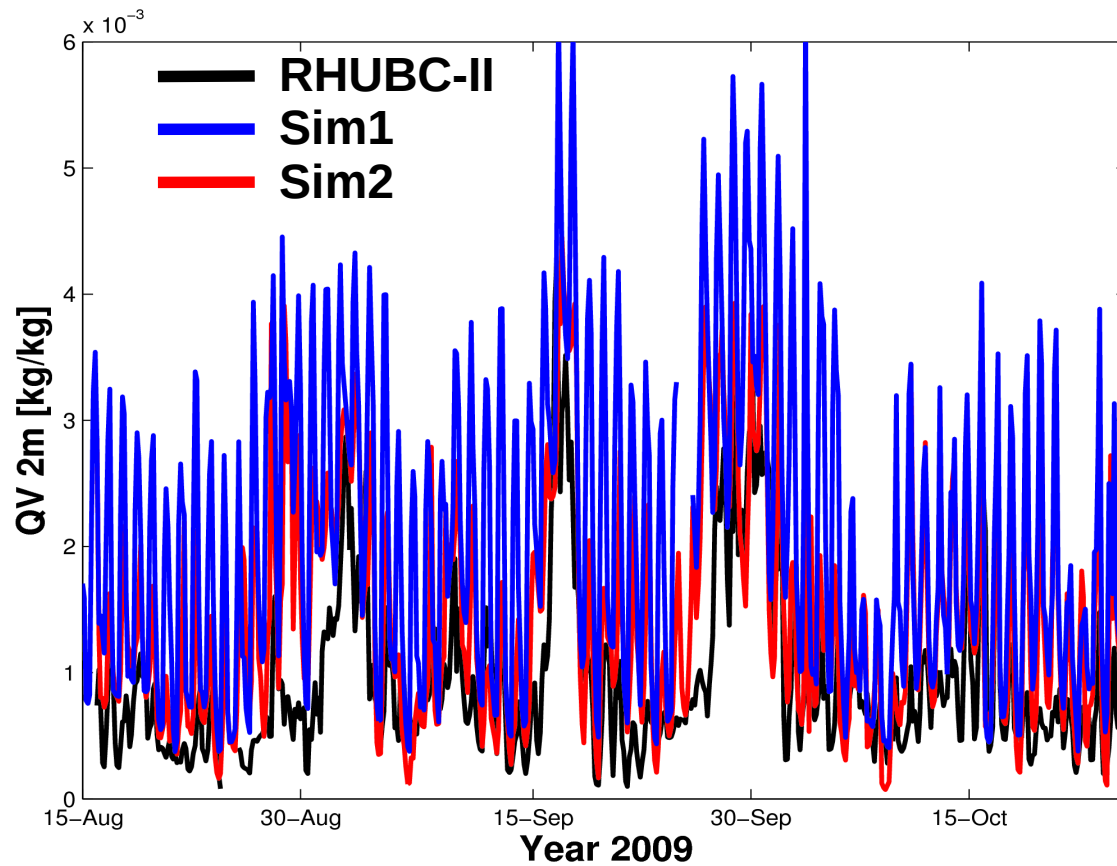
<i>WRF</i>	<i>RMSE</i> [°C]	<i>Mean Bias</i> [°C]
<i>Sim1</i>	2.0	0.3
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Preliminary analysis

Surface Variables: qv 2m

RMSE and mean Bias notably reduced in Sim2



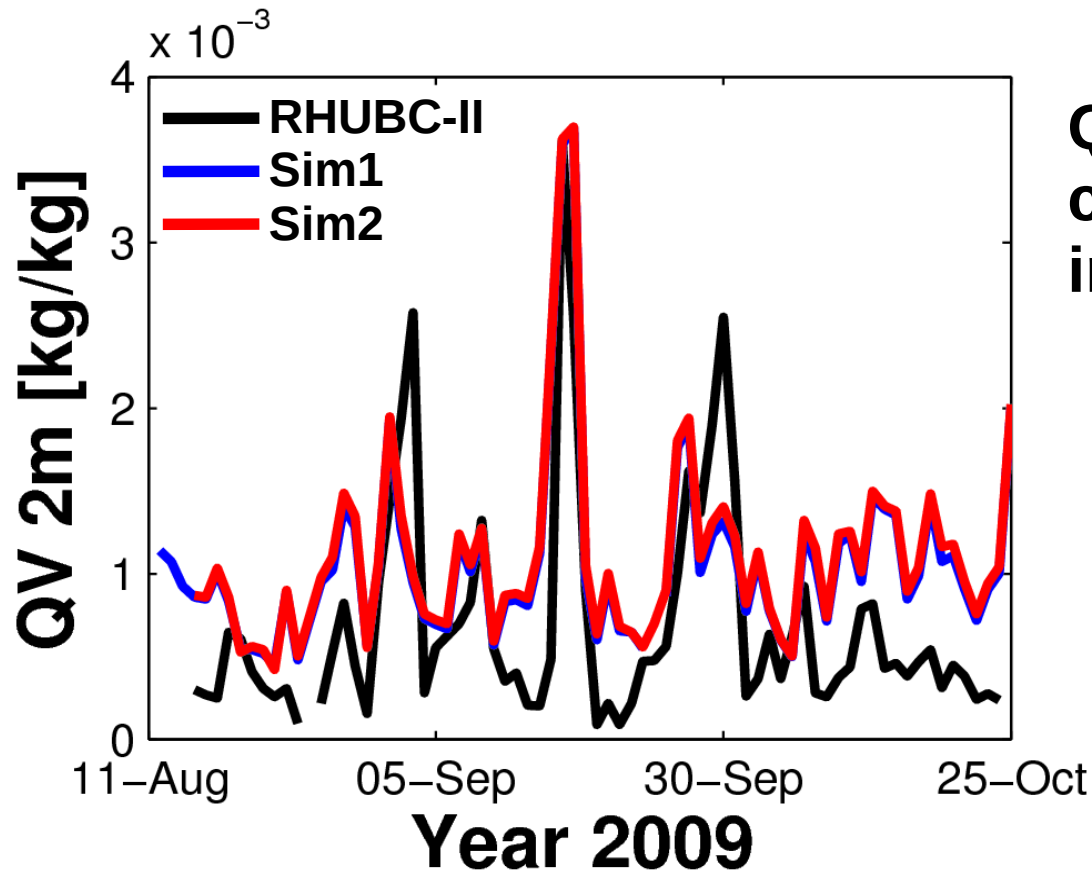
<i>WRF</i>	<i>RMSE</i> [kg/kg]	<i>Mean Bias</i> [kg/kg]
<i>Sim1</i>	1.6×10^{-3}	1.2×10^{-3}
<i>Sim2</i>	0.9×10^{-3}	0.5×10^{-3}

Preliminary analysis

Is the improvement in near-surface humidity related to the initial conditions or to the new configuration (land surface model and land-use file)???

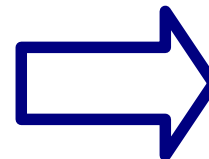
Preliminary analysis

Is the improvement in near-surface humidity related to the initial conditions or to the new configuration (land surface model and land-use file)???



Qv 2m at the initial conditions (12 UTC) in D4

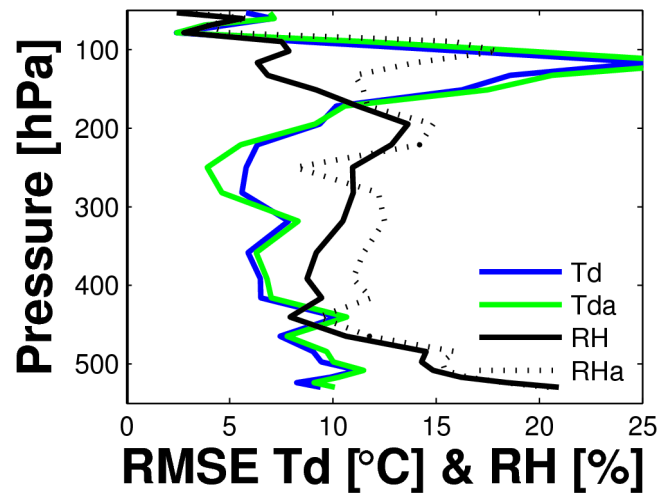
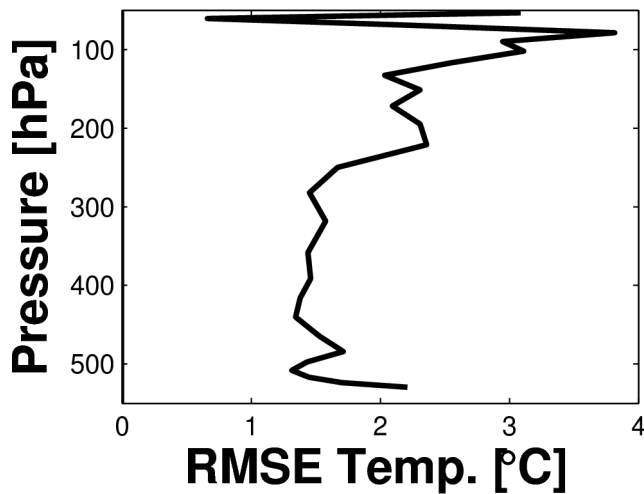
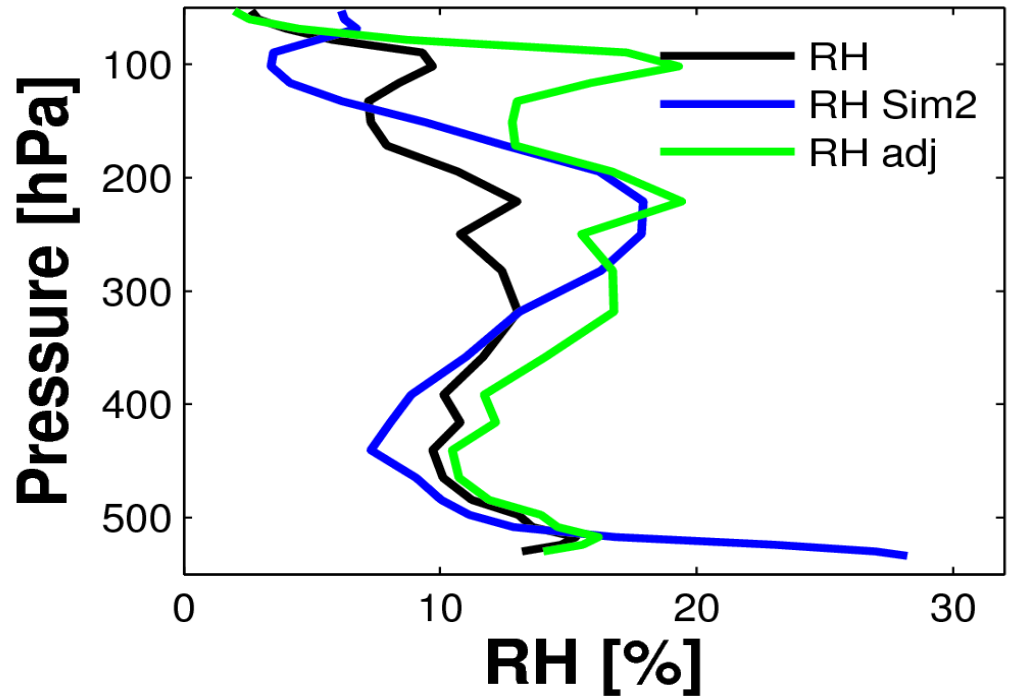
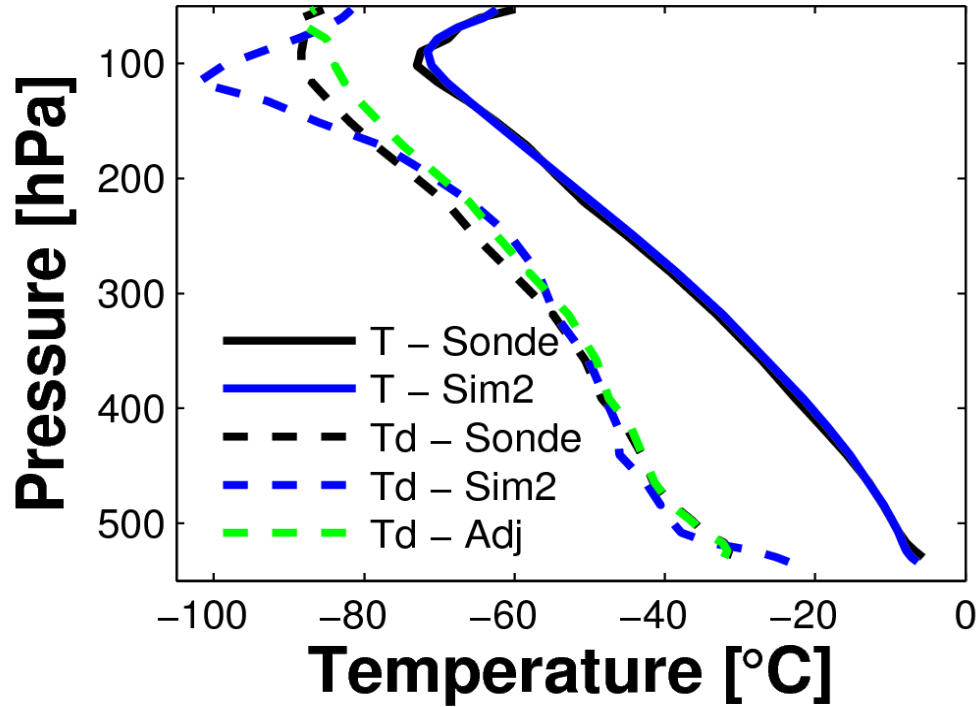
RMSE (Qv 2m) = 0.6×10^{-3} kg/kg !!!!!



The new configuration causes better results

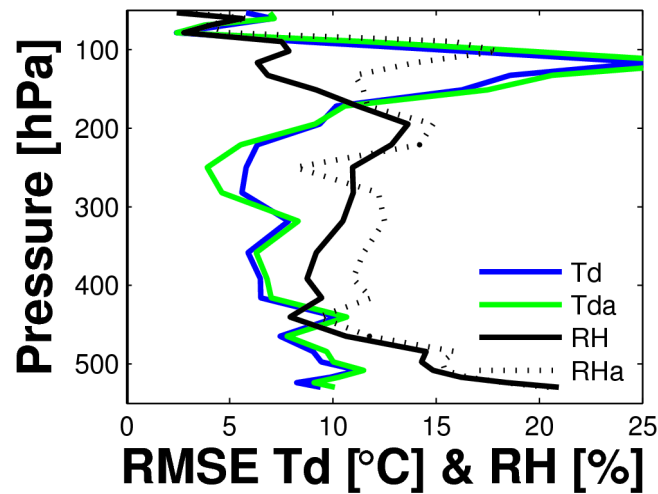
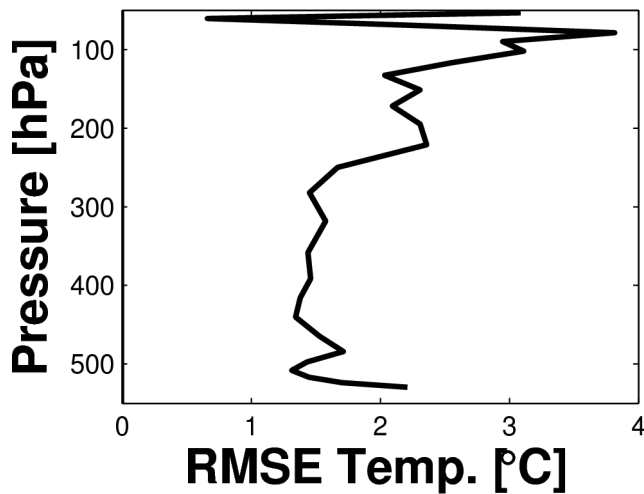
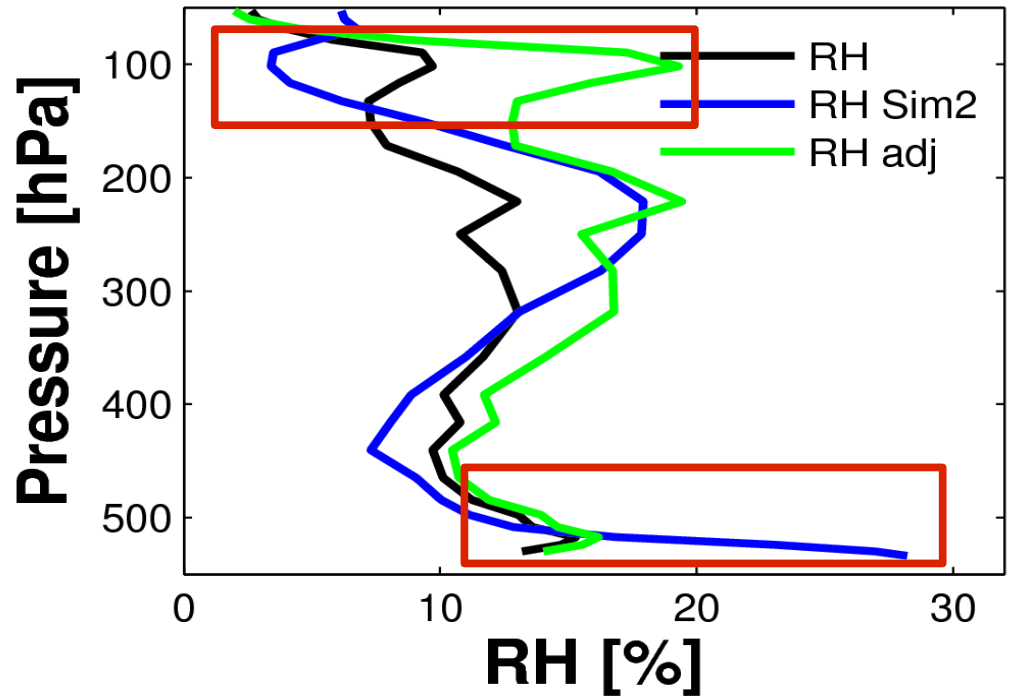
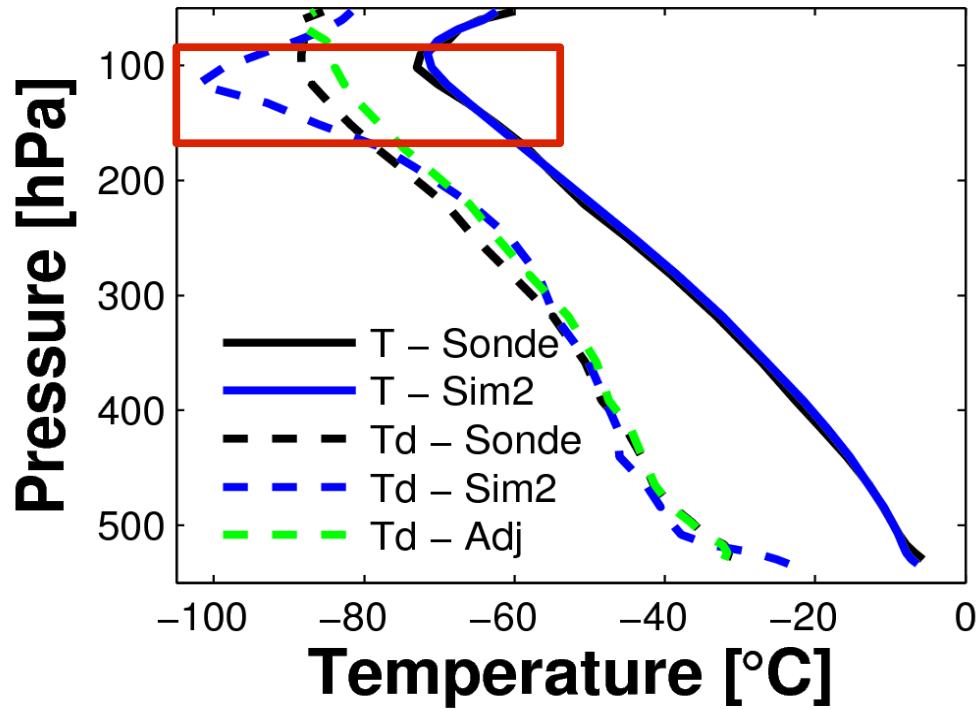
Preliminary analysis

Sondes: Temperature, Dew-point and RH



Preliminary analysis

Sondes: Temperature, Dew-point and RH

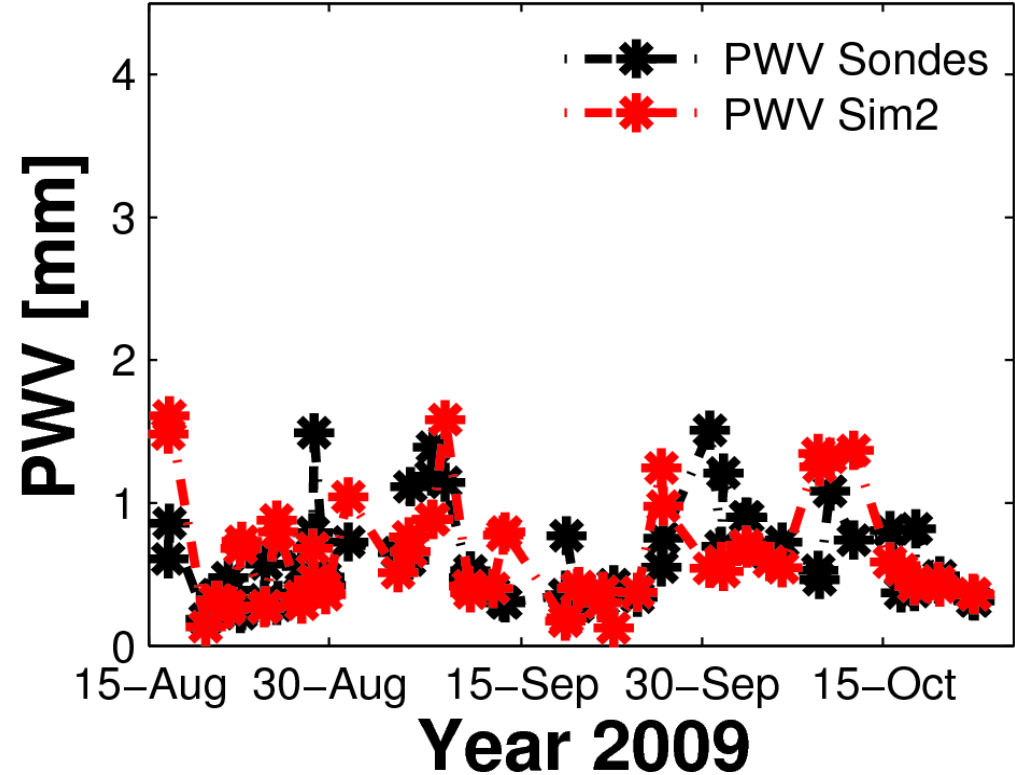
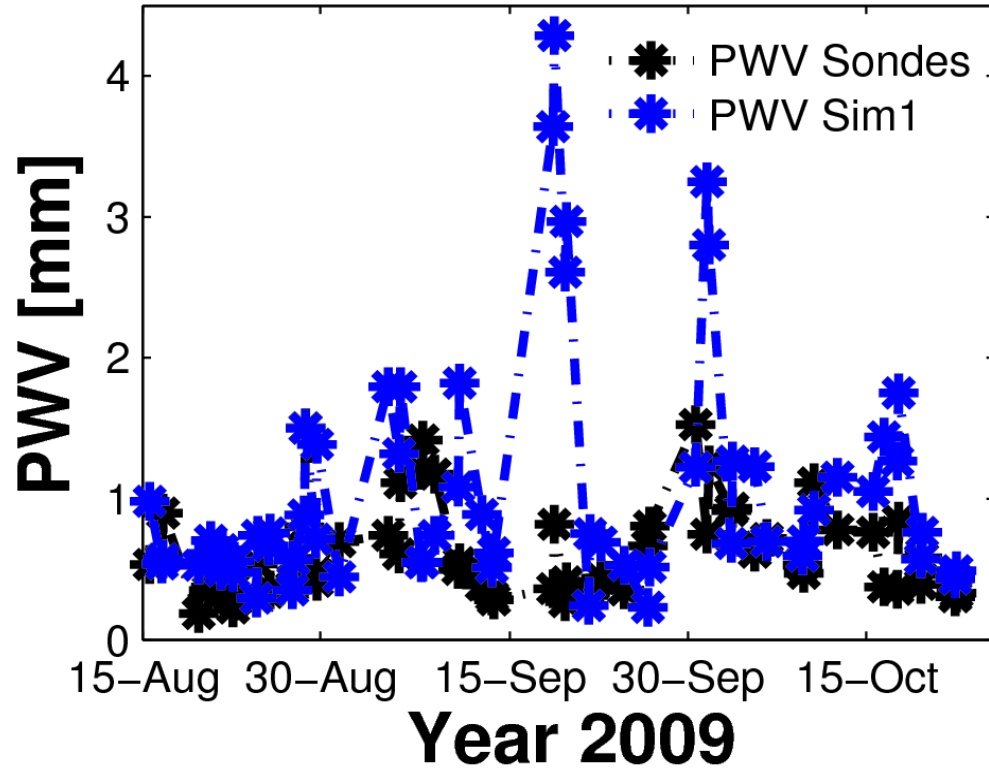


RH profile improves with the new configuration BUT

Still exist large differences at lower levels and ~100 hPa

Preliminary analysis

Sondes: PWV calculation



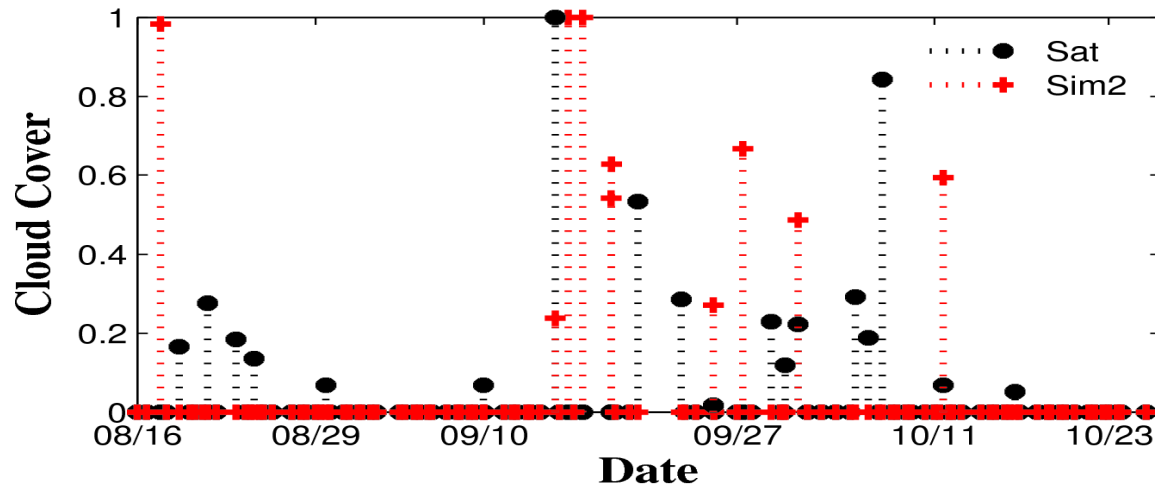
WRF	RMSE [mm]	Mean Bias [mm]	Ave. [mm]
Sim1	1.0	0.4	1.1
Sim2	0.4	0.02	0.6

PWV values are much better reproduced in **Sim2**

Similar results when using qv from the adjusted RH profiles

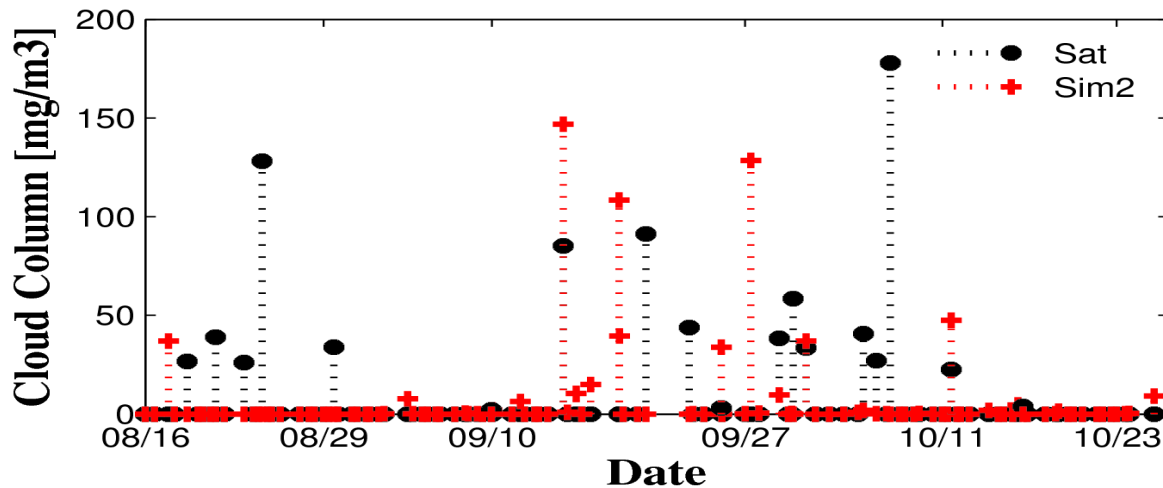
PWV average in Sondes = 0.6 mm !!!!

Preliminary analysis



Satellite data includes TRMM and CloudSat.

Cloud cover and cloud column averaged over D4.



More skill predicting days without clouds than days with clouds.

WRF seems to produce less clouds but more liquid water content.

WRF Sim2	Satellite	
	Cloud Present	Cloud Not Present
Cloud Present	4%	5%
Cloud Not Present	12%	79%

Conclusions

- It seems that Noah-LSM and the new land-use file improve notably the near-surface humidity.
- A large negative bias is introduced in the near-surface temperature.
- RH profiles and PWV improve in Sim2 but still large differences remain.
- WRF underestimates the presence of clouds in the region.

Future Plans

- Initialize WRF simulations with near-surface observations and/or radiosondes to analyze with more confidence the role of parametrizations.
- Use a more sophisticated microphysics package for a better comparison of cloud properties with satellite observations.