FIRST CORDEX WRF workshop & CORWES/WRF4G hands-on tutorial

WRF SIMULATIONS OF WATER VAPOR IN OROGRAPHICALLY COMPLEX TERRAINS (CANARY ISLANDS)

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GOTA Grupo de Observación de la Tierra y la Atmósfera

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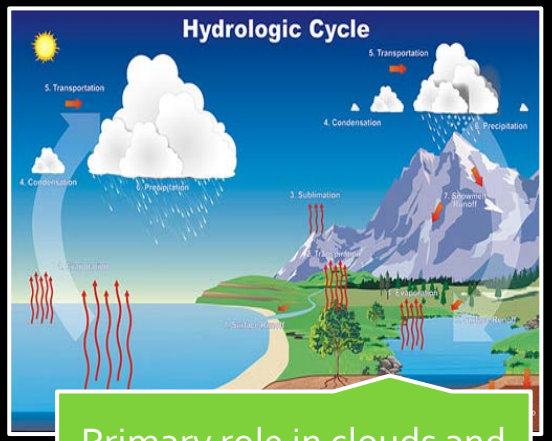
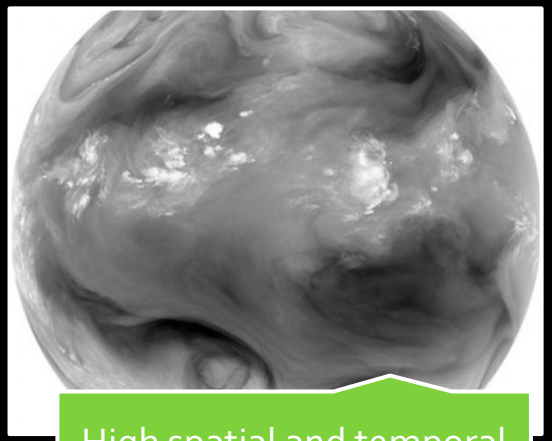
- Data
- Experimental Setup
- Results
- Conclusions

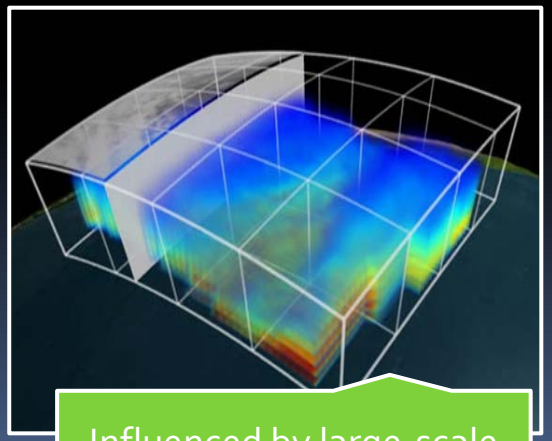
Water Vapor



Primary role in clouds and precipitation processes



High spatial and temporal variability



Influenced by large-scale and local processes

Affects human activities

Objectives

- Evaluates WRF skills to simulate water vapor
  - Integrated water vapor
  - Vertical profiles
- Sensitivity studies
  - Physical parameterizations
  - Analysis nudging
  - Diurnal analysis
- Forecast simulations

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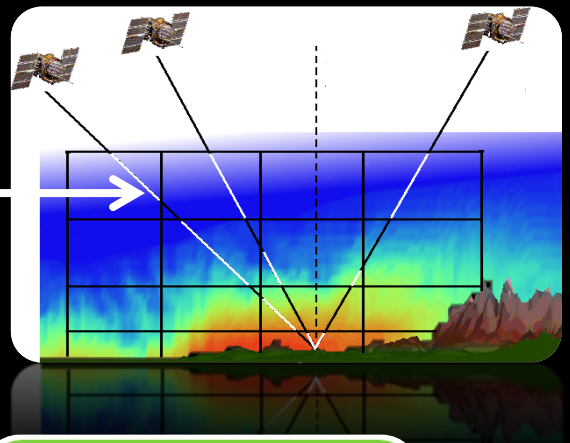
Data

- GPS



ZTD=ZHD+ZWD

$ZHD=f(P_{GPS})$

$PWV=\Pi * ZWD$

$$\Pi = \frac{10^6}{\rho_w R_w \left(\frac{K_3}{T_m} + K_2\right)}$$

PWV

- Three stations (GNSS network)
  - LPAL: 2153 masl
  - IZAN: 2367 masl
  - MAS1: 160 masl

Data

- Radiosondes
  - Launched at Güímar: 105 masl

  - Twice a day
    - Midnight 00:00 UTC
    - Noon: 12:00 UTC

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Experimental Setup

- **WRFv3.1.1**

  Two sets of experiments

  - Sensitivity studies
    - Initial and Boundary Conditions provided by analysis data (FNL), each 6 h.
  - Forecasts
    - Initial and Boundary Conditions provided by GFS forecast data

  Land use and topography prescribed from USGS

Experimental Setup

- **Domains (2-way nesting)**

DX:

D1: 27 km

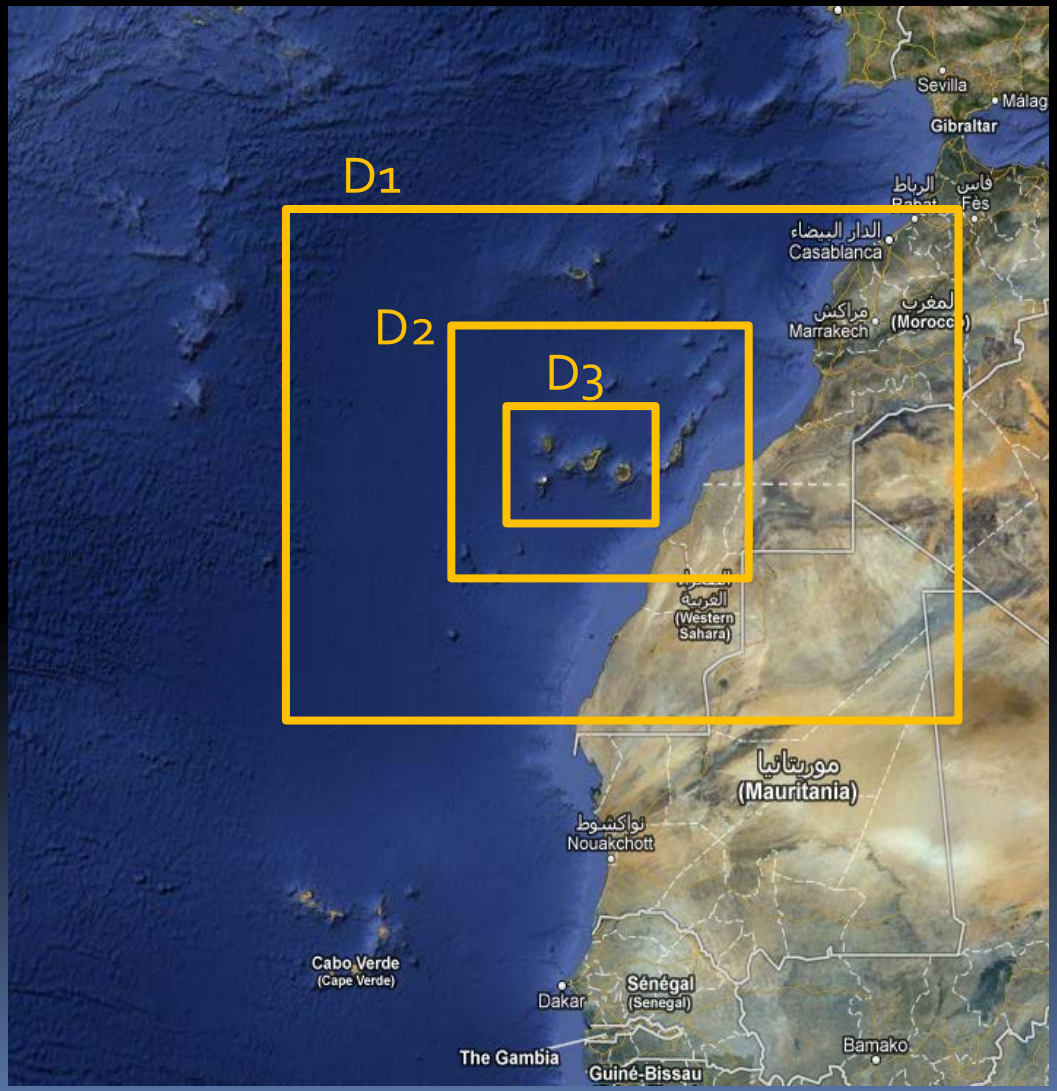
D2: 9 km

D3: 3 km

Cumulus:

D1, D2: Grell

D3: Resolved



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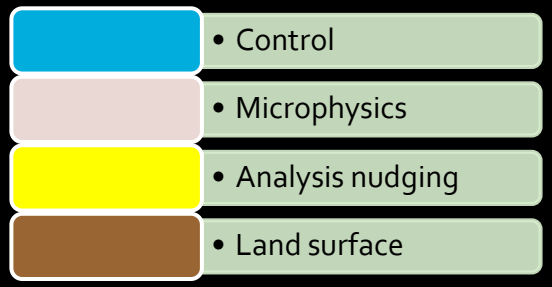
Results

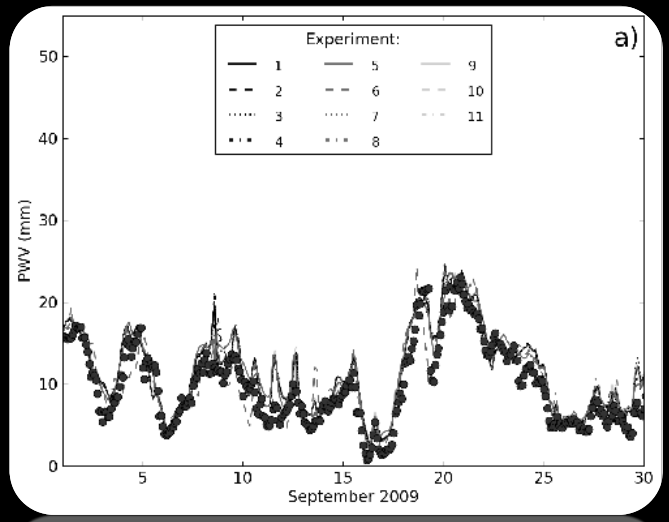
- **Sensitivity studies**



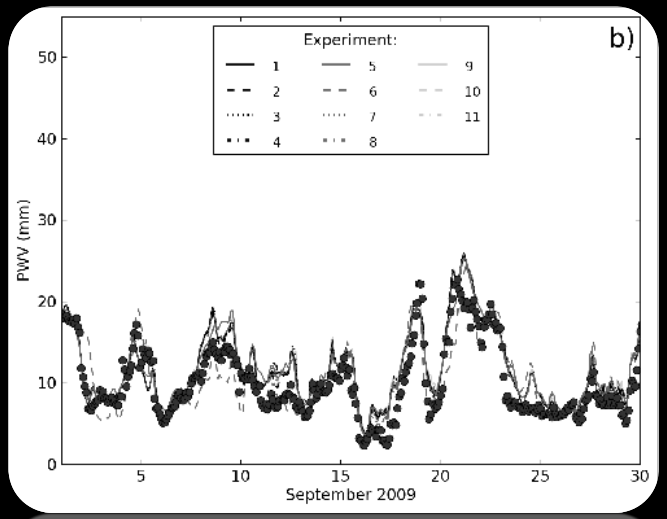
Name	Vert. Levels	Microphysics	Nudging			Positive definite	PBL	Land surface
			D1	D2	D3			
E1	35	WDM6	A	B	0	Yes	YSU	Noah
E2	60	WDM6	A	B	0	Yes	YSU	Noah
E3	35	WSM6	A	B	0	Yes	YSU	Noah
E4	35	Thompson	A	B	0	Yes	YSU	Noah
E5	35	WDM6	A	A	B	Yes	YSU	Noah
E6	35	WDM6	0	0	0	Yes	YSU	Noah
E7	35	WDM6	A	B	0	no	YSU	Noah
E8	35	WDM6	A	B	0	Yes	MYJ	Noah
E9	35	WDM6	A	B	0	Yes	YSU	Pleim-Xu
E10	35	WDM6	A	B	0	Yes	YSU	RUC
E11	35	WDM6	A	B	0	Yes	YSU	5-layera

September 2009

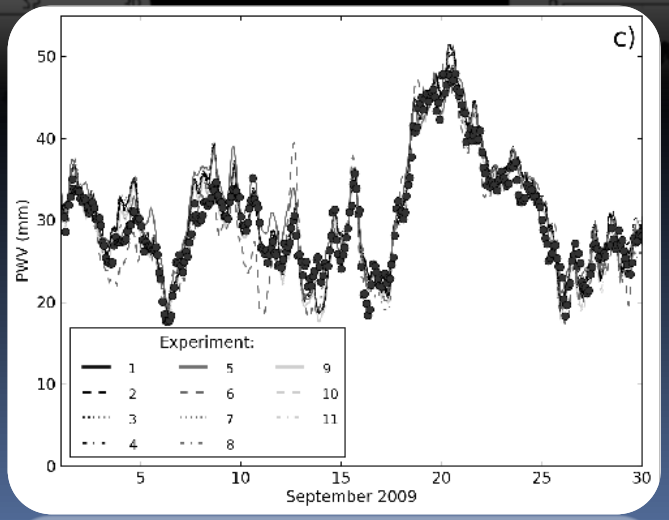
- One month continuous run (1 day spin-up)



Izaña

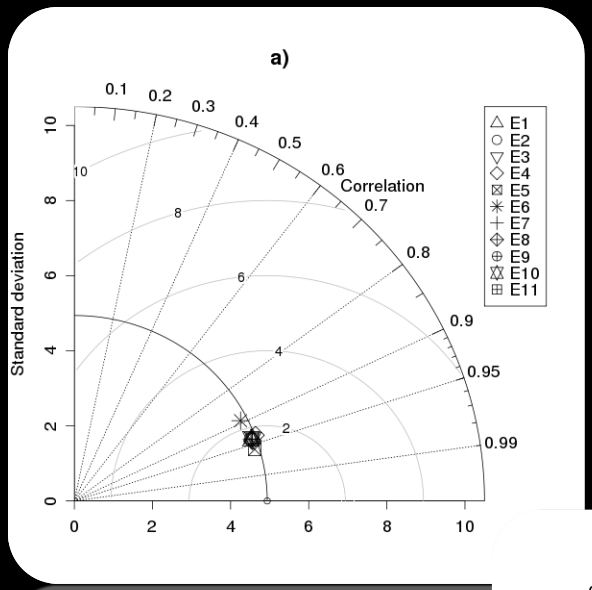


La Palma

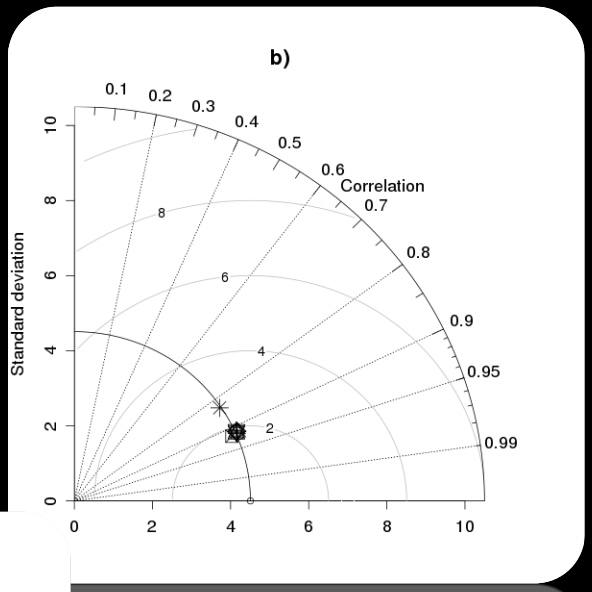


Maspalomas

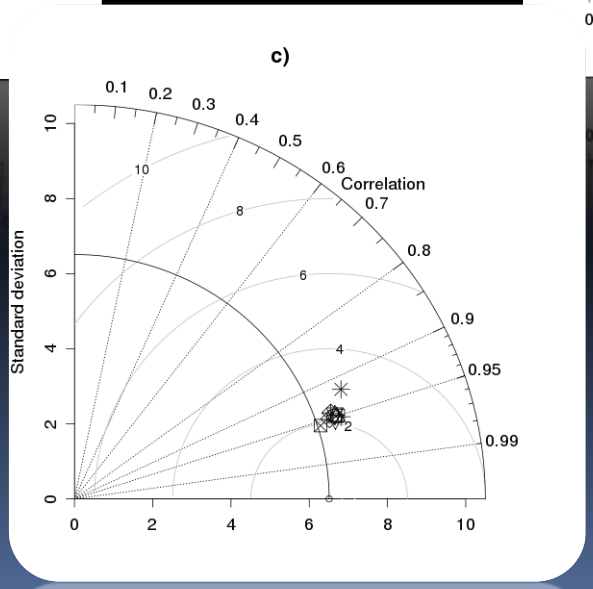
- # September 2009
  - ## Taylor diagrams



Izaña

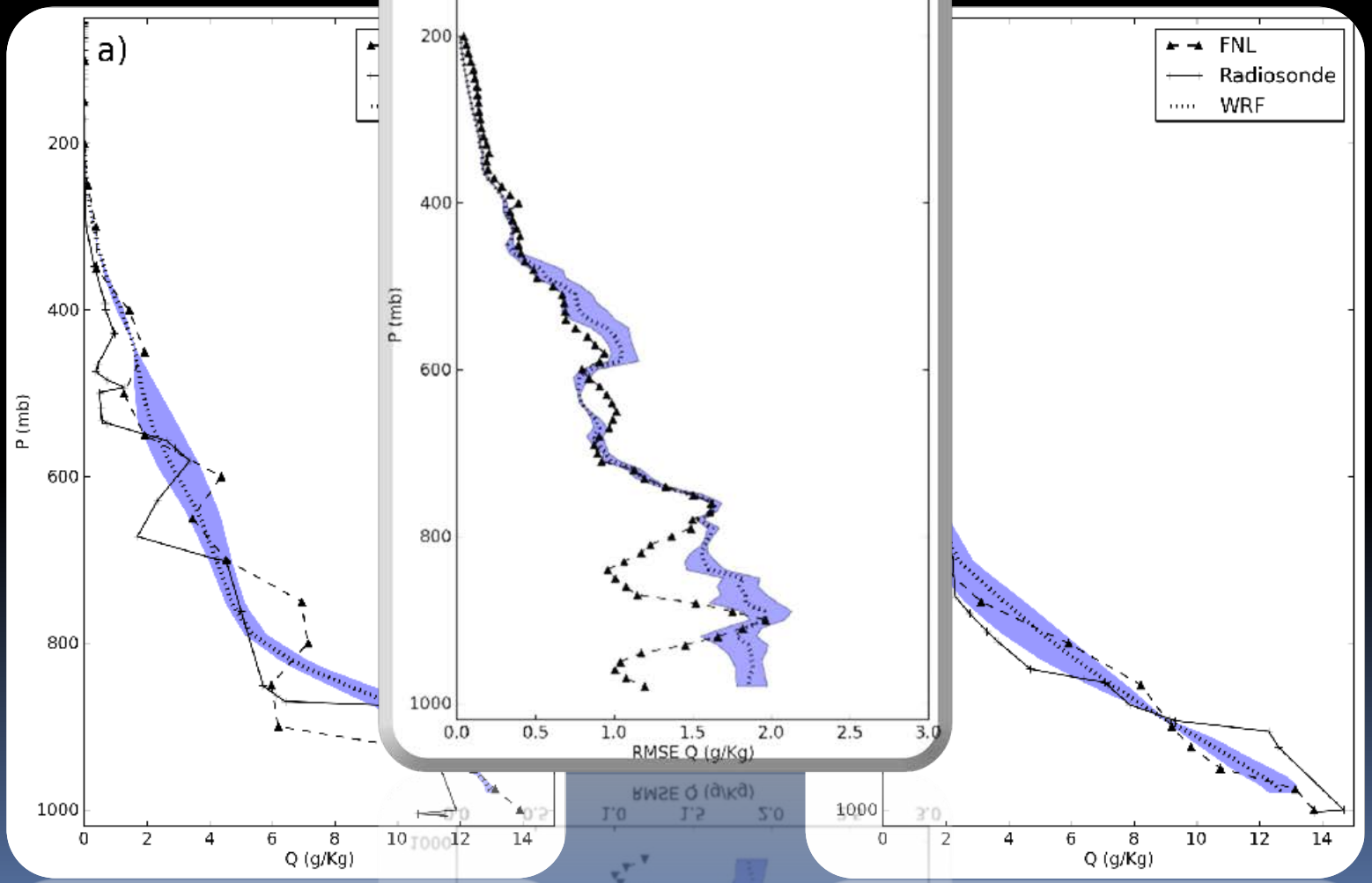


La Palma



Maspalomas

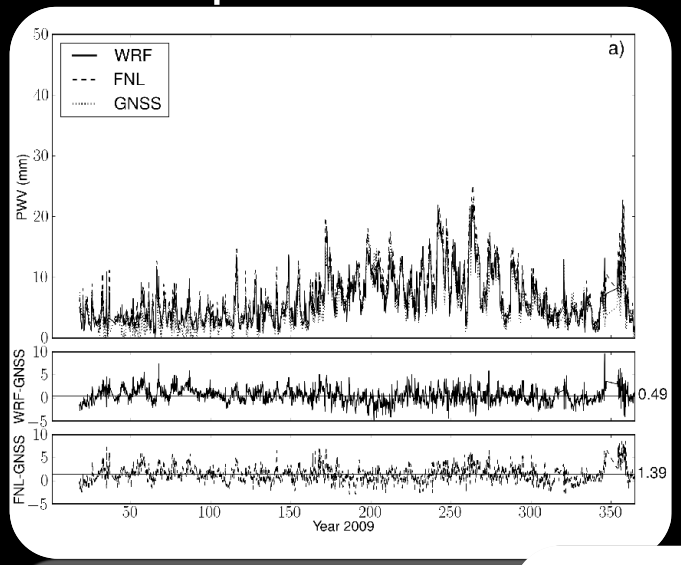
- **September 2009**
  - **Vertical profiles**
    - **Water vap… …with radiosondes**

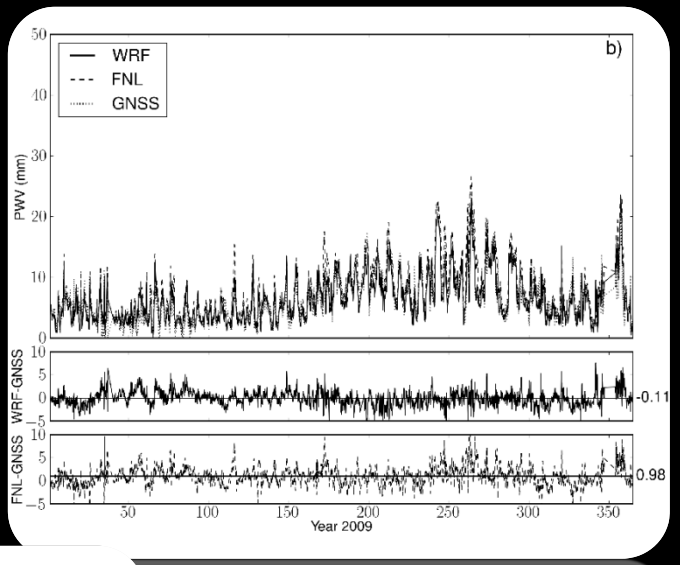


Results

- 2009 annual simulations (monthly re-initializated runs)
  - Experiment E1

Results





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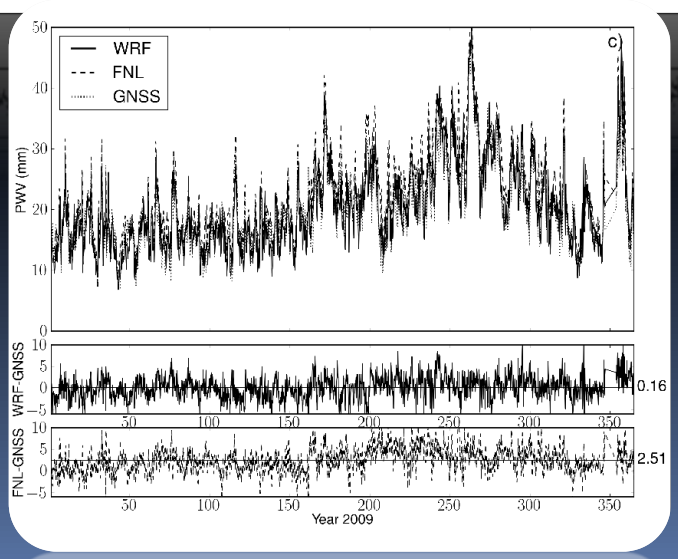


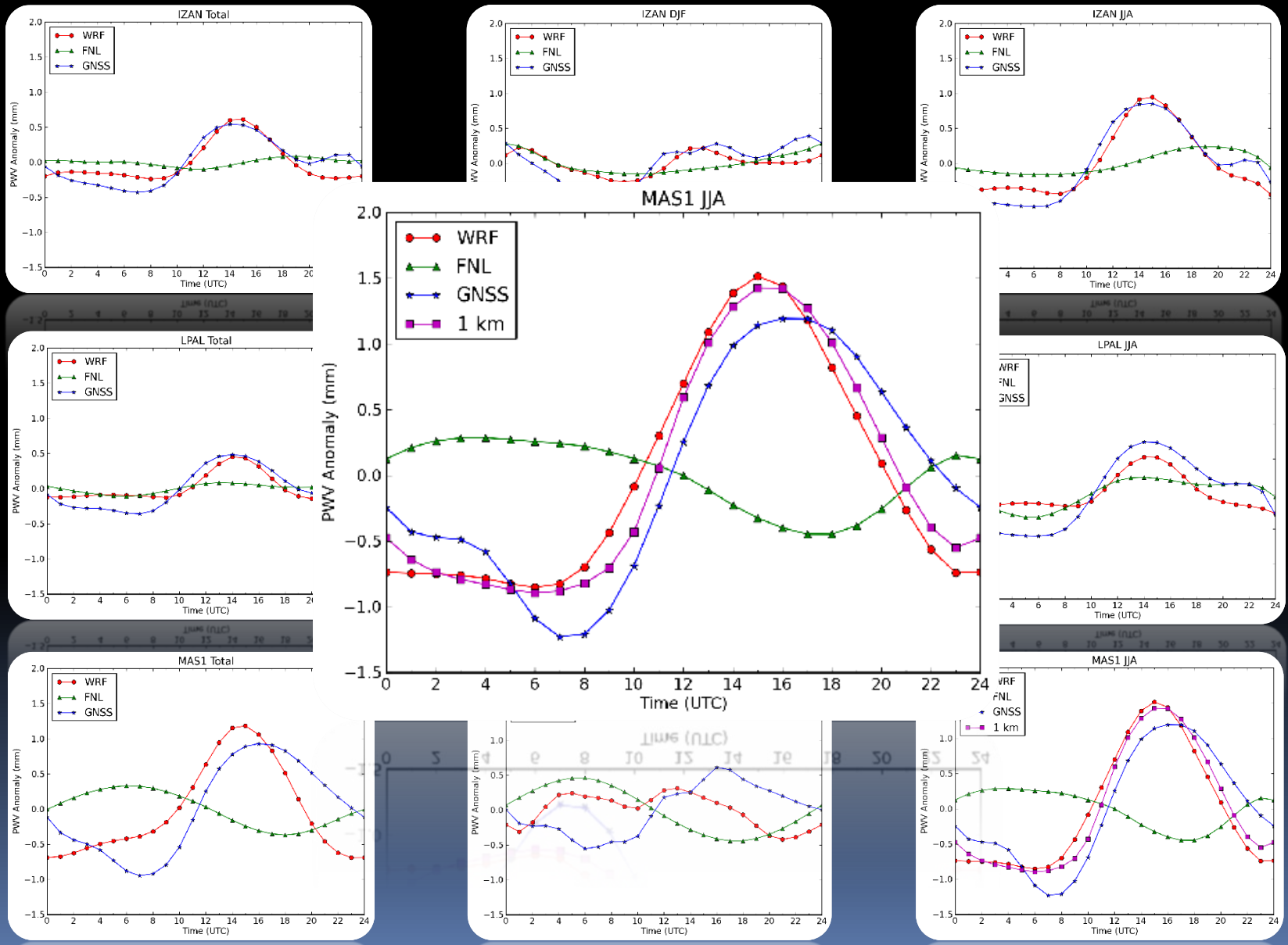
La Palma

Maspalomas

- # Diurnal cycle of PWV
  - Mainly local processes associated to diurnal variations
  - Diurnal anomaly.
  - $A_H = PWV_H - \overline{PWV_D}$
  - $\overline{PWV_D} = \frac{\sum_{H=0}^{23} PWV_H}{24}$
  - large-scale mechanisms are filtered by removing the daily average component and by averaging the anomalies over a large number of days.
    - Annual
    - Seasonal

Diurnal cycle of PWV

Results

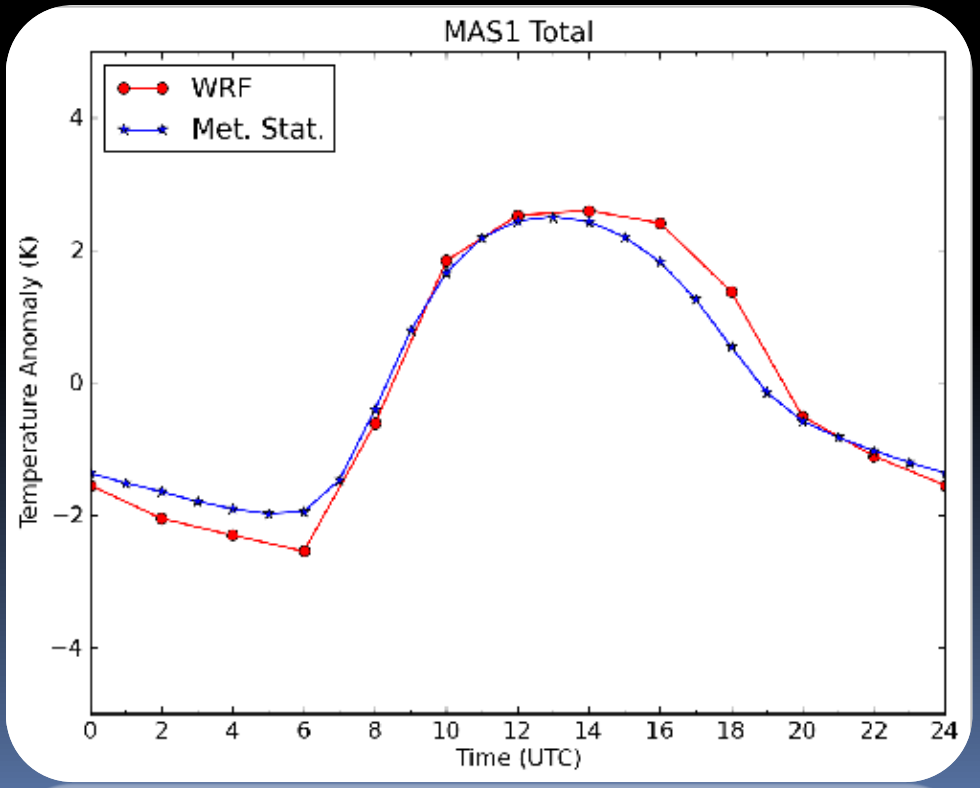


- **Diurnal cycle of PWV**
  - **Case study. Maspalomas**

Several factors analyzed:

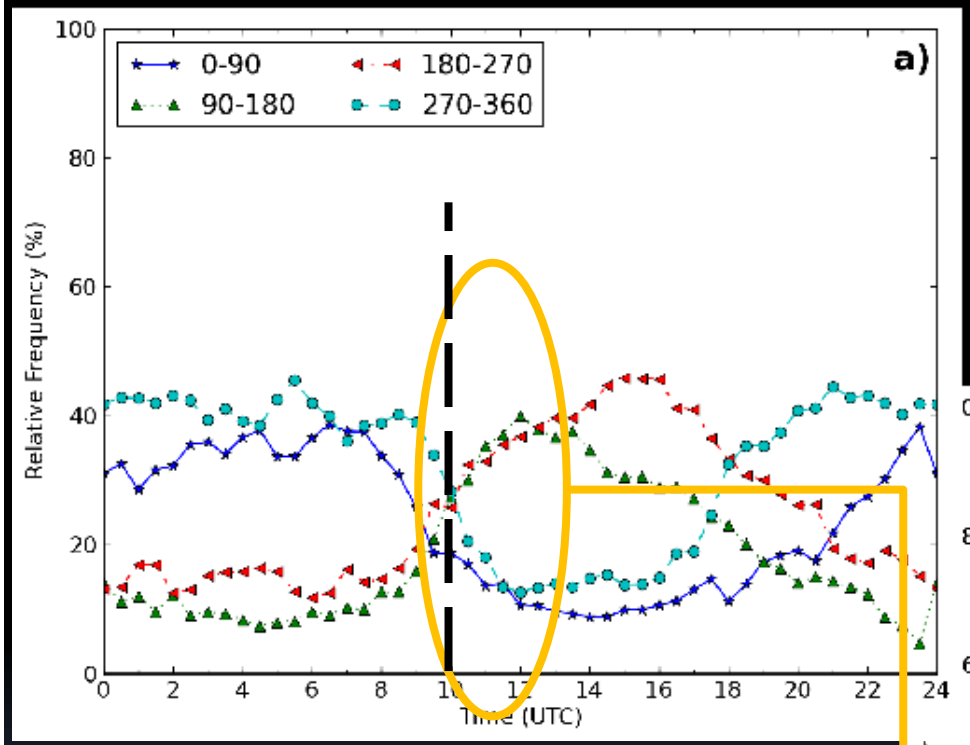
- Temperature
- Moisture transport by local processes

Temperautre



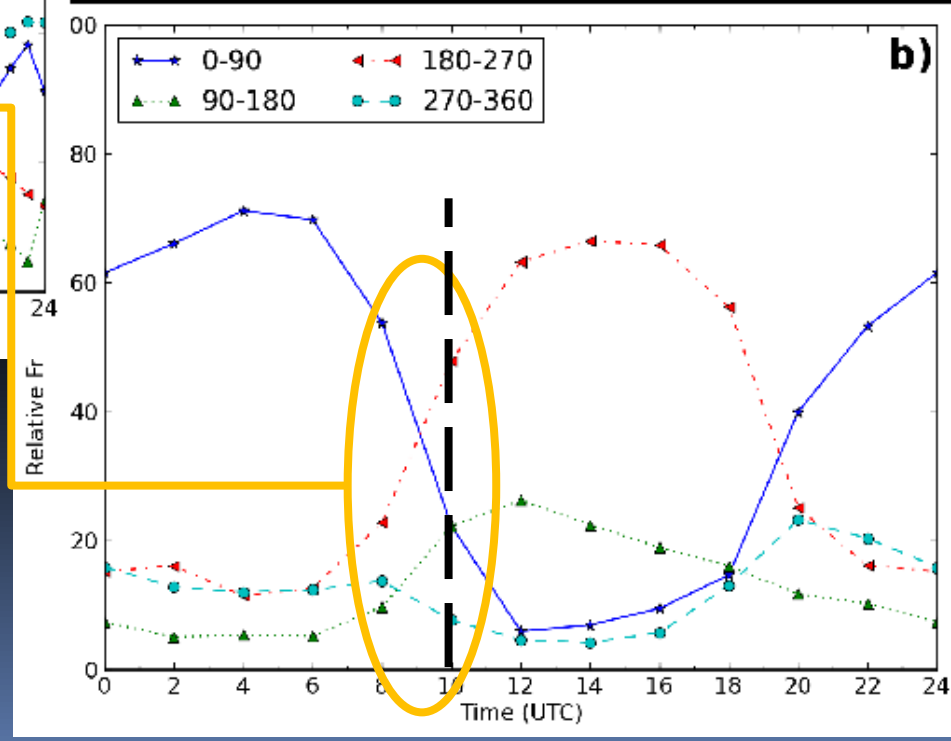
- Diurnal cycle of PWV
  - Diurnal wind anomaly

WRF simulated



Ground measurements

Relative frequency of wind direction



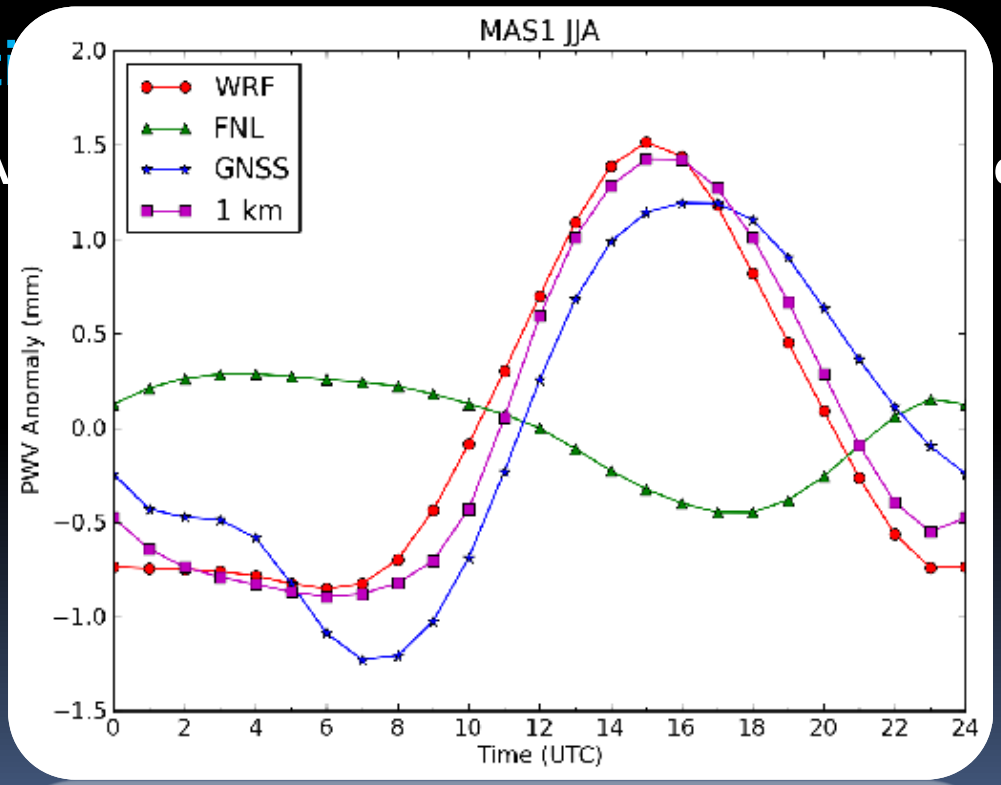
- **Diurnal cycle of PWV**
  - **Surface Sensible heat flux**

    New experiments for summer season

    - **Land surface model**
      - **3 new simulations**
        - **RUC**
        - **Pleim-XuN** → No appreciables differences found
        - **5 layer diffusion**
    - **Land cover**
      - **2 new simulations varying soil category**
        - **Lava**
        - **Playa** → No appreciables differences found
    - **Sea surface temperature**
      - NCEP Real Time Global sea surface temperature (RTG SST) (1/12° grid)

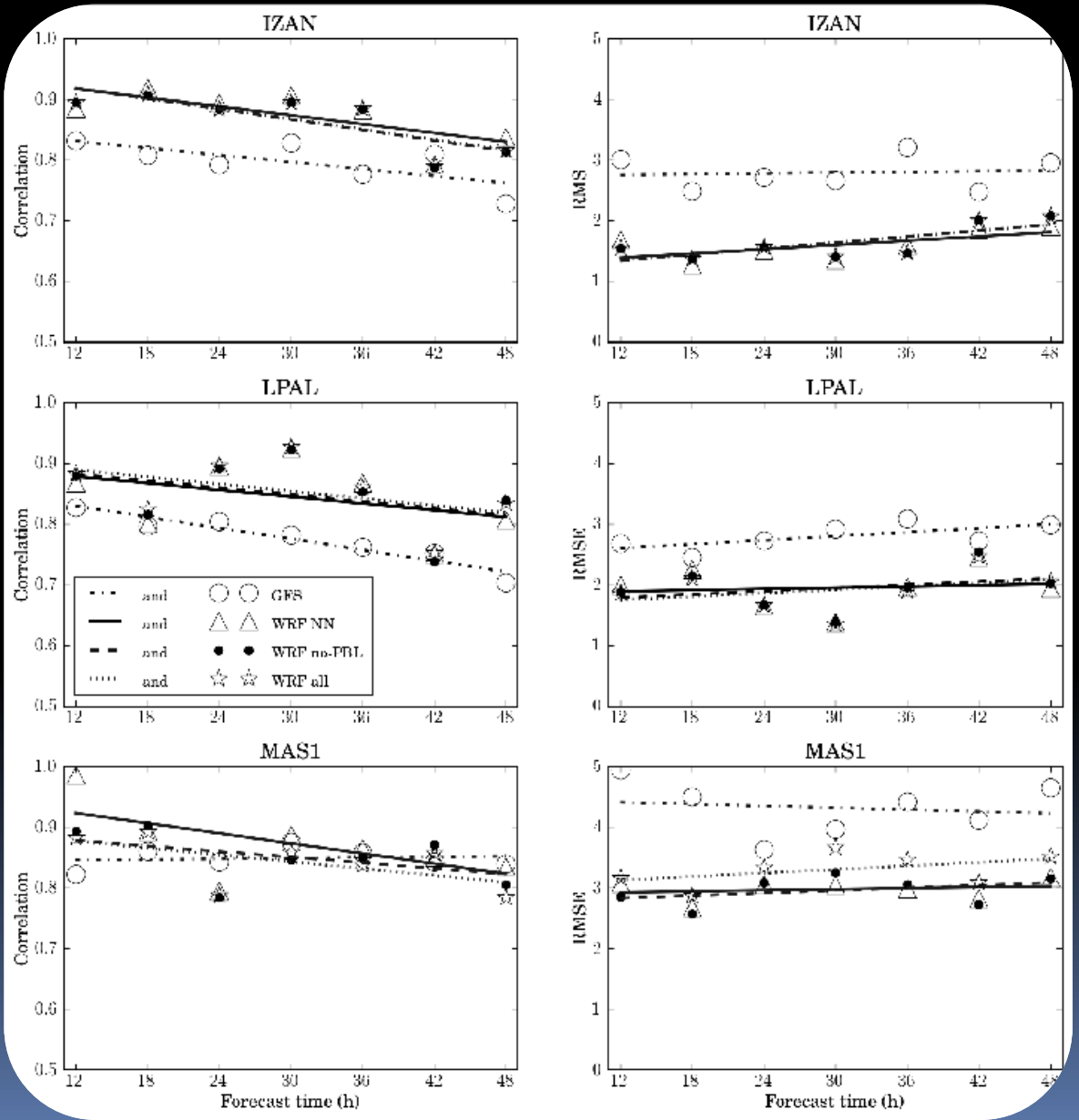
- Diurnal cycle of PWV
  - Sensible heat flux

    New experiments for summer season
    - PBL Mellor-Yamada-Janjic
    - Spati
      - A dx=1km)



- # Water vapor forecast
  - To evaluate nudging strategies
  - 48 hours forecast runs for March, 2010.
  - Initial and boundary conditions provided by GFS
  - Same configuration as experiment E1
  - Initial 12 hours are not considered (spin-up)
  - Three nudging strategies
    1. No nudging in any domain
    2. Nudging in the whole column in the outer domains D1 and D2
    3. Nudging above the PBL in D1 and D2
  - Model outputs are compared with GPS for different forecast times (every 6 hours)

Water vapor forecast



Results

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Conclusions

- **WRF skills to simulate water vapor over Canary Islands are evaluated**
  - **In general, good agreements**
    - **Correlations ~ 0.95, CRMS ~ 2.2 mm**
    - **No appreciable sensitivity to parameterizations:**
      - **Microphysics, Land Surface, PBL, vertical levels**
      - **Nudging techniques provide better results**
    - **Annual simulation (2009) shows no dependence in the simulated PWV with the total amount.**
    - **PWV diurnal cycle is also analyzed:**
      - **Better representation in high elevation sites**
      - **Time shift observed in sea-level areas**
      - **Further studies performed (land surface model, land type, PBL, SST, horizontal resolution)**

Conclusions

- **WRF skills to simulate water vapor over Canary Islands are evaluated**
  - **PWV forecast study**
    - **WRF improves GFS forcing data**
      - **Correlations from 0.9 (12 hours forecast) to approx. 0.8 (48 hours)**
      - **RMSE around 2 mm (high elevation sites) and 3 mm (coastal areas)**
    - **No appreciable differences found for the different nudging runs.**