Impact of the variational assimilation of ground-based GNSS Zenith Total Delay into AROME-Morocco model

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Outline

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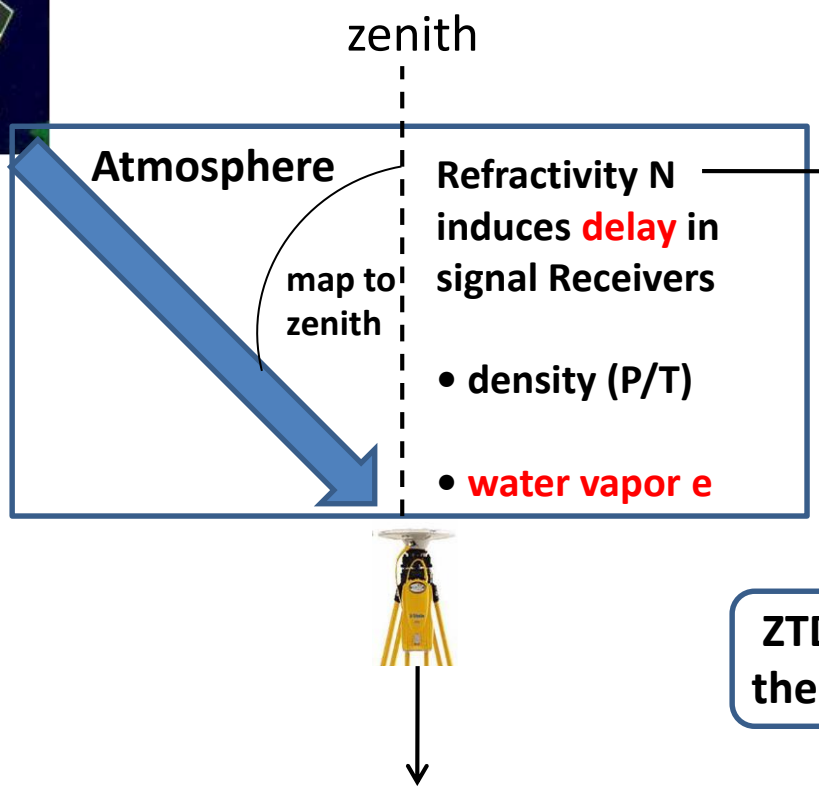
- Moroccan GNSS network
- Methodology of assimilating GNSS ZTD data in Arome-Morocoo model
- Impact of the ground-based GNSS ZTD in Arome-Morocco
- Case study
- Conclusion and future work

Zenith total delay (ZTD)



$$N = k_1 \frac{P}{T} + (k_2 - k_1)\frac{e}{T} + k_3 \frac{e}{T^2}$$

(k_1, k_2 et k_3 = cste)

[Thayer, 1974]

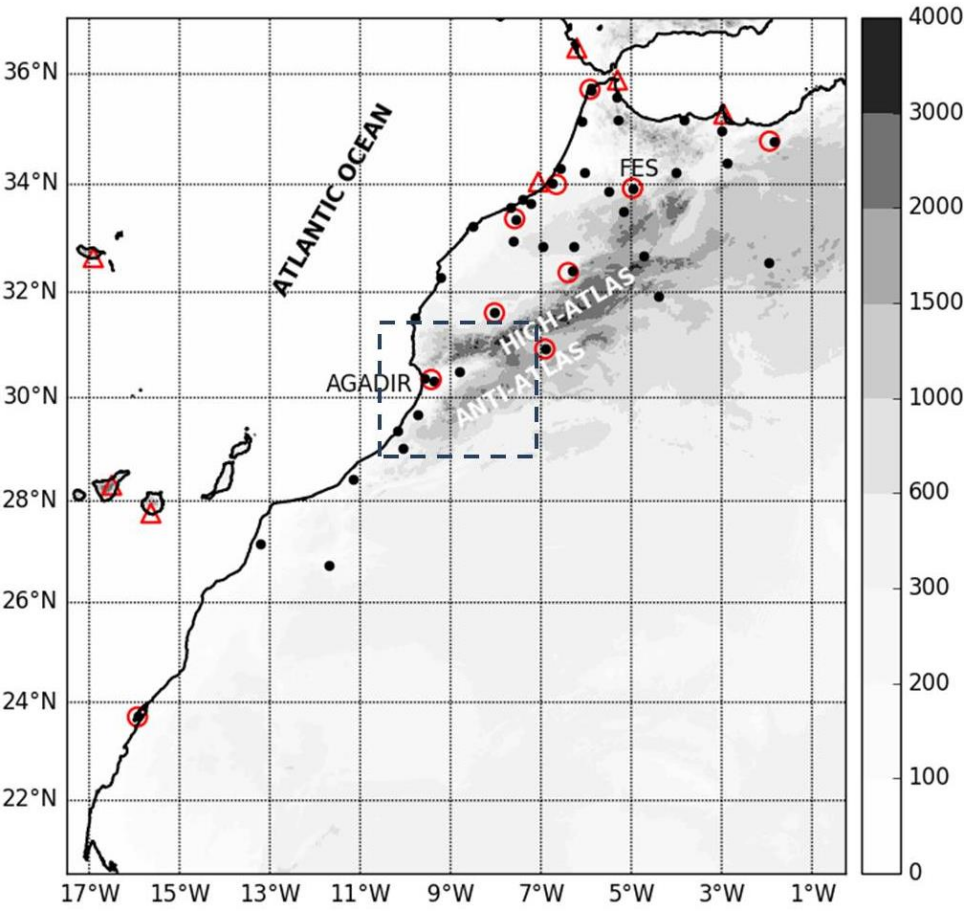
ZTD is the delay one would observe if there was a GNSS satellite at zenith

$$ZTD = 10^{-6} \int_0^{\infty} N(z)dz$$

ZTD is estimated from raw GNSS receiver data with geodetic processing software (e.g. Bernese) designed for precise positioning applications

Moroccan GNSS network

Moroccan ground-based GNSS network



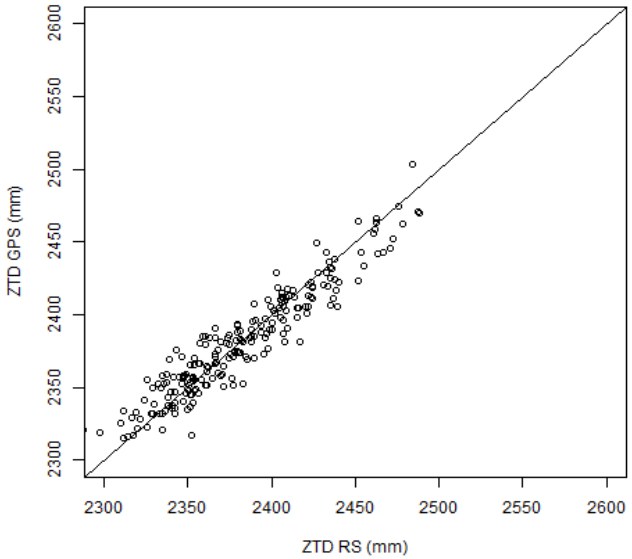
- Network started in 2012 by Maroc-Météo for NWP purpose
- IGS (International GNSS Service) stations are also added
- Raw observations processed locally by Bernese software
- GNSS ZTD available every 15 minutes
- Good data reliability and accuracy

GNSS Moroccan stations

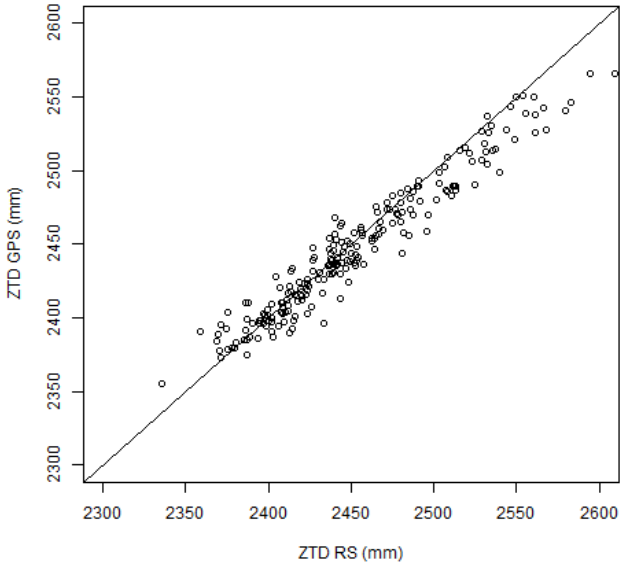
GNSS IGS stations

Near-real-time ZTD GNSS quality assessment

Casablanca

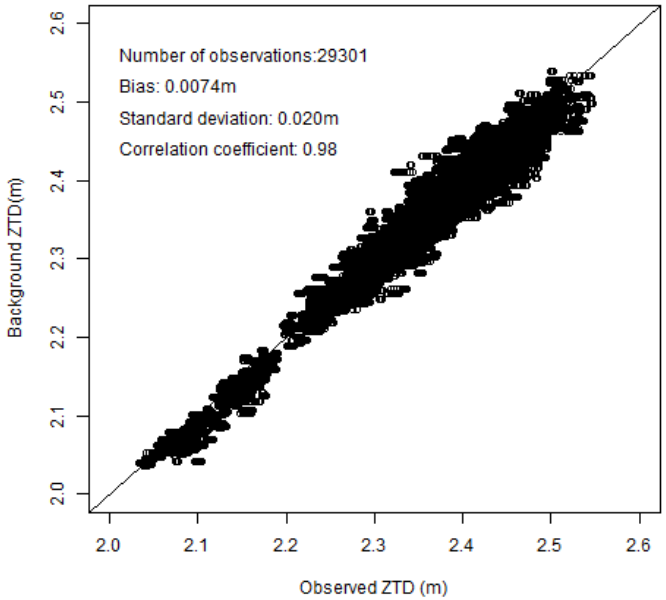


Dakhla



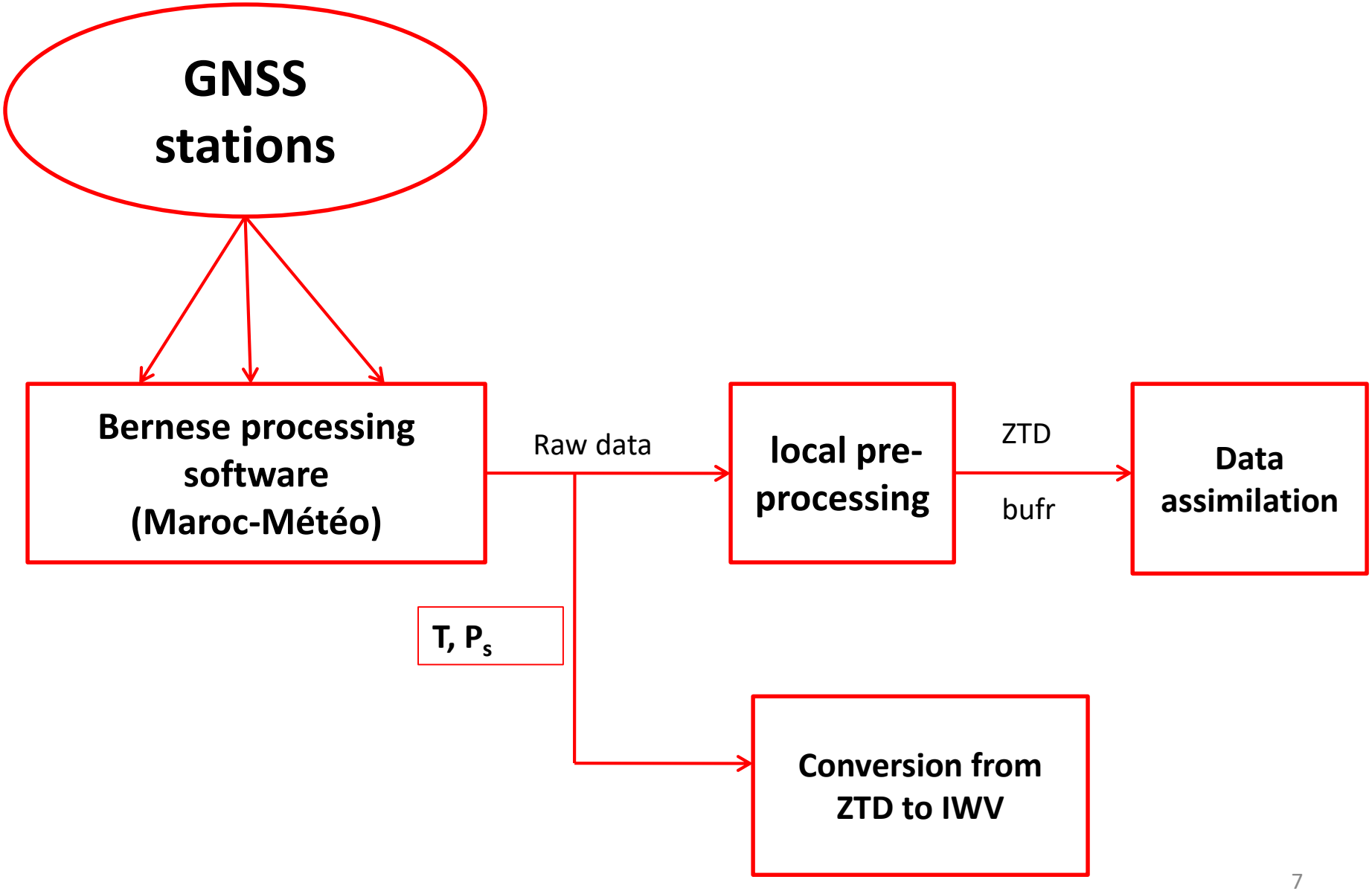
➢Comparison of GNSS ZTD observations with ZTD derived from radiosondes for CASA and DAKH (Hdidou et al., 2018)

all stations



➢Comparison of GNSS ZTD Observations with NWP 3h forecasts (fg)

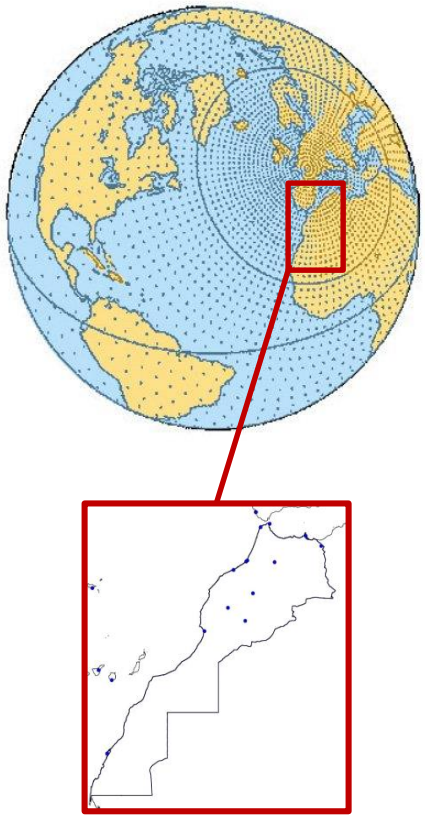
Analysis/production data flow



Methodology of assimilating GNSS ZTD data in AROME-Morocco

AROME-Morocco model

- horizontal resolution: 2.5 km,
- vertical resolution : 90 levels,
- runs twice a day (t0 = 00h and t0 = 12h) to produce forecasts up to 48h forecast range,
- lateral boundaries: ALADIN-Morocco model (7.5 km)
- initial conditions: 3D-Var data assimilation (3h cycling)

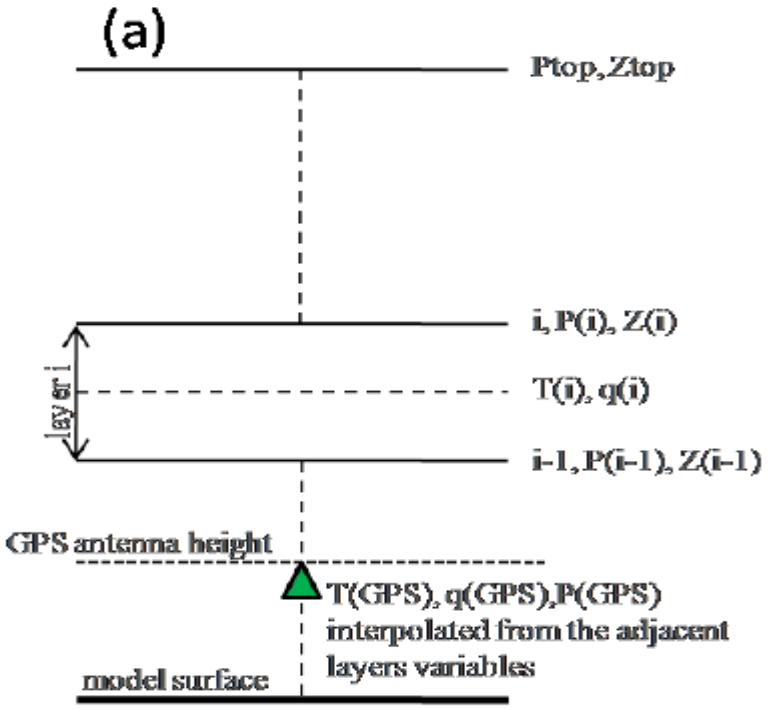


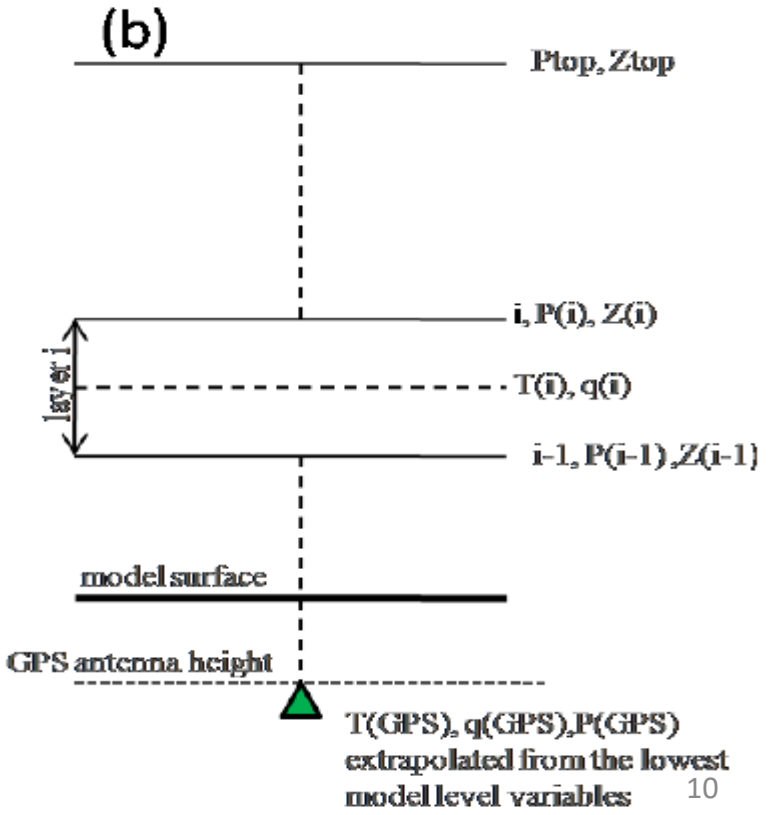
Computing ZTD from NWP fiels (Obs. operator)

(1) Interpolation of specific temperature and humidity profiles from model to observation point

(2) Computation of N (z) at the observation point (Thayer formulation)

(3) Vertical integration from GNSS antenna height to Z_{top} to obtain ZTD



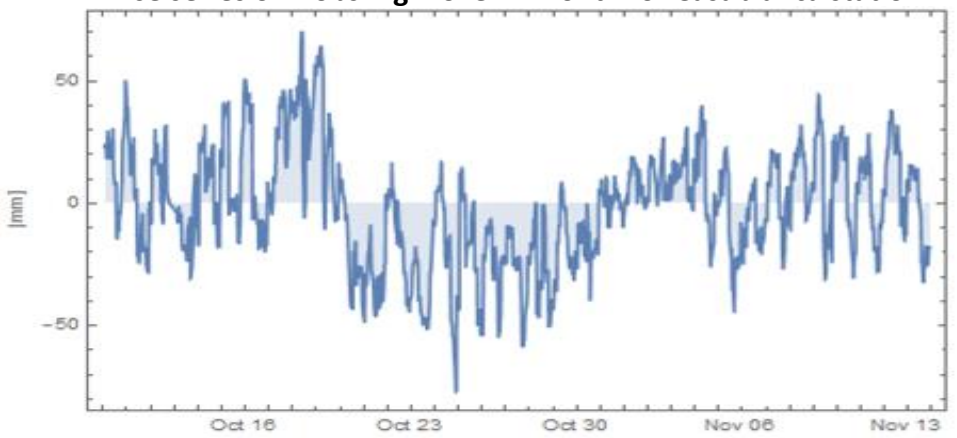


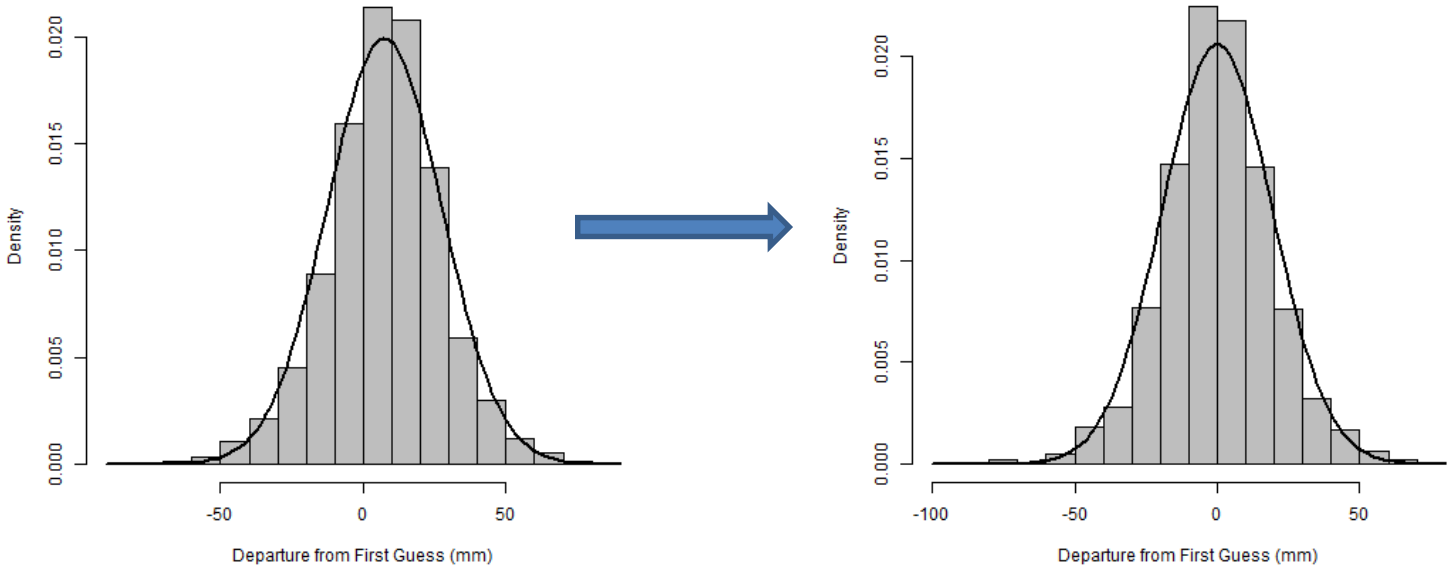
Pre-processing and bias correction

- Mean of departure “obs-fg” ZTD statistics reveal site-specific biases that are removed before assimilation using **a static bias correction system**

- **Observations errors** are estimated from the standard deviations of background departures

Timse series of « obs –fg » over 1-month for Casablanca station



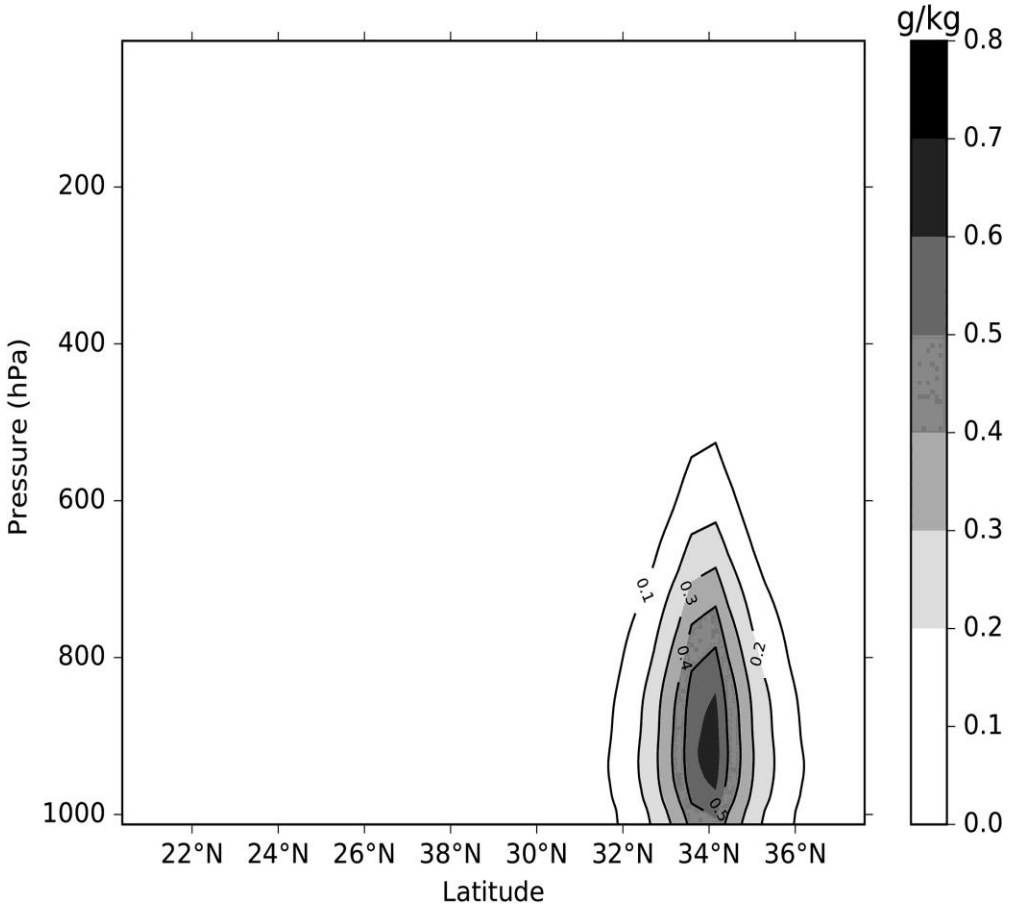


before BC

after BC

Impact of the ground-based GNSS ZTD in Arome-Morocco

Single observation experiment



- **Vertical cross-section of the analysis increment of specific humidity for the Fes station (02/26/2018 at 12 UTC):**

  Assimilation of GNSS ZTD produces increments in the low troposphere (below 500 hPa), with max impact around 900 hPa level.

- neutral impact on temperature parameter

Assimilation experiment design (OSE experiment)

➢ Two experimenst have been run over 1-month period (from 10 October to 10 November 2017)**: EXP-CRL && EXP-GNSS**

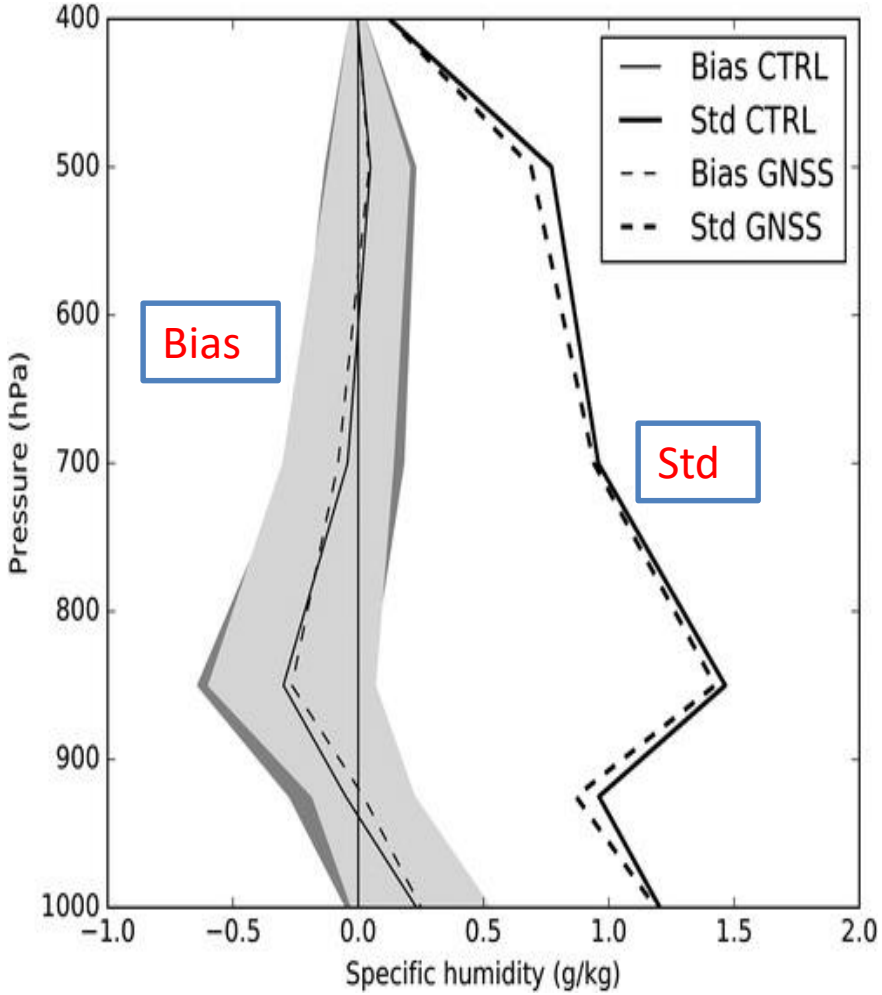
Type of observations	EXP-CTRL	EXP-GNSS
Conventional	SYNOP AIREP DRIBU TEMP	SYNOP AIREP DRIBU TEMP
Satellite	ATOVS	ATOVS **GNSS**

➢ forecast verifications done :

- verification of specific humidity with radiosonde observations
- verification of 2m relative humidity with surface weather observations
- verification of 24h precipitation accumulations with rain gauge observations

Assimilation Experiment results

➢ **verification of specific humidity with radiosonde observations**



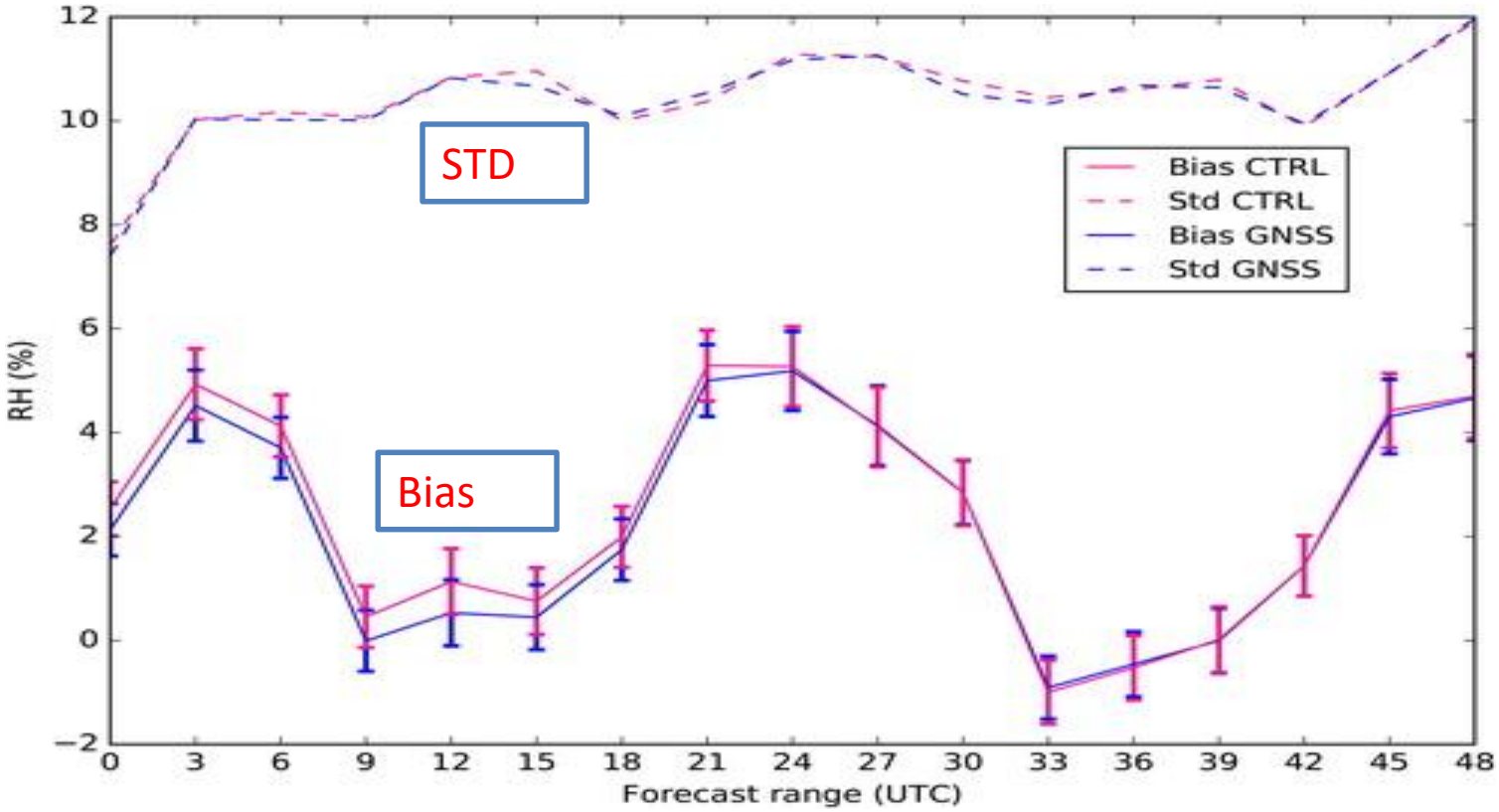
- **Statistics (Bias and STD) of background departures for specific humidity from radiosonde observations (in g/kg) for CTRL and GNSS**

- Small positive impact on standard deviation between 1000 hPa and 400 hPa levels

-mixed impact on bias

Assimilation Experiment results

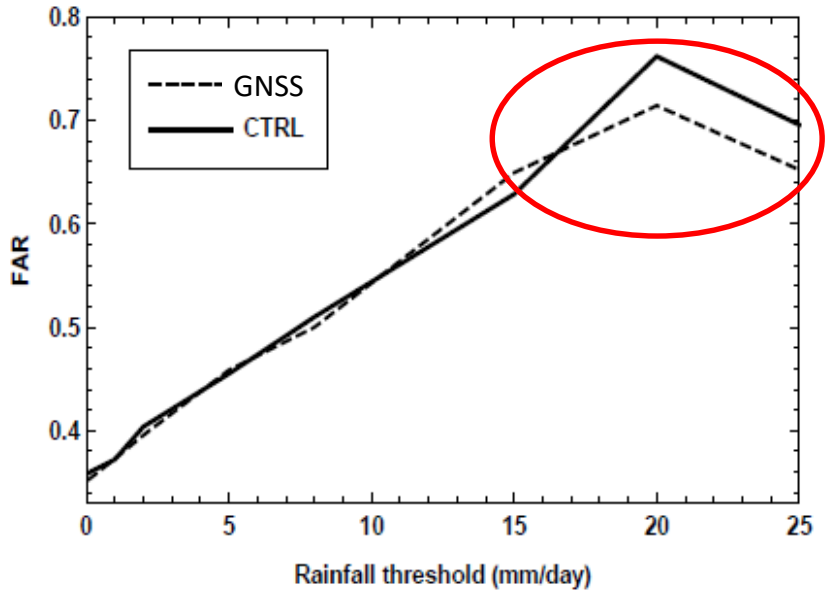
➢ **verification of 2m relative humidity forecast with surface weather observations**

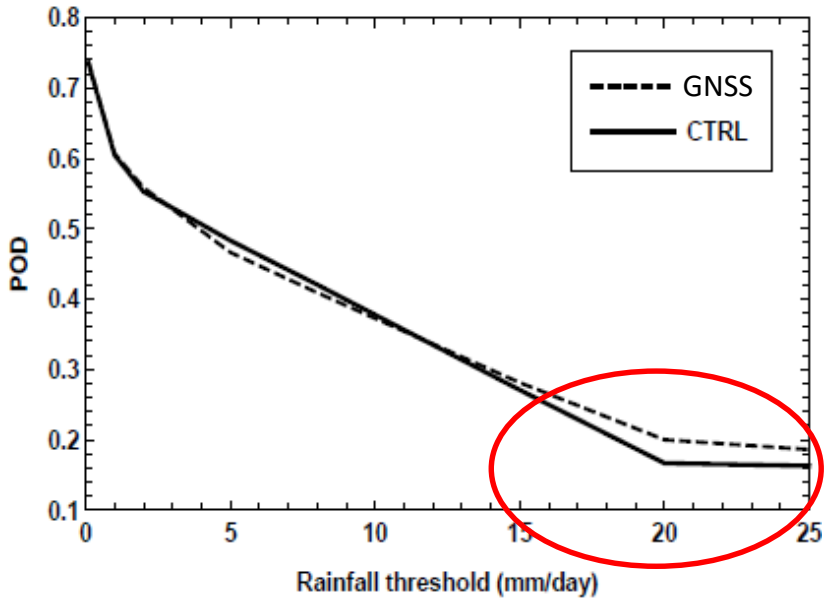


- positive impact on bias up to 24-hour forecast range
- neutral impact on standard deviation

Assimilation Experiment results

➢ **verification of 24-h precipitation accumulations (6h-36h) against rain gauge observations**





- **False Alarm Ratio (FAR) and Probability of Detection (POD)**

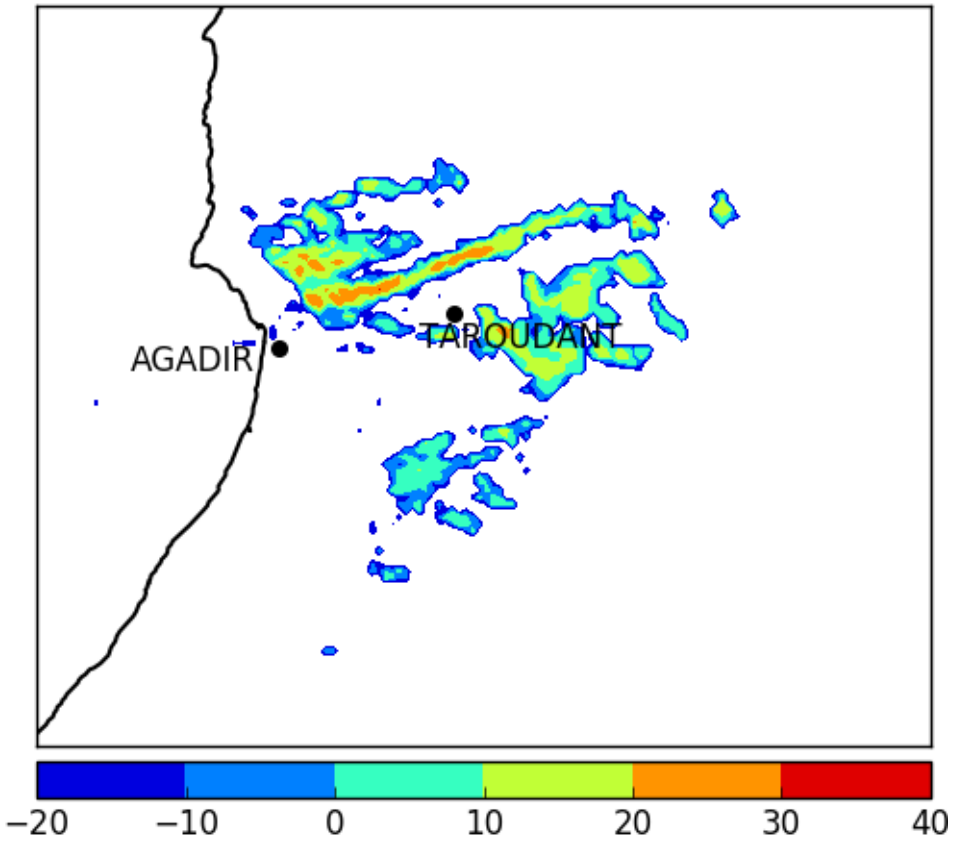
- postive impact for high precipitation (>15 mm).

-neutral impact for the lowest thresholds

Case study

Case study: HPE of 1 March 2018

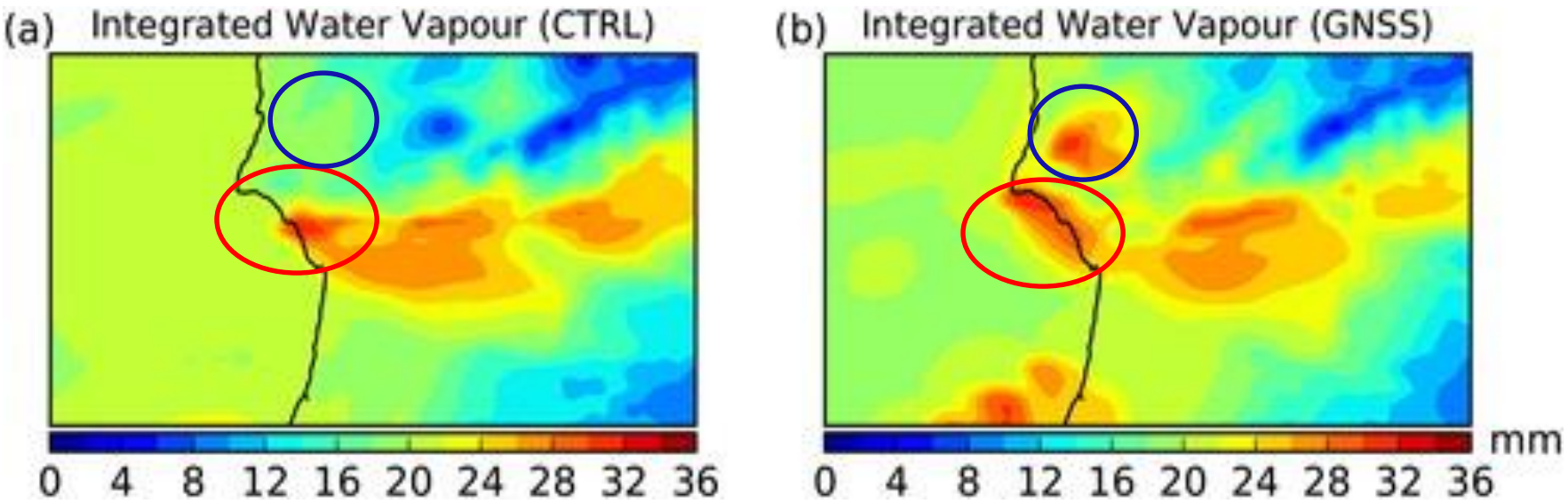
Reflectivity from the Agadir radar in dBZ on 1/03/2018 between 07 UTC and 12 UTC



- Case study over Souss-Massa region (South of Morocco)
- Daily accumulated precipitation reached 91 mm in the East of Agadir city

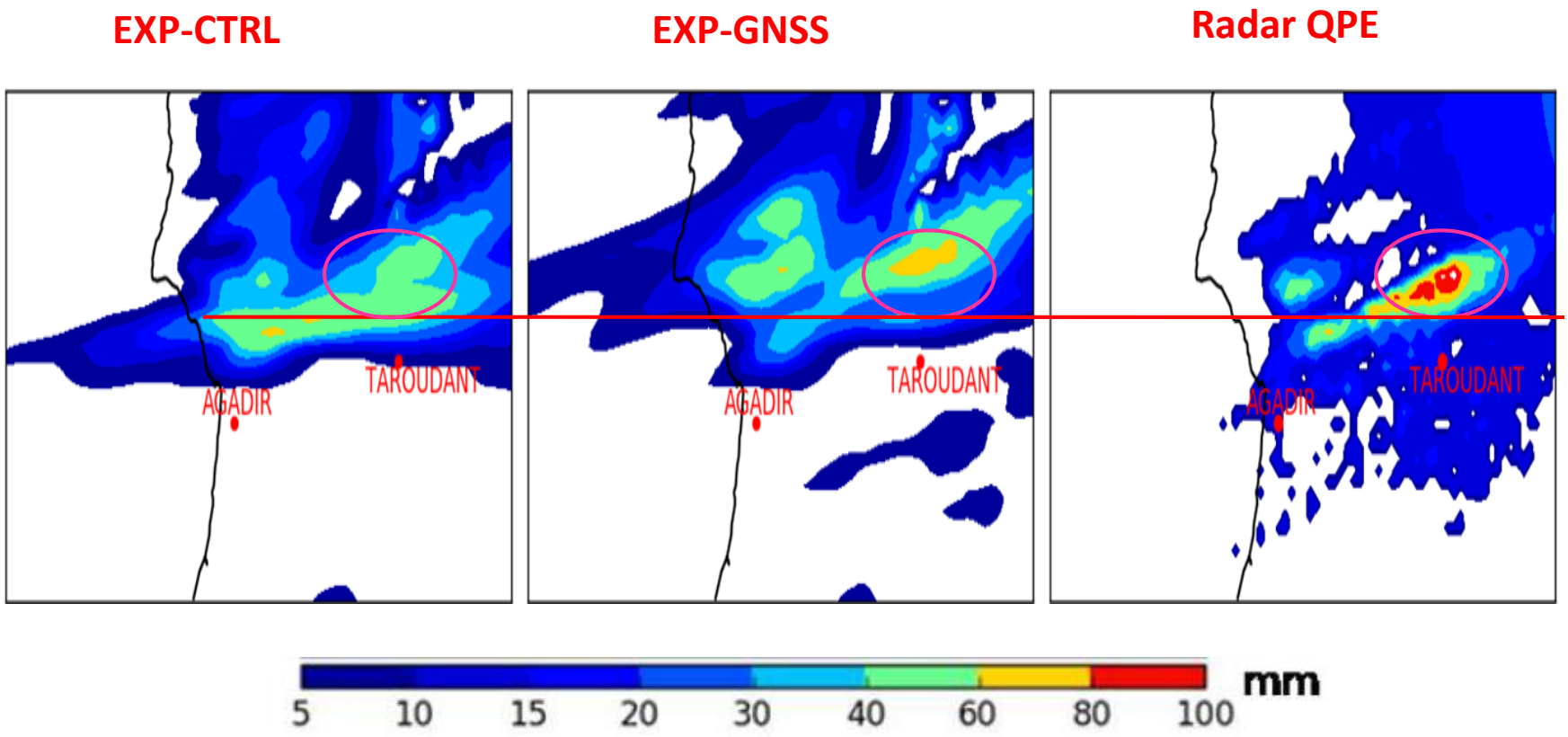
Case study: HPE of 1 March 2018

➢ **AROME-Morocco 8-hour forecast range valid at 08 UTC, 1 March 2018 for: integrated water vapour (in mm) from (a) CTRL experiment (b) GNSS experiment**



Case study: HPE of 1 March 2018

➢24-h accumulated rainfall from 1 March 2018 06 UTC to 2 March 2018 06 UTC



Conclusions and Future work

Conclusions

- ✓ Ground-based GNSS data from the Moroccan GNSS network have been assimilated into AROME-Morocco model.
- ✓ The assimilation of GNSS ZTD data modifies the moisture field in the low troposphere with a maximum around 900 hPa level.
- ✓ Diagnostic of the impact of GNSS ZTD assimilation into AROME-Morocco:
  - small postive impact on 3h forecast of specific humidity in low troposhere
  - positive impact on 0-24h forecast range of 2m relative humidity (RH2m)
  - mixed impact on precipitation : positive for high accumulations and neutral for small threshold accumulations
  - positive impacts in both location and intensity were evident when examining a case study.

Futur work

- Add more existing GNSS sites in Morocco (e.g. ANCFCC GNSS receiver networks)

- Conduct more experiments to investigate the impact of assimilating GNSS observations for different weather types and for other seasons

- Examine ZTD bias correction strategy: dynamic instead of static scheme (VarBC).

- Test the assimilation of other GNSS observation :

  - tropospheric gradients that can provide additional information on the horizontal variations of water vapour (work in progress/collaboration with MF).

Thank you for your attention