An Impact Study of FORMOSAT-3/COSMIC GPS Radio Occultation and Dropsonde Data on WRF Simulations

2007 Mei-yu season
Chien and Kuo (2009), GPS Solutions

2008 Mei-yu season, SoWMEX
Southwesterly Monsoon Experiment
12-h rainfall average over Taiwan (May 1-June 30 2007)

Pre-SoWMEX
FORMOSAT-3/COSMIC GPS
Flight track and dropsonde obs
Case Review

20070607 0000UTC

Radar

Accumulated rain

IR satellite picture

20070608 0000UTC
WRF Domain settings

D1: 45 km; D2: 15 km
WRF settings

- Model settings for the control experiment (CON)
  - WRF V2.2: WSM 5-class microphysics, Kain-Fritsch cumulus parameterization scheme, and YSU PBL scheme
  - WRF Var v2.2 beta (surface obs and soundings)
  - Contains 22 runs of 72-h simulation that are initialized twice daily from 0000 UTC 5 June to 1200 UTC 15 June 2007.
  - The initial data of the first run at 0000 UTC 5 June 2007 are obtained from the NCEP GFS + WRF Var.
  - The initial data of the other 21 runs are obtained from the 12-h update cycle of the previous WRF run + WRF Var.

- The GPS experiment (GPS)
  - CON + GPS RO data assimilation

- The DRP experiment (DRP)
  - CON + dropsonde data assimilation

- The ALL experiment (ALL)
  - CON + GPS RO + dropsonde data assimilation
### Amounts of OBS used in WRF Var

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**GPS RO:** $\Phi$, $T$, and $q$

**Dropsonde:** $\Phi$, $T$, $q$, and wind
0000 UTC 2007.6.6

- Sounding
- Dropsondes
- Synop
- GPS RO
Verification on pressure levels

- **Verification method:**
  - Root-mean-square error (RMSE)
  - Mean error (ME)
  - Correlation coefficient (CC)
  - Skill score (SS)
  - Averaged on (1) grid points of the 15-km domain against NCEP GFS analyses + WRF Var with sounding and surface obs, (2) traditional sounding stations inside the 15-km domain. Averaged for all the 22 runs of each experiment.

- **Variables:**
  - H, T, RH, U, V

- **Pressure levels:**
  - 850 hPa, 500 hPa, 300 hPa

- **Times:**
  - 0, 12, 24, 36, 48, 60, 72 h
RMSE averaged on grid points of D2

850hPa 500hPa 300hPa

H (m)
T (°C)
RH (%)

Forecast hours: 12 24 36 48 60 72 0 12 24 36 48 60 72
Skill Score of GPS against CON

\[ SS = \frac{RMSE_{\text{CON}} - RMSE_{\text{GPS}}}{RMSE_{\text{CON}}} \times 100\% \]
Skill Score of DRP against CON

\[ SS = \frac{RMSE_{CON} - RMSE_{DRP}}{RMSE_{CON}} \times 100\% \]
Skill Score of ALL against CON

300hPa

GPS 2007

ALL 2007

Forecast hours

300hPa

500hPa

850hPa
ETS and bias, verified against rain gauges

12-h accumulated rainfall

ETS

Bias

12-24 h

24-36 h

1: CON
2: GPS
3: DRP
4: ALL

0.3  2.5  5.0   10   15    25   35   50 mm
ETS and bias, verified against rain gauges

12-h accumulated rainfall

ETS

Bias

36-48 h

48-60 h

1: CON
2: GPS
3: DRP
4: ALL
The 12-h accumulated rainfall observation in Taiwan (May 1-June 30 2008)

Black: (0000UTC-1200UTC)
Gray: (1200UTC-0000UTC)

Dropsonde obs
Simulation period
Data amounts used in WRF Var (6-h)

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GPS RO: Φ, T, and q
Dropsonde: Φ, T, q, and wind
Data amounts used in WRF Var

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GPS RO: Φ, T, and q
Dropsonde: Φ, T, q, and wind
Skill Score of GPS against CON

GPS 2007

300hPa

500hPa

850hPa

Forecast hours

GPS 2008

300hPa

500hPa

850hPa
Skill Score of DRP against CON

DRP 2007

DRP 2008

- 300hPa
- 500hPa
- 850hPa

Forecast hours

V, U, RH, T, H
Skill Score of ALL against CON

300hPa

ALL 2007

Forecast hours

300hPa

ALL 2008

V

U

RH

T

H

500hPa

V

U

RH

T

H

850hPa

V

U

RH

T

H

Skill Score of ALL against CON
ETS and bias, verified against rain gauges

12-h accumulated rainfall

12-24 h

ETS

Bias

24-36 h

1: CON
2: GPS
3: DRP
4: ALL
Conclusions

2007 (12-h update cycle):

- The assimilation of the GPS data can help to improve the simulation for longer integration. The dropsonde data has smaller positive impact than the GPS data, and the impact decreases over time.
- There are few GPS RO observations in the fine domain. The large-scale simulation is first improved using the GPS RO observations, and the resulting changes can have a positive impact on the mesoscale at the later time. The dropwindsonde observations were taken inside the fine domain such that their impact can be detected early in the simulation.
- With both the GPS and the dropsonde data assimilated together, the simulation shows even greater improvement.
- At early time, there is no impact of GPS and dropsonde data on rainfall forecasts. However, when the integration time getting longer, the GPS and dropsonde data start to help the rainfall simulation.

2008 (6-h update cycle):

- A positive impact of GPS and dropsonde data is still found, but the influence of individual variable is slightly different to that of 2007. More investigation is needed.