Benefiting from high resolution in simulating Tibetan Plateau summer climate using WRF model

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• Motivation and model setup
• Model results and evaluation
• Discussion
• Summary
Motivation

GCMS and RCMs with coarse resolution show systematic errors over Tibetan Plateau.

(Mueller and Seneviratne, 2014)

(Ma et al., 2015)

(Gao et al., 2015)
Motivation

High resolution can simulate less air water vapor transported to interior Plateau by 30% (30km VS. 2km), which could be one important origination of precipitation bias in the model.

Courtesy of Dr. Changgui Lin
**WRF Model setup:** simulation domain

domain01: $0.1\degree \times 0.1\degree$ (~10km); domain02: $0.033\degree \times 0.033\degree$ (~3km)
Model setup: mainly follow HAR; Bold indicates exceptions

- **Time:** 2013, 2015, 2018
- **Nesting:** two-way
- **Forcing:** ERA5 (hourly)
- **Lake:** WRF-lake
- **Initialization:** once a day, at 12:00, duration is 36 hour, the first 12 hour is spinup, including sst update
- **Shortwave:** dudhia; longwave: RRTM
- **No cumulus parameterization**
- **Microphysics:** modified thompson
- **LSM:** noah
- **PBL:** MYJ
- **Sub-grid orographic drag scheme (TOFD) switch on**
- **Output:** 3hourly for the outer domain and hourly for the inner domain

Current Results: 2013.06-2013.09
• Motivation and model setup
• Model results and evaluations
• Discussion
• Summary
Model results and evaluation:
High resolution can better represent air water vapor transport (diurnal cycle: uqxvq (vector) and vq (color) at central HM)
Model results and evaluation

Mean 10-m wind speed (m/s) at station from observation (OBS) ERA5 HAR and WRF 3km simulation for the study period
Model evaluation

Statistical metrics derived from ERA5

![Graph showing 10-m wind speed comparison between OBS and ER.](image1)

![Graph showing RMSE for ERA5.](image2)
Model evaluation

Statistic metrics of 10-m wind speed (m/s) at station derived from daily data in ERA5 HAR and WRF 3km simulation versus observation (OBS)

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[Maps showing distribution of values for each category]
Model evaluation

Mean 2-m air temperature (°C) at station from observation (OBS) ERA5 HAR and WRF 3km simulation for the study period (elevation correction of -6.5 °C/km before comparisons)
Model evaluation
Statistical metrics based on the mean T2 (°C) derived from ERA5 HAR and WRF 3km simulation versus OBS
Statistic metrics of 2-m air temperature (°C) at station derived from **daily** data in ERA5 HAR and WRF 3km simulation versus observation (OBS)

### Mean bias
- **a ERA**:  
  - <3.6
  - 3.0-3.6
  - 3.0-2.4
  - 2.4-1.8
  - 1.8-1.2
  - 1.2-0.6
  - 0.6-0.0

- **b HAR**:  
  - >3.6
  - 3.0-3.6
  - 2.4-3.0
  - 1.8-2.4
  - 1.2-1.8
  - 0.6-1.2
  - 0.0-0.6

- **c WRF**:  
  - >3.6
  - 3.0-3.6
  - 2.4-3.0
  - 1.8-2.4
  - 1.2-1.8
  - 0.6-1.2
  - 0.0-0.6

### RMSE
- **a ERA**:  
  - >0.8
  - 0.7-0.8
  - 0.6-0.7
  - 0.5-0.6
  - 0.4-0.5
  - 0.3-0.4
  - <0.3

- **b HAR**:  
  - >0.8
  - 0.7-0.8
  - 0.6-0.7
  - 0.5-0.6
  - 0.4-0.5
  - 0.3-0.4
  - <0.3

- **c WRF**:  
  - >0.8
  - 0.7-0.8
  - 0.6-0.7
  - 0.5-0.6
  - 0.4-0.5
  - 0.3-0.4
  - <0.3

### Correlation coefficient
- **a ERA**:  
  - >0.8
  - 0.7-0.8
  - 0.6-0.7
  - 0.5-0.6
  - 0.4-0.5
  - 0.3-0.4
  - <0.3

- **b HAR**:  
  - >0.8
  - 0.7-0.8
  - 0.6-0.7
  - 0.5-0.6
  - 0.4-0.5
  - 0.3-0.4
  - <0.3

- **c WRF**:  
  - >0.8
  - 0.7-0.8
  - 0.6-0.7
  - 0.5-0.6
  - 0.4-0.5
  - 0.3-0.4
  - <0.3
Mean precipitation (mm/day) at station from observation (OBS) ERA5 HAR and WRF 3km simulation for the study period
Statistical metrics based on the **mean Precipitation (mm/day)** derived from ERA5 HAR and WRF 3km simulation versus OBS.
Statistic metrics of precipitation (mm/day) at station derived from daily data in ERA5 HAR and WRF 3km simulation versus observation (OBS)

Mean bias

RMSE

Correlation coefficient
• Motivation and model setup
• Model results and evaluation
• Discussion
• Summary
Data representativeness: Statistic metrics of precipitation (mm/day) at station derived from daily data in WRF 10km domain and the difference to those in WRF 3km domain

Statistical metrics at 10 km grid

Difference to 3 km grid
Precipitation amount (mm/day) (2013.07-09)

ERA5

HAR

WRF

Nepal
Precipitation in Nepal: Southern slop of HM

a OBS(mm/day)
b ERA
c HAR
d WRF
Precipitation biases and spatial pattern statistics based on mean precipitation within the study period:

Mean precipitation (mm/day):
- OBS: 12.43
- ERA: 14.31
- HAR: 12.17
- WRF: 11.63

Bias:
- OBS: -0.79
- ERA: -0.26
- HAR: 1.88
- WRF: -0.79

RMSE:
- OBS: 8.38
- ERA: 7.84
- HAR: 6.30
- WRF: 8.38

Corr:
- OBS: 0.30
- ERA: 0.20
- HAR: 0.38
- WRF: 0.30
Percentage distribution frequency

(a) absolute mean bias

(b) RMSE

(c) CORR
Summary

• High resolution simulation can obviously improve the model performance at the TP region
• Some variables may have the potential to take as a reference for the station-sparse region and may be used for evaluating low-resolution simulations (e.g. the spatial distribution of precipitation, the magnitude of the 10-m wind speed) and driving the land surface processes.
• Large difficulties still exists in simulating the precipitation at the southern slop of TP, which could be associated with the very steep terrain.
Thanks for your attention!
Model evaluation

Percentage distribution frequency of statistical metrics in 10-m wind

a absolute mean bias

b RMSE

c CORR
Percentage distribution frequency of statistical metrics in T2

(a) Absolute mean bias

(b) RMSE

(c) CORR
Percentage distribution frequency of statistical metrics in prec

a absolute mean bias

b RMSE

c CORR