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A comparison of MPAS and WRF meteorological models in California: 2013 winter and 2016 summer case studies

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Abstract:

MPAS-A and WRF-ARW models were compared to find the similarities and the differences between them in simulating the atmospheric conditions that occurred in California during January 10-24, 2013 Discover-AQ winter episode and July 18-30, 2016 CABOTS summer field campaign. The results of both models were compared using horizontal and vertical cross sections of typical meteorological variables, temporal evolution of variables at meteorological stations, 3D Lagrangian transport analysis, as well as statistical measures calculated over entire domain as well as at individual stations using METSTAT and AMET modeling analysis packages.

Background:

California Air Resources Board (CARB) is a regulatory agency that is responsible for keeping California's air clean and uses air quality models to investigate elevated air pollution episodes to find solution for the formation of air pollution events.

ARB uses the EPA approved Community Multiscale Air Quality (CMAQ) Model (CMAQ, 2010, Appel et al, 2017) to investigate the underlying reasons for the formation and the spatial and temporal extent of various pollutants, in particular, O3 and PM, and the transport of both primary and secondary pollutants downwind for the preparation of state implementation plans (SIP).

CARB focuses on standalone models to have a better control on individual models' input and output quality and to eliminate some uncertainties that may come from the meteorological and air quality models. Therefore, this study considers standalone WRF model as the EPA approved meteorological model for the preparation of atmospheric conditions to provide as meteorological input to the EPA approved standalone CMAQ air quality model.

The numerical experiment:

MPAS model was setup using a mesh with variable resolution changing between 3 and 48 km where 3 km resolution covers entire CA-NV domain and the resolution increases to 48 km outside of the region (Fig. 1).

WRF model was setup using two-way, three nested grids with 36,12 and 4 km horizontal resolutions (Fig. 2).

Both models were setup using 55 vertical layers with first layer depth being 20 m and increasing to a maximum 750 above 6 km with at least 15 layers within the first km above the surface.

Several physics parameterizations that are available in both models were used, such as, NOAH LSM, Monin-Obukhov surface layer, YSU PBL, WSM 6-class and RRTM SW and LW radiation.

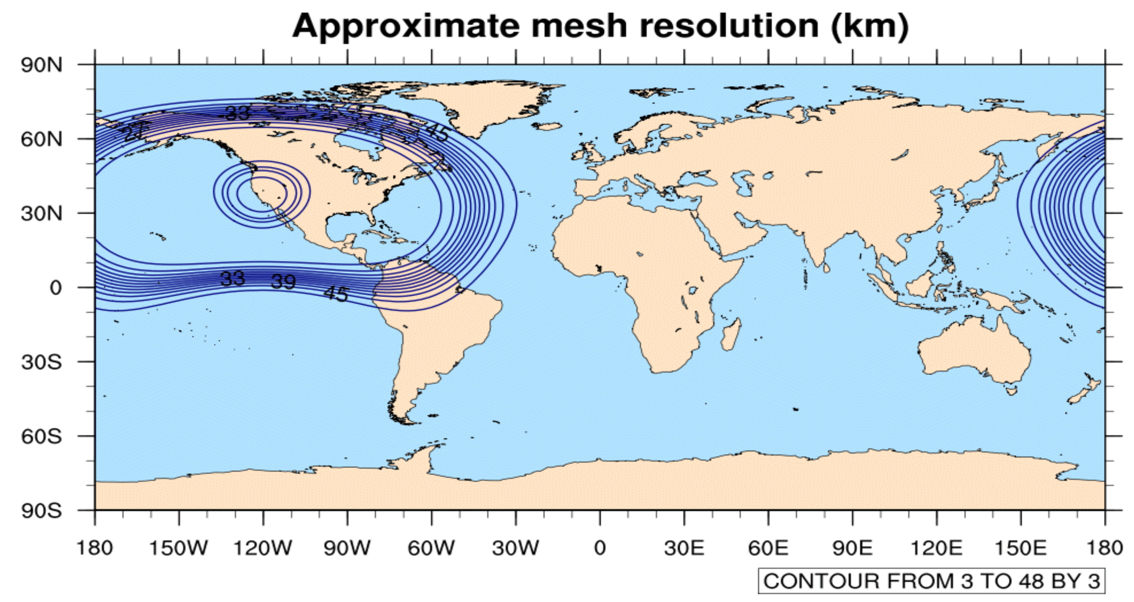

Figure 1: The mesh with spatial resolution changing from 3 to 48 km used to setup MPAS model.

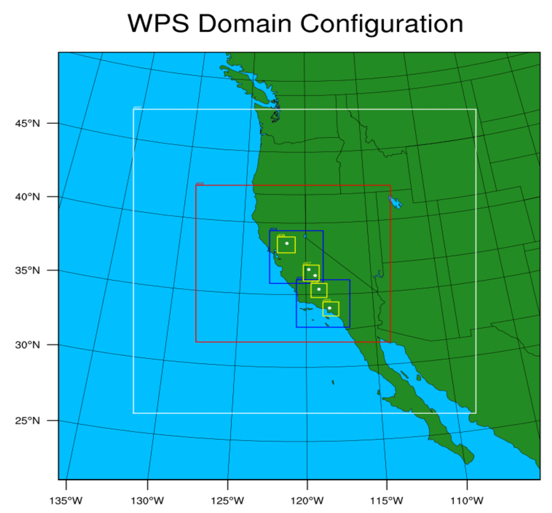

Figure 2 Two-way nested grid with 36,12, 4 km resolution used to setup WRF modeling domain.

Results:

The comparisons of near surface wind (Fig 3) and temperature averaged at 2 PM during winter episode show that wind vectors show more local heterogeneity and magnitudes are slightly larger in MPAS model than those in WRF as WRF winds are seen smoother.

Similarly, near surface temperature averaged at 2 PM during winter episode show temperature is colder in WRF model on over entire domain compared to those in MPAS model (Fig 4). Furthermore, there are large temperature differences between subregions.

The vertical cross section of temperature indicate that a deeper and moister marine layer is predicted by WRF model west of Napa valley and the magnitude of vertical motion at higher elevations is larger in WRF than to those in MPAS model. In addition, the PBL is drier and warmer within the valley during the day in WRF than that in MPAS.

Diurnal variation of 2m temperature bias estimated by MPAS is small with a variation between 0-1 (Figs 6a, b) while that of WRF shows large variation with a peak in the afternoon (Figs 7a, b).

Temporal evolution of meteorological variables against observations at several stations shows slightly better agreement with observations for MPAS than WRF (Fig 7).

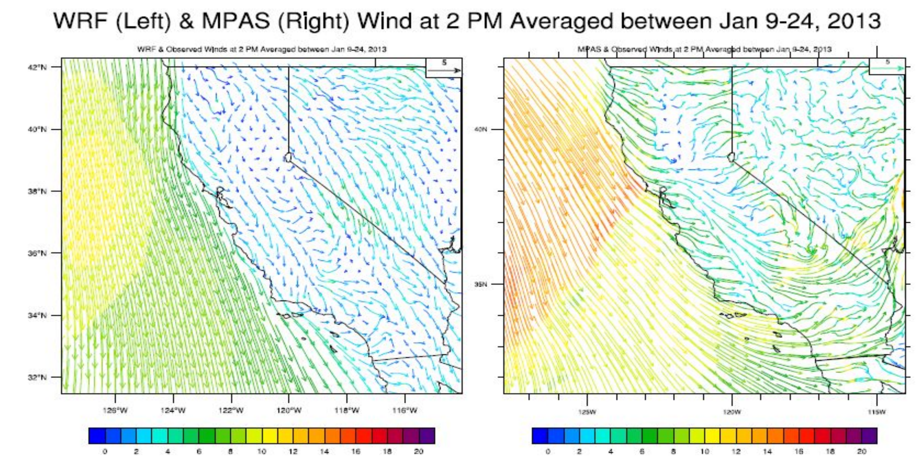

Figure 3: The comparison of near surface wind averaged at 2 PM during winter episode.

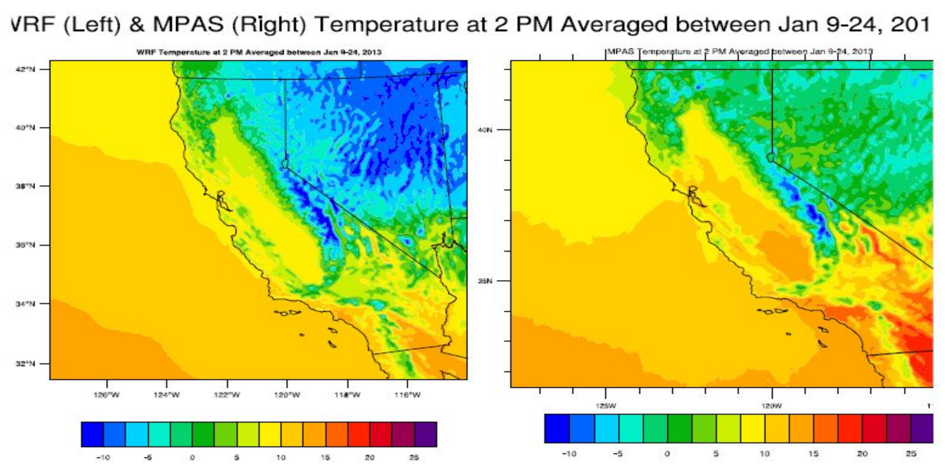

Figure 4: The comparison of near surface temperature averaged at 2 PM during winter episode.

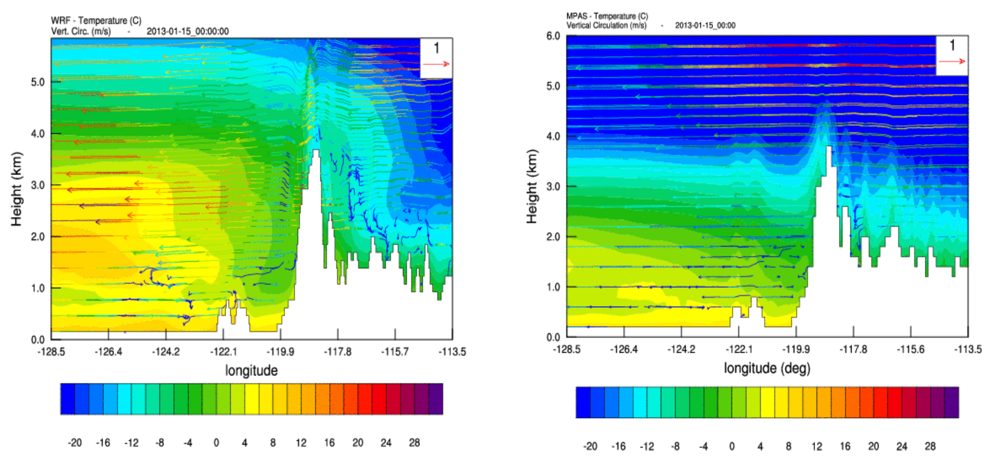

Figure 5: The vertical cross section of temperature for WRF (left) and MPAS (right) at 00Z on Jan 15, 2013.

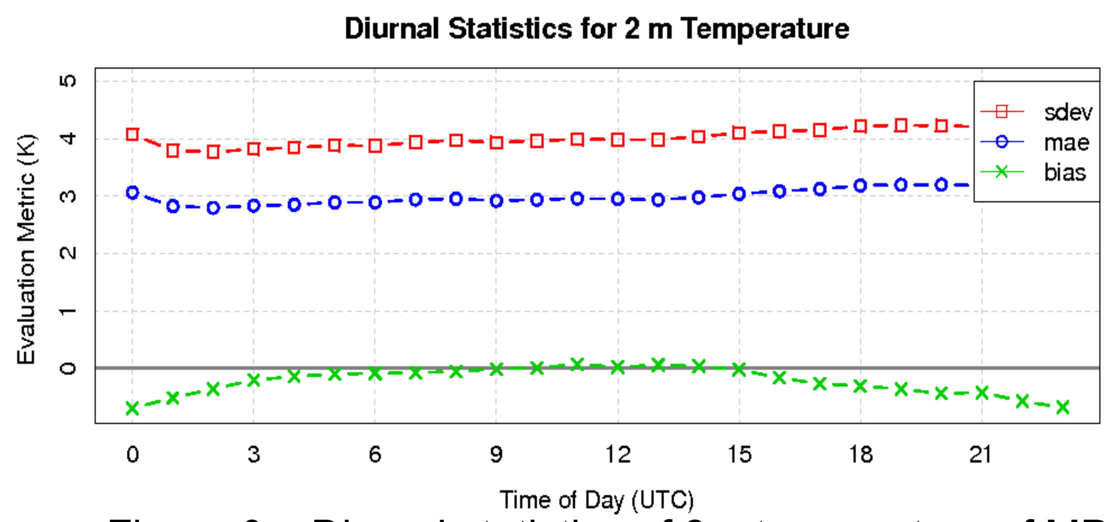

Figure 6a: Diurnal statistics of 2m temperature of MPAS for 2013 winter episode.

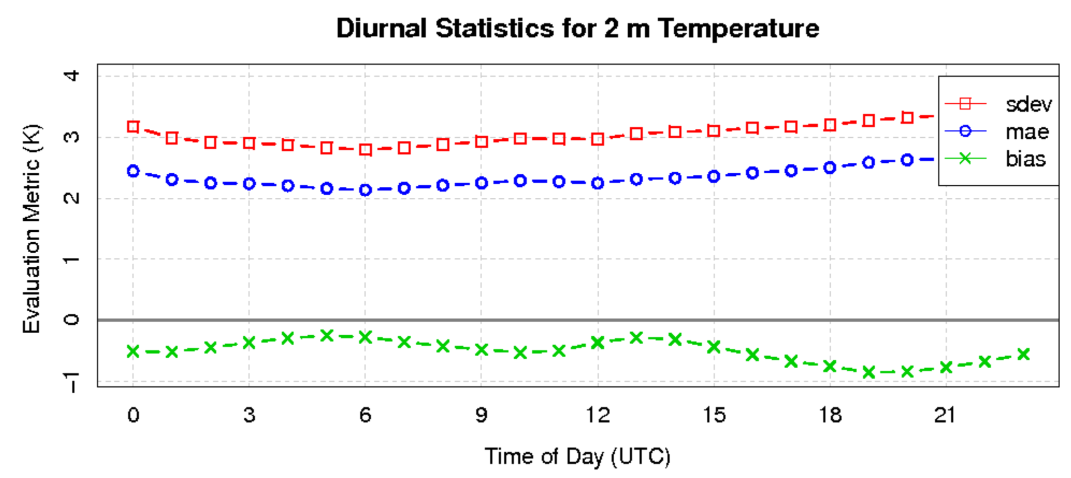

Figure 6b: Diurnal statistics of 2m temperature of MPAS for 2016 summer episode.

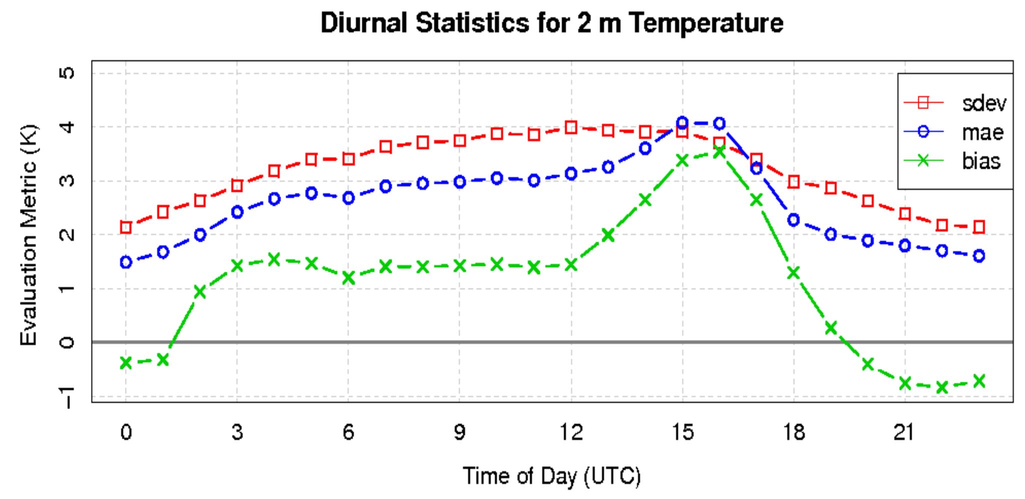

Figure 7a: Diurnal statistics of 2m temperature of WRF for 2013 winter episode.

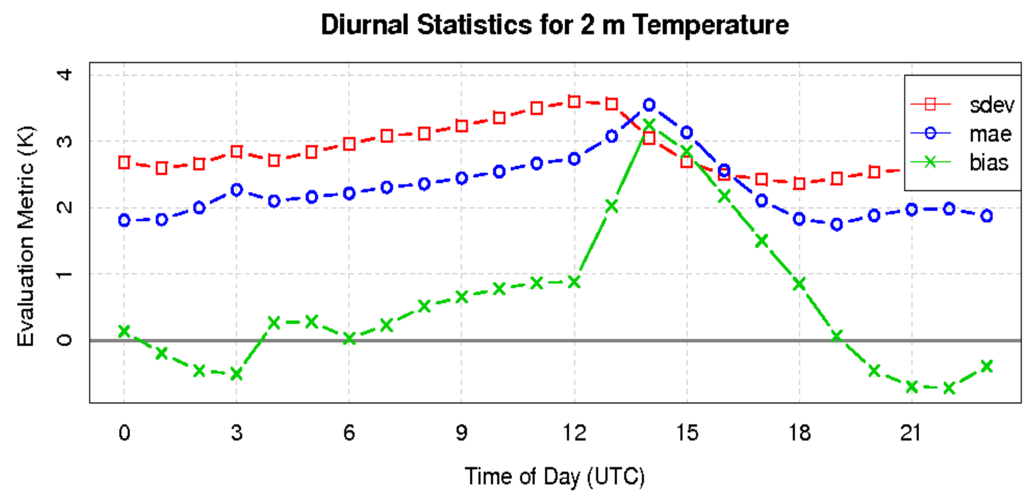

Figure 7b: Diurnal statistics of 2m temperature of WRF for 2016 summer episode.

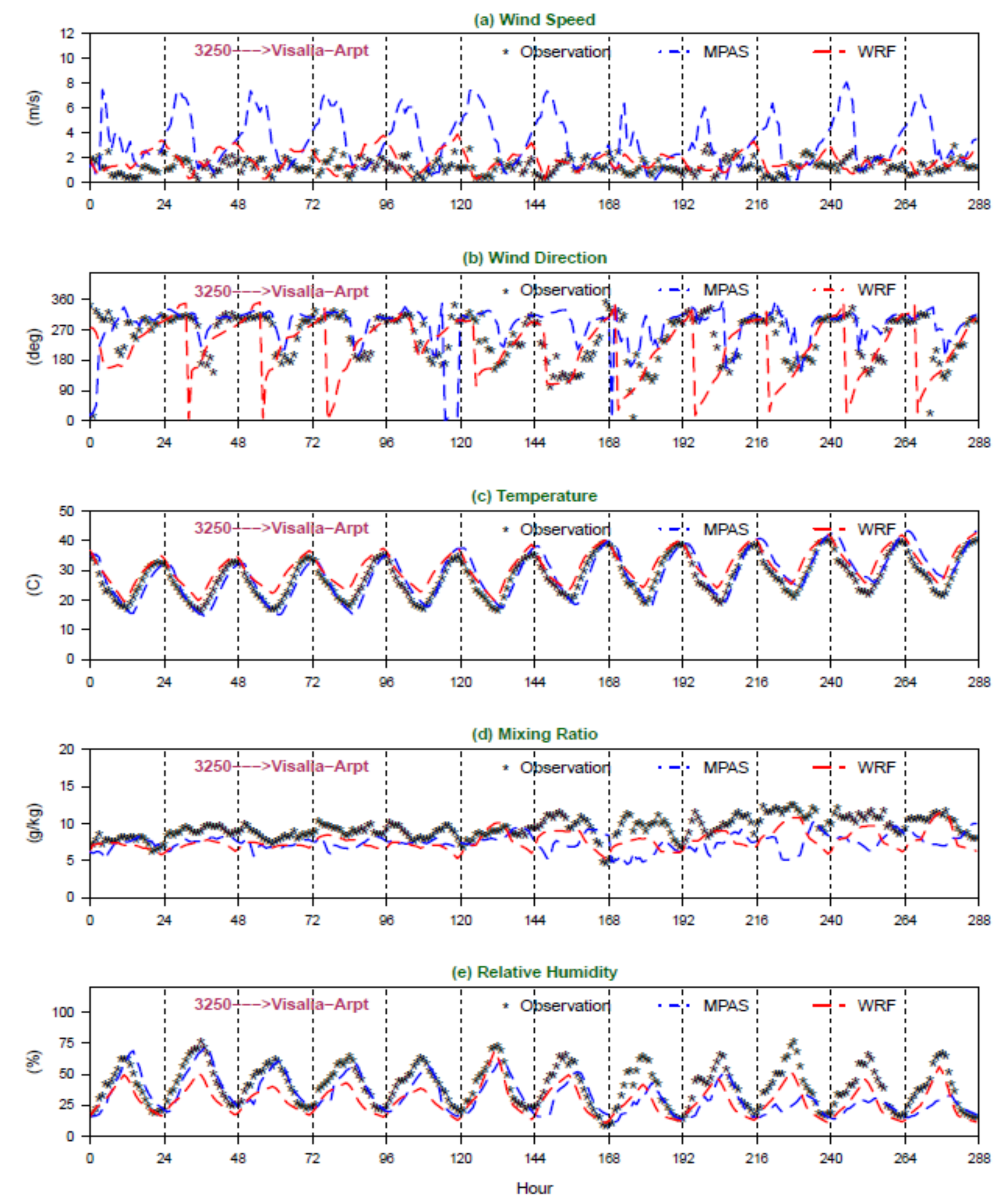

Figure 8: Time evolution of meteorological variables at Visalia, CA for July 18-29, 2016 time period

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