UtahStateUniversity
BINGHAM RESEARCH CENTER

Improving WRF/CAMx Model Performance using Satellite Data Assimilation Technique for the Uintah Basin

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Acknowledgements

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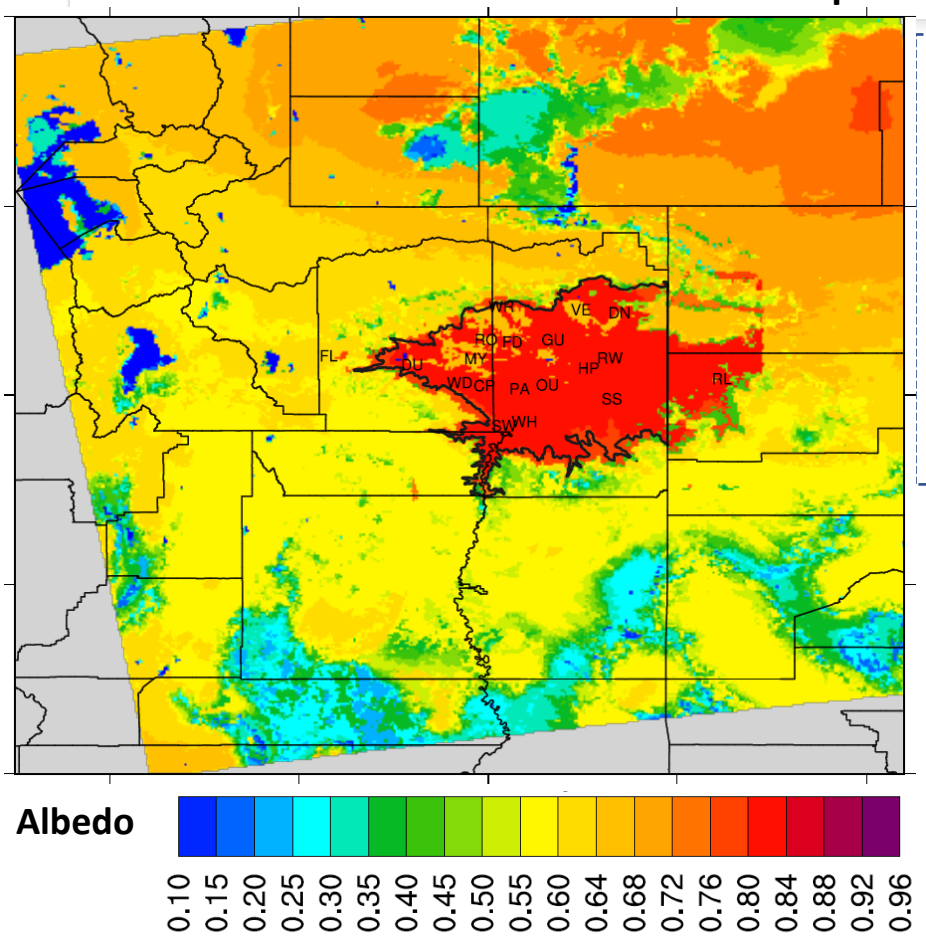
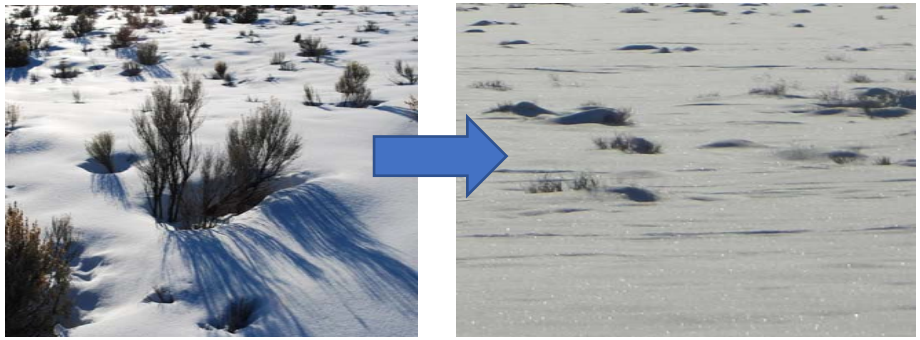
Manual and forcible corrections to WRF had to be made to capture surface albedo)

Corrected WRF Albedo in winter 2013 ozone episode





(Ref.: Crosman et al., 2015; Neemann et al., 2015)

Neemann, E. M., Crosman, E. T., Horel, J. D., and Avey, L.: Simulations of a cold-air pool associated with elevated wintertime ozone in the Uintah Basin, Utah, Atmos. Chem. Phys., 15, 135–151, https://doi.org/10.5194/acp-15-135-2015, 2015.

Surface albedo corrections are:

- Performed on case by case basic, and there is no standard method to perform the correction.
- Heavily relies on knowledge and observations of modelers on the actual surface conditions during simulated episode
- May results in unrealistic albedo estimations over model domain

Utilizing satellite observations (MODIS) to correct surface characteristics

Surface Shortwave Albedo (ALBEDO)

- ***MCD43A1:*** MODIS/Terra+Aqua BRDF/Albedo Model Parameters Daily L3 Global - 500m V006
- ***MCD19A1:*** MODIS/Terra+Aqua Land Surface BRF Daily L2G Global 500m, 1km and 10km SIN Grid V006
- ***MCD19A2***: MODIS/Terra+Aqua Land Aerosol Optical Thickness Daily L2G Global 1km SIN Grid V006

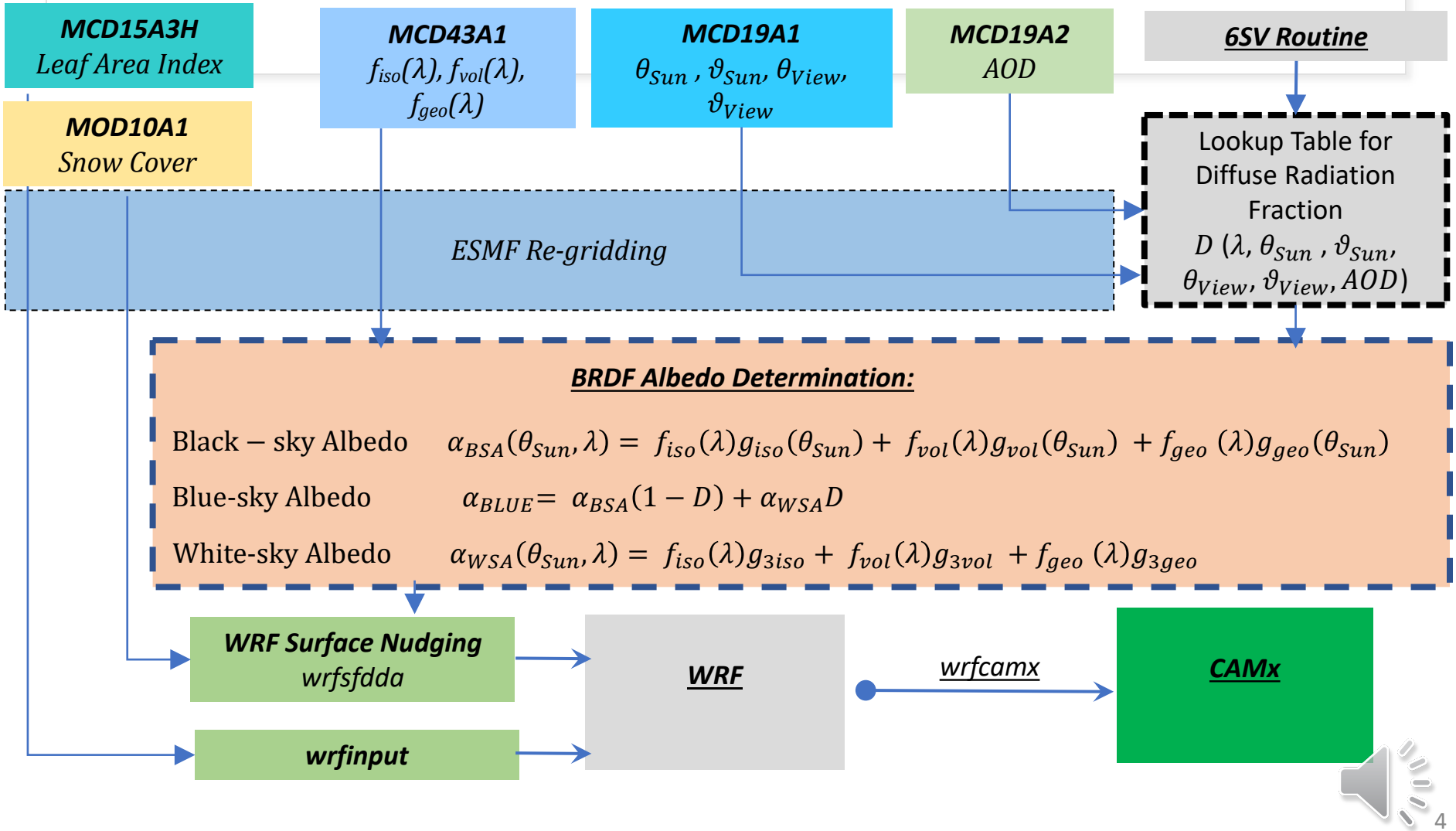
Surface Snow Cover Fraction (SNOWC)

- ***MOD10A1:*** MODIS (Terra) Snow Cover Daily L3 Global 500m Grid

Leaf Area Index (LAI)

- ***MCD15A3H:*** MODIS/Terra+Aqua Leaf Area Index/FPAR 4-Day L4 Global 500 m (4 days composite)

MODIS Data Assimilation Processes



Modifications to WRF source codes are required

WRF

Input files:

wrfinput (LAI)

wrfsfdda (ALBEDO, SNOWC)

/Registry

Registry.EM_COMMON

/share

output_wrf.F

/dyn_em

.module_first_rk_step_part1.F

/phys

module_physics_init.F

module_fddagd_driver.F

module_fdda_psufddagd.F

/run/namelist.input

```
…
 &fdda
 if_ramping          = 1,
 dtramp_min          = 60,
grid_fdda            = 1,
grid_sfdda           = 1,
sgfdda_interval_m    = 360,
 galb_sfc            = 0.950,
 gsnc_sfc            = 1.000,
/
```

WRF Model Configurations

Parameters	Values
Grid size (x,y)	298 x 322 in 1.3km horizontal resolution
Vertical levels	37
Vertical coordinates	Terrain-following Eta (non-hybrid)
Vertical grid spacing	12-16 m in the boundary-layer
Topographic dataset	USGS GTOPO30
Land use data set	modified NLCD2011
Veg parm table variables modified for winter simulations	SNUP, MAXALB
Snow cover initialization	SNODAS
Re-initialize	Every 5 days

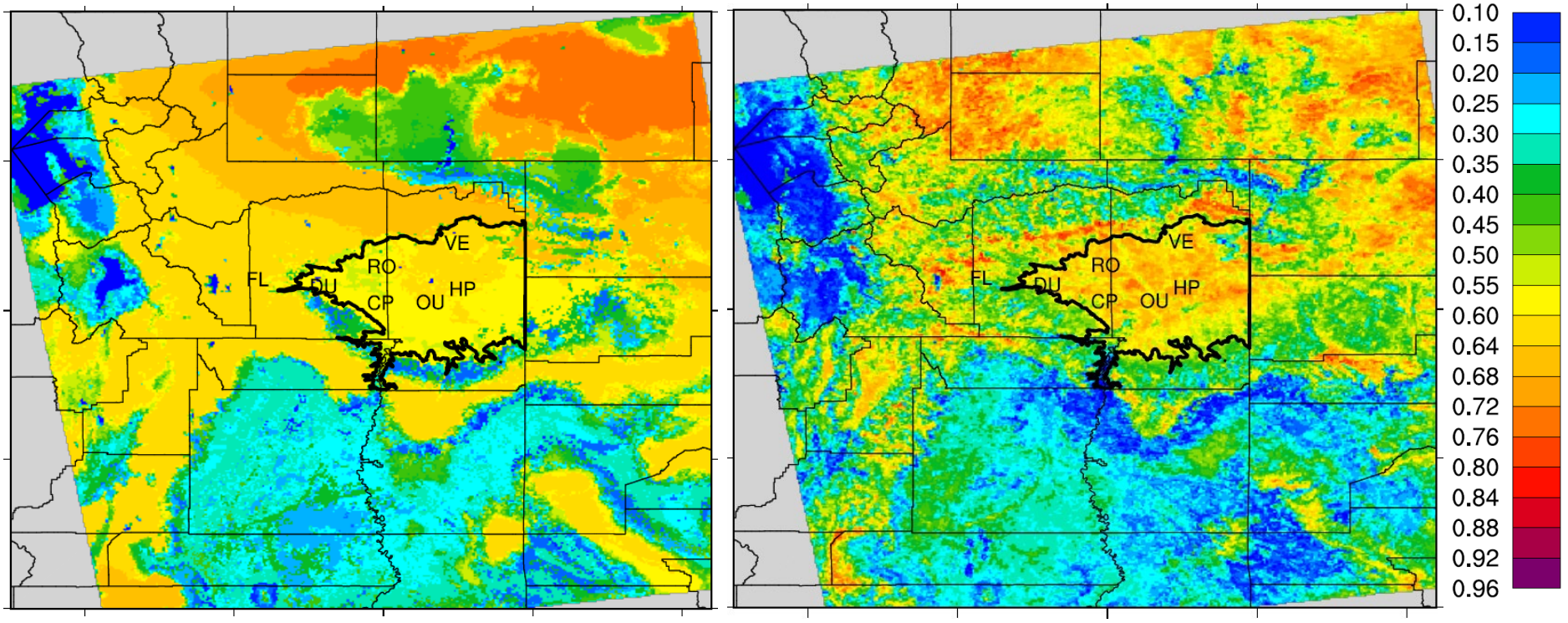
WRF Treatment	***Option Selected***
Microphysics	Thompson
Longwave radiation	RRTMG
Shortwave radiation	RRTMG
Land surface model (LSM)	NOAH
Planetary boundary layer (PBL) scheme	MYJ

MODIS data assimilation results in better estimations of ALBEDO

Modeling episode Feb 01- 28 2011

Default WRF (REF)

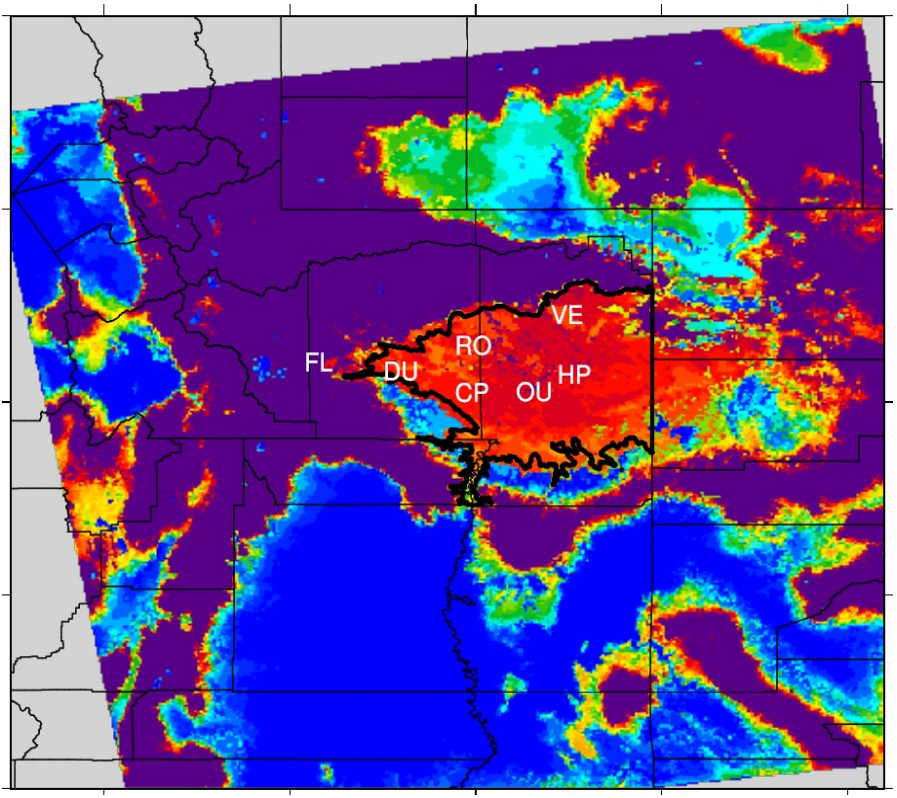
MODIS assimilation



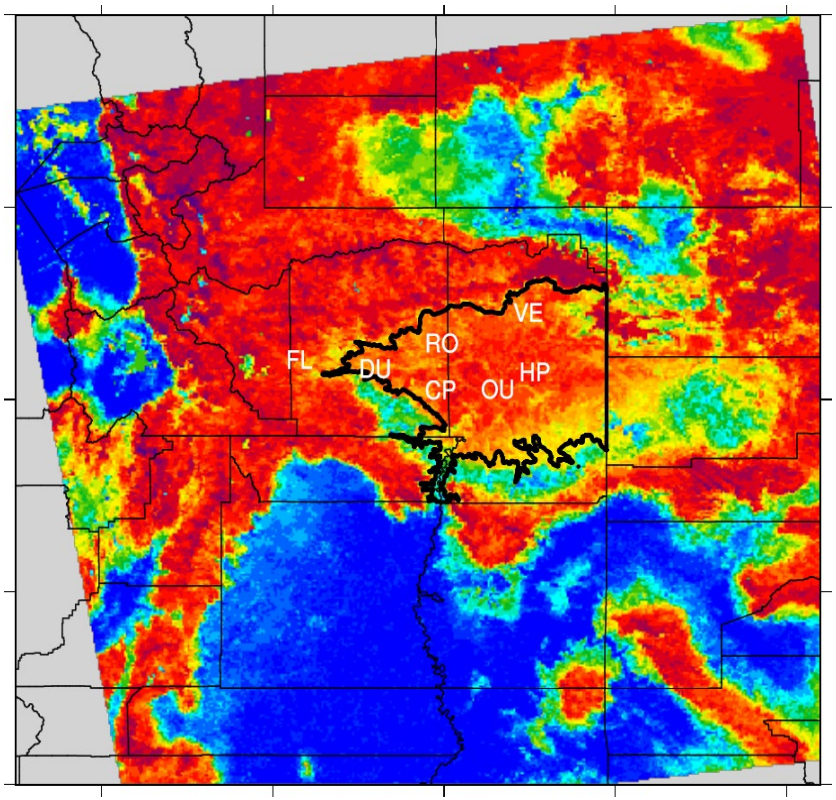
MODIS data assimilation results in “better” estimations of Snow Cover (SNOWC)

Modeling episode Feb 01- 28 2011

Default WRF (REF)

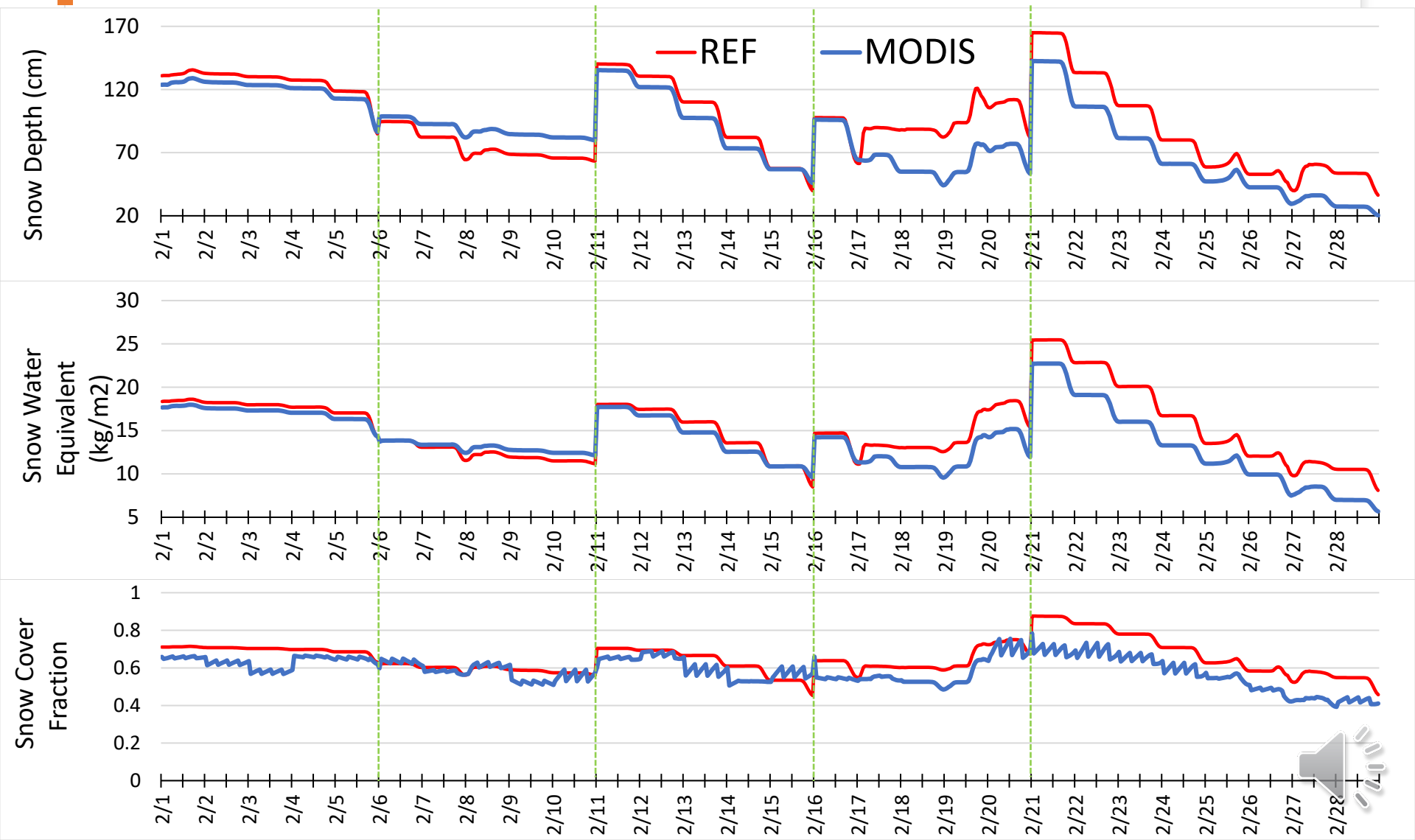


MODIS assimilation

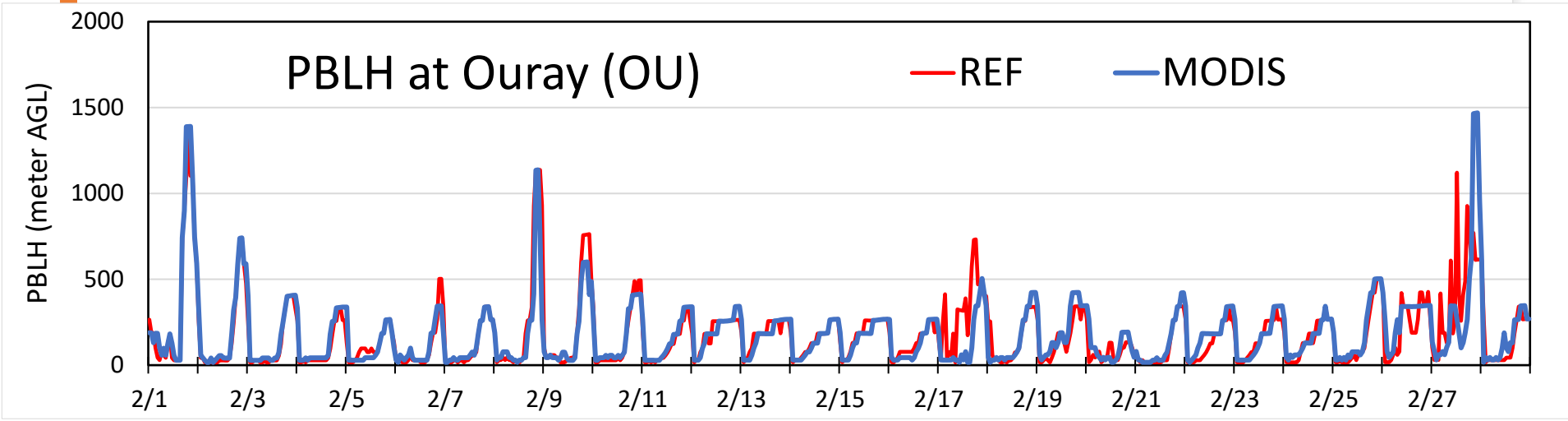


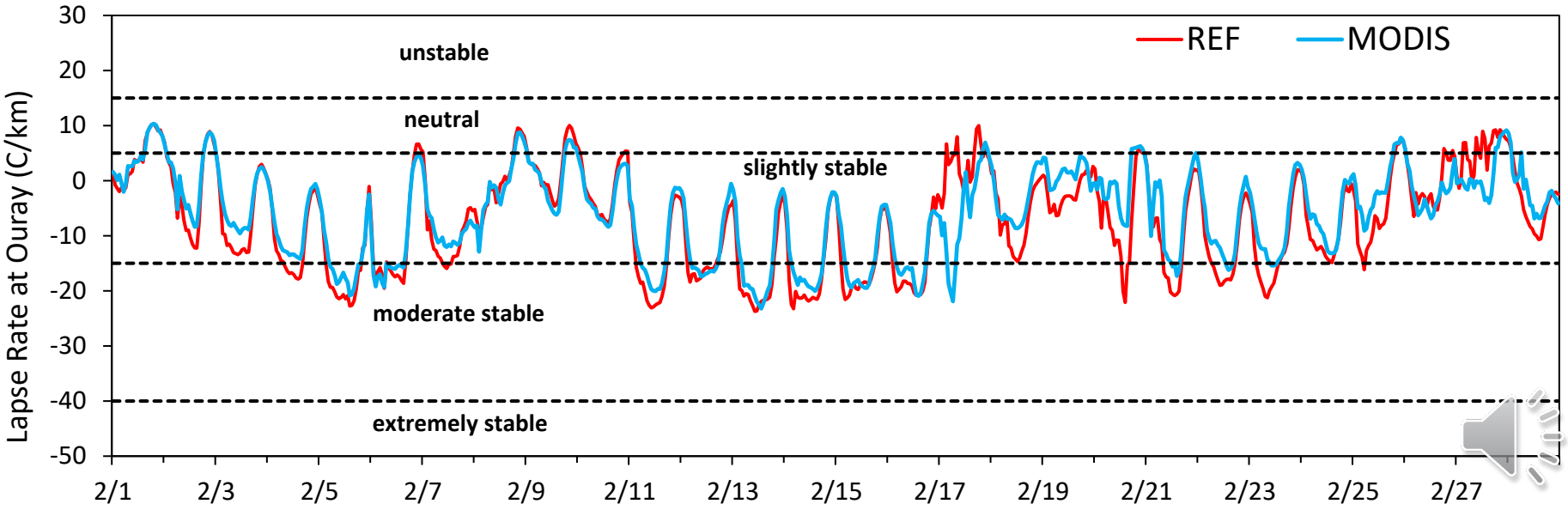
SNOWC

Effect of MODIS data assimilation

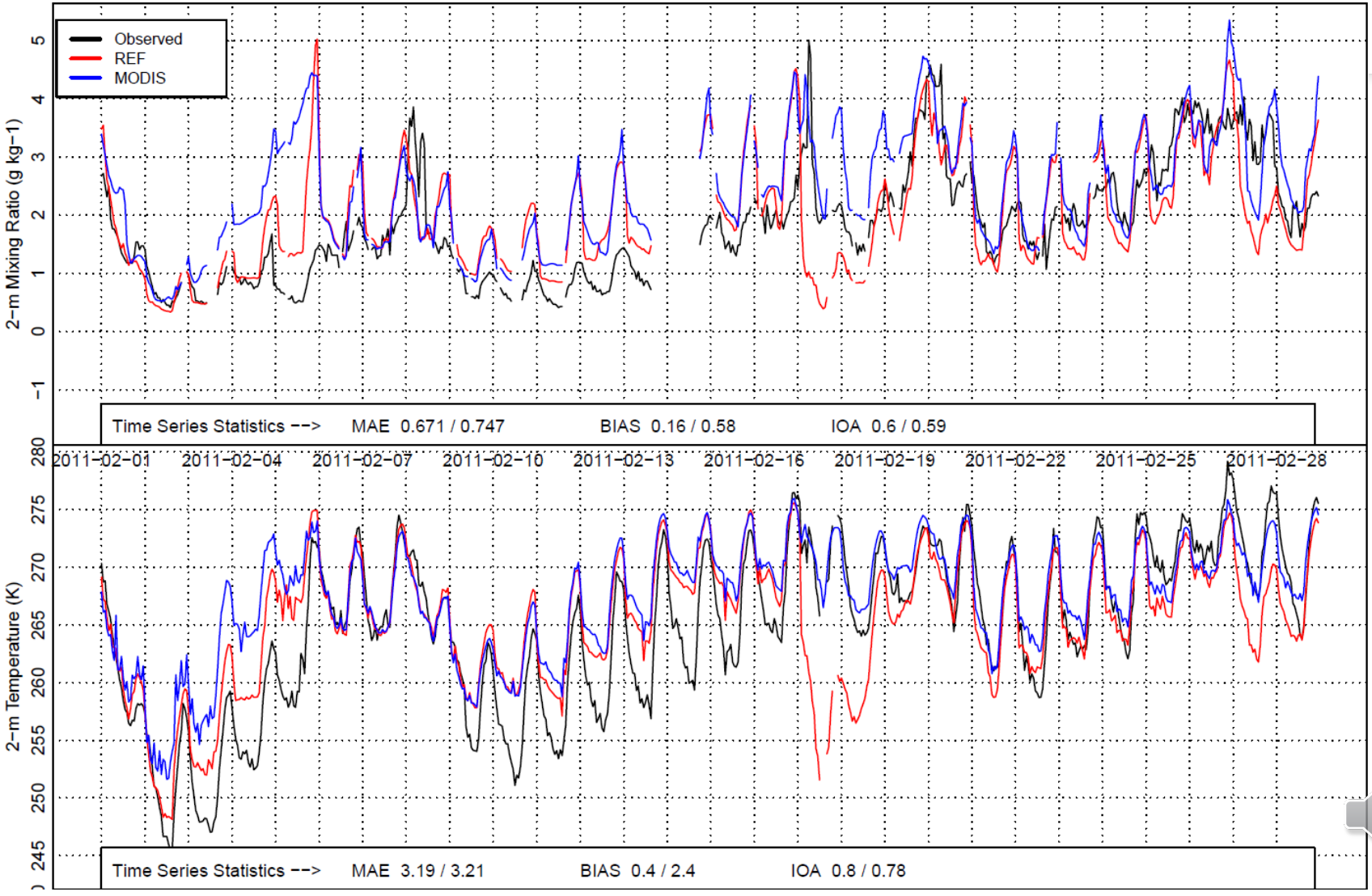


Effect of MODIS data assimilation (Cont.)





MODIS data assimilation does NOT necessarily result in better overall WRF performance



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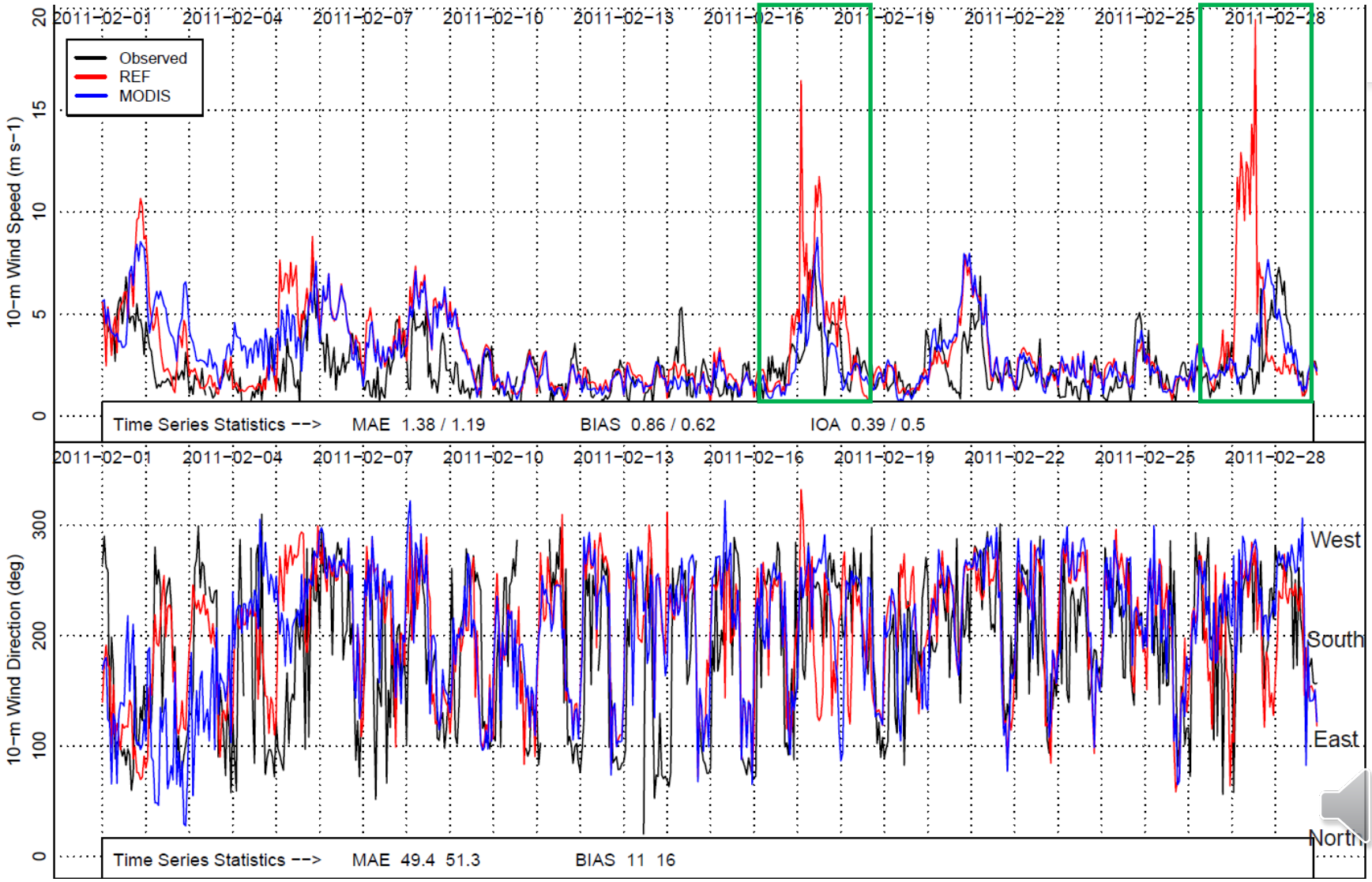


Modifications to CAMx source codes are also required

- CAMx calculates its own ALBEDO and SNOWC as the function of snow water equivalent, snow age, and landuse types

- At the initialization of CAMx simulation, CAMx-ALBEDO maybe higher than WRF-ALBEDO

CAMx

wrfcamx
(ALBEDO, SNOWC)

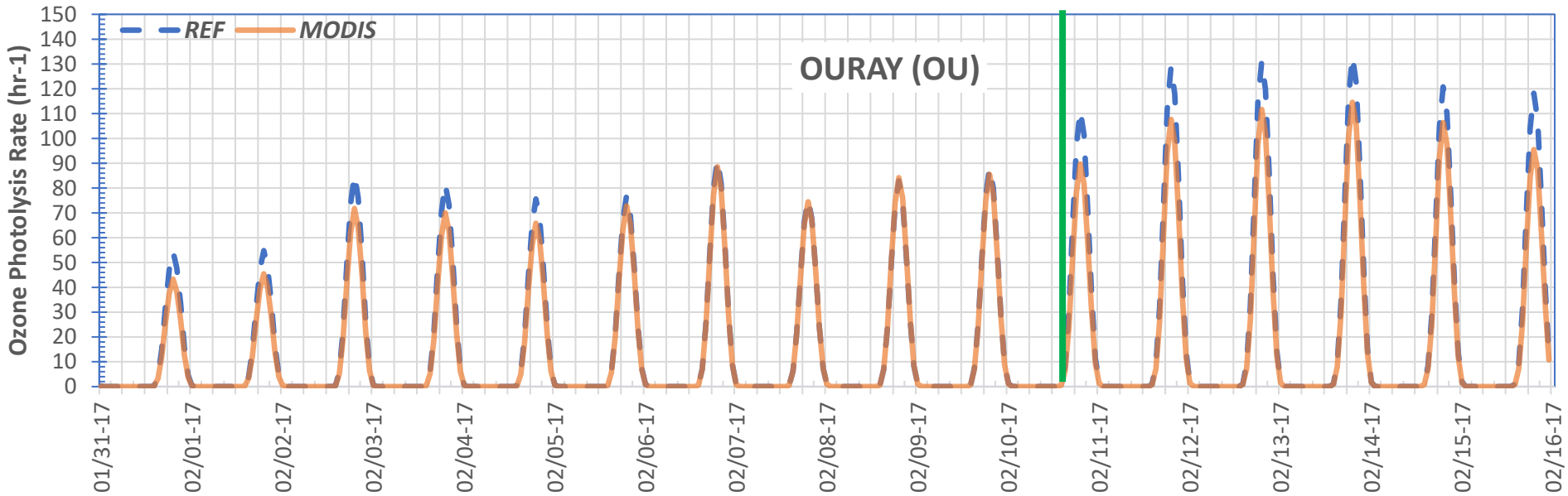
/Includes
camxfld.inc

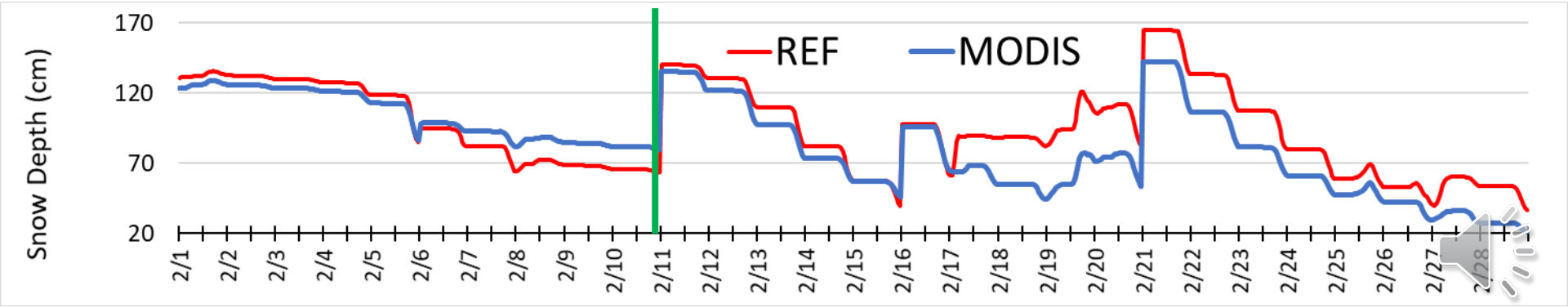
/Mod_src
camxfld.f

/IO_bins
readinp.f
metinit.f

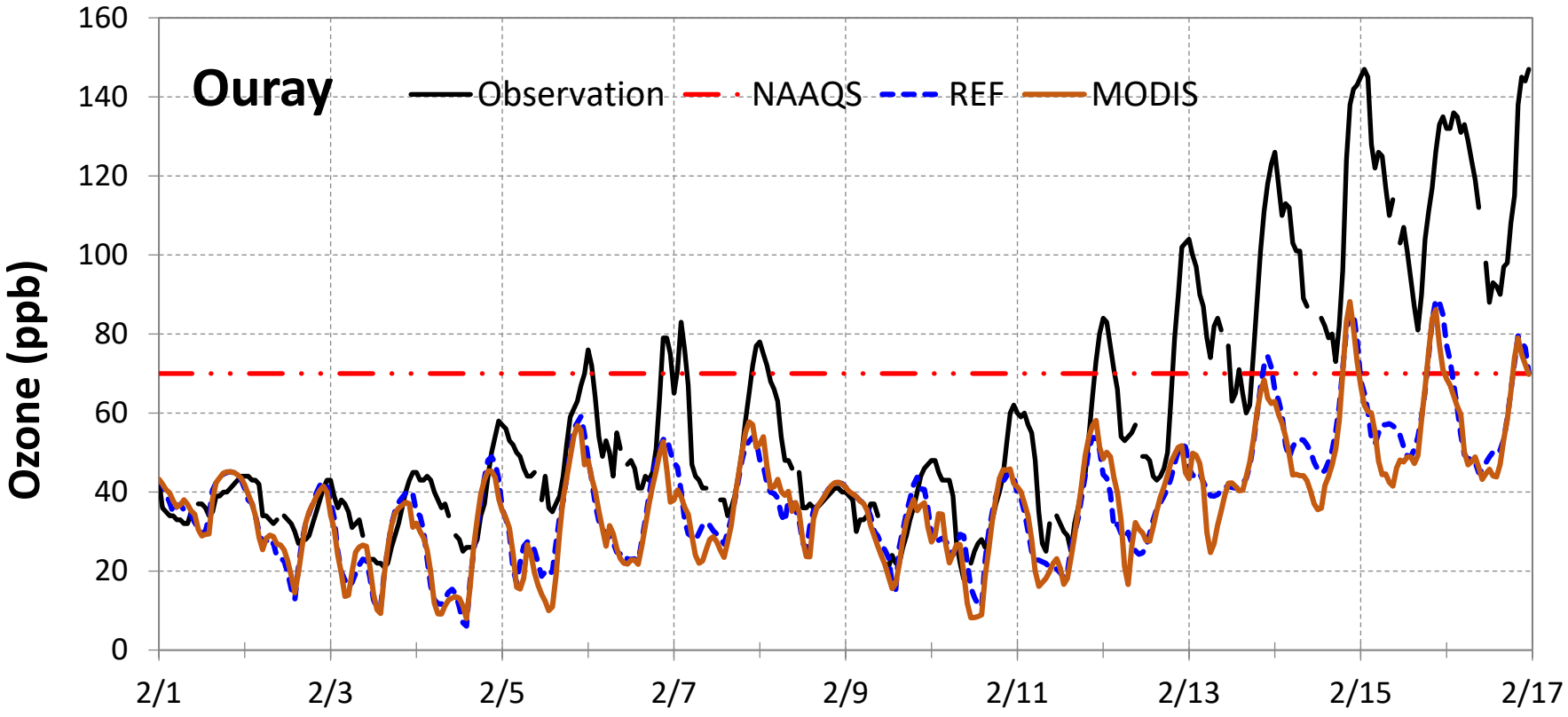
/CAMx
getalbedo.f
startup.f
tstep_init.f

Higher ALBEDO obtained in WRF-MODIS did not translate to higher photolysis rate in CAMx





MODIS data assimilation is not the magic wand to solve ozone underperformance issue



Summaries

- We have developed a methodological approach in improving WRF/CAMx performance using satellite data.
- MODIS data assimilation “improves” WRF and CAMx model performance.
- Positive effect of MODIS assimilation varies with different simulation episode and length of the episode.
- Effect of the technique could be more substantial in direct coupling meteorology-chemistry model.
- Better resolution and more frequent satellite dataset in future will enhance the benefit of satellite- base data assimilation technique.
- The same approach could be applied for assimilating other satellite data product to improve performances of both meteorology and chemistry model.