

WIND CHAPTER

PERCY LINK

1. METHODS

The sensitivity of Solano wind forecasts to soil moisture is tested using experiments with a regional atmospheric model, the Weather Research and Forecasting (WRF) model. The WRF model, described in detail in Skamarock et al. [2008], is a three-dimensional, non-hydrostatic regional atmospheric model with terrain following vertical coordinates near the surface that transition to *flat* vertical coordinates at high altitude. WRF solves the discretized equations for conservation of momentum, mass, energy, and scalars like water vapor, and it has a range of parameterization options for radiation, planetary boundary layer (PBL) turbulence, cloud microphysics, convection, bottom boundary fluxes of water vapor and heat, and lateral boundary forcing.

1.1. Model setup. We run WRF with two two-way-nested domains centered on the Solano wind farm (Figure 1); the domains are described in Table 1. The finest resolution presented here is 2.7 km; preliminary tests with a third finer grid (0.9 km) showed little change in the forecasted winds, similar to the results of Marjanovic et al. [2014]. The domain has 45 vertical levels, with a minimum spacing of **XX** near the surface and a maximum spacing of **XX** at the top of the model domain; wind forecasts are not very sensitive to vertical resolution beyond about 40 levels [Marjanovic et al., 2014, and references therein].

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The atmospheric model is coupled to the Noah land surface model with USGS land use and soil classifications. The observed distribution of land use and soil types are used, as are the default vegetation water-use parameters for each land use type, in order to simulate as closely as possible the real present day sensitivity of Solano winds to soil moisture. Uncertainties associated with errors in the model representation of water movement in the subsurface and plant water use are addressed in the Discussion.

The ACM2 PBL scheme is used, following the recommendations of Marjanovic et al. [2014] for a locally forced simple terrain case in California. The model is forced at the lateral boundaries with AWIP reanalysis at **XX km** resolution [CITATION]. Other parameterization schemes and settings are listed in Table 2. Model variables are output every 30 minutes.

All experiments are run for the period 2009-07-01 00:00 UTC to 2009-07-08 00:00 UTC, and the first **24** hours are discarded as model spin-up. This period was chosen for several reasons: (1) it contains a range of synoptic conditions (weak background wind July 1-5, and strong background wind July **6-7**), (2) turbine-level wind speeds in this region are highest in the spring and summer [WIND CLIMATOLOGY THESIS, WHARTON], and (3) the sensitivity to soil moisture is expected to be strongest in the warm season, because radiation incident to the land surface is greatest in the warm season, so changes in the relative partitioning between evapotranspiration and sensible heat flux have the largest absolute magnitude then.

1.2. Soil moisture experiments. The model experiments are listed in Table 3. In the first set of experiments, we test the sensitivity of Solano winds to soil moisture in different large-scale regions of California. In cases dryCR, dryCV,

Domain	Δx (km)	Δy (km)	nx	ny	nz	Δt (s)	USGS data res
d01	8.1	8.1	96	99	45	45	2 min
d02	2.7	2.7	175	175	45	15	2 min

TABLE 1. Model domains

and drySN, the background volumetric soil moisture (model variable SMOIS, m^3 water/ m^3 total volume) is set to 0.25, and the soil moisture of the test region (respectively, the Coast Range, Central Valley, and Sierra Nevada, shown in Figure 1b) is set to 0.1. In cases wetCR, wetCV, and wetSN, the background soil moisture is set to 0.1, and the soil moisture of the test region is set to 0.25.

The next set of experiments tests how the Solano wind response scales with soil moisture in the Central Valley, in both a normal-to-wet background (mountain) scenario and a dry background scenario. In cases CVXX (where XX is a numeric value), the Coast Range and Sierra Nevada regions' soil moisture is set to 0.2, and the Central Valley soil moisture is set to the value specified by XX. In cases CVXXdry, the Coast Range and Sierra Nevada regions' soil moisture is set to 0.1, and the Central Valley soil moisture again is specified by XX.

1.3. WRF regional atmospheric model. Physics of the model: (read how other people describe it)

- Three dimensional nonhydrostatic (compressible?) atmospheric model
- Solves equations of conservation of momentum, mass, and energy; uses finite difference (**check this*) method to discretize in space and time
- State variables that are calculated as they evolve through time: pressure, temperature, three-dimensional wind, moisture, plus a lot of other stuff...
- Widely used community regional atmospheric model (regional means it has lateral boundaries and thus requires lateral boundary conditions, as opposed to a global model which does not)

Scheme	Setting
WRF version	3.6
Grid nesting	two-way
Lateral boundary conditions	AWIP
Soil levels	4
Land use and soil categories	USGS
Land surface model	Noah
Surface layer	MM5 Monin-Obukhov
Planetary Boundary Layer (PBL)	ACM2
Microphysics	WSM 3-class simple ice
Longwave radiation	RRTM
Shortwave radiation	Dudhia
Cumulus	Kain-Fritsch (new Eta)
Turbulence closure	Horizontal Smagorinsky first order
Momentum advection	5th order horizontal, 3rd order vertical
Scalar advection	Positive definite
Lateral boundary	5 grid points

TABLE 2. WRF parameterization options. See **ARW USERS' GUIDE** for description of schemes.

- Operational version is used for weather forecasting, and research version is used for (XXX)
- List use in wind energy research and operational forecasting ...
- In this study, the bottom boundary condition is calculated using the Noah land surface model (but we prescribe initial soil moisture...) - *this is more methods*
- What WRF captures well, and what it does not do as well.
- Previous studies - how well has WRF done in simulating turbine-height winds (Marjanovic, BAMS article, ...), and major factors on which performance depends (resolution, PBL scheme, lateral forcing, soil moisture **)

Run name	Background SMOIS	Perturbed SMOIS region	Perturbed SMOIS value
CA-0.1	0.1	none	n/a
CA-0.2	0.2	none	n/a
CA-0.25	0.25	none	n/a
dryCR	0.25	Coast Range	0.1
dryCV	0.25	Central Valley	0.1
drySN	0.25	Sierra Nevada	0.1
wetCR	0.1	Coast Range	0.25
wetCV	0.1	Central Valley	0.25
wetSN	0.1	Sierra Nevada	0.25
CV0.05	0.2	Central Valley	0.05
CV0.1	0.2	Central Valley	0.1
CV0.15	0.2	Central Valley	0.15
CV0.25	0.2	Central Valley	0.25
CV0.3	0.2	Central Valley	0.3
CV0.35	0.2	Central Valley	0.35
CV0.05dry	0.1	Central Valley	0.05
CV0.15dry	0.1	Central Valley	0.15
CV0.2dry	0.1	Central Valley	0.2
CV0.25dry	0.1	Central Valley	0.25
CV0.3dry	0.1	Central Valley	0.3
CV0.35dry	0.1	Central Valley	0.35

TABLE 3. Model experiments