The synoptic forcing was the same between control and test cases, but the land surface heating varied. Soil moisture only declined by a maximum of XX (in the XX case) before being reset each midnight.

In both the control and test cases, winds at Solano have a strong diurnal cycle (time series figure), and tend to be strongest on days with stronger synoptic forcing (July XX). Solano wind speeds are greatest XX to XX hours and are weakest XX to XX hours (diurnal stacked figure). Solano winds are strongest in lowest 300 m, particularly in hours XX-XX (vertical profile figure). Solano winds are westerly at all heights and times, but at heights 300-1000 m the winds oscillate between northerly in night and morning to slightly southerly in afternoon and evening; but below 300 m, winds are southerly at all hours.

Regional low-level winds in the control case are consistent with previous studies of California surface winds (map figure first column, citations); flow is strong through the Solano pass, and splits into northward and southward branches in the Central Valley. The southward branch is stronger than the northward branch at 06:00 and 14:00, and the northward branch strengthens at 18:00 and 00:00. The pressure gradient from the San Francisco Bay to the Central Valley remains strong from 14:00 to 00:00 and weakens by 06:00.

The Solano wind in the regional test cases differs from the control case by as much as 2.5-3 m/s, and the changes are larger on days when the synoptic wind forcing is weaker (time series figures, e.g. XX days). The largest changes occur when Central Valley soil moisture is perturbed (dryCR and wetCR).

Drier soils on a wet background increase Solano winds in the afternoon and evening in all regional test cases (diurnal figure); the magnitude of this increase is larger in the dryCV case. The increases in both the dryCV and drySN cases are greatest between 11:00 and 18:00 (1-2 m/s for dryCV and 0.5-1 m/s for drySN), while the increase in the dryCR case happens later, between 16:00 and 21:00 (0.5-1 m/s).

\*\* NOTE that such increases in the afternoon cause the daily wind speed ramp-up to shift earlier, because the increases occur at the same time as the control ramp-up. Because there are no corresponding decreases at the hour of ramp-down, this means that the duration of the high-wind period increases. Predicting timing of ramps is important for utilities, and these results suggest that soil moisture influences ramp-up timing at Solano.

\*\* ALSO NOTE that drier soils (especially in CV) increase the minimum wind (XX hours) on many individual days, especially days with weaker synoptic wind forcing, but these changes do not appear in the two-week average diurnal cycle.

Wetter soils on a dry background have a smaller impact on Solano winds than drier soils on a wet background (diurnal figure). Again, the decrease is largest in when Central Valley soil moisture is perturbed. Both the wetCV and wetSN cases have changes during 10:00-18:00 that are more than one standard deviation from zero (0.25-1.5 m/s for wetCV and 0.2-0.7 m/s for wetSN); for the wetCR case, there are no times of day with wind changes more than one standard deviation from zero.

Vertical profiles: vertical center of increases in each case. Increases in u at all times and at all heights below 1700 m, but differences in magnitude, especially in morning. Changes in v tend to amplify existing diurnal pattern, with more northerly in night and morning and more southerly in afternoon. Degree to which the elevated increases propagate to the ground?

The Solano wind changes occur in the context of larger regional wind and pressure changes (map figure). In all dry regional tests, the changes in winds and pressure gradients throughout the Central Valley are largest in the afternoon (second and third rows in map figure). In the dry Coast Range test, both wind and pressure changes are largest in the northern Central Valley, where cyclonic flow develops around the northern Coast Range. In the dry Central Valley test, the pressure gradient from the San Francisco Bay to the Central Valley increases dramatically at 14:00, and these increases persist at 18:00 and to a lesser degree at 00:00. However, at 18:00, the zone of steepest pressure change has been pushed further eastward, and the strongest wind increases track this band of largest pressure gradient. The pattern of wind increases at 00:00 is disorganized, and wind speeds decrease in the southern Central Valley at 06:00. In the dry Sierra Nevada case, the pressure gradient strengthens moderately at 14:00 and 18:00, but pressure changes are minimal by 00:00 and 06:00. Wind speeds increase through the Solano pass and the middle Central Valley in the afternoon (14:00 and 18:00), and by 18:00, the bands of largest wind increases have moved northward and southward along Central Valley, again following zones of greatest pressure gradient increase. Wind changes at night (00:00 and 06:00) are small and disorganized.

Scaling of changes with central valley soil moisture

Drier CV soils increase Solano winds, while wetter CV soils decrease Solano winds (timeseries figure.) These changes can be up to XX m/s, and they occur most consistently in the hours of XX (diurnal figure), when they are XX-XX m/s on average in the driest CV case (CV0.05). The average changes during XX hours scale nonlinearly with CV soil moisture (shift stats figure), with larger increases in wind per unit soil moisture decrease when soil is dry. The greater sensitivity to soil moisture when soils are drier is likely due to the greater sensitivity of surface heating to soil moisture when soils are drier (forcing figure), which is related to rapid declines in soil hydraulic conductivity and plant stomatal conductance in the moderate-to-dry soil moisture range (cite something – Bonan? Sap flow paper? Transitional soil moisture regime paper of some kind?).

Physical mechanism

Set up: flow at Solano is topographically guided through the pass. Strong diurnal component relative to background synoptic wind, and peak at low levels (vertical profile figure), suggest significant forcing by land surface heating (and this is consistent with other studies [citations]). In order to understand the relative importance of terms in the momentum budget, we model wind at Solano as simple one-dimensional flow through the pass with a one-dimensional momentum equation,

neglecting Coriolis because of the topographic constraint on wind direction. The first term on the right hand side is the pressure gradient force, the second term is the advection of momentum, and the third term is frictional dissipation. We are interested in the importance of each of these terms through the diurnal cycle and in the influence of soil moisture changes on each of these terms.

In order to identify which regions most strongly control the pressure gradient relevant to Solano winds, we linearly regress the horizontal pressure anomaly against Solano wind (as described in Section XX), and the analysis is repeated for pressure at a range of heights and for a range of lag times, with wind lagging pressure. The regression slopes and correlation coefficients show a consistent pattern of positive slopes and correlation coefficients over the ocean near the central coast, and negative slopes and correlation coefficients throughout the Central Valley but especially just north and south of the Solano pass (regression map figure). The slopes and correlation coefficients are greatest with pressure anomalies from XX m altitude and with a lag of XX hr. Repeating the regression analysis using pressure changes and wind changes for the test cases minus control case, a similar spatial pattern of sensitivity emerges. Thus, we choose two boxes, shown in Figure XX (OCN2 and NCV), to represent the pressure gradient driving Solano winds.

The pressure gradient between the two boxes in the control case CA-0.25 (with pressure averaged over each box) has a diurnal cycle that is strong at low levels and lessens with height (Figure XX). The pressure gradient leads the wind diurnal cycle by approximately XX hours, and the pressure gradient declines more rapidly at night than does the wind. Using the pressure gradient between the two boxes outlined in Figure XX, we confirm that the peak sensitivity (as measured by the regression slope) and correlation occur with pressure at XX m altitude with a lag of XX hr.

- Connect pressure gradient changes to air temperature changes – time-height plots?

Using advection from the model output (u\_solano\*(u\_solano-u\_ocean)/dx\_solano-ocean), what do we get for du/dt? How does it compare to modeled? What does this imply the time series of friction must be? Does this compare favorably to time series of u\*? Can we attribute sustained nighttime winds to drop in friction that compensates for drop in pgrad?

How does each of these terms change in the test cases? When does pgrad change the most? How much does advection change? How much does u\* change, as a proxy for friction?

(If time: how much does temperature advection reduce the pressure gradient? Relative to radiative cooling, assuming some rate…)