Characterizing and Predicting along-coast and diurnal marine stratus variability on the U.S. West Coast

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Background

U.S West Coast Marine stratus forms and dissipates as the marine boundary layer (MBL) evolves as air flows southward around the subtropical high offshore. MBL depth, temperature, moisture, entrainment, and cloud processes combine to force cloud formation or clearing.

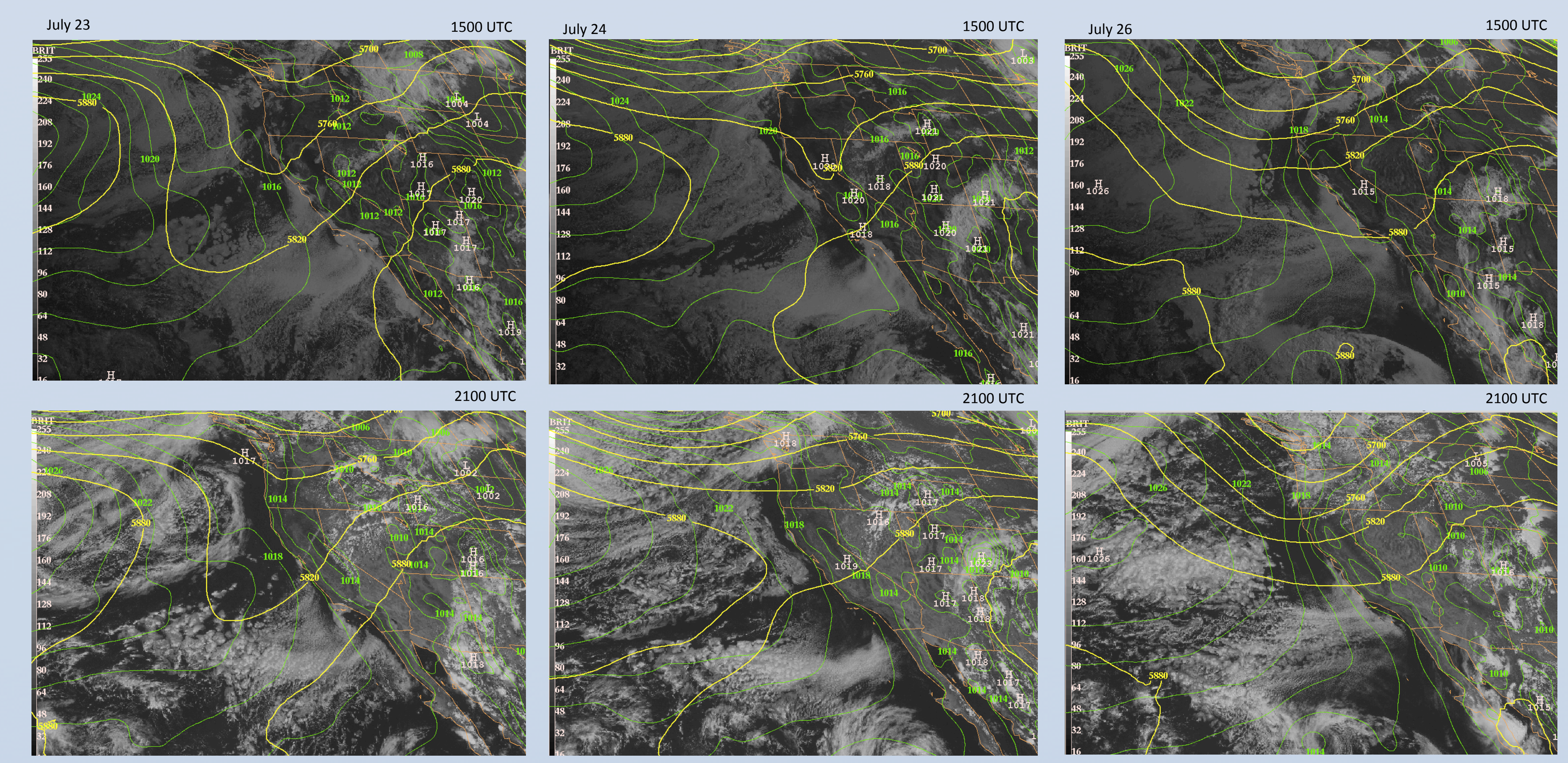
Key Questions:

- Can model MBL structure variations along Lagrangian trajectories be related to processes that create cloud versus clear regions?
- What are the primary processes that lead to spatial variations in stratus coverage?
- Does diurnal coastal clearing represent differences along trajectories or is it simply coastal effects?

Methodology

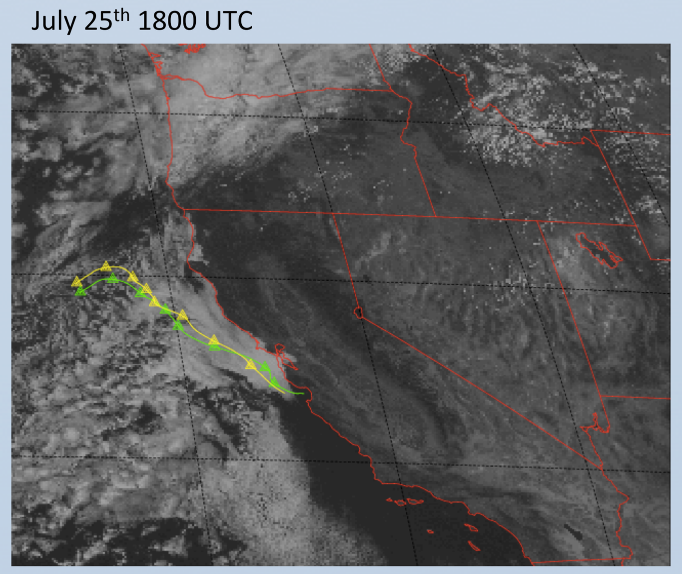
- Identified a sample period with both spatial and diurnal variation in marine stratus near the Monterey Bay region in summer of 2015.
- Created MBL (2D) back trajectories over 48 hours using NAM-32km and RAP-13km data to characterize source and evolution differences in cloudy versus clear areas and times.
- Created 3D back trajectories to characterize the role of subsidence and ascent leading to cloudy versus clear areas
- Examined source region differences and how they relate to cloud versus clear MBL conditions at trajectory endpoints.
- Analyzed vertical structure evolution of different parameters along 2D MBL back trajectories to identify processes leading to cloud formation or clearing.

Synoptic and Marine Stratus Evolution



Spatial Variations in Stratus

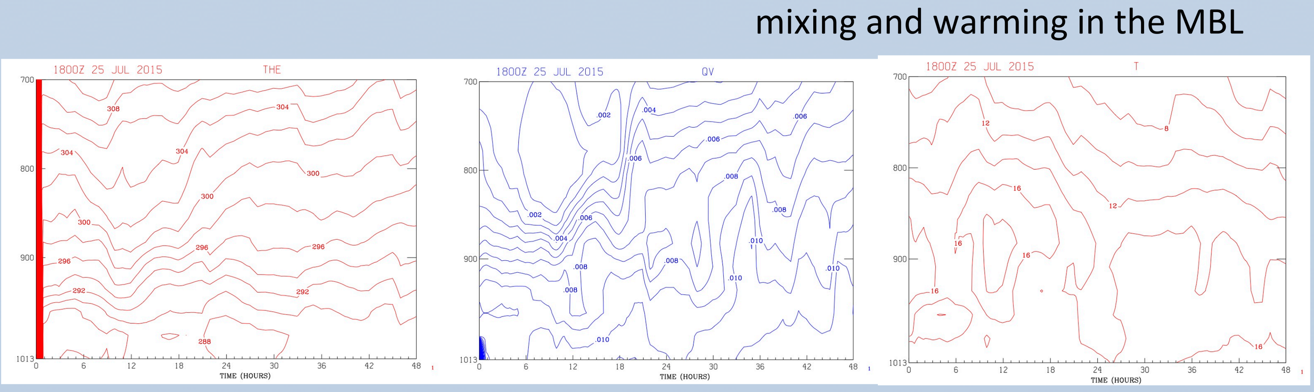
July 25th 1800 UTC



RAP back trajectories on the 25th at 1800 UTC that started on the same latitude with one being a half a degree west of the other were compared to assess how the MBL evolved to produce clear versus cloudy conditions.

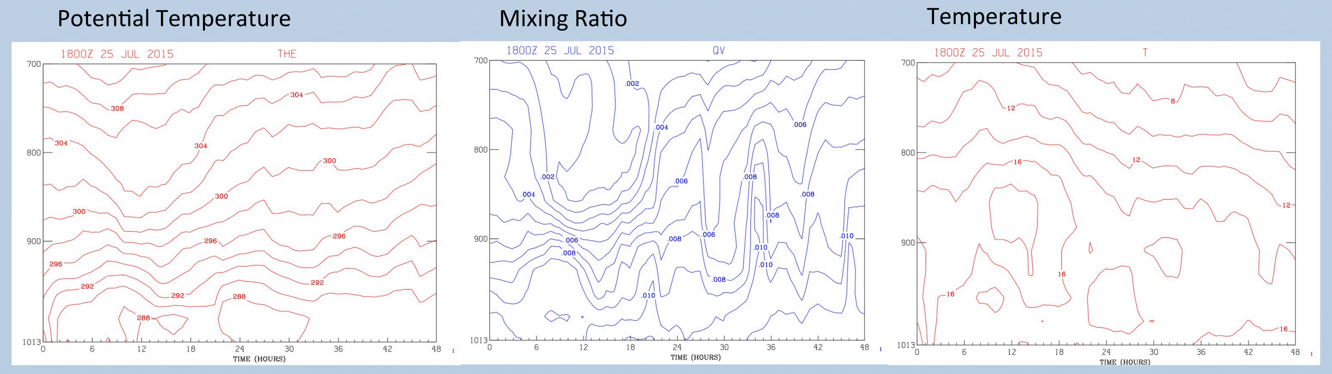
- Evolution similar until about last 12h
- Nearshore (clear) showed warming in MBL and just above
- Nearshore showed moisture dispersed more vertically through the inversion
- Suggests clearing near coast is associated with more mixing and warming in the MBL

Offshore



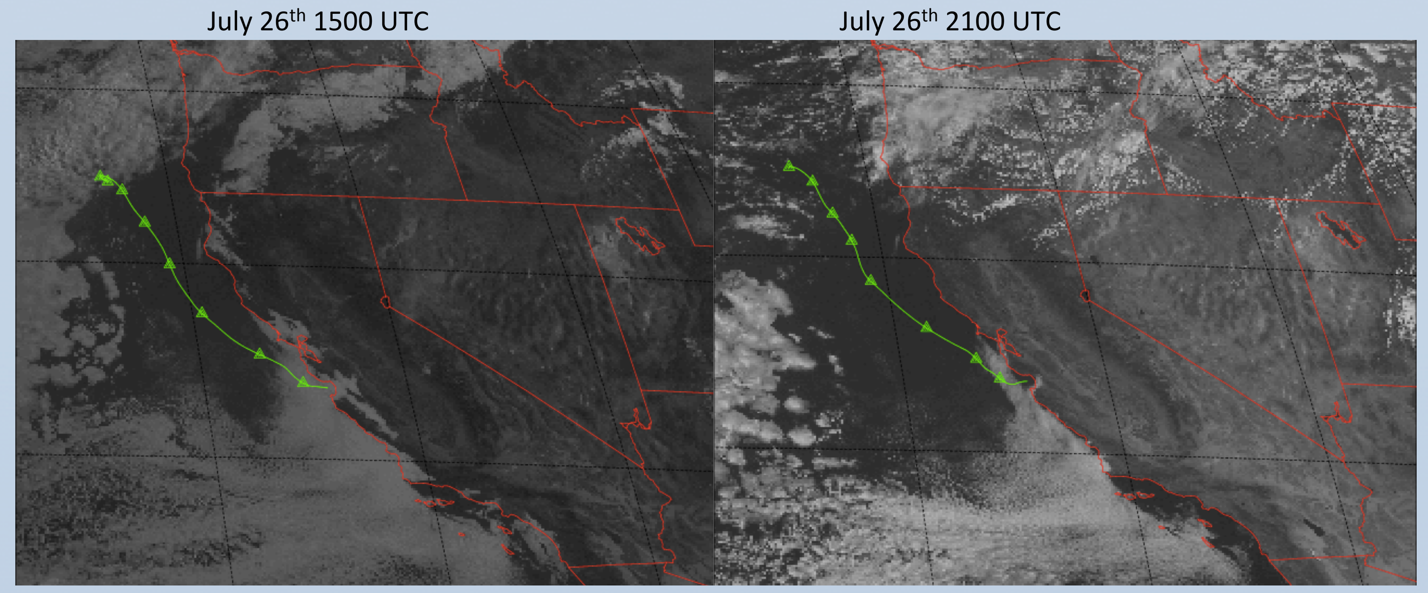
Potential Temperature | Mixing Ratio | Temperature

Nearshore



Diurnal Variations in Stratus

July 26th 1500 UTC | July 26th 2100 UTC

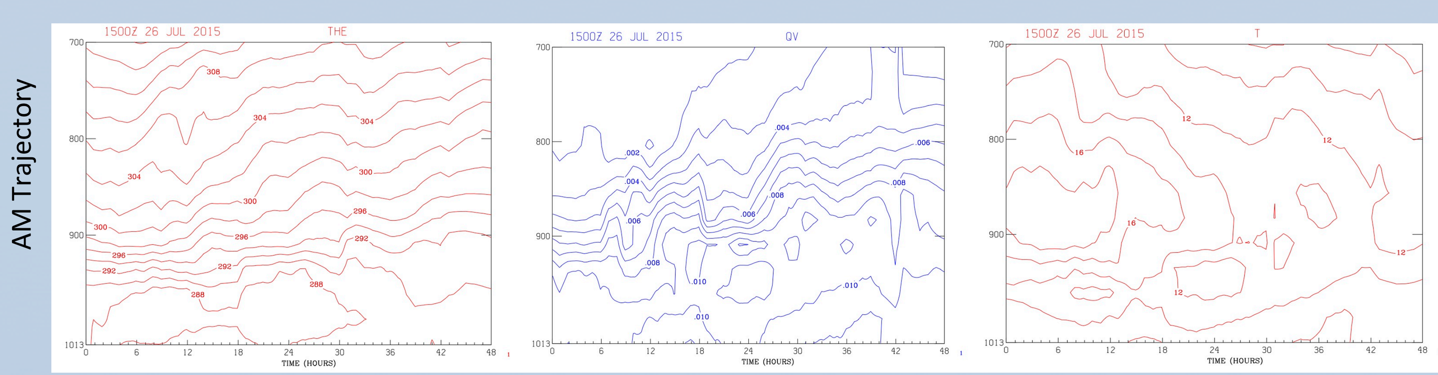


RAP back trajectories starting at two different times (1500UTC and 2100UTC) on the 26th (Pictured) were compared to assess diurnal impacts on MBL along the trajectory.

- no strong variation between the two back trajectories
- Later trajectory shows stronger MBL inversion suggesting increased subsidence through the day
- Pronounced warming and mixing occurs during the last 3-6 hours of the PM trajectory (diurnal warming)
- Moist layer deepens during the time of clearing consistent with increased mixing

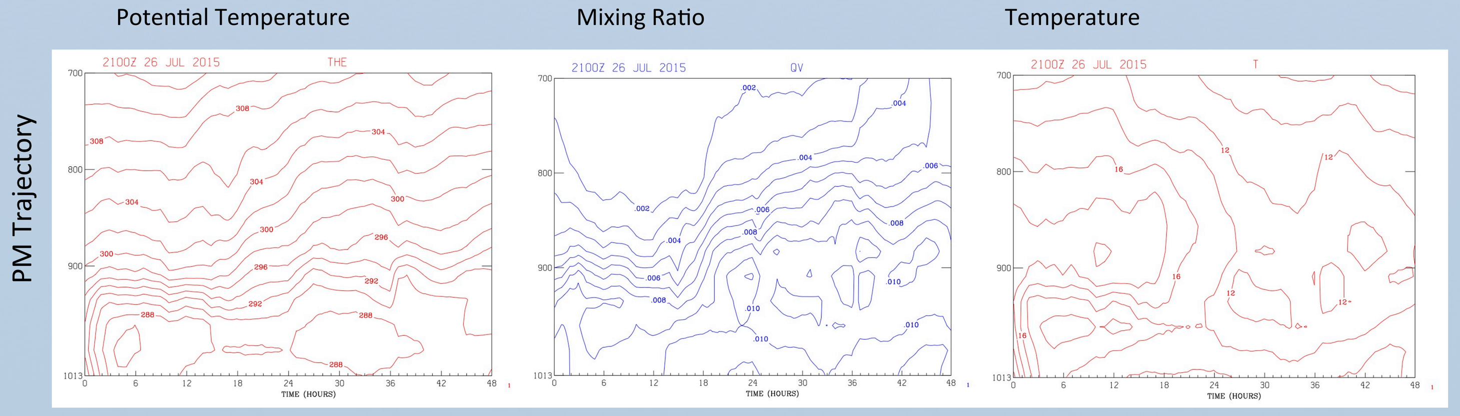
NAM temporal back trajectories (Not Pictured) analyzed a stronger difference, with 2100 UTC trajectories closer to the coast and more pronounced warming and deepening of the MBL in the afternoon.

AM Trajectory



Potential Temperature | Mixing Ratio | Temperature

PM Trajectory



Conclusions

The results of this case study show day to day variations stratus evolution due to the different synoptic and mesoscale setups of each day. However, each day had similar trajectories due to north to northwest winds near the surface and lower levels that produced marine stratus within Monterey Bay, Increases in the depth of the boundary layer in the afternoon indicates diurnal surface warming and rising motion due to boundary layer convection. This warming occurs in the last 6 hours of the trajectory into the Monterey Bay and is likely the main cause for the dissipation of the marine stratus layer on the 26th. Vertical motions, temperature, and surface moisture were different in the spatial analysis on the 25th with the near-shore trajectory showing warming and vertical mixing acting to produce stratus clearing that did not occur further offshore. 3D back trajectories (not shown) indicate a lack of vertical displacement throughout the 48 hours, with the mixing primarily occurring in MBL due to surface warming.

Diurnal oscillations in the horizontal movement of the trajectory on both the 25th spatial analysis and 26th temporal analysis demonstrate a possible sea/land breeze influences on the near-shore flow. More analysis needs to be done to confirm this influence and its impact on the MBL evolution as the air nears the coast. There were differences between the NAM and RAP analysis, with the case study, are likely due to the better representation of mesoscale features by the RAP. This case study points towards diurnal temperature changes have a larger impact on the marine stratus dissipation than synoptic scale along trajectory evolution differences.

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