Analysis of a Spring Coastal Stratus Surge: A WES Case

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Introduction

For this exercise the Weather Event Simulator (WES) was used by the Seattle WFO to examine an April coastal marine surge. This event resembled many other such events that regularly occur in the spring and summer months in the Pacific Northwest. Such events can be challenging to forecast, and have a significant impact on the users. Examining this case in a real-time WES environment proved useful in bringing a better understanding of such events to the forecasters.

Synoptic and Mesoscale Discussion

Early in the morning on 11 April 2004, marine stratus along the south Oregon coast began to propagate northward. This was in response to an approaching upper trough and a pre-frontal surface pressure ridge impinging the coastal zone, which acts to increase the onshore and along-shore pressure gradients. Thermal low pressure was still well established over interior Western Oregon and along the Washington coast at this time, with a very warm offshore flow. The North Bend, Oregon, to Seattle, Washington, sea-level pressure gradient is a locally monitored parameter used to anticipate coastal surges. It is a very long baseline, and in this case was already about 3 mb onshore even though the flow north of the surface trough was still offshore across western Washington. Although this value is somewhat marginal for penetration into the interior of western Washington, this gradient changes quickly and is continually monitored to anticipate the strength and timing of the surge.

The stratus continued propagating northward along the Oregon coast all morning. See figure 1 for its position at 1800 UTC. Observations in the stratus layer indicated surface temperatures only in the mid to upper 50s. While ahead of the surge, near record high temperatures were occurring over western Washington. By 2000 UTC, temperatures had soared well into to 70's along the Washington coast with Quillayute reporting 79F, and Hoquiam 74F. This kind of thermal pattern is quite typical during the triggering phase of the coastal surge.

Stratus continued to propagate northward along the Oregon coast to near Astoria (AST) by 2100 UTC. See Figure 2. Yet, given the close proximity of the weak surface trough to the west, the pressure ridge was much narrower horizontally than a few hours earlier. This narrowing dramatically influences the depth of the marine surge and thus its propagation speed, which is critical to timing the surge into Seattle's forecast area. In addition, at this same time, the upper ridge axis was beginning to shift east into eastern Washington (not shown) and coastal observations indicated a surface wind shift to onshore. Although the coastal stratus surge had yet to reach Washington, temperatures began to cool dramatically along the coast.

Typically, strong temperature gradients would be expected as the thermally-induced surface pressure trough shifts into the interior and cooler marine air surges inland replacing the warm interior air. However, in this case, the surface pattern evolved differently. A loop of the MSAS surface analysis indicated a continued thinning of the coastal ridge and its eventual dissipation. This essentially allowed the interior trough to be absorbed into the approaching frontal system. As a result of the dissipation of the coastal ridge, onshore pressure gradients gradually collapsed along the coast. This process weakened the coastal surge and the local temperature drops were much less dramatic than occurred farther south with the stratus surge; meanwhile, light flow inland from 2200 UTC - 0000 UTC allowed record high temperatures in the interior, including 80F at Seattle. By 0000 UTC, stratus had reached Hoquiam on the southwest Washington coast, where temperatures had already cooled into the mid 60s. The stratus surge continued to lose its characteristics and eventually became entrained into the main moisture flow off the Pacific.

Model performance

The Eta model run initialized at 1200 UTC on 11 April 2004 performed very well with this event. At 1200 UTC the fog product overlaid with surface observations clearly showed the leading edge of stratus just south of North Bend, OR. Model boundary layer winds and surface gradients clearly depicted the offshore flow north of the stratus surge. By 1800 UTC, the leading edge was just south of Newport, Oregon, which closely correlated to the Meso-Eta forecasted boundary layer parameters. Both the GFS and Eta accurately showed the approaching upper trough and resulting effects on the surface pattern over Washington. The higher resolution depiction of the Eta model run (40 km grid; Meso-Eta) was best at depicting the boundary layer moisture increase along the coast ahead of the main stratus surge.

WES exercise overview

For this exercise we identified three objectives:

1. Understand how such events impact various forecasts and users
2. Understand how such events evolve, both temporally and spatially
3. Identify and understand the salient physical processes

The case was conducted with two stopped-clock periods. The first was early in the morning, when the stratus was along the southern Oregon Coast. Self discovery of critical signatures in satellite imagery, models, and surface data was prompted through a series of questions. The second period was conducted just as the stratus was entering the Seattle CWA. For this part forecasters were asked to prepare short-term aviation forecasts and critique their earlier analysis and forecast.

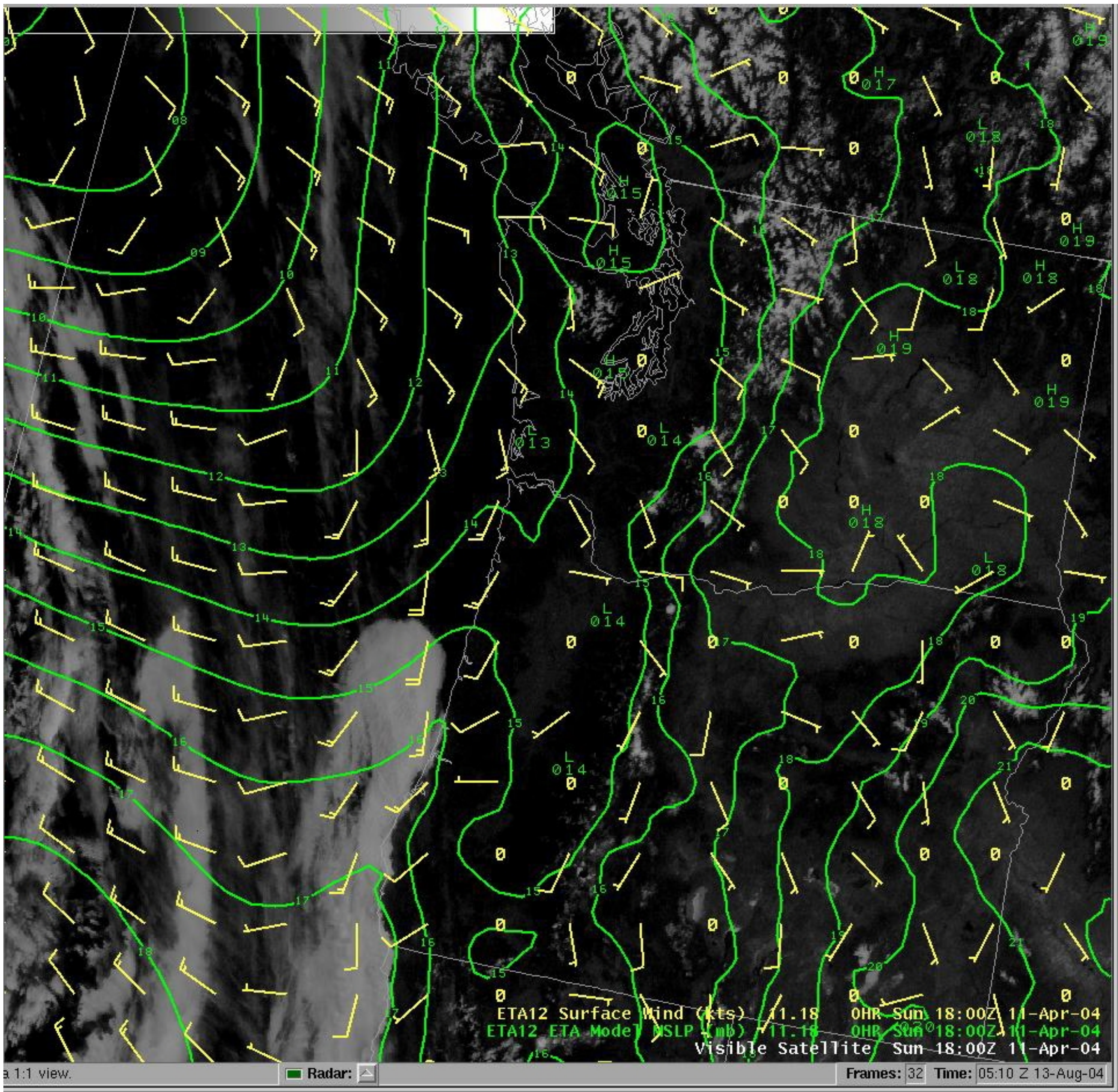

Figure 1: Visible satellite image from 1800 UTC, 11 April 2004. Overlays are Eta initializations for surface wind (barbs), and mean sea level pressure (green).

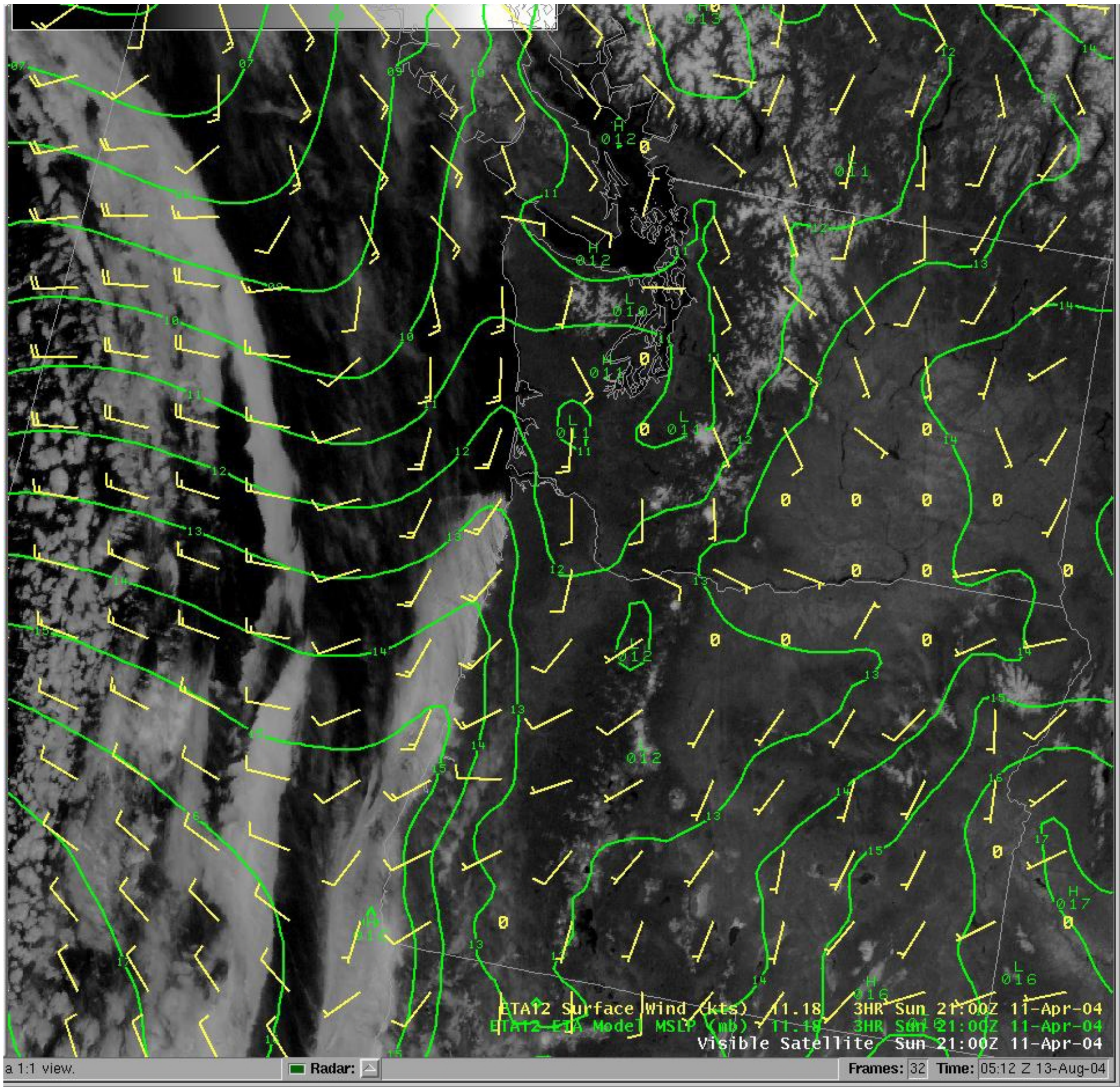

Figure 2: Visible satellite image from 2100 UTC, 11 April 2004. Overlays are Eta initializations for surface wind (barbs), and mean sea level pressure (green).