The Effect of The Blob marine heatwave on a U.S. West Coast Atmospheric River and Downstream Precipitation

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1. Abstract

Atmospheric rivers (ARs) and their impacts at landfall have been a growing topic of research over recent years, with associated intense rainfall important to ease drought conditions, but also bringing detrimental impacts, such as flooding and landslides. Despite the opportunity for ARs to interact with the ocean for days before landfall, there have been few studies on the air-sea interaction at locations away from western boundary currents, where we know these strong sea surface temperature gradients have an impact.

We conducted a case study of an AR that made landfall on the U.S. West Coast on 13-16 February 2016 using the Weather Research and Forecasting (WRF) regional model. We forced atmosphere-only simulations with the observed sea surface temperature, and with the sea surface temperature from February 2014, which featured a large-scale warming known as The Blob.

Alongside changes in surface fluxes and differences in integrated vapor transport, we find increased precipitation over the ocean and at landfall when the Blob warming is present. Future projections of precipitation are uncertain in relatively coarse resolution climate models and this study provides insight into how potential changes in the SST alter the dynamics of impactful AR systems.

2. Method

Weather Research and Forecasting (**WRF**) (Skamarock et al., 2008) regional model

- Domain over the northeast Pacific and U.S. West Coast
- Atmosphere-only with resolution: 0.08^0
- Ensembles: **72-member ensemble** based on microphysics, cumulus, boundary layer, surface layer schemes, and all members additionally had Stochastic Kinetic Energy Backscatter (SKEB) perturbations
- **'Real' and 'Blob' sea surface temperatures**

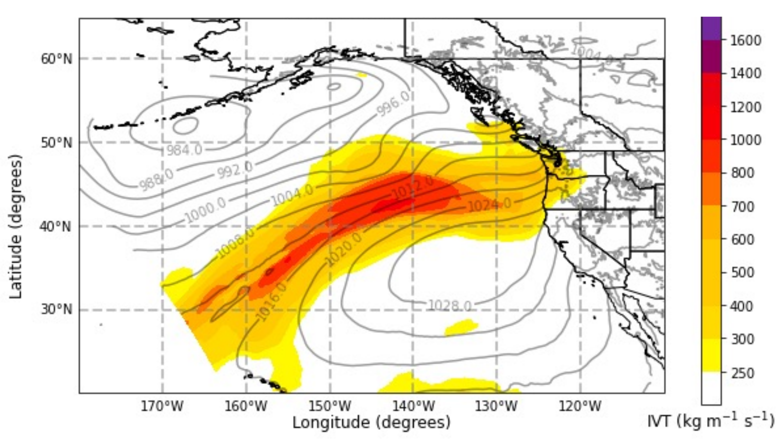


Figure 1. Extreme AR (>1000 kg m^{-1} s^{-1}) in the northeast Pacific on February 14th 2016. Colored contours: Integrated Vapor Transport (IVT). Contour lines: Sea level pressure (hPa).

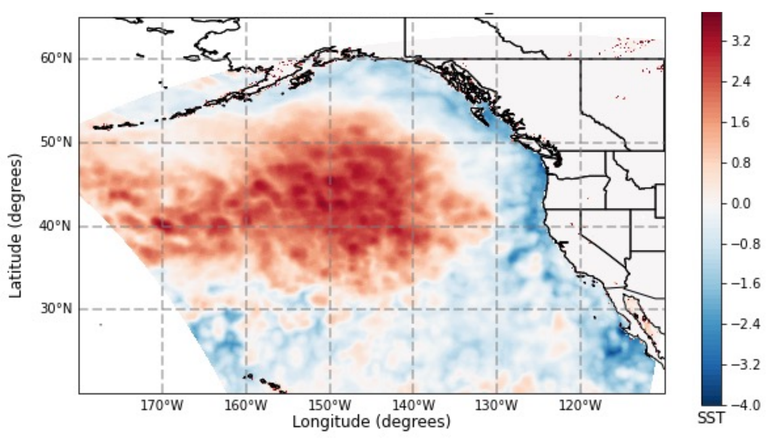


Figure 2. Sea surface temperature from the Blob minus Real simulation on February 14th 2016.

The Blob, winter 2013-2014: Unusually warm temperatures in the northeast Pacific, with the largest anomalies (>2.5C). In this 'Blob' simulation, there was large-scale warming of up to 2.5C in the northeast Pacific, directly underneath the path of the 2016 AR, with coastal cooling extending to around 500 km offshore.

3. Results

The core of the AR is wider in 'Real' in the first 6 timesteps, as the 'Blob' shrinks the extent of 1000 IVT on the southern edge. Elsewhere, there is generally a small increase in IVT over the Blob and particularly, in later timesteps, behind the AR.

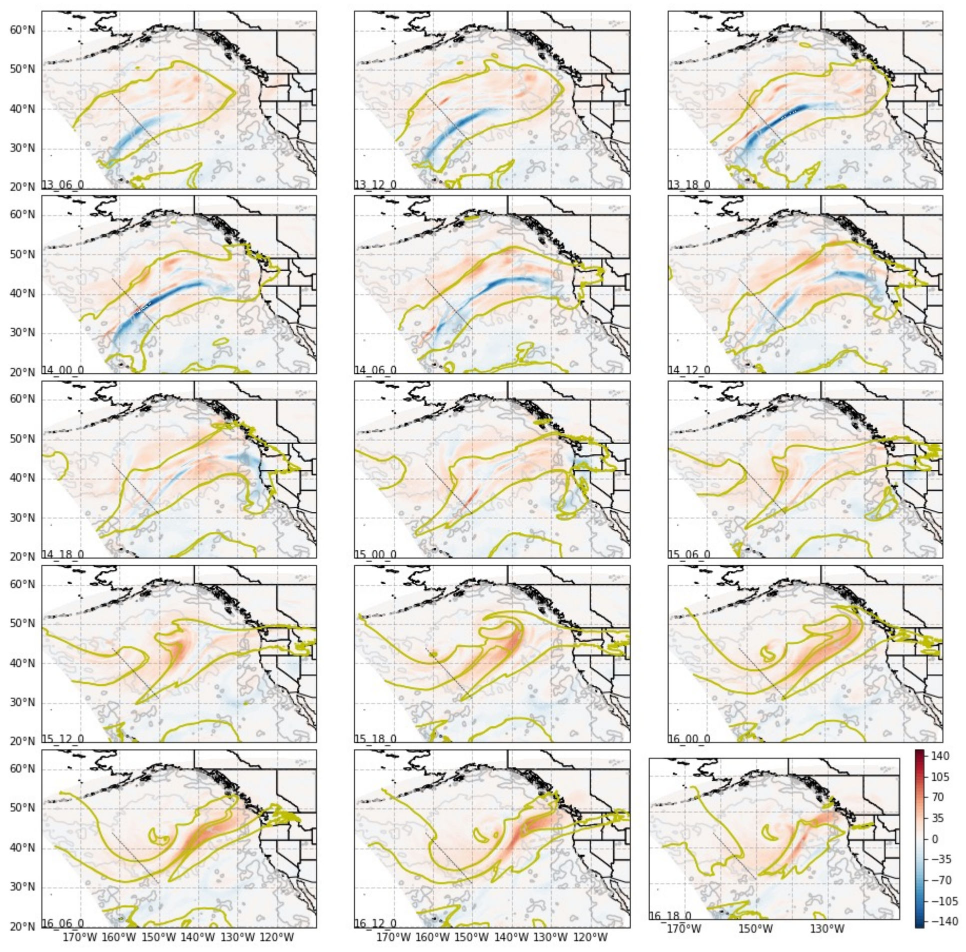
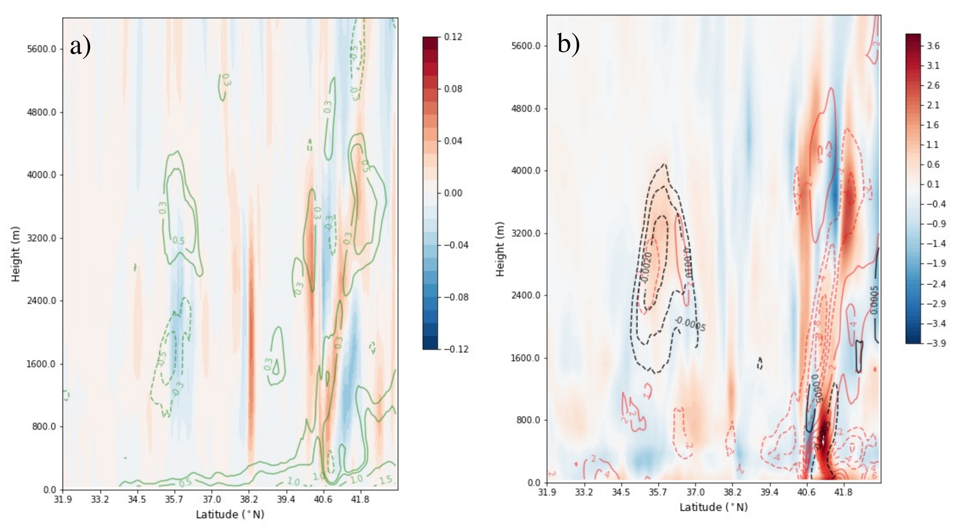


Figure 3. Blob minus Real IVT (colored contours) (ensemble mean) at 6-hourly intervals from 6 UTC 13 February 2016. Yellow contours show 250 IVT units for Blob and Real. Light and dark grey lines show SST difference of 2C.

Over the Blob, there are mainly increases in: convective rain (RAINC), grid-scale rain (RAINNC), sensible heat flux (HFX), evaporation (QFX), latent heat flux (LH), planetary boundary layer height (PBLH).

Figure 4. Ensemble mean cross section along black line in Figure 3, 12 UTC 13 February 2016. a) Blob minus Real omega (colored contours), theta (green contour lines). b) Blob minus Real wind speed (colored contours), wind direction (red contours), specific humidity (black contours).



The large difference in IVT (blue streak in Figure 3) is associated with reduced specific humidity in 'Blob' (~3000km), increased wind, change in wind direction, and heating above and cooling below, indicative of condensational heating.

We examine the accumulated precipitation from this AR (13-16 Feb) over land. The mean precipitation from different WRF output are: RAINNC (grid-scale): 800,000 mm; RAINC (convective): 4,000 mm; SNOWNC (grid-scale snow and ice): 200,000 mm.

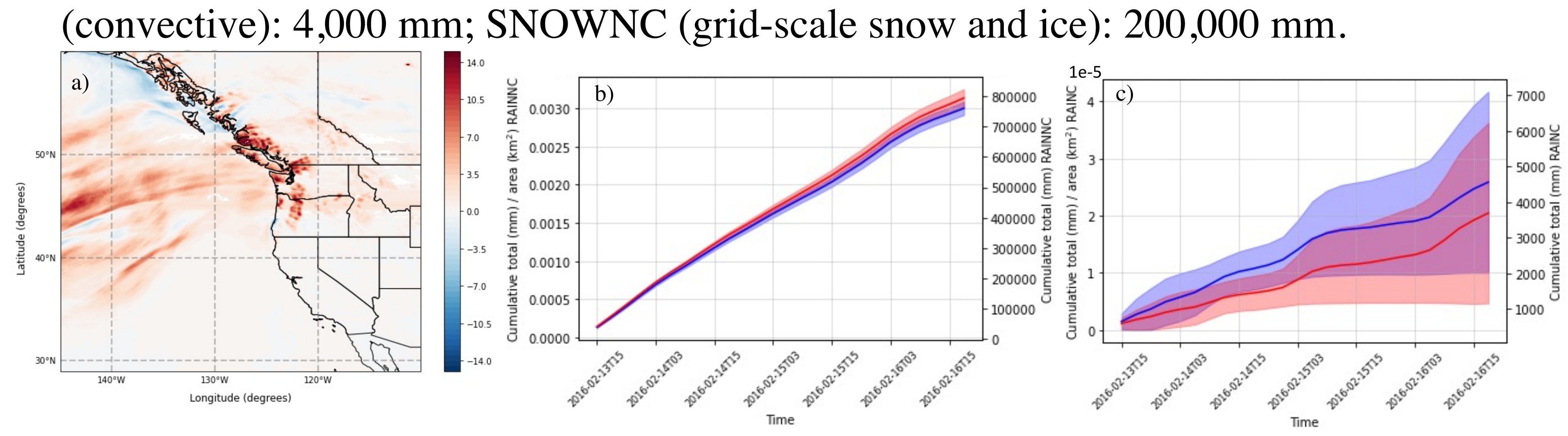


Figure 5. a) Blob minus Real RAINNC+RAINC accumulation from 13-16 February 2016 (ensemble means). b) Cumulative RAINNC Real (blue) and Blob (red) and standard deviation. c) Same as b, for RAINC.

More grid-scale precipitation over NE Pacific and land associated with the Blob AR.

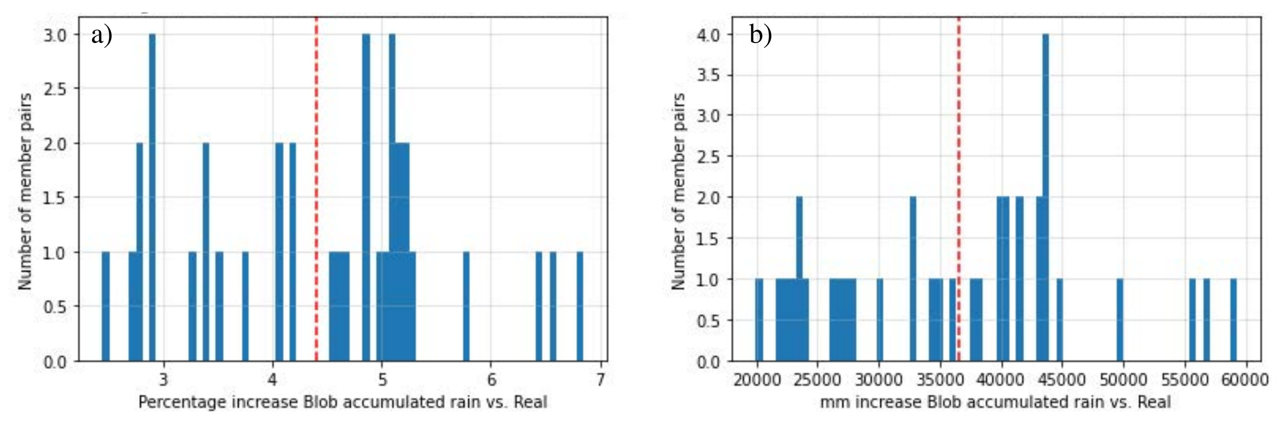


Figure 6. Difference in accumulated RAINNC over land (Blob minus Real) with red dotted lines showing the mean. a) Percentage difference. b) Difference in mm.

Every pair of ensembles (same physics perturbations in Real and Blob) show and increase in accumulated RAINNC over land in the Blob, with percentage increase between 2.5 and 7%, a mean of 4.5%.

Ranked ensemble members by highest accumulated landfalling RAINNC are in a very similar order for Real and Blob simulations, with Morrison, Tiedtke generally producing the highest RAINNC and Thompson GF producing the lowest. The effect of the SKEB seed is not reflected in total accumulated RAINNC rank.

Figure 7. Ranked histograms of total amount of accumulated RAINNC in the domain for each ensemble member for a) Real, b) Blob. Columns detail the microphysics, cumulus, PBL, surface layer parametrization schemes. Reds = Morrison, Blues = Thompson, Grey = Morrison or Thompson, different surface scheme.

4. Summary

- This study investigates the effect of realistic sea surface temperature (SST) anomalies on an overlying AR, focusing on the changes in precipitation over land
- We used an atmosphere-only regional model (WRF) and simulated an extreme AR, forced with 'Real' and 'Blob' SST in a 72-member perturbed physics ensemble
- Accumulated grid-scale rainfall over land significantly increased with warm SSTs (The Blob) for each ensemble member, with a mean of 4.5% increase.
- A similar order of ranked ensemble members by highest accumulated landfalling rainfall for Real and Blob
- Future projections of precipitation are uncertain in relatively coarse resolution climate models and this study provides insight into how potential changes in the SST alter the dynamics of impactful AR systems.

References

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