Investigating North Pacific Marine Stratocumulus Cloud Properties during a July 22, 2007 Event

Daniela Faggiani Dias, Tashiana Chanté Osborne, Nathalí Cordero Quiros

Stratocumulus Cloud Case

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2. Methods
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4. Likelihood of Precipitation
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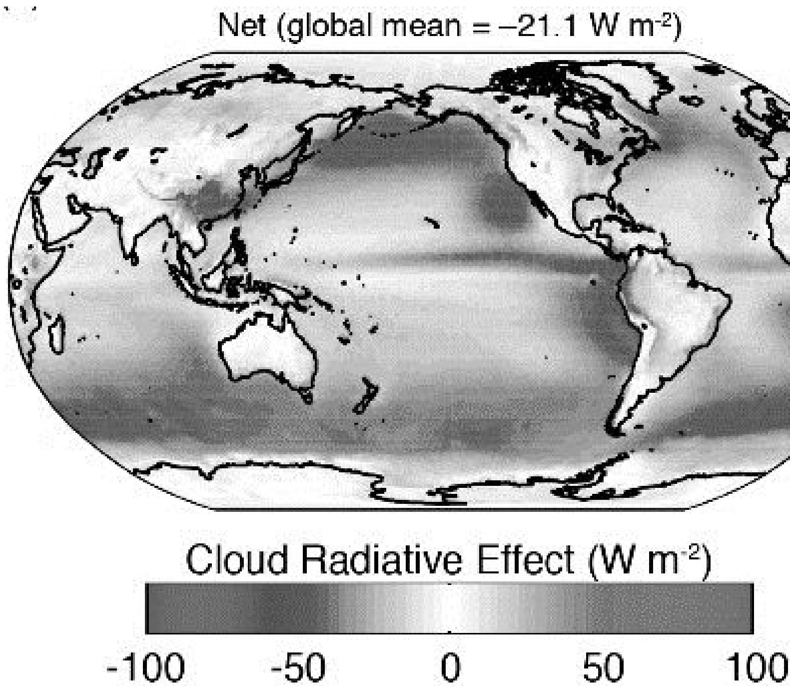
Introduction - Stratocumulus Clouds

Transfer of radiation from the atmosphere to Earth's surface

Impact on Earth's surface temperatures and on climate variability

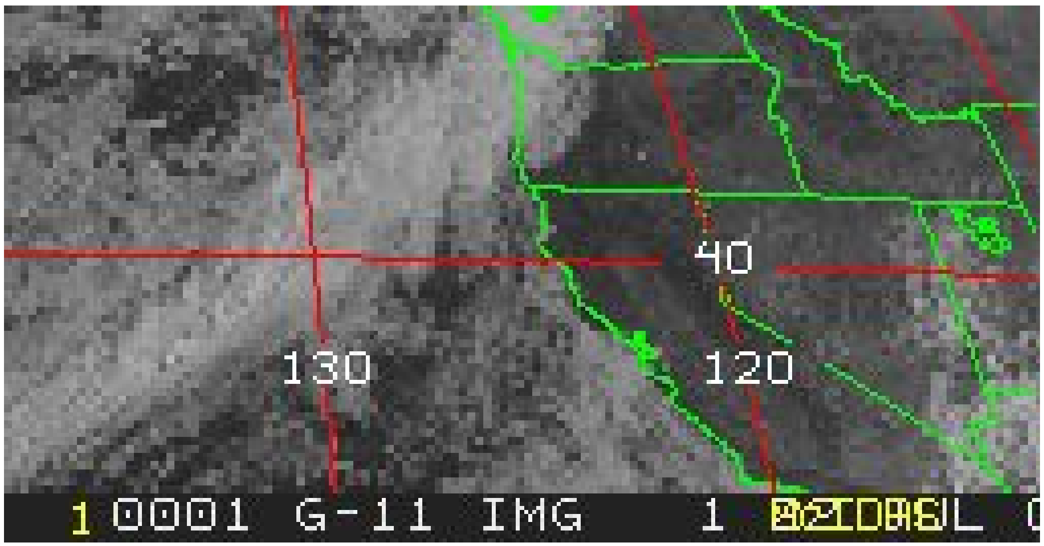
Predicted 2-3˚C rise in global temperature can be offset by a 4% increase in stratocumulus clouds

Introduction - Marine Stratocumulus Clouds



- Strongly correlated to underlying ocean temperatures: lower SST
  - High albedo - re-emit more SW radiation back to space;
  - Less radiation available for surface exchange
  - Strong net cloud radiative effect (negative North Pacific)
  - Decrease in SST
  - Important to be represented in GCM to account their role in cooling ocean surface

Introduction - Marine Stratocumulus Clouds



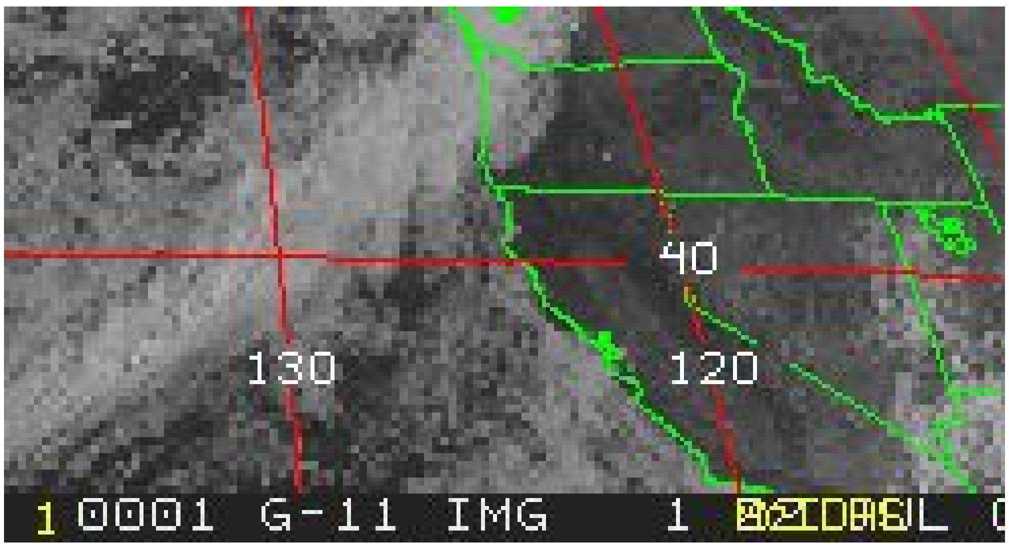
GOES image, 16 UTC July, 22, 2007

Satellite view:

Brighter than ocean: reflects 60% of sunlight against 2% reflected by ocean

Vast sheets of stratocumulus clouds are present over the eastern Pacific Ocean, off the coast of California to the north, and off the coast of Chile and Peru to the south.

Cloud case Study

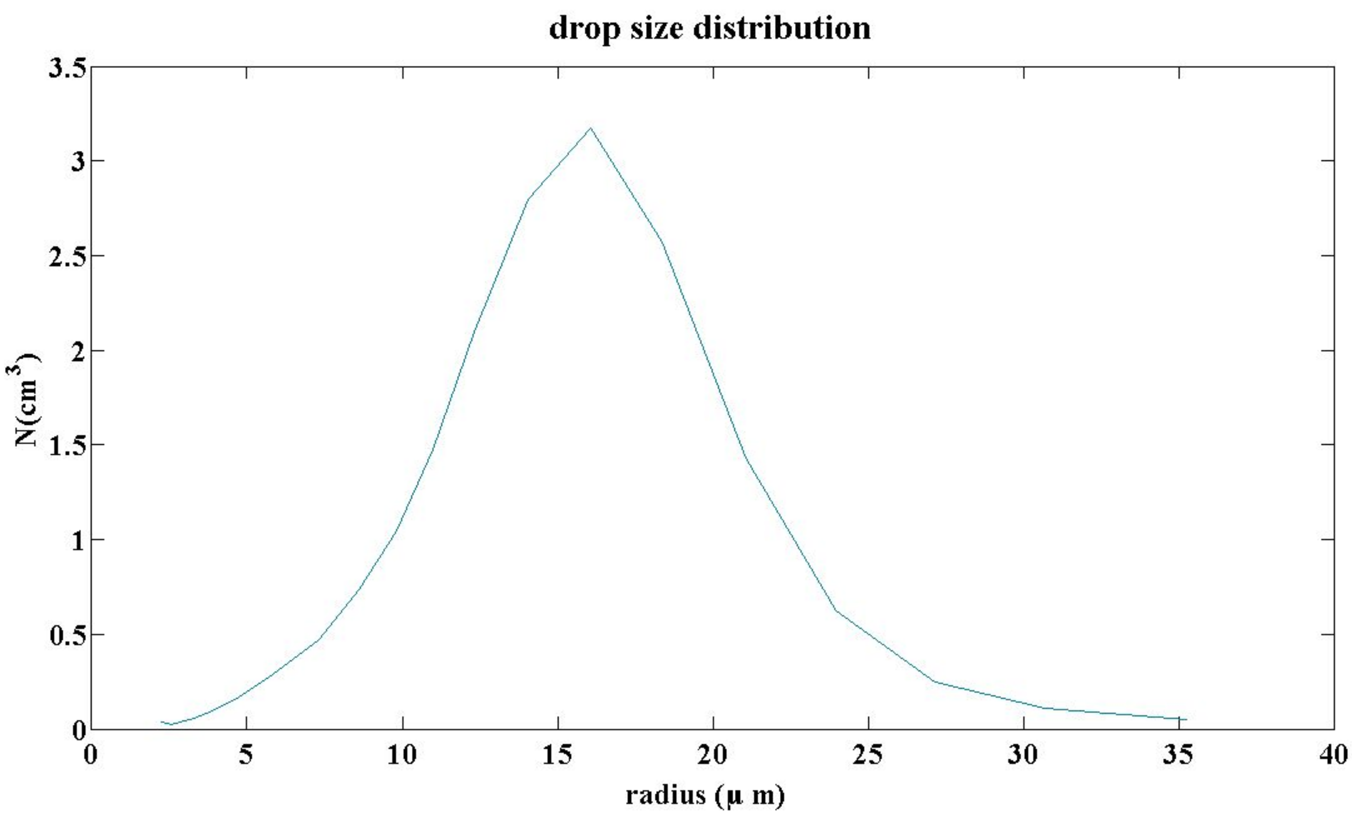


GOES image ,16 UTC July, 22, 2007

Marine Stratocumulus Event in the North Pacific Ocean off the coast of Monterey, California :

- Radiative properties
- Likelihood of precipitation associated with this cloud event
- Comparison of the results with an archived forecast pertaining to the same date.
- Droplet size distribution obtained from the second phase Marine Stratocumulus Experiment (MASE-II), carried on July, 22, 2007 (Lu et al., 2009).

Radiation properties - droplet distribution



Radiation properties - calculation

Total number of concentration	$N = \int_0^\infty n(r)\,dr \sim \sum n(r)$
Water mixing ratio	$w_l = \frac{\rho_l}{\rho_w}\frac{4}{3}\pi\int_0^\infty r^3 n(r)\,dr$
Liquid water path	$W_l = \int_{z_b}^{z_t} \rho_a w_l\,dz$

Effective radius	$r_e = \frac{\int_0^\infty r^3 n(r)\, dr}{\int_0^\infty r^2 n(r)\, dr}$
Volume extinction coefficient	$\sigma_{ext} = \pi \int_0^\infty r^2 n(r)\, dr Q_{ext}(\lambda)\, dr$
Extinction optical depth	$\tau_{ext} = \int_0^\infty \sigma_{ext}\, dz = \frac{3W_l}{2\rho_l r_e}$
Terminal velocity	$u_T = k_1 r^2$

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Terminal velocity	$$u_T = k_1 r^2$$

Results

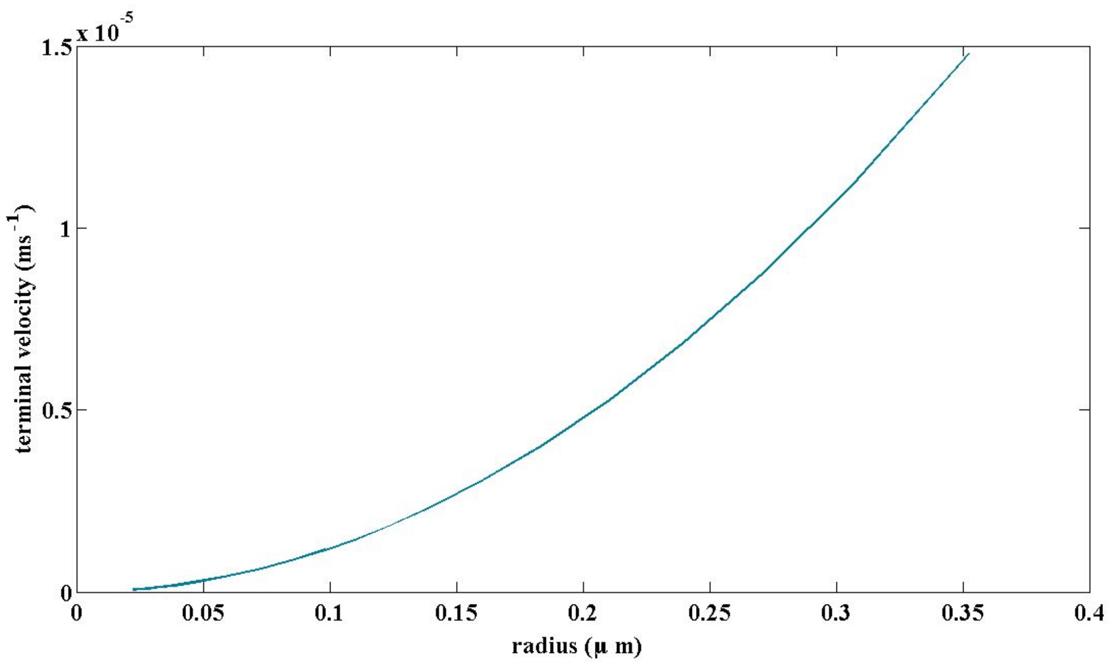
parameter	
Total number of concentration	17.52 cm^3
Water mixing ratio (ɯ)	$7.53x10^{-5}$ g_{air}/Kg H_2O
Liquid water path (𝔚l)	0.016 g/m^2
Effective radius	19.5 µm
Volume extinction coefficient	$2.97x10^{-9}$ cm
Extinction optical depth	12.18 cm
mean terminal velocity	$3.2x10^{-6}$ m/s

likelihood of precipitation

Using Stoke's law, the terminal velocity of the particle has quadratic dependence over its radius.

$$u_T = k_1 r^2$$

$^*k_1 = 1.19 \times 10^4 m^{-1} s^{-1}$



Precipitation Results

- Collision-coalescence: Process contributing to growth of individual droplets in cloud → precip
- For precip: the particle's terminal velocity > updraft velocity within the cloud
- Max terminal v for the droplet radius analyzed = 1.5×10^{-5} m/s (for r = 35 mm)
- Updraft v = 0.26 m/s (> max terminal v → low likelihood of precip)

Sounding Location

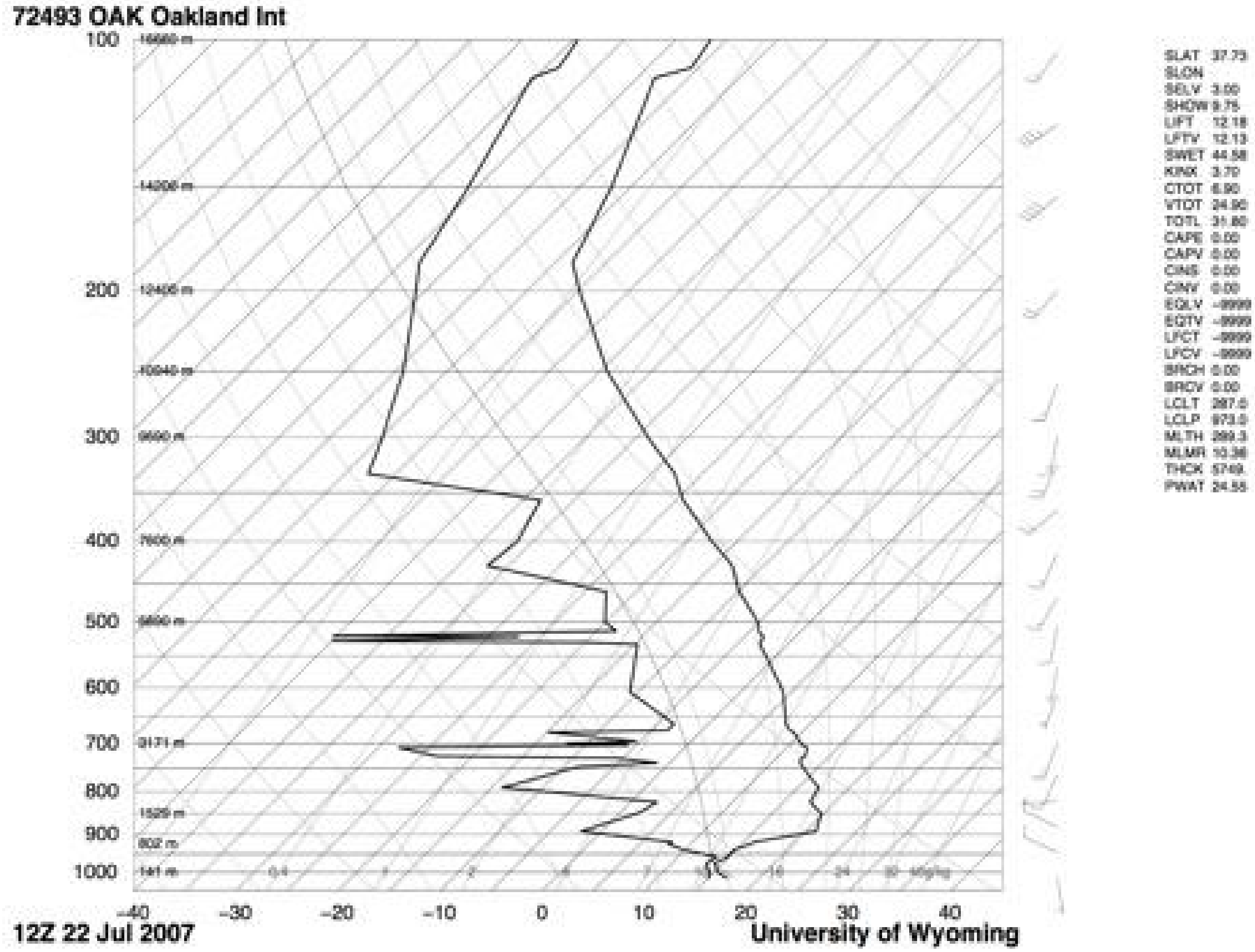
- July 22nd, 2015 at 12Z (5 am PDT)
- Launched from Oakland International Airport, ~135 km North of flight region

Fig. 6. Radiosonde launch location (OAK Airport) relative to the July 22, 2007 MASE-II flight location (in pale yellow).

Skew-T

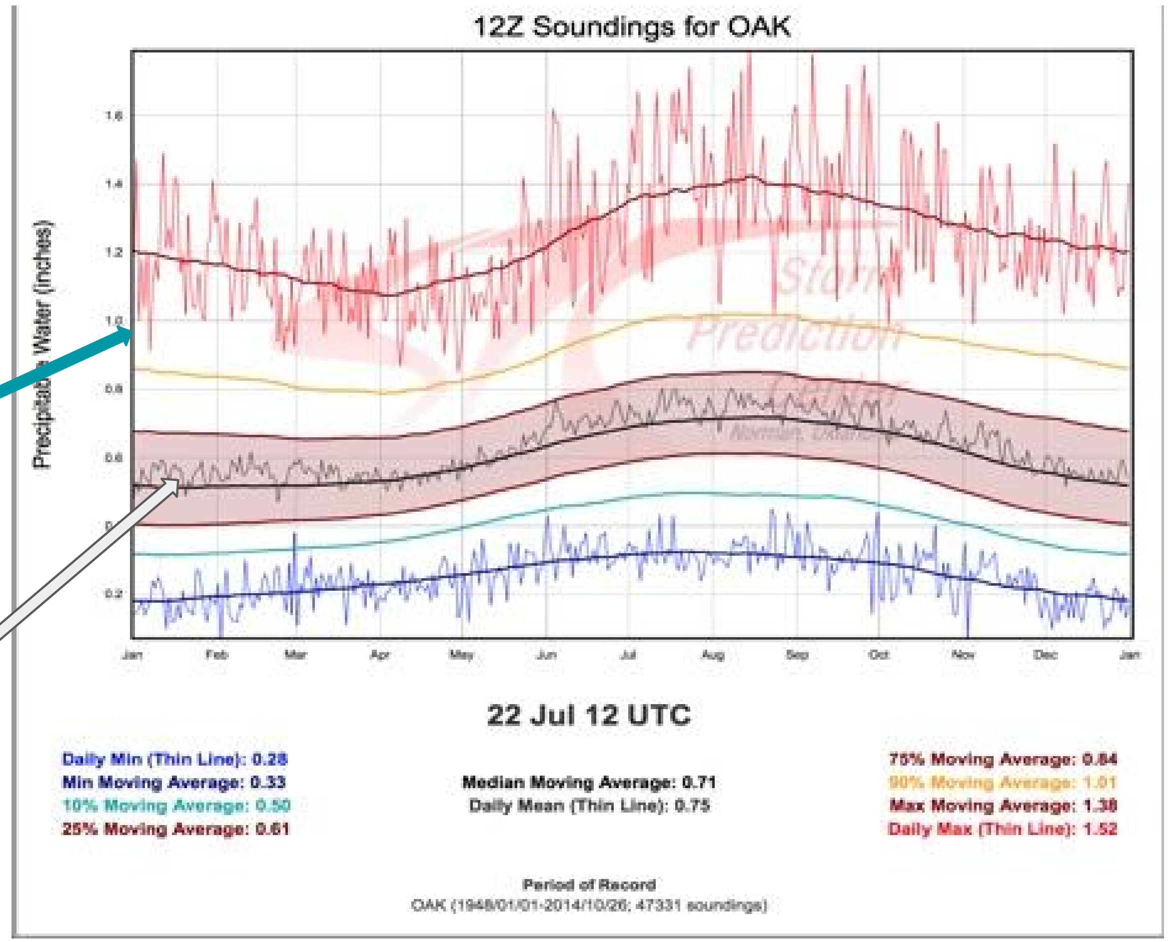
- Weak low-level winds (~5 -10 mph). At sfc: T ~ 6.5°C, and Td ~ 6°C
- Air is nearly saturated around 970 mb, small Td depression

→ Low-lying marine clouds



Precipitable Water

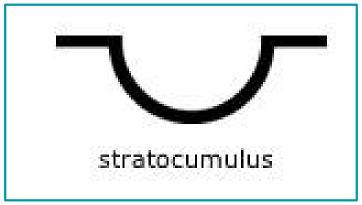
- Pw: Depth of water in a column of the atmosphere, if all the water in that column were precipitated as rain
- The amount of pw for the entire sounding = 24.55 mm (~0.97 in)
- In OAK on July 22, 0.97 inches is above the mean value of 0.75 inches for this date and location
- Evidence that the air in this case was more saturated than usual for this date, location, and time → formation of clouds
- Note: High pw does not assume the water in the column was precipitated as rain



Forecast Comparison

- WPC forecasters did not expect precip near Monterey, CA
- Interesting: Rain and t-storms expected in many other regions

Conclusions



- Moisture available in atmosphere to support cloud formation and precipitation...
- Droplets within the marine Sc clouds, however, did not grow large enough to allow for precip
- Cloud properties, archived weather forecast, and upper air Skew-T plot support this conclusion

Thank you!

Questions?