Separating Cloud and Ocean Pixels in Satellite IR Brightness Temperature Images

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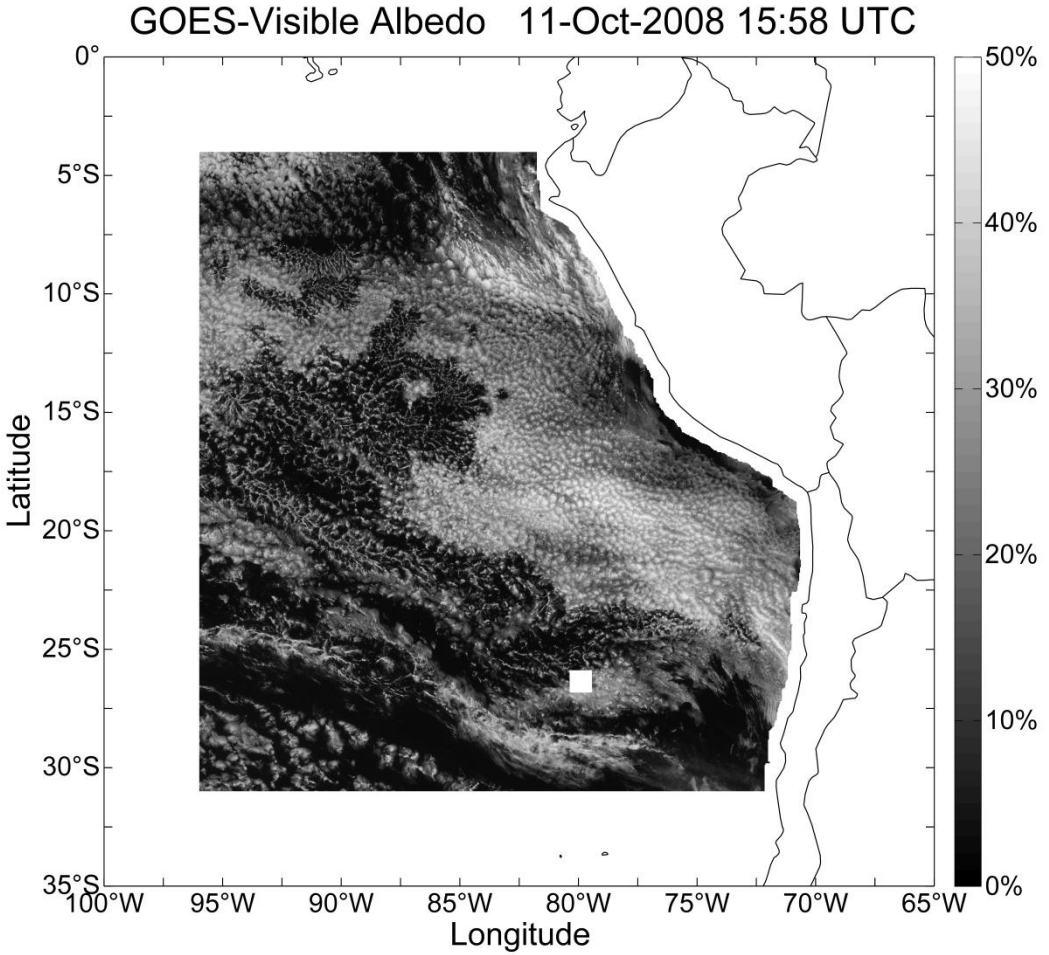
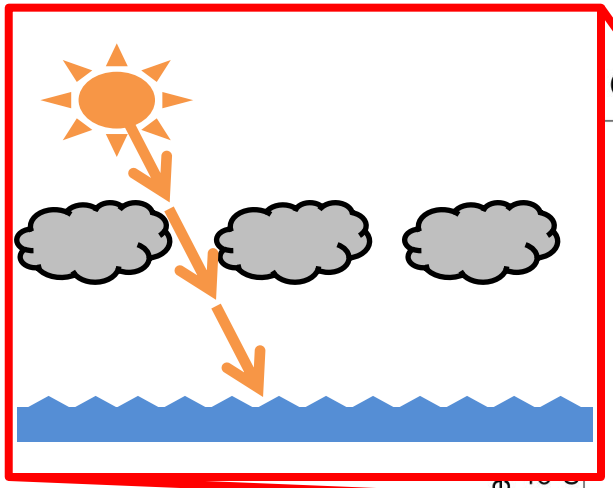
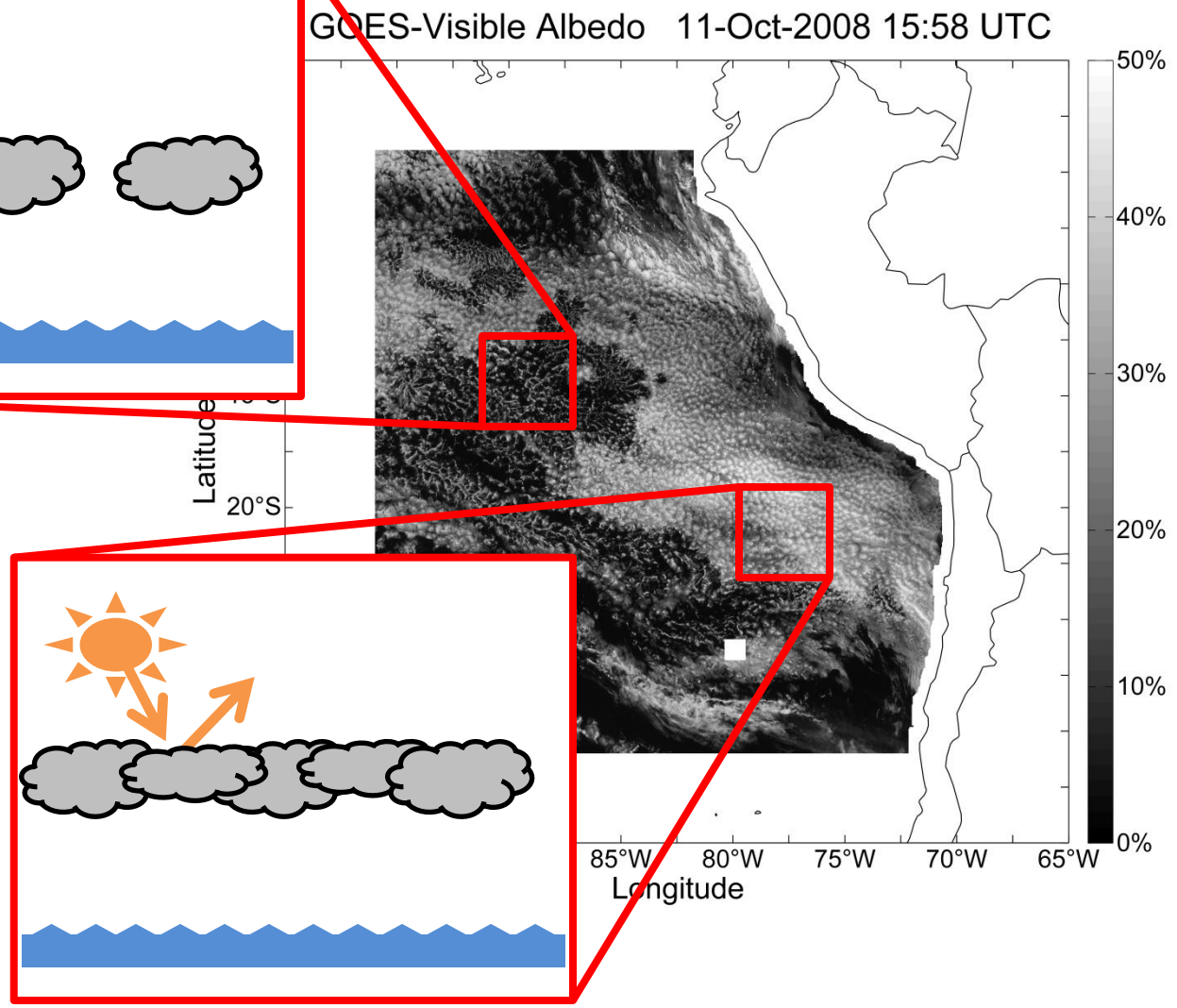
4-Jan 2013

Marine Stratocumulus Clouds Modify the Global Radiative Balance



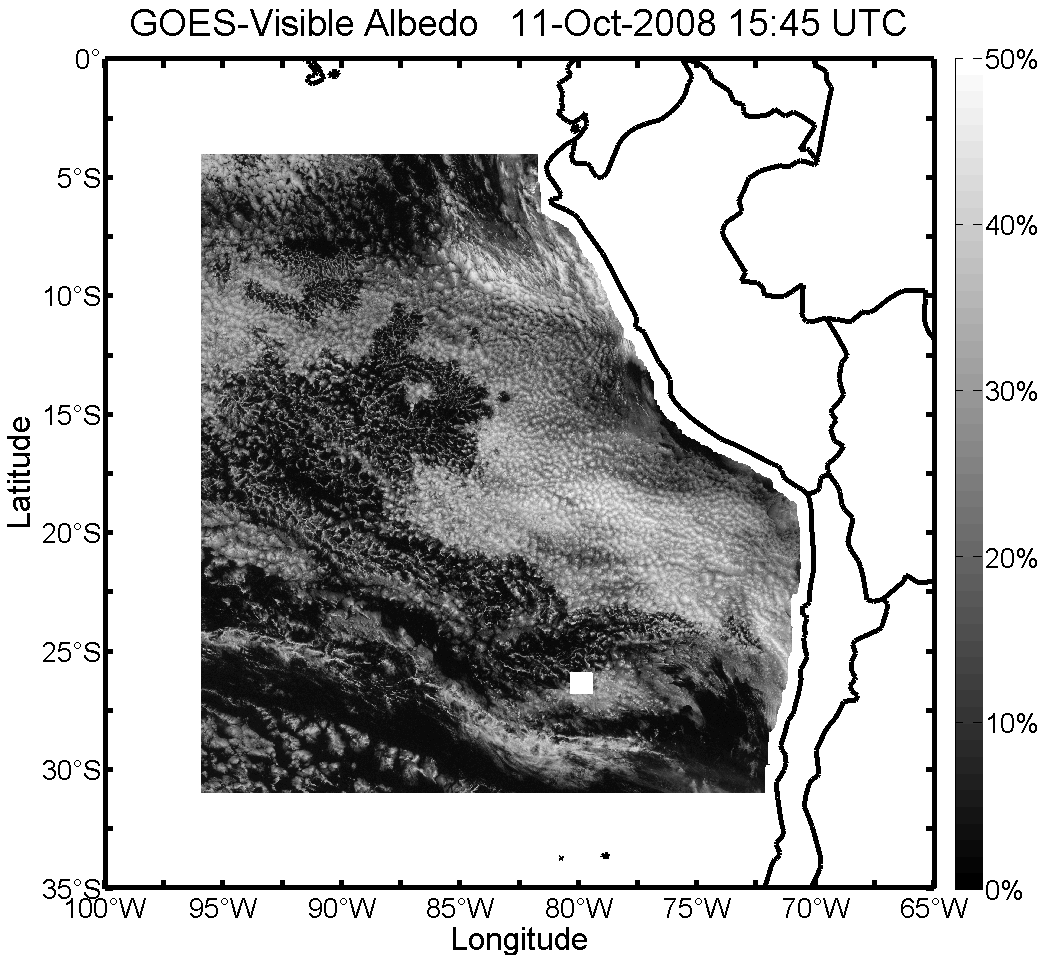
Marine Stratocumulus Clouds Modify the Global Radiative Balance





The magnitude of their impact is most directly tied to the net cloud fraction, or area covered by the clouds.

Observing Stratocumulus Clouds



Visible satellite data is quite useful…during the day

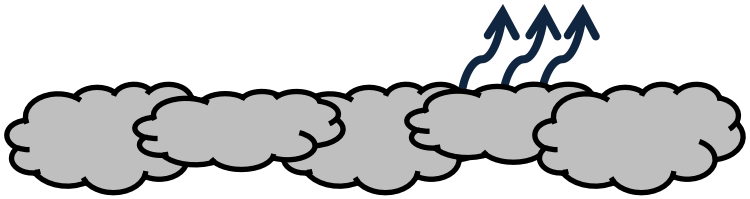
Observing Stratocumulus Clouds

It is possible to observe the clouds across the diurnal cycle by measuring the radiation they emit.

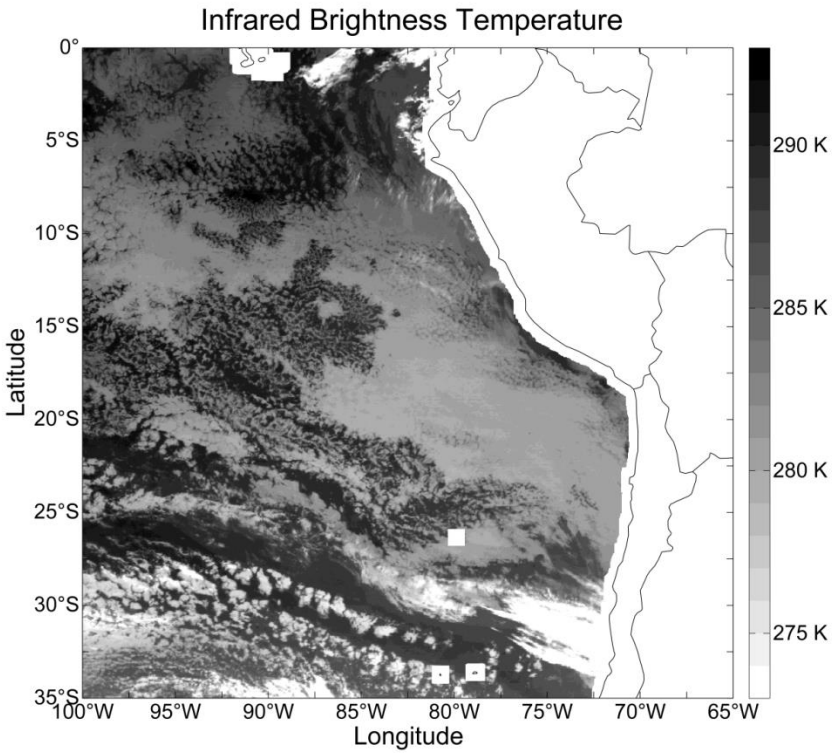
$$u^* = \varepsilon\sigma T^4$$

u^* = Irradiance T = Temperature (K)

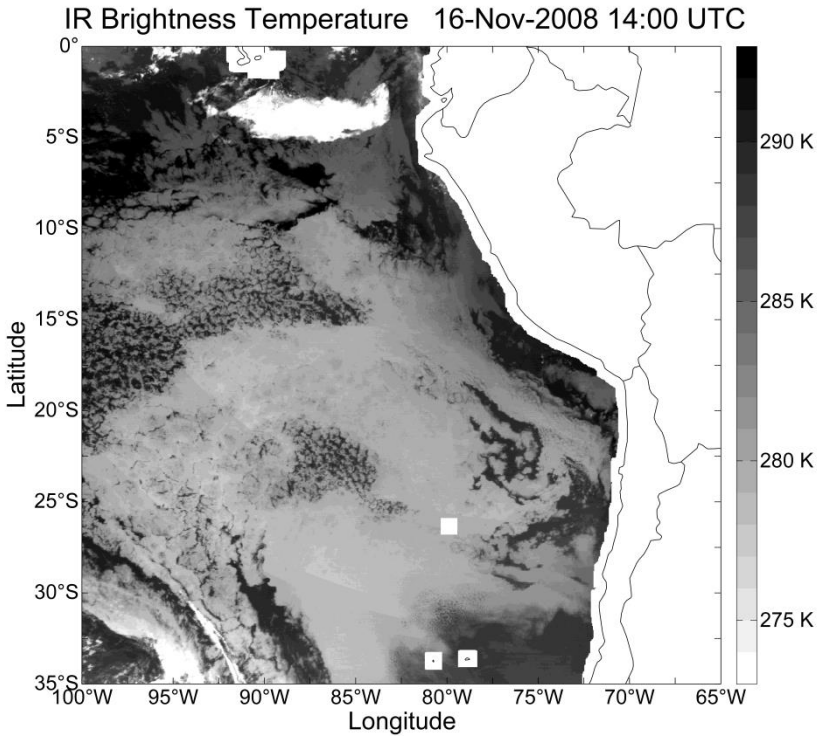
σ = Stefan-Boltzmann constant ε = Emissivity



$T_{Ocean} \approx 287$ K $T_{Clouds} \approx 279$ K



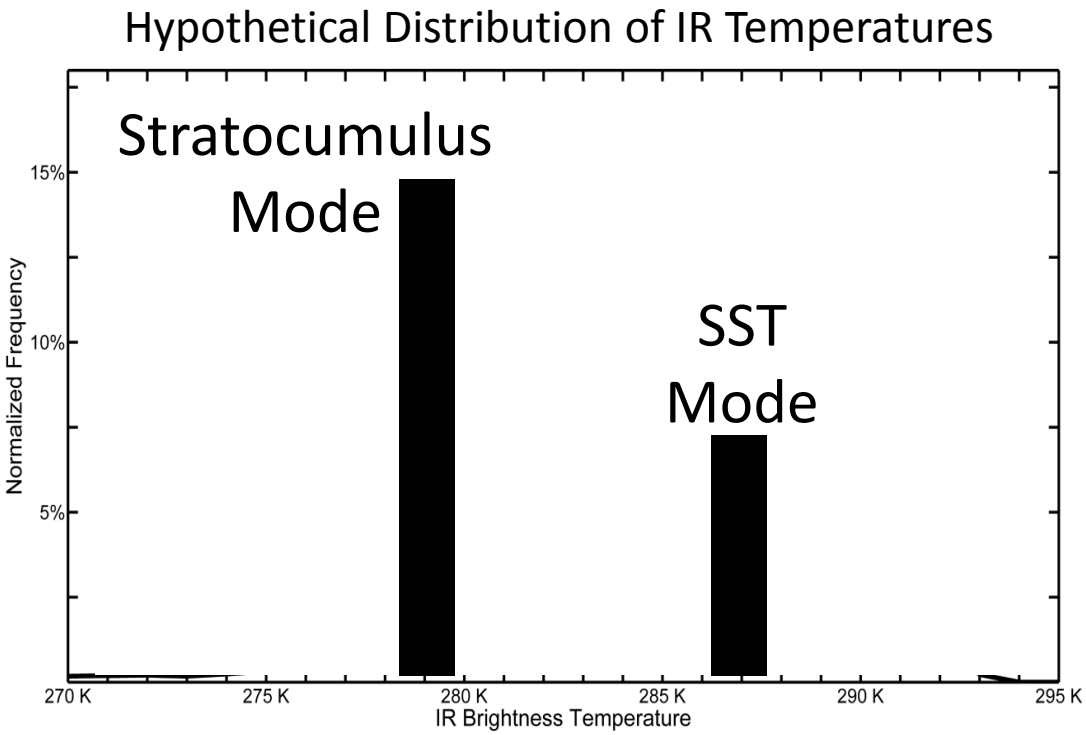
Separating Cloud and Ocean Pixels



In reality though

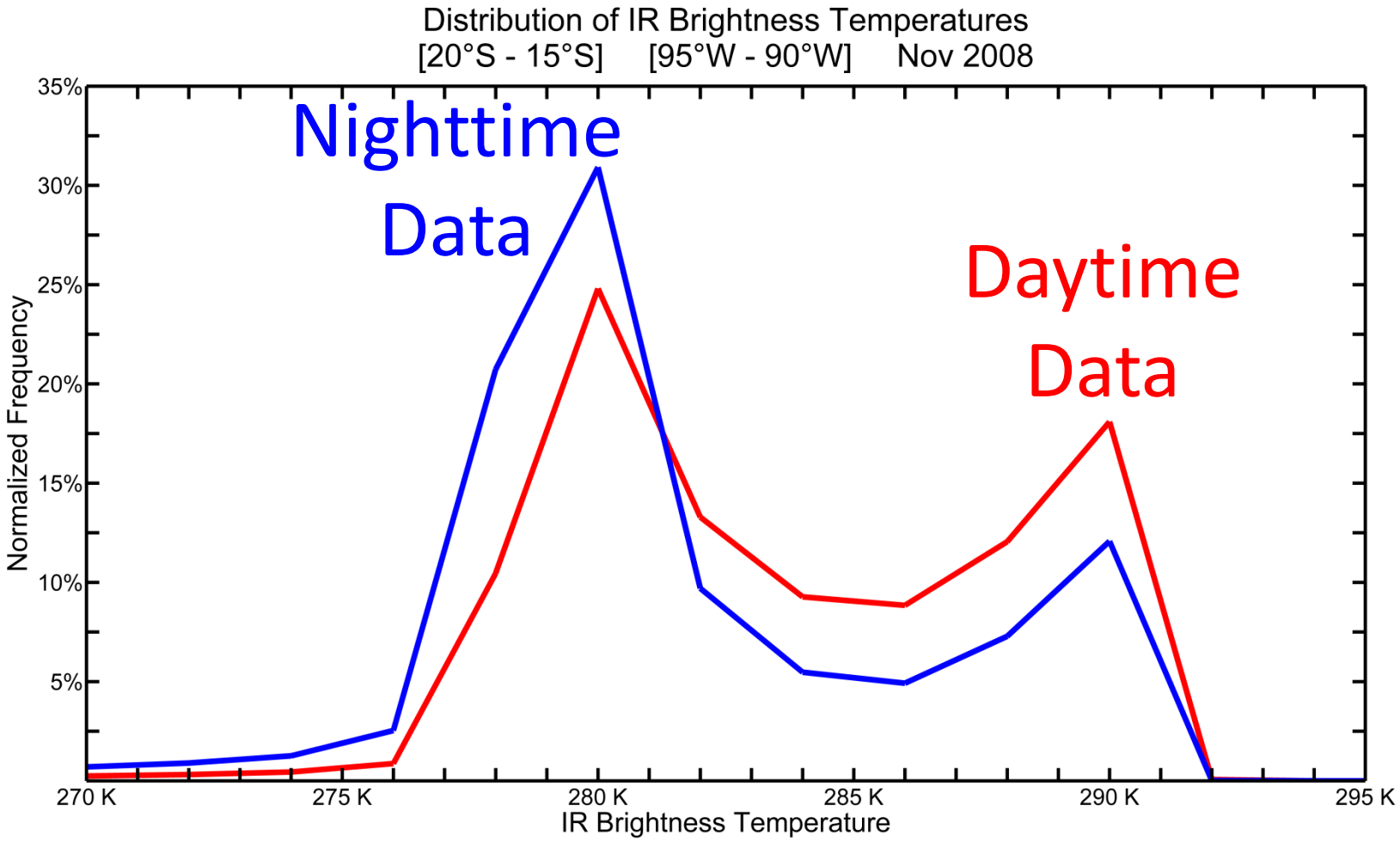
$$[\text{IR Temp}]_{\text{Ocean}} - [\text{IR Temp}]_{\text{Clouds}}$$

is not constant…complicating the separation of the two features



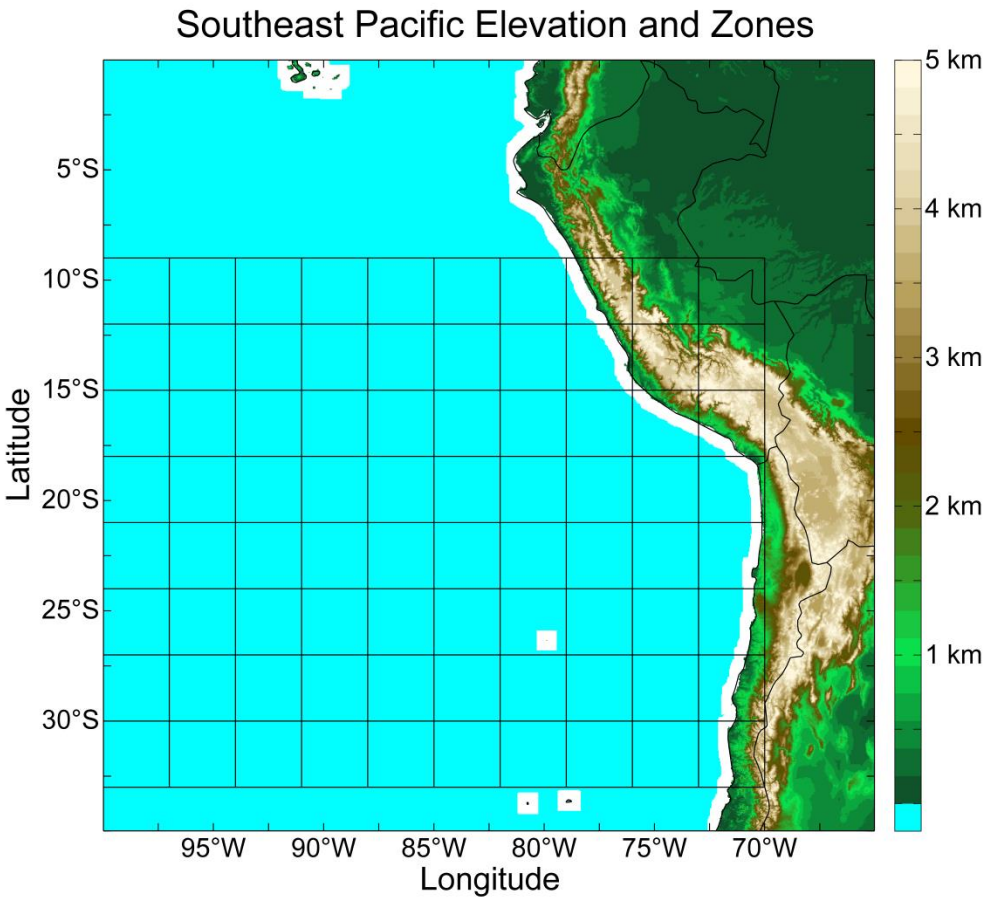
Separating Cloud and Ocean Pixels

Aggregating the distributions in space and time leads to a cleaner separation between the two modes



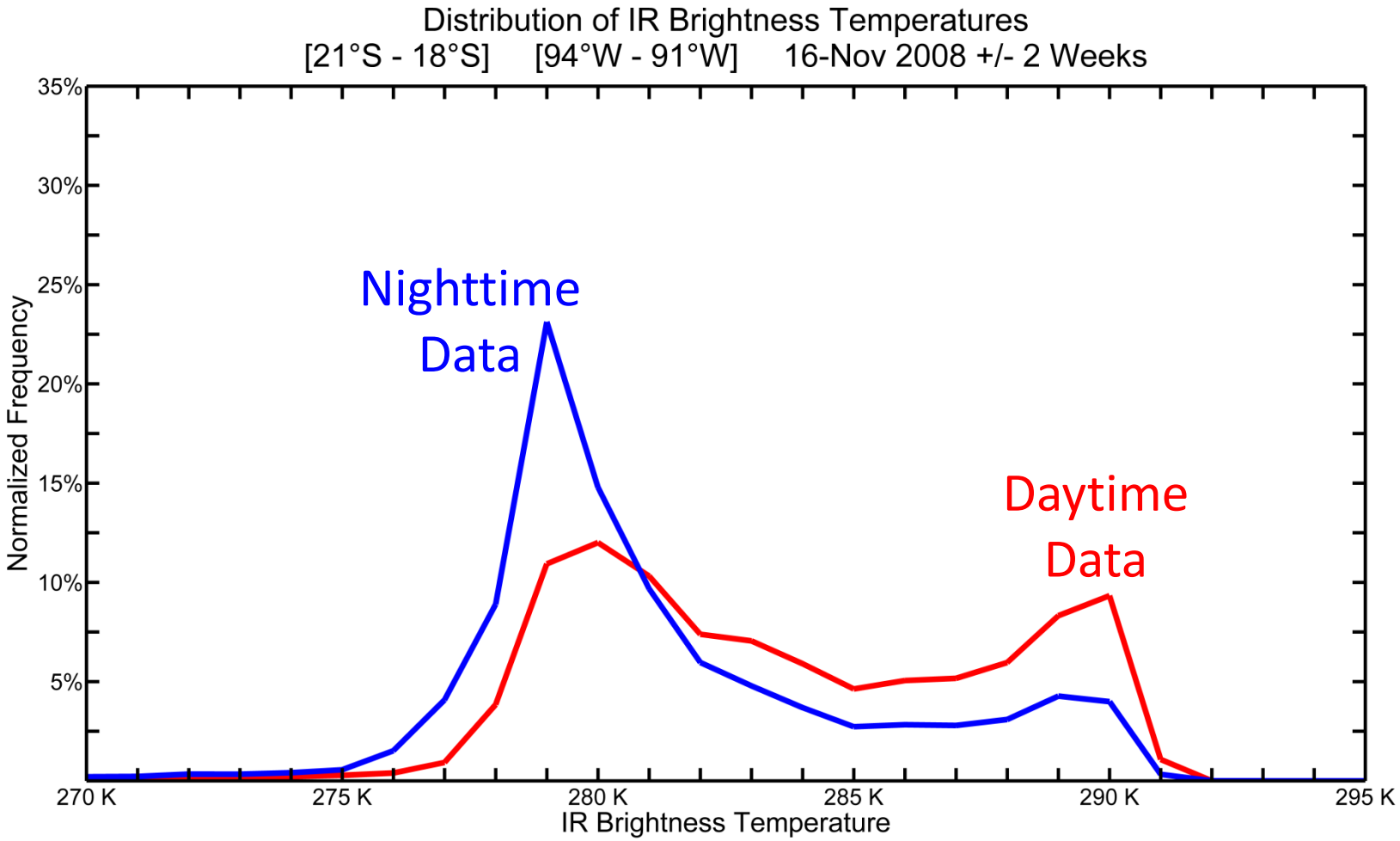
Separating Cloud and Ocean Pixels

Distributions were collected over a moving 4 week window for 3°x3° boxes spanning the largest stratocumulus regions



Separating Cloud and Ocean Pixels

Case 1) A clean bimodal structure exists (i.e. the box is “partly cloudy”)



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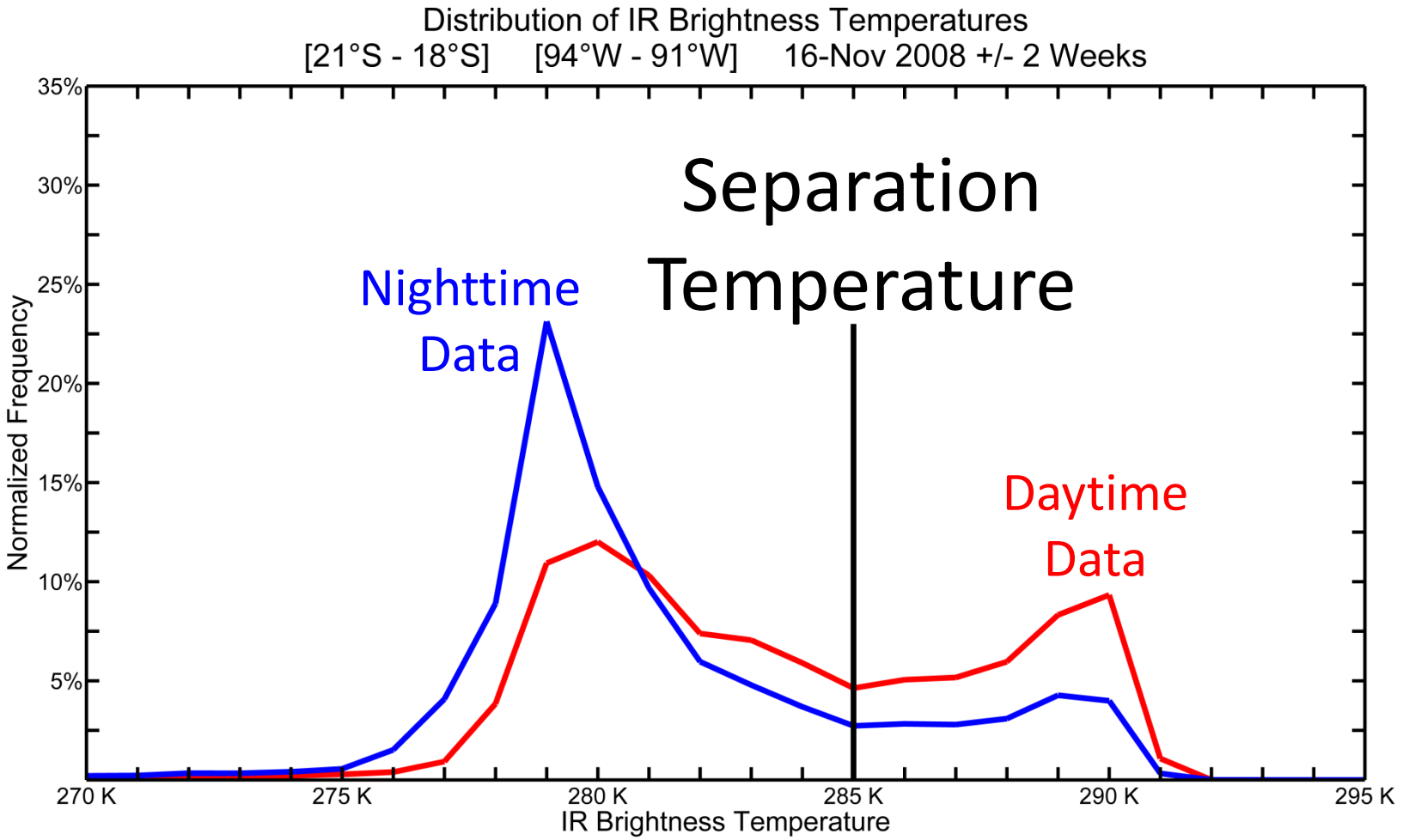
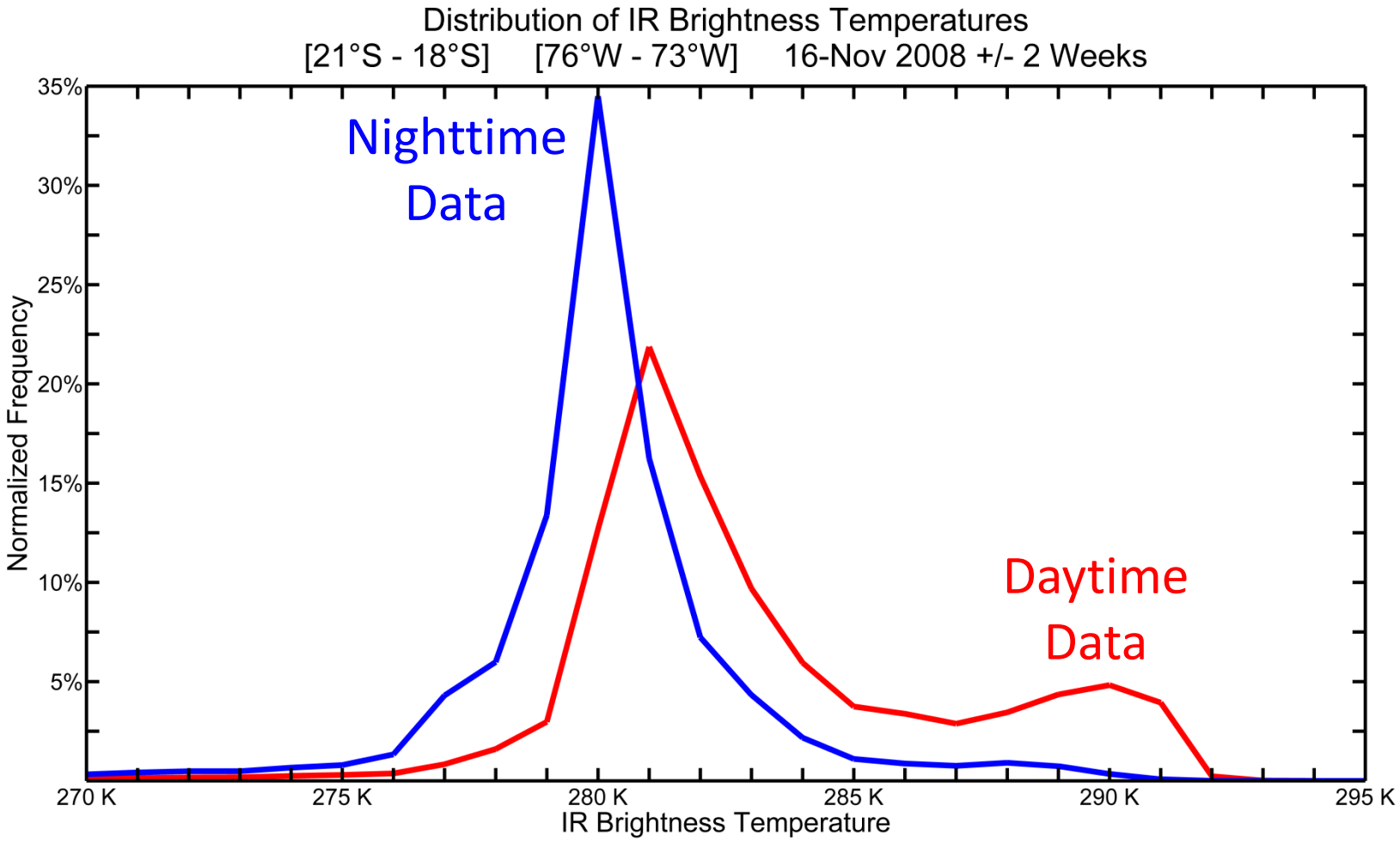


Separating Cloud and Ocean Pixels

Case 2) The distribution is not bimodal
(i.e. the box is either mostly clouds or mostly ocean)



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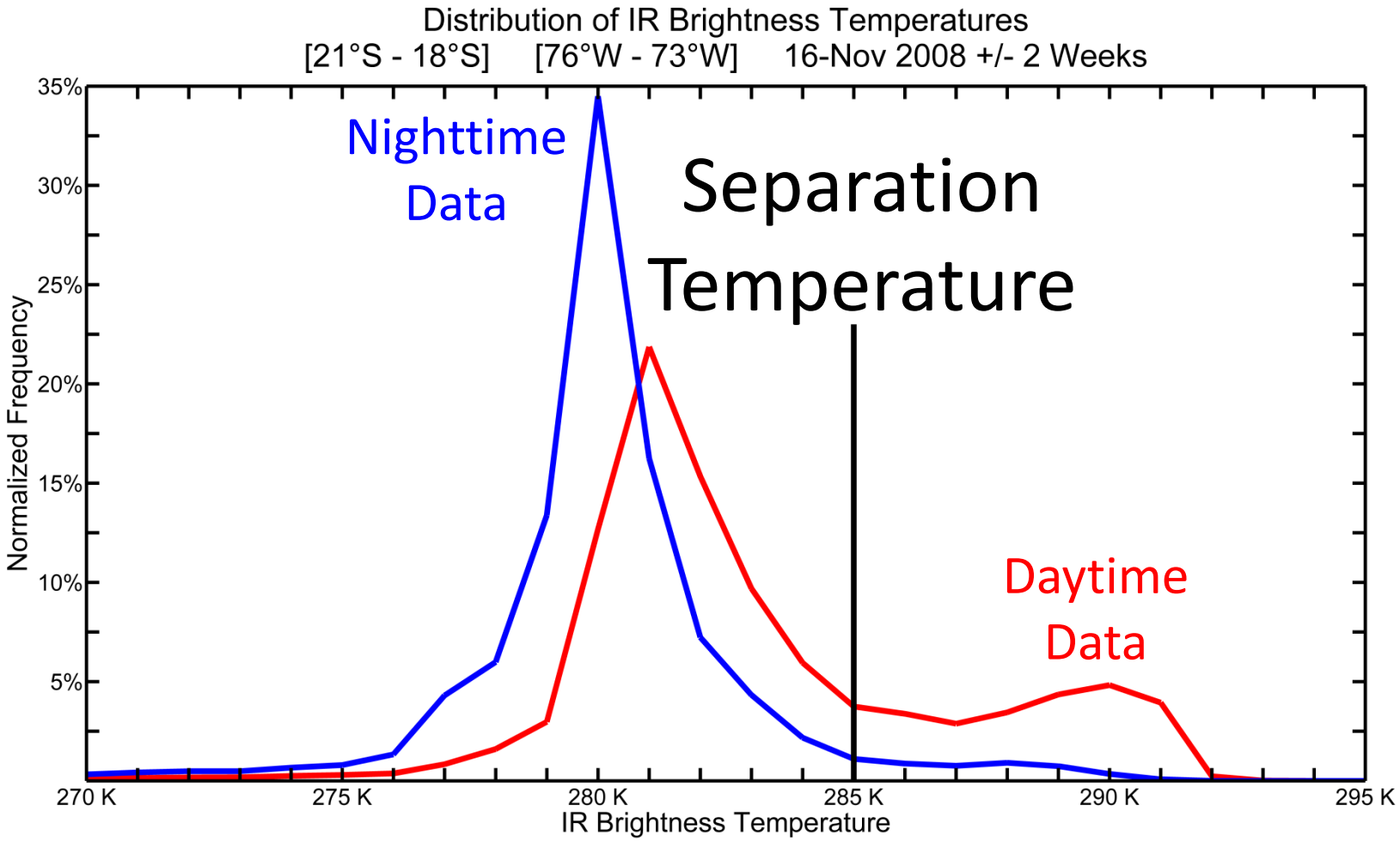
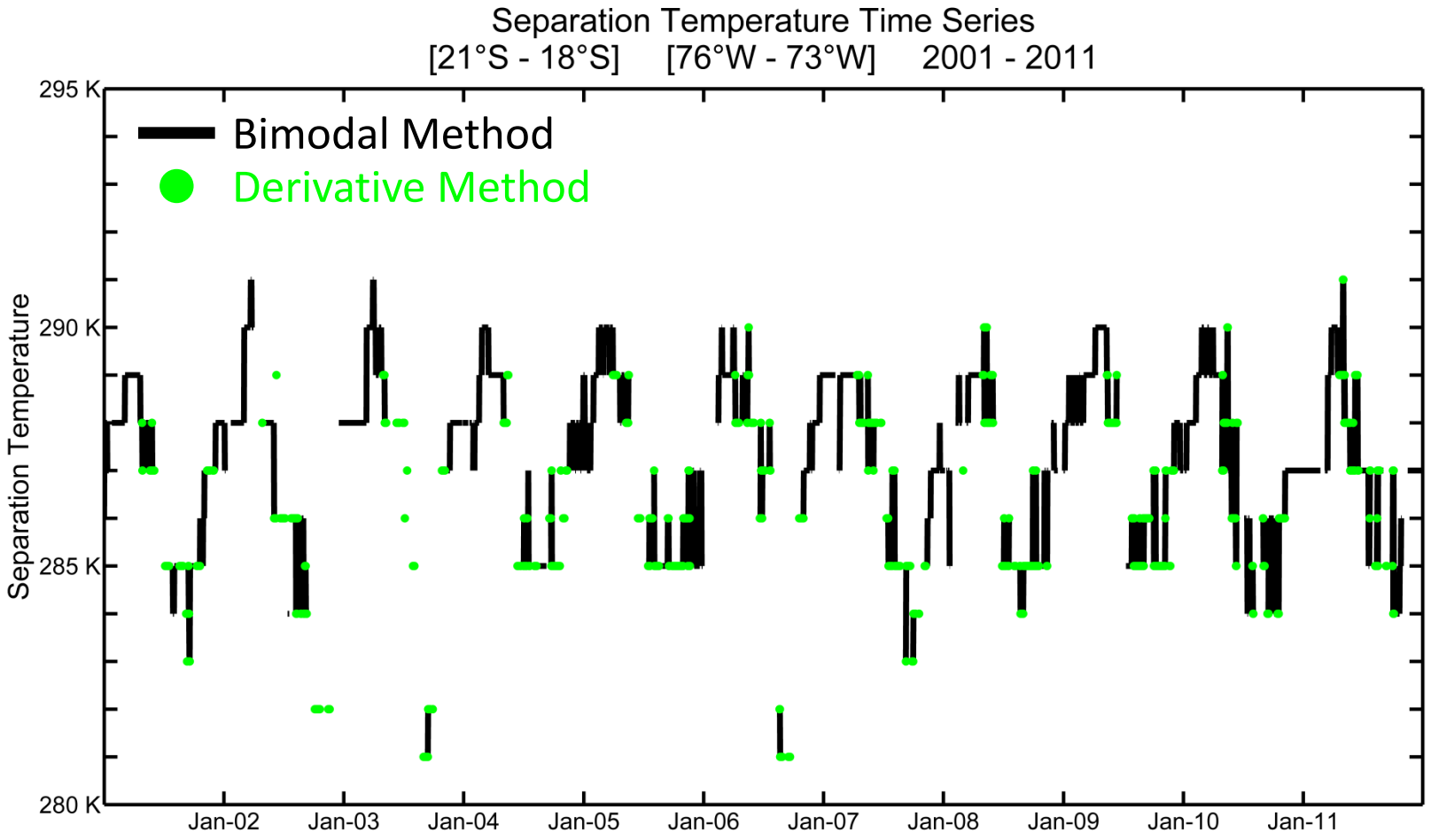


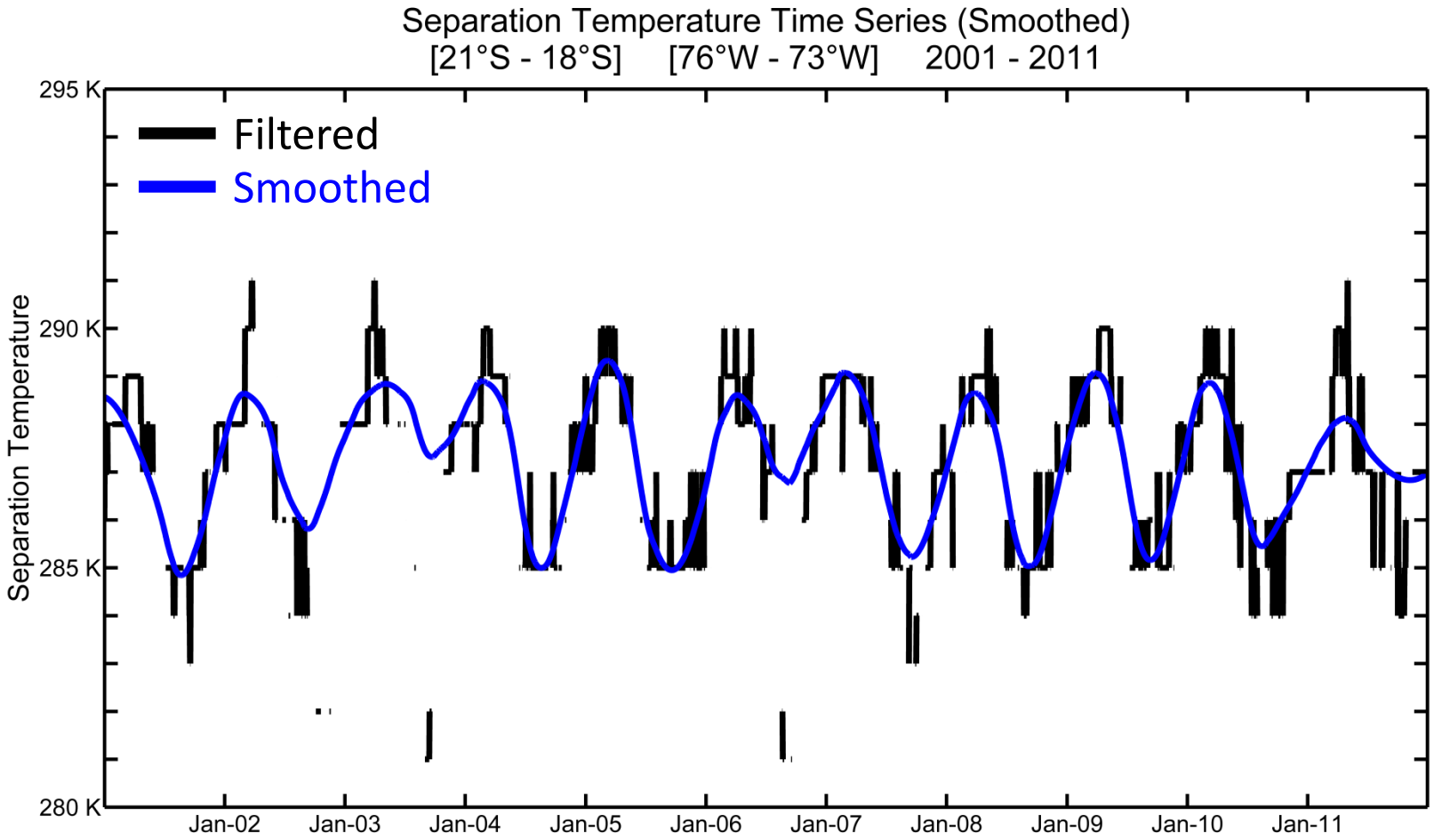
Separation Temperature Time Series

We create a time-series of the separation temperature values identified using both methods



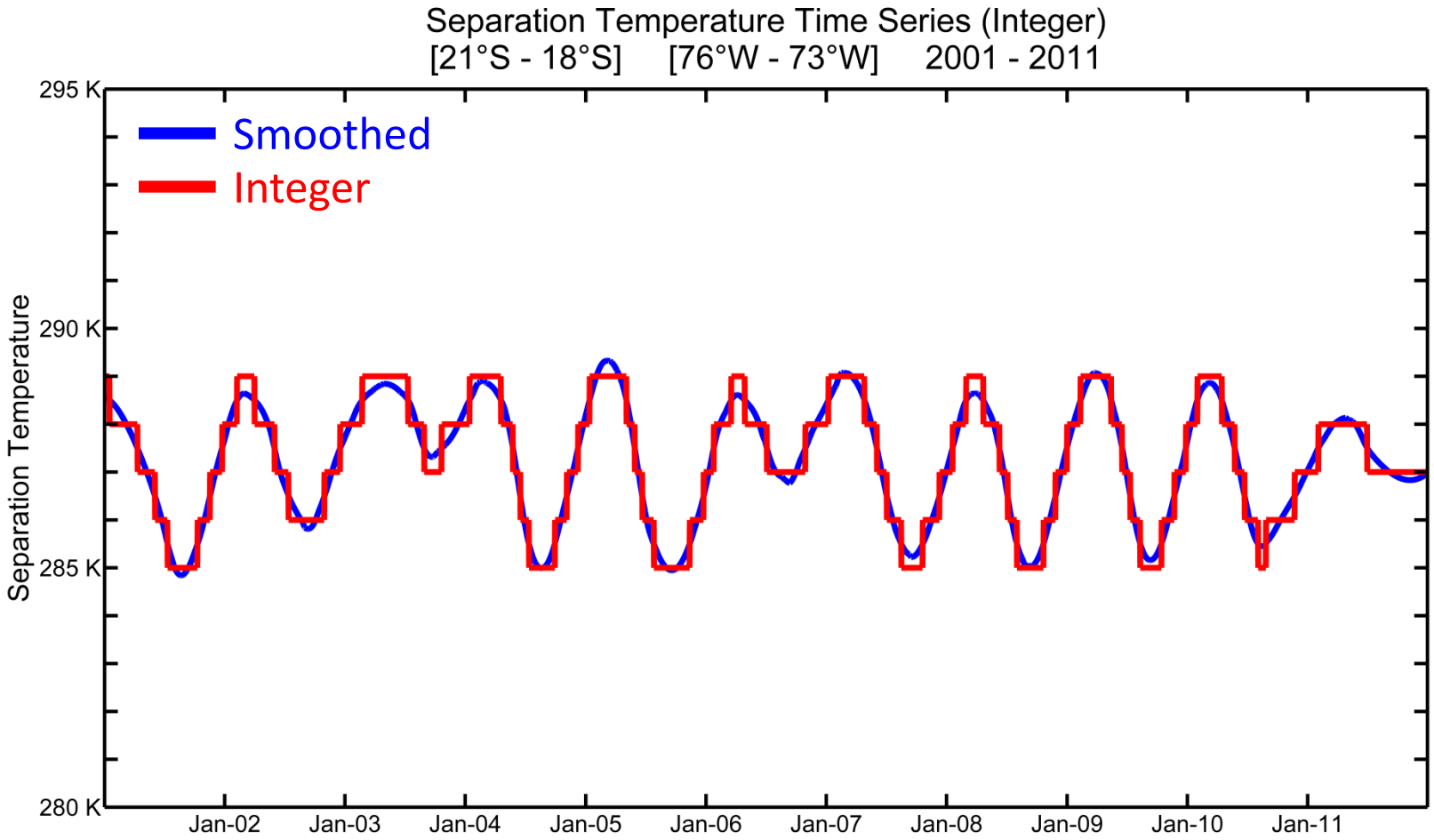
Separation Temperature Time Series

The time series is filtered to remove outliers and smoothed in time to fill in missing data points



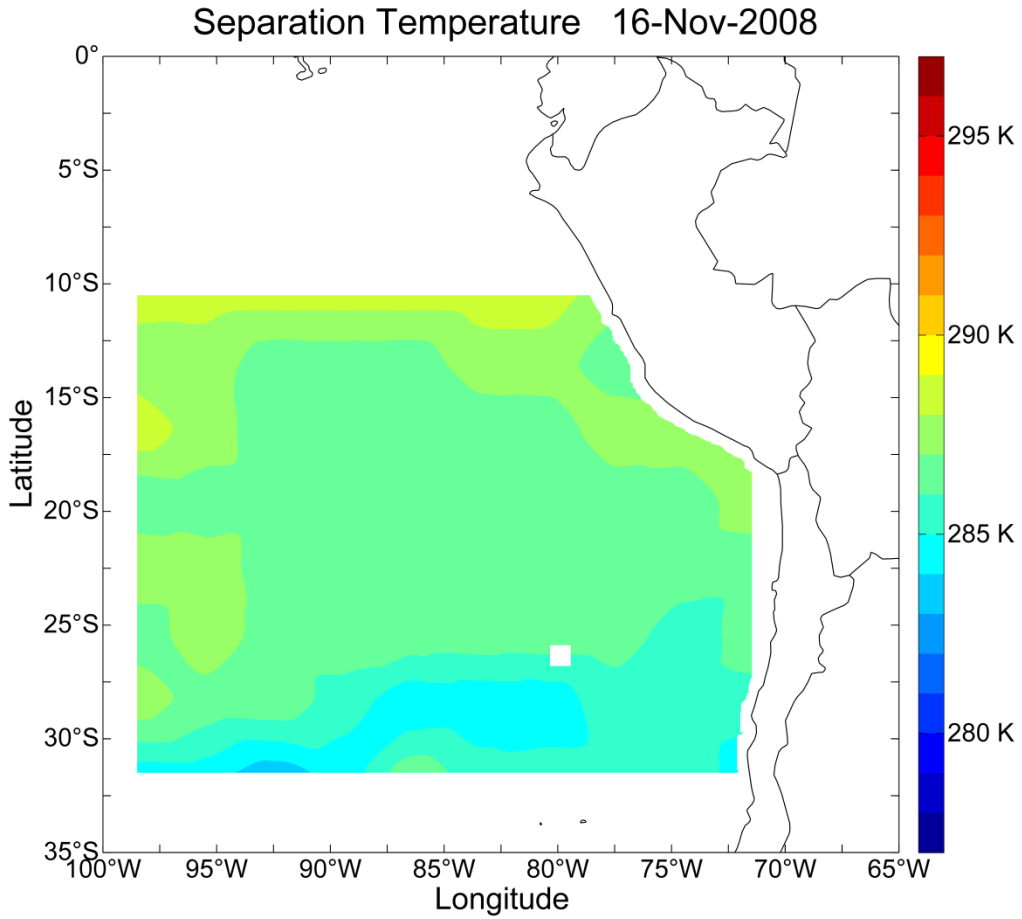
Separation Temperature Time Series

The time series is then converted back to integers to match the data precision of the IR satellite product



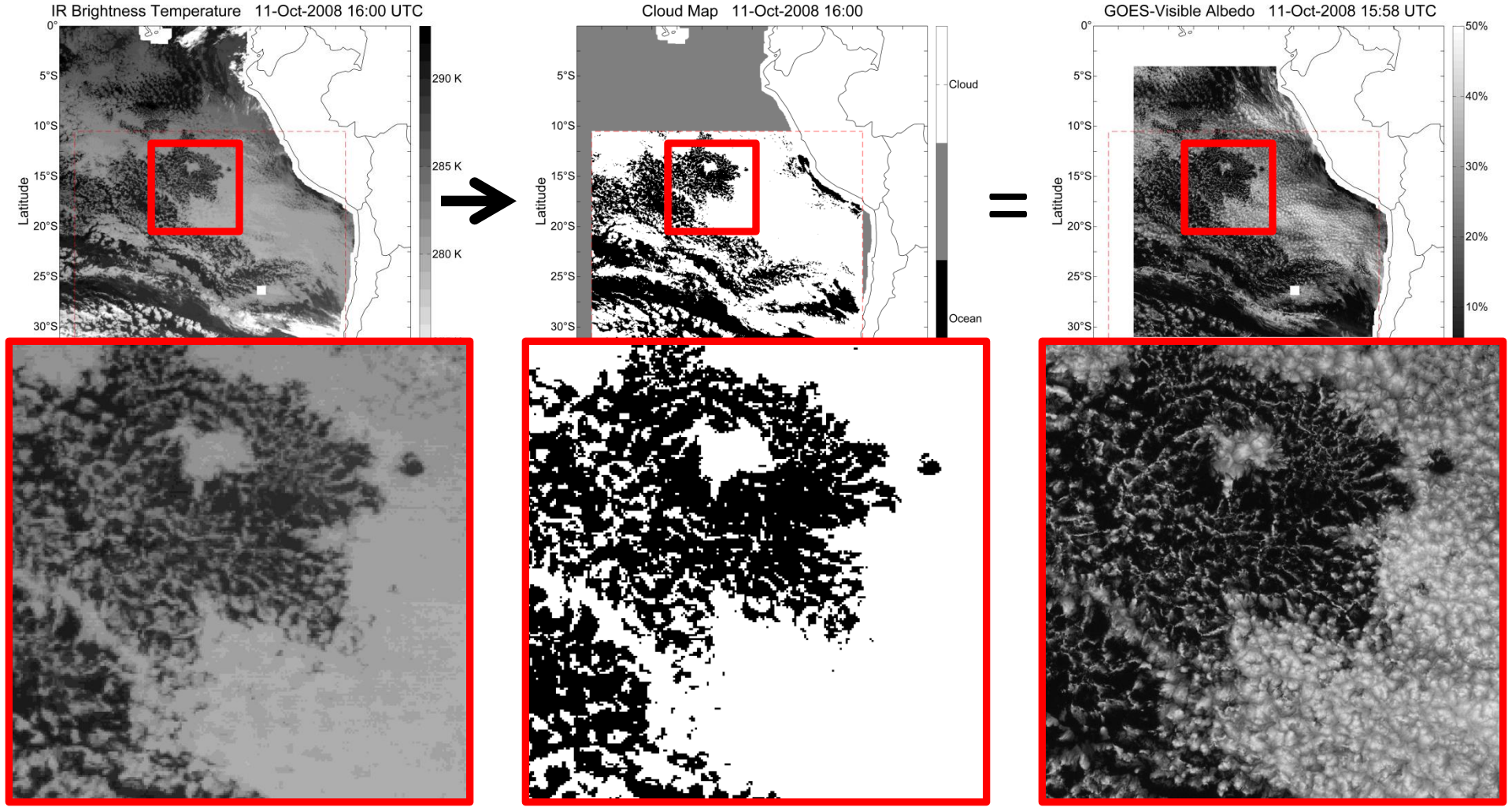
Separation Temperature Maps

Finally, the time series for each zone is mapped back to their respective coordinates and the field is spatially smoothed to minimize discontinuities at zone boundaries



Evaluation

Our cloud maps can be directly compared to visible satellite imagery during daytime scenes

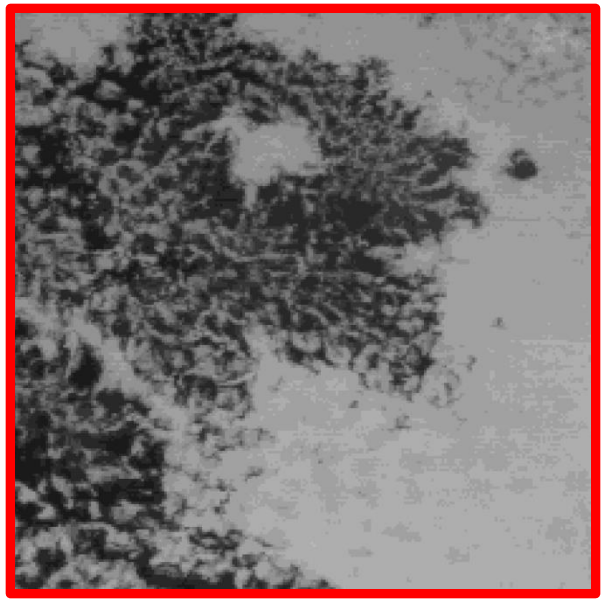


Summary

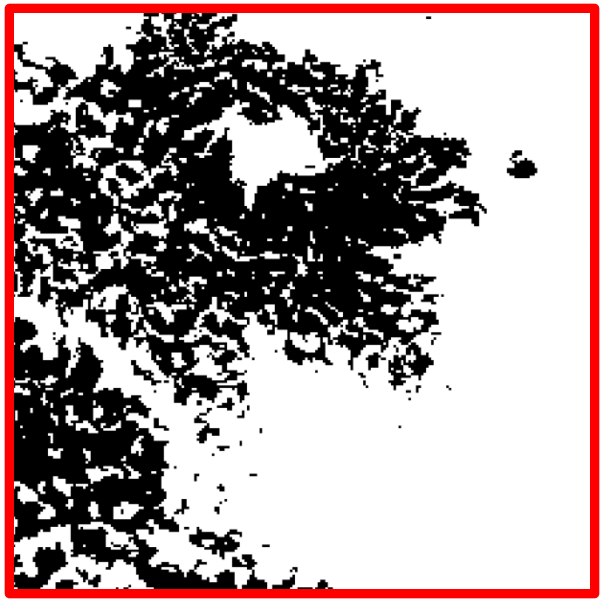
- A new method for distinguishing between cloud and ocean pixels in satellite brightness temperature images has been developed.

- The primary method is to find the minimum in the distribution between the two temperature modes. When this doesn't work the inflection point in the distribution is used instead.

IR Brightness Temperature



Our Cloud Map Product



Visible Satellite Imagery