



How to Use the NOAA Enterprise Cloud Mask (ECM)

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August 29, 2015



Outline



- Describe ECM and its differences to VCM
- Describe the Cloud Probability
- Demonstrate using the Cloud Probability to optimize cloud detection.
- Visually compare ECM and VCM



ECM



- ECM is the NOAA Enterprise Cloud Mask
- Uses the same tests as the GOES-R Cloud Mask.
- Naïve Bayesian methodology.
- Fundamental output is cloud probability.
- Supports GOES-Imager, AVHRR, VIIRS, MODIS, AHI, MTSAT, COMS, SEVIRI.

Note there is a full Bayesian Cloud Mask used by the GOES SST team which is unrelated to this effort.



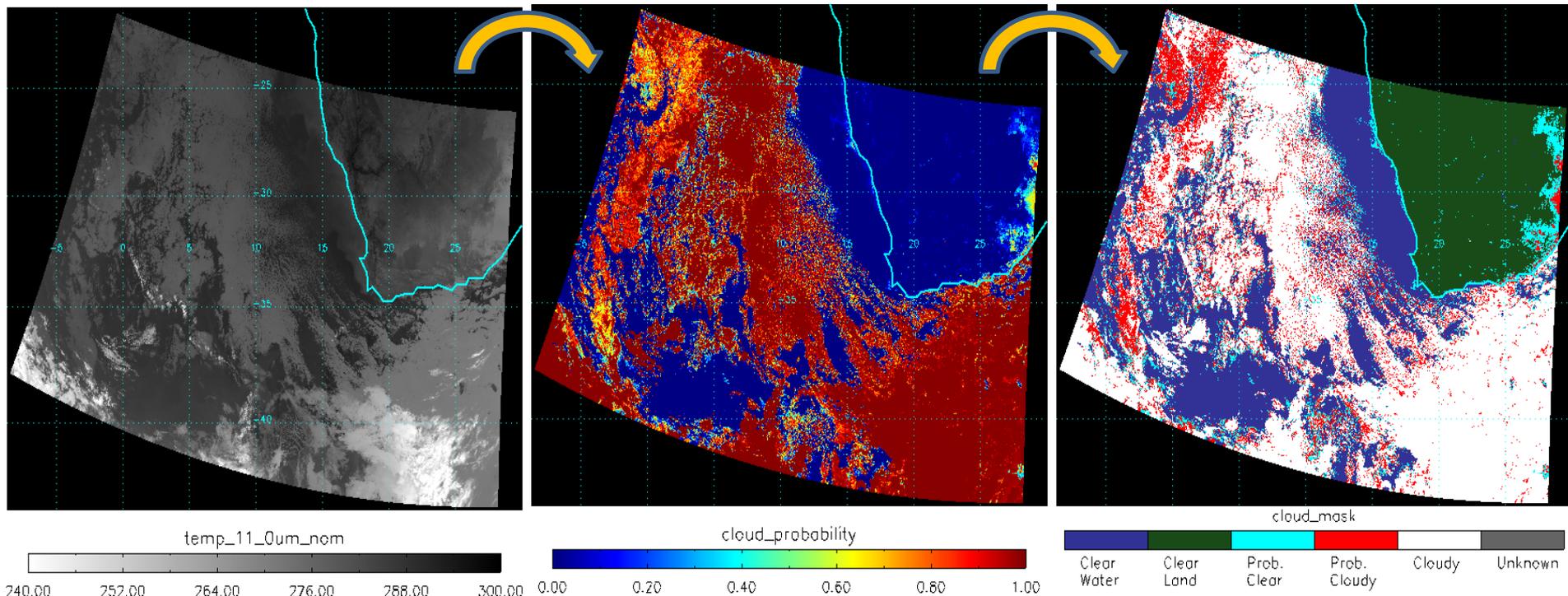
CLOUD PROBABILITY



Cloud Probability Example



- Cloud probability is defined as the probability (0-1) of a pixel being classified as cloudy and is the output of our Naïve Bayesian scheme.
- In our case, the definition of cloudy comes from the NASA CALIPSO/CALIOP (a space borne lidar).
- The 4-level mask comes directly from the cloud probability values.
- The example below shows results from nighttime data from the South Atlantic
- Very thin and warm cloudy at night often give probabilities less than 1. These result in probably-cloudy classifications (red mask values).

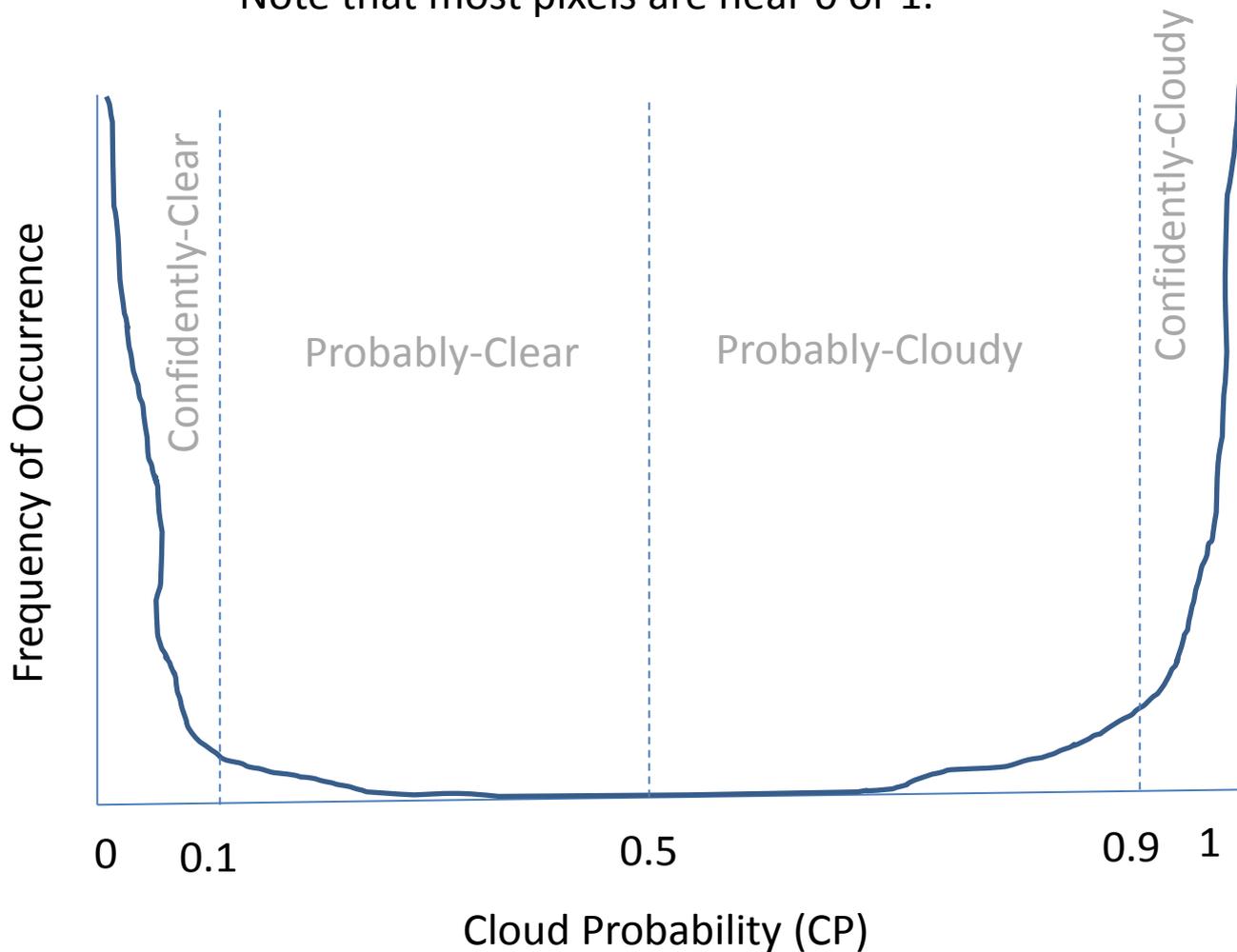




Relationship Between Cloud Probability and 4-Level Cloud Mask



- This is the relationship for an ice-free ocean.
- Note that most pixels are near 0 or 1.

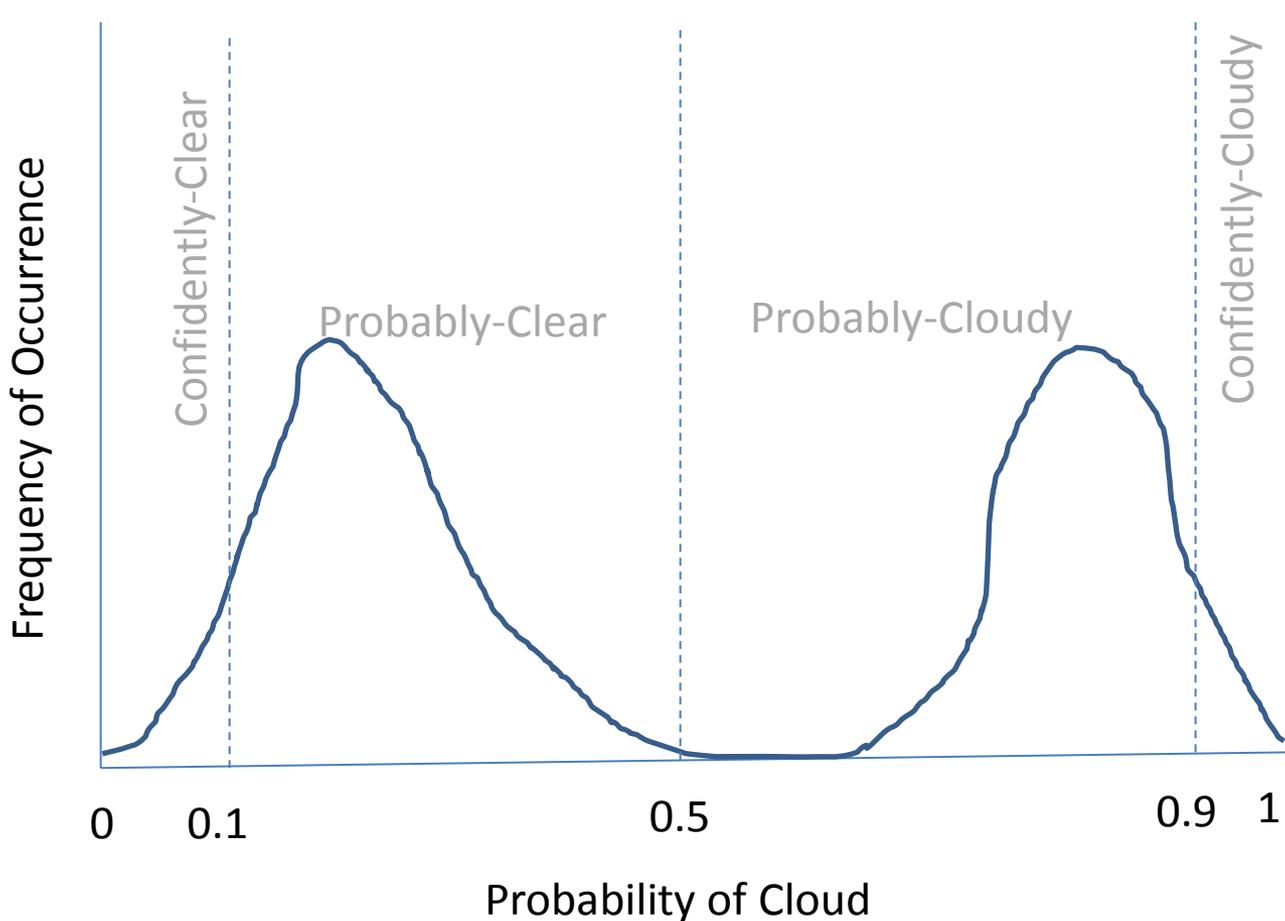




Relationship Between Cloud Probability and 4-Level Cloud Mask



- This is the relationship for a snow/ice covered region.
- Note that most pixels are NOT near 0 or 1.
- ECM does not change boundaries for each surface type.





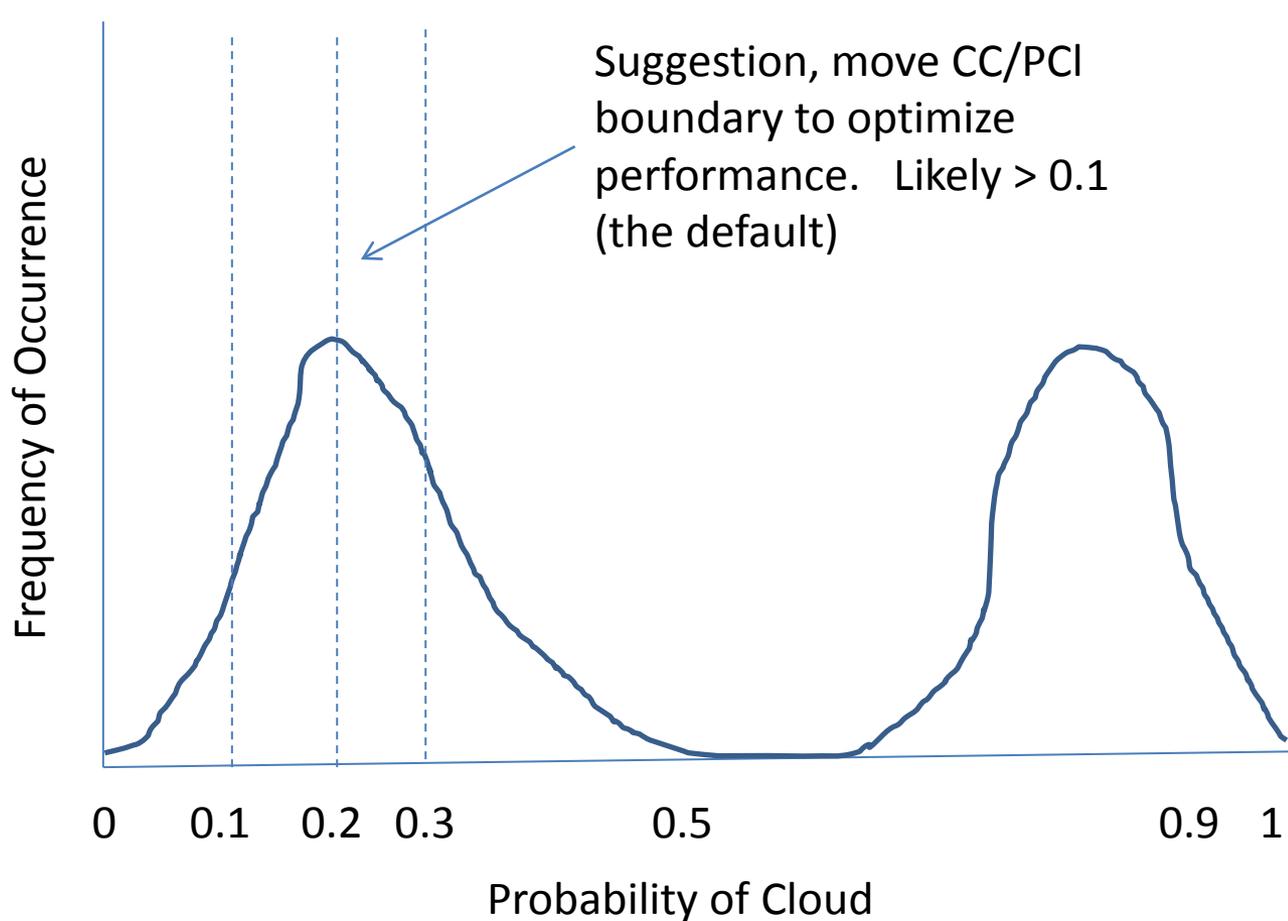
OPTIMIZING CLOUD DETECTION



Schematic Illustration of Tuning Cloud Probability for Optimally Clear Pixels



We have added different thresholds to illustrate moving the CP Threshold

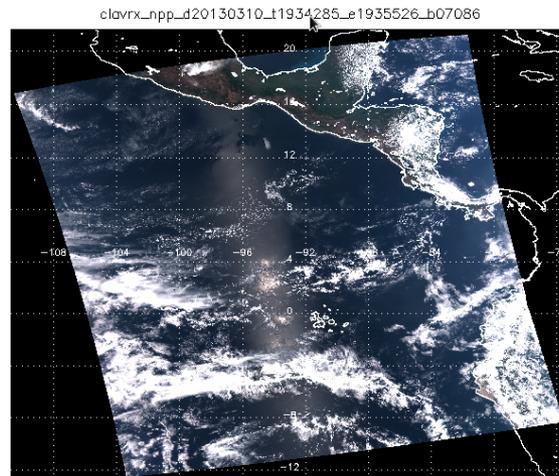




Using the Cloud Probability (CP) to Optimize Clear Data

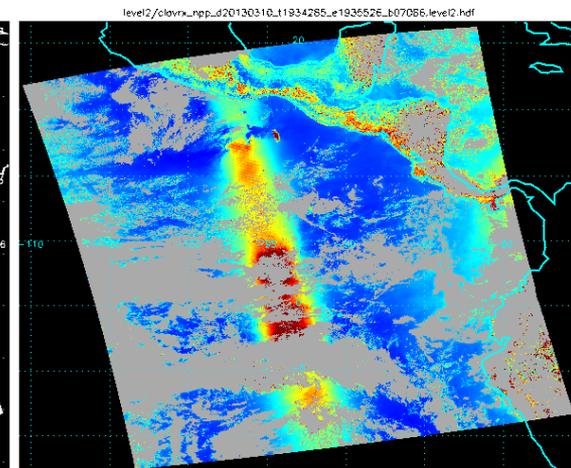


- The ECM provides the floating point cloud probability.
- In the 4-level mask, the confident clear is set for CP < 0.10.
- Maybe this value is not optimal?
- The images on the right show images of the 0.65 μm reflectance with masks overlaid. Each mask is a threshold of CP.
- Optimal CP value for clear ocean may be less than 0.1

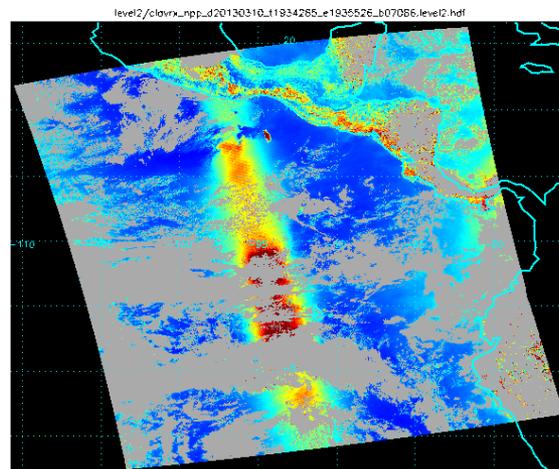


False Color Image

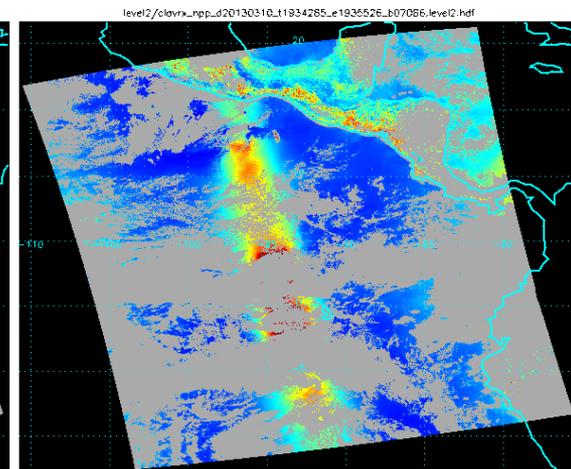
Red=0.65 μm , Green = 0.55 μm , Blue = 0.48 μm



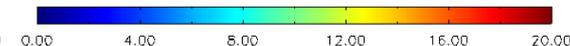
Cld Prob < 0.5



Cld Prob < 0.1

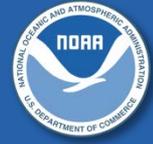


Cld Prob < 0.0001

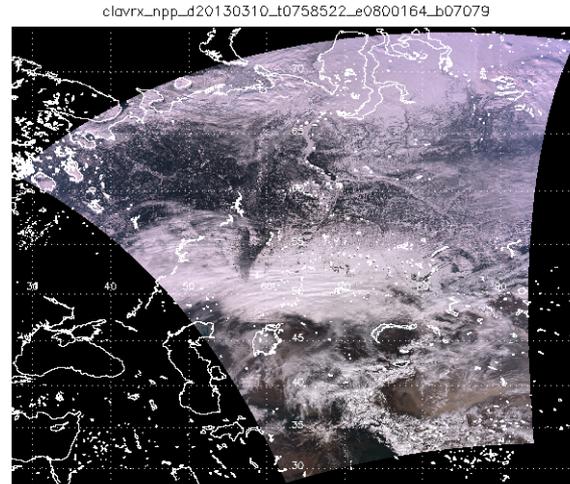




Using the Cloud Probability (CP) to Optimize Clear Data

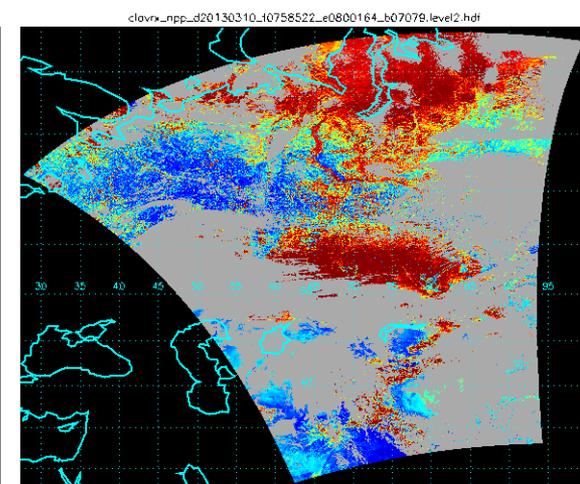


- Same analysis as before except applied to a Northern Europe/Asia.
- Note that presence of $CP < 0.1$ are rare.
- Optimal CP threshold is likely between 0.1 and 0.5.
- Unlike Ocean, very few pixels have $CP \ll 0.1$
- This behavior is expected since the ability to predict clear-sky drives how close to $CP=0$ we can get.

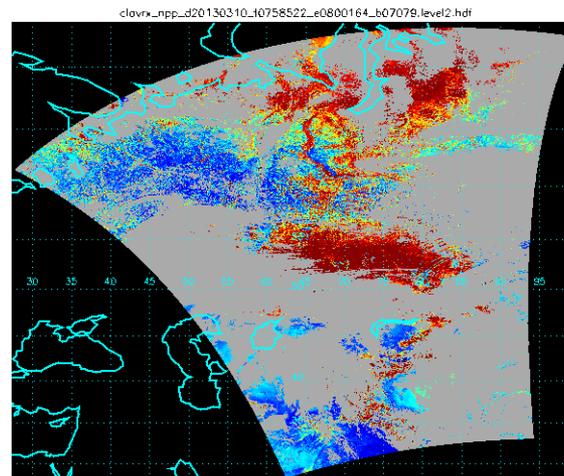


False Color Image

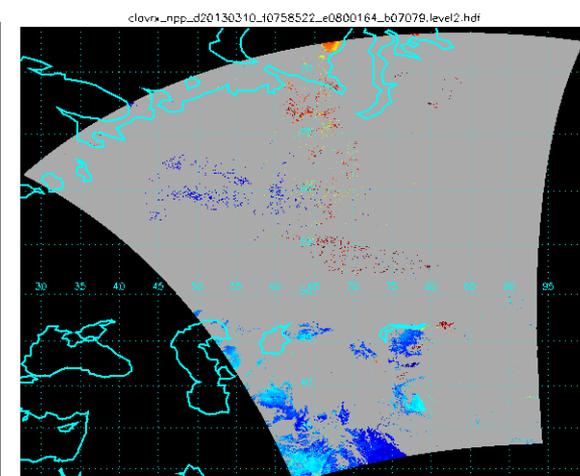
Red=0.65 μ m, Green = 0.55 μ m, Blue = 0.48 μ m



Cld Prob < 0.5



Cld Prob < 0.1



Cld Prob < 0.001



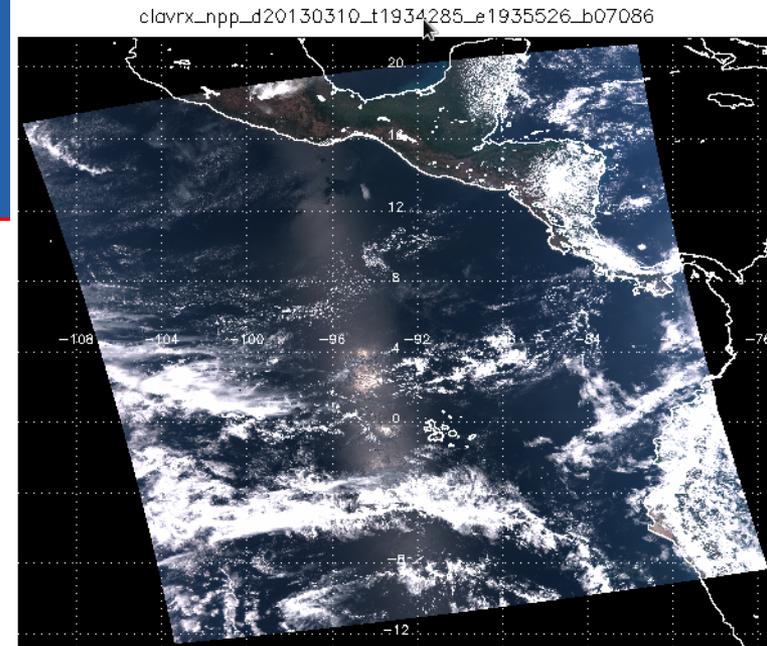


VISUAL COMPARISON OF ECM WITH VCM

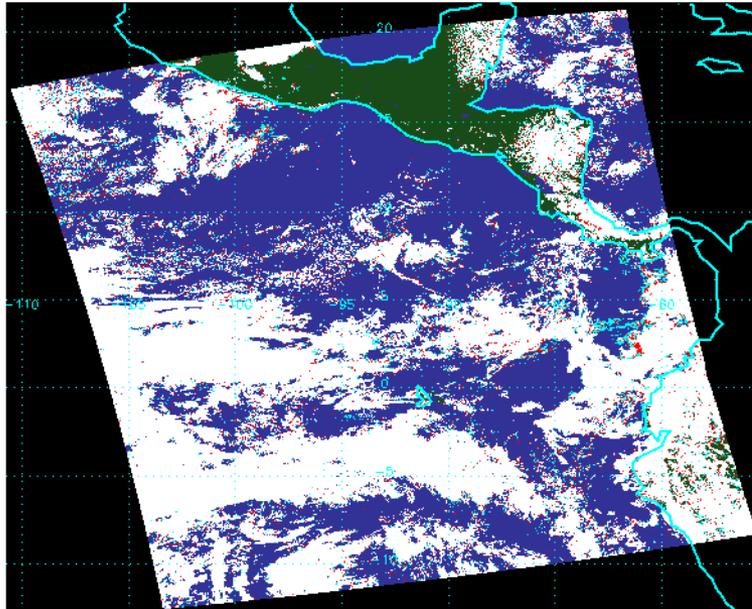


Difference with VCM for an ocean scene

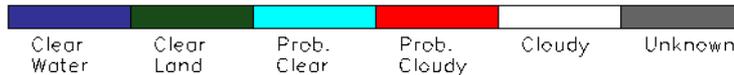
- This scene is from March 10, 2013 in Eastern Tropical Pacific.
- ECM on the bottom left. VCM on the bottom right.
- Differences in glint regions. (likely false Cloud in VCM)
- More probably clear in VCM. More Cloudy in ECM.



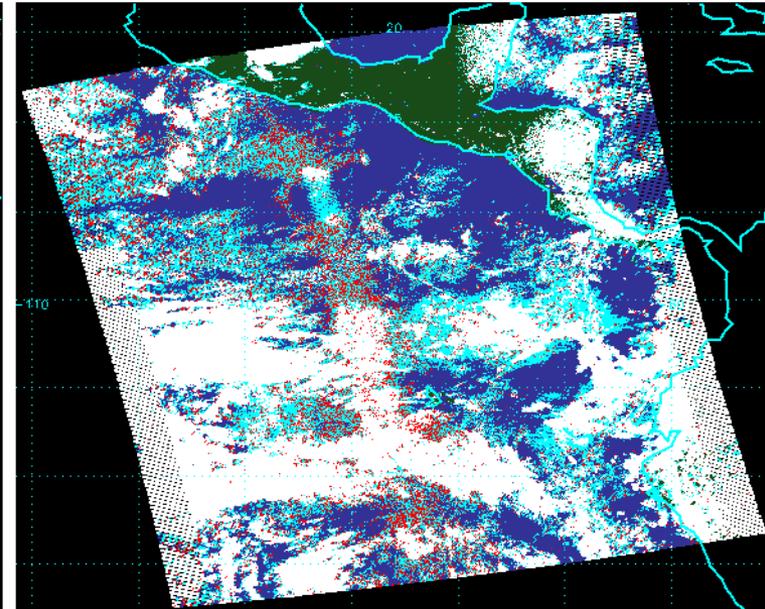
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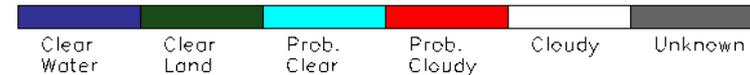
Enterprise VCM



clavr_x_npp_d20130310_t1934285_e1935526_b07086.level2 hdf



IDPS VCM

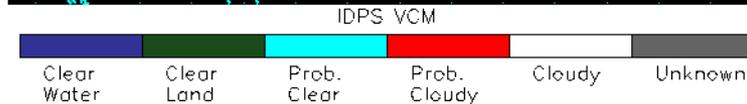
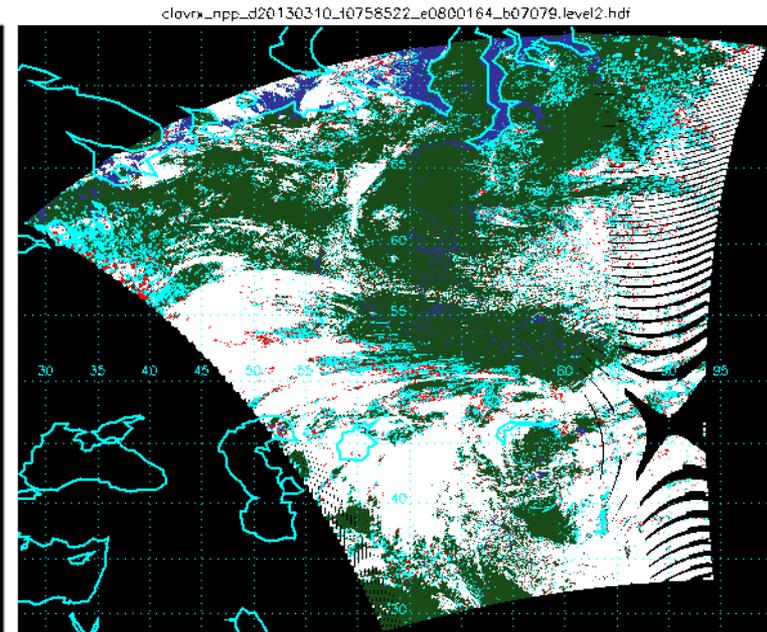
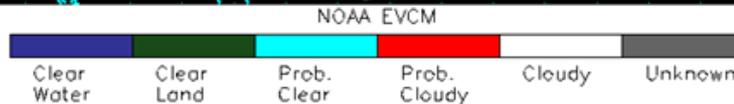
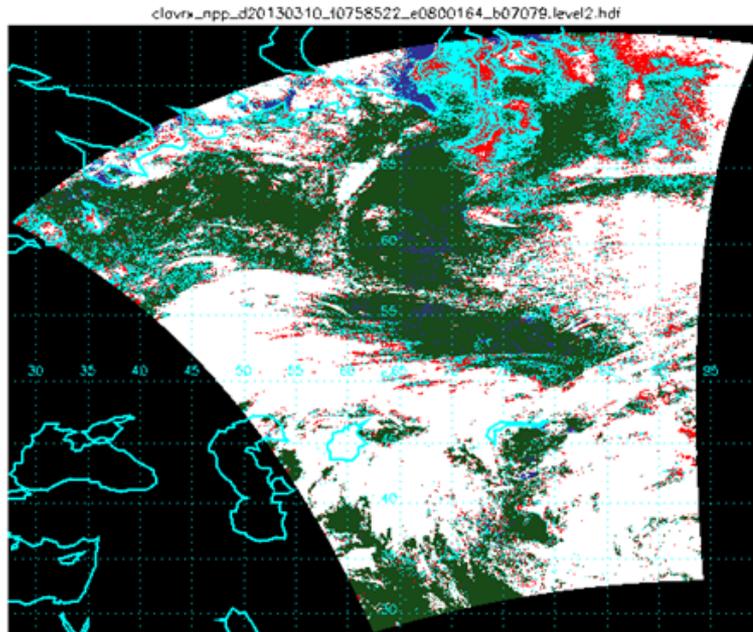
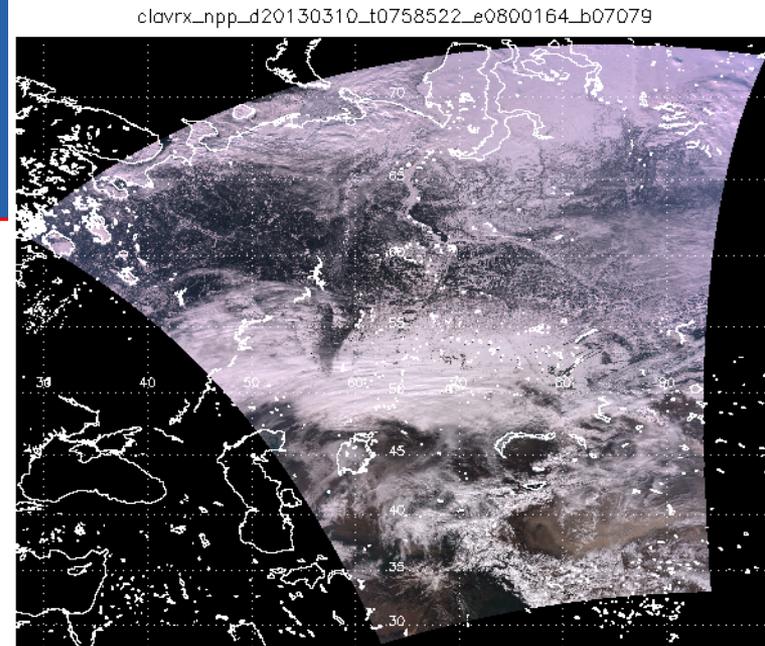


Note, SAPF and CLAVR-x use bow-tie gap filling.



Difference with VCM for an snow-covered land scene

- This scene is from March 10, 2013 over Russia / Kazakhstan.
- ECM on the bottom left. VCM on the bottom right.
- ECM now generates more Probably-Clear/Cloudy than VCM.





Summary



- ECM and VCM are both mature but differ in some philosophical ways
- Users of the ECM for clear-sky applications are **strongly encouraged to use the cloud probability** and define their own threshold for clear-pixels.
- Alternatively or additionally, a full array of test bits are available.
- ECM works well globally but we still want and need feedback on our performance for specific applications.



Extra Material Follows

THANK YOU



Difference with VCM



- Both the VCM and ECM make 4-level masks
- Both provide many diagnostic bits (generally unused)
- ECM officially provides a binary mask (yes/no) which comes from the 4-level mask.
- **ECM provides a floating point probability.**
- This is the fundamental output of the ECM.
- It means “the probability that CALIPSO/CALIOP would have detected cloud”
- Both break-up the world into different regions.
 - The manual tuning of the VCM allows VCM to adjust its mask’s appearance in regions of low confidence.
 - In the ECM, some surface types generate less certain probabilities (expected) and this impacts the appearance of the mask.
- **Limited use of ancillary data and RTM. This is by design and also imposed by IDPS restrictions.**

- Yes, there are still issues with ECM and the VCM.
- There are still traditional thresholds in the ECM that need to be optimized.
- One of these is the limit on the airmass.
- Reflectance tests are turned off when the airmass exceeds this threshold.
- Current limit of 5 may be too restrictive for VIIRS.

False Color

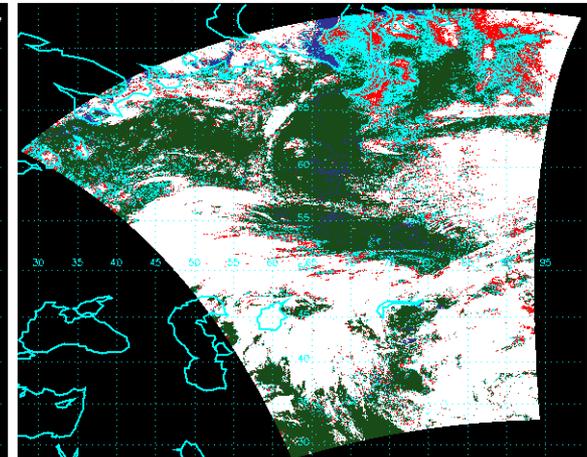
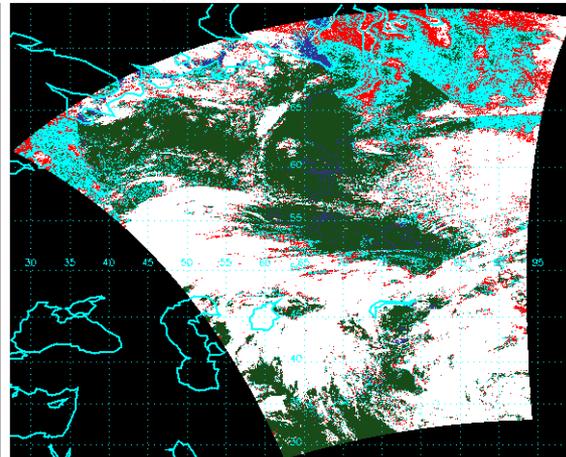
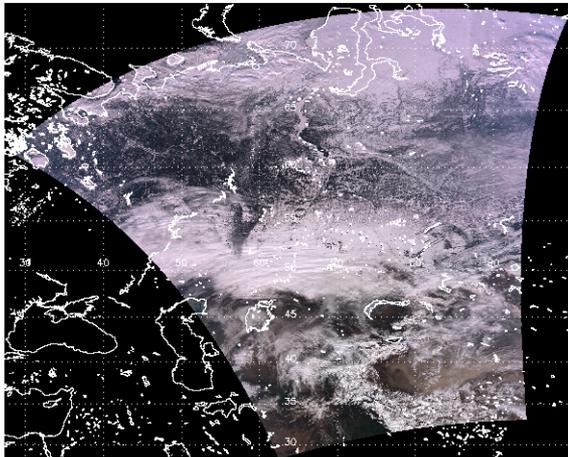
ECM with airmass
threshold = 5

ECM with airmass
threshold = 100

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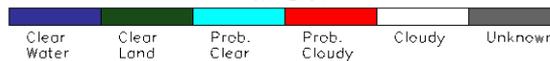
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False Color Image

Red=0.65 μ m, Green = 0.55 μ m, Blue = 0.48 μ m

NOAA EVCM



NOAA EVCM



Note, coming up with one set of thresholds for all sensors is a challenge



Comparisons to MYD35 provide an opportunity for a long-term global comparison of ECM to a well-established standard

GLOBAL LOOK AT ECM



ECM versus MYD35 over MODIS/AQUA (2003-2014)



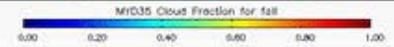
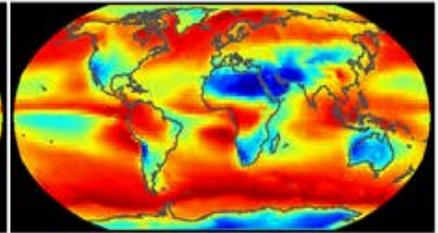
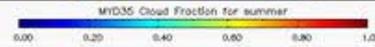
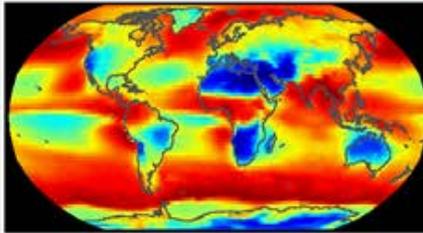
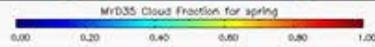
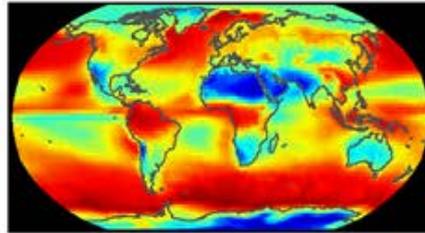
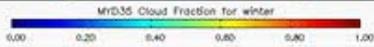
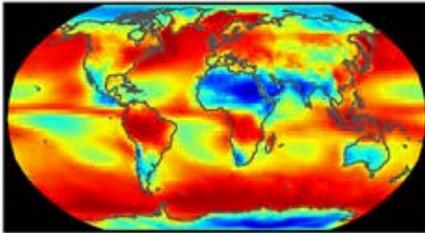
Winter

Spring

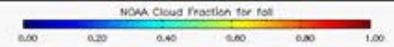
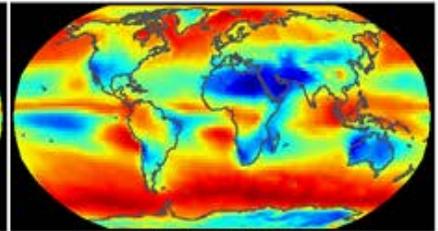
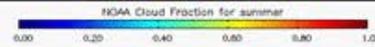
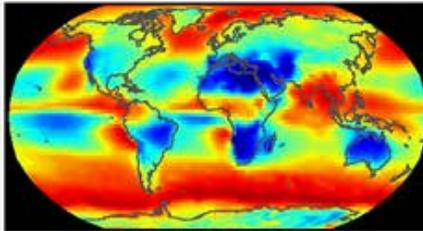
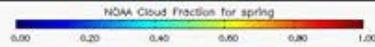
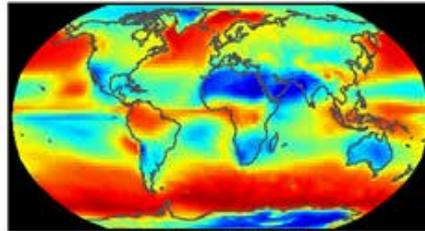
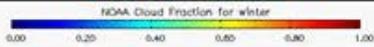
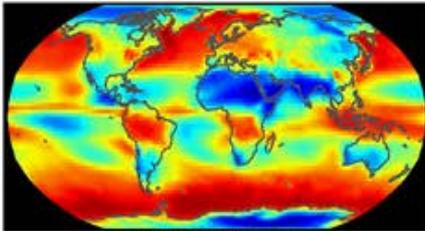
Summer

Fall

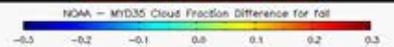
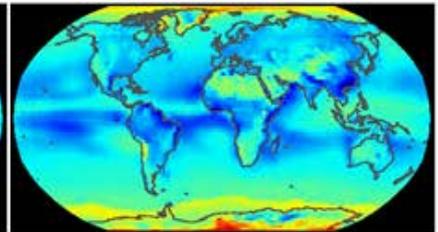
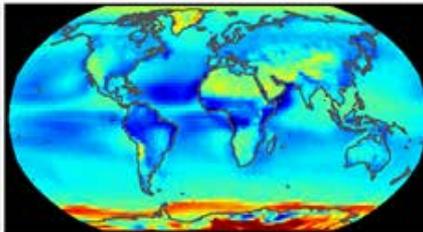
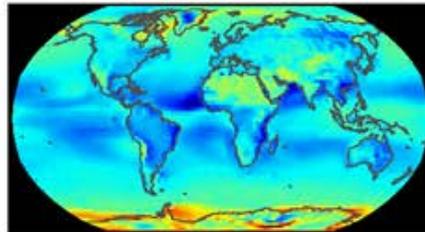
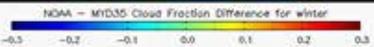
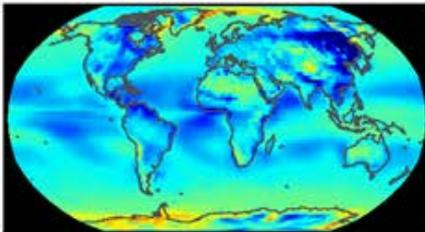
MYD35 Mean



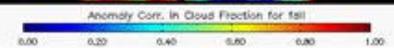
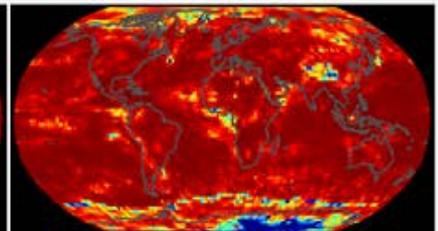
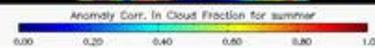
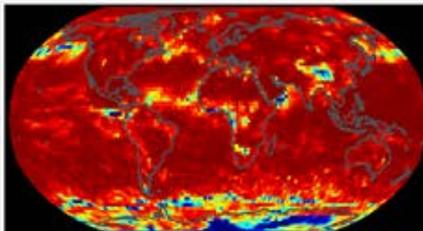
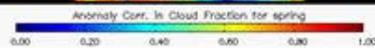
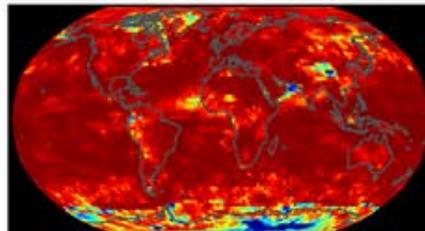
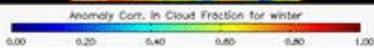
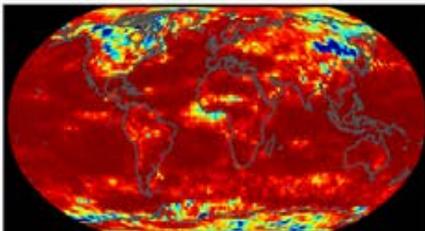
NOAA Mean



NOAA - MYD35

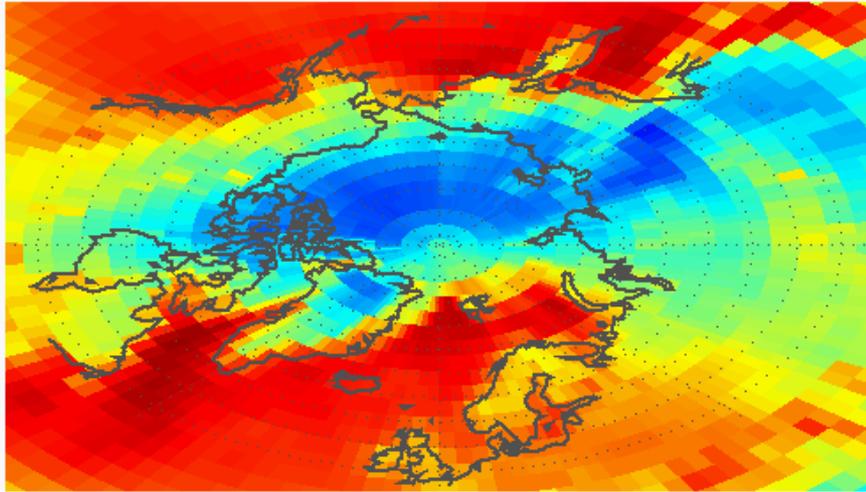


Anomaly Corr.

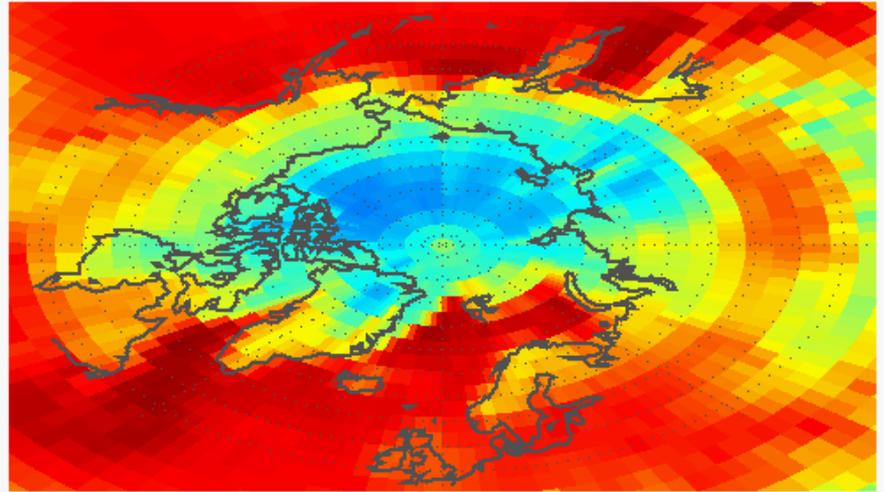




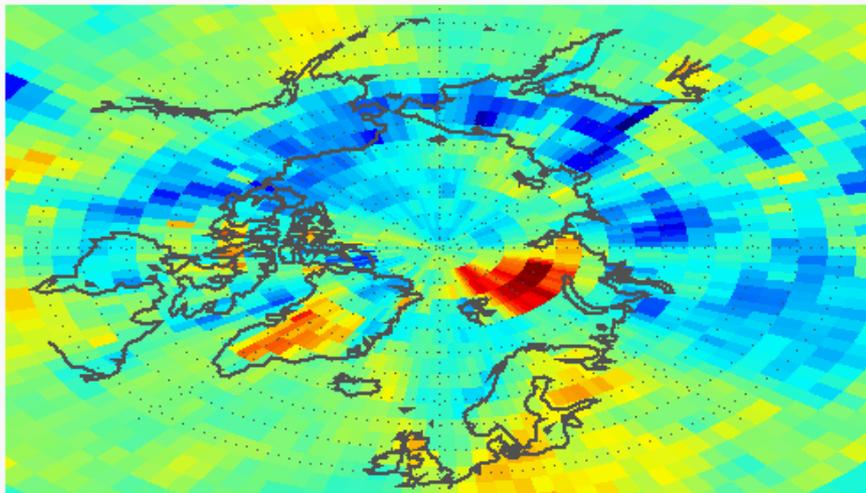
Arctic Winter Cloud Amount and Trend



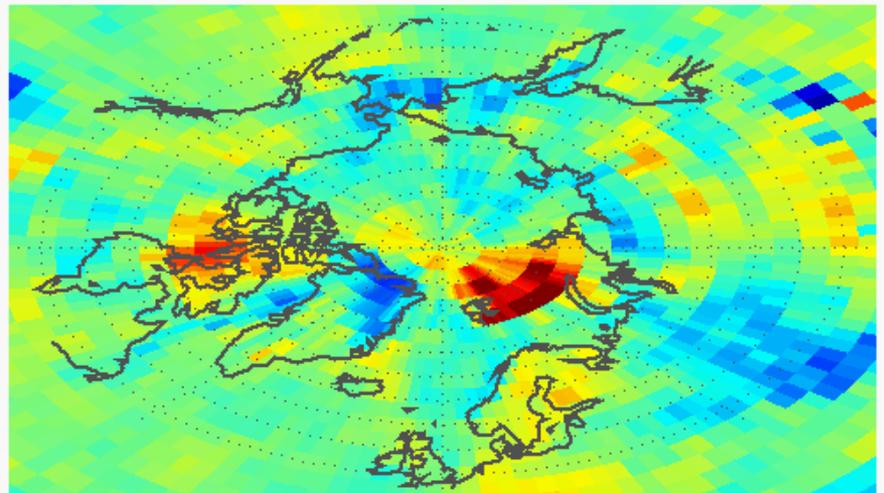
PATMOS-x Cloud Fraction for winter all



MYD35 Cloud Fraction for winter all



PATMOS-x Cloud Fraction Linear Trend for winter all



MYD35 Cloud Fraction Linear Trend for winter all

