



# An Investigation of Cloud Cover Probability for the HypsIRI Mission Using MODIS Cloud Mask Data



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Adam Gunderson, Montana State University  
Mark Chodas, MIT

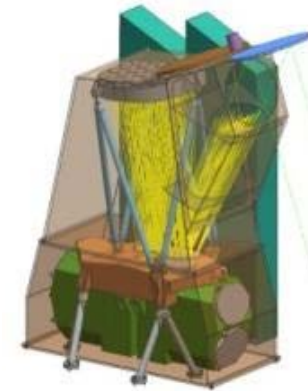
- Visible Shortwave Infrared Imager (VSWIR)

- Specifications

- 60 m spatial resolution
- 145 km swath width
- 380-2500 nm, 10 nm sampling

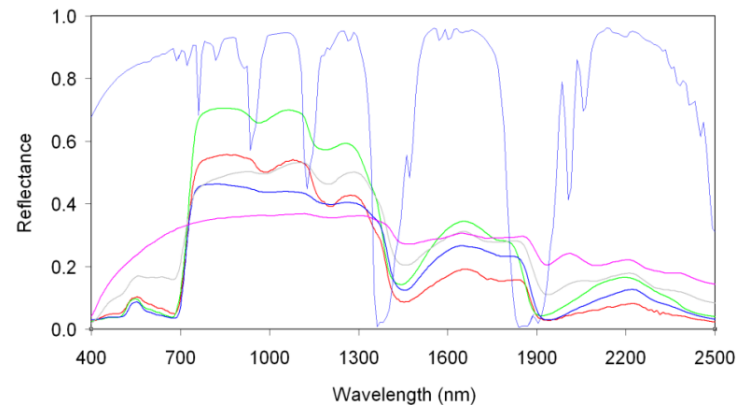
- **19 day revisit**

- **Global seasonal coverage**
- **Allows for better knowledge of the planets ecosystem changes**



- Current spacecraft orbit to fulfill coverage specifications

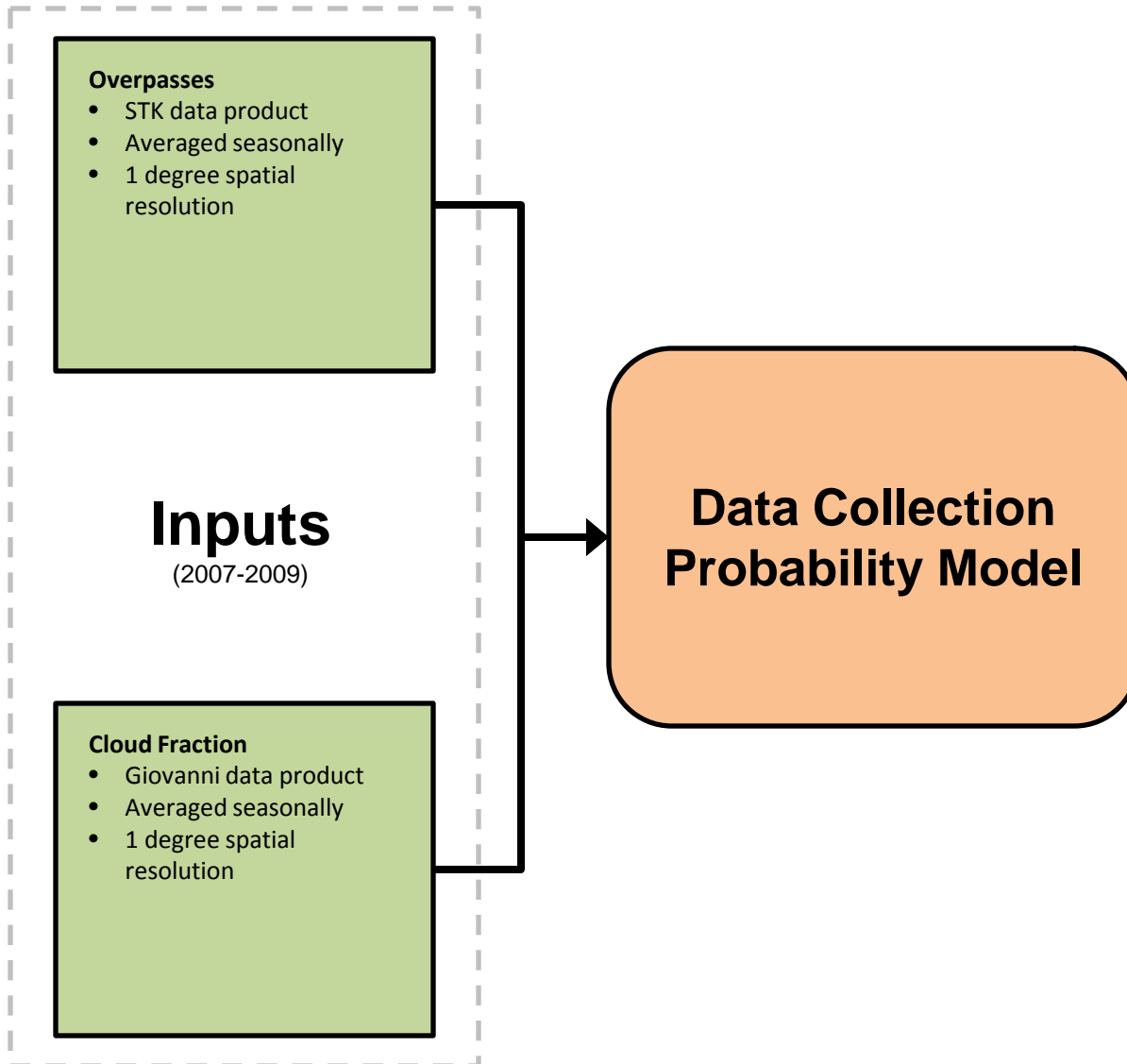
- Sun Synchronous
- 626 km LEO
- 1030 UTCG Descending
- 98° Inclination



# Objectives

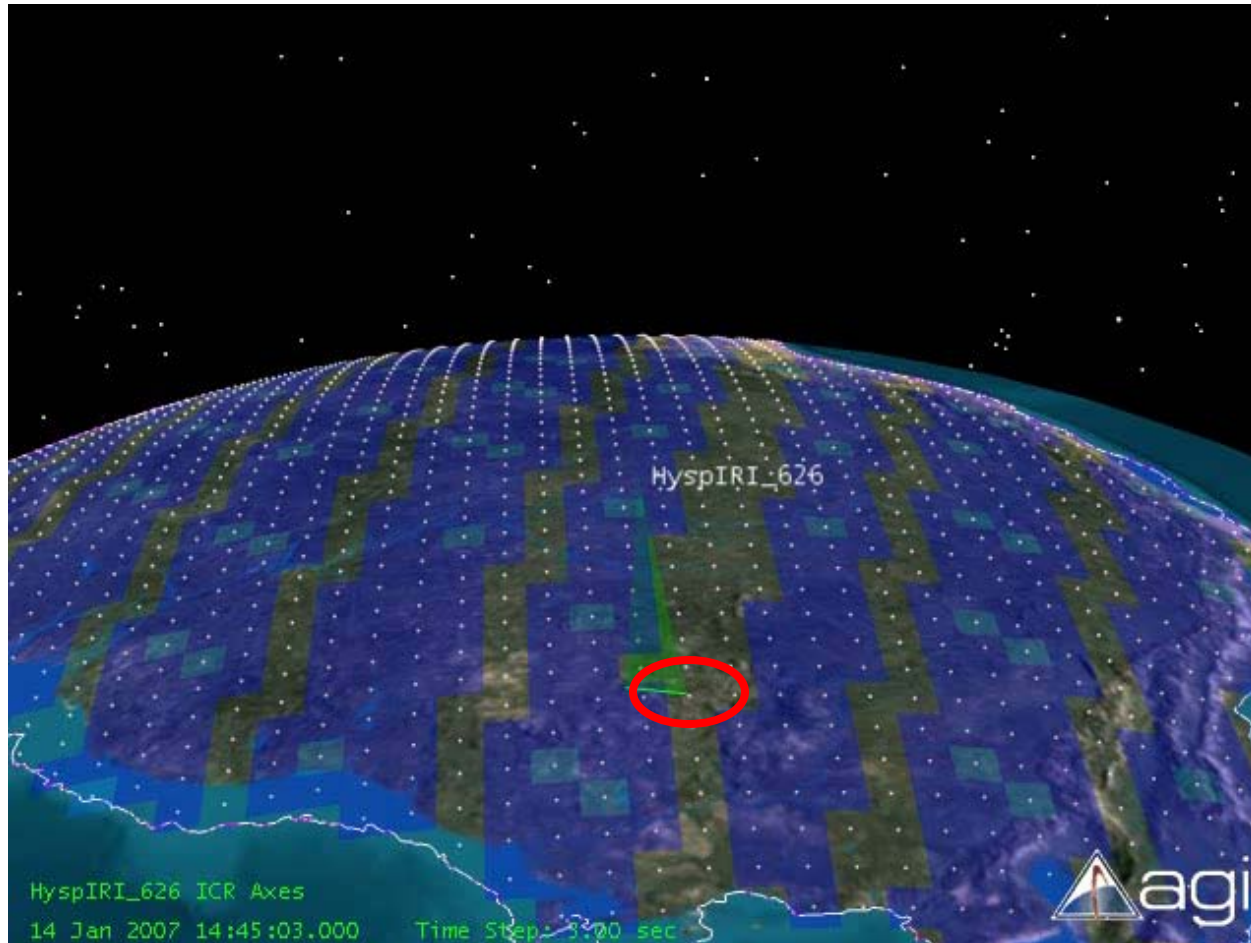


- Data Sampling Requirements from the Whitepaper:
  - **Baseline:** <20 day revisit to provide >60% seasonal and >80% annual coverage of the terrestrial and shallow water regions of the Earth.
  - **Minimum:** <20 day revisit to provide >50% seasonal and >70% annual coverage of the terrestrial and shallow water regions of the Earth
- *A probability science retrieval model shall provide a better understanding of the feasibility regarding these requirements.*



# Overpasses

- Defined: The number of times VSWIR's swath comes in contact with the centroid of a 1x1 degree cell.
- Bounded -50m elevation map derived from NOAA ETOPO5 data



## Example

- Uncolored: No overpasses
- **Blue: 1 overpass**
- **Aqua: 2 overpasses**

## Limitations

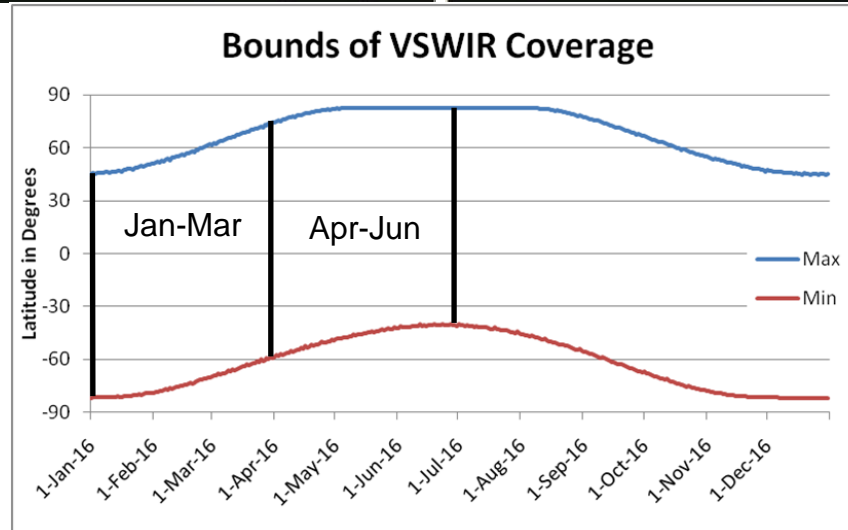
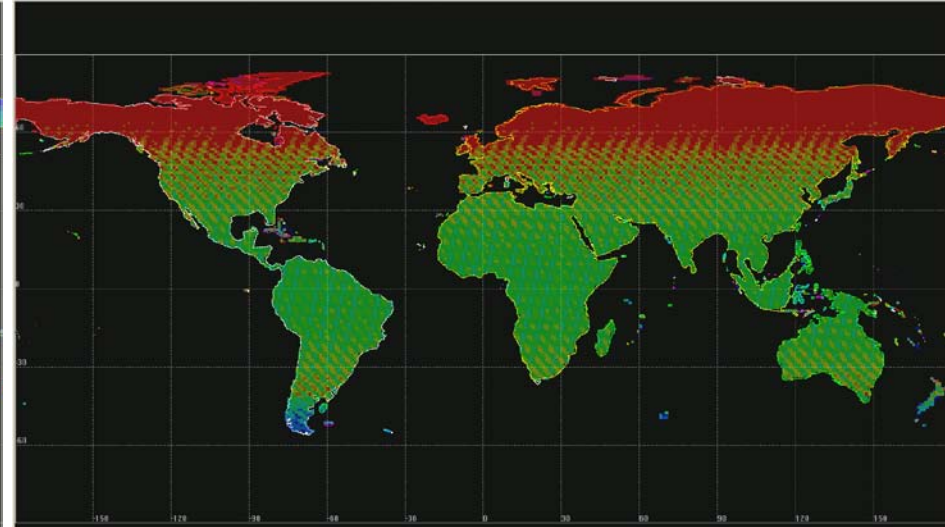
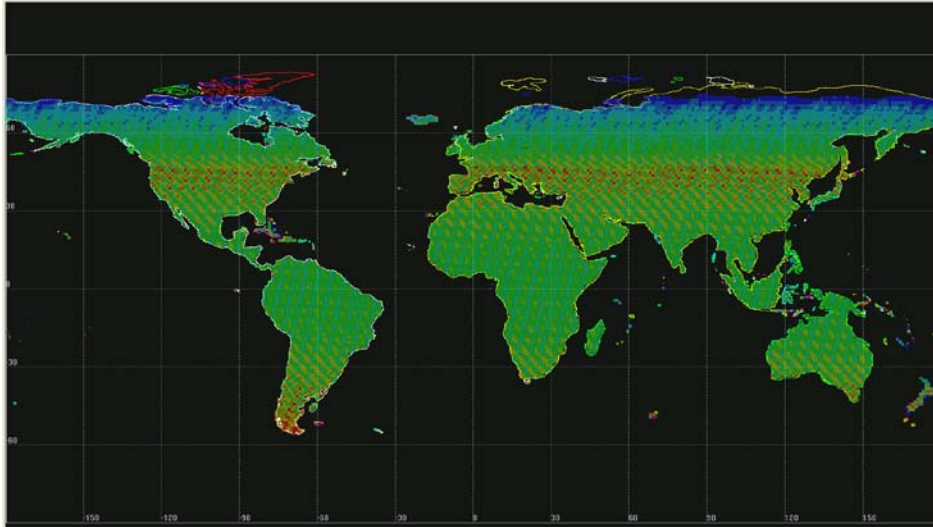
- Partial swath-to-cell contacts not counted
- Produces artifacting in results.
- Remedied by increasing grid resolution at the cost of processing time.



# Overpasses (2007)

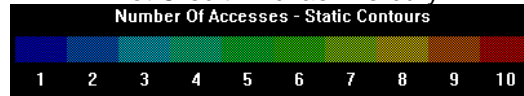
Jan-Mar

Apr-Jun



Plot Credit: Michael Mercury

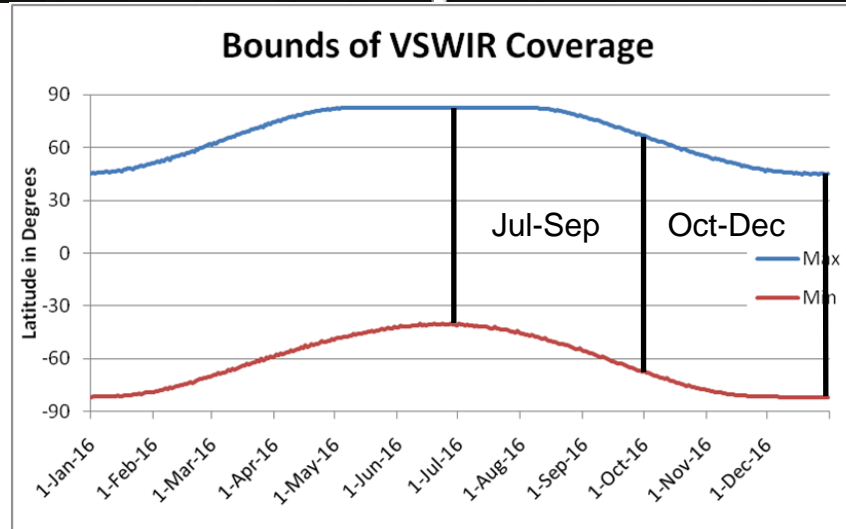
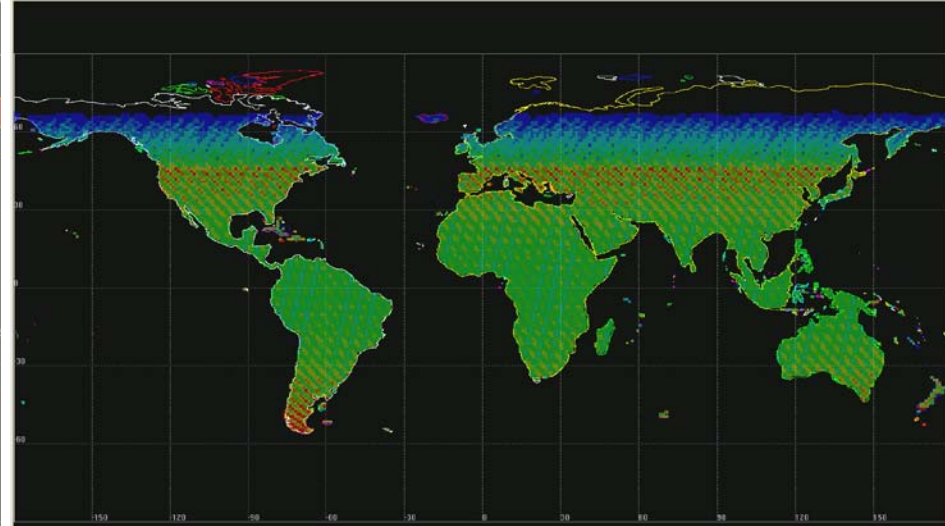
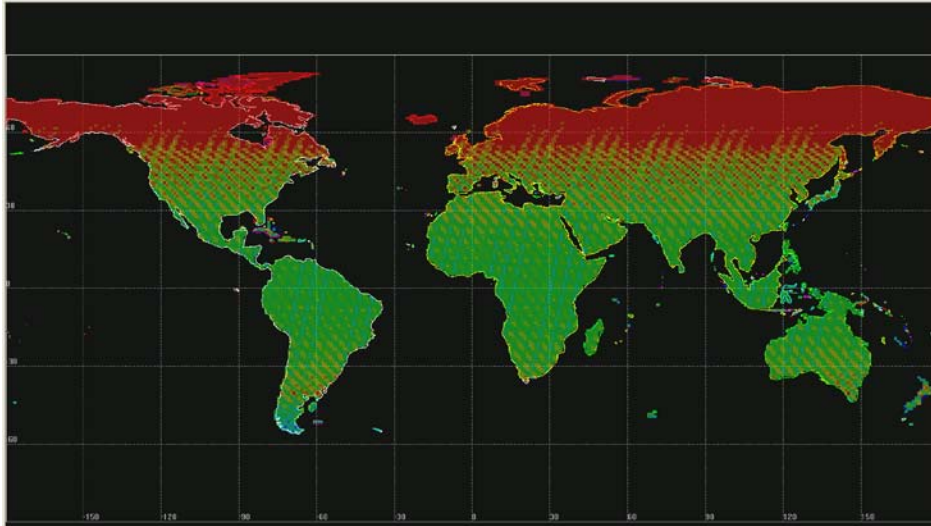
Number Of Accesses - Static Contours



# Overpasses (2007)

Jul-Sep

Oct-Dec



Plot Credit: Michael Mercury

Number Of Accesses - Static Contours



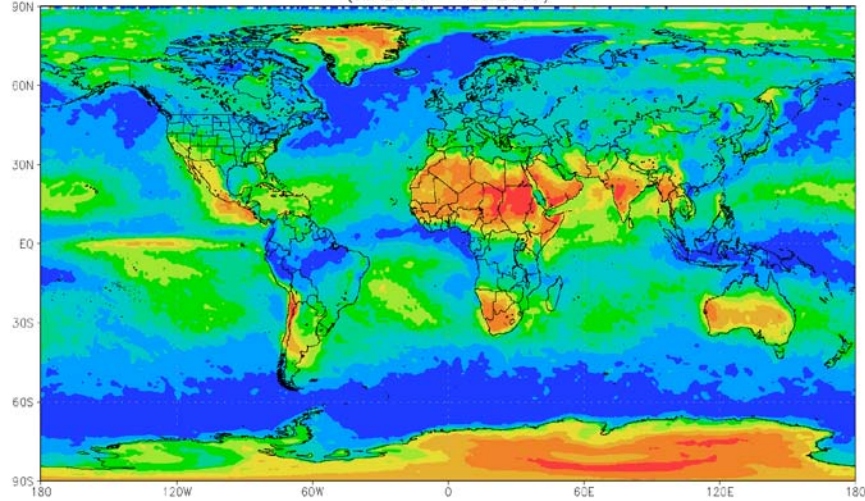
- Defined:
  - Count of cloudy and probably cloudy pixels divided by the total number of pixels.
- Compiled using Giovanni
  - Web-based application developed by Goddard
    - <http://disc.sci.gsfc.nasa.gov/giovanni>
  - Uses MODIS-Terra monthly (L3 data product MOD\_M3)
  - 1x1 degree pixels
  - Day pixels only, averaged seasonally



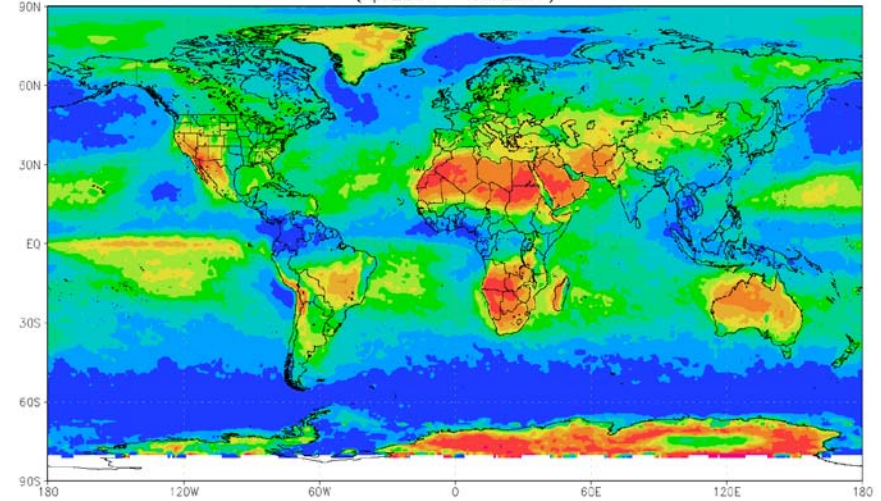
# Cloud Fraction

(Blue denotes high cloud fraction)

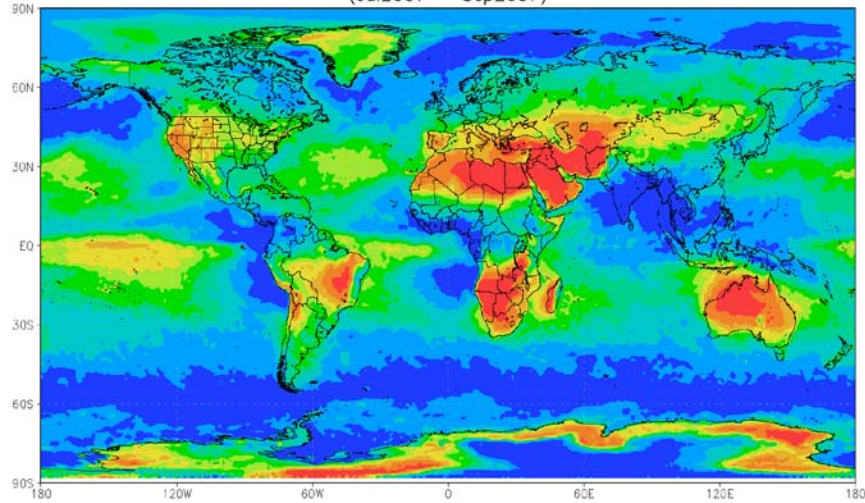
MOD08\_M3.005\_Cloud Fraction (Day only) [unitless]  
(Jan2007 - Mar2007)



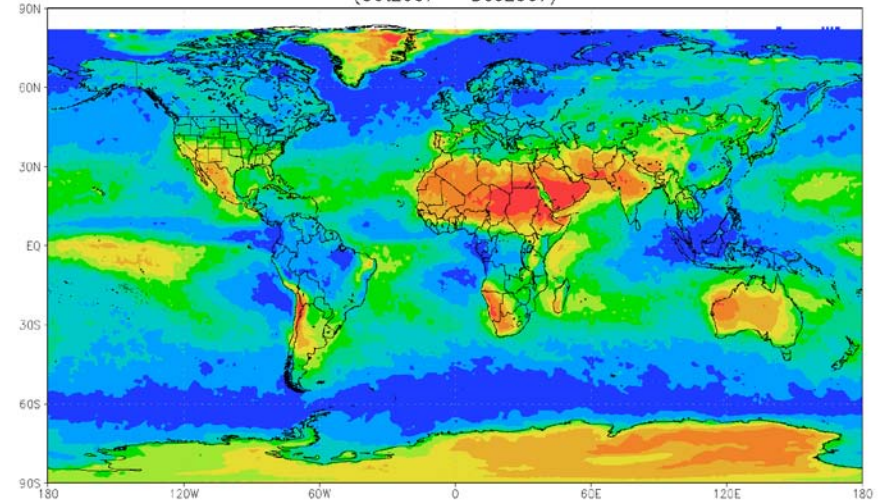
MOD08\_M3.005\_Cloud Fraction (Day only) [unitless]  
(Apr2007 - Jun2007)



MOD08\_M3.005\_Cloud Fraction (Day only) [unitless]  
(Jul2007 - Sep2007)



MOD08\_M3.005\_Cloud Fraction (Day only) [unitless]  
(Oct2007 - Dec2007)



**Inputs**

**MATLAB Scripts**

- Probability
  - Probability Calculations
  - Global Probability Map Creation
- Coverage
  - Surface Coverage Calculations
  - Distribution Plot Creation

**Data Collection  
Probability Model**

**Outputs**

**Probability Maps**

- Seasonal
- Averaged across 3 years

**Coverage Plots**

- Seasonal
- Averaged across 3 years

# Probability Calculations

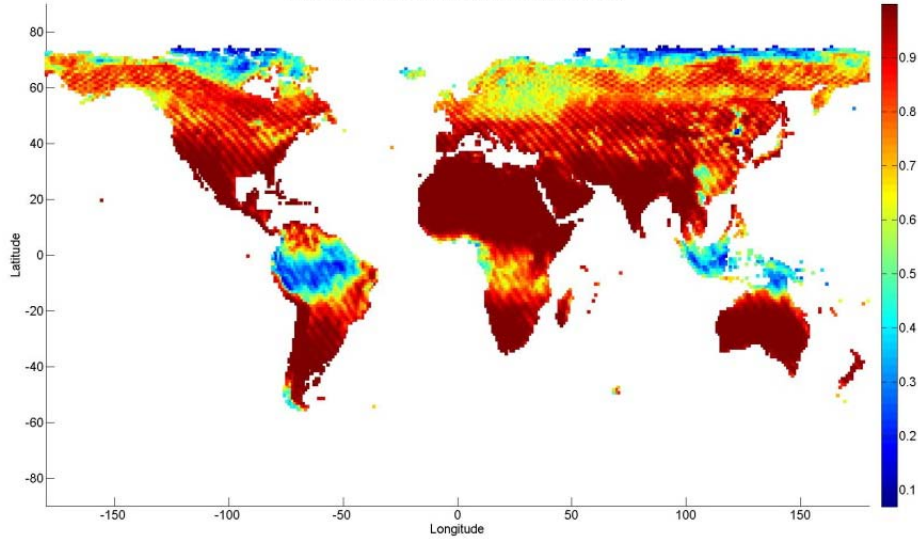


- Probability of Science Retrieval:  $P(s)$ 
  - $P(s) = 1 - C^n$ 
    - $C$  = Cloud Fraction (Giovanni Output)
    - $n$  = Number of VSWIR overpasses (STK Output)
    - Example Calculation
      - 25% cloud fraction, 4 overpasses
      - $0.25 * 0.25 * 0.25 * 0.25 = 0.0039$
      - $P(s) = 1 - 0.0039 = 99.6\%$
- $P(s)$  is calculated for each 1x1 degree cell
- Any missing “C” values from the MOD\_08 dataset are ignored.

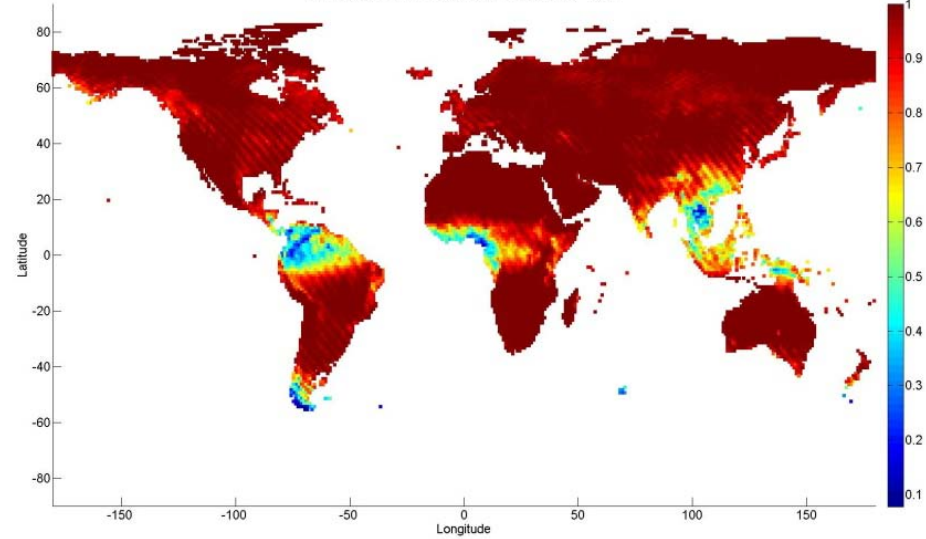


# Probability Maps (2007-2009)

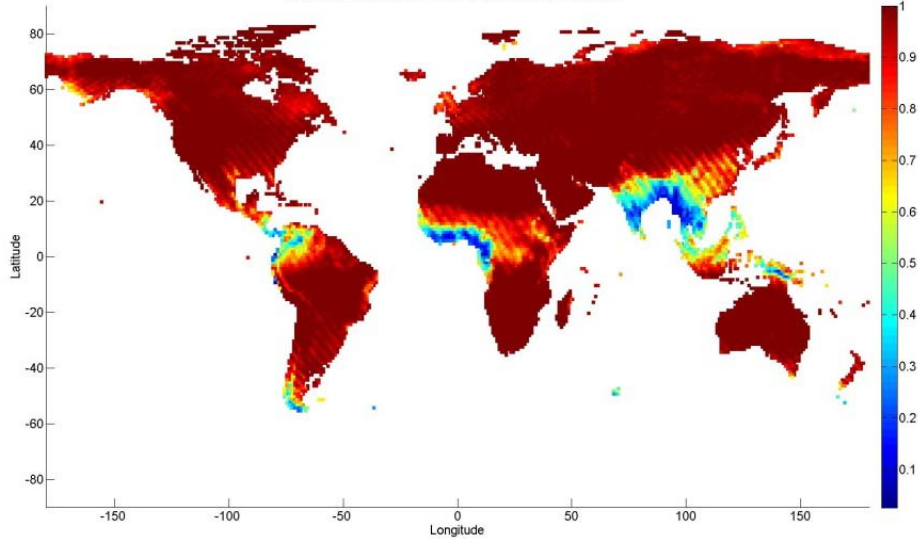
Probability of Successful Retrieval Map for January - March



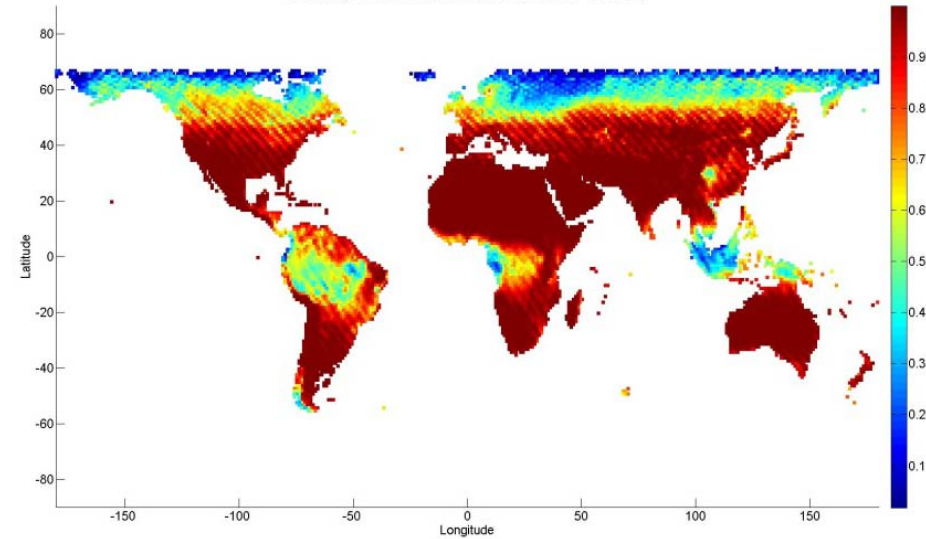
Probability of Successful Retrieval Map for April - June



Probability of Successful Retrieval Map for July - September



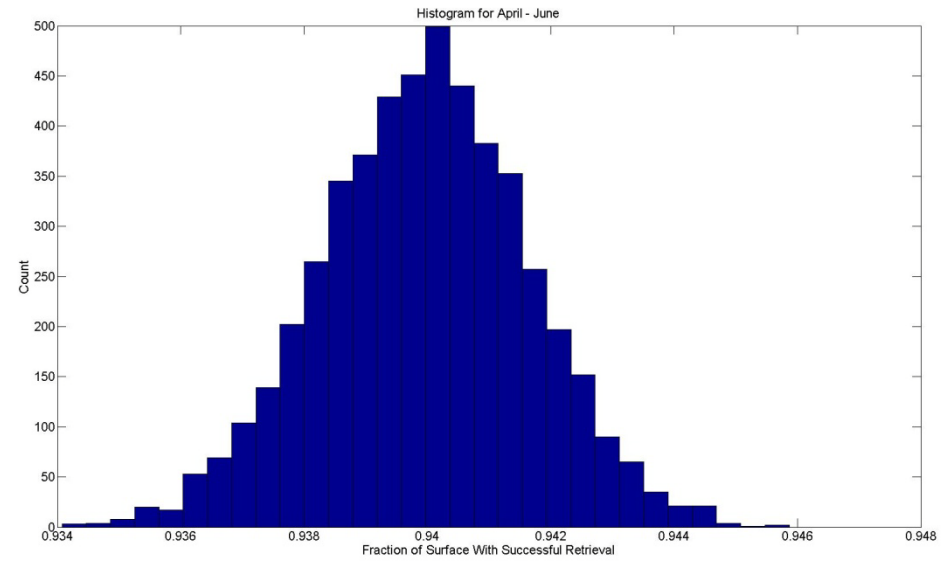
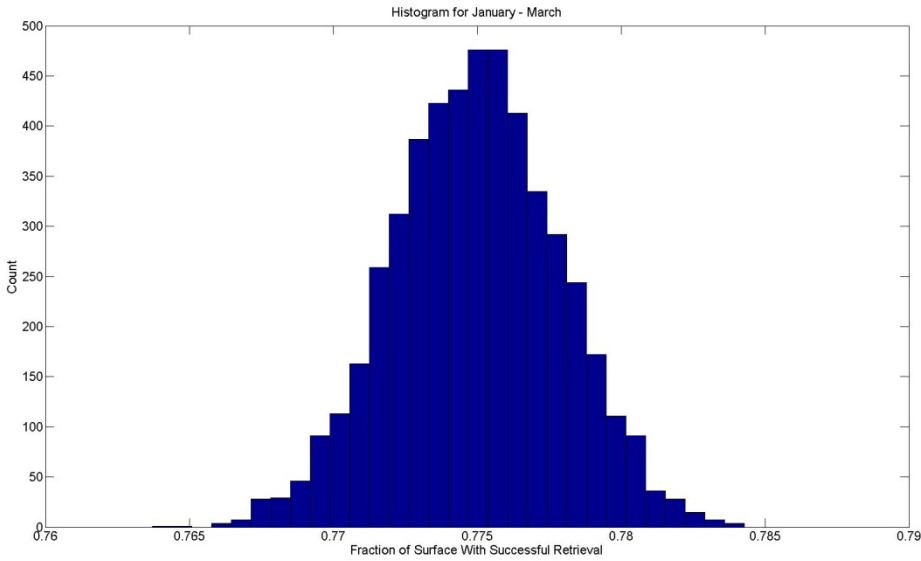
Probability of Successful Retrieval Map for October - December



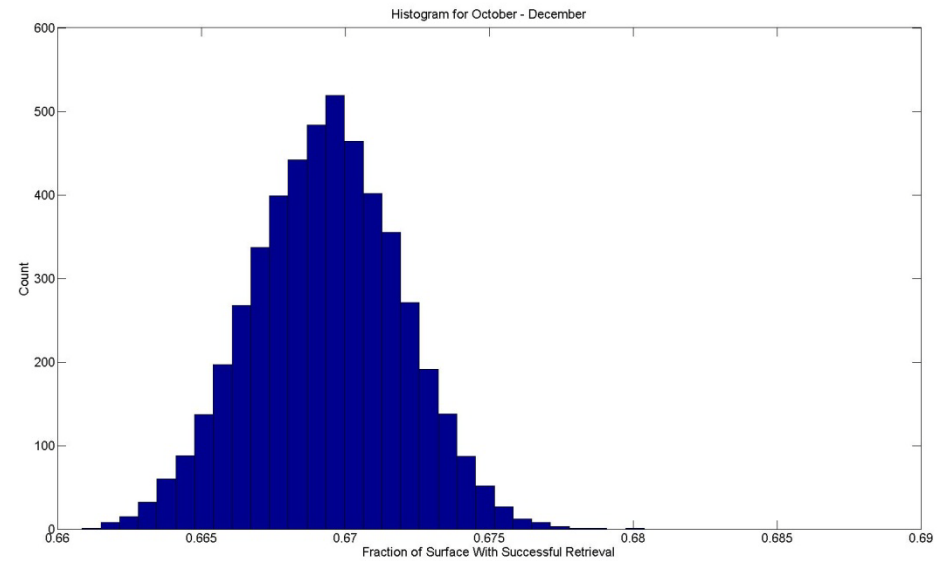
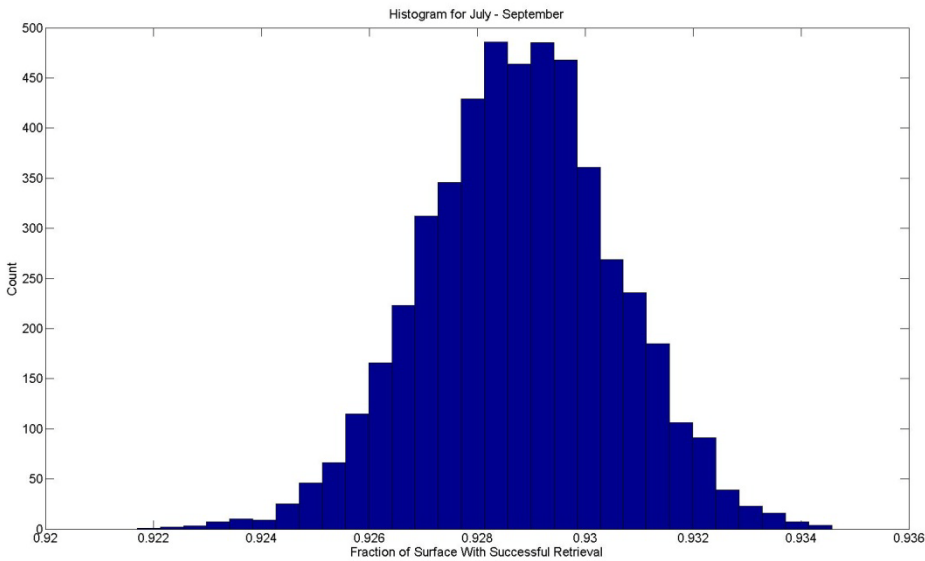
- Fraction of the terrestrial surface viewed by VSWIR:  $F(s)$ 
  - Random number generator with a threshold based on  $P(s)$  to determine if a point is cloudy or not
  - Weighted each grid point by the associated block area
  - Divided the clear area by the total area
- Simulated the entire grid 5000 times to create the probability mass function of  $F(s)$



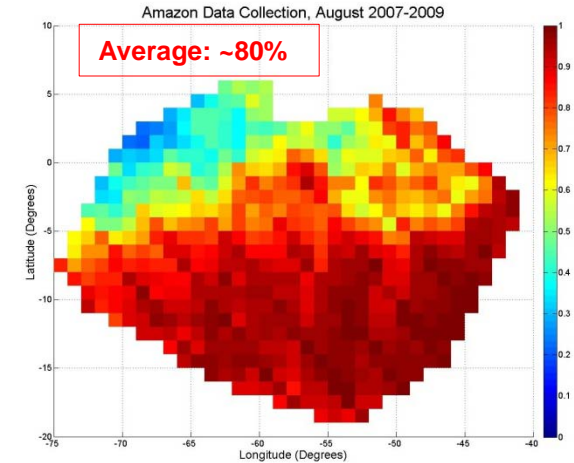
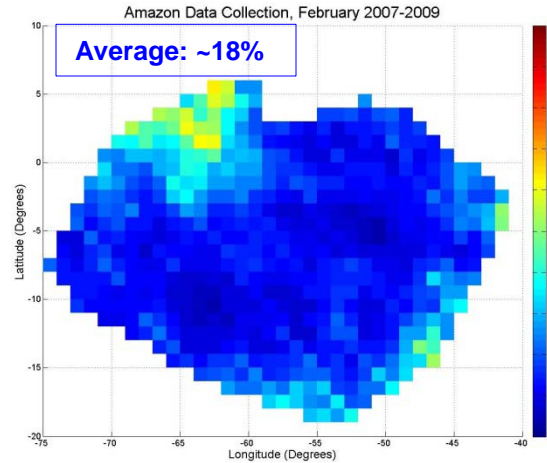
# Coverage Plots (2007-2009)



**Seasonal coverage never drops below 60%**



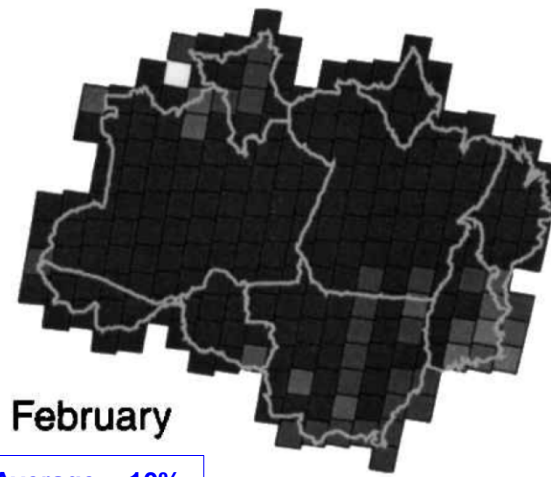
# Brazilian Amazon



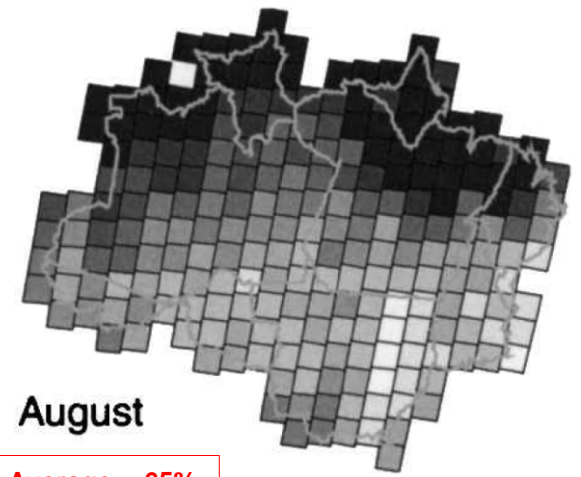
Brazilian States of the Amazon Basin



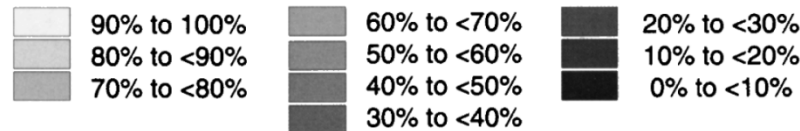
— State Boundary  
□ TM Footprint



**Average: ~10%**



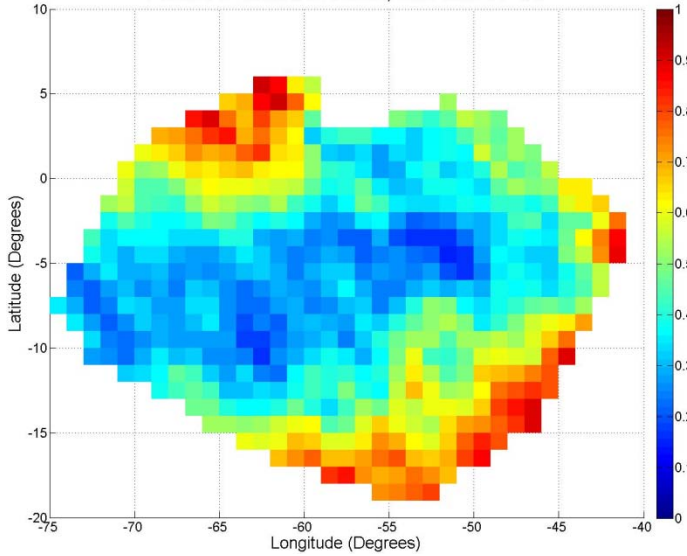
**Average: ~65%**



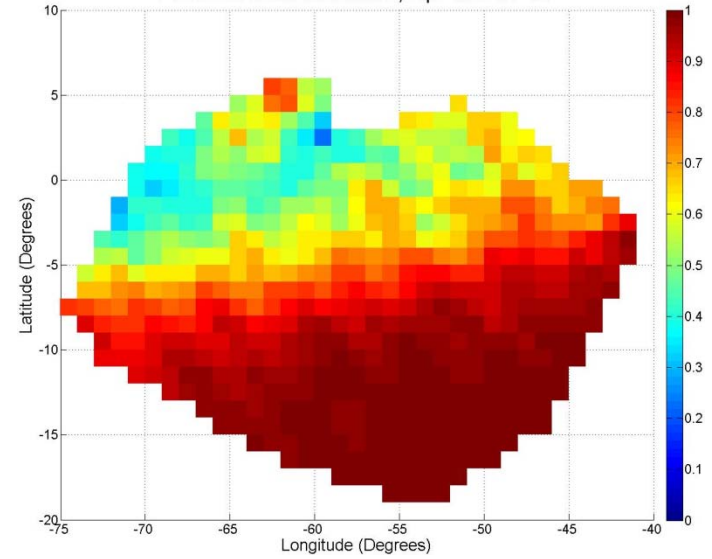
# Brazilian Amazon



Amazon Data Collection, Jan-Mar 07-09

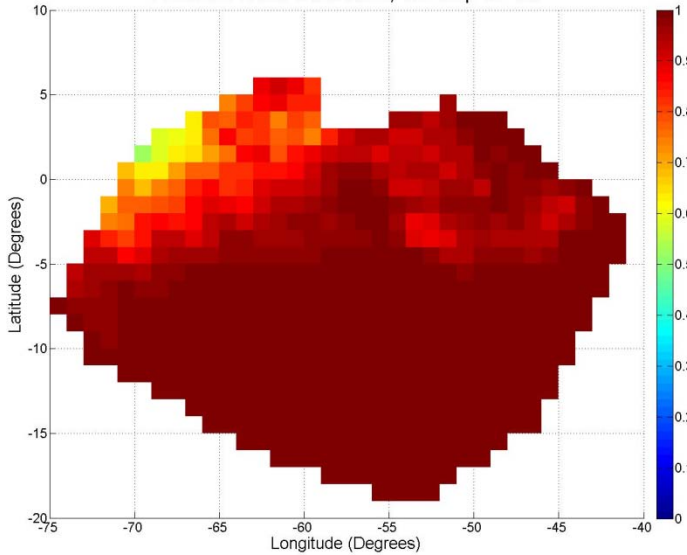


Amazon Data Collection, Apr-Jun 07-09



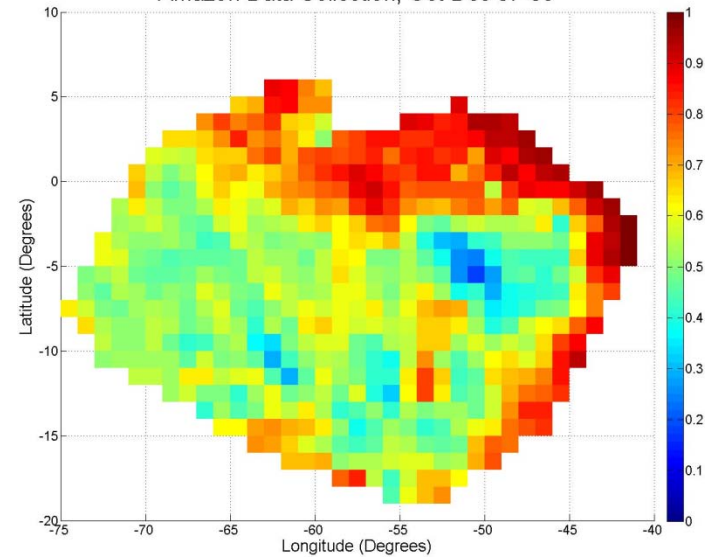
Brazilian  
Amazon

Amazon Data Collection, Jul-Sep 07-09



Seasonal  
View

Amazon Data Collection, Oct-Dec 07-09



# Conclusions



- Based on initial results VSWIR meets the current baseline requirements of >60% seasonal and >80% annual coverage of the terrestrial and shallow water regions of the Earth.
- Future Work
  - Similar analysis completed for TIR
  - Model with higher than one-degree resolution MODIS-Terra data.
  - Increase the resolution of the STK grid.





# Acknowledgements

National Space Grant Consortium

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Michael Mercury

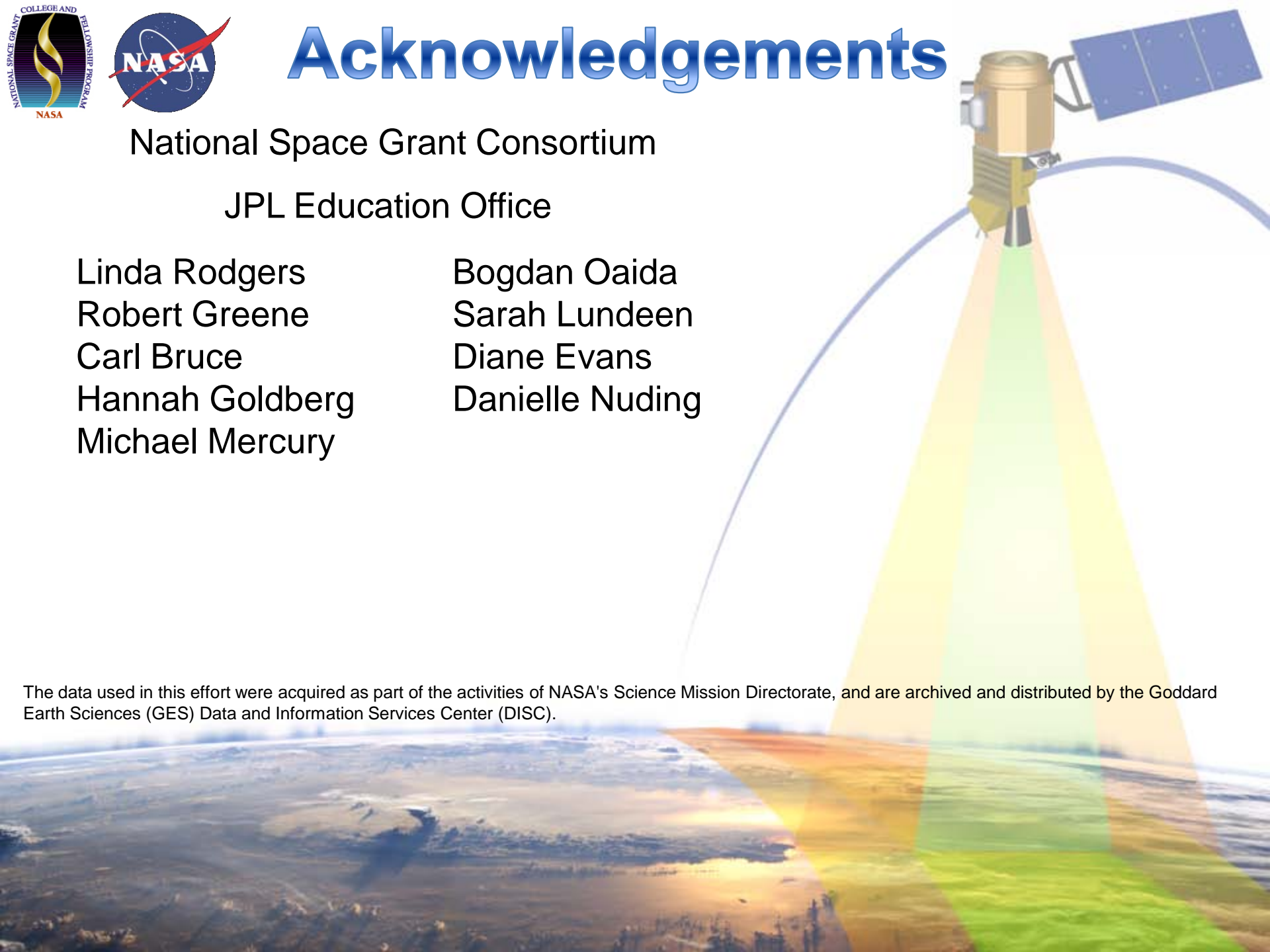
Bogdan Oaida

Sarah Lundeen

Diane Evans

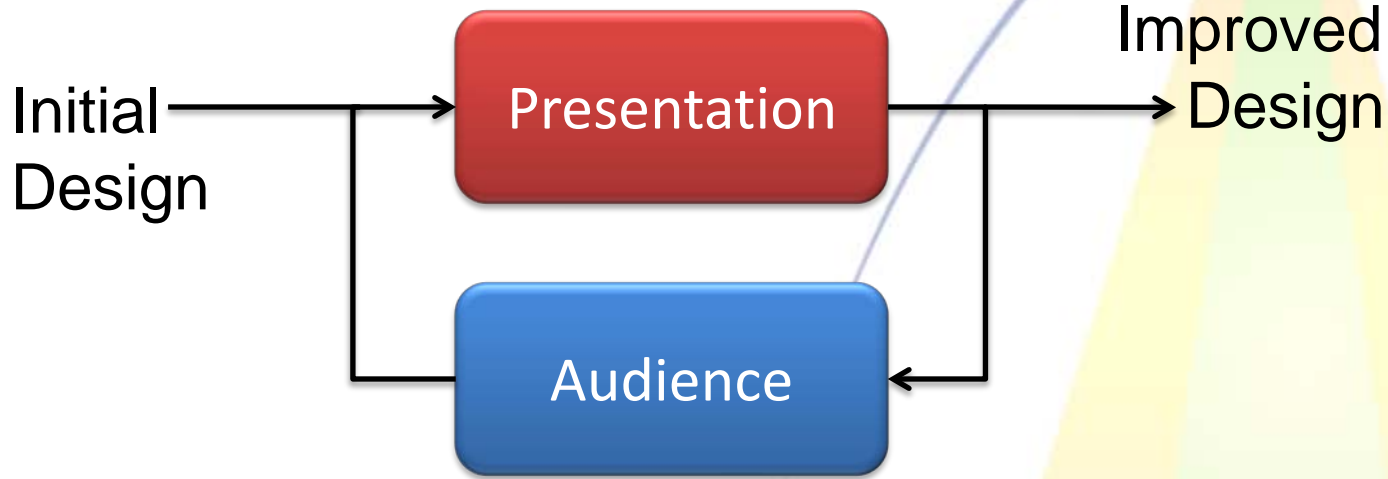
Danielle Nuding

The data used in this effort were acquired as part of the activities of NASA's Science Mission Directorate, and are archived and distributed by the Goddard Earth Sciences (GES) Data and Information Services Center (DISC).

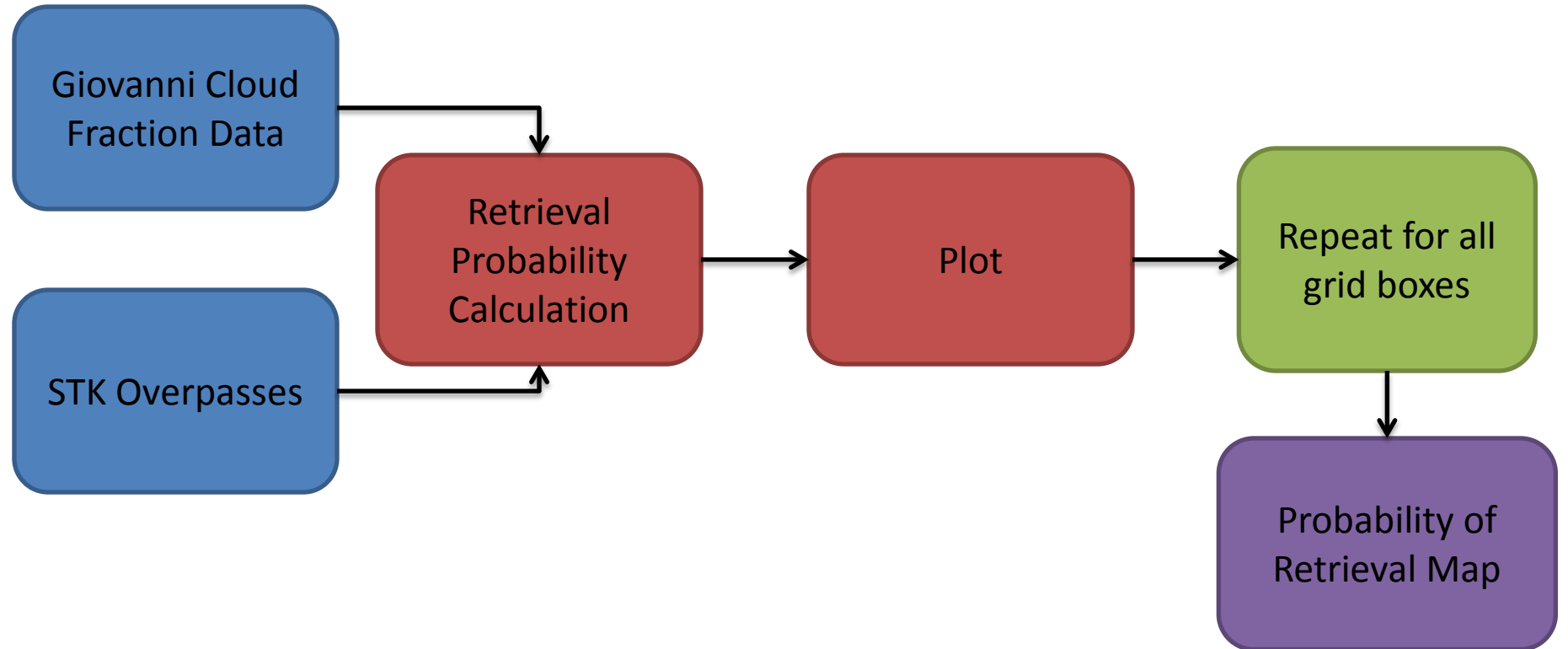




# Questions?



# Back-up Slides



# Coverage.m

