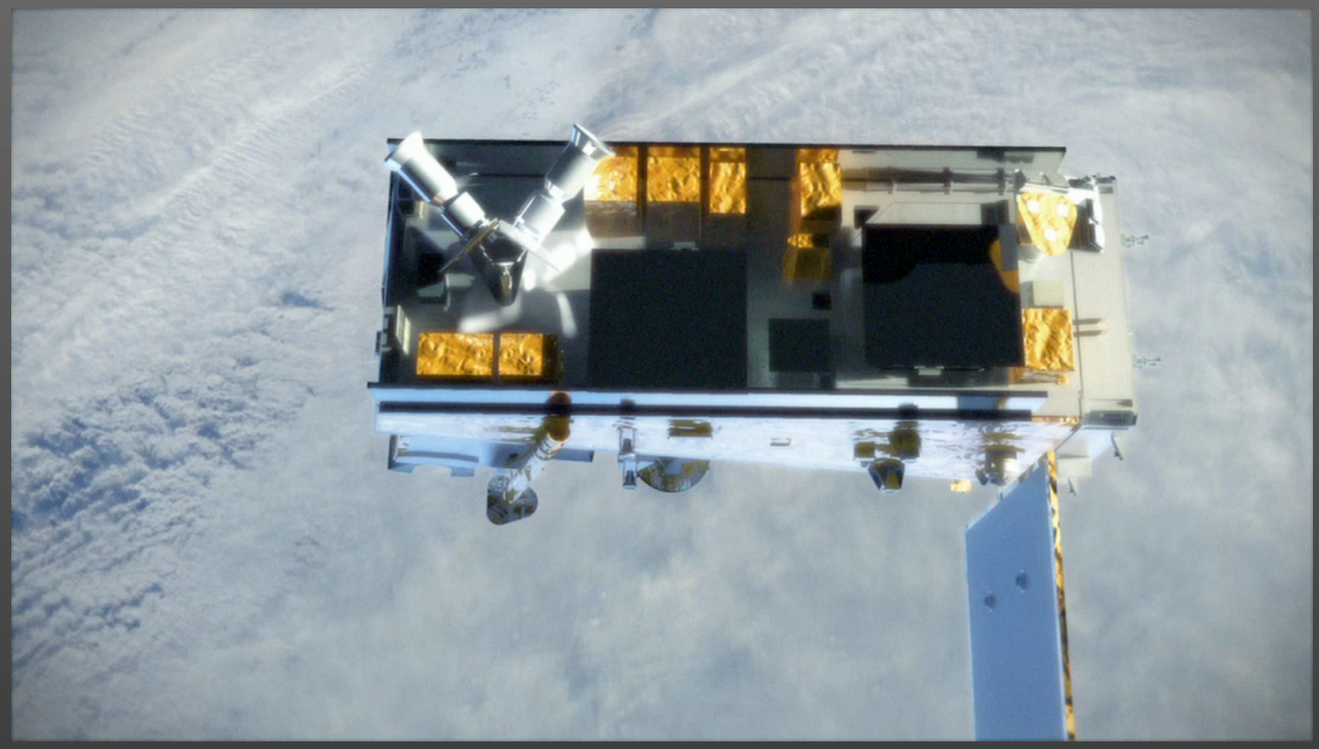
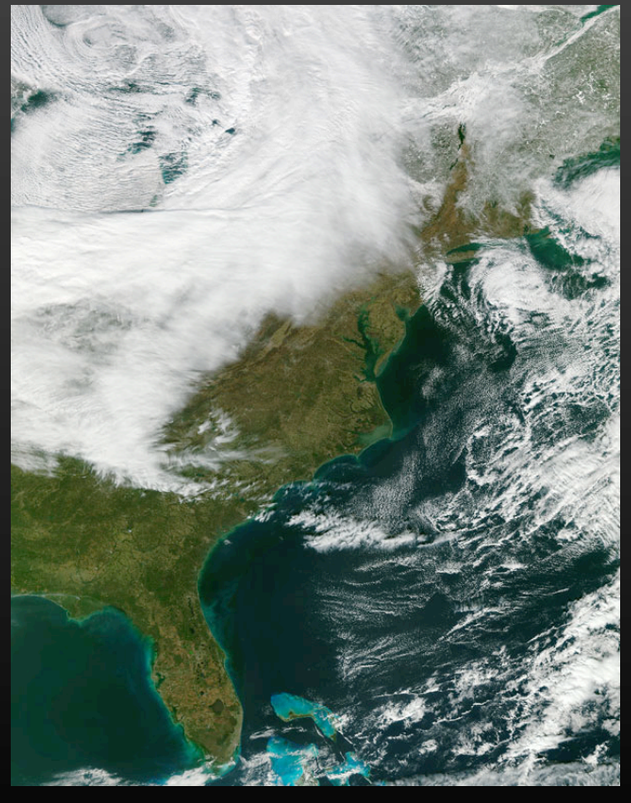
Climate Data Processing System for the NASA Suomi NPP Project

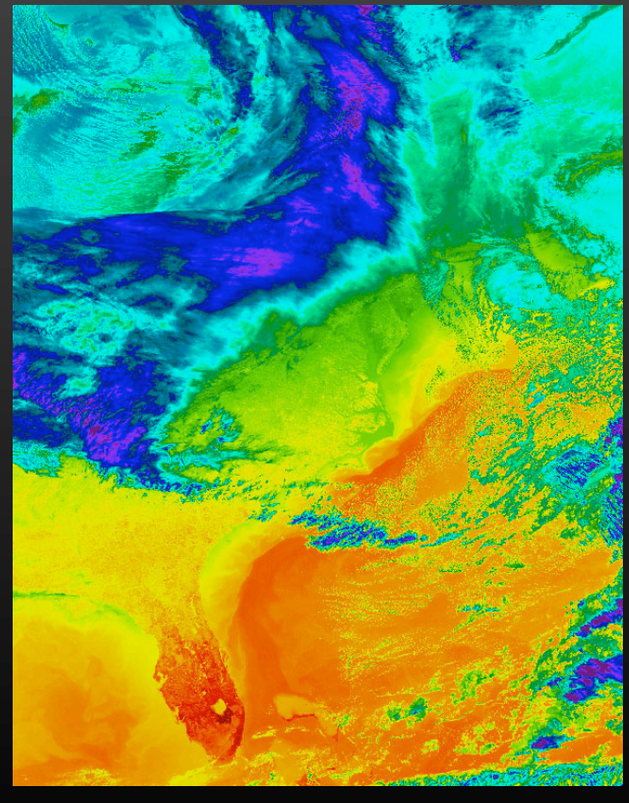


Liam Gumley

GeoMetWatch Briefing

7 February 2012





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What is Suomi NPP?

- Suomi NPP is the newest US earth observing spacecraft.
- Launched into a polar orbit on Oct 28, 2011.
- Developed by NASA and industry; operated by NOAA.
- Spacecraft and sensors were developed by industry.
- ***Science algorithms*** were also developed by industry.

Question: Can the science products (e.g., global cloudiness) continue the ***Climate Data Record*** established by previous NASA and NOAA satellites?

Climate Data Record = "A time series of measurements of sufficient length, consistency, and continuity to determine climate variability. and change."

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Suomi NPP at Ball Aerospace
July 2010

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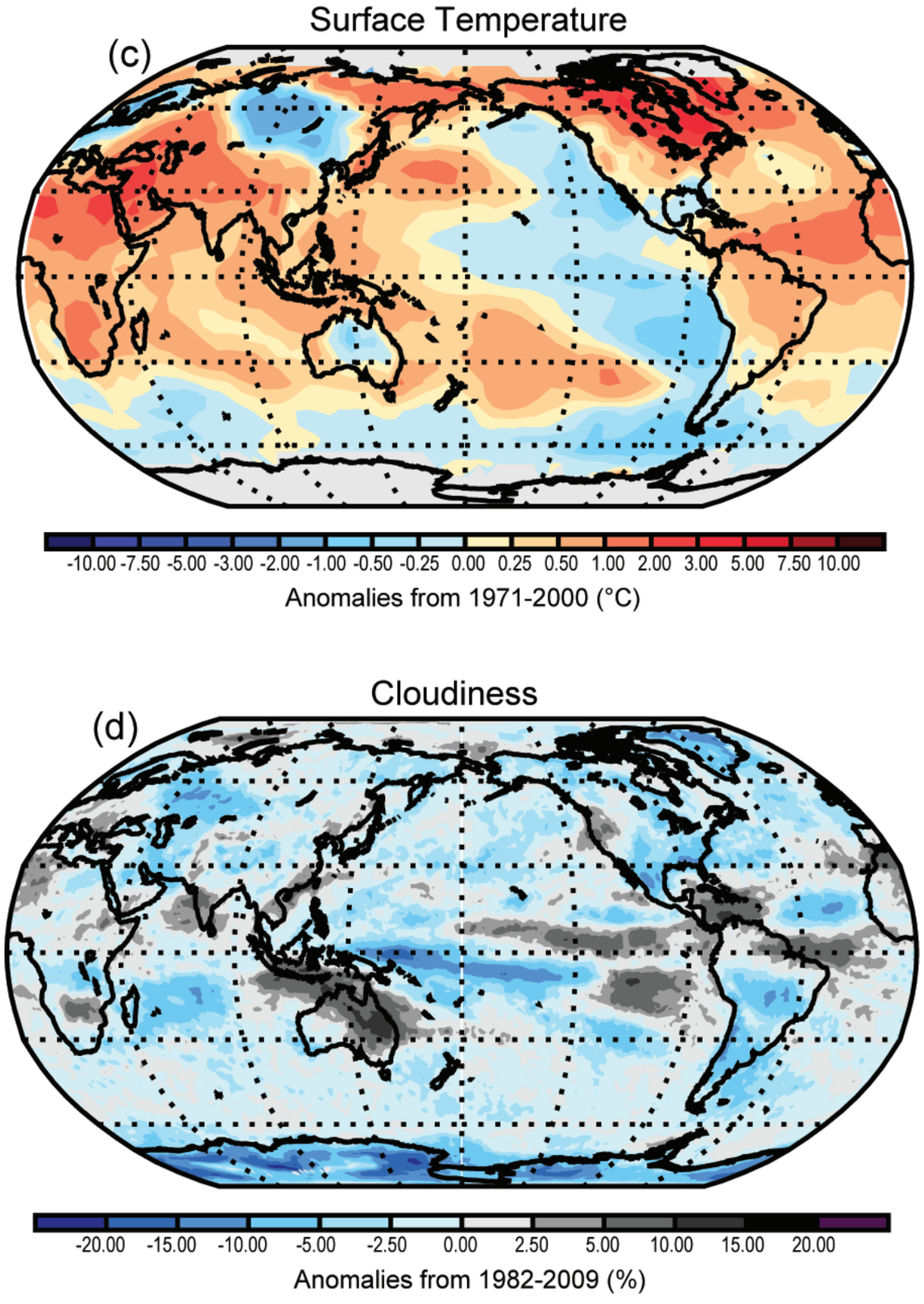
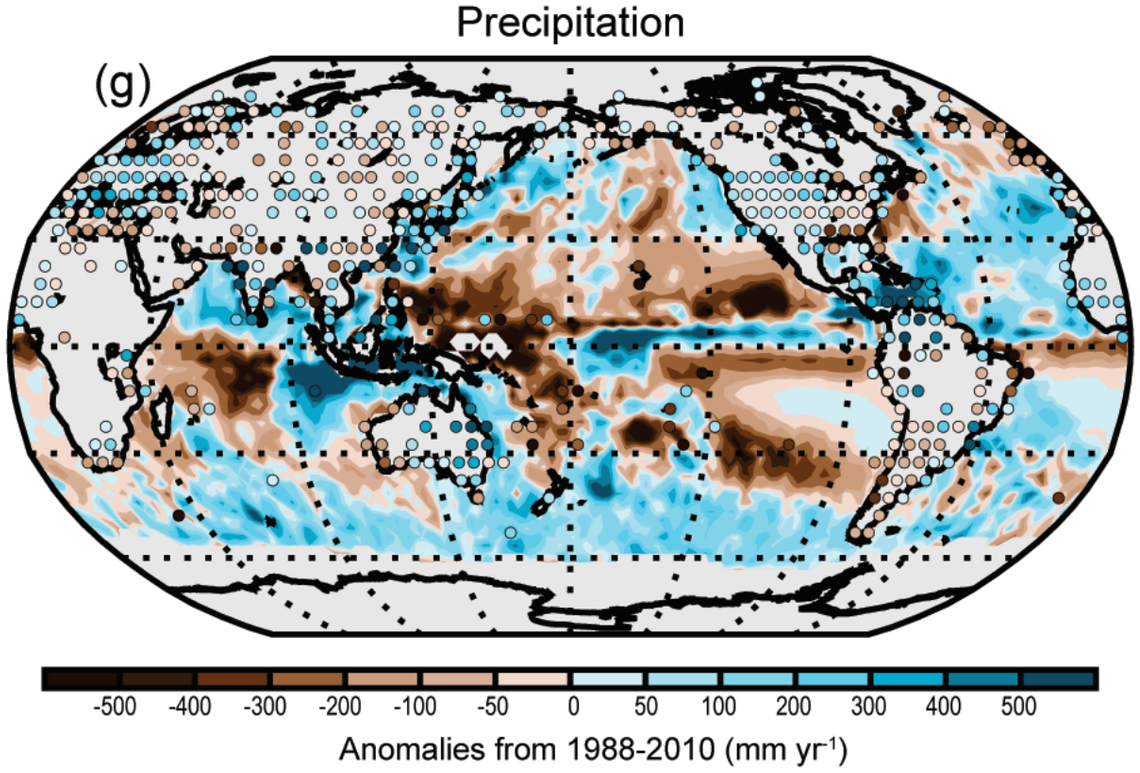
Examples of Climate Data Records Observed by Satellites





Global annual anomaly maps for those variables for which it is possible to create a meaningful 2010 anomaly estimate. Reference base periods differ among variables, but spatial patterns should largely dominate over choices of base period. (BAMS State of the Climate 2010).

Evaluating Suomi NPP Products

- To enable the evaluation of the atmosphere and cloud products from Suomi NPP, in 2005 NASA established 6 facilities known as "***P***roduct ***E***valuation and ***A***lgorithm ***T***est ***E***lements" or ***PEATEs***.
- PEATEs exist for Atmosphere, Land, Ocean, Ozone, Radiation Budget, and Soundings.
- ***Only one PEATE is located outside a NASA center***: the Atmosphere PEATE at SSEC, UW-Madison.
- The goal of the Atmosphere PEATE at UW-Madison is to help the NASA NPP Science Team to evaluate the Suomi NPP atmosphere and cloud products, and to test improved and alternative algorithms for creating these products.

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Atmosphere PEATE Primary Objectives

1. Provide an environment for pre-launch testing and evaluation of IDPS VIIRS Atmosphere EDR algorithms.
2. Create tools and techniques to allow rapid post-launch comparison of VIIRS Atmosphere EDRs to EDRs from other sensors (e.g., MODIS).
3. Create tools and techniques using available validation data (e.g., CALIOP) to allow rapid post-launch evaluation of VIIRS Atmosphere EDRs.
4. Assist the NPP Science Team in assessing the suitability of VIIRS Atmosphere EDRs for continuing the climate record of cloud and aerosol observations from space.
5. Provide an environment where the NPP Science Team can test alternative EDR algorithms on climatologically significant samples of global proxy data (pre-launch) and NPP data (post-launch).
6. Assist the NPP Science Team in delivering improved or alternative EDR algorithms to the IDPS.

Atmosphere PEATE Organization Chart

Project Management
Hank Revercomb (PI)
Liam Gumley (Co-I, PM)

Science Evaluation
Bob Holz
Min Oo
Rich Frey
Bryan Baum
Andy Heidinger
Dave Tobin
Fred Nagle

Systems Engineering
Steve Dutcher
Geoff Cureton
Greg Quinn
Bruce Flynn
Nick Bearson
Ralph Kuehn

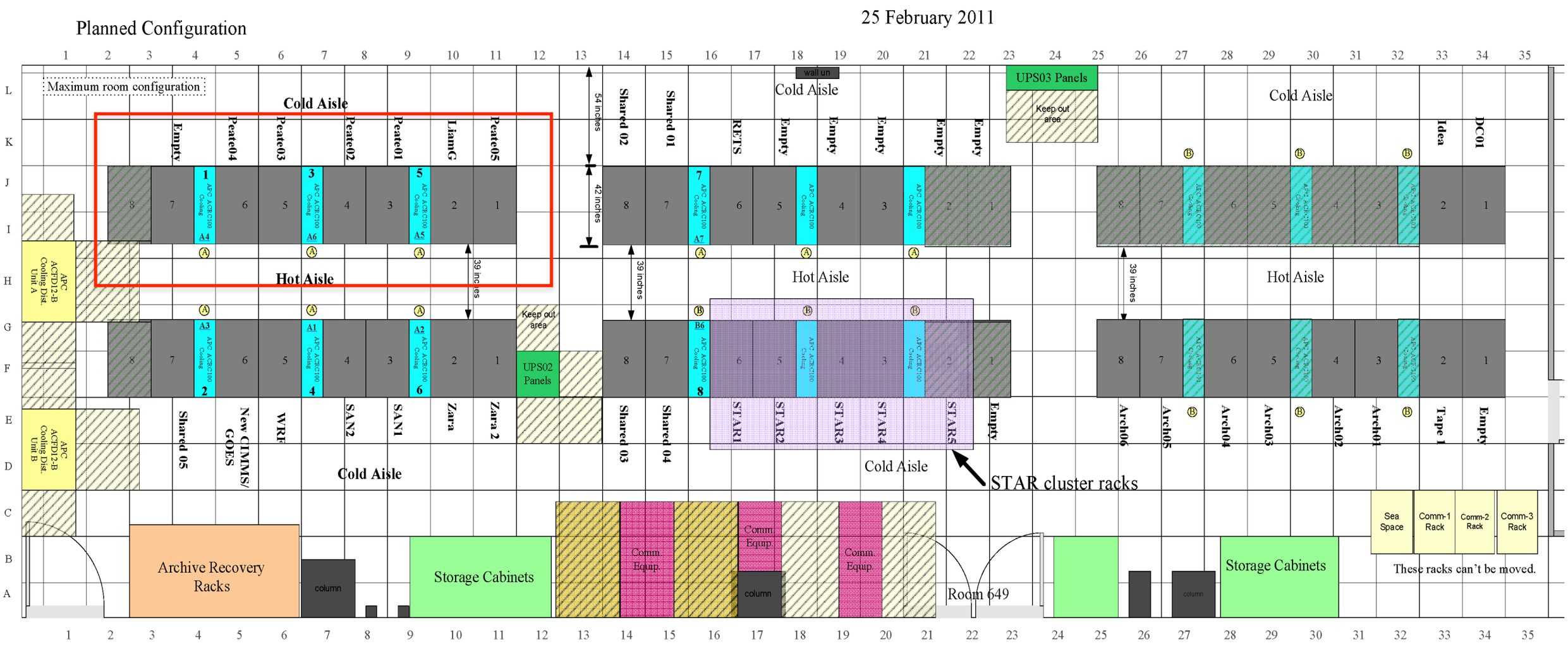
Data Center Operations
Jerry Robaidek
Rosie Spangler
Janean Hill

IT Support
Scott Nolin
Jesse Stroik
John Lalande

PEATE Hardware Resources

- Compute resources: 550 CPU cores running Linux.
- Storage resources: 620 TB disk space.
- All hardware is commodity off the shelf (Dell, Sun/Oracle).
- Additionally there are a handful of dedicated systems (e.g. DB server, FTP server, workspace for science users). We are moving towards virtualized servers for these functions.
- All systems are connected by dedicated Cisco Gigabit switched Ethernet.
- Have demonstrated a 200X reprocessing rate for a typical satellite data processing scenario (200 days of global data processed in 1 calendar day).

Atmosphere PEATE Facility



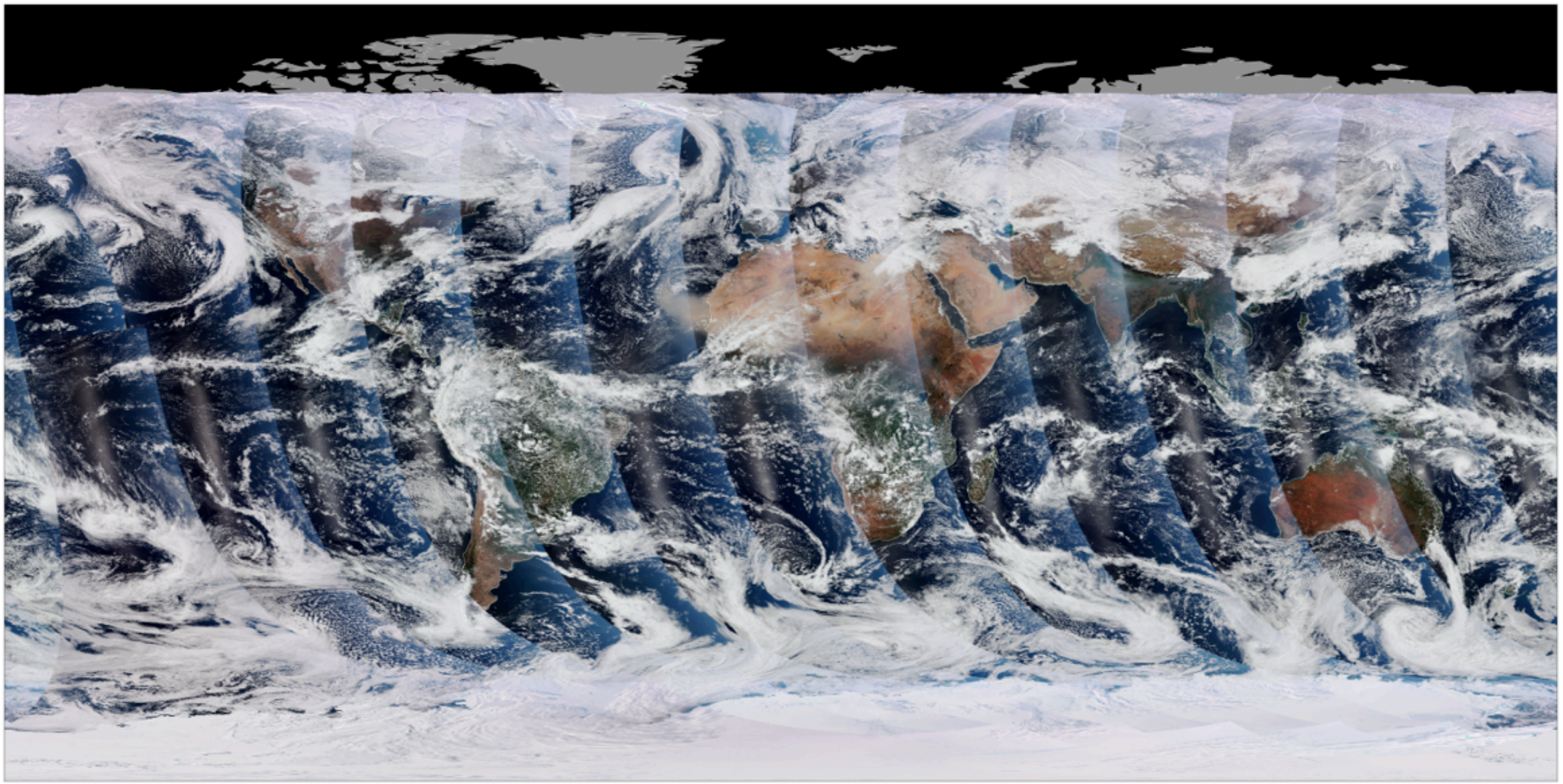
- PEATE hardware occupies 8 x 42U racks.
- Power available for Data Center is 260 KW, PEATE consumes about 50KW (all UPS).
- APC in-row coolers provide waste heat management.

PEATE Science Processing System

The Atmosphere PEATE Science Processing System builds on the PEATE cluster file system and batch scheduler to provide:

- Database and automation framework for algorithms recognizing how they may be chained together to reach various product types,
- Support for temporal and spatial matching of products from different sensors via orbital analysis,
- Web interface for creating, previewing, and monitoring large (year of data or more) work orders,
- Choose from list of supported products; the system will automatically construct the necessary workflow,
- Each step in the workflow may offer a variety of choices for the version / options for the algorithm that will run,
- User can choose which products will be saved as output from the work order,
- Previewing a work order will tell the user how much data is available for processing; this accounts for ancillary as well as sensor data files.

Atmosphere PEATE Automated Product: Example 1
Global True Color Imagery

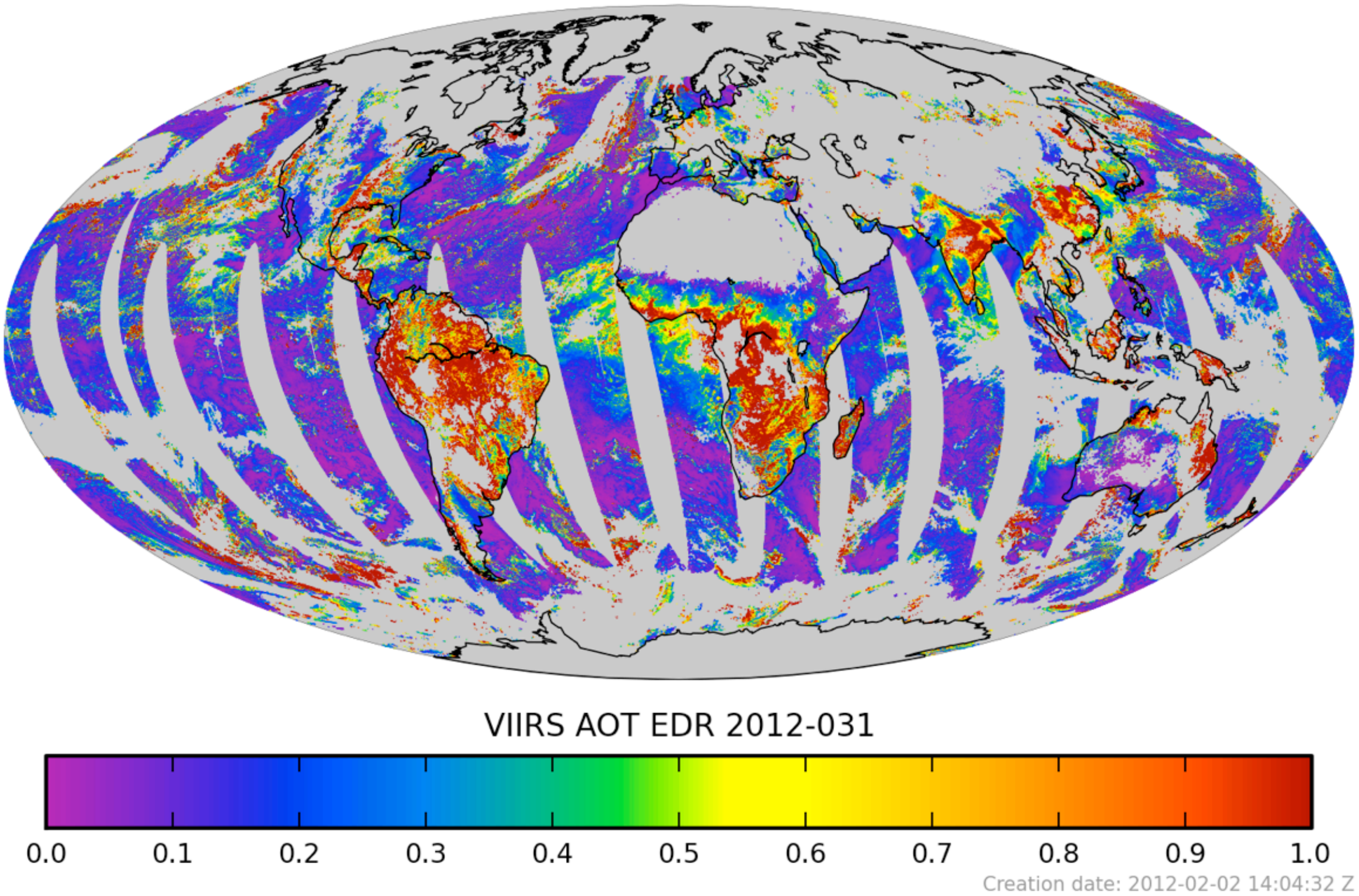


VIIRS RGB (True Color) 2012-02-06

R : M05 (0.672 μm); G : M04 (0.555 μm); B : M03 (0.488 μm)

Creation date: 2012-02-07 09:22:34 Z

Atmosphere PEATE Automated Product: Example 2
Global Air Quality (Purple=Good, Red=Bad)



Climate Data Processing

- Suomi NPP is very new. Evaluating products for Climate Record Quality will take 18-24 months.
- NOAA investigators at SSEC requested the assistance of the Atmosphere PEATE in processing a 33-year climate record of AVHRR data (14TB data input; 3TB output).
- PEATE ingested the required input data; integrated and tested the software with the science developers, and executed the processing jobs for the 33-year dataset.
- ***Processing was completed in one week (1720X reprocessing rate).***
- Benefit to scientists is (a) rapid product turnaround, (b) opportunity to do it again at low cost, if needed.

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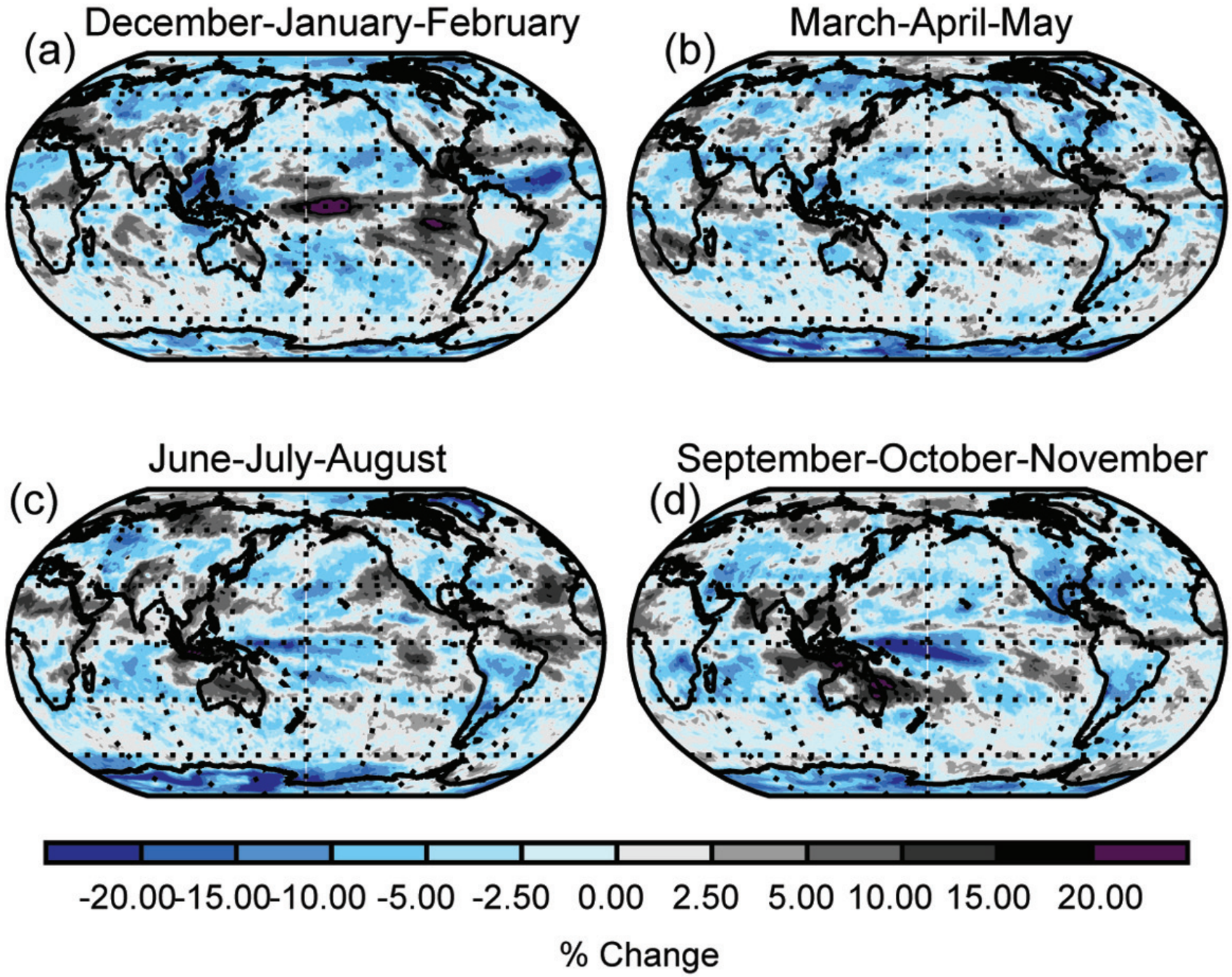
Examples of Global Cloudiness Anomalies Processed by the Atmosphere PEATE



Seasonal global cloudiness anomalies determined using the PATMOS-X dataset for (a) Dec 2009–Feb 2010, (b) Mar–May 2010, (c) Jun–Aug 2010, and (d) Sep–Nov 2010. Seasonal anomalies are calculated by subtracting the mean cloud fraction over the 1982–2010 base period from that of 2010 (BAMS State of the Climate 2010).

PATMOS-x Scientific Applications: Pollution from China increases cloud droplet number, suppresses rain over the East China Sea

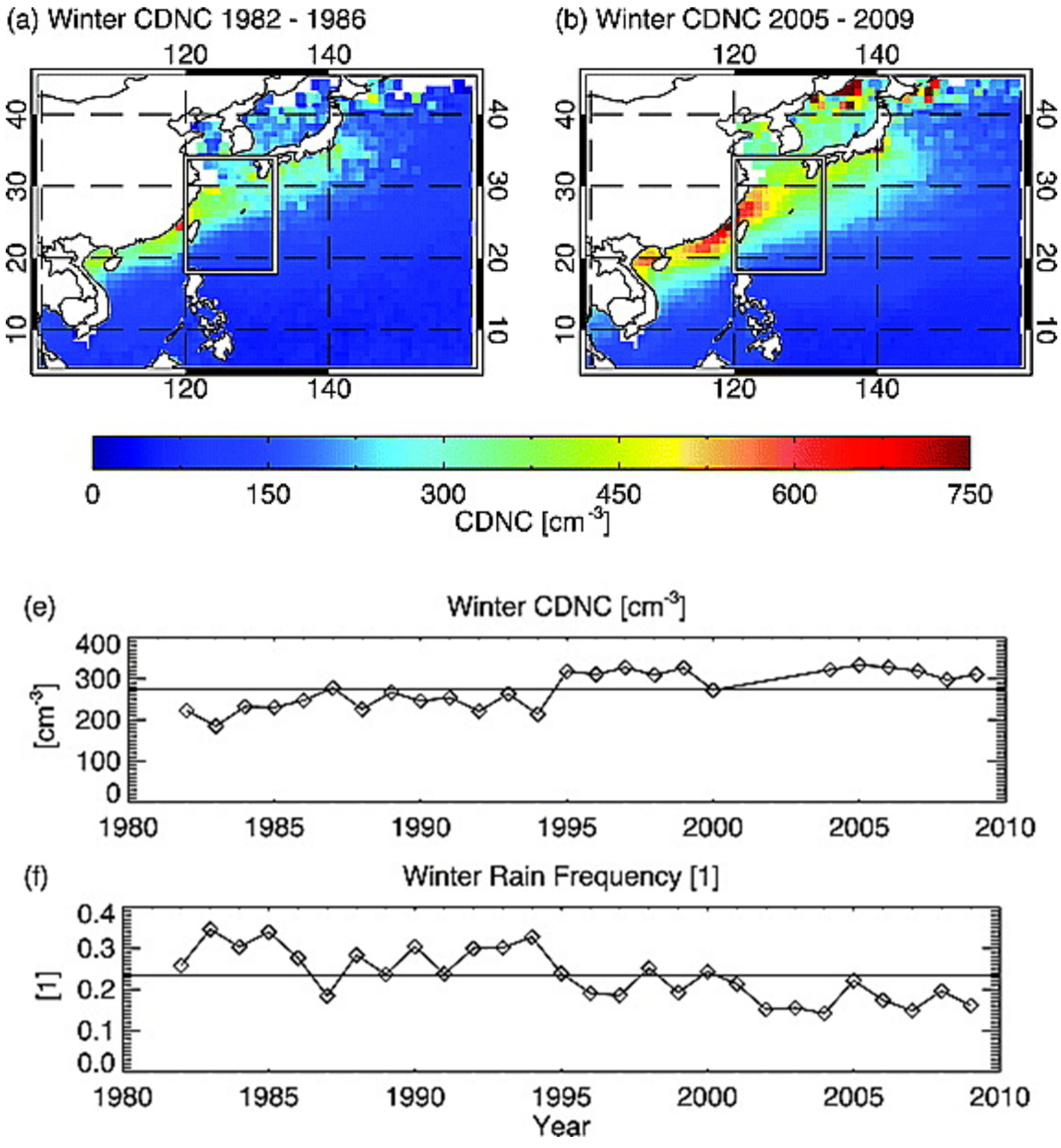
- PATMOS-x AVHRR data provides an estimate of Cloud Droplet Number Concentration (CDNC) which is the density of cloud droplets in a cloud.

- CDNC impacts precipitation. As CNDC increases, droplets tend to be smaller and precipitation formation is less efficient.

- CDNC is also driven by aerosols. The higher the aerosol content, the higher the values of CDNC.

- The recent study of Bennartz et al. (2011) used PATMOS-x data and other sources to explore this relationship in East China Sea from 1980 to 2010.

- They found that increasing air pollution from China was increasing CDNC and reducing winter rain frequency.



Bennartz, Ralf; Fan, Jiwen; Rausch, John; Leung, L. Ruby and Heidinger, Andrew K. Pollution from China increases cloud droplet number, suppresses rain over the East China Sea. Geophysical Research Letters, Volume 38, 2011, doi:10.1029/2011GL047235

Summary

- The Atmosphere PEATE at SSEC has created a new processing system to support the Suomi NPP mission, with funding from NASA since 2005.
- The Atmosphere PEATE has achieved a 1720X reprocessing rate for global climate data record creation.
- SSEC has a 30+ year track record in designing, constructing, operating, and maintaining satellite data processing systems.
- SSEC people, data resources, technical know-how, and experience over the last 30 years make it the logical and low-risk choice for developing the GMW/Storm ground system.

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