IPM Status

Daniel Mandl - NASA\GSFC
Oct 16, 2012

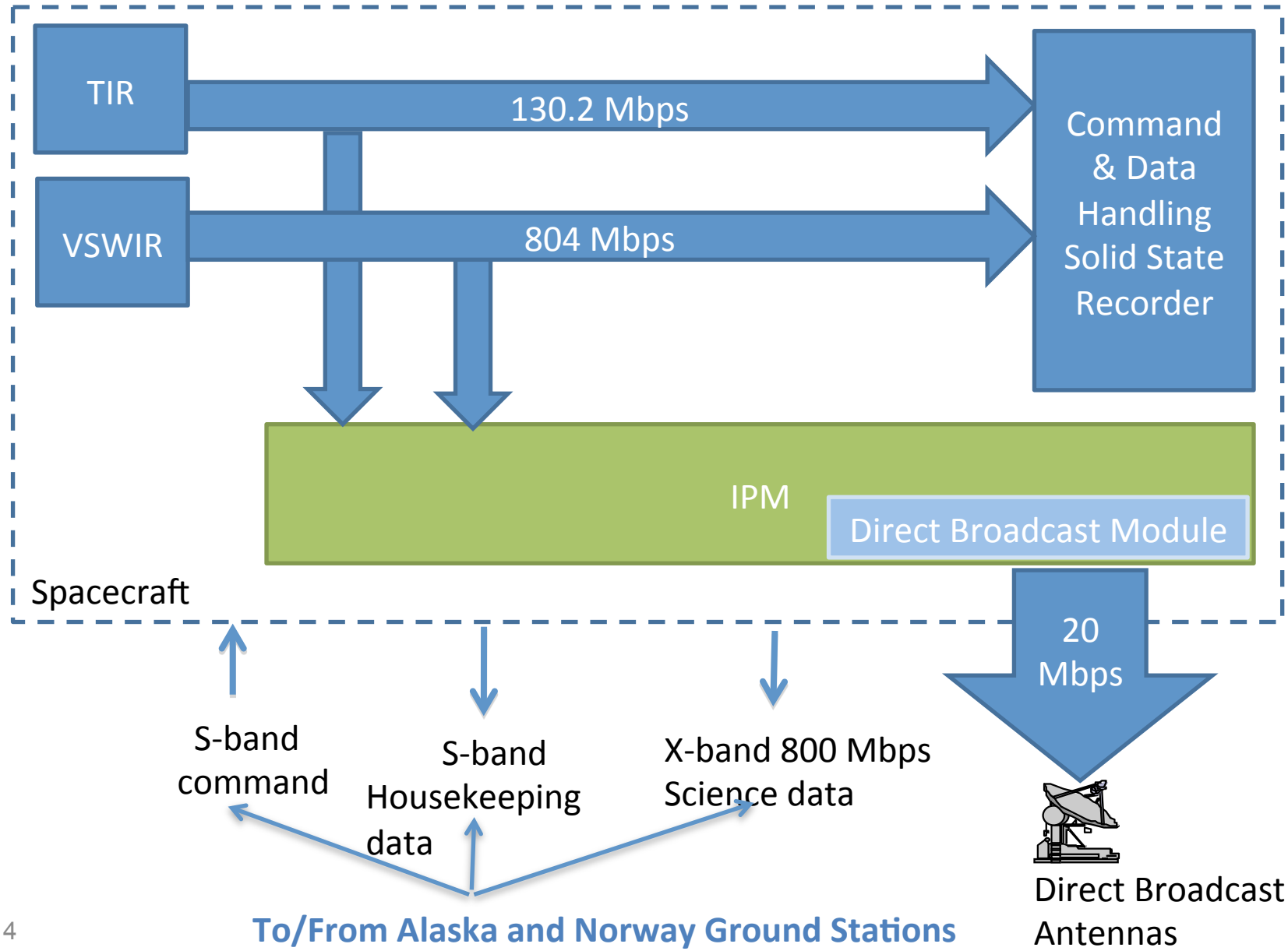
Team

Daniel Mandl – NASA/GSFC - lead
Robert Sohlberg – Univ. of Maryland/Dept. of Geography – SensorWeb scientist
Pat Cappelaere – Vightel Corporation – SensorWeb architecture
Stuart Frye – NASA/GSFC – SGT Inc. – systems engineer
Vuong Ly – NASA/GSFC – system engineer, software developer
Matthew Handy – NASA/GSFC – software developer
Donald Sullivan – NASA/Ames – flight SW, ground SW for AMES based airborne flights
Geoff Bland – NASA/WFF – Cessna flights
Enric Pastor – Univ. of Cataluña, Barcelona, Spain – UAV Helicopter
Vince Ambrosia - NASA/Ames – AMS instrument, B200/B100 flights, Ikhana
Steve Crago – ISI – Univ. of Southern Cal/ISI – Maestro onboard computer arch
Steve Chien – NASA/JPL – onboard algorithms
Tawanda Jacobs – NASA/GSFC – flight SW
Tim Creech – Univ. of Maryland – NASA Science and Technology Research Fellow
Chris Flatley – NASA/GSFC summer intern
Neil Shaw – NASA/GSFC summer intern
Joshua Bronston – NASA/GSFC co-op

Objectives

- Develop methods to provide low latency users of HyspIRI with quick look data products
- Augment concept of Science As A Service by providing an interface for non-programmer users to define new algorithms and select data sets and data feeds to run the algorithms against
- Virtualize the interface to various environments with adapters that take into account the resources and methods to expose key data and data products
- Experiment with high performance multicore space computing architectures in order to meet the future significantly higher data rates.
- Develop increasingly realistic operational architectures that emulate the target satellite architecture for HyspIRI and other Decadal missions

Original HyspIRI Low Latency Data Flow Operations Concept

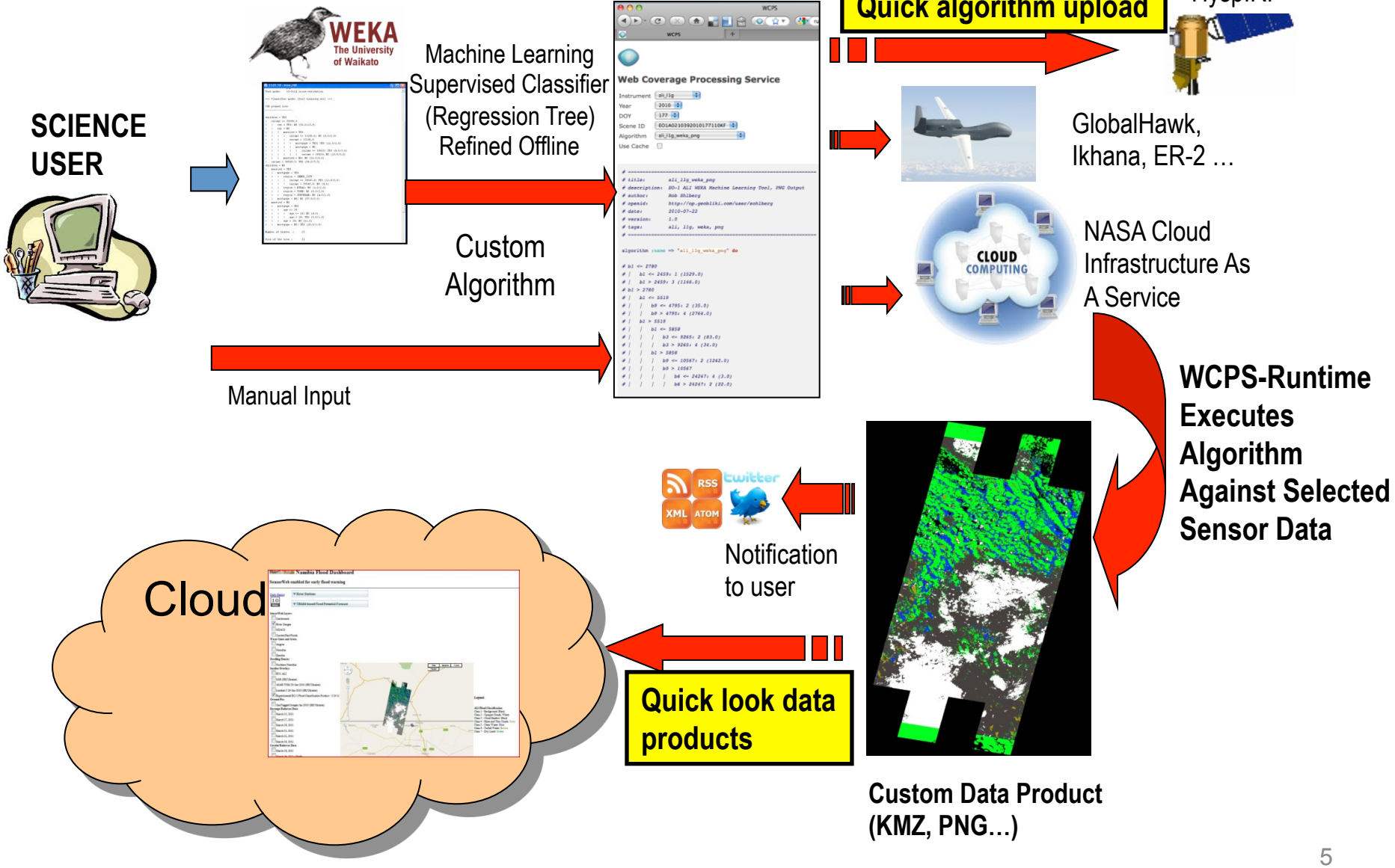


4

Experimental IPM Quick Load/Quick Look Ops Con

Enhanced Ops Con from Baseline IPM Ops Con

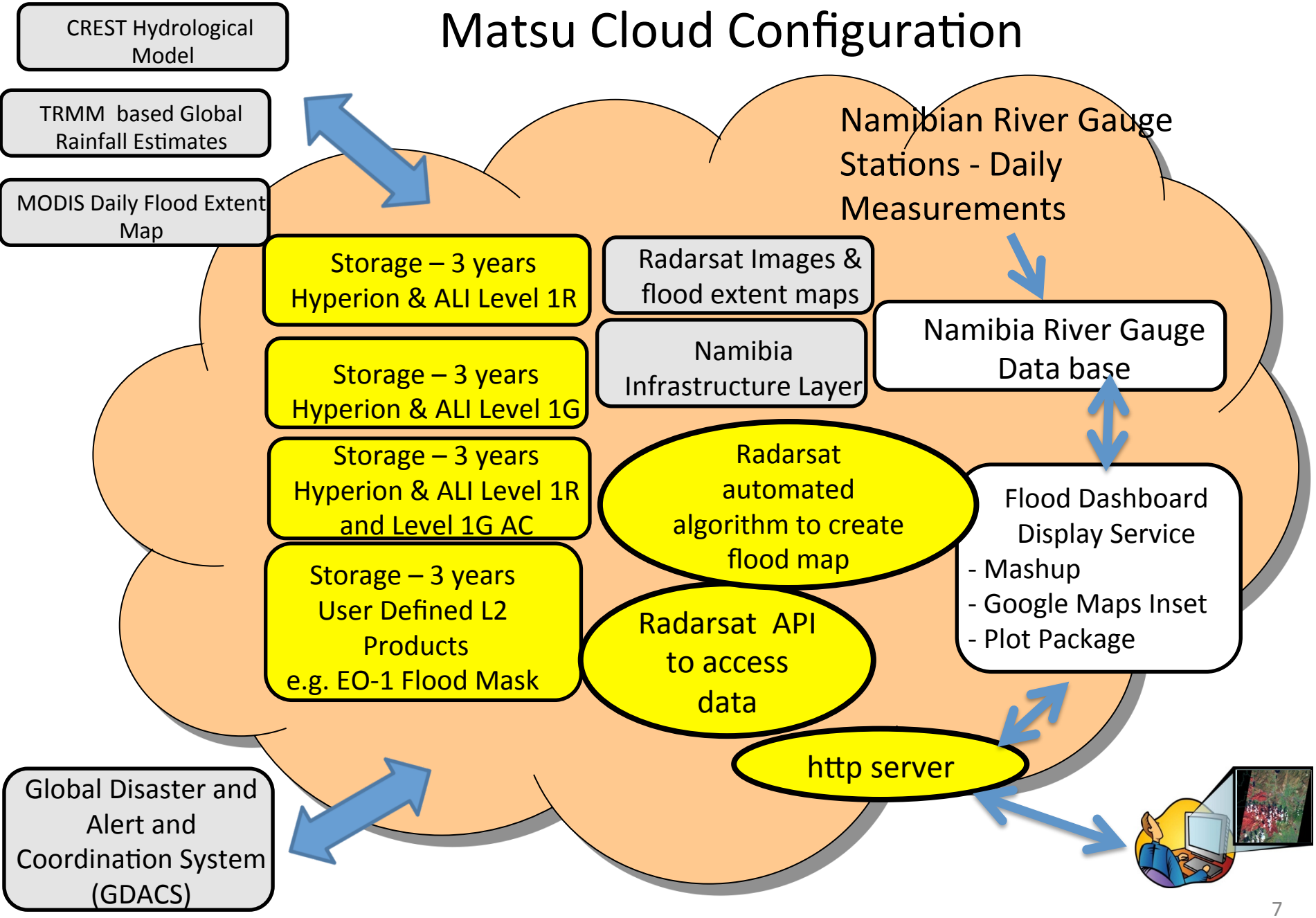
Web Coverage Processing Service (WCPS)-Client Uploads to Various Environments



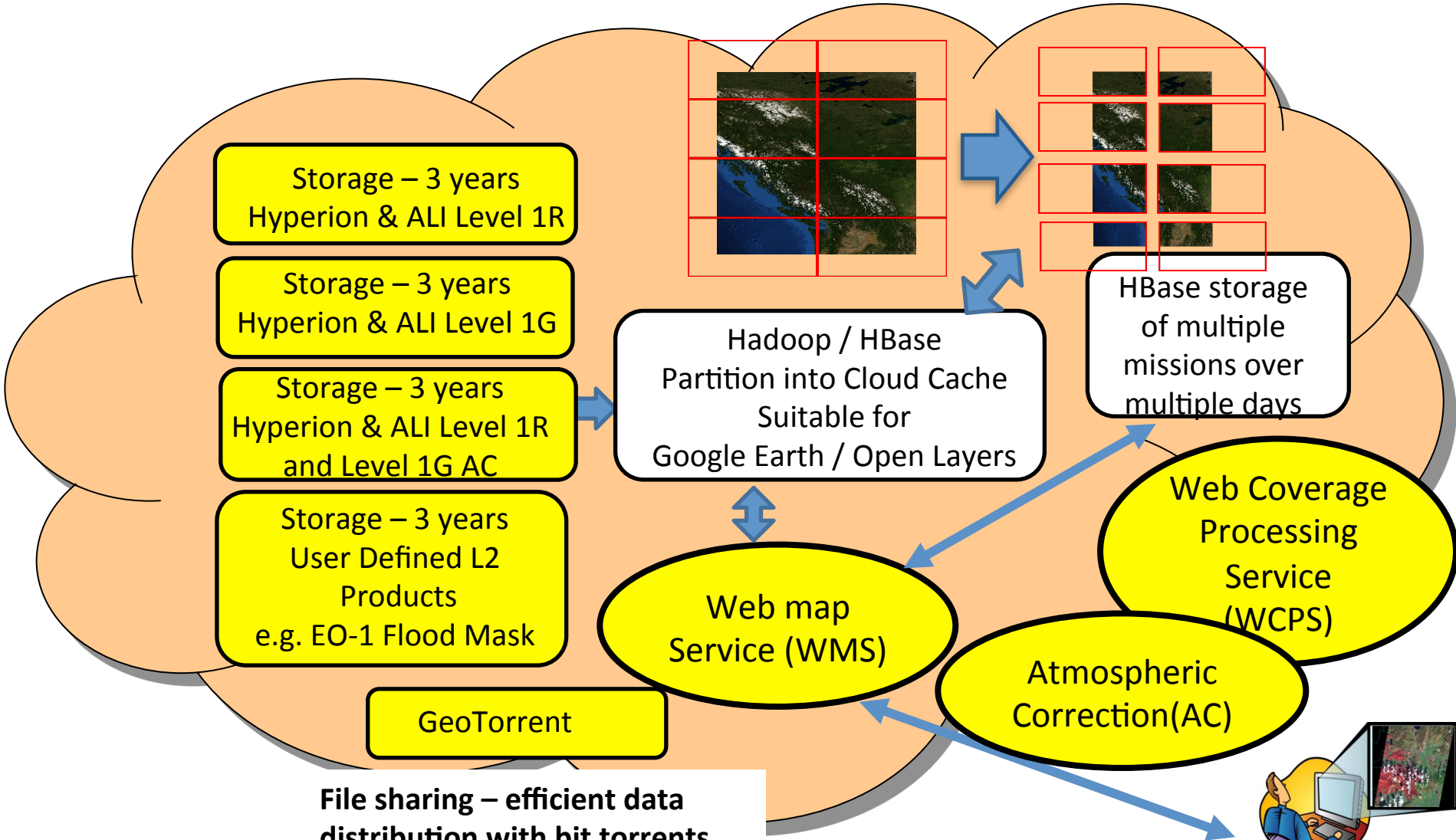
Matsu Cloud

- Has 35 Tbytes of EO-1 data
- Plan to grow to 1 -5 Petabytes (Robert Grossman/Director Open Cloud Consortium)
- Web Map Service with Hadoop file system for tiling
- Run science collaboration tools for large data sets

Matsu Cloud Configuration



Matsu Cloud (In process)
Hadoop and Tiling Handles Large Dataset Displays

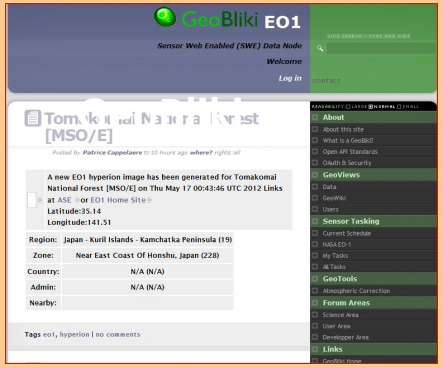


File sharing – efficient data distribution with bit torrents, trackers and seeders

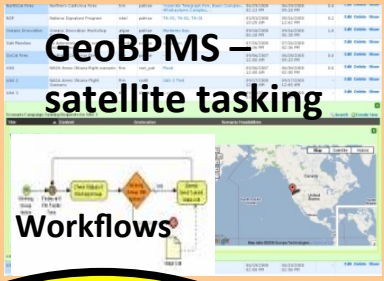
Joyent Cloud (commercial)

GeoTorrent

File sharing – efficient data distribution with bit torrents, trackers and seeders



GeoBliki (data product creation and distribution)



Radarsat Tasking API extension to GeoBPMS

OpenScienceDataCloud Experimental Website

OCC Project Matsu - Mozilla Firefox

File Edit View History Bookmarks Tools Help

OCC Project Matsu

matsu.opensciencedatacloud.org

OSDC Console Apply Public Data Status Projects Support News/PIRE

Open Science Data Cloud

OCC Project Matsu

An open source project for cloud-based processing of satellite imagery to support the earth sciences.

Project Matsu

Project Matsu is a collaboration between NASA and the Open Cloud Consortium to develop open source technology for cloud-based processing of satellite imagery to support the earth sciences. Technology developed by the collaboraton include:

- The Nambia Flood Dashboard.
- MapReduced based analytics for identifying floods and CO_2 concentrations.
- Using elastic infrastructure-as-a-service to create Level 1 images each day.
- A Hadoop-based OGC-compliant tiling service and Web MapService.

You can learn more from these five minute videos introducing some Matsu tools.

Matsu Resources

- Daily Nambia Flood Dashboard
- Hadoop-supported Web Map Service (WMS)
- Available Matsu images

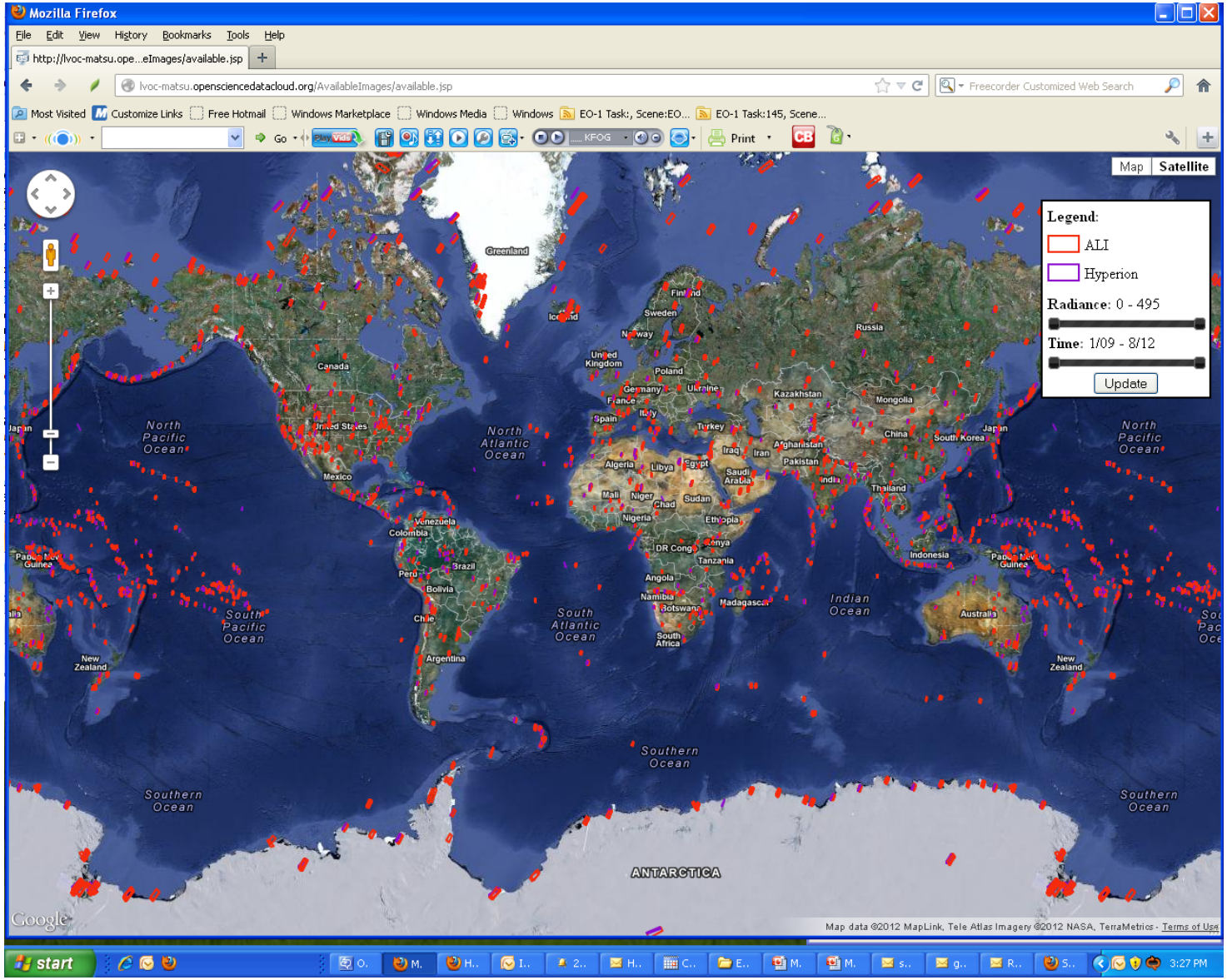
Matsu Support

- The code can be found at the OCC Github site.
- Description of Matsu Tile and WMS Services.
- Sample CO_2 Detection Query (click "CO_2")
- Sample Flood Detection Query (click "cloud, land, water")

The OSDC is a resource of the Open Cloud Consortium and made possible by our sponsors.

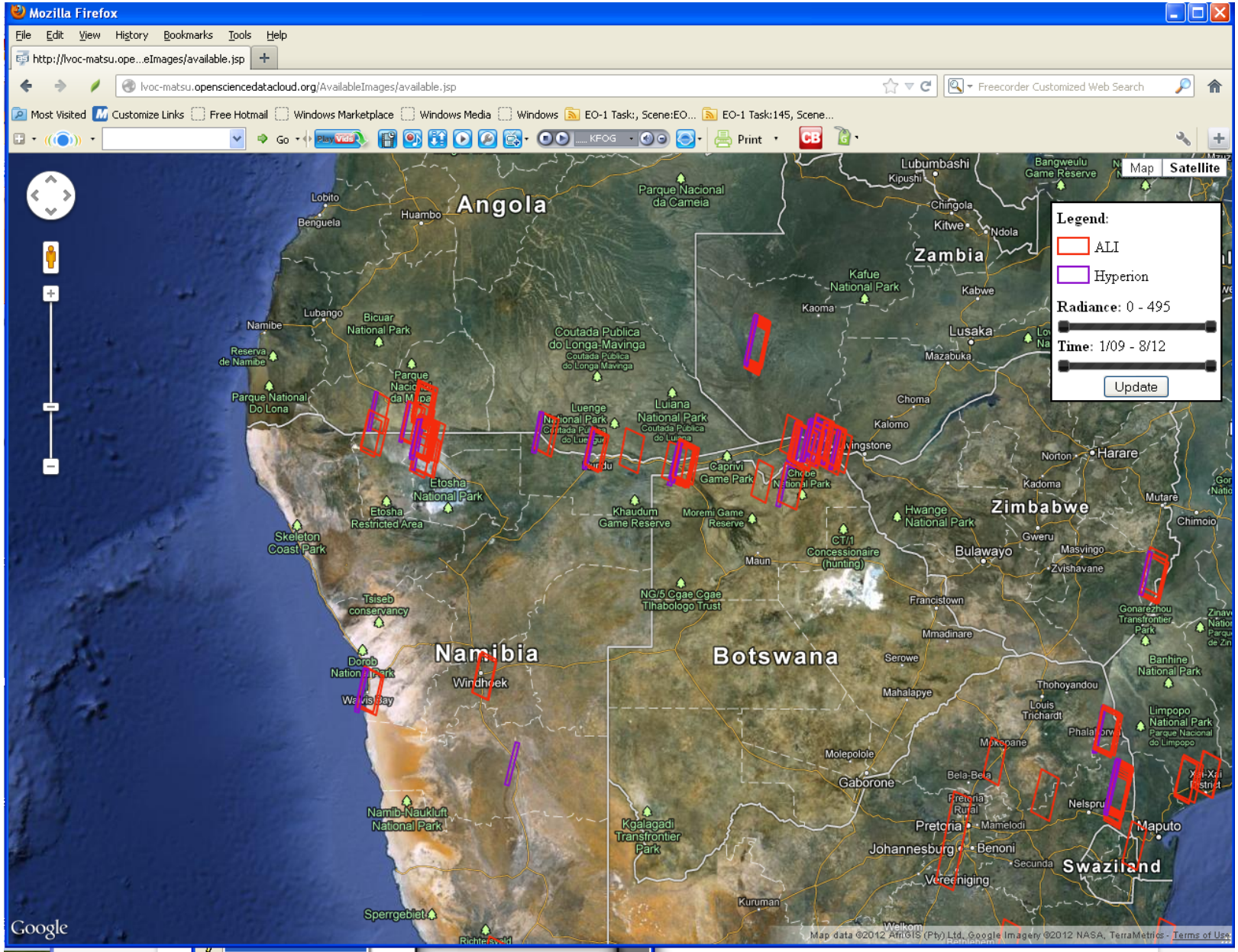
Available Matsu Data

All Hyperion and ALI Images on Cloud



Available Matsu Data (Zoom in)

All Hyperion and ALI Images on Cloud



OpenScienceDataCloud Experimental Website

OCC Project Matsu - Mozilla Firefox

File Edit View History Bookmarks Tools Help

OCC Project Matsu

matsu.opensciencedatacloud.org

OSDC Console Apply Public Data Status Projects Support News/PIRE

Open Science Data Cloud

OCC Project Matsu

An open source project for cloud-based processing of satellite imagery to support the earth sciences.

Project Matsu

Project Matsu is a collaboration between NASA and the Open Cloud Consortium to develop open source technology for cloud-based processing of satellite imagery to support the earth sciences. Technology developed by the collaboraton include:

- The Nambia Flood Dashboard.
- MapReduced based analytics for identifying floods and CO_2 concentrations.
- Using elastic infrastructure-as-a-service to create Level 1 images each day.
- A Hadoop-based OGC-compliant tiling service and Web MapService.

You can learn more from these five minute videos introducing some Matsu tools.

Matsu Resources

- Daily Nambia Flood Dashboard
- Hadoop-supported Web Map Service (WMS)
- Available Matsu images

Matsu Support

- The code can be found at the OCC Github site.
- Description of Matsu Tile and WMS Services.
- Sample CO_2 Detection Query (click "CO_2")
- Sample Flood Detection Query (click "cloud, land, water")

The OSDC is a resource of the Open Cloud Consortium and made possible by our sponsors.

Hadoop Based WMS Product Display
Flood Classifier Over Multiple ALI Images

SimpleWMS - Mozilla Firefox

File Edit View History Bookmarks Tools Help

SimpleWMS

lvoc-matsu.opensciencedatacloud.org/SimpleWMS/?lat=-17.4&lng=15.8&z=9

Most Visited | Customize Links | Free Hotmail | Windows Marketplace | Windows Media | Windows | EO-1 Task:, Scene:EO... | EO-1 Task:145, Scene...

Timespan

2009 2010 2011 2012 2013

Layers

- [ ] Canonical RGB
- [ ] CO_2
- [x] cloud, land, water

Latitude-longitude Points

Source: limit-of-resolution entities

- [x] Show points

Filter by "analyticsscore"

latitude	longitude	acquisition time	analyticsc
2.62903	102.197	2012-05-18 10:10	6.321395
2.72211	102.25	2012-05-18 10:10	7.585569
2.80338	102.237	2012-05-18 10:10	5.774875
2.79175	102.245	2012-05-18 10:10	5.950269
2.7807	102.27	2012-05-18 10:10	6.323581
2.8103	102.296	2012-05-18 10:10	5.480126
2.85526	102.282	2012-05-18 10:10	5.841407
2.97919	102.31	2012-05-18 10:10	7.364109
2.99525	102.339	2012-05-18 10:10	5.218334

Map | Satellite

Onayena Constituency

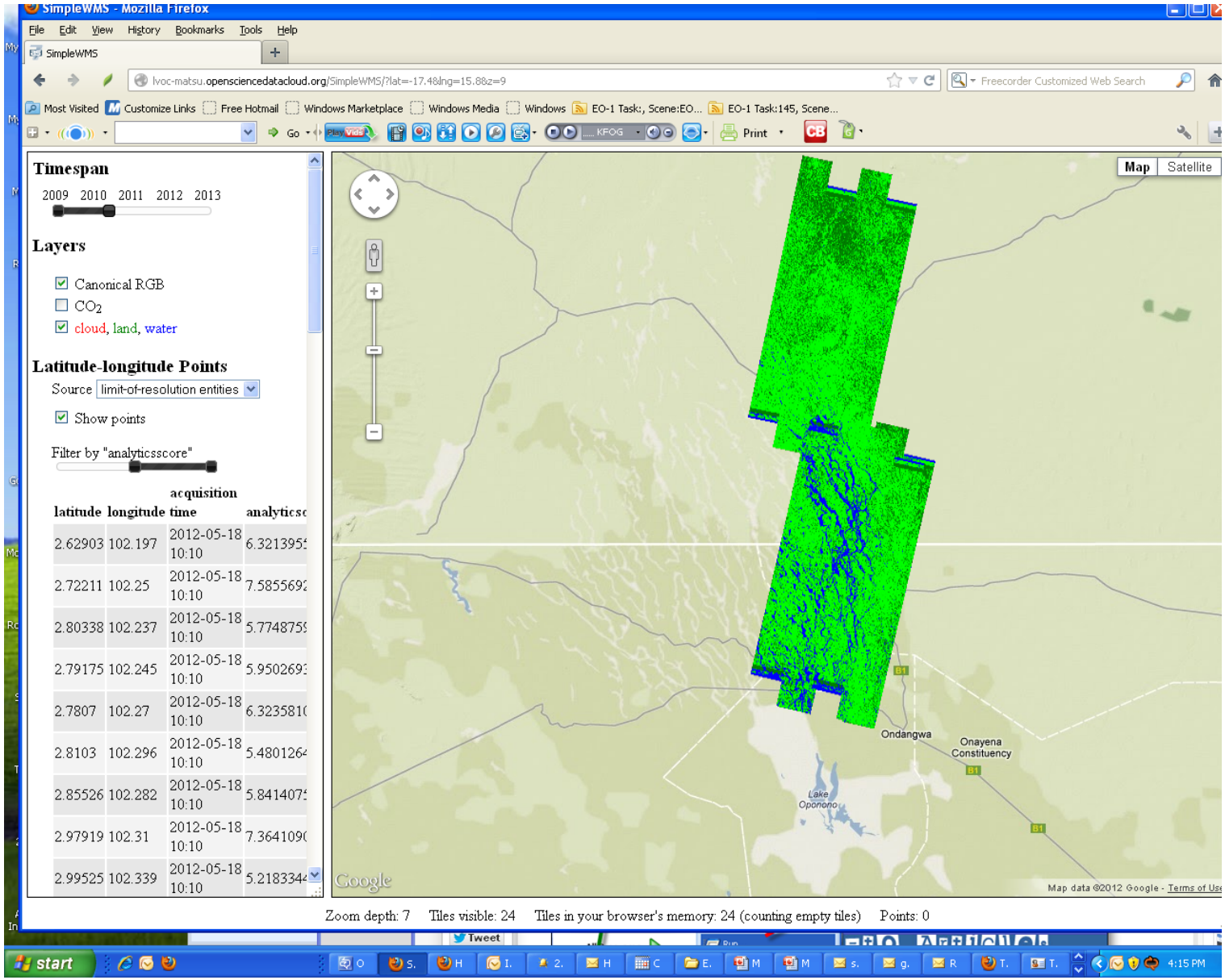
Google

Map data ©2012 Google - Terms of Use

Zoom depth: 7 Tiles visible: 24 Tiles in your browser's memory: 24 (counting empty tiles) Points: 0

start | Office Com... | SimpleWMS ... | How-To Tak... | E:\HyspIRI ... | TOMS Main -... | E:\SES Task ... | Sensorweb ... | 4:29 PM

Hadoop Based WMS Product Display
Flood Classifier, Time Span Reduced



OpenScienceDataCloud Experimental Website

OCC Project Matsu - Mozilla Firefox

File Edit View History Bookmarks Tools Help

OCC Project Matsu

matsu.opensciencedatacloud.org

OSDC Console Apply Public Data Status Projects Support News/PIRE Open Science Data Cloud

OCC Project Matsu

An open source project for cloud-based processing of satellite imagery to support the earth sciences.

Project Matsu

Project Matsu is a collaboration between NASA and the Open Cloud Consortium to develop open source technology for cloud-based processing of satellite imagery to support the earth sciences. Technology developed by the collaboraton include:

- The Nambia Flood Dashboard.
- MapReduced based analytics for identifying floods and CO_2 concentrations.
- Using elastic infrastructure-as-a-service to create Level 1 images each day.
- A Hadoop-based OGC-compliant tiling service and Web MapService.

You can learn more from these five minute videos introducing some Matsu tools.

Matsu Resources

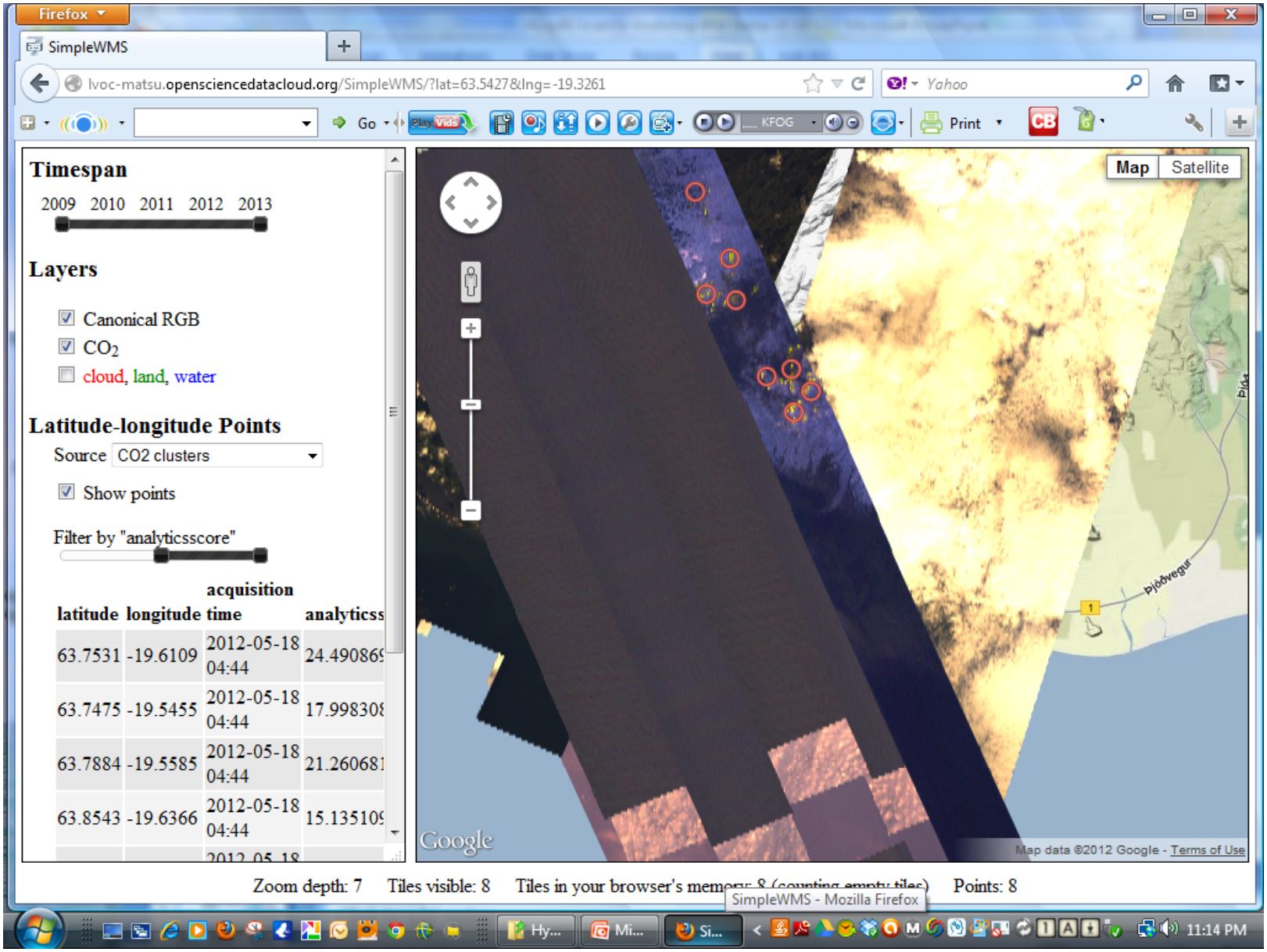
- Daily Nambia Flood Dashboard
- Hadoop-supported Web Map Service (WMS)
- Available Matsu images

Matsu Support

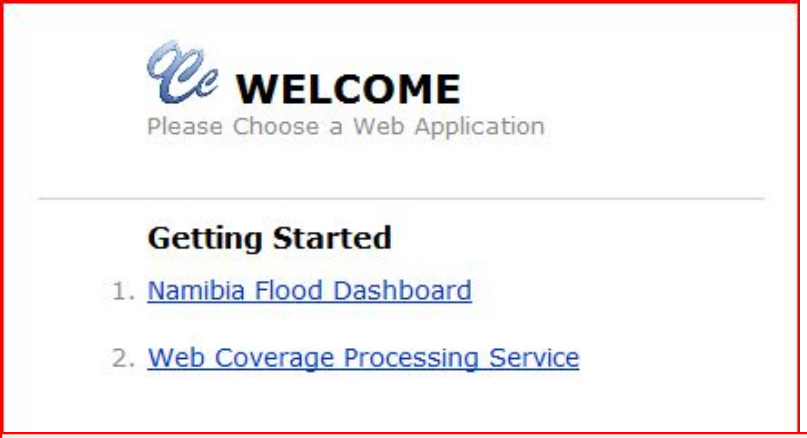
- The code can be found at the OCC Github site.
- Description of Matsu Tile and WMS Services
- Sample CO_2 Detection Query (click "CO_2")
- Sample Flood Detection Query (click "cloud, land, water")

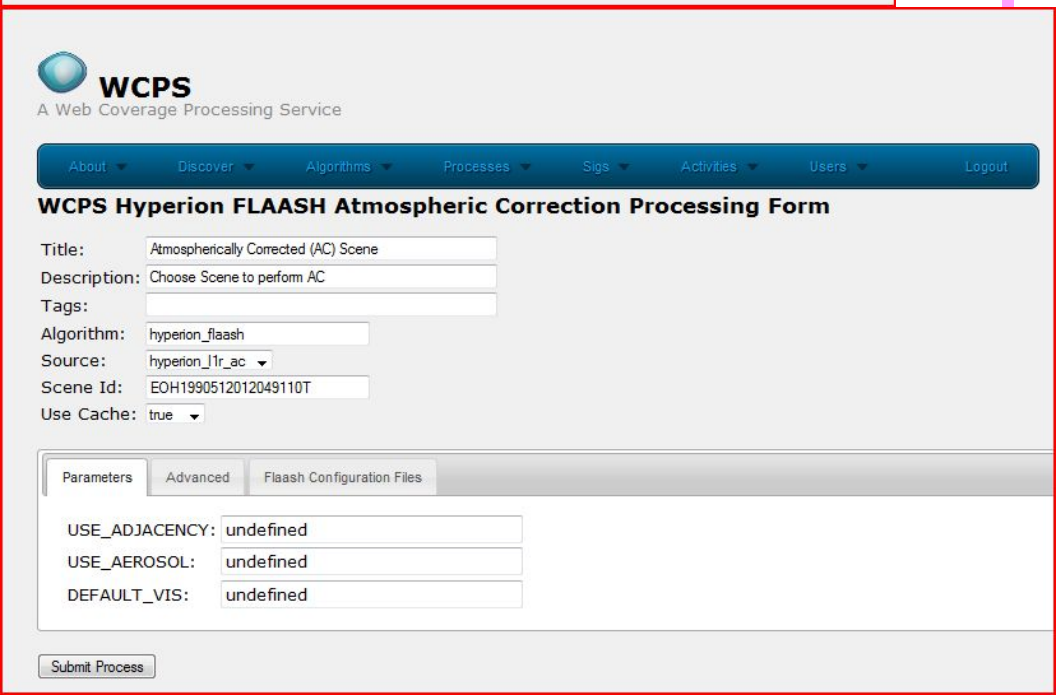
The OSDC is a resource of the Open Cloud Consortium and made possible by our sponsors.

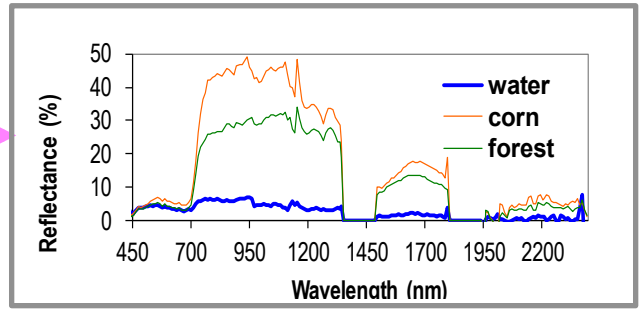
Hadoop Based WMS Product Display CO_2 Detection



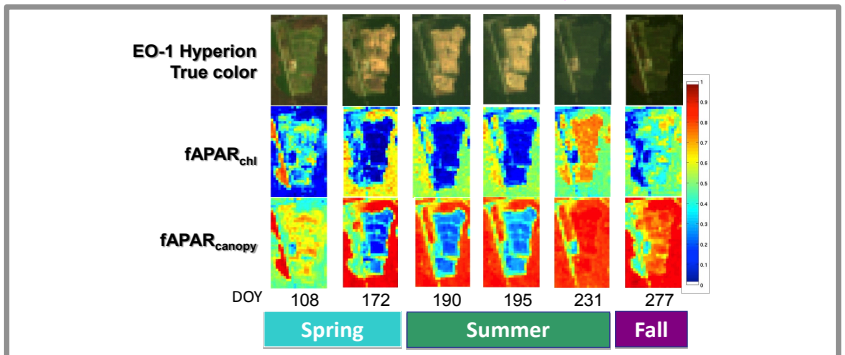
Web Coverage Processing Service







Selected scene with applied algorithms including atmospherics correction



EO-1 Product Prototypes: **albedo, water content, derivatives, fAPAR, chlorophyll, N .....**

Namibia Flood Dashboard

Namibia Flood Dashboard

SensorWeb enabled for early flood warning

Daily Report

April 12

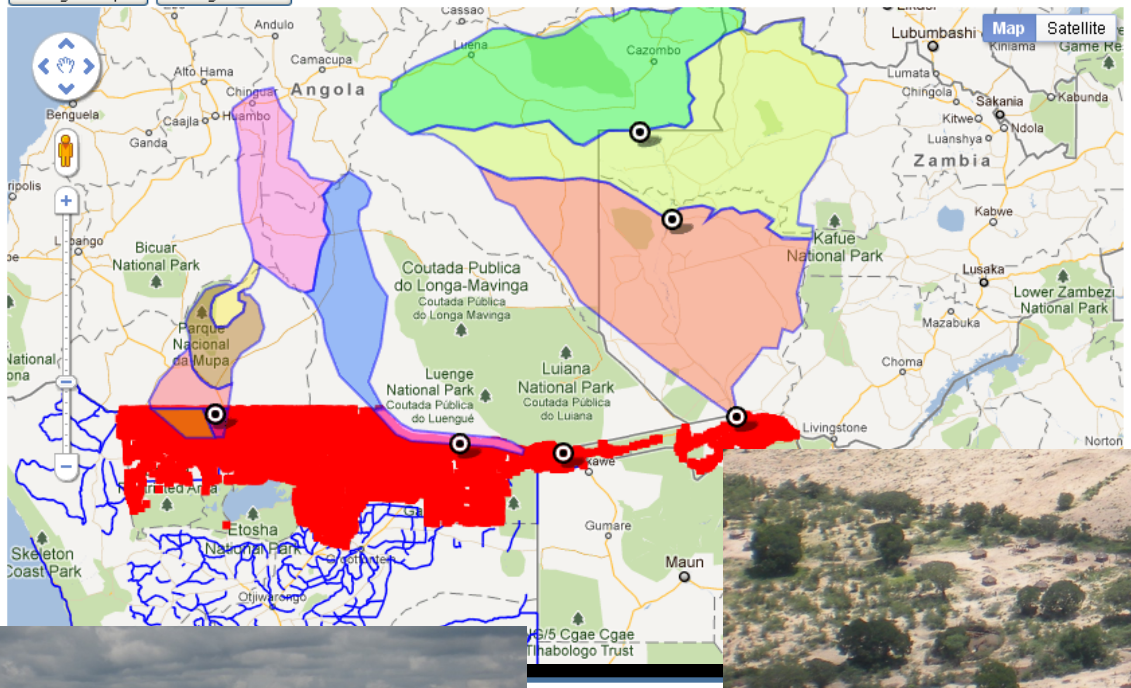
Daily Bulletin:

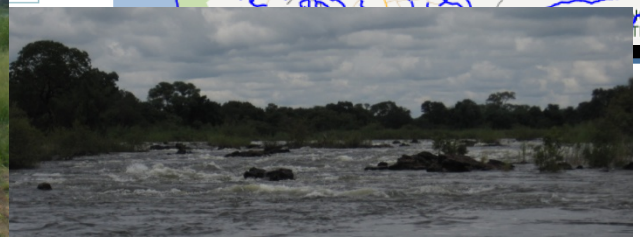
HYDROLOGICAL SERVICES NAMIBIA – DAILY FLOOD BULLETIN 03 APRIL 2012

- View Complete Current Bulletin
- View Bulletin Records
- Search Bulletin Records
- New Bulletin

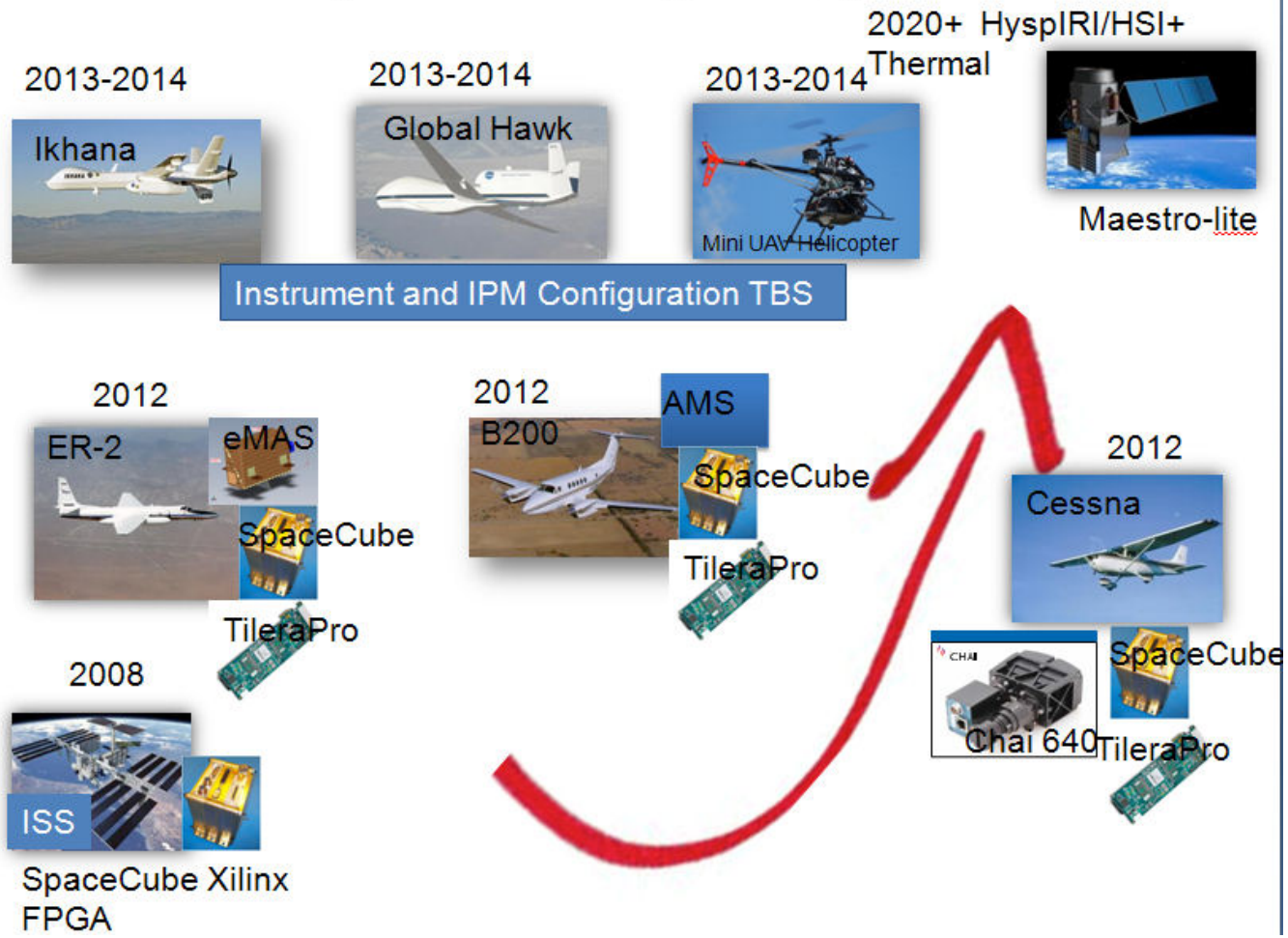
- River Stations
- SensorWeb Layers
- Water Lines and Areas
- Satelite Overlays
- Ground Pics
- Kavango Radarsat Data
- Cuvelai Radarsat Data
- TRMM Rainfall Accumulation and Flood Forecast
- Global Scene Counts

Google Maps | Google Earth

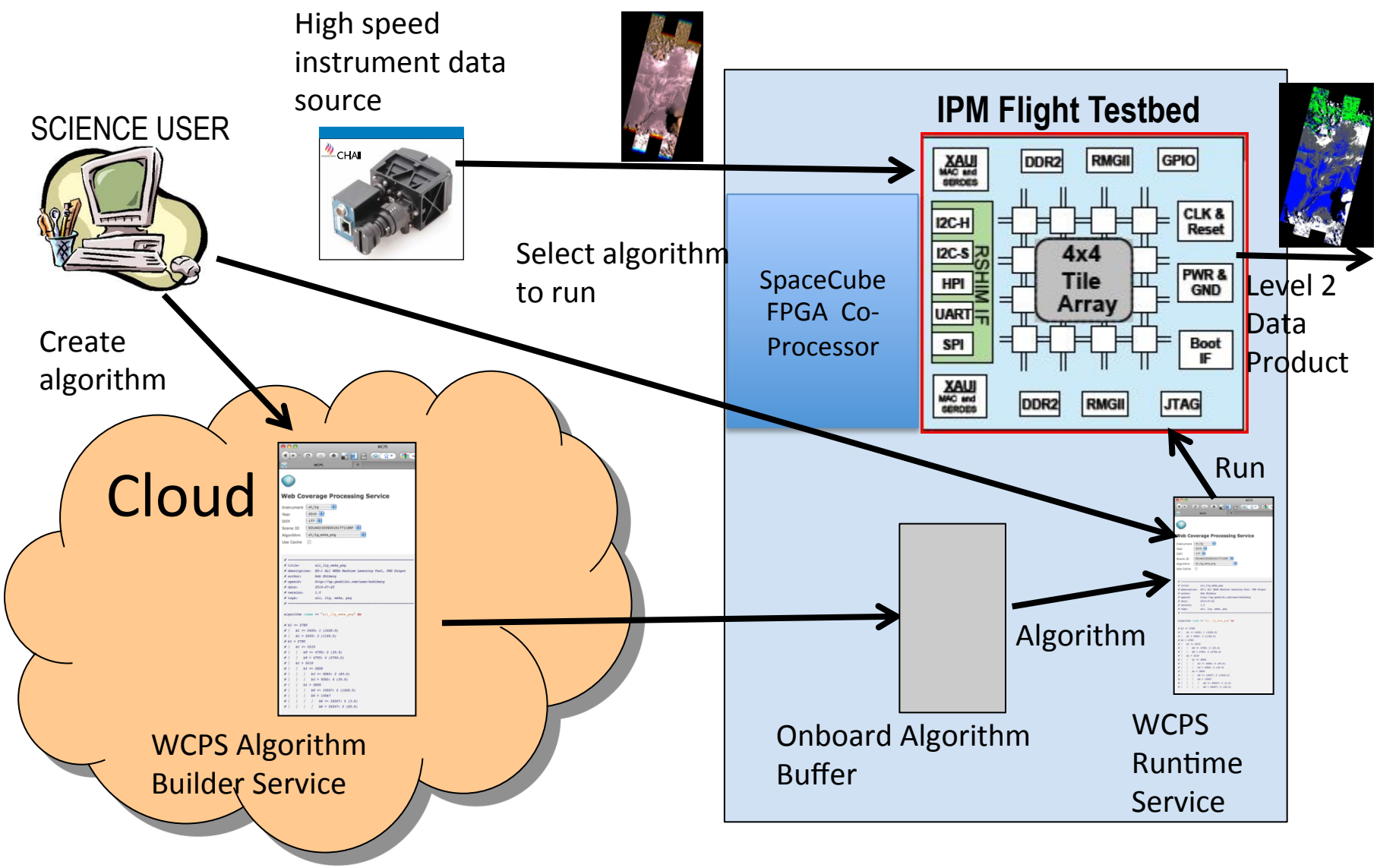




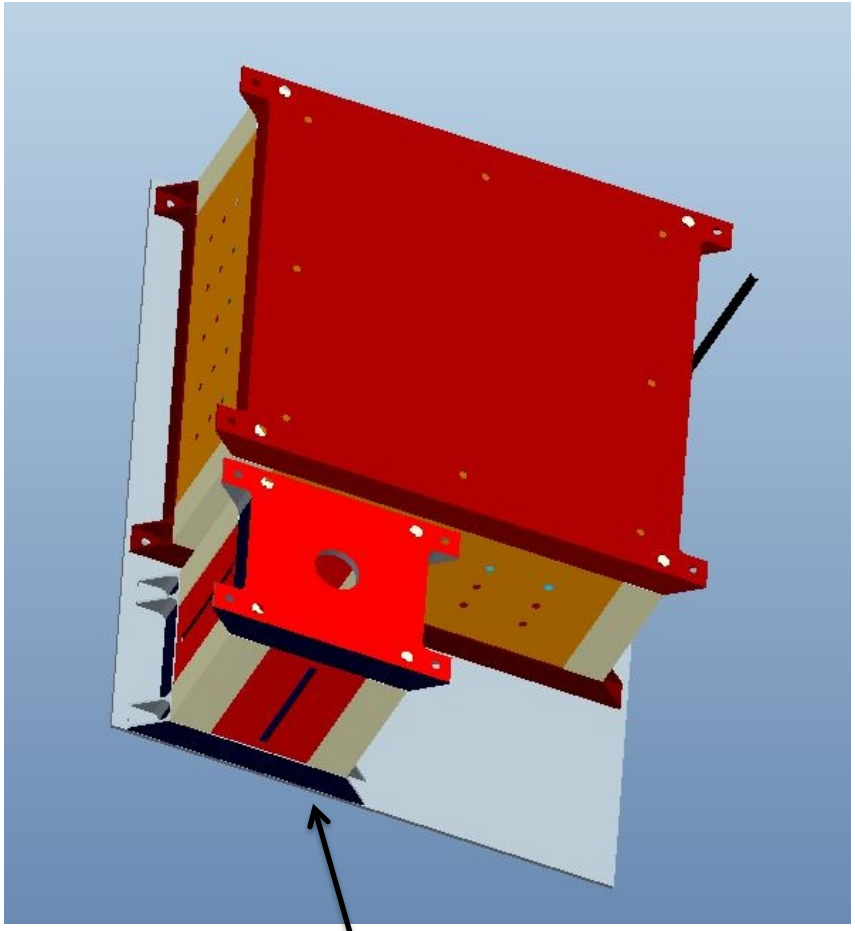
Roadmap for IPM Flight Opportunities



Top Level Ops Concept

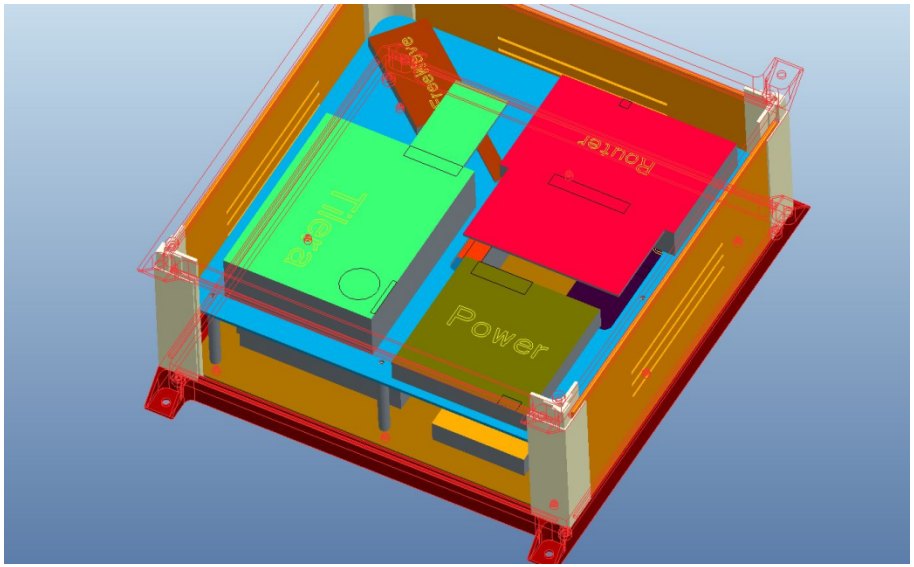


Mechanical Design of IPM Box



Chai640 Instrument

Revised Bussmann Plate for Helicopter Pro-E Design (C. Flatley, N. Shah), Merged Tilera and Space Cube Box



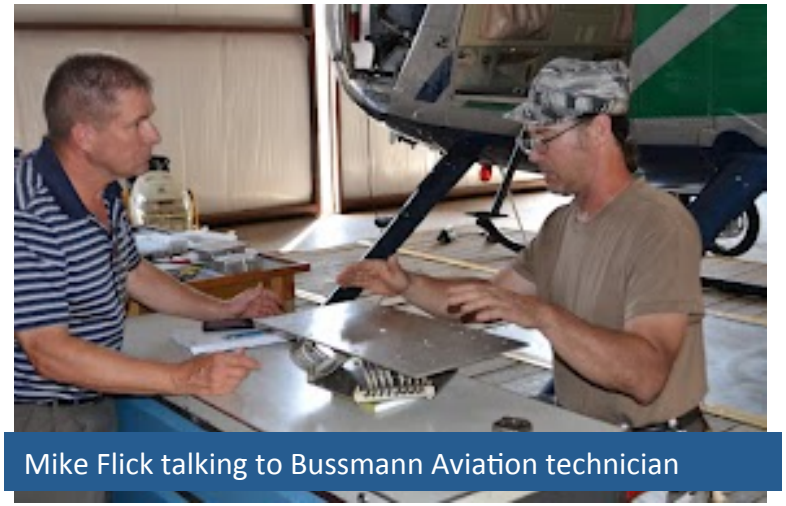
Plan to Mount IPM to Helicopter for Tests Under AIST ESTO Research Grant

Vibration isolation mount for helicopter

Mike Mandl/UMCP student

Chris Flatley/581 Summer intern

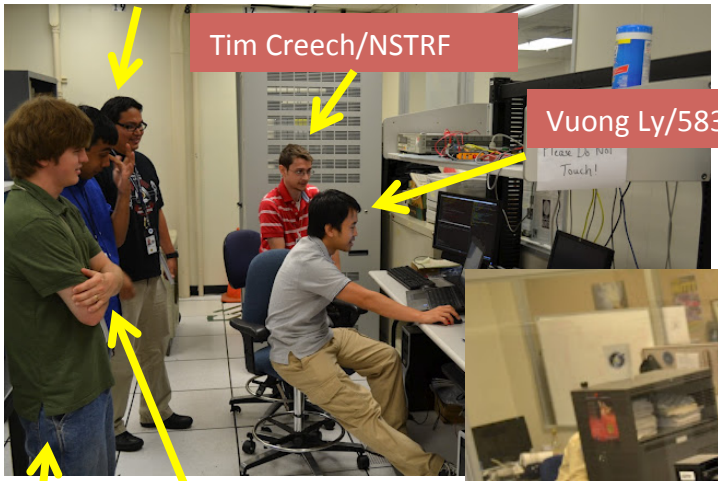
Joshua Bronston/581

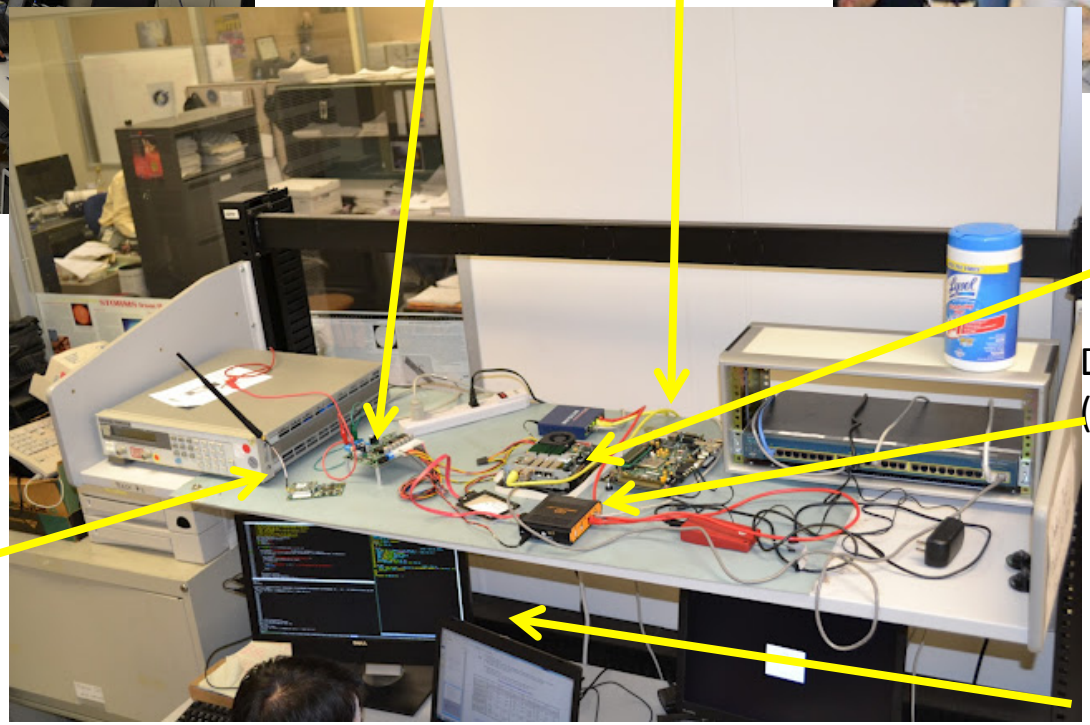


Mike Flick talking to Bussmann Aviation technician

Steve Bussmann/Bussmann Aviation

Intelligent Payload Module (IPM) Prototype without Box





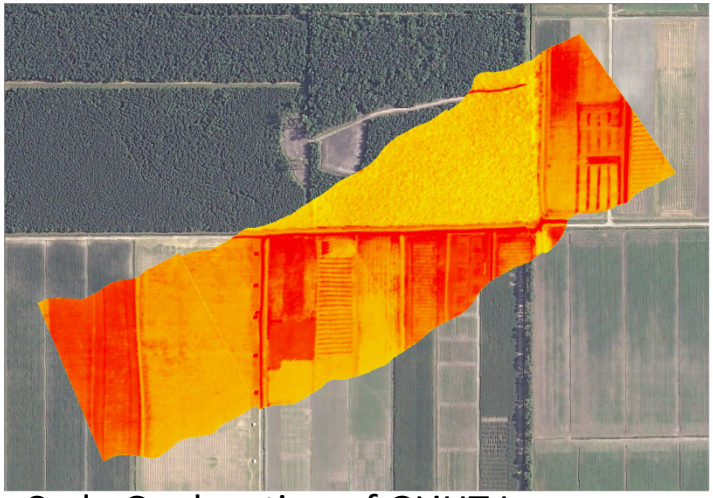
First Rooftop Test with IPM

Drove abut 1 mile away with ground software

Ground System Control for IPM

ASIST Ground Software - Used by Earth Observing 1 Flights Ops Team to control EO-1

Georeferenced Image from GLiHT



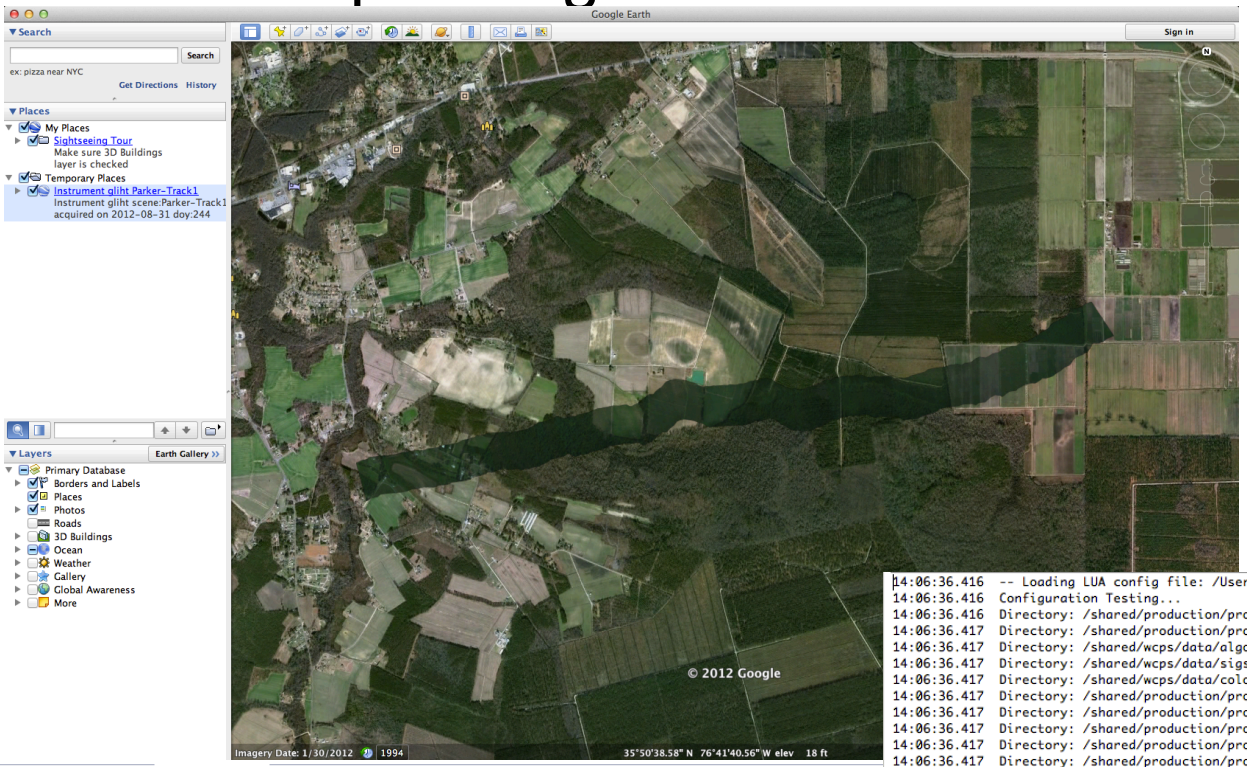
Code Geolocation of GLiHT Image

Geolocation augmented with ArcGIS

Overlay of both

Research being done by Joshua Bronston, 581 Coop Navajo Tech College, in Masters for EE Program

Geo-Correction for Airborne Platforms (GCAP) Operating on G-LiHT Airborne Data



Headwall imaging spectrometer

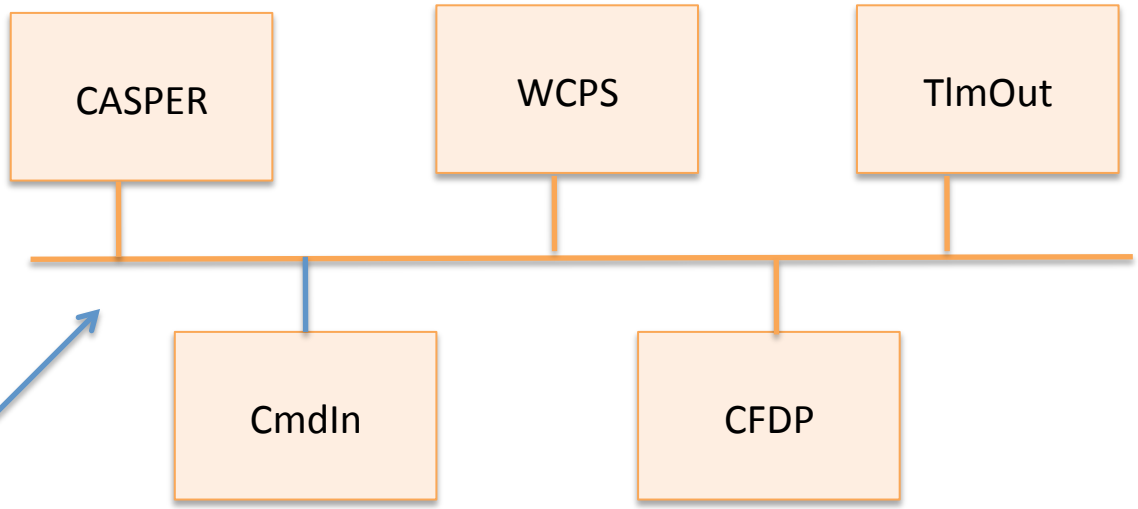
```
<terminated> gcap [C/C++ Application] /Users/imvuong/Documents/code/gcap/src/.libs/gcap (10/15/12 2:05 PM)
config.c:32: INPUT_FILENAME = /Users/imvuong/Documents/code/gcap/data/input/Parker-Track1.bin
config.c:32: IMU_POSITION_FILE = /Users/imvuong/Documents/code/gcap/data/input/110728_132454.pos
config.c:32: INSTR_TIMESTAMP_FILE = /Users/imvuong/Documents/code/gcap/data/input/Parker-Track1.asc
config.c:32: BAND = 40 80 160
config.c:32: OUTPUT_DIR = /shared/production/proddata/gliht_l1g/Parker-Track1/
config.c:57: ROLL_OFFSET = 0.000000
config.c:57: PITCH_OFFSET = 0.000000
config.c:57: ALTITUDE_OFFSET = 0.000000
config.c:57: HEADING_OFFSET = 0.000000
config.c:57: INSTR_TIMESTAMP_OFFSET = -0.460000
config.c:57: INSTR_VIEW_ANGLE = 53.000000
main.c:213: Input image size: 1004x5465x402.
gcap.c:166: UL: 35.851659867857456732,-76.730605800650906190
gcap.c:167: UR: 35.851659867857456732,-76.658554548188419631
gcap.c:168: LL: 35.836418930876448030,-76.730605800650906190
gcap.c:169: LR: 35.836418930876448030,-76.658554548188419631
main.c:218: Output image size: 6494x1695x402.
main.c:234: Writing file: /shared/production/proddata/gliht_l1g/Parker-Track1/Parker-Track1-B040.tif.
main.c:234: Writing file: /shared/production/proddata/gliht_l1g/Parker-Track1/Parker-Track1-B080.tif.
main.c:234: Writing file: /shared/production/proddata/gliht_l1g/Parker-Track1/Parker-Track1-B160.tif.
main.c:143: UL: 35.851659867857456732,-76.730605800650906190
main.c:144: UR: 35.851659867857456732,-76.658554548188419631
main.c:145: LL: 35.836418930876448030,-76.730605800650906190
main.c:146: LR: 35.836418930876448030,-76.658554548188419631
main.c:148: Writing file: /shared/production/proddata/gliht_l1g/Parker-Track1/Parker-Track1.meta.
```

Run GCAP

```
14:06:36.416  -- Loading LUA config file: /Users/imvuong/Documents/code/wcps/data/wcps.frodo.lua
14:06:36.416  Configuration Testing...
14:06:36.416  Directory: /shared/production/proddata exists
14:06:36.417  Directory: /shared/production/proddata/wcps exists
14:06:36.417  Directory: /shared/wcps/data/algos exists
14:06:36.417  Directory: /shared/wcps/data/sigs exists
14:06:36.417  Directory: /shared/wcps/data/colormaps exists
14:06:36.417  Directory: /shared/production/proddata/ams_l1g exists
14:06:36.417  Directory: /shared/production/proddata/ams_l2 exists
14:06:36.417  Directory: /shared/production/proddata/gliht_l1g exists
14:06:36.417  Directory: /shared/production/proddata/gliht_l2 exists
14:06:36.417  Directory: /shared/production/proddata/ali_l1g exists
14:06:36.417  Directory: /shared/production/proddata/ali_l1g_ac exists
14:06:36.417  Directory: /shared/production/proddata/ali_l2 exists
14:06:36.417  Directory: /shared/production/proddata/hyperion_l1r exists
14:06:36.417  Directory: /shared/production/proddata/hyperion_l1r_ac exists
14:06:36.417  Directory: /shared/production/proddata/hyperion_l1g exists
14:06:36.418  Directory: /shared/production/proddata/hyperion_l1g_ac exists
14:06:36.418  Directory: /shared/production/proddata/hyperion_l2 exists
14:06:36.418  wcps init  1
14:06:36.418  WCPS Execute vis_composite gliht_l1g Parker-Track1 0 1 NA  init 1
14:06:36.418  WCPS Execute vis_composite gliht_l1g Parker-Track1 0 1 NA
14:06:36.418  WCPS Execute algo:vis_composite inst:gliht data:l1g scene:Parker-Track1 cache:0 userid:1 sig:NA...
14:06:36.418  Execute file: /shared/wcps/data/algos/gliht_l1g/vis_composite.lua
14:06:36.419  Creating Atom file /shared/production/proddata/gliht_l2/gliht_l1g/Parker-Track1/vis_composite.atom...
14:06:36.419  get band for instrument: gliht data: l1g
14:06:36.420  get band 160 - file /shared/production/proddata/gliht_l1g/Parker-Track1/Parker-Track1-B160.tif
 min:0.000000 mean:30.582403 stdev:76.606514 max:3142.000000  zeroes:8943407 positive:2063923
14:06:36.492  get band for instrument: gliht data: l1g
14:06:36.492  get band 80 - file /shared/production/proddata/gliht_l1g/Parker-Track1/Parker-Track1-B080.tif
 min:0.000000 mean:59.534584 stdev:135.201553 max:4063.000000  zeroes:8943407 positive:2063923
14:06:36.549  get band for instrument: gliht data: l1g
14:06:36.549  get band 40 - file /shared/production/proddata/gliht_l1g/Parker-Track1/Parker-Track1-B040.tif
 min:0.000000 mean:35.607391 stdev:84.499809 max:3577.000000  zeroes:8943407 positive:2063923
14:06:37.165  write_file:/shared/production/proddata/gliht_l2/gliht_l1g/Parker-Track1/vis_composite.png
14:06:39.119  Making kmz
14:06:39.120  Creating doc file: /shared/production/proddata/gliht_l2/gliht_l1g/Parker-Track1/doc.kml
14:06:39.129  Output filesize: 4174419 and tiling is set to 1
14:06:39.307  Making thumnail
14:06:39.660  Making atom entry
14:06:39.661  closed Atom file /shared/production/proddata/gliht_l2/gliht_l1g/Parker-Track1/vis_composite.atom
execute result:0
14:06:39.682  Done.
```

Run WCPS

Flight & Ground Architecture Using Operational SW Components

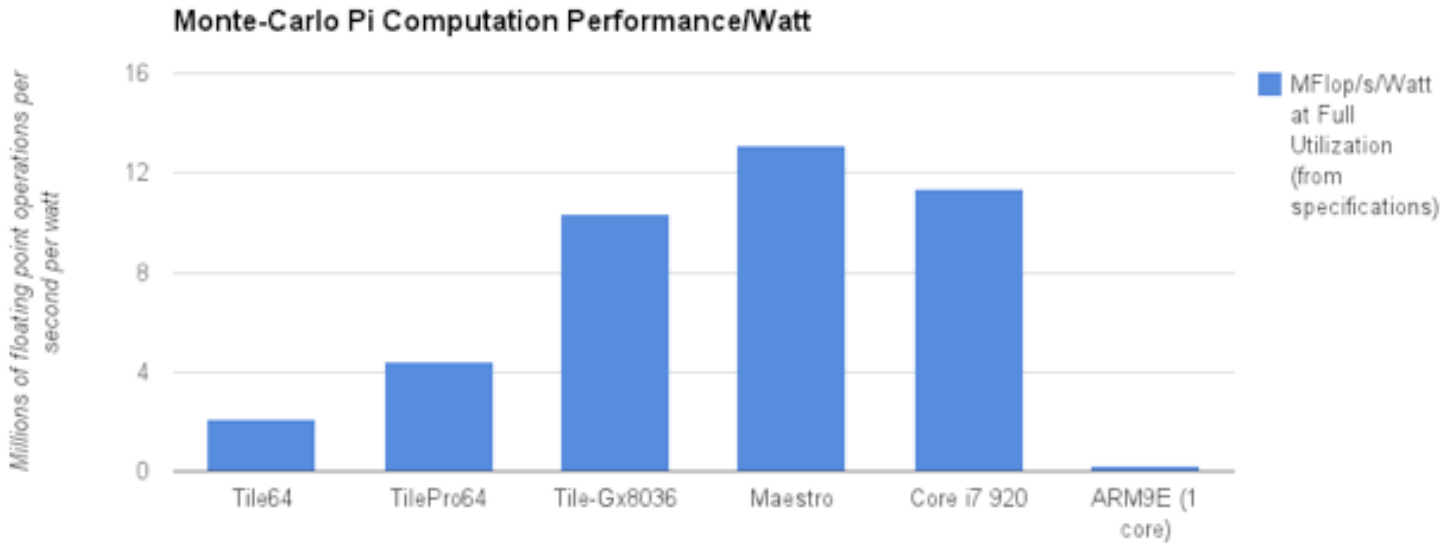


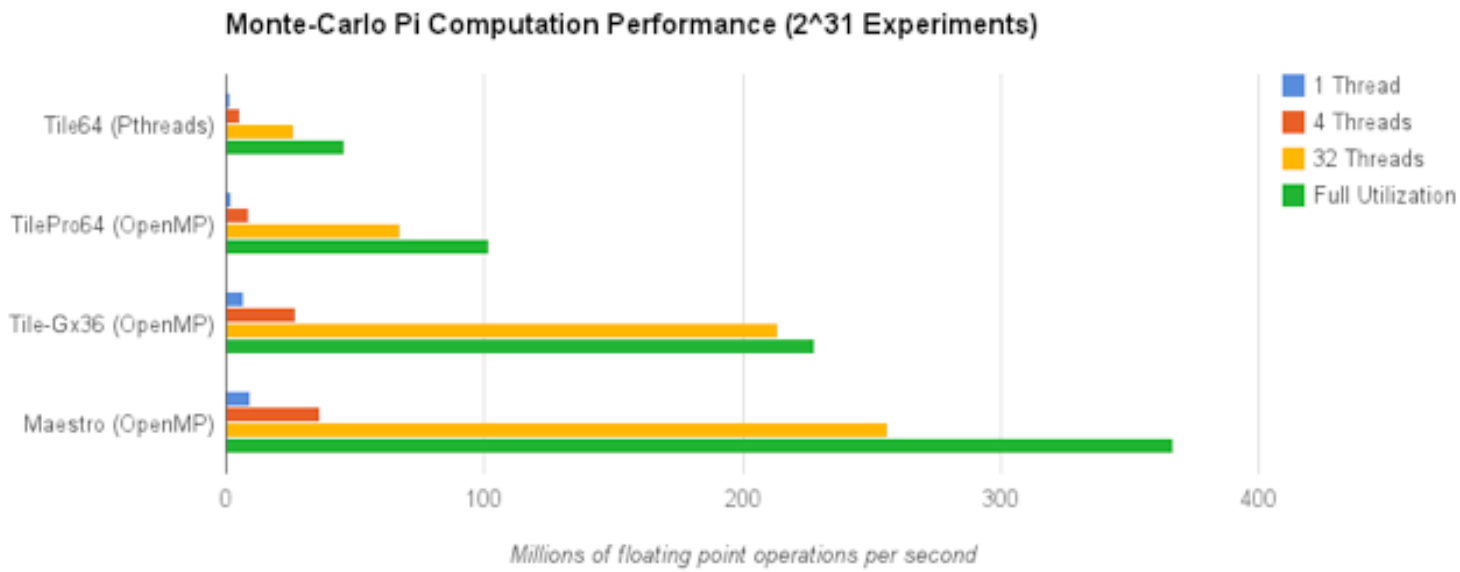
ASIST

WCPS – Web Coverage Processing Service
CmdIn – Command Ingest
TlmOut – Telemetry Output
CASPER - Continuous Activity Scheduling Planning Execution and Replanning system
CFDP - CCSDS File Delivery Protocol
ASIST - Advanced Spacecraft Integration and System Testing Software

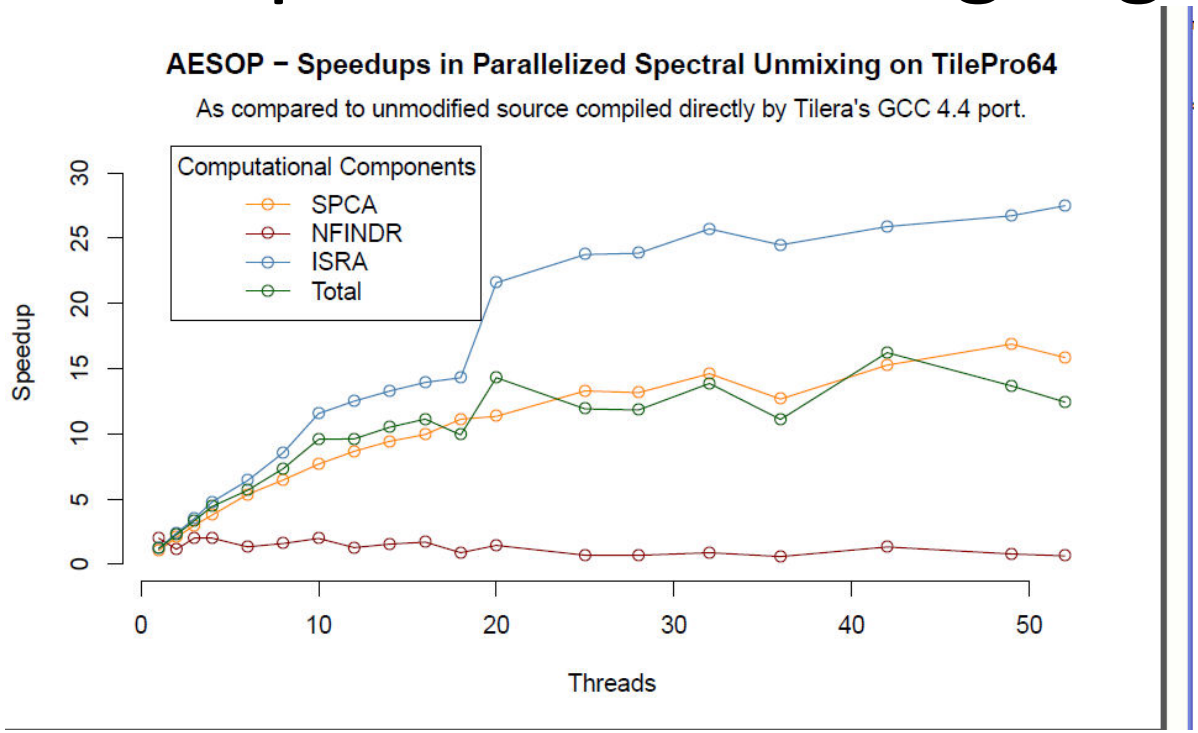
Benchmark Metrics

Geo-Correction for Airborne Platforms (GCAP) Operating on G-LiHT Airborne Data





Auto-parallelizing Using AESOP on Spectral Unmixing Algorithm



- Speedups on the TilePro64 obtained entirely automatically
  - ✓Tool chain consists of ~1000 lines of C code
  - ✓Written by a NASA collaborator (Antonio Plaza) for x86 with no special knowledge of or intent for AESOP or TilePro64 hardware
  - ✓ Speedups shown are for TilePro64, used as a proxy for Maestro which was not yet available

✓

SpaceCube FPGA Running 6S Atmospheric Correction

- Running FPGA code written by Matt French and ISI team
- Hyperion scene processed in under one second
- Points to using Field Programmable Gate Array (FPGA) as co-processor

Backup

Number

1000's

100's

10's

Individual scientists & small projects

Open Cloud Consortium

Community based science via Science as a Service

very large projects

Data Size

Small

Public infrastructure

Medium to Large

Shared community infrastructure

Very Large

Dedicated infrastructure

Open Cloud Consortium

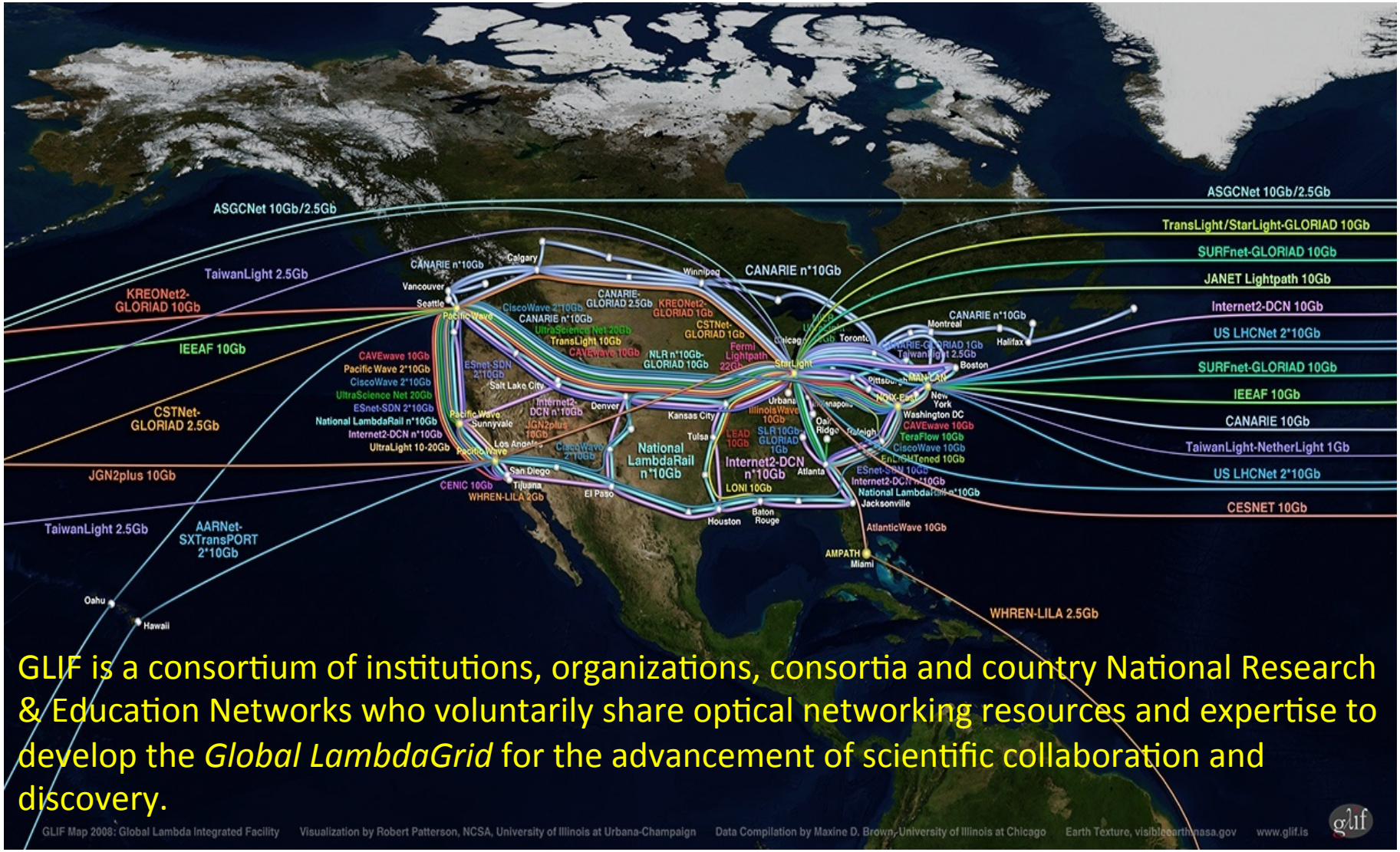
- U.S based not-for-profit corporation.
- Manages cloud computing infrastructure to support scientific, environmental, medical and health care research, such as the Open Science Data Cloud.
- Manages cloud computing testbeds such as the Open Cloud Testbed.
- Develops reference implementations of standards based software for clouds
- Engages in outreach and education to support cloud computing.

www.opencloudconsortium.org

OCC Members

- Companies: Cisco, Yahoo!, Citrix, …
- Universities: University of Chicago, Northwestern Univ., Johns Hopkins, Calit2, ORNL, University of Illinois at Chicago, …
- Federal agencies and labs: NASA, LLNL, ORNL
- International Partners: AIST (Japan)
- Partners: National Lambda Rail

Global Lambda Integrated Facility (GLIF)
OCC Collaboration with Starlight (part of GLIF)



GLIF is a consortium of institutions, organizations, consortia and country National Research & Education Networks who voluntarily share optical networking resources and expertise to develop the *Global LambdaGrid* for the advancement of scientific collaboration and discovery.

OSDC Distribution of Scientific Data

- By the end of the 2012, the OSDC will make available approximately 1.5 PB of scientific and data to the research community.
- The data is available through both the commodity internet and through high performance research networks, including NLR and Internet2
- The data is from a variety of scientific disciplines:
  - 100+ TB of earth science through Project Matsu (joint with NASA)
  - 500 TB of genomic data, including the 1000 Genomes data set
  - 100 TB of astronomy data
  - 100 TB of web related data

OCC Investments

Year	Organization	$M	Comment
2009	Cisco	c. $1M+	Cisco provides access to the Cisco C-Wave to connect OCC data centers and partners with 10G wide area networks
2009	Yahoo!	c. 1.2M	Yahoo! donated a 2000 core cluster to the OCC
2011	NSF	$3.5M	NSF grant "Training and Workshops in Data Intensive Computing Using The Open Science Data Cloud"
2011	Yahoo!	c. $1M	Approximately $1M of equipment for OCC-Y Hadoop Cluster
2011	Moore Foundation	$2M	$1M per year for 2 years for equipment to support OCC-Adler & OCC-Sullivan

The Open Science Data Cloud (OSDC) is a hosted distributed facility managed by the OCC that:

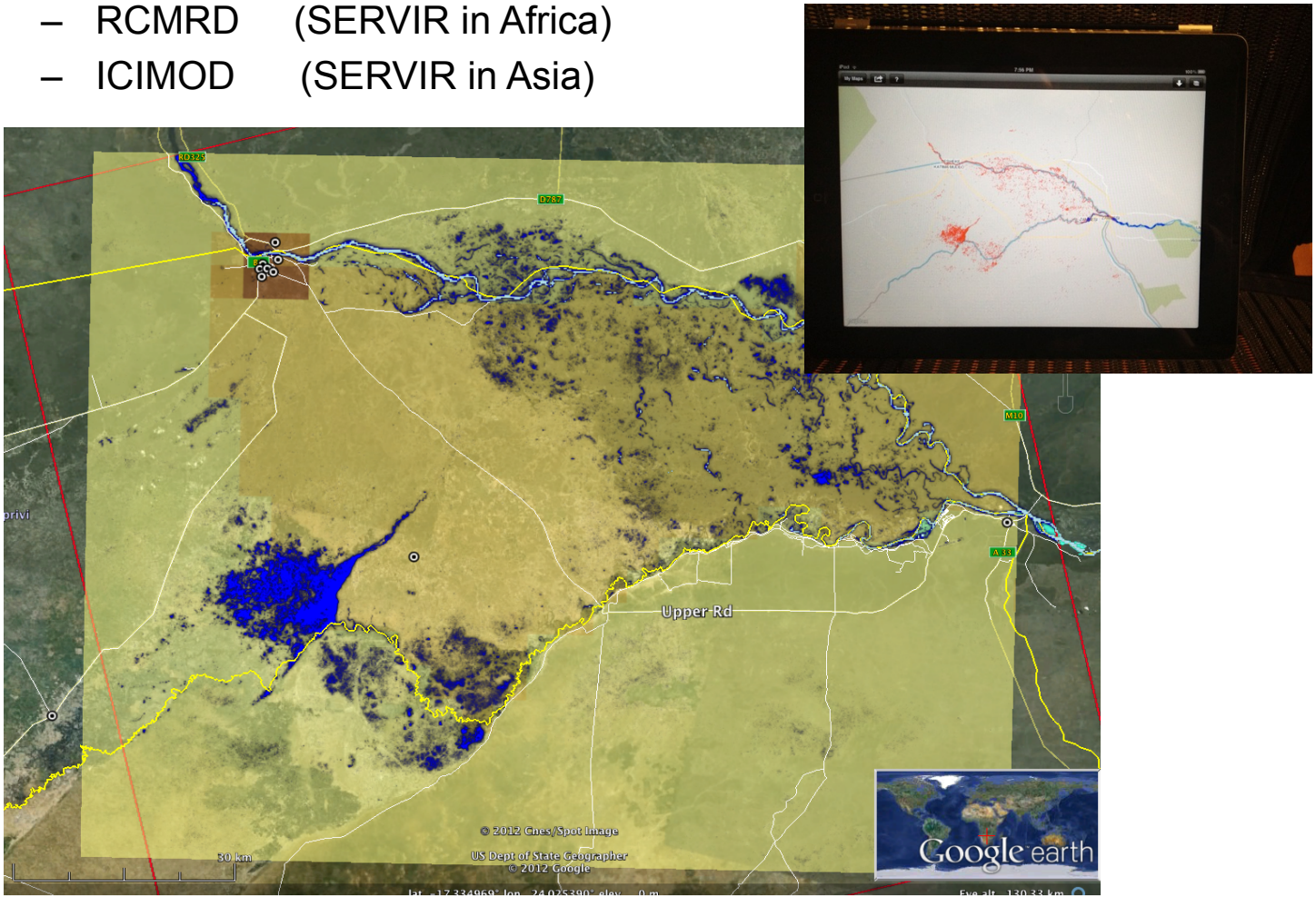
- Manages & archives medium and large size datasets.
- Provides computational resources to analyze them.
- Provides networking to share the datasets with your colleagues and with the public.

Matsu Cloud Functionality Enhancements

- Began developing method for automated co-registration using WCPS in Matsu Cloud
- Radarsat tasking Application Processing Interface (API) integrated with GeoBPMS (due in summer or fall 2012)
  - Funded by AIST ESTO QRS 2011
- Radarsat processing, and data distribution API
  - Display Radarsat data on IPAD
  - Funded by AIST ESTO QRS
- Waterpedia for Architecture Implementation Pilot 2 (AIP-5) (due summer/fall 2012)
  - High resolution water mask on map
  - Open street format
  - Crowd sourcing to validate and calibrate
  - Funded by AIST QRS 2011
- EO-1 tasking API for Pacific Data Center (due summer/fall 2012)
  - Funded by AIST ESTO QRS 2011

Matsu Cloud Functionality Enhancements

- Data distribution API for SERVIR nodes
  - CATHALAC (SERVIR in Caribbean)
  - RCMRD (SERVIR in Africa)
  - ICIMOD (SERVIR in Asia)



Radarsat data processed in cloud and tiled displayed on Ipad for field work and in preparation for Waterpedia with crowdsourcing

Conclusion: Relevance to HyspIRI

- HyspIRI will have large data sets
- Experiment with managing, processing and distributing large data sets in cloud on a “do-it-yourself” basis
- Prototype Science As A Service for users of the HyspIRI large data sets

StarLight – "By Researchers For Researchers"

StarLight is an experimental optical infrastructure and
proving ground for network services optimized for high-performance applications
GE+2.5+10GE
Exchange
Soon:
Multiple 10GEs
Over Optics –
World's "Largest"
10GE Exchange
First of a Kind
Enabling Interoperability
At L1, L2, L3

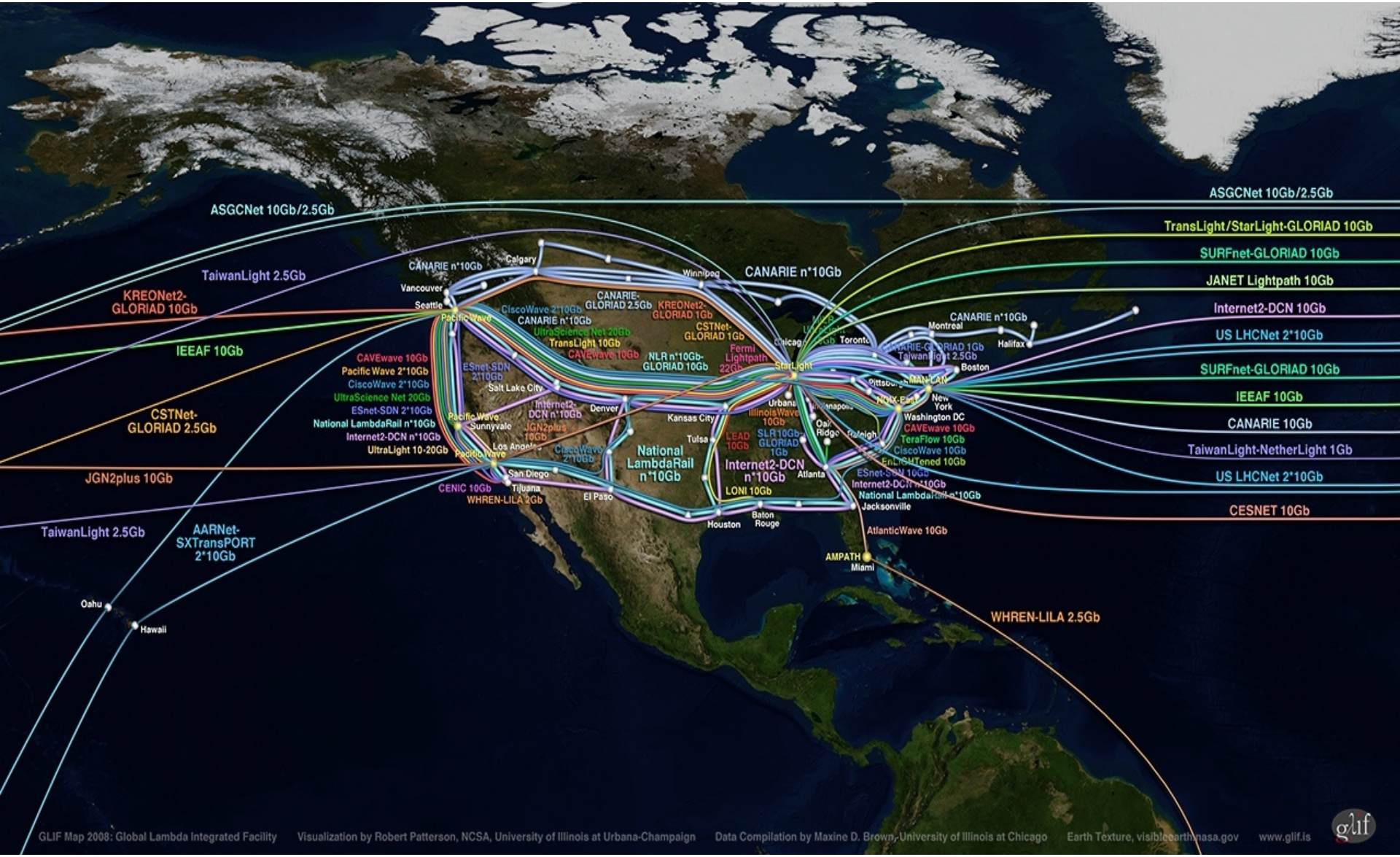
View from StarLight

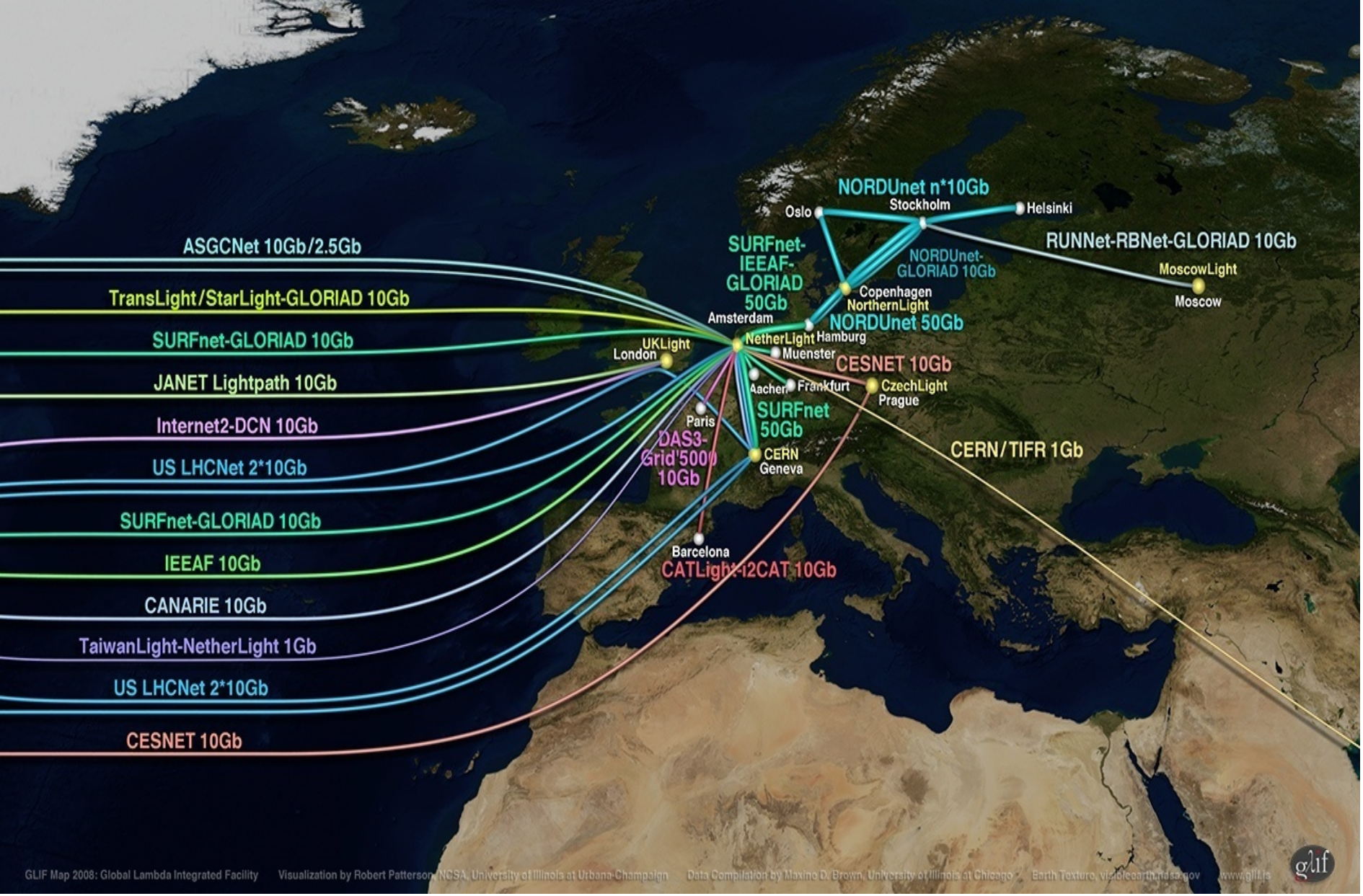
Abbott Hall, Northwestern University's Chicago downtown campus

iCAIR: Founding Partner of the Global Lambda Integrated Facility
Available Advanced Network Resources

GLIF is a consortium of institutions, organizations, consortia and country National Research & Education Networks who voluntarily share optical networking resources and expertise to develop the *Global LambdaGrid* for the advancement of scientific collaboration and discovery.

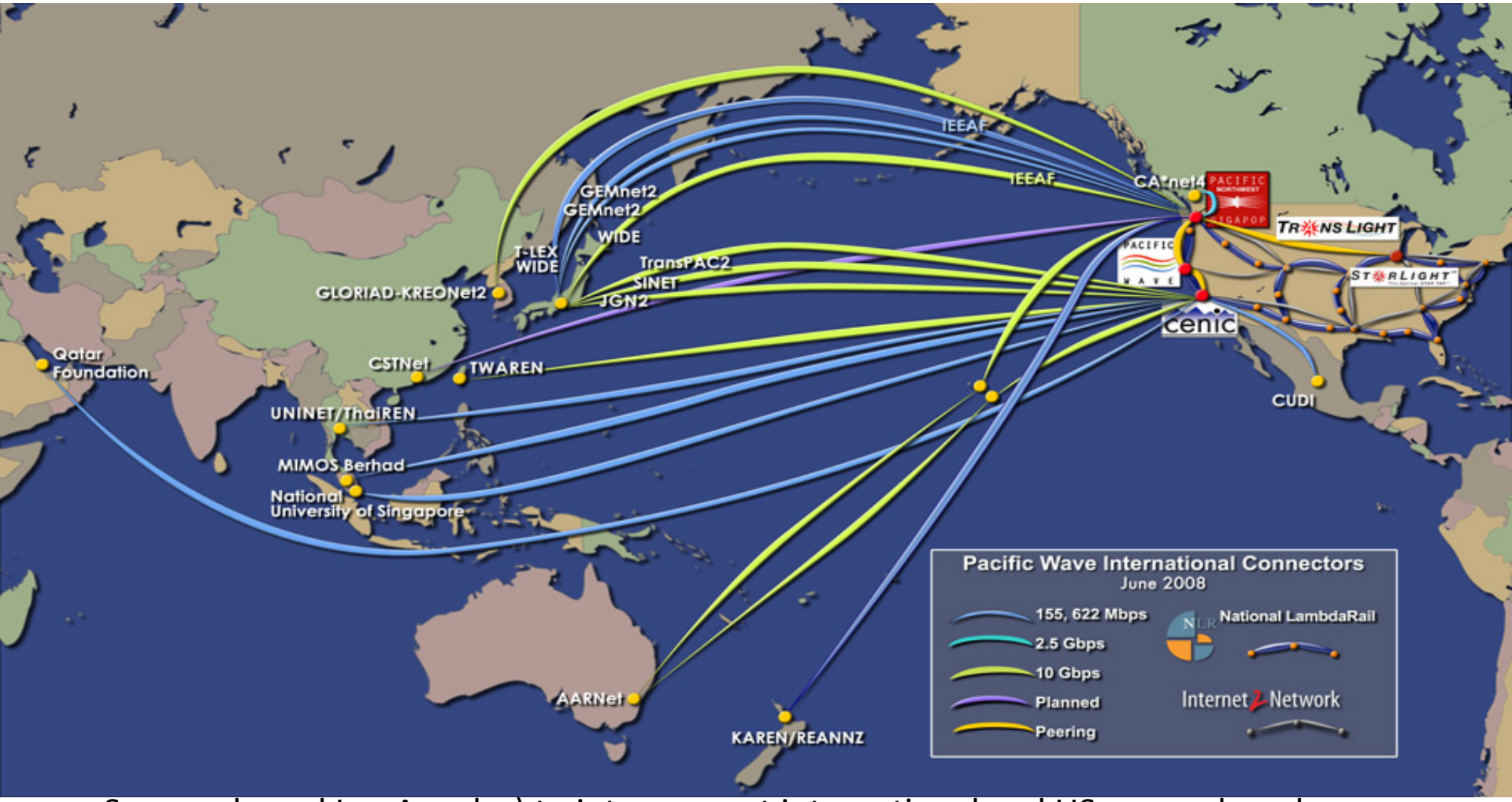
www.glif.is


ASGCNet 10Gb/2.5Gb
TaiwanLight 2.5Gb
KREONet2-GLORIAD 10Gb
IEEAF 10Gb
CSTNet-GLORIAD 2.5Gb
JGN2plus 10Gb
TaiwanLight 2.5Gb
AARNet-SXTransPORT 2*10Gb
Oahu
Hawaii
CANARIE n*10Gb
Calgary
Vancouver
Seattle
Pacific Wave
CiscoWave 2*10Gb
CANARIE n*10Gb
UltraScience Net 20Gb
TransLight 10Gb
CAVEwave 10Gb
Pacific Wave 2*10Gb
CiscoWave 2*10Gb
UltraScience Net 20Gb
ESnet-SDN 2*10Gb
National LambdaRail n*10Gb
Internet2-DCN n*10Gb
UltraLight 10-20Gb
ESnet-SDN 2*10Gb
Salt Lake City
Pacific Wave
Sunnyvale
Los Angeles
Pacific Wave
San Diego
Tijuana
CENIC 10Gb
WHREN-LILA 2Gb
Internet2-DCN n*10Gb
JGN2plus 10Gb
Denver
CiscoWave 2*10Gb
El Paso
CANARIE-GLORIAD 2.5Gb
KREONet2-GLORIAD 1Gb
CSTNet-GLORIAD 1Gb
NLR n*10Gb-GLORIAD 10Gb
Fermi Lightpath 22Gb
Kansas City
Tulsa
National LambdaRail n*10Gb
Winnipeg
CANARIE n*10Gb
Chicago
Toronto
StarLight
Urbana
IllinoisWave 10Gb
LEAD 10Gb
SLR 10Gb-GLORIAD 1Gb
Internet2-DCN n*10Gb
LONI 10Gb
Houston
Baton Rouge
Atlanta
Oak Ridge
Raleigh
Jacksonville
AMPATH
Miami
AtlanticWave 10Gb
CANARIE n*10Gb
Montreal
Halifax
CANARIE-GLORIAD 1Gb
TaiwanLight 2.5Gb
Boston
MAN LAN
New York
NGIX-East
Washington DC
CAVEwave 10Gb
TeraFlow 10Gb
CiscoWave 10Gb
EnLIGHTened 10Gb
ESnet-SDN 10Gb
Internet2-DCN n*10Gb
National LambdaRail n*10Gb
ASGCNet 10Gb/2.5Gb
TransLight/StarLight-GLORIAD 10Gb
SURFnet-GLORIAD 10Gb
JANET Lightpath 10Gb
Internet2-DCN 10Gb
US LHCNet 2*10Gb
SURFnet-GLORIAD 10Gb
IEEAF 10Gb
CANARIE 10Gb
TaiwanLight-NetherLight 1Gb
US LHCNet 2*10Gb
CESNET 10Gb
WHREN-LILA 2.5Gb
GLIF Map 2008: Global Lambda Integrated Facility
Visualization by Robert Patterson, NCSA, University of Illinois at Urbana-Champaign
Data Compilation by Maxine D. Brown, University of Illinois at Chicago
Earth Texture, visibleearth.nasa.gov
www.glif.is
glif


ASGCNet 10Gb/2.5Gb
TransLight/StarLight-GLORIAD 10Gb
SURFnet-GLORIAD 10Gb
JANET Lightpath 10Gb
Internet2-DCN 10Gb
US LHCNet 2*10Gb
SURFnet-GLORIAD 10Gb
IEEAF 10Gb
CANARIE 10Gb
TaiwanLight-NetherLight 1Gb
US LHCNet 2*10Gb
CESNET 10Gb
NORDUnet n*10Gb
Oslo
Stockholm
Helsinki
RUNNet-RBNet-GLORIAD 10Gb
MoscowLight
Moscow
SURFnet-IEEAF-GLORIAD 50Gb
NORDUnet-GLORIAD 10Gb
Copenhagen
NorthernLight
NORDUnet 50Gb
Amsterdam
NetherLight
Hamburg
Muenster
UKLight
London
CESNET 10Gb
Aachen
Frankfurt
CzechLight
Prague
Paris
SURFnet 50Gb
DAS3-Grid'5000 10Gb
CERN
Geneva
CERN/TIFR 1Gb
Barcelona
CATLight-i2CAT 10Gb
GLIF Map 2008: Global Lambda Integrated Facility
Visualization by Robert Patterson, NCSA, University of Illinois at Urbana-Champaign
Data Compilation by Maxine D. Brown, University of Illinois at Chicago
Earth Texture, visibleearth.nasa.gov
www.glif.is
glif

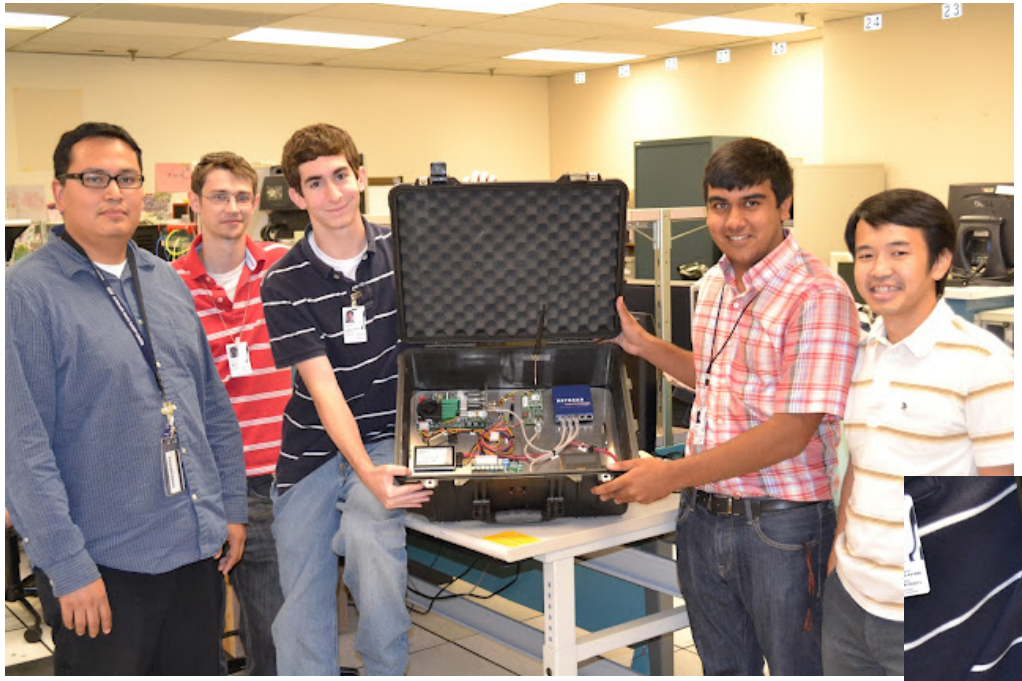
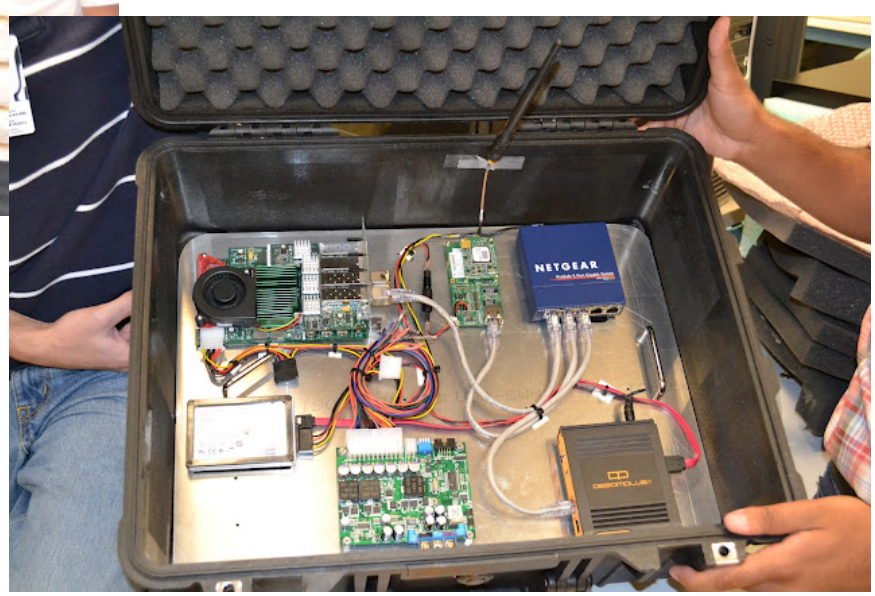
TransLight/Pacific Wave/StarLight

10GE Wave Facilitates US West Coast Connectivity



Sunnyvale and Los Angeles) to interconnect international and US research and education networks

www.pacificwave.net/participants/irnc/

CANARIE-
GLORIAD 2.5Gb
KREONet2-
GLORIAD 1Gb
CSTNet-
GLORIAD 1Gb
NLR n*10Gb-
GLORIAD 10Gb
Fermi
CANARIE n*10Gb
MiLR-
UltraLight
10Gb
Chicago
StarLight
Kansas City
Urbana
IllinoisWave
10Gb
Tulsa
LEAD
10Gb
SLR 10Gb-
GLORIAD
1Gb
Indianapolis
Pittsbu
NGIX
Oak
Ridge
Raleigh
Internet2-DCN
n*10Gb
LONI 10Gb
Atlanta

Flatsat Version of IPM