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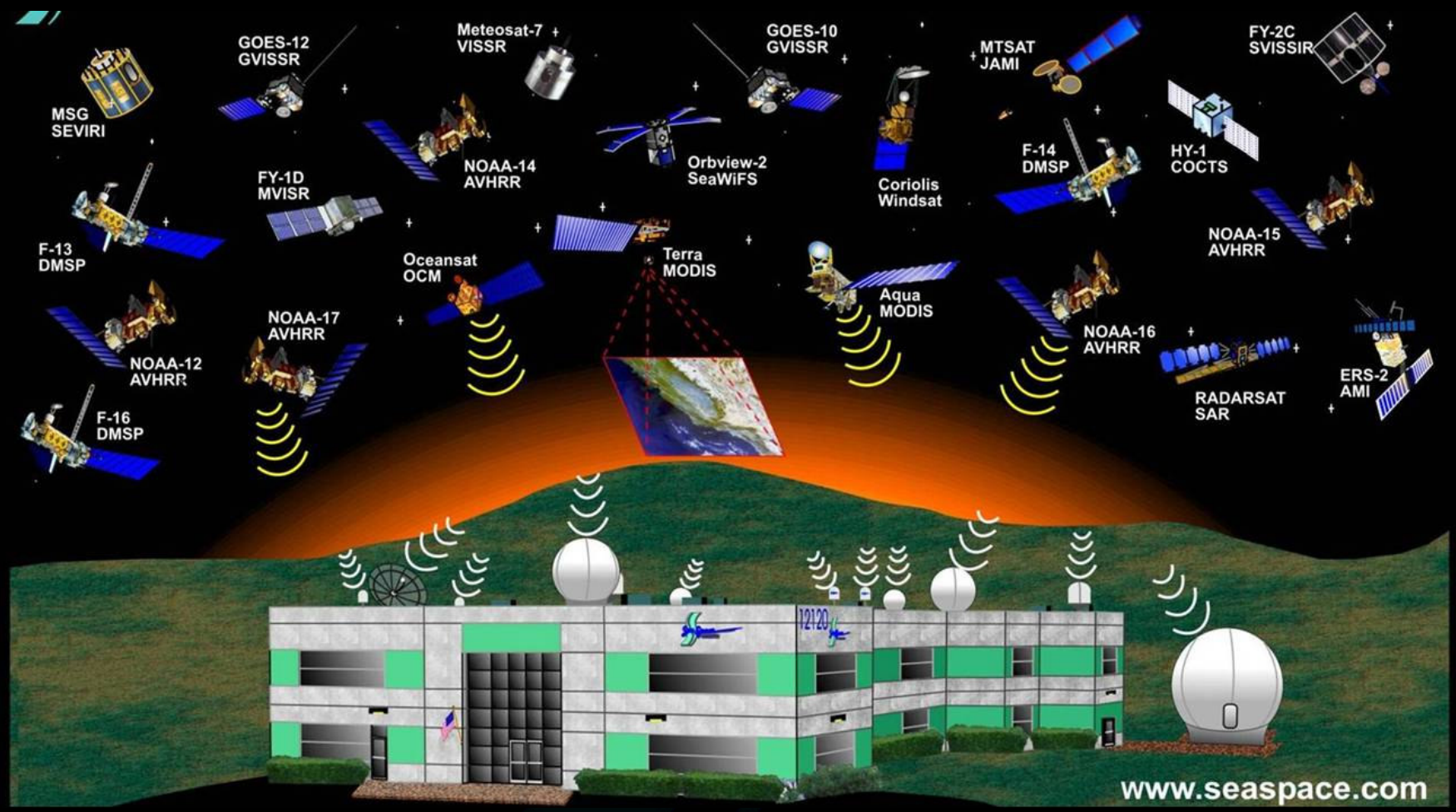

What do we do?

SeaSpace builds and integrates hardware and software products for the receipt, processing, display and routing of real-time and scientific quality satellite data.

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Real world. Real time.

Rapid product generation from MODIS and future satellite sensors

Overview

1. MODIS data acquisition and processing (*From clusters to high-end desktop workstations)*
2. Processing system hardware
3. Configuration files
4. Processing threads
5. Timing tests and results
6. Sample output products
7. Summary and future (NPP/NPOESS)

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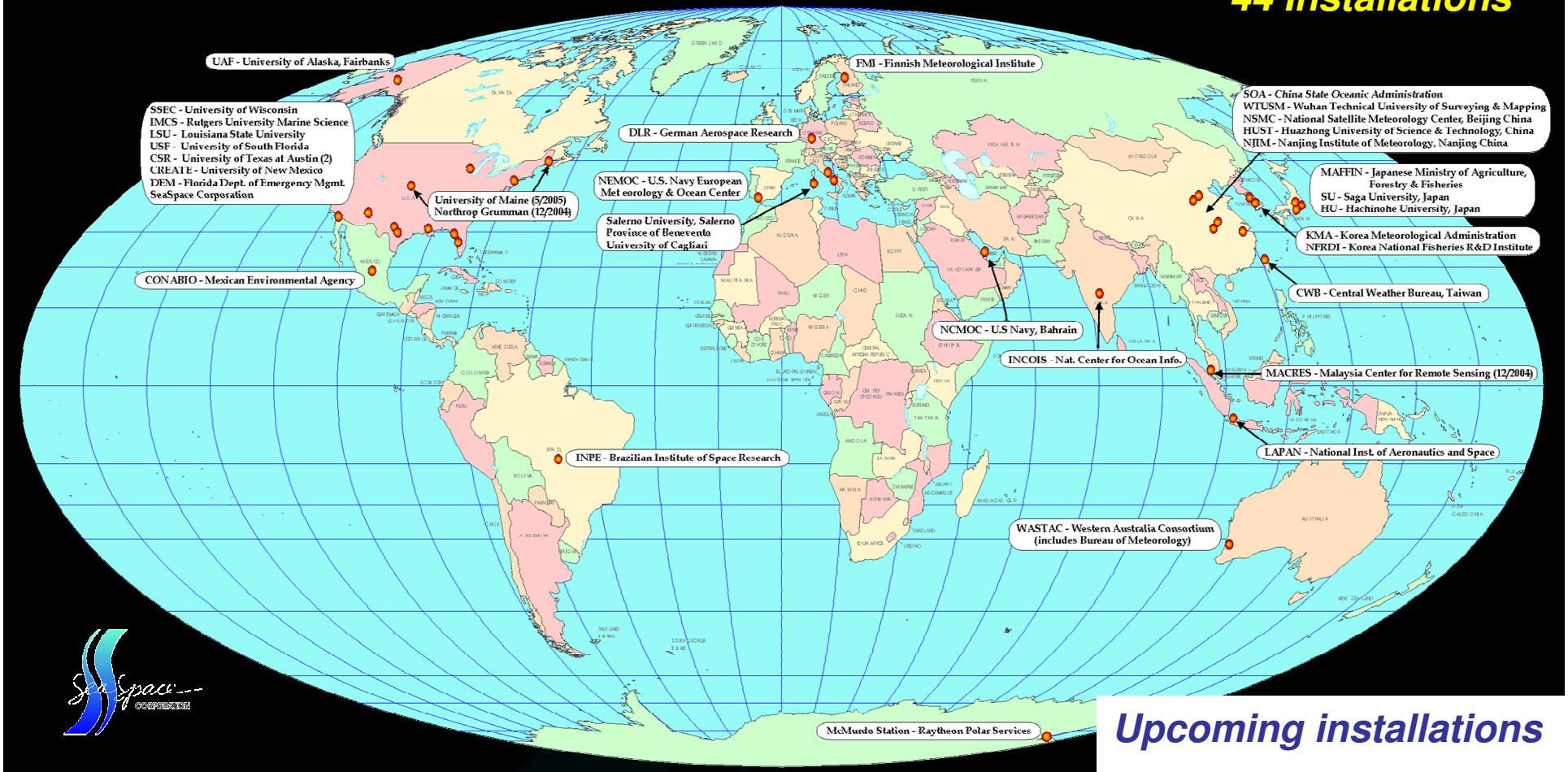
X-band Satellite Ground Station Installations - Leader

44 Installations



Upcoming installations

Telespazio, Matera, Italy

Turkish Met, Ankara

Philippine Met, Manila

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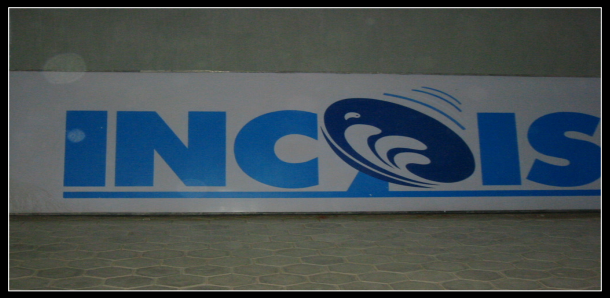

Indian National Centre for Ocean Information Services (INCOIS), Hyderabad – 2.4m Dual X/L System

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Processing considerations for direct broadcast users

- Ability to generate MODIS land, ocean, and atmospheric products rapidly (under 15 minutes of data acquisition). To be able to extend this to future telemetries.
- Ability to pre-define required products and Area of Interest
- Employ an easily editable configuration file for product generation
- Use percent area for land or ocean coverage to eliminate or include the processing of certain granules (*or defer processing to a later time*).
- Ability to easily add or remove products/telemetries (turn OFF or ON).
- Provide a processing frame work that can be extendable/scaleable for any telemetry in the future.
- Provide a reason for DB users to archive raw data *rather* than level 2 products

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Processing platform description

Dual Quad Core Xeon X5355 2.6 GHz

16 GB RAM

750 GB disk

8 simultaneous processing threads (optimal)

Optimization in the future may include:

- *CPU Speed*
- *Memory Speed*
- *Bus Speed*
- *Hard drive Speed*

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Processing test details

- Test pass: Aqua-1 2007/09/30 21:28:50 GMT 6023 lines
- Default Configproc (*configuration file)* settings
- Data processed into Granules
- Each Granule processed to Level0, Level 1a/1b, Level 2 HDF and remapped
- 8 simultaneous processing threads (*optimal*) – could be adjusted higher or lower depending on requirements
- TeraScan function "*waitd*" used to control the processing threads.

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What is waitd ?

- *Daemon* that waits for data to be delivered to one or more directories, then initiates processing.
- *-g* Normal mode, background in *non-idle* mode until it receives a signal to do otherwise
- *-i* Idle mode, background in *idle mode* until it receives a signal to do otherwise. Parameters include:

telem-or-format (kind of data, telemetry name etc)

Incoming-dir (directories where files are arriving)

name-template (Wildcard expression for matching files to be processed)

process-name (process to run on arriving file)

Wait-until-age (matching files must be at least this old (*secs*) to process)

Keep-after (number of matching files to keep around after processing; excess matching files are removed)

hours-too-old (get rid of matching files this many hours old, processed or not)

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Sample Configuration file

```
[Process]
scrub_max_files:
scrub_max_mbytes:
scrub_age_hours: 480
{
    [modis_products]
    active: yes
    function: process_thread
    input_directory: products/raw
    input_files: 20*.raw
    {
        [Thread]
        {
        [level0]
        active: yes
        function: eos_seadas_level0
        input_files: *.raw
        output_files: *.pds
        save_directory: products/hdf/modis/level0
        save_files: *pds
```

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Sample Configuration file

```
[Process]
scrub_max_files:
scrub_max_mbytes:
scrub_age_hours: 480
{
    [modis_products]
    active: yes
    function: process_thread
    input_directory: products/raw
    input_files: 20*.raw
    {
        [level1]
        active: yes
        function: eos_seadas_level1
        input_directory: products/hdf/modis/level0
        input_files: *.pds
        output_files: MYD03.*.hdf MYD02*.hdf
        save_directory: products/hdf/modis/level1
        save_files: MYD03.*.hdf MYD02*.hdf
        remove_work_files: *.pds
```

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Sample Configuration file

```
[Process]
scrub_max_files:
scrub_max_mbytes:
scrub_age_hours: 480
{
    [modis_products]
    active: yes
    function: process_thread
    input_directory: products/raw
    input_files: 20*.raw
    {
        [cloudmask]
        active: yes
        function: eos_seadas_cloudmask
        input_directory: products/hdf/modis/level1
        input_files: MYD02*.hdf MYD03.*.hdf
        output_files: MYD35.*.hdf MYD35X.*.hdf
        save_directory: products/hdf/modis/cloudmask
        save_files: MYD35.*.hdf MYD35X.*.hdf
        remove_work_files: MYD35X.*.hdf
```

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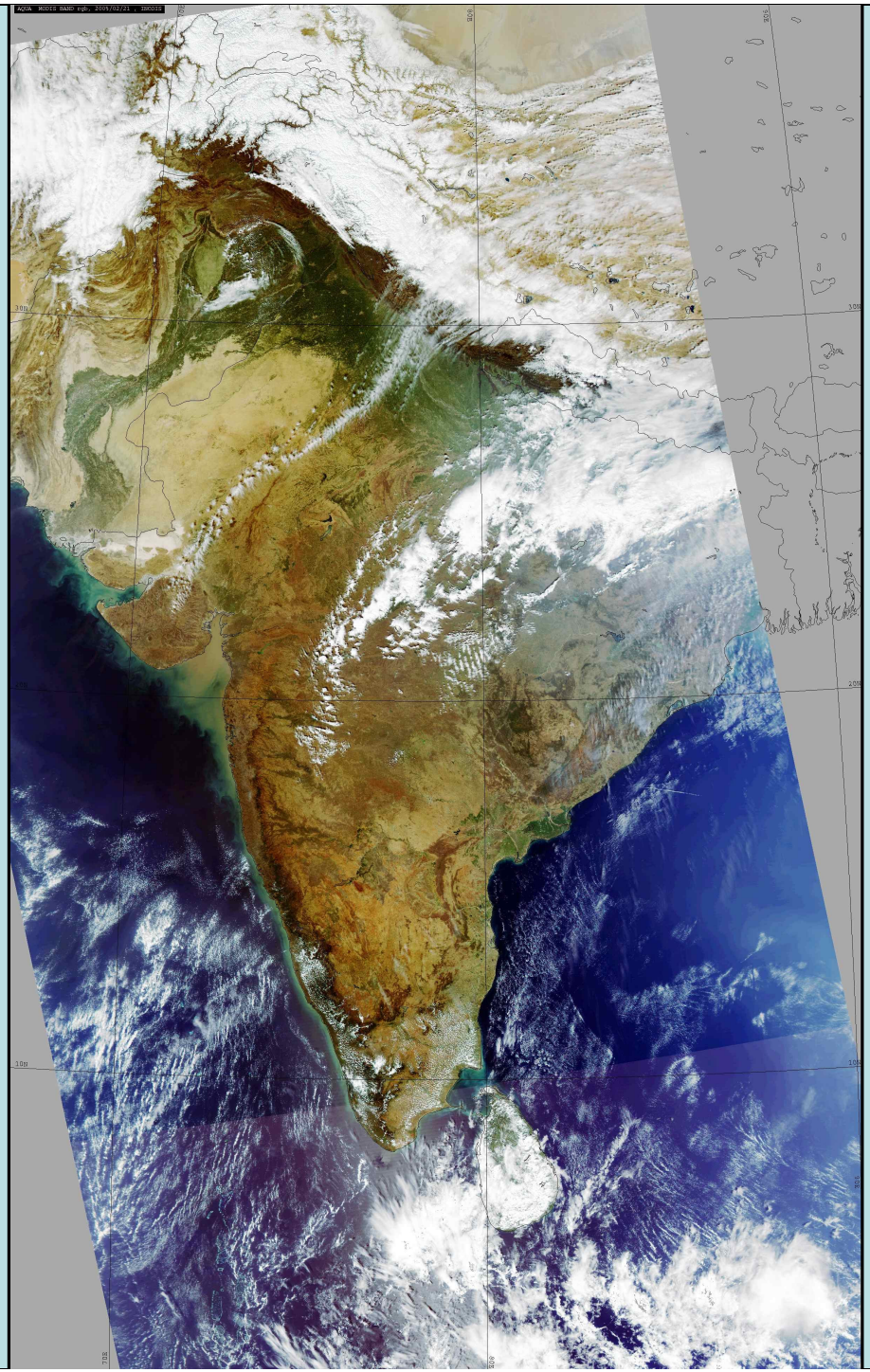
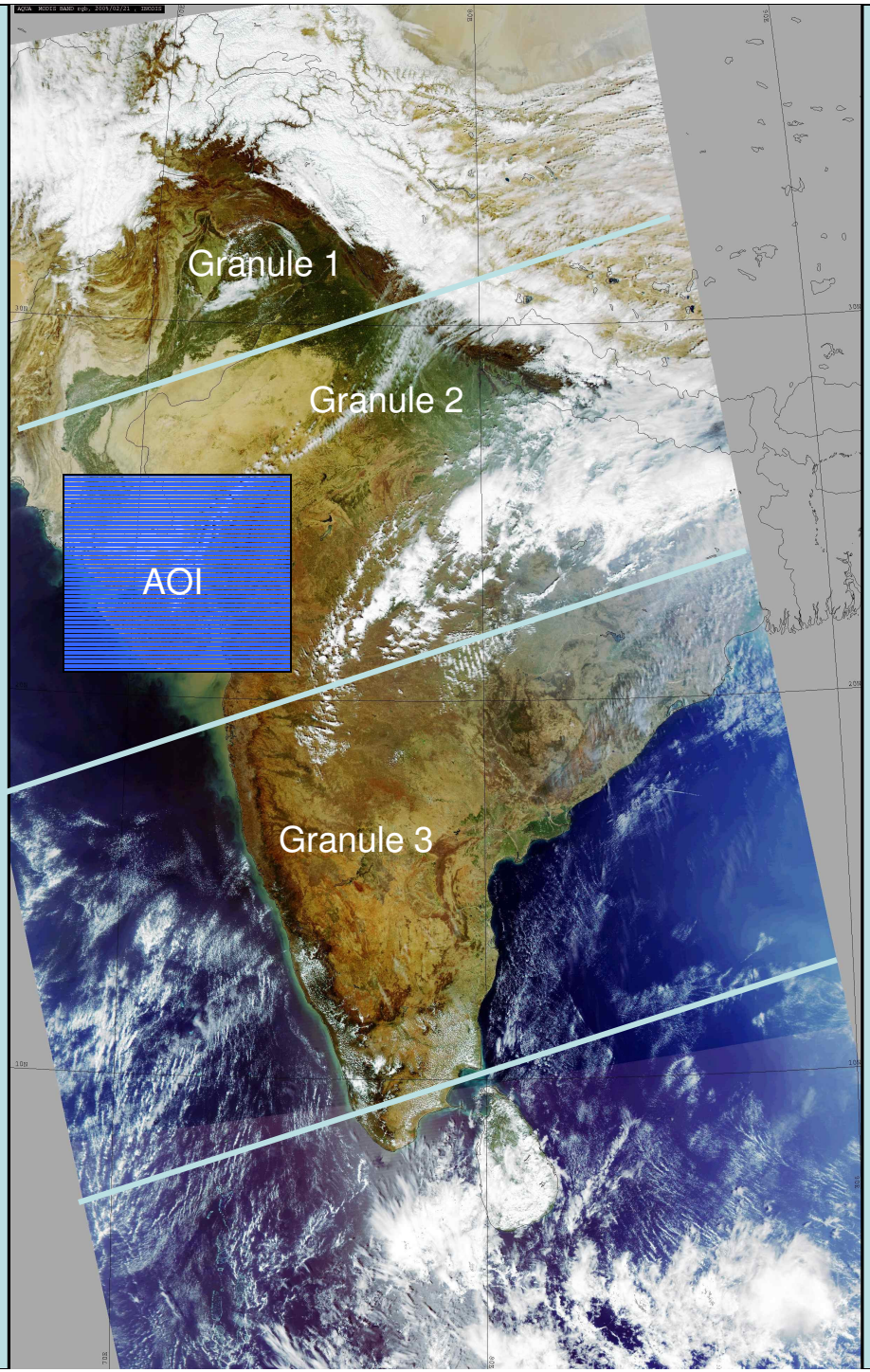
Aqua MODIS – RGB Color Composite. Data acquired and processed using SeaSpace's TeraScan at INCOIS.



Aqua MODIS – Granule and Area of Interest (AOI) based processing.



MODIS PRODUCTS AND APPLICATIONS

Calibration

MOD 01 - Level 1A
MOD 02 - Level 1B Calibrated Geolocated Radiances
MOD 03 - Geolocation Dataset

Atmosphere

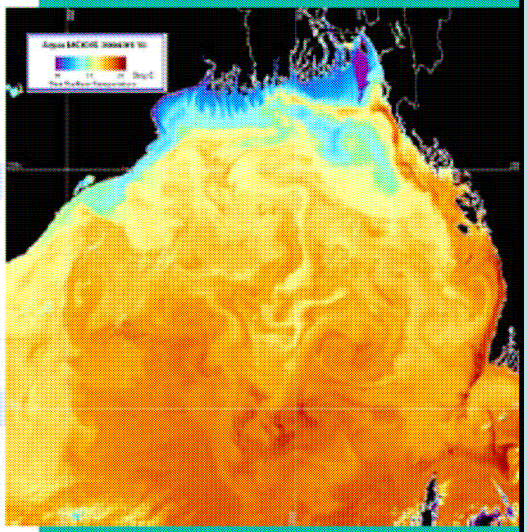
MOD 04 - Aerosol Product
Aerosol Angstrom Coefficient
Aerosol Optical Depth
MOD 05 - Total Precipitable Water (Water Vapor)
MOD 06 - Cloud Product, Cloud Top, and
Cloud Optical Depth
MOD 07 - Atmospheric Profiles
MOD 35 - Cloud Mask

Land

MOD 09 - Surface Reflectance
MOD 11 - Land Surface Temperature & Emissivity
MOD 13 - NDVI & Enhanced Vegetation Index (EVI)
MOD 14 - Thermal Anomalies, Hot Spots,
Active Fires & Biomass Burning

Ocean

MOD 18 - Normalized Water-Leaving Radiance
Pigment Concentration
Chlorophyll Fluorescence
Chlorophyll_a Pigment Concentration
Photosynthetically Available Radiation (PAR)
Organic Matter Concentration
Suspended-Solids Concentration
Coccolith Concentration
Ocean Water Attenuation Coefficient, K490
Sea Surface Temperature
Total Absorption Coefficient
Ocean Aerosol Properties
Clear Water Epsilon
Diffuse Attenuation Coefficient at 490 nm



Above:
Sea Surface Temperatures for the Bay of Bengal from Aqua MODIS

Below left: True color image from Aqua MODIS.

Processing test details

- Test pass: Aqua-1 2007/09/30 21:28:50 GMT 6023 lines
- Default Configproc (*configuration file)* settings
- Data processed into Granules
- Each Granule processed to Level0, Level 1a/1b, Level 2 HDF and remapped
- 8 simultaneous processing threads (*optimal*) – could be adjusted higher or lower depending on requirements
- TeraScan function "*waitd*" used to control the processing threads.

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Complete Aqua pass over San Diego ground station (6023 lines)

•MODIS Data Product	• Processing time
•Level 0	2 minutes
•Level 1B	2 minutes
•Level 2**	8 minutes
•Total	12 minutes

** Includes MODIS (land, Ocean, atmosphere), AIRS, and AMSRE products

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Area of Interest – San Diego MASTER 1000 X 1000

•MODIS Data Product	• Processing time
•Level 0	1 minutes
•Level 1B	3 minutes
•Level 2**	7 minutes
•Total	11 minutes

** Includes MODIS (land, Ocean, atmosphere), AIRS, and AMSRE products

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Processing time by product discipline

• Ocean Color	• Processing time
• San Diego AOI	8 minutes
• Whole Pass AOI	9 minutes

• NDVI, EVI, and Land Surface temperatures	• Processing time
• San Diego AOI	9 minutes
• Whole Pass AOI	9 minutes

• Cloudmask and All Level2 cloud products	• Processing time
• San Diego AOI	7 minutes
• Whole Pass AOI	7 minutes

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Summary of MODIS Processing Scripts

Product	TeraScan Script[A]	NASA DAAC Process	Depends On Output From
level0	eos_seadas_level0	AquaModisGbad.xml *or* TerraModis.xml[B]	granule_pproc
gbad	eos_seadas_gbad[1]	aqua_main[C]	eos_seadas_level0
level1	eos_seadas_level1	l1_aqua.pl or l1_terra.pl[C]	eos_seadas_level0
cloudmask	eos_seadas_cloudmask[2]	MOD_PR35.exe[C]	eos_seadas_level1
fire	eos_seadas_fire[2]	mod14[C]	eos_seadas_level1
ndvi	eos_seadas_ndvi	crefl.1.4 *and* ndvi_evi.2.1[C]	eos_seadas_level1
cloud_record	eos_seadas_cloud_record[2]	MOD_PR06CR.exe[C] MOD_PR06CT.exe[C] MOD_PR06CD.exe[C]	eos_seadas_level1 *and* eos_seadas_cloudmask
cloud_profiles	eos_seadas_cloud_profiles[2]	MOD_PR07.exe[C]	eos_seadas_level1 *and* eos_seadas_cloudmask
aerosol	eos_seadas_aerosol[2]	MOD_PR04_05.exe[C]	eos_seadas_level1 *and* eos_seadas_cloudmask
snow_cover	eos_seadas_snow_cover[2]	MOD_PR10.exe[C]	eos_seadas_level1 *and* eos_seadas_cloudmask
sst	eos_seadas_sst[2 3]	MOD_PR28.exe[C]	eos_seadas_level1 *and* eos_seadas_cloudmask
sea_ice	eos_seadas_sea_ice[2]	MOD_PR29.exe[C]	eos_seadas_level1 *and* eos_seadas_cloudmask
ocean_color	eos_seadas_ocean_color[2 3]	MOD_PR18.exe[C]	eos_seadas_level1, eos_seadas_cloudmask, *and* eos_seadas_sst

Ancillary Data

Processes that use ancillary data use a time window defined in **$PASSDIR/config/system.config** to find the best matching ancillary files in the following:

1. Ancillary data in $DATADIR/ancillary/eos_gbad
2. Ancillary data in $DATADIR/ancillary/modis_cloud
3. Ancillary data in $DATADIR/ancillary/ocean_color

Script Location

A. $TSCANROOT/batch/bin
B. $NASA_DAAC/JAVA_DAAC/config
C. $NASA_DAAC/bin

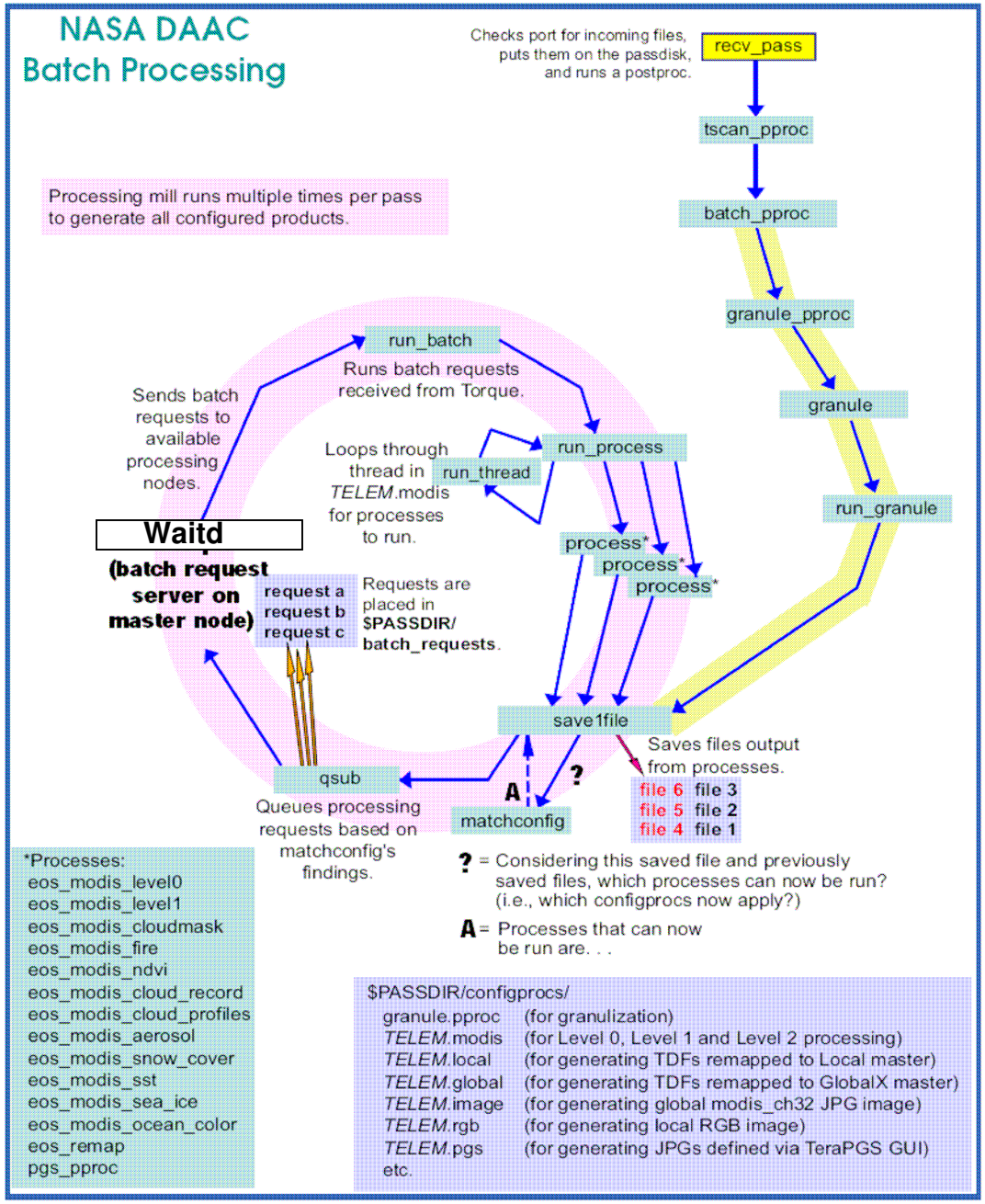

Figure 10-3. The Batch Processing Mill

Summary of Types of Products Delivered

MODIS Processing	Output Products	Location on System
recv_pass	CADU files	pass disk
Granulization	Three raw granules per pass (filenames have **.raw** extension).	$DATADIR/products/raw
Level 0	PDS files output by **eos_modis_level0** > **TerraModis.xml** or **AquaModisGbad.xml** according to **aquadb.modis** and **teradb.modis** configproc files.	$DATADIR/products/hdf/modis/level0
Level 1B	HDF products output by **eos_modis_level1** > **I1_aqua.pl** or **I1_terra.pl** according to **aquadb.modis** and **teradb.modis** configproc files.	$DATADIR/products/hdf/modis/level1
Level 2	HDF products output by Level2 processing specified in **aquadb.modis** and **teradb.modis** configprocs. Level 2 processes are:	$DATADIR/products/hdf/modis/ *product_subdirectories:*
	eos_modis_cloud_mask > MOD_PR35.exe	cloudmask
	eos_modis_fire > mod14	fire
	eos_modis_ndvi > crefl.1.v > ndvi_evi.2.1	ndvi
	eos_modis_cloud_record > MOD_PR06CR.exe > MOD_PR06CT.exe > MOD_PR06CD.exe	clouds
	eos_modis_cloud_profiles > MOD_PR07.exe	clouds
	eos_modis_aerosol > MOD_PR04_05.exe	aerosol
	eos_modis_snow_cover > MOD_PR10.exe	snow_cover
	eos_modis_sst > MOD_PR28.exe	sst
	eos_modis_sea_ice > MOD_PR29.exe	sea_ice
	eos_modis_ocean_color > MOD_PR18.exe	ocean_color
Remapping	TDF products remapped to the GlobalX master by **eos_remap**, as specified in the **aquadb.global** and **terradb.global** configprocs.	$DATADIR/products/tdf/Global/modis
	TDF products remapped to the Local master by **eos_remap**, as specified in the **aquadb.local** and **terradb.local** configprocs.	$DATADIR/products/tdf/Local/modis
Quicklook image processing	JPG images generated by **simple_image** run according to **aquadb.image** and **terradb.image** configprocs. **simple_rgb** is run according to **aquadb.rgb** and **terradb.rgb** configprocs	$DATADIR/products/images/modis
PGS processing	JPGs generated by **pgs_pproc** according to product definitions made by users via the TeraPGS GUI and stored in **$PASSDIR/pgsprocs**. Input is Global TDFs. (See "Module 9: TeraPGS" of this training guide for more about TeraPGS).	Directories or remote sites according to PGS distribution records.

Some sample MODIS imagery from our installations

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MODIS Image

Description:

MODIS RGB Product

Ch1, Ch3, Ch4 composite

August 23, 2004

S. Italy and the Mediterranean sea

Aqua/MODIS 250 m and 500m calibrated data

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MODIS Image

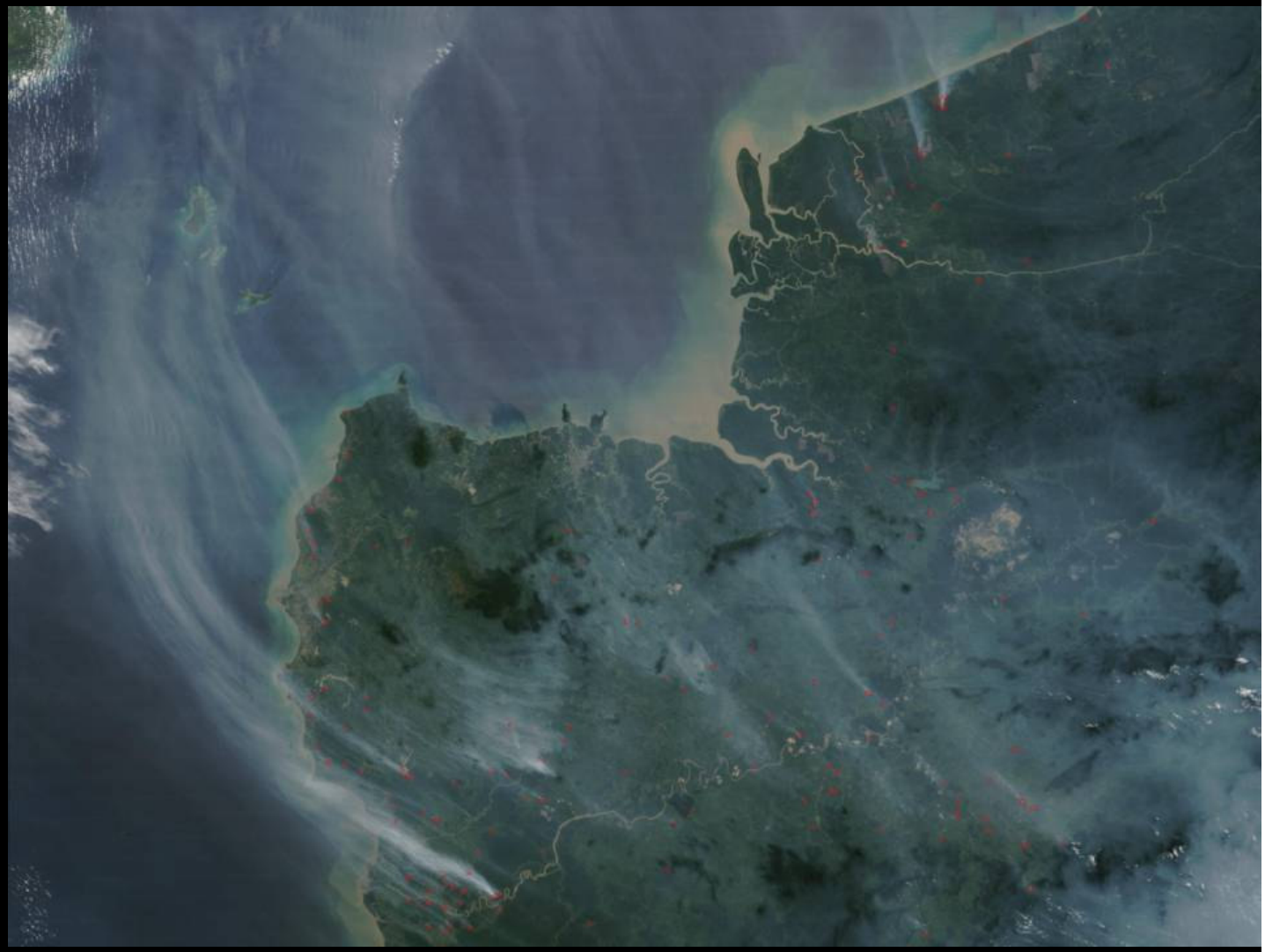
Description:

MODIS RGB Product

Ch1, Ch3, Ch4 composite

Borneo smoke plumes

Aqua/MODIS 250 m and 500m calibrated data



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Aqua MODIS

Volcanic Alert Algorithm

MOD_PRVOLC

October 28, 2002

Mt Etna, Sicily

Volcanic Eruption

From U.S. MeTOC, Rota Spain

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ASCII text files for line/sample where volcanic eruptions/or fires were detected.
Aqua MODIS Data Collection date & time 2002-10-28T12:15:00.000
This example is over Mt. Etna

Ch 21	Ch 22	Ch29	Ch31	Ch32	Lat.	Lon.	Sol Z	SenZ	SenAz	Line	Samp
8.336	10.000	6.318	12.075	11.364	37.705856	14.988217	0.969	0.369	-1.710	1530	444
4.886	10.000	7.172	11.324	10.382	37.704479	14.976489	0.969	0.367	-1.710	1530	445
26.416	10.000	4.147	14.065	13.456	37.716686	14.998108	0.969	0.370	-1.714	1531	443
43.175	10.000	16.790	41.324	36.209	37.715252	14.985903	0.969	0.369	-1.714	1531	444
16.077	10.000	14.844	13.741	11.508	37.713867	14.974114	0.969	0.367	-1.714	1531	445

Ch 21, 22, 29, 31, 32 – values reported as Corrected Radiance data (DN to radiance)
Solar and Satellite zenith angles reported in radians.
Latitude and Longitude reported in degrees.

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MODIS Image

Description:

MODIS RGB Product

Ch1, Ch3, Ch4 composite

Before/After flooding in Bangladesh

Aqua/MODIS 250 m and 500m calibrated data

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MODIS Image

Description:

MODIS RGB Product

Ch1 and Ch2

Enhanced Vegetation Index – NASA algorithm

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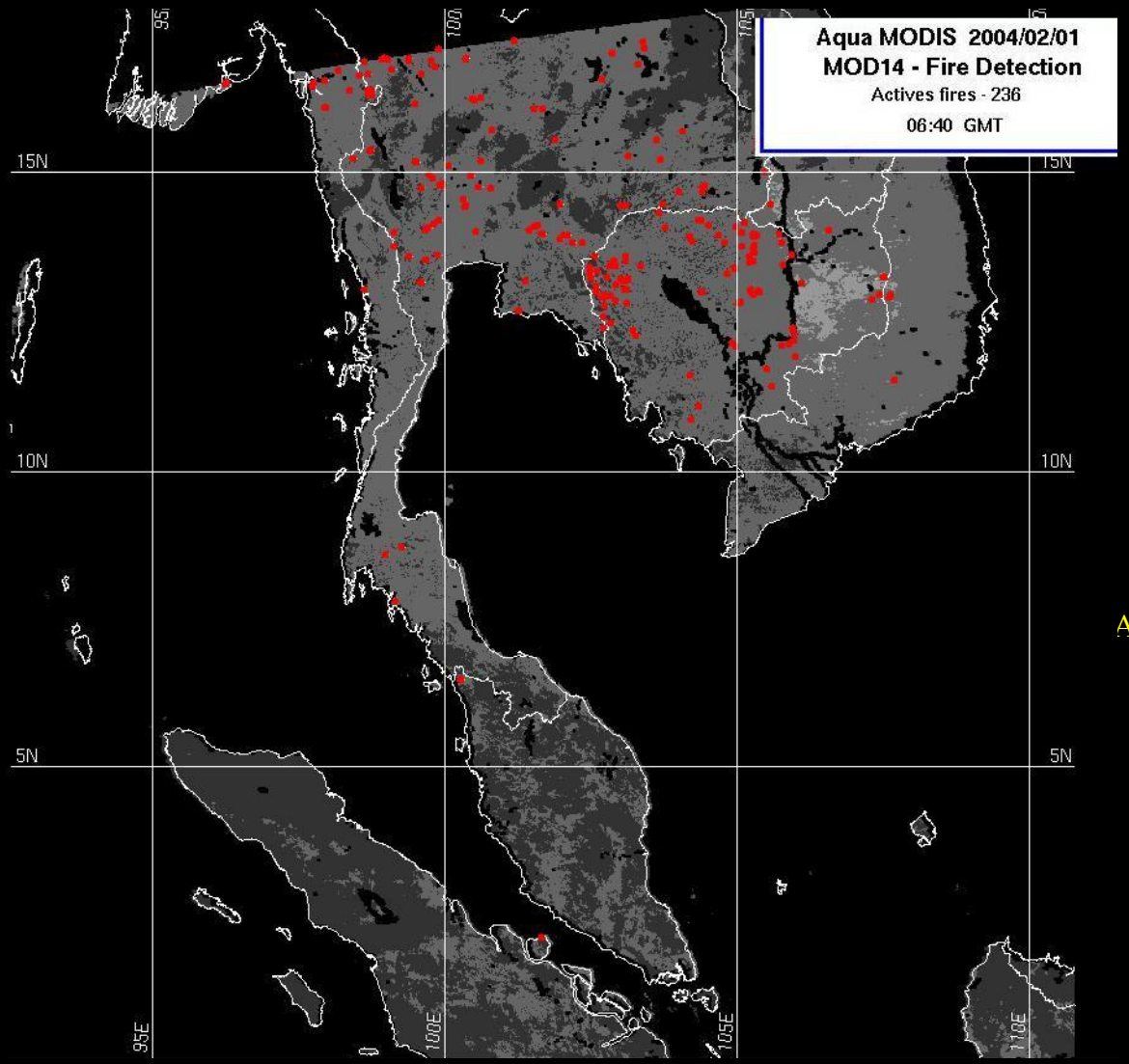
MODIS Image

Description:

MODIS Active Fire hot spot product

MOD14 algorithm



A

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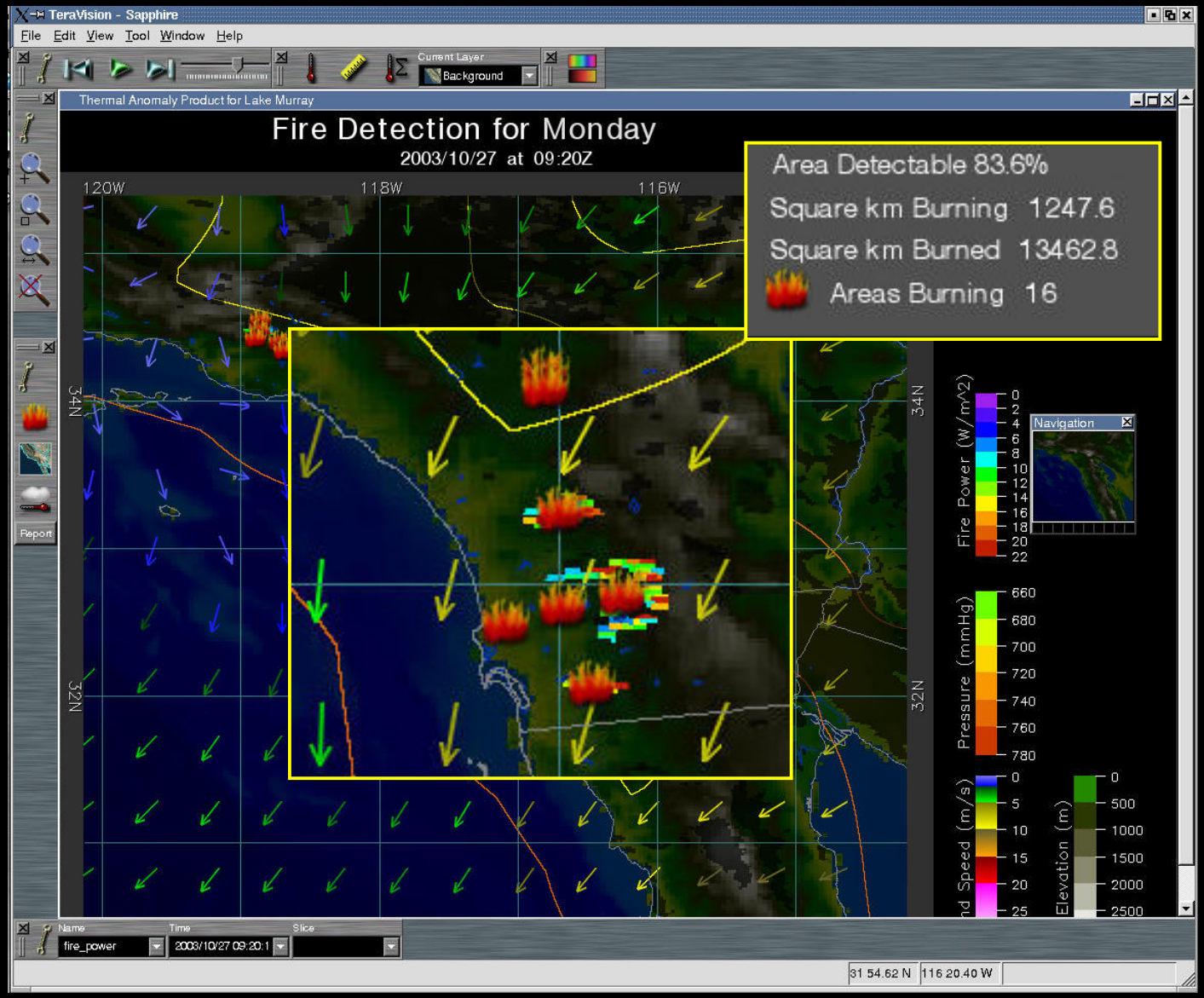
TeraScan® Vulcan
Thermal Anomaly Detection of Fires



Automated Vulcan Product

Using MODIS and AVHRR data:

Graphical Notification
Latitude/Longitude

Text Notification

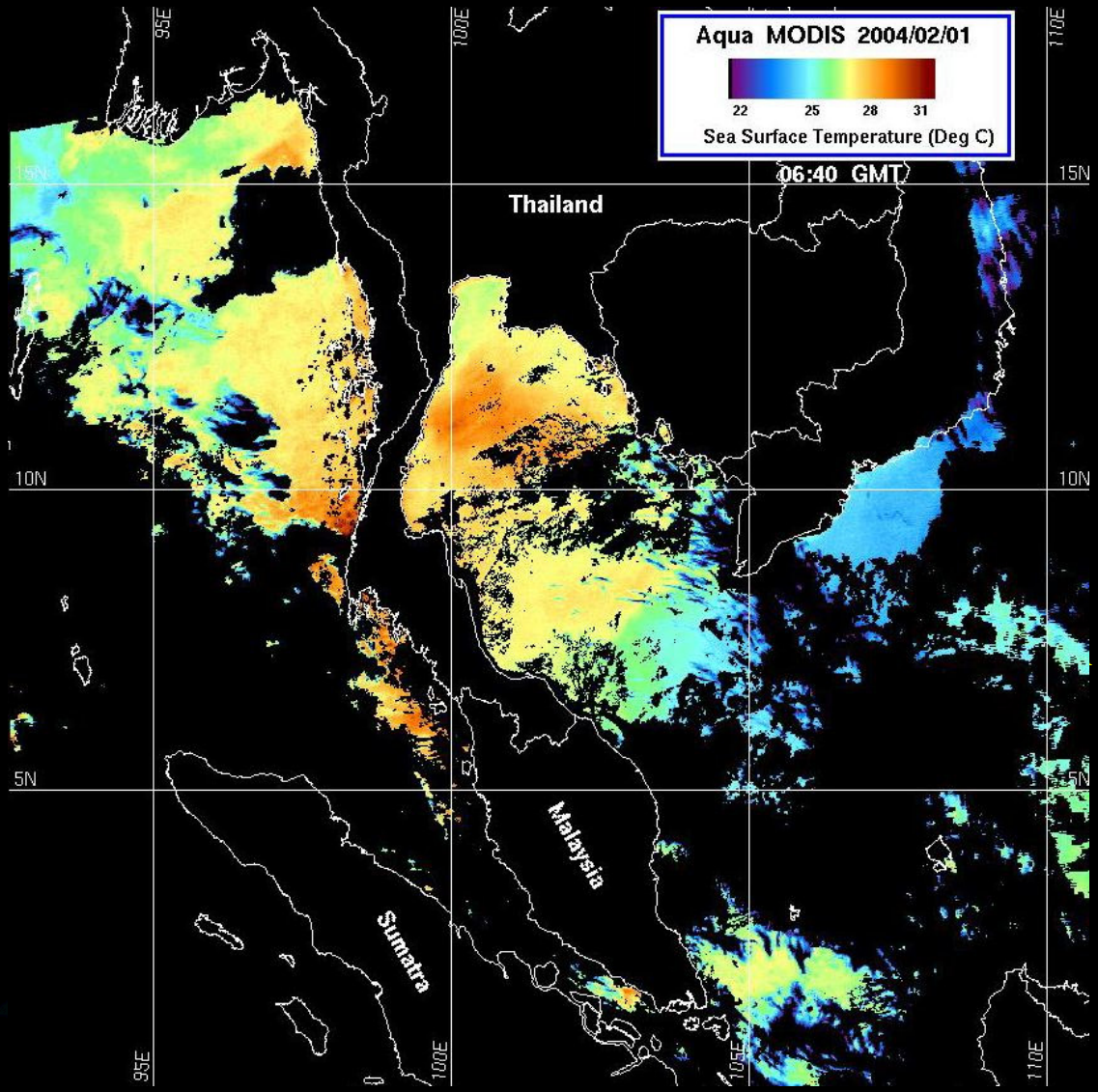
Relative Humidity
Wind Speed/dir
Fire intensity
Area burned
Active fires

MODIS Image

Description:

MODIS Sea Surface Temperature

NASA MOD28 algorithm – presently incorporated into the latest SeaDAS algorithm.



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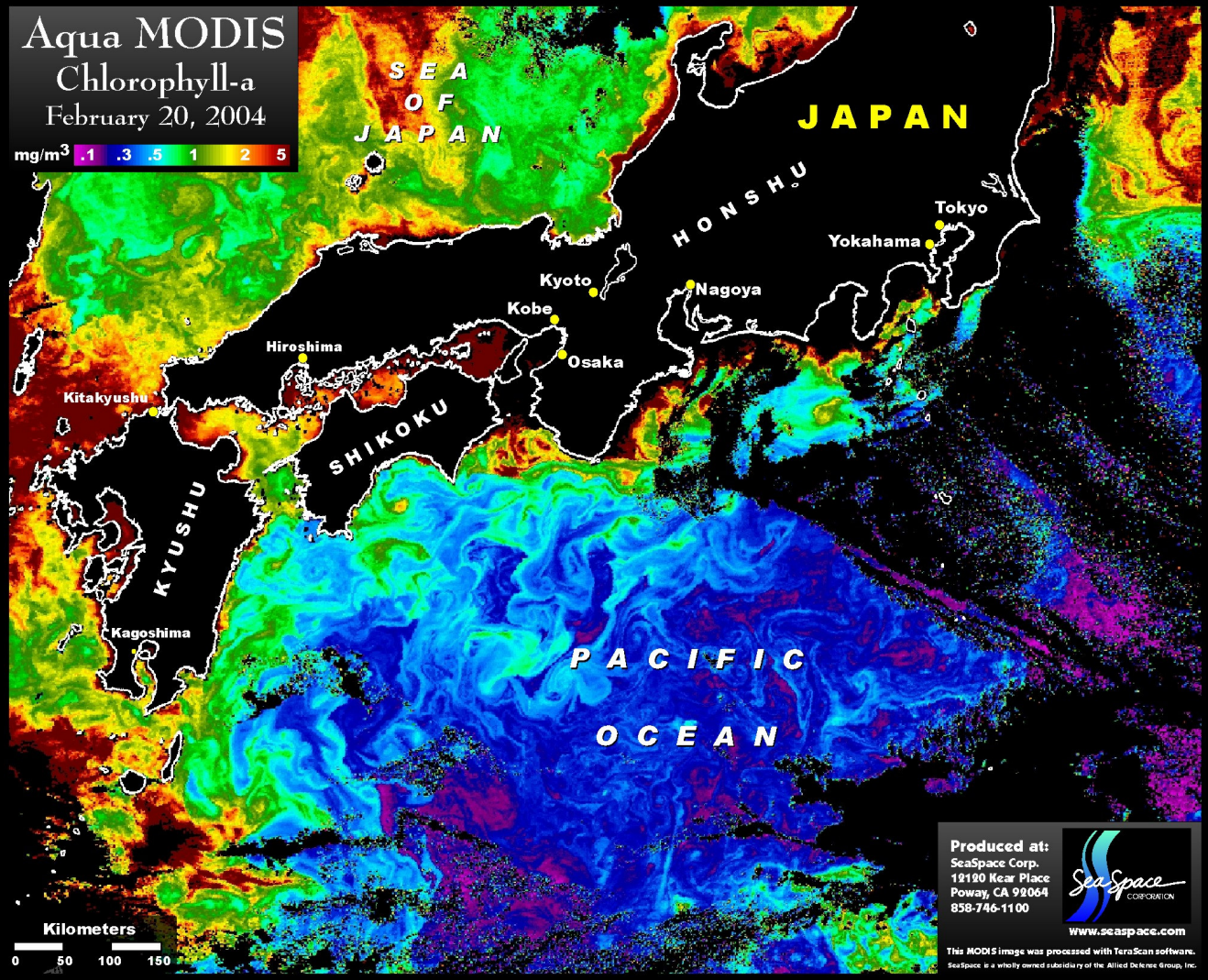
MODIS Image

Description:

MODIS Chlorophyll-a

Ocean Color algorithm – presently incorporated into the latest SeaDAS algorithm.

Hokkaido University, Japan



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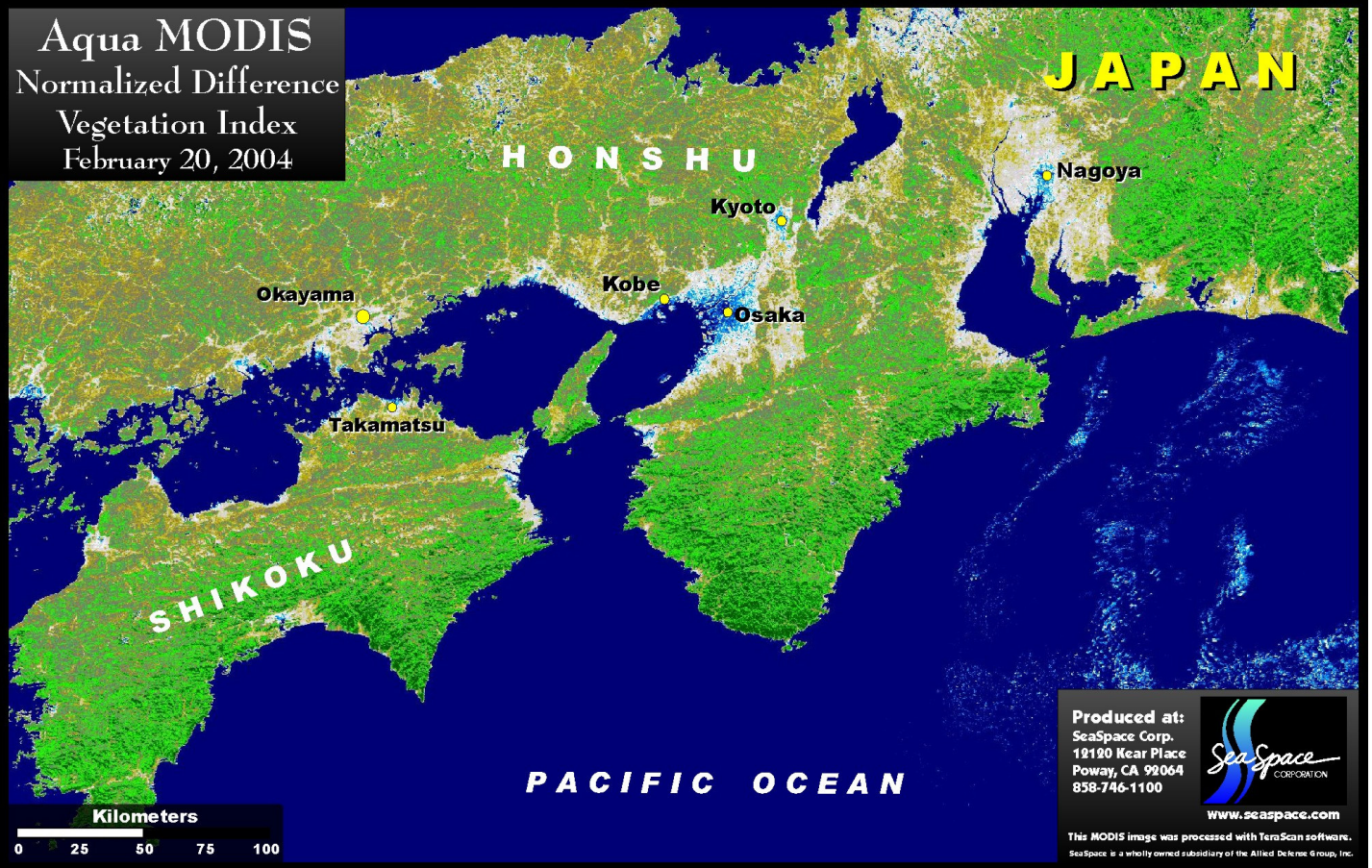
MODIS Image

Description:

MODIS NDVI

NDVI using 250m bands

Hokkaido University, Japan



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MODIS Image – RGB Color Composite

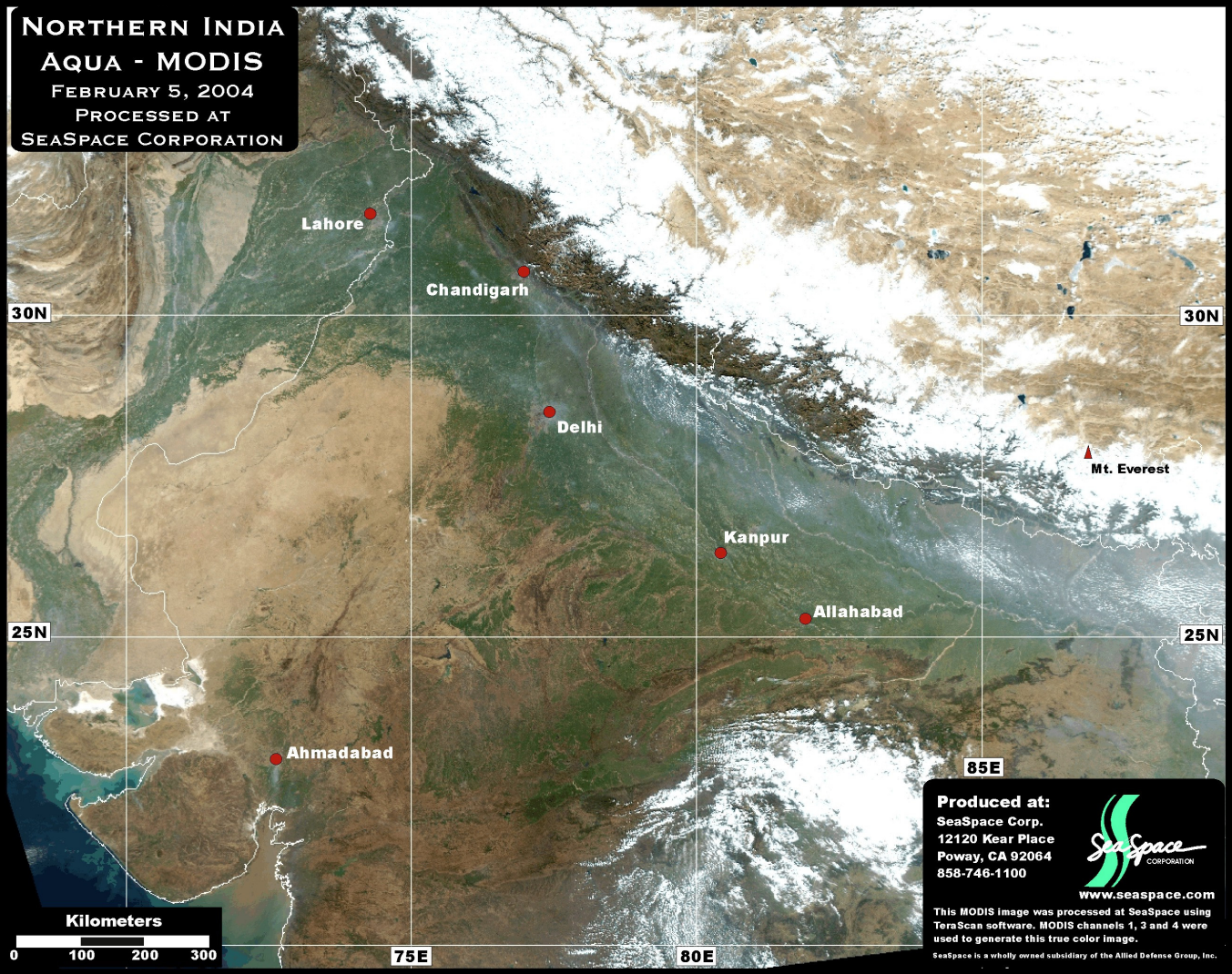
Description:

MODIS (250m, 500 m)

February, 5, 2004

Himalayas Region

CH1, CH4, CH3 - calibrated



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MODIS Image – Snow Cover product

Description:

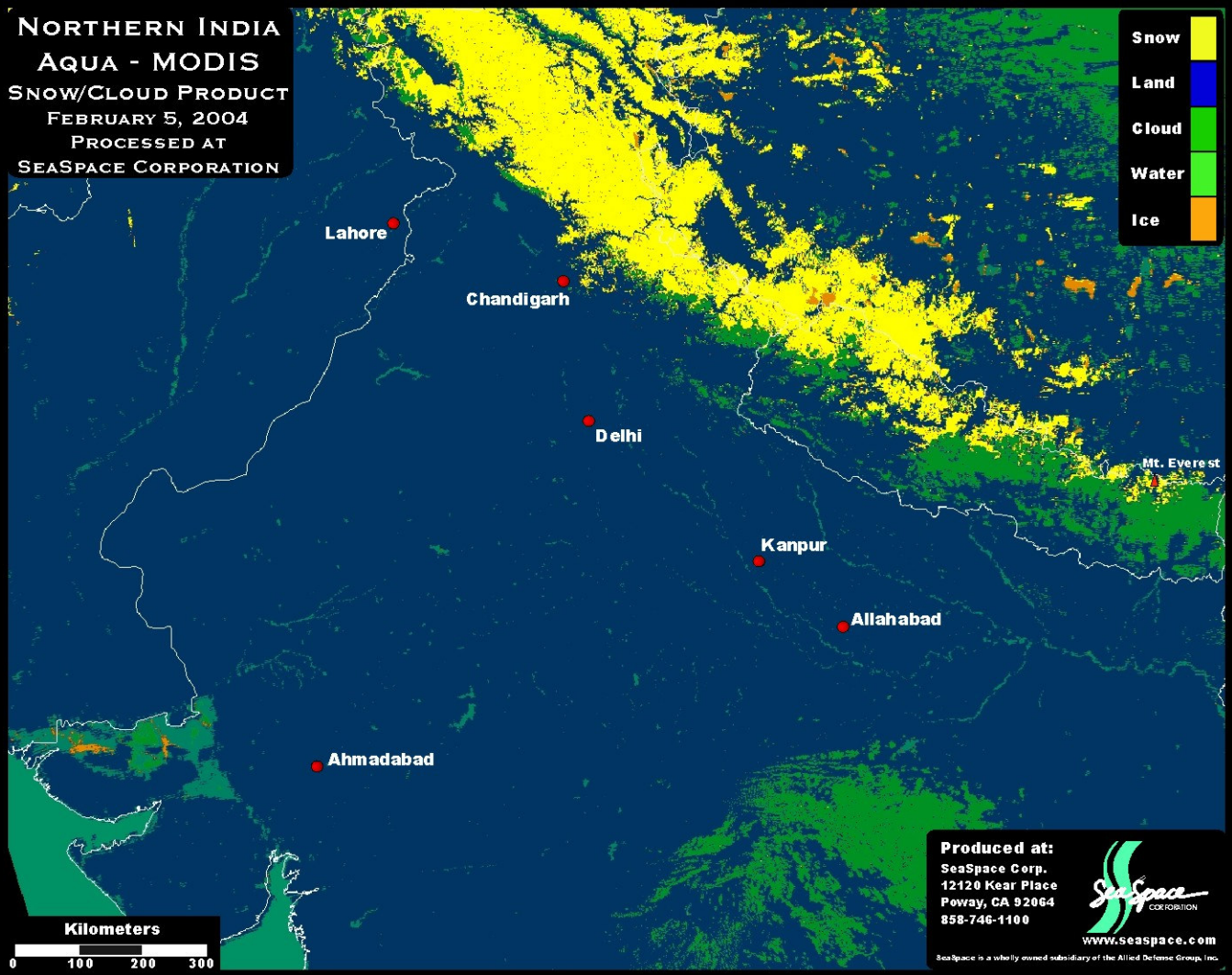
MODIS Snow Cover Product (500 m)

February, 5, 2004

Himalayas Region

MOD10 Automated supervised classification scheme

Discriminates between snow and clouds



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MODIS Image – Cloud Top Temperatures

Description:

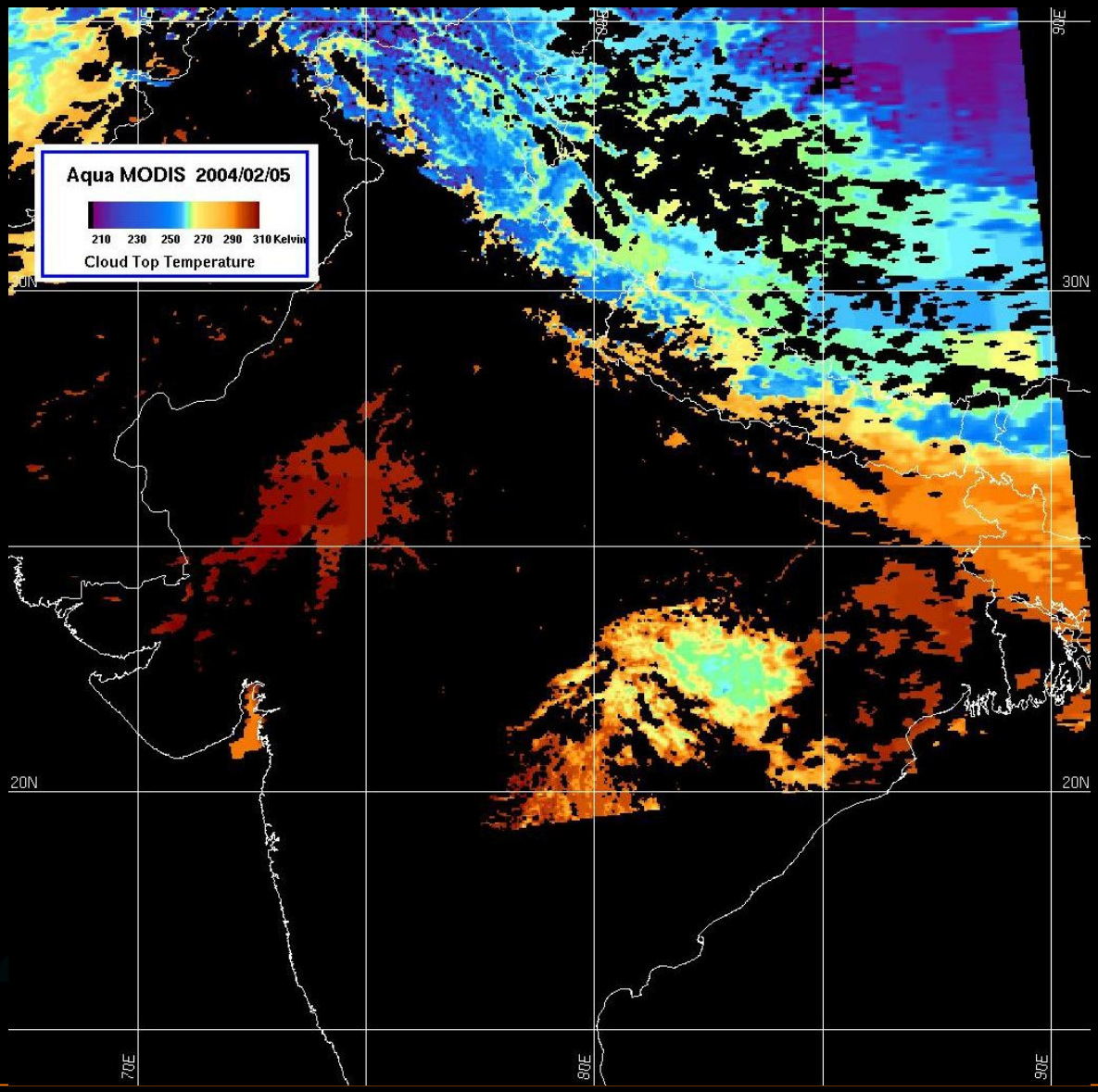
MODIS Cloud Top Temperature Product (1KM)

MOD06 Cloud Top product

Cloud Top Temperature

Aqua/MODIS 1000m calibrated data as inputs to the MOD06 algorithm – Automated supervised classification scheme

Estimates cloud top temperatures



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MODIS Image – Cloud Top Temperatures

Description:

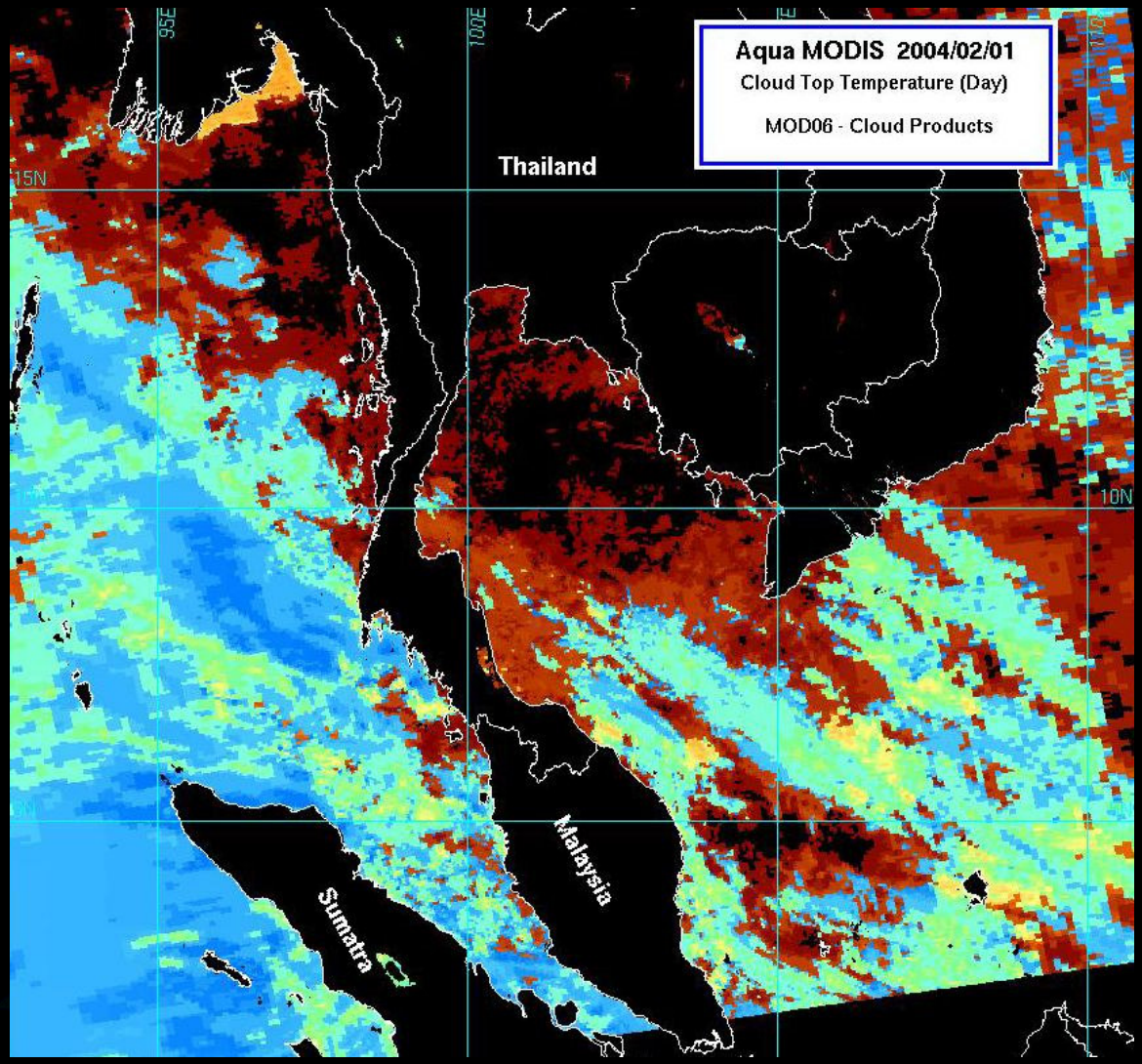
MODIS Cloud Top Temperature Product (1KM)

MOD06 Cloud Top product

Cloud Top Temperature

Aqua/MODIS 1000m calibrated data as inputs to the MOD06 algorithm – Automated supervised classification scheme

Estimates cloud top temperatures



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MODIS Image – Aerosol Optical depth

Description:

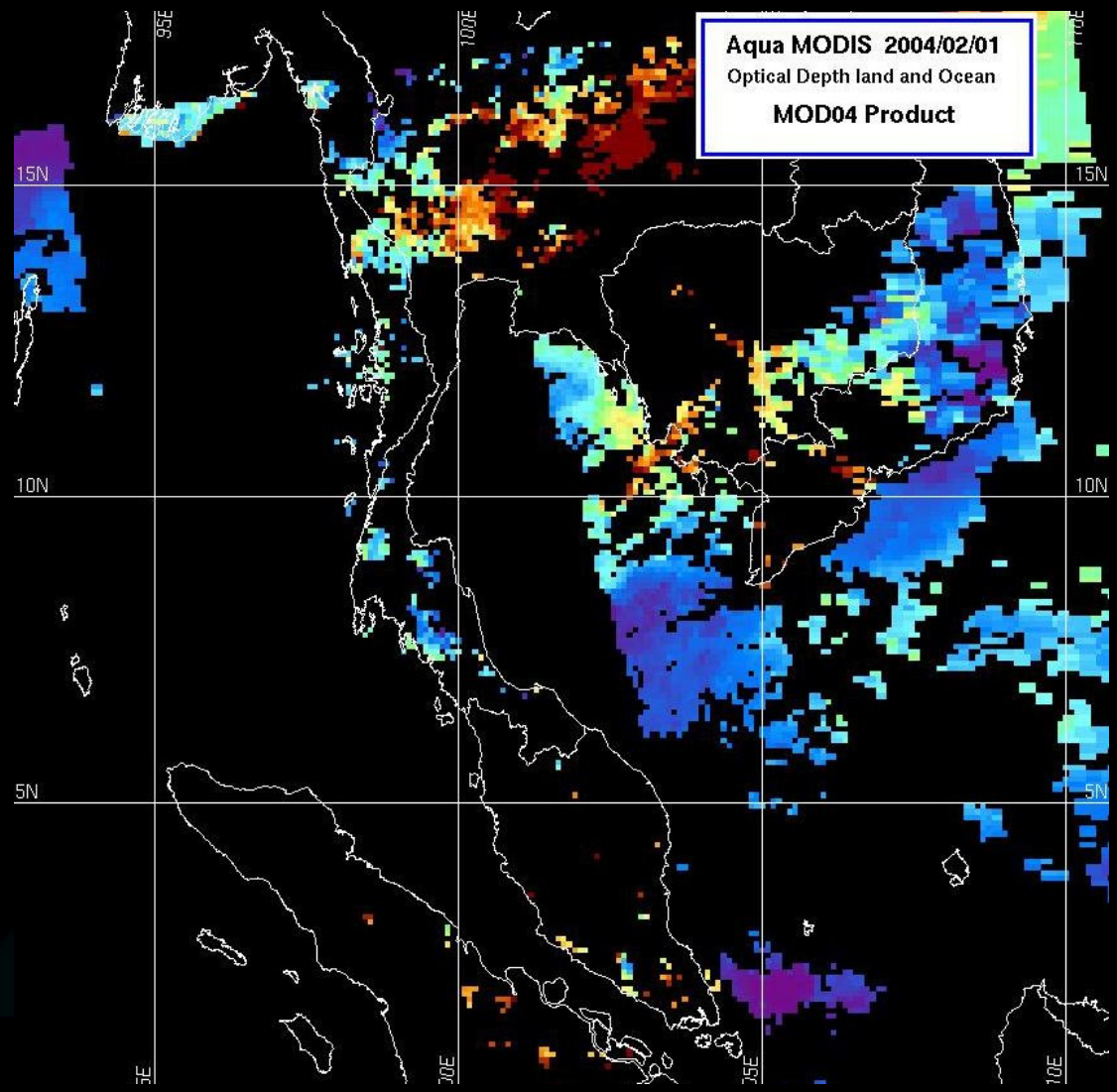
MODIS Aerosols

MOD04 product

Optical depth land & Ocean

Aqua/MODIS 1000m calibrated data as inputs to the MOD04 algorithm – Automated supervised classification scheme

Estimates Aerosols



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MODIS Image – Cloud Optical Depth (OD)

Description:

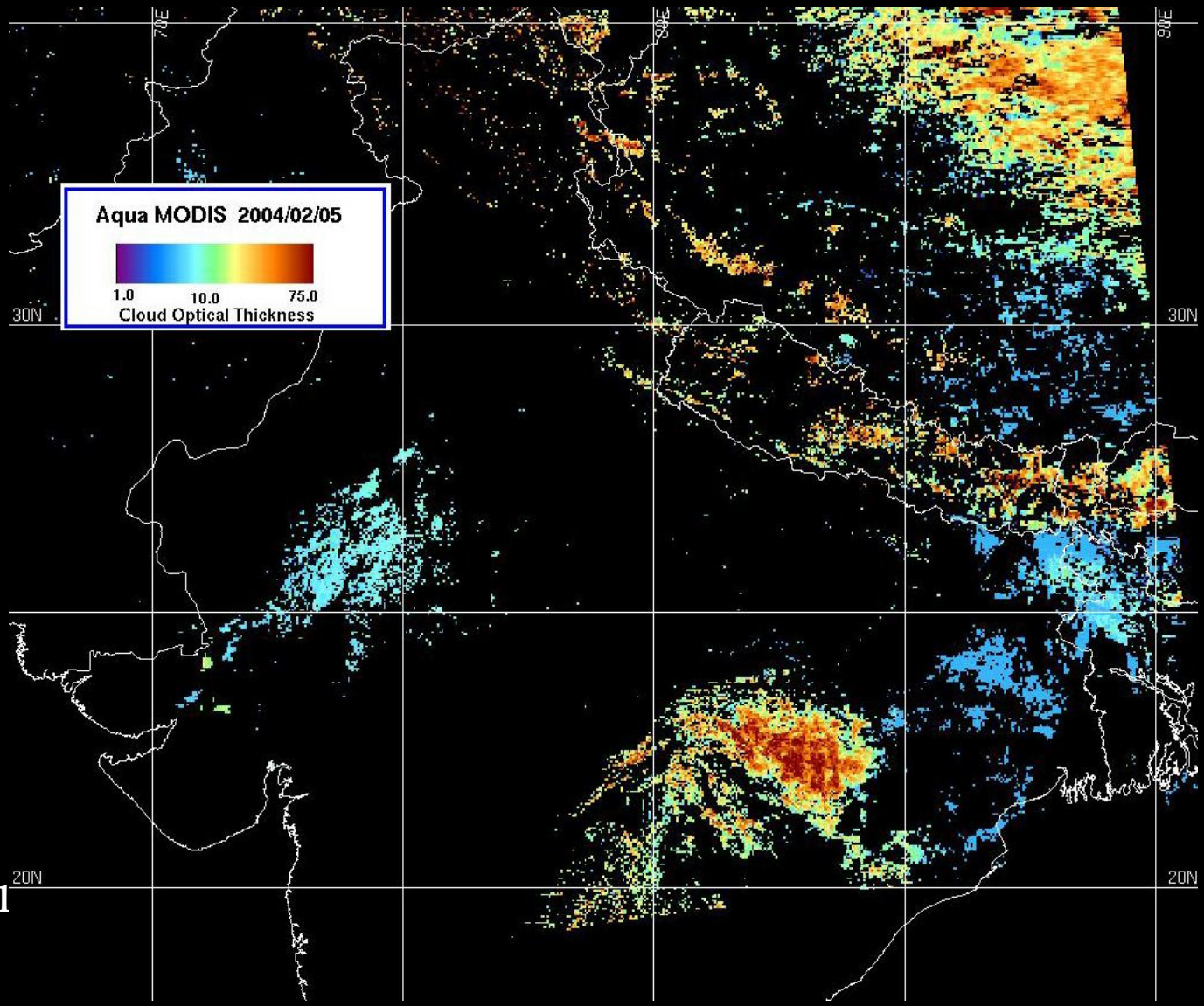
MODIS Cloud Optical Depth Product

MOD06 Cloud Optical Depth (OD) product

Cloud Optical Depth

Aqua/MODIS 1000m calibrated data as inputs to the MOD06 algorithm – Automated supervised classification scheme

Estimates cloud Optical depth



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MODIS Image – Cloud Phase IR

Description:

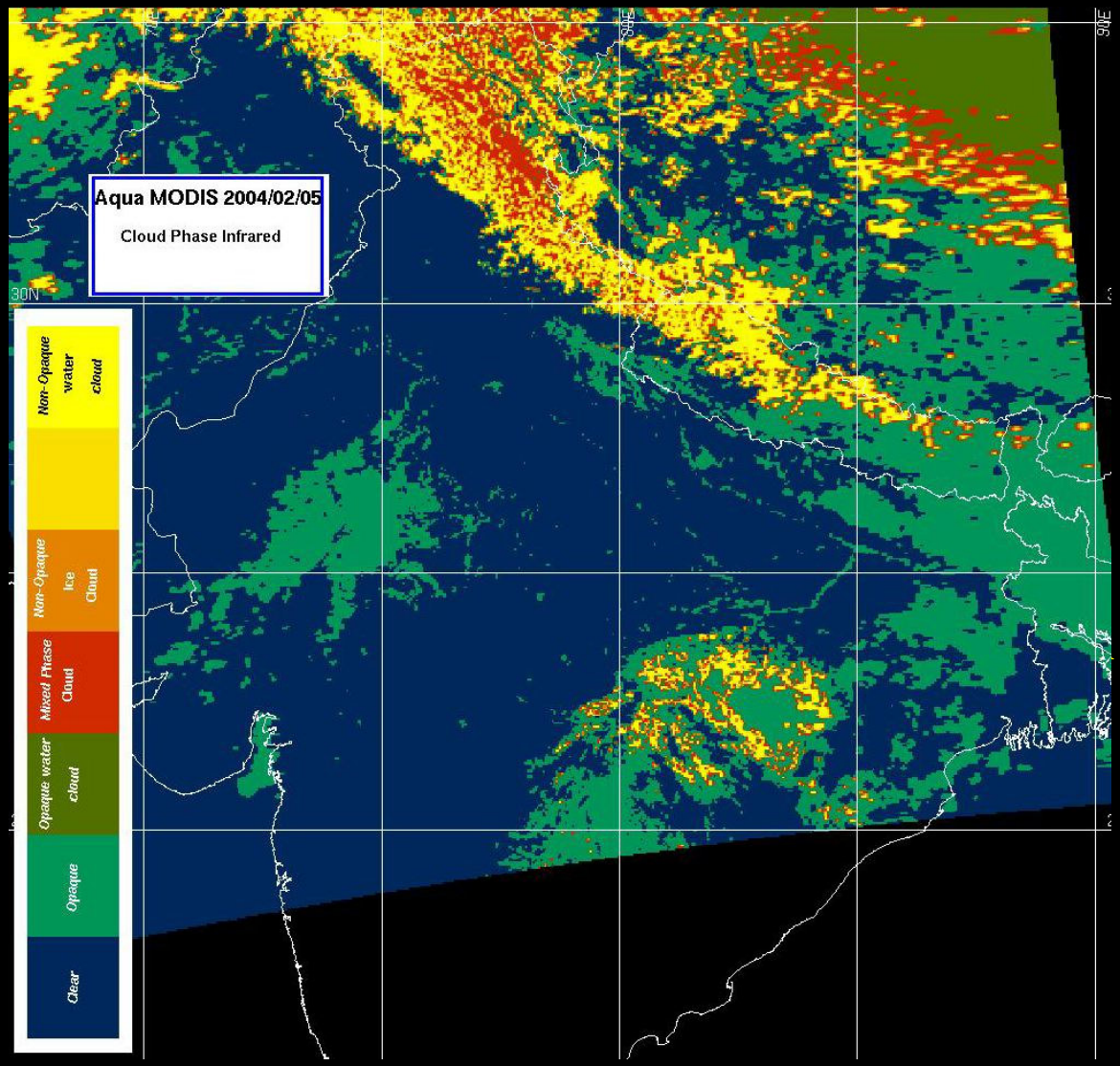
MODIS Cloud Phase Infrared

MOD06 Cloud product

Cloud Phase

Aqua/MODIS 1000m calibrated data as inputs to the MOD06 algorithm – Automated supervised classification scheme

Estimates cloud Phase



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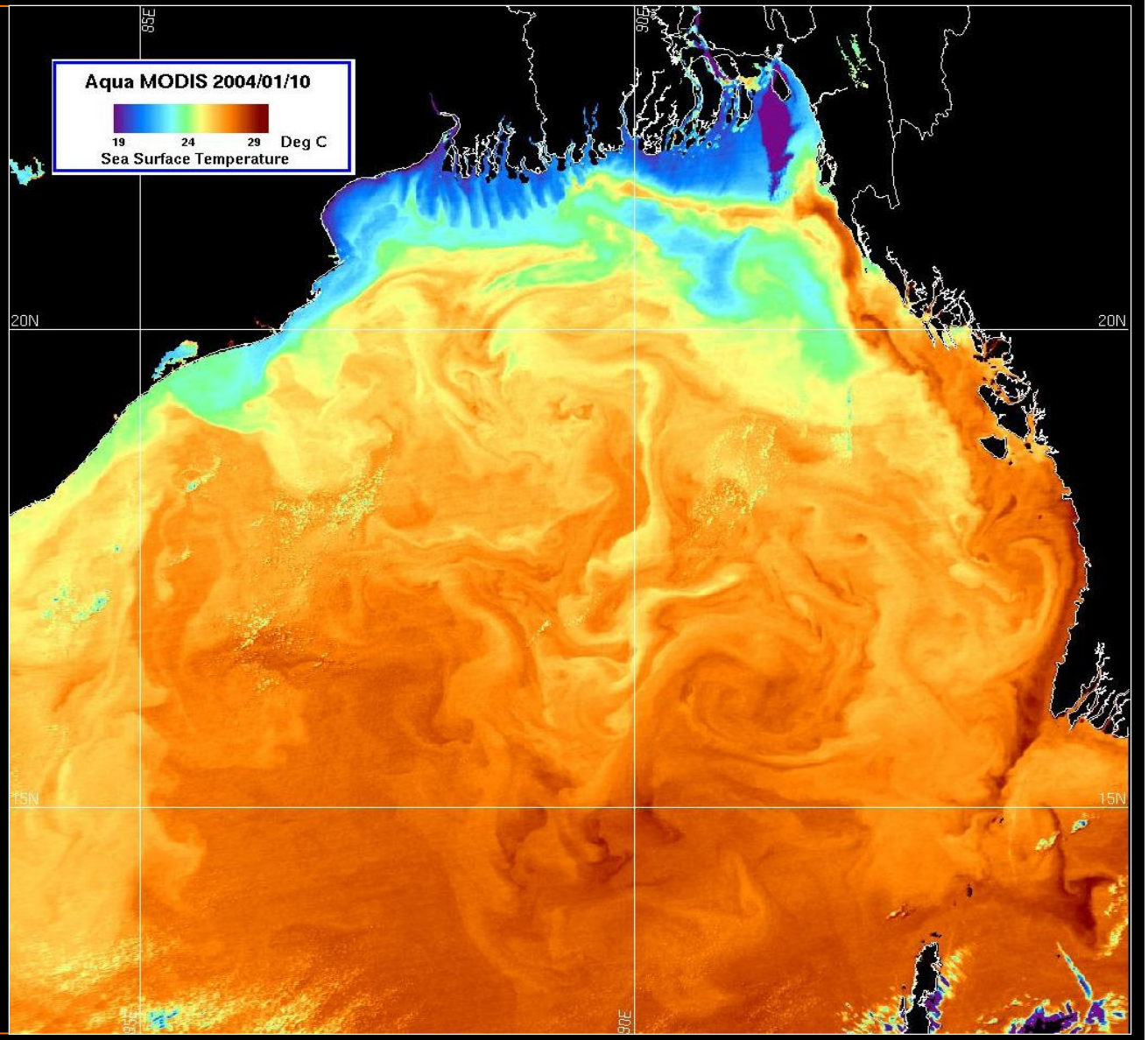
MODIS Image – Sea Surface Temperature



Description:

MODIS Derived Product

Sea Surface Temperature

January 11, 2004 (08:00 GMT),– Bay of Bengal.

Aqua/MODIS 1km Thermal IR bands, using MOD28 SST_MODIS algorithm

MODIS Sea Surface Temperature algorithm

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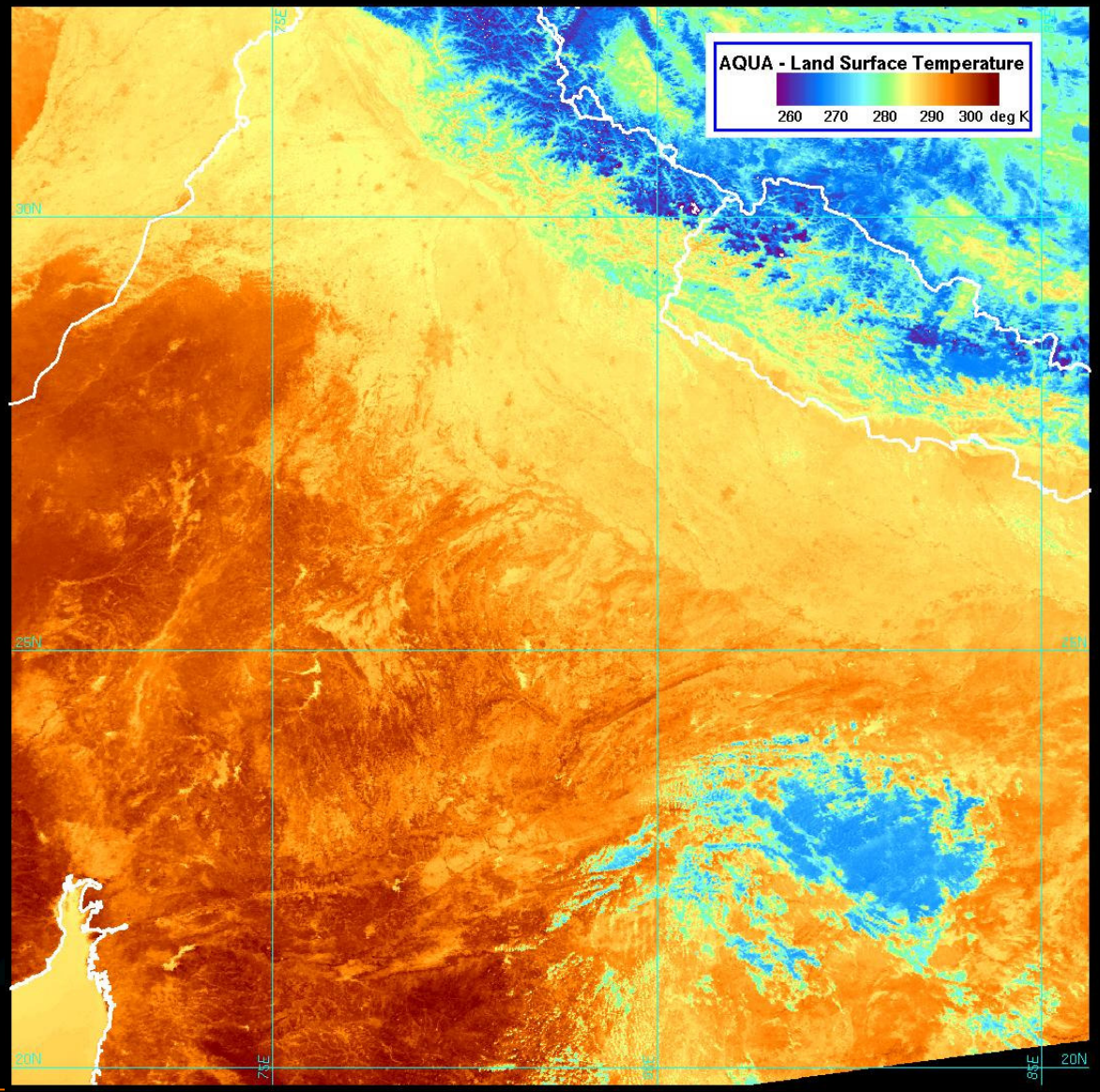
MODIS Image – Land Surface Temperature



Description:

MODIS Derived Product

Land Surface Temperature

January 11, 2004 (08:00 GMT),– India

Aqua/MODIS 1km Thermal IR bands, using MODLST algorithm

MODIS Land Surface Temperature algorithm

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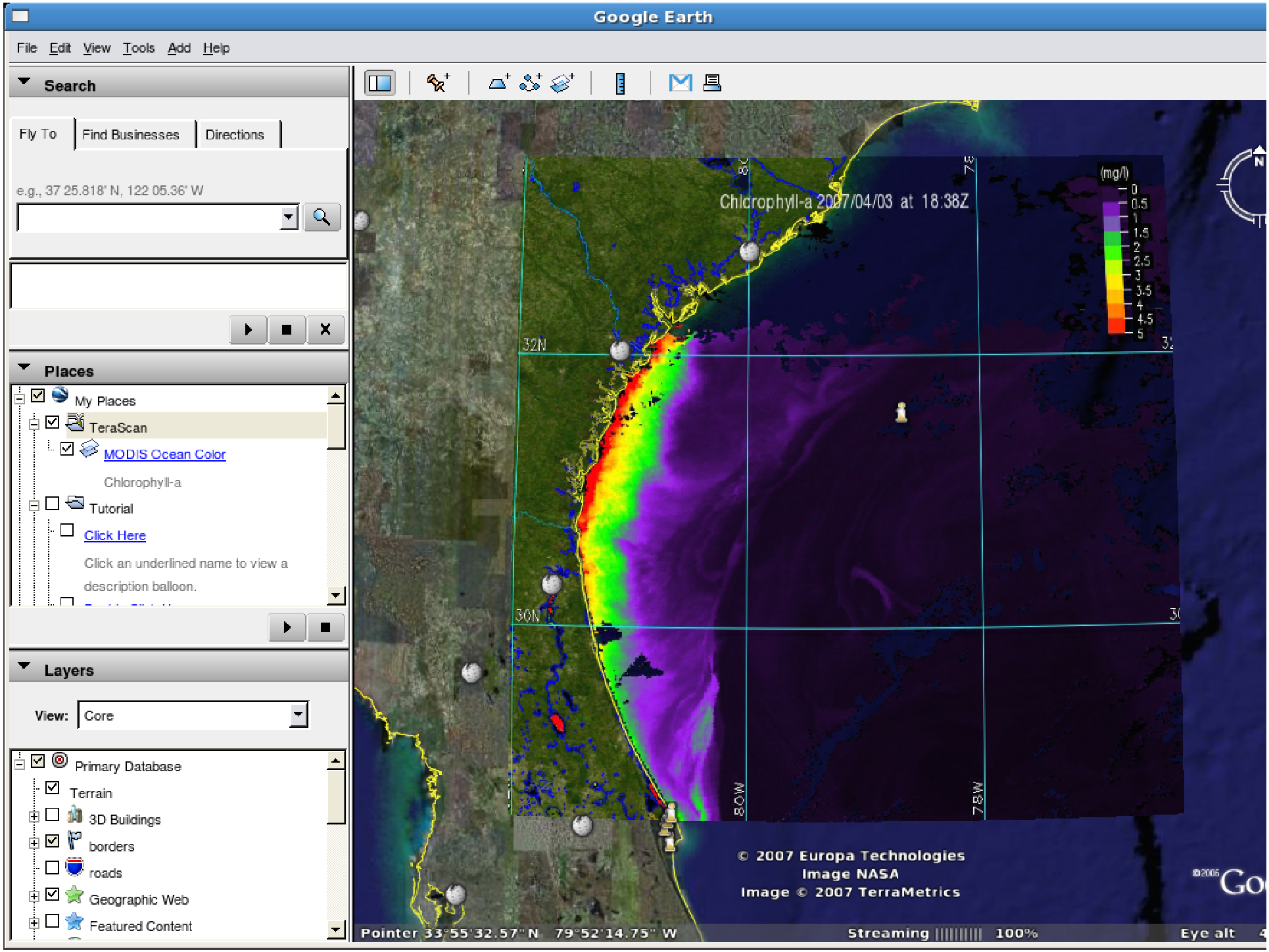
Google Earth
File Edit View Tools Add Help
Search
Fly To
Find Businesses
Directions
e.g., 37 25.818' N, 122 05.36' W
Places
My Places
TeraScan
MODIS Ocean Color
Chlorophyll-a
Tutorial
Click Here
Click an underlined name to view a description balloon.
Layers
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Primary Database
Terrain
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Featured Content
Chlorophyll-a 2007/04/03 at 18:38Z
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Image NASA
Image © 2007 TerraMetrics
Pointer 33°55'32.57" N 79°52'14.75" W
Streaming 100%
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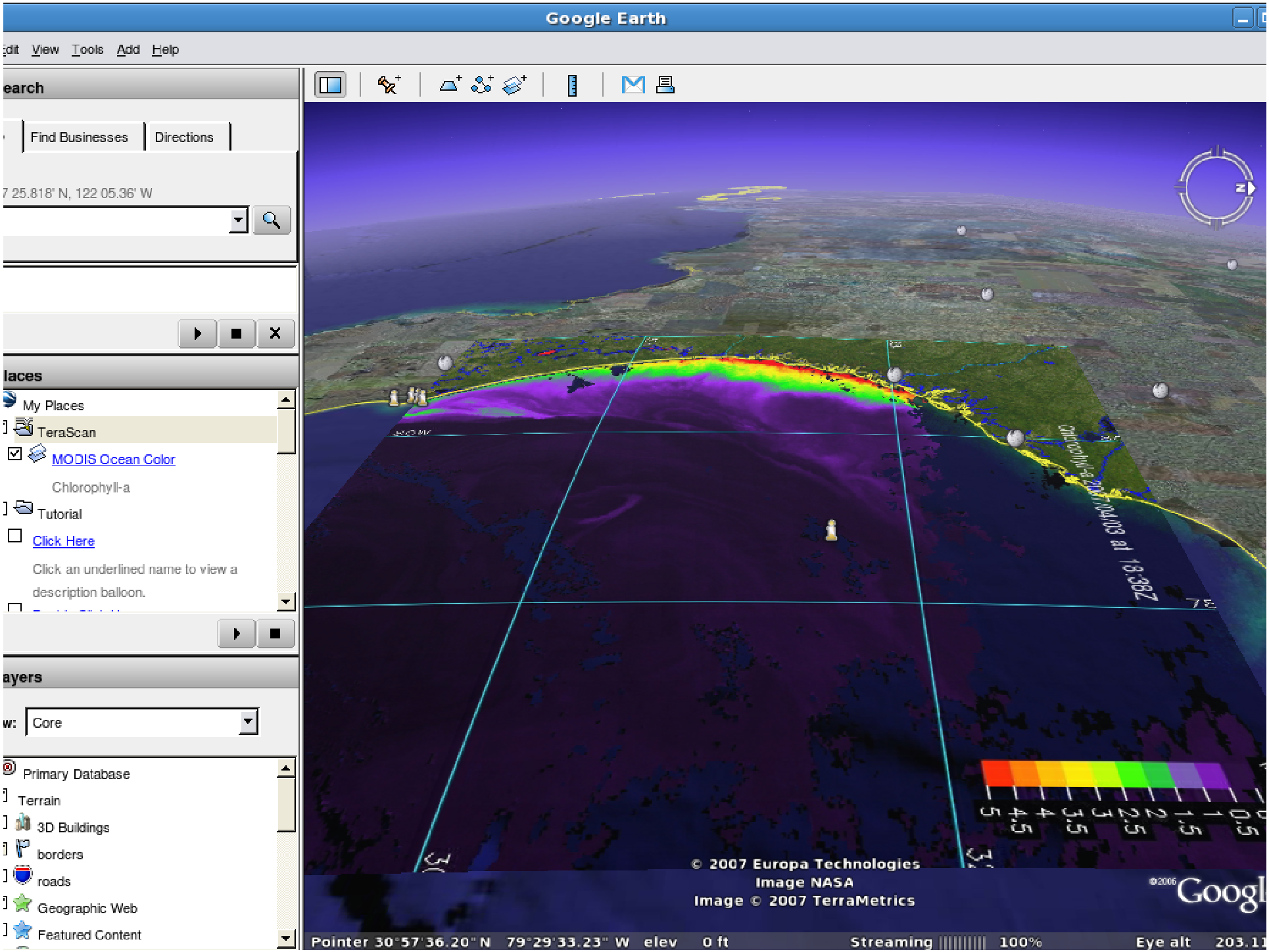
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MODIS Ocean Color
Chlorophyll-a
Tutorial
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borders
roads
Geographic Web
Featured Content
© 2007 Europa Technologies
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Image © 2007 TerraMetrics
Pointer 30°57'36.20" N 79°29'33.23" W elev 0 ft
Streaming 100%
Eye alt 203.11

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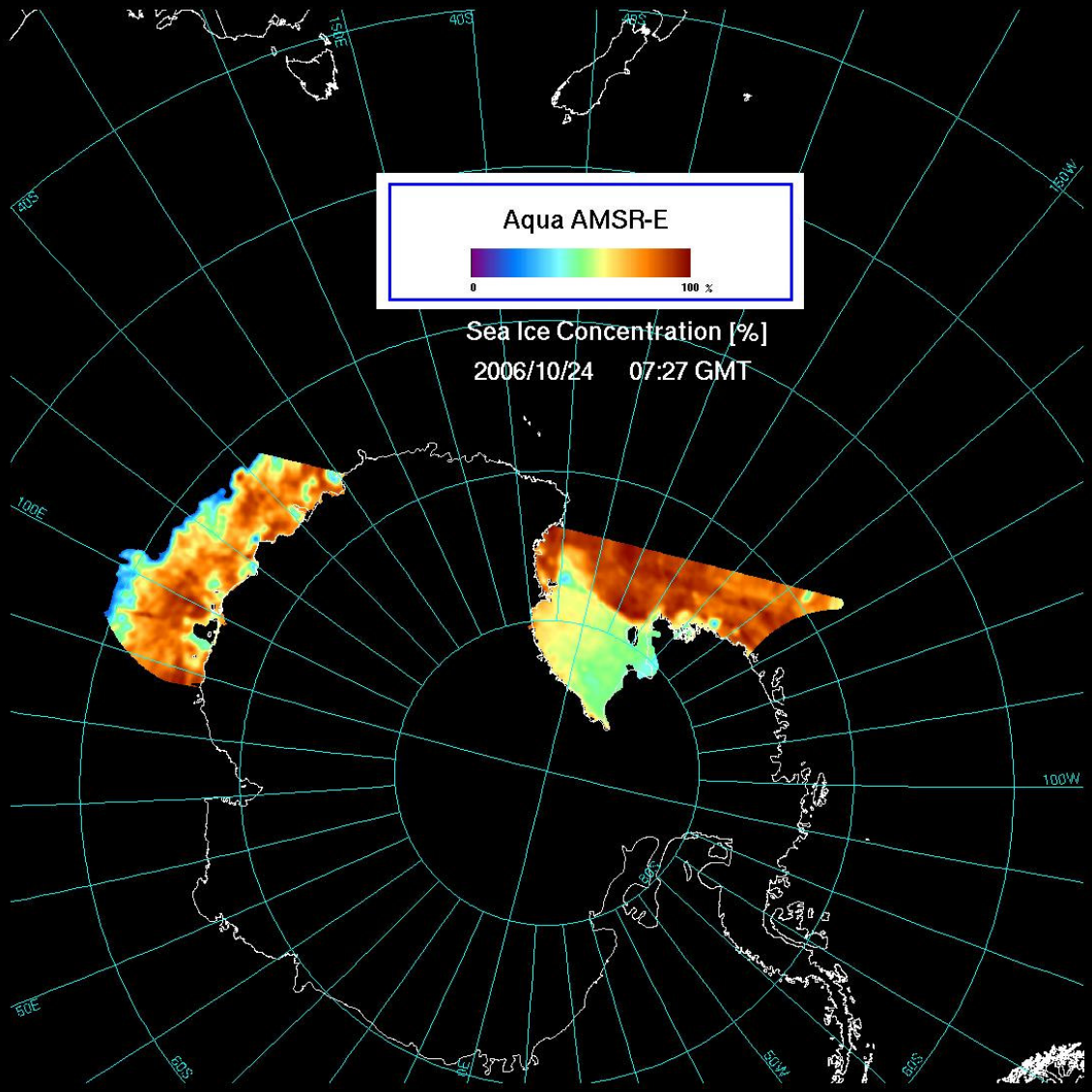
Aqua – AMSR-E Sea Ice Concentration %



Description:

AMSR-E Product

Sea Ice Concentration

October 24, 2006 07:27 GMT

Polar Stereographic projection

Data Acquired using SeaSpace System at the U.S. McMurdo Station.

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METOP Data processing & Sample Imagery

(AHRPT, AMSUA, ATOVS sounder, IASI).

Data acquired and processed at SeaSpace Corporation

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For all METOP sensors, processes raw CADU to CCSDS format using **Metopizer** functions/programs **cadu_to_ccsds** and **ccsds_demultiplexer**.

Ingests CCSDS data with TeraScan **atovsin** function, to generate ATOVS retrievals.

For all METOP sensors, processes CCSDS to Level 0 format using **Metopizer** software **ccsds_to_l0**.

For NOAA legacy sensors, processes Level 0 to Level 1 formats 1a, 1b, 1c, 1d, using **AAPP** script **AAPP_RUN_METOP**.

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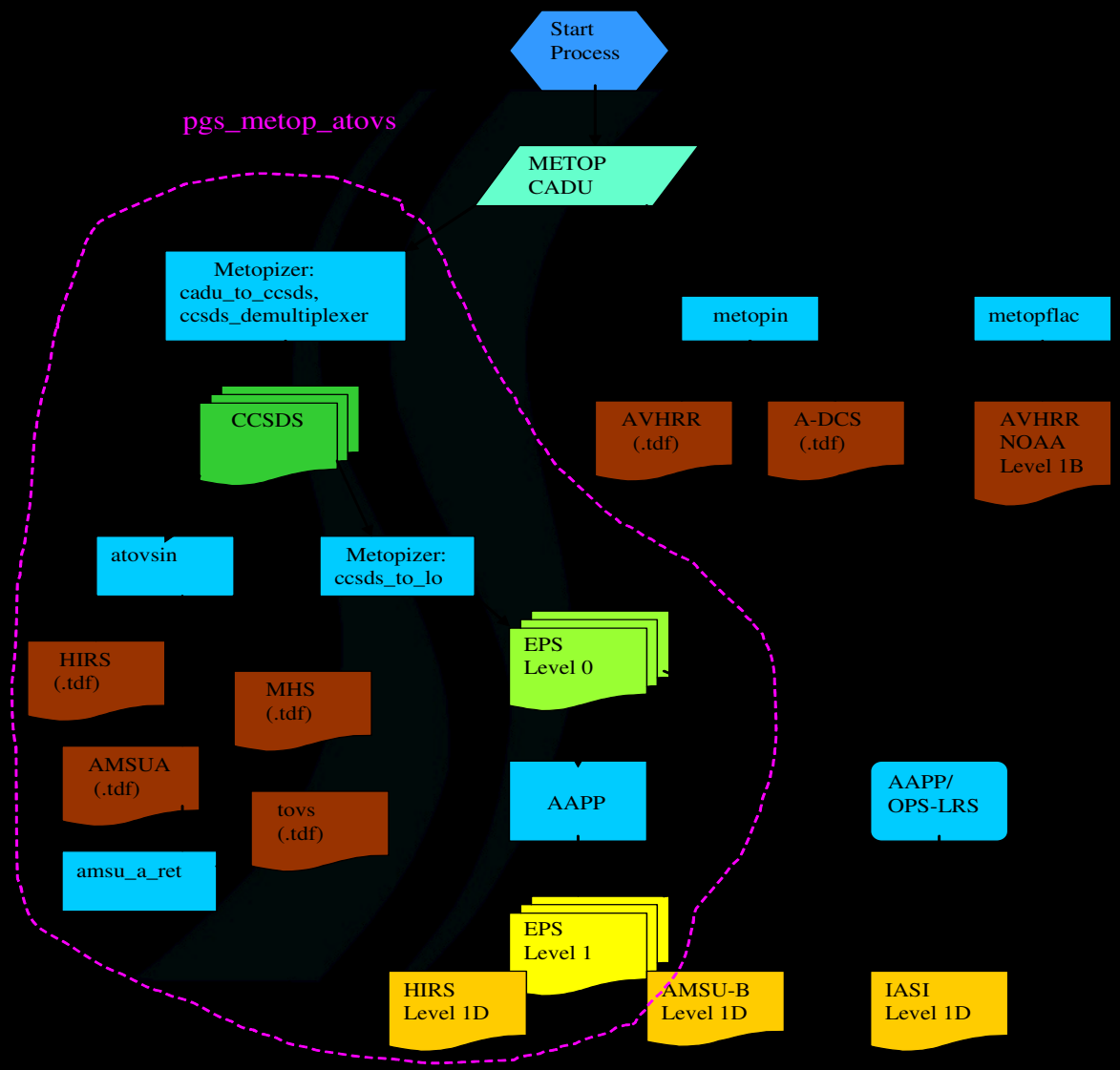

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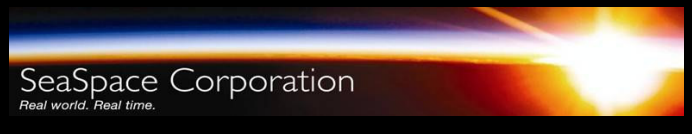

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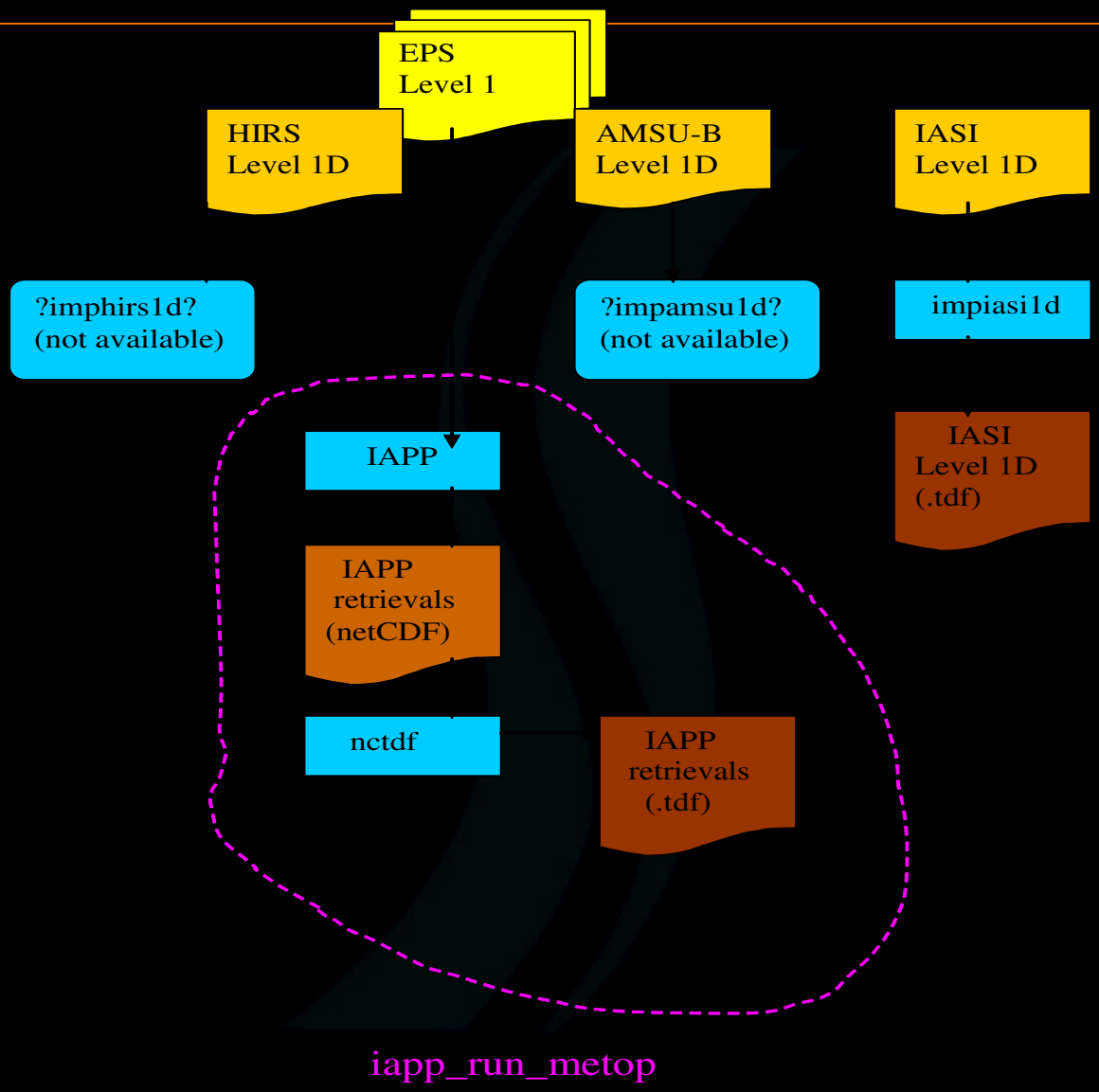

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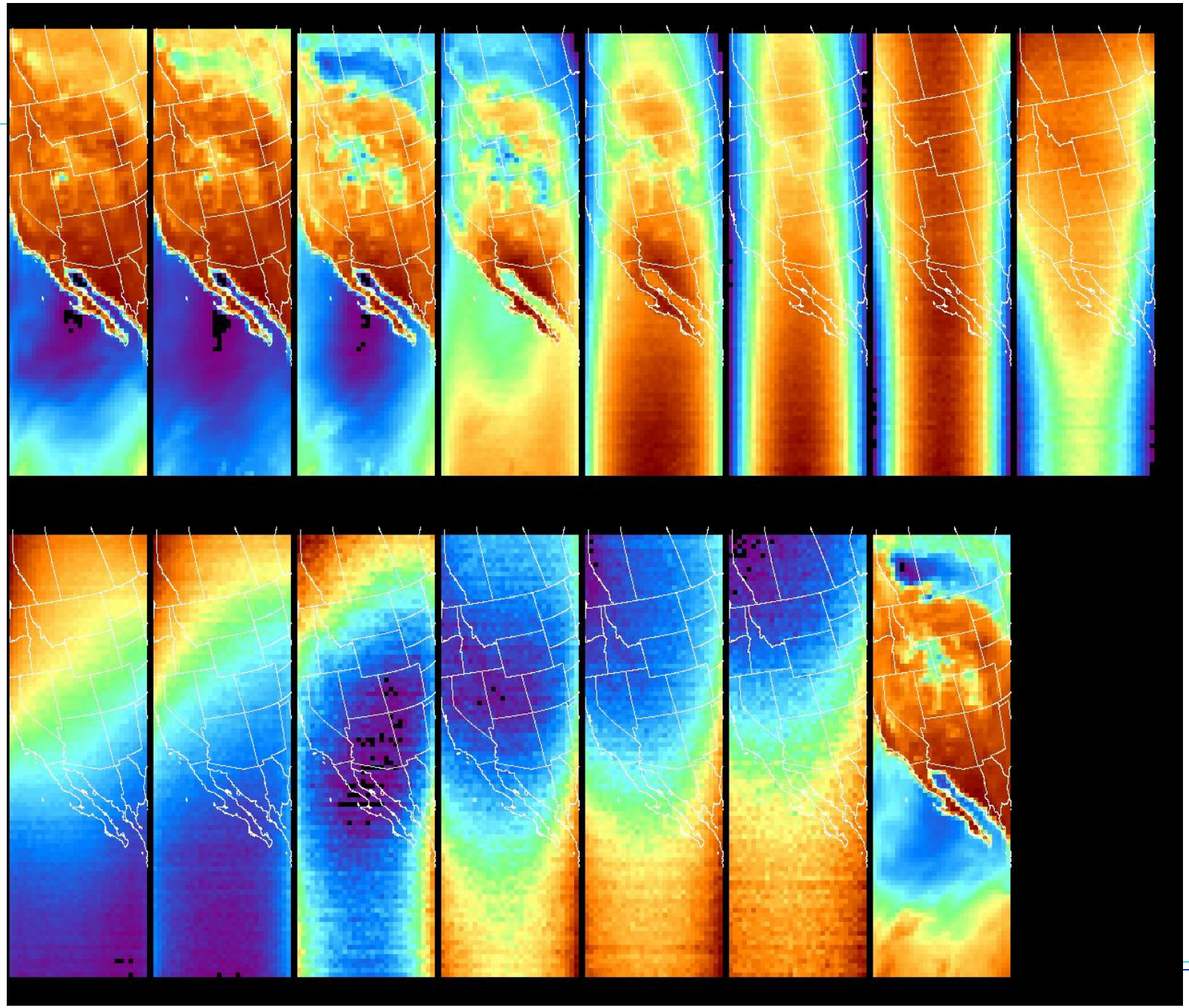
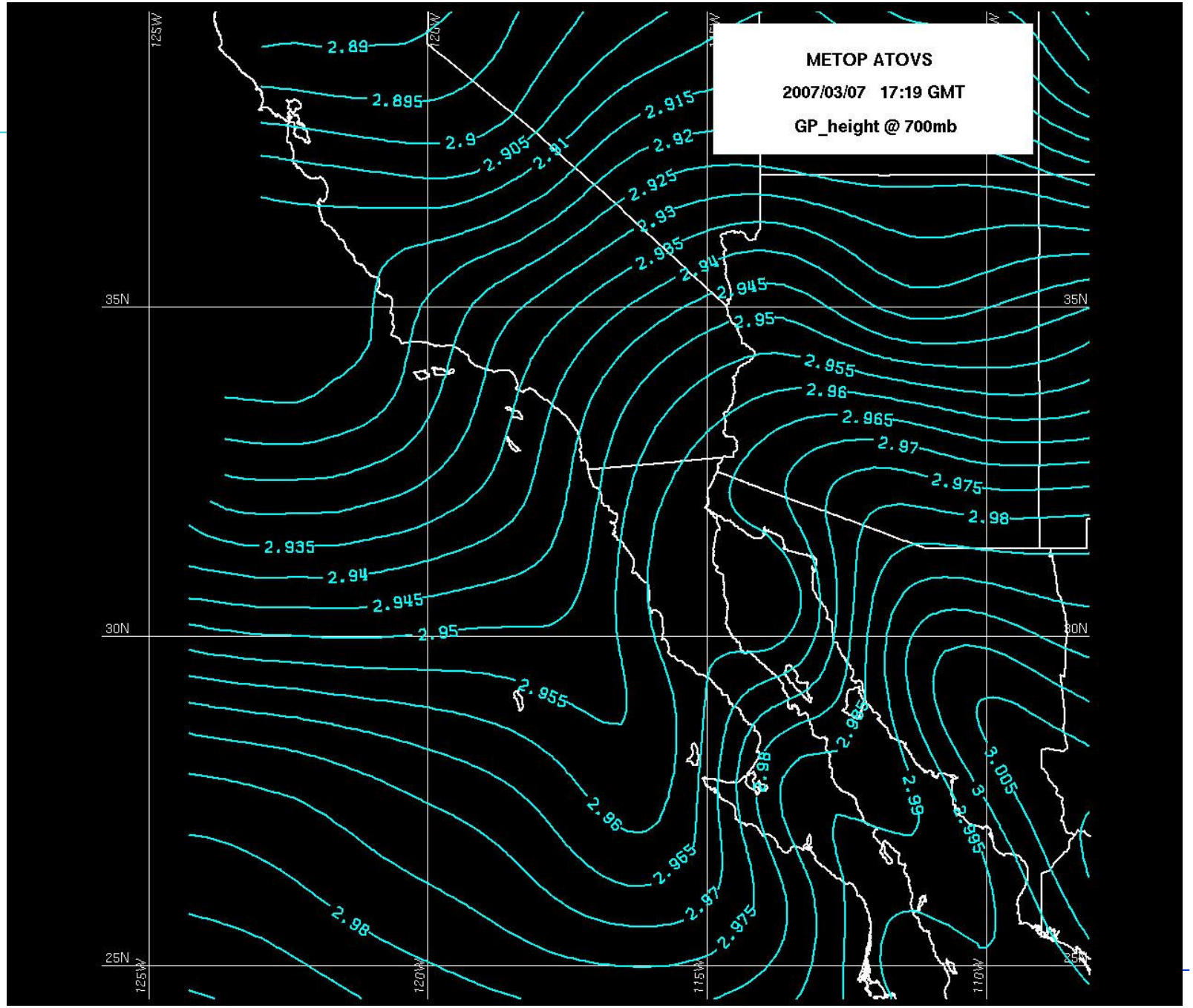
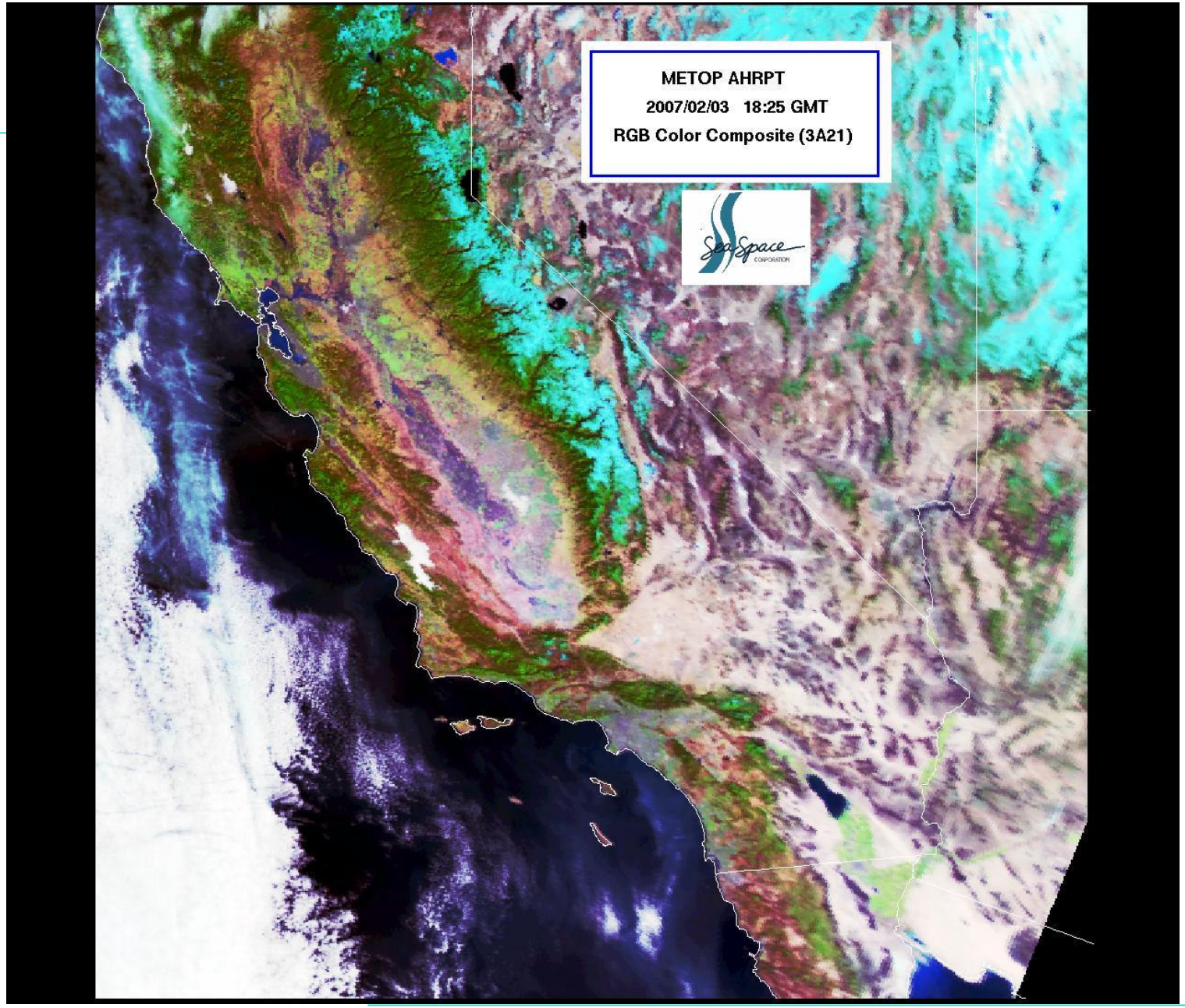
AMSU-A Brightness temperatures from METOP-2 2007/03/07 17:19 GMT



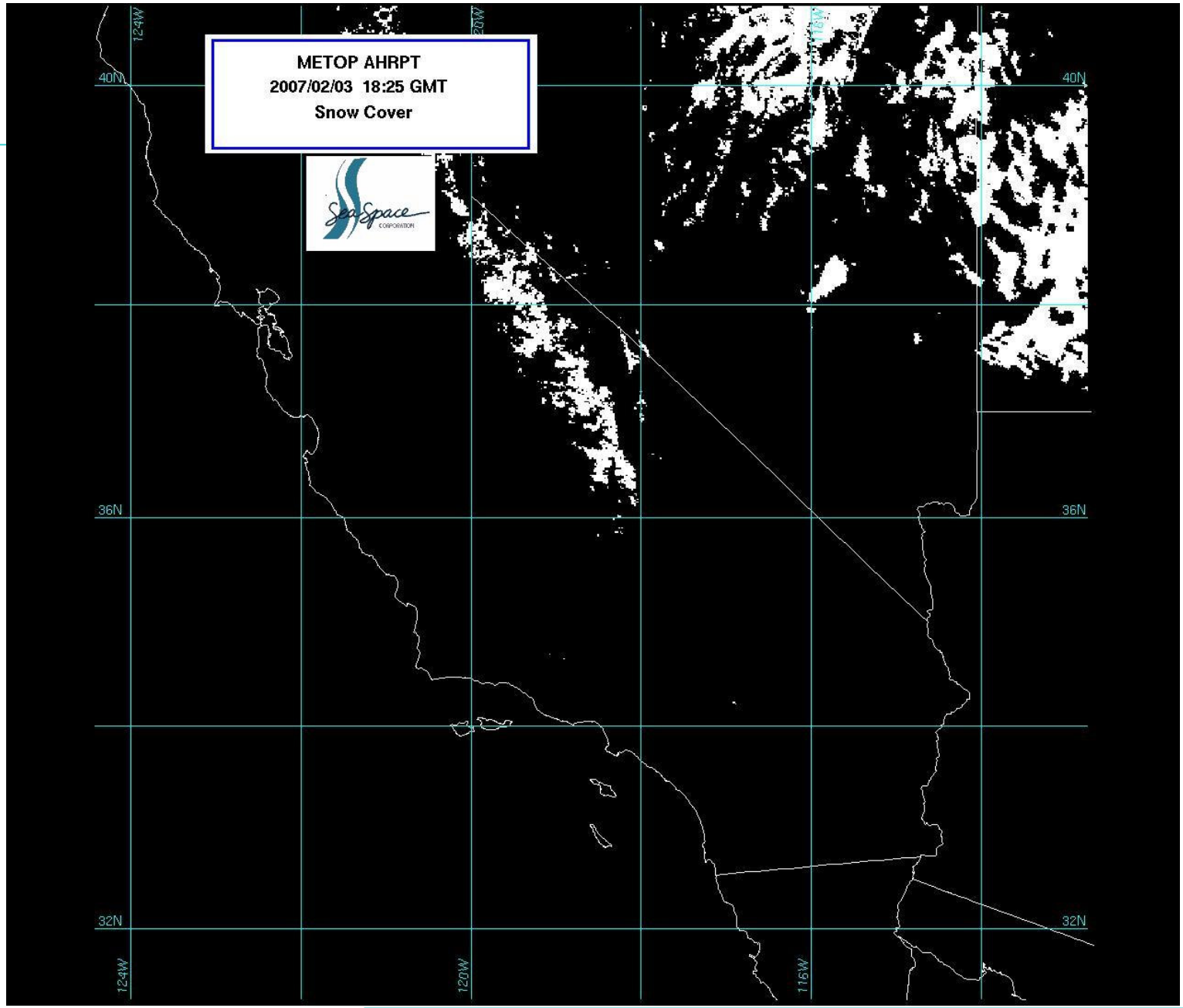
ATOVS GP_height @ 700mb from METOP-2 2007/03/07 17:19 GMT



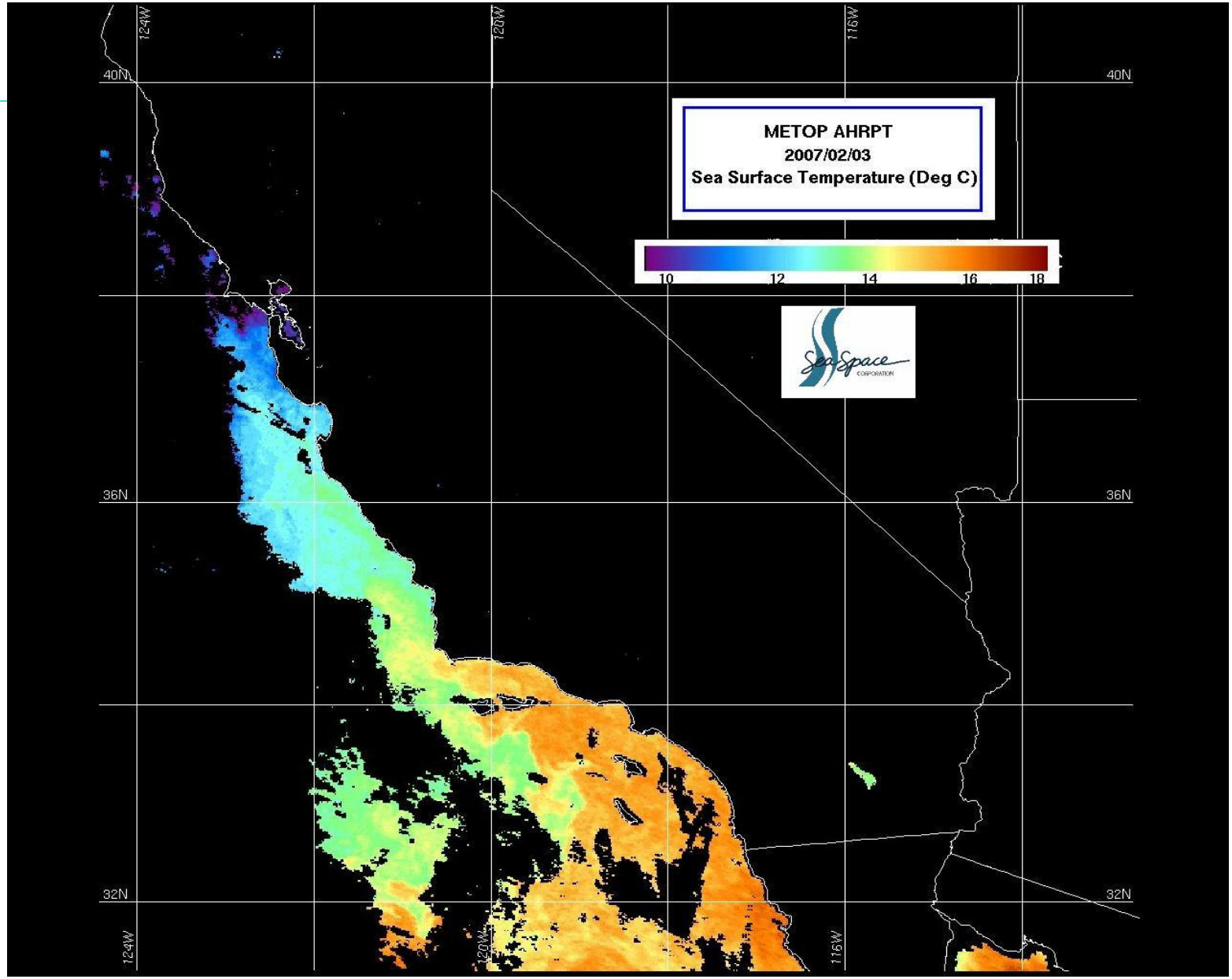
RGB Color Composite AHRPT from METOP-2 2007/02/03 18:21 GMT



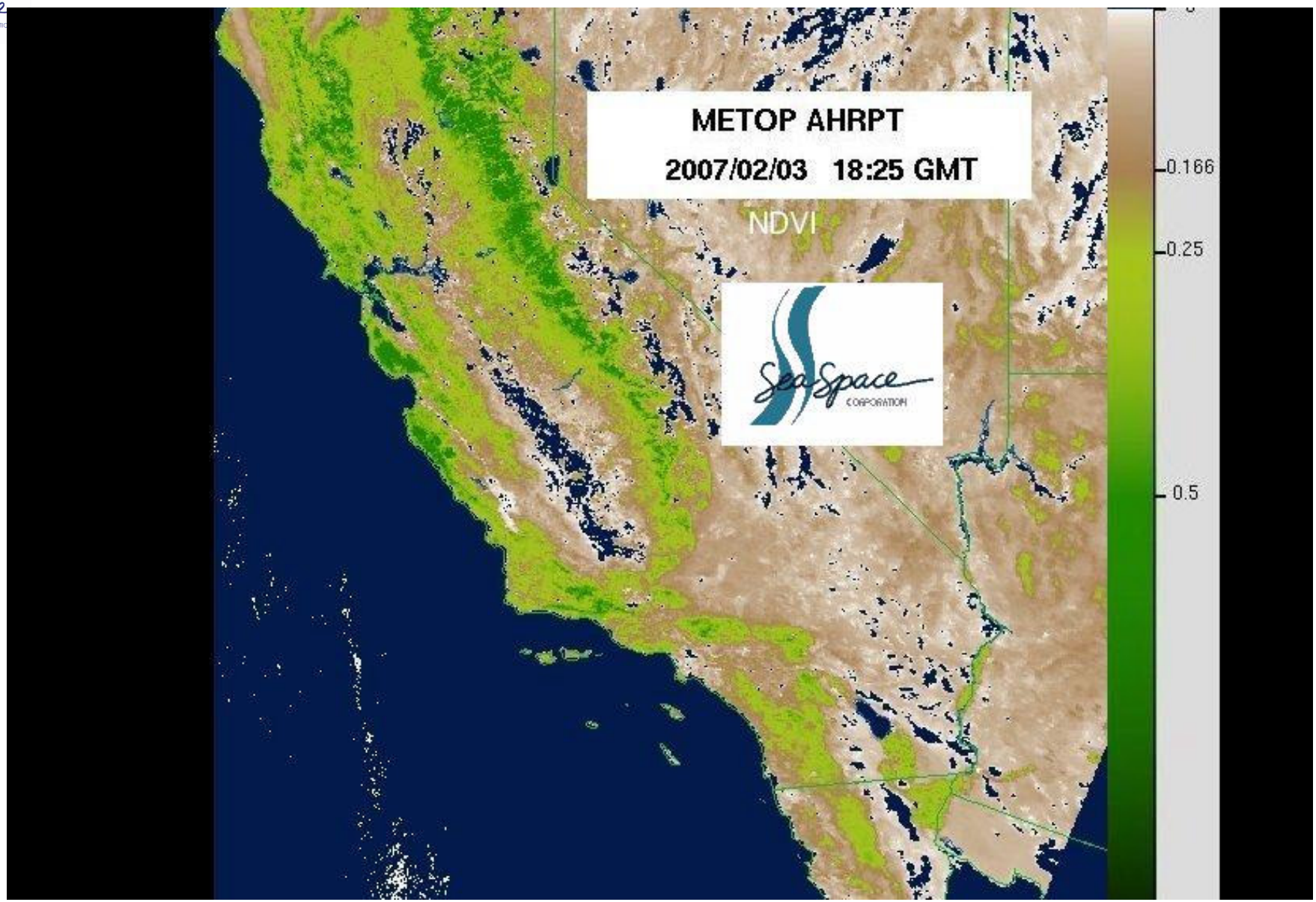
Snow Cover AHRPT from METOP-2 2007/02/03 18:21 GMT



Sea Surface Temperature AHRPT from METOP-2 2007/02/03 18:21 GMT



NDVI AHRPT from METOP-2 2007/02/03 18:21 GMT



METOP/NOAA HRPT Installation 1/27/2007 at Meteorological Service of Canada (MSC), Gander, Newfoundland

Summary

- MODIS DB Land, Ocean, and Atmospheric products can be generated under 12 minutes of data acquisition.
- Processing time can be further reduced to 9 minutes if *Area of Interest* or *products* can be pre-defined.
- Processing threads can be increased if multiple passes need to be processed
- Granule and configuration file concept can be adapted for any current telemetry or future satellites (NPP/NPOESS).
- There are less reasons to archive Level 2 products (raw data archival is sufficient).
- ***As CPU and memory speeds increase, the processing times can only come down in the future.***

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Thanks for your time !

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Fax: +1 858 746 1199