

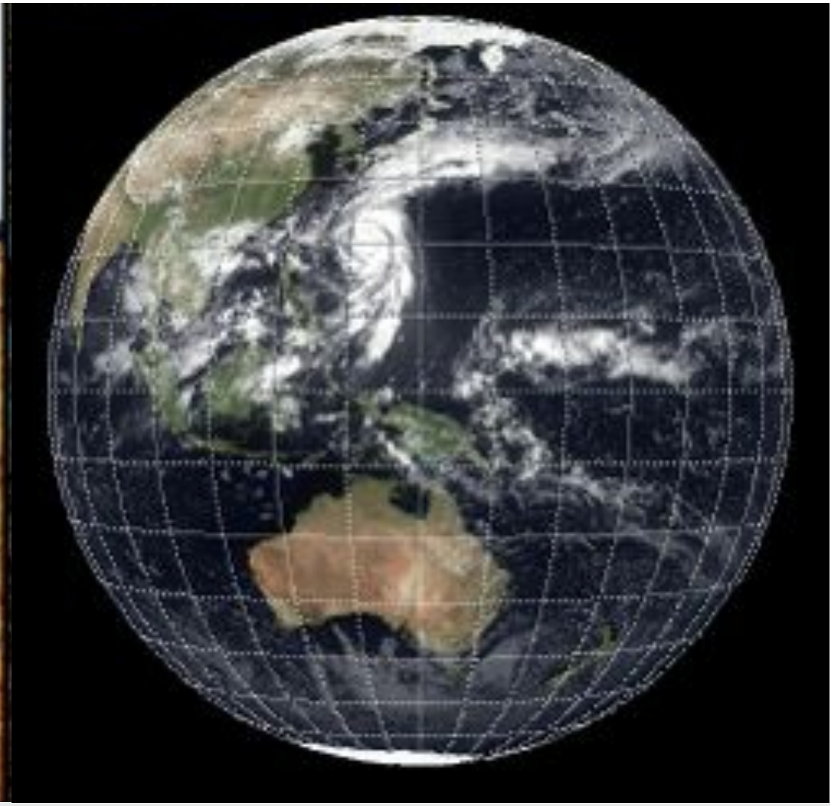

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# Himawari-8/9 and GCOM-C Non-Meteorological Application Opportunities


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*Centre for Australian Weather and Climate Research – CAWCR*


*December 2013*

Australian Government
Bureau of Meteorology

CSIRO

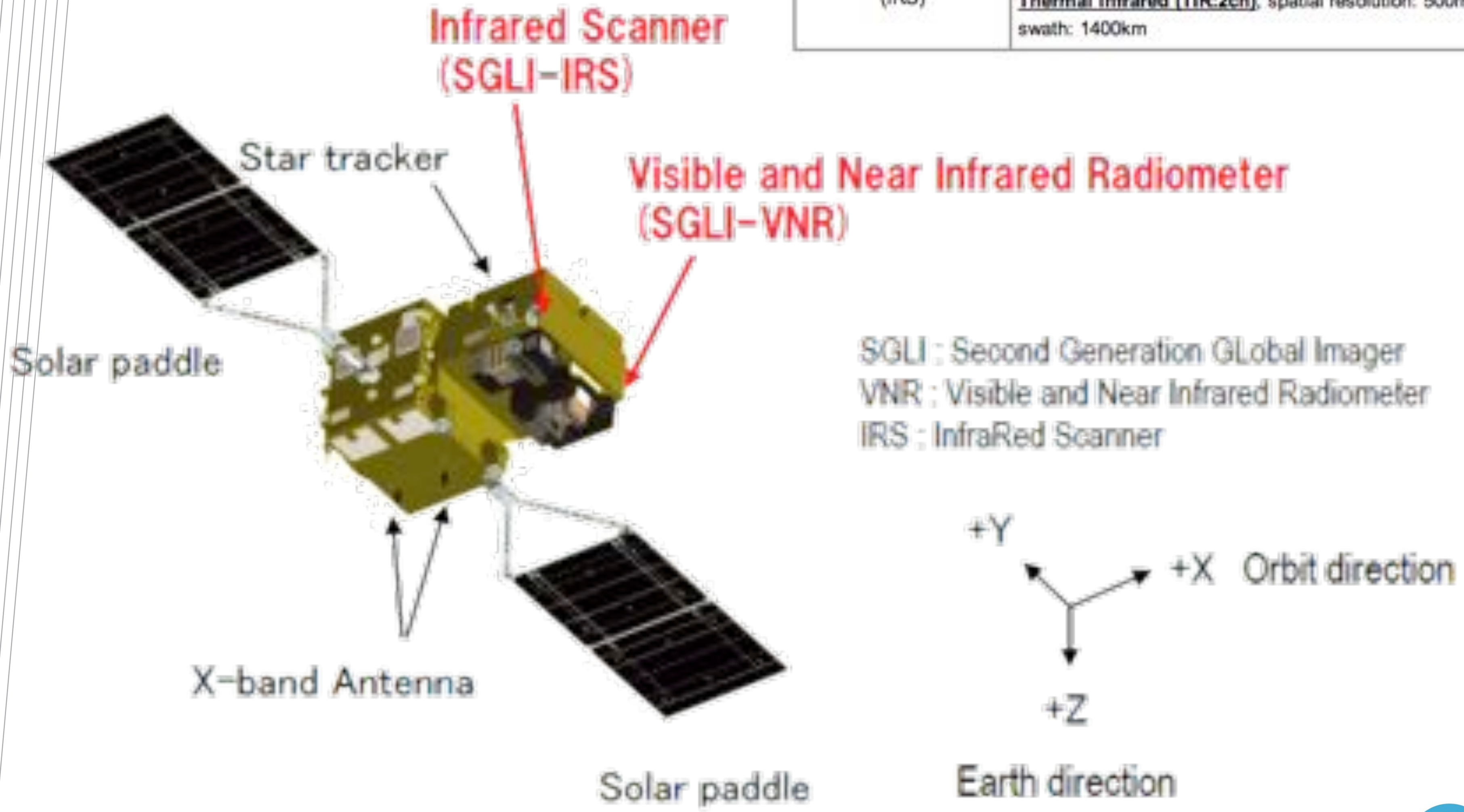
Selected materials from  C. Down – BoM)

# Non-Meteorological EOS Product Opportunities

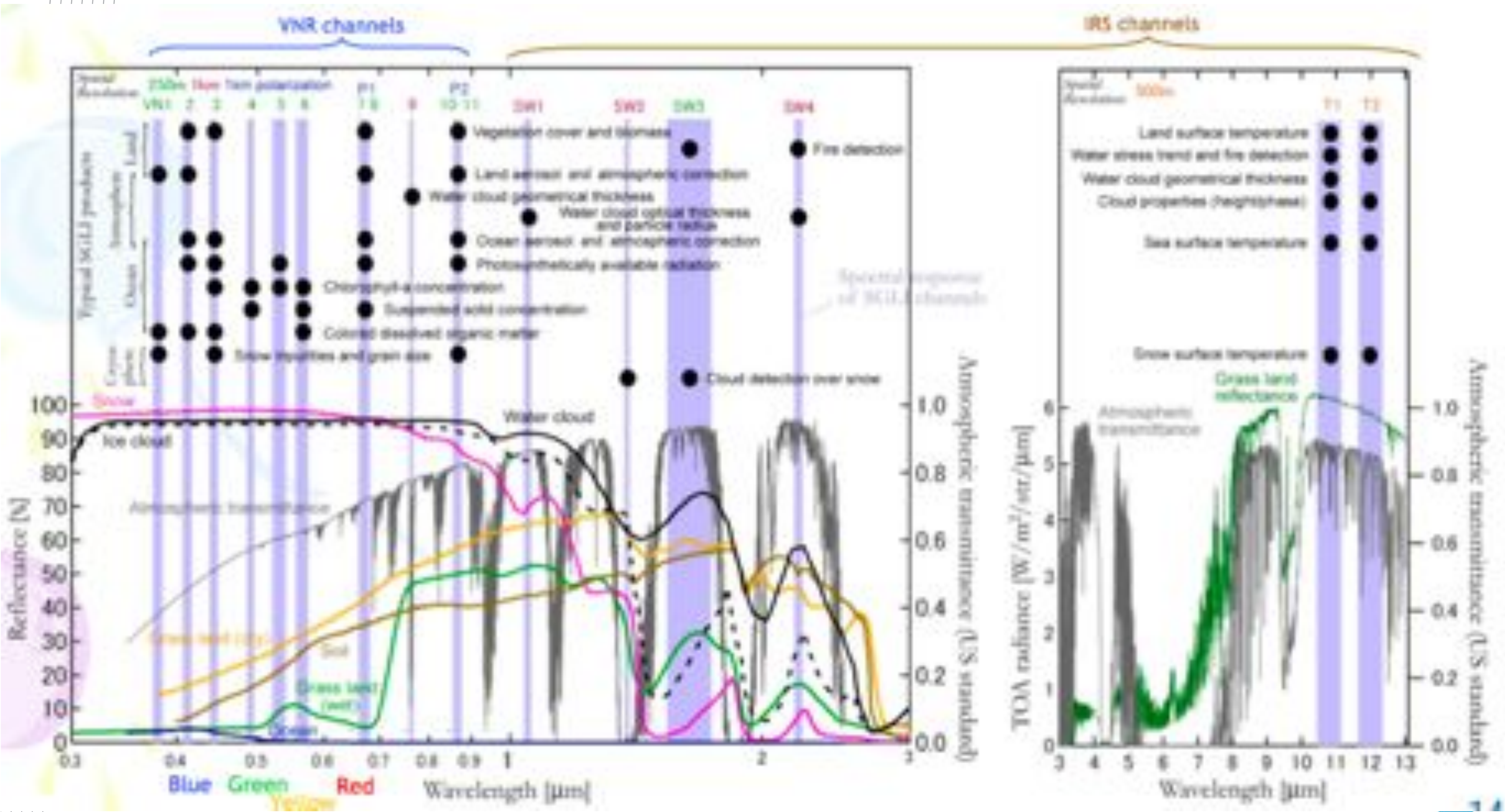
- Dynamic tracking of Fire spread and associated modelling
- Land-Surface Temperature and evapotranspiration
- Monitoring of rapid changes and land-surface dynamics, associated with:
    - Rainfall events
    - Drying/Droughts
    - Fires & Burnt Area Mapping
    - Flood Response
    - Cyclone Damage
    - Crop Phenology dynamics
- Aerosol Climatology
- Ocean and Coastal Water Dynamics and Composition

# GCOM-C (JAXA)

| Component | Characteristics |
|---|---|
| Visible and Near Infrared Radiometer (VNR) | **Non-polarization nadir view (11ch)**, spatial resolution: 250m, swath: 1150km<br>**Polarization/along-track slant view (2ch)**, spatial resolution: 1km, swath: 1150km |
| Infrared Scanner (IRS) | **Shortwave infrared (SWI:4ch)**, spatial resolution: 250m/1km, swath: 1400km<br>**Thermal infrared (TIR:2ch)**, spatial resolution: 500m, swath: 1400km |



# GCOM-C Specifications
# - SGLI



# GCOM-C SGLI Spectral Bands and Resolution

| SGLI channels | | | | | | |
|---|---|---|---|---|---|---|
| CH | λ | Δλ | $L_{std}$ | $L_{max}$ | SNR at Lstd | IFOV |
| | VN, P, SW: nm<br>T: μm | | VN, P: $W/m^2/sr/\mu m$<br>T: Kelvin | | VN, P, SW: SNR<br>T: NEΔT | m |
| VN1 | 380 | 10 | 60 | 210 | 250 | 250 |
| VN2 | 412 | 10 | 75 | 250 | 400 | 250 |
| VN3 | 443 | 10 | 64 | 400 | 300 | 250 |
| VN4 | 490 | 10 | 53 | 120 | 400 | 250 |
| VN5 | 530 | 20 | 41 | 350 | 250 | 250 |
| VN6 | 565 | 20 | 33 | 90 | 400 | 250 |
| VN7 | 673.5 | 20 | 23 | 62 | 400 | 250 |
| VN8 | 673.5 | 20 | 25 | 210 | 250 | 250 |
| VN9 | 763 | 12 | 40 | 350 | 1200 | 250/1000 |
| VN10 | 868.5 | 20 | 8 | 30 | 400 | 250 |
| VN11 | 868.5 | 20 | 30 | 300 | 200 | 250 |
| P1 | 673.5 | 20 | 25 | 250 | 250 | 1000 |
| P2 | 868.5 | 20 | 30 | 300 | 250 | 1000 |
| SW1 | 1050 | 20 | 57 | 248 | 500 | 1000 |
| SW2 | 1380 | 20 | 8 | 103 | 150 | 1000 |
| SW3 | 1630 | 200 | 3 | 50 | 57 | 250 |
| SW4 | 2210 | 50 | 1.9 | 20 | 211 | 1000 |
| T1 | 10.8 | 0.7 | 300 | 340 | 0.2 | 250/500 |
| T2 | 12.0 | 0.7 | 300 | 340 | 0.2 | 250/500 |

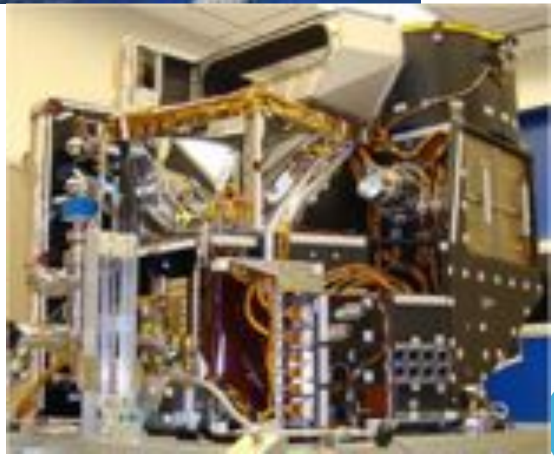
# Himawari (JMA)

• In 2014 Japan will launch the first of its next-generation geostationary meteorological satellites, Himawari- 8.

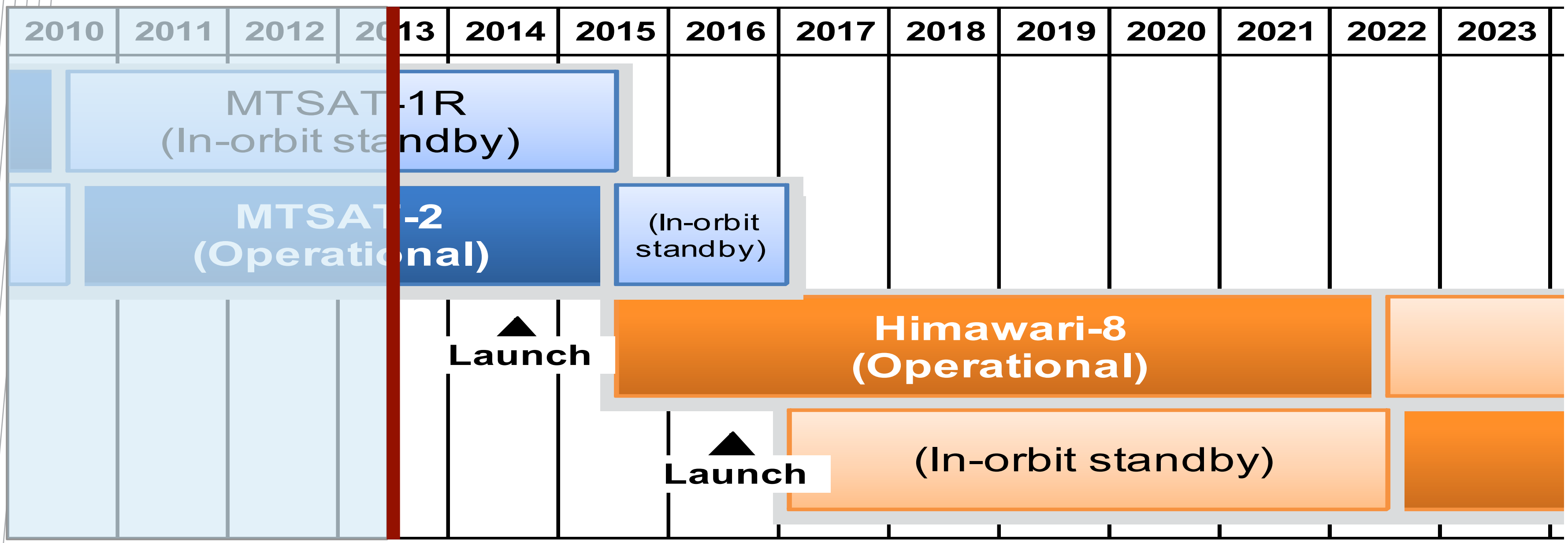
• The satellite is planned to be operational in mid 2015.

•The sensor for this satellite is the Advanced Himawari Imager AHI, based on the Advanced Baseline Imager developed for GOES-R.

•Himawari-8, and Himawari-9, will replace the current JMA satellites MTSAT-1R and MTSAT-2 over the Australian region.



# Himawari 8/9 Schedule




• JMA plans to launch Himawari 8 in 2014 and begin it's operations in 2015

• Himawari 9 is planned for in-orbit standby in 2016

•Himawari 8/9 will be in operation around 140 degrees Eastcovering east Asia and the Western Pacific

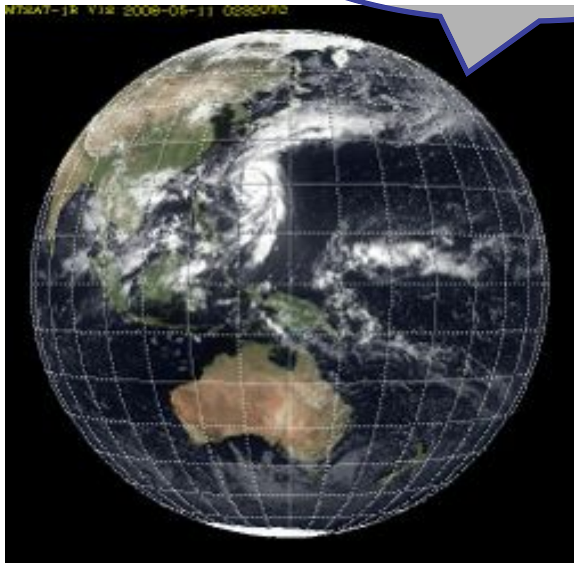
# Specification for Himawari 8/9 Imager (AHI)

## HIMAWARI-8/9

| MSG | Band | Central Wavelength [µm] | Spatial Resolution | |
|---|---|---|---|---|
| | 1 | 0.43 - 0.48 | 1Km | RGB Composited Color Image |
| X | 3 | 0.63 - 0.66 | 0.5Km | |
| X | 4 | 0.85 - 0.87 | 1Km | |
| X | 5 | 1.60 - 1.62 | 2Km | 1.3 µm for GOES-R |
| | 6 | 2.25 - 2.27 | 2Km | |
| X | 7 | 3.74 - 3.96 | 2Km | |
| X | 8 | 6.06 - 6.43 | 2Km | Water Vapour |
| | 9 | 6.89 - 7.01 | 2Km | |
| X | 10 | 7.26 - 7.43 | 2Km | |
| X | 11 | 8.44 - 8.76 | 2Km | $SO_2$ |
| X | 12 | 9.54 - 9.72 | 2Km | $O_3$ |
| | 13 | 10.3 - 10.6 | 2Km | Atmospheric Windows |
| | 14 | 11.1- 11.3 | 2Km | |
| X | 15 | 12.2 - 12.5 | 2Km | |
| X | 16 | 13.2 - 13.4 | 2Km | $CO_2$ |

X: MSG

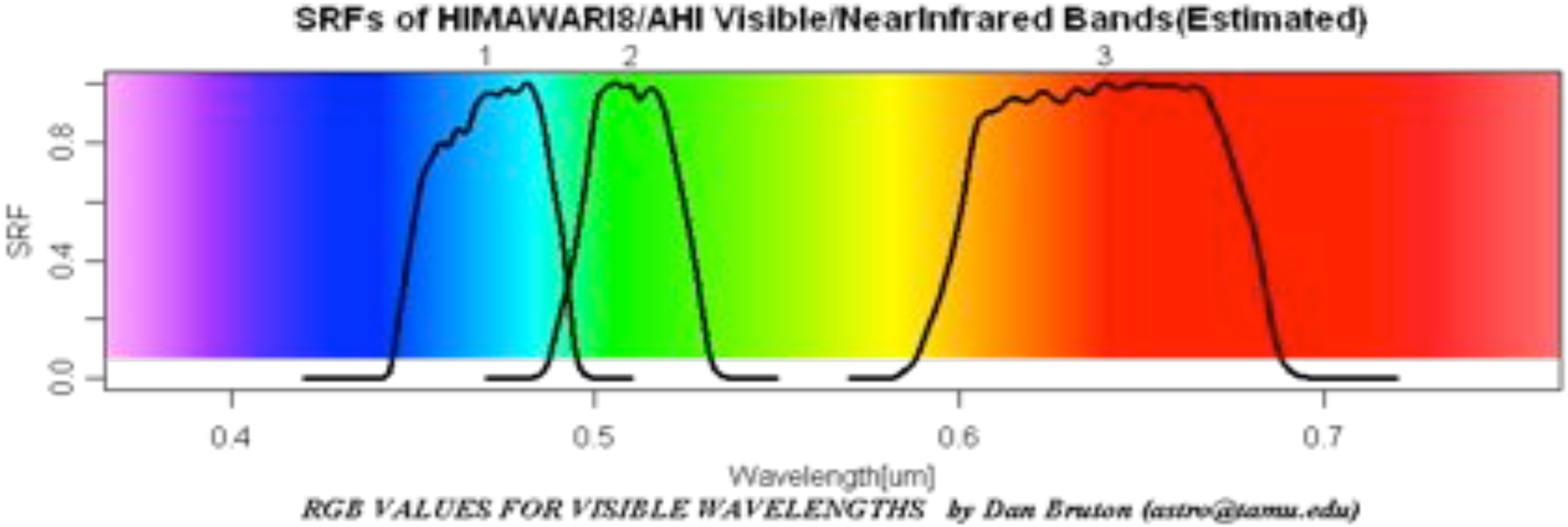
**Full Disk Image**
every 10 minutes

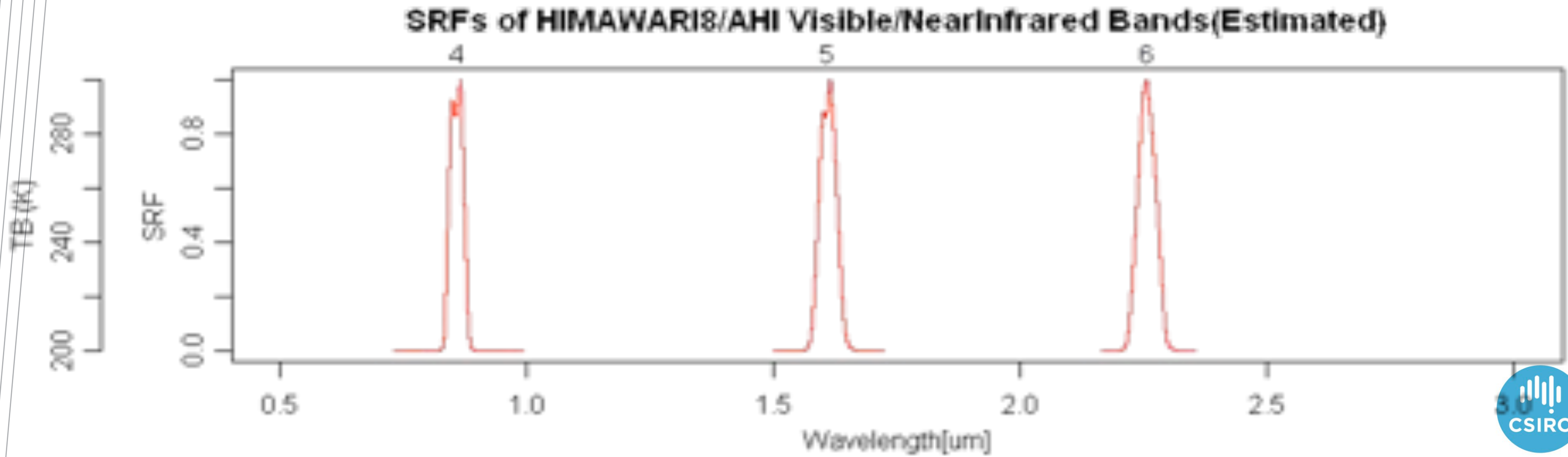


## MTSAT-1R/2

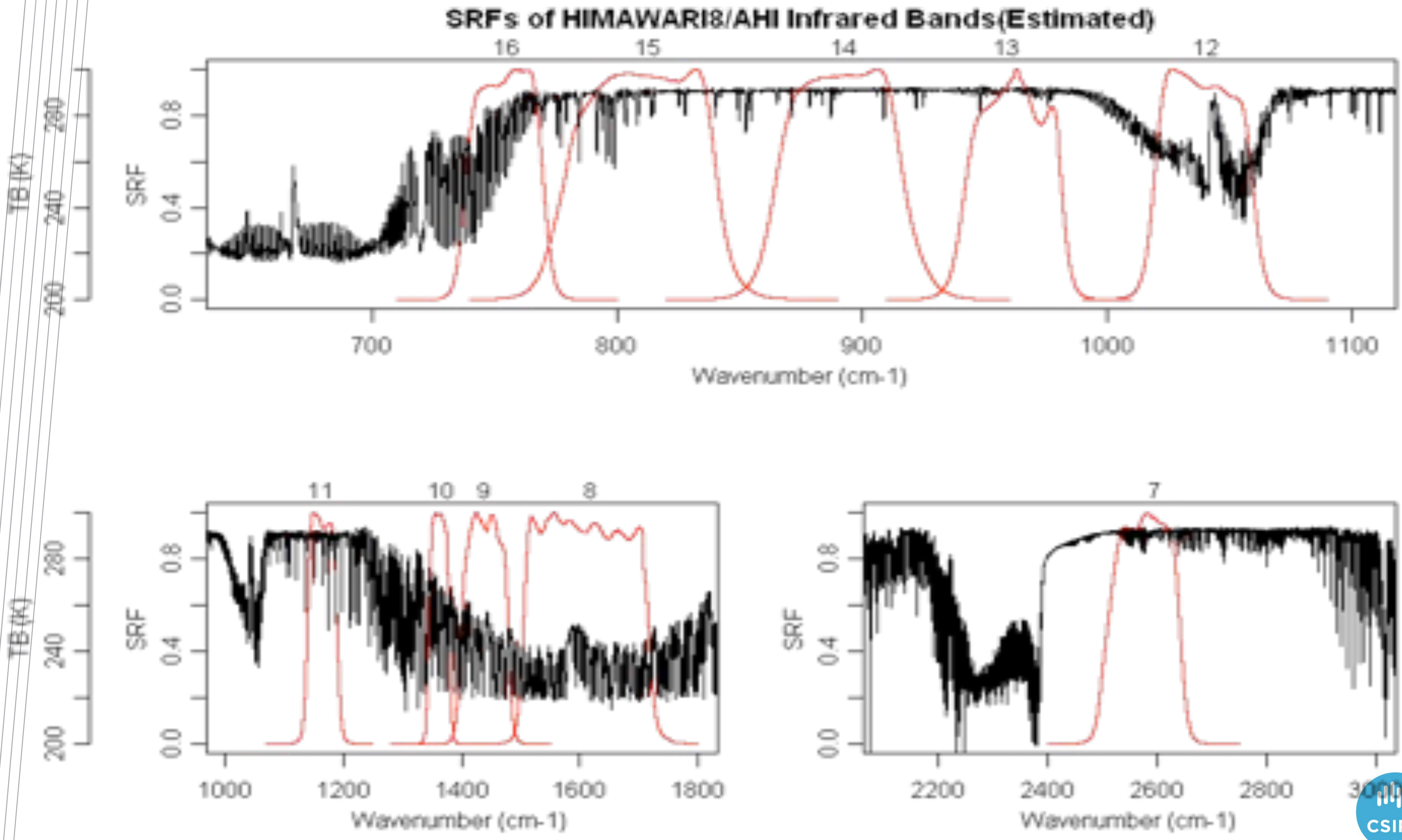
| Band | Central Wavelength [µm] | Spatial Resolution |
|---|---|---|
| 1 | 0.55 – 0.90 | 1Km |
| 2 | 3.50 – 4.00 | 4Km |
| 3 | 6.50- 7.00 | 4Km |
| 4 | 10.3 – 11.3 | 4Km |
| 5 | 11.5 – 12.5 | 4Km |

# AHI Spectral Response

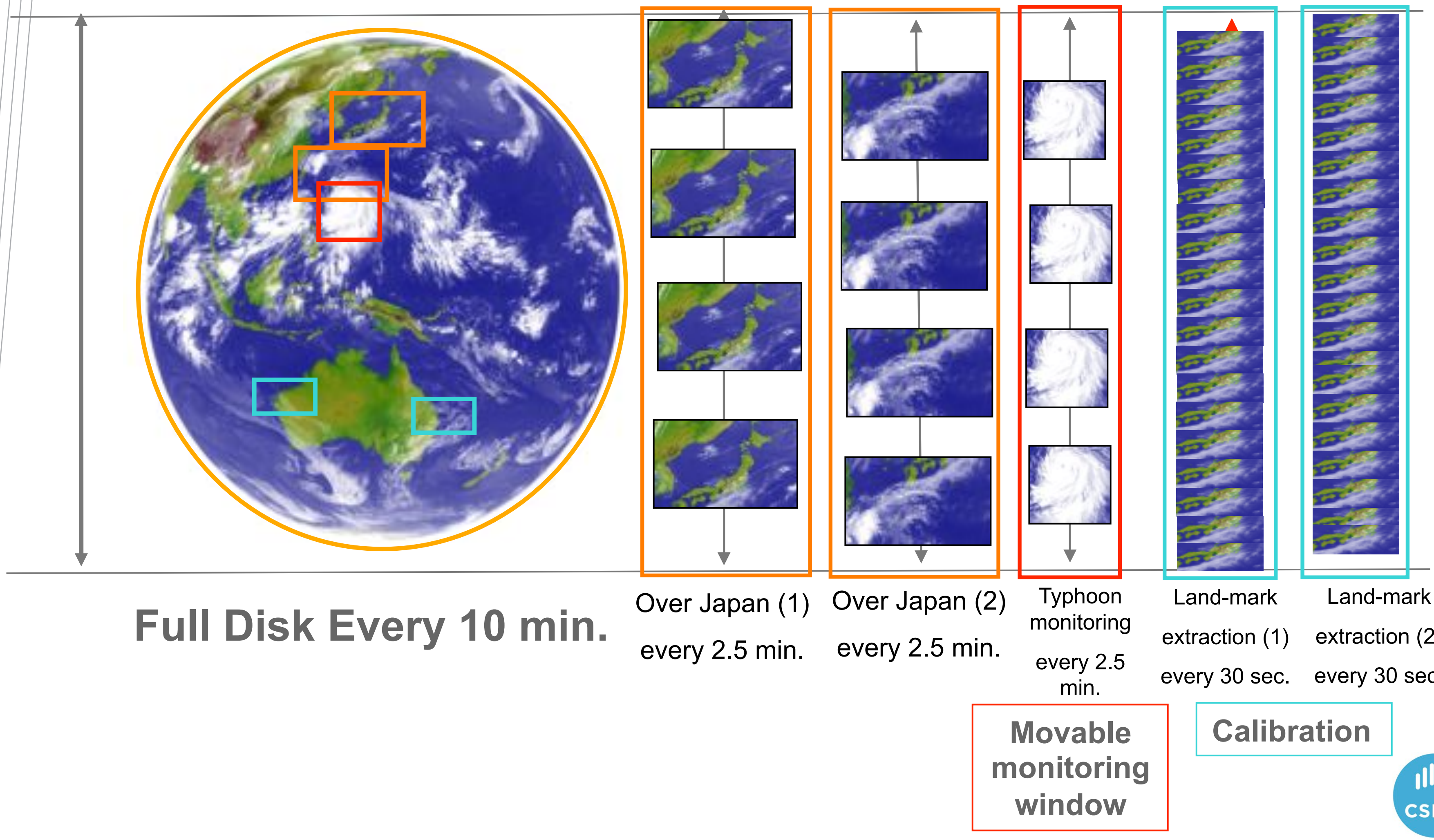


# AHI Spectral Response

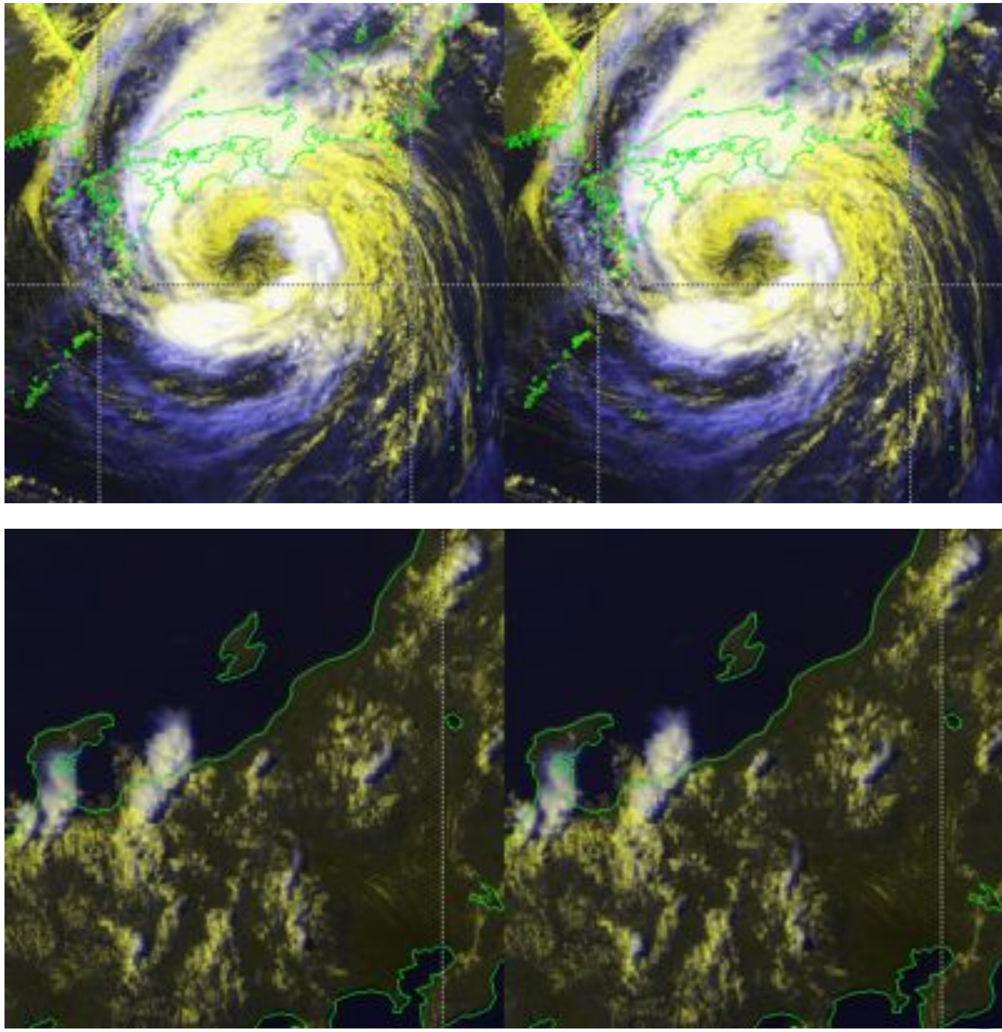


# Sequence of Himawari 8/9 AHI Observations in 10 Minute intervals

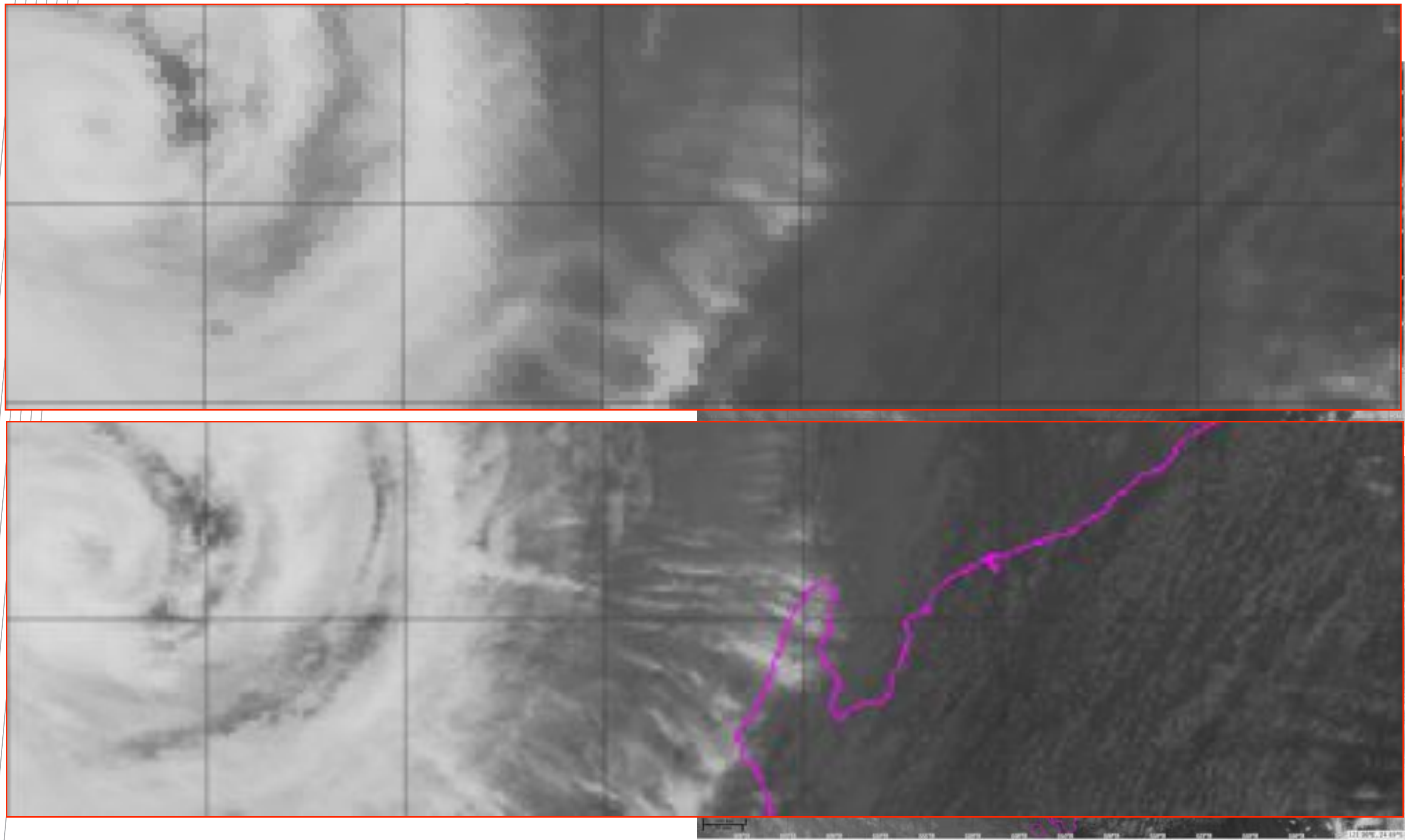


# Himawari 8/9: Temporal Resolution

- AHI imagery will be available to forecasters every 10 minutes.
- This is a significant step change from the current hourly imagery.
- The advantage will come through the ability to track synoptic patterns and severe systems



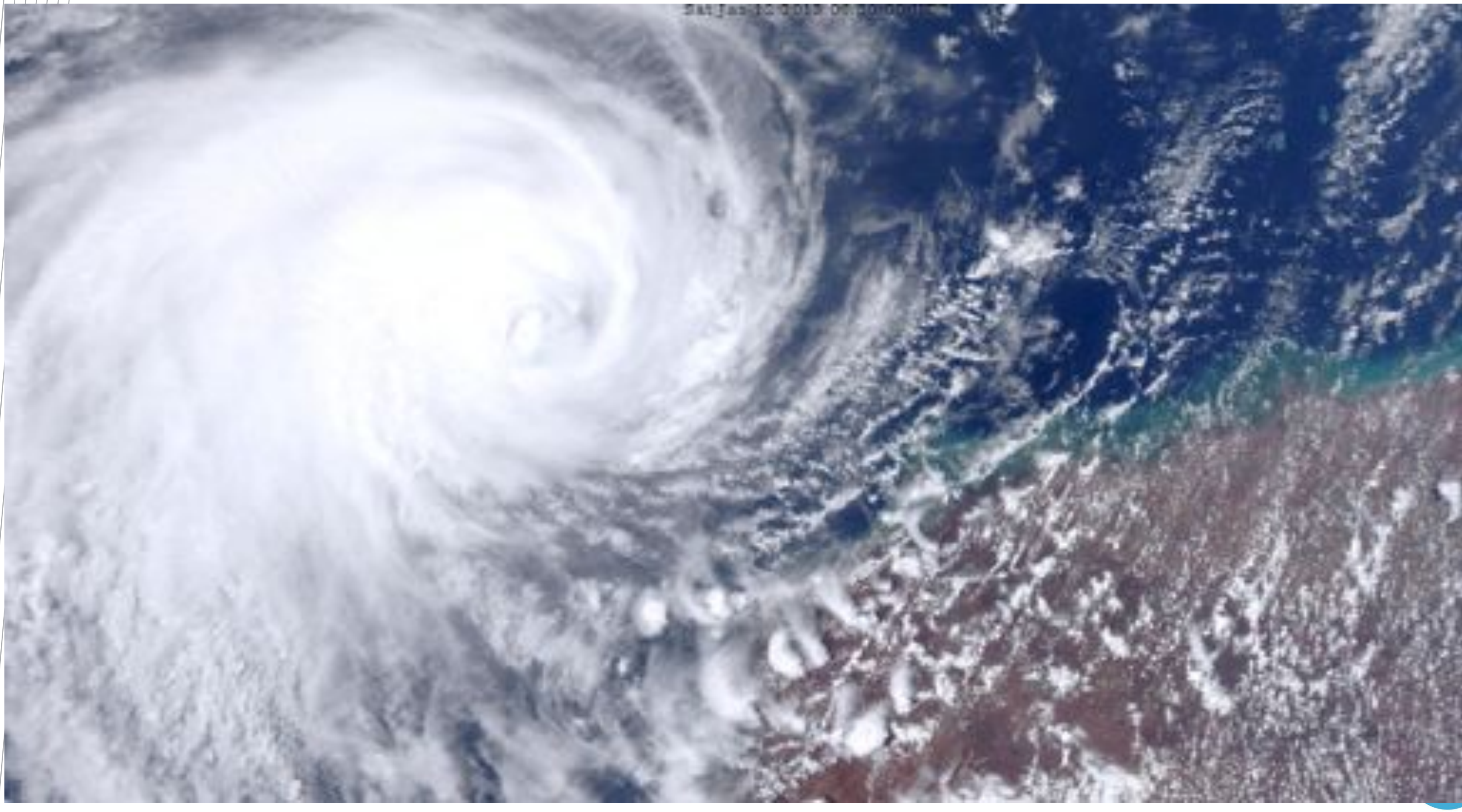
# Spatial Resolution



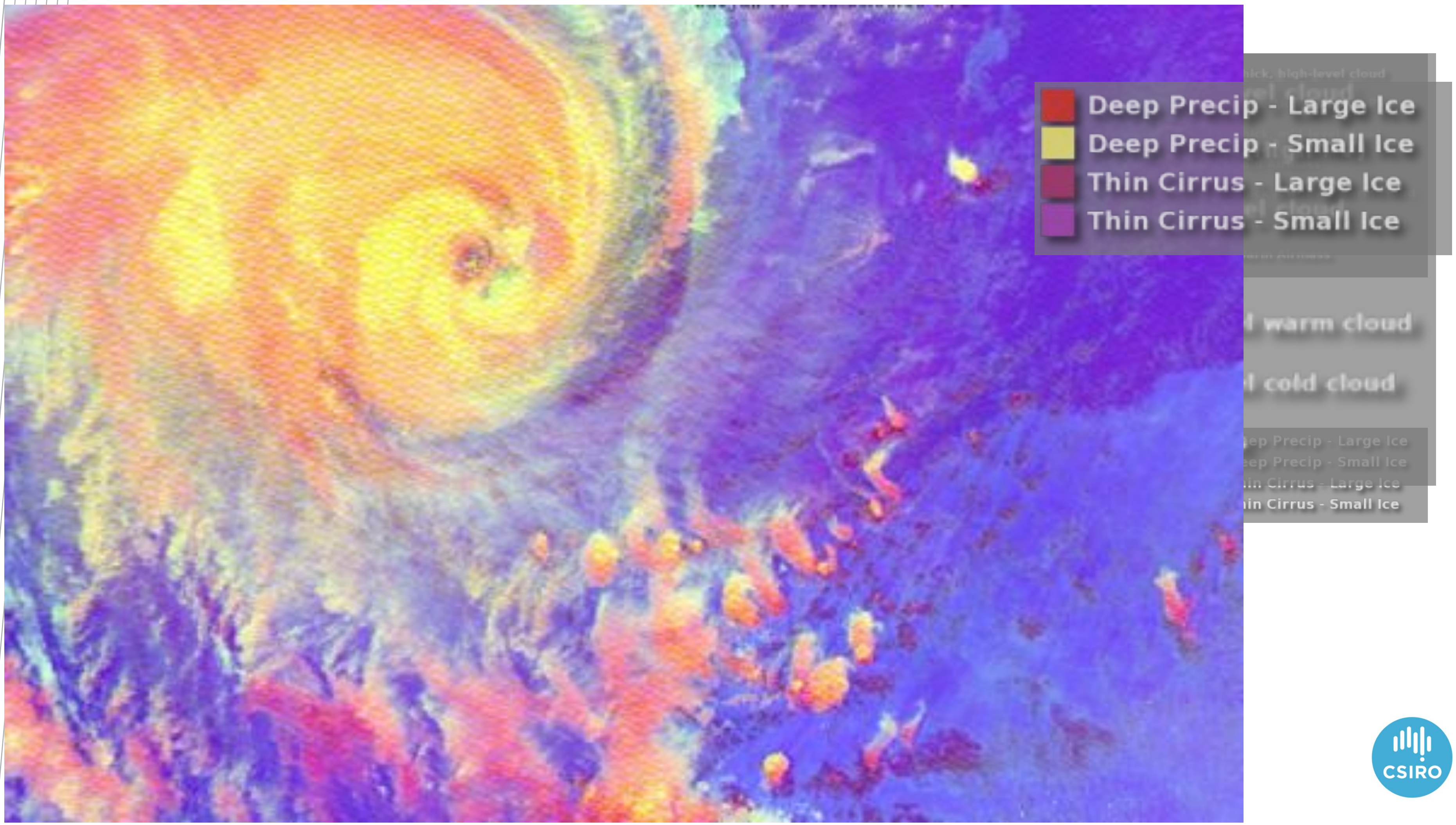
# Himawari Typical Meteorological Products

| Wave Length (µm ) | Spectrum | Resolution (km$^2$) | Sample Uses |
|---|---|---|---|
| 0.46 | | 1 | Daytime aerosol over land and coastal water mapping |
| 0.51 | Visible | 1 | Daytime aerosol, cloud and land properties |
| 0.64 | | 0.5 | Daytime cloud fog, and wind motion vectors |
| 0.86 | | 1 | Daytime vegetation/burn scar and aerosol over water, and winds |
| 1.6 | | 2 | Daytime cloud-top phase and particle size, and snow detection |
| 2.3 | | 2 | Daytime land/cloud properties, particle size, vegetation and snow |
| 3.9 | | 2 | Surface and cloud, fog at night, fire and winds |
| 6.2 | | 2 | High-level atmospheric water vapour, winds and rainfall |
| 7.0 | | 2 | Mid-level atmospheric water vapour, winds and rainfall |
| 7.3 | Near-IR | 2 | Lower-level water vapour, winds and $SO_2$ |
| 8.6 | | 2 | Total water for stability, cloud phase, dust, $SO_2$ and rainfall |
| 9.6 | | 2 | Total ozone, turbulence, and winds |
| 10.4 | | 2 | Surface and clouds |
| 11.2 | | 2 | Imagery, volcanic ash, sea surface temperatures, clouds and rainfall |
| 12.3 | | 2 | Total water, volcanic ash and sea surface temperatures |
| 13.3 | | 2 | Air temperature, cloud heights and amounts |

# True Colour Visible



# Multispectral Imagery



# Himawari8/9 - GOES-R Product Lists

**from GOES-R Algorithm Working Group (AWG) Report**

## BASELINE Products

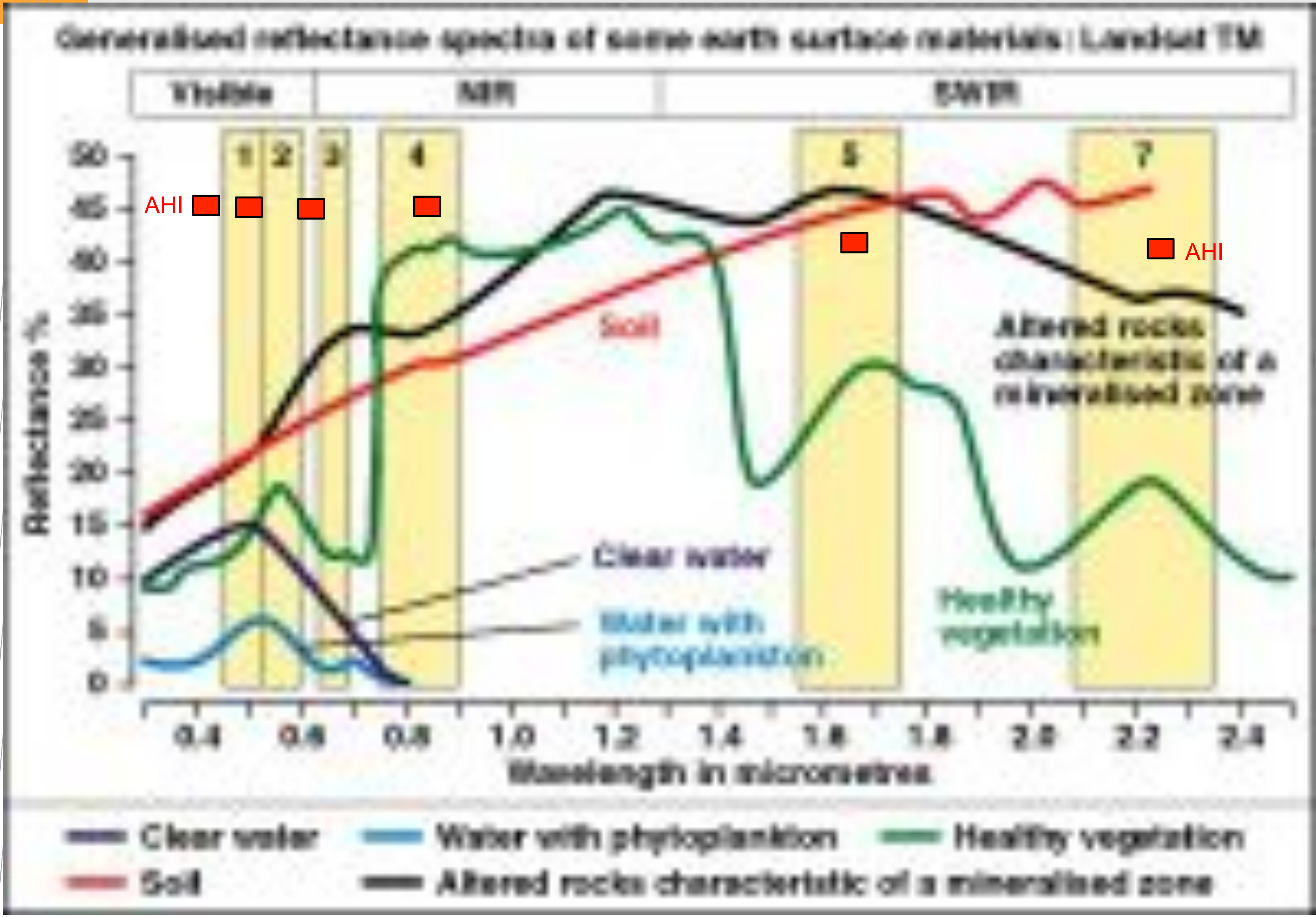
- Clouds and Moisture Imagery (KPP)
- Clear Sky Mask
- Cloud Top Pressure and Height
- Cloud Top Phase
- Cloud Top Temperature
- Cloud Particle Size Distribution
- Cloud Optical Path
- Temperature and Moisture Profiles
- Total Precipitable Water
- Stability Parameters (Lifted Index)
- Aerosol Detection
- Aerosols Optical Depth
- Derived Motion Winds
- Hurricane Intensity
- Fire/Hot Spot Characterization
- Land and Sea Surface Temperature
- Volcanic Ash
- Rainfall Rate
- Snow Cover
- Downward Solar Insolation: Surface
- Reflected Solar Insolation: TOA

## OPTION 2 Products

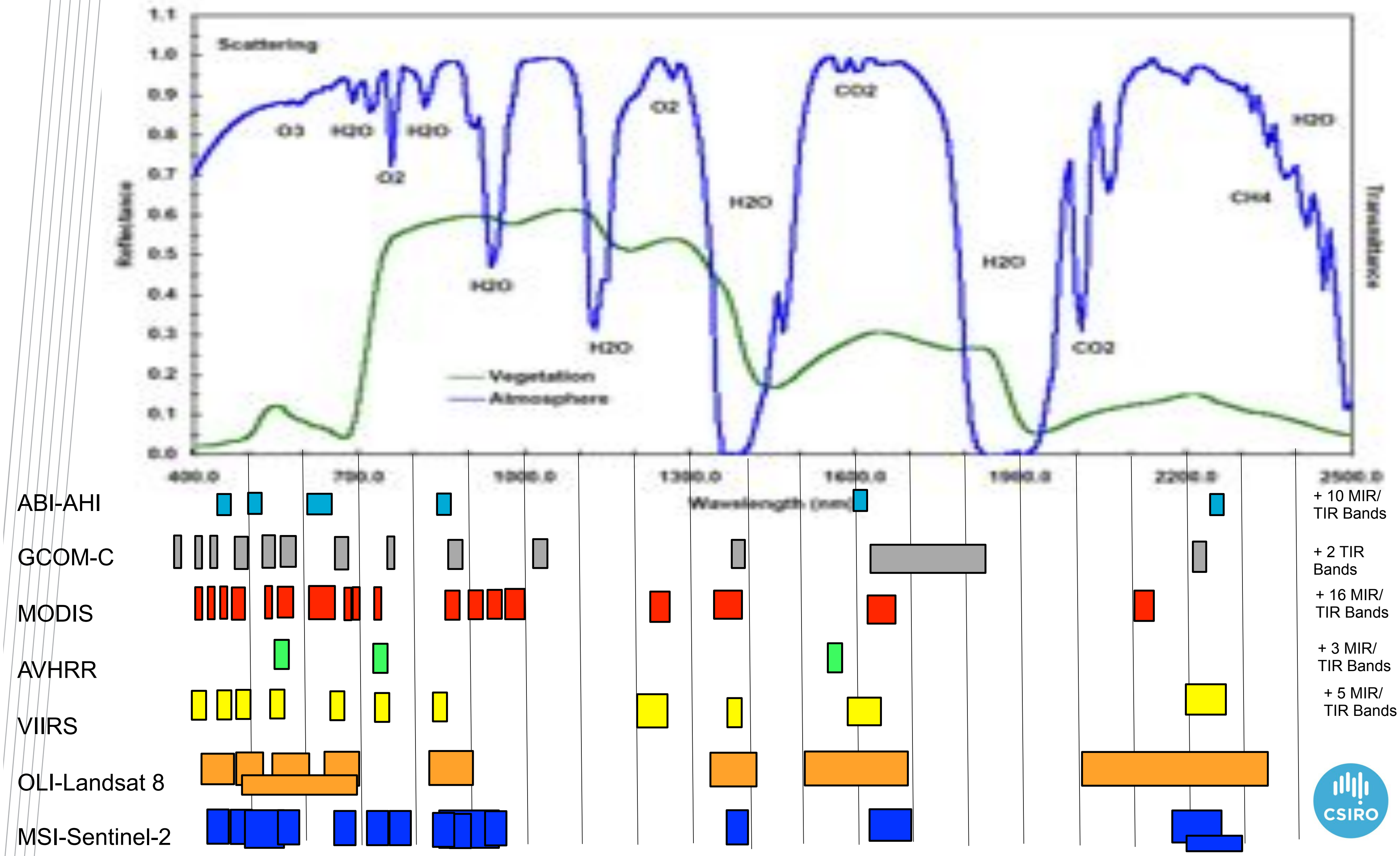
- Cloud Layer/Heights
- Cloud Ice Water Path
- Cloud Liquid Water
- Cloud Type
- Convective Initiation
- Turbulence
- Low Cloud and Fog
- Enhanced "V"/Overshooting Top
- Aircraft Icing Threat
- SO2 Detections (Volcanoes)
- Visibility
- Upward Longwave Radiation (TOA)
- Downward Longwave Radiation (SFC)
- Upward Longwave Radiation (SFC)
- Total Ozone
- Aerosol Particle Size
- Surface Emissivity
- Surface Albedo
- Vegetation Index
- Vegetation Fraction
- Flood Standing Water
- Rainfall probability and potential
- Snow Depth
- Ice Cover
- Sea & Lake Ice Concentration, Age, Extent, Motion
- Ocean Currents, Currents: Offshore

# NEW PRODUCTS AND JOINT R&D OPPORTUNITIES

# Multispectral Un-Mixing

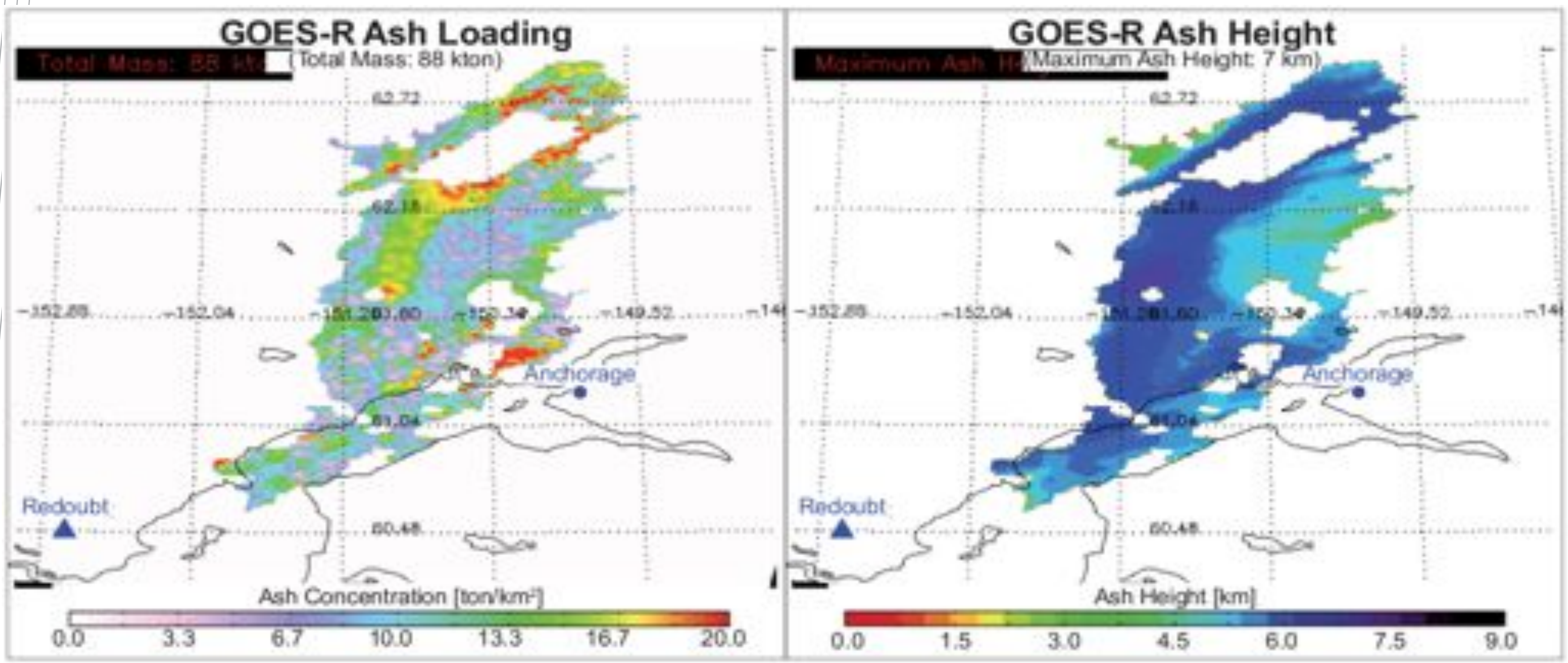


# Plant Spectra and Spectral Reflectance Bands



# Volcanic Ash

- Simulated GOES-R of Mount Redoubt eruption 2009 from MODIS
- Left: GOES-R Ash Loading
- Right: GOES-R Ash Height



# Non-Meteorological Product Opportunities

- Dynamic tracking of Fire spread and associated modelling
- Land-Surface Temperature and evapotranspiration
- Monitoring of rapid changes and land-surface dynamics, associated with:
    - Rainfall events
    - Drying/Droughts
    - Fires & Burnt Area Mapping
    - Flood Response
    - Cyclone Damage
    - Crop Phenology dynamics
- Aerosol Climatology
- Ocean and Coastal Water Dynamics and Composition

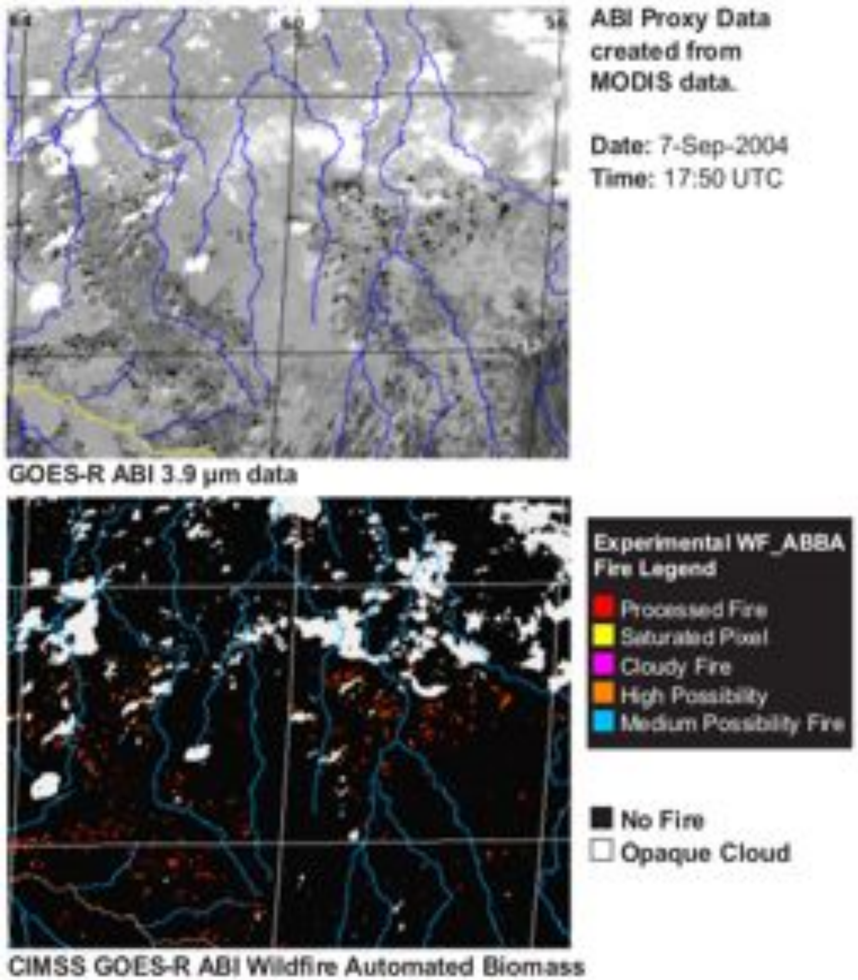
# Fire Detection Products

• Simulated GOES-R from MODIS

• Top: Simulated 3.9 micron

• Bottom: Wildfire Automated

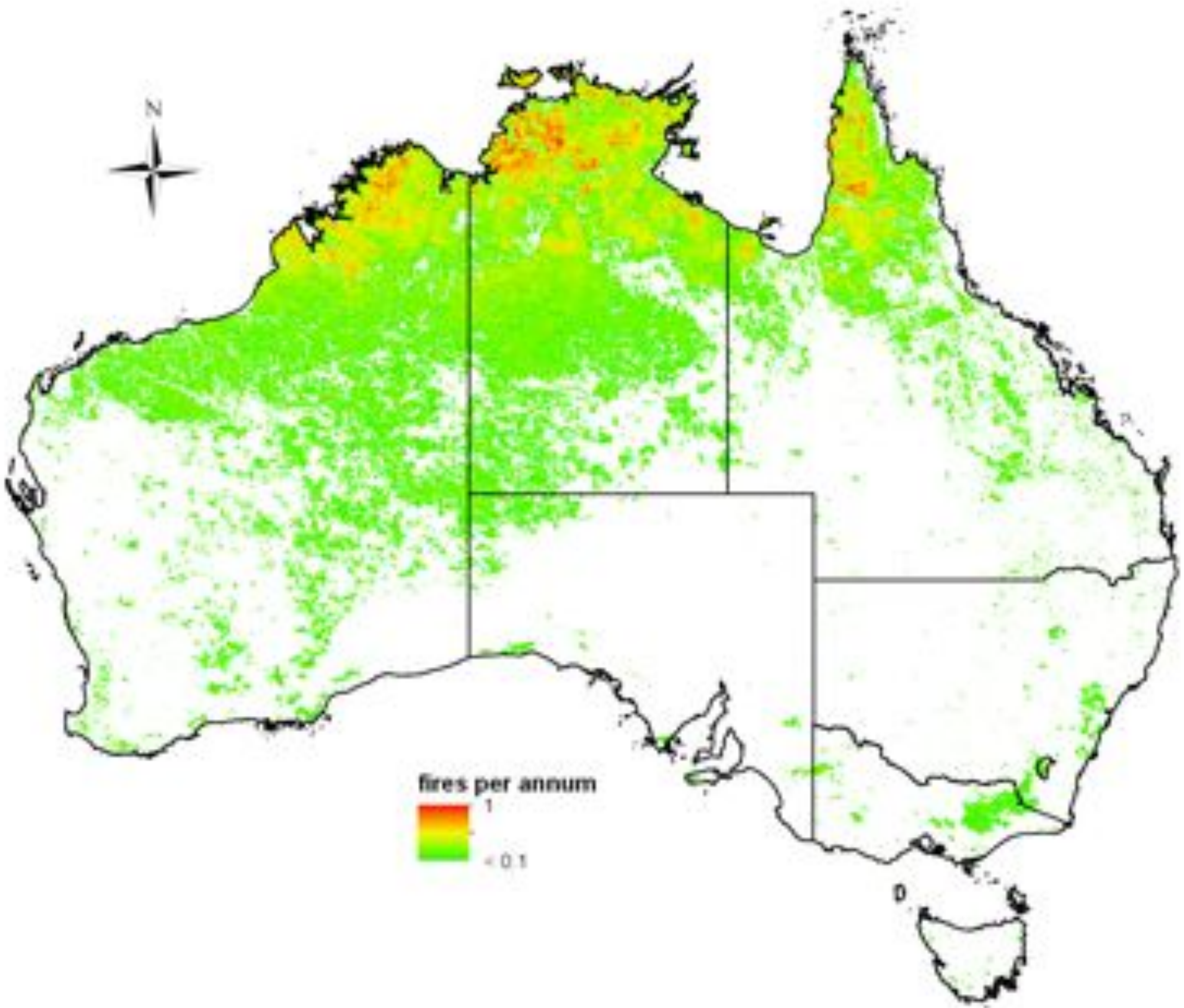
Biomass Burning Algorithm



CIMSS GOES-R ABI Wildfire Automated Biomass Burning Algorithm (WF_ABBA) fire mask product.

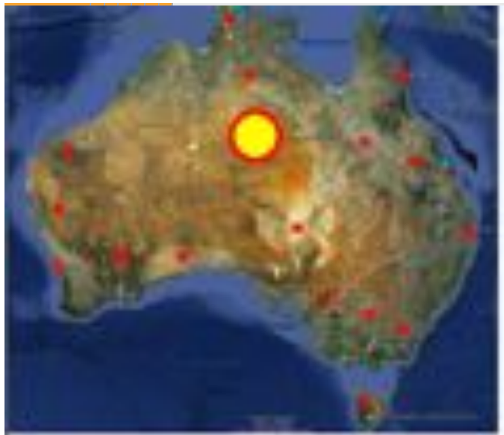
*Source: S. Maier - CDU*

# Burnt Area Mapping



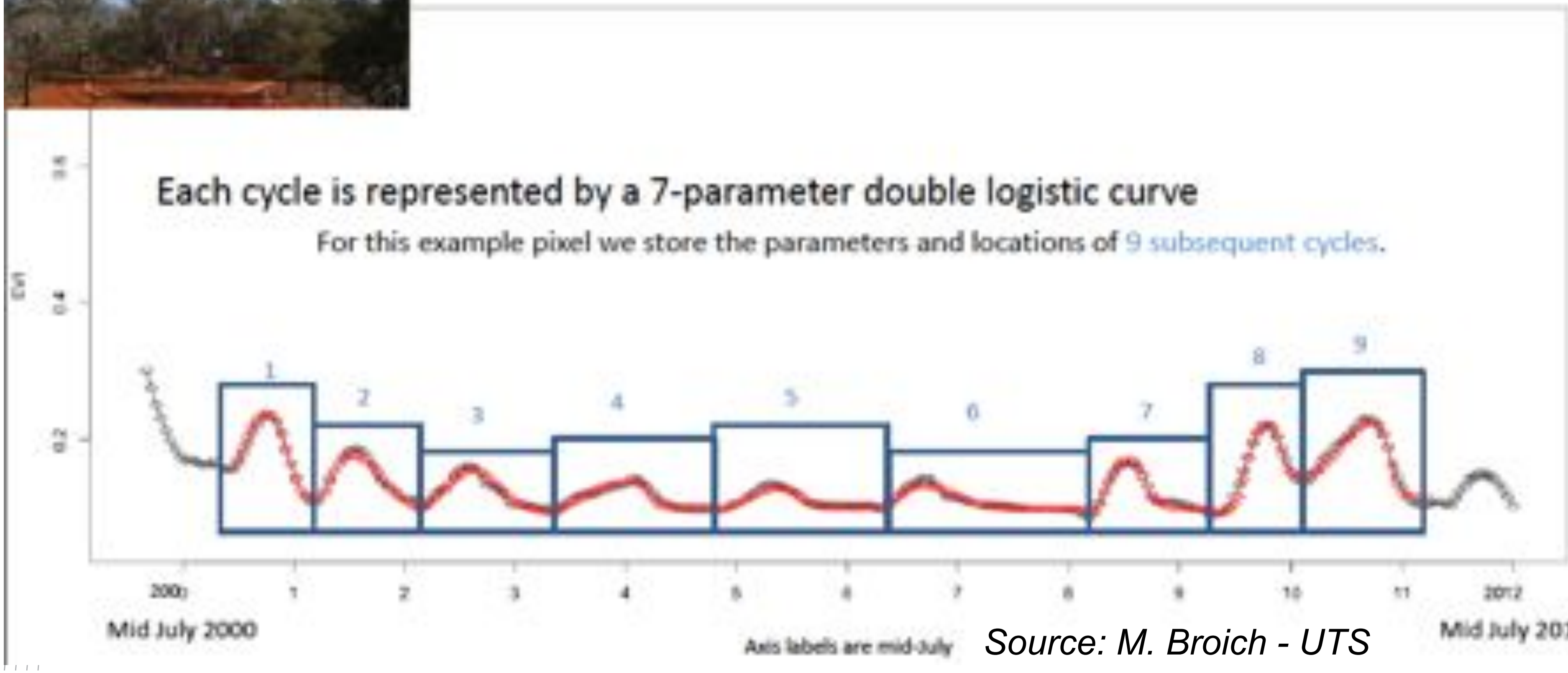

*Source: S. Maier - CDU*

# Improved analysis of time-series data for characterising episodic or seasonal phenology dynamics and carbon-cycle modelling



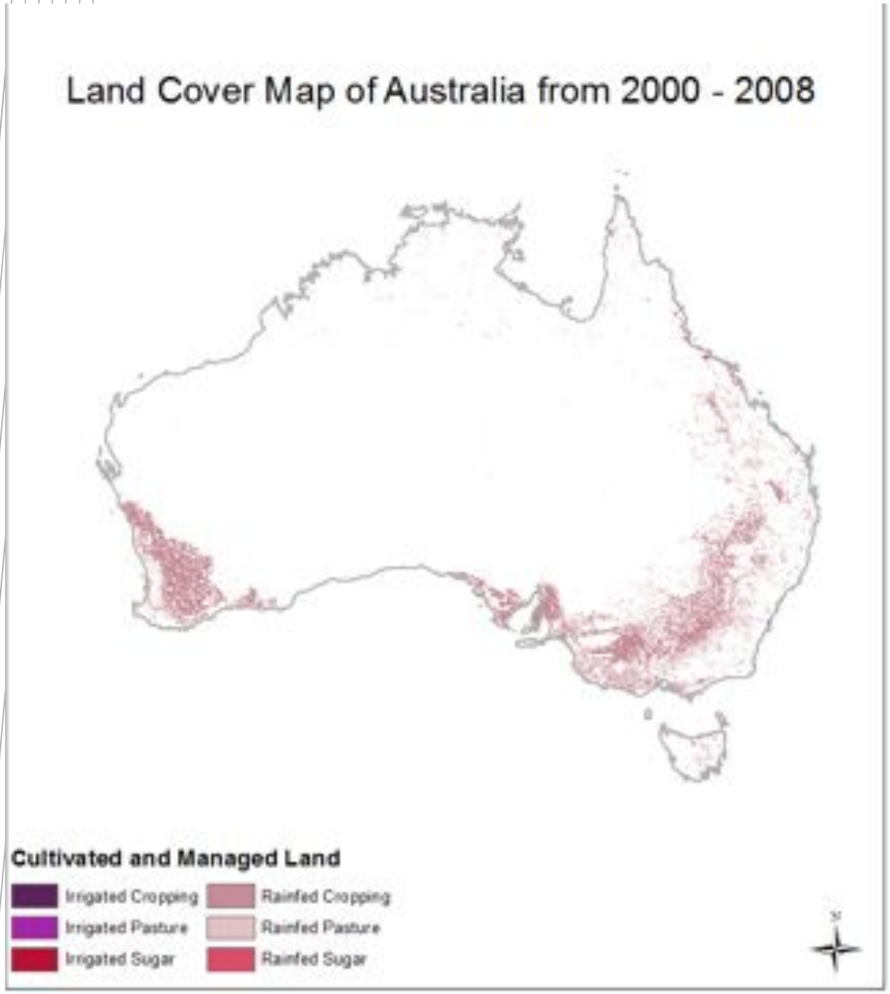
Alice Springs: Semi-arid mulga (Acacia aneura) ecosystem

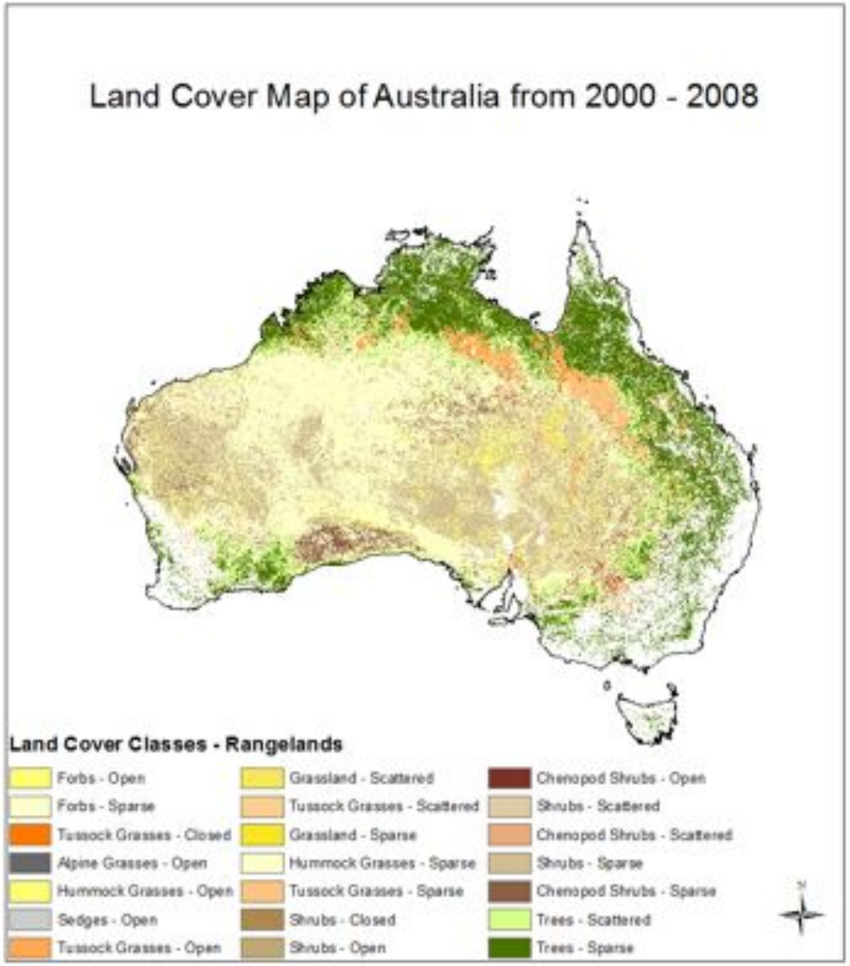
EVI 2000-2012
Black: gap filled and smoothed data
Red: series of double logistic curves fit to the subsequent cycles




Source: M. Broich - UTS

# Major Land Cover Types



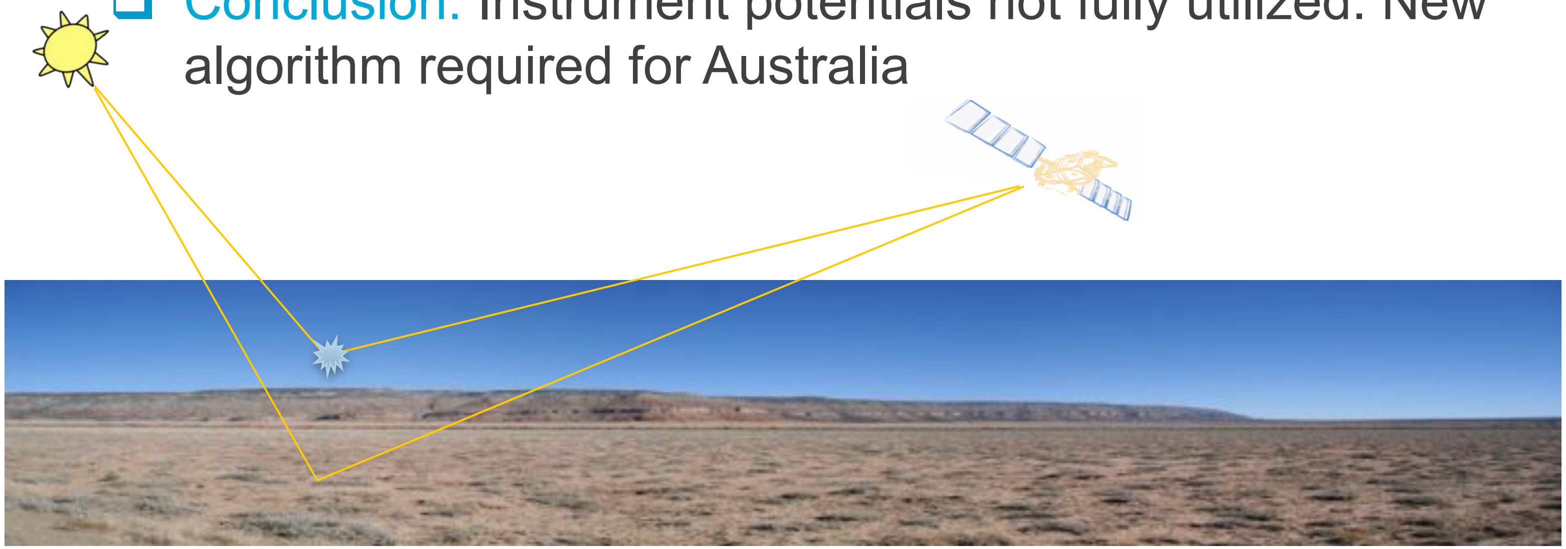




*Source: L. Lymburner - GA*

# Aerosol Retrieval Algorithm for AHI

- Algorithm: Essentially MODIS algorithm – dark-dense-vegetation approach
- Products: No product over desert and bare soil regions.

  Over regions where products are available, the accuracy is unsatisfactory with mean aerosol optical depth (AOD) error of 0.137
- Conclusion: Instrument potentials not fully utilized. New algorithm required for Australia

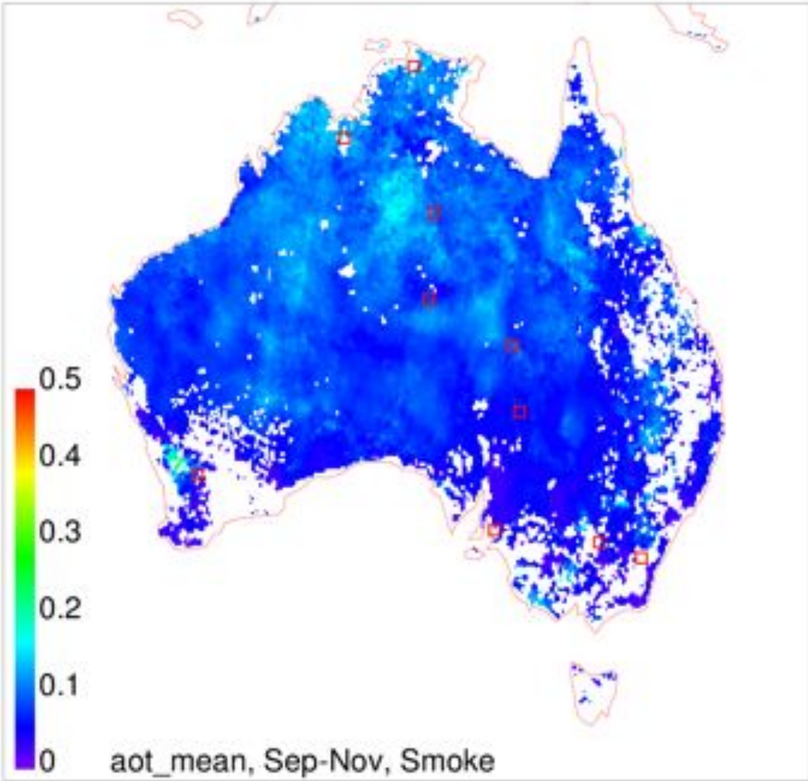




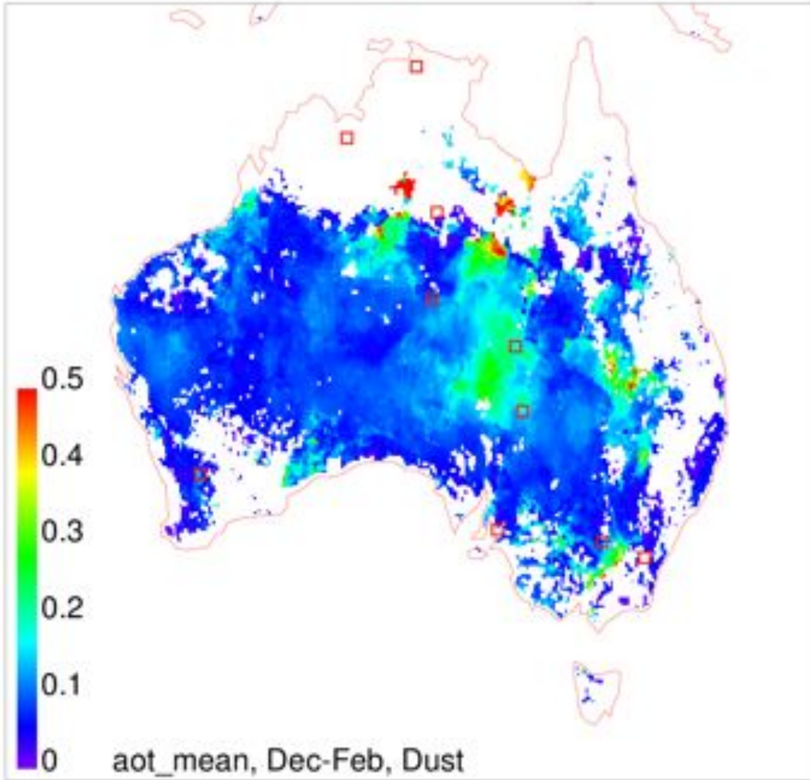
*Source: R. Mitchell - CSIRO*

# Sample: AATSR - Aerosol Distribution: Smoke & Dust

Biomass burning during fire season (Sep – Nov)



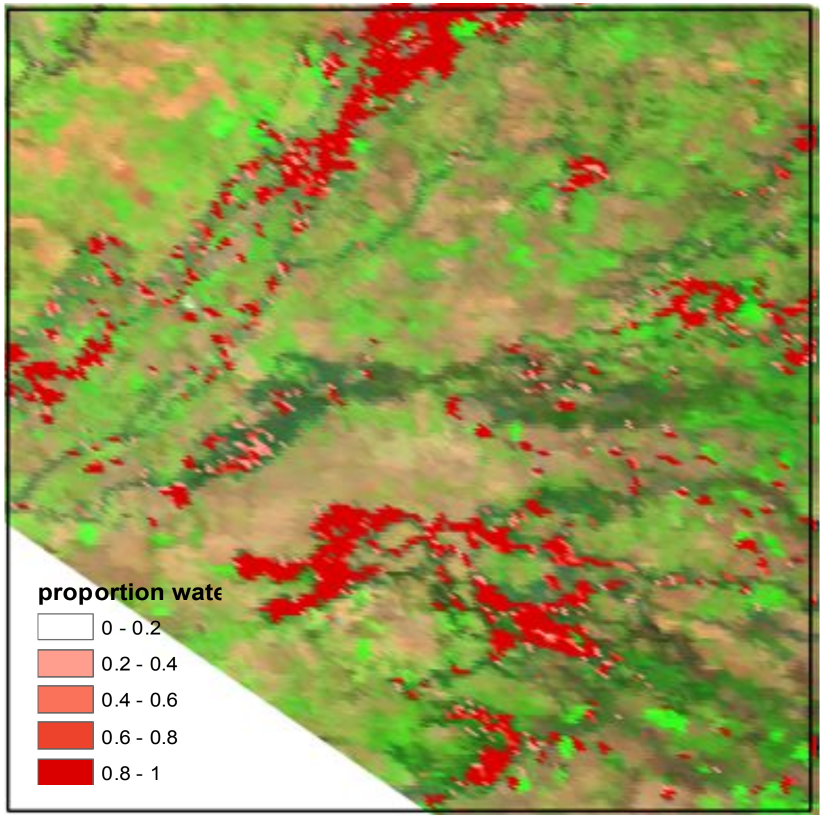

Mineral dust during summer (Dec – Feb)

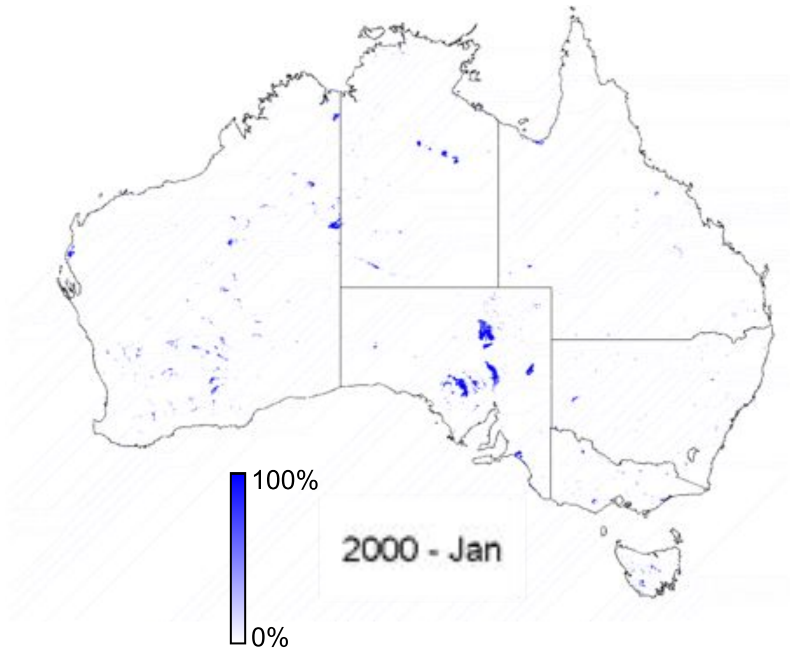



*Source: R. Mitchell - CSIRO*

# Flood Mapping

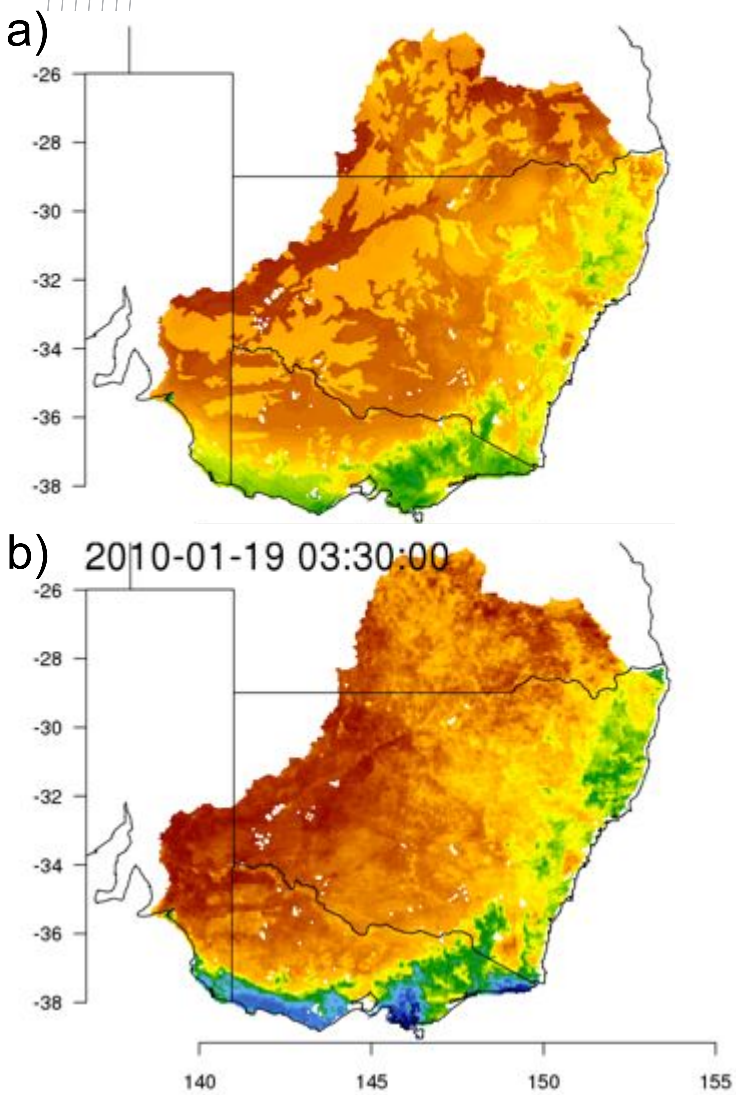
- Can apply algorithms based on MODIS Terra and Aqua – twice a day



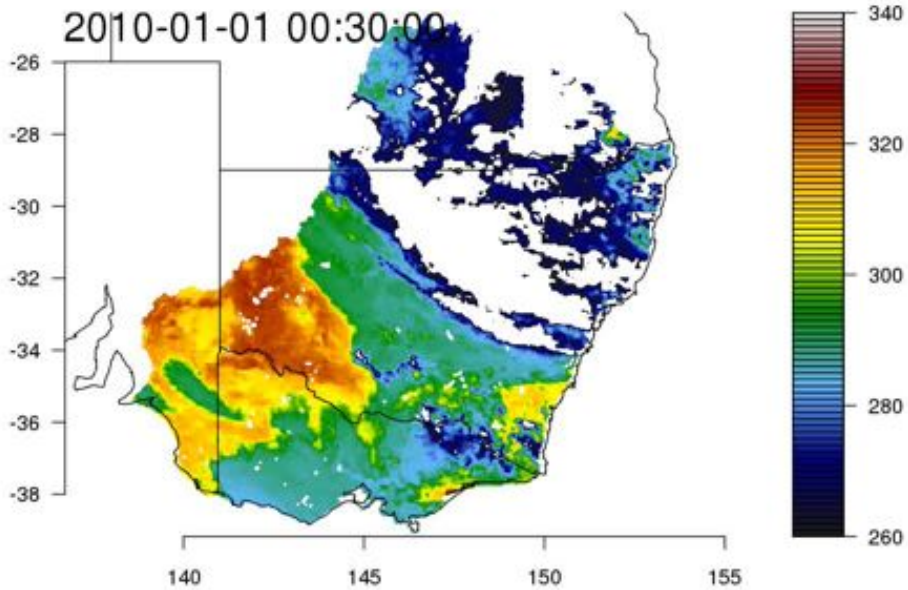

**Guerschman et al. (2009)**
**(In collaboration with Geoscience Australia)**

# Geostationary Land Surface Temperature - A very dynamic variable




(a) CABLE LST
- Complete/continuous coverage
- Hindered by “poor” model inputs

(b) MTSAT-1R LST
- Retrieved product
- Gappy in spatial & temporal coverage

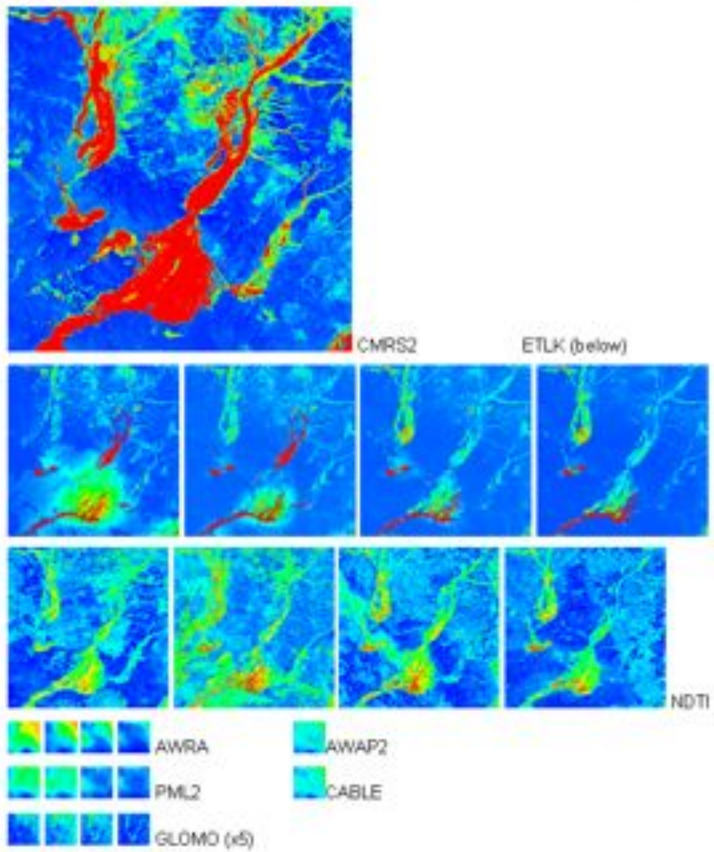



*Source: L. Renzullo - CSIRO*

# Testing up to 8 Australia-wide Evapotranspiration Products

- 1. Water Balance
  - Forced by rainfall
  - Constrains ETa by modelling water balance terms to estimate available water
  - Little to no remote sensing
  - **MODELS**: (Australian Water Resources Assessment model AWRA, and Australian Water Availability Project model AWAP aka Waterdyn)
- 2. Surface Energy Balance (SEB)
  - Use remotely sensed surface temperature to estimate H between two limiting temperatures derived by energy balance inversion
  - **MODEL**: The Normalised Difference Temperature Index NDTI
  - Inversion of the Penman-Monteith equation and uses coarse soil moisture
  - **MODEL**: ETLook ETLK
- 3. Vegetation Conductance
  - Estimate surface (canopy) conductance in surface energy balance model from sat. obs. or products – notably MODIS LAI
  - **MODELS**: Global MODIS ET product MOD16 GLOMO, and Penman-Monteith-Leuning PML
- 4. Hybrid
  - Empirical ETa model that also estimates (a) soil & water evaporation by including wetness (GVMI from SWIR) (b) rainfall interception loss. **MODEL**: CSIRO MODIS ReScaled potential ET model CMRS
  - Coupled Water+Energy+Carbon. **MODEL**: CSIRO Atmosphere Biosphere Land Exchange CABLE

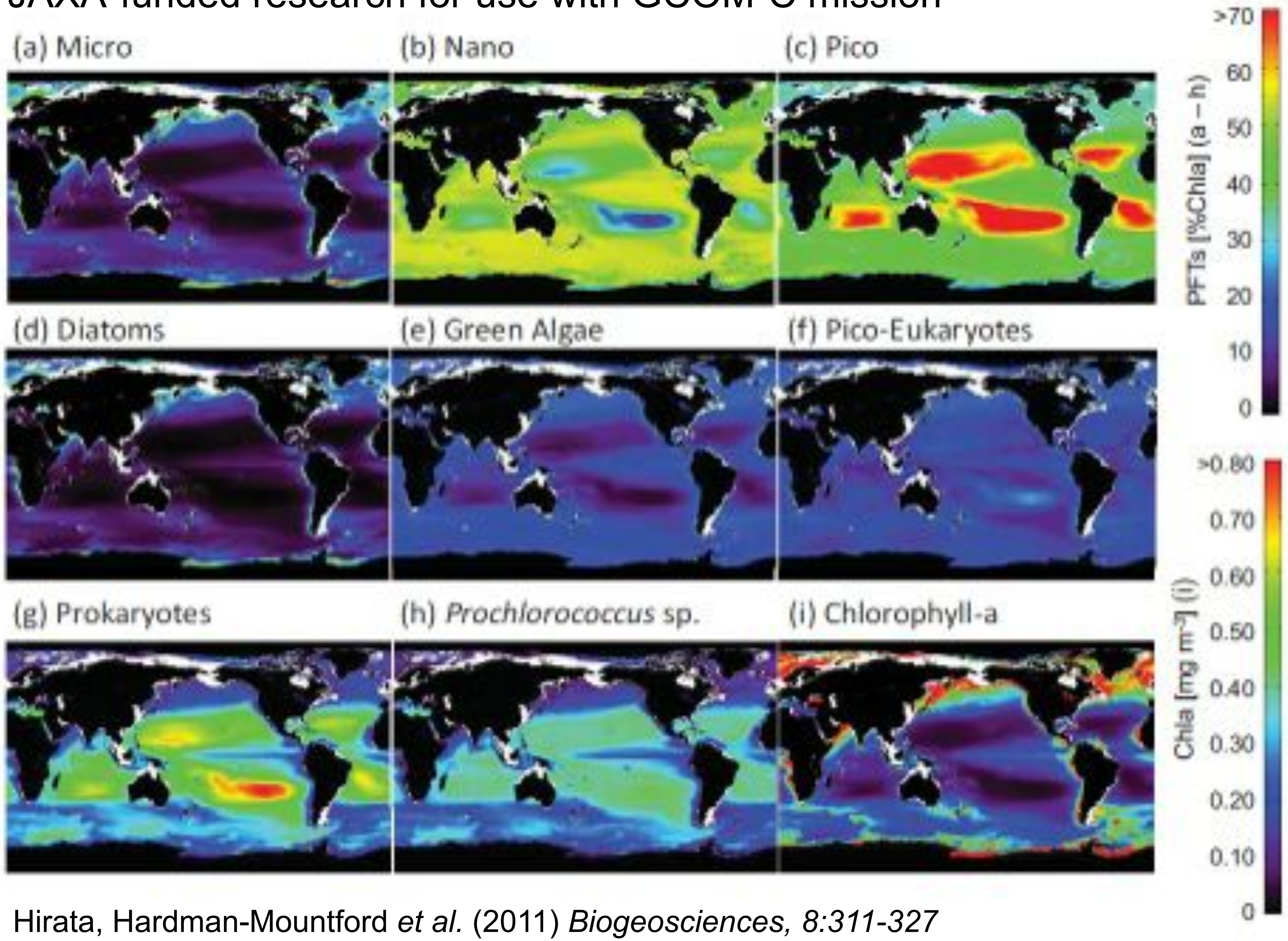
**Figure 13** Sample images of AET for a region in western Queensland (139E-142E, 23S-26S) during a flow event in February 2004 illustrating the effects of differing time and space resolution. For CMRS2, AWAP2 and CABLE only monthly data (2004/02/01–2004/02/28) are shown; for ETLK, NDTI, AWRA, PML2 and GLOMO, four 8-day intervals (02/02–02/09, 02/10–02/17, 02/18-02/25, 02/26-03/04) are given. All images cover the same area and are reproduced at the same pixel scale (dpi); the difference in size is due to the variation in spatial resolution (degrees/pixel). The colour scale is the same for all (blue-red=0-5mm/day), EXCEPT for GLOMO, where the scale is multiplied by a factor of 5 (0-1mm/day).




King EA, van Niel TG, van Dijk AIJM, Wang Z, Paget MJ, Raupach T, Guerschman J, Haverd V, McVicar TR, Miltenberg I, Raupach MR, Renzullo LJ, Zhang Y. 2011. Actual Evapotranspiration Estimates for Australia Intercomparison and Evaluation. CSIRO: Water for a Healthy Country National Research Flagship: Canberra.

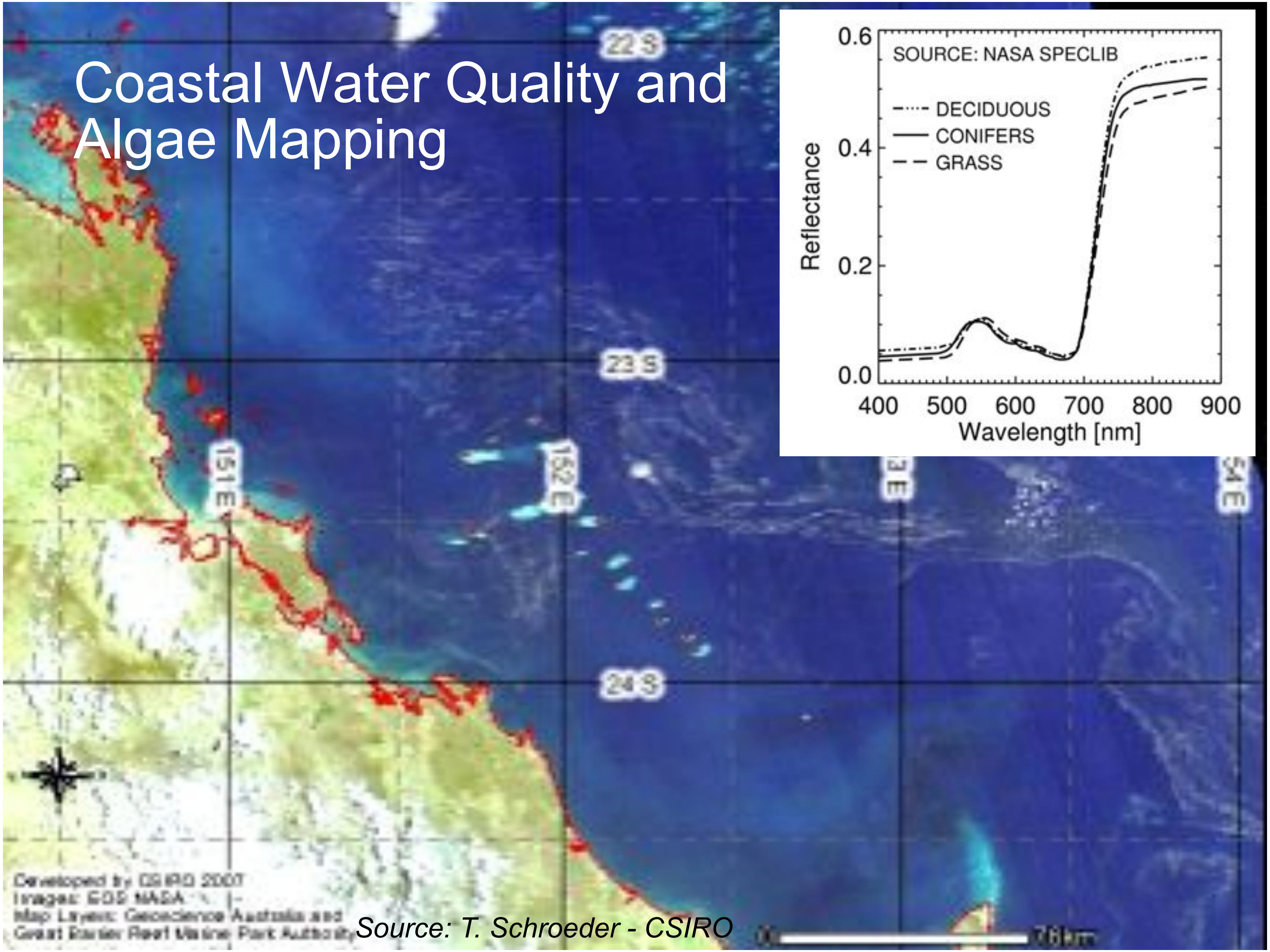
# Global Phyoplankton Functional Types Distribution

JAXA-funded research for use with GCOM-C mission



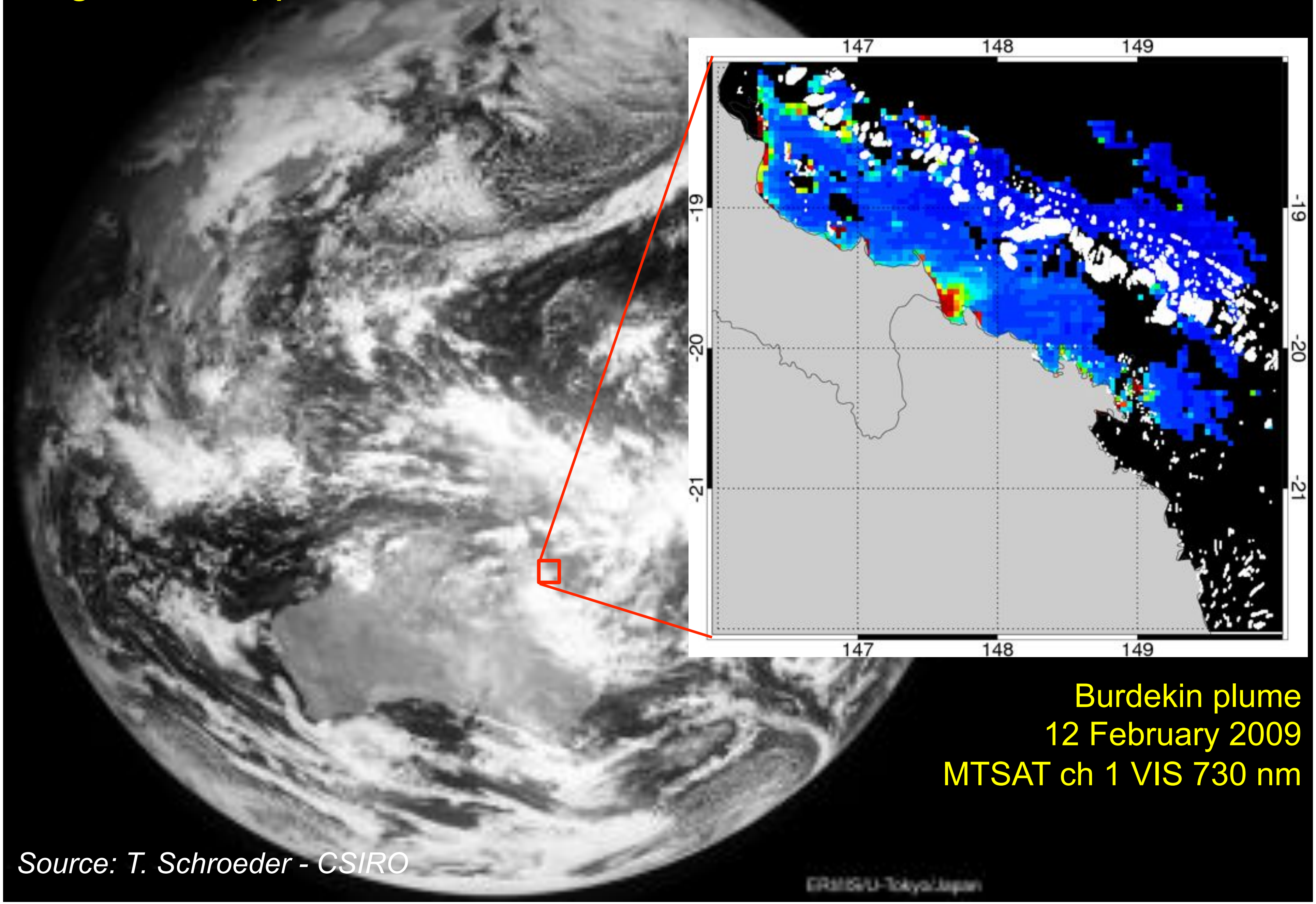

Hirata, Hardman-Mountford *et al.* (2011) *Biogeosciences, 8:311-327*

# Coastal Water Quality and Algae Mapping




*Source: T. Schroeder - CSIRO*

# Algorithm applied to MTSAT-1R




*Source: T. Schroeder - CSIRO*

# Proposed Next Steps

- Develop a new research program between JAXA-JMA-CSIRO & BoM
  - Undertake further analysis on top-five non-meteorological applications
  - Access Himawari simulation data for use in algorithm testing
  - Organise joint workshop in late 2014 ( in Japan or Australia) to evaluate results of simulation data analysis
  - Integrate key algorithms into operational processing system (in early 2015)

# THANKS