ESTABLISHING ACTIVE FIRE DATA CONTINUITY BETWEEN AQUA MODIS AND SUOMI NPP VIIRS

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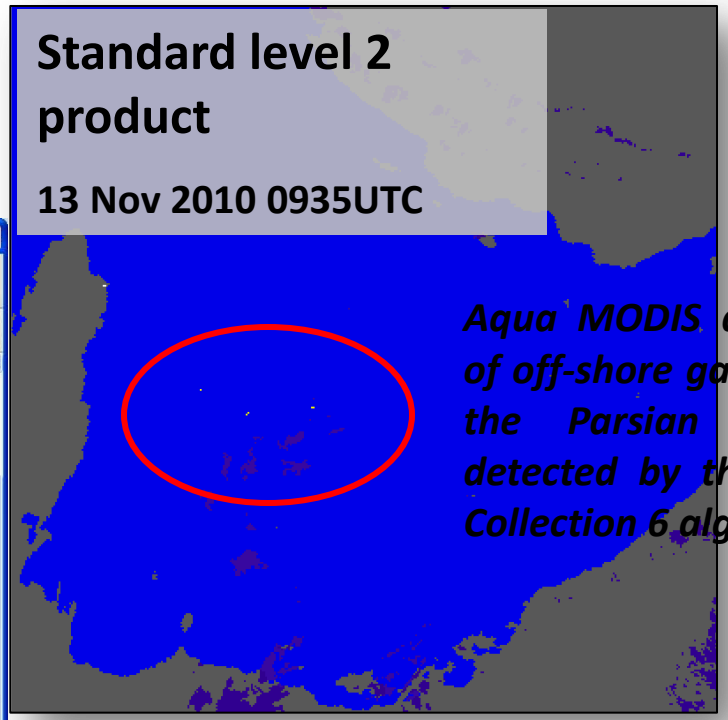
Why do we need MODIS-VIIRS continuity?

- MODIS is the first sensor designed to **detect and characterize hot targets** (predominantly actively burning fires) on a **global and systematic basis**
- MODIS fire data have been **extensively used** for disaster and resource management, air quality applications, ecosystem monitoring, climate studies etc.
- The community expects and **society needs** the continuation of these high quality observations from VIIRS on NPP (launched on October 28, 2011) and future JPSS satellites

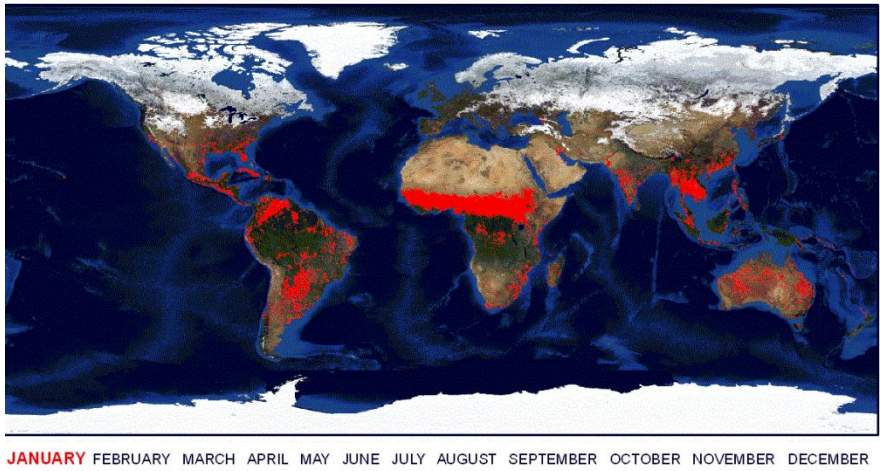
Examples of MODIS fires/thermal anomalies data

Real-time data



Aqua MODIS detections of off-shore gas flares in the Parsian Gulf as detected by the MODIS Collection 6 algorithm

Global dynamics



MODIS – VIIRS fire continuity: fundamental possible scenarios

1. **Orbital/daily** MODIS and VIIRS fire maps are **compatible**.

2. Spatially and temporally **aggregated fire statistics** from MODIS and VIIRS **are compatible**.

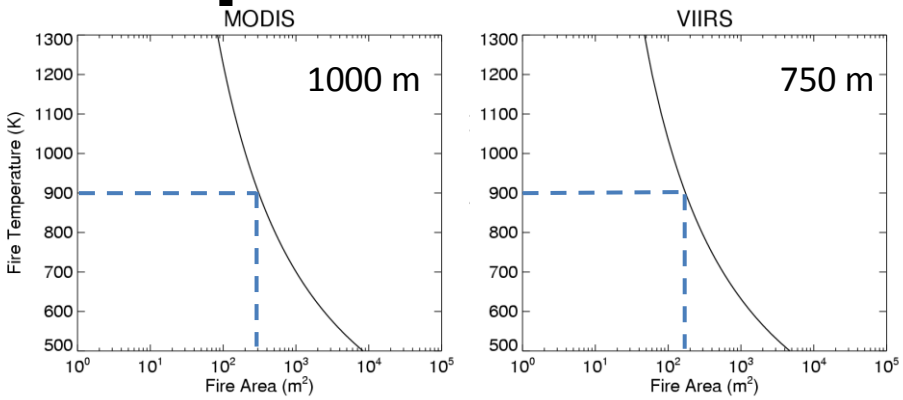
3. Not even spatially and temporally aggregated fire statistics from MODIS and VIIRS are compatible, but MODIS and VIIRS provide **compatible general patterns and trends of fire dynamics**.

Aqua MODIS vs. NPP VIIRS: fundamental features

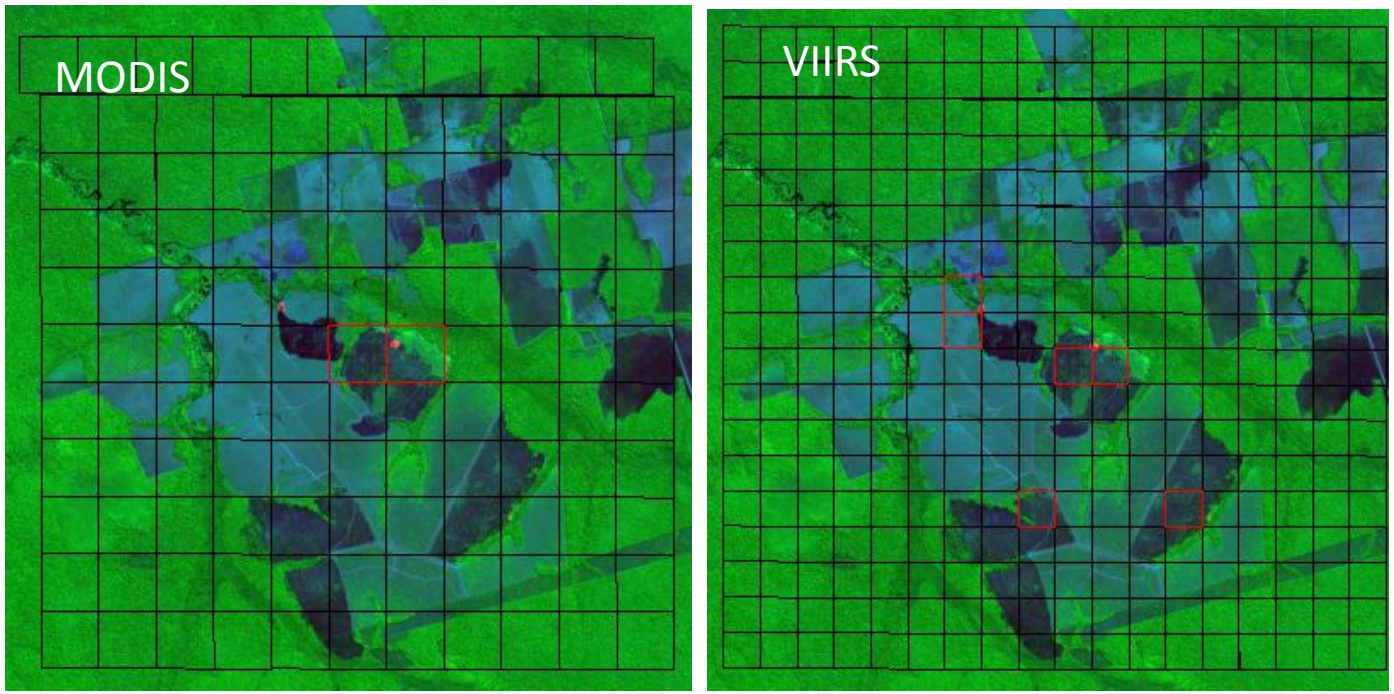
- Aqua and NPP have **similar overpass times (1:30pm)**
  - sampling of the diurnal fire cycle is similar
- Saturation levels of the primary bands allow **unsaturated radiance measurements** for most fires
  - Band 21/22 for MODIS and M13 for VIIRS
- Some differences in **spectral placement**
- Processing **algorithms are compatible**
  - Current VIIRS algorithm is based on MODIS, albeit an earlier version
  - Differences can be resolved and the impact can be minimized
- **Primary driver** of differences is **spatial sampling**
  - Pixel size
  - Variations along scanline (aggregation schemes)
  - Variations within pixels (line-spread function, aggregation)
  - Differences in swath width (VIIRS has no gaps at low latitudes)

Will orbital/daily MODIS and VIIRS fire maps be compatible?

VIIRS spatial resolution is higher that of MODIS; in general, VIIRS is expected to detect smaller fires at nadir



90% probability of detection; boreal forest; nadir view

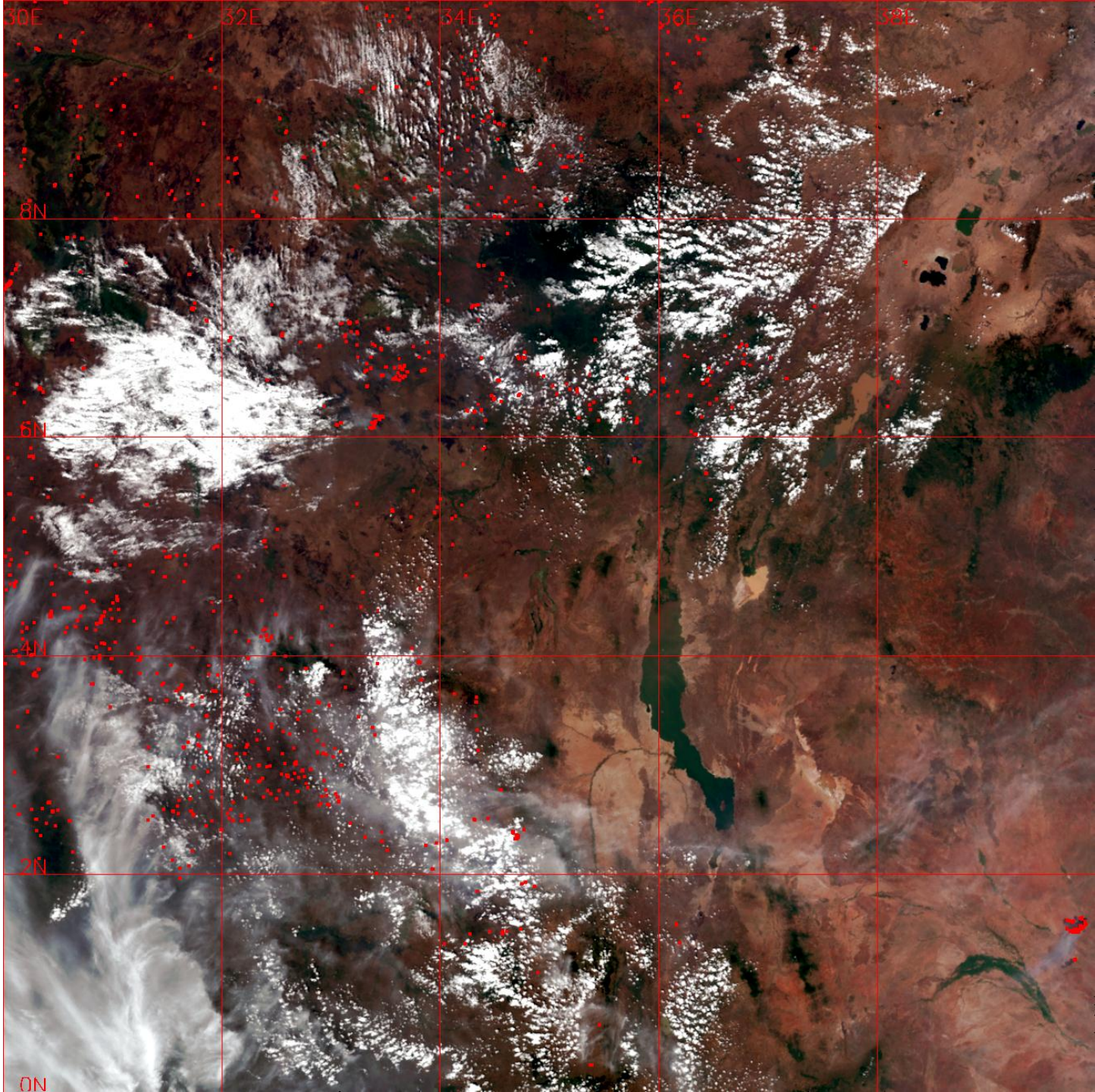


(based on modeling using ASTER fire masks)

7 Aug 2004 1405 UTC ~11.7° S 56.6° W (Brazil)

First light NPP VIIRS fire data

M5-M4-M3 RGB
+
IDPS Active Fire ARP

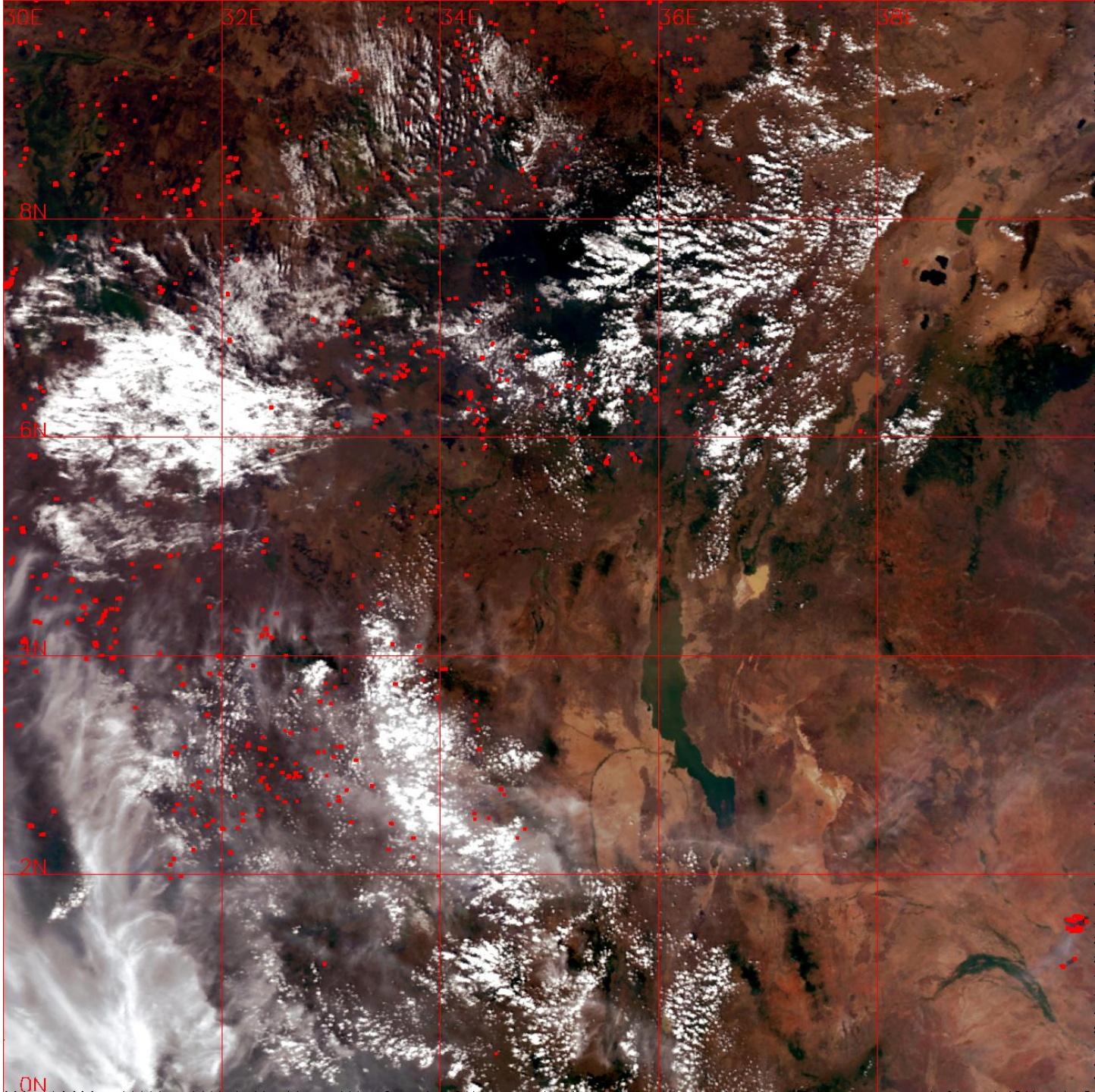


January 19, 2012
~11:05 UTC

…followed by Aqua MODIS five minutes later

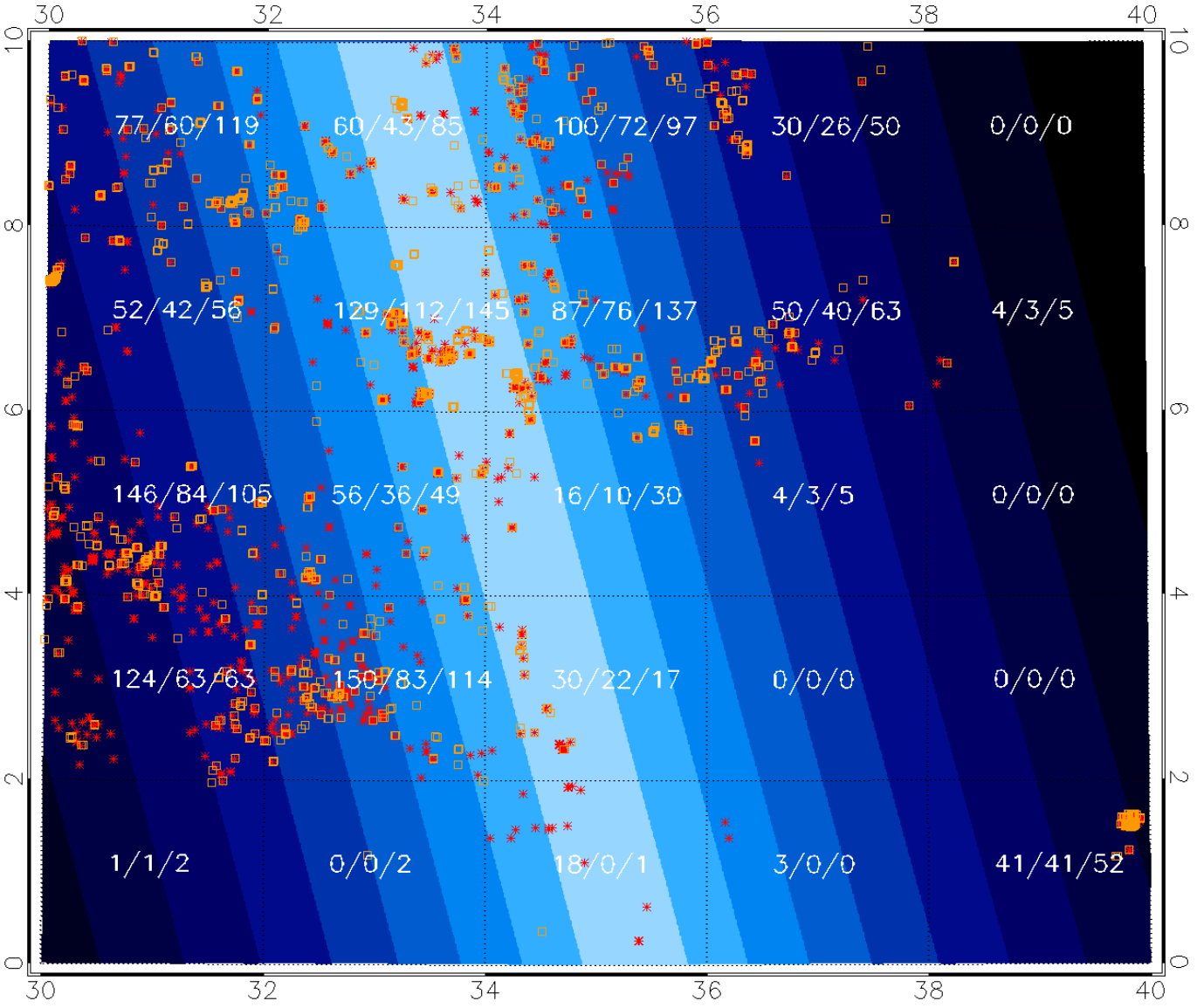
Band 1-4-3 RGB
+
MYD14

January 19, 2012
~11:05 UTC



MODIS vs. VIIRS detections

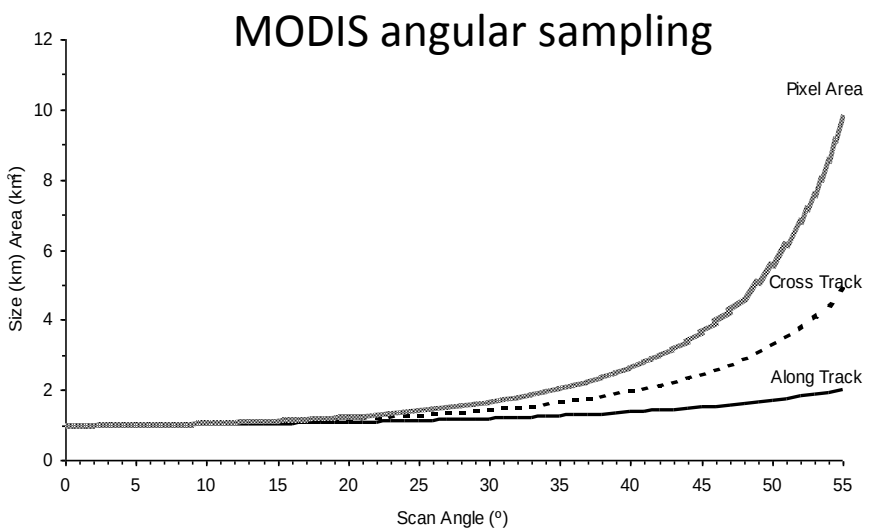
both near-nadir

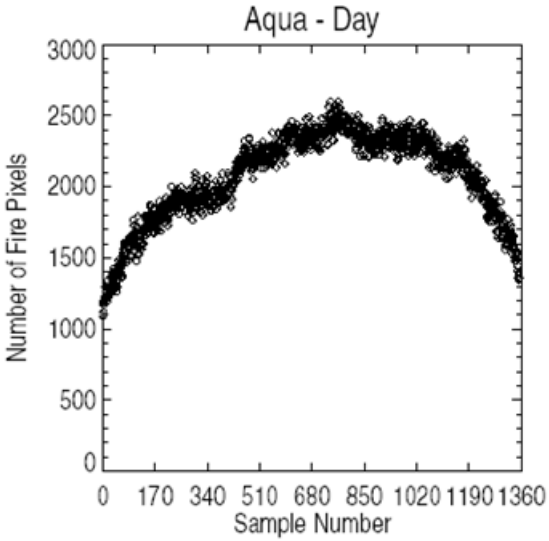


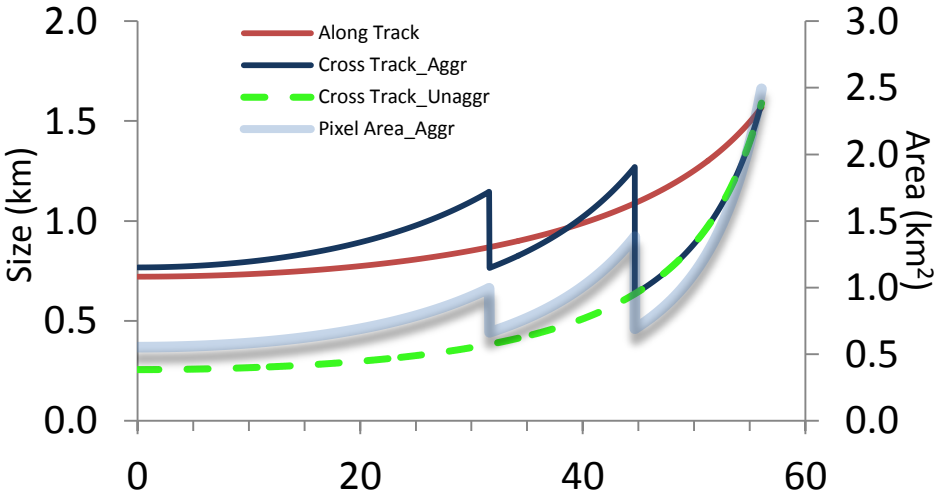
VIIRS/overlap/MODIS

January 19, 2012
~11:05 UTC

Angular sampling







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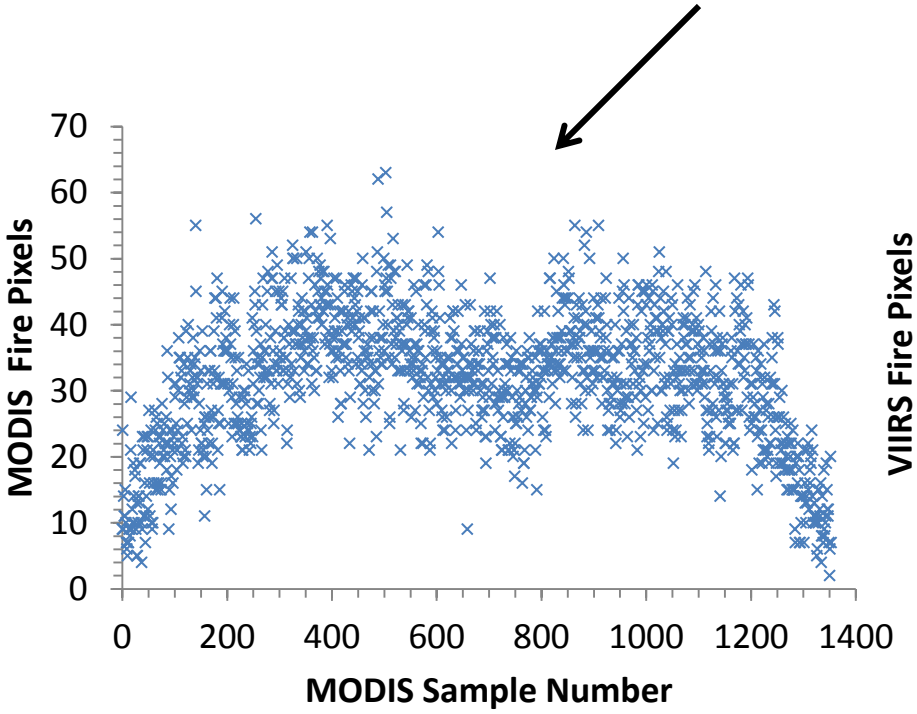
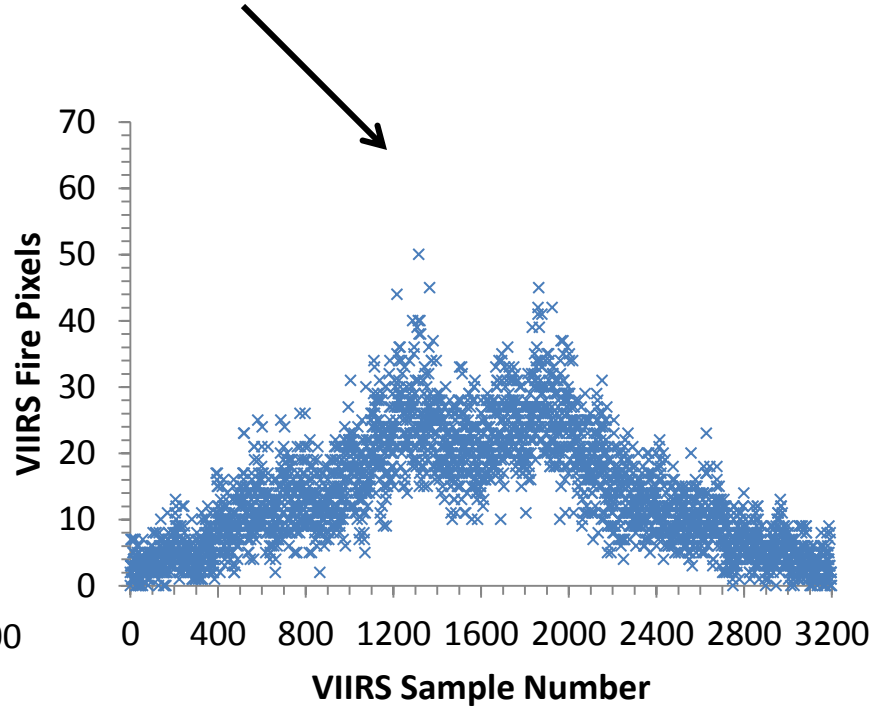
MODIS vs. VIIRS fire counts

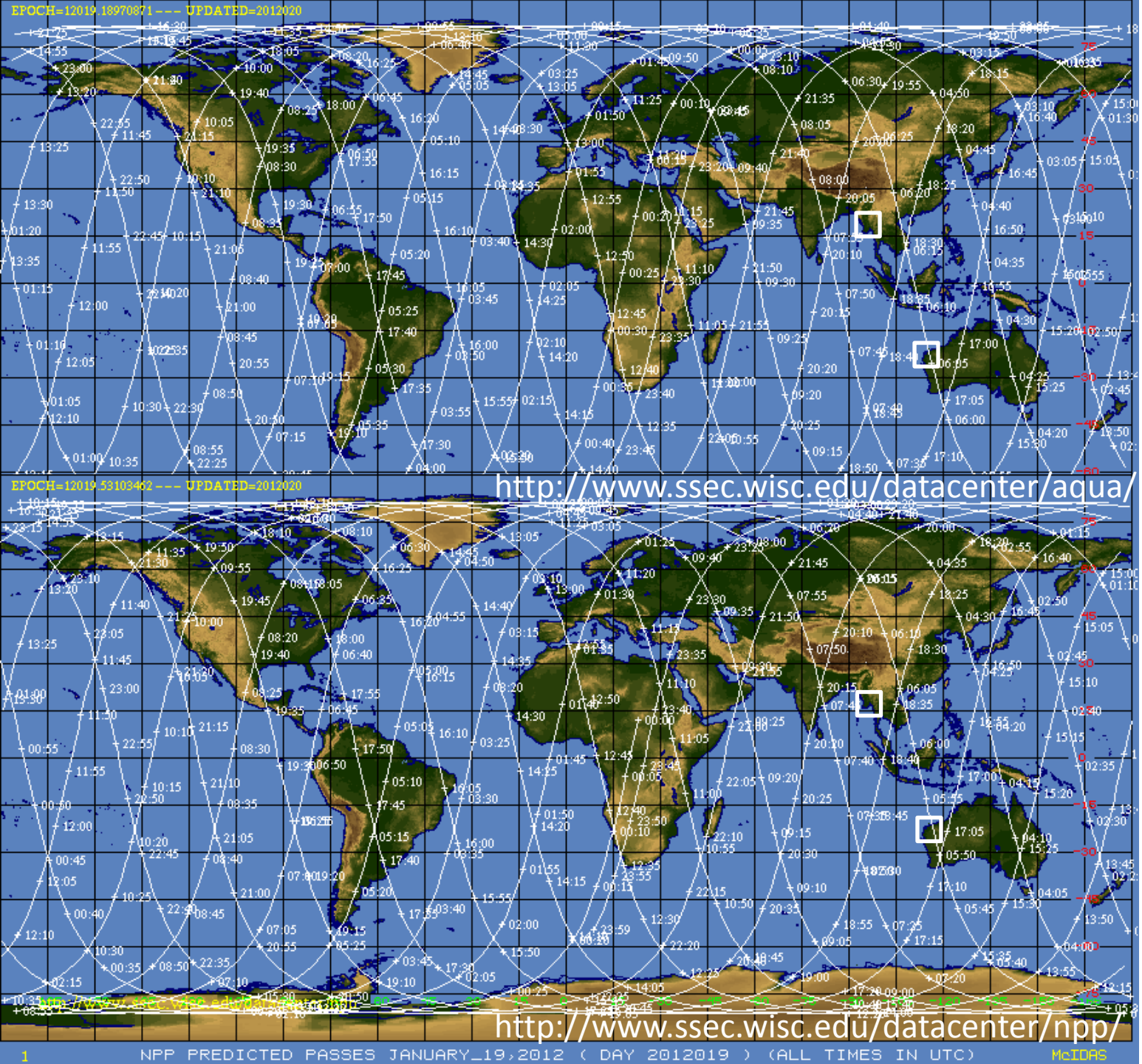
Jan 19-24

VIIRS has a wider swath than MODIS





Preliminary, for illustration purposes only!

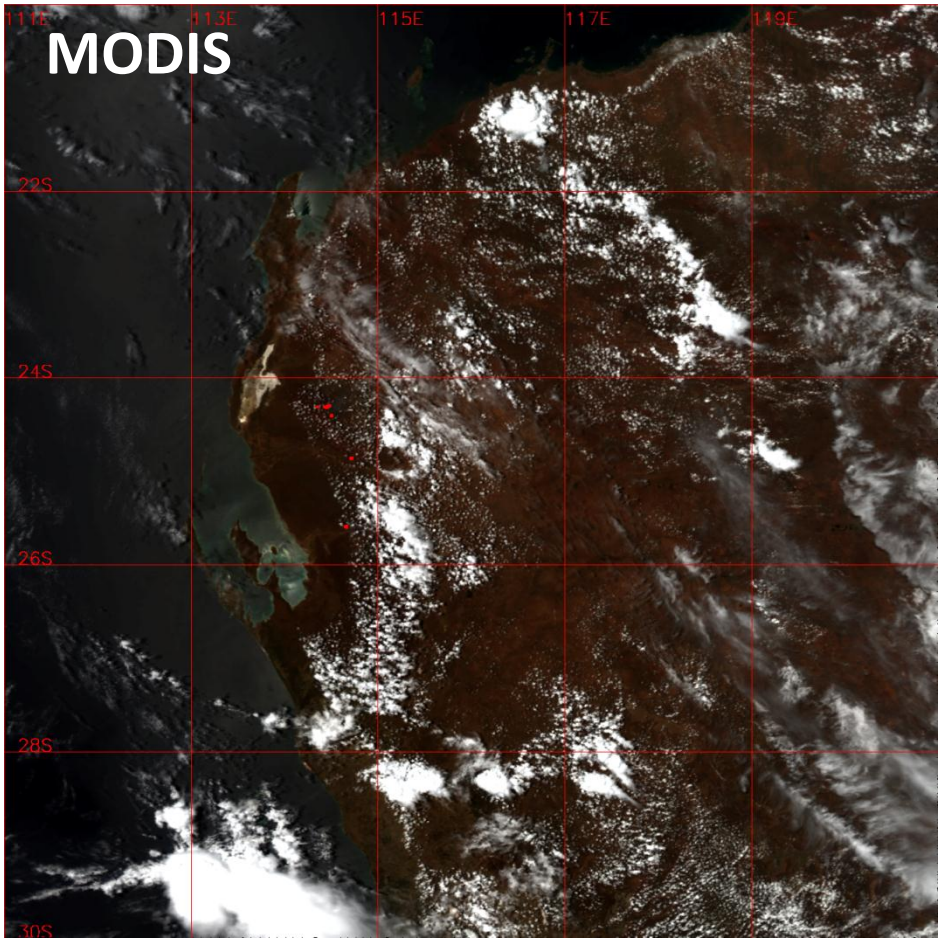


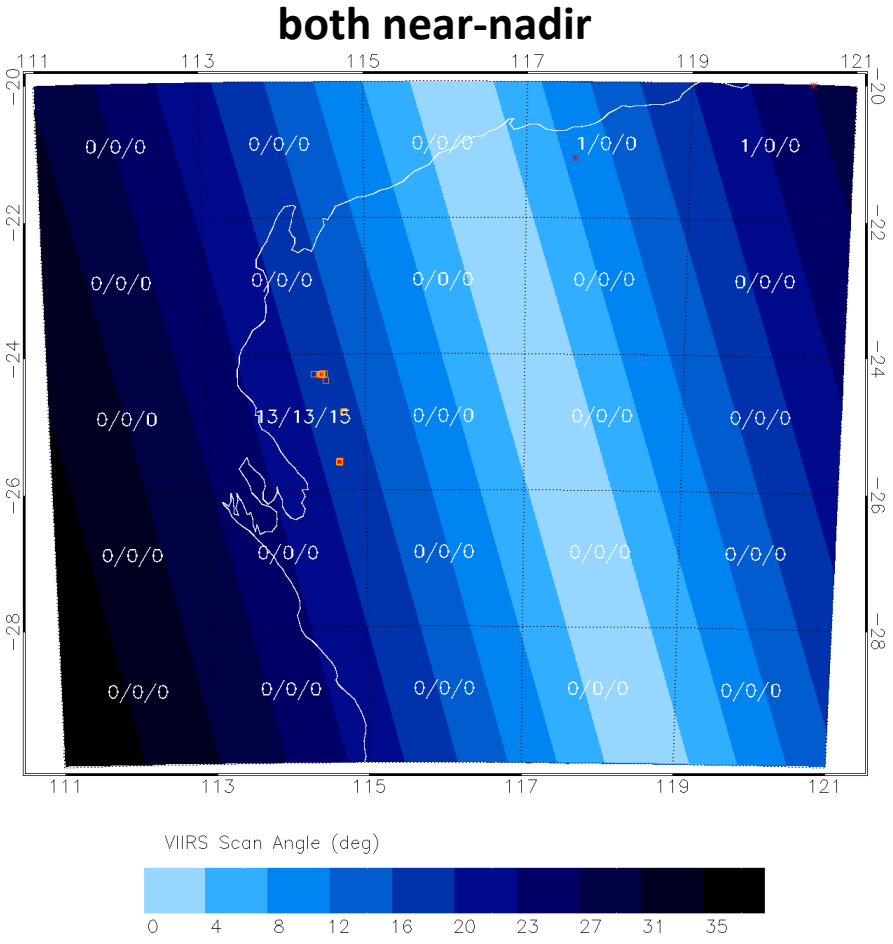
Aqua

Jan 19 2012

NPP

Western Australia

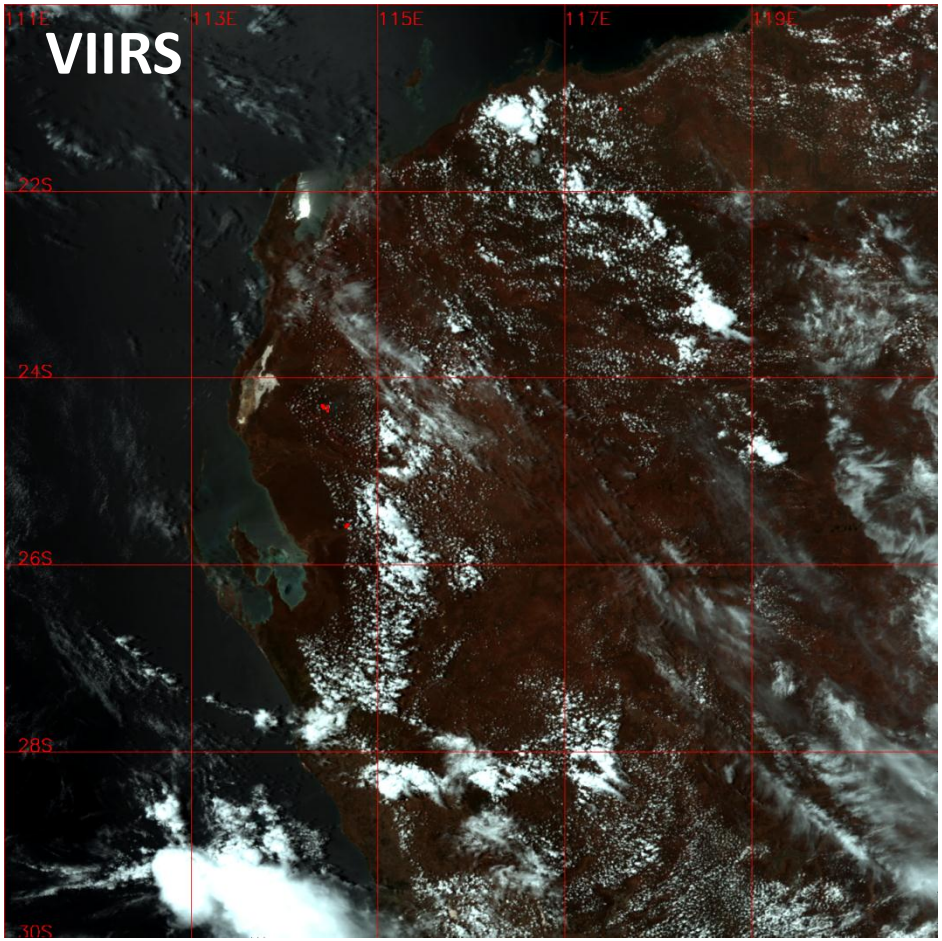


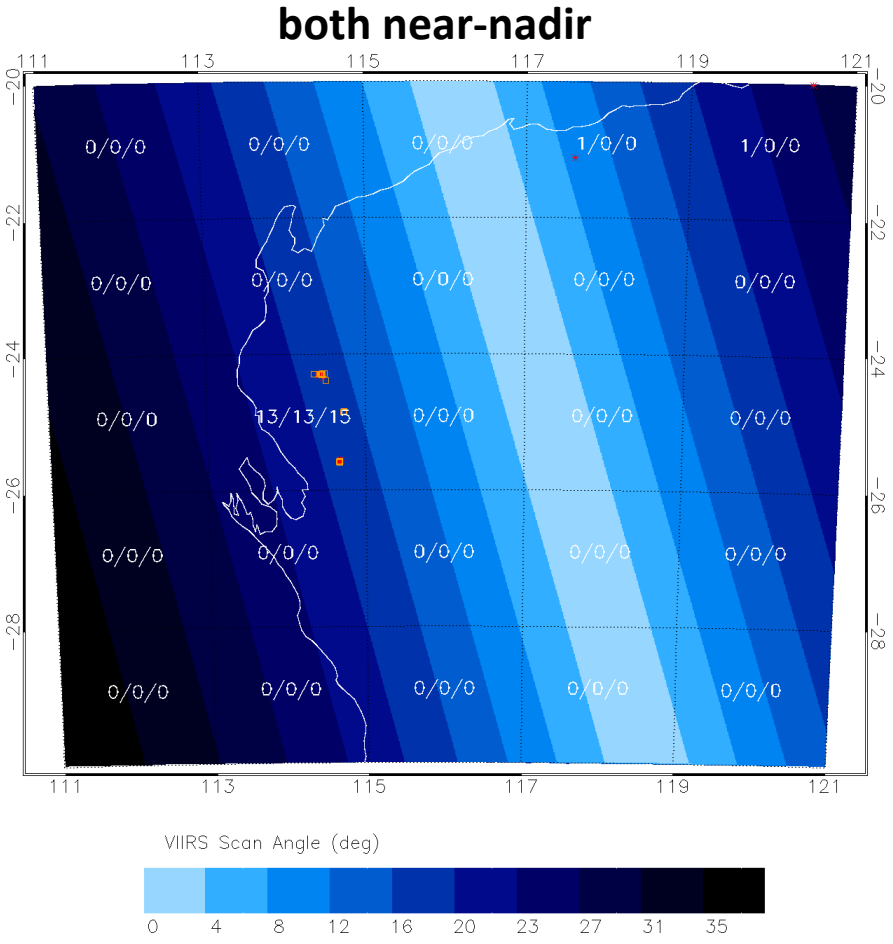


Jan 19 2012 06:00 UTC

VIIRS/overlap/MODIS

Western Australia

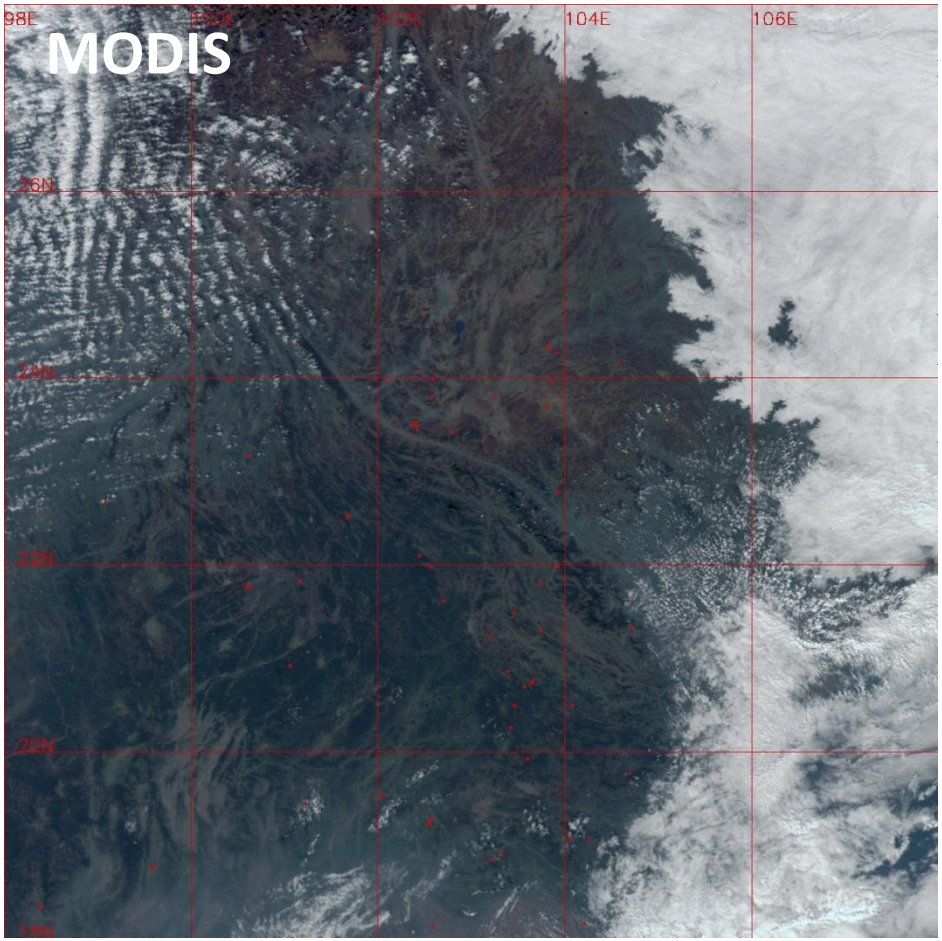


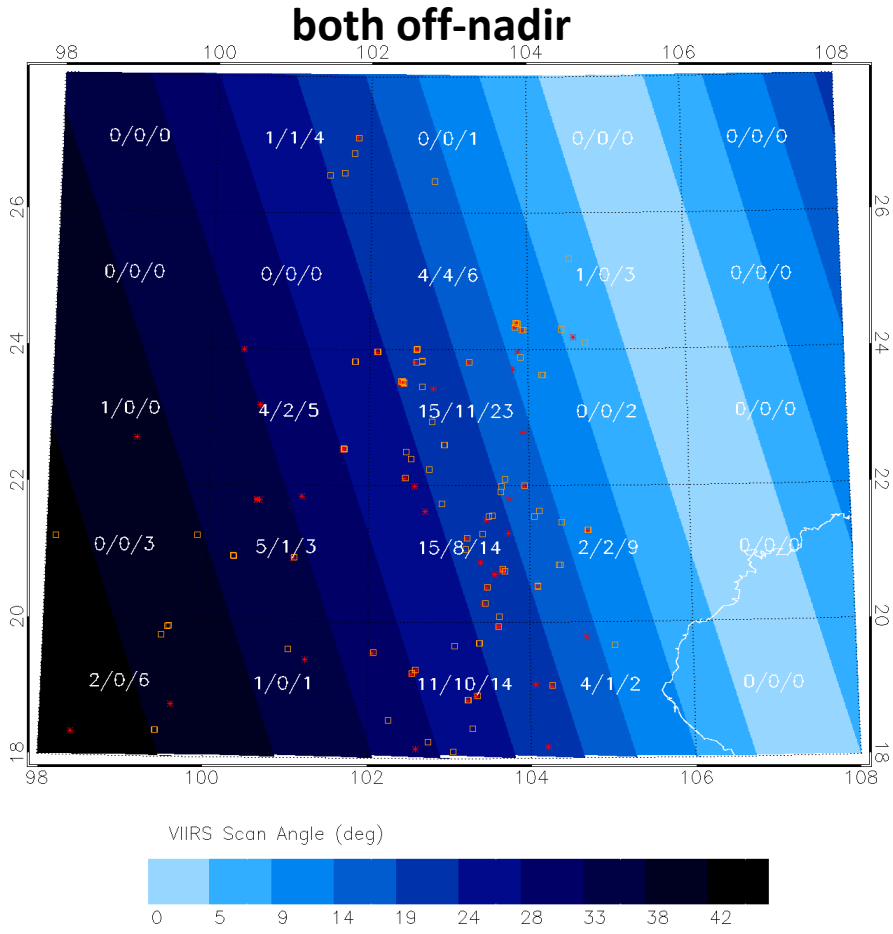


Jan 19 2012 05:45 UTC

VIIRS/overlap/MODIS

South-East Asia

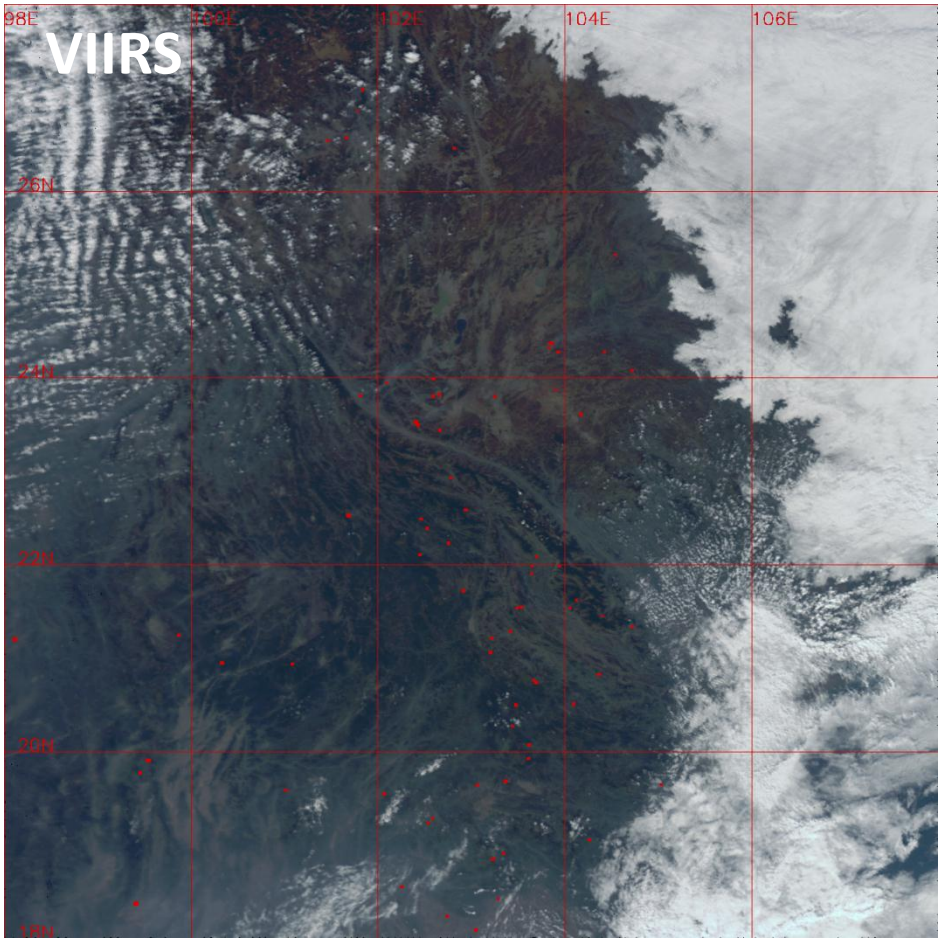


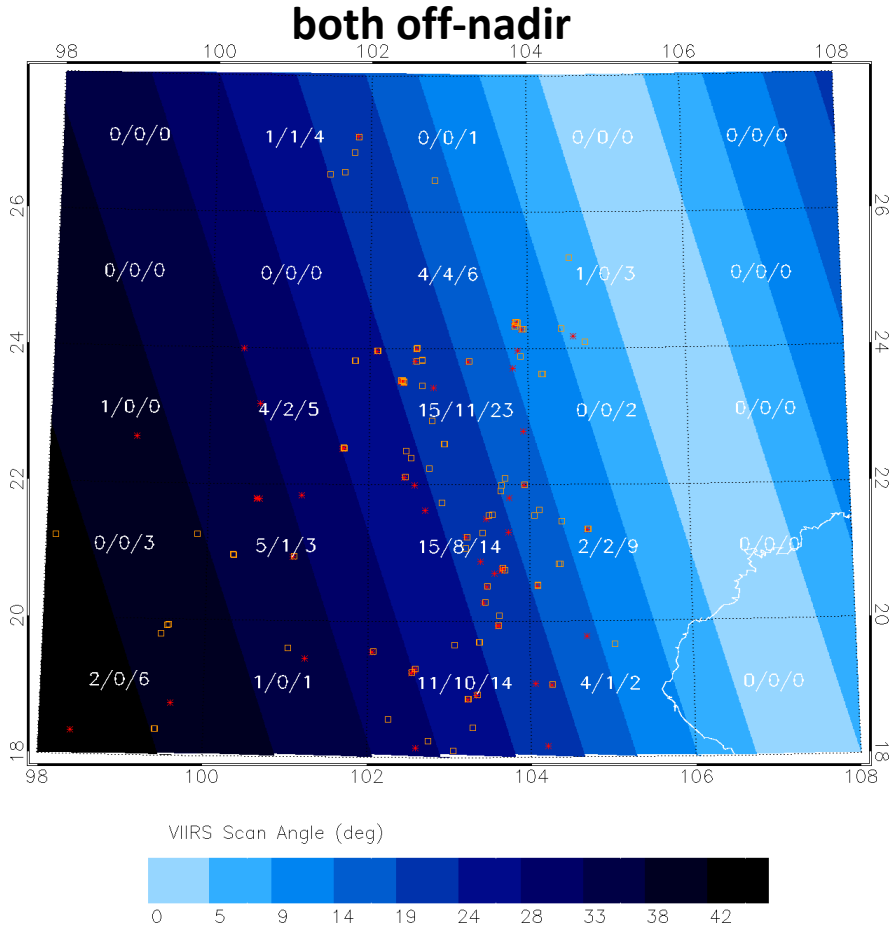


Jan 19 2012 06:15 UTC

VIIRS/overlap/MODIS

South-East Asia





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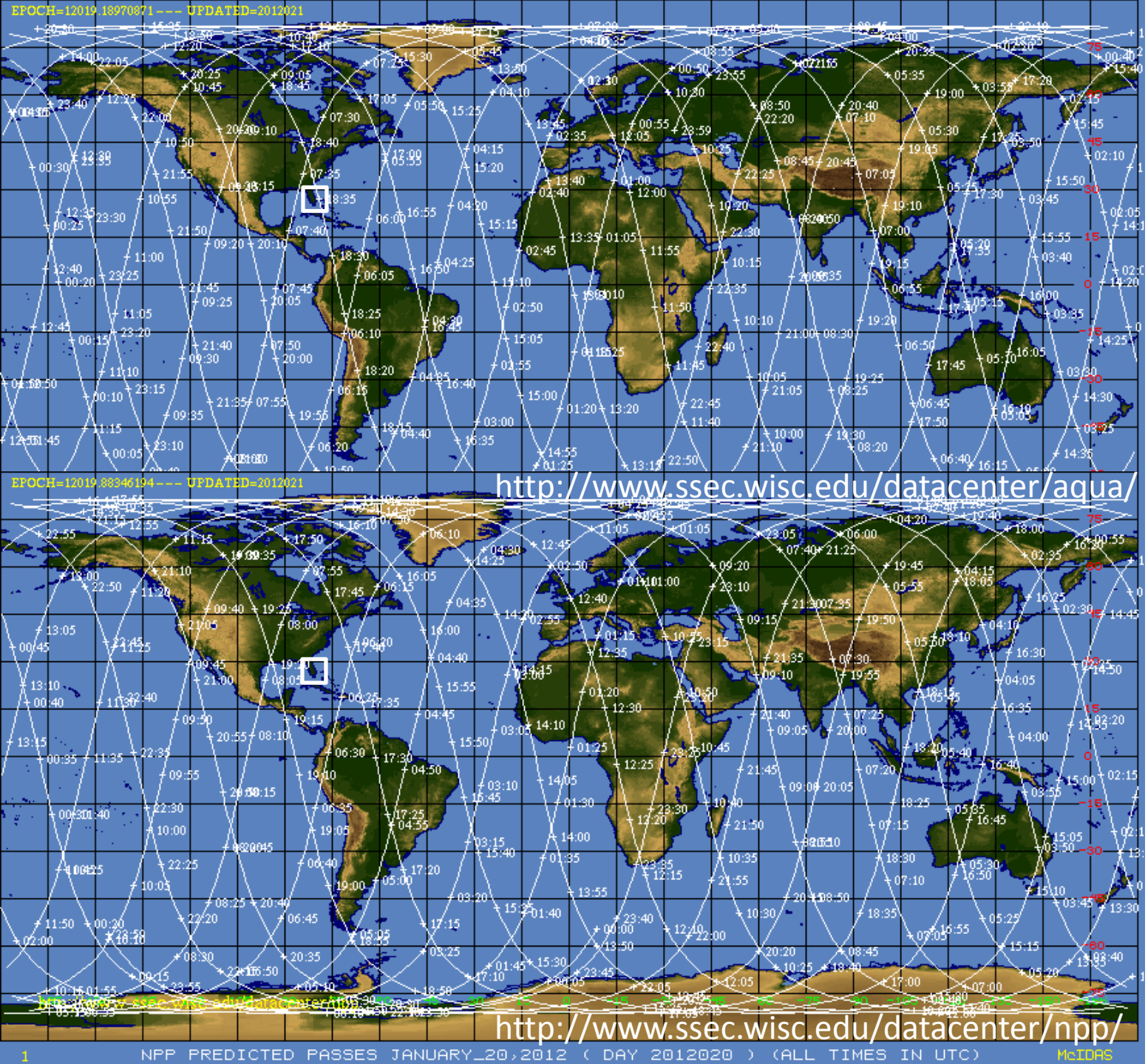
VIIRS/overlap/MODIS

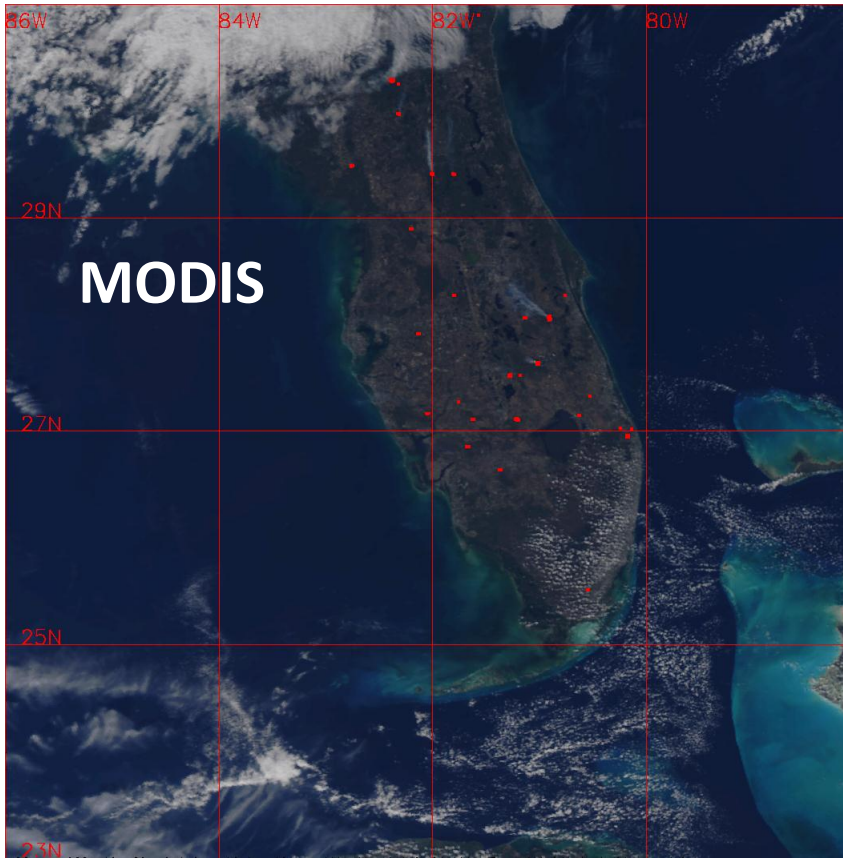


Aqua

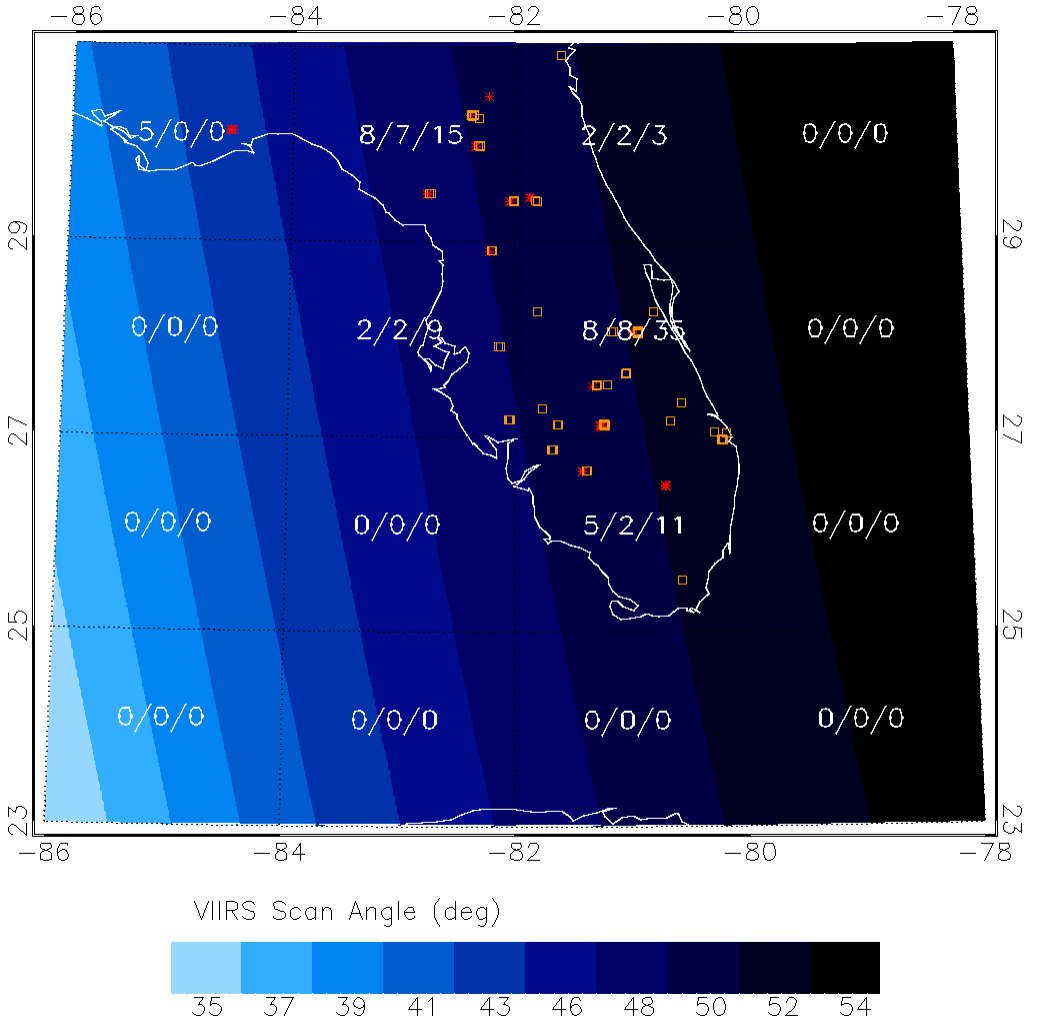
Jan 20 2012

NPP

Florida



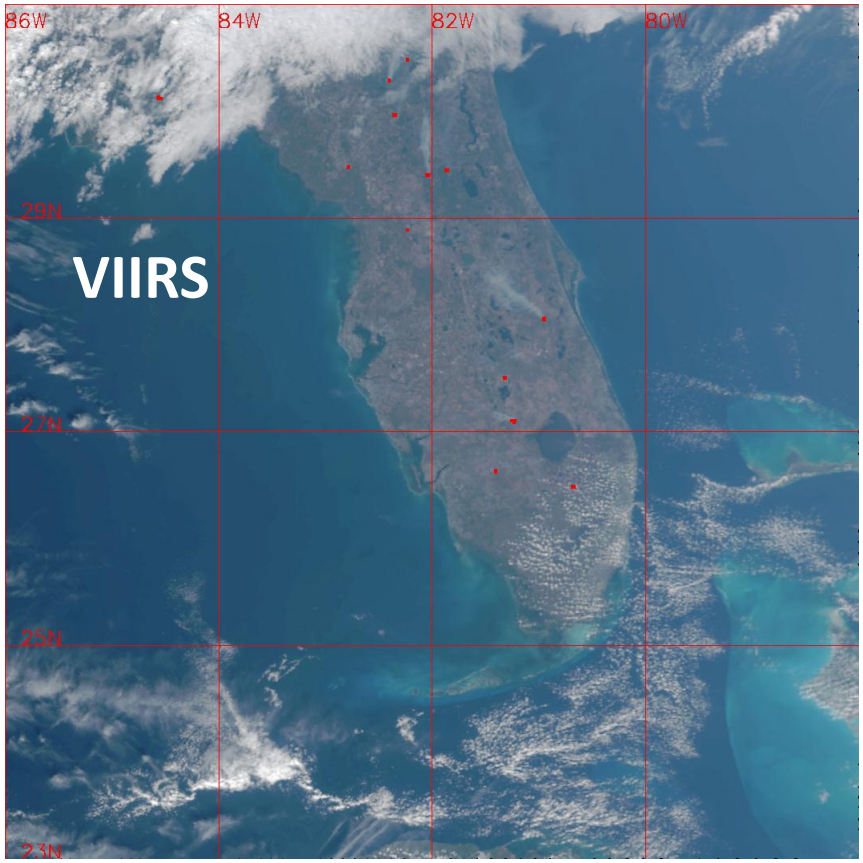
MODIS: near-nadir; VIIRS: off-nadir



Jan 20 2012 18:33 UTC

VIIRS/overlap/MODIS

Florida



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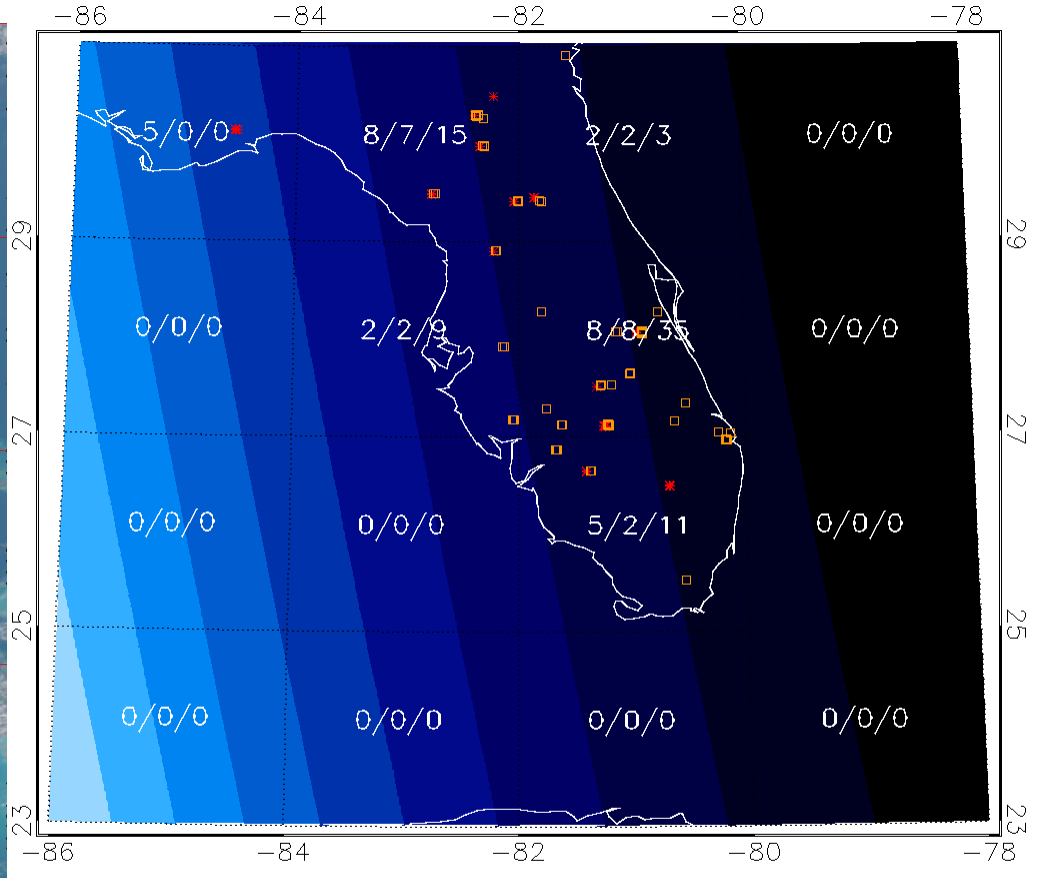


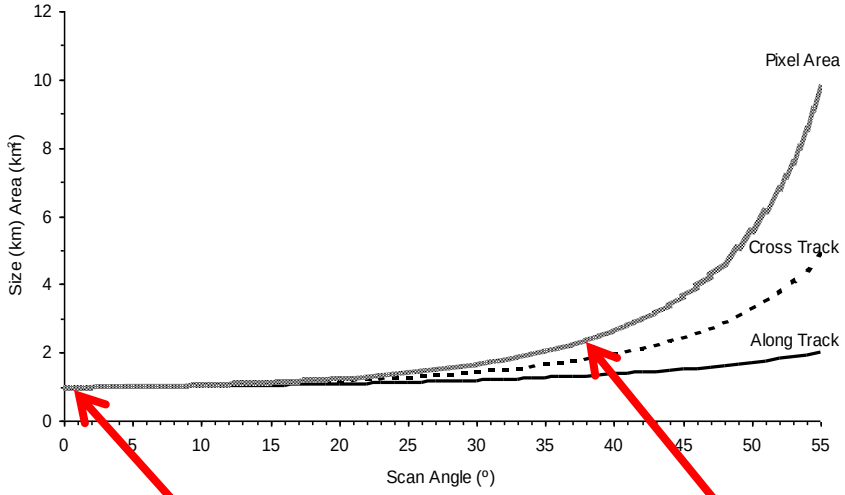
Jan 20 2012 19:15 UTC

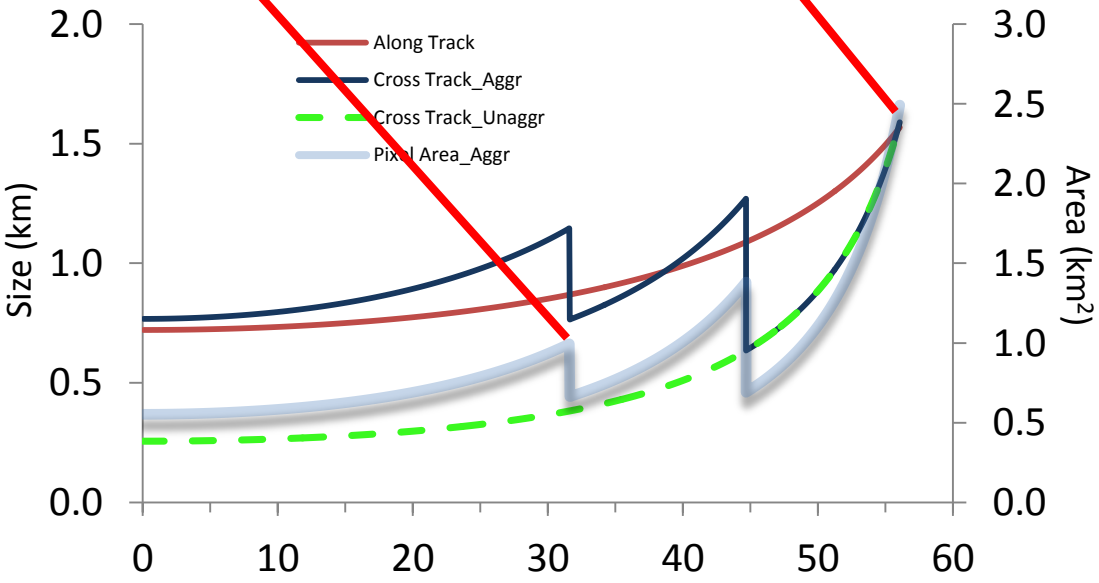
VIIRS/overlap/MODIS

Truly compatible spatial sampling for MODIS-VIIRS comparison

- Simultaneous, compatible spatial sampling
  - SNO/SNOx type method for intercalibration
  - primarily driven by sample size
  - angular effects secondary, but potentially non-negligible, especially for off-nadir looks
- Matching swath segments with similar spatial sampling
- Advantage: allows for direct comparison of fire data
- Disadvantage: angular effects are not accounted for

Compatible swath segments





In principle, it is possible to select swath segments with compatible sampling for direct intercomparison

Compatible cloud masks are crucial

(Need for spatially explicit land/water/cloud/fire mask in the VIIRS product!)

Possible scenarios - practicalities

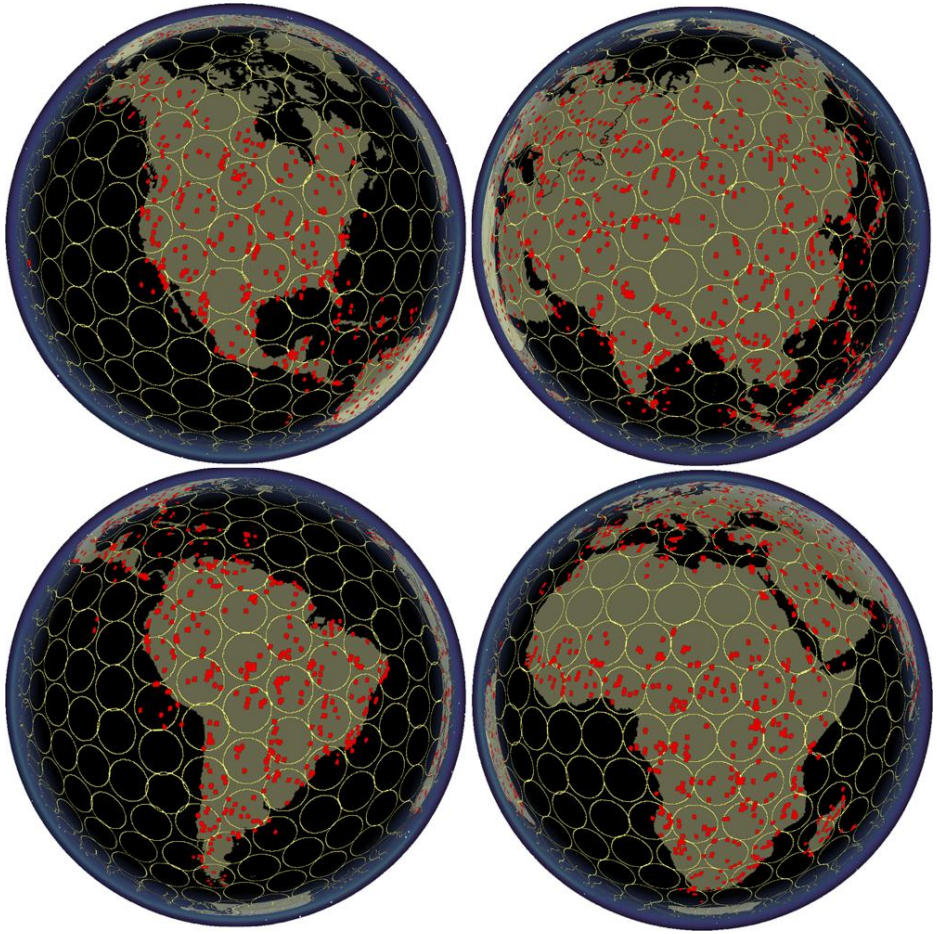
1. **Orbital/daily** MODIS and VIIRS fire maps are **compatible**.
    - Not crucial for operational users as long as VIIRS is comparable or superior to MODIS
2. Spatially and temporally **aggregated fire statistics** from MODIS and VIIRS **are compatible**.
    - Useful for evaluating algorithm consistency, data continuity
3. MODIS and VIIRS provide **compatible general patterns and trends of fire dynamics**.
    - Contingent upon the statistical population of fires
    - Statistics can be derived from Landsat-class data
    - Fire of interest – what is the desired lower limit?

Explicit validation

Near-nadir pixels
(using ~2,500 coincident ASTER scenes)

17K MOD14 pixels sampled

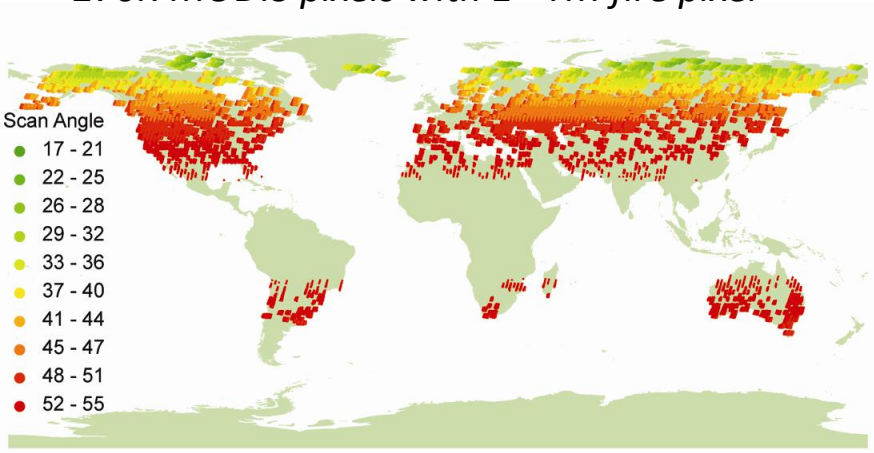
120K MODIS pixels with 1+ ASTER fire pixel

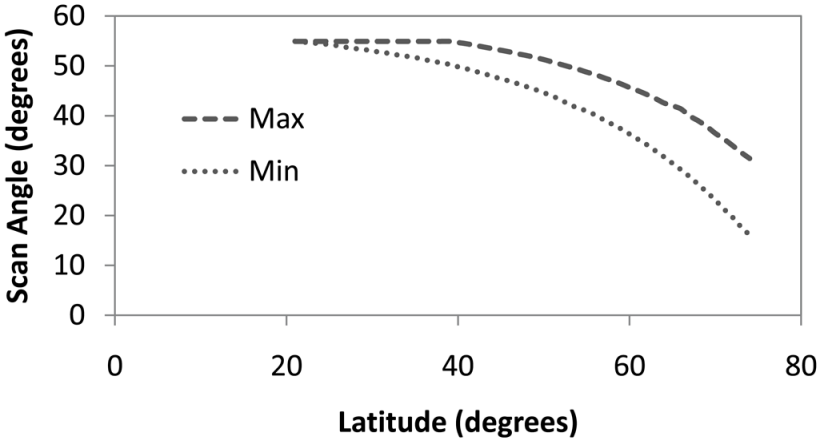


Off-nadir pixels
(using ~3,700 near-coincident TM scenes)

12K MOD14 pixels sampled

270K MODIS pixels with 1+ TM fire pixel



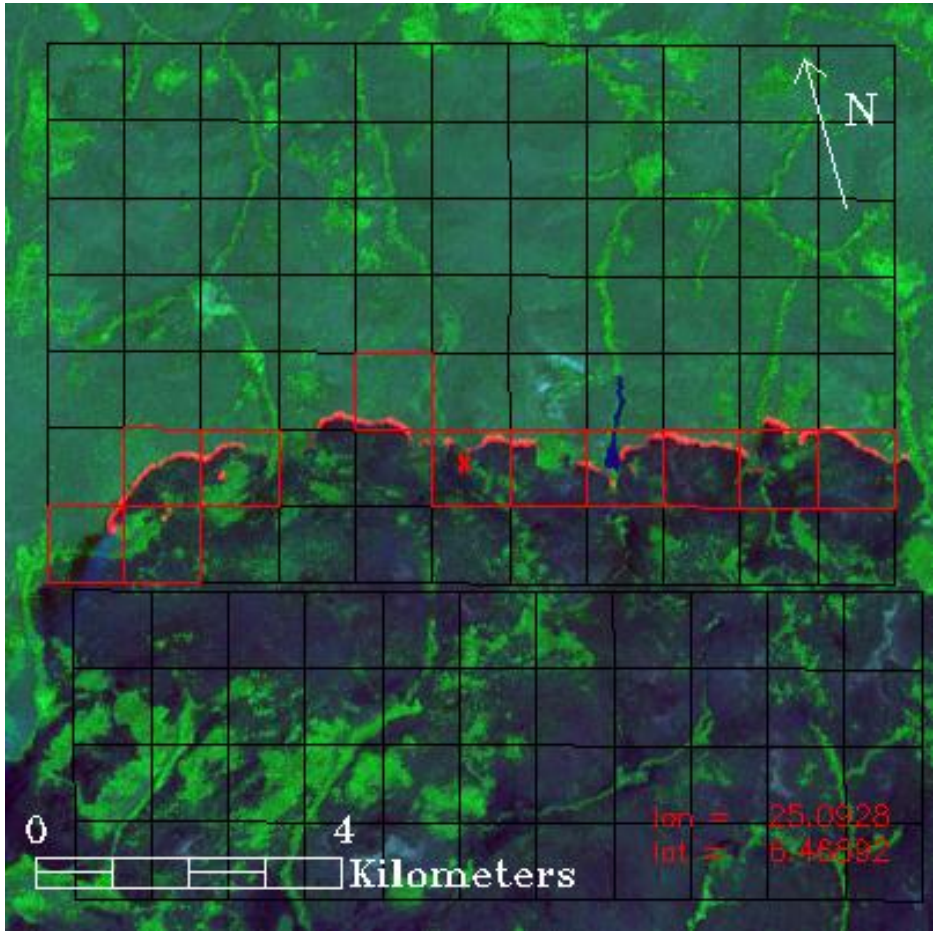


Explicit validation

Near-nadir pixels
(using ~2,500 coincident ASTER scenes)

ASTER 2001-2006

SWIR detector problem > May 2007

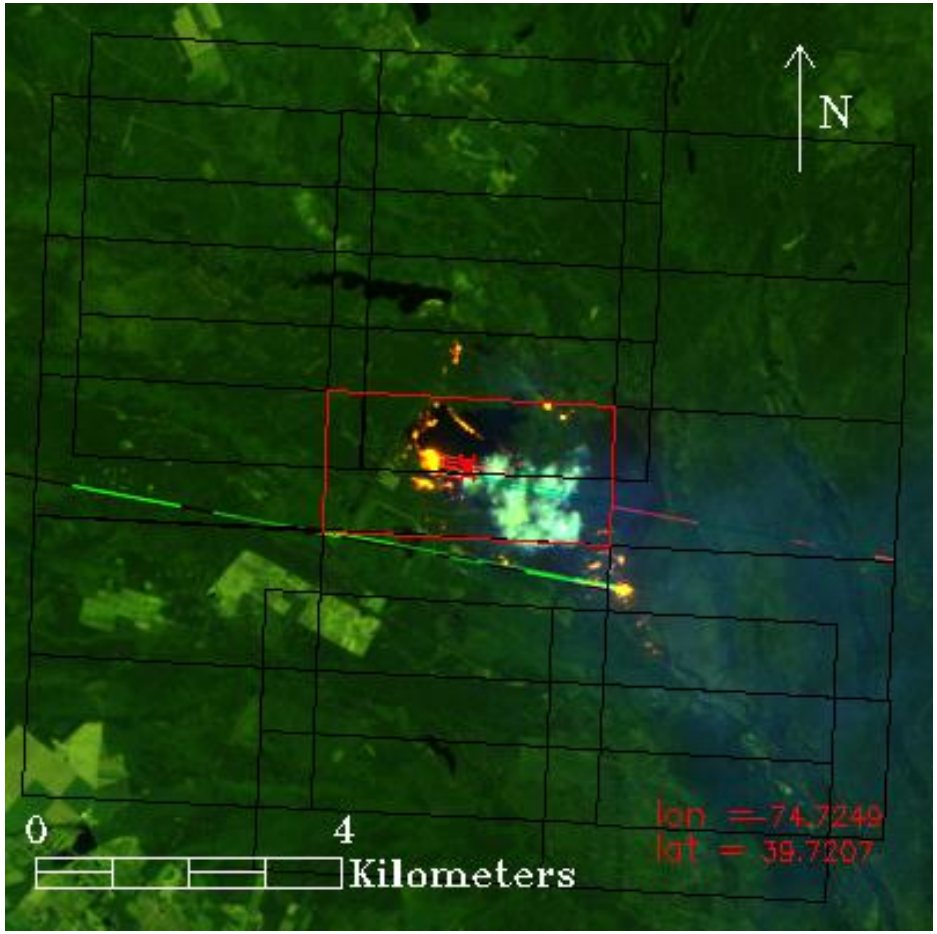


MODIS/ASTER 19 Jan 2006 0852UTC (near nadir)

Off-nadir pixels
(using ~3,700 near-coincident TM scenes)

Landsat5 TM 2001-2010

Fire-related artifacts – saturation/bleeding



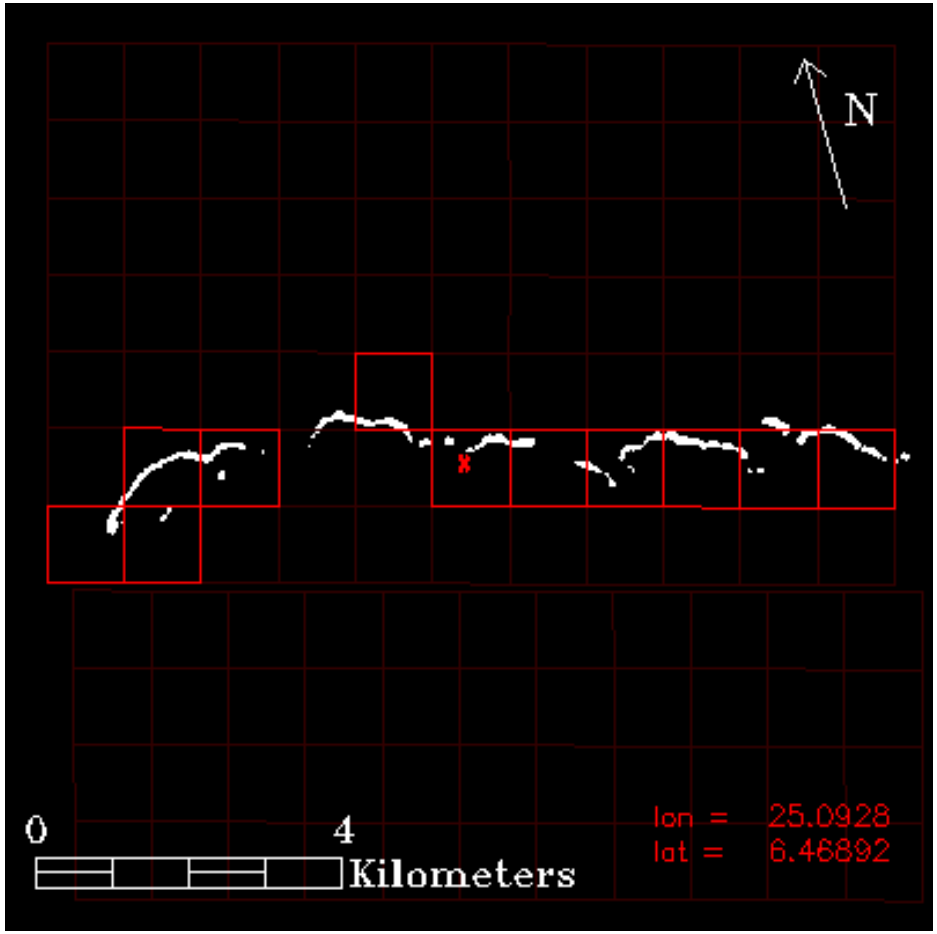
MODIS/TM 04 Aug 2007 1533UTC (52^{o} scan angle)

Explicit validation

Near-nadir pixels
(using ~2,500 coincident ASTER scenes)

ASTER 2001-2006

SWIR detector problem > May 2007



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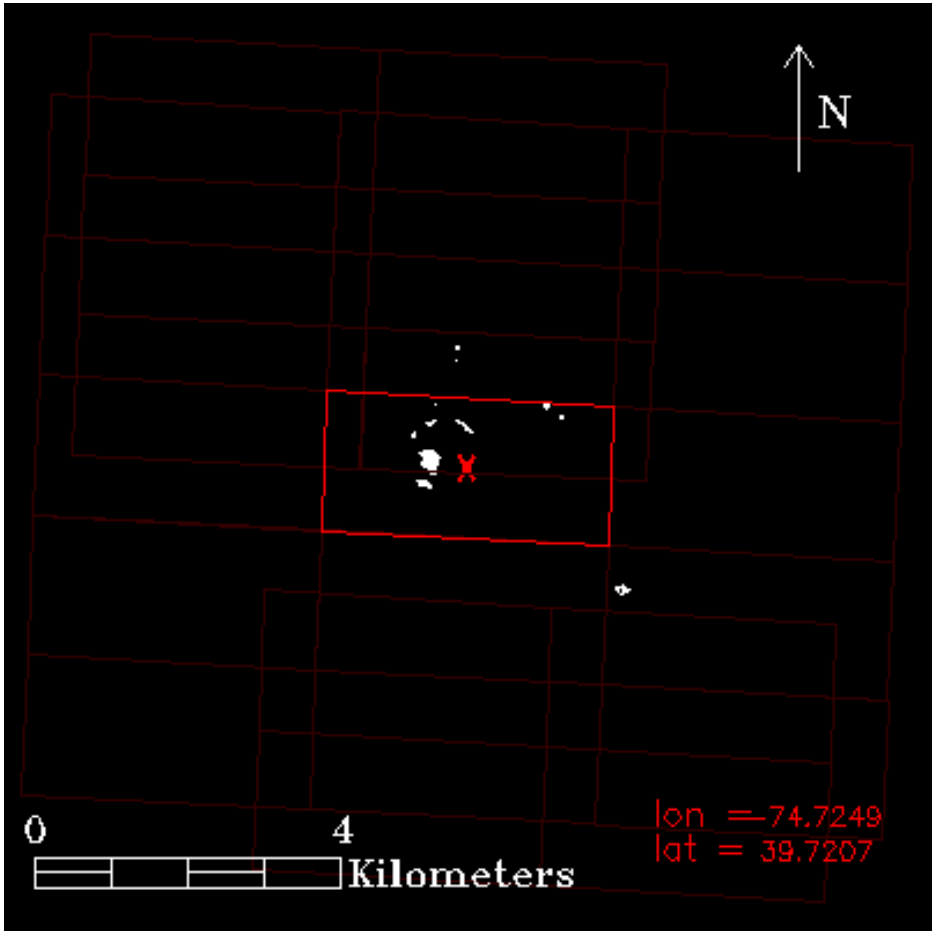


MODIS/TM 04 Aug 2007 1533UTC (52^{o} scan angle)

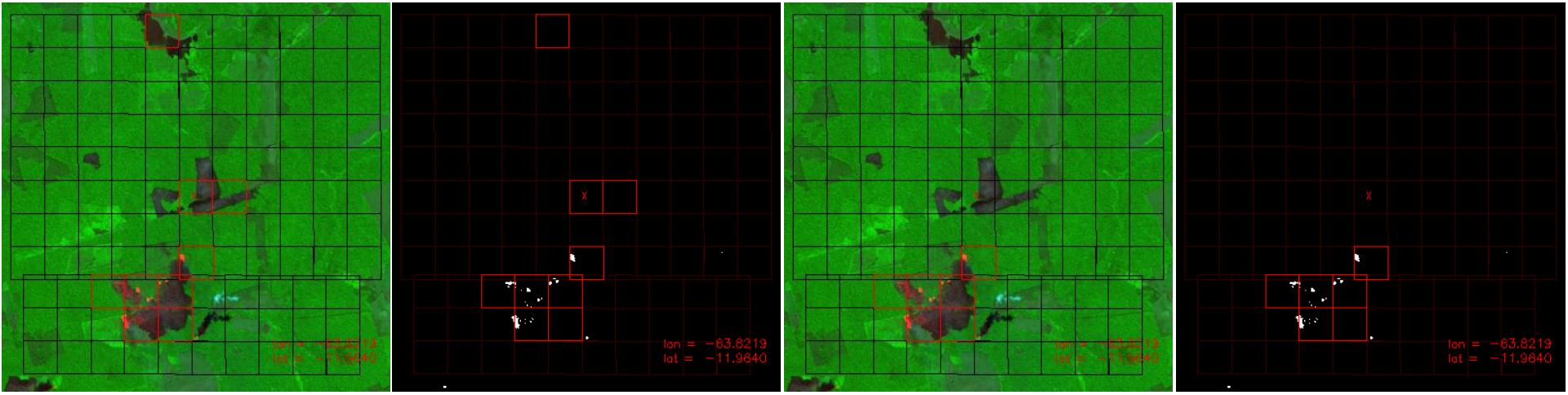
Algorithm continuity: MODIS Collection 6 updates

- Adaptive assignment of potential fire thresholds to **better capture small, cool fires** and **reduce false alarms** occurring in hot, arid environments;
- A new rejection test to **eliminate persistent false alarms** caused by **small clearings** within Amazonian rainforest
- Extended processing to **water pixels** to facilitate monitoring of offshore gas flaring
- Improvements to the **internal cloud mask** to eliminate occasional misclassification of snow and desert as cloud.

Algorithm continuity: MODIS Collection 6 updates

MODIS Collection 5 (and 4)

MODIS Collection 6



True fire detections and false alarms from Terra MODIS over a small-scale cleared area in the Amazon on August 27, 2001, as detected by the MODIS Collection 5 and 6 algorithms. The MODIS Collection 6 algorithm removed the false alarms.

Summary and conclusions

- **Initial assessment** of the NPP VIIRS fire product is **encouraging**
- True statistical **comparison is possible** using proper matching of similar sampling conditions
- Implementation of **new MODIS algorithm components** and sensor-specific tuning are necessary
- Need for spatially explicit **fire mask** and **Fire Radiative Power** in the VIIRS product
- Explicit **validation** is crucial
- Continuity of the MODIS **Climate Modeling Grid** (CMG) product is necessary for **long-term and large-scale monitoring**