Sea surface temperature measured by the *MOD*erate resolution *I*maging *S*pectroradiometer (MODIS).

R. H. Evans, E. J. Kearns, P. J. Minnett, O. B. Brown,
&
Warner Baringer, Jim Brown, Kay Kilpatrick, Sue Walsh.

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MODIS Team Meeting
23 July 2002

SST Status

- Focus areas -
  - L1b versions -> calibration, validation
    - Terra Reprocessing - Version 3 L1b
      - Collection 4 coefficients, validated
    - Terra Forward processing -Version 4.0.5 L1b
      - Collection 4 coefficients, validation comparison in progress
    - Aqua Forward processing - prelaunch LUT - V3
      - Collection 3 preliminary coefficients
    - Aqua Forward processing - first on-orbit LUT - V4
      - Repeat calculations based on LUT (should be available this week)

Approach

- Radiative transfer based pre-launch SST retrieval equation derivation
- Regression based (AVHRR) based operational retrieval equation derivation
- Validation based on comparison to contemporaneous, co-located (MAERI) radiometric SST
- Auxiliary validation provided by buoy observations to extend space, time, in situ conditions

Aqua, Terra L2 track and scan SST, SST4

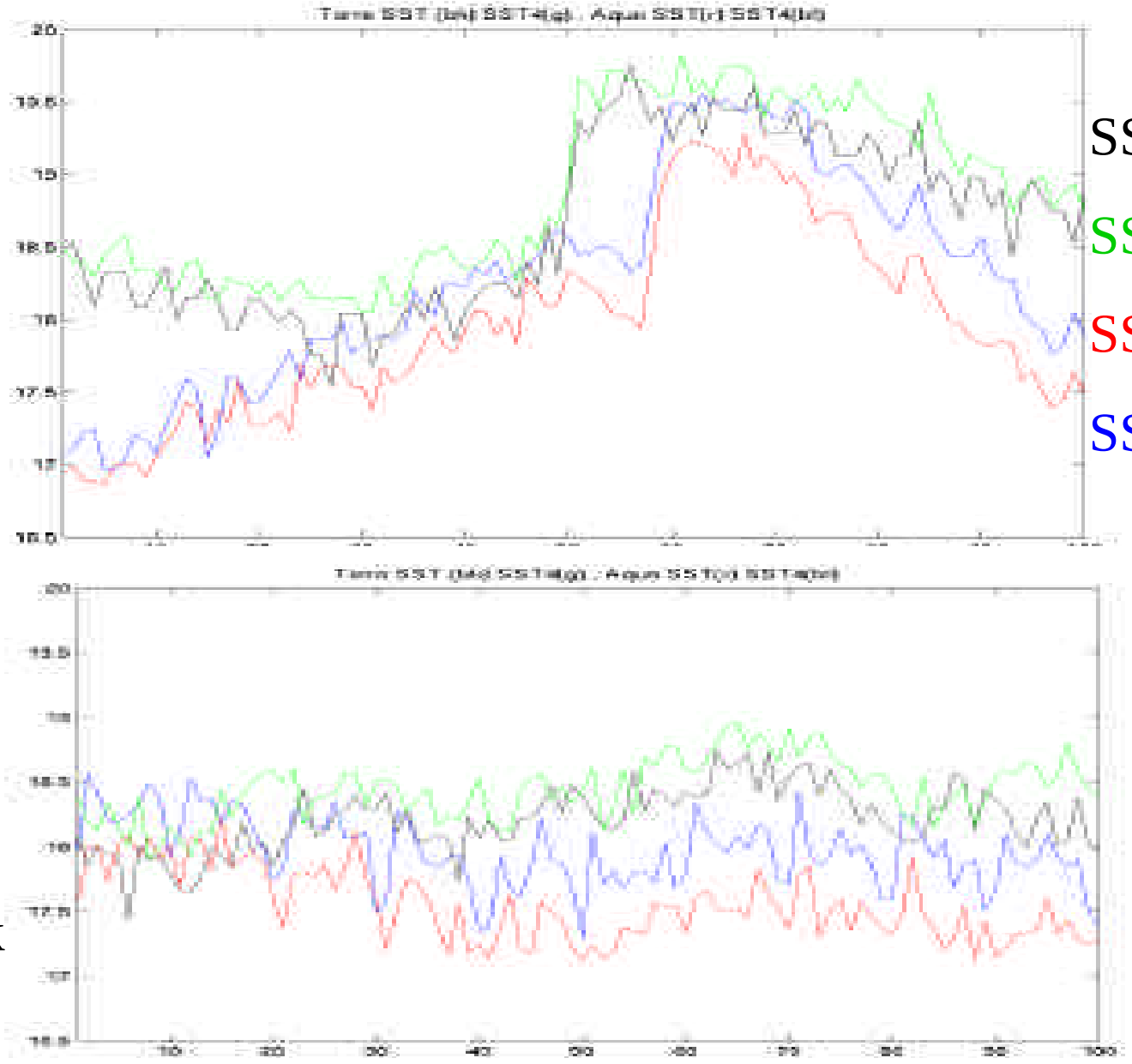
Along scan

Aqua, Terra tracks not co-registered

Pixel-pixel noise ~0.03C along scan

Along track order 2x along scan

Along track



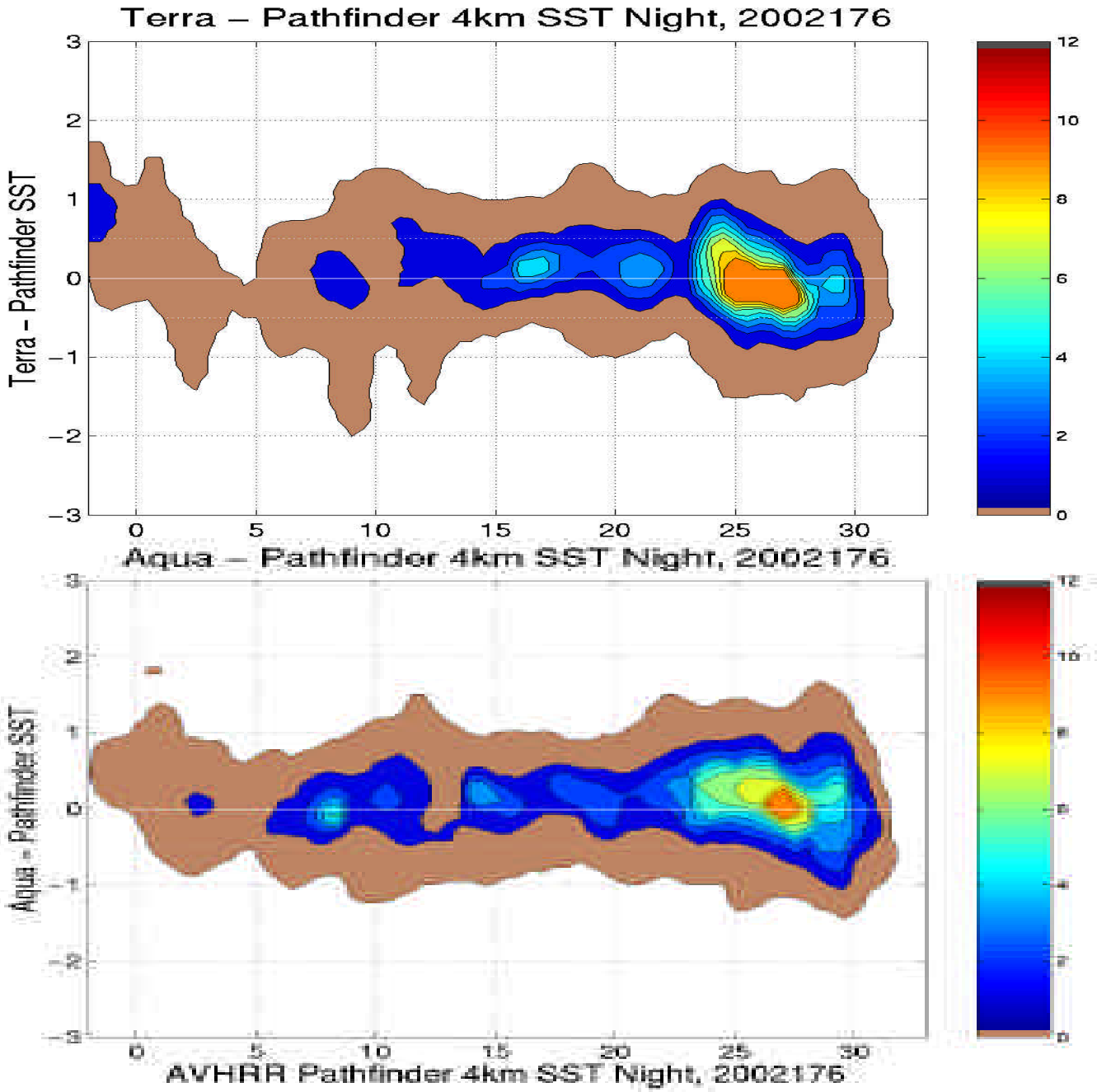
SST-Terra

SST4-Terra

SST-Aqua

SST4-Aqua

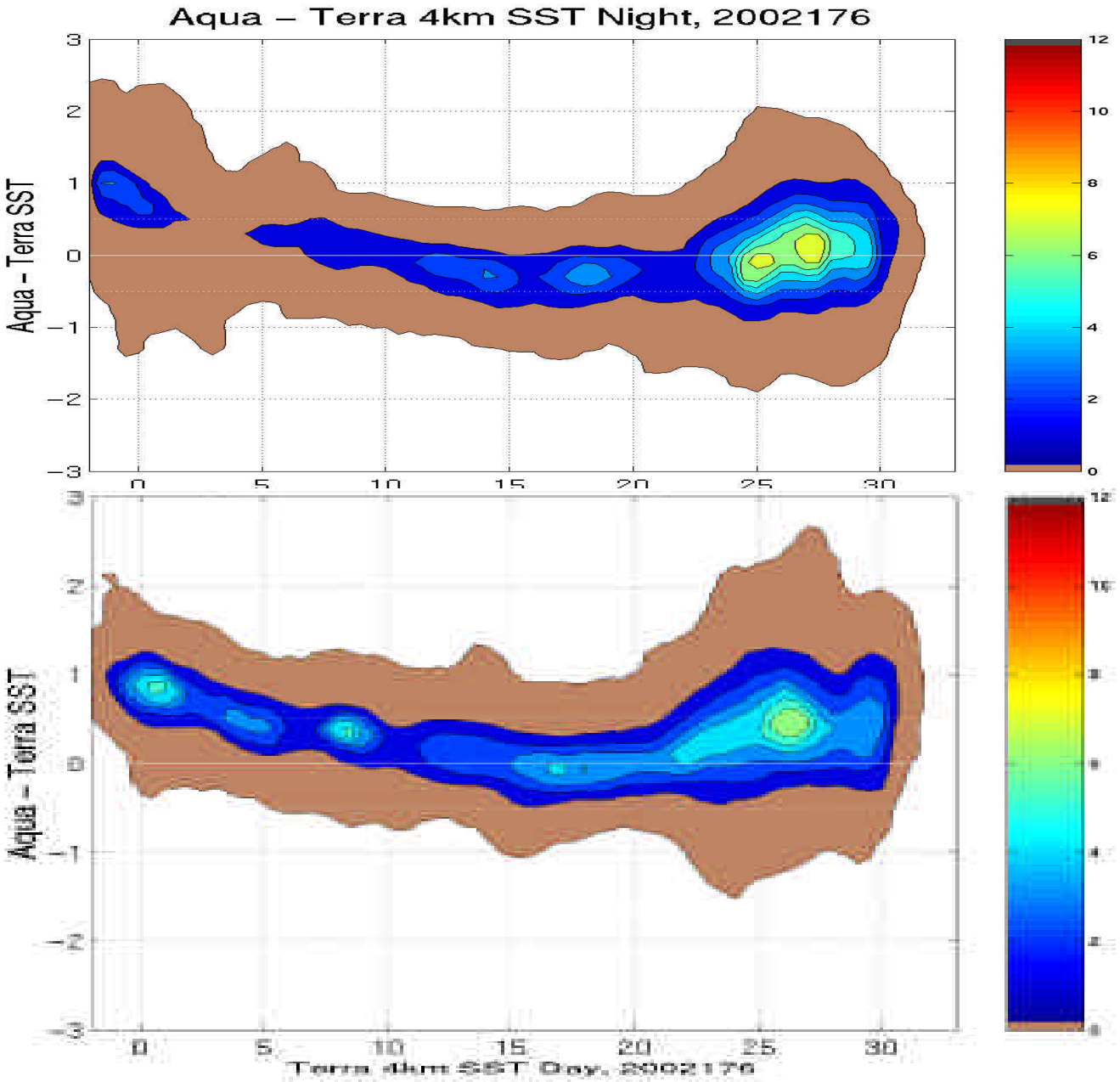
MODIS SST comparison to AVHRR Pathfinder



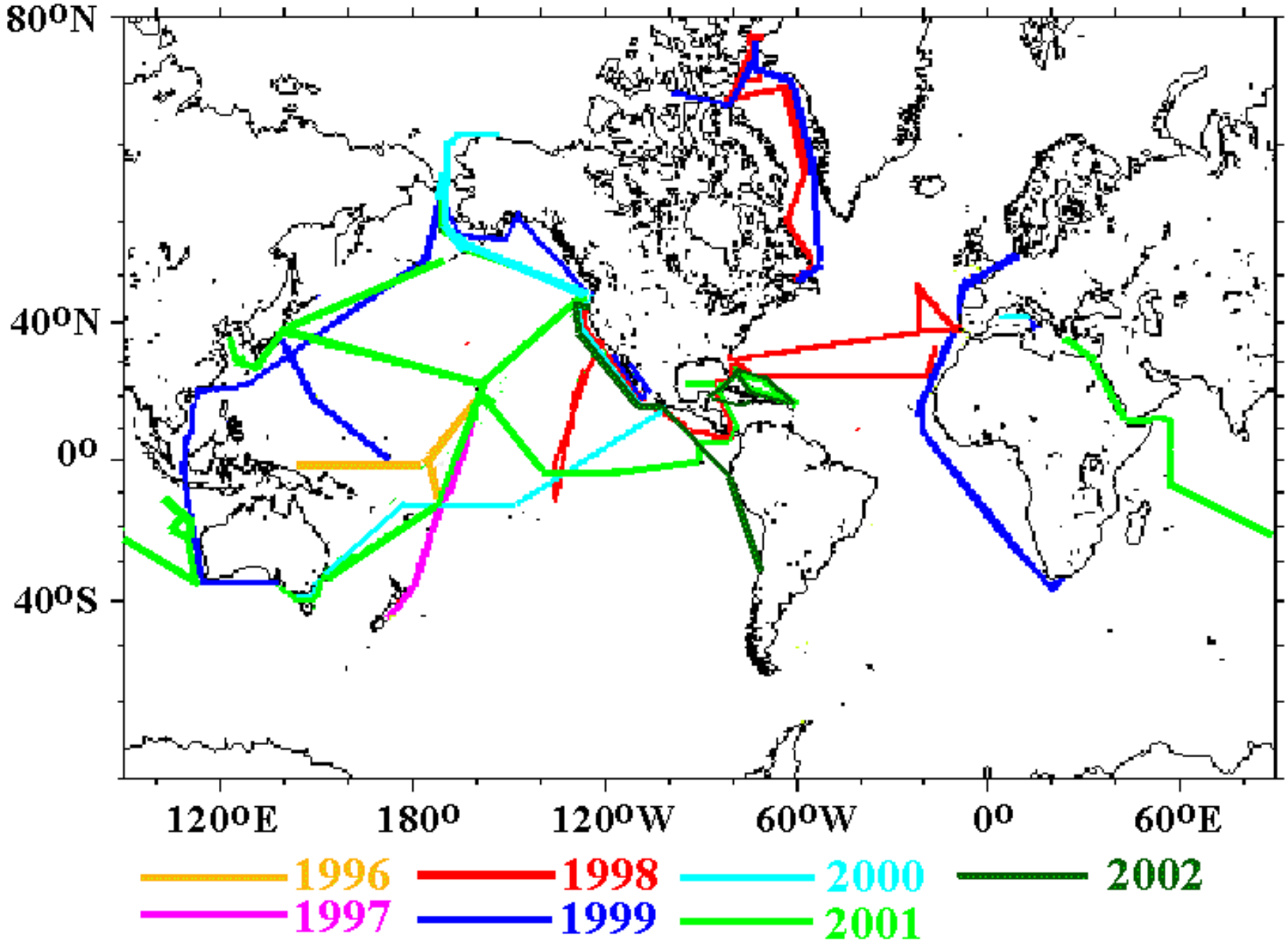
Aqua-Terra SST comparison

Curvature in A-T likely due to use of pre-launch LUT where a0, a2=0

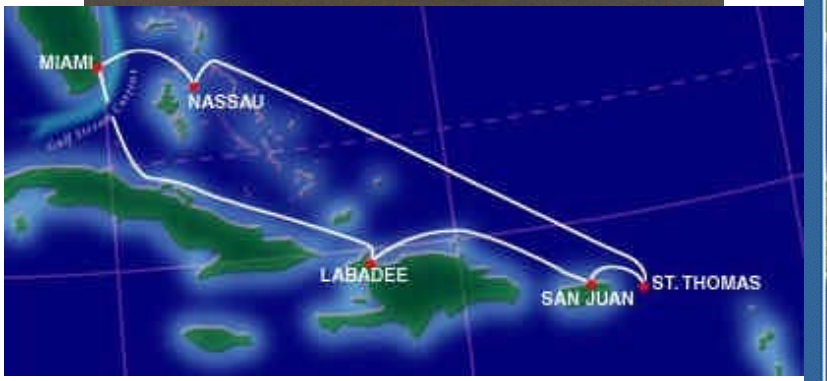
Increase in A-T for day due to diurnal warming, day field SST merge difficult



M-AERI cruises

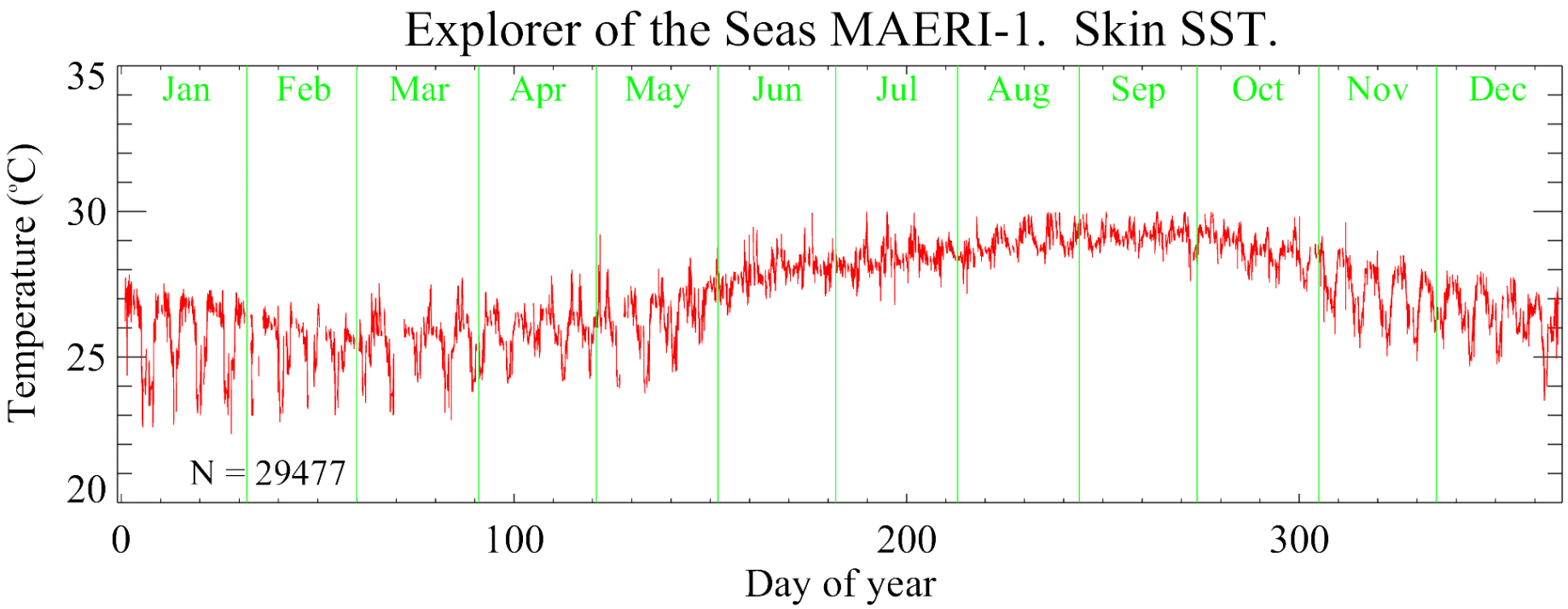


Time-series of M-AERI measurements on *Explorer of the Seas*



The *Explorer of the Seas* is a Royal Caribbean Cruise Liner, operating a bi-weekly schedule out of Miami. It is outfitted as an oceanographic and atmospheric research vessel, very suitable for satellite validation. For more details see http://www.rsmas.miami.edu/rccl/

M-AERI data from *Explorer of the Seas*



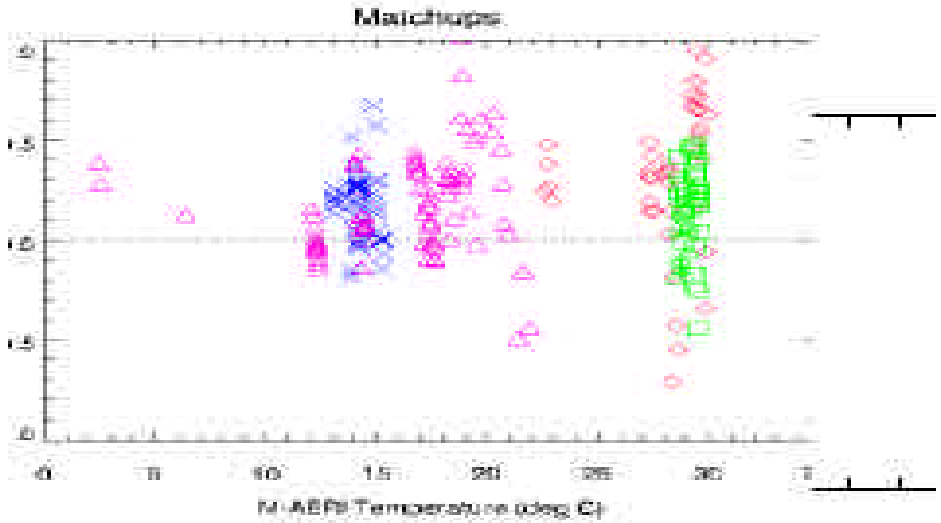
Validation of MODIS SSTs

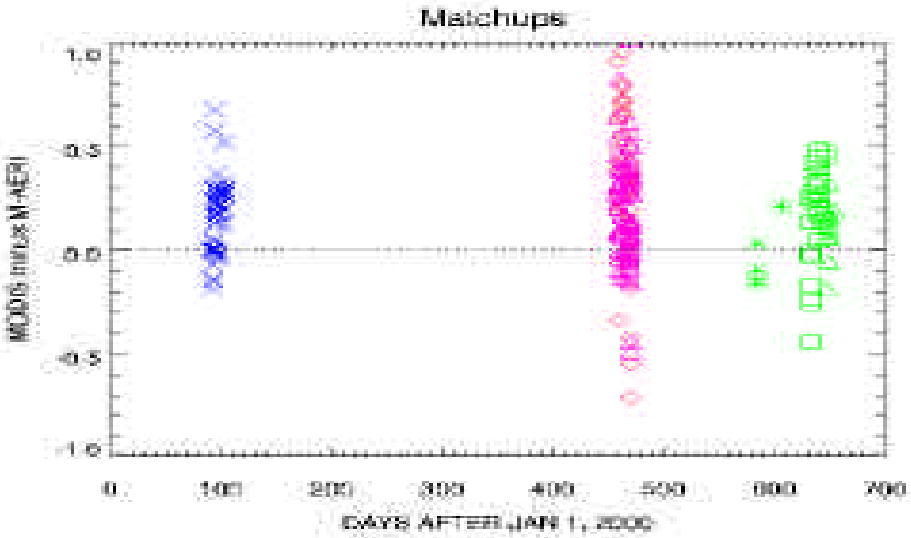
- M-AERI cruises:
  - ‘Hand-picked’ manually processed clear sky conditions for four cruises
  - Routine processing, January-May 2002
- Buoy matchups:
  - Routine processing, January-May 2002

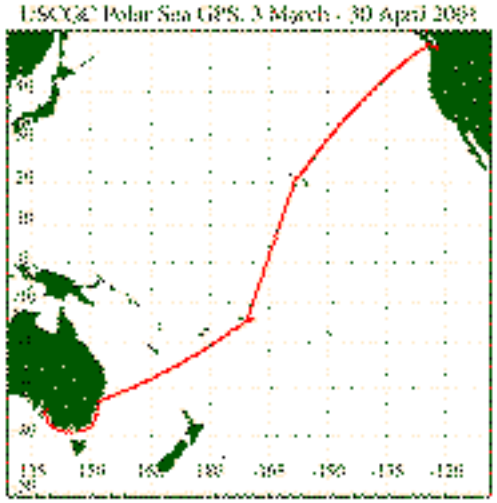
MODIS : M-AERI Matchups

Hand-picked set – Pathfinder derived coefficients

Blue = Mediterranean – April 2000; Red = Pacific – March, April 2001;
Pink = Pacific – March, April 2001; Green = Atlantic - Explorer of the Seas.





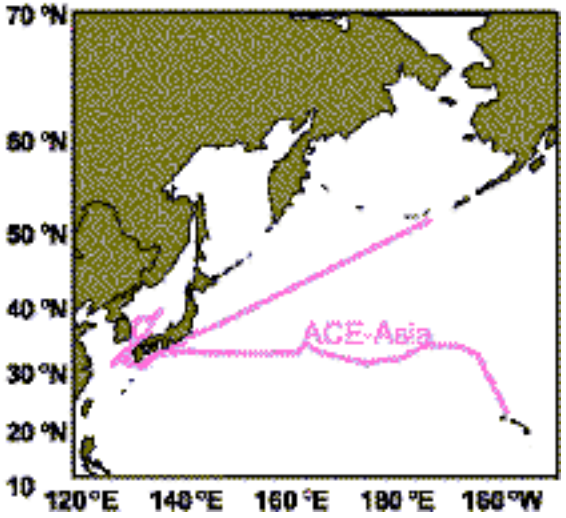


All data

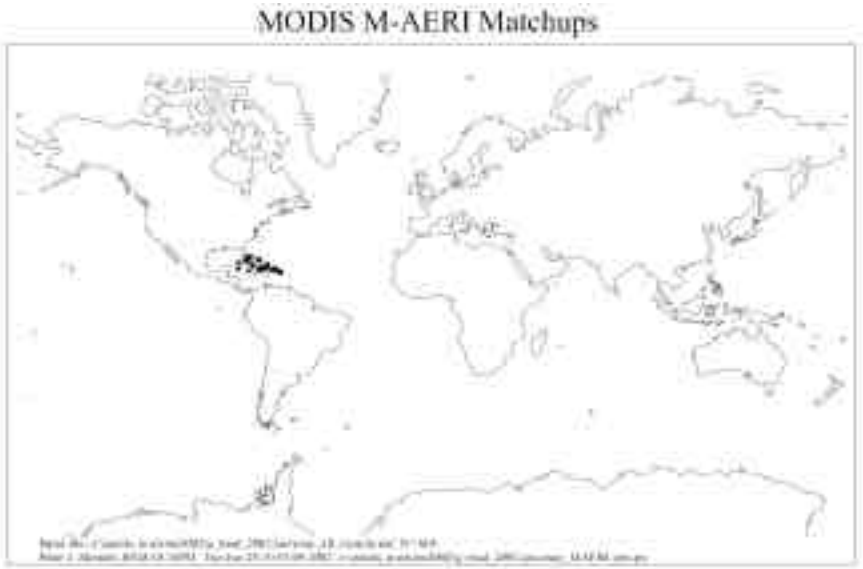
M = 0.20K
std= 0.26K
N = 242

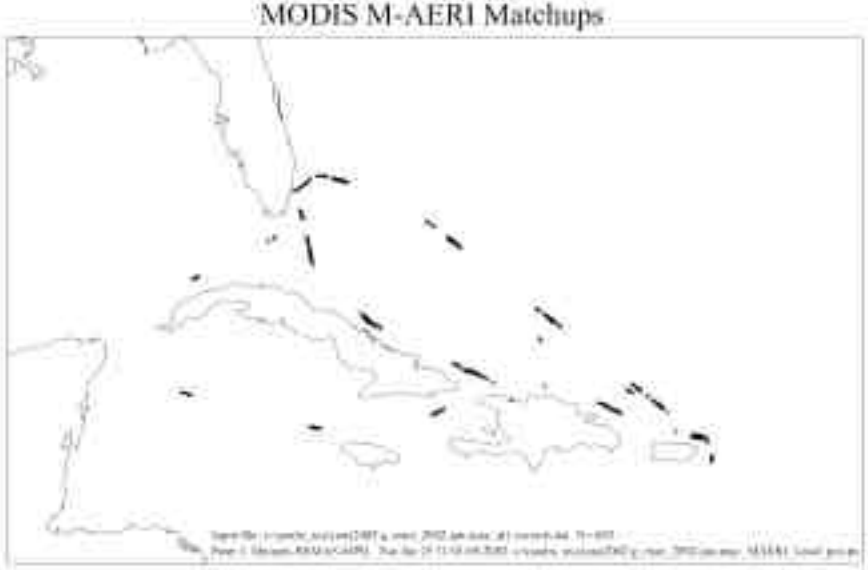
Explorer of the Seas

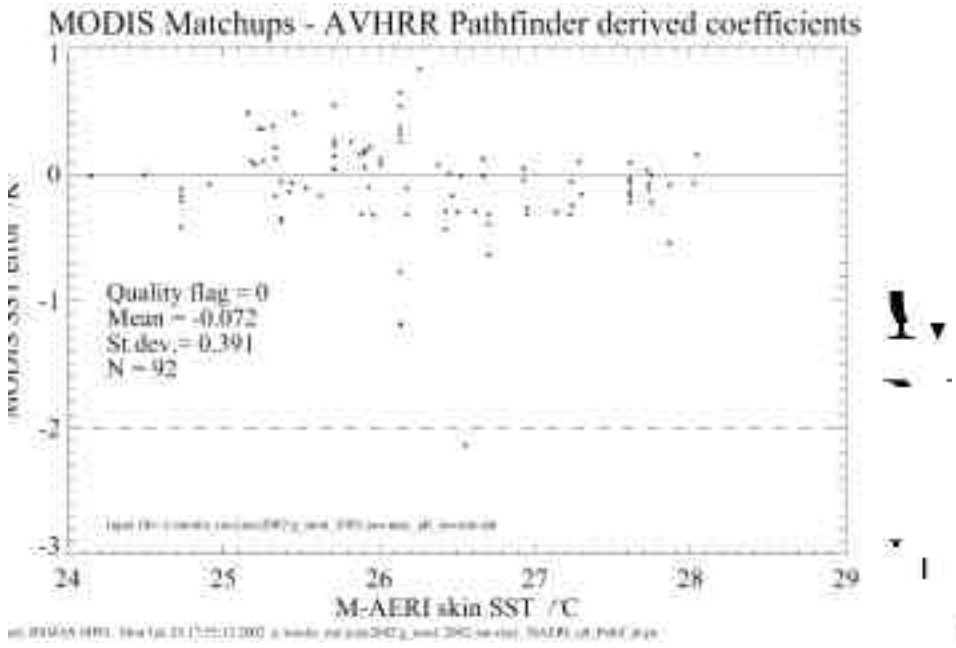
M = 0.15K
std= 0.21K
N = 50

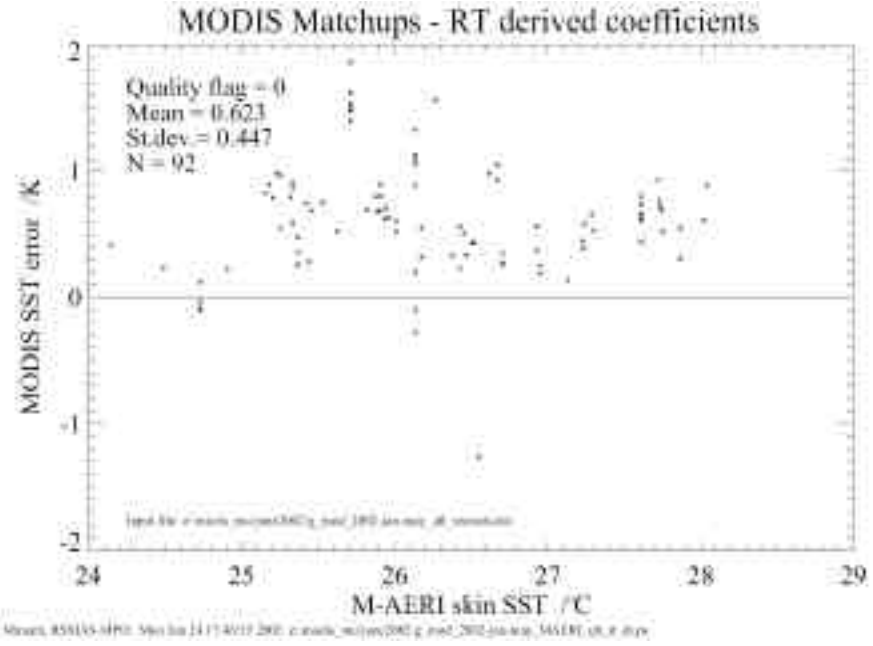


Explorer of the Seas MODIS : M-AERI Matchups, Jan-May 2002

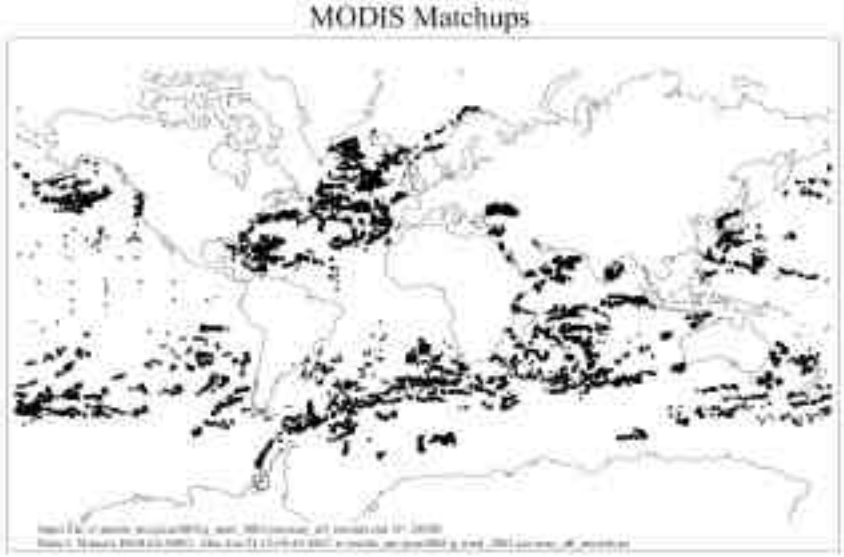


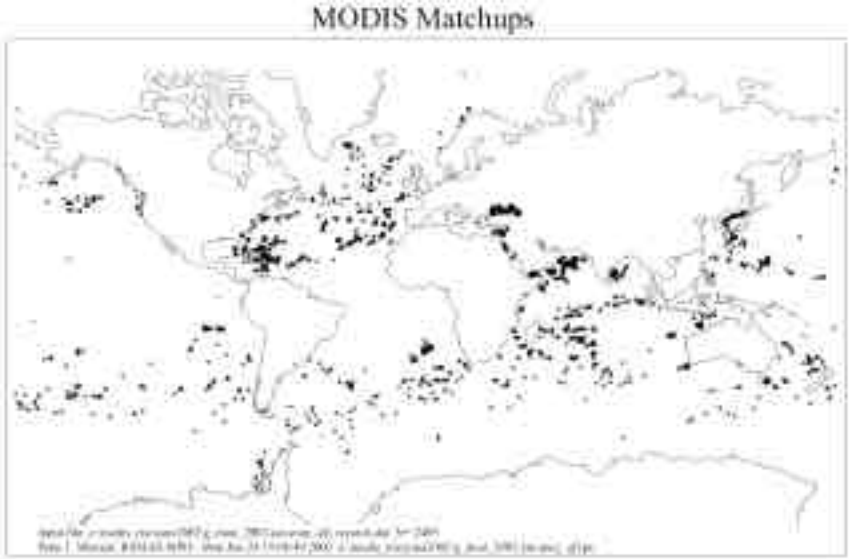


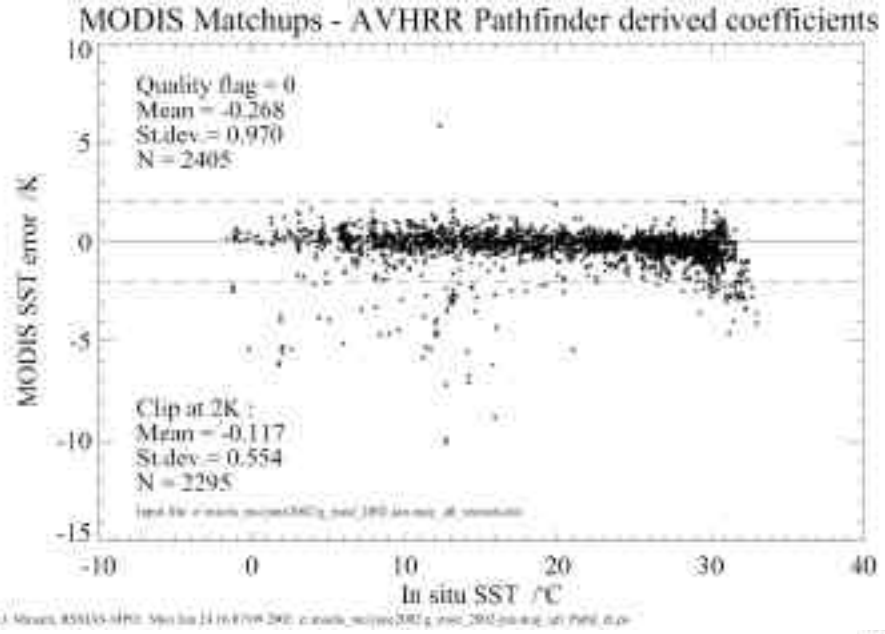


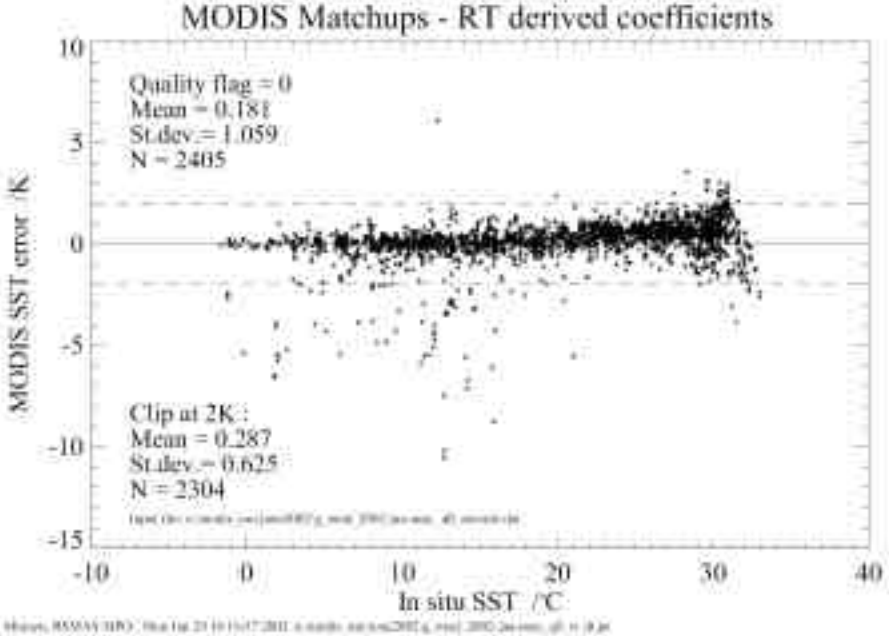


MODIS : Buoy Matchups, Jan-May 2002.

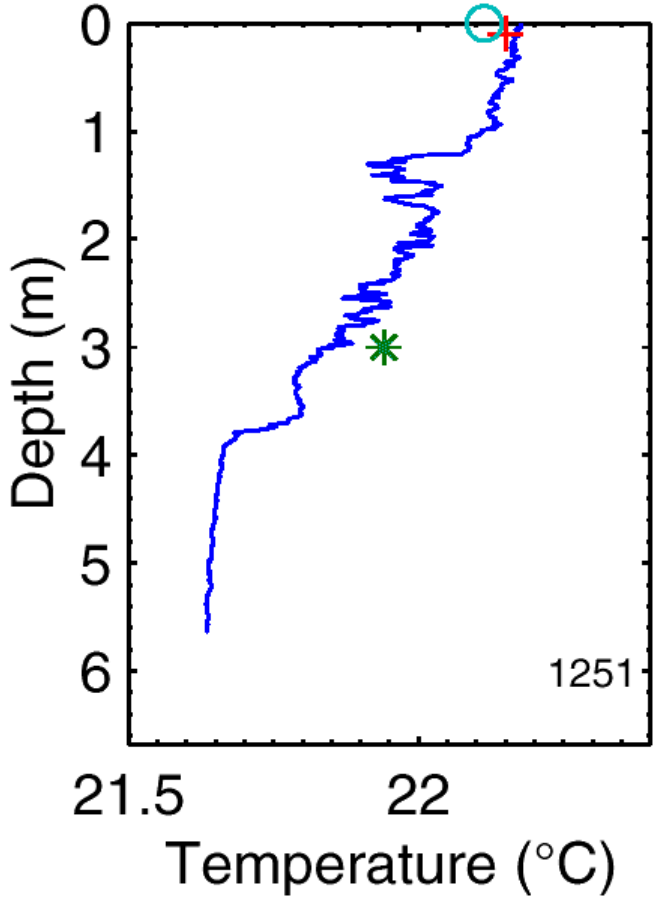








Near surface temperature gradients – reality



Profile measured at 12:51 local time on 4 October 1999. Off Baja California, R/V *Melville* MOCE-5 cruise.

Blue line = SkinDeEP* profile

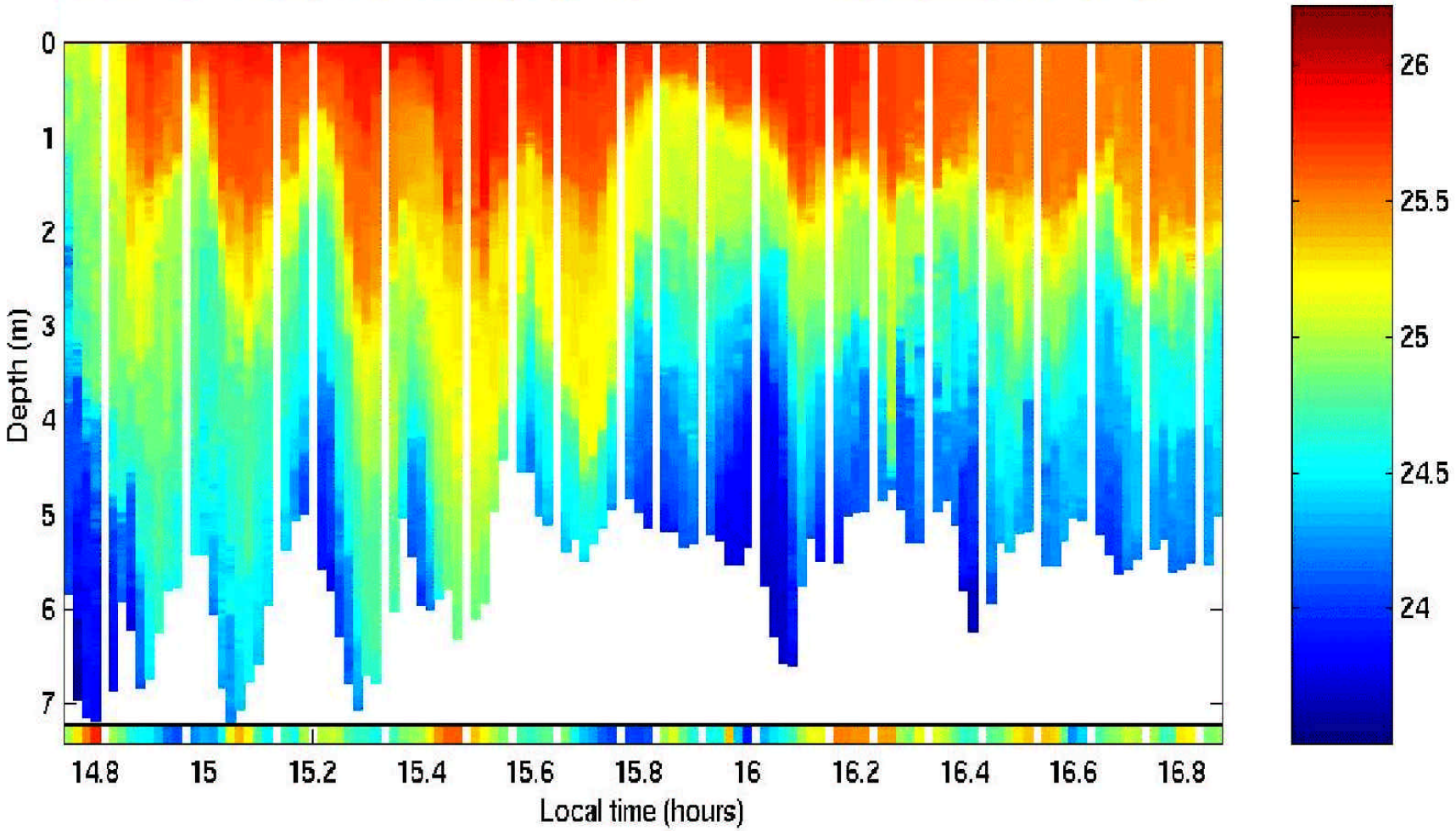
Blue circle = M-AERI skin temp.

Red cross = Float bulk SST at ~0.05m

Green star = Ship thermosalinograph at ~3m

From Ward, B. and P. J. Minnett, 2001. An autonomous profiler for near surface temperature measurements. *Gas Transfer at Water Surfaces.* M. A. Donelan, W.M. Drennan, E.S. Saltzmann and R. Wanninkhof (Eds.) *American Geophysical Union Monograph 127.* 167 - 172.

Time evolution of near-surface thermal gradients



SkinDeEP profiles on 12 October 1999. Off Baja California, R/V *Melville*.

From Ward, B. and P. J. Minnett, 2001. An autonomous profiler for near surface temperature measurements. *Gas Transfer at Water Surfaces.* M. A. Donelan, W.M. Drennan, E.S. Saltzmann and R. Wanninkhof (Eds.) *American Geophysical Union Monograph 127.* 167 - 172.

The need for validation

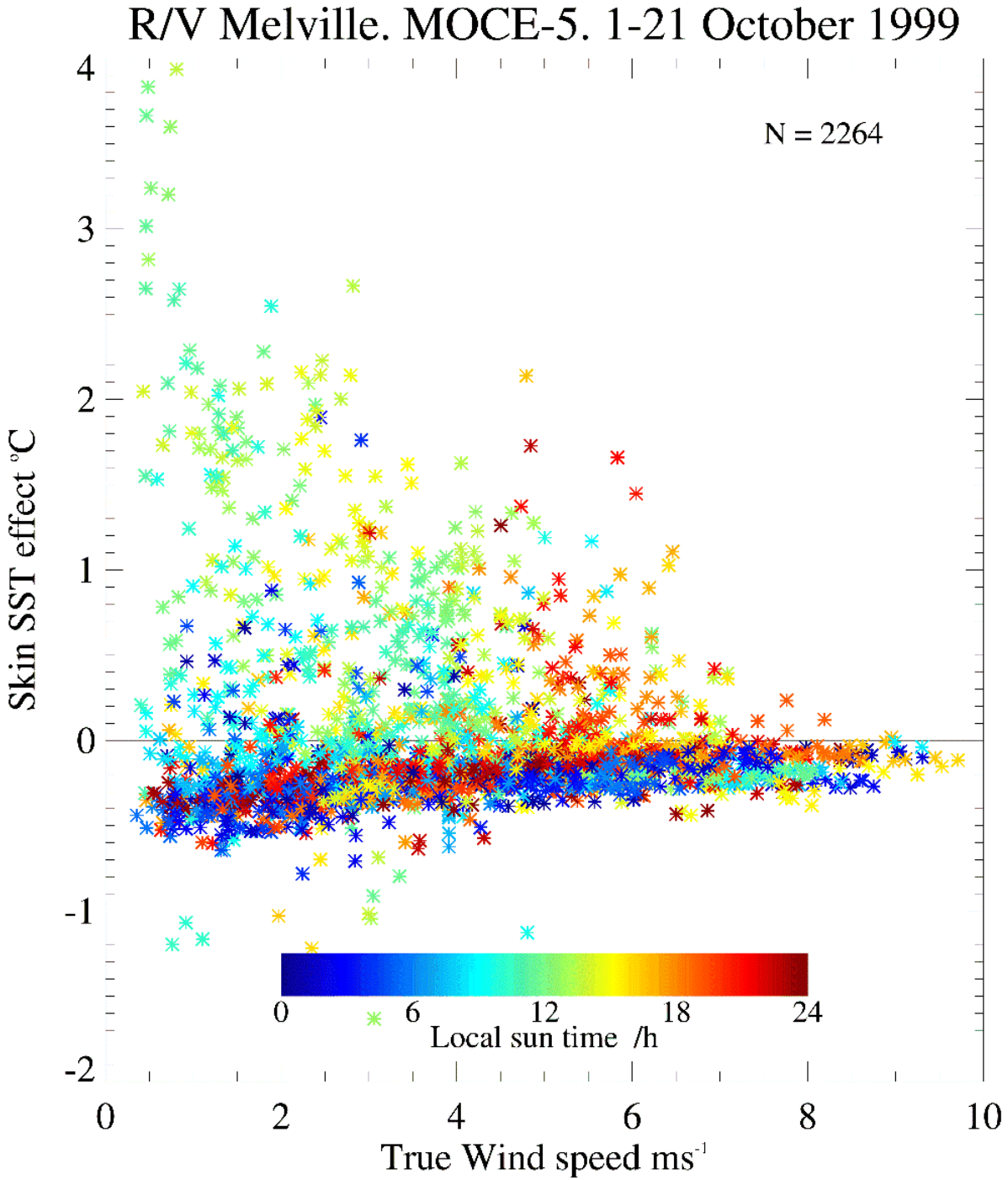
The **infrared bands** of MODIS form **self-calibrating radiometers.** The retrieved SST fields are validated to confirm the procedures used to generate them from the radiometer data are performing as believed, *i.e.* it is the **atmospheric correction algorithm that is being validated**.

This requires **instrumental imperfections** to be **known** and the data **corrected**.

The validation exercise provides a determination of the **accuracy characteristics of the derived fields.**

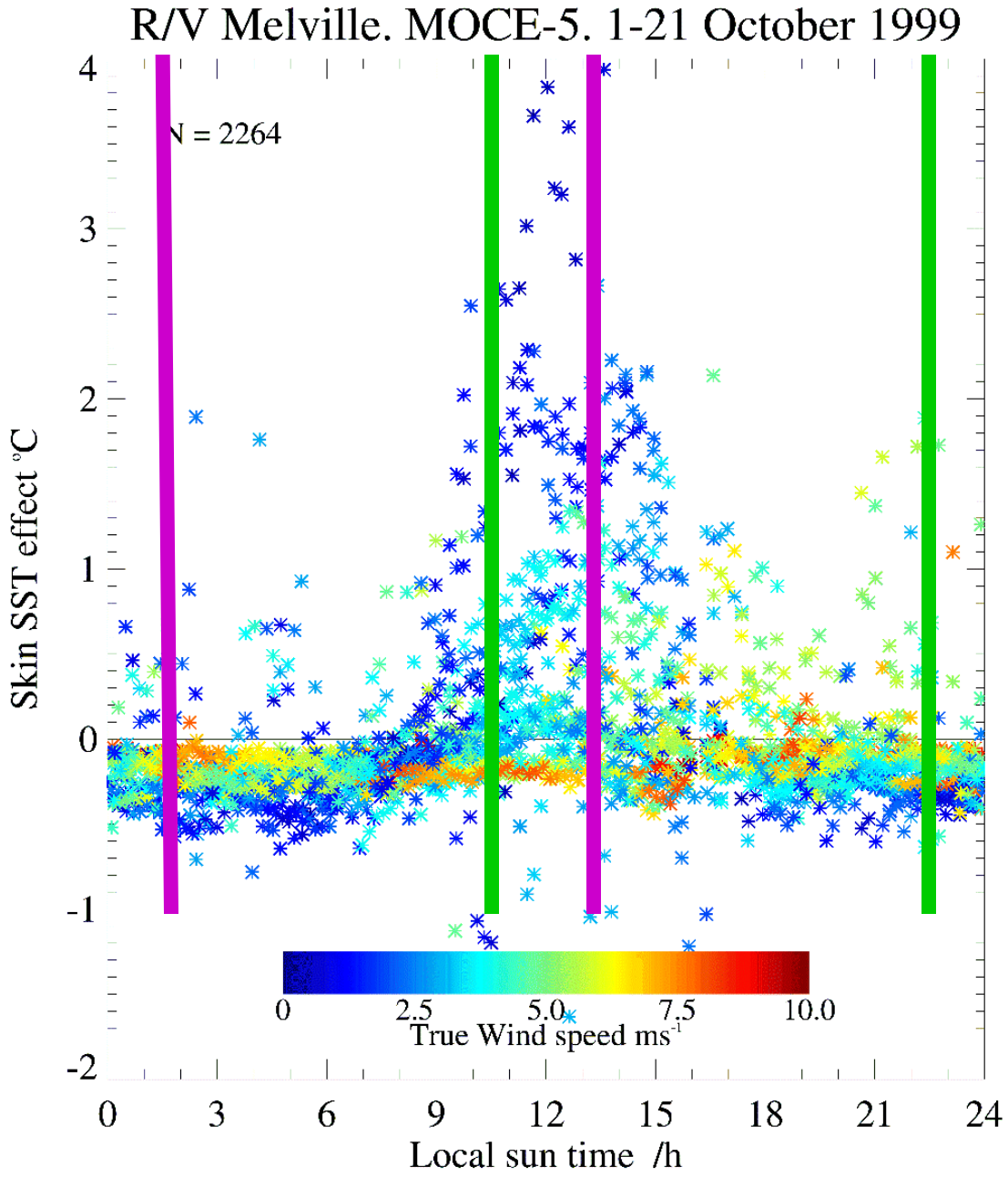
Wind speed dependence of the skin effect

Note collapse of envelope at moderate to high wind speeds.

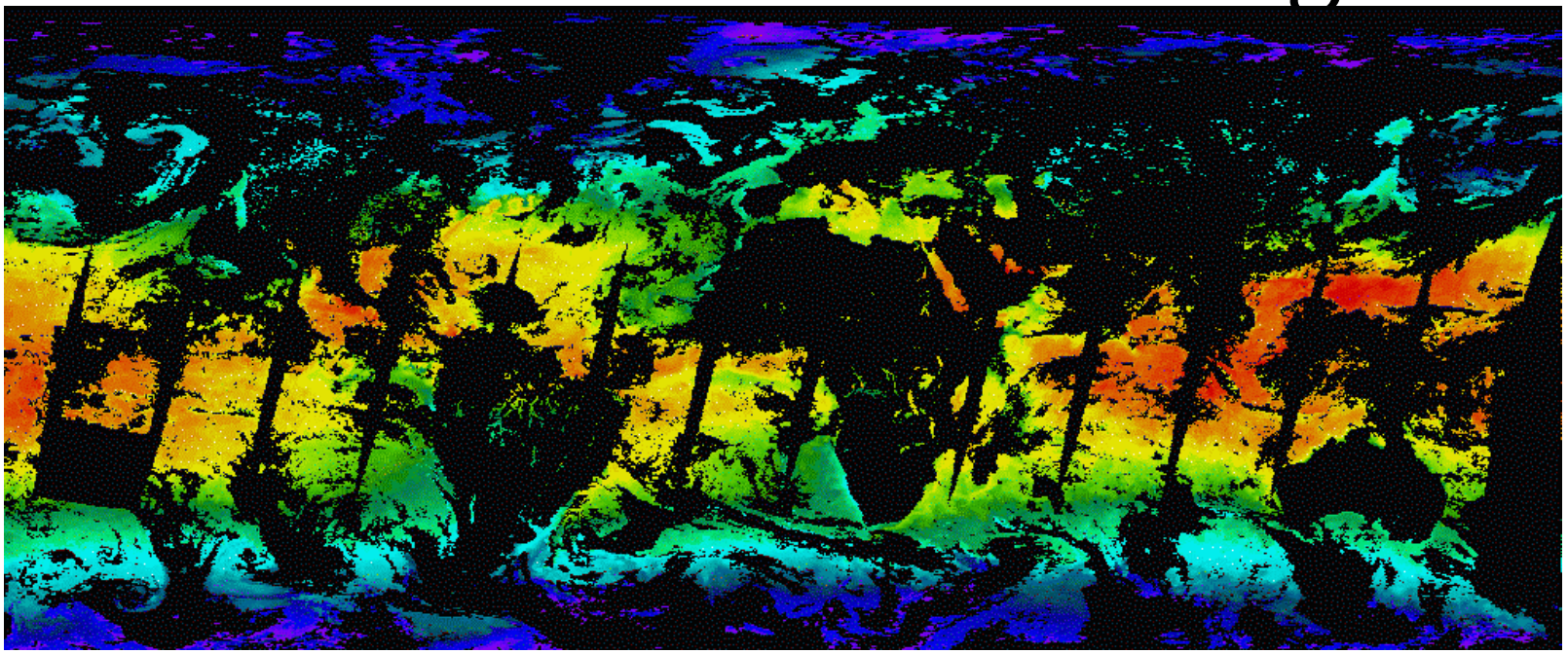


Wind speed dependence of diurnal & skin effects

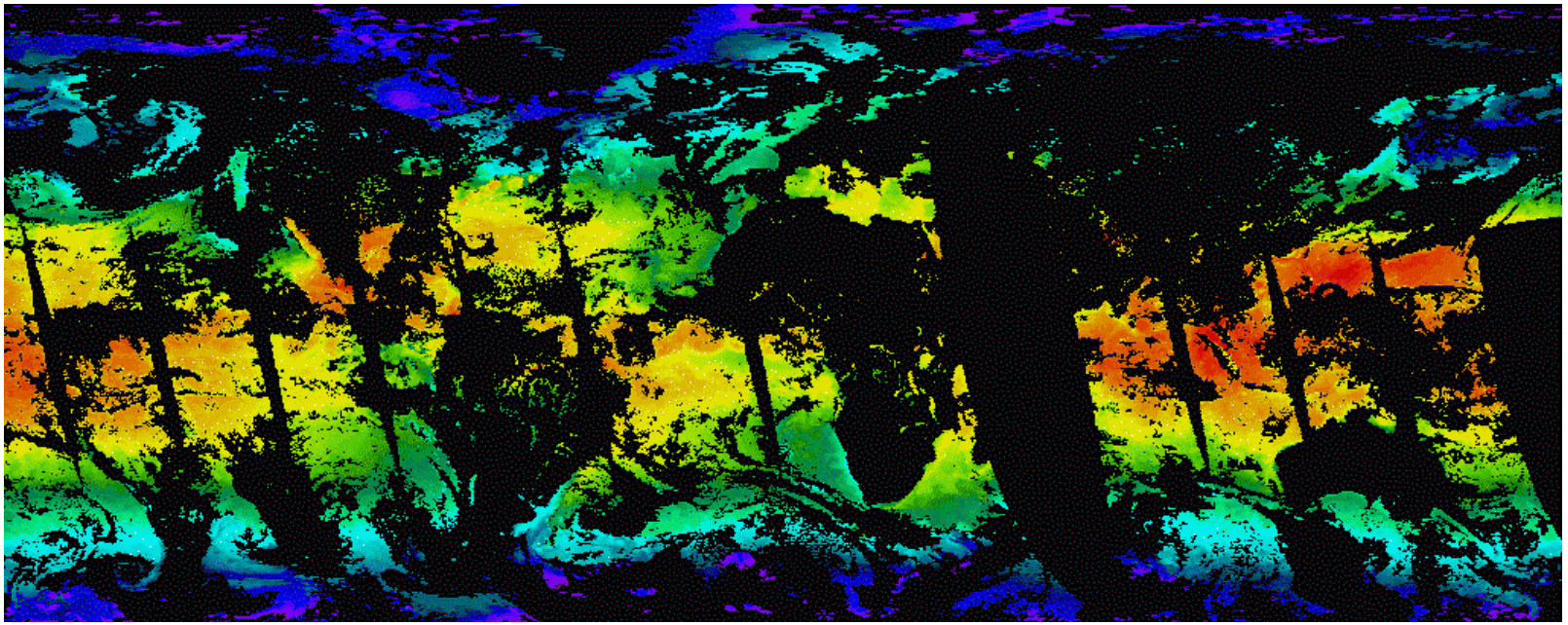
Terra and Aqua overpass times.



25-Jun-02 SST night

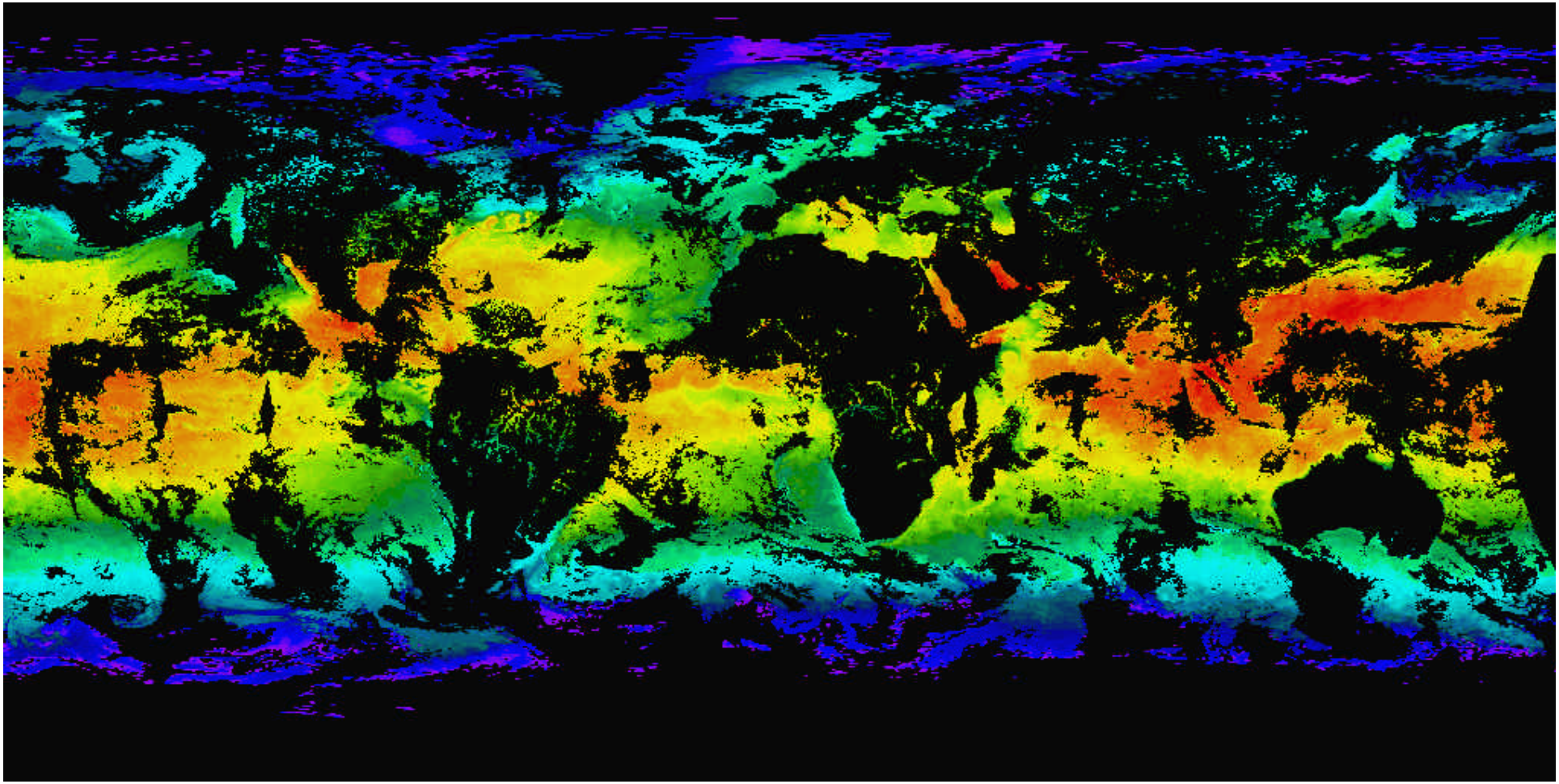


Aqua

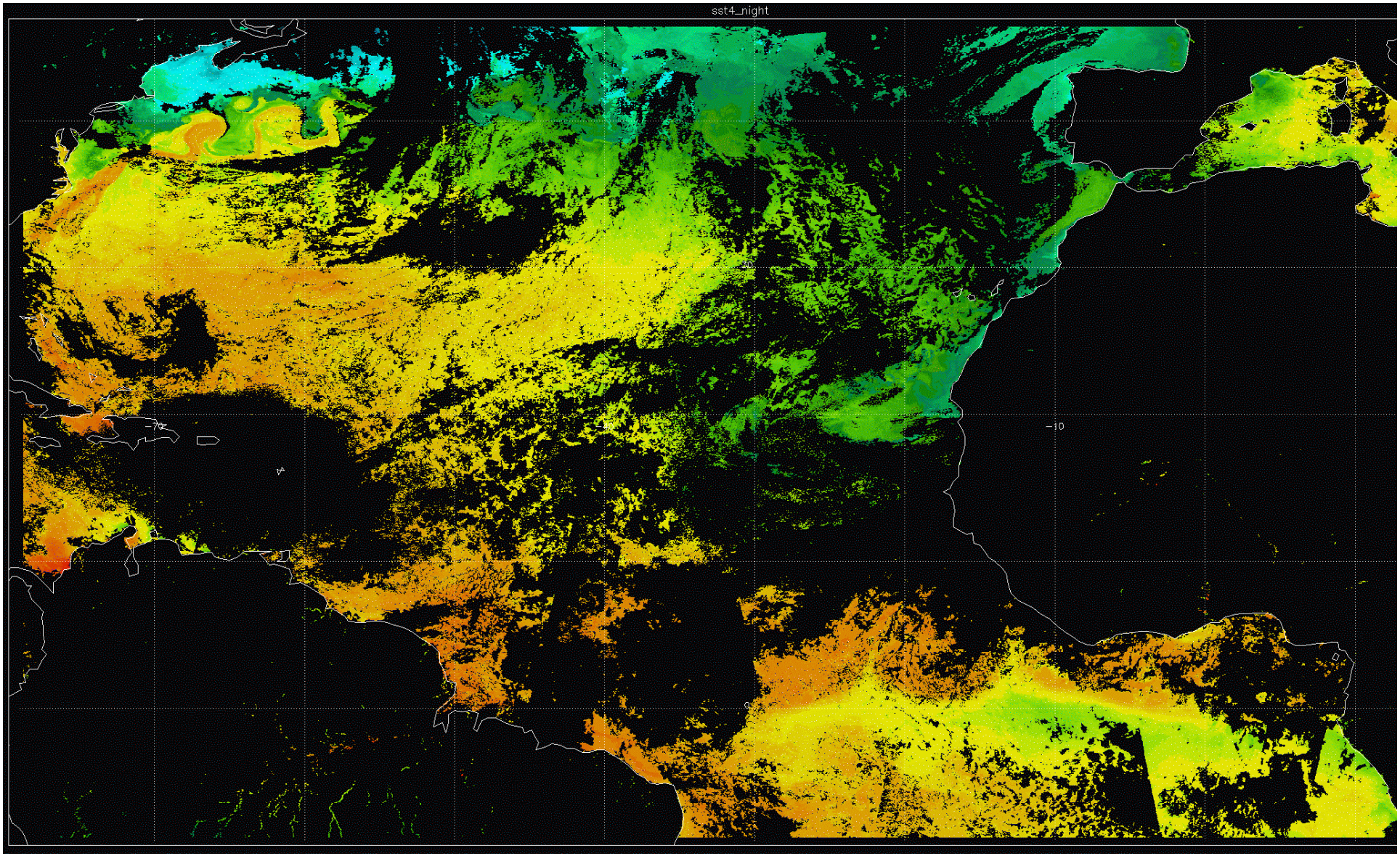


Terra

Merged Terra-Aqua SST night 25jun02



Merged T-A North Atlantic 25jun02 SST4



Conclusions

- Collection 4, Version 3L1b (Reprocessing) validated
- MAERI radiometric comparison, better than 0.25C
- Buoy comparison supports MAERI validation, extends to wider range of space, time, in situ conditions
- Collection 4, Version 4.0.5 (Forward Processing) validation in progress
- Aqua pre-launch equation coefficient test completed, night Terra-Aqua merged image provides near complete global coverage (not counting persistent cloud presence)
- Collection x, Aqua waiting for delivery of on-orbit LUT
- Outstanding Aqua issues: verify brightness temperatures, non-linear behavior for bands 31,32

- Manuscript with complete details near completion

Conclusions

- M-AERI provides a critical validation tool for MODIS SST
- Buoys provide a valuable secondary validation, numbers allow sampling a wider selection of environmental variability
- Preliminary SST validation shows *Terra* MODIS comparable to best AVHRR
- Need to establish lack of seasonal and regional biases
- Need to validate experimental SST_4 fields
- Look forward to *Aqua* MODIS data.

Ocean Color Radiances measured by the *MOD*erate resolution *I*maging *S*pectroradiometer (MODIS).

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23 July, 2002

Ocean Color Status

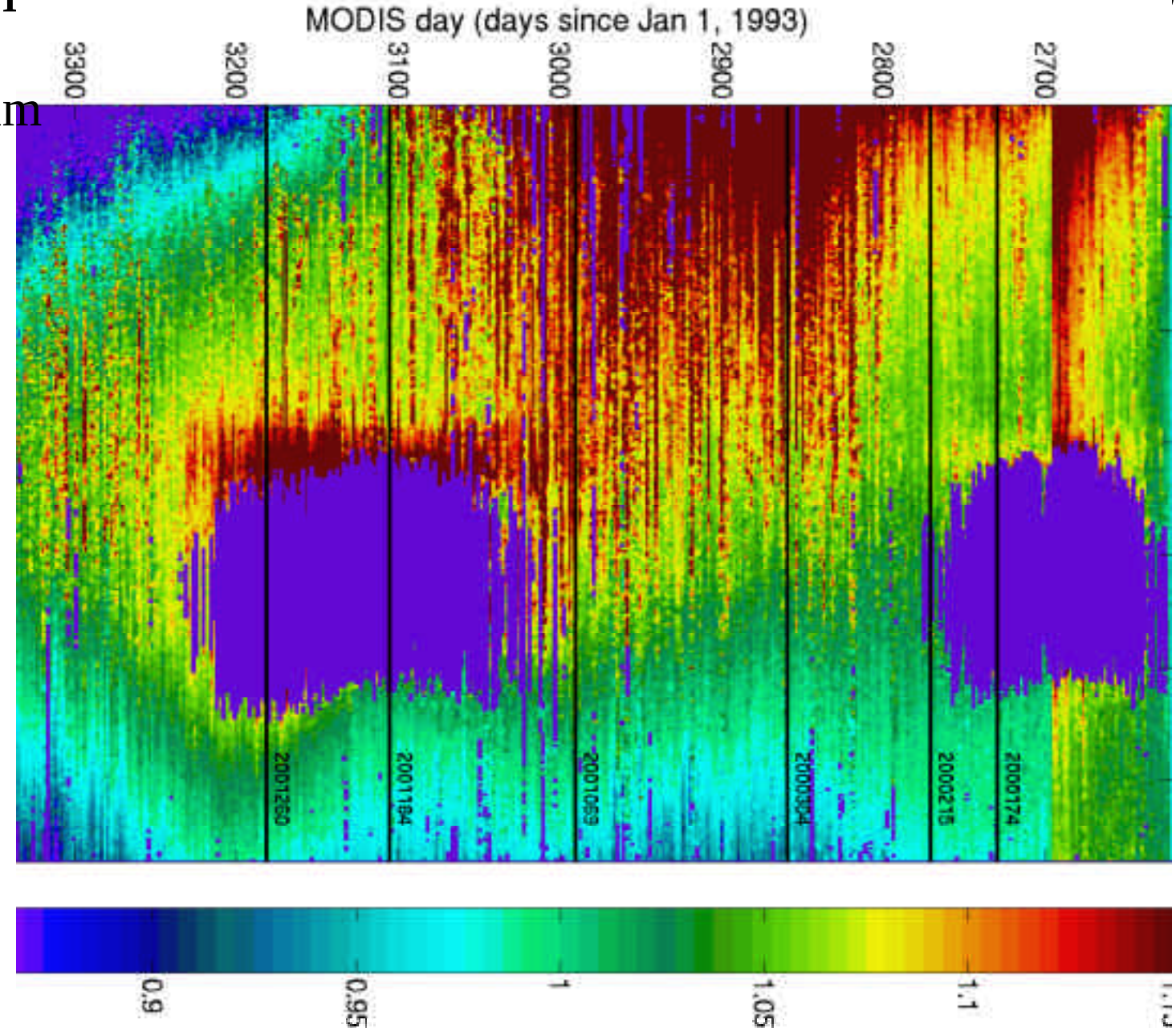
- Focus areas -
  - L1b versions -> calibration, validation
    - Terra Reprocessing - Version 3 L1b
      - Collection 4 coefficients, validation announcement this week
    - Terra Forward processing -Version 4.0.5 L1b
      - Collection 4 coefficients, validation comparison in progress
    - Aqua Forward processing - prelaunch LUT - V3
      - Collection ‘x’ preliminary coefficients
    - Aqua Forward processing - first on-orbit LUT -V4
      - Repeat calculations based on LUT (should be available this week)

Calibration Approach

- Use at surface nLw, atmospheric and surface reflectance corrected
- Validation site for in situ reference is MOBY @ Hawaii, more extensive validation for other regions will require completion of reprocessing (use of SIMBIOS reference data)
- Cross-scan: Referenced to pixel 500, minimum of sun glint
- Detector Balance: Referenced to detector 5, low noise, center of detector array
- Mirror side Balance: reference to side 1
- Remove time trends: Compare modal peak for area surrounding MOBY to MOBY, high temporal density, not dependent on cloud free conditions
- Calibration: Adjust MOBY-MODIS single pixel match-ups to remove bias

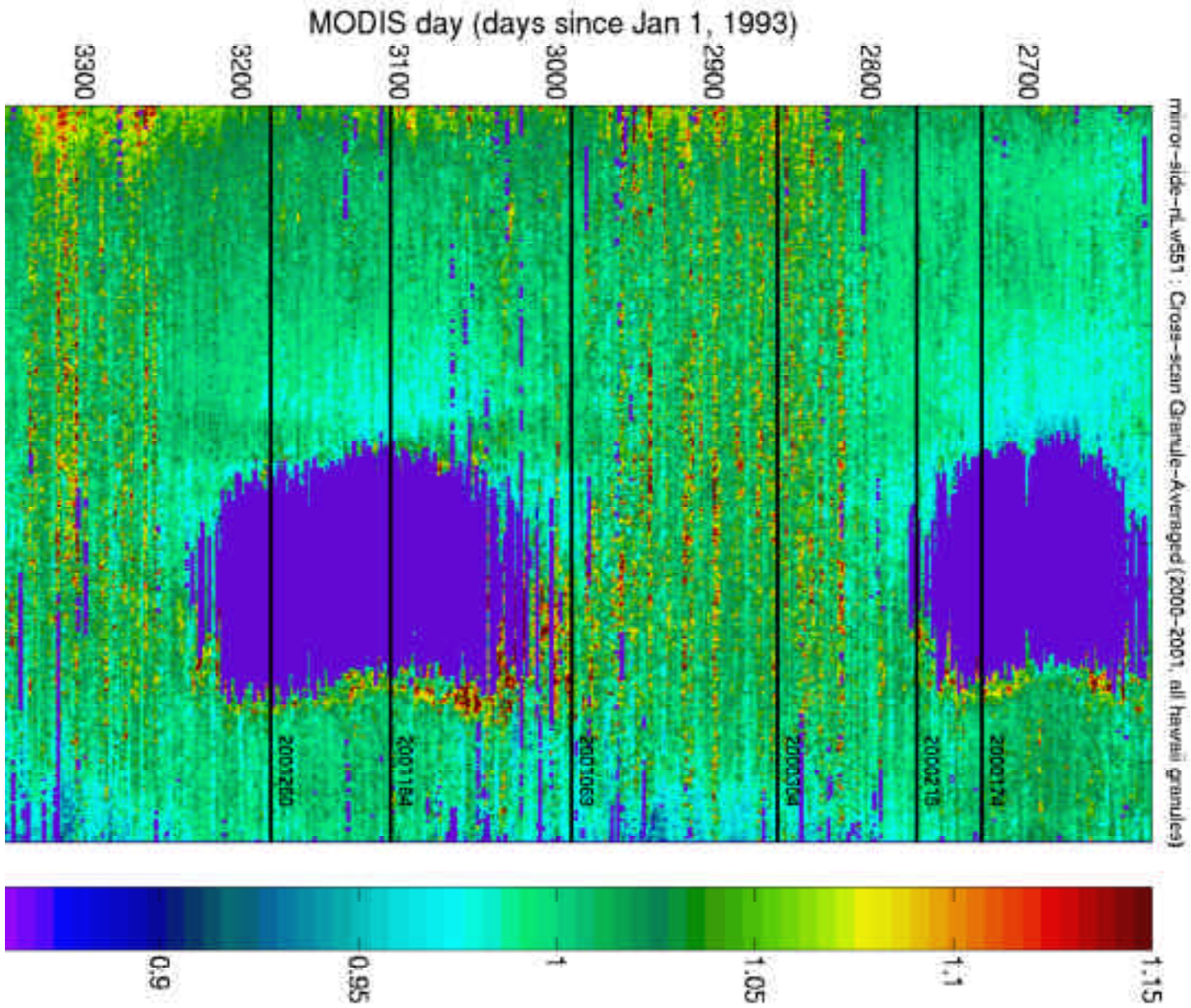
Terra Mirror Side Cross scan vs time gain, no cal

412 nm



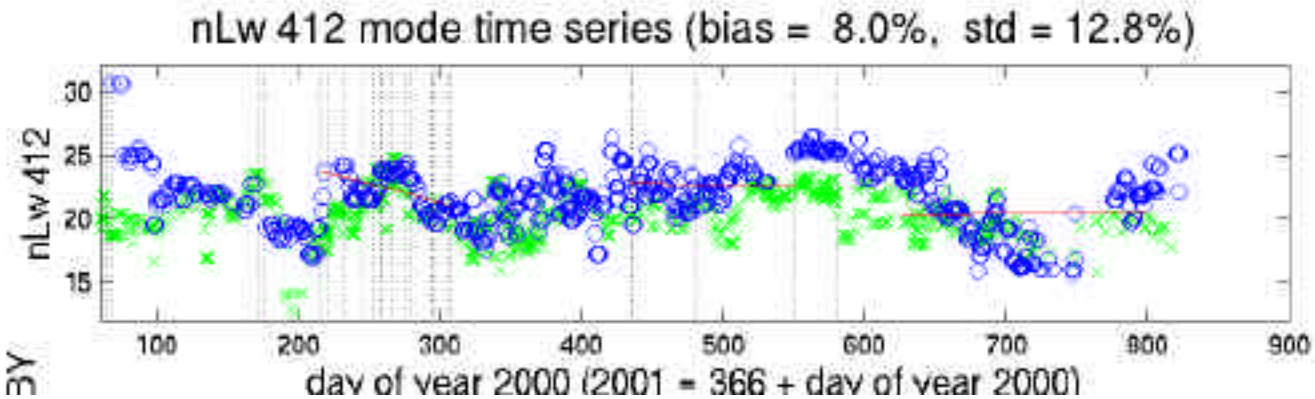
Terra Mirror Side Cross-scan vs time gain, corrected

551 nm



nLw412 Modal Terra-Moby Time Series

Reprocessing
Col 4, V3 L1b

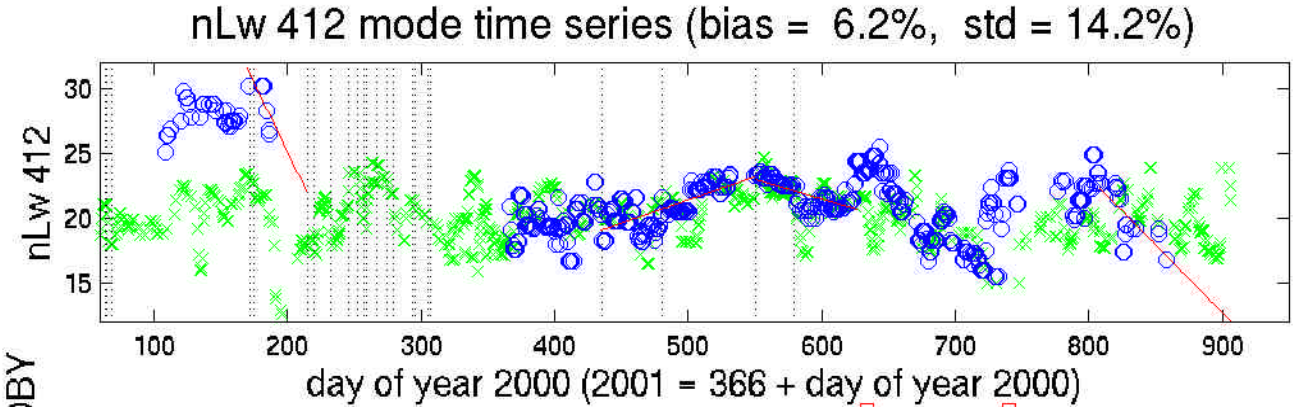


Moby

Terra

Overall bias must be removed with MOBY matchups

New Forward
Col 4, V4 L1b

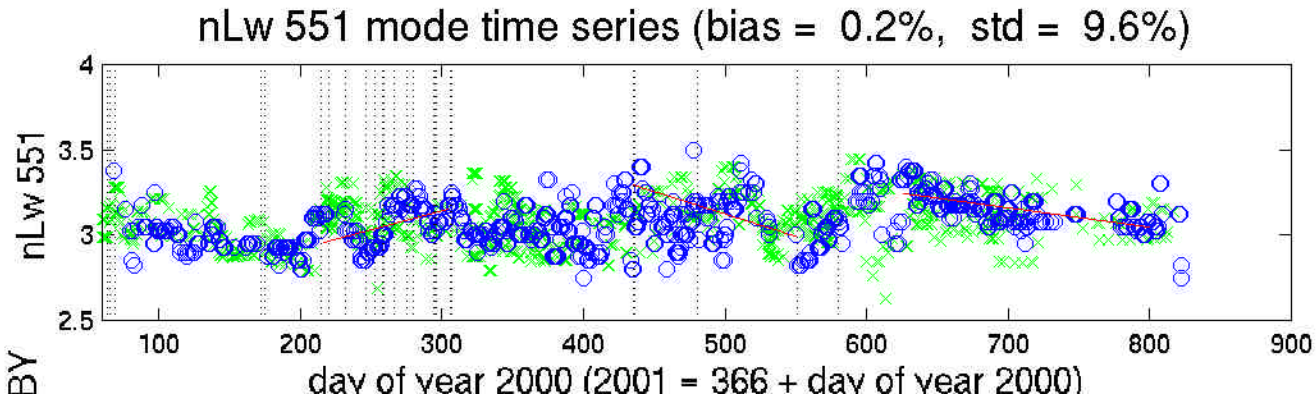


nLw551 Modal Terra-Moby Time Series

Reprocessing
Col 4, V3 L1b

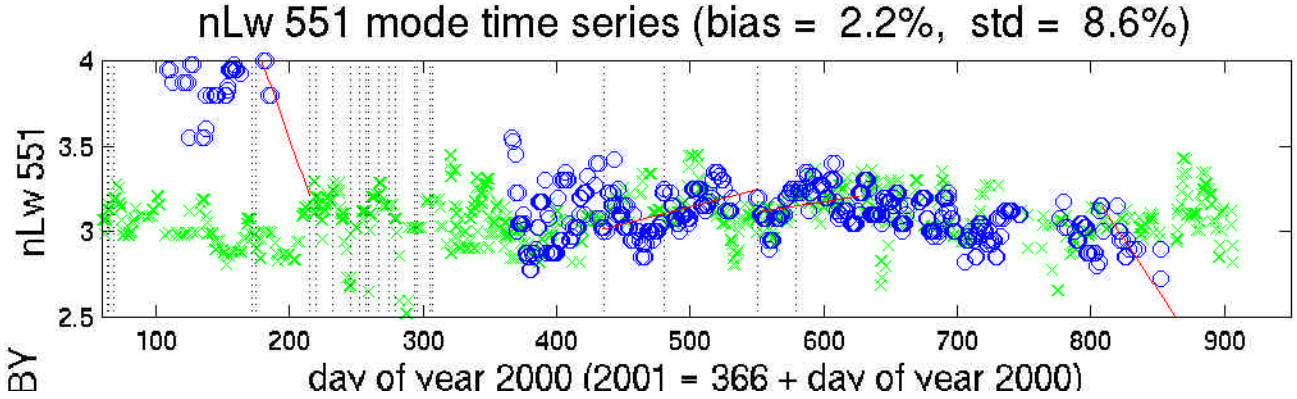
Moby

Terra



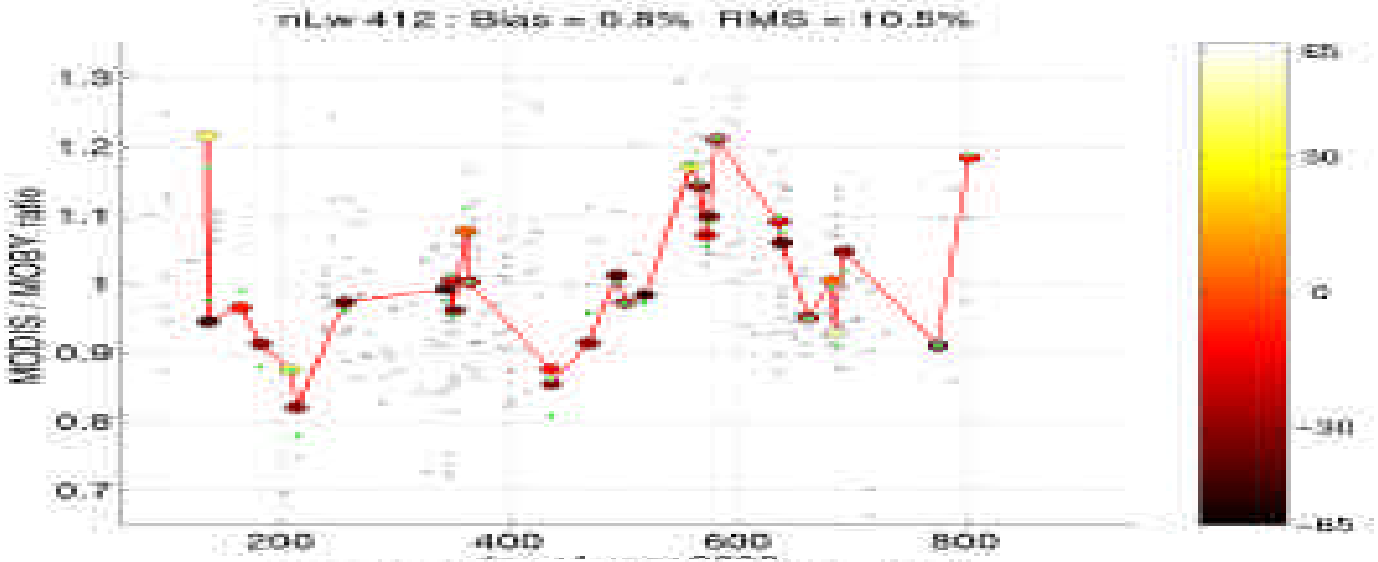
Overall bias must be removed with MOBY matchups

New Forward
Col 4, V4 L1b

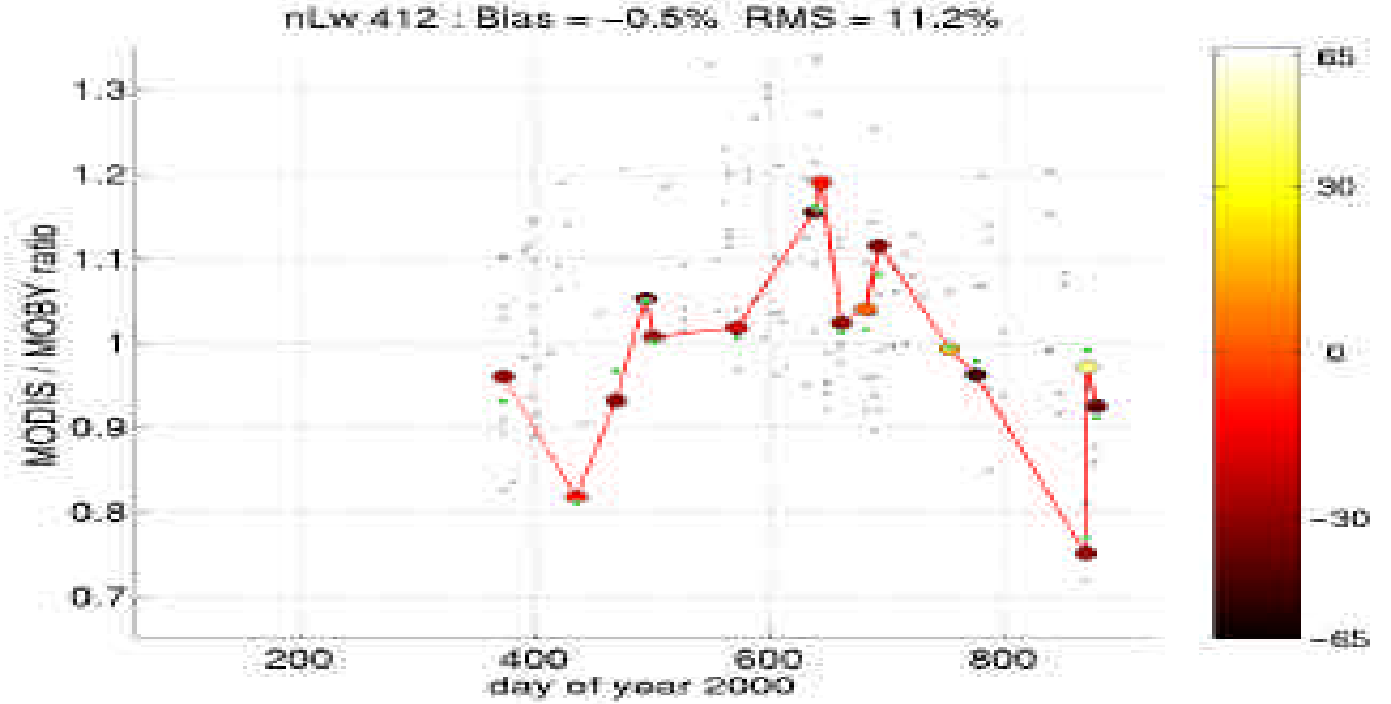


MODIS - MOBY nLw 412nm Calibration Matchups

Reprocessing
Col 4, V3 L1b



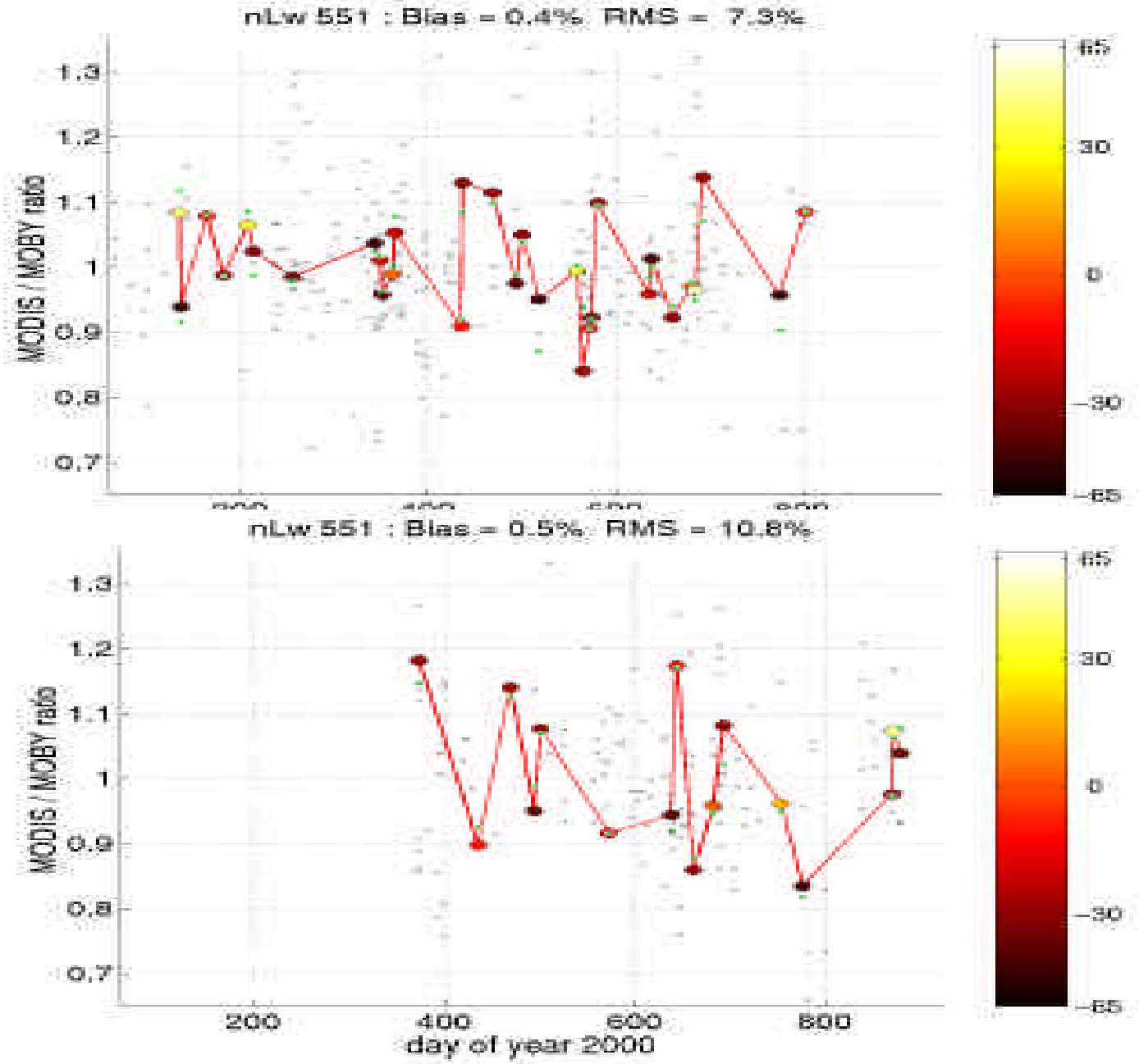
New Forward
Col 4, V4 L1b



MODIS - MOBY nLw 551nm Calibration Matchups

Reprocessing
Col 4, V3 L1b

New Forward
Col 4, V4 L1b

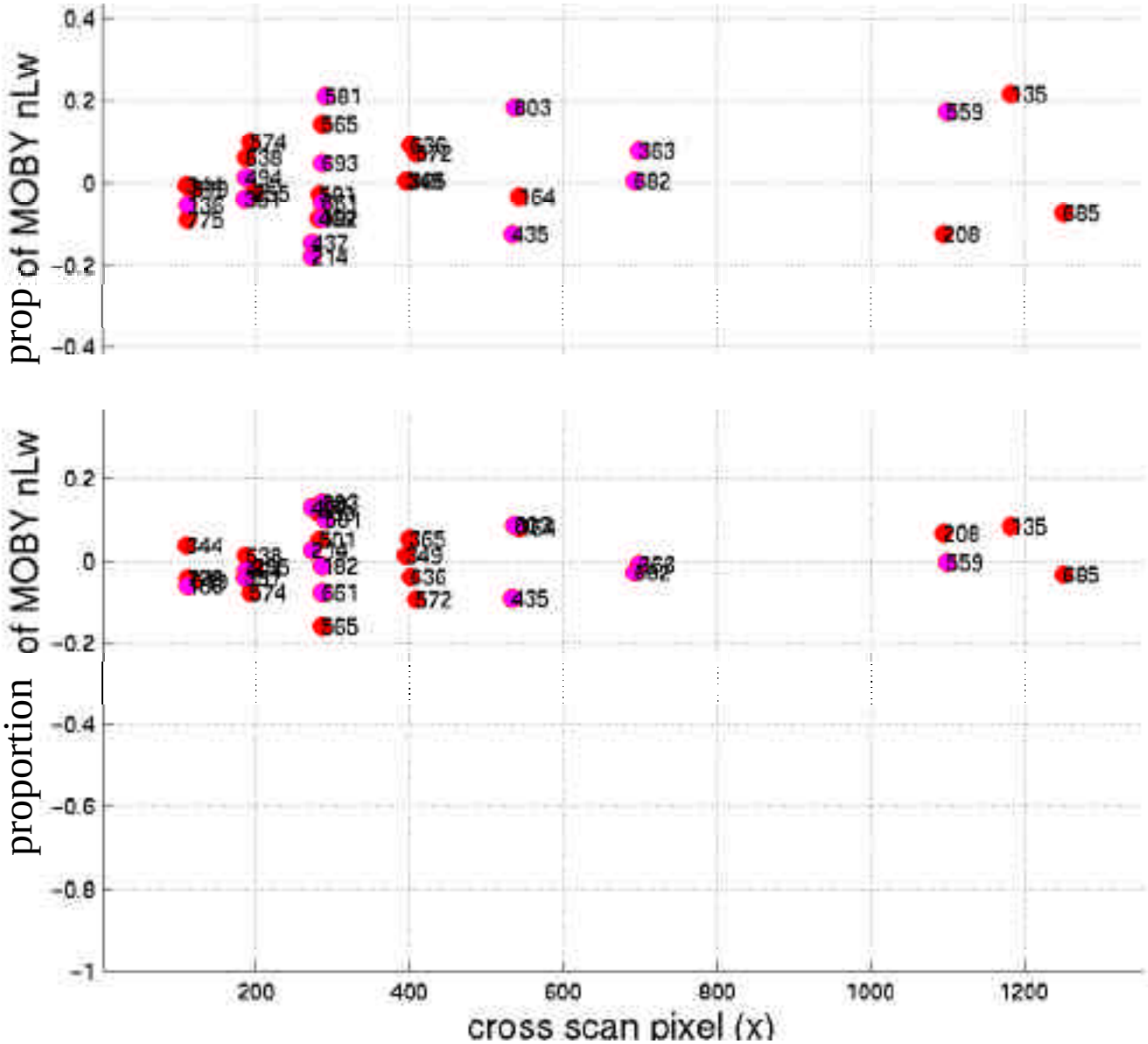


Cross-scan MODIS-Moby Comparison

412 nm

Reprocessing
Calibration
Coll 4, V3L1b

551 nm

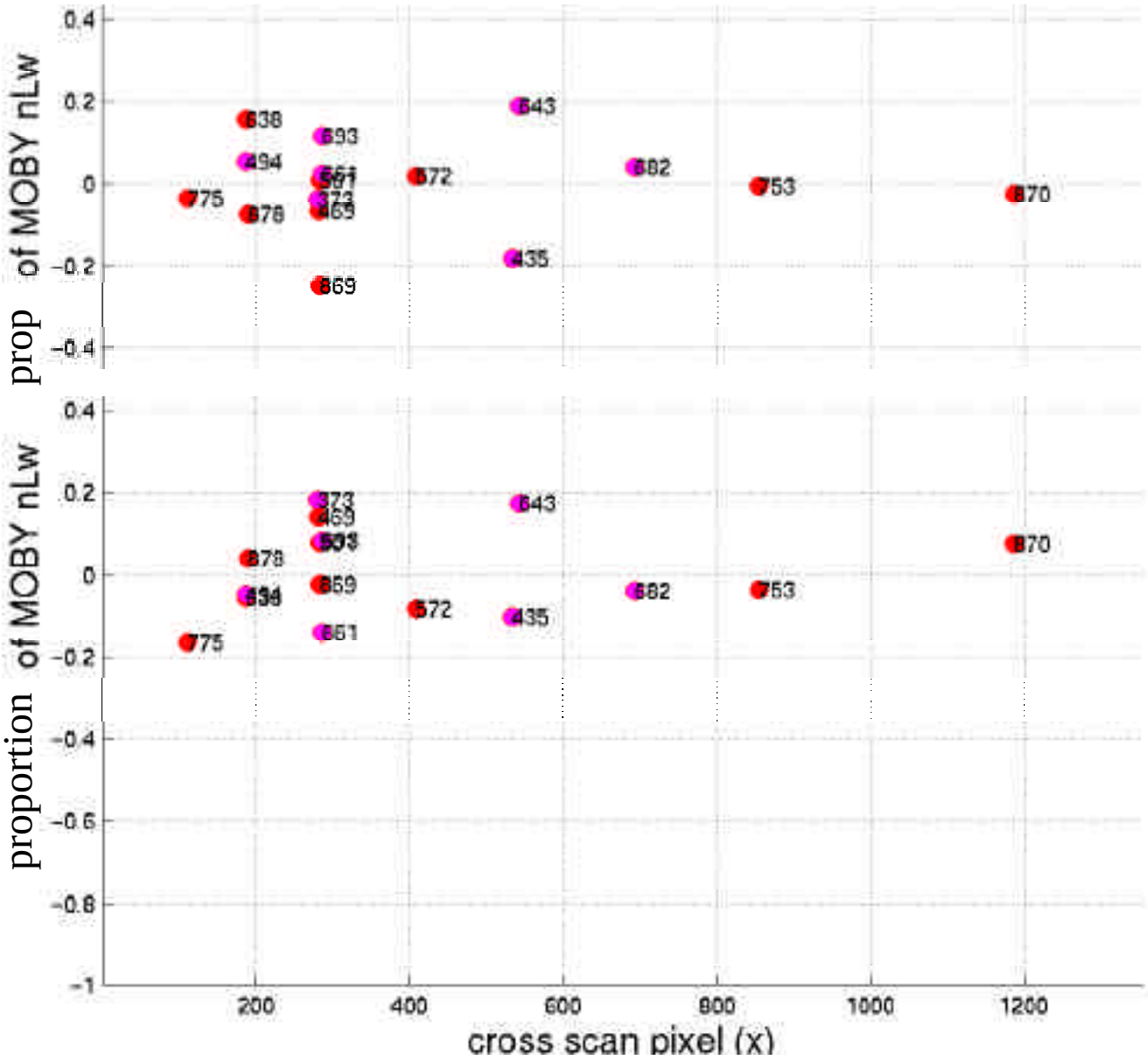


Cross-scan MODIS-Moby Comparison

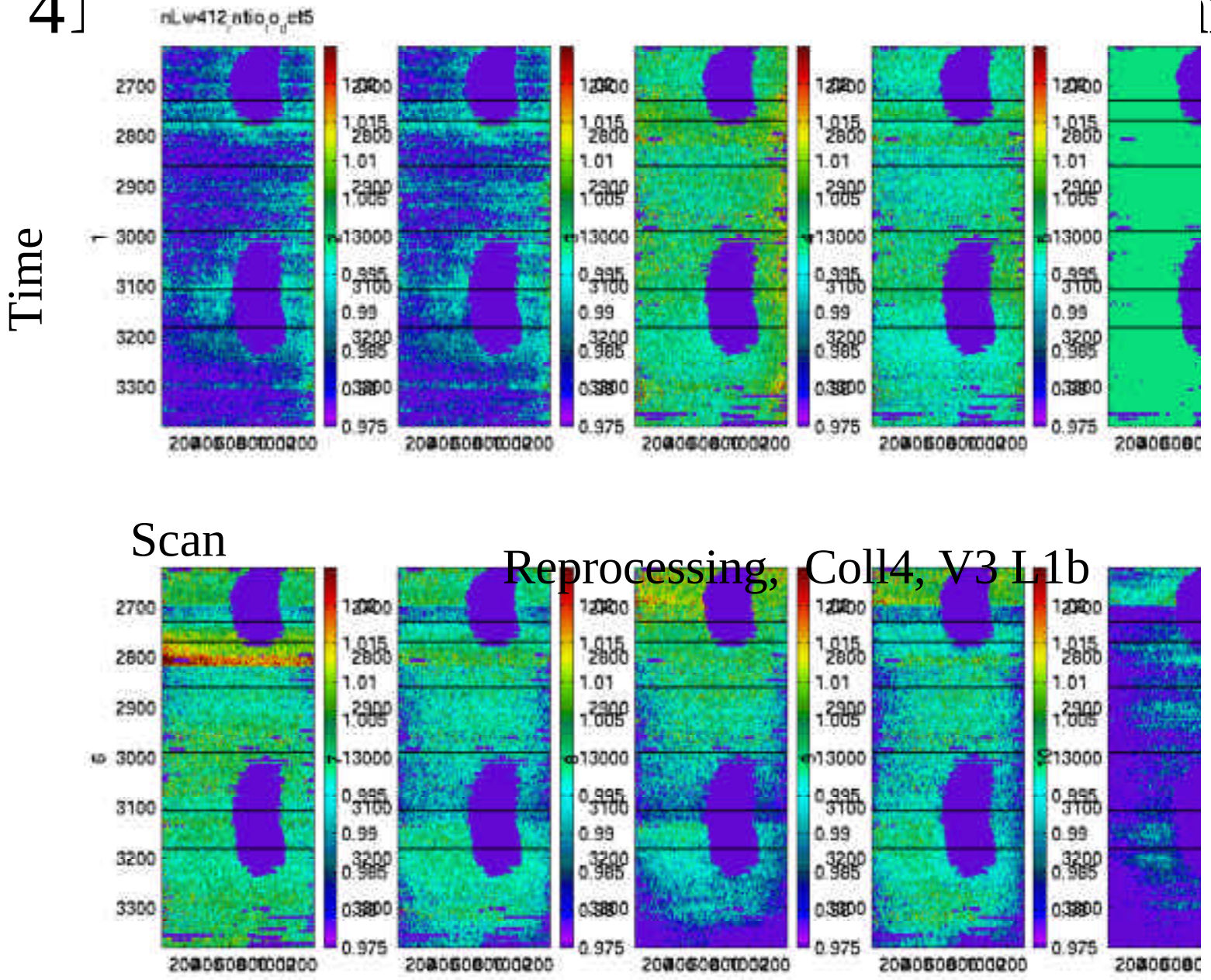
412 nm

New Forward
Calibration
Coll 4, V4L1

551 nm



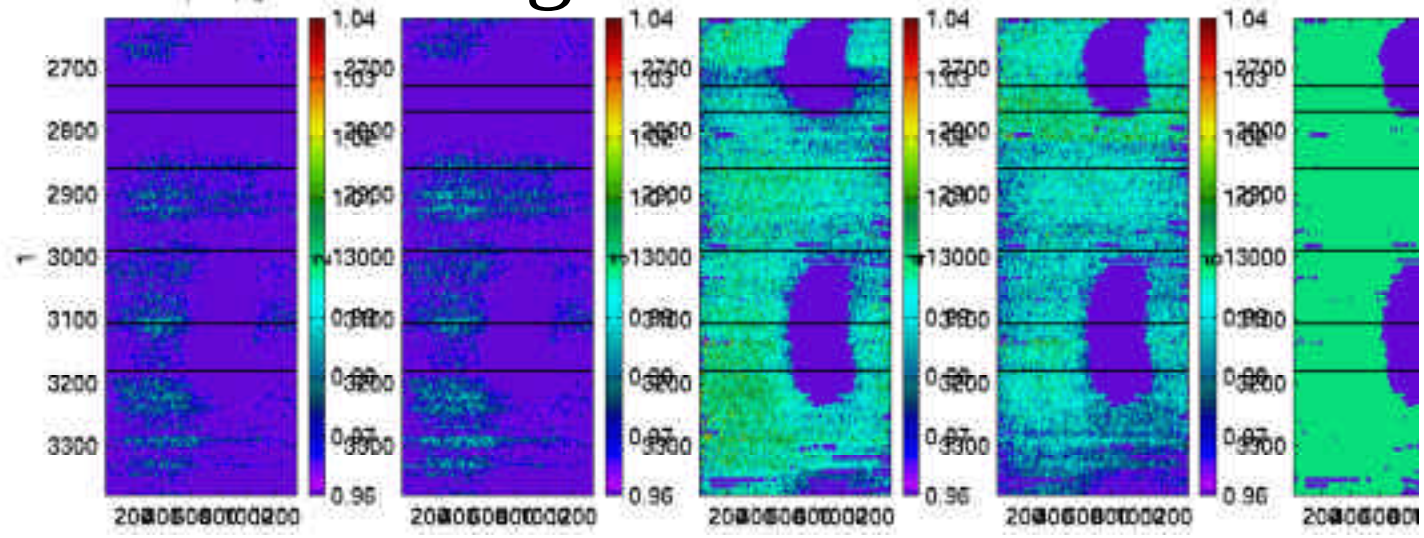
41[illegible]n



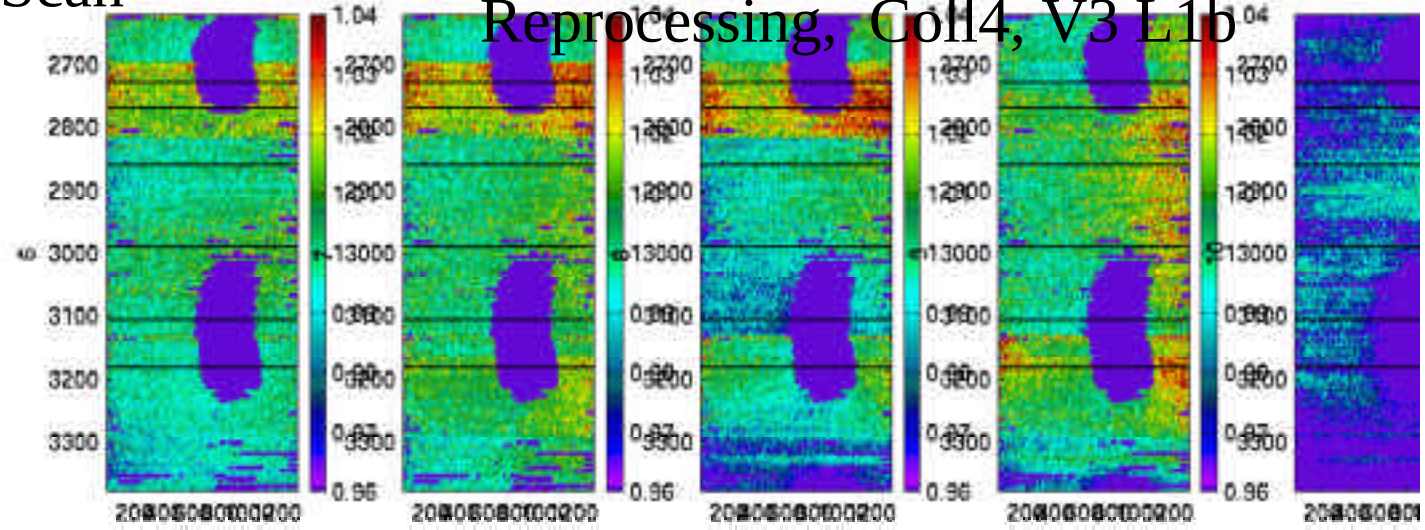
Reprocessing, Coll4, V3 L1b

551 nm Detector gain variation time-scan

Time



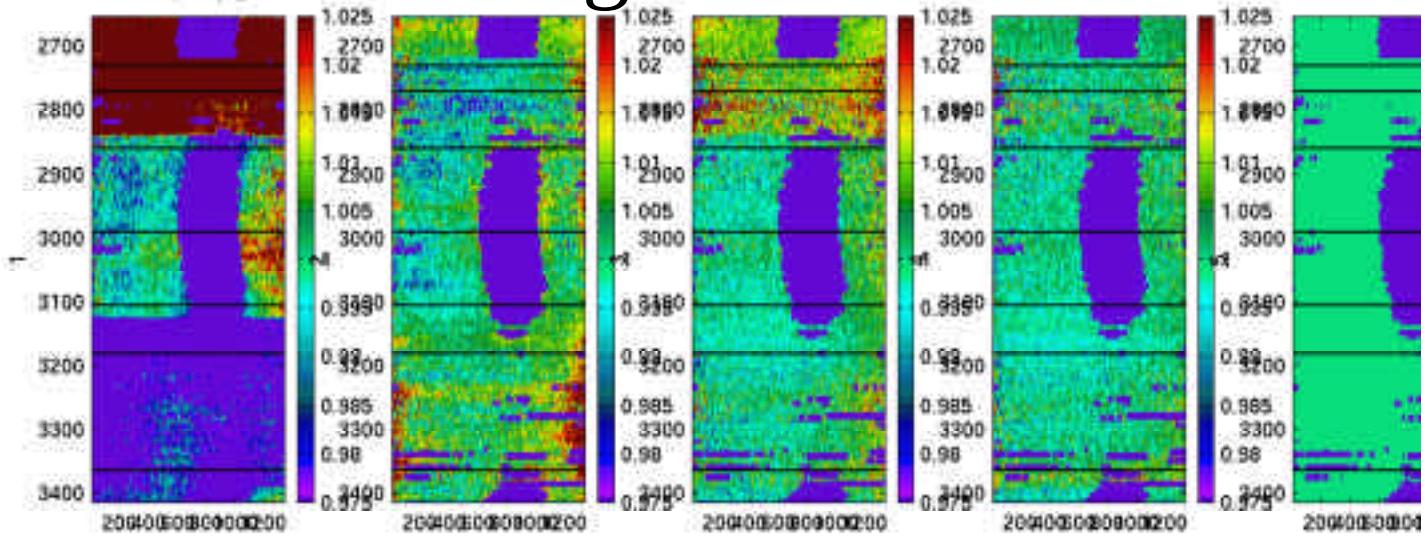
Scan



Reprocessing, Coll4, V3 L1b

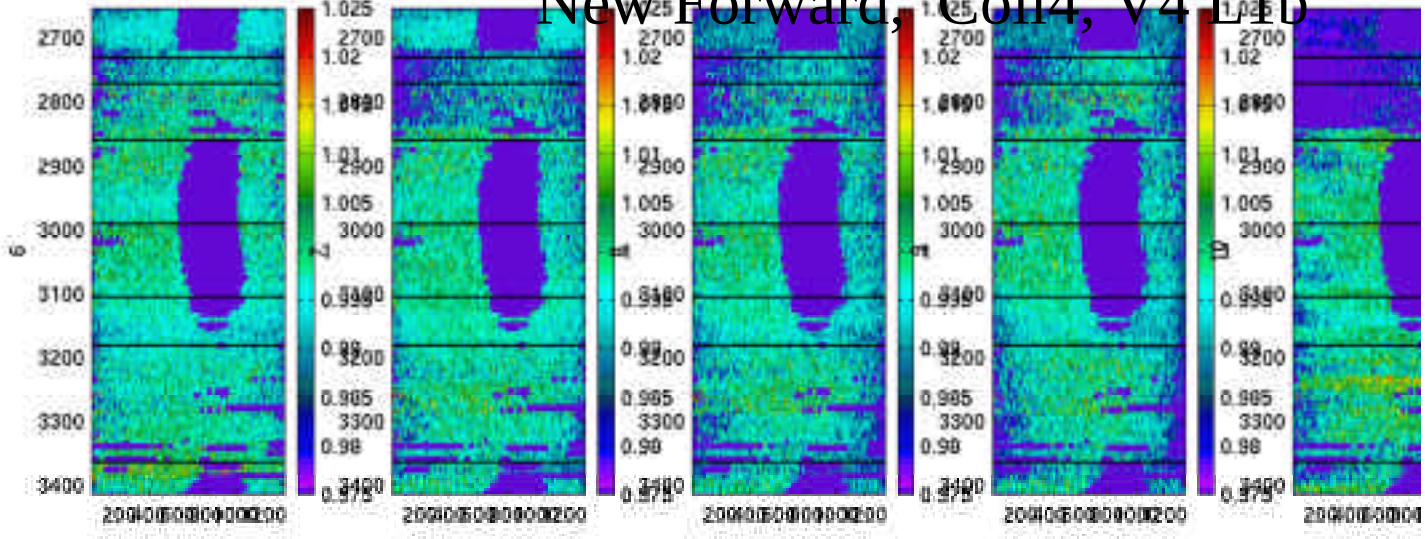
412 nm Detector gain variation time-scan

Time



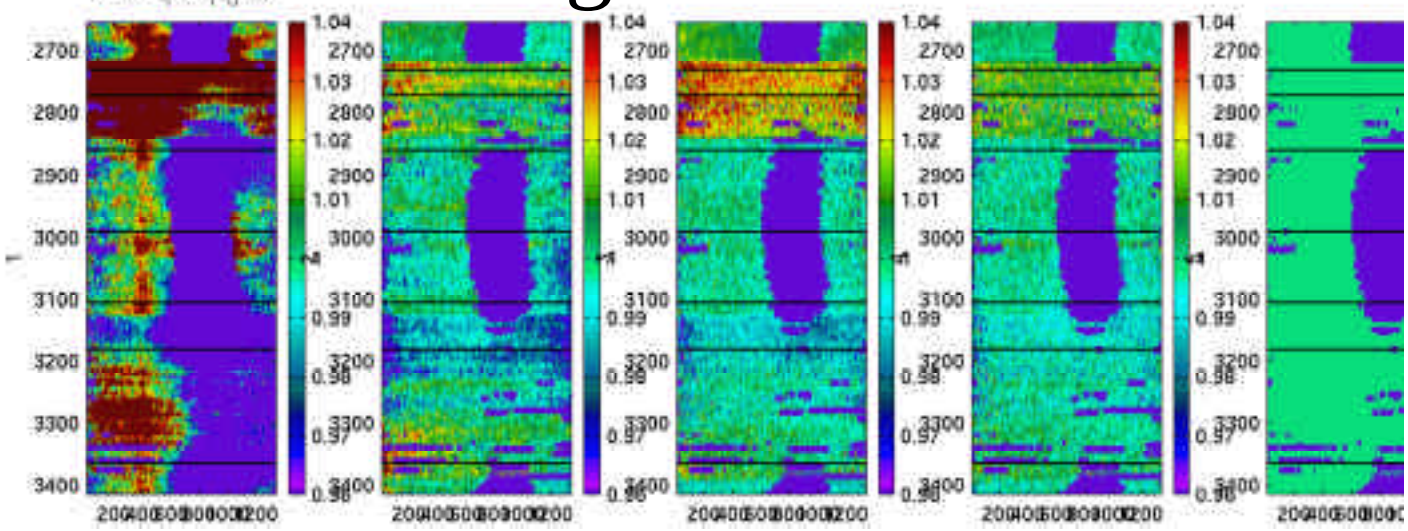
Scan

New Forward, Coll4, V4 L1b



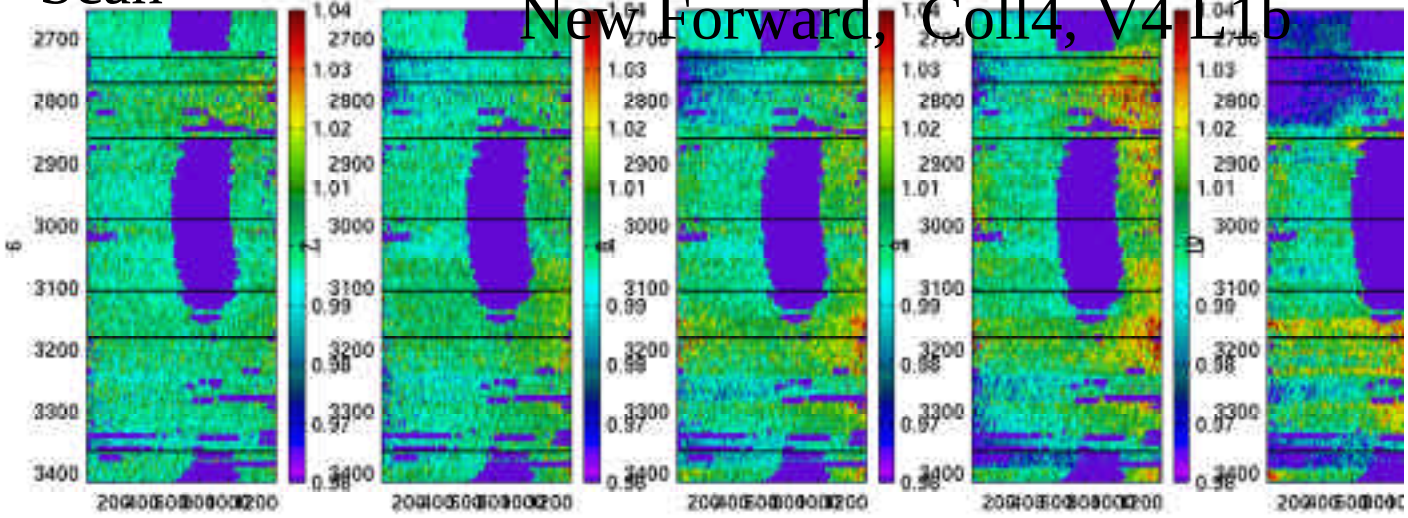
551 nm Detector gain variation time-scan

Time



Scan

New Forward, Coll4, V4 L1b

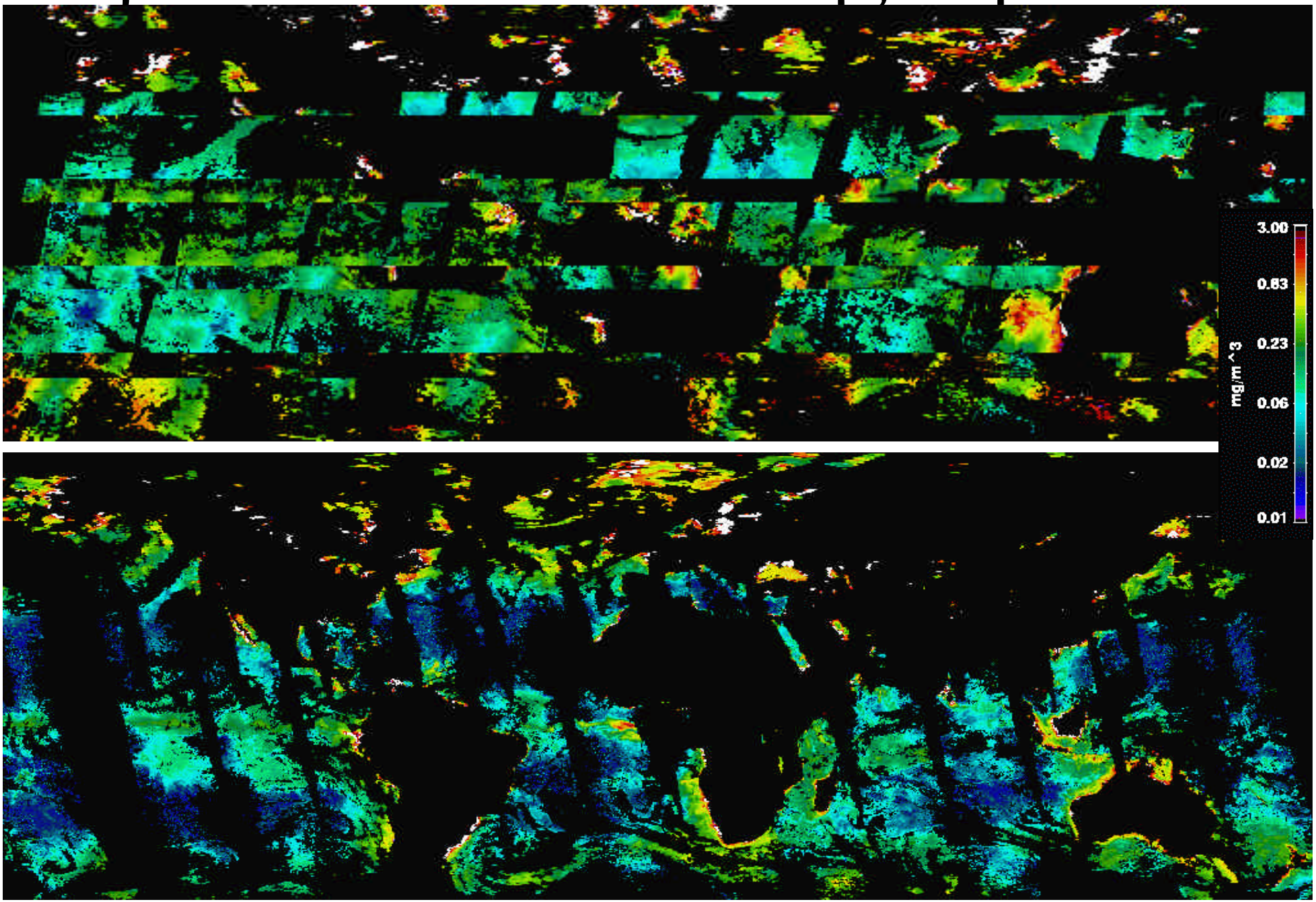


CalibrationStatistics

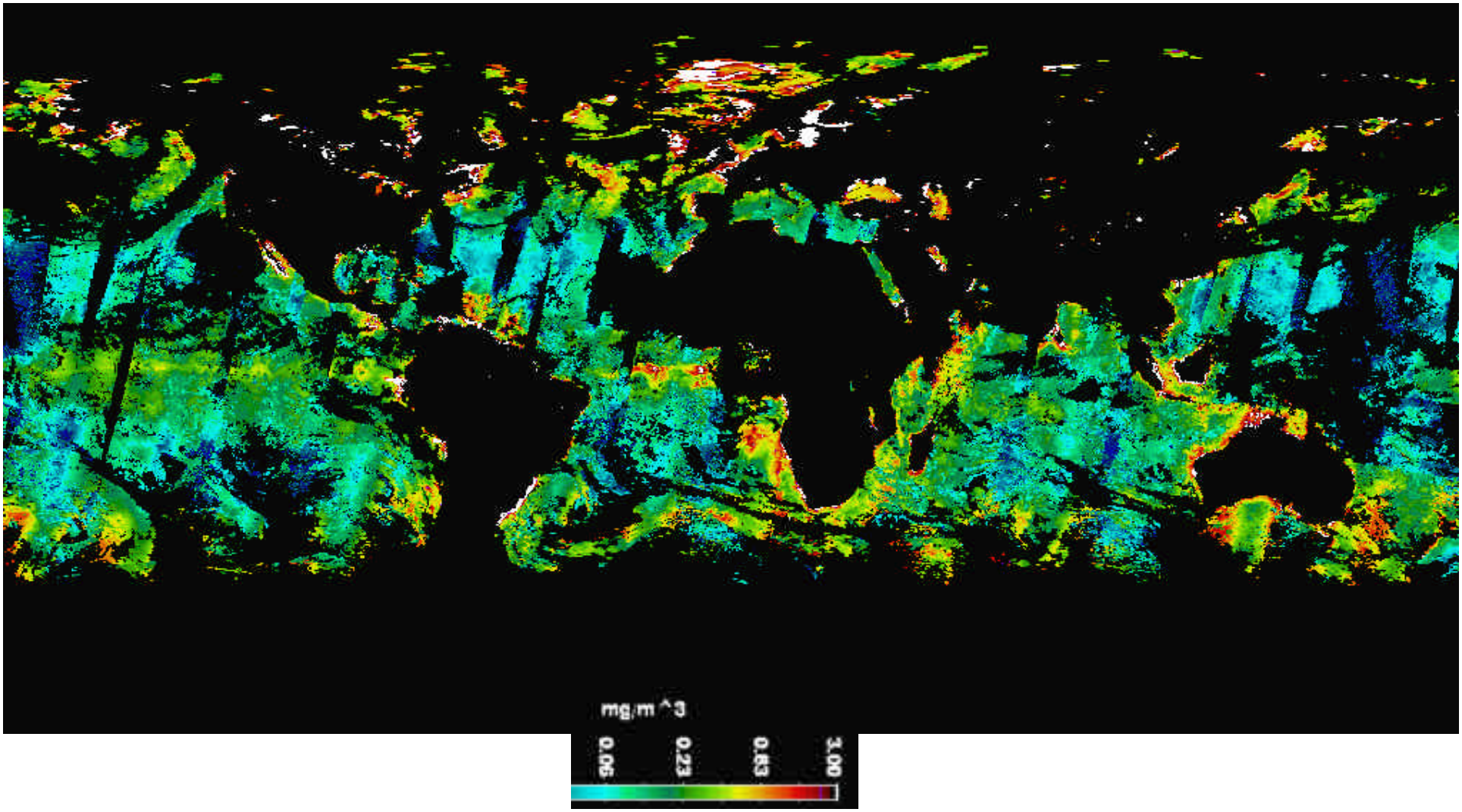
	V3 L1b		V4.0.5 L1b	
Wavelength	**Reprocessing**		**New Forward**	
	Bias	**Std. Dev.**	**Bias**	**Std. Dev.**
412	**1.008**	**0.105**	**0.995**	**0.112**
443	**1.001**	**0.075**	**1.003**	**0.089**
488	**1.001**	**0.045**	**1.010**	**0.069**
531	**1.004**	**0.067**	**1.010**	**0.095**
551	**1.004**	**0.073**	**1.005**	**0.108**
667*	**1.115**	**1.904**	**1.301**	**0.301**
678*	**1.312**	**0.450**	**1.440**	**0.310**

* MOBY measurements marginal at these wavelengths

25jun02 Chlmod Terra-up, Aqua down



25jun02 ChlMod Merge Terra-Aqua Pre-launch calibration



Conclusions

- Terra: Uncorrected mirror side, cross-scan, detector-detector and time variations can each exceed 30% in nLw
- Collection 4, Version 3L1b (Reprocessing) nLw validated
- Caveats: variations of ± 5% in nLw expected for cross-scan, detector-detector, mirror side and time
- Collection 4, Version 4.0.5 (Forward Processing) correction, validation tests in progress and nearing completion

- Aqua detector, mirror, cross-scan preliminary corrections in test, need to verify polarization correction factors
- Collection x, Aqua, waiting for delivery of on-orbit LUT

- Manuscript with complete details near completion