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Geophysical Retrievals from GCOM-W AMSR-2 Radiative Transfer Model (RTM) Inversion (RTM^{-1}) SST, Wind, Vapor, Cloud, Rain

Chelle Gentemann
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Remote Sensing Systems, Santa Rosa CA

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Earth Observation Research Center, JAXA
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January 17, 2014

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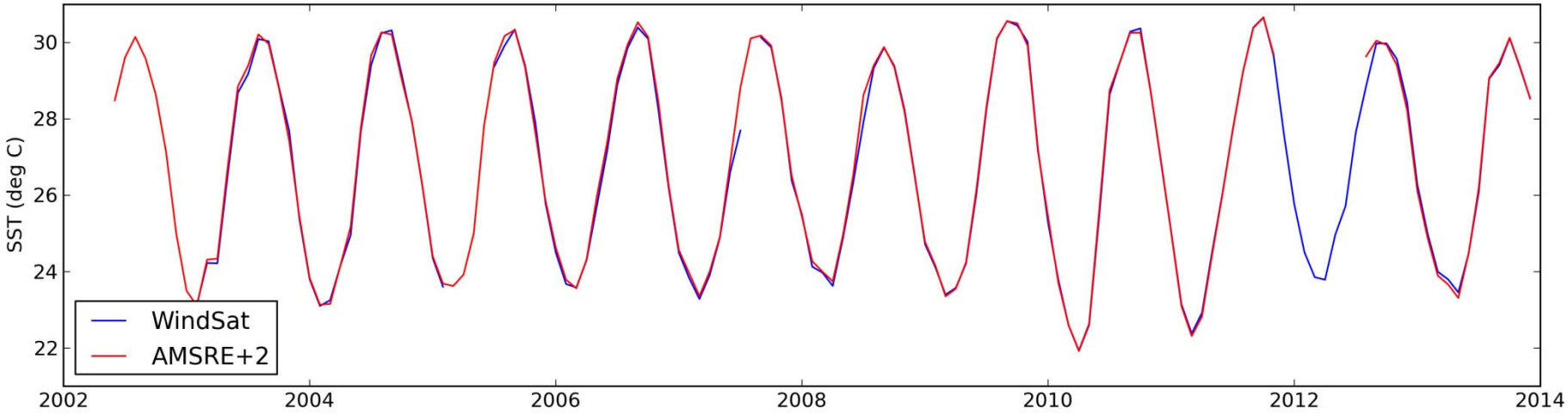
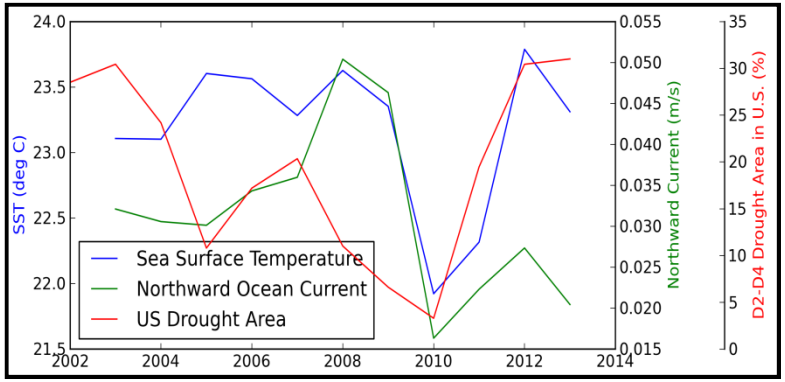
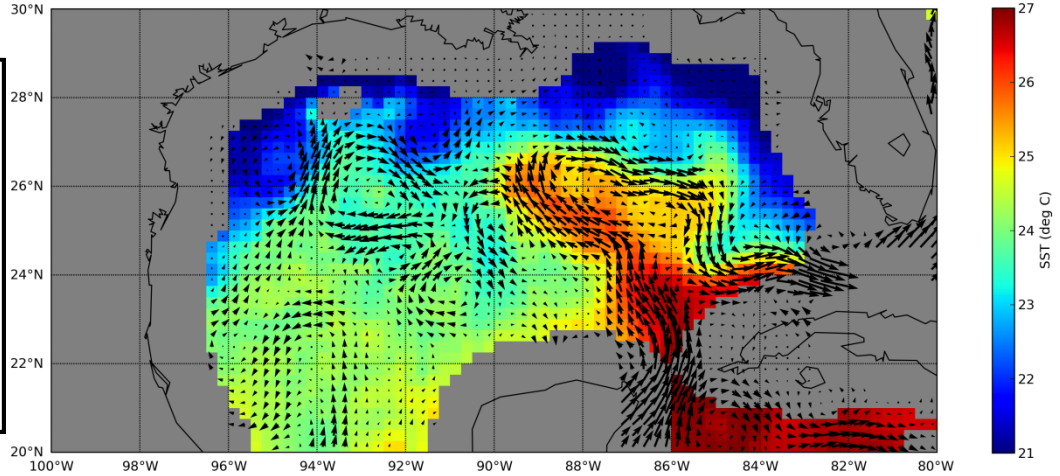
AMSR-E, WindSat, & AMSR-2
SST in the Gulf of Mexico Linked to Drought Area in U.S.







"In 2010, the area of severe drought is only 3.3%, compared with the average of 19.5%. This indicates that variability in the Loop Current can have profound impacts on precipitation (and hence agriculture) in the United States." -Hilburn

GPM Global Change Observation Mission

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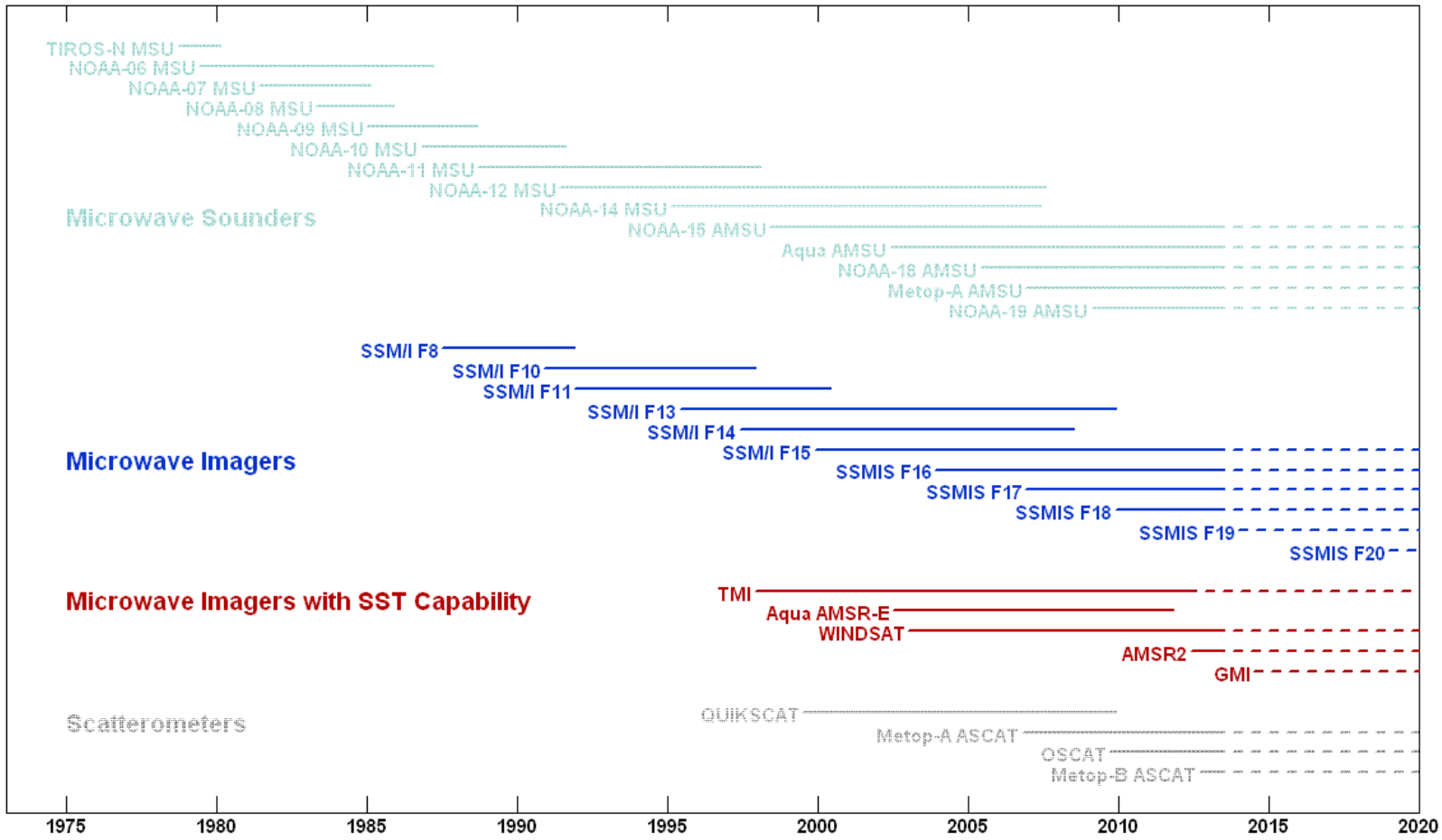
RSS Inventory of Satellite Microwave Observations:
AMSR-2 Needs to be Consistently Calibration into Existing Record



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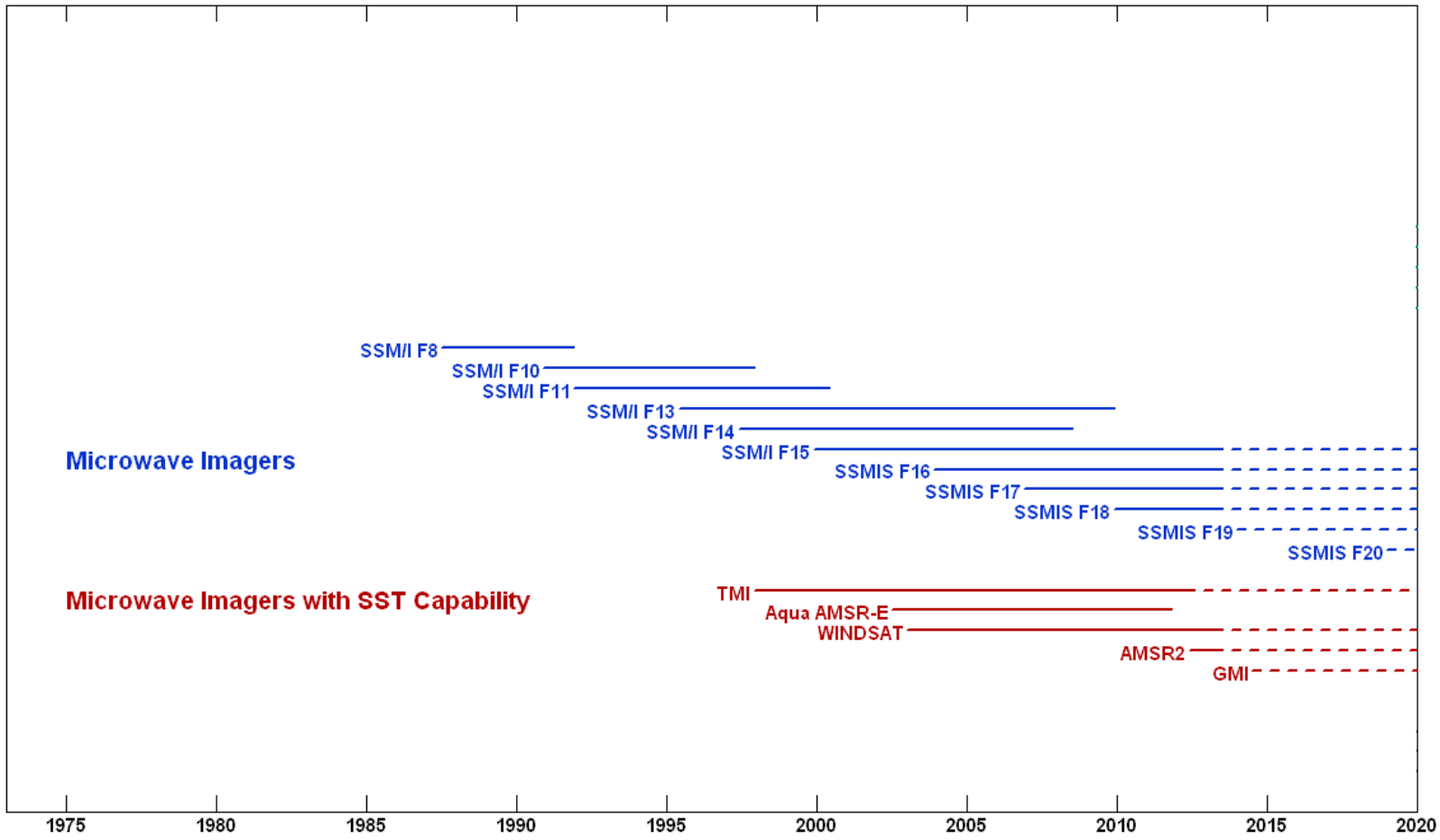

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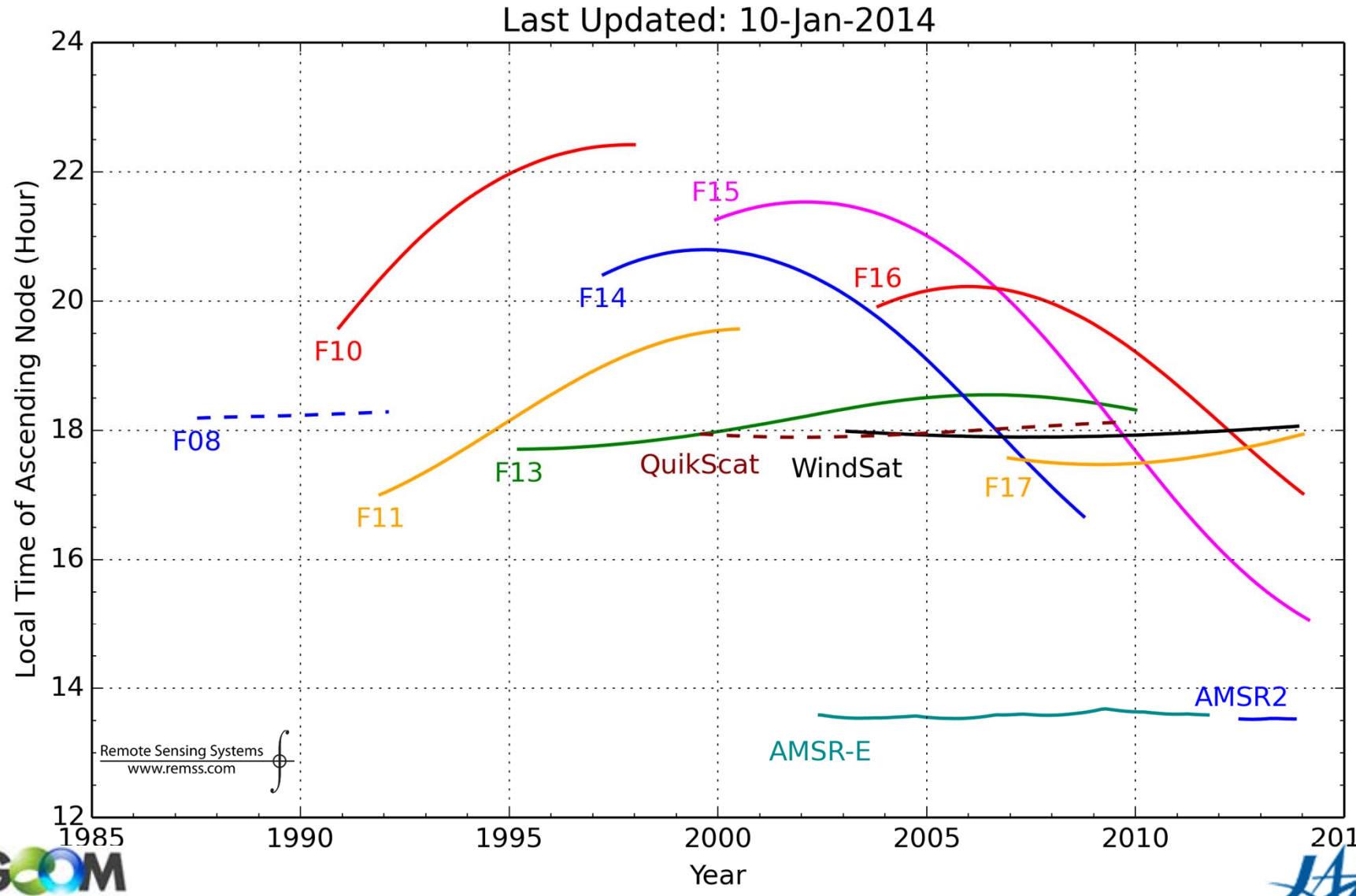

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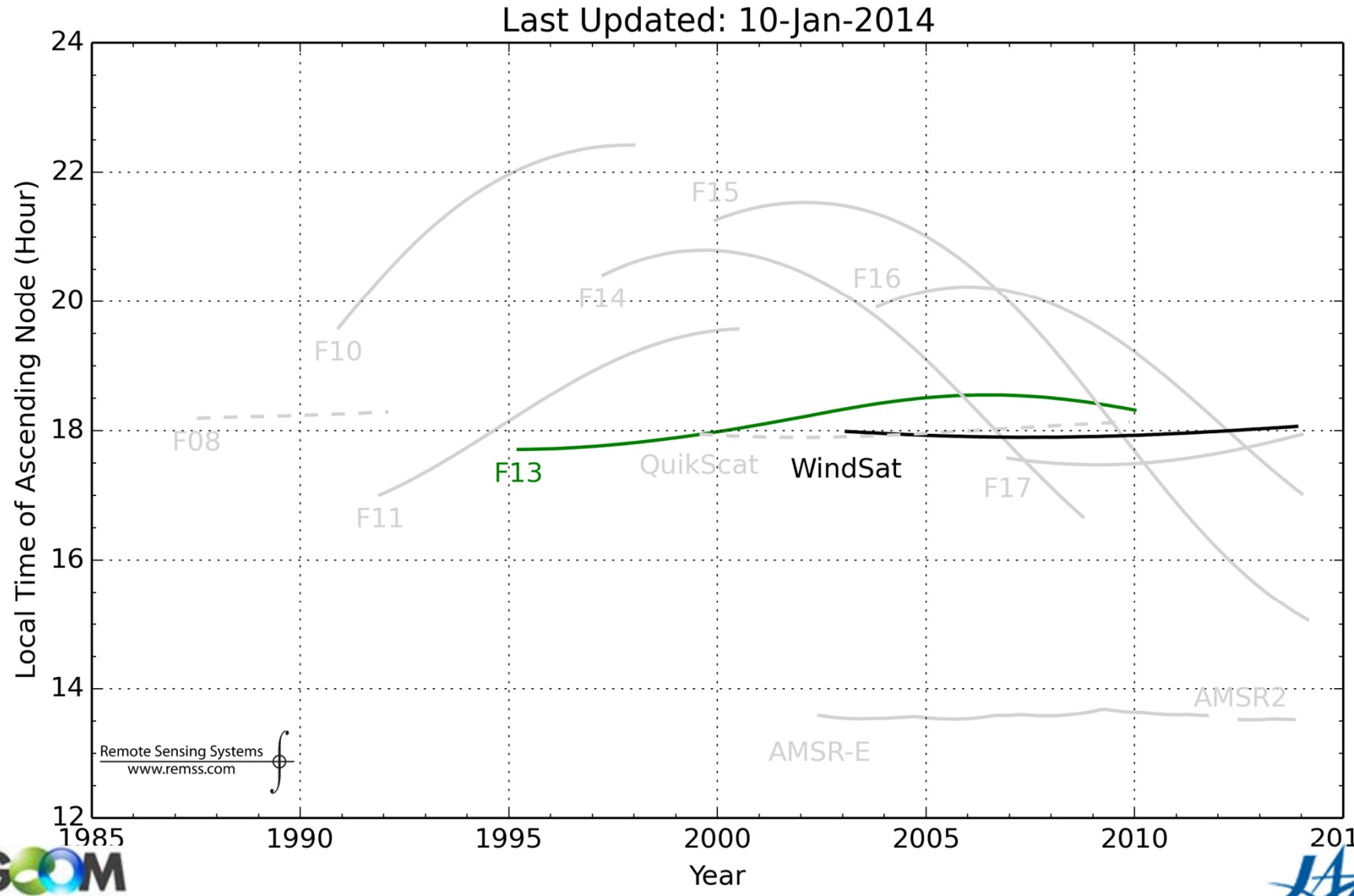

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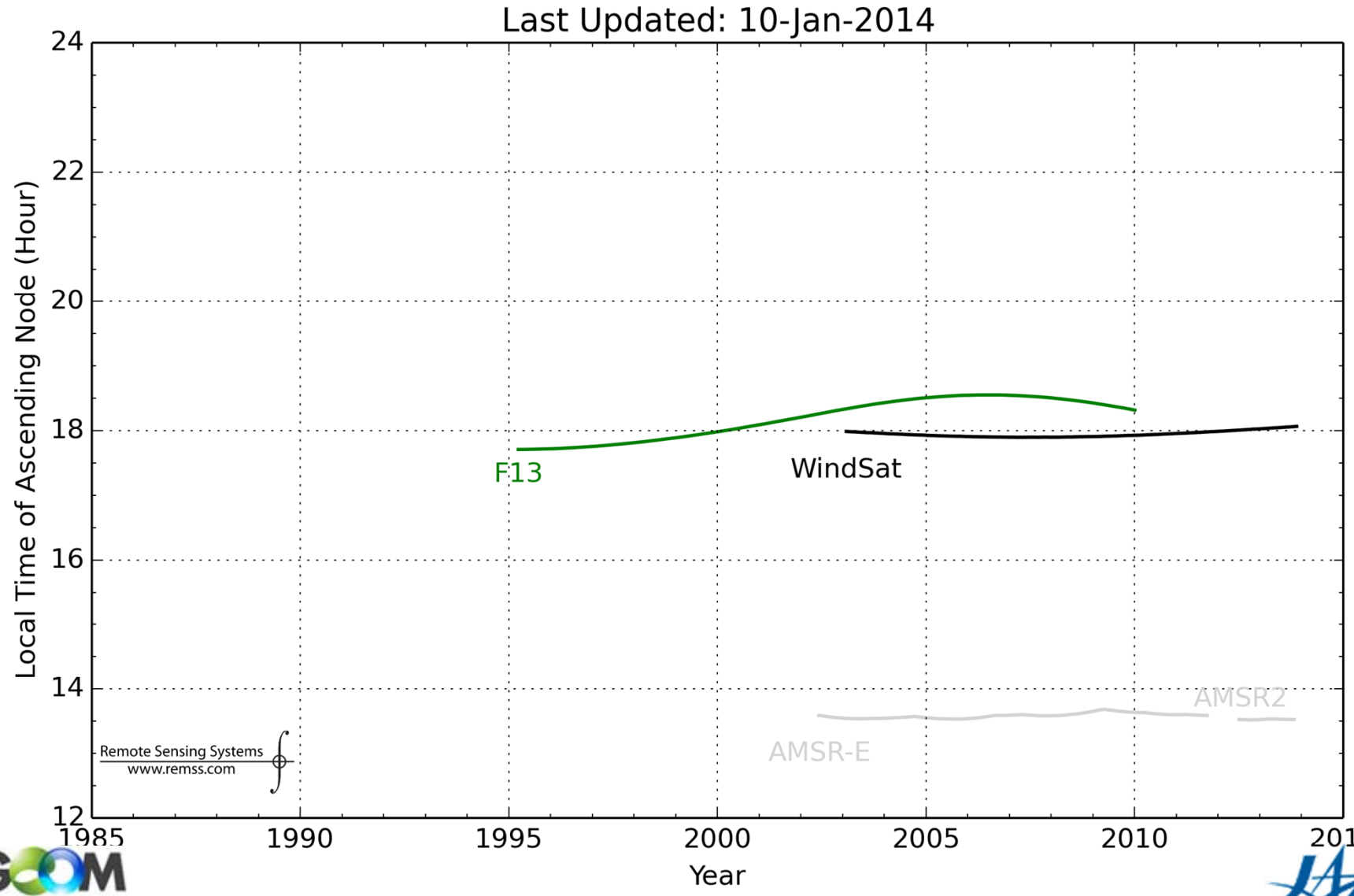

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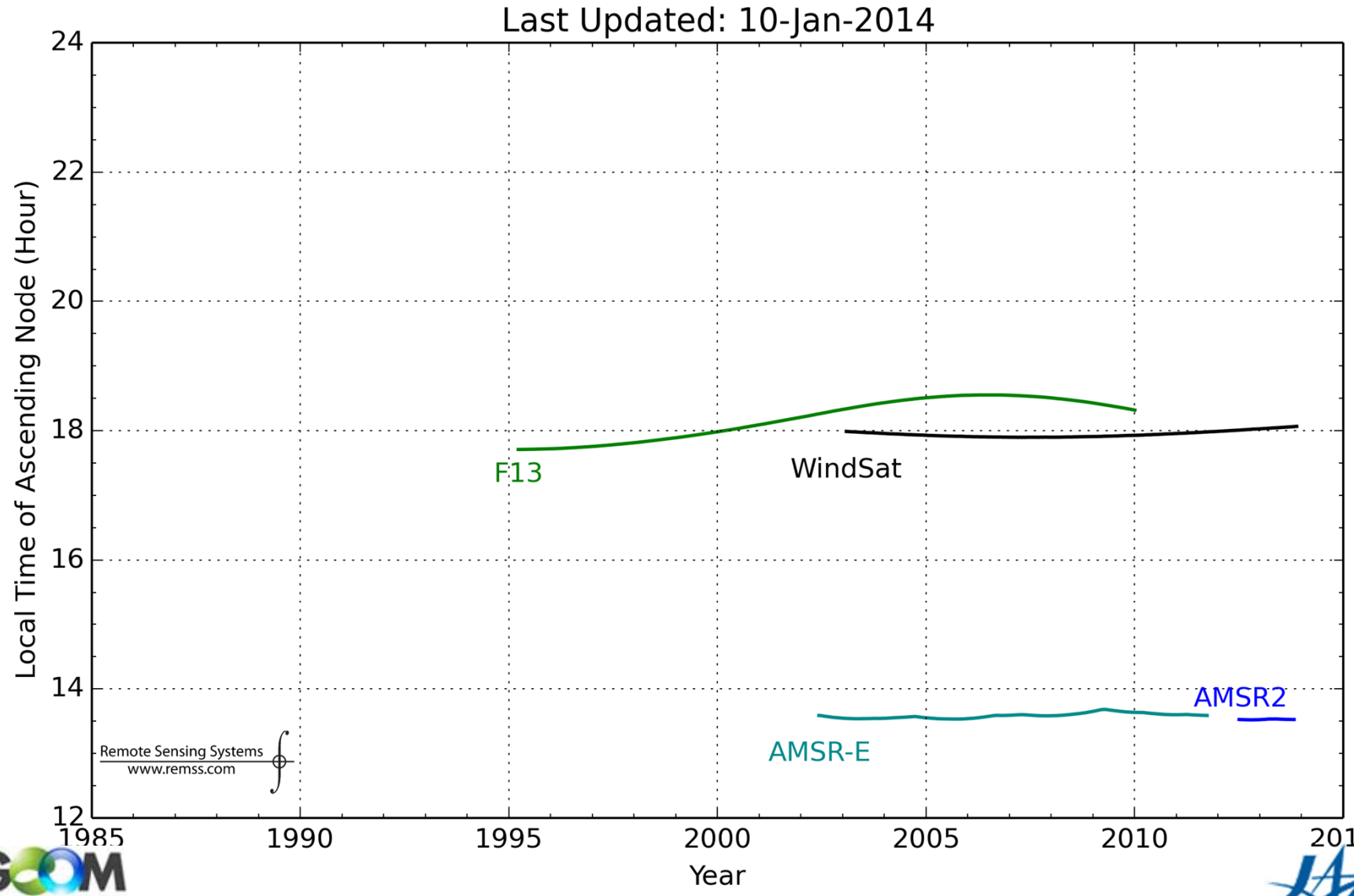

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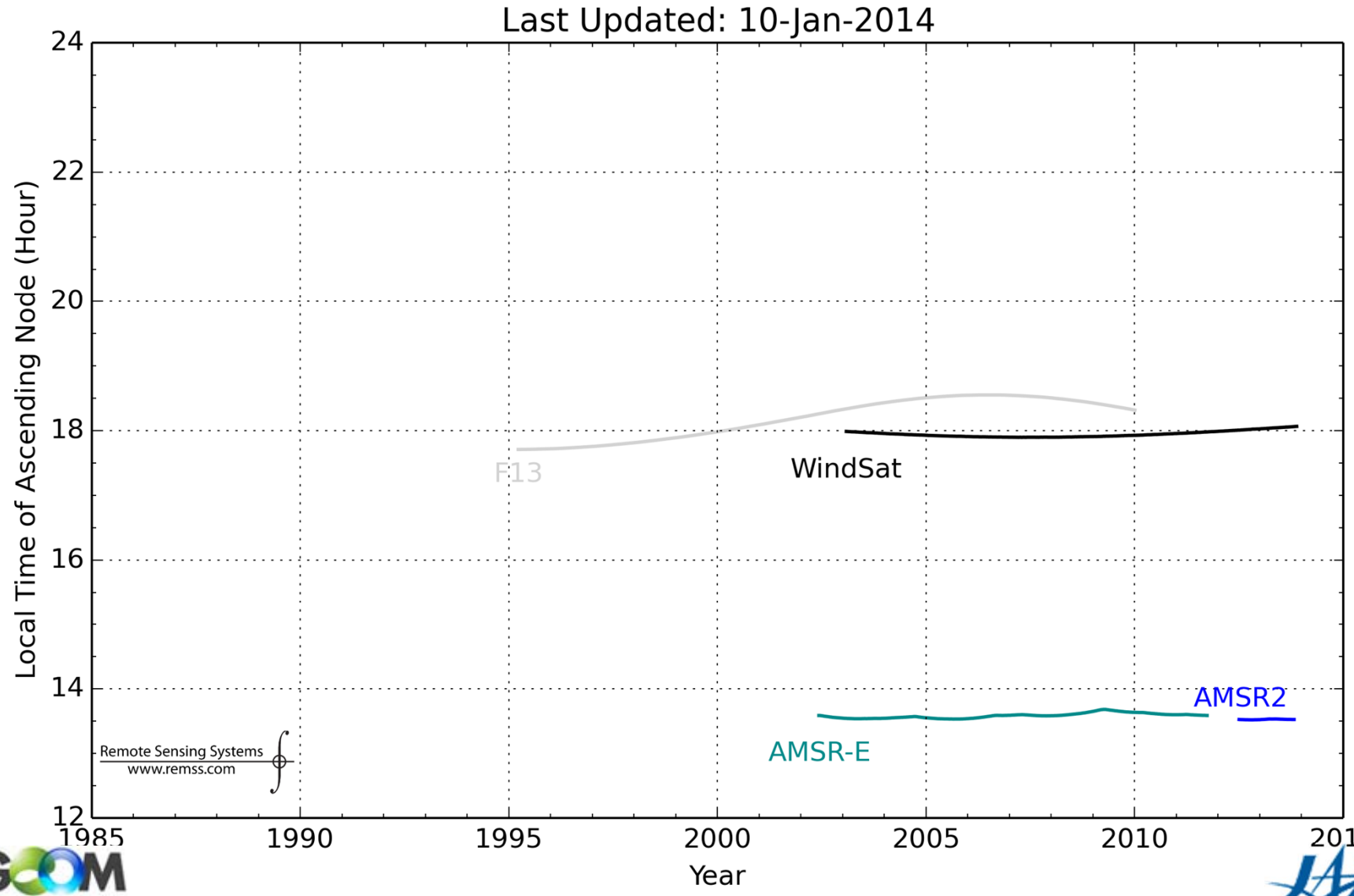

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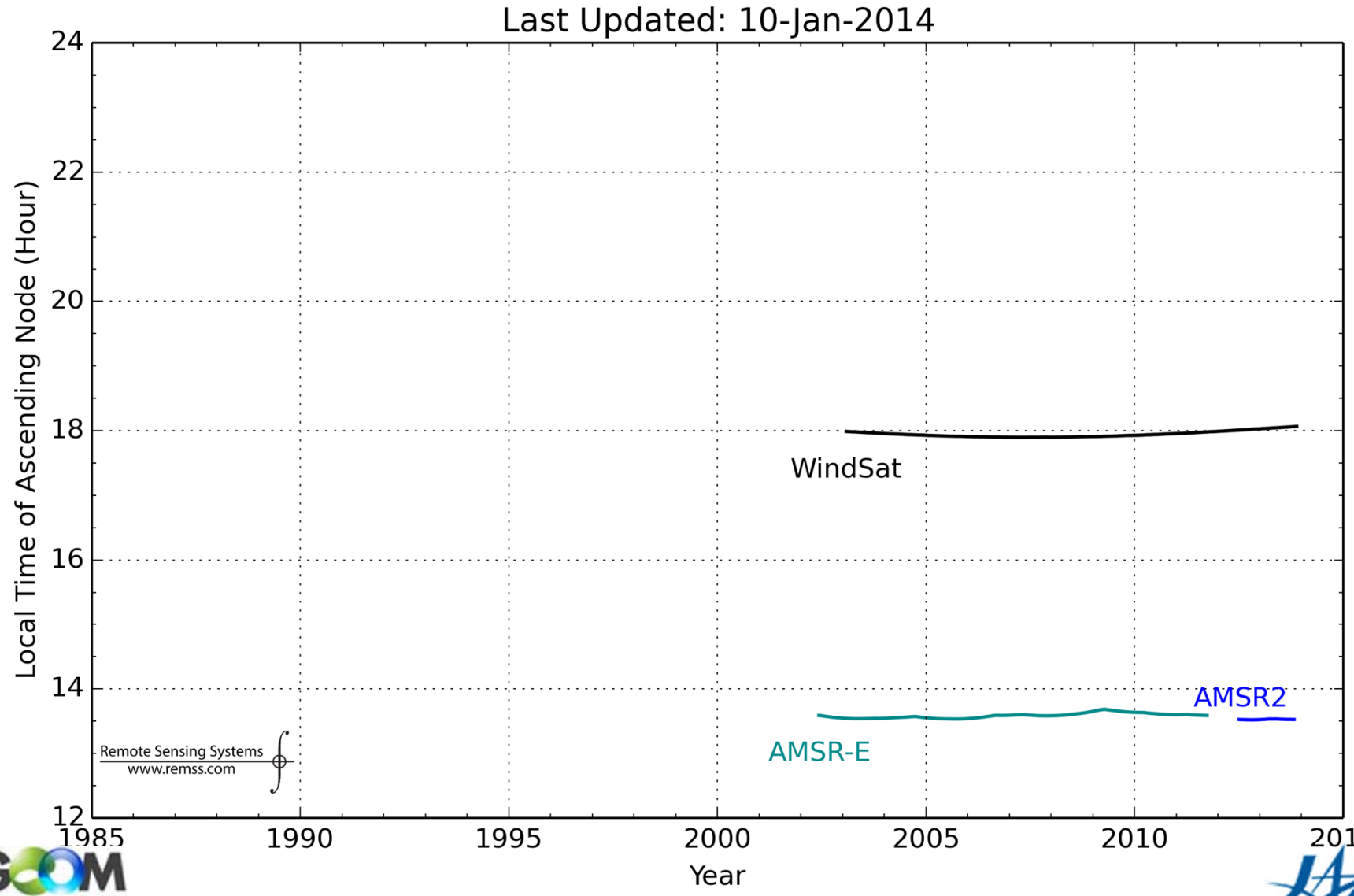

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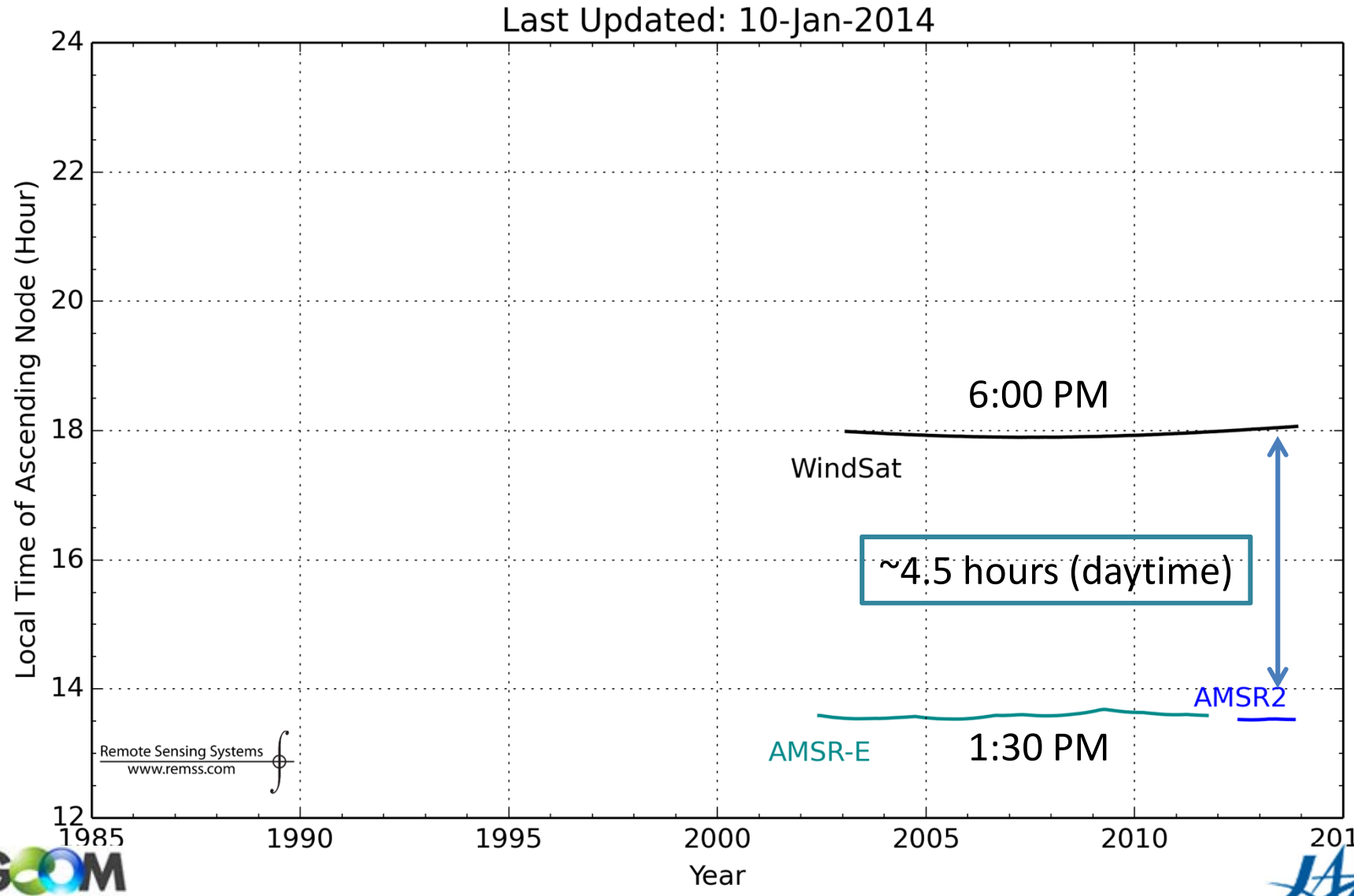
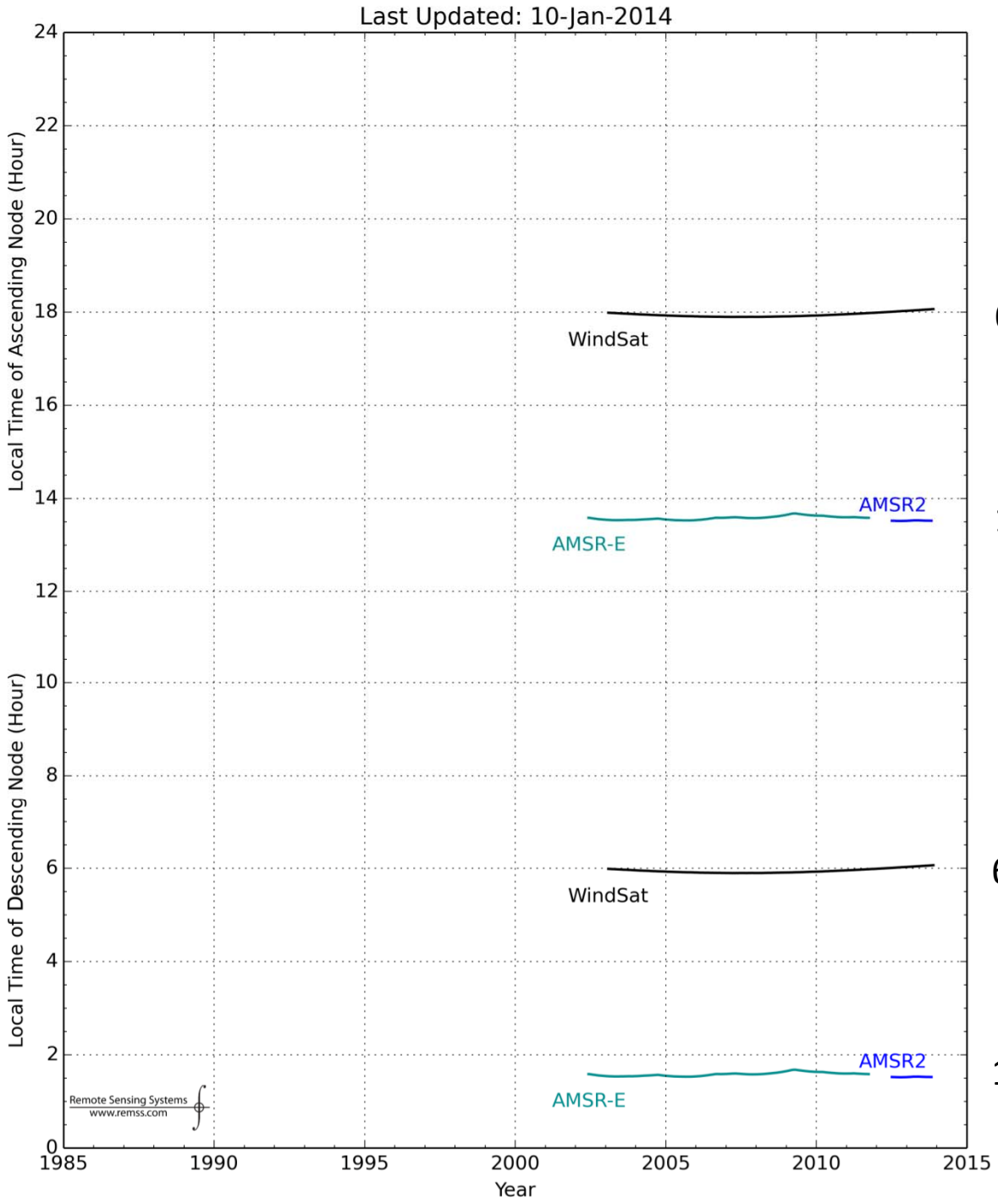




~7.5 hours (night)

6:00 PM

~4.5 hours (day)

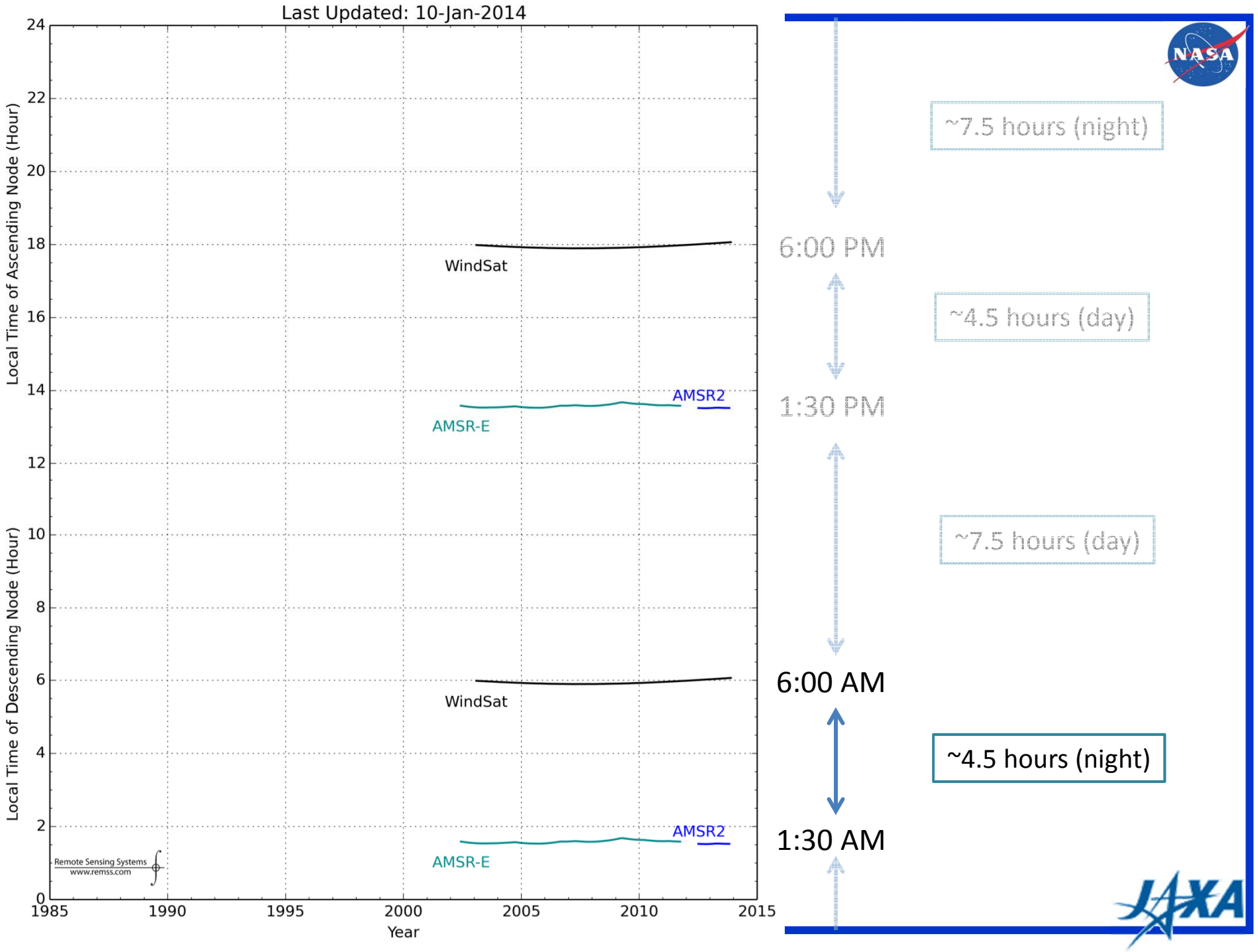
1:30 PM

~7.5 hours (day)

6:00 AM

~4.5 hours (night)

1:30 AM


Last Updated: 10-Jan-2014
Local Time of Ascending Node (Hour)
Local Time of Descending Node (Hour)
Year
WindSat
AMSR2
AMSR-E
WindSat
AMSR2
AMSR-E
Remote Sensing Systems
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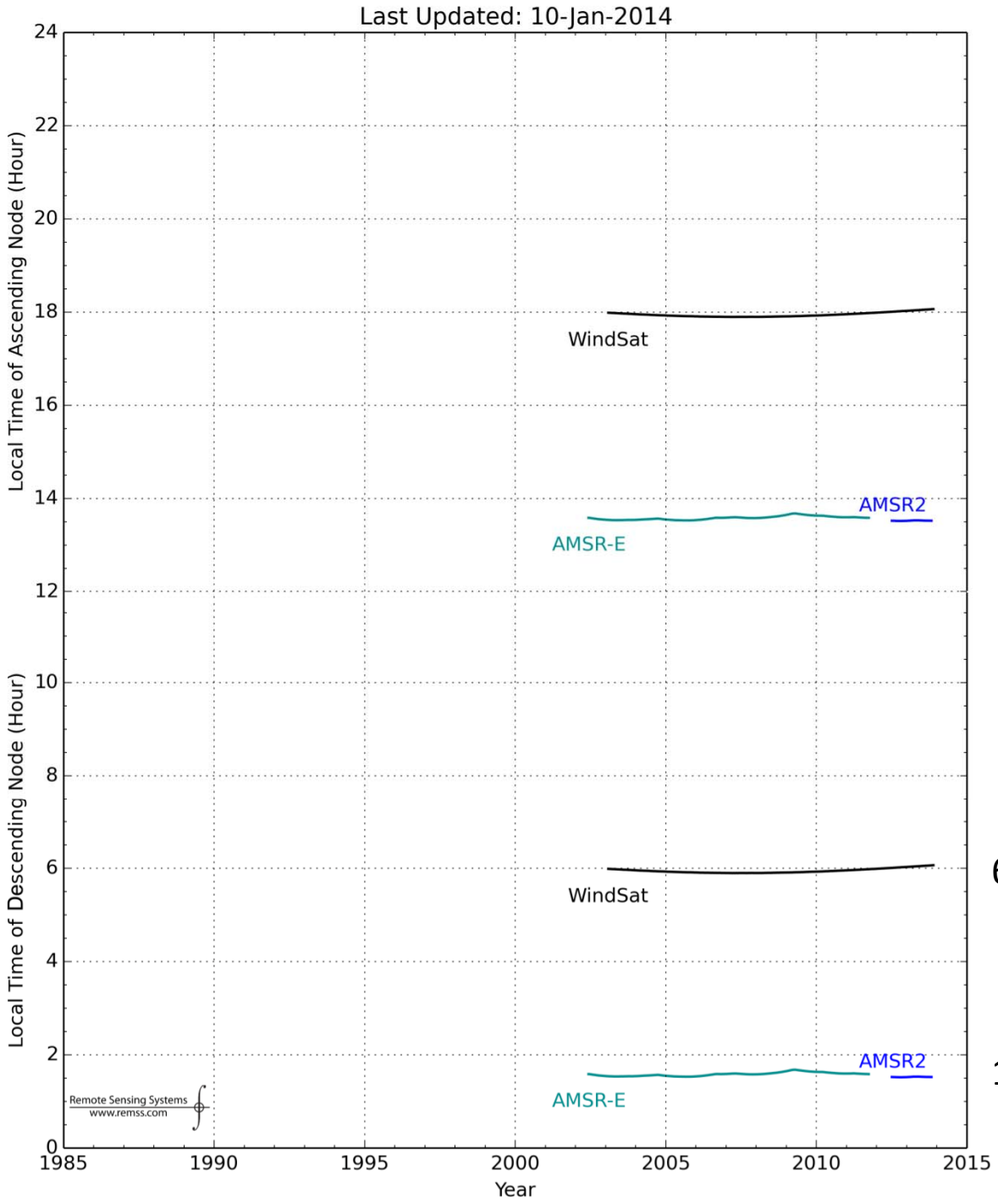
~7.5 hours (night)
6:00 PM
~4.5 hours (day)
1:30 PM
~7.5 hours (day)
6:00 AM
~4.5 hours (night)
1:30 AM



6:00 AM

1:30 AM

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Radiative Transfer Model (RTM) Inversion (RTM^{-1})
SST, Wind, Vapor, Cloud, Rain

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Radiative Transfer Model (RTM) Inversion (RTM^{-1})

SST, Wind, Vapor, Cloud, Rain

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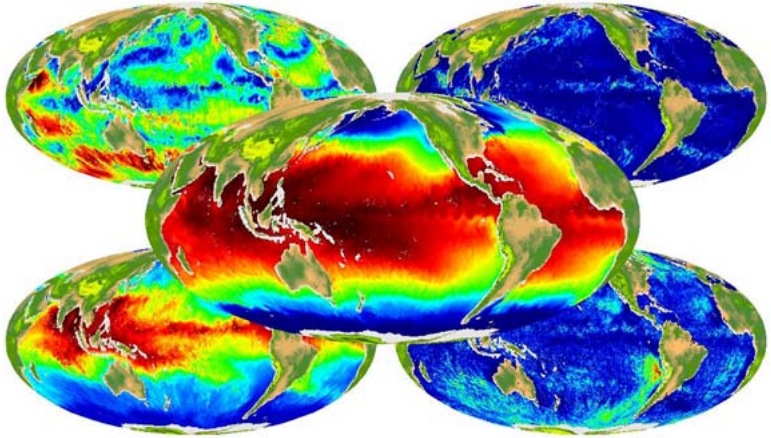
Radiative Transfer Model (RTM) Inversion (RTM^{-1})

SST

Wind Speed

Water Vapor



Rain Rate

Cloud Liquid

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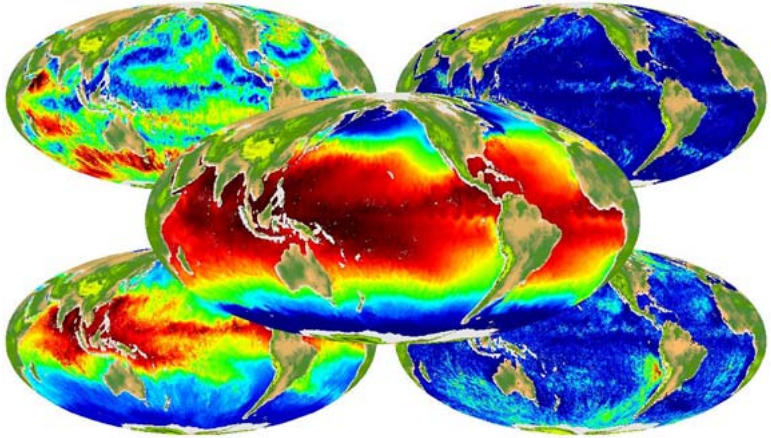
SST

Wind Speed

Rain Rate



Water Vapor

Cloud Liquid

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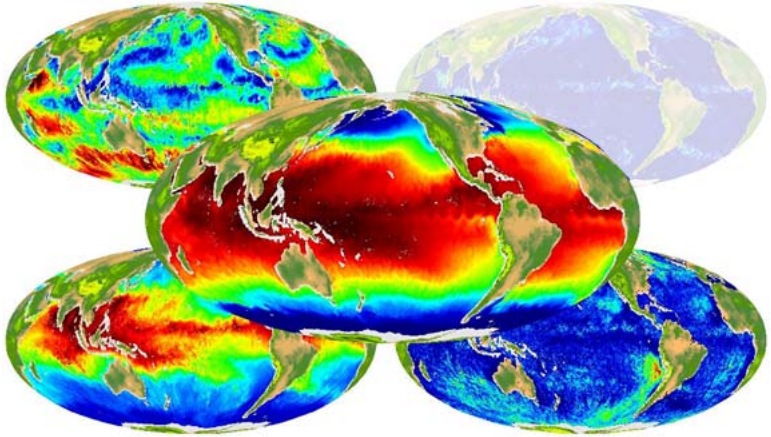
NASA

SST

Wind Speed



~~Rain Rate~~

Water Vapor

Cloud Liquid

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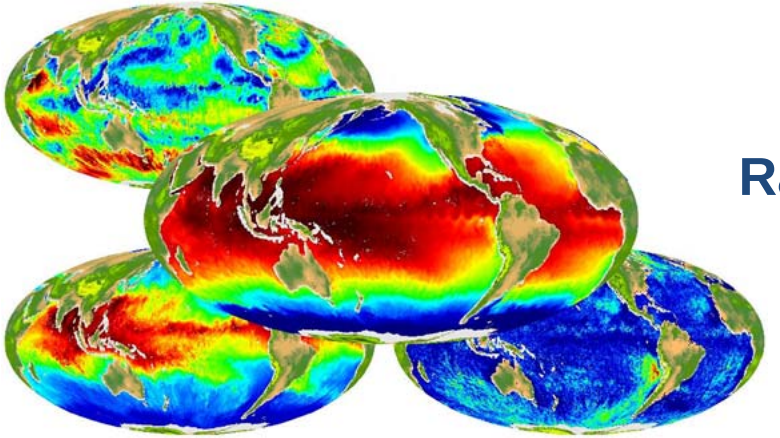
SST

Wind Speed



~~Rain Rate~~

Rain Free Scenes

Water Vapor

Cloud Liquid

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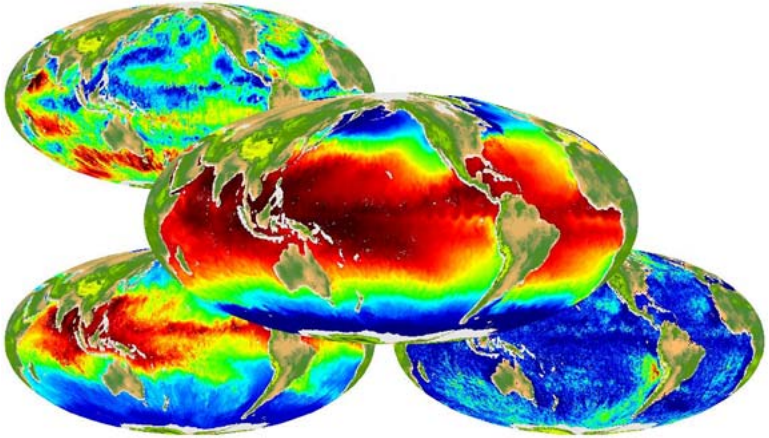
T

W



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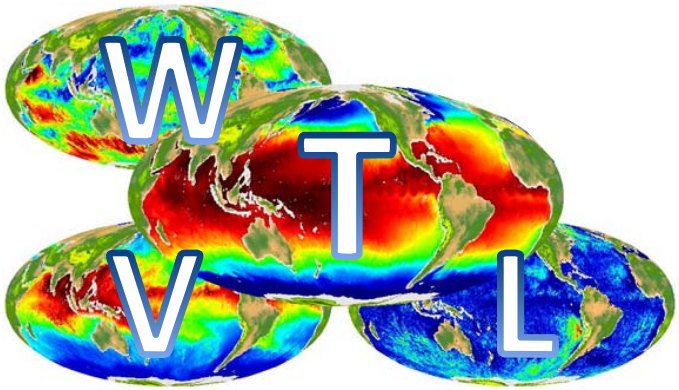

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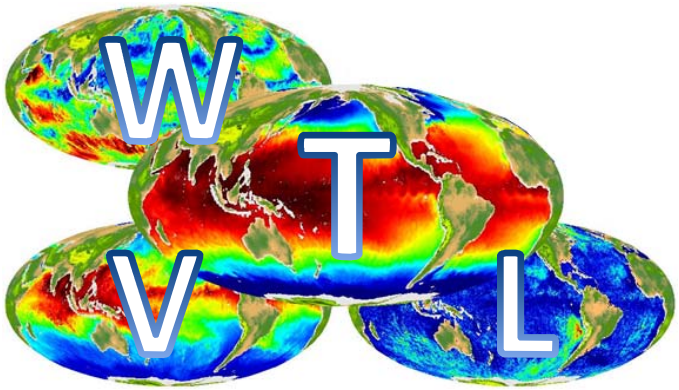
WindSat



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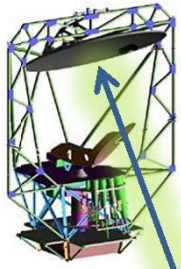
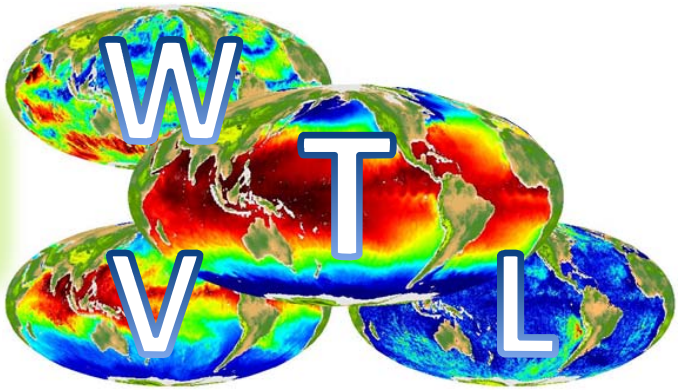


WindSat

T_B



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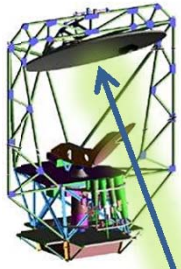
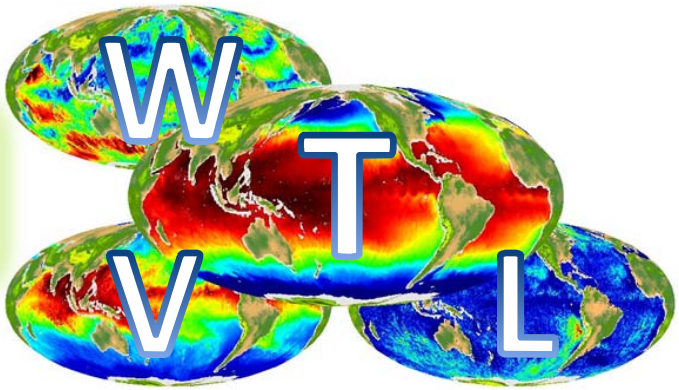
T_B

T_A



WindSat

T_B



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T_B

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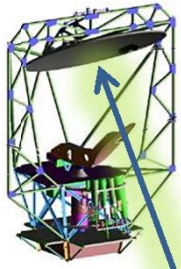
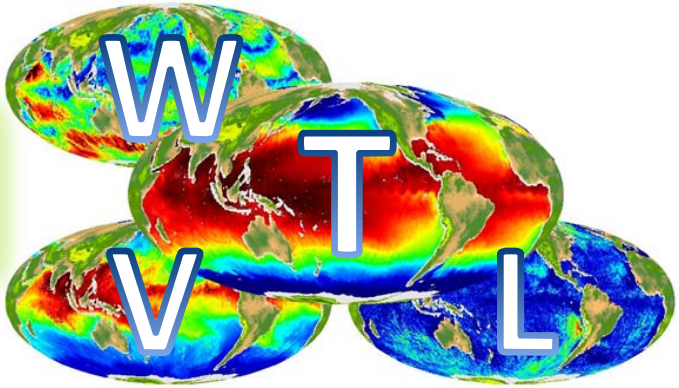


WindSat

RTM^{-1}

T,W,V,L



T_B

Remote Sensing Systems
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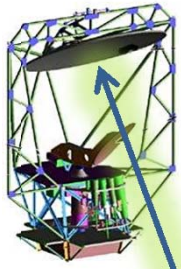
T_B

T_A

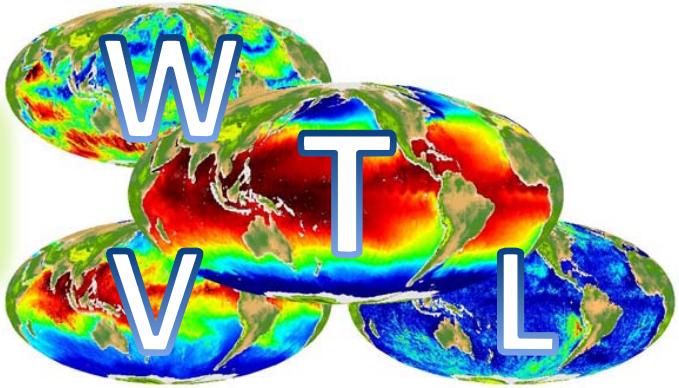


WindSat

RTM^{-1}

Adjust:
Frequency,
Incidence
Angle

T,W,V,L



T_B

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Global Change Observation Mission

NASA

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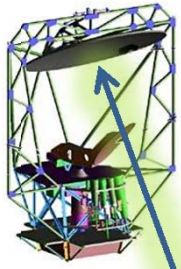
T_B

T_A



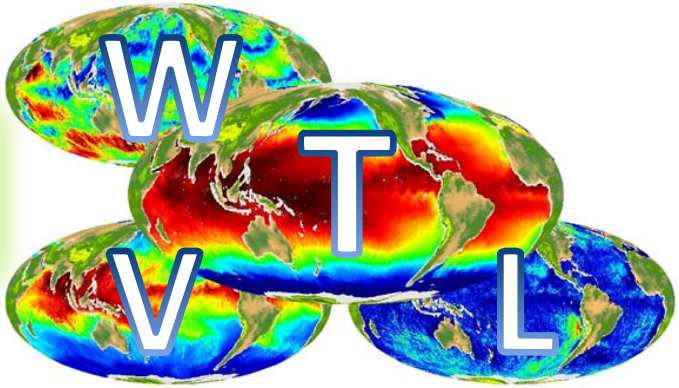
WindSat

AMSR-2

RTM^{-1}

Adjust:
Frequency,
Incidence
Angle

T,W,V,L



T_B

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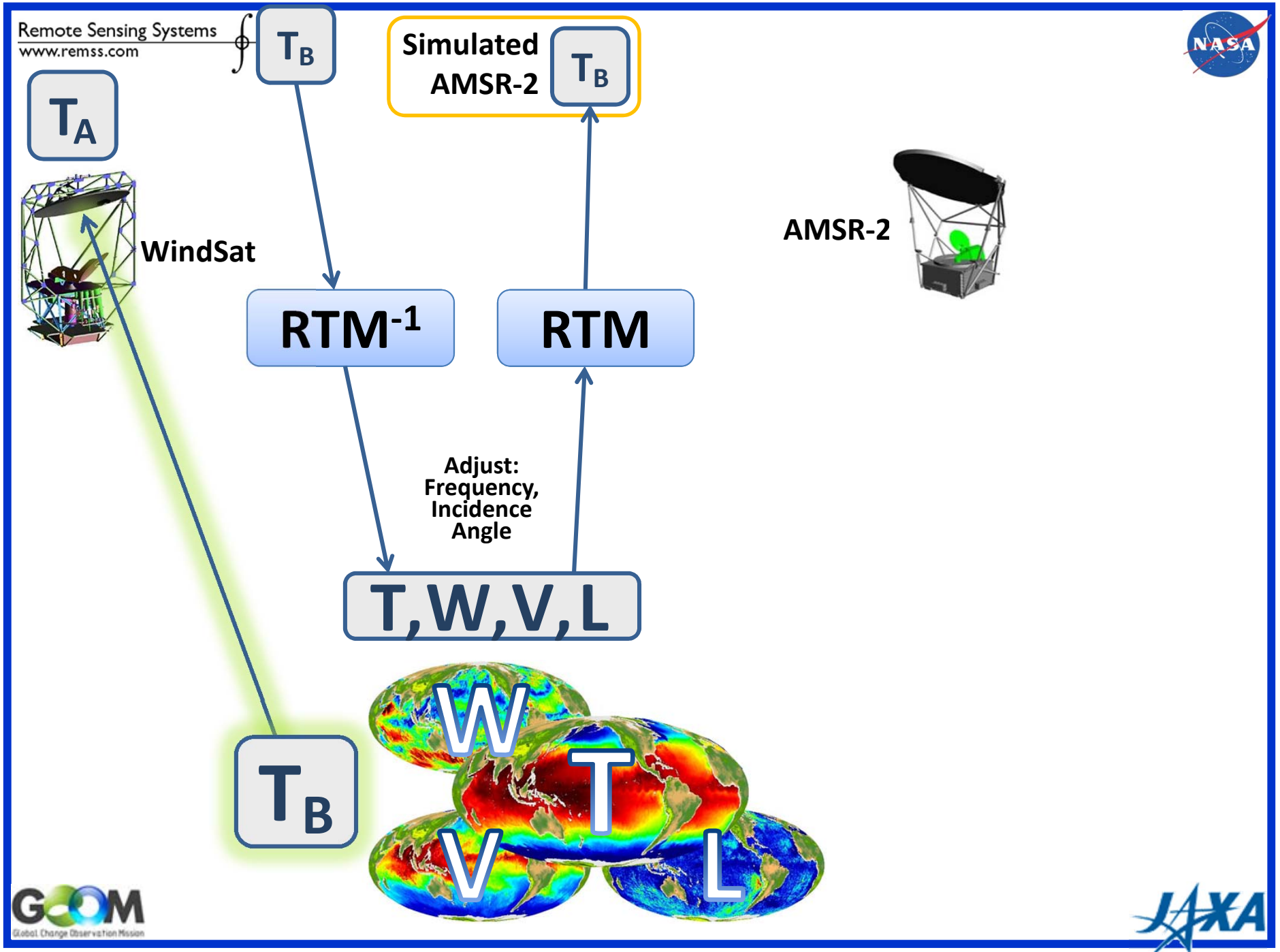
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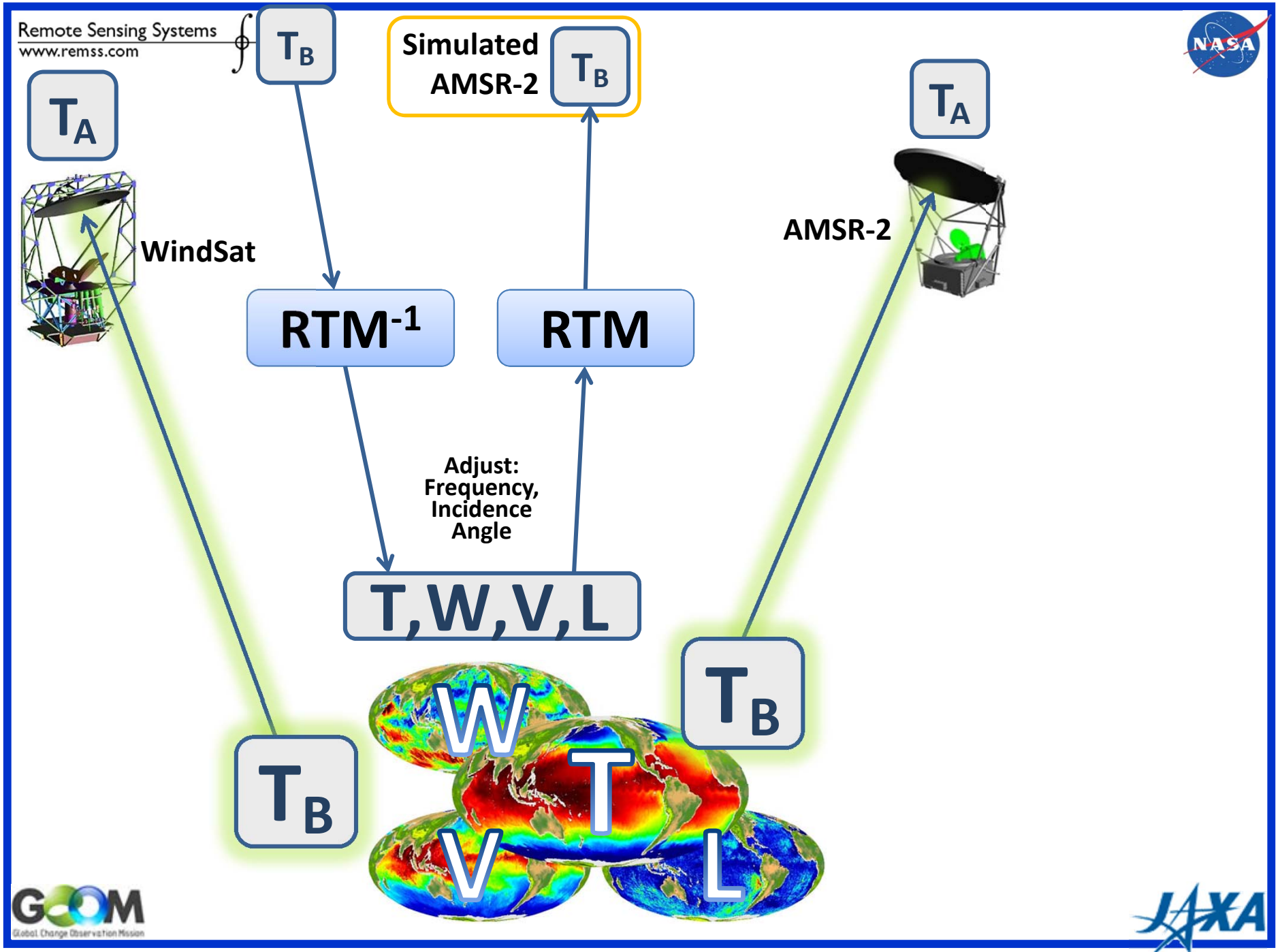
T_B
T_A
Simulated AMSR-2
T_B
WindSat
AMSR-2
RTM^{-1}
RTM
Adjust:
Frequency,
Incidence
Angle
T,W,V,L
W
T
V
L
T_B
GCOM
Global Change Observation Mission
NASA
JAXA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T_B
Simulated AMSR-2
T_B
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T_A
WindSat
AMSR-2
RTM^{-1}
RTM
Adjust: Frequency, Incidence Angle
T,W,V,L
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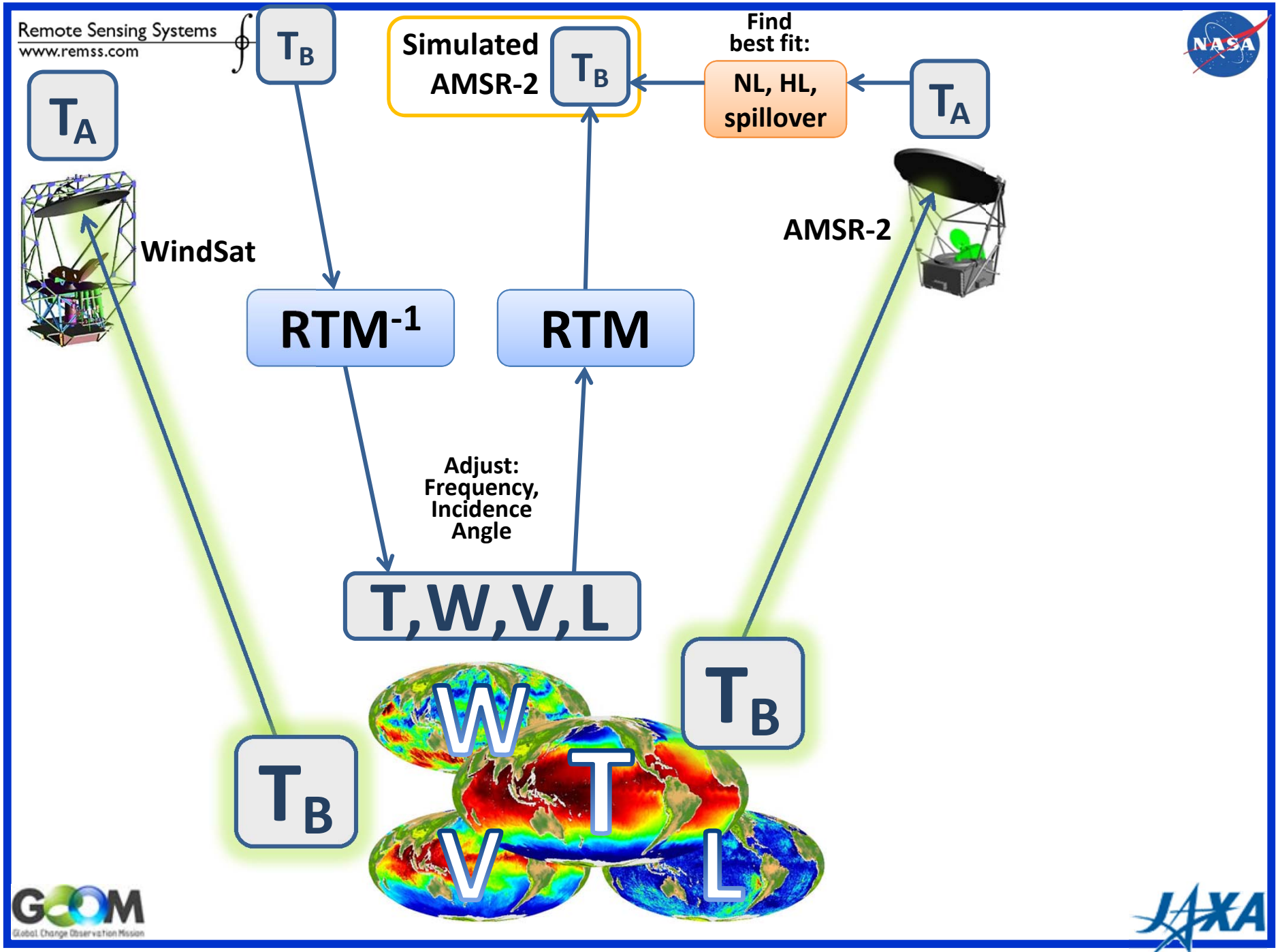
JAXA


Remote Sensing Systems
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T_B
T_A
WindSat
Simulated AMSR-2
T_B
Find best fit:
NL, HL, spillover
T_A
AMSR-2
RTM^{-1}
RTM
Adjust: Frequency, Incidence Angle
T,W,V,L
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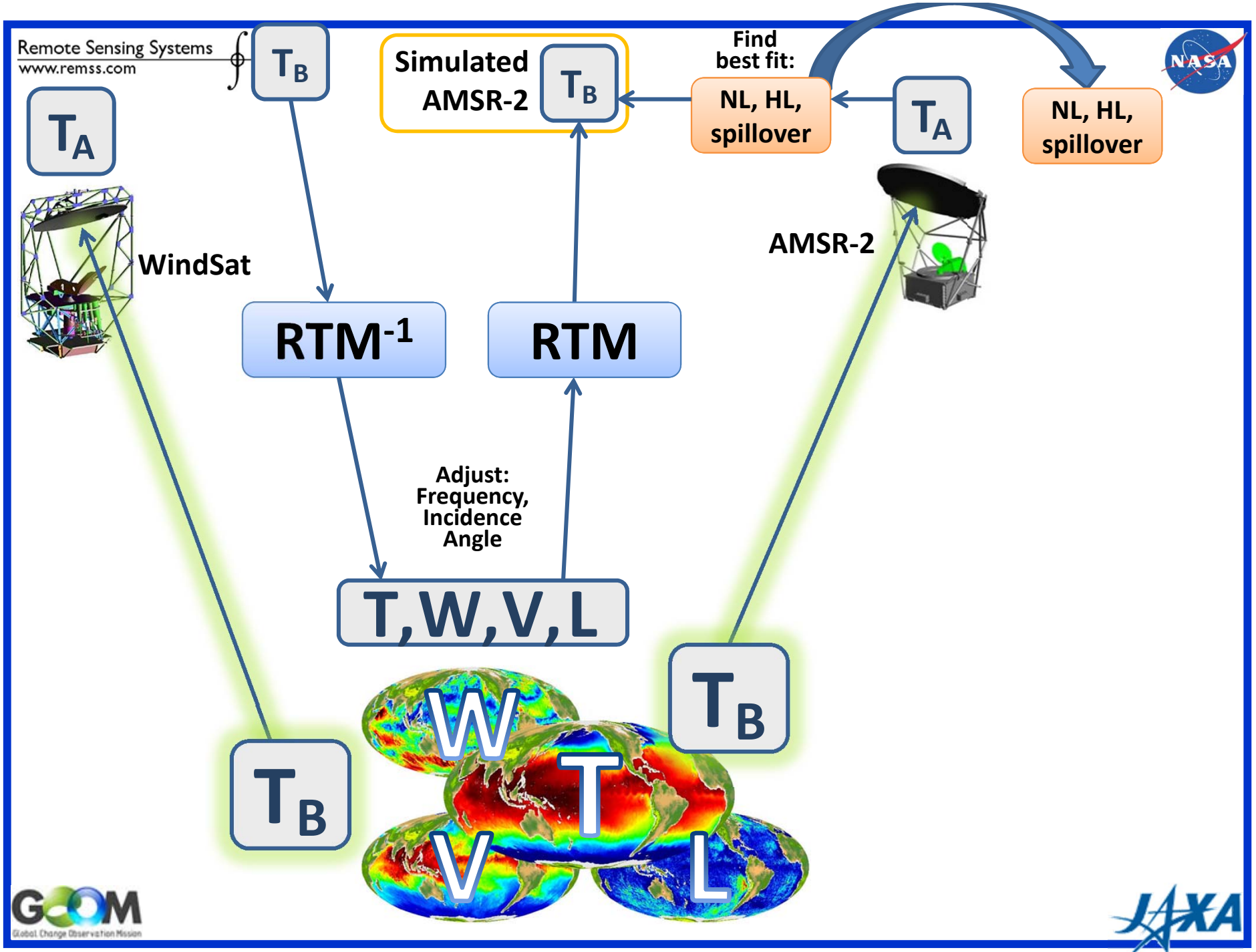
L
GCOM
Global Change Observation Mission
JAXA


Remote Sensing Systems
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T_B
Simulated AMSR-2
T_B
Find best fit:
NL, HL, spillover
T_A
NL, HL, spillover
T_A
WindSat
AMSR-2
RTM^{-1}
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Adjust: Frequency, Incidence Angle
T,W,V,L
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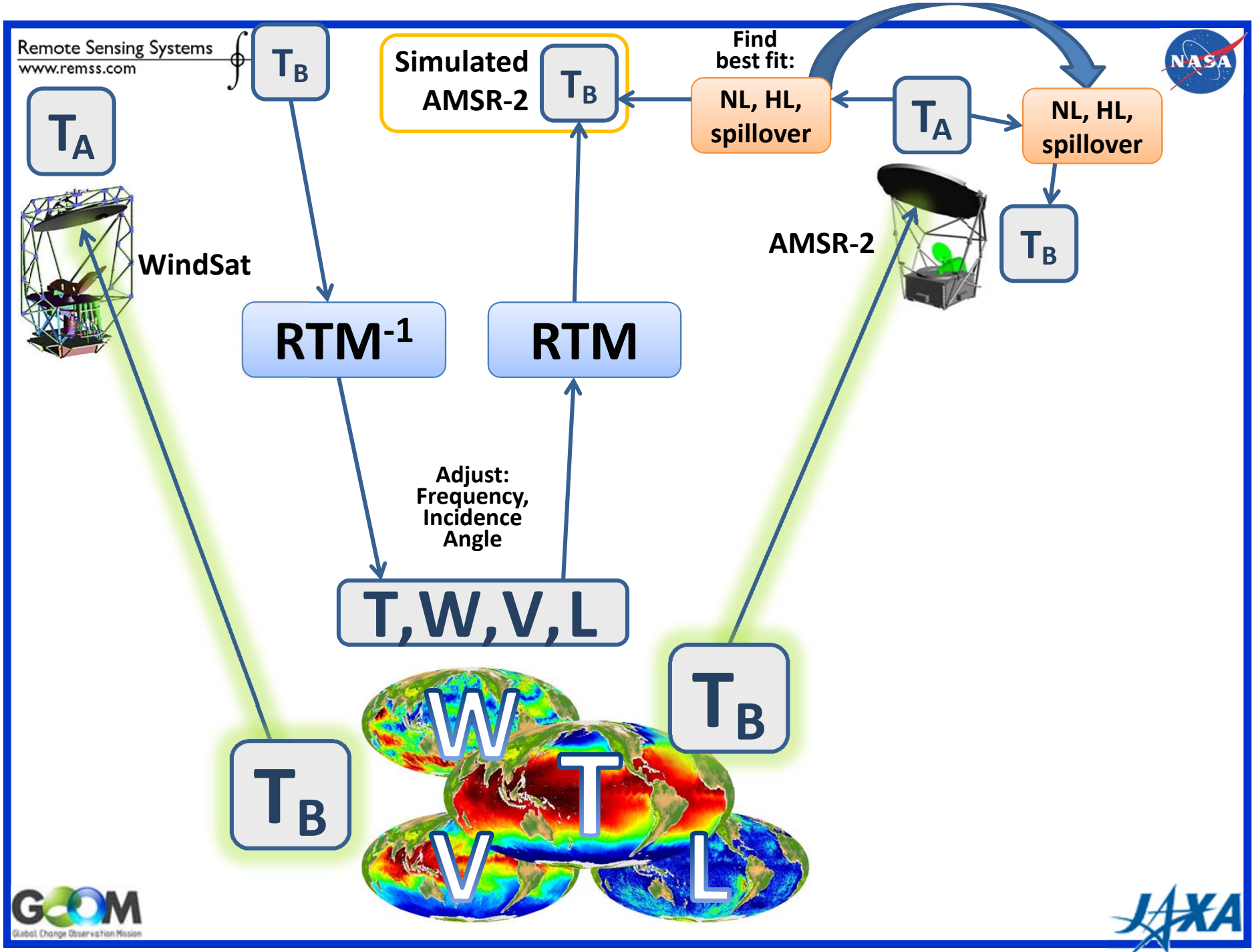
Remote Sensing Systems
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T_B
Simulated AMSR-2
T_B
Find best fit:
NL, HL, spillover
T_A
NL, HL, spillover
T_A
WindSat
AMSR-2
T_B
RTM^{-1}
RTM
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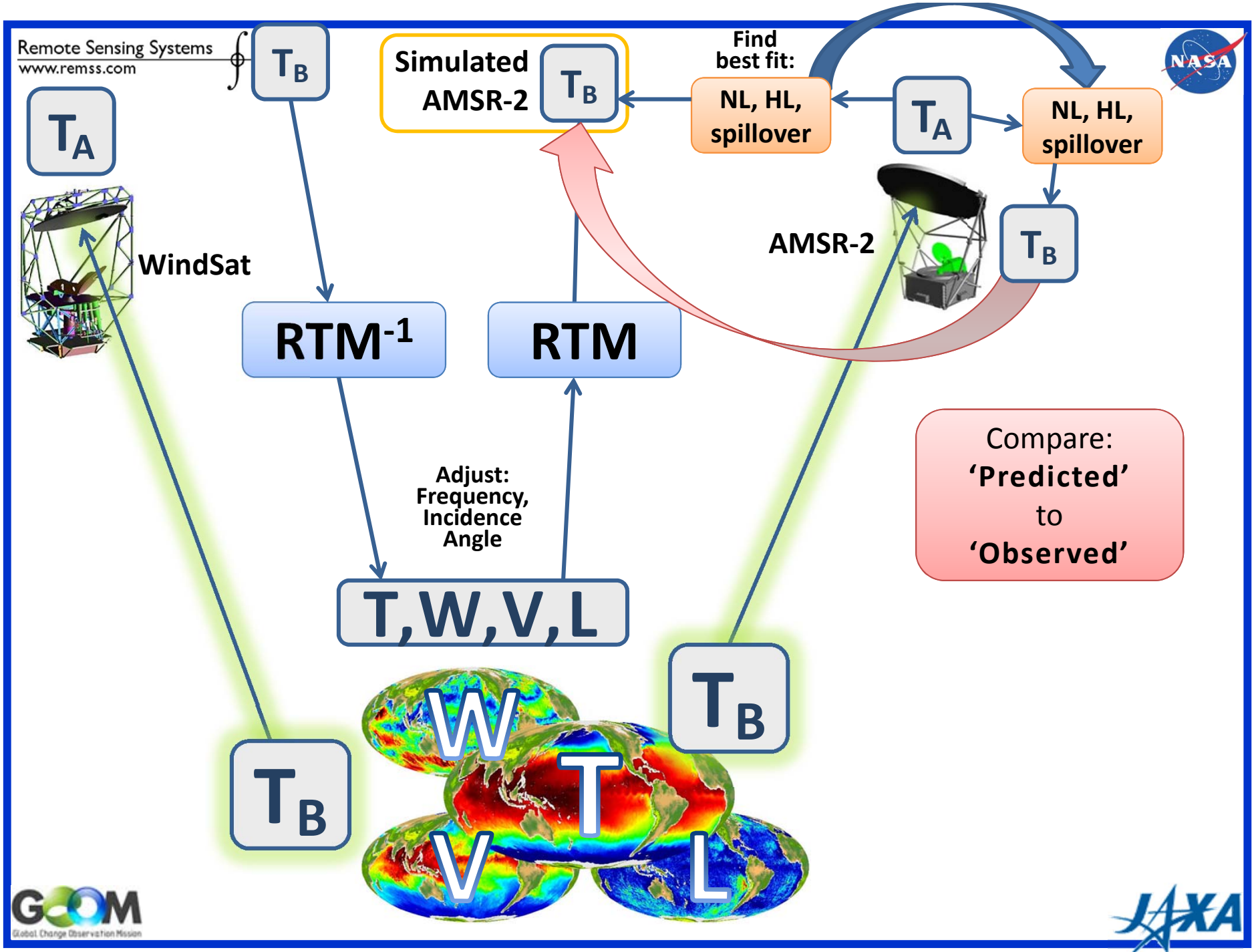
GOM
Global Change Observation Mission
JAXA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T_B
T_A
WindSat
Simulated AMSR-2
T_B
Find best fit:
NL, HL, spillover
T_A
NL, HL, spillover
AMSR-2
T_B
RTM^{-1}
RTM
Adjust: Frequency, Incidence Angle
T,W,V,L
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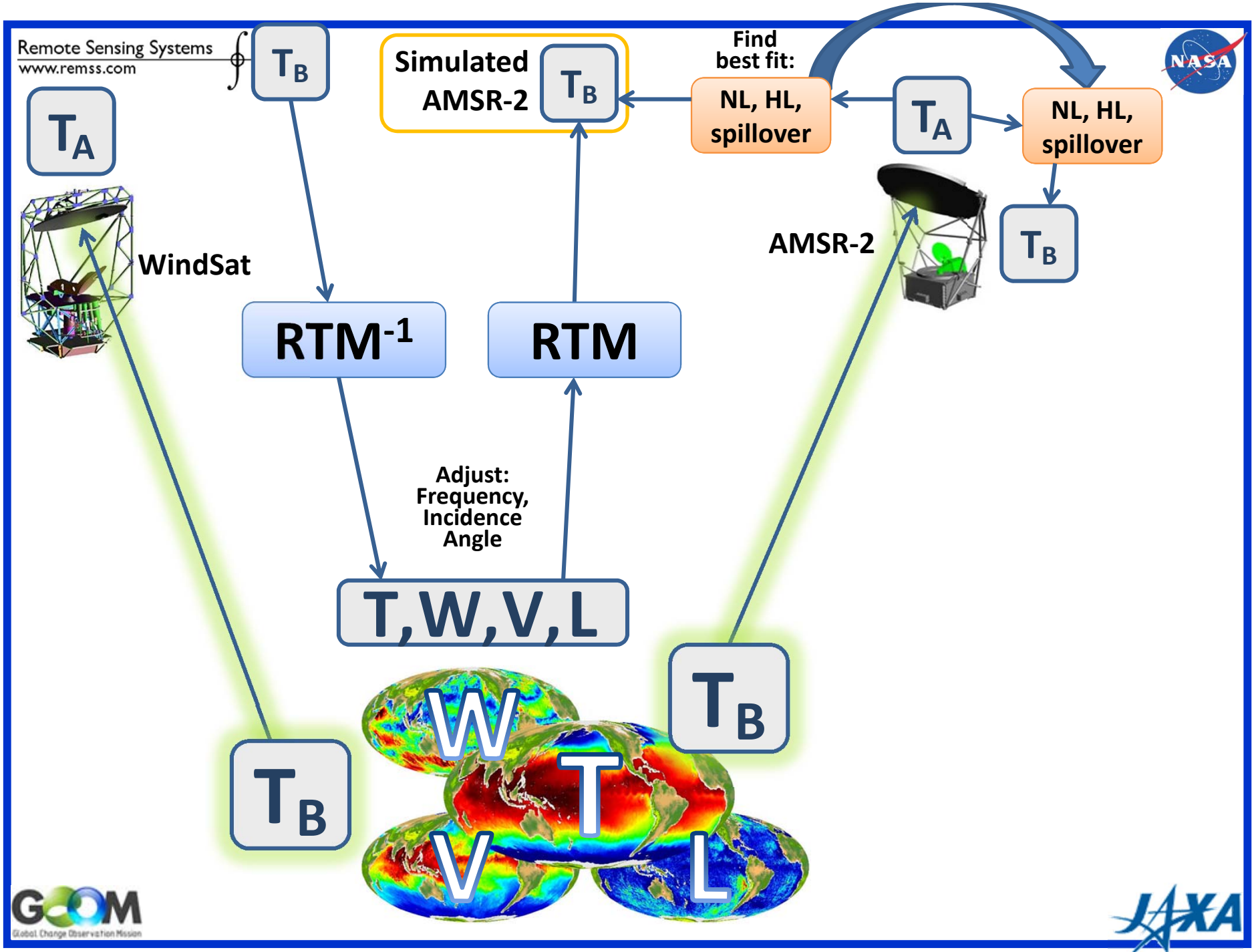
T_B
T_B
Compare: 'Predicted' to 'Observed'
GCOM
Global Change Observation Mission
JAXA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T_B
Simulated AMSR-2
T_B
Find best fit:
NL, HL, spillover
T_A
NL, HL, spillover
T_A
WindSat
AMSR-2
T_B
RTM^{-1}
RTM
Adjust: Frequency, Incidence Angle
T,W,V,L
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T_B
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V
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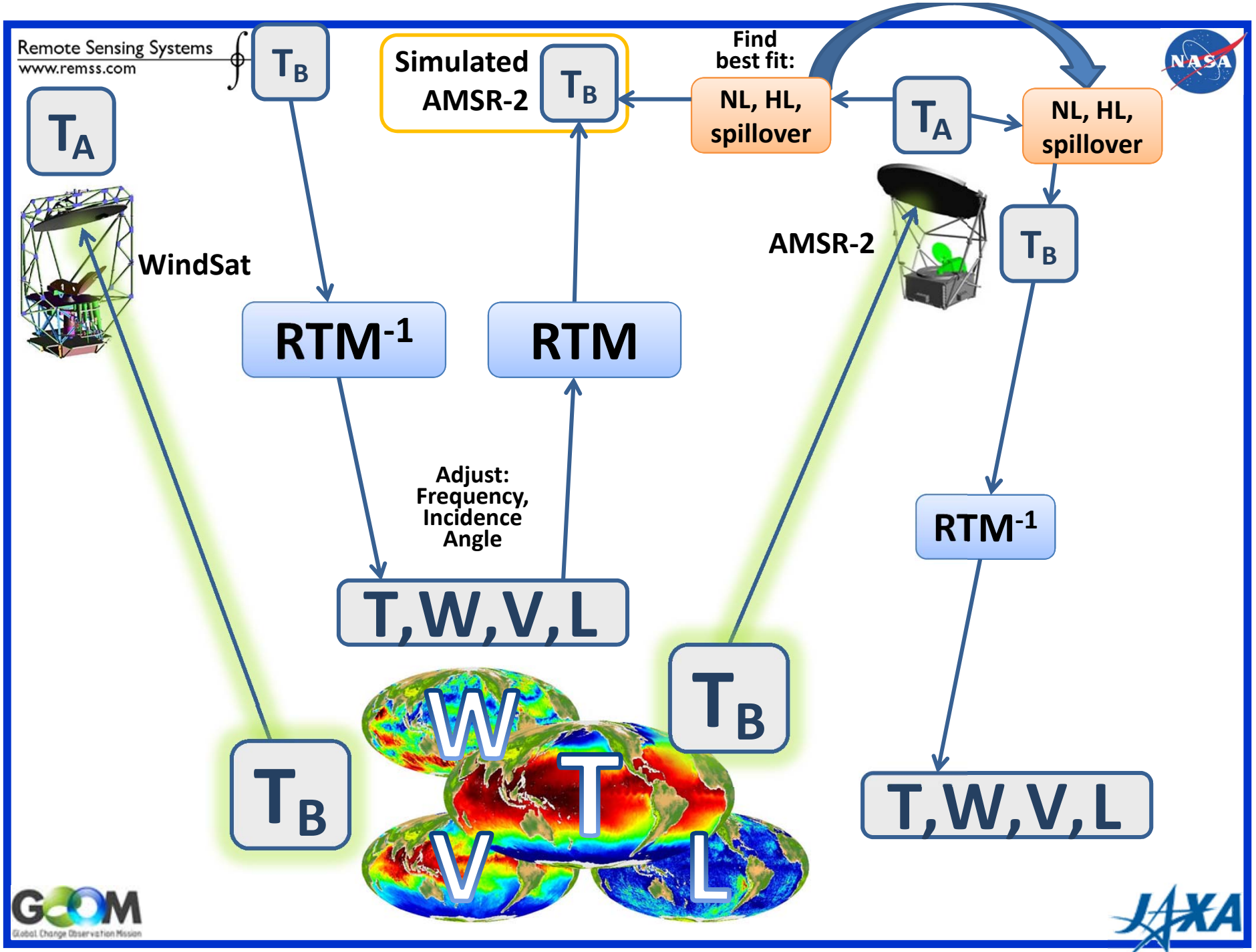
GOM
Global Change Observation Mission
JAXA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T_B
T_A
WindSat
Simulated AMSR-2
T_B
Find best fit:
NL, HL, spillover
T_A
NL, HL, spillover
AMSR-2
T_B
RTM^{-1}
RTM
Adjust: Frequency, Incidence Angle
T,W,V,L
T_B
T_B
W
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V
L
RTM^{-1}
T,W,V,L
GOM
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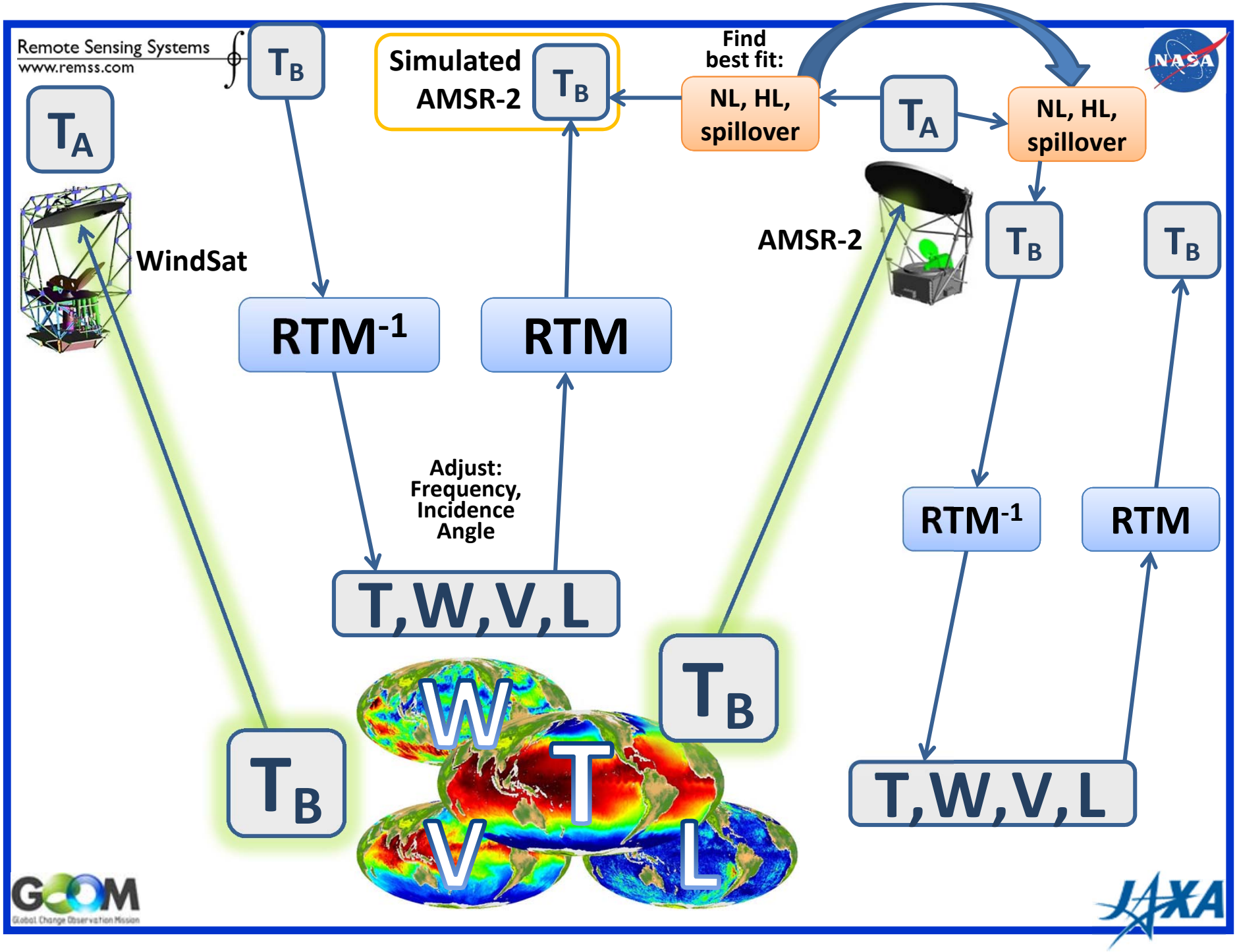
Remote Sensing Systems
www.remss.com
T_B
Simulated AMSR-2
T_B
Find best fit:
NL, HL, spillover
T_A
NL, HL, spillover
T_A
WindSat
AMSR-2
T_B
T_B
RTM^{-1}
RTM
Adjust: Frequency, Incidence Angle
RTM^{-1}
RTM
T,W,V,L
T_B
T_B
W
T
V
L
T,W,V,L
GCOM
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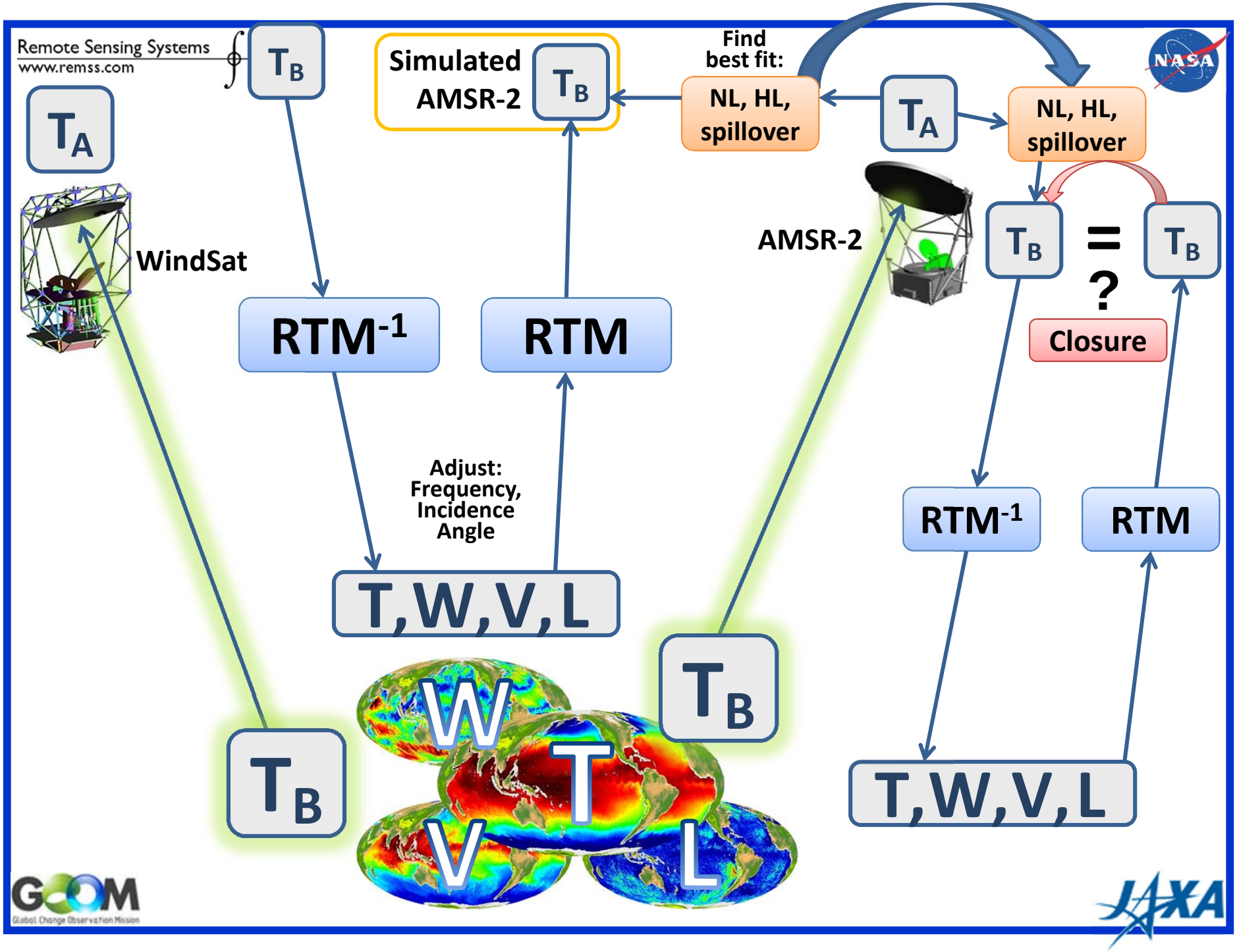
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RTM
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RTM Calibration Methodology

Ocean Radiative Transfer Model (RTM) is Calibration Reference for all MW Radiometers

- 0.2 K absolute (TBD), and 0.1 K relative
- Meissner and Wentz (2012): IGARSS Paper of the Year Award
- Publicly available

Inputs for RTM are the WindSat Retrievals of SST, Wind, Vapor, and Cloud (Rain excluded)

- WindSat is highly stable
- Observation period from 2003 to present
- Overlaps both AMSR-E and AMSR-2 and hence serves as a Calibration Bridge
- Ocean retrievals have been thoroughly validated
- Co-location window (6:00 AM -> (~4.5 hours) -> 1:30 AM)
  - 1:30 PM <-> 6:00 PM not used (large diurnal variability)

RTM[T,W,V,L from WindSat] ➔ Simulated AMSR-2 Brightness Temperatures

Amazon Forest calibration needed because of Receiver Non-Linearity.

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Calibration Model

$$T'_A = T_A + \sum_{i=1}^{5} a_i x^i$$

$$T_B = f_{APC}\left(T'_{AV}, T'_{AH} \middle| \delta, \chi\right)$$

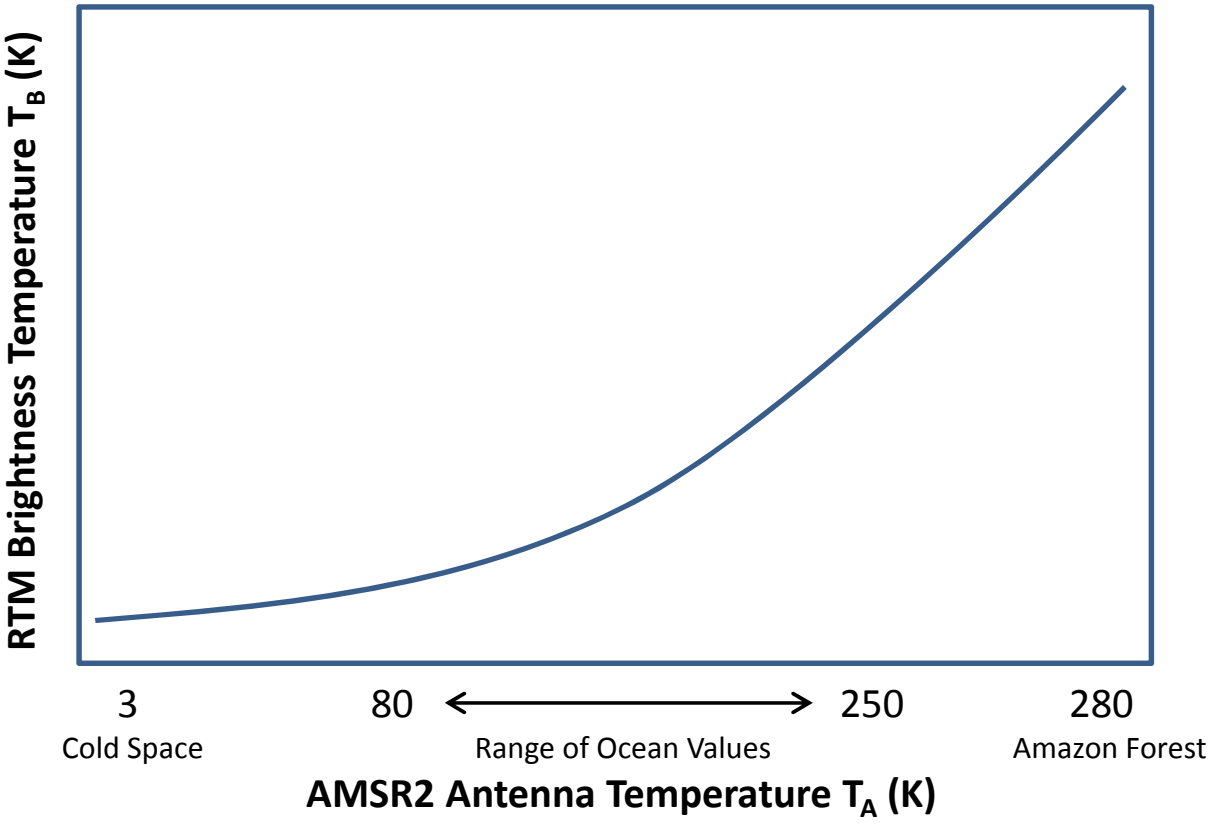
$$x = \frac{T_A - T_C}{T_A - T_H}$$

$$\sum_{i=1}^{5} a_i \equiv 0$$

Calibration Parameters

- Non-Linear coefs: $a_{1\text{-}5}$
- Hot Load Offset
- Antenna Spillover δ

- Cross-Pol NOT adjusted



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Hot Load Offset and Antenna Spillover Adjustments

Hot Load Temperature Offset: -1.3 K

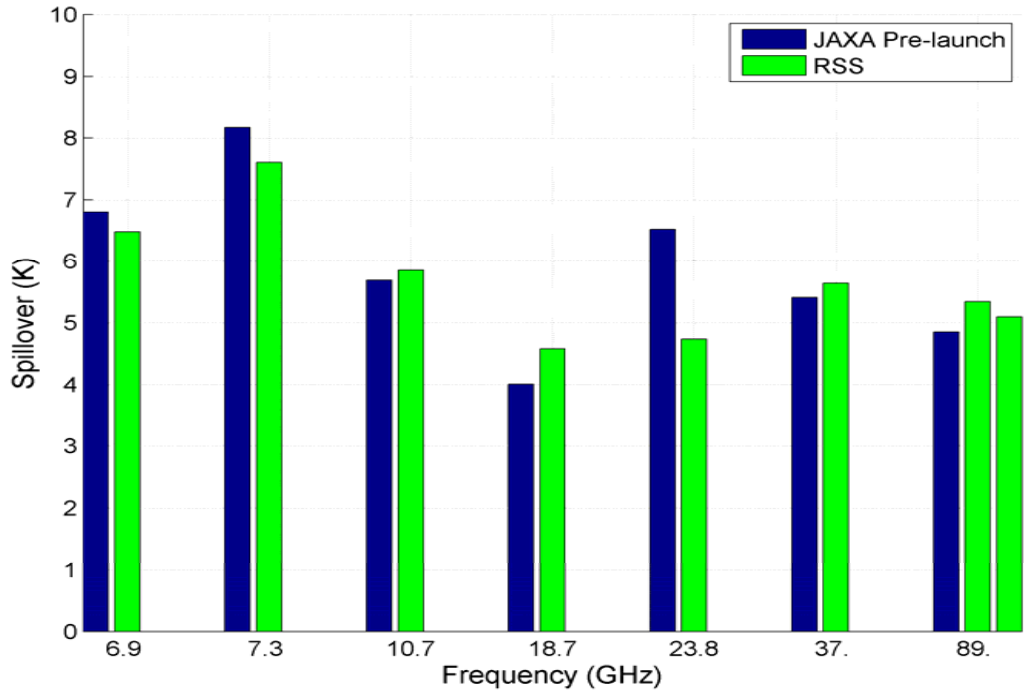
Adjustments to the antenna spillover value has the same effect as adding an offset to the hot load temperature.

A single hot load offset for all channels is found that minimizes the required changes to the spillover values.

The adjustment for AMSR2 is to subtract 1.3 K from the temperature reported by the hot load thermistors.

This adjustment is consistent with the -1.0 K offset found for previous radiometers

Spillover Adjustments (290 K times fractional spillover value)



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Brightness Temperature (TB)
Validation/Evaluation of Calibration

- In-Situ comparisons not available, so use a variety of methods, including, but not limited to…

- Amazon Canopy (~ land temperatures)
  - compare monthly/yearly averages: AMSR-2 TB <-> TB WindSat, SSMIs

- Ocean Comparisons

  1. Observed AMSR-2 – AMSR-2 Predicted by WindSat:
     Measured AMSR-2 TB (NL, HL, δ) <-> Simulated AMSR-2 TB (RTM(WSAT(T,W,V,L)))

     Look at Mission Plots for V, H:
     - before vapor+cloud adjustment
     - after vapor+cloud adjustment
     - zoom in, look for systematic errors

  2. Observed AMSR-2 – AMSR-2 Predicted by AMSR-2:
     Measured AMSR-2 TB (NL, HL, δ) <-> Simulated AMSR-2 TB (RTM(AMSR-2(T,W,V,L)))
     aka "Closure Analysis"

     Look at Earth Gridded mission averages:
     - ascending
     - descending minus ascending

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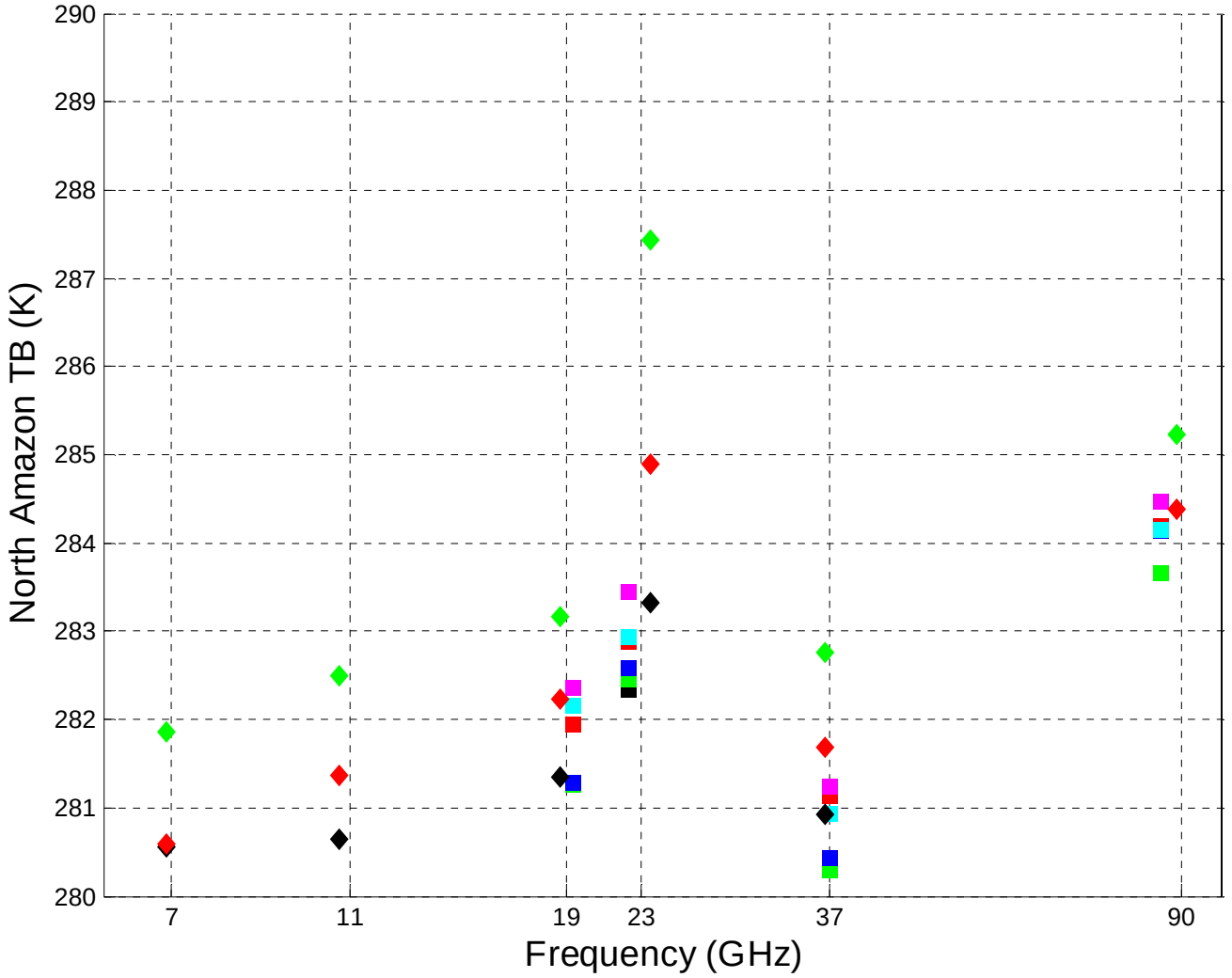
Amazon Forest Calibration

Before Adjusting Hot-Load Temperature, APC, and Non-Linear Correction



AMSR-2

WSAT

AMSR-2

WSAT

Black diamonds are WindSat. Red diamonds are AMSR-E. Green diamonds are AMSR-2.
Colored squares are the 6 SSM/Is
Same months used for averages, but averaging years are different.

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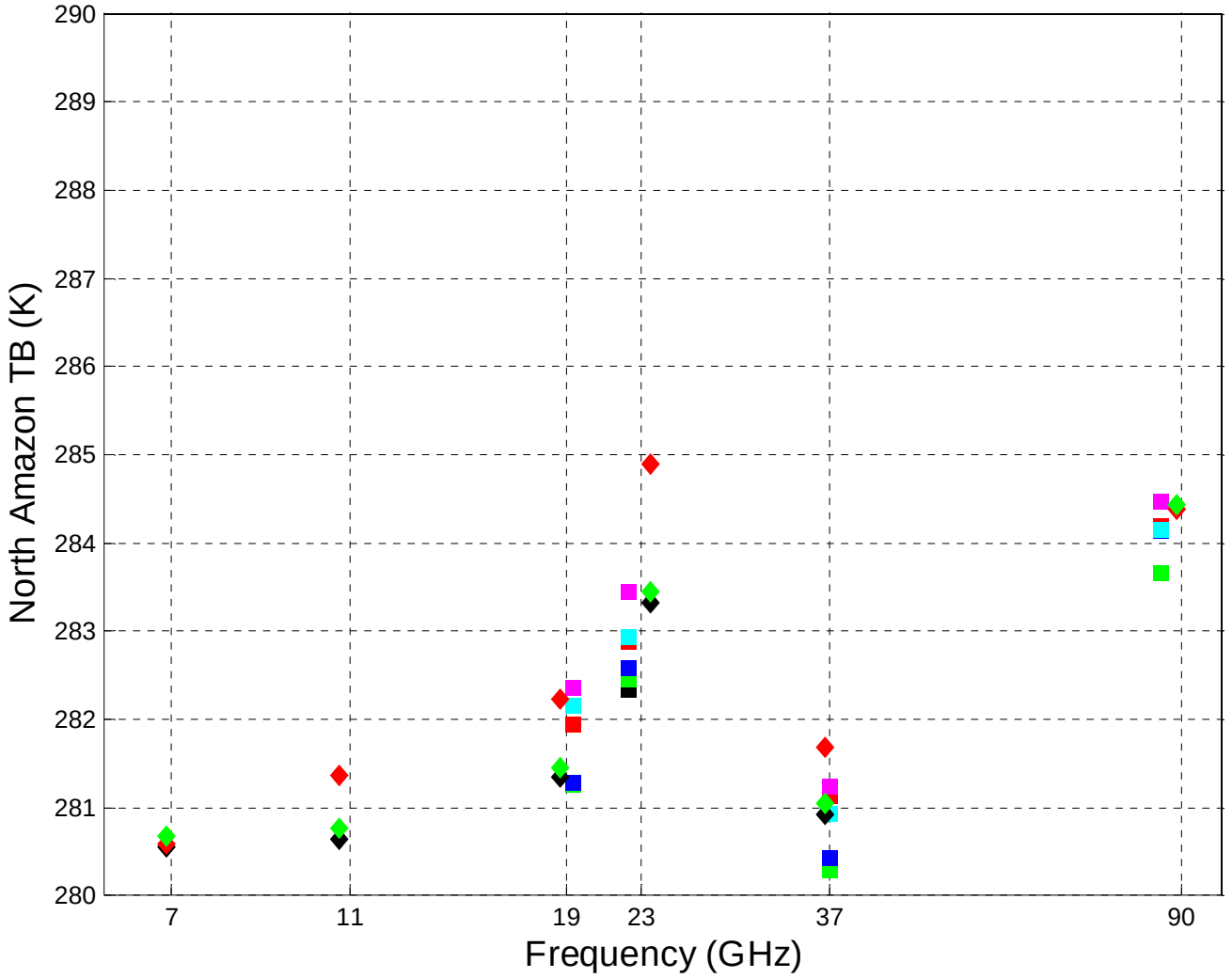
Amazon Forest Calibration

After Adjusting Hot-Load Temperature, APC, and Non-Linear Correction



WSAT

WSAT

Black diamonds are WindSat. Red diamonds are AMSR-E. Green diamonds are AMSR-2.
Colored squares are the 6 SSM/Is
Same months used for averages, but averaging years are different.

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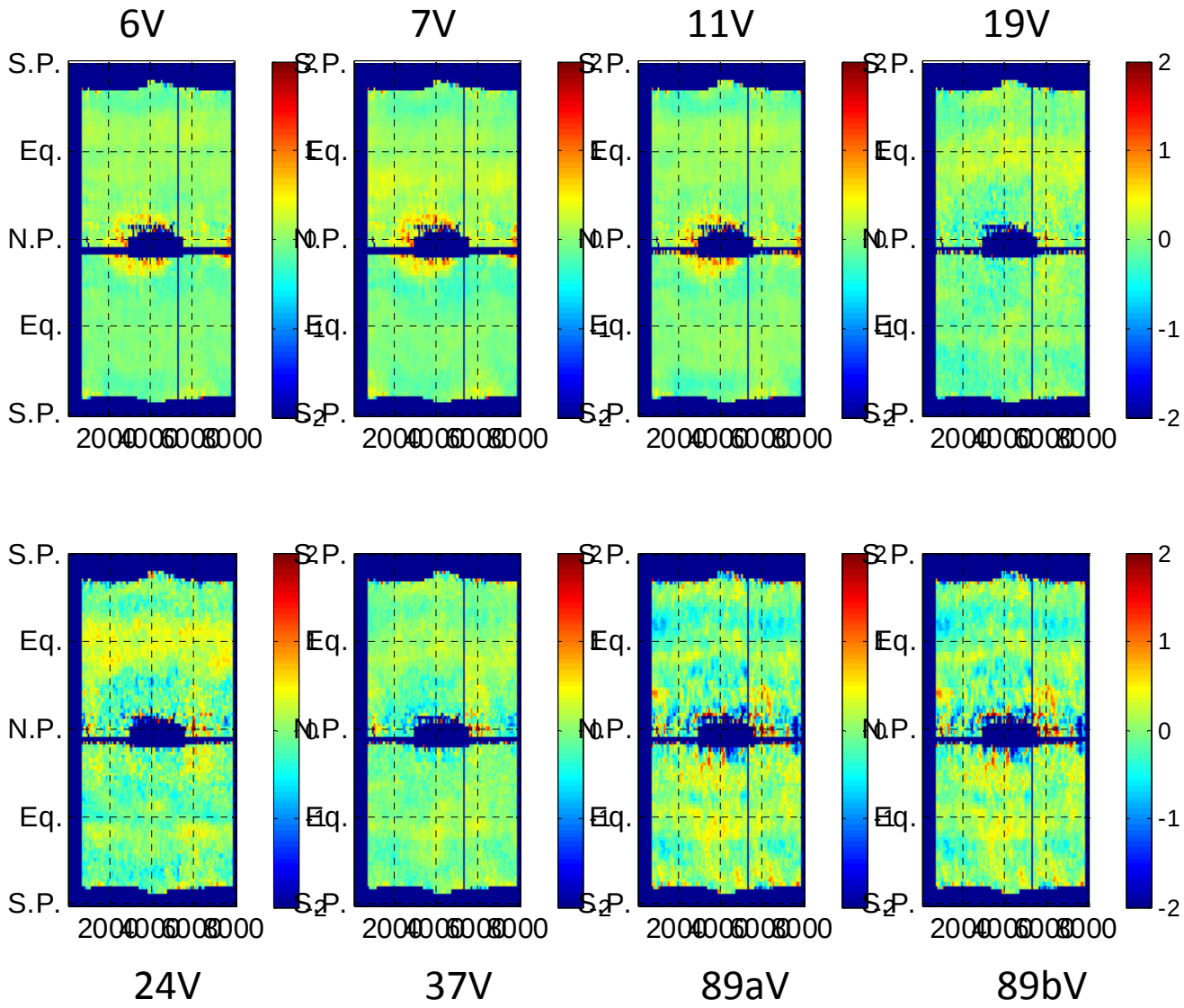
AMSR-2 TB Minus RTM(WindSat T,W,V,C) TB Over Ocean

Before Vapor/Cloud Adjustment



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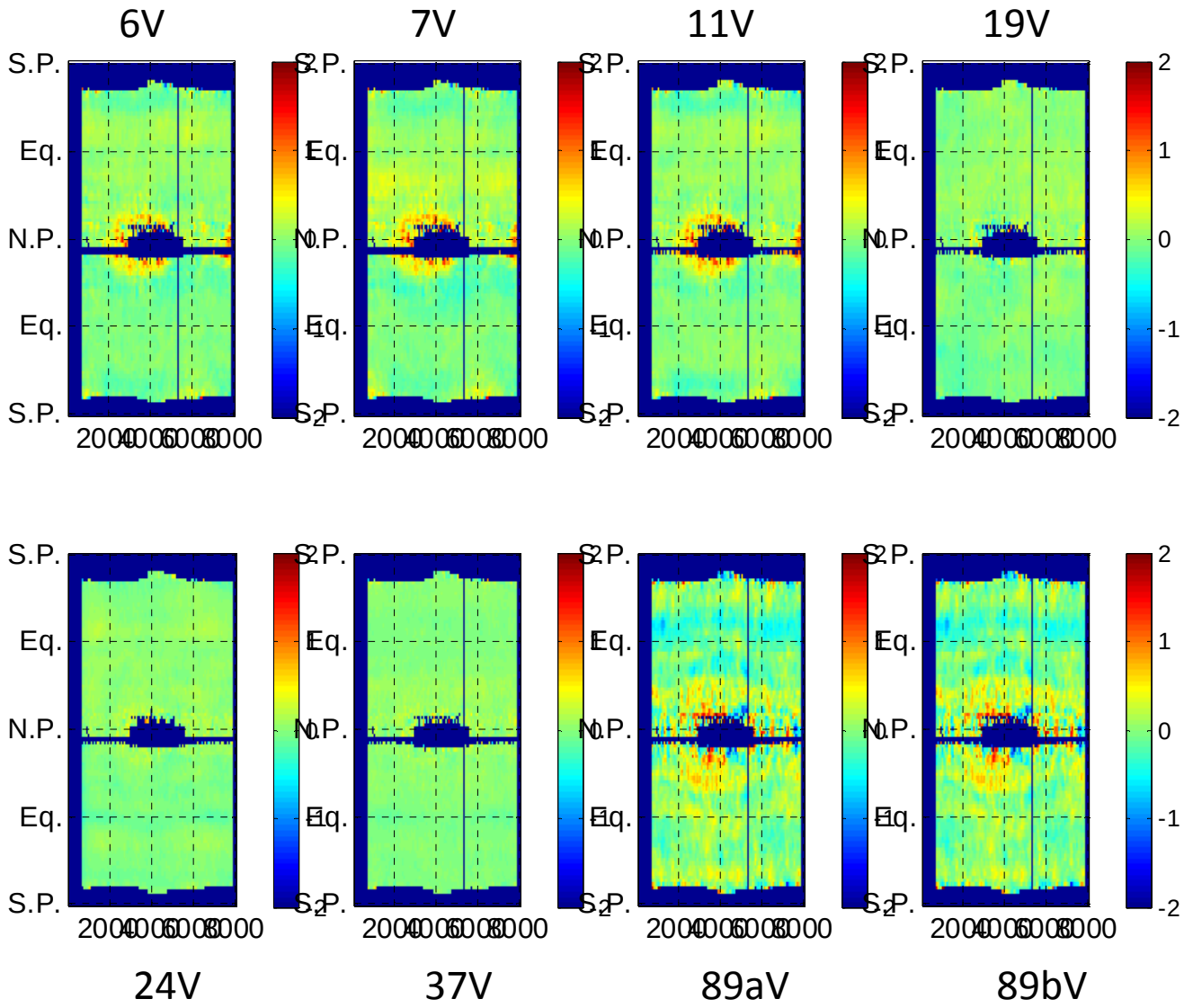

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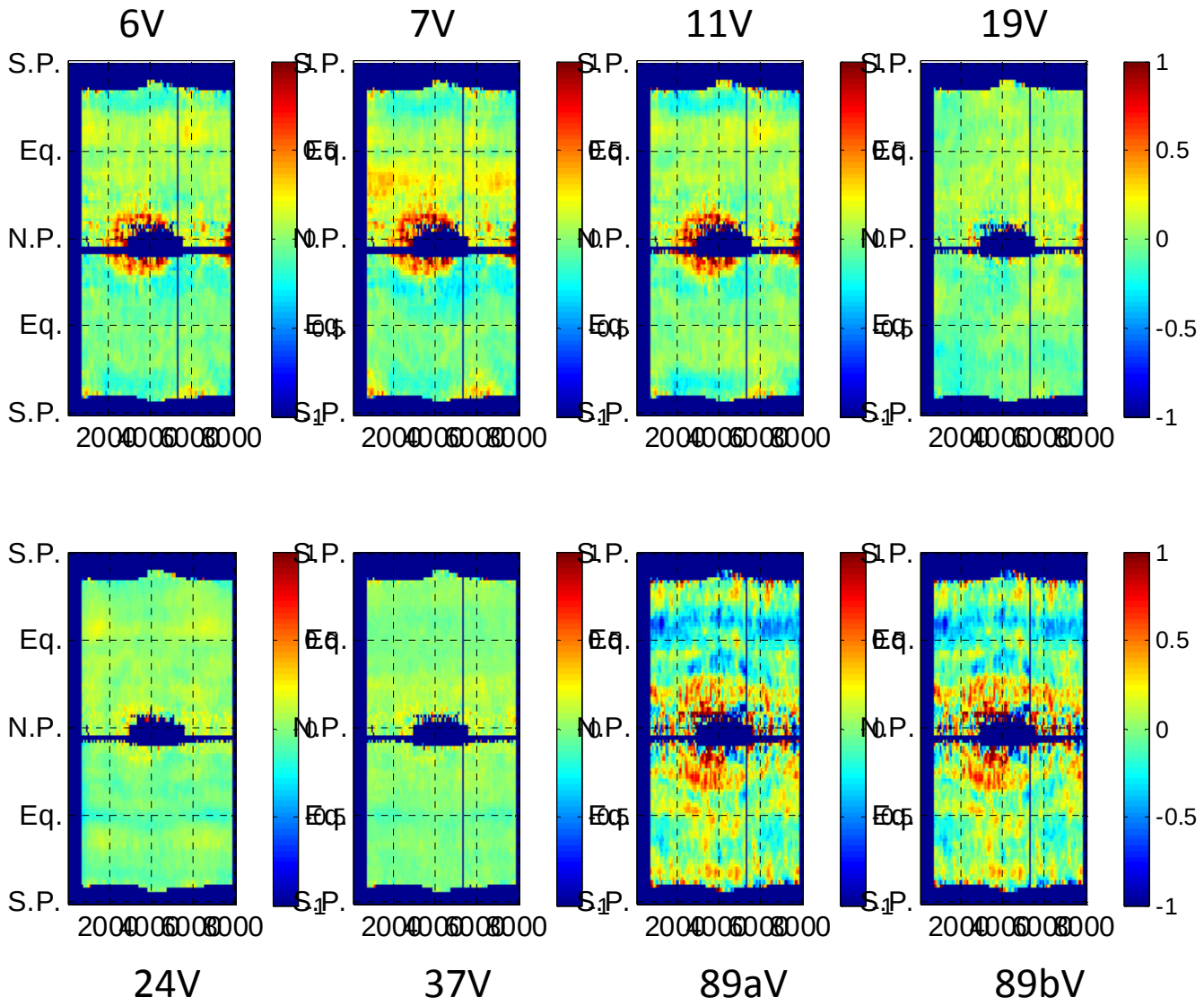

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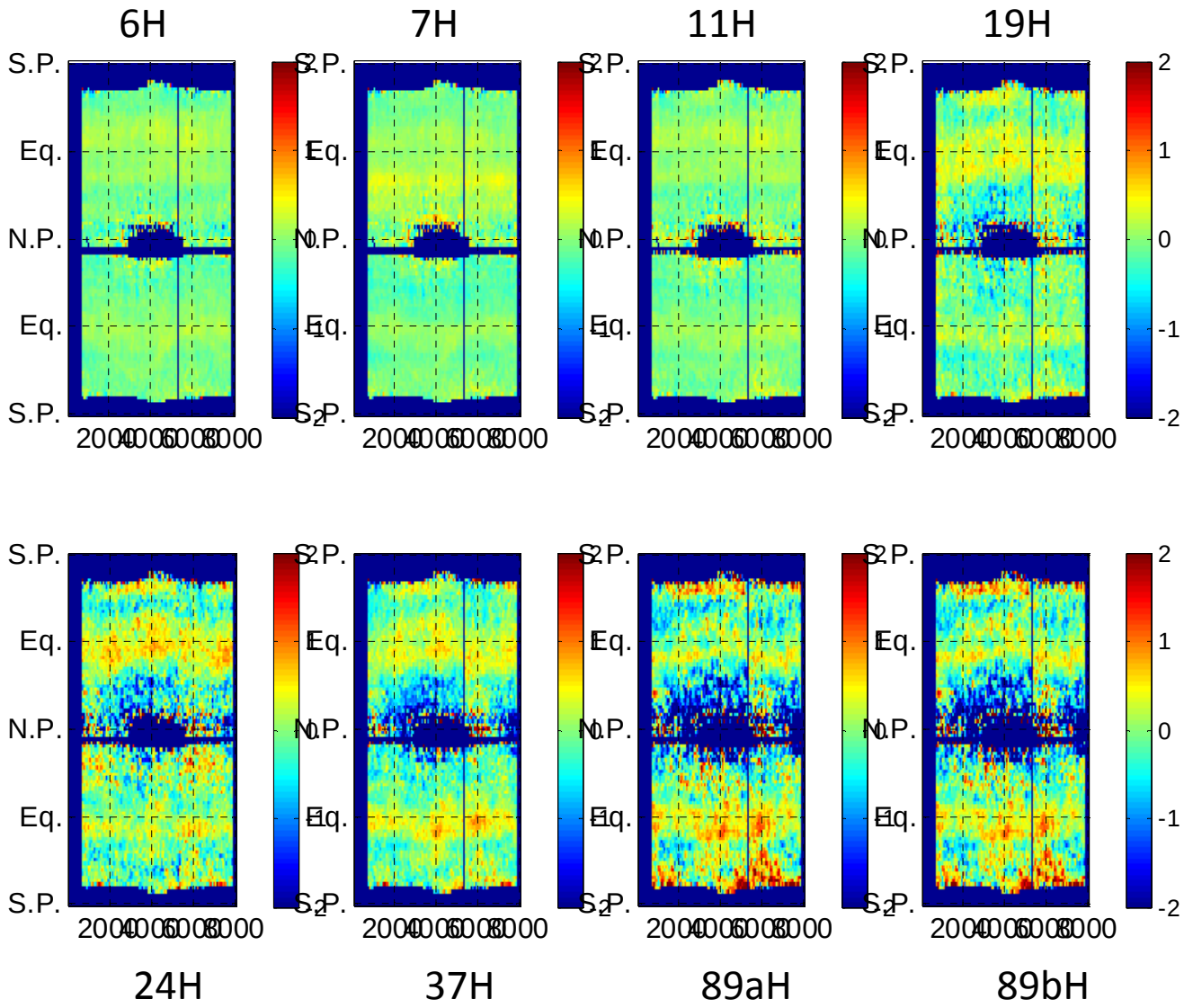

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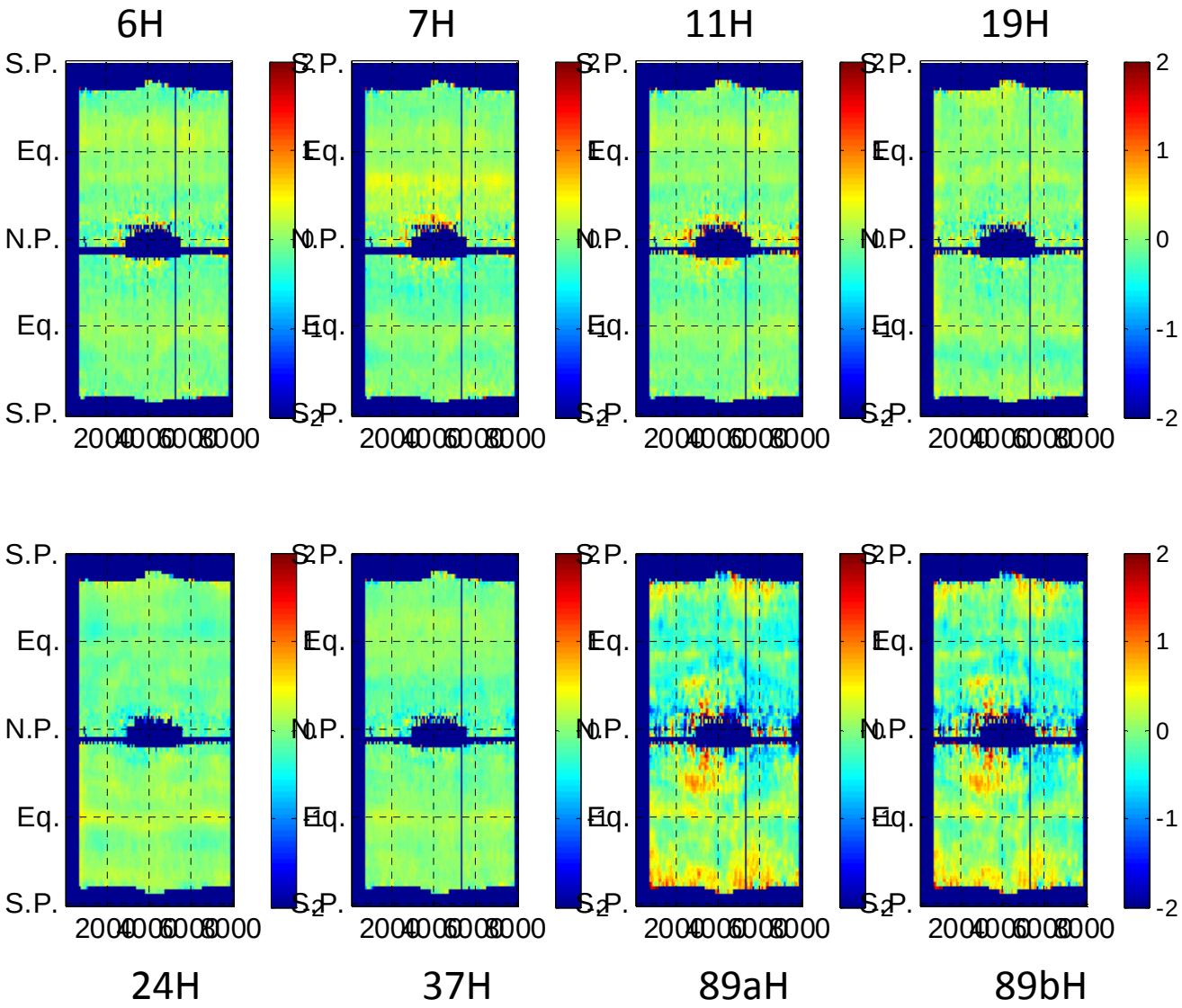

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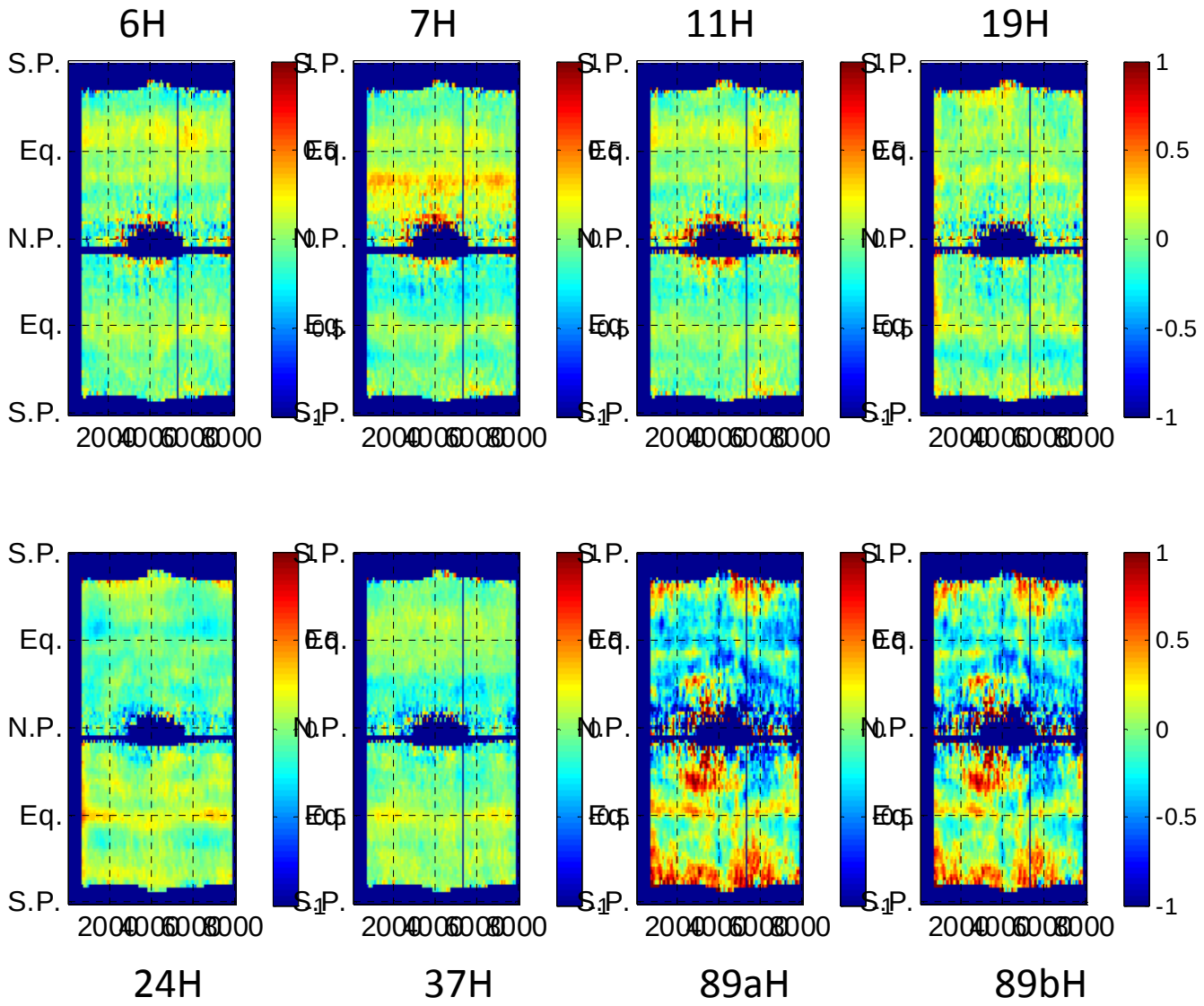

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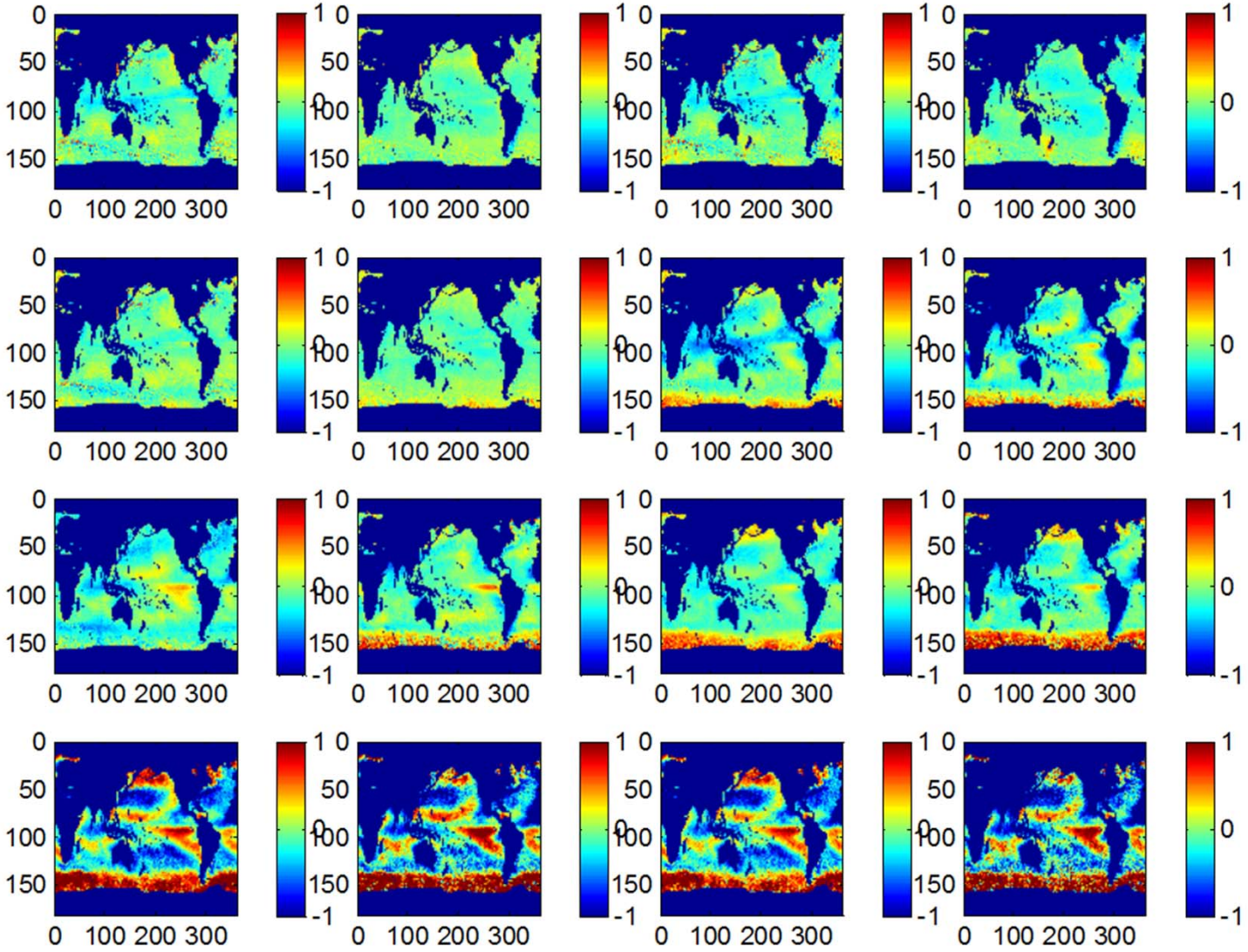
Closure Analysis:

AMSR-2 TB minus RTM with AMSR-2 Ocean Retrievals

Each image shows a separate channel.

All 16 channels are shown.



Only Ascending Orbit Segments

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Closure Analysis:

AMSR-2 TB minus RTM with AMSR-2 Ocean Retrievals

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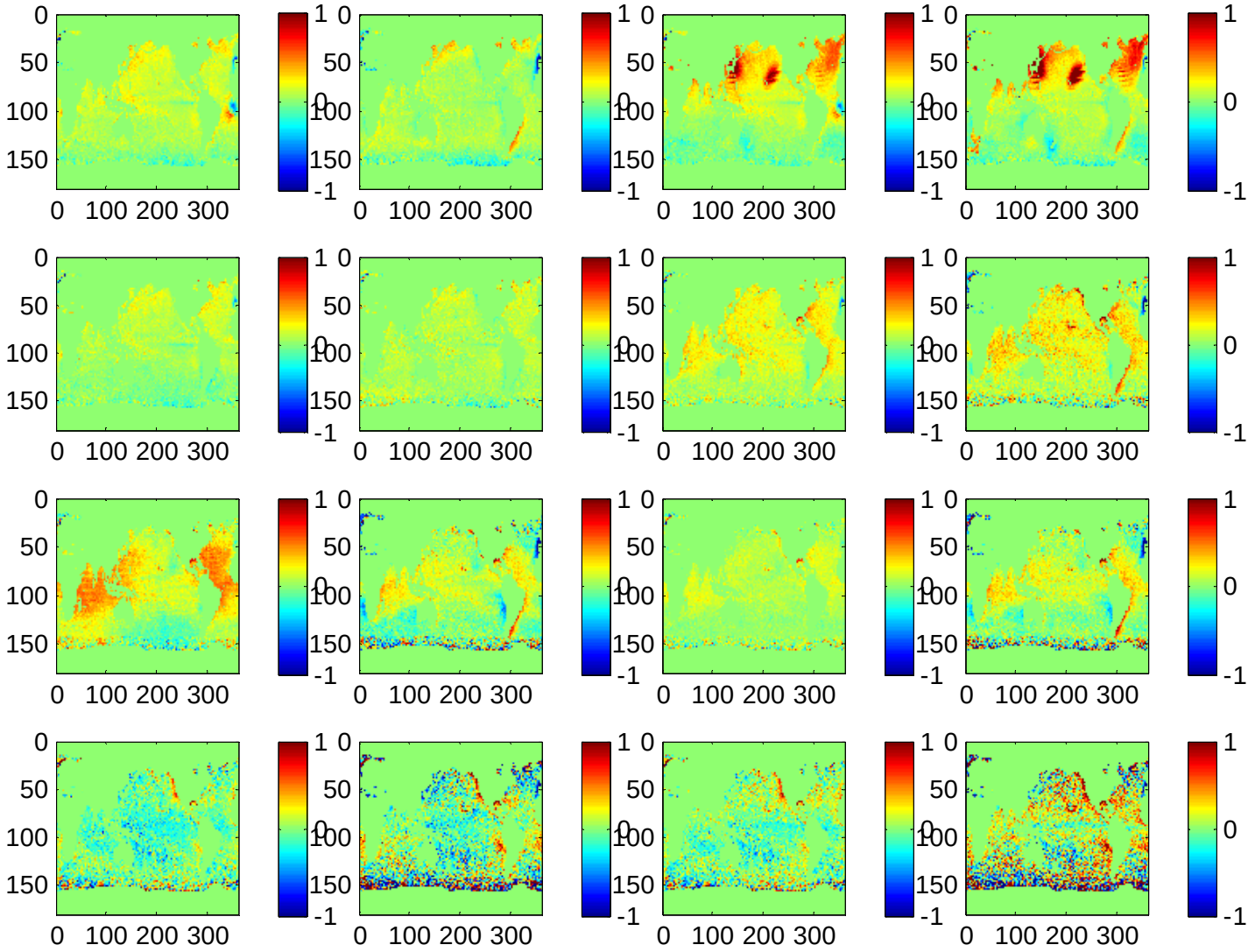

Descending Minus Ascending Orbit Segments

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Summary

- Most calibration issues for AMSR-2 are typical for satellite microwave radiometers
- Receiver non-linearity is a bit unusual and needs to be better understood
- First Round of T_B Calibration is completed
- Ocean Products have been Validate with other satellite retrievals and buoys
- Ocean Products will be available for download at www.remss.com in late January, 2014
  - ftp://ftp.remss.com/amsr2
- RFI Continues to be worrisome but Adaptive Mitigation Strategies are being employed

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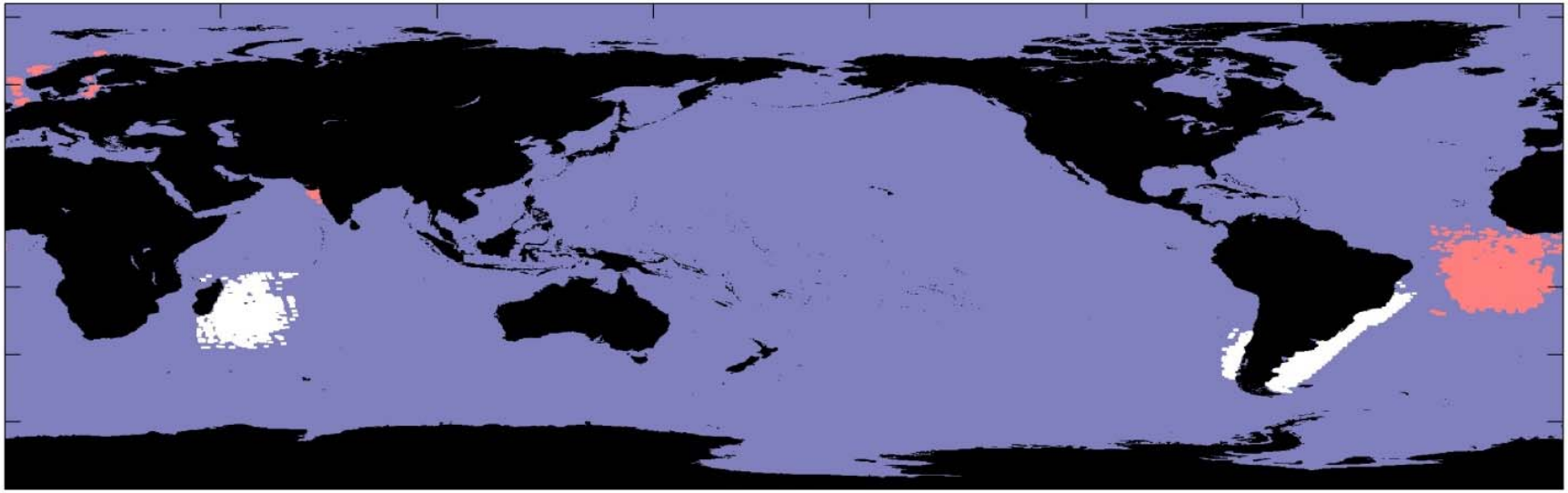
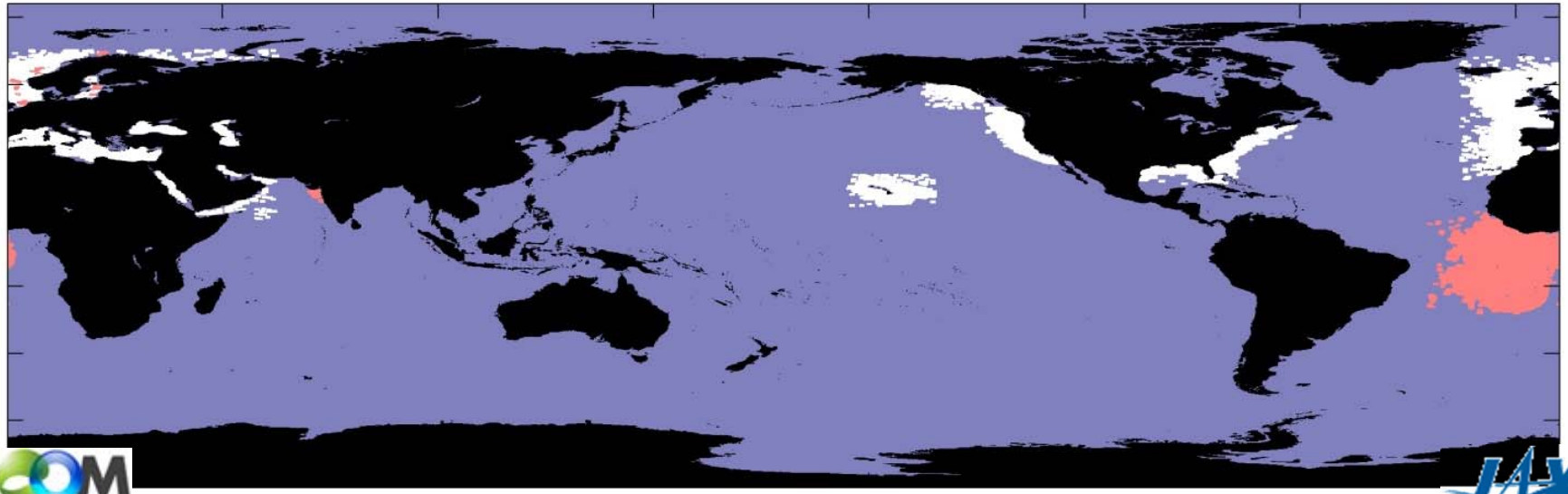
Ascending RFI Mask



Descending RFI Mask



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6.9GHz Space-Based Ocean-Reflected RFI

- **Ocean Reflected**
  - **Highly correlated with surface roughness**
- **Not Geostationary**
  - **Both ascending and descending passes**
- **6.9 GHz**
  - **SST only**
- **Identified by JAXA in AMSR-E many years ago?**
  - **Satellite Telephone Service?**
- **7.3 GHz to the rescue?**

Next 5 slides:
Cherry-picked example AMSR-2 2013.Jan.26-28

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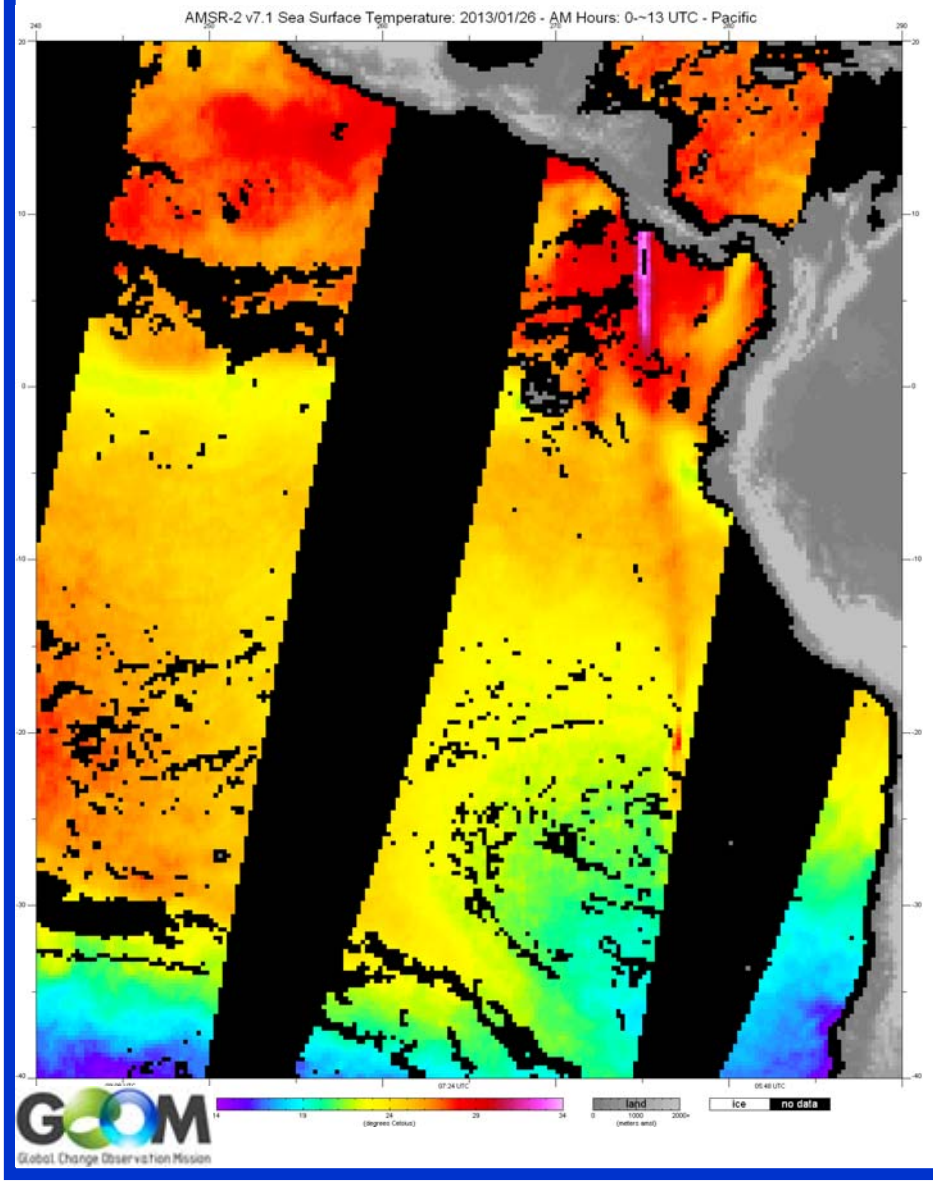
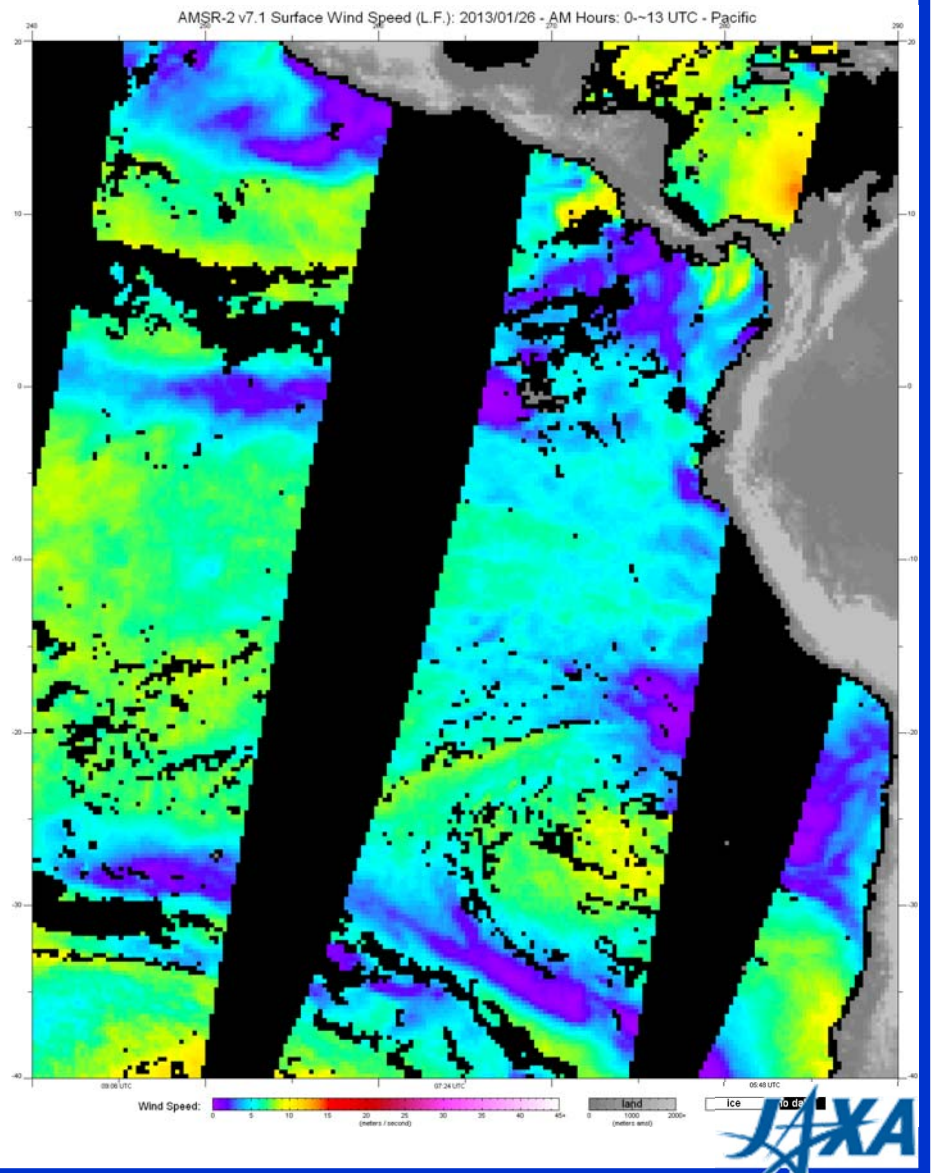
6.9GHz Space-Based Ocean-Reflected RFI

Night





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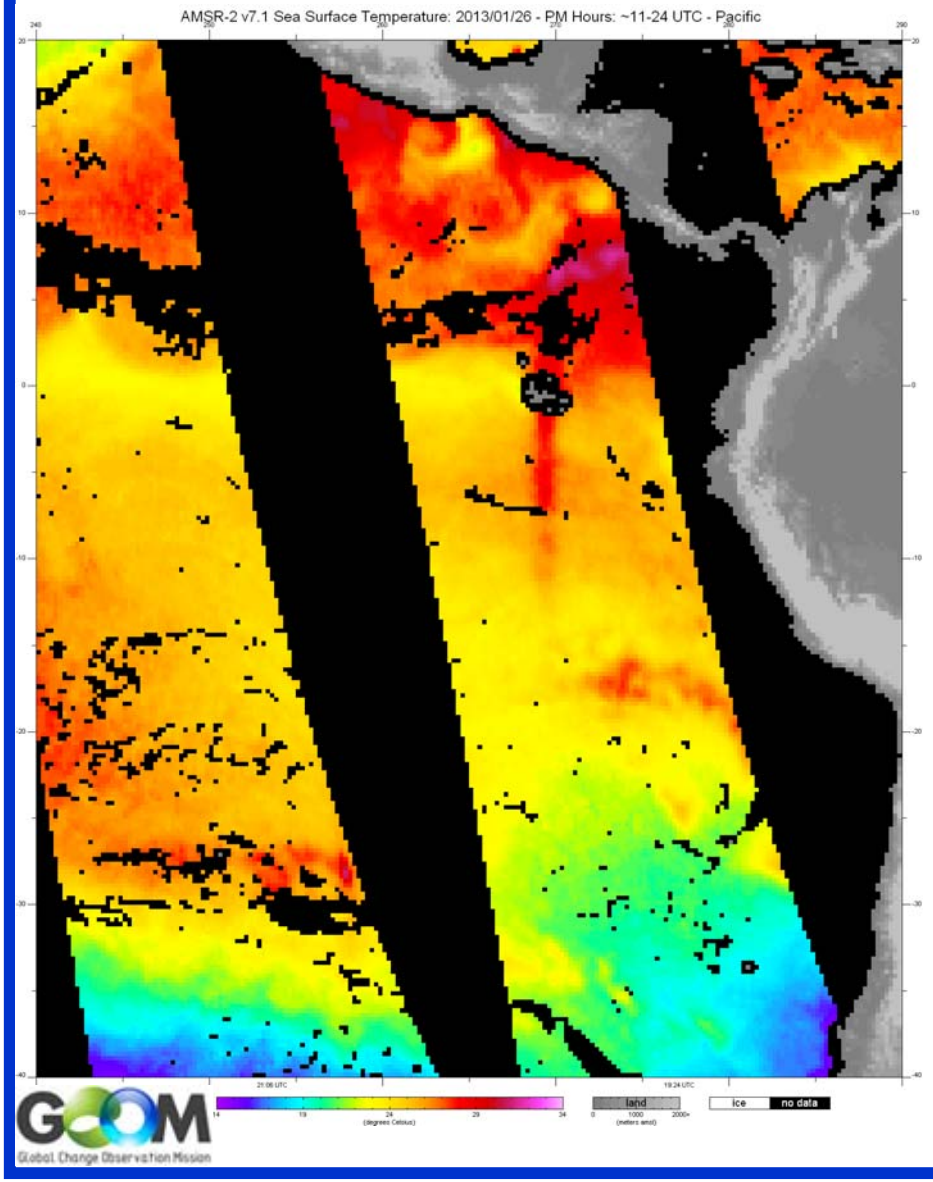
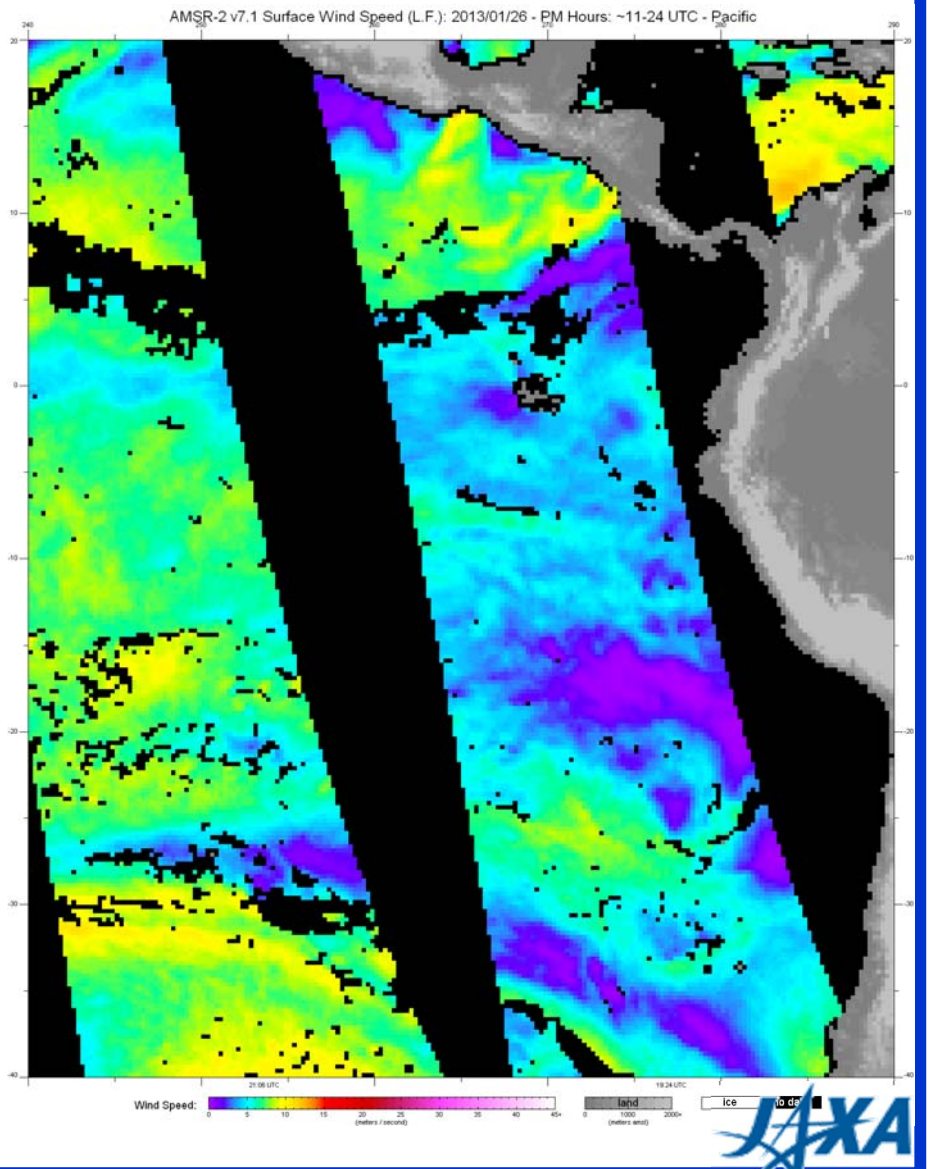
6.9GHz Space-Based Ocean-Reflected RFI

Day





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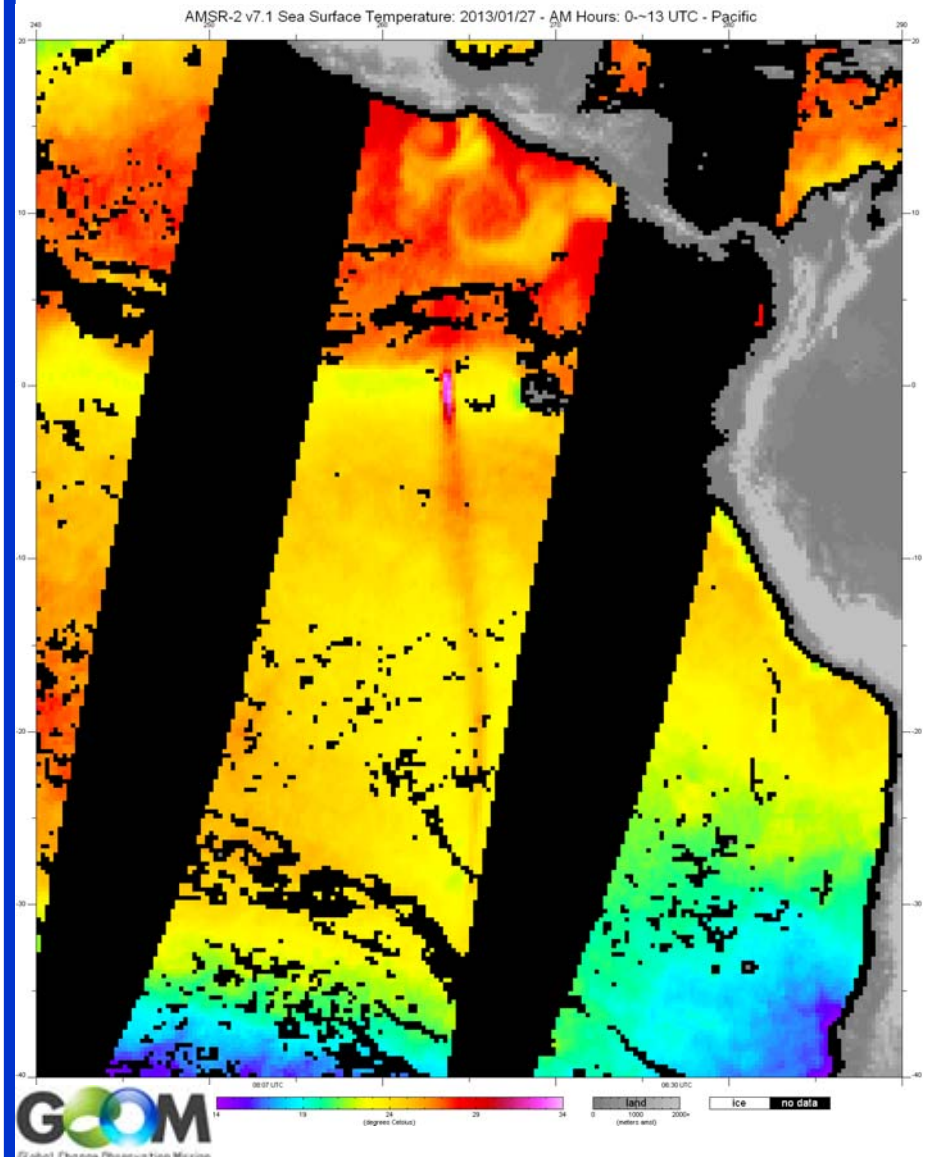

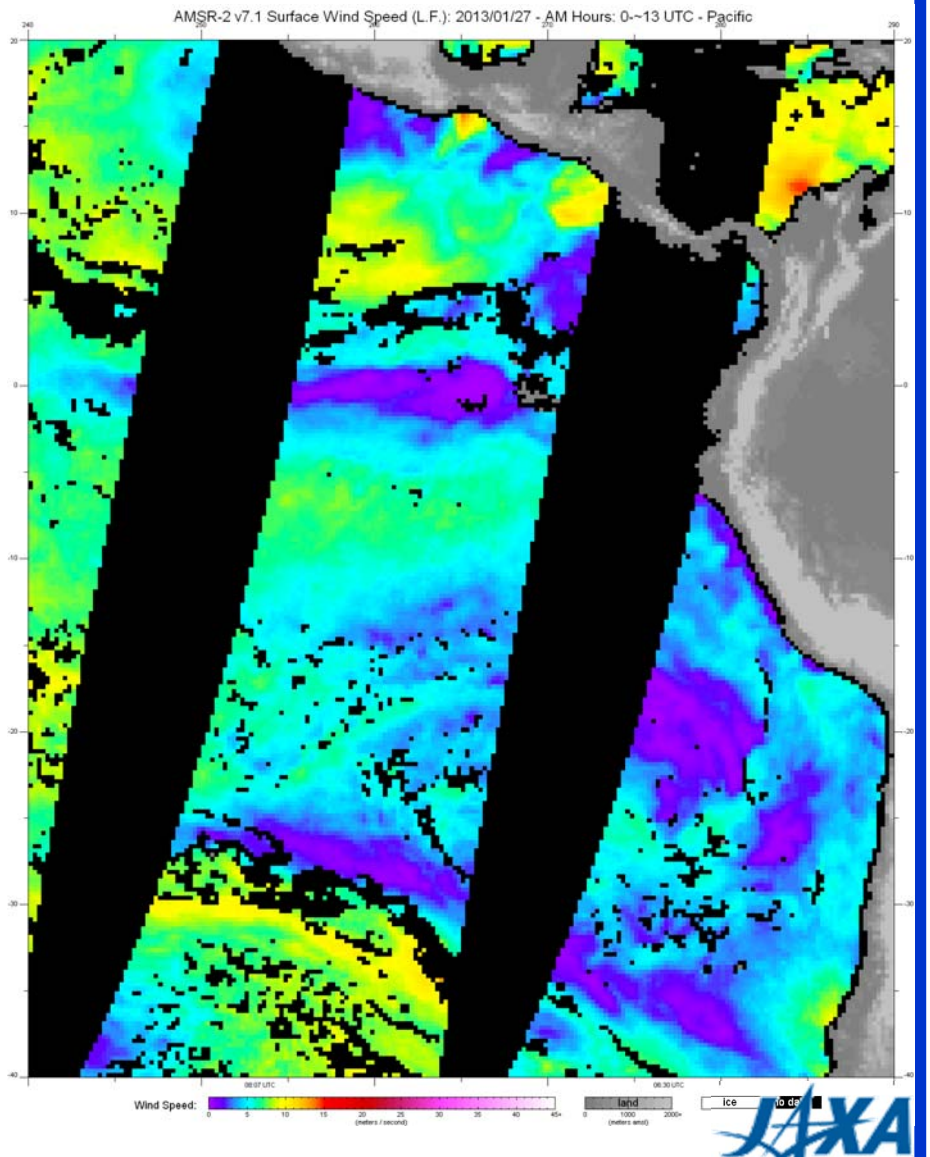

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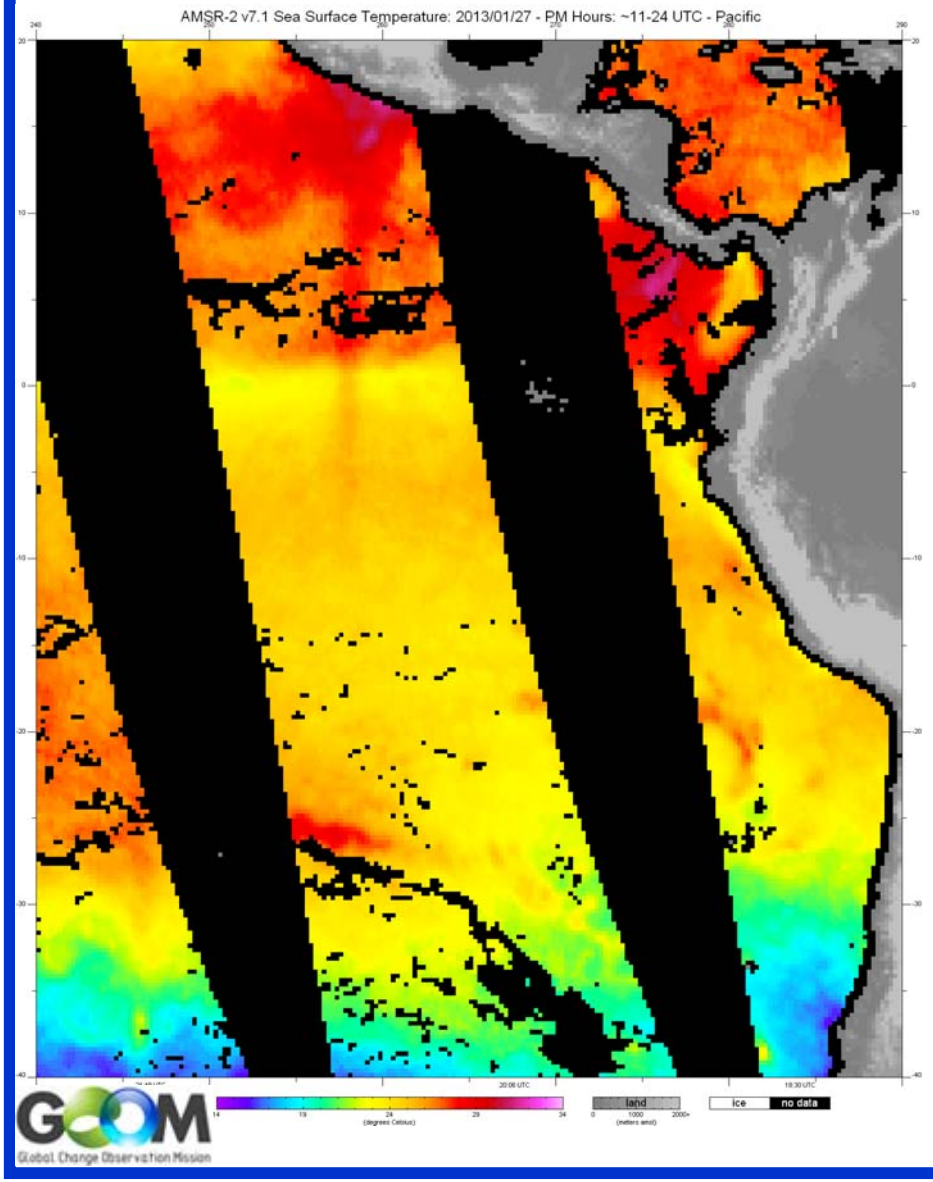
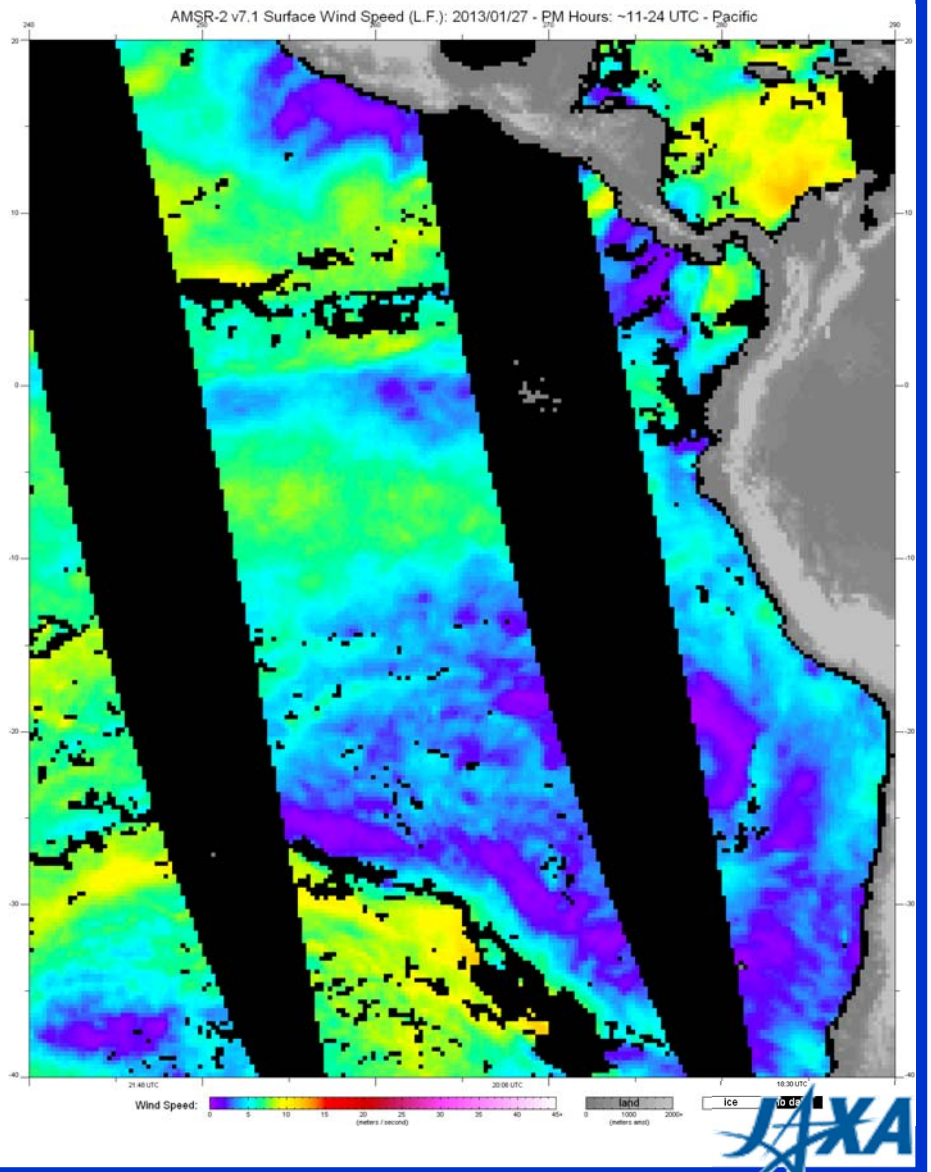
Day





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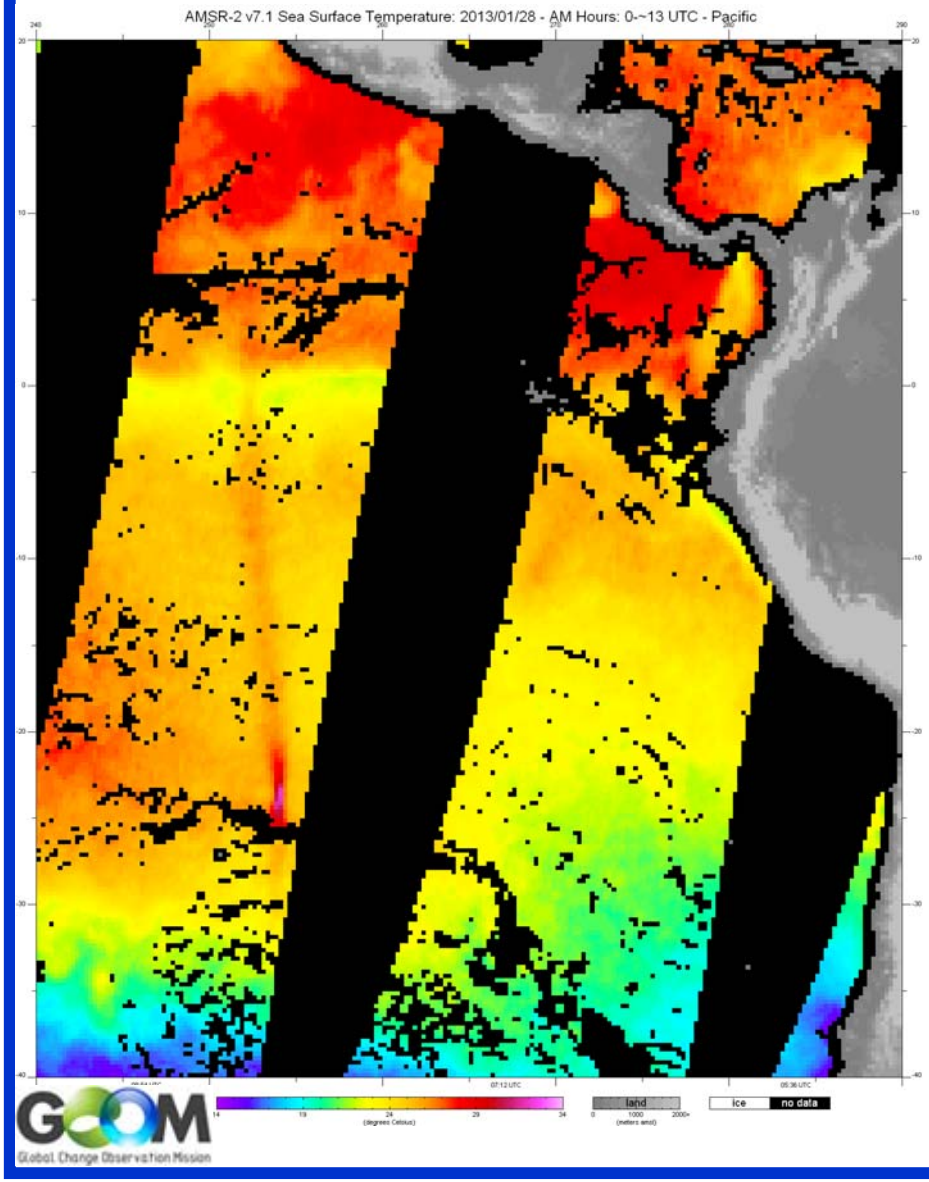

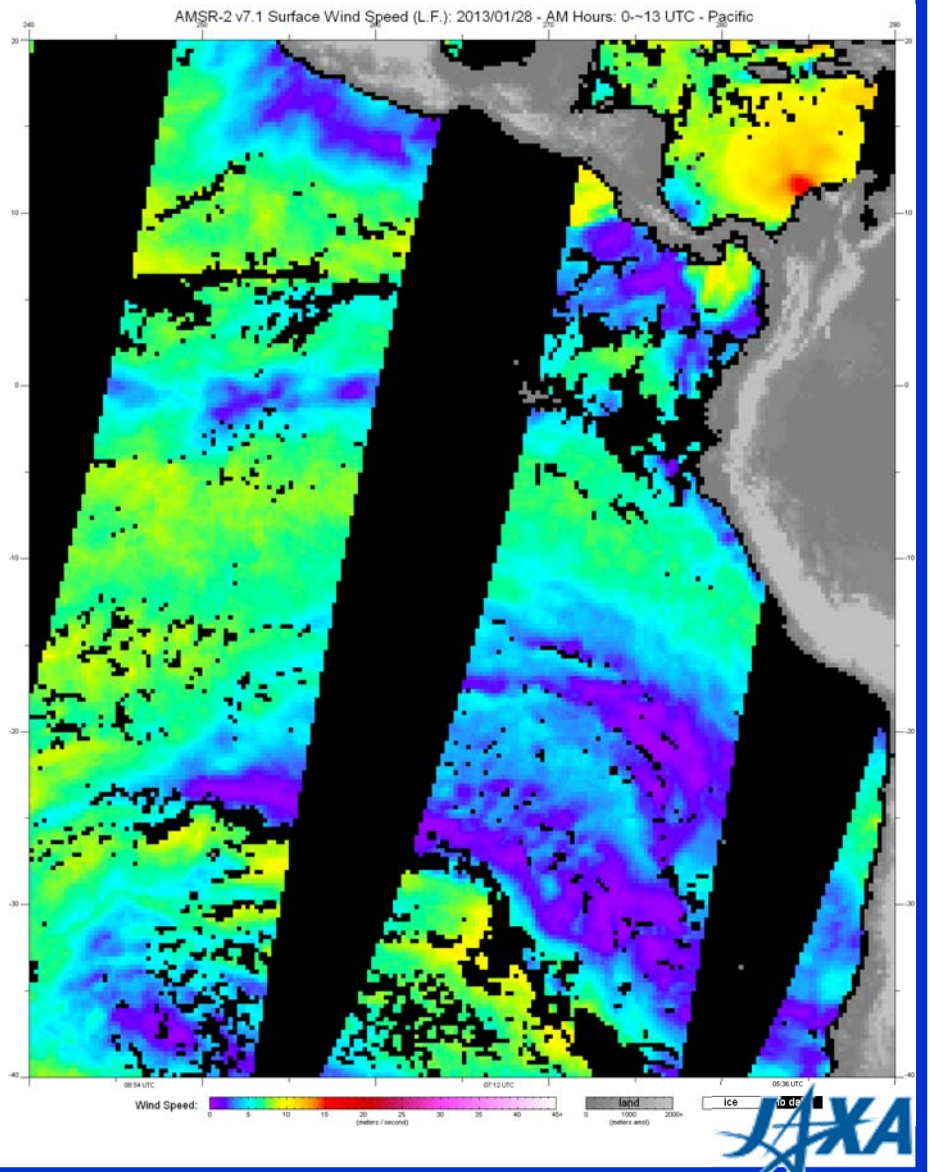

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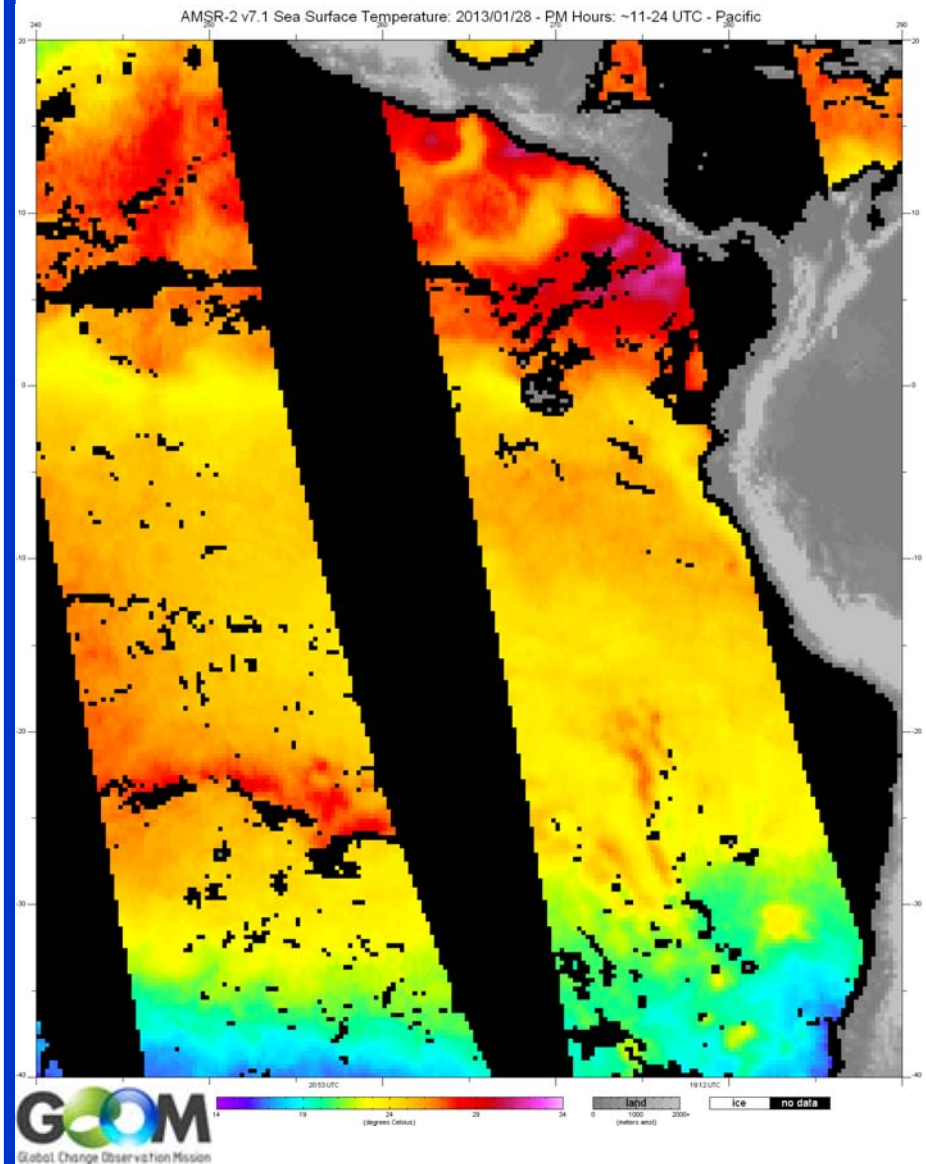

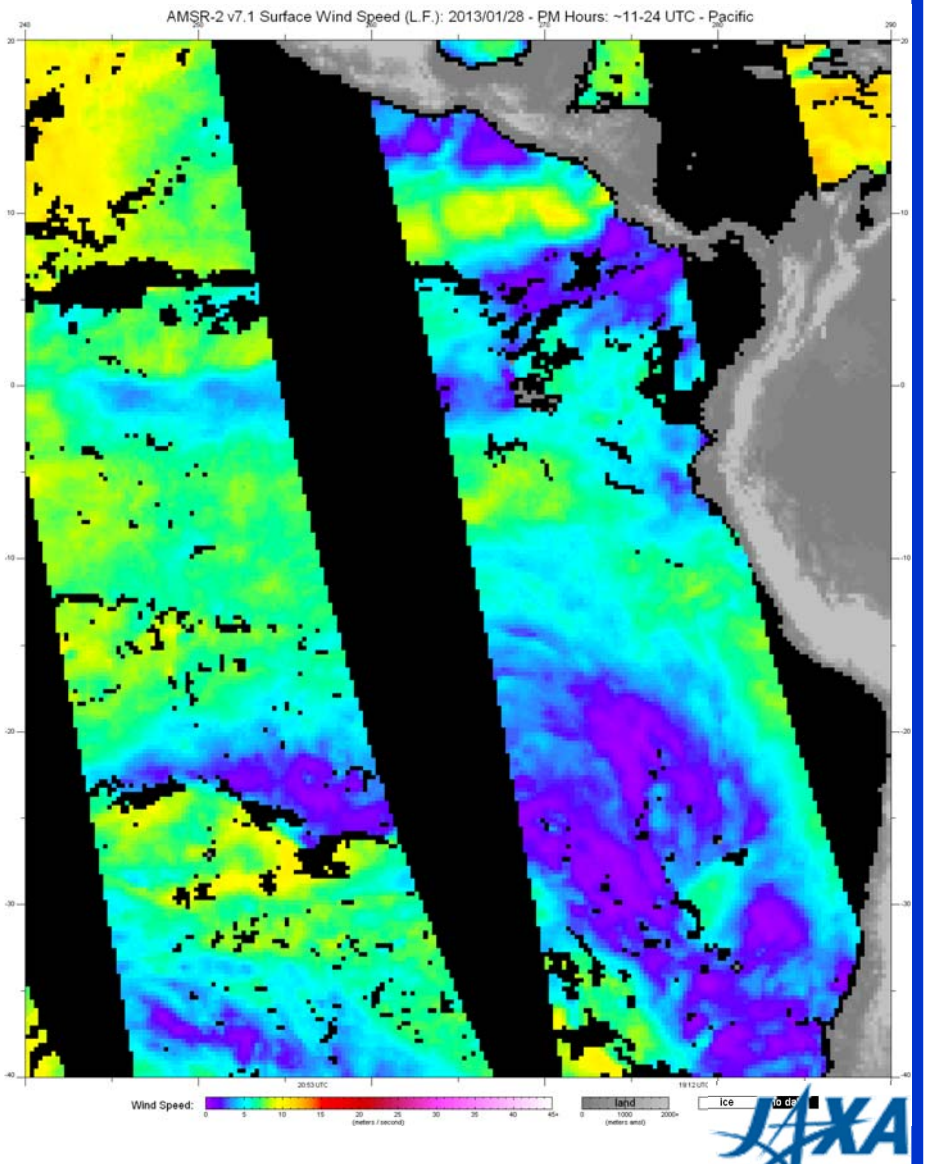

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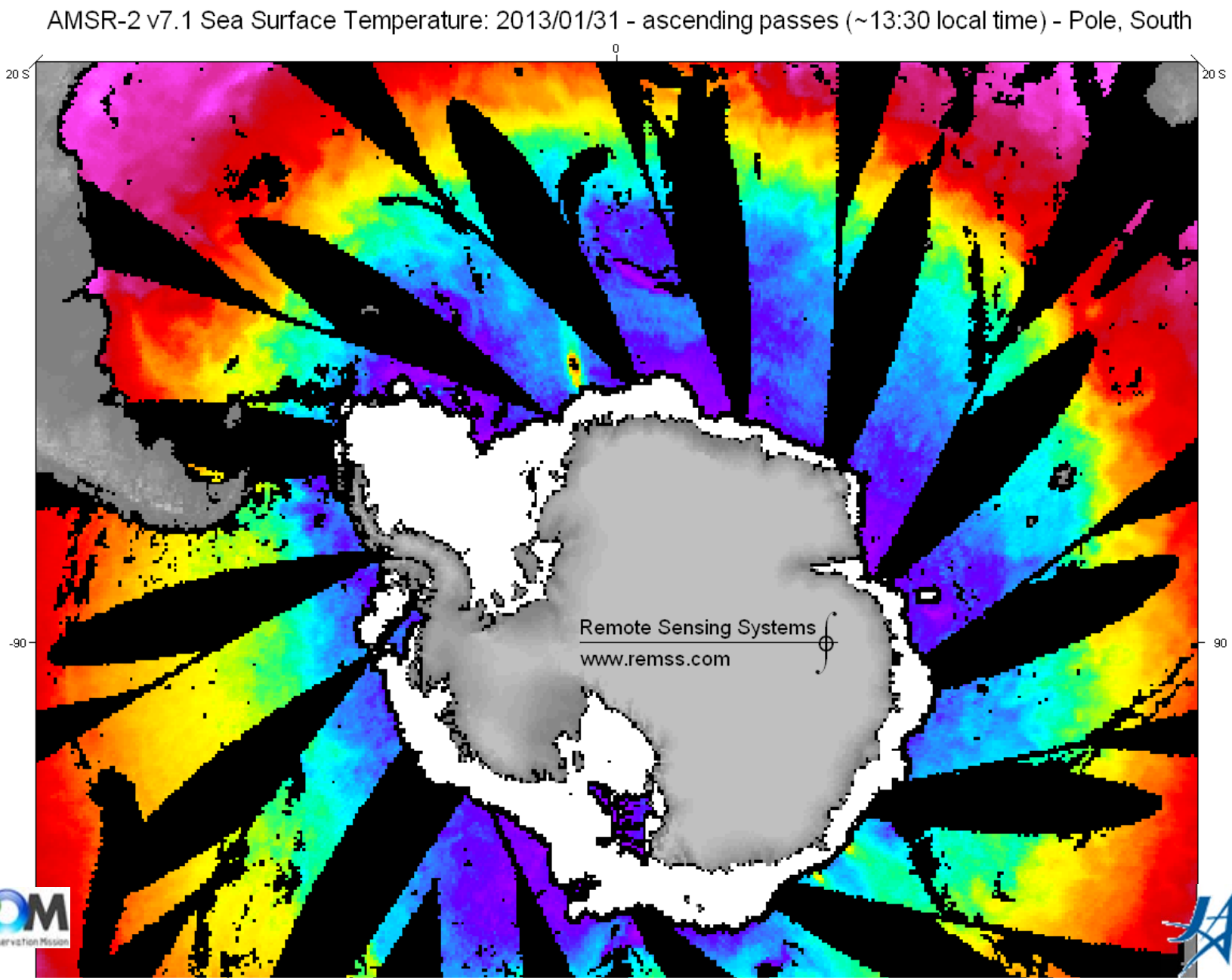

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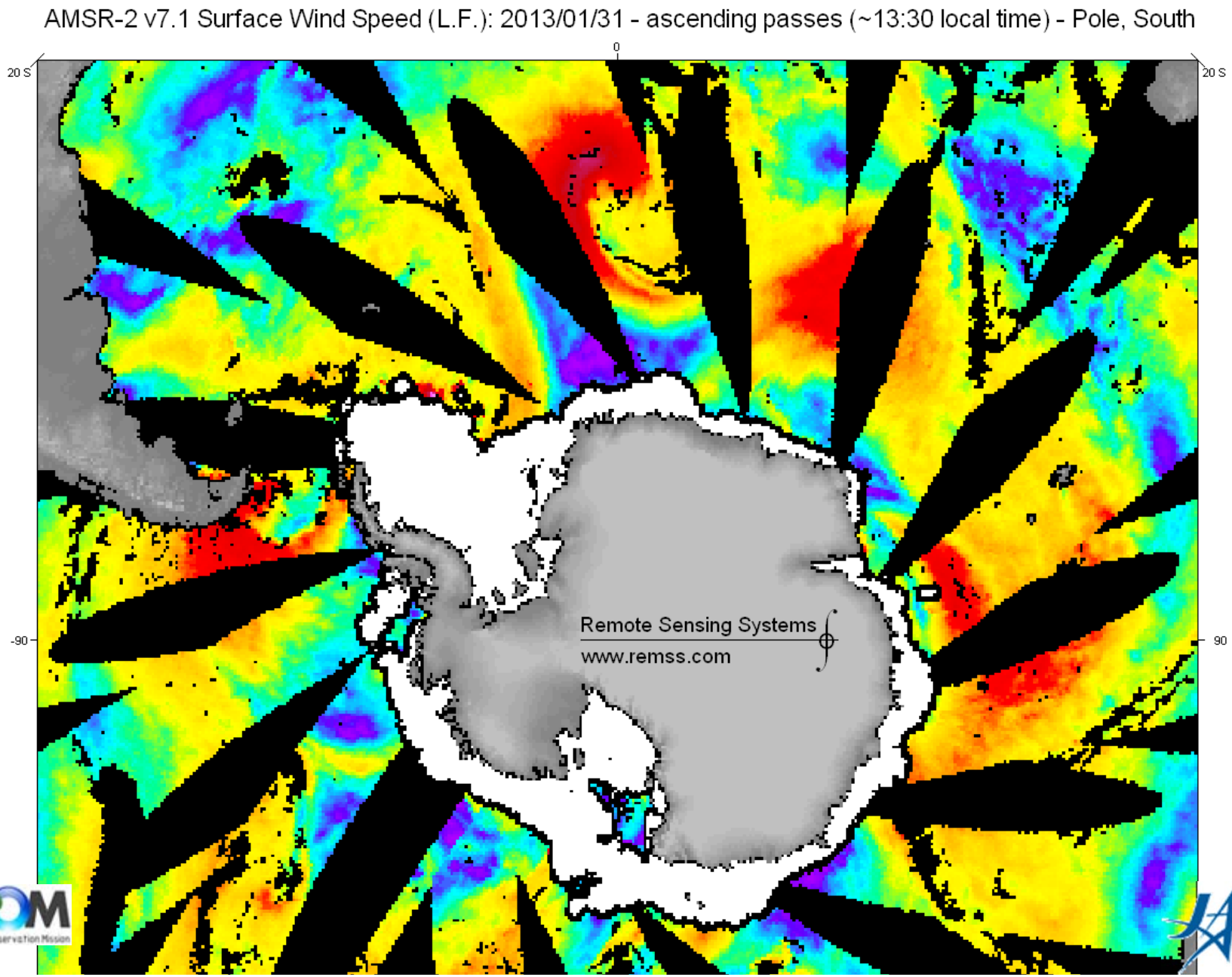

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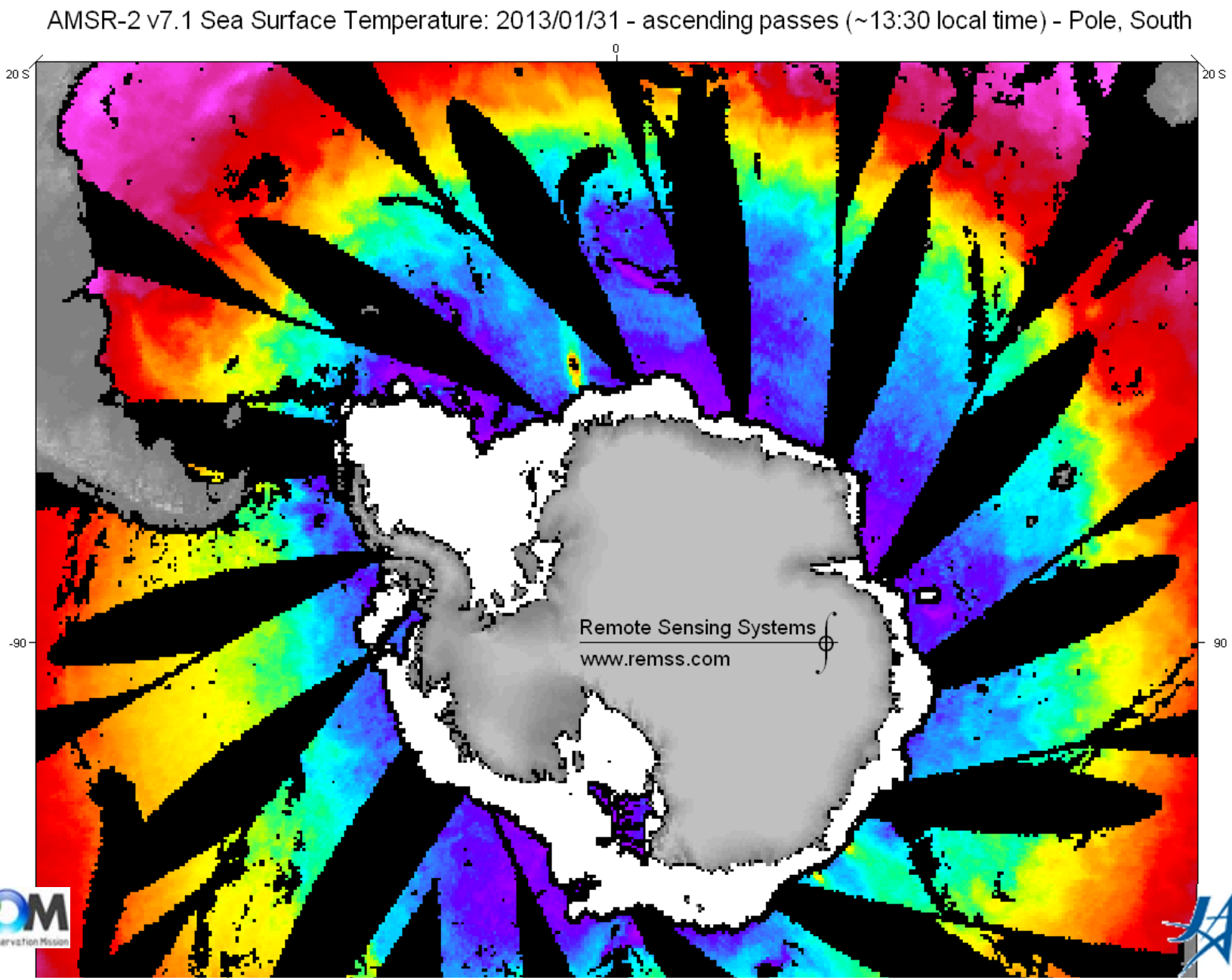

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Arigato Gozai Mas

Thank You

Geophysical Retrievals from GCOM-W AMSR-2
Radiative Transfer Model (RTM) Inversion (RTM^{-1})
SST, Wind, Vapor, Cloud, Rain

Chelle Gentemann
Frank J. Wentz, Kyle Hilburn
Marty Brewer
Remote Sensing Systems, Santa Rosa CA

Research Supported by NASA's Earth Science Division

Joint PI Workshop
Global Environment Observation Mission 2013
Earth Observation Research Center, JAXA
TKP Gardencity Takebashi, Tokyo JAPAN
January 17, 2014