Development of an Oceanic Rain Accumulation Product in Support of Sea Surface Salinity Measurements from Aquarius/SAC-D

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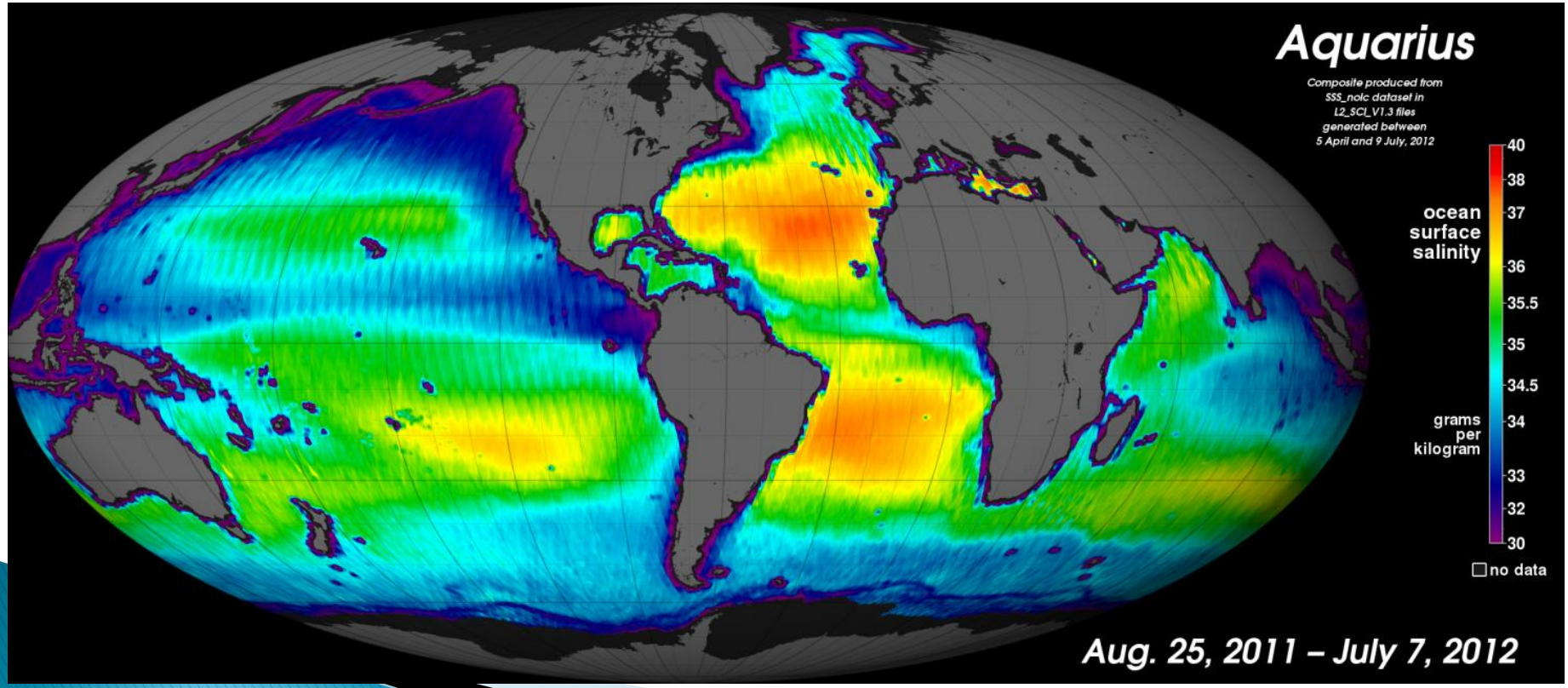
Objective

- To develop an oceanic Rain Accumulation (RA) data product in support of NASA's Aquarius (AQ) Sea Surface Salinity (SSS) measurements
  - This auxiliary science product will enable scientist and AQ remote sensing engineers to examine the influence of oceanic rainfall on the retrieval of SSS
    - Undetected rainfall can produce "false signals" that create errors in the AQ SSS retrieval
    - The use of this RA product will provide independent science data that may enable algorithm developers to mitigate the effects of rain from the SSS retrieval

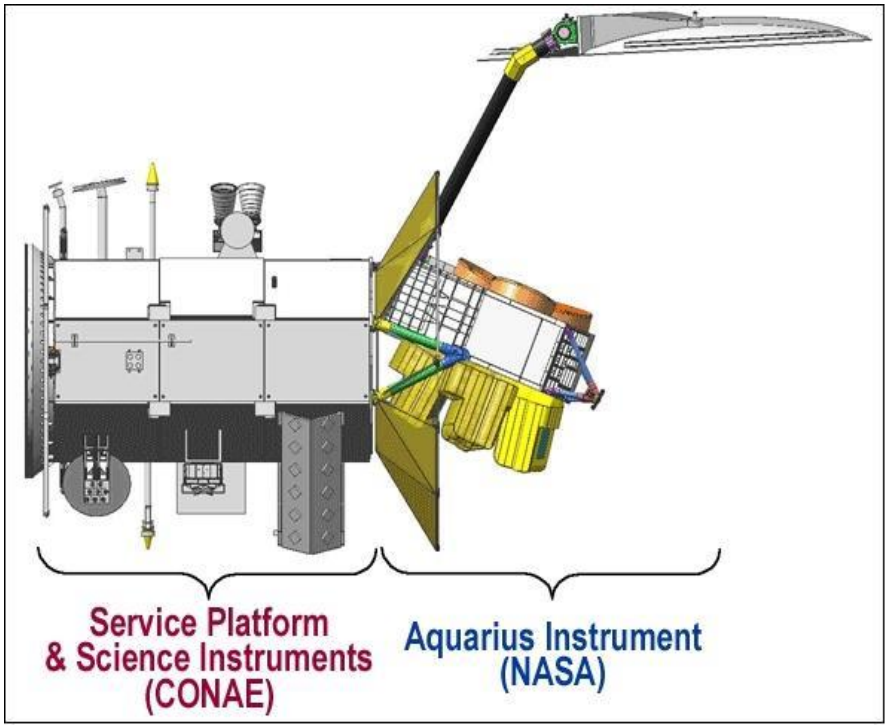
Aquarius/SAC-D Mission Overview

- A joint science program by NASA and the Argentine Space Agency (CONAE)
- The main objective of this mission is to provide the monthly global maps of Sea Surface Salinity (SSS)



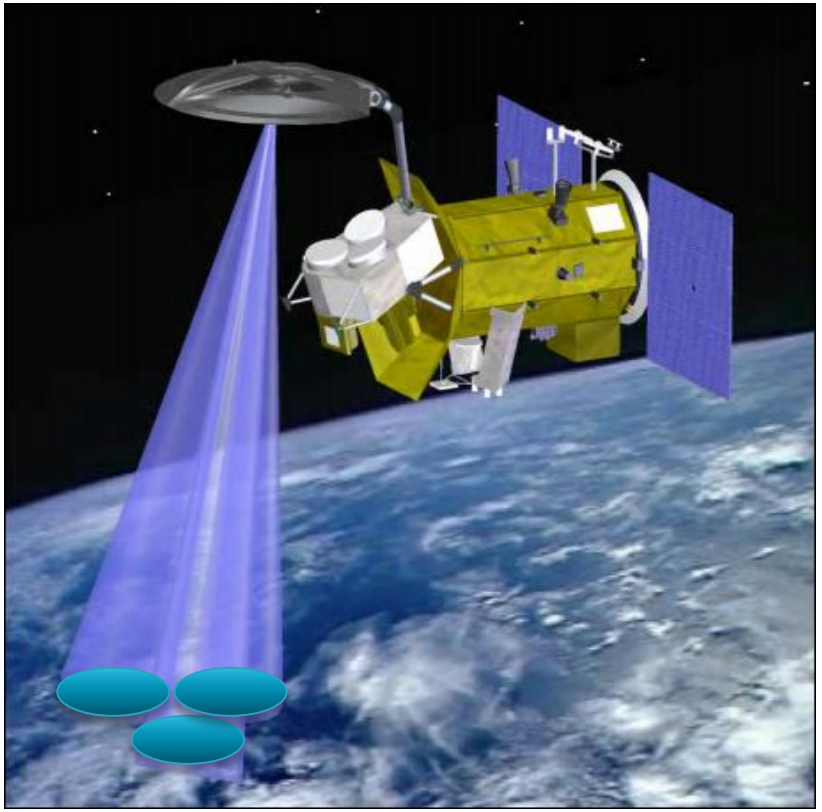
Aquarius Instrument

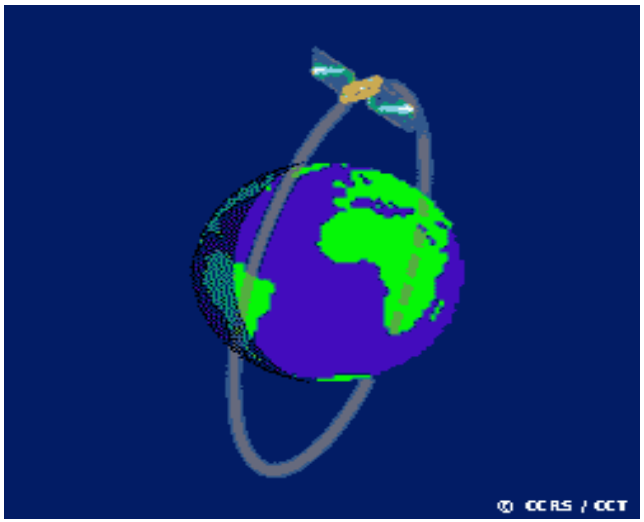
- The prime microwave remote sensor
- Passive Microwave
  - Dicke radiometer operating @ 1.41 GHz
- Active Microwave
  - Scatterometer operating @ 1.26 GHz



AQ Orbit and Geometry

- A sun-synchronous polar orbit satellite
- Flies in a terminator orbit: AQ collects blackbody emissions from the night side of ground track





Three beams

EIA = 28.7º, 37.8º and 45.6º

IFOV = 79×94, 84×120 and 96×156 Km

SSS Retrieval Algorithm

$T_B = e \times T$

e = Emissivity

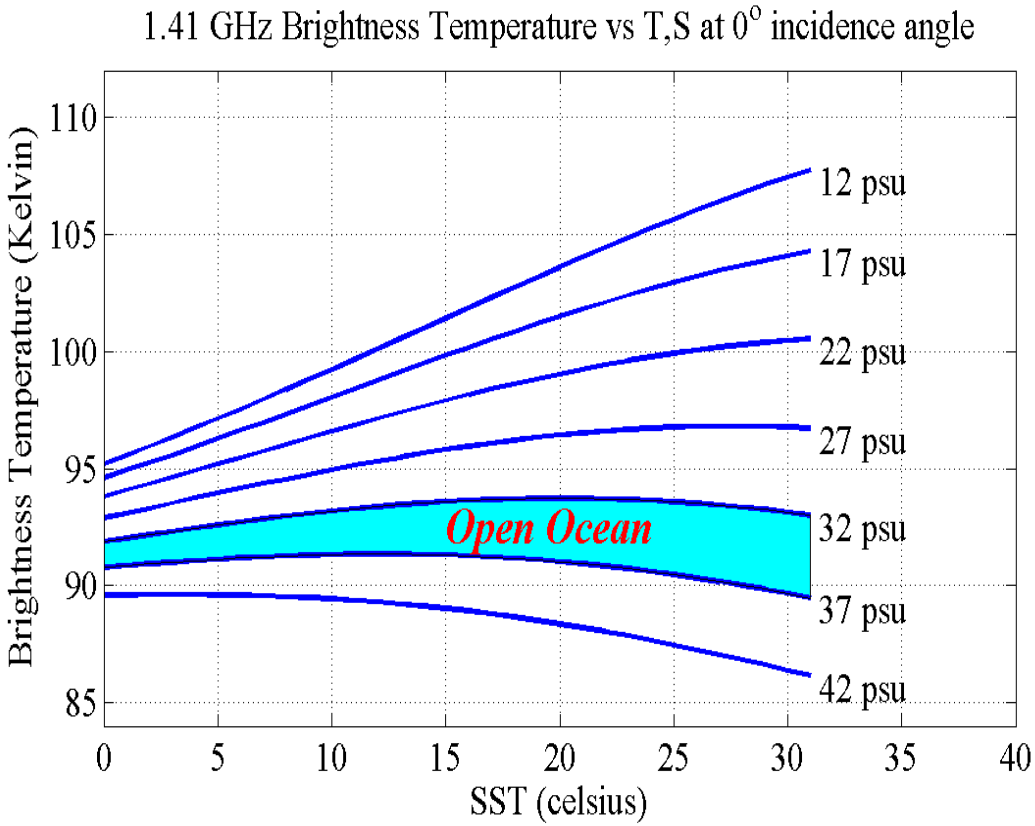
T = Physical Temperature

$e = 1 - [\,(1-\sqrt{\varepsilon}) / (1+\sqrt{\varepsilon})\,]^2$

(normal incidence)

ε = Relative Dielectric Constant

$= \varepsilon(f, T, \text{salinity})$



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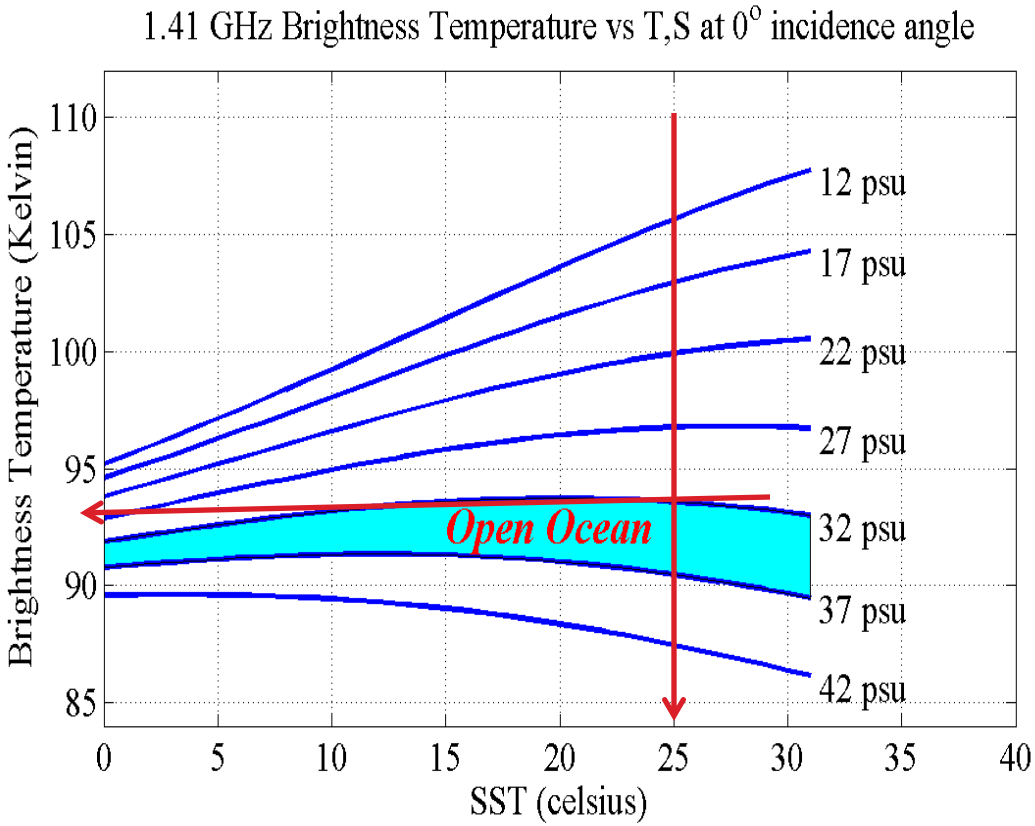
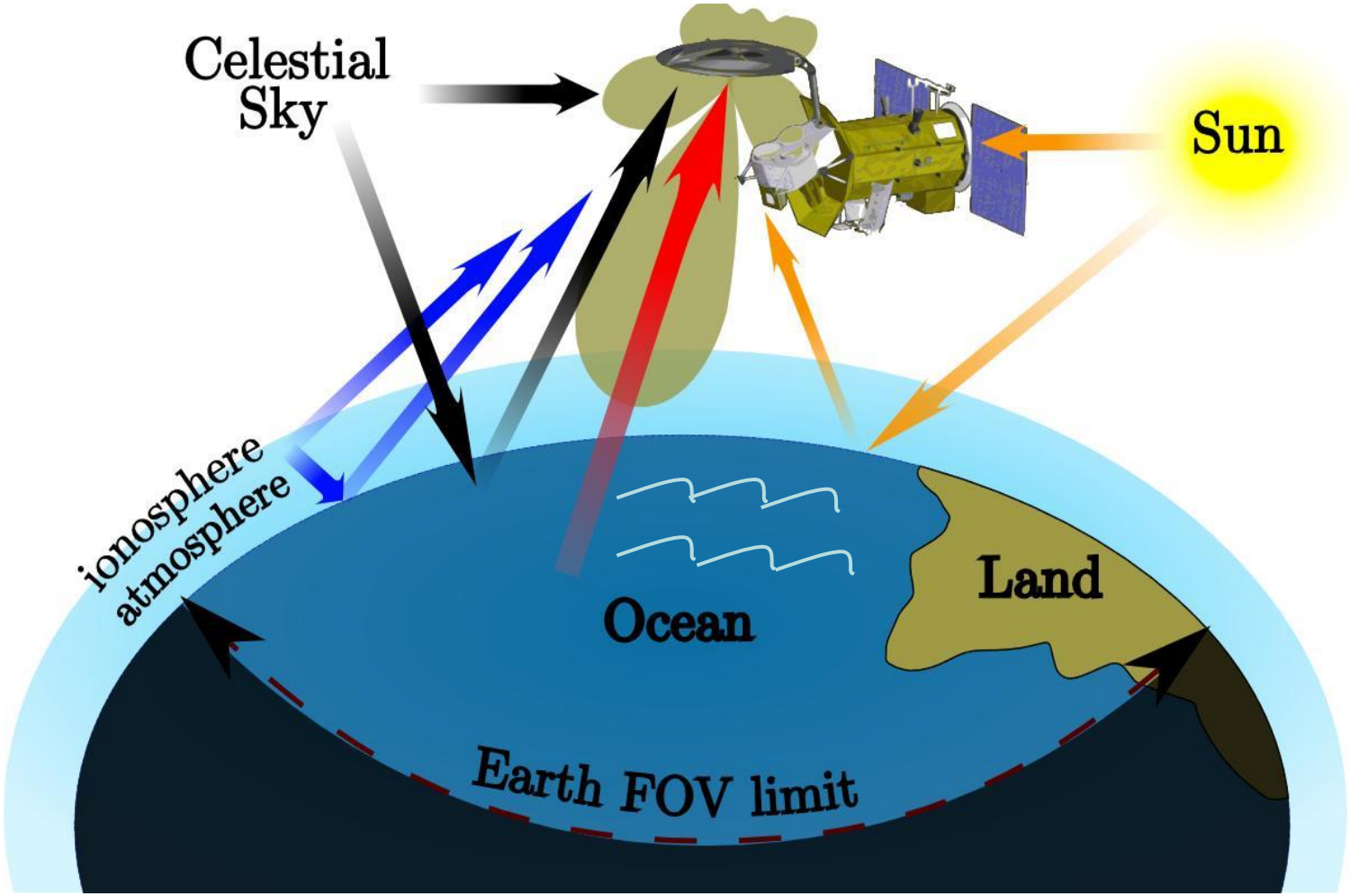
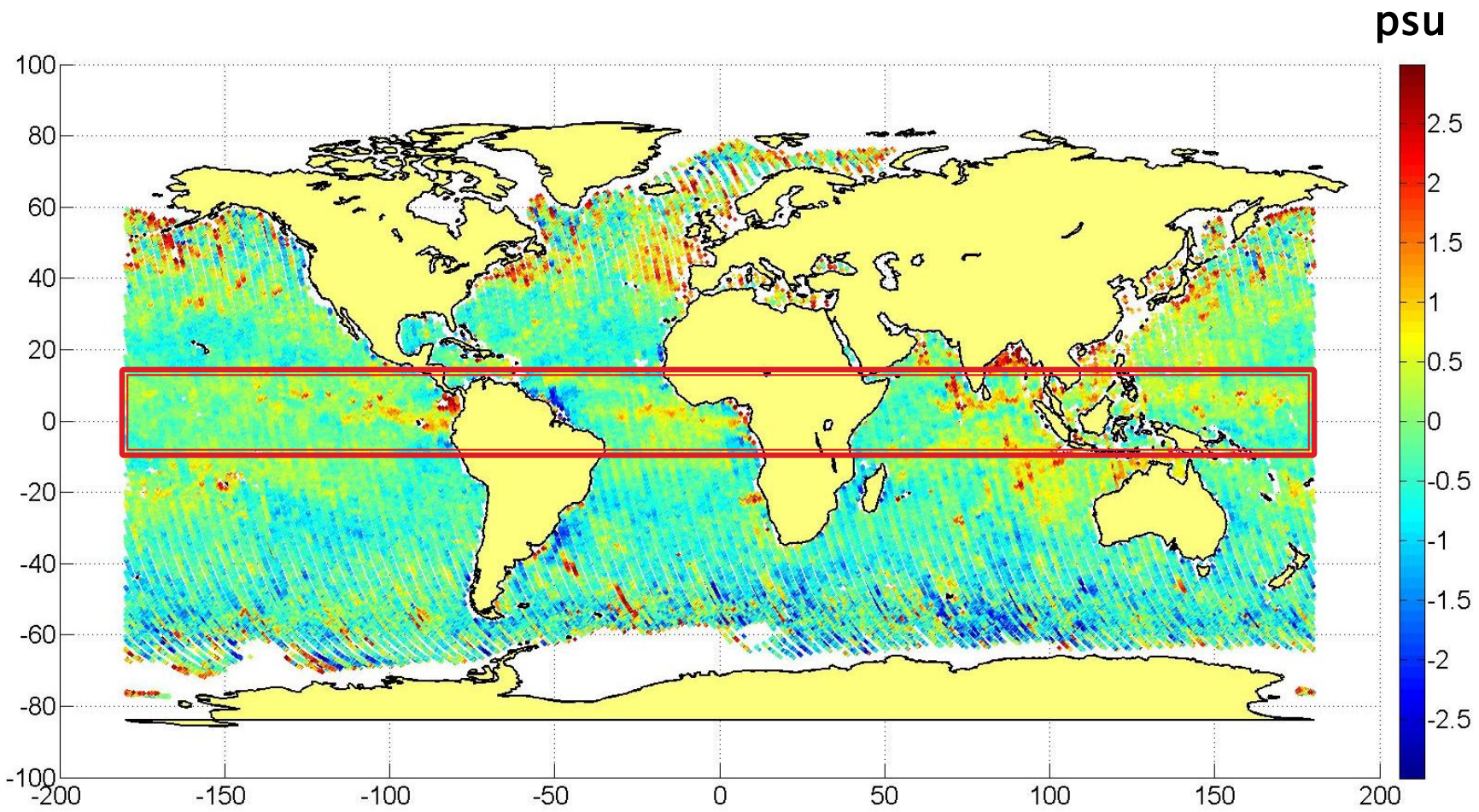


Impact of Environmental Parameters on SSS Retrieval



AQ SSS Error ($HYCOM_{SSS}$ - AQ_{SSS})



Retrieval of SSS: Impact of Oceanic Rainfall

- Rain Rate
  - Instantaneous Rain Rate – roughness effect
  - Rain Accumulation – layer of fresh water floating on sea water

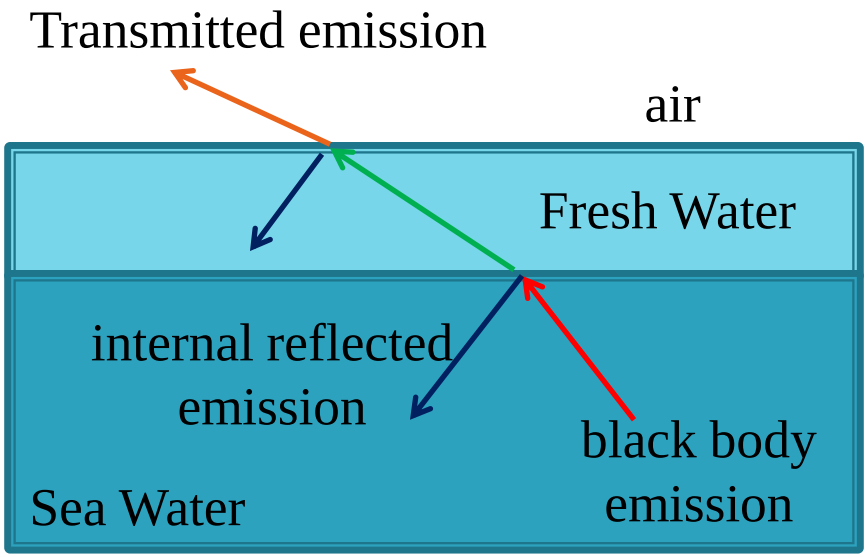
Why We Need RA Product?

- Instantaneous Rain effect on AQ SSS:
  - Instantaneous rain (splash effect) will cause increased roughness that raises the ocean surface brightness temperature
    - This decreases the retrieved SSS

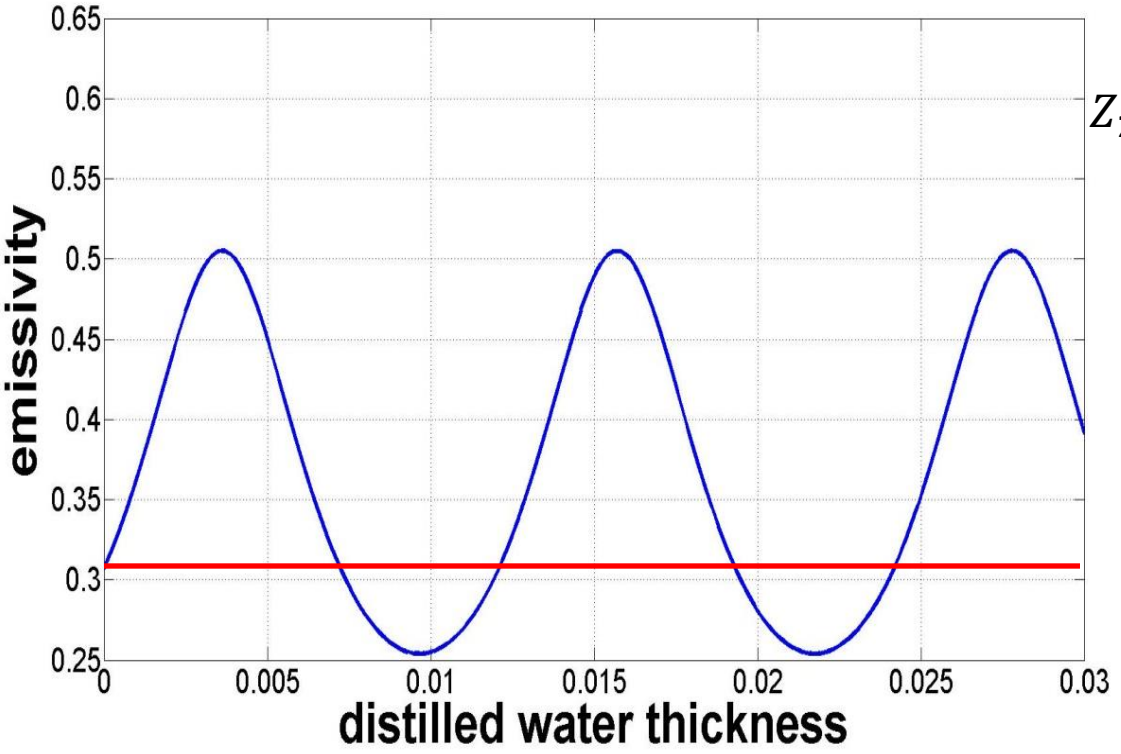
Why We Need RA Product? (Cont'd)

- Longer-term rain effect on AQ SSS:
  - Layered media effect that can affect the ocean T_b
    - This electromagnetic impedance matching effect can either increase or decrease ε depending upon l
    - Thus the apparent (retrieved) SSS may increase or decrease

ε is a measure of the efficiency of transmission of internal blackbody radiation across the air/sea interface



Emissivity of Layered Media: Distilled Water over Sea Water



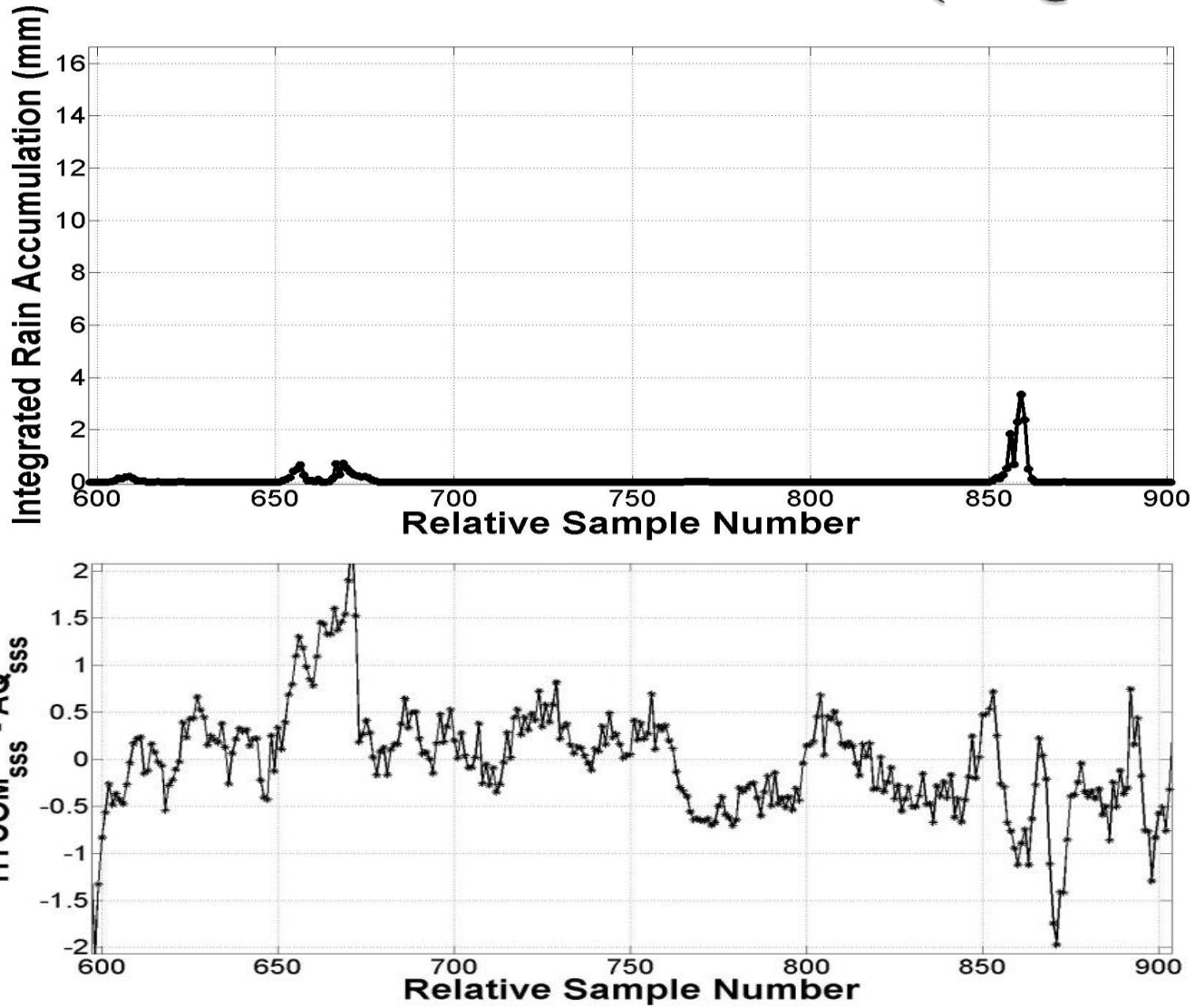
$$Z_{23} = \eta_2\left(\frac{\eta_3 \cos(k_2 l) + j\eta_2 \sin(k_2 l)}{\eta_2 \cos(k_2 l) + j\eta_3 \sin(k_2 l)}\right)$$

$$\rho = \frac{Z_{23} - \eta_1}{Z_{23} + \eta_1}$$

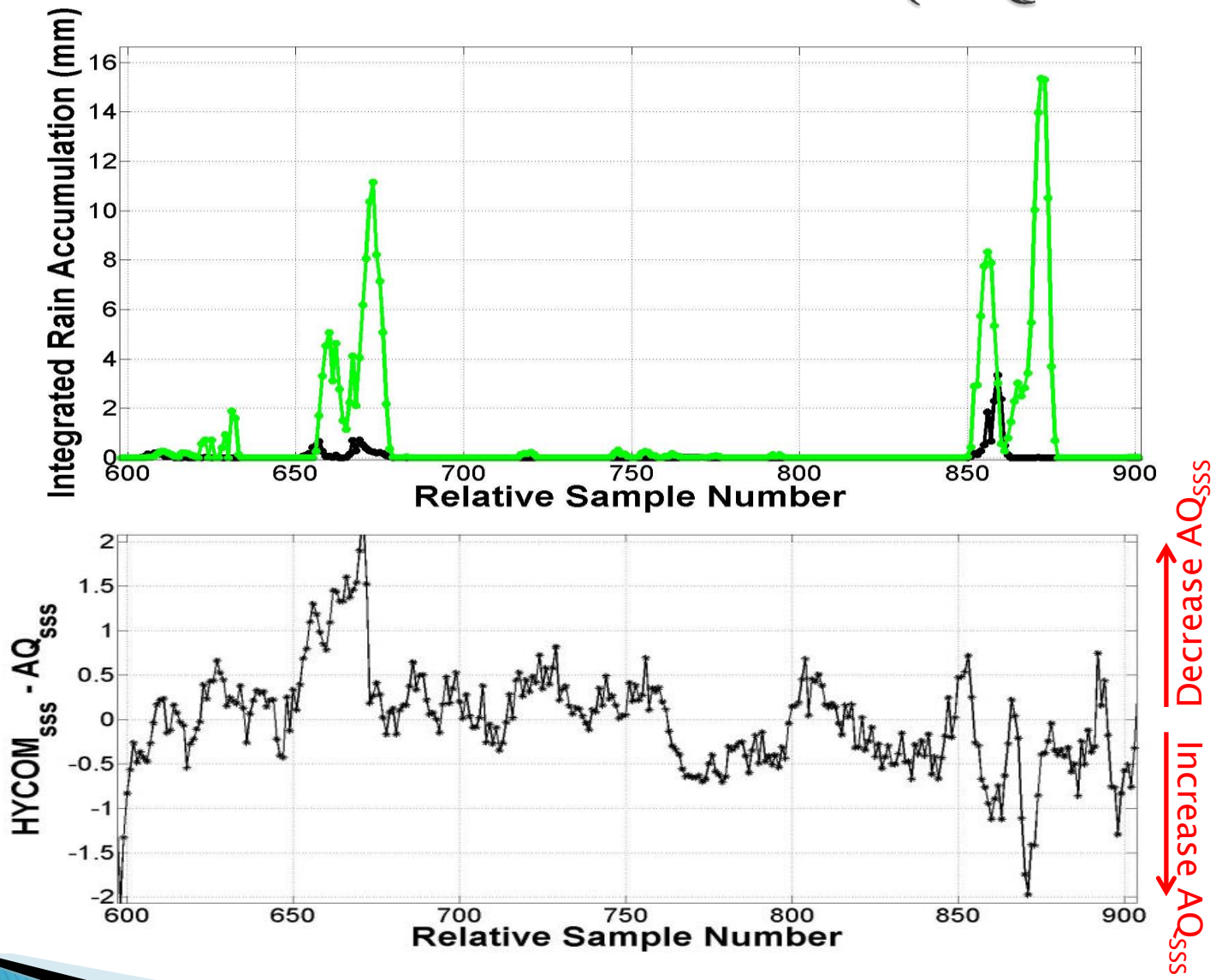
$$\Gamma = |\rho|^2$$

$$emissivity = 1 - \Gamma$$

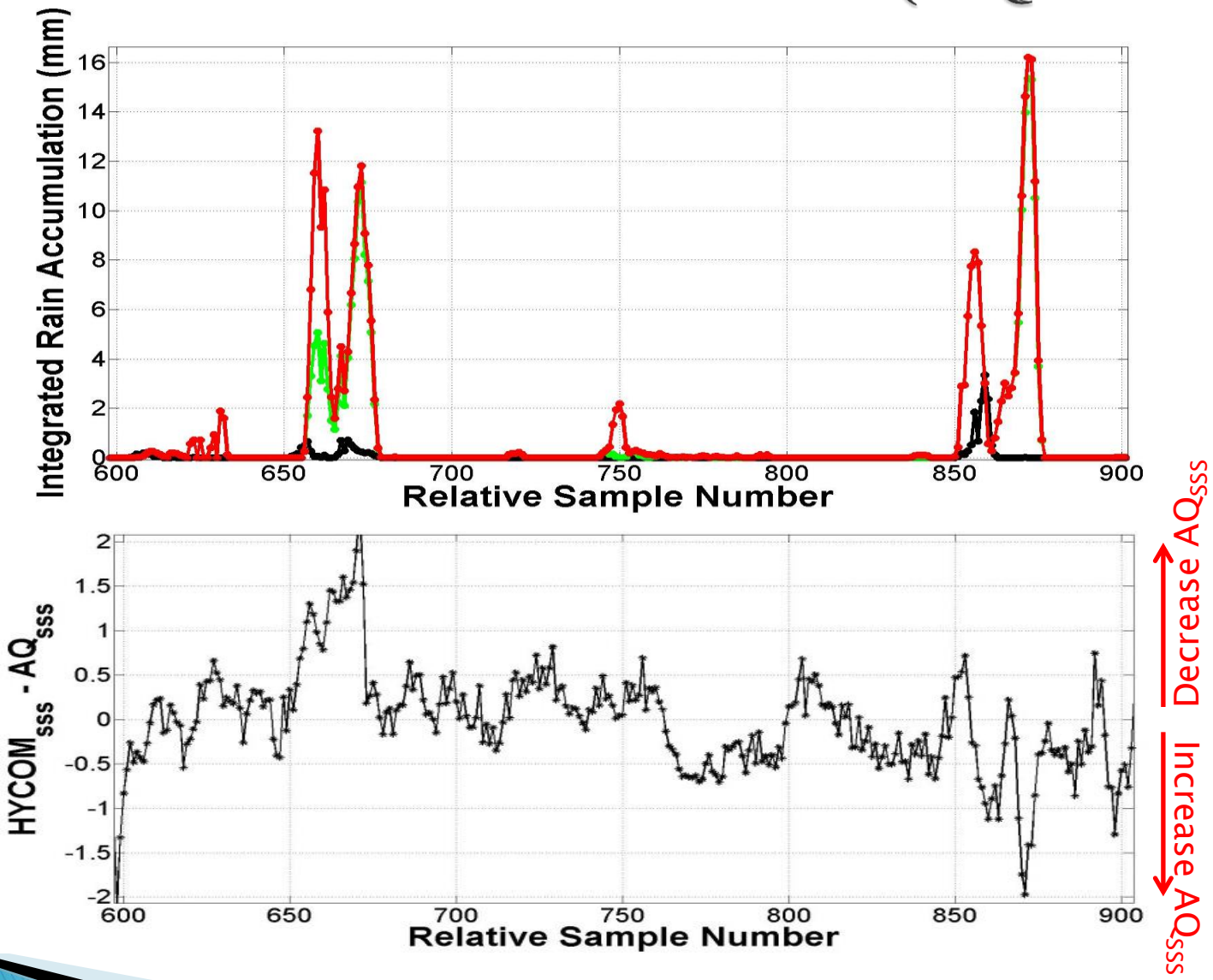
RR and SSS Error Time Series (AQ B1 Desc.)



RA and SSS Error Time Series (AQ B1 Desc.)



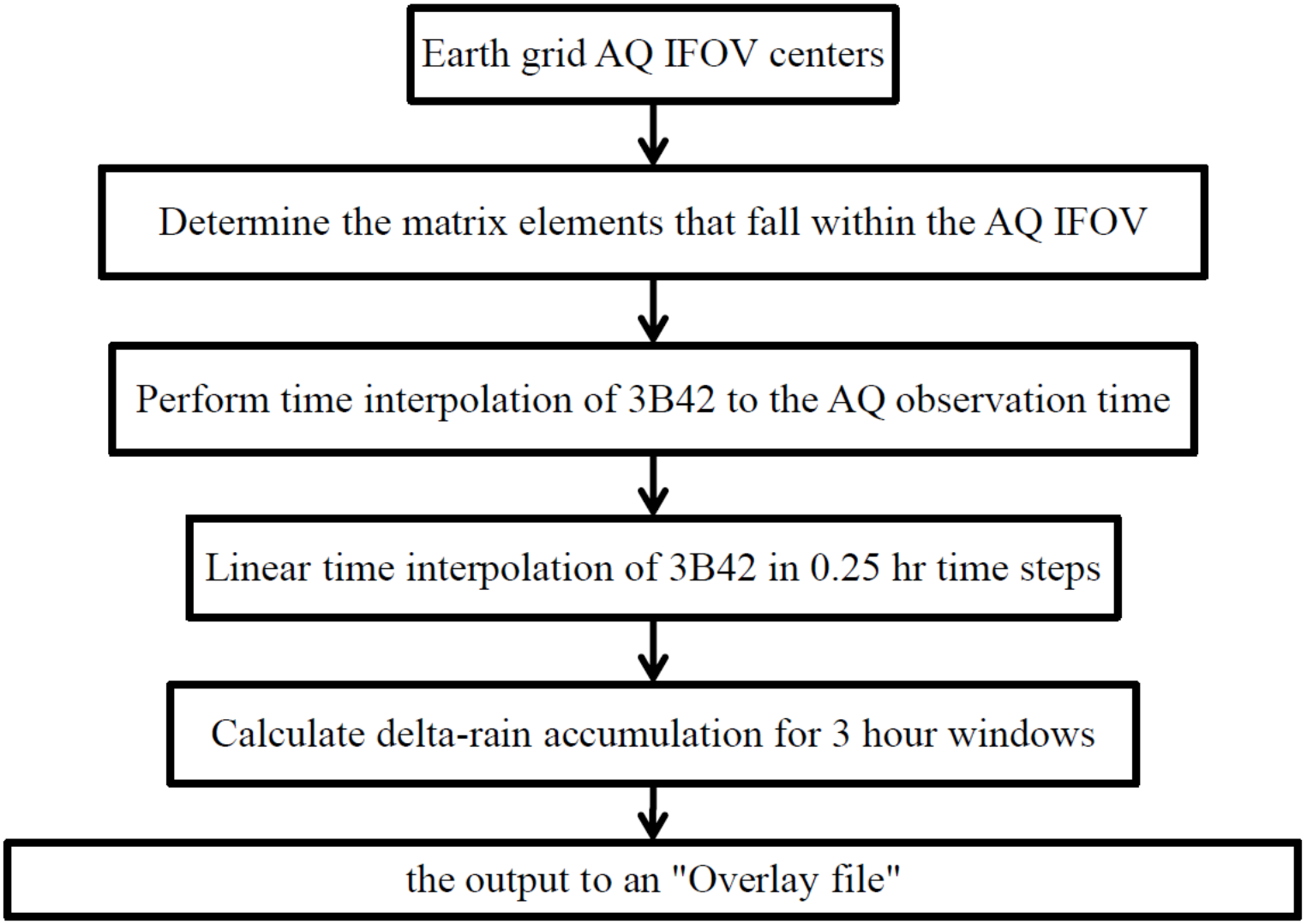
RA and SSS Error Time Series (AQ B1 Desc.)



Approach to Develop RA Product to Modify SSS Retrieval

- Use independent global 3-hr ocean rain rate measurements (TRMM 3B42 product)
  - Calculate the accumulated rain rate for each AQ footprint as a function of time before the AQ observation
    - Instantaneous rain rate @ observation time (T_o)
    - RA: Rain accumulations for $T_o - 3$, $T_o - 6$, $T_o - 9$, . . . $T_o - 24$
- the output to an "Overlay file“

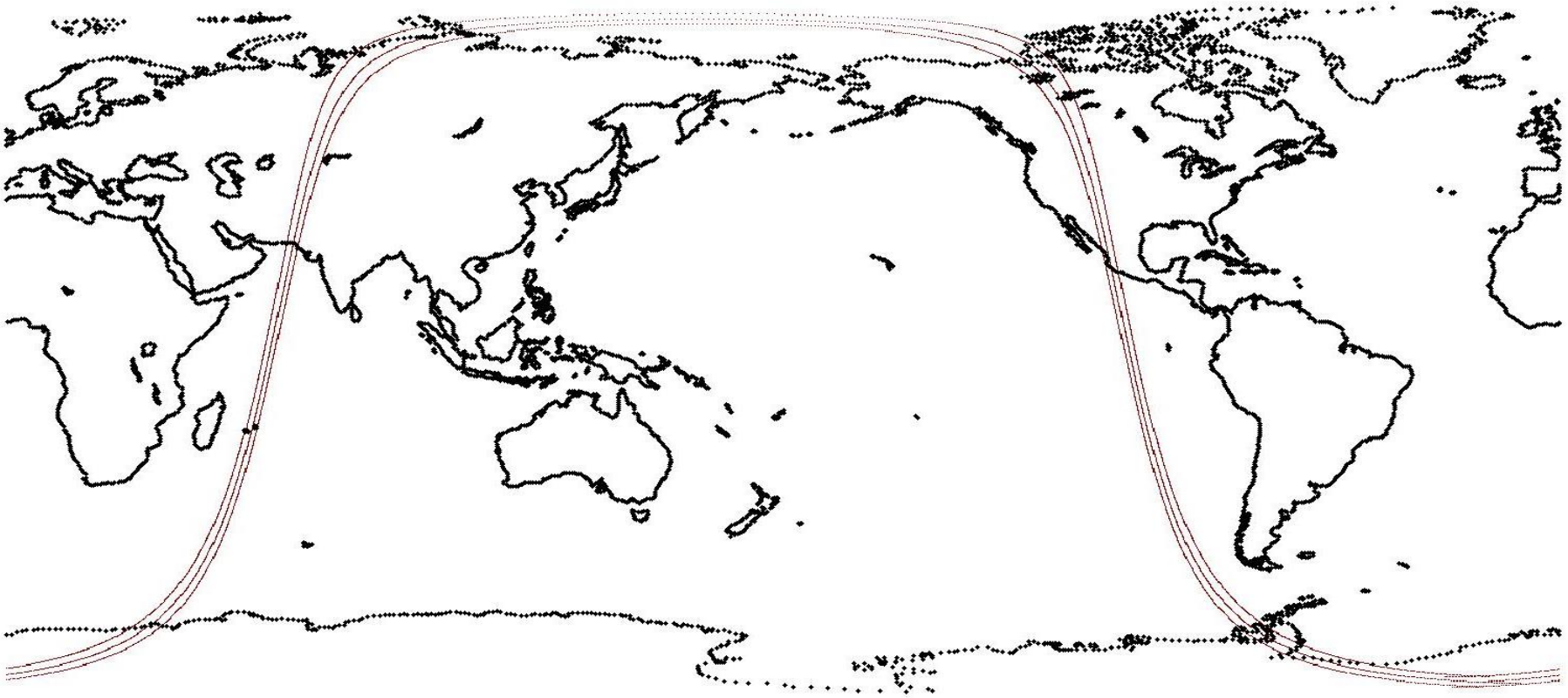
RA Algorithm Flowchart



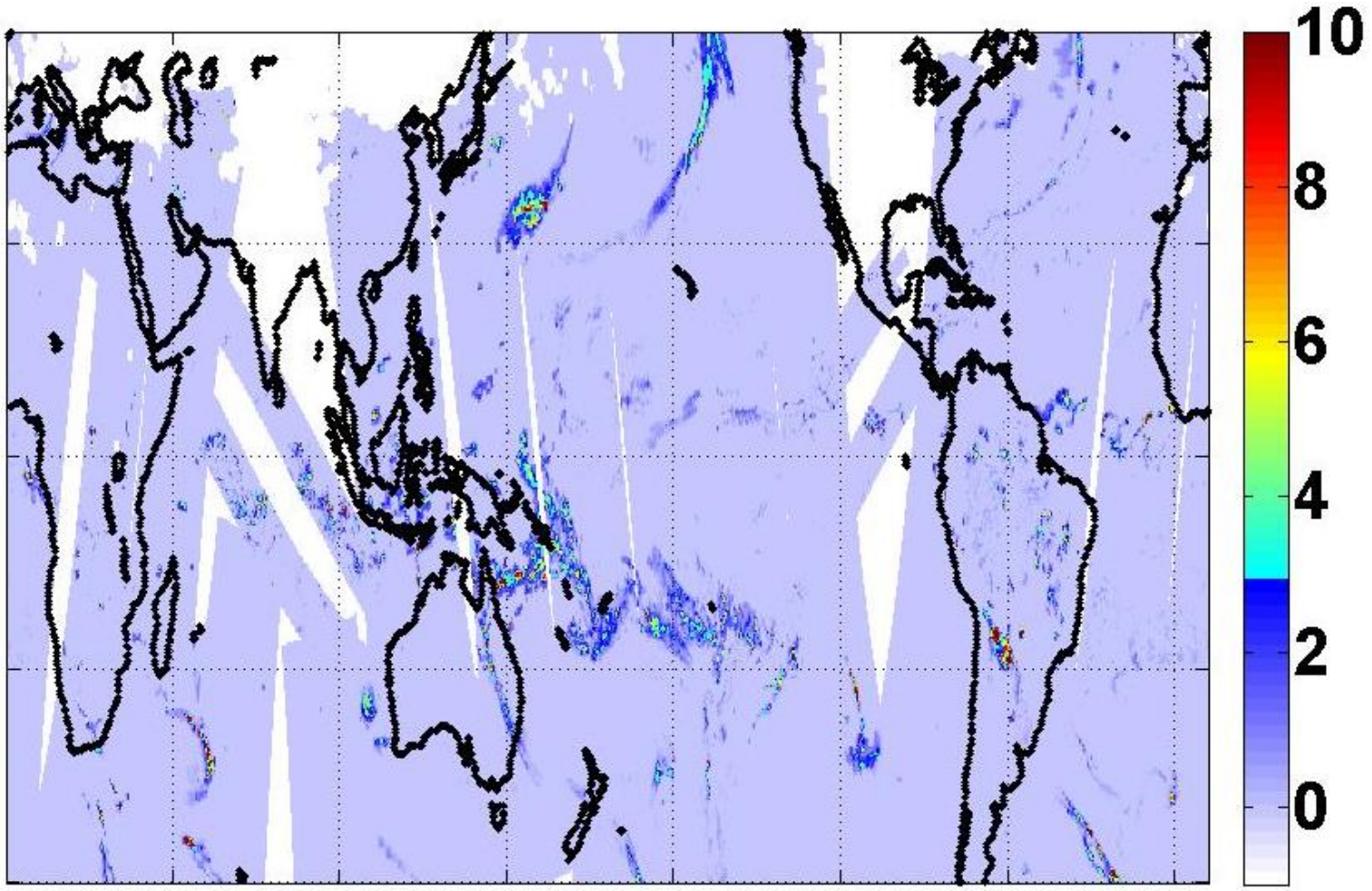
Algorithm Inputs

- AQ Level-2
- Produced by NASA/GSFC
- Available through PODAAC at NASA JPL
- Takes two weeks for files availability
  - AQ orbit#
  - AQ cycle#
  - AQ IFOV center location
  - AQ observation time
  - AQ flags
- TRMM 3B42
- Accessible through NASA GES
- Takes one month files availability
  - Every 3 hours snapshot
  - Earth gridded $0.25^{o} \times 0.25^{o}$
  - Covers ±50 Lat. and ±180 Lng.
  - Merged MW and IR

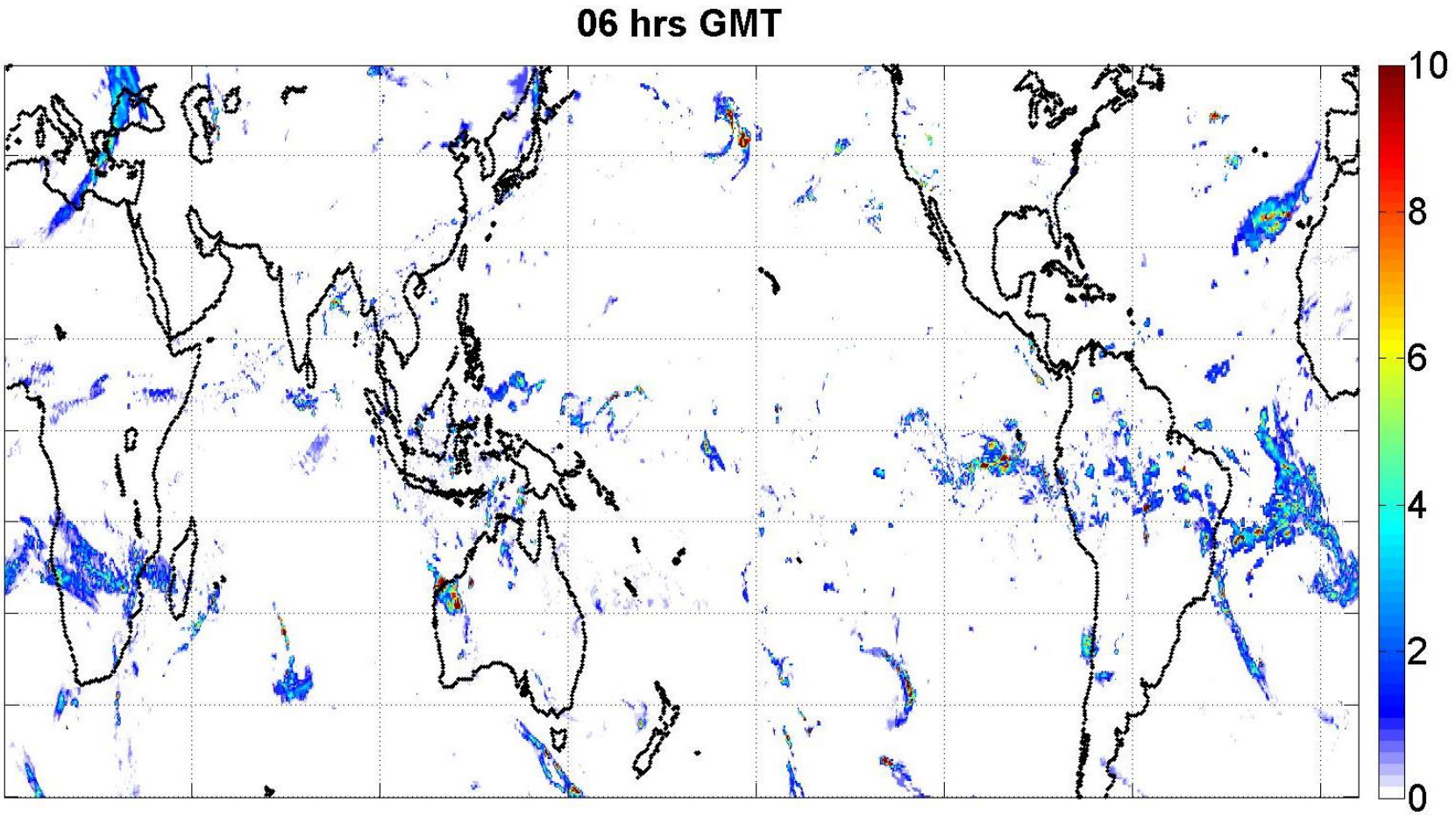
One Aquarius L-2 file



TRMM 3B42 Product: Only MW Measurements



TRMM 3B42 Product: MW and IR

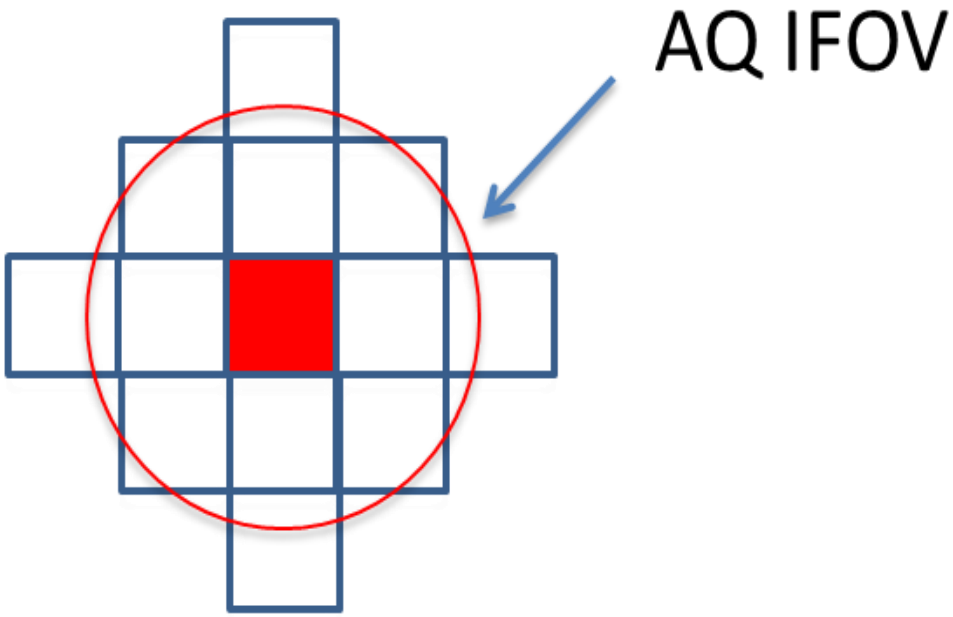


Algorithm Output: Rain Accumulation

- RA: is defined as the total amount of rainfall which accumulates over each $0.25^{o} \times 0.25^{o}$ box during the whole ΔT time prior to the observation time.

RA Algo. Step1

- Determine the matrix elements that fall within the AQ IFOV

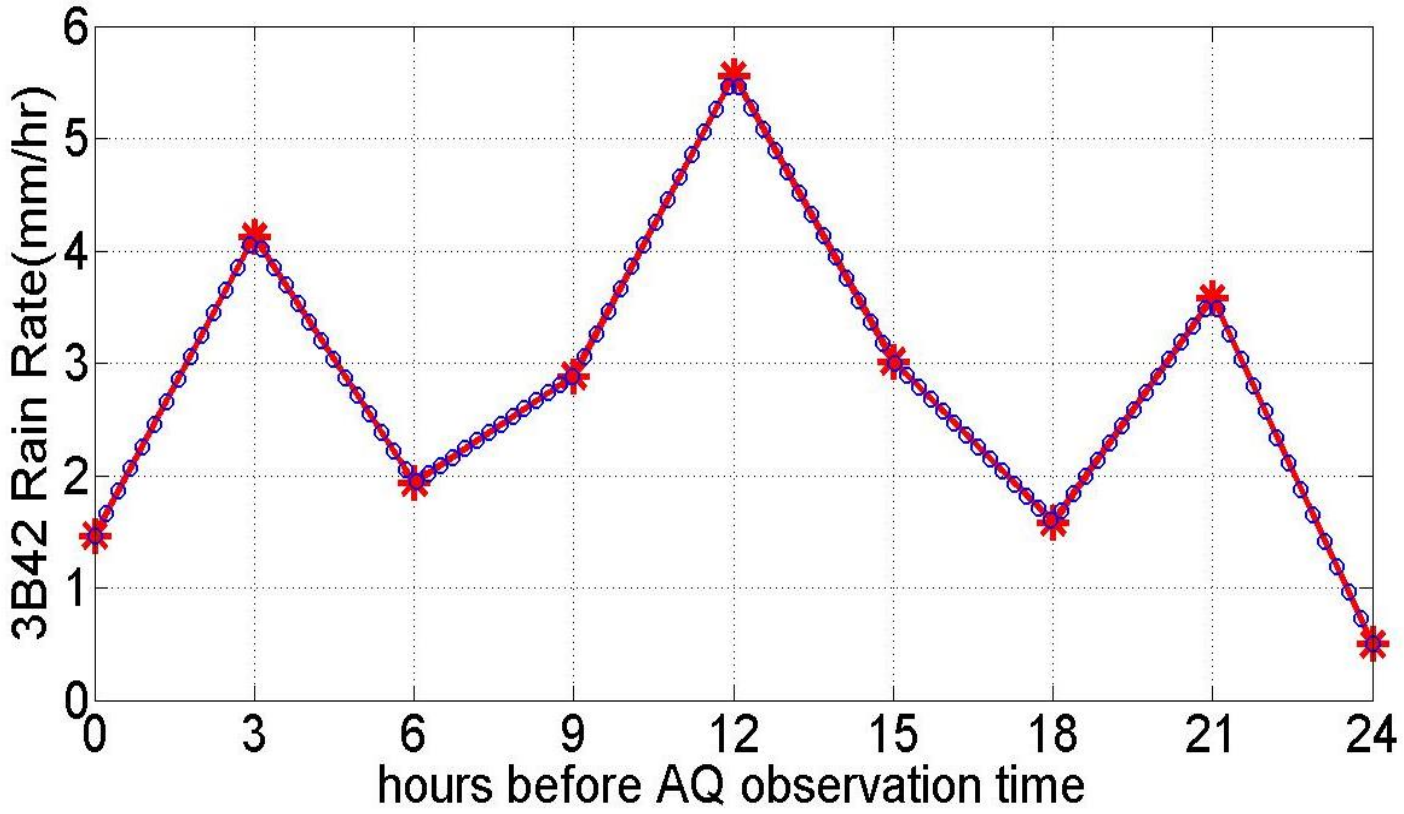


RA Algo. Step2

- Perform time interpolation of 3B42 to the AQ observation time
  - 3B42 every 3 hours: 00,03, 06, 09, 12, 15, 18 and 21 GMT
  - Pick the 3B42 file which has the closest time to the AQ observation time for rain rate at AQ observation time (T0)
  - Retreat in time and pick 3B42 files for 3, 6, 9, 12, 15, 18 and 21hr prior to T0 for previous rain rates

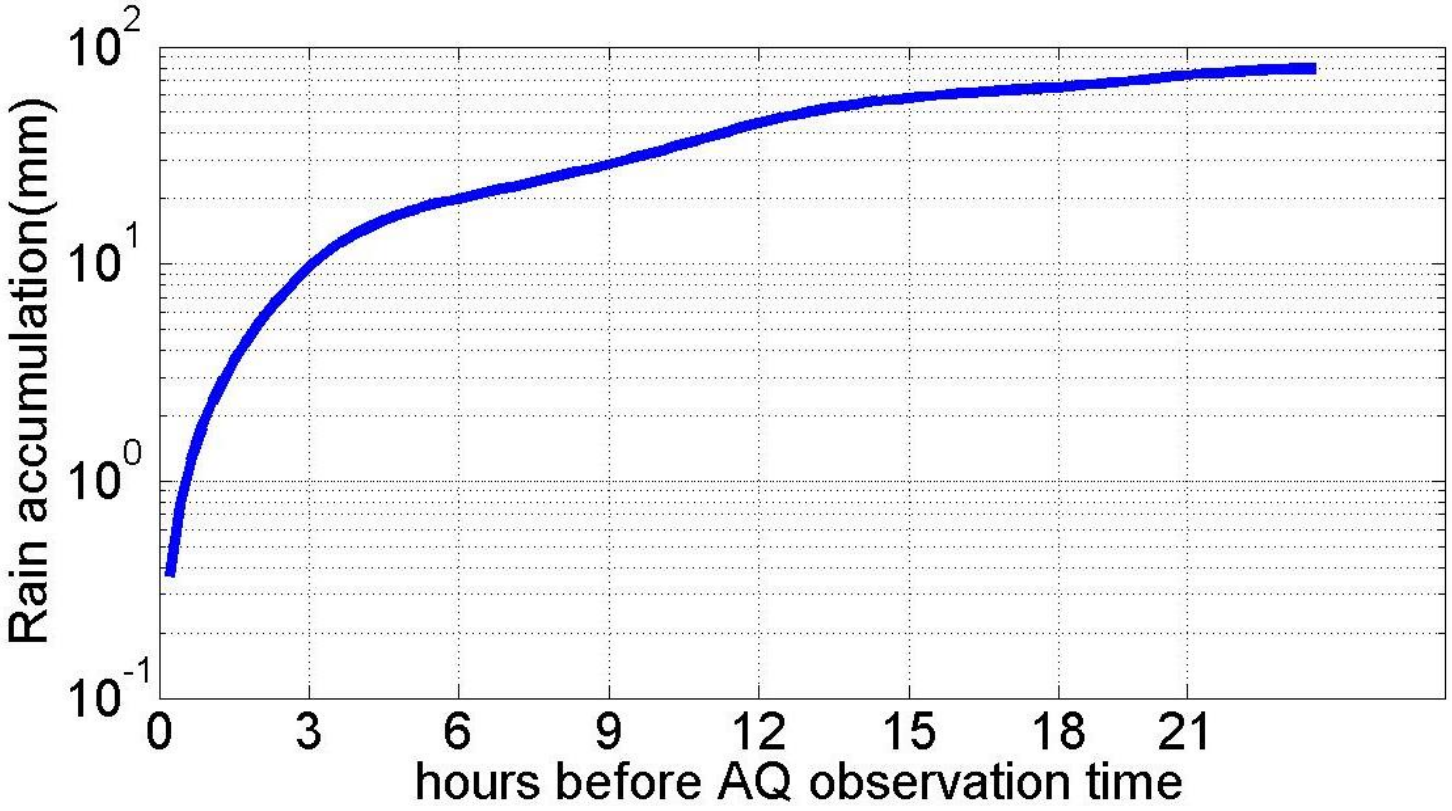
RA Algo. Step3

- Linear time interpolation of 3B42 in 0.25 hr

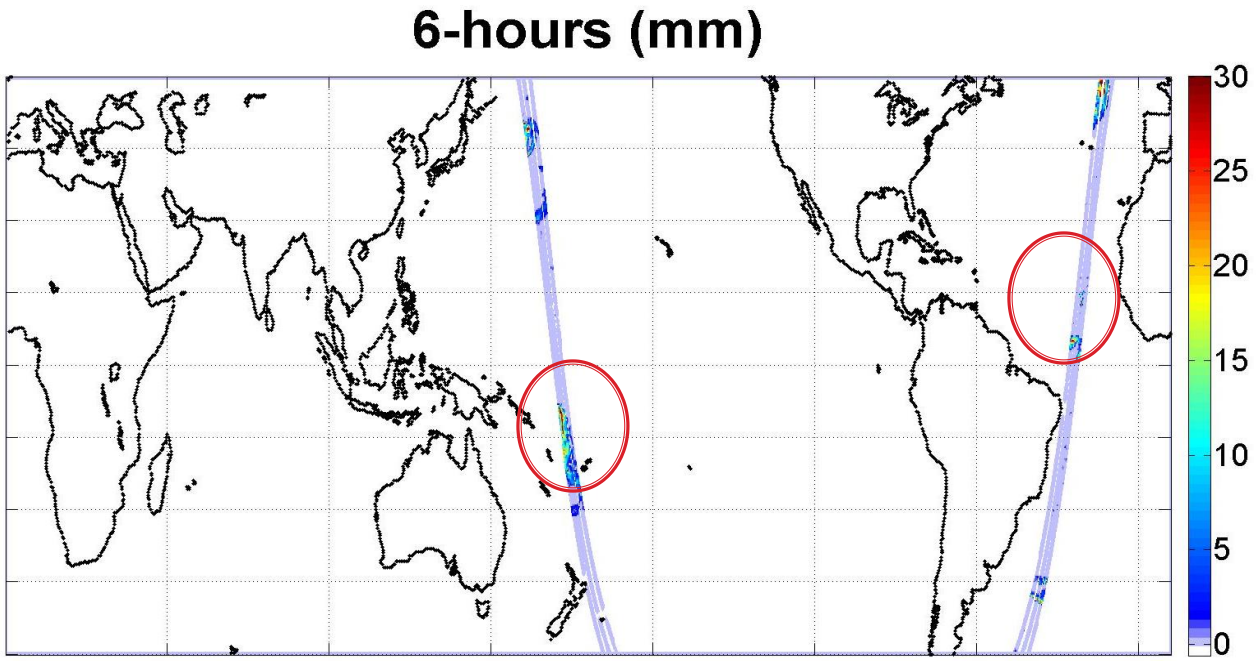


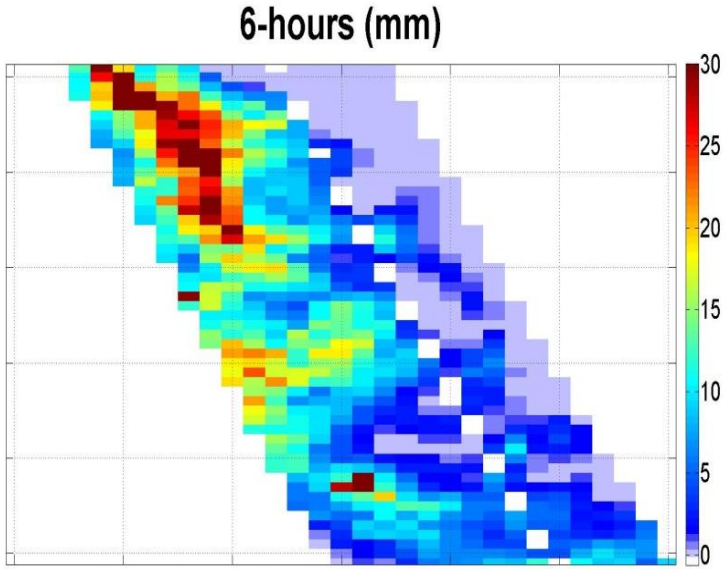
RA Algo. Step4

- Calculate rain accumulation for 3 hour windows



Results: RA for one AQ orbit

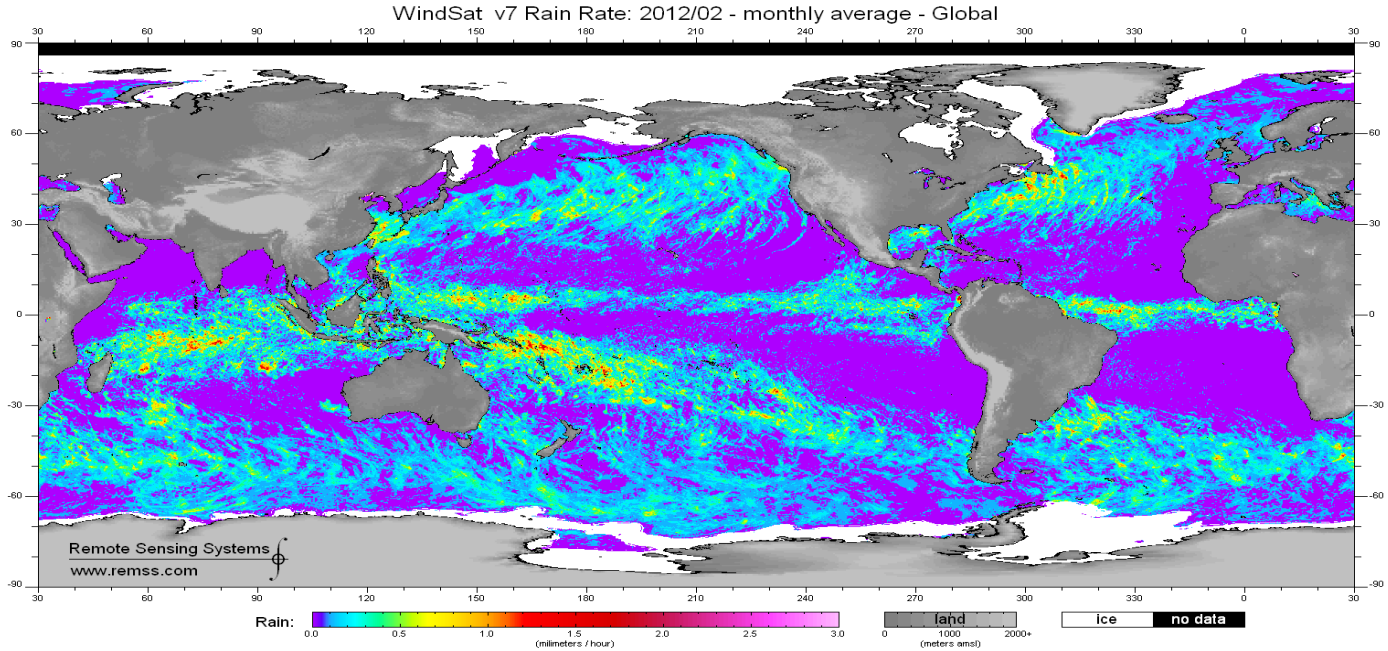


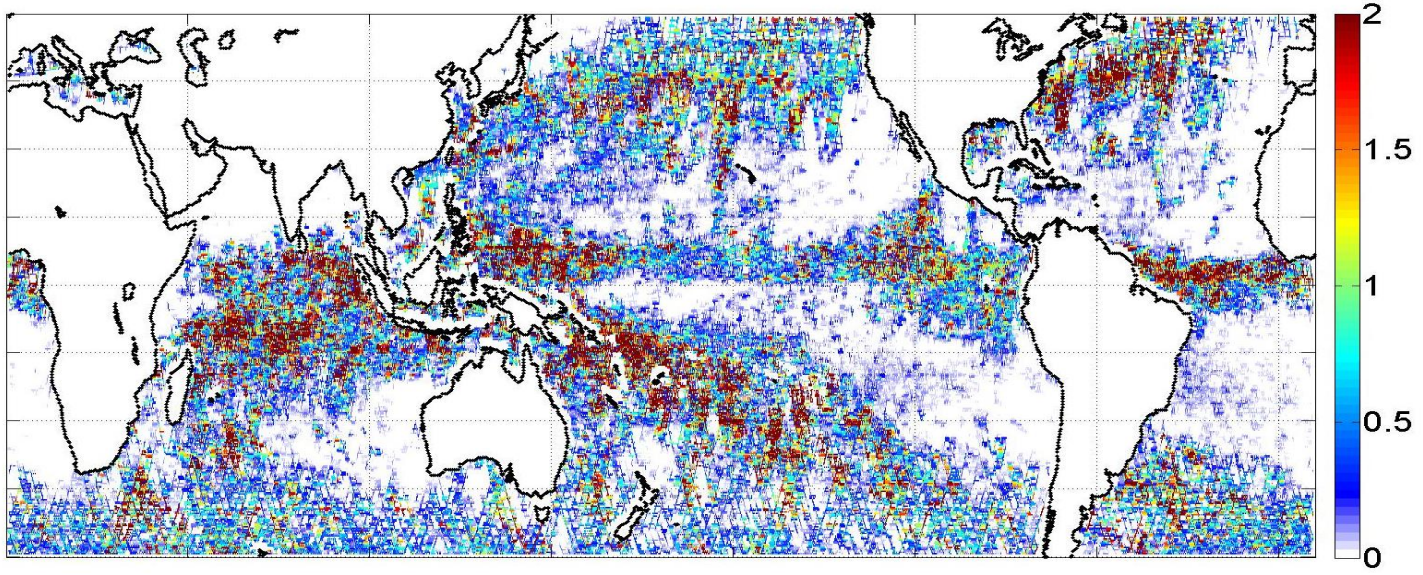


Validations

- RA is a new product → no "truth" value available for validations
  - To validate interpolation
  - To Validate the product: Use WindSat EDR rain rate and collocate with interpolated 3B42 rain rate at AQ observation time (TBD)

Validation


WindSat v7 Rain Rate: 2012/02 - monthly average - Global
Remote Sensing Systems
www.remss.com
Rain:
0.0 0.5 1.0 1.5 2.0 2.5 3.0
(milimeters / hour)
land
0 1000 2000+
(meters amsl)
ice
no data


2
1.5
1
0.5
0

Conclusions

- An algorithm has been developed to estimate the RA in a 3-hr window over the previous 24-hrs over the AQ IFOV's
- This RA product is important to AQ science objectives to improve SSS measurements.
- Based upon preliminary comparison of independent satellite rain measurements from the WindSat radiometer, we believe that the RA products are good approximations to the "true rain accumulations" over the AQ IFOV's.

Future Work

- A statistical analysis should be performed to develop an empirical relationship between the RA and observed errors in the retrieved SSS.
- An electromagnetic model should be established to calculate the AQ Tb for a lens thickness equal to RA over the oceans.
- Since diffusion of salt into fresh water lens caused by rain fall over oceans and mechanical mixing restores the ambient SSS in time, an independent study should be performed to model this procedure.

Publications

- **S. Aslebagh,** Y. Hejazin, L. Jones, C. May and R. Gonzalez, An Oceanic Rain Flag for Aquarius, Oceans'12, Oct. 2012
- Y. Hejazin, **S. Aslebagh** and L. Jones, Aquarius/SAC-D MicroWave Radiometer Ocean Wind Speed Measurements, Oceans'12, Oct. 2012
- **S. Aslebagh** and L. Jones, TMI-WindSat Double Difference XCAL Tb Bias, XCAL Science Team Meeting, Jul. 2012
- A. S. Garcia, **S. Aslebagh,** S. Biswas, L. Jones, M. Labanda and M. Marta Jacob, SAC-D MWR Brightness Temperature Inter-satellite Radiometric Calibration, Aquarius Science Team Meeting, Apr. 2012
- L. Jones, S. Bilanow, S. Farrar, **S. Aslebagh**, The Effect of TMI 1B11 V7 Solar Beta/Time Varying Bias Correction on 2A12 Rain Rate, XCAL Science Team Meeting, Nov. 2011

Thank You!

Questions?