**ARMS**: Advanced Clear-Sky Processor for Ocean (ACSPO) Regional Monitor for SST

www.star.nesdis.noaa.gov/sod/sst/arms/

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Global Monitoring and Validation of satellite & blended SST products has been established in NOAA SQUAM in 2009.

However, satisfactory global performance does not guarantee uniform & accurate regional performance.

Complementing global analyses with more regional focus was recommended by the Joint Polar Satellite System (JPSS) Program Office.

In 2016, ACSPO Regional Monitor for SST (ARMS) was launched [www.star.nesdis.noaa.gov/sod/sst/arms/](http://www.star.nesdis.noaa.gov/sod/sst/arms/)
What is ARMS?

1. A part of the NOAA SST Monitoring system, focusing on challenging areas, most interesting to data users & producers
   • Coastal/Internal waters
   • Dynamic areas
   • High-latitudes
   • Cloudy regions

2. Monitors regional performance of ACSPO SST & clear-sky mask

3. Checks for image quality, accuracy & consistency

4. Compares polar vs. geo ACSPO SSTs
   • Himawari-8 AHI
   • GOES-16 ABI

5. Compares ACSPO L2/L3 SSTs with several hi-res L4 SSTs
   • 0.01° JPL MUR
   • 0.05° Met Office OSTIA
   • 0.05° NOAA Geo Polar Blended
   • 0.09° RAMSSA
   • 0.10° Canadian Met Centre CMC
Regions in ARMS
Regions in ARMS

Currently, ARMS includes 20 special regions (can be changed/expanded based on users needs)
Multiple Overpasses
Multiple Overpasses

✓ Polar satellite may overfly the same region twice per day/night (or more, in high latitudes)

ACSPOR Regional Monitor for SST v1.30

- Clear Sky
- All Sky
- SST
- SST-CMC L4
- L2P
- L3U
- S-NPP
- AQUA
- METOP-A
- METOP-B
- NOAA-18
- NOAA-19
- GAC
- FRAC
- SSES bias correction

Cmp to: 0.01° MUR
2017 03 24
Night
Day
Day-Night transition

Multiple overpasses
Multiple Overpasses

✓ Display different overpasses; aggregating different overpasses → L3C products

ACSPO Regional Monitor for SST v1.30

Chesapeake Bay
- Clear Sky
- All Sky
- SST
- SST-CMC L4
- L2P
- L3U
- S-NPP
- AQUA
- METOP-A
- TERRA
- NOAA-18
- NOAA-19
- GAC
- FRAC
- SSES bias correction
- Cmp to
  - 0.01° MUR
- 2017
- 03
- 24
- Night
- Day
- Day-Night transition

NOAA

Data courtesy of NOAA/NESDIS/STAR
Satellite:
- NPP
- VIIRS
- L2P
Date:
- 2017/03/24 1D BBE
Time:
- 07:20:00 UTC
- 02:20:00 -0500
Scene Time:
- V011
- Projection:
- Mapped
- Map projection:
- 1 km/arcsec
- MERCATOR
- Latitude bounds:
- 25°N - 41°N
- Longitude bounds:
- 76°W - 72°W

hdf
Clear-sky and All-sky SSTs/ΔSSTs
ARMS Interface: Clear-sky and All-sky SSTs/ΔSSTs

- Monitoring: Clear-sky and All-sky SSTs and ΔSSTs=SST-Ref. SST (CMC L4)

ACSM False Alarms

ACSPO Regional Monitor for SST v1.30
ACSM False Alarms
ARMS Interface: Clear-sky and All-sky SSTs/ΔSSTs

✓ All-sky SST helps to identify over-screening of clouds

**ACSM False Alarms**
Data Levels
ARMS Interface: L2P

For visualization in ARMS, L2P is remapped to equal-grid (resolution is region specific; always 512×512)
ARMS Interface: L3U (un-collated)

L3U is also remapped to a projection/resolution consistent with re-projected L2P

ACSPSO Regional Monitor for SST v1.30
Platform / Sensor Selection
ARMS Interface: Product Selection

- Monitoring: VIIRS onboard NPP, MODIS onboard Aqua/Terra, AVHRR onboard Metop-A/B, NOAA-18/19

**ACSPO Regional Monitor for SST v1.30**

- **VIIRS**
- **MODIS**
- **AVHRR FRAC**
- **AVHRR GAC**
ARMS Interface: Product Selection

- Similar pass-time for NPP & Aqua; slightly different data coverage/cloud mask

ACSPO Regional Monitor for SST v1.30

- Chesapeake Bay
- Clear Sky
- SST
- L2P
- S-NPP
- AQUA
- METOP-A
- NOAA-18
- S-SSES bias correction
- Cmp to
- 2017
- 03
- 24
- Night
- Day
- Day-Night transition

Data courtesy of NOAA/NESS/STAR

Satellite: AQUA, SENSOR: L2P
Date: 2017/1/3/24 13:33
Time: 02:26:02 UTC
02:26:02 - 05:00
Scene Time: NIGHT
Projection type: WAPED
Map projection: 1 km/pixel
WACAKTOR
Latitude bounds: 35N - 31N
Longitude bounds: 76W - 72W
ARMS Interface: Product Selection

ACSPO Regional Monitor for SST v1.30

- Chesapeake Bay
  - Clear Sky
  - All Sky
  - SST
  - SST-CMC L4
  - L2P
  - L3U
  - S-NPP
  - J-1
  - AQUA
  - TERRA
  - METOP-A
  - METOP-B
  - NOAA-18
  - NOAA-19

Map showing SST data with a color scale from 270 to 298.

Data courtesy of NOAA NESDIS/STAR.

Satellite: TERRA, S-NPP, L2P
Date: 2017/03/24 10:05 UTC
Time: 02:05:00 UTC
Scenes:
- LAND
- NIGHT
Projection type: WRF
Map projection: 1 km/35 km
Mylon projection: 35 km
Latitude bounds: 35 N - 81 N
Longitude bounds: 78 W - 72 W
ARMS Interface: Product Selection

- FRAC Metop-A has warmer temperature compared to MODIS Aqua and FRAC Metop-A

ACSPO Regional Monitor for SST v1.30
ARMS Interface: Product Selection

✓ Multiple overpasses of different platforms → L3S (super-collated) product

ACSPO Regional Monitor for SST v1.30
Comparison to L4 SSTs
Including four L4 SSTs: 0.01° MUR, 0.05° OSTIA, 0.05° Geo_Polar_Blended, 0.09° RAMSSA, 0.10° CMC
ARMS Interface: Comparison to L4 SSTs

- 0.01° MUR shows more details where VIIRS_NPP data are available

**ACSPPO Regional Monitor for SST v1.30**

- **Chesapeake Bay**
  - Clear Sky
  - SST
  - L2P
  - S-NPP
  - AQUA
  - METOP-A
  - METOP-B
  - NOAA-18
  - GAC
  - FRAC
  - SSES bias correction

- **Cmp to**
  - 0.01° MUR
  - L4
  - 2017
    - 0.05° OSTIA
    - 0.05° GeoPolarBlend
    - 0.09° RAMSSA
    - 0.10° CMC

- **Daily mean L4**

Data courtesy of JPL

Satellite: 0.01° DEG MUR
Sensor: LA SAF
Date: 2017
Map projection: LAM.
Latitude bounds: 25 N - 41 N
Longitude bounds: 78 W - 72 W
ARMS Interface: Comparison to L4 SSTs

ACSPO Regional Monitor for SST v1.30

Chesapeake Bay
- Clear Sky
- SST
- L2P
- S-NPP
- AQUA
- METOP-A
- NOAA-18
- GAC
- SSES bias correction

- Cmp to 0.05° OSTIA
- 2017 03 24

Daily mean L4
Comparison to L4 & Geo SSTs

- 0.05° Geo_Polar_Blended reserves more details than OSTIA
ARMS Interface: Comparison to L4 SSTs

ACSPO Regional Monitor for SST v1.30

Daily mean L4
Comparison to Geo SSTs
ARMS Interface: Comparison to Geo SSTs

- Including geostationary SSTs: AHI onboard Himawari-8, ABI onboard GOES-16 (internal view only)
- AHI is available for three regions: Kuroshio Current, Korean Strait, and South China Sea

ACSSPO Regional Monitor for SST v1.30

Data courtesy of NOAA/NESDIS/STAR.

- Satellite: NPP
- Sensor: VIIRS-I
- Date: 2017-08-17 03:20 UTC
- Resolution: 7.5 km/pixel
- Projection: WGS-84
- Region: Southeast Asian, South China Sea

Legend:
- Clear Sky
- All Sky
- SST
- SST-CMC L4
- L2P
- L3U
- S-NPP
- AQUA
- TERRA
- METOP-A
- METOP-B
- NOAA-18
- NOAA-19
- GAC
- FRAC
- SSES bias correction
- Cmp to
- Himawari-8
- 2017
- 03
- 20
- Night
- Day
- Day-Night transition

8/17/2017
ARMS Interface: Comparison to Geo SSTs

ACSP0 Regional Monitor for SST v1.30

Kuroshio Current

- Clear Sky
- SST
- L2P
- S-NPP
- NOAA-18
- GAC
- SSES bias correction
- Cmp to
- 2017
- Night
- Day-Night

Data courtesy of NOAA NESDIS/STAR

Satellite: NOAA-18
Sensor: AVHRR
Data: 2017-08-17
Time: 01:20:00 UTC
Scene time: 01:20:00
Projection: MERCATOR
Latitude bounds: 33 N - 45 N
Longitude bounds: 140 E - 155 E

Closest in time geo
Date Selection
Starting date: July 18th 2015
Starting date: July 18th 2015
ARMS Interface: Date Selection

- Starting date: July 18th 2015

ACSPRO Regional Monitor for SST v1.30

Gulf of California
- Clear Sky
- SST
- L2P
- S-NPP
- AQUA
- METOP-A
- NOAA-18
- GAC
- Satellite: NPP Location: VIRS-L2P Date: 2017/03/30 10:38 Starting time: 20:00:02 UTC Ending time: 20:10:01 UTC Projection: WGS84 Map projection: Spherical Mercator Longitude bounds: 10 N -> 24 N Latitude bounds: 125 W -> 105 W

2017 - 03 - 30

Night
Day
Day-Night transition

Data courtesy of NOAA/NESSO/STAR
Day/Night Data
ARMS Interface: Day/Night Data

- Scene time options: nighttime, daytime, region crossing the day-night transition zone (high-lats)

**ACSSPO Regional Monitor for SST v1.30**

- Gulf of Mexico, US
- Clear Sky
- SST
- L2P
- S-NPP
- AQUA
- METOP-A
- NOAA-18
- GAC
- FRAC
- SSES bias correction

**Map:**
- Scene time options: Night, Day, Day-Night transition
- Color scale: 292 - 298
- Data courtesy of NOAA/NWS/NFD/STAR
- Satellite: NPP
- Sensor: 7/5/1 L2P
- Data: 2017/03/01 00:00 UTC
- Region: 30N-20N, 0W-0E
- Projection: WGS84
- Map projection: Lambert Conformal
- Latitudinal bounds: 15N - 24N
- Longitudinal bounds: 105W - 80W
ARMS Interface: Day/Night Data

- Scene time options: nighttime, daytime, region crossing the day-night transition zone (high-lats)

ACSPO Regional Monitor for SST v1.30

- Gulf of Mexico, US
  - Clear Sky
  - SST
  - L2P
  - S-NPP
  - AQUA
  - METOP-A
  - NOAA-18
  - Cmp to: 0.01° MUR
  - Night
  - Day
  - Day-Night transition

Data courtesy of NOAA NESDIS/STAR

Satellite: NPP
Sensor: VIRR-L2P
Date: 2017/08/01 01:36:00 UTC
Time: 19:16:02 UTC
Scene time: DAY
Projection type: WARPED
Map projection: 4 cm/pixel
WORLAD
Latitude bounds: 15° N - 30° S
Longitude bound: 100° W - 60° W
ARMS Interface: Day/Night Data

- Scene time options: nighttime, daytime, region crossing the day-night transition zone (high-lats)

ACSPO Regional Monitor for SST v1.30

Data courtesy of NOAA-NESS/STAR

Satellite: NPP
Sensor: VIRR-L2P
Data: 2017-08-17 08:30
Time: 04:20:30 UTC
04:20:30 +0000 UTC
Scene time: DAY/night
Projection type: Mapped
Map projection: 2.5 km/pixel
POLY6
STEREOGRAPHIC
Latitude bounds: 66 N -> 85 N
Longitude bounds: 42 W -> 26 E
Examples of Using ARMS for ACSPO Diagnostics

- Validate Clear-Sky Domain
- Validate Clear-Sky Mask and SST for day/night consistency
- Check the sea-ice mask in ACSPO (currently taken from CMC)

Identify areas of improvement
ACSPO Clear-Sky Mask Overly Conservative
In Coastal / Dynamic areas

Coastal Zone

Cloud

Dynamic
The cold regions (coastal and dynamic areas) may be identified as “cloud” by the ACSM.
Current ACSPO ice mask Comes from 0.1º CMC L4
May not be fully accurate and sufficiently hi-res

Stay still, does not move like clouds
Sea ice and cold water may be identified as “cloud” by the ACSM.

Current ACSPO ice mask comes from 0.1º CMC L4. It may not be fully accurate and sufficiently high-resolution.
Example #3: Discontinuity problem in day/night transition zone

SST algorithm is different in daytime and nighttime, which causes discontinuity.
Example #3: Discontinuity problem in day/night transition zone

Use of gross filter RGCT instead of ratio filter RRCT causes cloud mask discontinuity
Example #3: Discontinuity problem in day/night transition zone

SST algorithm is different in daytime and nighttime, which causes discontinuity
Example #3: Discontinuity problem in day/night transition zone

The use of gross filter \textbf{RGCT} instead of ratio filter \textbf{RRCT} may cause cloud mask discontinuity.
Conclusion

Potential improvements of ACSPO using ARMS

- The current “in-pixel” ACSPO Clear-Sky Mask may be overly conservative in coastal, dynamic, and hi-lat areas – work on pattern recognition improvements is underway (Irina’s talk)
- The current ice mask used in ACSPO comes from 0.1º CMC L4 and has room for improvement – have not looked into that yet
- Discontinuity in both SST and mask seen in day/night “twilight” zone in earlier versions of ACSPO – improved in recent ACSPO
- ARMS is a first step towards data fusion
  - Data of different overpasses from the same platform can “collated” to generate an L3C
  - Data from multiple platforms can be “super-collated” to generate an L3S

Potential improvements in ARMS

- SSES effectively reduce global consistency of satellite SST with in situ SST. We plan to add SSES “on-off” button in ARMS, to see its effect on local imagery
- Improve web speed efficiency
- Listen to users what else might be needed