In-Orbit Performance and Calibration Stability Assessment of the L-band Aperture Synthesis Microwave Radiometer (LASMR) on HY-4A

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Content

Part.01 Project Background

- Sea surface salinity is a key tracer for understanding the global water cycle, ocean circulation, and climate variability.
- The Chinese Ocean Salinity and Soil Moisture Mission (COSM) was successfully launched on November 14, 2024, Its primary mission is to acquire global ocean salinity and soil moisture information.
- It carries two main payloads:
  - ✓ The 2-D L-band Aperture Synthesis Microwave Radiometer (LASMR)
  - ✓ The Microwave Imager Combined Active and Passive (MICAP)

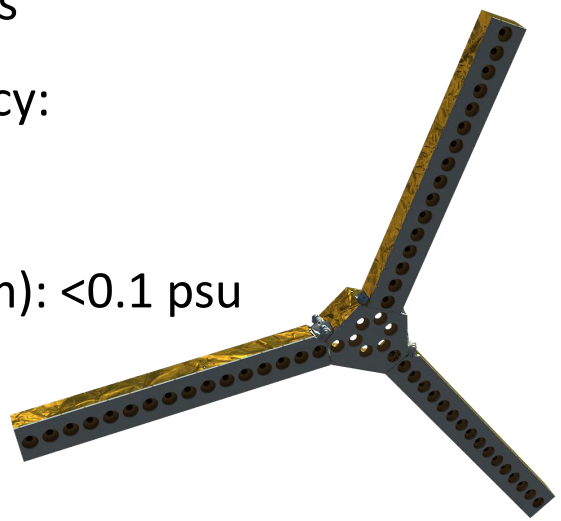
Key Mission and Instrument Parameters:

- Satellite Platform
  - ✓ Orbit Altitude: 654 km
  - ✓ Tilt Angle: 30°
  - ✓ Attitude Stability: 0.001°
- LASMR Instrument
  - ✓ Frequency Band: L-band(1415 ± 10 MHz)
  - ✓ Antenna Array: 56-element Y-shaped array
  - ✓ Channels: 112 receiver channels
  - ✓ Baseline: 5.4 m (maximum)

- Designed Performance:
  - ✓ Resolution: <50 km
  - ✓ Sensitivity: <1.5 K
  - ✓ Swath Width: >950 km
  - ✓ Stability: < 0.12 K / 3 days
  - ✓ Salinity Inversion Accuracy:

    Single-pass: <1 psu

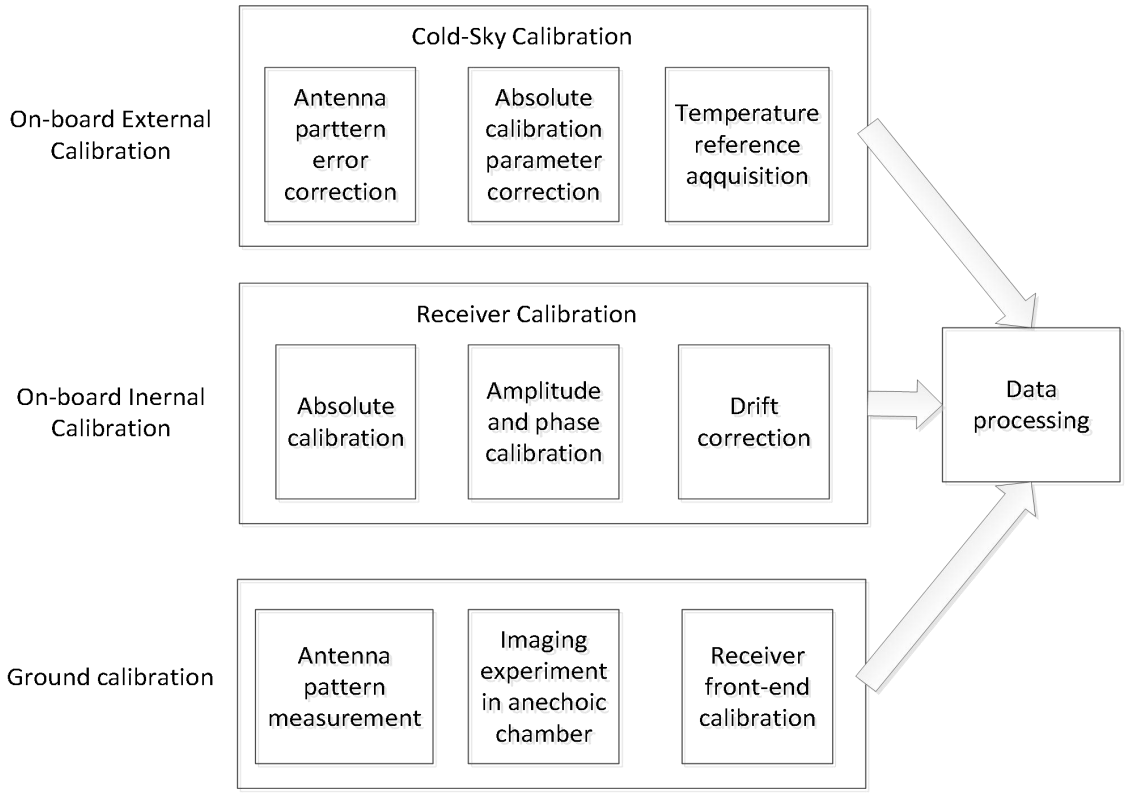
    Monthly average (200 km): <0.1 psu



Part.02 Calibration Strategy

The calibration strategy of LASMR consists of three main components:

- Ground Calibration:
  - ✓ Conduct antenna pattern tests, anechoic chamber calibration tests, and receiver calibration tests
  - ✓ Verify/Test auxiliary data of all individual units
- On-board Internal Calibration:
  - ✓ Employ correlated/unrelated noise injection to achieve receiver amplitude-phase calibration and absolute calibration
- On-board External Calibration:
  - ✓ Perform external calibration based on cold sky, ocean, and polar region scenarios

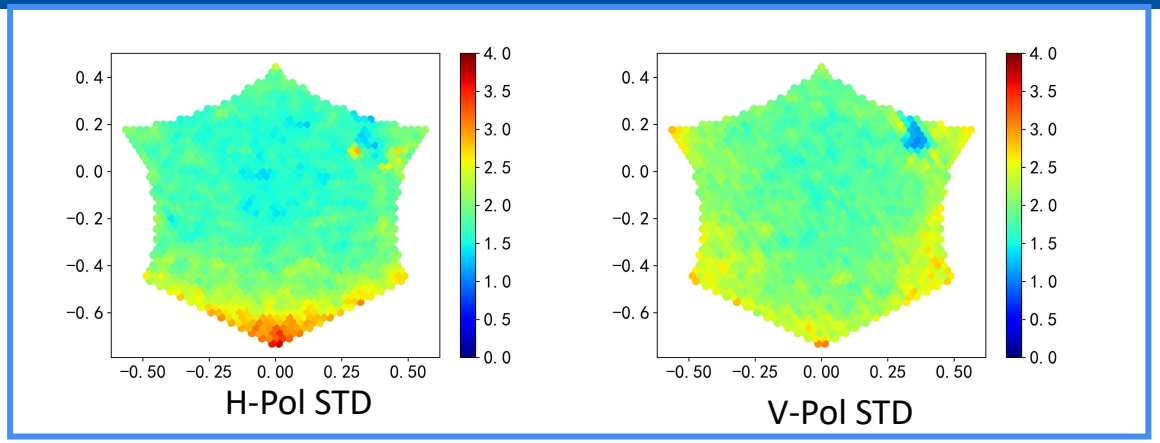


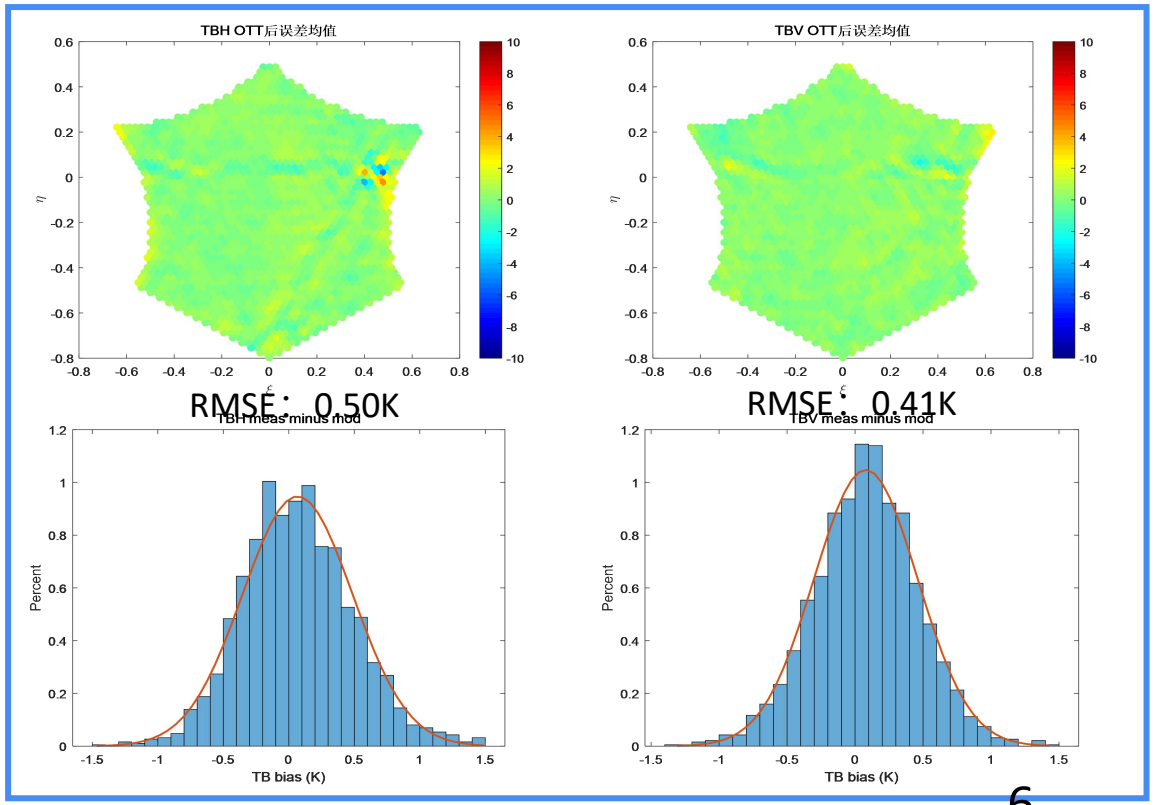
Calibration Results

Brightness Temperature (TB) Accuracy

- O-B STD (Measured vs. Model):
  - ✓ Fluctuation range for most pixels: 1.3 ~ 2.5 K

    (Including sensitivity and system errors)
- RMSE after Multi-Snapshot Averaging:
  - ✓ Achieved Brightness Temperature Error: < 0.5 K

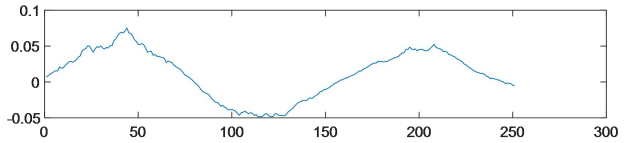




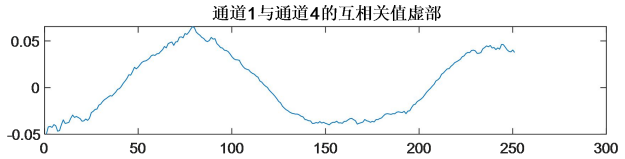
Interference Fringes

LASMR continuously observes Earth's RFI sources, generating interference fringes during satellite operation：

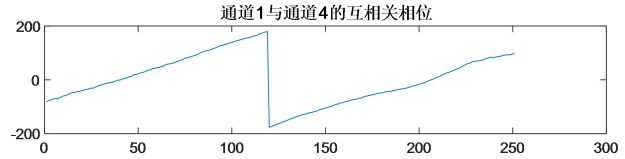
- Key Findings:
  - ✓ Interference Fringes: Regular periodic characteristics
  - ✓ Baseline Comparison: Long baselines show more variation periods compared to short baselines
- Results:
  - ✓ LASMR functionality is qualitatively verified
  - ✓ Successfully distinguishes directional information within FOV and demonstrates strong phase discrimination capability



Real Part



Imag Part

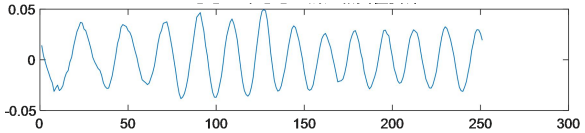


Phase

Short baseline

Long baseline

Real Part



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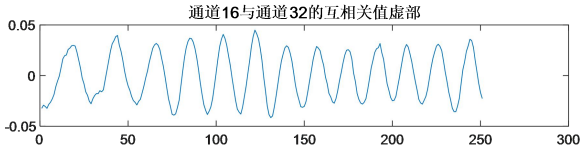
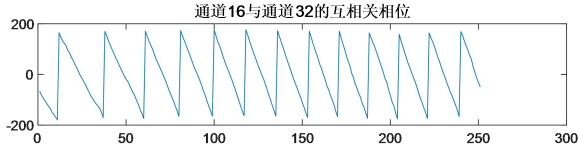
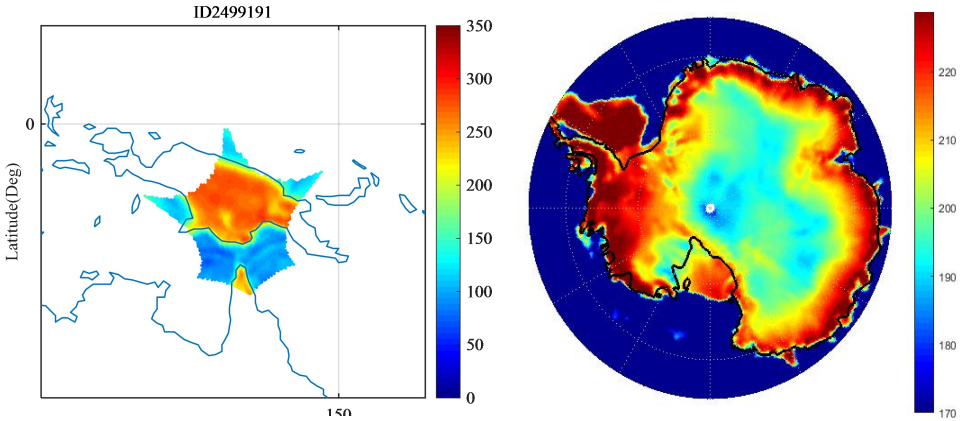


Phase



Brightness Temperature Imaging

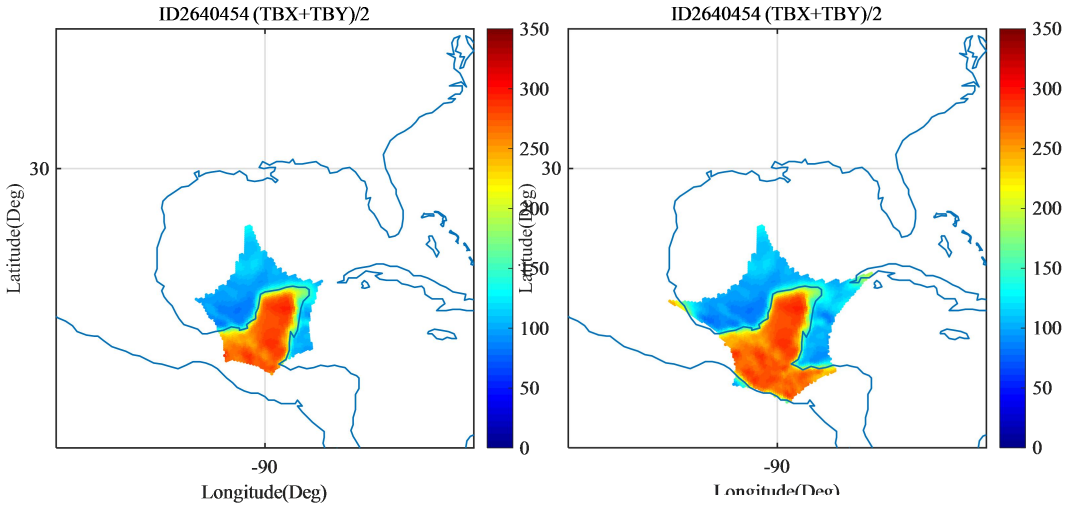
- Imaging Function: Validation of LASMR operation and data processing accuracy.
- The imaging demonstrates：
  - ✓ Sharp boundaries are visible in complex regions
  - ✓ Brightness temperature accurately reflects regional variations
  - ✓ High sensitivity to land-ocean transitions, with clear detail



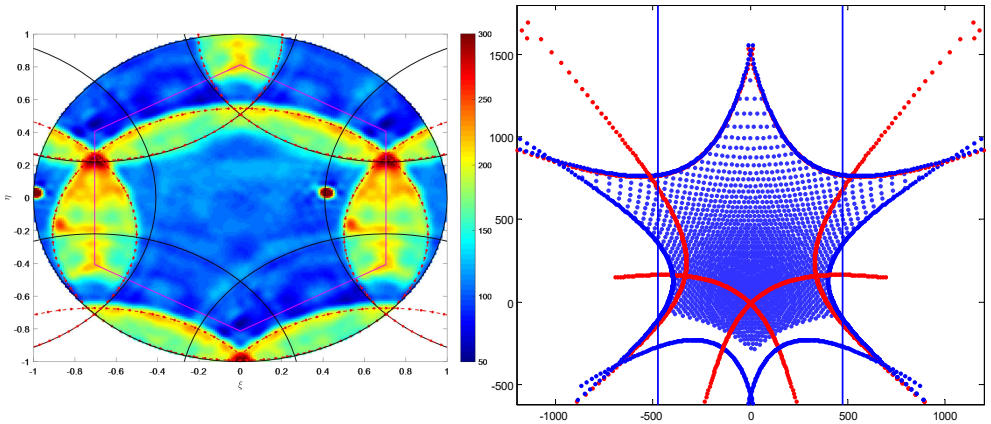
Island　　Antarctica

Swath Width

- LASMR: Synthetic Aperture Radiometer
  - ✓ Single imaging yields 2D wide swath
  - ✓ Interferometric measurement creates periodic FOV extensions with partial aliasing
- Swath width：
  - ✓ Fully alias-free FOV: 956 km
  - ✓ Extended alias-free FOV: 1512 km (after cold-sky correction)



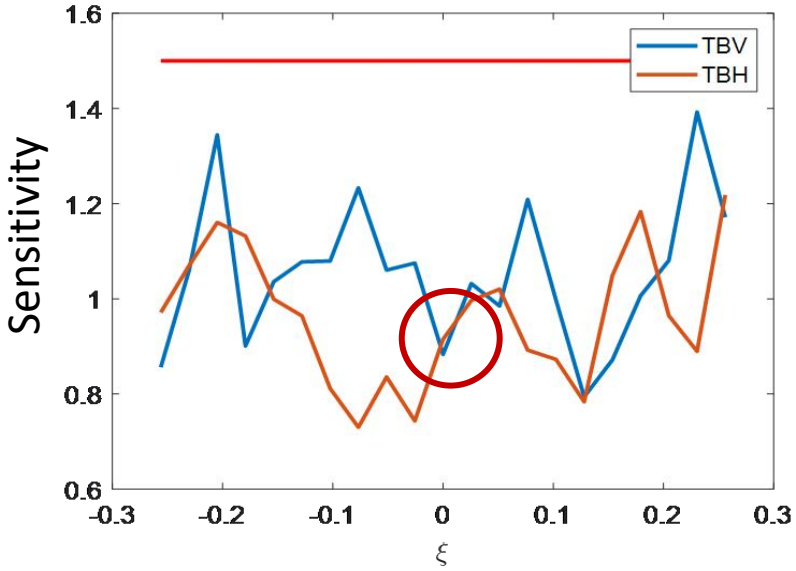
AFov　　Extend Fov



FOV Aliasing Effect

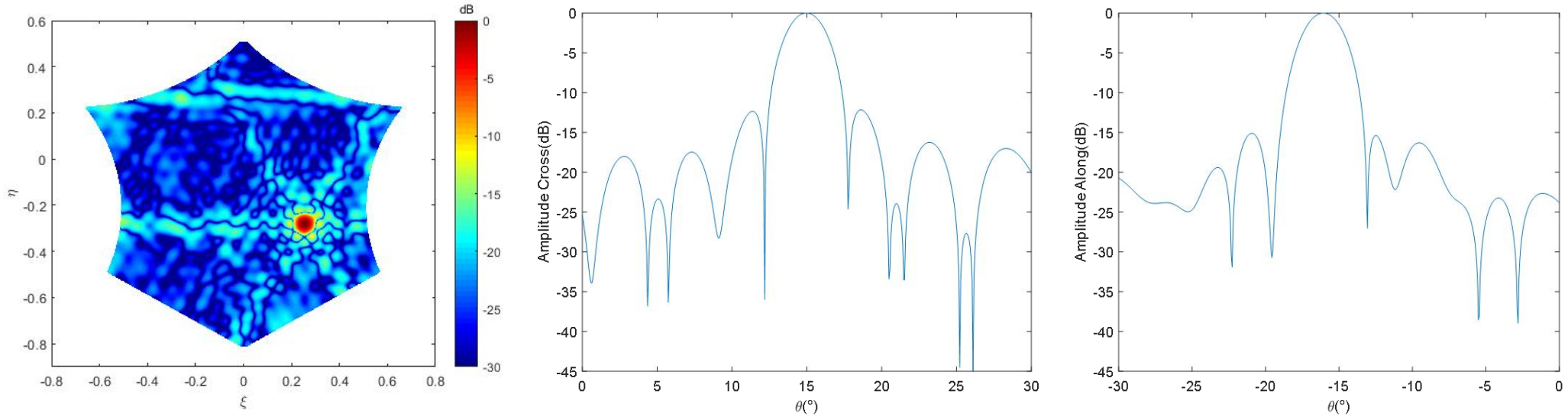
Sensitivity

- Sensitivity: The minimum detectable brightness temperature change at the boresight center during short-term cold-sky observations defines the single-measurement sensitivity.
- Single-measurement sensitivity (from short-term cold-sky observations)：
  - ✓ V Polarization: 0.91 K
  - ✓ H Polarization: 0.88 K
- The multi-incidence-angle equivalent sensitivity is:
  - ✓ V Polarization: 0.0599 K
  - ✓ H Polarization: 0.0580 K



Spatial Resolution

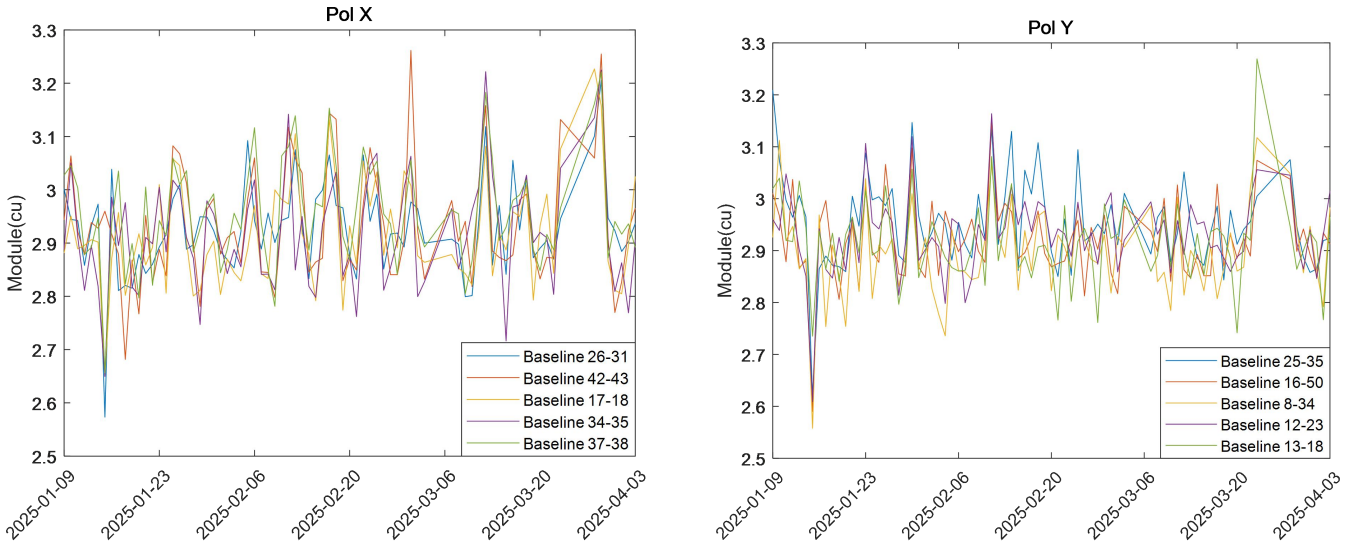
- RFI sources on Earth imaged to analyze angular resolution at different FOV positions:
  - ✓ Nadir: 37.21 km
  - ✓ Boresight: 41.64 km
  - ✓ Between Nadir & Boresight: 35.48 km
- All values meet the design requirement of < 50 km



Long-term Stability

Payload Stability:

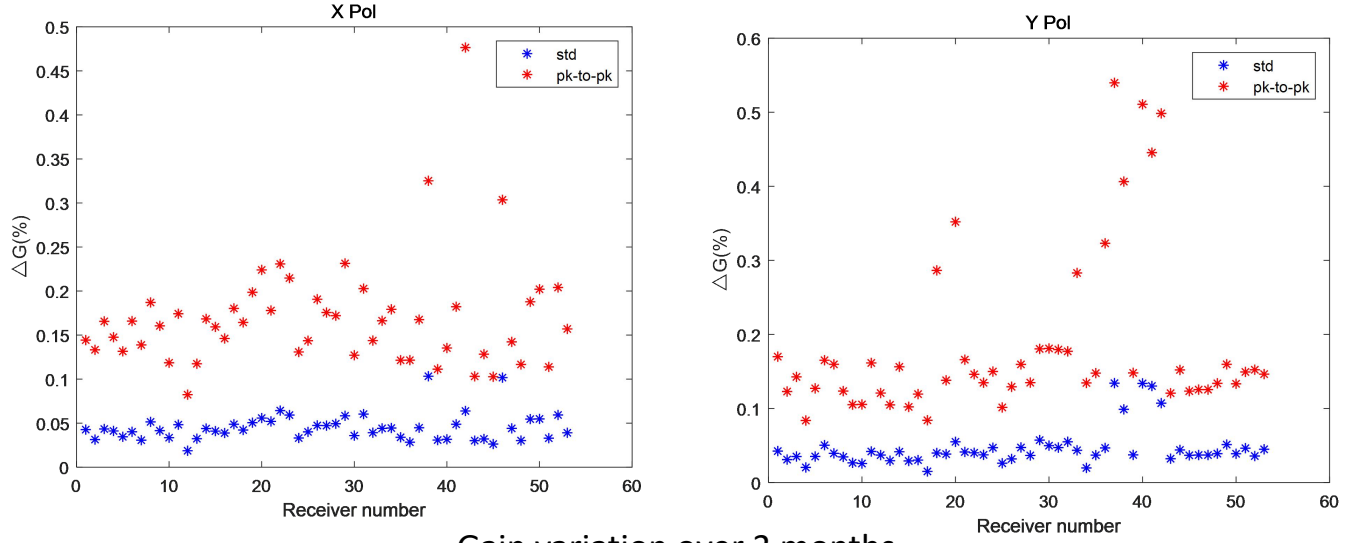
- Correlation coefficient variation over ~3 months:
  - ✓ All baselines < 0.65 cu



Variation of Load Correlation Coefficient

Absolute Calibration Gain Stability:

- LASMR gain variation over ~3 months:
  - ✓ Peak-to-peak: < 0.6%
  - ✓ Standard deviation: < 0.1%

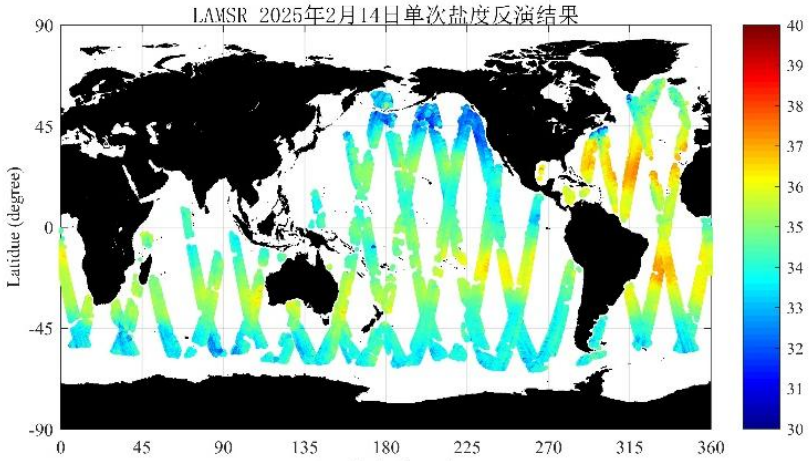


Gain variation over 3 months

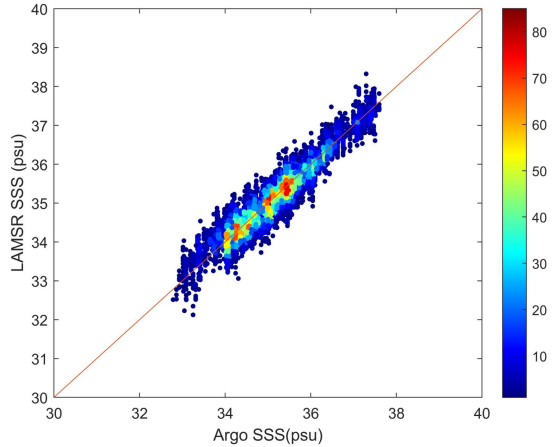
SSS Retrieval

- Single-Pass Retrieval Accuracy
  - ✓ Matched with Argo buoy salinity data using ±12 h, ±0.5° spatiotemporal window
  - ✓ RMS error: < 0.300 psu
  - ✓ Correlation coefficient: 0.945

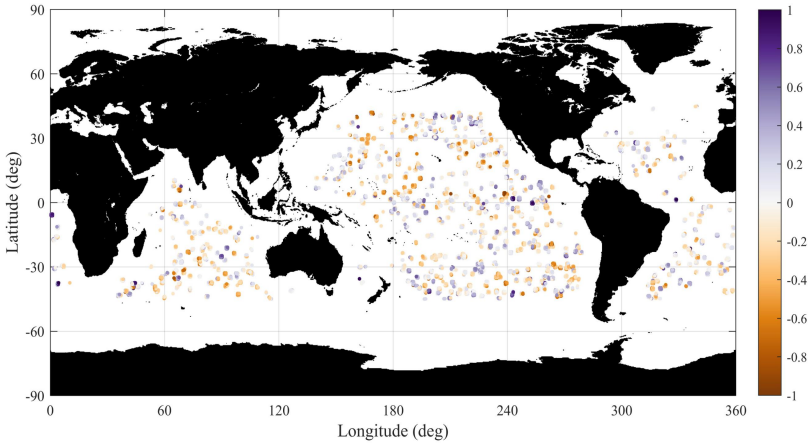
Item	Bias(psu)	STD(psu)	RMS(psu)	Corr
LASMR vs Argo	-0.008	0.299	0.300	0.945



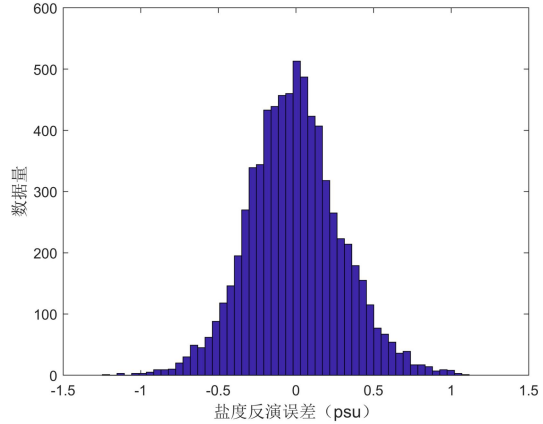
Single-pass Salinity Retrieval Resul



Scatter Plot of Salinity Retrievals vs. Argo



Salinity Retrieval Error Distribution

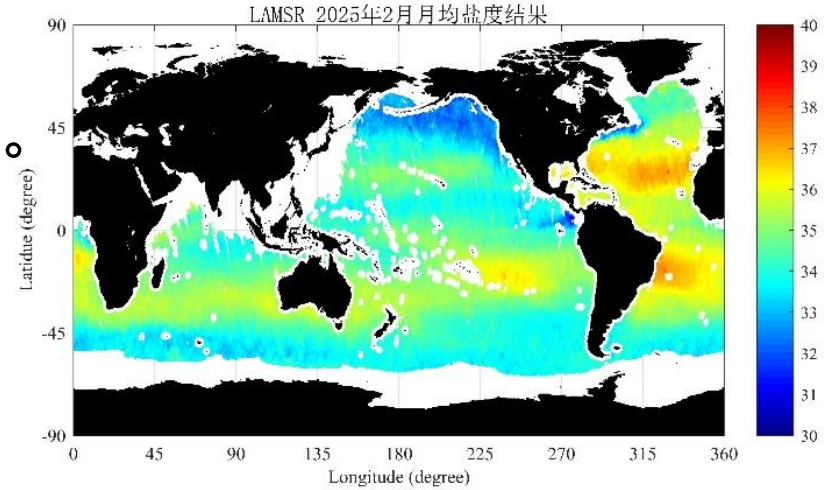


Histogram of Salinity Retrieval Errors

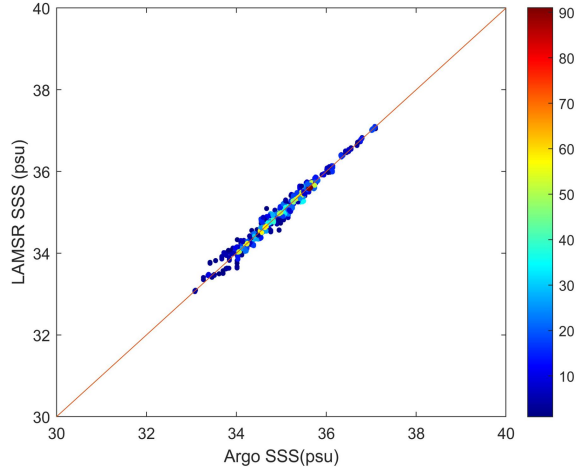
SSS Retrieval

- Monthly Average Salinity Retrieval Accuracy
  - ✓ Comparison with Argo buoy data using 2° resolution monthly products
  - ✓ RMS error: 0.097 psu
  - ✓ Correlation coefficient: >0.99

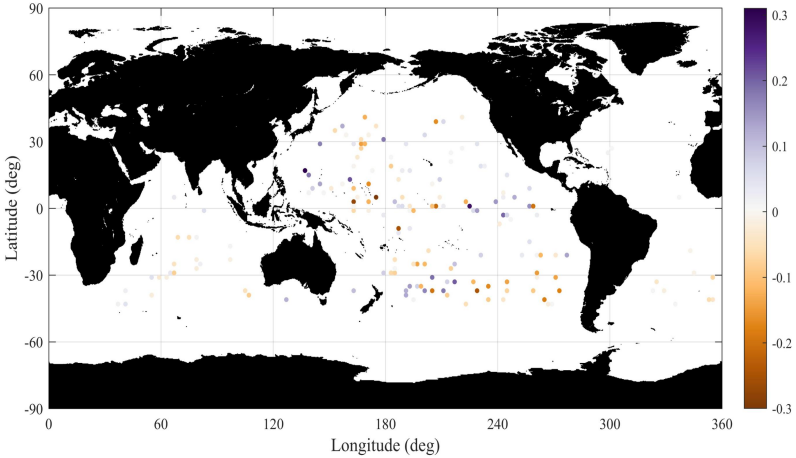
Item	Bias(psu)	STD(psu)	RMS(psu)	Corr
LASMR vs Argo	-0.0006	0.097	0.097	0.990



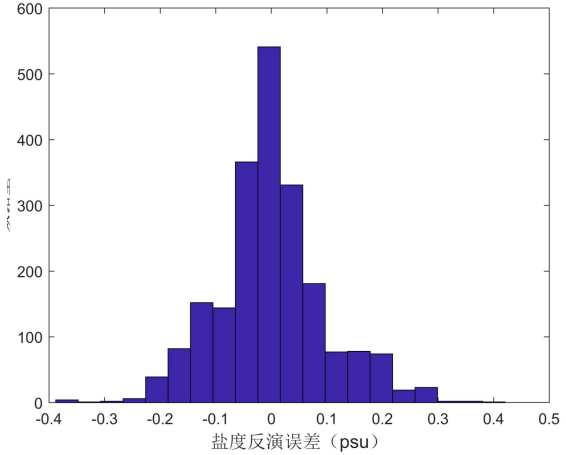
Monthly Average Distribution of Salinity



Scatter Plot of Salinity Retrievals vs. Argo



Salinity Retrieval Error Distributio

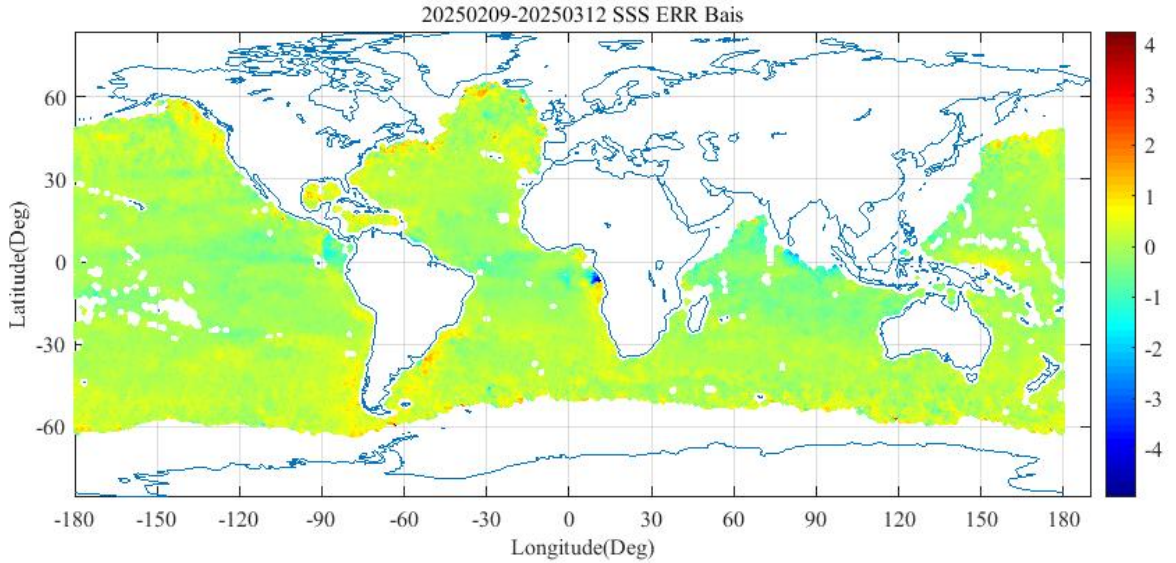


Histogram of Salinity Retrieval Errors

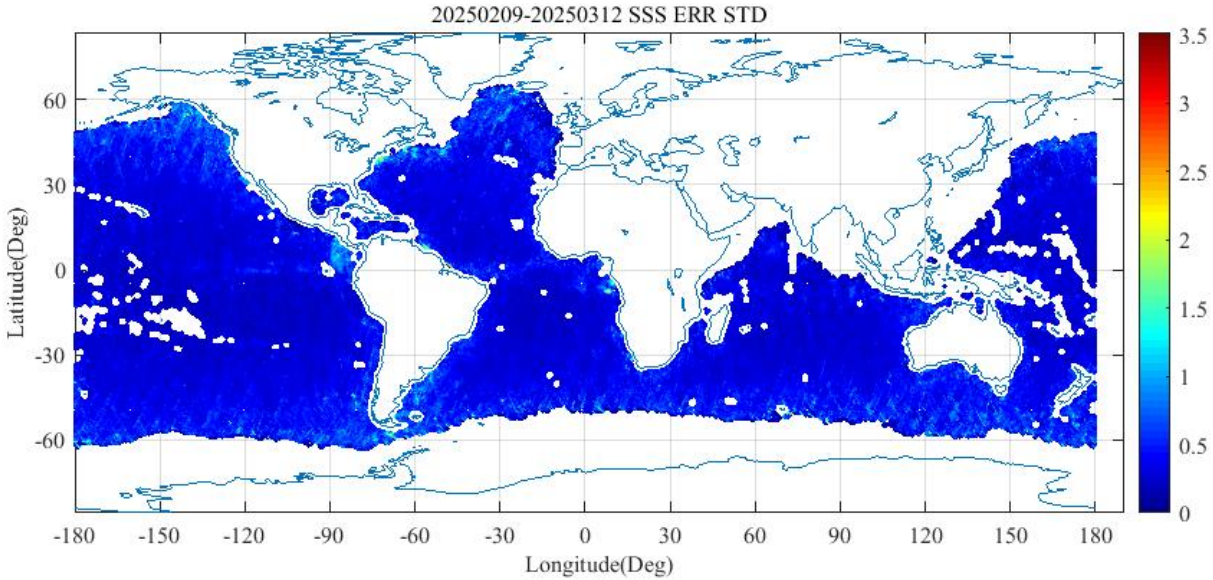
SSS Retrieval

LASMR Salidity vs. HYCOM Salinity Comparison

- STD calculated for each grid using ~1 month of data:
  - ✓ STD < 0.5 psu for 85% of global oceans
  - ✓ STD > 0.5 psu mainly in high-latitude and coastal regions (15%)



Bias of (LASMR - HYCOM)



STD of (LASMR - HYCOM)

- **LASMR on HY-4A has operated stably for over a year, with excellent in-orbit performance.**
- **Current Challenges& Ongoing Work:**
  - ✓ RFI: Impact is more severe than expected
  - ✓ Solar Contamination: Residual errors persist
  - ✓ Coastal Accuracy: Degraded by RFI and Gibbs effects
- **Path Forward:**
  - ✓ Continue long-term stability monitoring and correction
  - ✓ Optimize calibration and error correction methods
- **Data Availability:**
  - ✓ Data products are publicly released. We welcome collaboration and studies from the research community： https://osdds.nsoas.org.cn/OceanDynamics .

中国航天

Thanks!