Future scientific outlook for Jason-1: Geodesy and Oceanography

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with contributions from:
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Introduction

- Jason-1 orbit changed last Spring
  - Increased risk of platform failure and risk of collision with T/P
  - Necessity to preserve the historical orbit

- New phase: Jason-1 Geodetic Mission (GM)
  - No longer on the interleaved track → drifting geodetic orbit
  - Revisit time > 400 days (end of the 10-day exact repeat cycle)

- Purpose of this talk: to give some insights on the future scientific outlook
  - Oceanography: what has changed?
  - Geodesy: what is expected from Jason-1 GM?

Oceanography outlook

What has changed with the Geodetic Mission?

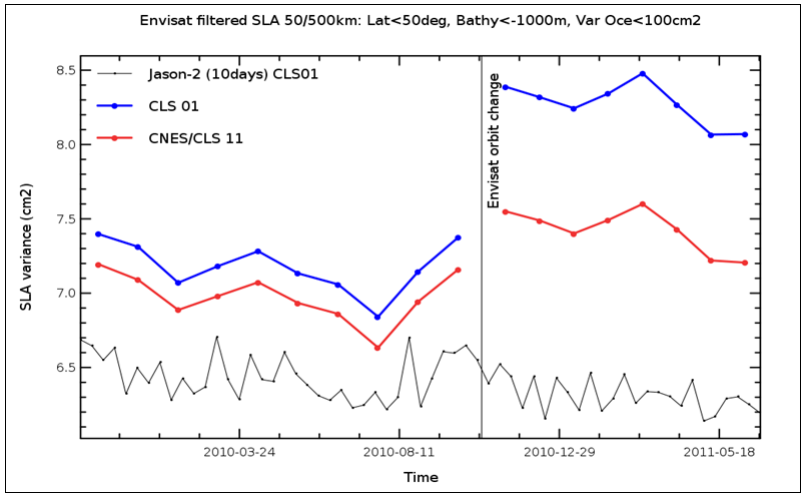
New Error budget (1/2)

- SSH error budget mostly unchanged (payload status ok)

- New drifting ground track ➔ TP-based history no longer usable
- Temporal average for SSHA: gridded Mean Sea Surface model

- Static and correlated error on Jason-1 GM SSHA (2 to 3 cm RMS)

➡ Main risk: false stationary eddies in SSHA (injected in ocean models)



⬅ SLA variance increase when ENVISAT left the charted ERS track for a geodetic orbit (same change as Jason-1 GM):

+11 cm RMS with 2001 MSS model

+2.5 cm RMS with 2011 MSS model

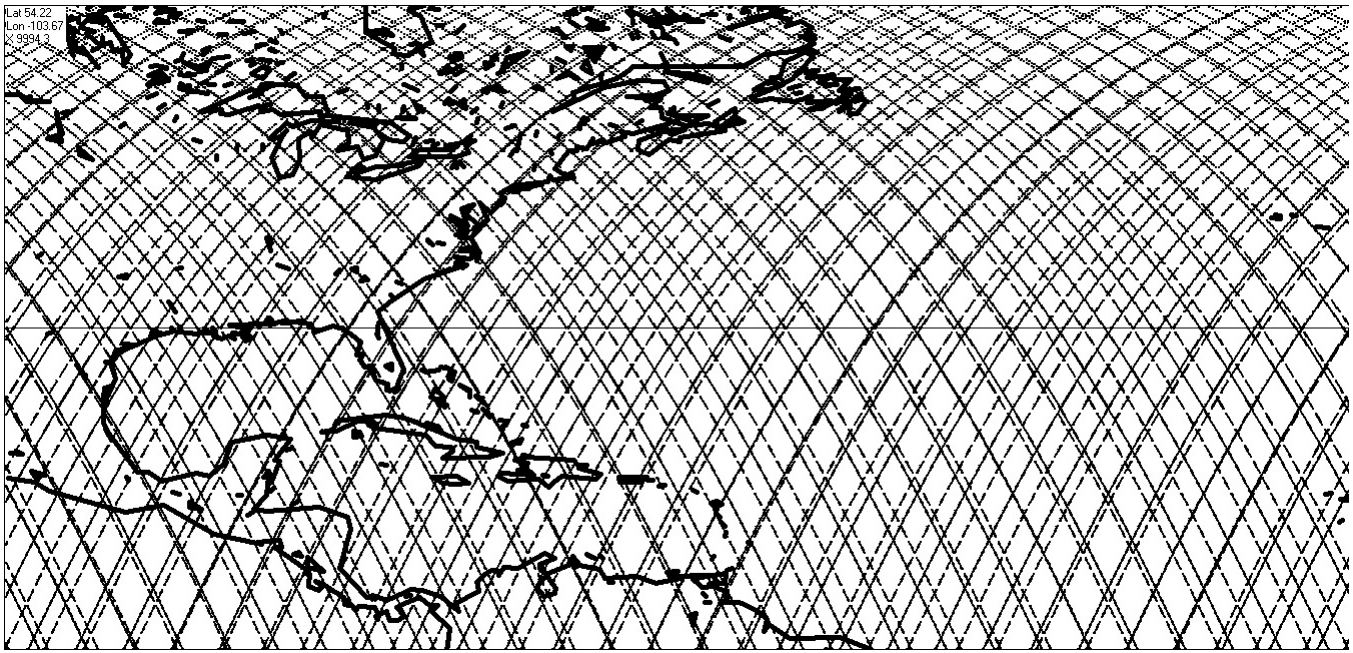
(Annual CalVal report ENVISAT 2011)

New Jason-1 GM sampling

- No coordination with Jason-2
  - Moiré patterns (2800 km bands) between JA2 and JA1 tracks
  - Temporal desynchronization ➔ Drift of relative sampling patterns

➡ A fraction of the Jason-1 GM sampling is lost (duplication with Jason-2)

Jason-2 (plain) vs
Jason-1 GM (dashed)
phasing over 44 days ➡



(from Jason-1 GM FAQ, AVISO website)

Oceanography outlook

Should we keep using Jason-1?

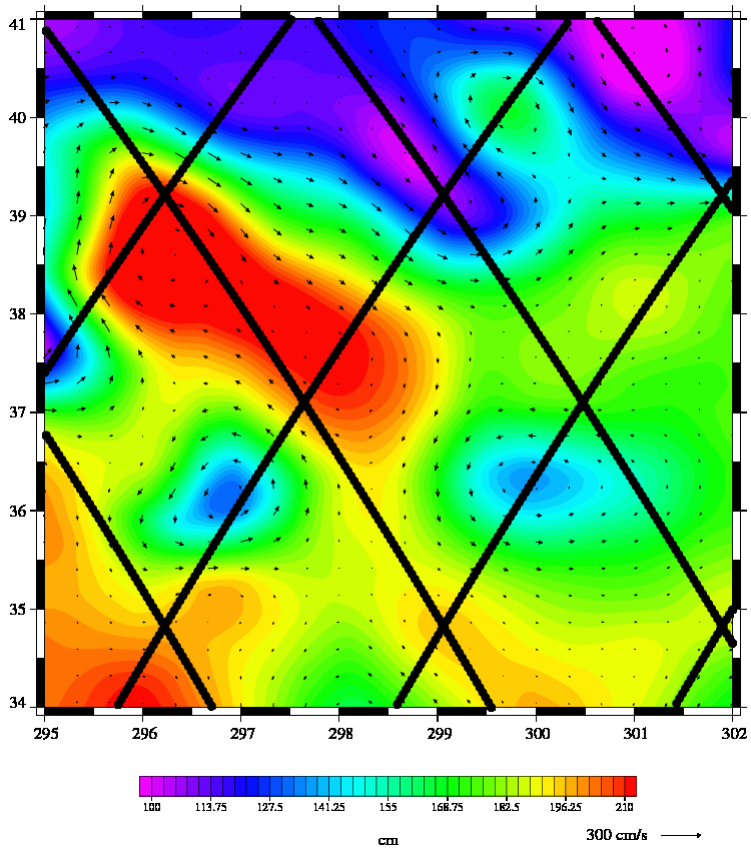
Mesoscale monitoring (1/2)

- To monitor mesoscale:
  - 2 altimeters needed for delayed time
  - 3 altimeters needed for near real time

- ENVISAT lost last Spring
- Available: Jason-2 and Cryosat-2
- Cryosat sampling/orbit not optimal for mesoscale

Jason-1 GM remains a strong asset until AltiKa or Jason-3 (or HY-2A) are validated and available in NRT

Dynamic Topography from Jason-2 alone vs Interleaved tandem

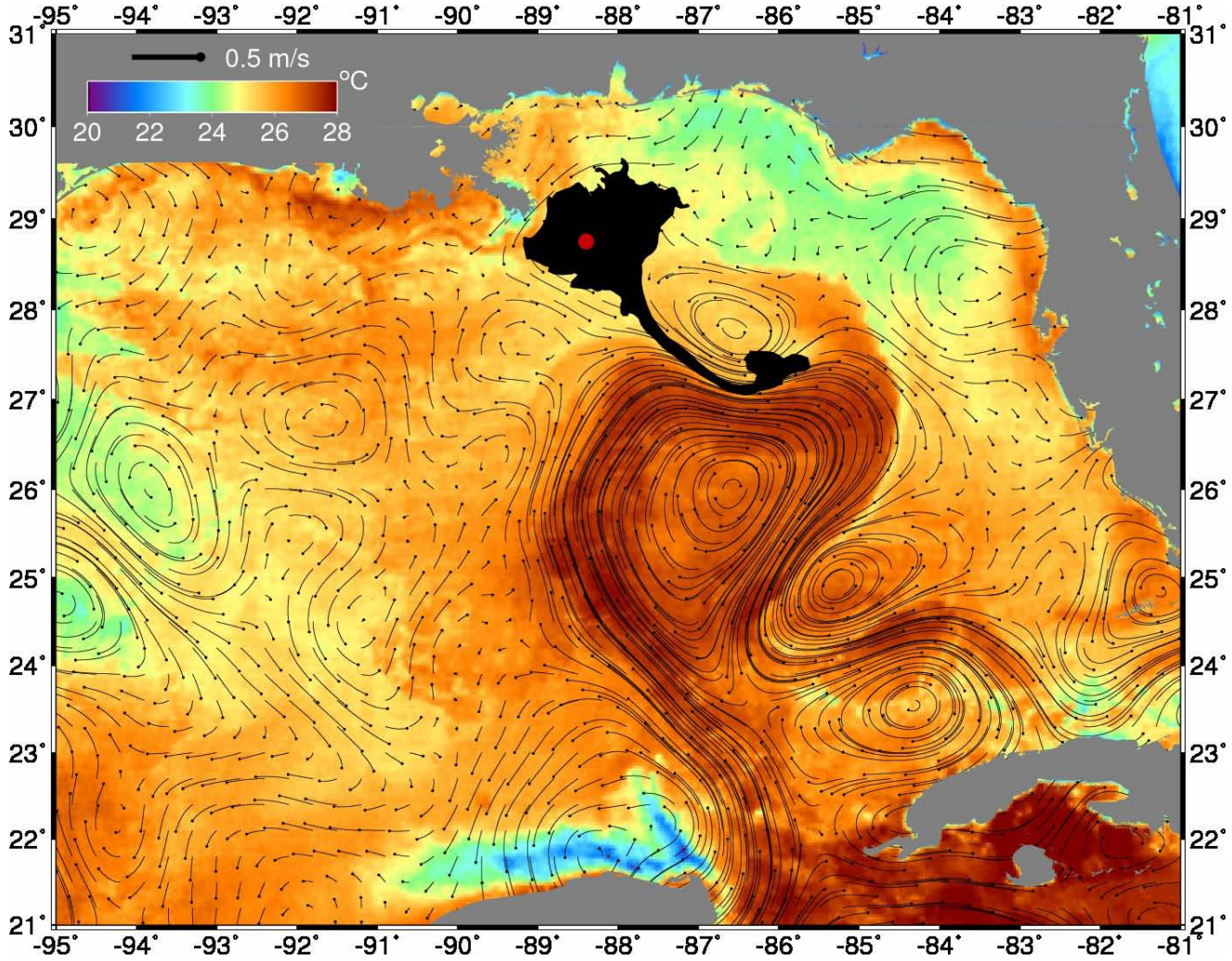


- Routinely re-Ingested by AVISO/DUACS since May

(Dibarboure et al, 2011)

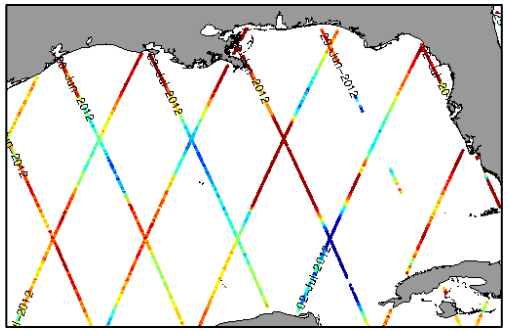
Mesoscale monitoring (2/2)

(Marine Geodesy 34 cover from N.Hoffmann)

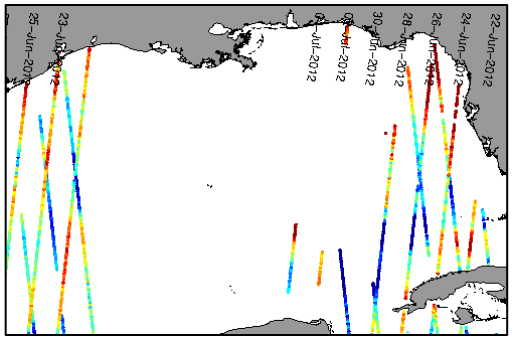


(NRT coverage, courtesy of G.Jacobs)

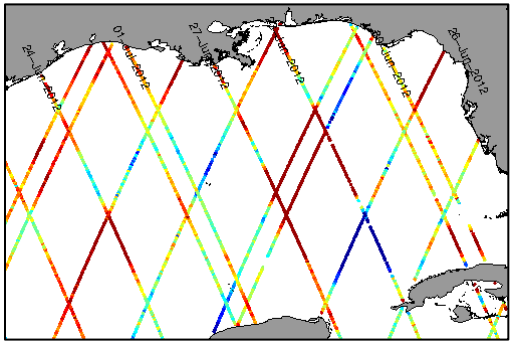
Jason-2



CryoSat-2



Jason-1 GM



Deepwater oil spill observed with SAR vs SST and lagrangian advection from altimetry-derived currents

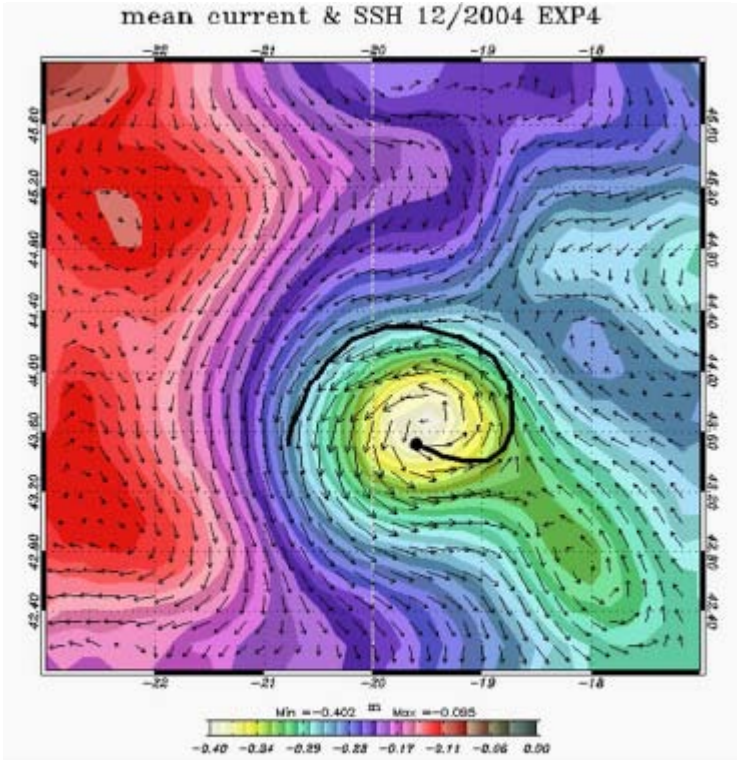
Operational model assimilation (1/2)

- Benefits of assimilating multiple altimeters published by most ocean modeling groups (e.g. Oke et al, Jacobs et al)
- Used to correct the position, shape and amplitude of mesoscale features if the model cannot propagate them perfectly

- Jason-1 GM routinely assimilated into global and nested systems from NRL, CSIRO, Mercator and most GODAE-OV models

- Risk of fake eddies injected in models ?
- Value of higher spatial resolution from the additional geodetic missions probably outweighs the errors in MSS references

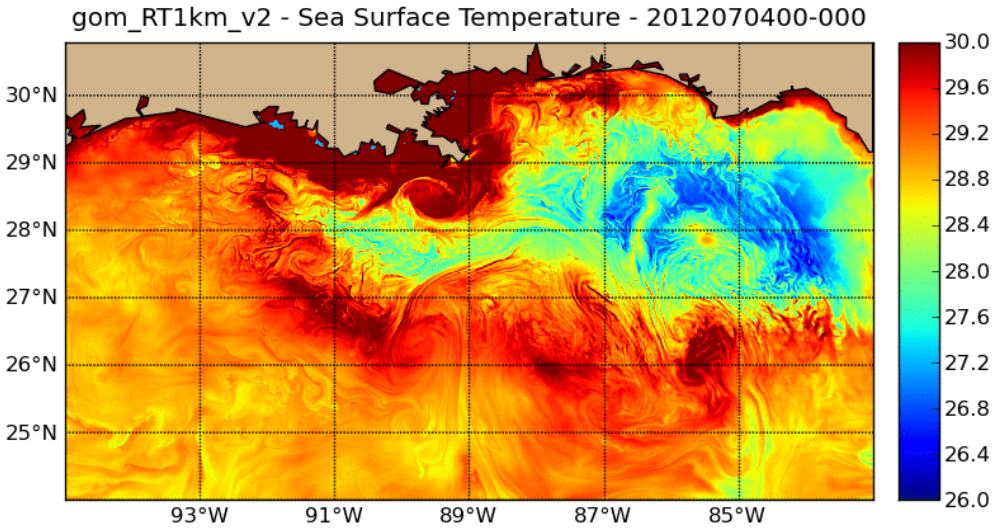
Assimilation from 1 vs 3 altimeters SSH Forecast from Mercator-Ocean



(from SHOM/Mercator report, 2006/10/CMO)

Operational model assimilation (2/2)

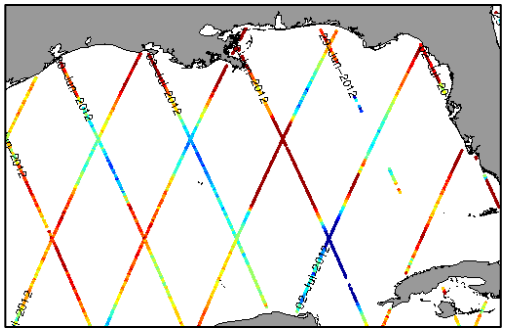
- Observation and deterministic predictability of frontogenesis filaments & mixed layer depth structure (Jacobs et al, 2012)
- Strongly dependent upon a denser observation of mesoscale flow from multi-sensor altimetry



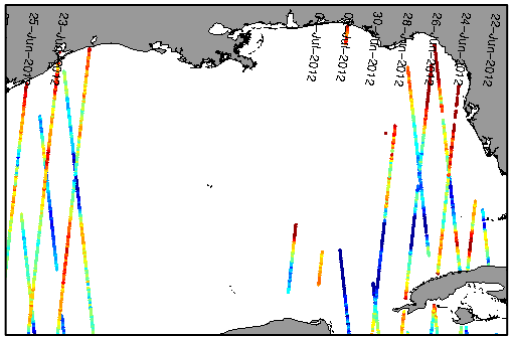
Gulf of Mexico SST: 1-km model from NRL

(courtesy of G.Jacobs)

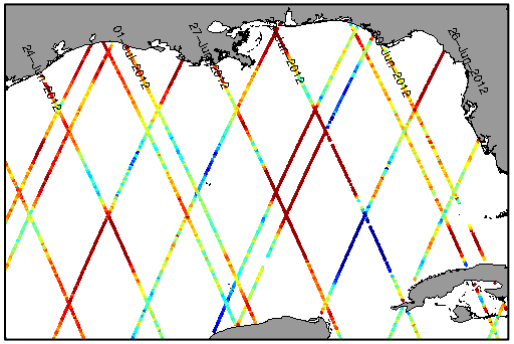
Jason-2



CryoSat-2



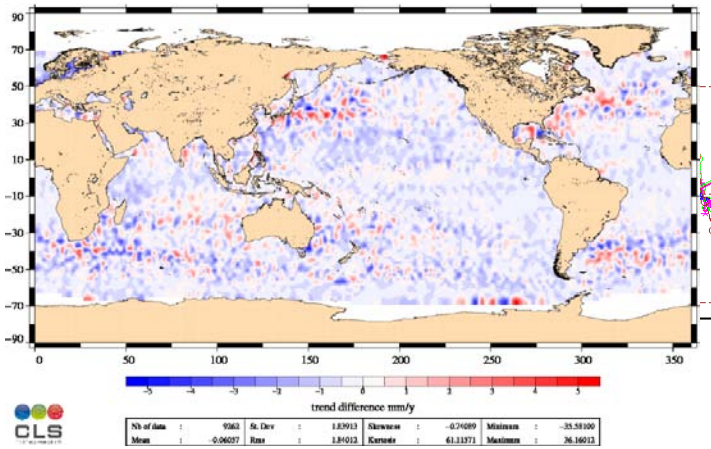
Jason-1 GM

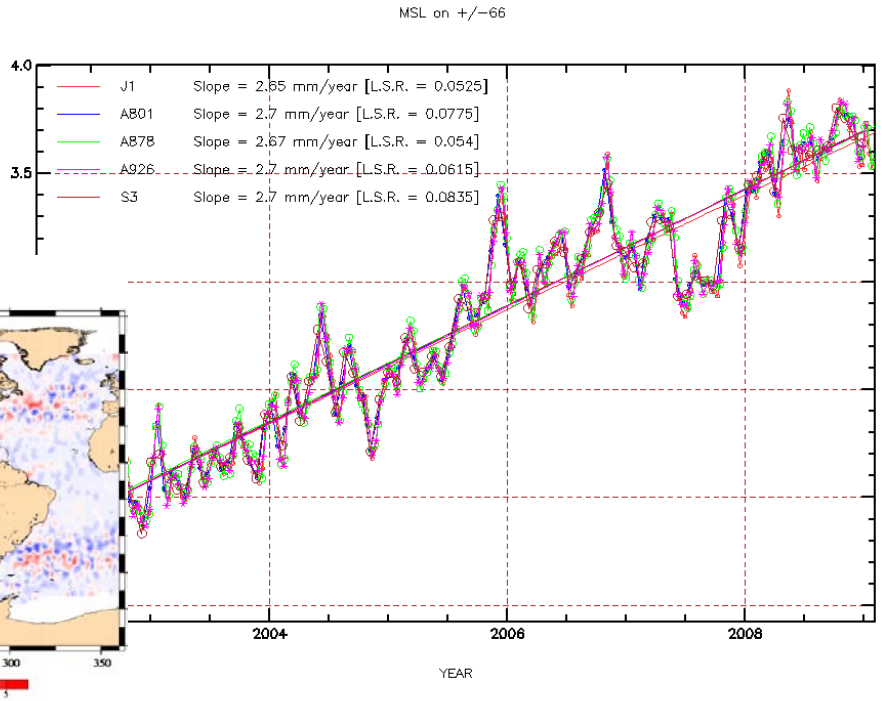


Climate

- The new sampling does not affect Jason-1's ability to monitor MSL
  - Global & regional trends are barely affected by the sampling pattern
- The new phase could introduce a bias in the Jason-1 GM series
  - Should be handled with care (e.g. think TOPEX A/B transition)
  - Measure bias through comparisons with Jason-2, tide gauges, or ARGO

The same MSL global and regional trends are observed by all orbits (simulation on Jason-1, Sentinel-3, and 3 orbit initially considered for Jason-CS)





(from Post-EPS orbit definition study WP4000, Eumetsat report, 2010)

Oceanography outlook

- SSHA error level slightly degraded (gridded MSS reference)
  …but it is still good

- Sampling degraded (no coordination with Jason-2)
  … but Jason-1 GM remains a strong asset for high-resolution applications
  … and Jason-1 is still a valuable source of data from Wind/Wave

- Possible bias between Jason-1 interleaved and geodetic phases
  …but if so, Cal/Val monitoring will detect and help mitigate the bias

Oceanographers are still successfully using Jason-1 GM !
…and they probably will until its very last measurement

Geodesy outlook

- Applications and requirements for improved gravity
- Range precision of Jason-1
- Gulf of Mexico validation
- Future outlook

Applications of non-repeat altimetry

Gravity/SSH:

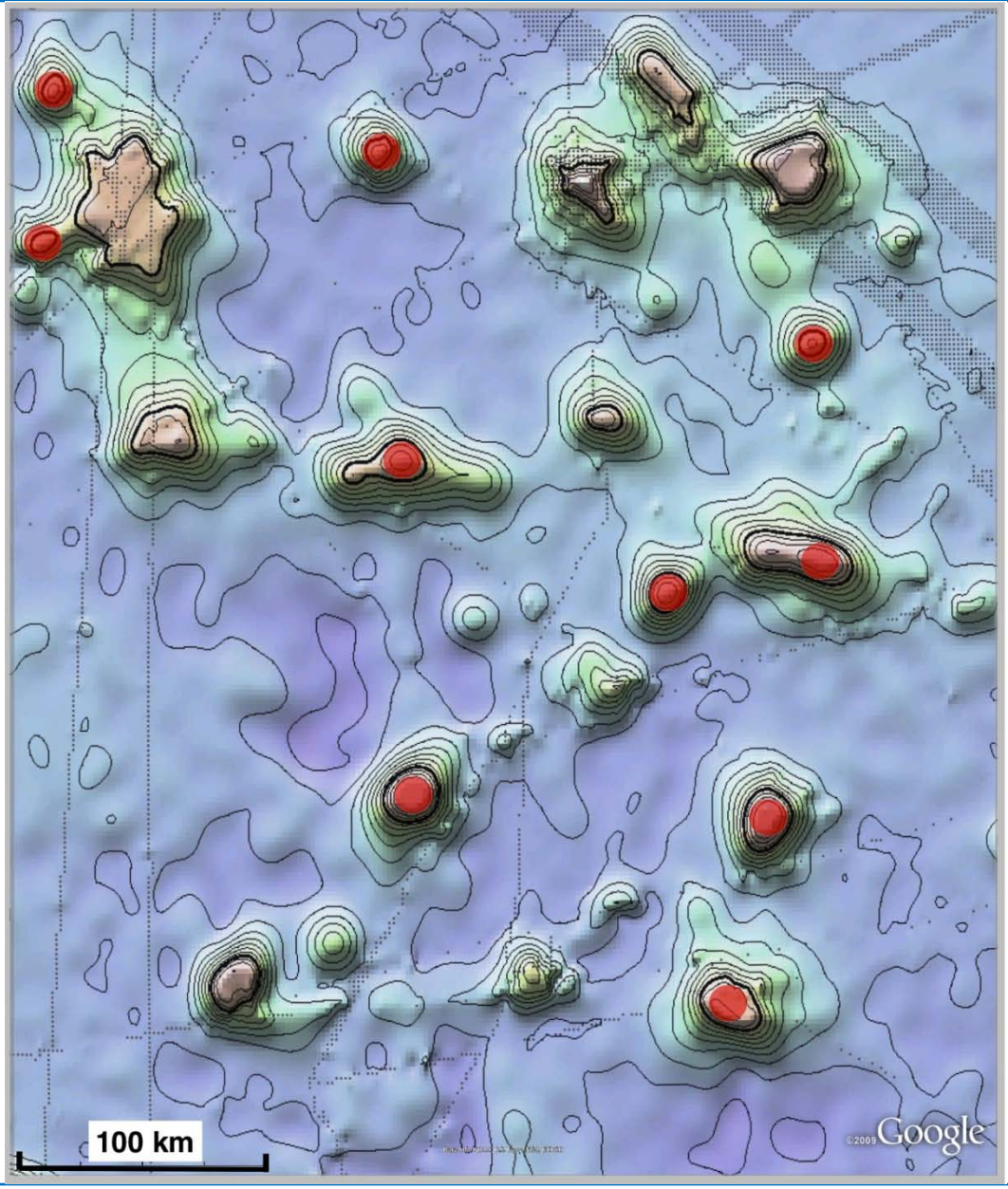
- average SSH for variability
- plate tectonics
- planning ship surveys
- inertial guidance (mostly military)
- petroleum exploration

Topography:

- seafloor roughness
- linear volcanic chains
- tsunami models
- tide models, tidal friction, thermohaline circulation
- planning undersea cables
- law of the sea
- education and outreach

Uncharted seamounts

Grounding of USS San Francisco into uncharted seamount



Achieving 1 mGal Gravity Accuracy
(1 cm over 10 km)

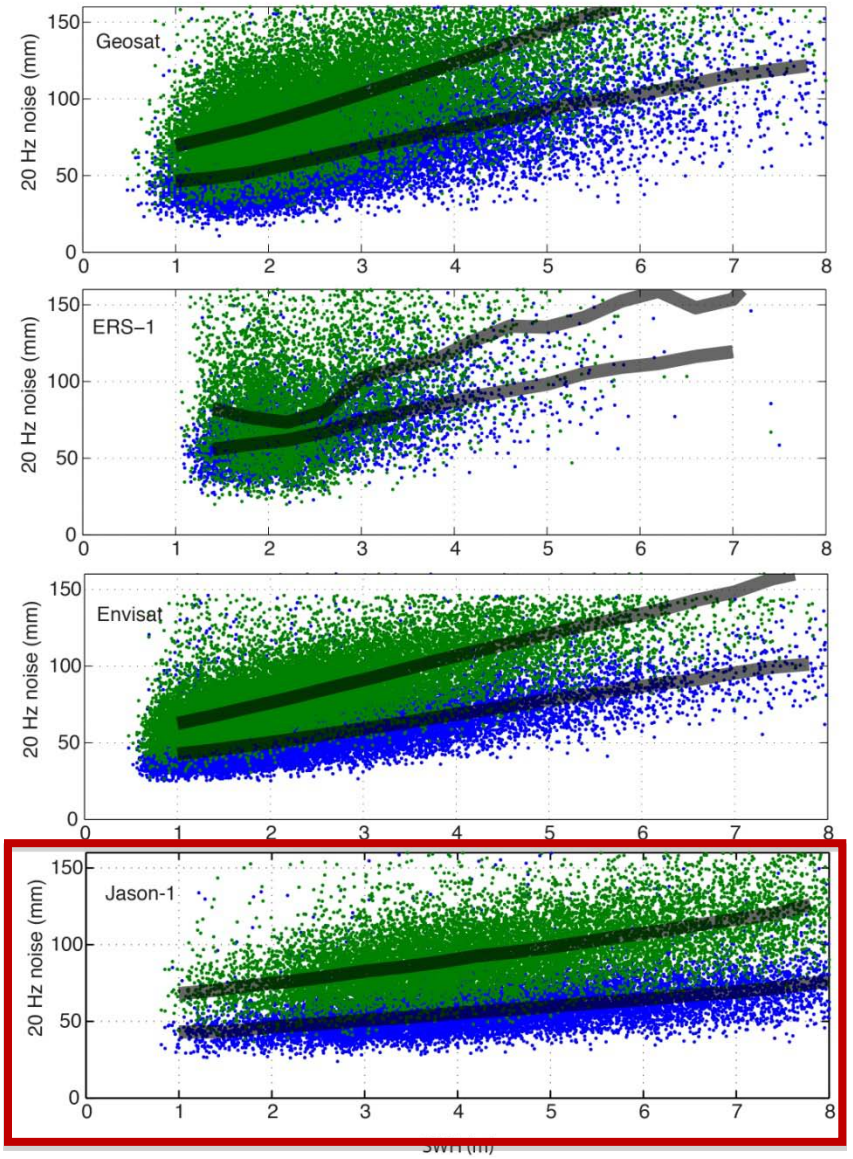
- Improved range precision -- A factor of 2 or more improvement in altimeter range precision, with respect to Geosat and ERS-1, is needed to reduce the noise due to ocean waves.

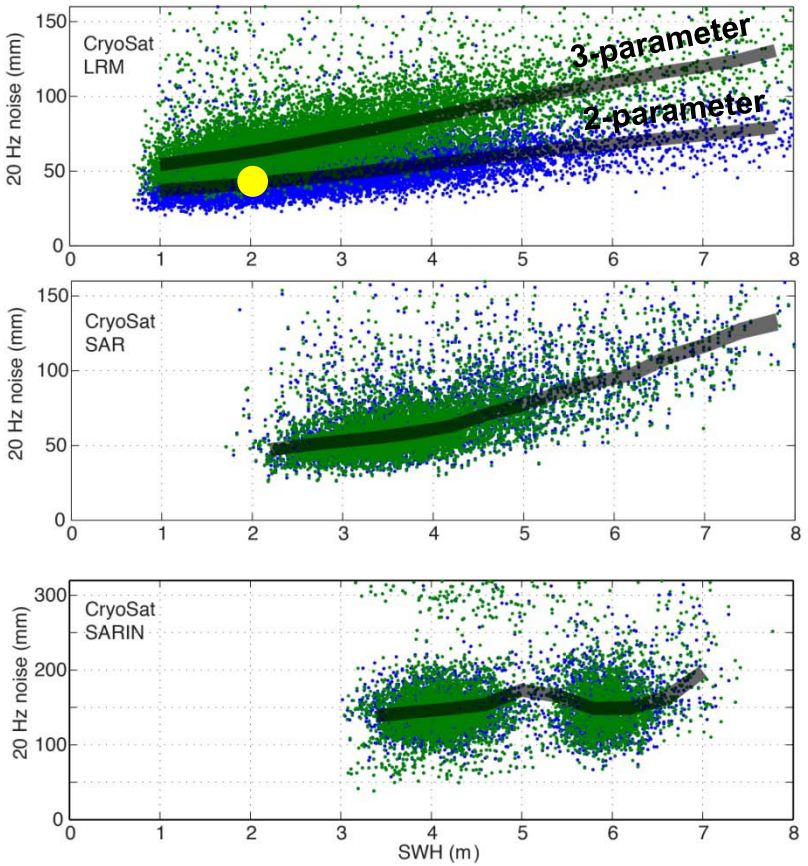
- Fine cross-track spacing and long mission duration -- A ground track spacing of 6 km or less is required.

- Moderate inclination -- Current non-repeat-orbit altimeter data have high inclination and thus poor accuracy of the E-W slope at the equator.

- Near-shore tracking -- For applications near coastlines, the ability to track the ocean surface close to shore is desirable.

20 Hz range precision of all altimeters





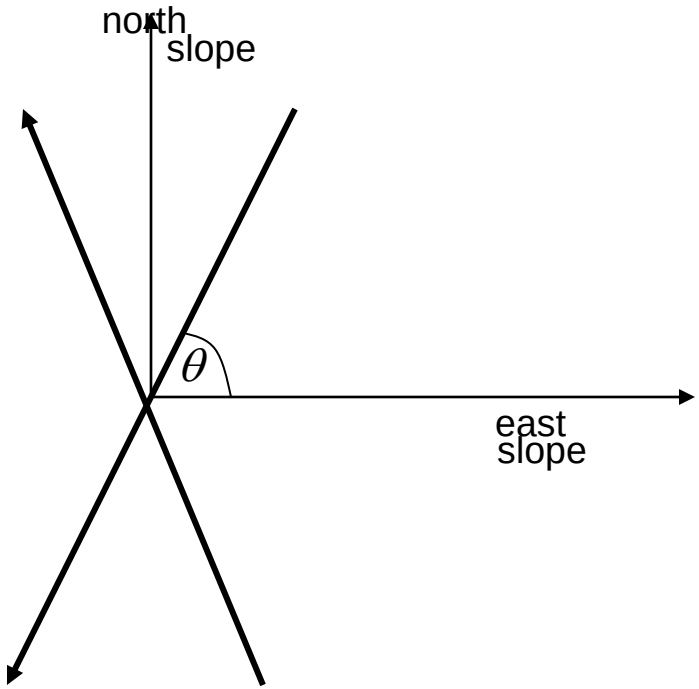
Altimeter	2-PAR @ 2 m
Geosat	57.0
ERS-1	61.8
Envisat	51.8
Jason-1	46.4
CryoSat LRM	42.7
CryoSat SAR	49.7
CryoSat SARIN	138.7

Orbit inclination controls error anisotropy

- Error propagation
  - θ - local inclination of track
  - σ - error in along-track slope
  - σ_x - error in east slope
  - σ_y - error in north slope

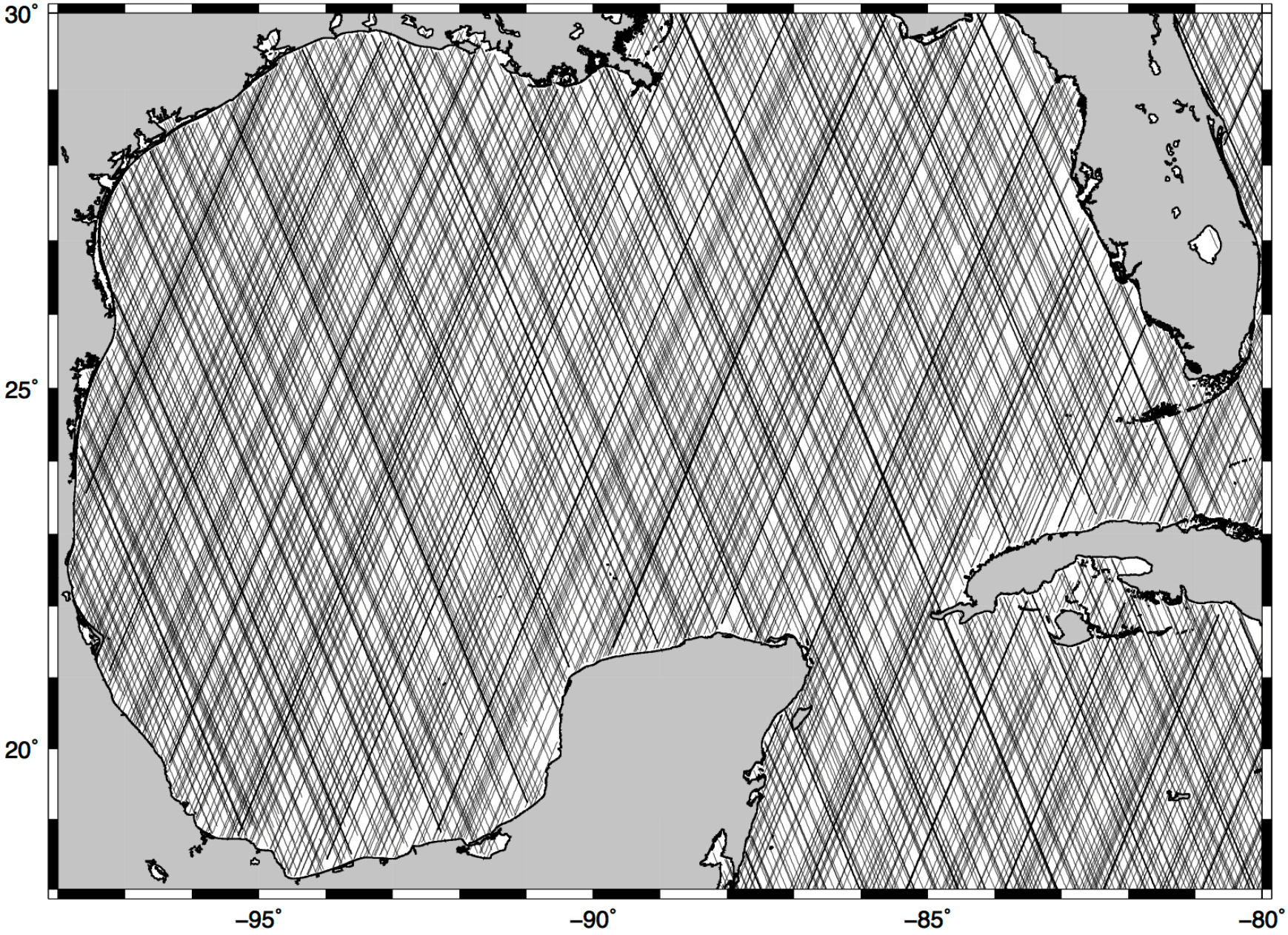
$$\sigma_x = \frac{\sigma}{\sqrt{2}\cos\theta}$$

$$\sigma_y = \frac{\sigma}{\sqrt{2}\sin\theta}$$

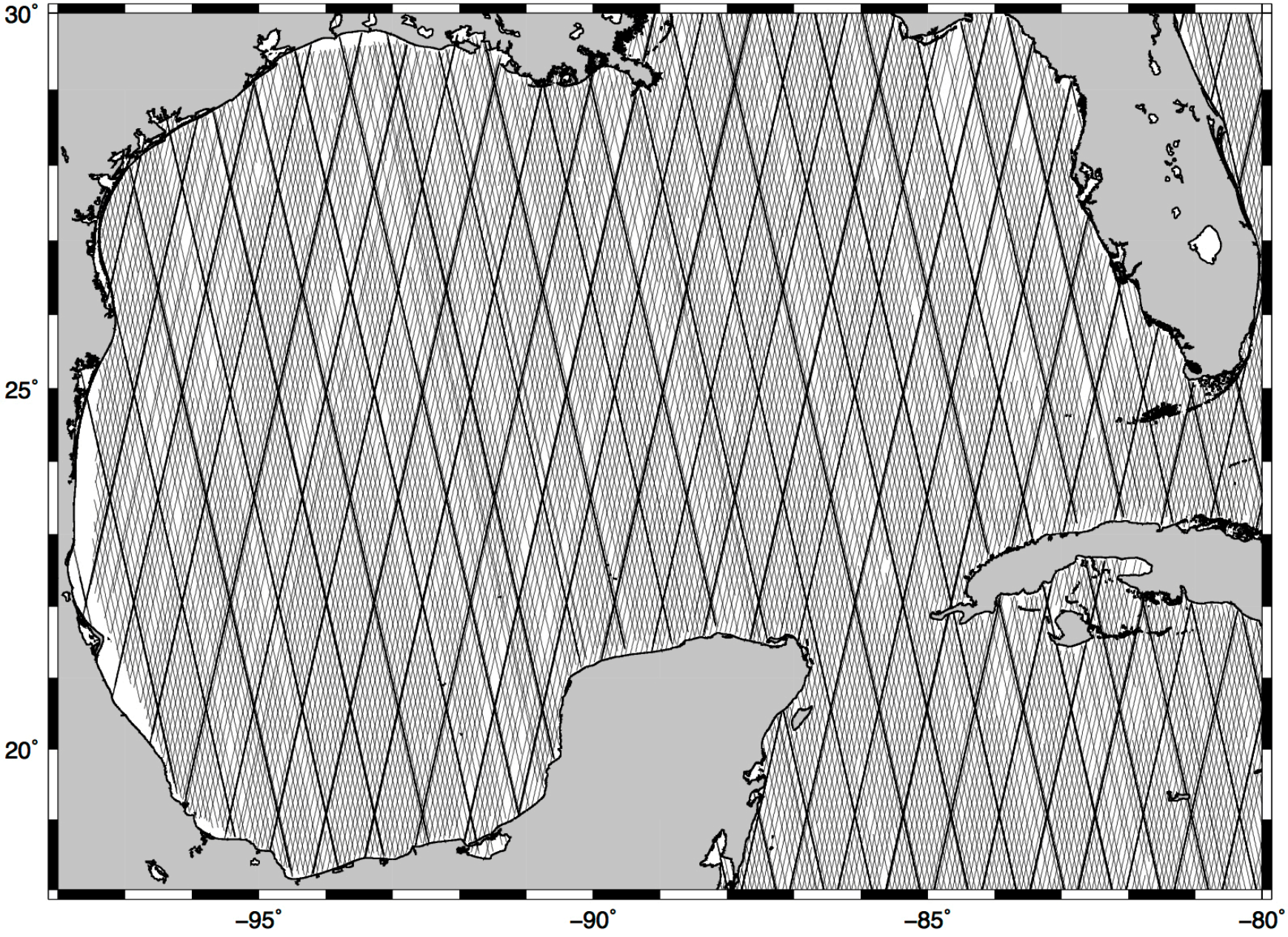


- Orthogonal tracks are optimal

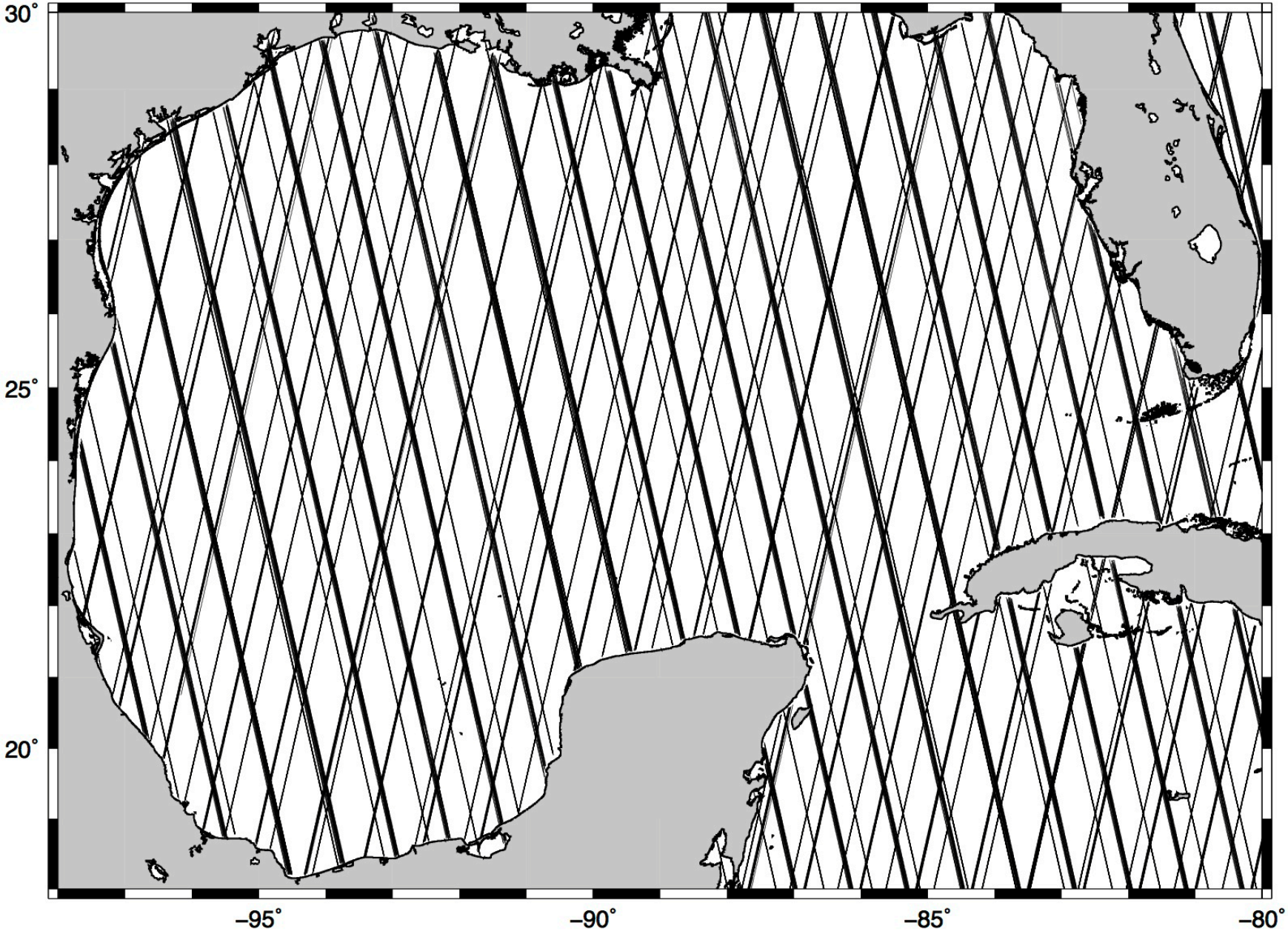
Geosat (old)



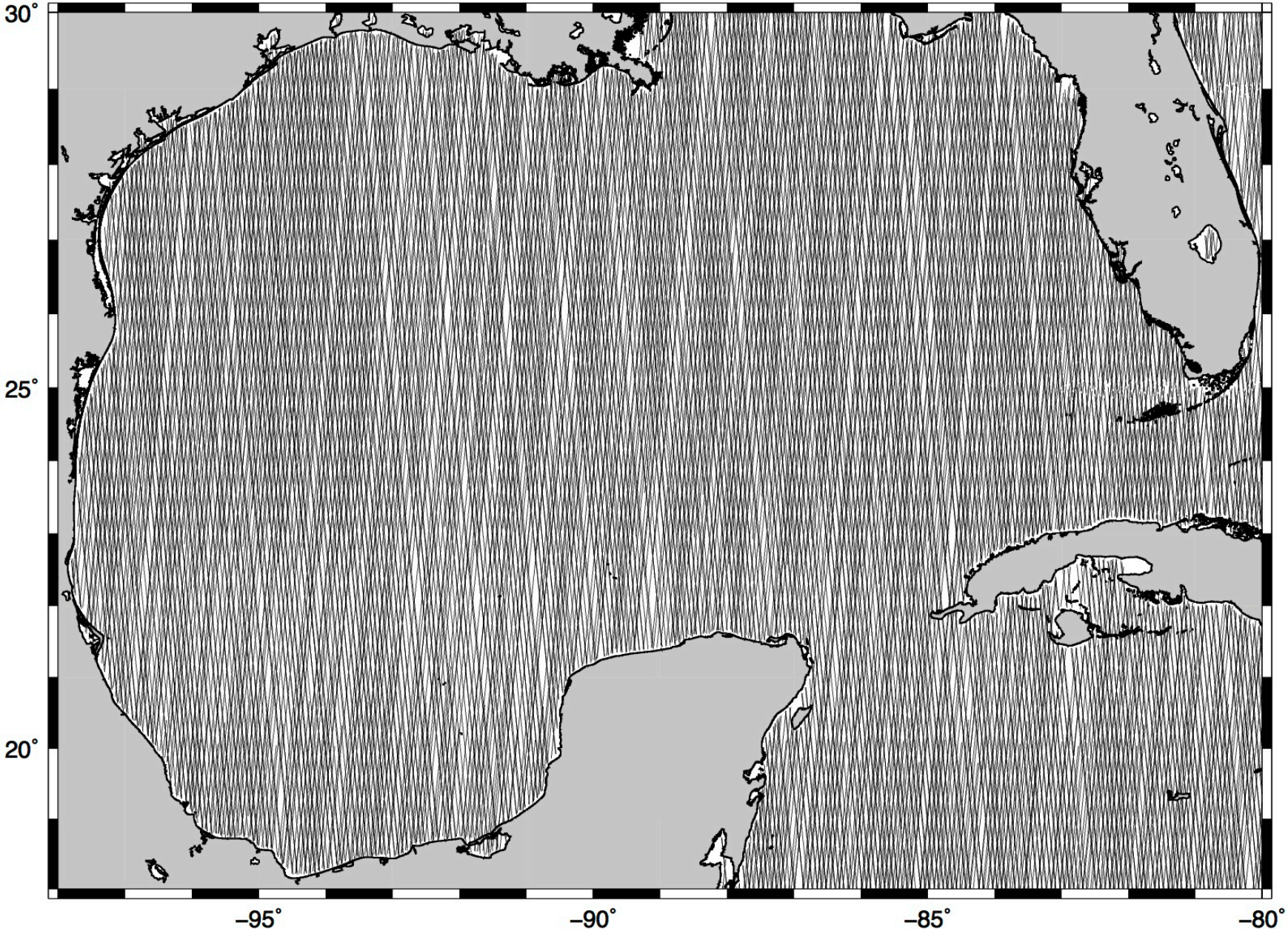
ERS-1 (old)



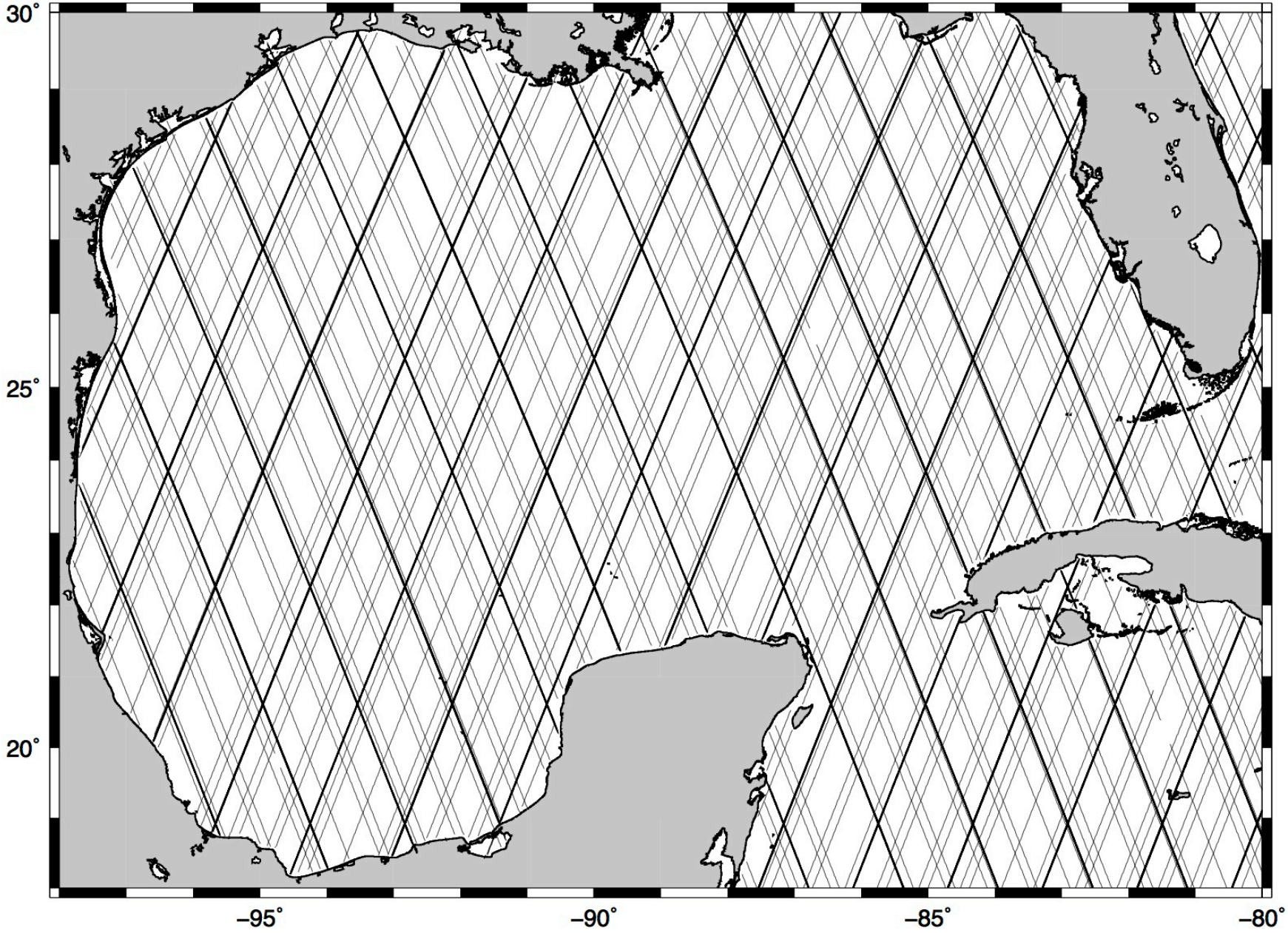
Envisat (new)



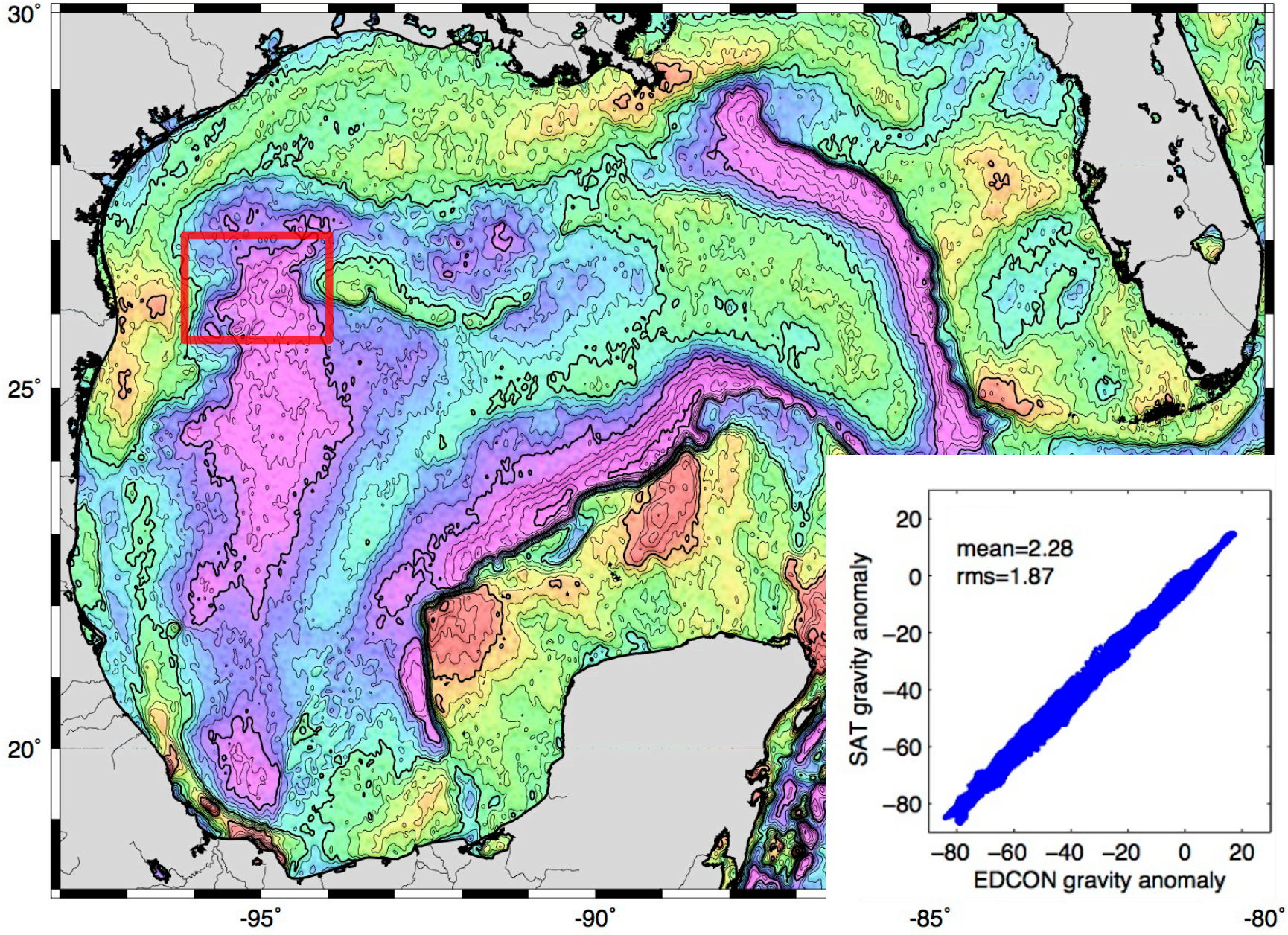
CryoSat (new)



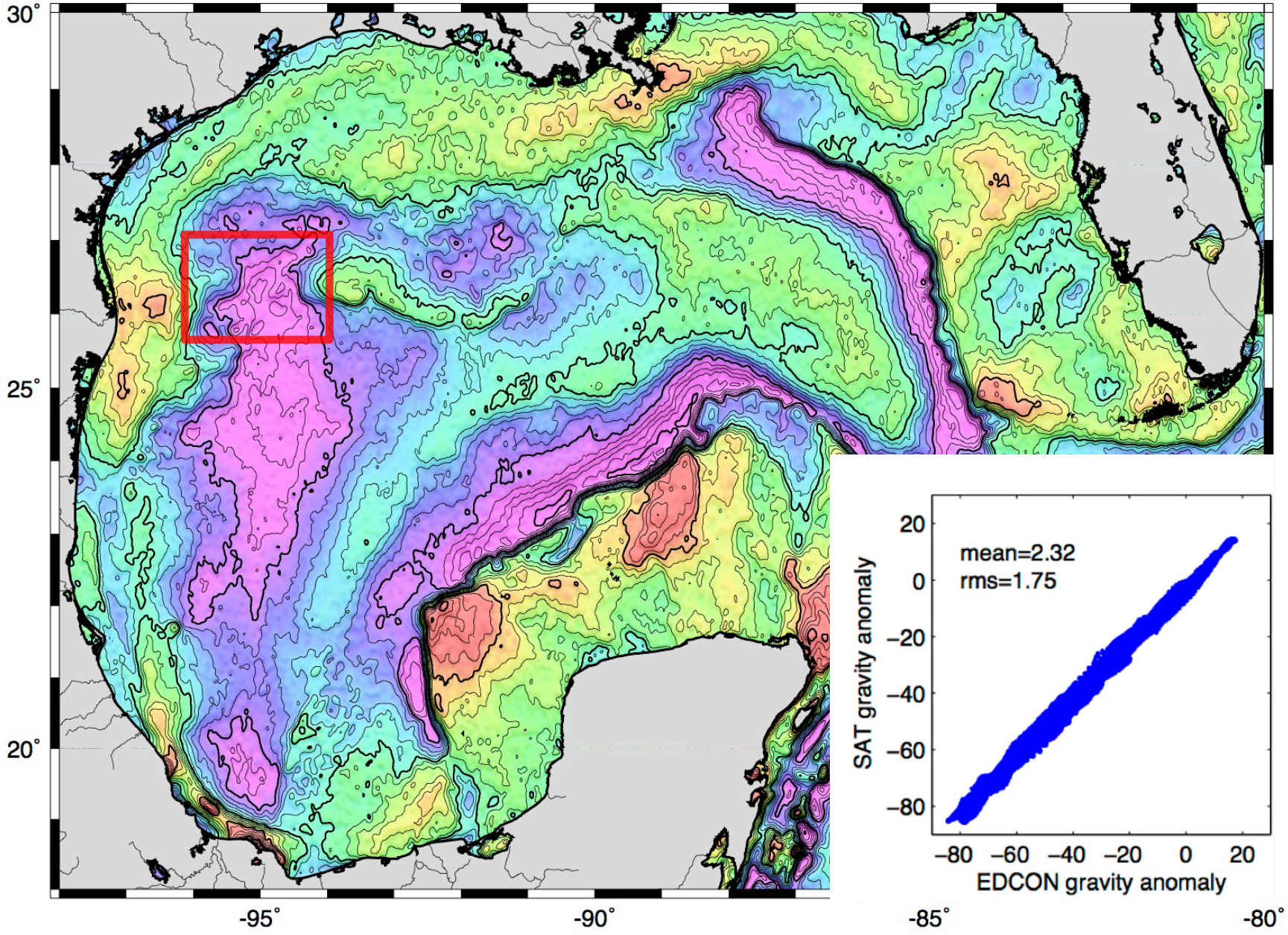
Jason-1 (new) – 80 days



Gravity Anomaly without Jason (10 mGal contours)

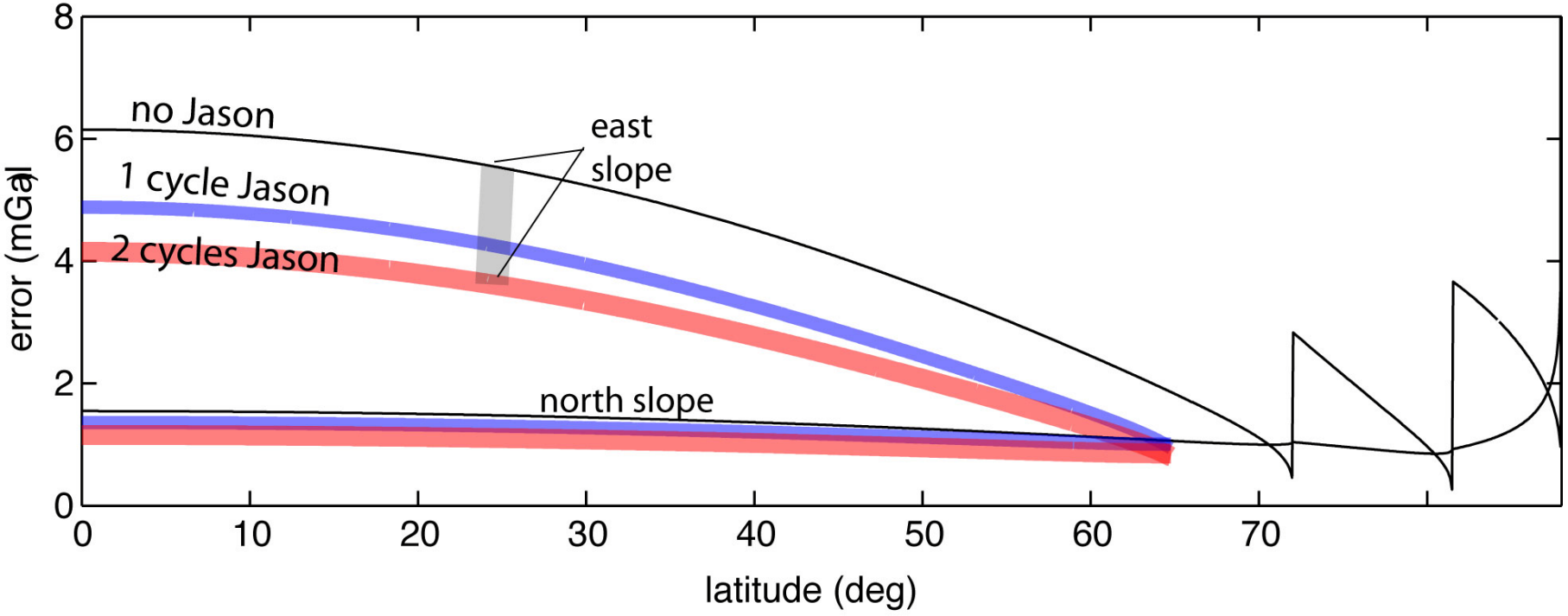


Gravity Anomaly with Jason (10 mGal contours)



Contributions from Jason-1

Without Jason, the error in the east slope component is large so N-S features such as the East Pacific Rise will be poorly resolved. One 409-day cycle provides about 25% improvement in east slope and two cycles provides about a 33% improvement. Most of the area of the earth is at latitude less than 60 degrees where Jason will make the largest improvement.



Geodesy outlook

- Pre-Jason-1/CryoSat gravity accuracy 2-4 mGal with large EW errors.
- Jason-1 has range precision comparable to CryoSat.
- The lower inclination of Jason-1 will result in gravity accuracy 1-2 mGal if 406 days are collected.
- An additional 406 days could result in ~1 mGal global marine gravity accuracy.

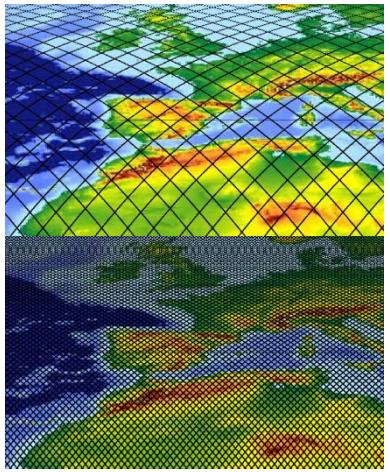
Thank you for your attention

New Jason-1 GM sampling

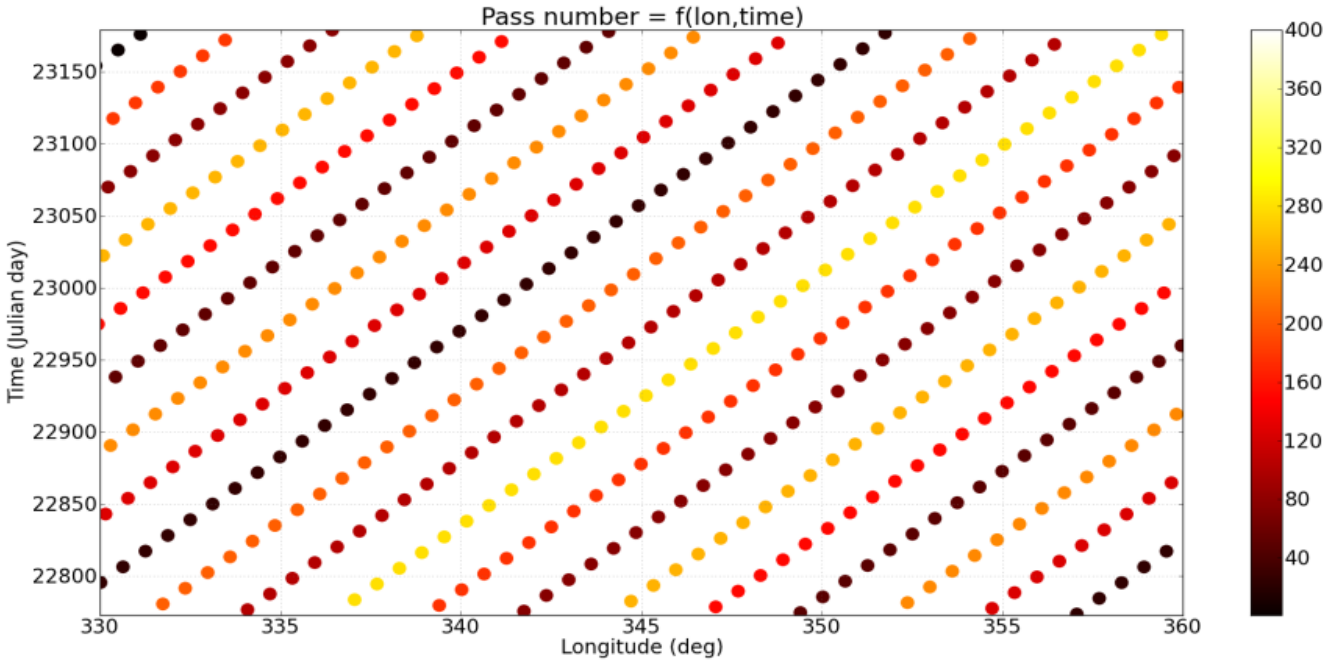
- Long cycle (406 days, 7 km cross-track resolution)
  - with intermediate sub-cycles (11 days, 48 days)
  - apparent « drift » of sub-cycles

11 days
(280 km)

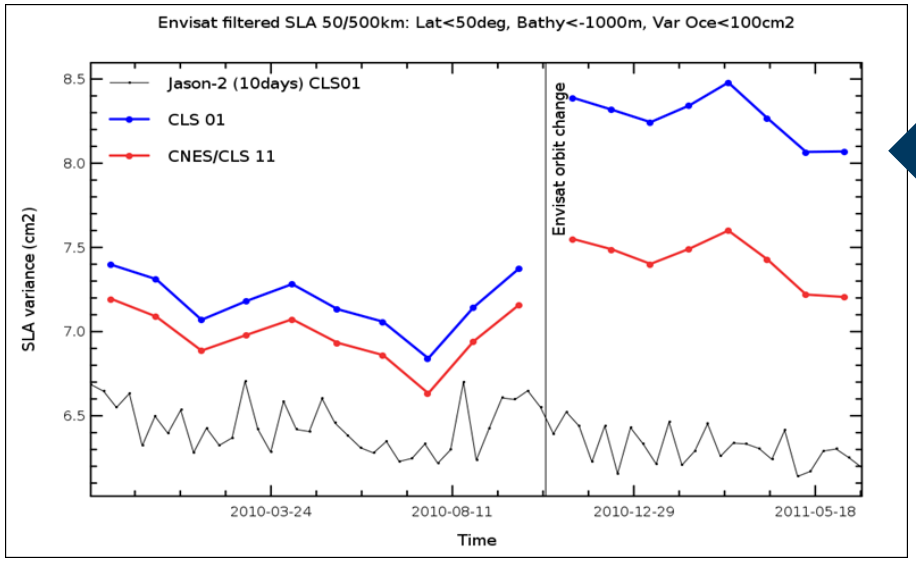
48 days
(65 km)



Temporal series no longer possible



Error budget (2/2)

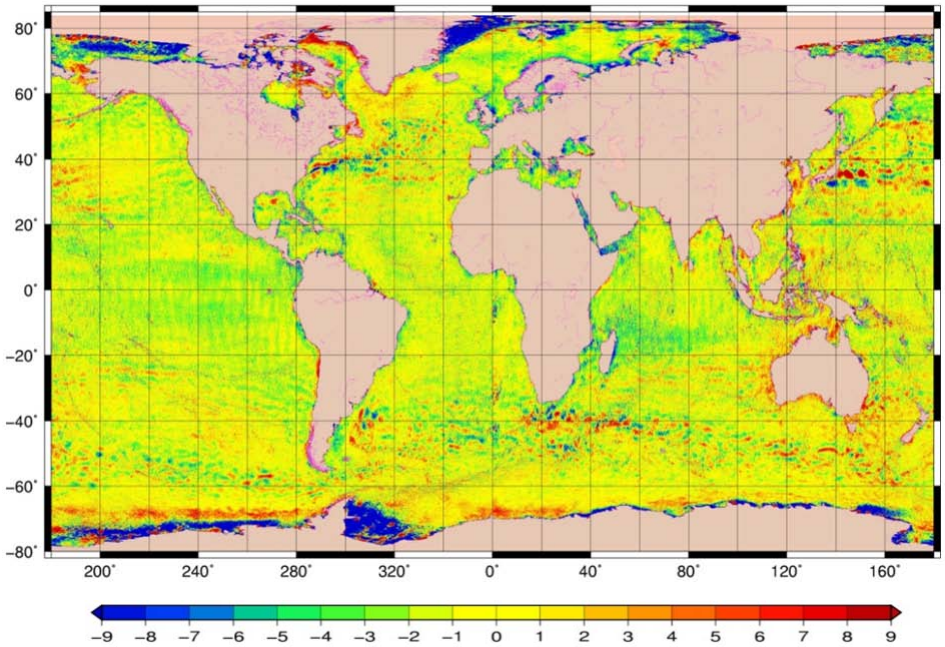


SLA variance increase when ENVISAT left the charted ERS track for a geodetic orbit (same change as Jason-1 GM):

+11 cm RMS with 2001 MSS model

+2.5 cm RMS with 2011 MSS model

Difference in cm between DTU10 and CNES/CLS2011 MSS models (inter-annual variability minimized)



(Annual CalVal report ENVISAT 2011, Dibarboure et al, 2012)