USE OF SATELLITE DATA IN THE RIO DE LA PLATA ESTUARY

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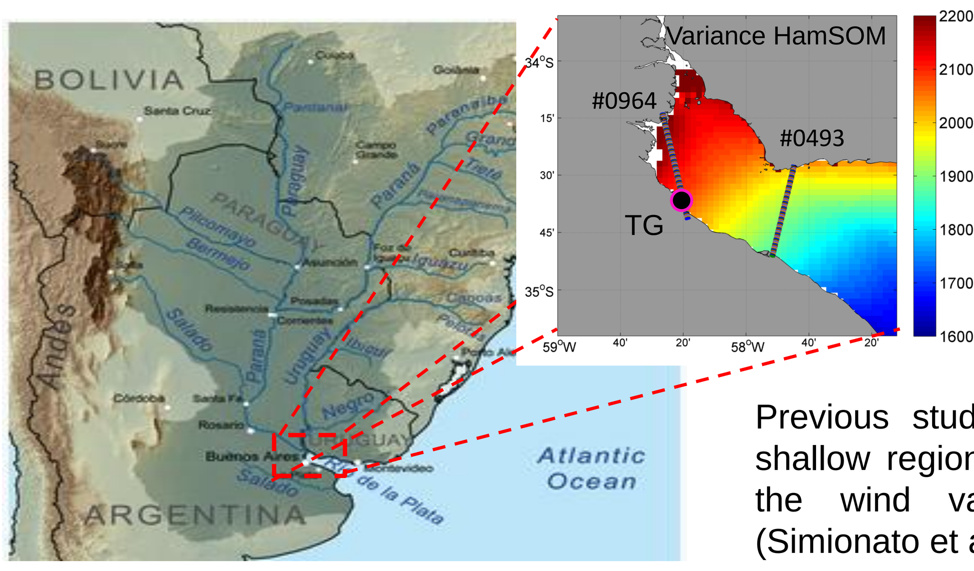
Introduction



The Río de la Plata estuary is formed by the confluence of the Uruguay River and the Paraná River on the border between Argentina and Uruguay. It is one of the largest estuaries of the world.

Besides its geographical extension, the area includes the capital cities of both countries (Buenos Aires, Montevideo, + than 30million people). The estuary has important fisheries and a large biodiversity.

Previous studies have shown that in this extensive and shallow region the estuarine circulation is mainly forced by the wind variability, especially at sub-annual scales (Simionato et al., 2006ab, 2007; Meccia et al., 2009).

The objective of this work is to analyze the altimetry data availability of descending pass #0964 and ascending pass #0493 of ENVISAT RA2 (18 Hz) in this region. Then we will examine the capabilities of the altimetry data to measure the sea level variability due to freshwater discharges from the main tributaries of Río de la Plata.

Result: Evaluation of two re-tracking in Total Water Level Envelope

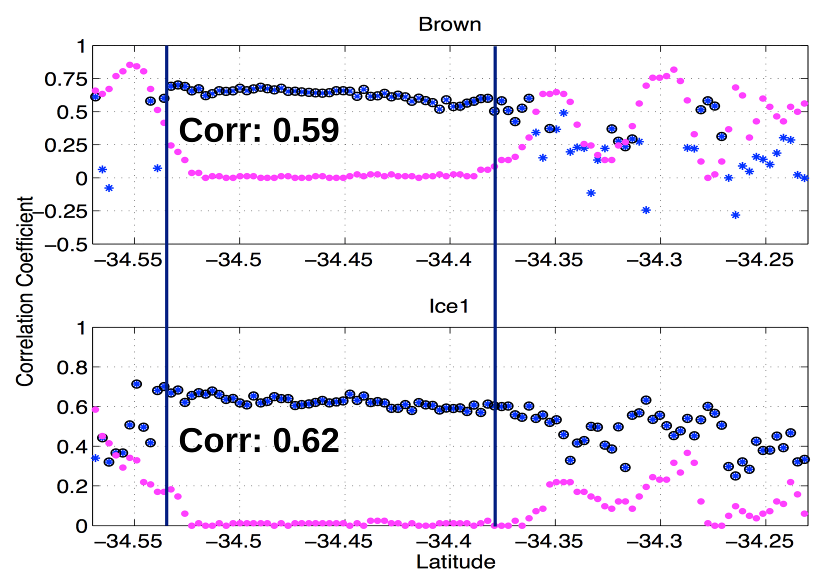


Fig. 1: Correlation between altimetry TWLE and Palermo TG along pass #0964, superimposed with significant values at CL 95% (black circles). The magenta dots represent the percentage of diminished values with the (mean ± 3std) criterion. Top: Re-tracking Brown. Bottom: Re-tracking Ice 1.

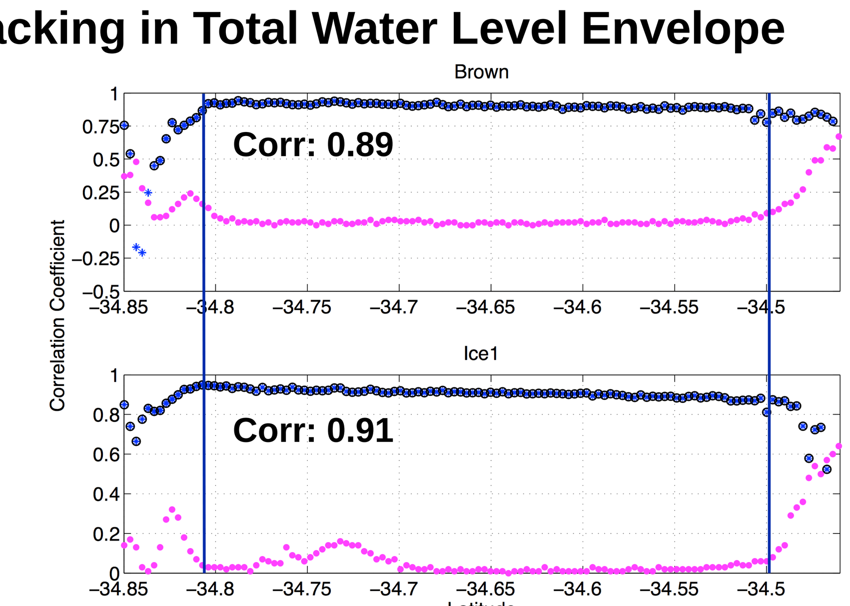


Fig. 2: Correlation between altimetry TWLE and Palermo TG along pass #0493, superimposed with significant values at CL 95% (black circles). The magenta dots represent the percentage of diminished values with the (mean ± 2std) criterion. Top: Re-tracking Brown. Bottom: Re-tracking Ice 1.

ICE1 recovers more data in the proximity of the coast in both passes and the mean correlation coefficient between TWLE and TG along the section delimitated by the lines is larger than the obtained with Brown. **ICE1 is slightly more adequate for the region.**

Result: Extreme events (ENSO)

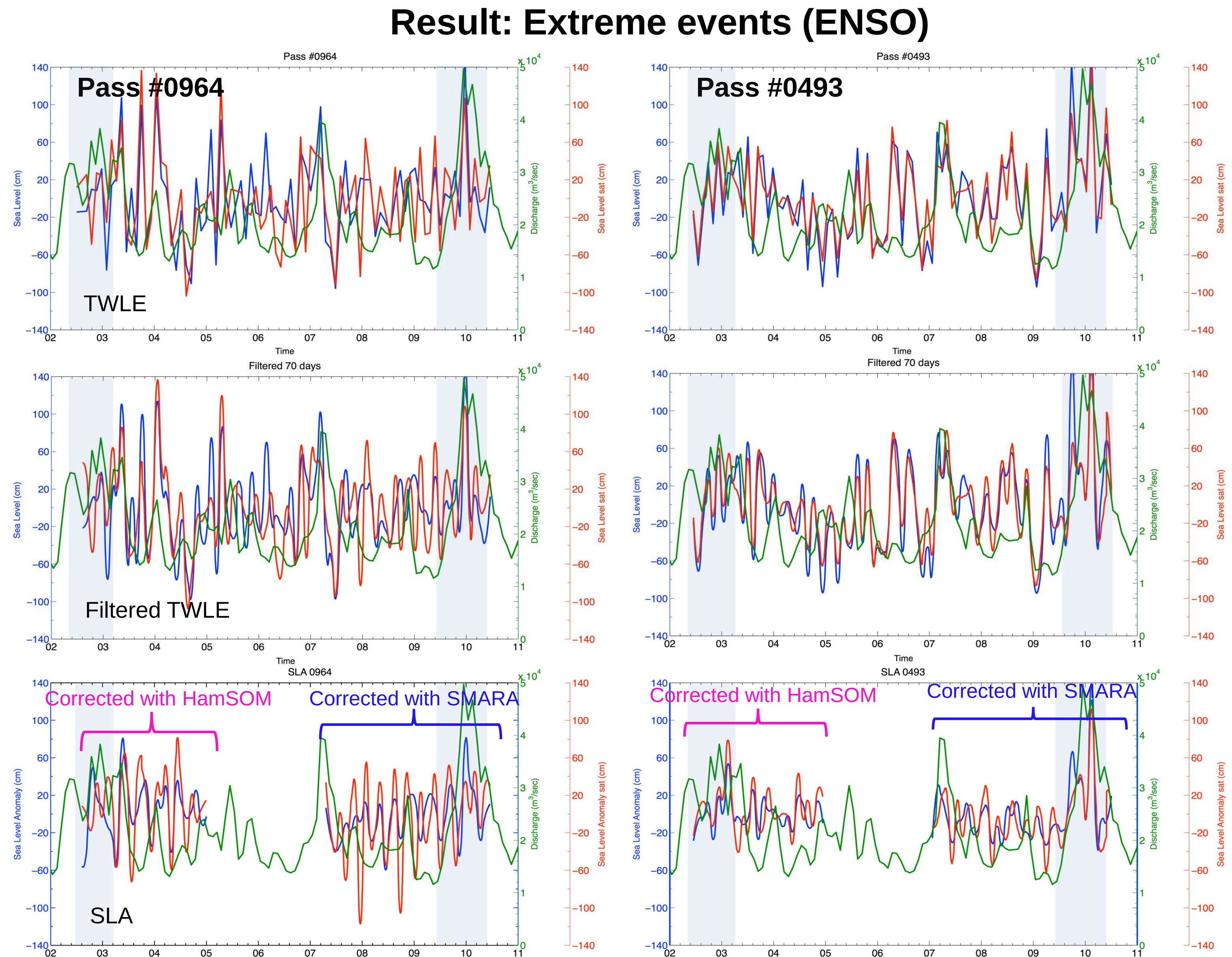


Fig. 5: Time series of the sea level height derived from Palermo TG (blue line) and derived from passes (red line) #0964 (left column) and #0493 (right column), superimpose with monthly river discharge (green line). Upper panel: TWLE. Middle panel: TWLE and in-situ data were filtered with a low pass filter with a 70-days window. Lower panel: satellite and in-situ SLA corrected with in-situ tide and HamSOM and SMARA models. Shaded areas indicate the period of moderate El Niño event.

When no tide and atmospheric corrections are applied, satellite data and in-situ data are more similar in pass #0493 than in pass #0964. Both passes (filtered and unfiltered) identify the extremes values of in-situ data. One of the extremes values (year 2009-2010) is due to the El Niño event that affect the river discharge. When tide (from Palermo TG) and DAC (HamSOM or SMARA) are applied to the satellite and in-situ data, the discrepancies between Pass #0964 and TG increase. Pass #0493 still captures the sea level variability due to El Niño 2009-2010, and El Niño 2002-2003.

Conclusions

- Re-tracking ICE 1 recovers more measurements than Brown, after eliminating the outliers.
- **ENVISAT RA2 (18Hz) data is capable of adequately represent the sea level variability (TWLE) in the upper Rio de la Plata.**
- **The altimetry data can capture the river discharge variability due to ENSO (El Niño).**
- The variability of the sea level due to the wind and pressure is underestimated by the global model Mog2D. This could bias the altimeter signal when the region is dominated by storm surges.
- Tide models must improve to adequately represent the astronomical tide.
- Regional tide models like HamSOM show the best results.
- In pass #0964, the discrepancies between satellite and in-situ data are more evident when tide and DAC corrections are applied. A more careful study must be done.

Data

Sea Level Height
- Along track data: ascending pass #0493 and descending pass #0964 of ENVISAT RA2 (18 Hz). Repeat period: 35 days. Period: June 2002-July 2010
- *TG Palermo (34.567ºS-58.383ºW):* hourly time series, period 1/1/1965-31/12/2012. Provided by Servicio de Hidrografía Naval (SHN).

Tide
- Regional
  - •HamSOM (Simionato et al., 2004): 1/3ºx1/4º
  - •Palma: (Palma et al., 2004): 1/10ºx1/10º
  - •SMARA: (Etala et al., 2009): 1/3ºx1/3º
- In-situ
  - Constants provided by SHN
- Global
  - •Fes2012 (Carrère et al., 2012): 1/16ºx1/16º
  - •Fes2004 (Lyard et al., 2006): 1/8ºx1/8º
  - •GOT4.7 (Ray et al., 1999): 1/2ºx1/2º
  - •EOT08a (Savcenko and Bosh, 2008): 1/8ºx1/8º

DAC
- Global
  - *DAC (AVISO):* Mog2D (Carrère and Lyard 2003) + IB (>20days) period 1/1/1993-31/12/2012, 6-hourly, ¼ºx ¼º, forced by ECMWF.
- Regional
  - *HamSOM (Simionato et al. 2006):* period 1/1/1993-31/12/2004, 6-hourly, 3x3 km, forced by NCEP.
  - *SMARA (Etala et al. 2009):* period 1/1/2007-29/2/2012, 3-hourly, 1/20ºx1/20º forced by NCEP.

Methodology

•Total Water Level Envelope: TWLE=Altitude-range-MSL(DTU13)-Ionosphere-wet troposphere-dry troposphere-SSB-loading tide-earth tide

•SLA=TWLE-Tide-DAC

•Root Mean Square error to compare tide models with in-situ:

$$\mathrm{RMSE_J} = \sqrt{\left(\frac{(\mathrm{amp_1} * \cos(\mathrm{fase_1}) - \mathrm{amp_2} * \cos(\mathrm{fase_2}))^2 + (\mathrm{amp_1} * \mathrm{sen}(\mathrm{fase_1}) - \mathrm{amp_2} * \mathrm{sen}(\mathrm{fase_2}))^2}{2}\right)}$$

Result: comparison of Dynamic Atmospheric Corrections

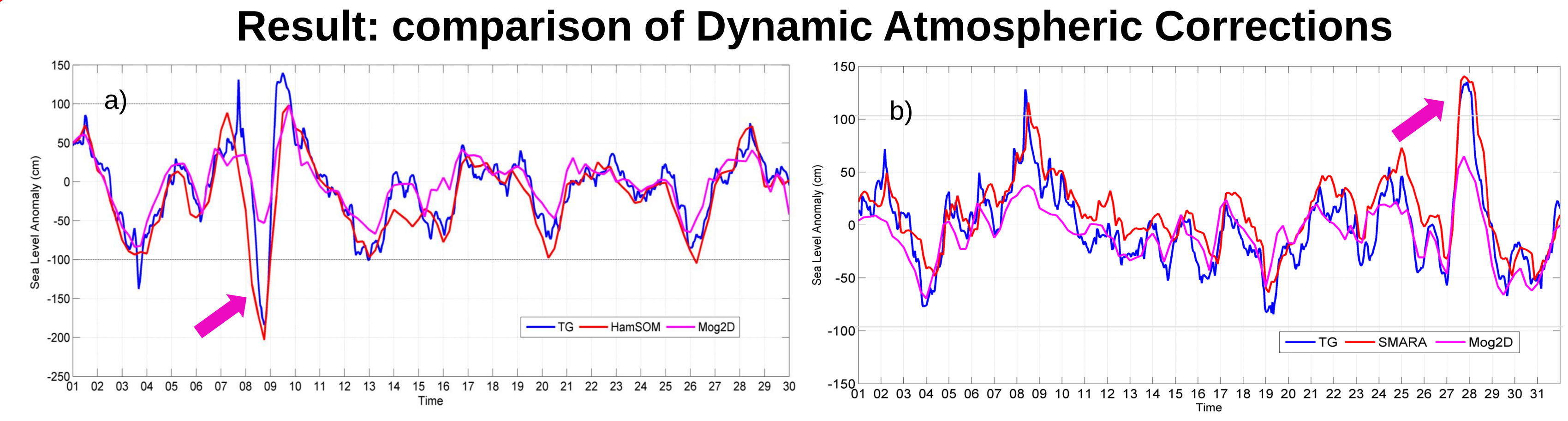


Fig. 3: a) Example of extreme events in a) April1993 and b) July 2007. Red and magenta lines represent the time series of the sea level variability simulated by HamSOM (b) SMARA) and Mog2D respectively. The blue line represent the in-situ data from Palermo station without tide effect

Table 1: Variance of hourly in-situ sea level (cm^2) with corrections as indicated in the first row. Comparison between HamSOM and Mog2D for the period January 1993- period 2004.

Variance cm^2	No correction	Tide	Hamsom	Mog2D	SLA+tide+ Ham	SLA+tide+ mog2d
Palermo	2947.8	699.7	2099.2	720.4	**757.1**	966.4

Table 2: Variance of hourly in-situ sea level (cm^2) with corrections as indicated in the first row. Comparison between SMARA and Mog2D for period January 2007- December 2012.

Variance cm^2	No correction	Tide	SMARA	Mog2D	SLA+tide+ Smara	SLA+tide+ mog2d
Palermo	2904.0	722.9	1705.9	690.7	**805.9**	862.8

Both regional models show a larger variability associated with atmospheric forcing than the global one. Fig. 3 shows two examples of sea level peaks due to wind.

The variance of the SLA decreases more when HamSOM is applied.

Result: Performance of Tide models

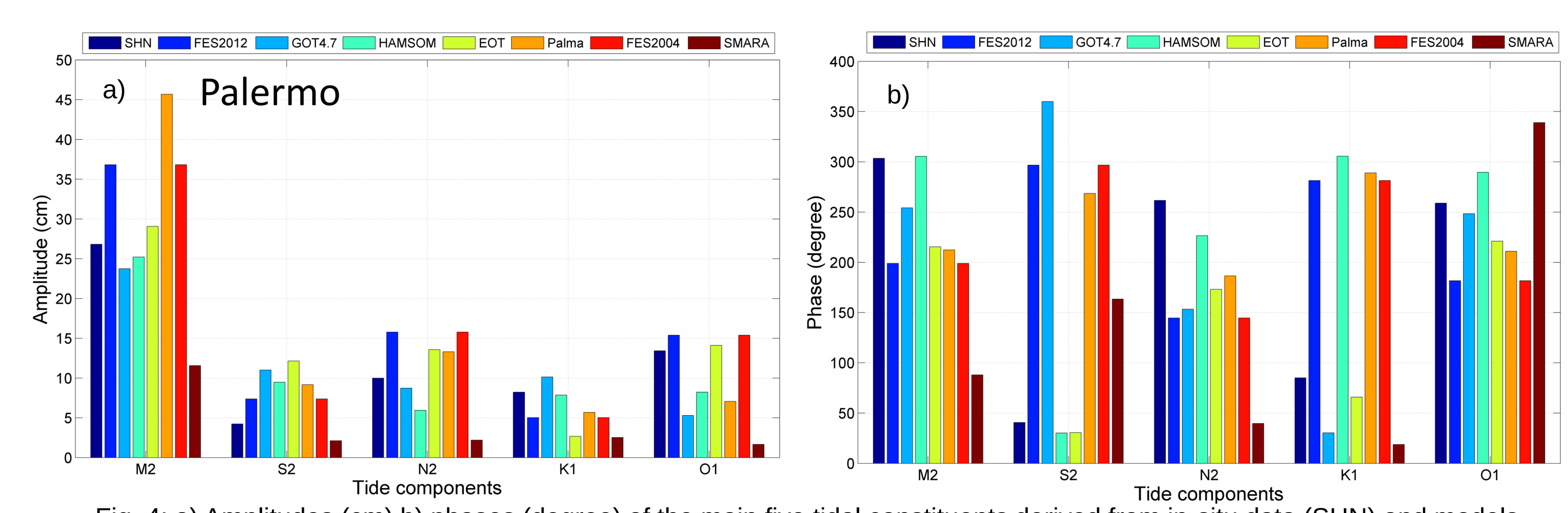


Fig. 4: a) Amplitudes (cm) b) phases (degree) of the main five tidal constituents derived from in-situ data (SHN) and models.

Table 3: RMS (cm) between models and Palermo TG for the five tidal constituents (M2, S2, N2, K1, O1). RSS error (cm) of the five tidal constituents for each model.

	M2	S2	N2	K1	O1	RSS
Fes2012	35.86	6.60	15.68	9.28	12.75	42.71
GOT4.7	15.02	5.85	10.73	6.07	5.85	21.12
Fes2004	35.86	6.59	15.67	9.29	12.75	42.70
EOT08a	27.47	5.67	11.76	**4.08**	6.34	31.33
Palma	37.74	8.77	10.20	9.63	7.17	41.83
HamSOM	**1.31**	**3.80**	**4.36**	10.67	**5.38**	**13.33**
SMARA	26.05	3.99	8.29	5.35	9.36	29.66

The lowest RMS is obtained with HamSOM (13.33 cm). This model was validated by Simionato et al. (2004) to simulated the semidiurnal component M2 in the region (RMS=1.31 cm).

The M2 amplitude in Palermo station is 27 cm. Therefore, a RSS of the order of 10 cm (or more) is not optimal.

For the upper river, the tide effect can be removed with the tide derived from Palermo TG.

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