Resolution Dependency of Future Caribbean Sea Level Response

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High-resolution climate model

- Ocean: 0.1° × 0.1°
- Atmosphere: 0.5° × 0.5°
- Ocean eddies resolved
- Retroflection resolved
- Strong η_M gradient near western boundary current

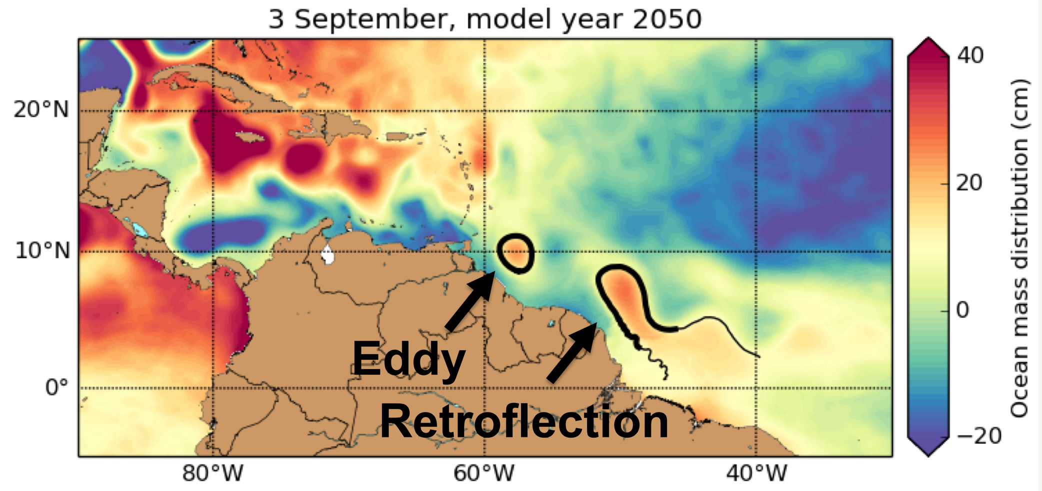

Figure 2: Daily-averaged ocean mass distribution.

- Normalised dynamical sea level trend with respect to η_S^g trend (**Figure 3**).
- Region 1 is **above-averaged** and region 2 is **below-averaged** (**Figure 4**).

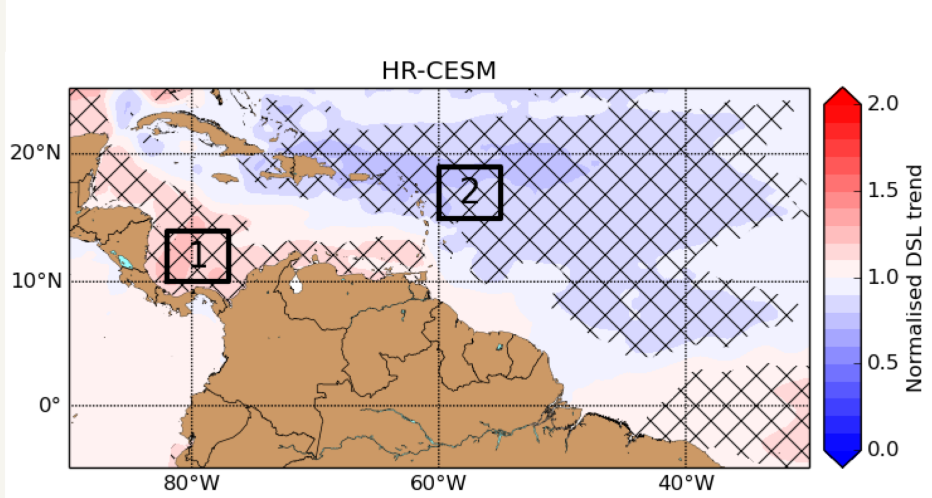

Figure 3: Normalised dynamical sea level trend, hatched regions indicate significant trends.

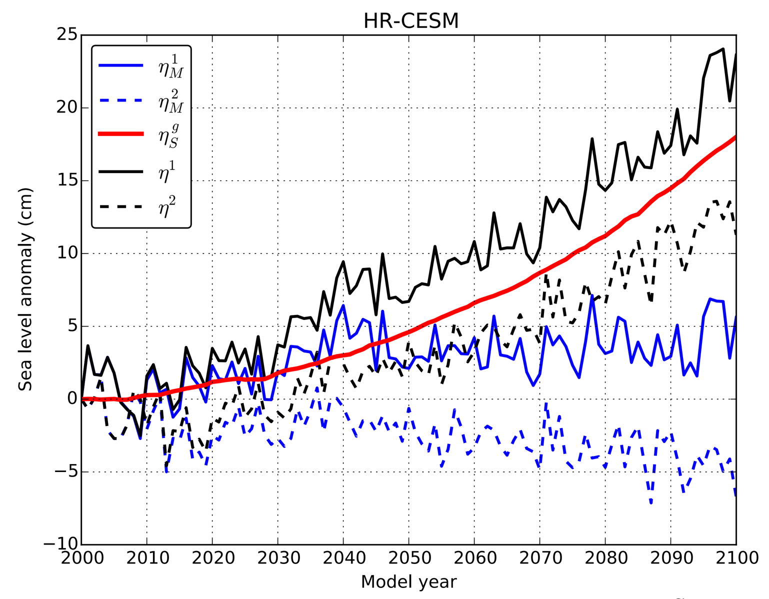

Figure 4: Time evolution of the η_M, η_S^g and η, for region 1 and region 2.

- Changes in η are related to a weaker overturning circulation (**Figure 5**).

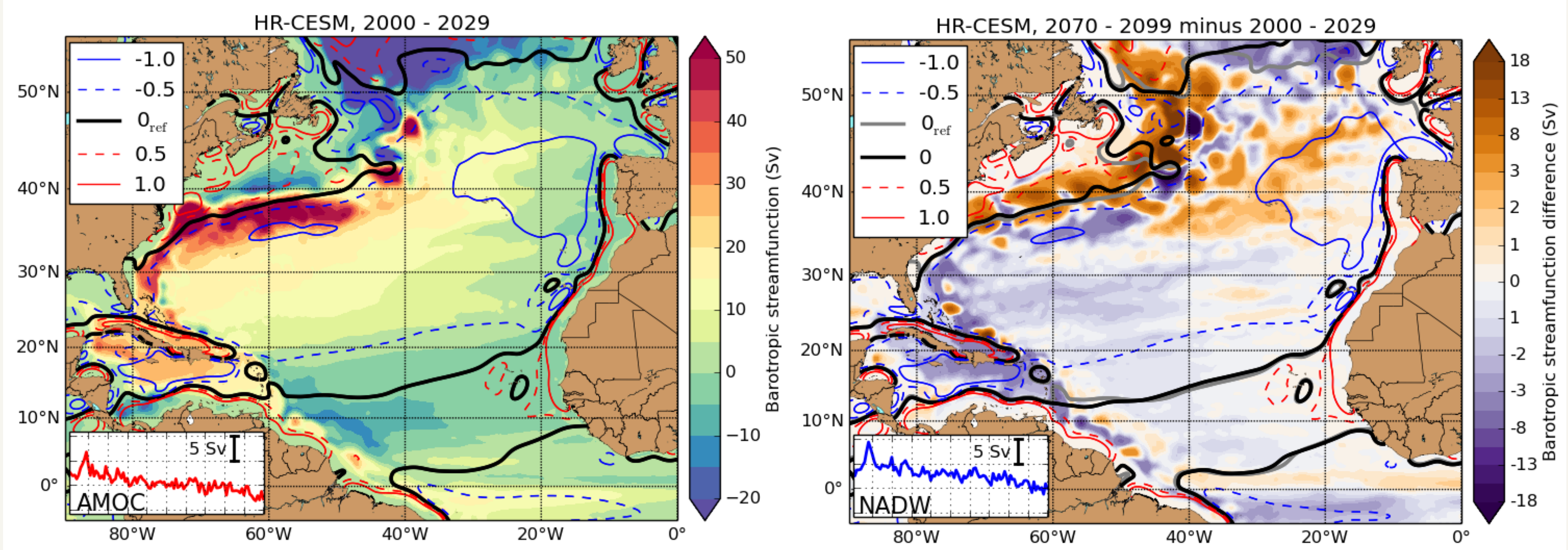

Figure 5: Barotropic streamfunction (colours) strength and anomaly. Magnitude of wind-stress curl (curves, spaced by 0.5 Pa per 10^4 km). Insets: Time evolution overturning circulation strength.

- Extreme η_M events are related to eddies near the Lesser Antilles (**Figure 6**).
- 1:5 year event decreases by -7.2 cm (-16%) over 100 years (**Figure 7**).

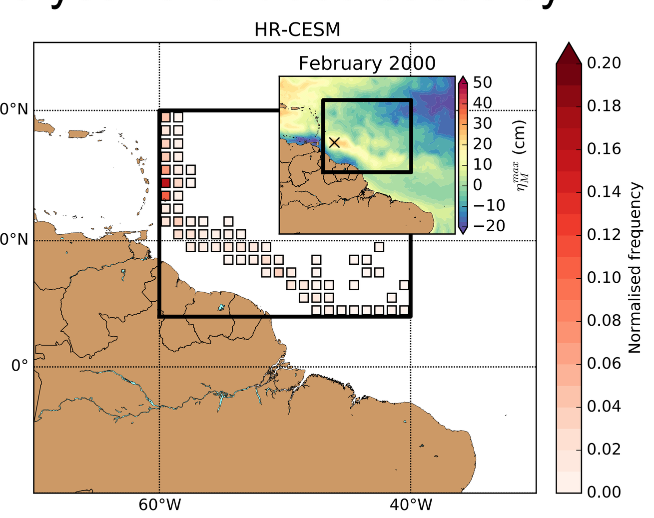

Figure 6: Monthly maximum η_M distribution.

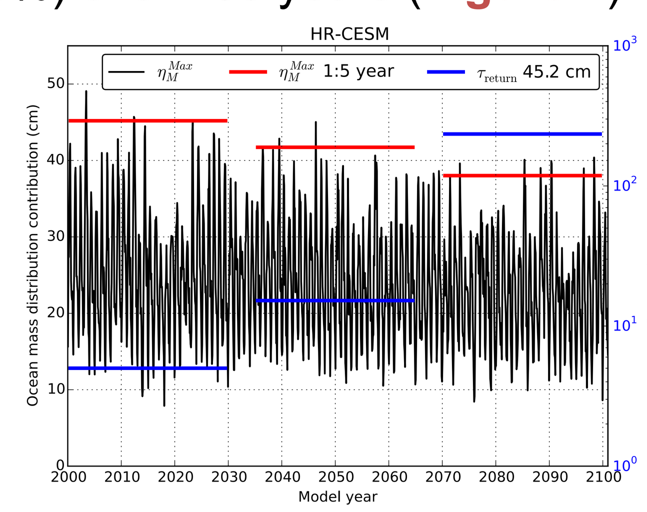

Figure 7: Evolution of the extreme η_M events.

CHOOSE YOUR MODEL

Introduction and Research Question

- Global sea level rise threatens coastal regions[1].
- Regions experience **above-averaged** or **below-averaged** sea level rise[2], such as **region 1** and **region 2** (**Figure 1**).
- Adequate sea level rise projections are needed for coastal regions.
- Current sea level projections are based on coarse climate models (1° × 1°).

Are sea level rise projections model resolution dependent?

- Analysis of two versions of the Community Earth System Model (**CESM**).
- Anthropogenic forcing of 1% pCO_2 increase per year between 2000 – 2100.
- Dynamical sea level trend: $\eta = \eta_S^g + \eta_M$
- Global steric effect - η_S^g
- Ocean mass distribution - η_M

CHOOSE YOUR MODEL

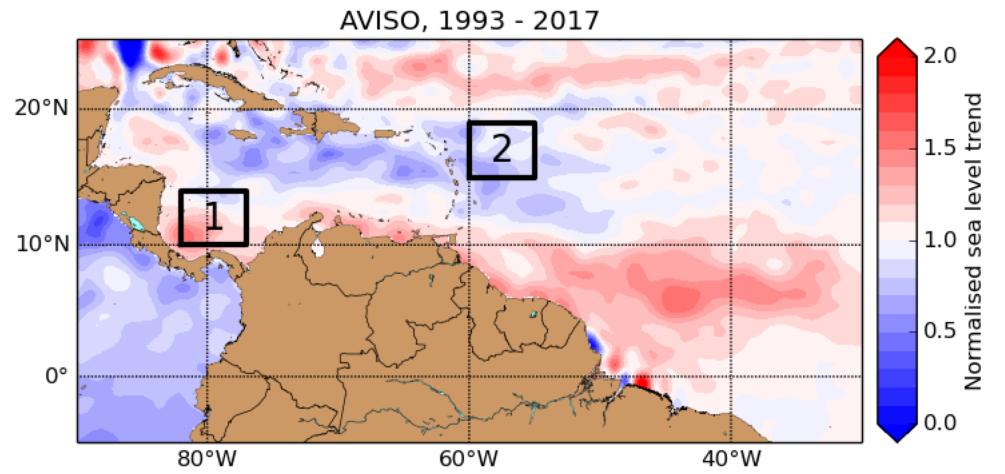

Figure 1: Observed sea level rise trend, normalised to the global averaged sea level rise trend (= 3 mm year^{-1}).

Summary and Conclusions

- **Yes**, sea level rise projections are model resolution dependent.
- **Factor of 5** difference in the 1:5 year event between the models.
- The LR-CESM and most CMIP6 models do **not** have the same normalised η trend sign as observations (**Figure 14**).
- Low resolution climate models are **not fit** for the purpose of making adequate regional sea level projections.

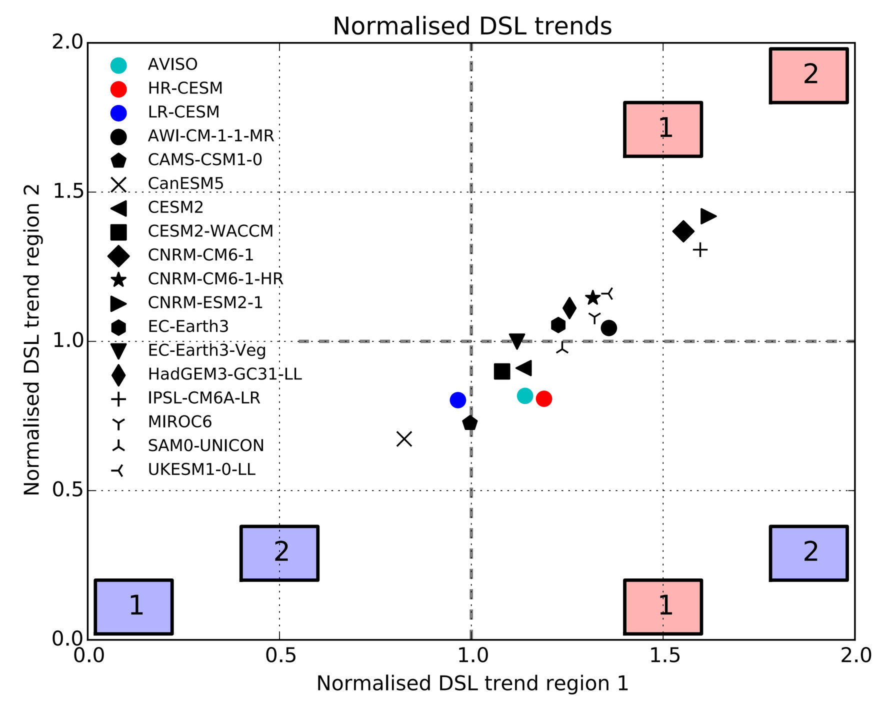

Figure 14: Normalised dynamical sea level trend of the two regions for observations, the HR-CESM, LR-CESM and 15 CMIP6 models.

Low-resolution climate model

- Ocean: 1° × 1°
- Atmosphere: 1.25° × 1.25°
- Ocean eddies paramaterised
- Retroflection paramaterised
- Weak η_M gradient near western boundary current

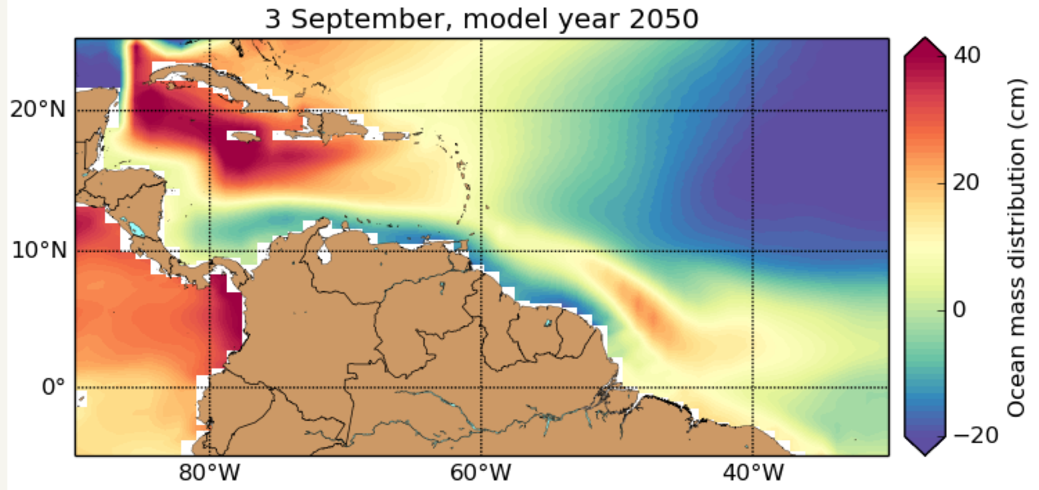

Figure 8: Daily-averaged ocean mass distribution.

- Normalised dynamical sea level trend with respect to η_S^g trend (**Figure 9**).
- Region 1 is **below-averaged** and region 2 is **below-averaged** (**Figure 10**).

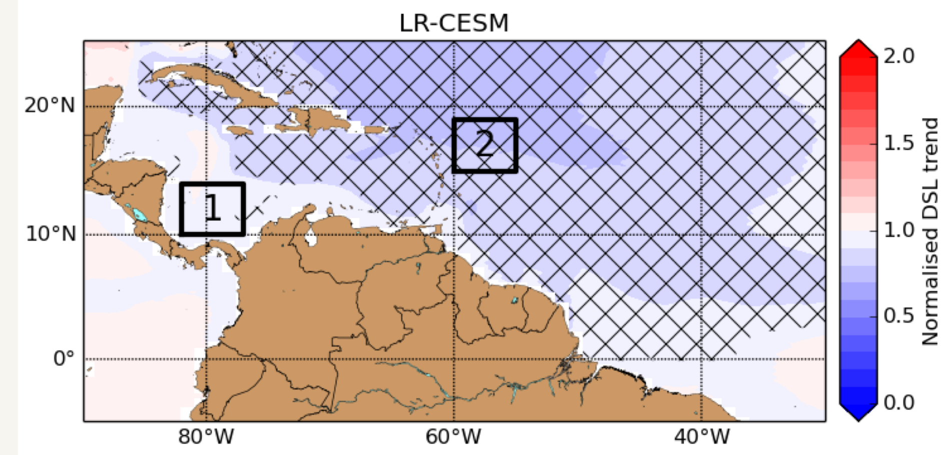

Figure 9: Normalised dynamical sea level trend, hatched regions indicate significant trends.

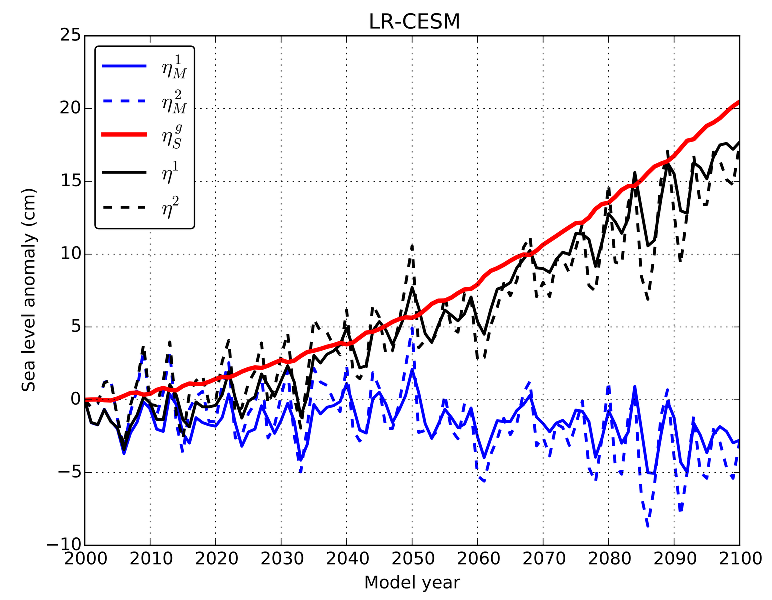

Figure 10: Time evolution of the η_M, η_S^g and η, for region 1 and region 2.

- Changes in η are related to a weaker overturning circulation (**Figure 11**).

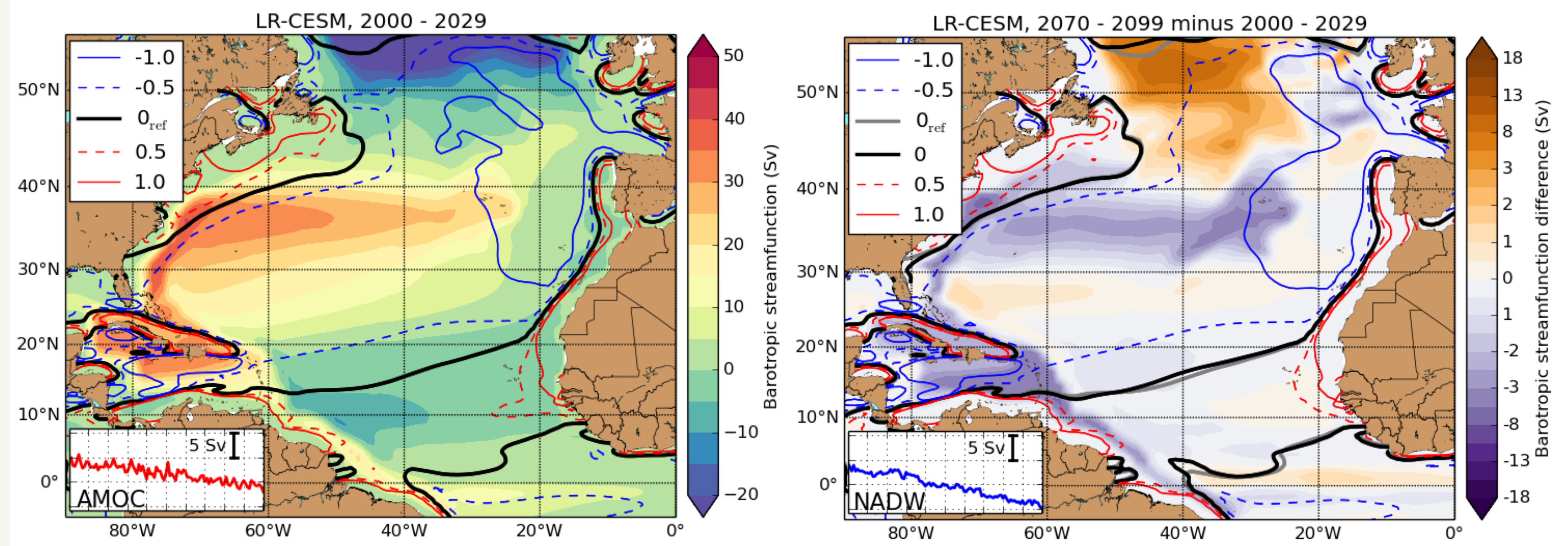

Figure 11: Barotropic streamfunction (colours) strength and anomaly. Magnitude of wind-stress curl (curves, spaced by 0.5 Pa per 10^4 km). Insets: Time evolution overturning circulation strength.

- Eddies are not resolved near the Lesser Antilles, no extreme η_M (**Figure 12**).
- 1:5 year event decreases by -1.5 cm (-6%) over 100 years (**Figure 13**).

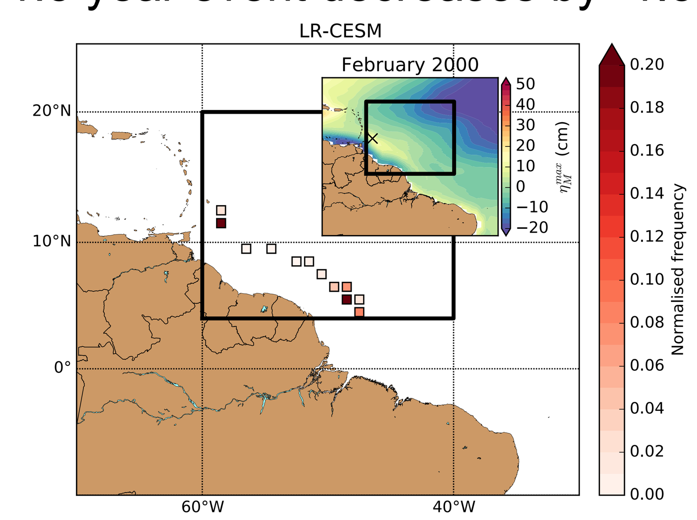

Figure 12: Monthly maximum η_M distribution.

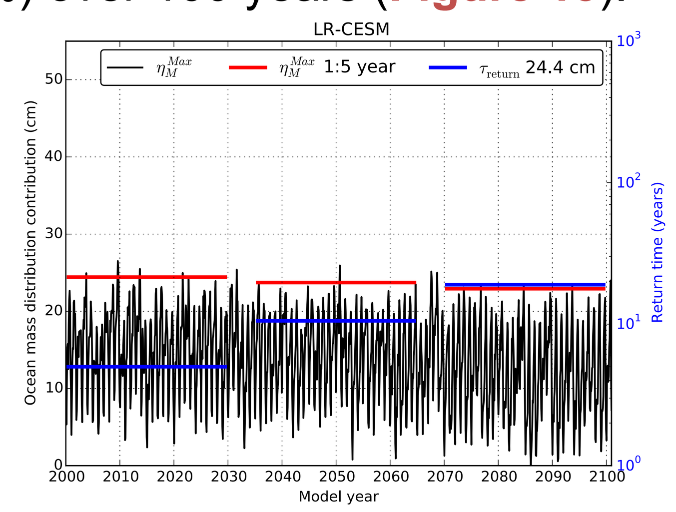

Figure 13: Evolution of the extreme η_M events.

References:

1. **Nicholls and Cazenave (2010)**, Sea-level Rise and its Impact on Coastal Zones, *Science*, **328**(5985), 1517–1520.
2. **Cazenave et al. (2018)**, Contemporary Sea Level Changes from Satellite Altimetery: What have we Learned? What are the New Challenges? *Advances in Space Research*, **62**(7), 1639–1653.
3. **van Westen et al. (2020)**, Ocean Model Resolution Dependence of Future Sea Level Projections, *in review*.

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