Observed Response of the Atlantic Ocean to Atmospheric Pressure Loading at Periods Near 5 Days

OS35H–02

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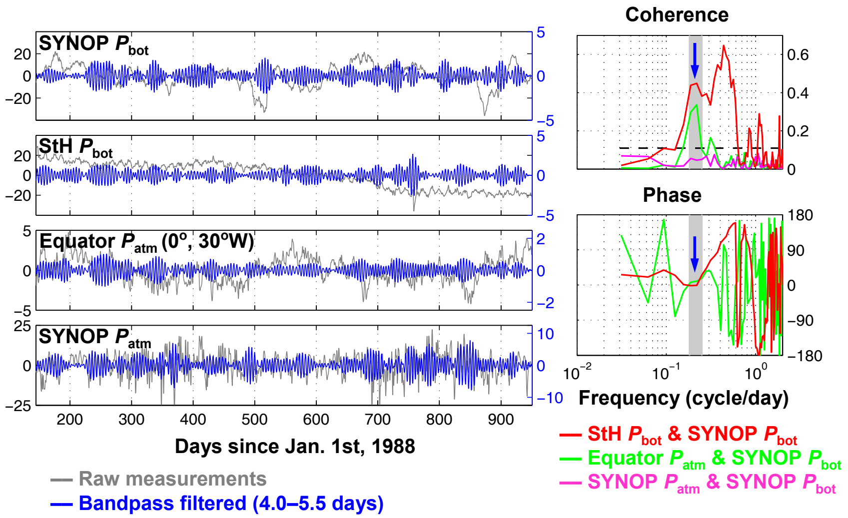
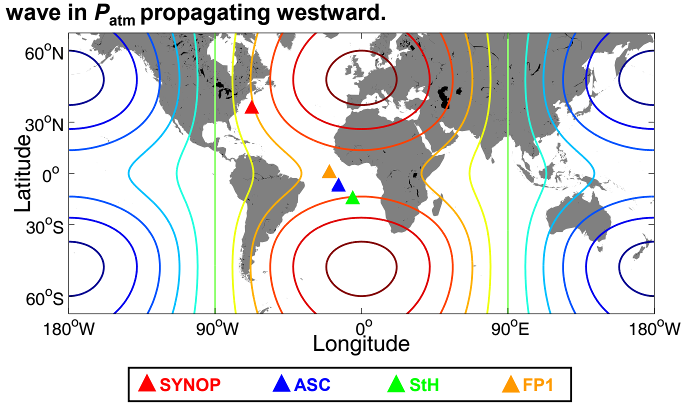
1. Measured bottom pressure (P_{bot}) south of New England in SYNOP.
- a) Incoherent with local atmospheric pressure (P_{atm})
- b) Coherent near 5 days with equatorial Atlantic P_{atm} ~5700 km away
- c) Coherent near 5 days with St. Helena Island P_{bot} ~8500 km away



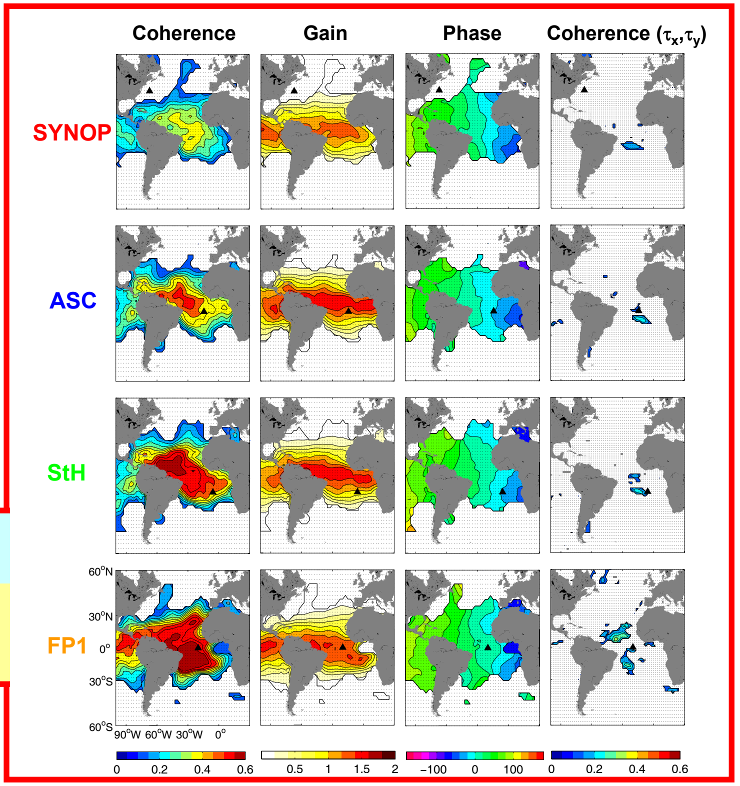
PUZZLE: Why does SYNOP P_{bot} reveal no coherence with local P_{atm} and maximum coherence with equator P_{atm} ?

ANS: Inverted barometer (IB) response to energetic synoptic-scale local P_{atm} at SYNOP obscures global–scale non–IB response to 5–day Rossby–Haurwitz wave.

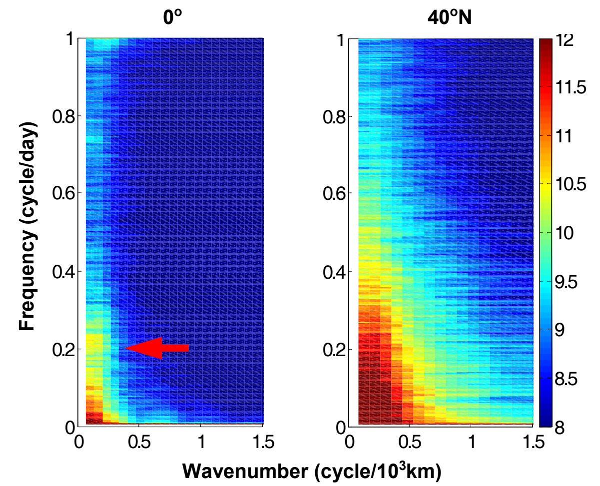
2. Theoretical spatial structure of the 5–day Rossby–Haurwitz wave in P_{atm} propagating westward.



3. Cross spectra between P_{bot} and P_{atm} near 5–day period.
- 4 P_{bot} sites
- NCEP/NCAR P_{atm} and τ_x, τ_y fields
- Coherence and gain maps show maxima along equator
- Phase maps exhibit westward propagation of P_{atm}
- Only values > 95% confidence level are plotted



4. Frequency–wavenumber P_{atm} spectra at the equator (0°) reveal remarkable Rossby–Haurwitz wave (←), but extratropical region (40°N) are dominated by energetic synoptic weather patterns.



o Summary of bottom pressure (P_{bot}) data

Name	Location	Duration (length)	Deployed by
Synoptic Ocean Prediction Experiment (SYNOP)	36.84°N 67.46°W	6/88 – 8/90 (807 days)	URI
Ascension (ASC)	07.92°S 14.42°W	6/88 – 8/90 (807 days)	POL
St. Helena (StH)	15.97°S 05.70°W	6/88 – 8/90 (807 days)	POL
FP1	0.00° 20.00°W	2/83 – 9/84 (600 days)	POL

URI: University of Rhode Island, POL: Proudman Oceanography Laboratory

The open ocean sea level responds almost isostatically to most fluctuations of atmospheric pressure loading, i.e., inverted barometer response, by a ratio of about –1 cm/mbar. Large departures from isostatic response have been observed, however, for example in the tropical regions of the Pacific and Atlantic Oceans at period near 5 days. Barotropic ocean model simulations coupled to atmospheric forcing predict that this nonisostatic ocean response is driven not regionally but globally by the Rossby–Haurwitz wave, a 5–day period large–scale global oscillation in barometric pressure, meridionally symmetric with predominantly zonal wavenumber –1 (westward propagating). To date no observational evidence has been provided to support the model simulations at extratropical latitudes. This study exhibits the basin-scale nature of the nonisostatic response in the Atlantic Ocean near 5–day period using four historical long-term (> 1 Year) bottom pressure measurements spanning from 16°S to 37°N. One was deployed by University of Rhode Island and three by Proudman Oceanographic Laboratory. Joint analysis of bottom pressure measurements together with global–gridded atmospheric pressure reveals a basin–scale nonisostatic sea level fluctuation in the North and tropical Atlantic Oceans at period near 5 days with zonally uniform phase. It also confirms that the driving force for this near 5–day fluctuation is the westward propagating Rossby–Haurwitz wave. The observed basin–scale nonisostatic sea level fluctuation at period near 5 days can alias satellite altimetry measurements at coarser temporal sampling (e.g., 10 days for Jason), and could in principle be removed for improved utilization of satellite sea surface height observations.