On the scientific accomplishments of AMS Fellow Dr. José A. Colón Pérez (1921-2015), the first Puerto Rican- born hurricane researcher

Daniel Meléndez – DOC/NOAA/ National Weather Service, Silver Spring, MD
Neal Dorst – DOC/NOAA/Hurricane Research Division, Miami, FL
Howie Friedman – DOC/NOAA/Hurricane Research Division, Miami, FL
T.N. Krishnamurti – Distinguished Professor of Meteorology, The Florida State University, Tallahassee, FL
William Gray – Emeritus Professor, The Colorado State University, Fort Collins, CO
Israel Matos – Puerto Rico Emergency Management Agency, San Juan, PR (retired MIC San Juan WFO)
Rafael Méndez – Professor, University of Puerto Rico, Carolina, PR
Rafael Mojica – Retired NWS San Juan WFO Warning Coordination Meteorologist
Ada Monzón – WKAQ-580 am and President, EcoExploratorio: Museo de Ciencias de PR, San Juan, PR
John Toohey-Morales – WTVJ-TV NBC-6 and Climadata Corp., Miami, FL
Ed Zipser – Professor, Dept. of Atmospheric Sciences, University of Utah, Salt Lake City, UT

Daniel Meléndez

American Meteorological Society 32nd Conference on Tropical Cyclones and Meteorology

Tuesday 19 April, 2016 – San Juan, PR

Outline

- **Biographical Notes**
- **Publications**
- **Scientific Contributions**
- **Consulting Work**
- **Mentees**

Biographical Notes

- University of Puerto Rico (1939-44)
  - Magna Cum Laude, Math and Chemistry (minor)
  - Worked for ionospheric lab of Dr. G. Kenrick (PhD, MIT) at UPR
- University of Chicago, Dept. of Meteorology (1944-46)
  - Recommended by UPR Dr. Kenrick and Dean F. Bueso (PhD Chicago)
  - Professional Certificate in Meteorology (wartime A-course) - 1945
  - Published as a student papers and reports
  - Chicago awarded SM 1950; Elected to Sigma Xi; PhD 1960
  - Came back to teach at UPR in 1946
- UPR Institute of Tropical Meteorology (1946-49)
  - -- Research Assistant ITM and Instructor, Mathematics
  - -- UPR-ITM was a joint Chicago-UPR Cooperative Institute [Riehl's 1947 PhD work was done there; visitors - J. Simpson, Dunn, others]
  - -- JAC Taught and published at UPR
- U of Chicago Research Associate and Instructor (1951-54)

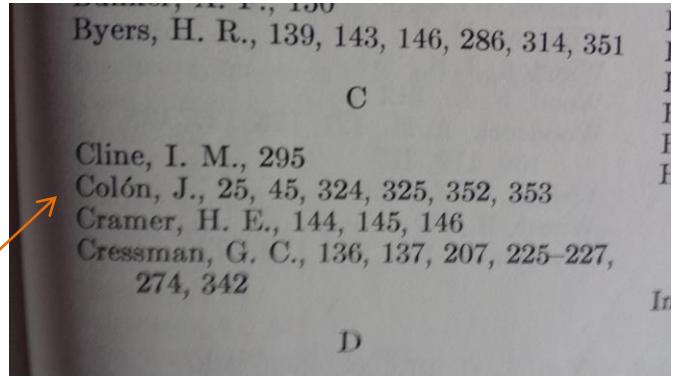
Biographical Notes J. Colón - cont'd

- San Juan Hurricane Warning/Forecast Office (1954-58; 1964 through retirement in 1986)
  - Research Forecaster ('54-'58) then on to NHRP (part of USWB then)
  - Back to PR @1964 as MIC of Hurricane Warning Office (then NHC-East)
  - Published papers and a book chapter on PR/VI climatology
- National Hurricane Research Project, Miami (1958-64)
  -- Published as Data Librarian/Supervisory Research Meteorologist
  -- Did PhD work there as well (58-60)
  -- Volunteered as Meteorological Advisor International Indian Ocean Expeditions (IIOE, 1963) as sole NHRP personnel 1962-1963
- International Indian Ocean Expedition (IIOE, 1962-64)
  -- Colón published two significant papers
  -- Flew many missions including first penetrations of Arabian Sea cyclone
  -- Stay in India cut short by accident boarding USWB DC-6
- AMS Fellow, 1983
- Post-1984 retirement - Meteorological Consultant
  - Published book - Climatología de PR (Editorial UPR, 1999)
  - Over 20 forensic meteorology consultancies on record

Publications

- Reports
  - A few U. of Chicago Tech Reports (mostly lost) while a graduate student
  - Several NHRP Reports (available)
  - Various USWB Technical Notes

- Refereed Journal Articles
  - Over 13 referee journal articles



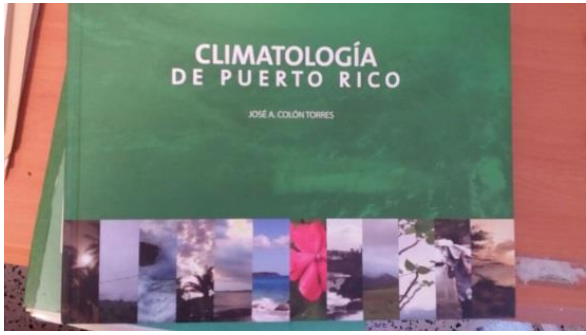
- Books/Chapters

-- Colón is cited six times in H. Riehl's seminal book, *Tropical Meteorology* (1954), before he got his PhD

-- Chapter on Climatología, *Geovisión de PR*, Universidad de Puerto Rico, 1977, ed. M. T. Galiñanes, pp47-122

-- *Climatología de Puerto Rico*, editorial UPR, 2009

-- Incorrect last name

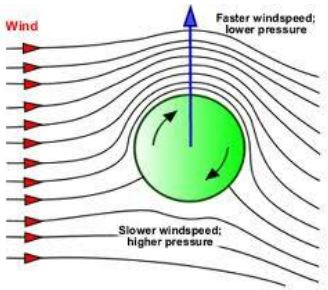


Colón's Key Scientific Contributions

- Settled postulated Magnus effect on track - nil
- First to notice highs/lulls in TC activity over Atlantic?
- One of the first (1961) to observe TC core upper level thermal anomaly and radial cycle trends during development phase
- Defined Heat balance of the Caribbean Sea/Atmosphere
  - Specified ocean heat content structure
  - Devised method to compute precipitation based on energy
- Identified two types of hurricane inner-core evolution
- Discovered existence of monsoon inversion (MI) and Arabian Trade wind circulation
- Found tropical cyclogenetic processes in Arabian/Indian Ocean identical to those elsewhere
- First complete concentric eye evolution and its relation to intensity change with implications for STORMFURY project
- First comprehensive climatology of Puerto Rico

The Magnus Effect on TC Motion (1947)

- Colón, *Influence of the Magnus Effect on the Motion of Tropical Cyclones*, BAMS, 28, 1947
  - JAC at UPR - Institute of Tropical Meteorology
  - Magnus effect is slipstream flow influence on pressure or interaction between rotating cylinder and mean flow
  - Hypothesized by tropical meteorologist of the time
  - Effect would show difference between steering current and track
  - Examined upper and surface synoptic charts (1935-1942) from JAX
  - Evaluated suggestion by Riehl of possible correlation between changes in track and in the surface pressure gradient right-of-track
- Concluded that Magnus effect, if real, is very small
  - No track deviation was related to any surface pressure gradient change
  - Appears to settle issue definitively



Forecasting Hurricane Track (1953)

- Colón, *A Study of Hurricane Tracks for Forecasting Purposes*, MWR, 81, March 1953
  - Also Univ of Chicago Tech Report Task Order 23
  - JAC was a Research Associate at U of Chicago
  - Statistical analysis of Caribbean TC genesis and motion
  - Annual and monthly frequencies based on 1887-1950 data
  - 473 cyclones in 5^{o}x 5^{o} lat/lon grids following grid-center fixes
- TCs form in clusters of two or more in rapid succession in Aug-Oct
- Median speed highest in 10^{o}-20^{o} N and north of 30^{o} N
  -- Especially in Gulf of Mexico
  -- Persistence in track computed
- Finds find lulls and highs in Atlantic tropical cyclone activity
  - Looked at one- and five-year activity means
  - Above average counts in 1887-1895 and 1931-1950
  - Below average counts in 1896-1930
  - Frequency of low count seasons higher than high count season
  - First to find activity variability prior to discovery of climate patterns?

Forecasting Hurricane Track (1953)- cont'd

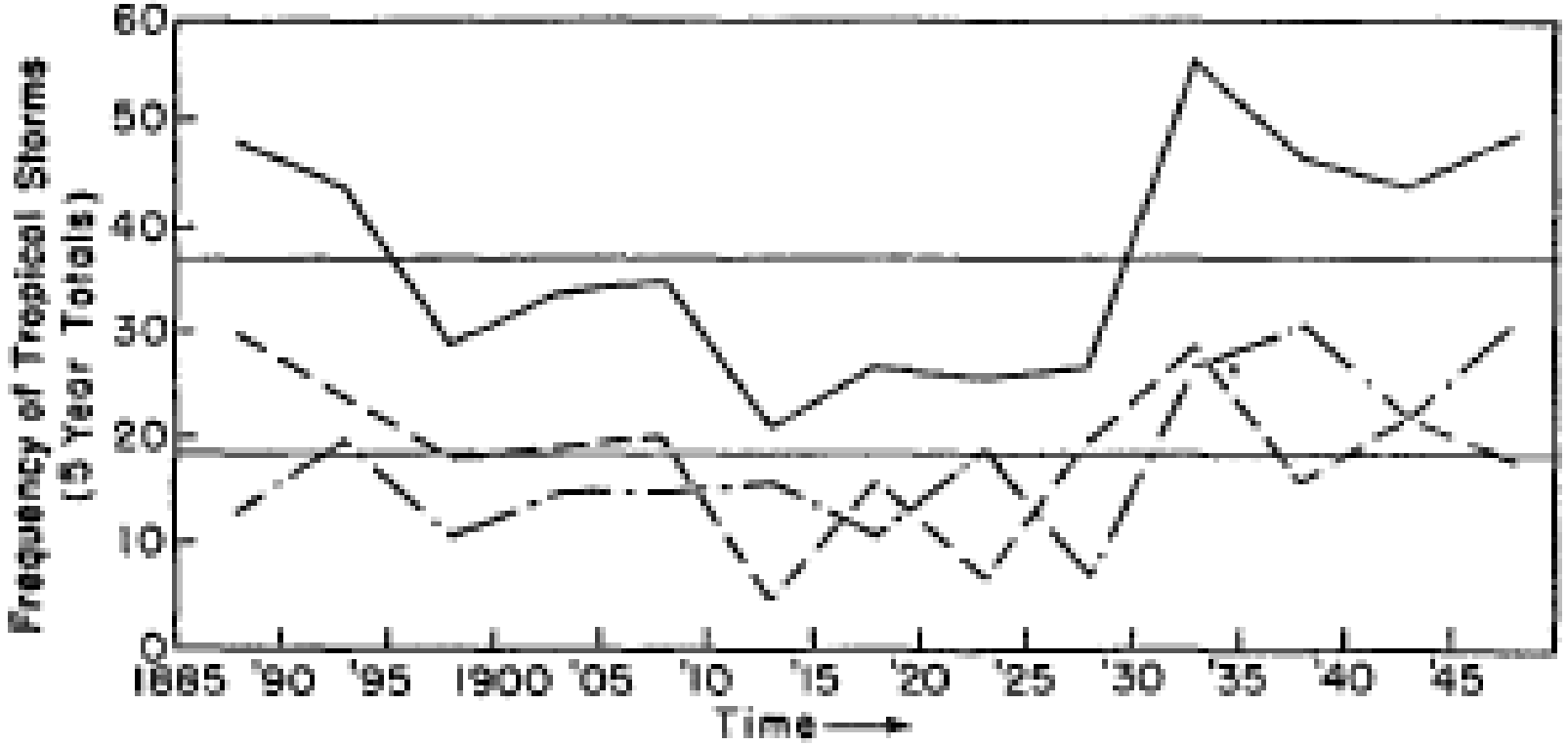


FIGURE 2.—Frequency of tropical cyclones of all intensities in the Caribbean-Atlantic area by five-year sums from 1886–1950. Solid curve indicates total frequency; dashed curve, frequency of storms formed east of 70° W.; dot-dashed curve, storms formed west of 70° W. Thin horizontal solid lines indicate the averages on a five-year basis.

Forecasting Hurricane Track (1953)- cont'd

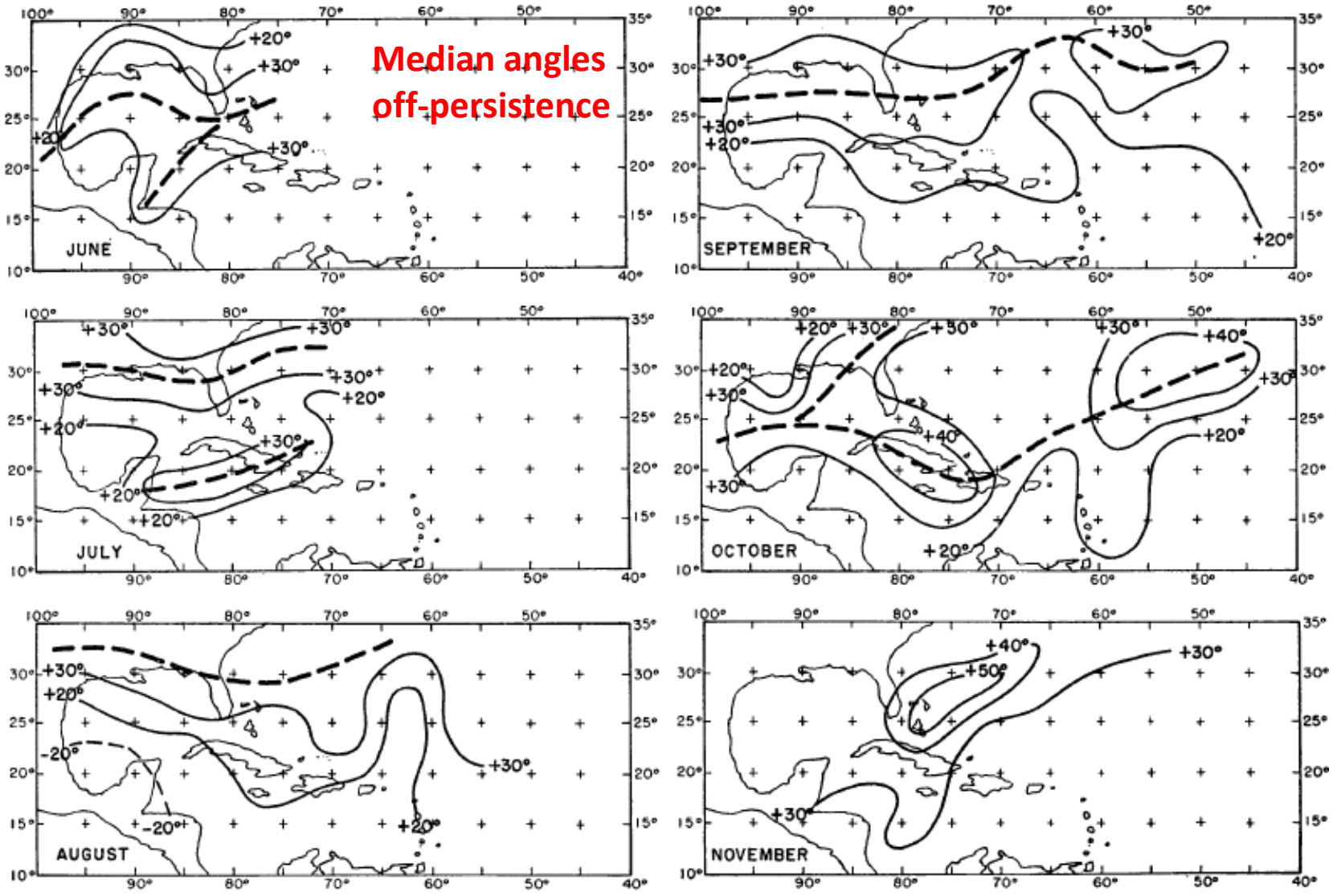
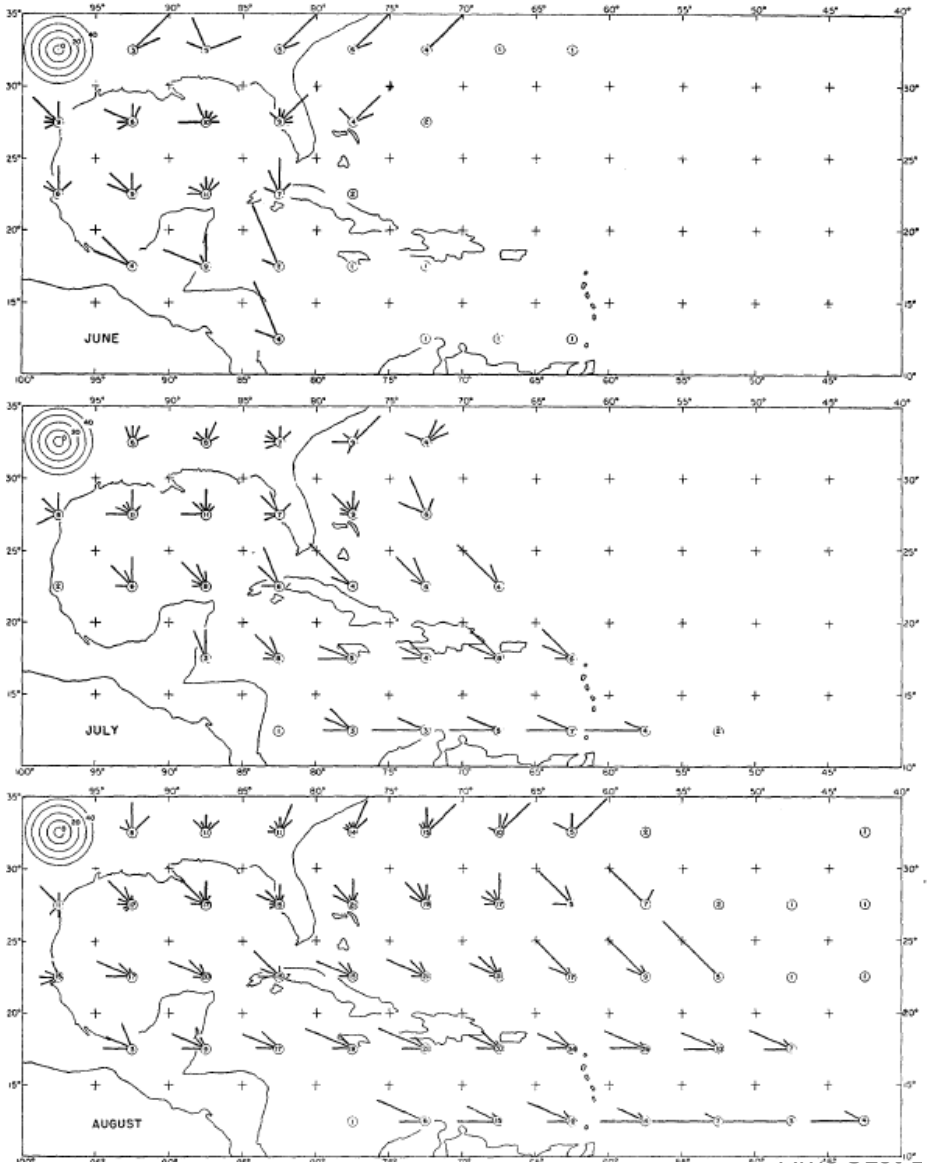
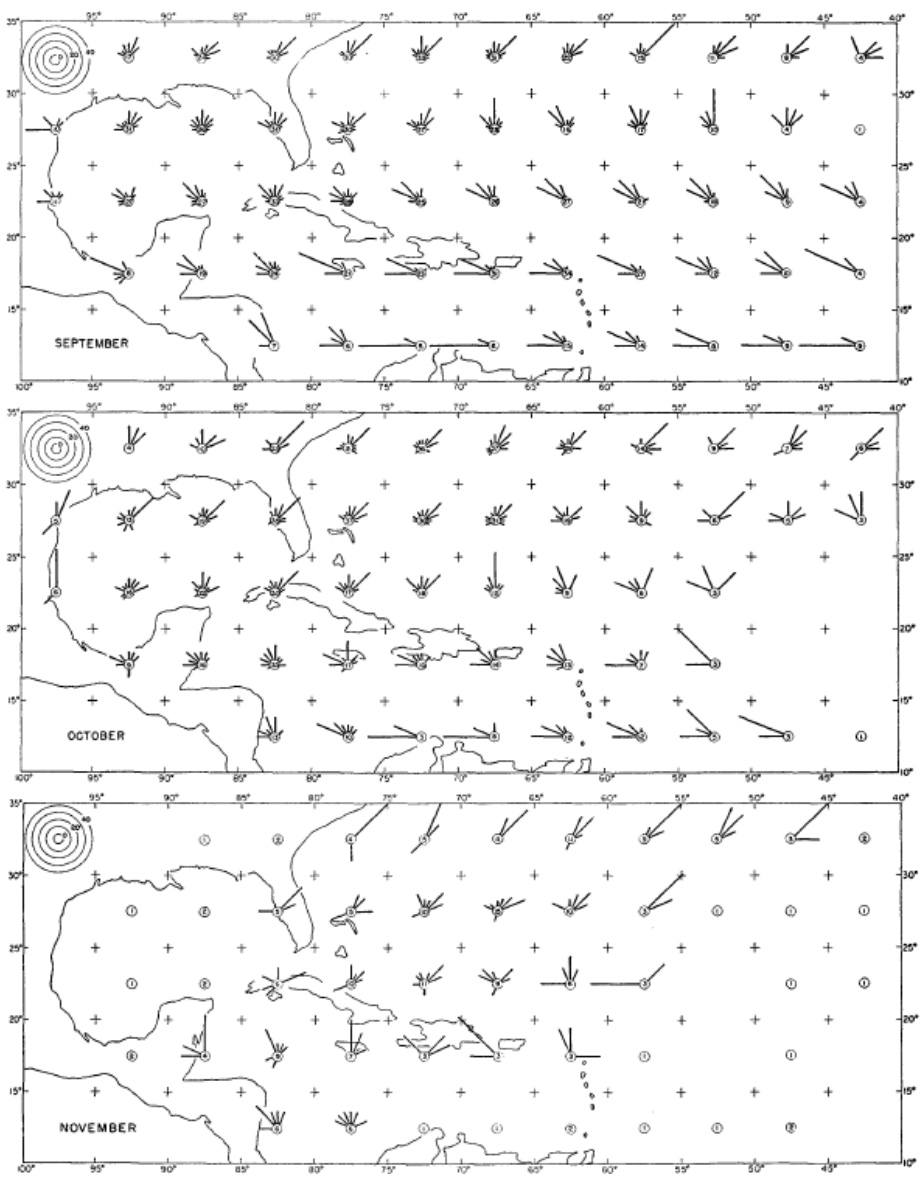


FIGURE 12.—Median angle of change in direction of motion of nonpersistent storms. Dashed heavy lines indicate axes of largest median angle.

Forecasting Hurricane Track (1953)- cont'd





Energetics of the Caribbean Region (1960)

- Colón, *On the Heat Balance of the Troposphere and Water-Body of the Caribbean Sea*, NHRP Report 41, Dec 1960
  - PhD 1960 thesis of JAC under Herb Riehl (Chicago); JAC then at NHRP
  - Computes monthly heat balance from climatology summaries
  - Constructed sea temp-depth profiles down to ~100m from 8000 bathys (provided by J. Simpson – WHOI)
- Verified Trades model of Riehl and Malkus (1959)
  - Simpson credits Colón with observationally confirming her 2-D model
    - Trades as source and exporter of latent+sensible heat
    - Downstream energy gains from ocean maintain pressure field
    - "Diabatic heating by cumuli sustains flow against friction"
- Upper ~200 mb westerlies have KE structure like Jet Stream

-- Vertical heat/moisture distribution via convective clouds…not broad uplift

-- Flow above PBL largely quasi-geostrophic

Energetics of the Caribbean (1960)- cont'd

- Developed new method of estimating oceanic precipitation
  - -- Used energy balance to get correct order of magnitude precipitation
  - -- Adjusting Qrad by 10% reconciles JAC and Jacobs (1951) precipitation
  - -- Technique predates TRMM rain estimates based on sea surface energy
- About 20% of evaporation flux from sea is precipitated back and the rest exported by Trade layer
  - Constructed sea temp-depth profiles down to ~100m from 8000 bathys
  - OHC is largely seasonally invariant below ~100 m depth
- Caribbean Trades similar to those in Pacific Ocean
  - Pacific Trades studied by [Riehl and Malkus, QJRMS, 1957]
  - Ocean energy supports local circulation by maintaining pressure(r,t)
- Caribbean is net heat exporter with different annual SST range & phases at western and eastern edges
  - -- Exports KE northeast-ward into Atlantic

Seasonal Heat Fluxes in the Caribbean (1963)

- Colón, *Seasonal Variations in Heat Flux from the Sea Surface to the Atmosphere Over the Caribbean Sea*, JGR, 68(5), Mar 1963
  - Follow on to 1960 PhD thesis; JAC then leading SJU HWO
- Finds C. sea peak cooling (Dec) and heating (Apr/Aug) rates
  - Winter-to-summer warming takes 7 months but summer-winter cooling only 5 months
  - Caribbean sea exports Qdiv in summer and imports in winter
    - Qdiv ≤ 10% of Q(absorbed)
  - Max heat flux from sea in Nov; minimum in Dec
  - Peak evaporation rate is 0.58 cm/d (Dec)
- JAC asserts main changes to his results would come from revised cloud cover data and thermal depth profiles below 100m

  -- Hastenrath (1976)'s values of residual (Qdiv + Qt) and Qrad are similar to Colón (1963) with drag coefficient uncertainty accounting for much of the difference of about 10%

Hurricane Dynamics (1963)

- Colón and LCDR Nightingale, *Development of Tropical Cyclones in Relation to Circulation Patterns at the 200-mb Level*, MWR, 91, 1963
  - 40 cases of 200-mb flow over low-level disturbances at time of genesis
  - 28/40 developed under southerly (poleward) flow aloft
  - Only 5 under equatorward flow
  - Did not consider non-developing events
- Poleward flow aloft more favorable than equatorward flow
  - As in eastern side of trough over low-level perturbation
  - Anticyclonic flow aloft more favorable than cyclonic
- Generalizes and extends earlier work
  -- Miller (1958) did not identify growth phase but noted poleward flow
  -- Ramage (1959) only considered subtropical ridge line
  -- Riehl et al (1962) concurs but only considered Gulf of Mexico
- 5-to-1 likelihood of development under poleward flow aloft
  --

Tropical Cyclone Evolution (1963)

- Colón, *On the Evolution of the Wind Field During the Life Cycle of Tropical Cyclones*, NHRP Report 65, 1963
  - Studies radial profiles of wind in nearly similar hurricanes
  - One of the first along with Riehl and Simpson to document eyewall contraction based on published and internal NHRP data 2000-14000 ft
  - Classified two modes of dynamical evolution: HELENE- and DAISY-like
  - Key to pressure evolution is vortex convective organization
- DAISY-like change is fast and explosive with ~constant size vortex
  - Little or no change in eye diameter while pressure drops
  - Small RMW/sharp Umax/faster growth
- HELENE-like vortex contracts/eye replacement occurs
  - -- More common mode but arising from less optimal disturbances
  - -- Steady RMW and intensity decrease before reaching MPI
  - -- Has distinct "α" values in wind-radius relationship $U_{azimuthal} * r^{\alpha}$
- Finds single dissipation stage mode regardless of growth mode
  - -- RMW increases along with central pressure
  - -- Eye widening typical of weakening

Tropical Cyclone Evolution (1963)

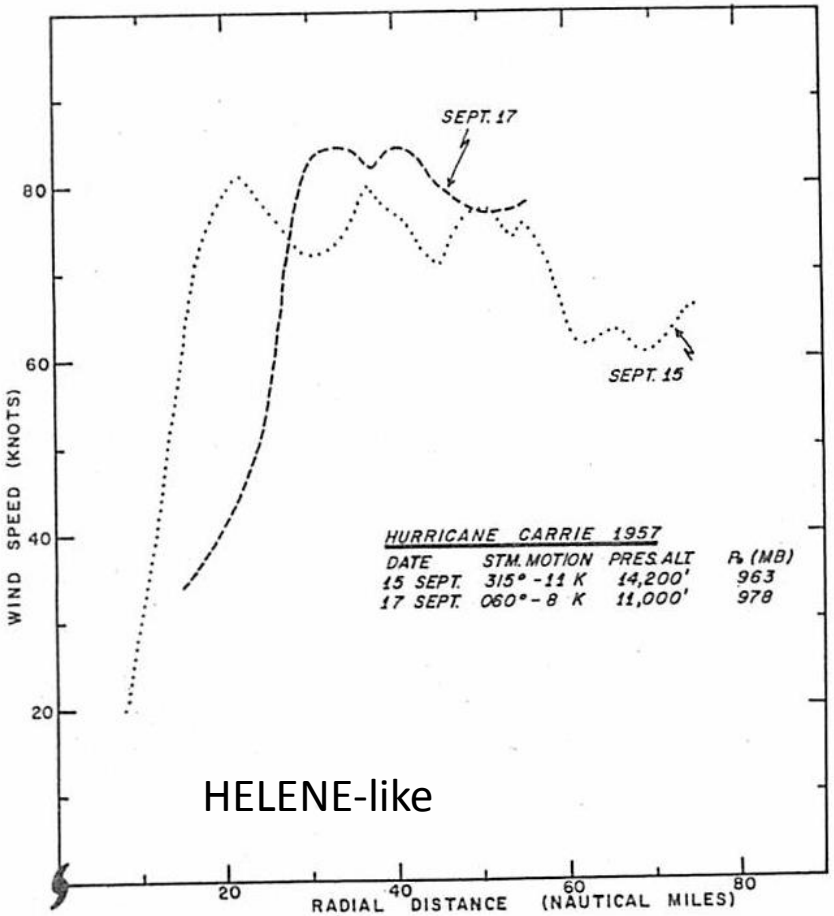


Figure 15. - Wind profiles recorded in hurricane Carrie, Sept. 15-17, 1957

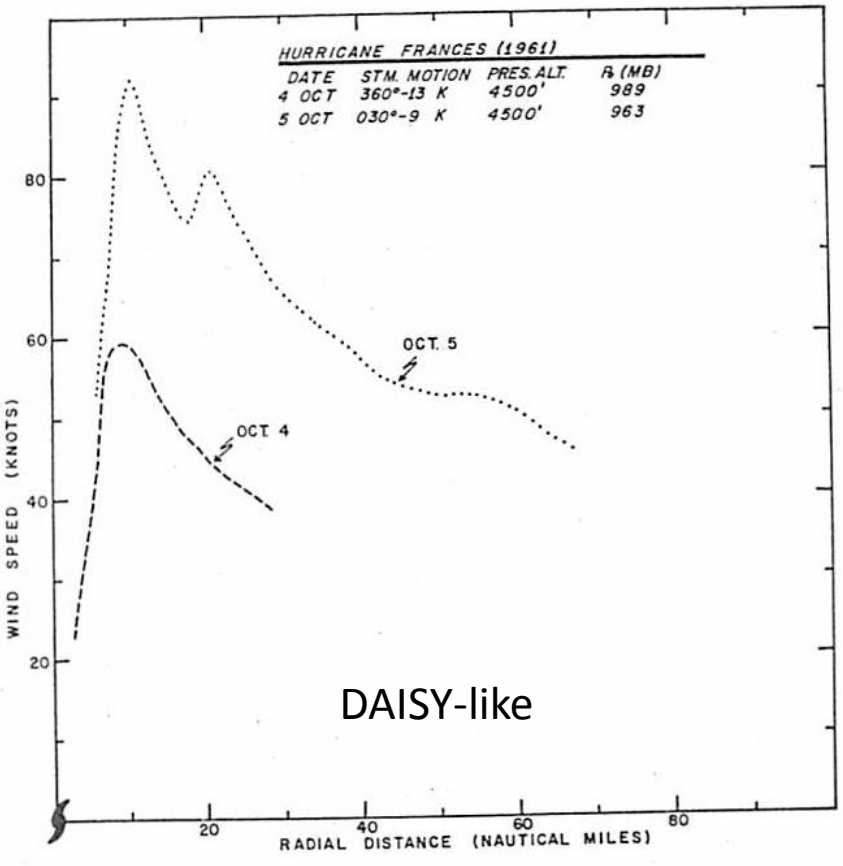


Figure 16. - Wind profiles recorded in hurricane Frances, Oct. 4-5, 1961.

Monsoon Thermal Inversion (MI) (1964)

- Colón, *On the Interaction Between the Southwest Monsoon Current and the Sea Surface over the Arabian Sea*, Indian Jou. Meteor. Geophys., 15, pp183-200. (Colón at NHRP)
  - Aircraft /dropsonde obs during International Indian Ocean Exp (1963-64)
  - IIOE provided aerological obs 26 Jun-02 Jul 1963
  - Two US Weather Bureau DC-6 flew 1500 ft and 500 mb altitudes
- Colón is credited with discovery of low-level thermal inversion over West/Central Arabian Sea along with Ramage (1966)
  - Noted by Dr Dev Sikka (personal comm, 2015), former director IMS
  - Noted by Rao (1976), standard IMS Monsoon Manual
  - Noted by Dwivedi et al (2015)
  - Strong 900-750 mb inversion provides low-level stability
  - Controls mid-troposphere (0.5-2 km) moisture during monsoon phases
  - Colón proposed hot air advection from Arabia riding over cool maritime air and large scale subsidence over Arabian Sea due to M. convection
  - Later paper notes two-layer thermal structure of MI [Colón, USWB Tech Note 9-SAIL-1, 20 Aug 1965]
  - Next confirmation relied on SAT obs [Narayanan and Rao, 1981]

Monsoon Thermal Inversion (1964)- cont'd

- Colón also computed heat energy balance of Arabian Sea/air
- Large ocean-to-air heat flux increase coincident with onset of SW Monsoon phase
  -- Found heat flux increasing downstream to central Arabian Sea
  -- Very large evaporation rate (> 1 cm/day)
  -- SST drops due to cold air advection and larger heat losses to atmosphere
  -- Radiative heating highly reduced by cloud-induced cooling during SW monsoon
  -- Proposes vertical mixing across inversion layer as air mass nears land as having strong implications for rainfall
  -- Indian Ocean Trade winds and profiles like those in ATL and PAC
- Basis for much of the current understanding and modeling of Arabian Sea circulation preceding monsoonal rains over India

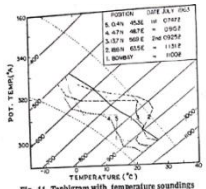


Fig. 11. Tephigram with temperature soundings at various positions downstream along the monsoon current

Monsoon Thermal Inversion (1964)- cont'd

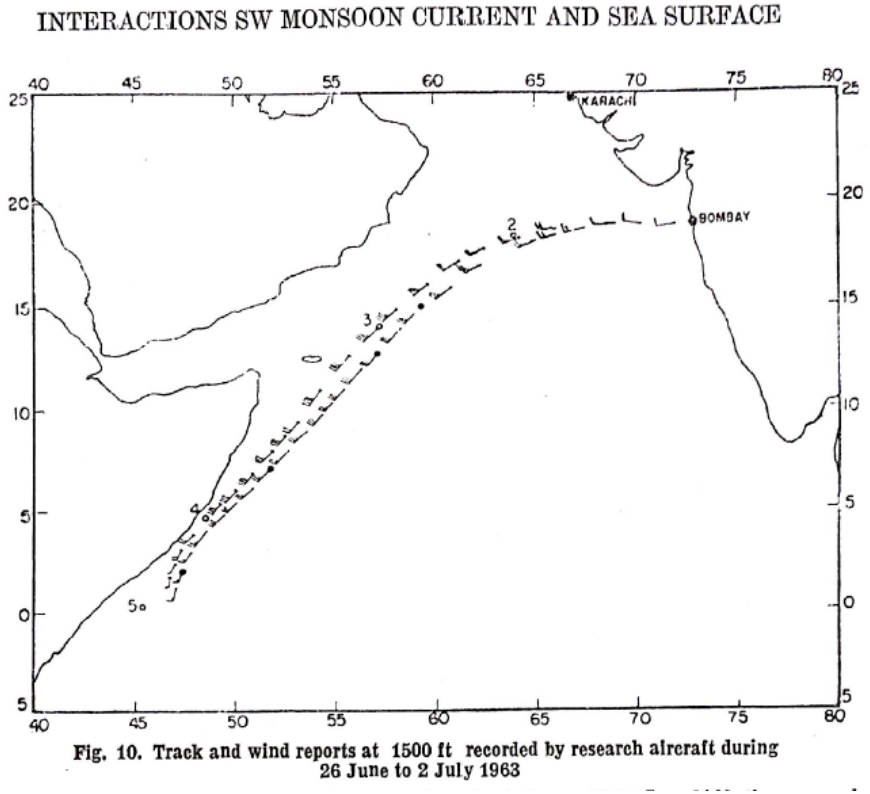


Fig. 10. Track and wind reports at 1500 ft recorded by research aircraft during 26 June to 2 July 1963

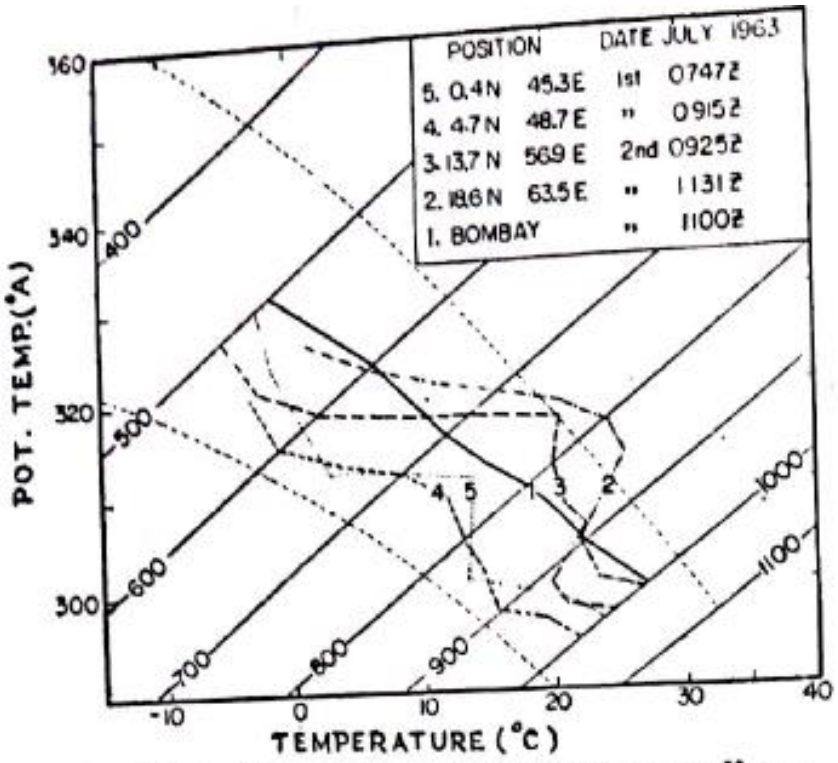
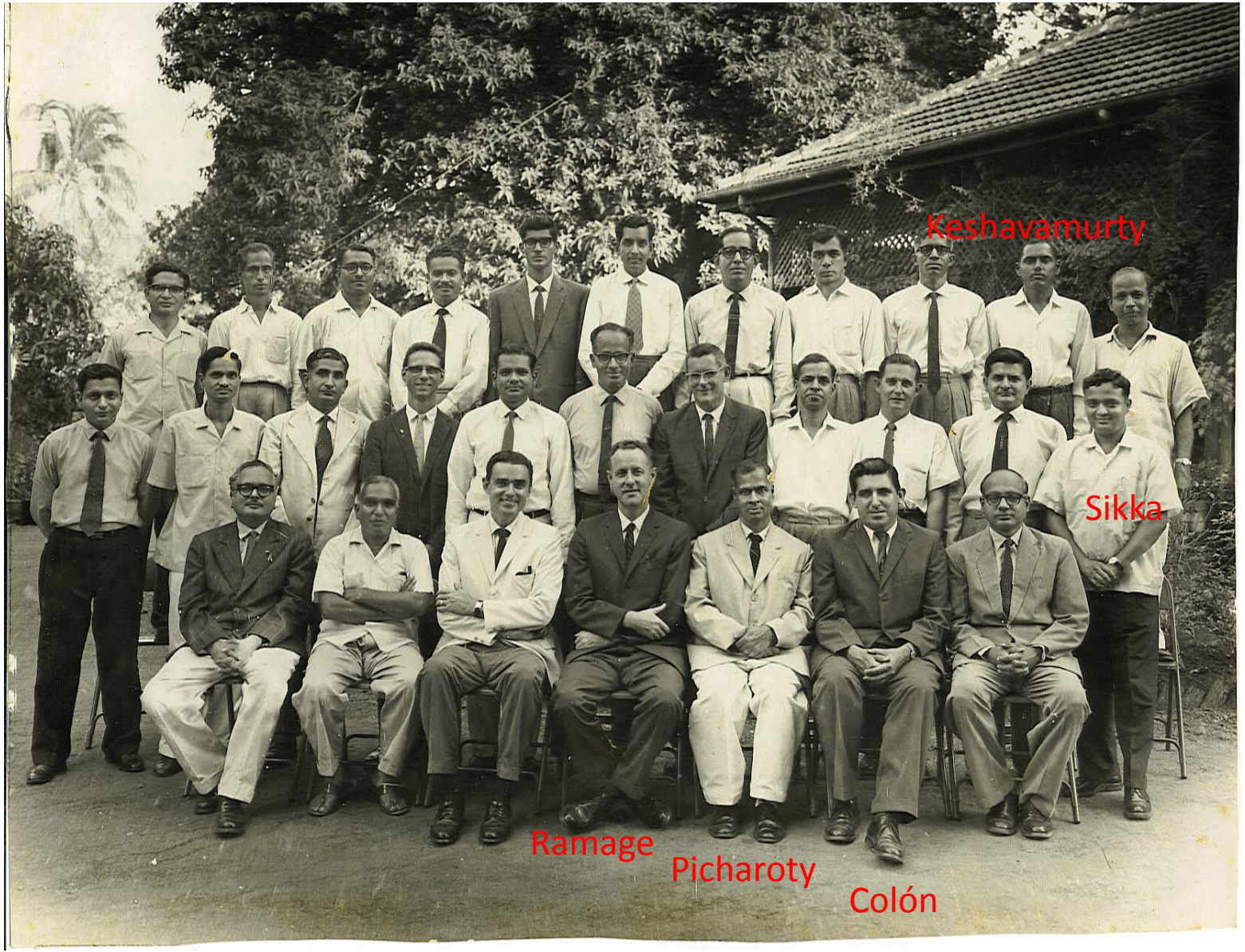


Fig. 11. Tephigram with temperature soundings at various positions downstream along the monsoon current

Colón at IIOE in 1963



Colón & Sally at IIOE in 1963

Tropical Cyclone Formation over Arabian Sea (1970)

- Colón, C.R.V. Raman and V. Srinivasan, *On Some Aspects of the Tropical Cyclone of 20-29 May, 1963, Over the Arabian Sea*, Indian Jou. Meteor. Geophys., 21, pp1-22
  -- Colón MIC of NHC-San Juan in 1970
  -- Paper received June 1968
  -- Arabian Sea typhoon (20-29 May 1963) reconnaissance…IIOE (1962-64)
  -- First aircraft observation of region's "severe cyclone" (est. 984-988 mb)
  -- First aircraft reconnaissance overwater in region
- Development and structure factors similar to Atlantic hurricanes
  -- Unknown fact at the time as well as upper flow similarity
  -- Upper level disturbance was nucleus of typhoon
  -- Upper troposphere structure of pre-monsoon over northern IO similar to Atlantic and Pacific during summer
  -- Also similar is pre-monsoon to summer monsoon transition (northern IO)

Concentric Eyewall Evolution (1970)

- Hoose H. and J.A. Colón, *Some Aspects of the Radar Structure of Hurricane BEULAH on September 9, 1967*, MWR, 98, July 1970
  -- Hoose and Colón at HWO-San Juan PR
  -- US Navy report (1949) and Fortner (1958) first to report concentric eye
  -- Documented complete concentric eye cycle hourly with radar for 36 h
  -- Outer eye of 67 km contracting to 30 km diameter in 13 h
  -- Inner eye of 11 km diameter vanished
- One of firsts to link concentric eye contraction/intensity change
  -- Fortner (BAMS, 1958) was first to describe but not relate to intensity
  -- Hoose and Colón: first complete documentation of inner eye ring evolution (per J. Simpson, 1975)
  -- "Double" eye appears shortly before peak intensity (940 mb)
  -- Peak wind shifts outward into clear annulus and RMW remains constant during contraction
  -- Implications of this paper helped end STORMFURY project
  -- Eyewall Replacement Cycle still not fully understood (Wang et al., 2013)

First complete documentation eyewall contraction Hurricane BEULAH Sep 1967 (Hoose and Colón, 1970)

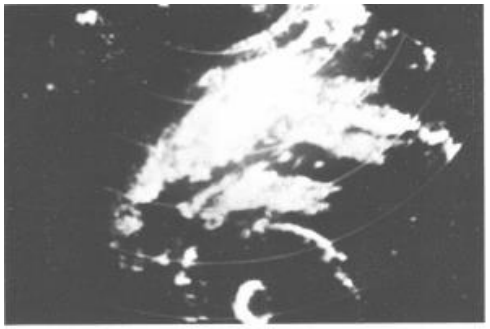


FIGURE 2.—Photograph of the San Juan PPI scope taken at 1030 GMT on Sept. 9, 1967. Range markers are at 20-n.mi. intervals; the top of the photograph is north.

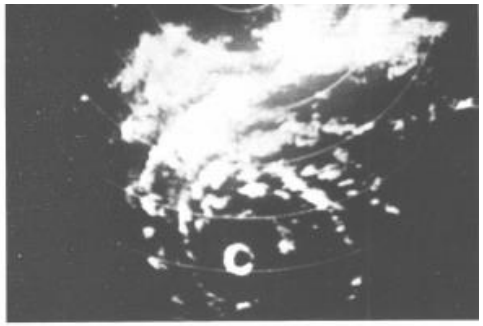


FIGURE 4.—Similar to figure 2, taken at 1630 GMT on Sept. 9, 1967.

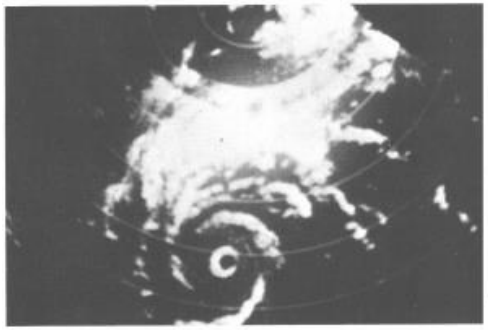


FIGURE 3.—Similar to figure 2, taken at 1430 GMT on Sept. 9, 1967.

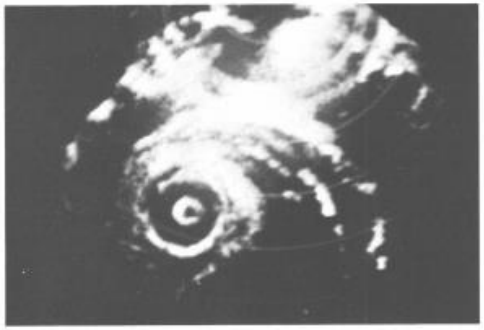
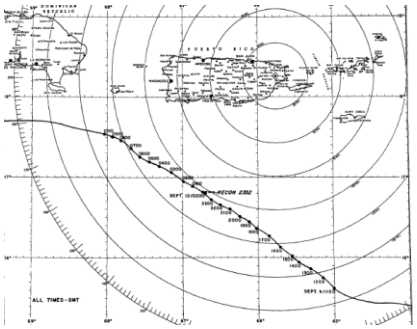


FIGURE 5.—Similar to figure 2, taken at 1930 GMT on Sept. 9, 1967.



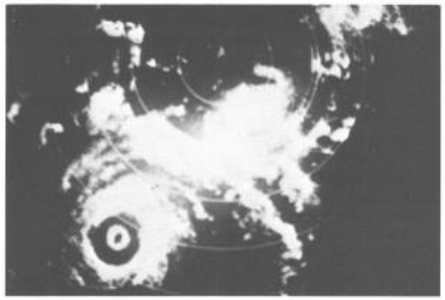


FIGURE 6.—Similar to figure 2, taken at 2130 GMT on Sept. 9, 1967.

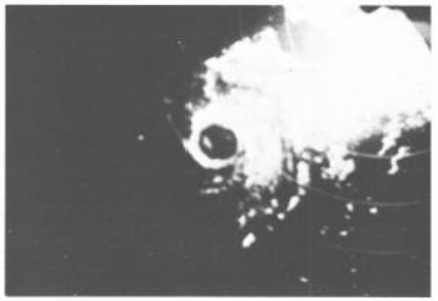


FIGURE 8.—Similar to figure 2, taken at 0230 GMT on Sept. 10, 1967.

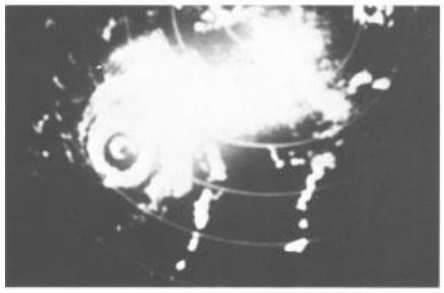


FIGURE 7.—Similar to figure 2, taken at 0045 GMT on Sept. 10, 1967.

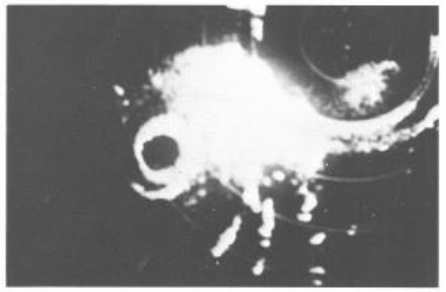


FIGURE 9.—Similar to figure 2, taken at 0330 GMT on Sept. 10, 1967

Mentees of Dr. José A. Colón

- Jesús Colón, Former Lead Meteorologist, San Juan WFO
- Israel Matos, Former MIC San Juan WFO
- Dr. Daniel Meléndez, NWS Meteorologist, prev. NRL researcher
- Rafael Mojica, Former WCM San Juan WFO
- Ada Monzón, WKAQ Meteorologist/President EcoExploratorio
- John Toohey Morales, Chief Meteorologist, NBC-6 TV & President Climadata Corporation
- Prof. Ed Zipser, Professor of Meteorology, University of Utah
- …and many colleagues

Bonus: First Puerto Rican-born Woman Meteorologist

- Gloria M. Sepúlveda (NYU, Bernard Haurwitz; UPR)

  -- Haurwitz B., and Sepúlveda, G.M. (1957), *Geographical distribution of the semidiurnal pressure oscillation at different seasons*, J. Meteor. Soc. Japan, 75th Anniv. Vol.

  -- "The results of this important paper [Haurwitz, 1956] were documented the following year in two studies with Gloria Sepulveda in which they verified that in the Northern Hemisphere poleward of about 70° the amplitude and phase of the semidiurnal pressure oscillations are mainly controlled by the standing wave." (Biographical memoir of B. Haurwitz by J. London, Natl Academies Press, 1996, p102)

- JAC mentions her in newspaper article
- Born in Yabucoa, PR
- Had long career at NCAR developing climate models with Akira Kasahara and Warren Washington

eteorólogos Ven Mezcla Arte y Ciencia en

Rodríguez
EL MUNDO

meteorólogos
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Colón como
studiaron la

disciplina en la Universidad de Chicago. Colón es el único puertorriqueño que ejerce su profesión aquí.

DOS FASES CIENCIAS ATMOSFERICAS

"Las ciencias atmosféricas", explicó Colón, "se dividen en dos fases: la científica y la fase de pronósticos. Esta última lidia principalmente con interpretación. Podríamos describirla como la "fase artística" y en la científica entra la contribución de las computadoras y la experiencia".

Colón entiende que la meteorología se aprende en la práctica, debido a que hay factores que no pueden enseñarse por lo variables. "Una persona con buena memoria puede reconocer una situación y compararla con situaciones similares anteriores y ésto lo convierte en buen pronosticador".

El profesor McDowell coincide con esta visión. Además enfatiza que la

JOSE A. COLON

persona debe tener una curiosidad natural por los cambios y las ciencias. Comentó que se ha notado que ciertas clases de personas tienen 'más habilidad que otros... "como una especie de intuición, de sensibilidad para captar las variantes sutiles y analizarlas mejor".

Colón dirige la oficina del Servicio Nacional de Meteorología en Isla Verde. Tiene a su cargo unos diez meteorólogos que trabajan allí la data que se recibe a través de las fotografías del satéli-

te y la información de las computadoras. Es natural de Coamo y es casado con tres hijas y un nieto.

McDowell es norteamericano pero reside en la Isla desde el 1943.

En 1936 obtuvo su bachillerato en física y en 1941, mientras se encontraba de vacaciones en Miami, vivió de cerca una tormenta tropical y se fascinó con el fenómeno.

Explica que durante la guerra entró a la Universidad de Chicago en un programa de entrenamiento de meteorología. El caos que había producido el estado de guerra hizo que en poco tiempo se convirtiera de estudiante a profesor allí mismo. La Universidad le encomendó en 1943 que inaugurara un Instituto de Meteorología Tropical en Puerto Rico, trabajo que estimaron podría hacerse en tres meses. Se extendió un año y ya para entonces McDowell estaba tan entusiasmado con Puerto Rico que decidió quedarse.

MCDOWELL

GRAN SENTIDO DEL HUMOR DE MCDOWELL

McDowell tiene un gran sentido del humor. Comenta, antes de que le pregunten, que mucha gente esperaba sus pronósticos cuando tenía el programa de televisión para esperar lo contrario al día siguiente.

"Lo que pasa es que la gente sólo recuerda las veces en que uno falla. Pero no somos tan malos, los pronósticos son exactos en un 80 por ciento de los casos, que

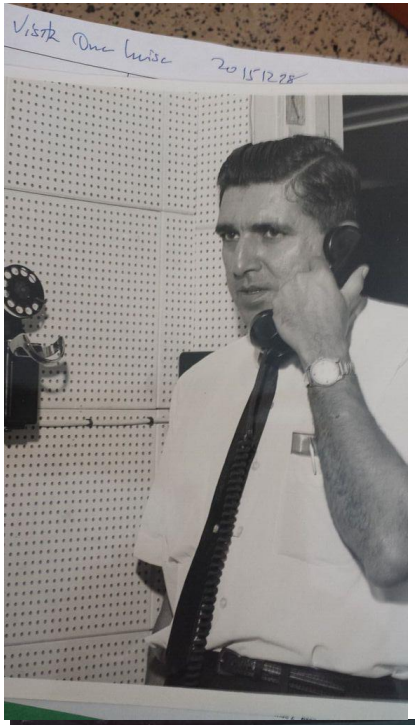
no es un mal promedio", afirmó. Seguidamente comendó a los que dan dedicarse a la p sión, a tener "la dura" para poder por alto los comen de la gente.

"Bueno... en quier caso, a lo mej ayudaría el tener ca el ser aguacatero... ayuda. Ya le dije, tiene 30 por ciento arte y 30 por cient ciencia".

NO HAY DAMA METEOROLOG EN LA ISLA

Curiosamente, profesión en la Isl hay mujeres. Ambos teorólogos recuerda puertorriqueña, G Sepúlveda, que Ine estudiar el curso el continuó estudios e tados Unidos, pero maneció allá un el po de investigad científica y termina doctorado en me cia.

"Las muchac

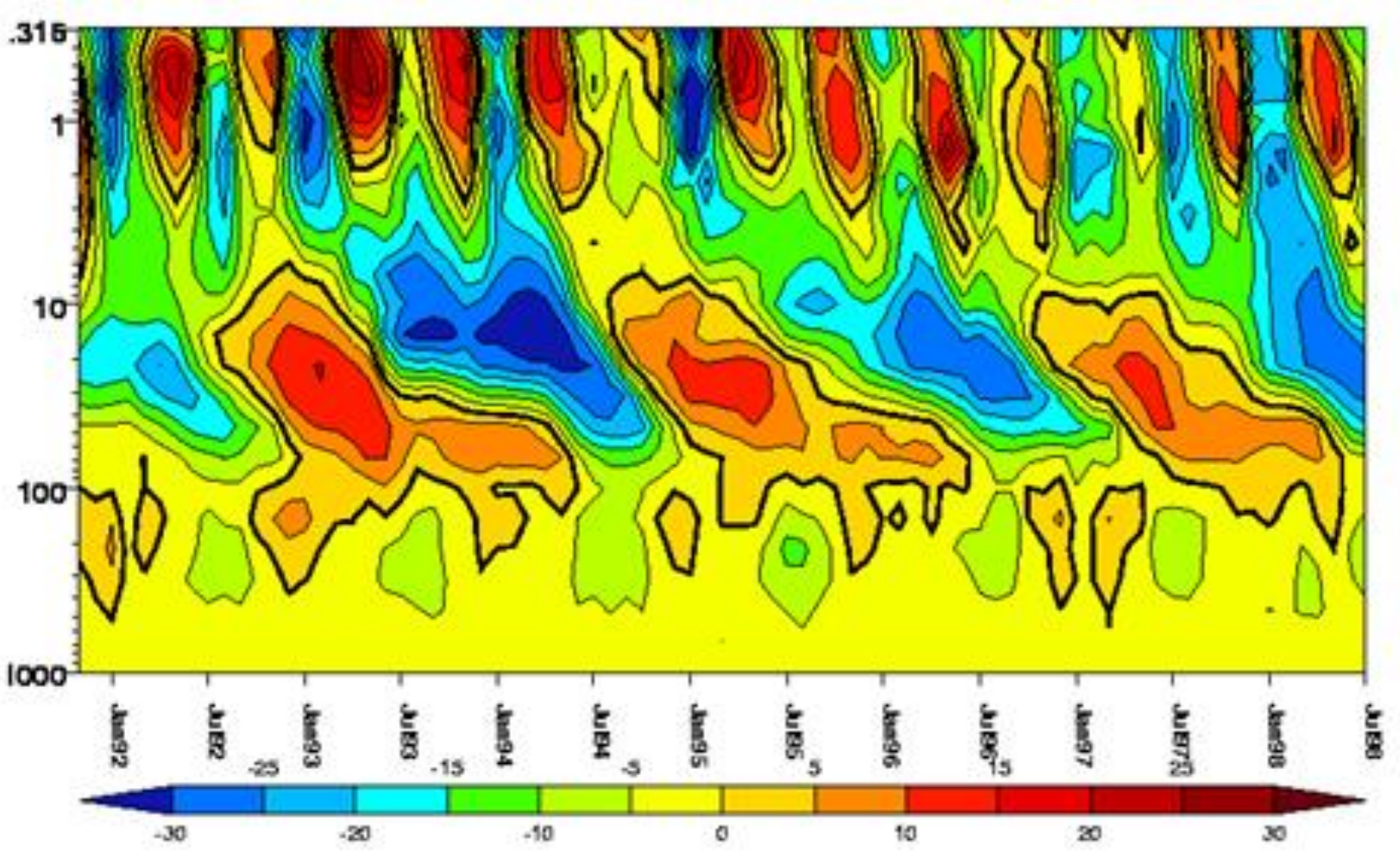


¡GRACIAS!
¿Preguntas?
Questions?

Tropopause/Stratospheric Winds Over PR (1951)

- Colón, *On the Wind Structure Above the Tropopause over Puerto Rico*, BAMS, 32, Feb 1951
  - Used 89 1948 rawinsonde "raw" soundings reaching ≥ 20 km
  - Computed wind roses for each raob level from 1 km below to 7 km above tropopause level (ATL)
- Winds turn increasingly westward between tropopause and 7 km above it
  - Winds below tropopause change from W or NW to ENE
    - Westerly QBO phase unknown at the time
  - Max easterly frequency reached at 3 km ATL and in summer
  - Extends and generalizes special soundings of Fassig (1933) during cosmic ray experiment over San Juan PR
  - Similar to *Krakatao* winds in over stratospheric regions of the globe

Quasi-Biennial Oscillation (QBO)



The Mean Rainy Season Over the Western Tropical Pacific (1953)

- Colón, *The Mean Summer Atmosphere of the Rainy Season Over the Western Tropical Pacific Ocean*, BAMS, 34(7), 1953
  - Also Univ of Chicago Tech Report Task Order 23, Sep 1952
  - JAC was research assistant (Masters degree) at U of Chicago
  - Constructed "standard atmosphere" using nighttime summer data from Kwajalein, Guam, and Palau and compared to Caribbean soundings of Schacht (tephigrams, 1946)
  - Google Scholar Citation Count - 10

- Found small differences between Western Pacific and Caribbean temperature and moisture fields with West Pac -
  - warmer at low levels and colder at upper levels
  - more moist everywhere

Hurricane ALICE 1955 (1956)

- Colón, *On the Formation of Hurricane Alice, 1955: With Notes on Other Cold-Season Tropical Storms*, MWR, 84, Jan 1956
  - JAC was Research Forecaster, US Weather Bureau, San Juan PR
  - Presented evidence of Alice as first warm-core hurricane in cold-season
  - Alice was small hurricane
  - Alice formed thanks to mid-Atlantic blocking high, strong easterly flow, and high enough SSTs (1^{o}F above normal) over SJU-Bermuda area
  - Atypical south- and west-ward track
- Warm-core conversion process enabled by blocking High in spite of cooler low level air
  - Thermodynamic eye profile similar to strong typhoons IAW Jordan (1952)
  - Earlier 1951 cyclone retrospectively analyzed also from blocking High
  - Simpson (1952) postulated two main processes in Hawaii regions
    - Transformation of mid-latitude cyclone
    - Reduction of pre-existing cold upper low

Hurricane BETSY 1956 (1959)

- Colón, *Meteorological Conditions over Puerto Rico During Hurricane Betsy*, 1956 - MWR, Feb 1959
  - JAC at US Weather Bureau, San Juan PR
- Documented sinusoidal track oscillation about mean path
  - Inferences of intensity change made upon radar structures

On the Structure of Hurricane Daisy 1958 (1961)

- Colón and Staff, *On the Structure of Hurricane Daisy*, NHRP Report No. 48, 1961
  - Describes structure and evolution of DAISY using aircraft data
  - DAISY had small but intense eye early on with in-radius intensification
- Major changes in DAISY were concentrated in and near eye-core
- In terms of mass change there is as much loss below as aloft but largest warming anomaly is aloft during deepening

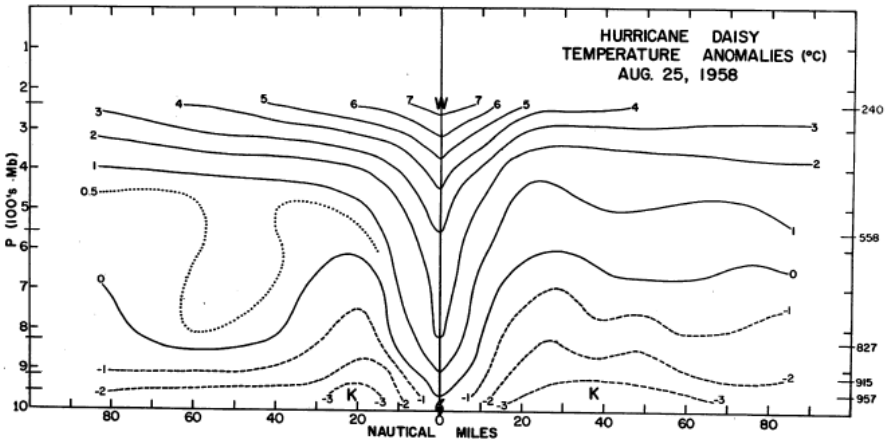


Figure 47. - Vertical cross section of temperature anomalies from the mean August atmosphere in a direction perpendicular to the direction of motion, hurricane Daisy, August 25, 1958. Pressure levels shown at the right edge indicate levels at which data was available.

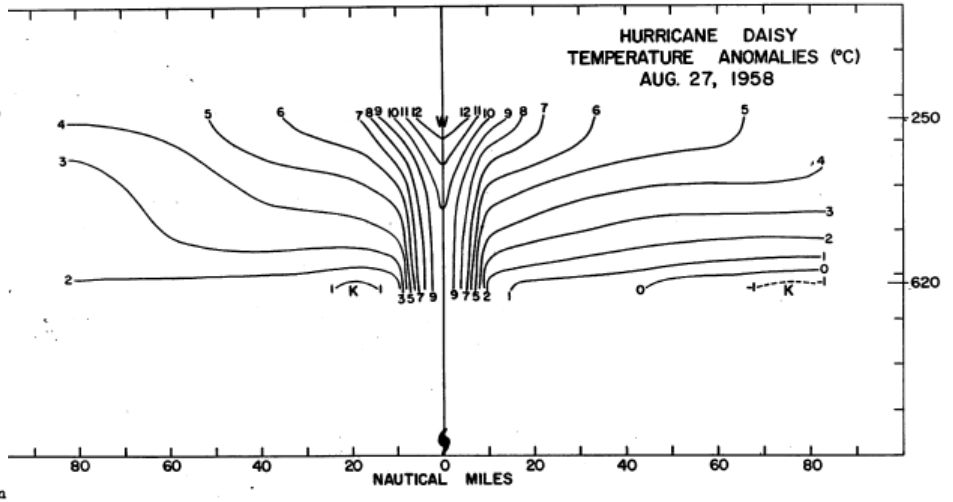


Figure 50. - Vertical cross section of temperature anomalies, August 27, 1958.

Tropical Analysis (1962)

- Colón and E. Zipser, *Mean Layer Wind Charts in a Tropical Analysis*, MWR, 90, Nov 1962
  - Discusses biases in mean-layer winds in tropical analyses
  - First paper by Ed Zipser while a graduate student at NHRP
- Winds reported in center of layer less reliable than mean layer
  - Can significantly bias divergence, vorticity

- Mean layer winds convenient in regions of relative consistency such as the Trades

Hurricane HELENE (1958)

- Colón, *On the Hurricane HELENE (1958)*, NHRP Report 72, 1964
  - Aircraft reconnaissance 24-26 Sep 1958 inside core of HELENE
  - HELENE intensified within 48 h… 60 mb drop…was highly disorganized
  - HELENE analyses published also by Miller, Krishnamurti ,Gentry, others
  - Aircraft measured winds, temps, pressure, humidity 3000-30,000 ft
- Importance of inner core to hurricane dynamics
  - Max T(eye, p=700 mb) = 20^{o}C (+11^{o}C anomaly)

- Isotherms slope outward from center with altitude
  -- Invoked and noted by others to account for eye pressure reduction
  -- Not seen in all hurricanes studies by NHRP
- "Unmistakable evidence of the reduction in the radius of the eye"
  --