Modelación Aplicada del Océano

Curso Básico - CROCO

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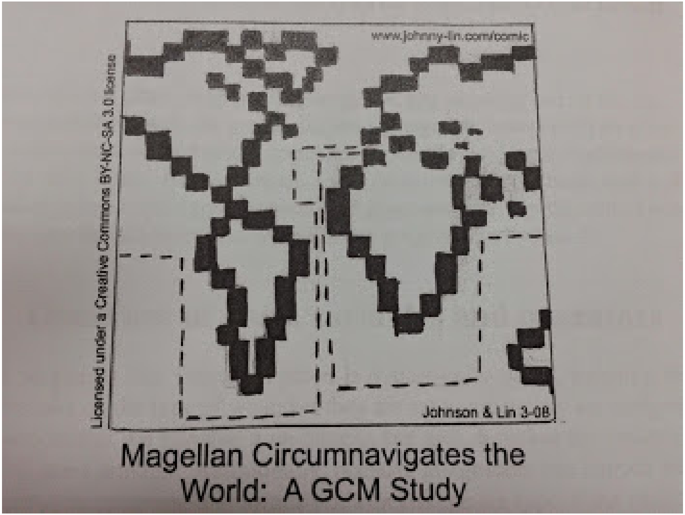
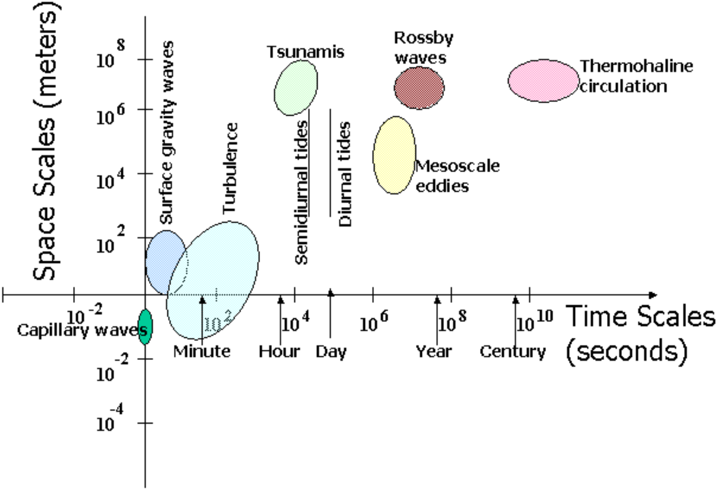
Anuncios

- **Historia de la Modelación del Océano**

Planificación de la Navegación



Escalas de los Procesos en el Océano



Svedrup

1947

- Desarrolla la teoría de la circulación oceánica.
- La circulación superficial del océano está relacionada con el rotor del esfuerzo del viento.

$$f\underbrace{\left(\frac{\partial M_x}{\partial x}+\frac{\partial M_y}{\partial y}\right)}_{=0}+M_x\underbrace{\frac{\partial f}{\partial x}}_{=0}+M_y\underbrace{\frac{\partial f}{\partial y}}_{\beta}=-\underbrace{\left(\frac{\partial^2 P}{\partial x\partial y}-\frac{\partial^2 P}{\partial x\partial y}\right)}_{=0}+\underbrace{\left(\frac{\partial \tau_y}{\partial x}-\frac{\partial \tau_x}{\partial y}\right)}_{curl\,\tau}$$

$$\boxed{\beta M_y = curl\,\tau,}\quad \beta=\frac{\partial f}{\partial y},\ M_y=\int \rho v dz,\ curl=\frac{\partial \tau_y}{\partial x}-\frac{\partial \tau_x}{\partial y}$$

Svedrup

1947

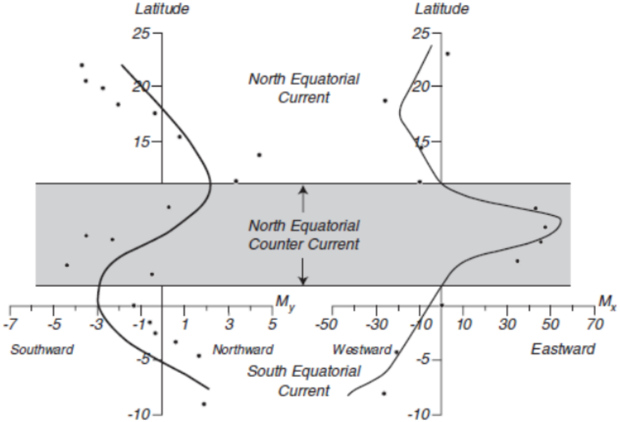


Figure 11.2 Mass transport in the eastern Pacific calculated from Sverdrup's theory using observed winds with 11.8 and 11.10 (solid lines) and pressure calculated from hydrographic data from ships with 11.4 (dots). Transport is in tons per second through a section one meter wide extending from the sea surface to a depth of one kilometer. Note the difference in scale between M_y and M_x. After Reid (1948).

Henry Stommel

1948

- Muestra que la circulación de los giros oceánicos es debido al cambio de Coriolis con la latitud (efecto Beta)
- Al balance de Svedrup, le agrega la fricción de fondo.

$$0 = -\frac{1}{\rho}\frac{\partial p}{\partial x} + fv + \frac{1}{\rho}\frac{\partial \tau_x}{\partial z} - Ju$$

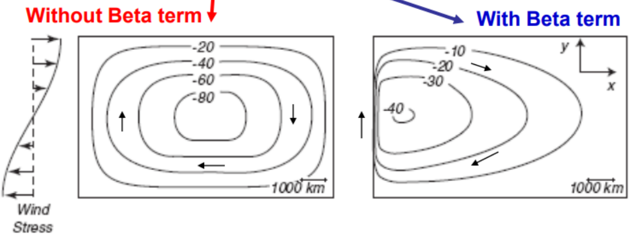
$$0 = -\frac{1}{\rho}\frac{\partial p}{\partial y} - fu + \frac{1}{\rho}\frac{\partial \tau_y}{\partial z} - Jv$$

Stommel

1948

$$0 = \underbrace{\overbrace{\frac{1}{\rho}\frac{\partial}{\partial z}\left(\frac{\partial \tau_x}{\partial y} - \frac{\partial \tau_y}{\partial x}\right)}^{wind-stress\ curl} - \overbrace{J\left(\frac{\partial u}{\partial y} - \frac{\partial v}{\partial x}\right)}^{friction}} + \overbrace{v\frac{\partial f}{\partial y}}^{Coriolis\ change\ with\ latitude\ (\beta v)}$$

Beta Term



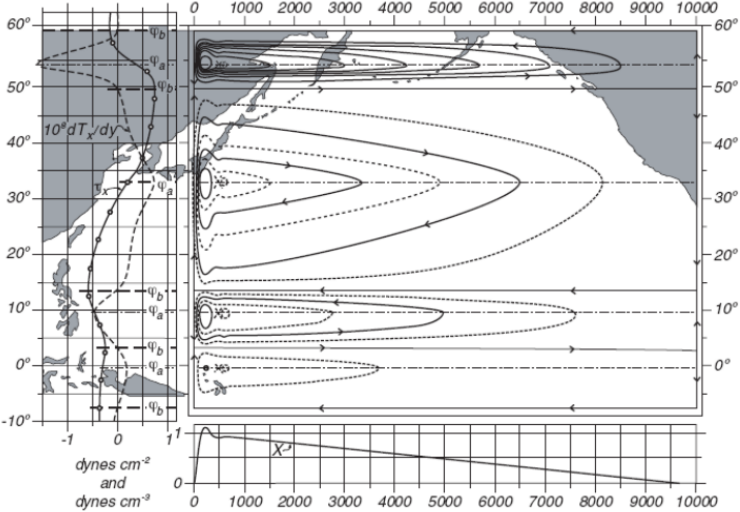
Walter Munk

1950

- Agregó una capa superficial (1000m) sobre un océano profundo sin movimiento.
- Agregó fricción lateral para considerar cuencas oceánicas mas realistas.

Munk

1950



60°
50°
40°
30°
20°
10°
0°
-10°
$10^8 dT_x/dy$
τ_x
φ_a
φ_b
-1
0
1
dynes cm^{-2}
and
dynes cm^{-3}
0
1000
2000
3000
4000
5000
6000
7000
8000
9000
10000
X
1
0

Teoría de la Circulación Oceánica

Svedrup/Stommel/Munk

- Corrientes de Borde Oriental
- Intensificación de las Corrientes de Borde Occidental.
- Efecto de los continentes (fricción lateral)

- Kirk Bryan, en el *Geophysical Fluid Dynamics Laboratory, NOAA* aplicó técnicas de la predicción numérica de la atmósfera para solucionar la ecuación de vorticidad barotrópica en un dominio rectangular.

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  Bryan, K., 1963. "A numerical investigation of
  a nonlinear model of a wind-driven ocean".
  Journal of the Atmospheric Sciences, 20(6):
  594-606.
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- Independientemente Holland en Scripps Institution of Oceanography (SIO), hizo algo similar, en 1967.
- En 1967 publica con Michael Cox el primer modelo 3D de la circulación océanica con forzamiento por vientos y termodinámico. (fondo plano!)

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  Bryan, K; Cox, M. D. (1967), "A
  numerical investigation of the oceanic
  general circulation", Tellus, 19 (1):
  54-80,
  ```

- Nuevamente Bryan, con S. Manabe, crean un modelo acoplado Atmósfera–Oceáno, indicando la importancia de los flujos de calor en el clima. (1969)

  `Manabe, S. and Bryan, K., 1969. "Climate calculations with a combined ocean-atmosphere model". Journal of the Atmospheric Sciences, 26(4): 786-789.`

- En 1971, con A. Gill, se estudia el efecto de la topografía de fondo en la circulación global

  `Bryan, K; Gill, A. E. (1971), "Effects of geometry on the circulation of a three-dimensional southern-hemisphere ocean model", Deep-Sea Research, 18: 685-721,`

Bryan 1963

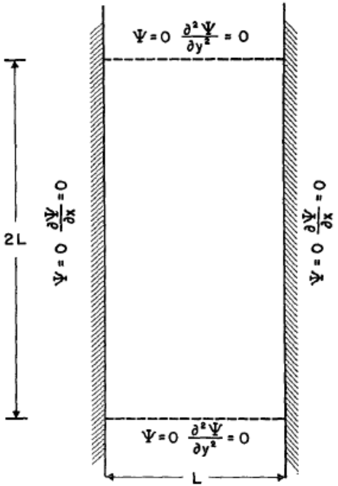


FIG. 1. The horizontal configuration of the model ocean. The boundary conditions conform to those of Munk (1950), with free slip at the upper (poleward) and lower (equatorward) boundaries, and no slip at the lateral (eastern and western) boundaries. The non-dimensional variable y' varies from 0 to 2 between the lower and upper boundaries.

Bryan Cox 1967

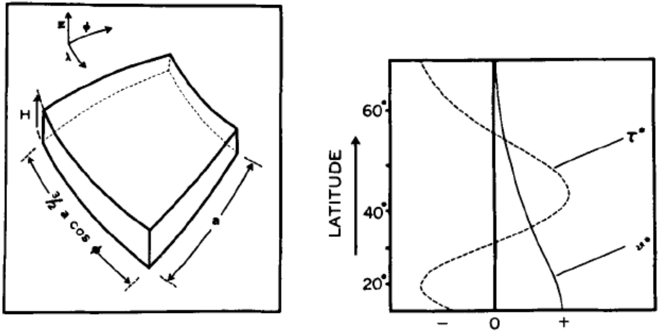


Fig. 2*a* Fig. 2*b*

FIG. 2. (*a*) Sketch of the basin, (*b*) The temperature specified at the surface, ϑ^*, and the x-component of the surface wind stress.

Manabe Bryan

1969

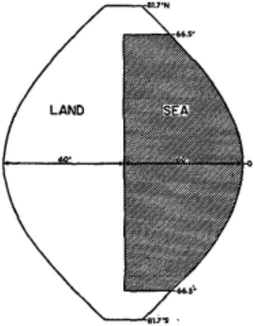


FIG. 1. Ocean-continent configuration of the model.

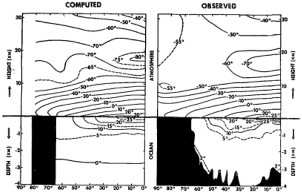
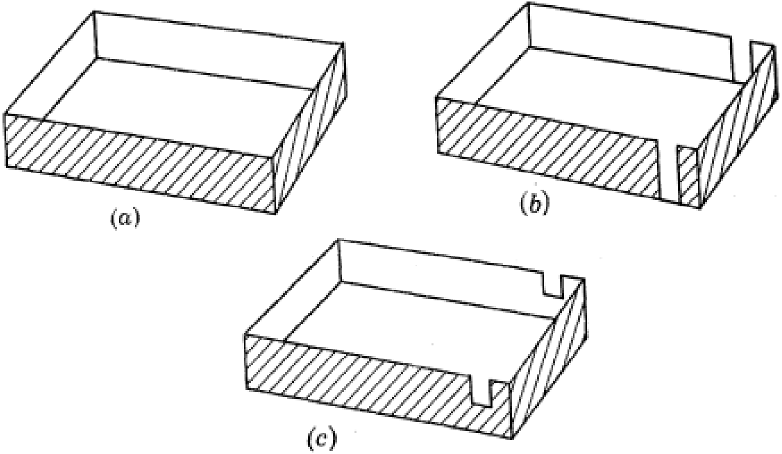


FIG. 2. Zonal mean temperature of the joint ocean-atmosphere system, left-hand side. This distribution, which is the average of two hemispheres, represents the time mean over two-sevenths of the period of the final stage of the time integration. The right-hand side shows the observed distribution in the Northern Hemisphere. The atmospheric part represents the zonally averaged, annual mean temperature. The oceanic part is based on a cross section for the western North Atlantic from Sverdrup *et al.* (1942).

Gill Bryan 1971



- El primer modelo usable para simulaciones globales fue presentado por Bryan en 1969.

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Bryan, K., 1969. "A numerical method for
the study of the circulation of the world
ocean". Journal of Computational Physics,
4(3): 347-376.
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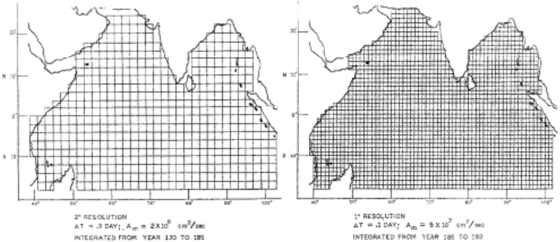

FIG. 4. Numerical grid used for calculation of the seasonal changes in circulation of the Indian Ocean. (Left) 2° resolution and (right) 1° resolution.

- Sin embargo, limitaciones computacionales llevaron a implementar primero las configuraciones regionales (Gill and Bryan, 1971; Holland, 197; Holland and Hirschman, 1971; Cox, 1970).
- Desarrollos alternativos fueron implementados también por Haney (1971), y Cox (1975).
- A partir de los 80s se empiezana implementar modelos de superficie libre, con coordenadas que siguen el terreno, entre ellos el precursor del modelo conocido como *Princeton Ocean Model* (POM, Blumberg and Mellor, 1983, 1987)
- Otra línea de investigación fueron los modelos espectrales, notablemente el *Semi-Spectral Primitive Equation Model* (SPEM, Haidvogel et al., 1991)
- También destaca el llamado *s-coordinate Rutgers model* (SCRUM, Song and Haidvogel, 1994), el cual derivó en el *Regional Ocean Modeling System* (ROMS, Haidvogel et al., 2000).

- FVCOM, FUNDY_5, MOM, POP, POM, ECOMSi, GOLD, ADCIRC, MIKE3, FRAM, NCOM, NLOM, DIECAST, CANDIE, MARS3D, SYMPHONIE, OPA, NEMO, HYCOM, TELEMAC, ...
- HYCOM & POP2 $-- >$ MOM6
- SPEM, SCRUM $-- >$ ROMS
- ROMS: ROMS_Rutgers, ROMS_LA, ROMS_AGRIF
- ROMS_AGRIF + MARS3D (Sedimentos) + Symphonie (NH) + NEMO (no LAND) + HYCOM (cood. vertical) $-- >$ **CROCO**
- MIKE (DHI, $$) / Delft (Deltares, OSS)

Lista de modelos de océano

Acronym	Full name
ADCIRC	**AD**vanced **CIRC**ulation model
COHERENS	**CO**upled **H**ydrodynamical **E**cological model for **RE**gio**N**al **S**helf seas
FVCOM	**F**inite **V**olume **C**ommunity **O**cean **M**odel
FESOM	AWI **F**inite-**E**lement/volum**E** **S**ea ice-**O**cean **M**odel
HOPE	The **H**amburg **O**cean **P**rimitive **E**quation General Circulation Model [1]
HYCOM	**HY**brid **C**oordinate **O**cean **M**odel
LSG	The Hamburg **L**arge **S**cale **G**eostrophic Ocean General Circulation Model [2]
MICOM	**M**iami **I**sopycnic **C**oordinate **O**cean **M**odel
MITgcm	M.I.T. **G**eneral **C**irculation **M**odel
MOHID	**MO**delo **HID**rodinâmico
MOM	GFDL **M**odular **O**cean **M**odel
NEMO	**N**ucleus for **E**uropean **M**odelling of the **O**cean
OPYC	The **O**cean Iso**PYC**nal General Circulation Model [3][4]
POM	**P**rinceton **O**cean **M**odel
POP	The **P**arallel **O**cean **P**rogram
ROMS	The **R**egional **O**cean **M**odeling **S**ystem
SLIM-Ocean Model	**S**econd-generation **L**ouvain-la-Neuve **I**ce-**O**cean **M**odel

Figura: https://en.wikipedia.org/wiki/List_of_ocean_circulation_models
o también https://csdms.colorado.edu/wiki/Model_download_portal

Genealogía del modelo TIMCOM

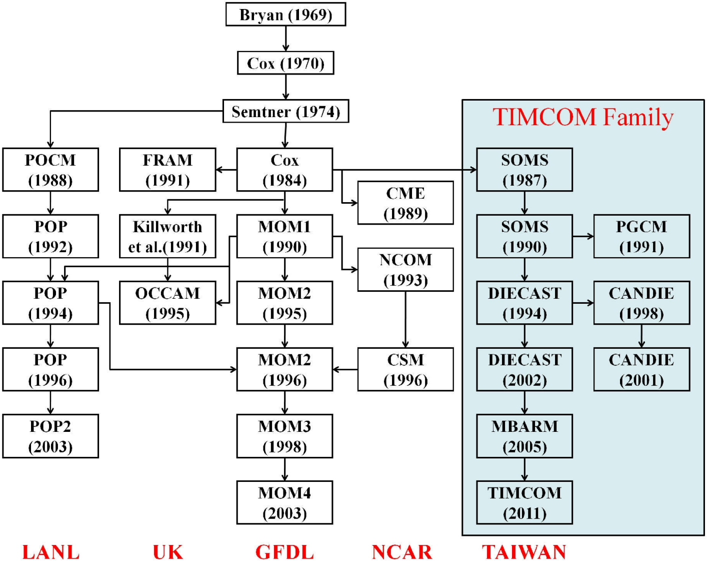

Figura: http://efdl.as.ntu.edu.tw/research/timcom/

Genealogía de Modelos Climáticos

KNUTTI ET AL.: CLIMATE MODEL GENEALOGY

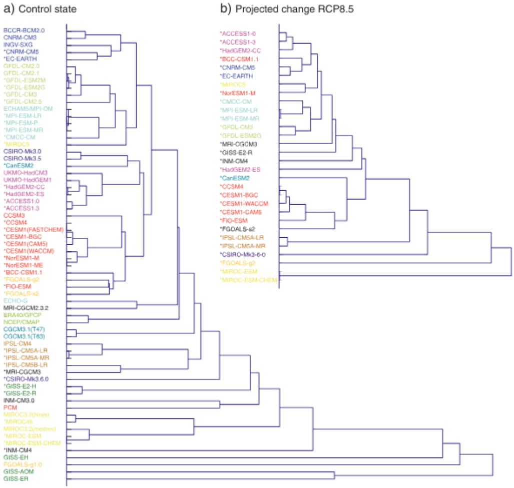

Figure 1. (a) The model "family tree" from CMIP3 and CMIP5 (marked with asterisks) control climate plus observations (ERA40/GPCP and NCEP/CMAP), shown as a dendrogram (a hierarchical clustering of the pairwise distance matrix for temperature and precipitation fields, see text). Some of the models with obvious similarities in code or produced by the same institution are marked with the same color. Models appearing in the same branch are close, and similarity is larger the more to the left the braches separate (for a detailed description of the method, see *Masson and Knutti* [2011]). (b) Same but based on the predicted change in temperature and precipitation fields for the end of the 21st century in the RCP8.5 scenario relative to the control.