Isopycnal Surface Circulation in Water Mass Crossroads

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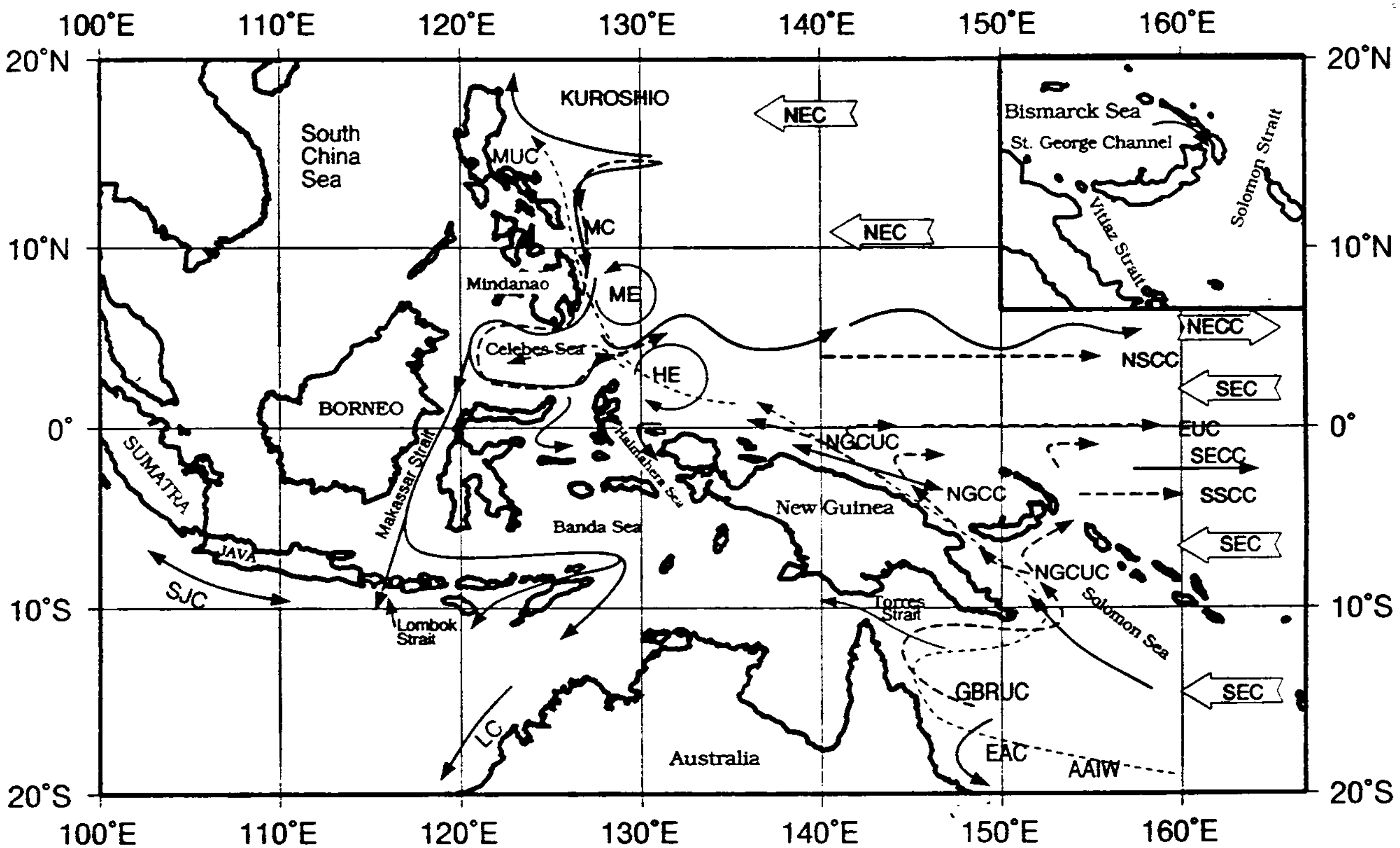
Water Mass Crossroads (Fines et al. 1994)

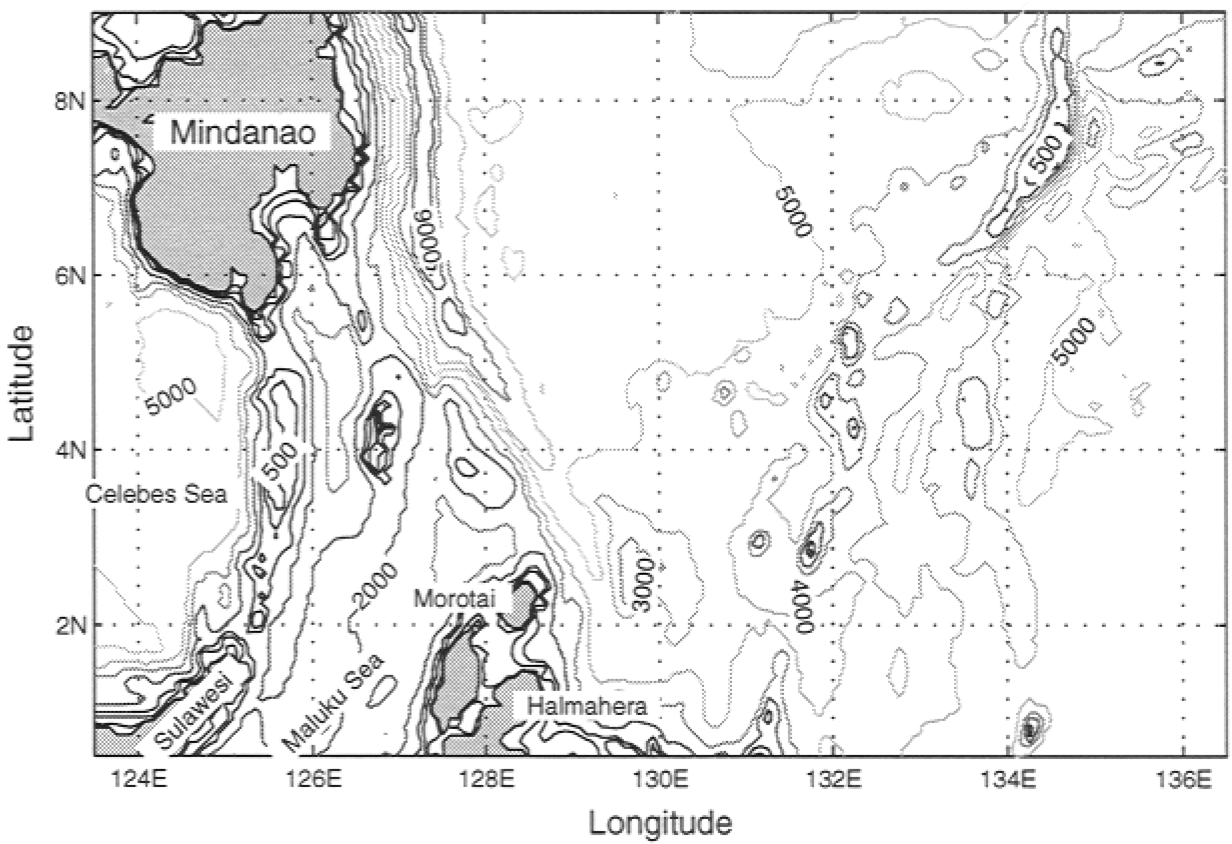


Literature

- Lukas (1988, JGR)
- Lukas et al. (1991, 1996)
- Godfrey (1996)
- Fine et al. (1994)
- Qiu and Lukas (1999)
- Qiu et al. (1998)
- Qu (1998. 1999)
- Wajsowicz (1993, 1999a, b)

Can we get seasonal variability of current structure from T, S data?

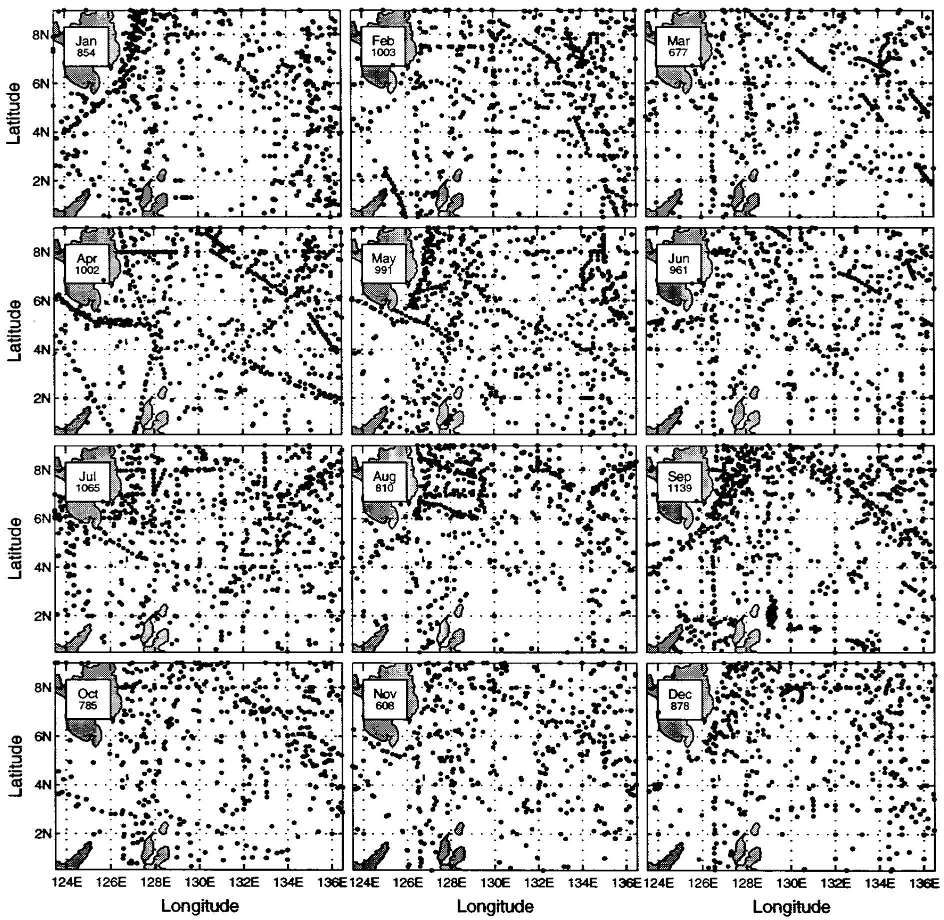
Geography and Topography



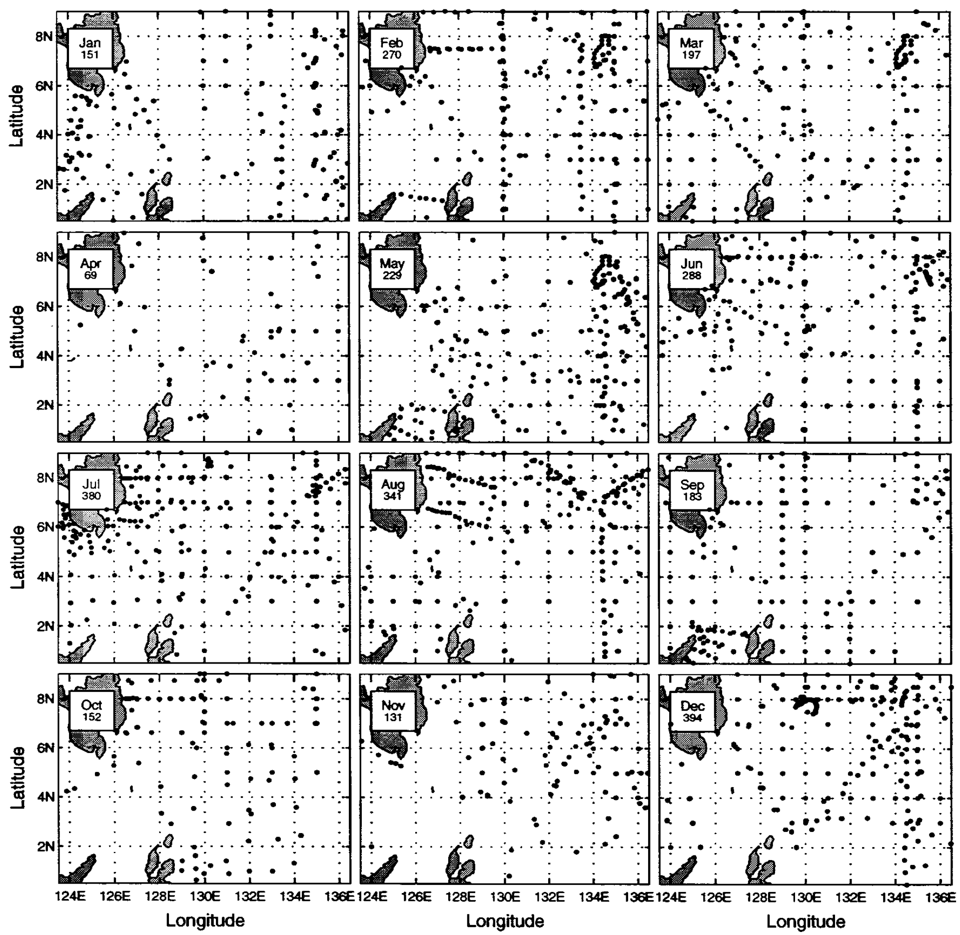
Navy's GDEM Climatology

- Monthly mean temperature and salinity
- 0.5^{o} Horizontal resolution
- 59 Vertical levels
- Built-up from The Navy's Master Oceanographic Observational Data Set (MOODS)

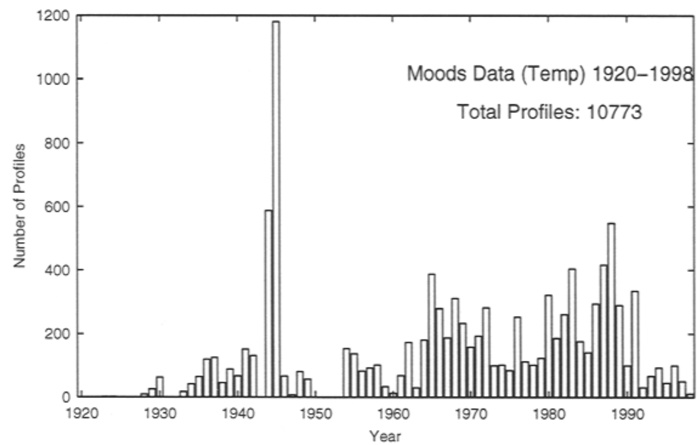
Navy's MODDS (Temperature)

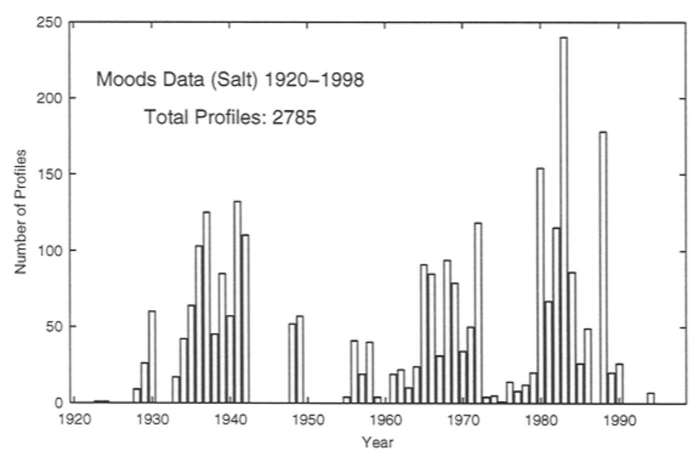


MOODS Data (Salinity)

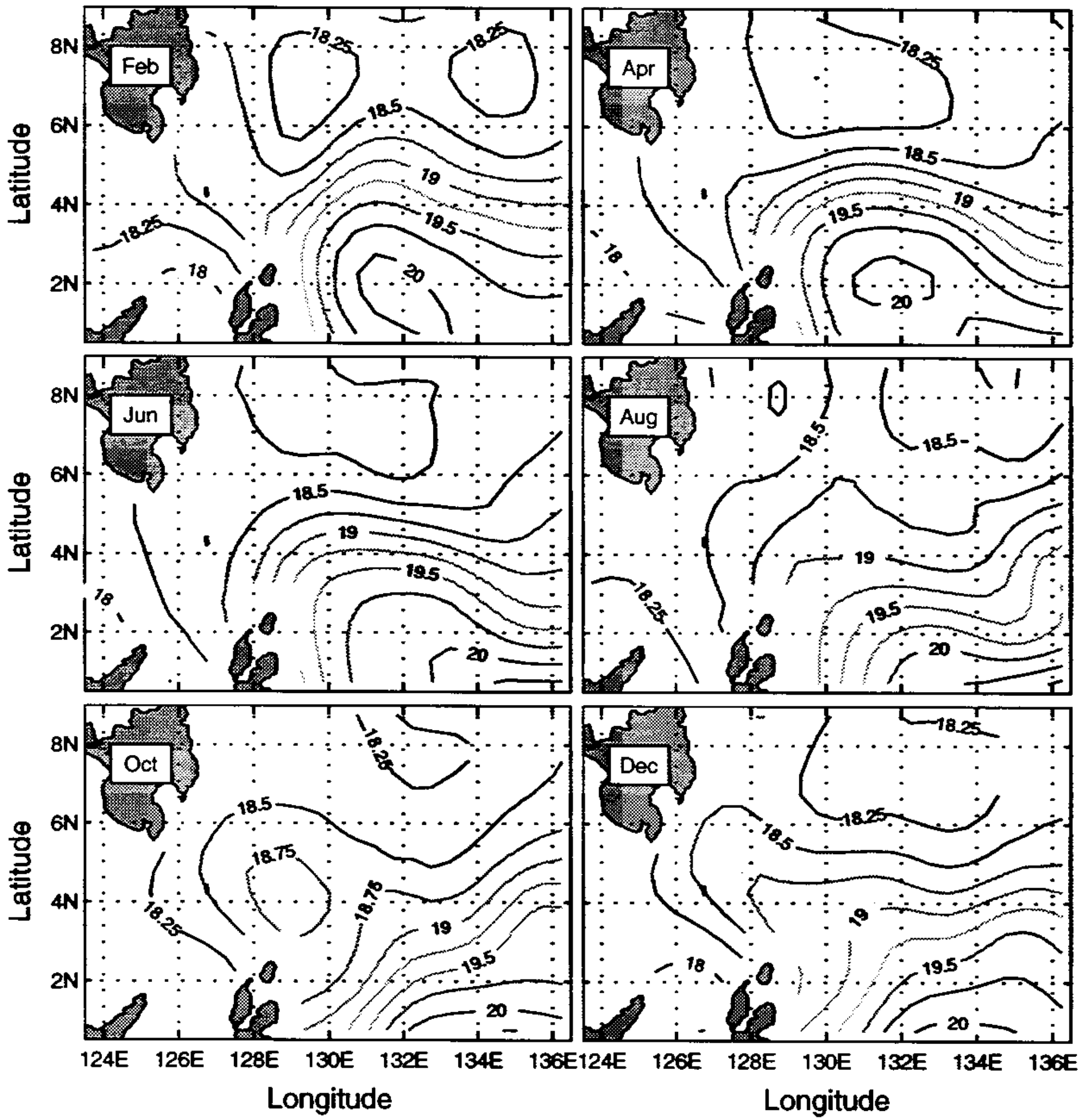


Temporal Distributions of MOODS Stations

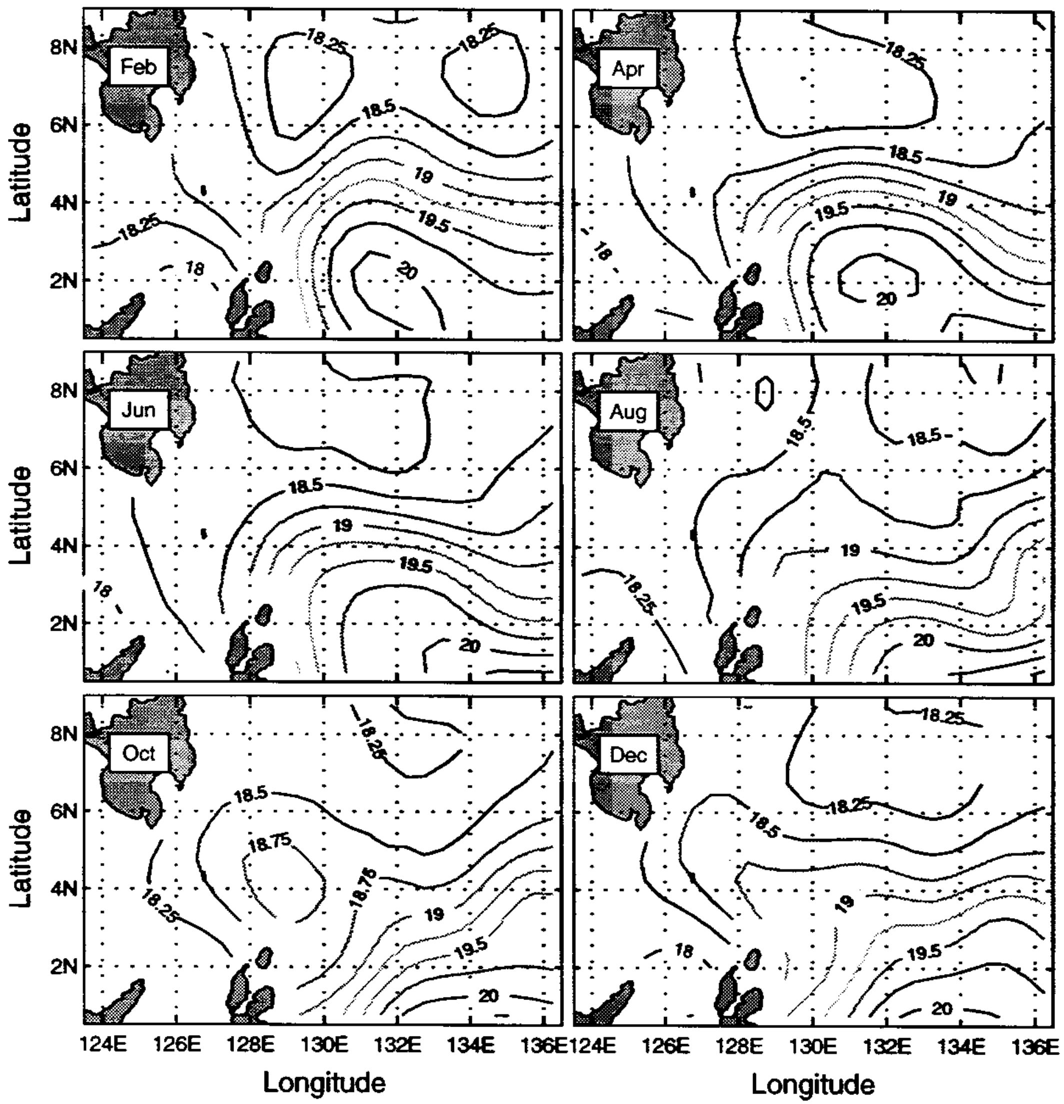




Temperature (GDEM)



Salinity (GDEM)

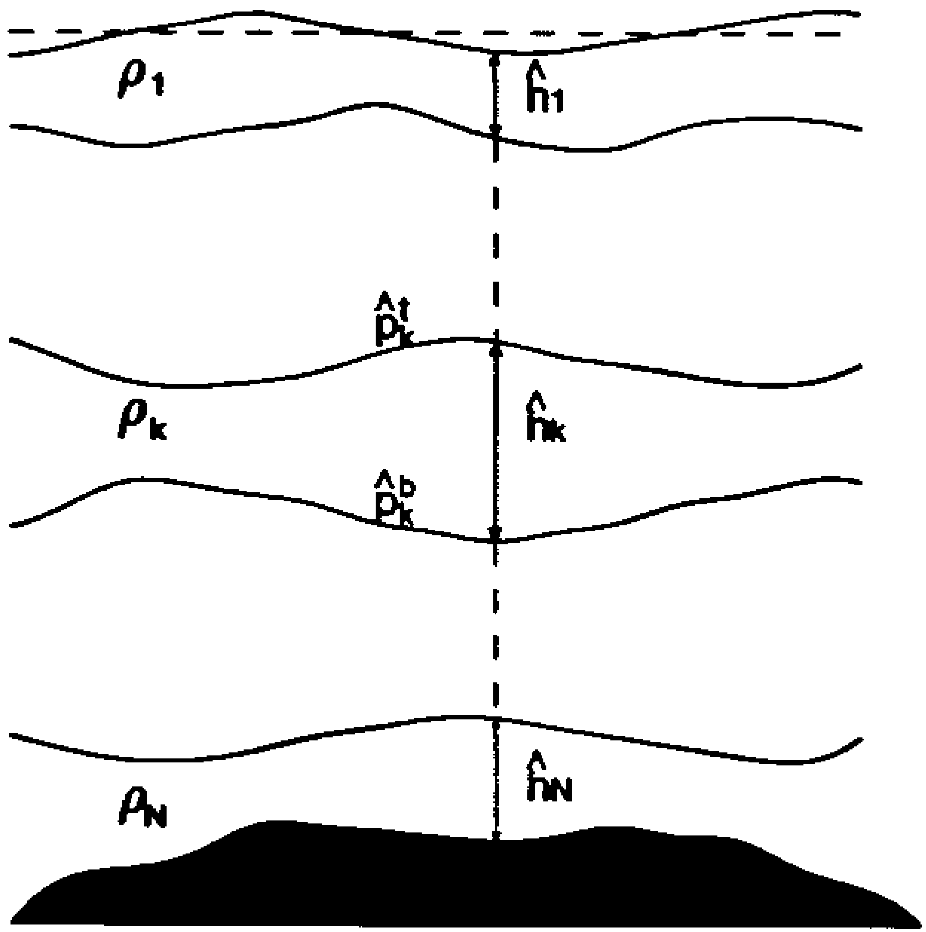


Absolute Velocity

$$\boldsymbol{V} = \boldsymbol{V}_0 + \frac{1}{f}\boldsymbol{k} \times \int_{z_0}^{z} \nabla\left[\frac{\partial}{\partial z}\left(\frac{p}{\rho}\right)\right] dz',$$

$$\boldsymbol{V}' = \frac{1}{f}\boldsymbol{k} \times \int_{z_0}^{z} \nabla\left[\frac{\partial}{\partial z}\left(\frac{p}{\rho}\right)\right] dz' = -\frac{g}{f\rho_0}\boldsymbol{k} \times \int_{z_0}^{z} \nabla \rho\, dz'.$$

Isopycnal Surface



Isopycnal Surface

- Potential Density Surfaces (σ_θ) with the Depth $z^{(\sigma)}$

$$z^{(\sigma)} = R(x, y, \sigma).$$

- Vertical Distance Between two σ-Levels

$$h^{(\sigma)} = \frac{\partial z^{(\sigma)}}{\partial \sigma} \Delta\sigma.$$

Pseudo-Potential Vorticity Conservation on Isopycnal Surface (McDogall 1988)

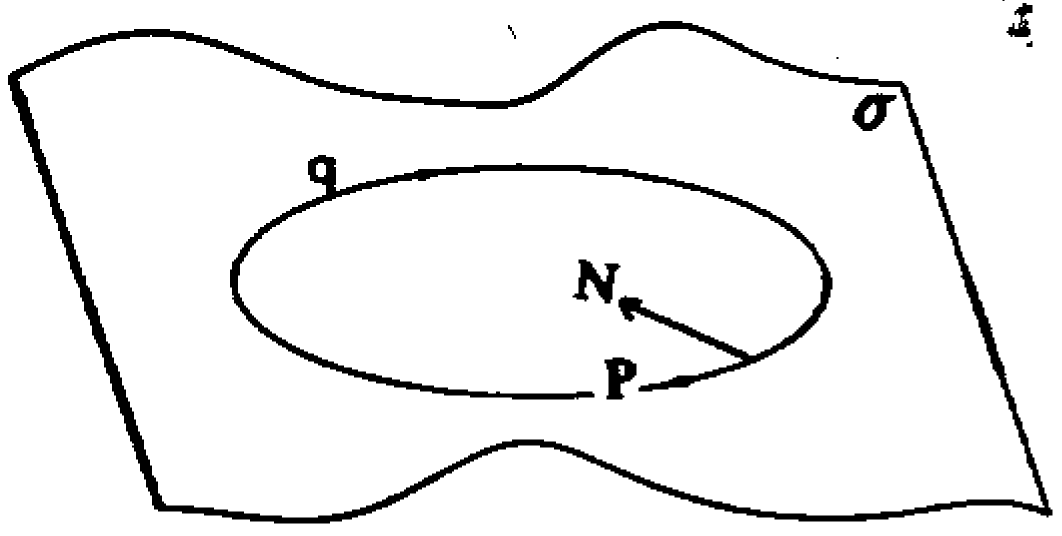
- Pseudo Potential Vorticity

$$q^{(\sigma)} = \ln\left[Q^{(\sigma)}\right], \quad Q^{(\sigma)} = \frac{f}{h^{(\sigma)}}$$

- Conservation of Seudo Potential Vorticity on Isopycnal Surafce

$$V^{(\sigma)} \bullet \nabla_{\sigma}\left[q^{(\sigma)}\right] = \frac{\partial w^{(\sigma)}}{\partial z},$$

Two Unit Vectors on Isopycnal Surface



Two Unit Vectors on Isopycnal Surface

- P – Vector

$$\boldsymbol{P} = \frac{1}{\left|\nabla q^{(\sigma)}\right|}\left(\frac{\partial q^{(\sigma)}}{\partial y}\boldsymbol{i} - \frac{\partial q^{(\sigma)}}{\partial x}\boldsymbol{j}\right),$$

- N - Vector

$$\boldsymbol{N} = \frac{\nabla_{\sigma}\left(q^{(\sigma)}\right)}{\left|\nabla_{\sigma}\left(q^{(\sigma)}\right)\right|}$$

P-Vector Components

$$P_x = \left(\frac{\beta}{f} - \frac{\partial \ln h^{(\sigma)}}{\partial y}\right) \Bigg/ \left[\left(\frac{\beta}{f} - \frac{\partial \ln h^{(\sigma)}}{\partial y}\right)^2 + \left(\frac{\partial \ln h^{(\sigma)}}{\partial x}\right)^2\right]^{1/2}.$$

$$P_y = \frac{\partial \ln h^{(\sigma)}}{\partial x} \Bigg/ \left[\left(\frac{\beta}{f} - \frac{\partial \ln h^{(\sigma)}}{\partial y}\right)^2 + \left(\frac{\partial \ln h^{(\sigma)}}{\partial x}\right)^2\right]^{1/2}$$

Absolute Velocity on Isopycnal Surface

- With Diapycnal Velocity

$$V^{(\sigma)} = \gamma P + \frac{\partial w^{(\sigma)} / \partial z}{\left|\nabla_\sigma\left(q^{(\sigma)}\right)\right|} N$$

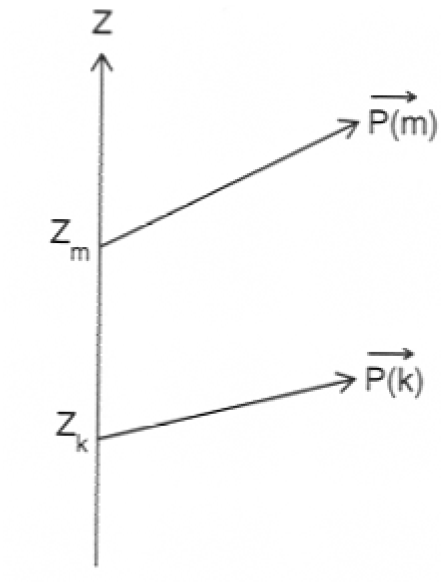
- Without Diapycnal Velocity

$$V^{(\sigma)} = \gamma P$$

P-Vector Inverse Method

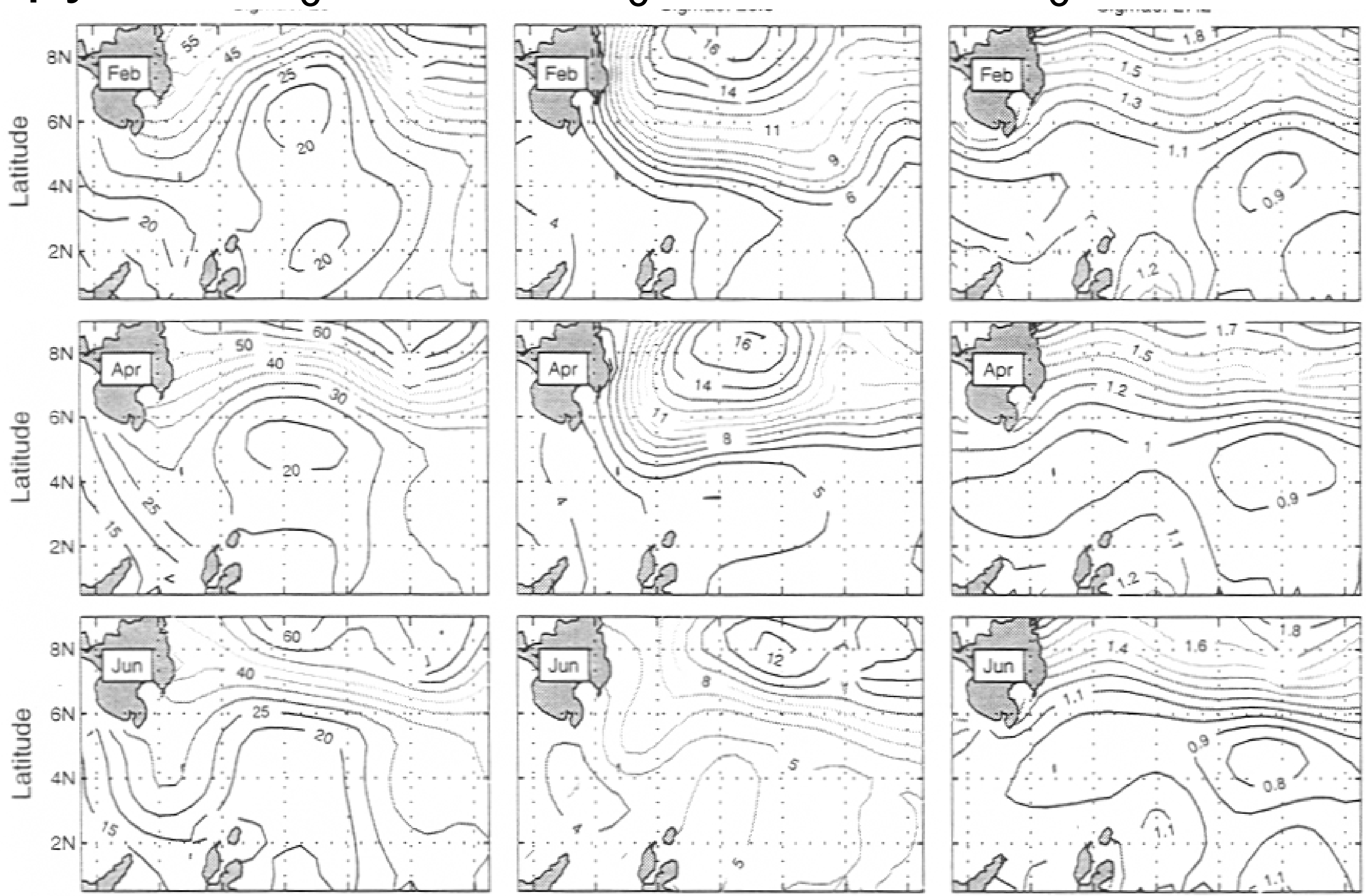
$$\gamma^{(k)} P_x^{(k)} - \gamma^{(m)} P_x^{(m)} = \Delta u_{km} =$$

$$\gamma^{(k)} P_y^{(k)} - \gamma^{(m)} P_y^{(m)} = \Delta v_{km} =$$



Potential Vorticity on Isopycnal Surfaces

- Isopycnal: $\sigma_\theta=25$ $\sigma_\theta=26.5$ $\sigma_\theta=27.2$



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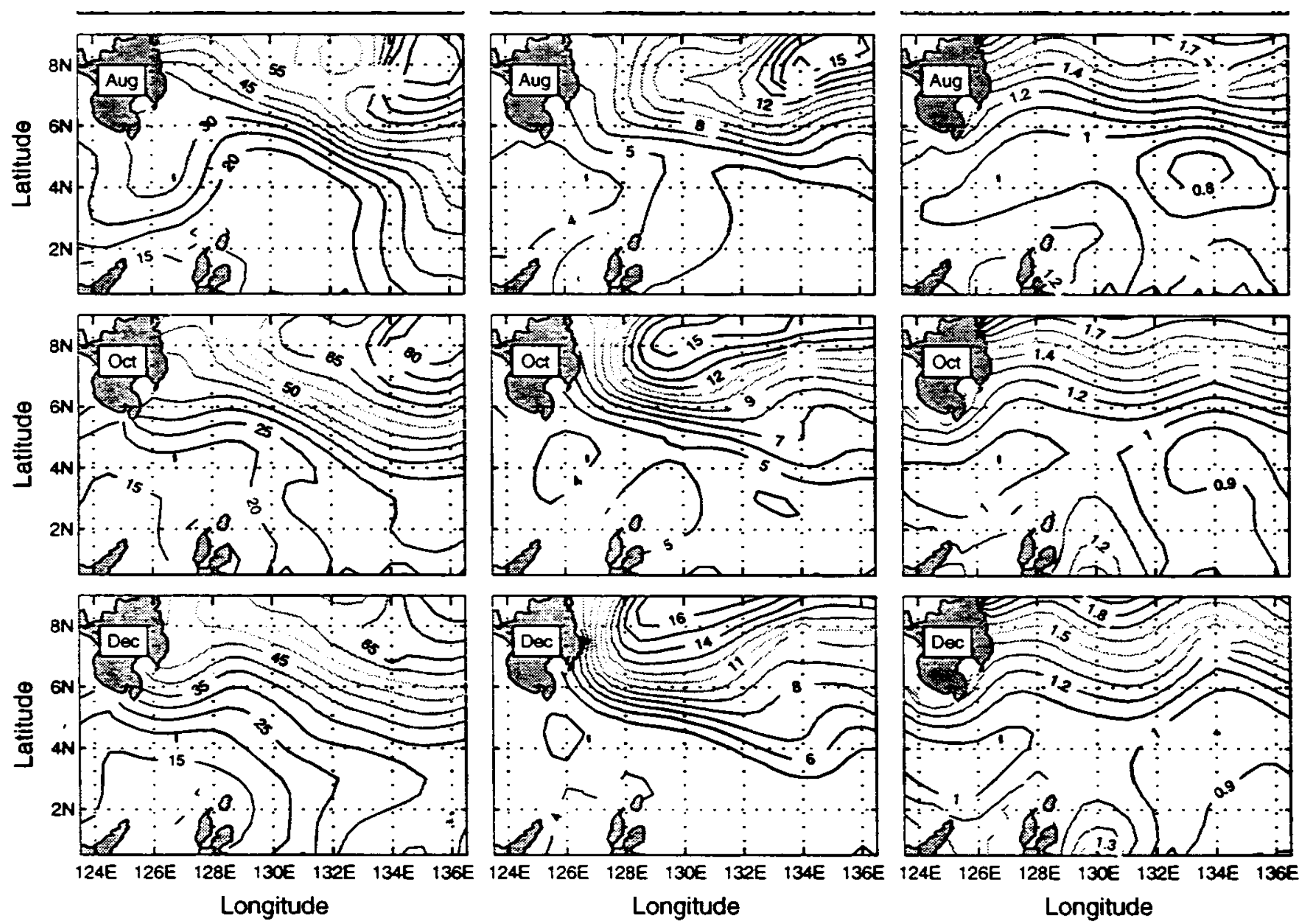

Circulation on Isopycnal Surface

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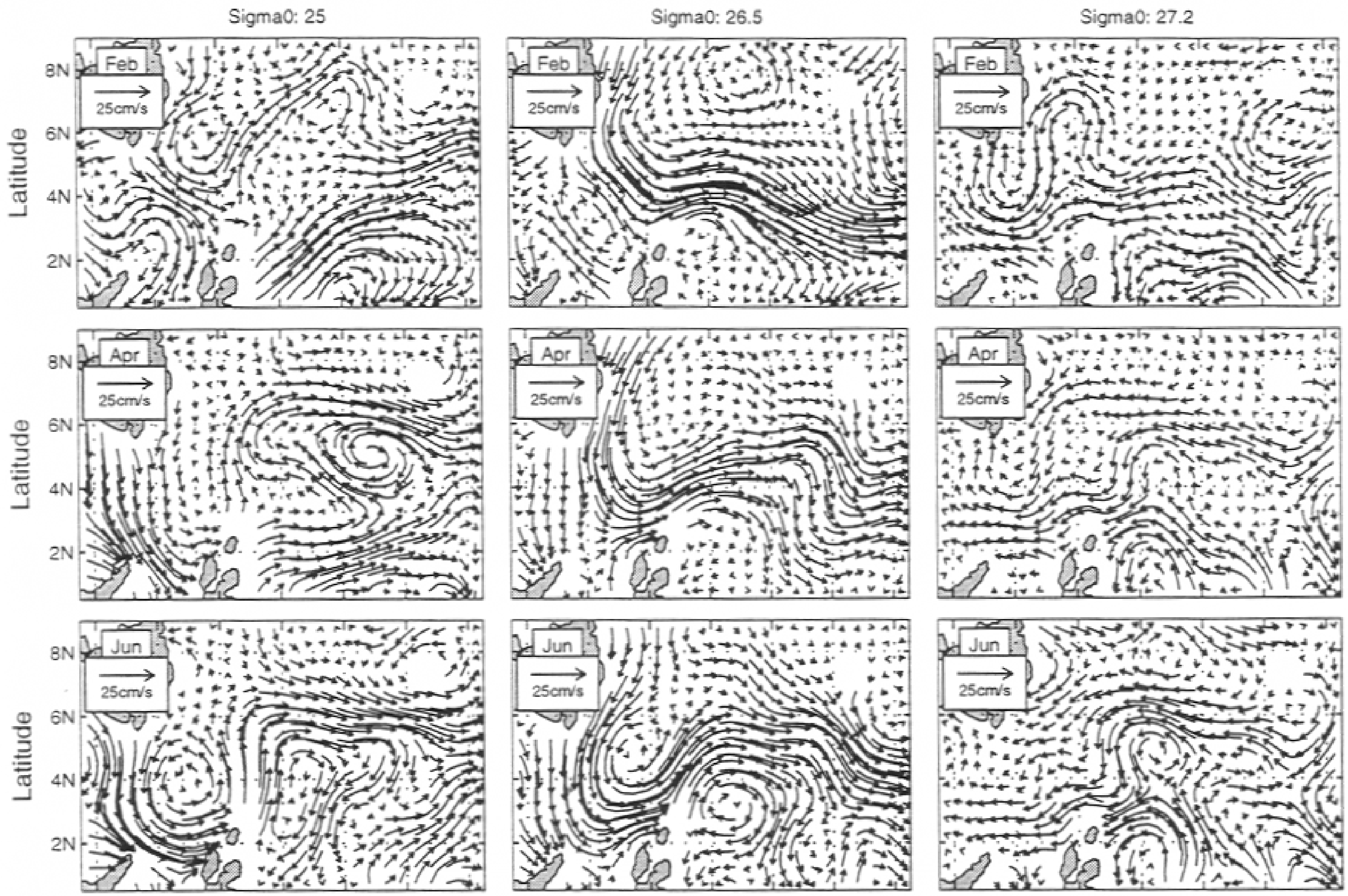

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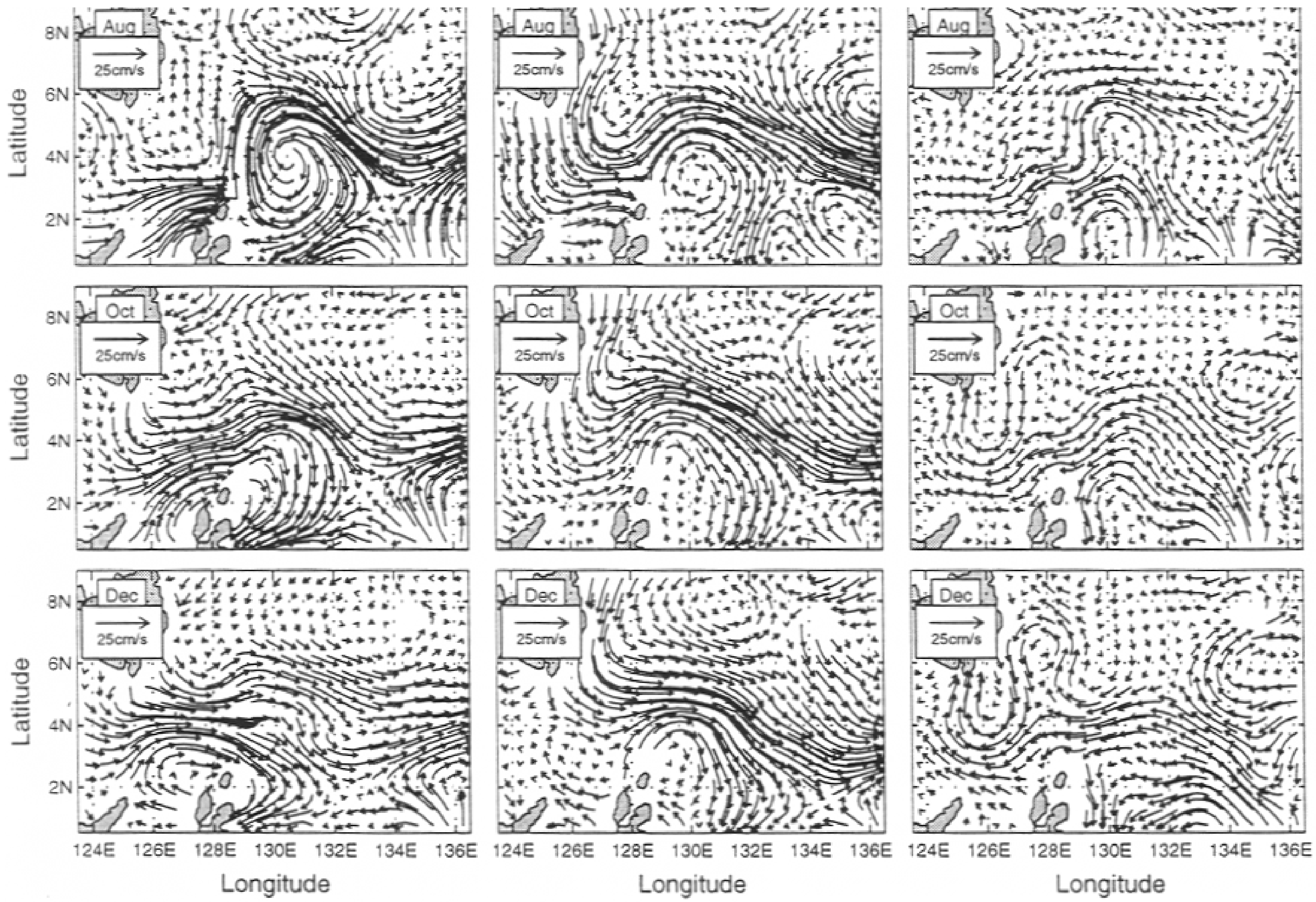
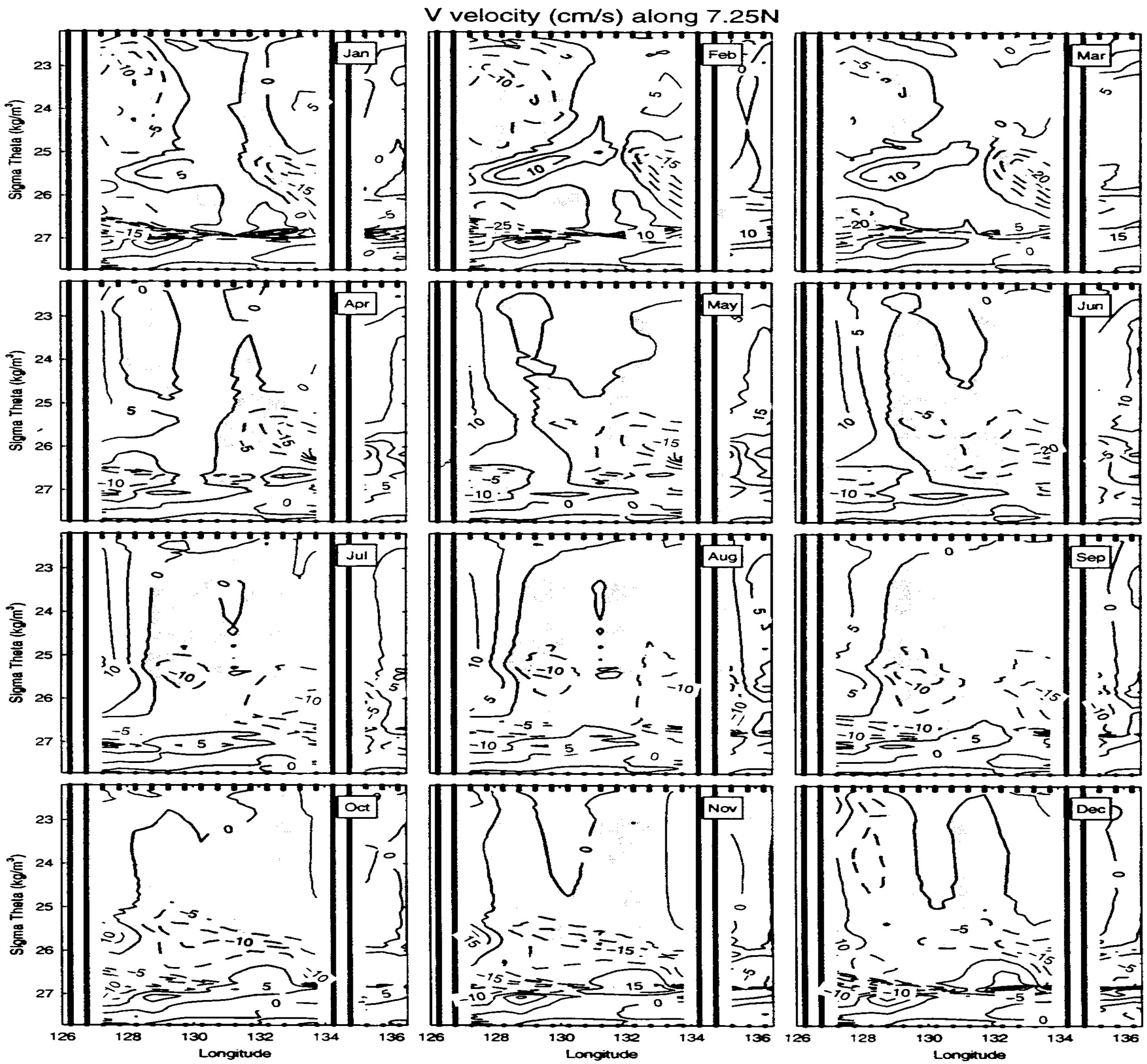
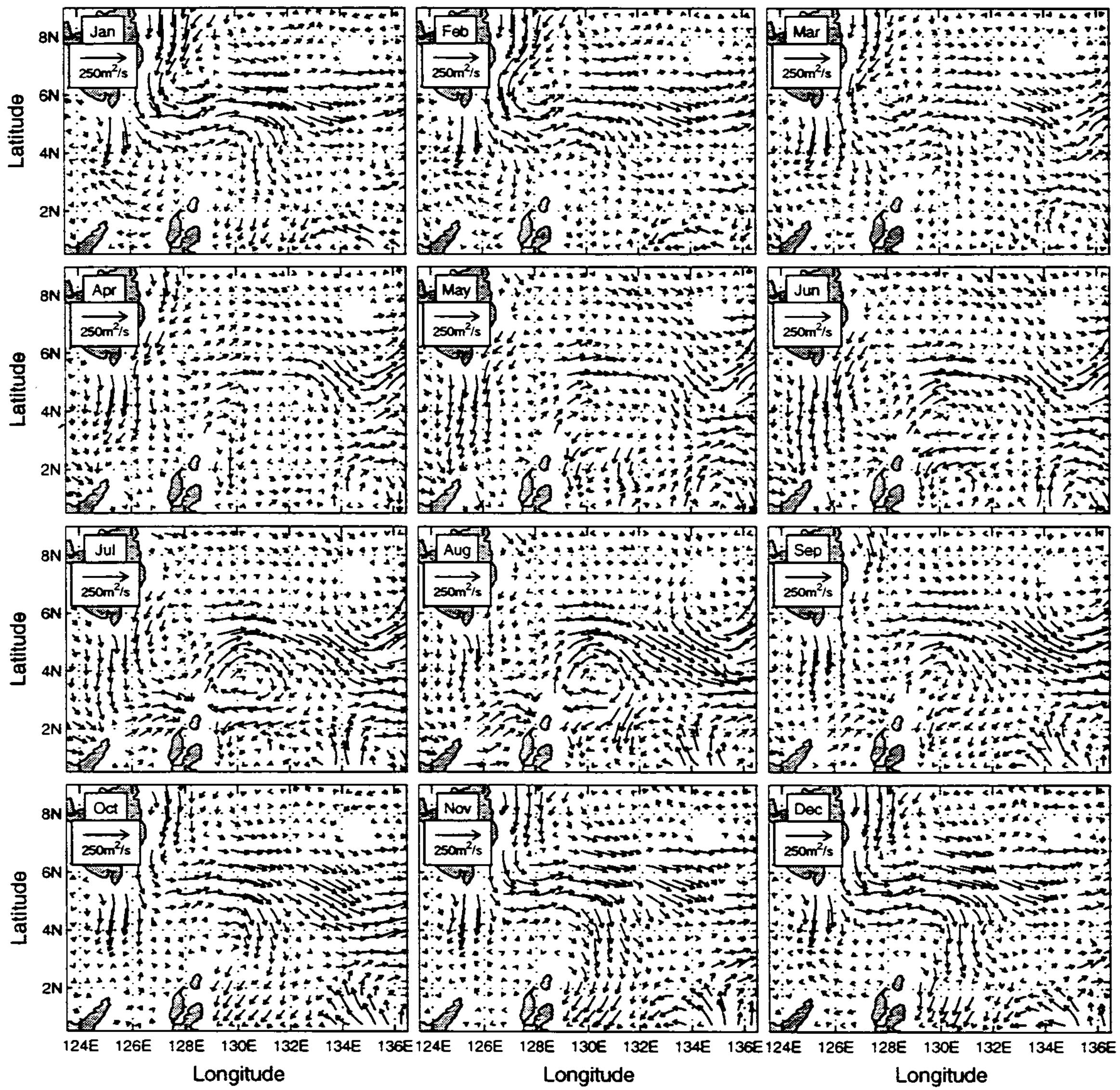


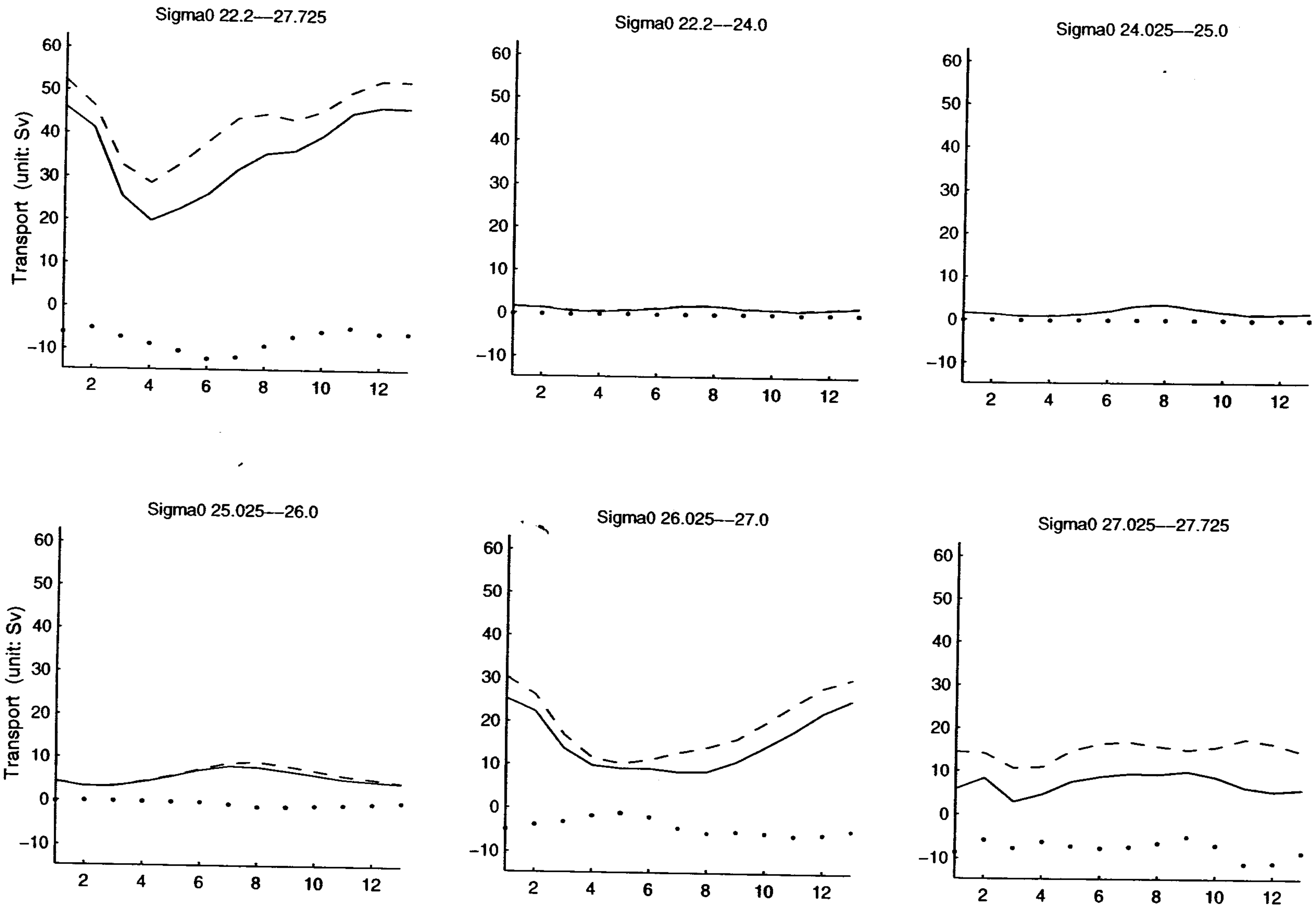
V-Velocity (cm/s) along 7.25° N



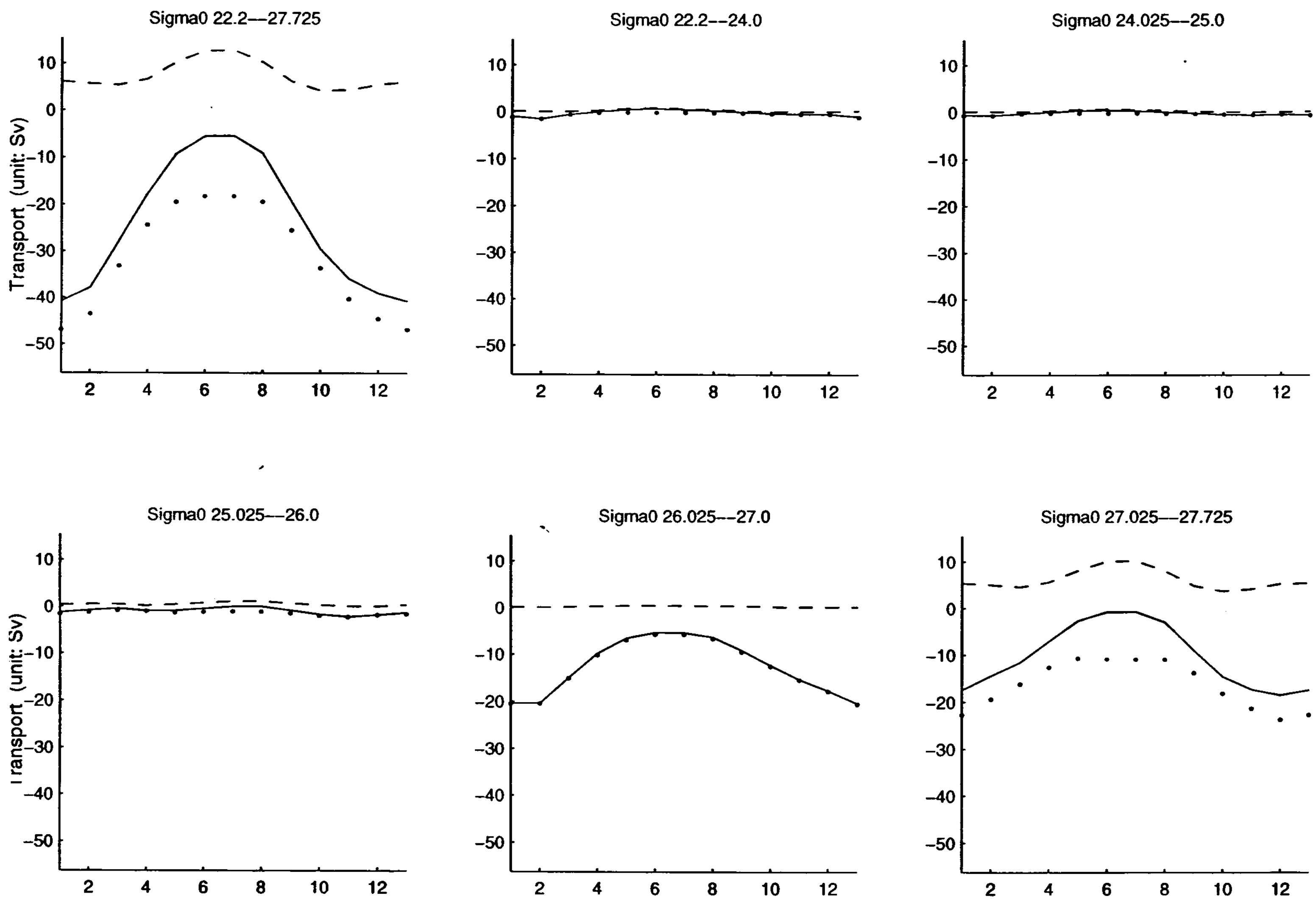
Vertically integrated velocity vectors (250 m^2 /s)



Volume Transport (Sv) of North Pacific Equatorial Counter Current (0.75 to 8.25° N) along 130.25° E



Volume Transport (Sv) of Midanao Current (126.75 to 130.75° E) along 8.25° N



Conclusions

- Seasonal Variability of Four Major Currents

  Mindanao Current, Mindanao Counter Current, New Guinea Coastal Undercurrent, and North Equatorial Counter Current

  Two Eddies

  Mindanao Eddy and Halmahera Eddy