GHRSST XVIII

SST Oceanography: A Few Examples

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5 June 2017· Qingdao

Outline

1. Background Introduction
2. SST in China Seas
3. SST Amphidrome
4. Niño Pipe
5. Seasonality Spiral
6. Eddy Tracking
7. Concluding Remarks

5 stories in S(S)T oceanography

Welcome to a Fans-Idols Gathering

- My professional career started with remote sensing of SST in 1987.
- I 'grew up' with radiometer, but got 'married' with altimeter. In the past 30 years, we produce over 100 'babies' (papers) with SST and SSH.
- Many of us, particularly myself, have become loyal fans of SST, of this group, of all of you, so it is a truly fans-idols gathering, that's why you are so welcome!
- Coincidently, 2017 is the 30-year anniversary of the first graduate with a MS degree on SST in China, I consider you are here to celebrate it with us, that's why you are more than welcome!

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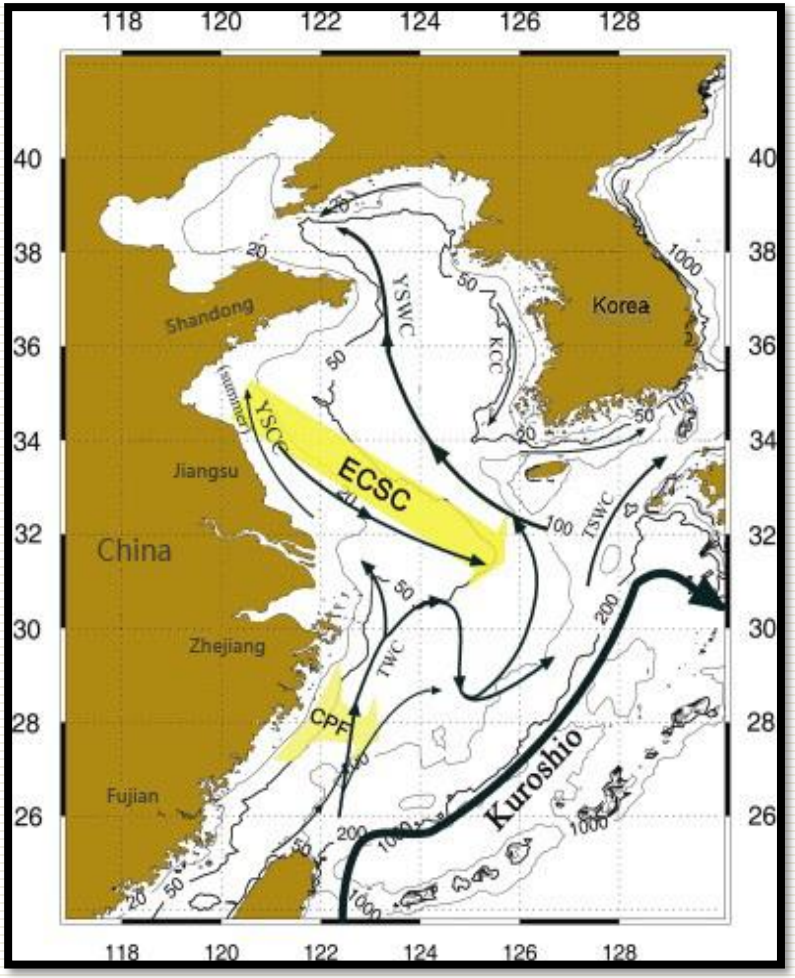
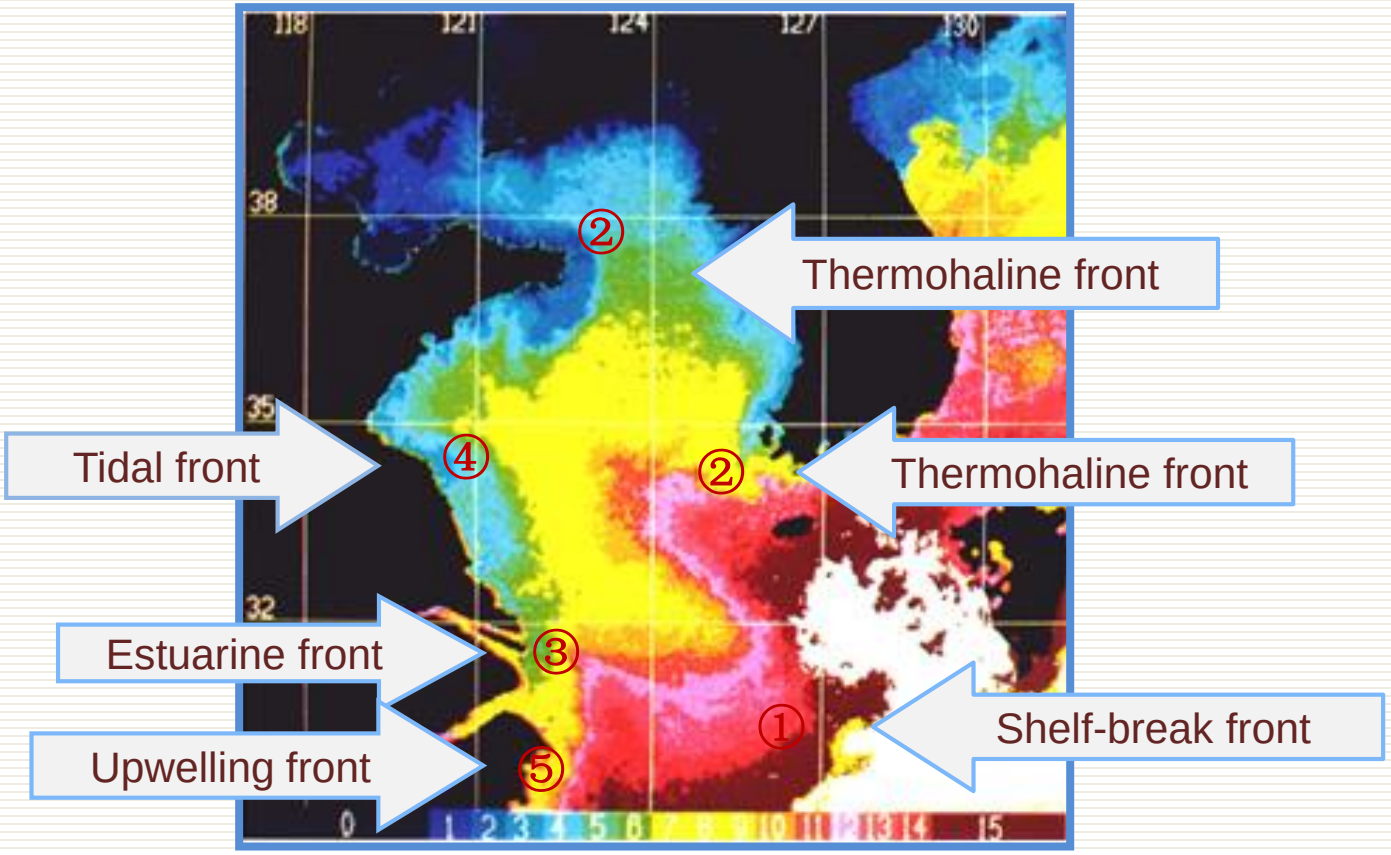
Dynamic Features in China Seas



- Front
- Eddy
- Upwelling

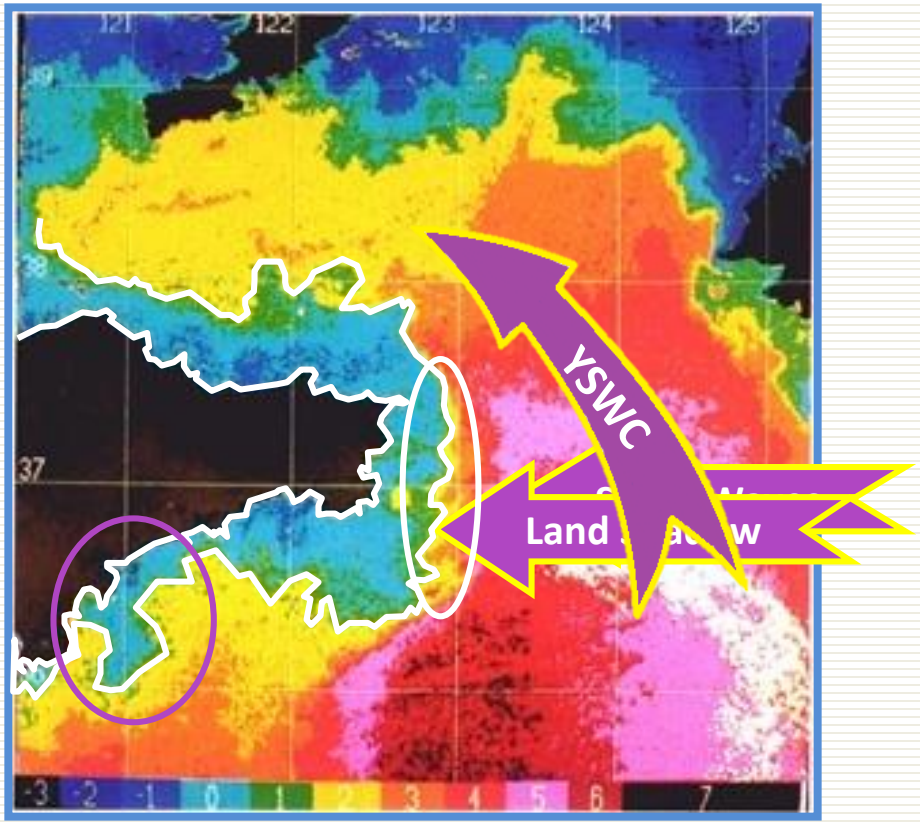
Schematic showing the bathymetry and circulation system of the eastern China Seas (winter pattern).

Fronts



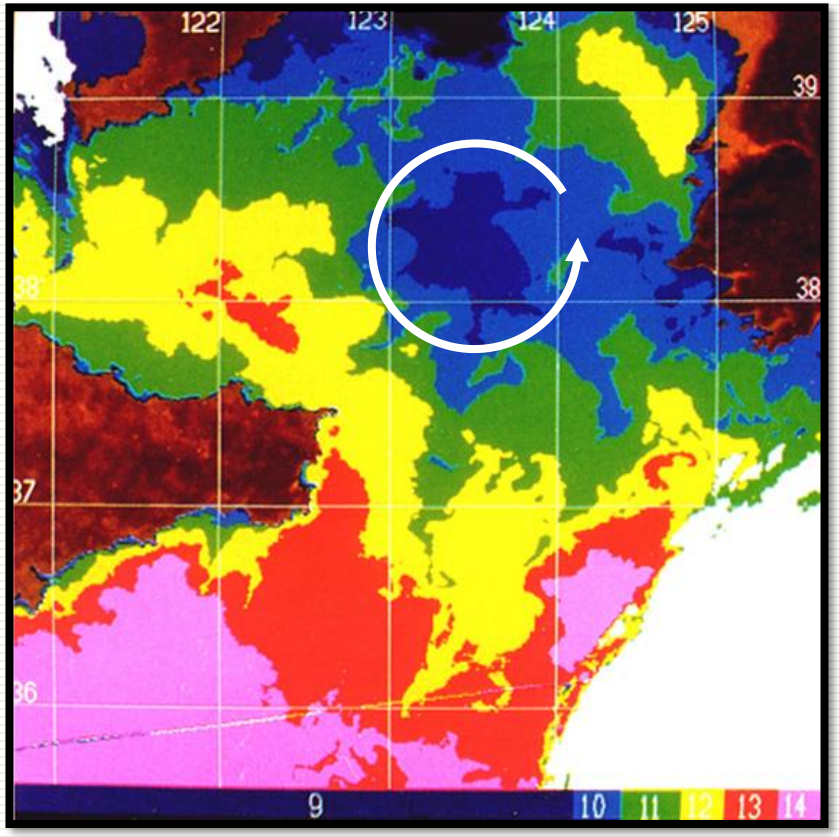
SST image of February 18, 1984 derived from AVHRR data showing different types of frontal zones in the eastern China Seas.

Fronts and Shear Waves



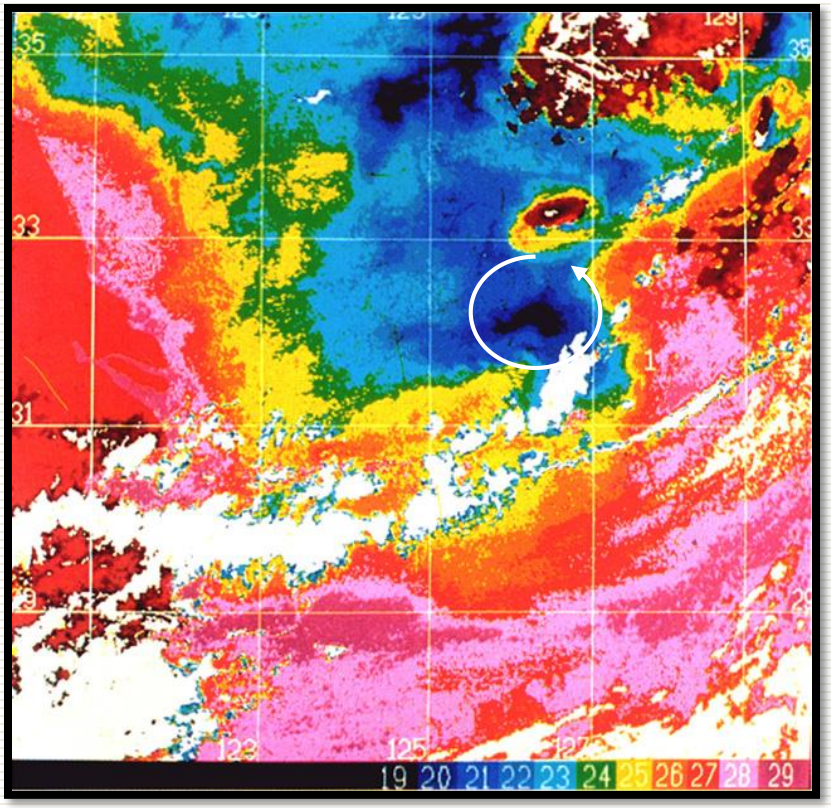
SST image of February 18, 1984 derived from AVHRR data showing a sharp frontal zone with a group of shear waves created around the east tip of Shandong peninsula. The land-sea interaction is also clearly evident with the land shadow around the peninsula.

Mesoscale Eddy



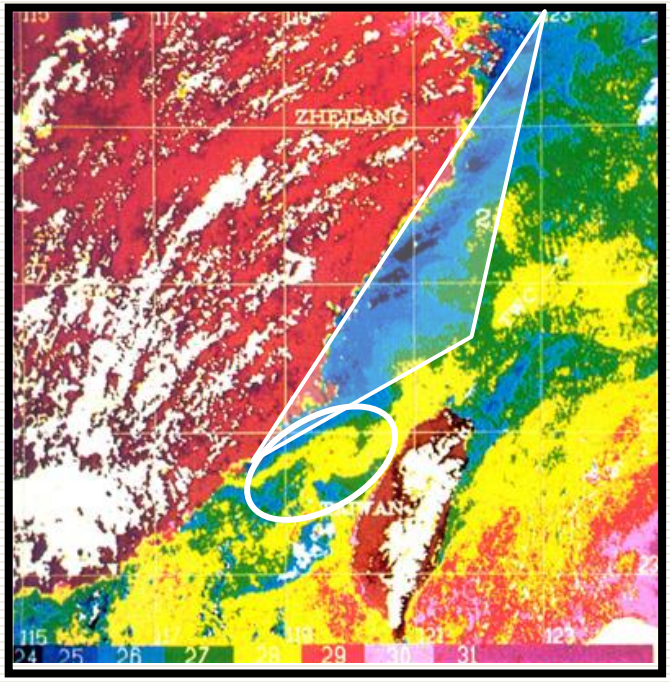
SST (in˚C) image of 17 November 1987 derived from AVHRR data showing a cyclonic cold eddy in the northern Yellow Sea created by convection due to autumn cooling.

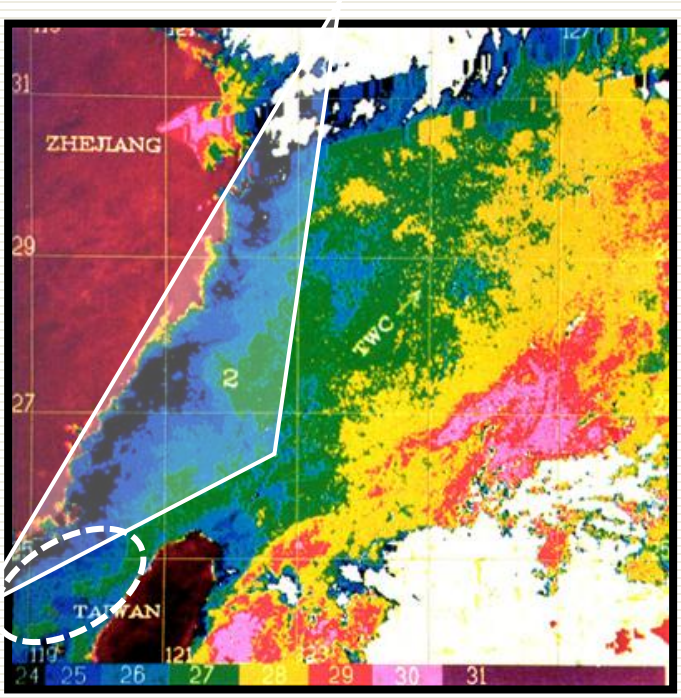
Mesoscale Eddy



SST (in°C) image of 29 August 1986 derived from AVHRR data showing a front-eddy coupling structure in the East China Sea caused by shear effect of local currents.

Coastal Upwelling





- ages

He, M., **G. Chen**, and Y. Sugimori, Investigation of mesoscale fronts, eddies and upwelling in the China Seas with satellite data, *The Global Atmosphere and Ocean System*, 3(4): 273-288, 1995.

- which disappears after 3 days.

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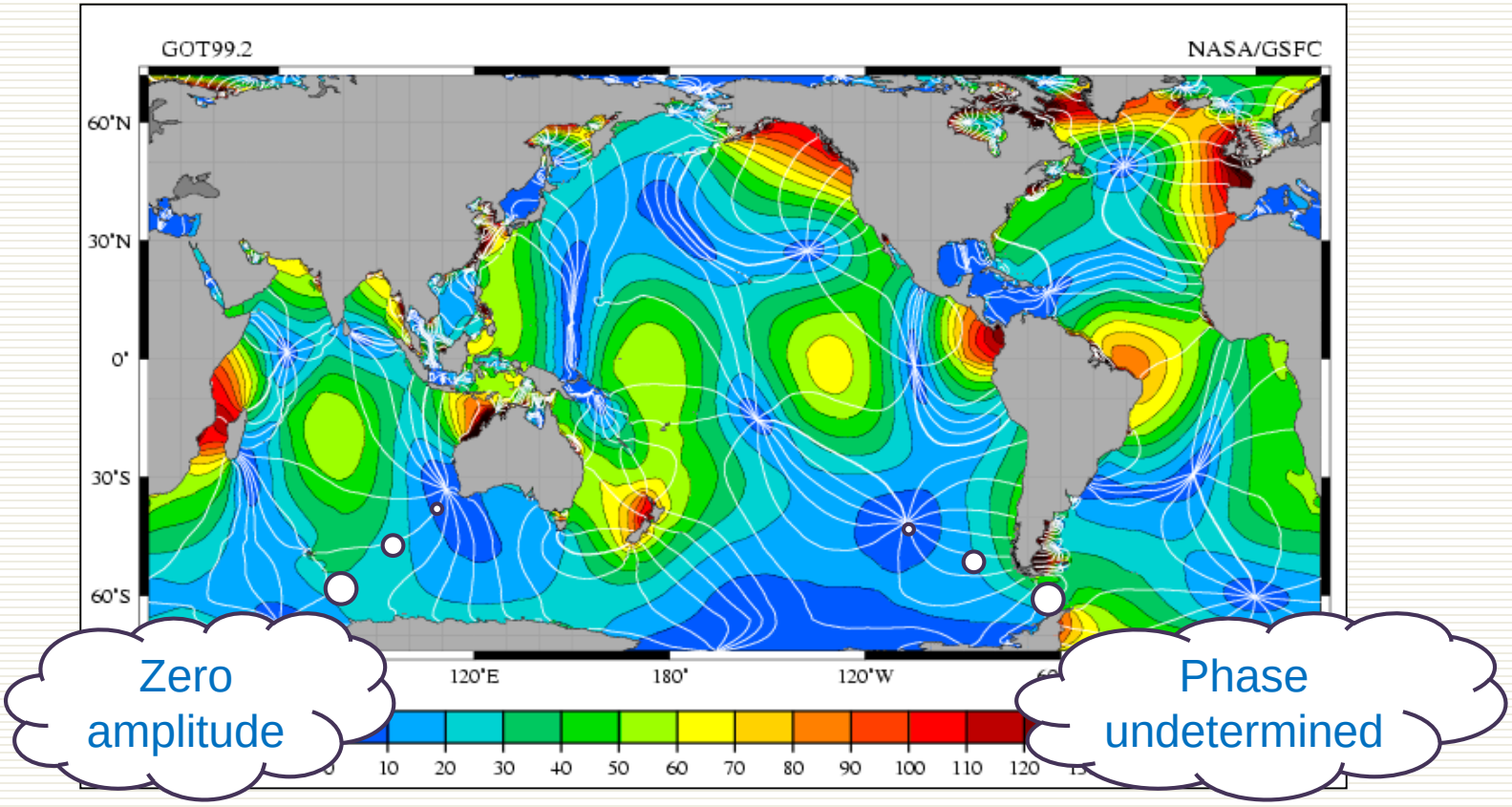
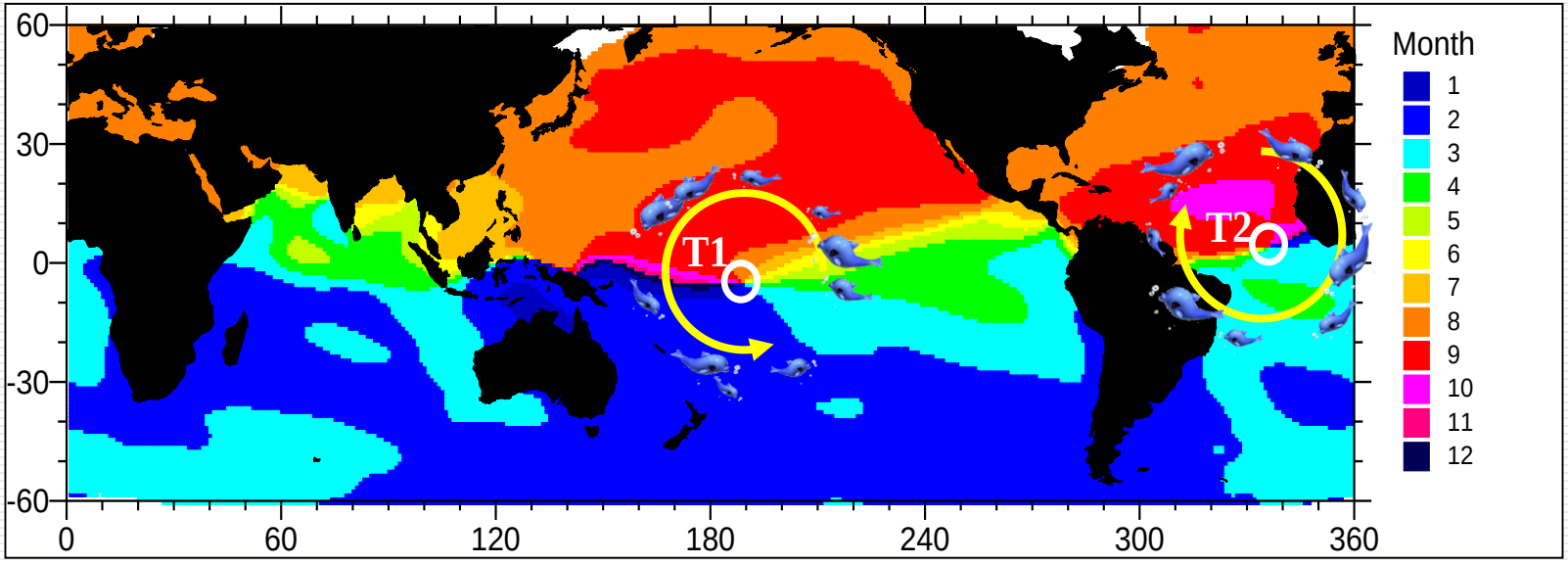
Global Chart of M2 Tide



About a dozen well-defined amphidromic points associated with diurnal and semidiurnal tides exist in the world ocean, forming a fundamental feature of the global tidal system.

Calendar Month in Which Annual SST Peaks



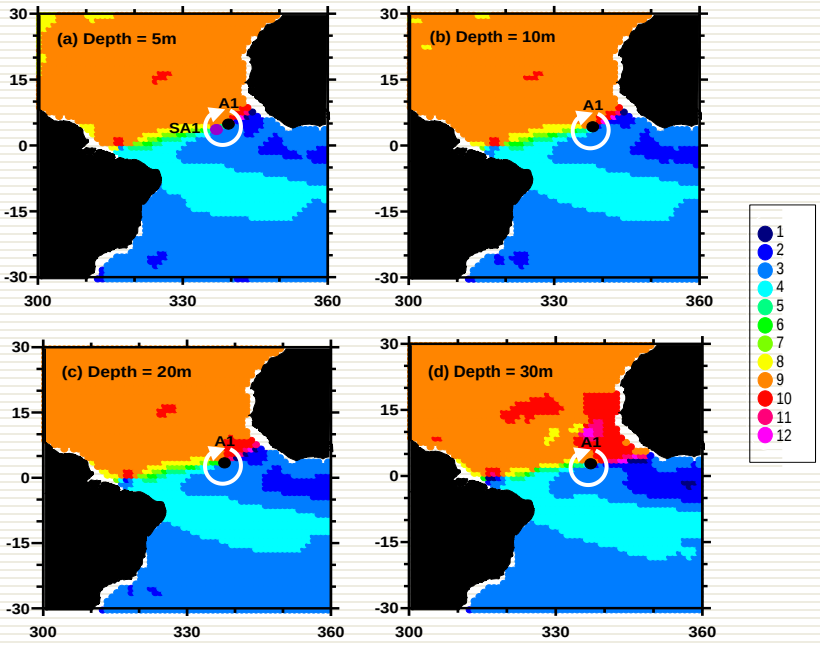
T1 and T2: Annual amphidromes of SST, serve as ideal sites for monitoring of global warming.

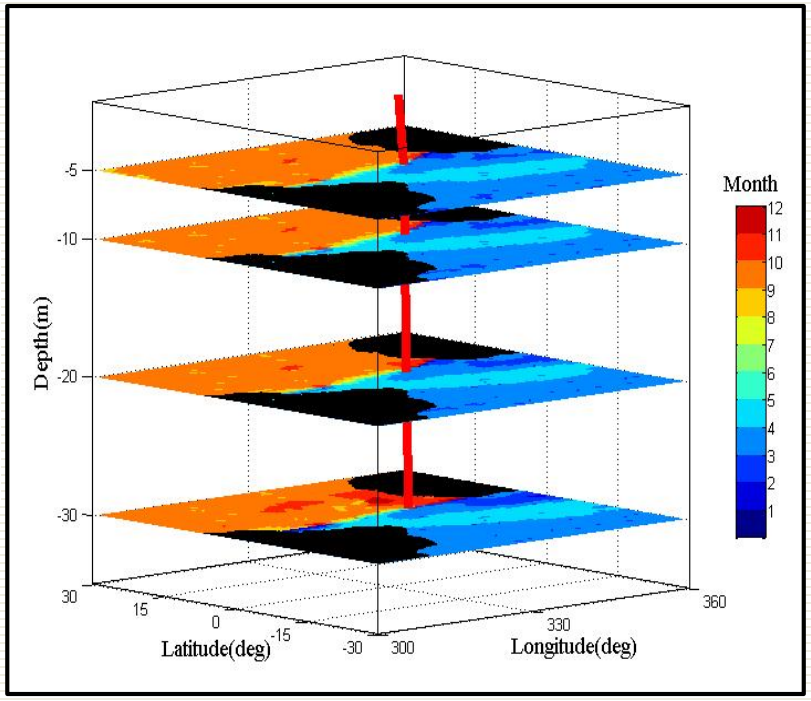
- Amphidrome is not a tide only feature, it may also exist with other geophysical variables with

Chen, G., and G. D. Quartly, Annual amphidrome: A common feature in the ocean? *IEEE Geoscience and Remote Sensing Letters*, 2(4): 423-427, 2005.

- The temperatures around these amphidromes are nearly constant throughout the year, and are likely to be of significant importance to some of the biological processes and fishing grounds migration in the tropical Pacific and Atlantic.

The AACST in the Atlantic Ocean

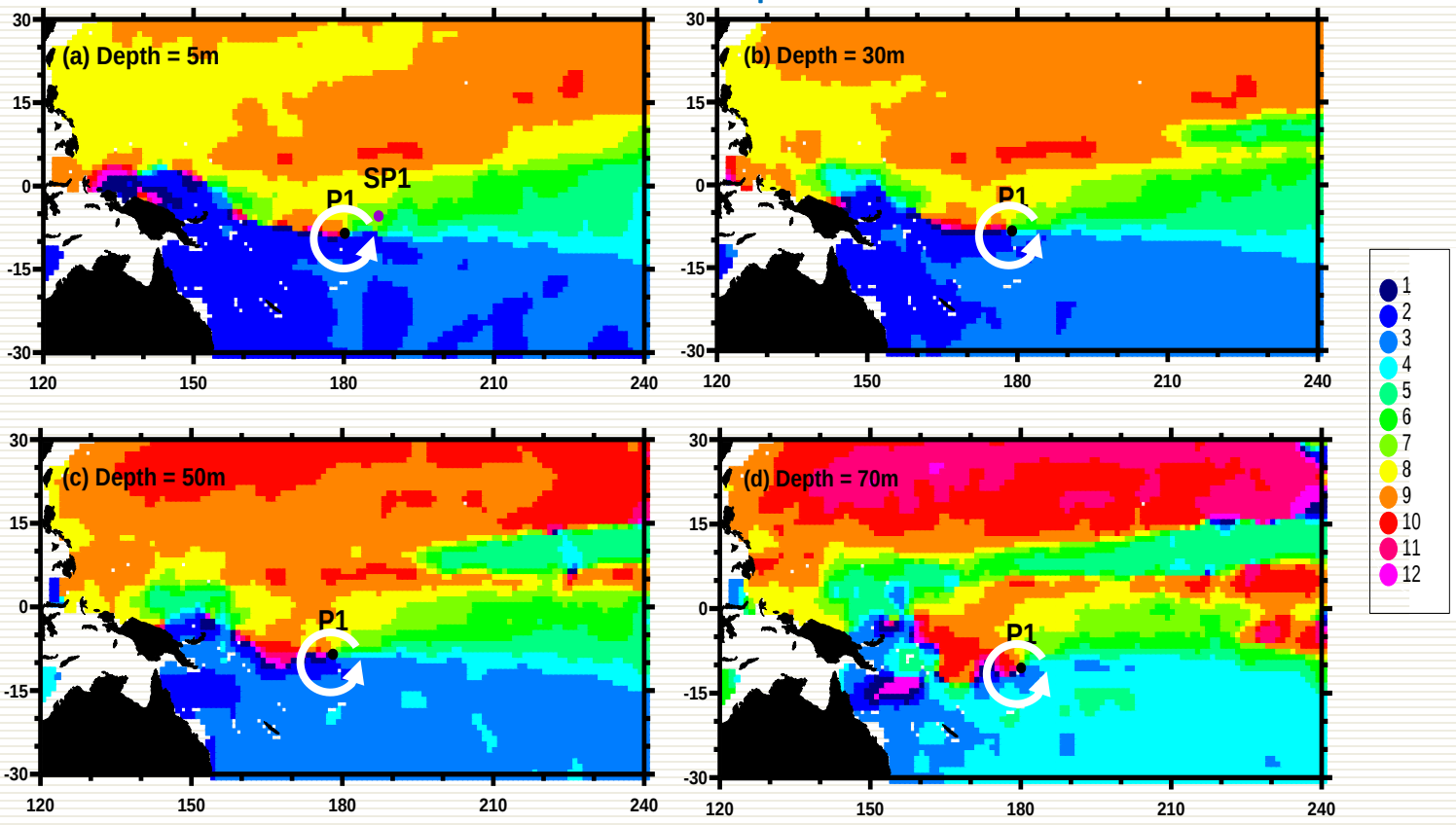




Amphidrome is not a surface-only phenomenon. Using the 3-D Argo measurements, 4 annual amphidromic columns of sea temperature have been precisely identified in the global ocean, which range from a depth of 30 m in the Atlantic to 120 m in the Indian Ocean.

The AACST in the Pacific Ocean

Penetration depth: 70 m.



Chen, G., H. Zhang, and X. Wang, Annual amphidomic columns of sea temperature in global oceans from Argo data, *Geophysical Research Letters*, 41(6): 2056-2062, doi:10.1002/2014GL059430, 2014.

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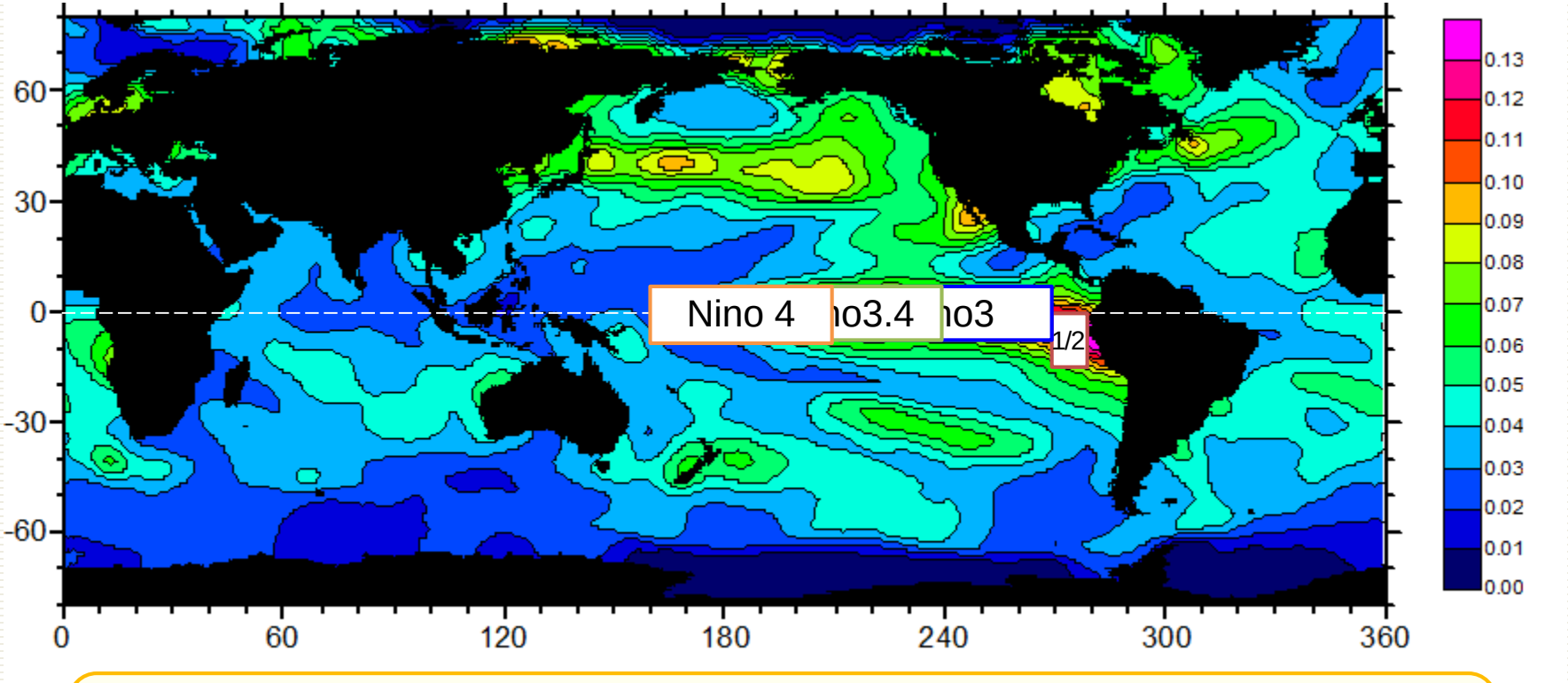
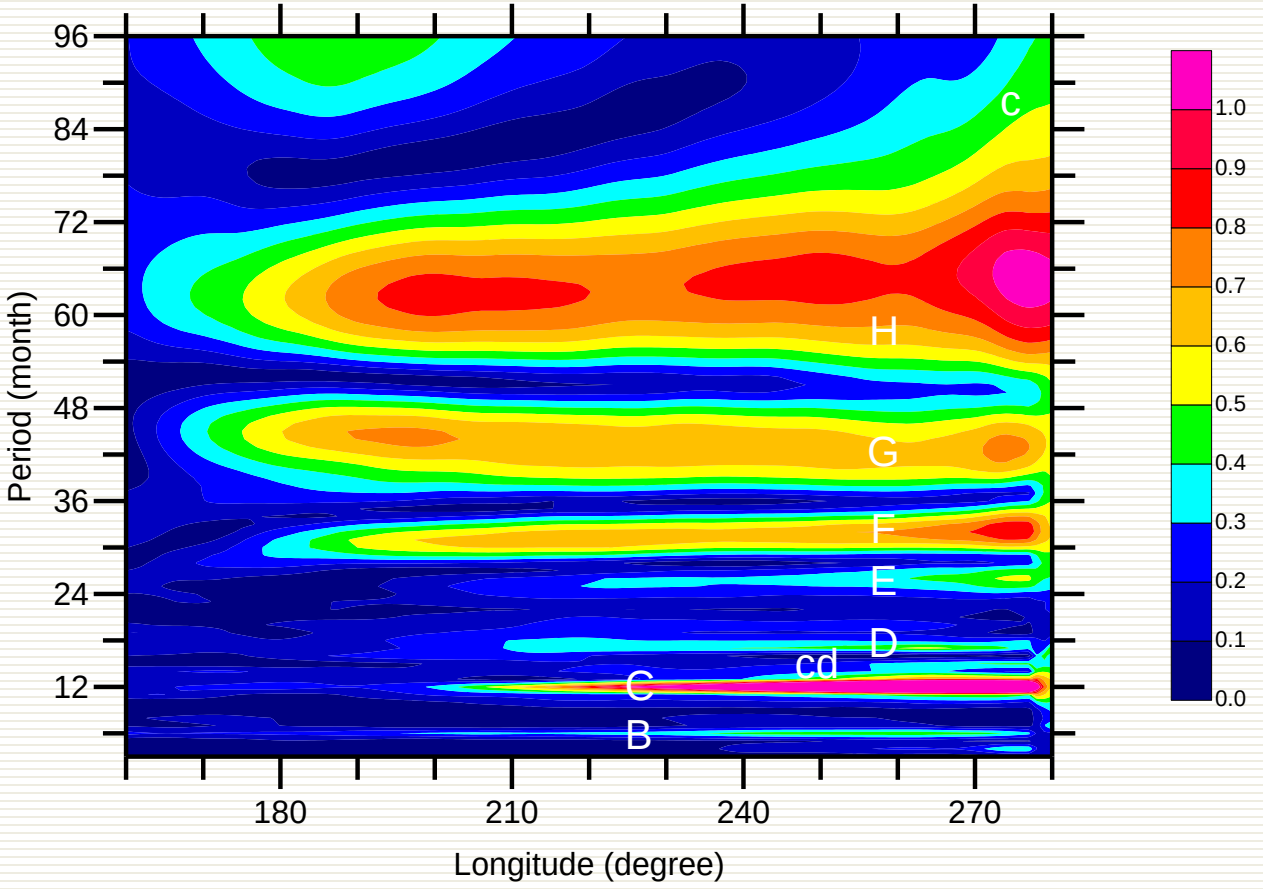
Niño Regions

Global Distribution of ENSO Modes



A very important role that SST plays is to define the ENSO index. For this purpose, a number of Niño regions have been proposed. They are believed to be the heart of El Niños/La Niñas.

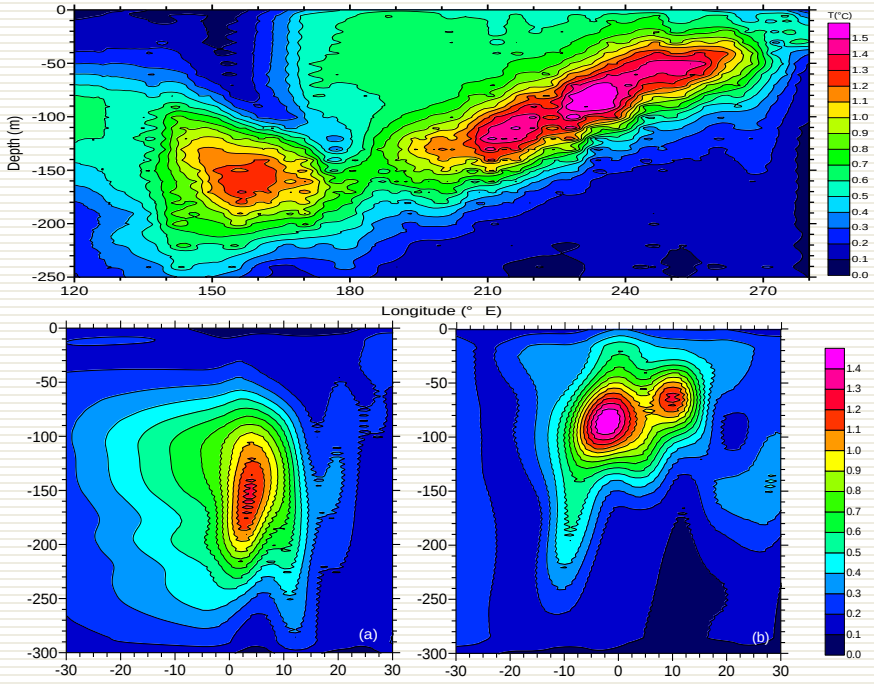
Sub-ENSO Modes in the Niño Region

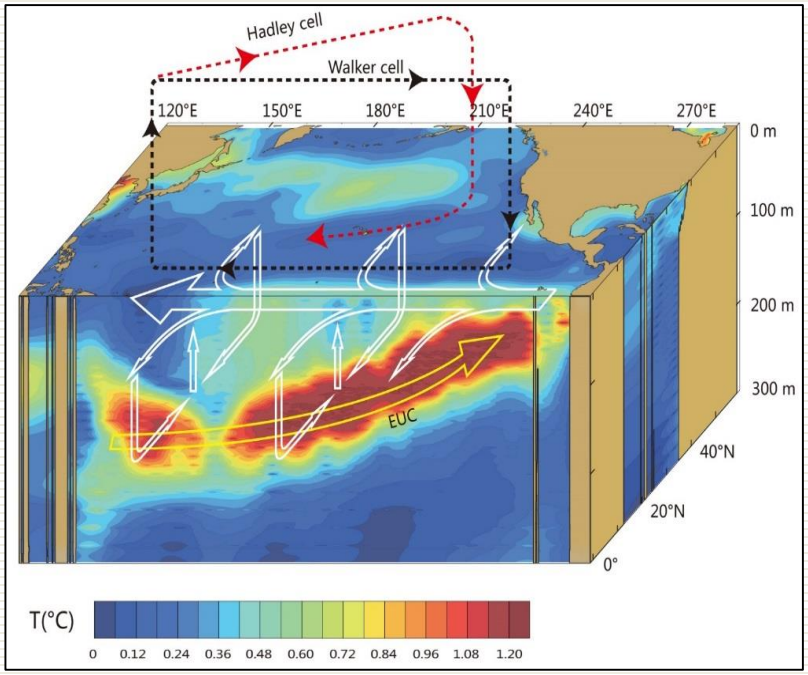


The fine pattern of rich and stable sub-ENSO modes derived from SST in the Niño region, very useful in ENSO prediction.

From Niño Regions to Niño Pipe

3-D structure of the “Niño Pipe” in the upper mixed layer of the Pacific Ocean.





Chen, **G.**, and H. Li, Fine pattern of natural modes in sea surface temperature variability: 1985-2003, *Journal of Physical Oceanography*, 38(2): 314–336, 2008.

Chen, G., and H. Chen, Interannual modality of upper ocean temperature: 4-D structure revealed by Argo data, *Journal of Climate*, 28(9): 3441-3452, 2015.

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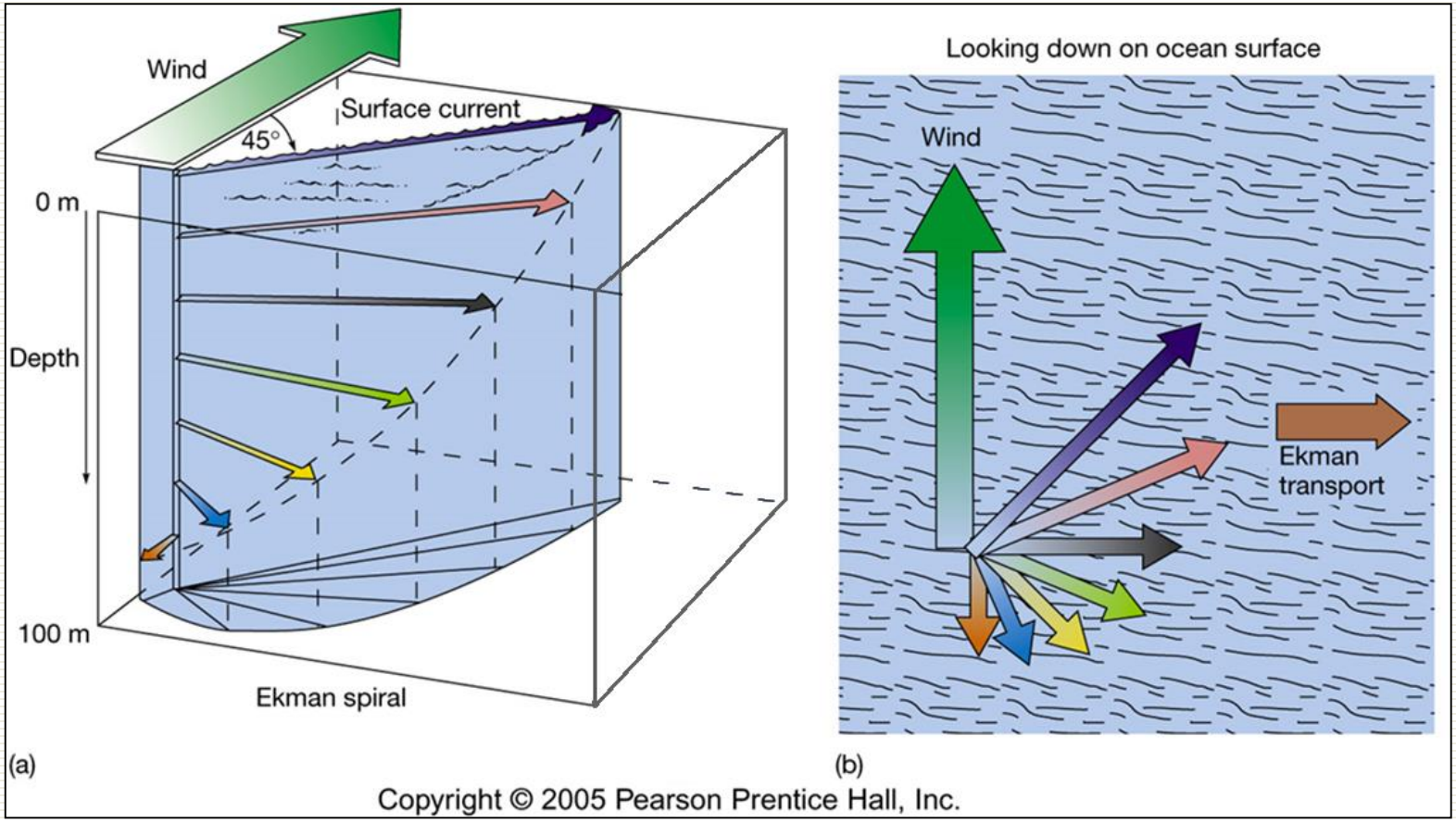
Ekman Spiral



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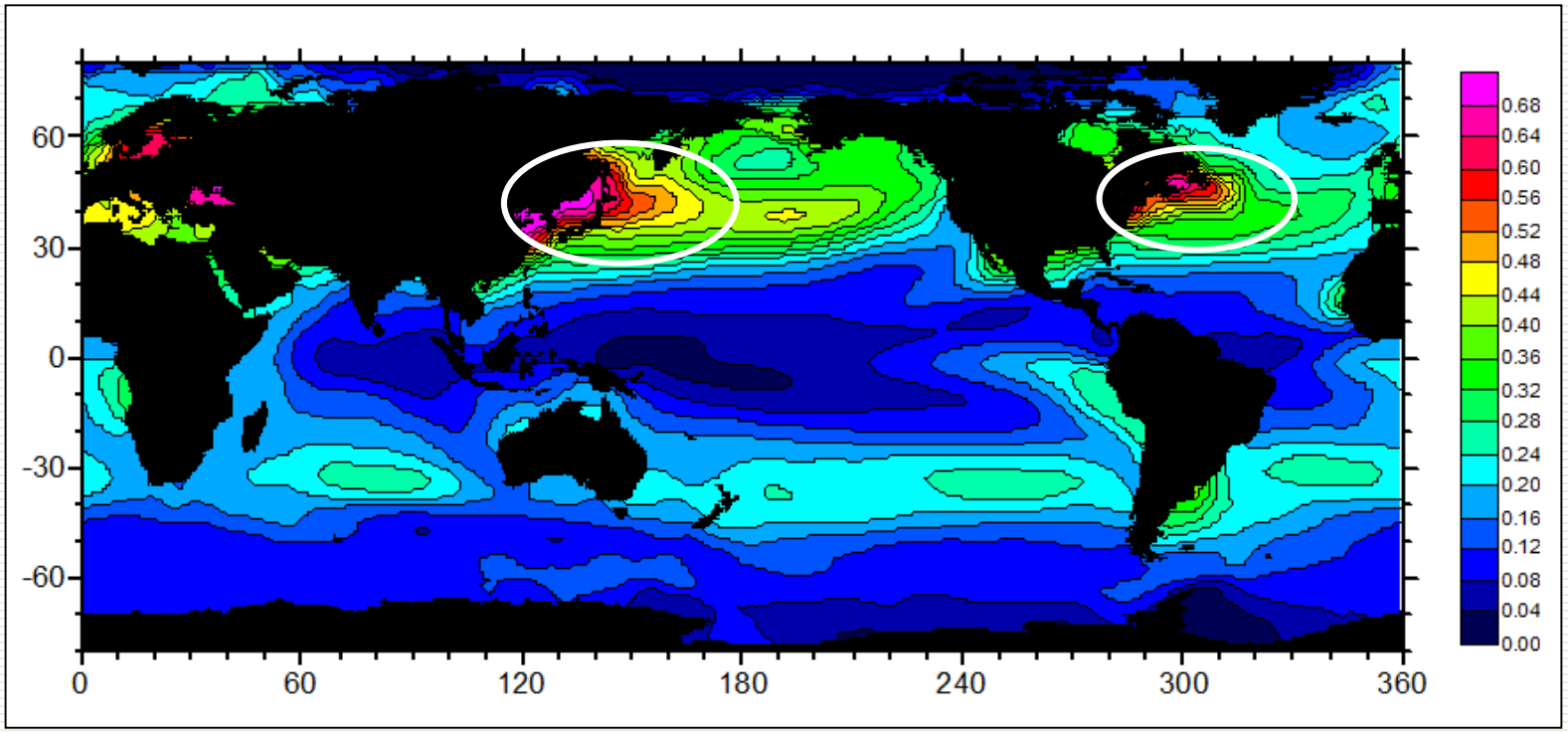
The Ekman Spiral is a structure of currents near a horizontal boundary in which the flow direction rotates as one moves away from the boundary.

SST Derived Sea Surface Seasonality

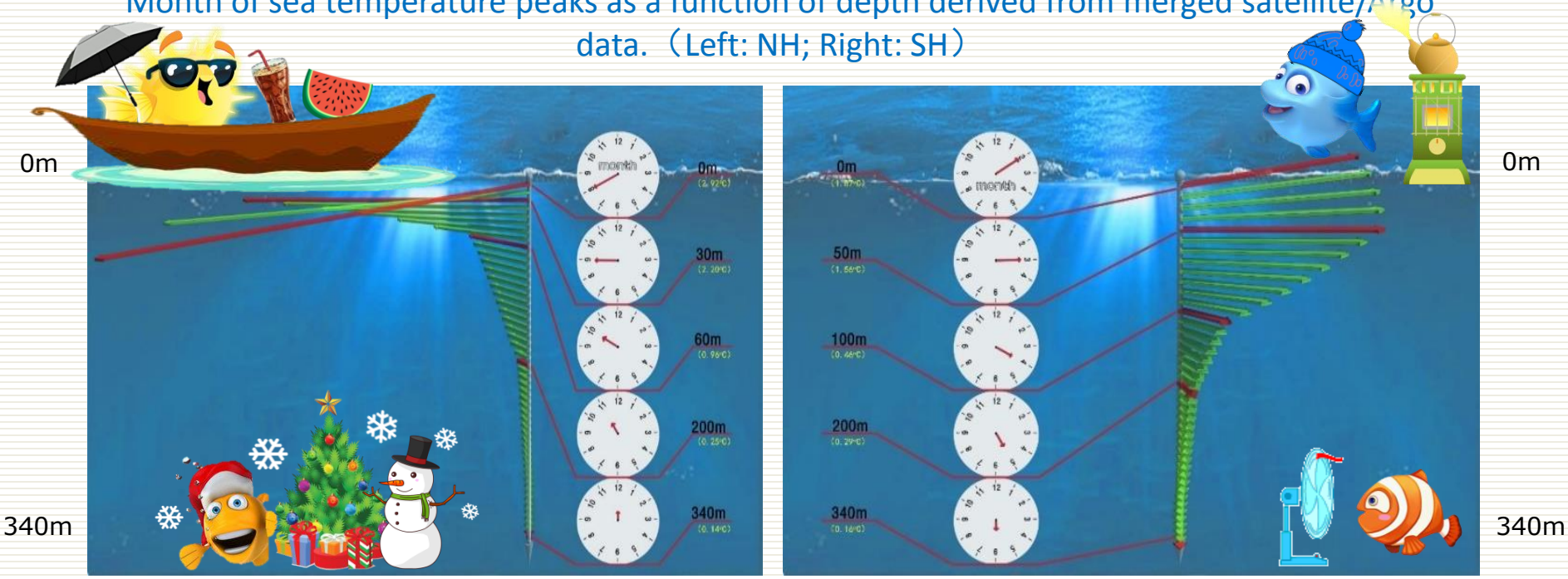
Mid-latitude dominance globally, west preference in the NH. Peak in China and Japan Seas.



The SST derived surface seasonality over the global oceans. Those of us who live in the mid-latitude NW Pacific and NW Atlantic are very lucky to enjoy the most distinct four seasons in the world!

Seasonality Spiral

Month of sea temperature peaks as a function of depth derived from merged satellite/Argo data.（Left: NH; Right: SH）



Using SST along with Argo data, it is identified that the seasonality of the subsurface ocean

Chen, G., X. Wang, and C. Qian, Vertical structure of upper ocean seasonality: Extratropical spiral versus tropical phase lock, *Journal of Climate*, 29(11): 4021-4030, 2016.

Aug, the fish family is celebrating their X'mas 340 m below! The opposite is true for the SH.

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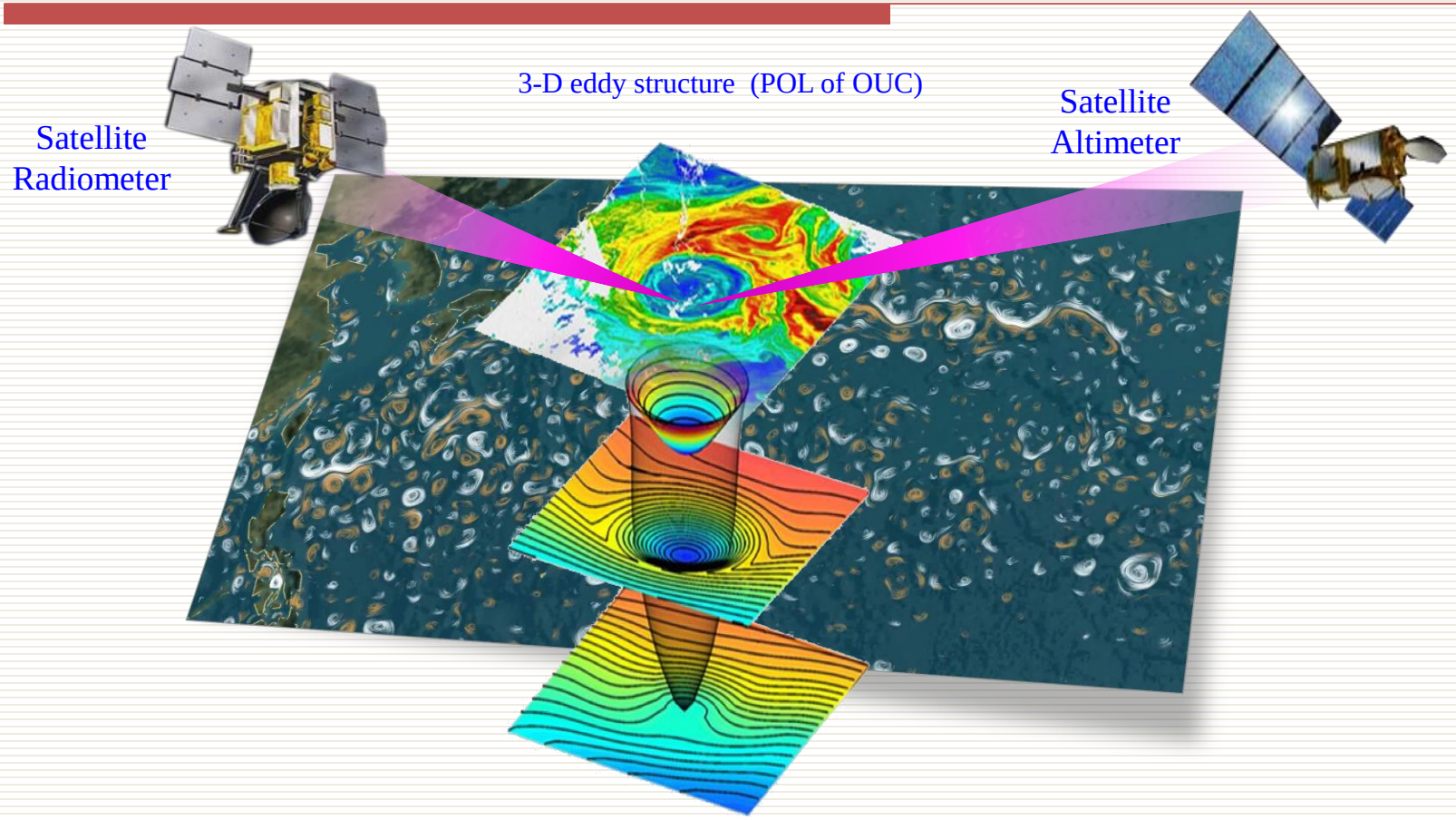
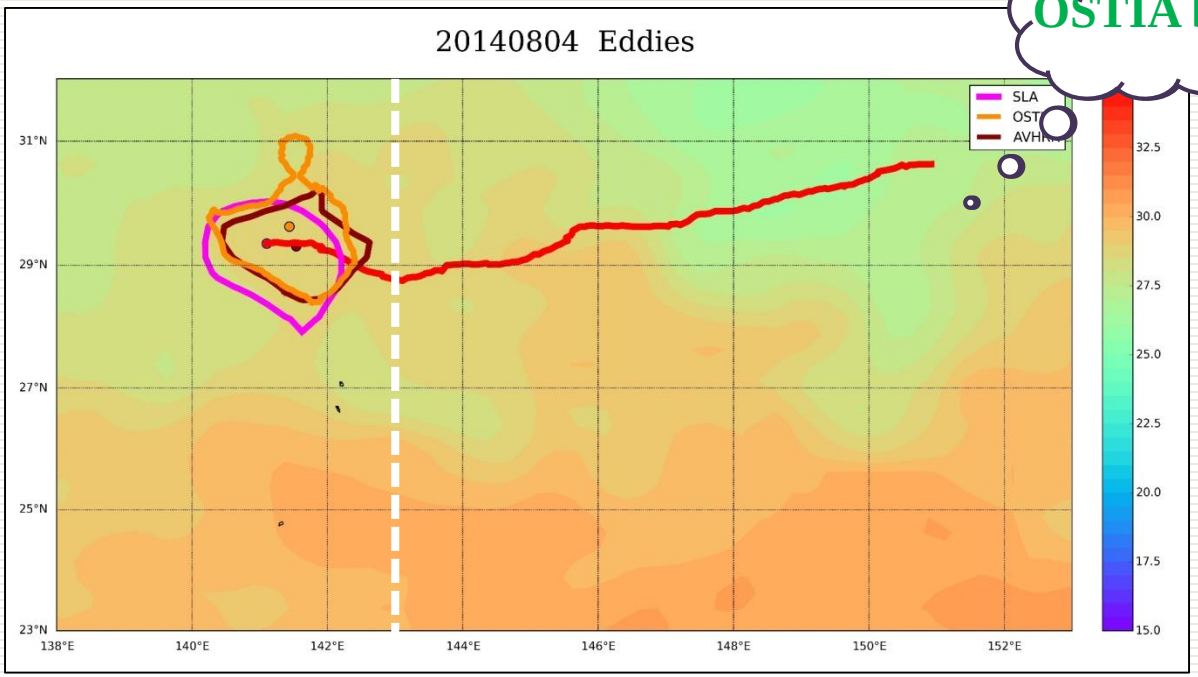
3-D Eddy Tracking and Observation



With the continuous improvement of SSH and SST data quality, we are now able to track the evolution of a mesoscale eddy for as long as a few years. It was found that SSH is most effective in doing this job, while SST is also a very good helper.

3-D Eddy Tracking and Observation



OSTIA better

2014.1.27-2014.9.4

Liu, Y., **G. Chen**, M. Sun, S. Liu, and F. Tian, A parallel SLA-based algorithm for global mesoscale eddy identification, *Journal of Atmospheric and Oceanic Technology*, 33(12): 2743-2754, 2016.

while OSTIA is effective for ~70 days. There are some ~85 days in which both datasets lost tracking.

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Concluding Remarks

- As initiated by TIROS over half a century ago, SST was no doubt a pioneer in satellite oceanography.

- SST set many milestones in modern oceanography, such as ENSO Index which plays a key role in the research of global climate change.

- The 21st century is certainly a century of big data, and SST will be a key player of big data oceanography for many years to come!

THANK YOU !

AUSTRALIA
OCEANIA
Northern Territory
Queensland
Western
Sandy Desert
Gibson Desert
Alice Springs
Mount Isa
Townsville
Cairns
Chesterfield
New Caledonia
VANUATU
Port-Vila
TONGA
Brisbane
Grafton
Victoria
Sydney
Canberra, ACT
North Island
NEW ZEALAND
Tasman Sea
South Island
Hamilton
Auckland