Pacific Climate Change Science Program

Ocean acidification in the Pacific Islands region

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Australian Government

Background: Definition

OA is the decrease in ocean pH due to the increase of atmospheric CO_2

Atmosphere
CO_2 (g)

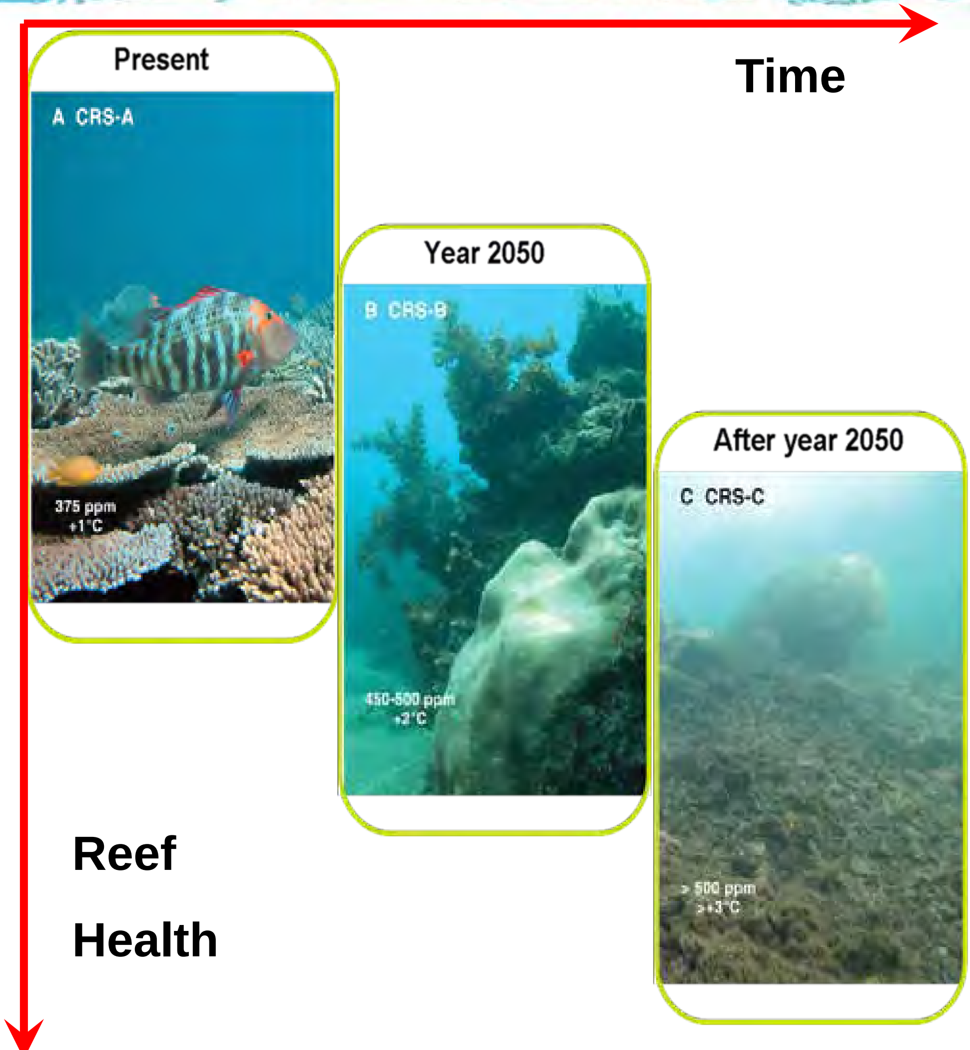
$$CO_3^{2-} + CO_2 + H_2O \Leftrightarrow 2HCO_3^-$$

Ocean

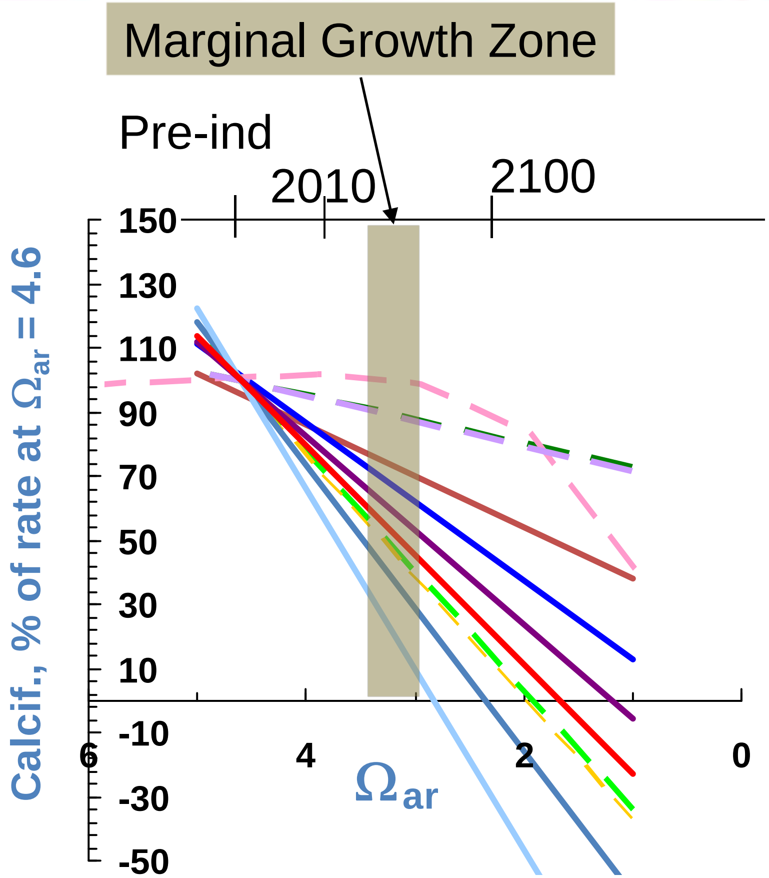
Ω, Carbonate Saturation State $\Omega = f(CO_3^{2-})$

Ω = indicator of CO_3^{2-} availability

Motivation: Acidification and Reef Health



Adapted from Hoegh-Guldberg et al. 2007



Adapted from Langdon et al. 2005

Background: Ω and the Carbonate Chemistry

$$Ca^{2+} + CO_3^{2-} = CaCO_3$$

$$\Omega = [Ca^{2+}] \times [CO_3^{2-}] / Ksp$$

SAL

SST
SAL

Total Alkalinity (TA)
Total Inorganic CO_2 (TCO_2)

Drivers:

Temporal and spatial variation in saturation state (and OA) can be attributed to:

1- net transport across the air-sea interface (long term)

2- vertical mixing and horizontal advection

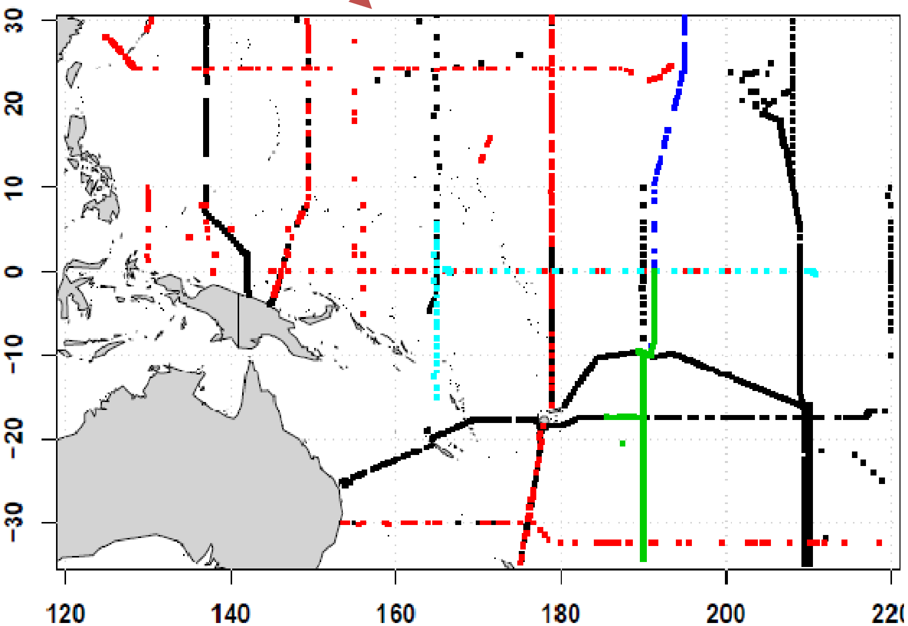
3- biological activity (calcification/production)

Outline:

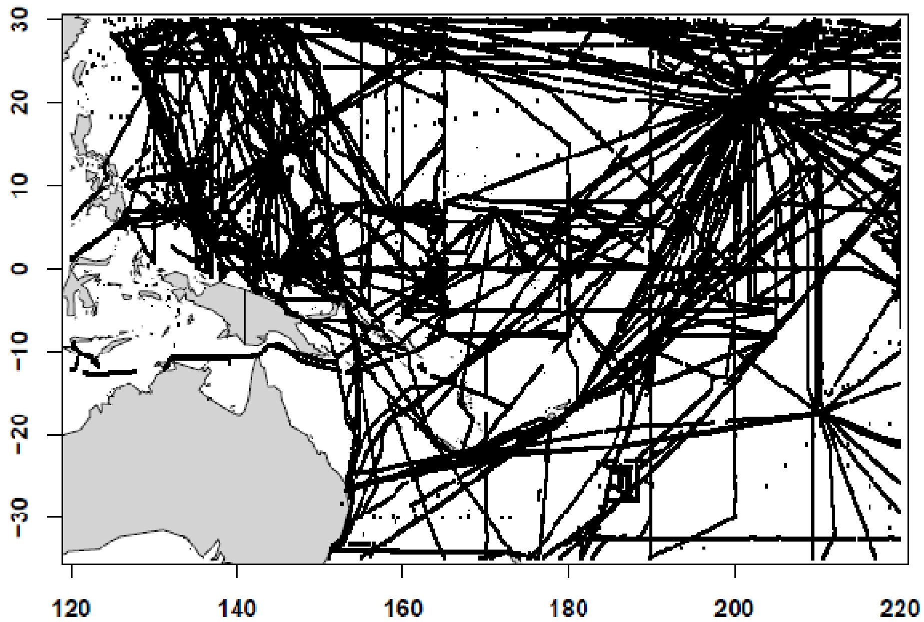
- **Data**
- **Seasonal variability in TA, TCO_2 and Ω_{ar}**
- **Ω_{ar} sensitivity to TA and TCO_2**
- **Summary and conclusion**

Data:

Description of carbonate chemistry requires two parameters of total alkalinity, total dissolved CO_2, partial pressure CO_2, or pH



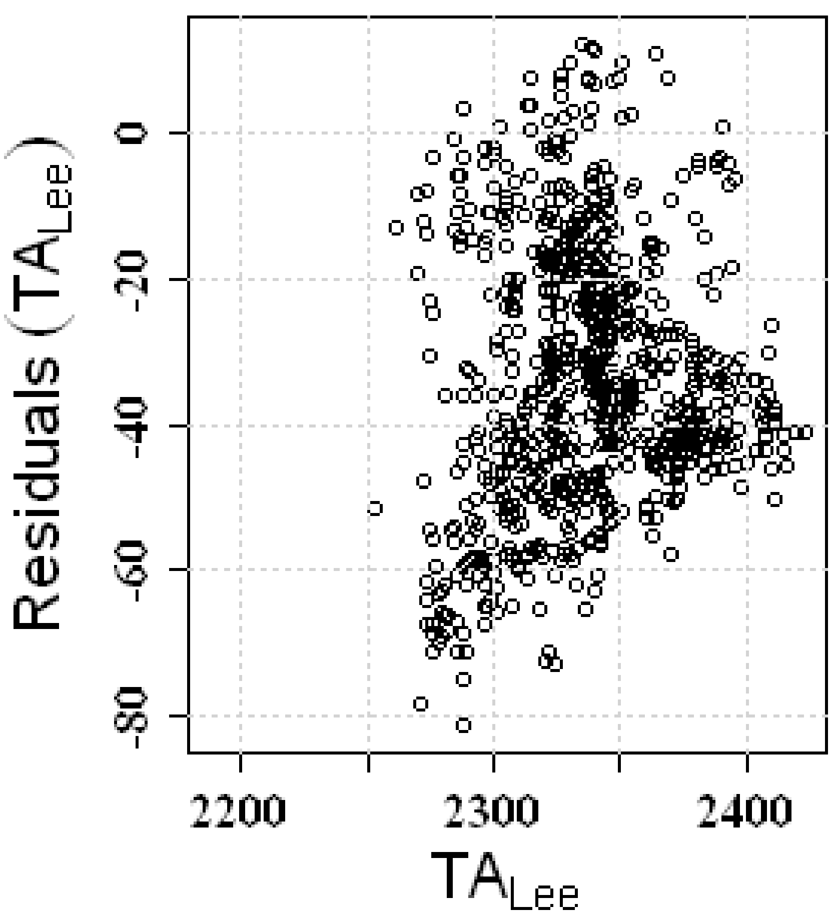
Discrete measurements from 1990 to 2009:Aus. (green), Can. (dark blue), Fra. (cyan),Jap. (black), USA (red)



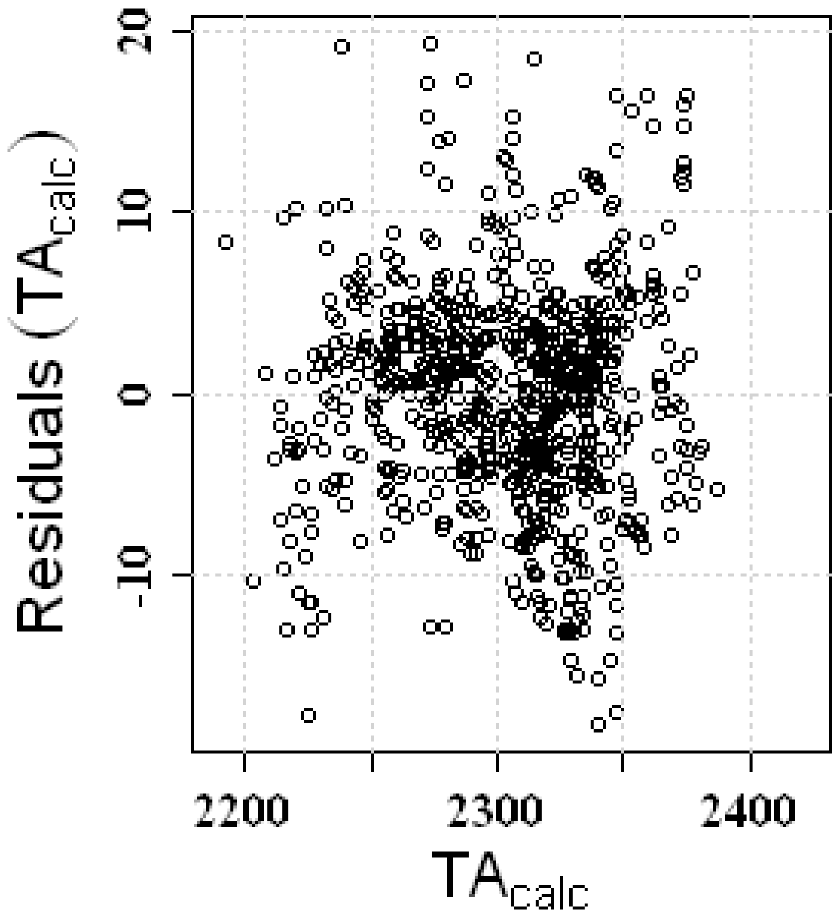
Takahashi et al., 2009
Underway measurements since 1968 @ LDEO V2009 Database

TA-SAL relationship:

TALee = f(SST,SAL)



TAcalc = 2300 + 66.3(SAL-35)



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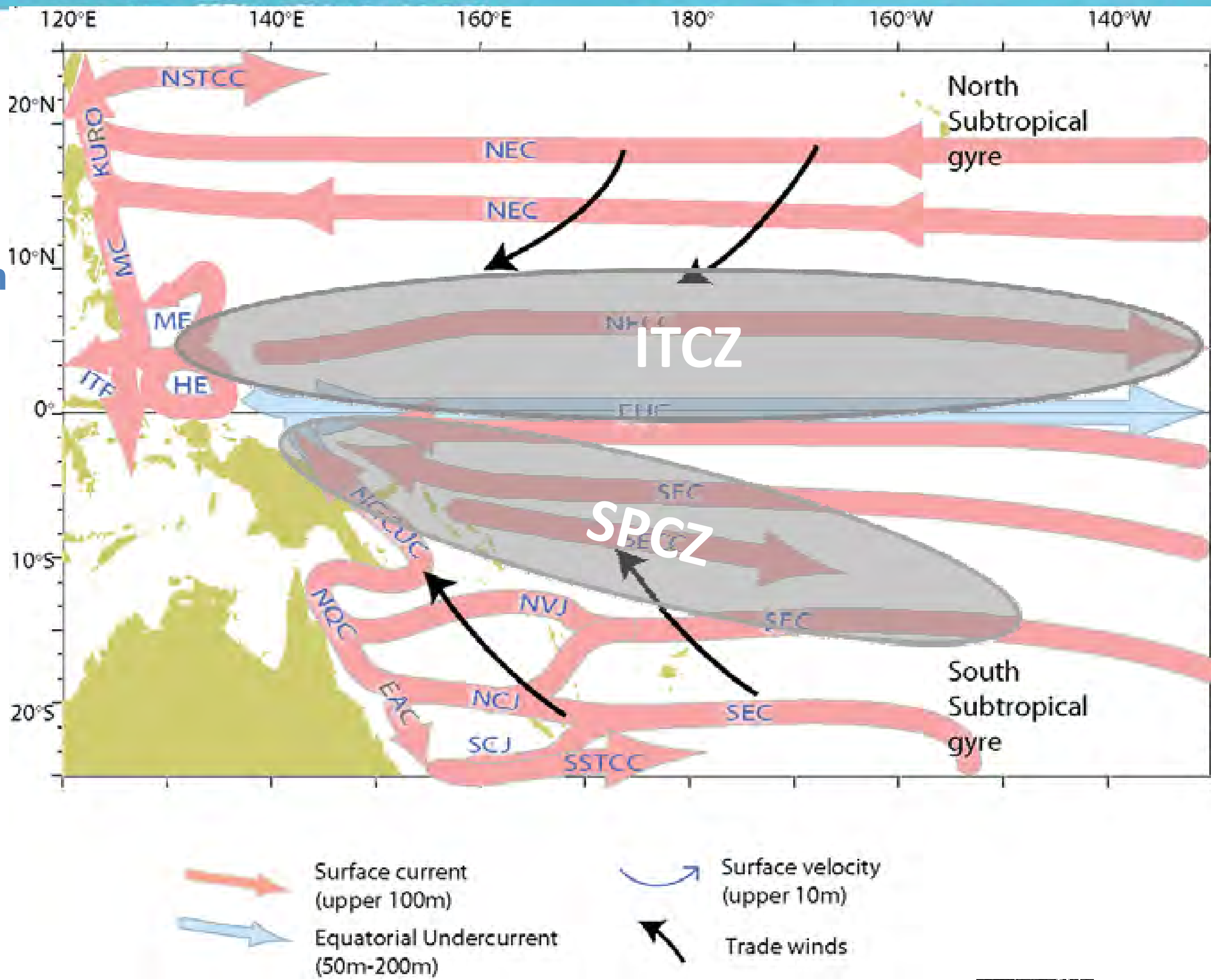
Surface currents

-NEC & SEC strongest in winter months

-SECC & NECC strongest in summer months

SPCZ -> SECC
ITCZ -> NECC



Ganachaud et al., 2010

Seasonal variability in TA (umol/kg)

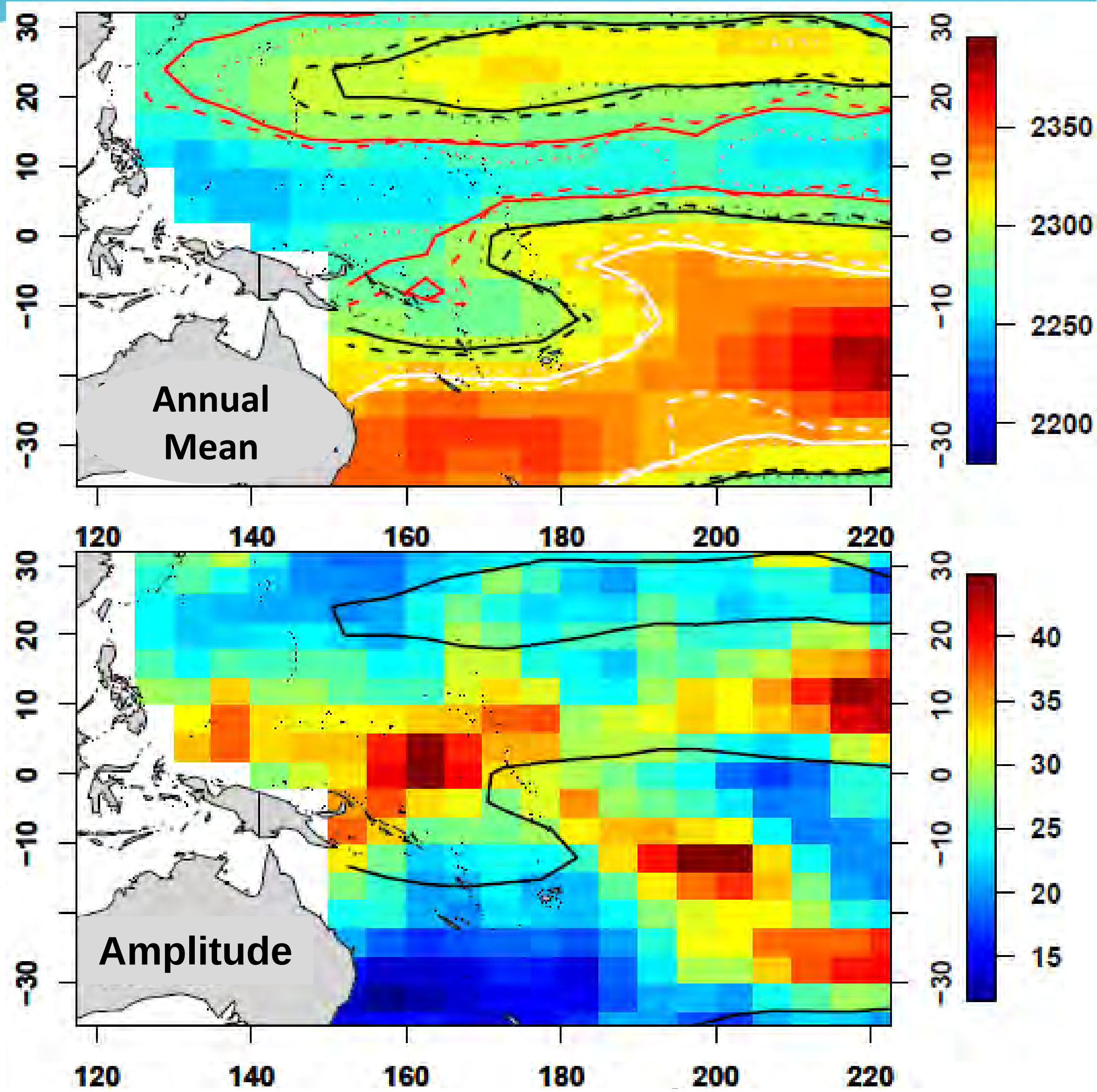
TA = f(SAL)

SAL depends on the hydrological cycle (Evaporation and Precipitation).

SubTropical Gyres:
Hi(E-P) => Hi SAL => Hi TA

NECC and SECC:
Low(E-P) => low SAL => low TA

largest variation in E-P => Largest seasonal variation in TA in Warm Pool, NECC, SECC



Seasonal variability in TCO_2 (umol / kg)

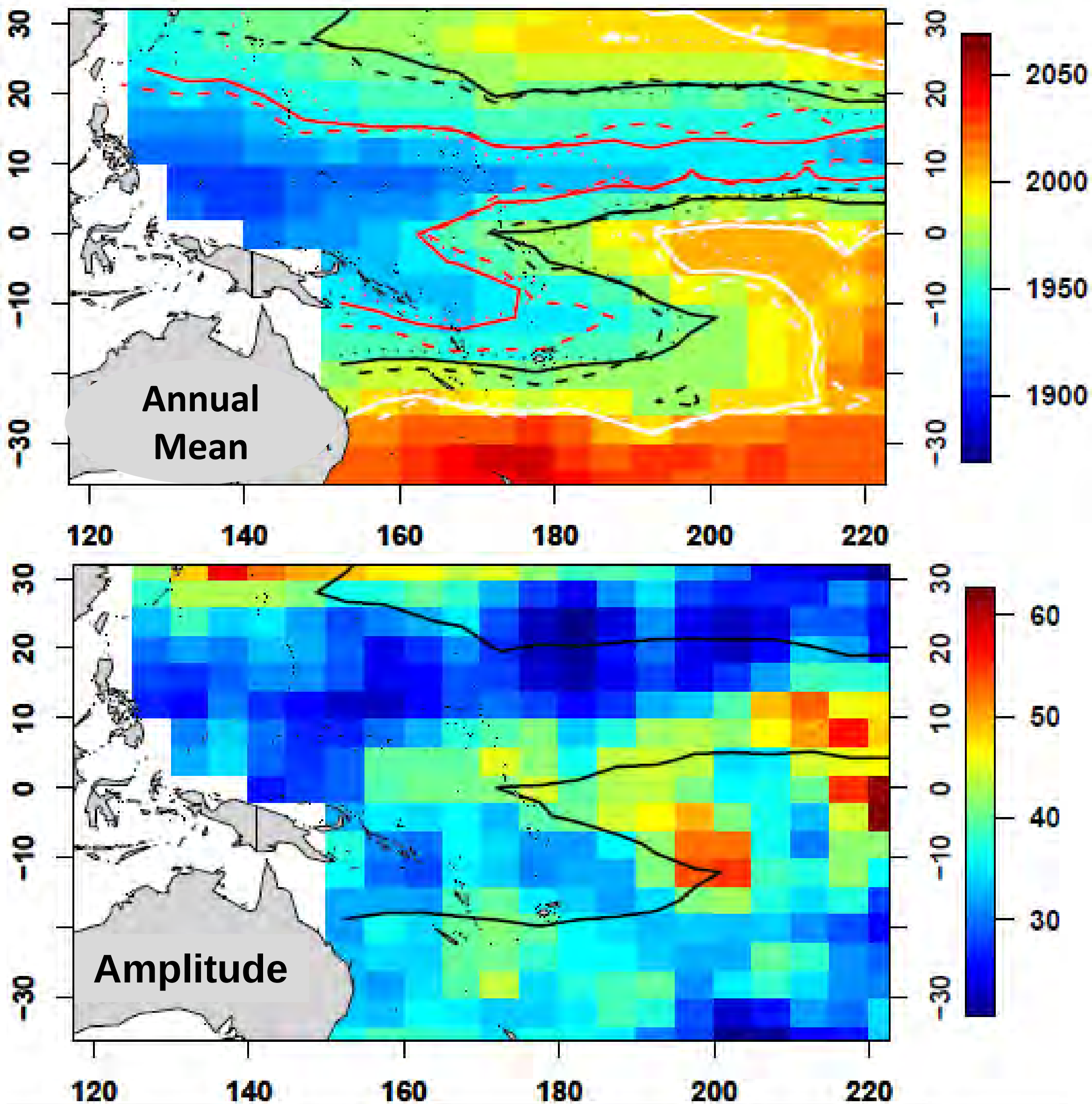
SubTrop. Gyres

- Mixed layer deepens from summer to winter increasing TCO_2 and nutrients. Biological drawdown leads to lower TCO_2 towards Summer

Equator:

-Extension of SEC in winter => more TCO2

-stratified WPWP => less upward migration of CO_2



Variability in Ω_{ar}

Sub-Tropical gyres:
-summer => increase in Ω
-Biological CO_2 drawdown

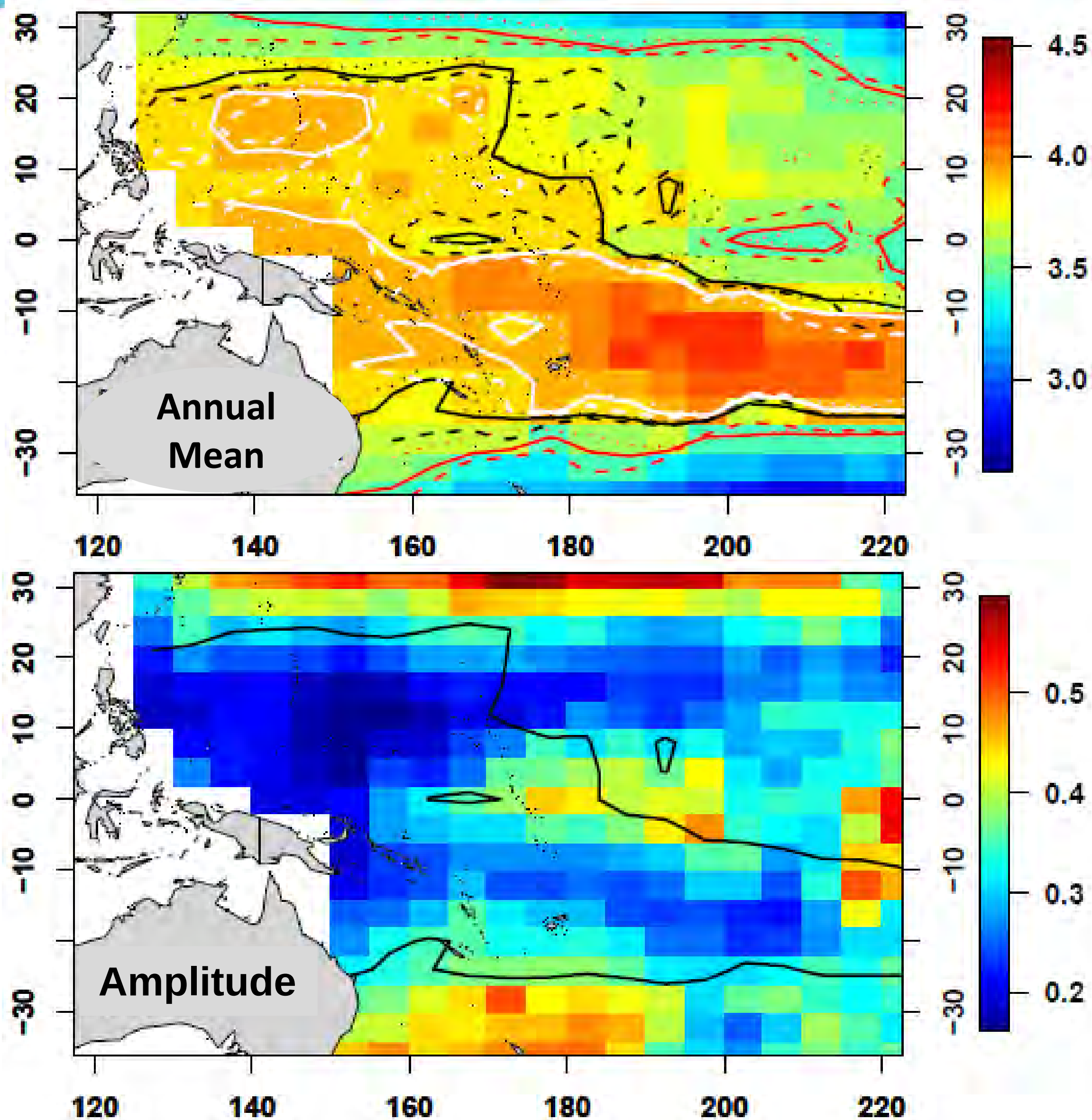
Eastern Equatorial:
-summer => increase in Ω
-weakening of SEC

Western Equatorial:

-monsoon => fresher WPWP => decrease in TA => Ω↓

-monsoon => more stratified WPWP => inhibits upward migration of CO_2 => Ω↑

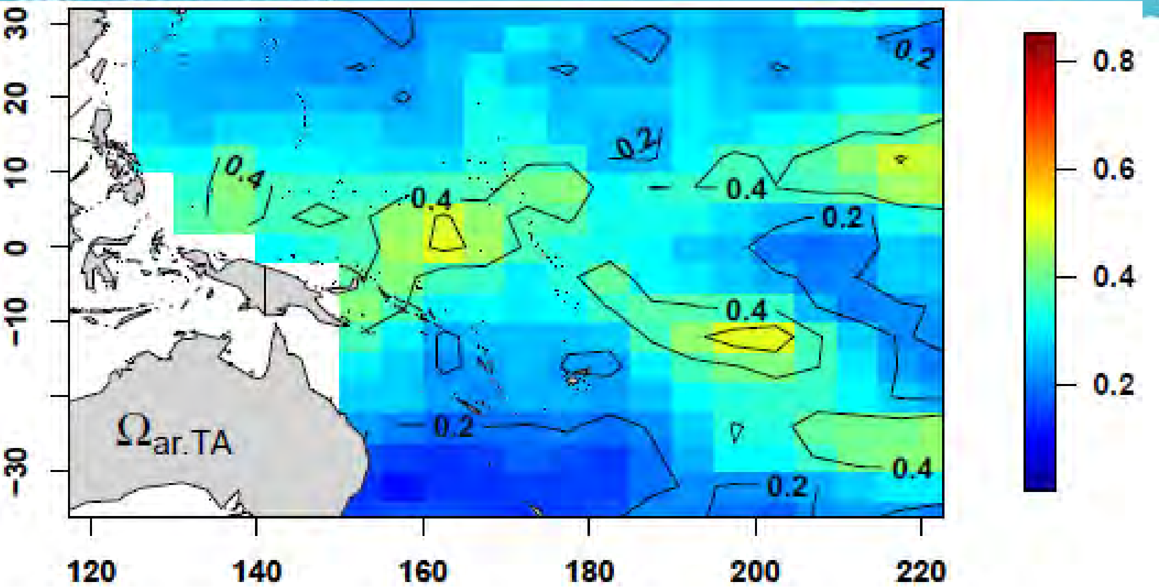
- summer => increase in Ω



Ω_{ar} Sensitivity

Sensitivity of Ω_{ar} to TA :

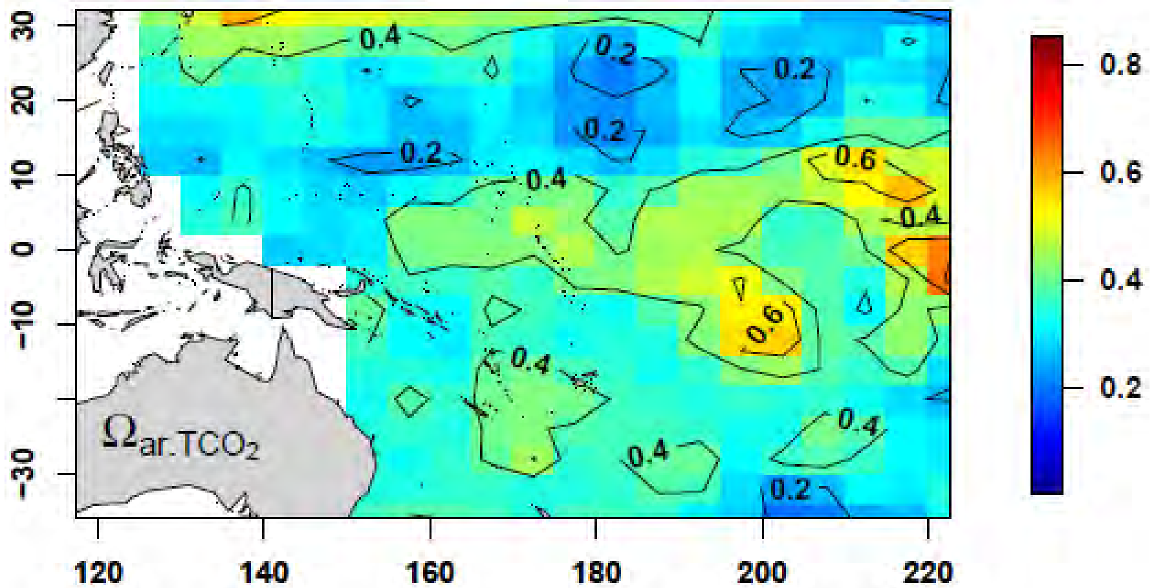
- due to salinity changes (greater in NECC and SECC)



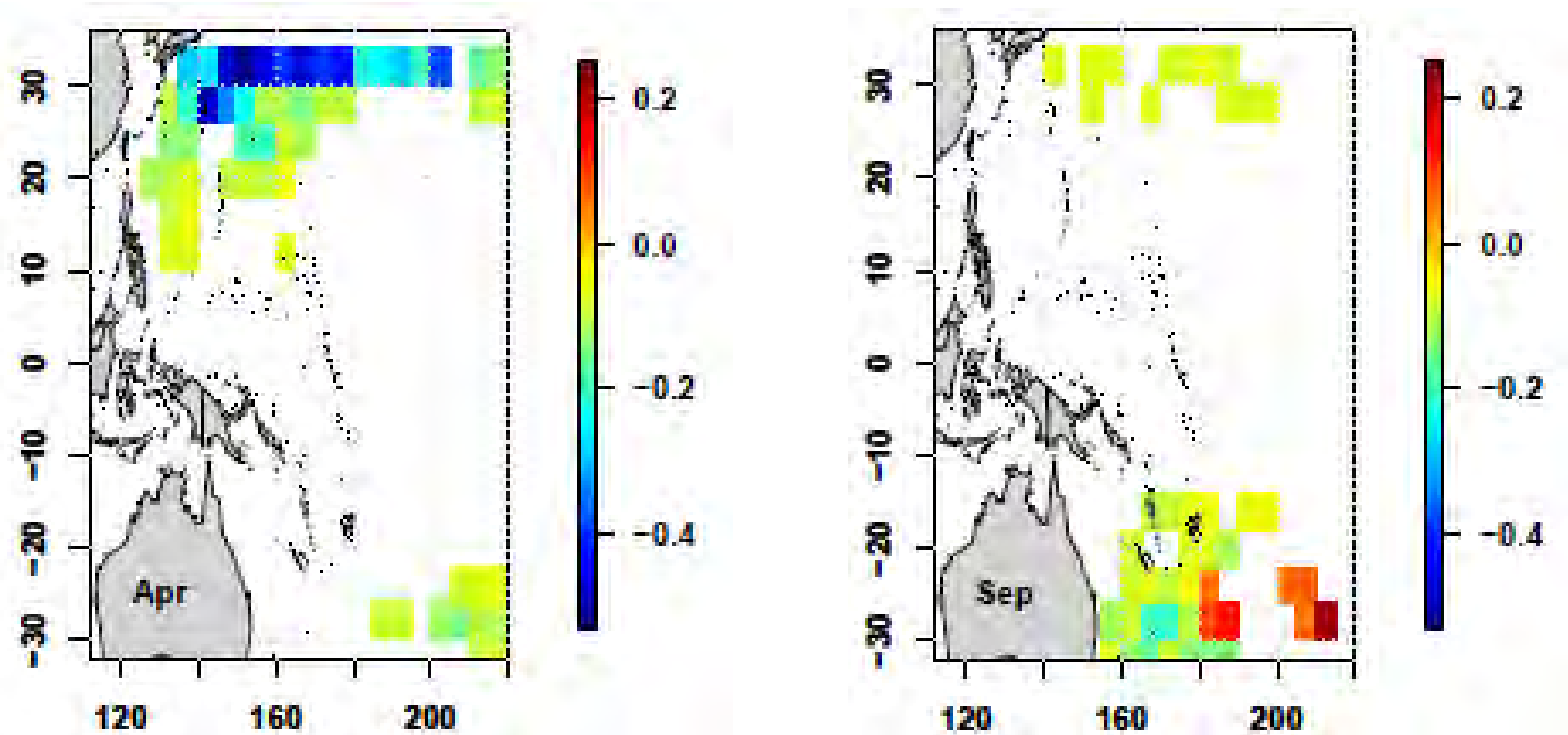
Sensitivity of Ω_{ar} to TCO2:

- due to seasonal changes in the position and strength of NECC/SECC and SEC

- due to vertical mixing and biological activity in sub-tropical gyres



Processes controlling $\Omega_{ar:}$ 2- Vertical mixing



Monthly changes in Ω_{ar}

1- insignificant where mixed layer depth is unchanged

2- larger in the North subtropics

3- decreases with shallowing of MLD

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Summary and Conclusion

- **Ocean acidification: changes in aragonite saturation state, Ω_{ar} -> affect reef ecosystems, coastal protection, tourism.**

- **conditions for coral growth:**
  - **Optimal (Ω_{ar}> 4.0)**
  - **Marginal (Ω_{ar} 3.0 – 3.5) !may vary with species/location**

- **Ω_{ar} varies seasonally and spatially.**
  - **3.4 - 4.2 (Cook Is., Kiribati, Marshall Is., Nauru, PNG)**
  - **4.0 – 4.2 (Samoa)**
  - **3.7 – 4.2 (other PCCSP partner countries)**

Thank you

For further information

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