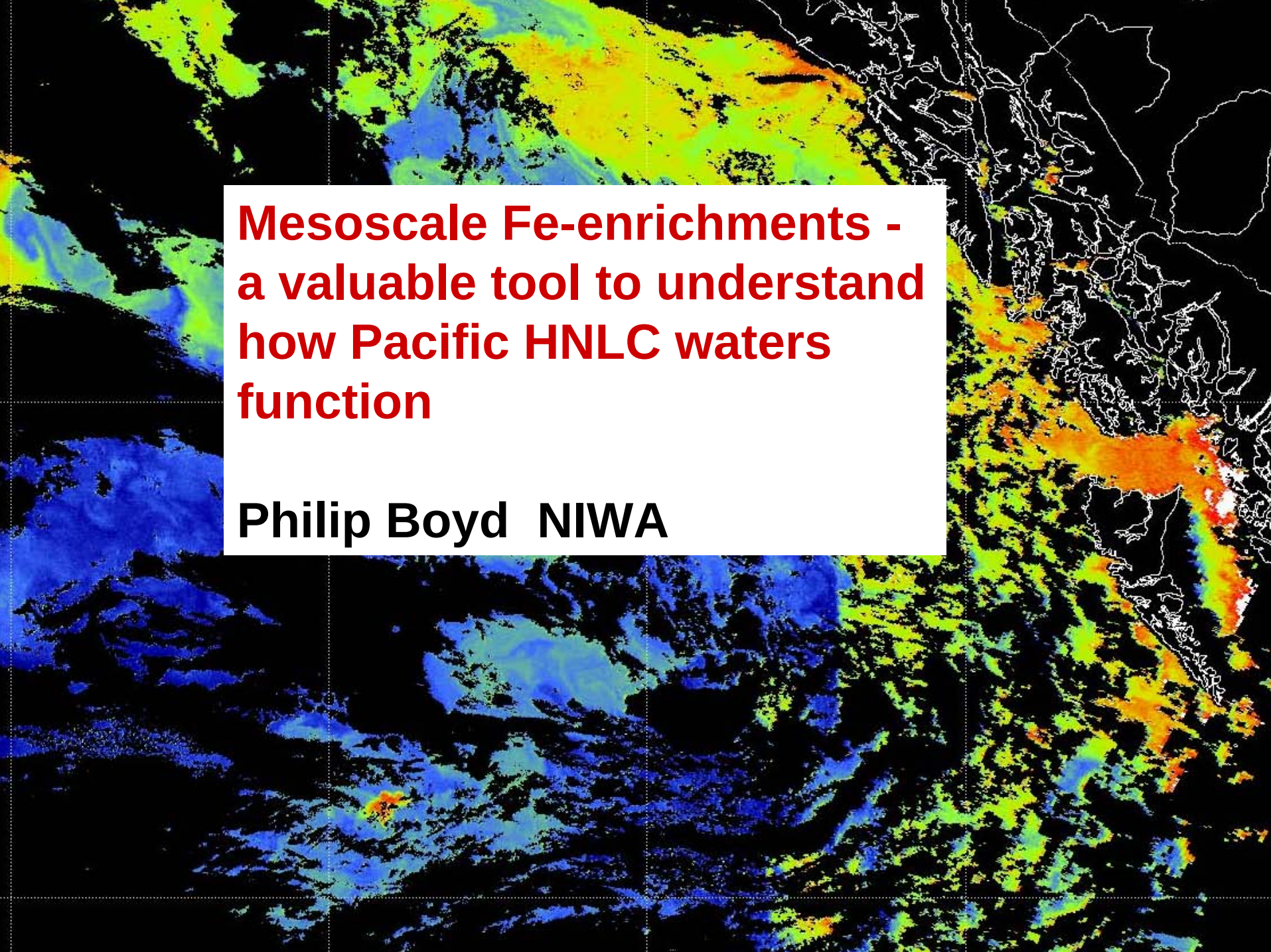


Mesoscale Fe-enrichments - a valuable tool to understand how Pacific HNLC waters function

Philip Boyd NIWA

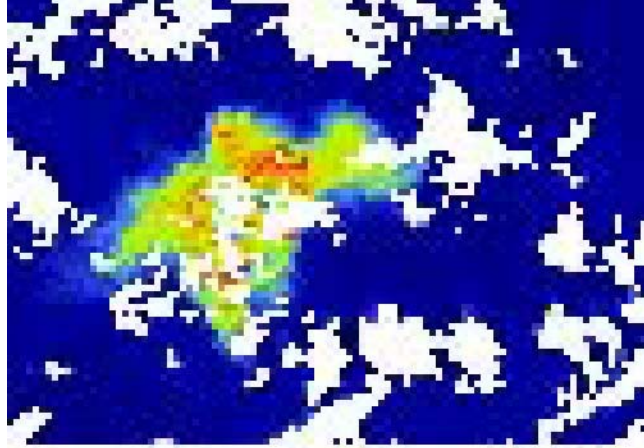
OUTLINE

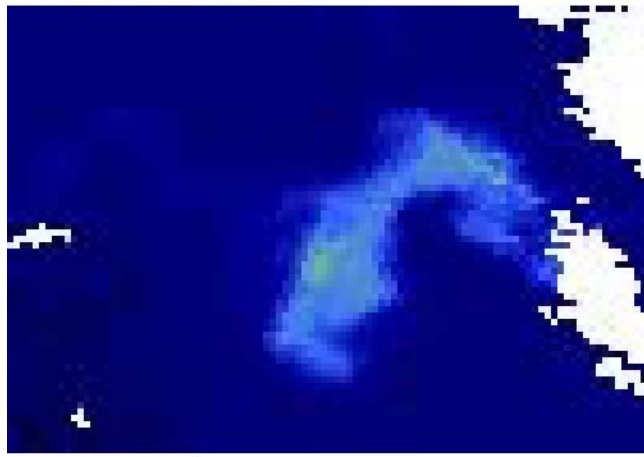
a) 11 mesoscale iron-enrichment experiments - main trends from global synthesis

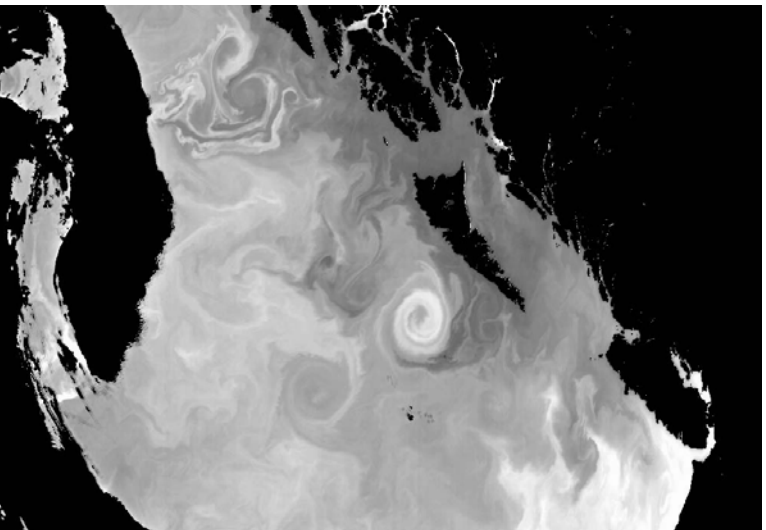
b) Comparison of NW and NE Pacific iron experiments

c) Implications for N Pacific Fe biogeochemistry

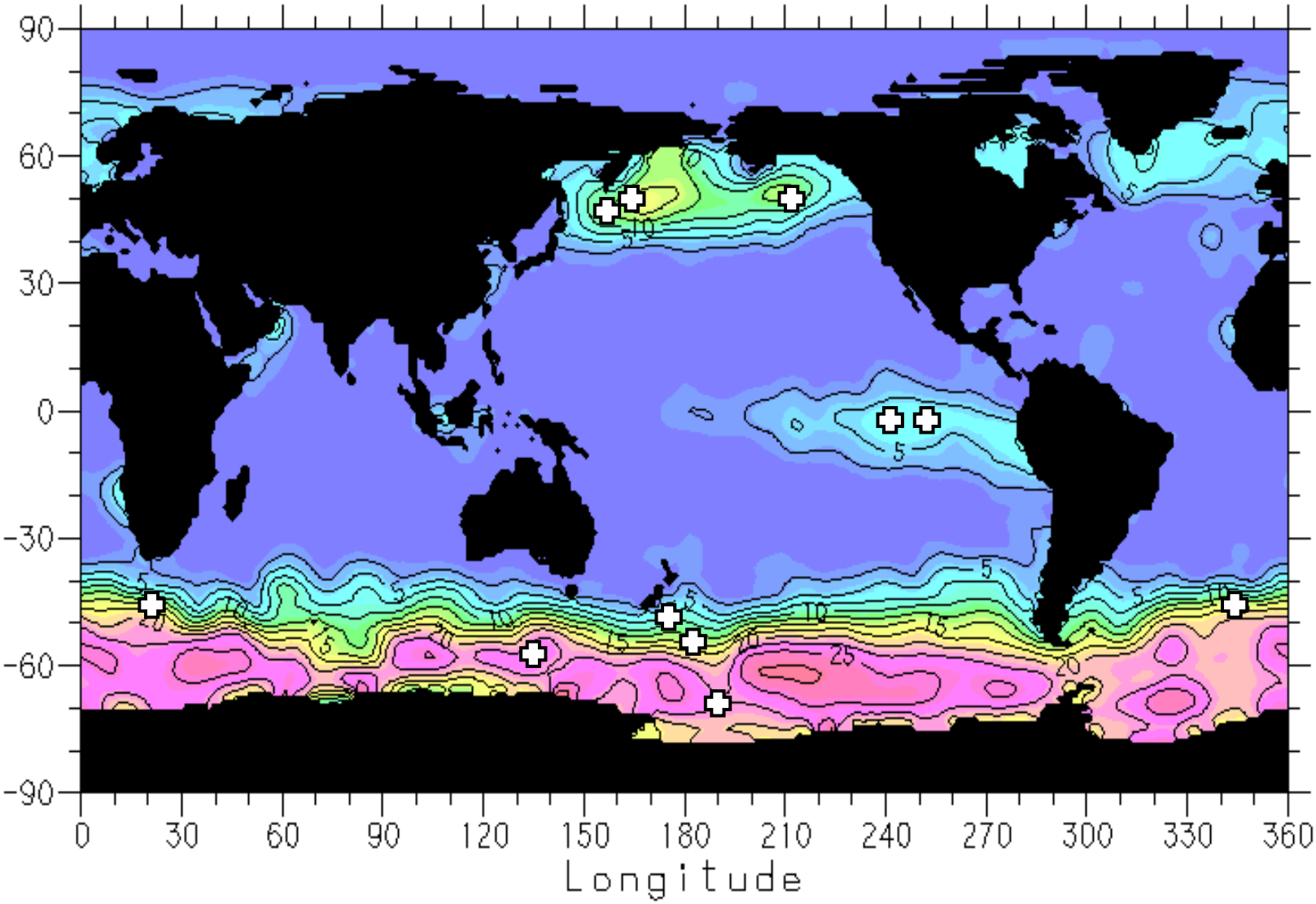
d) Recommendations for future experimental and modeling studies



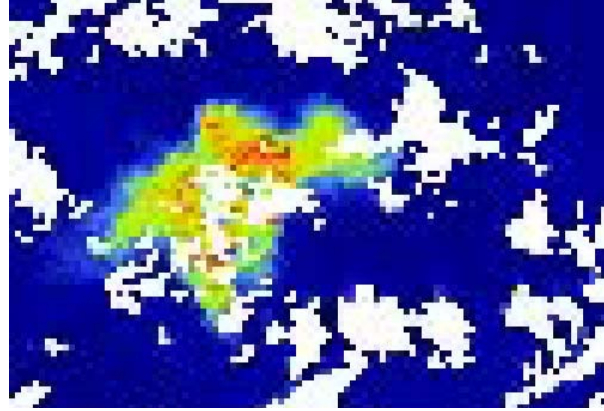




1993 to 2004 – 11 Mesoscale Fe experiments in HNLC waters

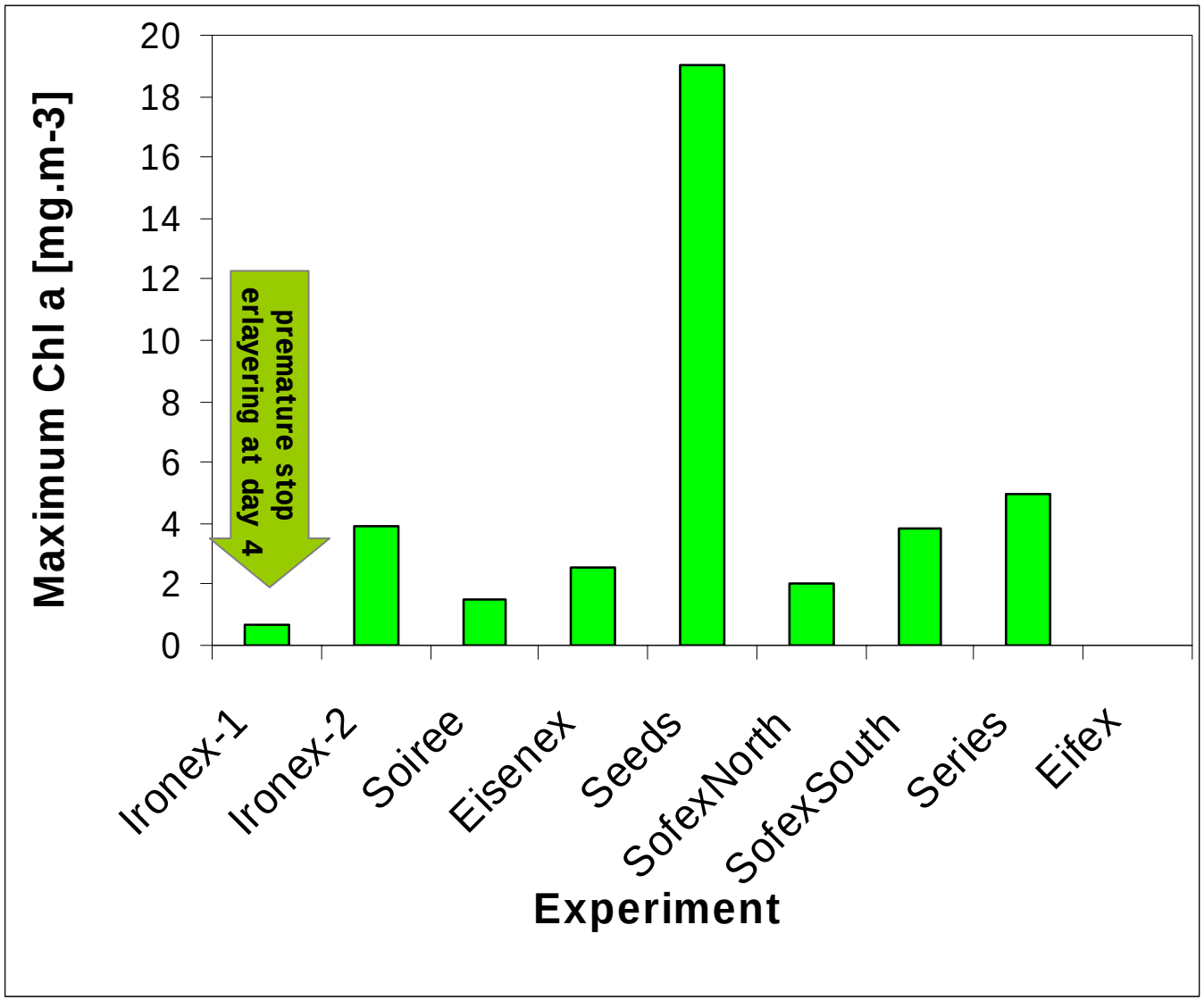


Range of environmental conditions for Fe experiments



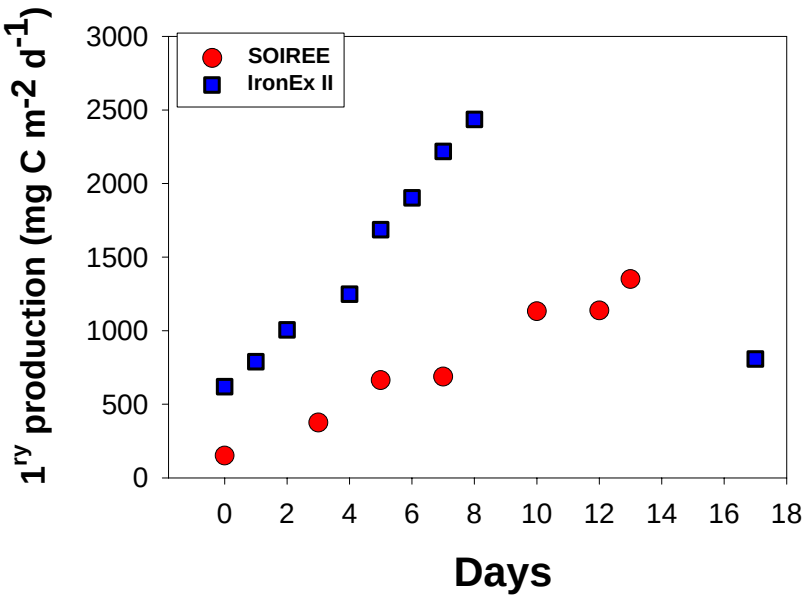
• Temperature	• -1 to > 24 C
• Mixed-layer depth	• 13 to 100 m
• Light climate	• 45 to 250 umol m^{-2} s^{-1}
• Silicic acid	• 2 to 60 umol l^{-1}
• Dissolved Fe	• 0.04 to 0.10 nmol l^{-1}
• Chlorophyll	• 0.2 to 0.9 ug l^{-1}
• Season	• Spring to autumn
• F_v/F_m	• 0.2 to 0.3

A wide range in bloom signatures



De Baar et al. 2005

Many of the bloom observations are consistent with well established oceanographic relationships

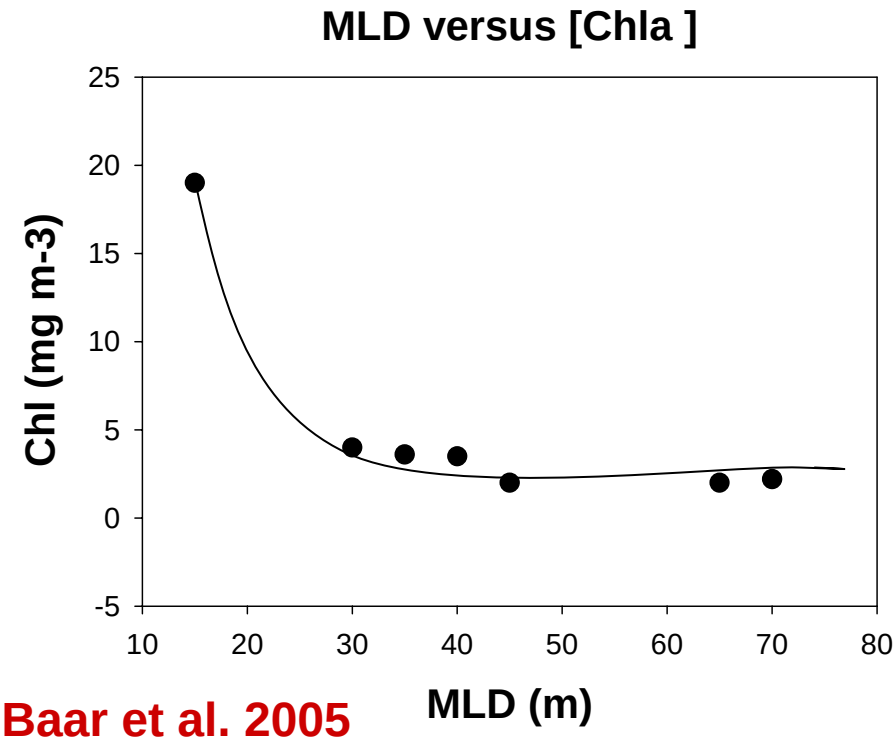


Sverdrup's Critical Depth Theory

Mitchell et al. (1991)

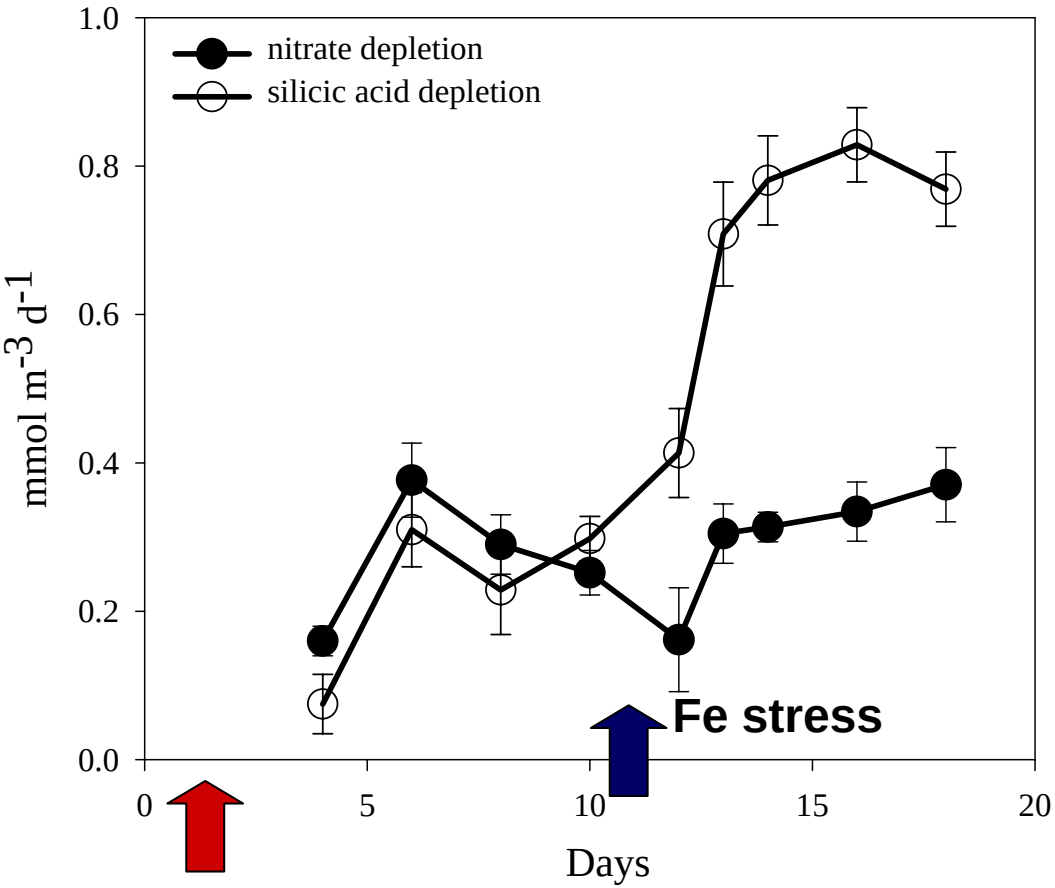
$P_b$opt
Algal growth rate
Vs. temperature

Eppley 1975



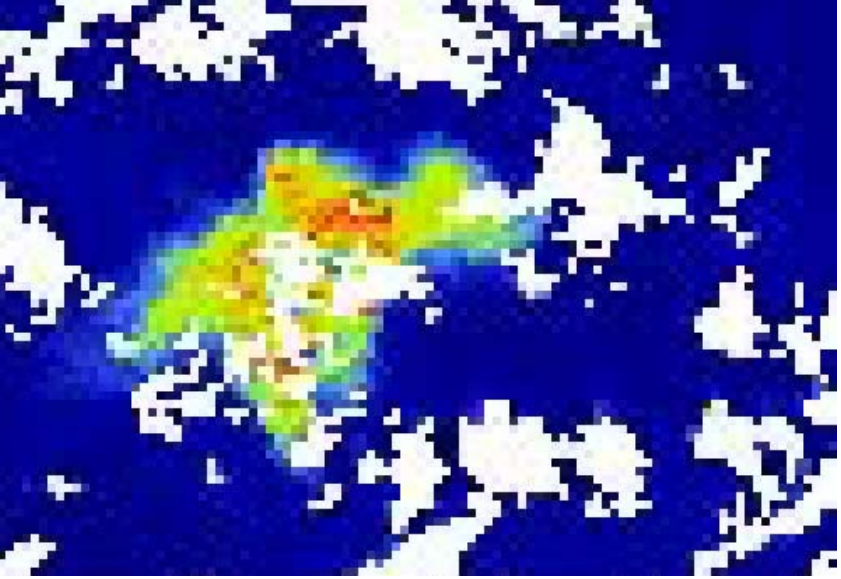
De Baar et al. 2005

Many algal processes are altered by Fe supply
Physiology, floristics etc.

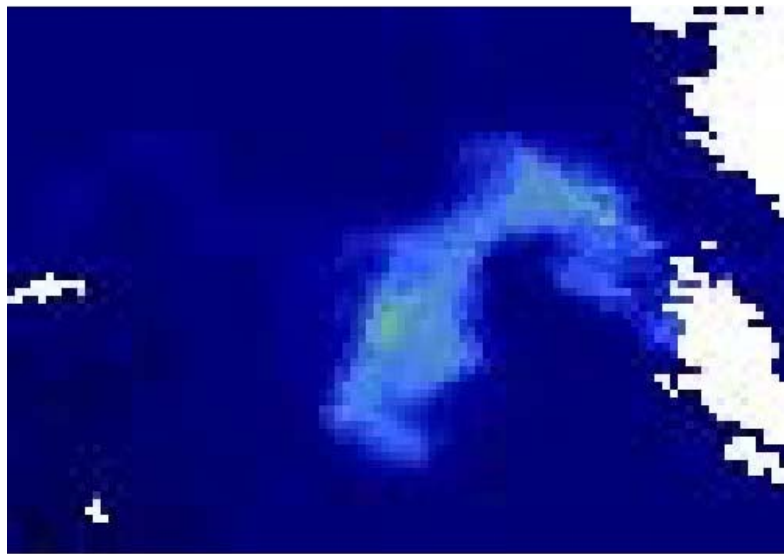


Fe supply

Boyd et al 2005 L&O

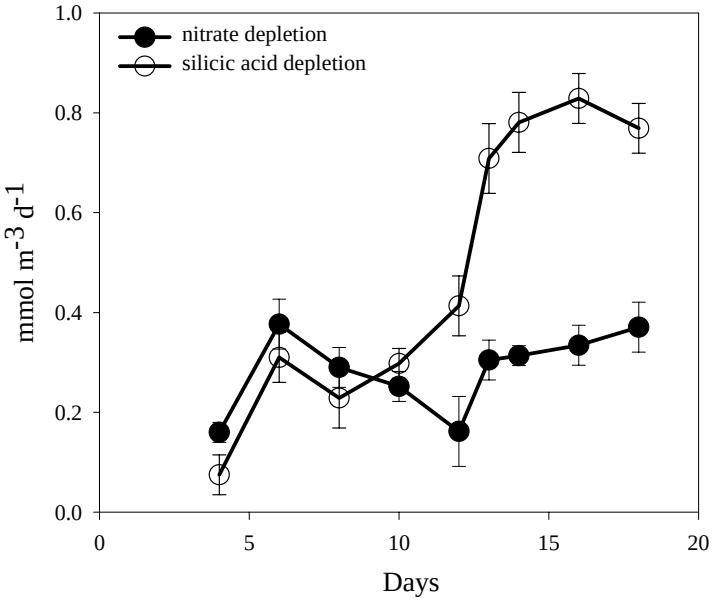


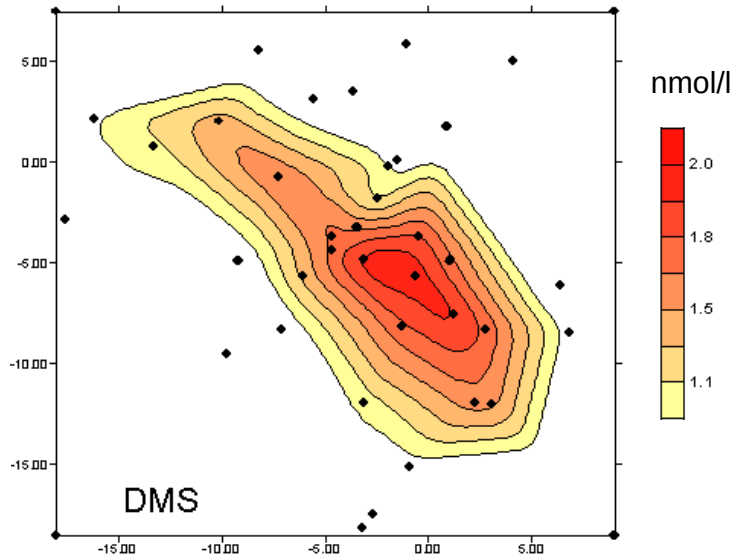
Mesoscale Fe enrichments enable us to determine the lag phase between bloom development and decline

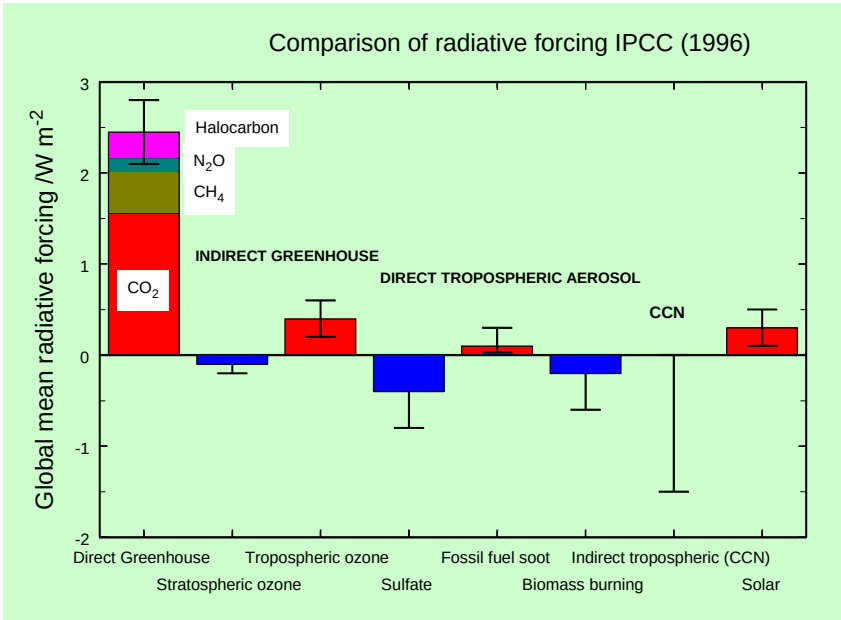


Boyd et al
2005 L&O

Fe supply impacts the biogeochemical cycles of multiple elements

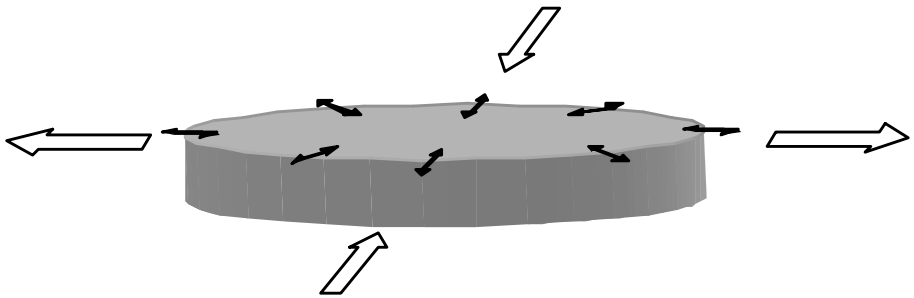






All mesoscale Fe experiments reveal significant entrainment of surrounding HNLC waters – i.e. experimental artefacts

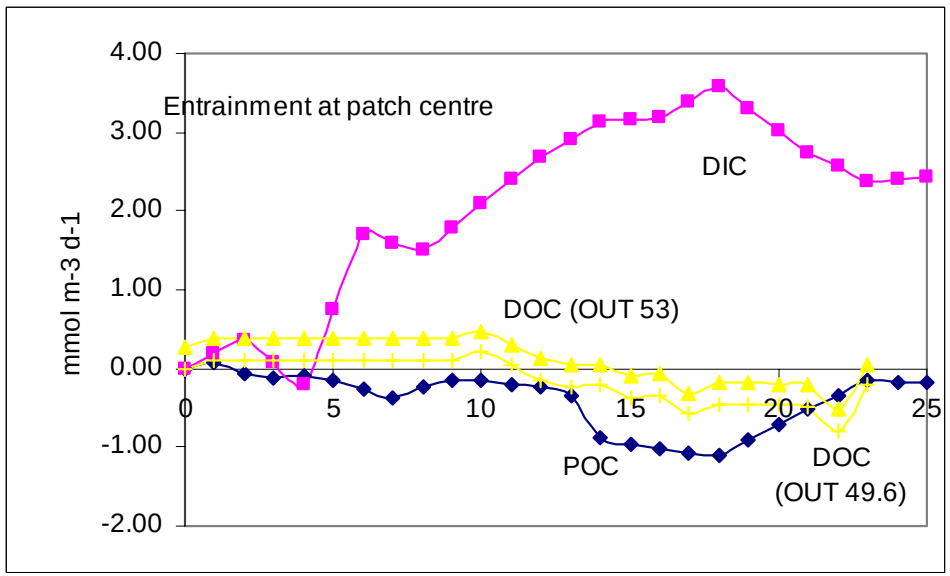
This in turn modifies the biogeochemical signature of the Fe-stimulated bloom



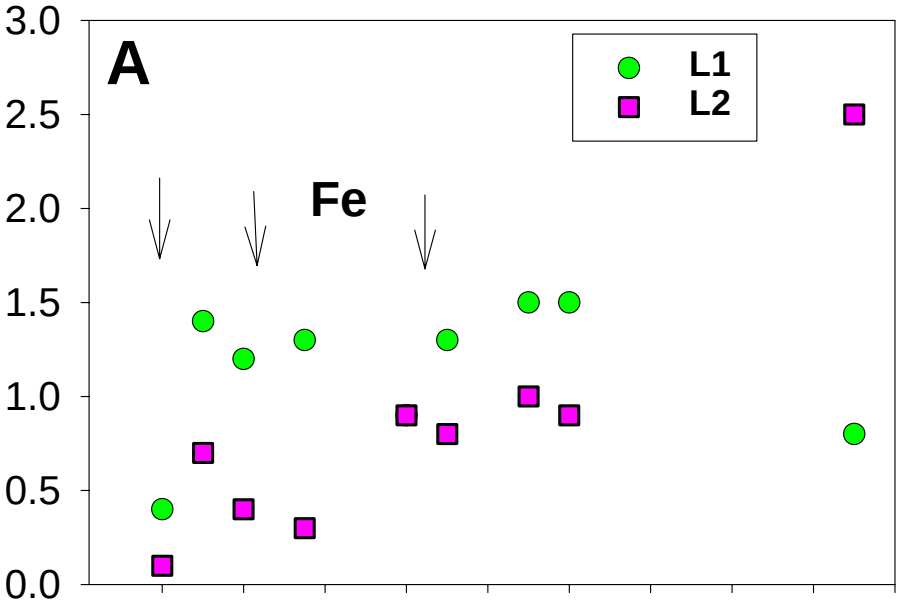
Stretching via horizontal flows

Mixing of water by horizontal diffusion

Law et al. 2006

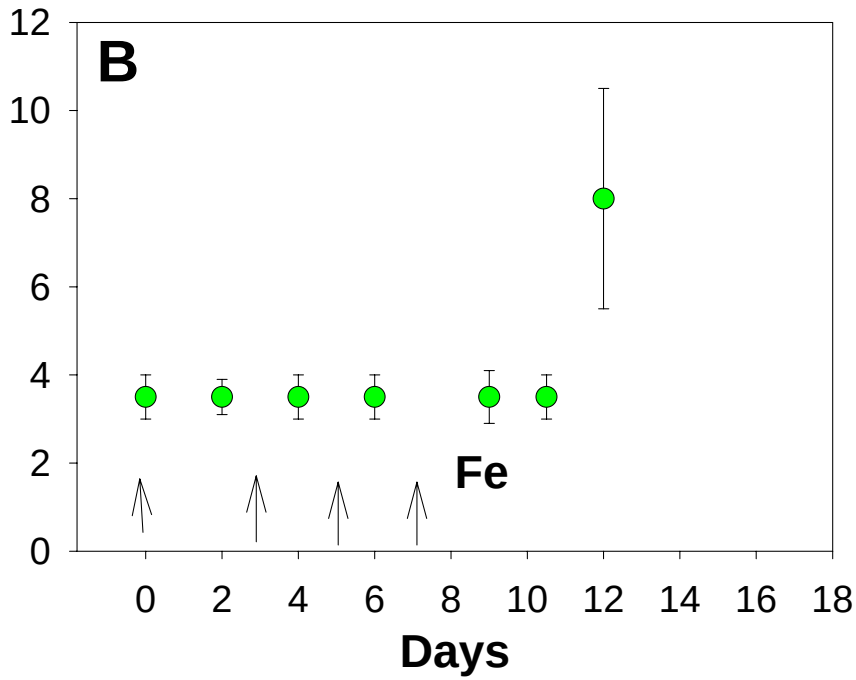


Fe-enrichments have enabled us to investigate aspects Of Fe chemistry in detail



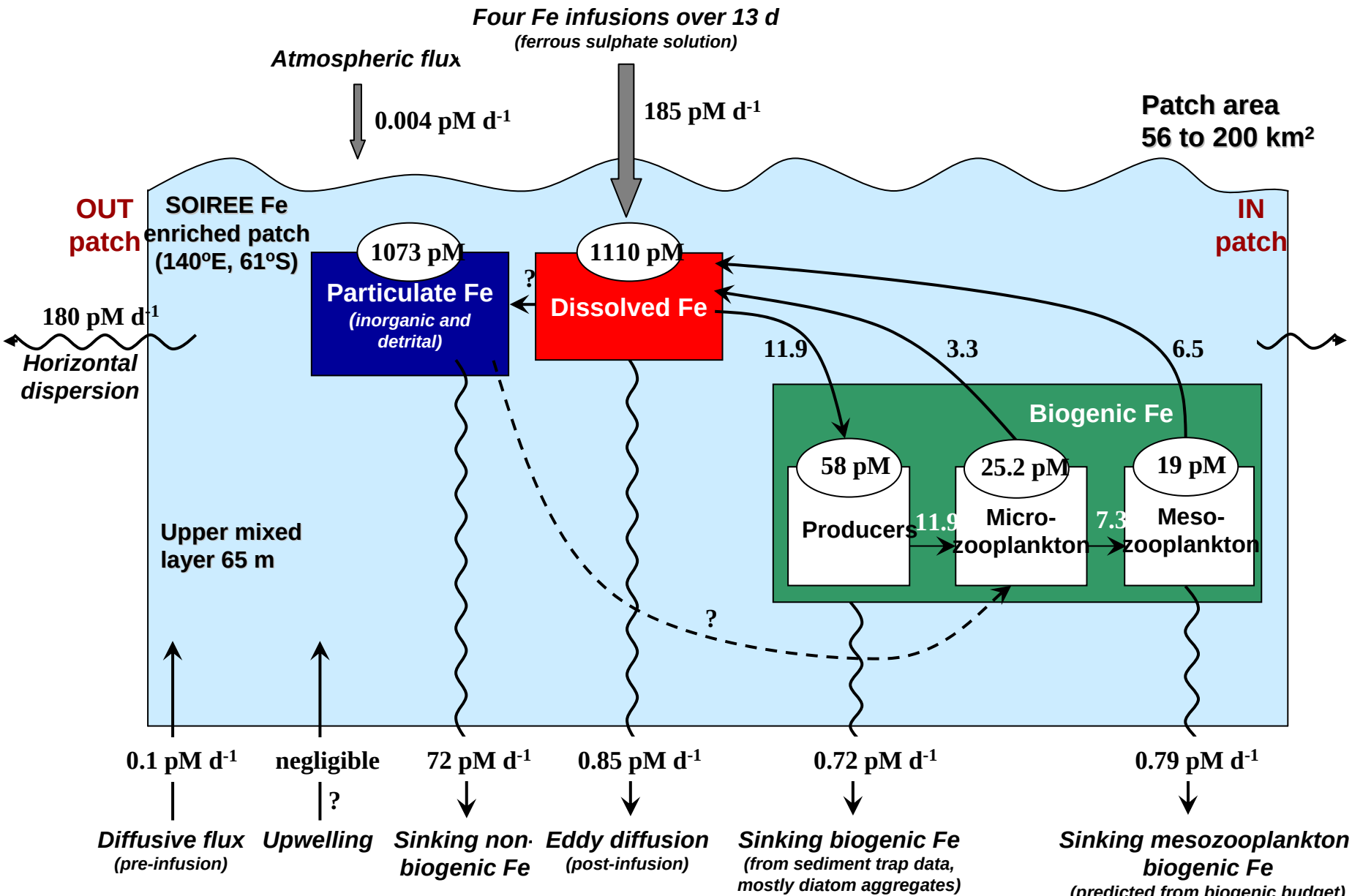
Boyd 2002

Such as the production of Fe-binding ligands (nM)

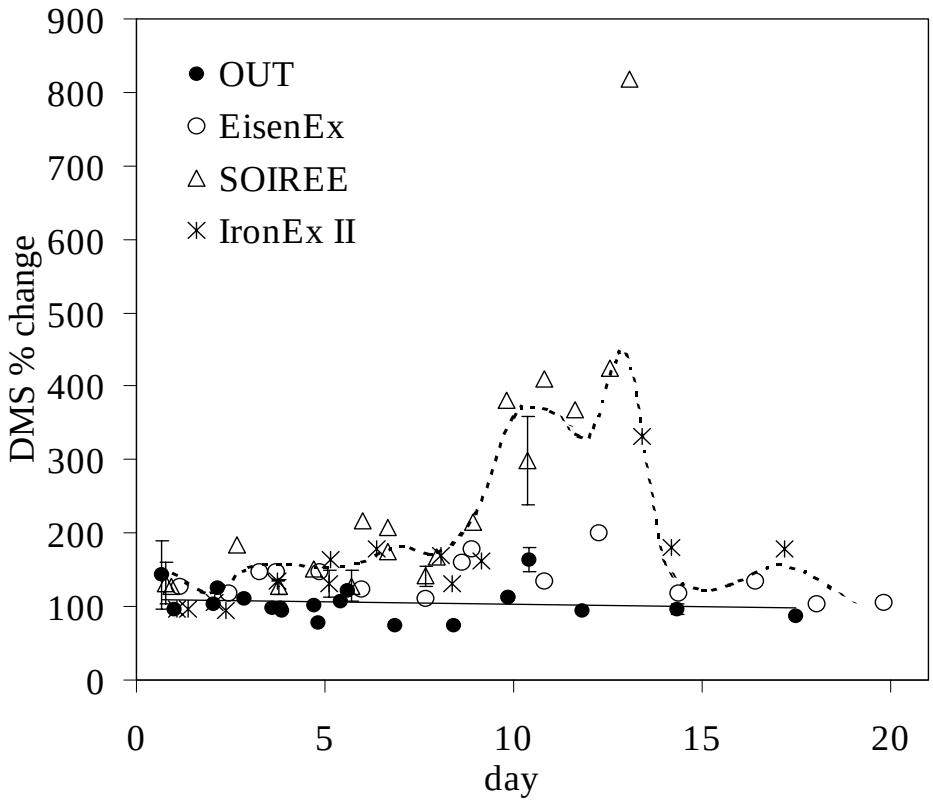


Mesoscale experiments in conjunction with SF_6-labelling facilitate budget development

Bowie et al. 2000



Mesoscale Fe experiments provide the datasets to test new conceptual models – such as in DMS dynamics

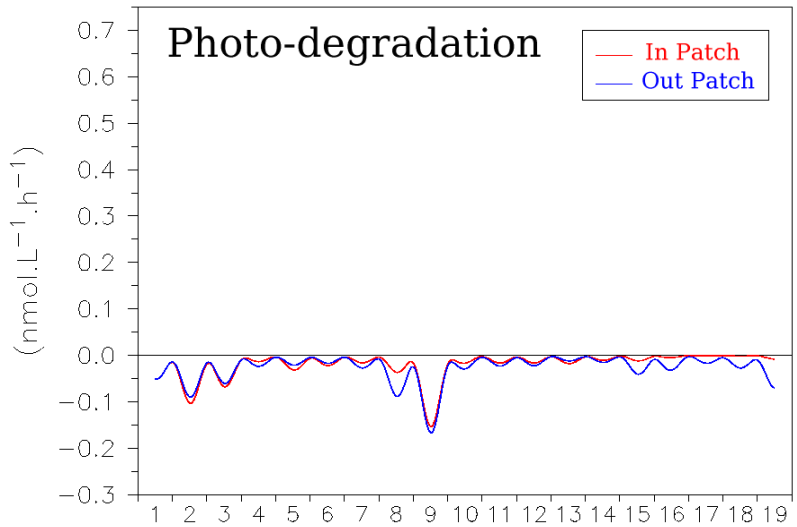


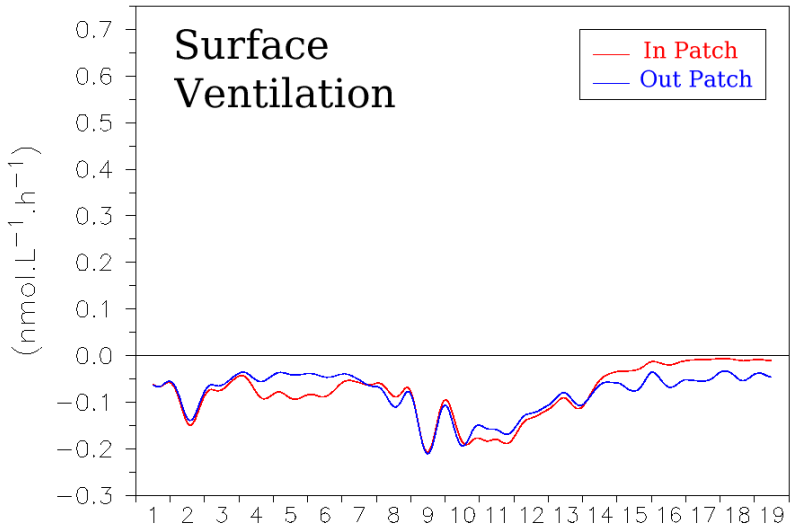
Turner *et al*. GRL 2004

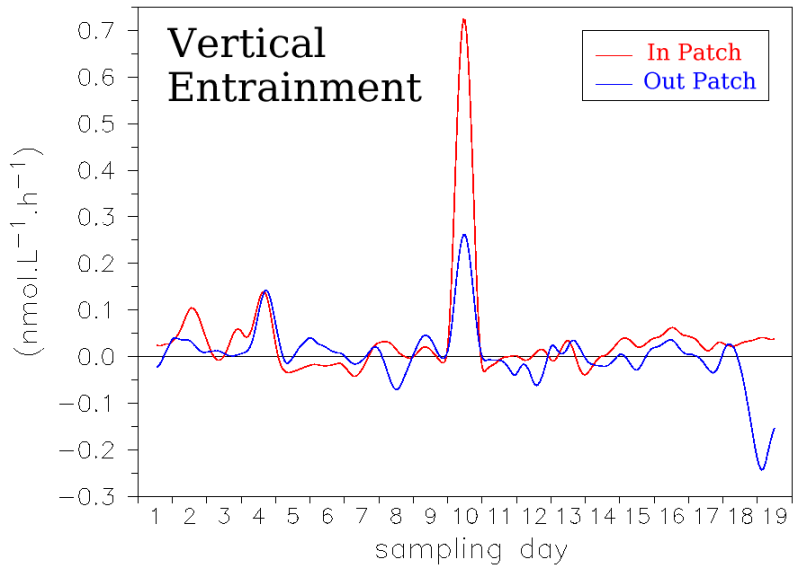
LeClainche et al. JGR 2005

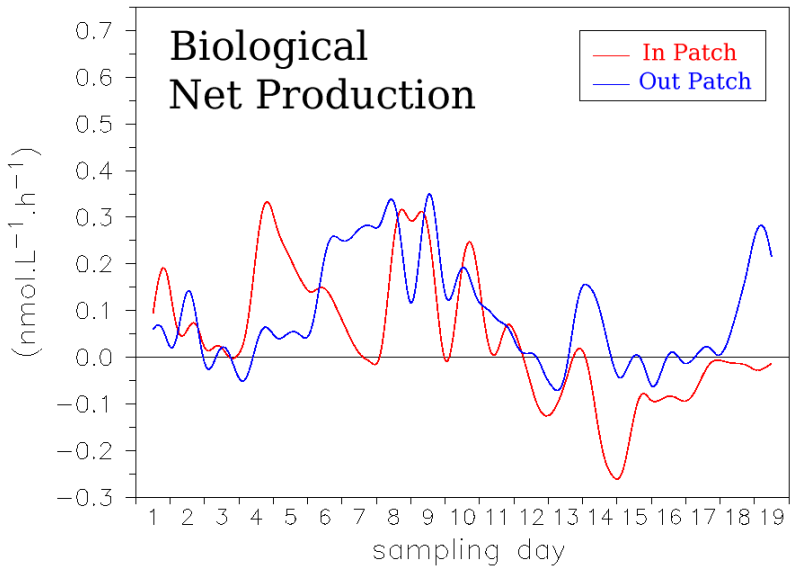
A model that examines the Interplay of physics, optics, floristics, microbial dynamics and ecosystem structure on DMS

The relative importance of physical and biological processes on DMS pool

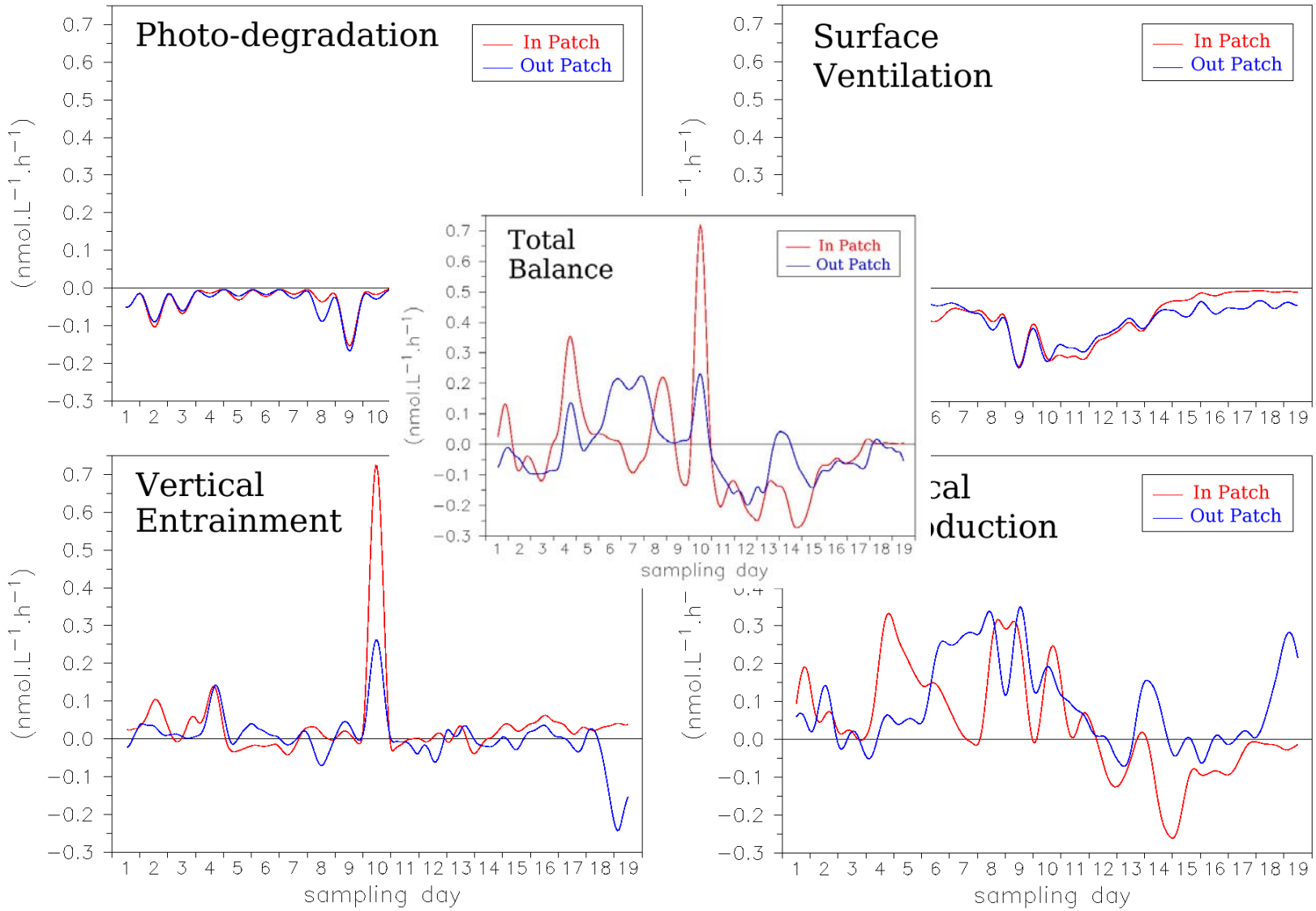




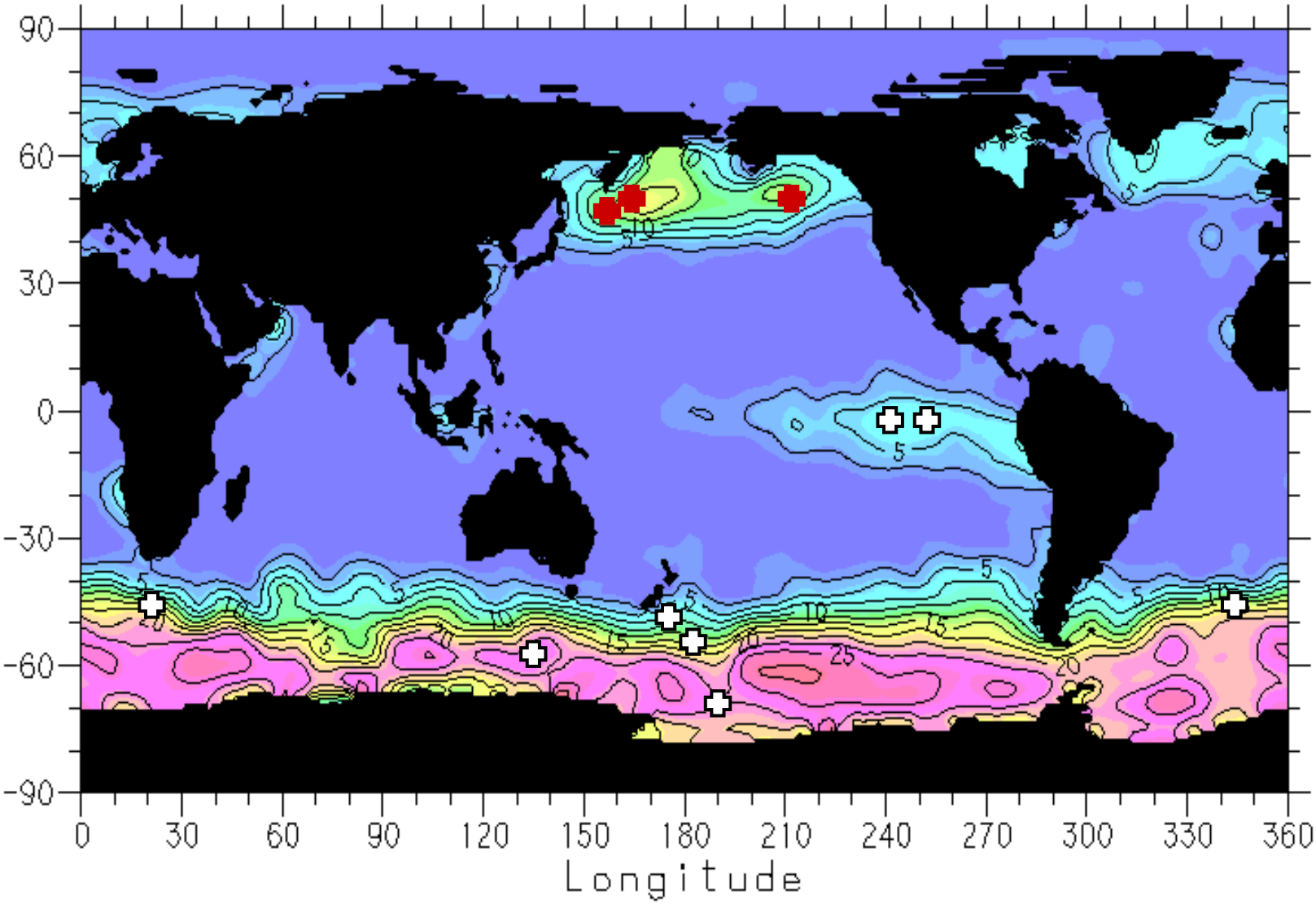




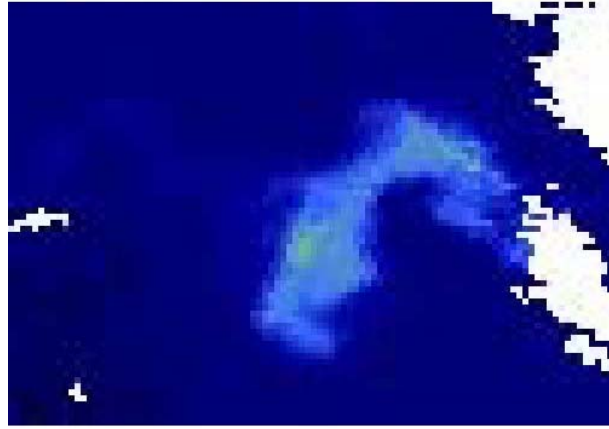
The relative importance of physical and biological processes on DMS pool



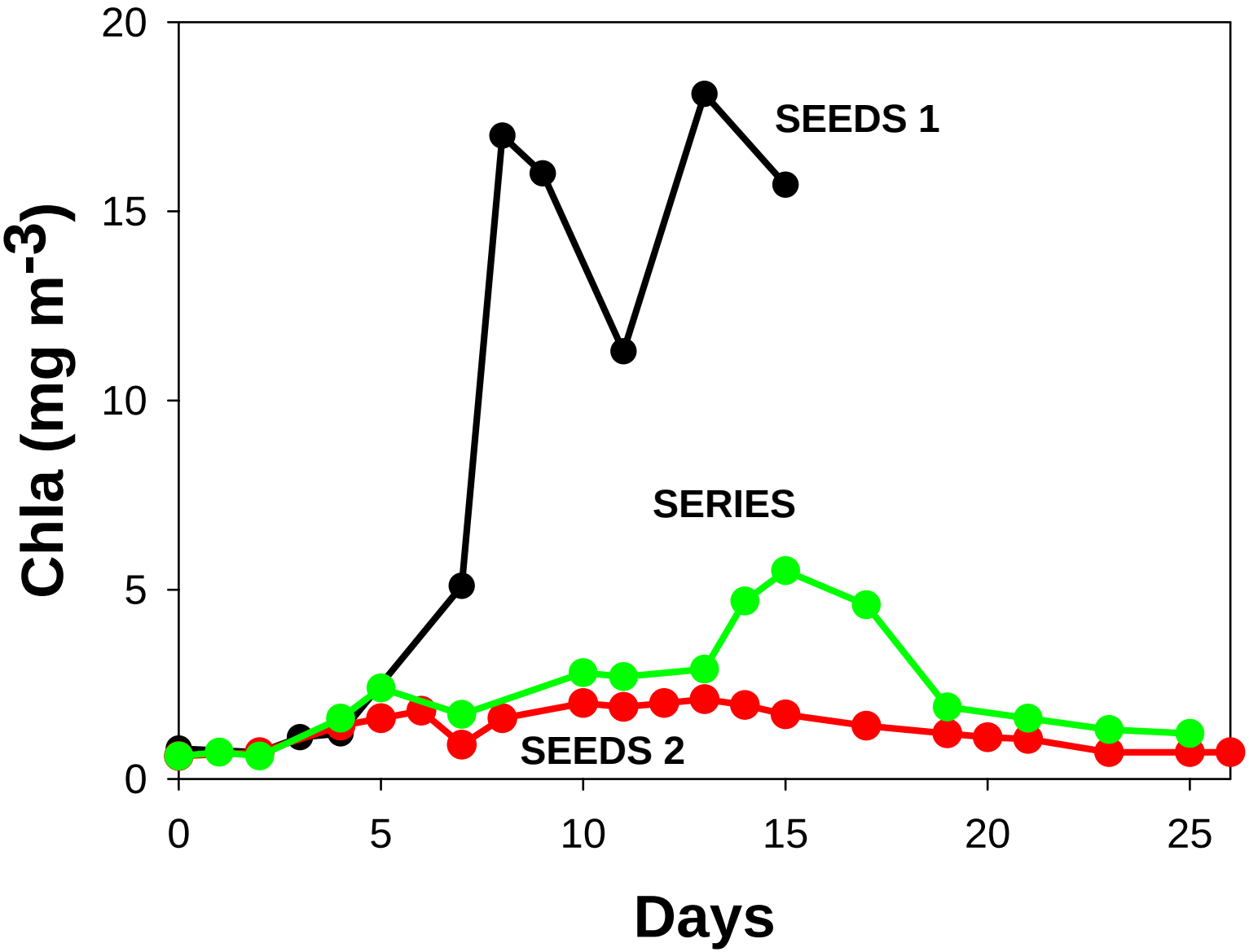
N Pacific mesoscale Fe experiments in HNLC waters



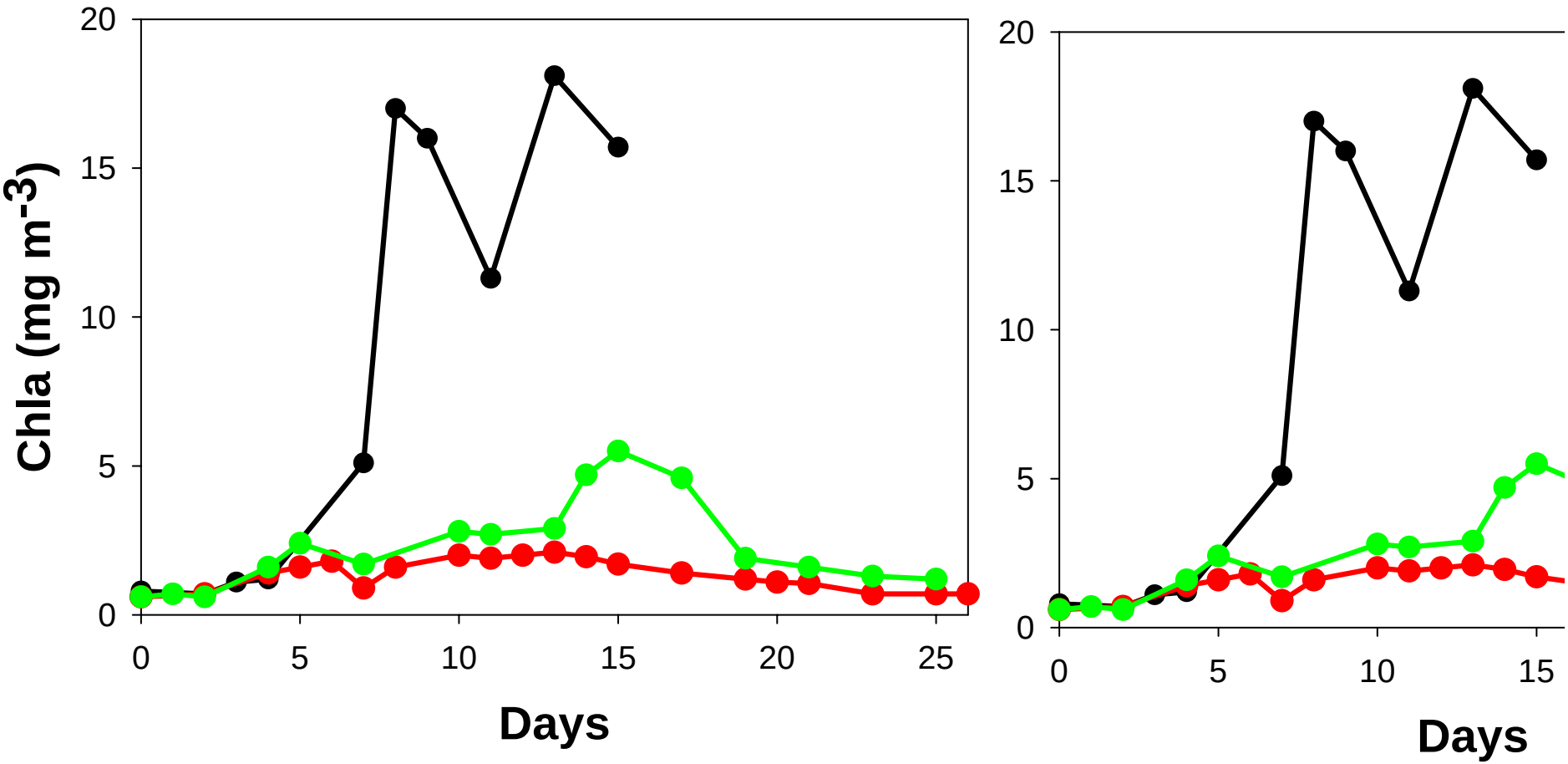
Environmental conditions for N Pacific experiments

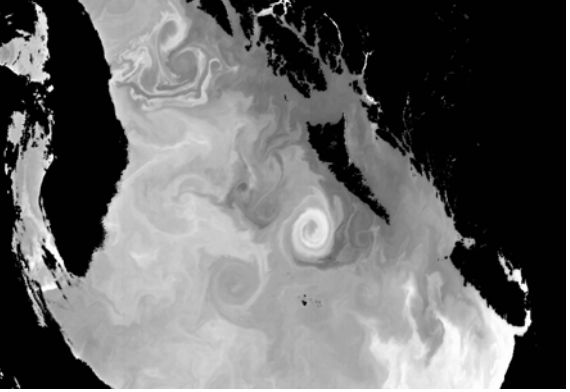


• Temperature	• 11 to 13 C
• Mixed-layer depth	• 13 to 30 m
• Light climate	• 140 to 173 umol m^{-2} s^{-1}
• Silicic acid	• 14 to 34 umol l^{-1}
• Dissolved Fe	• 0.04 to 0.08 nmol l^{-1}
• Chlorophyll	• 0.4 to 0.9 ug l^{-1}
• Season	• Summer
• F_v/F_m	• 0.2 to 0.3

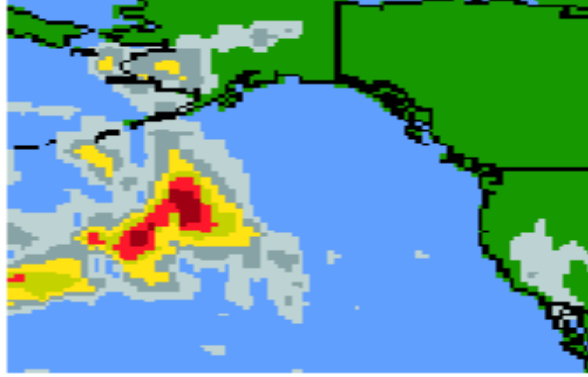

20
15
10
5
0
Chla (mg m-3)
SEEDS 1
SERIES
SEEDS 2
0
5
10
15
20
25
Days

Importance of the duration of the study to our interpretation of the bloom signature





Application of Fe experiments to the N Pacific



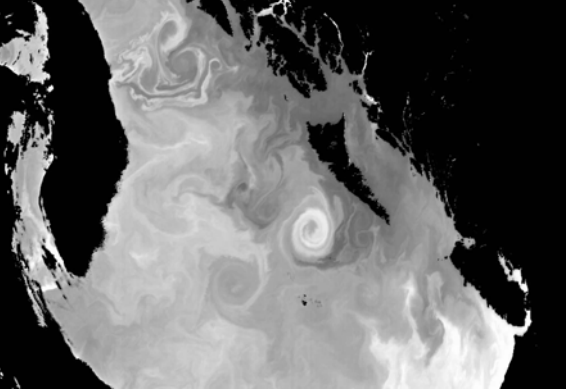
a) Experiments provide a good general model of the impacts of Fe-enrichment on ecosystem function and biogeochemistry

b) Detection of episodic Fe inputs using proxies, increased chlorophyll, diatom biomass, F_v/F_m – use of remote-sensing, autonomous floats and survey voyages

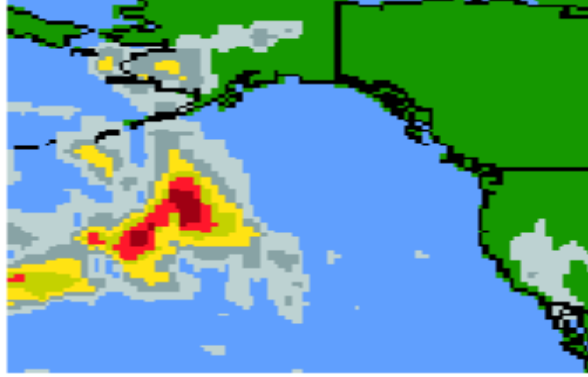
c) Identification and comparison of natural Fe inputs in N Pacific – mode of Fe supply and temporal and spatial scales

d) Comparison of natural Fe inputs in N Pacific – Fe:nutrient stoichiometry etc.

e) Monitoring natural Fe supply using time-series and/or proxies – climate variability and change



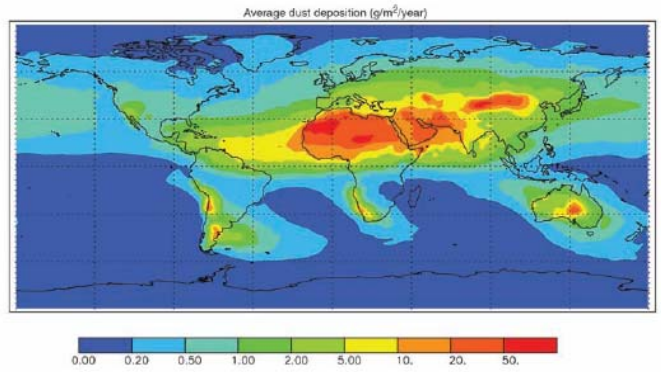
Monitoring natural Fe supply to the N Pacific



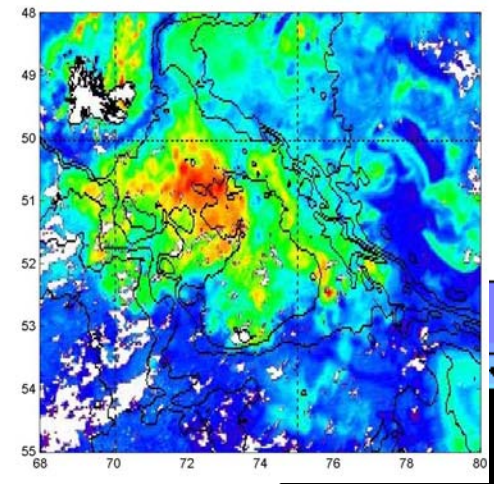
a) Different approaches to study different Fe sources – eddies versus dust events – ship-based studies on eddies

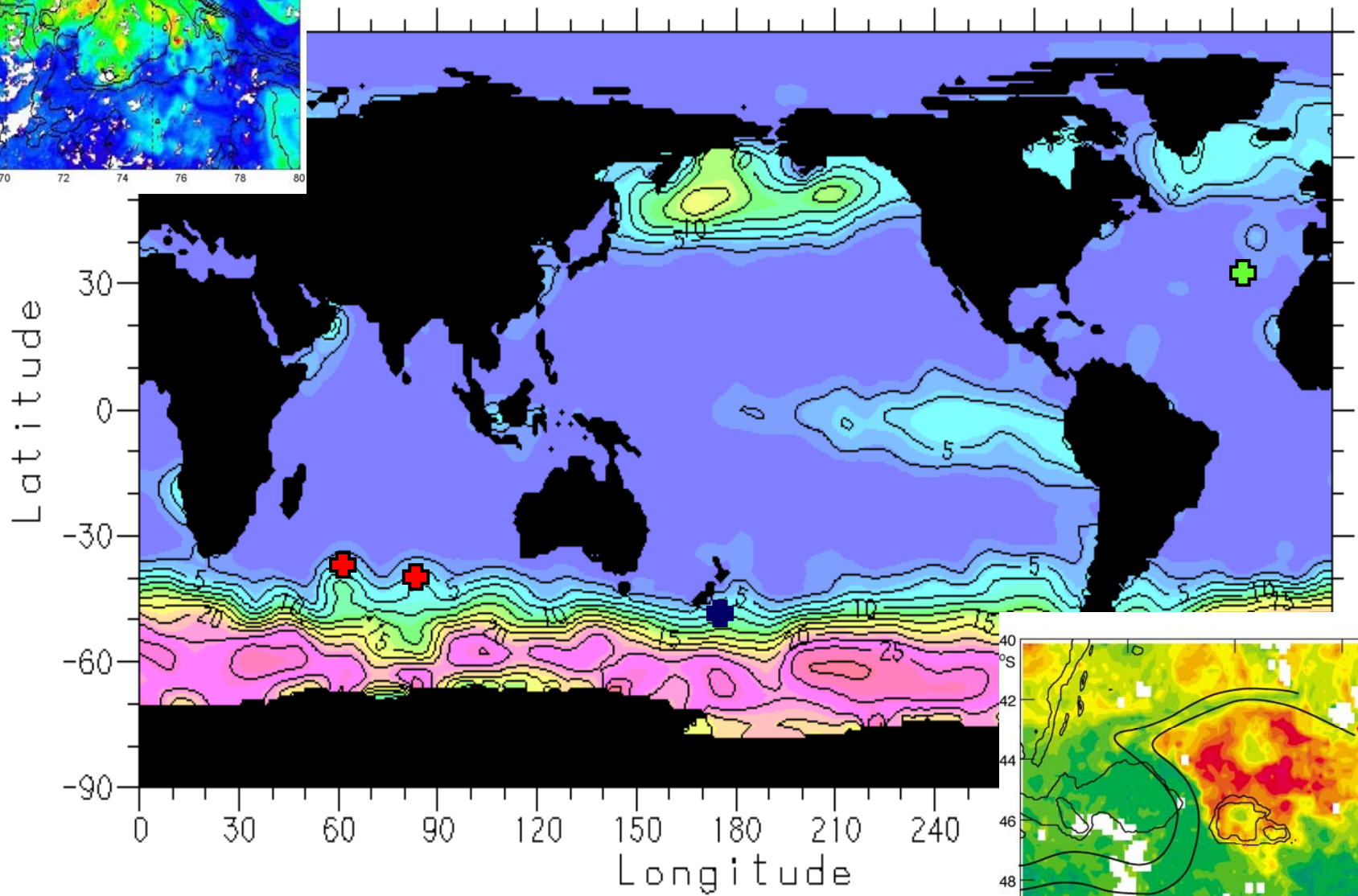
b) Need for intensive sampling - use of new technologies and approaches– gliders, aerosol sampling buoys, ships-of-opportunity, Fe isotopes, space-borne LIDAR

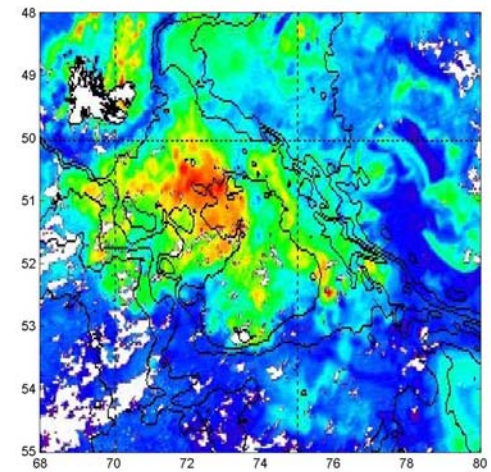
c) Forcing of Fe supply events – modelling and better understanding of how they will vary/change over time



New approaches to studying Fe-enrichment and biogeochemistry







Conclusions

- **Fe-enrichments – time for synthesis, data compilation and modelling**
- **Fe-enrichments – time to reappraise their design – new approaches + utility of deckboard experiments**
- **Need to better relate Fe-enrichment experiments to natural Fe enrichments**
- **Fe biogeochemistry – relating observations from GEOTRACES, SOLAS, to findings from all types of Fe experiments**