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Santos city, Brazil, 23-27 March 2015

High variability of dissolved iron concentrations in the vicinity of the Kerguelen Islands (Southern Ocean)

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Townsend A.T.⁴, Bucciarelli E.¹, Planquette H.F.¹, Cheize M.¹, Blain S.⁵,
d'Ovidio F.⁶ and Bowie A.R.^{2,3}

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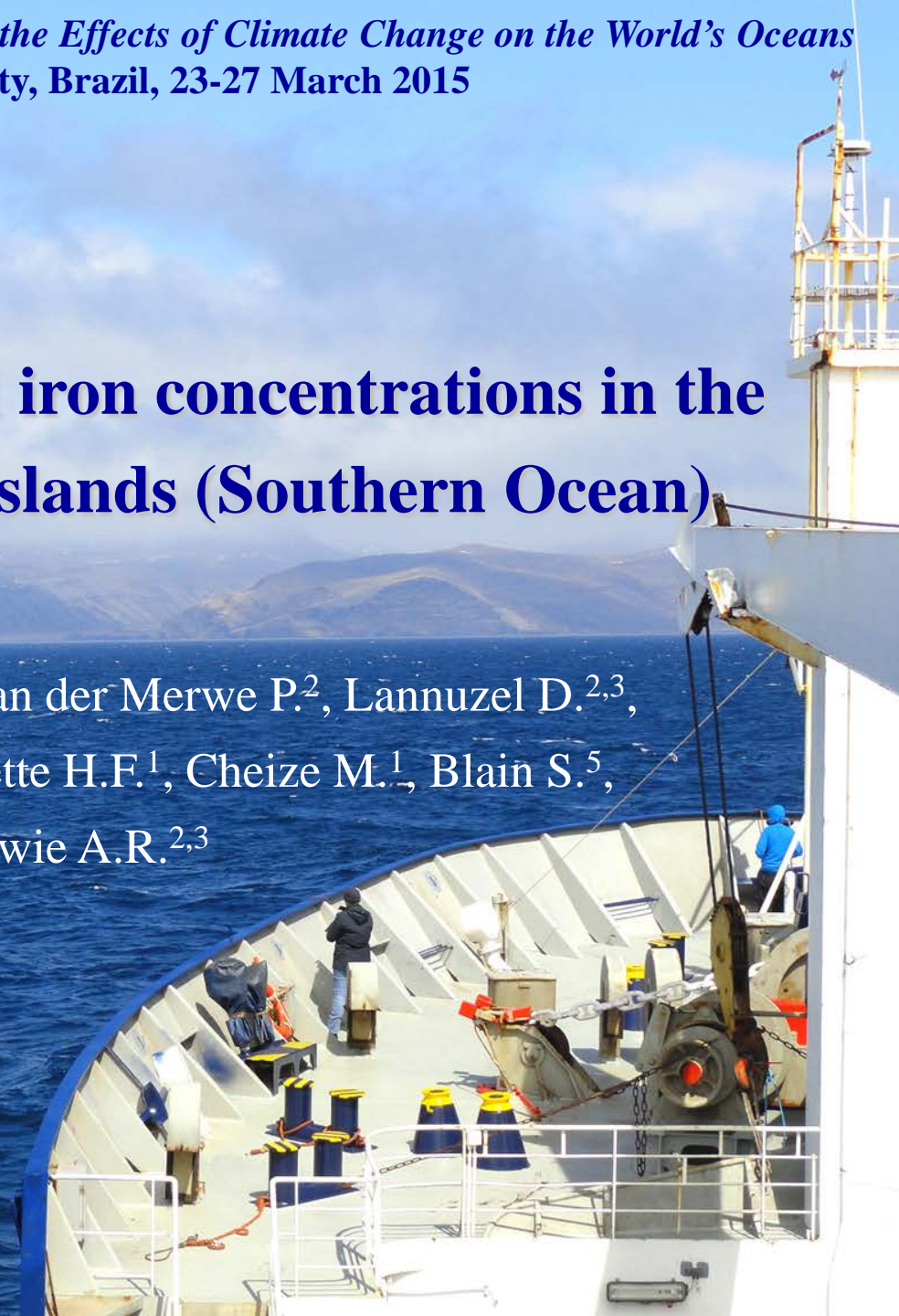
³IMAS, University of Tasmania, Hobart, Australia

⁴Central Science Laboratory, University of Tasmania, Hobart, Australia

⁵LOMIC-UMR 7621, Banyuls sur mer, France

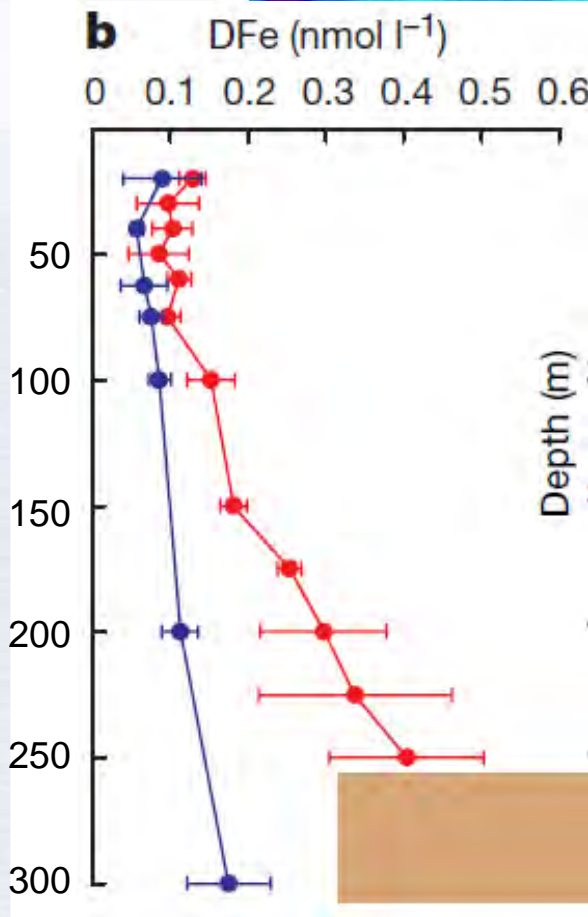
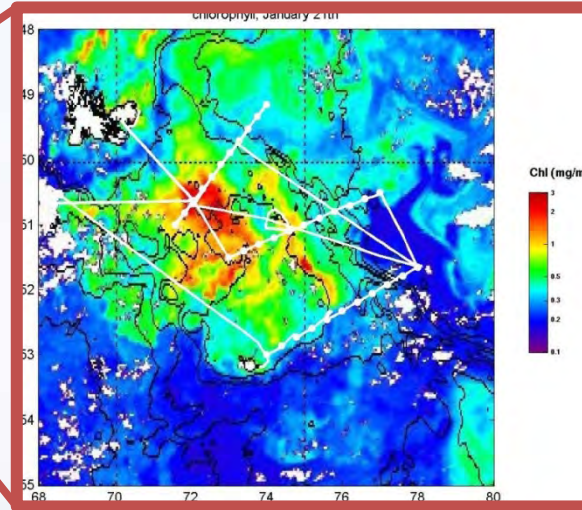
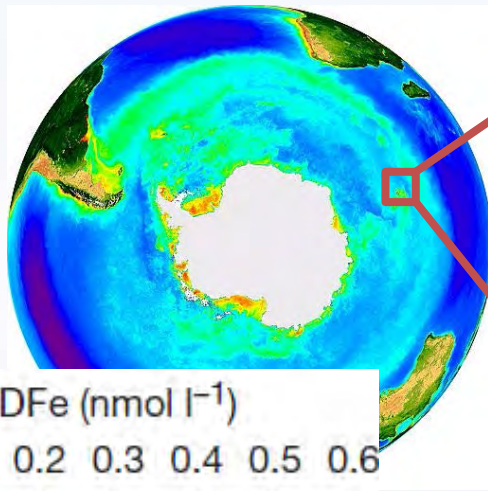
⁶LOCEAN-IPSL, Paris, France

Qu  rou   et al., *Biogeosciences Discuss.*, 12, 231–270





The KEOPS 1 experiment (Jan.-Feb. 2005)

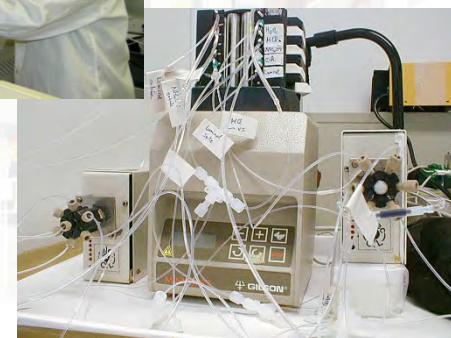
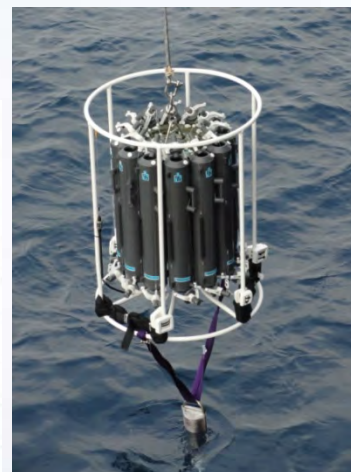
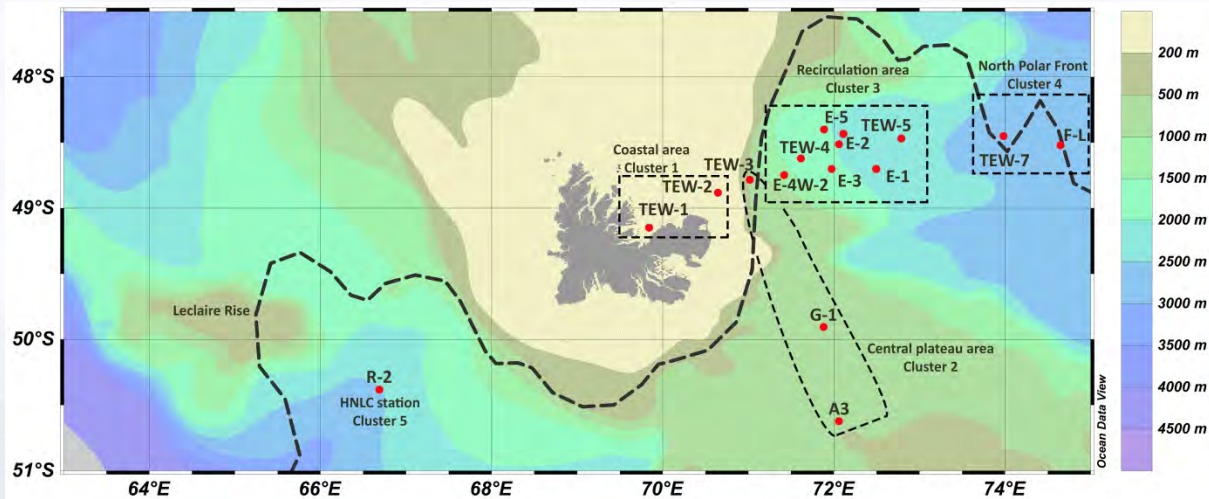


- Fe fertilization (Blain et al., 2007; 2008; Chever et al., 2010; van Beek et al., 2008):**
- Deep Fe rich reservoir
 - Winter mixing
 - Vertical mixing
 - Horizontal advection



The KEOPS 2 experiment (Oct.-Nov. 2011)

Pre-bloom conditions, sources and transport of Fe, and impact on biological activity



✓ Sampling & analysis: **ultra clean techniques**

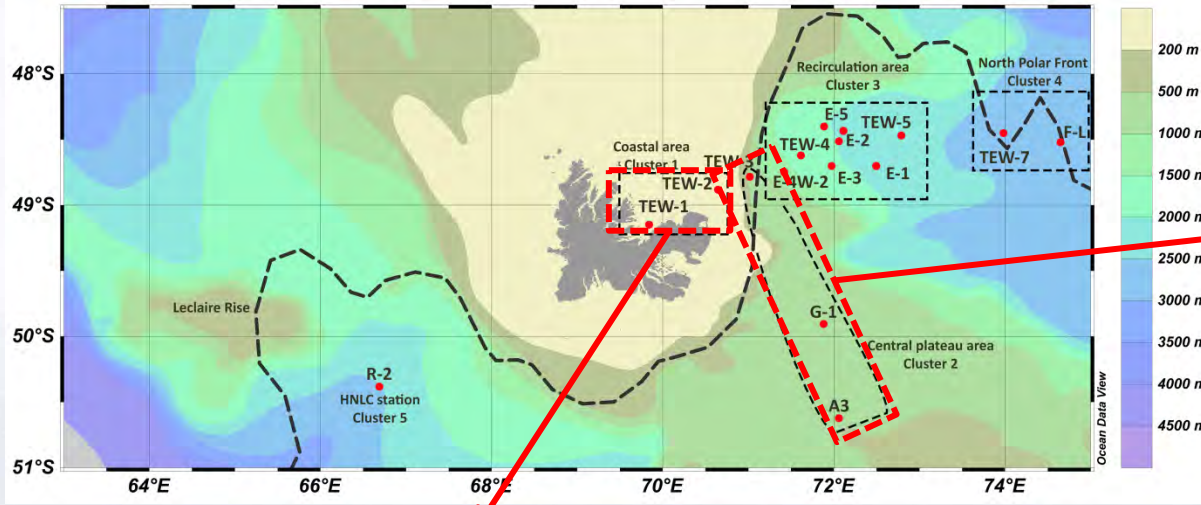
✓ **DFe:** Analysis by FIA with chemiluminescence detection (Obata et al., 1993). DL= 20 pM





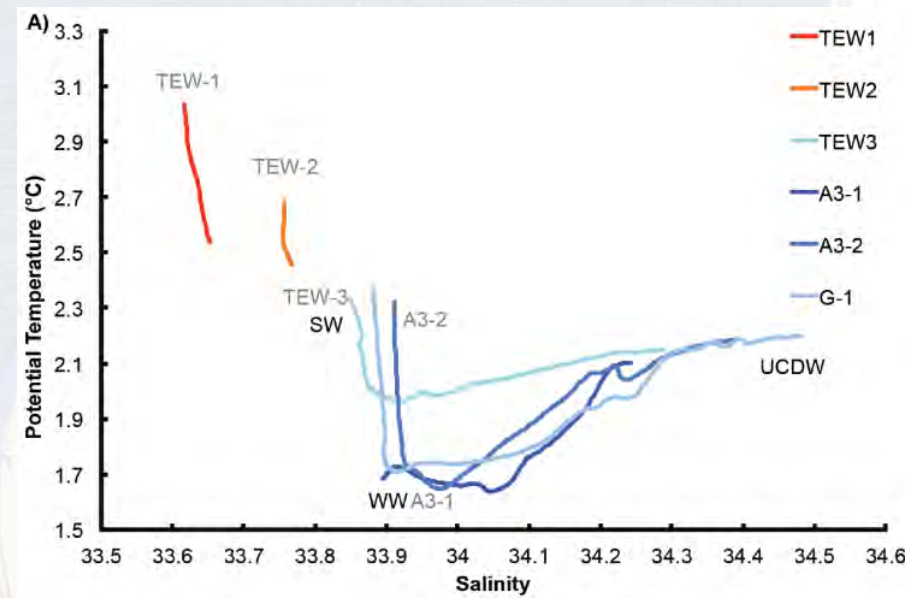
The KEOPS 2 experiment (Oct.-Nov. 2011)

Pre-bloom conditions, sources and transport of Fe, and impact on biological activity



Cluster 2: Plateau stations, depths < 600 m, T min ⇔ Winter Waters

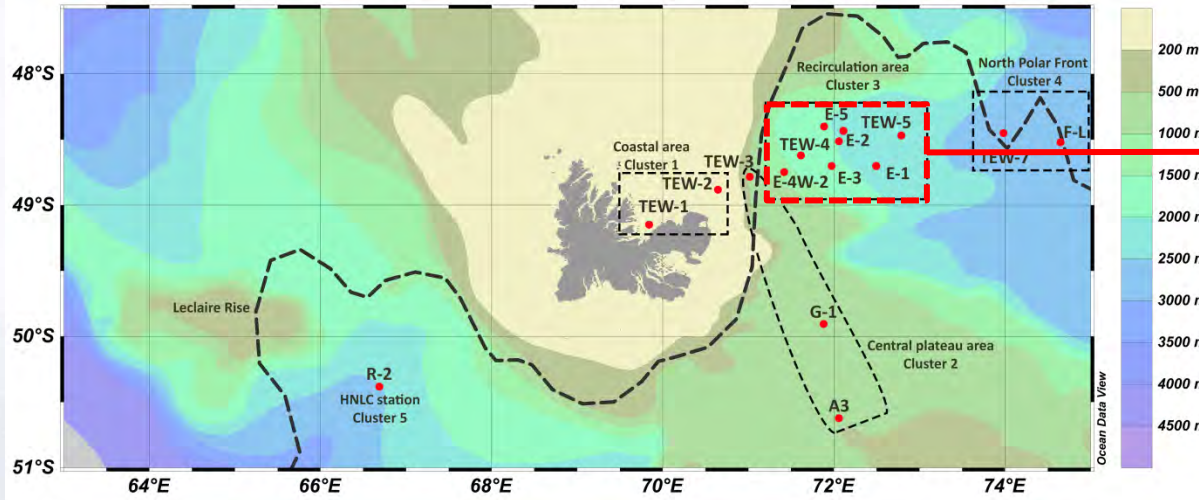
Cluster 1: near-coastal stations, depths < 85 m, low salinity



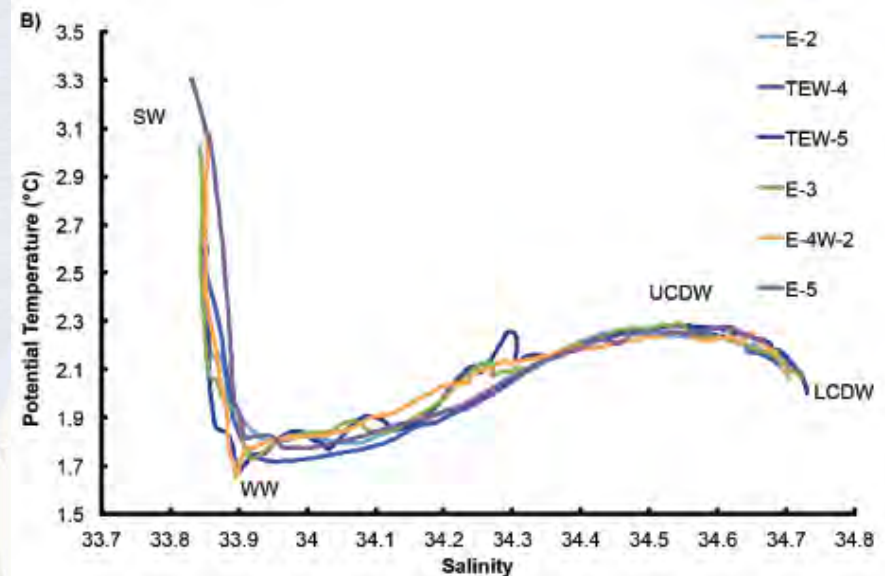


The KEOPS 2 experiment (Oct.-Nov. 2011)

Pre-bloom conditions, sources and transport of Fe, and impact on biological activity



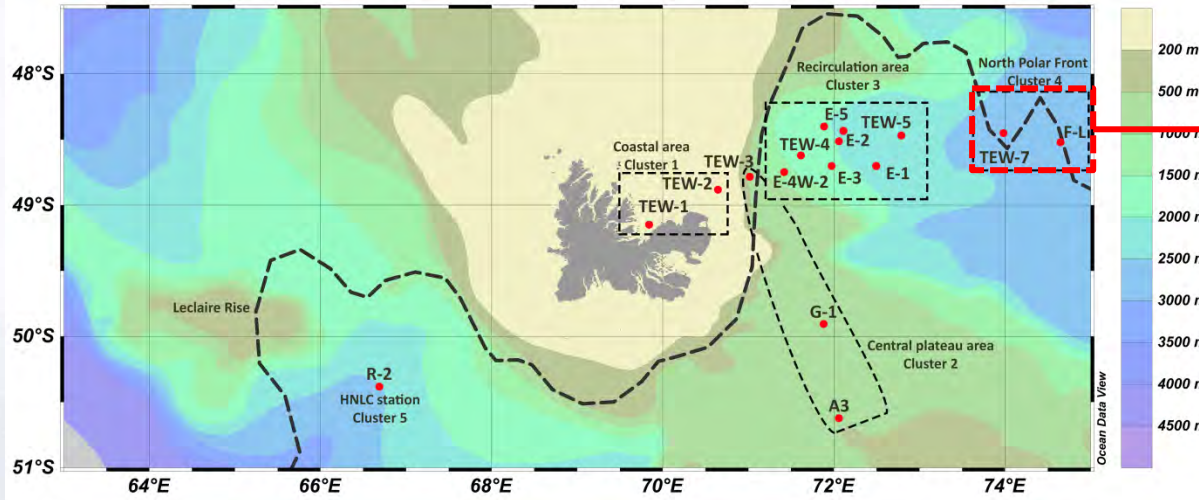
Cluster 3: Permanent meander of the Polar Front



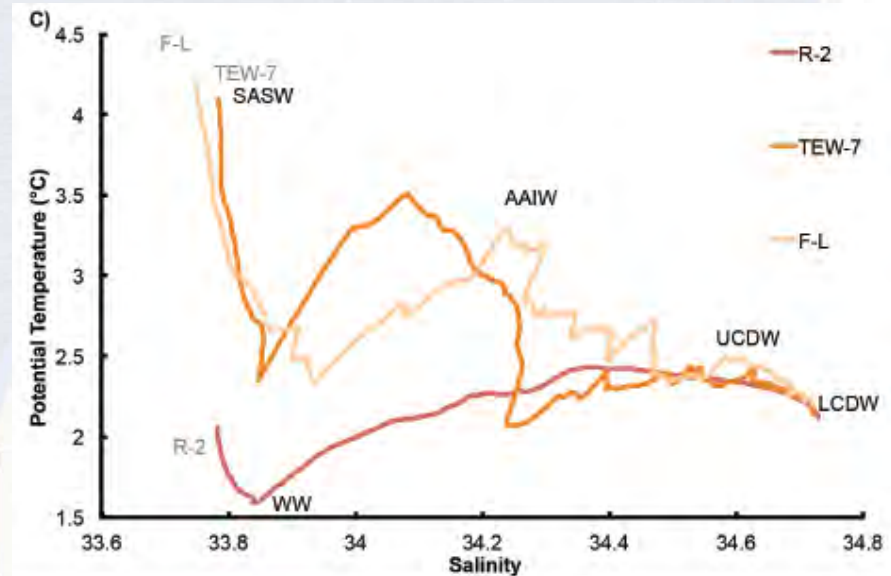


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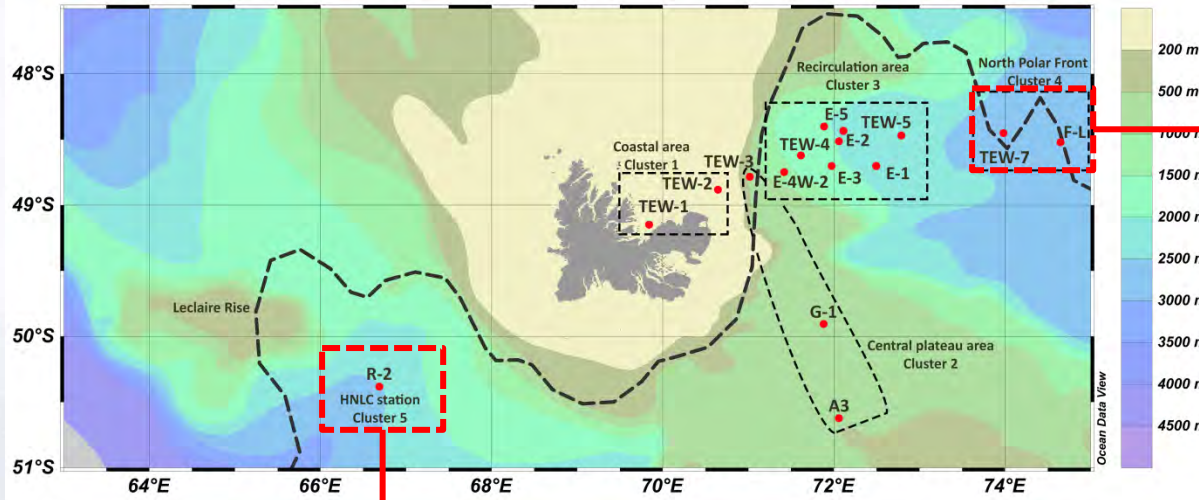
Cluster 4: North of the Polar Front





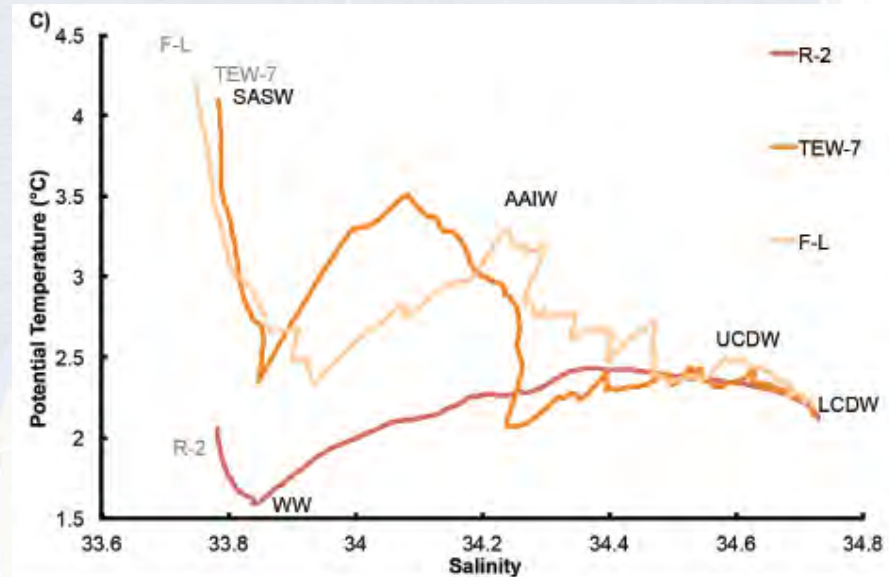
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Cluster 4: North of the Polar Front

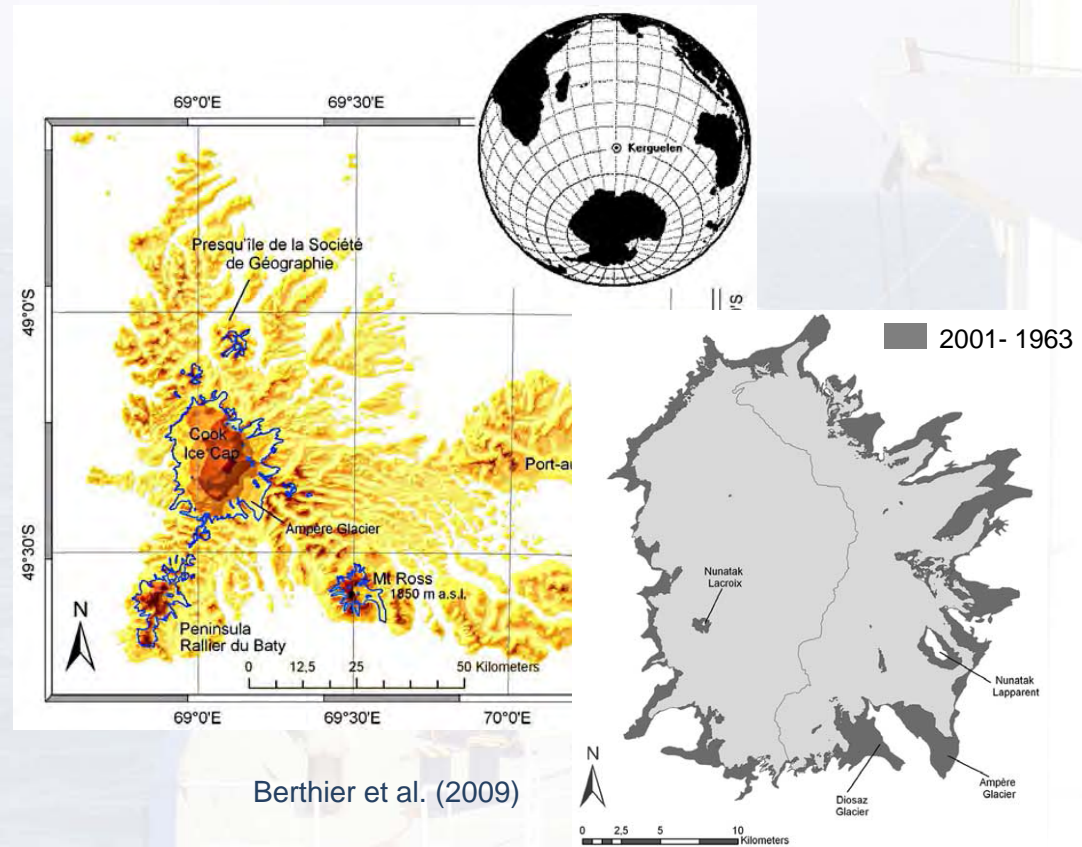
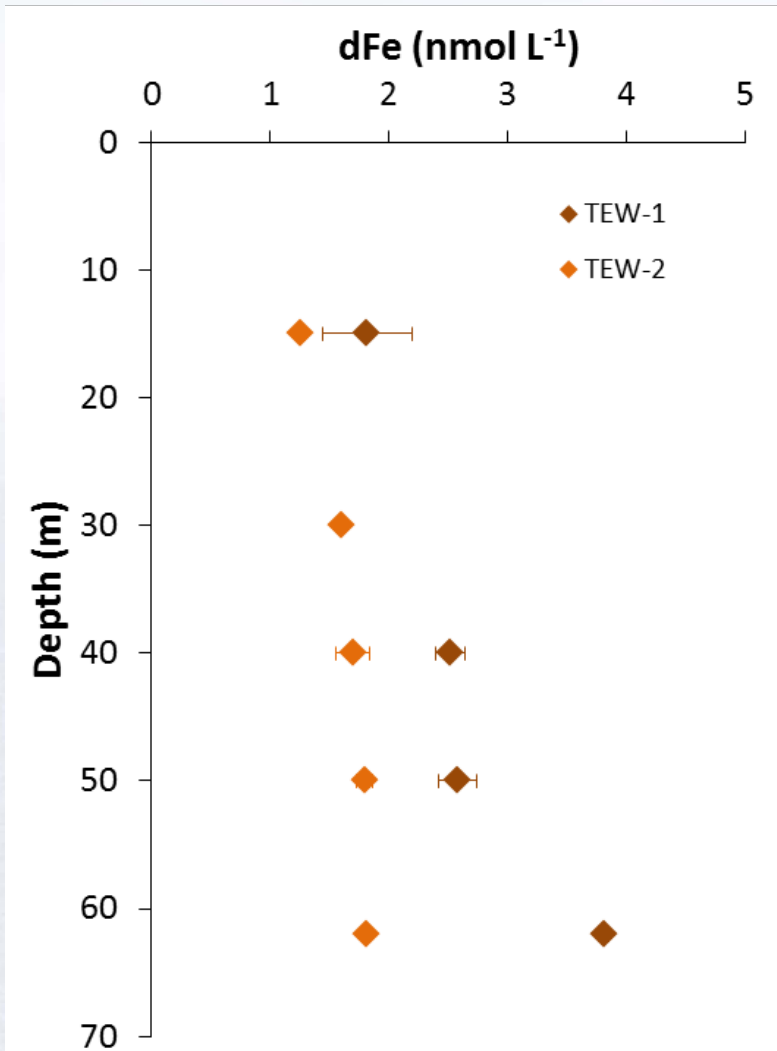
Cluster 5: HNLC station



Cluster 1: the coastal area

- Highest conc. of the KEOPS 2 cruise
(coherent with literature values¹)

⇒ Fe sources from the islands: glacial melt, direct runoff, and resuspended sediments

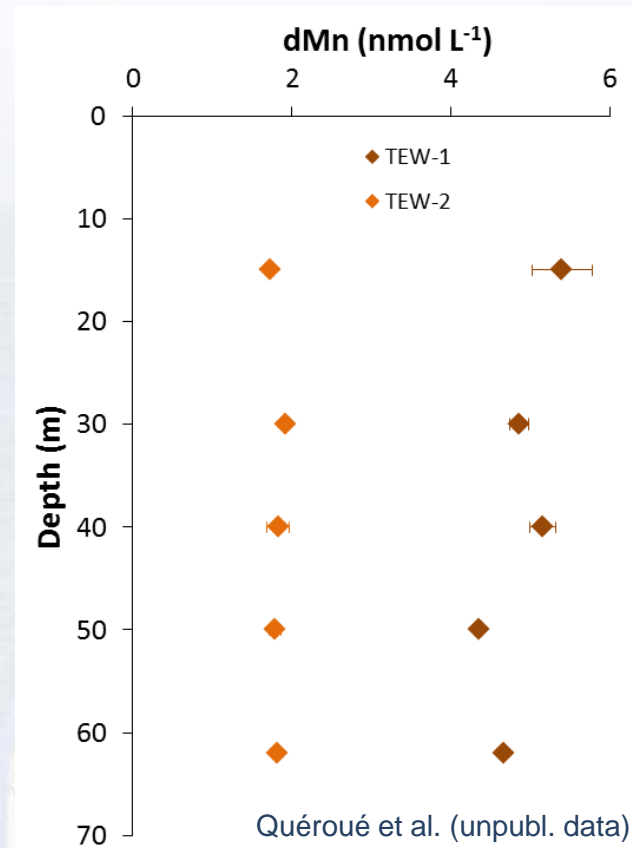
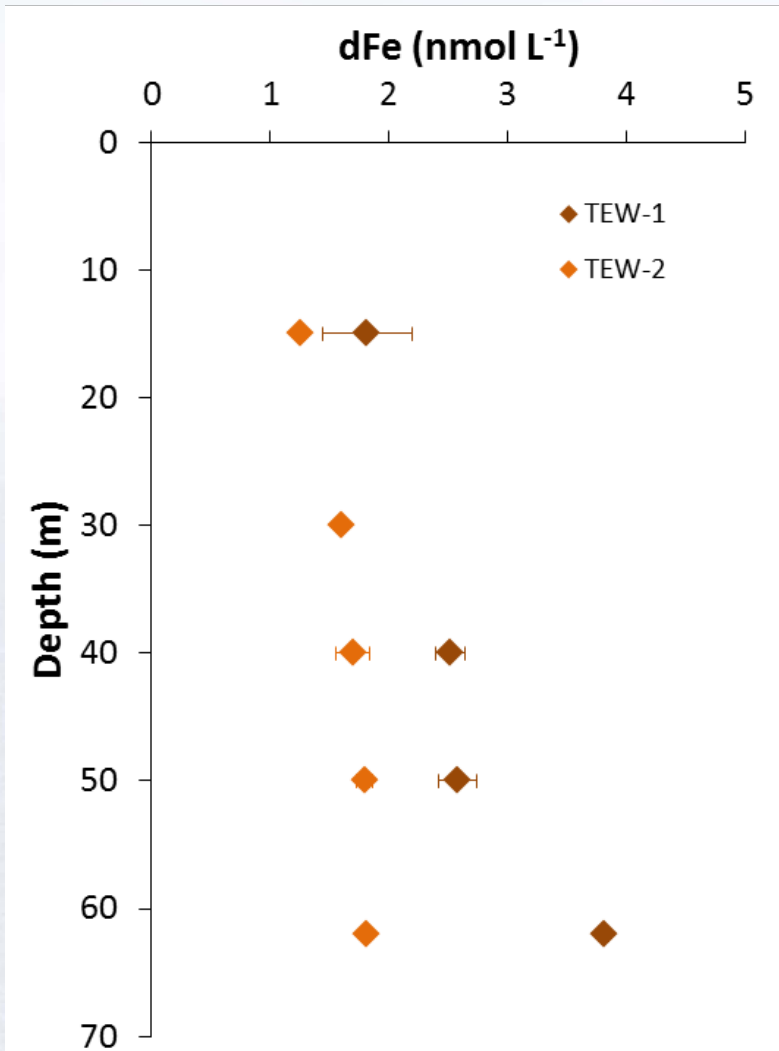


¹ Bucciarelli et al. (2001), Planquette et al., (2007), Blain et al. (2008), Hatta et al. (2013)

Cluster 1: the coastal area

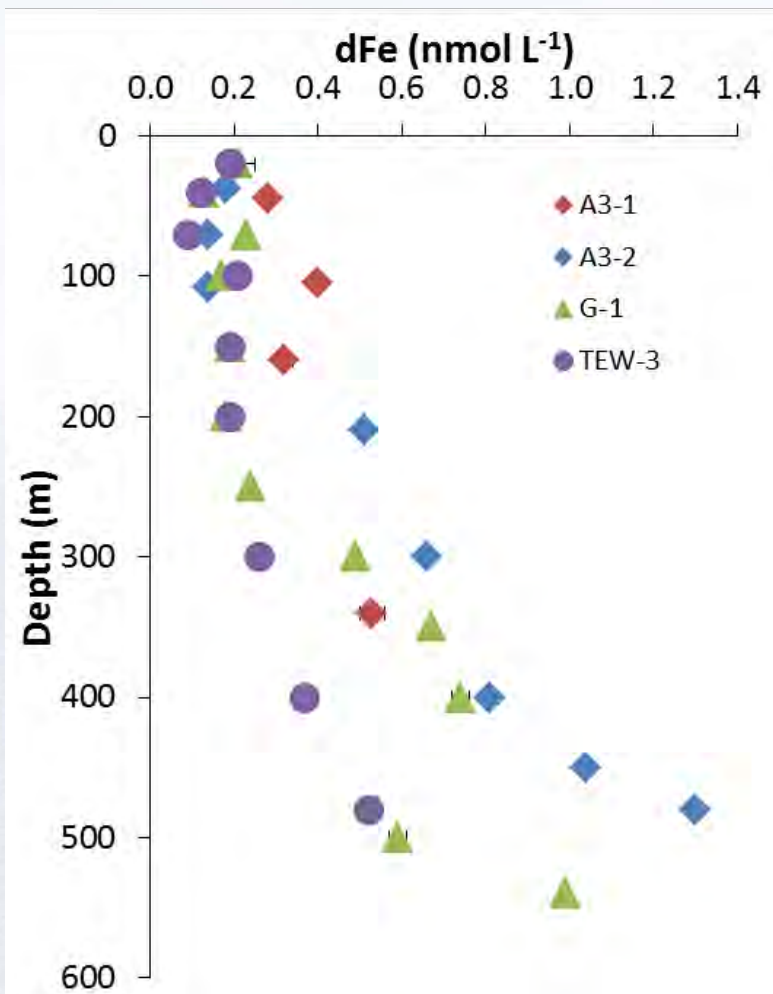
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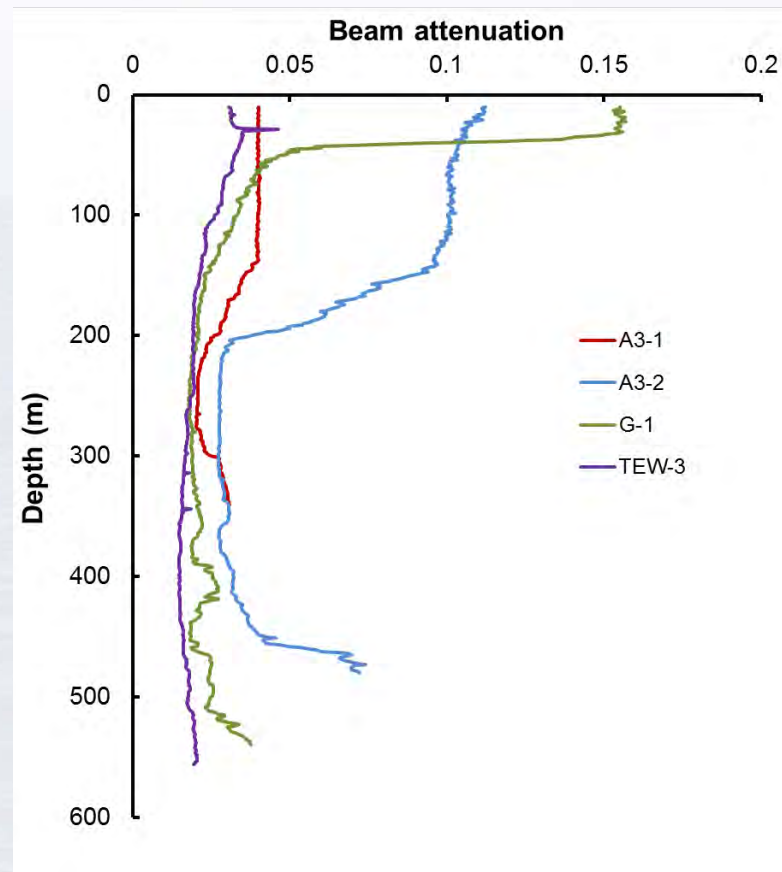
Cluster 2: the Plateau area



- Deep Fe-enriched reservoir (as during KEOPS1¹)

⇒ Resuspended sediments

⇔ High beam attenuation



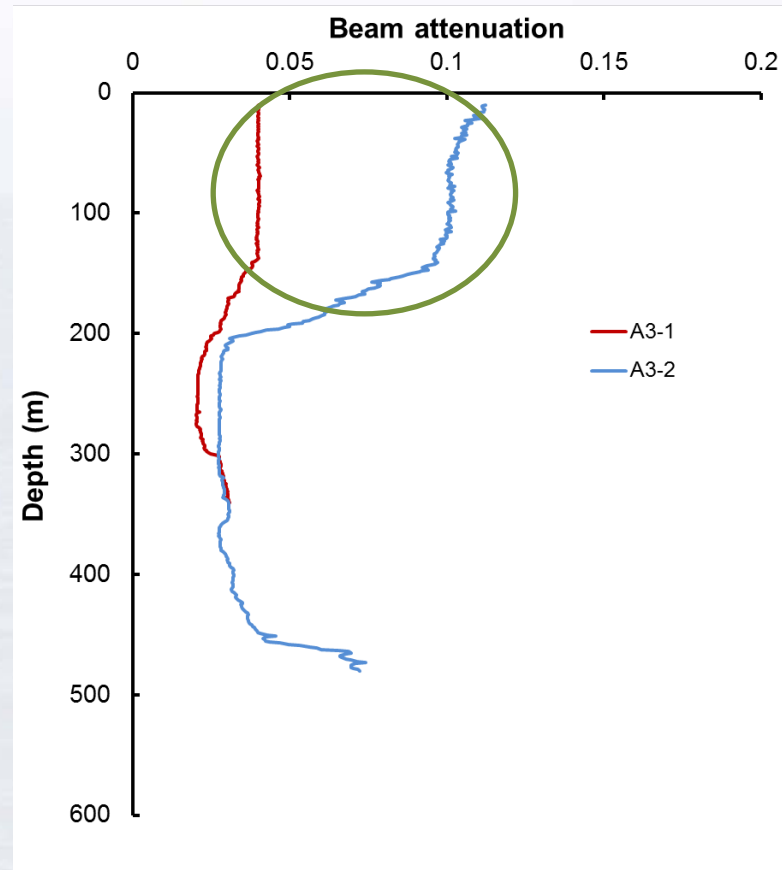
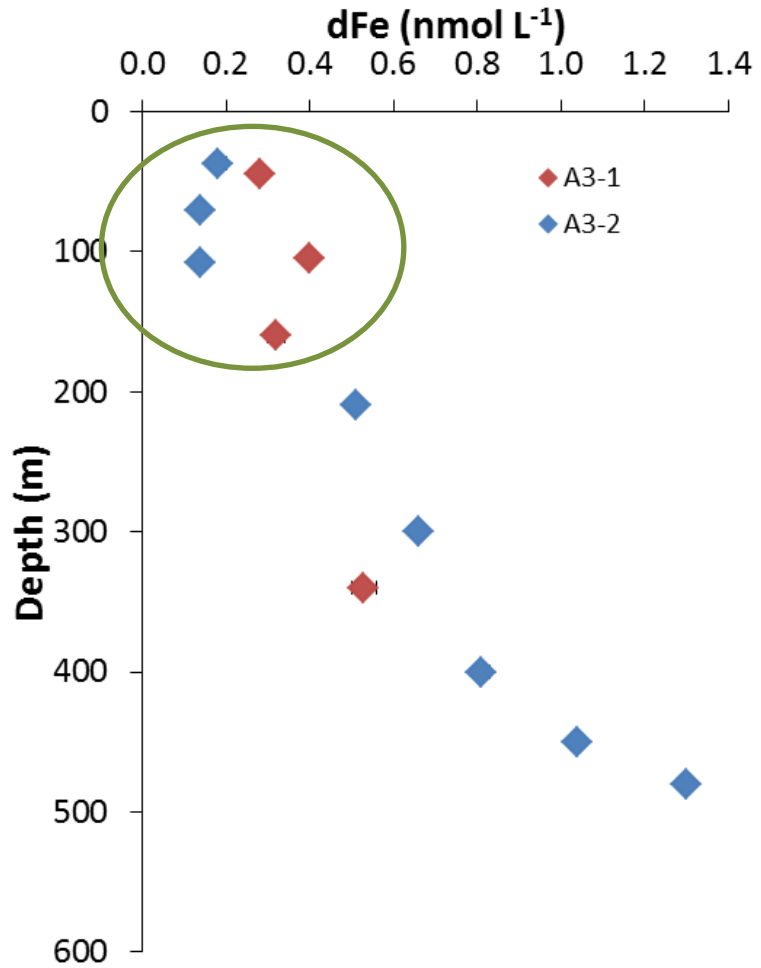
¹ Blain et al. (2007)

Cluster 2: the Plateau area

A3-1: 20 Oct. 2011

A3-2: 16 Nov. 2011 (28 days later)

Chl a increased: 106.2 mg m⁻² (A3-1) - 371.7 mg m⁻² (A3-2) (Lableiz et al., 2014)

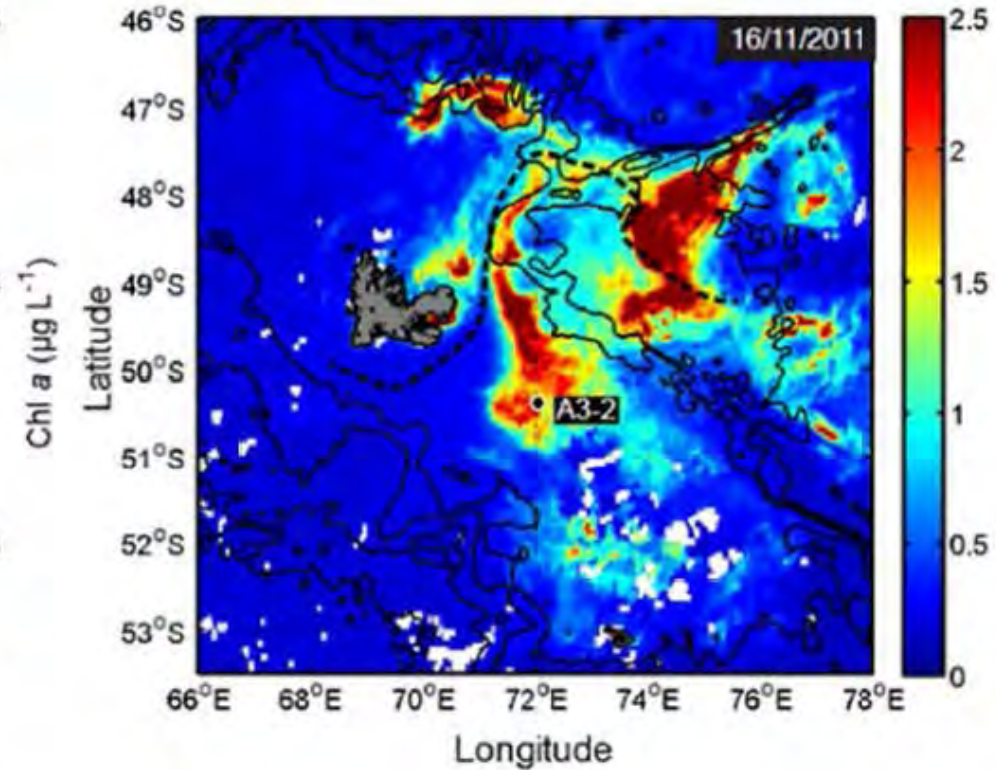
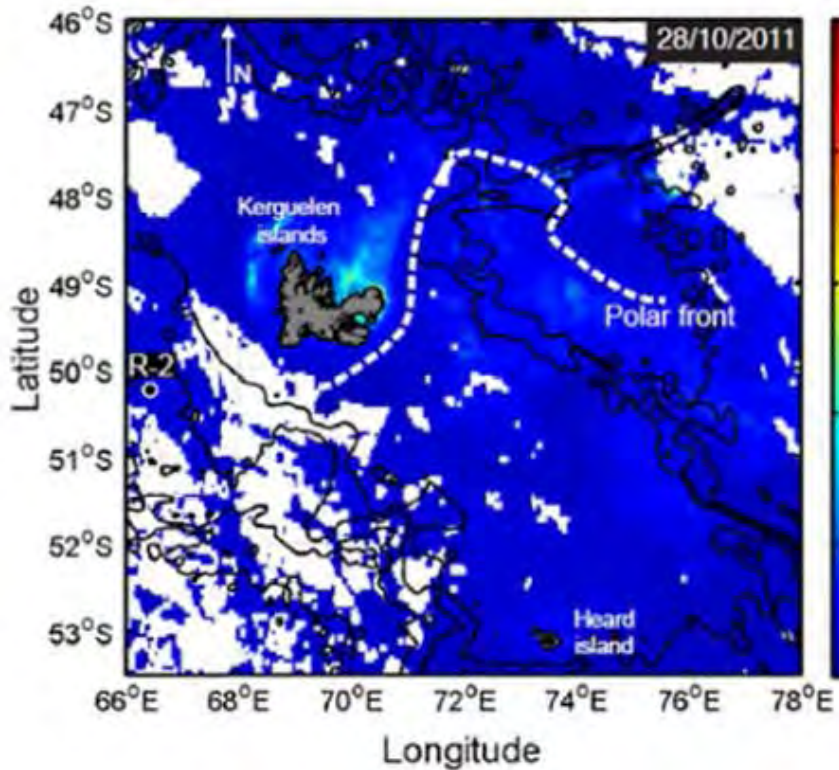
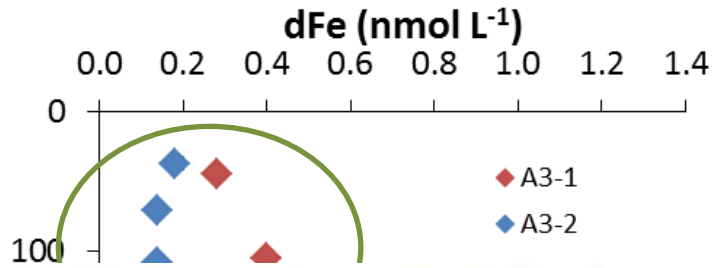


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$$\Delta(\text{dFe}_{\text{int-200m}}) = 34.5 \mu\text{mol m}^{-2}$$

$$\Delta(\text{POC}_{\text{int-200m}}) = 1008 \text{ mmol m}^{-2}$$

(Lasbleiz et al., 2014)

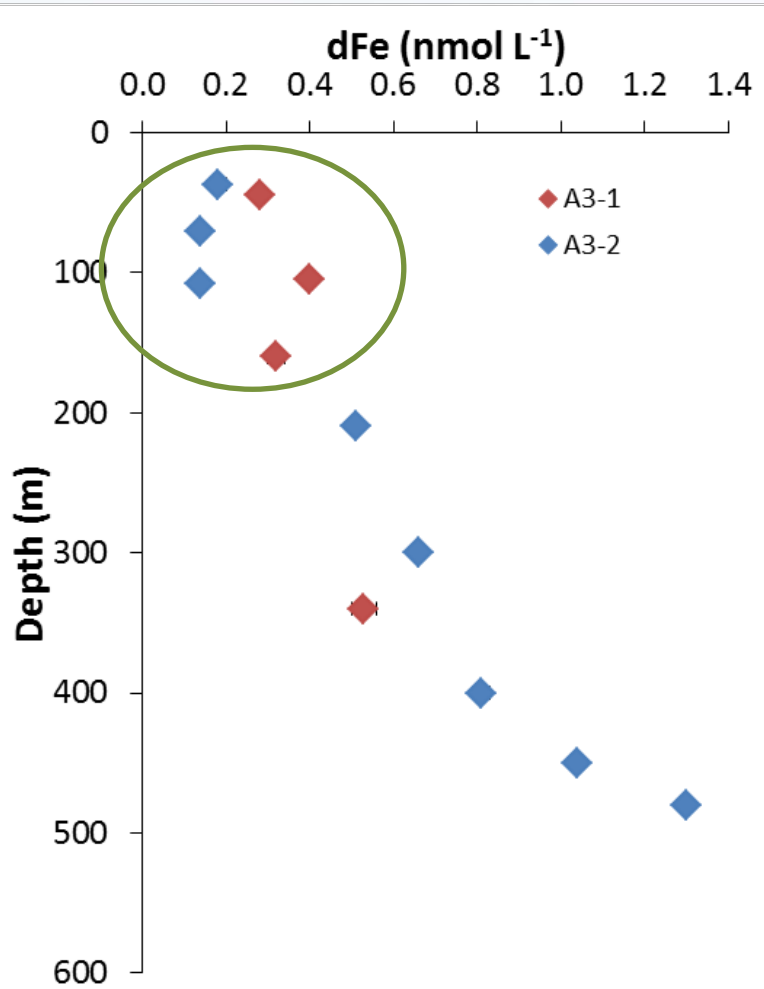


$$\text{Fe/C} = 34 \mu\text{mol/mol}$$

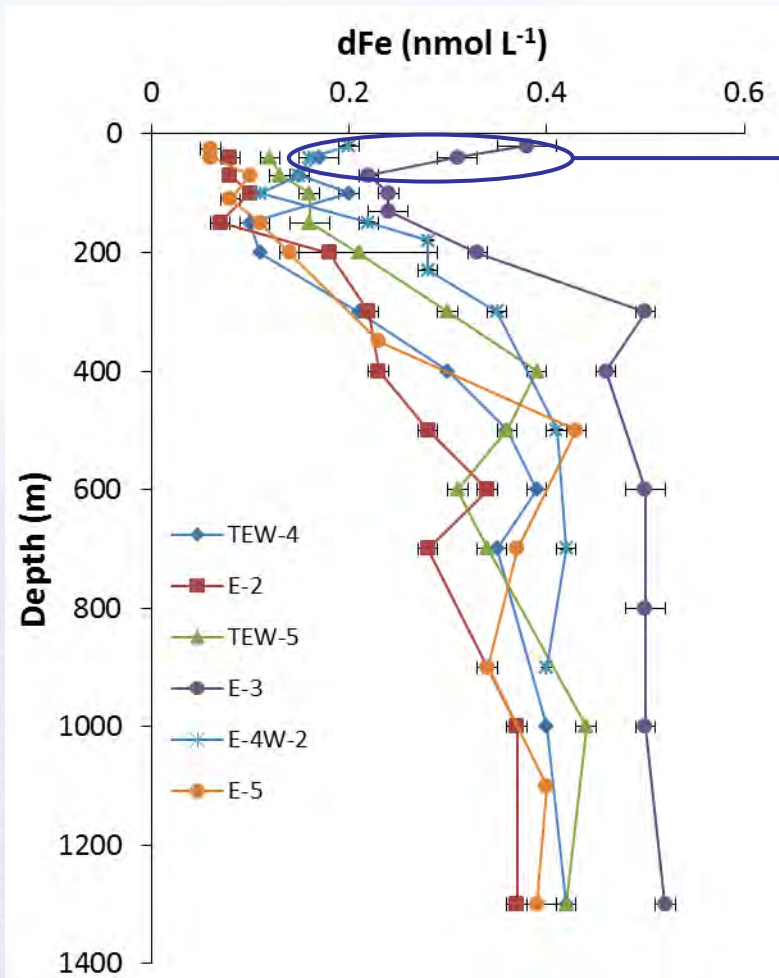
~ Diatoms in Fe-replete conditions

(Sarhou et al., 2005)

Fe decrease ⇔ Biological uptake

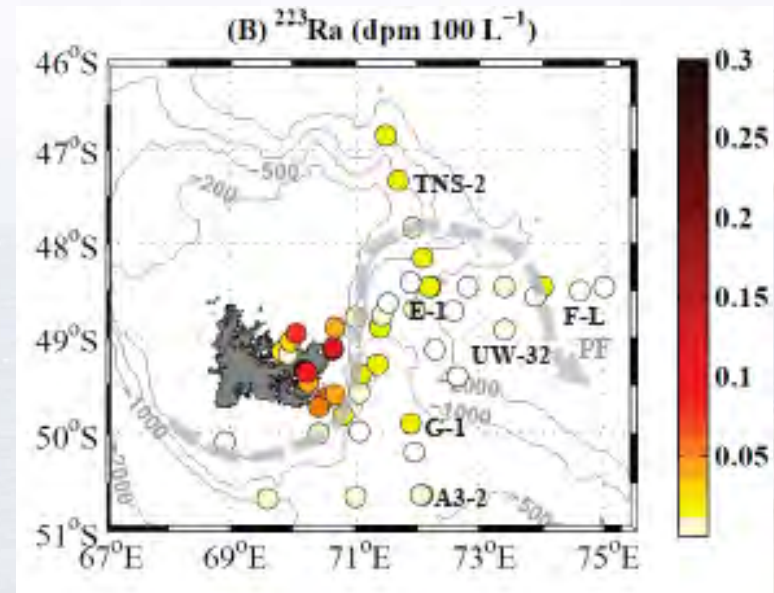


Cluster 3: the recirculation area



Nutrient-like profiles

Low [pAl] (van der Merwe et al., 2015)
Negligible atmospheric inputs

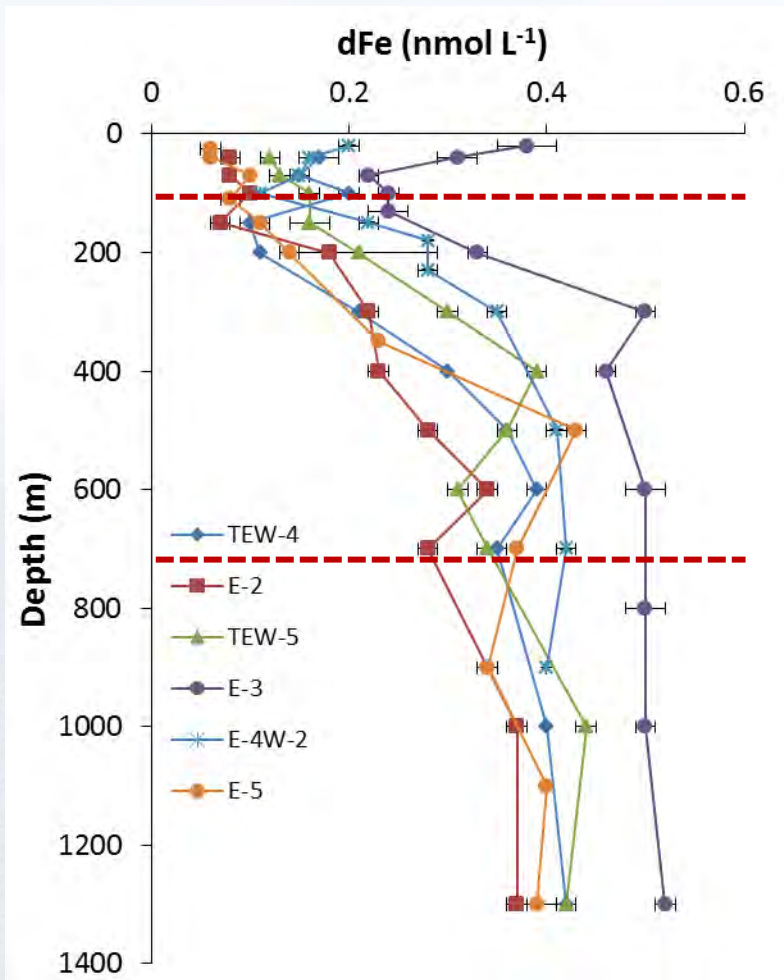


Sanial et al. (2014)

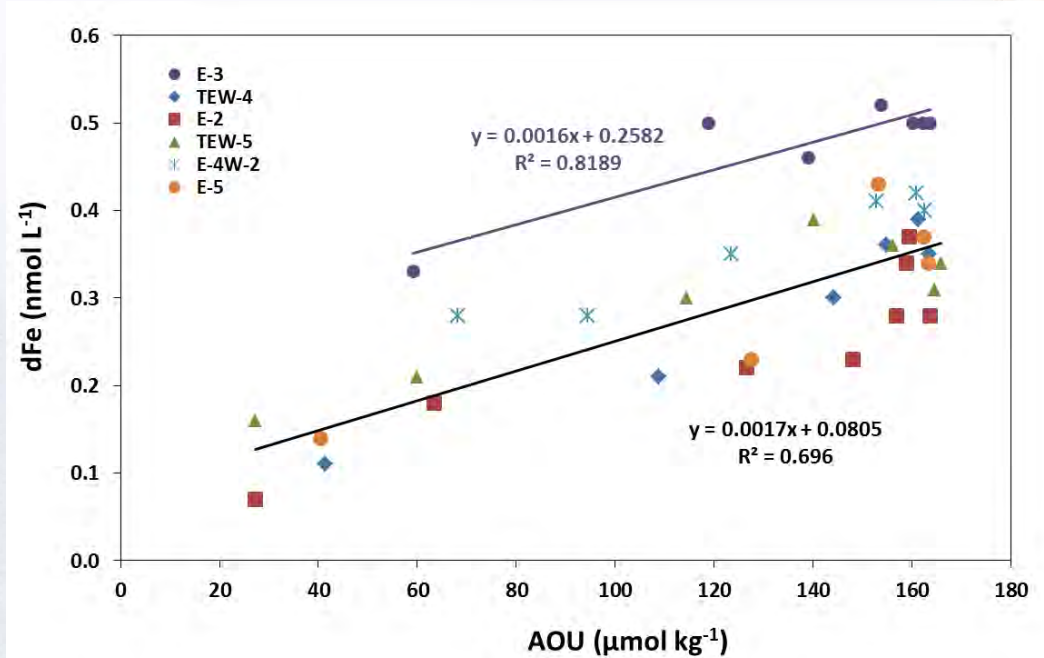
Dissolved Ra sediment-derived inputs can be rapidly transferred through the Polar Front

↔ **Dissolved Fe sediment-derived inputs**

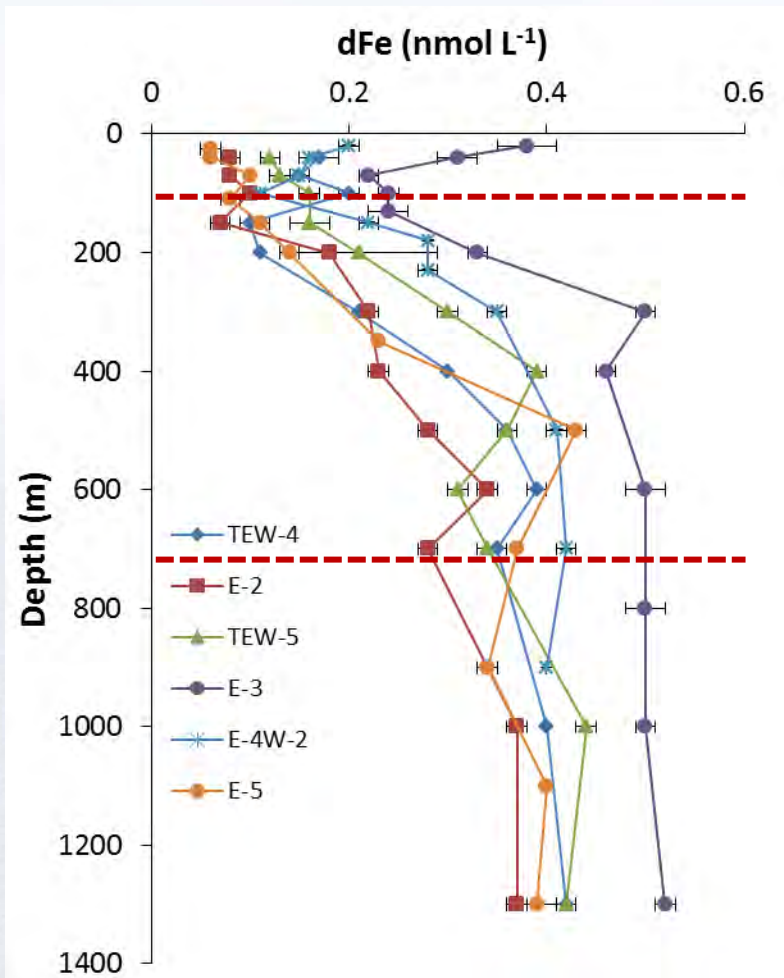
Cluster 3: the recirculation area



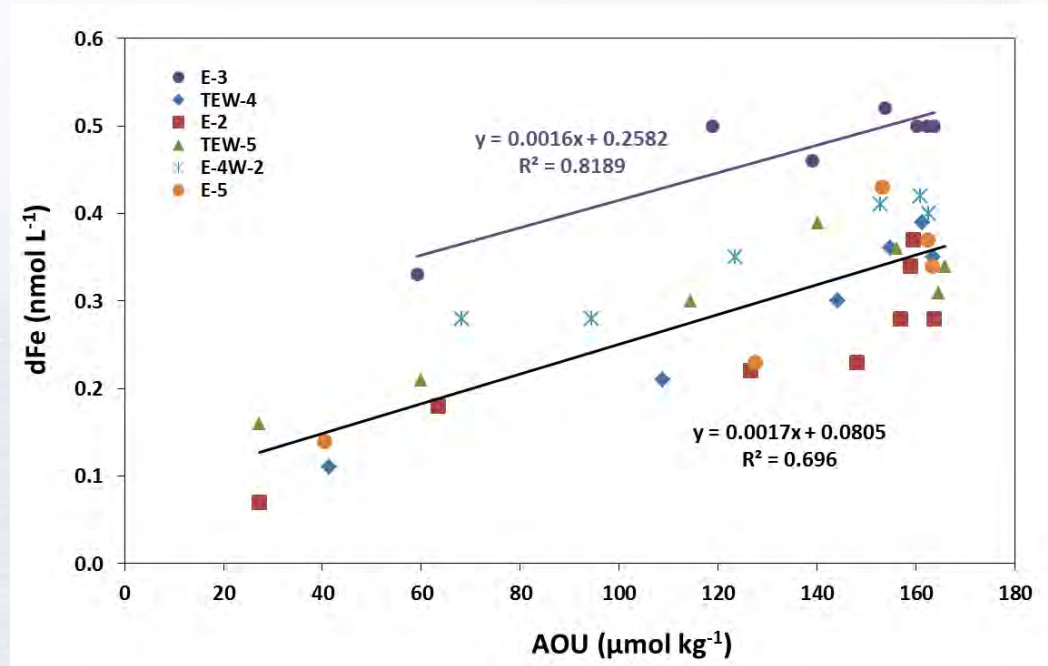
Link with the remineralization



Cluster 3: the recirculation area

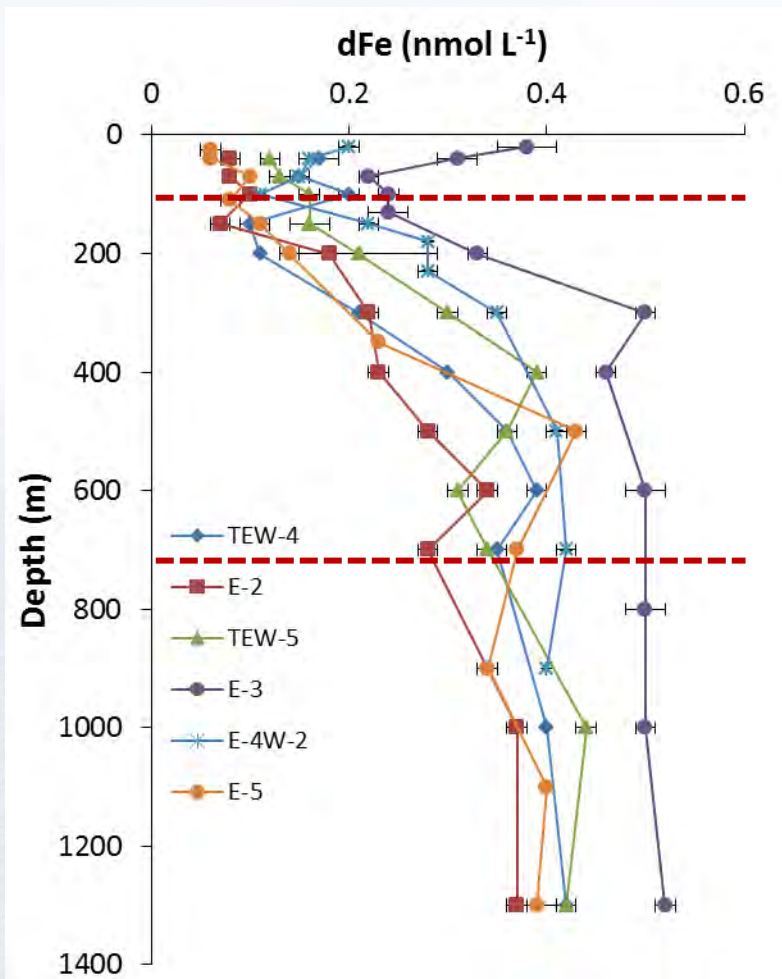


Link with the remineralization

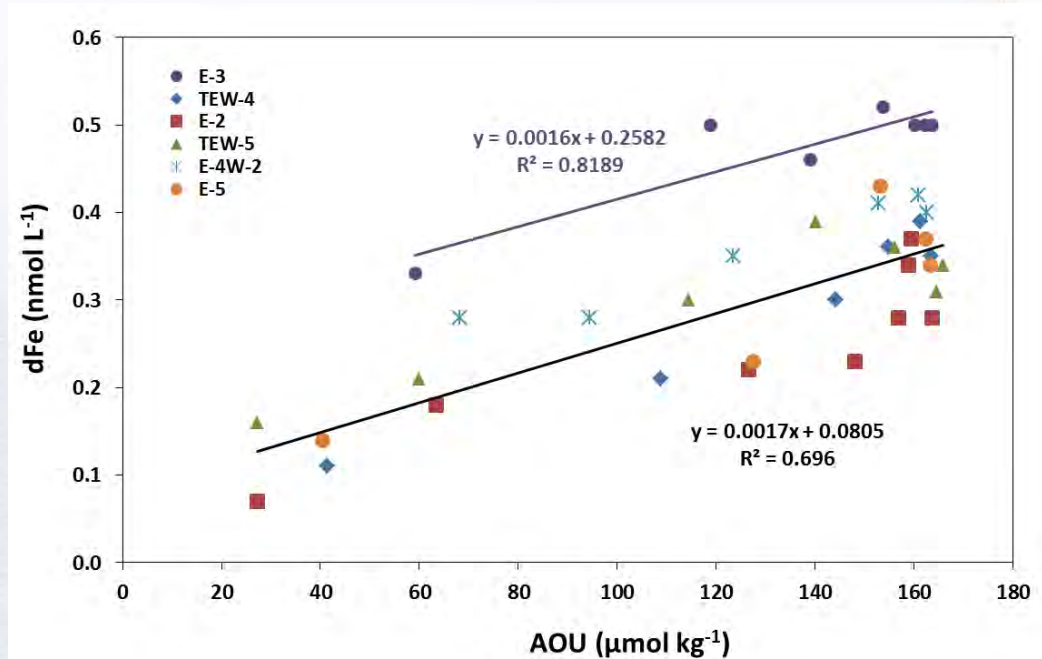


**Different intercept at E-3: pre-formed Fe signal
⇒ Higher dFe at this station**

Cluster 3: the recirculation area



Link with the remineralization



Same slopes

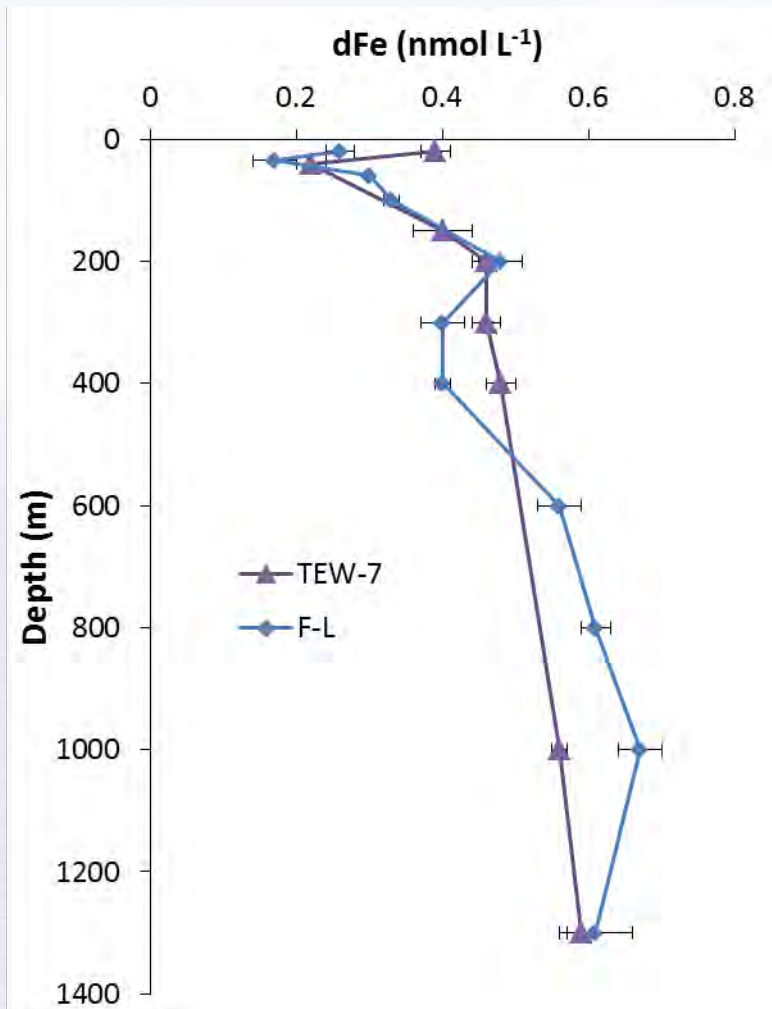
O₂:C = 1.6 (Martin et al., 1987)

Fe:C ~ 3 μmol:mol

~ Diatoms in Fe-limited conditions

(Sarhou et al., 2005)

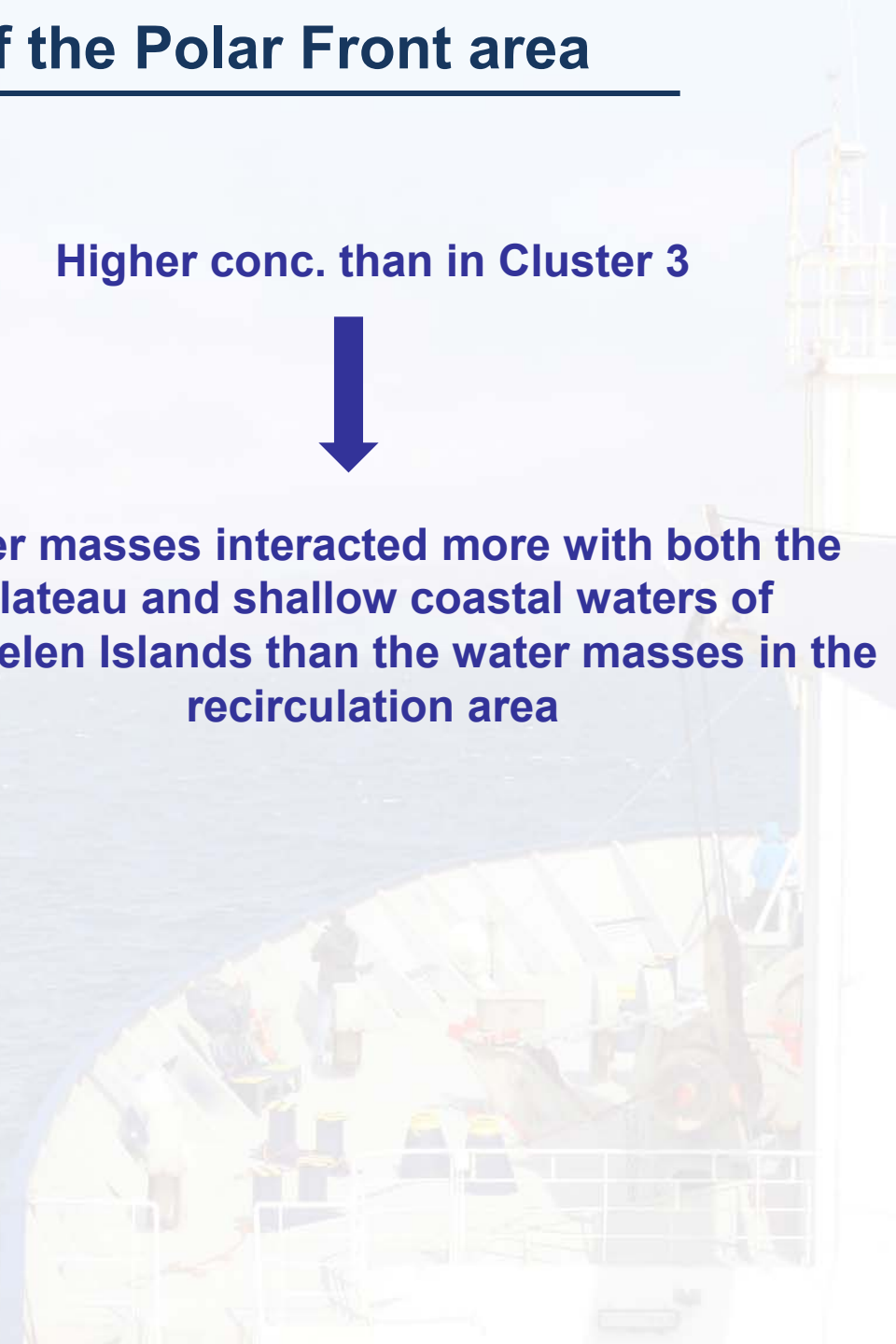
Cluster 4: North of the Polar Front area



Higher conc. than in Cluster 3



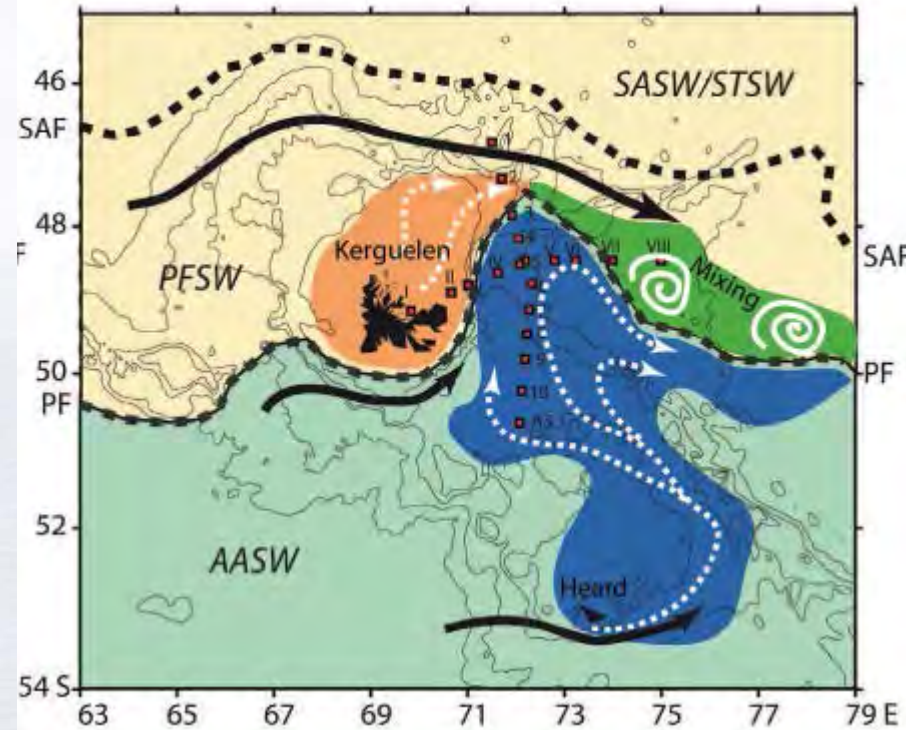
Water masses interacted more with both the plateau and shallow coastal waters of Kerguelen Islands than the water masses in the recirculation area



Cluster 4: North of the Polar Front area

Waters are mainly coming from the northern part of the Plateau
 ⇒ Fe-enriched waters

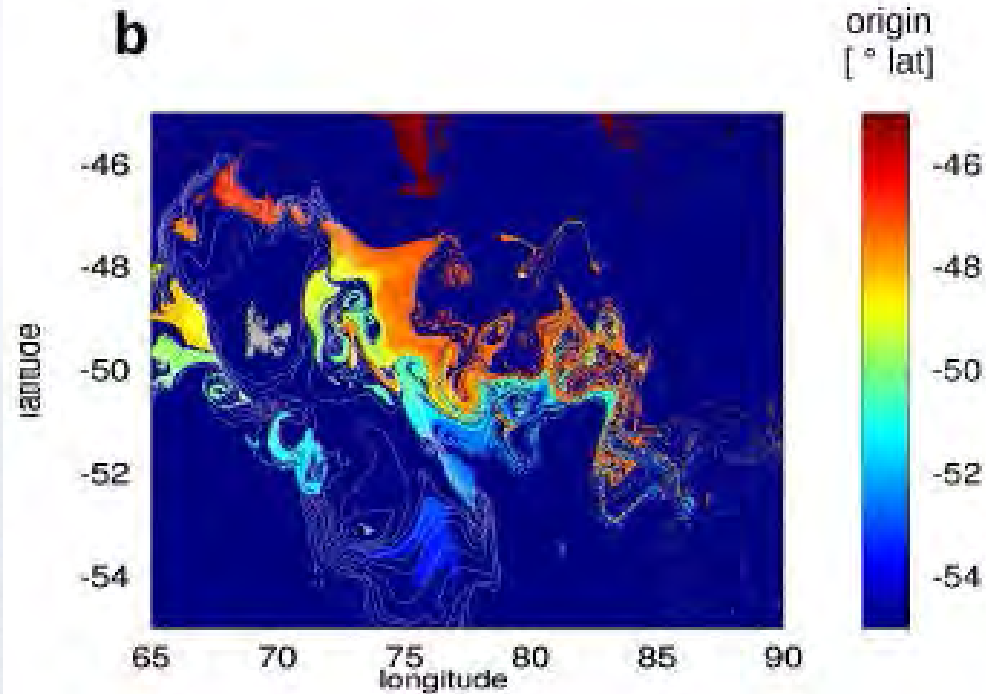
(b) Schematic of regional circulation



Park et al. (2014)

Water masses are carried northwards between the island and the recirculation area and looped back east of the recirculation area

b

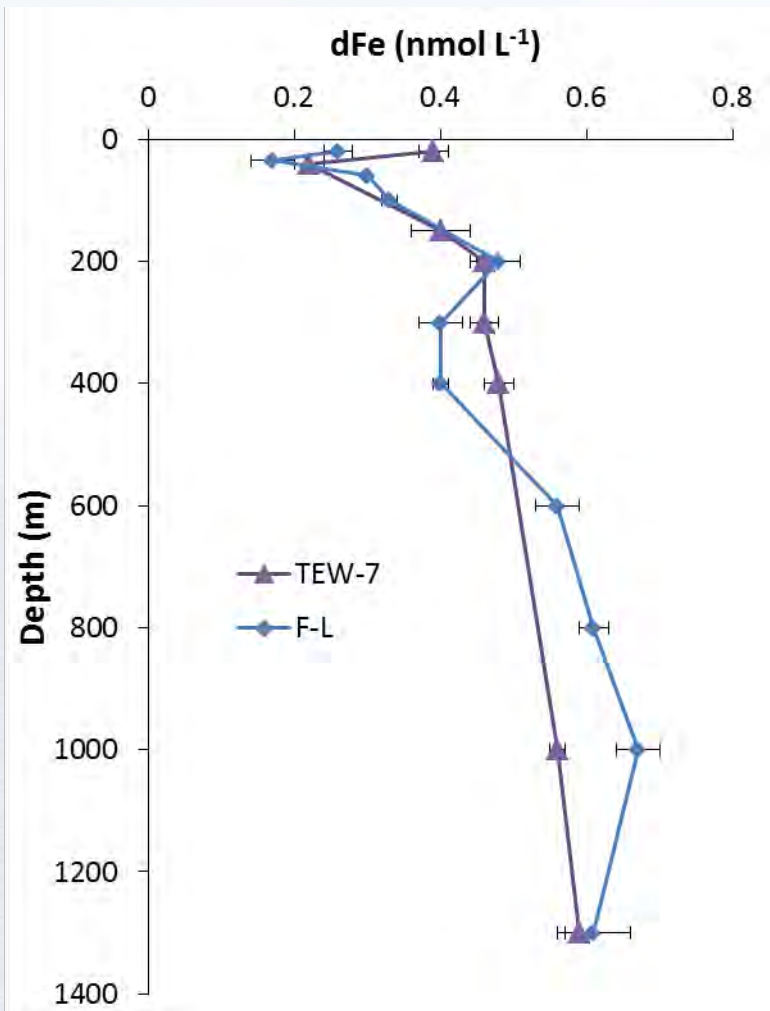


d'Ovidio et al. (2015)

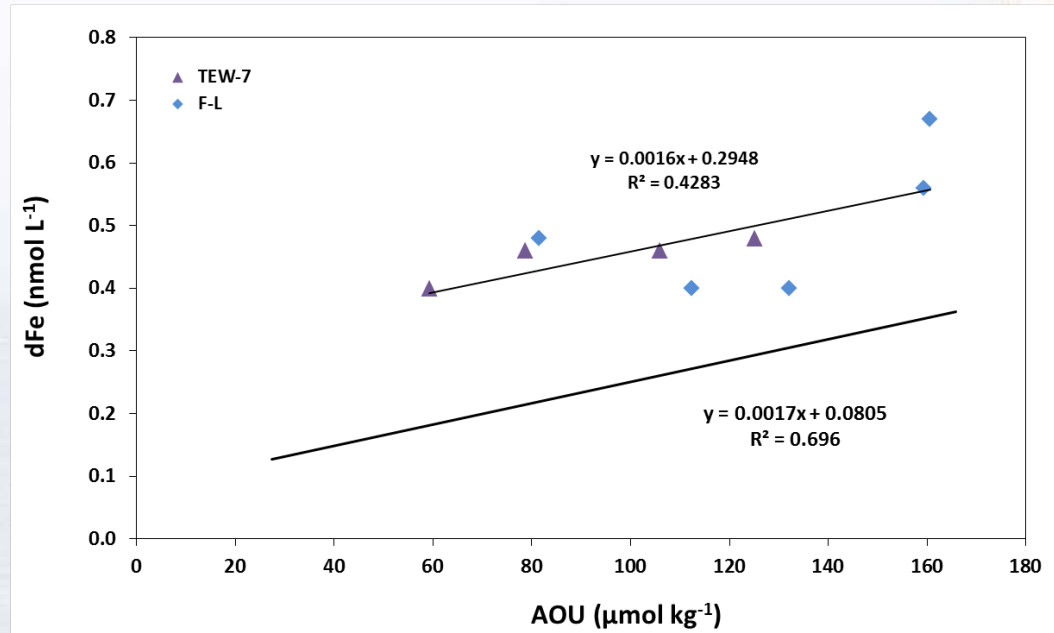
A Lagrangian model of Fe transport based on altimetry ⇒ the waters are mainly coming from the northern part of plateau



Cluster 4: North of the Polar Front area



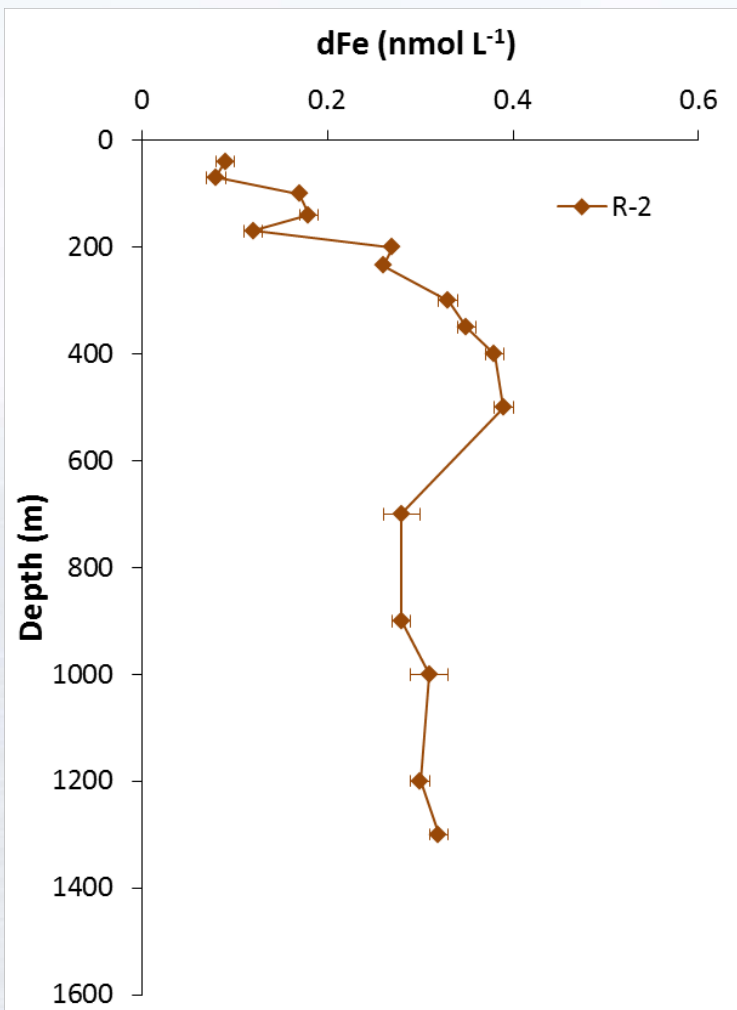
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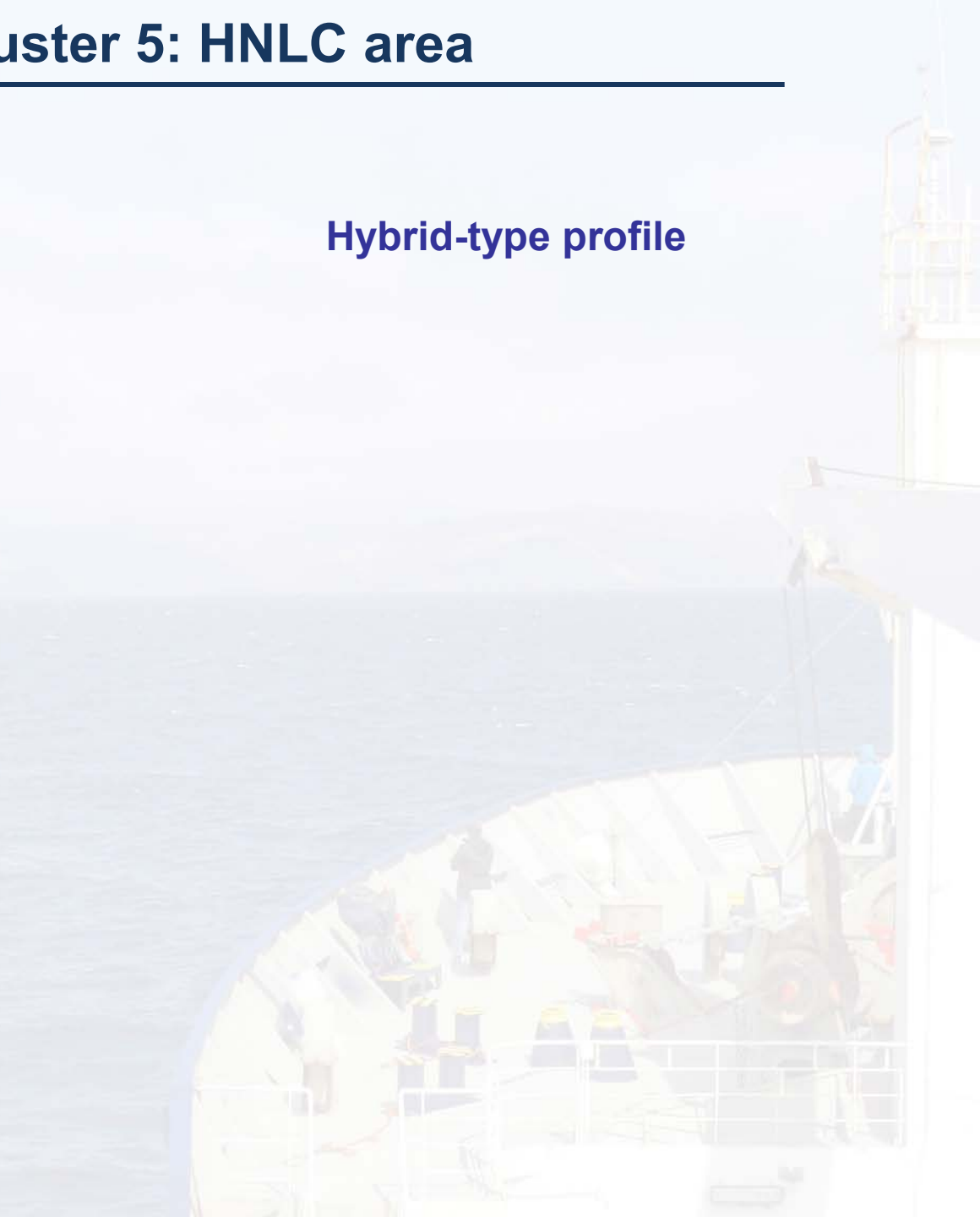
Same slopes
Different intercepts: pre-formed Fe



Cluster 5: HNLC area

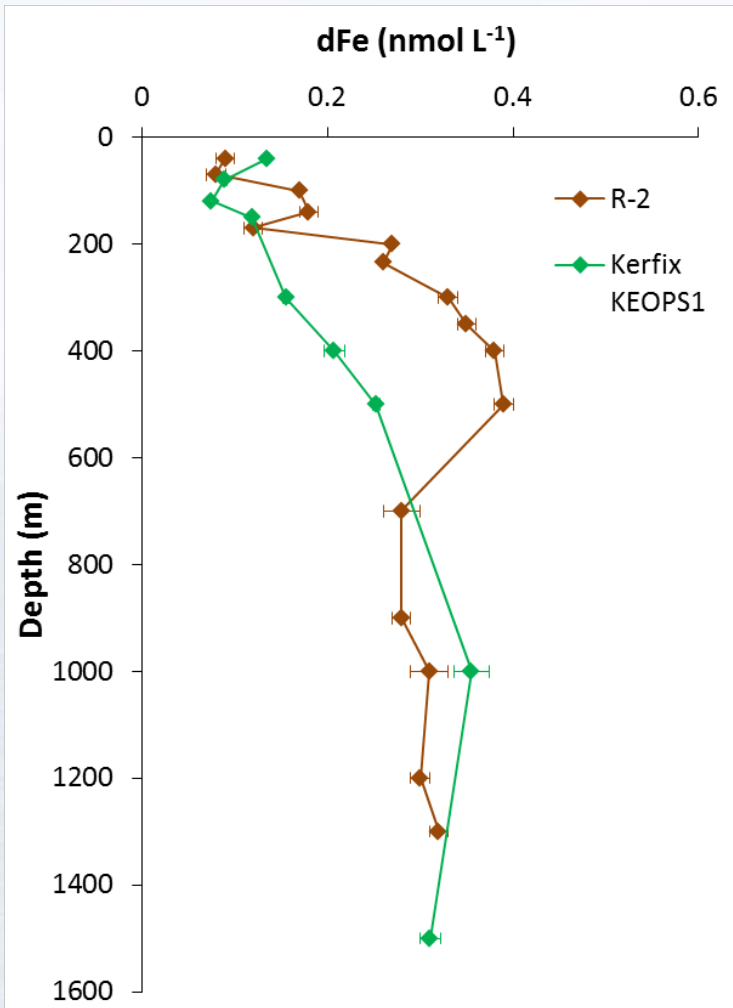


Hybrid-type profile





Cluster 5: HNLC area



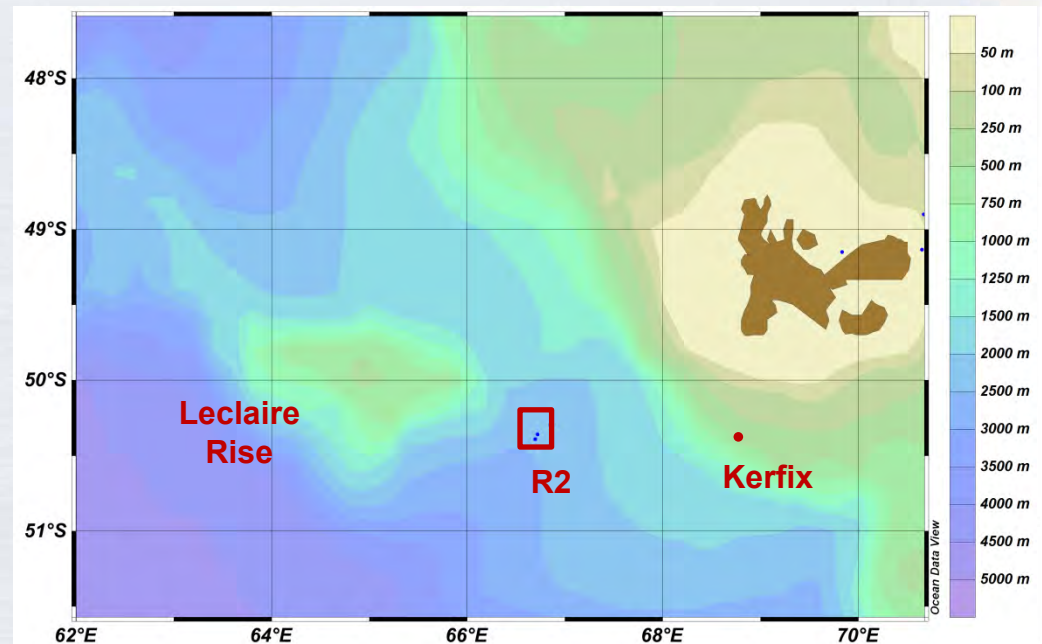
Hybrid-type profile

Higher conc. between 200-500 m

High conc. of LSi (Lasbleiz et al., 2014)

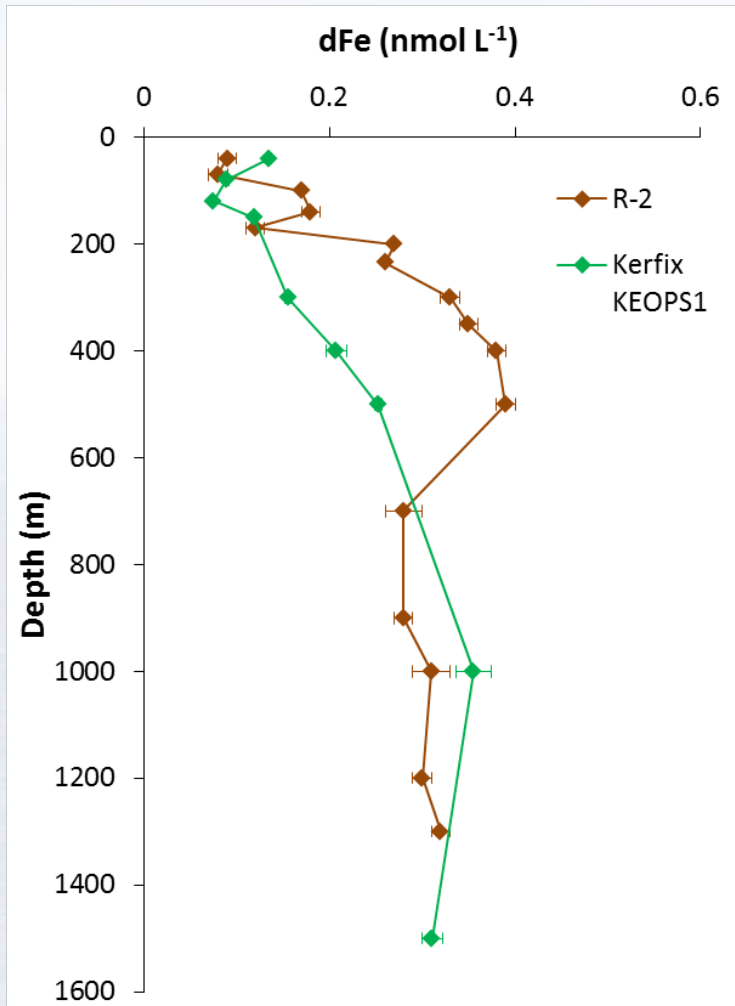
High conc. of pFe, pMn, and pAl

(van der Merwe et al., 2014)

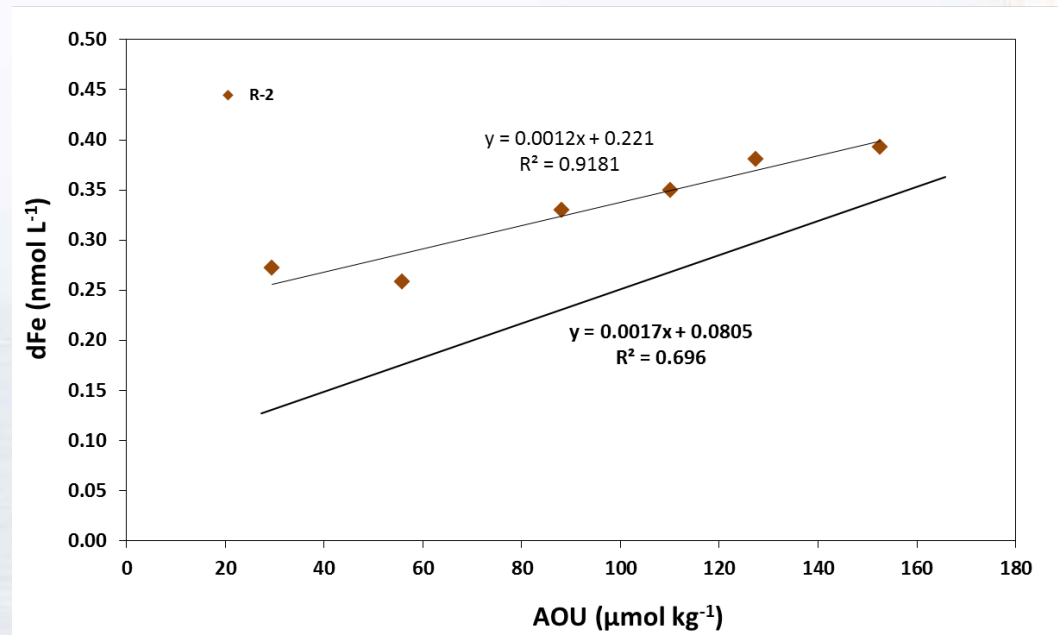




Cluster 5: HNLC area



Link with the remineralization



Fe and C remineralized at the same rates as in clusters 3 and 4

The intercept $\neq 0 \Rightarrow$ dFe additional inputs



To sum up...

- **New insights into Fe fertilization in the vicinity of the Kerguelen Islands**
- **No evidence of atmospheric inputs but direct runoff, glacial and sedimentary inputs are important sources near the coast and above the Plateau**
- **Fe fertilization in the region North of the Polar Front in the Eastern area due to the strong advection of the Polar Front**
- **Fe fertilization in the recirculation area through filaments crossing the Polar Front**
- **Evidence of a high biological Fe consumption above the Plateau when the bloom was developing**
- **Importance of Fe remineralization in intermediate waters offshore**

Many thanks to:

- Young-Hyang Park (large scale hydrography)
- Bernard Quéguiner (chief scientist)
- The captain and the crew of the R/V Marion Dufresne

Thanks for your attention!

Study funded by:



KEOPS 2

ANR-2010-BLAN-614



Programme LEFE-CYBER

