Gas Exchange in Polar Seas

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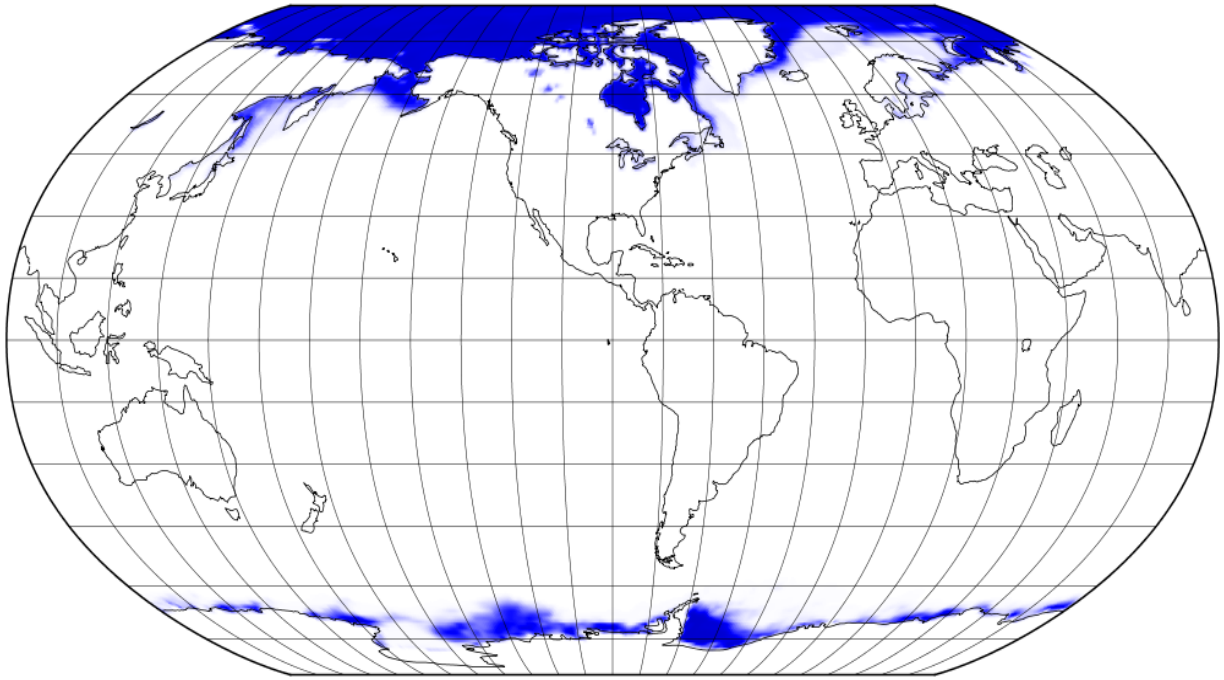
Flux Engine in polar seas

- Have a disproportionate contribution to global gas flux
- Are areas of deep water formation

Arctic accounts for 5-15% of total global sink of CO^2

Are conventional estimations of gas exchange accurate in areas affected by sea ice?



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In-situ measurements in the mixed ice zone (MIZ) have identified **CO_2 fluxes 1–2 orders of magnitude higher than those expected** under similar conditions in the open ocean.

(Else *et al.* 2011),

In contrast to previous studies, we show that **in partially ice-covered regions, gas exchange is lower than expected** based on a linear scaling to percent ice cover.

(Rutgers van der Loeff *et al.* 2014)

Standard method

Ice is a barrier to gas exchange

Gas exchange scaled according to percentage cover of ice

Exchange in open water is a function of wind speed, the same as in open ocean

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Ice is a barrier to gas exchange

?

Ice floes also a source of turbulence that can increase exchange

Buoyant convection/stratification

Ice changes how wind affects the sea surface

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Loose *et al.* (2014) propose a model for estimating the near surface turbulence due to ice, in order to derive an effective gas exchange velocity for MIZ

Initial results estimate a **40% increase in the rate of gas exchange** when compared to scaled open ocean values (For <10ms^{-1} wind speeds).

Loose, B., McGillis, W.R., Perovich, D., Zappa, C.J., Schlosser, P., 2014. A parameter model of gas exchange for the seasonal sea ice zone. Ocean Science 10, 17-28. 10.5194/os-10-17-2014

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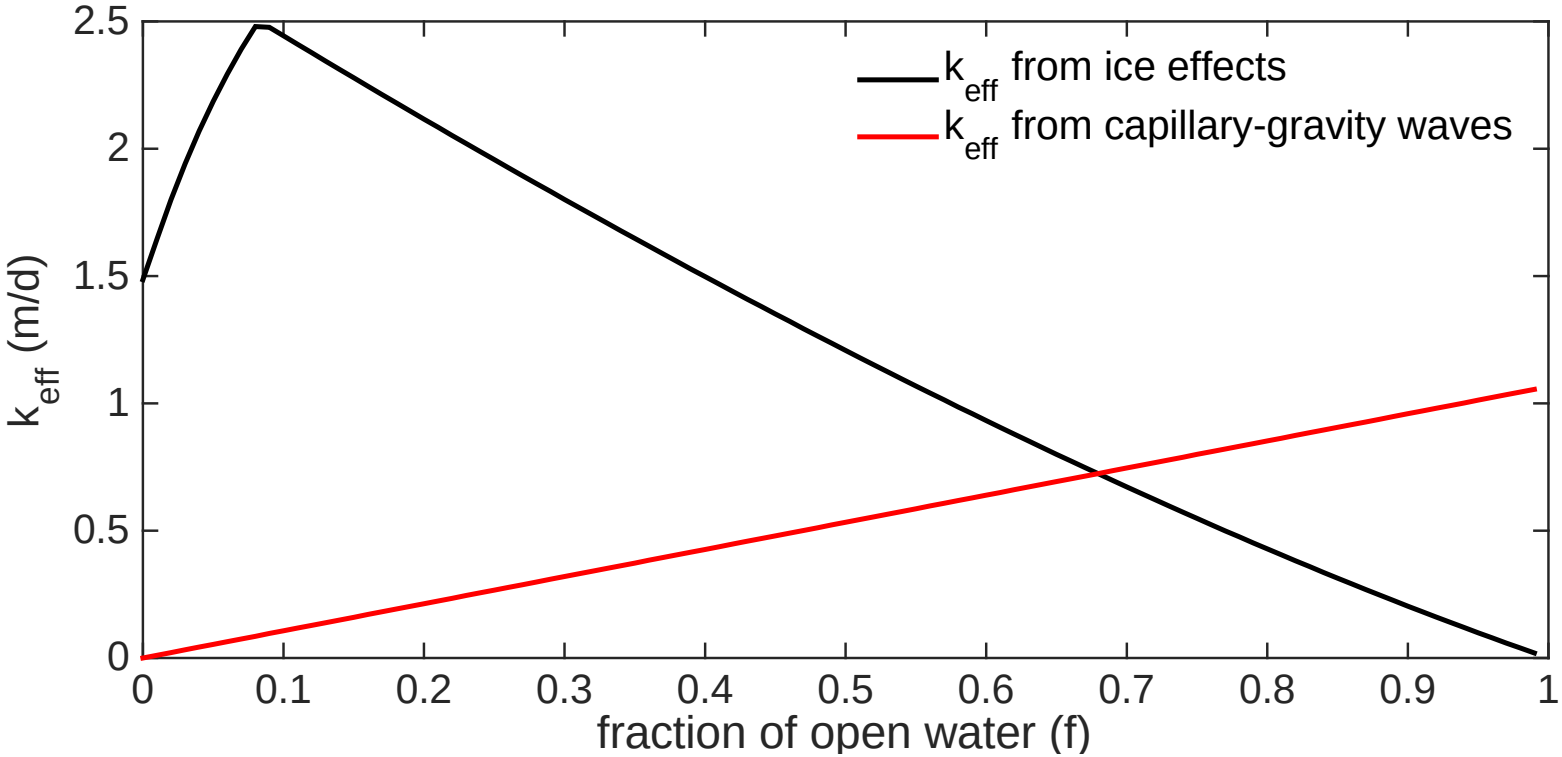
Loose et al. 2014 – What affects gas transfer?

- **Shear** between ice floes and water, uses floe Size distribution and ice velocity
- **Buoyant convection/stratification** requires the temperature of air and water
- **Wind driven turbulence (waves)** estimated using mean square slope
- **Scaling** based on percentage of ice cover



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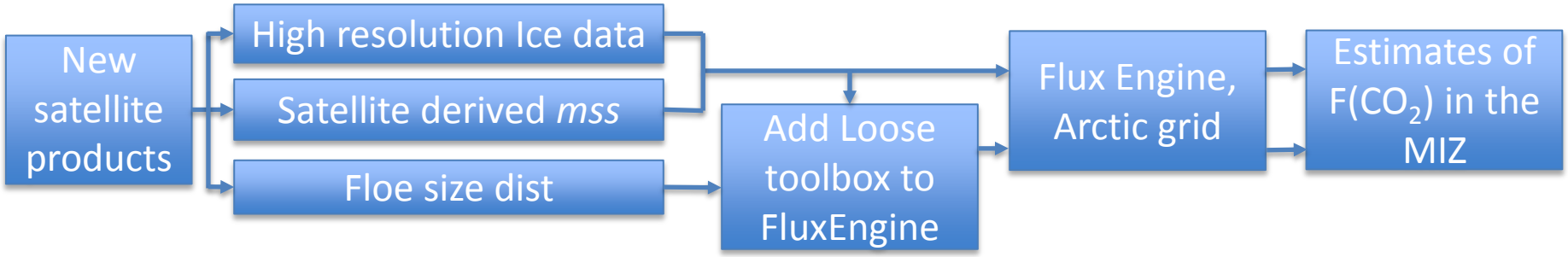
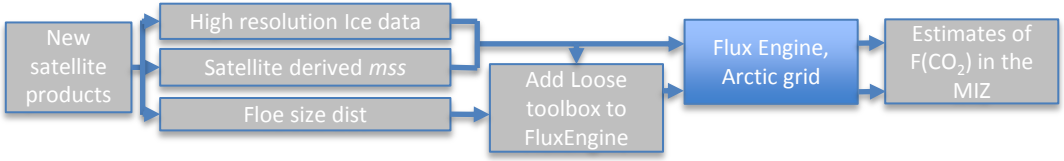
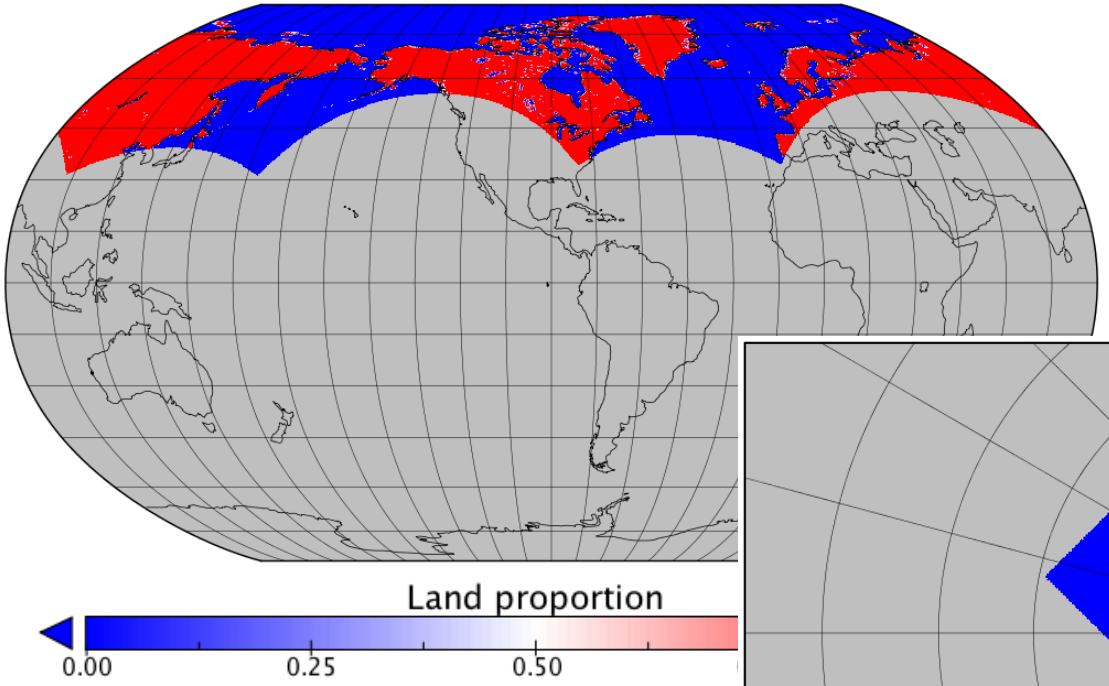
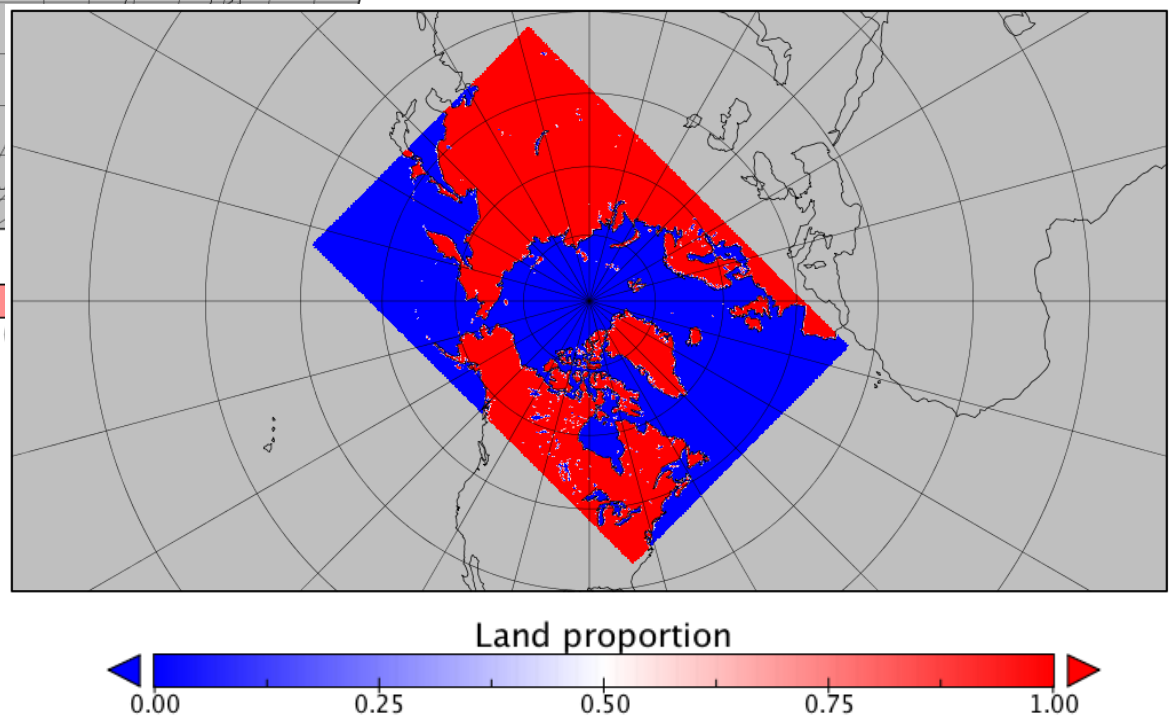


1. Adapt FluxEngine to get gas exchange estimates on a 25km resolution polar grid
2. Take advantage of new satellite products to:
   a. Use higher resolution ice coverage data
   b. Get direct measurements of floe size distribution
   c. Estimate gas transfer velocity with *mss* derived directly from satellite radar backscatter
3. Implement the Loose (2014) model in FluxEngine
4. Establish the potential impact of MIZ on global and regional gas transfer estimates (e.g. CO_2 budgets)



Step 1 – Improve resolution by using an Arctic grid





Arctic Grid – 25km x 25km resolution
Data provided on this grid by Ifremer

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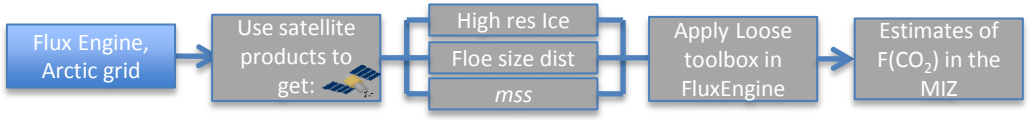

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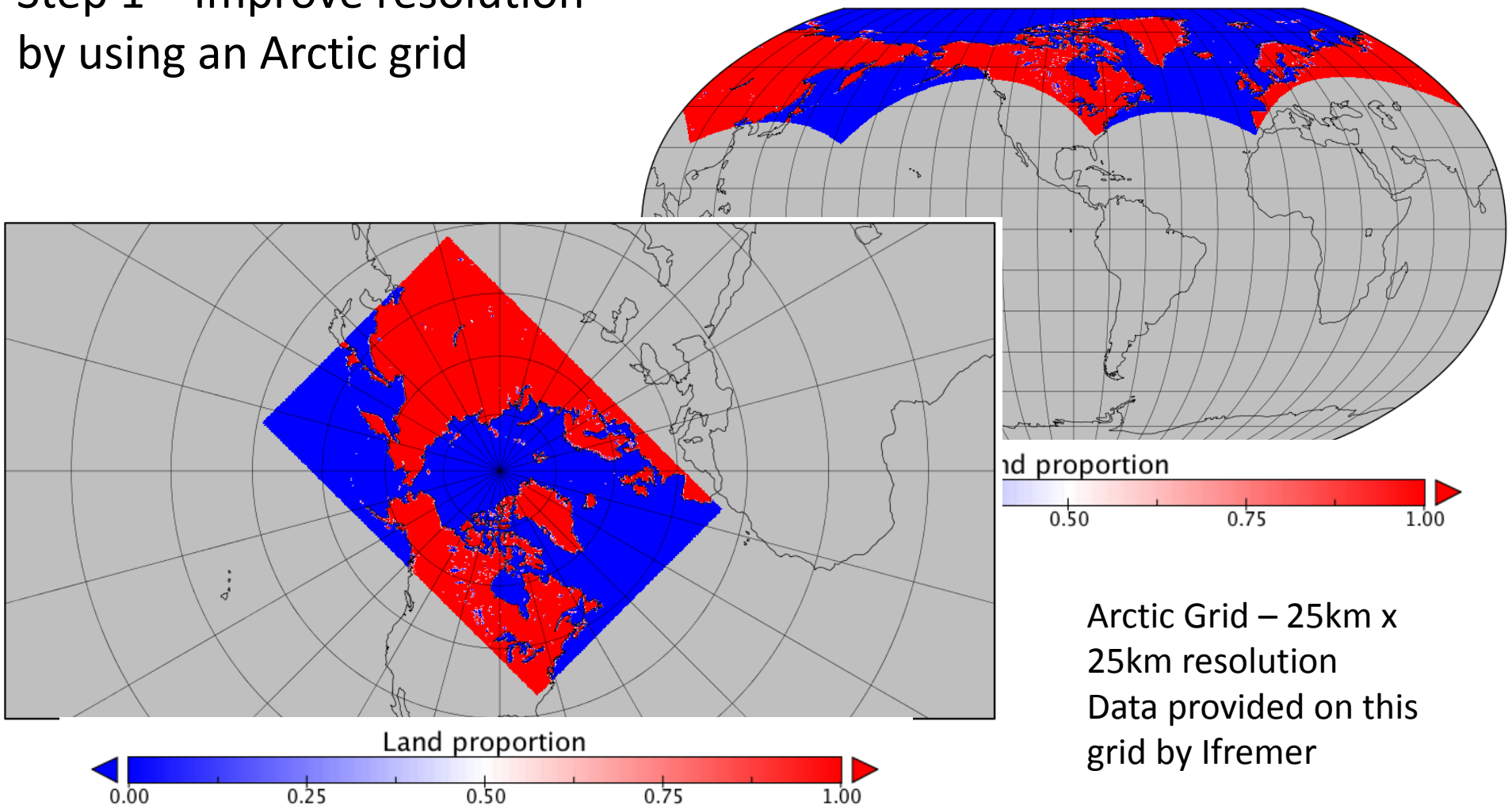

Arctic Grid – 25km x 25km resolution
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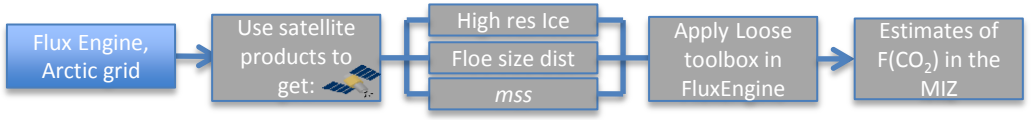
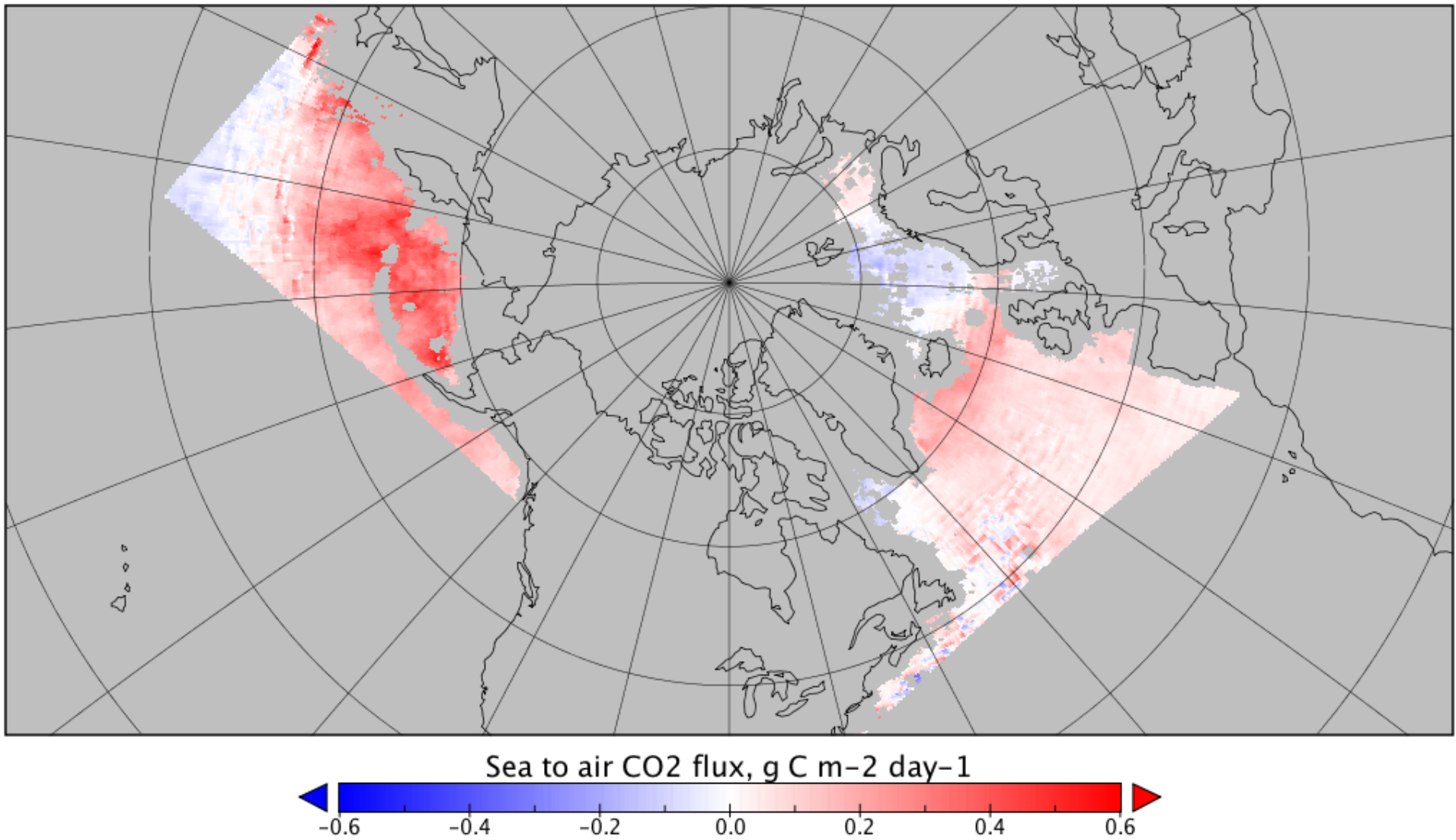
Net Co2 flux, Jan 2010





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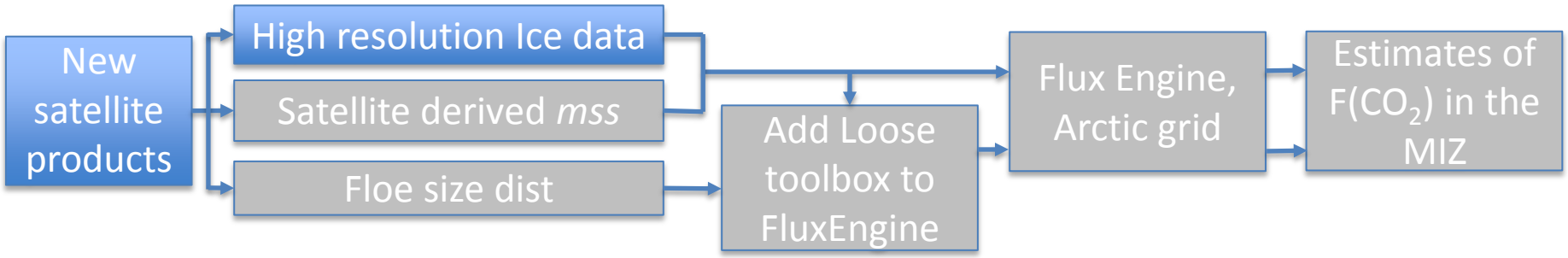
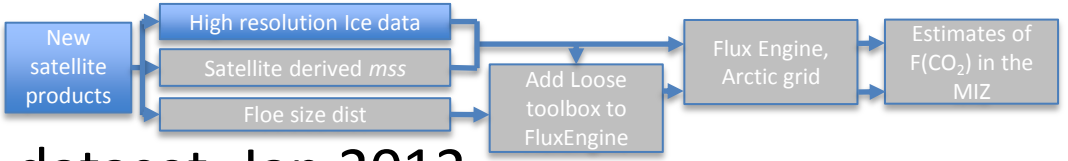
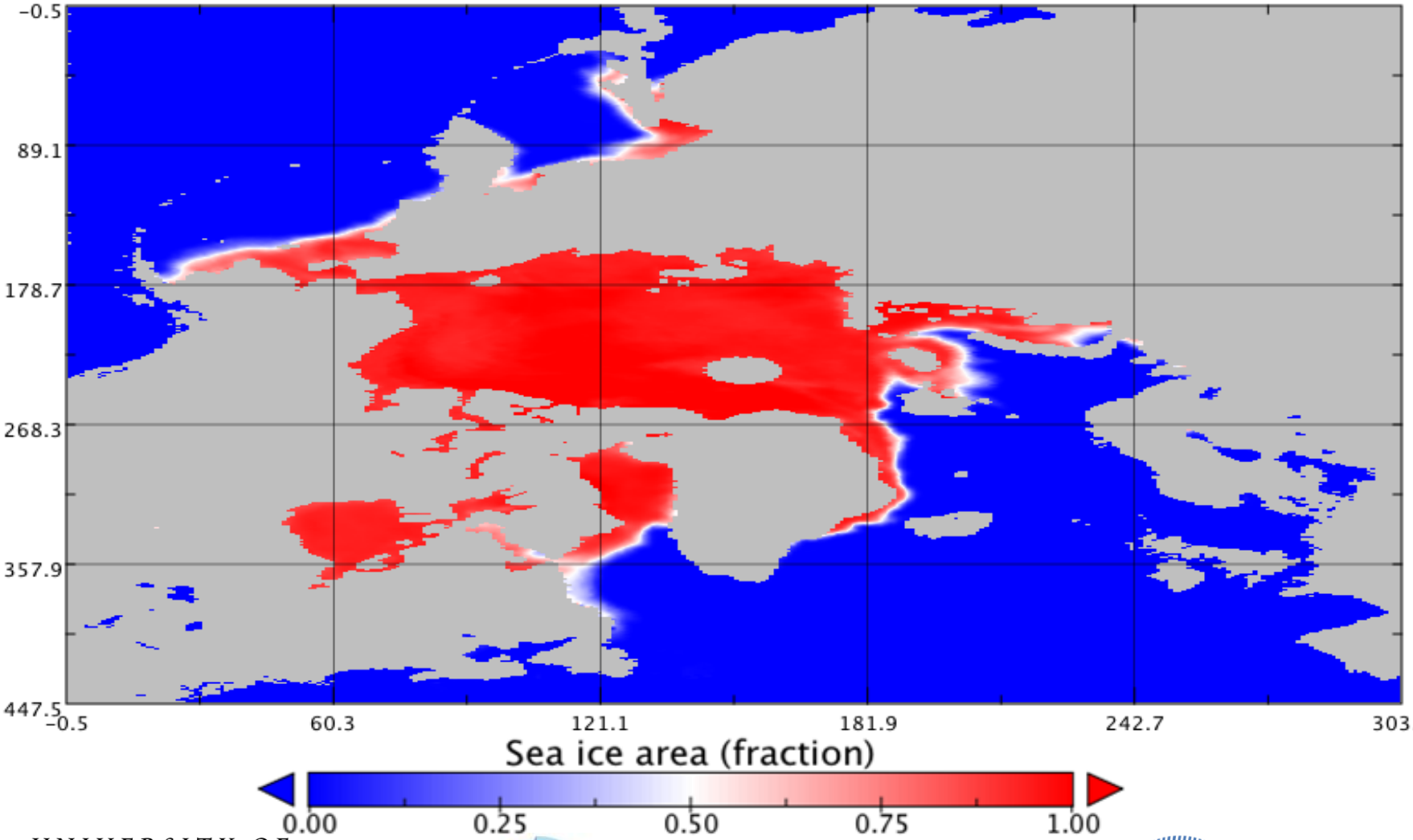


Step 2a – Take advantage of improved resolution ice products

Examine the differences between Cryosat II data and ODYSSEA data that has previously been used



Proportion of Sea ice, ODYSSEA dataset, Jan 2012



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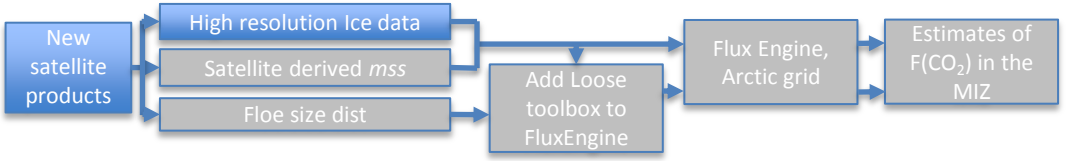
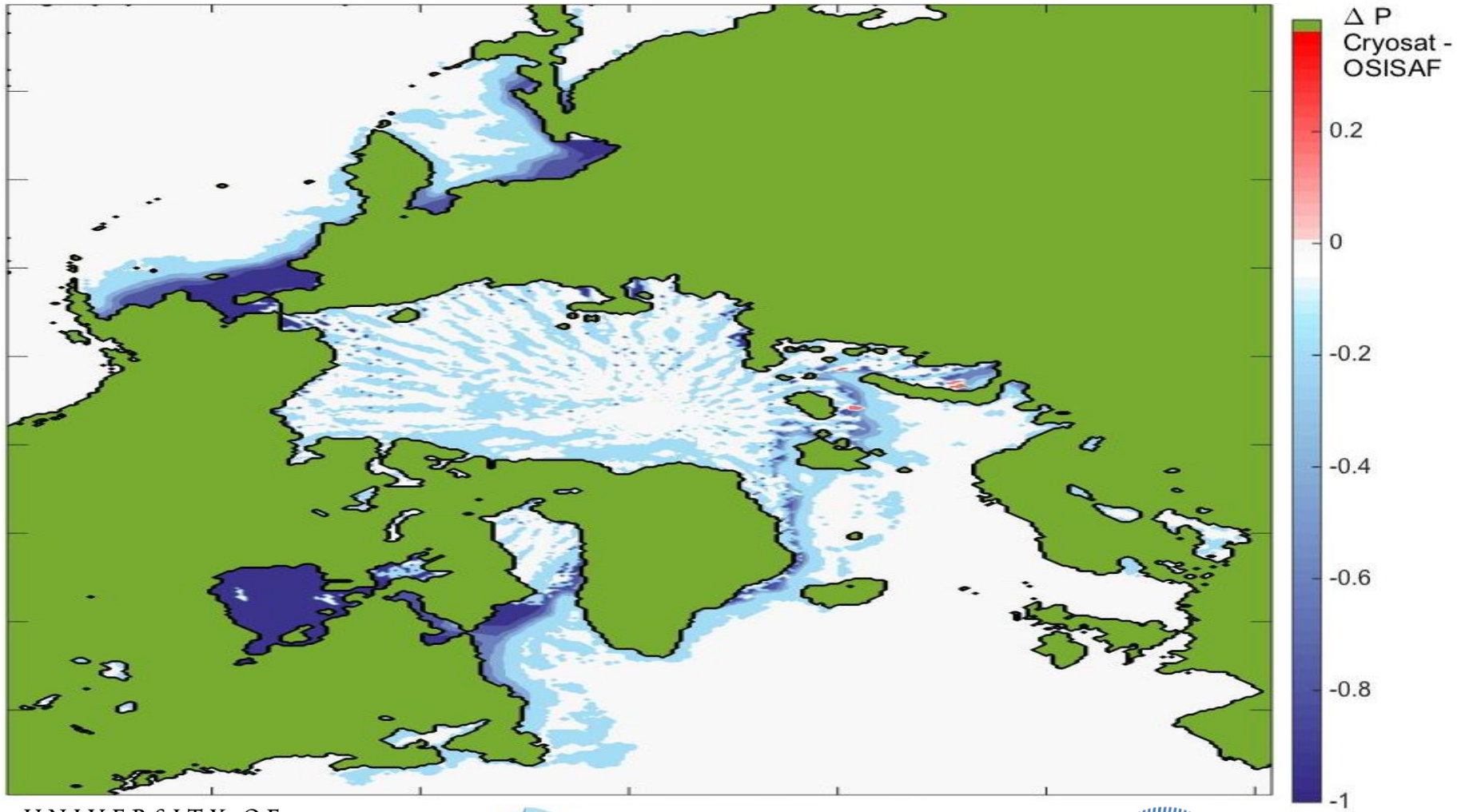


Difference in Ice between ODYSSEA and CRYOSAT, Jan 2012



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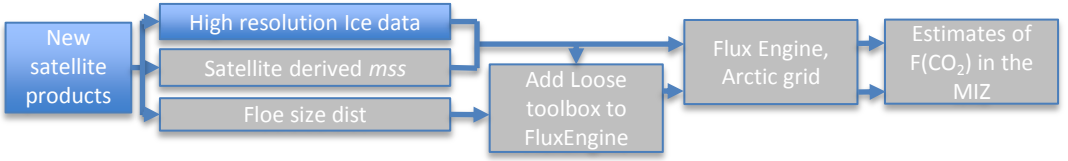
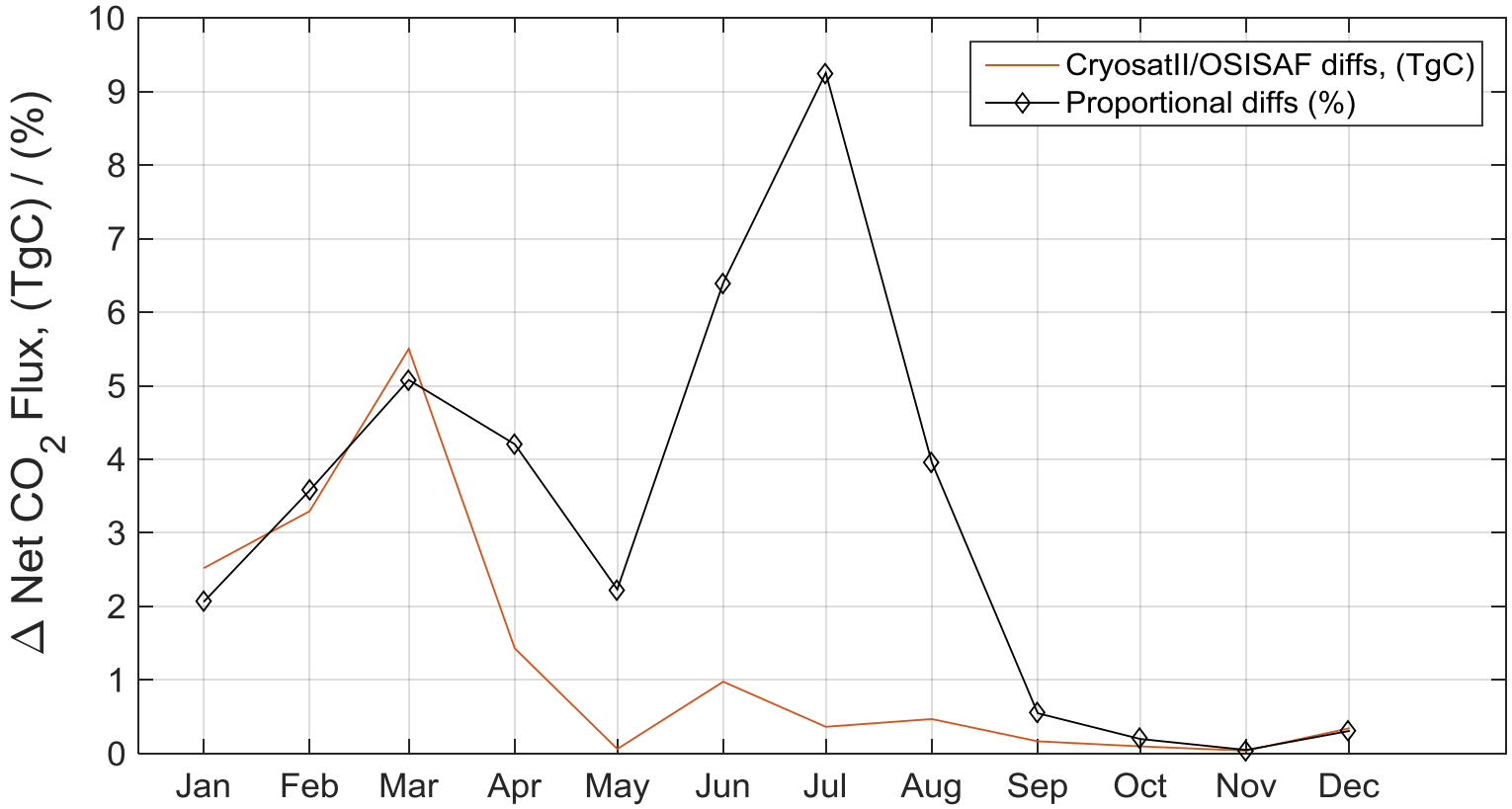


The difference in net CO_2 flux

	Osisaf	Cryosat II	Diff	Diff(%)
2012	**652.53**	**632.11**	**20.42**	**3.179101**



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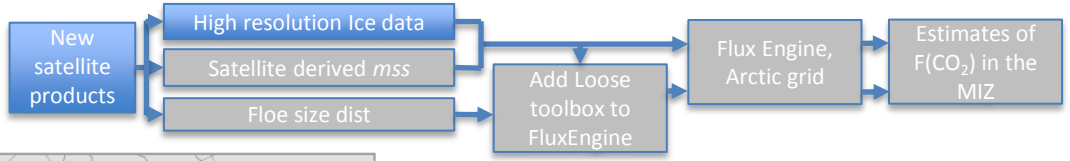
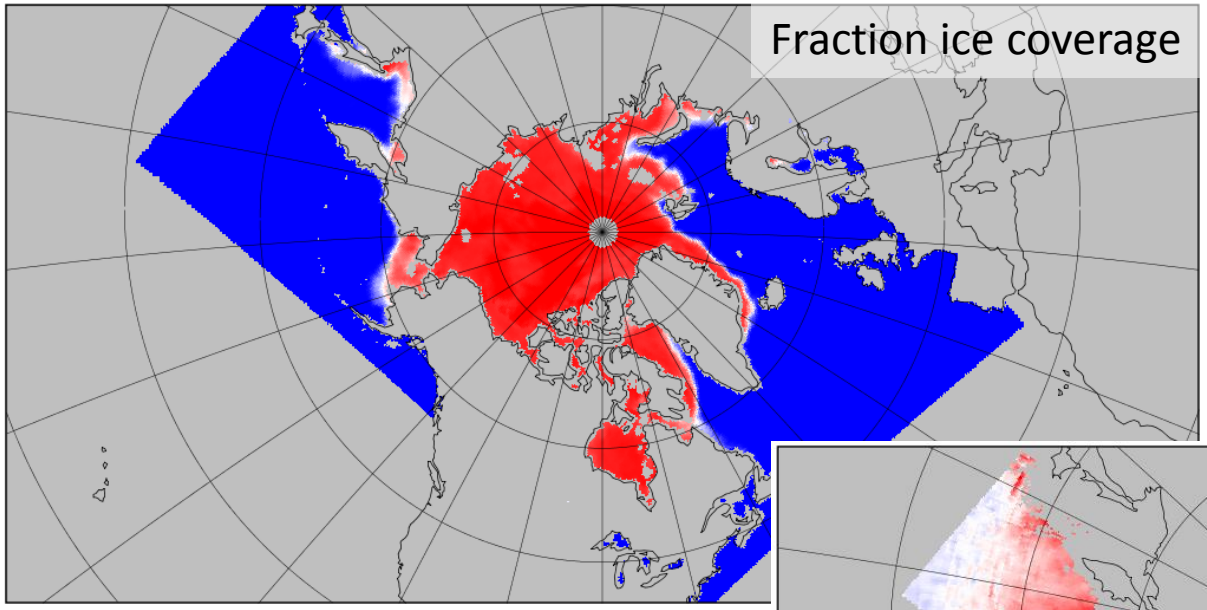
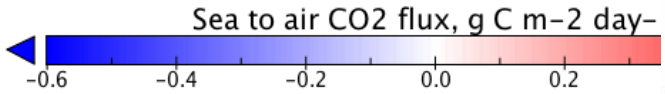
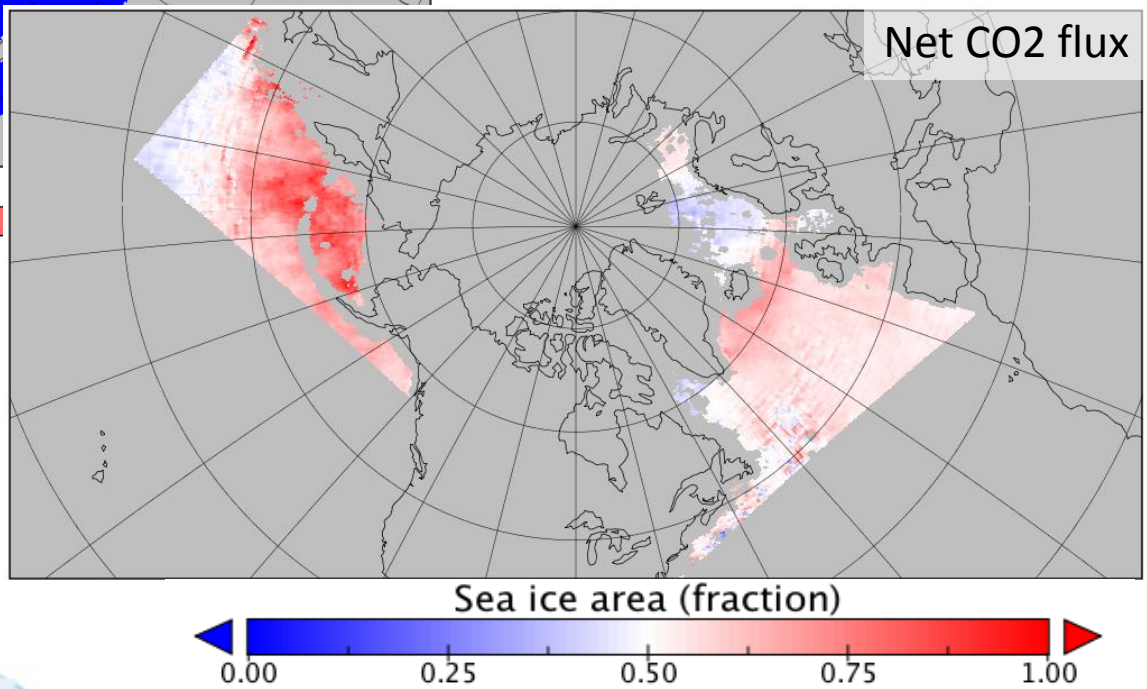




Flux is commonly not calculated in areas affected by ice.





Supporting data sets could improve the coverage of gas flux estimations in polar regions.

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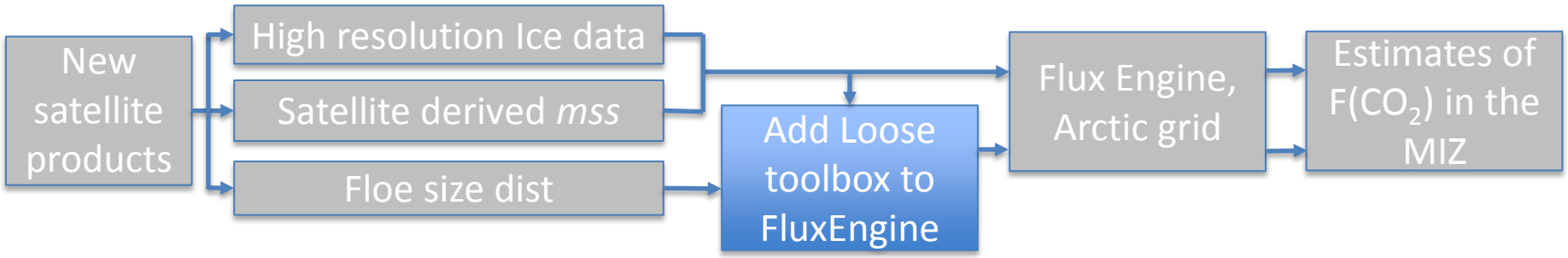
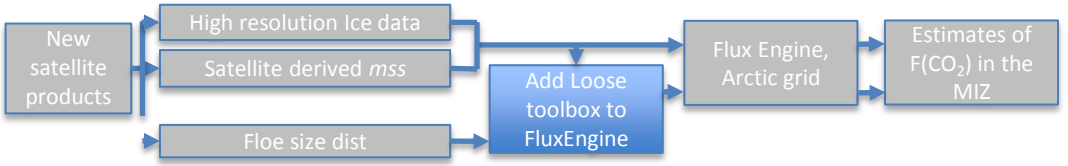
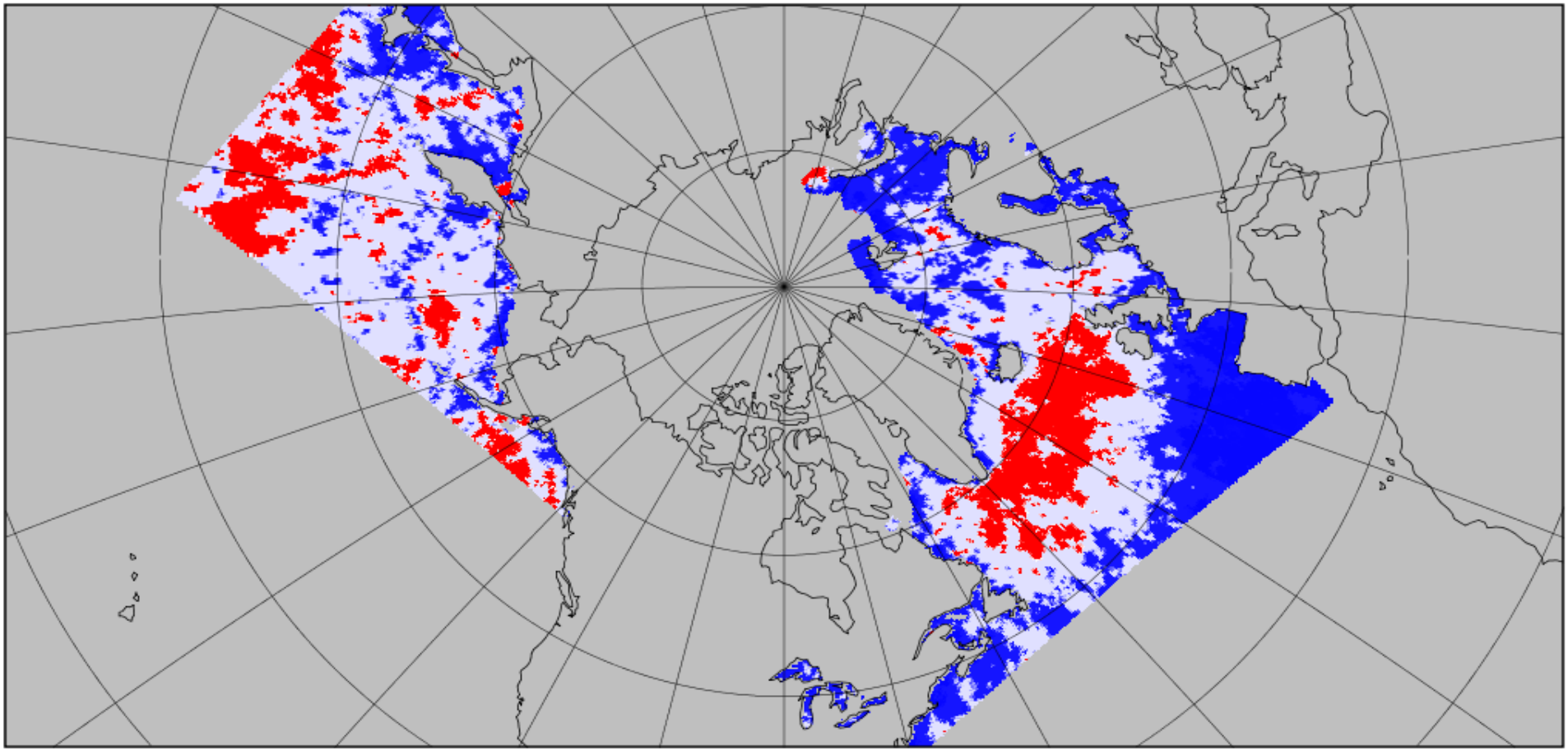


Step 3 – Implement the Loose et al. 2014 parameter model

Gas transfer velocity, estimated from mss





Effective gas transfer velocity, Keff wave, cm hr−1

0.00 37.50 75.00 112.50 150.00

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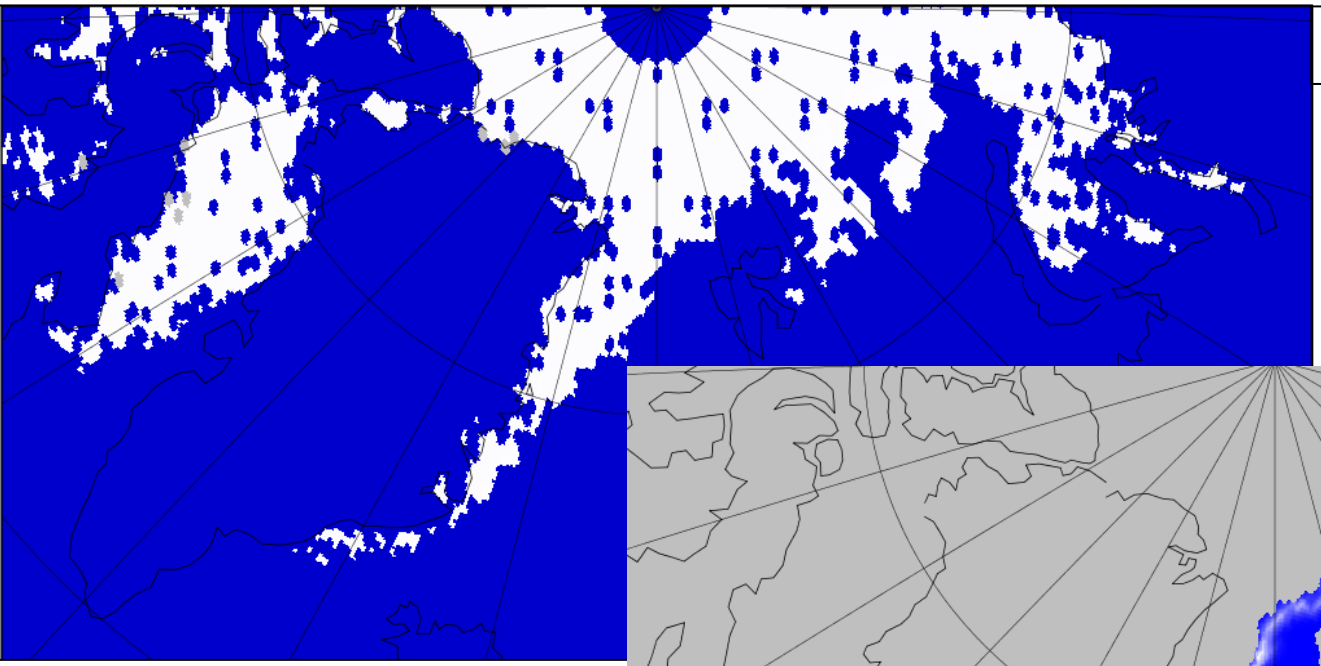
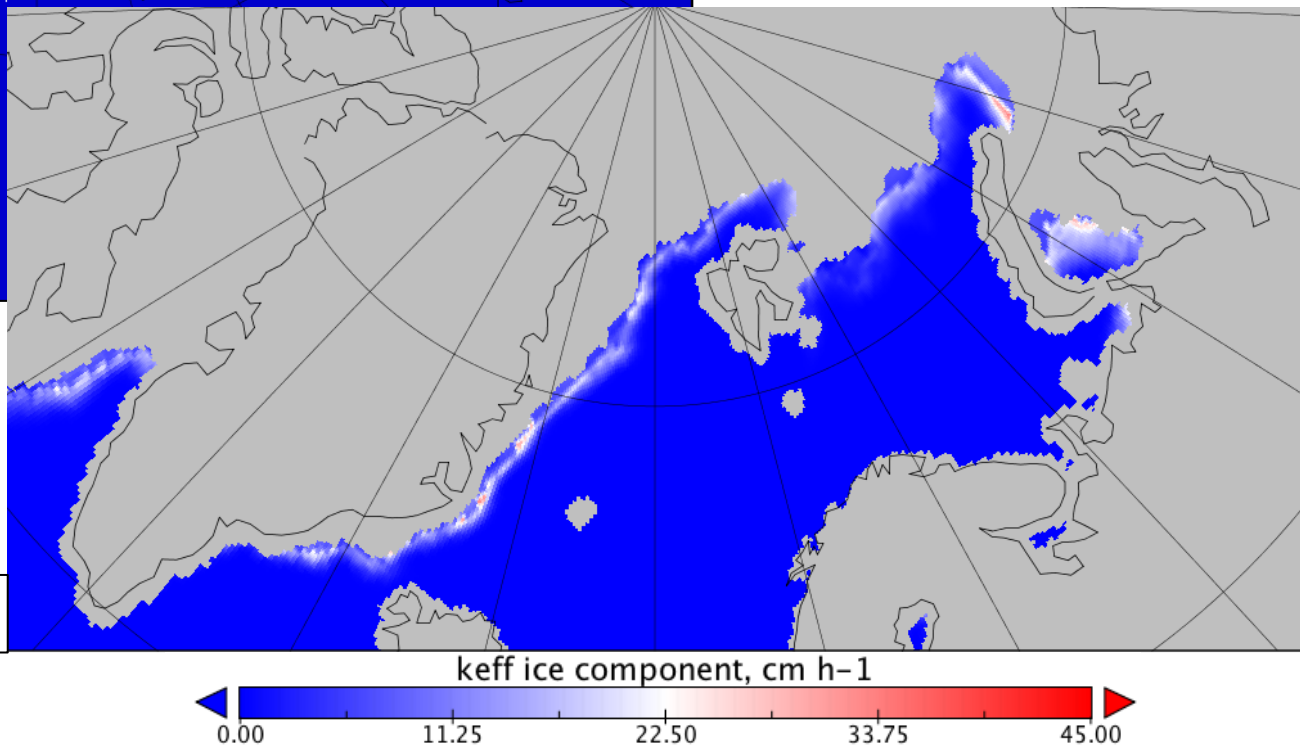


Ice coverage, Jan 2012

K_{eff} ice is predicted to be of the same order of magnitude as k in the MIZ

Wind data not available over ice, which limits the coverage for k_{eff} ice estimations

k_{eff}, Jan 2012



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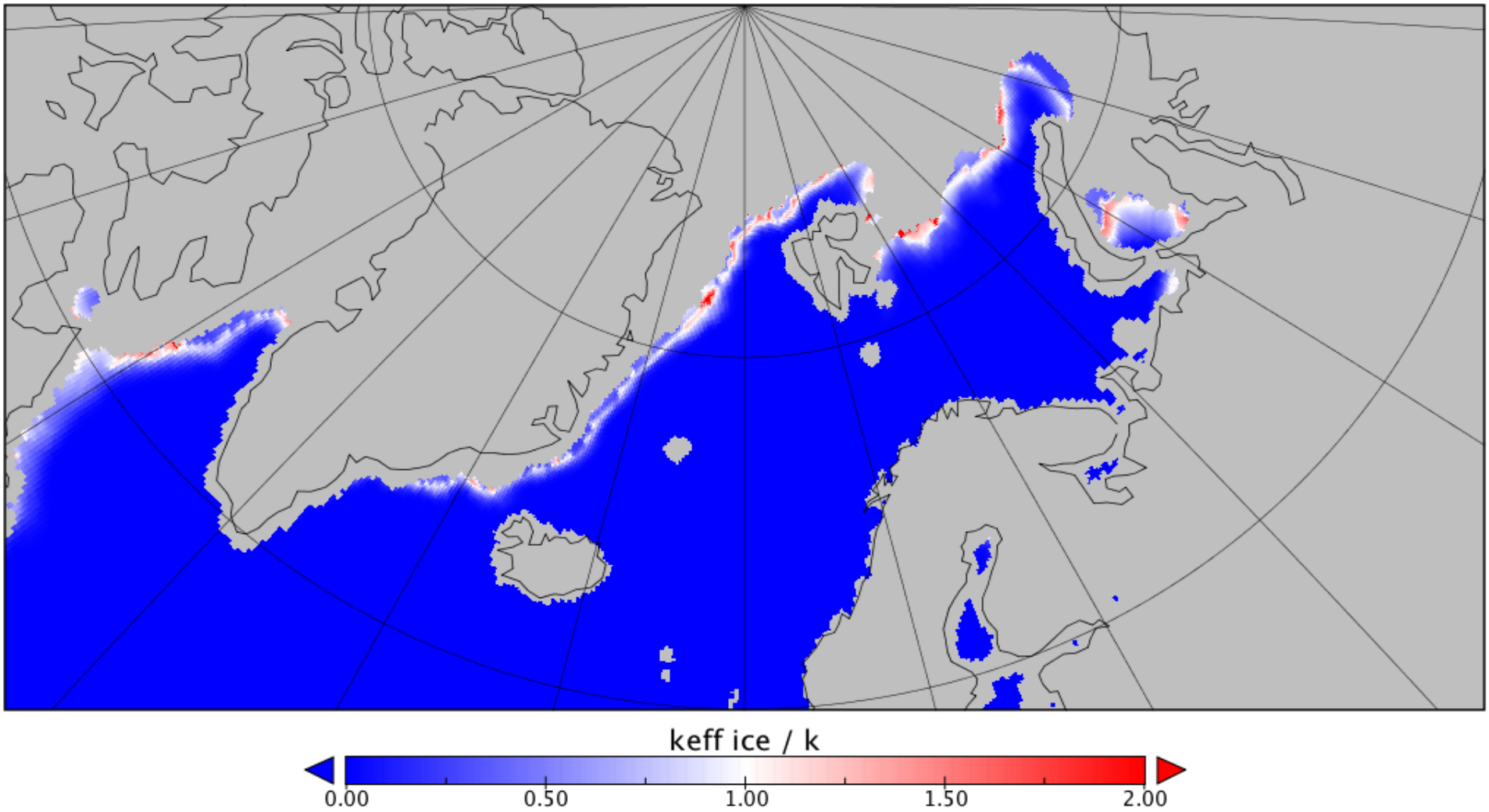
Gas transfer velocity due to ice as a fraction of that due to wind



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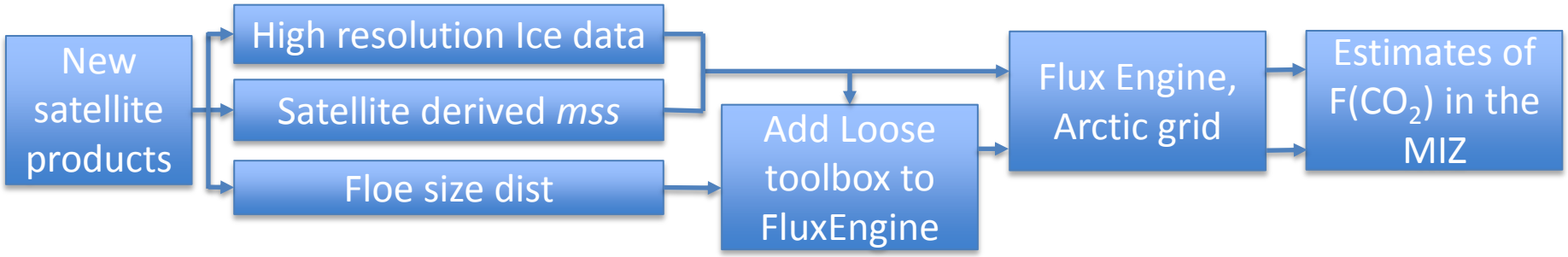

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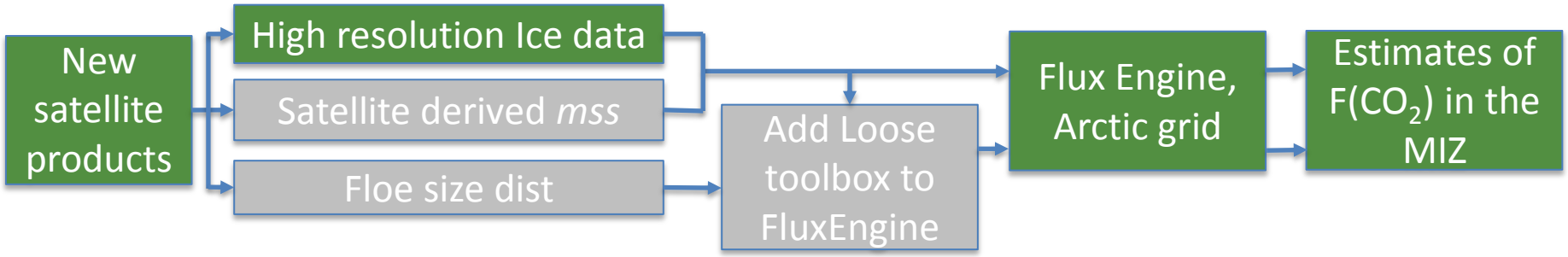

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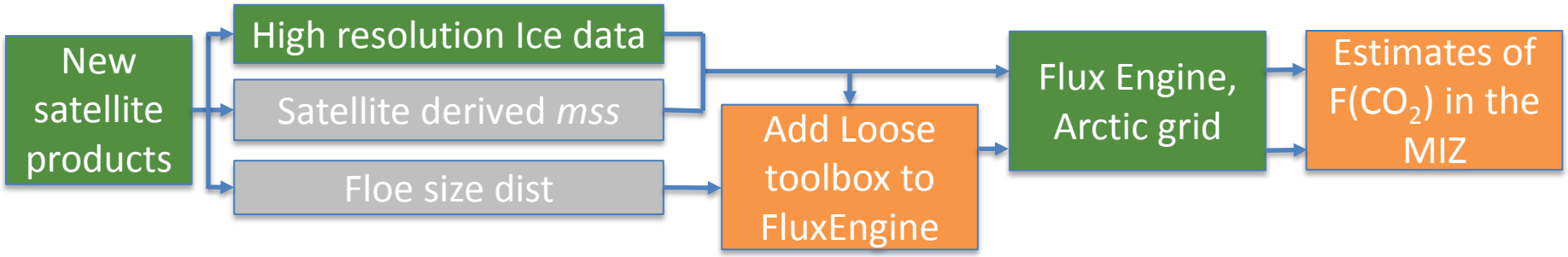

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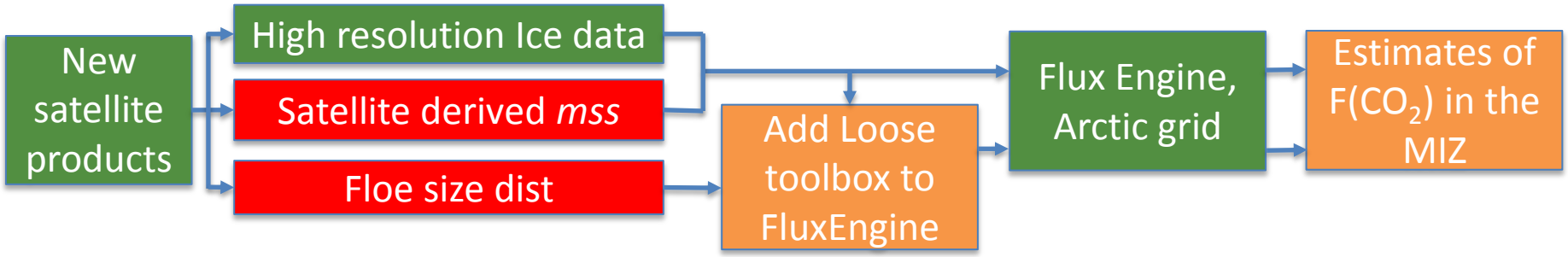

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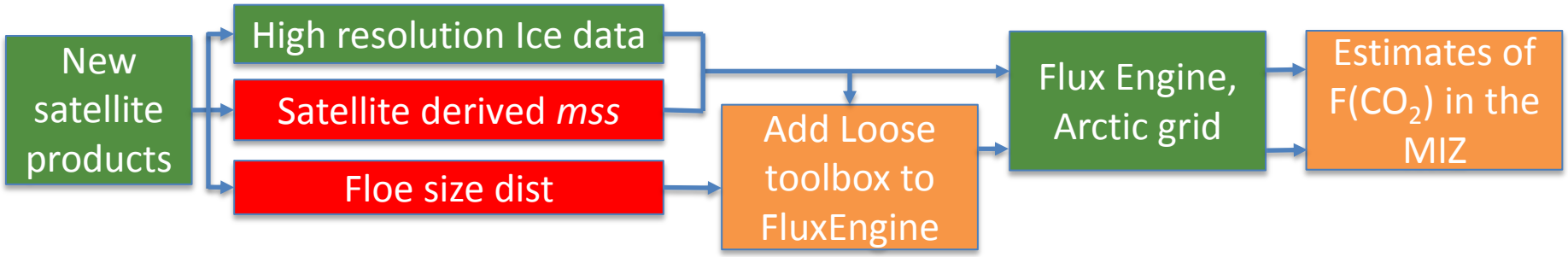

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Thank you for listening and collaborating

Any questions?

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