Task 6.5
Multi-disciplinary data assimilation to advance process understanding in Arctic greenhouse gas exchange

MPG, UiB, NIVA, AU, UB

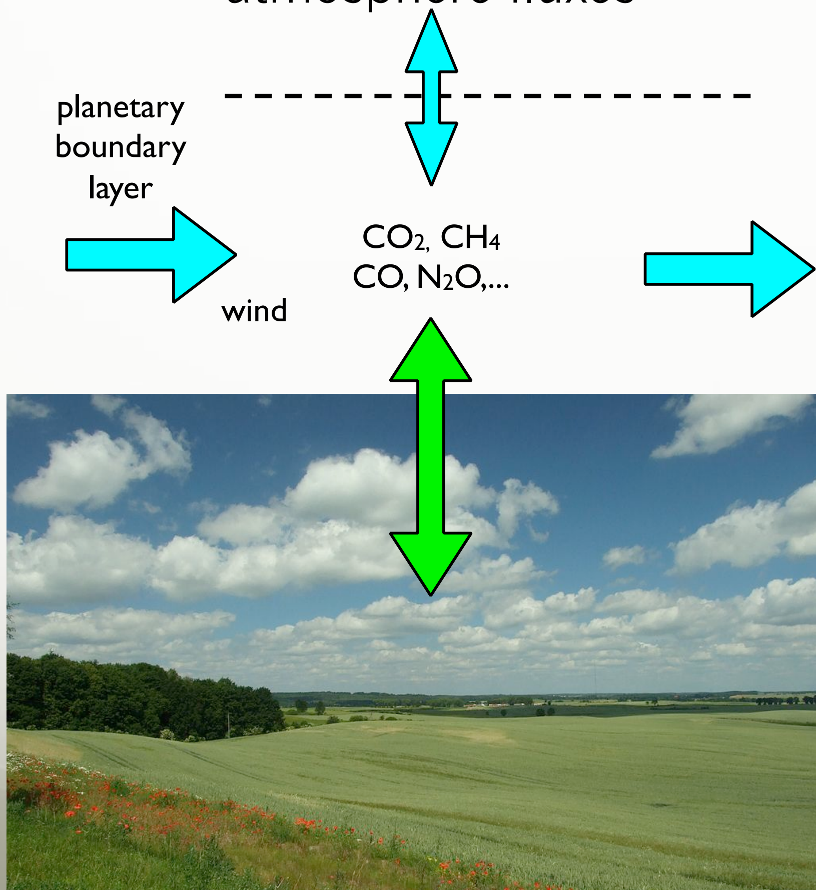
Overall objective

Multi-disciplinary data assimilation that improves quantifying regional Arctic carbon budgets

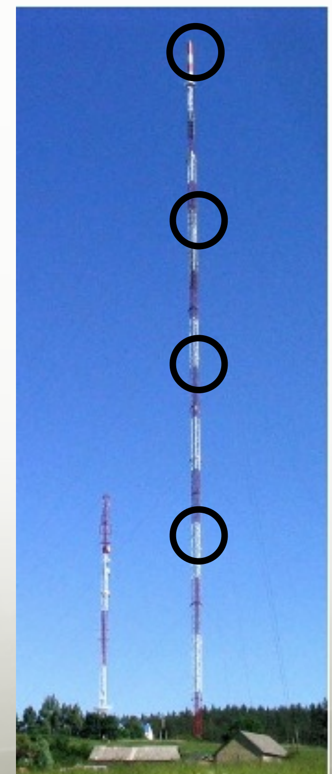
- (Atmospheric) inverse modeling of greenhouse gases, including a geostatistical data assimilation component
- Inter-disciplinary GHG assessment in the North Atlantic ocean region

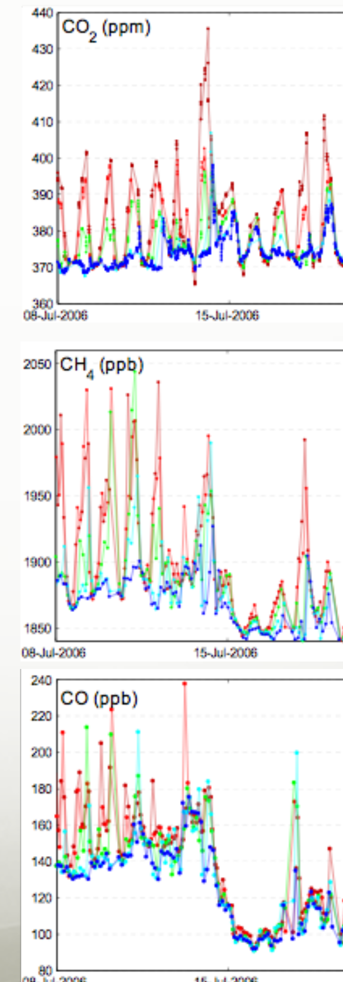
Atmospheric inversion: atmosphere as 'integrator'

atmospheric transport constitutes a natural integrator of surface-atmosphere fluxes



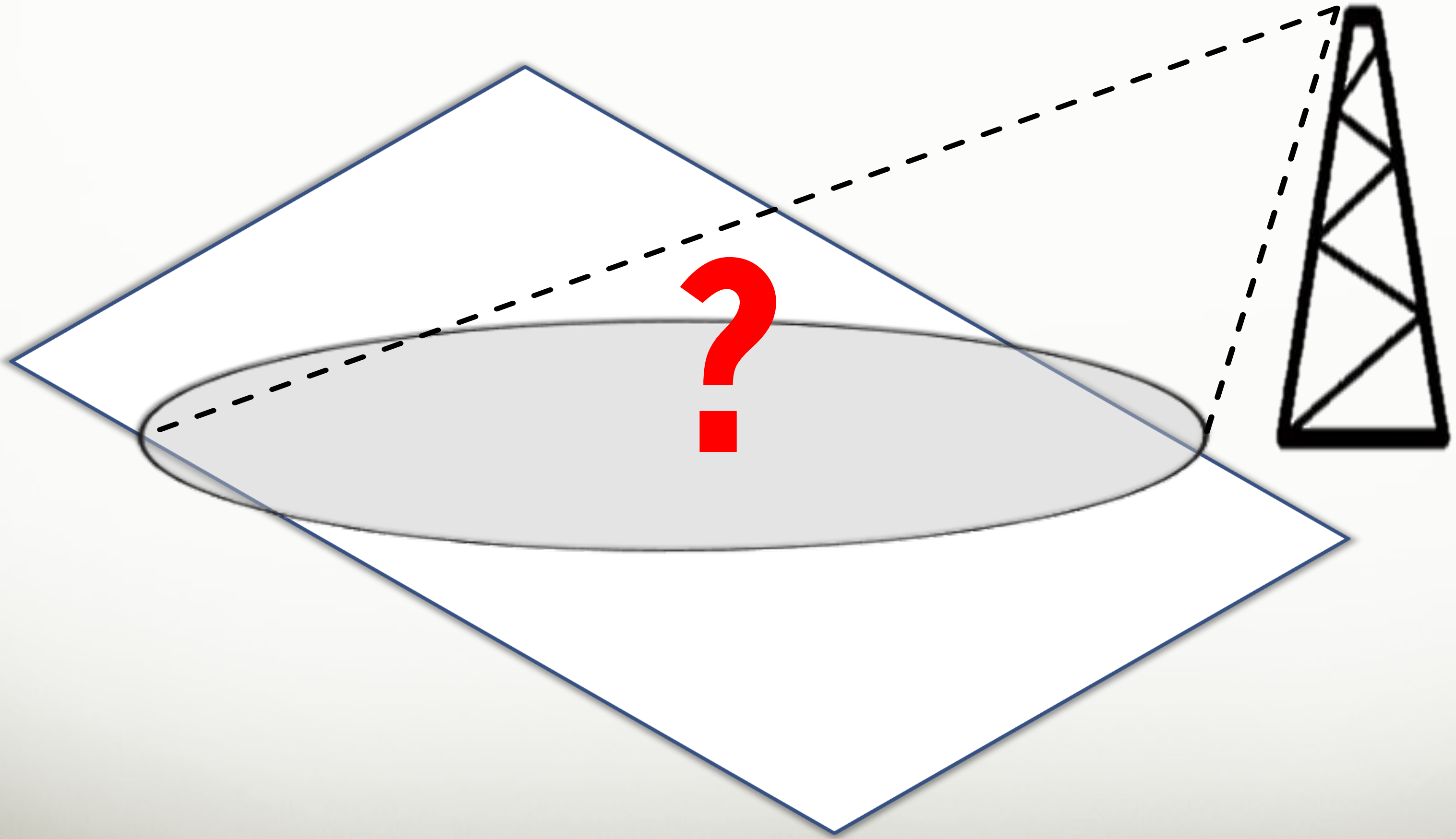
Bialystok tower (Eastern Poland) Trace gas concentration measurements



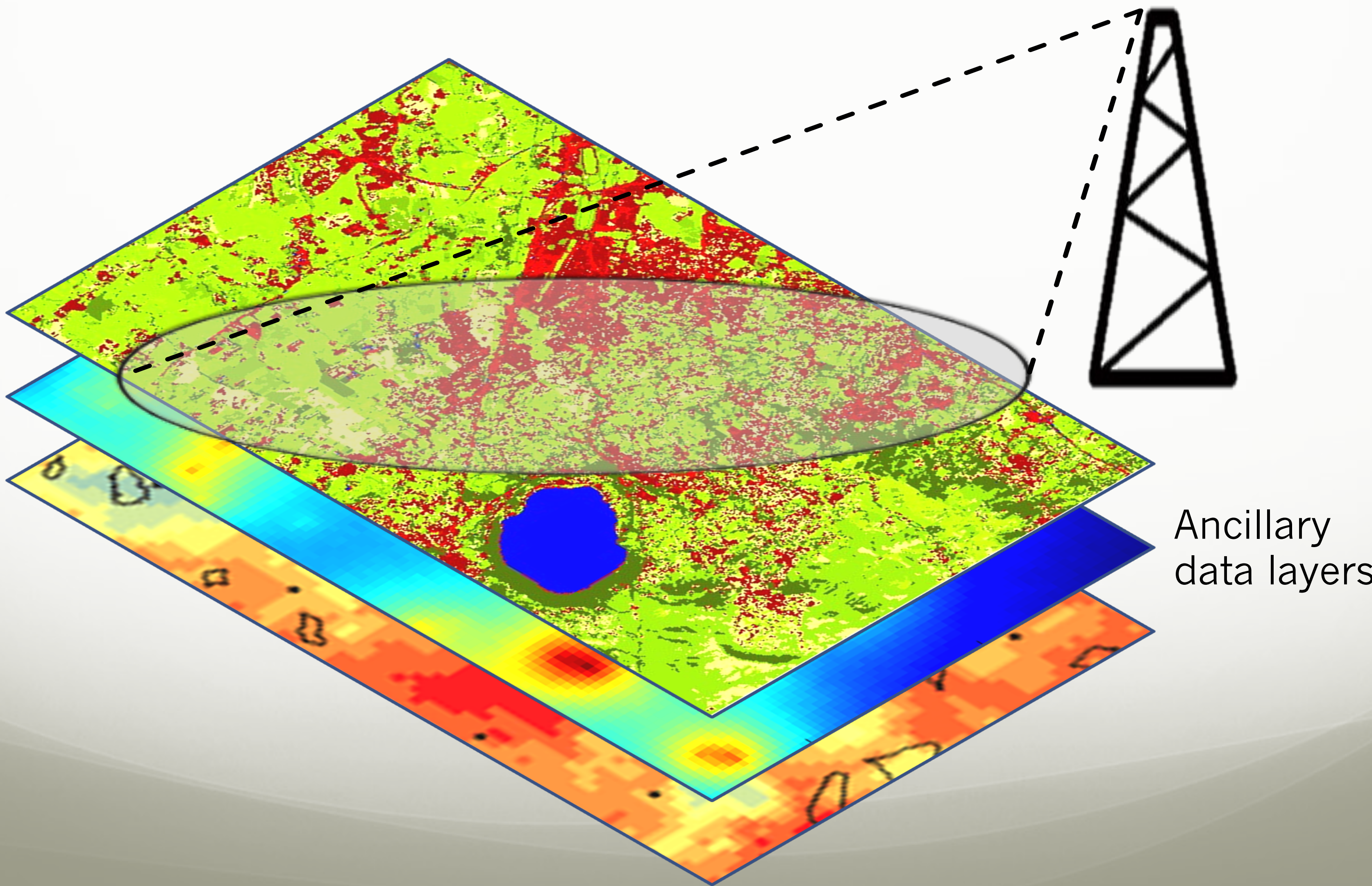


source: Popa et al., 2010

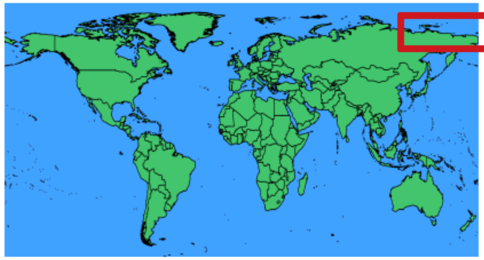
Under-constrained problem

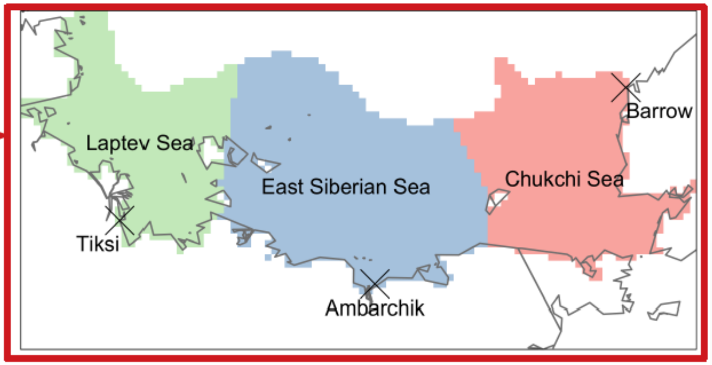


Add information for structuring solution space



Pilot study: East Siberian Arctic Shelf





East Siberian Arctic Shelf

Candidate parameters considered for prior ocean CH_4 flux:

Category	variable	Process described
Bathymetry	ocean depth	Ebullition
	shelf edge	
Meteorology	wind speed[2]	Turbulent diffusion
Sea ice	ice-free ocean fraction	Ice barrier
	sea ice growth	Brine rejection
	sea ice melt	Accumulation below ice

Geostatistical CH_4 inversion for ESAS: major findings

- Total emissions rather low: 0.4 – 1.5 Tg CH_4 yr^{-1}
- Emissions mostly from shallow waters
  - Emissions distribution, or mixing of CH_4
- No emission spike during ice melt
  - Biological consumption, ocean currents, etc.
- Large emissions in fall/winter possible
  - Mixing due to sea ice growth, and/or storms?

➢ Ancillary data layers helped structuring results, link emission patterns to specific processes

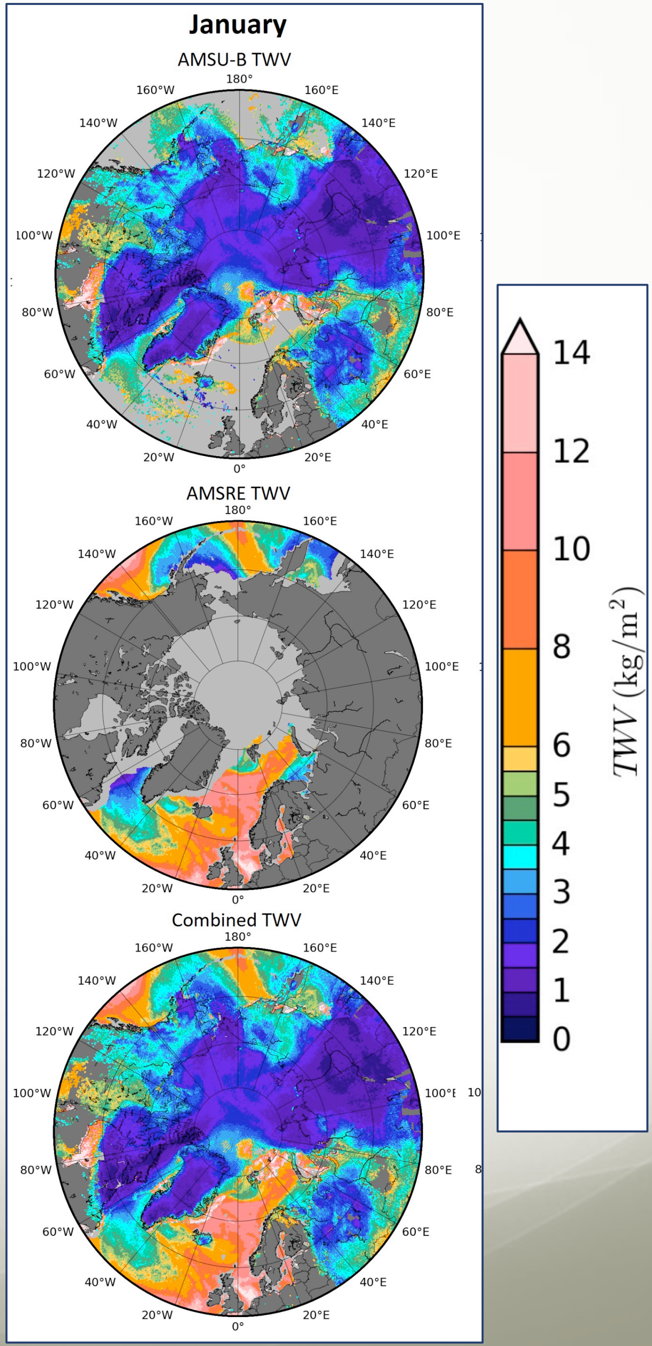
Extension: embed new INTAROS data

e.g. seamless data set of atmospheric total water vapor (TWV) over Arctic ocean and sea ice (UB)

Based on
- *AMSU-B/MHS microwave humidity sounders*.
  (Triana Gomez et al., AMT (2020))
- *AMSR-E/AMSR-2 microwave imagers.*
  (Wentz and Meissner (2002) global ocean TWV product)

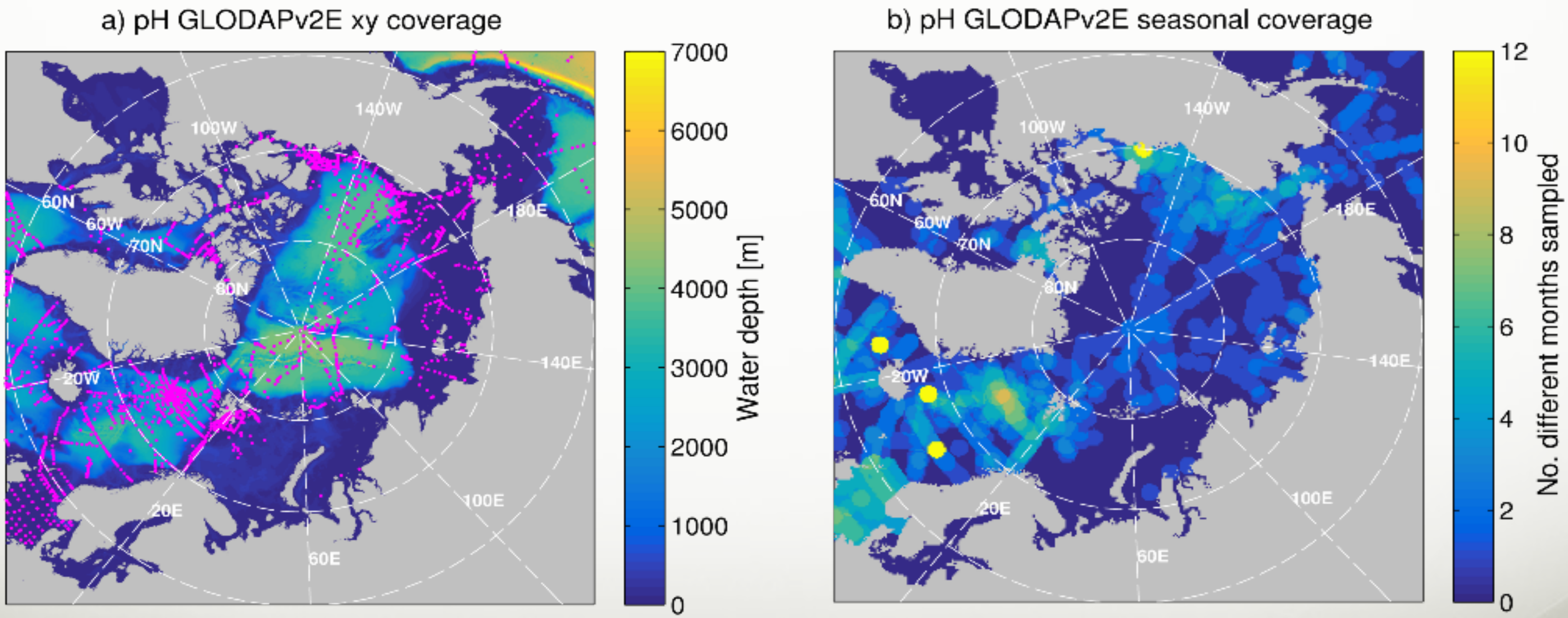
Merged product
- Data years 2008-2009 produced, daily NETcdf maps

Challenges
- *with sounders*:
  – Screen out opaque ice clouds values by image processing
  – Merging of results from three sub-algorithms, with different TWV range and different channel combinations
- *Merging sounder and imager retrieval* into TWV fields with homogeneous statistics & no jumps along merging lines.



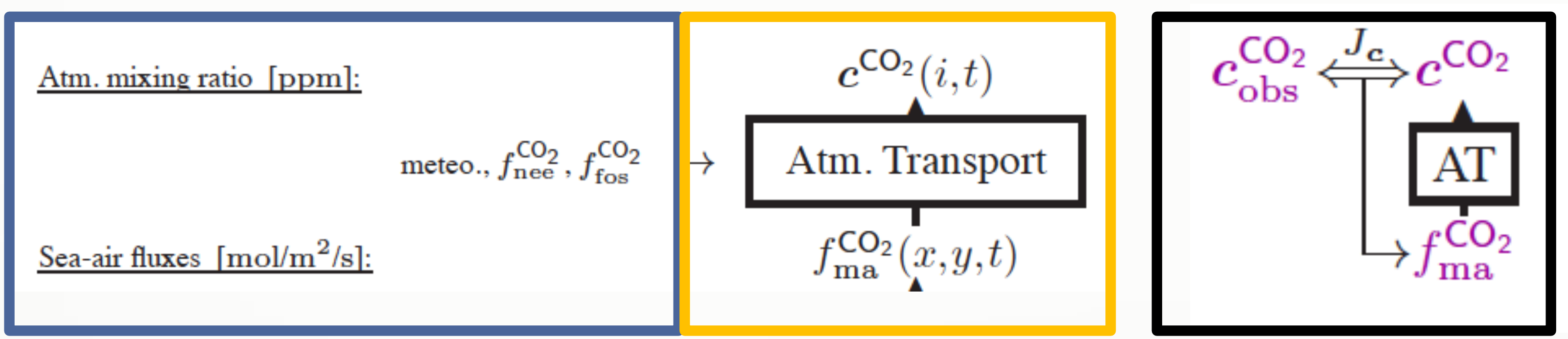
Data aggregated in Task 2.2

Task 2.2: "Exploitation of existing in situ datasets for Arctic seawater carbonate system chemistry, nutrients, and phytoplankton biomass" (Aggregation and QC/QA of existing GLODAPv2 dataset together with CARINA, WOD, and ICES dataset into "GLODAPv2E" INTAROS dataset)



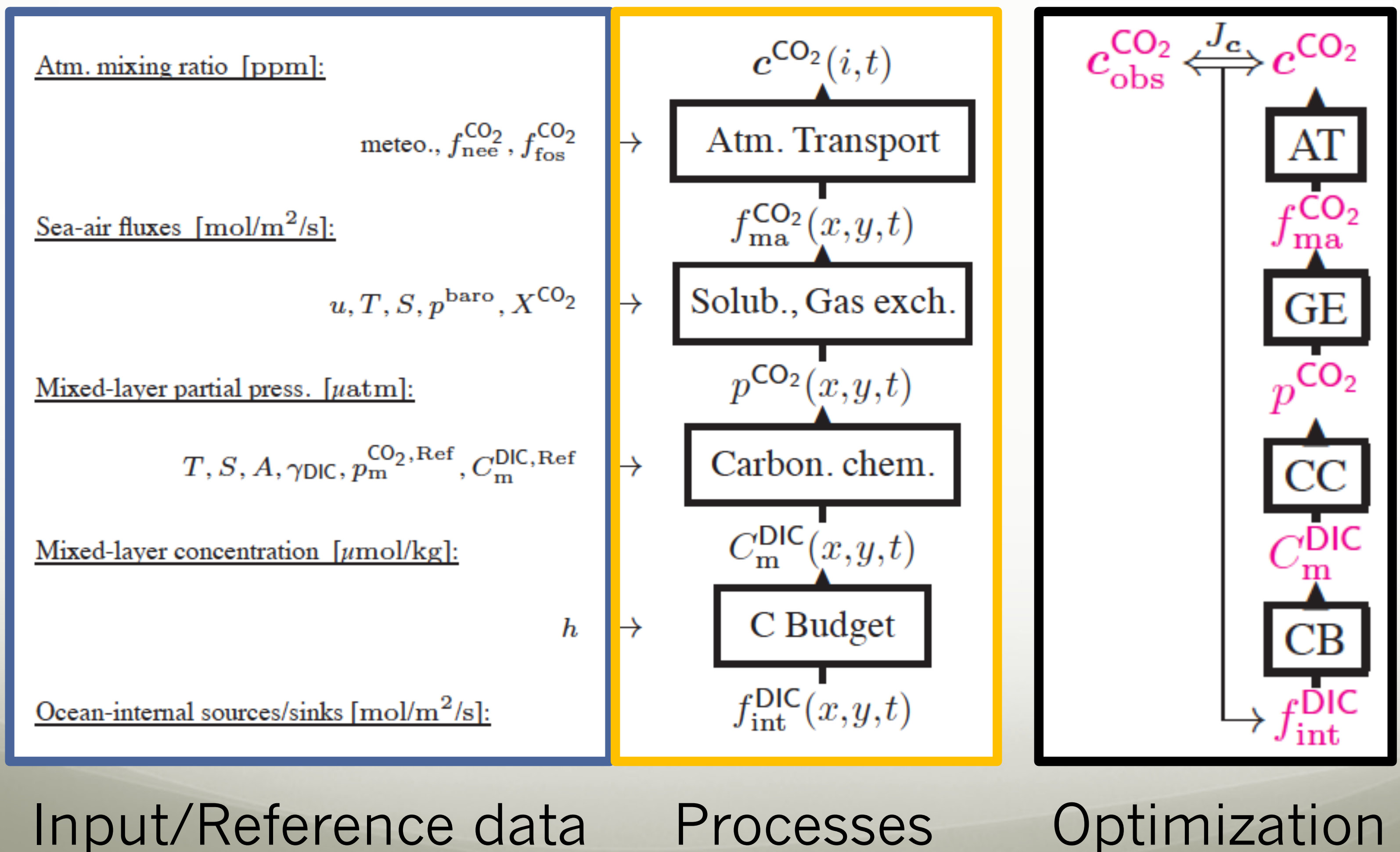
- Relatively good carbonate chemistry coverage in Norwegian Sea and central Arctic
- Poor carbonate chemistry coverage in Barents Sea/Kara Sea
- Relatively poor seasonal coverage throughout the Arctic

Standard atmospheric inversion



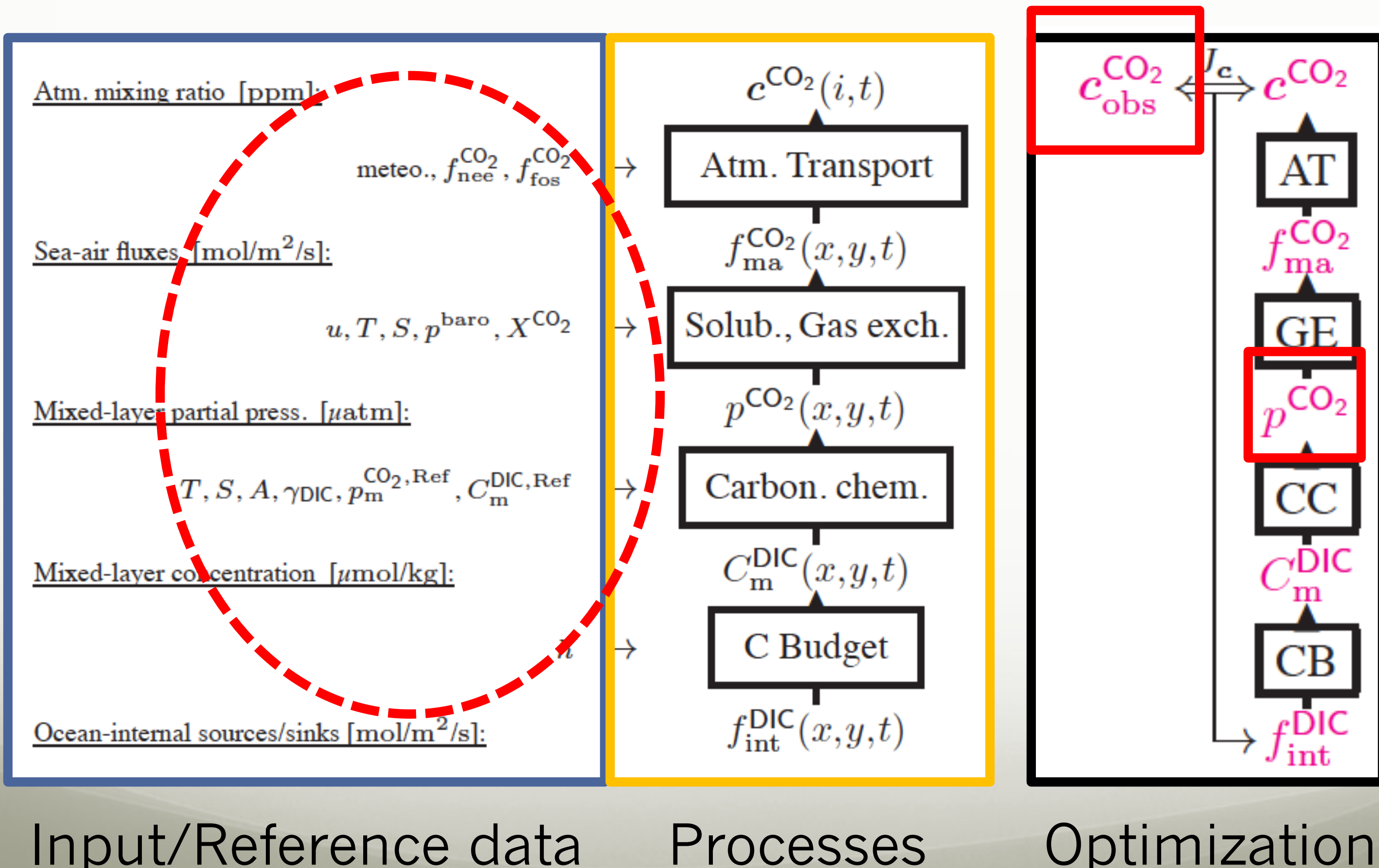
Input/Reference data　　Processes　　Optimization

Generalized data assimilation framework



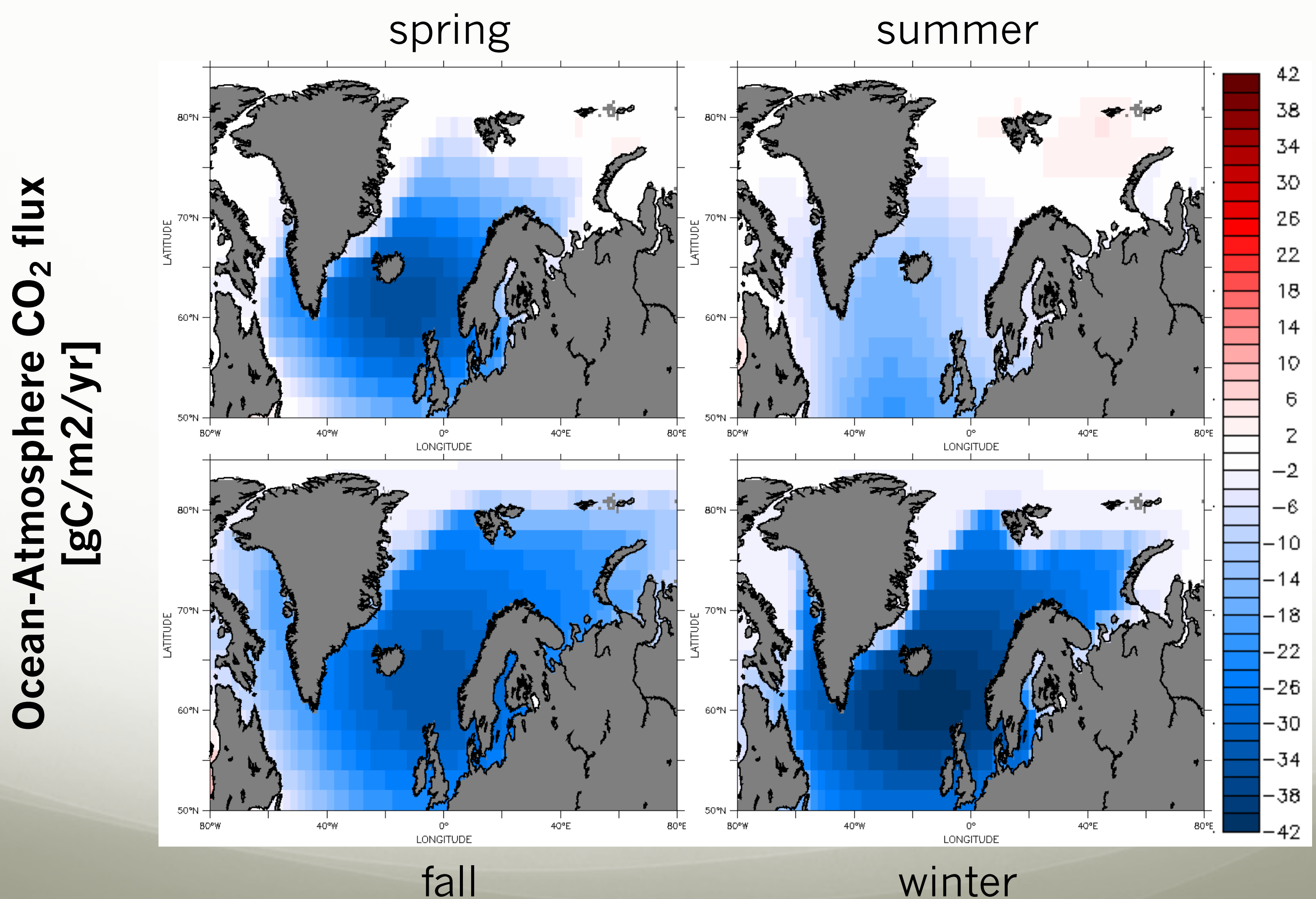
source: Rödenbeck et al., Ocean Science, 2013

Multi-disciplinary data assimilation

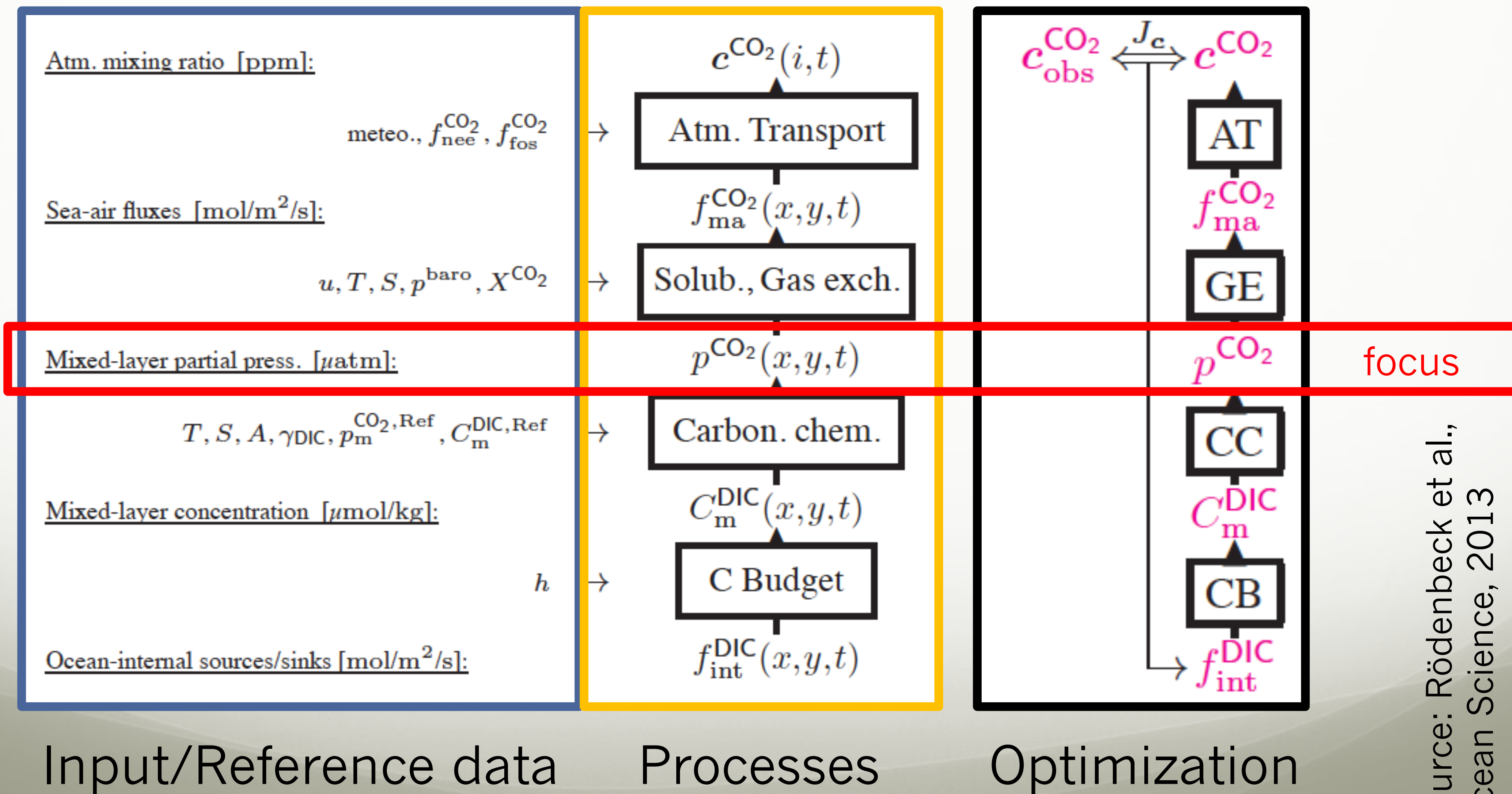


source: Rödenbeck et al., Ocean Science, 2013

Regional CO_2 inversions, focusing on ocean domains

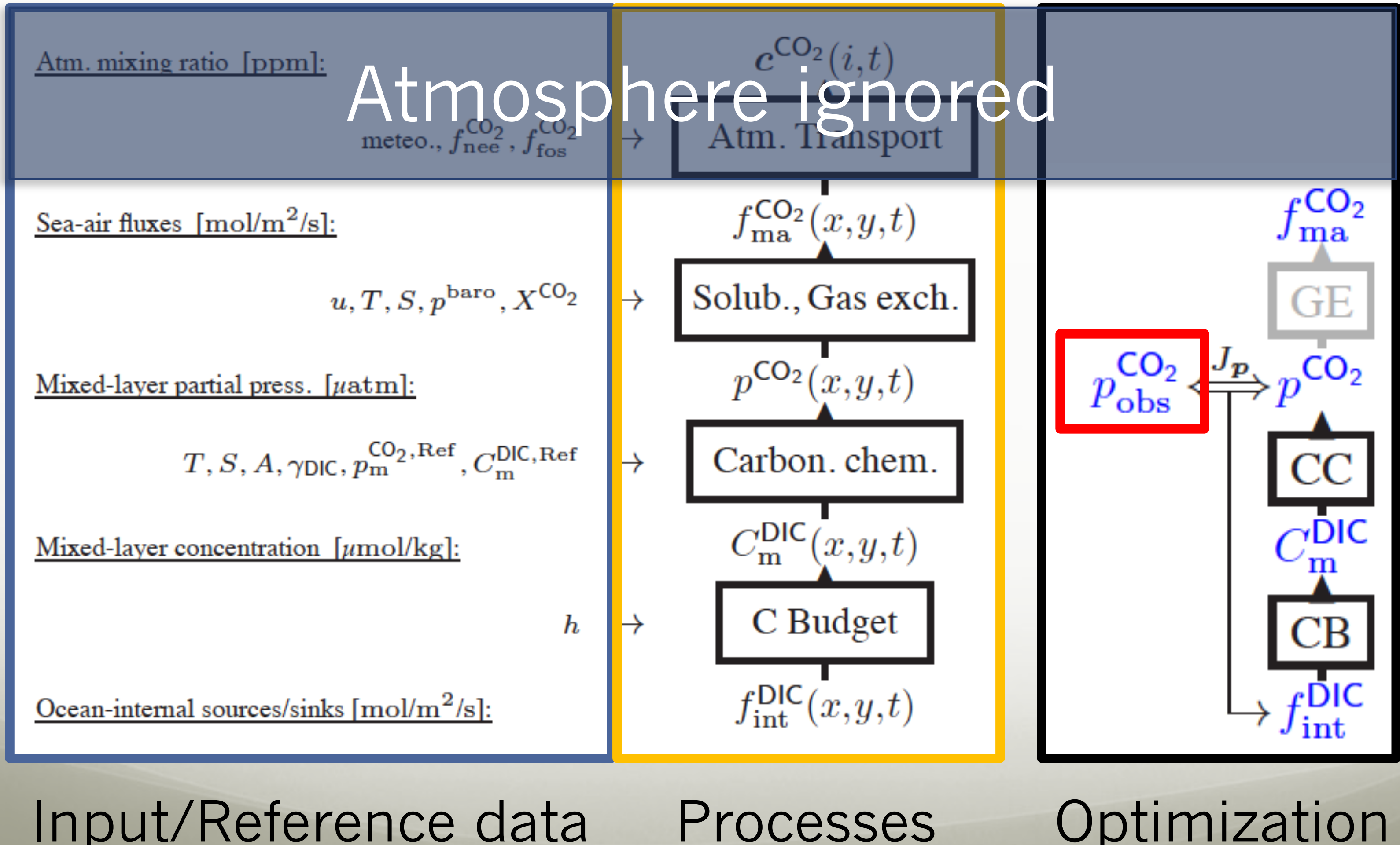


Generalized data assimilation framework



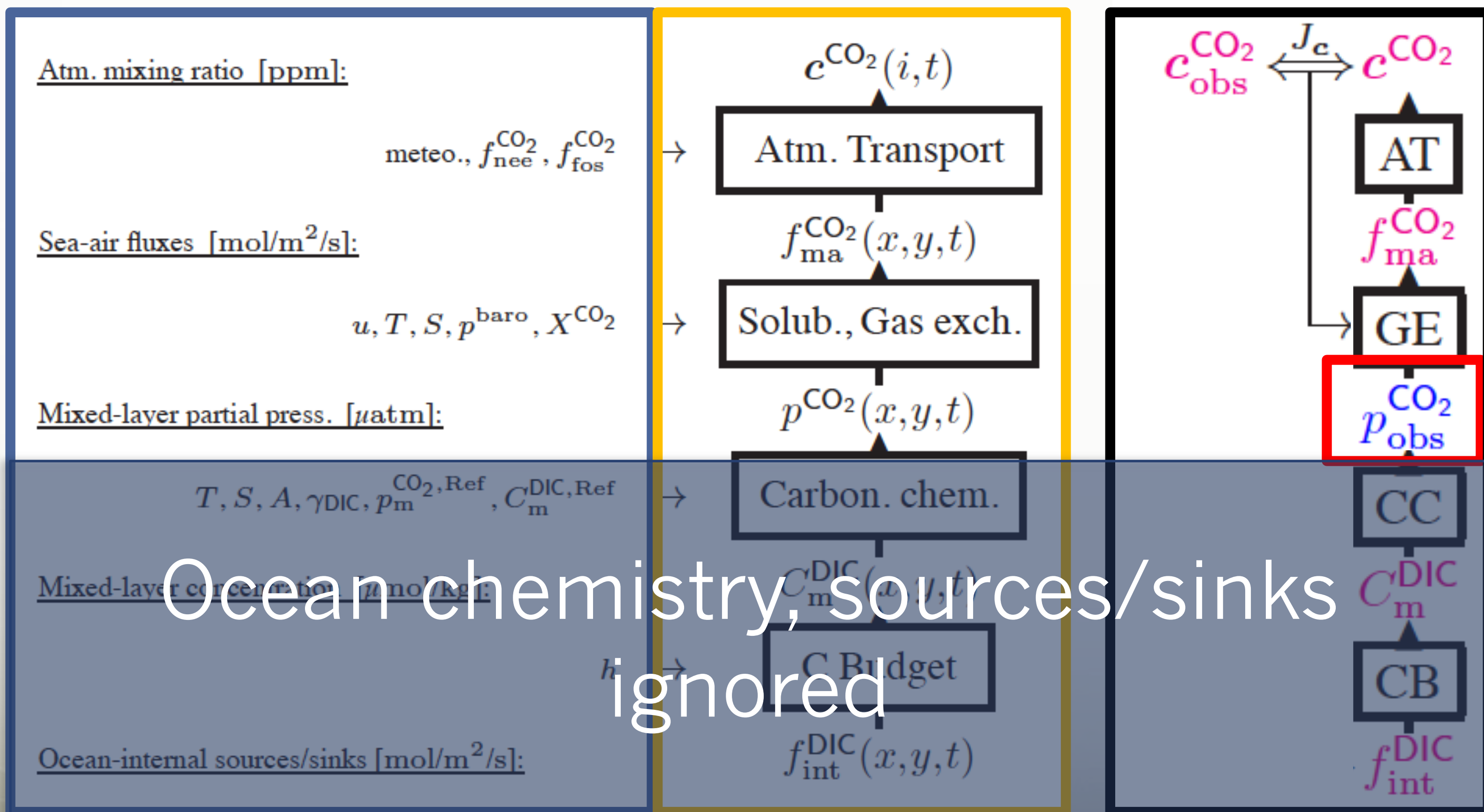
source: Rödenbeck et al., Ocean Science, 2013

1: optimize ocean components (pCO_2 inversion)



source: Rödenbeck et al., Ocean Science, 2013

2: optimize gas exchange coefficients

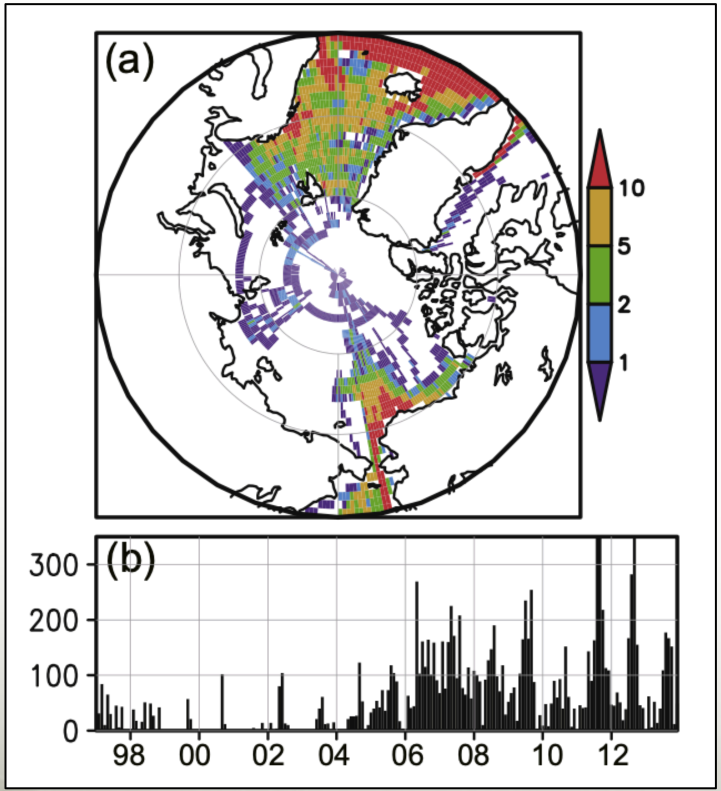


Input/Reference data   Processes   Optimization

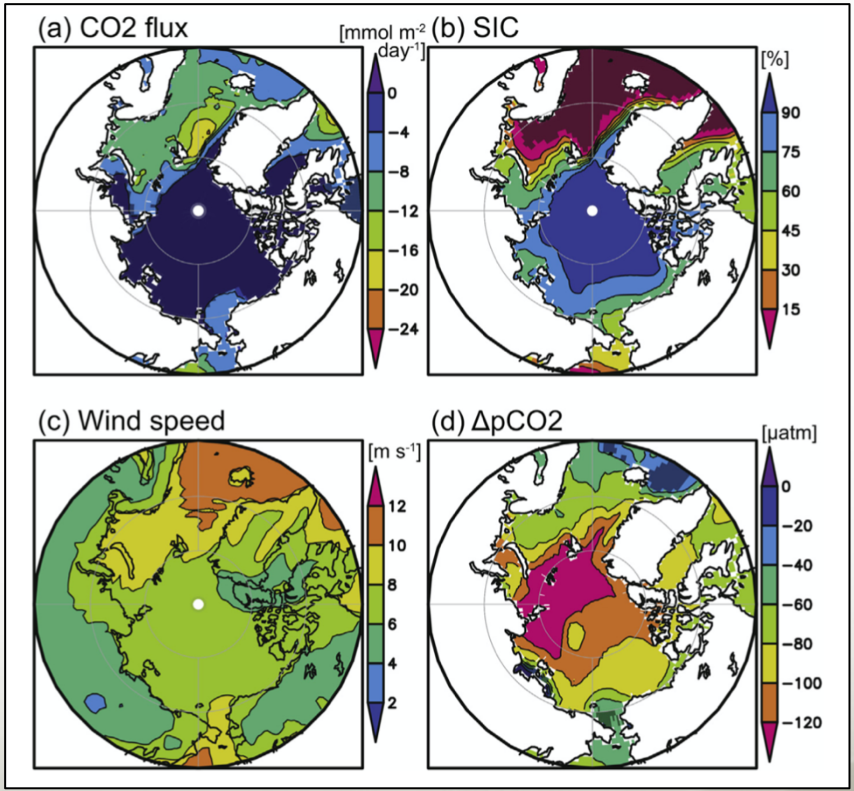
source: Rödenbeck et al., Ocean Science, 2013

Mapping air-sea CO_2 fluxes

Data coverage

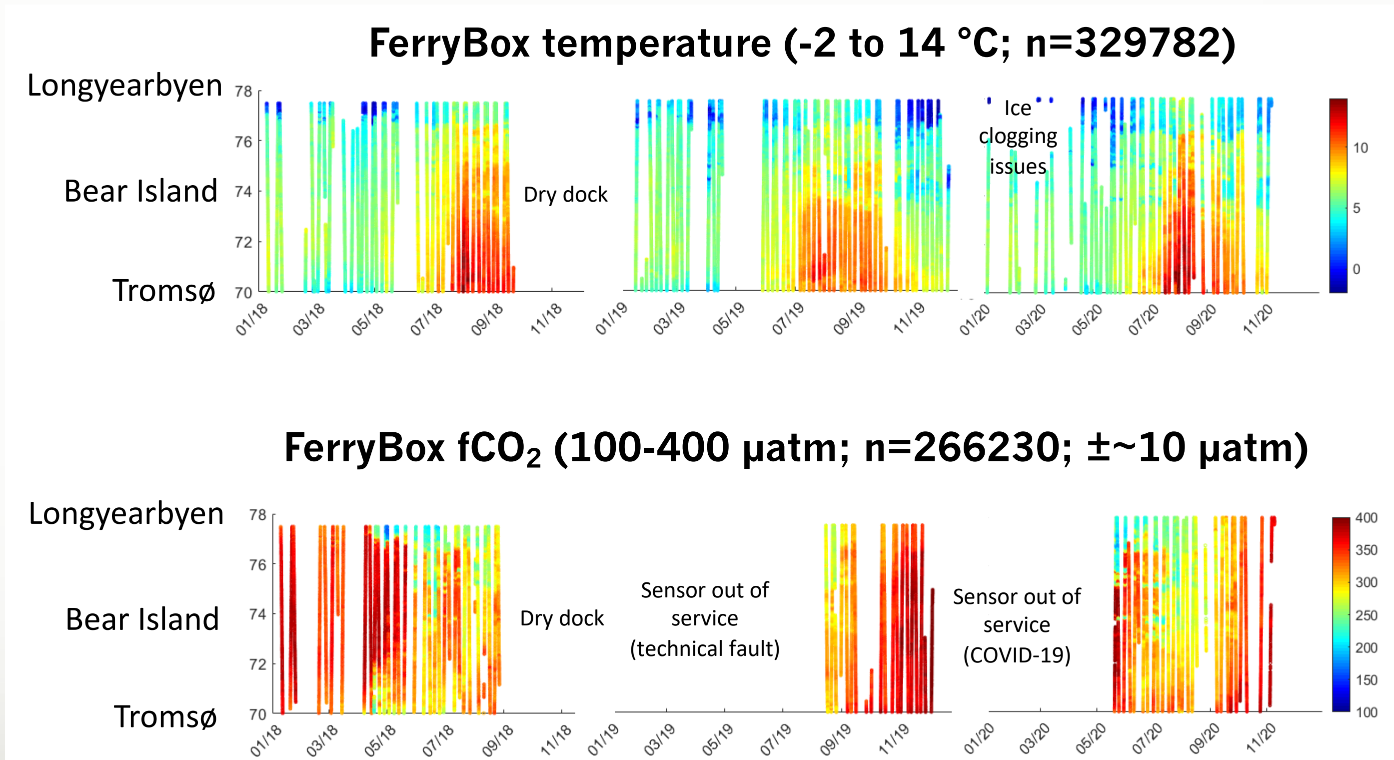


Long-term integration



figures: Yasunaka et al., Polar Science, 2016

New NIVA pCO_2 observations from INTAROS



Utilizing new INTAROS pCO_2 observations

A self-organizing neural network mapping technique can produce estimates of surface water pCO_2 by resolving the nonlinear and often discontinuous relationships among proxy parameters, such as chl-a, SSS, SST, MLD and geographical location.

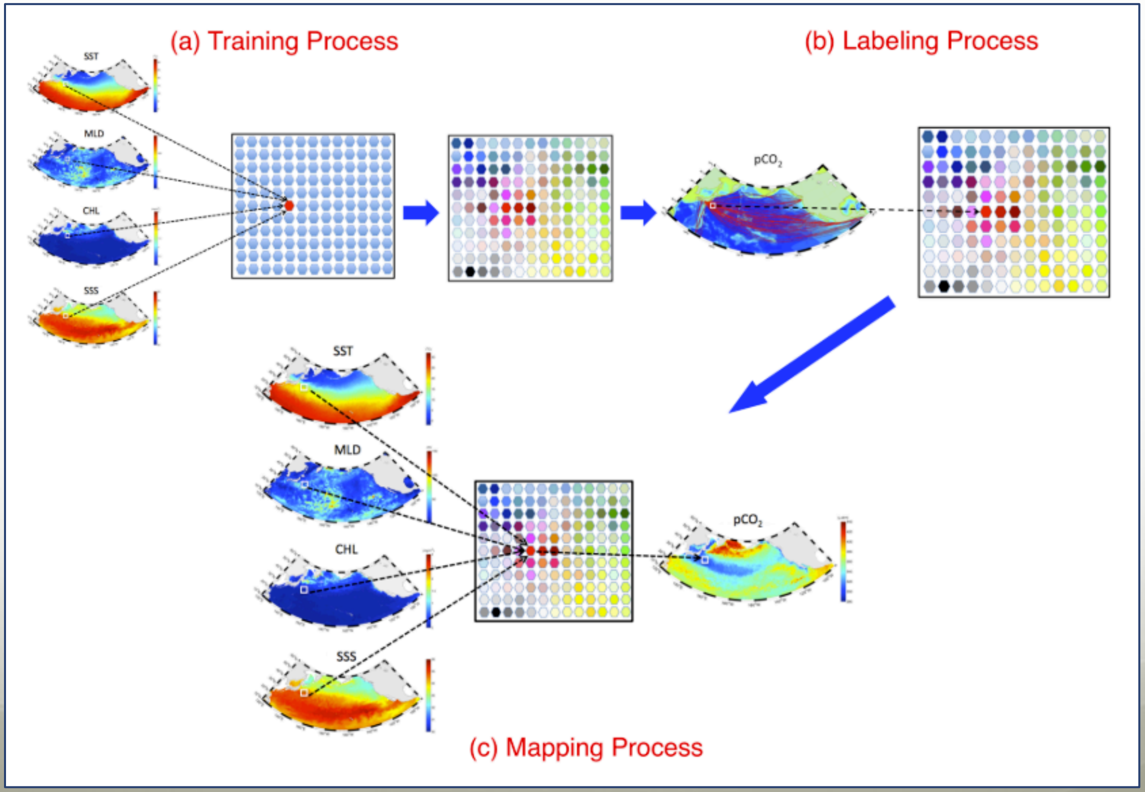


Figure: Nakaoka et al., Biogeosciences, 2013

Utilizing new INTAROS pCO_2 observations

New pCO_2 observations from NIVA's FerryBox system, combined with other data products from the INTAROS Data Catalogue, will be used to test the validity of self-organizing map techniques in the Barents Sea region.

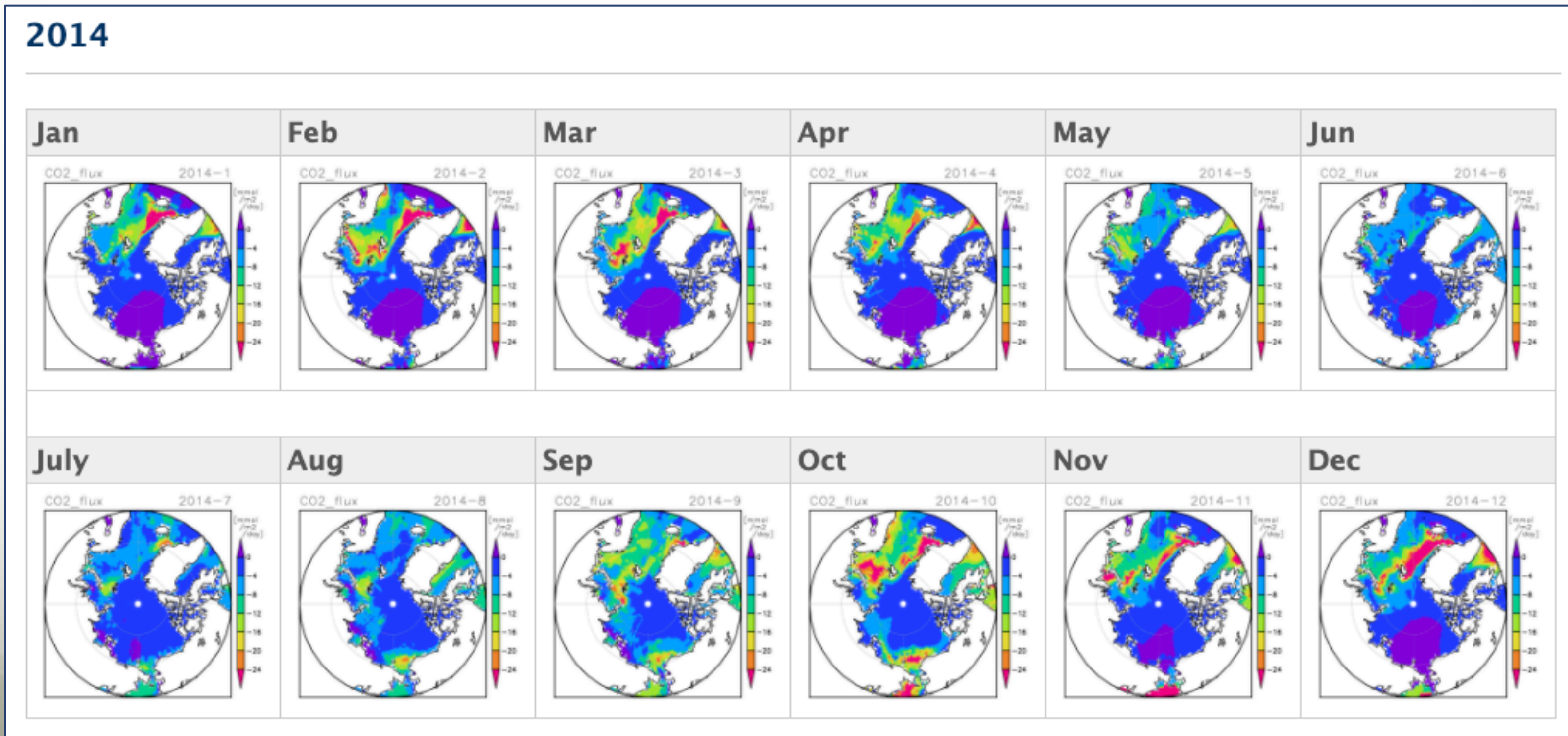


Figure: Yasunaka et al. 2018

Work plan 2021

- Test new gridded datasets from INTAROS database in regional geostatistical inversion
- Finalize new INTAROS pCO_2 products (WP5 collaboration)
  - Use data to investigate spatio-temporal variability in ocean carbon processes (chemistry, sources/sinks)
  - Couple pCO_2 data with atmospheric observations to investigate variability in gas transfer coefficients in ocean surface layer
- Correlate observed process variability with ancillary data layers from INTAROS database