



StraitFlux

A Python package for calculating ocean transports on native model grids.



Susanna Winkelbauer¹

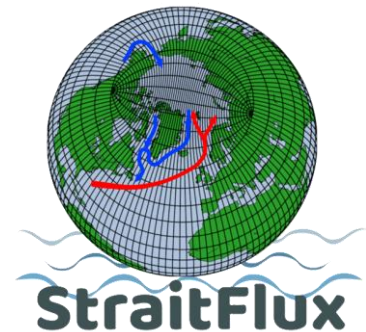
¹University of Vienna, Department of Meteorology and Geophysics



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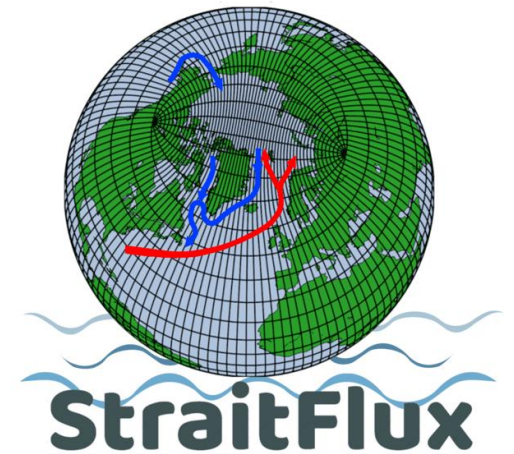
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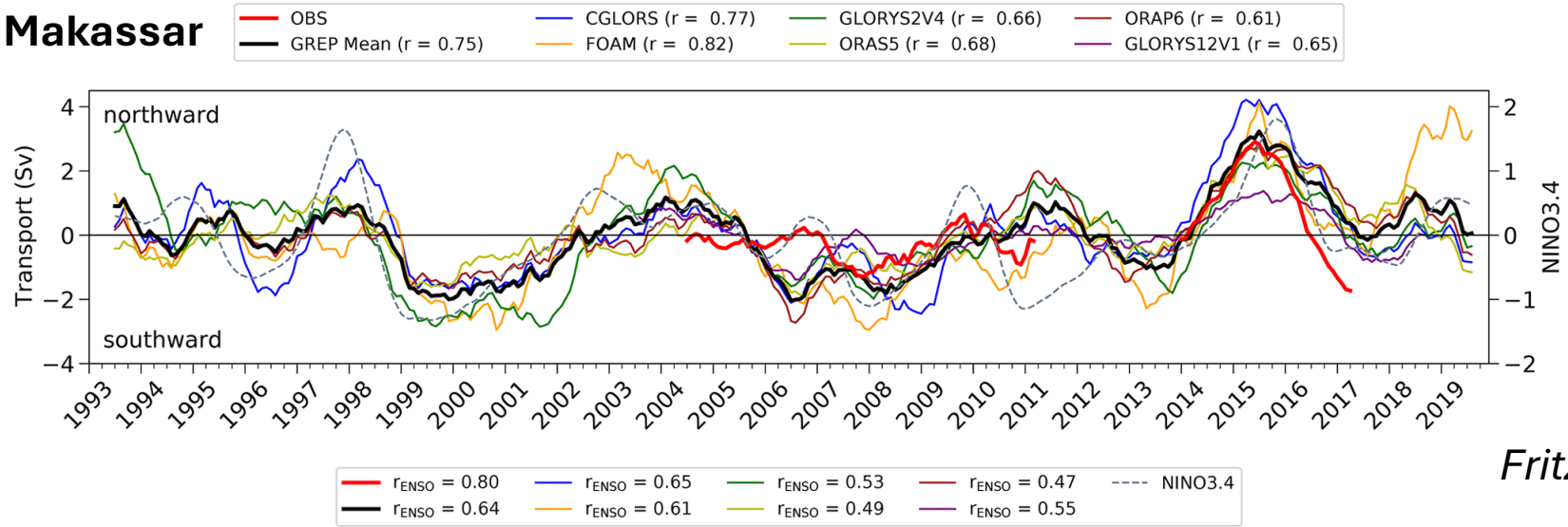
PART 1

Introduction

- Motivation
- Challenges for models and reanalysis
- Introducing **StraitFlux**
 - Methods
 - Functions
 - Limitations



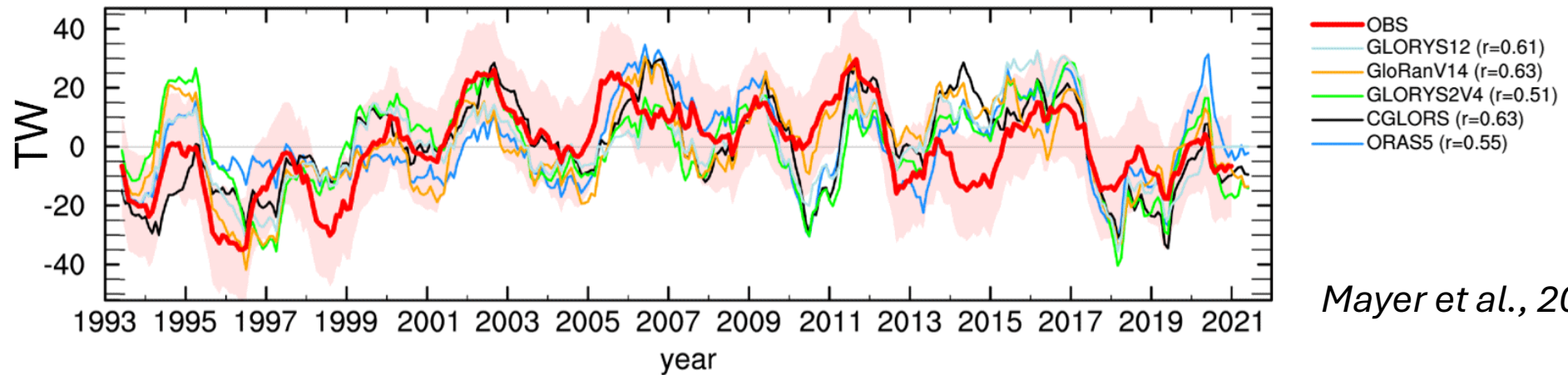
Makassar



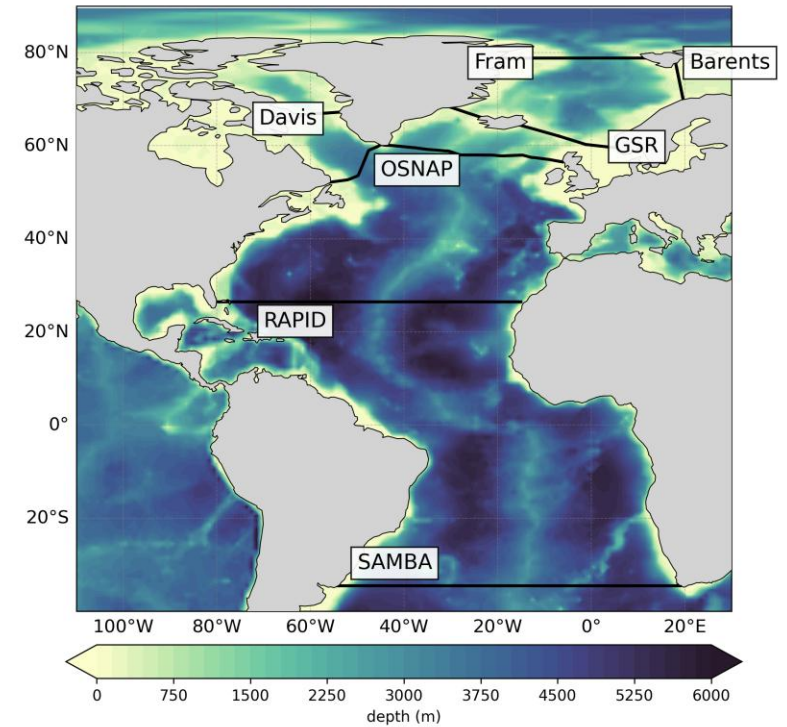
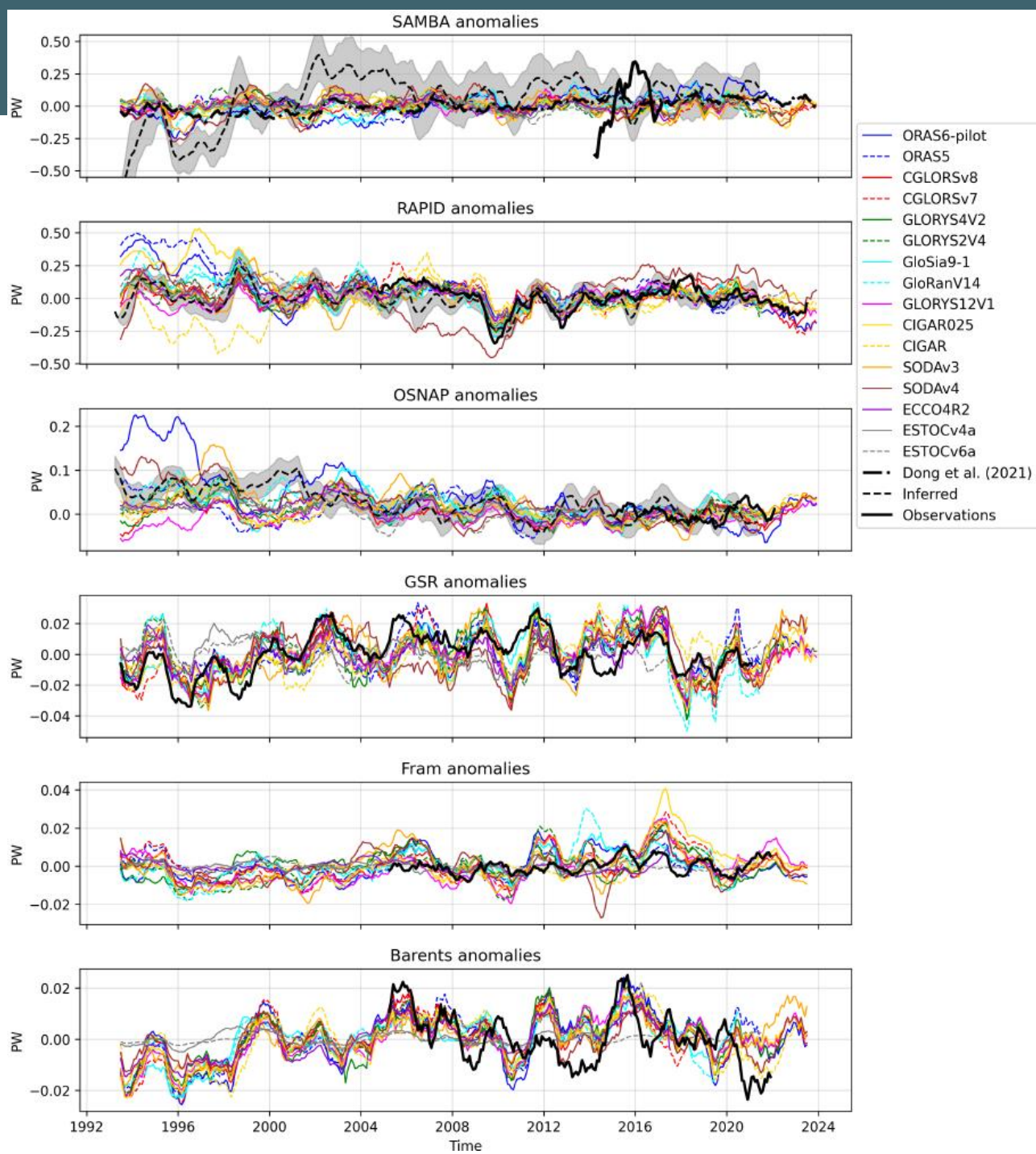
Fritz et al., 2023

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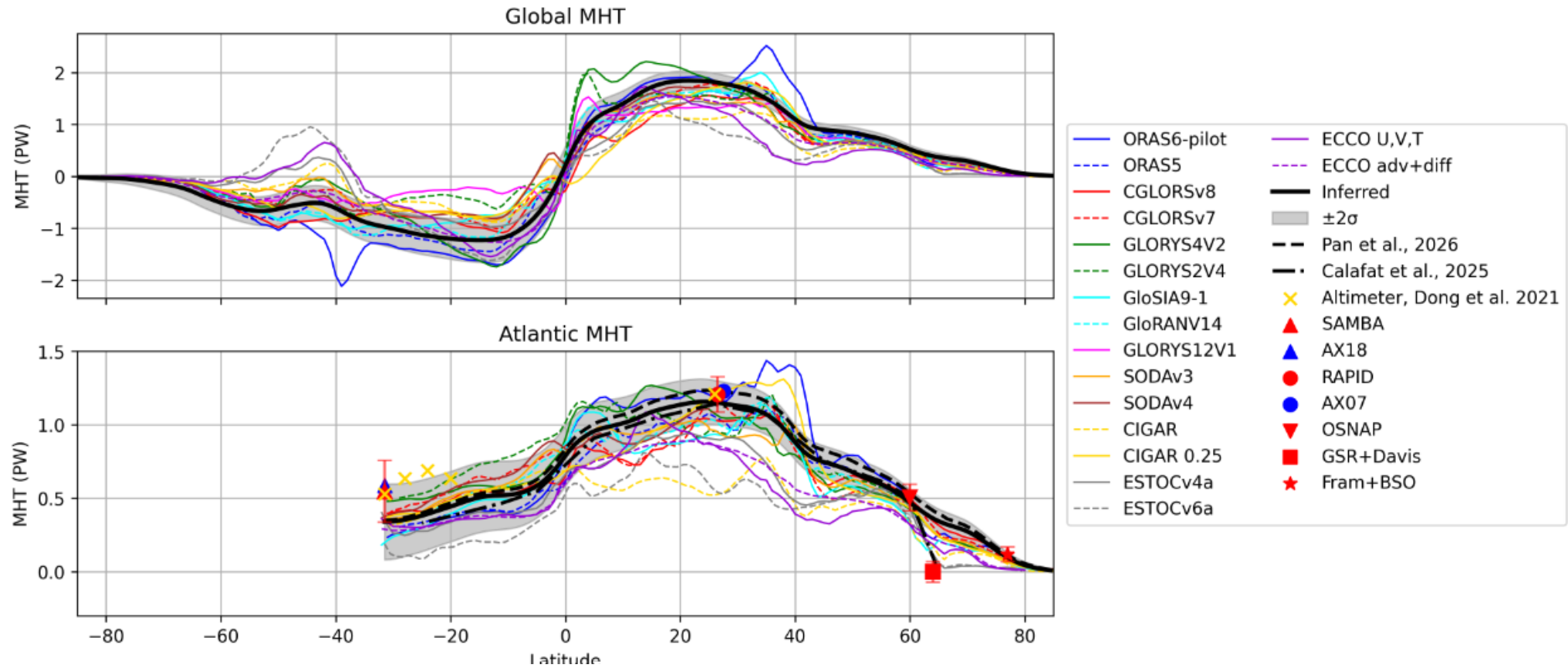
GSR total heat flux anomalies



Mayer et al., 2023



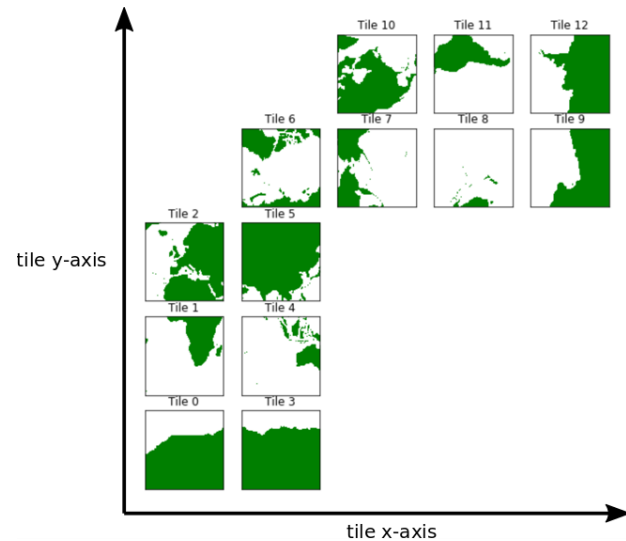
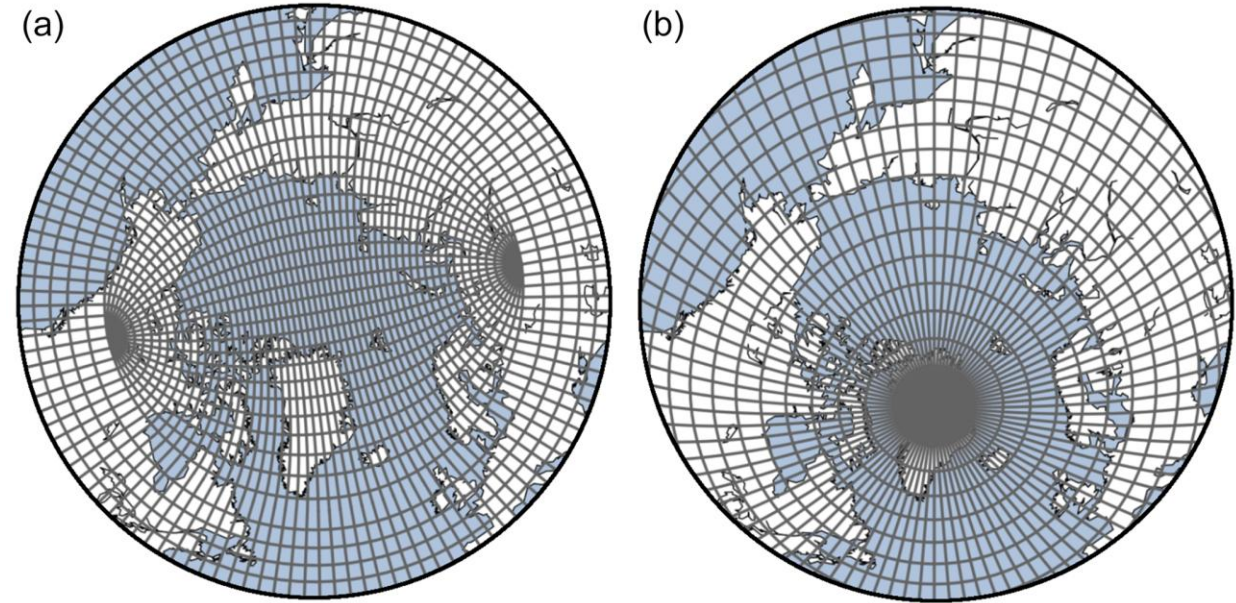
Winkelbauer et al., in prep



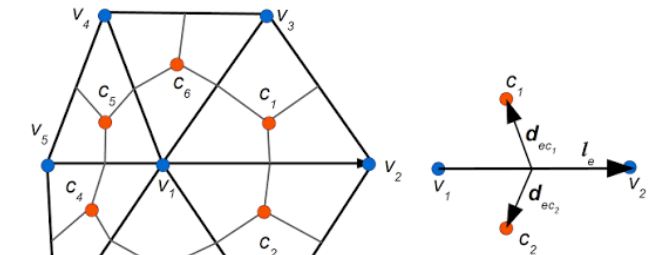
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Challenges

- Complicated grids:
 - Curvilinear grids (Tripolar, Displaced dipolar)
 - “lat-lon-cap 90” grid
 - Unstructured grids



“lat-lon-cap 90”

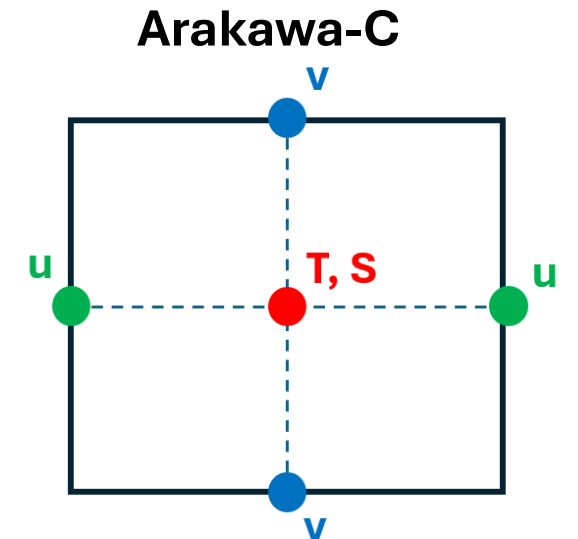
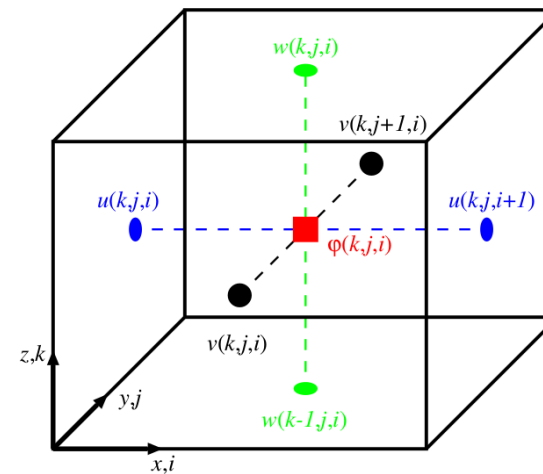
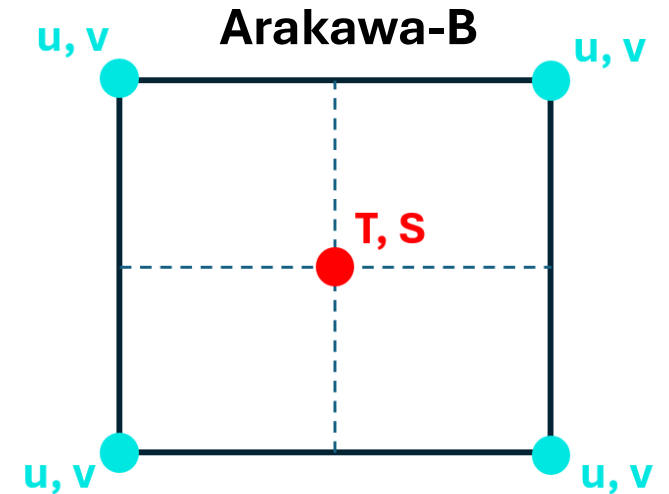
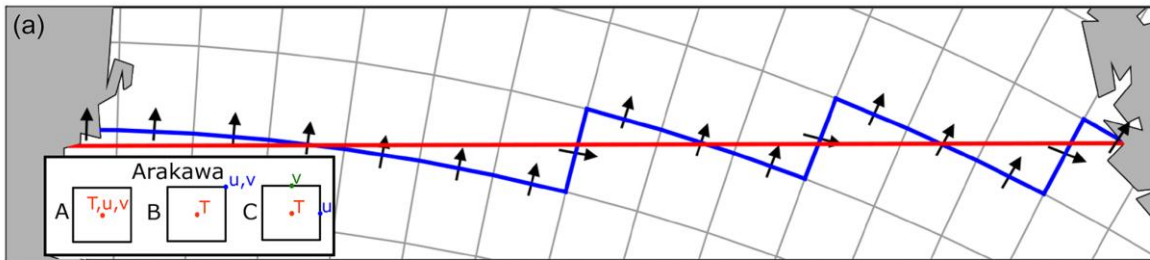


Alfred Wegener Institute, FESOM

<https://ecco-v4-python-tutorial.readthedocs.io/fields.html>

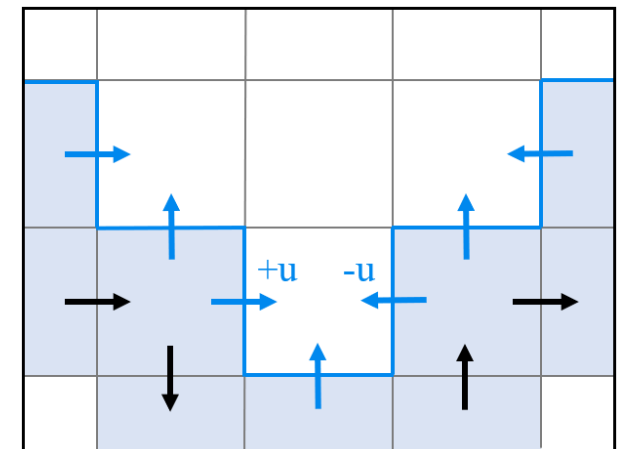
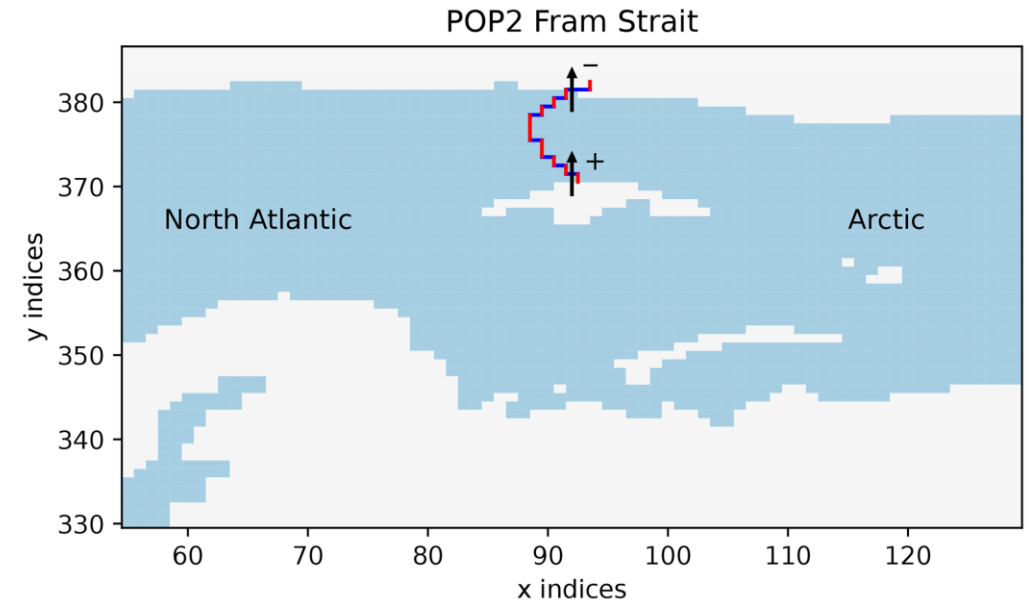
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- Different staggering
 - Arakawa-B and Arakawa-C most common



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- Boundaries
 - North Fold boundary, periodic cells

8.3. Exchange with neighbouring processors (*lbclnk*, *lib_mpp*)

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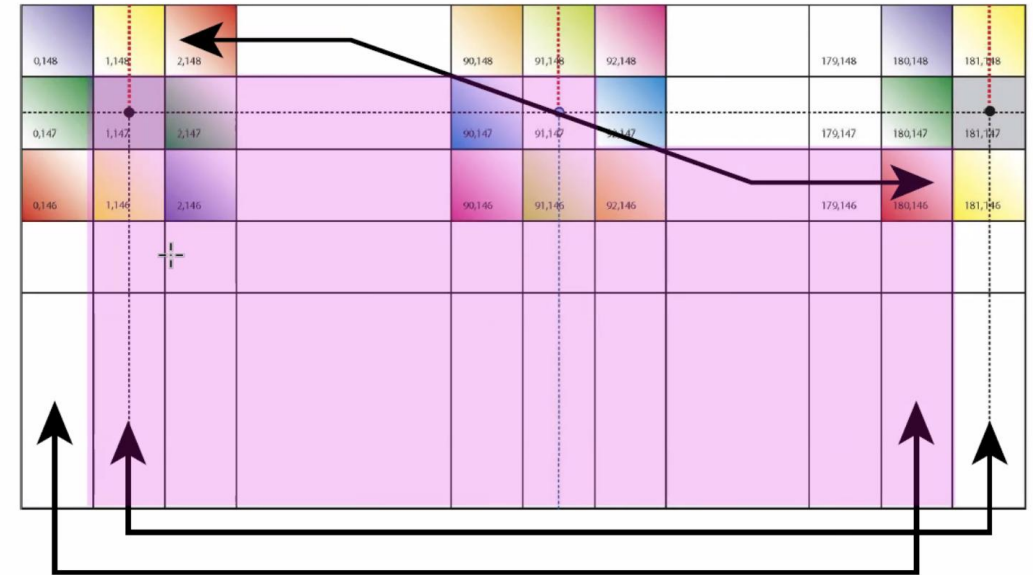
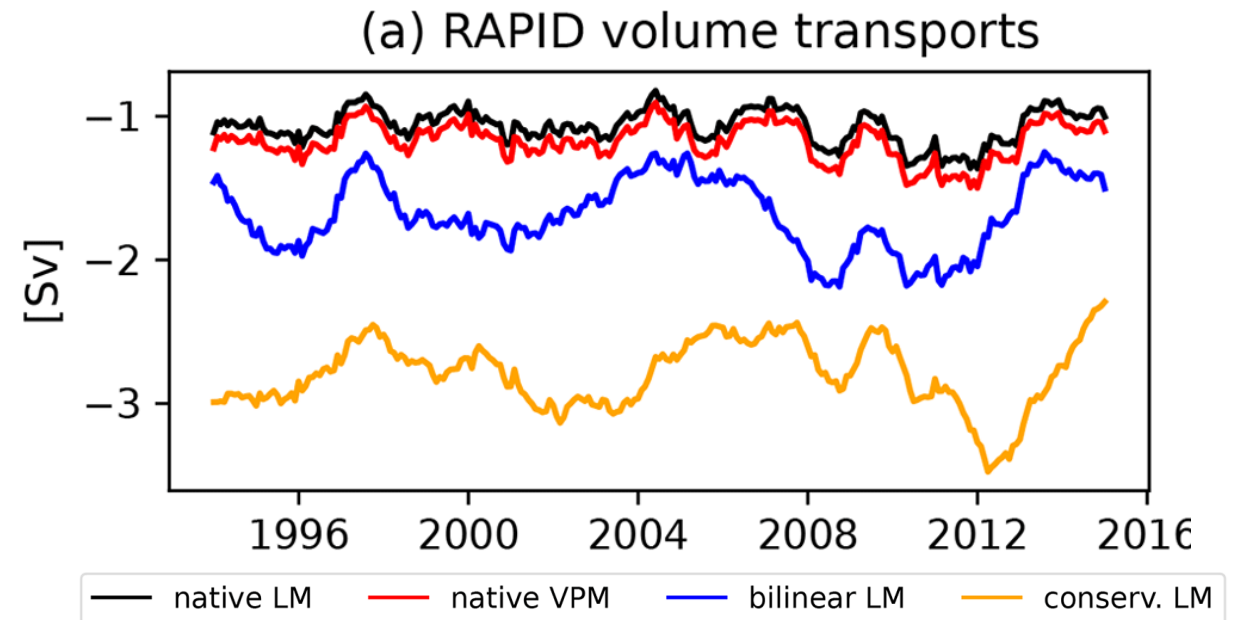


FIGURE 8.4: North fold boundary with a T -point pivot and cyclic east-west boundary condition ($i_{perio} = 4$), as used in ORCA 2, 1/4, and 1/12. Pink shaded area

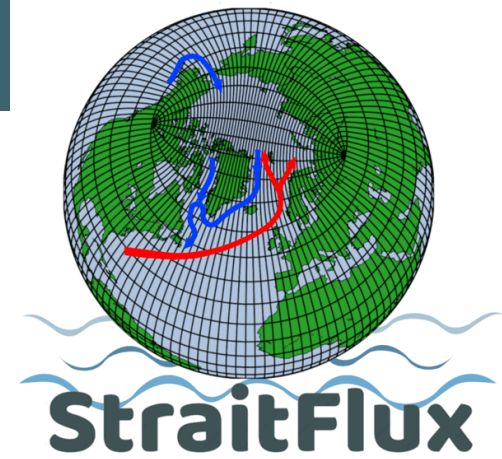
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- Boundaries
 - North Fold boundary, periodic cells
- Interpolation of velocities should be avoided!



<https://github.com/susannawinkelbauer/StraitFlux>

- Transport calculations on different modelling grids (reanalyses, CMIP6)
- User provides velocity (+ temperature, salinity, etc.) files and section coordinates
 - Automated workflow detects grid type, Arakawa, sign orientations etc. and calculates transports, AMOC, cross-sections, ...



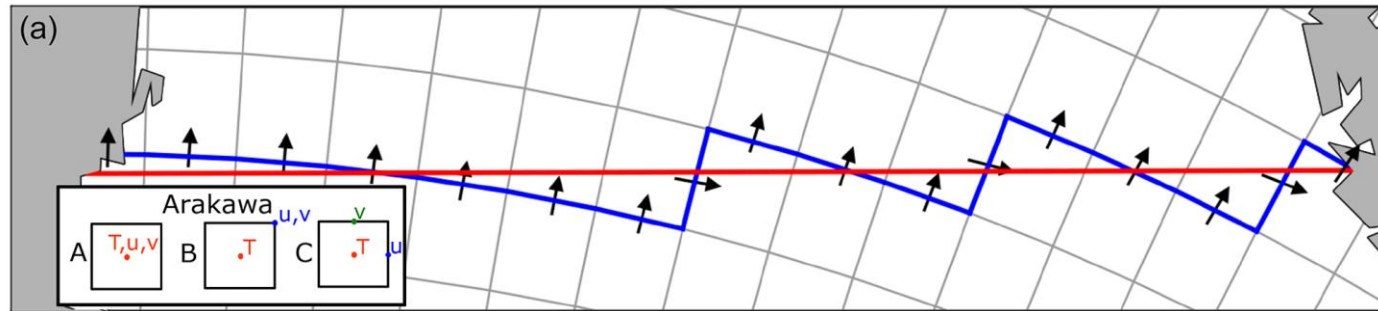
StraitFlux Methods I

1) Line Integration Concept

Most conservative approach (no interpolation needed).

Zig-zag line placed as closely to section as possible

Integration of velocities through the grid cell faces



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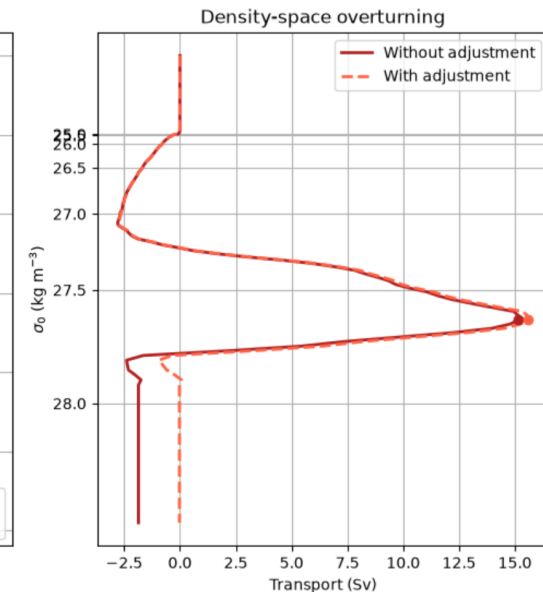
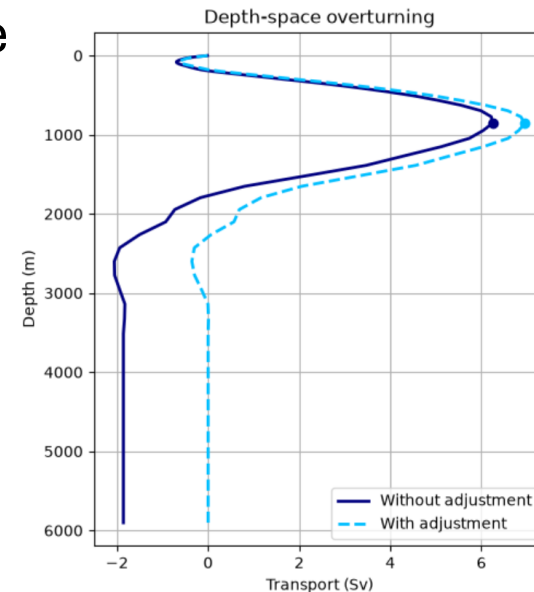
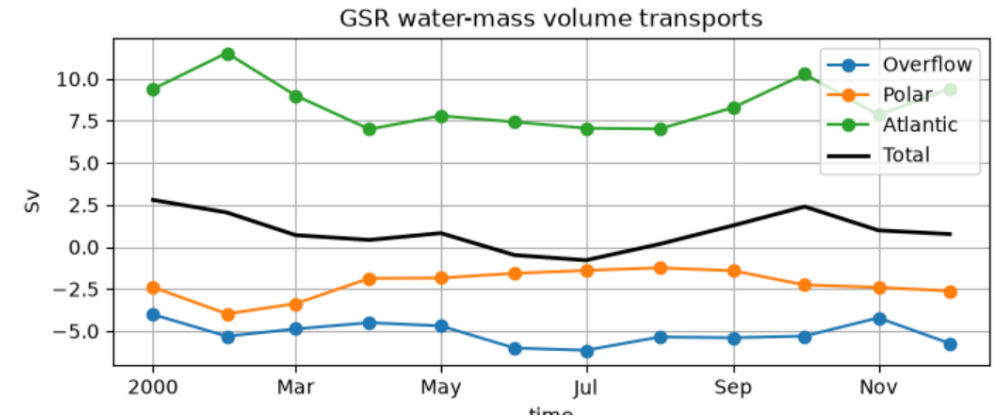
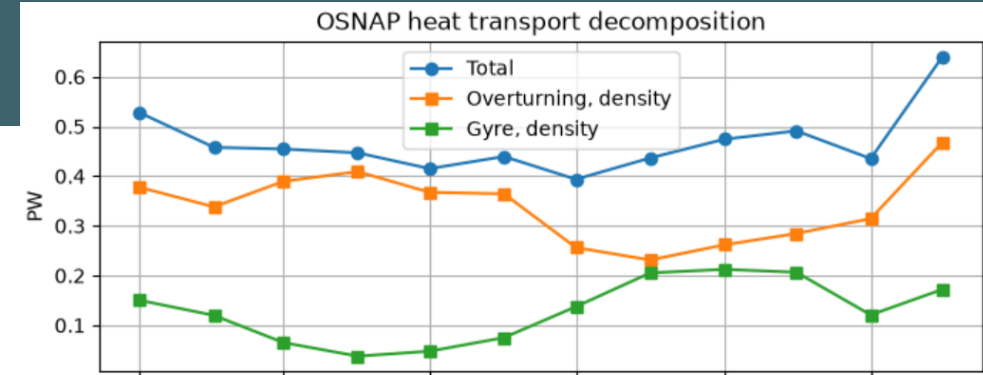
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Integration of velocities through the grid cell faces

Core functions:

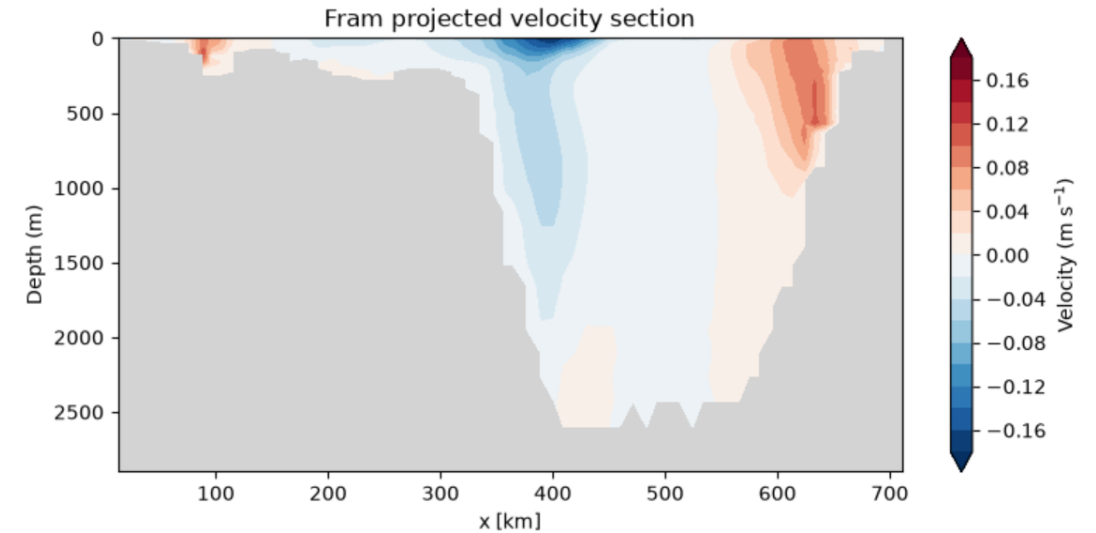
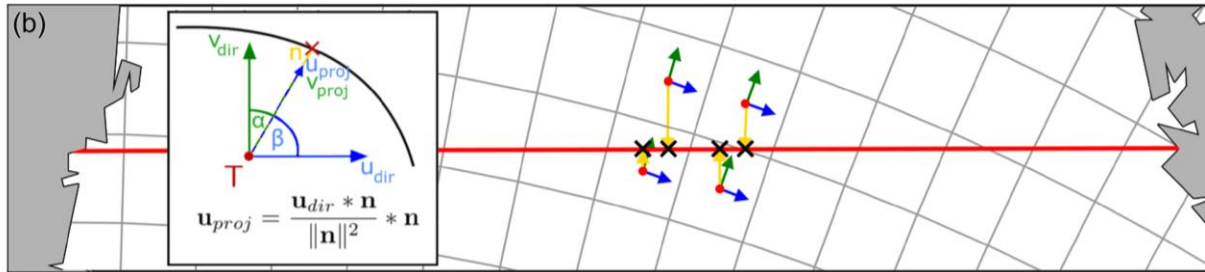
- Volume transport, Heat transport, Salt transport, ...
- MOC + streamfunctions in depth and density space
- Overturning vs. Gyre transport
- Barotropic adjustments
- Watermass decompositions on transports



StraitFlux Methods II

2) Vector Projection Concept

If more than a number is needed → Velocity structures, heat transport structures,...



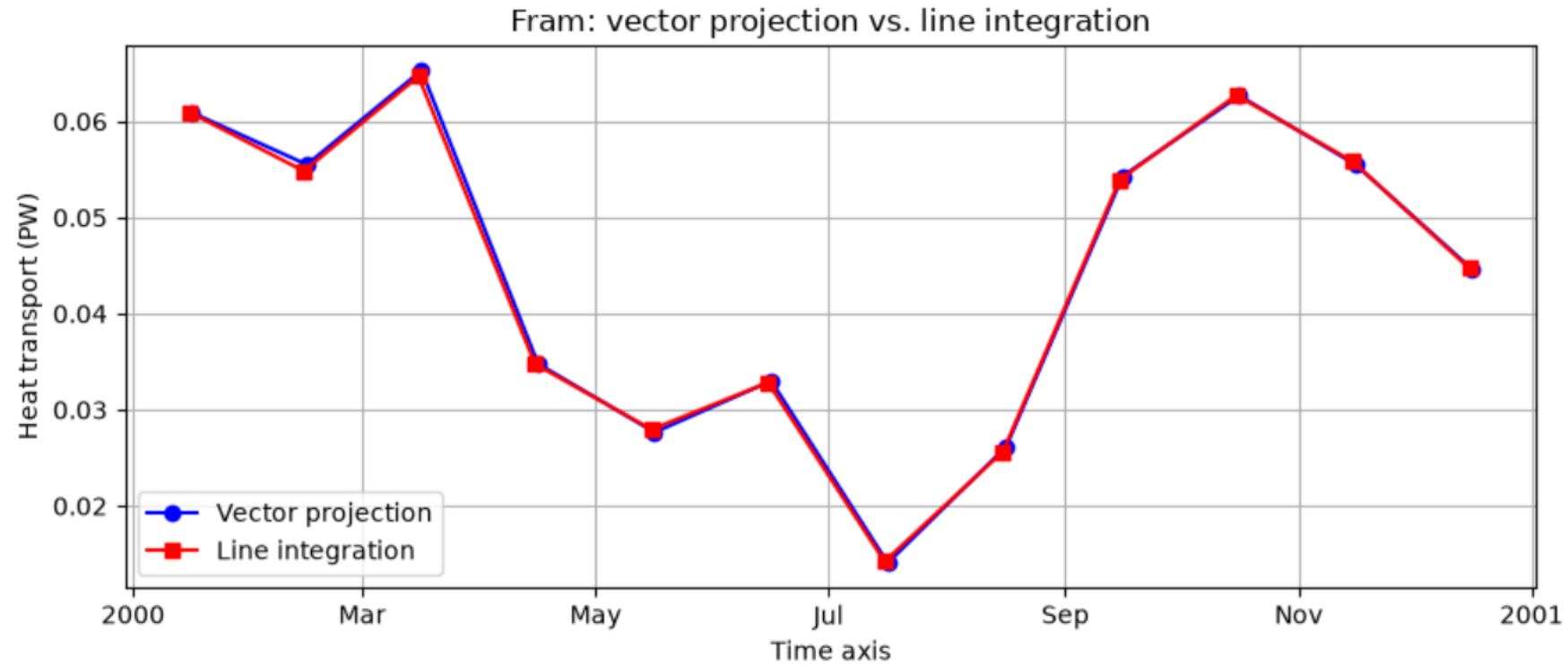
Core functions:

- Cross-sections of velocities and transports
- Temperature and salinity sections at exactly the same sections

StraitFlux Methods III

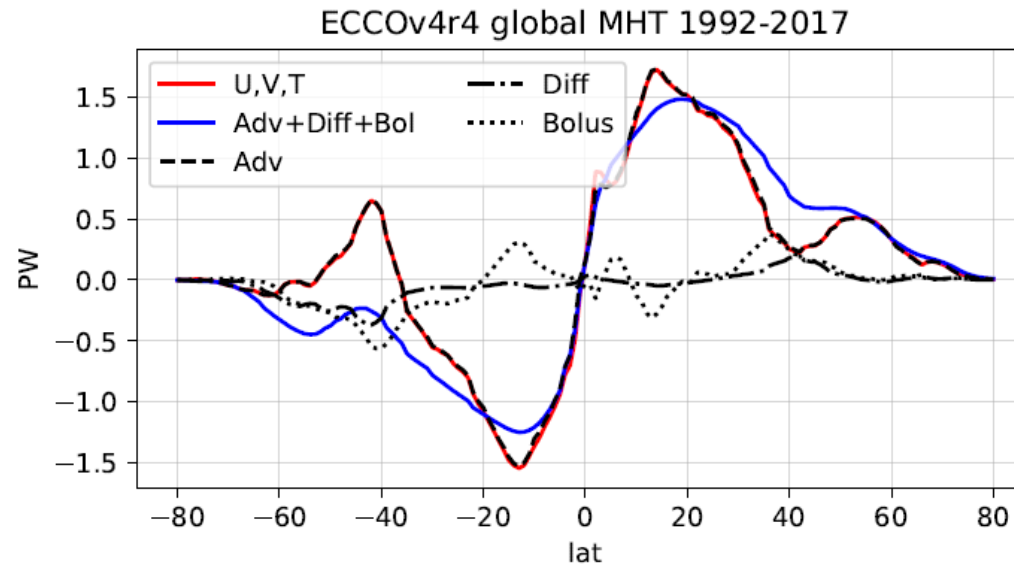
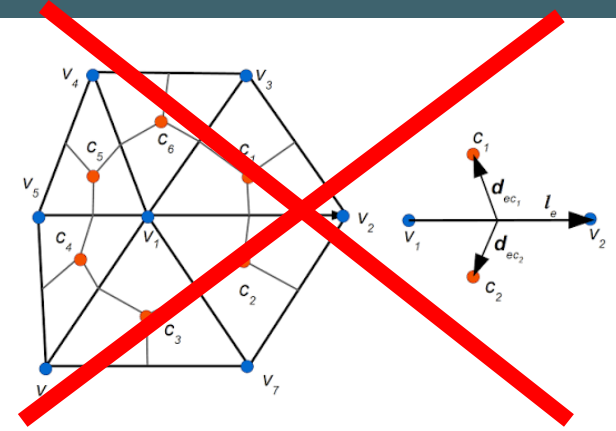
Comparisons:

Differences of integrated transports mostly below 1%



Main Limitations

- Unstructured grids not supported (yet!)
- StraitFlux computes advective transports
 - diffusive and parameterized/bolus fluxes not included
 - Especially important for coarse-resolution ($\sim 1^\circ$) models.



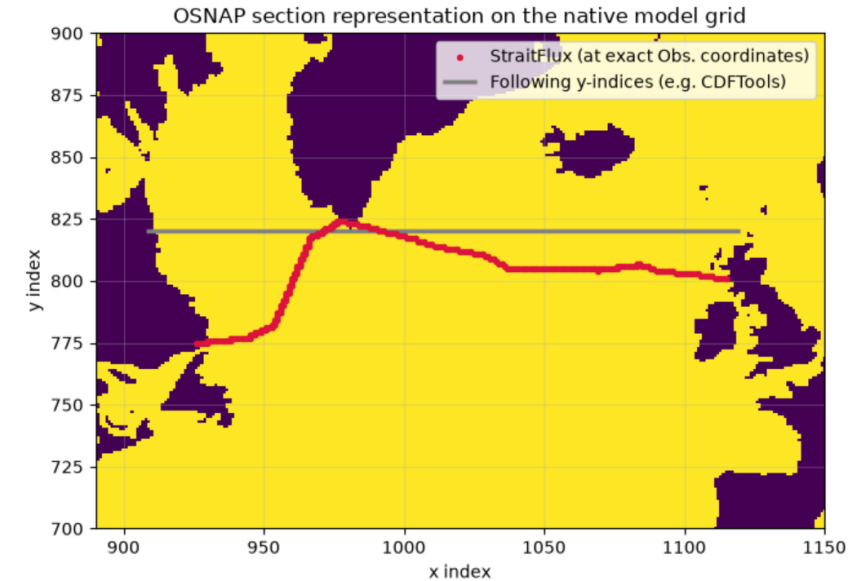
Other tools

CDFTools (<https://github.com/meom-group/CDFTOOLS>):

- Comprehensive toolbox for analysis of NEMO model output
- Large collection of diagnostics
- Mature and widely used within the NEMO community
- Primarily designed for NEMO grids and output
- Transport calculations are based on fixed y-lines (less flexible!)

METRIC (<https://github.com/AMOCcommunity/metric>):

- Designed for direct comparison between model output and major observing arrays
- Computes overturning, heat, and freshwater transports
- Supports observation-style transport decomposition (e.g. Florida Current, Ekman, and Upper Mid-Ocean components for RAPID)
- Supports both NEMO and POP models
- Standardized diagnostics for RAPID, OSNAP, and MOVE
- Focused on specific observing sections rather than general-purpose transport analysis



PART 2

Applications

→ Move into the InfoLab

- Open StraitFlux_Examples.ipynb
- Calculate:
 - Transports of heat, volume and salt
 - Cross-sections of velocities, T and S
 - MOC in depth and density space
 - Overturning vs. Gyre heat transport
 - Barotropic adjustment
 - Water-mass decomposition
 - Play around with your own sections

Goal: Compare your GO-SHIP project data to transports etc. from ocean reanalysis