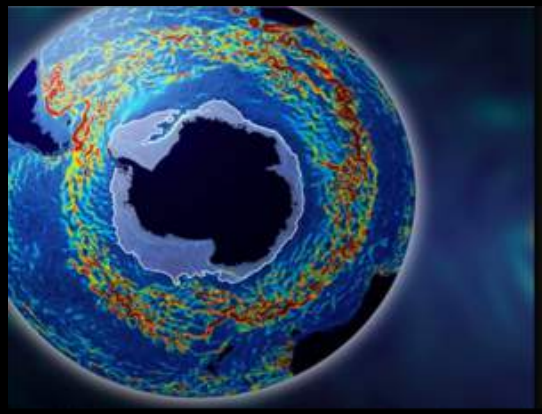


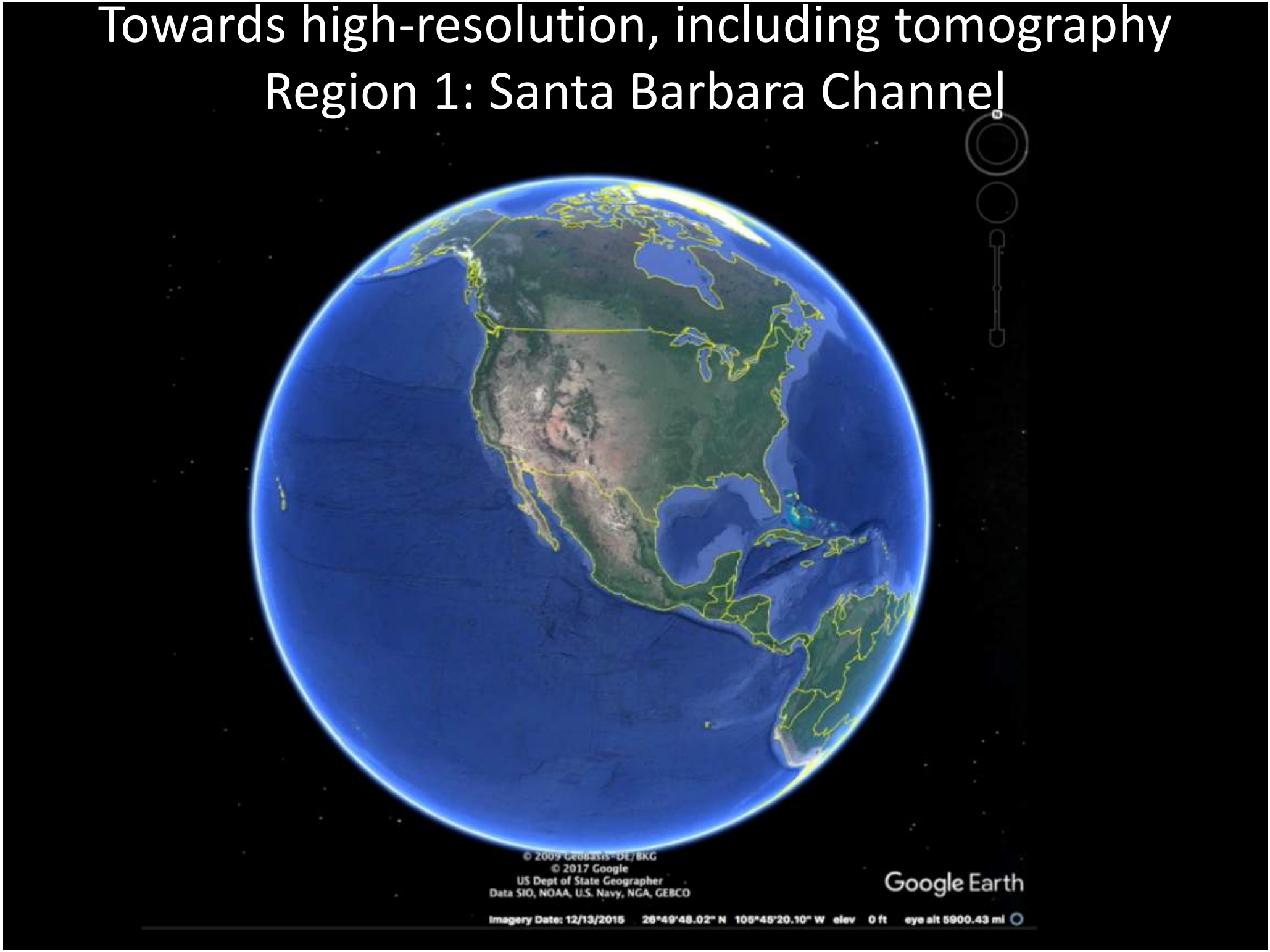
Development activities at SIO

ECCO Meeting 2017

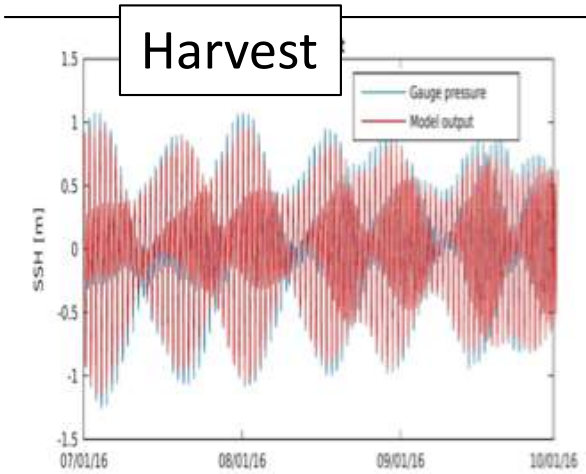
Matt Mazloff, Paul Chamberlain, Bruce Cornuelle, Ganesh Gopalakrishnan, Heriberto Vazquez Peralta, Aneesh Subramanian, Rui Sun, Ariane Verdy, Kasia Zaba

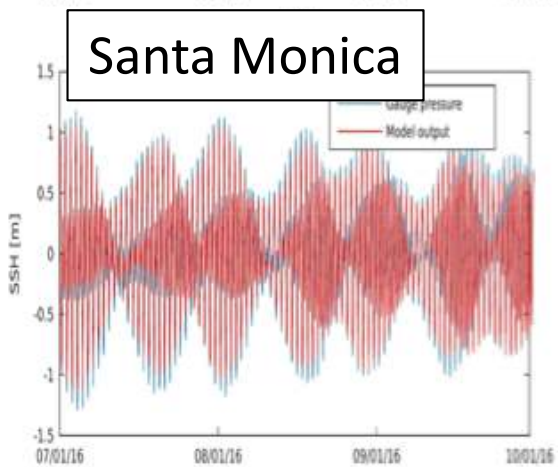
SCRIPPS INSTITUTION OF OCEANOGRAPHY

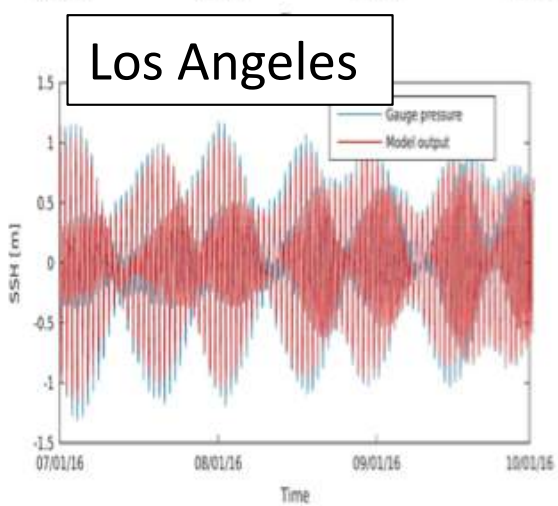
Towards high-resolution, including tomography
Region 1: Santa Barbara Channel

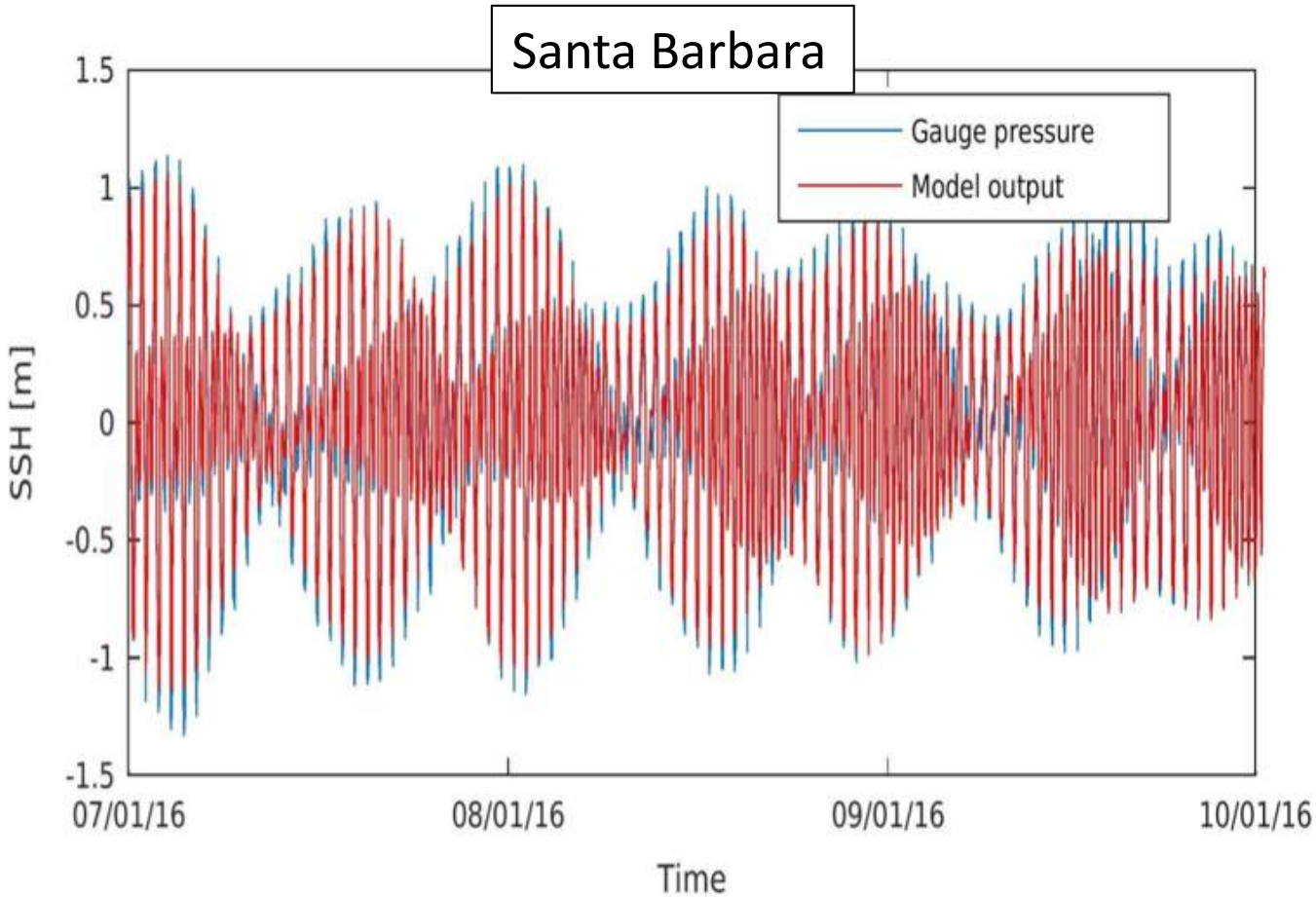


Santa Barbara Channel: Tides







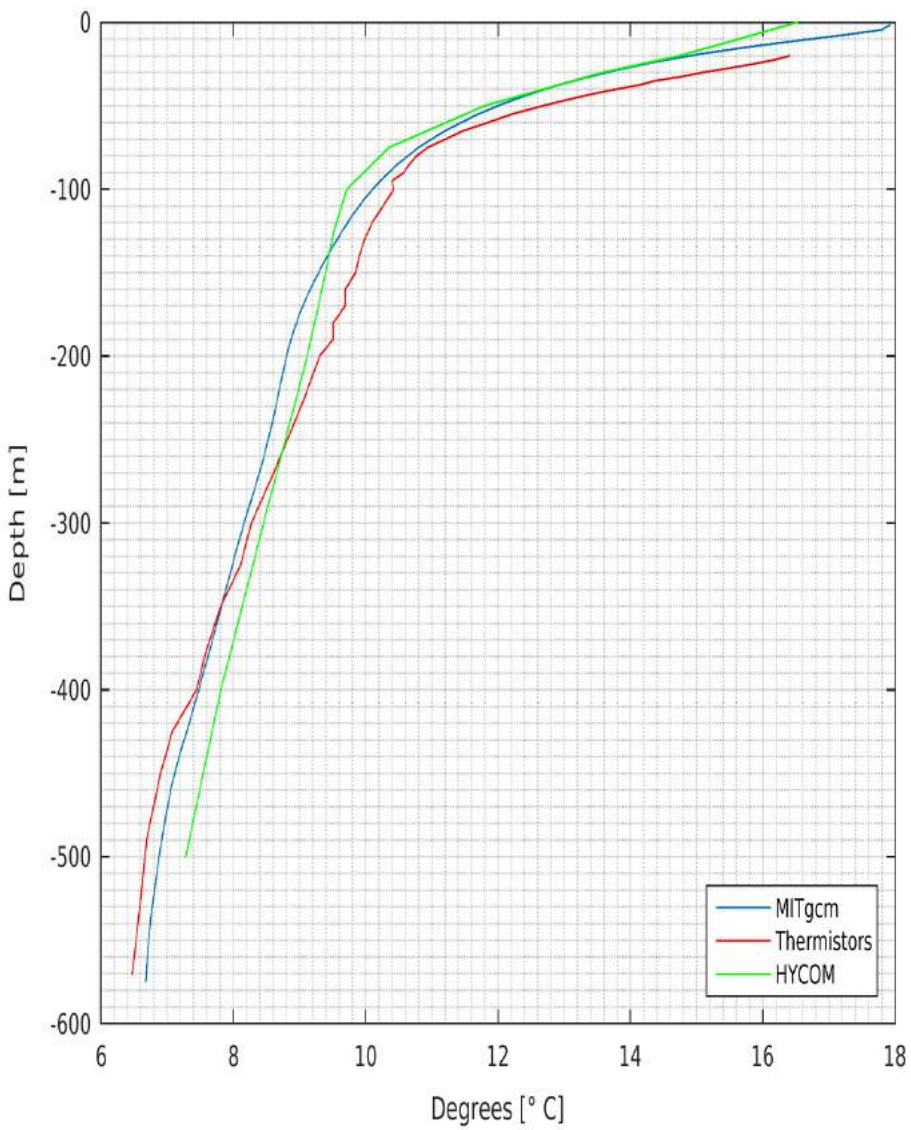


	AmpModel	PhaModel	AmpGauge	PhaGauge
M2	0.4585	110.8746	0.5147	117.8186
S2	0.1897	154.3182	0.1799	155.4385
N2	0.1086	354.0570	0.1070	6.3637
K1	0.2636	163.7538	0.3016	174.4392
O1	0.1935	210.2600	0.1852	209.3420
Q1	0.0392	104.8524	0.0332	108.6514

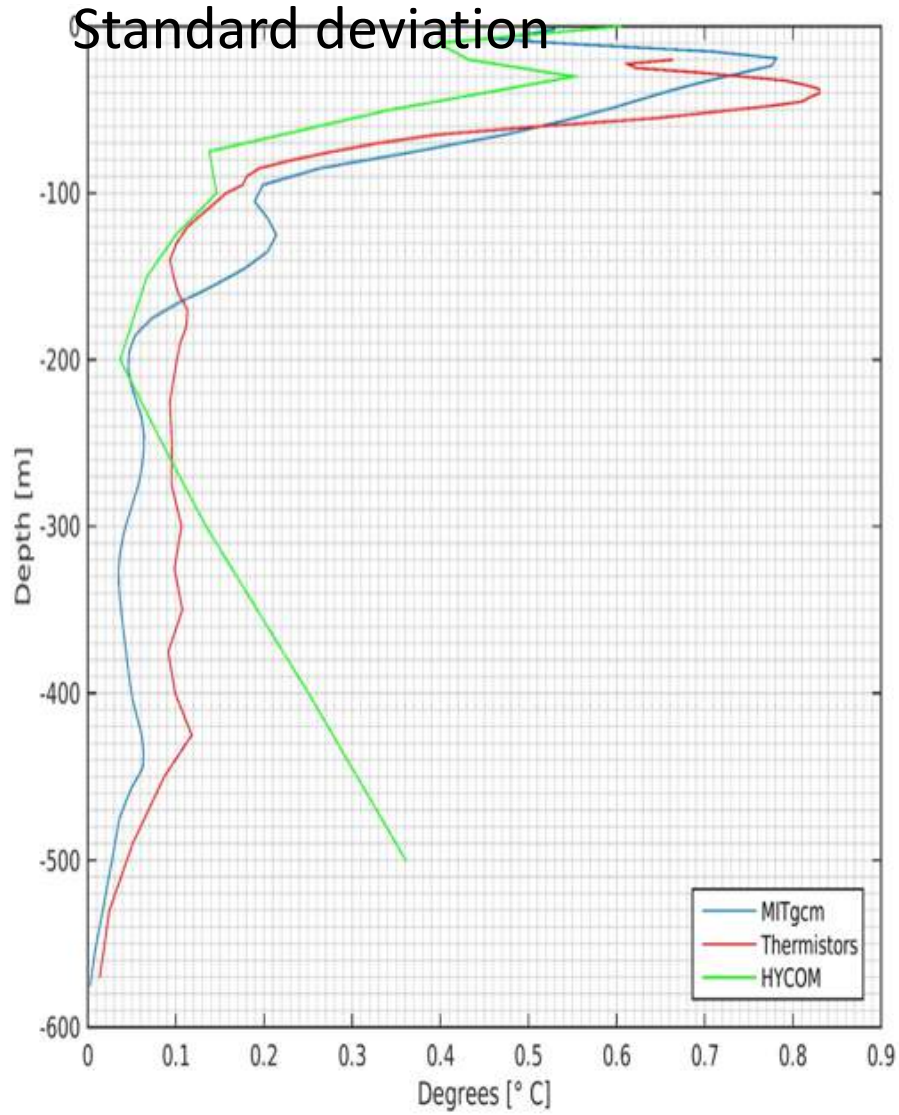
Santa Barbara Channel: Thermistor chains

Temperature for the SBC model, HYCOM, and thermistor chains

Mean

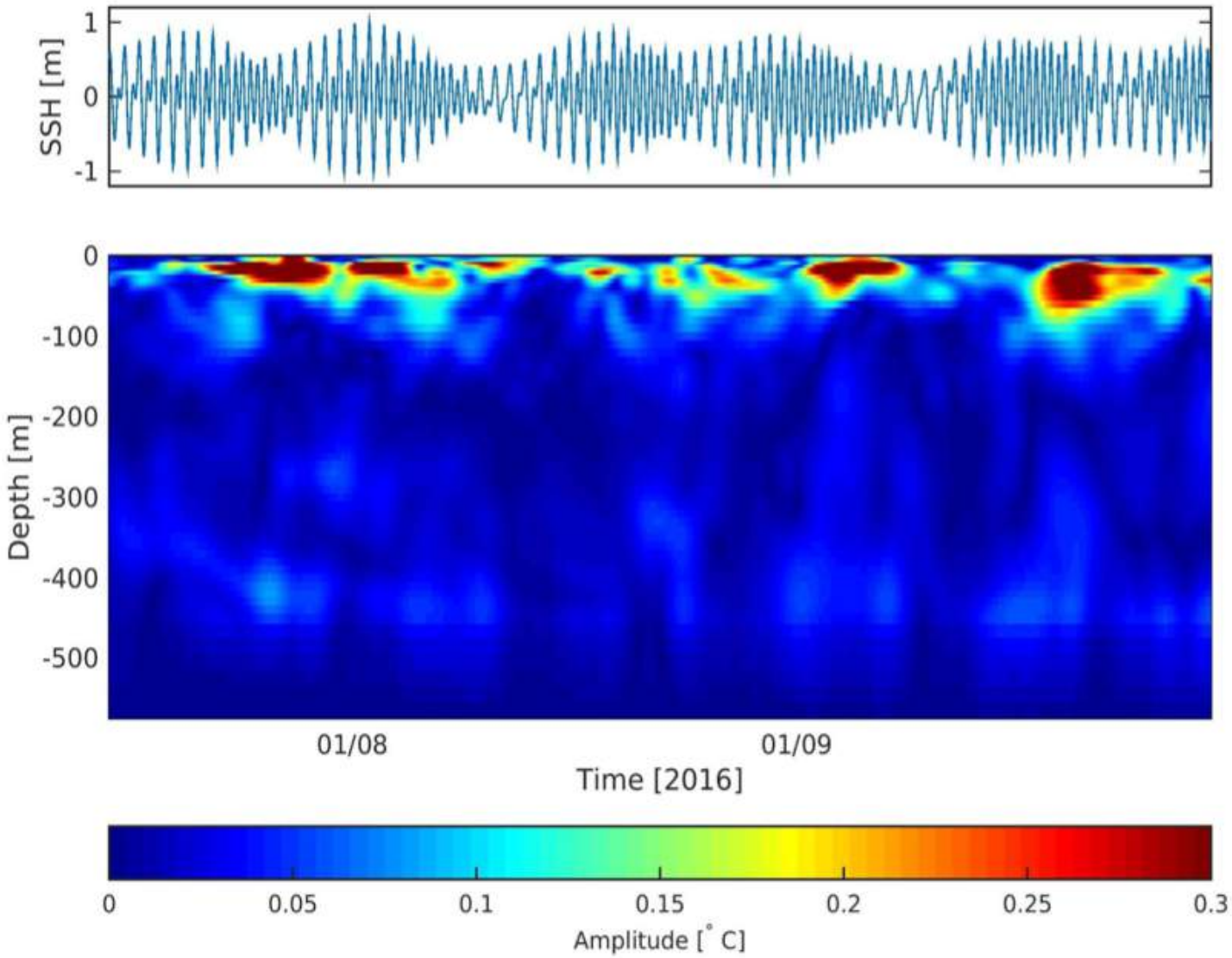


Standard deviation



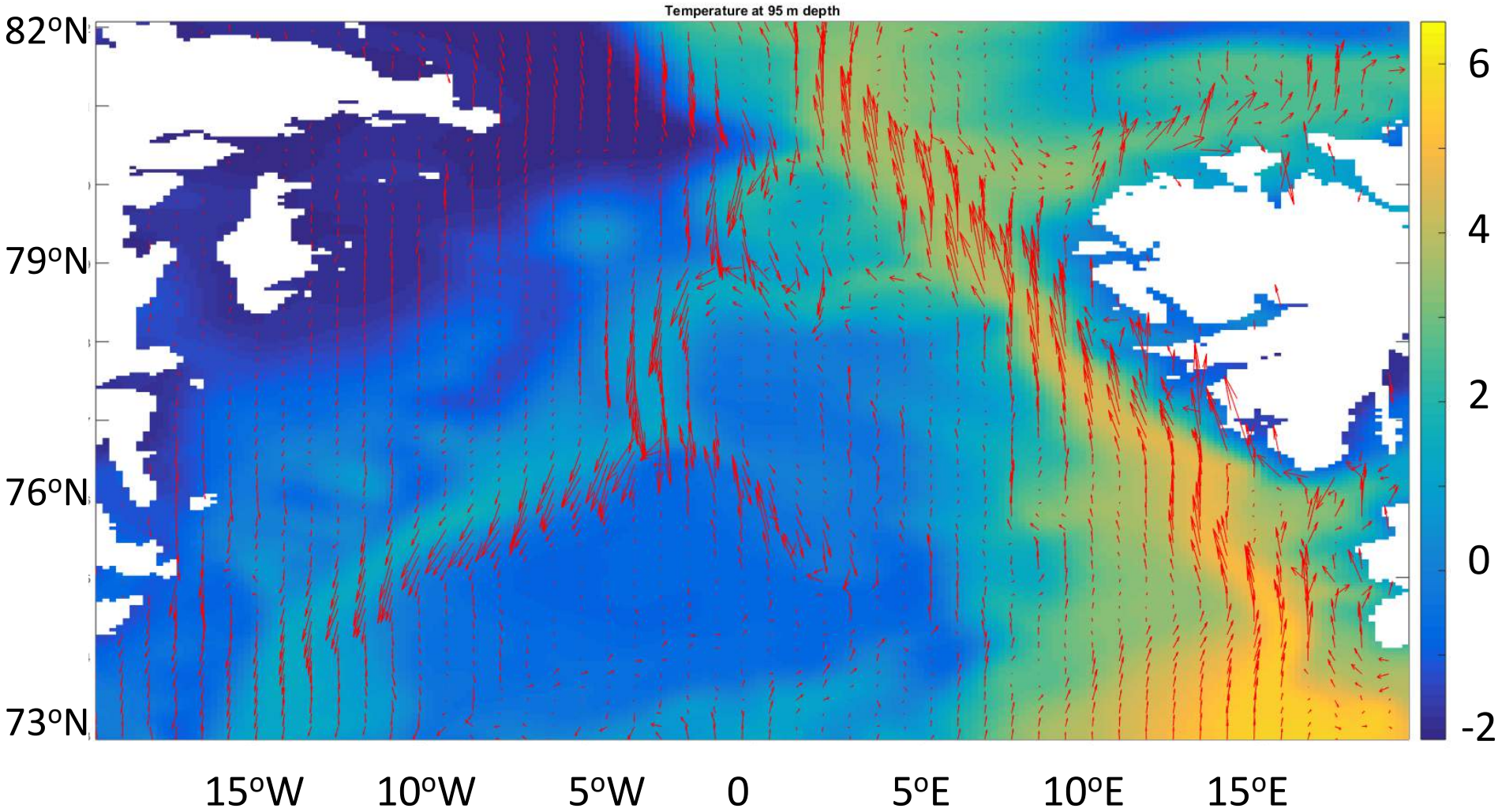
Santa Barbara Channel:

Complex demodulation, semidiurnal frequency



Towards high-resolution, including tomography

Region 2: Fram Straight



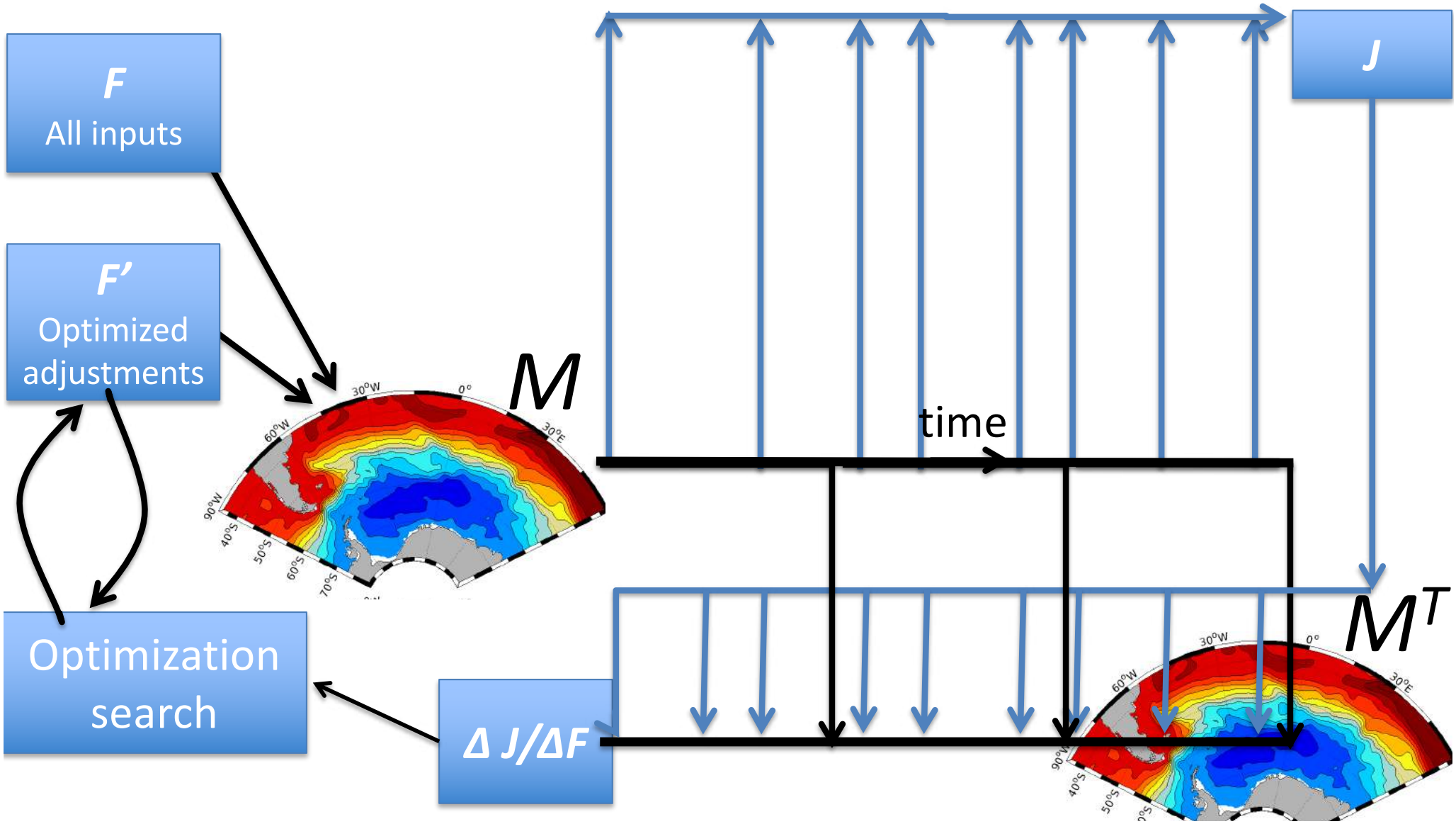
Temperature at 95m

In collaboration with Nansen Environmental and Remote Sensing Center

Multiscale coupling

A model, ***M***, and its adjoint, $\boldsymbol{M^T}$, are used to optimize input adjustments, **F'**, to the input forcing ***F***, such that $\boldsymbol{F_{opt} = F + F'}$

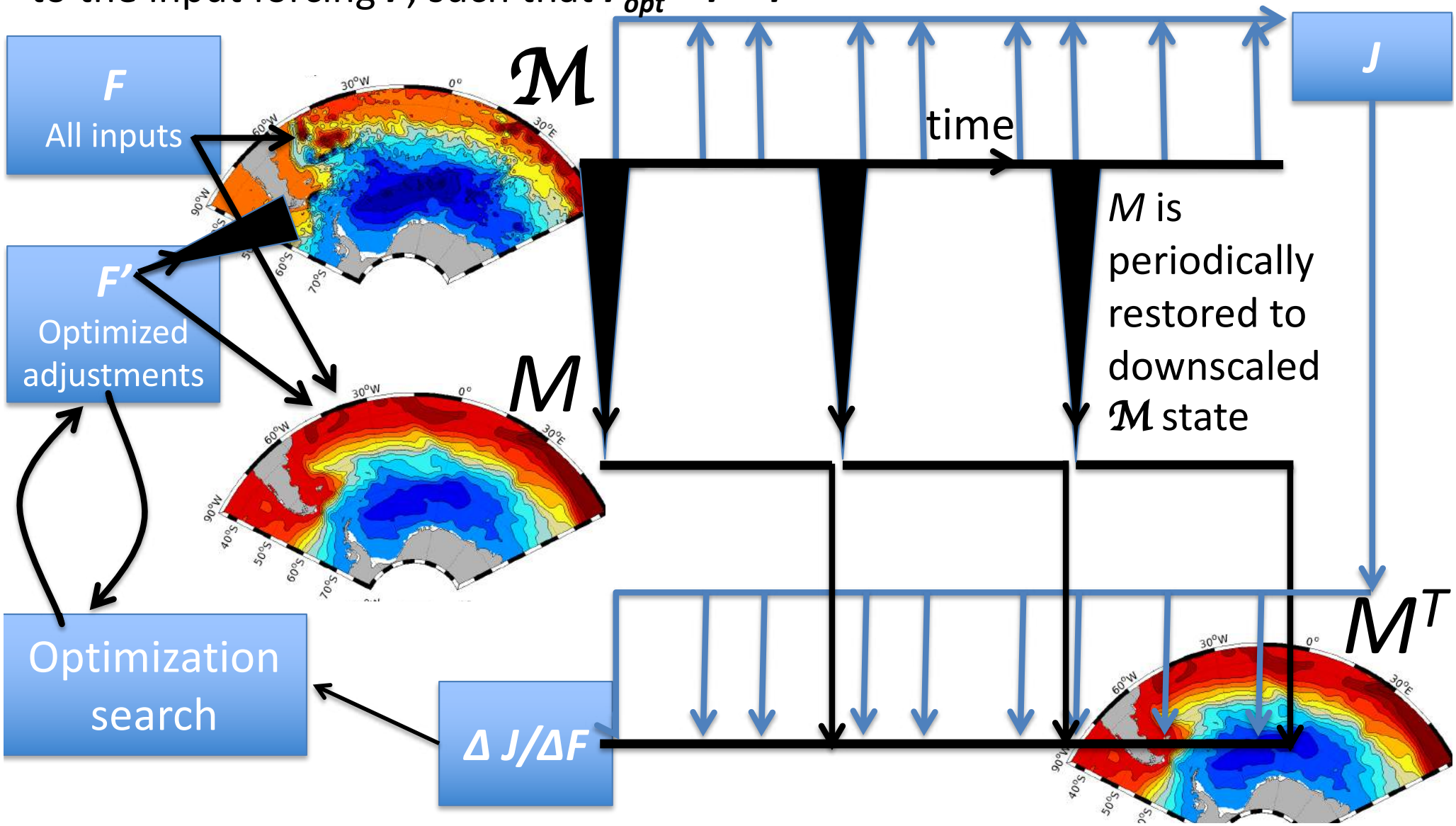
Cost function, ***J***, is calculated by sampling ***M***. It is stored in data and model space and forces $\boldsymbol{M^T}$



Multiscale coupling

A state-of-the-art high-resolution model, $\mathcal{M}$, an upscaled model, $\boldsymbol{M}$, and its adjoint, $\boldsymbol{M}^T$, are used to optimize input adjustments, $\boldsymbol{F'}$, to the input forcing $\boldsymbol{F}$, such that $\boldsymbol{F}_{opt} = \boldsymbol{F} + \boldsymbol{F'}$

Cost function, $\boldsymbol{J}$, is calculated by sampling $\mathcal{M}$. It is stored in data space and forces $\boldsymbol{M}^T$



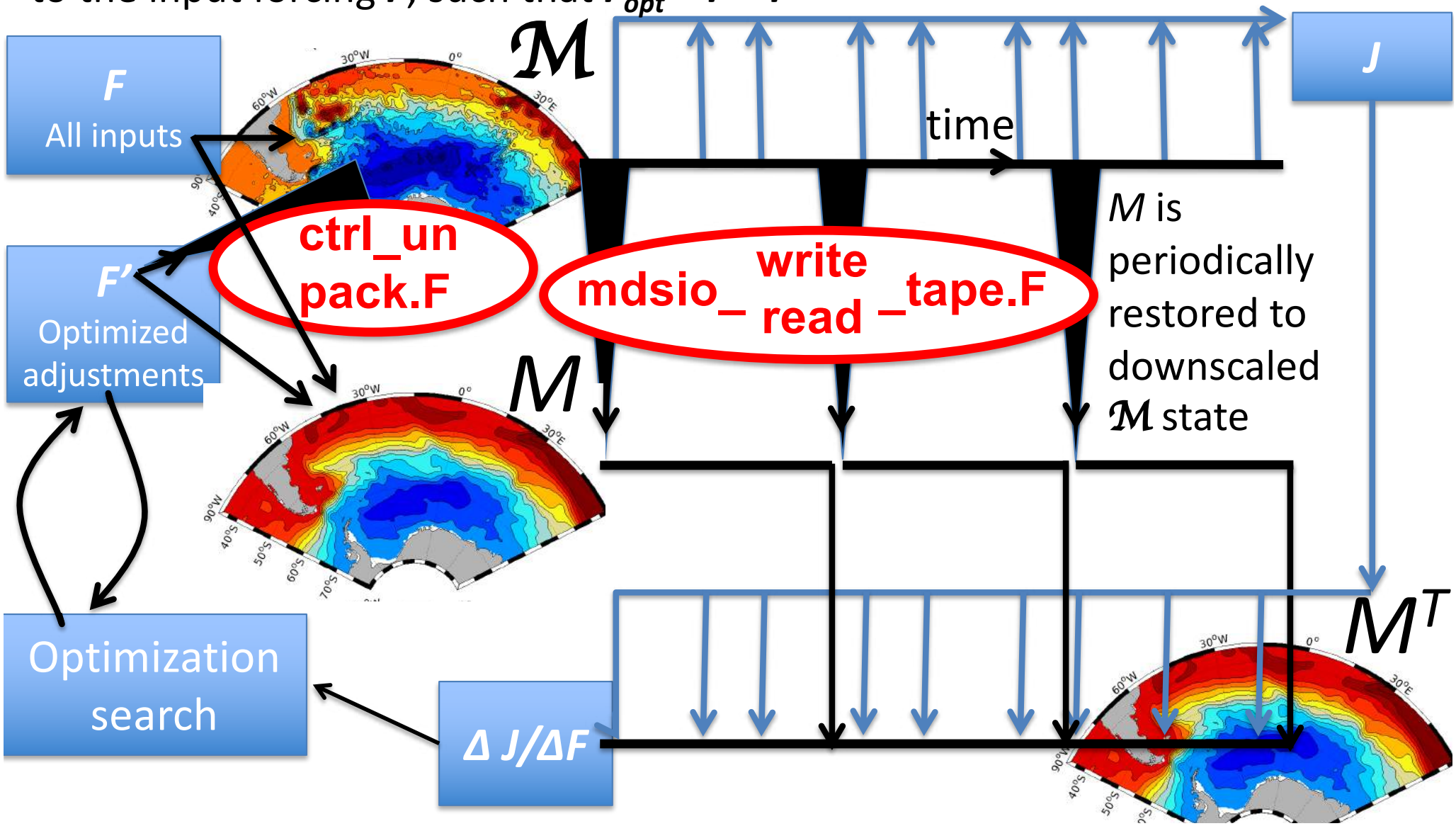
Multiscale coupling

- Goal is to run the adjoint at lower resolution than the forward model to speed up the optimization.
- Readily implemented in DIVA checkpointing algorithm using integer factor in scale difference.
- Currently testing with a coarse global setup (2.5^{o} res tutorial FWD and 5.0^{o} res tutorial tapelevel 1 and adjoint run)
  1. **Two executables** are compiled: one for the high-res forward run and one for the low-res tapelevel 1 and adjoint run.
  2. **In FWD run** the tape stores are coarsened before writing.
     1. This is done in routine mdsio_write_tape.F and only compatible with singleCPUIO = true.
     2. Fields are written in order of grid location (not ordered by tile or by process).
  3. **In tapelevel 1 and adjoint run:** tape stores are read, sorted and scattered to cores consistent with model setup in mdsio_read_tape.F
  4. After line-search optimization step, unpacking able to map new control vector to higher grid resolution. This is done in routines ctrl_set_unpack_*.F

Multiscale coupling

A state-of-the-art high-resolution model, $\mathcal{M}$, an upscaled model, $\boldsymbol{M}$, and its adjoint, $\boldsymbol{M^T}$, are used to optimize input adjustments, $\boldsymbol{F'}$, to the input forcing $\boldsymbol{F}$, such that $\boldsymbol{F_{opt} = F + F'}$

Cost function, $\boldsymbol{J}$, is calculated by sampling $\mathcal{M}$. It is stored in data space and forces $\boldsymbol{M^T}$



Data space cost function

- A generalization of the current “profile” package.
  - Observations input as netcdf vector
  - Constraints can be an integral or average. Give a number of data for each constraint and weight for each point along path:

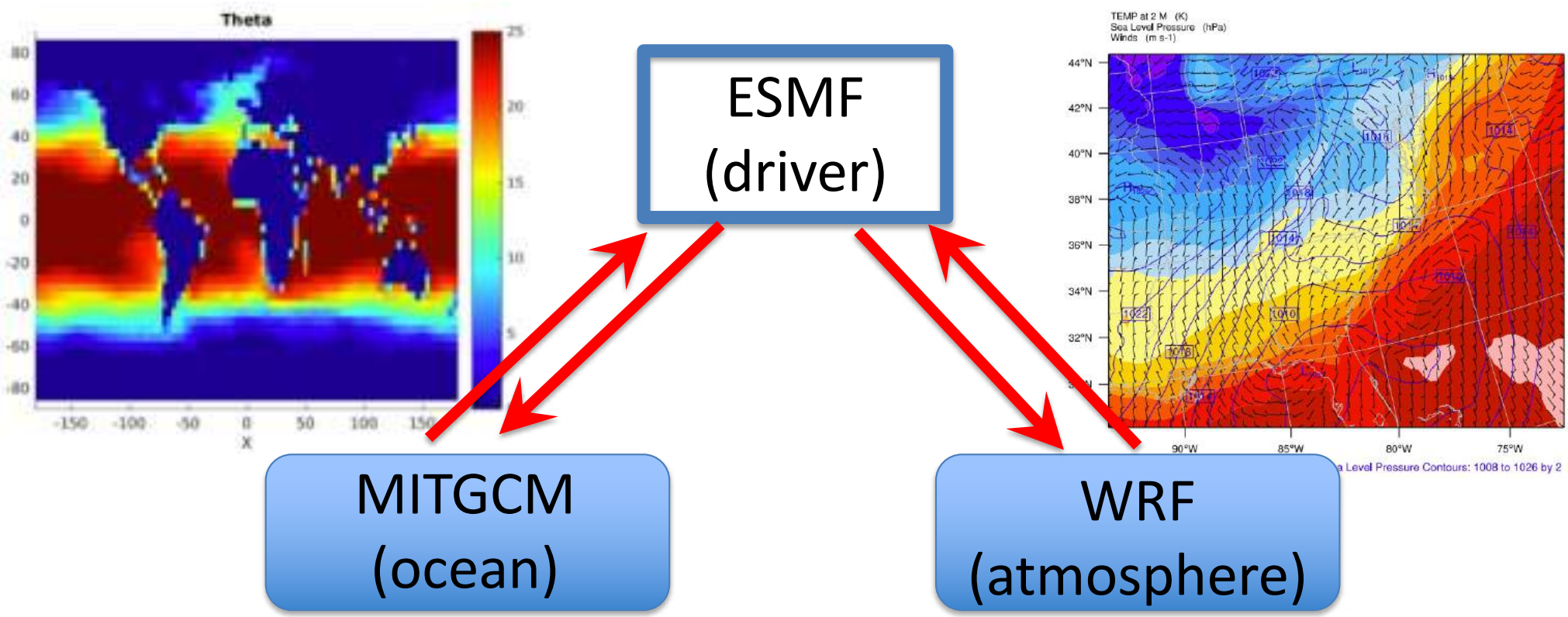
    Each constraint in the vector is made of ***NP*** data with each having an associated ***(x, y, z, t, dx, dy, dz, dt, value, weight)***
  - Point measurements have ***NP = dx = dy = dz= dt = 1***
- Advantages:
  - Deals efficiently with many forms of data (e.g. tomography, moorings)
  - Eliminates need for any interpolation in pre-processing of data
  - Allows one cost function to be used for multi-scale assimilation

Developing a Regional Ocean-Atmosphere Coupled Model

- Rui Sun, A. Subramanian, M. Mazloff, B. Cornuelle, A. Miller, I. Hoteit, F. Ralph

Goals

- Research tool for studying coupled ocean-atmosphere interactions and its role in extended range regional prediction.
- Develop a coupled ocean-atmosphere model with coupled data assimilation capabilities



Surface gravity waves

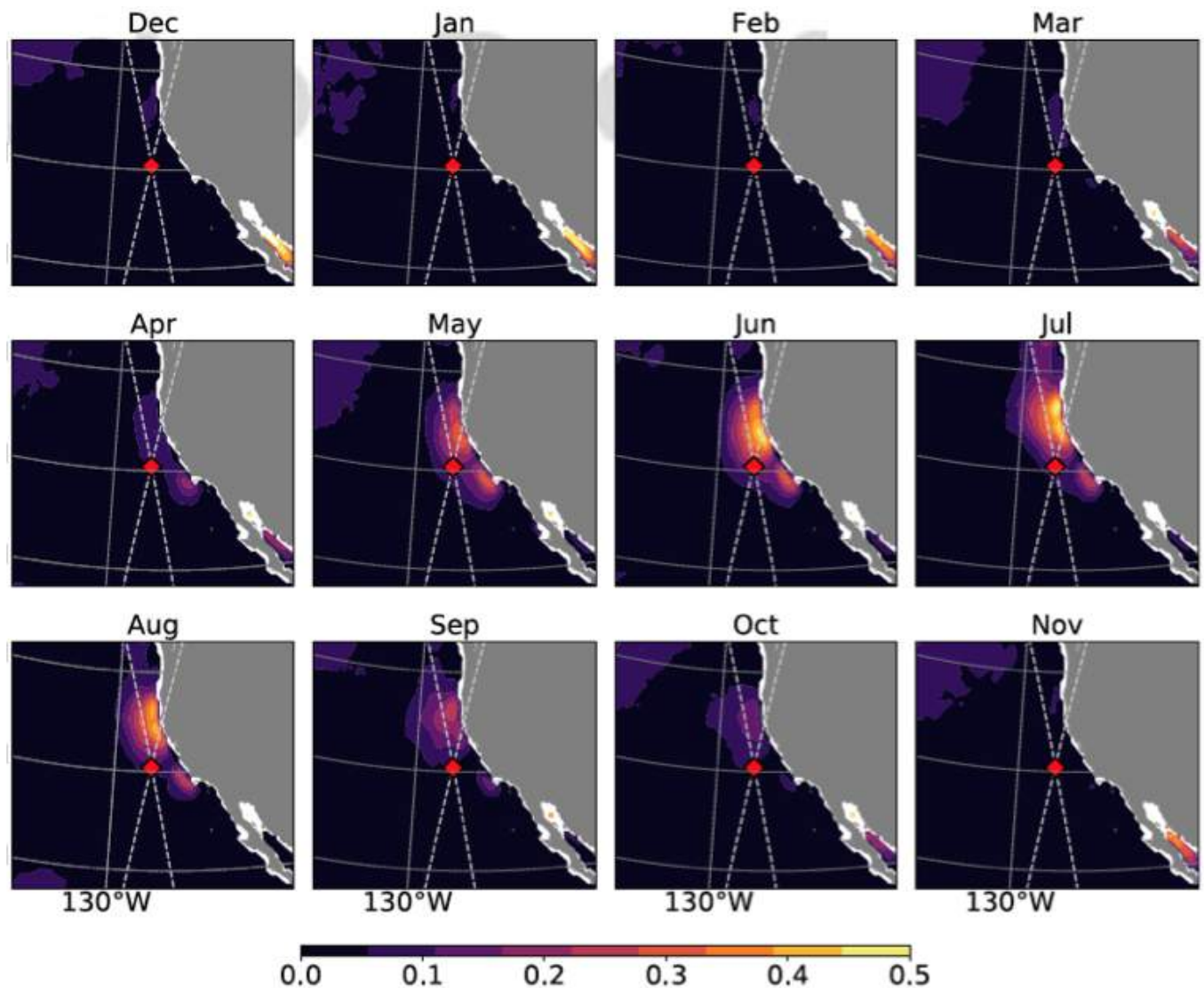
Ana B. Villas Boas (Bia) evaluated the CCS surface wave climatology

During spring/summer the sea state is often dominated by short-period, locally generated waves that are forced by regional-scale strong wind events occurring along the Coast

Bia is now carrying out experiments in this region to determine impacts of:

1. including ocean currents in WaveWatch 3
2. including surface waves in the MITgcm

Long term goal is coupling the two models.



Fraction of the month with wind-sea dominated sea states. The monthly maps were computed using peak phase speed and wind speed from the WW3 hindcast.

Villas Boas et al. JGR, 2017

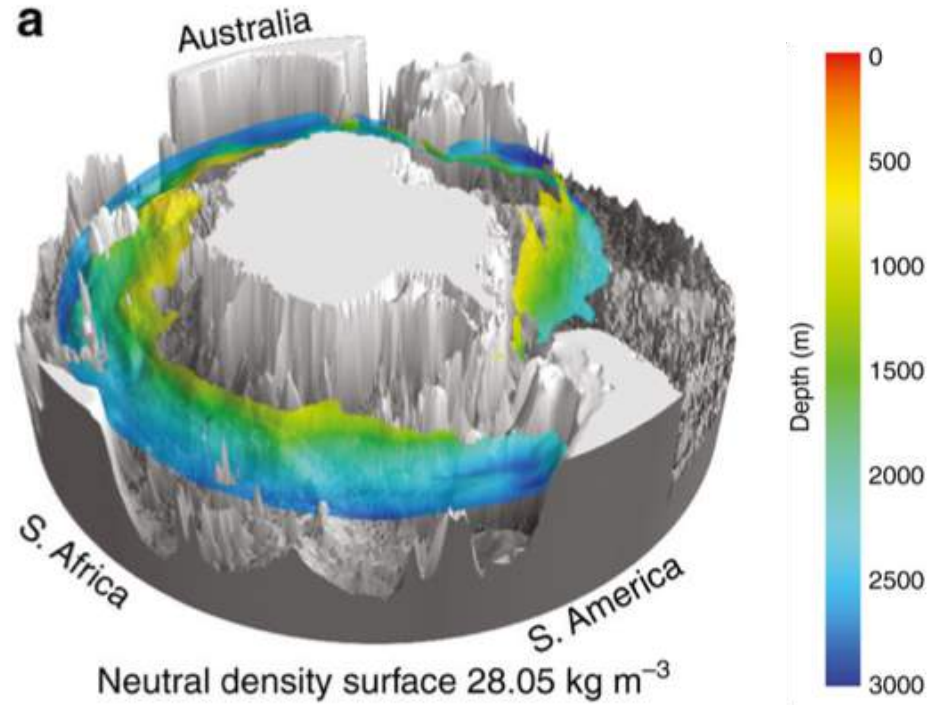
https://github.com/jinbow/Octopus/

Octopus: Jinbo Wang's offline particle tracking code.

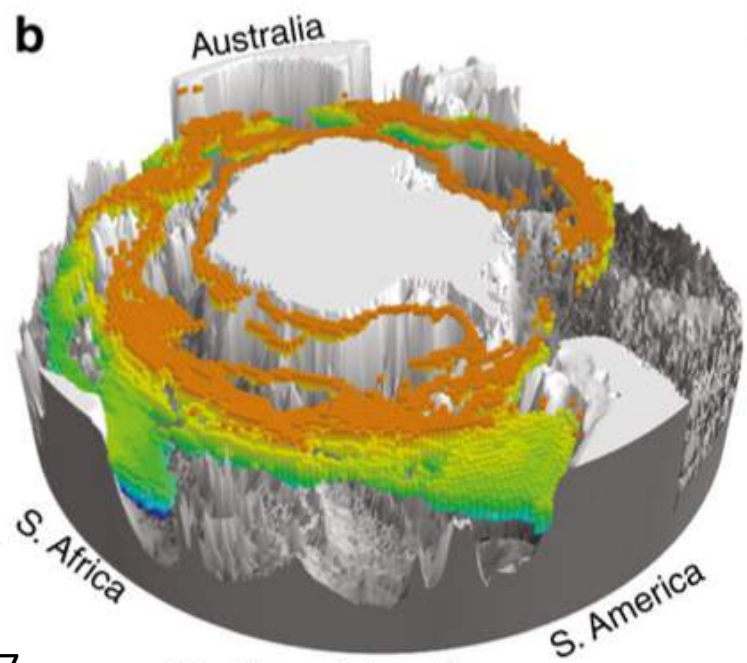
Set to work on c-grid. (Original build intended for SOSE)

Two configurations:

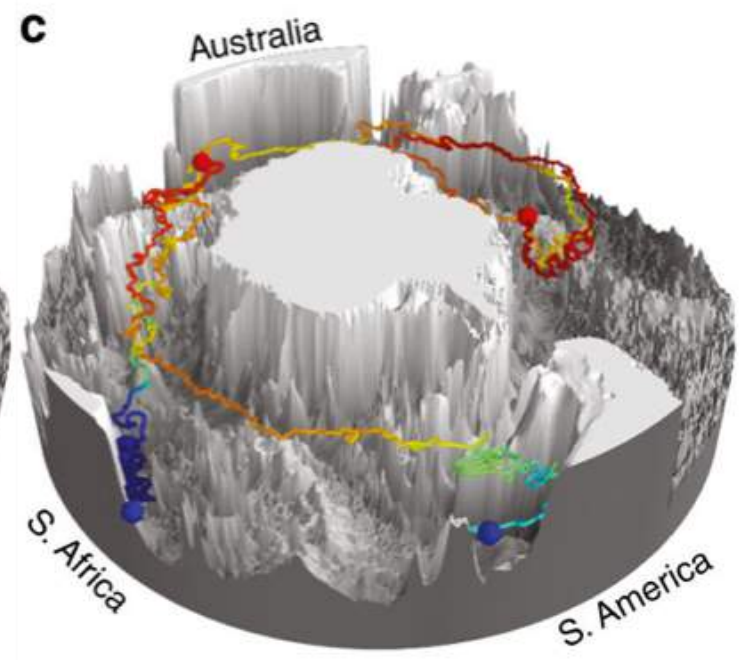
- Lagrangian particle tracking
- Argo float trajectory simulations



Neutral density surface 28.05 kg m^{-3}



Atlantic particle pathways



Example Atlantic particle trajectories

Tamsitt, et al.
Spiraling pathways of global deep waters to the surface of the Southern Ocean.
Nature Communications. 2017

Development activities at SIO summary

- High resolution optimizations assimilating tomography
- Surface waves (towards coupling with WW3)
- Coupling to WRF via ESMF
- Multi-scale optimization
- Data space cost function