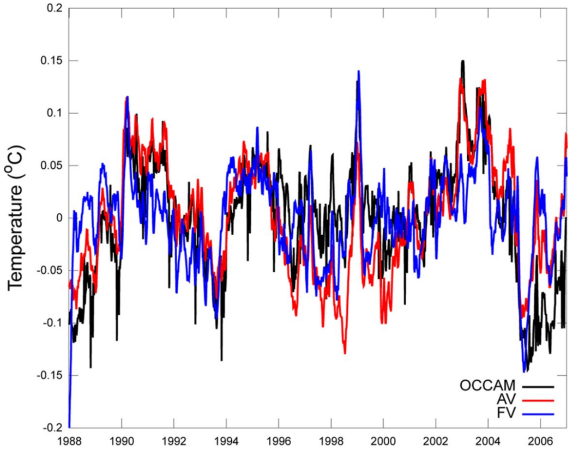
Junior Chair in Data Science for Earth, Space and Environmental Sciences, MEOM Team, IGE

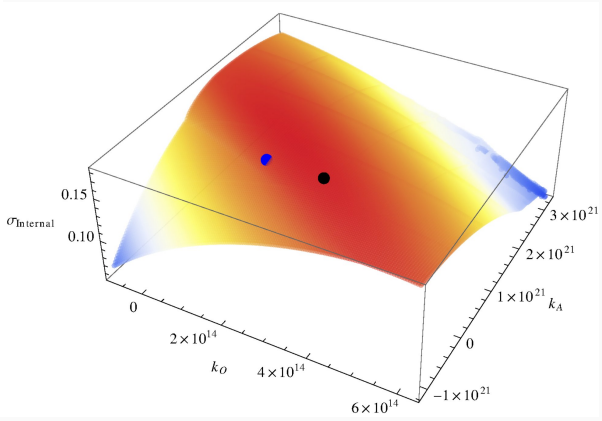
Maike Sonnewald

Massachusetts Institute of Technology, visitor Harvard

Background and research vision

Background: National Oceanography Centre & Institute for Complex Systems Simulation





Masters: NOCS&ICSS

1 paper

9 invited talks & conference contributions

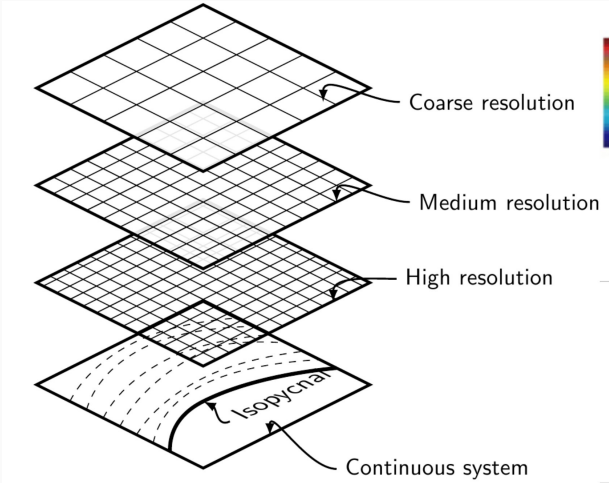
Awards

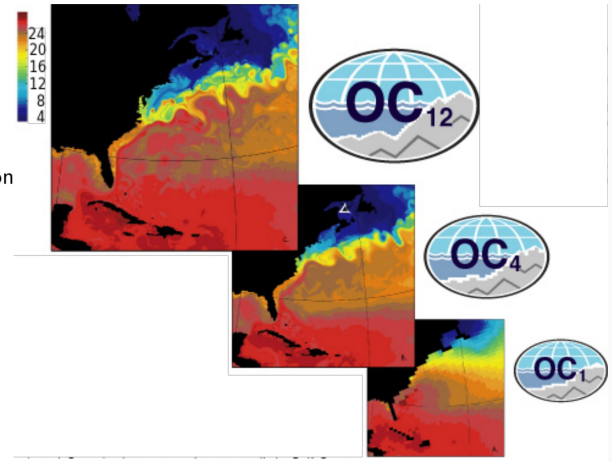
PhD: Ocean model utility

1 published and 3 papers in prep

20 invited talks & conference contributions

Numerous awards





noc.soton.ac.uk/JRD/OCCAM/OC12

PostDoc at MIT: Uncertainty and predictability

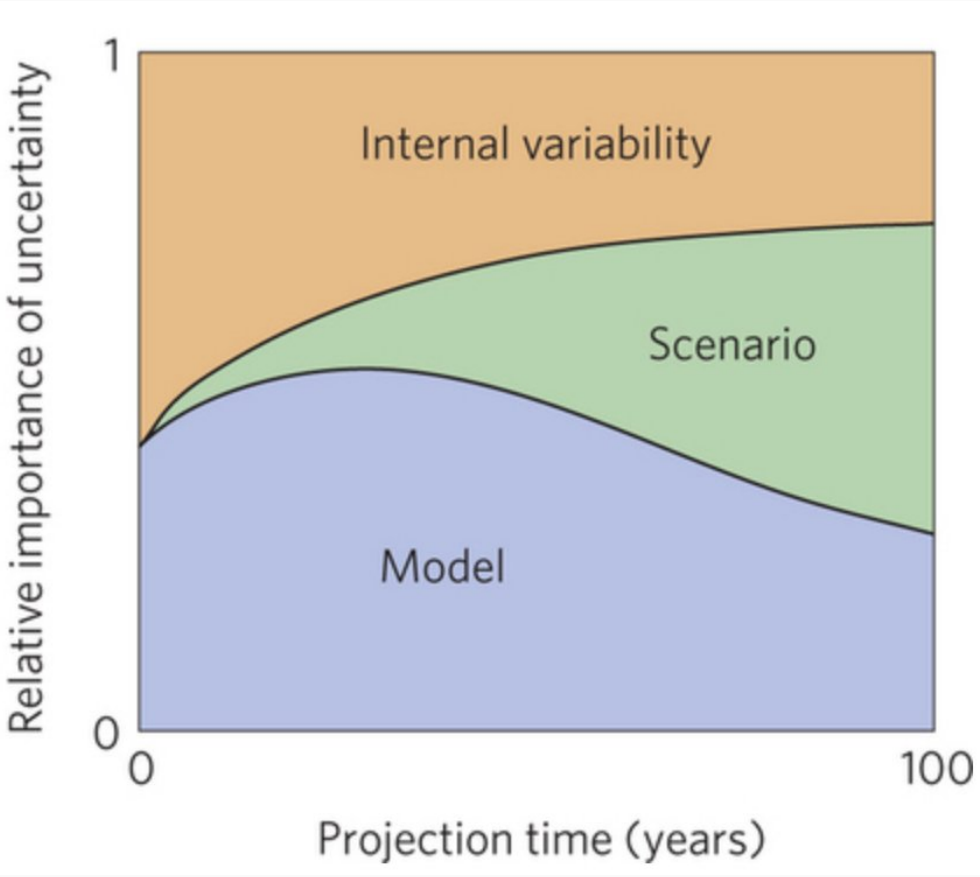
Prof. Carl Wunsch and Prof. Patrick Heimbach on ECCO adjoint State Estimate project

Interface of ocean theory and advanced analytical methods

PostDoc at MIT: Uncertainty and predictability

Prof. Carl Wunsch and Prof. Patrick Heimbach on ECCO adjoint State Estimate project

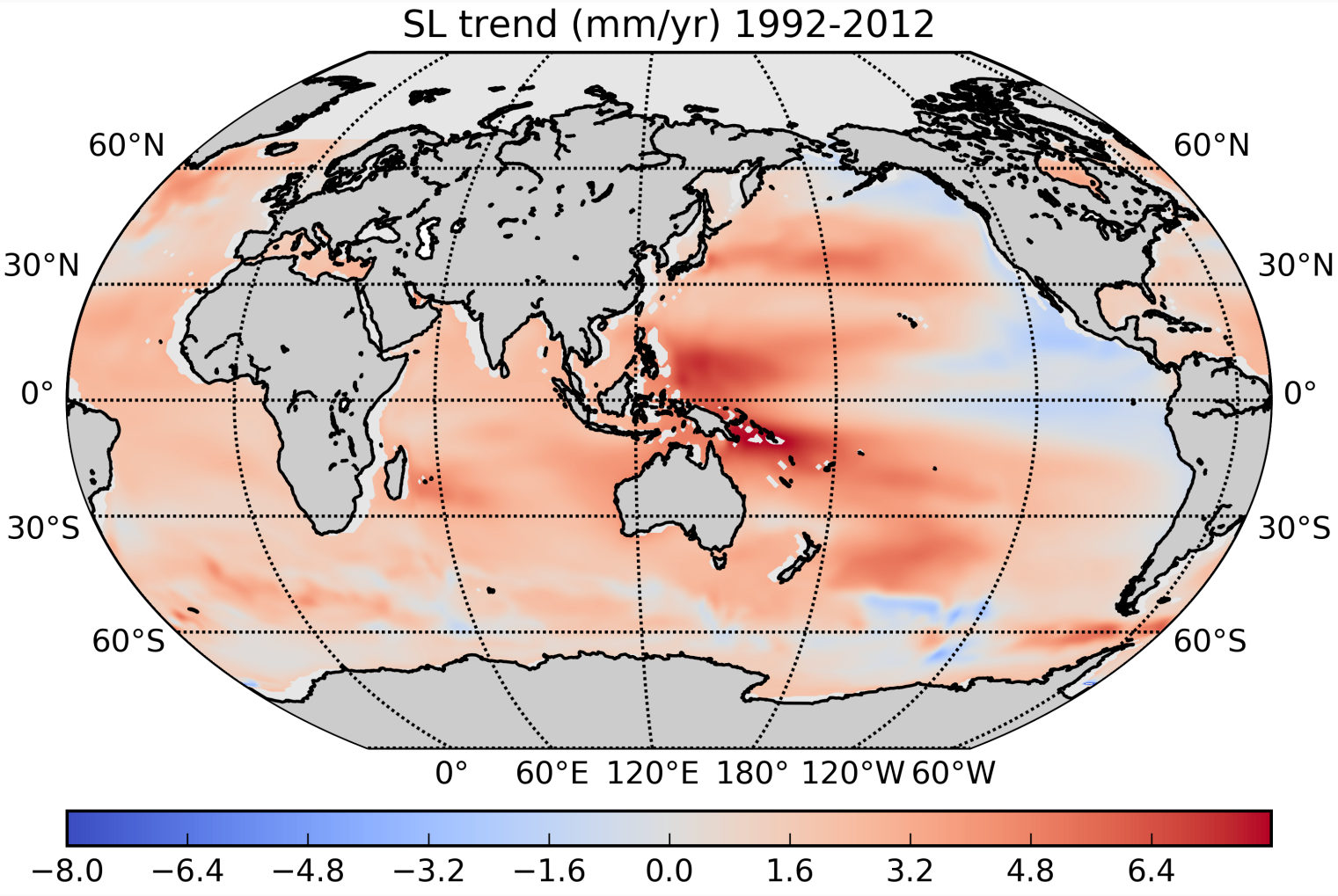
Interface of ocean theory and advanced analytical methods



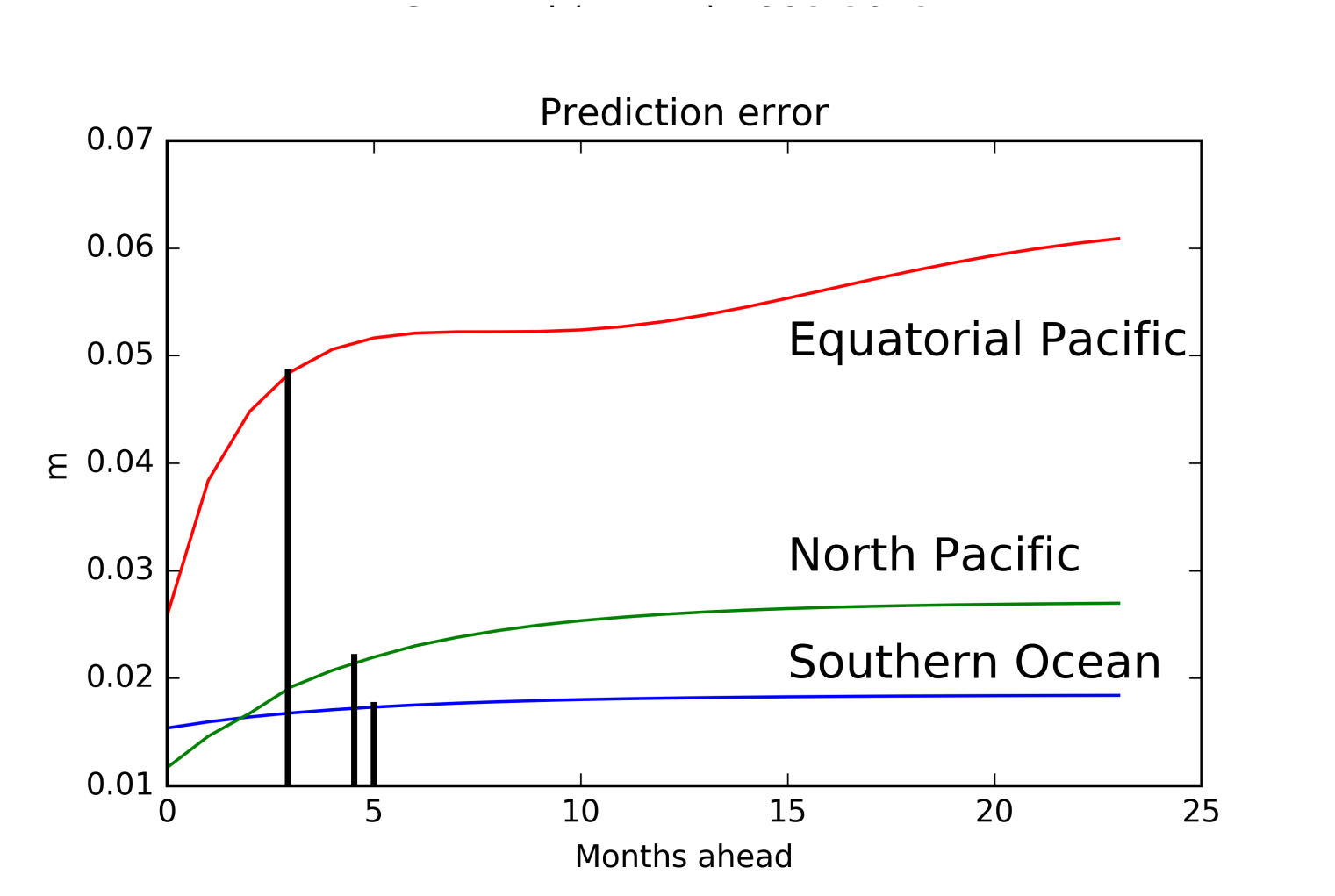
Yin, 2015

- Global and local dynamical balances
- Statistics and predictability of sea level
- Uncertainty quantification using Lagrangian Coherent Structures

Linear Predictability of Sea Level: Statistical applications

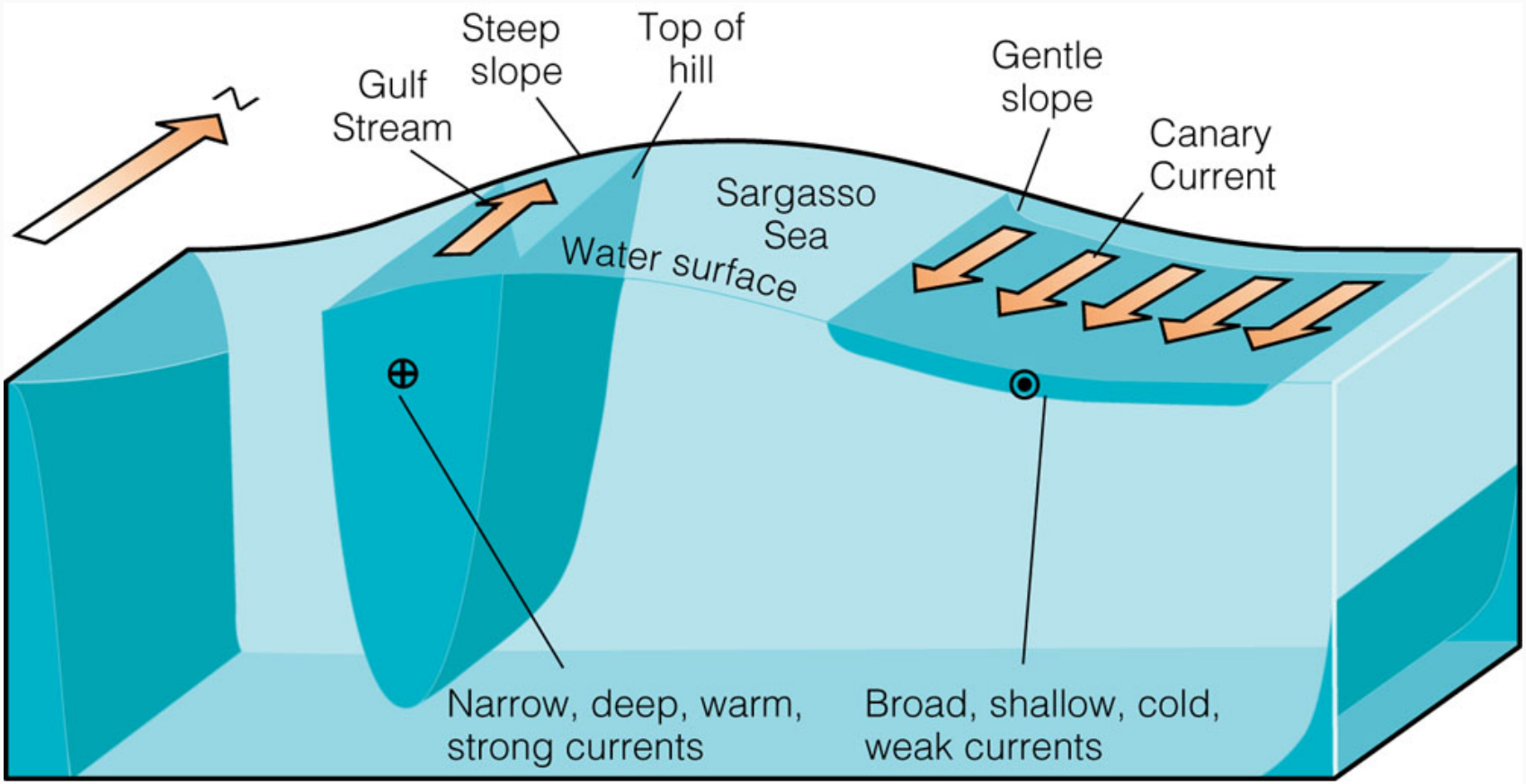


Linear Predictability of Sea Level: Statistical applications



Paper in review, 3 invited talks and 1 conference contribution

What dynamics dominate: Theoretical expertise



Momentum balance:

Use adjoint sensitivities to have data-constrained error-bars

Research vision: Probabilistic Oceanography

- Exciting time: Vast quantities of data from observations and models offer insight
- Modern oceanography; need for new tools
- Data science is interface!

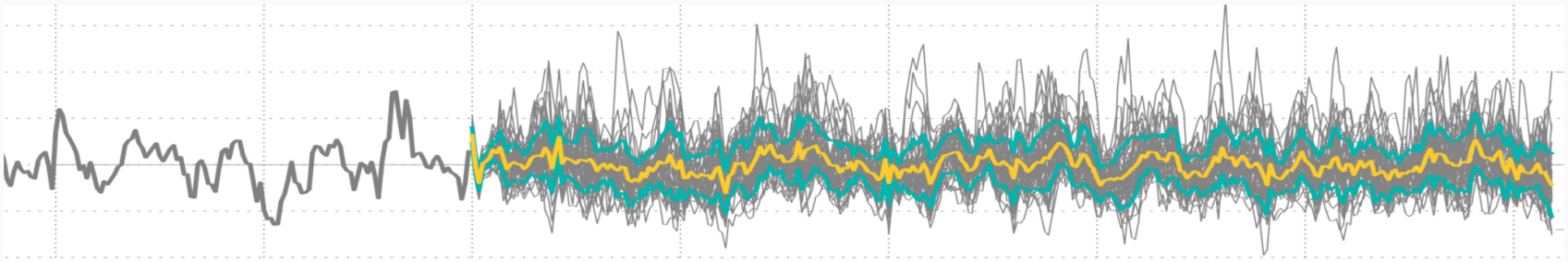
Research vision: Probabilistic Oceanography

- Exciting time: Vast quantities of data from observations and models offer insight
- Modern oceanography; need for new tools
- Data science is interface!

Paradigm shift unavoidable

Well posed scientific questions $\rightarrow$ Probabilistic Oceanography

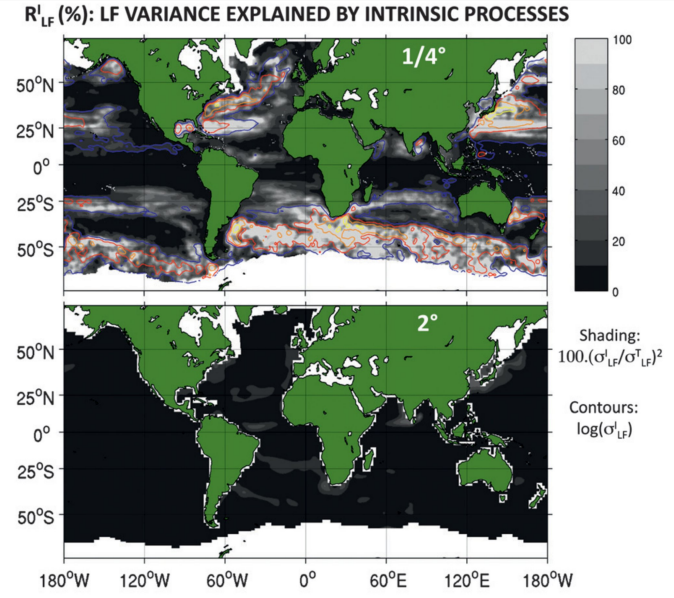
Meet societal needs

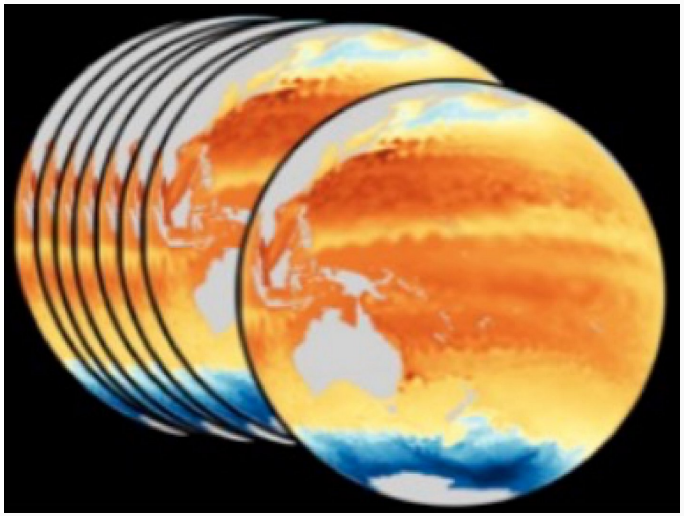


https://meom-group.github.io/

Proposed project

Ocean models as probabilistic tools: OCCIPUT project at MEOM IGE





Penduff *et al.*, 2011

OCCIPUT: 50 member ensemble, 56 yr, high res. global model

Climate-relevant water mass var. $\leftrightarrow$ turbulence-driven chaos

Systemic view: Characterize and understand along water pathways

Reduce 100TB dataset: Lagrangian particle trajectories

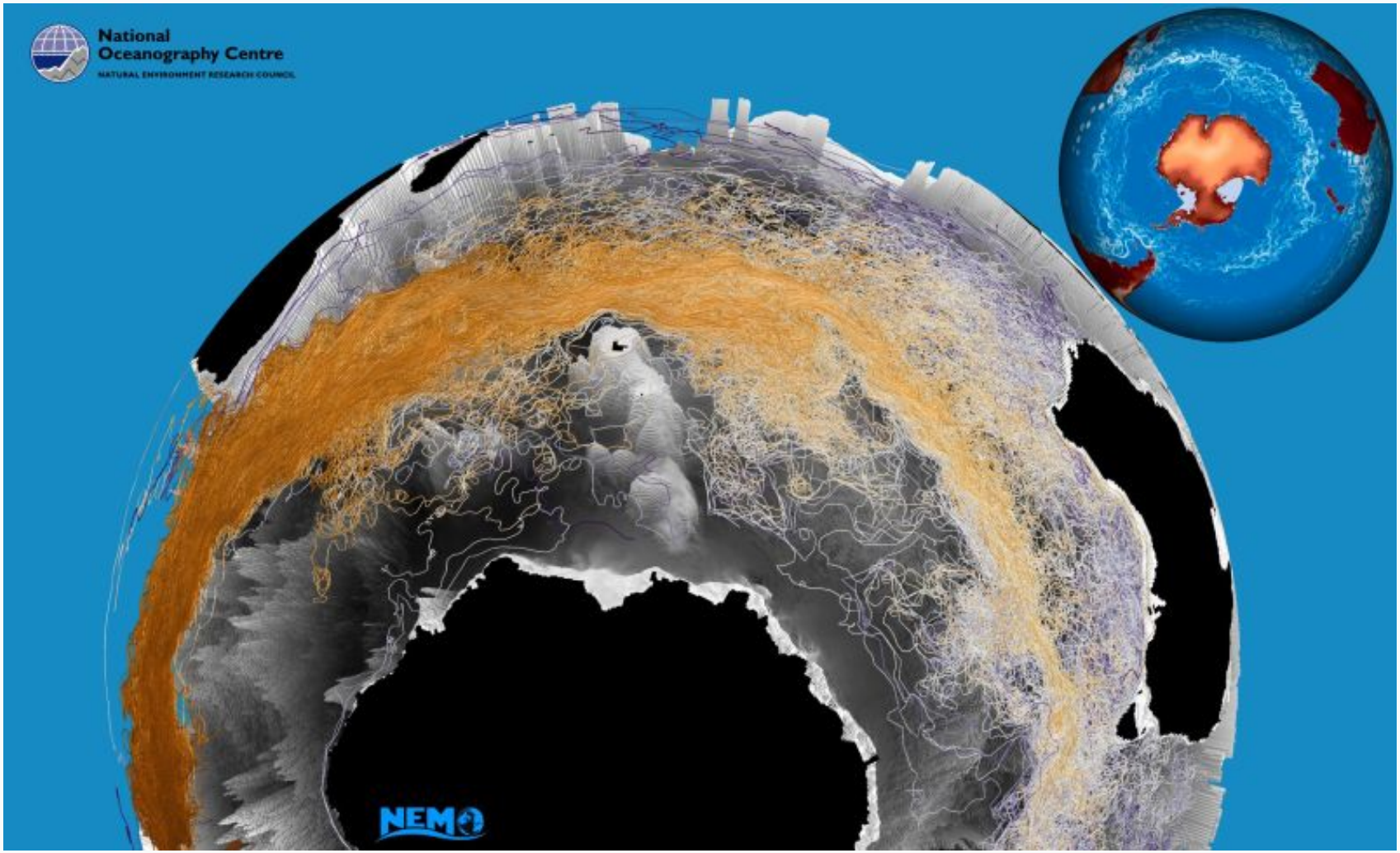
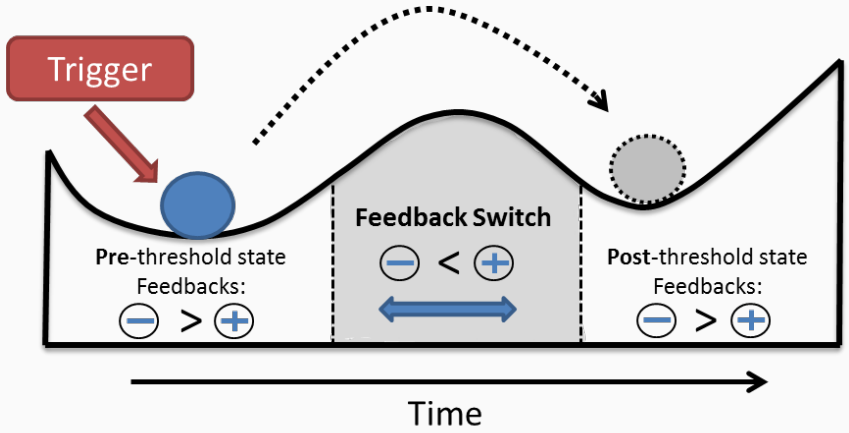


Image credit: Andrew Coward

Describe stable states: PDFs



Briske *et al.* 2006

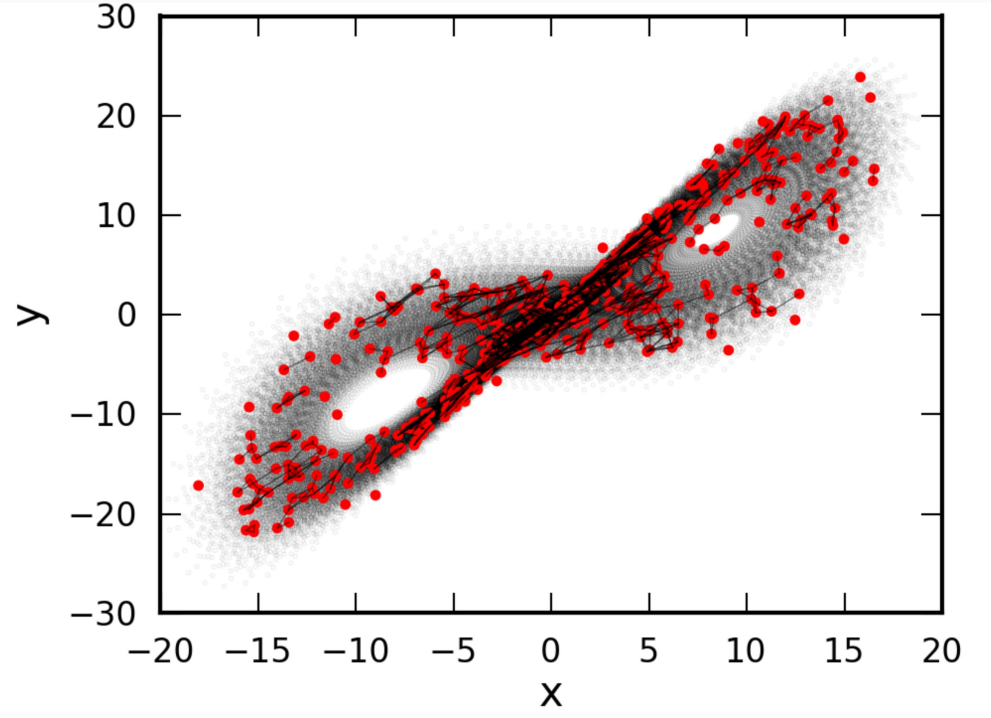
- *Shannon's theory* informs us how likely a trajectory is:
  - Spatially oriented PDFs highlight key transitions
- Visibility graphs:
  - Unsupervised clustering: Can we see common properties between state transitions?

Result: Original classification

Deliver novel classification with probabilistic insight from information theory

Understanding mechanisms of member divergence

- Recurrence network analysis:
  - Chaotic or regular? Assortativity to characterize geometrical properties
  - Ocean transport associated with mechanisms?
- Assess likelihood of cascades of causality
  - Identify priors
  - Associate likelihood



Donges *et al.*, 2015

Novel approach

Key insights into dynamics of intrinsic var. key to climate projections

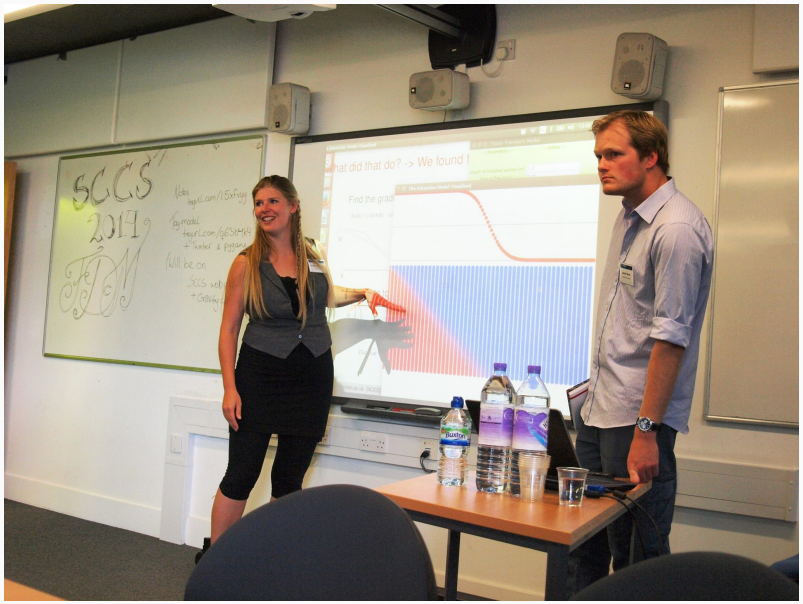
Université Grenoble Alpes: How I will work in ocean team

Institute connections and social vision

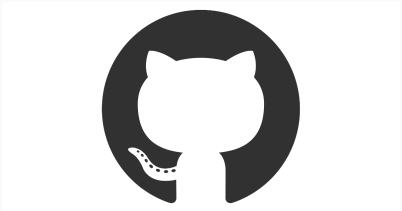
Experience

- Taught/organised numerous workshops, conference sessions
- Hosted interdisciplinary seminars at ICSS, NOCS, MIT and UT

- Collaborate with GIPSA-lab (mentoring)
- Seminars and events:
  - Help develop common language to collaborate
  - Overcome interdisciplinary barriers
  - Gather communities
- Teaching and mentoring
- Organize workshop



Software development: Global contributions and collaboration

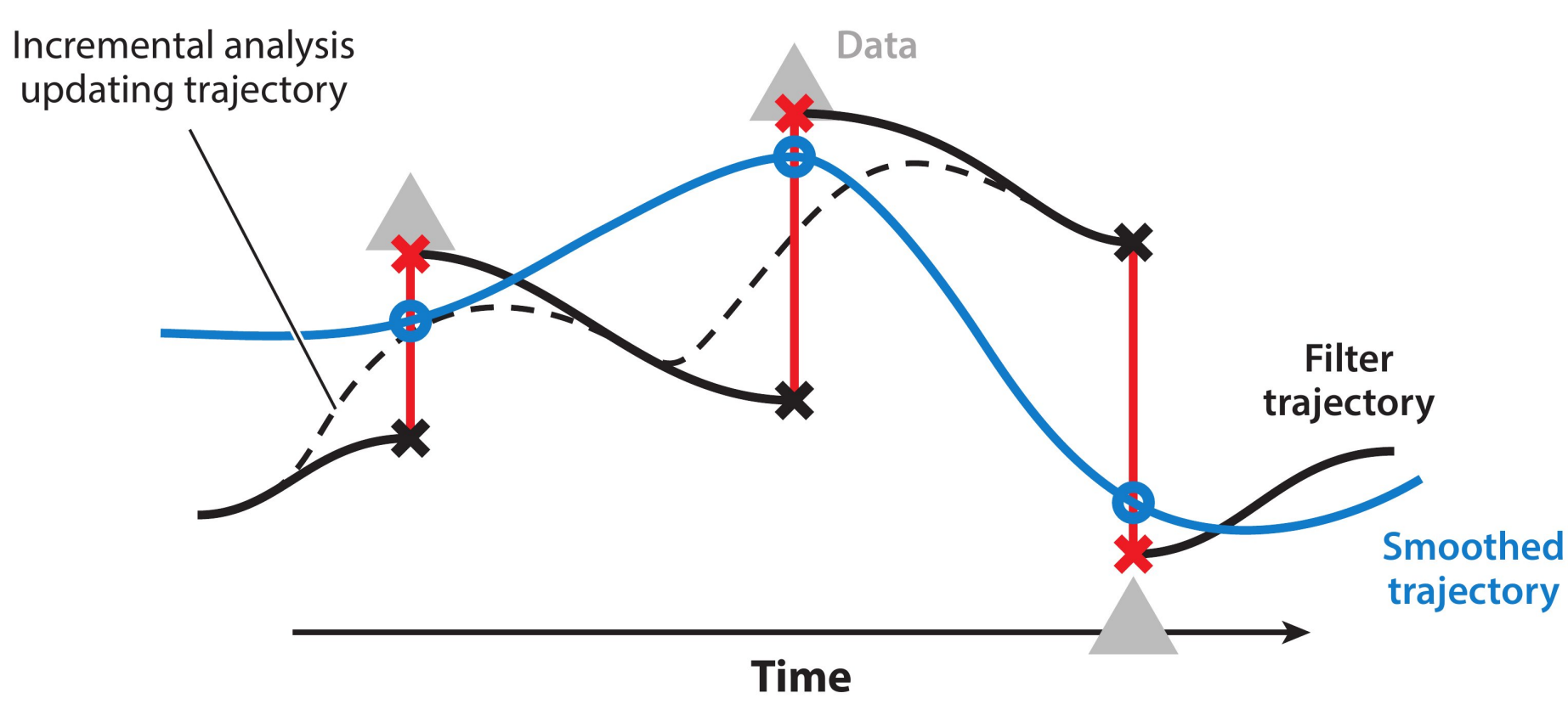


- Make data available to wider community
- Université Grenoble Alpes on the map for oceanographic software development
- Contribute code:
  →Pyunicorn and Pangeo (xarray)
- Promote good coding practices:
  →Software carpentry, hackathons

Thank you for your attention

Questions?

ECCO state estimate: Supervised inverse problems



Stammer *et al.* 2016

Model uncertainty

ECCO gives us an Ocean State consistent with known physics and data