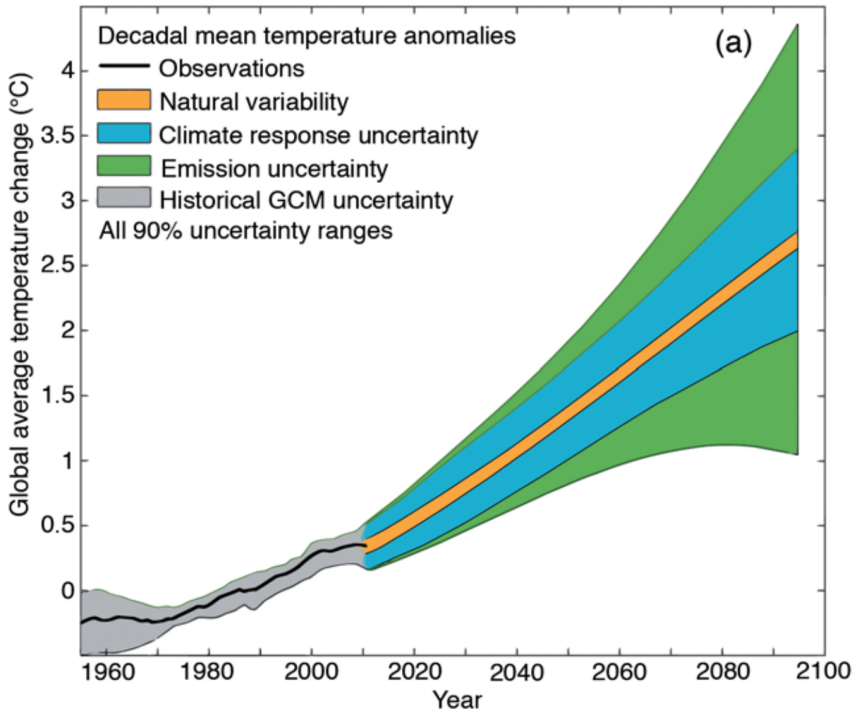
TRR181 ENERGY TRANSFERS IN ATMOSPHERE AND OCEAN

Carsten Eden

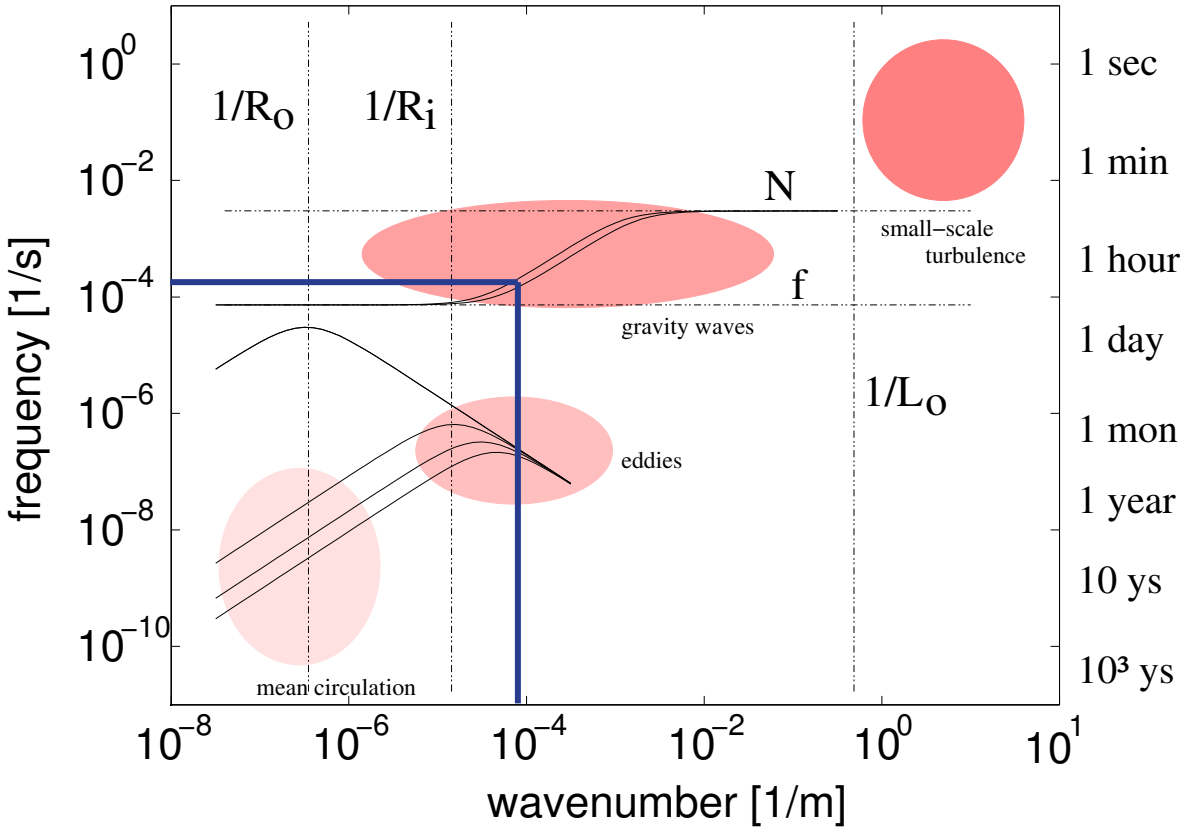
Uncertain climate model projections



from Cubasch et al (2013)

- historical record and projections of decadal mean surface temperature
- climate response uncertainty $\rightarrow$ model error $\rightarrow$ better parameterisations and numerics $\rightarrow$ TRR 181 (www.trr-energytransfers.de)

Dynamical Regimes

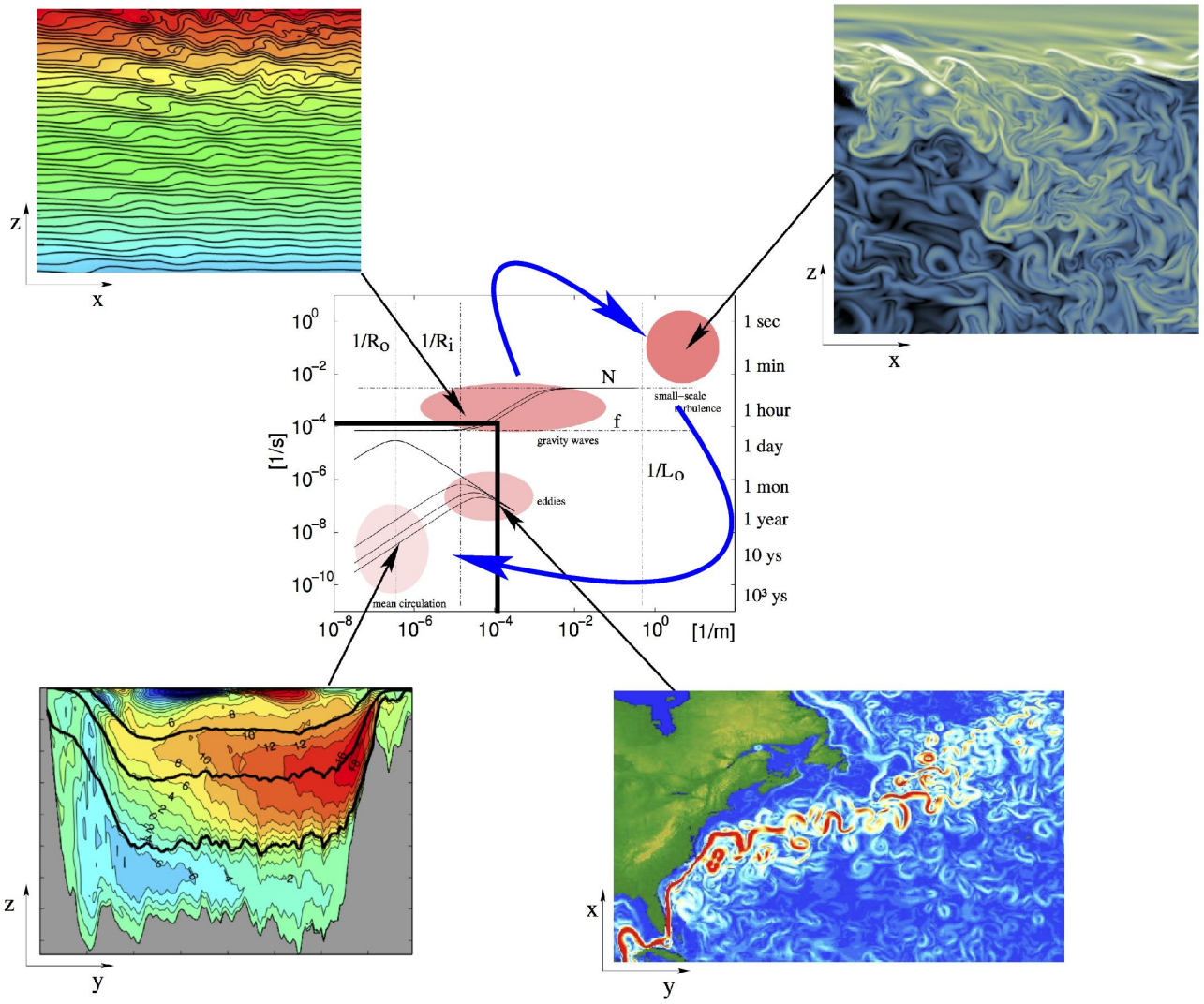


Solid lines:
dispersion relations of linear wave solutions

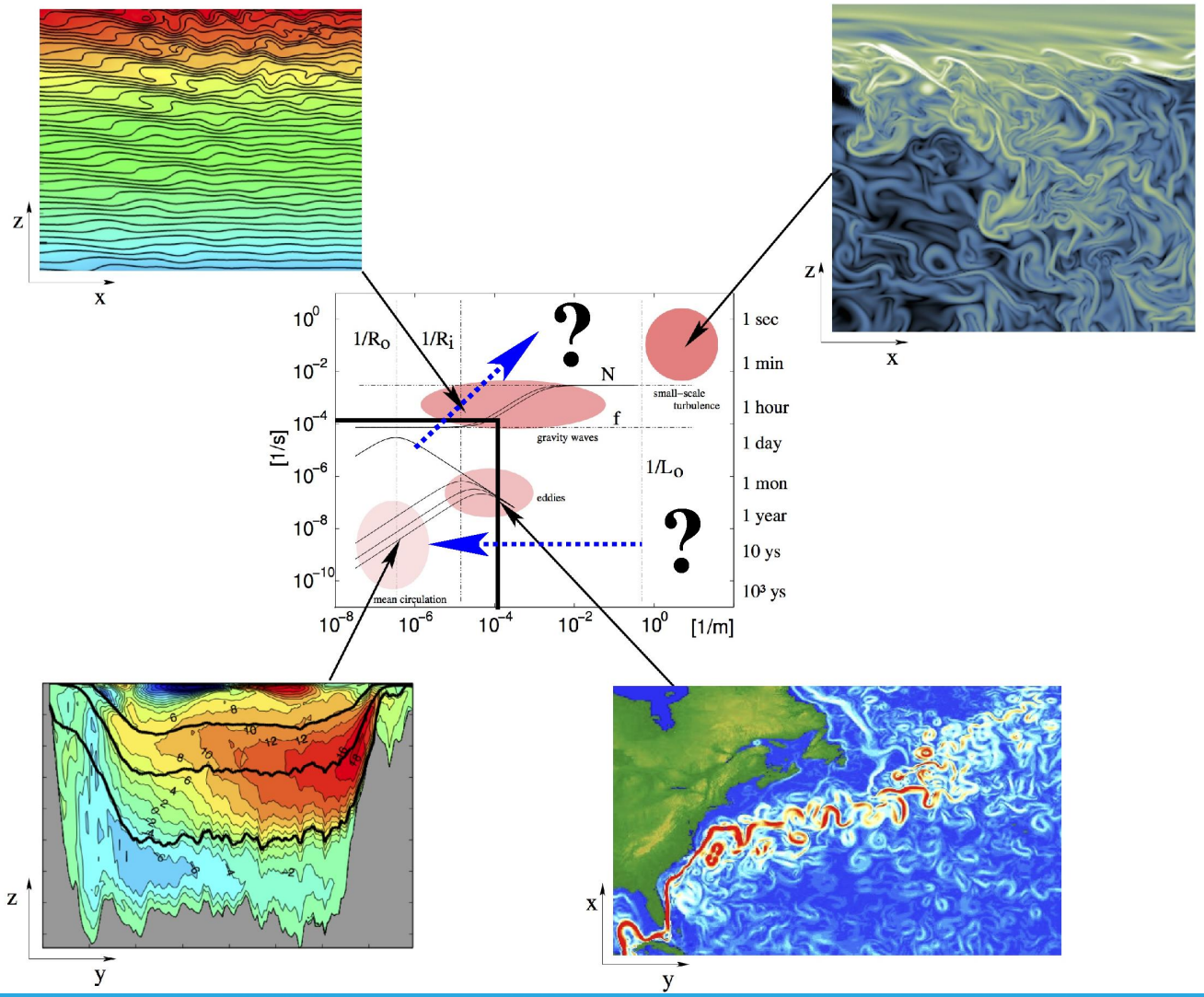
Red ellipses:
dynamical regimes

Box:
ocean models

Inconsistent formulation of energetics in models



Inconsistent formulation of energetics in models



Aims and strategy of TRR181

Problems:
Missing understanding
inconsistent formulation of energetics in current models
Inconsistent numerics and theory
Consequences: large biases in current climate models

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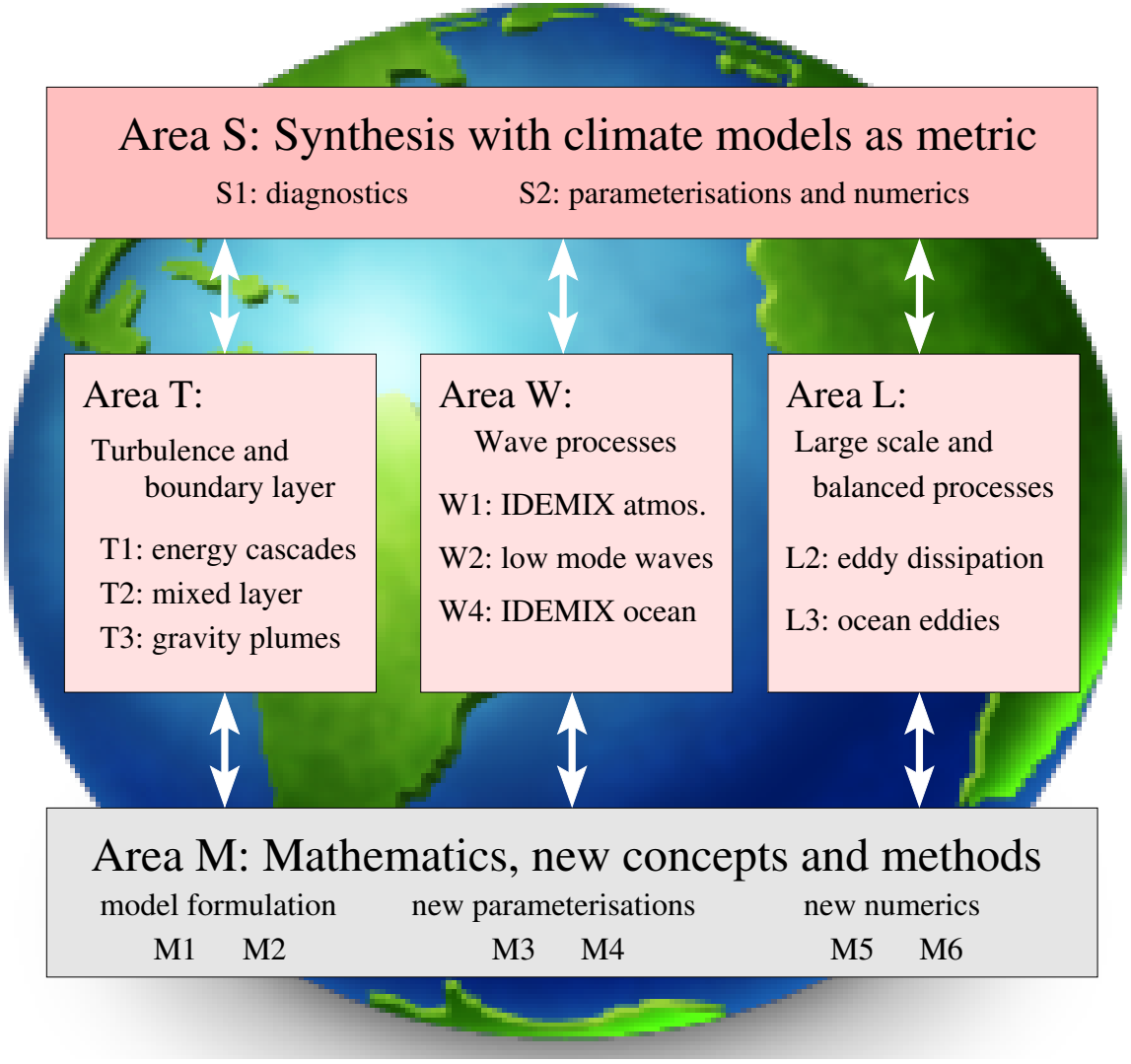
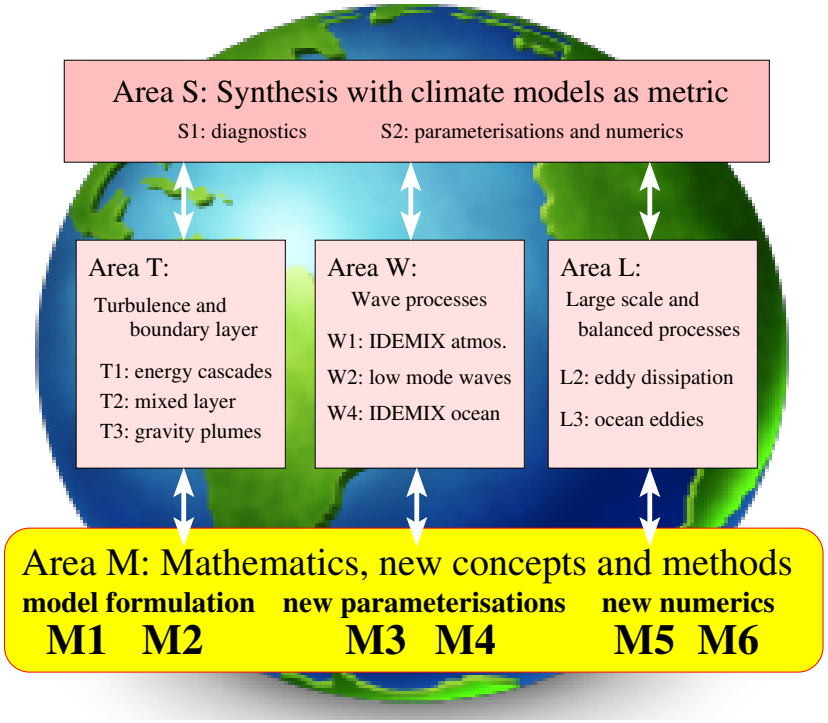
- To develop the necessary understanding of all important processes relevant for the energy cycle and the interaction of the different dynamical regimes
- To develop, test and implement with this understanding new and consistent parameterizations for the effect of unresolved processes and interactions of dynamical regimes in the models
- To develop numerical methods featuring consistent energetics and minimal and controlled unwanted dissipative effects
- Combining expertise in ocean, atmosphere with mathematics, combining observational and modelling work

Structure of TRR181



Research area M: Mathematics



What is a mathematically and physically consistent model formulation for the different dynamical regimes and their interaction ?

M1: instabilities across scales
M2: systematic multi-scale modelling

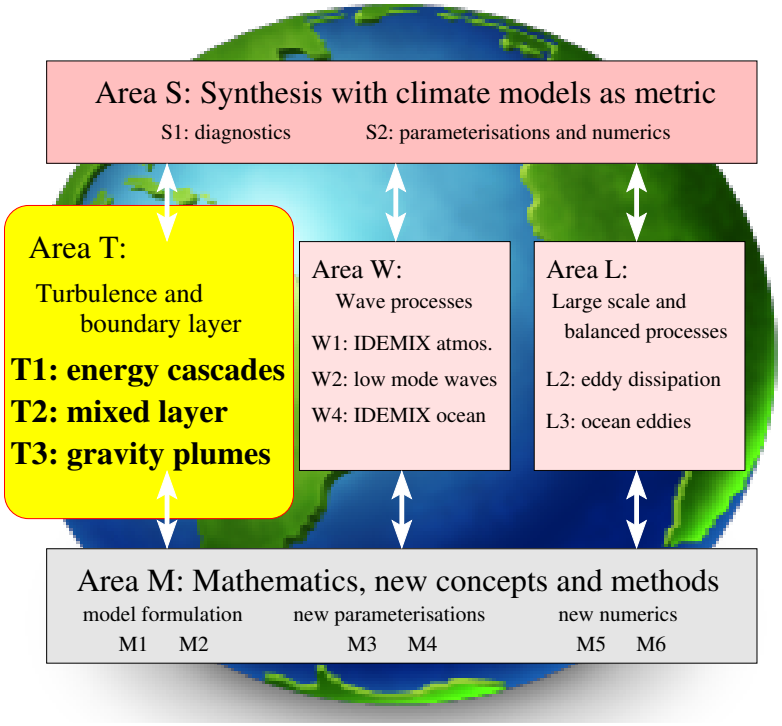
Can we formulate better and physically consistent subgrid scale parameterizations?

M3: toward consistent subgrid momentum closures
M4: entropy production in turbulence parameterizations

Can we develop better numerical schemes ?

M5: reduced spurious diapycnal mixing
M6: techniques for atmosphere-ocean wave coupling

Research area T: Turbulence and boundary layer



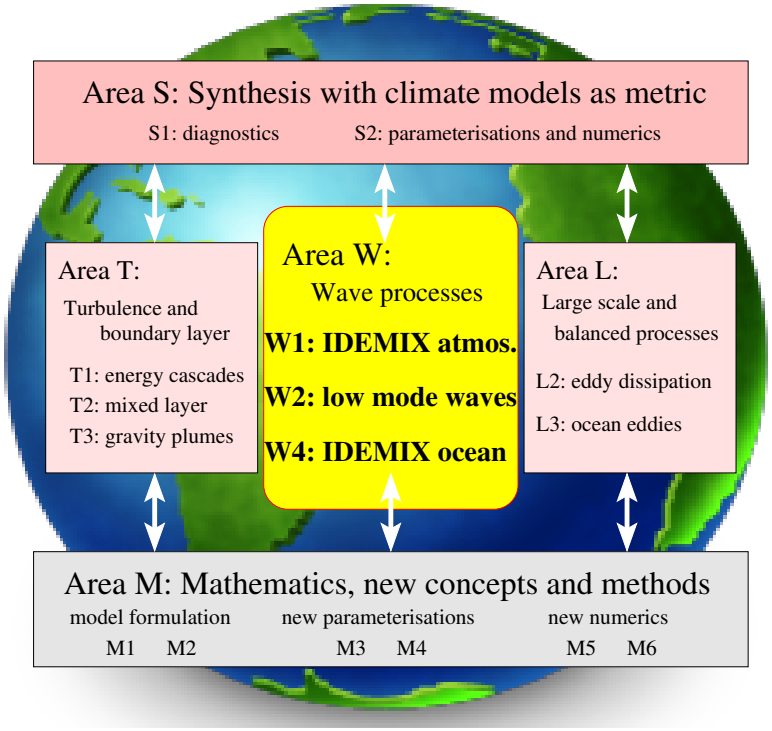
How to quantify and parameterize stratified turbulence in the atmosphere?

T1: Energy cascades in the lower and middle atmosphere

What are processes, energy transfers and interactions between small-scale turbulence, gravity waves and eddies in the surface and bottom boundary layers of the ocean?

T2: Energy budget of the surface mixed layer
T3: Energy transfers in gravity plumes

Research area W: Wave processes



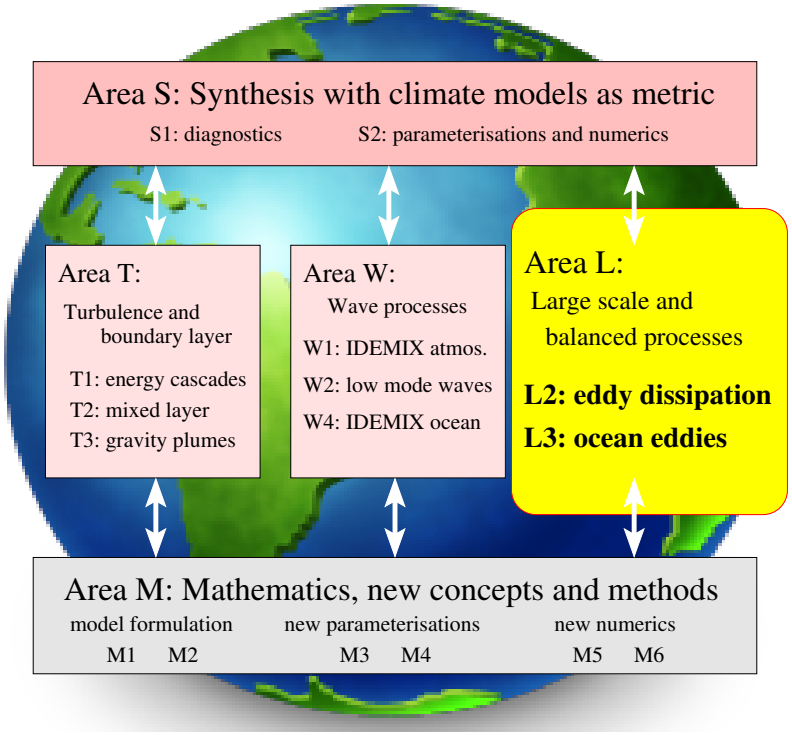
What are dominant mechanisms and processes for gravity waves in the atmosphere and how can we better parameterize them?

W1: Gravity wave parameterization for the atmosphere

How do gravity waves in the ocean propagate and dissipate and how can we better parameterize them?

W2: Energy transfer through low-mode internal waves
W3: Gravity wave parameterization for the ocean

Research area L: Large scale, balanced processes

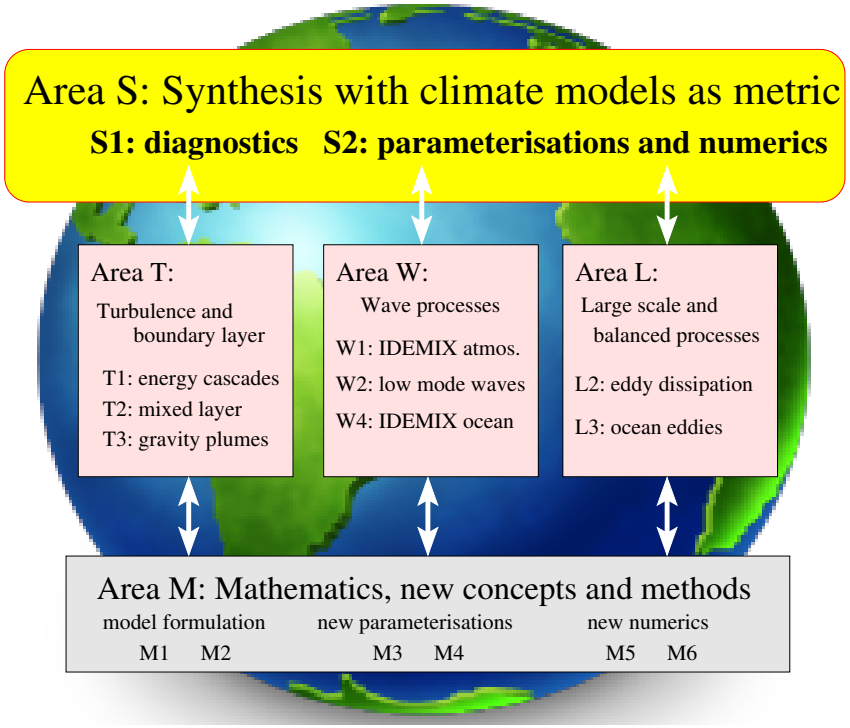


How is the balanced flow dissipated in the ocean and how can we quantify and parameterize the effects of meso-scale eddies?

L2: The interior energy pathway: internal wave emission by quasi-balanced flows

L3: Diagnosing and parameterizing the effects of eddies

Synthesis area S: Climate models as metrics



Implementation of new parameterizations and numerics into two leading coupled climate models

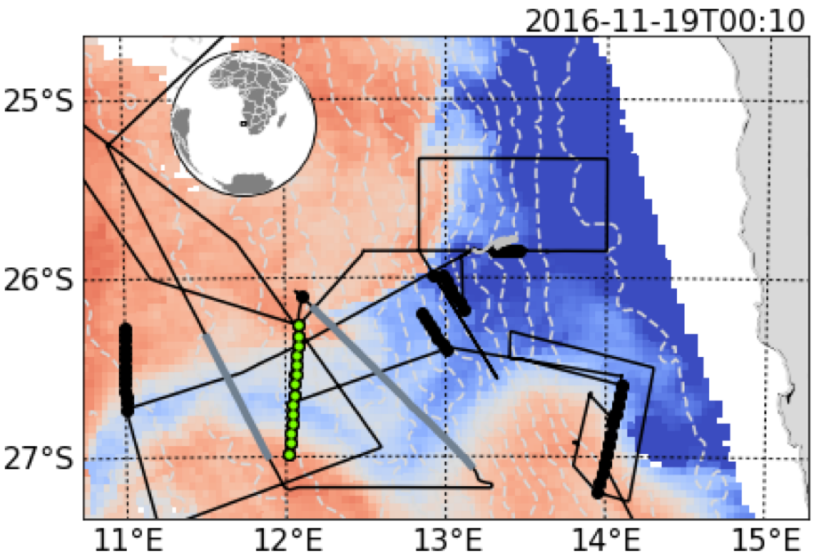
S1: Diagnosis and metrics in climate models

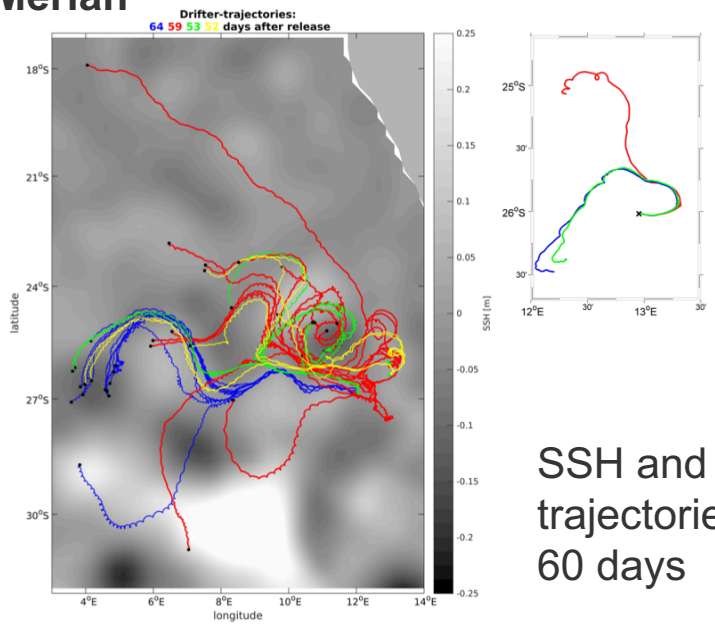
S2: Parameterization and numerics in climate models

ICON-a/ICON-o and ECHAM/FESOM

Phase I Observations

Benguela upwelling region Nov/Dec 2016 Merian





SSH and drifter trajectories after 60 days

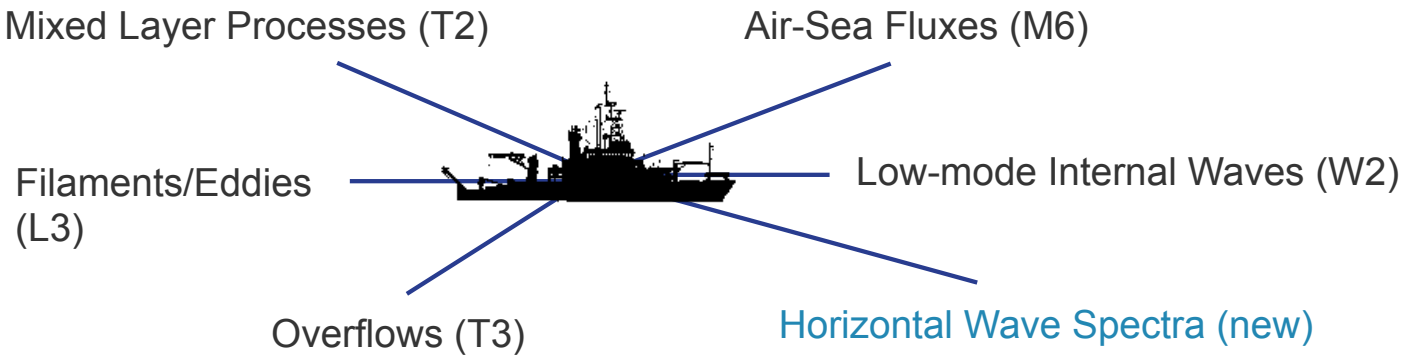
Sampling of an upwelling filament
drifters, microstructure, gliders, CTD, ADCP, submesoscale instabilities

Other (ocean) observational campaigns

Baltic Sea (mixed layer) J. Carpenter, L. Umlauf, H. Burchard
Denmark Strait overflow K. Jochumsen, R. North
Internal tide observations south of the Azores M. Walter, J. Köhler
In situ and lab surface wave observations J. Carpenter, M. Buckley

TRR181

Toward Phase II

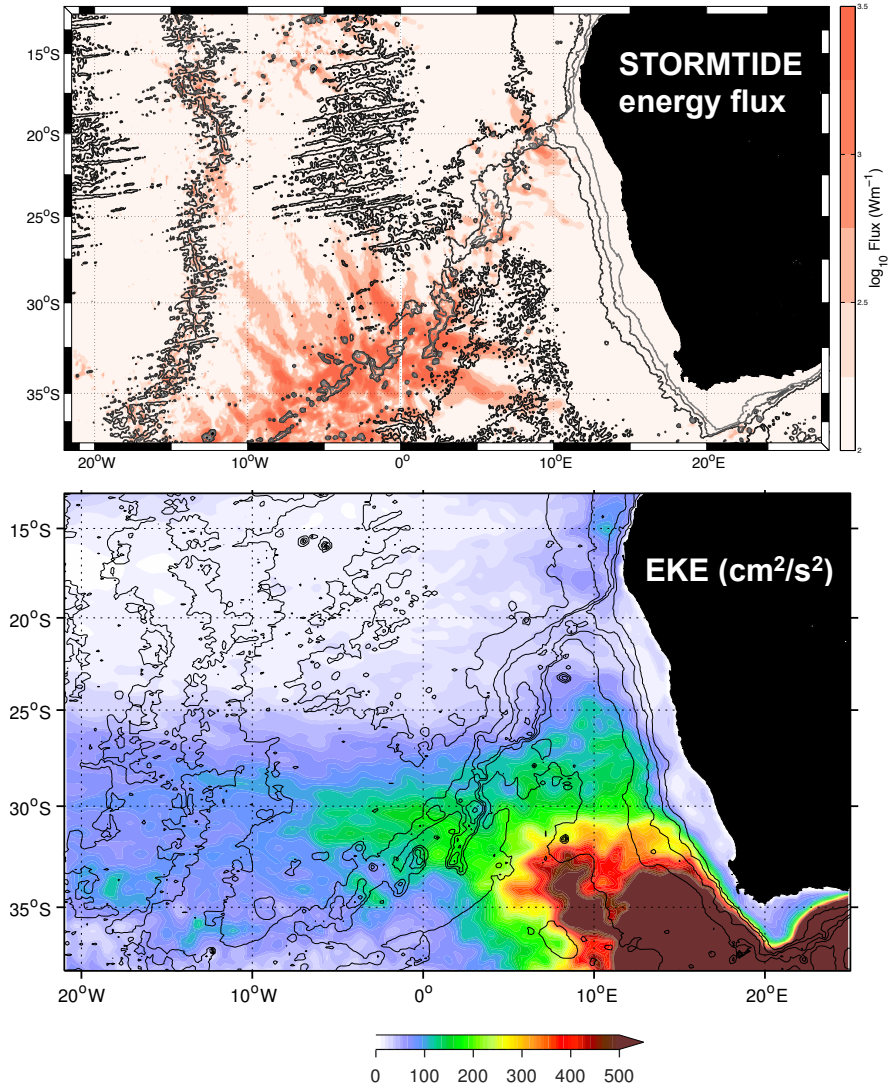


Joint ship campaign of the observational projects

- pursue the individual subproject goals
- Vision: work together on energy budget in a box to combine all scales and different dynamical regimes, from forcing to dissipation
- Use this box for model/observation comparison/validation/parameterization development

Stronger research focus on atmosphere and consistent atmosphere-ocean coupling

Phase II Planned Observations



Led by Maren Walter (Bremen)

Walvis Ridge:

- Site of significant IW generation and low mode internal wave fluxes
- Elevated EKE (Agulhas rings)
- Proposal for shiptime in prep for cruise to be carried out early 2021 (FS Meteor)

Combine direct observations with high resolution regional modelling and satellite altimetry to attempt energy budget

Phase II Planned Observations People

- Julia Dräger-Dietel, Alexa Griesel (Hamburg): meso- to submesoscale transition, structure functions, pair dispersion (surface drifter deployments, 15m drogue)

- Janna Köhler, Monika Rhein (Bremen): influence of mesoscale eddies on propagation of internal tides, transfer from low to high modes (time series stations CTD,LADCP, moorings)

- Ralf Bachmeyer, Maren Walter (Bremen): turbulence and internal wave spectra in the open deep water (pelagic glider, microstructure)

- Jeff Carpenter, Lars Umlauf, Peter Holtermann, Marc Buckley (Geesthacht,Rostock): mixed layer processes, surface waves, coupling between small-scale surface forcing and mixed layer (microstructure, catamaran, gliders, mooring, scanfish)

Connection to EURECA?
Joint data analyses (eddies, submesoscale processes, microstructure..)
Drifters: connect to Meteorological community for instruments on drifters ?
Air-sea interaction ?