



# Global chemistry-climate modelling with EMAC

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Institut für Physik der Atmosphäre  
Oberpfaffenhofen

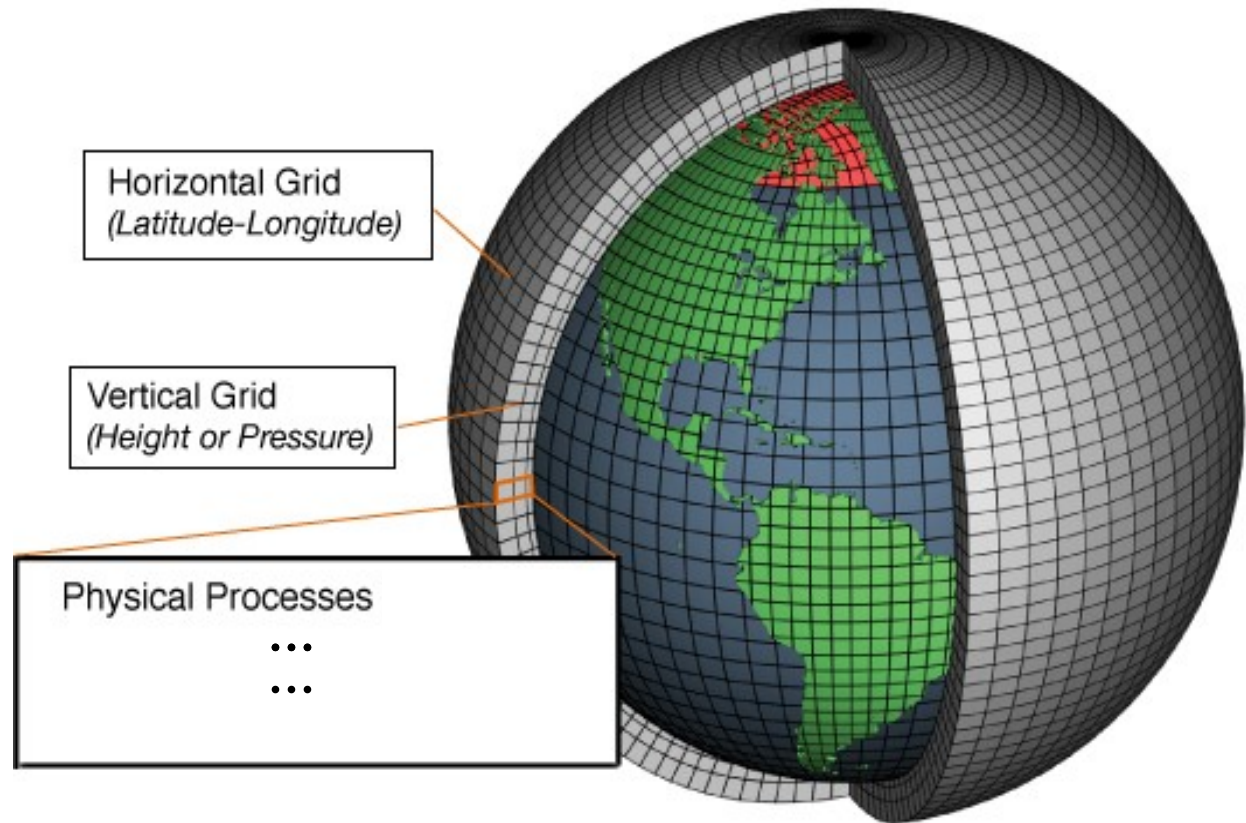
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Garching, 8 - 9 December 2009



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# Introduction

## Global climate models



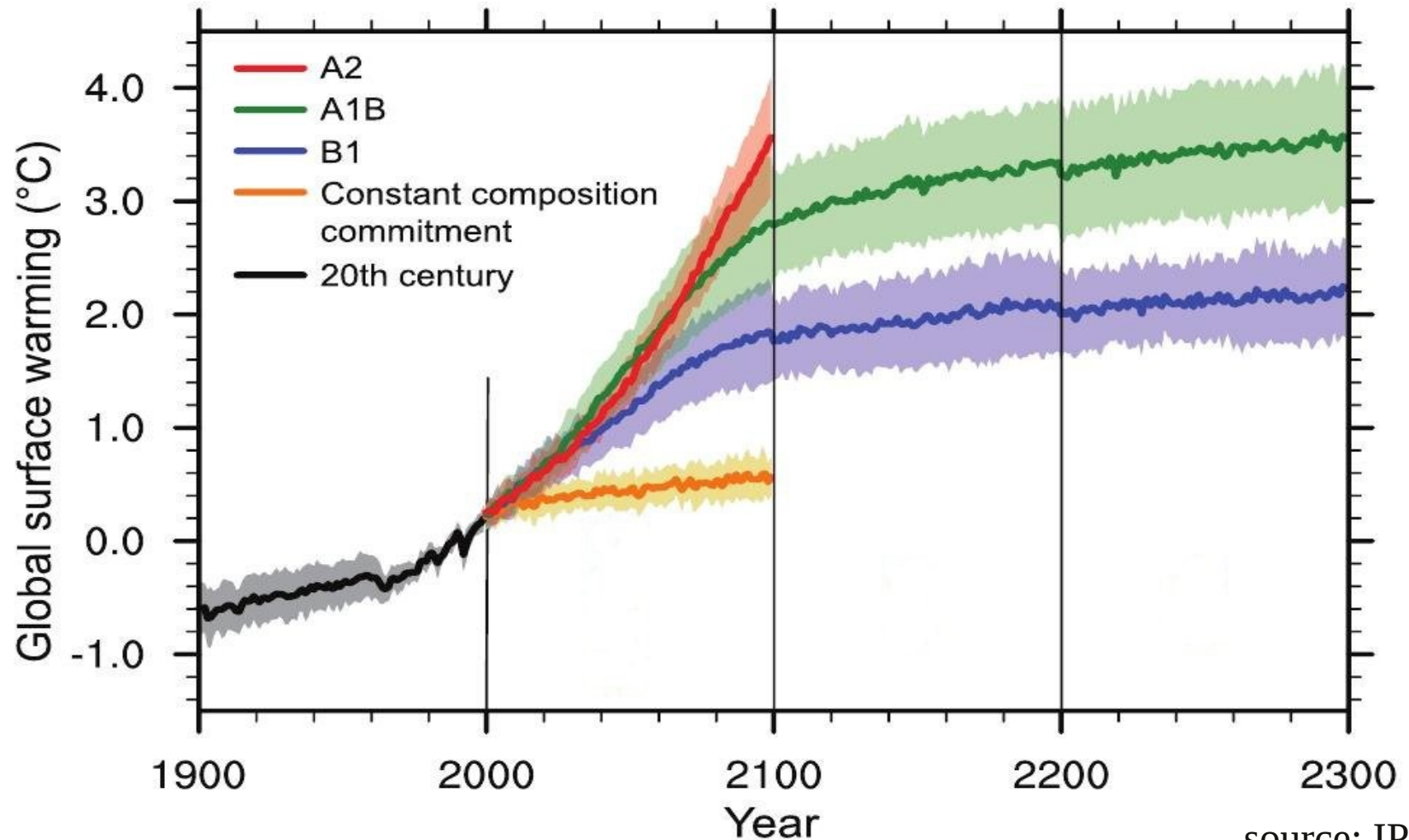
adapted from NOAA



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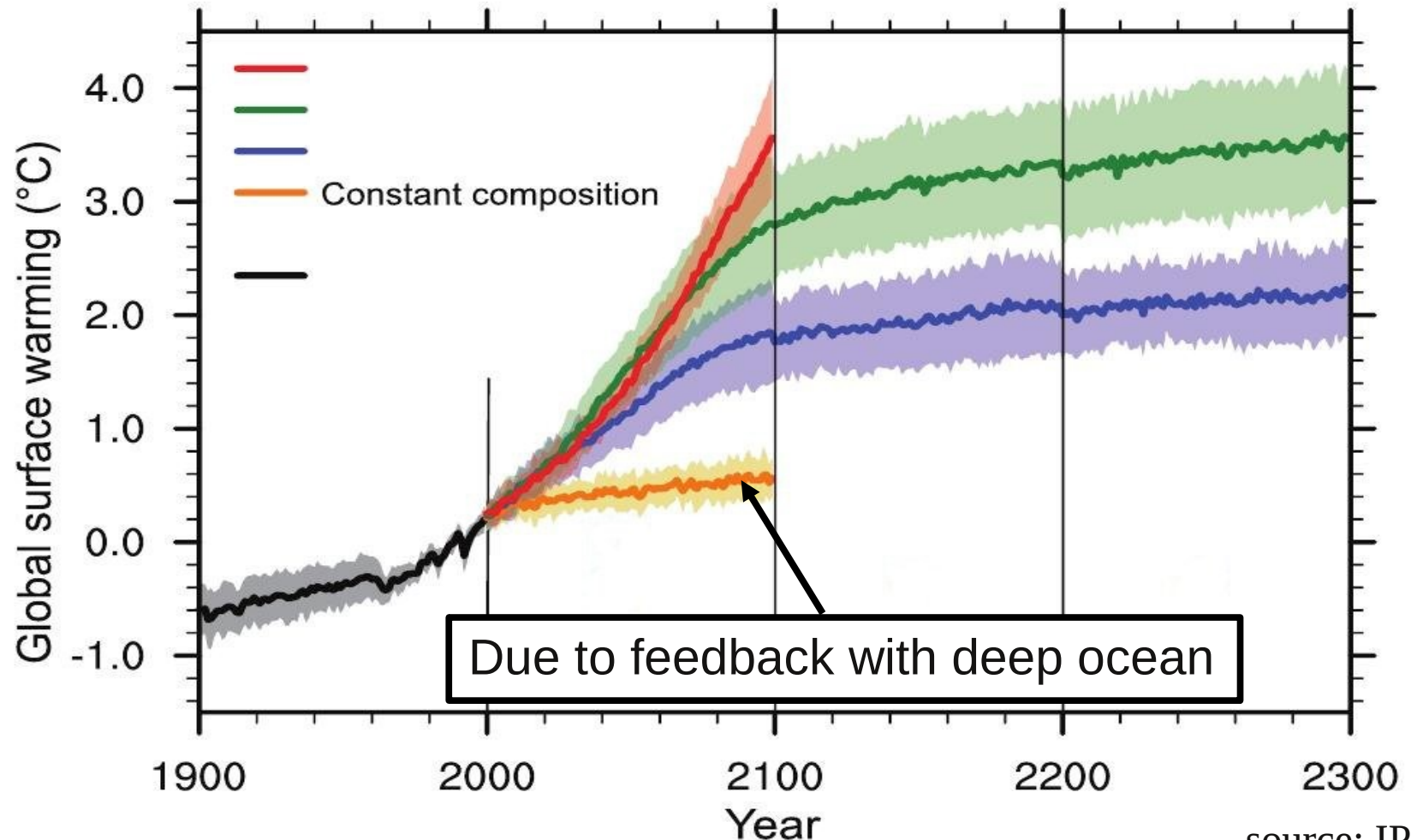
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source: IPCC

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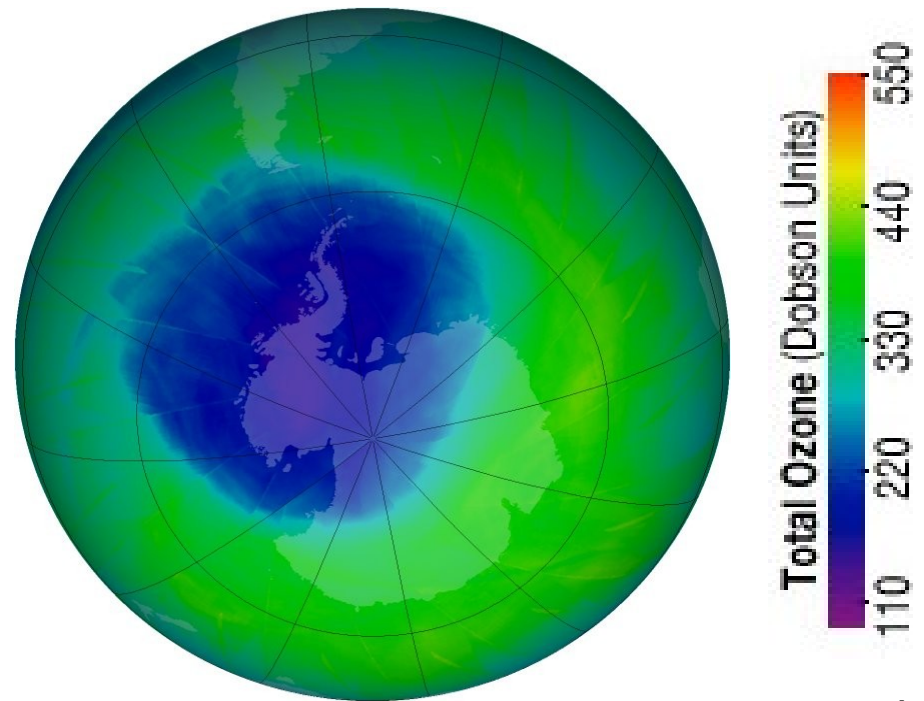


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Global climate models: no atmospheric chemistry

- Future ozone layer?

21<sup>st</sup> November 2009



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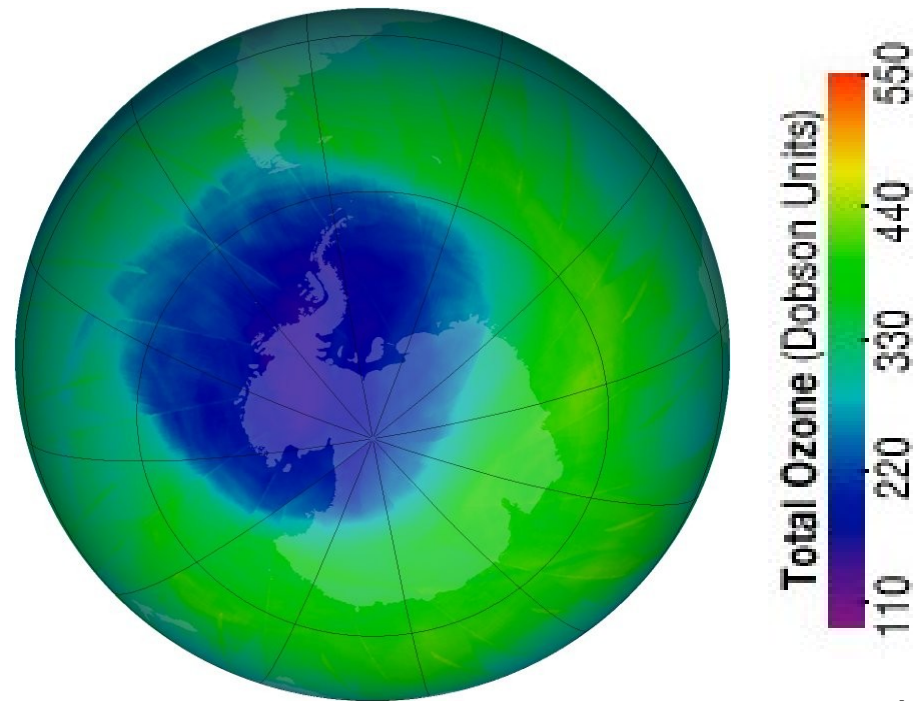


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- Atmosphere ~~↔~~ deep ocean

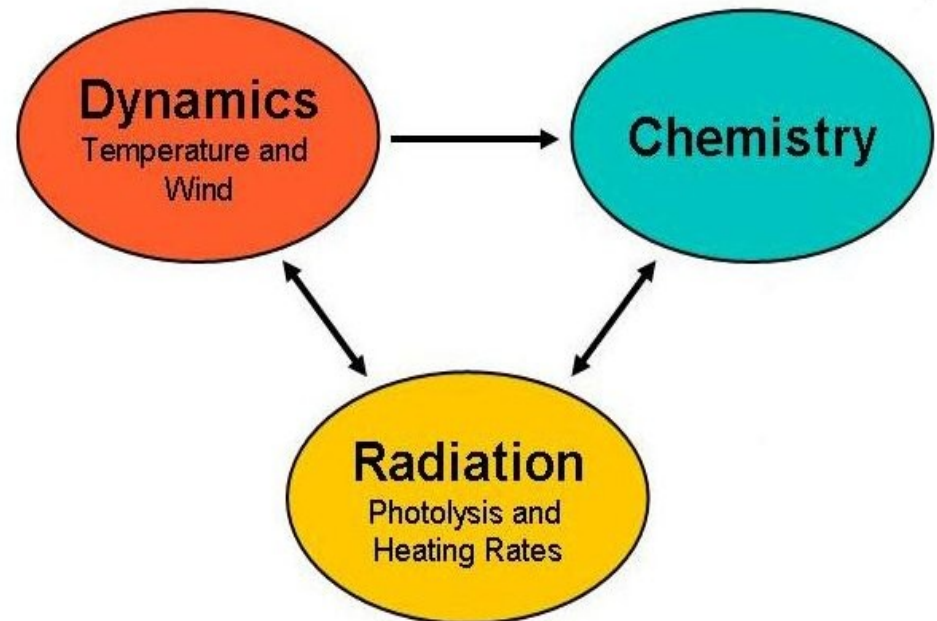




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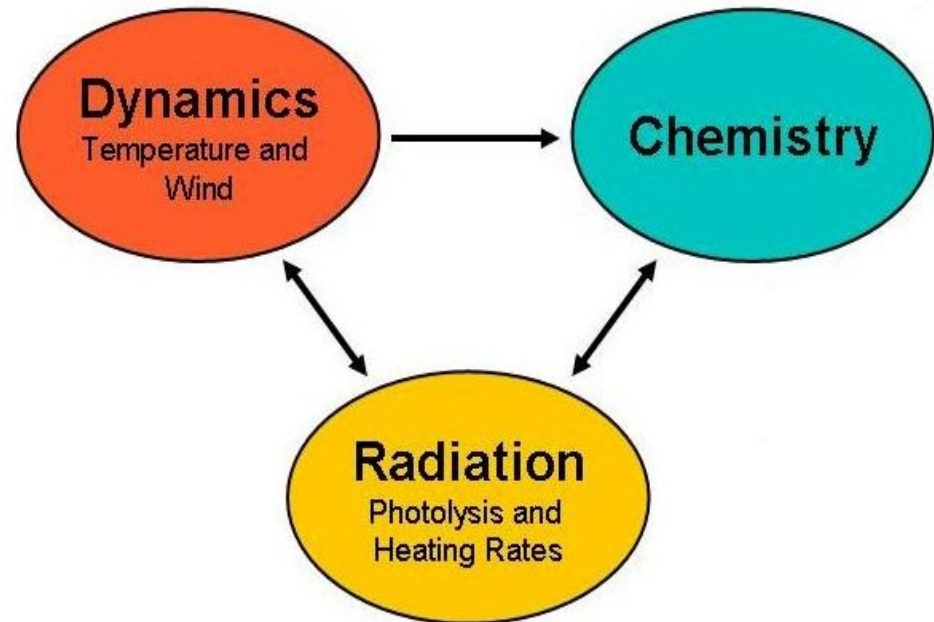


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- Atmosphere ~~↔~~ deep ocean
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We use and refine a CCM



# Outline

- Model description
- Performance on LRZ/ALTIX
- Modelling activities on LRZ/ALTIX

# Description

CCM system **EMAC** (**E**CHAM/**M**ESSy **A**tmospheric **C**hemistry)

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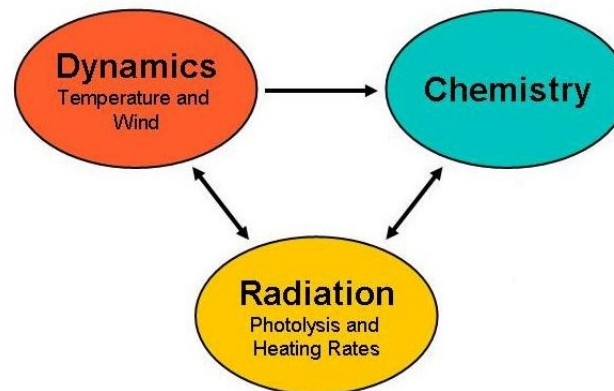
EMAC is flexible

- Selectable spatial resolution
- Configurable chemistry scheme
- Modular structure (see <http://www.messy-interface.org>)

# Description

## Atmospheric primitive equations – spectral representation

- Spectral transformation (horizontal)
- Finite differences (vertical)
- Semi-implicit leap frog (time)





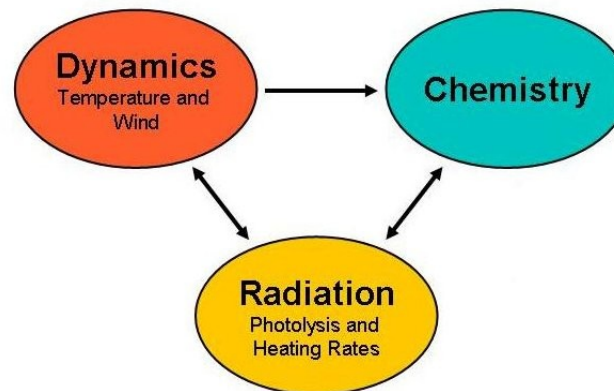
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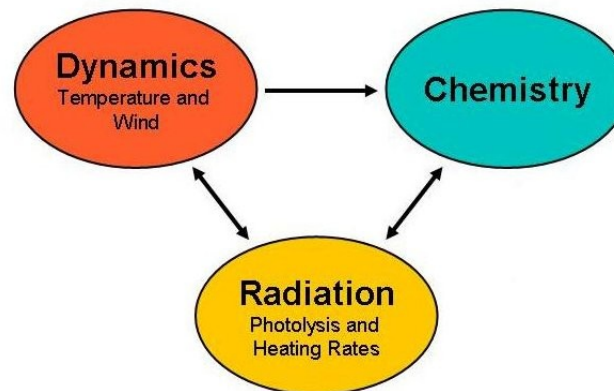
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## Radiative transfer, tracer transport, other sub-models – gaussian grid

Miscellaneous techniques



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→ EMAC valuable for benchmarking

# Performance on LRZ/ALTIX

Good performance, but gain limited

EMAC with  
detailed  
physics/chemistry

<i>vertical layers</i>	<i>CPUs</i>	<i>CPU time [kh/model year]</i>	<i>wall time [days/model year]</i>
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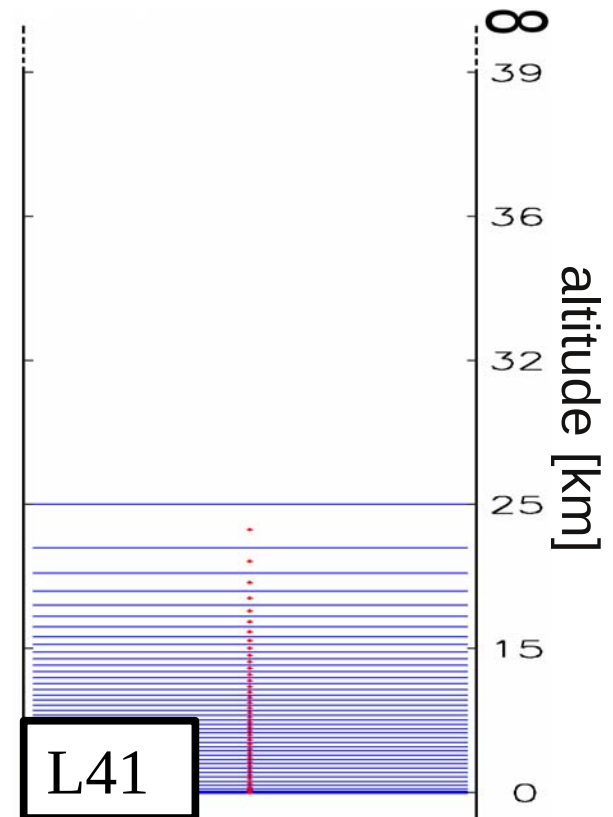
L41 version: multi-decadal simulations sensible

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# Development: new upper boundary

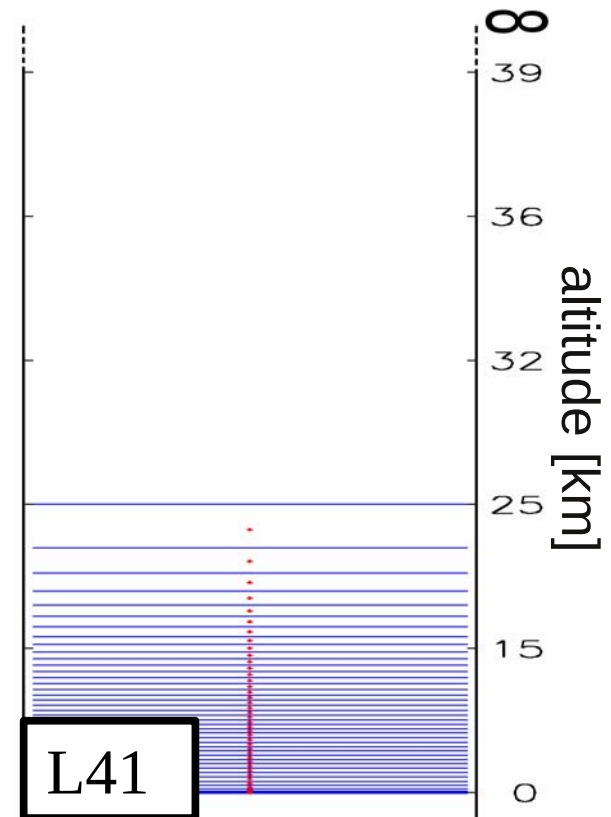
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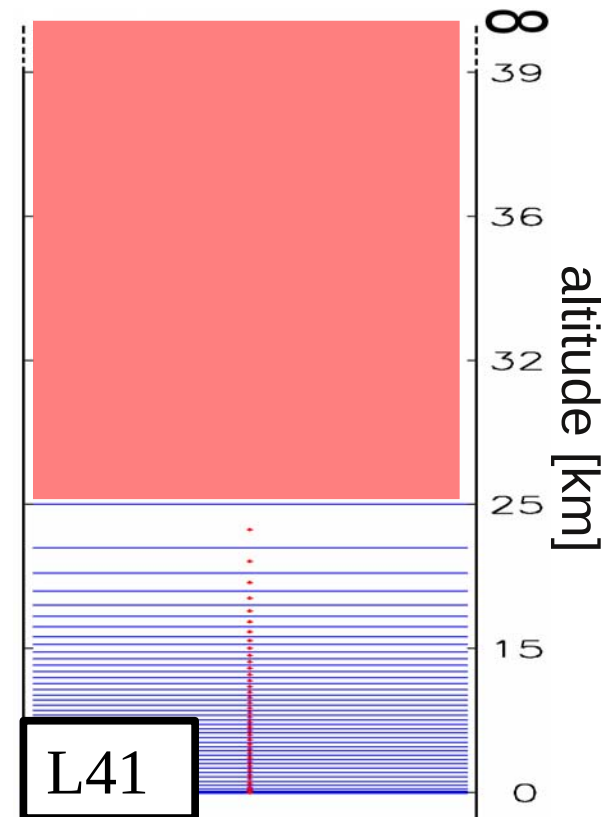
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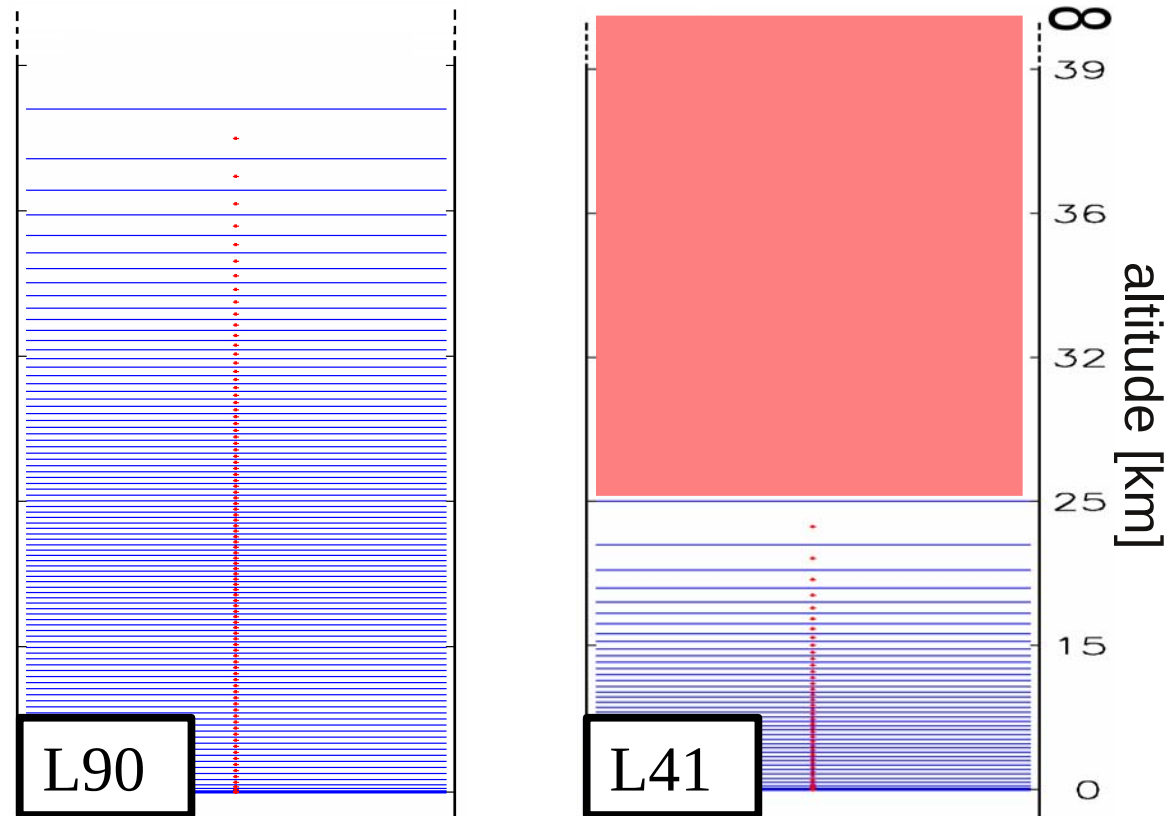
- Appropriate for our purposes
- But: single layer for whole atmosphere above 25 km
- Impact on chemistry below



# Development: new upper boundary

Solution: highest layer with chemical parameterisation

- Calibration via L90 version

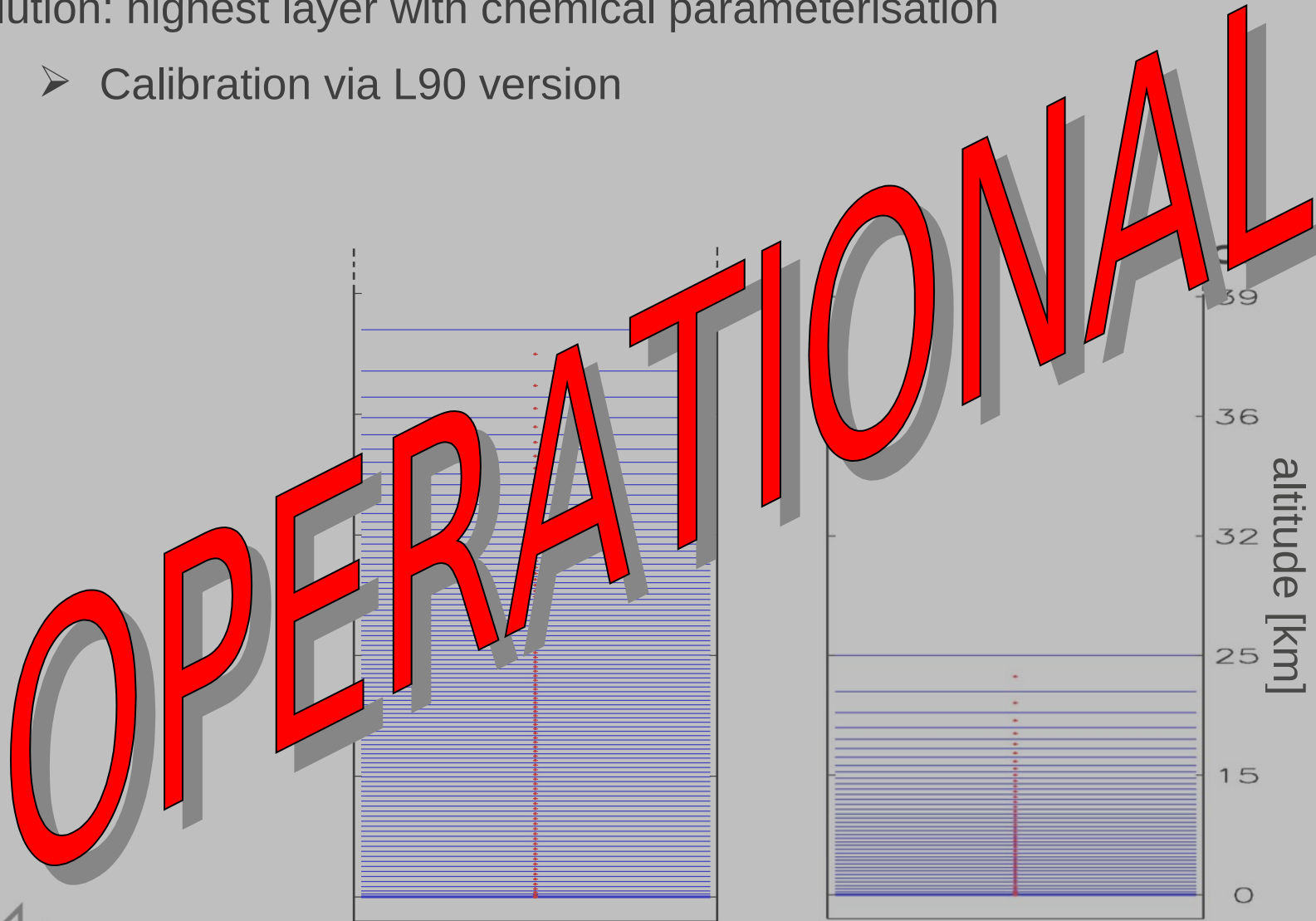




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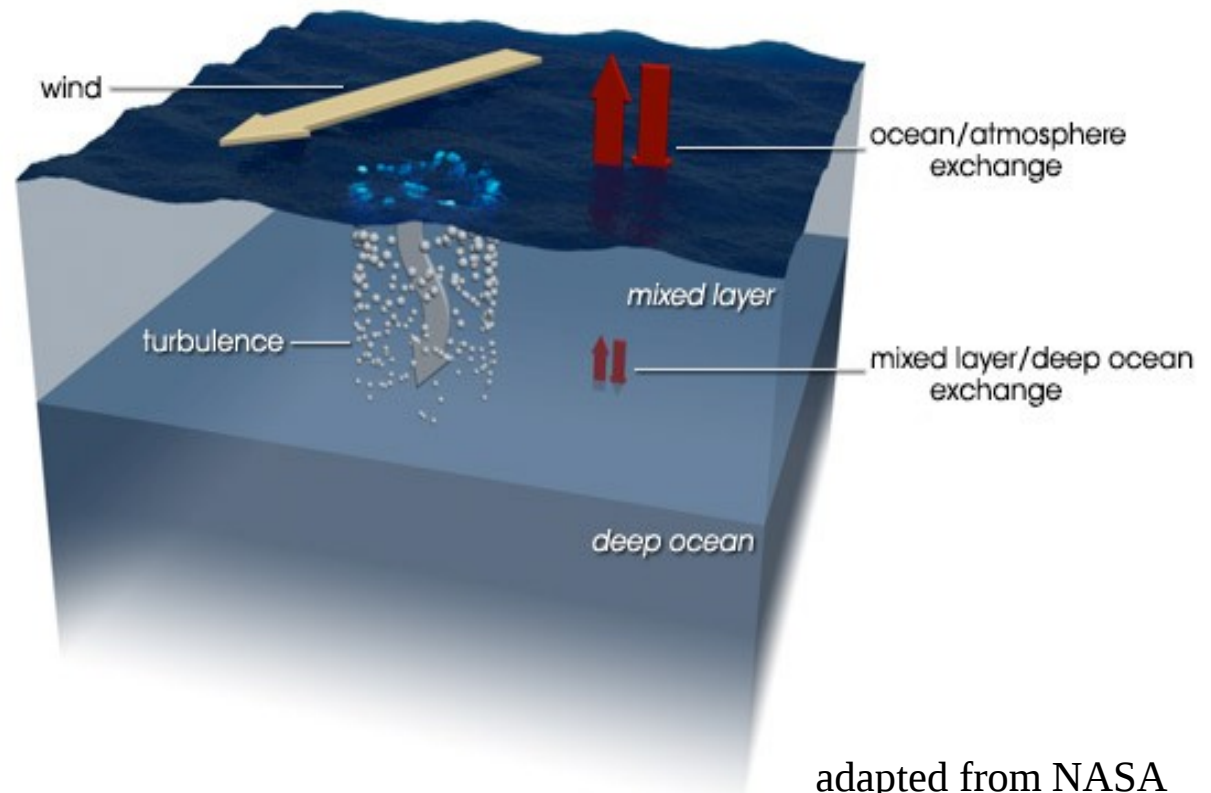
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# Development: mixed-layer ocean

## Implementation of mixed-layer ocean

- Feedback: atmosphere ↔ mixed-layer ocean
- No feedback: mixed-layer ocean ↔ deep ocean



adapted from NASA



# Development: mixed-layer ocean

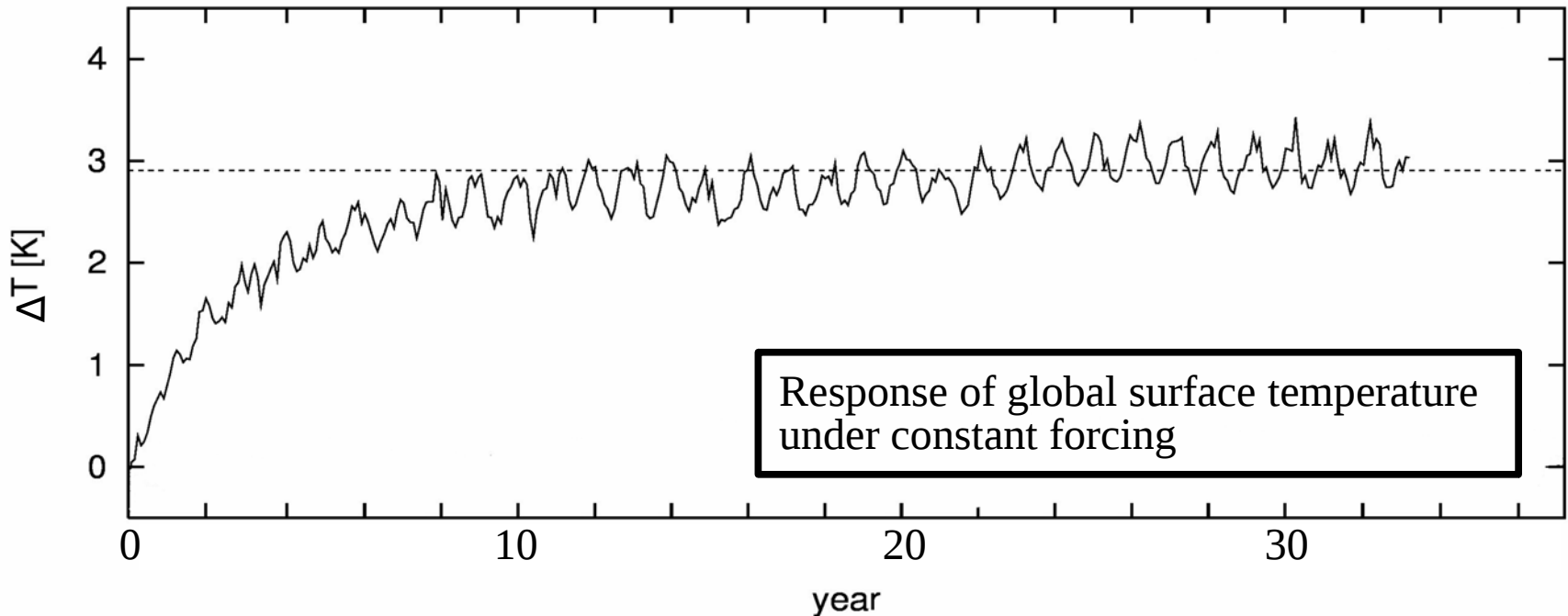
Mixed-layer ocean – additional computational demands

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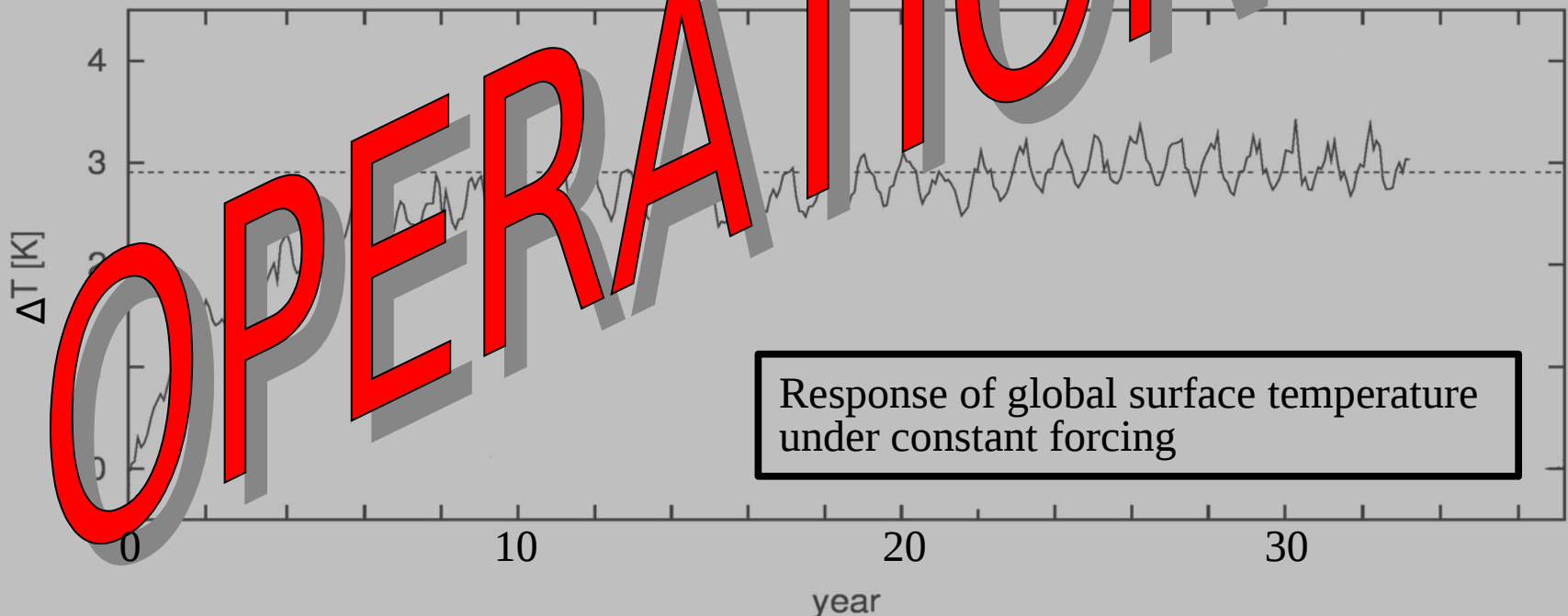
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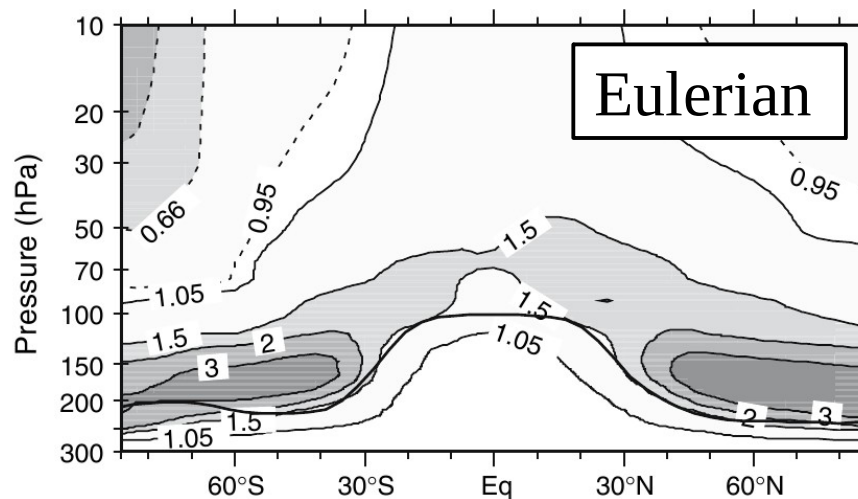
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Water vapour: ratio EMAC/satellite



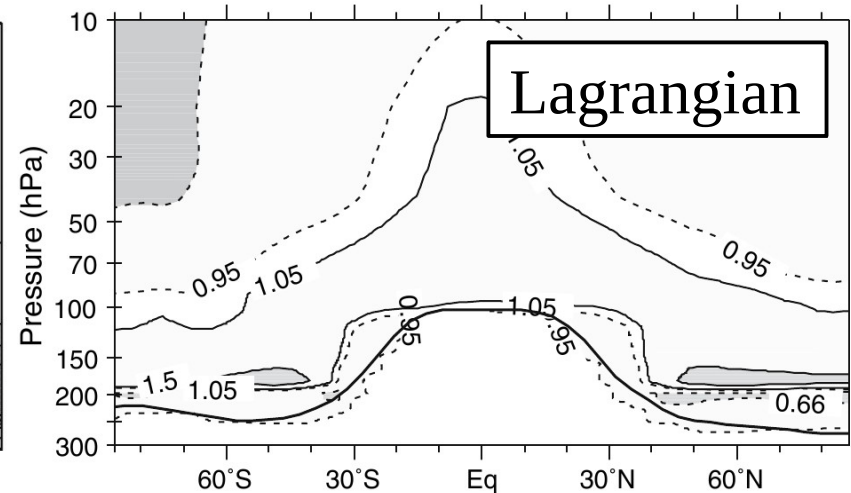
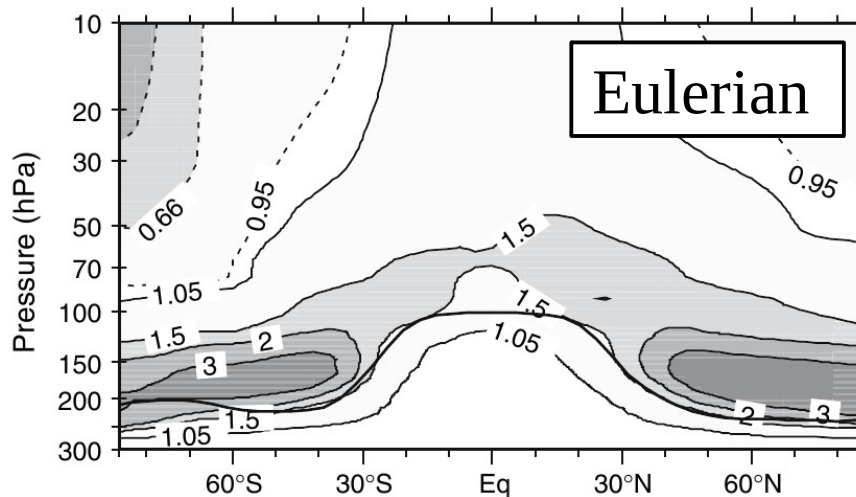
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**OPERATIONAL**



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In development: full-Lagrangian dynamical core

- Finite-mass method (Gauger et al., 2000)
- Lagrangian air parcels with variable spatial extent
- Completely new approach in climate modelling

# Development: chemistry-transport mode

## Important question

- Impact of disturbed emission rates on atmospheric composition and climate
- E.g. human-made nitrogen oxide → near-surface ozone

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- Dynamics binary identical despite chemistry unequal
- Main challenge: polar stratospheric clouds

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# Production simulations

Focus on model development:  
prerequisite for production simulations

→ Now feasible and going to start

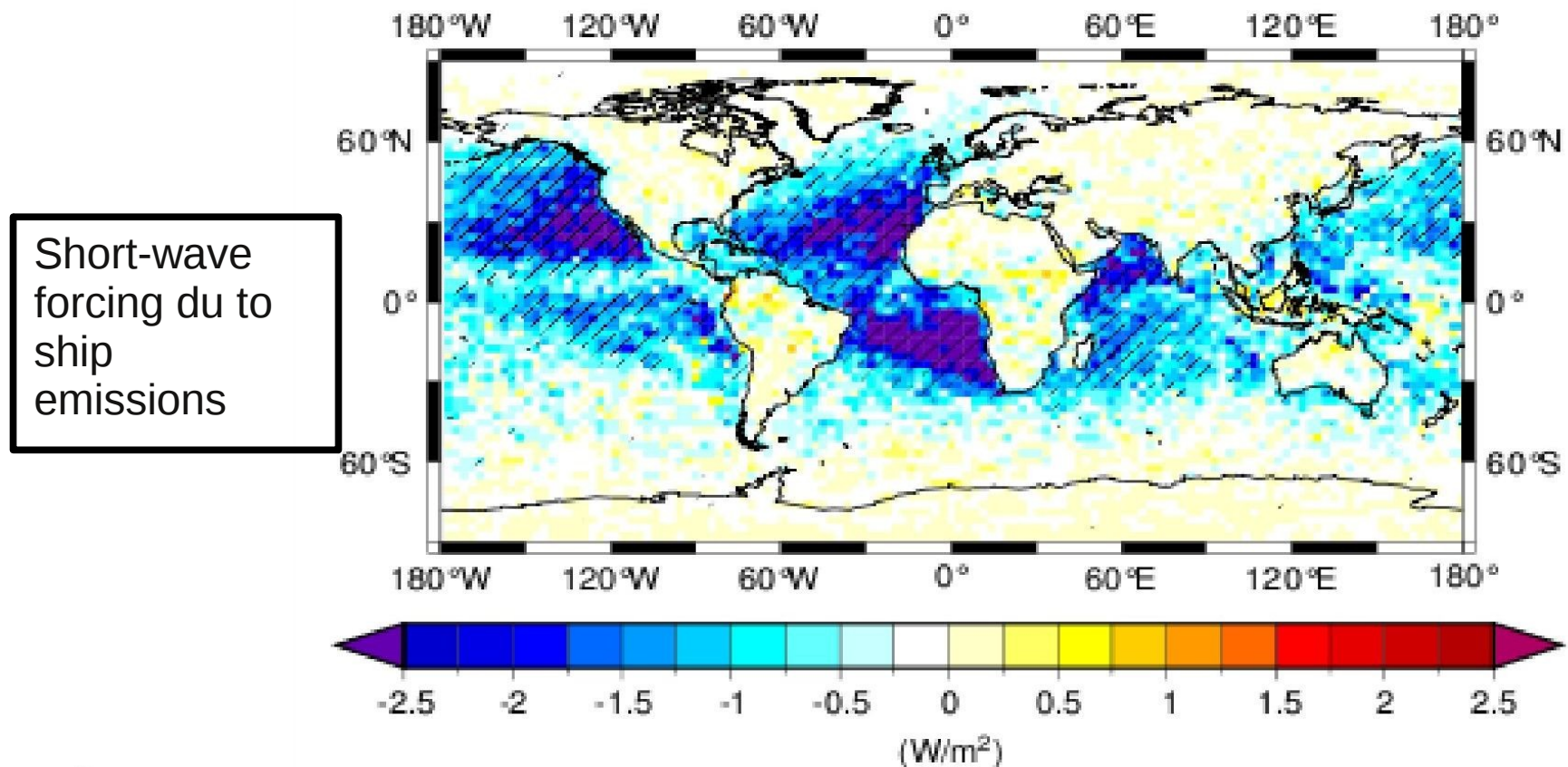




# Production simulations

Climate impact of nitrogen oxide and sulfur dioxide from shipping

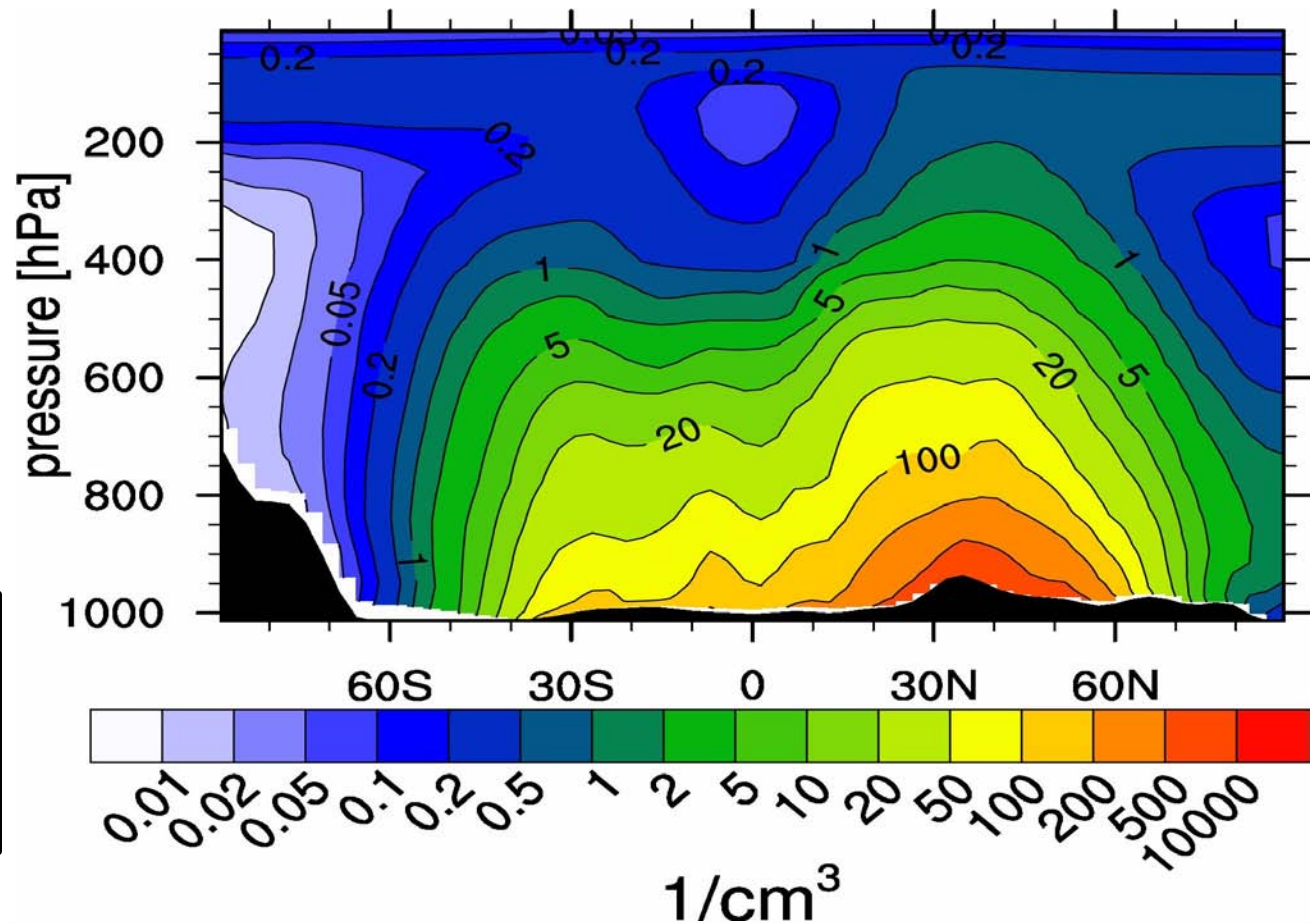
- Affects optical and microphysical cloud properties
- Mostly cooling



# Production simulations

## Aerosol aging

- Can result in ice nuclei
- Affects cirrus clouds



Number  
concentration of  
potential ice  
nuclei

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